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ASVAB

by Fred N. Grayson, M.A.
1st Lt., USAF (Ret'd)

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Fred N. Grayson, M.A., 1st Lt., USAF (Ret'd)

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- ❑ 9. Examine the explanations for any questions that you missed or that you were unsure of.
- ❑ 10. Either reread the review sections for any areas where you are struggling or proceed to take the other two practice tests.

PART I

INTRODUCTION

Introduction to the ASVAB

Format of the ASVAB

If you're reading this book, it means that you've already decided to consider taking the ASVAB (Armed Services Vocational Aptitude Battery) to qualify for the military. The ASVAB is an exam that presents a series of individual tests to measure various academic and vocational skills.

Until recently, the exam had ten subtests, but in 2002, the test changed. Two tests—Numerical Operations and Coding Speed—have been eliminated. A new test—Assembling Objects—has taken their place.

There are actually three forms of this exam. One is for high school students who are planning to take the exam some time in their junior or senior year. A second form, known as the *production version,* is for those enlisting directly in the service. The third form is a CAT ASVAB. This exam format is a computer-based test that presents questions based on your answers. CAT stands for *computer adaptive test* and means that the computer adapts its questions based on your answers. The first question you will get will be of medium difficulty. If you answer it correctly, the next question you get will be slightly more difficult. If you answer it incorrectly, the next question will be somewhat easier, and so on. The key to scoring well on the CAT ASVAB is to focus your efforts on the earlier questions. The better you do in the beginning, the better you will do overall, since the final score is normally based on both the number of correct answers and the level of difficulty.

Regardless of the type of test you'll be taking, there are specifics about the test that you should know. First of all, the following are the subtests that are on the test:

General Science
Arithmetic Reasoning
Word Knowledge
Paragraph Comprehension
Auto and Shop Information
Mathematics Knowledge
Mechanical Comprehension
Electronics Information
Assembling Objects

Currently, the ASVAB is given in about 14,000 schools. More than 900,000 students take the ASVAB each year. In 2001, a short-form version of the exam was developed, and consists of only those parts of the exam that make up the Armed Forces Qualification Test (AFQT). These consist of Arithmetic Reasoning, Mathematics Knowledge, Word Knowledge, and Paragraph Comprehension. However, if you decide to enlist, you will have to take the balance of the test in order to qualify.

If you've taken the institutional version, it is likely that you will be contacted by a recruiter to find out about your plans after graduation. Are you planning to go to college, go to a vocational or trade school, or enlist directly in the military? If you are planning to enlist, your scores will be used when you join.

Contents of the ASVAB

The following chart provides the details and purpose of each test you will take.

Test	***Time Allowed***	***Number of Test Items***	***Purpose***
General Science	11 minutes	25	To evaluate your understanding of physical and biological sciences
Arithmetic Reasoning	36 minutes	30	To evaluate your ability to solve arithmetic word problems
Word Knowledge	11 minutes	35	To evaluate your ability to understand the correct meaning of words, and to select appropriate synonyms where applicable
Paragraph Comprehension	13 minutes	15	To evaluate your ability to understand and identify information from given passages
Auto and Shop Information	11 minutes	25	To evaluate your knowledge of automobiles, shop procedures, and tools
Mathematics Knowledge	24 minutes	25	To evaluate your ability to perform mathematical computations, including algebra and geometry
Mechanical Comprehension	19 minutes	25	To evaluate your understanding of the principles of mechanics and your ability to utilize these physical principles
Electronics Information	9 minutes	20	To evaluate your knowledge of basic electricity, electronics, and radio principles
Assembling Objects	9 minutes (as of this printing)	16 (as of this printing)	To evaluate your ability with spatial relations and your understanding of how objects are connected
TOTAL	143 minutes	216 questions	

Taking The Test

In this book, you will be able to practice with questions that replicate the types of questions that you will find on the exam. There are several test-taking techniques that are important if you are to score as high as possible on this test.

Guess the Correct Answer

Should you guess? Absolutely! The ASVAB test is a multiple-choice test, and each section presents four answer choices. Because there is no penalty for incorrect answers on this test, it is to your advantage to guess if you don't know the answer.

Understand Multiple-Choice Questions

Because the ASVAB is made up of multiple-choice questions and each question has four choices, you must understand that to begin with you have a 25% chance of guessing correctly, merely by closing your eyes and selecting an answer. However, if you understand how multiple-choice questions are constructed, it will be somewhat easier to approach these questions. For each question, *there is only one correct answer*. The other three choices are incorrect.

There are levels of incorrectness. Some are more wrong than others. In test-development language, these incorrect answers are called *distracters* because they distract you from the correct answer. You may find one choice that is almost correct, but not quite right. Another choice may be completely incorrect. And the third choice may be almost right, almost wrong, or totally incorrect.

If you think you know the correct answer without even looking at the other choices, you're probably right. Most studies have shown that your first instinct is usually correct. Those who do poorly on multiple-choice tests are those who overanalyze the question. They think they know the answer, and then start to question their choice.

For example, if you were asked the following question, what would you select?

The Washington Monument is located in

A. Washington state.

B. New York City.

C. Washington, D.C.

D. Chicago.

The correct choice would be **C,** Washington, D.C. However, the over-thinker starts to get concerned and thinks, "This question is too easy. I wonder if it's asking about some other Washington Monument—maybe there's another one in Washington state."

Now, this is a very simplistic example, but it is actually what happens to you if you analyze a question too much. Read the question for what it is. The questions are not tricky. The trick is in choosing the answers.

Since you don't lose any points for guessing, understanding how to guess and improve your odds is helpful. The multiple-choice questions on this test have four choices, so your odds are 1 out of 4 that you can pick correctly. To put it another way, you have a 25% chance of guessing correctly.

These aren't great odds, so you have to find a way to increase them. To do so, you use the process of elimination. Start by eliminating any answers that you know are completely incorrect. In the earlier question, you might be reasonably sure that the Washington Monument isn't located in Chicago, so you can eliminate choice **D.** Now you only have to select the correct answer out of three choices—1 out of 3, or 33%. You've just increased your odds from 25% to 33%.

How do you get to the next level? Suppose that you know that the Washington Monument is on the East Coast. You can eliminate Washington state. You only have two choices—1 out of 2, 50%. The odds are getting better. You may be confused as to whether the Washington Monument is in New York City or Washington, D.C., but you can take a guess, and you have a reasonable chance of guessing correctly. Of course, if you knew the answer immediately, you got it right—and that's 100%.

How can you use this technique to increase your score on the entire test? Let's say, for example, there are 300 questions on the ASVAB. If you know the answers to 200 of the questions, you've already reached a score of 66%. That leaves only 100 questions for which you don't know the answers immediately. It is important, however, that you answer all of the questions on the test, and now you can make educated guesses. If you can increase your odds to 50% on each of the questions you're not sure about, you've now answered another 50 questions correctly—a total of 250 out of 300 questions—a score of 83%. Not bad.

Therefore, it makes sense to guess. Whether it's an educated guess or just a blind guess, you increase your odds of improving your score on every question.

Examples of Questions

This book goes into detail in other sections, but here are the types of questions you will encounter on the actual exam. See how you do on them.

Circle the letter of the answer choice that best answers the question.

General Science

1. An eclipse of the sun throws the shadow of the

A. moon on the sun.

B. moon on the Earth.

C. Earth on the sun.

D. Earth on the moon.

Arithmetic Reasoning

2. How many 36-passenger buses will it take to carry 144 people?

A. 3
B. 4
C. 5
D. 6

Word Knowledge

3. The wind is **variable** today.

A. mild
B. steady
C. shifting
D. chilling

Paragraph Comprehension

4. In certain areas, water is so scarce that every attempt is made to conserve it. For instance, on one oasis in the Sahara Desert, the amount of water necessary for each date palm tree has been carefully determined.

How much water should each tree be given?

A. no water at all
B. exactly the amount required
C. water on alternate days
D. water only if it is healthy

Auto and Shop Information

5. A car uses too much oil when which of the following parts are worn?

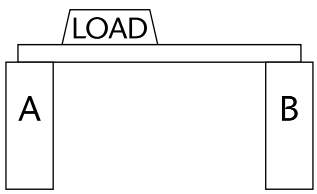
A. pistons
B. piston rings
C. main bearings
D. connecting rods

Mathematics Knowledge

6. If $x + 6 = 7$, then x is equal to

A. -1
B. 0
C. 1
D. 8

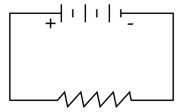
Mechanical Comprehension



7. Which post holds up the greater part of the load?

A. post A
B. post B
C. both equal
D. not clear

Electronics Information



8. In this circuit diagram, the resistance is 100 ohms, and the current is 0.1 amperes. The voltage is

A. 5 volts.

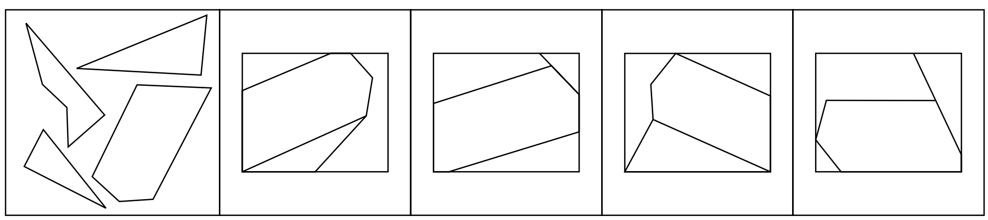
B. 10 volts.

C. 100 volts.

D. 1,000 volts.

Assembling Objects

9. In the following question, determine how the object will look when its parts in the first box are reassembled.



A B C D

The correct answers are: 1. **B,** 2. **B,** 3. **C,** 4. **B,** 5. **B,** 6. **C,** 7. **A,** 8. **B,** 9. **C.**

Scoring

Your ASVAB scores are compiled into various subsets to help measure your potential for various activities. The scores from the ASVAB can be used for both civilian and military careers. These scores are valid predictors of success in training programs and on-the-job performance for enlisted military occupations, 80% of which are applicable in civilian life. That means that even if you don't join the military, you can still use your scores to help you choose a career path.

The subsets are as follows:

- **Verbal Ability Composite:** Word Knowledge plus Paragraph Comprehension; measures your potential for verbal activities.
- **Math Ability Composite:** Arithmetic Reasoning plus Mathematics Knowledge; measures your potential for mathematical activities.
- **Academic Ability:** Verbal Ability plus Math Ability composites; measures your potential for further formal education.

Questions Commonly Asked About the ASVAB

Q. Who can take the ASVAB?

A. This test is primarily designed for students in the 10th through 12th grades, as well as those in two-year postsecondary schools.

Q. What is my aptitude?

A. Your aptitude is your readiness to become proficient in a specific type of activity. The test measures this aptitude, and offers you an indication of where your strengths lie.

Q. Do I need parental consent to take the test?

A. No, there is no requirement to obtain parental consent in order to take this exam. The scores generated on the test become records of the school.

Q. Where do I take the ASVAB?

A. Most of the over 900,000 students who take the ASVAB take the test in their own high schools. Check with your guidance counselor. If, however, you're planning to take the test on your own, visit your local recruiter. He or she will direct you to the nearest testing center, one of approximately 65 Military Entrance Procession Stations (MEPS) throughout the country.

Q. What if I plan to go to college?

A. Whether college is in your plans or not, the ASVAB results will provide you with information that can be extremely helpful in determining your capacity for advanced academic education, as well as in helping you identify the areas that might be ideal for further career exploration.

Q. What does it cost to take the test?

A. There is no charge to take the ASVAB. The Department of Defense provides all of the test materials for you, as well as paying for the administration and scoring of the test.

Q. Once I've taken the test, what is my obligation to the military?

A. You have no obligation to join the military. However, you will be required to sign an authorization that permits the release of your scores to all of the military services. Then, you will undoubtedly be called by recruiters from the Army, Navy, Air Force, and Marine Corps, as well as the U.S. Coast Guard, so they can try to convince you to join their branch of the service.

Q. What about recruiters?

A. If a recruiter contacts you, make the time to talk to him or her. A recruiter can answer a lot of your questions about the benefits available to you in the military, including salaries, jobs, training, and travel.

Q. Is there a relationship between the ASVAB and Selective Service registration?

A. No, there is no relationship between them. Your ASVAB scores are not available to the Selective Service.

Q. What if I'm planning to become a commissioned officer?

A. Most branches of the service require you to have a college degree in order to become a commissioned officer, and you need the degree if you are applying for Officer Training Schools or Officer Candidate Schools. However, despite the fact that the ASVAB is not required for these schools, the results can still assist you in career planning.

Q. Are my scores going to be released?

A. No. The scores are only for use by the Armed Services and your guidance counselor, and are good for enlistment purposes for up to two years after taking the ASVAB. After that, your personal information and scores are retained by the Department of Defense only for research purposes.

Q. How are my ASVAB scores used?

A. If you are planning to enter the military, your scores are used to help determine which military specialties would be right for you. If you have no intention of enlisting, you can still use the scores as an aptitude test that can help guide you in future career choices.

You will receive your scores on a report called the *ASVAB Student Results Sheet*. This is not a pass/fail test. Instead, your grade will be a percentile score, indicating how you compare to others who have taken the test. For example, if you receive a percentile score of 75%, it means you have scored as well as, if not better than, 75% of the other people taking the test when you did.

Q. Do I need to prepare for this test?

A. Although many test developers think that it's not necessary to prepare for a test like this, history has proven otherwise. The more you study and the more you take practice tests, the better prepared you will be for the actual exam. The purpose of this book is to give you that practice, and to help you achieve your highest possible score.

Q. How can I prepare for the ASVAB?

A. Reviewing the content and concepts of these various subtests will be invaluable in helping you understand the material that you will encounter on the test. In addition, familiarity with directions and question types is a major step toward scoring high on the actual ASVAB.

Furthermore, it is always extremely helpful to go back to some of your textbooks to review the material you may already have learned. Once you've read through this book and taken the practice tests, you will have a better idea of what you need to focus on to improve your scores. Reread the book. Reread your old textbooks. Talk to your teachers if you are having specific problems in some of the ASVAB test subjects.

Q. How can I find out more about careers?

A. You can consult *ASVAB 18/19 Career Exploration Program,* usually available in your guidance office. The book includes an Interest Finder, which is a self-administered interest inventory.

A Final Word About Careers

One of the major purposes of this exam is to help you and the military find a career choice that will be suitable for your level of knowledge and skill levels. But first you should determine which branch of the service is for you. Take the time to visit your local recruiters from each of the four branches of the military—Army, Navy, Air Force, and Marines, as well as the U.S. Coast Guard. Even though they may be similar in a lot of ways, each branch of the service will offer you different opportunities, both educationally and toward your future career path.

PART II

DIAGNOSTIC TEST

The following test is half the length of the official ASVAB. Use this test to get an idea of your strengths and weaknesses.

Give yourself the following time limits for the various problem types:

General Science: 5.5 minutes
Arithmetic Reasoning: 18 minutes
Word Knowledge: 5.5 minutes
Paragraph Comprehension: 6.5 minutes
Auto and Shop Information: 5.5
Mathematics Knowledge: 12 minutes
Mechanical Comprehension: 9.5 minutes
Electronics Information: 4.5 minutes
Assembling Objects: 4.5 minutes

CUT HERE

Answer Sheet for Diagnostic Test

(Remove this sheet and use it to mark your answers)

General Science

1 Ⓐ Ⓑ Ⓒ Ⓓ
2 Ⓐ Ⓑ Ⓒ Ⓓ
3 Ⓐ Ⓑ Ⓒ Ⓓ
4 Ⓐ Ⓑ Ⓒ Ⓓ
5 Ⓐ Ⓑ Ⓒ Ⓓ
6 Ⓐ Ⓑ Ⓒ Ⓓ
7 Ⓐ Ⓑ Ⓒ Ⓓ
8 Ⓐ Ⓑ Ⓒ Ⓓ
9 Ⓐ Ⓑ Ⓒ Ⓓ
10 Ⓐ Ⓑ Ⓒ Ⓓ
11 Ⓐ Ⓑ Ⓒ Ⓓ
12 Ⓐ Ⓑ Ⓒ Ⓓ

Arithmetic Reasoning

1 Ⓐ Ⓑ Ⓒ Ⓓ
2 Ⓐ Ⓑ Ⓒ Ⓓ
3 Ⓐ Ⓑ Ⓒ Ⓓ
4 Ⓐ Ⓑ Ⓒ Ⓓ
5 Ⓐ Ⓑ Ⓒ Ⓓ
6 Ⓐ Ⓑ Ⓒ Ⓓ
7 Ⓐ Ⓑ Ⓒ Ⓓ
8 Ⓐ Ⓑ Ⓒ Ⓓ
9 Ⓐ Ⓑ Ⓒ Ⓓ
10 Ⓐ Ⓑ Ⓒ Ⓓ
11 Ⓐ Ⓑ Ⓒ Ⓓ
12 Ⓐ Ⓑ Ⓒ Ⓓ
13 Ⓐ Ⓑ Ⓒ Ⓓ
14 Ⓐ Ⓑ Ⓒ Ⓓ
15 Ⓐ Ⓑ Ⓒ Ⓓ

Word Knowledge

1 Ⓐ Ⓑ Ⓒ Ⓓ
2 Ⓐ Ⓑ Ⓒ Ⓓ
3 Ⓐ Ⓑ Ⓒ Ⓓ
4 Ⓐ Ⓑ Ⓒ Ⓓ
5 Ⓐ Ⓑ Ⓒ Ⓓ
6 Ⓐ Ⓑ Ⓒ Ⓓ
7 Ⓐ Ⓑ Ⓒ Ⓓ
8 Ⓐ Ⓑ Ⓒ Ⓓ
9 Ⓐ Ⓑ Ⓒ Ⓓ
10 Ⓐ Ⓑ Ⓒ Ⓓ
11 Ⓐ Ⓑ Ⓒ Ⓓ
12 Ⓐ Ⓑ Ⓒ Ⓓ
13 Ⓐ Ⓑ Ⓒ Ⓓ
14 Ⓐ Ⓑ Ⓒ Ⓓ
15 Ⓐ Ⓑ Ⓒ Ⓓ

Paragraph Comprehension

1 Ⓐ Ⓑ Ⓒ Ⓓ
2 Ⓐ Ⓑ Ⓒ Ⓓ
3 Ⓐ Ⓑ Ⓒ Ⓓ
4 Ⓐ Ⓑ Ⓒ Ⓓ
5 Ⓐ Ⓑ Ⓒ Ⓓ
6 Ⓐ Ⓑ Ⓒ Ⓓ
7 Ⓐ Ⓑ Ⓒ Ⓓ

Auto and Shop Information

1	Ⓐ Ⓑ Ⓒ Ⓓ
2	Ⓐ Ⓑ Ⓒ Ⓓ
3	Ⓐ Ⓑ Ⓒ Ⓓ
4	Ⓐ Ⓑ Ⓒ Ⓓ
5	Ⓐ Ⓑ Ⓒ Ⓓ
6	Ⓐ Ⓑ Ⓒ Ⓓ
7	Ⓐ Ⓑ Ⓒ Ⓓ
8	Ⓐ Ⓑ Ⓒ Ⓓ
9	Ⓐ Ⓑ Ⓒ Ⓓ
10	Ⓐ Ⓑ Ⓒ Ⓓ
11	Ⓐ Ⓑ Ⓒ Ⓓ
12	Ⓐ Ⓑ Ⓒ Ⓓ

Mathematics Knowledge

1	Ⓐ Ⓑ Ⓒ Ⓓ
2	Ⓐ Ⓑ Ⓒ Ⓓ
3	Ⓐ Ⓑ Ⓒ Ⓓ
4	Ⓐ Ⓑ Ⓒ Ⓓ
5	Ⓐ Ⓑ Ⓒ Ⓓ
6	Ⓐ Ⓑ Ⓒ Ⓓ
7	Ⓐ Ⓑ Ⓒ Ⓓ
8	Ⓐ Ⓑ Ⓒ Ⓓ
9	Ⓐ Ⓑ Ⓒ Ⓓ
10	Ⓐ Ⓑ Ⓒ Ⓓ
11	Ⓐ Ⓑ Ⓒ Ⓓ
12	Ⓐ Ⓑ Ⓒ Ⓓ

Mechanical Comprehension

1	Ⓐ Ⓑ Ⓒ Ⓓ
2	Ⓐ Ⓑ Ⓒ Ⓓ
3	Ⓐ Ⓑ Ⓒ Ⓓ
4	Ⓐ Ⓑ Ⓒ Ⓓ
5	Ⓐ Ⓑ Ⓒ Ⓓ
6	Ⓐ Ⓑ Ⓒ Ⓓ
7	Ⓐ Ⓑ Ⓒ Ⓓ
8	Ⓐ Ⓑ Ⓒ Ⓓ
9	Ⓐ Ⓑ Ⓒ Ⓓ
10	Ⓐ Ⓑ Ⓒ Ⓓ
11	Ⓐ Ⓑ Ⓒ Ⓓ
12	Ⓐ Ⓑ Ⓒ Ⓓ

Electronics Information

1	Ⓐ Ⓑ Ⓒ Ⓓ
2	Ⓐ Ⓑ Ⓒ Ⓓ
3	Ⓐ Ⓑ Ⓒ Ⓓ
4	Ⓐ Ⓑ Ⓒ Ⓓ
5	Ⓐ Ⓑ Ⓒ Ⓓ
6	Ⓐ Ⓑ Ⓒ Ⓓ
7	Ⓐ Ⓑ Ⓒ Ⓓ
8	Ⓐ Ⓑ Ⓒ Ⓓ
9	Ⓐ Ⓑ Ⓒ Ⓓ
10	Ⓐ Ⓑ Ⓒ Ⓓ

Assembling Objects

1	Ⓐ Ⓑ Ⓒ Ⓓ
2	Ⓐ Ⓑ Ⓒ Ⓓ
3	Ⓐ Ⓑ Ⓒ Ⓓ
4	Ⓐ Ⓑ Ⓒ Ⓓ
5	Ⓐ Ⓑ Ⓒ Ⓓ
6	Ⓐ Ⓑ Ⓒ Ⓓ
7	Ⓐ Ⓑ Ⓒ Ⓓ
8	Ⓐ Ⓑ Ⓒ Ⓓ

CUT HERE

Diagnostic Test

The following is like the ASVAB test that you will take, only half-length.

General Science

1. Which choice below shows the correct order from most to least inclusive?

A. kingdom, phylum, order, class, species

B. kingdom, phylum, class, order, species

C. species, order, class, phylum, kingdom

D. species, class, order, phylum, kingdom

2. Which of the following are not correctly paired?

A. proteins: amino acids

B. lipids: fatty acids and glycerol

C. nucleic acids: ribose

D. carbohydrates: monosaccharides

3. Given the reaction 2 CO (g) + O_2 (g) → $2CO_2$ (g), how many oxygen atoms are represented to the left of the arrow?

A. 1

B. 2

C. 3

D. 4

4. The correct formula for carbon tetrachloride is

A. C_4C4.

B. C_4Cl.

C. CCl_4.

D. CCl.

5. In a plant, pollen is produced in the

A. anther.

B. pistil.

C. xylem.

D. phloem.

6. Isotopes of the same element differ in the number of

A. electrons.

B. protons.

C. neutrons.

D. neurons.

7. A ball rolls down an incline. A block slides down the same incline. If both start from rest at the same place, which reaches the bottom first? Neglect friction on the block.

A. ball

B. block

C. both at the same time

D. the more massive of the two

8. The pH of a 0.001 NaOH solution is

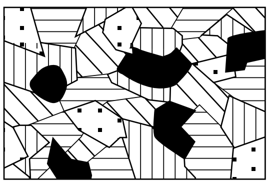
A. -3.

B. 3.

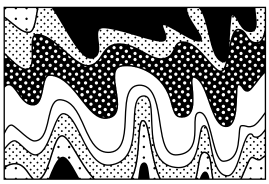
C. 4.

D. 11.

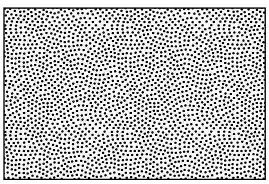
9. Which of the following diagrams best represents a sample of the igneous rock granite?



A



C



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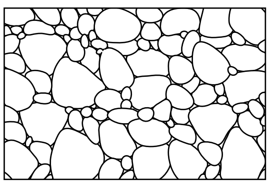


D

A. Illustration A

B. Illustration B

C. Illustration C

D. Illustration D

10. As you hike along a trail, you encounter the remains of an old volcano. Which of the rocks listed below would you expect to find?

A. sandstone, cobblestone, limestone

B. pumice, obsidian, scoria

C. marble, gneiss, slate

D. all of the above

11. The plant hormone most closely associated with stress is

A. auxin.

B. cytokinin.

C. ethylene gas.

D. abscisic acid.

12. What numbers should be placed in front of magnesium (Mg) and gold (Au) in order to balance the following equation? $Mg + AuCl_3 \rightarrow MgCl_2 + Au$

A. 1, 2

B. 2, 2

C. 2, 3

D. 3, 2

Arithmetic Reasoning

1. Mary has an appointment in 50 minutes. It is now 3:50 p.m. When is Mary's appointment?

A. 3:00 p.m.
B. 4:00 p.m.
C. 4:40 p.m.
D. 4:45 p.m.

2. Siri earned $520 last week. Her pay is based on a 6% commission of all sales. What were Siri's total sales last week?

A. $31.20
B. $86.67
C. $3,120.00
D. $8,666.67

3. Marty has 16 pencils and 4 times as many erasers. How many more erasers than pencils does Marty have?

A. 4
B. 32
C. 48
D. 64

4. Last week, Craig ran the race in $13\frac{2}{3}$ minutes. This week, he ran it in $12\frac{5}{12}$ minutes. By how many seconds did his time improve?

A. 15
B. 75
C. 120
D. 150

5. Trey can tie 45 knots in 8 minutes. At this rate, how long will it take him to tie 60 knots?

A. 10 minutes
B. $10\frac{2}{3}$ minutes
C. 12 minutes
D. $12\frac{1}{2}$ minutes

6. Security answered five calls between 5:00 and 6:00, three calls between 6:00 and 7:00, no calls between 7:00 and 8:00, and eight calls between 8:00 and 9:00. What was the average number of calls answered during this time?

A. 4
B. $5\frac{1}{3}$
C. 6
D. 16

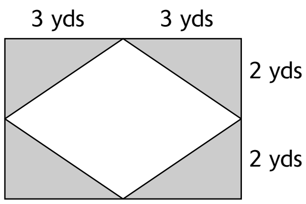
7. A recliner originally priced at $900 was discounted 30%. Since it didn't sell, it was reduced another 20%. What is the total percent of discount?

A. 56%
B. 50%
C. 48%
D. 44%

8. A circular swimming pool 5 feet high has a volume of 125π cubic feet. What is the distance across the widest part of the pool?

A. 5 feet
B. 10 feet
C. 20 feet
D. 25 feet

9. Mrs. Lanis plans to put flowers in her yard except in each corner, as shown. What area of her yard remains for the flowers?



A. 24 square yards
B. 18 square yards
C. 12 square yards
D. 6 square yards

10. A check register shows a $512.33 beginning balance, a deposit of $120.30, withdrawals of $35 and $60, another deposit of $21.84, and a withdrawal of $36.89. What is the ending balance?

A. $238.30
B. $522.58
C. $596.36
D. $786.36

11. Carlo takes out a loan of $600 that charges an annual interest rate of 15%. If he repays the loan in monthly installments over a 1-year period, what will his payments be?

A. $690.00
B. $90.00
C. $57.50
D. $7.50

12. Danielle is decorating a package with ribbons. If she cut a 5-foot piece of ribbon into 4-inch pieces, how many smaller ribbons are there?

A. 12
B. 15
C. 18
D. 24

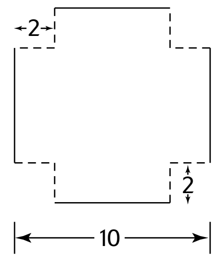
13. Admission to a museum costs $15.50 per adult and $8.75 per child. What is the cost for a family of two adults and four children to see the museum?

A. $52.50
B. $66.00
C. $79.50
D. $93.00

14. You have 7 quarters. How many more quarters are needed to fill a $10.00 quarter wrapper?

A. 3
B. 13
C. 28
D. 33

15. A cardboard square measuring 10 inches on each side is to be cut from a box. If 2-inch squares are cut from each corner and the sides are then folded upward, what is the volume of the resulting box?



A. 40 in^3
B. 72 in^3
C. 80 in^3
D. 100 in^3

Word Knowledge

1. **Finagle** most nearly means

A. fly.
B. trick.
C. turn a corner.
D. sell out.

2. **Impair** most nearly means

A. weaken.
B. help.
C. encourage.
D. double.

3. His play on the court was **pivotal.**

A. laughable
B. crucial
C. helpful
D. blameless

4. The sound was **amplified** throughout the ship.

A. filtered
B. dampened
C. heard
D. expanded

5. They were engaged in a very **tenuous** negotiation.

A. strong
B. faulty
C. tentative
D. important

6. **Mature** most nearly means

A. full grown.
B. inedible.
C. overweight.
D. concise.

7. **Stalwart** most nearly means

A. unmoving.
B. brave.
C. fearful.
D. timid.

8. They had **rudimentary** plans for the building.

A. mature
B. elementary
C. final
D. complete

9. She was unable to **placate** her child.

A. encourage
B. pacify
C. argue with
D. forget

10. **Provincial** most nearly means

A. metropolitan.
B. unhelpful.
C. thoughtful.
D. unsophisticated.

11. **Terminate** most nearly means

A. start.
B. stop.
C. endure.
D. devour.

12. They thought that he was **imprudent**.

A. tactful
B. careful
C. careless
D. willing

13. He was unable to find his **quarry**.

A. lake
B. prey
C. home
D. demolition site

14. **Ruse** most nearly means

A. a trick.
B. a track.
C. cake icing.
D. a collar.

15. **Torpid** most nearly means

A. hot.
B. excitable.
C. sluggish.
D. compassionate.

Paragraph Comprehension

1. In the early 1900s, horticulturist George Washington Carver developed more than 325 products from the peanut. Peanut meat loaf and chocolate-covered peanuts were just two of the food items that Carver developed. However, most interestingly, Carver also engineered many unusual peanut products. For example, he formulated beauty products from the peanut such as hand lotion, shaving cream, and shampoo.

The best title for this selection is

A. Carver and Peanut Food Products.

B. Carver's Many Peanut Products.

C. Carver's Beauty Products from the Peanut.

D. The Life of George Washington Carver.

2. College professors often present pedantic lectures. This fact is emphasized by yawning, sleepy students in many classrooms.

In this context, the word *pedantic* means

A. dull.

B. exciting.

C. childish.

D. inspiring.

3. To the untrained eye, differentiating between an alligator and a crocodile is a difficult task. However, there is one main difference between these two reptiles. Alligators tend to have wide, rounded snouts, while crocodiles have longer, more pointed noses.

Which of the following is implied by the above passage?

A. You can never tell the difference between a crocodile and an alligator.

B. There are no discernible physical differences between crocodiles and alligators.

C. Most people can differentiate between crocodiles and alligators if they know about the reptiles' differing snout structures.

D. Only experts can distinguish between crocodiles and alligators.

4. Mineral forms of carbon vary greatly. For example, both diamonds and graphite are forms of carbon. However, graphite is very weak and soft while diamonds are the hardest gemstones known to man.

This passage is mainly about

A. diamonds.

B. graphite.

C. the likenesses between diamonds and graphite.

D. the varying mineral forms of carbon.

Questions 5 and 6 relate to the following passage.

Many environmentalists believe natural gas to be the answer to decreasing pollution produced by other traditional forms of energy. Although natural gas comes from the Earth's crust like oil, it burns cleaner than oil does.

As a result, there is great emphasis from environmentalists and manufacturers on developing more vehicles that operate on natural gas rather than regular fuel. Proponents of natural gas vehicles state that such vehicles emit up to 95% less pollution than standard gasoline or diesel vehicles.

5. The principal reason for using natural gas vehicles is

A. they are more attractive than their gasoline and diesel counterparts.

B. they emit less pollution and are safer for the environment.

C. they are less expensive to operate than traditional vehicles.

D. they are mandated by law.

6. You may conclude from the above selection that

A. there is great emphasis on producing natural gas vehicles to reduce pollution.

B. traditional vehicles that operate on gasoline or diesel fuel produce very little pollution.

C. the difference in emissions between regular vehicles and natural gas vehicles is unimportant.

D. natural gas is a pollutant and should not be used to fuel vehicles.

Questions 7 and 8 relate to the following passage.

Because of their reputation from myth and legend of sucking blood from animals and humans, vampire bats are viewed as heinous creatures. However, someday these greatly feared but little-known animals might save lives.

Scientists have discovered that vampire bats do not suck blood from other animals. Rather, they make tiny cuts in the skin of such animals as cows. Interestingly, the bats' saliva contains a substance that aids in blood clotting. Thus, perhaps this substance might eventually be used to prevent heart attacks and strokes.

7. In this context, the word *heinous* means

A. playful.

B. friendly.

C. busy.

D. monstrous.

8. The author apparently feels that

A. vampire bats are dangerous to humans.

B. vampire bats are harmful to cows.

C. vampire bats have potential in the medical field.

D. vampire bats are friendly creatures.

Auto and Shop Information

1. A stoplight is not working. A test light is touched to the first accessible connector. The test light lights. The next connector towards the light is probed. The test light does not light. This indicates

A. that the bulb is bad.

B. an open circuit before the first connector.

C. an open circuit between the two connectors.

D. a short to ground.

2. An engine is using too much oil. Which one of the following is the most likely cause?

A. vacuum leak

B. tapered cylinder walls

C. stuck thermostat

D. worn valve guide

3. The component that releases the hot air to the outside in an A/C system of a vehicle is

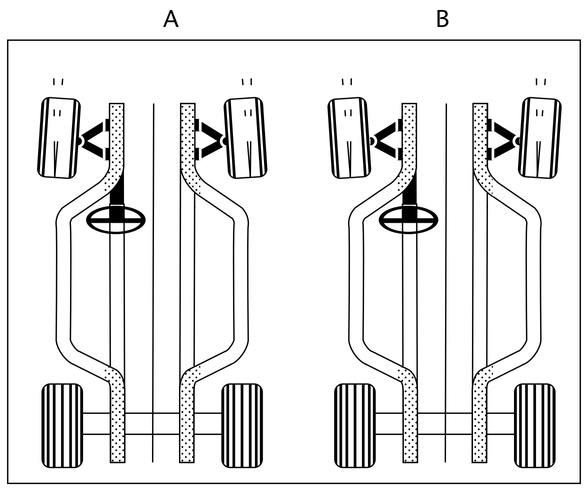
A. the evaporator.

B. the accumulator.

C. the A/C compressor.

D. the condenser.

4. Looking at the following figure, what is being illustrated?



A. caster angles

B. camber angles

C. toe in and toe out

D. thrust angle

5. To tighten any critical bolts

A. use a proper bar.

B. use a breaker bar.

C. use an impact wrench.

D. use a torque wrench.

6. Which of the following measurements is the dial caliper not used for?

A. inside measurement

B. outside measurement

C. depth measurement

D. pressure measurement

7. A camber measurement can tell us which of the following about a tire problem?

A. The top of the tire is leaning towards the car.

B. The top of the tire is leaning away from the car.

C. The tire is straight up.

D. All of the above.

8. A forstner bit would be used if you were

A. installing ceiling lighting.

B. starting screw holes to avoid splitting wood.

C. installing cabinet doors.

D. drilling thin holes in sheet metal.

9. A whetstone is used to

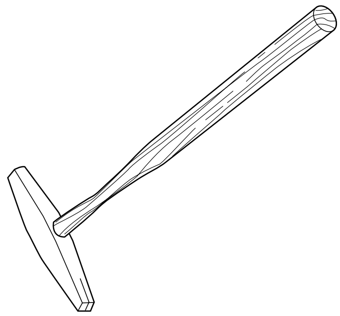
A. flatten bent nails.

B. drive a cold chisel into metal.

C. repair a loose hammer head.

D. sharpen chisels.

10. The hammer illustrated below has one magnetized end and one non-magnetized end. It is primarily used



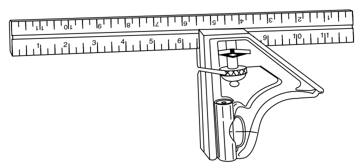
A. to hang picture frames.

B. for upholstery work.

C. for working in tight places.

D. to remove old glass shards.

11. The tool below is a



A. contractor's square.

B. sliding T-bevel.

C. try square.

D. combination square.

12. A block plane is used to

A. smooth cross-grained wood.

B. smooth long pieces of wood.

C. smooth convex surfaces.

D. smooth concave surfaces.

13. If you're pouring concrete for a walk, you should dig down at least

A. 2 inches.

B. 4 inches.

C. 6 inches.

D. 8 inches.

Mathematics Knowledge

1. $\left(\sqrt{2}\right)^4 =$

A. 2

B. 4

C. 8

D. 16

2. Simplify $\frac{9x^2}{y} \div \frac{3y^2}{x^3}$.

A. $\frac{27y}{x}$

B. $\frac{3x^5}{y^3}$

C. $\frac{3x^6}{y^2}$

D. $\frac{27x^2y^2}{x^3y}$

3. The probability of rolling an even number on a set of two dice is

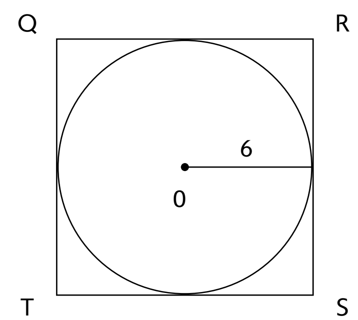
A. $\frac{1}{2}$

B. $\frac{5}{9}$

C. $\frac{15}{36}$

D. $\frac{17}{36}$

4. In circle O, the radius is 6 units long. Find the diagonal of square QRST.



A. $6\sqrt{2}$

B. 12

C. $12\sqrt{2}$

D. 18

5. If 6 less than twice a number is added to 10, the result is 2. An equation that represents this is

A. $6 - 2x = 10 + 2$.

B. $6 - 2x + 10 = 2$.

C. $2x - 6 = 10 + 2$.

D. $2x - 6 + 10 = 2$.

6. Rounded to the nearest tenth, $826 \div 12$ is

A. 68.8.

B. 68.9.

C. 69.0.

D. 70.0.

7. If $x = -1$, then $-2x^2 - 3x + 4 =$

A. -1

B. 1

C. 5

D. 9

8. 9 is what percent of 60?

A. 5.4%

B. 15%

C. 18%

D. 54%

9. If a rectangle has a length of 18 inches and a width of 6 inches, what is the perimeter of the rectangle in feet?

A. 4

B. 24

C. 48

D. 108

10. Solve for b: $\frac{b}{5} + \frac{b}{3} = 1$

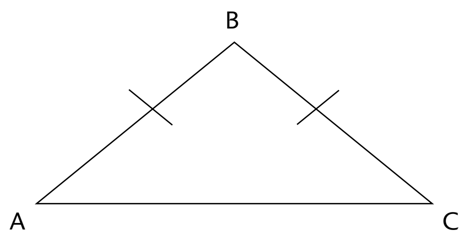
A. $\frac{1}{8}$

B. $\frac{1}{15}$

C. $\frac{8}{15}$

D. $\frac{15}{8}$

11. In triangle ABC, if the measure of $\angle A$ is half the measure of $\angle B$, what is the measure of $\angle C$?



A. 30°

B. 45°

C. 60°

D. 90°

12. Simplify $2\sqrt{18} - 3\sqrt{8}$.

A. $-\sqrt{10}$

B. $\sqrt{2}$

C. $-\sqrt{2}$

D. 0

Mechanical Comprehension

1. A body resists motion because of its

A. mass.

B. weight.

C. volume.

D. all the above

2. Block A has the same volume as block B but twice the weight. Hence

A. A has twice the density of B.

B. B has twice the density of A.

C. A and B have the same mass.

D. A and B have the same density.

3. A Volvo moving in a straight line with an initial velocity of 15.6 m/s accelerates at a rate of 1.24 m/s^2 for 8 seconds. The displacement during this time is

A. 425 meters.

B. 850 meters.

C. 165 meters.

D. 400 meters.

4. A ball thrown vertically upward with an initial speed *v* reaches a maximum height *h*. If the initial speed of the object is doubled, then the maximum height will increase by a factor of

A. 8.

B. 6.

C. 4.

D. 2.

5. An object is dropped from a building. If the speed of impact is to be tripled, how much higher should the object be dropped from?

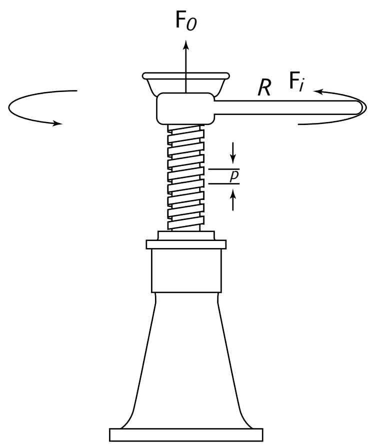
A. 3 times

B. 4 times

C. 6 times

D. 9 times

6. In the screw jack shown in the figure, if the ratio $R/p = 7$, the mechanical advantage (F_o/F_i) is most approximately



A. 14.

B. 21.

C. 22.

D. 44.

7. If the centers of an 800-kilogram mass and a 600-kilogram mass are separated by 0.25 meters, then the magnitude of the gravitational force *F* between them is nearly

A. 5.00×10^{-4} N.

B. 1.3×10^{-4} N.

C. 5.00×10^{-5} N.

D. 1.67×10^{-7} N.

8. The weight of a 70-kilogram astronaut on the surface of a planet with a mass of 3×10^{24} kilograms and radius of 5×10^{6} m is nearly

A. 686 N.

B. 586 N.

C. 560 N.

D. 70 N.

9. Two spheres of 3-kilogram mass each are joined by a 2-meter rod of negligible weight. If the system rotates at 5 rad/s around the center point of the rod, the rotational kinetic energy of the system (considering the spheres to be point masses) is

A. 7.50 joules.

B. 75.0 joules.

C. 3.00 joules.

D. 30.0 joules.

10. The amount of work needed to stop a moving object depends most on

A. speed and mass of the object.

B. mass and acceleration of the object.

C. weight and momentum of the object.

D. all the above.

11. A truck pulls a crate at a constant speed with a 1,500 N force. The frictional force on the crate equals

A. more than 1,500 N.

B. less than 1,500 N.

C. 1,500 N.

D. impossible to figure out

12. A stone thrown straight up takes 4 seconds to reach its maximum height. The maximum height is nearly

A. 39 meters.

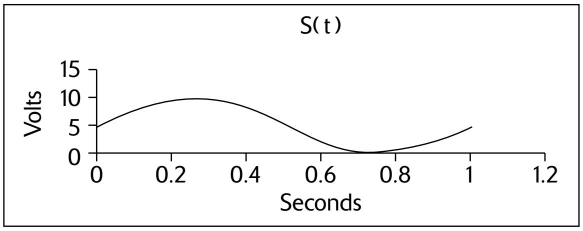
B. 78 meters.

C. 157 meters.

D. none of the above

Electronics Information

1. The signal s(t) shown in the figure below has an amplitude of



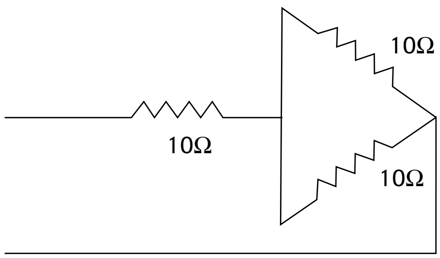
A. 10 volts.

B. 2.5 volts.

C. 15 volts.

D. 5 volts.

2. The total resistance for the circuit shown in the figure below is



A. 20 ohms.

B. 15 ohms.

C. 30 ohms.

D. 25 ohms.

3. Which of the following components has an identification number only?

A. capacitor

B. coil

C. resistor

D. diode

4. Changing the amplitude of a high frequency signal in correspondence with the amplitude of a low frequency signal is called

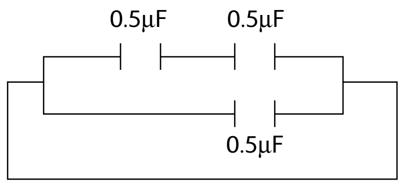
A. frequency multiplication.

B. frequency filteration.

C. amplitude modulation.

D. DC shifting.

5. The total capacitance of the circuit shown in the figure below is



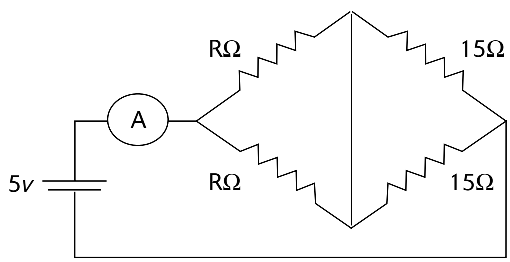
A. 0.75µF.

B. 1µF.

C. .5µF.

D. 1.5µF.

6. If the power dissipated in the circuit shown in the figure below is 1 watt, then the value of the unknown resistors R =



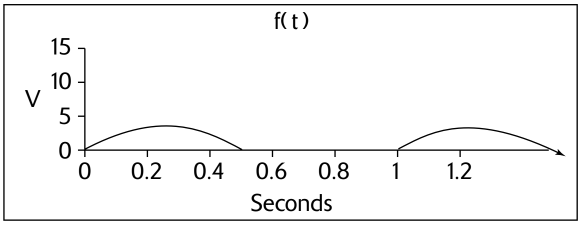
A. 25 ohms.

B. 10 ohms.

C. 15 ohms.

D. 35 ohms.

Questions 7 and 8 are based on the following figure.



7. The signal f(t) shown in the figure above is a

A. triangular signal.

B. square wave.

C. half wave rectified sinusoidal signal.

D. DC shifted wave.

8. The following electronic component can be used to generate the signal f(t) shown in the figure above.

A. a diode

B. a resistor

C. a transistor

D. a capacitor

9. The resistance of a copper wire is proportional to its

A. diameter.

B. length.

C. radiance.

D. cross-section area.

10. In a semiconductor device, the current is conducted by

A. electrons only.

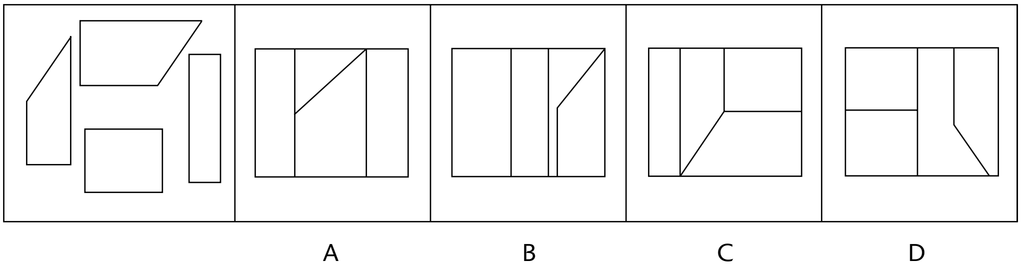
B. holes only.

C. electrons and holes.

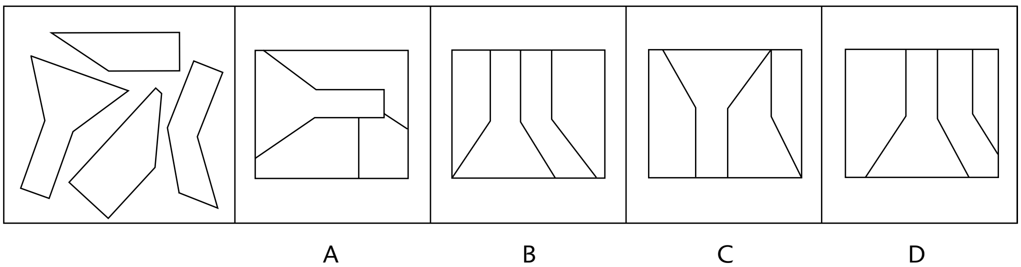
D. photons.

Assembling Objects

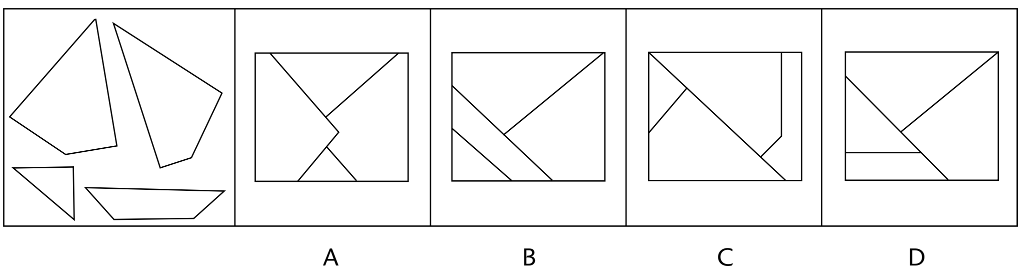
1.



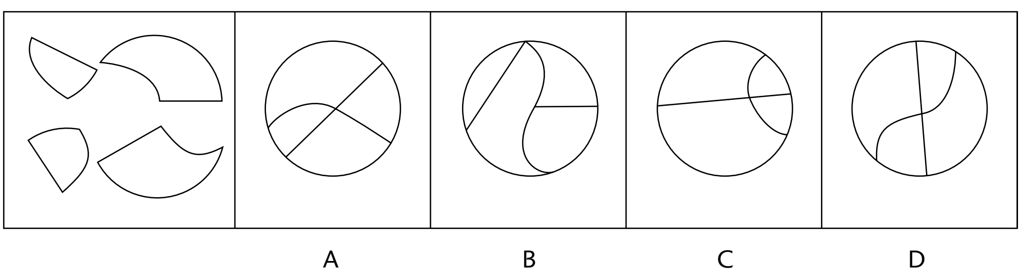
2.



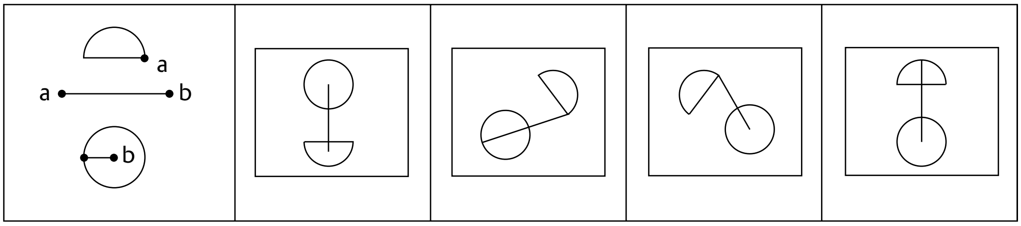
3.



4.

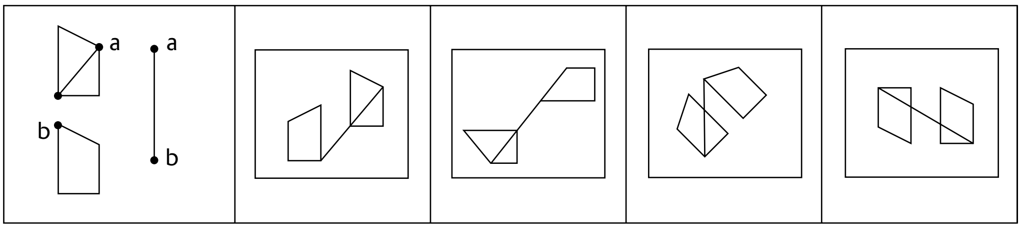


5.



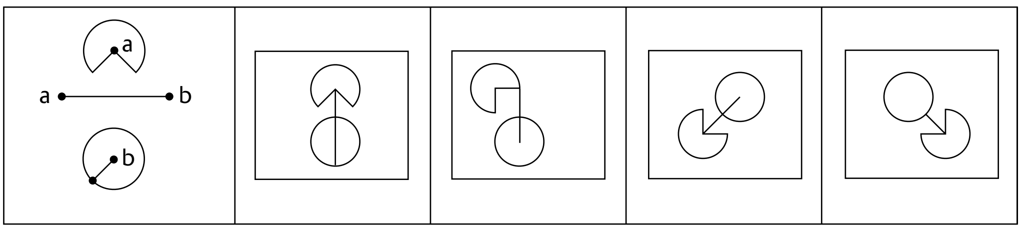
A B C D

6.



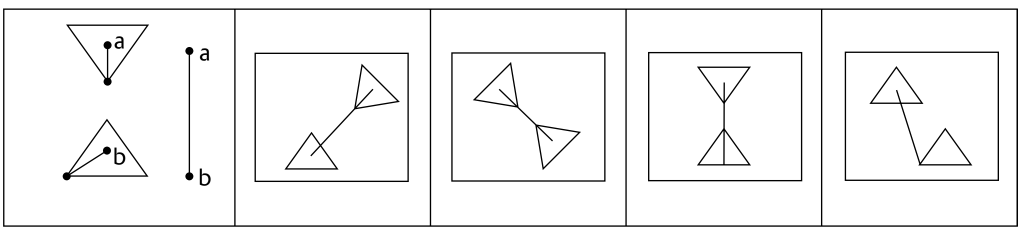
A B C D

7.



A B C D

8.



A B C D

Answer Key for Diagnostic Test

General Science

1. B
2. C
3. D
4. C
5. A
6. C
7. B
8. D
9. A
10. D
11. D
12. D

Arithmetic Reasoning

1. C
2. D
3. C
4. B
5. B
6. A
7. D
8. B
9. C
10. B
11. C
12. B
13. B
14. D
15. B

Word Knowledge

1. B
2. A
3. B
4. D
5. C
6. A
7. B
8. B
9. B
10. D
11. B
12. C
13. B
14. A
15. C

Paragraph Comprehension

1. B
2. A
3. C
4. D
5. B
6. A
7. D
8. C

Auto and Shop Information

1. C
2. D
3. D
4. C
5. D
6. D
7. D
8. C
9. D
10. B
11. D
12. A
13. C

Mathematics Knowledge

1. B	**5.** D	**9.** A
2. B	**6.** A	**10.** D
3. A	**7.** C	**11.** B
4. C	**8.** B	**12.** D

Mechanical Comprehension

1. A	**5.** D	**9.** B
2. A	**6.** D	**10.** B
3. C	**7.** A	**11.** C
4. C	**8.** C	**12.** B

Electronics Information

1. D	**5.** A	**9.** B
2. B	**6.** D	**10.** C
3. D	**7.** C	
4. C	**8.** A	

Assembling Objects

1. C	**4.** D	**7.** C
2. B	**5.** C	**8.** B
3. B	**6.** B	

Diagnostic Test Answers and Explanations

General Science (Diagnostic Test Answers)

1. **B.** The most inclusive groups have more various types of organisms within their group.
2. **C.** The building blocks of nucleic acids are nucleotides.
3. **D.** There are two molecules with two atoms each.
4. **C.** Carbon is +4 and fluorine -1. A neutral atom will equal zero.
5. **A.** The anther produces pollen, the male gamete, while the pistil or carpel produces the female gamete.
6. **C.** All isotopes of any element have the same number of electrons and protons, only differing in the number of neutrons in the nucleus.
7. **B.** Both will have about the same kinetic energy at the bottom of the incline, but some of this energy is devoted to rotation of the ball. So, the block will have a higher speed.
8. **D.** NaOH is a strong base. pH + pOH = 11.
9. **A.** This diagram shows a clear crystalline structure. Diagrams (b) and (d) represent sedimentary rock structures and diagram (c) represents the banding pattern common in some metamorphic rocks.
10. **D.** The old volcano would lead you to expect igneous rocks of assorted types **B** for sure, but the question mentions no other geologic processes that may have occurred at the site. It would be possible to find sedimentary rocks, choice **A**, and metamorphic rocks, choice **C**, in the region as well, depending on other geologic factors.
11. **D.** Abscisic acid is responsible for the closing of stomatal opening by the guard cells.
12. **D.** Make sure the number of specific atoms on each side is the same, and that the lowest possible whole number ratio is achieved.

Arithmetic Reasoning (Diagnostic Test Answers)

1. **C.** If it is 3:50, there are 10 minutes to 4:00 and an additional 40 minutes afterwards, so the time would be 4:40.
2. **D.** Earnings = sales × commission rate. So \$520 = sales × 6%. Therefore, sales = $\frac{\$520}{6\%} = \frac{\$520}{.006} = \$8666.67$.
3. **C.** There are 4 × 16, or 64 erasers. So there are 64 – 16, or 48 more erasers.
4. **B.** Convert minutes to seconds. $13\frac{2}{3}$ minutes $= 13\frac{2}{3} \times 60 = 820$ seconds. $12\frac{5}{12}$ minutes = $12\frac{5}{12} \times 60 = 745$ seconds. The overall improvement is 820 – 745 = 75 seconds.
5. **B.** The proportion $\frac{45\text{ knots}}{8\text{ minutes}} = \frac{60\text{ knots}}{x\text{ minutes}}$ can be used to find the number of minutes to tie 60 knots. Cross multiply. $45x = 8 \times 60$ so $45x = 480$ and $x = \frac{480}{45} = 10\frac{2}{3}$ minutes.

6. **A.** The average is found by adding the total number of calls answered and dividing by the number of hours. The total number of calls is $5 + 3 + 0 + 8 = 16$. The number of hours between 5:00 and 9:00 is 4. So the average is $\frac{16}{4} = 4$

7. **D.** The total percent discounted is the total dollar amount discounted divided by the original price. The first discounted amount is $900 × 30% = $270. The second discounted amount is 20% of the reduced price. So $900 – $270 = $630 × 20% = $126. The total dollar amount discounted is $270 + $126 = $396. The percent discounted is $\frac{396}{900} = 0.44 = 44\%$.

8. **B.** The distance around the widest part of the pool is equivalent to the pool's diameter. The diameter is twice the radius. The volume of a circular pool is $\pi r^2 h$. So $125\pi = \pi r^2 5$. $r^2 = \frac{125\pi}{5\pi}$ and $r = \sqrt{25} = 5$. Therefore, the diameter of the pool is $5 \times 2 = 10$ feet.

9. **C.** Find the total area of the figure and subtract each shaded region. The dimensions of the figure are 6 yards by 4 yards so the area of the total figure is $6 \times 4 = 24$ square yards. Each shaded region is a triangle with a base of 2 yards and height of 3 yards. The area of each triangle is $\frac{1}{2}bh = \frac{1}{2} \cdot 2 \cdot 3 = 3$. Since there are 4 triangles, the area of the shaded region is $4 \times 3 = 12$ square yards. The area remaining for the flowers is $24 - 12 = 12$ square yards.

10. **B.** Deposits are added to the balance while withdrawals are subtracted. $512.33 + $120.30 = $632.63 – $35 = $597.63 – $60 = $537.63 + $21.84 = $559.47 – $36.89 = $522.58.

11. **C.** The interest on the loan is $600 × 15% = $90. The total amount to be repaid is $600 + $90 = $690. If this is paid in monthly installments, the amount paid each month is $\frac{690}{12} = \$57.50$.

12. **B.** There are $12 \times 5 = 60$ inches in a 5-foot piece of ribbon. If this is divided into 4-inch pieces, there are $\frac{60}{4} = 15$ pieces.

13. **B.** The cost for two adults is 2 × $15.50 = $31.00. The cost for four children is 4 × $8.75 = $35.00. The total cost for the family is $31.00 + $35.00 = $66.00.

14. **D.** There are 4 quarters in $1.00. So 40 quarters are needed to fill a $10.00 quarter wrapper. If there are 7 quarters, then 40 – 7 = 33 quarters are still needed.

15. **B.** The volume of a box = length × width × height. The length and width are both equal to $10 - 2 - 2 = 6$ inches. The height = 2 inches, so the volume is $6 \times 6 \times 2 = 72$ in^3.

Word Knowledge (Diagnostic Test Answers)

1. **B.** *Trick. Finagle* means connive or scheme.
2. **A.** *Weaken. Impair* means diminish or undermine.
3. **B.** *Crucial. Pivotal* means important or critical.
4. **D.** *Expanded. Amplified* means increased or boosted.

5. **C.** *Tentative. Tenuous* means provisional or trivial.
6. **A.** *Full-grown. Mature* means developed or ripened.
7. **B.** *Brave. Stalwart* means resolute or valiant.
8. **B.** *Elementary. Rudimentary* means primary or basic.
9. **B.** *Pacify. Placate* means calm or soothe.
10. **D.** *Unsophisticated. Provincial* means rural or unpolished.
11. **B.** *Stop. Terminate* means cease or halt.
12. **C.** *Careless. Imprudent* means heedless or reckless.
13. **B.** *Prey. Quarry* means the hunted or victim.
14. **A.** *A trick.* A *ruse* is a ploy, subterfuge, or scheme.
15. **C.** *Sluggish. Torpid* means inactive or lethargic.

Paragraph Comprehension (Diagnostic Test Answers)

1. **B.** Since both food products and beauty products are mentioned, this title best describes the paragraph as a whole.
2. **A.** The second sentence states that students in college classrooms are often yawning and sleepy. Thus, many college lectures might be described as dull.
3. **C.** The third sentence explains that snout structure is different in crocodiles and alligators.
4. **D.** The first sentence of the selection states that carbon has varying forms and the paragraph develops this topic sentence further.
5. **B.** The selection states that environmentalists believe natural gas to be a way to decrease pollution. The next paragraph states that natural gas vehicles emit up to 95% less pollution than their gasoline and diesel counterparts.
6. **A.** The first sentence of the second paragraph states that there is great emphasis on producing such vehicles.
7. **D.** Since vampire bats are thought to be ruthless blood suckers, many perceive them to be evil creatures.
8. **C.** The selection states that vampire bats' saliva might be useful in blood clotting, thus preventing heart attacks and strokes.

Auto and Shop Information (Diagnostic Test Answers)

1. **C.** The first connector showed the potential for current flow up to that point. Between that point and the next one, the path for current flow is lost (open) because the test light that took the place of the stoplight did not light.
2. **D.** Worn valve guides allow oil to seep into the combustion chamber, where it becomes part of the combustion process and winds up emitted from the tailpipe.
3. **D.** The condenser sits in front of the radiator exposed to the incoming rush of air.
4. **C.** In the illustration, Part A is a toe in configuration and Part B is a toe out configuration. Toe settings are designed to compensate for the amount the tire will turn away from

straight ahead. A correct setting allows the tires to go straight down the road without scraping against the road surface.

5. **D.** To ensure proper clamping, a torque wrench must be used to tighten any critical bolts to specific torque values.
6. **D.** The dial caliper is a multi-functioning measuring instrument capable of inside, outside, depth, and step measurements.
7. **D.** Leaning towards the car is considered a negative camber, leaning away from the car is considered a positive camber, and a straight up is considered a zero camber.
8. **C.** A forstner bit is used to drill holes that extend nearly all the way through a piece of wood. It is often used to insert cabinet hinges. The bits range from 1/4 inch to 1 inch or larger.
9. **D.** A whetstone is a sharpening stone and may be used to sharpen chisels or knives, or even to flatten screwdriver heads that have lost their shape.
10. **B.** This is a tack hammer, used primarily for upholstery work. The magnetic end picks up and starts a tack into the upholstery. The non-magnetic side is then used to finish driving in the tack the rest of the way.
11. **D.** The combination square is a multi-function tool. It can mark 90° and 45° angles. It can be used as a try-square, depth gauge, and marking gauge. It is an extremely precise instrument.
12. **A.** A block plane is ideal for smoothing cross-grained (end-grain) wood. For long pieces of wood, use a bench plane. A spoke-shave is used to smooth both convex and concave surfaces.
13. **C.** You should dig down at least 6 inches, cover and level the bottom with 2 inches of sand and/or gravel, and pour the concrete to a depth of 4 inches.

Mathematics Knowledge (Diagnostic Test Answers)

1. B. $\left(\sqrt{2}\right)^4 = \sqrt{2} \bullet \sqrt{2} \bullet \sqrt{2} \bullet \sqrt{2} = \sqrt{16} = 4$
2. B. $\frac{9x^2}{y} \div \frac{3y^2}{x^3} = \frac{9x^2}{y} \times \frac{x^3}{3y^2} = \frac{9x^5}{3y^3} = \frac{3x^5}{y^3}$
3. **A.** There are 6^2, or 36 total, possible outcomes when rolling two dice. There is one way to roll 2, three ways to roll 4, five ways to roll 6, five ways to roll 8, three ways to roll 10, and one way to roll 12. So there are 1 + 3 + 5 + 5 + 3 + 1 or 18 ways to roll an even number. Therefore, the probability of rolling an even number is $\frac{18 \text{ even rolls}}{35 \text{ total rolls}} = \frac{1}{2}$.
4. **C.** If the radius is 6, the diameter is 12, so the square has a side length of 12.The diagonal of the square is the hypotenuse of a right triangle with sides equal in length to the square. The diagonal, *d,* is found by using the Pythagorean theorem. $d^2 = 12^2 + 12^2 = 144 + 144 = 288$, so $d = \sqrt{288} = \sqrt{2 \times 144} = 12\sqrt{2}$.
5. **D.** Six less than twice a number is represented by $2x - 6$. If 10 is added to that, the expression is $2x - 6 + 10$, so the equation is $2x - 6 + 10 = 2$.

6. A. $826 \div 12 = 68.83$. Rounded to the nearest tenth, it's 68.8.

7. C. Substitute –1 for x. So $-2x^2 - 3x + 4 = -2(-1)^2 - 3(-1) + 4 = -2 + 3 + 4 = 5$.

8. B. $9 = p \times 60$ so $p = \frac{9}{60} = 0.15 = 15\%$

9. A. Convert inches to feet. 12 inches = 1 foot, so 18 inches = 1.5 feet and 6 inches = 0.5 feet. The perimeter, in feet, is $1.5 + 0.5 + 1.5 + 0.5 = 4$.

10. D. Eliminate the fractions by multiplying the entire equation by the least common multiple (LCM) of 5 and 3. The LCM is 15, so $15 \bullet \frac{b}{5} + 15 \bullet \frac{b}{3} = 15 \bullet 1$ and $3b + 5b = 15$. $8b = 15$, therefore $b = \frac{15}{8}$.

11. B. All angles in a triangle add to 180°, so $\angle A + \angle B + \angle C = 180°$. Triangle ABC is isosceles, so $\angle A = \angle C$ and if $\angle A$ is half $\angle B$, then $\angle B = 2\angle A$. Using substitution, $\angle A + 2\angle A + \angle A = 180°$. $4\angle A = 180°$ so $\angle A = \frac{180}{4} = 45°$. Therefore, $\angle C$ also $= 45°$.

12. D. $2\sqrt{18} - 3\sqrt{8} = 2\sqrt{2 \times 9} - 3\sqrt{2 \times 4} = 2 \bullet 3\sqrt{2} - 3 \bullet 2\sqrt{2} = 6\sqrt{2} - 6\sqrt{2} = 0$

Mechanical Comprehension (Diagnostic Test Answers)

1. A. Newton's first law states that a body remains in its present condition until acted on by external forces. Newton's second law states that force is proportional to mass.

2. A. Since density is the ratio of mass to volume, and since mass is proportional to weight, then doubling the weight doubles the mass and hence doubles the density.

3. C. $s = v_o t + 0.5at^2 = 15.6 \times 8 + 0.5(1.24)(8^2) =$ approximately 165.

4. C. Since $s = v_o t + \frac{1}{2}at^2$ and $v_f = v_o + at$, where s = distance of travel, v_o = initial velocity, a = acceleration, and t = time, we see that t changes from v/g to 2 v/g and s changes from 1.5 v^2/g to $6v^2/g$, i.e., it increases by a factor of 4.

5. D. The new height should be 9 times greater since the speed of impact is proportional to the square root of the height.

6. D. The mechanical advantage equals 2π times the ratio R/p, which is approximately 44.

7. A. $F = 6.67 \times 10^{-11} \times 800 \times 600/(0.25^2) = 5.12256 \times 10^{-4}$ N

8. C. $F = 6.67 \times 3 \times 10^{24} \times 70/(5 \times 10^6)^2 = 560.28$ N

9. B. The rotational kinetic energy $E_k = 0.5\ I\omega^2$ where I = moment of inertia = (2)(3)(1) = 6 $kg.m^2$ and $\omega = 5$ rad/s. Thus $E_k = 75$ joules.

10. B. Mass and speed are the most determining factors.

11. C. This is a consequence of Newton's first and second laws of motion.

12. B. Since the stone reaches its maximum height in 4 seconds, that maximum height equals $\frac{1}{2}gt^2 = \frac{1}{2}(9 \bullet 8)(4^2) = 78.4m$.

Electronics Information (Diagnostic Test Answers)

1. **D.** The shown signal has an amplitude of 5 volts. Its frequency is 1 HZ, and its DC shift is 5 volts.
2. **B.** The total resistance in the circuit can be calculated as follows:
$$\frac{1}{\frac{1}{10}+\frac{1}{10}}+10=15\Omega$$
3. **D.** Diodes have identification numbers to identify them. Capacitance is measured in farads. Inductance of a coil is measured in henrys. Resistance is measured in ohms.
4. **C.** Changing the amplitude of a high frequency signal in correspondence with the amplitude of a low frequency signal is called amplitude modulation.
5. **A.** Total capacitance of the circuit is calculated as follows:
$$\frac{1}{\frac{1}{.5}+\frac{1}{.5}}+.5=.75\mu F$$
6. **D.** The unknown resistors values (R) can be calculated as follows:
$$P=\frac{V^2}{R_{Total}}=\frac{5^2}{\frac{1}{\frac{1}{R}+\frac{1}{R}}+\frac{1}{\frac{1}{15}+\frac{1}{15}}}=1\text{Watt}$$
$$\therefore=\frac{25}{\frac{R}{2}+\frac{15}{2}}=1\Rightarrow R=2\times\left(25-\frac{15}{2}\right)=35\Omega$$
7. **C.** f(t) is a half-wave rectified sinusoidal signal.
8. **A.** A diode can be used to generate the signal f(t).
9. **B.** The resistance of a wire conductor is proportional to its length.
10. **C.** The current is conducted by electrons and holes in a semiconductor device.

Assembling Objects (Diagnostic Test Answers)

1. **C.**
2. **B.**
3. **B.**
4. **D.**
5. **C.**
6. **B.**
7. **C.**
8. **B.**

PART III

SUBJECT AREA REVIEW

The following subject areas are reviewed in this part:

- General Science
- Arithmetic Reasoning
- Word Knowledge
- Paragraph Comprehension
- Auto and Shop Information
- Mathematics Knowledge
- Mechanical Comprehension
- Electronics Information
- Assembling Objects

General Science

The General Sciences section of the ASVAB is designed to evaluate your understanding of the basic concepts that you studied in the life sciences, the physical sciences, and Earth/space sciences. The material that this section covers reviews the concepts that you covered in your High School General Sciences courses. This section also includes review questions and answers with explanations Please note that on the ASVAB exam, the General Sciences questions are not broken down by branch. The questions are mixed together.

The ASVAB has 25 General Science questions. You will have 11 minutes to answer these questions.

Life Sciences

The Cellular Basis of Life

Cells make up all living organisms. Some organisms consist of a single cell, while others are composed of multiple cells organized into tissues and organs.

All cells share two basic features:

- **A plasma membrane** (the outer boundary of the cell)
- **Cytoplasm** (a semi-liquid substance that composes the foundation of the cell)

Cells can be classified as either prokaryotic or eukaryotic:

- **Prokaryotic cells** are relatively simple cells, such as those of bacteria.
- **Eukaryotic cells** are more complex and contain many internal bodies (*organelles*) that carry out specialized functions.

The main components of eukaryotic cells include the following:

- **The nucleus** contains DNA.
- **Mitochondria** is where the cell produces energy.
- **Chloroplasts** are where plant cells make food (sugar); animal cells do not contain chloroplasts.
- **Ribosomes** are where the cell makes proteins.

Movement Through the Plasma Membrane

In order for cells to exchange materials with the external environment, substances must be able to move through the plasma membrane (the “skin” of a cell). Materials pass through the plasma membrane in one of the following four ways:

- **Diffusion:** The passive movement of molecules from a region of higher concentration to a region of lower concentration.
- **Osmosis:** A special type of diffusion that involves the movement of water into and out of the cell.
- **Facilitated diffusion:** Diffusion of molecules across the cell membrane with the help of special proteins in the cell membrane.
- **Active transport:** Molecules move across the cell membrane from a region of lower concentration to a region of higher concentration with the help of special proteins in the cell membrane; active transport requires the cell to expend energy.

Photosynthesis

Plants make their own food from simple molecules such as carbon dioxide and water in a process known as *photosynthesis.* This process requires energy, which the plant obtains from sunlight and captures by way of specialized pigments *(chlorophyll)* in the chloroplasts of its cells. As a byproduct of photosynthesis, oxygen is released into the atmosphere. This process can be summarized with the following equation:

$$\text{carbon dioxide} + \text{water} \rightarrow \text{glucose (sugar)} + \text{oxygen} + \text{water}$$

Plants absorb light in the red and blue wavelengths for use in photosynthesis. Chlorophyll molecules reflect green light, which is why most plants' leaves appear green.

Cellular Respiration and Fermentation

Animals, plants, and microorganisms obtain the energy they need through the process of *cellular respiration.* In cellular respiration, the cell breaks down carbohydrates (such as glucose) in order to produce water and carbon dioxide. Energy is released during this process and is stored in the form of *adenosine triphosphate (ATP)*. When a cell needs energy, the bonds in ATP molecules are broken down and the cell uses the stored energy in metabolism. This process of cellular respiration, which requires the presence of oxygen, can be summarized by the following equation:

$$\text{glucose} + \text{oxygen} \rightarrow \text{water} + \text{carbon dioxide} + \text{energy (ATP)}$$

When no oxygen is present, the cells of some organisms (for example, yeast) carry out a form of *anaerobic respiration* (respiration without oxygen) known as fermentation. The products of fermentation are carbon dioxide and ethanol.

Cell Division

One distinguishing feature of living organisms is that their cells can divide and reproduce exact copies of themselves. Cell division, combined with cell expansion, allows for the growth and development of organisms.

There are two types of cell division, mitosis and meiosis.

Mitosis

Most of the cells in the body of an organism undergo mitosis. When a cell undergoes mitosis, it produces two exact copies of itself. Before the cell divides, it goes through a synthesis phase during which the *DNA* (genetic information of a cell) molecules duplicate in each chromosome. Because the DNA duplicates before cell division, the two cells produced during mitosis *(daughter cells)* each have a complete set of chromosomes containing all of the necessary DNA that was present in the original cell *(parent cell).* After the chromosomes divide, the cytoplasm of the cell divides into two new cells. Thus, the end result of mitosis is an equal separation and distribution of the chromosomes from one parent cell into two new daughter cells.

Meiosis

Specialized cells in the body of an organism *(germ cells* or *sex cells)* undergo a unique type of cell division that produces four daughter cells from each parent cell. These daughter cells, each containing half the number of chromosomes as the parent cell, function as *gametes* (eggs and sperm). Most plant and animal cells have two sets of chromosomes. In human cells, there are 46 chromosomes organized into 23 pairs. In order for sexual reproduction to occur, gametes from two individuals must unite to form a new individual *(embryo).* For this to occur successfully, while maintaining the normal number of chromosomes in each individual, the germ cells giving rise to the gametes must undergo meiosis. In humans, meiosis produces egg cells and sperm cells that contain 23 chromosomes each—one member of each chromosome pair. When the gametes unite at fertilization, the normal chromosome number (46 in humans) is reestablished in the resulting *zygote.* The end result of meiosis is the production of four genetically distinct daughter cells from each parent cell.

Genetics

Genetics is the study of how genes control characteristics or traits in living organisms. Genes are portions of DNA molecules that determine the characteristics of an individual. Through the processes of meiosis (which produces eggs and sperm) and *reproduction* (when eggs and sperm unite to form a zygote), genes are transmitted from parents to offspring.

Genes can take on various forms called *alleles.* For example, in humans there are two alleles controlling earlobe type. One allele codes for earlobes that are attached, while the other allele codes for earlobes that hang free. The alleles inherited from each of their parents determine the type of earlobes a person has.

The following terms summarize the most important genetic concepts:

- **Genotype:** All of the genes present in an individual.
- **Phenotype:** The expression of the genes in an individual.
- **Homozygote:** An individual in which both alleles for a given gene are the same.
- **Heterozygote:** An individual in which the two alleles for a given gene are different.
- **Dominant allele:** When two alleles are present together in an individual, the allele that is expressed is dominant; usually represented by a capital letter.
- **Recessive allele:** An allele that is masked (not expressed) when present together with a dominant allele in an individual; usually represented by a lowercase letter.

Example: In humans, the free earlobes allele is dominant over the attached earlobes allele. There are three possible genotypes that an individual may have for earlobe structure:

- Two alleles for free earlobes (EE)
- Two alleles for attached earlobes (ee)
- One allele for free earlobes and one allele for attached earlobes (Ee)

Because free earlobes is dominant to attached earlobes, the homozygous dominant individual (EE) and the heterozygous individual (Ee) both have free earlobes, while only the homozygous recessive individual has attached earlobes.

For some characteristics, one allele does not display dominance over another allele. Instead, the two characters blend to give an intermediate phenotype in the heterozygote. For example, in snapdragons, there are two alleles for flower color: one red (R) and one white (r). Heterozygous snapdragons (Rr), which contain one red allele and one white allele, are pink. When neither allele shows dominance over the other, the alleles are said to display *incomplete dominance.*

Multiple genes on one or more chromosomes control many traits. This condition is known as *polygenic inheritance.*

DNA is packaged into chromosomes inside the nucleus of cells. In order for the DNA of an individual (*genotype*) to be expressed (as a *phenotype*), the cell must process the DNA into proteins. In order to convert the message encoded in the DNA molecule into the appropriate protein(s), two basic processes must occur:

- **Transcription:** The message encoded on the DNA molecule inside the nucleus is copied onto another molecule called *messenger RNA (mRNA).*
- **Translation:** The mRNA molecule moves out of the nucleus into the cytoplasm of the cell and attaches to a *ribosome* (the part of a cell that manufactures protein). *Transfer RNA (tRNA)* molecules pick up amino acids (the building blocks of proteins) in the cytoplasm, bring them to the ribosome, and link them together in the order of the code that the mRNA molecule contains. Strings of amino acids make up proteins.

The flow of information from DNA → mRNA → protein is known as the *central dogma* of molecular biology.

Principles of Evolution

Evolution is defined as the change in one or more characteristics of a population of organisms over time. The process of evolution can be summarized by using the following principles:

- There is a large amount of genetic variation present among living organisms.
- Organisms must compete with each other for a limited supply of natural resources.
- Those individuals that are best able to survive and reproduce will be selected for through a process called *natural selection.*

Two essential points underlie natural selection:

- The genetic variation that occurs among individuals is random.
- Traits that allow an individual to survive and reproduce will be passed on to the individual's offspring.

Therefore, individuals that are better adapted to their environment will be more likely to reproduce and pass on their genes to the next generation. The ability of some individuals to survive and reproduce to a greater degree than other individuals is known as *differential reproductive fitness* or "survival of the fittest."

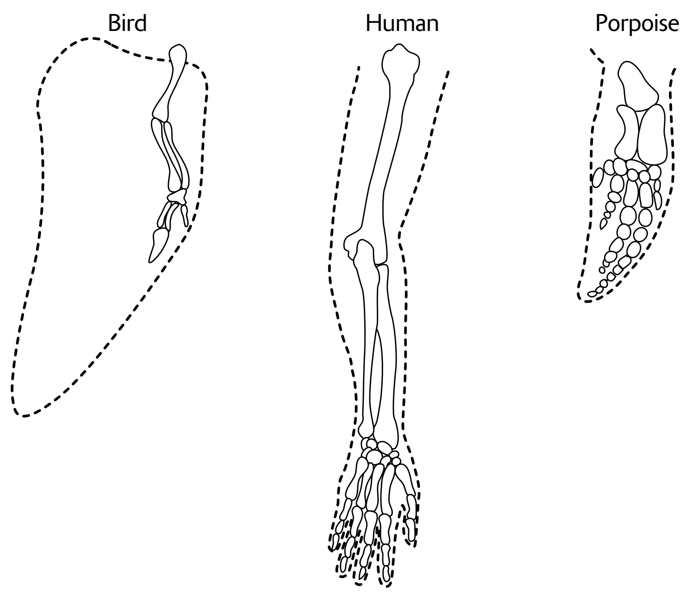
As the most reproductively-fit individuals contribute a higher percentage of alleles to the next generation, the population gradually evolves.

Other factors that contribute to evolution include:

- **Mutations:** These give rise to new alleles that didn't previously exist in the population. Mutations may be harmful and selected against, or they may be beneficial and selected for.
- **Migration:** Movement of individuals into or out of a population, which results in gene flow between two or more populations.
- **Random genetic drift:** Occurs when a small group of individuals leaves a population and establishes a new population in a geographically isolated region. These individuals may become reproductively isolated from the original population and develop into a separate species.

Several pieces of evidence strongly support evolution:

- **The fossil record** illustrates evidence of a descent of modern organisms from common ancestors.
- **Comparative anatomy** has shown similar structures on many organisms. For example, the forelimbs of such diverse animals as humans, porpoises, cats, birds, and bats are strikingly similar, even though the forelimbs are used for very different purposes (lifting, swimming, flying, and so on). Also, many organisms have structures that they don't use. In humans, these vestigial structures include the appendix, the fused tail vertebrae, and wisdom teeth. The following figure illustrates the forelimbs of a human and two other animals showing the similarities in construction. These anatomical similarities are considered evidence for evolution.



- **Embryology** offers additional evidence for evolution. The embryos of fish, reptiles, chickens, rabbits, and humans share many similarities. For example, all have gill slits, a two-chambered heart, and a tail with muscles. In the later stages of embryo development, the organisms appear less and less similar.
- **Biochemical studies** have shown there are similarities among all living organisms. For example, DNA and RNA serve as the basis for inheritance in all living organisms, and the structure of the genetic code is virtually identical in all living organisms.

The Origin and Evolution of Life

Scientists believe that the universe originated about 15 billion years ago with a huge explosion known as the Big Bang. The gases and dust from the explosion produced the earliest stars, and over a period of years, the stars exploded and their debris formed other stars and planets. The solar system is thought to have formed this way 4 to 5 billion years ago. During the next billion years, the Earth cooled, forming a hardened outer crust, and the first living organisms appeared approximately 3.5 billion years ago.

Scientists believe that the first cells lived within the organic environment of the Earth and used organic compounds to obtain energy. However, the organisms would soon use up the organic materials if they were the only source of nutrition and energy. The evolution of a pigment system that could capture energy from the sun and store it in chemical bonds was essential for the evolution of living things. The first organisms to possess these pigments were photosynthetic bacteria, ancestors of modern cyanobacteria. Oxygen, which is produced as a byproduct of photosynthesis, enriched the atmosphere.

Approximately 1.5 billion years ago, in an oxygen-rich environment, the first eukaryotic cells came into being. One theory explaining the development of eukaryotic cells suggests that bacteria were engulfed by larger cells. The bacteria remained in the larger cells and performed specific functions, such as energy production or photosynthesis. This could explain the origin of *mitochondria* (energy producing organelle of a cell) and *chloroplasts* (sites of photosynthesis in plant cells). The cells were then able to carry out more complex metabolic functions, and eventually came to be the dominant life forms.

For billions of years, the only life on Earth existed in the nutrient-rich environments of the oceans, lakes, and rivers. About 600 million years ago, as the atmosphere became rich in oxygen, living organisms began to colonize land. The first multicellular organisms were probably marine *invertebrates* (animals that lack a spine), followed by wormlike animals with stiff rods in their backs. These organisms, now called *chordates,* were the ancestors of the amphibians, reptiles, birds, and mammals.

Human Evolution

Fossils and fragments of jaws suggest to scientists that the ancestors of monkeys, apes, and humans began their evolution approximately 50 million years ago. Additional evidence comes from studies of biochemistry and changes that occur in the DNA of cells.

Scientific evidence indicates the following species led to modern humans:

- ***Austrolopithecus:*** The first hominids (human-like organisms)—members of this group displayed a critical step in human evolution: the ability to walk upright on two feet. Their brains were small in comparison with humans, and they had long, monkey-like arms. Members of this group eventually died out about 1 million years ago.

- ***Homo habilis:*** Scientists have found fossils dating back to 2 million years ago that have brain capacities much larger than any Australopithecus fossil. On the basis of brain size, these fossils are called *Homo habilis. Homo habilis* is regarded as the first human. Members of this species were able to make tools, build shelters, and make protective clothing. They also walked upright on two feet.
- ***Homo erectus:*** The first hominid to leave Africa for Europe and Asia—members of this species were about the same size as modern humans and were fully adapted for upright walking. Their brains were much larger than those of their ancestors, and scientists believe that they developed the concept of language.

The earliest fossils of *Homo sapiens* date to about 200,000 years ago. Scientists classify modern humans in this species. The evolution from *Homo erectus* to *Homo sapiens* is thought to have taken place in Africa. Fossil evidence shows a gradual change in 200,000 years, but no new species have emerged.

Classification of Life (Taxonomy)

The Earth is home to more than 300,000 species of plants and over 1 million species of animals. Taxonomists classify organisms in a way that reflects their relationships with each other. All living organisms are named according to an international system in which the organism is given a two-part name. The first name reflects the *genus* in which the organism is classified, while the second name is the species. For example, humans are assigned the name *Homo sapiens*.

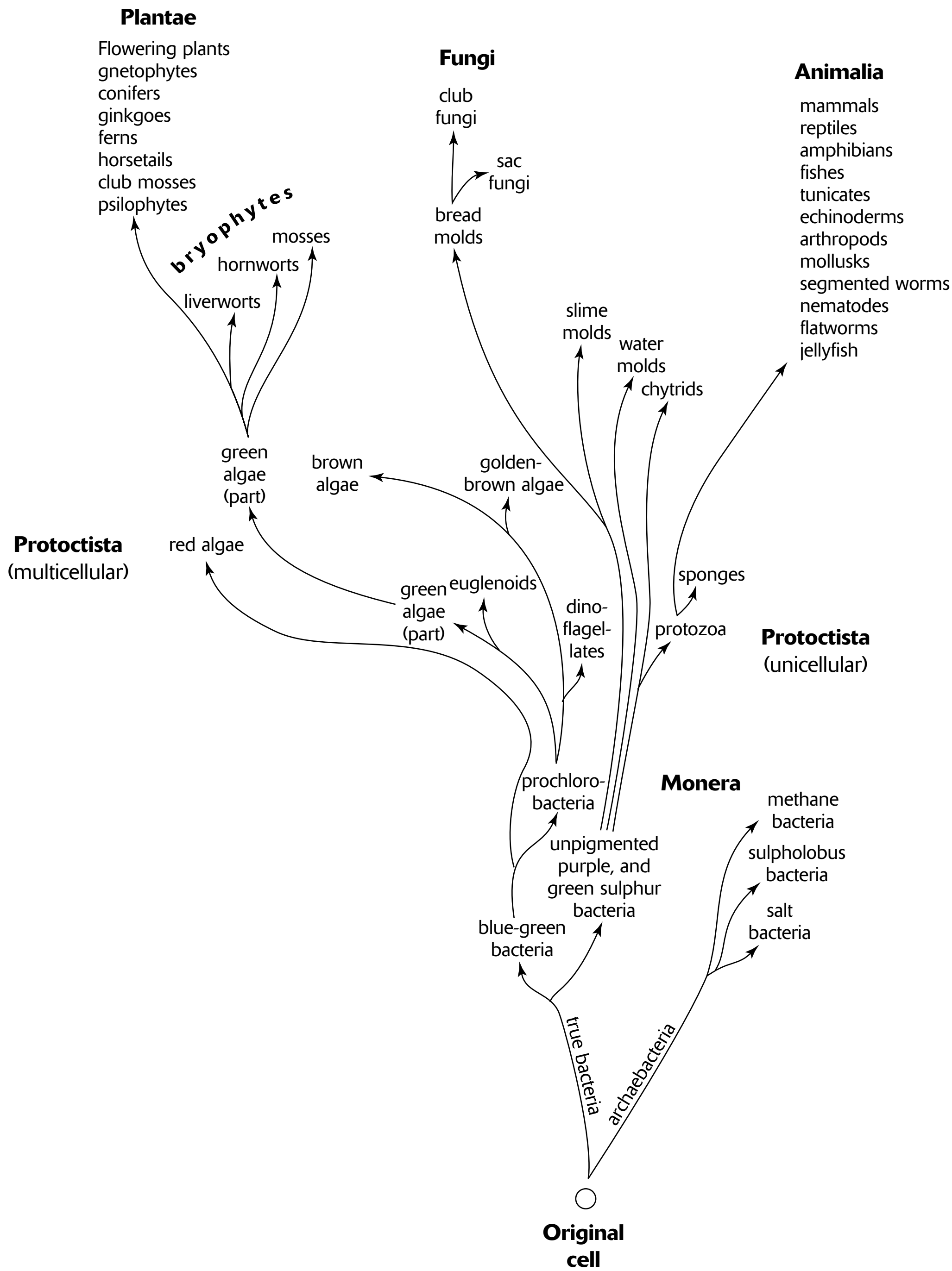
A group of organisms that can mate with each other under natural conditions and produce fertile offspring is known as a *species.* Individuals of different species usually do not mate. If they are forced to mate, their offspring are usually sterile and cannot produce offspring of their own. For example, a horse (*Equus caballus*) can mate with a donkey (*Equus assinus*); however, the offspring (a mule) is sterile and cannot reproduce.

The standard classification scheme provides a mechanism for bringing together various species into progressively larger groups, as follows:

- **Genus:** Consists of one or more related species
- **Family:** Consists of similar genera
- **Order:** Consists of families with similar characteristics
- **Class:** Consists of orders with similar characteristics
- **Phylum (or Division):** Consists of related classes (the term division is used for classifying plants and fungi, while phylum is used for classifying animals and animal-like organisms.)
- **Kingdom:** Consists of related divisions or phyla
- **Domain:** The broadest level of classification

The classification scheme that is currently most widely accepted recognizes three domains: domain Archaea, domain Eubacteria, and domain Eukarya. Domain Eukarya is subdivided into four kingdoms: Protista, Fungi, Plantae, and Animalia.

The following illustration shows hypothetical relationships among organisms.



Domain Archaea

Members of the domain Archaea are primitive bacteria, most of which are prokaryotic anaerobic organisms that use methane production in their energy metabolism. They are primarily found in marshes and swamps.

Domain Eubacteria

Members of the eubacteria are prokaryotic organisms. You can find them in nearly all environments on Earth, including soil, water, and air. Most species of eubacteria are *heterotrophic*—they acquire their food from organic matter. Many are *saprobic*—they feed on dead and decaying organic matter. Some are *parasitic* —living within a host organism and causing disease. There also are several species of eubacteria that are *autotrophic*—they have the ability to synthesize their own food. Most of the autotrophic eubacteria use pigments to absorb light energy and make food through the process of photosynthesis. Some autotrophic bacteria are *chemosynthetic*—they use chemical reactions as a source of energy from which they synthesize their own food.

Many eubacteria species are beneficial for the following reasons:

- Some species are responsible for the decay of organic matter in natural ecosystems.
- Some species are responsible for the decay of organic matter in landfills.
- Some species of eubacteria are used to prepare certain food products, including cheeses, fermented dairy products, sauerkraut, and pickles.
- Some species of eubacteria are used to produce antibiotics, chemicals, dyes, vitamins, and insecticides.
- In the human intestine, eubacteria are responsible for the synthesis of several vitamins that are not readily obtainable from food, especially vitamin K.

Unfortunately, many eubacteria are *pathogenic,* causing diseases in plants, animals, and humans, including such diseases as tuberculosis, gonorrhea, syphilis, pneumonia, and food poisoning.

The *cyanobacteria* are photosynthetic members of the eubacteria. They are important components of the plankton found in oceans, and they contribute a significant amount of oxygen to the atmosphere. Scientists believe the cyanobacteria were among the first photosynthetic organisms to colonize the Earth's surface.

Domain Eukarya

Members of the domain Eukarya are all eukaryotic organisms. They include members of the kingdoms Protista, Fungi, Plantae, and Animalia.

Kingdom Protista

Members of the kingdom Protista are a highly varied group of organisms, including protozoa, slime molds, and algae. Many species are autotrophs, creating their own food, while others are heterotrophs, feeding on organic matter.

- **Protozoa:** Protozoa are subdivided into four phyla based on their method of locomotion:
    - **Mastigophora:** Organisms that move about by using one or more whip-like flagella. Some species live within the bodies of animals, such as the wood-digesting organisms found in the intestines of termites. Other species contain photosynthetic pigments and are often found as components of plankton.
    - **Sarcodina:** The amoebas and their relatives. They each consist of a single cell that lacks a definite shape, and they typically feed on small particles of organic matter, which they engulf.

- **Ciliophora:** Organisms that move by means of cilia, such as the common paramecium.
- **Sporozoa:** Organisms in this phylum are all parasites.

- **Slime molds:** Slime molds have certain properties that resemble fungi, as well as protozoa-like properties. *True slime molds* consist of a single, flat, large, multinucleate cell, while *cellular slime molds* consist of amoeba-like cells that live independently but unite with other cellular slime mold cells to form a single, large, flat, multinucleate organism.
- **Algae:** The term *algae* refers to a large number of photosynthetic organisms that range from single-celled forms to complex, multicellular organisms that resemble plants. Algal species occur in bodies of both fresh and salt water. Algae are subdivided into several divisions, based in part on the pigments they possess.
  - **Red algae:** These are almost exclusively marine organisms (seaweeds) and include both single-celled and multicellular species.
  - **Golden-brown algae (dinoflagellates):** These are single-celled organisms that are surrounded by thick plates that give them an armored appearance.
  - **Golden algae (diatoms):** These are single-celled organisms with cell walls containing *silica* (glass). In the ocean, diatoms carry out photosynthesis and serve as an important food source at the base of food chains.
  - **Brown algae:** These are primarily multicellular marine organisms (seaweeds), and include the rock-weeds and kelps.
  - **Green algae:** These include both single-celled forms and complex, multicellular organisms. They share many characteristics with plants and are thought to be the ancestors of higher plants.

Kingdom Fungi

Fungi, together with eubacteria and some protists, are the major decomposers of organic matter on Earth. Most fungi digest non-living organic matter such as wood, leaves, and dead animals. However, some fungi are parasitic, living off other living organisms. Parasitic fungi cause many diseases affecting plants, animals, and humans. Other fungi are economically important, including species used to flavor cheeses. One species, *Penicillium notatum,* is the original source of the antibiotic penicillin.

The method by which they obtain nutrients distinguishes fungi from the other kingdoms. Fungi secrete enzymes into the environment that break down organic matter, and then they absorb the nutrients through their cell membranes. This process is referred to as *extracellular digestion.*

Kingdom Plantae

Plants are multicellular eukaryotic organisms with the ability to produce their own food through the process of photosynthesis. They are divided into two main groups:

- **Nonvascular plants:** These are plants that do not have specialized tissues for transporting water and nutrients. Nonvascular plants include the mosses, liverworts, and hornworts. Because these plants lack conducting tissues, they cannot grow very large and cannot retain water for extended periods of time. This is why they are typically found only in moist areas. They also must rely on the presence of water for fertilization to occur.

- **Vascular plants:** These are plants that contain specialized structures for transporting water and nutrients. The vascular plants encompass several divisions of plants. They are characterized by the presence of two types of specialized tissue, the xylem and the phloem. *Xylem* conducts water and minerals upward through the plant, while *phloem* transports sugars from the leaves, where they are made during photosynthesis, to other parts of the plant body. The vascular tissue also serves as a means of support in the plant, so vascular plants are capable of maintaining a much larger size than nonvascular plants.

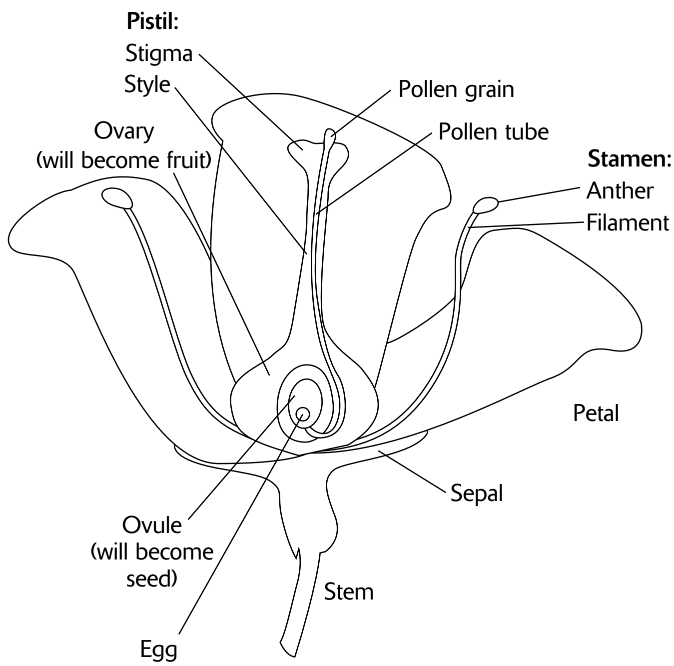
There are different types of vascular plants:

- **Seedless vascular plants:** Among the seedless vascular plants are the ferns and fern allies (whisk ferns, club mosses, spike mosses, and horsetails). These plants reproduce by producing spores on the surfaces of their leaves or in specialized cone-shaped structures.
- **Vascular plants with unprotected seeds:** The vascular plants that produce unprotected (naked) seeds are known as *gymnosperms.* Their seeds are not enclosed within tissues of the female parent. Included in the gymnosperms are pines, firs, spruces, redwoods, cypress, yews, cycads, ginkgo, and ephedra.

  Mature trees produce male and female cones. The male cones produce pollen grains, which contain sperm, while the female cones produce two or three egg cells that develop within ovules located on the surfaces of the cone scales.
- **Vascular plants with protected seeds:** The *angiosperms* are the most highly developed and complex of the vascular plants. They are the flowering plants, of which more than a quarter of a million species have been identified. The seeds of angiosperms develop within protective tissues of the female parent.

Angiosperms deserve more discussion. The flower of the angiosperm consists of four rings of modified leaves:

- **Sepals:** These comprise the outer ring of modified leaves that enclose and protect the developing flower bud. In some species the sepals are small and green, while in others they become colored and resemble petals.
- **Petals:** These comprise the next ring of modified leaves found in the flower. Flower petals are usually colorful and serve to attract pollinators.
- **Stamens (male reproductive structures):** These comprise the third ring of modified leaves. Each stamen consists of a stalk called the *filament* with a bulbous structure at the end called the *anther,* in which pollen grains are produced.
- **Pistil (female reproductive structure):** These consist of a tubular structure called the *style,* with a sticky surface at the top for catching pollen called the *stigma,* and an enlarged region *(ovary)* at the base. Within the ovary, an embryo sac develops that consists of eight nuclei.



During pollination, pollen grains land on the stigma of a female flower where they germinate and form a pollen tube. The pollen tube grows down the style and into an opening in the ovary. When the pollen tube reaches the ovary, two sperm cells are released. One sperm cell unites with the egg cell in the embryo sac to form a diploid zygote, while the second sperm unites with two other nuclei to form a triploid endosperm. The remaining nuclei in the embryo sac degenerate.

The zygote develops into an embryo surrounded by the endosperm, which serves as nutritive tissue for the developing embryo. The ovary tissue expands, forming a fruit, which serves as a protective covering for the developing seed. The protective fruit tissue also serves as an important dispersal mechanism:

- Fleshy fruits are often eaten by animals, and the seeds travel inside the animals to other locations where they are dispersed when the animals defecate.
- Some fruits have barbs or hooks on the outer fruit that attach to the fur of animals and are dispersed in that manner.
- Some fruits become dry when they mature. Some of these split open quite forcefully, ejecting their seeds great distances, while other dry fruits have thin paper tissue attached to them that serve as wings for dispersal by wind.

Structure and Function of Higher Plants

Higher plants have four types of tissues:

- **Vascular tissues:** These include xylem, which conducts water and minerals from the roots upward throughout the plant, and phloem, which transports dissolved foods in all directions throughout the plant.
- **Dermal tissues:** Dermal tissues cover the outside of the plant and consist primarily of *epidermal cells* (equivalent to the skin cells of humans). These tissues protect the plant from injury and water loss.

- **Ground tissues:** These tissues are located between the vascular tissues and dermal tissues and are responsible for storing carbohydrates that the plant produces.
- **Meristematic tissues:** Meristematic tissues are found in regions where the plant is actively growing (where cell division is occurring). *Primary meristematic tissues* are found in the root tips and shoot tips and are responsible for growth in length. *Secondary (lateral) meristematic tissues* are found only in woody plants and are responsible for growth in width.

Plant Organs

The three organs found in plants are the roots, the stems, and the leaves. Flowers are modified leaves.

The main functions of the roots are:

- Anchoring the plant in the soil
- Taking in water and minerals from the soil

The main functions of stems are:

- Supporting the plant
- Transporting water, minerals, and sugars by the vascular system
- Storing water and food

The main functions of the leaves are:

- Making food for the plant through photosynthesis
- Allowing for evaporation and gas exchange through pores on the surfaces of leaves called *stomata*

Kingdom Animalia

Animals are multicellular eukaryotic organisms. They differ from plants in that they are heterotrophic: They take in food and digest it into smaller components. The primary mode of reproduction in animals is sexual. Two major groups of animals exist: the invertebrates and the vertebrates. *Invertebrates* are animals that do not have a spine, while *vertebrates* are animals with spines.

Invertebrates

The invertebrates are represented by numerous phyla, and comprise approximately 95 percent of all animal species.

- **Phylum Porifera** includes a number of simple animals commonly referred to as sponges.
- **Phylum Cnidaria** includes hydras, jellyfish, sea corals, and sea anemones.
- **Phylum Platyhelminthes** includes the flatworms, such as planaria and tapeworms.

- **Phylum Aschelminthes** (also known as Nematoda) includes the nematodes, or roundworms, many of which are microscopic.
- **Phylum Annelida** includes the segmented worms, such as earthworms and leeches.
- **Phylum Mollusca** includes soft-bodied animals, such as the snail, clam, squid, oyster, and octopus. Some members secrete a hard shell.
- **Phylum Arthropoda** includes spiders, ticks, centipedes, lobsters, and insects.
- **Phylum Echinodermata** includes sea stars, brittle stars, sea urchins, and sea cucumbers. These animals have spiny skin that helps protect them from predators. All echinoderms have an internal support system called an *endoskeleton* and a large body cavity containing a set of canals called a *water vascular system.*
- **Phylum Chordata** includes both invertebrate members and vertebrate members.

Vertebrates

Members of the phylum Chordata that have spines are classified in the subphylum Vertebrata. There are more than 40,000 living species of vertebrates, divided into several classes encompassing the fishes, amphibians, reptiles, birds, and mammals.

- **Fishes** are aquatic animals with a streamlined shape and a functional tail that allows them to move rapidly through water. Fishes exchange gases with their environment through gills, although a few species have lungs that supplement gas exchange.
- **Amphibians** are animals that live both on land and in the water. They include the frogs, toads, and salamanders. Amphibians live on land and breathe air, however, they also are able to exchange gases through their skin and the inner lining of their mouth. Amphibians remain in moist environments to avoid dehydration, and lay their eggs in water because the eggs would quickly dry out on land. Young amphibians (for example, tadpoles) live in the water, while the adults live on land.
- **Reptiles** include lizards, snakes, crocodiles, alligators, and turtles. Reptiles have a dry, scaly skin that retards water loss, and the structure of their limbs provides better support for moving quickly on land. Their lungs have a greater surface area than those of amphibians, allowing them to inhale greater quantities of air. The circulatory system in reptiles includes a three-chambered heart that separates oxygen-rich blood from oxygen-poor blood. Reproduction in reptiles occurs on land.
- **Birds** have many structures that make them adapted to flight. For example, the body is streamlined to minimize air resistance, they have feathers, and their bones are light and hollow. Feathers also serve to insulate against loss of body heat and water. Birds are *homeothermic,* meaning they are able to maintain a constant body temperature. The rapid pumping of their four-chambered heart and a high blood flow rate contribute to this characteristic.

- **Mammals** are animals that have hair and nourish their young with milk that they produce through mammary glands. The presence of body hair or fur helps maintain a constant body temperature in these homeothermic animals. Several types of mammals exist:
  - **Monotremes** are egg-laying mammals that produce milk. The duck-billed platypus and the spiny anteater are monotremes.
  - **Marsupials** are mammals whose embryos develop within the mother's uterus for a short period of time before birth. After birth, the immature babies crawl into the mother's abdominal pouch where they complete their development. Kangaroos, opossums, and koala bears are marsupials.
  - **Placental mammals** include rabbits, deer, dogs, cats, whales, monkeys, and humans. These mammals have a placenta—a connection between the embryo and the mother's uterine wall that allows the embryo to obtain nutrients from the mother. Embryos are attached to the placenta and complete their development within their mother's uterus.

All mammals have a highly developed nervous system, and many have developed acute senses of smell, hearing, sight, taste, or touch. Mammals rely on memory and learning to guide their activities. They are considered the most successful group of animals on Earth today.

Anatomy and Physiology

Nutrition and Digestion

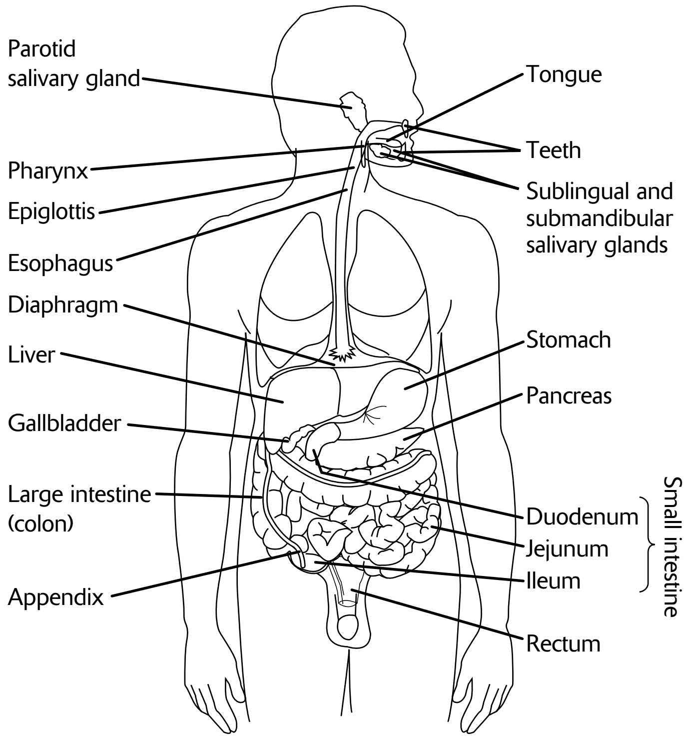
All the elements and compounds that a living organism takes in are considered nutrients. Animals, including humans, are heterotrophic organisms, and their nutrients consist of pre-formed organic molecules. These organic molecules usually must be processed into more simple forms by digestion before cells can take them in.

The nutrients used by animals include:

- **Carbohydrates:** These are the basic source of energy for all animals. Glucose is the carbohydrate most often used as an energy source; it is metabolized during cellular respiration to provide energy in the form of adenosine triphosphate (ATP). Other useful carbohydrates include maltose, lactose, sucrose, and starch.
- **Lipids:** These are used to form cellular membranes, the sheaths surrounding nerve fibers, and certain hormones. One type of lipid, fat, is a useful energy source.
- **Nucleic acids:** These are used to make DNA and RNA. They are obtained from ingesting plant and animal tissues.
- **Proteins:** These form the framework of the animal body and are major components of membranes, muscles, ligaments, tendons, and enzymes. Twenty different amino acids make up proteins. While the body can make some amino acids, others must be supplied by diet.
- **Minerals:** These are required by animals in small amounts and include phosphorous, sulfur, potassium, magnesium, and zinc. Animals usually obtain these minerals when they consume plants.
- **Vitamins:** These are organic compounds essential in trace amounts for animal health. Some vitamins are *water-soluble* (break down easily in water), while others are *fat-soluble* (break down easily in fats).

The Human Digestive System

Human digestion is a complex process that consists of breaking down large organic masses into smaller particles that the body can use as fuel. The major organs or structures that coordinate digestion in humans include the mouth, esophagus, stomach, small intestine, and large intestine.



The following list goes into more detail on the major parts of the digestive system:

- **Mouth:** This is a specialized organ for receiving food and breaking up large organic masses into smaller particles. This is accomplished through a combination of biting and chewing by the teeth and moistening by saliva. During chewing, the tongue moves food around and manipulates it into a mass called a *bolus.* The bolus is pushed back into the *pharynx* (throat) and forced through the opening to the esophagus.
- **Esophagus:** This is a thick-walled muscular tube located behind the windpipe that extends through the neck and chest to the stomach. The bolus of food moves through the esophagus by a series of rhythmic muscular contractions *(peristalsis).* The esophagus joins the stomach at a point just below the diaphragm. A valve-like ring of muscle called the *cardiac sphincter* surrounds the opening to the stomach. The sphincter relaxes as the bolus passes through and then quickly closes.
- **Stomach:** This is an expandable pouch located high in the abdominal cavity. Layers of stomach muscle contract and churn the bolus of food with gastric juices to form a soupy liquid called *chyme.* The stomach stores food and prepares it for further digestion. The chyme spurts from the stomach through a sphincter into the small intestine.

- **Small intestine:** This structure, which is about 23 feet long in the average human, is divided into three sections:
  - **Duodenum:** The first 10-12 inches; where most chemical digestion takes place.
  - **Jejunum:** The next 10 feet; where most absorption occurs.
  - **Ileum:** The final 12 feet; where absorption is completed. Substances that have not been digested or absorbed then pass into the large intestine.
- **Large intestine:** This structure, also known as the colon, is about three feet in length. The colon's chief functions are to absorb water and to store, process, and eliminate the residue following digestion and absorption. The intestinal matter remaining after water has been reclaimed is known as *feces.* Feces consist of non-digested food particles, billions of mostly harmless bacteria, bile pigments, and other materials. The feces are stored in the rectum and passed out through the anus to complete the digestion process.

Human Respiratory System

The human respiratory system consists of a complex set of organs and tissues that capture oxygen from the environment and transport the oxygen to the lungs. The organs and tissues that comprise the human respiratory system include the following:

- **Nose:** The human respiratory system begins with the nose, where air is conditioned by warming and moistening. Hairs trap dust particles and purify the air.
- **Pharynx:** Air passes from the nose into the pharynx (throat). From the pharynx, two tubes called *Eustachian tubes* open to the middle ear to equalize pressure. The pharynx also contains tonsils and adenoids, which trap and filter microorganisms.
- **Trachea:** From the pharynx, air passes into the trachea (windpipe). The opening to the trachea is a slit-like structure called the *glottis.* A thin flap of tissue called the *epiglottis* folds over the opening during swallowing and prevents food from entering the trachea. At the upper end of the trachea, several folds of cartilage form the *larynx,* or voicebox. In the larynx, flap-like tissues called *vocal cords* vibrate when a person exhales and produce sounds. At its lower end, the trachea branches into two large *bronchi.* These tubes branch into smaller *bronchioles,* which terminate into sacs called *alveoli.*
- **Lungs:** Human lungs are composed of approximately 300 million alveoli, which are cup-shaped sacs surrounded by a capillary network. Red blood cells pass through the capillaries, and oxygen enters and binds to the hemoglobin. In addition, carbon dioxide contained in the red blood cells leaves the capillaries and enters the alveoli.

Human Circulatory System

The function of the human circulatory system is to transport blood and oxygen from the lungs to various tissues of the body. The components of the human circulatory system include the following:

- **Heart:** The human heart is about the size of a clenched fist. It contains four chambers: two atria and two ventricles. Oxygen-poor blood enters the right atrium through a major vein called the *vena cava.* The blood passes into the right ventricle and is pumped through the *pulmonary artery* to the lungs for gas exchange. Oxygen-rich blood returns to the left atrium via the *pulmonary vein.* The oxygen-rich blood flows into the left ventricle, from which it is pumped through a major artery, the *aorta. Coronary arteries* supply the heart muscle with blood. The heart is controlled by nerves that originate on the right side in the upper region of the atrium at a node called the *pacemaker.*

- **Blood:** The fluid portion of the blood, the *plasma,* is a straw-colored liquid composed primarily of water. Nutrients, hormones, clotting proteins, and waste products are transported in the plasma. Red blood cells and white blood cells are also suspended in the plasma.
- **Red blood cells:** Also called *erythrocytes,* red blood cells are disk-shaped cells produced in the bone marrow. They do not have a nucleus and are filled with hemoglobin. *Hemoglobin* is a red-pigmented protein that binds loosely to oxygen and carbon dioxide and transports these substances throughout the body. Red blood cells usually have immune-stimulating antigens on their surfaces.
- **White blood cells:** Also called *leukocytes,* white blood cells are generally larger than red blood cells and contain nuclei. They are also produced in the bone marrow and have various functions in the body. Certain white blood cells, called *lymphocytes,* are part of the immune system. Other cells, called *neutrophils* and *monocytes,* function primarily as *phagocytes;* they attack and engulf invading microorganisms.
- **Platelets:** Platelets are small, disk-shaped blood fragments produced in the bone marrow. They lack nuclei and are much smaller than red blood cells. They serve as the starting material for blood clotting.
- **Lymphatic system:** The lymphatic system is an extension of the circulatory system consisting of:
  - **Lymph:** A watery fluid derived from plasma that has seeped out of capillaries.
  - **Lymphatic vessels:** Capillaries that return fluids to the circulatory system.
  - **Lymph nodes:** Hundreds of tiny, capsule-like bodies located in the neck, armpits, and groin; the lymph nodes filter the lymph and digest foreign particles.
  - **Spleen:** Composed primarily of lymph node tissue; it is the site where red blood cells are destroyed.

Human Excretory System

The human excretory system removes waste from the body through the kidneys. The human kidneys are bean-shaped organs located on either side of the spine at about the level of the stomach and liver. Blood enters the kidneys through renal arteries and leaves through renal veins. Tubes *(ureters)* carry waste products from the kidneys to the urinary bladder for storage or release. The product of the kidneys is *urine,* a watery solution of waste products, salts, organic compounds, uric acid, and urea. *Uric acid* results from the breakdown of nucleic acids and *urea* results from the breakdown of amino acids in the liver. Both of these nitrogen-rich compounds can be poisonous to the body and must be removed in the urine.

Human Endocrine System

The human body has two levels of coordination: nervous coordination and chemical coordination. *Chemical coordination* is centered on a system of glands known as *endocrine glands,* which secrete hormones that help coordinate the major body systems. These glands are situated throughout the body and include the following:

- **Pituitary gland:** The pituitary gland is located at the base of the human brain.
- **Thyroid gland:** The thyroid gland lies against the pharynx at the base of the neck.
- **Adrenal glands:** The adrenal glands are two pyramid-shaped glands lying atop the kidneys.
- **Pancreas:** The pancreas is located just behind the stomach. It produces two hormones: insulin and glucagon.
- **Ovaries:** The ovaries in females function as endocrine glands; they secrete *estrogens,* which encourage the development of secondary female characteristics.
- **Testes:** The testes in males also function as endocrine glands; they secrete *androgens* (including testosterone), which promote secondary male characteristics.

Human Nervous System

Nervous coordination enables the body to rapidly respond to external or internal stimuli. The human nervous system is divided into the *central nervous system* (the brain and spinal cord) and the *peripheral nervous system* (the nerves extending to and from the central nervous system).

Central Nervous System

The spinal cord extends from the base of the brain to the end of the spine. Three membranes called *meninges* surround the spinal cord and protect it. The neurons of the spinal cord serve as a coordinating center and a connecting system between the peripheral nervous system and the brain.

The *brain* is the organizing and processing center of the central nervous system. It is the site of consciousness, sensation, memory, and intelligence. The brain receives impulses from the spinal cord and from 12 pairs of cranial nerves coming from and extending to the other senses and organs. The brain can also initiate activities without external stimuli. Three major regions of the brain are recognized:

- **Hindbrain:** The hindbrain consists of the following three regions:
  - **Medulla:** The swelling at the tip of the brain; serves as a passageway for nerves extending to and from the brain.
  - **Cerebellum:** Lies adjacent to the medulla; coordinates muscle contractions.
  - **Pons:** The swelling between the medulla and the midbrain; acts as a bridge between various regions of the brain.
- **Midbrain:** The midbrain lies between the hindbrain and forebrain. It consists of a collection of crossing nerve tracts and a group of fibers that arouse the forebrain when something unusual happens.

- **Forebrain:** The forebrain consists of the following regions:
  - **Cerebrum:** The site of such activities as speech, vision, movement, hearing, smell, learning, memory, logic, creativity, and emotion
  - **Thalamus:** Serves as an integration point for sensory impulses
  - **Hypothalamus:** Synthesizes hormones for storage in the pituitary gland and serves as the control center for hunger, thirst, body temperature, and blood pressure
  - **Limbic system:** A collection of structures that ring the edge of the brain and serve as centers of emotion

Peripheral Nervous System

The peripheral nervous system is a collection of nerves that connect the brain and spinal cord to other parts of the body and the external environment. It includes the following:

- **Sensory somatic system:** Carries impulses from the external environment and the senses; it permits humans to be aware of the outside environment and react to it voluntarily.
- **Autonomic nervous system:** Works on an involuntary basis; it is divided into two regions:
  - **Sympathetic nervous system:** Prepares the body for emergencies; impulses propagated by the sympathetic nervous system cause the heartbeat to increase, the arteries to constrict, and the pupils to dilate.
  - **Parasympathetic nervous system:** Allows the body to return to its normal state following an emergency, and is also responsible for helping digestion and preparing the body for sleep.

Human Reproduction

Reproduction is an essential process for the survival of a species. Human reproduction takes place by the coordination of the male and female reproductive systems. In humans, both males and females have evolved specialized organs and tissues that produce haploid cells by meiosis, the sperm and the egg. These cells fuse to form a zygote that eventually develops into a growing fetus. A network of hormones is secreted that controls both the male and female reproductive systems and assists in the growth and development of the fetus, as well as the birthing process.

Male Reproductive System

The male reproductive system is composed of the following structures:

- **Testes (or testicles):** Two egg-shaped organs located in a pouch outside the body called the *scrotum.*
- **Seminiferous tubules:** Coiled passageways within the testes where sperm cells are produced.
- **Penis:** The organ responsible for carrying the sperm cells to the female reproductive tract; within the penis, the sperm are carried in a tube called the *urethra.*
- **Semen:** Composed of secretions from the prostate gland, seminal vesicles, and Cowper's glands, plus the sperm cells.

Female Reproductive System

The organs of the female reproductive system include the following structures:

- **Ovaries:** Two oval organs lying within the pelvic cavity.
- **Fallopian tubes:** Tubes leading from the ovaries that the eggs enter after they are released from the ovaries following meiosis; the site of fertilization of the egg by the sperm.
- **Uterus:** A muscular organ in the pelvic cavity to which the eggs travel through the Fallopian tubes.
- **Endrometrium:** The inner lining of the uterus; it thickens with blood and tissue in anticipation of a fertilized egg cell. If fertilization fails to occur, the endometrium degenerates and is shed in the process of *menstruation.*
- **Cervix:** The opening at the lower end of the uterus.
- **Vagina:** The tube leading from the cervix to outside the body; the vagina receives the penis and the semen.

The sperm cells in the semen pass through the cervix and uterus into the Fallopian tubes, where fertilization takes place. Fertilization brings together 23 chromosomes from the male (sperm) and 23 chromosomes from the female (egg), resulting in the formation of a fertilized egg cell (called a zygote) with 46 chromosomes—the number present in normal human cells.

Ecology

Ecology is the discipline of biology concerned primarily with the interaction between organisms and their environments. There are many levels of organization among living organisms, including the following:

- **Population:** A population is a group of individuals belonging to one species living in a defined area.
- **Community:** A community consists of the various plant and animal species living in a defined area. Within a community, each population of organisms has a *habitat* (the physical location where an organism lives) and a *niche* (the role that organism plays in the community).
- **Ecosystem:** An ecosystem includes all the organisms living together in a community, interacting with each other and with non-living factors (water, light, soil, and so on).

Organisms living together in an ecosystem interact with each other in various ways, including the following:

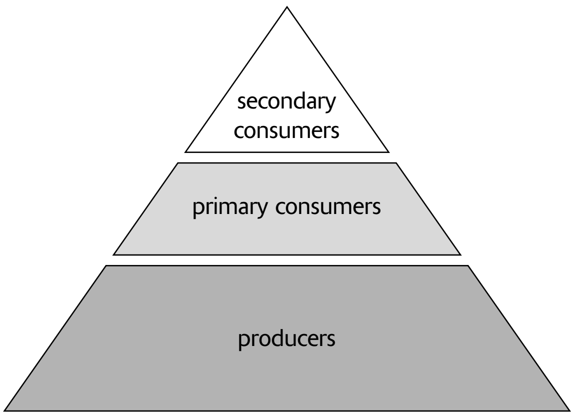
- **Mutualism:** The relationship between two organisms is mutually beneficial, such as the relationship between fungi and cyanobacteria in lichens.
- **Commensalism:** The relationship benefits one organism but does not affect the other organism, such as the bacteria living in the guts of humans.
- **Parasitism:** The relationship benefits one organism, while the other is harmed. The microorganisms that cause human diseases are parasites.
- **Predation:** This occurs when one organism feeds on another organism. In this type of relationship, one organism benefits and the other is harmed (as in parasitism).

One of the major factors responsible for sustaining an ecosystem is the flow of energy within it. Energy is transferred from one organism to another in an ecosystem through food chains. Food chains are composed of the following:

- **Producers:** Photosynthesizing organisms (plants, algae) that trap the energy from the sun to make their own food
- **Primary consumers:** Organisms that feed directly on producers (herbivores)
- **Secondary consumers:** Organisms that feed on primary consumers (carnivores)
- **Decomposers:** Organisms (fungi, slime molds, bacteria) that break down dead organisms and recycle the nutrients back into the environment

Many food chains interact to form a food web.

The food pyramid illustrates the availability of food in an ecosystem at successive levels (*trophic levels*) of a food chain. The number of producers, which are always at the base of the pyramid, is high, and the number of consumers at the top of the pyramid is always low. The difference in numbers of individuals at each trophic level occurs because only a small percentage of the food energy available at one level can be passed on to the next, because much of the energy is used up during metabolism in the organisms at each level. The following figure shows a hypothetical food pyramid.



Another mechanism for sustaining an ecosystem is the recycling of nutrients and minerals. Carbon, nitrogen, and phosphorus are examples of substances that are recycled through ecosystems. Much of the carbon is recycled through respiration; however, the majority is recycled through decomposition. Nitrogen, which is vital for the synthesis of proteins and nucleic acids, is released to the atmosphere as waste products by bacteria.

All of life is confined to a five-mile vertical space around the surface of the Earth, called the *biosphere.* The biosphere is composed of the living organisms and the physical environment that blankets the Earth. The physical environment includes the rocky material of the Earth's surface, the water on or near the Earth's surface, and the blanket of gases surrounding the Earth.

The biosphere is divided into subunits called *biomes.* Each biome is characterized by climatic conditions present, which determine which species will live there. Examples of biomes include deserts, tropical forests, temperate forests, prairies, tundra, and taiga (the southern edge of the tundra).

Chemistry

Matter and Atomic Structure

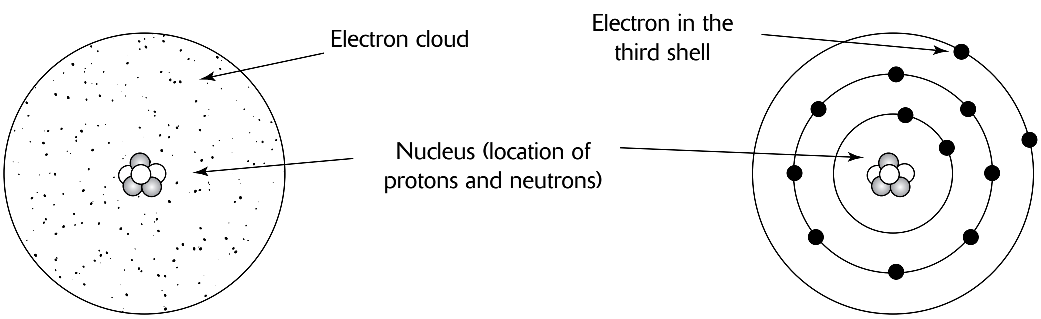
Matter is defined as anything with a definite mass that takes up volume. There are three common states of matter with which you are familiar: solids, liquids, and gases. Matter can be made of simple things like diamond, water, or neon, or it can be made of very complex things like heat resistant shields on the Space Shuttle, blood plasma, or anesthesiology gases. There are several considerations when looking at the differences between solids, liquids, and gases, but they can be summarized as follows:

- **Solids** have a defined mass, volume, and shape.
- **Liquids** have a defined mass and volume, but not a defined shape.
- **Gases** have a defined mass, but not a defined volume or shape (they will expand to fill any container).

All of the matter you see and use is made of a few fundamental particles called protons, neutrons, and electrons. These *subatomic particles* make up atoms. *Atoms* are specific collections of protons and neutrons surrounded by electrons. Each of these subatomic particles is different by mass and charge, as seen in the following table:

Subatomic particle	***Symbol***	***Actual mass (grams)***	***Relative charge***
Proton	p or p^+	$1.673 \cdot 10^{-24}$	+1
Neutron	n	$1.675 \cdot 10^{-24}$	0
Electron	e or e^-	$9.109 \cdot 10^{-28}$	–1

Protons and neutrons are located at the center of the atom and make up a region called the *nucleus.* Outside of the nucleus are the electrons, which make up the electron cloud. The current model of an atom is fairly complex, but the figure below gives a rough estimate. The electrons are not randomly arranged in the electron cloud, but occupy locations called *orbitals.* These orbitals can be arranged in shells. The illustration shows how electrons can be arranged in shells around the nucleus of an atom, though the actual picture is much more complex than this "solar system model" of the atom would indicate.



With these three particles, atoms can be made, and from these atoms, every solid, liquid, and gas in the universe is formed. Conceivably, there could be an infinite number of combinations of subatomic particles, but not all combinations are stable. In fact, only 112 elements have been found or created. An *element* is a material that cannot be chemically broken down into something simpler. Elements are made of atoms and, as noted, atoms are made of electrons, protons, and neutrons.

The Periodic Table

To save time and space, elements have been assigned a one- or two-letter designation called an *atomic* or *elemental symbol.* Always capitalize the first letter and, if there is a second letter, always write it in lower case. Without this rule, some chemical formulas might be misinterpreted. (Co is the symbol for cobalt, but CO is the symbol for a compound containing one carbon atom and one oxygen atom.) A list of all atomic symbols is given in the periodic table.

Key: Atomic number / Elemental symbol / Atomic mass

1A	2A	3B	4B	5B	6B	7B		8B		1B	2B	3A	4A	5A	6A	7A	8A
1 **H** 1.00794																	2 **He** 4.00260
3 **Li** 6.941	4 **Be** 9.01218											5 **B** 10.811	6 **C** 12.011	7 **N** 14.0067	8 **O** 15.9994	9 **F** 18.99840	10 **Ne** 20.1797
11 **Na** 22.98977	12 **Mg** 24.305											13 **Al** 26.9815	14 **Si** 28.0855	15 **P** 30.97376	16 **S** 32.066	17 **Cl** 35.4527	18 **Ar** 39.948
19 **K** 39.0983	20 **Ca** 40.07838	21 **Sc** 44.9556	22 **Ti** 47.88	23 **V** 50.9415	24 **Cr** 51.994	25 **Mn** 54.938	26 **Fe** 55.847	27 **Co** 58.9332	28 **Ni** 58.6934	29 **Cu** 63.546	30 **Zn** 65.39	31 **Ga** 69.723	32 **Ge** 72.61	33 **As** 74.9216	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 93.80
37 **Rb** 85.4678	38 **Sr** 87.62	39 **Y** 88.9059	40 **Zr** 91.224	41 **Nb** 92.9064	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.9055	46 **Pd** 105.42	47 **Ag** 107.868	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.710	51 **Sb** 121.757	52 **Te** 127.60	53 **I** 126.9045	54 **Xe** 131.29
55 **Cs** 132.9045	56 **Ba** 137.33	57 **La** 138.9055	72 **Hf** 178.49	73 **Ta** 180.9479	74 **W** 183.85	75 **Re** 186.207	76 **Os** 190.2	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.966	80 **Hg** 200.59	81 **Tl** 204.383	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226.0254	89 **Ac** (227)	104 **Rf** (261)	105 **Ha** (263)	106 **Sg** (263)	107 **Ns** (265)	108 **Hs** (265)	109 **Mt** (266)	110 **–** (269)	111 **–** (272)	112 **–** (277)						

58 **Ce** 140.12	59 **Pr** 140.9077	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.965	64 **Gd** 157.25	65 **Tb** 158.9253	66 **Dy** 162.50	67 **Ho** 164.9303	68 **Er** 167.26	69 **Tm** 168.9342	70 **Yb** 173.04	71 **Lu** 174.967
90 **Th** 232.0381	91 **Pa** 231.0359	92 **U** 238.029	93 **Np** 237.0482	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

Though it may appear to have an unusual shape, the periodic table is an incredibly useful document. Reading left to right across the periodic table, the elements are arranged in order of the number of protons in their nucleus (the number of protons in a nucleus is called an element's *atomic number).* Thus, the element hydrogen is listed first since atoms of hydrogen have only one proton in the nucleus. The element helium has two protons in the nucleus, so it is listed second. The atomic number of iron (Fe) is 26 so it has 26 protons in its nucleus and is listed just after manganese (Mn, atomic number 25) and just before cobalt (Co, atomic number 27). The atomic number is a very important concept in chemistry. Not only does every iron atom have 26 protons in its nucleus, but any atom that has 26 protons in its nucleus *must be* an iron atom. The atomic number is the defining characteristic of an atom. All atoms of the same element must have the same number of protons, but can have differing numbers of neutrons and electrons.

If the number of electrons is the same as the atomic number (number of protons), then the atom is neutral since there are the same number of negative and positive charges from the electrons and protons, respectively. If there are fewer electrons than protons, a *cation* (pronounced CAT-ion) will result which will have a positive charge. Metals usually form cations (for example, Ag forms Ag^+). If there is an excess of electrons compared to the number of protons, a negative charge will arise on the atom resulting in an *anion* (pronounced AN-ion). Non-metals usually form anions (for example, N forms N^{3-}). An atom, or group of atoms, with a charge is called an *ion.*

Elements that have the same number of protons, but different numbers of neutrons, are called *isotopes.* An example of an element with two isotopes is copper. All copper atoms contain 29 protons; however, 69% of copper atoms contain 34 neutrons and 31% contain 36 neutrons. The two types of copper atoms will have different masses because they have a different number of neutrons; however, they are both copper atoms. Magnesium is an element with three isotopes; all magnesium atoms have 12 protons, but 79% have 12 neutrons, 10% have 13 neutrons, and 11% have 14 neutrons. To differentiate between these isotopes, a value called the mass number is used. The *mass number* of an element is the number of protons and neutrons in an atom. Thus, 79% of magnesium atoms have a mass number of 24, 10% have a mass number of 25, and 11% have a mass number of 26.

This difference in atomic composition is reflected by the atomic mass (or atomic weight) of an element. In the periodic table, it is the number found underneath each atomic symbol. By definition, the *atomic mass* is the average mass of all the naturally occurring isotopes of an element. The atomic mass of magnesium is listed as 24.305 *amu (atomic mass units),* though no atom of Mg actually has this mass; it is obtained by averaging the masses of the three Mg isotopes.

Another piece of useful information found within the periodic table is the number of electrons found in the outer shell of an atom. These electrons are known as the *valence electrons* and are responsible for holding atoms together when making a compound. Each column in the periodic table is called a *group* and each group of atoms has a similar configuration of electrons. Taking a look at the first column of the periodic table (1A), you will find H, Li, Na, K, Rb, Cs, and Fr. Each of these elements has only one electron in its outer shell; group 2A elements have two electrons in their outer shell; group 8A elements have 8 electrons in their outer shell.

The periodic table gets its name from the repetitive trends occurring for the elements when the elements are arranged by atomic number (*not* the atomic mass). This allows distinctions between the different elements, and a major distinction is that of metals and non-metals. Notice that in the periodic table there is a dark "stair step" line found on the right-hand side of the periodic table. Elements to the left of the line are *metals,* elements to the right of the line are called *non-metals,* and elements that straddle the line are called *metalloids* (or *semimetals).* Two exceptions to this rule are hydrogen (H) and aluminum (Al). Clearly, hydrogen is a non-metal, though it is often written to the right of the bold line, and aluminum is a metal, despite the fact that it is next to the bold line.

Atoms, Molecules, and Compounds

From the periodic table, you can see that there are many elements. Think for a moment, though, about the matter around you. The number of different materials, colors, odors, tastes, and tactile sensations is almost limitless. How can 112 different elements make up the billions of different materials that we perceive everyday?

Most of the materials you see are not made of just one type of element. Most of the materials are made of compounds. *Compounds* are substances with two or more *different* atoms of an element bound together. Examples of compounds are water (H_2O), sulfuric acid (battery acid, H_2SO_4), sodium hydrogen carbonate (baking soda, $NaHCO_3$), sucrose (table sugar, $C_{12}H_{22}O_{11}$), and sodium chloride (table salt, NaCl). Each of these substances is made of more than one kind of element. If those elements are nonmetals (for example, H_2O, H_2SO_4, and $C_{12}H_{22}O_{11}$), they are classified as molecules. *Molecules* are collections of non-metals that are tightly bound together. In the case where a metal and a non-metal are bound together (for example, NaCl or Na_2CO_3), they are classified as *formula units.*

Some elements also occur in molecular form, and examples include oxygen (O_2), hydrogen (H_2), nitrogen (N_2), and fluorine (F_2). Thus, when chemists speak of elemental hydrogen, they actually refer to two hydrogen atoms bound together, which is different than just two atoms of hydrogen.

A compound will have different properties than the elements that make it up. Thus, hydrogen is a gas at room temperature and is quite flammable, oxygen is a gas at room temperature that supports combustion, but water (made from hydrogen and oxygen) is a *liquid* at room temperature and *doesn't* burn or support combustion. Because water has different properties than the elements that comprise it, water is a compound of hydrogen and oxygen and not simply a mixture.

Chemical Equations and Reactions

In order to describe the chemical changes that are occurring around and inside of you, chemists have developed a shorthand notation in which the symbols for elements and compounds are written showing the chemical change. An example of a chemical equation is the combustion of propane (C_3H_8) with elemental oxygen (O_2) to form carbon dioxide (CO_2) and water (H_2O).

$$C_3H_8 + O_2 \rightarrow CO_2 + H_2O$$

The equation is written with *reactants* on the left and the *products* of the reaction on the right. The arrow shows that a reaction is taking place. While this shows the transformation of propane and oxygen into two different compounds, the equation is not quite complete. Because of the *Law of Mass Conservation,* matter cannot be created or destroyed, and the same kind and number of atoms must be on each side of the reaction arrow. Thus, to correctly write the equation above, coefficients in front of each chemical species must be added.

$$C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$$

Thus, one molecule of propane will react with five molecules of oxygen to form three molecules of carbon dioxide and four molecules of water. Information about the state of the reactant or product is written after each chemical formula to indicate if that substance is a gas (g or ↑), liquid (l), solid (s or ↓), or dissolved in water (aq).

$$C_3H_8\ (g) + 5\ O_2\ (g) \rightarrow 3\ CO_2\ (g) + 4\ H_2O\ (l)$$

There are many different types of chemical reactions; however, you can classify some of these according to one of the four basic reaction types: synthesis, decomposition, single replacement, or double replacement.

Synthesis (or combination) reaction: When two or more different substances react to form one compound.

Examples: $Mg(s) + F_2(g) \rightarrow MgF_2(s)$

$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

Decomposition reaction: When one substance breaks down into two or more different materials.

Examples: $2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(l)$

$Cu(OH)_2(s) \rightarrow CuO(s) + H_2O(l)$

Single replacement (or single displacement) reaction: When an element reacts with a compound and an exchange takes place.

Examples: $Zn(s) + CuBr_2(aq) \rightarrow Cu(s) + ZnBr_2(aq)$

$3Ag(NO_3)(aq) + Al(s) \rightarrow Al(NO_3)_3(aq) + 3Ag(s)$

In the first reaction, zinc (Zn) and copper (Cu) exchange, and in the second reaction, silver (Ag) and aluminum (Al) exchange.

Double replacement (or double displacement or metathesis) reactions: When two compounds react and an exchange occurs.

Examples: $Ag(NO_3)(aq) + NaCl(aq) \rightarrow Na(NO_3)(aq) + AgCl(s)$

$FeCl_3\ (aq) + 3Na(OH)(aq) \rightarrow 3NaCl(aq) + Fe(OH)_3(s)$

In the first reaction, silver (Ag) and sodium (Na) exchange, and in the second reaction, iron (Fe) and sodium (Na) exchange.

Acids, Bases, and Solutions

An *acid* is a compound that increases the quantity of hydrogen ions (H^+) in an aqueous solution. A *base* is a compound that decreases the H^+ concentration by increasing hydroxide (OH^-) concentration. The *pH scale* is a measure of how much acid is in a solution. Solutions with low pH's (0-7) are considered *acidic,* solutions with a pH of exactly 7 are *neutral* (neither acidic nor basic), and solutions with a high pH (7-14) are considered *basic.*

Because acids and bases are all around you, it is a good idea to know some of the more common compounds that constitute acids and bases. Examples of common acids are the following:

- **Acetic acid** ($HC_2H_3O_2$): Vinegar is a 5% solution of acetic acid.
- **Carbonic acid** (H_2CO_3): This is found in carbonated beverages, resulting from CO_2 dissolving in water.
- **Citric acid** ($H_3C_6H_5O_7$): This is found in citrus fruits and is responsible for their tangy flavor.
- **Hydrochloric acid** (HCl): This is found in gastric juices of humans.
- **Nitric acid** (HNO_3): This is used in fertilizer production.
- **Phosphoric acid** (H_3PO_4): This is used in colas to prevent bacterial growth, and is also used in fertilizer production.
- **Sulfuric acid** (H_2SO_4): This is the most industrially produced compound in the world and is also used in car batteries.

Examples of common bases:

- **Ammonia** (NH_3): This is used as a general cleanser and in fertilizers.
- **Lime** (CaO): This is used to raise the pH of soil for farming.
- **Lye** (NaOH): This is used in the manufacture of soap.
- **Milk of magnesia** ($Mg(OH)_2$): This is used as an antacid.
- **Sodium carbonate** (Na_2CO_3): This is used in paper manufacturing and water softening.

Pure water is neutral and therefore is neither acidic nor basic. When acids and bases react, they form water and salt as the products. For example:

$$NaOH(aq) + HCl(aq) \rightarrow H_2O(l) + NaCl(aq)$$

The sodium hydroxide (base) reacts with hydrochloric acid to form water and sodium chloride (salt).

A *solution* is a homogeneous mixture that is composed of a *solvent* (the material in greater proportion) and a *solute* (the material dissolved in the solvent). Salt water is an example in which water is the solvent and sodium chloride (NaCl) is the solute.

Important Elements of the Periodic Table

The first 20 elements of the periodic table are among the most abundant on Earth and in the universe. These elements are important in the materials that we use everyday and especially in our own metabolic function.

- **Hydrogen (H) (Atomic number: 1):** A clear, colorless, odorless, low-density gas that is the most abundant element in the universe (though not on Earth). It occurs as a diatomic molecule in its elemental form (H_2) and was used in balloons and dirigibles until the *Hindenburg* disaster. When hydrogen ions (H^+) are dissolved in water, they cause the solution to be acidic. Water is made of two parts hydrogen to one part oxygen (H_2O).

- **Helium (He) (Atomic number: 2):** This clear, colorless, odorless, low-density gas is the second most abundant element in the universe, though it is only present as a very small fraction of the Earth. Because it is not flammable, it is used as a substitute for hydrogen in balloons and blimps. It is very unreactive and occurs as single atoms in its elemental form.
- **Lithium (Li) (Atomic number: 3):** This low-density metal is very reactive in the elemental state, and easily forms a +1 ion (Li^+). A major use of lithium is to treat bipolar disorders like schizophrenia.
- **Beryllium (Be) (Atomic number: 4):** This low-density metal is used in high-tech alloys for its strength, but machinists must be careful since the dust is very toxic.
- **Boron (B) (Atomic number: 5):** Boron is a metalloid, but its oxide finds use in heat resistant glass and in borax, a cleaning agent.
- **Carbon (C) (Atomic number: 6):** Carbon is a solid at room temperature, but is a very versatile element. Diamond, one of the hardest substances known, and graphite, a material used as a lubricant and in pencil lead, are both made of pure carbon. Obviously, these two materials are remarkably different and their properties have to do with how the carbon atoms are bonded together. Carbon always forms four bonds and is one of the few elements that can form stable, long chains with itself. Carbon is the basis of organic chemistry. A major environmental concern is the production of carbon dioxide (CO_2) from the burning of fossil fuels. Though CO_2 only constitutes a small percentage of the overall atmosphere (less than 0.1%), it is one of the major contributors to the greenhouse effect.
- **Nitrogen (N) (Atomic number: 7):** This clear, colorless, odorless gas makes up about 75% of the Earth's atmosphere. In its elemental form, it occurs as a diatomic species (N_2) and is a very stable molecule. It is not flammable and reacts with very few other elements. SCUBA divers have to be careful about not rising to the water's surface too quickly or nitrogen bubbles can form in their blood vessels and cause the bends. A major use of nitrogen is in ammonia (NH_3) and in nitrates (NO_3^-), both of which are used in fertilizers. Nitrogen isn't toxic, but neither plants nor animals can metabolize it. Certain bacteria (*nitrogen-fixing* bacteria) can metabolize nitrogen.
- **Oxygen (O) (Atomic number: 8):** Oxygen is a clear, colorless, odorless gas that supports combustion. It reacts with almost all elements to form stable oxides. In its elemental state, it is a diatomic molecule (O_2) and makes up about 20% of the atmosphere. The ozone layer in the stratosphere is made of a triatomic oxygen molecule (O_3). Hydrogen peroxide (H_2O_2) is a common disinfectant for minor cuts that decomposes into water and molecular oxygen.
- **Fluorine (F) (Atomic number: 9):** Fluorine is a pale yellow gas that is very reactive. Elemental fluorine occurs as a diatomic molecule (F_2) and can etch glass. Compounds containing fluoride (F^-, the anion of fluorine) are used in toothpaste to help make tooth enamel more resistant to decay.
- **Neon (Ne) (Atomic number: 10):** Neon is a clear, colorless, odorless, nonflammable gas that does not support combustion. Neon is quite unreactive. It is used in neon signs, but not exclusively; other gases may be used in signs as well.

- **Sodium (Na) (Atomic number: 11):** Sodium is a shiny, soft, solid, reactive metal in its elemental state. It reacts vigorously with water to liberate elemental hydrogen and sometimes this reaction is violent enough to ignite the evolving H_2. It readily forms +1 cations (Na^+) and is only found in the cationic state in nature. It makes up a major constituent of ocean brine; table salt is made up of one part sodium with one part chlorine (NaCl).
- **Magnesium (Mg) (Atomic number: 12):** Magnesium is a shiny, solid metal that reacts only slowly with water at room temperature. Elemental magnesium burns very brightly when ignited. Chlorophyll, a chemical responsible for the green color of plants and used by plants to capture the sun's energy, contains a magnesium atom in the center of the molecule.
- **Aluminum (Al) (Atomic number: 13):** Aluminum is a lightweight, shiny, solid metal that is used in applications from soft drink cans to airplane wings. It is a durable metal that forms a thin oxide coating (Al_2O_3) that prevents further reaction. As a result, you often find aluminum in applications where iron would rust (for example, railings at a beach).
- **Silicon (Si) (Atomic number: 14):** Silicon is a solid, shiny semimetal whose oxide (SiO_2) is a major constituent in glass, sand, and quartz. Computer technology is a large user of elemental silicon on computer chips. Many caulking materials use silicone, a silicon-based polymer.
- **Phosphorous (P) (Atomic number: 15):** Phosphorous is a solid at room temperature, but can occur as white, red, or even black forms. White and red are the most common and can be symbolized as P_4. White phosphorous is so reactive it must be stored in water so it will not ignite spontaneously with oxygen in the air. Phosphate salts (PO_4^{3-}) are mined for use in fertilizers, matches, and even soft drinks.
- **Sulfur (S) (Atomic number: 16):** Sulfur is a yellow, brittle solid that is mined in its elemental form (S_8). The major use of sulfur is as sulfuric acid (H_2SO_4) which finds many industrial uses, but the common consumer is familiar with its use in car batteries. Sulfur emissions from coal-burning power plants result in the formation of sulfur oxides (SO_2 and SO_3) which ultimately are converted to H_2SO_4, the principle acid in acid rain.
- **Chlorine (Cl) (Atomic number: 17):** Chlorine is a yellow gas with a choking odor. In its elemental form it is diatomic (Cl_2), toxic, and quite reactive. This element readily forms anions with a −1 charge (Cl^-). This ion is a major constituent of ocean brine and when reacted with sodium will form table salt. Bleach consists of a solution of hypochlorite (ClO^-), a chlorine-oxygen anion. Swimming pools are kept relatively free of mold and bacteria by chemicals that contain chlorine. Ozone destruction in the stratosphere is thought to occur when chlorofluorocarbons (CFCs) are subjected to high intensity ultraviolet radiation causing chlorine atoms to be torn off CFC molecules and react with O_3.
- **Argon (Ar) (Atomic number: 18):** Argon is a clear, colorless, odorless, non-reactive gas that makes up about 1% of the atmosphere. Its major uses are in light bulbs to blanket tungsten filaments, neon signs, and in welding to avoid more reactive gases (for example, oxygen) from reacting with hot materials.
- **Potassium (K) (Atomic number: 19):** Potassium is a shiny, soft, solid, reactive metal in its elemental state. It reacts with water even more vigorously than sodium to liberate hydrogen. In nature, only the +1 cation (K^+) is found, not the elemental state. Potassium is an important nutrient in muscle contraction and is used in fertilizers.

- **Calcium (Ca) (Atomic number: 20):** Calcium is a shiny metal that reacts with water more vigorously than magnesium, but not enough to ignite the liberated hydrogen like sodium and potassium metals. Calcium readily forms a +2 cation (Ca^{2+}) and is a major constituent of tooth enamel ($Ca_5(PO_4)_3(OH)$) and bones. Marble is the mineral calcium carbonate ($CaCO_3$) and lime, used to reduce soil acidity, is CaO.

By looking at the various descriptions of the elements, you can note that there is a reoccurrence of properties. This periodic nature of the elements is why the periodic table is so useful. Some of the groups of the periodic table are particularly important.

- **Group 1A, the alkali metals.** This group consists of Li, Na, K, Rb, Cs, and Fr and all react to form +1 ions. These elements form salts that are soluble in water.
- **Group 2A, the alkaline earth metals.** This group consists of Be, Mg, Ca, Sr, Ba, and Ra and all react to form +2 ions.
- **Group 5A, the pnictogens.** This group consists of N, P, As, Sb, and Bi and all react to form −3 ions.
- **Group 6A, the chalcogens.** This group consists of O, S, Se, Te, and Po and all react to form −2 ions.
- **Group 7A, the halogens.** This group consists of F, Cl, Br, I, and At and all react to form −1 ions.
- **Group 8A, the noble gases.** This group consists of He, Ne, Ar, Kr, Xe, and Rn, none of which are very reactive. These elements do not readily form ions, or even compounds.

Measurements

Knowing the chemical properties of various elements and compounds is obviously essential to understanding chemistry, but of nearly equal importance is being able to measure quantities of chemicals. In order to systematically quantify such properties as mass, length, temperature, and the quantity of material, the *Systeme Internationale d'Unites* (SI units) was developed. The following table lists common SI units.

Common SI Units of Measurement in Chemistry

Property	***Unit***	***Abbreviation***
Mass	kilogram	kg
Length	meter	m
Temperature	kelvin	K
Amount of material	mole	mol

To express very large or very small numbers, another concept is used, metric system prefixes. The following table lists common prefixes encountered in chemistry.

Common Metric Prefixes		
Prefix Name	***Prefix Abbreviation***	***Meaning***
giga-	G	1 billion, 1,000,000,000
mega-	M	1 million, 1,000,000
kilo-	k	1 thousand, 1,000
hecta-	h	100
deka-	da	10
deci-	d	0.1
centi-	c	0.01
milli-	m	1 thousandth, 0.001
micro-	μ	1 millionth, 0.000 001
nano-	n	1 billionth, 0.000 000 001

With these two concepts, it is possible to express very large or very small quantities in a uniform way that other scientists can understand. Thus, if you have 1,000,000 grams, it can be reported as 1 megagram or 1 Mg. If the length of a piece of material is 0.00005 meters, it can be reported as 0.05 mm or 50 μm.

There is no SI unit for volume. Since volume will have units of length cubed, officially, scientists would use cubic meters (m^3) to express volume. In practice, this is rarely done and a unit called the liter was established. See the following table for common conversions for mass, length, and volume.

Common Conversions for Mass, Length, and Volume		
Mass Conversions	***Length Conversions***	***Volume Conversions***
1 pound = 453.59 g	1 inch = 2.54 cm	1 m^3 = 264.17 gallons
1 kg = 1000 g	1 km = 0.6214 miles	1 dm^3 = 1 liter (1 L)
1 g = 1000 mg	1 m = 100 cm	1 cm^3 = 1 mL
	1 m = 1000 mm	1 L = 1000 mL
	1 km = 1000 m	

Though the SI unit of temperature is the kelvin, it is more common to measure temperature in the Celsius scale (this used to be called the centigrade scale) or in Fahrenheit. The formulas to convert from one scale to another are given below.

To convert from Celsius (°C) to kelvin (K): $K = 273 + °C$

To convert from Celsius (°C) to Fahrenheit (°F): $°F = (1.8 \times °C) + 32$

To convert from Fahrenheit (°F) to Celsius (°C): $°C = (°F - 32) \div 1.8$

The unit most useful to chemists is the mole, since this defines how much material is present. By definition, one *mole* of anything is $6.022 \cdot 10^{23}$ of those things. This is an unfathomable number because it is so large. (For example, a mole of pennies would stretch to the sun and back 38 billion times stacked side-by-side!) The reason this is useful for chemists is because dealing with individual atoms means dealing with masses so small, no balance in the world would be able to measure it. Due to the way mass and moles are defined, the atomic weight of any atom is equivalent to one mole of that element. Thus, 55.847 grams of element 26 (iron, Fe) is $6.022 \cdot 10^{23}$ Fe atoms. For oxygen (atomic number 8), only 15.9994 grams contains 1 mole ($6.022 \cdot 10^{23}$) of oxygen atoms. This concept can be further extended to compounds, so that one mole of water (H_2O) has a mass of 18.01528 grams (this was obtained by adding the atomic mass of two hydrogens and one oxygen). The value 18.01528 g/mol is called the *molar mass* (the mass of one mole of a compound or element).

This is directly applicable to chemical reactions since chemical reactions are written in terms of molar ratios. Look at the balanced chemical reaction below:

$$C(s) + O_2(g) \rightarrow CO_2(g)$$

You can interpret this as one atom of carbon reacting with one molecule of oxygen to form one molecule of carbon dioxide. You can also interpret this as one mole of carbon reacting with one mole of oxygen molecules to form one mole of carbon dioxide. Furthermore, you can now associate masses with this reaction since one mole of carbon is 12 grams, one mole of O_2 is 32 grams, and one mole of CO_2 is 44 grams. In all reactions, the combined masses of the reactants should equal the combined masses of all of the products. This is a result of the Law of Mass Conservation that was stated earlier.

This concept can be applied to another chemical reaction, $2C(s) + O_2(g) \rightarrow 2CO(g)$.

In this reaction, two moles of carbon react with one mole of molecular oxygen to yield two moles of carbon monoxide. In such a case, 24 grams of carbon (2 moles of C × 12 g/mole) and 32 grams of O_2 will form 56 grams of CO (2 moles of CO × 28 g/mole).

Energy

In addition to mass conservation, energy is conserved, too. Energy can be either a reactant or a product of a reaction. There are two main types of energy, kinetic and potential. *Kinetic energy* is the energy of motion. The faster something is moving, the higher the kinetic energy. Kinetic energy will often express itself in terms of temperature; materials that are hot generally have atoms that are moving more quickly than the atoms of materials that are cold. *Potential energy* is energy that is stored (it has the potential to do work). This type of energy is dependent on the distance an object is from the ground or, more importantly for chemists, the types of chemical bonds that are present. When bonds form, energy is released; when bonds break, energy is absorbed.

Radioactivity

The energy stored in the nucleus of an atom is also a type of potential energy. This energy is used in nuclear power plants, radiation therapy medical treatments, and even to build powerful bombs. This energy releases when an unstable nucleus decomposes into a more stable nucleus. Often times, this nuclear change results in the emission of a *gamma ray* (a high energy light particle) or it may even emit a neutron, a *beta particle* (an electron), or an *alpha particle* (two neutrons and two protons).

It is impossible to determine exactly which atom will emit radiation, but scientists can measure an average decay time. The most useful measurement is the half-life. The *half-life* of a material is the time it takes for 50% of it to decay into another species. The half-life of the uranium isotope with a mass number of 235 (U-235, the isotope used in building the first nuclear bomb) is 700 million years; if you had 100 grams of U-235, in 700 million years (one half-life) there would only be 50 grams left. After 1.4 billion years (two half-lives), only 25 grams of U-235 would be left. After 2.1 billion years (three half-lives), only 12.5 grams of U-235 would remain. After each half-life period, 50% of the remaining material converts to a new material.

Metals

A quick look at the periodic table indicates that the vast majority of elements are metals. Because of this, many elements share common properties. The metals all are:

- Solid at room temperature (mercury—Hg—is an exception, since it is a liquid)
- Malleable, which means that you can hammer them into thin sheets
- Ductile, which means that you can draw them into thin wires
- Sectile, which means that you can cut them into thin sheets
- Good conductors of heat and electricity
- Shiny
- Silvery in color (except for copper and gold)

Most metals are found combined with oxygen or sulfur in nature, however the *coinage metals* (copper, silver, and gold) can occur in their native (that is, elemental) state.

Metals can also form *alloys,* which are solid mixtures of two or more metals. An *amalgam* is a mixture of mercury with some other metal and can be a solid or liquid, depending on the amount of mercury.

Organic Chemistry

Organic chemistry is the study of carbon-based molecules. (There are a few exceptions, materials that contain pure carbon (diamond, graphite, charcoal, anthracite, and so on) and carbon oxides like CO, CO_2, or carbonates (CO_3^{2-}) are not considered organic molecules.) Because carbon can attach to other carbon atoms and form long chains, the number and variety of organic compounds is vast. Proteins, DNA, cell walls, oils, hair, pharmaceuticals, gasoline, ethanol, herbicides, and plastics are all examples of organic (carbon-based) materials.

As an example of the differences between organic compounds, look at the properties of these various alcohols:

- Methanol (wood alcohol), CH_4O, is used as a solvent in chemistry, but can cause blindness if consumed orally by humans.
- Ethanol (grain alcohol), C_2H_6O, is the main ingredient in alcoholic beverages for consumption.
- Propanol (rubbing alcohol), C_3H_8O, is used topically to disinfect open cuts.

You name simple organic compounds by the number of carbon atoms in a continuous chain, so that the prefix *meth-* indicates one carbon atom, *eth-* indicates two carbon atoms, and *prop-* indicates three carbon atoms. The following table shows common prefixes.

Organic Prefixes

Number of C Atoms in a Chain	*Prefix*	*Number of C Atoms in a Chain*	*Prefix*
1	meth-	6	hex-
2	eth-	7	hept-
3	prop-	8	oct-
4	but-	9	non-
5	pent-	10	dec-

Physics

Motion

Motion occurs when an object or body is moved from one place to the next. There are three types of motion: *translational*, *rotational*, and *vibrational*. Translational (or linear) motion involves motion in a straight line, rotational motion happens when motion occurs about an axis, and vibrational motion entails motion about a fixed point.

Translational Motion

Two factors characterize the motion of an object in a straight line: a change in position or *displacement* of the object over a period of time, and movement with respect to a reference point. The motion of an object can be described quantitatively by making references to its *speed*, *velocity*, and *acceleration*.

Speed and Velocity

The *speed* of an object is a measure of how fast it is moving and can be calculated using the following equation:

$$\text{Speed} = \frac{\text{Distance traveled}}{\text{Time taken}}$$

Like speed, *velocity* describes how fast an object is moving. Unlike speed, velocity specifies the direction of motion as well. In this respect, speed is said to be a *scalar quantity* while velocity is described as a *vector quantity*. The mathematical representation of the velocity of an object is given by the following equation:

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

When the velocity of an object changes with time, the object is said to be *accelerating*. In general, an increase in velocity is called *acceleration* and a decrease in velocity is called *deceleration*. Both can be calculated using the following equation:

$$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{Time}}$$

Acceleration, like velocity, is a vector quantity. Acceleration is positive when acceleration occurs in the same direction in which the object is moving *(acceleration),* and negative when acceleration occurs in a direction opposite to that in which the object is moving *(deceleration).*

Graphical Analysis of Motion

You can analyze the motion of an object by using two types of graphs: *position-time graphs* and *velocity-time graphs.*

- **A position-time graph** shows how the displacement or position of a moving object changes with time. As a result, the velocity of such an object is equal to the slope of the graph.
- **A velocity-time graph** illustrates how the velocity of an object changes over time. Hence, you can determine the acceleration of an object from the slope of a velocity-time graph. In addition to acceleration, you can use a velocity-time graph to determine the distance covered by an object that is undergoing acceleration. You can derive the distance traveled by an object in motion from the area under the graph.

Motion in One Dimension

Motion occurs in one dimension when an object or body moves along either the x or y coordinate. Motion along the x coordinate is often referred to as *linear motion*, while motion along the y coordinate is referred to as *motion in a vertical plane* or *free fall.* In many instances, the acceleration of an object along either coordinate is constant or is such that the acceleration can be considered constant. When this occurs, motion can be quantified using a series of equations called the *equations of kinematics*.

Equations of Kinematics

The equations of kinematics consist of four main equations that are the result of the mathematical manipulation of the equations used to calculate velocity and acceleration. These equations involve five variables:

x = displacement

a = acceleration

v = final velocity

v_o = initial velocity

t = time

The equations are:

$$v = v_o + at$$

$$x = \frac{1}{2}(v_o + v)t$$

$$x = v_o t + \frac{1}{2}at^2$$

$$v^2 = v_o^2 + 2ax$$

Each of the equations of kinematics contains four of these five variables. Therefore, if you know three of them, you can calculate the fourth variable by transposing the relevant equation.

Motion in Vertical Plane

All objects above the Earth undergo vertical motion with an acceleration of about 9.81m/s^2. This *vertical motion* is called *free fall* and is the result of the force of gravity. Because all objects above the Earth have the same acceleration, the motion of an object undergoing vertical motion can be quantified using the equations of kinematics.

When using the equations of kinematics to describe the motion of an object in free fall, the acceleration due to gravity, g, is substituted for a, and x is substituted for y. In addition, you can consider the vector quantities v and y as positive when they are directed downward and negative when directed upward.

When an object is thrown upwards it will undergo uniform deceleration, as a result of gravity, until it comes to rest. The object will then begin to fall, during which time it is uniformly accelerated by the force of gravity. If air resistance is neglected, then the time required for the object to rise is the same as the time required for the object to fall.

Newton's Laws Of Motion

A force is defined as a *push* or *pull* and can result in the motion of an object at rest, or a change in the velocity of an object in motion. At any particular time, multiple forces can act on an object. How these multiple forces affect the motion of the object is governed by a collection of laws called *Newton's laws of motion*. The laws of motion are as follows:

- **First law of motion:** An object that has no net or unbalanced force acting on it will remain at rest or it will move with a constant velocity in a straight line.
- **Second law of motion:** The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass.
- **Third law of motion:** When one object exerts a force on a second object, the second object will exert a force on the first that is equal in magnitude but opposite in direction.

The first law of motion emphasizes the concept of *inertia,* which is defined as the tendency of an object to resist changes in its motion. Thus, the first law is often called the *law of inertia*.

The second law enables us to calculate the net force acting on an object and is often stated in the form of the following equation: $F = ma$

F is the net force in newtons, m is the mass of the object in kilograms, and a is acceleration in meters per second squared (m/s^2).

Like velocity, force is a vector quantity, having both magnitude and direction. Force is positive when it is applied in the same direction as the motion it generates and negative when applied in a direction that is opposite to the motion.

Weight and Mass

The *weight (W)* of an object is the force exerted on it by the force of gravity and, like all forces, is measured in newtons. The force of gravity acts on an object whether or not it is falling, resting on the ground, or being lifted, and results in a downward acceleration of 9.81 m/s^2. The weight of an object can be calculated using the equation: $W = mg$

W is the weight of the object, m is the mass of the object, and g is the acceleration due to gravity.

From the weight equation, it is obvious that the *mass* of an object is not the same as its *weight*. The weight of an object depends on the acceleration due to gravity, and thus varies from place to place. On the other hand, *mass* is a measure of the amount of matter contained within an object and is independent of gravity. Hence, an astronaut weighs less on the moon, where the acceleration due to gravity is about 1.6 m/s^2, but his or her mass is the same as it is on Earth.

Frictional Force

Friction is the force that opposes the motion between two surfaces that are in contact. There are two types of friction, static and kinetic. *Static friction* is the force that opposes motion of an object at rest, while *kinetic friction* is the opposing force between surfaces in relative motion, and it is always less than static friction.

Energy and Work

The mass of an object not only measures the amount of matter it contains, but also the amount of energy. The energy of an object can be divided into two main types: *potential* and *kinetic*. Potential energy is the energy possessed by an object due to its position and is often called *stored energy.* Kinetic energy is the energy possessed by an object because of its motion.

Both the kinetic and potential energy of an object change when *work* is done by or on the object. Therefore, *work* is defined as the transfer of energy to an object when the object moves due to the application of a force. The work done on an object can be calculated using the formula: $W = F \times d$

W is work measured in joules, F is force measured in newtons, and d is distance measured in meters.

Gravitational Potential Energy

Energy is defined as the capacity to do work. When you raise an object, such as a hammer, above the Earth, you do work against gravity. The work that you do against gravity is the *gravitational potential energy,* and you can calculate it by using the following equation: $PE = mgh$

PE is the potential energy in joules, m is mass of the object in kilograms, g is the acceleration due to gravity, and h is the height above the ground.

As the object falls it is accelerated by the force of gravity and the object loses gravitational potential energy. According to the law of conservation of energy, energy can neither be created nor destroyed but can be converted from one form to another. Thus, any decrease in the gravitational potential energy of the object is accompanied by a corresponding increase in the object's kinetic energy. You can calculate the kinetic energy of a moving body by using the following equation: $KE = \frac{1}{2}mv^2$

KE is the kinetic energy of the object, m is its mass, and v is its velocity.

The conversion of energy from one form to another is generally carried out by a number of practical devices. Such devices include the following:

- **Generators:** Convert mechanical energy into electrical energy
- **Motors:** Convert electrical energy into mechanical energy
- **Batteries:** Convert chemical, thermal, nuclear, or solar energy into electrical energy
- **Photocells or Photovoltaic cells:** Convert light energy into electrical energy

The rate at which any device converts energy from one form to another is called the *power* and is defined by the following formula: $P = \frac{W}{t}$

P is power in watts, W is work in joules, and t is time in seconds.

Fluids

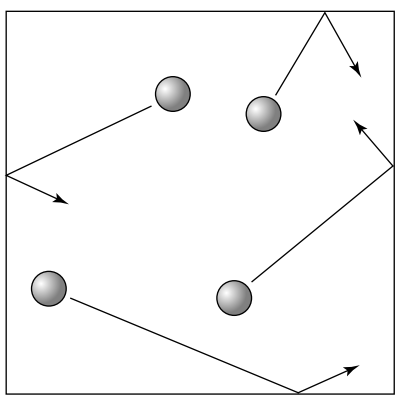
A *fluid* is any substance that offers little resistance to changes in its shape when pressure is applied to it. Of the three states of matter, only gases and liquids are considered fluids. Of all the properties that characterize fluids, one of the most important is their ability to exert pressure.

Pressure

Pressure is defined as the force exerted per unit area and is mathematically represented by the following equation: $P = \frac{F}{A}$

P is pressure in pascals, F is force in newtons, and A is area in square meters.

You can explain the ability of fluids to exert pressure by the *kinetic molecular theory,* which states that the particles that make up fluids are in continuous, random motion, as illustrated in the following figure. These particles will undergo collisions with the walls of their container or any surface with which they make contact. Each time a particle makes contact, it exerts a force, and it is this force that is referred to as pressure.



Molecular motion and collisions of particles in a fluid

When dealing with fluids in motion or at rest, there are three governing principles that are essential: *Archimedes', Pascal's* and *Bernoulli's principles.*

Archimedes' Principle

According to *Archimedes' principle,* an object immersed in a fluid is buoyed up by a force equal to the weight of the fluid that the object displaces. The magnitude of the buoyant force is given by the following equation: $F = \rho Vg$

F is the buoyant force in newtons, ρ is density of the fluid, V is volume of the fluid displaced, and g is acceleration due to gravity. It can be proven that the volume of an object immersed in a fluid is the same as the volume of the fluid that it displaces.

An object immersed in a fluid will sink or float depending on the relative value of its weight and the buoyant force exerted on it by the fluid. An object will sink if the buoyant force is less than the weight of the object. If the buoyant force equals the weight of the object, the object will float at any depth in the liquid; if the buoyant force is greater than the weight of the object, the object floats with part of its volume above the surface.

Pascal's Principle

Pascal's principle states that any pressure applied to a confined fluid, at any point, is transmitted undiminished throughout the fluid. Pascal's principle led to the development of *hydrostatics,* in which machines, such as the hydraulic lift, use pistons to multiply forces applied to fluids at rest. Pascal's principle is represented by the following equation: $\frac{F_1}{A_1} = \frac{F_2}{A_2}$

F_1 and F_2 are the forces on pistons 1 and 2 respectively and A_1 and A_2 are their respective areas.

Bernoulli's Principle

According to this principle, as the velocity of a fluid increases, the pressure exerted by that fluid decreases. This principle underlies the study of *hydrodynamics,* which is a study of the effects of fluids in motion. Most aircraft get part of their lift by taking advantage of this principle.

Sound Waves

Sound waves consist of a series of pressure variations that are transmitted through matter. These pressure variations are of two types: compressions and rarefactions. *Compressions* are areas of high pressure and *rarefactions* are areas of low pressure. The compressions and rarefactions associated with sound waves are produced when a vibrating source causes air molecules to collide and, in so doing, transmit the pressure variations away from the source of the sound. As such, sound cannot travel through a vacuum because there are no particles present for motion and collision to occur.

The speed at which sound travels in air depends on the temperature of the air. At sea level and room temperature, the speed of sound is about 343 m/s. In addition to gases, sound can also travel through solids and liquids. In general, the speed of sound is greater in solids and liquids than in gases.

When sound waves encounter hard surfaces, they undergo reflections called *echoes*. The time required for an echo to return to its source can be used to determine the distance between the source and the reflecting surface. The use of echoes to determine distance is used by bats to navigate their night flights, as well as by ships equipped with sonar.

The number of compressions or rarefactions generated in one second by sound waves is called the *frequency* or *pitch* of the sound. However, if the source of the sound is in motion, an observer detecting the sound will perceive sound of higher or lower frequencies. If the source of the sound is moving away from the observer, the observer will detect sound waves of decreasing frequencies. Conversely, if the source is moving towards the observer, the observer will detect sound waves of increasing frequencies. This apparent change in the frequency of sound due to movement on the part of the sound source or an observer is called the *Doppler effect*. The Doppler effect has many practical applications, such as its use in radar detectors and ultrasound.

Electricity

Electricity involves the flow of electrical energy from a source, such as a battery or generator, to a *load,* such as a lamp or motor. A load is any device that transforms electrical energy into other forms of energy. For example a lamp transforms electrical energy into light and heat energy, while a motor transforms electrical energy into mechanical energy.

Electrical energy is transported in the form of an *electric current,* consisting of the flow of negatively charged *electrons*. This flow of electrons occurs in a closed conducting path, called an *electrical circuit,* in which conducting metal wires provide the pathway for the flow of electrons from the source of the electrical energy to the various loads within the circuit. A substance that allows for the flow of an electric current is called a *conductor* and a substance that does not is called an *insulator*.

In order for an electric current to flow in a conductor, a *potential difference* or *voltage* must exist between its ends. The greater the voltage is, the greater the current is, and vice versa. All substances, insulators or conductors, offer some form of *resistance* to the flow of an electric current. The amount of resistance depends on the length of the material, the area of the material, an intrinsic property called *resistivity,* as well the temperature. The magnitude of the current flowing in a conductor can be calculated using the following equation: $I = \frac{V}{R}$

I is current in amperes, V is voltage in volts, and R is resistance in ohms.

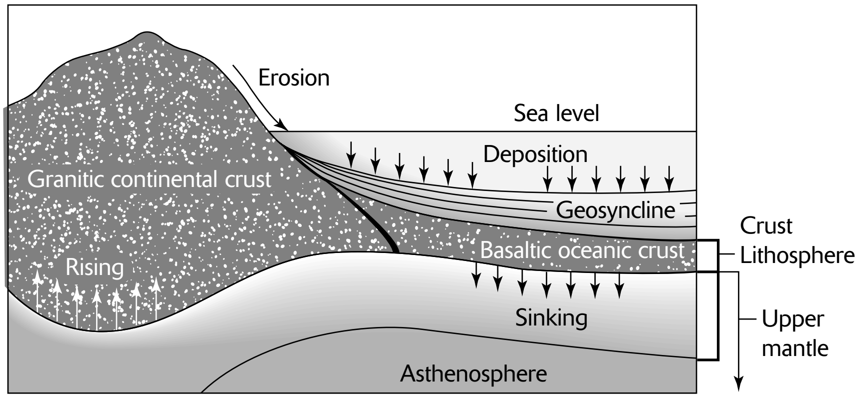
Earth Science

Geology

The Earth is a relatively solid planet revolving around the sun. It is approximately 8,000 thousand miles in diameter. It is not a uniform sphere but is comprised of several different layers: core, mantle, asthenosphere (plastic mantle), and crust.

We live on the thinnest layer, the crust. The nature of Earth's interior structure has been inferred from seismic (earthquake) activity and studies. The illustration shows the upper level of the Earth.

The Earth's Crust and Interior



The crust (our home) is, itself, not uniform. The continental portion of the crust is mostly granitic rock. The portions of the crust underlying the oceans are comprised mostly of basaltic rock. Both segments of the crust are broken into large tectonic plates that move over the plastic asthenosphere.

This activity is known as *plate tectonics* and helps explain many patterns of major crustal activity, including earthquake zones, volcanic zones, mountain building, sea-floor spreading, and ocean trench zones.

The Earth's crust is stable only over a relatively short period of geologic time. Minor earthquakes occur constantly throughout the crust, volcanoes are active, and the ocean bottoms are constantly in flux.

The rocks of the Earth themselves are constantly changing. Rocks are comprised of a mixture of *minerals* (inorganic crystalline substances with definite chemical compositions and unique physical properties). The most common minerals on Earth's crust are feldspar, quartz, mica, pyroxene, and olivine, but there are many others. These myriad minerals are recombined into various rock types due to crustal activity.

The major rock types are named based on their origin: igneous rock, sedimentary rock, and metamorphic rock. Each type has specific structures that allow geologists to identify it. *Igneous rocks* are crystalline; *sedimentary rocks* are comprised of cemented rock fragments and may contain fossils; *metamorphic rocks* are usually foliated (minerals aligned into bands).

Earth's crust is in contact with other layers, the atmosphere and hydrosphere. There's a vast exchange of energy where these disparate structures meet (interfaces). The result of this energy exchange is erosion, weathering, and deposition. The crustal material above sea level is constantly worn down but it is constantly replaced as tectonic activity adds new material. Thus the Earth's crust is in a dynamic equilibrium.

Meteorology

The Earth's gaseous envelope, our atmosphere, provides a means to absorb, refract, and reflect the energy reaching us from the sun (insolation). In the process of these activities the atmosphere maintains a dynamic equilibrium of energy flow that gives us weather and climate. *Weather* is the day-to-day condition of the atmosphere; *climate* is the long-term condition in a given area.

Earth's atmosphere is a layered structure of mainly two gases, nitrogen (78%) and oxygen (21%), with many other gases (1%) mixed in. Though they make up less than 1% of the air, these other gases are important in meteorological events; they include carbon dioxide, water vapor, sulfur dioxide, argon, and ozone.

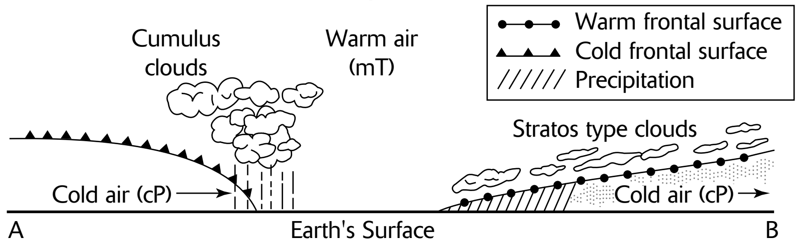
The following table shows what elements make up various parts of the Earth and its atmosphere.

		Percentage by Volume		
Element	***Symbol***	***Crust***	***Hydrosphere***	***Troposphere***
Aluminum	Al	0.47	—	—
Calcium	Ca	1.03	—	—
Hydrogen	H	—	66	—
Iron	Fe	0.43	—	—
Magnesium	Mg	0.29	—	—
Nitrogen	N	—	—	78
Oxygen	O	93.77	33	21
Potassium	K	1.83	—	—
Silicon	Si	0.86	—	—
Sodium	Na	1.32	—	—
Others		—	1	1

The layer of the atmosphere we live in is called the *troposphere,* and it is here that the phenomenon called weather occurs. Weather variables include temperature of the air, barometric pressure (air's weight), wind speed and direction, humidity (air's moisture content), cloud cover, and precipitation. The measurement of these weather elements requires the use of specialized instruments such as thermometers, barometers, wind vanes, anemometers, hydrometers, and rain gauges.

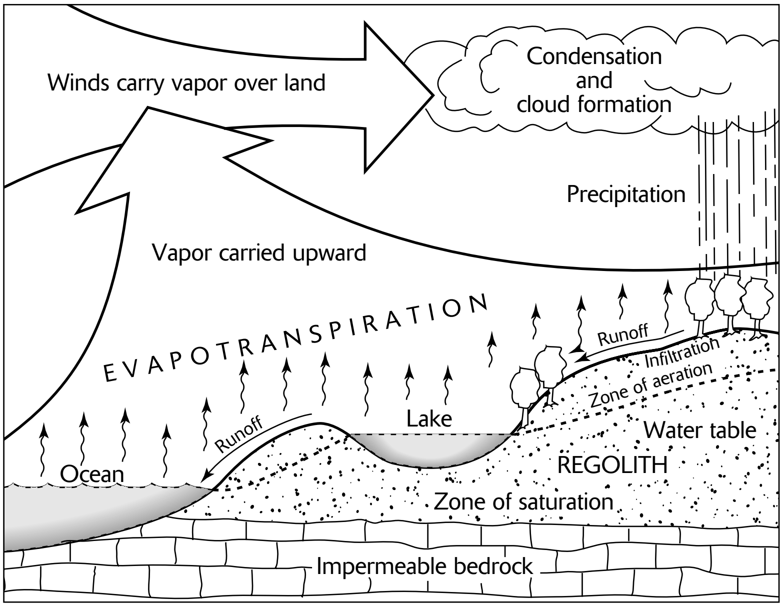
Meteorologists use present weather readings from widespread locations to map and delineate large chunks of the troposphere into *air masses* (air parcels with relatively uniform temperature and moisture content). The movement and interaction of these air masses allow scientists to predict or forecast weather changes. An example of this can be seen when a cold, dry air mass moves into a warm, moist air mass. The resulting cold front (interface between the two) triggers thunderstorms as it moves.

The Atmosphere and Weather



Climate and seasonal variations are caused by the complex interactions of latitude, altitude, water proximity, and change in the Earth's relative axial tilt with respect to the sun. The complexity of these events is one reason why climate change and even seasonal changes are not easy to predict.

Much of the energy needed to power Earth's weather and climate is the result of the water cycle that converts insolation into useable force in Earth's transparent air.



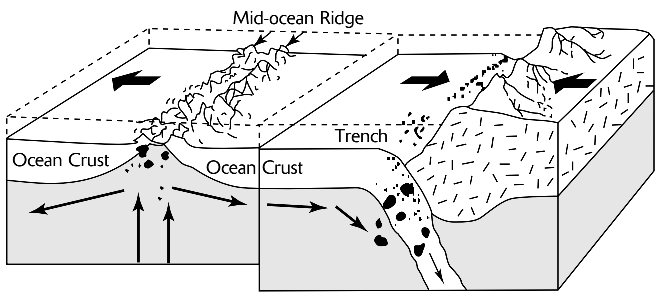
The water cycle

Oceanography

The Earth's surface (71%) is covered by a relatively thin layer of water. Most of this water contains dissolved salts and resides in four major ocean basins. The rest of the water is found frozen in ice caps at both poles, in seas, lakes, rivers, and in porous rocks in the crust.

The four oceans, in size order largest to smallest, are the Pacific, Atlantic, Indian, and Artic. They are largely responsible for maintaining the relatively stable environment that allowed our world to evolve as it has. The tilt of the Earth's axis, its spherical shape, and its rotation all work to cause uneven heating of Earth's oceans. This variation in thermal distribution, coupled with the *Coriolis effect* (deflection due to rotation), gives rise to ocean currents. The ocean waters absorb and release insolation, thus regulating weather and climate. The oceans' currents also influence atmospheric circulation. They are the source of life on Earth. The oceans' currents shape coastlines and constantly resupply fresh water on land.

The ocean basins (land under the oceans) are mostly stable areas of fine-grained basaltic rock. There are, however, sites on the ocean floor where scientists have studied considerable crustal and seismic activity. These locations are responsible for much of the plate tectonic activity, including sea-floor spreading, rise of mid-oceanic ridges, sea floor trenching, and continental plate movement.

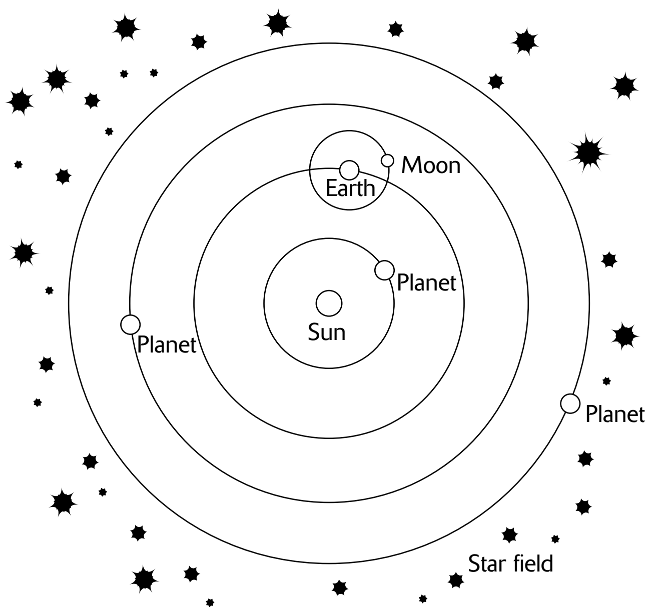


Ocean Basin Reformation

Astronomy

The science of astronomy involves the study of all celestial objects (objects in space) including planet Earth. It was only approximately 400 years ago that the actual nature of Earth's relationship to the vast array of heavenly bodies was observed.

Earth is part of a *heliocentric* (sun-centered) system of planets. It is the third of nine planets that are all moving in *elliptical paths* (orbits) around a typical yellow star, our sun. The *sun* holds our solar system together by its enormous gravitational effect. Its tremendous energy output of electromagnetic radiation provides energy for many of Earth's activities. Like the other planets, Earth spins on its axis (rotates) as it moves counterclockwise around the sun (revolution). Earth also has a satellite that orbits Earth, the moon. Earth's axis of rotation is tilted 23½ degrees.



Heliocentric model

The two major motions of Earth, *rotation* and *revolution,* coupled with Earth's tilt, result in a number of important and familiar effects. Day and night, as well as variations in daylight periods, are due to rotation and the tilt of the Earth's axis. The year and seasons are due to revolution and axial tilt. Variation in incoming solar radiation (insolation) that powers many of Earth's processes is due to all three factors.

General Science Practice Questions

1. How much power is developed by a machine that does 300 joules of work in 10 seconds?

A. 30 W

B. 2500 W

C. 240 W

D. 260 W

2. What is the magnitude of the current flowing through a lamp with resistance of 30 Ω and a potential difference of 10.0 volts?

A. 0.25 A

B. 0.33 A

C. 3.0 A

D. 0.5 A

3. The process by which green plants manufacture food in the form of glucose is

A. photosynthesis

B. photorespiration

C. cellular respiration

D. fermentation

4. A reproductive cell containing 30 chromosomes will produce __________ cells with __________ chromosomes during meiosis.

A. 2 , 30

B. 2 , 15

C. 4 , 30

D. 4 , 15

5. __________ spend part of their life on land and part of their life in water.

A. Sponges

B. Fishes

C. Amphibians

D. Reptiles

6. An object is in free-fall near the surface of the Earth. What is the velocity before impact if it takes 5 seconds to hit the ground? Assume g to be 10 m/s^2.

A. 5 m/s

B. 2 m/s

C. 50 m/s

D. 125 m/s s

7. Which of the following represents the correct order of structures through which food travels in the human digestive system?

A. mouth → duodenum → esophagus → stomach → large intestine

B. mouth → pancreas → stomach → small intestine → large intestine

C. mouth → esophagus → stomach → large intestine → small intestine

D. mouth → esophagus → stomach → small intestine → large intestine

8. Interactions between the organisms in communities and their physical environment form __________.

A. food chains

B. food webs

C. populations

D. ecosystems

9. Which of the following compounds would form a basic solution?

A. battery acid

B. water

C. lye

D. vinegar

10. The __________ is the genetic makeup of an individual, while the __________ is the physical appearance of the individual.

A. gene , allele

B. genotype , phenotype

C. phenotype , genotype

D. chromosome , protein

11. What mass of product would you expect given that you started with 17 g of NH_3 and 36.5 g of HCl? $NH_3 + HCl \rightarrow NH_4Cl$

A. 17 g

B. 36.5 g

C. 53.5 g

D. 19.5 g

12. Which of the following elements is found in bones?

A. iron

B. calcium

C. fluorine

D. helium

13. Our Earth is part of a heliocentric system which has at its center the:

A. sun

B. Earth

C. moon

D. none of these

14. Which statement is true?

A. Minerals are comprised of rocks.

B. Minerals are formed during erosion.

C. Rocks are made of minerals.

D. All minerals have the same chemical makeup.

15. If the temperature is 25°C, what is the temperature in °F?

A. 25°F

B. 298°F

C. 0°F

D. 77°F

16. Toothpaste contains __________ in order to prevent tooth decay.

A. calcium

B. phosphorous

C. iron

D. fluoride

17. A major constituent of sea water is __________.

A. sodium chloride

B. nitrogen

C. iron

D. aluminum

18. Oxygen-poor blood enters the human heart through the __________, is pumped to the lungs where it receives oxygen, and returns to the heart through the __________.

A. right atrium , left atrium

B. left atrium , right atrium

C. left ventricle , right ventricle

D. pulmonary artery , vena cava

19. What element is found in matches, soft drinks, DNA, and fertilizers?

A. phosphorous

B. fluorine

C. iron

D. silicon

20. What is the acceleration of a car whose velocity changes from 60 m/s to 45 m/s in 5 seconds?

A. 3.0 m/s^2

B. 53 m/s^2

C. 15 m/s^2

D. 9.8 m/s^2

21. What is the approximate weight of an object having a mass of 5 kg?

A. 5.0 kg

B. 25 N

C. 49 kg

D. 49 N

22. Which phrase best describes the environment of Earth?

A. a steady, unchanging star

B. a dynamic equilibrium

C. regular predictable catastrophes

D. constant energy imbalance

23. Which of the following structure-function pairs is mismatched?

A. ribosome — protein synthesis

B. mitochondrion — cellular respiration

C. chloroplast — photosynthesis

D. nucleus — ATP production

24. Life on Earth is found on Earth's:

A. core

B. mantle

C. asthenosphere

D. crust

25. The largest ocean on the planet is the:

A. Antarctic Ocean

B. Pacific Ocean

C. Indian Ocean

D. China Sea

Answers and Explanations for Practice Questions

1. **A.** The solution requires direct substitution into the equation $P = W/t$.
2. **B.** The result is obtained by substituting the known values into the equation $I = V/R$.
3. **A.** Answers **B, C,** and **D** are all forms of cellular respiration, which is the process by which organisms break down glucose to obtain energy.
4. **D.** Meiosis leads to the production of four haploid daughter cells from one diploid parent cell.
5. **C.** Amphibians spend the early part of their life cycle (from the egg stage through the tadpole stage) in water before moving onto land, where they spend their adult stages. Sponges, **A,** and fishes, **B,** spend their entire life cycle in the water, whereas, reptiles, **D,** spend their entire life cycle on land.
6. **C.** The answer is obtained by direct substitution into one of the equations of kinematics: $v = v_o + gt$. Since the object falls from rest, v_o is equal to 0 m/s and the equation is reduced to $v = gt$.
7. **D.** Movement of food in the human digestive system begins in the mouth where it is chewed and moisturized to form a bolus. It then moves down the esophagus to the stomach where it is combined with gastric juices and churned into a soupy liquid called *chyme.* From the stomach, it moves into the small intestine where much of the digestion and absorption occurs. Any substances that are not digested or absorbed move into the large intestine, which processes the residue into feces for elimination from the body.
8. **D.** An ecosystem is formed through the interaction of the living organisms in communities and their physical environment (rocks, soil, light, air, and water). Food chains, **A,** and food webs, **B,** describe the transfer of energy among organisms in an ecosystem. A population, **C,** is a group of individuals of the same species occupying a defined area.
9. **C.** Lye is sodium hydroxide and any compound that increases the hydroxide concentration is considered a base. Battery acid (sulfuric acid) and vinegar (acetic acid) are acidic. Water is neutral (neither acidic nor basic).
10. **B.** The genetic makeup of an individual constitutes that individual's genotype, while the appearance of the individual (the expression of the genes in the genotype) constitutes that individual's phenotype. An allele is one version of a gene, **A;** for example, the red allele is the gene for flower color. The chromosome, **D,** is the physical structure that contains the DNA of an organism, but does not itself confer the genotype.
11. **C.** The Law of Mass Conservation must be obeyed, so the mass of products must equal the mass of reactants ($17 + 36.5 = 53.5$).
12. **B.** Bones are made mostly of a calcium phosphate mineral. Iron is an important component in red blood cells, fluorine is not biologically important, though it can be used to reduce dental caries, and helium has no known human biological activity.
13. **A.** The sun is the center of our solar system and holds the other members of the system (planets, asteroids, comets, and so on) in orbit with its enormous gravitational pull.

14. **C.** Rocks are made of minerals. All of the other answer choices are false.

15. **D.** Using the formula °F = [1.8 × (°C)] + 32, you can see that the answer will be 77°F. For answer **B,** 273 was added to 25, which would give the temperature in kelvin.

16. **D.** Calcium and phosphorous are important nutrients to maintain teeth and bones, but fluoride is added to react with the surface of the tooth enamel so that it becomes less soluble to the acids secreted by bacteria.

17. **A.** Sodium chloride (NaCl) is table salt and causes seawater to be salty.

18. **A.** The pathway for blood through the human heart starts when oxygen-poor blood enters the right atrium through a major vein called the vena cava. The blood passes through the tricuspid valve into the right ventricle, and is then pumped through the pulmonary artery to the lungs for gas exchange. Oxygen-rich blood returns to the left atrium of the heart through the pulmonary vein. It then flows through the bicuspid (mitral) valve into the left ventricle, from which it is pumped through a major artery called the aorta.

19. **A.** Phosphorous is found in all of these applications.

20. **A.** The first step in solving the problem is to determine the change in velocity, which is simply the difference between the final and initial velocity. Dividing the difference by the time gives you the acceleration of the car. In this case, the difference in velocity is negative and is an indication that the car is decelerating.

21. **D.** The weight of an object is a force and, as such, is simply the product of its mass and the acceleration due to gravity. You should note that a unit of force is expressed in newtons and not kilograms.

22. **B.** Earth's environment is constantly changing, but at any given time the Earth's environment is stable enough to support life and provide changes without major crust, atmospheric, or hydrospheric disruption.

23. **D.** The nucleus contains the genetic information for an organism in the form of DNA. ATP is produced by cellular respiration, which takes place in the mitochondria and the cytoplasm.

24. **D.** Life on Earth requires liquid water, atmospheric gases, and nutrients from the solid Earth. All of these are found on or near the surface of the crust.

25. **B.** The Pacific Ocean has the largest surface area and greatest average depth of the four oceans of the Earth.

Arithmetic Reasoning

None of the questions on the Arithmetic Reasoning section simply ask you to do a numerical computation; instead, you will need to solve mathematical word problems by doing arithmetic computations.

This section reviews all of the computational skills that you need to do well on this part of the ASVAB, and it includes plenty of examples. There are also sample problems for you to try, so that you can be certain that you can handle the material on the test.

The ASVAB has 30 Arithmetic Reasoning questions. You will have 36 minutes to answer these questions.

Using Numbers

Whole Numbers

The numbers 0, 1, 2, 3, 4, and so on are called *whole numbers.* The whole number system is a *place value* system, that is, the value of each digit in a whole number is determined by the place it occupies. For example, in the number 6,257, the 6 is in the thousands place, the 2 is in the hundreds place, the 5 is in the tens place, and the 7 is in the units place.

The following table contains a summary of whole number place values:

Ones	1
Tens	10
Hundreds	100
Thousands	1,000
Ten-thousands	10,000
Hundred-thousands	100,000
Millions	1,000,000
Ten millions	10,000,000
Hundred millions	100,000,000
Billions	1,000,000,000

Therefore, for example, you would read the number 5,124,678 as "five million, one hundred twenty-four thousand, six hundred and seventy-eight."

Write the number thirty million, five hundred seven thousand, three hundred twelve.

30,507,312

Write in words the number 34,521.

Thirty-four thousand, five hundred twenty-one.

Rounding Whole Numbers

Rounding whole numbers can often help you to determine the correct answer to a multiple choice question more quickly. When you only need an approximate value of a whole number, you can use the following procedure to round off the number to a particular place.

Procedure for Rounding Whole Numbers:

1. Underline the digit in the place being rounded off.
2. If the digit to the right of the underlined digit is less than 5, leave the underlined digit as it is. If the digit to the right of the underlined digit is equal to 5 or more, add 1 to the underlined digit.
3. Replace all digits to the right of the underlined digit by 0s.

Round off the number 34,521 to the nearest hundred.

Since you are rounding to the nearest hundred, begin by underlining the digit in the hundreds place, which is a 5.

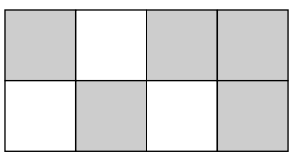
$34{,}\underline{5}21$

Now, look to the right of the underlined digit. Since the number to the right of the 5 is 2, leave the 5 as it is, and replace all digits to the right of the 5 with 0s.

34,500

Fractions

A fraction is made up of two numbers separated by a line that is known as a *fraction bar.* Typically, you use a fraction to represent a part of a whole. For example, in the diagram below, note that 5 out of 8 pieces of the diagram are shaded:



In this case, you could use the fraction $\frac{5}{8}$ to represent the fact that 5 of the 8 equal pieces have been shaded. In the same way, you could use the fraction $\frac{3}{8}$ to represent the fact that 3 of the 8 pieces are unshaded.

Fractions where the number on the top is *less than* the number on the bottom are said to be *proper* fractions. Thus, for example, the fractions $\frac{2}{9}$, $\frac{5}{8}$, and $\frac{3}{7}$ are proper fractions. The value of a proper fraction is always less than 1.

Fractions where the number on the top is either *equal to or greater than* the number on the bottom are called *improper fractions.* For example, the fractions $\frac{5}{2}$, $\frac{7}{4}$, and $\frac{11}{5}$ are improper. If the number on the top of the fraction is greater than the number on the bottom, the value of the fraction is greater than 1. If the number on the top and the number on the bottom are equal, such as in $\frac{8}{8}$, the fraction is equal to 1.

A *mixed number* is a whole number together with a fraction, such as $7\frac{1}{2}$ or $3\frac{5}{8}$. The mixed number $7\frac{1}{2}$ represents the number 7 plus the fraction $\frac{1}{2}$. As you will see later, every improper fraction can be written as a mixed number, and vice versa.

> Classify the following numbers as proper fractions, improper fractions, or mixed numbers: $\frac{8}{9}$, $\frac{6}{6}$, $5\frac{2}{3}$, $\frac{6}{4}$, and $\frac{112}{113}$.

The numbers $\frac{8}{9}$ and $\frac{112}{113}$ are proper fractions, the numbers $\frac{6}{6}$ and $\frac{6}{4}$ are improper fractions, and $5\frac{2}{3}$ is a mixed number.

Decimals

The numbers 10, 100, 1,000, 10,000, and so on, are called the *powers of 10.* Fractions like $\frac{7}{10}$, $\frac{59}{100}$, and $\frac{323}{1000}$, which have numbers on the bottom that are powers of 10, are called *decimal fractions*, or *decimals.*

Decimals are typically written using a shorthand notation in which the number on the top of the fraction is written to the right of a dot, called a *decimal point.* The number on the bottom of the fraction is not written, but is indicated in the following way: If the number to the right of the decimal point contains one digit, the number on the bottom of the fraction is 10, if the number to the right of the decimal point contains two digits, the number on the bottom of the fraction is 100, etc. Therefore, $\frac{7}{10} = .7$, $\frac{59}{100} = .59$, and $\frac{323}{1000} = .323$. The decimal .7 is read "point seven," or "seven tenths." In the same way, .59 is read "point fifty-nine," or "fifty-nine hundredths."

> Write the following fractions using decimal notation: $\frac{3}{10}$, $\frac{157}{1000}$, and $\frac{7}{100}$.

$\frac{3}{10} = .3$, $\frac{157}{1000} = .157$, and $\frac{7}{100} = .07$. Note that in the last example, you must place a 0 between the decimal point and the 7 to indicate that the number on the bottom is 100.

> Write the following decimals as fractions: .7, .143, and .079.

$.7 = \frac{7}{10}$, $.143 = \frac{143}{1000}$, and $.079 = \frac{79}{1000}$.

A number that consists of a whole number and a decimal is called a *mixed decimal.* The number 354.56, for example, represents the mixed number $354\frac{56}{100}$.

Write the following mixed numbers as mixed decimals: 76.3 and 965.053.

$76.3 = 76\frac{3}{10}$ and $965.053 = 965\frac{53}{1000}$.

Percents

A *percent* is a fraction whose bottom number is 100. Percents (the word percent means *per hundred)* are often written using a special symbol: "%." Thus, for example, $\frac{67}{100}$ can be written 67%, and $\frac{3}{100}$ can be written 3%. Note that, just as every percent can be written as a fraction, every percent can also be written as a decimal. For example, $51\% = \frac{51}{100} = .51$, and $7\% = \frac{7}{100} = .07$.

A quick way to rewrite a percent as a decimal is to move the decimal point two places to the left and drop the percent sign. Thus, for example, 35% = .35. In a similar way, in order to write a decimal as a percent, move the decimal point two places to the right and put in a percent sign. Thus, .23 = 23%

Write the following decimals as percents: .23, .08, and 1.23.

.23 = 23%, .08 = 8%, and 1.23 = 123%.

Write the following percents as decimals: 17%, 2%, and 224%.

17% = .17, 2% = .02, and 224% = 2.24

Arithmetic Operations

Addition, subtraction, multiplication, and division are called the *Fundamental Operations of Arithmetic.* In order to be able to solve the word problems that the ASVAB asks in the Arithmetic Reasoning section, you need to be able to add, subtract, multiply, and divide whole numbers and decimals. This section reviews these mathematical techniques.

Addition

Addition of Whole Numbers

When you add numbers, the result is called the *sum*. The first step in adding whole numbers is to line them up, placing ones under ones, tens under tens, hundreds under hundreds, and so on. Then, add each column of numbers, beginning with the ones, and moving to the tens, hundreds, thousands, and so on. If the sum of the digits in any column is 10 or more, write down the last figure of the sum as a part of the answer, and then carry the other figures into the next column.

For example, suppose you are asked to add 37, 64, and 151. Begin by lining up the numbers in columns as shown below:

$$\begin{array}{r} 37 \\ 64 \\ \underline{151} \end{array}$$

Now, add the digits in the units column: 7 + 4 + 1 = 12. Since this number is more than 10, write the 2 below the units column in the answer, and carry the 1 over to the tens column.

$$\begin{array}{r} 1 \\ 37 \\ 64 \\ 151 \\ \hline 2 \end{array}$$

Now add the 1 that you carried to the other digits in the tens column: 1 + 3 + 6 + 5 = 15. Put the 5 below the tens column, and carry the remaining 1 to the hundreds column:

$$\begin{array}{r} 37 \\ 164 \\ 151 \\ \hline 52 \end{array}$$

Since 1 + 1 = 2, the final answer would be 252:

$$\begin{array}{r} 37 \\ 64 \\ 151 \\ \hline 252 \end{array}$$

Add 235, 654, and 12.

$$\begin{array}{r} 235 \\ 654 \\ 12 \\ \hline 901 \end{array}$$

Addition of Decimals

Adding decimal numbers is also very straightforward. Simply line up the decimal points of the numbers involved, and add as you normally would. Suppose, for example, you wish to add 23.31, 19, and 3.125. Begin by writing the numbers in a column, lining up the decimal points:

$$\begin{array}{l} 23.31 \\ 19. \\ 3.125 \\ \hline \end{array}$$

Note that the number 19 is a whole number, and, as such, the decimal point is to the right of the number, that is, 19 and 19. mean the same thing. If it helps you when you add these numbers, you can fill in the missing spaces to the right of the decimal points with 0s:

$$\begin{array}{r} 23.310 \\ 19.000 \\ 3.125 \\ \hline \end{array}$$

Now, position a decimal point in the answer directly below the decimal points of the numbers in the problem:

$$\begin{array}{r} 23.310 \\ 19.000 \\ 3.125 \\ \hline . \end{array}$$

Finish by adding as described above:

```
 23.310
 19.000
  3.125
 45.435
```

There will be problems on the test that ask you to add money. Of course, in order to add money, just line up the decimals points, as above, and add the money. Thus, for example, expenses of $32.25, $52.35, and $97.16 would lead to a total expense of:

```
$ 32.25
$ 52.35
$ 97.16
$172.76
```

Add 23.56, 876.01, 34, and .007.

```
 23.56
876.01
 34
    .007
```

If you like, before doing the addition, you can put in some 0s so that all of the numbers have the same number of digits:

```
 23.560
876.010
 34.000
   .007
933.577
```

If Brian buys three items priced at $3.45, $65.21, and $143.50, how much has he spent?

In order to find the answer to this problem, you need to add the three amounts spent:

```
$  3.45
$ 65.21
$143.50
$212.16
```

Subtraction

Subtraction of Whole Numbers

When you subtract two numbers, the result is called the *difference*. The first step in subtracting two whole numbers is to line them up, placing ones under ones, tens under tens, hundreds under hundreds, and so on. Then, subtract each column of numbers, beginning with the ones, and moving to the tens, hundreds, thousands, and so on. If, in any step, the digit on the top is smaller than the digit on the bottom, increase the figure on top by 10 by borrowing 1 from the figure directly to the left.

Let's take the following problem as an example:

$$\begin{array}{r} 567 \\ -382 \\ \hline \end{array}$$

The first step is, of course, to subtract 2 from 7. Since 7 is bigger than 2, no borrowing is necessary, so this step is easy:

$$\begin{array}{r} 567 \\ -382 \\ \hline 5 \end{array}$$

Now, you need to subtract the numbers in the tens column. Note that 6 is smaller than 8, so you need to borrow 1 from the 5 to the left of the 6. This makes the 6 into a 16, and, by borrowing the 1 from the 5, it becomes 4:

$$\begin{array}{r} \overset{4}{\cancel{5}}67 \\ -382 \\ \hline 5 \end{array}$$

Next, you can subtract the 8 from the 16, which leaves you with 8. Finally, in the hundreds column, subtracting the 3 from the 4 leaves you with 1:

$$\begin{array}{r} \overset{4}{\cancel{5}}67 \\ -382 \\ \hline 185 \end{array}$$

Remember that, if you would like to check the answer to a subtraction problem, you can add the difference (that is, the answer) to the number on the bottom of the subtraction, and see if you get the number on top. Here, since 185 + 382 = 567, you know that you have the correct answer.

Subtract 534 from 893.

$$\begin{array}{r} 893 \\ -534 \\ \hline 359 \end{array}$$

Subtraction of Decimals

Just as with addition of decimals, begin by lining up the decimal points of the two numbers that you are subtracting. Then, place a decimal point for the answer directly below the decimal points of the two amounts. For example:

$$\begin{array}{r} 265.01 \\ -127.5 \\ \hline . \end{array}$$

When performing a subtraction, it helps to write in extra 0s so that both numbers have the same number of digits to the right of the decimal point.

$$\begin{array}{r} 265.01 \\ -127.50 \\ \hline 137.51 \end{array}$$

Of course, in order to subtract monetary amounts, line up the decimal points and subtract as usual, as in the following example:

$$\begin{array}{r} \$324.56 \\ -\$34.07 \\ \hline \$290.49 \end{array}$$

Jimmy pays a $14.51 dinner charge with a $20 bill. How much change does he receive?

Simply subtract $14.51 from $20:

$$\begin{array}{r} \$\ \ 20.00 \\ -\$14.51 \\ \hline \$\ \ \ \ 5.49 \end{array}$$

Multiplication

Multiplication of Whole Numbers

When you multiply two numbers, the result is called the *product*. The first step in multiplying whole numbers is to line the numbers up, placing ones under ones, tens under tens, hundreds under hundreds, and so on. Now, consider two possible cases.

Case 1: If the number on the bottom of your multiplication contains a single digit, multiply every digit in the number on top by this digit. Start on the right, and move to the left. If, at any time, the result of a multiplication is a number that contains more than one digit, write down the ones digit of the number, and carry the tens digits over to the next column, to be added to the result of the multiplication in that column.

For example, suppose you need to multiply 542 by 3. Write the problem down as the following:

$$\begin{array}{r} 542 \\ \times\ 3 \\ \hline \end{array}$$

Begin by multiplying 3 by 2, and write the result, which is 6, below the 3:

$$\begin{array}{r} 542 \\ \times\ 3 \\ \hline 6 \end{array}$$

Next, multiply the 3 on the bottom by the 4 on the top. The result is 12. Write the ones digit from the 12 below the 4 in the problem, and carry the tens digit, which is 1, over to the next column:

$$\begin{array}{r} {\scriptstyle 1} \\ 542 \\ \times\ 3 \\ \hline 26 \end{array}$$

Finally, multiply the 3 by 5. You should add the result of 15 to the 1 that you carried from the previous column:

$$\begin{array}{r} 542 \\ \times\ \ \ 3 \\ \hline 1,626 \end{array}$$

Case 2: If the number on the bottom contains more than one digit, begin as you did above and multiply every digit on the top by the ones digit of the number on the bottom. Write the result in the usual spot. Then move over to the tens digit of the number on the bottom, and multiply each number on the top by this number. Write the result below the previous result, but position the ones digit of the result below the number you are multiplying by. Continue on to the hundreds digit, multiplying as usual, but positioning the ones digit of the result below the hundreds digit of the number on the bottom. Continue until you have multiplied the number on top by every digit on the bottom. Finish by adding together all of the partial products you have written.

The following example illustrates the process that Case 2 discusses. In order to multiply 542 by 63, set up the problem as follows:

$$\begin{array}{r} 542 \\ \times 63 \\ \hline \end{array}$$

Begin exactly as you did in the earlier example and multiply the 542 by 3. After doing this, you should have the following:

$$\begin{array}{r} 542 \\ \times\ 63 \\ \hline 1626 \end{array}$$

Now, multiply the 542 by the 6 in the tens digit of the number on the bottom. Note that the result of this multiplication is 3,252. Also note where you position this number:

$$\begin{array}{r} 542 \\ \times\quad 63 \\ \hline 1626 \\ 3252 \end{array}$$

Be very careful when multiplying to line up the numbers carefully and correctly. As the last step, add the 1,626 to the 3,252, as the following shows:

$$\begin{array}{r} 542 \\ \times\quad 63 \\ \hline 1626 \\ 3252 \\ \hline 34{,}146 \end{array}$$

Multiply 234 by 16.

$$\begin{array}{r} 234 \\ \times\ 16 \\ \hline 1404 \\ 234 \\ \hline 3{,}744 \end{array}$$

Multiplication of Decimals

Earlier in the sections discussing addition and subtraction with decimals, you saw that the very first step in finding the answer is to correctly position the decimal point of the answer. When multiplying numbers with decimals, the procedure is almost exactly the opposite. Begin by ignoring the decimal points in the numbers you are multiplying, and figure out the answer as if the numbers in the problem are whole numbers. Then, after you finish multiplying, you can figure out where the decimal point in the answer goes.

To figure out where the decimal point in the answer goes, you need to do some counting. Begin by counting the total number of digits to the right of the decimal points in the two numbers you are multiplying. However many digits you count when you do this should also be the number of digits to the right of the decimal point in the answer.

The following examples help to make this procedure clear. Remember that, earlier, you solved the problem:

$$\begin{array}{r} 542 \\ \times \quad 63 \\ \hline 1626 \\ 3252 \\ \hline 34{,}146 \end{array}$$

Now, suppose that instead the problem had been:

$$\begin{array}{l} 5.42 \\ \underline{\times 6.3} \end{array}$$

Note that the number on the top contains two digits to the right of the decimal point, and that the number on the bottom contains one digit to the right of the decimal point. To start, multiply as you normally would, ignoring the decimal points:

$$\begin{array}{r} 5.42 \\ \times \quad 6.3 \\ \hline 1626 \\ 3252 \\ \hline 34146 \end{array}$$

Now, since you have a total of 2 + 1 = 3 digits to the right of the decimal point in the two numbers that you are multiplying, you need to have three digits to the right of the decimal point in the numbers in the product:

$$\begin{array}{r} 5.42 \\ \times \quad 6.3 \\ \hline 1626 \\ 3252 \\ \hline 34.146 \end{array}$$

That's all there is to it!

What if the problem had been instead:

$$\begin{array}{l} 5.42 \\ \underline{\times .63} \end{array}$$

In this case, you have a total of four digits to the right of the decimal point in the two numbers you are multiplying. Thus, the answer is not 34.146, but rather 3.4146.

Note that, if you are multiplying an amount of money by a whole number, you can use the same process as earlier. Of course, when you do this, you will have a total of two digits to the right of the decimal point in the two numbers you are multiplying by, so that the answer will end up looking like money, that is, it will have two digits to the right of the decimal point.

> John buys four calculators, each of which costs $3.51. What is the total cost of the four calculators?

$$\begin{array}{r} \$\ 3.51 \\ \times \quad 4 \\ \hline \$14.04 \end{array}$$

Division

Division of Whole Numbers

When you divide one number into another, the result is the *quotient.* Division is probably the most complicated of the four fundamental arithmetic operations, but it becomes easier after you realize that the procedure for division consists of a series of four steps that you repeat over and over again until you finish. The following sample problems illustrate these four steps.

Suppose you are asked to divide 7 into 245. Begin by writing the problem in the usual way:

$$7\overline{)245}$$

Now, for the first step, determine the number of times that 7 goes into 24. Since 7 goes into 24 three times (with something left over), begin by writing a 3 above the 4 in the problem:

$$\begin{array}{r} 3 \\ 7\overline{)245} \end{array}$$

As a second step, multiply the 3 by the 7 to obtain 21 and write this product below the 24:

$$\begin{array}{r} 3 \\ 7\overline{)245} \\ 21 \end{array}$$

The third step is to subtract the 21 from the 24. When you do this, you get 3. This should be written below the 21, as the following shows:

$$\begin{array}{r} 3 \\ 7\overline{)245} \\ -21 \\ \hline 3 \end{array}$$

The final step in the four-step process is to *bring down* the next digit from the number that you are dividing into. This next (and last) digit is 5, so bring it down next to the 3 as the following shows:

$$\begin{array}{r} 3 \\ 7\overline{)245} \\ -21 \\ \hline 35 \end{array}$$

Now, the entire procedure starts over again. Divide 7 into 35. It goes in 5 times, so put a 5 next to the 3 in the solution.

$$\begin{array}{r}
35 \\
7\overline{)245} \\
\underline{-21} \\
35
\end{array}$$

When you multiply and subtract, note that you end up with 0. This means that you have finished, and the *quotient* (answer) is 35:

$$\begin{array}{r}
35 \\
7\overline{)245} \\
\underline{-21} \\
35 \\
\underline{-\ \ 35} \\
0
\end{array}$$

The procedure for dividing by two digit numbers (or even larger numbers) is essentially the same, but involves a bit more computation. As an example, consider the following problem:

$$23\overline{)11408}$$

Note that 23 will not go into 11, so you have to divide 23 into 114. In order to determine how many times 23 goes into 114, you are going to have to estimate. Perhaps you might think that 23 is almost 25, and that it seems as if 25 would go into 114 four times. So, try 4. Write a 4 on top, and multiply, subtract, and bring down in the usual way:

$$\begin{array}{r}
4 \\
23\overline{)11408} \\
\underline{-92} \\
220
\end{array}$$

Continue, as before, by trying to estimate the number of number of times 23 will go into 220. If you try 9, things will continue rather nicely:

$$\begin{array}{r}
49 \\
23\overline{)11408} \\
\underline{-92} \\
220 \\
\underline{-207} \\
138
\end{array}$$

As a final step, estimate that 23 will go into 138 six times.

$$
\begin{array}{r}
496 \\
23\overline{)11408} \\
-92 \\
\hline
220 \\
-207 \\
\hline
138 \\
-138 \\
\hline
0
\end{array}
$$

If, at any point, you make the incorrect estimate, simply modify your estimate, and start over. For example, suppose in the last step above, you thought that 23 would go into 138 seven times. Look what would have happened:

$$
\begin{array}{r}
497 \\
23\overline{)11408} \\
-92 \\
\hline
220 \\
-207 \\
\hline
138 \\
-161 \\
\hline
\end{array}
$$

Since 161 is larger than 138, it means that you over-estimated. Try again, with a smaller number.

Divide 12 into 540.

$$
\begin{array}{r}
45 \\
12\overline{)540} \\
-48 \\
\hline
60 \\
-60 \\
\hline
0
\end{array}
$$

Remember that you can always check division problems by multiplying. In this case, since 12 $\times$ 45 = 540, you know that you have the right answer.

Division with Decimals

Recall that when you add and subtract with decimals, you begin by positioning the decimal point for the answer and then add or subtract as usual. When you are dividing a whole number into a decimal number, the idea is similar. Begin by putting a decimal point for the quotient (answer) directly above the decimal point in the number that you are dividing into. Then divide as normal. So, for example, if you need to divide 4 into 142.4, begin as the following shows:

Note the decimal point positioned above the decimal point in 142.4

$$
\begin{array}{r}
. \\
4\overline{)142.4}
\end{array}
$$

Now, divide in the usual way:

$$\begin{array}{r}
35.6 \\
4\overline{)142.4} \\
-12 \\
\hline
22 \\
-20 \\
\hline
24 \\
24 \\
\hline
0
\end{array}$$

That's all that there is to it.

> A dinner bill of $92.80 is shared equally between four friends. How much does each friend pay?

To find the answer, you need to divide $92.80 by 4:

$$\begin{array}{r}
23.20 \\
4\overline{)92.80} \\
-8 \\
\hline
12 \\
-12 \\
\hline
08 \\
-8 \\
\hline
00 \\
-0 \\
\hline
0
\end{array}$$

Arithmetic Word Problems

As this section previously mentioned, the Arithmetic Reasoning part of the ASVAB contains 30 real-world word problems that involve arithmetic calculations. If you know how to do the computations that this section discusses, then the hardest part of these word problems is for you to determine which of the arithmetic operations you need in order to solve the problem.

Basic One-Step and Two-Step Problems

Some of the word problems on the test will involve only a single computation. Others may be multiple-step problems in which you need to perform several computations. The following are examples of problems of both types. Following this will be some examples of special types of problems that also appear on the test.

> Brett earned $225.25 during his first week on a new job. During the second week, he earned $325.50, during the third week he earned $275.00, and during the fourth week he earned $285.75. How much did he earn over the course of the four weeks?

In this problem, all you need to do is add the weekly payments to find the total.

$$\begin{array}{r} \$225.25 \\ \$325.50 \\ \$275.00 \\ \$285.75 \\ \hline \$1,111.50 \end{array}$$

> Brett has a job which pays him $8.25 an hour. If, during the first week, he works 21 hours, and during the second week he works 19 hours, how much money does he earn over the course of the two weeks?

This is an example of a two-step problem. One way to find the answer is to find how much he made each week by multiplying, and then adding the two weekly totals:

$$\begin{array}{r} \$8.25 \\ \times 21 \\ \hline \$173.25 \end{array} \qquad \begin{array}{r} \$8.25 \\ \times 19 \\ \hline \$156.75 \end{array}$$

Then, since $173.25 + $156.75 = $330, he earned $330.

Perhaps you notice that there is an easier way to solve the problem. If you begin by adding the number of hours he worked each week, you get 19 + 21 = 40 as a total. Then, you only need to multiply $8.25 by 40 to get the answer.

> An office building is 540 feet high, including a 23-foot antenna tower on the roof. How tall is the building without the antenna tower?

In this problem, you need to remove the 23-foot tower from the top of the building by subtracting. This is a one-step problem:

$$\begin{array}{l} 540 \\ -23 \\ \hline 517 \text{ feet} \end{array}$$

> At a restaurant, the bill for dinner is $137.50. Bill contributes $20 to the bill, and then leaves. The rest of the bill is split evenly between the remaining five people. How much does each person contribute?

Here is another two-step word problem. After Bill leaves, there still remains $137.50 - $20 = $117.50 to pay. This has to be divided by the five people that remain.

$$\begin{array}{r} 23.50 \\ 5\overline{)117.50} \\ -10 \\ \hline 17 \\ -15 \\ \hline 25 \\ 25 \\ \hline 00 \end{array}$$

Therefore, each person needs to pay $23.50

Percent and Interest Problems

The ASVAB Arithmetic Reasoning section also contains some problems that involve working with percents and interest. Typically, these problems will involve finding percents of numbers. There are two things you need to remember—first, the way to find a percent of a number is by multiplying, and second, before multiplying, you should write the percent as a decimal.

Below are several examples of this type of problem.

> A family spends 26% of their monthly income on their mortgage. If their monthly income is $2,400, how much do they spend on their mortgage each month?

This problem asks you to find 26% of $2,400. To do this, write 26% as .26, and then multiply.

$$\begin{array}{r} \$2,400 \\ \times \quad .26 \\ \hline 14400 \\ 4800 \\ \hline 624.00 \end{array}$$

Thus, the monthly expenditure is $624.00

> Bob invests $5,500 in an account which pays 9% annual interest. How much interest does he earn in one year?

Another one-step percent word problem. For this problem, you need to find 9% of $5,500. Begin by writing 9% as a decimal, which is .09 *(Note carefully—9% is equal to .09, not .9).* Then multiply to finish the problem:

$$\begin{array}{r} \$\ 5,500 \\ \times \quad .09 \\ \hline \$495.00 \end{array}$$

He will earn $495 in interest in one year.

> Bob invests $5,500 in an account which pays 9% annual interest. How much money will be in the account at the end of one year?

Note that this problem is based on the previous problem, but includes an extra step. After determining how much interest is in the account at the end of the year, this amount needs to be added to the $5,500 to obtain $5,500 + $495 = $5,995.

Ratio and Proportion

Another type of word problem that may appear on the test involves ratios and proportions.

A *ratio* is a comparison of two numbers. For example, a school might say that its student-teacher ratio is 8 to 1. This means that, for every 8 students at the school, there is one teacher. Another way to look at this ratio is that, for every 1 teacher, there are 8 students.

You may have seen a ratio written with a colon between the two numbers, like 8:1. A ratio can also be written as a fraction, like $\frac{8}{1}$. When it comes to solving word problems involving ratios, it is usually best to write the ratios as fractions so that you can perform computations with them.

In the previous ratio, you were comparing a number of people (students) to a number of people (teachers). When you use a ratio to compare two different kinds of quantities, it is called a *rate*. For example, suppose that a car drives 300 miles in 5 hours. Then you can write the rate of the car as $\frac{300\text{ miles}}{5\text{ hours}}$. If you divide the number on the bottom into the number on the top, you get the number 60, and can then say that the rate of the car is $\frac{60\text{ miles}}{1\text{ hour}}$ or simply 60 *miles per hour*. Sixty miles per hour is also known as the speed of the car.

When you divide the number on the bottom of a ratio or a rate into the number on the top, the result is what is known as a *unit ratio* or a *unit rate.* Often, solving ratio problems hinges on computing a unit ratio or rate. The following problems illustrate the techniques of working with ratios and rates.

> A supermarket customer bought a 15-ounce box of oatmeal for $3.45. What was the cost per ounce of oatmeal?

The rate of cost to ounces is given in the problem as $\frac{\$3.45}{15\text{ oz}}$. To find the *unit cost*, you divide $3.45 by 15 ounces.

$$\begin{array}{r} .23 \\ 15\overline{)3.45} \\ -30 \\ \hline 45 \\ -45 \\ \hline 0 \end{array}$$

Therefore, the cost is 23 cents per ounce.

> A supermarket sells a 15-ounce box of oatmeal for $3.45. At the same rate, what would be the cost of a 26-ounce box of oatmeal?

This type of problem is what is known as a proportion problem. In a proportion problem, you are given the rate at which two quantities vary, and asked to find the value of one of the quantities given the value of the other. A good way to approach a problem of this type is by first finding the unit rate and then multiplying. Note that in the previous problem, you already found the unit rate of the oatmeal, which was 23 cents per ounce. The cost of 26 ounces, then, will be 23 cents times 26:

$$\begin{array}{r} .23 \\ \times 26 \\ \hline 138 \\ 46 \\ \hline 5.98 \end{array}$$

Thus, 26 ounces costs $5.98.

A bus travels at a constant rate of 45 miles per hour. How far can the bus go in $5\frac{1}{2}$ hours?

Previously, you saw that the rate of a vehicle is equal to its distance divided by its time. In the same way, the distance that the vehicle travels is equal to its rate multiplied by its time. You may remember from previous math classes that this formula is written $d = r \times t$, meaning *distance equals rate times time.*

It is easier to solve this problem if you write $5\frac{1}{2}$ as its decimal equivalent, 5.5. Then, you simply need to multiply 45 by 5.5 to find the distance:

$$\begin{array}{r} 45 \\ \times 5.5 \\ \hline 225 \\ 225 \\ \hline 247.5 \end{array}$$

Thus, the bus will go 247.5 miles in $5\frac{1}{2}$ hours.

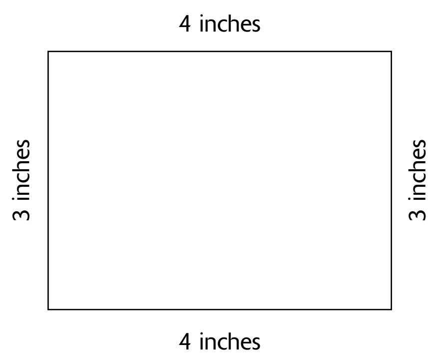
Measurement

Some of the problems on the ASVAB involve working with measurements and geometric shapes. Two concepts that you should be familiar with are *perimeter* and *area*.

The *perimeter* of a figure is the distance around it, that is, the sum of the lengths of its sides. You measure perimeter in units of length, such as inches, feet, or meters. The area of a figure is the amount of surface contained within its boundaries. You measure area in square units, such as square inches, square feet, or square meters.

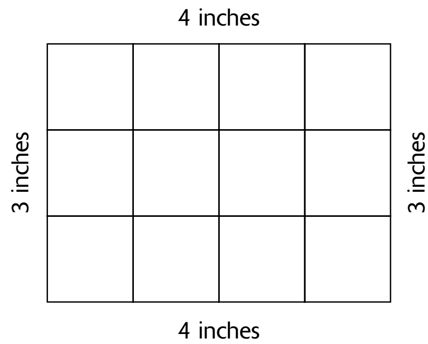
Two important geometric figures that you should know how to find the perimeter and area of are the rectangle and the square.

A *rectangle* is a figure with four sides. The opposite sides are the same length. For example, the following figure depicts a rectangle with measurements of 4 inches by 3 inches:



The perimeter of a rectangle is given by the formula $P = 2l + 2w$, which means that, to find the perimeter of a rectangle, you need to add together two lengths and two widths. If the rectangle is 4 inches by 3 inches, then its perimeter is $P = 3 + 3 + 4 + 4 = 14$ inches.

The area of a rectangle is given by the formula $A = l \times w$, which means that the area is the length times the width. In this case, the area is 3 inches × 4 inches = 12 square inches. By the way, a square inch is simply a square that is an inch long on all four sides. If you look again at the picture of the previous rectangle, you can see that it can be thought of as consisting of 12 squares that are each an inch on all sides. That is what is meant when you say that the area is 12 square inches.



A square is a rectangle with 4 equal sides. In the case of a square, the formulas for the perimeter and the area of a rectangle take a simpler form. The perimeter of a square is $P = 4s$, where s is the length of the side, and the area is $A = s \times s$.

It also helps you to know some common measurement conversions, such as the fact that there are 12 inches in a foot, 3 feet in a yard, and 36 inches in a yard.

The following examples review the concepts that this section previously discusses.

> A small bag of fertilizer covers 20 square feet of lawn. How many bags do you need in order to cover a lawn that is 4 yards by 3 yards?

The most direct way to handle this problem is to change the measurements of the lawn to feet, because that is how the capacity of the bag of fertilizer is measured. A lawn that is 4 yards by 3 yards is 12 feet by 9 feet. Thus, its area is 12 × 9 = 108 square feet. Now, to determine the number of bags that you need, you need to divide 20 into 108. When you do this division, you get an answer of 5.4 bags. Since, obviously, you cannot purchase 5.4 bags, you would need 6 bags in order to cover the lawn.

> A lot of land measures 50 meters by 40 meters. A house 24 meters by 18 meters is built on the land. How much land is left over?

Begin by finding the area of the lot and the house:

$$\begin{array}{r} 50 \\ \times 40 \\ \hline 2000 \end{array} \qquad \begin{array}{r} 24 \\ \times 18 \\ \hline 432 \end{array}$$

Thus, the area of the lot is 2,000 square meters, and the area of the house is 432 square meters. To determine how much area is left, you need to subtract 432 square meters from 2,000 square meters: 2,000 – 432 = 1,568 square meters left over.

Arithmetic Knowledge Practice Questions

1. On opening night, 3,127 people attend a new play. The attendance for the next two nights is 2,944 and 3,009. What is the total number of people who saw the play on the first three nights?

A. 8,070
B. 8,080
C. 9,080
D. 9,800

2. A truck driver makes $0.10 for every mile he drives. The truck driver is also paid $8.00 per hour. If he drives 200 miles in 4 hours, how much does he earn, total?

A. $28
B. $52
C. $232
D. $450

3. An employee works 25 hours one week, 32 hours the next week, and 15 hours the week after that. In that three-week period, how many hours did she average each week?

A. 20
B. 22
C. 24
D. 25

4. A homeowner must pay 2% of the appraised value of the home every year in taxes. If the house is appraised at $256,000, how much will the homeowner pay each year in taxes?

A. $520
B. $1,280
C. $5,120
D. $51,200

5. A company buys 500 bumper stickers. If the price of bumper stickers is $2 each for the first 200 and $0.50 for each bumper sticker after that, how much does the company pay for the bumper stickers?

A. $250
B. $450
C. $550
D. $1,050.50

6. The distance from Mark's house to Peter's house is 12 yards, 1 foot and 17 inches. How far apart are the houses, in inches?

A. 173
B. 360
C. 449
D. 461

7. What is the perimeter, in inches, of a rectangular wall that measures 6 feet 4 inches by 8 feet 3 inches?

A. $87\frac{1}{2}$
B. 164
C. 175
D. 350

8. What is the area, in square inches, of a square piece of carpet that measures 6 feet 2 inches on a side?

A. 296
B. 384
C. 2,738
D. 5,476

9. Twenty people each contribute $20 for a party. If 30% of that money is spent on food, how much money was spent on food?

A. $60
B. $120
C. $130
D. $230

10. Tickets for an amusement park cost $35. When bought over the phone, there is a 5% service charge. What is the total price for four tickets bought over the phone?

A. $135
B. $136.75
C. $145
D. $147

11. A car is driven 750 miles in 25 hours. What is the rate of the car in miles per hour?

A. 30
B. 60
C. 65
D. 75

12. A 15-lb roast contains 45 servings of meat. What is the rate in servings per pound?

A. 2
B. 3
C. 4
D. $6\frac{3}{4}$

13. Light travels 744,000 miles in 4 seconds. What is its speed in miles per second?

A. 186,000
B. 187,000
C. 188,000
D. 189,000

14. An item is priced at $300. It goes on sale for 25% off. What is the new price?

A. $225
B. $250
C. $275
D. $325

15. Mark's car mileage in May was 2,374 miles. If 1,752 of those miles were driven for business purposes, how many miles were driven for other than business purposes?

A. 522

B. 622

C. 1,622

D. 4,126

16. In the election for Union County Comptroller, Mr. Heine got 33,172 votes, and Mr. Palisano got 25,752 votes. By how many votes did Mr. Heine win the election?

A. 7,420

B. 8,420

C. 18,420

D. 58,924

17. Bob buys 25 pads of paper, each of which contains 70 pieces of paper. What is the total number of pieces of paper that Bob purchases?

A. 1,750

B. 1,770

C. 2,800

D. 3,571

18. If the average speed of an airplane is 525 miles per hour, how many miles can it travel in 6 hours?

A. 3,050

B. 3,120

C. 3,150

D. 8,750

19. Jimmy earns an annual salary of $26,124. What is his average monthly salary?

A. $2,107

B. $2,177

C. $2,179

D. $5,024

20. Mr. Norwalk bought 24 gallons of gasoline, which enables him to drive 648 miles. On the average, how many miles does he get per gallon of gasoline?

A. 24

B. 25

C. 26

D. 27

21. Steve played in 14 basketball games. He scored a total of 53 field goals (2 points each), and 20 free throws (1 point each). What was his average score per game?

A. 5

B. 9

C. 11

D. 126

22. How many yards of fencing do you need to enclose a rectangular yard that is 42 feet long and 84 feet wide?

A. 126

B. 252

C. 336

D. 353

23. How many feet of baseboard would you need to go around a rectangular room if the room has a length of 12 feet and a width of $7\frac{1}{2}$ feet, and you must deduct 4 feet for a doorway?

A. $15\frac{1}{2}$

B. 31

C. 35

D. 39

24. An equilateral triangle is a triangle that has all three sides the same length. What is the perimeter of an equilateral triangle whose sides are 5 inches?

A. 5

B. 10

C. 15

D. 20

25. Fred wishes to enclose a square garden with wire whose sides measure 20 feet. If he decides to have the wire go around the garden five times, how much will the wire cost him if wire costs 40 cents for a spool of 50 feet?

A. $1.60

B. $3.20

C. $6.40

D. $10.00

26. How much would it cost per month to rent a rectangular office that measures 20 feet by 30 feet if the cost per square foot per month is $8?

A. $800

B. $4,800

C. $5,600

D. $7,500

27. What is the cost of putting grass seed on a 480-square-yard field, if a bag of grass seed covers 60 square yards and costs $7.45?

A. $44.70

B. $56.60

C. $57.20

D. $59.60

28. Janet wants to carpet a 12-feet by 15-feet rectangular room. If carpet costs $11.50 per square yard, how much will it cost her to carpet the room?

A. $230

B. $690

C. $1,380

D. $2,070

29. George bowls three games. His scores are 222, 208, and 197. What was his average score for the three games?

A. 206

B. 207

C. 208

D. 209

30. A baseball stadium has 1,350 box seats, 3,527 reserve seats, 2,007 general admission seats, and 4, 275 bleacher seats. What is the total number of seats in the stadium?

A. 10,059

B. 10,159

C. 11,149

D. 11,159

Answers and Explanations for Practice Questions

1. **C.** To find the total number of people who saw the play, add 3,127 and 2,944 and 3,009 to get 9,080.
2. **B.** First, figure out how much the driver makes for his mileage: $0.10 $\times$ 200 miles = $20. Then calculate 4 $\times$ $8.00 to figure his hourly wages, which equals $32. $20 + $32 = $52.
3. **C.** Add 25 + 32 + 15 and divide by 3 to get 24.
4. **C.** $256,000 $\times$ 2% = $256,000 $\times$ .02 = $5,120
5. **C.** The company pays a total of $400 for the first 200 stickers, then a total of $150 for the next 300 stickers.
6. **D.** Since there are 36 inches in a yard, 12 yards is the same as 12 $\times$ 36 = 432 inches. In the same way, 1 foot contains 12 inches, and the total distance is 432 inches + 12 inches + 17 inches = 461 inches.
7. **D.** To begin, find the length of each side in inches. 6 feet 4 inches is equal to 72 inches + 4 inches = 76 inches. 8 feet 3 inches is the same as 96 inches + 3 inches = 99 inches. The perimeter is (76 $\times$ 2) + (99 $\times$ 2) = 152 + 198 = 350 inches.
8. **D.** Since the problem asks for the area in square inches, you need to express the length of the side in inches. A length of 6 feet 2 inches is 6 $\times$ 12 + 2 = 72 + 2 = 74 inches. The area, then, is 74 $\times$ 74 inches = 5,476 square inches.
9. **B.** There is a total of $400 contributed ($20 $\times$ 20). Multiply this by 30% (.30) to get $120.
10. **D.** The four tickets, without the service charge, cost $140. Multiply this amount by 5% (.05) to get the service charge: $7. Add $140 + $7 to get $147.
11. **A.** The rate of the car is $\frac{750\text{ miles}}{25\text{ hours}}$. Dividing 25 into 750 gives 30, so the car is traveling at 30 miles per hour.
12. **B.** The rate is $\frac{45\text{ servings}}{15\text{ pounds}}$. Dividing 15 into 45 gives you 3, so there are 3 servings per pound.
13. **A.** The speed (rate) is $\frac{744{,}000\text{ miles}}{4\text{ seconds}}$. Dividing 4 into 744,000 gives you 186,000 miles per second.
14. **A.** $300 $\times$ 25% = $300 $\times$ 0.25 = $75. Subtract $75 from the original price of $300 to get $225.
15. **B.** To solve this problem, you need to subtract 1,752 from 2,374. This tells you how many miles the car was driven for purposes other than business. Since 2,374 − 1,752 = 622, the car went 622 miles for other than business purposes.
16. **A.** You need to determine how many more votes Mr. Heine got than Mr. Palisano. Since 33,172 – 25,752 = 7,420, Mr. Heine got 7,420 more votes.
17. **A.** To solve this problem, you need to multiply the number of pads times the number of pieces of paper in a pad. Since 25 $\times$ 70 = 1,750, this is the total number of sheets of paper that he bought.

18. **C.** Previously, you saw that the formula for distance is $d = r \times t$, that is, distance = rate × time. In this case, distance = 525 × 6 = 3,150 miles.

19. **B.** Since there are 12 months in a year, Jimmy's average monthly salary is \$26,124 ÷ 12 = \$2,177.

20. **D.** He got $\frac{648\text{ miles}}{24\text{ gallons}}$. Dividing 648 by 24 gives you 27 miles per gallon.

21. **B.** This problem has several steps. To begin, you need to determine the number of points he scored. The 53 field goals give him 53 × 2 = 106 points. Adding on the 20 free throws gives him 126 points. The average per game is 126 ÷ 14 = 9 points.

22. **B.** You need to find the perimeter of the rectangle. $P = 2 \times 42 + 2 \times 84 = 84 + 168 = 252$ yards.

23. **C.** The perimeter of the room is 2 × 12 + 2 × 7.5 = 24 + 15 = 39 feet. Subtracting 4 feet for the doorway leaves you needing 35 feet of baseboard.

24. **C.** Three sides of length 5 gives a perimeter of 3 × 5 = 15 inches.

25. **B.** The perimeter of the garden is 20 × 4 = 80 feet, so you would need 5 × 80 = 400 feet to go around it five times. Now, divide 400 feet by 50 feet and you get 8, which means that you need to buy 8 spools. Finally, 8 spools at 40 cents a spool would cost \$3.20.

26. **B.** The area of the office is 20 feet × 30 feet = 600 square feet. At \$8 a square foot, the total cost would be 600 × \$8 = \$4,800 a month.

27. **D.** Since 480 ÷ 60 = 8, you need 8 bags to cover the yard. Since each bag costs \$7.45, the total cost will be \$7.45 × 8 = \$59.60.

28. **A.** Be careful with this one. Note that the measurement of the room is given in feet, but the cost of the carpet is given in square yards. The easiest way to deal with this is to express the measurement of the room in yards; 12 feet by 15 feet is the same as 4 yards by 5 yards, so the room measures 20 square yards. At \$11.50 per square yard, the cost to carpet the room would be 20 × \$11.50 = \$230.

29. **D.** To find the average of three numbers, begin by adding the numbers, and then divide by 3. Since 222 + 208 + 197 = 627, and 627 ÷ 3 = 209, his average score was 209.

30. **D.** The total number of seats is 1,350 + 3,527 + 2,007 + 4,275 = 11,159.

Word Knowledge

The ASVAB presents Word Knowledge questions in two formats; both formats test your knowledge of words that have the same or nearly the same meaning. In the first type of question, synonyms, the test gives you an underlined word and then asks you to choose the word or phrase that has the same or nearly the same meaning. The second type of question, word in context, presents a sentence. You must find the word or phrase that has a nearly identical meaning as the underlined word in the context of the sentence. In short, the Word Knowledge section measures your ability to recognize the meanings of certain words.

The ASVAB has 35 Word Knowledge questions. There are 22 questions in the synonyms format and 13 in the word-in-context format. You will have 11 minutes to answer these questions.

Improving Your Vocabulary

The ability tested in the Word Knowledge portion is your command of the language—in other words, your vocabulary. By this point in your life, you might think that you know all of the words you will ever need or that it will be impossible to improve your vocabulary. On the contrary! If you are diligent and put your mind to it, there are several ways in which you can improve your vocabulary. Here are two that will definitely help:

- **Read, read, read.** Pick up a newspaper, a magazine, or a novel and make note of words you do not understand. Make a list or put them on note cards. First, try to figure out the meaning of the words by looking at the context in which they are used. Make an educated guess. If you are still not sure, then look up the meaning of the words in a dictionary and write them out in a notebook or on note cards. Then try to make up your own sentences using the words.
- **Learn a new word every day or every other day.** You can get into the habit of looking up a new word in the dictionary every day. Write out the word and its definition on a piece of paper. Then write out a sentence using the word. This will help you visualize it. Try using this new word in conversation. Don't pick words that are too technical or specialized (such as medical/scientific terms or proper names).

Unfortunately, neither of the two methods above is going to get you ready for the ASVAB in a short amount of time. The best way to learn a lot of words quickly is to understand prefixes, roots, and suffixes. The "Boosting Your Score with Prefixes, Roots, and Suffixes" section gives you the details.

Boosting Your Score with Prefixes, Roots, and Suffixes

Many words are made up of prefixes, roots, and suffixes.

- **Prefixes:** These go in front of the root word to change its meaning. For example, *re* is a prefix meaning *again,* as in *redo* or *remake*.
- **Roots:** These are the base of a word. For example, *cred* is the root of *creed* or *credible*. *Cred* is from the Latin word that means believe. A creed is something you believe, and a person who is credible is a person who you are willing to believe.
- **Suffixes:** These come at the end of a word. For example, *ly* means in a certain fashion. *Slowly* means *in a slow fashion*.

If you can familiarize yourself with prefixes, roots, and suffixes, you will find that you can arrive at the meaning of some words by breaking them down. The following sections offer you some common prefixes, roots, and suffixes to help you tackle words that you are unfamiliar with in the Word Knowledge section.

Prefixes

In order to break down words you do not understand or to help you recognize why a word means what it means, you should become familiar with prefixes. Prefixes come at the beginning of words.

As an example, look at the word *synonym.* This word is made up of the prefix *syn* plus the root *nym.* If you knew that the prefix *syn* means *with/together* or *same* and the root *nym* means *name* or *word,* then you could conclude that the word *synonym* means *same word.* And that's what it means!

Here is another example. The word *circumvent* is made up of the prefix *circum* plus the root *vent.* If you knew that the prefix *circum* means *around* and the root *vent* means *go* or *come,* then you could conclude that the word *circumvent* means *go around.*

What follows is a list of common prefixes that you will often find at the beginning of certain words. Following the prefix, you will find the meaning of the prefix and a word using the prefix (with a rough definition in parentheses following the word). Try including a word of your own for each prefix in the space provided. If you want, you can browse through a dictionary to find many examples of words that start with these prefixes.

Prefix	*Meaning*	*Word (Definition)*	*Your Example*
ab-	away from	abnormal (not normal)	
ad-	to, toward	adjoin (join to)	
a-, an-	not, without	apathy (without feeling)	
anti-	against	antiviolence (against violence)	
ambi-	both	ambidextrous (able both hands)	
bene-	good	benign (good or harmless)	

Prefix	***Meaning***	***Word (Definition)***	***Your Example***
circum-	around	circumvent (go around)	
con-	with, together	connect (come together)	
contra-	against	contradict (speak against)	
com-	with, together	communion (coming together)	
de-	down, away	descend (move down)	
dis-	apart, not	discontent (not content)	
e-	out of, from	eject (throw out)	
ex-	out of, from	exclude (leave out)	
hyper-	over	hyperactive (overactive)	
hypo-	under	hypodermic (below the skin)	
inter-	between	interconnected (connected between)	
il-	not	illegal (not legal)	
im-	not	impossible (not possible)	
im-	into	imbibe (drink in)	
in-	not	indiscreet (not discreet)	
in-	into	ingest (take into the body by mouth)	
ir-	not	irrational (not rational)	
mal-	bad, evil	malign (speak badly of)	
ob-	against	obstruct (build against)	
omni-	all	omniscient (knows all)	
peri-	around	periscope (something used to view around)	
post-	after	postgraduate (after graduation)	
pre-	before	precede (go before)	
pro-	for, forward	proceed (move forward)	
re-	again, back	reconvene (get together again)	
retro-	back	retrogression (a step back)	
se-	away from	seduce (lead away)	
sub-	under	subhuman (below human)	
sur-, super-	over, above	supersonic (above sound)	
sym-, syn-	together, with	sympathy (feeling with or for)	
trans-	across	transatlantic (across the Atlantic)	

Roots

Roots are central to the meanings of words. If you familiarize yourself with some common roots, then you may be able to better recognize certain words or at least get a general feel for them. By studying the following list of roots, you will be better equipped to break down many words and make sense of them.

Below you will find a root, its meaning, a word using the root (with the definition), and a space in which you can write another word that uses the same root.

Root	*Meaning*	*Word (Definition)*	*Your Example*
ami, amic	love	amicable (friendly)	
anthrop	human, man	anthropology (the study of humanity)	
auto	self	autobiography (a biography of one's self)	
aud	sound	audible (able to be heard)	
brev	short	brief (short)	
bio	life	biography (a piece of writing about a life)	
cap	take, seize	capture (take)	
ced	yield, go	intercede (go between)	
corp	body	corporal (having to do with the body)	
cred	believe	credible (able to be believed)	
culp	guilt	culpable (guilty)	
chron	time	synchronize (set to the same time)	
crac, crat	rule, ruler	plutocracy (governance by the wealthy)	
dic	speak, say	malediction (a curse)	
duc, duct	lead	deduct (take away—in other words, lead away)	
demo	people	democracy (governance by the people)	
equ	equal	equidistant (at the same distance)	
grad, gress	step	progression (forward movement)	
graph	writing, printing	autograph (a signature)	
ject	throw	inject (put in)	
luc	light	elucidate (shed light on something)	
log	study of	geology (the study of the earth)	
mono	one	monotone (all the same color)	
man	hand	manual (something done with the hands)	

Root	*Meaning*	*Word (Definition)*	*Your Example*
min	small	miniscule (very small)	
mit, miss	send	emit (send out)	
mort	death	mortal (able to be killed)	
mut	change	mutate (change)	
nym	word or name	pseudonym (a false name)	
nov	new	renovate (redo, make new)	
pac	peace	pacify (calm down)	
pel, puls	push	compel (make a person do something)	
pot	power	potent (powerful)	
port	carry	portable (able to be carried)	
path	feeling	apathy (a lack of feeling)	
phil	lover of	philosopher (a lover of wisdom)	
quer, quis	ask	query (ask)	
scrib	write	manuscript (something written)	
sed	sit	sedentary (stationary)	
sens	feel	sensory (having to do with the senses)	
sequ	follow	sequel (something that follows another thing)	
son	sound	sonic (having to do with sound)	
tang, tact	touch	tangible (able to be touched)	
vac	empty	vacant (empty)	
ven	come, go	intervene (go between)	
ver	truth	verify (prove true)	
vert	turn	introvert (a person focused inward)	
vit	life	revitalize (fill with energy, life)	
voc	call	convocation (when many people are called together)	

Suffixes

Suffixes come at the end of words and usually change the part of speech (noun, adjective, adverb, and so on) of words, which also subtly changes the meaning. Becoming familiar with suffixes may help you get a sense of the meaning the word is conveying, even if you are not sure of what the definition of the word is exactly.

The word *sedate* means to calm or relax. The following sentences contain words that are made up of the root word *sedate* with different suffixes attached to the end:

> The doctor prescribed a sedat*ive* (something that sedates) to calm her nerves.
>
> The speech was delivered sedate*ly* (in a sedate manner).
>
> The dog was under sedat*ion* (in a state of sedation) for the long trip.
>
> Many office workers live a sedent*ary* (non-active) lifestyle.

As you can see, in each of the sentences, the word *sedate* means generally the same thing, but the part of speech changes. However, you can get a sense of how the word changes if you know what the suffixes mean.

What follows is a list of common suffixes that you may encounter at the ends of certain words. Try applying theses suffixes at the ends of words you know (or words from the lists above) to see how the part of speech or the meaning of the word changes.

Suffix	***Meaning***	***Your Example***
-able, -ible	capable of or susceptible to	
-ary	of or relating to	
-ate	to make	
-ian	one relating to or belonging to	
-ic	relating to or characterized by	
-ile	relating to or capable of	
-ion	action or condition of	
-ious	having the quality of	
-ism	quality, process, or practice of	
-ist	one who performs	
-ity	state of being	
-ive	performing or tending to	
-ize, ise	to cause to be or become	
-ly	resembling or in the manner of	
-less	without	
-ment	action or process or the result	
-ology	study of	
-y, -ry	state of	

Strategies for Scoring Well

In the ASVAB test, you are not penalized for incorrect answers, so it is to your benefit to answer ALL of the questions, whether you are sure of the answer or not. Do your best to eliminate one or two of the answers and then take your best guess, or you can take a random guess—just be sure to answer all of the questions!

That said, you should also try some of the following test-taking strategies to help you through the Word Knowledge section:

- **Do not panic.** At first, all of the questions and words may seem confusing or overwhelming. But if you relax, take a few deep breaths, and focus, you will be much more mentally equipped to handle the test.
- **Do not look at the multiple choices at first.** Try to see if you can come up with your own synonym or definition. You may find that you already know the answer before looking at the choices!
- **Read the word and mentally sound it out.** Are there roots or prefixes you recognize? Does the word seem to have a negative or positive "feel" (sometimes you have to use your instincts!)? Does it sound like any other word you have heard before?
- **Try putting the word in a sentence.** Even if the sentence seems ridiculous, by putting the word in a context you may recognize the meaning. Have you heard this word before? In what context was it used?
- **Eliminate one or two choices immediately.** It is a general rule of most multiple-choice test makers to offer one or two choices that are clearly wrong, one choice that seems possible, and one that is the correct choice. When it comes to deciding between the two "possible" answers, you must replace the word in the question with both choices. For word-in-context questions, try out both possible words in the sentence to see which one "feels" more appropriate.
- **Don't spend too much time on one question.** Every question is worth the same number of points, so move on if you are stuck. You can go back. Go through the section answering the questions that come easily to you and then return to tackle the more difficult questions later.

Word Knowledge Practice Questions

1. **Graphic** most nearly means

   A. unclear.
   B. detailed.
   C. large.
   D. childish.

2. **Indispensable** most nearly means

   A. trashy.
   B. ridiculous.
   C. necessary.
   D. uninvited.

3. **Concoct** most nearly means

A. make up.
B. throw away.
C. go through.
D. walk around.

4. **Degradation** most nearly means

A. happiness.
B. anger.
C. celebration.
D. poverty.

5. **Contradict** most nearly means

A. talk about.
B. see the future.
C. fall down.
D. be opposed to.

6. The girl **emitted** a shrill scream at the sight of the realistic Halloween decorations.

A. hid
B. hoped for
C. let out
D. kept in

7. The mother could not sleep all night because of her newborn baby's **incessant** crying.

A. loud
B. nonstop
C. angry
D. sorrowful

8. **Sequentially** most nearly means

A. sensibly.
B. randomly.
C. in order.
D. out of order.

9. **Culprit** most nearly means

A. a shy person.
B. a shallow waterway.
C. the guilty party.
D. the most qualified person.

10. **Omnipotent** most nearly means

A. all-knowing.
B. all-seeing.
C. all-hearing.
D. all-powerful.

11. **Submissive** most nearly means

A. meek.
B. not intelligent.
C. kind.
D. strong.

12. The couple held **disparate** opinions on every topic.

A. selfish
B. loving
C. humorous
D. different

13. My boss often speaks to me in a **condescending** manner.

- **A.** thoughtful
- **B.** mysterious
- **C.** silly
- **D.** snobbish

14. **Demeaning** most nearly means

- **A.** boring.
- **B.** humiliating.
- **C.** colorful.
- **D.** ignorant.

15. **Fluctuate** most nearly means

- **A.** remain the same.
- **B.** follow a downward course.
- **C.** follow an upward course.
- **D.** change.

16. **Renovate** most nearly means

- **A.** destroy.
- **B.** restore.
- **C.** return.
- **D.** go around.

17. Why do songs **evoke** such strong emotions in certain people?

- **A.** hold back
- **B.** make fun of
- **C.** call out
- **D.** change

18. The main challenge of the hike was to **circumvent** the large mountain.

- **A.** get over
- **B.** go under
- **C.** get through
- **D.** get around

19. **Intercede** most nearly means

- **A.** bring something to an end.
- **B.** act as a judge.
- **C.** act as mediator.
- **D.** laugh at something.

20. **Validate** most nearly means

- **A.** make better.
- **B.** make worse.
- **C.** make different.
- **D.** make authentic.

21. **Equity** most nearly means

- **A.** injustice.
- **B.** same distance.
- **C.** fairness.
- **D.** different sizes.

22. **Culmination** most nearly means

- **A.** the beginning of a project.
- **B.** the end result.
- **C.** the process.
- **D.** the idea behind a project.

23. In **hindsight**, Mary realized that driving over the drawbridge was a bad idea.

A. watching from above

B. seeing through a haze

C. perception after the fact

D. looking around

24. A mother's love **transcends** time.

A. skips

B. stops for

C. crosses

D. grows with

25. Hockey games tend to **incite** violence.

A. stir up

B. maintain

C. discourage

D. like

26. The mayor **recanted** his troubling statement.

A. stood by

B. took back

C. was confused by

D. repeated

27. The dog's **fixated** gaze was on the hamburger.

A. unaware

B. interested

C. hungry

D. stuck

28. **Sonic** most nearly means

A. relating to the sun.

B. relating to the moon.

C. relating to sound.

D. relating to the earth.

29. **Assimilate** most nearly means

A. take in.

B. make fun of.

C. rob of.

D. ignore.

30. The team made a **concerted** effort to win the baseball game.

A. separate and disinterested

B. combined and determined

C. fast and efficient

D. slow and painful

31. In many reality-television shows, contestants are encouraged to form **alliances**.

A. groups that share the same goals

B. groups that constantly argue

C. groups that trick each other

D. groups that hate each other

32. **Ambiguous** most nearly means

A. small.

B. certain.

C. bitter.

D. unclear.

33. **Facilitate** most nearly means

A. make easy.
B. make new.
C. make difficult.
D. make different.

34. **Tactile** most nearly means

A. airy.
B. strategic.
C. concrete.
D. sweet.

35. **Benign** most nearly means

A. behind.
B. above.
C. outside.
D. kind.

Answers and Explanations for Practice Questions

If the underlined word from the question contains a clearly recognizable root or prefix, it is noted in parentheses within the explanation.

1. **B.** *Graphic* (*graph = written or drawn*) means *described in vivid detail* or *clearly drawn out,* so *detailed* would most closely mean graphic.
2. **C.** *Indispensable* literally means *not dispensable* (able to be thrown away). So if something is indispensable, it is necessary; you cannot do away with it.
3. **A.** *Concoct* means *to create* or *make up,* like in the sentence "The two boys concocted a plan to skip school."
4. **D.** *Degradation* is a *state of poverty or squalor.* Using its prefix and root, you can come up with "a step down" (*de = down, grad = step*).
5. **D.** *Contradict* means to *go against,* as in "Joe's statement that he didn't eat the last slice of pie is contradicted by the empty pie plate." You may have been able to use the roots to help you decipher the meaning (*contra = against, dict = speak*).
6. **C.** *To emit* is *to send out* (*e = out, mit = send*) or *let out.*
7. **B.** *Incessant* (*in = not, cess = end*) means *not ceasing, never ending, not stopping.*
8. **C.** *Sequentially* means *items are arranged in order* or *in a sequence* (*sequ = follow*).
9. **C.** The *culprit* is *the person who is guilty* (*culp = guilt*).
10. **D.** *Omnipotent* means *all-powerful* (*omni = all, pot = power*).
11. **A.** A *submissive* (*sub = under, miss = send*) person is one who is *meek and passive,* not aggressive.
12. **D.** *Disparate* means *opposing* or *different.*

13. **D.** *Condescend* means *to go down to the level of someone inferior* (*con = with, descend = down*); therefore, a condescending manner can be *snobby.*
14. **B.** Something that is *demeaning* (*de = down*) is something *that puts one down* or *is humiliating*.
15. **D.** *Fluctuate* (*fluc = change*) means *to change, to go up and down, to not be constant.*
16. **B.** *Renovate* means *to restore* or *to make new again* (*re = again, nov = new*).
17. **C.** *Evoke* means *to call out* (*e = out, voc = call*).
18. **D.** *Circumvent* means *to go around* (*circum = around, vent = go*).
19. **C.** *Intercede* means *to go between* (*inter = within, ced = go*) or *to mediate.*
20. **D.** *Validate* means *to make authentic or lawful,* in other words, *to show the validity of something.*
21. **C.** *Equity* means *fair and just treatment to something or someone.*
22. **B.** *Culmination* means *the coming together of all parts resulting in the end,* thus *the end result.*
23. **C.** *Hindsight* is *looking back after the fact.*
24. **C.** *Transcends* (*trans = across*) means *crosses over.*
25. **A.** *Incite* means *to cause, provoke,* or *stir up.*
26. **B.** *Recant* means *to take back.*
27. **D.** *Fixated* means *to be obsessed with* or *stuck on.*
28. **C.** *Sonic* means *relating to sound* (*son = sound*).
29. **A.** *Assimilate* means *to absorb* or *take in.* If a group of individuals successfully assimilates, then they have converged and incorporated into one group.
30. **B.** *Concerted* (*con = with*) means *determined and together.*
31. **A.** *Alliances* are *groups that share the same goal;* people in an alliance are *allies.*
32. **D.** *Ambiguous* means *not certain, something that could go either way, vague* or *unclear.*
33. **A.** *Facilitate* means to *make able to do* (*fac = do, ate = to make*) or *to make easy.*
34. **C.** *Tactile* means *solid or concrete.*
35. **D.** *Benign* (*ben = good*) means *kind* or *good, not evil.*

Paragraph Comprehension

The Paragraph Comprehension section of the ASVAB is designed to measure your ability to understand what you have read and your ability to obtain information from written passages. This section has 15 questions based on 15 or fewer short passages. One or more multiple choice questions follows each passage. The test asks you to select the best answer that completes a statement or answers a question.

Understanding what you read requires two skills. The first skill is the ability to understand exactly what the passage says. Questions about understanding may ask you to identify facts stated in the passage, or to identify facts from the passage that the question presents in different words. When the same idea or fact is presented in different words, it is known as a paraphrase. You will need to be able to recognize paraphrases. Some of these questions require you to understand the meaning of a word from the passage in which it appears. This skill means you can understand words in context. A third type of literal comprehension question asks you to determine in what order events described in a passage happened.

The second skill for paragraph comprehension requires you to analyze what you have read. One kind of question asks you to identify the main idea of a passage. Another kind asks you to draw a conclusion from the information that the passage presents. This skill requires you to infer something that is not directly stated but that is implied by the content of the passage. Other types of questions ask you to think about how the passage is written. What is the purpose of the passage? What technique of organization or structure did the author use to write the passage? What mood or tone does the passage reflect?

The ASVAB has 15 Paragraph Comprehension questions. You will have 13 minutes to answer these questions.

Test-Taking Strategies

The test requires that you answer 15 questions in a 13-minute period. You should not need to read the directions because you are familiar with them from this chapter. You cannot spend a long time on any single question. If one of the answers immediately appears to you to be correct, quickly check the passage to see if your answer is accurate, and select that answer on the answer sheet. If you are not certain which answer is correct, first eliminate choices which you are sure are not correct. Then glance at the passage and decide which of the remaining possibilities is the best answer. If you find that the question is difficult to understand and do not have any idea about which answer is correct, go on to the next question. Return to the difficult questions after you have completed as many of the other questions as you can.

Be sure that you base your answers **only on the information that is given in the passage.** Sometimes you may have more information about a subject than is given in a passage. You may find a statement in a passage that you do not think is correct. But this section tests your reading ability, not your general knowledge about the subject of the passage. Do not choose an answer that you think is correct based on what you know about the subject of the passage. Only choose answers that are based on information in the passage.

Some test takers find it helpful to read the question before reading the passage. As you work on the practice questions in this chapter, try that method, as well as the method of reading the passage first and then the question. You should be able to decide which of these two methods makes it easier for you to determine the correct answer.

A sure way to do well on this section is to improve your general reading ability. Reading teachers agree that the best way to improve reading skills is to read as much as possible. The passages on this test use the kind of information that you are likely to find in newspapers and magazines as well as in books. Practice in reading all three kinds of reading material will be helpful when taking this test.

Kinds of Questions

In this part of this chapter, you can find samples and explanations of each type of question on this test. These are followed by practice questions with the answers explained.

Identifying Stated Facts

These questions require that you read carefully for facts in a passage. Do not choose an answer that adds information not contained in the passage, and be sure that your answer states all the information in the passage about the question. Look for an answer that uses exactly the same wording as a part of the passage.

A ballad is a type of poem that tells a story. It is written in groups of four lines. The lines rhyme in a set pattern. Often, ballads tell stories about death, or ghosts, or other supernatural beings. Sometimes ballads tell love stories.

To be a ballad, a poem must

A. tell a story.

B. contain a love story.

C. be only four lines long.

D. tell stories about death.

The correct answer is **A.** It is stated in the first sentence of the passage. Choices **B** and **D** are only sometimes true of ballads. Choice **C** is not true according to the passage's second sentence.

The laws of the United States include rules and customs about the display of the United States flag. The flag should be displayed only from sunrise to sunset. It may be displayed at night if it is lighted so that it can be seen. It should be displayed at or near every place where voting is held on election days. It should never touch the ground or the floor. It should never be used for advertising purposes.

The flag should never be displayed

A. from sunrise to sunset.

B. at night.

C. above the ground or floor.

D. for advertising purposes.

The correct answer is **D.** It uses the same words that appear in the passage. You probably have seen advertisements that show the American flag. But according to the passage, those advertisements violate rules about the display of the flag. Choices **A** and **C** state the opposite of what the paragraph says. The third sentence says the flag "may" be displayed at night, so **B** is not a correct choice.

Identifying Reworded Facts

When you answer these types of questions, look for information in the answer that states the same facts that the passage states, even though the wording is different. The answer means the same thing as the statement in the passage, even though the words are not exactly the same.

In certain areas, water is so scarce that every attempt is made to conserve it. For instance, on an oasis in the Sahara Desert the amount of water necessary for each date palm has been carefully determined.

How much water is each tree given?

A. no water at all

B. water on alternate days

C. exactly the amount required

D. water only if it is healthy

The correct answer is **C.** The passage states "the amount of water necessary for each date palm has been carefully determined." "The amount required" means the same as "necessary."

Liaison can refer to a person who communicates information between groups. The press secretary to the President of the United States is a *liaison* between the President and journalists. A manufacturing engineer is a *liaison* between a product's designers and the workers involved in making the product.

The word *liaison* means someone who

A. argues for a point of view.

B. analyzes political issues.

C. helps groups understand each other.

D. designs products.

The correct answer is **C.** The phrase "communicates information between groups" means a way of helping them understand each other. **A** is not correct because it states the *liason* only represents one point of view. Choices **B** and **D** are suggested by the examples in the paragraph, but they do not define *liaison*.

Determining Sequence of Events

The sequence of events means the order in which events occur. When a question asks about the order of events, look for key words that tell about time. These are words and phrases that you are familiar with such as "soon," "then," "before," "after," "later," "next," "previously," "lastly," "to begin," "in a little while," "shortly," and "after an hour." These key words in the passage point to the answer to the question.

To check the engine oil on a car, lift the hood of the car. Be sure it is propped open securely. Locate the dipstick, a rod that goes into the engine. Remove the dipstick to check the oil. Then see if the oil comes up to the line marked on the dipstick. If it does, the engine is full. Next, look at the condition of the oil. It should be light brown and clear, not dark or gritty looking. After replacing the dipstick, add or change oil if necessary. Finally, close the hood, and you're ready to drive.

After removing the dipstick,

A. see if the engine is full.

B. check the condition of the oil.

C. replace the dipstick.

D. close the hood.

The correct answer is **A.** According to the passage, this is the first thing to do after removing the dipstick. Choices **B, C,** and **D** are introduced by "next," "after," and "finally" words showing these acts occur later in the order of events.

> Antarctica is now a continent of ice and rocks. It was not always so. Millions of years ago, Antarctica, South America, Australia and New Zealand formed a supercontinent near the equator. Then moving oceanic plates began to split the supercontinent apart. First, Antarctica, still attached to Australia, drifted south. Later, Antarctica separated from Australia and moved further south until it rested over the South Pole.
>
> When did Antarctica come to rest over the South Pole?
>
> **A.** When it was part of a supercontinent
>
> **B.** When it was attached to Australia
>
> **C.** After it began to drift to the south
>
> **D.** After it separated from Australia

The correct answer is **D.** According to the passage, choices **A, B,** and **C** list events that occurred before Antarctica came to rest over the South Pole.

Identifying Main Ideas

The main idea of a paragraph is a general statement that tells what the passage says. The main idea is a broad general statement. The other information in the paragraph is specific, providing support for the main idea by explaining the main idea or giving details and examples to illustrate or prove it. An example of a general statement would be a sentence like "Green vegetables provide nutrients necessary for good health." Specific details supporting this could be "spinach contains iron," and "broccoli has large quantities of B vitamins."

Sometimes the main idea of the paragraph is stated. A stated main idea is called the paragraph's topic sentence. This most often is the paragraph's first sentence, but the main idea can also be stated at the end of the paragraph. It is unusual for the main idea to be stated in the middle of a paragraph, but sometimes a paragraph is written that way.

When a question asks you to identify a paragraph's main idea, the correct answer may present the main idea in slightly different words than those used in the paragraph.

Sometimes a writer chooses not to write a sentence stating the main idea. If so, the reader must decide what the main idea is by figuring out what general statement could be made by adding up the specific information in the passage. When you do this, you are inferring the main idea.

In the fifty years between the end of the Civil War and the beginning of World War I, the United States changed from a rural nation to a power in the modern world. The country expanded to include all the territory between the Atlantic and the Pacific oceans. The population grew, partly as a result of immigration. The economy became increasingly industrial. Increased production of goods led to more trade with other nations.

The main idea of this passage is that

A. immigration increased the country's population.

B. international trade increased.

C. the country became a powerful modern nation.

D. the country's territory expanded.

The correct answer is **C.** It is a general statement. All of the other choices are specific details that demonstrate the growth of the country.

Toothpaste can be used to clean chrome faucets and make them shiny. A few tablespoons of white vinegar mixed with water in a spray bottle create an excellent cleaner for windows or mirrors. And wet tea leaves will take the sting out of a burn.

The main idea of this paragraph is

A. some ordinary products have surprising uses.

B. cleaning products don't have to be expensive.

C. vinegar and water mixed create a glass cleaner.

D. tea is a refreshing beverage.

The correct answer is **A.** The three sentences in the paragraph are examples of the general statement that **A** makes. Choice **B** describes an idea that the first two sentences of the paragraph imply, but it does not apply to the third sentence. Choices **C** and **D** are specific details, not general statements, and while **D** may be true, the paragraph does not state this idea.

Drawing Conclusions

These questions ask you to decide what you can conclude from information that is in the passage, although the passage does not directly state a conclusion. You can infer the conclusion from the information in the passage. The passage presents separate pieces of information, and drawing a conclusion requires that you see what these pieces of information imply. The passage does not tell you what the answer to the question is. Whatever is directly stated in the passage is not a conclusion. You determine the conclusion based on the logical relationships of information in the passage.

> Twenty-five percent of all household burglaries can be attributed to unlocked windows or doors. Crime is the result of opportunity plus desire.
>
> To prevent crime, it is each individual's responsibility to
>
> **A.** provide the desire.
>
> **B.** provide the opportunity.
>
> **C.** prevent the desire.
>
> **D.** prevent the opportunity.

The correct answer is **D.** The first sentence states twenty-five percent of burglaries result from leaving doors and windows unlocked. This is an *opportunity* for burglars. The second sentence tells you that crime is made up of not only opportunity but also the criminal's *desire* to commit a crime. Choice **B,** providing opportunity, is the opposite of preventing crime. Choices **A** and **B** are actions an individual cannot be responsible for in another person. The only logical conclusion, therefore, is that individuals can help to prevent crime by preventing the opportunity.

> In a survey taken in July of residents of Metropolis, 44% approved of the mayor's job performance, 52% disapproved, and 4% had no opinion. In a similar survey one year ago, 51% approved, 39% disapproved, and 10% had no opinion.
>
> Based on this information, you can conclude
>
> **A.** the mayor's popularity increased.
>
> **B.** the mayor's popularity decreased.
>
> **C.** the mayor took an action the residents did not like.
>
> **D.** the mayor took an action the residents approved of.

The correct answer is **C.** Choice **A** contradicts the statistics in the passage. Choice **B** states in different words facts given in the passage about the change in the mayor's approval rating, but is not a conclusion. You can logically conclude there was a cause for the change. Since the approval rating declined, the cause would have to be an action the residents did not like.

Determining Purpose

Questions about purpose ask you to decide what the passage aims at or intends to do. A paragraph may be written to provide information or explanations. The reader thinks "now I know something I didn't know before." The passage may give directions or instructions. The reader learns how to do something. It may wish to persuade the reader to agree with what it says. A reader may agree or disagree with the main idea of the passage. This kind of writing is known as an argument.

In determining the purpose of a passage, consider how the sentences relate to each other. If the passage provides reasons for agreeing with a statement, it is probably an argument. If the sentences list a series of steps occurring in a process, the passage usually gives instructions. If the sentences present a series of facts, the passage's purpose is to inform or explain.

This medicine may be taken on an empty stomach or with food. Do not drive a car or operate heavy machinery after taking this medication because it may make you sleepy. Take one pill each morning until all the pills have been taken. If you forget to take a pill, do not take two pills the following day.

The purpose of this passage is to

A. argue against taking two pills in one day.

B. explain how the medicine may affect you.

C. give instructions about how to take the medicine.

D. inform the reader how the medicine will help cure symptoms.

The correct answer is **C. A** is not correct because "do not take two pills" is not an idea you can agree or disagree with. Although the passage says the medication may make you sleepy, the rest of the passage does not explain how the medicine may affect you, so **B** is not a correct choice. **D** is incorrect because nothing in the passage discusses how the medicine works.

As far as genes are concerned, those of chimpanzees and human beings are nearly 99% identical. The bonobo, a species related to chimpanzees, also has this genetic similarity. The genes of monkeys and orangutans are not as similar to human genes. Scientists are trying to find out which genes differ in humans and chimpanzees and how they are different.

The author of this passage wants to

A. inform readers about animal and human genes.

B. explain why chimpanzee and human genes differ.

C. argue for learning about genes.

D. argue against experiments using animals.

The correct answer is **A. B** is incorrect because the paragraph does not state the causes for the differences, so it does not explain why the genes differ. The passage does not give reasons for learning about genes. Therefore, **C** is incorrect. **D** is incorrect because the passage does not say anything about experiments on animals.

Identifying Technique

Authors can organize a brief passage or paragraph using different techniques. Questions about technique ask you to identify the basis of the passage's structure. Key words connecting sentences in the passage can help you to identify its technique.

If a passage tells a story of events in time order, using words or phrases like "first," "soon after," "then," "next," or "after a few minutes," its structure is based on narrative technique. Some paragraphs use description. What is known through the five senses makes up the passage's content. Descriptive paragraphs use the technique of organizing details spatially. Words and phrases like "on," "next to," "in front of," "over," "under" and "to the right (or left)" are what you can expect to see in paragraphs that organize details spatially.

Paragraphs that show how things are similar use comparison as a technique. Paragraphs that show how things are different use contrast as a technique. Some paragraphs use both comparison and contrast. Words and phrases like “similarly,” “also,” “likewise,” and “in the same way” show comparison. “But,” “yet,” “however,” and “on the other hand” indicate contrasts.

Paragraphs based on cause give information about why things, events, or ideas happen. Paragraphs based on effects give information about the results of events or ideas. Some paragraphs discuss both causes and effects. Words and phrases like “because,” “for this reason,” and “since” show organization based on cause. “As a result,” “so,” “therefore,” “thus,” and “consequently” indicate effects.

Today’s professional golfers often hit the ball farther than golfers did in the past. One reason is that they spend time physically conditioning themselves. Therefore, they are strong. Golf clubs made of materials developed for modern technology are light, so they are easy to swing. Using computers, engineers design the surface of golf balls to make them travel great distances in the air.

The organizing technique of this paragraph is best described as

A. comparison and contrast.

B. description.

C. narration.

D. cause and effect.

The correct answer is **D.** Although the first sentence is a comparison, the rest of the paragraph gives reasons that the ball is hit farther and shows how these causes produce the effect of greater distance.

The Boston Tea Party was not the first protest against British taxes by the American colonists. A tax had been placed on sugar in 1764. Then, in 1765, the Stamp Act taxed legal documents and newspapers. These taxes were removed after the colonists stopped buying British goods. Two years later, the British put new taxes on lead, paper, glass, and tea. After further protests, all but the tax on tea were removed. Finally, in 1773, the colonists tossed boxes of tea overboard from ships in Boston Harbor to protest this tax.

The organizing technique of this paragraph is

A. description.

B. contrast.

C. narration.

D. cause and effect.

The correct answer is **C.** The first date mentioned is 1764, and the last is 1773, so time has passed. Time indicators like “then,” “after,” and “two years later” confirm that the passage’s technique is narration.

Determining Mood and Tone

The mood and tone of a passage consist of the emotions that its content suggests. To answer questions about mood and tone, think about the words in the passage. Are they associated with things that make people feel happy, like a bright sunny day or a special birthday party? Or are they words related to events that usually make people sad, like illness or gloomy weather? Is the language strong and harsh, suggesting that the writer of the passage is angry? Are there exclamation points to indicate excitement? If the passage is a description, think about how you would feel if you were in the place being described or were watching the events described. If the passage describes a person, what facts about that person indicate how the person feels?

Through the open window, she saw that the tops of the trees were breaking out in little green buds, which would soon be leaves. The rain had cleaned the air, and she felt a warm breeze signaling the end of winter. Patches of blue sky showed through the clouds, and she heard birds singing.

The mood of this passage could best be described as

A. fearful.

B. hopeful.

C. disgusted.

D. comical.

The correct answer is **B.** The clean air, the green buds, the blue sky, the warm air, and singing birds are all descriptive details connected to springtime. Spring is the season when things that have stopped growing during the winter begin to grow again, so it is associated with life and hope. While the passage is happy, it is not funny, so **D** would not be a good answer.

It was a dark and stormy night. The rain rattling on the roof sounded like skeletons dancing. Then I heard a strange sound outside the front door. What could it be? Who would go out in such a storm? I approached the door slowly, and opened it just a crack. I could see nothing. Cautiously, I opened the door another inch or two. But still I saw nothing. A gust of wind—or something—I don't know what—caught the door and opened it fully. With trembling hands, I slammed the door shut to keep out the wind.

The tone of the this passage is

A. angry.

B. frightened.

C. thoughtful.

D. unhappy.

The correct answer is **B.** Storms often create a spooky mood. Words like "slowly" and "cautiously" as well as the description of the sound of the rain and being unable to see anything when the door is opened add to the tone of fright. The speaker's trembling hands in the last sentence also indicate fear.

Paragraph Comprehension Practice Questions

1. In January 2002, a person buys a car that comes with a three-year or 36,000-mile free replacement guarantee on the engine and transmission. In June 2005, the car has 34,300 miles on it. The transmission fails.

   According to the situation described in the paragraph, the car dealer will

   A. put in a new transmission.
   B. give the person a new car.
   C. not fix the transmission at no cost.
   D. not replace the car's engine.

2. A sonnet is a specific type of poem. It has 14 lines. The lines must rhyme in a set pattern. Sometimes, the last six lines of a sonnet contrast with the first eight lines. Many sonnets are love poems.

   To be a sonnet, a poem must

   A. be a love poem.
   B. present a contrast.
   C. have fewer than fourteen lines.
   D. rhyme in a specific way.

3. When many people want to buy a product, the price will probably go up. In the summer, Americans travel more than they do at other times of year. They may take planes or trains, and many families drive to their vacation spots.

   From the information in the paragraph, you can conclude that

   A. gasoline prices will rise in the summer.
   B. gasoline prices will rise in the winter.
   C. gasoline prices will go down in the summer.
   D. gasoline prices will not change in any season.

4. When you send a document to someone by electronic means, you are faxing it. The word "fax" comes from the word "facsimile." Earlier ways of making facsimiles included photocopying and photographing. The oldest facsimiles were handwritten versions of original texts.

   The word "facsimile" means

   A. an electronic copy.
   B. an exact copy.
   C. any document.
   D. a photocopy.

5. The United States Supreme Court is the highest court in the nation. Its nine judges review cases from other courts. They decide if these courts have ruled in a way that agrees with the United States Constitution. But they cannot make new laws. Their decisions are based on a majority vote of the nine judges.

The main idea of this paragraph is that

A. The Supreme Court has nine judges.

B. The Supreme Court is the highest court in the United States.

C. The Supreme Court cannot make new laws.

D. The Supreme Court's decisions are based on a majority vote.

6. Most cars today have automatic transmissions. But it is useful to know how to shift gears in a car with a standard transmission. Press the clutch pedal in with your left foot. Then use the shift lever to choose the proper gear. Release the clutch pedal while gently applying pressure to the gas pedal.

The last thing to do when shifting gears is to

A. step on the gas.

B. release the clutch.

C. use the shift lever.

D. press down on the clutch.

7. Recycling household waste is very important. Space for landfills where garbage is dumped is becoming scarce. Putting waste in the oceans causes pollution. Recycling is a way for cities to make money by selling recyclable items. And recycling items helps to saves natural resources.

The author's purpose in this passage is to

A. explain what recycling is.

B. tell a story.

C. show a contrast.

D. argue for recycling.

8. Jackrabbits are not rabbits but members of the hare family. Hares are larger than rabbits, and they have longer ears. Newborn rabbits are naked and helpless, but infant hares are covered with fur and aware of their surroundings.

Hares and rabbits are contrasted by describing all of the following except

A. their size.

B. length of their ears.

C. what color they are.

D. newborn rabbits and hares.

9. Superman originated as a character in a comic book in the 1930s. Then a radio program called *The Adventures of Superman* was created. Later, Superman became part of going to the movies. Short episodes were shown each week in theaters in addition to a feature film. When television became part of American life, it, too, had a weekly program about Superman. In the 1980s several full-length films about Superman appeared.

From this passage, you can conclude

A. Superman is a great hero.

B. Superman has been popular for a long time.

C. Superman has often appeared in films.

D. Superman began in comic books.

10. People may think of pizza as a snack food. But it is nutritious. The crust, made of a kind of bread, provides carbohydrates. The tomatoes contain Vitamin C and provide fiber. The cheese is a good source of calcium that is needed for healthy bones.

Pizza is healthful because it

A. includes a good source of calcium.

B. tastes good.

C. is a snack food.

D. can be ordered in a restaurant or bought frozen to bake at home.

11. The space shuttle is coming in for a landing. Over a loudspeaker, the waiting spectators hear "STS 42 is now over Brandenburg, making its turn for the coast." They quickly stand, look up, turn their eyes skyward. They hear the sonic boom and stare at the sky even more closely. There it is! First it is only a speck. Then the crowd applauds and cheers as they see it approaching earth.

The spectators who watch the shuttle land feel

A. fear.

B. anger.

C. happiness.

D. excitement.

12. When people are in a group, they may not react to an emergency the same way they would if they were alone. One reason may be that each person thinks someone else has already done something. Or, seeing no one else speak, a person may feel nothing needs to be done. A third possibility is that the person does not want to draw attention to himself or herself.

This passage explains

A. differences between individuals and people in groups.

B. effects of being part of a group.

C. causes for behavior in a group.

D. how people react to an emergency.

13. In 1963, Martin Luther King, Jr. led a protest march in Birmingham, Alabama. Because he did not have a permit to hold the march, he was arrested. Then eight clergymen wrote a letter that was published in the local newspaper. The letter opposed protest marches as a way to end racial problems. While King was in jail, he wrote a reply to that letter. It has been reprinted many times since then under the title "Letter from Birmingham Jail."

King wrote the letter

A. before the protest march.

B. when he was arrested.

C. while he was thinking about racial problems.

D. after he read the clergymen's letter.

14. King was arrested because

A. The clergymen wrote a letter.

B. He did not have a permit to hold the march.

C. There were racial problems in Birmingham.

D. He was put in jail.

15. People sometimes say they will return back to a place they have visited. But since *return* means the same thing as *go back to,* the expression *return back* is *redundant.*

The word *redundant* could be used to describe which one of the following phrases?

A. cooperate together

B. walk slowly

C. review again

D. add information

Answers to Practice Questions

1. **C.** Because the car is more than three years old, the free replacement guarantee will not apply. **A** is not correct because it does not tell whether the customer will have to pay for the work. No information in the paragraph suggests that **B** would be what would happen. While **D** may be a true statement, the situation in the paragraph does not describe any problem with the engine.
2. **D.** Choices **A** and **B** are statements that describe some but not all sonnets according to the paragraph. **C** is incorrect because the paragraph states a sonnet has fourteen lines.

3. **A.** The paragraph states that Americans travel more in the summer. You can conclude that if they travel more, more gasoline will be used, and the paragraph states that when people want to buy more of a product, the price goes up.

4. **B.** Answers **A** and **D** are examples of facsimiles; they do not define the word. **C** is incorrect because the paragraph indicates that ways of making facsimiles are ways of making copies.

5. **B.** A main idea is a general statement. The other choices are specific facts.

6. **A.** The paragraph is written in the order of things to do, and this is the last action mentioned in the paragraph.

7. **D.** The paragraph explains why recycling is a good idea. The paragraph is not a story (choice **B**), and does not have a contrast (choice **C**). It does not tell what recycling is, so **A** is incorrect.

8. **C.** The paragraph discusses all of the other choices.

9. **B.** The paragraph discusses Superman from the 1930s to the 1980s, so one can conclude he has been popular for a long time. Choices **C** and **D** are facts stated in the paragraph. Most people would agree with choice **A,** but it is not part of the information in the paragraph.

10. **A.** It is the only choice that states a fact about why pizza is a nutritious food.

11. **D.** The details in the paragraph about standing up, staring at the sky, the exclamation "there it is," and the applause and cheering show that the spectators are excited.

12. **C.** Since the paragraph gives reasons, it is explaining causes. Although the first sentence of the paragraph is a contrast, the paragraph does not explain the contrast, so **A** is an incorrect choice.

13. **D.** Since King's letter was a reply to the clergymen, he had to have written it after he read their letter.

14. **B.** This fact is stated in the second sentence of the paragraph.

15. **A.** From the paragraph, you can infer that a *redundant* expression is one in which both words have the same meaning. "Cooperate" means "work together," so **A** is an example of a redundant expression. Choice **C** may look appropriate because "review" means look at again. But something can be reviewed more than once.

Auto and Shop Information

The ASVAB includes a section that tests your knowledge of things related to automobiles and to shop. To do well on the Auto questions, you need to understand how automobiles work, and how to fix and repair them. To do well on the Shop section, you need to know what sorts of tools are used for what purposes.

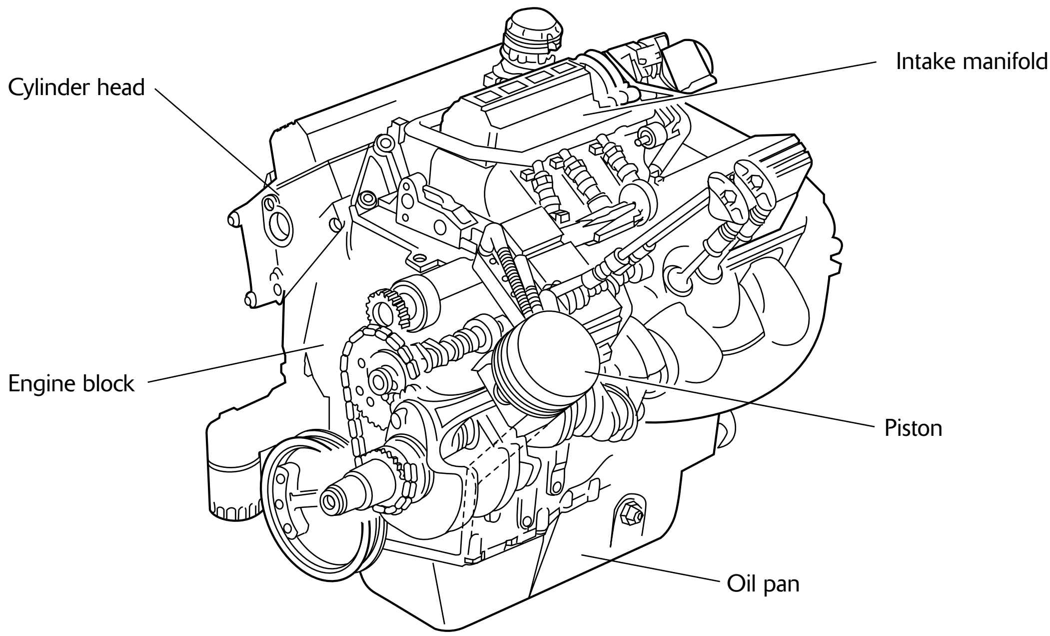
This section starts with an explanation of how automobiles work, and then goes into shop-related content.

The ASVAB has 25 Auto and Shop Information questions. You will have 11 minutes to answer these questions.

Automobile Knowledge

The Basics on Engines

The vast majority of vehicles are powered by gasoline-burning engines. Gasoline is mixed with air and burned in cylinders in an *engine block*. The engine block is generally cast of iron or aluminum. Casting is the foundry process of forming a part by pouring molten metal into a mold. All other engine parts are connected to the block.



The engine block cylinders are closed at the top by a *cylinder head*. The head is bolted to the block, forming a *combustion chamber*. In the combustion chamber, the air-fuel mixture is burned to power the engine. The combustion process is initiated by an electric spark. To a large extent, the combustion chamber's shape determines how efficiently combustion occurs. Burning the air-fuel mixture progressively and quickly makes an engine more efficient and responsive.

The cylinder head also contains passages that let the unburned air-fuel mixture into the combustion chamber, and the burnt gases back out. Cylinder heads are usually cast of iron or aluminum. Aluminum has become very popular because it's lighter and dissipates heat better. Burning fuel generates immense pressure and heat.

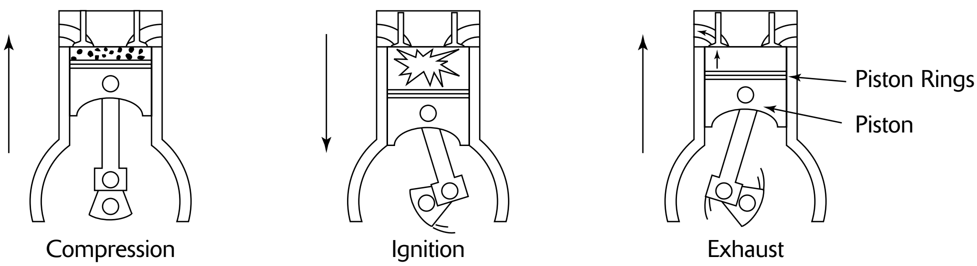
No matter how well the surfaces between the engine block and cylinder head fit together, a cylinder head *gasket* is needed to keep hot gases from escaping during combustion. Gaskets are used to seal joints between many parts of an engine against oil, water, or vapor leaks.

Getting the air-fuel mixture into the cylinder head is the job of the *intake manifold.* The *exhaust manifold* lets the burnt gases back out.

At the bottom of the engine block is an *oil pan.* The oil pan holds a gallon or more of oil that is needed to lubricate the engine's moving parts. The oil pan and the bottom of the engine block house the *crankshaft.* The base of the block and the oil pan form an area called the *crankcase.*

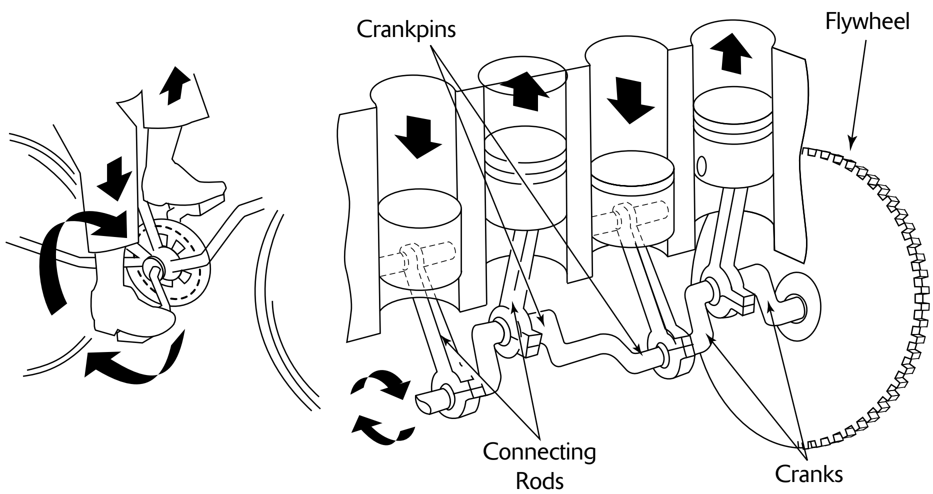
Inside each cylinder of the engine block is a lightweight aluminum alloy *piston.* A piston fits in the cylinder that is closed off at the top by the cylinder head. A piston operates similarly to a cannon. In a cannon, the combustion pressures created by a chemical explosion of gunpowder push the cannonball out at great speed. In an engine, the air-fuel mixture acts as the gunpowder, pushing the piston down. While the cannonball flies out of the cannon, the piston can't escape from the cylinder because the crankshaft pushes it back up to burn a fresh charge of air-fuel mixture. Up and down, over and over—this process is called *reciprocating motion.*

The pistons must fit tightly in the cylinders to keep the air-fuel mixture and burnt gases in the combustion chambers, but not so tightly that they can't move up and down smoothly and rapidly with minimal friction. However, no piston can fit tightly enough in the cylinder bore without help. A tight seal and free movement are made possible by the use of *piston rings* that surround the pistons and seal them against the cylinder walls.



Pistons go up and down, but cars move on rotating tires. Reciprocating motion within the engine must be turned into *rotary motion.* Think of riding a bicycle: Your legs push up and down (reciprocating motion) on pedals attached to a crank, which is attached to the bicycle sprocket (rotary motion). The up-and-down motion of the pistons turns a crankshaft in the same way that a bicyclist's legs turn a pedal sprocket.

In an engine, the pistons are attached to connecting rods that take the place of your legs. A crank pin for each connecting rod replaces the bicycle's pedals and is connected to a crank on each end. A series of crank pins, one for each piston, forms the crankshaft. The crankshaft is the engine's power output shaft.



The violent back-and-forth motion of the connecting rods and the friction from rapid rotation of the crankshaft require *bearings* between the connecting rods and the crankshaft, and between the crankshaft and the surfaces of the engine block. These bearings are made of softer metal than other parts and are lubricated with oil to help them move freely.

The crankshaft turns rapidly under normal engine operation, at times at more than 6,000 revolutions per minute (rpm). Each combustion chamber has an explosion every other rotation of the crankshaft. For a four-cylinder engine, that means there can be as many as 12,000 explosions every minute of operation. (While the engine is idling, there can be as few as 1,200.)

The explosions in the combustion chambers are evenly spaced so that power output from the crankshaft is fairly even and continuous. But smoothing out these power impulses is a major engineering concern. A heavy *flywheel* attached to the end of the crankshaft helps a lot. Because of its weight, it resists changes in speed. The fewer the cylinders, the fewer the power impulses, and the more important, and usually larger, the flywheel.

Car engines generally use four, six, or eight cylinders. One convenient way to categorize engines is by the number and arrangement of cylinders. The two most common arrangements are in-line and V configurations.

Valve Operation

Air-fuel mixture gets into a combustion chamber through round holes in the cylinder head called *intake ports.* Burnt gases leave through other round holes called *exhaust ports.* The intake and exhaust ports are opened and closed by precisely machined parts called *valves.* Most engines use one intake and one exhaust valve per cylinder.

A valve spring holds the valve closed except when the action of a *cam* forces it open. A cam is like a wheel with a bulge on it called a *lobe.* The camshaft carries one cam lobe for each valve and is turned by the crankshaft. The cam may operate the valve directly by pushing on the stem, or a rocker arm may do the actual pushing. The rocker arm may be operated either directly by the cam or by a push rod between the cam and the rocker arm.

Between the end of the push rod and the cam is a *valve lifter.* This is what is actually pushed by the cam lobe. The valve lifter is kept in contact with the push rod by hydraulic action. It is usually designed so that the end that rides on the cam is spherical.

Auto Measurements

There are many technical terms that relate to engine performance: bore and stroke, displacement, and others. Here's a brief review of what some of them mean and how they apply to an engine.

Bore and Stroke

Bore is the diameter of a cylinder, and *stroke* is how far a piston moves from its highest to lowest point. *Clearance volume* is the volume in a cylinder with a piston at top dead center. The top position of a piston is called *top dead center* (TDC), while the lowest position is *bottom dead center* (BDC). Movement of a piston from TDC to BDC, or from BDC to TDC, is the stroke. When a bore and stroke are of equal length, an engine is said to be *square. Under square* and *over square* mean the bore is smaller or larger than the stroke, respectively.

Piston Displacement

Piston displacement is the volume covered as a piston moves from BDC to TDC. *Engine displacement* is the displacement of one cylinder multiplied by the number of cylinders in the engine. Bore, stroke, and displacement can be measured in imperial or metric units, but it has become customary to state total engine displacement in metric liters. To convert liters to cubic inches, multiply the number of liters by 61.4 to get the engine's cubic inch displacement (CID).

Torque

Torque is a turning or twisting force that may or may not result in motion. Torque is applied to the lid of a jar when someone tries to open it, whether the lid comes off or not. The engine applies torque to turn the wheels of the car. Torque is measured in foot-pounds. If 50 pounds of force are applied to a crank with a 2-foot handle, then 100 ft-lb of torque will be applied to the crank (50 lb. × 2 ft. = 100 ft-lb).

In an engine, ideally a lot of torque is produced at low engine speeds to help the car move smoothly without racing the engine.

Work

Work is the movement of an object against a force. That force can be gravity, friction, or other resistance. Work is measured in terms of force and distance. If a 5-pound weight is lifted 5 feet, the work done is 25 foot-pounds (5 lb. × 5 ft. = 25 ft-lb).

Power

Power is a measure of how fast work is done. A 5-pound weight can be lifted in 2 seconds or in 30 seconds. The faster the work is accomplished, the greater the power: power = torque × speed.

The power of an engine is measured in horsepower, a unit supposedly equivalent to the power of one horse, or 33,000 foot-pounds of work per minute. If a horse, or a machine, lifts a 330-pound weight 100 feet in 1 minute, its power will equal 1 horsepower (330 lb. × 100 ft. = 33,000 ft-lb).

If torque gets a car going, horsepower keeps it going. The power output of an engine is measured in *brake horsepower* (bhp).

Engine Lubrication

If an engine is run without oil, even for a few seconds, severe engine damage can result. This is because metal should never touch metal in an engine. All moving metal parts actually ride on a thin film of oil. That film of oil is about as thick as the paper of this page.

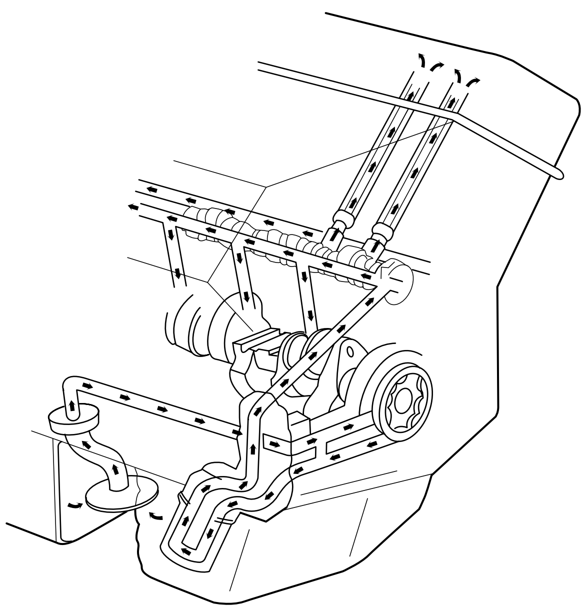
Oil does more than reduce friction. Oil acts as a coolant, absorbs shocks between bearings and other engine parts, reduces noise, and extends engine life. Oil also helps form a good seal between piston rings and cylinder walls and acts as a cleaning agent.

To do all these jobs, oil must possess a variety of qualities. The most important one is *viscosity,* or the tendency to resist flowing. Since viscosity decreases as oil's temperature increases, oil must not be too thick to properly coat parts at cold temperatures or too thin to maintain an adequate film when warm.

Viscosity of an oil is rated according to standards set by the Society of Automotive Engineers (SAE). A higher viscosity number means the oil is more viscous than oil with a lower number. A "W" after the number means the oil has been formulated for use in cold weather. Some oils have a rating such as 10W-30. The first number is the viscosity of the oil when cold. The second number is the *viscosity index,* an indication of how the oil will flow when hot.

Oil under pressure must circulate through an engine to lubricate all moving parts. An oil pump driven by the crankshaft picks up oil from the oil pan. From the oil pump, the oil first goes through a filter, then into an oil line or gallery that distributes oil to the main bearings and camshaft bearings.

The following illustration shows oil moving through an engine.



The oil flows through oil passages to all moving parts inside the block and cylinder head. Oil-feed holes and grooves in the main bearings allow oil to flow around the crankshaft and connecting rod bearings. In some engines, there's also a passage for oil to flow up the connecting rods to the piston connecting pins. Cylinder walls are lubricated by oil thrown off by the connecting rod bearings.

The valve train needs lubrication also. In some engines, oil flows up the hollow push rods to the rocker arms and valve stems. In overhead cam engines, an oil gallery runs the length of the cylinder head to lubricate camshaft bearings.

Warning Lights and Gauges

A constant flow of oil at a steady pressure is necessary for an engine to operate without severe damage. That's why the instrument panel of a car has either a warning light or a gauge that registers oil pressure. If the light comes on or if the needle falls below an indicated level during normal operation, the engine should be turned off immediately.

It is normal for the oil light to turn on for a second or two when the engine is first started. This is because it takes a moment for oil to begin to circulate and for the system to build up pressure. Until then, only a thin film of oil that didn't drain off from the previous operation coats the parts.

That's why the greatest wear on engine parts takes place during the first few seconds after starting. The system hasn't yet delivered a full supply of oil to all the parts. It is best to allow an engine to idle for 10 or 15 seconds before putting it in gear. Wait at least 30 seconds to put a car in gear during cold winter weather, because cold, thick oil takes longer to circulate.

Engine Cooling

Thousands of individual explosions, each one producing temperatures up to 6,000°F, means an engine has a lot of heat to dissipate. Some of the combustion heat leaves with the hot exhaust gases. The rest is absorbed by engine components. Petroleum-based engine oil loses most of its lubricating properties above 400 or 500°F, so cylinder-wall temperatures must stay below that level.

Small, single-cylinder engines like a lawn mower can easily be cooled by air. Most automobile engines are liquid-cooled. A water mixture called *coolant* (or *antifreeze*) circulates through passages throughout the engine. These passages are called *water jackets* and are cast in the engine block and cylinder head to absorb heat. The water jackets then pass back through a radiator to dissipate the heat into the air. A useful byproduct of this process is a supply of hot water to operate the car's heater.

The radiator provides a lot of surface area over which air can flow to cool the hot liquid inside. Pure water is not a good coolant in a radiator, although it is often used in an emergency. Pure water freezes if the temperature falls below 32°F, and expands as it becomes ice. This expansion will crack cylinder block or head castings or split radiator seams. Also, water boils at 212°F, a temperature too low for modern cooling systems. In addition, water does not inhibit corrosion within the cooling system itself.

Four-Stroke Cycle

The opening and closing of the valves by the camshaft must exactly correspond to the up-and-down movement of the piston. As mentioned earlier, the top position of a piston is called top dead center (TDC), while the lowest position is bottom dead center (BDC). Movement of a piston from TDC to BDC, or from BDC to TDC, is called a stroke.

Nearly all modern car engines work on a four-stroke cycle. The four-stroke cycle simply means that each cycle is made up of four strokes. The strokes are called the *intake stroke*, *compression stroke*, *power stroke*, and *exhaust stroke*. A running engine repeats that cycle over and over in each cylinder.

Fuel Supply

Liquid gasoline does not burn. To be used as a fuel in an engine, gasoline must be vaporized and mixed with air. Breaking down gasoline into tiny droplets to be vaporized is called *atomization,* even though the gasoline is not actually broken down into atoms, as the name might imply.

Gasoline may be vaporized by using either a carburetor or a fuel injection system. Carburetors are not often used on modern engines. A *carburetor* is a completely mechanical and somewhat crude device that uses flowing air to create a partial vacuum that draws gasoline in a fine spray from a fuel nozzle. A carburetor does not alter fuel flow very rapidly when the throttle is open or shut quickly. Also, because of its positioning on top of the intake manifold, it cannot provide an optimum fuel mixture to each cylinder. The performance and economy of a carbureted engine are lacking when compared to an otherwise similar fuel-injected engine.

Ignition

Lighting the air-fuel mixture with an electrical spark from a spark plug causes an explosion of gases and heat. In a high-speed V8 engine, there can be more than 20,000 explosions every minute of operation.

Ignition Coil

A spark plug requires a lot of volts, about 10,000, for the current to jump across the gap between the electrodes like a bolt of lightning. The volts are boosted from the battery by a *coil.* A coil increases the volts (like increasing the pressure on a hose) but reduces the amps (like decreasing the amount of water flowing through a hose).

Distributor

Each spark plug must fire at precisely the proper instant in the piston cycle. In many gasoline engines, the timing is controlled by the *distributor.* The distributor shaft is driven by the engine camshaft at the same speed. The outside terminals on the distributor cap are connected by wires to the spark plugs, while the central terminal is connected to the secondary circuit of the coil. One end of the rotor is in constant contact with the central terminal. The other end lines up with each of the side terminals in succession. As the rotor spins with the shaft, it sends high-voltage surges from the secondary circuit to the spark plugs. The rotor does not actually touch the outside terminals; the voltage jumps from the rotor as it does at the spark plug electrodes.

The rotor is attached to the distributor shaft and sends current to each spark plug in turn as it lines up with the outside terminals. Breaking the primary circuit, so that the high-voltage burst from the secondary circuit occurs just as the rotor meets each side terminal, can be done several ways. Old-fashioned ignition systems used breaker points that physically opened and closed. These breaker points wore out, causing inaccurate spark timing and requiring regular maintenance and frequent replacement. Virtually all modern cars use electronic switching systems.

If the spark plug fires too soon, detonation can occur. *Detonation* is a spontaneous explosion of some of the unburned air-fuel mixture in the combustion chamber, set off by the heat and pressure of the air-fuel mixture that has already been ignited. This detonation, or *knock,* greatly increases the stresses on an engine and may cause piston failure, as well as an objectionable noise.

Electrical System

In addition to the high-voltage ignition system, all of the lights, fans, electric motors, sound systems, and control modules of a vehicle require electric power. Modern automobiles use 12-volt systems to power all of their components and accessories.

Electricity can be made by moving a magnet within or around a coil of wire. This generates a flow of electricity in the wire. The amount of electricity can be increased by using a more powerful magnet, by moving the magnet faster, or by putting more windings in the coil.

Electricity can also be generated by a chemical reaction. As chemicals react with each other, they can cause electrons to flow between them. This is the principle behind a battery. Electrons flow through a wire just like water flows through a hose. However, there are two major differences between the flow of electricity and the flow of water. Electricity always moves at almost the same speed as light (186,000 miles per second), while water can move at any speed; and, except at very high voltages, electrons need a continuous path or they won't move at all, while water will flow from an open hose. Electrons almost always return to where they started, so the flow is circular. If the circuit is broken anywhere, the electrical flow stops. Switches operate by physically connecting and disconnecting a circuit.

Battery

A car's *battery* produces electrical current through a chemical reaction between sulfuric acid and lead. Grid plates of lead alternate with grid plates of lead oxide in a solution of sulfuric acid and water. The lead plates are linked by a wire or other conductor, as are the lead oxide plates. Separators prevent the grids from touching each other. A group of plates arranged this way is called a *cell.* When a wire connects the two sets of plates, chemical reactions take place and electrons flow through the wire from one set of plates to the other. A cell generates about 2 volts of electrical pressure. Modern car batteries link six cells to generate 12 volts. Adding more plates, or making them larger, increases the amount of electricity a battery can produce.

Batteries are rated in either amp-hours or cold-cranking amps. An amp-hour rating tells you how much electricity can be generated before all the chemicals are used up. A 60 amp-hour battery can deliver 3 amps of current per hour for 20 hours (3 amps × 20 hours = 60 amp-hours). A cold-cranking amp rating tells you how much current a battery can generate for 30 seconds at 0°F without dropping below 7.2 volts. That's a useful measure for cold-weather starting ability.

In cold weather, the chemical reactions in a battery slow down, so the battery provides fewer amps than when it's warm. Cars that have many electrical accessories, such as power windows and air conditioning, need powerful batteries.

Starting System

To start an engine, the crankshaft must be turned by an external force so the pistons and valves can begin drawing in the air-fuel mixture. A powerful electric *starter* engages the flywheel when the ignition switch is turned to the start position. The starter motor rotates the crankshaft at about 200 rpm. The starter is the largest single user of electrical energy in the car, requiring about 200 amps to crank.

Once the engine is started, the starter must disengage. Otherwise, the high rotating speeds of the gasoline engine will destroy it. A solenoid usually pulls the gear on the end of the starter into engagement with the flywheel as the starter is energized. When the ignition key returns to the on position, the current to the starter and solenoid is shut off. A spring pushes the starter gear out of engagement.

Charging System

Chemical reactions inside a battery cause electricity to flow out of it. But if an electrical current is put into a battery, the reactions will reverse and the chemicals will return to their original states. In an automobile, a *generator* (also called an *alternator*) produces electricity to recharge the battery. A generator works by spinning a magnet within a coil of wire. It is driven by a belt connected to the crankshaft pulley. The faster the engine runs, the more electricity it makes. A battery can be damaged if too much current is put back into it at once or if current is put into it when it is fully charged. A regulator, built into the generator or attached to it, prevents this overcharging.

If the generator doesn't produce enough electrical current to recharge the battery, the battery will eventually use up all its stored electricity. Starting the engine takes a lot of electricity, but as soon as the engine is running, the generator should provide more than enough power to recharge the battery. Automobiles with lots of electrical equipment need powerful generators as well as powerful batteries.

Transmissions and Axles

Transmissions

No matter how advanced any vehicle's engine is, how much state-of-the-art technology it employs, or how much horsepower it churns out, the vehicle is of little use unless you can apply that power to drive the vehicle's wheels. The transmission, axle, and all related parts are referred to as the *drivetrain.* On vehicles with manual transmissions, the drivetrain includes the clutch. The drivetrain transfers power from the engine to the front wheels, the rear wheels, or all four wheels.

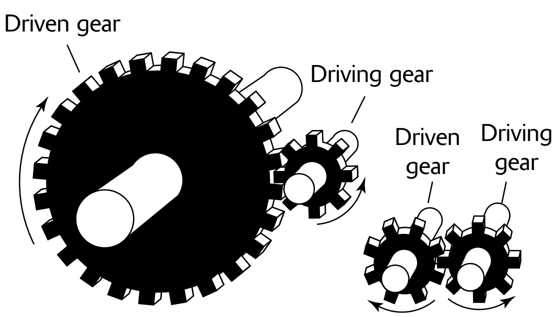
On rear-wheel-drive vehicles, the drivetrain usually consists of a *transmission, drive shaft,* and *rear drive axle.* On front-wheel-drive vehicles, the drivetrain consists of a *transaxle* that is a combination of transmission and drive axle. All-wheel-drive or four-wheel-drive vehicles send power to both front and rear axles.

The key internal components in any transmission are the gears. It takes a powerful turning force to move a vehicle. Such turning force is known as *torque.* Internal combustion engines develop very low torque at low engine speeds, far too low to supply the force needed to move a vehicle's driving wheels.

Torque Multiplication

You probably know how to use a long lever to lift a very heavy weight. This is the principle of leverage. The ratio of the length between the long end of the lever and the pivot point and the short end and the pivot point indicates how much your strength will effectively multiply. Take the simple example of a child's teeter-totter. It has levers of equal length at each end, so two children must be about the same weight to move the opposite ends of the teeter-totter up and down. The ratio of lever lengths in this case is one-to-one, usually expressed as 1:1; consequentially, the downward force and the upward force are roughly equal.

Gears are really a series of levers joined to a shaft. While a lever can move only a limited distance, a gear can turn continuously about its shaft. It can also be turned by another gear. In this case, the gear doing the turning is called the *driving gear,* while the one being turned is called the *driven gear.*



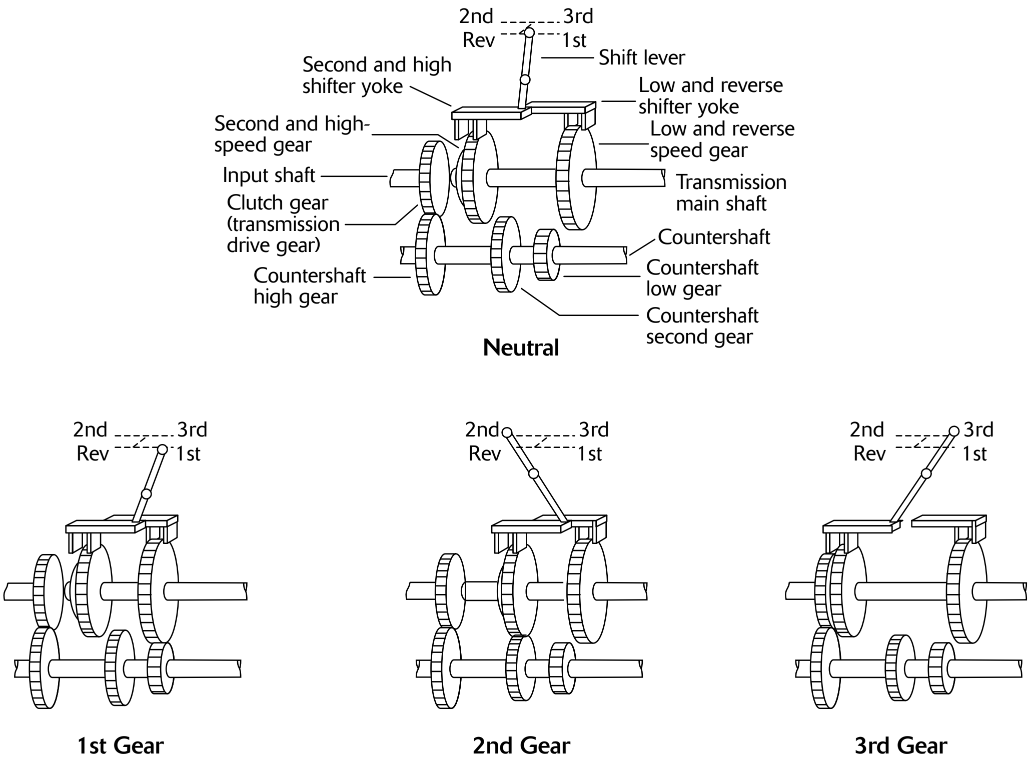
If each gear is the same diameter, each gear turns at the same speed and there is no change in torque. If a driven gear is made three times larger, then the driving gear would have to rotate three times to turn the driven gear once, and the work would be three times easier. This is called a *gear reduction,* because the driven shaft turns slower than the driving one. A transmission—manual or automatic—uses gear reduction to increase the torque of the engine so the wheels can be turned. A 3:1 gear reduction, or gear ratio, is about average for the transmission gears that get a vehicle moving.

Gear Ratio

As the vehicle goes faster, it needs less turning force, or torque, to keep it moving. To make the most efficient use of an engine, a transmission uses other gear combinations, with lower gear ratios, as the vehicle's speed increases.

For example, a 3:1 gear ratio may be used to get the vehicle going, then a 2:1 gear ratio, and finally a 1:1 ratio as the vehicle reaches highway speeds. A transmission that has three gears is called a *three-speed transmission.* Transmissions generally offer three, four, or five gear combinations, in addition to reverse. Some high-performance vehicles have as many as six speeds.

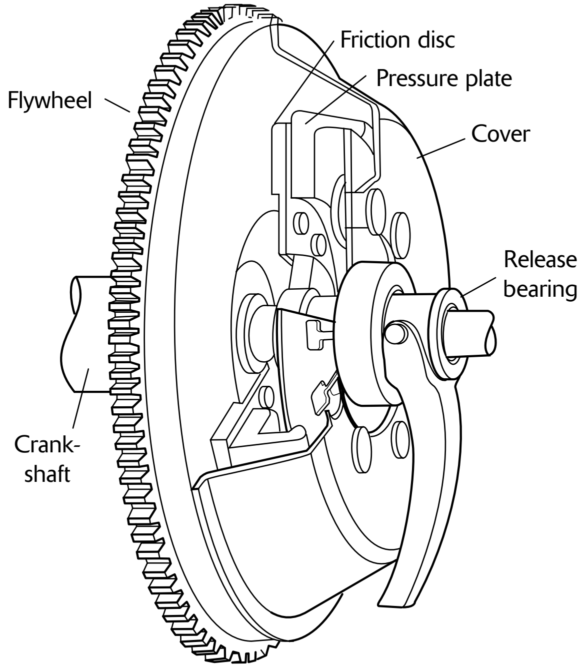
A transmission is a very simple and extremely reliable mechanical unit. For various forward gear positions, the gearshift lever acts to slide a gear or gears on the main shaft into engagement with a countershaft gear or gears.



Most automatic transmissions have a drive gear called the *overdrive gear.* The overdrive gear has a gear ratio less than 1:1; for example, 0.7:1. For each 0.7 turns of the transmission input shaft, the output shaft turns once. At highway speeds, the engine revolutions per minute (rpm) are lowered. The overdrive gear thus reduces engine wear while improving fuel economy.

Clutch

With a manual transmission, the *clutch,* shown in the following figure, connects and disconnects the engine crankshaft to the transmission.



The main components of a clutch are the *flywheel, friction disc,* and *pressure plate.* The cover and pressure plate are bolted to the flywheel, while the friction disc positioned between them is connected by an internal spline to the transmission shaft.

The clutch is disengaged when the flywheel, friction disc, and pressure plate are not contacting each other. When these components are not in contact, the engine and transmission do not transfer power to the drive wheels. When the three parts are in contact, power from the engine is delivered to the transmission, which in turn delivers power to the drive shaft, which in turn transmits power to the drive wheels.

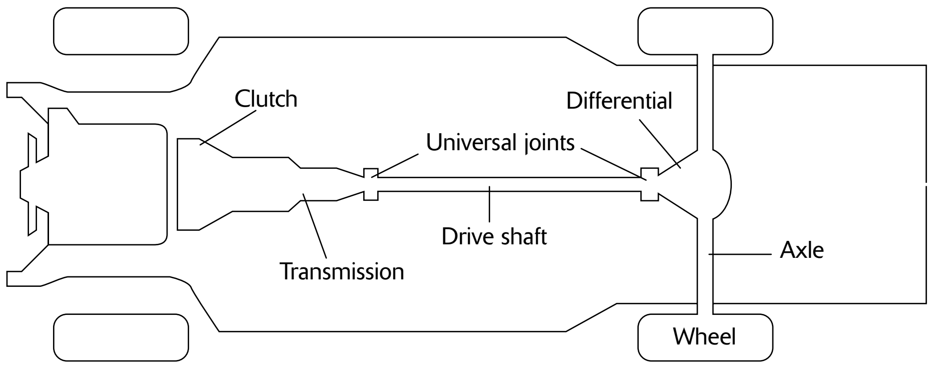
Torque Converter

Virtually every automatic-transmission vehicle today is equipped with a torque converter. The torque converter works as an automatic transmission's clutch. One side of the torque converter is attached to the crankshaft and is called the *pump* or *driving member.* The other side is linked to the transmission shaft and is called the *turbine* or *driven member.* The two sides don't touch each other. Transmission fluid, which is just a special type of oil, fills the assembly.

Drivetrain Configurations

Rear-Wheel Drive

For years, most vehicles put the engine and transmission at the front of the car, but used them to drive the rear wheels. Rear-wheel drive requires a drive shaft to transfer power from the transmission. The drive shaft has to move up and down at the axle end as the axle goes over bumps, even though the engine and transmission are bolted firmly to the frame. Universal joints at each end of the drive shaft allow rotary motion to be transferred between two shafts through varying angles.



Front-Wheel Drive

Most small to mid-size vehicles today are front-wheel drive designs. Front-wheel-drive vehicles mount the engine transversely or sideways in the engine compartment. The drive shaft is eliminated and the transmission and drive axle are combined into a single unit called a *transaxle.* Like a transmission, a transaxle may be either manually or automatically shifted. While the clutch, gearing, differential, and other drivetrain components are arranged differently in a front-wheel-drive vehicle, they operate in a manner similar to those in a rear-wheel-drive vehicle.

Turning the Drive Wheels

When a vehicle goes around a corner, its inside wheels travel a shorter distance than its outside wheels. If the drive axle is geared so that both rear wheels always turn at the same speed, one of the wheels will skid during cornering. This would make the vehicle difficult to handle, and tire wear would increase greatly.

The design of the gears inside the rear axle allow the rear wheels to rotate at different speeds while going around corners. As the inner wheels slow down during a turn, the axles' differential allows the outer wheels to speed up.

Axle Ratio

Because the drive pinion is always smaller than the ring gear, a gear reduction is also created at the rear axle. This is called the *axle ratio* and the reduction is generally between 2:1 and 4:1. The transmission ratio multiplied by the rear axle ratio gives the final drive ratio.

The important thing to keep in mind with the final drive ratio is to pick the right combination when several are available. A higher final drive ratio gives high torque and quick acceleration. A lower ratio gives lower torque and better fuel economy.

Drivetrain Advantages

Each of the types of drivetrains have distinct advantages:

- **Rear-wheel drive:** Conventional front-engine/rear-wheel drive often offers design and handling advantages in large vehicles and vehicles with very high towing capacity. It's often preferred for high-performance applications.

- **Front-wheel drive:** Front-wheel-drive vehicles with transverse engines have become almost as common as rear-wheel-drive vehicles used to be. With small and mid-size vehicles, front-wheel drive offers a number of advantages. No drive shaft or heavy rear axle and support components means less weight. The transverse engine shortens the engine compartment, leaving more room for passengers. Traction on slippery roads is improved because the weight of the engine is over the drive wheels, and the vehicle is pulled instead of pushed.
- **Four-wheel drive:** Four-wheel-drive enthusiasts have known for years that when road conditions vary, there are real advantages to having all the wheels drive the vehicle. Four-wheel-drive vehicles generally operate in two-wheel drive except when four-wheel drive is specifically selected.
- **All-wheel drive:** A useful hybrid of the four-wheel-drive system is called all-wheel drive. All-wheel drive is designed for full-time use in vehicles; engine power is sent to both the front and rear wheels. All-wheel-drive vehicles can offer superior traction in the worst driving situations, but the systems are more expensive to engineer, produce, and operate.

The Chassis

Traditionally, the *chassis* of an automobile included everything bolted to the frame except the body. With today's unibody vehicles, however, the chassis includes so much more hardware that discussions of the chassis are now usually limited to the mechanical parts that locate, isolate, support, direct, or redirect the dynamic activity of the vehicle. The front and rear suspensions and the steering and braking systems are the most important elements of the chassis.

Put simply:

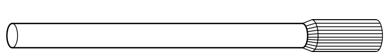
- **Suspensions** cushion a car's ride and ensure that the wheels maintain contact with the road surface when the car turns, accelerates, and brakes.
- **The steering system** moves the front wheels left or right, controlling vehicle direction.
- **Brakes** slow down and/or stop the vehicle by applying frictional pressure to assemblies in contact with the wheels.

The rest of the Auto section covers these elements in more detail.

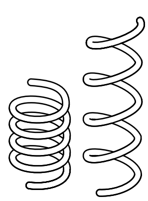
Suspensions

The Key Parts of Suspensions

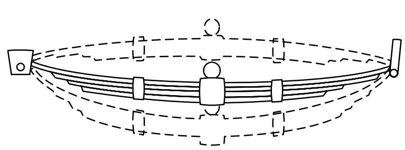
The heart of a modern vehicle's suspension is a system of springs and shock absorbers. Springs hold the vehicle up, while shock absorbers control or dampen the action of the springs. Three different types of springs are used in current car models: the *coil spring,* the *leaf spring,* and the *torsion bar.*



Torsion bar



Coil spring



Leaf spring

Coil Spring

A coil spring is constructed from a wire or metal bar wound into a coil. A coil spring will return to its original shape after it is stretched or compressed. The coil spring is the most common type of spring used in today's cars.

Leaf Spring

A leaf spring is made of layered metal or fiber-reinforced plastic strips. When the two ends of the leaf spring are fastened down, the center springs up and down. Like a coil spring, a leaf spring will return to its natural position when forces acting upon the spring stop. Leaf springs are primarily used on rear-wheel-drive vehicles.

Torsion Bar

A torsion bar is simply a coil spring that has been straightened out. The spring action comes from twisting the bar torsionally. Torsion bars are widely utilized on four-wheel-drive vehicles.

Shock Absorbers

If you've ever ridden in a car with worn-out shocks, you know that the car rolled and pitched long after the car passed by a bump. Good shocks, on the other hand, make for a smooth ride and good handling.

Shock absorbers return the suspension to its natural position quickly and smoothly. Not only do shock absorbers control the compression of the spring, they control the expansion (or rebound) as well. They do this by using fluid or gas forced through holes in the shock absorbers' pistons. The sizes of the holes determine the damping effect of the shock. As a shock absorber compresses or expands, a piston inside moves through oil or hydraulic fluid. The piston's movement is resisted by the fluid, which must pass through small holes in it. If the holes are made smaller, the shock absorber becomes stiffer, and delivers what's commonly known as a sportier ride with firmer handling characteristics.

Springs and shocks are matched with vehicle weight. Sometimes they are chosen to correspond with the weight of optional equipment added to individual vehicles as they are built. This is referred to as *computer-selected springs* or as a *tuned suspension.*

Front Suspension

The *front suspension* of any car is a critical subsystem because it performs so many vital functions. In addition to suspending the front-wheel assemblies from the frame, isolating road harshness, and handling braking and steering functions, front-wheel-drive front suspensions must control front wheels powered by the drivetrain.

Coil Springs

In rear-wheel-drive vehicles, a coil spring front suspension is the most widely used design. The coil springs are mounted on upper and lower control arms to support the vehicle's suspension.

MacPherson Struts

The *MacPherson strut* design has become popular because it takes up very little space. A MacPherson strut front suspension is a combination strut and shock absorber that's mounted inside a coil spring. The MacPherson strut replaces an upper control arm and is used in most front-wheel-drive cars as well as on some rear-wheel-drive vehicles. MacPherson struts are also used on the rear suspensions of many vehicles.

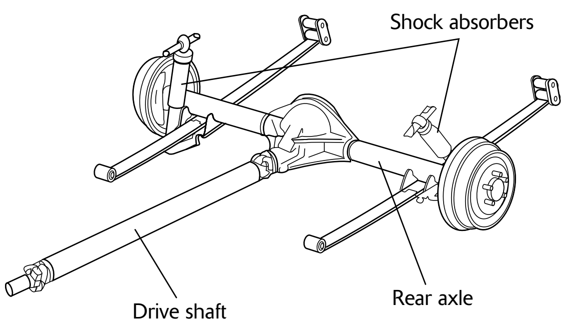
Rear Suspension

Even though the rear suspension does not have to contend with steering functions, it is still a significant part of a vehicle's suspension system. Generally, rear suspensions fall into one of three types:

- Solid axle
- Independent
- Semi-independent

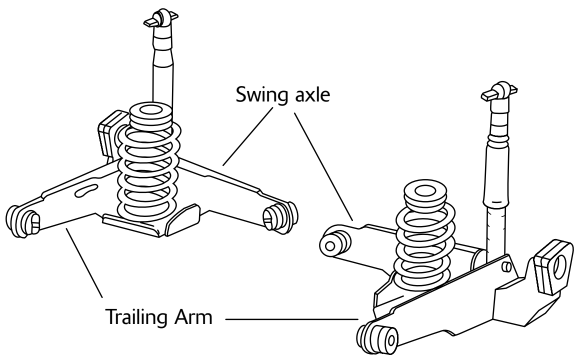
Solid Axle Rear Suspension

In a solid axle rear suspension, a solid axle is suspended and located with leaf springs. The axle can move up and down with road inconsistencies. This durable design is found on most rear-wheel-drive cars and trucks. However, as the rear wheel on one side of the axle rolls over a bump, the axle's reaction to the bump affects the wheel at the other side of the axle. The result is that vehicles with solid rear axles cannot achieve as smooth a ride as those with independent rear suspension designs.



Independent Rear Suspension

On a front-wheel-drive vehicle, an independent rear suspension is much simpler to design because there are no drivetrain components to deal with. This type of system has no physical connection between the rear wheels. Each rear wheel is mounted on a trailing arm and a short swing axle that swings down from the car body. Generally, an independent rear suspension uses a coil spring and shock absorber or MacPherson strut design. Some vehicles use transversely mounted leaf springs instead of coil springs. The independent rear suspension design provides the smoothest ride available because each wheel's action is isolated from the actions of the other wheels.

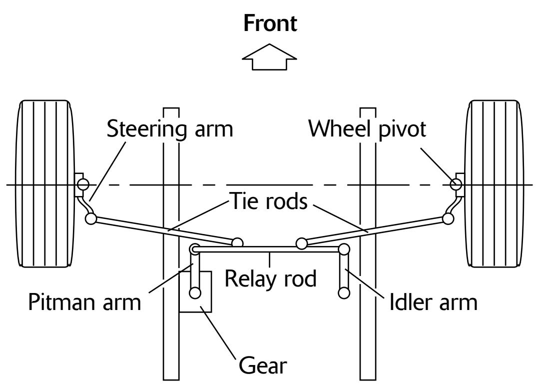


Semi-Independent Rear Suspension

Sometimes the two wheels use a cross member linking the two trailing arms for greater stability. This design is called a semi-independent suspension. To control sideways movements, a semi-independent rear suspension often uses a track bar.

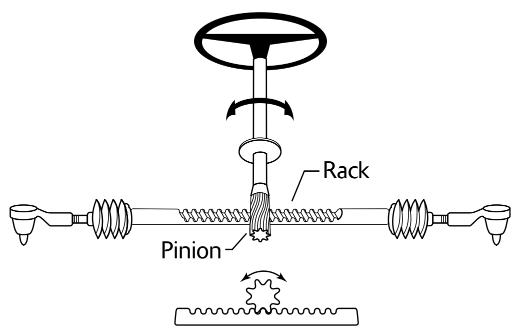
Steering Systems

The basic operation of a steering system is really quite simple. As you turn the steering wheel, it rotates a shaft connected to a steering gear. The gear moves the tie rods that are connected to the steering arms and steering knuckles.



A gear reduction in the steering gear makes turning the wheels easier.

A *rack-and-pinion steering gear* is light and compact, and it offers good steering feel. The steering wheel is attached to a pinion gear. The pinion gear interacts with a rack, and the ends of the rack are connected directly to the tie rods that turn the front wheels.



Another common type of steering gear is the *recirculating ball*. In this system a worm gear converts steering wheel movement to sector shaft movement. A pitman arm attached to the bottom of the sector shaft moves one tie rod, and an intermediate rod moves the other.

Both rack-and-pinion and recirculating ball systems offer a power-assist feature. In power steering systems, a pump is driven by a belt connected to the engine crankshaft by a pulley. The pump circulates hydraulic fluid through the steering gear. The pump does most of the work once the driver turns the steering wheel.

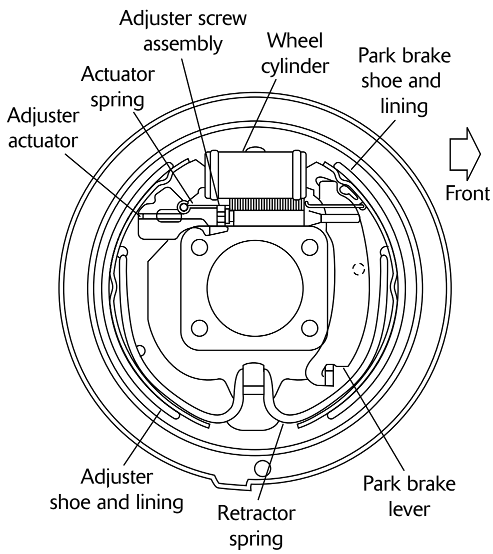
Brakes

The brake system applies friction material to parts that revolve with the wheels. The friction material slows the speed of the rotating components. Brake linings provide the friction by pressing on the drums or discs. The brake drums or discs must dissipate the heat that the friction creates, so drums are often finned or discs are vented to provide extra cooling surface.

Drum Brakes

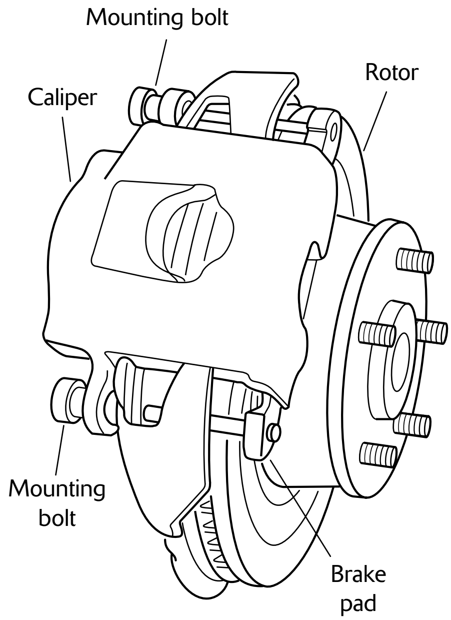
In a drum brake system, an aluminum or cast iron drum is bolted to the inside of the wheel mounting surface. Two metal brake linings (shoes) are covered with a high-friction/heat-resistant material and positioned inside the drum. It is important that the linings do not touch the drum unless the brakes are applied. A wheel cylinder contains two pistons that push on the brake linings.

When you push the brake pedal, pistons inside the wheel cylinder push on the brake linings and the brake linings push into the sides of the drum which, in turn, slows the turning of the wheels.



Disc Brakes

On disc brakes, the disc revolves with the wheel. The linings (pads) are mounted in a caliper assembly which forces the linings into contact with the disc. The linings create friction the same way drum brake shoes do. On disc brakes, a wear sensor contacts the disc when the brake linings are worn. The sensor rubbing the disc vibrates at a high pitch to warn the driver that the linings require service.



Brake System Wear

Friction means wear. All brake shoes or brake pads wear each time they are used. Virtually all braking systems are self-adjusting; they compensate for loss of lining and constantly reposition themselves to maintain the slight clearance between linings and drums or discs. Excessive clearance in the system will result in excessive brake pedal travel.

Short of actual inspection, drivers have always depended on their ears to tell them when the brake linings need replacement. By the time the sound of metal-on-metal can be heard, the discs or drums have probably been damaged.

Except for the mechanical parking brake, braking systems use hydraulic pressure from the master cylinder. The brake pedal forces brake fluid from the master cylinder through the brake lines to push on the pistons in the brake wheel cylinders or calipers.

Brake System Flushing

The entire brake hydraulic system should be flushed thoroughly with clean brake fluid whenever new parts are installed, if there is any doubt about the grade of the fluid in the system, or if a fluid has been used which contains the slightest trace of mineral oil. Approximately 1 quart of fluid is required to flush the brake hydraulic system.

Brake Power Assist Systems

Virtually all current brake systems use a power booster to increase braking effectiveness and reduce pedal effort. Power assist systems can use either hydraulic or vacuum assist to provide the additional boost. On a hydraulic boost system, the pressure for braking assist is generated by a hydraulic pump. The pump can be driven by the engine or a remotely mounted motor. Most vacuum assist systems use engine vacuum to boost brake performance.

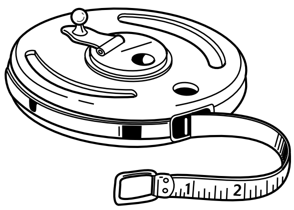
Shop Information

Throughout history, tools have been humans' pathway to success. In the earliest times, prehistoric people figured out how to create and use tools to make their lives easier. They used rocks as hammers. They sharpened stones to make axes to chop down trees. And now, in the twenty-first century, there are tools for every conceivable need. There are even specialized tools to be used in outer space.

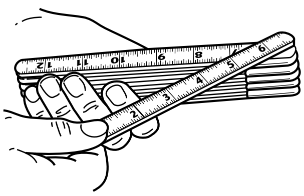
The material in this section covers the basics of shop tools—both hand and motor tools. In the military, you may be called upon to demonstrate your knowledge of these items, and certainly, on the ASVAB exam, you will be tested on much of this material.

Measuring Tools

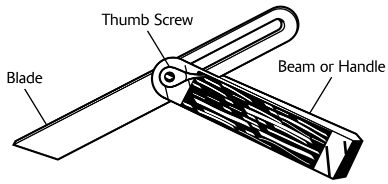
It is important to have the proper tools for measuring and marking as well as skill and accuracy in their use. The foot (') and the inch (") are the measurements used most frequently. Most measuring tools used in woodworking are divided into inches marked in halves, quarters, eighths, and sixteenths. Metric measuring devices may be found, but devices with customary units of measure are more common. In order for a finished product to turn out as planned, measurements must be made accurately. There's an old adage that says, "Measure twice, cut once." The illustration shows some common measuring tools, and the list that follows gives a brief explanation of how to use them.



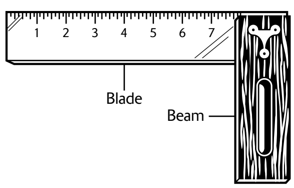
Steel Tape



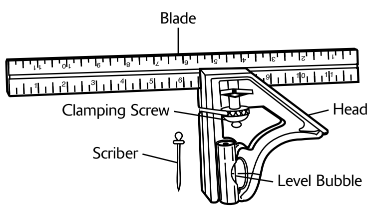
Folding Rule



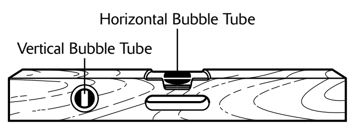
Sliding T-Bevel



Try Square



Combination Square



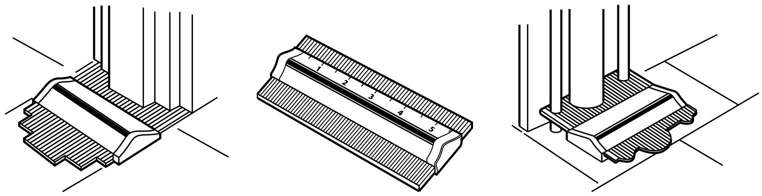
Carpenter's Level

- **Rulers:** The ordinary 12-, 18-, and 24-inch rulers are used for measuring small projects, as they are more manageable than the larger rulers. They may be made of wood, plastic, or steel.
- **Folding or zigzag rule:** This rule, made of wood or lightweight metal, unfolds to 6 feet in length. It is used to measure distances where slight variations in measurement are not important. This rule is easily bent or broken, particularly when it is not opened properly.
- **Steel tape:** The steel tape is a ribbon of steel ⅜-inch wide and graduated in feet, inches, and fractions of an inch. Available in lengths of 6, 8, 12, 50, and 100 feet, it is ordinarily

used to measure distances too long to be measured conveniently with a folding rule. This tape is fixed to a reel housed in a case. After the tape is used, it will retract onto the reel either automatically by a spring or manually by means of a small handle on the case.

- **Steel or carpenter's square:** A carpenter's square is an all-steel, L-shaped or two-arm tool. The long arm is called the blade, and the short arm is called the tongue. These arms meet at right angles; this part of the tool is called the heel. The blade and tongue are marked in inches and fractions. The carpenter's square can be used to measure a board, test it for squareness, or check it for warping. The blade is held along the edge of the board with the tongue across the face of the board; then a line is made along the tongue. If this is done correctly, the line will be at a right angle to the edge of the board.
- **Try square:** The try square is composed of a steel graduated blade set at a right angle to a thicker beam of steel, plastic, or wood. The beam butts against the stock that is being squared. The try square may be used to mark lines at right angles to an edge or surface, to determine whether a board is the same thickness throughout its length, and to test an edge or surface for squareness.
- **Sliding T-bevel:** The sliding T-bevel is sometimes called a bevel square. At one end is a steel blade from 6 to 12 inches in length, along with a 45° bevel point. The other, slotted end is fitted into a slotted wooden or metal beam or handle and held in place with a thumbscrew. The sliding T-bevel can be set at any desired angle. It can be used to transfer angles from one piece of lumber to another and to test bevels.
- **Combination square:** The combination square is a steel graduated blade from 6 to 24 inches long. It is grooved along the entire length of one side. The blade is fitted to a metal head, which can be clamped at any distance along the blade. This head has machined edges which are at 90° and 45° angles to the blade. The head is fitted with a level vial, and a steel scriber is set into the end of the head opposite the blade. The head is clamped securely in any position along the blade with the clamping screw. It can be used as a try square, a depth gauge, or a marking gauge. It can also be used to check 45° angles and to test for levelness.
- **Marking gauge:** The marking gauge is used to mark a line parallel to the edge or end of a piece of wood. (A light line is preferable to a deep one. If the line is not plain, a light pencil mark is put on the gauge line.) The marking gauge is made of wood or metal.
- **Divider:** A divider is a pair of pointed metal legs joined together at or near the top. The wing in a wing divider is an arc used to hold the legs apart at the desired distance by means of a setscrew. At one end of the wing is an adjusting screw with a spring that permits fine setting of the legs. A divider is used to describe circles or arcs, to transfer measurements from the work to the rule or from the rule to the work, and to mark lengths into equal parts.
- **Carpenter's level:** The carpenter's level is a 24-inch woodblock with true surface edges. It is used to determine whether a surface is level or an upright is plumb. It usually has two bubble tubes. The bubble tube in the middle of one of the long edges indicates levelness of a surface. If the bubble comes to rest exactly between the two scratch marks on the bubble tube, the surface is level. The other bubble tube is at a right angle to the first one and indicates vertical level or "plumb." A carpenter's level should be handled with care, as the bubble tubes break easily.

- **Contour gauge:** A contour gauge is used to form an outline of a particular shape. This device is made of many steel teeth which slide backward when they are pressed against a surface. Therefore, when this device is pressed against a surface with an irregular contour, each steel tooth slides backward to the extent necessary, thus forming an outline or template of the irregular shape. The opposite end of the steel teeth automatically forms a template of the same shape in reverse. The outline desired can be traced onto wood, paper, tile, linoleum, or any surface. A contour gauge is only 6 inches long; however, two or three of them can be joined together to make templates of wider areas.



Contour Gage

Fasteners

Innumerable types of wood fasteners are on the market. To get the desired results in a finished product, the woodworker must use the most suitable size and type of fastener. Selection of the proper fastener is dependent upon an adequate knowledge and understanding of fasteners and their uses.

Nails

Nails provide the simplest and quickest way of fastening two pieces of wood together. They are used primarily on rough or inexpensive work such as house framing, packing boxes, and crates, for which a well-finished surface is of minor importance.

Since nails may be used for numerous purposes, they are manufactured in many different sizes and of different materials.

Nails

- **Common wire nails:** Common wire nails are made with large flat heads. They are made in different lengths, and each length is heavier than a finishing or box nail of the same length. They are available in more sizes than any other nail. They are sized by the old English penny system. Penny as applied to nail stands for "pound" and refers to the weight of 1,000 nails. For example, nails weighing 6 pounds per 1,000 are six-penny (6d) nails. The letter "d" following the numeral is an abbreviation of *denarius,* which is the Latin word for penny. The largest sizes of these common nails are called spikes.

- **Finishing nails:** These small-headed nails have the same diameters and lengths as penny nails. They are used for medium fine work in which nail heads should not show. They are sized by the penny and purchased in the same way as common nails.
- **Box nails:** These nails have heavy heads but are made in smaller gauges than common nails. They are used when nails of a larger gauge might split the wood. They are made plain, barbed, coated with resin, or coated with cement. The plain ones are easier to remove from wood, but the others hold better.
- **Casing nails:** Casing nails, which are the same gauges as box nails, have small heads. They are used for such work as blindnailing flooring, as their small heads can be countersunk into the wood.
- **Brads:** Brads are used for fine work such as interior trim and small projects. They are made in lengths from $\frac{3}{8}$ to 3 inches in various gauges and are usually sold in 1-pound cardboard boxes labeled with length and gauge. The higher the number, the smaller the diameter of the wire. One of the most commonly used brads is the 1-inch long, 18-gauge size. Brads should be countersunk into the wood with a nail set; and in finer work, the hole should be covered with plastic wood or putty.
- **Tacks:** Carpet or upholstery tacks are made of iron and have sharp points and large heads. They are made in lengths from $\frac{3}{16}$ to $1\frac{1}{8}$ inches and are sold in $\frac{1}{4}$- to 1-pound cardboard boxes.
- **Brass nails or escutcheon pins:** These nails are made of either brass or copper and have small round heads. They are available in lengths of $\frac{1}{4}$ to $1\frac{1}{2}$ inches and in various thicknesses.
- **Shingle nails, felt roofing nails, and plaster board nails:** These nails are short with very large heads to prevent the secured material from pulling over the heads.

Techniques for Driving and Pulling Nails

While it's relatively simple to drive and pull nails, there are a few things you should keep in mind.

Driving

In order to drive a nail with the claw hammer (carpenter's hammer), grip the handle firmly with one hand near the end of the handle; hold the nail near the point with the thumb and forefinger of the other hand. Place the point of the nail on the wood at the exact spot in which it is to be driven and tap it squarely but lightly until it penetrates the wood to a depth sufficient to hold securely. Remove the fingers and drive the nail into the wood. The face of the hammer should hit flat against the head of the nail. It is helpful to first rest the hammer on the exact spot in which the nail is to be driven to obtain the "feel" or "aim" and ensure a more accurate blow on the nail.

Pulling

To pull a nail, slide the claw of the hammer under the head, making certain that the head is caught securely in the slot of the claw. Pull back until the handle of the hammer is nearly vertical; then slip a block of wood under the head of the hammer and pull the nail completely free. The block of wood will prevent the hammer from marring the wood, will increase leverage, and will prevent the nail from pulling out sideways and making a large hole.

Using Nails

Here are the basics on how to use nails:

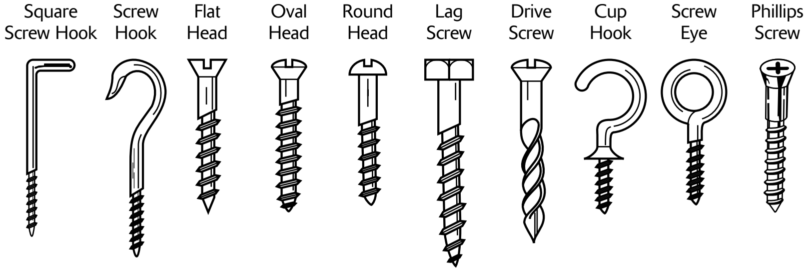
- You should not drive nails close together in a line following the grain of the wood, as this will split the wood.
- If a nail bends while it is being hammered, it must be replaced with another nail driven into the same hole.
- If a nail does not go into the wood straight, it must be removed; then another nail must be driven into the wood at a different place.
- Nails have a tendency to follow the grain of the wood. If the nail does not go in the desired direction because of this, blunt the point slightly with a hammer.
- When inserting nails into hardwoods, it is helpful to bore holes for the nails, using an awl or a hand drill. Instead of using the twist drill, cut off the head of the nail and use the nail in the chuck.

Screws

There are several advantages to using screws instead of nails. Screws hold wood more securely and are neater in appearance; they can be tightened as necessary and can be removed without damaging the wood. They are, however, more expensive and require more care, time, and effort to insert. Screws are available in various types and are made of steel, cooper, bronze, brass, or metal plated with nickel or brass. Steel screws (bright) are the strongest and the least expensive, but they rust when they become damp or wet. Rust can be prevented by blueing them with a material available commercially.

Classification of Screws

Screws are mainly classified according to the shape of the head. The illustration shows some screws, and the list gives some details.



Screws

- **Flathead:** These screws are used where the head is not supposed to show. They should be countersunk and may be covered with plastic wood or with doweling. They are usually made with a bright, blued, or brass finish.
- **Oval head:** These screws are designed primarily for fastening hinges and other hardware to wood. They should be countersunk to the oval part of the head. They usually come in a blued or brass finish.
- **Roundhead:** These screws should not be countersunk. They are for use in places where the head is supposed to show. They are commonly made of brass, though they may be blued or plated.
- **Lag:** These screws, which have a square bolt-type head, are driven in place with a wrench. They are used in heavy timber construction. They are available in diameters of ¼ to 1 inch and in lengths of 1 to 16 inches.
- **Drive:** Drive screws, which are half nail and half screw, are driven into wood like nails. The partial threading gives them better holding power than nails.
- **Phillips:** Instead of the usual groove in the head, these screws have cross-shaped recesses. They are easier to start than the standard screws because the driver point centers itself and the screwdriver is less likely to slip. A Phillips screwdriver is used to insert these screws.
- **Screw hooks, cup hooks, and screw eyes:** These screws, available in various sizes, are made of steel, brass, and galvanized iron. In an occupational therapy clinic, they have many uses such as hanging tools, paint brushes, belts, and pictures.

Sizes of Screws

Wood screws are made in lengths from ¼ to 5 inches. The diameter or gauge is indicated by numbers running from 0 to 24. The higher the gauge number, the greater the diameter of the screw. The size numbers of the most commonly used screws are from 5 to 12; their lengths are from ⅛ inch to nearly ¼ inch.

Selection of Type and Size

The types and sizes of screws selected for use depend upon the item being made. About two-thirds of the screws should enter the wood. If the wood is thin, a thin screw should be used. One with a small gauge number should be the desired length. If a strong, long screw is required, one with a high gauge number is selected.

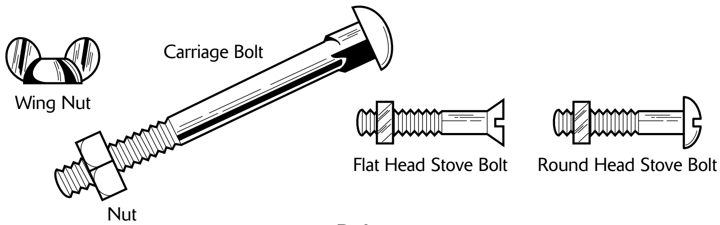
Application of Screws

Two holes of different diameters must be bored in the wood when screws are to be used. The first hole should equal the diameter of the shank, and the second or pilot hole should equal the diameter of the root. In hard woods, the second hole should be bored as deeply as the screw enters the wood; in soft woods it should be bored about half this distance. When flathead or oval head screws are used, the upper end of the first hole is widened with a countersink bit. The correct size and type of screwdriver must be used for ease in driving and protection of the screw. If the screw is difficult to insert, rubbing it across a piece of dry soap sometimes makes it go into the wood more easily. The screw should be turned so that the screwhead is parallel to the grain of the wood.

Bolts

Bolts differ from screws in that they are not tapered but are the same diameter from end to end. The bolt projects through the pieces being held together, and a square or hexagonal piece of metal, called a nut, is screwed on the projected threaded end. When it is desired that the piece by easily removable, a winged nut is used instead of a bolt. Bolts are used on heavy items which require great holding strength and on items where wood is fastened to metal or masonry.

There are various kinds of bolts. The most common woodworking bolts are stove bolts and carriage bolts. The illustration shows some common bolts.



Bolts

When bolts are used, a hole of the same diameter as the bolt is drilled through both of the pieces that are to be held together. A metal washer is always placed between the nut and the wood and usually between the head and the wood. These washers distribute the pressure of the bolt over a larger area, thus preventing the head and nut from digging into the wood. A washer is sized by the hole in its center.

Miscellaneous Hardware

In addition to nails, brads, and bolts, other types of hardware are used in woodworking.

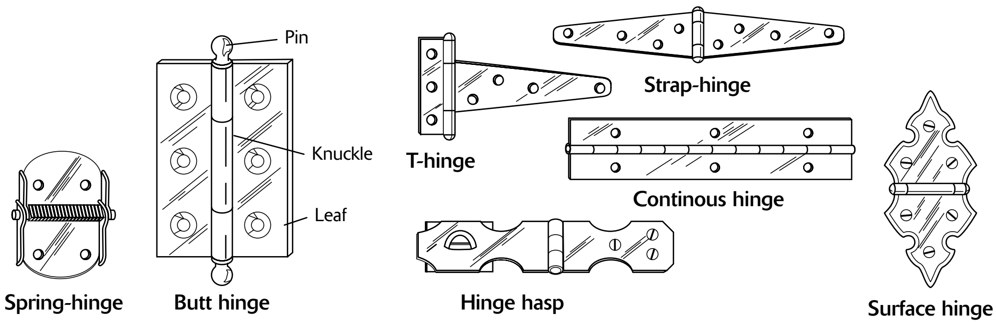
Braces

Braces are used to reinforce joints or cracks and to hold two or more pieces of wood together. The more commonly used braces are the corner brace, the flat corner iron, the mending plate, and the T-plate.

Hinges

Application of a hinge is the easiest way to make a joint movable between two pieces of wood. Hinges are made in many different forms and of different materials such as brass, iron, galvanized iron, brass-plated iron, and nickel. Hinges are sized according to the length and width of each leaf.

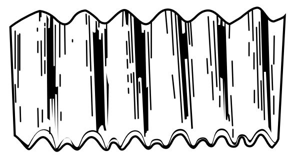
There are different types of hinges: The butt hinge is used for many items, ranging from doors to jewel boxes. The continuous hinge can be obtained in any length and is used for pianos, boxes, and cabinet doors. Both the strap and the T-hinge are used on garage and cellar doors, gates, and toolboxes. The illustration shows these and other types of hinges.



Hinges may be set flush or a little below the surface of the wood in a groove called a *gain.* Strap, surface, spring, hasp, and T-hinges are screwed to the surface of the wood without cutting any recess, whereas butt and continuous hinges are recessed. For greater security, hasps should be attached in such a way that the screws are hidden or covered so that they cannot be removed. When hinges are used for the lid of a box or chest, they should be placed so that the distance from each of the end hinges to the edge of the box is equal to the length of the hinge.

Corrugated fasteners

These fasteners are one of several means by which joints and splices in small timbers and boards may be fastened. They do not provide a secure joint; however, in places that will receive only slight strain, such as the corners of a mitered picture frame, they are a satisfactory means of quickly joining two pieces of wood.



Corrugated fastener

Hand Tools

In spite of modern power equipment, hand tools are still the fundamental tools of woodworking. Even in this age of machines, a great deal of personal satisfaction can be derived from making a project entirely by hand. It is important, however, to know the possibilities and limitations of each hand tool, how to keep the tools in good working order, and the methods for developing skills in their use.

Hammer and Nail Sets

Hammers are some of the most used and misused of all hand tools. An understanding of the types and their proper uses will increase the efficiency of the user.

Carpenter's Hammer

Hammers are sized by the weight of the head: The most common heads weigh 12, 16, and 20 ounces. The 16-ounce head is the best for general use. The carpenter's hammer or claw hammer, which has a steel head and a wooden handle, is the most commonly used tool for driving nails.

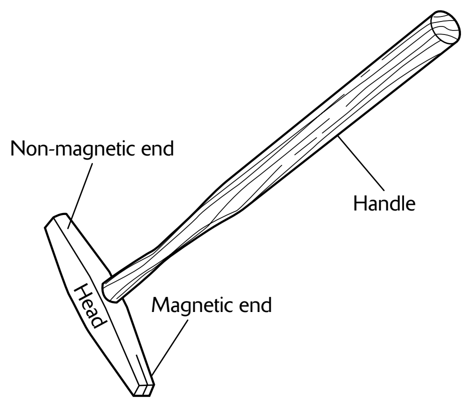
The face of the head is used to drive nails, and the claw is used to pull nails out of the wood. There are two types of carpenter's hammers: The plain-faced claw hammer has a flat face. With this hammer it is easier for the beginner to learn to drive nails, but it is more difficult to drive the heads of the nails flush with the surface of the wood without leaving hammer marks. The face of the ball-faced hammer is slightly rounded or convex. It is generally used in rough work. An expert can use it to drive a nail flush with the surface of the work without damaging the wood.

For safety and efficiency, a hammer handle which becomes loose must be replaced or tightened immediately. If the handle is in good condition, it can be tightened by striking its end with a mallet, thus driving the wedges back into the handle. If the handle is broken, it must be removed from the head and replaced with a new one. If removing the old handle is difficult, it can be sawed off close to the head and driven through the larger end of the eye. Wedges made of either metal or straight-grained soft wood are used to secure the handle to the head. Nails or screws should not be used in place of wedges.

The face of a hammer should be kept clean and smooth. This can usually be done by rubbing it with an emery cloth. If restoring the surface requires grinding, care must be taken to retain its proper shape (ball or plain).

Tack Hammer

The tack hammer is available in 5- and 7-ounce sizes. The 7-ounce double-faced hammer, with one face magnetic, is preferred for upholstery work. This tack hammer is recommended for light work. The head of a tack can be picked up with the magnetic face of the hammer; then the tack can be tapped into the wood far enough to hold it. The hammer is then turned over, and the nonmagnetic side of the hammer is used to pound the tack in place. Care and safety precautions are the same as for the carpenter's hammer.



Tack hammer

Nail Set

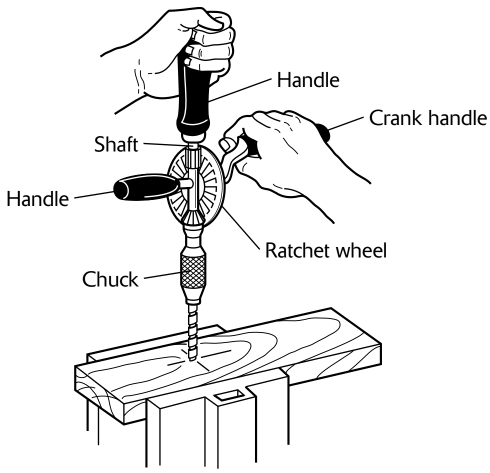
In finer work, it is often desirable to have the nailheads below the wood surface. Sinking a finishing nail or brad is done with a nail set. It is a round knurled steel shaft 4 to 5 inches long and about $\frac{1}{4}$ inch in diameter with a tapered point. The point is cup-shaped to keep it from slipping off the nailhead. The point is available in various sizes from $\frac{1}{32}$ to $\frac{1}{8}$ inch across the cup; it should not be larger than the diameter of the nail being set. The nail set is placed on the nailhead, held in line with the nail, and hit with a hammer until the nail is the desired distance below the surface of the wood.

Drills and Bits

Frequently, it is necessary to drill holes in wood, such as pilot holes for screws, and holes for insertion of saw blades or as part of making a joint. Several kinds of drills and bits, each designed for a certain purpose, are used.

Hand Drill

This is a relatively small drill used to bore holes with a diameter of ¼ inch or less in either wood or metal. It consists of a shaft with a handle at one end and a chuck for holding twist drills at the other. Near the middle of the shaft is a ratchet wheel with a crank handle. Turning this handle causes the shaft and the chuck to turn. Straight shank twist bits from 1⁄32 to ¼ inch may be used in this drill.



Hand Drill

The chuck for a drill has several V-grooved jaws that hold the tang of the bit. The jaws of the chuck are opened to receive the bit by grasping the shell and turning it to the left. The jaws are closed to secure the bit in place by turning the shell to the right.

A hole can be drilled to a specific depth or several holes can be drilled to the same depth by placing a depth gauge (wooden dowel) over the twist bit. This wood gauge cut to the proper length and slipped over the bit prevents the drill from cutting a hole deeper than desired.

When boring a hole, care must be taken to avoid putting too much force on the head of the drill. The bit may break or unexpectedly go completely through the lumber, thus throwing the operator off balance and causing an injury.

Brace

A brace is used to drill holes larger than can be drilled with the hand drill. It is made to take bits with round or square shanks as large as ½ inch in diameter, including the screwdriver bit, twist drill, expansive bit, auger bit, and countersink bit. It has a head fastened to the crank by a bearing that permits the crank to turn. The crank, which is a steel shaft, provides leverage. The ratchet mechanism on the ratchet brace controls whether or not the chuck turns when the crank is turned. It may be set to permit the chuck to run either forward or backward while remaining stationary as the crank is turned in the other direction. This makes it possible to bore holes and drive screws in places where complete turns of the crank cannot be made.

Breast Drill

The breast drill is used to drill holes in either metal or wood. It will take bits with square or round shanks as large as ½ inch. This drill has a lever for changing the speed of the drill or bit at any time from high (a 3-to-1 ratio) for small holes to low (a 1-to-1 ratio) for large holes. The center position of this lever locks the gears so that the chuck can be opened or closed. The breast plate is adjustable for the operator's comfort. As the operator leans against this plate, more pressure can be applied as the drill is turned. This drill can be used in any position.

Automatic or Yankee Drill

The automatic drill provides an easy and quick way to drill small holes. The drill can be used with one hand. It takes special bits which are inserted in the chuck. These bits range in size from $\frac{1}{16}$ to $\frac{11}{64}$ inch. Usually, these special bits are stored in the handle of the drill.

Types of Drill Bits

A drill bit is what actually comes in contact with the material that is being drilled. Various types of bits exist:

- **Twist bits:** Twist bits can be used to bore holes in both wood and metal. Smaller holes can be made with these bits than with any of the others. They range from $\frac{1}{32}$ to ½ inch in diameter; they are sized by thirty-seconds and sixty-fourths of an inch. The size of each bit is stamped on its shank. A twist bit with a round shank is used in the hand drill or in the drill press. (In the drill press, it is advisable to use high speed bits rather than carbon bits.)

  When inserting the shank of the bit into the chuck of the drill, make sure that it is straight. Before starting to drill, it may be helpful to make a very small guide hole in the wood or metal with an awl or center punch to keep the bit on the right spot. With the point of the bit where the hole is to be drilled, turn the crank of the ratchet in a clockwise direction. Apply light pressure to the handle of the drill, as this pressure keeps the bit progressing through the wood or metal. When the hole is deep enough, pull the bit from the hole while turning the ratchet wheel in a clockwise direction. This will clear the hole of shavings.

- **Auger bits:** Auger bits have a square tang and are used in a brace or a breast drill. These bits are used exclusively for boring holes in wood. They vary in length from 7 to 10 inches and graduate from ⅛ to 1⅛ inches in diameter by $\frac{1}{16}$ inch.

  Insert the tang of the bit into the chuck of the brace as far as possible. Put the point of the spur at the exact center of the spot where the hole is to be bored. Turn the crank of the brace or the handle of the breast drill and apply only enough pressure to assist the spur in drawing the bit into the wood. (As the spur draws the bit down, first the nibs cut the fibers of wood at the edges of the hole; then the lips chip out the wood to make a hole.) When the hole is the desired depth, back the bit out by turning the crank or handle in the opposite direction until the spur is free from the bottom of the hole. Withdraw the bit the remainder of the way, turning it in the direction that it entered in order to remove the shavings from the hole. If an auger bit is allowed to bore completely through a board, it will split the board as it comes out.

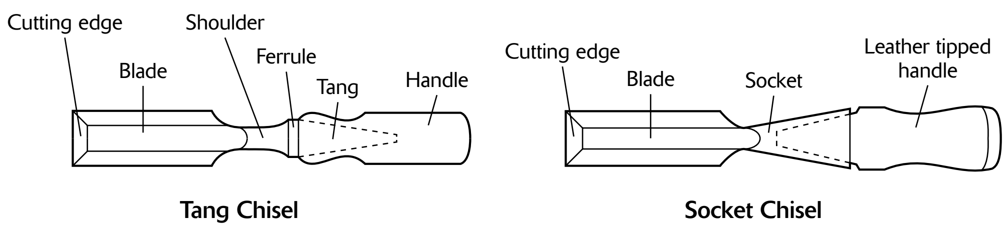
- **Forstner bit:** The forstner bit is used to bore holes that must extend nearly all the way through a piece of wood, as it does not split the other side. It is also used to clean out the rough bottom of a hole made by an auger bit and to bore a large hole where a small one has been previously drilled. It cuts end grain and knots effectively, as well as holes in thin stock. The average set of forstner bits ranges from ¼ to 1 inch in diameter.
- **Expansion bit:** This is an auger-type bit. Since it has adjustable cutting blades, it takes the place of several large auger bits. Usually, two interchangeable cutting blades are available. The smaller one cuts holes from ⅞ to 1½ inches in diameter, and the larger one cuts holes from 1½ to 3 inches in diameter.
- **Screwdriver bit:** This specialized bit has a screwdriver blade on one end and a square shank that fits a brace or a breast drill on the other end. It is used for driving screws. Care must be taken to select the bit with the blade tip that will fill the slot of the screw.
- **Countersink bit:** The countersink bit has a conical cutting head and a square shank. It is to be used in a brace or a breast drill to form the top of the pilot hole for a screw. This allows the flat head of a screw to be flush with the surface of the wood. The rose type suitable for both wood and soft metals is ordinarily used.

Chisels

Chisels are simple tools with a single blade that is used for the careful removal of small areas of wood, often from otherwise inaccessible places.

Wood chisels are used for accurate cutting and for fitting and shaping as required in making wood joints. They are also used for surface decorating. The chisel consists of a single beveled steel blade fitted with a wooden handle. Chisels are divided into two types according to the way in which the handle is attached.

- **Tang Chisel:** The upper end of a tang chisel blade is shaped into a tapering point which is driven into the wooden handle. A ring, called a ferrule, is fitted around the lower end of the handle to prevent the wood in the handle from splitting. Because of its design and light construction, the tang chisel will not withstand heavy blows.
- **Socket Chisel:** The upper part of a socket chisel blade is shaped like a hollow cone. The handle of the tool is fitted into it. The construction is heavy so that the chisel will withstand the blow of a mallet when heavy work is being done. Chisel handles used for heavy or medium work are usually tipped with leather to prevent the handle from splitting under the blows of the mallet. The handle should fit well so that the chisel does not come out and cause an accident.



Chisels

Chisel Blades

Chisel blades are made in different weights and thicknesses and are shaped appropriately for the type of work to be done. Some are designed specifically for a certain type of job. Most chisel blades fall into one of the three general types. They range in width from ⅛ inch to 2 inches. The width of the chisel should be smaller than the width of the cut to be made. The three general types of blade are:

- **Paring:** The paring chisel blade is the thinnest and longest one and is usually beveled. It is used for fine smoothing rather than for heavy work.
- **Firmer:** The firmer chisel blade is thicker than the paring chisel blade. It is used for heavier work that requires a stronger blade.
- **Framing:** The framing chisel blades are for heavy work. They are for socket chisels which can be tapped with a mallet.

How to Use the Chisel

When using a chisel, the wood must be held securely in a vise. The cuts must be planned, taking into consideration the following.

Cutting against the grain of the wood tends to split the wood and make the tool more difficult to control. To obtain a cut that is well controlled and smooth, cut with the grain of the wood. When making heavy cuts in which wood is to be removed, the work must be planned so that if the wood splits, it will split in only the portion that is to be removed. This is done through a stop cut, which is made by tapping the chisel vertically into the wood at the point where the cut should stop. In making this vertical cut, it should be remembered that when the beveled edge goes vertically into the wood, it will leave a straight cut on the flat side of the blade and an angular cut on the beveled side. Therefore, the bevel should always face the area to be removed.

Holding the chisel with the bevel down gives a lifting or gouging action; holding the bevel up or away from the surface gives a planing action. For smoothing cuts, the chisel should be held with the left hand close to the cutting edge so as to guide the chisel accurately. The right hand furnishes the power to make the cut. If the smoothing or planing stroke is done in a sideways manner, the shearing action will give a smoother cut. In smoothing an outside curve with a chisel, the chisel is held with the bevel up, and a series of short strokes are used.

Chisel Safety

Safety precautions are important to observe when using a chisel. Its shape and sharpness and the way in which it is used make it a dangerous tool.

- Always keep both hands in back of the cutting edge.
- Always cut away from the body.
- Do not carry a chisel in a clothing pocket.
- Clamp the wood firmly so that it does not move.
- Place the chisel on the workbench in a way that will prevent it from rolling off the bench onto someone's foot.

Gouges

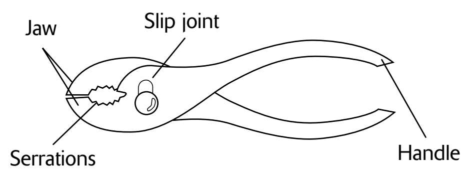
These tools are very similar to chisels except for the shape of the cutting end. The different shapes (sweeps) vary from a wide arc to a V-shape. There are two kinds of gouges: the outside ground with the bevel on the convex surface or outside the blade; and the inside ground with the bevel on the concave surface or inside of the blade. Some gouges are made with an offset shank to make room for the hand when the bevel is being held parallel to the cutting surface.

Gouges are used for wood carving, for decorating, and for shaping wood as in modeling. Special gouges are made to be used with a lathe to turn wood. Gouges are handled in the same manner as chisels.

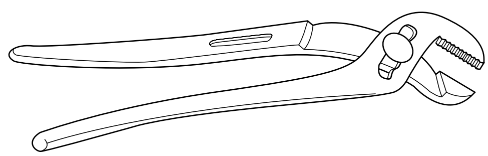
Pliers

Pliers are used to hold materials, to grasp objects that are difficult to reach with the fingers, to bend wire, and to accomplish various tasks pertaining to specific crafts.

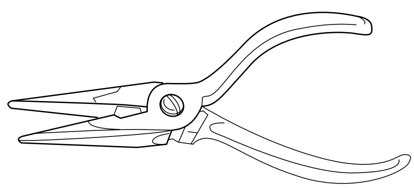
Pliers are made in a variety of shapes and sizes. The size of pliers is determined by the overall length, which ranges from 5 to 10 inches. The better ones are made of drop-forged steel to withstand hard use. The slip joint on the pliers permits a wider opening of the jaws, which are serrated for gripping.



Pliers



Angle nose pliers



Long nose/Needle nose pliers

Some pliers are *side-cutting* pliers. The jaws of side-cutting pliers do not open as far as those with slip joints. These pliers have two sharp edges between the nose and the joint. They are designed to cut and strip wire. Side-cutting pliers also come in various shapes and sizes.

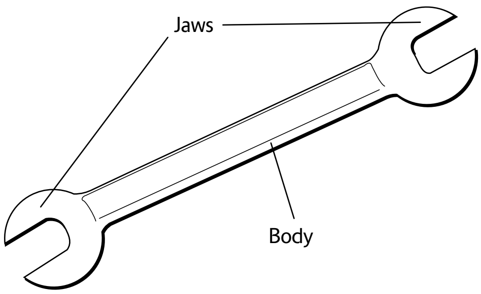
When using side-cutting pliers, keep the wire being cut as near the joint as possible, thus increasing the leverage and preventing misalignment of the jaws. Select the appropriate size of pliers for cutting a specific weight of wire. If force is required to cut wire, either the wire is too heavy for the pliers or the cutters are dull.

Wrenches

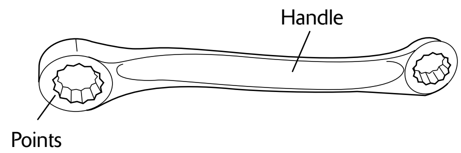
Wrenches are used to tighten or to loosen nuts and bolts. Many wrenches have been designed to serve various purposes. They can be described as either fixed-end or adjustable.

Fixed-End Wrenches

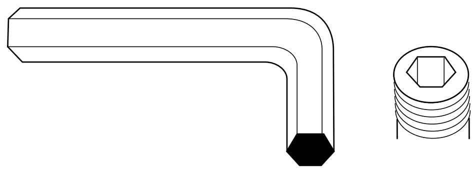
As the name implies, fixed-end wrenches are not adjustable. Instead, they are made in various sizes that can be purchased in sets. These fixed-end wrenches are designed with open ends and with closed (box) ends.



Open-end wrench



Box-end wrench



Allen wrench and setscrew

Open-End Wrenches

These tools are forged from chrome vanadium steel and are heat-treated. They usually have a double end with each end angled 10° to 23° to the body of the wrench. These angles enable the user to work more effectively in close quarters. The jaws may also be offset to facilitate turning a nut that is recessed. The size of the opening between the jaws is the size shown on the wrench. A double-end wrench with $\frac{1}{2}$-inch and $\frac{9}{16}$-inch openings is called a $\frac{1}{2}$ by $\frac{9}{16}$ wrench. The size is usually stamped on the side of the wrench. As the size increases, the length and weight increase to provide greater leverage and strength.

It is important for a wrench to fit squarely on the nut or bolt head. If it is too loose, the wrench will slip and round the corners. After each turn of the nut, the wrench should be turned over with the angle of its opening in reverse. If a nut is difficult to turn, a very small amount of penetrating oil should be applied and allowed to run into the threads of the bolt.

Box-end Wrenches

Box-end wrenches are made to surround or box in a nut or bolt head. They usually have a double end with either 6 or 12 points arranged within the circle. They are available in the same sizes as open-end wrenches. The circular ends on some of the wrenches are set at an angle to provide clearance for the user's hand. Such wrenches are available with a ratchet that eliminates the need to remove the wrench from the nut to start a new stroke.

Compared with the open-end wrench, the box-end wrench has some advantages and at least one disadvantage.

The advantages:

- With 12 points within the circle, the wrench can be used with a 15° swing of the handle, making it suitable for working in close quarters.
- The thin sides of the circular end allow the wrench to be used in places where the thick jaws of the open-end wrench will not fit.
- The box end does not slip off the nut.

The disadvantage is that the box end must be lifted off the nut at the end of each stroke and placed back onto the nut in a different position for the next stroke. This disadvantage does not apply to the ratchet box wrench.

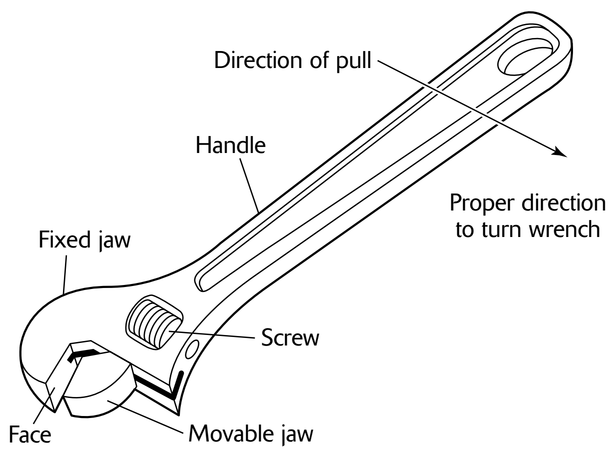
A combination wrench with one end the open type and the other end the box type is made in different sizes, offsets, and angles. The advantage of this wrench is that a tight nut can be broken loose more easily with the box end and removed more quickly with the open end.

Allen Wrenches

The Allen wrench is a special bar of tool steel which is usually six-sided and L-shaped. Both ends fit into hollow setscrews. The steel bars come in a set sized to fit most setscrews. The short portion of the L-shape serves as the handle for turning screws rapidly, as little leverage is needed. The long portion is used as the handle when leverage is needed for the final tightening or for breaking a tight screw loose.

Adjustable Wrenches

These wrenches are for turning nuts and bolts and various parts that have threads. Since they are adjustable, the same wrench fits a number of different sizes of nuts and bolts. The two adjustable wrenches used most frequently are the crescent and monkey wrenches.



Crescent or Single Open-End Wrench

The crescent wrench, which is light and easy to handle, is made of forged alloy steel and is often chrome-plated. This wrench comes in various sizes, each with a range of adjustable jaw capacities. The handle is somewhat longer as the sizes increase to provide the necessary leverage.

The wrench is placed on a nut or bolt so that the force used to turn it is applied to the stationary jaw side of the wrench. After the wrench is positioned on a nut or bolt head, the knurled screw is tightened until the wrench fits securely. This prevents the wrench from slipping and possibly injuring the user's hand, as well as damaging the nut or bolt.

Monkey wrenches are larger and heavier than the crescent wrench. They are used less frequently. A monkey wrench functions in the same way as the crescent wrench; the turning force is applied on the fixed jaw. The care and safety precautions are also the same as those for the crescent wrench.

Screwdrivers

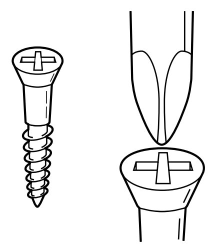
A joint or fixture held with screws is more secure and durable than one held with nails; furthermore, it can be taken apart and reassembled. For the insertion of screws, many types of screwdrivers are available. Some are designed for highly specialized jobs; however, only the most frequently used ones will be discussed.

Types of Screwdrivers

The standard screwdriver has a round or square steel blade anchored firmly in a hardwood or plastic handle. For heavy duty work, an integral-handle screwdriver is standard; its blade, which forms an integral part of the handle's surface, is locked in place by rivets. The tip of a standard screwdriver is flat and it is made of steel. The standard screwdriver is sized according to its blade lengths, ranging from 1¼ to 12 inches with tips ranging from ⅛ to ⅜ inch. It is very important that the screwdriver tip fit securely into the screw slot and that the width of the tip equal the length of the screw slot.

The Phillips screwdriver is available with blades of various lengths. The blade tips, which are shaped like a cross to fit the Phillips screw, are made in four sizes.

Screwdriver Tip Sizes	*Phillips Screw Sizes*
1	4 and smaller
2	5 through 9
3	10 through 16
4	18 and larger



Phillips Screw and Screwdriver

While standard and Phillips head are the two main types of screwdrivers, variations exist:

- **Clutch-head screwdriver:** This screwdriver is made to fit the recessed head of the clutch-bit screw, more commonly called the butterfly or figure-8 screw. It comes in several sizes to fit the various sizes of screws.
- **Offset screwdriver:** The offset screwdriver is used to reach screws located in tight corners inaccessible to other screwdrivers. It is made in a variety of sizes and tip widths.
- **Ratchet screwdriver:** With the ratchet screwdriver, screws can be driven and removed more rapidly than with a standard screwdriver. The ratchet arrangement makes it possible to drive in one direction and release in the other. This screwdriver can be adjusted to turn to the right or to the left and can be locked so it works like a standard screwdriver. Some screwdrivers of this type have a chuck into which various sizes of blades may be inserted.

In addition, screwdriver bits (blades) are made to fit into the chuck of other tools such as the breast drill and socket wrench. The use of such tools reduces the work and time required to drive screws. Care must be taken to select the bit with a tip that fits the screws to be driven.

Using Screwdrivers

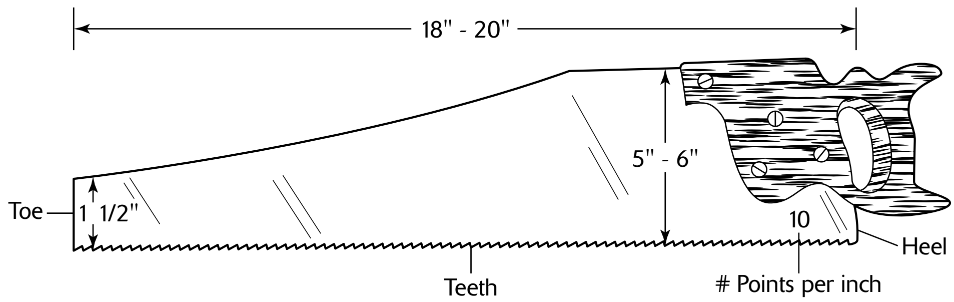
First, select the screwdriver with the largest tip that will properly fit into the screw slot. Hold the screwdriver in the palm of one hand with the forefinger extending down the handle toward the ferrule. With the other hand, steady the tip of the blade in the head of the screw. Apply downward pressure to the handle of the screwdriver and at the same time turn the screw clockwise (to the right). If the screw is difficult to drive or if it is going into hardwood, drill a pilot hole. If difficulty continues, apply soft soap to the threads of the screw. For additional leverage, use a wrench, placing it either at the flared tip or near the handle of the screwdriver with a square blade.

When driving brass screws, do not force them, as they are soft and easily damaged. If such a screw becomes difficult to turn before it is seated, remove the screw and enlarge the pilot hole. Finally, if a screw is difficult to remove, tighten it slightly; then loosen it. Use this back and forth motion until the screw can be removed.

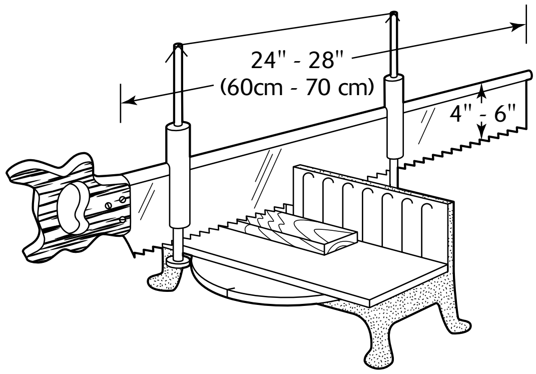
Saws

The saws used in woodworking are the crosscut, ripsaw, backsaw, miter, keyhole, compass, plumber's, and coping. Although these saws have certain similarities, each one has a specific use.

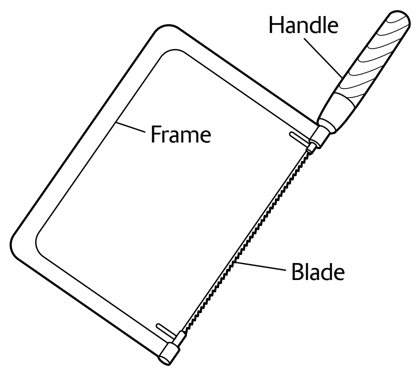
The cutting edge of a saw is a line of sharp teeth. Since these teeth are set with one to the right and one to the left, alternately, they act as two rows of cutting instruments, running close together in parallel grooves. With the cut made wider than the thickness of the saw, the saw does not bind as it is pushed through the wood. This cut or groove is known as the *kerf*. The kerf width that is necessary depends largely upon the type of lumber to be cut. Green or soft lumber requires a wider kerf than hard or dry lumber. A coarse saw is better for doing fast work and for cutting green (undried) wood; a fine saw does smoother, more accurate cutting on seasoned lumber. The teeth of woodworking saws are designed to cut as the saw is being pushed away from the operator. Saws are sized by the number of tooth points to the inch. There is always one more point per inch than there are teeth per inch.



Crosscut Saw or Ripsaw



Miter Saw and Box



Coping Saw

Crosscut Saw

The teeth of a crosscut saw are designed to cut *across* the grain of the wood. The cutting edge of each tooth is on the side; the sharp point is on the outside of each tooth and the bevel is on the inside. For general use, a good size of crosscut saw is 8 to 10 points per inch. The number stamped near the handle indicates the number of points per inch. The blade of a crosscut saw is tapered in width and is 18 to 20 inches long.

To use a saw, grasp the handle with the index finger extended toward the point, the other fingers curled around the grip, and the thumb pointed in the direction opposite to the fingers. The extended index finger tends to give better accuracy in sawing.

Start the cut by placing the saw on the wood so that the heel of the saw rests with the inside edge touching the line to be sawed. Use the thumb of the opposite hand to guide the blade and the fingers and palm to hold the lumber. Pull the saw, exerting no pressure but allowing the weight of the saw to rest on the lumber. In this manner, a small groove is made in which the saw can be run.

Cut the wood by holding the saw perpendicular to the lumber at about a 45° angle and pushing it forward with just enough pressure to make a cut. During this pushing motion, guide the saw with the forefinger of the hand on the handle and with the thumb of the other hand. Do not force the saw, as this may cause it to bend or to jump out of the groove and scar the face of the lumber.

Continue the backward (pull) and forward (push) motions, exerting pressure only on the push (cutting) stroke. Just before the cut is completed, support the part which may fall until all of the fibers are cut. This prevents the edge from splitting when the last strokes are made.

Other Types of Saws

The crosscut saw is the most common type of saw, but there are many other varieties:

- **Ripsaw:** The parts of a ripsaw are the same as those of the crosscut saw. The teeth, however, are designed to cut *with* the grain of the wood. They are sharpened straight across the front edge, making the cutting edge like two rows of chisels cutting into the wood. A good size for a ripsaw is 5 to 7 points per inch. It is used in the same manner as the crosscut saw except that the blade is held at a 60° angle to the lumber.
- **Backsaw:** The teeth of a backsaw are similar to those of a crosscut except that they are smaller and finer. There are about 14 teeth per inch. On an average, the blade is about 12 inches in length. The blade is thin; however, it is stiffened with a heavy metal back. The construction of the backsaw makes it more suitable than the crosscut saw for cutting pieces which must fit together exactly, such as joints. The backsaw, which cuts either with or across the grain, is used in the same manner as the crosscut saw and ripsaw.
- **Miter saw:** The miter saw looks like a hacksaw, except that it is longer than a hacksaw. A miter box issued with the miter saw makes it possible to cut lumber accurately at almost any angle. It is especially useful in cutting lumber for joints. A device on the commercial miter box is set for cutting the desired angle. A small wooden miter box can be designed for cutting certain angles used frequently.
- **Keyhole saw:** The keyhole saw is made for small jobs, such as cutting keyholes and fitting locks in doors. It is narrow enough to enter a ¼-inch hole. It cuts a wide kerf so that the blade may turn in making curved cuts. It frequently comes nested with a compass saw and a plumber’s saw with a common, easily removable pistol-grip handle.
- **Coping saw:** The coping saw is a versatile saw for cutting thin wood and plastic. It consists of a steel frame, handle, and replaceable blade. The blade can be inserted with the teeth pointing away from or toward the handle. With the teeth pointing away from the handle, the saw can be used in the same way as a ripsaw or crosscut saw. With the teeth pointing toward the handle, the saw can be used in the same way as a jeweler’s saw.

Maintenance of Handsaws

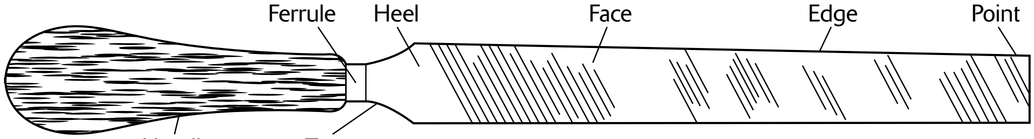
There are a few things that you should keep in mind when using a saw or when putting away the saw:

- Do not bend or kink the blade of a handsaw, as such distortions prevent the blade from sliding through the kerf. Applying pressure to force a jammed handsaw through the wood causes the blade to bend, usually resulting in a kinked blade. Laying a handsaw on an uneven surface and placing other tools on top of it will bend the blade.
- Do not saw through a metal object in the wood with a saw designed to cut only wood; either remove the object or cut it with a plumber’s saw.

- When a saw is not in use, oil and store it properly to prevent it from becoming rusty and bent. A rusty saw will bend easily in a cut.
- Do not use a saw to twist off waste pieces of wood, as this distorts the blade. Break off such pieces with the hand or a mallet.
- When sawing, do not let the blade strike the floor. If necessary, either raise the work being sawed or use short strokes.
- Keep saws sharpened. Since the sharpening process requires a great deal of skill, this should be done commercially.
- Label the saws, especially the ripsaw and the crosscut saw, to prevent misuse.

Files

Files are used for shaping and for smoothing materials in many trades. In occupational therapy, they are used for smoothing metal, plastic, and wood. Since filing wood leaves a rather rough surface, it should be done sparingly unless the primary goal is therapy. There are supposed to be over 3,000 types of files, each made for a specific purpose.



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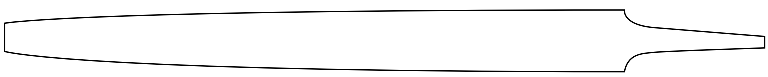

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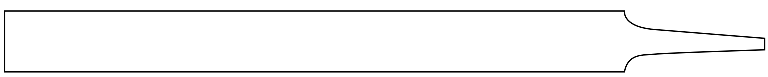
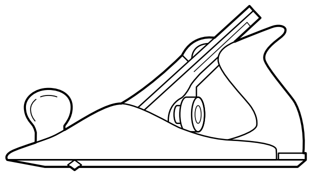


Blunt

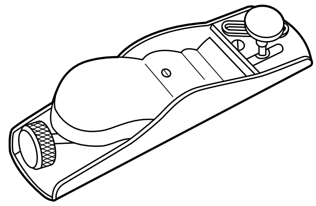
Shapes of Files

Planes

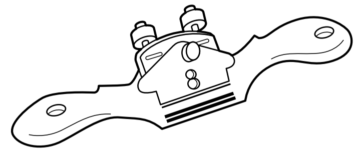
Planes are used to smooth boards; to remove relatively small amounts of wood from the surface or edge of a board, thereby obtaining the desired thickness or width; or to true or square a board. Generally, planes are classified as either bench planes or block planes. Although planes are similar in general construction, method of operation, and care, they vary in size, shape of blade, and other details, as each one is designed for a specific job.



Bench Plane



Block Plane



Spokeshave

Bench Plane

A bench plane is designed, as its name implies, for use while the work is held on a workbench. It is used primarily for shaving and smoothing with the grain of the wood. For this purpose, the bevel of the cutting edge of the blade is turned down.

Types of bench planes include:

- **Jointer plane:** This largest bench plane is 18 to 24 inches long with blades $2\frac{3}{8}$ to $2\frac{5}{8}$ inches wide. Because of its length, it rides across small hollows or depressions in the work without cutting. This jointer plane is, therefore, used to true edges or surfaces of boards.
- **Jack plane:** The jack plane is similar to the jointer. It is $11\frac{1}{2}$ to 15 inches long with blades $1\frac{3}{4}$ to $2\frac{3}{8}$ inches wide. It can be used for the same type of work as the jointer plane, provided the lumber is not too wide. Furthermore, when only one plane is to be purchased, the jack plane is a good choice in that its size is between the sizes of the jointer plane and the smoothing plane.
- **Junior jack plane:** The junior jack plane is smaller than the jack plane. It is 10 to $11\frac{1}{2}$ inches long with blades about $1\frac{3}{4}$ inches wide. Since it is smaller and lighter in weight than the jack plane, it is easier to handle.
- **Smoothing plane:** The smallest bench plane is the smoothing plane, which is $5\frac{1}{2}$ to 10 inches long with blades $1\frac{1}{4}$ to $2\frac{3}{8}$ inches wide. Unlike the other bench planes, it is not used to true a board but rather to smooth rough surfaces. For this reason, the cutting edge of the blade is shaped like that of the block plane.

To use a bench plane:

1. Clamp the piece of wood to be planed securely.
2. Grasp the plane with the left hand on the knob and the right hand on the handle.
3. Position and keep the body well over the work to facilitate the control of the pressure.
4. Keep the board even while planing by bearing down firmly on the knob when starting the stroke, bearing evenly on both knob and handle in the middle of the stroke, and lightening the pressure on the knob and bearing down on the handle at the end of the stroke.
5. On the return stroke, raise the cutting edge of the plane so that it will not drag on the wood.

When using a bench plane, keep the following in mind:

- For rough cuts, angle the plane approximately 30°; for smooth cuts, angle it about 10 to 15°.
- When planing sides and edges, work from the outside toward the middle and, as much as possible, with the grain of the wood.
- If the grain is torn or roughened by the plane, reverse the direction in which the plane is being pushed. A common cause of this difficulty is a plane adjusted to take too deep a cut; the shaving should be thin and should come up and through the mouth to be deflected by the cap iron.
- To avoid splits in the wood, bevel the edges of excess (waste) stock; then work toward the bevel.
- To keep the edges true while planing, hold a block of wood against the side of the work and under part of the plane.

Block Plane

The block plane is smaller than the bench plane. It is 4 to 8 inches long, with a blade from 1 to 1⅝ inches wide. It is designed to smooth across end grain and to make close joints. It is also used for smoothing many other small areas. Although it is made somewhat differently from a bench plane, it is adjusted in the same manner. The blade is shaped like that of the smoothing plane, but it is used with the bevel up instead of down. Also, the blade is held in place by a lever lock instead of a cap iron. Guidelines for using the block plane follow.

- Hold the plane with only one hand.
- To smooth cross-grained wood, adjust the plane to take light, not deep cuts; make the strokes short and at an angle.
- Always plane cross-grained wood toward the center of the board to prevent the blade from running over the edge and splitting off a corner of the wood. Slightly beveling the waste portion of the stock also helps prevent a split.

Related Tools

The tools in this list are variations on the two basic types of planes:

- **Spokeshave:** The spokeshave is a greatly modified plane used for smoothing and shaping convex and concave surfaces of wood. It has a short bottom that makes it adaptable for shaping. The blade is held in place with a screw and a clamp. The adjustments for the spokeshave are similar to those of a plane. Before starting the planing process, the work is clamped firmly in a vise. The spokeshave is grasped by the handle with the thumbs near the center of the tool. The cut is then made either by pushing or by pulling the tool. It is best to cut with, rather than against, the grain of the wood.
- **Cabinet scraper:** The cabinet scraper, made of a metal frame with two handles, holds a blade that can be adjusted to the desired depth by means of the thumbscrew. This blade produces fine, thin, even shavings as it is pushed with the grain, using long even strokes. A cabinet scraper removes irregularities left in the wood by the plane. It also works well in the final dressings of burls or woods with irregular grain.

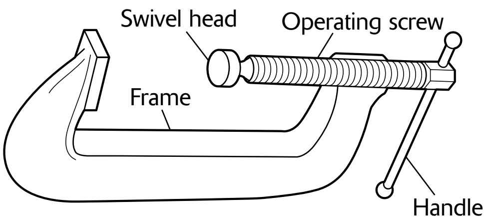
- **Hand scraper:** The hand scraper is a rectangular piece of steel. The sharp edge of this piece of steel, rather than an actual blade, is used to remove mill marks and scratches before the sanding process is started. The scraper is held firmly in both hands and is angled toward the wood about 30° in the direction that it is being pushed or pulled. Before steel is stored, it must be covered with a light coat of oil to prevent rust.

Clamps and Vises

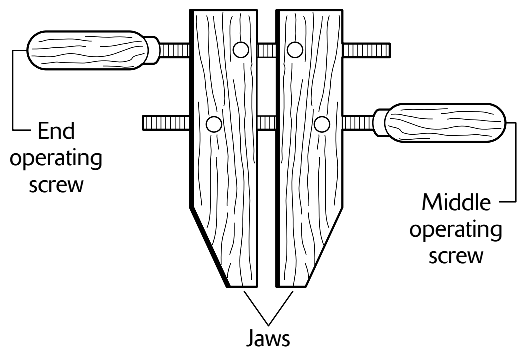
Holding tools such as C-clamps, hand screws, bar clamps, miter clamps, and vises are very important in holding pieces to be shaped and in assembling the finished parts of a project. Knowledge of these tools and skill in their use make the work easier and help in producing a better finished product.

Clamps

Clamps are holding devices made of two parts that are brought together, usually with screws. These clamps are not fixed to a bench or worktable. Clamps most commonly used in woodworking are described below.



C-Clamp

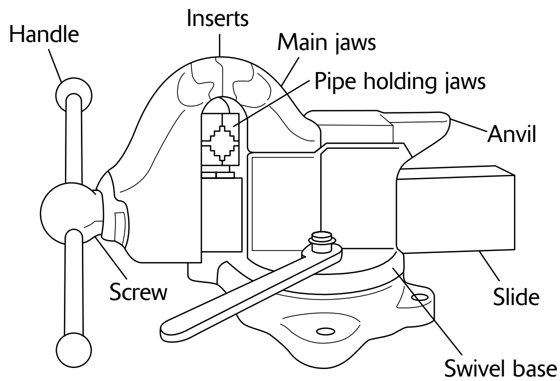


Hand-Screw Clamp

- **C-clamp:** This clamp is shaped like the letter "C". Its shape makes it suitable for clamping small pieces of wood, for applying pressure at points inaccessible to other clamps, and for holding work onto the bench. The C-clamp consists of a steel frame, threaded to receive an operating screw with a swivel head. Small pieces of soft wood or heavy leather should be placed between the clamp and the wood.
- **Hand-screw clamp:** This clamp consists of two hard maple jaws with two operating screws. Each jaw has two metal inserts into which the screws are threaded. Although this clamp was designed to hold flat wood blocks together, the jaws may be adjusted to hold a wide variety of irregularly shaped objects.
- **Bar clamp:** This steel clamp is available with opening sizes ranging from 2 feet to 6 feet. Several clamps are ordinarily used at one time to hold stock too wide to be spanned by other clamping devices, such as wide pieces being glued together for a tabletop.
- **Miter (corner) clamp:** This clamp makes it easy to miter corners such as those of picture frames. Miter clamps open to 3 inches, thus accommodating most sizes of molding. Using four clamps, one for each corner of the frame, decreases the time required for the gluing process.

Vises

Vises are holding devices made to fasten to a workbench and to hold objects by means of two jaws which open and close as a screw is turned. The most common woodworking vise is the bench vise; however, the machinist's vise is often used in woodworking.



Machinist's Bench Vise

The woodworker's bench vise holds lumber to be worked. It is attached to the bench so that the top edges of the vise are flush with the top of the bench. The movable jaws may be adjusted entirely by turning the handle; or in some vises, they may be more rapidly adjusted by setting the handle, pushing the movable jaw to approximately the correct position, and then firming it against the work by turning the handle. These vises vary in size and weight and usually open from 9 to 12 inches. Material to be worked on is held between the jaws of the vise. It is wise to protect it from damage with small pieces of wood. Lumber too large to be held in the vise may be held between the vise dog (the part of the vise which can be pulled higher than the top of the bench) and the bench dog (the metal, T-shaped piece that fits into holes in the bench).

The less commonly used machinist's bench vise is a heavy-duty, versatile, large steel vise with rough jaws to prevent work from slipping. The vise is bolted to the bench, where it swivels and stands about 9 inches above the bench. Work must be protected with wood to prevent marking by the rough jaws.

Abrasives and Wood Preparation

One of the most important steps in woodworking is the careful preparation of the wood for finishing. Most of the sanding and smoothing should be done before the work is assembled. It is this part of the work that brings out the beauty of the wood and produces the fine smooth surface so admired in good woodworking. Too often, woodworkers, especially amateurs, take shortcuts in repairing the wood. This practice frequently results in a disappointing piece of work rather than in one to be admired.

Preparation of Wood

In preparation of wood for finishing, you must carefully examine it to determine the nature of the defects. Some of the defects commonly found in wood and the methods of correction are explained below.

Mill marks may be wavy unevenness across the surface of the lumber caused by the planer or jointer, marks from the saw blade, or circular marks from the disc sander. If they are deep, removal may be started with a belt sander. In order to finish the job or to remove the mill marks if they are not deep, a cabinet scraper or sandpaper of different grades is used.

Scratches along the grain are less noticeable than those across the grain. The method used to remove the scratches depends upon the extent and depth of the scratches. If they are deep, sanding may be started with a belt sander and finished with hand sanding. Light scratches may be removed with only hand sanding. In order to prevent wavy areas in the surface of the wood, the scratches and the area around them must be sanded.

Dents that have only crushed the wood and not broken its surface can often be raised by wetting the affected area with a few drops of water. If this does not raise the dents, steam may be more effective. Steaming may be accomplished by placing a few drops of water on the area and touching the dents with a hot instrument. Also, holding a steam iron over the area may bring up the dents.

Dents that do not respond to the previous treatment may be filled with a material that will adhere to the wood and take stain well but will not fill the pores of the surrounding wood nor shrink when it becomes dry. Materials which can be used include plastic water putty, wood compound paste, plastic wood, a glue and sawdust mixture, and melted stick shellac.

Sanding

After dents have been raised or filled, the unassembled pieces are sanded. Although sanding tends to be tedious, selection of the best type of abrasive paper with the correct grit and employment of the best working methods can speed this process without sacrificing the desired results.

Three types of abrasive papers are commonly used in woodworking:

- **Flint paper:** Grayish-tan in color, this paper is used most frequently because it is the least expensive. It is less durable than other papers, as it dulls rather rapidly.
- **Garnet paper:** Reddish in color, this paper is more expensive than flint paper and becomes dull less rapidly. It cuts not only longer but also faster than flint paper. It is especially good when sanding plastic.
- **Aluminum oxide paper:** Dark gray (almost black) in color, this paper can be used either wet or dry. It is used wet only on varnished and lacquered surfaces.

All three types of abrasive papers are available with different sizes of grits, ranging from very fine to very coarse. Flint and garnet papers are usually marked very fine, fine, medium, or coarse rather than with a number. Selecting the best paper for the job is a matter of judgment sharpened by experience. The rougher the flaws in the wood, the coarser the abrasive paper must be to remove them. Fine abrasive paper is used to remove the scratches left by the coarse paper.

Sandpaper is ordinarily purchased in sheets that are 9 by 11 inches in size. For ease of handling and for economy, it can be torn into several pieces. The smooth side of the paper should first be worked over the rounded edge of the bench to limber the paper and to prevent cracking when it is torn or wrapped around the sandblock.

Most sanding should be done with the sandpaper wrapped around a sandblock. The block can be made of scrap wood. It should be a size comfortable to hold and should also fit the pieces of sandpaper. A good size is about ¾ by 2½ by 4 inches. A cushioning substance such as cork, rubber, felt, or leather should be glued to the bottom of the block. This cushion prolongs the life of the sandpaper and makes the sanding smoother.

Different types of surfaces require different techniques of sanding:

- Flat surfaces are always sanded with the grain of the wood, never across it or with a circular motion.
- End grain should be sanded in one direction rather than with a back-and-forth motion.
- Corners or a curve should be sanded in one direction (not back and forth) and with the grain of the wood.
- Concave surfaces and the edges of holes are sanded with the sandpaper wrapped around a dowel or broom handle. The dowel should be padded before the sandpaper is wrapped around it.
- Edges may be rounded or rounded edges may be sanded by holding the paper in the palm of the hand while sanding.

An extra smooth finish may be obtained by sponging the wood with water after sanding to raise the small wood fiber. After the wood has dried, the raised fibers are smoothed off by using extra fine sandpaper held in the hand. For an extra fine surface, this sponging process is repeated several times.

After the work has been assembled and sanded the final time, any glue which has not been removed with the sandpaper should be removed with a knife. Just before the finish is applied, the sanded piece is cleaned of dust and sandpaper residue, using either a clean brush with fairly stiff bristles or a clean cloth dampened slightly with turpentine.

Steel Wool

Steel wool is another form of abrasive used in woodworking. It is used for rubbing down wood between coats of finish. It is frequently used with a lubricant such as linseed oil to prevent scratching.

Final Polishing

Pumice and rottenstone are both fine powders used with an oil in the final polishing of shellac, varnish, and lacquer finishes.

- **Pumice** is a spongy, light, porous volcanic rock ground to different degrees of fineness for the polishing of wood finishes, ivory, marble, and fine metals. Pumice stone is available in several types and colors; the type most commonly used in woodworking is grayish in color. FF and FFF indicate the amount of coarseness. Pumice is mixed with fine motor oil, paraffin oil, linseed oil, or lemon oil to form a paste; then it is rubbed on the final coat of shellac, varnish, or lacquer to make the surface highly polished and smooth.

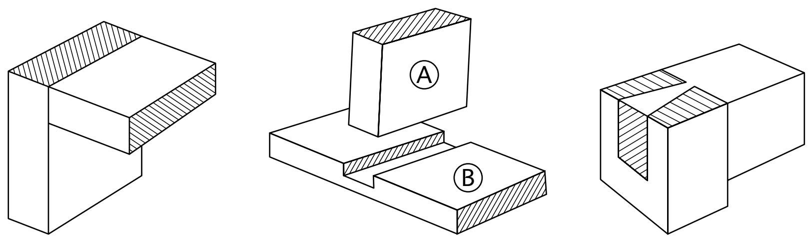
- **Rottenstone** is limestone decomposed to a powder. Dark brown and finer than pumice, it is used in the same way as pumice to produce a higher polish.

Joints and Gluing

The strength, durability, and worth of a piece of furniture or equipment depend a great deal upon the suitability of joints used, the workmanship employed in making the joints, and the types of glues and fasteners used to reinforce the joints.

Types of Joints

A piece of furniture or equipment usually includes one or more types of joints. Fundamental to wise planning is a knowledge of joint designs and their specific purposes.



Here are the most common types of joints:

- **Butt joint:** This commonly used joint is simple to make; however, care must be taken to ensure that the ends and surfaces where the two pieces meet are as square as possible. The butt joint does not look as nice as other joints; furthermore, it is not as strong as others. Its strength can be increased by applying glue and reinforcing with dowels, nails, screws, or corrugated fasteners.
- **Dado joint:** The dado joint is useful in making items with shelves and drawers. It is also used in the construction of doors and windows. One piece of wood fits snugly into a recess cut into another piece.
- **Dovetail joint:** The dovetail joint is one of the strongest joints. If it is made well, it has strength without being glued. In better furniture, both old and new, this joint appears in a series to give strength and to improve appearance.
- **Lap joints:** There are several types of lap joints; each serves a specific purpose. Lap joints tend to be stronger than many of the other joints because of their shape and the extent of the area to which glue can be applied.
- **Miter joint:** The miter joint is one of the more commonly used joints. It is useful in making such items as picture frames, in which symmetry is desirable and view of the end grain is undesirable. Miter joints are usually made at a 45° angle, which can be cut with an accurate miter box or measured with a try square, combination square, or T-bevel.

- **Mortise-and-tenon joint:** In this joint the tenon is one half, and the mortise is the other half. Since this joint is one of the strongest and most attractive, it is used extensively in tables, chairs, desks, window sashes, and other articles in which both strength and attractiveness are important.
- **Rabbet joint:** The rabbet joint is similar to the dado joint, except that the pieces are joined at the ends. This joint is used extensively in making such things as drawers, window and door frames, book shelves, and furniture. Both pieces must be squared. The joint is marked, cut, chiseled, and reinforced in the same manner as the dado joint. If the joint is made with the grain, it can be cut with a power saw or a rabbet plane.
- **Tongue-and-groove joint:** This joint is similar to the mortise-and-tenon joint; however, both the mortise and the tenon are continuous. The tongue-and-groove joint is usually machine-made. Lumber for flooring can be purchased already tongued and grooved.

Joint Reinforcements

Only a few joints are so strong that no reinforcement is required. Selection of a particular reinforcement depends upon the strength needed and the appearance desired.

Common reinforcements are:

- **Spline:** A spline is a thin piece of wood that fits into a groove made in both parts of a joint. Since it is glued into place, it strengthens the joint. Splines are often used to reinforce miter joints or to join two long boards. The spline can be hidden if the groove for the spline is made with the circular saw in such a way that the cut does not run the full length of the board.
- **Dowels:** Almost any type of joint can be strengthened with dowels. Dowels are round wood, usually birch or maple, that comes in 36-inch lengths, ranging from ¼ to 1 inch in diameter. Dowels grooved to hold additional glue are also available. To insert a dowel, you must drill holes, measured carefully, through each piece to be joined. A depth gauge is used to ensure accuracy in drilling the holes the correct depth, and either a doweling jig or try square is used to ensure the holes are drilled at a 90° angle to the edge of the board.
- **Screws:** A joint held with glue and screws is solid and durable; even a butt or miter joint reinforced in this manner is very stable.
- **Nails:** Nails are used to hold joints in rough work. If the nails are driven at an angle (called *toenailing),* they have greater holding power. The addition of glue greatly strengthens a nailed joint.
- **Corrugated fasteners:** Since appearance is not important in rough temporary constructions, corrugated fasteners may be used to hold miter and butt joints together. Glue may or may not be used, depending upon the amount of stability and use required.

Gluing

Gluing is said to be the oldest, neatest, strongest, and most durable method of fastening wood joints together. It is ordinarily used in combination with various types of fasteners to provide added strength. It must not, however, be used as a filler of space created by a poorly fitted joint.

Selection of the most suitable glue depends not only upon the design of a particular object but also upon how and where the object is to be used. Casein and plastic glues are more resistant to water and dampness; hot animal glue and plastic glue are stronger than others. Some glues set in a short time; others do not. The newer types of glues come ready to use; others must be mixed. The following table contains the most commonly used types of glues and their general characteristics.

Type	*Drying Time*	*Strength*	*Shop Uses*	*Water Resistance*
Animal	Sets rapidly	Very strong	Joint work, not exposed to water	Low
Cold liquid animal	Varies with type	Medium	Repair work	Low
Casein, powdered	4-5 hours	Good for oily woods	For semi-water-resistant joint work and as filler	Good
Plastic	4-5 hours. Clamping necessary	Very strong	Joint work	Very high
Epoxy	Hardens overnight	Strong, resists heat	Wood, masonry, metal, china, glass	Waterproof
Resorcinol glue	8-10 hours. Clamping necessary	Strong at any temperature	Outdoor furniture, boats, etc.	100% waterproof
Powdered resin	Clamping necessary	Strong if joint fits well	Not good for poor joints or oily surfaces	Good
Contact cement	Bends on contact when dry	Light duty	Leather, large surfaces like wall paneling	High
White glue	Sets in 20-30 minutes with moderate pressure	Moderate	Paper, fabric, canvas, felt, and cork to wood	Moderate

A glued joint must be put under pressure until the glue becomes set. The joint can be held with nails, screws, or clamps. Various types of clamps are available for holding glued work under pressure. When clamps are not available in the appropriate type or in an adequate number for a particular piece, an improvised method may be used. The method to be used must be planned and set up before the glue is applied. If clamps are to be used, the clamps and protective blocks must be in place before the glue is applied. This is especially important when using a fast-drying glue.

Lumber

Many kinds of lumber are used in woodworking. Each one has certain qualities that make it more or less adaptable for specific types of work. The appearance of a finished product is greatly dependent upon selection of the most appropriate lumber in the correct size, grade, and finish.

Categories of Wood

The two main categories of wood are hardwood and softwood. These terms are somewhat misleading, as they have nothing to do with the hardness or softness of the wood.

- **Hardwoods:** The hardwoods are cut from deciduous (broad-leaf) trees. Both maple and basswood are considered hardwoods even though maple is hard and basswood is soft. The more common hardwoods include maple, basswood, birch, oak, yellow poplar, chestnut, mahogany, cherry, walnut, ash, and elm.
- **Softwoods:** Conifers (trees with needle-shaped leaves) furnish the type of lumber classified as softwood. Georgia yellow pine is heavy and hard, and northern white pine is light and soft; yet both are considered softwoods. Yellow pine, Douglas fir, western pine, hemlock, white pine, redwood, cedar, cypress, and spruce are some of the most common softwoods.

Purchasing Lumber

Specific terms, abbreviations, and numerals are used by wood dealers to describe wood qualities, grades, and measurements. Since lumber dealers have not converted their measurements to the metric system, measurements are normally expressed in feet and inches.

Grades of Wood

Lumber is graded by the number of flaws it contains. In relation to flaws, the following terminology is used: A *blemish* is a small knot in the wood that mars the appearance but does not alter the soundness of the wood. A *defect* mars the soundness of the wood. A knot of more than 1¼ inches in diameter is considered a defect.

Select lumber, as the name indicates, is the better of the two. It is subdivided into grades:

- Grade A is practically free from defects.
- Grade B may have minor defects or blemishes.
- Grade C has more defects or blemishes.
- Grade D has still more defects or blemishes.

Common lumber is not as free from imperfections as select lumber, but it is adequate for some purposes and is less expensive. It is subdivided as follows:

- No. 1 Common is sound, even though it may have small knots.
- No. 2 Common has large, coarse defects.
- No. 3 Common contains a greater number of defects.
- No. 4 Common contains still more defects.
- No. 5 Common is considered poor lumber and is unusable for shop work.

Measurement of Lumber

The price of lumber is based on the cost per board foot. A board foot is 1 inch thick, 12 inches wide, and 1 foot long. The measurements are given in the following order: thickness, width, and length. Thickness and width are given in inches; length is given in feet. To determine how many board feet are in, for example, four pieces of lumber with measurements 2 inches by 6 inches by 5 feet, multiply $2 \times \frac{6}{12} \times 5 \times 4 = 20$ board feet.

The measurements discussed above are used for rough lumber. Planing not only smoothes the surface but also decreases the size of the piece. A board sold as 1 inch thick is actually $\frac{13}{16}$ of an inch thick. When lumber is requested, this variation must be taken into consideration.

Plywood is made in sheets 4 by 8 feet. The request for plywood must indicate whether the plywood is to be clear on both sides or on just one side.

Power Tools

Some woodworking and plastic operations can be accomplished more easily, quickly, and accurately with power tools. Some of the more common power tools are discussed in this section.

Bandsaw

The bandsaw consists of an endless saw blade that is tracked over two or three rubber-tired pulley wheels. Although it can be used to cut a variety of materials including wood, it can not perform as many different operations as the circular saw.

Cutting should be done only when the saw is running at full speed. The stock is fed into the blade with light pressure from one hand; the other hand helps guide the work. Both hands must be kept well away from the blade. The blade must be the appropriate width for the size of the circle to be cut. The more narrow the blade, the smaller the circle that may be cut. Attempting to cut too small a circle can result in a pinched or broken blade. In some designs, several cuts can be made to the edge of the curve to break it into smaller parts and release the pinch on the blade. A change in the sound of the saw often indicates when the blade is being pinched.

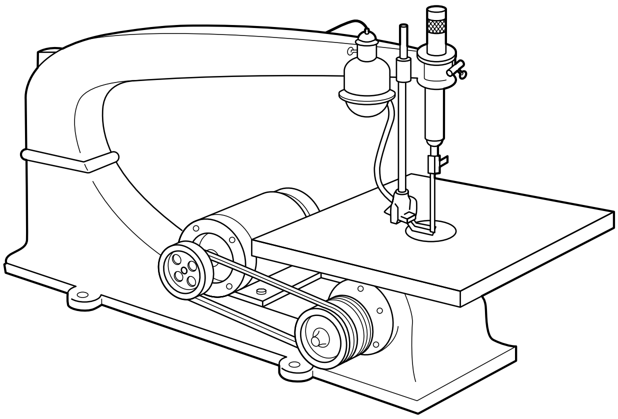
A square corner may be cut by boring a hole in the square corner and cutting the stock sawed away. Although stock is usually fed into the band saw manually, it is possible to use a fence for straight cuts or a miter gauge for miter cuts.

Several pieces of lumber can be sawed at the same time. One way to keep all the pieces in proper alignment is to drive flails or brads into the waste parts through all the pieces. Care must be taken, however, to avoid sawing through the nails.

Sawing at an angle is done by tilting the table of the saw to the desired angle as indicated on the gauge under the table.

Jigsaw

The jigsaw is regarded by some as an auxiliary to the bandsaw. It can be used for such sawing operations as curved outlines or pierced work that cannot be done with a bandsaw. The jigsaw blade moves rapidly up and down through a ⅛- to ¾-inch stroke; it saws on the downward part of the stroke. The jigsaw can be a hand-held type or bench type.



Jigsaw

Table or Circular Saw

The table saw is considered by some to be the most useful power tool. A motor-driven circular saw blade is adjusted by a hand wheel until it projects through a slot in the top of the flat cast-iron table a little farther than the thickness of the board to be sawed. The *fence* is set as far from the blade as the length of the lumber to be cut; the wood is fed into the saw by holding it against this guide. It is possible to do various operations, such as grooving and mitering, by adjusting the saw or by using different blades. To be safe, a saw guard should be used.

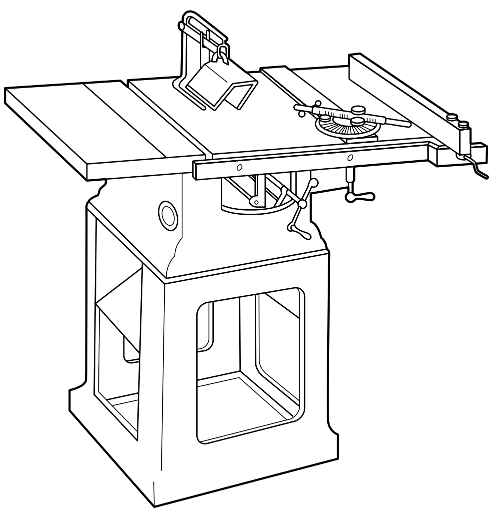


Table Saw

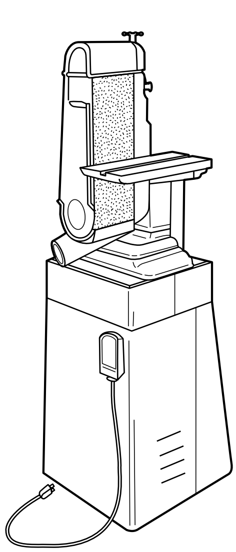
The saw is sized according to the maximum diameter of the saw blade used with the machine, such as a 7-, 8-, or 10-inch blade.

Three types of circular saw blades are used for all ordinary work. These are the *rip blade, crosscut blade,* and *combination blade.* The combination blade, which has both crosscut and ripsaw teeth, can be used for both ripping and crosscutting. For general shop work, this blade is used the most frequently.

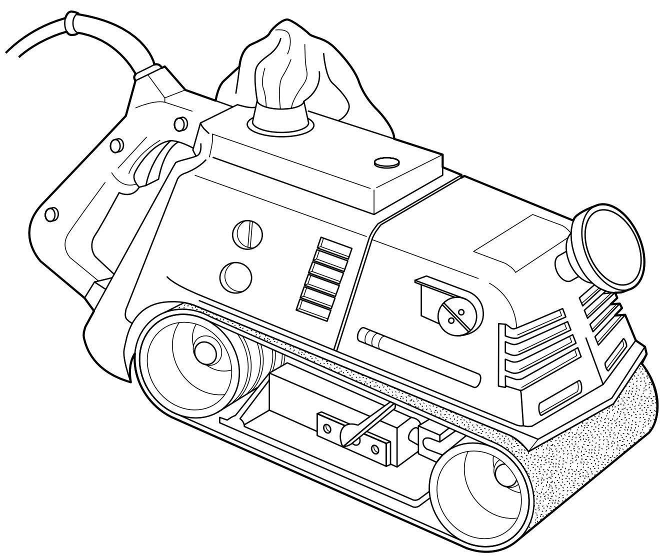
Sanders

Two types of power sanders are most commonly used:

- **Disk sander:** A disk sander is a sandpaper-covered metal disk which is rotated rapidly by a motor. An adjustable table fastened to the sander can be tilted to hold the stock at an angle for beveling. The disk can also be attached to an electric drill for hand use.
- **Belt sander:** The belt sander is used to sand flat as well as curved surfaces. This is done by pressing the work against an endless abrasive belt. There are several types of belt sanders: the vertical, the horizontal, and the combination of disk and belt sanders. Also available is a sander that can be used in either the vertical or the horizontal position, or as a portable hand tool.



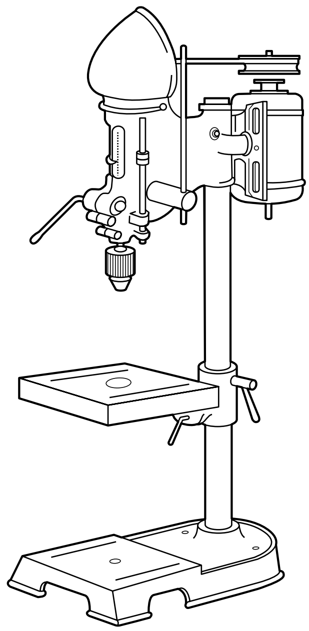
Vertical Belt Sander



Portable Belt Sander

Drill Press

A drill press has a vertical column set in a bench or floor base. On the upper end of the column is the motor that drives the drill. Both the column and drill are moved down to the work by means of either a hand-operated or foot-operated lever. The press is equipped with a depth-gauge mechanism. The table can be raised, lowered, or tilted 45° to both sides.



Drill Press

Jointer

The jointer is essentially an electric planer. It differs from an electric planer, however, in that it is designed to plane the *edges* of wood so that they can be joined together. The planer is designed to smooth the surfaces of wood. The size of a jointer is determined by the maximum width of the stock that can be passed through it, such as a 6-inch width.

Lathe

The wood-turning lathe, invented centuries before other machines, rotates a piece on a horizontal axis to allow it to be shaped with a hand tool. This machine is unique in that the art and skill of hand-tool work must be combined with the mechanical movement of the machine. The lathe is sized by the distance between the headstock and the lathe bed. A 6-inch lathe will turn a 12-inch bowl.

Portable Router

A portable router has a high-speed motor mounted to a base that is fitted with two handles and a guide for cutting both straight and curved edges. It is held in the hands and guided over the stock. The depth of the cut can be controlled by adjusting the depth gauge. It is used for veining, shaping, and other purposes:

- **Veining:** To vein and flute means to cut shallow grooves. Veined lines are narrow; flutes are somewhat larger. These grooves are used to decorate a wood surface.

- **Shaping:** Shaping work may be done with special bits that have a round shank below the cutting edges.
- **Miscellaneous work:** Small holes, mortises, grooves, dadoes, and rabbets may be easily and quickly made with a router.

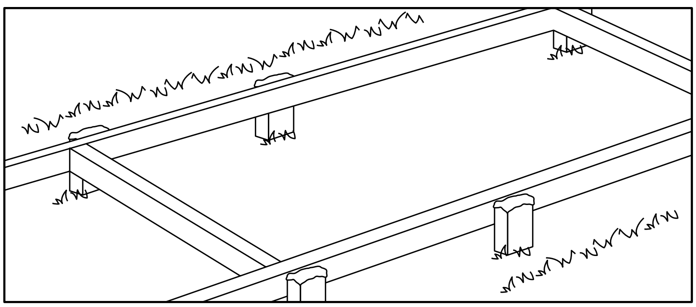
Working with Concrete

One of the strongest building mediums is concrete. Concrete is a mixture of cement, sand, gravel, and water, combined in specific proportions. Mixing them together produces a chemical reaction that changes these separate materials into a uniform compound. Concrete is ideal for building driveways and runways or for small jobs such as steps or anchoring fence posts.

For big jobs, it is normal to have the concrete delivered by a specialized truck. The truck has an apparatus that continually mixes the ingredients so they are ready to use.

To determine how much concrete you need, you would measure the length times the width times the thickness that you intend to pour. Once you know how much you need, you can either order it by the truckload, or if it is just a small amount, you can prepare it yourself.

Concrete is prepared by mixing cement with sand, gravel, and water in a container, such as a trough or a wheelbarrow. Premixed concrete only requires you to add water. Using a shovel, work the mixture thoroughly until the proper consistency is reached. If it is too dry, it will not float in the frame, and pieces or chunks will show. If it is too wet, it will not adhere properly, nor will it dry well.



Building a Form

Concrete is normally poured into a form that you can create with scrap wood. The form can be straight or curved. Normally, if you're pouring a walk or driveway, you will want to pour about 4 inches of concrete, and thus you should dig down at least 6 inches and fill the bottom 2 inches with sand or gravel. Pack down the filler with a concrete block or special tamping tool. The concrete is poured on top of the filler.

As you pour the concrete, continue to smooth it down with a trowel. Then, using a long, flat board, run it over the surface in a back-and-forth sawing motion to ensure that everything is level. This is called *screeding*. Then, using a tool called a *darby,* give a final smoothing to make sure there are no unsightly bumps, ridges, or open areas along the frame.

Once the concrete has dried, you should then apply a concrete sealer. It is helpful to cover the concrete with a plastic tarp in order to let it dry slowly and make sure all of the water has evaporated.

To join bricks or cement blocks, you would use concrete of the same consistency. Because this is a smaller job and you're not pouring the cement, use a mason's trowel to apply *(butter)* concrete to the bricks. Then fit the blocks in the appropriate pattern, and using a jointer, finish the joints between the bricks.

Keep in mind that well-mixed and cured concrete reaches most of its strength in about a month.

To clean an existing concrete walk or driveway, use a stiff brush and a mixture of muriatic acid (5%) and water. Make sure to wear protective clothing, gloves, and eye protection. After scrubbing, flush the acid wash with a trisodium phosphate solution and then use your garden hose to wash it clean. Again, use a sealer to preserve the finish.

Design, Layout, and Planning

Design

The three elements of good design are *usefulness, durability,* and *proportions* pleasing to the eye.

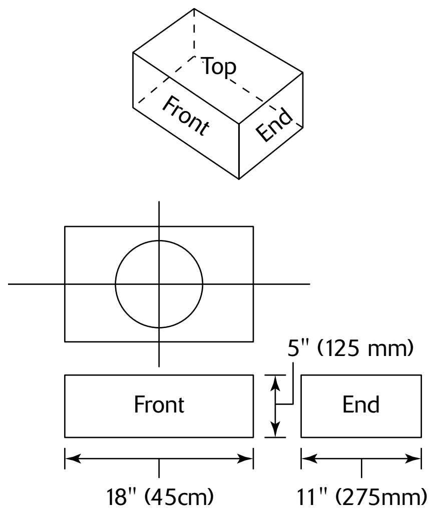
For a piece to be useful, it must fulfill the purpose for which it is intended. The size depends in part upon the use to which it will be put and where it will be used. There are somewhat standard heights for such things as chairs, tables, coffee tables, and lamps. These standard measurements should be used unless a good reason makes deviation logical. A table designed to fit into a small space in the kitchen should be made the standard table height so that it will fit with chairs and other furniture. An invaluable source for standard measurements of many everyday items is a large mail-order catalog.

Durability of a project is obtained by use of suitable materials and proper construction.

Proportion is the size relationship of the parts to the whole object. A good proportion relationship is 2 to 3; a table that is 2 units wide and 3 units long is in proportion. Deviations from this basic rule, however, can be interesting and pleasing.

Putting Ideas on Paper

When planning the general style and proportions of an object, it is often helpful to make a number of small sketches. After the general idea is formulated, the dimensions can be determined and the pieces drawn to scale.



Arrangement of a Three-View Drawing

In the drawings, an object may be shown from several views. The front-view drawing is usually done on the lower part of the paper with the side view to one side of it. If a top view is necessary, it is customarily drawn above the front view. These drawings are usually made to scale with various types of lines used to convey specific meanings.

Step-by-Step Planning

Proper planning is worthwhile in time saved and in the quality of the finished product. Each joint must be planned. The operations must be done in the proper sequence, and the proper tools must be used for each operation.

Layout

Laying out the pattern on your building material is the important first step. Errors made in measuring are almost impossible to correct later.

1. Examine the lumber for cracks, knots, or any other flaws. Plan the layout of the pattern so that these flaws will not be incorporated into or visible in the completed project.
2. Ensure that the lumber is of the required thickness.
3. Lay out the pattern to avoid waste of lumber.
4. Use a square for marking lines so that the cuts will be square with the edge.
5. Check the measurements before starting the sawing process.

Auto and Shop Information Practice Questions

1. The __________ means that each cycle is made up of four strokes.

   A. four-stroke cycle
   B. quad four
   C. rotary cycle
   D. none of the above

2. The engine block cylinders are closed at the top by a

   A. piston.
   B. air filter.
   C. cylinder head.
   D. all of the above

3. Car engines generally use

   A. four, six, or eight cylinders.
   B. diesel fuel.
   C. glow plugs.
   D. manual transmissions.

4. The source of the vehicle's electricity is the

   A. diode.
   B. regulator.
   C. generator.
   D. digital volt/ohm meter.

5. There are many technical terms that relate to engine performance: _____________, torque, bore, stroke, and displacement are just a few.

   A. Newton-meters
   B. kilopascals
   C. horsepower
   D. amperes

6. The strokes of the combustion process occur in a specific sequence and are called the ____________ stroke, __________ stroke, __________ stroke, and __________ stroke.

   A. exhaust, compression, intake, power
   B. compression, intake, power, exhaust
   C. power, intake, compression, exhaust
   D. intake, compression, power, exhaust

7. Most automatic transmissions have a final drive gear called the __________ gear.

   A. passing
   B. overdrive
   C. reverse
   D. neutral

8. In a four-speed automatic transmission, the fourth gear is a(n) ___________ gear.

   A. overdrive
   B. passing
   C. reverse
   D. 3:1 ratio

9. With a manual transmission, the ____________ connects and disconnects the engine crankshaft to the transmission.

A. clutch assembly

B. flex plate

C. bell housing

D. all of the above

10. The drivetrain transfers power from the ___________ to the ____________ .

A. engine, transmission

B. tires, pavement

C. tires, transmission

D. engine, driving wheels

11. A _____________ brake system matches a front brake hydraulic circuit on one side with a rear brake hydraulic circuit on the other side.

A. diagonally split

B. disc/drum

C. front and rear split

D. none of the above

12. A _____________ front suspension is a combination strut and shock absorber mounted inside a coil spring.

A. torsion bar

B. coil spring

C. MacPherson strut

D. all of the above

13. The brake linings contact the drum or rotor and through friction convert the ___________ to ___________.

A. motion energy, stopping power

B. vehicle's speed, rested power

C. motion energy, heat energy

D. heat energy, stopping distance

14. ______________ hold the vehicle up while __________ work to control or dampen the action of the spring.

A. Springs, shocks

B. Tires, struts

C. Shocks, springs

D. Struts, dampers

15. ______________ are used in currently produced vehicles.

A. Torsion bars

B. Leaf springs

C. Coil springs

D. All of the above

16. While sharpening a chisel, you should dip it in cold water frequently. This is called

A. steeling.

B. bluing.

C. tempering.

D. washing.

17. When clamping large pieces of wood stock together, you would normally use a

A. vise.

B. bar clamp.

C. C-clamp.

D. miter clamp.

18. In order to round over an edge of a wooden table, you would use a

A. router.

B. electric drill.

C. electric plane.

D. miter box.

19. To pour a curved walk for concrete, you should

A. build a form from wood.

B. cut the surrounding grass to fit the shape.

C. pour the concrete and shape it with a trowel.

D. mark the boundaries with string.

20. The final smoothing of a concrete driveway should be done with a

A. trowel.

B. 2×4 board.

C. darby.

D. rake.

21. The term “hardwood” refers to

A. the ability to withstand drilling.

B. the type of tree from which it comes.

C. its tensile strength.

D. whether or not the wood can be used for woodworking.

22. To install a hammer head on a new handle, you would use

A. a wedge.

B. an awl.

C. glue and nails.

D. glue and screws.

23. A miter clamp is used to

A. hold together long pieces of wood.

B. hold together the edges of a picture frame.

C. steady wood when sawing.

D. hold plastic tubing.

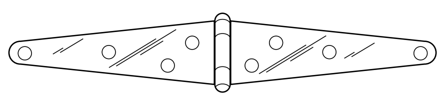
24. To affix a sheet of veneer to a plywood counter top, you would use

A. epoxy.

B. white glue.

C. contact cement.

D. finishing nails.



25. The illustration above is an example of a

A. butt hinge.

B. T-hinge.

C. spring hinge.

D. strap hinge.

Answers and Explanations for Practice Questions

1. **A.** The four cycles of the internal combustion engine are intake, compression, power, and exhaust.
2. **C.** The engine block is where the crankshaft, connecting rods, and pistons are located. The engine block is sealed by a cylinder head gasket and cylinder head.
3. **A.** The most common engines used in today's vehicles are 4 (inline), 6 (inline and V), and 8 (V) cylinders. Other configurations are used as well. Examples are the Honda inline 3 cylinders, Audi inline 5 cylinders, and Chrysler and Ford V 10. Some manufacturers use an inline 8 and V12 and V16 engines.
4. **C.** The generator, mostly referred to today as the alternator, produces electrical energy to charge the battery. It is usually belt driven and produces AC voltage that is changed to DC voltage by the diodes that are part of the alternator.
5. **C.** Horsepower is a unit of power that measures the rate at which a mechanical device performs work.
6. **D.** The following takes place in the internal combustion four-cycle ignition fired engine. Intake: Air and fuel are introduced into the cylinder (intake valve open). Compression: Air and fuel are compressed with both valves (intake and exhaust) closed. Power: The spark plug fires and the piston is forced into the downward stroke with both valves closed. Exhaust: The piston now moves upward from the burn that has taken place in the previous cycle. The exhaust valve is open for emissions. Diesel engines do not use a spark plug; they use 20 to 1 or more compression to heat the air mixture in the cylinder. The diesel engine sprays fuel into the cylinder with the correct timing (cycle) and burns the mixture.
7. **B.** Most manufacturers use overdrive for better fuel economy. Overdrive is like fourth or fifth gear on a standard transmission. When the vehicle is at the correct speed and rpm, overdrive is applied by the computer that controls solenoids in the transmission. This gives the driveline a 1 to 1 ratio.
8. **A.** Fourth gear or overdrive allows a 1 to 1 driveline ratio. This connection of 1 to 1 allows the output and input shafts to turn at the same speed or rpm.
9. **A.** The clutch plate is a thin steel disc connected to the transmission input shaft by a hub. The disc is covered with material that is similar to the brake linings.
10. **D.** The engine produces power that is transferred through the transmission (transfer case power) to the wheels. This is accomplished with the help of the drive shaft and/or CV axles.
11. **A.** Many front-wheel-drive vehicles with disc and drum brakes use the diagonally split brake system. This system connects the right front caliper and the left rear wheel cylinder through one chamber of the master cylinder. The left front caliper and right rear wheel cylinder will be connected the same way.
12. **C.** The MacPherson strut unit consists of a shock absorber, coil spring, upper pivot plate, bearing, and lower metal rim that sometimes uses a rubber insert. The upper plate assembly usually has three studs that attach the unit to the vehicle's body. The lower end is usually attached to a hub knuckle.

13. C. The brake system uses friction material to slow or stop the vehicle when the brake pedal is depressed. Brake pads/shoes are forced into contact with the brake rotor/drums that slow the rotation of the wheels.

14. A. Springs take the weight of the frame/body and level/stabilize the vehicle. Shocks control bounce and some body roll of the vehicle.

15. D. Manufacturers use different types of springs on today's cars and trucks. Their construction, shapes, sizes, rates, and capacities vary. Types include leaf springs, coil springs, air springs, torsion bars, and electromagnetic. Their main job is to stabilize the vehicle while keeping a specific ride height.

16. C. Dipping hot steel into water is a way to temper the metal, maintaining its strength, which may be lost from the heat that builds up during the grinding process.

17. B. A bar clamp is a steel clamp with openings as wide as 6 feet or more, ideal for large projects.

18. A. You would use a round-over bit in a router. Or, if you wanted to create a decorative edge on the tabletop, there are hundreds of bit designs that can be used in the router to create almost any style you want.

19. A. The proper way to pour any walk or curved area is to build a form from wood so that the concrete will flow into that form in the shape you desire. Once the concrete has cured, you should remove the form; the shape will remain.

20. C. A darby is a long, smooth board with a handle used specifically for smoothing concrete.

21. B. Hardwoods and softwoods have nothing to do with the hardness or softness of the wood. The terms refer to the types of trees from which the wood comes.

22. A. The handle of a hammer has a saw cut in the top end. The handle is inserted into the head of the hammer and then a wedge is driven into the cut to expand the handle and ensure a tight fit.

23. B. A miter clamp is designed to hold together corners of molding as well as picture frames.

24. C. Contact cement is perfect for attaching surfaces together. The contact cement is applied to both sides of the pieces to be joined. In this case it would be to the plywood top and the underside of the veneer. When both sides are dry and tacky, the veneer is carefully laid on top of the plywood surface. Once the two sides have touched, they cannot be moved or adjusted. To remove any air bubbles between surfaces, use a roller to push them out.

25. D. The strap hinge is usually used on garage and cellar doors, gates, and even toolboxes.

Mathematics Knowledge

The Mathematics Knowledge section of the ASVAB tests your knowledge of major concepts and principals taught in high school math. While you will, of course, need to perform some mathematical computations in the course of solving these problems, the emphasis is not on computation. Instead, the emphasis is on mathematical procedures and ideas.

The following section contains a summary of the math you need to know in order to be able to answer the questions on the test. The material has been written as a continuation of the material discussed in the Arithmetic Reasoning section, so, if you are not familiar with that material, it is a good idea to review it now. In addition to the examples throughout, at the end of this section there is a series of questions that review the material in this section and give you a lot of practice for the test itself.

The ASVAB has 25 Mathematics Knowledge questions. You will have 24 minutes to answer these questions.

Number Theory

Factors

Whole numbers are the set of numbers 0, 1, 2, 3, 4, 5, and so on. This section looks at some of the properties of whole numbers, and then of the set of numbers called the *integers*.

To begin, a *factor* of a given whole number is any number that you can use in multiplication that results in the given whole number. For example, consider the whole number 24. Both 6 and 4 are factors of 24, since $6 \times 4 = 24$. Further, both 2 and 12 are factors of 24, since $2 \times 12 = 24$. Technically, both 1 and 24 are also factors of 24, since $1 \times 24 = 24$.

To determine whether a particular number is a factor of a given whole number, simply divide the number into the given whole number. If there is no remainder, then the number is a factor.

Is 8 a factor of 72?

To determine if 8 is a factor of 72, divide 8 into 72. Since it goes in evenly (9 times), 8 is a factor of 72.

If 13 is a factor of 91, determine another factor other than 1 and 91.

You are told that 13 is a factor of 91, so you know that if you divide 13 into 91 it will go in evenly. If you do this division, you get $13\overset{\displaystyle 7}{\overline{)91}}$.

Thus, $13 \times 7 = 91$, so 7 is another factor of 91.

Common Factors

A number that is a factor of each of two different whole numbers is called a *common factor,* or a *common divisor,* of those numbers. As the following examples show, two given whole numbers may have no common factors (other than, of course, 1) or they may have one or more. If two numbers have several common factors, the largest one is called the *greatest common factor.*

Find all of the common factors and the greatest common factor of 36 and 48.

The factors of 36 are 1, 2, 3, 4, 6, 9, 12, 18, and 36.

The factors of 48 are 1, 2, 3, 4, 6, 8, 12, 16, 32, and 48.

The common factors of 36 and 48 are 1, 2, 3, 4, 6, and 12.

The greatest common factor is 12.

Prime Numbers

Obviously, every number has at least two factors—the number itself and 1. Some other numbers have additional factors as well. For example, the number 14 not only has 1 and 14 as factors, but also 2 and 7, since $2 \times 7 = 14$.

Numbers that have no additional factors other than themselves and 1 are known as *prime numbers.* An example of a prime number is 13. While 1 and 13 divide evenly into 13, there are no other whole numbers that divide evenly into 13.

By definition, the smallest prime number is 2. The first 10 prime numbers are

2, 3, 5, 7, 11, 13, 17, 19, 23, 29

In order to determine if a number is prime or not, you need to find out if there are any whole numbers (other than the number itself and 1) that divide evenly into the number.

Which of the following numbers are prime: 33, 37, 39, 42, 43?

33 is not prime since $33 = 3 \times 11$.

37 is prime; it has no factors other than 1 and 37.

39 is not prime since $39 = 3 \times 13$.

42 is not prime since $42 = 2 \times 21$, or 6×7, and so on.

43 is prime; it has no factors other than 1 and 43.

A number that is not prime is called a *composite* number. Any composite number can be *prime factored,* that is, can be written as a product of prime numbers (excluding 1) in one, and only one, way. For example, 35 is a composite number, and can be prime factored as 5×7. The number 12 is also composite. Note that 2×6 is a factorization of 12, but is not the prime factorization since 6 is not prime. The prime factorization of 12 would be $2 \times 2 \times 3$. The quickest way to prime factor a number is to break the number up as a product of two smaller numbers, and then to break those two numbers up, until you are left with only prime numbers. The example below illustrates this process.

Prime factor the number 150.

By inspection, you can see that 150 can be factored as 15×10. This is not the prime factorization, however, as neither 15 nor 10 is prime. The number 15, however, can be further broken down as $15 = 3 \times 5$, and both 3 and 5 are prime. The number 10 can be further broken down as

$10 = 2 \times 5$, and both 2 and 5 are prime. Therefore, the number 150 can be prime factored as $3 \times 5 \times 2 \times 5$. When prime factoring numbers, it is standard to rearrange the factors so that the numbers are in increasing order. Therefore, the prime factorization of 150 can best be expressed as $2 \times 3 \times 5 \times 5$.

Multiples

A multiple of a given whole number is a number that results from the multiplication of the given whole number by another whole number factor. For example, the multiples of 7 are 7, 14, 21, 28, 35, 42, 49, and so on, since $7 = 7 \times 1$, $14 = 7 \times 2$, $21 = 7 \times 3$, and so on.

A *common multiple* of two numbers is a number that is a multiple of both of the numbers. For example, 32 is a common multiple of both 8 and 16 because it is a multiple of both 8 and 16. Should you ever need to find a common multiple of two numbers, one quick way is to multiply the two numbers together. For example, a common multiple of 4 and 10 would be $4 \times 10 = 40$. Note, however, that 40 is not the smallest common multiple of 4 and 10, since 20 is also a common multiple.

The smallest common multiple of two numbers is called the *least common multiple,* abbreviated *LCM.* A quick way to find the LCM of two numbers is to write out the first several multiples of each number, and then find the smallest multiple that they have in common. The examples that follow show how to do this.

Find the first eight multiples of 11.

To answer this question, you simply need to compute 11×1, 11×2, 11×3, and so on. The first eight multiples would be 11, 22, 33, 44, 55, 66, 77, and 88.

Find the least common multiple of 3 and 8.

The first several multiples of 3 are 3, 6, 9, 12, 15, 18, 21, 24, and 27.

The first several multiples of 8 are 8, 16, 24, 32.

The LCM is 24 (in this case, the LCM is the same as the product of 3 and 8).

Exponents

As you saw previously, the numbers that you use in multiplication are called factors. Whenever the same factor is repeated more than once, there is a special shorthand, called *exponential notation,* that you can use to simplify the expression. In this notation, the repeated factor (called the *base*) is written only once, and above and to the right of this number is written another number that is called the *exponent,* or *power,* and which indicates the number of times the base is repeated.

For example, instead of writing 7×7, you can write 7^2. This expression is read "7 to the second power," or more simply, "7 squared," and represents the fact that the 7 is multiplied by itself. In the same way, $5 \times 5 \times 5 \times 5$ can be written as 5^4, which is read "5 to the fourth power," or simply "5 to the fourth."

Recall that earlier, you saw how to prime factor the number 150 and obtain $2 \times 3 \times 5 \times 5$. It is more common (and a bit simpler) to write this prime factorization using exponential notation as $2 \times 3 \times 5^2$.

> What is the value of 3^5?

Based on the definition above, 3^5 represents $3 \times 3 \times 3 \times 3 \times 3 = 243$.

> Simplify the expression $a \times a \times a \times a \times b \times b \times b \times b \times b \times b \times b$ by using exponential notation.

Since you have four factors of a and seven factors of b, the expression is equal to $a^4 \times b^7$.

> Prime factor the number 72, and write the prime factorization using exponential notation.

Begin by prime factoring the number 72. One way to do this is as follows:

$72 = 2 \times 36 = 2 \times 6 \times 6 = 2 \times 2 \times 3 \times 2 \times 3 = 2 \times 2 \times 2 \times 3 \times 3$. Then, writing this using exponents, you get $2^3 \times 3^2$.

Square Roots

The *square root* of a given number is the number whose square is equal to the given number. For example, the square root of 25 is the number which, when multiplied by itself, yields 25. This number would be 5, since $5 \times 5 = 25$. The square root of 25 is denoted by the symbol $\sqrt{25}$.

The square roots of most numbers turn out to be messy, infinite, non-repeating decimal numbers. For example, $\sqrt{2}$ is equal to 1.414213562 . . . to nine decimal places. When such numbers appear on the test, you will be able to leave them in what is known as *radical form,* that is, if the answer to a problem is $\sqrt{2}$, you can express the answer as $\sqrt{2}$, without worrying about its value.

There are, however, certain numbers that have nice whole number square roots. Such numbers are called *perfect squares.* You should certainly be familiar with the square roots of the first 10 or so perfect squares. You can see them in the following table.

Perfect Square	*Square Root*
1	$\sqrt{1} = 1$
4	$\sqrt{4} = 2$
9	$\sqrt{9} = 3$
16	$\sqrt{16} = 4$
25	$\sqrt{25} = 5$
36	$\sqrt{36} = 6$
49	$\sqrt{49} = 7$
64	$\sqrt{64} = 8$
81	$\sqrt{81} = 9$
100	$\sqrt{100} = 10$

From time to time, the test may ask you to find the *cube root* of a number. The cube root is similar to the square root. For example, the cube root of 8 is the number which, when multiplied by itself three times, is equal to 8. The cube root of 8 would be 2, since $2 \times 2 \times 2 = 8$. There is also a special notation for cube root. The cube root of 8 is written as $\sqrt[3]{8}$. Therefore, $\sqrt[3]{8} = 2$.

Just as there are perfect squares that have nice whole number square roots, there are also *perfect cubes,* numbers that have whole number cube roots. You don't really have to learn many of these, as they become large very quickly, but it is helpful to know the cube roots of the first five perfect cubes. The following table gives the values for these numbers.

Perfect Cube	***Cube Root***
1	$\sqrt[3]{1} = 1$
8	$\sqrt[3]{8} = 2$
27	$\sqrt[3]{27} = 3$
64	$\sqrt[3]{64} = 4$
125	$\sqrt[3]{125} = 5$

What is the value of $\sqrt{81} \times \sqrt{36}$?

Since $\sqrt{81} = 9$ and $\sqrt{36} = 6$, $\sqrt{81} \times \sqrt{36} = 9 \times 6 = 54$.

What is the value of $12\sqrt{49}$?

To begin, you must know that $12\sqrt{49}$ is shorthand for $12 \times \sqrt{49}$. Then, since $\sqrt{49} = 7$, $12\sqrt{49} = 12 \times 7 = 84$.

The Order of Operations

Whenever a numerical expression contains more than one mathematical operation, the order in which you perform the operations can affect the answer. For example, consider the simple expression $2 + 3 \times 5$. If you perform the addition first, the expression becomes $5 \times 5 = 25$. On the other hand, if you perform the multiplication first, the expression becomes $2 + 15 = 17$. In order to eliminate this ambiguity, mathematicians have established a procedure that makes the order in which you need to perform the operations specific. This procedure is called the *order of operations,* and is stated below:

1. Perform all operations in parentheses or any other grouping symbol.
2. Evaluate all exponents and roots.
3. Perform all multiplications and divisions in the order they appear in the expression, from left to right.
4. Perform all additions and subtractions in the order they appear in the expression, from left to right.

Note, then, that the order of operations consists of four steps. A common acronym to help you remember these steps is PEMDAS—parentheses, exponents, multiplication and division, addition and subtraction. If you choose to memorize this acronym, be careful. The expression PEMDAS may make it appear as if the order of operations has six steps, but actually there are only four. In the third step, all multiplications and divisions are done in the order they appear. In the fourth step, all additions and subtractions are done in the order they appear. The examples that follow will help make this clear.

> Evaluate the expression $18 - 6 \div 3 \times 7 + 4$.

Resist the temptation to begin by subtracting 6 from 18. Since this expression contains no parentheses and no roots, begin by starting on the left and performing all multiplications and divisions in the order they occur. This means that the division must be performed first. Since $6 \div 3 = 2$, you obtain:

$$18 - 6 \div 3 \times 7 + 4 = 18 - 2 \times 7 + 4$$
$$18 - 2 \times 7 + 4 = 18 - 14 + 4$$
$$18 - 14 + 4 = 4 - 4 = 0$$

> Evaluate $14 - 2(1 + 5)$.

To begin, you must perform the operation in parentheses. This makes the expression $14 - 2(6)$. Now, remember that a number written next to another number in parentheses, such as $2(6)$, is a way of indicating multiplication. Since multiplication comes before subtraction in the order of operations, you multiply $2(6)$ to get 12. Finally, $14 - 12 = 2$.

> Evaluate $5^3 - 3(8 - 2)^2$.

The first operation to perform is the one in parentheses, which gives you $5^3 - 3(6)^2$.

Next, evaluate the two exponents: $125 - 3(36)$. You now multiply, and then finish by subtracting: $125 - 108 = 17$

Operations with Integers

When you include the negatives of the whole numbers along with the whole numbers, you obtain the set of numbers called the *integers*. Therefore, the integers are the set of numbers

$$\ldots -4, -3, -2, -1, 0, 1, 2, 3, 4, \ldots$$

where the dots to the left and right indicate the numbers continue forever in both directions.

Up to this point, when this chapter discussed adding, subtracting, multiplying, and dividing, you have worked with positive numbers. However, on the ASVAB, you are just as likely to have to compute with negative numbers as positive numbers. Therefore, this chapter looks at how to perform mathematical operations on positive *and* negative numbers—that is, how to perform mathematical operations on *signed* numbers.

Adding Positive and Negative Numbers

There are two different circumstances to consider as you see how to add positive and negative numbers. The first circumstance is how to add two signed numbers with the same sign. If the numbers that you are adding have the same sign, simply add the numbers in the usual way. The sum will then have the same sign as the numbers you have added. For example:

$(+4) + (+7) = +11$

$(-5) + (-9) = -14$

In the second problem, since the signs of the two numbers you are adding are the same, simply add them ($5 + 9 = 14$). The result is negative since both numbers are negative. It may help to think of positive numbers as representing a gain, and negative numbers as representing a loss. In this case, $(-5) + (-9)$ represents a loss of 5 followed by a loss 9, which, of course, is a loss of 14.

Now, what if you have to add two numbers with different signs? Again, the rule is simple. Begin by ignoring the signs, and subtract the two numbers—the smaller from the larger. The sign of the answer is the same as the sign of the number with the larger size.

For example, to compute $(+9) + (-5)$, begin by computing $9 - 5 = 4$. Then, since 9 is bigger than 5, the answer is positive, or +4. You can think of the problem in this way: A gain of 9 followed by a loss of 5 is equivalent to a gain of 4.

On the other hand, to compute $(-9) + (+5)$, begin in the same way, by computing $9 - 5 = 4$. This time, however, the "larger" number is negative, so the answer is −4. In other words, a loss of 9 followed by a gain of 5 is equivalent to a loss of 4.

$(+6) + (-8) + (+12) + (-4) =$

There are two ways that you can evaluate this expression. One way is to simply perform the additions in order from left to right. To begin, $(+6) + (-8) = -2$. Then, $(-2) + (+12) = +10$. Finally, $(+10) + (-4) = +6$.

The other way to solve the problem—that may be a bit quicker—is to add the positive numbers, then add the negative numbers, and then combine the result. In this case, $(+6) + (+12) = +18$, $(-8) + (-4) = -12$, and, finally $(+18) + (-12) = +6$.

Subtracting Positive and Negative Numbers

The easiest way to perform a subtraction on two signed numbers is to change the problem to an equivalent addition problem, that is, an addition problem with the same answer. In order to do this, you simply need to change the sign of the second number and add instead of subtract. For example, suppose you need to compute $(+7) - (-2)$. This problem will have the same solution as the addition problem $(+7) + (+2)$, and is therefore equal to +9. Take a look at the samples below that will help clarify the procedure:

To evaluate $(-7) - (+2)$, you make it into an equivalent addition problem by changing the sign of the second number. Therefore, $(-7) - (+2) = (-7) + (-2) = -9$.

In the same way, you see that $(-7) - (-2) = (-7) + (+2) = -5$.

> Find the value of $(-7) - (+4) - (-3) + (-1)$.

Begin by rewriting the problem with all subtractions expressed as additions:

$$(-7) - (+4) - (-3) + (-1) = (-7) + (-4) + (+3) + (-1)$$

Now, just add the four numbers in the usual way:

$$(-7) + (-4) + (+3) + (-1) = (-11) + (+3) + (-1) = -8 + (-1) = -9$$

Multiplying and Dividing Positive and Negative Numbers

An easy way to multiply (or divide) signed numbers is to begin by ignoring the signs, and multiply (or divide) in the usual way. Then, to determine the sign of the answer, count up the number of negative signs in the original problem. If there was an even number of negative signs, the answer will be positive; if there was an odd number of negative signs, the answer will be negative. Thus, for example, $(-2) \times (+3) = -6$, since there is one negative sign in the original problem. However, $(-2) \times (-3) = +6$, since there are two negative signs in the original problem.

What about the problem $(-4) \times (-2) \times (-1) \times (+3)$? First of all, ignoring the signs and multiplying the four numbers, you get 24. Now, since there are a total of three negative signs in the problem, the answer must be negative. Therefore, the answer is -24.

Division works in exactly the same way. For example, $(-24) \div (+6) = -4$, but $(-24) \div (-6) = +4$

> Find the value of $\frac{(-6)(+10)}{(-2)(-5)}$.

The easiest way to proceed with this problem is to evaluate the number on top and the number on the bottom separately, and then divide them. Now, since $(-6)(+10) = -60$, and $(-2)(-5) = +10$, you have $\frac{(-6)(+10)}{(-2)(-5)} = \frac{-60}{+10} = -6$.

> Find the value of $(+5)(-2)(+4) - 6(-3)$.

The multiplications in this problem must be done before the subtractions. Since $(+5)(-2)(+4) = -40$, and $6(-3) = -18$, you have:

$$(+5)(-2)(+4) - 6(-3) = -40 - (-18) = 40 + 18 = 58$$

Negative Numbers and Exponents

Be a little bit careful when evaluating negative numbers raised to powers. For example, if you are asked to find the value of $(-2)^8$, the answer will be positive, since you are technically multiplying together eight -2s. On the other hand, for a similar reason, the value of $(-2)^9$ will be negative.

Also, you must be careful to distinguish between an expression like $(-3)^2$ and one like -3^2. The expression $(-3)^2$ means -3×-3 and is equal to +9. On the other hand, -3^2 means $-(3^2)$ which is equal to −9.

> Evaluate $-2^4 - (-2)^2$.

Evaluating the exponents first, you get $-2^4 - (-2)^2 = -16 - (4) = -16 - 4 = -20$.

> Find the value of $\dfrac{(-3)^3 + (-2)(-6)}{-5^2 + (-19)(-1)}$.

Again, determine the values of the top and bottom separately and then divide. To begin, $(-3)^3 = -27$, and $(-2)(-6) = +12$, so the value on the top is $-27 + 12 = -15$. On the bottom, you have $-25 + 19 = -6$. Therefore:

$$\frac{(-3)^3 + (-2)(-6)}{-5^2 + (-19)(-1)} = \frac{-15}{-6} = \frac{15}{6} = 2.5$$

Operations with Fractions

The Arithmetic Reasoning review section of this book discusses how to write a fraction as a decimal and vice versa. One thing that it doesn't discuss is how to perform arithmetic operations on fractions. This section reviews how to do this.

Equivalent Fractions

You probably remember learning a procedure called *reducing* or *simplifying* fractions. Simplifying a fraction refers to rewriting it in an equivalent form, with smaller numbers. As an easy example, consider the fraction $\frac{5}{10}$. You can simplify this fraction by dividing the top and bottom by the number 5. If you do this division, you get $\frac{5}{10} = \frac{5 \div 5}{10 \div 5} = \frac{1}{2}$. Thus, $\frac{5}{10}$ and $\frac{1}{2}$ have the same value, but $\frac{1}{2}$ is in simpler form.

In general, to simplify a fraction, you need to find a number that will divide evenly into both the top and bottom numbers of the fraction, and then do this division. Sometimes, after you divide by one number, you may notice that there is another number you can further divide by. As an example, suppose you wish to simplify $\frac{12}{18}$. The first thing that you may notice is that the top and bottom can be divided by 2. If you do this division, you get the fraction $\frac{6}{9}$. Now, this fraction can be further divided by 3, and if you do this division, you get the fraction $\frac{2}{3}$. Since there are no other numbers (except 1, of course) that can divide evenly into the top and bottom, you have reduced the fraction to *lowest terms.* If a problem on the test has a fractional answer, you should always reduce the answer to lowest terms.

Just as you can reduce a fraction to lower terms by dividing the top and bottom by the same number, you can raise a fraction to *higher terms* by multiplying the top and bottom by the same number. For example, consider the fraction $\frac{3}{4}$. If you multiply the top and bottom by 2, you get $\frac{6}{8}$.

If you instead multiply the top and bottom by 5, you get $\frac{15}{20}$. The fractions $\frac{6}{8}$ and $\frac{15}{20}$ are two different ways to write $\frac{3}{4}$ in higher terms. As you can see in the next section, it is often necessary to raise fractions to higher terms in order to be able to add and subtract them.

Express the fraction $\frac{12}{15}$ in lowest terms.

The number 3 can be divided evenly into both the numerator and the denominator. Performing this division, you get $\frac{12}{15} = \frac{12 \div 3}{15 \div 3} = \frac{4}{5}$, which is in lowest terms.

Rewrite the fraction $\frac{2}{3}$ as an equivalent fraction with a denominator of 21.

To change the denominator of 3 to 21, you need to multiply by 7. Since you need to perform the same operation to the numerator as well, you would get $\frac{2}{3} = \frac{2 \times 7}{3 \times 7} = \frac{14}{21}$.

Adding and Subtracting Fractions

The number on the top of a fraction is called the *numerator* and the number on the bottom of a fraction is called the *denominator.* If two fractions have the same denominator, they are said to have *common denominators.*

Adding or subtracting two fractions with common denominators is easy. Simply add or subtract the numerators and retain the common denominator. For example:

$$\frac{2}{9} + \frac{5}{9} = \frac{7}{9} \text{ and } \frac{7}{8} - \frac{5}{8} = \frac{2}{8} = \frac{1}{4}$$

Note that, in the subtraction problem, you get a fraction that can be simplified, and you perform the simplification before finishing.

If you need to add or subtract two fractions that do not have the same denominator, you need to begin by raising them to higher terms so that they do have a common denominator. The first step in this process is determining a common denominator for the two fractions. For example, suppose that you are asked to add $\frac{3}{4} + \frac{1}{3}$. You need to find a common denominator for 4 and 3. There are actually an infinite number of common denominators for 4 and 3. Some of them would be 24, 36, and 48. While you can work with any of these denominators, it is easiest to work with the smallest one, which in this case is 12. This number is the *least common denominator* of 4 and 3, and it is actually the same number as the least common multiple (discussed earlier). Thus, you can find the least common denominator by using the same process as you use to find the least common multiple.

After you know the least common denominator (LCD), you simply need to multiply the top and bottom of each fraction by the appropriate number to raise the denominators to the LCD. In this case, for example:

$$\frac{3}{4} + \frac{1}{3} = \frac{3}{3} \times \frac{3}{4} + \frac{4}{4} \times \frac{1}{3} = \frac{9}{12} + \frac{4}{12} = \frac{13}{12}$$

Note that the answer, $\frac{13}{12}$, is an improper fraction. You can also write any improper fraction as a mixed number by dividing the denominator into the numerator and writing the remainder as the numerator of a fraction with the original denominator. In this case, 12 goes into 13 one time, with a remainder of 1, so $\frac{13}{12} = 1\frac{1}{12}$, which is another way to write the answer to the question.

Note that you can also reverse the process of making a mixed number into an improper fraction. So, for example, the mixed number $2\frac{1}{5}$ can be written as an improper fraction. The denominator is the same—5—and the numerator is the denominator times the whole number plus the numerator—$5 \times 2 + 1 = 11$. Therefore, $2\frac{1}{5} = \frac{11}{5}$. Often, when performing operations on mixed numbers, it is helpful to write them as improper fractions. The upcoming examples illustrate this.

Add $2\frac{3}{5} + 3\frac{1}{7}$.

There are two ways to proceed to solve this equation. You can write both mixed numbers as improper fractions and add, but it is quicker to just add the whole number part $(2 + 3 = 5)$ and the fractional part: $\frac{3}{5} + \frac{1}{7} = \frac{21}{35} + \frac{5}{35} = \frac{26}{35}$. The answer is $5\frac{26}{35}$.

Multiplying and Dividing Fractions

Multiplying fractions is actually a bit easier than adding or subtracting them. When multiplying, you don't need to worry about common denominators—just multiply the numerators, and then multiply the denominators, and then simplify if possible. For example:

$$\frac{2}{3} \times \frac{4}{5} = \frac{2 \times 4}{3 \times 5} = \frac{8}{15}$$

That's all you need to do!

In order to understand the procedure for dividing fractions, you need to know one definition. The *reciprocal* of a number is the number that is obtained by switching the numerator and the denominator. For example, the reciprocal of $\frac{3}{8}$ is simply $\frac{8}{3}$. To find the reciprocal of a whole number, such as 7, visualize the 7 as the fraction $\frac{7}{1}$. The reciprocal, then, is $\frac{1}{7}$.

The easiest way to divide two fractions is to change the division sign to a multiplication sign and then change the second fraction to its reciprocal and multiply. For example:

$$\frac{4}{5} \div \frac{3}{4} = \frac{4}{5} \times \frac{4}{3} = \frac{16}{15} = 1\frac{1}{15}$$

What is the value of $2\frac{2}{3} \times 1\frac{4}{5}$?

Before you can multiply these mixed numbers, you need to write them as improper fractions:

$$2\frac{2}{3} \times 1\frac{4}{5} = \frac{8}{3} \times \frac{9}{5} = \frac{72}{15} = 4\frac{12}{15} = 4\frac{4}{5}$$

> Evaluate $2\frac{2}{5} \div 6$.

Begin by writing the problem as $\frac{12}{5} \div \frac{6}{1}$. Then:

$$\frac{12}{5} \div \frac{6}{1} = \frac{12}{5} \times \frac{1}{6} = \frac{12}{30} = \frac{2}{5}$$

Algebraic Operations and Equations

Numerical Evaluation

Algebra is a generalization of arithmetic. In arithmetic, you learn how to perform mathematical operations (such as addition, subtraction, multiplication, and division) on different types of numbers, such as whole numbers, decimals, percentages, and fractions. Algebra extends these concepts by considering how to perform mathematical operations on symbols standing for numbers, and how to use these techniques to solve a variety of practical word problems.

In algebra, numbers that have a definite value are called *constants*. For example, the numbers 17, –3, $\frac{2}{3}$, $\sqrt{41}$, 5.123, and 12% are constants. Symbols standing for numbers are called *variables* since, until it is further specified, they can take on any value. For example, in the expression $3x + 13y + 29$, the numbers 3, 13, and 29 are constants, and the symbols x and y are variables. As the examples that follow show, after you know the values of all variables in an expression, you can find the value of the expression.

> If $a = 4$ and $b = -3$, find the value of the expression $a^3 - b$.

When evaluating numerical expressions, it is crucial to remember the order of operations and to pay careful attention to plus and minus signs. Begin by substituting the values of a and b into the given expression, then carefully evaluate them as in the previous section:

$$a^3 - b = (4)^3 - (-3) = 64 + 3 = 67$$

> The formula for the perimeter of a rectangle is $p = 2l + 2w$, where l represents the length of the rectangle and w represents the width. What is the perimeter of a rectangle with length 21 and width 15?

$$p = 2l + 2w = 2(21) + 2(15) = 42 + 30 = 72$$

Solving Equations

An *equation* is simply a mathematical expression that contains an equal sign. For example, $10 = 4 + 6$ is an equation, and is always true. On the other hand, $10 = 5 + 4$ is also an equation, only this time, it is always false.

An equation that contains a variable, such as $2x + 1 = 7$, may or may not be true depending upon the value of x. *Solving an equation* refers to finding the value of the unknown that makes both sides of the equation equal. Note that the number 3 makes both sides of $2x + 1 = 7$ equal. You therefore say that 3 *solves* the equation, or that 3 is the *solution* of the equation.

Some equations, like the one above, are easy to solve by just looking at them. Others are so complicated that you need an organized series of steps in order to be able to solve them. This section examines how to do this.

The principal for solving equations is, essentially, to rewrite the equation in simpler and simpler form (without, of course, changing the solution) until the solution becomes obvious. The simplest equation of all is an equation of the form $x = a$, where x is the variable and a is some number. Whenever you are given an equation that is more complicated than $x = a$, the idea is to change the equation so that it eventually looks like $x = a$.

Now, what can you do to "change" an equation? The answer is simple: Almost anything you want as long as you do the same thing to both sides. To start, you can add or subtract the same number to or from both sides, multiply both sides by the same number, or divide both sides by the same number (as long as that number isn't 0). The following examples demonstrate this procedure with some very simple equations; after this, you will look at some that are more complicated.

Solve for x in the following equation: $x + 7 = 20$.

Remember that the easiest possible type of equation is one in the form $x = a$. The equation that you have isn't quite like that; it has a +7 on the left-hand side that you would like to get rid of. Now, how can you get rid of it? Easy—you just subtract 7 from both sides.

$$\begin{array}{r} x + 7 = 20 \\ \underline{\;-7 \;\; -7} \\ x = 13 \end{array}$$

So, the solution to this equation is $x = 13$.

Solve for t in the following equation: $4t - 3 = 9$.

In this equation, you have a few things on the left-hand side that you need to get rid of. First of all, undo the subtraction of 3 by adding 3 to both sides:

$$\begin{array}{r} 4t - 3 \;= 9 \\ \underline{\;+3 \;\; +3} \\ 4t = 12 \end{array}$$

Now, you need to undo the multiplication by 4; you can undo it by dividing both sides by 4:

$$\frac{4t}{4} = \frac{12}{4}, \text{ or } t = 3$$

Note that you can check your answer to any equation by substituting the answer back into the equation and making certain that it makes both sides equal. For example, you know that you did the above problem correctly since:

$$\begin{aligned} 4(3) - 3 &= 9 \\ 12 - 3 &= 9 \\ 9 &= 9 \end{aligned}$$

Solve for p in the following equation: $15p = 3p + 24$.

This problem puts you in a situation that you have yet to encounter. The variable p appears on both sides of the equation, but you only want it on one side. In order to get this into the form you want, subtract $3p$ from both sides:

$$\begin{array}{rl} 15p = & 3p + 24 \\ \underline{-3p} & \underline{-3p} \\ 12p = & 24 \end{array}$$

Now, you have an equation that looks better. If you divide both sides of $12p = 24$ by 12, you end up with the answer $p = 2$.

Solve for q in the following equation: $5q - 64 = -2(3q - 1)$.

Begin by eliminating the parentheses, using the distributive property:

$$5q - 64 = -6q + 2$$

Now, add $6q$ to both sides:

$$11q - 64 = +2$$

Next, add 64 to both sides:

$$11q = 66$$

Finally, dividing both sides by 11 gives you the answer: $q = 6$

Solving Word Problems

Many problems that deal with practical applications of mathematics are expressed in words. In order to solve such problems, it is necessary to take them and translate the words into an equation that you can solve. The table below lists some common words and the mathematical symbols that they represent:

Words	***Mathematical Representation***
a equals 9, a is 9, a is the same as 9	$a = 9$
a plus 9, the sum of a and 9, a added to 9, a increased by 9, a more than 9	$a + 9$
9 less than a, a minus 9, a decreased by 9, the difference of a and 9, a less 9	$a - 9$
9 times a, the product of 9 and a, 9 multiplied by a	$9a$ (or $9 \times a$)
The quotient of a and 9, a divided by 9, 9 divided into a	$\frac{a}{9}$
$\frac{1}{2}$ of a	$\frac{1}{2} \times a$
50% of a	$50\% \times a$

When you have to solve a word problem, begin by translating the words into an equation, and then solve the equation to find the solution.

If 5 increased by 3 times a number is 20, what is the number?

Call the number x.

The problem statement tells you that $5 + 3x = 20$

Subtract 5 from both sides to get $3x = 15$

Divide by 3 to get $x = 5$

Thus, the number is 5.

Brian needs $54 more to buy new hockey gloves. If the gloves cost $115, how much money does he already have to spend on the gloves?

In this problem, let m represent the amount of money that Brian has to spend on the gloves. Then, you have an easy equation: $m + 54 = 115$. If you subtract 54 from both sides, you get $m = 61$. Brian already has $61 to spend on the gloves.

Multiplication with Exponents

Consider the problem $x^3 \times x^5$. If you think about it, you will realize that, if you compute $x^3 \times x^5$, you end up with eight x's multiplied together, and that therefore $x^3 \times x^5 = x^8$. This indicates the general rule for multiplication of numbers with exponents: $x^n \times x^m = x^{m+n}$. In other words, to multiply two numbers with exponents, simply add the exponents and keep the common base.

You can extend this result to enable you to perform other types of multiplication. For example, if you need to multiply $x(x + 3)$, you can use the distributive property to obtain

$$x(x + 3) = x^2 + 3x.$$

Now, how would you multiply something like $(x + 2)(x + 5)$? Basically, you need to take each of the terms in the first expression, that is, the x and the 2, and distribute them to both of the terms in the second expression. Doing this, you end up with:

$$(x + 2)(x + 5) = x^2 + 5x + 2x + 10 = x^2 + 7x +10.$$

Multiply $2x(x^2 - 3x)$.

Begin by distributing as you did previously:

$$2x(x^2 - 3x) = 2x(x^2) - 2x(3x).$$

Now, perform the multiplication:

$$2x(x^2) - 2x(3x) = 2x^3 - 6x^2$$

Multiply $(2x + 7)(3x - 4)$.

As above, begin by distributing the $2x$ and the 7 to the other terms:

$$(2x + 7)(3x - 4) = 2x(3x) - 2x(4) + 7(3x) - 7(4)$$

Now, perform the multiplications and combine terms where possible:

$$2x(3x) - 2x(4) + 7(3x) - 7(4) = 6x^2 - 8x + 21x - 28 = 6x^2 + 13x - 28$$

Factoring

Earlier, this chapter talked about factoring whole numbers; for example, you can factor 35 as $35 = 5 \times 7$. As you can see, the word *factoring* refers to taking a mathematical quantity and breaking it down into a product of other quantities.

You can factor certain algebraic expressions, too. Earlier in this review section, you saw how to perform two types of multiplication. In the first, you used the distributive property to perform multiplications such as $x(x + 3) = x^2 + 3x$. To use the correct vocabulary, the x at the front of this expression is a *monomial* (one term), whereas the expression $x + 3$ is a *binomial* (two terms). Thus, you use the distributive property to help you multiply a monomial by a binomial. You also saw how to multiply two binomials together, for example, $(2x + 7)(3x - 4) = 6x^2 + 13x - 28$.

The process of taking the results of these multiplications and breaking them back down into their component factors is factoring. It is not difficult to factor, but it does often require a bit of trial and error.

For example, if the exam asks you to multiply the expression $2x(x - 7)$, you would get $2x^2 - 14x$. If you were, on the other hand, given $2x^2 - 14x$ and asked to factor it, you would basically need to undo the distribution process, and get the expression back to what it originally was.

To do this, begin by looking at the expression $2x^2 - 14x$, and try to find the *largest common monomial factor,* that is, the largest monomial that divides into both $2x^2$ and $14x$ evenly. In this problem, the largest common factor is $2x$. You then place the $2x$ outside a set of parentheses. Finish by dividing the $2x$ into each of the two terms $2x^2$ and $14x$, and write the resulting terms inside the parentheses. This will leave you with $2x(x - 7)$, and you are successful in factoring the expression.

Factor $2a^2b - 8ab$.

The largest common monomial factor in this expression is $2ab$. If you divide $2a^2b$ by $2ab$, you get a. If you divide $8ab$ by $2ab$, you get 4. Thus, putting the $2ab$ outside of the parentheses, and the a and 4 on the inside, you get $2ab(a - 4)$

Note that it is easy to check whether you have factored correctly or not by multiplying the expression out and seeing if you get the original expression back.

It is also possible to factor certain *trinomial* (three term) expressions into two binomials. Consider a simple example. If you were asked to multiply $(x + 2)(x + 3)$, you would get $x^2 + 5x + 6$. Now, what if you were given the expression $x^2 + 5x + 6$ and asked to factor it back down into the two binomials it came from?

To begin, make two sets of parentheses, and note that you can position x's in the first position of each set, since the two first-most terms in the binomials multiply to give the x^2 in $x^2 + 5x + 6$. Therefore, to begin:

$$x^2 + 5x + 6 = (x \quad)(x \quad)$$

Next, since both signs in $x^2 + 5x + 6$ are positive, you can position plus signs within the parentheses:

$$x^2 + 5x + 6 = (x + \ )(x + \ )$$

Now, what are the two last entries? Well, you know that whatever you put in these spots must multiply out to 6, so the possibilities would be 1 and 6 or 2 and 3. The correct entries, however, must add up to 5 to get the correct middle term. Thus, it must be 2 and 3, and you get $x^2 + 5x + 6 = (x + 2)(x + 3)$. You can check the answer by multiplying:

$$(x + 2)(x + 3) = x^2 + 3x + 2x + 6 = x^2 + 5x + 6.$$

As you can see, factoring a trinomial into two binomials requires a bit of trial and error. The examples below give you a bit more practice with this.

Factor $x^2 - 8x + 12$.

Begin as before, by making two sets of parentheses and entering first terms of x in each: $x^2 - 8x + 12 = (x \quad)(x \quad)$.

Now, the two last entries must multiply out to +12, but add to −8, so that you get the correct middle term. Proceed by trail and error, and it won't take you long to determine the two numbers that work are −2 and −6, and the factorization is $x^2 - 8x + 12 = (x - 2)(x - 6)$.

Factor $x^2 - 49$.

This one may look at bit tricky, but actually it is rather easy. Begin, as before, by writing $x^2 - 49 = (x \quad)(x \quad)$. Now, the two last entries must multiply to 49, and add up to 0, so that the middle term is, essentially, 0. This will work with +7 and –7. Thus, $x^2 - 49 = (x + 7)(x - 7)$.

Simplifying Algebraic Expressions

Earlier this chapter talked about simplifying fractions. If, for example, the answer to a problem turns out to be $\frac{15}{20}$, you should simplify it to $\frac{3}{4}$. In the same way, you can simplify certain algebraic expressions as well. For example, consider this algebraic fraction:

$$\frac{x^2-16}{3x+12}$$

To simplify this expression, begin by factoring the expressions on the top and on the bottom:

$$\frac{x^2-16}{3x+12} = \frac{(x+4)(x-4)}{3(x+4)}$$

Now, the common factor of $x + 4$ can be divided out from the top and bottom, giving you a simplified fraction of $\frac{x-4}{3}$.

You can perform mathematical operations on algebraic fractions in much the same way as you perform them on fractions that contain only numbers. Consider this example:

Add $\frac{x+1}{4x+6} + \frac{x+2}{4x+6}$.

Since these two fractions have the same denominator, they can be added in the usual way:

$$\frac{x+1}{4x+6} + \frac{x+2}{4x+6} = \frac{x+1+x+2}{4x+6} = \frac{2x+3}{4x+6}$$

Now, finish by factoring the expression on the bottom and dividing out:

$$\frac{x+1}{4x+6} + \frac{x+2}{4x+6} = \frac{x+1+x+2}{4x+6} = \frac{2x+3}{4x+6} = \frac{2x+3}{2(2x+3)} = \frac{1}{2}.$$

$$\frac{x^2-7x+6}{x^2-1} \times \frac{x+1}{x-6}$$

Begin by factoring as much as possible, then multiply and cancel:

$$\frac{x^2-7x+6}{x^2-1} \times \frac{x+1}{x-6} = \frac{(x-6)(x-1)}{(x-1)(x+1)} \times \frac{x+1}{x-6} = \frac{(x-6)(x-1)(x+1)}{(x-1)(x+1)(x-6)} = 1$$

$$\frac{a^2-b^2}{5} \div \frac{a^2+ab}{5a-5}$$

Begin by changing the problem to a multiplication problem by reciprocating the second fraction. Then factor and cancel:

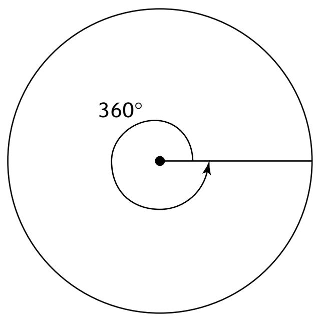
$$\frac{a^2-b^2}{5} \div \frac{a^2+ab}{5a-5} = \frac{a^2-b^2}{5} \times \frac{5a-5}{a^2+ab} = \frac{(a+b)(a-b)(a-1)}{5a(a+b)} = \frac{(a-b)(a-1)}{a}$$

Geometry and Measurement

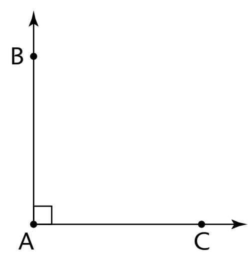
The chapter about the Arithmetic Reasoning section of the ASVAB looks at some geometric properties of squares and rectangles. On the Mathematics Knowledge section, you are responsible for some additional facts from geometry, which the following section discusses.

Angle Measurement

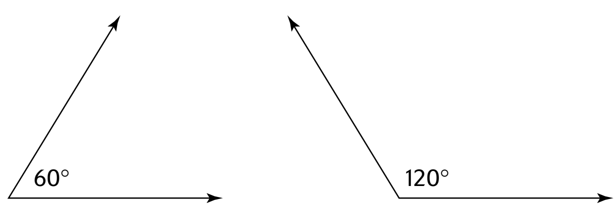
You measure angles in degrees, which you indicate by the symbol °. By definition, the amount of rotation needed to go completely around a circle one time is 360°.



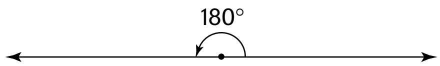
You can measure every angle by determining what fraction of a complete rotation around a circle it represents. For example, an angle that represents ¼ of a rotation around a circle would have a measurement of ¼ of 360° = 90°. The diagram below depicts a 90° angle. AB and AC are the sides of the angle, and the point A is the vertex.



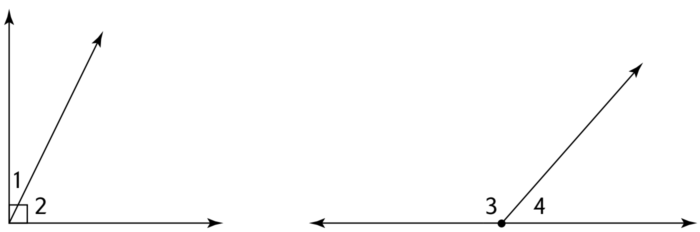
Angles that measure less than 90° are called *acute* angles, and angles that measure more than 90° are called *obtuse* angles. The diagram below depicts an acute angle of 60° as well as an obtuse angle of 120°.



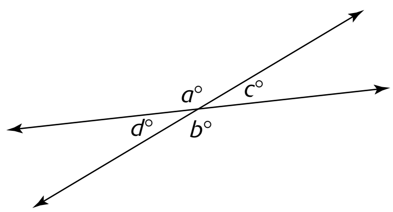
Note that an angle that has the size of ½ of a revolution around the circle has a measure of 180°. In other words, a straight line can be thought of as an angle of 180°.



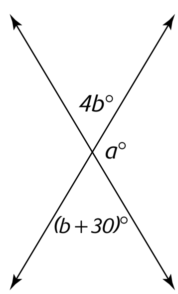
Two angles whose measures add up to 90° are called *complementary angles,* and two angles whose measures add up to 180° are called *supplementary* angles. In the diagram below, angles 1 and 2 are complementary, and angles 3 and 4 are supplementary. As the diagram shows, whenever a straight angle is partitioned into two angles, the angles are supplementary.



Another very important fact about angles relates to *vertical angles.* As the diagram below shows, when two lines intersect, four angles are formed. In this situation, the angles that are across from each other are called *vertical angles.* All vertical angles are equal, so $a° = b°$, and $c° = d°$.



In the diagram below, what is the value of a?



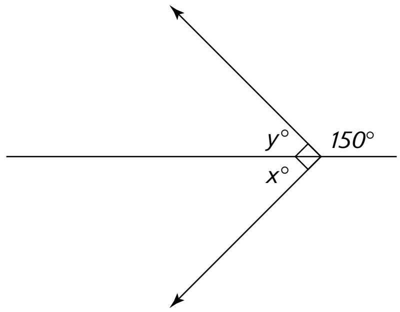
Begin by noting that the angles labeled $4b$ and $b + 30$ are vertical angles, and therefore have the same measure. In this case, you can set the two angles equal and solve the resulting equation for b.

$$4b = b + 30$$
$$3b = 30$$
$$b = 10$$

If $b = 10$, then $4b = 40$.

Since the angle labeled $a°$ is supplementary to this angle, a must be equal to 140°.

In the diagram below, what is the value of x?

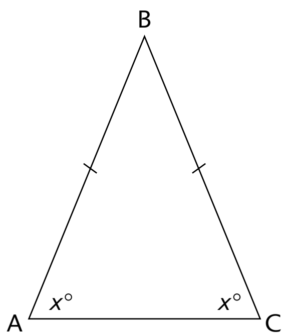


Begin by noting that the angle labeled y is supplementary to the angle labeled 150°, and is therefore equal to 30°. Next, note that the angle labeled x is complementary to that 30° angle, and is therefore equal to 60°.

Properties of Triangles

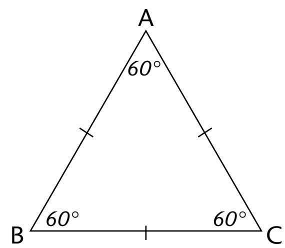
A triangle is a geometric figure that has three straight sides. One of the most important facts about a triangle is that, regardless of its shape, the sum of the measures of the three angles it contains is always 180°. If you know the measures of two of the angles of a triangle, you can determine the measure of the third angle by adding up the two angles you are given, and subtracting from 180.

There are some special triangles that have special properties that you should know. To begin, an *isosceles* triangle is a triangle that has two sides of the same length. In an isosceles triangle, the two angles opposite the equal sides have the same measurement. For example, in the figure below, $AB = BC$, and therefore the two angles opposite these sides, labeled $x°$, have the same measure.

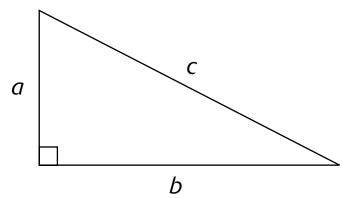


AB = BC

A triangle that has all three sides the same length is called an *equilateral* triangle. In an equilateral triangle, all three angles also have the same measure. Since the sum of the three angles must be 180°, each angle in an equilateral triangle must measure $180° \div 3 = 60°$. Therefore, in the equilateral triangle that follows, all three angles are 60°.



Another extremely important triangle property relates to what are known as *right triangles,* that is, triangles containing a right angle. In such triangles, the side opposite the right angle is called the *hypotenuse,* and is the longest side of the triangle. The other two sides of the triangle are called its legs. Therefore, in the right triangle below, the side labeled c is the hypotenuse, and sides a and b are the legs.



The three sides of a right triangle are related by a formula known as the Pythagorean theorem. The Pythagorean theorem states that the square of the hypotenuse is equal to the sum of the squares of the legs of the triangle, or, using the notation in the diagram above, $a^2 + b^2 = c^2$. The importance of this result is that it enables you, if you're given the lengths of two of the sides of a right triangle, to find the length of the third side.

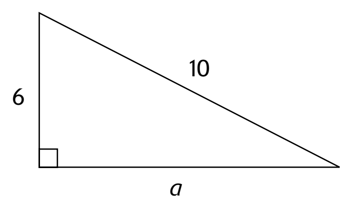
> In triangle XYZ, angle X is twice as big as angle Y, and angle Z is equal to angle Y. What is the measure of angle X?

Since the measure of angle X is twice as big as angle Y, you can say that the measure of angle X is equal to $2Y$. Since it must be true that $X + Y + Z = 180$, you can write:

$$2Y + Y + Y = 180$$
$$4Y = 180$$
$$Y = 45$$

If the measure of angle Y is 45°, the measure of angle X, which is twice as big, must be 90°.

> In the triangle below, what is the length of a?

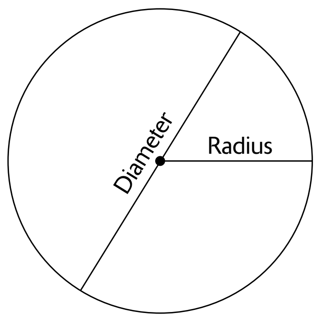


The triangle is a right triangle, so you can use the Pythagorean theorem to find the length of the missing side. Note that the hypotenuse is 10, one of the legs is 6, and you are looking for the length of the other leg. Therefore:

$a^2 + 6^2 = 10^2$, or $a^2 + 36 = 100$, so $a^2 = 64$, and $a = 8$.

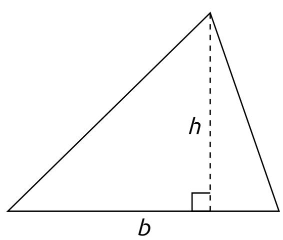
Properties of Circles

A *circle* is a closed figure, consisting of all of the points that are the same distance from a fixed point—the *center* of the circle. A line segment from the center of the circle to any point on the circle is a *radius* of the circle. A line segment from one point on a circle, through the center of the circle, and to another point on the circle, is a *diameter* of the circle. As you can see in the diagram that follows, the length of a diameter of a circle is always twice the length of a radius of the circle.



Perimeter and Area

The Arithmetic Reasoning chapter discusses the formulas for finding the perimeter and the area of rectangles and squares. In order to find the perimeter of a triangle, you simply need to add together the lengths of the three sides. The area of a triangle is given by the formula area = ½ *bh,* where *b* represents the length of the base of the triangle and *h* represents the height of the triangle. The *height of a triangle* is the length of a line segment drawn from a *vertex* (corner) of the triangle to the base so that it hits the base at a right angle.



Concerning circles, formulas exist for the perimeter (which is more commonly known as the *circumference*) and the area. These formulas are based on the length of the radius, and include the symbol π, which represents a number that is approximately equal to 3.14.

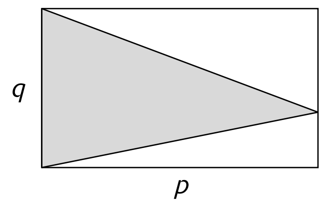
The circumference of a circle is given by the formula $C = 2\pi r$, where r is the radius of the circle. The area of the circle is given by the formula $A = \pi r^2$. Unless you are told otherwise, when answering problems involving the circumference or the area of a circle, you can leave the answer in terms of π, as in the following problem.

What is the circumference of a circle whose area is 36π?

The area of a circle is πr^2, so you have $\pi r^2 = 36\pi$. This means that $r^2 = 36$, so $r = 6$.

Now, the circumference of a circle is $2\pi r$, so the circumference in this case would be $2\pi(6) = 12\pi$.

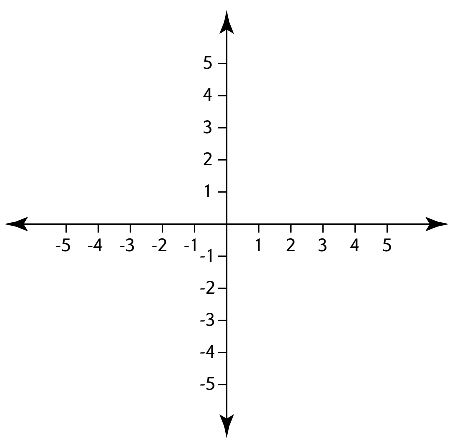
What is the area of the shaded part of the rectangle below?



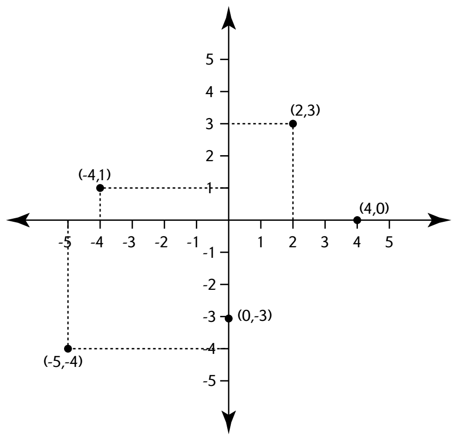
The shaded area is a triangle, so you can use the formula $A = \frac{1}{2} bh$ to find its area. The width of the rectangle, labeled q, is also the base of the triangle. You can also see that the length of the rectangle, labeled p, is also equal to the height of the triangle. Therefore, the area of the shaded region is $\frac{1}{2} pq$.

Coordinates and Slope

You can locate points in a plane by means of a reference system called the *coordinate system*. Two number lines are drawn at right angles to each other, and the point where the lines cross is considered to have the value 0 for both lines. Then, positive and negative numbers are positioned on the lines in the usual way:



The horizontal line is called the *x-axis,* and the points on this axis are called *x-coordinates.* The vertical line is called the *y-axis,* and the points on this axis are called *y-coordinates.* Points on the plane are identified by first writing a number that represents where they lie in reference to the x-axis, and then writing a number which expresses where they lie in reference to the y-axis. You call these numbers the *coordinates* of the point. You can see the coordinates of a variety of points in the diagram below:



Any two points on a plane determine a line. One of the important characteristics of a line is its steepness, or *slope*. You can determine the slope of a line from the coordinates of the two points that determine the line. If the coordinates of the two points are (x_1, y_1) and (x_2, y_2), the formula for the slope is:

$$\frac{y_2 - y_1}{x_2 - x_1}$$

In other words, to find the slope of a line, find two points on the line and divide the difference of the y-coordinates by the difference of the x-coordinates.

Find the slope of the line which goes through the points (9, 5) and (3, −2).

The slope of the line can be computed as:

$$\frac{y_2 - y_1}{x_2 - x_1} = \frac{5-(-2)}{9-3} = \frac{5+2}{6} = \frac{7}{6}$$

Mathematics Knowledge Practice Questions

1. Find the value of $4^3 \times 3^2$

   A. 343
   B. 576
   C. 16,807
   D. 248,832

2. Find the value of $(2 \times 3)^2$

   A. 10
   B. 12
   C. 25
   D. 36

3. What is the greatest common factor of 42 and 28?

   A. 6
   B. 7
   C. 14
   D. 21

4. Prime factor the number 48, and write the prime factorization using exponential notation.

   A. $2^4 \times 3$
   B. $2^3 \times 3^2$
   C. $2^5 \times 3$
   D. 6×8

5. Evaluate 18 – 3(5 – 2)

   A. 0
   B. 1
   C. 9
   D. 45

In problems 6 through 8, perform the indicated operations.

6. (+8) – (+2) – (–7)

   A. –1
   B. 3
   C. 13
   D. 17

7. $(-1)^{100}(-2)^3$

   A. –800
   B. –8
   C. 8
   D. 800

8. $\dfrac{(+12)(-4)}{(-2)(-8)}$

   A. –3
   B. $-1\frac{1}{2}$
   C. $1\frac{1}{2}$
   D. 3

9. $\dfrac{8}{9} - \dfrac{1}{3} =$

   A. $\dfrac{5}{9}$
   B. $\dfrac{2}{3}$
   C. $\dfrac{7}{9}$
   D. $\dfrac{7}{6}$

10. $4\frac{1}{4} \times 3\frac{2}{3}$

A. $7\frac{1}{6}$

B. $12\frac{1}{6}$

C. $15\frac{7}{12}$

D. $15\frac{11}{12}$

11. $\frac{4}{5} \div \frac{7}{10} =$

A. $\frac{14}{25}$

B. $\frac{7}{8}$

C. $1\frac{1}{7}$

D. $1\frac{1}{5}$

12. Find the value of $-3a + 4b$ if $a = -2$ and $b = -3$

A. –30

B. –18

C. –6

D. 18

In problems 13 and 14, solve for the variable indicated.

13. $\frac{x}{4} = -9$

A. –36

B. $-\frac{1}{9}$

C. $-\frac{1}{36}$

D. 13

14. $2(a - 3) = 14 - 3a$

A. –8

B. $\frac{17}{5}$

C. 4

D. 8

15. A piece of wood that is 27 inches long is cut into two pieces, such that one piece is twice as long as the other. Find the length of the shorter piece.

A. 6 inches

B. 9 inches

C. 12 inches

D. 18 inches

16. If the sum of three consecutive integers is 57, find the smallest of the integers.

A. 17

B. 18

C. 19

D. 20

17. If a number is added to twice the same number, and the result is equal to 8 less than five times the number, what is the number?

A. 4

B. 6

C. 8

D. 12

18. Multiply $(3x - 7)(4x + 2)$

A. $12x^2 + 21x - 14$

B. $12x^2 - 21x - 14$

C. $12x^2 + 34x + 14$

D. $12x^2 - 21x + 14$

19. Factor $6x^4y^3 - 3x^3y^5$

A. $3x^3y^3(2x - y^2)$

B. $6x^3y^3(x - y^2)$

C. $3x^4y^5(2x - y^2)$

D. $3x^4y^3(2 - y^2)$

20. Factor $x^2 - 2x - 35$

A. $(x + 7)(x - 5)$

B. $(x + 35)(x - 1)$

C. $(x - 35)(x + 1)$

D. $(x - 7)(x + 5)$

21. $\frac{x}{3x+15} \div \frac{x^2}{x^2-25} =$

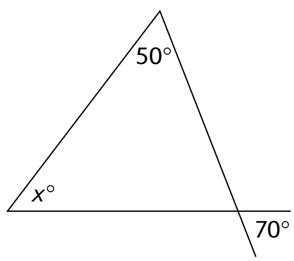
A. $\frac{x^3}{3(x+5)^2(x-5)}$

B. $\frac{3(x-5)}{x}$

C. $\frac{3x}{x+5}$

D. $\frac{x-5}{3x}$

22. In the diagram below, $x =$



A. 50°

B. 60°

C. 65°

D. 70°

23. An airplane flies 50 miles due north, then turns and flies 120 miles due east. How far has the plane flown from its starting point?

A. 70 miles

B. 130 miles

C. 145 miles

D. 170 miles

24. What is the slope of the line that goes through the points (8, –2) and (–4, 4)?

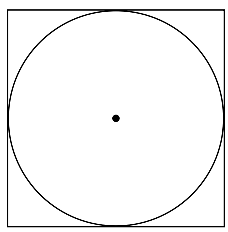
A. –2

B. $-\frac{1}{2}$

C. $\frac{1}{2}$

D. 2

25. In the figure below, the circle fits exactly inside the square. If the circumference of the circle is 10π, what is the area of the square?



A. 5

B. 10

C. 20

D. 25

Answers and Explanations for Practice Questions

1. **B.** $4^3 \times 3^2 = (4 \times 4 \times 4) \times (3 \times 3) = 64 \times 9 = 576$
2. **D.** $(2 \times 3)^2 = 6^2 = 36$
3. **C.** The factors of 42 are 1, 2, 3, 6, 7, 14, 21, and 42. The factors of 28 are 1, 2, 4, 7, 14, and 28. The greatest common factor, therefore, is 14.
4. **A.** $48 = 6 \times 8 = 2 \times 2 \times 2 \times 2 \times 3 = 2^4 \times 3$
5. **C.** $18 - 3(5 - 2) = 18 - 3(3) = 18 - 9 = 9$
6. **C.** $(+8) - (+2) - (-7) = (+8) + (-2) + (+7) = +13$
7. **B.** $(-1)^{100}(-2)^3 = (+1)(-8) = -8$
8. **A.** $\frac{(+12)(-4)}{(-2)(-8)} = \frac{-48}{+16} = -3$
9. **A.** $\frac{8}{9} - \frac{1}{3} = \frac{8}{9} - \frac{3}{9} = \frac{5}{9}$
10. **C.** $4\frac{1}{4} \times 3\frac{2}{3} = \frac{17}{4} \times \frac{11}{3} = \frac{187}{12} = 15\frac{7}{12}$
11. **C.** $\frac{4}{5} \div \frac{7}{10} = \frac{4}{5} \times \frac{10}{7} = \frac{40}{35} = 1\frac{5}{35} = 1\frac{1}{7}$
12. **C.** $-3a + 4b = -3(-2) + 4(-3) = +6 - 12 = -6$
13. **A.** $\frac{x}{4} = -9$. Multiplying both sides by 4 gives $x = -36$.
14. **C.** $2(a - 3) = 14 - 3a$. Distribute to get $2a - 6 = 14 - 3a$. Add +6 and $+3a$ to get $5a = 20$. Thus, $a = 4$.
15. **B.** Let S = the length of the shorter piece. Then, the longer piece is of length 2S, and S + 2S = 27, or 3S = 27, so S = 9.
16. **B.** Let N = the smallest integer. Then, N + 1 is the middle integer, and N + 2 is the largest. N + (N + 1) + (N + 2) = 57 or 3N + 3 = 57, so 3N = 54 or N = 18.
17. **A.** Let N equal the number. Then N + 2N = 5N – 8 or 3N = 5N – 8. Subtract 5N to get –2N = –8. Divide by –2 to get N = 4.
18. **B.** $(3x - 7)(4x + 2) = 12x^2 + 6x - 28x - 14 = 12x^2 - 21x - 14$
19. **A.** $6x^4y^3 - 3x^3y^5 = 3x^3y^3\left(2x - y^2\right)$
20. **D.** $x^2 - 2x - 35 = (x - 7)(x + 5)$
21. **D.** $\frac{x}{3x+15} \div \frac{x^2}{x^2-25} = \frac{x}{3x+15} \times \frac{x^2-25}{x^2} = \frac{x}{3(x+5)} \times \frac{(x-5)(x+5)}{x^2} = \frac{x-5}{3x}$
22. **B.** The unlabeled angle of the triangle has the same measure as the angle labeled 70°. Thus, the triangle has angles of 70° and 50°. The missing angle must be 60° so that the three angles add up to 180°.

23. **B.** The airplane is flying the two legs of a right triangle, and the distance from the starting point is equal to the hypotenuse of the triangle. By the Pythagorean theorem, $50^2 + 120^2 = d^2$, or $2{,}500 + 14{,}400 = d^2$. Thus, $d^2 = 16{,}900$, or $d = 130$.

24. **B.** $\frac{y_2 - y_1}{x_2 - x_1} \div \frac{-2-(4)}{8-(-4)} = \frac{-6}{12} = -\frac{1}{2}$

25. **D.** The circumference of the circle is $2\pi r = 10\pi$, so the radius of the circle is 5. Then, the diameter of the circle is 10. Since the side of the square is equal to the diameter of the circle, the area of the square is $5^2 = 25$.

Mechanical Comprehension

A thorough knowledge of the mechanical world is necessary in order to successfully complete numerous everyday tasks. From understanding how engines operate, to using tools to build and repair existing structures, to providing support against various external forces, understanding a few general principles will provide a solid base that you can use as you gain a more specific understanding. This section presents various physical concepts ranging from application of forces and properties of materials to fluid dynamics and compound machines.

The ASVAB has 25 Mechanical Comprehension questions. You will have 19 minutes to answer these questions.

Properties of Materials

You encounter many different types of materials on a daily basis. Almost all of these are better suited for specific uses than for others. For example, wood and metal are more appropriate when you need a rigid, sturdy structure (as with a bookcase, sturdy door, or large crate to transport heavy objects). You would use cardboard and plastic for smaller containers designed to hold lighter material. This section explores in detail the differences between various materials that determine their usefulness in various situations.

Weight, Density, and Strength

Consider first the weight of a given material. You can consider the weight of the material as a measure of how much force is needed to move (or support) a given amount of this material. At first thought, most people would say that iron is heavy while paper is light. This statement by itself is false, and needs to be more specific. You can see this immediately by considering that it is possible to have 5 pounds of iron on one table and 10 pounds of paper on an adjacent table.

The detail that is missing is that you must also consider the density of the material. *Density* is defined as the ratio of the mass (or weight) of an object to the volume that it occupies. In other words, if two objects take up the exact same amount of space (if they have the same volume), the one that weighs more has a higher density.

It is important, however, to make sure that you don't confuse the weight of a material and the density of a material with the strength of a material. While, for the most part, a material that is heavier will also be stronger, this is not always the case. The *strength* of a material can best be considered as its ability to maintain its shape as external forces on the material increase. The challenge to create materials that are lightweight (have a lower density) but also have high strength is important to transportation (such as building airplanes) and in many other fields.

Expansion and Contraction

Materials *expand* (take up more volume) and *contract* (take up less volume) when exposed to a change in temperature. As a general rule, a substance expands with heat and contracts with cold. This general rule applies to solids, liquids, and gases. Different solids, as well as different liquids, will expand and contract at varying rates. In other words, one solid may expand noticeably more when exposed to a specific temperature change than another solid.

Gases, on the other hand, have a more uniform expansion rate. In other words, most gases will expand by the same amount when exposed to a similar change in temperature.

For example, the following materials are listed in order of increasing expansion under a similar temperature change. The materials at the beginning of the list will expand and contract more than those near the end of the list.

lead—aluminum—brass—copper—concrete—glass

Water is an interesting exception to the previous general rule about temperature-related expansion and contraction. Recall that water boils at 100°C and freezes at 0°C. When the temperature of water drops anywhere in the range between 4°C and 100°C, its volume decreases (the water is contracting). However, when the temperature of water drops anywhere in the range between 4°C and 0°C, its volume increases (the water is expanding). A direct consequence of this is that water has its greatest density at 4°C.

Absorption

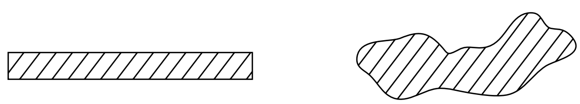
Absorption refers to the ability of the material to pick up and retain a liquid that it comes in contact with. For example, sponges and paper towels are very good at picking up and retaining liquid. Thus they are considered to be very good at absorbing the liquids with which they come in contact.

Some materials do not absorb liquid very well at all. One example is the coating used on the hulls of boats. Other materials can absorb a large quantity of liquid but require a considerable amount of time to do so. Wood (such as a fallen tree or a non-treated piece of lumber) would be such an example.

Center of Gravity

An object's center of gravity is important in determining structural support, among other things. The simplest definition for the *center of gravity* is that it is the point on the object where the object can be balanced. In other words, it is the point where gravity exerts the same force on either side of the balance point so that the object does not fall.

Consider the following diagram, which shows two objects and their respective centers of gravity. The first object is considered to be uniform, while the second is considered to be nonuniform. Following the diagrams are several thoughts and examples to explain the process that you use to find the center of gravity.



Object 1 Object 2

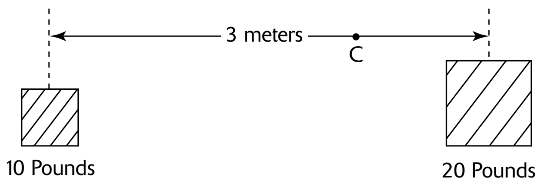
The first step is to define a rigid, uniform body. A body is *rigid* if it is solid and does not alter its shape easily due to external forces. A body is *uniform* if its volume and density are constant from one end of the body to the other. A meter stick is an example of a uniform body. Any automobile that you see on the road is an example of a nonuniform body.

The center of gravity for a uniform body is at its *geometric center.* A meter stick is 100 centimeters in length. Therefore, the center of gravity for the meter stick will be at the point marked

50 centimeters, which is midway between the two ends of the meter stick. If you have a piece of treated lumber (like a 5- or 6-foot-long two-by-four), the center of gravity is midway between the two ends of the piece of lumber (a long piece of lumber is like an enlarged version of the meter stick). For nonuniform bodies, determining the location of the center of gravity requires a bit more analysis. In order to understand the process fully, it is best to build up using several examples.

Consider two golf balls that, for all intents and purposes, can be considered completely identical to each other. Now place these golf balls on a table some distance apart—use 80 centimeters for this example. The center of gravity between the two golf balls is on the line that connects the centers of the two golf balls and is the same distance from each golf ball. In other words, the center of gravity is directly between the two golf balls and 40 centimeters away from either golf ball. This type of example works for any two identical objects.

Now think about having two objects that are not identical. Consider placing an object that weighs 10 pounds 3 meters away from an object that weighs 20 pounds. The center of gravity is no longer midway between the two objects, and will be closer to the object that is heavier (with two objects of different weights, the center of gravity is *always* closer to the heavier object). Use the following diagram to help determine and understand the location for the center of gravity between these two objects.



The object on the left weighs 10 pounds and the object on the right weighs 20 pounds. The distance between the two objects is 3 meters. Notice that this distance is measured from the centers of the objects and is not the distance from the right-hand side of the 10-pound object to the left-hand side of the 20-pound object. The center of gravity is located at the point marked “C” and is 2 meters from the 10-pound object and 1 meter from the 20-pound object.

Justification is when the ratio of the weights of the two objects must equal the inverse ratio of the respective distances of the center of gravity from the two objects. In other words, let x be the distance between the 10-pound object and the center of gravity. Let y be the distance between the 20-pound object and the center of gravity. The following equation must be true:

$$\frac{20}{10} = \frac{x}{y}$$

This equation can be written as:

$$20 \times y = 10 \times x.$$

You also know that $x + y$ must be equal to 3. This is because the distance between the two objects is 3 meters. Combining these two pieces of information, you can figure out that x must be equal to 2 meters and y must be equal to 1 meter.

Now consider a nonuniform body. The center of gravity is *not* simply the point where there is an equal weight of material on either side. This can be understood from the previous example, where there was 10 pounds of material on one side of the center of gravity and 20 pounds of material on the other side. Problems that require determining the precise location of the center of gravity for nonuniform bodies are beyond the scope of the ASVAB, but a general understanding of the principles mentioned here will be helpful in theoretical questions regarding this matter.

If the volume of an object is increased while its weight remains the same, then the density of the object

A. increases.

B. decreases.

C. remains the same.

D. cannot be determined.

The answer is **B.** Recall that density is equal to mass (weight) divided by volume. By keeping the weight unchanged and increasing the volume, you are effectively increasing the denominator of a fraction. This causes the value of the fraction to decrease.

From the beginning of spring until the end of spring, it would be expected for the segments of a bridge to

A. expand.

B. contract.

C. remain the same size.

D. cannot be determined.

The answer is **A.** Remember that, generally, objects expand when heated and contract when cooled. Generally, the average temperature increases from the beginning of spring to the end of spring.

Two identical basketballs are placed 50 centimeters apart. How far from the first basketball is the center of gravity?

A. 15 centimeters

B. 20 centimeters

C. 25 centimeters

D. 30 centimeters

The correct answer is **C.** Recall that the center of gravity between two identical objects is midway between the objects.

There are two crates of supplies in a room. Some of the supplies from the first crate are moved into the second crate. What happens to the center of gravity between the two crates?

A. Nothing, it remains where it was originally.

B. It moves closer to the first crate.

C. It moves closer to the second crate.

D. Cannot be determined.

The correct answer is **C.** This is a slightly trickier question. Recall that the center of gravity is located closer to the heavier object. By moving supplies from the first crate to the second crate, the second crate is becoming heavier than it was originally, while the first crate is becoming lighter than it was originally. As a result, the center of gravity moves closer to the second crate.

Structural Support

Structural support combines the concepts of strength, density (weight), expansion, and center of gravity. The general idea is to take a given amount of materials and use it to provide effective support for a large weight.

For a first example, consider the structural support that a tall building requires. A sturdy foundation must be used that can support the weight of the building and all the furniture and people that will eventually occupy the building. Also, a solid skeletal structure must be built that will be able to separate and support the individual floors, walls, and other building components. Finally, the building must be constructed in such a way that it can withstand the forces associated with the various winds that will be blowing against the building.

Now consider bridges. They must be able to support the constant flow of traffic across the top of the bridge. If the bridge crosses a large body of water, the supports must be able to withstand the pressures that the water exerts.

On a smaller scale, consider the average table. It has four legs that are placed, for the most part, one at each of the four corners of the table (if the table is round, the legs are spaced evenly around the perimeter of the table). This is done for two reasons. First, the center of gravity for the table lies inside the four legs, so that the table will not topple over (if all four legs were along the same side of the table, it would not be able to stand). The other reason is so that the weight of the table plus whatever is placed on the table will be shared fairly evenly by the legs.

Consider a square table with four legs placed at the corners as described earlier. The center of gravity for the top of the table will be in the center of the table, an equal distance away from each leg. As a result, each leg will support the same amount of weight. Now, imagine that you place a heavy box in the exact center of the table. Each leg of the table will still support the same amount of weight, because the center of gravity is still the same distance from each leg. However, if you place the box closer to one leg in particular (call this leg A), then that leg will support a larger weight than any of the three remaining legs. This is because the center of gravity has been moved so that it is closest to leg A. This is the same basic theory that is used in the construction of buildings and bridges, simply on a much larger and more intricate scale.

The other point to remember is that materials (solids especially) expand and contract when exposed to a change in temperature. Any structure must be able to withstand the internal forces that accompany such structural changes.

When figuring out the wind force on the side of a building, the most important characteristic of the building to consider is its

A. height.

B. width.

C. area.

D. foundation.

The correct answer is **C.** Remember that the force from the wind becomes greater as the area of the building increases. Thus, while the height and width are important, it is their product (the area) that is of primary concern.

A large number of circular pieces of wood, each of different size (radius), need to be stacked. It would be best to stack them

A. larger radius toward the bottom.

B. larger radius toward the top.

C. in the order they are found.

D. does not matter.

The correct answer is **A**. The wood pieces on the bottom need to support more weight than the wood pieces on top. By placing a smaller piece atop a larger piece, the entire smaller piece receives support. This would not be the case if the larger piece were placed atop the smaller piece.

A bridge is being built on the hottest day of the year. The surface that vehicles will drive on consists of several concrete slabs with a small space between each slab. Compared with building the bridge on a much colder day, the spaces should be

A. separated more.

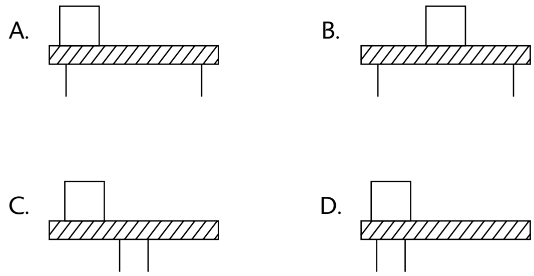
B. separated less.

C. no difference in separation.

D. cannot be determined.

The correct answer is **B.** Remember that materials expand when they are heated. Thus, there should be very little space between the slabs on the hot day, so that when the temperature falls the slabs won't be overly far apart.

Consider the following four configurations for two supports, a rigid uniform beam, and various loads. Which configuration will be the most stable?

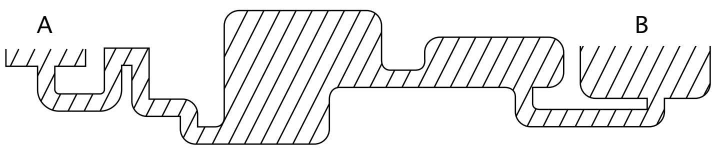


The correct answer is **B.** Convince yourself that this is true by comparing the positions of the supports relative to the center of gravity for the board as well as the position of the added load relative to the supports.

Fluid Dynamics

There are a few differences between the ways that a solid behaves and the ways that a fluid behaves. Some of the more general differences are outlined in this section. First, however you need to understand a few terms.

The first one is *viscosity,* which is the relative ease with which a fluid will flow. Engine oil has a high viscosity because it flows easily. Molasses has a low viscosity because it flows slowly. If the two liquids were allowed to flow down an incline, the oil would reach the bottom of the incline first. The second term is *compressibility.* Liquids are very difficult to compress—much more so than solids. Compressibility is one of the two main characteristics of liquids that lead to hydraulics—the other characteristic is the way that liquids transfer a force from one region to another region. In a closed container filled with liquid, the pressure of the liquid will be the same at all points that are at the same height.



This means that in the diagram above, the pressure at point A is the same as the pressure at point B. Notice first that the liquid is open to the atmosphere at points A and B and that the remainder of the container is closed. Also notice that neither the shape nor the height of the rest of the container has any bearing on the fact that the pressure is the same at points A and B. Remember that pressure is defined as the force *per unit area*. In other words, since the area at point B is larger than the area at point A, a small force exerted at point A results in a larger force at point B. This is a simple definition for the process of hydraulics. The ratio of the force applied at point A to the force exerted at point B is equal to the ratio of the area at point A to the area at point B.

There are two main ideas to remember about hydraulics:

- It is very difficult to compress a liquid.
- The pressure (not the exerted force) remains the same throughout a liquid.

The reason that specific liquids are chosen to use in hydraulic mechanisms is that they flow easily and are more resistant to being compressed.

A force is applied at one end of a hydraulic jack. The area at the other end of the jack is five times the area where the force is applied. How much larger is the exerted force than the applied force?

A. Twice as large

B. One-fifth as large

C. Five times as large

D. Half as large

The correct answer is **C.** Remember that the ratio of the applied force to the exerted force is the same as the ratio of the areas. Also remember that the force is greater where the area is greater.

Choose the best answer. A hydraulic jack works because

A. liquids are incompressible.

B. liquids maintain the same pressure in a closed system.

C. both A and B.

D. none of the above.

The correct answer is **C.** This is one of the key concepts in hydraulics.

Mechanical Motion

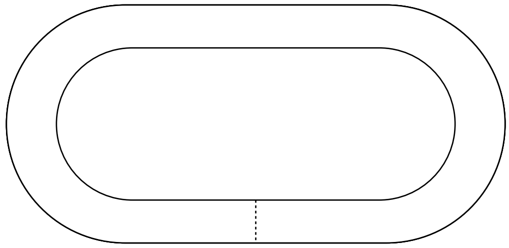
When discussing the motion of an object, there are several things that you need to consider. In order to understand these concepts, it is best to develop them from very basic ideas. You can combine these ideas to understand more complicated situations.

First, consider the difference between speed and velocity. *Speed* is the total distance traveled divided by the total time required to travel that distance. *Velocity* is the total *displacement* divided by the time in which this displacement occurs. Consider the following example.

A racetrack is shaped in an oval and has a total length of 1 mile. Now consider that a car drives around this track ten times and does so in exactly 6 minutes. The total distance traveled is 10 miles. The speed is found using the following equation:

speed = 10 miles/6 minutes = 100 miles/60 minutes = 100 miles/hour.

Thus, the speed of the car is 100 miles per hour. However, the velocity of the car is zero! Why is this true? Because after the car has gone around the track ten times, it returns to where it started. Thus, its *displacement* is zero. Remember that displacement is the distance between the starting point and the finishing point, regardless of the path traveled between the two points.



The acceleration of an object is defined as the change in the speed (or velocity) of the object divided by the amount of time required for that change to take place. In other words, consider a person who is walking at a speed of 3 feet every second. Now consider that this person's speed changes to 4 feet every second. The person is said to have accelerated his or her speed (he or she is traveling faster than he or she was before). Had the person slowed to a speed of 2 feet every second, he or she would have decelerated (slowed down).

These ideas can be applied to machines. Instead of thinking about a car going around a track, think of a machine that is doing work. If the machine begins to do the work faster, then the machine has accelerated the rate at which it is doing work. In other words, the machine has increased the speed with which it is doing the work. Similarly, if the machine begins to do the work more slowly, then the machine has decelerated the rate at which it is doing work. The machine has decreased the speed with which it is doing the work.

Friction is a related concept. There are two types of friction, referred to as static friction and kinetic friction. *Static friction* tends to keep things from moving. When you push against an object on the floor that does not move because it is so heavy, static friction between the object and the floor is what keeps the object from moving. *Kinetic friction* tends to slow moving objects. Kinetic friction is the reason why an object sliding across the floor will eventually come to rest.

Consider now any type of engine that has moving parts. These parts interact with one another as well as with stationary parts of the engine. These moving parts produce kinetic friction, which tends to slow the speed of the engine. In this case, the friction is referred to as *internal friction.* This is because the interaction of the moving parts of the engine tends to decrease the speed with which the engine can operate.

When approaching a steep hill in a car, you must depress the accelerator further in order to maintain the same speed up the hill that the car had on level ground before reaching the hill. Which of the following statements is true?

A. The engine is doing the same amount of work.

B. The engine is doing more work.

C. The engine is doing less work.

D. Cannot be determined.

The answer is **B.** This question is a bit trickier than most. Even though the speed of the car has not changed, the speed of the engine has. The engine has increased its speed to compensate for the extra work needed to go up the hill.

Centrifuges

A *centrifuge* is a machine that is designed to spin very rapidly in order to separate a liquid from a solid that is dissolved within the liquid. A container holding the mixture is placed in the centrifuge and then it accelerates to a high rate of rotation very quickly. After spinning for an amount of time, the solid forms on the inner portion of the container that is farthest from the center of the centrifuge.

To understand why this happens, consider a car traveling straight on a level road. The car comes to a moderately sharp left-hand turn. As the car goes around the turn, the passengers lean toward the right side of the car. Are the people being pushed to the right?

No—the car is turning to the left and the passengers are merely trying to continue in a straight line.

The same thing is happening in the centrifuge. The container is spinning rapidly while the liquid and solid within the container are trying to continue in a straight line. This causes the solid within the container to collect on the portion of the container farthest from the center.

A vehicle driving down the road approaches a right hand turn. Which side of the vehicle should the passengers brace against if they are going to round the turn quickly?

A. the left side

B. the right side

C. either side

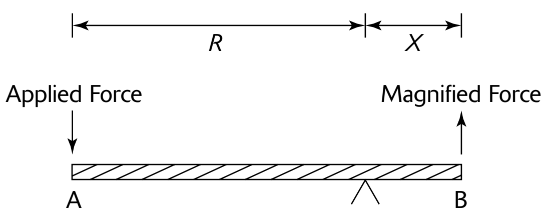
D. the roof

The answer is **A.** In trying to continue in a straight line, the passengers will end up leaning toward the left side of the vehicle.

Simple Machines

Simple machines are used by nearly everyone in some form or another on a daily basis. This section specifically addresses how and why these machines are helpful. Also, this section examines the concept of *mechanical advantage* for some of the machines discussed. Mechancical advantage is a measure of the degree to which a specific job is made easier by a simple machine.

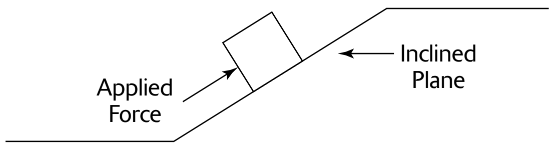
The first simple machine to be considered is a **lever** (sometimes referred to as a lever arm). A *lever* is a rigid object (this could be a board, rod, pipe, bar, or whatever) that pivots about a single point. A crowbar is a good example of a lever. The force applied at one end of the lever is magnified at the other end of the lever.



In the illustration, the applied force is at point A and a magnified force is produced at point B. Notice that the applied force is farther away from the pivot point than the magnified force—this will always be the case. The mechanical advantage is the ratio of the distance R (from the applied force to the pivot point) to the distance X (from the pivot point to the magnified force). In other words, if the distance R is three times the distance X, then the mechanical advantage for this lever is:

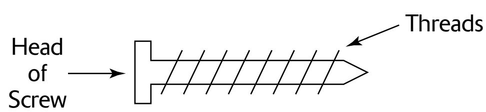
mechanical advantage = R/X = 3.

Another example of a simple machine is the **inclined plane.** This is nothing more than a flat surface that is used to move a heavy object from one height to another. A frequent application of an inclined plane is to move a heavy crate from a lower point to a higher point (when loading a truck, for instance).



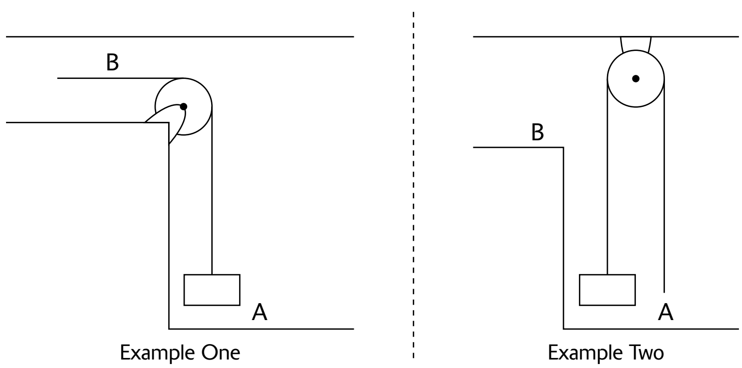
The concept of mechanical advantage does not apply directly to an inclined plane, because the applied force is not magnified by the inclined plane. Notice that the most efficient way to use the inclined plane is to have the applied force be parallel to the inclined plane. In other words, you want to push the crate up the plane, not into the plane.

Another example of a simple machine that does not magnify the applied force is a **screw.** You use a screw to hold two objects together.



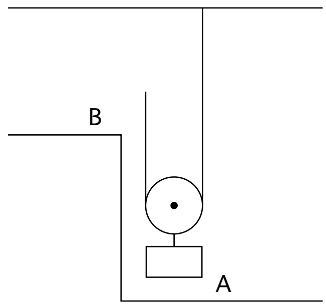
Consider, for example, using a screw to fasten a nameplate to a wooden door. You insert the screw into the door until the nameplate is flush against the door and the head of the screw is flush against the nameplate. The main characteristic of the screw that holds the nameplate to the door is the threads. The threads act much like the barb on a fishing hook. Once you insert the screw into the door, you cannot simply pull it back out.

One of the more intricate simple machines is the **pulley.** Pulleys are very useful in that there are many diverse ways in which to combine them, depending on the task at hand. You can use a single pulley in conjunction with a rope to lift a heavy object above the ground.



Notice that you can arrange the pulley system so that you can raise the object from point A to point B in several different ways. In example one, the person operating the pulley is at point A lifting the object to someone else at point B. In example two, however, the person is already at point B and uses the pulley to bring the heavy object to point B. In both of these examples, though, the applied force is equal to the exerted force.

Now consider a slight variation of example two. In the example below, the mechanical advantage is two.



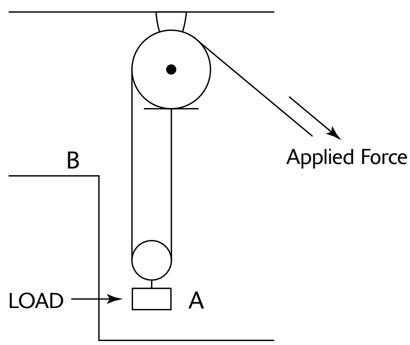
Example Three

Why is this true? Look back to example one. In this case, the person lifting the load is pulling down on the rope and gravity is pulling down on the load. The rope supporting the pulley is actually supporting *twice* the weight of the load! In example three, however, the person is pulling *up* on the rope, gravity is pulling down on the load, and the point where the rope is secured acts as another upward force.

As an additional point of interest, notice that in example three the pulley is moving, while in example one the pulley is stationary. In order for any pulley system to have a mechanical advantage greater than one, there must be at least one movable pulley. In other words, it is impossible to construct a pulley system where all the pulleys are fixed (don't move) that has a mechanical advantage greater than one.

As a result, the person doing the lifting only needs to exert half of the force required in example one. However, the person must pull twice as much rope. In other words, if the person in example three wants to lift the load 10 feet, then 20 feet of rope must be pulled through the pulley. Recalling that work is equal to force times distance, we see that the amount of work done has remained the same.

Two more thoughts about pulley systems should be mentioned. First, it is possible to create systems with many movable pulleys that have mechanical advantages of two, three, or even higher. The following diagram shows a pulley system that has a mechanical advantage of three.



Remember, though, that in order to lift the crate 5 feet, 15 feet of rope must be pulled through the pulley system (the person lifting the crate is exerting less force but is still doing the same amount of work).

The final thought is that the mechanical advantages that this section discusses are theoretical. In other words, the actual mechanical advantage will be slightly less. This is due mainly to friction in the pulleys and from the rope through the pulleys.

A system of pulleys is designed to lift heavy objects. This system has a total of three pulleys. What is the mechanical advantage of the system?

A. 1

B. 2

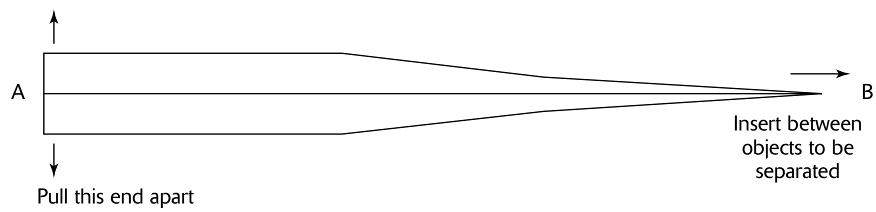
C. 3

D. Cannot be determined

The correct answer is **D.** If all of the pulleys are fixed, the mechanical advantage will be one. The configuration of the pulleys must be known in order to determine the mechanical advantage.

Another simple machine that is used frequently is a **wedge.** A wedge is designed to split apart a single object or separate two objects from one another. Using a crowbar is one method to separate two objects (two boards that have been nailed together, for example). A wedge accomplishes the same thing but works a bit differently.

The following diagram shows an example of a wedge.



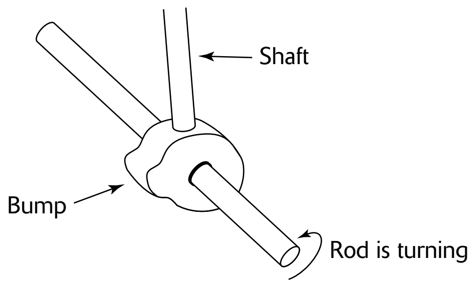
At end A, the rods are not connected. This end is used as the handle for the wedge. At end B, the rods are connected and are very thin. This end is inserted between the two objects to be separated, and the handles are pulled apart. This simple machine will be more effective if the length of the wedge is long compared with the size of the objects to be separated.

The last simple machine that this section discusses is the **wheel and axle.** For this simple machine, the force is applied by turning the wheel, and is then transferred through the axle to the point where the force is to be exerted. One of the most common examples of a wheel and axle is a steering wheel for a car or boat. Another example is an outdoor water faucet.

Compound Machines

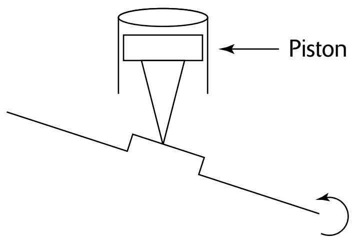
Compound machines require a bit more explanation than simple machines. Compound machines normally consist of moving parts and multiple components. Some of them produce a mechanical advantage, just as some simple machines do.

Consider a **cam** and a specific application of a cam, the **piston.** These compound machines are used to change linear motion into circular motion, and vice versa. First, consider a cam where a rotating rod is used to change circular motion to linear motion.



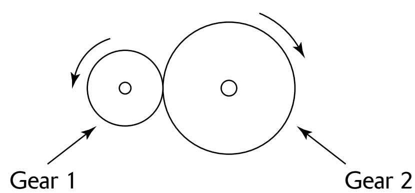
The rod turns, and as it turns so does the attached ring. Notice that the ring has a bump on it, and as this bump passes beneath the shaft, it causes the shaft to move up and down. The circular motion of the rod creates linear motion in the shaft.

There are many applications converting circular motion to linear motion in the mechanical world today. One such example is an oil pump. A more common example, however, is a piston.



Although the appearance of the piston is slightly different, the principles involved are exactly the same. In this case, part of the rod is slightly displaced and a second bar connects this displaced portion of the rod to the actual piston. The turning of the rod causes the piston to move up and down.

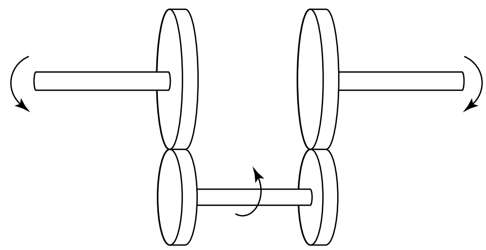
Now consider how a system of **gears** works. Consider the simple example, consisting of only two gears, in the following diagram.



The smaller gear is designed to have five teeth, while the larger gear is designed to have twenty teeth. This means that for every rotation of the larger gear, the smaller gear has gone through four rotations. This system of gears can be used to increase or decrease the speed of circular motion. Also notice that if the smaller gear is turning clockwise, then the larger gear must be turning counterclockwise. The mechanical advantage for such a system of gears is simply the ratio of number of teeth for the gears, as in the following equation:

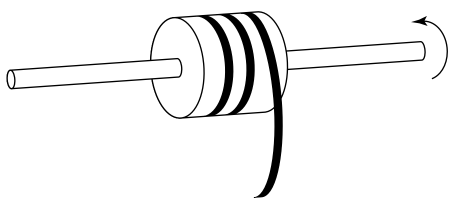
mechanical advantage = 20/5 = 4

If you want both components to rotate in the same direction, then you can use a system of four gears, as in the illustration below.



In going from the first rod to the intermediate rod, the direction of rotation changes. Then, in going from the intermediate rod to the final rod, the direction of rotation changes again, returning to what it was originally. A common application of this type of gear system is in an automobile transmission.

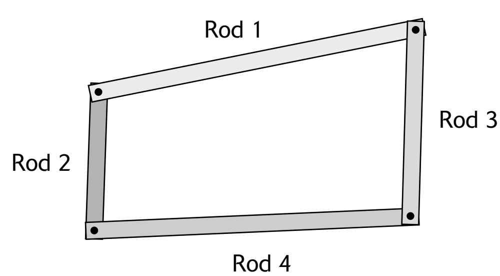
Another compound machine is the **crank.** A *crank* consists of a rod of varying radius with a rope (or chain, or other connecting device) that wraps around the larger radius portion of the rod and connects to the weight that is being lifted (or otherwise moved).



The mechanical advantage for this type of compound machine is simply the ratio of the larger radius portion of the rod to the smaller radius portion. You can also call this type of device a winch.

The next compound machine requires a bit more discussion—**linkages.** Stated as simply as possible, *linkages* are capable of converting the rotating motion of a crank into a different type of rotating motion, oscillatory motion, or reciprocating motion. This is a reversible process. In other words, a linkage is also capable of taking any of the three types of motion and using them to turn a crank.

The simplest type of a linkage is the four-bar variety, shown below.



By making the four bars the appropriate length, it is possible to hold rod 1 fixed and allow rod 2 to rotate in full circular motion. Rod 3, then, will oscillate back and forth. A good example of this system in use is an automobile windshield wiper.

The last two compound machines this section covers are **belts** and **chains.** These serve the same purpose: changing rotational motion of one speed to rotational motion of another speed. The principle is quite similar to a system of gears, except that the rotating elements are not in contact with one another. Belts are used in automobile motors, while a chain is used on a bicycle. Motorcycles can be either belt driven or chain driven.

Strategies for Scoring Well

There is more to doing well on any test than simply understanding the material. For a test such as the ASVAB, there is a distinct advantage in that the exact format of the test is known before the test begins. In this section, you can find some suggestions to help maximize your performance on the exam.

You can also apply the most important suggestion to the other sections. **Do not spend too much time on any one question.** After you read the question, if you know the answer, then simply select the correct answer and move on. If, however, you are unsure of the correct answer, then determine if there are any answers that you can rule out. Cross out any answers that you know are wrong. At this point, if you know the answer, select it. If you are still unsure of the correct answer, then move on to another question. Sometimes it just takes a few moments for the correct answer to pop into your head.

Here is some advice for particular types of questions:

- For properties-of-materials questions, you need to understand how liquids and solids respond to outside stimuli, most specifically, forces and temperature. Be familiar with the way that mass, volume, and density are related. Finally, be able to understand what types of material are best suited for specific applications.
- For structural-support questions, try to visualize whether or not the configuration in question is well-balanced. In other words, will it be able to have external forces applied to it without falling over, or otherwise changing its orientation?
- For fluid-dynamics qustions, determine if a high-viscosity or low-viscosity fluid would be more appropriate. Be certain to understand that a fluid maintains equal pressure throughout (as long as the height remains the same), while an applied force can be magnified by increasing the area over which it acts.
- For mechanical-motion questions, be sure to understand the concepts of position, speed, velocity, and acceleration. Know how to apply these concepts to both linear motion and circular motion. Also, be aware that friction is present in all mechanical systems. Understand the consequences of friction for each situation that you are considering.
- For both simple- and compound-machine questions, be able to visualize in your head a diagram of the machine. Be completely aware of which parts have to remain stationary as well as which parts are mobile. Be familiar with the mechanical advantage for the various machines, and understand that in order to gain one thing another must be lost. In linear motion, you gain force but you lose distance. In circular motion, you gain torque but you lose speed.

Mechanical Comprehension Practice Questions

1. When pedaling a bicycle, a chain is used to connect the gear associated with the pedals to the gear associated with the rear tire. Which of the following statements is true?

A. Force is gained while work is lost.

B. Torque is gained while force is lost.

C. Speed is gained while force is lost.

D. Speed is gained while torque is lost.

2. Which of the following compound machines would you expect to be associated with an automobile?

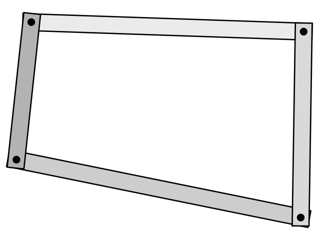
A. gear

B. cam

C. piston

D. all of the above

3. What type of compound machine is shown in the diagram?



A. piston

B. linkages

C. cam

D. crank

4. An unevenly shaped object will have its center of gravity

A. such that the weight is equal on both sides.

B. such that the density is equal on both sides.

C. such that the torque is equal on both sides.

D. none of the above.

5. A crank is a useful compound machine that

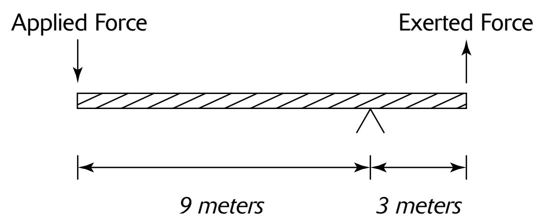
A. increases torque.

B. decreases friction.

C. increases speed.

D. none of these.

6. In the lever shown, what is the mechanical advantage?



A. 4

B. 3

C. 2

D. 1

7. A system consists of two pulleys, both of which are fixed. What is the mechanical advantage for the system?

A. 1

B. 2

C. 3

D. Cannot be determined

8. All of the following are simple machines except

- **A.** pulley.
- **B.** cam.
- **C.** screw.
- **D.** wheel and axle.

9. While traveling from one point to another, a poorly secured load in the back of a truck hits the left wall of the truck in a curve. Which way did the truck turn?

- **A.** left
- **B.** right
- **C.** need to know the speed of the truck
- **D.** cannot be determined regardless of truck speed

10. Which of the following statements is true?

- **A.** The average speed can never be less than the average velocity.
- **B.** The average speed can never equal the average velocity.
- **C.** The average speed always equals the average velocity.
- **D.** The average speed may or may not equal the average velocity.

11. A force of 50 pounds is applied to a hydraulic jack. If the area where the force is exerted has an area that is five times the area where the force is applied, what is the maximum load that the jack can lift?

- **A.** 100 pounds
- **B.** 200 pounds
- **C.** 300 pounds
- **D.** None of these

12. A hydraulic system works best with a fluid that is

- **A.** highly viscous.
- **B.** moderately viscous.
- **C.** not highly viscous.
- **D.** does not depend on fluid viscosity.

13. On a cold day in the winter, compared to a hot day in the summer, solids and liquids will generally

- **A.** expand.
- **B.** contract.
- **C.** retain the same volume.
- **D.** cannot be determined.

14. Which substance has the highest density?

- **A.** lead
- **B.** wood
- **C.** water
- **D.** paper

15. In general, a load is best supported by a structure when it is placed as close as possible to that structure's

- **A.** center of gravity.
- **B.** geometric center.
- **C.** both of these.
- **D.** neither of these.

Answers and Explanations for Practice Questions

1. **D.** Remember that for linear motion the two quantities that you need to concern yourself with are work and force. For circular motion, the two quantities are speed and torque. When either of these quantities gains, the other one loses. For the case of pedaling a bicycle, circular motion is present.
2. **D.** The cam is used to move the piston back and forth while the gear is part of the system that connects the drive shaft to the wheels.
3. **B.** Remember that the most common type of linkage is the four-bar variety, which is shown in the diagram.
4. **D.** Finding the center of gravity for an irregularly shaped object is beyond the scope of the ASVAB, but you should know that the center of gravity is not necessarily where the weight is equal on both sides. Density (**B**) and torque (**C**) are unrelated.
5. **A.** A crank produces circular motion, so your two properties of interest are torque and speed. A crank increases torque at the sacrifice of speed (number of rotations).
6. **B.** This is found using the ratio mechanical advantage = 9/3 = 3.
7. **A.** Remember that for a system of pulleys to create a mechanical advantage greater than one, at least one of the pulleys must be mobile. Since both pulleys are fixed, there is no mechanical advantage.
8. **B.** A cam is a compound machine.
9. **B.** Remember that the load will try to continue in a straight line. As the truck moves to the right, the load will hit the left side.
10. **D.** Velocity is displacement divided by time and may never be greater than speed. It may be equal to speed if the motion is in a straight line.
11. **D.** To find the exerted force, multiply the applied force by the ratio of the areas. In other words, exerted force = $50 \times 5 = 250$ pounds.
12. **A.** It is desirable to use a fluid that can flow through the system readily, without much internal friction to retard the flow.
13. **B.** Remember that both solids and liquids generally expand when heated and contract when cooled.
14. **A.** Higher density means that there is a greater weight in a given volume. A container filled with lead will be much heavier than the same container when it's filled with any of the other three substances.
15. **A.** While the center of gravity can be near the geometric center, it does not have to be.

Electronics Information

Electricity is an essential part of a modern technological society. Electricity is used to power and control everything from simple devices like electric lights to sophisticated electronics like computers. The Electronics Information test measures your knowledge of electrical theory, components, systems, and test equipment. The sections that follow cover the key elements of electricity that you will need to know to do well on this part of the ASVAB.

The ASVAB has 20 electronics information questions on it. You will have 9 minutes to answer these questions.

Basics of Electricity

There are two kinds of electric charges: positive and negative. In ordinary matter, the positive charges are protons and the negative charges are electrons. Relatively heavy protons are found in the dense core of an atom, the nucleus, while the much lighter electrons are in a cloud surrounding the nucleus.

Electric charges create an *electric field* around themselves, and this field exerts a force on other charges. Like charges repel each other, while opposite charges attract. Charges in motion create a *magnetic field* that exerts a force on other moving charges. If the magnetic field varies with time, it creates an electric field through *electromagnetic induction*. Time-varying electric fields also produce magnetic fields.

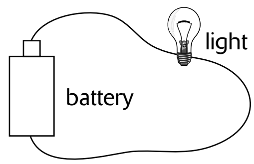
Electric and magnetic fields are both forms of energy. When charges are accelerated, they create changing electric and magnetic fields that can travel through space far from any charges that created them. Since time-varying electric and magnetic fields can create one another, the fields exist even where there are no charges. This traveling electric and magnetic disturbance is called an *electromagnetic* (EM) wave. The electric and magnetic fields vary with time so that they repeat many times each second. That rate is known as the *frequency* and is measured in hertz (Hz).

Light, radio waves, and x-rays are examples of EM waves. Electromagnetic waves can travel through a variety of media, depending on their frequency. Visible light can travel through air, glass, or water, while x-rays can penetrate those and many other materials. On the other hand, radio waves do not travel through water or metals. Unlike sound or water waves, EM waves do not require a medium to propagate; all EM waves can travel through a vacuum. All EM waves travel through the vacuum at the same speed, the speed of light, about 300,000 kilometers per second (or 186,000 miles per second).

Most applications of electricity involve *electric current*: the movement of charges in a conductor. Current is denoted by I and measured in amperes or amps. By convention, the direction of current is defined to be the direction of the flow of positive charge. Generally, the conductor is a metal, which means that the charges in motion are electrons. Only the electrons (negative charges) are free to move in a metal. So, the direction of current flow is opposite the flow of electrons.

Some materials are better conductors than others. Most metals are excellent conductors, with silver and copper as the best. Materials such as silicon and germanium are called *semiconductors* because they do not have free electrons, but it is relatively easy for electrons to become free to conduct electricity. Impurities are often added to silicon to change its electrical properties to make devices like transistors and diodes, as discussed below. Finally, there are materials, *insulators,* that are very poor conductors. These include most plastics, glass, wood, and ceramics.

When electric current flows for any period of time, it must flow in a complete circuit; charge cannot accumulate in any one place. In the simple circuit shown below, electric current flows from the battery to the light and back to the battery or, more generally, from the *source* to the *load* and back to the source. If the circuit is not complete, so electrons cannot flow back to the source, it is called an *open circuit*. If an unintended path closes the circuit so that it does not flow through the load, it is a *short circuit*.



The electrons will not flow in the circuit unless they are pushed. The force pushing them is provided by the battery as a source of *voltage,* usually denoted by *V.* The voltage is like pressure pushing water through a pipe. In this analogy, the electric current is the flowing water. The light bulb resists the flow of current. In general, any component that affects the flow of current is an *impedance.* A particular kind of impedance is *resistance,* in which electrical energy is converted to heat, as in the light bulb. Inductors and capacitors, described in the section "Electrical Components, Units, and Symbols" are also impedances, but do not dissipate energy.

The questions below illustrate how this content may appear on the ASVAB.

In a metal conductor, charges flow

A. in the same direction as the current.

B. in the opposite direction from the current.

C. in both directions.

D. in either direction, depending on the metal.

The answer is **B.** The moving charges in a metal are electrons, so they flow in the opposite direction from the direction of current flow.

A short circuit is

A. the shortest path for current flow.

B. a circuit with short wires.

C. an accidental path for current that bypasses the load.

D. a path for current that is shorter than the one through the load.

The answer is **C.** In a short circuit, the current flows through an unintended path instead of through the load.

Poor conductors of electricity are known as

A. metals.

B. insulators.

C. semiconductors.

D. electrons.

The answer is **B.** Insulators are the poorest conductors.

Which of the following is an electromagnetic wave?

A. light

B. radio

C. x-rays

D. all of the above

The answer is **D.** Light, radio, and x-rays are all electromagnetic waves.

All electromagnetic waves can travel through

A. a vacuum.

B. water.

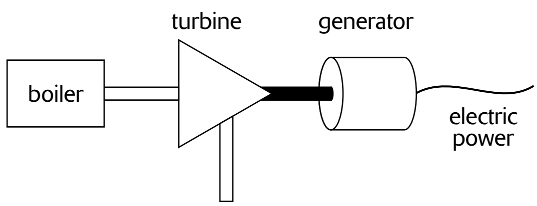
C. metals.

D. electrical conductors.

The answer is **A.** Any EM wave travels through a vacuum. Radio waves cannot penetrate water or metals. Metals are electrical conductors, so **D** is also wrong.

Electric Power Generation

Electricity is typically generated from fuels, either fossil or nuclear, that are used to heat water in a boiler that turns a turbine, which then turns an electric generator (see the following figure). Certain renewable methods, such as wind or hydroelectric generation, do not require the consumption of fuels. Instead, natural forces provide the motion directly to the generator. For instance, in a hydroelectric plant, water flows through a turbine to turn the generator.



Most electricity generation is in the form of alternating current (AC), discussed in the section "AC and DC Power," later in this chapter. The voltage of the generator's output is increased to hundreds of thousands of volts for transmission over large distances on the *power grid,* then stepped back down to lower voltage near the users. Voltage is stepped down and power is distributed at electrical *substations*. Transformers on power poles or underground bring the voltage down to levels used in homes and offices. Large motors in manufacturing plants often use power delivered at higher voltages.

The questions below illustrate how this content may appear on the ASVAB.

Electricity is generated by

A. fossil fuels.

B. nuclear materials.

C. renewable sources.

D. all of the above.

The answer is **D.** All three of those methods are used, though fossil fuels are the most common.

Voltage from the generator is

A. sent directly to the users.

B. stepped up for transmission.

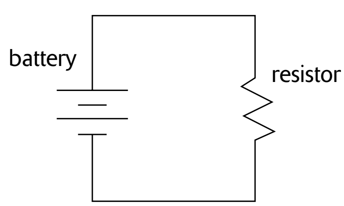
C. stepped down for transmission.

D. decreased for transmission, then increased for users.

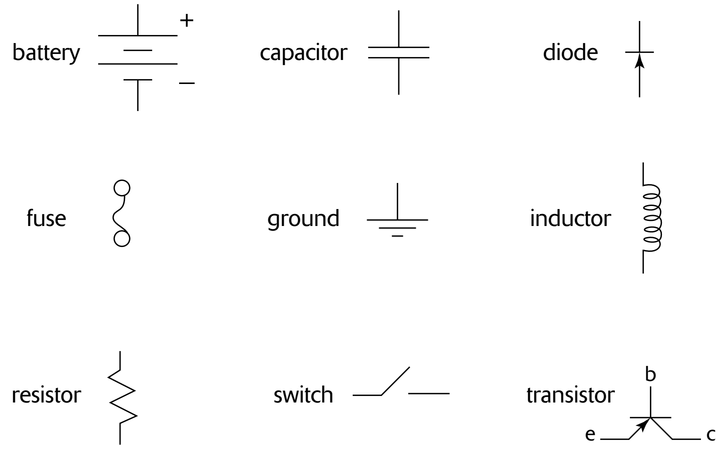
The answer is **B.** Voltage from the generator is increased (stepped up) for transmission.

Electrical Components, Units, and Symbols

There are special symbols for drawing electric circuits. For example, the circuit in the "Basics of Electricity" section would be drawn as follows:



The figure below is a partial list of electrical components and their symbols.



The following list describes the functions and composition of the components in the figure above.

- **Battery:** A source of voltage to push current through a circuit. The longer horizontal lines indicate the positive terminal, as shown in the figure. Current flows from the positive to the negative terminal. Batteries consist of cells in which a chemical reaction provides the energy to the electrons in the conductors (*electrodes*) that are immersed in the chemicals (*electrolytes*) in the cell. Batteries wear out when the electrolytes are consumed.
- **Capacitor:** A component that accumulates charge, storing electrical energy in an electric field. The letter *C* denotes capacitance, which is measured in *farads.* Two metal plates or curved surfaces close together that are separated by an insulator make up a capacitor.
- **Diode:** A semiconductor component that only allows current flow in one direction, defined by the arrow in the figure. Diodes are used to convert AC current to DC (see "AC and DC Power," later in this chapter).
- **Fuse:** A circuit element that allows the flow of current below a certain value, but opens the circuit when the current exceeds this value. Fuses are used to protect circuits from damage by excessive electric current. Fuses consist of a strip or coil metal with a low melting temperature. When too much current flows through the metal, it melts and opens the circuit.
- **Ground:** A common voltage reference level defined by the container of the electric circuit (chassis ground) or by the Earth (Earth ground).
- **Inductor:** A device that opposes changes in the flow of current, storing electrical energy in a magnetic field. The letter *L* denotes inductance, which is measured in *henries.* Inductors usually consist of a coil of wire, sometimes wrapped around a piece of iron (*iron core*) or an insulating shell (*air core*).
- **Resistor:** A component that opposes the flow of current, transforming electrical energy to heat. The letter *R* denotes resistance, which is measured in *ohms.*
- **Switch:** A device that interrupts or allows the flow of current in a circuit.

- **Transistor:** Controls the flow of current between the *emitter (e)* and *collector (c)* by the voltage applied to the *base (b).* Transistors are the essential element in an electrical amplifier. A small amount of current can be used to change the voltage applied to the base, resulting in a large change in the current flowing between the emitter and collector.

The following table is a summary of units used in electronics.

Quantity	*Unit Name*	*Unit Symbol*
voltage	volt	V
current	ampere	A
frequency	hertz	Hz
resistance	ohm	Ω
inductance	henry	H
capacitance	farad	F
charge	coulomb	C
power	watt	W
energy	joule	J

Many electrical quantities are very small or large. To avoid writing many zeros before or after the decimal point for very small or large numbers, prefixes are used for powers of 10. The following table gives the decimal and scientific notation equivalent of common prefixes.

Decimal	*Scientific Notation*	*Prefix*	*Abbreviation*
0.000000000001	10^{-12}	pico	p
0.000000001	10^{-9}	nano	n
0.000001	10^{-6}	micro	μ
0.001	10^{-3}	milli	m
1,000	10^{3}	kilo	k
1,000,000	10^{6}	mega	M
1,000,000,000	10^{9}	giga	G

Electrical components are frequently connected using *solder*, a metal alloy of tin and lead with a low melting temperature that joins wires mechanically and electrically. Electrical solder usually includes a rosin core, called a *flux,* to clean the oxidation from the wires being joined. Some solder, such as the kind used for plumbing, contains acid flux. Acid-core solder should not be used for electric circuits because it will eventually corrode the wires. A joint that has been soldered and allowed to cool correctly has a smooth, shiny appearance. A joint that appears dull and rough is called a *cold solder joint*.

The questions below illustrate how your knowledge of electrical components may be tested on the ASVAB.

Electric current is measured in

A. volts.
B. amps.
C. watts.
D. farads.

The answer is **B.** Electric current is measured in amps (or *amperes*).

One thousand ohms could be written as

A. $1M\Omega$.
B. $1k\Omega$.
C. $1m\Omega$.
D. $1{,}000\ k\Omega$.

The answer is **B.** The prefix *k* denotes 1,000, and the symbol **Ω** denotes the unit ohms.

Solder for electric circuits usually consists of

A. acid flux and a tin-lead alloy.
B. rosin flux and an acid core.
C. a tin-lead alloy and a rosin core.
D. oxidation and a rosin core.

The answer is **C.** Electrical solder is made of a tin-lead alloy and usually contains a rosin core.

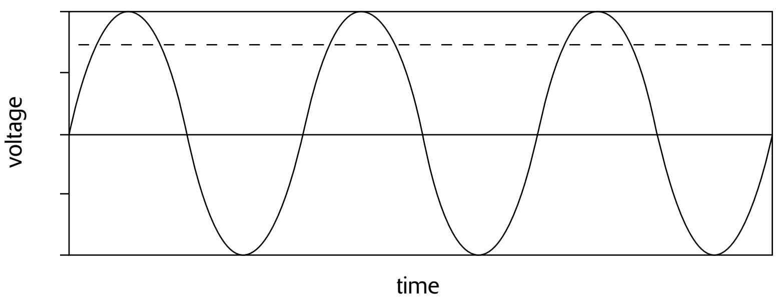
Properly soldered joints appear

A. shiny and rough.
B. shiny and smooth.
C. dull and smooth.
D. dull and rough.

The answer is **B.** Joints that have been soldered correctly are shiny and smooth.

AC and DC Power

Electric current can be constant (direct current, *DC*) or oscillating (alternating current, *AC*). Batteries are sources of DC current. Power outlets are generally sources of AC. Alternating current is delivered by making the voltage vary with time, as shown in the following figure (a solid curve). The voltage waveform repeats many times each second, usually at either 50 or 60 Hz.

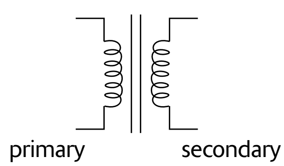


In the United States and Canada, the voltage of AC outlets is about 115 V at 60 Hz. Most European countries use 220 to 240 V and 50 Hz. The voltage quoted is the *root-mean-square* (rms) value, drawn as a dashed line in the figure. For AC power, this is typically about 70% of the peak voltage. For instance, 115 V AC power has a peak voltage of about 163 V.

One hot and one neutral terminal deliver the power in home or office electrical outlets. Three-prong outlets also have a separate ground terminal, which is connected to the neutral terminal at the service entrance (circuit breakers or fuses). Polarized electrical plugs have flat prongs of different widths: the narrow one is hot, the wide one is neutral. In a three-pronged plug, the ground connector has a U-shaped cross section.

Home and office power for lights and small appliances is generally delivered at 115 V in a *single phase*. This means that the voltage at the hot terminal oscillates with time as shown in the figure above. Current flows between the hot and neutral terminals. Higher voltages are often in the form of *three-phase* power, which means that there are three hot terminals. Each terminal has the same oscillatory voltage, but with phases separated by 120 degrees. Current flows between each phase and the other two terminals. Three-phase power is often used for heavy machinery with large motors.

The main advantage of AC power is its voltage can be easily changed using a transformer. It usually consists of two inductors, the primary and the secondary, wrapped around an iron core, as shown in the figure below. The side of the transformer nearest the voltage source is the primary inductor. The two inductors have a different number of loops or turns. The ratio of primary to secondary voltage is equal to the ratio of the number of turns. For instance, a transformer with 500 turns on the primary and 100 turns on the secondary will transform 115 V to 23 V. This is a *step-down* transformer since the voltage on the secondary inductor is lower than on the primary inductor. If the secondary voltage is higher, it is a *step-up* transformer.



Electric generators normally produce AC power because they use rotating coils in magnetic fields, which result in time-varying voltage. If DC power is required, a *rectifier* is used to convert AC power to DC power. Diodes are usually the key element of a rectifier since they only allow current to flow in one direction. It is also possible to transform DC power into AC power by using a solid state device called an *inverter*.

The questions below illustrate how your knowledge of AC and DC power may be tested on the ASVAB.

Homes and offices are normally served by

A. three-phase power.

B. two hot terminals and one neutral.

C. single-phase power.

D. three hot terminals and one ground.

The answer is **C.** Outlets in homes and offices have single-phase power, which has one hot terminal and one neutral. Sometimes they also include one ground terminal.

A transformer with 250 turns on the primary coil and 1,000 turns on the secondary is connected to a 230 V source. The voltage on the secondary is about

A. 57 V.

B. 115 V.

C. 230 V.

D. 920 V.

The answer is **D.** The secondary voltage is equal to the primary voltage times the ratio of the number of turns in the secondary to the primary: $230 \times (1{,}000/250) = 920$ V

A device that transforms AC current to DC is a(n)

A. inverter.

B. converter.

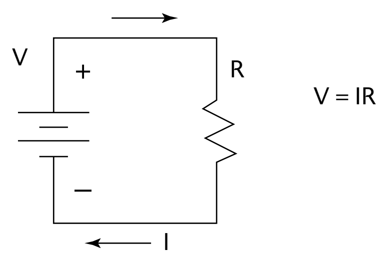
C. rectifier.

D. transformer.

The answer is **C.** AC to DC converters are rectifiers. Inverters convert DC to AC and transformers change the voltage and current of AC power.

Ohm's Law

Consider the circuit shown in the following figure. The current flows from the positive terminal of the battery, through the resistor, and back to the negative terminal. The current can only follow one path, so it is the same everywhere in the circuit. The voltage, current, and resistance are related by *Ohm's law*, which states that the voltage is equal to the current times the resistance: V = IR. Using algebra, you can change the equation so that if you know any two of these values, you can calculate the third: I = V/R and R = V/I.



The questions below illustrate how Ohms's law may appear on the ASVAB.

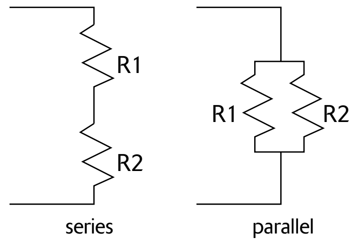
A 5 ohm resistor is connected across a 10 V battery. What is the current flowing through the resistor? **A.** 2 A **B.** 5 A **C.** 10 A **D.** 50 A

The answer is **A.** According to Ohm's law, the current is the voltage divided by the resistance: I = V/R = 10/5 = 2 A.

A circuit requires that 3 A flow through a 30 ohm resistor. How much voltage is required across the resistor? **A.** 3 V **B.** 10 V **C.** 30 V **D.** 90 V

The answer is **D.** The voltage is the current times the resistance: V = IR = (3)(30) = 90 V.

You can apply Ohm's law to more complicated circuits. Electrical components can be connected in *series* or in *parallel*. When components are in series, the same current flows through both of them; when they are in parallel, the current divides between them. The following figure illustrates these two modes with resistors.



Resistors in series have an equivalent resistance to the sum of their individual resistances: $R = R_1 + R_2$. Resistors in parallel combine in a somewhat more complicated way: $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ The questions illustrate how this content may appear on the ASVAB.

A 10-ohm resistor is wired in series with a 40-ohm resistor. The composite resistance is

A. 8 ohm.

B. 30 ohm.

C. 40 ohm.

D. 50 ohm.

The answer is **D.** Series resistors are summed: 10 + 40 = 50. Answer **A** would have been correct if the resistors had been in parallel.

Two 10-ohm resistors are wired in parallel. A single resistor can be substituted for these two without changing the behavior of the circuit. What is the value of the replacement resistor?

A. 5 ohm

B. 10 ohm

C. 20 ohm

D. 100 ohm

The answer is **A.** The correct answer is found by applying the parallel resistance equation:

$$\begin{aligned}\frac{1}{R} &= \frac{1}{R_1} + \frac{1}{R_2} \\ &= \frac{1}{10} + \frac{1}{10} \\ &= \frac{2}{10} \\ &= \frac{1}{5} \\ R &= 5 \text{ ohm}\end{aligned}$$

Joule's Law

When current flows through a resistor, it converts electrical energy into heat. The power dissipated in a resistor, R, is the product of the current through the resistor and the voltage across the resistor, V: P = IV. Ohm's law can be used to substitute for the voltage in Joule's law to obtain a form only in terms of current and resistance: $P = I^2R$. For AC power, rms (root mean square) values for voltage and current are used in the formulas.

Many appliances, such as toasters, space heaters, electric stoves, and hair dryers use resistive heating. The heating element in these appliances is usually a long metal wire with a high resistance. Incandescent light bulbs also work by resistive heating. The filament in a light bulb has a high resistance and heats to a high temperature so that it radiates light.

The questions illustrate how this content may appear on the ASVAB.

A toaster draws 10 A from a 115 V outlet. How much power does it use?

A. 11.5 W

B. 115 W

C. 115 W

D. 1,150 W

The answer is **D.** To find the power, multiply the current times the voltage: $10 \times 115 = 1{,}150$ W.

A hair dryer with a 15 Ω resistive element draws 10 A of current. How much power does it consume?

A. 1,500 W

B. 150 W

C. 15 W

D. 10 W

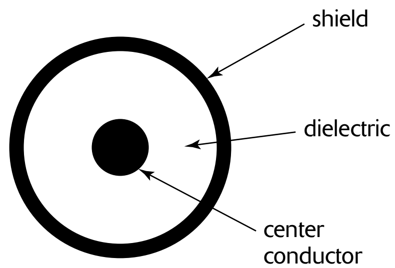
The answer is **A.** $P = I^2R = (10)^2(15) = 1{,}500$ W.

Wires, Cables, and Traces

The simplest connection between electrical components is made with simple wires. They can be either *solid* or *stranded*. A solid wire consists of a single piece of metal wire, while a stranded wire is composed of many thinner solid wires twisted together to form a single conductor. Stranded wires have increased flexibility and are more resistant to breaking than solid wires. Single conductors can be bare or *insulated,* for example, covered by a thin layer of plastic that does not conduct electricity. Insulated wires are used to avoid unintended connections when conductors need to be close together.

Some connections require more elaborate conductors. Single conductors are subject to noise from other parts of the circuit or the environment. This can be minimized by having a signal wire very near its return path, as in a *twisted pair,* where two insulated conductors are twisted around each other. For example, Category 5 Ethernet computer networking cables consist of four twisted pairs held together in an insulating jacket.

Coaxial cables (coax cables) provide even better isolation from noise. The cross section of a coax cable is shown in the following figure. It consists of a solid or stranded center conductor, surrounded by an insulator (the *dielectric*) and a braided outer conductor (the shield). In addition to enhanced noise immunity, coax cables can carry high-frequency signals without distortion.



Electrical components are frequently mounted on printed circuit boards. These boards are made of an insulating material and coated with a conductor, usually copper. Most of the copper is etched away by acid, leaving a pattern of conducting strips on the insulator that will connect the components that are installed on it. The conducting strips are called *traces*.

The questions illustrate how this content may appear on the ASVAB.

Compared to solid wires, stranded wires are

A. better conductors.

B. stronger.

C. more flexible.

D. thicker.

The answer is **C.** Stranding makes conductors more flexible. They are not necessarily stronger, thicker, or better conductors.

Category 5 Ethernet cable consists of

A. a single wire.

B. four twisted pairs.

C. one conductor.

D. a coax cable.

The answer is **B.** Category 5 networking cables are made up of four twisted conductor pairs.

Coax cables are used to obtain

A. better noise immunity.

B. more flexibility.

C. distortion-free high-frequency signals.

D. A and B.

The answer is **D.** Coax cables have better noise immunity than ordinary wires and can carry high-frequency signals with minimal distortion. They are generally less flexible than single conductors or twisted pairs.

Traces on printed circuits are

A. conductors.

B. insulators.

C. dielectrics.

D. components.

The answer is **A.** Traces are the conductors on circuit boards. They connect the components on circuit boards.

Electric Motors

Electrical energy can be converted to mechanical energy by an electric motor. Motors are used in a wide variety of appliances, from refrigerators and hair dryers to VCRs and windshield wipers. A typical car has about a dozen electric motors. It would be hard to imagine a modern industrial society without electric motors.

A typical motor consists of one or more coils of wire and a permanent magnet. In some motors, an electromagnet is substituted for the permanent magnet. When electric current is passed through the coil, it produces a magnetic field. There is an attractive force between the magnet and the coil that causes the motor to turn. The current in the coil is reversed when the coil passes the magnet so the force reverses direction to repel the coil. If DC current is used to power the motor, a device is required to reverse the direction of the current flow twice each revolution of the motor. With AC current, the direction of the current itself reverses so no steps have to be taken to change the direction of the force.

There are two kinds of AC motors: *synchronous* and *induction*. A synchronous motor follows the oscillations of the AC current; it turns at the frequency of the AC. While that can be an advantage, more often it is a limitation, since motors need to be able to turn at different speeds for different situations. This limitation is overcome by induction motors, in which the coils surround a conductor rather than a magnet. Electromagnetic induction causes a current to flow in the conductor as the magnetic field created by the coils varies. In this kind of motor, it is not necessary to have a permanent magnet or rotating coil.

Industrial applications usually use three-phase motors, either synchronous or induction, to avoid some of the limitations of single-phase motors. Three-phase motors are more efficient and capable of delivering higher power.

The questions illustrate how this content may appear on the ASVAB.

All electric motors work by using

A. electric attraction.

B. magnetic attraction.

C. the force between static charges.

D. electromagnetic induction.

The answer is **B.** Electric motors use magnetic forces. Electrostatic attraction is not used in motors. Some use electromagnetic induction, but not all, so **D** is incorrect.

Synchronous motors

A. have the highest torque.

B. can turn at any speed.

C. turn at the frequency of the AC current.

D. can be either AC or DC.

The answer is **C.** Synchronous motors turn at the frequency of the AC current, so they cannot be DC. Their torque is not necessarily higher or lower than that of other kinds of motors.

Analog and Digital Devices

Electronic devices can be *analog* or *digital*. In analog devices, voltages vary continuously. In digital devices, voltages can only take on discrete values. Most signals are analog, but digital devices sample analog signals to make them easier to store and manipulate. Numbers are represented as series of ones and zeros, called *binary* numbers. Each binary digit (one or zero) is called a *bit;* a string of eight bits is a *byte*. Digital information is usually converted to analog form for people to use; human interfaces are analog.

Many analog electronics have digital counterparts. For instance, a CD player is the digital replacement for a cassette tape player. Music is stored in analog form on an audiotape, while the same information is stored in digital form on a music CD. A CD player converts the digitally stored information to analog voltages that become analog audio signals.

Computers manipulate and store information in binary form. Once the information is ready to be presented to the user, the computer converts the information to analog form. Pictures stored as digital data are converted analog electrical signals that a monitor displays. Likewise, digitally stored sounds become analog voltages that drive speakers.

The questions illustrate how this content may appear on the ASVAB.

> Digital devices use
>
> **A.** analog data.
>
> **B.** binary numbers.
>
> **C.** continuous signals.
>
> **D.** audio signals.

The answer is **B.** Information is represented as binary numbers in digital devices. Analog data is continuous and audio signals can be digital or analog.

> How many bits are in each byte?
>
> **A.** 2
>
> **B.** 4
>
> **C.** 8
>
> **D.** 10

The answer is **C.** Each byte consists of 8 bits.

Vacuum Tubes

Complex electronic devices such as amplifiers require components that control the flow of electric current, essentially electronic switches. Before the advent of semiconductor devices, vacuum tubes filled this function. They consist of an enclosure, usually glass, from which the air has been removed. A metal electrode (*cathode*) inside the tube emits electrons that another electrode (*anode*) collects. The cathode is heated to boil off the electrons. An electric field between cathode and anode can be used to push the electrons toward the anode. One or more electrodes between the cathode and the anode are used to control the flow of electrons.

The simplest tube is a diode. When a negative voltage is applied to the cathode, electrons flow toward the anode. If the voltage is reversed, electrons do not flow from anode to cathode because only the cathode is heated. A triode has a third electrode (the *grid*) that controls the flow of electrons from cathode to anode by repelling or attracting the electrons from the cathode. If a voltage is applied to the grid to repel the electrons, the current flow to the anode stops. The semiconductor replacement for a triode is a transistor.

Almost all vacuum tubes have been replaced by semiconductor devices; semiconductors are smaller and consume less power. Since they consume less power, they also dissipate less heat, which makes it possible to put them closer together since they require less cooling. Tubes are still used in displays—televisions, for example—and a few other selected applications that semiconductors cannot handle because of the voltage or current requirements.

The questions illustrate how this content may appear on the ASVAB.

A vacuum tube is filled with

A. helium.

B. no gas.

C. oxygen.

D. air.

The answer is **B.** All the gases are removed from a vacuum tube.

Vacuum tubes are rarely used because they

A. use too much power.

B. take up too much space.

C. are too hard to cool.

D. all of the above.

The answer is **D.** Tubes use more power, take up more space, and produce more heat than semiconductors.

Semiconductors

There are certain materials, *semiconductors*, that can be either fairly good conductors or insulators, depending on some external control. The external control might be a voltage applied to the material or a light shining on it. For instance, a transistor's conductivity between collector and emitter depends on how much voltage is applied to the base. Similarly, light shining on a photodiode changes its electrical properties. Silicon, germanium, selenium, and gallium arsenide are commonly used semiconductors.

Semiconductors are essential to the manufacture of miniaturized electronic components such as integrated circuits, described in the "Integrated Circuits" section. The first application of semiconductors to electronics came about with the invention of the transistor in 1947. Since that time, semiconductors have replaced vacuum tubes in an increasing number of applications. Diodes and transistors are the two most common semiconductor devices.

The questions illustrate how this content may appear on the ASVAB.

Semiconductors are

A. good insulators.

B. good conductors.

C. somewhere between conductors and insulators.

D. A or B, depending on external control.

The answer is **D.** The conductivity of semiconductors depends on external conditions. They can act like insulators or conductors.

Semiconductors are used to make

A. vacuum tubes.

B. transistors.

C. lamps.

D. batteries.

The answer is **B.** Transistors are made of semiconductor materials.

Integrated Circuits

The need for a higher density of components than a circuit board could accommodate led to the development of *integrated circuits* (ICs) in 1958, informally known as *chips*. A silicon wafer is covered with an insulating layer that is patterned with conducting paths and components, much like a printed circuit but on a much smaller scale. The process of patterning and etching is called *photolithography*. Photolithography is currently capable of putting about one hundred million transistors on a single chip.

A great variety of components can be made with photolithography on silicon, including resistors, capacitors, diodes, and transistors. This capability makes it possible to create almost any electronic function on a chip. This has made it possible to use chips in place of circuit boards with larger components, resulting in a dramatic miniaturization of modern electronics.

Integrated circuits are used in many electronic devices from cars and telephones to refrigerators and toasters. A *microprocessor* is a particular kind of chip that is at the heart of personal computers and other sophisticated electronics. Microprocessors consist of a large number of transistors and other components, and are designed to do arithmetic operations.

Computers also contain memory chips to store data for the microprocessor. Random access memory (RAM) is usually dynamic, meaning that it must continuously be refreshed and is erased when there is no power applied to the chip. The processor can write data to, or read data from, RAM. On the other hand, read-only memory (ROM) retains information stored even without power, but the data in ROM is written when the chip is made, and can only be read by the processor.

The questions illustrate how this content may appear on the ASVAB.

Integrated circuits are usually made mostly of

A. copper.

B. silicon.

C. germanium.

D. gold.

The answer is **B.** Silicon is the most common material for wafers used to make ICs.

The chip that does the arithmetic operations in a personal computer is a

A. diode.

B. RAM.

C. ROM.

D. microprocessor.

The answer is **D.** Microprocessors do the calculations in computers. RAM and ROM are memory chips, and a diode is a component.

Microprocessors are found in

A. telephones.

B. cars.

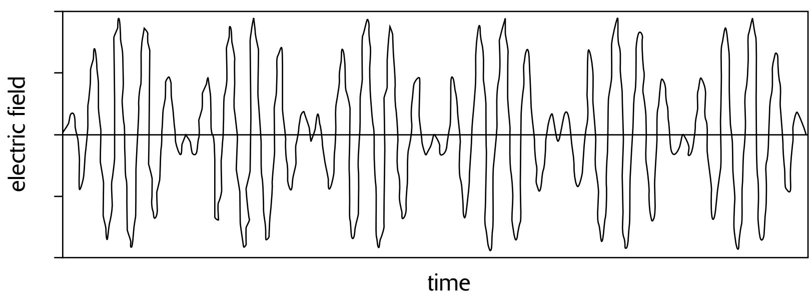
C. refrigerators.

D. all of the above.

The answer is **D.** Microprocessors are found in almost every kind of appliance.

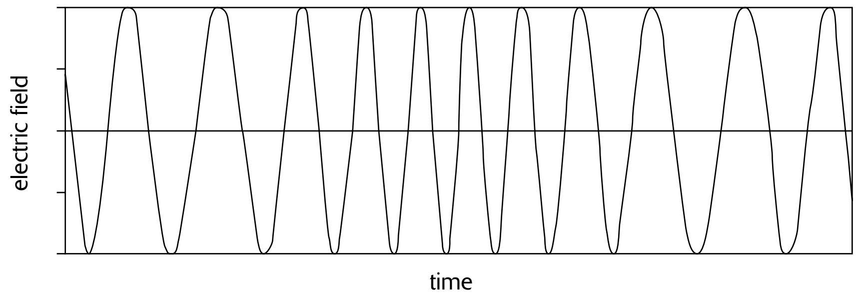
Radio and Television

Electromagnetic waves are used to communicate because they travel over long distances almost instantaneously. The first practical use of EM waves for communication was radio. The simplest way to send signals with radio is to use *amplitude modulation* (AM), which means that the signal is used to modulate the strength of the EM wave. In its most primitive form, the signal is an on-off code like Morse code and the EM is simply turned on and off to send a signal. More complicated signals, such as voice and music, can be sent by continuously increasing and decreasing the intensity of the EM wave to follow the signal. This is illustrated in the following figure.



The name of the basic EM wave is the *carrier,* while the signal is the modulation. Typically, commercial AM radio is broadcast with a carrier at about 1 MHz frequency. The carrier frequency is the one that the station gives when it identifies itself. The rate of modulation (frequency) is about 5 kHz, only a fraction of the audio band, which extends to about 20 kHz.

A more sophisticated transmission method is *frequency modulation* (FM). Instead of changing the intensity of the EM wave, FM changes the frequency of the wave to carry the signal, as shown in the following figure. Note that the amplitude remains constant and the changing frequency of the wave contains the signal. In commercial FM radio, the carrier is modulated up to about 15 kHz, giving better audio fidelity than AM radio.



Broadcast radio and television signals use this method. The frequency for commercial FM radio is between 88 MHz and 108 MHz, with channels spaced at 200 kHz. Each of the broadcast TV channels 2 through 13 (VHF) is 6 MHz wide, between 54 MHz and 216 MHz. There is a gap between channels 6 and 7 for the FM radio band and other uses. The higher (UHF) channels begin at 470 MHz (channel 14) and extend almost to 900 MHz. Many other users (maritime, aeronautical, police, fire, and other emergency) also use various frequencies between 10 kHz and 1 GHz.

Other communications applications such as cellular telephones and other wireless technologies use these same methods. Cellular telephone service is near 1 GHz and 2 GHz. Further improvements in modulation methods and the introduction of digital methods have resulted in more reliable service.

The questions illustrate how this content may appear on the ASVAB.

Which typically broadcasts at a lower frequency?

A. television

B. AM radio

C. FM radio

D. FM radio and television

The answer is **B.** Commercial AM radio uses about 1 MHz, about 100 times lower than FM and television.

Compared to commercial television and FM radio, the frequency of cellular telephone service is

A. similar.

B. 10 times lower.

C. 10 times higher.

D. 100 times higher.

The answer is **C.** The 1 GHz used for cellular service is about 10 times higher than the 100 MHz used for FM and television.

A radio station identifies itself as being at "93.7 on your FM dial." This means that

A. the carrier is at 93.7 MHz.

B. the carrier is 93.7 kHz.

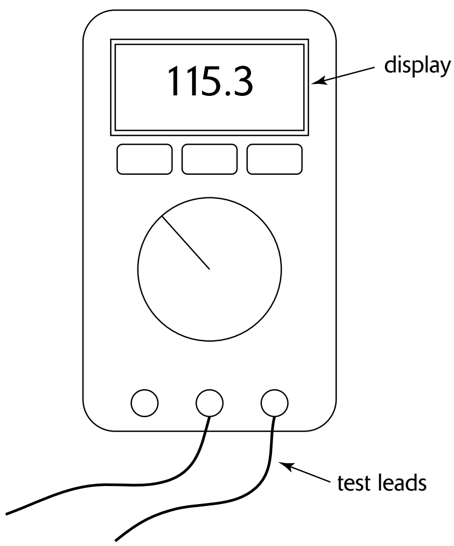
C. the modulation is at 93.7 MHz.

D. the modulation is at 93.7 kHz.

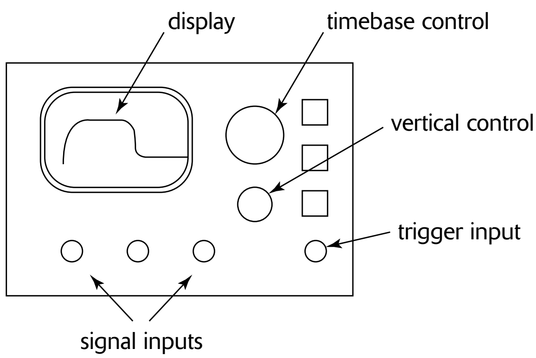
The answer is **A.** The carrier frequency is part of the station's identification, not the modulation rate. The commercial FM broadcast band is between 88 and 108 MHz, so 93.7 MHz could be an FM radio frequency, but 93.7 kHz could not.

Electronic Test Equipment

Troubleshooting and characterization of electric circuits requires the use of specialized equipment to measure the values of current and voltage at various locations in the circuit. The simplest and most commonly used instrument is the *digital multimeter* (DMM), shown in the following figure. Test leads are wires connected to the terminals of the meter and used to probe the circuit. The dial in the center allows the user to select different scales or parameters to measure (voltage, current). Usually, the user must also choose between AC and DC. The digital display shows the parameter selected, with some averaging so that the display does not change faster than the user can read it. For AC values, the voltage or current displayed is the rms value.



The analog equivalent is a *volt-ohm meter* (VOM). The term *multimeter* refers to analog and digital versions. A basic multimeter can measure the voltage or current across the test leads. The multimeter normally contains a battery to enable it to measure resistance by applying a known voltage across the test leads, measuring the resulting current, and using Ohm's law to find the resistance.



Another commonly used instrument is the oscilloscope, shown in the previous figure. This device is most useful when measuring voltages that are not constant with time, such as AC voltages. The oscilloscope is also widely used in characterizing complex circuits such as radio and television receivers.

Oscilloscopes display a graph of the voltage as a function of time. In other words, there is a line on the display that shows how the voltage varies with time, where voltage is plotted in the vertical direction and time is in the horizontal direction. The plot is made by sweeping an electron beam in a cathode ray tube (CRT) across a screen coated with a phosphor, much like a television set. Some oscilloscopes also use liquid crystal displays instead of CRTs.

A trigger signal begins the sweep at the left of the screen. In an analog oscilloscope, the signal voltage is amplified and applied to horizontal plates inside the CRT to deflect the beam vertically, tracing out a curve of the voltage plotted against time. Digital oscilloscopes digitize the voltage signal and store it in RAM. A microprocessor controls analog electronics that drive the display.

Almost all applications use digital oscilloscopes instead of analog. The fastest such devices have bandwidths of several GHz and digital sampling rates of several times the bandwidth. A 1 GHz bandwidth means that the oscilloscope can display up to a 1 GHz signal without much distortion.

The signal is usually connected to the oscilloscope using a coaxial cable. Most oscilloscopes can accept more than one signal and display them on the screen at the same time. The timebase control knob sets the horizontal scale of the display, while the vertical control knob sets the voltage scale. Digital oscilloscopes can display stored signals alongside new signals and can write data to disks, making them more versatile than analog models.

The questions illustrate how this content may appear on the ASVAB.

Which of the following is *not* measured by a multimeter:

A. voltage

B. current

C. inductance

D. resistance

The answer is **C.** Multimeters only measure voltage, current, and resistance.

An oscilloscope displays

A. voltage as a function of time.

B. current as a function of time.

C. resistance as a function of current.

D. current as a function of voltage.

The answer is **A.** Oscilloscopes plot voltage as a function of time.

The fastest oscilloscopes can display signals up to

A. a few kHz.

B. 1 MHz.

C. a few MHz.

D. a few GHz.

The answer is **D.** Modern digital oscilloscopes have a bandwidth of several GHz.

Compact Discs and Digital Video Discs

Compact discs (CDs) and digital video discs (DVDs) are storage media for music, data, and video. The information on these discs is stored as digital data in microscopic pits in a 10 cm-diameter piece of thin plastic. A laser shining on the disc is reflected differently from the pits than from the rest of the plastic, resulting in either a high or low voltage: a digital signal. CD and DVD writers, or burners, use a laser to make the pits in a recordable disc to store data, including music, video, or other kinds of information.

Audio CDs can hold over an hour of music, about 700 megabytes (MB) of data. Compact discs are used for the long-term storage of information. DVDs can store about ten times as much data because of several improvements in the technology, including smaller pits. The video data is compressed so that a DVD can hold an entire feature-length movie. A single-sided DVD can hold about 4 GB, corresponding to a two-hour movie. Multi-layer and double-sided DVDs have even higher capacities. The video information on commercial DVDs is stored in an encrypted form so that the DVDs cannot easily be copied.

The question illustrates how this content may appear on the ASVAB.

Compact discs can store

A. 100 MB.

B. 700 kB.

C. 700 MB.

D. 4 GB.

The answer is **C.** CDs can store up to about 700 megabytes (MB) of data.

Electronics Information Practice Questions

1. The best conductors of electricity are

A. glass and ceramics.
B. metals.
C. semiconductors.
D. plastics.

2. The carriers of electric current in metal conductors are

A. protons.
B. ions.
C. electrons.
D. electrons and protons.

3. For transmission over long distances, electric power is

A. stepped up to higher voltage.
B. stepped down to lower voltage.
C. stepped up to higher current.
D. converted to DC.

4. Which of the following electrical components dissipates electricity as heat?

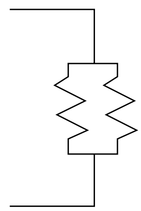
A. inductor
B. capacitor
C. diode
D. resistor

5. AC electric power in the United States is delivered at

A. 50 Hz.
B. 60 Hz.
C. 50 kHz.
D. 60 kHz.

6. 15 kΩ is the same as

A. 150Ω
B. 1,500Ω
C. 15,000Ω
D. 150,000Ω



7. The figure above represents

A. two resistors in series.
B. two resistors in parallel.
C. two inductors in series.
D. two inductors in parallel.

8. 240 pF is an amount of

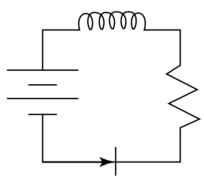
A. energy.
B. frequency.
C. current.
D. capacitance.

9. The speed of electromagnetic waves in a vacuum is

A. the same for all frequencies.
B. higher for higher frequencies.
C. lower for higher frequencies.
D. higher for stronger waves.

10. Two 30Ω resistors are connected in parallel. The equivalent resistance is

A. 60Ω.
B. 30Ω.
C. 15Ω.
D. 10Ω.



11. In the figure above, the battery supplies 10 V, the resistor is 100Ω, and the inductor is 10 mH. What is the current in this circuit?

A. 10 A
B. 1 A
C. 100 mA
D. 0

12. Two amps flows through a 30Ω resistor. How much power is dissipated in the resistor?

A. 30 W
B. 60 W
C. 120 W
D. 240 W

13. Cellular telephones operate

A. between 1 and 2 GHz.
B. between 100 MHz and 1 GHz.
C. near 10 MHz.
D. below 1 MHz.

14. FM stands for

A. fast modulation.
B. frequency mixing.
C. frequency modulation.
D. fast mixing.

15. Commercial television broadcast frequencies are

A. higher than commercial AM radio.
B. lower than commercial AM radio.
C. about the same as commercial AM radio.
D. higher than cellular telephone.

16. Digital multimeters generally measure

A. current and resistance.
B. resistance and voltage.
C. capacitance and resistance.
D. current, voltage, and resistance.

17. An oscilloscope displays a plot of

A. current vs. voltage.
B. voltage vs. time.
C. resistance vs. current.
D. inductance vs. capacitance.

18. Integrated circuits are made using

A. photolithography.

B. printed circuits.

C. coax cables.

D. vacuum tubes.

19. Vacuum tubes are used in

A. most electronics.

B. televisions and other displays.

C. radios.

D. no modern electronics.

20. Electric motors work by using

A. electric attraction and repulsion.

B. DC current only.

C. magnetic attraction and repulsion.

D. resistive heating.

Answers and Explanations for Practice Questions

1. **B.** Metals are good electrical conductors. Glasses, ceramics, and plastics are insulators. Semiconductors are much poorer conductors than metals.
2. **C.** Only electrons carry electric current in metals.
3. **A.** Power is stepped up to a higher voltage for transmission. It is not converted to DC. Stepping the power to higher current is equivalent to stepping down to lower voltage.
4. **D.** Resistors convert electrical energy to heat. Ideal inductors, capacitors, and diodes do not.
5. **B.** AC power has a frequency of 60 Hz in the U.S.
6. **C.** The prefix *k* means 1,000, so 15 k is 15,000Ω.
7. **B.** The symbols represent resistors, and they are connected in parallel.
8. **D.** The symbol "F" stands for farad, a unit of capacitance. The prefix "p" means 10^{-12}.
9. **A.** All EM waves have the same speed in a vacuum, about 300,000 km/sec.
10. **C.** Resistors in parallel are combined according to this formula:

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$
$$= \frac{1}{30} + \frac{1}{30}$$
$$= \frac{2}{30}$$
$$R = 15\Omega$$

11. **D.** The diode in this circuit prevents current from flowing from the positive to the negative terminals of the battery, so no current can flow.

12. **C.** Calculate the power using Joule's law, $P = I^2R = (2)^2(30) = 120$ W.

13. **A.** Cellular frequencies are between 1 and 2 GHz, much higher than the numbers given in the other answers.

14. **C.** FM is frequency modulation.

15. **A.** Commercial FM radio is at about 100 MHz, about 100 times higher than AM radio and 10 times lower than cellular telephones.

16. **D.** Digital multimeters measure voltage and current, and have a battery to measure resistance by applying Ohm's law.

17. **B.** An oscilloscope trace sweeps with time horizontally and plots voltage vertically.

18. **A.** Photolithography is the manufacturing method used to make integrated circuits. Printed circuits are much larger, and coax cables are used to connect electronic devices. Vacuum tubes are not used in ICs.

19. **B.** Vacuum tubes are still used in CRT displays for televisions and computers. Semiconductors have replaced tubes in most appliances, including radios.

20. **C.** Motors turn because of magnetic forces. There is no electrostatic force in motors. They can use AC or DC current. Resistors are not usually a part of a motor.

Assembling Objects

Past versions of the ASVAB test have included two sections that have been dropped: Coding and Numerical Operations. Assembling Objects was recently added to the computerized version of the exam, and it is likely that it will appear on the latest versions of the paper-and-pencil tests. Prior to taking the test, you will undoubtedly receive the latest information about the ASVAB from your school or local recruiter, and if this section is part of the test, you can prepare yourself fully for this new section. For some people, this section will seem to be fairly easy. For others—almost impossible. However, when you finish this chapter, you should have very little trouble with these types of questions.

Keep in mind that this is not a pass-fail test; instead, it's designed to measure your aptitudes in a variety of different areas. If you do well on one portion of the ASVAB, and not as well on another portion, it merely signals your strengths and weaknesses. In football, for example, a right-handed quarterback would not be asked to pass the ball with his left hand. It is normal to play toward one's strengths. Doing poorly on the verbal portions of this exam might indicate that you're not really cut out to be a company clerk in the Army. Weak mechanical skills would probably steer you away from the base motor pool.

So it is with the Assembling Objects part of this test. It is supposed to measure your spatial aptitude and your ability to understand and process information about form, direction, and path. For some, this comes easy. For others, it's a complete mystery, although this section will try to demystify it for you.

On the computer version of the ASVAB, you have 9 minutes to answer 16 questions, and it is likely that the paper-and-pencil version will be similar. As of this printing, the precise details on the Assembling Objects section are not available.

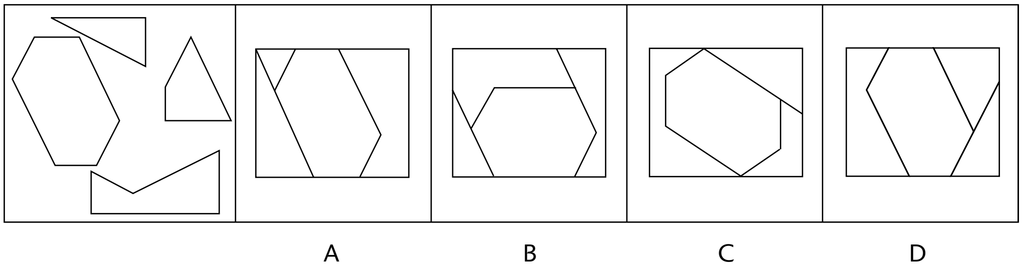
The Questions

There are two different types of Assembling Objects questions on the ASVAB, each consisting of five pictures.

- One set of questions are like puzzles. You are given a picture with several individual, odd-shaped pieces, and you are asked to fit them together. You're presented with four choices, one of which is correct. This enables you to narrow down the choices.
- The second set of questions also gives you separate pieces to join, but unlike the puzzle questions, each of the parts in this type of question are labeled, and you are asked to figure out how the pieces should be joined together. Since the parts that represent where the pieces join are clearly marked, it should be a little easier to determine which of the four choices are correct.

Puzzles

Words cannot fully explain these questions, so it's necessary to use actual examples. Here's the first puzzle-type question.

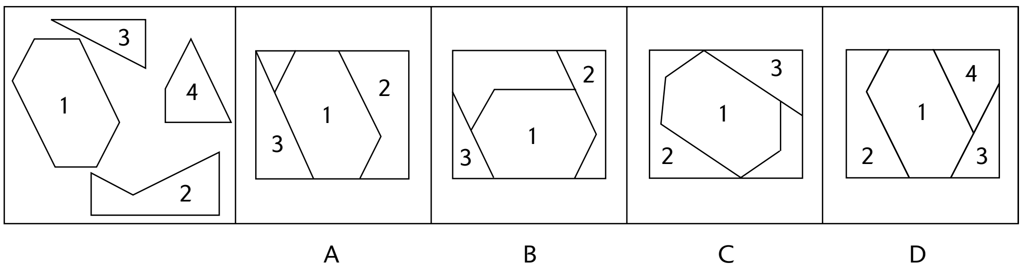


In the first, larger box are the four parts to be assembled. Which of the four choices—**A, B, C,** or **D**—would you choose as the correct answer?

There are several ways to solve this, and if you're good at puzzles like these—and you've probably seen hundreds of these types of puzzles made out of wood or plastic in toy or game stores—you may have easily visualized the answer.

The correct answer is **D.**

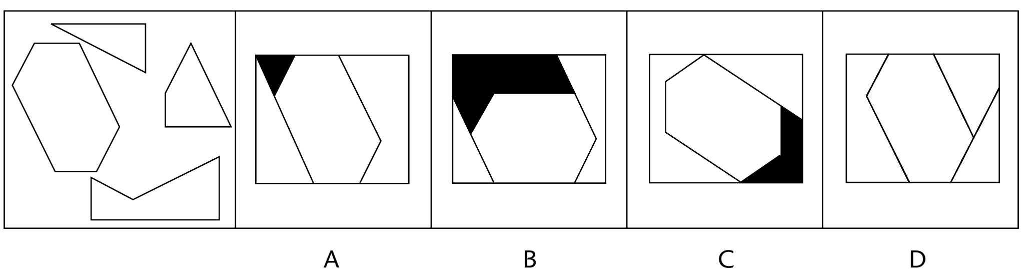
Here's one suggestion for finding the solution. Start by numbering each of the parts, starting with the largest first.



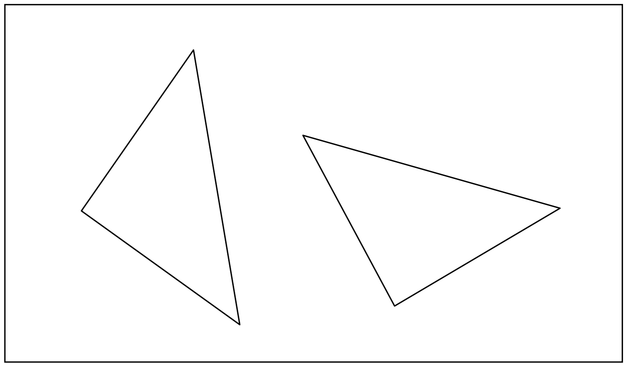
Then move to each of the four choices. Number each of the pieces in each choice that seems similar to those in the question box. This is the start of the process of elimination, a way to find the correct answer that is standard for solving multiple-choice questions. Start with the piece you've labeled number 1 and label all of them in each of the four answer choices, then label all the number 2s, and so on.

If you can't find a piece that is the same as one of the unassembled pieces in an answer choice, you can cross off that choice.

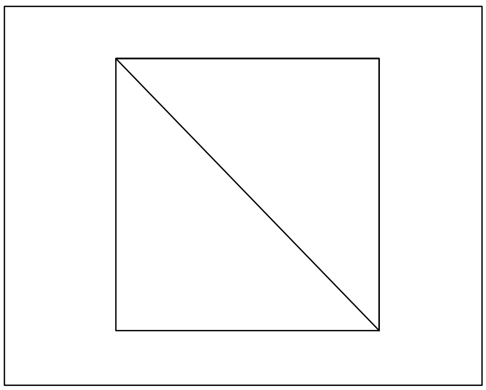
In the following illustration, those pieces that don't match are shaded. You can see that the only possible answer is **D.**



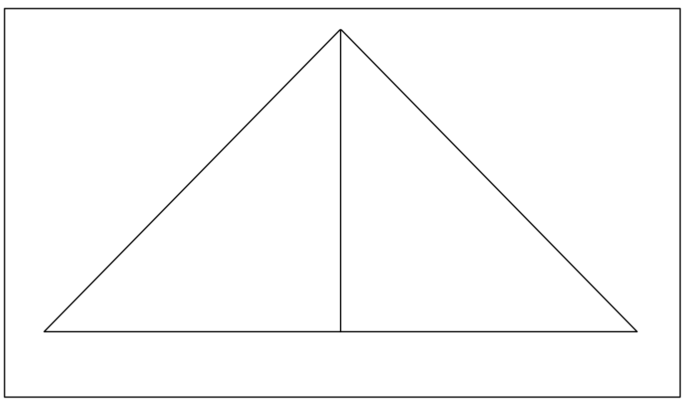
Here's a simple exercise that gives you another way to think about these problems, and then you will move up to more complicated versions.



This is a very simple problem left over from high school geometry. You have two identical right triangles. How would you join them to make a square?



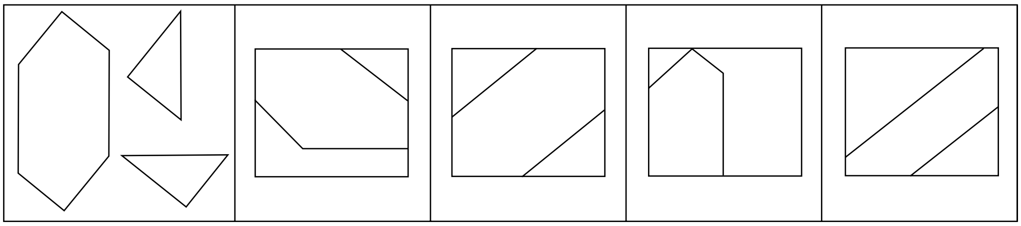
How would you fit them to make a single, larger triangle?



If you're having trouble visualizing the solutions to these before you look at the answers, make a copy of the triangles, cut them out and move them around until you get the correct answer.

Now move them around and make the shapes that are shown above. Sometimes working with physical representations of the objects will make it easier.

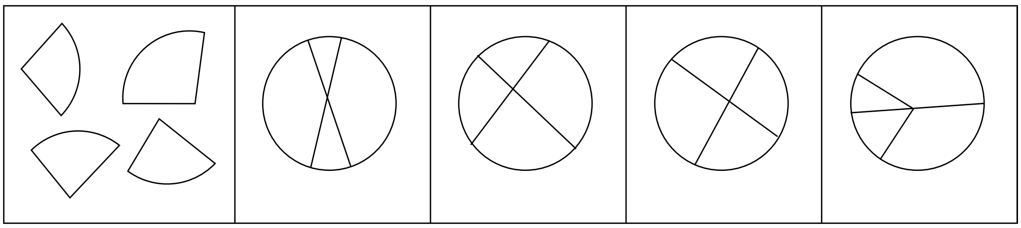
Here's another test-like puzzle, one with three pieces.



A B C D

The give-away in this puzzle is the hexagon (the six-sided piece). The only ones that are similar are **B** and **D.** However, the hexagon in choice **D** is a slightly different shape, so the correct answer is **B.**

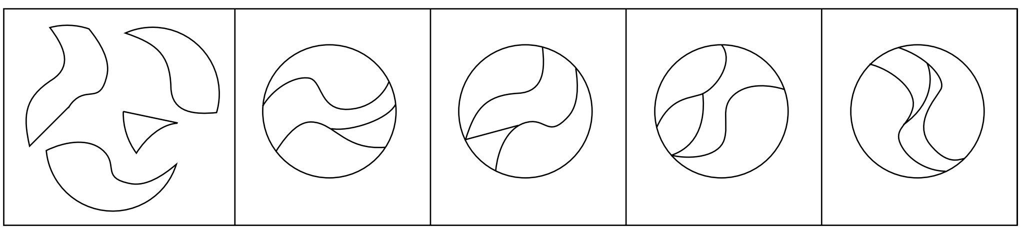
There *may* be another, similar type of problem you will find on the test. These puzzles are built on the same premise as the previous puzzles—the only difference is that they are circular. Here's an example of this type of puzzle.



A B C D

The individual pieces are four pie-shaped slices, and you should be able to see that these four pieces, when joined, make a whole pie. Therefore, **C** is the correct answer.

These circular puzzles should prove no more difficult than the other puzzles. The shape may be different, but the process is the same. Try one more.



A B C D

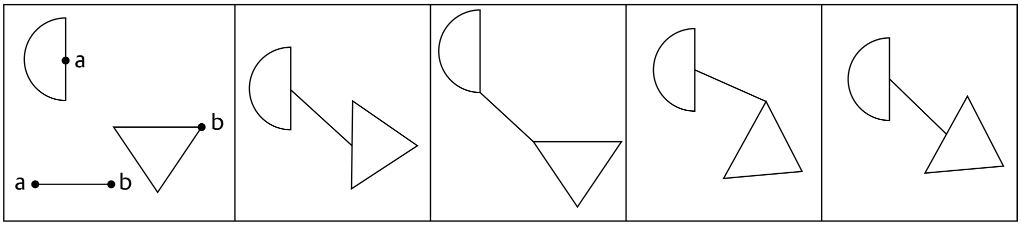
In this puzzle, it might be easier to number the pieces as in the earlier sample. The correct answer is **B.**

The round edges may make these questions a little more intriguing that those in boxes. Most of us have put together jigsaw puzzles at some time in our lives. The first thing you do, especially when working with larger puzzles, is to align the corners, sides, and edges. This is easier to accomplish with the puzzles you worked on earlier in this chapter. But the principle is the same with these circular ones—you have to put them together so that the edges fit together to form the circle.

If you are not one of those people who can just visualize the correct answer at first glance, then you can do the numbering and shading—and finding the answers will be a lot easier.

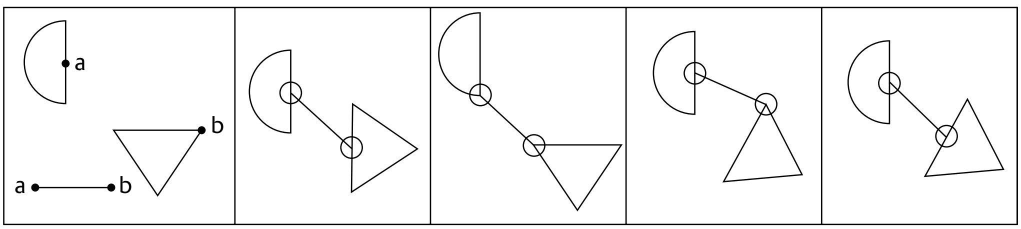
Connections

This type of question asks you to put pieces together that are marked. If you've ever built model airplanes as a child, assembled a bicycle, or put together anything that had pictured explanations, you should do well on this portion. Here's the first puzzle.



A B C D

Here's how you can solve this quickly and effortlessly. Circle the points in each answer choice picture that are the same as "a" and "b" in the question portion.

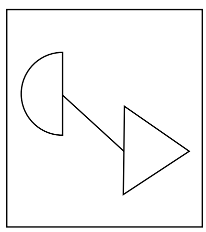


A B C D

That should be pretty easy to solve. Another way to solve this is to say aloud—quietly, of course—the parts that join. "Middle of semicircle and corner of triangle." Here's how that works with each of the answer choices.

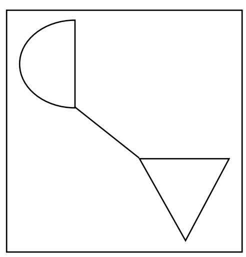
A: Middle of semicircle and corner of triangle.

No, it's middle of semicircle, middle of triangle.



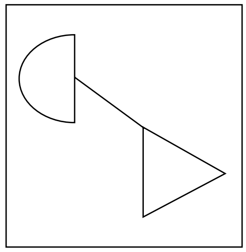
B: Middle of semicircle and corner of triangle

No, it's corner of semicircle, corner of triangle.

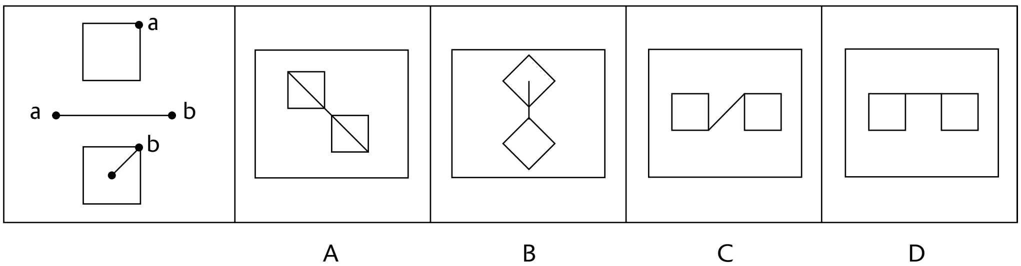


C: Middle of semicircle and corner of triangle.

Yes, these are what are connected.
No need to answer the last choice.



Try this one.



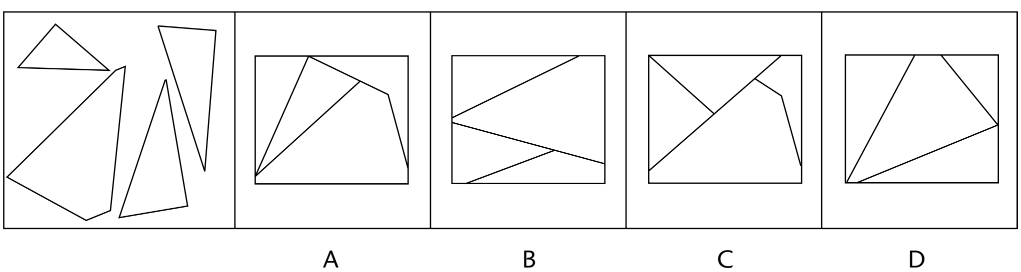
In choice **A,** the lines run all the way through both squares. In choice **B,** the top square has a line from the middle, like part b, to the corner of the second square, like part a, so this is correct. (Don't be misled by the squares that have been turned on their edges to look like diamonds.) In choice **C,** both squares are joined at the corners, unlike part b. And in choice **D** the squares are also joined at the corners, unlike part "b."

Final Word

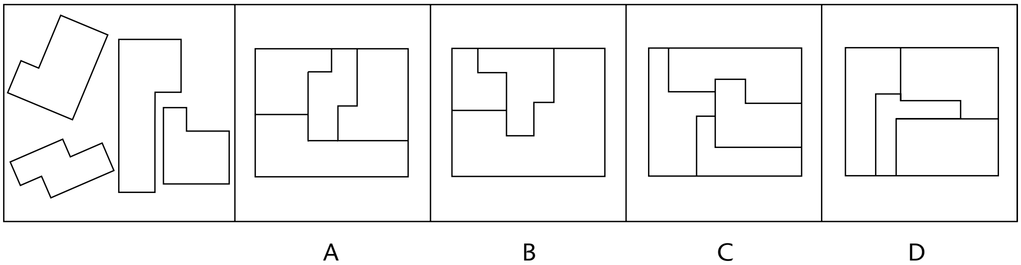
Now that these problems are demystified, here are a few more practice problems. Remember the various techniques for solving them. You can number the parts and shade the similar pieces that are alike. Solving the connection problems is easier if you circle the connections and compare them to the original. Keep in mind that the key to success in all of the parts of the ASVAB is to continuously practice and review the material in both the text and review questions and solutions throughout the rest of this book.

Assembling Objects Practice Questions

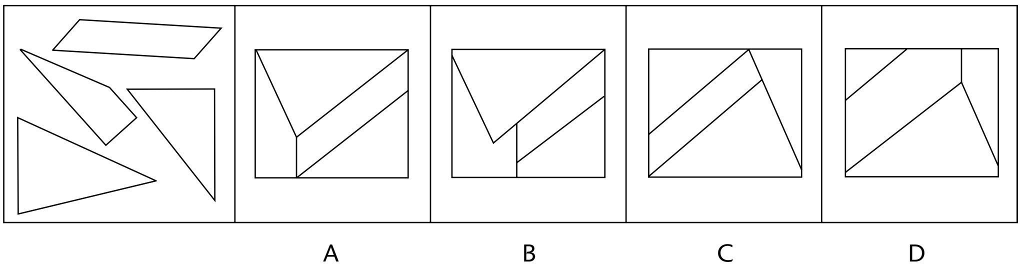
1.



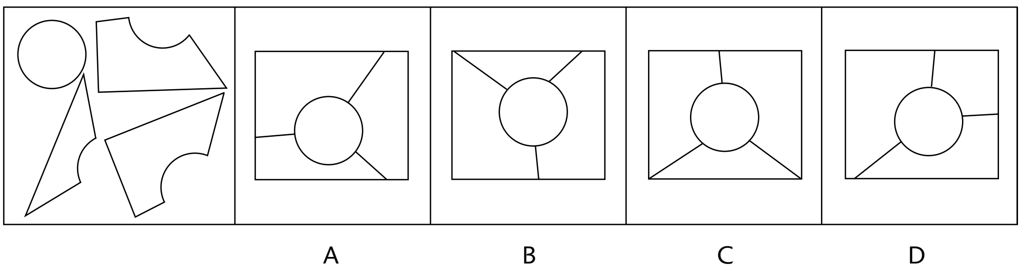
2.



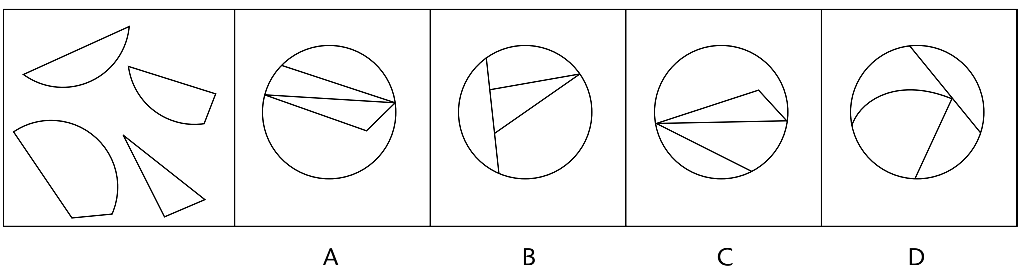
3.



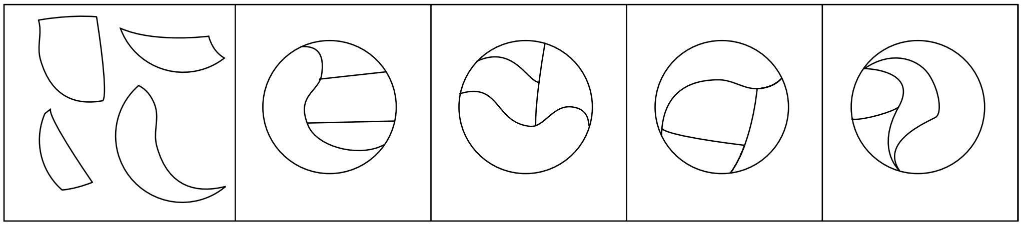
4.



5.

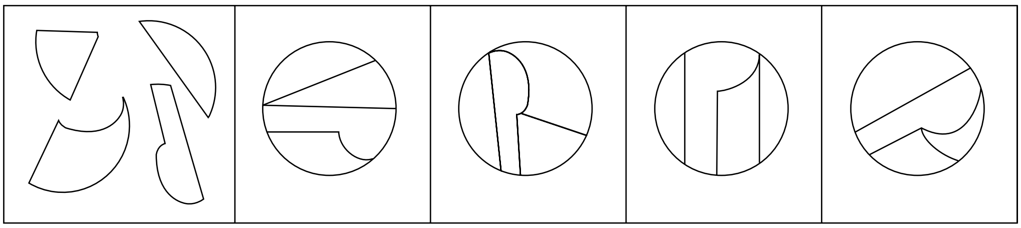


6.



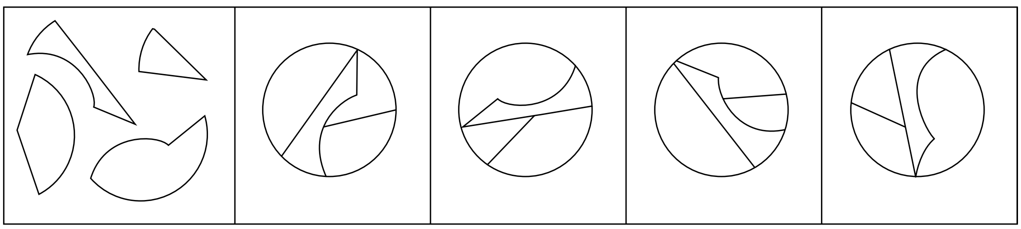
A B C D

7.



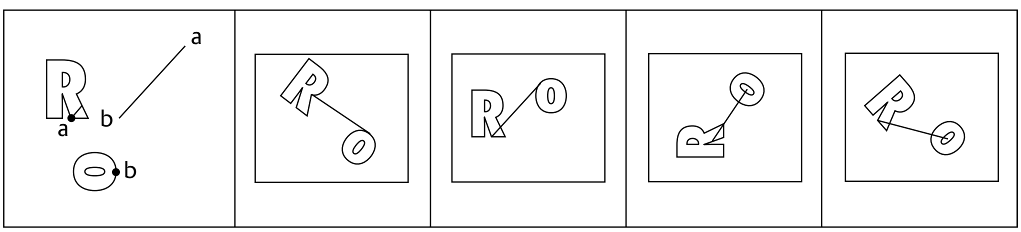
A B C D

8.



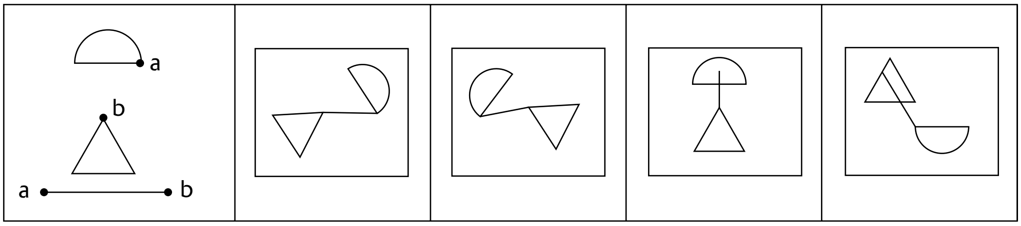
A B C D

9.



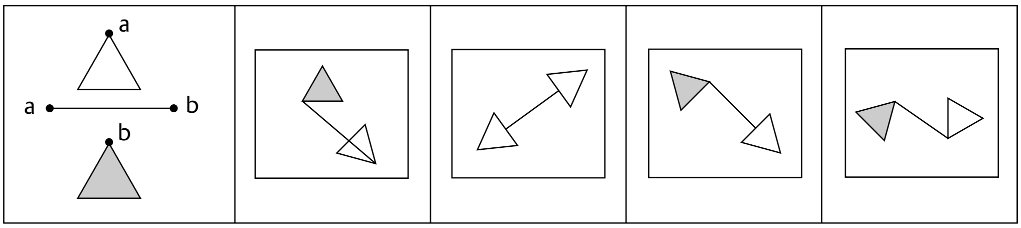
A B C D

10.



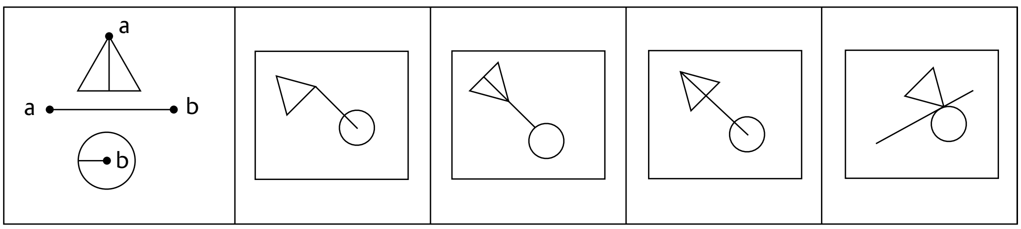
A B C D

11.



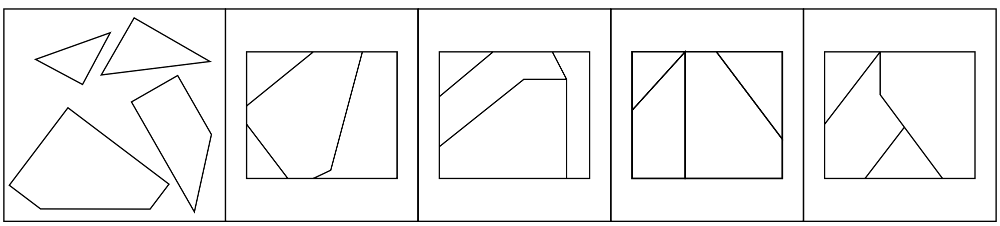
A B C D

12.



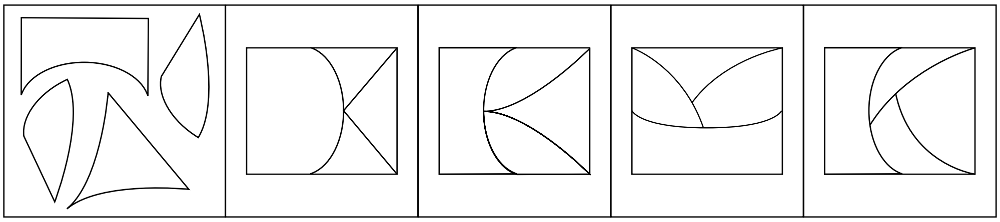
A B C D

13.



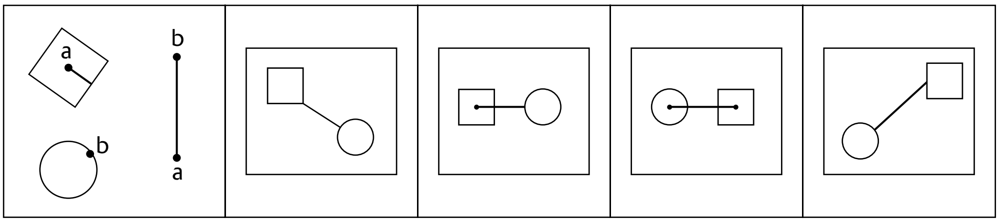
A B C D

14.



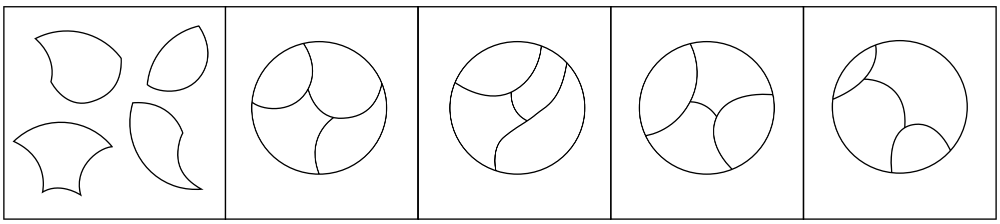
A B C D

15.



A B C D

16.



A B C D

Answers for Practice Questions

1. **D.** puzzle
2. **A.** puzzle
3. **A.** puzzle
4. **C.** puzzle
5. **B.** circles
6. **C.** circles
7. **B.** circles
8. **B.** circles
9. **B.** joining
10. **A.** joining
11. **D.** joining
12. **C.** joining
13. **C.** puzzle
14. **B.** puzzle
15. **B.** joining
16. **A.** circles

PART IV

THREE FULL-LENGTH PRACTICE TESTS

CUT HERE

Answer Sheet for Practice Test 1

(Remove this sheet and use it to mark your answers)

General Science

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Arithmetic Reasoning

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Word Knowledge

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Paragraph Comprehension

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Auto and Shop Information

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Assembling Objects

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CUT HERE

ASVAB Practice Test 1

General Science

Time: 11 minutes

25 questions

1. The building blocks of sugars, and the substances used by plants in photosynthesis, are

A. oxygen and nitrogen.

B. oxygen and carbon dioxide.

C. water and carbon dioxide.

D. water and oxygen.

2. Members of a group that can interbreed and produce fertile offspring are in the same

A. kingdom.

B. phylum.

C. family.

D. species.

3. The normal body temperature of a person is

A. 37° Fahrenheit.

B. 37° centigrade.

C. 98° Celsius.

D. 98° centigrade.

4. A liter is about the same as

A. a quart.

B. a gallon.

C. a pint.

D. a half-gallon.

5. When heat is added to water, the added energy

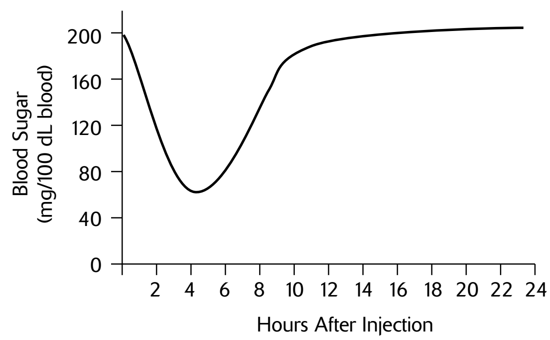
A. raises the electrons to a higher energy level.

B. makes the molecules move faster.

C. splits the molecules apart.

D. increases the number of electrons in the molecules.

6.



Look at the graph of someone's blood sugar after he or she had been injected with a substance. Which of the following statements is true?

A. The person's blood sugar level fell faster than it rose.

B. The person had just eaten a big meal.

C. The person was injected with glucagon, which converts glycogen to glucose.

D. The person was a diabetic.

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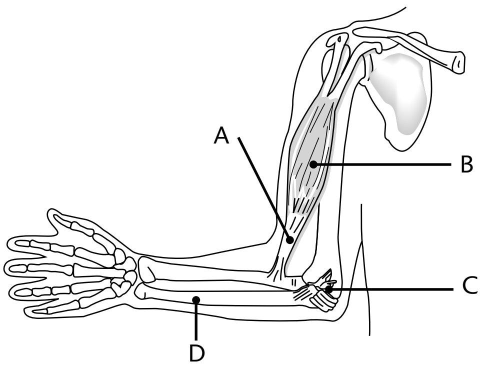
7.



Using the drawing of the arm, which of the following statements is true?

A. A is a ligament, and C is a tendon.

B. A is the biceps muscle, and C is a tendon.

C. C is a ligament, and A is a tendon.

D. A and C are both tendons.

8. There are 2.54 centimeters in 1 inch, 10 millimeters in 1 centimeter, 12 inches in a foot, and 3 feet in a yard. Approximately how many millimeters are in a yard?

A. 30

B. 300

C. 390

D. 900

9. The expression 35 parts per million (35 ppm) is the same as

A. 0.035.

B. 3.5%.

C. 0.35%.

D. 0.035%.

10. Two masses fall 3 meters to the ground. If friction is neglected, when they reach the ground

A. both masses have the same speed.

B. both masses have the same energy.

C. both masses have the same momentum.

D. the heavier mass has a higher speed.

11. The electric current in a metal conductor is carried by

A. positive ions.

B. electrons.

C. both.

D. either, depending on the metal.

12. Which of the following statements about diffusion is false?

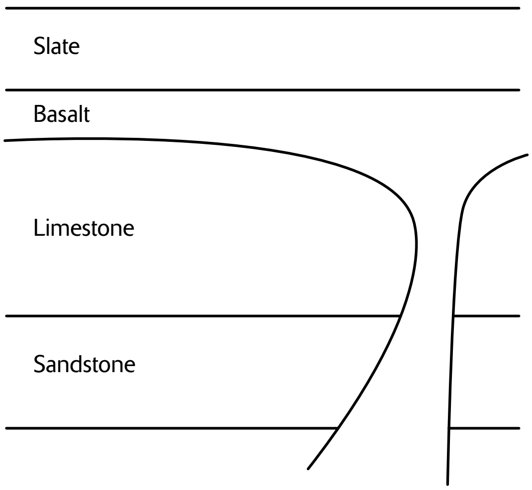
A. Diffusion is very effective over very short distances.

B. Diffusion requires energy to do its work.

C. The diffusion of water is called osmosis.

D. Diffusion is the movement of molecules from a greater to a lesser concentration.

13.



Based on the geologic diagram above, which of the following statements is not true?

A. The slate layer is older than the basaltic intrusion.

B. The limestone is not the oldest layer portrayed.

C. Basalt is an igneous rock.

D. The sandstone layer is older than the basalt.

14. Which of the following is the result of the angle of tilt that the Earth has on its axis?

A. day and night

B. summer and winter

C. continental drift

D. different stars visible in Northern and Southern hemispheres

15. An extinct volcano has steep sides. Rock samples from the immediate area contain both basaltic and granitic rock samples. Excavation of the area reveals alternating layers of ash and lava flows. The volcano was most likely of which volcanic variety?

A. cinder cone

B. shield cone

C. composite cone

D. You cannot determine volcanic type from the data provided.

16. When air masses meet, why does warm air rise over cooler air, often causing rain?

A. Warm air is less dense than cooler air.

B. Warm air is denser than cooler air.

C. Cooling air can hold less water vapor than warmer air.

D. Cooler air is very volatile.

17. The process of dividing one cell nucleus into two nuclei is called

A. mitosis.

B. meiosis.

C. cytokinesis.

D. cell division.

18. Sodium ions have a charge of +1. This is because

A. they have one more proton than electron.

B. they have one more neutron than electron.

C. they have one more electron than neutron.

D. they have one more proton than neutron.

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19. Which of the following statements is true?

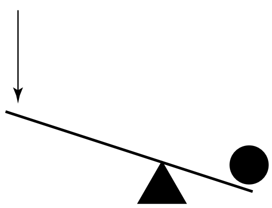
A. Electrons are negatively charged and are found in the nucleus of an atom.

B. Electrons are negatively charged and are found outside the nucleus.

C. Neutrons are positively charged and are found in the nucleus.

D. Protons are positively charged and are found outside the nucleus.

20.



In the lever shown above, a force is exerted on the left side to lift the mass on the right. Assuming the lever is ideal, which of the following is the same on both sides?

A. force

B. momentum

C. velocity

D. work

21. People have 46 chromosomes in each of their cells. How many are in their gametes?

A. 46

B. 23

C. 92

D. 2

22. A gas has a volume of 0.25 liter at a pressure of 1 atmosphere. If the volume increases to 0.50 liter, and the temperature remains constant, the new pressure will be

A. 1 atmosphere.

B. 0.5 atmosphere.

C. 0.25 atmosphere.

D. 2 atmospheres.

23. What are the total number of hydrogen atoms represented in the following formula: $C_6H_{10}(OH)_6$?

A. 6

B. 16

C. 22

D. 60

24. If red flowers were crossed with white flowers and all the resulting flowers were pink, what percentage of a cross between two pinks would be pink?

A. 0%

B. 25%

C. 50%

D. 100%

25. Vaccines work well because they prepare one's

A. T-helper cells.

B. T-killer cells.

C. antibodies.

D. memory cells.

STOP

Arithmetic Reasoning

Time: 36 minutes

30 questions

1. A bread recipe calls for $3\frac{1}{4}$ cups of flour. If you only have $2\frac{1}{8}$ cups, how much more flour is needed?

A. $1\frac{1}{8}$

B. $1\frac{1}{4}$

C. $1\frac{3}{8}$

D. $1\frac{3}{4}$

2. How many omelets can be made from 2 dozen eggs if an omelet contains 3 eggs?

A. 1

B. 3

C. 6

D. 8

3. Two runners finished a race in 80 seconds, another runner finished the race in 72 seconds, and the final runner finished in 68 seconds. The average of these times is

A. 73 seconds.

B. 74 seconds.

C. 75 seconds.

D. 76 seconds.

4. If 400 people can be seated in eight subway cars, how many people can be seated in five subway cars?

A. 200

B. 250

C. 300

D. 350

5. An employee earns $8.25 an hour. In 30 hours, what earnings has the employee made?

A. $240.00

B. $247.50

C. $250.00

D. $255.75

6. There are 72 freshmen in the band. If freshmen make up $\frac{1}{3}$ of the entire band, the total number of students in the band is

A. 24.

B. 72.

C. 144.

D. 216.

7. Dana receives $30 for her birthday and $15 for cleaning the garage. If she spends $16 on a CD, how much money does she have left?

A. $29

B. $27

C. $14

D. $1

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8. A television is on sale for 20% off. If the sale price is $800, what was the original price?

A. $160

B. $640

C. $960

D. $1,000

9. Staci earns $9.50 an hour plus 3% commission on all sales made. If her total sales during a 30-hour work week were $500, how much did she earn?

A. $15

B. $250

C. $285

D. $300

10. The area of one circle is four times as large as a smaller circle with a radius of 3 inches. The radius of the larger circle is

A. 12 inches.

B. 9 inches.

C. 8 inches.

D. 6 inches.

11. You use a $20 bill to buy a magazine for $3.95. What change do you get back?

A. $16.05

B. $16.95

C. $17.05

D. $17.95

12. Standing by a pole, a boy $3\frac{1}{2}$ feet tall casts a 6-foot shadow. The pole casts a 24-foot shadow. How tall is the pole?

A. 14 feet

B. 18 feet

C. 28 feet

D. 41 feet

13. Rae earns $8.40 an hour plus an overtime rate equal to $1\frac{1}{2}$ times her regular pay for each hour worked beyond 40 hours. What are her total earnings for a 45-hour work week?

A. $336

B. $370

C. $399

D. $567

14. A sweater originally priced at $40 is on sale for $30. What percent has the sweater been discounted?

A. 25%

B. 33%

C. 70%

D. 75%

15. A cardboard box has a length of 3 feet, height of $2\frac{1}{2}$ feet, and depth of 2 feet. If the length and depth are doubled, by what percent does the volume of the box change?

A. 200%

B. 300%

C. 400%

D. 600%

16. Mr. Triber earns a weekly salary of \$300 plus 10% commission on all sales. If he sold \$8,350 last week, what were his total earnings?

A. \$835

B. \$865

C. \$1,135

D. \$1,835

17. Jamie collects 300 stamps one week, 420 stamps the next week, and 180 stamps the last week. He can trade the stamps for collector coins. If 25 stamps earn him one coin, how many coins can Jamie collect?

A. 36

B. 50

C. 900

D. 925

18. On a map, 1 centimeter represents 4 miles. A distance of 10 miles would be how far apart on the map?

A. $1\frac{3}{4}$ centimeters

B. 2 centimeters

C. $2\frac{1}{2}$ centimeters

D. 4 centimeters

19. Davis donates $\frac{4}{13}$ of his paycheck to his favorite charity. If he donates \$26.80, what is the amount of his paycheck?

A. \$8.25

B. \$82.50

C. \$87.10

D. \$348.40

20. Rachel ran $\frac{1}{2}$ mile in 4 minutes. At this rate, how many miles can she run in 15 minutes?

A. $1\frac{7}{8}$

B. 4

C. 30

D. 60

21. Tiling costs \$2.89 per square foot. What is the cost to tile a kitchen whose dimensions are 4 yards by 5 yards?

A. \$57.80

B. \$173.40

C. \$289.00

D. \$520.20

22. One-eighth of a bookstore's magazines are sold on a Friday. If $\frac{1}{4}$ of the remaining magazines are sold the next day, what fractional part of the magazines remains at the end of the second day?

A. $\frac{1}{32}$

B. $\frac{1}{8}$

C. $\frac{7}{32}$

D. $\frac{21}{32}$

23. Roxanne deposited \$300 into a savings account earning $5\frac{1}{4}$% annually. What is her balance after 1 year?

A. \$15.75

B. \$315

C. \$315.25

D. \$315.75

GO ON TO THE NEXT PAGE

24. One phone plan charges a \$20 monthly fee and \$0.08 per minute on every phone call made. Another phone plan charges a \$12 monthly fee and \$0.12 per minute for each call. After how many minutes would the charge be the same for both plans?

A. 60 minutes

B. 90 minutes

C. 120 minutes

D. 200 minutes

25. The length of a rectangle is three times its width. If the perimeter of the rectangle is 48, what is its area?

A. 108

B. 96

C. 54

D. 48

26. A machine can produce 8,000 widgets in 3 hours. How many widgets are produced in 1 day?

A. 96,000

B. 64,000

C. 32,000

D. 8,000

27. Sam buys three candy bars for 45 cents each and two packs of gum for 79 cents each. What is the total cost of this purchase?

A. \$1.24

B. \$2.93

C. \$6.20

D. \$6.24

28. Devin throws a football $7\frac{1}{3}$ yards. Carl throws it $2\frac{1}{2}$ times farther. How much farther did Carl's throw travel than Devin's?

A. $2\frac{1}{2}$ yards

B. $7\frac{1}{3}$ yards

C. 11 yards

D. $18\frac{1}{3}$ yards

29. This morning, Taryn drove 13 miles to the library and then returned home. In the afternoon, she drove 9 miles to the movies and returned home. How much farther did Taryn travel in the morning?

A. 4 miles

B. 6 miles

C. 8 miles

D. 9 miles

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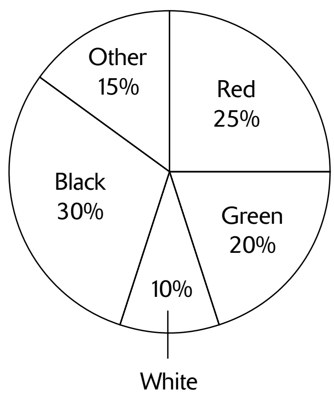

Heidi tallied the different car colors in the parking lot and summarized her results in a pie chart. There are 260 cars in the lot. How many cars are either red or black?

A. 65

B. 78

C. 130

D. 143

STOP

Word Knowledge

Time: 11 minutes

35 questions

1. **Adversity** most nearly means
   - **A.** help.
   - **B.** hardship.
   - **C.** love.
   - **D.** ease.

2. **Caustic** most nearly means
   - **A.** smooth.
   - **B.** corrosive.
   - **C.** soft.
   - **D.** heavy.

3. They tried not to **mar** the furniture.
   - **A.** spoil
   - **B.** move
   - **C.** overturn
   - **D.** sell

4. **Zest** most nearly means
   - **A.** enjoyment.
   - **B.** sadness.
   - **C.** stealth.
   - **D.** annoyance.

5. Several of the people in the audience began to **sway**.
   - **A.** tumble head-over-heels
   - **B.** move back and forth
   - **C.** laugh
   - **D.** jump around

6. **Enigma** most nearly means
   - **A.** pleasure.
   - **B.** discomfort.
   - **C.** celebration.
   - **D.** mystery.

7. **Punctual** most nearly means
   - **A.** missing.
   - **B.** prompt.
   - **C.** late.
   - **D.** quick.

8. **Loiter** most nearly means
   - **A.** dawdle.
   - **B.** dive.
   - **C.** enlarge.
   - **D.** lose.

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9. Fortunately they had an **auxiliary** light.

- **A.** bright
- **B.** helping
- **C.** halogen
- **D.** welcoming

10. You could tell that the carpenter was **deft** with his tools.

- **A.** angry
- **B.** foreign
- **C.** skillful
- **D.** careless

11. **Meander** most nearly means

- **A.** skip.
- **B.** scold.
- **C.** wander.
- **D.** want.

12. **Parsimony** most nearly means

- **A.** generosity.
- **B.** stinginess.
- **C.** willingness.
- **D.** payment.

13. The crop was extremely **prolific** this year.

- **A.** wasted
- **B.** barren
- **C.** necessary
- **D.** fruitful

14. **Pithy** most nearly means

- **A.** full.
- **B.** concise.
- **C.** enlarged.
- **D.** incomplete.

15. The movie seemed **bizarre** to the crowd.

- **A.** exciting
- **B.** slow
- **C.** scary
- **D.** strange

16. The gathering was a **tribute** to the policemen.

- **A.** show of respect
- **B.** protest
- **C.** dinner
- **D.** payment

17. The man was accused of **slandering** his opponent.

- **A.** hitting gently
- **B.** speaking untruth
- **C.** pleasing
- **D.** tricking

18. **Somber** most nearly means

- **A.** straight.
- **B.** tipsy.
- **C.** elevated.
- **D.** grave.

19. The mansions indicated the town's **affluence**.

A. decline
B. growth
C. silence
D. wealth

20. **Docile** most nearly means

A. sweet.
B. easily led.
C. soft.
D. heavy.

21. **Hale** most nearly means

A. wet.
B. healthy.
C. snowy.
D. ill.

22. The old man became **reclusive**.

A. annoyed
B. solitary
C. queasy
D. obstinate

23. His work was of the highest **caliber**.

A. price
B. quality
C. respect
D. size

24. **Infinite** most nearly means

A. endless.
B. original.
C. marked.
D. happy.

25. **Opulent** most nearly means

A. golden.
B. wealthy.
C. slim.
D. empty.

26. **Trite** most nearly means

A. pleasurable.
B. ordinary.
C. magnificent.
D. tawdry.

27. **Vital** most nearly means

A. healthy.
B. essential.
C. wasted.
D. needless.

28. My mother gave me a present as an **incentive**.

A. surprise
B. motivator
C. punishment
D. accident

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29. The workers began to **raze** the old building.

A. burn
B. sell
C. repair
D. demolish

30. **Scurry** most nearly means

A. tumble.
B. stroll.
C. clean.
D. scamper.

31. **Prudent** most nearly means

A. toothy.
B. wise.
C. careless.
D. willing.

32. **Ardent** most nearly means

A. passionate.
B. starchy.
C. ignorant.
D. final.

33. **Bland** most nearly means

A. gourmet.
B. tasteless.
C. landlocked.
D. homey.

34. **Solicit** as much advice as possible before your trip.

A. worry about
B. take
C. ask for
D. scorn

35. In the **interim,** I used my brother's car.

A. winter
B. meantime
C. morning
D. first stage

STOP

Paragraph Comprehension

Time: 13 minutes

15 questions

1. Tsunamis are large waves or earthquakes caused by earthquakes or underwater landslides. The word “tsunami” is a Japanese word meaning “harbor wave” because of the destructive effects that these waves have had on coastal Japanese communities.

What is the best title for this selection?

A. What is a Tsunami?

B. Japanese Natural Disasters

C. Japanese Words and Their Meanings

D. Effects of a Tsunami

2. Pyromaniacs are very rarely the setters of most criminal fires. Most people who set fires do so for insurance fraud, although others often set fires for revenge and terrorism. Very few people actually start fires because they receive strong psychological gratification from the act.

A *pyromaniac* could best be defined as

A. a person who never sets fires.

B. a person who is afraid of fire.

C. a person who sets fires and receives strong psychological gratification from the act.

D. a person who sets fires to obtain revenge.

3. *Panther* refers to two different types of animals—the leopard and the concolour. Concolours are called by many other names: cougar, puma, mountain lion, and panther are just a few. In fact, the panther has more dictionary names than any other known predator.

Which of the following is *not* mentioned as another name for the concolour?

A. cougar

B. mountain lion

C. bobcat

D. panther

Questions 4 and 5 relate to the following passage.

Thomas Alva Edison is one of the most well-known inventors in history. He is most famous for inventions like the phonograph, the motion picture camera, and the light bulb. However, even Edison failed in a few attempts at invention, namely in trying to develop a better way to mine iron ore during the late 1880s and early 1890s. He was tenacious in his attempts to find a method that worked, but he eventually gave up after having lost all the money he had invested in iron-ore mining projects.

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4. In this context, the word *tenacious* means

A. angry.

B. persistent.

C. lazy.

D. happy.

5. This passage is mainly about

A. Edison's successful inventions.

B. the light bulb.

C. iron-ore mining.

D. Edison's invention attempt in iron-ore mining.

6. In Alaska, there are long periods of darkness in certain regions since much of the state is located so far north of the Arctic Circle. Thus, those regions above the Arctic Circle experience unending daylight in certain summer months and unending darkness in some winter months.

It can be inferred from the above passage that

A. all regions of Alaska experience unending dark in winter.

B. all regions of Alaska experience unending daylight in summer.

C. regions south of the Arctic Circle experience alternating dark and daylight in the winter and summer months.

D. regions south of the Arctic Circle have unending daylight in summer.

7. In an age that stresses the importance of water conservation, there are many plants that require less water than other more traditionally grown plants. In order to optimize their water usage efficiency, experts recommend watering such plants during the cooler times of the day.

One may conclude from the above statements that water efficient plants should be watered

A. at 12:00 noon, when the sun is at its hottest.

B. at 6:00 a.m., when the sun has just risen.

C. at 10:00 a.m., when the day is warming up.

D. at 3:00 p.m., before the sun goes down.

8. Water is needed to sustain us as human beings. In fact, two-thirds of the human body is comprised of water. Since our bodies are so water dependent, we must drink water every day.

In this context, the word *comprised* means

A. consists of.

B. less than.

C. full of.

D. demands.

9. Obesity has become a national epidemic. Recent studies have shown that obesity is more serious than previously thought. In fact, obesity is harder on the health than cigarette smoking. Since 27% of Americans are currently obese, and 61% are overweight, this weight problem is exacting a huge cost from the medical community.

The percentage of Americans who are currently overweight is

A. 27%.

B. 52%.

C. 73%.

D. 61%.

10. Weight loss experts recommend lowered calorie intake and regular exercise to get rid of excess weight. However, lowering calories too much or exercising too strenuously can be detrimental to good health. Caloric intake should never go lower than 1,200 calories per day, and exercise should consist of at least 30 minutes four to five times per week to achieve healthy weight loss.

The best title for this selection is

A. How to Achieve Healthy Weight Loss and Avoid Injury.

B. Warning About Too Much Exercise.

C. Weight Loss Woes.

D. Caloric Recommendations for Weight Loss.

Questions 11 and 12 relate to the following passage.

Recently, cellular phone use has become a nationwide epidemic. A new study confirms that this epidemic might not be such a positive one. The study found that drivers who talk on their cellular phones while driving perform 30% worse as drivers than drunk drivers do. Many have proposed using a hands-free cellular phone to solve this problem of dangerous driving. However, researchers discovered that even hands-free cellular phones distract drivers.

11. The author probably believes that

A. cellular phone use is not dangerous while driving.

B. hands-free cellular phones are safe for drivers to use.

C. cellular phones of any kind should never be used while driving.

D. cellular phones are a safe alternative to drunk driving.

12. This paragraph is mainly about

A. drunk driving.

B. hands-free cellular phones.

C. the dangers of driving with cellular phones.

D. the safe alternative provided by hands-free cellular phones.

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Questions 13, 14, and 15 relate to the following passage.

Although carjacking has become more common in the past 10 years, there are several preventive measures that drivers can take. The first way to prevent carjacking is to never walk alone to your car at night. Another means of prevention is always driving with the windows rolled up and the doors locked.

Also, driving on well-lit and often-traveled roads is another preventive measure that drivers can take to ensure their safety from carjacking.

13. The best title for this selection is

A. Preventing Carjacking.

B. Carjacking Becoming More Common.

C. Driving Safety.

D. Night Driving Safety.

14. Which of the following is not mentioned as a preventive measure against carjacking?

A. driving on well-lit roads

B. carrying pepper spray

C. driving with windows rolled up

D. never walking to your car alone at night

15. The author probably believes that

A. it is almost impossible to avoid carjacking.

B. carjacking cannot be avoided at night.

C. carjacking never happens during the day.

D. carjacking can often be avoided by employing simple preventive measures.

STOP

Auto and Shop Information

Time: 11 minutes

25 questions

1. A technician is performing a cylinder leakage test on an engine. The technician sees air bubbles in the radiator with the cap off. Which one is the most likely cause?

A. cracked cylinder head

B. bad intake valve

C. bad exhaust valve

D. bad piston rings

2. Looking at a brake system with the drum off, the secondary brake shoe location is

A. the front shoe (closest to the front).

B. the rear shoe (closest to the rear).

C. not important.

D. only required for disc/drum systems.

3. If a thermostat in a vehicle's engine is stuck open, the engine will

A. overheat.

B. not heat up to a proper temperature.

C. wind up with a blown head gasket.

D. use too much antifreeze.

4. A relay is an electrical device that

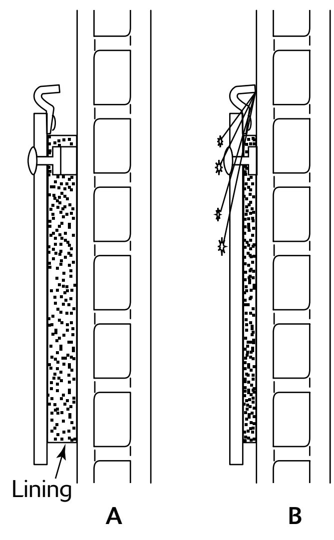
A. uses high current to control low current.

B. uses low current to control high current.

C. steps up low voltage to a higher voltage.

D. reduces current flow.

5. Looking at the figure below, technician A says Figure A indicates an improperly installed brake lining, while technician B says Figure B indicates worn brake pads. Who is right?



A. A only

B. B only

C. both A and B

D. neither A or B

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6. A vehicle with front disc brakes and rear drum brakes has wheel cylinders on

A. the front wheels only.

B. all four wheels.

C. the rear wheels only.

D. one front wheel and one rear wheel.

7. Which of the following components is not part of the secondary of an ignition system?

A. spark plug wires

B. rotor

C. distributor cap

D. pick-up coil

8. A distributor with vacuum advance compensates for varying

A. engine loads.

B. engine speeds.

C. altitudes.

D. barometric pressures.

9. In a computer-controlled ignition system, the ignition module

A. changes ignition timing.

B. controls the amount of secondary voltage.

C. controls the magnetic pick-up.

D. turns on and off the primary current.

10. A starting system includes components such as the starter, motor, solenoid, and/or relay. What do these components have in common?

A. They are mechanically controlled.

B. They are parallel to each other.

C. They use the principles of electromagnetism.

D. They operate on A/C current.

11. In an automotive electrical series circuit, what will be the effect of adding an additional resistance?

A. increase the current flow

B. increase the voltage

C. reduce the current flow

D. does not affect current flow

12. Which of the following requires an extractor for removal?

A. pistons

B. bushings

C. broken bolts

D. all of the above

13. A tap is used to

A. cut internal threads.

B. cut external threads.

C. center punch before drilling.

D. detect vibration.

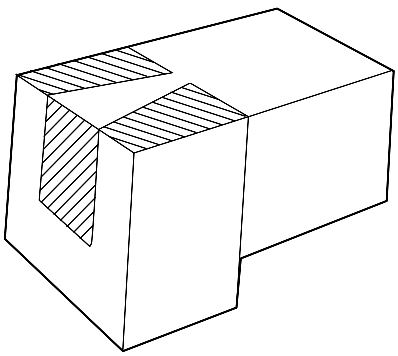
14. A veining bit is used with a

A. hand drill.
B. drill press.
C. router.
D. electric saw.

15. To repair the corners of a picture frame, the best hardware to use would be

A. finishing nails.
B. corrugated fasteners.
C. #10 screws.
D. glue.

16. The illustration below is an example of a

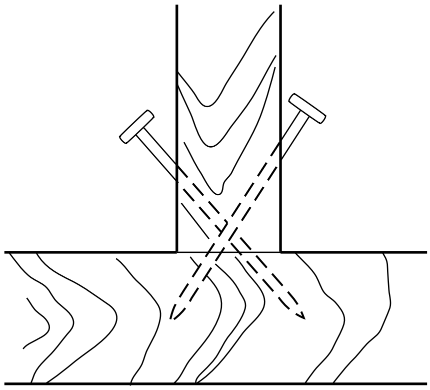


A. bevel joint.
B. notch joint.
C. lap joint.
D. dovetail joint.

17. A monkey wrench would usually be used by a

A. plumber.
B. carpenter.
C. woodworker.
D. auto-body repairperson.

18. The illustration below is an example of

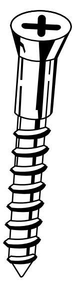


A. clamping.
B. lapjoints.
C. doweling.
D. toenailing.

19. A lathe is normally used to make

A. walls.
B. cabinet doors.
C. chair legs.
D. a bookshelf.

20. The screwhead illustrated below is a



A. dry wall screw.
B. Phillips head screw.
C. round head screw.
D. flat head screw.

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21. To mix concrete, you should mix

A. cement, stones, and sand.

B. cement, water, gravel, and sand.

C. cement and sand.

D. cement, dirt, and water.

22. To use a bit in a hand drill,

A. insert the lip into the flute.

B. insert the auger into the base.

C. insert the tang into the chuck.

D. insert the spur into the chuck.

23. What is a countersink?

A. type of drill

B. type of file

C. type of inlay material

D. type of bench plane

24. A contour gauge measures

A. the length of an object.

B. the width of an object.

C. the diameter of an object.

D. the size of an object.

25. To stop a board from chipping on the end as you plane, you can

A. nail a piece of wood to the end of the board as an extension of the board.

B. cut off the end after planing.

C. Glue the chipped pieces back after finishing.

D. Insert a nail into the end of the board to hold it together.

STOP

Mathematics Knowledge

Time: 24 minutes

25 questions

1. If $a = \frac{5}{2}$ then $\frac{1}{a} =$

A. 2

B. 5

C. $\frac{2}{5}$

D. $\frac{5}{2}$

2. 12 is 15% of what number?

A. 0.0125

B. 1.8

C. 18

D. 80

3. Evaluate $3x + 7$ when $x = -3$.

A. –2

B. 10

C. 16

D. 30

4. Find the diagonal of a square whose area is 36.

A. 6

B. $6\sqrt{2}$

C. 9

D. $9\sqrt{2}$

5. If $a + b = 6$, what is the value of $3a + 3b$?

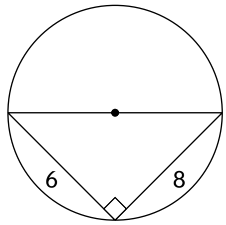
A. 9

B. 12

C. 18

D. 24

6. Find the length of the radius in the following figure.



A. 3

B. 4

C. 5

D. 10

7. $(3 - 1) \times 7 - 12 \div 2 =$

A. 1

B. –2

C. 4

D. 8

8. The greatest common factor of 24 and 36 is

A. 6

B. 12

C. 36

D. 72

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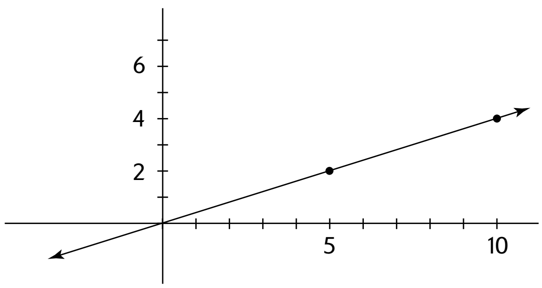
9. Solve for m: $3m - 12 = -6$

A. –6
B. 0
C. 2
D. 6

10. If $7p + 5q = -3$, find q when $p = 1$.

A. –1
B. –2
C. $-\frac{8}{7}$
D. $-\frac{2}{7}$

11. The slope of the line shown is

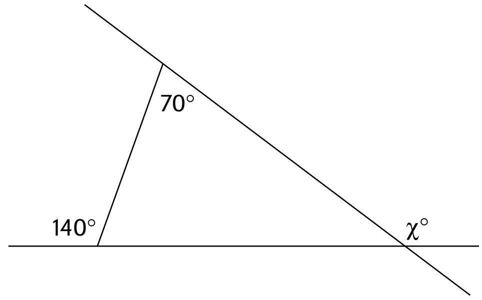


A. $-\frac{2}{5}$
B. $-\frac{5}{2}$
C. $\frac{2}{5}$
D. $\frac{5}{2}$

12. Simplify $\frac{9x^2y^3z - 12xy^2z^2}{3yz}$

A. $3xy^2z^2 - 4xyz$
B. $3xy^2z - 12xyz$
C. $3x^2y^2 - 4xyz$
D. $3y^2 - 4xy^2z^2$

13. The value of x is



A. 70°
B. 110°
C. 140°
D. 210°

14. In a standard deck of playing cards, a king of hearts is drawn and not replaced. What is the probability of drawing another king from the deck?

A. $\frac{1}{4}$
B. $\frac{1}{13}$
C. $\frac{1}{17}$
D. $\frac{3}{52}$

15. How many minutes are there in 1 week?

A. 10,080
B. 1,440
C. 420
D. 168

16. If $2^{b+3} = \frac{1}{8}$, $b =$

A. –6
B. –3
C. 0
D. 2

17. The angles of a triangle are in the ratio 3:4:5. What is the measure of the smallest angle?

A. 15°

B. 30°

C. 45°

D. 75°

18. Subtract $(2x^3 - 3x + 1) - (x^2 - 3x - 2)$

A. $2x^3 - x^2 + 3$

B. $2x^3 - x^2 - 6x - 1$

C. $x^3 - 6x - 1$

D. $x^2 + 3$

19. If the area of a square is 400, what is the length of its side?

A. 20

B. 40

C. 100

D. 200

20. Seven more than 3 times a number is equal to 70. Find the number.

A. 10

B. 17

C. 21

D. 30

21. Which expression represents the volume of a cylinder whose height is equivalent to the length of the radius?

A. πr^2

B. πr^3

C. $(\pi r)^2$

D. $(\pi r)^3$

22. How many distinct prime factors are there in 120?

A. 2

B. 3

C. 4

D. 5

23. What percent of $\frac{3}{4}$ is $\frac{1}{8}$?

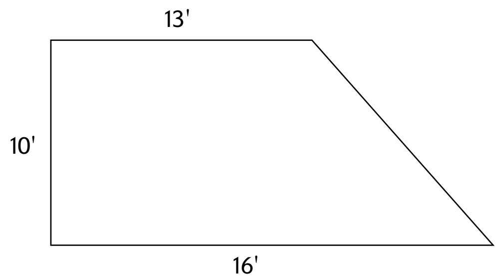
A. $9\frac{3}{8}\%$

B. 12%

C. $16\frac{2}{3}\%$

D. 25%

24. What is the area of the figure shown?



A. 130 ft^2

B. 145 ft^2

C. 160 ft^2

D. 175 ft^2

25. If x is a positive integer, solve $x^2 + 6x = 16$.

A. 2

B. 4

C. 8

D. 10

STOP

Mechanical Comprehension

Time: 19 minutes

25 questions

1. A stone is tied to the end of a string and swings in a circular motion. If the speed of the stone is tripled, the centripetal force of the stone will become

   A. 3 times as great.

   B. 1/3 as much.

   C. 9 times as great.

   D. 1/9 as much.

2. Which of the following units measures the weight of a body?

   A. pound

   B. Newton

   C. kilogram

   D. $kg.m/s^2$

3. The joule is a unit of

   A. work only.

   B. kinetic energy only.

   C. potential energy only.

   D. heat.

4. Two objects with different weights are dropped at the same moment from the top of the Leaning Tower of Pisa.

   A. Both objects hit the ground at the same time.

   B. The heavier object hits the ground first.

   C. The heavier object hits the ground last.

   D. The arrival time at the ground depends on the density of each object.

5. The quantity 2 m/s^2 is a measure of

   A. speed.

   B. acceleration.

   C. velocity.

   D. metric volume.

6. For a car moving around a circular track at a constant speed, the acceleration is

   A. away from the center of the circle.

   B. towards the center of the circle.

   C. in the direction of motion.

   D. opposite to the direction of motion.

7. A ball thrown vertically upward has an initial potential energy of 100 J and an initial kinetic energy of 700 J. At the top of the trajectory its energy in joules is

   A. 100.

   B. 700.

   C. 800.

   D. 1,000.

8. A simple pendulum has a frequency of oscillation *f*. In order to double *f*, the length of the pendulum should be

A. increased by a factor of 2.
B. decreased by a factor of 2.
C. increased by a factor of 4.
D. decreased by a factor of 4.

9. The velocity of a baseball 4 seconds after it is thrown vertically upward with a speed of 32.1 m/s is

A. –7.2 m/s.
B. 71.2 m/s.
C. 7.20 m/s.
D. 14.6 m/s.

10. In order for a volleyball player to jump vertically upward a distance of 0.8 meters, his initial velocity must be

A. 3.92 m/s.
B. 1.96 m/s.
C. 4.27 m/s.
D. 2.15 m/s.

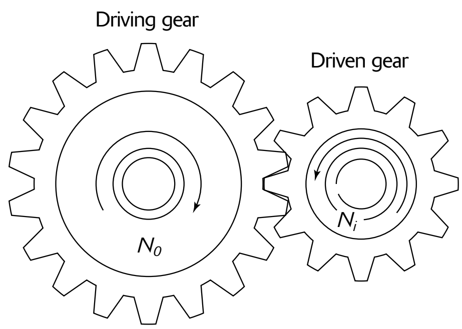
11. The graph of velocity versus time for an object with a constant negative acceleration would be

A. a straight line with a positive slope.
B. a straight line with a negative slope.
C. a line curving upward with a positive slope.
D. a line curving downward with a negative slope.

12. The torque required to loosen a nut that holds a wheel on a car has a magnitude of 56 newton-meters. If a 0.35-meter lug wrench is used to loosen the nut when the angle of the wrench is 56°, the force that must be exerted at the end of the wrench is

A. 200 N.
B. 286 N.
C. 143 N.
D. 100 N.

13. In the spur gear arrangement shown in the figure, the ratio of the number of teeth on the output gear (N_o) to the number of teeth on the input gear (N_i) is 2. The speed ratio of the input and output gears is



A. $\frac{1}{2}$.
B. 2.
C. $\frac{1}{4}$.
D. 4.

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14. The gain in kinetic energy if a 400-kilogram satellite moves from a distance of 3×10^6 meters above the surface of the Earth to a point 1.50×10^6 meters above the surface is _______ J. The mass of the Earth is 5.98×10^{24} kilograms and the radius of the Earth is $6.37x10^6$ meters.

A. -1.7×10^9

B. 3.25×10^9

C. 1.7×10^9

D. -3.25×10^9

15. The speed of a baseball with a momentum of 5.8 kilograms m/s and a mass of 0.145 kilograms is

A. 0.841 m/s.

B. 1.19 m/s.

C. 36.0 m/s.

D. 40.0 m/s.

16. A 0.24-kilogram glider moving with a velocity of 0.6 m/s collides with and sticks to a 0.26-kilogram glider moving with a velocity of 0.2 m/s. The final velocity v of the two gliders is

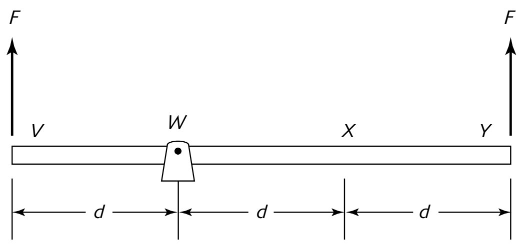
A. 0.392 m/s.

B. 0.184 m/s.

C. 0.092 m/s.

D. –0.092 m/s.

17. A massless, horizontal, rigid rod of length $3d$ is pivoted at a fixed point W, and two forces each of magnitude F are applied vertically upward as shown in the figure. In order to achieve rod equilibrium, a third vertical force of magnitude F is to be applied at which of the labeled points?



A. X only

B. W only

C. V or X only

D. X or Y only

18. Two balls of different masses are thrown vertically up from the same point and at the same time. The two balls will experience the same change in

A. velocity.

B. acceleration.

C. momentum.

D. kinetic energy.

19. An arrow is shot vertically up. As the arrow approaches its maximum altitude, the amount of work done against gravity

A. increases.

B. decreases.

C. increases and then decreases.

D. remains the same.

20. The resistance of an object to a change of motion is determined by its

A. mass.

B. weight.

C. prior motion.

D. distance of travel.

21. Which of the following units is equivalent to the joule?

A. kg.m/s

B. kg.m/s^2

C. kg/s^2

D. kg.m^2/s^2

22. A 15-gram bullet is fired into a 3-kilogram block of plastic suspended from the ceiling by a string. As a result of the impact, the block with the bullet swings 12 centimeters above its original level. The velocity of the bullet as it strikes the block is nearly

A. 3.08 m/s.

B. 30.8 m/s.

C. 308 m/s.

D. 3,080 m/s.

23. An astronaut lands on Jupiter. Which of the following is true?

A. Mass increases but weight decreases.

B. Mass remains the same but weight decreases.

C. Mass decreases but weight remains the same.

D. Both mass and weight decrease.

24. Ignoring air resistance, the acceleration of a person sliding down an inclined plane with a constant coefficient of kinetic friction

A. is constant.

B. increases with time.

C. decreases with time.

D. depends on the mass and shape of the person.

25. A bicycle collides head-on with a large truck moving at the same speed. Following the collision, the bicycle and the truck stick together. Which of the two had the larger change in momentum?

A. the bicycle

B. the truck

C. both had equal change

D. none of the above

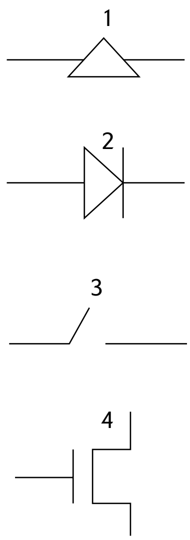
STOP

Electronics Information

Time: 9 minutes

20 questions

1. Which of the following symbols represents a diode?



A. 1

B. 2

C. 3

D. 4

2. Electronic current is measured in

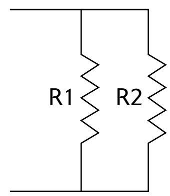
A. farads.

B. volts.

C. amperes.

D. ohms.

3. The total resistance for this circuit if all resistors are 200 ohms is



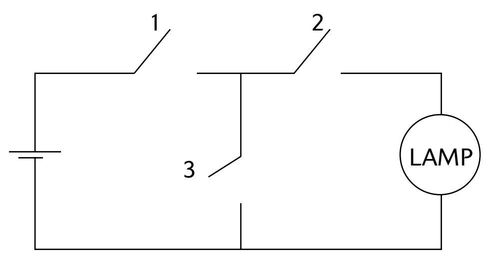
A. 100 ohms.

B. 200 ohms.

C. 150 ohms.

D. 400 ohms.

4. For the lamp to be turned on in the following circuit



A. switch 1only should be closed.

B. switch 2 only should be closed.

C. switches 1 and 2 only should be closed.

D. all the switches must be closed.

5. A voltmeter is a device used for measuring

A. electrical current.

B. electrical charge.

C. energy.

D. difference in voltage.

6. Leather gloves must be used when

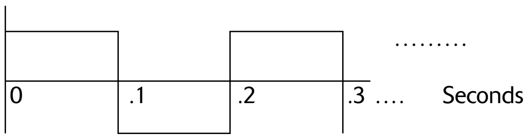
A. working with low-power transistors.

B. working with live high-voltage devices.

C. testing low-power DC circuits.

D. designing a low-power circuit.

7. The frequency of this signal is



A. 100 Hz.

B. 10 Hz.

C. 5 Hz.

D. 1 Hz.

8. An AM radio signal is

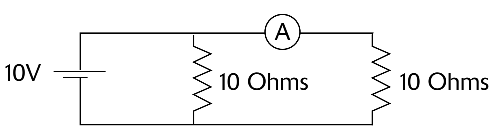
A. amplitude modulated.

B. frequency modulated.

C. phase modulated.

D. DC modulated.

9. The reading of the ammeter in this circuit is



A. 10 A.

B. 5 A.

C. 1 A.

D. 2 A.

10. In order to protect an electric circuit, the following component can be used:

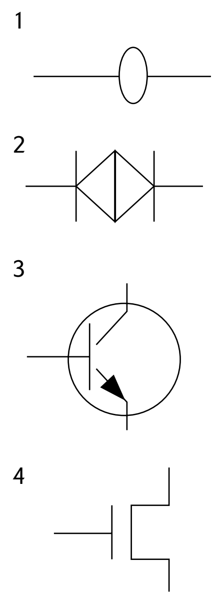
A. a fuse

B. a capacitor

C. an inductor

D. an ammeter

11. Which of these symbols represents a bipolar junction transistor (BJT)?



A. 1

B. 2

C. 3

D. 4

12. A signal is transmitted wirelessly by carrying it on

A. a square wave.

B. a DC signal.

C. a triangular wave.

D. a high-frequency sinusoidal wave.

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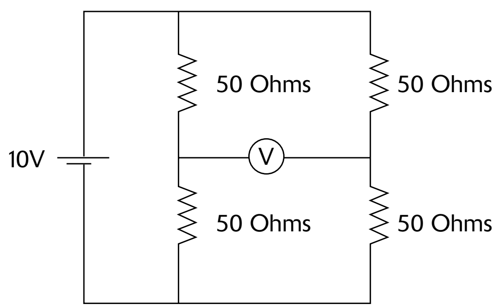
13. The signal $s(t) = 10 \sin(120\pi t)$ has the following amplitude and frequency, respectively:

A. 5 V and 120 Hz
B. 10 V and 60 Hz
C. 10 V and 120 Hz
D. 5 V and 60 Hz

14. The reading of the voltmeter in this circuit is



A. 5 V
B. 10 V
C. 0 V
D. 2.5 V

15. An ohmmeter is a device used to measure

A. resistance.
B. voltage.
C. power.
D. current.

16. A certain signal is carried on a radio signal by using the following electronic component:

A. resistor
B. mixer
C. capacitor
D. on-off switch

17. In a diode (PN Junction), the current flows

A. from anode to cathode.
B. from cathode to anode.
C. in both directions.
D. when voltage is below threshold.

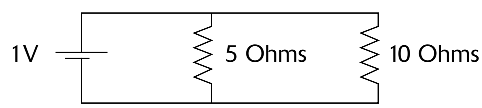
18. A component of a parts list has the following specifications: "10 mH." The component specified is a

A. capacitor.
B. transistor.
C. coil.
D. resistor.

19. Electronic devices are grounded to

A. reduce the cost.
B. protect the user.
C. reduce the power dissipation.
D. enhance performance.

20. The power dissipated across the resistors in the following circuit is



A. 0.3 watt.
B. 0.5 watt.
C. 1.0 watt.
D. 1.5 watt.

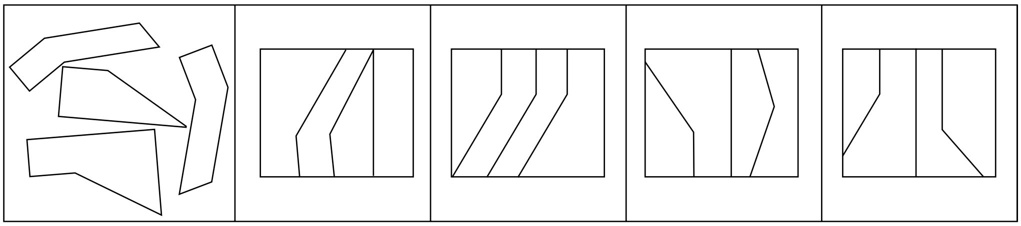
STOP

Assembling Objects

Time: 9 minutes

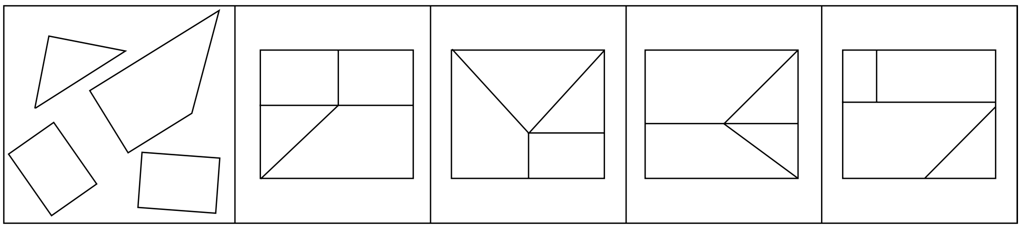
16 questions

1.



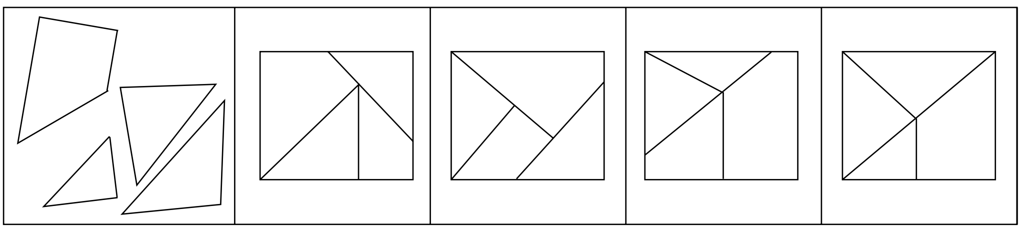
A B C D

2.



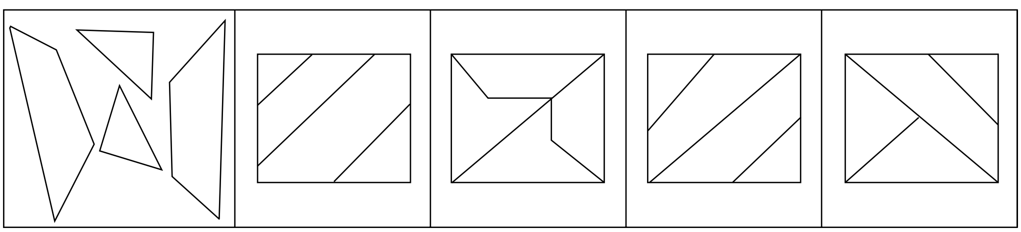
A B C D

3.



A B C D

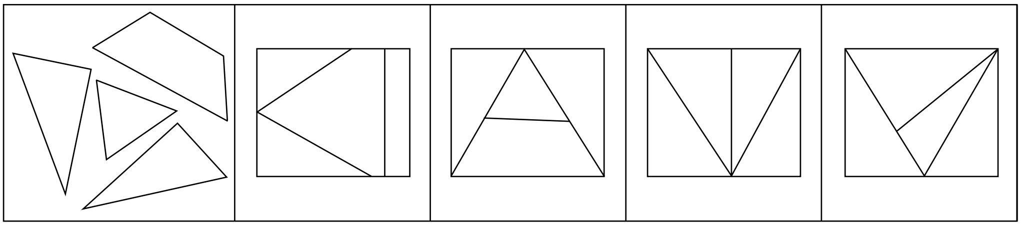
4.



A B C D

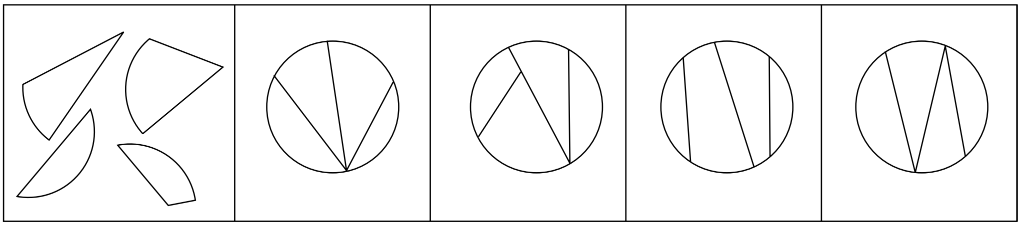
GO ON TO THE NEXT PAGE

5.



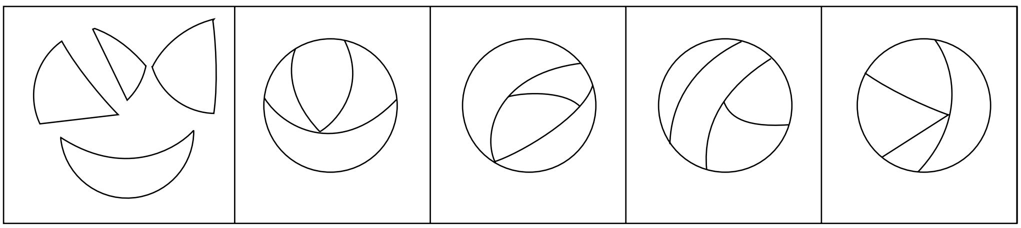
A B C D

6.



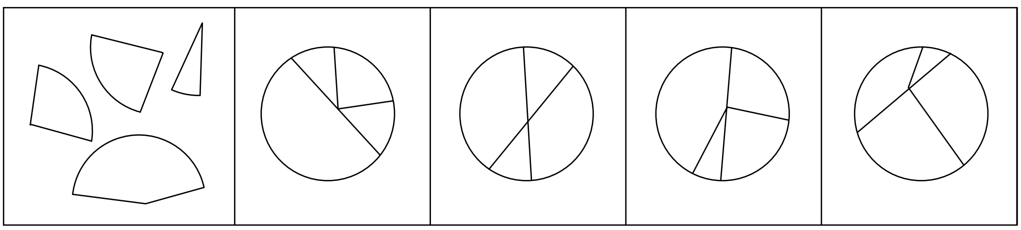
A B C D

7.



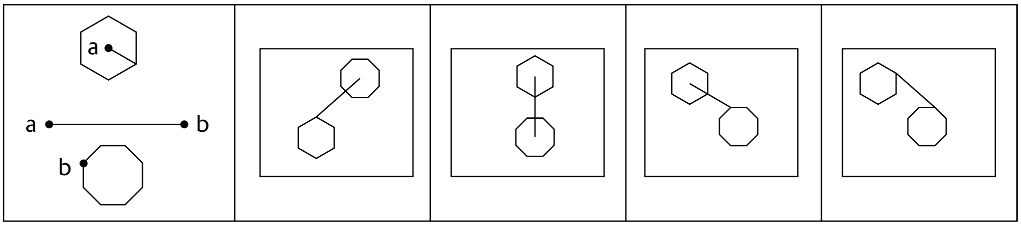
A B C D

8.



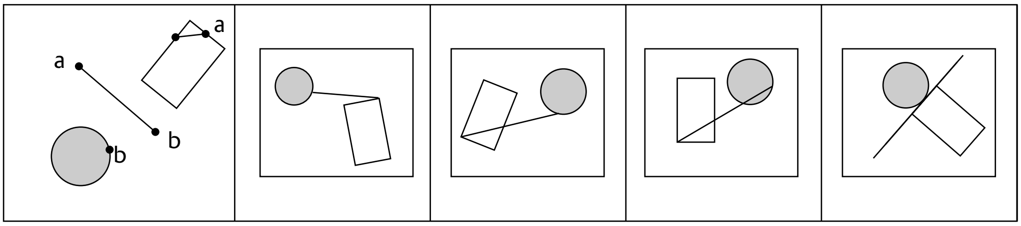
A B C D

9.



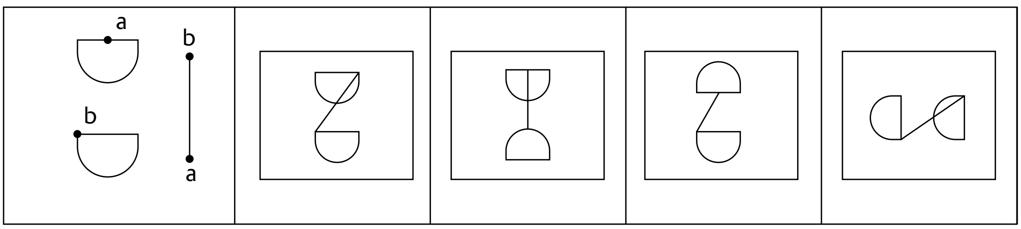
A B C D

10.



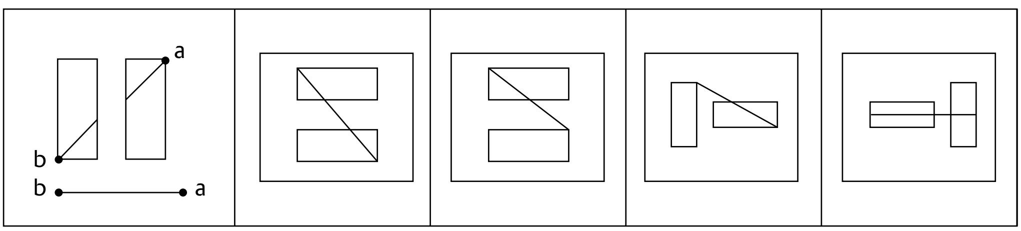
A B C D

11.



A B C D

12.



A B C D

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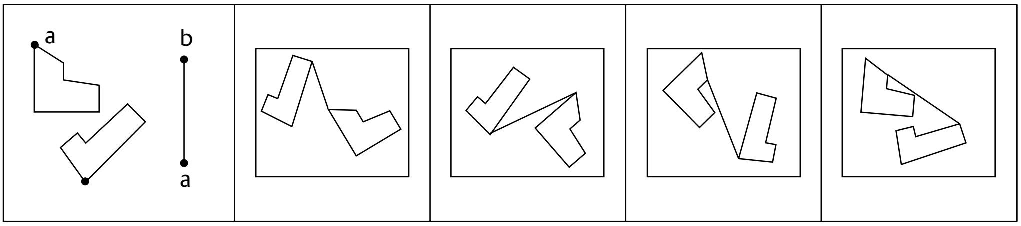
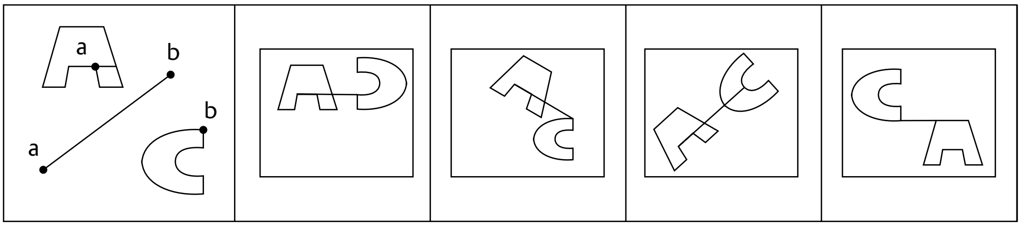
13.



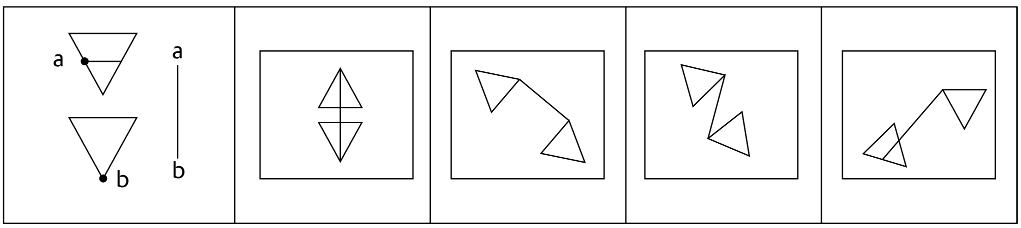
A B C D

14.



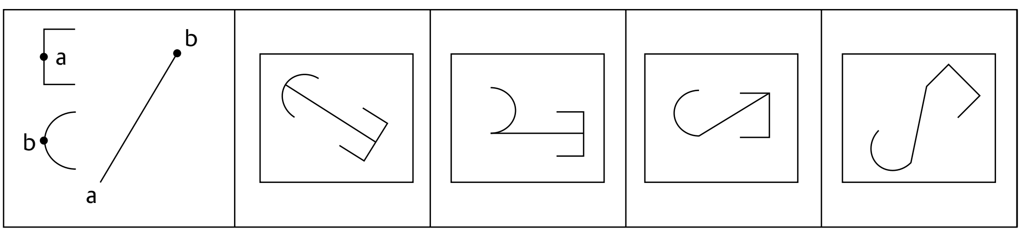
A B C D

15.



A B C D

16.



A B C D

STOP

Answer Key for Practice Test 1

General Science

1. C
2. D
3. B
4. A
5. B
6. A
7. C
8. D
9. C
10. A
11. B
12. B
13. A
14. B
15. C
16. C
17. A
18. A
19. B
20. D
21. B
22. B
23. B
24. C
25. D

Arithmetic Reasoning

1. A
2. D
3. C
4. B
5. B
6. D
7. A
8. D
9. D
10. D
11. A
12. A
13. C
14. A
15. B
16. C
17. A
18. C
19. C
20. A
21. D
22. D
23. D
24. D
25. A
26. B
27. B
28. C
29. C
30. D

Word Knowledge

1. B
2. B
3. A
4. A
5. B
6. D
7. B
8. A
9. B
10. C
11. C
12. B
13. D
14. B
15. D
16. A
17. B
18. D
19. D
20. B
21. B
22. B
23. B
24. A

25. B
26. B
27. B
28. B
29. D
30. D
31. B
32. A
33. B
34. C
35. B

Paragraph Comprehension

1. A
2. C
3. C
4. B
5. D
6. C
7. B
8. A
9. D
10. A
11. C
12. C
13. A
14. B
15. D

Auto and Shop Information

1. A
2. B
3. B
4. B
5. B
6. C
7. D
8. A
9. D
10. C
11. C
12. C
13. A
14. C
15. B
16. D
17. A
18. D
19. C
20. B
21. B
22. C
23. A
24. D
25. A

Mathematics Knowledge

1. C
2. D
3. A
4. B
5. C
6. C
7. D
8. B
9. C
10. B
11. C
12. C
13. B
14. C
15. A
16. A
17. C
18. A
19. A
20. C
21. B
22. B
23. C
24. B
25. A

Mechanical Comprehension

1. C
2. B
3. D
4. A
5. B
6. B
7. C
8. D
9. A
10. A
11. B
12. B
13. B
14. B
15. D
16. A
17. C
18. A
19. D
20. A
21. D
22. C
23. B
24. A
25. C

Electronics Information

1. B
2. C
3. A
4. C
5. D
6. B
7. C
8. A
9. C
10. A
11. C
12. D
13. B
14. C
15. A
16. B
17. A
18. C
19. B
20. A

Assembling Objects

1. B
2. A
3. D
4. C
5. B
6. B
7. D
8. C
9. C
10. B
11. C
12. A
13. B
14. B
15. D
16. A

Practice Test 1 Answers and Explanations

General Science (Practice Test 1 Answers)

1. **C.** In photosynthesis, water is split, oxygen is given off as a waste product, and hydrogen is combined with carbon dioxide to form sugars.
2. **D.** Only members of the same species meet in the wild and mate to produce fertile offspring.
3. **B.** Celsius and centigrade are the same thing. Water boils at 100° centigrade or 212° Fahrenheit.
4. **A.** A liter is slightly larger than a quart. There are about 33 ounces in a liter, while a quart has 32 ounces.
5. **B.** Adding heat to water gives the molecules more kinetic energy, resulting in faster motion. It does not change the energy level of electrons or the number of electrons in the molecules.
6. **A.** The slope of the line is a measure of the rate. Anyone who is injected with insulin has the same type of response.
7. **C.** Ligaments connect bone to bone and tendons connect bone to muscle.
8. **D.** A yard is slightly less than a meter. Since there are 1,000 millimeters in a meter, there should be slightly less in a yard.
9. **C.** Parts per million can be converted to parts per hundred by dividing by 10,000 or setting up a proportion. 35 ppm = 0.0035 parts per hundred. Any number can be expressed as a percent by multiplying that number by 100%. So, $0.0035 \times 100\% = 0.35\%$.
10. **A.** The acceleration of objects in freefall is independent of mass, resulting in the same speed at the end of a fall. The momentum and energy are proportional to the mass.
11. **B.** Electrons are the only charges free to move in a metal.
12. **B.** Diffusion is the movement of molecules of liquid from a greater to a lesser concentration. The diffusion of water is osmosis, and no energy is required as these molecules move down a concentration gradient.
13. **A.** According to the Law of Superposition, all other factors being accounted for, the most recent (youngest) geologic layers are on the top. Since the slate layer is closest to the surface, it is the youngest.
14. **B.** Day and night are the results of the rotation of the earth. Continental drift is often offered as evidence of plate tectonics. While the variable star field may be affected by planetary tilt, the position of the observer relative to the star field is also a major factor. The seasons, choice **B,** are the result of the directness of the Sun's rays hitting Earth's surface. The primary factor controlling directness of the rays of the Sun is planetary tilt.
15. **C.** The hallmark of a composite cone composition is the mixture of cinder cone characteristics (granitic debris, very steep cone profile, and explosive eruptions) with shield cone characteristics (large footprint with gently sloping sides, basaltic debris, and lava flows).

16. **C.** Choice **A** is a true statement but it does not explain rain, only the motion of the fronts. The motion of the warmer air over cooler air is due to differing densities, but it is the drop in temperature due to increased elevation and contact with cooler air (among other things) that causes the rain. As air cools, its capacity to hold water vapor decreases. As the saturation point is reached, excess water vapor condenses on particles in the air and eventually can fall as rain.

17. **A.** Mitosis is nuclear division, cytokinesis is cell division, and meiosis is used for sex cell production.

18. **A.** Protons have a positive charge and electrons have a negative charge.

19. **B.** Both protons and neutrons exist in the nucleus, while electrons orbit the nucleus.

20. **D.** The work done by the force is the same as the work done on the load in an ideal simple machine.

21. **B**. Gametes (eggs and sperm) need to have half the normal chromosome number, so that when they combine the correct number appears in the new cell.

22. **B.** As you decrease the volume, the pressure will increase proportionally, and if you increase the volume, then the pressure will decrease.

23. **B.** The subscript applies to each of the atoms within the parentheses.

24. **C.** In this case of incomplete dominance, each pink flower has one gene for red and one for white. When they combine randomly, one-fourth will be white, one-fourth red, and half pink.

25. **D.** Memory cells help us mount quicker responses to antigens we have previously encountered.

Arithmetic Reasoning (Practice Test 1 Answers)

1. **A.** $3\frac{1}{4} - 2\frac{1}{8} = \frac{13}{4} - \frac{17}{8} = \frac{26}{8} - \frac{17}{8} = \frac{9}{8} = 1\frac{1}{8}$ more cups of flour.

2. **D.** There are 24 eggs in 2 dozen eggs. If 3 eggs are in an omelet, then $24 \div 3$, or 8 omelets, can be made.

3. **C.** Since two runners finished in 80 seconds, the average of 80, 80, 72, and 68 must be found. This average is $\frac{80+80+72+68}{4} = \frac{300}{4} = 75$ seconds.

4. **B.** If 400 people fit in eight subway cars, then $400 \div 8$, or 50, people fit in one subway car. Therefore, 50×5, or 250, people fit in five subway cars.

5. **B.** The earnings for 30 hours are $\$8.25 \times 30 = \$247.50$.

6. **D.** Let n represent the number of students in the band. Then $\frac{1}{3}n = 72$, so $n = 72 \times 3 = 216$.

7. **A.** Add the amount of money received and subtract the amount spent. $\$30 + \$15 - \$16 = \$29$.

8. **D.** If an item is discounted 20%, the sale price is 80% of the original price. Let p represent the original price. Then $\$800 = 80\% \times p$ and $p = \frac{800}{80\%} = \frac{800}{.80} = \$1,000$.

9. **D.** For a 30-hour week with \$500 in sales, total earnings are $(30 \times \$9.50) + (3\% \times \$500) = \$285 + \$15 = \$300$.

10. **D.** The area of the circle with a radius of 3 is $\pi r^2 = \pi \times r^2 = 9\pi$. The area of the larger circle is $4 \times 9\pi = 36\pi$. Therefore, $r^2 = 36$, so $r = \sqrt{36} = 6$. The radius of the larger circle is 6.

11. **A.** $\$20 - \$3.95 = \$16.05$.

12. **A.** Using the ratio $\frac{\text{height}}{\text{shadow}}$, the proportion $\frac{3\frac{1}{2}}{6} = \frac{x}{24}$ models this situation, where x represents the height of the pole. Cross multiply. $3\frac{1}{2} \times 24 = 6x$, so $84 = 6x$, and $x = \frac{84}{6} = 14$ feet.

13. **C.** The overtime rate is $\$8.40 \times 1.5 = \$12.60$. Five hours of overtime were completed, so the total earnings are $(\$8.40 \times 40) + (\$12.60 \times 5) = \$336 + \$63 = \$399$.

14. **A.** The amount of discount is $\$40 - \$30 = \$10$. The percent of discount is the amount of discount divided by the original price. $10/40 = 1/4 = 25\%$.

15. **B.** The volume of the original box is $3 \times 2\frac{1}{2} \times 2 = 15$. The volume of the box with the length and depth doubled is $6 \times 2\frac{1}{2} \times 4 = 60$. The amount of change in volume is $60 - 15 = 45$. The percent change is the amount of change in volume divided by the original volume: $\frac{45}{15} = 3 = 300\%$.

16. **C.** The amount of commission is $10\% \times \$8,350 = \$835$. Total earnings are \$300 + \$835 commission = \$1,135.

17. **A.** The total number of stamps collected is $300 + 420 + 180 = 900$. The number of coins that can be collected is $\frac{900}{25} = 36$.

18. **C.** The proportion $\frac{1\text{ cm}}{4\text{ miles}} = \frac{x\text{ cm}}{10\text{ miles}}$ models this situation. Cross multiply. $1 \times 10 = 4x$, so $10 = 4x$ and $x = \frac{10}{4} = 2\frac{1}{2}$.

19. **C.** Let p represent the amount of the paycheck. $\frac{4}{13}p = \$26.80$, so $p = \$26.80 \times \frac{13}{4} = \$87.10$.

20. **A.** The proportion $\frac{\frac{1}{2}\text{ mile}}{4\text{ minutes}} = \frac{x\text{ miles}}{15\text{ minutes}}$ models this situation. Cross multiply. $\frac{1}{2} \times 15 = 4x$, so $\frac{15}{2} = 4x$ and $x = \frac{15}{2} \times \frac{1}{4} = \frac{15}{8} = 1\frac{7}{8}$ miles.

21. **D.** There are 3 feet in a yard, so a kitchen 4 yards by 5 yards is equivalent to (4×3) feet by (5×3) feet, or 12 feet by 15 feet. The area of the kitchen is $12 \times 15 = 180$ square feet. The cost to tile is $\$2.89 \times 180 = \$520.20$.

22. **D.** At the end of the first day, there are $1 - \frac{1}{8} = \frac{7}{8}$ of the magazines remaining. $\frac{7}{8} \times \frac{1}{4} = \frac{7}{32}$ sold the next day. So at the end of the second day, there are $\frac{7}{8} - \frac{7}{32} = \frac{28}{32} - \frac{7}{32} = \frac{21}{32}$ of the magazines remaining.

23. **D.** Interest earned in 1 year is $\$300 \times 5\frac{1}{4}\% = \$15.75$. The total amount of the account after 1 year is $\$300 + \$15.75 = \$315.75$.

24. **D.** Let m represent the minutes of the phone calls. The monthly charge for the first plan is $20 + 0.08m$. The monthly charge for the second plan is $12 + 0.12m$. When the monthly charges are the same, $20 + 0.08m = 12 + 0.12m$.

$20 + 0.08m - 0.08m = 12 + 0.12m - 0.08m$

$20 = 12 + 0.04m$

$20 - 12 = 12 + 0.04m - 12$

$\frac{8}{0.04} = \frac{800}{4} = 200$ minutes

25. **A.** The perimeter of a rectangle is $l + w + l + w = 48$. Since $l = 3w$, the perimeter is $3w + w + 3w + w = 48$ so $8w = 48$ and $w = 6$. Therefore, the length is 3×6 or 18 and the area of the rectangle is $l \times w = 18 \times 6 = 108$.

26. **B.** If a machine produces 8,000 widgets in 3 hours, it produces $\frac{8000}{3}$ widgets in 1 hour. There are 24 hours in a day, so $\frac{8000}{3} \times 24$ or 64,000 widgets are produced in 1 day.

27. **B.** The total cost of the purchase is $(3 \times \$0.45) + (2 + \$0.79) = \$1.35 + \$1.58 = \$2.93$.

28. **C.** Carl's throw went $7\frac{1}{3} \times 2\frac{1}{2} = \frac{22}{3} \times \frac{5}{2} = \frac{110}{6} = 18\frac{1}{3}$ yards. The difference between the two throws is $18\frac{1}{3} - 7\frac{1}{3} = 11$ yards.

29. **C.** The total distance traveled in the morning was $13 \times 2 = 26$ miles. The total distance traveled in the afternoon was $9 \times 2 = 18$ miles. The difference between the two distances is $26 - 18 = 8$ miles.

30. **D.** The percentage of cars that are either red or black are $25\% + 30\% = 55\%$. The total cars that are either red or black is $260 \times 55\% = 143$.

Word Knowledge (Practice Test 1 Answers)

1. **B.** *Hardship,* which means a difficult time or experience.

2. **B.** *Corrosive,* which means harsh or stinging.

3. **A.** *To spoil,* which means to ruin or destroy.

4. **A.** *Enjoyment. Zest* means enthusiasm or delight.

5. **B.** *To move back and forth. Sway* in this sentence means to lean or incline.

6. **D.** *Mystery. Enigma* refers to a puzzle or problem, as *mystery* also suggests.

7. **B.** *Prompt. Prompt* means precise or immediate.

8. **A.** *To dawdle,* which means to loaf or waste time.

9. **B.** *Helping. Auxiliary* here means supplementary.

10. **C.** *Skillful.* In this sentence, *deft* means adept or proficient.

11. **C.** *To wander,* which can mean to ramble or roam.

12. **B.** *Stinginess. Stingy* means miserly, closefisted, or selfish.

13. **D.** *Fruitful. Prolific* in this sentence means abundant or plentiful.
14. **B.** *Concise. Concise* means brief, to the point, or condensed.
15. **D.** *Strange. Bizarre* can mean odd, weird, or unusual.
16. **A.** *A show of respect. Tribute* means acclaim or recognition.
17. **B.** *Speaking untruth. Slander* can mean to vilify or to denigrate.
18. **D.** *Grave,* which can mean dismal or gloomy.
19. **D.** *Wealth. Affluence* means riches or abundance.
20. **B.** *Easily led. Docile* can mean submissive, compliant, or tame.
21. **B.** *Healthy. Hale* can mean hardy or fit, as in good health.
22. **B.** *Solitary. Reclusive* means reserved or aloof.
23. **B.** *Quality. Caliber* means nature or essence.
24. **A.** *Endless,* which can mean limitless or unbounded.
25. **B.** *Wealthy,* which can mean rich or prosperous.
26. **B.** *Ordinary. Trite* can mean commonplace, stale, or stereotyped.
27. **B.** *Essential,* meaning important or necessary.
28. **B.** *Motivator. Incentive* means driving force or impetus.
29. **D.** *To demolish,* which means to destroy, damage, or wreck.
30. **D.** *To scamper. Scamper* means to hasten or hustle.
31. **B.** *Wise. Prudent* can mean sensible or cautious.
32. **A.** *Passionate,* which can mean excitable or eager.
33. **B.** *Tasteless,* which can mean dull or uninteresting.
34. **C.** *To ask for. Solicit* means to beg or to implore.
35. **B.** *Meantime. Interim* means time between events or interval.

Paragraph Comprehension (Practice Test 1 Answers)

1. **A.** This selection explains what a tsunami is. It does not focus on any other Japanese words, natural disasters, or the effects of a tsunami.
2. **C.** The first sentence discusses the fact that pyromaniacs rarely start fires. The last sentence explains what a pyromaniac is.
3. **C.** The bobcat is the only name not listed in the paragraph as another name for the concolour.
4. **B.** Since the selection states that Edison did not give up easily, you can assume that being tenacious is a synonym for persistent.
5. **D.** The third sentence states that Edison had a few failed inventions, and the rest of the selection elaborates on the iron-ore mining invention attempt.

6. **C.** The selection states that regions north of the Arctic Circle experience unending periods of daylight and dark. However, regions below the Arctic Circle are not included in this analysis of daylight and dark.
7. **B.** The selection states that such plants should be watered during the cooler parts of the day. 6:00 a.m. is the coolest time of day listed.
8. **A.** This choice is the only one that makes sense in the context of the first and last sentences. That is why our bodies are "water dependent," as the selection states.
9. **D.** The answer is stated in the fourth sentence of the selection.
10. **A.** The entire selection focuses on proper steps to ensure healthy weight loss and to avoid injury by too much exercise or too much calorie restriction.
11. **C.** The article discusses the dangers of driving with any type of cellular phone; thus, it can be inferred that this is the best answer.
12. **C.** The article focuses on the dangerous nature of cellular phone usage while driving.
13. **A.** The first sentence of the paragraph states that there are many preventive measures drivers can take to avoid carjacking. The supporting sentences in the paragraph give specific ways to prevent carjacking.
14. **B.** Carrying pepper spray is not mentioned in the paragraph as a preventive measure against carjacking.
15. **D.** The author of the selection gives several practical ways to avoid carjacking. None of the other choices are statements made by the author. Thus, you may assume that carjacking can often be avoided by following the preventive measures given in the selection.

Auto and Shop Information (Practice Test 1 Answers)

1. **A.** The high pressures developed in the combustion chamber can reach the coolant through the crack in the head and show up as air bubbles in the radiator as the coolant is circulated.
2. **B.** The self-energizing effect of this type of brake system requires that the longer lined secondary shoe be in the rear part of that wheel's brake system.
3. **B.** The idea of a thermostat is to be in a closed position until a proper engine temperature is reached.
4. **B.** To control a higher current load with reduced length of large wiring, a relay is placed in the circuit.
5. **B.** The scraping metal clip is used to audibly indicate a worn brake pad condition to the driver.
6. **C.** The front wheels have calipers that combine the function of a wheel cylinder and can also be an attaching component for the brake pads.
7. **D.** The pick-up coil is part of the primary control circuit.
8. **A.** Because of the relationship between engine load (throttle position) and vacuum, some ignition systems use a vacuum advance retard unit to advance the spark proportionally to engine vacuum. This is a form of timing control.

9. D. The ignition module turns on and off the primary current based on a signal it gets from the computer.

10. C. All three components use an electromagnetic field to perform work. In the motor, the electromagnetic field is used to turn the armature. In the solenoid, it is used to move a plunger, and in the relay it is used to move a set of contacts.

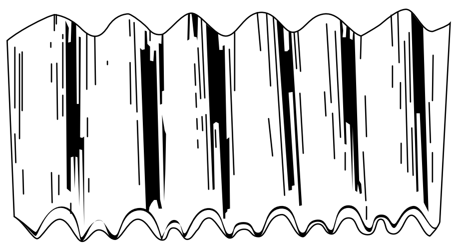
11. C. A relationship exists between voltage, current flow, and resistance in a series circuit. If resistance is increased, current flow is reduced. If resistance is reduced, current flow will increase.

12. C. Extractors are used on bolts and screws that are typically broken off flush or below the surface.

13. A. A tap is a hard tool used for cutting internal threads.

14. C. A veining bit is used in a router to cut fine lines in material, often for decorative purposes.

15. B. Corrugated fasteners (one is shown below) are probably best to use to repair split wood, since they draw the edges of the wood together. A #10 screw would be too big. Nails and glue don't really support the corners.



16. D. This is an example of a dovetail joint. It can be cut by hand or with a dovetail jig and an electric jigsaw.

17. A. The large jaws and heavier weight of a monkey wrench are ideal for loosening and tightening large nuts and bolts that are usually encountered by plumbers. While it is possible for other workers to use a monkey wrench, the question uses the word "usually," suggesting that one type of person would be more likely than the others to use the wrench. Read the questions carefully for clues.

18. D. The use of toenailing lends greater strength and holding power to joints. It is used often in framing and other rough construction projects.

19. C. A lathe is used for "turning" and cutting grooves and other decorative lines in spindle legs for chairs and tables. It is also used for turning wooden bowls.

20. B. The Phillips screw has a cross-shaped opening and is usually easier to start than a standard screw, since the screwdriver will be more secure in the grooves. You need a Phillips head screwdriver to insert these screws.

21. B. Concrete is a mixture of cement, sand, gravel, and water. If you are using premixed cement, you only need to add water.

22. C. The tang is the end of the drill that is inserted into the chuck and tightened. The tang may be square for slower hand drills, and round for high-speed electric drills.

23. A. A countersink is a bit with a cone-shaped cutting head, used to expand the top of a screw hole. This allows the head of the screw to lie flush with the material into which it is screwed.

24. D. A contour gauge is used to measure and form an outline of an object. The gauge presses against the object, assumes its shape with dozens of little steel pins, and then is transferred to whatever you are cutting—wood, glass, metal, tile, and so on.

25. A. If you nail an extension piece of wood to the end of the board you are cutting, the plane will continue along from one board to the next without chipping the end of the first board.

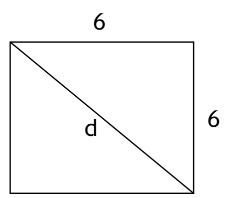
Mathematics Knowledge (Practice Test 1 Answers)

1. C. Substitute $\frac{5}{2}$ for *a,* giving you $\frac{1}{a} = \frac{1}{\frac{5}{2}} = 1 \div \frac{5}{2} = 1 \times \frac{2}{5} = \frac{2}{5}$.

2. D. Let n represent the number. If 12 is 15% of n, then $12 = 0.15n$. Divide both sides by 0.15. Therefore, $n = 80$.

3. A. Substitute -3 for x. Then $3(-3) + 7 = -9 + 7 = -2$.

4. B. The area of a square is s^2 where s is a side of the square. If $s^2 = 36$, then $s = 6$. The diagonal of a square forms two right triangles; d is the hypotenuse and the two legs are 6 units long.



Using the Pythagorean theorem, $d^2 = 6^2 + 6^2 = 36 + 36 = 72$. Therefore, $d = \sqrt{72} = 6\sqrt{2}$.

5. C. $3a + 3b = 3(a + b)$. Since $a + b = 6$, $3a + 3b = 3(6) = 18$.

6. C. The hypotenuse of the triangle is the diameter of the circle. By the Pythagorean theorem, $d^2 = 6^2 + 8^2 = 36 + 64 = 100$. So $d = \sqrt{100} = 10$ and the radius is $\frac{10}{2} = 5$.

7. D. Following the correct order of operations produces:

$(3 - 1) \times 7 - 12 \div 2 = 2 \times 7 - (12 \div 2) = 14 - 6 = 8$.

8. B. Factors of 24 are $2 \times 2 \times 2 \times 3$. Factors of 36 are $2 \times 2 \times 3 \times 3$. The greatest common factor is $2 \times 2 \times 3 = 12$.

9. C. $3m - 12 + 12 = -6 + 12$

$3m = 6$

Dividing both sides by 3 results in $m = 2$.

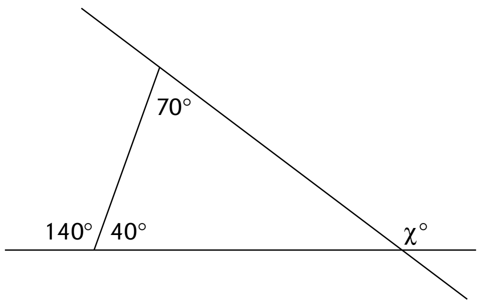
10. **B.** Substitute 1 for p and solve for q. $7(1) + 5q = -3$ and $7 + 5q = -3$.

$7 + 5q - 7 = -3 - 7$ and $5q = -10$. Dividing both sides by 5 results in $q = -2$.

11. **C.** Slope is found by identifying two points on the line and finding the $\frac{\text{change in } y}{\text{change in } x}$. The points (0, 0) and (5, 2) form the slope $\frac{2-0}{5-0} = \frac{2}{5}$.

12. **C.** $\frac{9x^2y^3z - 12xy^2z^2}{3yz} = \frac{9x^2y^3z}{3yz} - \frac{12xy^2z^2}{3yz} = 3x^2y^2 - 4xyz$

13. **B.**



The angle adjacent to the 140° angle is 40° since supplementary angles add to 180°. The angles of a triangle add to 180° so the angle adjacent to angle x is $180° - 70° - 40° = 70°$. Angle x and 70° are supplementary, so $x = 180° - 70° = 110°$.

14. **C** Probability is $\frac{\text{number of expected outcomes}}{\text{number of possible outcomes}}$. Since one king was drawn and not replaced, three kings remain in the deck of 51 cards. So the probability of drawing another king is $\frac{3}{51} = \frac{1}{17}$.

15. **A.** There are 60 minutes in 1 hour, 24 hours in 1 day, and 7 days in 1 week. So 1 week = $\frac{7\text{ days}}{1\text{ week}} \times \frac{24\text{ hours}}{1\text{ day}} \times \frac{60\text{ minutes}}{1\text{ hour}} = 7 \times 24 \times 60 = 10{,}080$ minutes.

16. **A.** $\frac{1}{8} = \frac{1}{2^3} = 2^{-3}$ so $2^{b+3} = 2^{-3}$ and $b + 3 = -3$. Therefore, $b + 3 - 3 = -3 - 3 = -6$.

17. **C.** Angles in a triangle add to 180°. So $3x + 4x + 5x = 180°$ and $12x = 180°$. Dividing both sides by 12 results in $x = 15°$. The smallest angle is represented by $3x = 3(15°) = 45°$.

18. **A.** Subtraction can be changed to addition by changing the signs in the entire term being subtracted. $(2x^3 - 3x + 1) - (x^2 - 3x - 2) = (2x^3 - 3x + 1) + (-x^2 + 3x + 2)$. Combine like terms: $2x^3 - x^2 - 3x + 3x + 1 + 2 = 2x^3 - x^2 + 3$.

19. **A.** The area of a square is s^2 where s is a side of the square. If $s^2 = 400$, then $s = \sqrt{400} = 20$.

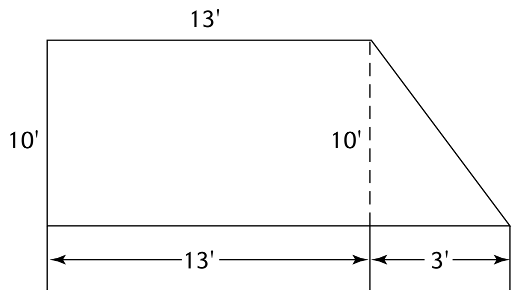
20. **C.** Translate to a mathematical expression and solve. $3x + 7 = 70$ so $3x + 7 - 7 = 70 - 7$ and $3x = 63$. Divide both sides by 3. Therefore, $x = 21$.

21. **B.** The volume of a cylinder is given by the formula $V = \pi r^2 h$, where r is the radius of the circular base and h is the height. Since $h = r$, $V = \pi r^2 r = \pi r^3$.

22. **B.** Prime factors of 120 are $2 \times 2 \times 2 \times 3 \times 5$. Distinct factors are 2, 3, and 5. Therefore, there are three distinct prime factors.

23. **C.** Let p represent the unknown percent. $p \times \frac{3}{4} = \frac{1}{8}$. Solve for p by multiplying both sides by the reciprocal of $\frac{3}{4}$. $p \times \frac{3}{4} \times \frac{4}{3} = \frac{1}{8} \times \frac{4}{3} = \frac{4}{24} = \frac{1}{6}$. As a percent, $\frac{1}{6}$ is $16\frac{2}{3}\%$.

24. **B.** Divide the figure into a rectangle and triangle as shown.



The area of the figure equals the area of the rectangle plus the area of the triangle. The rectangle = length × width or 10 × 13 = 130 ft^2; the triangle = $\frac{1}{2}$ base × height or $\frac{1}{2} \times 3 \times 10 = 15ft^2$. Together, the area is 130 + 15 = 145 ft^2.

25. **A.** Set the equation equal to 0 and factor. $x^2 + 6x - 16 = 0$ and $(x + 8)(x - 2) = 0$. Then, either $x + 8 = 0$ or $x - 2 = 0$, so $x = -8$ or $x = 2$. Since x is positive, $x = 2$ only.

Mechanical Comprehension (Practice Test 1 Answers)

1. **C.** The centripetal force of the stone is proportional to the square of the velocity.

2. **B.** The weight of a body is a force, and newton is the unit of force.

3. **D.** The joule is the unit of work, kinetic energy, potential energy, and heat.

4. **A.** The travel time depends on the height above ground and the acceleration of gravity, both of which are the same for both objects.

5. **B.** The quantity 2 m/s^2 can be thought of as 2 m/s per second; that is, speed per unit time, or acceleration.

6. **B.** From Newton's second law of motion, the centripetal force, or the inward force necessary to maintain uniform circular motion, is the product of mass and centripetal acceleration.

7. **C.** At the top of the trajectory the ball stops and all the kinetic energy has already been converted to potential energy. Thus the total energy is the sum of 100 and 700, or 800 J.

8. **D.** Since the frequency of oscillation is inversely proportional to the square root of the length of the pendulum, the length has to be decreased by a factor of 4 for the frequency to be doubled.

9. **A.** The final velocity is the initial velocity minus four times the acceleration of gravity (9.8 m/s) or –7.14 (about 7.2) m/s

10. **A.** Using the expressions $s = v_o t + \frac{1}{2}at^2$ and $v_f = v_o + at$, you obtain = 0.4 s and $v_o = 3.92$ m/s.

11. B. Since acceleration is the time derivative of the velocity, the slope has to be constant and must also be negative since the acceleration is constant and negative.

12. B. Since the torque $T = Fd \cos \theta$ where F is the force, d is the arm, and θ is the angle between the force and arm, then you can solve for F to obtain 286 N.

13. B. The speed ratio of input to output gears equals the mechanical advantage, which is the ratio N_o/N_i, or 2.

14. B. $K + \dfrac{(6.67 \times 10^{11})(400)(5.96 \times 10^{24})}{(6.37 \times 10^{6} + 3 \times 10^{6})} = \dfrac{(6.67 \times 10^{-11})(400)(5.98 \times 10^{24})}{(6.37 \times 10^{6} + 1.5 \times 10^{6})}$ or

$K = -3.25 \times 10^{9}$ J.

15. D. Since the momentum P equals the mass m times the velocity v, it follows that $v = P/m = 40.00$ m/s.

16. A. Conservation of momentum requires that $0.24(0.6) + 0.26(0.2) = (0.24 + 0.26)v$. Hence $v = 0.392$ m/s.

17. C. For rod equilibrium the clockwise and counterclockwise torques must be equal, i.e., (F at V + F at V)(d) = (F at Y) (2d) or (F at V)D = (F at Y) (2d) – (F at X)D, which means that the third force can only be applied upward at V or downward at X.

18. A. Acceleration will be the same for both arrows. Momentum and energy are dependent on mass and will therefore be different. Only the change in velocity will be the same for both arrows.

19. D. The work done does not depend on time or path of travel since the deceleration of the arrow is constant.

20. A. The resistance to motion is a force that is determined by mass in accordance with Newton's second law.

21. D. The joule is a unit of work that is force times distance. The force is mass times acceleration, which has the units of $kg.m/s^2$. Hence, $kg.m^2/s^2$ is the product of the units of force and distance.

22. C. Letting the masses of the bullet and block be m and M, and their initial velocities be u and U and their combined velocity be V, then the conversion from kinetic to potential energy requires that $\frac{1}{2}(m+M)V^2 = (m+M)gh$, where h is the increment in height (12 cm). This leads to $V = 1.533$ m/s. The conservation of momentum requires that $mu + MU = (m + M)V$ where $U = 0$. Hence, solving for u you obtain 308.258, or about 308 m/s.

23. B. Mass cannot change because of changes in the gravitational acceleration, but weight changes—and in this case decreases—since the gravitational acceleration is lower.

24. A. The acceleration is the ratio of the force and the mass. The mass remains the same while the net force is set by the mass, acceleration of gravity, slope of the inclined plane, and the coefficient of kinetic friction, which are all constant. Thus the acceleration remains the same.

25. C. Since the momentum is conserved, there is no change in speed due to the collision, and the momentum of both remains the same.

Electronics Information (Practice Test 1 Answers)

1. **B.** Symbol 2 represents a diode.
2. **C.** Electronic current is measured in amperes. Capacitance is measured in farads. Voltage difference is measured in volts. Resistors are measured in ohms.
3. **A.** Total resistance for parallel resistors is $\frac{1}{\frac{1}{200}+\frac{1}{200}} = 100\Omega$
4. **C.** Switch 1 and switch 2 only should be closed. Switch 3 must be opened; otherwise, it will cause a short circuit.
5. **D.** A voltmeter is a device used to measure the difference in voltage. An ammeter is used to measure electrical current. Electrical charge or energy cannot be measured by a voltmeter.
6. **B.** Leather gloves withstand high voltage.
7. **C.** Frequency of a wave is given as $\frac{1}{\text{wave period}} = \frac{1}{.2} = 5\text{H}$.
8. **A.** An AM modulated signal is an amplitude modulated signal. FM signals are frequency modulated signals. PSK signals are phase modulated signals. DC cannot be used for modulation.
9. **C.** The ammeter in the circuit reads the value of the current flowing in the resistor. The current flowing is calculated as $\frac{\text{V}}{\text{R}} = \frac{10}{10} = 1\text{A}$.
10. **A.** In order to protect an electric circuit, a fuse can be used. Once the current rating is higher than the fuse rating, the fuse will break, preventing the flow of current.
11. **C.** Symbol 3 represents a bipolar junction transistor (BJT).
12. **D.** A signal is transmitted by being carried on a high frequency sinusoidal signal called a carrier signal.
13. **B.** The signal $s(t)$ can be written in the form $s(t) = \text{amplitude} \times \sin(2\pi ft)$, so that the amplitude is 10 V and the frequency is 60 Hz.
14. **C.** Since all of the resistors are equal in value, then the currents in both branches of the circuit are equal. This makes the voltage difference between the leads of the voltmeter equal to zero.
15. **A.** An ohmmeter is a device used to measure resistance. A voltmeter is used to measure a voltage difference. A wattmeter is used to measure power, and an ammeter is used to measure current.
16. **B.** Signals are carried on other high frequency signals by frequency mixers.
17. **A.** A diode permits the flow of the current in one direction only: from the anode to the cathode, when the voltage applied is greater than the threshold level.
18. **C.** A coil inductance is measured in henrys. Capacitance is measured in farads. Transistors have numbers to identify them. Resistance is measured in ohms.

19. B. Electronic devices are grounded to protect the user from an electric shock.

20. A. Power dissipated in the circuit can be calculated as $\frac{V^2}{R1}+\frac{V^2}{R2}=\frac{1}{5}+\frac{1}{10}=0.3\,\text{watt}$.

Assembling Objects (Practice Test 1 Answers)

For answers, see the answer key, earlier in this section.

CUT HERE

Answer Sheet for Practice Test 2

(Remove this sheet and use it to mark your answers)

General Science

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Arithmetic Reasoning

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Word Knowledge

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Paragraph Comprehension

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Auto and Shop Information

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Mathematics Knowledge

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Mechanical Comprehension

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Electronics Information

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Assembling Objects

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ASVAB Practice Test 2

General Science

Time: 11 minutes

25 questions

1. Increasing which of the following factors would not help a plant photosynthesize faster?

A. oxygen
B. carbon dioxide
C. light intensity
D. water

2. A man with O-type blood and a woman with AB-type blood could have which type of children?

A. O
B. AB
C. A or B
D. all of the above

3. Ammonia can be produced from nitrogen and hydrogen, according to the unbalanced equation: N_2 (g) + H_2 (g) : NH_3 (g).

After balancing the equation, the coefficient before ammonia should be

A. 1.
B. 2.
C. 3.
D. 4.

4. Given the reaction 2 CO (g) + O_2 (g) : 2 CO_2 (g), when there is an increase in pressure to the system you would expect

A. an increase in the amount of carbon dioxide.
B. an increase in the amount of carbon monoxide and oxygen.
C. a decrease in the amount of carbon dioxide.
D. no change in the system.

5. Summers are warmer than winters in the Northern Hemisphere because the Earth

A. is closer to the Sun in the summer.
B. is inclined on its axis toward the Sun in the summer.
C. slows in its orbit in the summer.
D. speeds up in its orbit in the winter.

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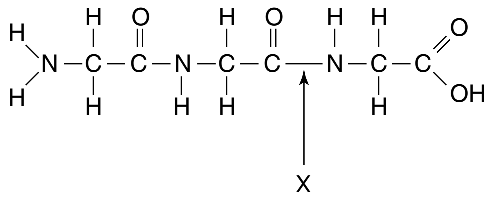
6. Consider the following chemical structure. Which of the following statements is true?



A. It represents an amino acid and X points to a disulfide bridge.

B. It represents two amino acids and X points to a peptide bond.

C. It represents three amino acids and X points to a disulfide bridge.

D. It represents three amino acids and X points to a peptide bond.

7. When blood leaves the heart and enters the pulmonary artery, it

A. has just left the right atrium.

B. is heading to the lungs.

C. has just left the left atrium.

D. is heading to the aorta.

8. A snake is an example of a

A. mammal.

B. reptile.

C. amphibian.

D. rodent.

9. Jack has 100 milliliters of a 12 molar solution of sulfuric acid. How much of it should he put into a graduated cylinder to make 20 milliliters of a 1.2 molar solution?

A. 1

B. 2

C. 10

D. 12

10. The transformation of a solid directly into a gas is called

A. vaporization.

B. ionization.

C. sublimation.

D. polarization.

11. A 50-centimeter-long metal rod expands 2 millimeters when heated in an oven. How much would a 75-centimeter-long rod of the same material expand in the same oven?

A. 2 millimeters

B. 3 millimeters

C. 4 millimeters

D. 6 millimeters

12. The organ that is most closely associated with the digestion of proteins is the

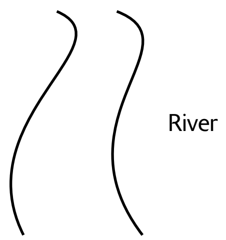
A. stomach.

B. liver.

C. small intestine.

D. large intestine.

13.



Based on the dynamics of the river portrayed in the figure above, what are the most likely changes in river flow over 500 years?

A. The bends in the river will diminish and the river will straighten.

B. The bends in the river will increase and the river will bend more.

C. The river will flow faster as it matures.

D. It is not possible to deduce the changes in the river in 500 years.

14. The further a planet is from the Sun, the longer it takes to complete an orbital revolution. The closest planet, Mercury, has an orbital period of almost 88 days. Jupiter has an orbital period of about 12 Earth-years. Based on this information, what is your best guess as to the length of the orbital period of Neptune?

A. 200 days

B. 5 years

C. 10 years

D. 165 years

15. The vast dust bowls of the American Midwest during the Great Depression of the 1930s were the result of a combination of factors leading to massive erosion. Which of the following could be argued as the most instrumental in creating wastelands?

A. high winds

B. lack of ground cover

C. flat topography

D. periodic thunderstorms

16. Which of the following gases is least common in the atmosphere?

A. methane

B. oxygen

C. argon

D. nitrogen

17. Which of the following organisms is NOT an invertebrate?

A. sponge

B. jellyfish

C. snail

D. fish

18. If a solution has a hydronium ion concentration of 0.1 mole/liter, what would be its pH?

A. 0.1

B. 0.2

C. 1.0

D. 2.0

19. The correct structural formula for ethyne is

A. $H - C = C - H$

B. $H - C = C = H$

C. $H - C \equiv C - H$

D. $H = C = C = H$

GO ON TO THE NEXT PAGE

20. A car is driving around a curve on a level road. The force holding the car on the curve is

A. friction.
B. gravity.
C. tension.
D. magnetic.

21. If you were looking for DNA in a cell, you would find it in the

A. endoplasmic reticulum.
B. nucleus.
C. vacuole.
D. plasma membrane.

22. What is the oxidation number of lead (Pb) in PbF_2 ?

A. -1
B. -2
C. +1
D. +2

23. As you move down a column on the left side of the periodic table, which of the following statements is true?

A. The size of the ion becomes smaller.
B. The electronegativity decreases.
C. The electrons are held more tightly.
D. The number of neutrons remains the same.

24. The male part of a flower is referred to as the

A. ovary.
B. pistil.
C. sepal.
D. stamen.

25. The central nervous system in humans is made up of

A. the brain and the spinal cord.
B. the brain and the muscles.
C. the brain and the heart.
D. the brain and the lungs.

STOP

Arithmetic Reasoning

Time: 36 minutes

30 questions

1. Mattie walked 45 yards north, 36 yards west, and 41 yards south. Jacob walked 16 yards north, 49 yards west, and 33 yards south. How much farther did Mattie walk than Jacob?

   A. 20 yards
   B. 22 yards
   C. 24 yards
   D. 28 yards

2. A cylinder whose height is 8 inches has a volume of $128\pi cm^3$. If its radius is doubled and its height is cut in half, the volume of the resulting cylinder is

   A. $64\pi cm^3$.
   B. $128\pi cm^3$.
   C. $256\pi cm^3$.
   D. $512\pi cm^3$.

3. The sum of 2 feet $2\frac{1}{2}$ inches, 4 feet $3\frac{3}{8}$ inches, and 3 feet $9\frac{3}{4}$ inches is

   A. 9 feet $\frac{7}{8}$ inches.
   B. 9 feet $9\frac{5}{8}$ inches.
   C. 10 feet $\frac{5}{8}$ inches.
   D. 10 feet $3\frac{5}{8}$ inches.

4. Doug earns 15% commission on all sales over $5,000. Last month, his sales totaled $12,500. What were Doug's earnings?

   A. $750
   B. $1,125
   C. $1,875
   D. $2,625

5. Fencing costs $4.75 per foot. Posts cost $12.50 each. How much will it cost to fence a garden if 10 posts and 34 feet of fencing are needed?

   A. $472.50
   B. $336.50
   C. $315.50
   D. $286.50

6. How much change would you get back from a $20.00 bill if you purchased eight CD covers costing $1.59 each?

   A. $7.28
   B. $10.41
   C. $12.00
   D. $18.41

7. The scale on a map shows 500 feet for every $\frac{1}{4}$ inch. If two cities are 6 inches apart on the map, what is the actual distance they are apart?

   A. 125 feet
   B. 750 feet
   C. 2,000 feet
   D. 12,000 feet

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8. A 10-foot rope is to be cut into equal segments measuring 8 inches each. The total number of segments is

A. 1.

B. 8.

C. 15.

D. 40.

9. Rayanne can read one page in 2 minutes. If a book has 80 pages, how long will it take her to read?

A. 160 minutes

B. 120 minutes

C. 80 minutes

D. 40 minutes

10. Three boxes are needed to hold 18 reams of paper. How many boxes are needed for 90 reams?

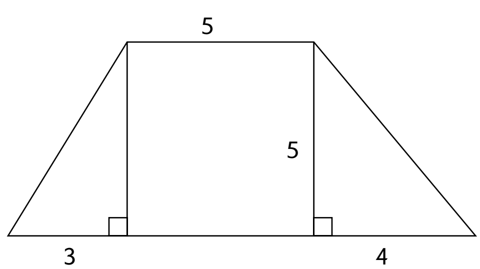
A. 5

B. 6

C. 9

D. 15

11. The area of the figure is



A. 42.5.

B. 47.

C. 52.5.

D. 60.

12. Cards normally sell for $3.00 each. How much was saved if five cards were purchased on sale for two for $5.00?

A. $2.50

B. $5.00

C. $12.50

D. $15.00

13. One gallon of paint covers 400 square feet. How many gallons are needed to cover 2,225 square feet?

A. 5 gallons

B. 6 gallons

C. 7 gallons

D. 8 gallons

14. A restaurant bill without tax and tip comes to $38.40. If a 15% tip is included after a 6% tax is added to the amount, how much is the tip?

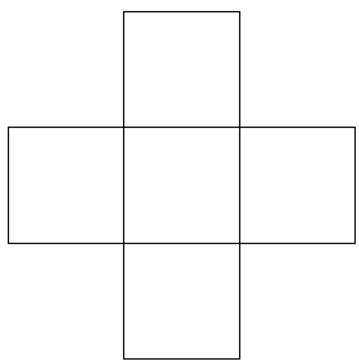
A. $6.11

B. $5.76

C. $5.15

D. $2.30

15. The figure contains five equal squares. If the area is 405, what is the perimeter?



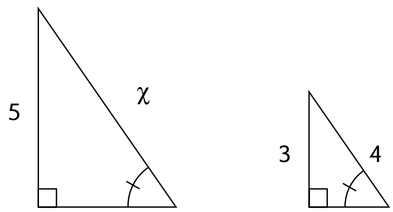
A. 81

B. 90

C. 108

D. 144

16. Find the length of x in the figure.



A. $6\frac{2}{3}$

B. $7\frac{1}{3}$

C. $8\frac{1}{4}$

D. $\frac{15}{4}$

17. Joann eats $\frac{1}{4}$ of a peach pie and divides the remainder of the pie among her four friends. What fraction of the pie does each of her friends receive?

A. $\frac{1}{3}$

B. $\frac{7}{12}$

C. $\frac{3}{16}$

D. $\frac{1}{8}$

18. Max weighs 209 pounds. If he loses 2 pounds per week, how much will he weigh in 7 weeks?

A. 191 pounds

B. 195 pounds

C. 202 pounds

D. 207 pounds

19. An appliance originally costing $1,000 goes on sale one week for 25% off. The following week, it is discounted an additional 10%. What is the new sale price of the appliance?

A. $650

B. $675

C. $750

D. $900

20. Dennis ran a race in 2.2 minutes. Kayla ran the same race in 124 seconds. What is the difference between these two times?

A. 2 seconds

B. 8 seconds

C. 14 seconds

D. 22 seconds

21. A taxi ride costs $3.00 for the first mile and $1.00 each additional half mile. What is the cost of a 10-mile ride?

A. $10

B. $12

C. $13

D. $21

22. If 3 cans of soup cost $5.00, how much do 10 cans cost?

A. $15.00

B. $16.45

C. $16.67

D. $17.33

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23. Kyle ran 3 miles in $17\frac{1}{2}$ minutes on Saturday, $4\frac{1}{2}$ miles in 22 minutes on Sunday, and 2 miles in 9 minutes on Monday. What was Kyle's average rate of speed while running?

A. 1.6 minutes per mile

B. 5.1 minutes per mile

C. 16.2 minutes per mile

D. 17.8 minutes per mile

24. You have 40 nickels and 12 dimes. What is the total amount of money that you have?

A. $0.52

B. $3.20

C. $4.60

D. $5.20

25. A savings account earns $2\frac{1}{4}$% interest each year. How much interest is earned on a $1,000 deposit after a 5-year period?

A. $22.50

B. $100.00

C. $112.50

D. $150.00

26. Vanda put some water in the freezer. When she removed it, the water's temperature was 0°C. Leaving it out will raise the temperature 4°F each hour. At this rate, when will the water's temperature be 52°F?

A. 4 hours

B. 5 hours

C. 13 hours

D. 52 hours

27. Stanley types 35 words per minute. If it takes him a half hour to type a document, how many words are in it?

A. 900

B. 1,050

C. 1,500

D. 2,100

28. Sandy bought $4\frac{1}{2}$ pounds of apples and six kiwi fruits. Brandon bought $3\frac{1}{4}$ pounds of apples and nine kiwi fruits. If apples cost $1.39 per pound and kiwis are two for $1.00, how much more money did Sandy spend than Brandon?

A. $0.24

B. $0.94

C. $1.54

D. $2.32

29. Bryan agrees to pay back a $50,000 loan over a 10-year period. If the interest rate is 8%, what will his monthly payments be?

A. $450

B. $540

C. $3,333

D. $5,400

30. In a nut mixture, there are $1\frac{1}{8}$ pounds of almonds, $2\frac{3}{4}$ pounds of cashews, and $3\frac{1}{3}$pounds of peanuts. The total weight of the mixture is

A. $6\frac{1}{3}$ pounds.

B. $6\frac{23}{24}$ pounds.

C. $7\frac{5}{24}$ pounds.

D. $7\frac{7}{12}$ pounds.

STOP

Word Knowledge

Time: 11 minutes

35 questions

1. **Innovation** most nearly means

- **A.** a myriad.
- **B.** a threat.
- **C.** an antique.
- **D.** a new idea.

2. She would not **divulge** who told her.

- **A.** care for
- **B.** leave
- **C.** reveal
- **D.** hurt

3. The child did not **heed** her mother's advice.

- **A.** pay attention to
- **B.** learn from
- **C.** ignore
- **D.** solicit

4. **Foil** most nearly means

- **A.** pass time.
- **B.** prevent.
- **C.** jump.
- **D.** assist.

5. **Startle** most nearly means

- **A.** climb.
- **B.** surprise.
- **C.** reject.
- **D.** sparkle.

6. **Stupefy** most nearly means

- **A.** stretch.
- **B.** repress.
- **C.** astonish.
- **D.** agonize.

7. She was upset by the **blemish** on her record.

- **A.** grade
- **B.** writing
- **C.** defect
- **D.** message

8. She cared only about her child's **proximity** to her.

- **A.** obedience
- **B.** behavior
- **C.** grades
- **D.** nearness

9. They were all involved in the **clash**.

- **A.** conflict
- **B.** party
- **C.** dance
- **D.** singing

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10. **Wry** most nearly means

A. seeded.
B. twisted.
C. on-target.
D. holistic.

11. **Verdant** most nearly means

A. green.
B. late.
C. mountainous.
D. true.

12. The crowd began to **jeer** when Alvin got up to speak.

A. laugh
B. scoff
C. cry
D. whistle

13. **Strident** most nearly means

A. harsh.
B. running.
C. walking.
D. soft.

14. **Shear** most nearly means

A. cut.
B. clear.
C. empty.
D. violate.

15. They would always **relish** their time in Vermont.

A. feel sorrow at
B. enjoy
C. forget
D. talk about

16. She was dressed in a **crimson** sweater.

A. reddish
B. yellow
C. moth-eaten
D. torn

17. **Obsolete** most nearly means

A. original.
B. out of use.
C. new.
D. beginning.

18. **Facet** most nearly means

A. a waterfall.
B. a side.
C. a trophy.
D. a quest.

19. **Extol** most nearly means

A. slander.
B. remove.
C. withdraw.
D. praise.

20. **Exodus** most nearly means

- **A.** bundle.
- **B.** departure.
- **C.** religion.
- **D.** season.

21. He rubbed his arms **vigorously**.

- **A.** painfully
- **B.** energetically
- **C.** slowly
- **D.** quietly

22. Emily was a **familiar** figure in town.

- **A.** lonesome
- **B.** well-known
- **C.** welcome
- **D.** unusual

23. **Detriment** most nearly means

- **A.** sludge
- **B.** pleasure
- **C.** damage
- **D.** decision

24. **Glutton** most nearly means

- **A.** gourmet
- **B.** flavor
- **C.** overeater
- **D.** sheepskin

25. They could not **refute** his testimony.

- **A.** care for
- **B.** disprove
- **C.** return to
- **D.** ignore

26. **Luster** most nearly means

- **A.** intelligence.
- **B.** dullness.
- **C.** cleanliness.
- **D.** brilliance.

27. **Lucrative** most nearly means

- **A.** barren.
- **B.** majestic.
- **C.** profitable.
- **D.** probable.

28. They wanted to go on a **leisurely** ride along the water.

- **A.** quick
- **B.** cautious
- **C.** sight-seeing
- **D.** unhurried

29. **Accord** most nearly means

- **A.** bicycle.
- **B.** agreement.
- **C.** threat.
- **D.** sideline.

GO ON TO THE NEXT PAGE

30. He showed her the **excerpt** in the notebook.

- **A.** drawing
- **B.** extract
- **C.** poem
- **D.** signature

31. The coach could not **diagnose** the team's scoring problem.

- **A.** diminish
- **B.** analyze
- **C.** talk about
- **D.** grant

32. **Innate** most nearly means

- **A.** stalwart.
- **B.** inborn.
- **C.** favorite.
- **D.** primary.

33. **Maxim** most nearly means

- **A.** an enlargement.
- **B.** an endorsement.
- **C.** a saying.
- **D.** a faculty.

34. **Hyperbole** most nearly means

- **A.** exaggeration.
- **B.** a joke.
- **C.** withdrawal.
- **D.** excitement.

35. The oil began to **seep** through the surface of the earth.

- **A.** fall
- **B.** ooze
- **C.** rain
- **D.** stretch

STOP

Paragraph Comprehension

Time: 13 minutes

15 questions

1. The business executive's presentation was incoherent. His slurred words and mumbling made his speech very difficult to understand.

In this context, the word *incoherent* means

A. brilliant.

B. successful.

C. illogical.

D. understandable.

2. Many plants that appear pretty are actually invasive and harmful to the environment in which they grow. Such plants establish themselves in new areas and eventually displace plants that grow naturally in the region. Eventually, many plant species become displaced and then endangered.

The best title for this selection is

A. Endangered Species.

B. Beautiful Plants Can Be Dangerous to the Environment.

C. Displaced Species.

D. The Plant World.

3. There are many easy ways to conserve water in the home. One way to use less water is to take shorter showers. Another method of conserving water is to make sure there are no leaky faucets or running toilets in the home. These are only a few ways to conserve water, and there are many other quick and easy tricks everyone can learn in order to help conserve environmental resources and lower the water bill.

Which of the following is *not* mentioned as a method of conserving water?

A. checking for leaky faucets

B. taking shorter showers

C. using dishwashers

D. checking for running toilets

4. Regular weight lifting has been shown to improve muscle mass in people of all ages. Even ninety-year-old participants in weight-lifting studies benefited by supplementing their muscle mass.

It can be inferred from the above passage that

A. ninety-year-old participants show the most improvements in muscle mass in weight-lifting studies.

B. younger people would not benefit from weight lifting.

C. weight lifting 10 times a year would produce benefits for all ages.

D. you can begin regular weight lifting at any age and see benefits.

GO ON TO THE NEXT PAGE

5. Comets have been known of since antiquity, unlike many of the planets and other small bodies in space. In fact, Chinese records dating as far back as 240 B.C. mention Halley's Comet in particular. The famous Bayeux Tapestry, which portrays the Norman Conquest in 1066, also shows the image of Halley's Comet.

The best title for this passage is

A. Halley's Comet.
B. Ancient Knowledge of Comets.
C. Art and Comets.
D. Comets and Planets.

6. Alexander Fleming's discovery of penicillin in the 1920s happened in part because of his disorganized lab. While straightening up his lab one day, he noticed an unidentified type of mold growing in his petri dishes. All around this particular mold, staph bacteria had been killed. Fleming noted that this eradication of staph bacteria by a mold was highly unusual. Thus began his work on penicillin for which he won the Nobel Prize in 1945.

It can be inferred from the above passage that Fleming's discovery of penicillin was partly due to

A. his long search for it.
B. his years of work with mold of all types.
C. his disorganized lab.
D. his belief that such a wonder drug existed.

7. Recent sociological studies report that violence among adolescents is linked to television watching. Researchers found that teens who watch more than 1 hour of television per day are at increased risk for being involved in assaults, fights, and other violent criminal behaviors later in life.

The author probably believes that

A. television exposure should be strictly limited for teens.
B. teens should watch only nonviolent programming.
C. teens can watch as much television as they would like.
D. teens can watch more than 1 hour of television per day as long as they watch nonviolent programs.

8. Newly developed cheap, plastic solar cells could be the answer to more effective use of solar energy. Such cells offer many advantages over current solar cells. The first advantage is the small size of these plastic solar cells that would replace the bulky solar cells being used at this time. Also, such plastic solar cells are very easily manufactured. Perhaps the most convincing argument for implementing these new plastic solar cells is that they are very inexpensive to make.

Which of the following is not mentioned as a reason for using plastic solar cells?

A. They are cheap.
B. They are very energy efficient.
C. They are small.
D. They are easy to make.

9. Early, controversial studies of chimpanzees and language showed that these animals can understand the basics of language on the two-and-a-half-year-old level of children. Recent studies have shown that other chimpanzees, such as the Bonobo or pygmy, are more humanlike and adept at language and communication than the earlier chimpanzees who were studied.

The best title for this selection is

A. Recent Studies of Chimpanzees and Language Skills.

B. Language Levels of Various Chimps.

C. The Pygmy Chimp.

D. The Evolution of Chimpanzees and Language Skills.

10. In the winter of 1999, many central and northeastern states received less snow in winter than the average. Scientists have proposed several reasons for the situation. One possible factor is global warming; however, scientists still know very little about this phenomenon. Another credible reason for less snowfall is La Niña, which causes unusually cold ocean temperatures in the Equatorial Pacific. The result of a strong La Niña is greatly increased snowfall in the northwest and less snowfall in the central and northeastern United States. Thus, it may appear that there is less snow in a given year.

It may be inferred from the selection that

A. many environmental factors influence average annual snowfall.

B. La Niña determines annual snowfall averages.

C. global warming affects annual snowfall averages.

D. annual snowfall averages always stay constant.

Questions 11 and 12 relate to the following passage.

Recent sociological studies indicate several key factors in determining a person's risk of being mugged. One factor is the particular neighborhood in which a person lives and works. If the home or workplace is on a street in a suburban area or in the inner city, risk increases significantly. Also, weekdays present a higher risk for mugging than weekends. Finally, a person who walks alone either during the day or at night is more likely to be targeted for mugging.

11. According to the selection, a person is most likely to be mugged if

A. he or she lives in a rural area.

B. he or she is in a small group of people.

C. he or she goes shopping during the week.

D. he or she takes the bus to work.

12. The most appropriate title for this selection is

A. Risk Factors for Mugging.

B. How to Prevent Mugging.

C. Recent Studies on Mugging.

D. Popularity of Mugging in the Suburbs.

GO ON TO THE NEXT PAGE

Questions 13 to 15 relate to the following passage.

If you are thirsty, most likely you are already dehydrated. Most people underrate the importance of drinking water all day long. They wait until their throats are parched or they eat meals before they drink any fluids—and they usually don't choose water. Since the human body is about two-thirds water, drinking it is essential to maintaining good health. Just a few of the benefits of staying hydrated are better memory throughout the day, increased energy, and less tiredness.

13. In this context, *parched* means

A. sore.

B. wet.

C. dry.

D. hydrated.

14. It can be inferred from this selection that most people are

A. rarely ever dehydrated.

B. dehydrated quite often without knowing it.

C. dehydrated despite drinking large quantities of water.

D. often hospitalized for severe dehydration.

15. The best title for this selection is

A. The Benefits of Drinking Water.

B. Dehydration and the Importance of Drinking Water.

C. Better Memory with Water.

D. How to Stay Hydrated.

STOP

Auto and Shop Information

Time: 11 minutes

25 questions

1. When replacing a battery, what is the first step of a replacement procedure?

A. Clean the battery area.

B. Remove any hold-down device.

C. Disconnect the ground cable.

D. Disconnect the positive cable.

2. Which is the most likely cause of a vibration after a U-joint is replaced on a two-piece drive shaft?

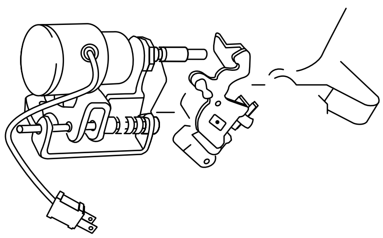
A. The U-joint is not lubricated.

B. The drive shaft is out of phase.

C. A snap ring is not seated.

D. The pinion seal let go.

3.



On carbureted vehicles, the device shown above is used to

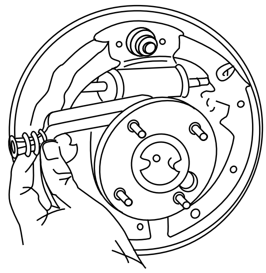
A. control EGR flow.

B. control engine fast idle during warm-up.

C. control engine idle speed.

D. modulate fuel pressure.

4.



In the illustration above, a bar is being removed. What is the purpose of this bar?

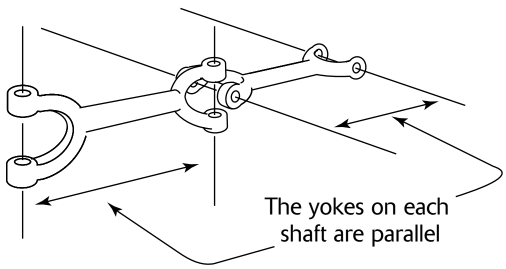
A. to force the shoes against the drum when the parking brakes are applied

B. to prevent the shoes from going too far into the wheel cylinder

C. to center the shoes

D. to allow the shoes to return after a brake application

5.



Looking at the figure above, Technician A says this figure shows the setup for the drives on a front-wheel-drive car. Technician B says this setup shows a two-piece drive in phase. Who is right?

A. A only

B. B only

C. both A and B

D. neither A nor B

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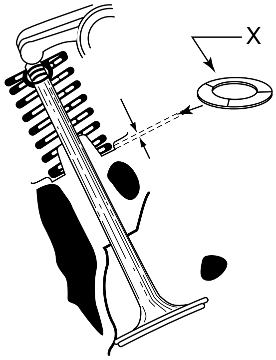
Practice Test 2



6. The part "X" shown above is used for what purpose?

A. to seal the valve guide

B. to rotate the valve spring

C. to correct spring height

D. to adjust valve clearance

7. A torque converter in an automatic transmission is used to

A. shift the transmission through different gears.

B. transfer engine torque from the engine to the transmission.

C. convert torque direction from forward to reverse.

D. reduce engine torque to the transmission.

8. The front of a vehicle with disc/drum brakes has an abnormal dip when the brakes are lightly applied. Which of these is the most likely cause?

A. defective booster

B. defective metering valve

C. defective proportioning valve

D. collapsed brake hose

9. The primary purpose of a vacuum check valve on a power brake booster is to

A. balance vacuum with atmosphere pressure.

B. provide power assist in the event of engine failure.

C. prevent excess vacuum from entering booster.

D. reduce vacuum flow.

10. The function of a brake drum or rotor is to act as

A. a friction element.

B. a heat sink.

C. a heat extinguisher.

D. all of the above.

11. Which of the following statements about carburetor systems is not true?

A. A dashpot is used during rapid deceleration to speed the closing of the throttle.

B. An accelerator pump is needed to supply fuel rapidly during sudden acceleration.

C. A power valve is a vacuum-operated metering rod.

D. Metering rods are actuated mechanically or by vacuum.

12. Which of the following measurements cannot be performed with a DVOM?

A. open circuit voltage

B. voltage drop

C. resistance

D. resistance on a live circuit

13. When an ammeter is directly connected to the negative and positive of a vehicle's battery, the result will be

A. slow discharge of the battery.

B. an indication of the battery's amperage.

C. usually a burned-out meter.

D. an accurate reading.

14. To make a wide groove in a board with a table saw, what type of blade would you use?

A. mitre

B. cross-cut

C. rip

D. dado

15. The proper consistency of concrete is

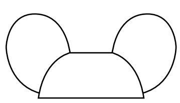
A. like mud.

B. loose and watery.

C. hard and well-packed.

D. lumpy.

16.



This type of nut is called

A. a butterfly nut.

B. a wing nut.

C. a clip nut.

D. a screw bolt.

17. You are most likely to find a dovetail joint

A. on the back of a mirror.

B. on the back of a drawer.

C. on floorboards.

D. on metal appliances.

18. A cold chisel is used to cut

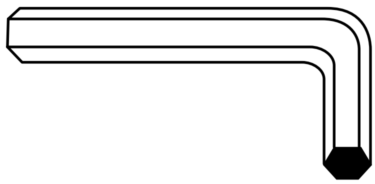
A. metal.

B. plywood.

C. hardwood.

D. glass.

19.



This is an illustration of a

A. hex screw.

B. Allen wrench.

C. corner joiner.

D. square screw hook.

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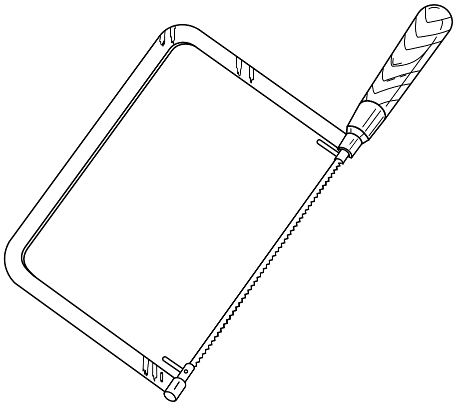
20.



The tool illustrated above is used to

A. cut through soft metals or nails.

B. cut thin wood or plastic.

C. cut Sheetrock.

D. cut holes in wood for door locks.

21. For heavy-duty construction work, such as sectioning large framing timber, you would probably choose a

A. circular saw.

B. saber saw.

C. reciprocating saw.

D. chain saw.

22. The strongest bond for a wood joint would be

A. carpenter's glue.

B. corrugated fasteners.

C. tack nails.

D. grooved dowels and glue.

23. Which of the following is used for finishing a piece of wood?

A. belt sander

B. palm sander

C. disk sander

D. no. 40 sandpaper

24. What is a kerf?

A. an unused portion of wood that has been sawed

B. the width of a saw's cut

C. the angle of the saw's teeth

D. the number of teeth on a saw

25. A nail set is used to

A. align nails in a straight line.

B. drive nail heads below the surface of the wood.

C. remove old nails.

D. flatten the heads of finishing nails for decorative purposes.

STOP

Mathematics Knowledge

Time: 24 minutes

25 questions

1. Multiply $(2x + 1)(2x + 1)$.

A. $2x^2 + 1$

B. $4x^2 + 1$

C. $4x^2 + 2x + 1$

D. $4x^2 + 4x + 1$

2. $\frac{5}{16} + \frac{9}{24} =$

A. $\frac{11}{16}$

B. $\frac{14}{40}$

C. $\frac{7}{20}$

D. $\frac{14}{48}$

3. The sum of $\sqrt{50} + 3\sqrt{72}$ is

A. $4 + \sqrt{122}$

B. $4\sqrt{122}$

C. $7\sqrt{2}$

D. $23\sqrt{2}$

4. Simplify $5(a \times 2) \times (4a \times 6)$.

A. $a \times 4$

B. $a \times 8$

C. $a \times 10$

D. $a + 4$

5. What is the diameter of a circle whose circumference is equivalent to its area?

A. 2

B. 3

C. 4

D. 6

6. The cube of 8 is

A. 2.

B. 24.

C. 512.

D. 8,000.

7. Find the area of a triangle whose base is 3 inches less than its height.

A. $\frac{1}{2}h^2 - 3h$

B. $\frac{1}{2}h^2 - \frac{3}{2}h$

C. $\frac{1}{2}h - \frac{3}{2}$

D. $\frac{1}{2}h^2 - 3$

8. Evaluate $3r^3 - 2s^2 + t$ if $r = -1$, $s = -2$, and $t = -3$.

A. 2

B. 4

C. –8

D. –14

9. The product of two numbers is 117. If one of the numbers is 9, what is the other?

A. 11

B. 13

C. 15

D. 17

Practice Test 2

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10. Simplify $\left(\dfrac{a^{-3}b^{2}}{2ab^{-1}}\right)^{-3}$

A. $\dfrac{2a^6}{b}$

B. $\dfrac{8a^{12}}{b^9}$

C. $\dfrac{a^8}{8b^3}$

D. $\dfrac{a^{12}}{8b^9}$

11. There are five more boys in the kindergarten class than girls. If there are 27 children altogether, how many are boys?

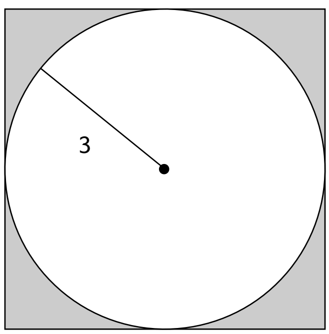
A. 10

B. 11

C. 16

D. 22

12. The area of the shaded region is



A. $9 - 3\pi$

B. $36 - 3\pi^2$

C. $36 - 9\pi$

D. $81 - 9\pi$

13. The product of the square of x and three less than x is

A. $\sqrt{x}(x - 3)$

B. $\sqrt{x}(3 - x)$

C. $x^2(x - 3)$

D. $x^2(3 - x)$

14. The cube root of 512 is

A. 8

B. 56

C. $170\frac{2}{3}$

D. 1,536

15. What is the probability of rolling a sum of 9 using two dice?

A. $\frac{1}{4}$

B. $\frac{1}{9}$

C. $\frac{5}{12}$

D. $\frac{7}{36}$

16. If the diameter of a circle is increased by 100%, the area is increased by

A. 50%.

B. 100%.

C. 200%.

D. 400%.

17. Which mathematical statement best represents the following? Six less than a number is four.

A. $6 = n - 4$

B. $6 < n + 4$

C. $6 - n = 4$

D. $n - 6 = 4$

18. Factor $2a^2 - 4ab + ab - 2b^2$

A. $(a + 2b)(2a - b)$

B. $(a - 2b)(2a + b)$

C. $(2a - b)(a + 2b)$

D. $(2a + b)(a - b)$

19. If $\frac{m}{n} = \frac{3}{5}$, what is the value of $m + n$?

A. 2

B. 8

C. $\frac{6}{5}$

D. $\frac{9}{25}$

20. Floor tiling costs $13.50 per square yard. What would it cost to tile a room 15 feet long by 18 feet wide?

A. $20

B. $405

C. $1,350

D. $3,645

21. A rope is made by linking beads that are $\frac{1}{2}$ inch in diameter. How many feet long is a rope made from 60 beads?

A. $2\frac{1}{2}$ feet

B. 10 feet

C. 30 feet

D. 120 feet

22. If $2y + 6 = 3y - 2$, then $y =$

A. –2

B. 2

C. 4

D. 8

23. $-3(-4 - 5) - 2(-6) =$

A. 0

B. –5

C. 15

D. 39

24. Which of the following expressions represents the cost of five books and three magazines if books cost twice as much as magazines?

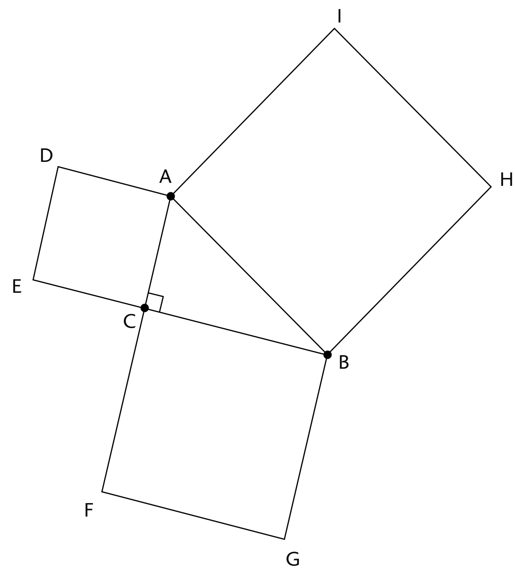
A. $8b$

B. $8m$

C. $11b$

D. $13m$

25. Squares ADEC, BCFG, and ABHI are shown. If the area of ADEC is 81 and the area of BCFG is 144, what is the perimeter of triangle ABC?



A. 36

B. 72

C. 225

D. 450

STOP

Practice Test 2

Mechanical Comprehension

Time: 19 minutes

25 questions

1. Which of the following best describes a ball's path in the air after it is thrown by one player to another?

   A. straight line
   B. parabola
   C. circle
   D. hyperbola

2. Mr. James pushes against the wall with a force of 30 newtons for 30 seconds. If the wall does not move, then the work done on the wall is

   A. positive.
   B. negative.
   C. zero.
   D. none of the above.

3. Kinetic energy is that type of energy that depends upon

   A. acceleration.
   B. temperature.
   C. position.
   D. velocity.

4. Potential energy is that type of energy that depends upon

   A. temperature.
   B. position.
   C. mass.
   D. motion.

5. In the absence of any force, a moving object will

   A. continue to move in a circular path.
   B. immediately stop.
   C. slow down and eventually stop.
   D. move in a straight line at a constant speed.

6. If the acceleration of an object is zero, then

   A. the net force on the object is zero.
   B. there are no forces acting on the object.
   C. the object is at rest.
   D. the applied force is larger than zero.

7. A ball is thrown horizontally from the top of a building. At the same time, another ball is dropped from the same height. Which ball will hit the ground first?

   A. the ball thrown horizontally
   B. the ball dropped from rest
   C. depends on the height of the building
   D. both will hit the ground at the same time

8. The force of kinetic friction is always directed opposite to

   A. the applied force.
   B. the direction of motion.
   C. the direction of gravity.
   D. the normal force.

9. If a mass at the end of a simple pendulum with a small amplitude of motion is increased by a factor of 2, other things remaining constant,

A. its period will double.
B. it will have the same frequency.
C. the period will increase by a factor of 2.
D. the frequency remains the same.

10. For an object with simple harmonic motion, simultaneously its

A. displacement is maximum when its acceleration is maximum.
B. velocity is maximum when its displacement is maximum.
C. kinetic energy is maximum when its displacement is maximum.
D. velocity is maximum and its acceleration is maximum.

11. A wheel is rotating with a constant frequency. A point on the outside of the wheel compared to a point near the center has ________ linear speed and _________ angular speed.

A. the same, the same
B. the same, a smaller
C. a greater, the same
D. a smaller, the same

12. A skater is spinning with a constant angular momentum. If she pulls her arms in towards her body, her angular momentum will

A. double.
B. increase.
C. decrease.
D. remain constant.

13. The average acceleration of a runner who changes her speed from 3.60 to 4.24 m/s in a time of 5.6 seconds is

A. 0.700 m/s^2
B. 0.114 m/s^2
C. 0.580 m/s^2
D. 0.230 m/s^2

14. A ball is thrown vertically upward with a speed of 14.5 m/s from the top of a 50-meter-tall building. The ball will reach the ground after a time of

A. 1.48 seconds.
B. 2.96 seconds.
C. 3.00 seconds.
D. 5.00 seconds.

15. A 4-kilogram ball moving at a speed of 2 m/s collides head-on with another ball of 2-kilogram mass and 4 m/s speed. If the two balls stick together, their joint speed after the elastic collision is

A. 0 m/s.
B. 1 m/s.
C. 2 m/s.
D. 4 m/s.

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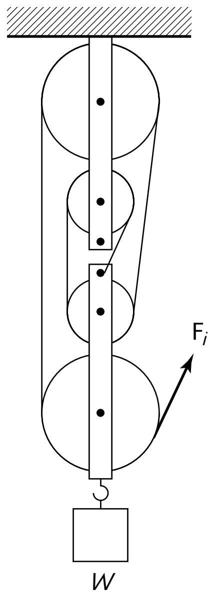
16. The input force required to lift a 200-newton load *W* in the pulley arrangement shown in the figure is



A. 40 newtons.

B. 50 newtons.

C. 800 newtons.

D. 1,000 newtons.

17. A force of 20 newtons is applied for 10 seconds to an object that has an initial momentum of 300 kilograms m/s. The final momentum of the object is

A. 100 kilograms m/s.

B. 200 kilograms m/s.

C. 300 kilograms m/s.

D. 500 kilograms m/s.

18. An object is thrown with a horizontal velocity of 10 m/s from the edge of a building that is 12.5 meters above ground level. If the air resistance is negligible, the time *t* that it takes the object to reach the ground and the distance *d* from the building where it strikes the ground are most nearly

A. 3, 100

B. 1.6, 16

C. 3.2, 32

D. 1.6, 32

19. A block of mass 3 kilograms slides along a horizontal tabletop. A horizontal force of 10 newtons and a downward vertical force of 17.4 newtons act on the block at the same time. If the coefficient of kinetic friction of the table is 0.25, the net horizontal force exerted on the block is nearly

A. 3 newtons.

B. 5 newtons.

C. 7 newtons.

D. 9 newtons.

20. A man pulling a small box along the floor suddenly decides to raise his pulling hand. If the pulling force remains the same, the amount of work done to pull the box the same distance

A. increases.

B. decreases.

C. remains the same.

D. depends on the mass of the box.

21. An ice skater is touching her waist while spinning. Suddenly the music changes and she extends her hands out so that her fingers are twice as far from the axis of rotation. Her spin rate

A. increases significantly.
B. decreases significantly.
C. increases slightly.
D. decreases slightly.

22. A net force of 40 newtons on an object results in an acceleration of 8 m/s^2. The mass of the object is

A. 0.2 kilograms.
B. 2 kilograms.
C. 5 kilograms.
D. 320 kilograms.

23. The unit kg. m^2/s^2 is equivalent to

A. a newton.
B. horsepower.
C. a watt.
D. a joule.

24. A 15-newton horizontal force is used to push a 2-kilogram mass up a 30° frictionless inclined plane. The acceleration of the mass is nearly

A. 0.32 m/s^2.
B. 3.2 m/s^2.
C. 0.16 m/s^2.
D. 1.6 m/s^2.

25. A 20-kilogram box is raised to a height of 75 meters in 2 minutes. The power required is

A. 12.25 watts.
B. 122.5 watts.
C. 750 watts.
D. 1,500 watts.

STOP

Electronics Information

Time: 9 minutes

20 questions

1. An ammeter is a device used for measuring

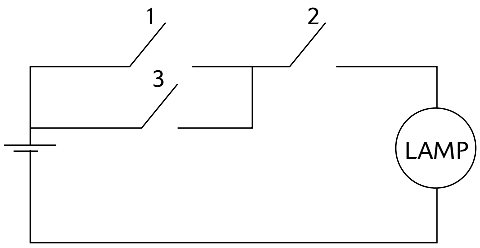
A. electrical current.

B. electrical charge.

C. energy.

D. difference in voltage.

2. For the lamp to be turned on in the following circuit



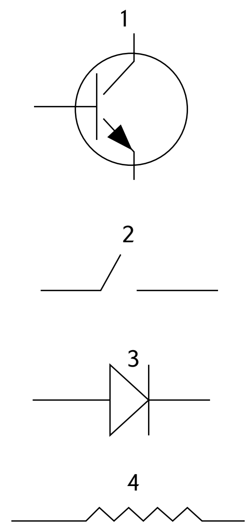
A. switch 1 or switch 2 should be closed.

B. switch 2 only should be closed.

C. switches 1 or 3 and 2 should be closed.

D. all the switches should be opened.

3. Which of the following symbols represents a transistor?



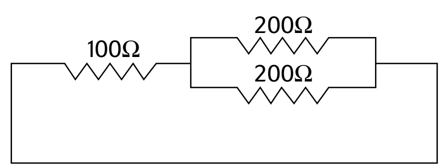
A. 1

B. 2

C. 3

D. 4

4. The total resistance for this circuit is



A. 100 ohms.

B. 400 ohms.

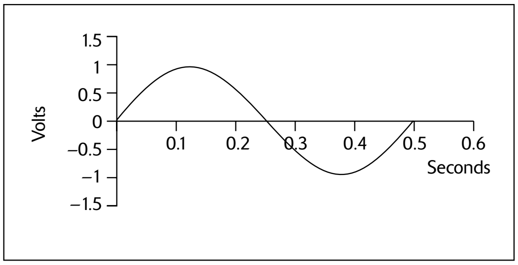
C. 50 ohms.

D. 200 ohms.

5. Inductance is measured in

A. farads.
B. volts.
C. amperes.
D. henrys

6. The following signal is expressed as

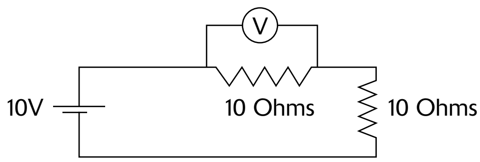


A. sin (πt)
B. 5 sin (πt)
C. sin (4πt)
D. sin (2πt)

7. An FM radio signal is

A. amplitude modulated.
B. frequency modulated.
C. phase modulated.
D. DC modulated.

8. The reading of the voltmeter in this circuit is

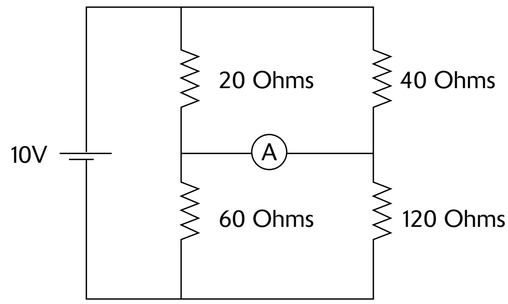


A. 10 V.
B. 5 V.
C. 1 V.
D. 2 V.

9. Capacitors are used in transistor circuits to

A. separate AC signals from DC bias.
B. rectify currents.
C. invert signals.
D. reduce cost.

10. The reading of the ammeter in this circuit is



A. 5 V.
B. 0 A.
C. 0 V.
D. 2.5 A.

11. Modulation is used when

A. measuring a current.
B. designing a transistor circuit.
C. transmitting a radio signal.
D. amplifying a current.

12. A transistor can be used to

A. store a charge.
B. generate a DC signal.
C. generate a triangular wave.
D. amplify a current.

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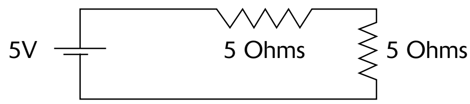
13. The total power dissipated across the resistors in the following circuit is



A. 5 watts.

B. 6 watts.

C. 10 watts.

D. 2.5 watts.

14. Electric transformers use the following component to transform the level of voltage:

A. resistor.

B. coil.

C. power.

D. current.

15. A component of a parts list has the following specifications: "10 Ω." The component specified is a

A. capacitor.

B. transistor.

C. coil.

D. resistor.

16. A diode can be used to

A. rectify a signal.

B. store a charge.

C. amplify a current.

D. induce an electromagnetic field.

17. Frequency mixers are used to

A. mix electrical charges.

B. amplify audio signals.

C. carry audio signals on RF signals.

D. rectify RF signals.

18. Shapes of electrical signals can be monitored by

A. a voltmeter.

B. an oscilloscope.

C. an ammeter.

D. an ohmmeter.

19. As a safety design requirement, electronic devices must be

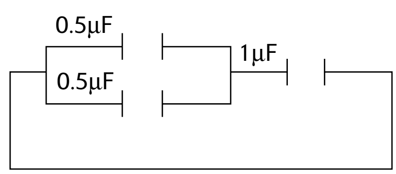
A. low in cost.

B. low in weight.

C. grounded to avoid electric shock.

D. digitally designed.

20. The total capacitance of this circuit is



A. 0.5μF.

B. 1μF.

C. 2μF.

D. 3μF.

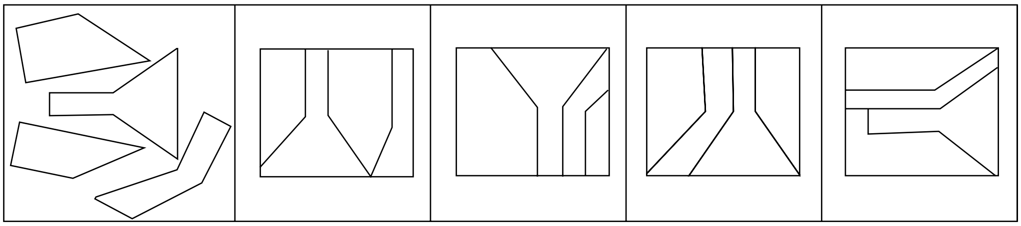
STOP

Assembling Objects

Time: 9 minutes

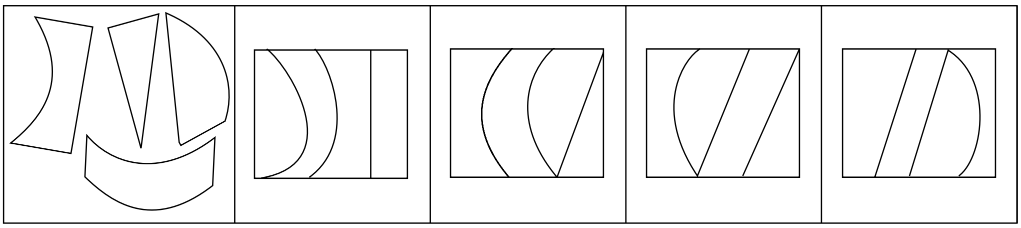
16 questions

1.



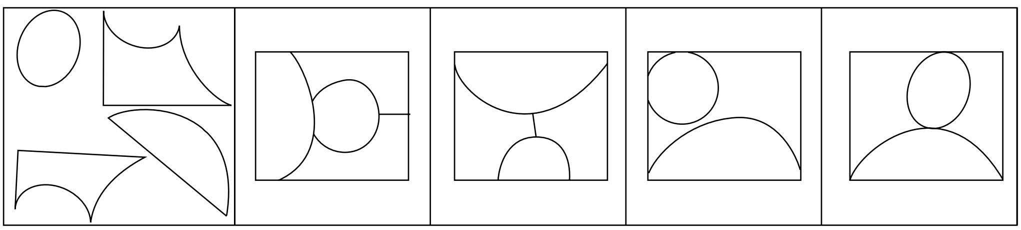
A B C D

2.



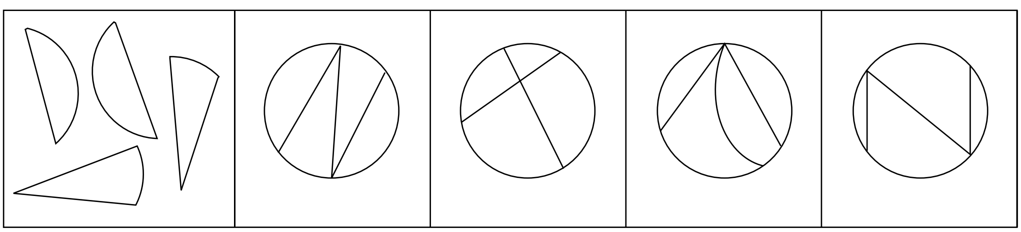
A B C D

3.



A B C D

4.



A B C D

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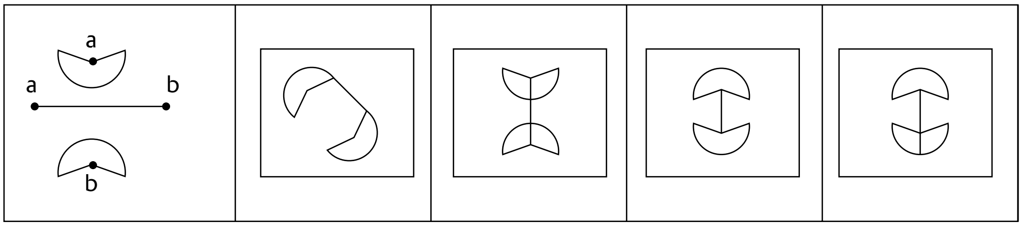
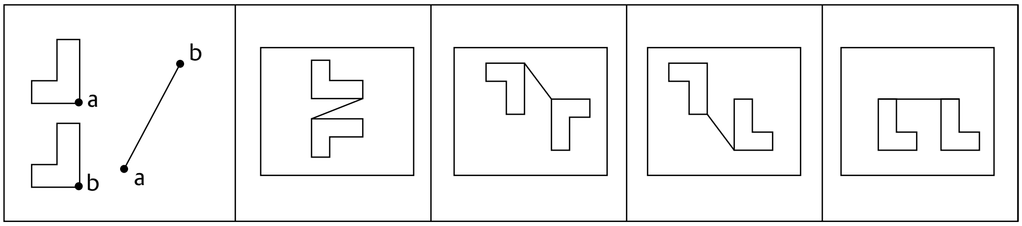
5.



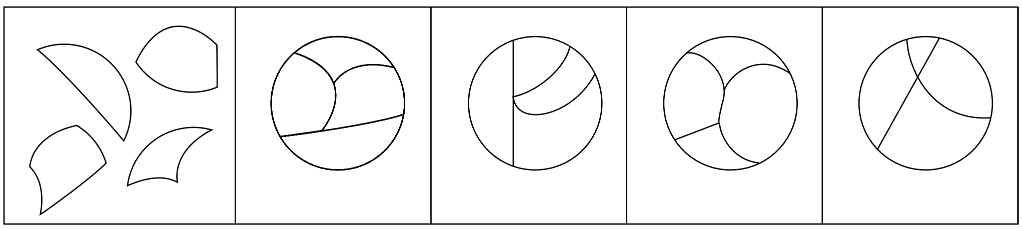
A B C D

6.



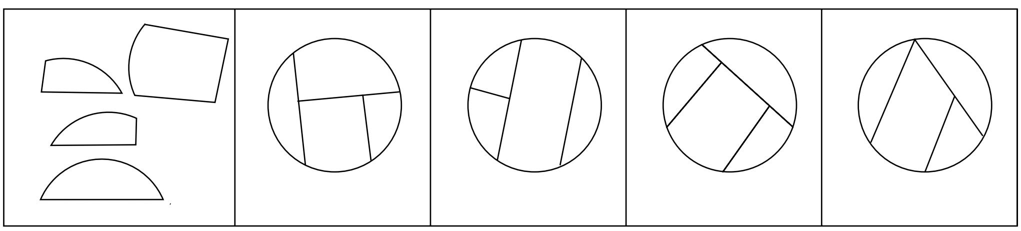
A B C D

7.



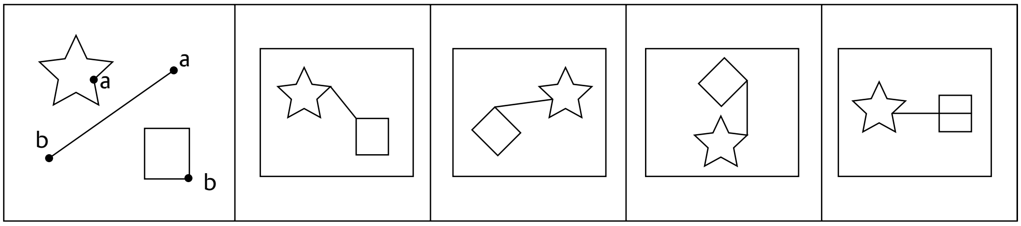
A B C D

8.



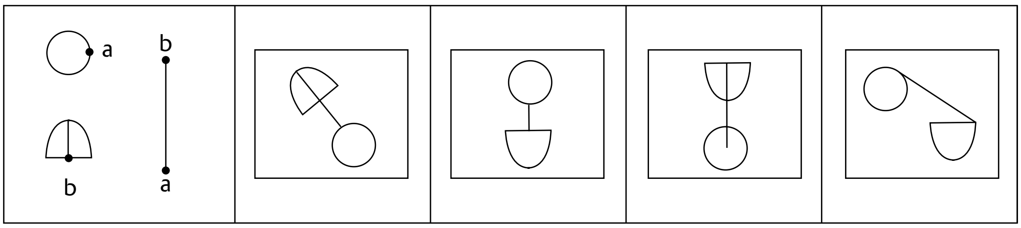
A B C D

9.



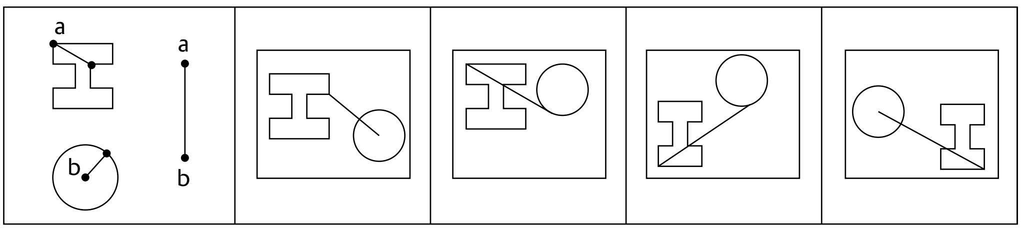
A B C D

10.



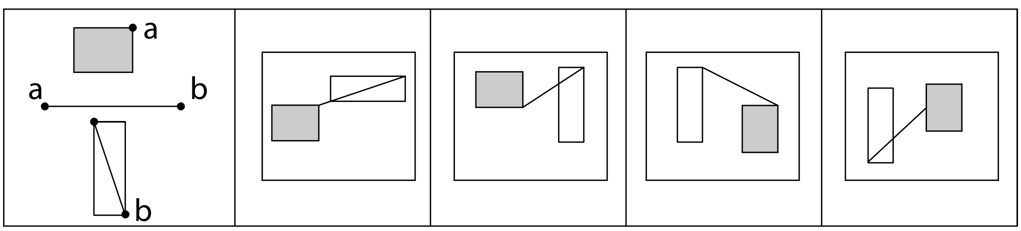
A B C D

11.



A B C D

12.



A B C D

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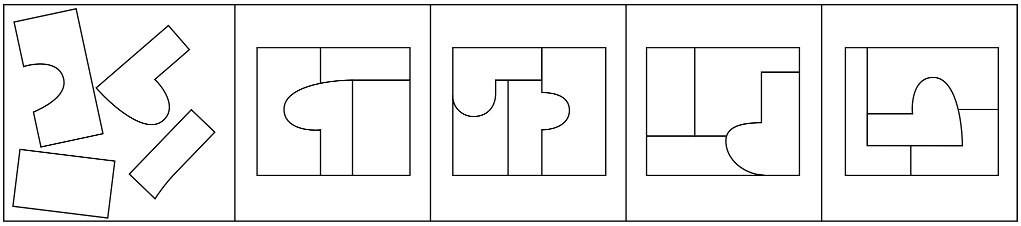
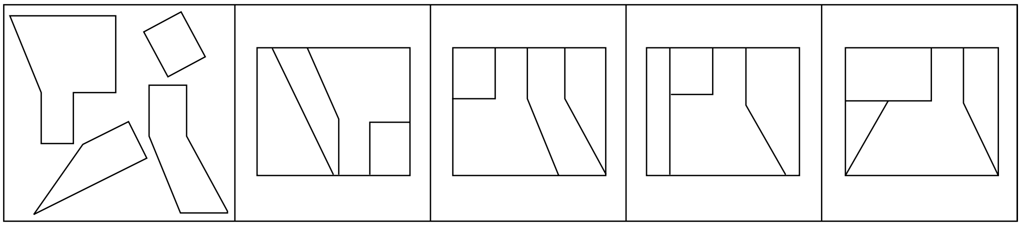
13.



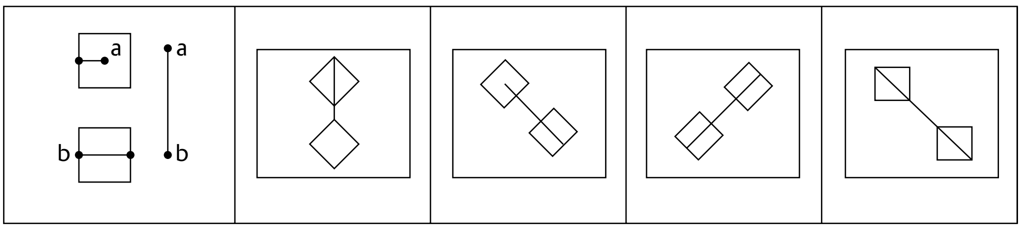
A B C D

14.



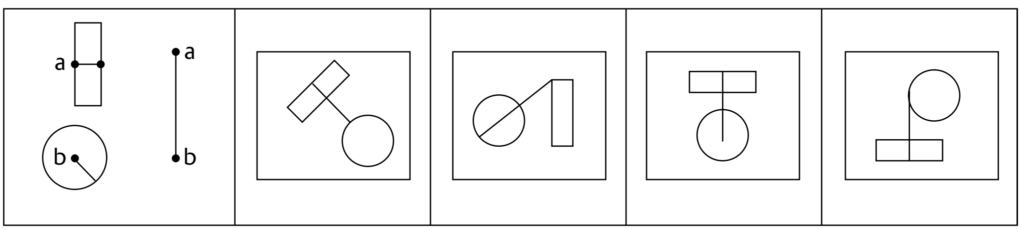
A B C D

15.



A B C D

16.



A B C D

STOP

Answer Key for Practice Test 2

General Science

1. A
2. C
3. B
4. A
5. B
6. D
7. B
8. A
9. B
10. C
11. B
12. A
13. B
14. D
15. B
16. A
17. D
18. C
19. C
20. A
21. B
22. D
23. B
24. D
25. A

Arithmetic Reasoning

1. C
2. C
3. D
4. B
5. D
6. A
7. D
8. C
9. A
10. D
11. A
12. A
13. B
14. A
15. C
16. A
17. C
18. B
19. B
20. B
21. D
22. C
23. B
24. B
25. C
26. B
27. B
28. A
29. A
30. C

Word Knowledge

1. D
2. C
3. A
4. B
5. B
6. C
7. C
8. D
9. A
10. B
11. A
12. B
13. A
14. A
15. B
16. A
17. B
18. B
19. D
20. B
21. B
22. B
23. C
24. C

25. B
26. D
27. C
28. D
29. B
30. B
31. B
32. B
33. C
34. A
35. B

Paragraph Comprehension

1. C
2. B
3. C
4. D
5. B
6. C
7. A
8. B
9. D
10. A
11. C
12. A
13. C
14. B
15. B

Auto and Shop Information

1. C
2. B
3. C
4. A
5. B
6. C
7. B
8. B
9. B
10. D
11. A
12. D
13. C
14. D
15. A
16. B
17. D
18. A
19. B
20. B
21. C
22. D
23. B
24. B
25. B

Mathematics Knowledge

1. D
2. A
3. D
4. A
5. C
6. C
7. B
8. A
9. B
10. B
11. C
12. C
13. C
14. A
15. B
16. D
17. D
18. B
19. B
20. B
21. A
22. D
23. D
24. D
25. A

Mechanical Comprehension

1. B
2. C
3. D
4. B
5. D
6. A
7. D
8. B
9. D
10. A
11. C
12. D
13. B
14. D
15. A
16. A
17. D
18. B
19. C
20. C
21. D
22. C
23. D
24. D
25. B

Electronics Information

1. A
2. C
3. A
4. D
5. D
6. C
7. B
8. B
9. A
10. B
11. C
12. D
13. D
14. B
15. D
16. A
17. C
18. B
19. C
20. A

Assembling Objects

1. C
2. B
3. D
4. A
5. C
6. B
7. A
8. C
9. B
10. A
11. D
12. A
13. A
14. B
15. B
16. C

ASVAB Practice Test 2 Answers and Explanations

General Science (Practice Test 2 Answers)

1. **A.** Oxygen slows down the rate because most plants will use it in photorespiration, which is caused by the plants' enzymes picking up oxygen rather than carbon dioxide.
2. **C.** Both A and B are dominant to O and will be expressed.
3. **B.** The balanced equation is N_2 (g) + $3H_2$ (g) : $2NH_3$ (g).
4. **A.** To relieve the stress on the system, fewer moles will exist. This is an application of LeChatlier's principle.
5. **B.** The inclination of the Earth's axis causes seasons. The Earth is closer to the Sun during winter in the Northern Hemisphere. Though the Earth's orbital speed changes slightly over the course of the year, it is not the cause of seasonal variation.
6. **D.** Amino acids are joined by peptide bonds.
7. **B.** Arteries carry blood away from the heart.
8. **B.** Even though some snakes are able to spend time in water, snakes, by definition, are reptiles.
9. **B.** You should apply the equation $V_1M_1 = V_2M_2$, where V = volume and M = molarity. Solving, $V_1 = V_2M_2/M_1$.
10. **C.** The transformation of a solid directly to a gas is called sublimation.
11. **B.** The amount of thermal expansion of a rod is proportional to its length for a given temperature change. Since the 75-centimeter rod is 50% longer, its expansion is 50% greater.
12. **A.** The only function for the stomach is protein digestion, while the small intestine digests all food types.
13. **B.** As the river matures, more erosion and deposition of sediments will effectively increase the meanders in the river. Choice **C** is incorrect because river speed is determined by water volume and net elevation change. While volume may increase over time, as rivers mature, dramatic changes in elevation are often eroded away.
14. **D.** Since the orbit of Neptune is further than Jupiter, the orbital period would also be longer. The only choice larger than 12 years (Jupiter's orbital period) is 165 years, choice **D**.
15. **B.** While the other choices are definitely major agents of erosion, ground cover is the single best way to combat erosion. Vegetation helps maintain topsoil through high winds and heavy rains.
16. **A.** The three most common gases in the atmosphere are nitrogen (78%), oxygen (21%), and argon (0.3%). All other gases combined make up the remaining 0.7%.
17. **D.** Fish are vertebrates (they have backbones). The other organisms listed (sponge, jellyfish, snail) are all invertebrates (they do not have backbones).
18. **C.** pH is defined as the negative log of the hydrogen ion concentration.

19. C. Knowing that carbon has four bonds leaves C as the only choice.

20. A. Friction between the tires and the road provides the centripetal force to keep the car in the turn.

21. B. DNA never leaves the nucleus.

22. D. Lead (Pb) is a metal and will have a positive oxidation number. Fluorine is the most electronegative, and has an oxidation number of –1.

23. B. The most electronegative elements, those that will attract electrons the most readily, are on the top right.

24. D. The stamen is made up of the anther, which makes pollen, and the filament, which holds up the anther. The pistil is the homologous female structure.

25. A. The brain and the spinal cord constitute the central nervous system.

Arithmetic Reasoning (Practice Test 2 Answers)

1. C. Mattie walked 45 + 36 + 41 = 122 yards. Jacob walked 16 + 49 + 33 = 98 yards. The difference between these two distances is 122 – 98 = 24 yards.

2. C. The volume of a cylinder is $\pi r^2 h$. In the original cylinder, $\pi r^2 h = 128\pi$ so $r^2 \frac{128\pi}{8\pi} = 16$ and the radius, r, equals $\sqrt{16} = 4$. In the new cylinder, the radius is doubled to 8 and the height is cut in half to 4. The resulting volume is $\pi \times 8^2 \times 4 = 256\pi$ cm^3.

3. D. First add the number of feet together and then add the number of inches.

2 feet + 4 feet + 3 feet = 9 feet.

$$2\frac{1}{2}\text{ in} + 3\frac{3}{8}\text{ in} + 9\frac{3}{4}\text{ in} = \frac{5}{2} + \frac{27}{8} + \frac{39}{4} = \frac{20}{8} + \frac{27}{8} + \frac{78}{8} = \frac{125}{8} = 15\frac{5}{8}\text{ in}$$

$15\frac{5}{8}$ in = 1 ft $3\frac{5}{8}$ in, so altogether 9 ft + 1 ft $3\frac{5}{8}$ in = 10 ft $3\frac{5}{8}$ in.

4. B. The amount of commissions over \$5,000 is \$12,500 – \$5,000 = \$7,500. Earning are \$7,500 × 15% = \$1,125.

5. D. The total cost for the posts and fencing is (10 × \$12.50) + (34 × \$4.75) = \$125.00 + \$161.50 = \$286.50.

6. A. The cost of the eight CD covers is 8 × \$1.59 = \$12.72. The change received back is \$20.00 – \$12.72 = \$7.28.

7. D. The proportion $\frac{500\text{ ft}}{\frac{1}{4}\text{ in}} = \frac{x\text{ ft}}{6\text{ in}}$ can be used to find the actual distance. Cross multiply. $500 \times 6 = \frac{1}{4}x$, so $3{,}000 = \frac{1}{4}x$ and $x = 3{,}000 \times 4 = 12{,}000$ feet.

8. C. The total number of inches in a 10-foot rope is 10 × 12 = 120 inches. The number of 8-inch segments that can be cut is $\frac{120}{8} = 15$.

9. A. If 1 page can be read in 2 minutes, then 80 pages can be read in 80 × 2 or 160 minutes.

10. D. The proportion $\frac{3\text{ boxes}}{18\text{ reams}} = \frac{x\text{ boxes}}{90\text{ reams}}$ can be used to find the number of boxes. Cross multiply. $3 \times 90 = 18x$, so $270 = 18x$ and $x = \frac{270}{18} = 15$ boxes.

11. A. Add the areas of the two triangles and the square to find the total area. The area of the square is $5^2 = 25$. Both triangles have a height of 5. The area of one triangle is $\frac{1}{2}bh = \frac{1}{2} \cdot 3 \cdot 5 = \frac{15}{2} = 7.5$. The area of the other triangle is $\frac{1}{2}bh = \frac{1}{2} \cdot 4 \cdot 5 = \frac{20}{2} = 10$. The total area is $25 + 7.5 + 10 = 42.5$.

12. A. Five cards at \$3.00 each cost $5 \times \$3.00 = \$15.00$. If cards are two for \$5.00, the cost per card is $\frac{\$5.00}{2} = \$2.50$, so five cards would cost $\$2.50 \times 5 = \$12.50$. The amount saved is $\$15.00 - \$12.50 = \$2.50$.

13. B. If 1 gallon covers 400 square feet, then $\frac{2,225}{400} = 5.5625$, or 6 whole gallons are needed to cover 2,225 square feet.

14. A. The tax on the bill is $\$38.40 \times 6\% = \$2.30$. The amount, including tax, is $\$38.40 + \$2.30 = \$40.70$. The tip is $\$40.70 \times 15\% = \$6.11$.

15. C. The area of one square is $\frac{405}{5} = 81$. So the length of each side is $\sqrt{81} = 9$. The total number of sides in the figure is 12, so the perimeter is $9 \times 12 = 108$.

16. A. The proportion $\frac{5}{3} = \frac{x}{4}$ can be used to find x. Cross multiply. $5 \times 4 = 3x$ so $20 = 3x$ and $x = \frac{20}{3} = 6\frac{2}{3}$.

17. C. After eating $\frac{1}{4}$ of a pie, what remains is $1 - \frac{1}{4} = \frac{3}{4}$. If four friends share the remainder, then each receives $\frac{3}{4} \div 4 = \frac{3}{4} \times \frac{1}{4} = \frac{3}{16}$.

18. B. If 2 pounds are lost each week, then after 7 weeks $7 \times 2 = 14$ pounds are lost. The weight after 7 weeks is $209 - 14 = 195$ pounds.

19. B. The discounted amount after the first week is $\$1,000 \times 25\% = \$250$, so the sale price is $\$1,000 - \$250 = \$750$. The discounted amount after the second week is $\$750 \times 10\% = \$75$, so the sale price is $\$750 - \$75 = \$675$.

20. B. Convert 2.2 minutes to seconds. $2.2 \times 60 = 132$ seconds. The difference in the two times is $132 - 124 = 8$ seconds.

21. D. In a 10-mile trip, after the first mile, there are 9 additional miles. If each additional half mile is \$1, then an additional mile is \$2. The cost of the trip is \$3 for the first mile + $(\$2 \times 9)$ for the additional miles. $\$3 + \$18 = \$21$.

22. C. The proportion $\frac{\$5.00}{3\,\text{cans}} = \frac{\$x}{10\,\text{cans}}$ can be used to find the cost of 10 cans. Cross multiply. $5 \times 10 = 3x$, so $50 = 3x$ and $x = \frac{50}{3} = \$16.67$.

23. B. Average is the total time divided by the total miles run. The total time is $17.5 + 22 + 9 = 48.5$ minutes. The total number of miles run is $3 + 4.5 + 2 = 9.5$. The average is $\frac{48.5}{9.5} = 5.1$ minutes per mile.

24. B. The total amount of money is $(40 \times \$0.05) + (12 \times \$0.10) = \$2.00 + \$1.20 = \$3.20$.

25. C. Interest = principal × rate × time. Interest $= \$1,000 \times 2\frac{1}{4}\% \times 5 = \$1,000 \times 0.0225 \times 5 = \$112.50$.

26. B. 0°C is equivalent to a Fahrenheit temperature of $0^\circ\left(\frac{9}{5}\right)+32=32^\circ$ F. To become 52° F, the temperature must rise 20° F. If it rises 4° F every hour, then $\frac{20}{4}$ or 5 hours later, it will be at 52° F.

27. B. There are 30 minutes in a half hour. 30 × 35 = 1,050 words.

28. A. The cost of Sandy's purchase is $\left(4\frac{1}{2}\times\$1.39\right)$ + (6 × \$0.50) = \$9.26. The cost of Brandon's purchase is $\left(3\frac{1}{4}\times\$1.39\right)$ + (9 × \$0.50) = \$9.02. Sandy spent \$9.26 – \$9.02 = \$0.24 more.

29. A. The interest on a \$50,000 loan is \$50,000 × 8% = \$4,000. The amount that must be paid back is \$50,000 + \$4,000 = \$54,000. There are 120 months in 10 years. If this is to be paid over a 10-year period, each monthly payment will be $\frac{\$54,000}{120}=\$450$.

30. C. $1\frac{1}{8}+2\frac{3}{4}+3\frac{1}{3}=\frac{9}{8}+\frac{11}{4}+\frac{10}{3}=\frac{27}{24}+\frac{66}{24}+\frac{80}{24}=\frac{173}{24}=7\frac{5}{24}$ pounds.

Word Knowledge (Practice Test 2 Answers)

1. **D.** *A new idea. Innovation* involves making changes or offering new methods.
2. **C.** *Reveal. Divulge* means disclose or make known.
3. **A.** *Pay attention to. Heed* means listen, mind, or obey.
4. **B.** *Prevent. Foil* means hinder, thwart, or frustrate.
5. **B.** *Surprise. Startle* means disturb or frighten.
6. **C.** *Astonish. Stupefy* means astound or bewilder.
7. **C.** *Defect. Blemish* means flaw or imperfection.
8. **D.** *Nearness. Proximity* means closeness.
9. **A.** *Conflict. Clash* means hostility or strife.
10. **B.** *Twisted. Wry* means distorted, crooked, or bent.
11. **A.** *Green. Verdant* means flourishing, thriving, or covered with plants.
12. **B.** *Scoff. Jeer* means mock or ridicule.
13. **A.** *Harsh. Strident* means shrill, blaring, or loud.
14. **A.** *Cut. Shear* means to clip or to prune.
15. **B.** *Enjoy. Relish* means appreciate or value.
16. **A.** *Reddish. Crimson* means cherry or scarlet, both of which refer to red.
17. **B.** *Out of use. Obsolete* means outmoded, ancient, or extinct.
18. **B.** *A side. Facet* means phase or aspect.
19. **D.** *Praise. Extol* means exalt or glorify.
20. **B.** *Departure. Exodus* means leaving or exit.

21. **B.** *Energetically. Vigorously* means strenuously or actively.
22. **B.** *Well-known. Familiar* means recognized or famous.
23. **C.** *Damage. Detriment* means harm or injury.
24. **C.** *Overeater. Glutton* means greedy person or hog.
25. **B.** *Disprove. Refute* means undermine or deny.
26. **D.** *Brilliance. Luster* means brightness or radiance.
27. **C.** *Profitable. Lucrative* means money-making or gainful.
28. **D.** *Unhurried. Leisurely* means casual, tranquil, or sedate.
29. **B.** *Agreement. Accord* means peace, conformity, or unanimity.
30. **B.** *Extract. Excerpt* means piece, section, or portion.
31. **B.** *Analyze. Diagnose* means investigate, study, or look into.
32. **B.** *Inborn. Innate* means intrinsic or native.
33. **C.** *A saying. Maxim* means adage or proverb.
34. **A.** *Exaggeration. Hyperbole* means overstatement or embellishment.
35. **B.** *Ooze. Seep* means leak or trickle.

Paragraph Comprehension (Practice Test 2 Answers)

1. **C.** The second sentence states that the speaker's slurred words and mumbling made the speech very difficult to understand. Thus, the speech would be illogical.
2. **B.** The first sentence in the paragraph states that beautiful plants are often dangerous to their environments.
3. **C.** Using dishwashers is not mentioned as a way to conserve water.
4. **D.** The first sentence states that people of all ages can benefit from regular weight lifting. Furthermore, the selection cites the example of ninety-year-old participants who saw improvements in muscle mass. Thus, it can be inferred that you can start lifting weights at any age and see improvements.
5. **B.** The paragraph discusses historical references to comets since antiquity.
6. **C.** The first sentence implies that the discovery of penicillin was mainly due to the disorganization of Fleming's lab.
7. **A.** Since watching more than an hour a day of television increases the risk for violent behavior later in life, it is safe to conclude that the author believes that children should watch less than an hour of television per day.
8. **B.** Energy efficiency is not mentioned in the selection. The other three choices are.
9. **D.** The article suggests that chimpanzees are now viewed in a different and more positive light concerning their ability to use language and to communicate.

10. **A.** At least two possible reasons—La Niña and global warming—are given as factors in decreased average annual snowfall. Thus, you must reason that there may be other factors that work together to influence average annual snowfall.
11. **C.** Weekdays present the highest risk for muggings, according to the selection.
12. **A.** The article states the major risk factors for being a victim of mugging.
13. **C.** The article discusses dehydration and the fact that most people do not feel the need to drink water until their throat signals them that they need to drink something. Thus, the only logical answer is **C.**
14. **B.** The first sentence of the selection states that being thirsty is a sign of dehydration.
15. **B.** The selection discusses both dehydration and the benefits of drinking water.

Auto and Shop Information (Practice Test 2 Answers)

1. **C.** If you accidentally come in contact with the frame or body with your wrench, no current will flow because the wrench will also be at the negative potential. However, if the positive cable is removed first while accidentally touching the frame or body with the wrench, sparks can occur.
2. **B.** A multiple-piece drive shaft requires that the yokes on the same shaft be parallel to each other when reassembling. The technician probably neglected this.
3. **C.** This component is an idle solenoid.
4. **A.** This component, through the action of a park cable and a lever attached to the brake shoe, forces the shoes against the brake drum.
5. **B.** Some vehicles have a multiple drive shaft system that requires the end yokes to be in phase.
6. **C.** This shim is used to correct installed valve spring height to maintain a proper spring tension after a valve's face and seat have been ground.
7. **B.** The torque converter automatically engages and disengages power from the engine to the transmission. At idle, there is not enough fluid flow for power transfer. Increased engine speed increases the fluid flow to transmit engine power through the torque converter assembly to the transmission.
8. **B.** A metering valve is used to hold off initial hydraulic pressure to the front disc brakes until rear drum shoe return spring pressure can be overcome. This allows the rear brakes to apply at approximately the same time as the front brakes.
9. **B.** A vacuum check valve is a one-way valve that prevents vacuum from escaping from the booster. This allows for a few boosted brake applications in the event the engine cannot provide any vacuum.
10. **D.** A brake system works on the principle of friction, which develops heat in the process of braking. The drum absorbs and dissipates the heat developed.
11. **A.** The dashpot is used during rapid deceleration to retard the closing of the throttle to prevent a possible stalling due to an overly rich air/fuel mixture.

12. **D.** A live circuit can damage the meter when in the ohms setting.
13. **C.** Most ammeters, unless they are inductive types, are only protected to 10 amps. A battery is typically rated over 450 amps.
14. **D.** A dado head blade is actually a series of blades packed together to make wide grooves. By adjusting the number of blades (or dividers between the blades) on the saw spindle, you can adjust the width of the dado cut.
15. **A.** Well-mixed concrete should be like mud, easily poured but not too loose, not too hard, and certainly not lumpy.
16. **B.** This is called a wing nut.
17. **B.** Dovetails are often used to make drawers for higher-quality furniture.
18. **A.** Unlike a wood chisel, a cold chisel is made of forged steel and is heat tempered in order to be able to withstand the shock of cutting metal.
19. **B.** The Allen wrench is normally six-sided and L-shaped and is used to tighten set-screws.
20. **B.** This is a coping saw, used to cut thin wood or plastic. The blade can be adjusted to different angles in order to cut irregular shapes.
21. **C.** The reciprocating saw is a tool designed for contractors for use in heavy-duty remodeling. The circular saw is good for cutting smaller lumber like two-by-fours, the saber saw or jig saw is used for fine lines or cutting contours, and the chain saw is used primarily for pruning or delimbing trees.
22. **D.** The grooved dowel plus glue is the strongest joint. Glue alone would not last, since the glue can dry out and crack. The fasteners and nails are weak connectors.
23. **B.** The palm sander vibrates rapidly and is used to give a piece of furniture a smooth finish. The belt and disk sanders are rougher on the wood, and can accidentally cut grooves if the user is not careful. Number 40 sandpaper is very coarse. The higher the number, the finer the grit—number 400 would be used for fine finishing.
24. **B.** The cut or groove made by the saw's blade is called the kerf. It is important to know that measurement when cutting different types of wood in order to prevent the saw from binding, or getting stuck in the wood as it is being cut. It is also important to know the kerf size when cutting true sizes, since you will lose part of the wood to the saw's blade, and therefore you must allow for that loss.
25. **B.** In order to have a smooth finish, the nail set is used to hammer the nail below the surface of the wood. Then the hole is filled with putty or wood filler, sanded, and painted or stained.

Mathematics Knowledge (Practice Test 2 Answers)

1. **D.** Using the distributive property, $(2x + 1)(2x + 1) = 4x^2 + 2x + 2x + 1 = 4x^2 + 4x + 1$.
2. **A.** The least common multiple of the divisors 16 and 24 is 48.
$\frac{5}{16} + \frac{9}{24} = \frac{15}{48} + \frac{18}{48} = \frac{33}{48} = \frac{11}{16}$.

3. **D.** Simplifying $\sqrt{50} + 3\sqrt{72}$ yields $\sqrt{25 \cdot 2} + 3\sqrt{36 \cdot 2}$, which yields $5\sqrt{2} + 18\sqrt{2} = 23\sqrt{2}$.

4. **A.** $5(a - 2) - (4a - 6) = 5a - 10 - 4a + 6 = a - 4$.

5. **C.** The circumference of a circle is given by the formula $C = 2\pi r$ and the area of a circle is given by $A = \pi r^2$. If the circumference is equal to the area, then $2\pi r = \pi r^2$. Solving for r, $\frac{2\pi r}{\pi r} = \frac{\pi r^2}{\pi r}$ and $2 = r$. The diameter is $2r$, or 4.

6. **C.** The cube of 8 is $8^3 = 8 \times 8 \times 8 = 512$.

7. **B.** The area of a triangle is $A = \frac{1}{2}bh$. If the base is 3 inches less than the height, then $b = h - 3$. Substituting this value in for b gives $A = \frac{1}{2}(h-3)h = \frac{1}{2}h^2 - \frac{3}{2}h$.

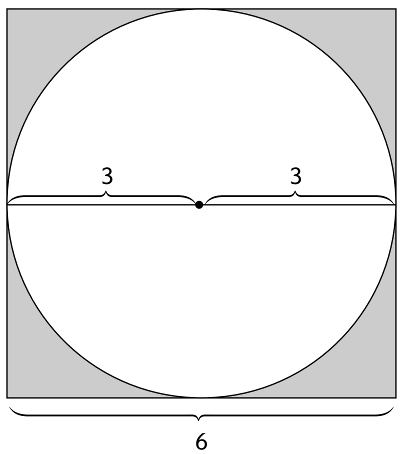
8. **A.** Substituting the given values for r, s, and t into $3r^3 - 2s^2 + t$ gives $3(-1)^3 - 2(-2)^2 + (-3) = 3(-1) - 2(4) - 3 = -3 + 8 - 3 = 2$.

9. **B.** Let x be the unknown number. Then $9x = 117$ and $x = \frac{117}{9} = 13$.

10. **B.** $\left(\frac{a^{-3}b^2}{2ab^{-1}}\right)^{-3} = \frac{a^9 b^{-6}}{2^{-3}a^{-3}b^3} = 2^3 a^{9-(-3)} b^{-6-3} = 8a^{12}b^{-9} = \frac{8a^{12}}{b^9}$

11. **C.** Let b represent the number of boys in the class and g represent the number of girls. Then $b + g = 27$. If $b = g + 5$, then $(g + 5) + g = 27$. $2g + 5 = 27$ and $2g = 22$ so $g = 11$. Therefore, the number of boys is $27 - 11$, or 16.

12. **C.**



The area of the shaded region equals the area of the square minus the area of the circle. Since the radius of the circle is 3, the square has a side length of 6. The area of the square is 6^2 or 36. The area of the circle is $\pi r^2 = \pi \times 3^2 = 9\pi$. The shaded region, therefore, is $36 - 9\pi$.

13. **C.** The square of x is x^2. Three less than x is $x - 3$. Their product is $x^2(x - 3)$.

14. **A.** The cube root of 512 is $\sqrt[3]{512} = \sqrt[3]{8 \times 8 \times 8} = 8$.

15. **B.** There are four possible ways to roll a 9 using two dice: 3 and 6, 4 and 5, 5 and 4, 6 and 3. The total number of possible outcomes when rolling two dice is 6^2 or 36. Therefore, the probability of rolling a 9 is $\frac{4}{36} = \frac{1}{9}$.

16. **D.** The radius $r = \frac{d}{2}$. The area of the circle is $\pi r^2 = \pi\left(\frac{d}{2}\right)^2 = \frac{\pi d^2}{4}$. If the diameter is increased 100%, the diameter is $2d$ and $r = \frac{2d}{2} = d$. The area of the enlarged circle is $\pi r^2 = \pi d^2$. The enlarged circle is $\frac{\pi d^2}{\frac{\pi d^2}{4}} = \pi d^2 \div \frac{\pi d^2}{4} = \pi d^2 \bullet \frac{4}{\pi d^2} = 4$ or 400% bigger.

17. **D.** Six less a number is shown by $n - 6$. So "six less than a number is four" is represented by $n - 6 = 4$.

18. **B.** Group the first two terms and the last two terms together: $(2a^2 - 4ab + (ab - 2b^2)$ Factoring out common terms from each group gives $2a(a - 2b) + b(a - 2b)$. Common to both terms is $(a - 2b)$. Factoring this out results in $(a - 2b)(2a + b)$.

19. **B.** In the proportion $\frac{m}{n} \times \frac{3}{5}$, let $m = 3$ and let $n = 5$. Therefore, $m + n = 3 + 5 = 8$.

20. **B.** The area of a room 15 feet wide by 18 feet long is $15 \times 18 = 270$ square feet. Since there are 3 feet in a yard, there are 3×3 or 9 feet in a square yard. Convert 270 square feet to square yards. $\frac{270}{9} = 30$ square yards. Since the cost is \$13.50 per square yard, the total cost is $\$13.50 \times 30$, or \$405.

21. **A.** $60\text{ beads} \times \frac{1}{2}\text{ inches} = 30$ inches. Converting this to feet gives 30 inches $\times$ $\frac{1\text{ foot}}{12\text{ inches}} = \frac{30}{12} = 2\frac{1}{2}$ feet.

22. **D.** Subtract $2y$ from both sides. $2y + 6 - 2y = 3y - 2 - 2y$, so $6 = y - 2$. Adding 2 to both sides gives $y = 8$.

23. **D.** Using the correct order of operations, $-3(-4 - 5) - 2(-6) = -3(-9) - 2(-6) = 27 - (-12) = 27 + 12 = 39$.

24. **D.** If books are twice as much as magazines, then $b = 2m$. Five books + three magazines = $5b + 3m$. Substituting $2m$ for b gives $5(2m) + 3m = 10m + 3m = 13m$.

25. **A.** Since the area of ADEC is 81, AC = $\sqrt{81} = 9$. Since the area of BCFG is 144, BC = $\sqrt{144} = 12$. Use the Pythagorean theorem to find the length of the remaining side AB. $AB^2 = 9^2 + 12^2$ so $AB^2 = 81 + 144 = 225$ and AB = $\sqrt{225} = 15$. Therefore, the perimeter of the triangle = $9 + 12 + 15 = 36$.

Mechanical Comprehension (Practice Test 2 Answers)

1. **B.** Neglecting friction with air, the velocity vector of the ball has a horizontal component that remains constant and a vertical component that suffers deceleration due to the force of gravity. Since distance is speed times time, the path gradually curves downward due to gravity.

2. **C.** Work is force times distance. That is zero in this example.

3. **D.** Kinetic energy is half the product of the mass and the square of the velocity.

4. **B.** Potential energy is proportional to the weight of the object and its elevation above the ground reference.

5. **D.** This is clearly stated in Newton's first law.

6. **A.** Since acceleration is the net force divided by the mass, the net force must be zero since the mass is not infinite.

7. **D.** The horizontal component of the velocity of the first ball has no effect on the vertical travel, and initially both balls have zero vertical velocity.

8. **B.** Friction tries to slow down the motion.

9. **D.** If the acceleration of gravity is constant, the period and, hence, the frequency is determined solely by the length of the connecting cord or rod.

10. **A.** Since the direction of the vibrating body is reversed at the end point of its motion, its velocity must be zero when its displacement is a maximum. It is then accelerated toward the center by the restoring force until it reaches its maximum speed at the center of oscillation, i.e., when its displacement is zero. Since the restoring force is maximum at the end point, its acceleration at that moment is also a maximum by Newton's second law of motion.

11. **C.** The farther the particle is from the axis of rotation of a rigid body, the greater its linear speed, since the linear speed is two times the product of the frequency of rotation and the radius of rotation. On the other hand, the angular speed is the linear speed divided by the radius of rotation, thus resulting in both points having the same angular speed.

12. **D.** The total angular momentum is equal to the product of the body's angular velocity and the moment of inertia. Pulling the arms towards the body increases the first by a certain ratio and decreases the second by the same ratio, thus keeping the angular momentum the same.

13. **B.** $(4.24 - 3.6)/5.6 = 0.114$

14. **D.** Using the expressions $s = v_o t + \frac{1}{2}at^2$ and $v_f = v_o + at$, we set the time of travel as the sum of t_1 to travel the distance s_1 from the top of the building to the maximum height and t_2, s_2 as the corresponding values from the maximum height to the ground. Substituting numbers, we obtain $t_1 = 1.48$ seconds, $s_1 = 10.72$ m and $t_2 = 3.52$, $s_2 = 50$ meters, so the total time = 1.48 + 3.52 = 5 seconds.

15. **A.** Since this is an elastic collision, momentum is conserved. Hence $4(2) – 2(4) = (4 + 2)v$, in other words, $v = 0$ m/s.

16. **A.** Since five strands support the movable load, the required force is 200/5 = 40 newtons.

17. **D.** The final momentum equals $300 + 20 \times 10 = 500$ kg m/s.

18. **B.** $12.5 = \frac{1}{2}gt^2$, hence t is about 1.6 seconds while $d = 1.6\ (10) = 16$ meters.

19. **C.** The net vertical force on the block = 3 grams (upward reaction force) – 17.4 (downward applied force) = 12 newtons. The resulting force of friction = 12 (0.25) = 3 newtons. Since friction acts against any motion, the net horizontal force on the block = 10 – 3 = 7 newtons.

20. **C.** Since work equals the travel distance times the component of the force along the direction of travel, the angle θ between the pulling rope and the floor increases and hence both its cosine and the work done decrease.

21. **D.** The spin rate (or angular velocity) is inversely proportional to the distance from the axis of rotation, so that as the skater stretches her hands the distance from her hands to the axis of rotation increases and the spin rate decreases slightly.

22. C. This is a consequence of Newton's second law relating force, mass, and acceleration.

23. D. This unit is equivalent to kg.m/s^2 times m. This is also equivalent to the unit of force times distance, which is the unit of work or the joule.

24. D. The net force acting on the mass is the component of the 15 newton force up the inclined plane minus the component of the weight down the inclined plane: 15 cos 30° – 2g(sin 30°) = 3.19 newtons. The resulting acceleration is the ratio of the net force to the mass or nearly 1.6 m/s^2.

25. B. The power required is the work done divided by time. The work in this case is potential energy that equals the mass times the acceleration of gravity times the increment in height or 14,700 J. The power required is hence 14,700/120 = 122.5 W.

Electronics Information (Practice Test 2 Answers)

1. A. An *ammeter* is a device used to measure current. A voltmeter is used to measure a voltage difference. Electrical charge or energy cannot be measured by an ammeter.

2. C. For the lamp to be on, switches 1 or 3 must be closed, and switch 2 must be closed to allow the current to flow in the circuit.

3. A. Symbol 1 represents a transistor.

4. D. The total resistance in the circuit can be calculated as follows:

$$100 + \frac{1}{\frac{1}{200} + \frac{1}{200}} = 200\Omega$$

5. D. Inductance is measured in henrys. Capacitance is measured in farads. Voltage difference is measured in volts. Electrical current is measured in amperes.

6. C. The shown signal can be written in the form: Amplitude × sin($2\pi ft$). From the figure, the amplitude is 1 V and the frequency is 1/period = 2 Hz, so the signal is sin(4πt).

7. B. An FM radio signal is a frequency modulated signal. An AM modulated signal is an amplitude modulated signal. PSK signals are phase modulated signals. DC cannot be used for modulation.

8. B. The voltmeter reads the voltage across the resistor. Since both resistors are equal, then the battery voltage will be equally divided between the two resistors, so that the reading of the voltmeter will be 5 V.

9. A. Capacitors are used to separate AC signals from the DC bias of the bipolar junction transistor.

10. B. The reading of the ammeter will be 0 A. This means that there is no current flowing into the ammeter. This is because the ratio of the 20 ohms resistor to the 60 ohms resistor is equal to the ratio of the 40 ohms resistor to the 120 ohms resistor. This causes the voltage at both ammeter leads to be equal. As a result, no current will flow.

11. C. Modulation is used when transmitting a radio signal. It involves carrying a certain signal on a high frequency.

12. **D.** A transistor can be used to amplify a current. The input current is the base current and the output current is the collector current. The amplification ratio is called Beta, β.

13. **D.** The power dissipated in the circuit can be calculated as $P = I^2R$

$$= \left(\frac{5}{5+5}\right)^2 (5+5) = 2.5 \text{ watts.}$$

14. **B.** Electronic transformers use coils to transform the level of voltage. The value of the induced voltage depends on the number of turns of the coil.

15. **D.** Resistors are measured in ohms. Capacitance is measured in farads. Transistors have numbers to identify them. Inductance of a coil is measured in henrys.

16. **A.** A diode can be used to rectify a signal. This is because it allows the current to pass in one direction only. As a result, the positive part of the signal passes and the negative part is blocked.

17. **C.** Frequency mixers are used to carry certain signals (like audio signals) on a high-frequency carrier for wireless transmission.

18. **B.** Shapes of electrical signals can be watched on an oscilloscope. Other instruments will measure a certain parameter, but will not show the shape of the signal with respect to time.

19. **C.** Electronic devices must be grounded to avoid electrical shock.

20. **A.** Total capacitance of the circuit is calculated as follows: $\dfrac{1}{\dfrac{1}{(.5\mu F + .5\mu F)} + \dfrac{1}{1\mu F}} = .5\mu F$

Assembling Objects (Practice Test 2 Answers)

The answers for the Assembling Objects questions can be found in the answer key, earlier in this section.

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Answer Sheet for Practice Test 3

(Remove this sheet and use it to mark your answers)

General Science

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Arithmetic Reasoning

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Word Knowledge

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Paragraph Comprehension

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Auto and Shop Information

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Mathematics Knowledge

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Mechanical Comprehension

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Electronics Information

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Assembling Objects

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ASVAB Practice Test 3

General Science

Time: 11 minutes

25 questions

1. The oldest fossils are those of bacteria. They existed as far back as

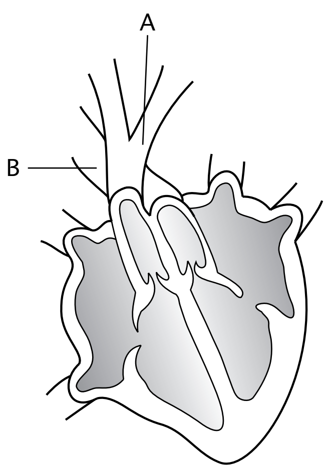
A. 35 thousand years ago.

B. 35 million years ago.

C. 350 million years ago.

D. 3.5 billion years ago.

2.



When blood is leaving the left ventricle, it is

A. oxygenated and moving to structure A.

B. not oxygenated and moving to structure A.

C. oxygenated and moving to structure B.

D. not oxygenated and moving to structure B.

3. In the Haber process, ammonia is produced according to the following equation: N_2 (g) + $3H_2$ (g) : $2NH_3$ (g)

How many moles of hydrogen gas are needed to react with 1 of nitrogen?

A. 1

B. 3

C. 6

D. 22.4

4. Given the reaction:

$2CO$ (g) + O_2 (g) : $2CO_2$ (g)

How many liters of oxygen are required to react with the carbon monoxide to make carbon dioxide at STP?

A. 1

B. 2

C. 22.4

D. 6.02×10^{23}

GO ON TO THE NEXT PAGE

5. A heavy object is dropped from the top of a tower. If it falls 5 meters after 1 second, how far from the top will it be 3 seconds after it was released? Neglect air resistance.

A. 10 meters
B. 15 meters
C. 30 meters
D. 45 meters

6. An example of a marine animal with radial symmetry would be

A. a clam.
B. a jellyfish.
C. a squid.
D. a tuna fish.

7. Water moves up a stem because of

A. the cohesion of water molecules.
B. the adhesion of water molecules.
C. the transpiration of water molecules.
D. all of the above.

8. The phase in which molecules move the fastest is

A. liquid.
B. solid.
C. gas.
D. plasma.

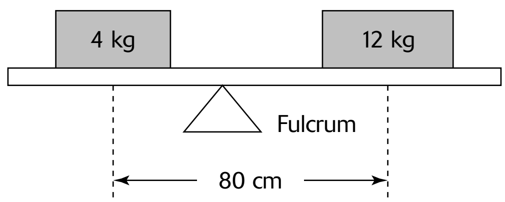
9. Mixing carbon and oxygen together to make carbon dioxide is a

A. chemical reaction.
B. physical reaction.
C. liquid reaction.
D. none of the above.

10. The gravitational attraction of the Moon on the Earth results in a high tide

A. every 24 hours.
B. on the side of the Earth facing the Moon.
C. on the sides 90° to the Moon.
D. on the side facing the Moon and on the opposite side.

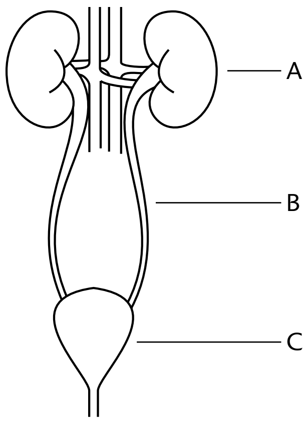
11.



Two masses are resting on a beam of negligible mass, as shown above. Where should the fulcrum be positioned so that the masses will be in balance?

A. 20 centimeters from the 4-kilogram mass
B. 20 centimeters from the 12-kilogram mass
C. 30 centimeters from the 4-kilogram mass
D. 40 centimeters from the 12-kilogram mass

12.



Consider the drawing of the interior of a human. Which of the following statements is true?

A. A is the kidney, B is the urethra, and C is the bladder.

B. A is the bladder, B is the ureter, and C is the kidney.

C. A is the kidney, B is the ureter, and C is the bladder.

D. A is the bladder, B is the urethra, and C is the kidney.

13. Which of the following options could represent fossil evidence of the existence of an extinct life form?

A. footprints found in slate

B. dinosaur bones

C. pottery shards

D. a carbonized imprint of a fish skeleton

14. Which layer of the Earth's structure is densest?

A. crust

B. mantle

C. outer core

D. inner core

15. Oxygen is most abundant in which atmospheric layer?

A. stratosphere

B. ionosphere

C. troposphere

D. mesosphere

16. Evolution can be defined as

A. competition among populations of organisms for natural resources.

B. populations that are best adapted to their environment at a given time.

C. populations whose characteristics do not change over time.

D. a change in one or more characteristics of a population over time.

17. Blood is approximately

A. 20% cells and 80% plasma.

B. 30% cells and 70% plasma.

C. 45% cells and 55% plasma.

D. 30% plasma and 70% cells.

18. A liquid sample has a volume of 50 milliliters at 20° Celsius. What will the new volume be at 100° Celsius if the pressure stays the same?

A. 1 milliliter

B. 250 milliliters

C. 4,980 milliliters

D. .004 milliliters

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19. Which of the following is the best heat conductor?

A. metalloid
B. plastic
C. metal
D. wood

20. A transformer that doubles the voltage from the primary to the secondary side

A. can deliver the same current on the secondary as is provided on the primary.
B. can deliver half the primary current on the secondary.
C. can deliver twice the primary current on the secondary.
D. can only work with direct current (DC).

21. Organelles that are considered "powerhouses of the cell" are

A. mitochondria.
B. vacuoles.
C. peroxisomes.
D. ribosomes.

22. As the volume of a gas increases, the pressure

A. increases.
B. decreases.
C. remains the same.
D. remains the same if it is a gas.

23. The number of ______ determines the atomic mass of a substance.

A. protons
B. neutrons
C. protons and electrons
D. protons and neutrons

24. Red-green colorblindness is a sex-linked trait in humans. If a girl is born colorblind, which of the following statements is true?

A. Her father is colorblind.
B. Her mother is colorblind.
C. Her mother is a carrier for the mutant gene.
D. All of the above could be true.

25. The HIV virus infects which type of cells?

A. cytotoxic T cells
B. helper T cells
C. phagocytes
D. monocytes

STOP

Arithmetic Reasoning

Time: 36 minutes

30 questions

1. Jack lives $6\frac{1}{2}$ miles from the library. If he walks $\frac{1}{3}$ of the way and takes a break, what is the remaining distance to the library?

A. $5\frac{5}{6}$ miles

B. 4 miles

C. $4\frac{1}{3}$ miles

D. $2\frac{1}{6}$ miles

2. Amelia casts a shadow 5 feet long. Her father, who is 6 feet tall, casts a shadow 8 feet long. How tall is Amelia?

A. 6 feet 8 inches

B. 4 feet 10 inches

C. 4 feet 6 inches

D. 3 feet 9 inches

3. John spent 30 minutes vacuuming, 12 minutes dusting, and 37 minutes washing dishes. How many minutes did John spend cleaning?

A. 34

B. 79

C. 100

D. 124

4. A recipe calls for 3 cups of wheat and white flour combined. If $\frac{3}{8}$ of this is wheat flour, how many cups of white flour are needed?

A. $1\frac{1}{8}$

B. $1\frac{7}{8}$

C. $2\frac{3}{8}$

D. $2\frac{5}{8}$

5. Jared rents three videos for $8.00. What would the cost of two video rentals be?

A. $1.33

B. $5.00

C. $5.33

D. $6.00

6. Rockford is 439 miles from Springville and 638 miles from Davenport. How much closer is Rockford to Springville than Rockford to Davenport?

A. 199 miles

B. 201 miles

C. 439 miles

D. 1,077 miles

7. A winter coat is on sale for $150. If the original price was $200, what percent has the coat been discounted?

A. 50%

B. 40%

C. 33%

D. 25%

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8. A square garden is to be built inside a circular area. Each corner of the square touches the circle. If the radius of the circle is 2, how much greater is the area of the circle than the square?

A. $4 - 4\pi$

B. $4 - 8\pi$

C. $4\pi - 4$

D. $4\pi - 8$

9. A blueprint has a scale of 3 feet per $\frac{1}{2}$ inch. If a bathroom is $1\frac{1}{2}$ inches $\times$ 2 inches, what are its actual dimensions?

A. $4\frac{1}{2}$ feet $\times$ 6 feet

B. 6 feet $\times$ $7\frac{1}{2}$ feet

C. $7\frac{1}{2}$ feet $\times$ 9 feet

D. 9 feet $\times$ 12 feet

10. A barrel holds 60 gallons of water. If a crack in the barrel causes $\frac{1}{2}$ gallon to leak out each day, how many gallons of water remain after 2 weeks?

A. 30

B. 53

C. $56\frac{1}{2}$

D. 59

11. The basketball game starts at 8:00. If it is now 5:30, how much time is left before the game starts?

A. 1 hour, 30 minutes

B. 2 hours, 30 minutes

C. 3 hours, 30 minutes

D. 4 hours, 30 minutes

12. How many blocks 6 inches $\times$ 4 inches $\times$ 4 inches can fit in a box 8 feet $\times$ 6 feet $\times$ 4 feet?

A. 2

B. 48

C. 576

D. 3,456

13. Janice buys a quart of milk and two dozen eggs. If milk costs \$1.39 and eggs are \$1.28 a dozen, how much change will Janice get back if she pays with a \$10.00 bill?

A. \$3.95

B. \$5.94

C. \$6.05

D. \$7.33

14. There are 800 employees at a company. If 60% drive to work and 30% take the train, how many employees arrive at work by car?

A. 240

B. 480

C. 540

D. 600

15. Min read three hardcover mysteries and four soft-cover mysteries. She read three times as many nonfiction books as she did mysteries. How many nonfiction books did Min read?

A. 9

B. 12

C. 18

D. 21

16. The volume of a cube is 343 cm^3. The surface area of the cube is

A. 7 cm^2

B. 49 cm^2

C. 294 cm^2

D. 2,401 cm^2

17. Melodi eats $\frac{3}{8}$ of a pizza and divides the rest between her two friends. What percentage of the pizza do her friends each receive?

A. 62.50%

B. 37.50%

C. 31.25%

D. 18.75%

18. Kim's favorite movie is 144 minutes long. Justin's favorite movie is 127 minutes long. How much longer is Kim's favorite movie?

A. 17 minutes

B. 23 minutes

C. 36 minutes

D. 44 minutes

19. Roger collects bottle caps. Each cap can be traded for 5 cents. If Roger receives $40.50, how many bottle caps did he trade?

A. 810

B. 405

C. 200

D. 8

20. A batch of cookies requires 2 cups of milk and 4 eggs. If you have 9 cups of milk and 9 eggs, how many batches of cookies can be made?

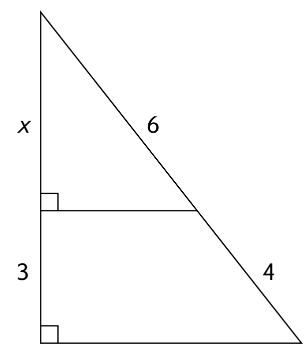
A. 9

B. 6

C. 4

D. 2

21. Find the value of *x* in the figure:



A. 4.5

B. 4.8

C. 5

D. 5.2

22. A piece of wood measuring 16.5 inches long is cut into 2.75-inch pieces. How many smaller pieces of wood are there?

A. 3

B. 5

C. 6

D. 8

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23. Shanella has 17 quarters, 33 dimes, and 8 pennies. The total amount of money is

A. \$7.63.

B. \$7.95.

C. \$5.80.

D. \$15.55.

24. While dining out, Chad spent \$25.00. If the bill totaled \$21.00 before the tip was added, approximately what percent tip did Chad leave?

A. 16%

B. 19%

C. 21%

D. 25%

25. A right triangle has an area of 24 feet. If one leg is 3 times as long as the other, what is the length of the longest side?

A. 12.6

B. 12

C. 8.4

D. 6.3

26. Interest earned on an account totals \$100. If the interest rate is $7\frac{1}{4}\%$, what is the principal amount?

A. \$725

B. \$1,333

C. \$1,379

D. \$1,428

27. Yan can read two pages in 3 minutes. At this rate, how long will it take him to read a 360-page book?

A. 30 minutes

B. 2 hours

C. 6 hours

D. 9 hours

28. Tanya's bowling scores this week were 112, 156, 179, and 165. Last week, her average score was 140. How many points did her average improve?

A. 18

B. 13

C. 11

D. 8

29. Felix buys three books for \$8.95 each. How much does he owe if he uses a \$12.73 credit toward his purchase?

A. \$39.58

B. \$26.85

C. \$21.68

D. \$14.12

30. The value of 18 quarters, 6 dimes, and 24 nickels is

A. \$5.34.

B. \$6.30.

C. \$18.84.

D. \$24.24.

STOP

Word Knowledge

Time: 11 minutes

35 questions

1. There was not enough room to **display** everything.

- **A.** sell
- **B.** exhibit
- **C.** store
- **D.** worry about

2. **Superficial** most nearly means

- **A.** deep.
- **B.** cursory.
- **C.** quality.
- **D.** intensive.

3. Please **cease** your complaining.

- **A.** stop
- **B.** forget
- **C.** change
- **D.** continue

4. He was **prevented** from boarding the ship.

- **A.** assisted
- **B.** encouraged
- **C.** hindered
- **D.** called

5. **Uniform** most nearly means

- **A.** unchanging.
- **B.** decreasing.
- **C.** increasing.
- **D.** forming.

6. **Conveyed** most nearly means

- **A.** talked about.
- **B.** carried.
- **C.** forgot.
- **D.** spotted.

7. **Impose** most nearly means

- **A.** protect.
- **B.** halt.
- **C.** require.
- **D.** border.

8. They tried to ignore the **hazard** in the alley.

- **A.** water
- **B.** hole
- **C.** danger
- **D.** odors

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9. **Vacant** most nearly means

A. empty.
B. full.
C. dependable.
D. relaxed.

10. He enjoyed the **camaraderie** of the other soldiers.

A. singing
B. friendship
C. playfulness
D. yelling

11. She thought that the sweater was **irritating**.

A. tight
B. loose
C. annoying
D. sloppy

12. **Abandon** most nearly means

A. affect.
B. placate.
C. enjoin.
D. relinquish.

13. **Triumph** most nearly means

A. delegation.
B. victory.
C. enjoyment.
D. wistfulness.

14. **Taboo** most nearly means

A. painted.
B. off limits.
C. skinny.
D. on target.

15. **Prior** most nearly means

A. earlier.
B. humorous.
C. latest.
D. matured.

16. **Require** most nearly means

A. extricate.
B. be silent.
C. need.
D. hope.

17. **Appropriate** most nearly means

A. incorrect.
B. sufficient.
C. purchased.
D. quarantined.

18. He was able to **specify** what he wanted.

A. cite
B. order
C. forget
D. take heed

19. **Intermittent** most nearly means

- **A.** constant.
- **B.** at irregular intervals.
- **C.** warm.
- **D.** between buildings.

20. He was able to sift through the **residue**.

- **A.** odor
- **B.** remainder
- **C.** garden
- **D.** residence

21. The two lawyers could not **concur** about the result.

- **A.** satisfy
- **B.** plead
- **C.** argue
- **D.** agree

22. **Implore** most nearly means

- **A.** explode.
- **B.** set on fire.
- **C.** beg.
- **D.** find.

23. Fortunately, the teacher was always **convivial**.

- **A.** inquisitive
- **B.** punctual
- **C.** absent
- **D.** pleasant

24. **Impeccable** most nearly means

- **A.** penniless.
- **B.** flawless.
- **C.** degrading.
- **D.** bored.

25. **Quandary** most nearly means

- **A.** foil.
- **B.** definition.
- **C.** predicament.
- **D.** trust.

26. They searched for a **resolution** to the problem between them.

- **A.** payoff
- **B.** decision
- **C.** exclusion
- **D.** relationship

27. **Obnoxious** most nearly means

- **A.** smelly.
- **B.** unpleasant.
- **C.** hurtful.
- **D.** plentiful.

28. **Encroach** most nearly means

- **A.** intrude.
- **B.** depart.
- **C.** prosecute.
- **D.** slither.

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29. **Divergent** most nearly means

A. stubborn.
B. despicable.
C. drawn apart.
D. not desirable.

30. **Duplicity** most nearly means

A. double.
B. official.
C. deceit.
D. anger.

31. The man used an **alias** to join the club.

A. strange look
B. another name
C. smiling face
D. frown

32. **Sparse** most nearly means

A. complete.
B. meager.
C. empty.
D. enormous.

33. **Diminutive** most nearly means

A. loud.
B. small.
C. revived.
D. magnified.

34. **Exhort** most nearly means

A. call to task.
B. urge strongly.
C. falter.
D. yell at.

35. She was able to **suppress** the noise.

A. tune out
B. enhance
C. hold up
D. stifle

STOP

Paragraph Comprehension

Time: 13 minutes

15 questions

1. More American children are obese than ever before. Experts blame increased television watching, easy access to junk food, less outdoor exercise, and unhealthy school lunches as possible culprits.

In this context, the word *culprits* means

A. causes.

B. burglars.

C. outcomes.

D. criminals.

2. A new study suggests that one in four Americans does not get enough sleep. Sleep experts recommend 8 hours of sleep per night, and most Americans report an average of 6.9 hours of sleep on weeknights and 7.5 hours of sleep on weekends.

The average American sleeps

A. 8 hours on weekend nights.

B. 9 hours on weekend nights.

C. 6.5 hours on weeknights.

D. 7.5 hours on weekend nights.

3. According to a recent study, sports cause the most accidental injuries for children. Sports-related injuries increase with age, and adolescence is the peak time period for such injuries to occur.

The best title for this selection is

A. Adolescents and Sports.

B. Most Childhood Accidental Injuries Caused by Sports.

C. Sports Are Harmful to Children.

D. Sports and Your Child.

4. The phenomenon of planetary alignment only occurs once every several hundred years. Such an alignment occurs when all of the planets line up on the right side of the sun within 90° of each other or closer. This positioning of the planets is visible to the naked eye. A true planetary alignment occurred in May of 2002. Before that, such an alignment had not occurred since April of 1128.

The following fact is *not* mentioned in the selection:

A. Planetary alignments are visible to the naked eye.

B. Planetary alignments cause planets to line up on the left side of the sun.

C. Planetary alignments cause planets to line up on the right side of the sun.

D. The last planetary alignment occurred in 2002.

GO ON TO THE NEXT PAGE

5. In most cases, ferns are easy plants for the beginning gardener to grow. There are hundreds of species around the world that require only soil, a little compost, and water. After the initial planting and care for the plant, many ferns can survive outdoors on their own. They only needed to be weeded and thinned occasionally.

The best title for this selection is

A. Outdoor Ferns.

B. The Beginning Gardener.

C. Ferns: The Easy Care Plants.

D. What You Need to Plant Ferns.

6. The Gila monster may be more than just a ghoulish looking creature that frightens people with its appearance. According to scientists, this creature might hold the key to a cure for Alzheimer's Disease. Although the bite of the Gila monster can be deadly, its saliva contains a chemical that affects memory.

In this context, *ghoulish* means

A. friendly.

B. horrid.

C. silly.

D. cute.

7. Health experts claim that an aspirin a day may cut the risk of developing polyps commonly found in colon cancer. However, a full-size aspirin does not cut the risk as much as the smaller baby aspirin does.

The best title for this selection is

A. Health Benefits of Aspirin.

B. Cancer and Aspirin Dosage.

C. Aspirin May Prevent Colon Cancer.

D. Colon Cancer Prevention.

8. The debate continues among experts concerning whether organic foods are more healthy or just more expensive. Organic foods are those that are free of artificial pesticides and fertilizers and contain no herbicides.

Organic foods are

A. more healthy than regular foods.

B. ones that do not contain any pesticides.

C. inexpensive.

D. ones that contain no herbicides.

9. Scientists have recently found two stars that could possibly change the current understandings of physics and astronomy. Initially, these stars were thought to be neutron stars, which are the remnants of supernovas. However, they are smaller and cooler than neutron stars. Scientists hypothesize that these objects are indeed neutron stars but that they are just smaller and cooler than those that have been studied previously.

You may conclude from this selection that

A. the two stars are definitely neutron stars.

B. more study is needed to determine what these stars are.

C. neutron stars are usually much smaller than these stars.

D. neutron stars are usually much cooler than these stars.

10. Global warming and the greenhouse effect may not be all that human beings need to worry about. Environmentalists predict that climate change over the next 50 years will shift the current balance of ecosystems and bring new predators and prey closer together. This shift may not cause vast extinction of species, but it will most probably cause unbalanced distributions of predators and prey throughout the world. Such an altered distribution of animal species will affect humans in unpredictable ways.

The author of this selection probably feels that climate changes in the next 50 years

A. can only be beneficiary to humans.

B. will have no effect on humans.

C. may have ill effects on humans.

D. will not happen.

Questions 11 and 12 refer to the following excerpt.

Cardiologists say that a better survival rate for heart attack patients is at the touch of the patients' fingertips. Although the typical American suffering from a heart attack waits 2 hours to call 911, damage to the heart that can lead to death occurs much sooner. One doctor's answer is house calls which would be performed in response to 911 calls. With his plan, a team of trained doctors would come to the patient's home and quickly assess the situation. This novel heart attack treatment plan would alleviate patients' worries of calling unneeded ambulances to their residence. Since more than 1.1 million Americans will suffer a heart attack every year, the American Heart Association is backing this experiment to save more lives.

11. The author of this selection probably feels that house calls to heart attack patients

A. will be an improvement over the current system.

B. will cause more problems than the current system does.

C. will be alarming for suffering heart attack patients.

D. will be too expensive to implement.

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12. In this context, *alleviate* means

A. irritate.

B. increase.

C. ease.

D. strengthen.

Questions 13, 14, and 15 refer to the following selection.

A new study in the latest issue of *Archives of Dermatology* shows that even though doctors in casual dress might be acceptable on television sitcoms, patients in the real world want their doctors to dress formally. Instead of the often popular informal garb of blue jeans and sandals, patients want to see their physicians wearing white lab coats and name badges. Thus, even though our society as a whole is entering an age of casualness, people still want their doctors to dress professionally.

Researchers speculate that patients feel that their doctor appears more professional in formal clothes and is thus more trustworthy. Informal dress such as blue jeans and sandals might also suggest flippancy about the job being performed.

13. The best title for this selection is

A. Doctors and Dress.

B. Informally Dressed Society Prefers Formally Dressed Physicians.

C. Doctors' Clothing Style Unimportant.

D. Reasons Professionals Should Dress Professionally.

14. You might infer from the selection that informal garb

A. is acceptable in all other professions.

B. is preferred for certain kinds of doctors.

C. such as scrubs for doctors is also viewed negatively.

D. includes white lab coats and badges.

15. In this context, *flippancy* means

A. concern.

B. thoughtlessness.

C. worry.

D. anger.

STOP

Auto and Shop Information

Time: 11 minutes

25 questions

1. A car comes in with a complaint of the brakes seeming to not release after the driver steps on the brakes. Which of these could be the cause?

A. no brake pedal, free travel
B. a leaking wheel cylinder
C. air in the hydraulic
D. a bad cup in the master cylinder

2. You have just installed an engine that you rebuilt. When should you time the distributor?

A. after road testing the vehicle
B. before starting the engine
C. after the engine has warmed up
D. while cranking the engine

3. Technician A says planetary gears are used in automatic transmissions. Technician B says planetary gears are used in manual transmissions. Who is right?

A. A only
B. B only
C. both A and B
D. neither A nor B

4. Hydraulic systems in automatic transmissions are being discussed. Technician A says fluid is used to perform work. Technician B says fluid transfers heat. Who is correct?

A. A only
B. B only
C. both A and B
D. neither A nor B

5. The front suspension system of a vehicle is being discussed. Technician A says that the spindle and knuckle assembly support braking system components. Technician B says the spindle and knuckle assembly support steering components Who is right?

A. A only
B. B only
C. both A and B
D. neither A nor B

6. The component of an ignition system that transforms voltages from 12 volts to thousands of volts is the

A. distributor.
B. coil.
C. spark plug.
D. rotor.

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7. Port fuel injection systems are being discussed. Technician A says that some systems fire each injector individually. Technician B says that some systems have pairs of injectors turned on at the same time. Who is correct?

A. A only

B. B only

C. both A and B

D. neither A nor B

8. In which of the strokes in a four-cycle engine is the piston going down and are both valves closed?

A. intake

B. compression

C. power

D. exhaust

9. Which of the following statements about four-wheel-drive vehicles is not true?

A. Front hubs must be locked during 4WD operation.

B. Some front hub designs lock automatically.

C. All 4WD systems require the driver to lock the hubs manually at the wheels.

D. When unlocked in 2WD, the front wheels still turn.

10. Technician A says when a vehicle is locked in 2WD on a 4WD system, the front wheels still turn, including the front axles. Technician B says the front wheels still turn but the entire front drivetrain stops turning. Who is correct?

A. A only

B. B only

C. both A and B

D. neither A nor B

11. Clutches are being discussed. Technician A says when the clutch pedal is depressed, the pressure plate squeezes the clutch disc onto the flywheel. Technician B says when the clutch pedal is released, the pressure plate stops squeezing the clutch disc onto the flywheel. Who is correct?

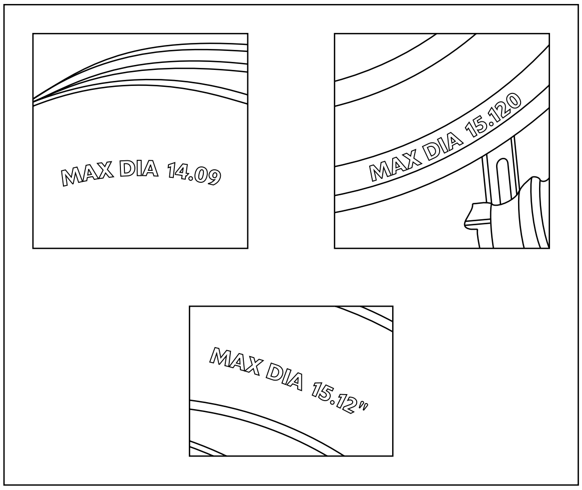
A. A only

B. B only

C. both A and B

D. neither A nor B

12.



Looking at the figure above, what is indicated on the drums?

A. diameter of the drums

B. maximum drum to lining fit

C. drum discard dimension

D. none of the above

13. An accurate reading for brake rotor runout requires the use of a

A. dial indicator.

B. micrometer.

C. straight edge.

D. caliper.

14. Before cutting a piece of metal, the best way to mark the cut is by using a

A. saw blade.

B. chisel.

C. scratch awl.

D. grease pen.

15. The term "penny" is used

A. to designate the size of a nail.

B. to indicate the cost of screws.

C. when installing roof flashing.

D. as a measure of battery size.

16. What type of saw is used in a miter box?

A. rip saw

B. coping saw

C. back saw

D. keyhole saw

17. The purpose of a push stick is to

A. push scrap wood from a radial arm saw.

B. guide wood through the blade of a bench saw.

C. hold wood in the frame of a drill press.

D. align the fence on a router table.

18. Of the following, which is the best wood for building furniture?

A. balsa

B. cedar

C. spruce

D. maple

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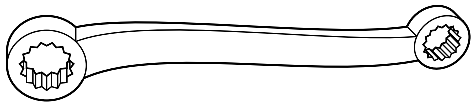
19.



The illustration above is an example of a

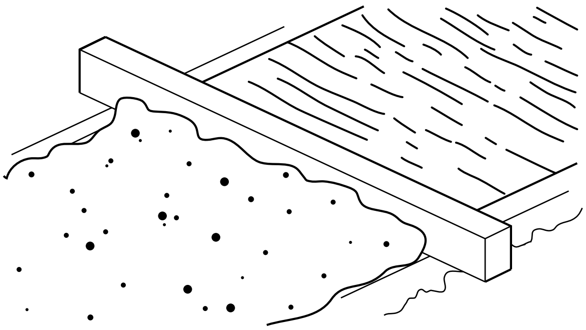
A. pipe wrench.

B. box-end wrench.

C. combination wrench.

D. open-end wrench.

20.



The illustration above is an example of

A. flattening.

B. screeding.

C. turning.

D. troweling.

21. Flooring lumber can be purchased that uses which of the following type of joint?

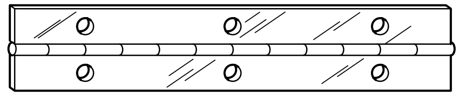
A. mortise

B. rabbit

C. tongue-and-groove

D. lap

22.



The hinge illustrated above is often used on

A. closets.

B. pianos.

C. garage doors.

D. outdoor gates.

23. A bolt differs from a screw in that

A. a bolt has more threads.

B. bolts are not tapered like screws.

C. screws have more threads.

D. bolts cannot hold two pieces of wood together.

24. A spline is used to

A. support the end of a window frame.

B. join two pieces of wood.

C. seal the open end of a plywood sheet.

D. test the sharpness of a wood chisel.

25. Concrete cures in about

A. 1 day.

B. 1 week.

C. 1 month.

D. 1 year.

STOP

Mathematics Knowledge

Time: 24 minutes

25 questions

1. If $w - 3 = 3 - w$, what is the value of w^2?

A. 0

B. 1

C. 3

D. 9

2. $\frac{24}{96} - \frac{8}{12} =$

A. $\frac{1}{4}$

B. $\frac{5}{96}$

C. $-\frac{5}{12}$

D. $\frac{4}{21}$

3. If $6m - 2$ is divided by 2, the result is -4. What is the value of m?

A. -1

B. 0

C. 1

D. 2

4. The diagonal of a square is 10 inches. What is the area of the square?

A. 40 in^2

B. 50 in^2

C. 100 in^2

D. 150 in^2

5. A car travels 20 miles in 30 minutes. At this rate, how far will the car travel in 2 hours?

A. 40 miles

B. 60 miles

C. 80 miles

D. 100 miles

6. Simplify $\frac{15\sqrt{3}}{\sqrt{5}}$.

A. $3\sqrt{3}$

B. $3\sqrt{15}$

C. $15\sqrt{15}$

D. $75\sqrt{3}$

7. How many blocks with sides 4 inches in length can fit into a crate 3 feet × 2 feet × 2 feet?

A. 3

B. 32

C. 196

D. 324

8. If $x = -3$ and $y = 2$, evaluate x^{2y}.

A. -64

B. -81

C. 64

D. 81

GO ON TO THE NEXT PAGE

9. $0.00525 \div 0.01 =$

A. 5.25

B. 0.525

C. 0.0525

D. 0.000525

10. $\frac{3}{4} \div \frac{4}{3} =$

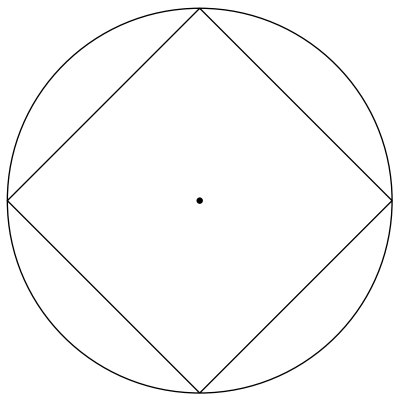
A. 0

B. 1

C. $\frac{9}{16}$

D. $\frac{16}{9}$

11. If the area of the circle is 121π, find the area of the square.



A. 121

B. 242

C. 363

D. 484

12. Simplify $(3x^2 + 2x - 5) - (2x^2 - 5) + (4x - 7)$.

A. $x^2 + 6x - 17$

B. $x^2 + 4x - 7$

C. $x^2 + 6x - 2$

D. $x^2 + 6x - 7$

13. One-fourth of the cars purchased at a dealership are luxury models. If 360 luxury models were purchased last year, how many total cars were purchased?

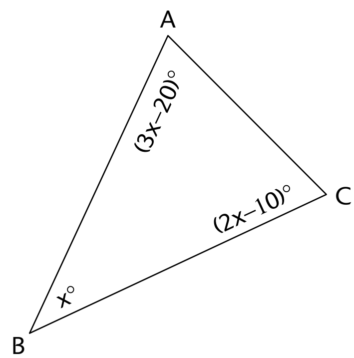
A. 90

B. 250

C. 1,440

D. 3,600

14. What is the measure of ∠A?



A. 35°

B. 60°

C. 75°

D. 85°

15. Find the product of $(3 - 4x)$ and $(3 + 4x)$.

A. 9

B. $9 + 12x - 16x^2$

C. $9 - 16x^2$

D. $9 + 16x^2$

16. Round $(2.5)^4$ to the nearest tenth.

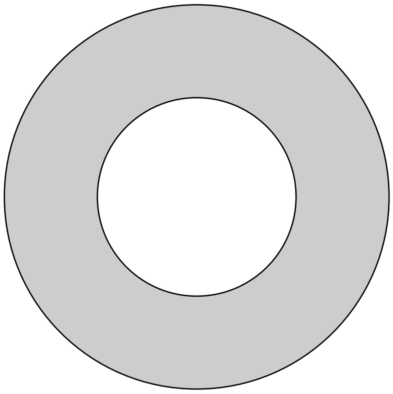
A. 10.0

B. 25.4

C. 39.0

D. 39.1

17. The radius of the smaller circle is $\frac{1}{4}$ as long as the larger. What percent of the figure shown is shaded?



A. $6\frac{1}{4}\%$

B. 25%

C. 75%

D. $93\frac{3}{4}\%$

18. The least common multiple of 8, 12, and 20 is

A. 4.

B. 24.

C. 60.

D. 120.

19. Multiply $(5a^3bc^2)(-3a^2c)$.

A. $-15a^5bc^3$

B. $15a^5bc^3$

C. $-15a6bc^2$

D. $2abc$

20. Simplify $\frac{x^2-25}{5-x}$.

A. $x + 5$

B. $x - 5$

C. $-(x + 5)$

D. $5 - x$

21. Given that the point $(x, 1)$ lies on a line with a slope of $-\frac{3}{2}$ and a y-intercept of –2, find the value of x.

A. –2

B. –1

C. 1

D. 2

22. What is the probability of flipping three heads in a row using a fair coin?

A. $\frac{1}{2}$

B. $\frac{2}{3}$

C. $\frac{1}{8}$

D. $\frac{3}{8}$

23. If $0.08z = 6.4$, then $z =$

A. 0.8.

B. 8.

C. 80.

D. 800.

24. Find the area of a regular hexagon whose sides measure 6 centimeters.

A. 36

B. $9\sqrt{2}$

C. $54\sqrt{3}$

D. 108

25. The girls' basketball team won three times as many games as they lost. How many games were won if they played a total of 24 games?

A. 6

B. 8

C. 12

D. 18

STOP

Practice Test 3

Mechanical Comprehension

Time: 19 minutes

25 questions

1. The location of the center of mass of a person

A. is always located inside the person.

B. is always located outside the person.

C. is a fixed point that does not change.

D. can change if the person moves.

2. If a baseball is thrown, then ____________ follows a parabolic path.

A. every part of the baseball

B. only the center of mass always

C. every part of the surface of the ball

D. every part of the ball except the center of mass

3. If the Earth exerts a force of 400 N on a woman, then the gravitational force that the woman exerts on the Earth is

A. zero.

B. 400 N.

C. much less than 400 N.

D. much more than 400 N.

4. People driving up a mountain will find that their mass will ______ and their weight will _______.

A. increase, decrease

B. increase, decrease

C. decrease, remain the same

D. remain the same, decrease

5. In order for Jean to drive her station wagon at constant speed around a curve without accelerating, she must

A. maintain a constant speed.

B. speed up gradually.

C. slow down gradually.

D. It is impossible to maintain her speed without accelerating.

6. During an elastic collision

A. both momentum and kinetic energy are conserved.

B. only momentum is conserved.

C. only kinetic energy is conserved.

D. only kinetic and potential energies are conserved.

7. A car bumper protects a car during a collision because it

A. decreases the impact time.

B. increases the impact time.

C. increases the impact force.

D. increases the transfer of kinetic energy.

8. A student makes a graph of the force applied in the direction of motion versus the displacement. The work done by this force is associated with

A. the slope of the graph.

B. the area under the graph.

C. the value of the force at a particular value of displacement.

D. cannot be determined from the graph

9. In simple harmonic motion, there is always a constant ratio between the displacement of the mass and its

A. acceleration.

B. speed.

C. period.

D. mass.

10. The angular velocity of the seconds hand of a clock is

A. 0.105 rad/s.

B. 9.53 rad/s.

C. 6.28 rad/s.

D. 0.159 rad/s.

11. If Jean runs with a constant velocity of −5 m/s, then her speed is

A. 5 m/s.

B. −5 m/s.

C. impossible to have a negative velocity

D. cannot be determined

12. An object can accelerate by

A. changing the direction of its velocity but not the magnitude.

B. changing the magnitude of the velocity but not the direction.

C. changing the speed.

D. any of the above.

13. A foul ball hit vertically upward with an initial speed of 46.8 m/s will take _____ to reach the top of its trajectory.

A. 9.56 seconds

B. 5.82 seconds

C. 4.78 seconds

D. 0.21 seconds

14. Anne walks 8 meters to the right, then 24 meters to the left, and finally 48 meters to the right. If she completes this in 160 seconds, then her average velocity is

A. 0.6 meters.

B. 0.5 meters.

C. 0.2 meters.

D. 0.3 meters.

GO ON TO THE NEXT PAGE

15. A wheel with a moment of inertia of 0.3 kg(m^2) is rotating with an initial angular velocity of 4 rad/s. The magnitude of the torque needed to increase the angular velocity to 6.5 rad/s in 4 seconds is

A. 1.50 newton-meters.

B. 3.00 newton-meters.

C. 0.188 newton-meters.

D. 0.788 newton-meters.

16. The work done on a building by a 75-kilogram wrecking ball striking at a speed of 4 m/s is

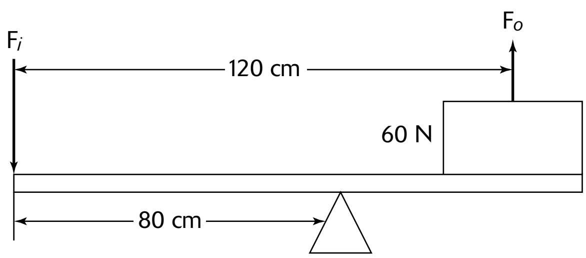
A. 300 joules.

B. 1,200 joules.

C. 600 joules.

D. none of the above.

17. A 60-N weight is lifted by the lever arrangement shown in the figure. If the weight of the lever is negligible, the ideal mechanical advantage (F_o/F_i) and the input force F_i required to achieve equilibrium are



A. 3, 30.

B. 2, 30.

C. 2, 120.

D. 3, 1.

18. The velocity needed to escape the gravitational pull of a planet of 8×10^{24} kilograms and a radius of 5×10^{6} meters is nearly

A. 11.2 km/s.

B. 14.6 km/s.

C. 18.7 km/s.

D. 23.4 km/s.

19. The magnitude of the force necessary to change the momentum of a particle from 10 kg m/s to 50 kg m/s in 12 seconds is

A. 3.33 newtons.

B. 4.16 newtons.

C. 4.0 newtons.

D. 720 newtons.

20. An 80-kilogram man jumps with a velocity of 3 m/s off the bow of a 120-kilogram boat initially at rest. Ignoring the friction of the water on the boat, the velocity v of the boat after the man jumps will be

A. –1.00 m/s.

B. –1.50 m/s.

C. –2.00 m/s.

D. –3.00 m/s.

21. A 10-kilogram mass attached to a spring oscillates with a period of 3.14 seconds. The force constant of the spring *k* is

A. 40.

B. 20.

C. 4.

D. 2.

22. A 5-kilogram block starts downward from rest at the top of a 40-meter-long frictionless inclined plane. If the block starts at a height of 10 meters above the ground, its speed as it hits the ground is _________ m/s and the force on the block while sliding is _________.

A. 19.6, 1.225 newtons

B. 19.6, 12.25 newtons

C. 14, 12.25 newtons

D. 14, 1.225 newtons

23. The instantaneous momentum times acceleration of a body is proportional to

A. work done.

B. travel distance.

C. mechanical force.

D. output power.

24. A worker is pulling a box at a constant speed in a straight line along the floor.

Which of the following statements is true?

A. The forces on the box equal the force of gravity acting on the box.

B. The forces on the box are unbalanced and in the direction of motion.

C. The forces on the box are balanced and the net force is zero.

D. The forces on the box exceed the frictional forces opposing motion.

25. An object is moving at a constant speed. It is safe to say that

A. a constant force is applied to move the object.

B. no forces are acting on the object.

C. the object is moving on a frictionless surface.

D. the kinetic energy of the object is constant.

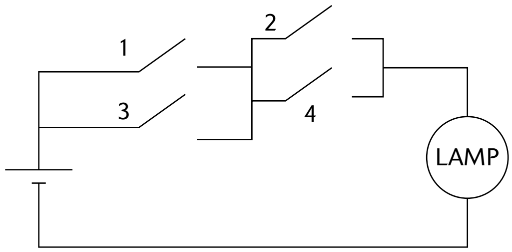
STOP

Electronics Information

Time: 9 minutes

20 questions

1. For the lamp to be turned on in the circuit shown below,



A. switch 1or switch 2 should be closed.

B. switch 4 only should be closed.

C. switches 1 and 3 should be closed.

D. switches (1 or 3) and (2 or 4) should be closed.

2. A wattmeter is a device used for measuring

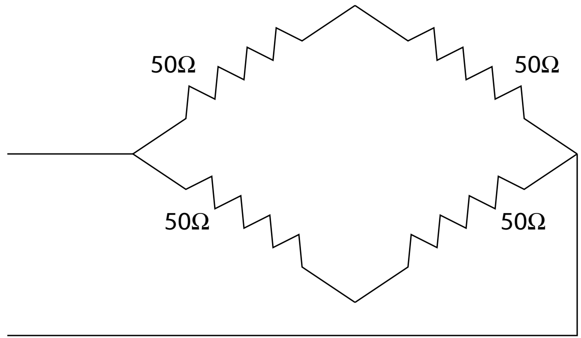
A. electrical current.

B. electrical voltage.

C. electrical power.

D. electrical charge.

3. The total resistance for the circuit shown below is



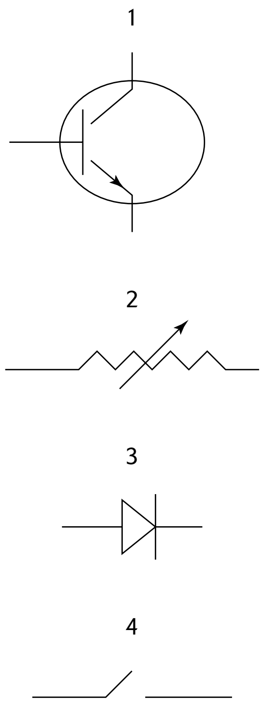
A. 400 ohms.

B. 100 ohms.

C. 50 ohms.

D. 200 ohms.

4. Which one of the symbols shown in the art below represents a variable resistor?



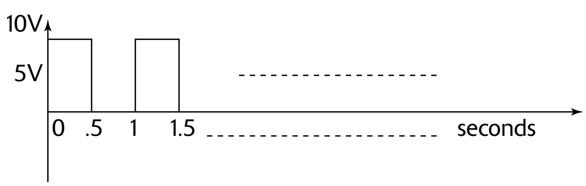
A. 1

B. 2

C. 3

D. 4

5. The square wave voltage signal shown in the following illustration has



A. a frequency of 100 Hz.

B. an amplitude of 10 volts.

C. a period of .5 second.

D. a DC shift of 5 volts.

6. Which of the following components has a measurement unit of farads?

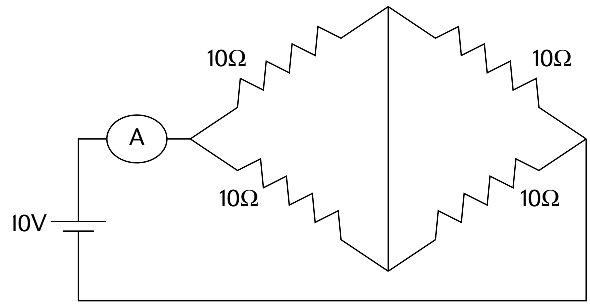
A. capacitor

B. coil

C. resistor

D. diode

7. The reading of the ammeter in the circuit shown in the following figure is



A. 0.5 amperes.

B. 1 amperes.

C. 0.1 amperes.

D. 0.25 amperes.

8. An audio signal is transmitted by

A. storing it.

B. multiplying it with a triangular wave.

C. carrying it on a sinusoidal signal.

D. filtering it.

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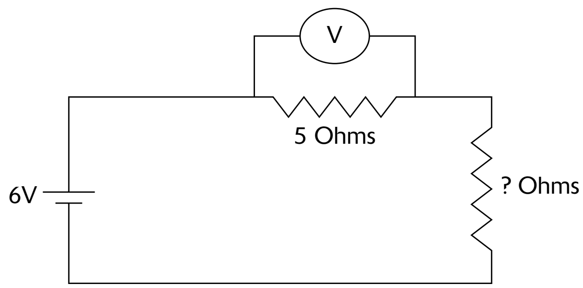
9. If the reading of the voltmeter in the circuit shown in the following figure is 2 volts, then the value of the unknown resistor is



A. 5 ohms.

B. 10 ohms.

C. 1 ohm.

D. 2 ohms.

10. A diode will pass electrical current when the

A. voltage applied is less than the threshold level.

B. voltage applied is zero.

C. voltage applied is greater than the threshold level.

D. voltage difference between the anode and the cathode is zero.

11. If a transistor is connected using the common emitter configuration, then the collector current will be

A. less than the base current.

B. an amplification of the base current.

C. same as the base current.

D. a rectification of the base current.

12. As a safety requirement, electrical devices are

A. designed to be effective.

B. grounded.

C. used in communications systems.

D. placed on tables.

13. An oscillator circuit is used to

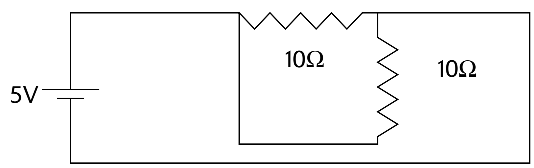
A. amplify current.

B. generate a DC signal.

C. rectify current.

D. generate a high frequency carrier signal.

14. The total power dissipated across the resistors in the circuit shown in the following figure is



A. 5 watts.

B. 2.5 watts.

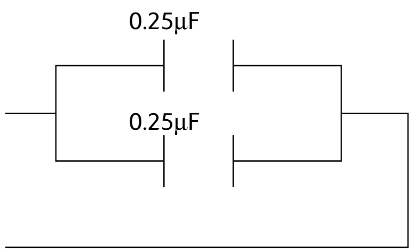
C. 6 watts.

D. 2.5 watts.

15. A capacitor can be used as a

A. frequency filter.
B. rectifier.
C. transformer.
D. current amplifier.

16. The total capacitance of the circuit shown below is



A. 0.125μF.
B. 1μF.
C. .5μF.
D. 1.5μF.

17. A square wave can be obtained from

A. a voltmeter.
B. a function generator.
C. an ammeter.
D. an ohmmeter.

18. Coils are used in electric transformers to

A. rectify the current.
B. induce a different level of voltage.
C. reduce the value of the current.
D. pass the DC signal.

19. Bipolar Junction Transistors (BJTs) can be

A. NP.
B. PN.
C. PNP.
D. PPN.

20. In order to reduce the total resistance of a circuit, resistors are connected in

A. series.
B. parallel.
C. series followed by parallel.
D. parallel followed by series.

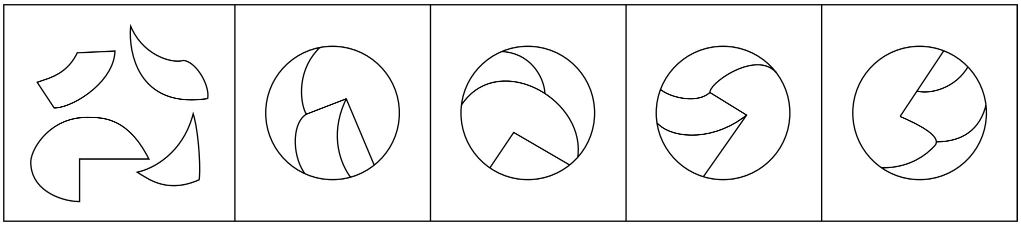
STOP

Assembling Objects

Time: 9 minutes

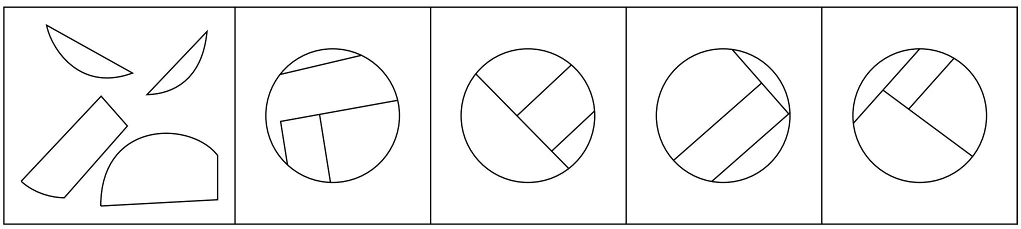
16 questions

1.



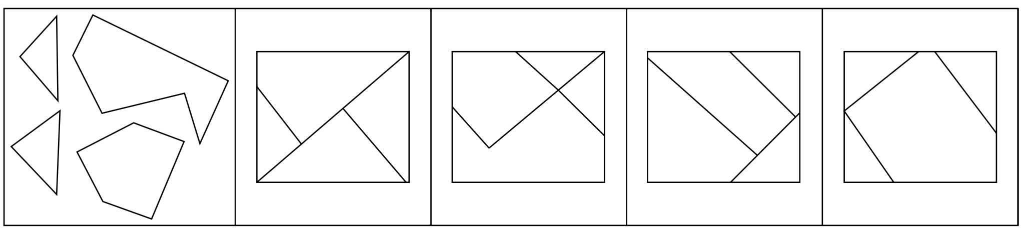
A B C D

2.



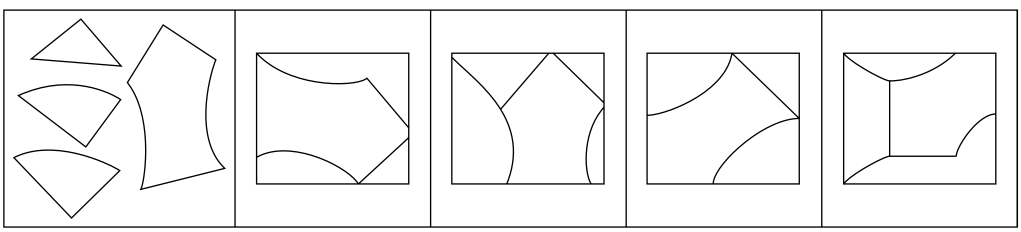
A B C D

3.



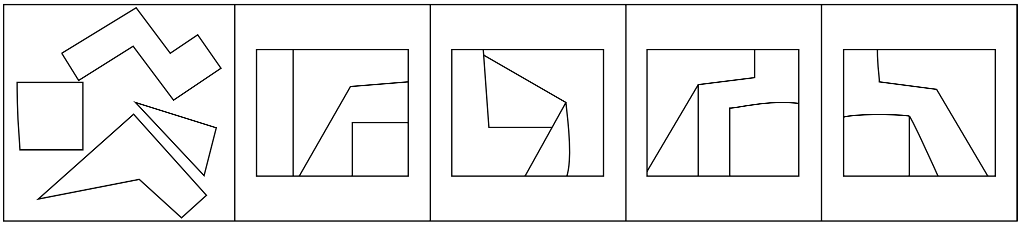
A B C D

4.



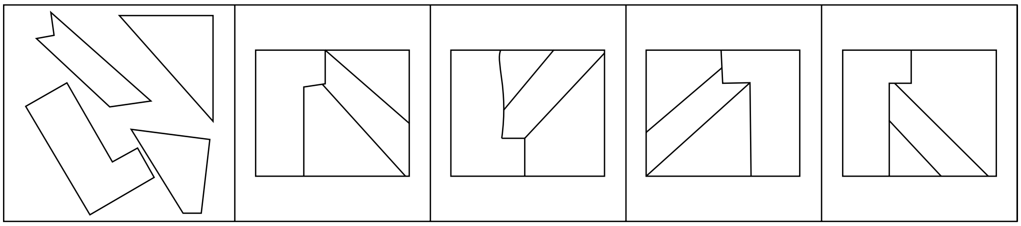
A B C D

5.



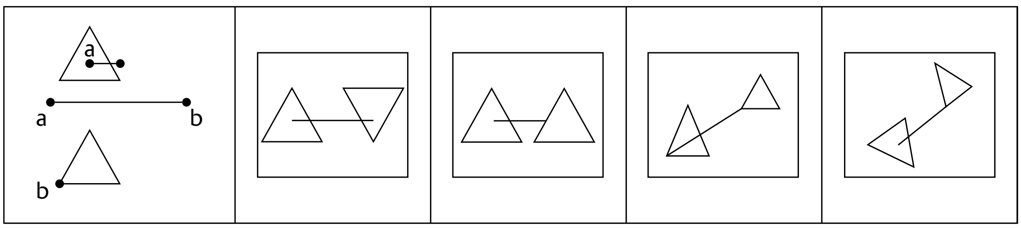
A B C D

6.



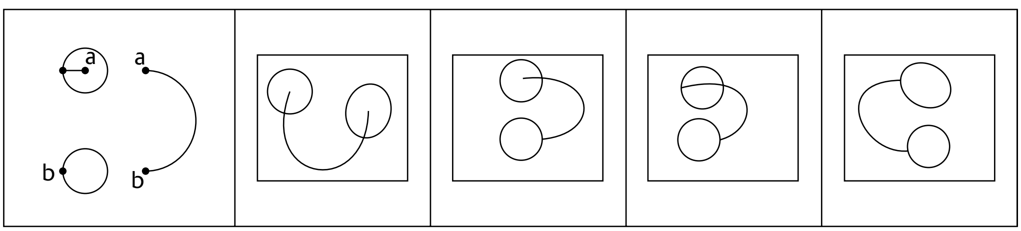
A B C D

7.



A B C D

8.



A B C D

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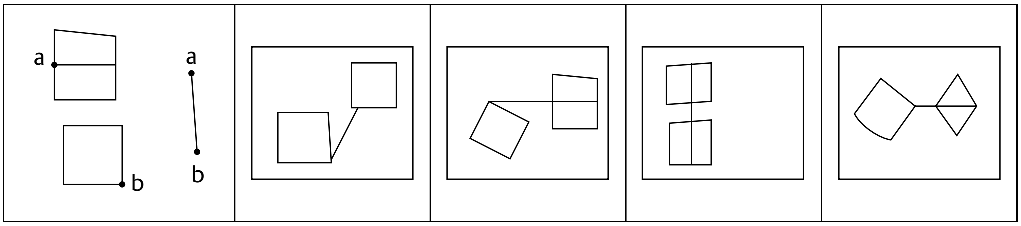
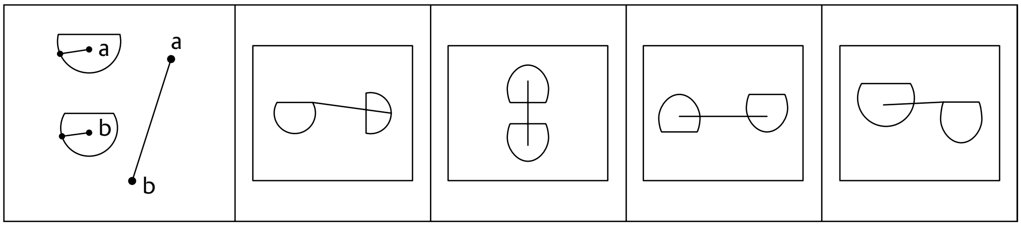
9.



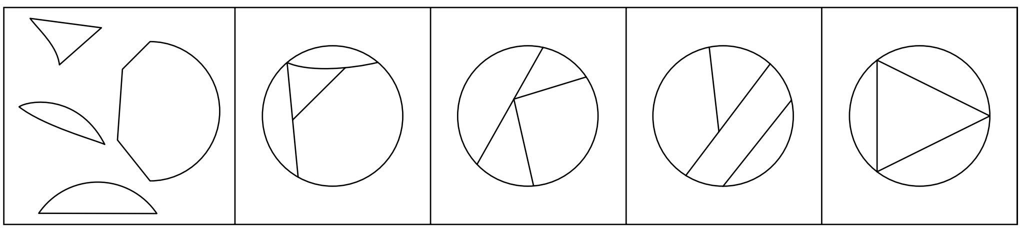
A B C D

10.



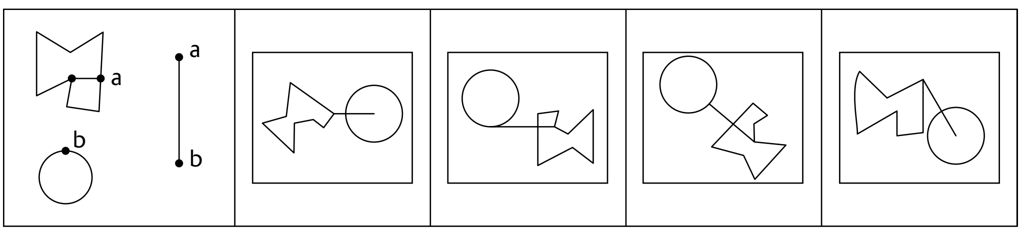
A B C D

11.



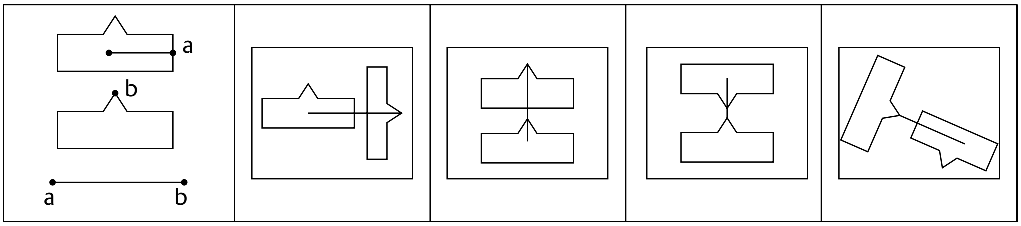
A B C D

12.



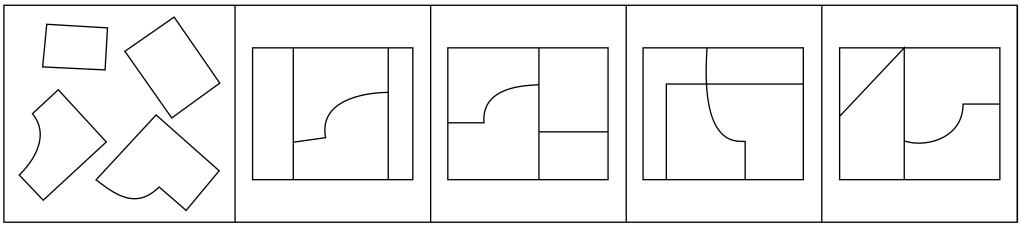
A B C D

13.



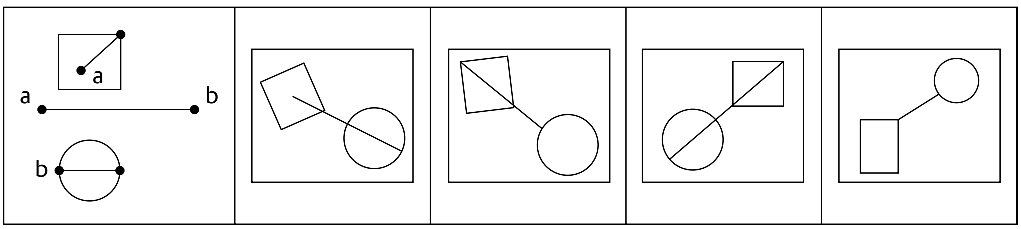
A B C D

14.



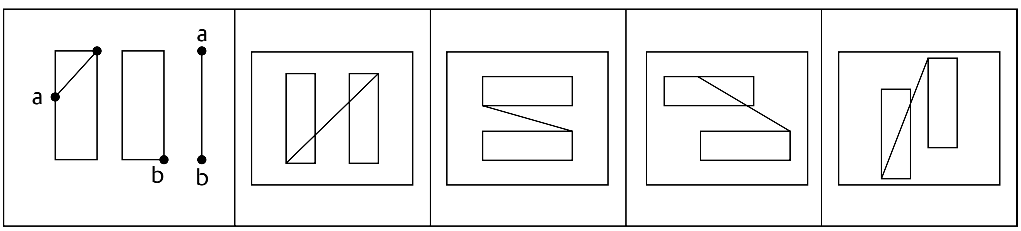
A B C D

15.



A B C D

16.



A B C D

STOP

Answer Key for Practice Test 3

General Science

1. D
2. C
3. B
4. C
5. D
6. B
7. D
8. D
9. A
10. D
11. B
12. C
13. C
14. D
15. C
16. D
17. C
18. B
19. C
20. B
21. A
22. B
23. A
24. D
25. B

Arithmetic Reasoning

1. C
2. D
3. B
4. B
5. C
6. A
7. D
8. D
9. D
10. B
11. B
12. D
13. C
14. B
15. D
16. C
17. C
18. A
19. A
20. D
21. A
22. C
23. A
24. B
25. A
26. C
27. D
28. B
29. D
30. B

Word Knowledge

1. B
2. B
3. A
4. C
5. A
6. B
7. C
8. C
9. A
10. B
11. C
12. D
13. B
14. B
15. A
16. C
17. B
18. A
19. B
20. B
21. D
22. C
23. D
24. B

25. C
26. B
27. B
28. A
29. C
30. C
31. B
32. B
33. B
34. B
35. D

Paragraph Comprehension

1. A
2. D
3. B
4. B
5. C
6. B
7. C
8. D
9. B
10. C
11. A
12. C
13. B
14. C
15. B

Auto and Shop Information

1. A
2. B
3. A
4. C
5. C
6. B
7. C
8. C
9. C
10. B
11. D
12. C
13. A
14. C
15. A
16. C
17. B
18. D
19. B
20. B
21. C
22. B
23. B
24. B
25. C

Mathematics Knowledge

1. D
2. C
3. A
4. B
5. C
6. B
7. D
8. D
9. B
10. C
11. B
12. D
13. C
14. D
15. C
16. D
17. D
18. D
19. A
20. C
21. A
22. C
23. C
24. C
25. D

Mechanical Comprehension

1. D
2. B
3. B
4. D
5. D
6. A
7. B
8. B
9. A
10. A
11. A
12. D
13. C
14. C
15. C
16. C
17. B
18. B
19. A
20. C
21. A
22. C
23. D
24. C
25. D

Electronics Information

1. D
2. C
3. C
4. B
5. D
6. A
7. B
8. C
9. B
10. C
11. B
12. B
13. D
14. A
15. A
16. C
17. B
18. B
19. C
20. B

Assembling Objects

1. C
2. C
3. B
4. C
5. C
6. C
7. D
8. C
9. B
10. C
11. A
12. B
13. D
14. B
15. A
16. C

Practice Test 3 Answers and Explanations

General Science (Practice Test 3 Answers)

1. **D.** The Earth is approximately 4.5 billion years old. There has been life on Earth for much of that time.
2. **C.** The heart pumps blood from its right side to the lungs. The left ventricle pumps blood throughout the rest of the body, initially through the aorta (B).
3. **B.** The coefficients are the number of moles.
4. **C.** A mole of any gas occupies 22.4 liters at STP.
5. **D.** The distance a mass travels in free fall is proportional to the square of the time. Since 3 seconds is 3 times more than 1 second, the distance is 9 times greater, $9 \times 5 = 45$ meters.
6. **B.** Radial symmetry is like a wheel with spokes. Of the possible answers, only a jellyfish displays radial symmetry.
7. **D.** Cohesion is the attraction of water molecules to one another. Adhesion is the attraction of water molecules to the walls of a vessel. And transpiration is the force that provides the pull of the water molecules up the stem.
8. **D.** Plasma molecules have the highest kinetic energy.
9. **A.** The two substances come together to form a new compound; hence, it's a chemical reaction.
10. **D.** Tidal bulges occur on the side of the Earth facing the Moon and on the opposite side, resulting in a high tide about every 12 hours in most locations.
11. **B.** The fulcrum must be placed at the center of gravity of the masses, which is the place where the product of the mass times the distance is the same for all masses. At 20 centimeters from the 12-kilogram mass (60 centimeters from the 4-kilogram mass), the product is the same: $20 \times 12 = 60 \times 4$.
12. **C.** The kidneys produce urine that travels through the ureters to the bladder and then out the urethra.
13. **C.** While pottery may be evidence of an extinct civilization, mankind is still striving. The other three choices offer evidence of organisms that may have died off long ago.
14. **D.** The inner core has an average density of about 13 g/cm^2. The crust has an average density of about 2.5 g/cm^2, the mantle has an average density of about 4.5 g/cm^2, and the outer core has an average density of 11 g/cm^2. It is possible to deduce the answer without knowing the actual numbers, knowing that gravity pulls the densest materials closest to the center of an object's mass. Since the inner core matter is closest to the center, it must be densest.
15. **C.** The troposphere is the atmospheric layer closest to the Earth and contains 75% of all gases, oxygen included.

16. D. Evolution is a change in one or more characteristics of a population over time.

17. C. Plasma takes up slightly more space than cells. Blood plasma, by the way, is about 90% water with dissolved nutrients, waste, hormones, and proteins.

18. B. $\frac{T^1}{T_2} = \frac{V_1}{V_2}$.

19. C. Metal is the best heat conductor.

20. B. The product of the current and voltage in an ideal transformer is the same on both the primary and secondary sides. Since the voltage is double, the current must be half. Transformers do not work with direct current (DC).

21. A. Mitochondria are used in the cell respiration of eukaryotic organisms.

22. B. $\frac{V_1}{V_2} = \frac{P_1}{P_2}$, as they are inversely proportional.

23. A. Both protons and neutrons have mass, but only protons determine atomic mass.

24. D. Any sex-linked trait is carried on the X chromosome. Males have one, a copy of which they give to all their daughters. Females have two X chromosomes, and they give a copy of one of them to all their daughters. The mother could have two mutated chromosomes or just one. Women who carry a mutated gene but do not express it are said to be carriers. Any boy born to a carrier has a 50% chance of inheriting that mutated gene.

25. B. The HIV virus infects the T helper cells that are used to initiate many specific immune responses.

Arithmetic Reasoning (Practice Test 3 Answers)

1. C. $\frac{1}{3}$ of $6\frac{1}{2}$ miles is $\frac{1}{3} \times 6\frac{1}{2} = \frac{1}{3} \times \frac{13}{2} = \frac{13}{6}$ miles walked. The remaining distance is $6\frac{1}{2} - \frac{13}{6} = \frac{13}{2} - \frac{13}{6} = \frac{39}{6} - \frac{13}{6} = \frac{26}{6} = 4\frac{1}{3}$ miles.

2. D. Using the ratio $\frac{\text{height}}{\text{shadow}}$, the proportion $\frac{x\text{ feet}}{5\text{ feet}} = \frac{6\text{ feet}}{8\text{ feet}}$ can be used to find the unknown height. Cross multiply. $8x = 5 \times 6$, so $8x = 30$ and $x = \frac{30}{8} = 3\frac{3}{4}$ feet. Convert $\frac{3}{4}$ feet to inches. $\frac{3}{4} \times 12 = 9$ inches. The height is therefore 3 feet 9 inches.

3. B. The time cleaning was 30 minutes + 12 minutes + 37 minutes = 79.

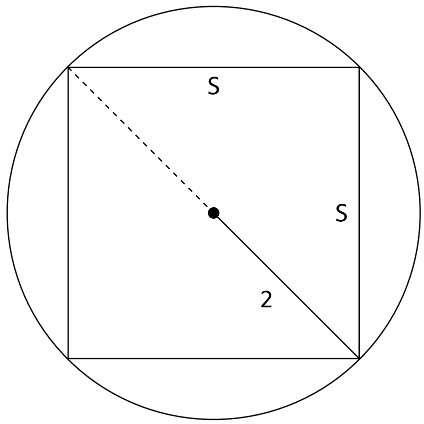
4. B. If $\frac{3}{8}$ is wheat flour, then $1 - \frac{3}{8}$ or $\frac{5}{8}$ is white flour. So $3 \times \frac{5}{8} = \frac{15}{8} = 1\frac{7}{8}$ cups of white flour are needed.

5. C. Using the ratio $\frac{\text{price}}{\text{video}}$, the proportion $\frac{8}{3} = \frac{x}{2}$ can be used to find the cost to rent two videos. Cross multiply. $8 \times 2 = 3x$ so $16 = 3x$ and $x = \frac{16}{3} = \$5.33$.

6. A. The difference in miles is 638 – 439 = 199.

7. D. The percent discounted is the amount discounted divided by the original price. The amount discounted is \$200 – \$150 = \$50. The percent discounted is $\frac{50}{200} = 0.25 = 25\%$.

8. D.



Find the difference between the area of the circle and the area of the square. The area of the circle is $\pi r^2 = \pi \times 2^2 = 4\pi$. The area of the square is s^2, where s represents the length of the square. The radius is half the length of the square's diagonal, so the diagonal is 4. By the Pythagorean theorem, $s^2 + s^2 = 4^2$. $2s^2 = 16$ so $s^2 = 8$. The difference in area is $4\pi - 8$.

9. D. If the blueprint shows $\frac{1}{2}$ inch for every 3 feet, then 1 inch represents 6 feet. The actual dimensions of a room $1\frac{1}{2}$ inches $\times$ 2 inches would be $\left(1\frac{1}{2} \times 6\right)$ by (2×6) or 9 feet by 12 feet.

10. B. In 2 weeks, or 14 days, $\frac{1}{2} \times 14 = 7$ gallons leak out, leaving $60 - 7 = 53$ gallons.

11. B. At 5:30, there are 30 minutes to 6:00 and 2 additional hours until 8:00 for a total of 2 hours and 30 minutes.

12. D. Convert the dimensions of the box from feet to inches. 8 feet $\times$ 6 feet $\times$ 4 feet is equivalent to $(8 \times 12$ inches$) \times (6 \times 12$ inches$) \times (4 \times 12$ inches$) = 96$ inches $\times$ 72 in $\times$ 48 inches. The volume $= 96 \times 72 \times 48 = 331{,}776$. The volume of each block is $6 \times 4 \times 4 = 96$. The number of blocks that fit in the box is $\frac{331{,}776}{96} = 3{,}456$.

13. C. The cost for milk and 2 dozen eggs is $\$1.39 + (2 \times \$1.28) = \$3.95$. The change is $\$10.00 - \$3.95 = \$6.05$.

14. B. 60% arrive to work by car, so $800 \times 60\% = 480$.

15. D. Min read a total of 3 + 4 or 7 mysteries. Therefore, she read 3×7 or 21 nonfiction books.

16. C. The volume of a cube is s^3, where s represents the length of an edge. Surface area is $6s^2$. If the volume = 343 cm^3, then $s = \sqrt[3]{343} = \sqrt[3]{7 \cdot 7 \cdot 7} = 7$. So the surface area is = 294 cm^2.

17. C. If $\frac{3}{8}$ of the pizza is eaten, then $1 - \frac{3}{8} = \frac{5}{8}$ remains. If that is divided by 2, then each receives $\frac{5}{8} \div 2 = \frac{5}{8} \times \frac{1}{2} = \frac{5}{16} = 0.3125 = 31.25\%$.

18. A. The difference in times is $144 - 127 = 17$ minutes.

19. A. Let c represent the number of caps traded in. Then $0.05c = 40.50$ and $c = \frac{40.50}{0.05} =$ 810 caps.

20. D. With 9 cups of milk, $\frac{9}{2} = 4\frac{1}{2}$ or four full batches can be made. However, with nine eggs, only $\frac{9}{4} = 2\frac{1}{4}$ or two full batches can be made. At most, only two batches can be made with the given ingredients.

21. A. The proportion $\frac{x}{6} = \frac{x+3}{10}$ can be used to find x. Cross multiply. $10x = 6(x + 3)$ and $10x = 6x + 18$. Bring all x terms to one side by subtracting $6x$ from each side. Then $4x = 18$ and $x = \frac{18}{4} = 4.5$.

22. C. The number of smaller pieces is $\frac{16.5}{2.75} = 6$.

23. A. The total amount is $(17 \times \$0.25) + (33 \times \$0.10) + (8 \times \$0.01) = \$4.25 + \$3.30 + \$0.08 = \$7.63$.

24. B. The percent tip is the amount of tip over the total before tip. The amount of the tip is $\$25.00 - \$21.00 = \$4.00$. The percent of the tip is $\frac{4}{21} = 0.19 = 19\%$.

25. A. The area of a triangle is $\frac{1}{2}bh$. Let b represent the length of one leg. Then $h = 3b$ so the area is $\frac{1}{2}bh = \frac{1}{2} \cdot b \cdot 3b = \frac{3}{2}b^2 = 24$, so $\frac{2}{3} \cdot \frac{3}{2}b^2 = \frac{2}{3} \cdot 24$ and $b^2 = 16$. $b = \sqrt{16} = 4$ and $h = 3 \times 4 = 12$. The longest side of a right triangle is the hypotenuse. Using the Pythagorean theorem, $\text{leg}^2 + \text{leg}^2 = \text{hypotenuse}^2$, so $4^2 + 12^2 = c^2$ and $16 + 144 = c^2$. Therefore, $160 = c^2$ and $c = \sqrt{160} = 12.6$.

26. C. Interest = principal × rate. Let p represent the principal. Then $\$100 = p \times 7\frac{1}{4}\%$, so $p = \frac{\$100}{7\frac{1}{4}\%} = \frac{\$100}{0.0725} = \$1,379$.

27. D. Using the ratio $\frac{\text{pages}}{\text{minutes}}$, the proportion $\frac{2}{3} = \frac{360}{x}$ can be used to find the time. Cross multiply. $2x = 3 \times 360$, so $2x = 1,080$ and $x = \frac{1080}{2} = 540$ minutes. Convert minutes to hours. There are 60 minutes in 1 hour so $\frac{540}{60} = 9$ hours.

28. B. The average is found by adding up all the scores and dividing by the total number of scores. The average this week is $\frac{112 + 156 + 179 + 165}{4} = \frac{612}{4} = 153$. The amount of improvement is $153 - 140 = 13$.

29. D. The total cost of the purchase is $\$8.95 \times 3 = \$26.85$. With a \$12.73 credit, the amount owed is $\$26.85 - \$12.73 = \$14.12$.

30. B. The total is $(18 \times \$0.25) + (6 \times \$0.10) + (24 \times \$0.05) = \$4.50 + \$0.60 + \$1.20 = \$6.30$.

Word Knowledge (Practice Test 3 Answers)

1. B. *Exhibit. Display* means to show or make visible.

2. B. *Cursory. Superficial* means casual or perfunctory.

3. A. *Stop. Cease* means to stop, halt, or end.

4. C. *Hindered. Prevented* means stopped, restrained, or restricted.

5. **A.** *Unchanging. Uniform* means constant or invariable.
6. **B.** *Carried. Conveyed* means transported or brought.
7. **C.** *Require. Impose* means demand or direct.
8. **C.** *Danger. Hazard* means pitfall or peril.
9. **A.** *Empty. Vacant* means uninhabited or unoccupied.
10. **B.** *Friendship. Camaraderie* means companionship or fellowship.
11. **C.** *Annoying. Irritating* means disturbing or bothersome.
12. **D.** *Relinquish. Abandon* means to yield or give up.
13. **B.** *Victory. Triumph* means success or a win.
14. **B.** *Off limits. Taboo* means forbidden or prohibited.
15. **A.** *Earlier. Prior* means previously or beforehand.
16. **C.** *Need. Require* means desire or call for.
17. **B.** *Sufficient. Appropriate* means adequate or satisfactory.
18. **A.** *Cite. Specify* means designate or point out.
19. **B.** *At irregular intervals. Intermittent* means recurrent or periodic.
20. **B.** *Remainder. Residue* means leavings or remnants.
21. **D.** *Agree. Concur* means to reach an agreement or come to terms.
22. **C.** *Beg. Implore* means plead or appeal.
23. **D.** *Pleasant. Convivial* means friendly or congenial.
24. **B.** *Flawless. Impeccable* means perfect or faultless.
25. **C.** *Predicament. Quandary* means dilemma or difficulty.
26. **B.** *Decision. Resolution* means determination or conclusion.
27. **B.** *Unpleasant. Obnoxious* means offensive, repulsive, or detestable.
28. **A.** *Intrude. Encroach* means to trespass, infringe, or bother.
29. **C.** *Drawn apart. Divergent* means different, digressing, or deviating.
30. **C.** *Deceit. Duplicity* means dishonesty or deviousness.
31. **B.** *Another name. Alias* means assumed name, pseudonym, or pen name.
32. **B.** *Meager. Sparse* means insufficient, inadequate, or lacking.
33. **B.** *Small. Diminutive* means little, miniature, or tiny.
34. **B.** *Urge strongly. Exhort* means to advise or alert.
35. **D.** *Stifle. Suppress* means to restrain, repress, or check.

Paragraph Comprehension (Practice Test 3 Answers)

1. **A.** This word is the only one that is logical when placed in the context of the selection. All of the listed activities are causes of increased obesity among children.
2. **D.** The last sentence of the selection states that the average night's sleep on weekends is 7.5 hours.
3. **B.** The first sentence of the selection, or topic sentence, states this.
4. **B.** The selection states that in a planetary alignment, the planets line up on the right side of the sun.
5. **C.** The whole selection focuses on how easy ferns are to care for.
6. **B.** The first sentence states that this creature frightens people.
7. **C.** Aspirin is discussed as a possible preventive medication for colon cancer.
8. **D.** The last sentence states that organic foods do not contain herbicides.
9. **B.** The selection makes it clear that scientists are puzzled by these stars, and their "hypothesis" is that they are neutron stars.
10. **C.** The last sentence of the selection states that such changes in climate will affect humans in "unpredictable ways." Thus, you may infer that these changes could be negative ones.
11. **A.** The overall tone of the selection is positive with regard to the move to incorporate a system of house calls for heart attack patients.
12. **C.** The selection describes a new procedure for handling heart attack patients that would ease worry concerning 911 calls.
13. **B.** The selection discusses how today's casual society still prefers physicians who dress formally, rather than casually.
14. **C.** Scrubs, like jeans and sandals, are also informal garb. Thus, you might conclude that such dress would not be acceptable to most patients.
15. **B.** Since the passage as a whole is concerned with the negative effects that doctors in informal dress have on patients, this meaning is the clear choice.

Auto and Shop Information (Practice Test 3 Answers)

1. **A.** If there is no free play, chances are the compensating port is covered inside the master cylinder. This prevents fluid from returning properly, thus keeping enough pressure in the brake circuit to possibly keep the brakes slightly applied.
2. **B.** To prevent backfire or possible damage, time the ignition distributor before attempting to start this engine.
3. **A.** Automatic transmissions rely on planetary gear sets to transfer power and multiply engine torque to the drive axle.
4. **C.** Both A and B. Transmission fluid performs multiple jobs. It transmits engine torque in the torque converter and controls valve body operation. It acts as a cooling agent to transfer heat at the transmission cooler to maintain a safe operating temperature of the transmission.

5. **C.** The spindle and knuckle assembly do support components of the braking, suspension, and steering systems.
6. **B.** The coil acts as a step up transformer. When the electromagnetic field is collapsed in the primary coil windings, a higher voltage is induced into the secondary coil windings.
7. **C.** Port fuel injection systems can use a grounded single fire, simultaneous double fire, grouped double fire, or sequential fire strategies.
8. **C.** The intake and exhaust stroke have a valve that is open. The compression stroke has both valves closed; however, the piston is going up.
9. **C.** There are two basic hub systems used with 4WD systems: systems that lock automatically and systems that require the driver to get out and turn a knob or lever at each wheel.
10. **B.** When unlocked in 2WD, both are correct "in only that" the wheels still turn, but only B is correct because the entire drivetrain stops turning, including the front axles.
11. **D.** As long as the clutch pedal is depressed, the clutch is disengaged (not squeezed). When the pedal is released, the pressure plate moves to squeeze the clutch disc between the flywheel and pressure plate.
12. **C.** Brake drums are manufactured stamped with a discard dimension. This is the allowable wear dimension, not the allowable machining dimension.
13. **A.** By installing the dial indicator in a fixed position, the rotor is turned to indicate a runout in thousandths of an inch.
14. **C.** A scratch awl will leave a clear and thin mark on whatever material you are cutting. Using a saw blade or chisel on metal will damage the blades. A grease pen may often leave side, messy marks, and can easily smear.
15. **A.** It is a measure of the size of a nail. The term "penny" is from the old English penny system and actually stands for "pound." The letter "d" is now used instead. Thus, nails weighing 6 pounds per 1,000 are six-penny (or 6d) nails.
16. **C.** The back saw is used in a miter box. It is used with or across the grain, and its thin blade makes it ideal for cutting pieces that have to fit together.
17. **B.** Using a push stick to guide wood through the blades of a bench (table) saw keeps your fingers away from the rotating blades.
18. **D.** Maple is the hardest wood of those on the list. It is fairly easy to work with and resists splitting.
19. **B.** This is a box-end, or closed-end, wrench.
20. **B.** Screeding is the process of using a board in a sawing motion to smooth down concrete and assure that all of the spaces and air holes are filled in.
21. **C.** Similar to a mortise and tenon joint, the tongue of the board fits into the groove of the adjoining board.
22. **B.** This is a continuous hinge, also known as a piano hinge. It is probably not strong enough to support the other types of doors.

23. **B.** Unlike screws, bolts are not tapered, and are ideal for holding heavy-duty work together. They are fastened with a bolt or wing nut.

24. **B.** A spline is a thin piece of wood that fits into a groove cut into both parts of a joint. It is glued and gives strength to the joint.

25. **C.** It takes about 30 days (a month) to cure concrete.

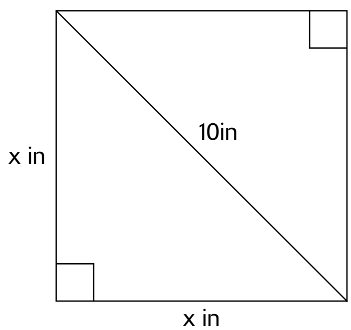
Mathematics Knowledge (Practice Test 3 Answers)

1. **D.** Solve for w by adding w to both sides. $w - 3 + w = 3 - w + w$, so $2w - 3 = 3$. Adding 3 to both sides gives $2w = 6$. So $\frac{2w}{2} = \frac{6}{2}$ and $w = 3$. Therefore $w^2 = 3^2 = 9$.

2. **C.** The least common denominator of 96 and 12 is 96, so $\frac{24}{96} - \frac{8}{12} = \frac{24}{96} - \frac{64}{96} = \frac{-40}{96} = -\frac{5}{12}$.

3. **A.** $\frac{6m-2}{2}$, so $3m - 1 = -4$. Solve for m by adding 1 to both sides. $3m - 1 + 1 = -4 + 1$ and $3m = -3$. Dividing both sides by 3 gives $m = -1$.

4. **B.**



Let x represent a side of the square. The area of the square is x^2. To find the value of x^2, use the Pythagorean theorem. $x^2 + x^2 = 10^2$, so $2x^2 = 100$ and $x^2 = x^2 = \frac{100}{2}$ or 50.

5. **C.** There are 120 minutes in 2 hours. Setting up a proportion yields $\frac{20\text{ miles}}{30\text{ minutes}} = \frac{x\text{ miles}}{120\text{ minutes}}$. Cross multiplying results in $30x = 20 \times 120$ or $30x = 2{,}400$. Dividing both sides by 30 gives $x = \frac{30}{2{,}400} = 80\text{ miles}$.

6. **B.** $\frac{15\sqrt{3}}{\sqrt{5}} = \frac{15\sqrt{3}}{\sqrt{5}} \bullet \frac{\sqrt{5}}{\sqrt{5}} = \frac{15\sqrt{15}}{5} = 3\sqrt{15}$

7. **D.** The volume of each cube is $4 \times 4 \times 4 = 64\text{ in}^3$. The volume of the crate, in inches, is $(3 \times 12) \times (2 \times 12) \times (2 \times 12) = 20{,}736\text{ in}^3$. The number of blocks that can fit in the crate is $\frac{20{,}736}{64} = 324$.

8. **D.** If $x = -3$ and $y = 2$, then $x^{2y} = (-3)^{2(2)} = (-3)^2 = 81$.

9. **B.** $0.00525 \div 0.01 = \frac{0.00525}{0.01} = 0.525$

10. **C.** $\frac{3}{4} \div \frac{4}{3} = \frac{3}{4} \times \frac{3}{4} = \frac{9}{16}$

11. **B.** The area of the circle is $\pi r^2 = 121\pi$. So $r^2 = 121$ and $r = 11$. The radius represents half the diagonal of the square, so the diagonal is 22 units long. If x represents the length of a side of the square, then x^2 is the area of the square. Using the Pythagorean theorem, $x^2 + x^2 = 22^2$ and $2x^2 = 484$. Therefore $x^2 = \frac{484}{2} = 242$.

12. **D.** $(3x^2 + 2x - 5) - (2x^2 - 5) + (4x - 7) = 3x^2 + 2x - 5 - 2x^2 + 5 + 4x - 7 = 3x^2 - 2x^2 + 2x + 4x - 5 + 5 - 7 = x^2 + 6x - 7$

13. **C.** $\frac{1}{4}$ of the total cars, t, sold are luxury. Luxury cars sold = 360, so $\frac{1}{4}t = 360$ and $t = 360 \times 4 = 1{,}440$ total cars sold.

14. **D.** The sum of all angles in a triangle equals 180°. So $(3x - 20)° + x° + (2x - 10)° = 180°$. $3x + x + 2x - 20 - 10 = 180$ and $6x - 30 = 180$. Then $6x = 210$ and $x = \frac{210}{6} = 35$. Therefore, $\angle$A is 3(35) – 20 or 85°.

15. **C.** $(3 - 4x)(3 + 4x) = 9 + 12x - 12x - 16x^2 = 9 - 16x^2$.

16. **D.** $(2.5)^4 = 2.5 \times 2.5 \times 2.5 \times 2.5 = 39.0625$. Rounded to the nearest tenth, it's 39.1.

17. **D.** Let the radius of the smaller circle = 1. Then the radius of the larger circle is 4. The shaded region is found by subtracting the area of the smaller circle from the area of the larger circle. The area of the smaller circle is $\pi(1)^2$ or π. The area of the larger circle is $\pi(4)^2$ or 16π. The shaded region is $16\pi - \pi$ or 15π. The percent of the whole figure that is shaded is $\frac{15\pi}{16\pi} = 0.9375 = 93\frac{3}{4}\%$.

18. **D.** Factors of 8 are $2 \times 2 \times 2$; factors of 12 are $2 \times 2 \times 3$; factors of 20 are $2 \times 2 \times 5$. The least common multiple of 8, 12, and 20 is $2 \times 2 \times 2 \times 3 \times 5$ or 120.

19. **A.** $\left(5a^3bc^2\right)\left(-3a^2c\right) = 5 \cdot -3 \cdot a^{3+2}bc^{2+1} = -15a^5bc^3$

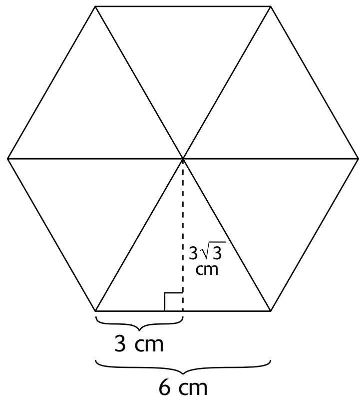
20. **C.** $\frac{x^2 - 25}{5 - x} = \frac{(x+5)(x-5)}{5-x} = \frac{(x+5)(x-5)}{-(x-5)} = \frac{(x+5)}{-1} = -(x+5)$

21. **A.** The equation of a line with a slope of $-\frac{3}{2}$ and a y-intercept of –2 is $y = -\frac{3}{2}x - 2$. To find the value of x in the point $(x, 1)$, substitute 1 for y and solve the equation for x. Then $1 = \frac{-3}{2}x - 2$, which you can rewrite as $3 = \frac{-3}{2}x$. So $(3)\left(-\frac{2}{3}\right) = \left(-\frac{2}{3}\right)\left(-\frac{3}{2}x\right)$ and $x = -\frac{6}{3}$ or –2.

22. **C.** The probability of flipping one head is $\frac{1}{2}$. The probability of flipping three heads in a row is $\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2}$ or $\frac{1}{8}$.

23. **C.** If $0.08z = 6.4$ then $\frac{0.08z}{0.08} = \frac{6.4}{0.08}$. Moving the decimal two places to the right in both the numerator and denominator gives $z = \frac{640}{8} = 80$.

24. C.



A regular hexagon is made up of six equilateral triangles. Find the area of one equilateral triangle and multiply that by 6 to find the area of the hexagon. The height, or altitude, of a triangle can be found by the Pythagorean theorem. The right triangle formed by the altitude has a hypotenuse of 6 and a shorter leg of $\frac{6}{2}$ or 3. So $3^2 + h^2 = 6^2$, so $9 + h^2 = 36$ and $h^2 = 27$. Therefore, $h = \sqrt{27} = 3\sqrt{3}$. The area of one equilateral triangle is $\frac{1}{2}bh = \frac{1}{2} \cdot 6 \cdot 3\sqrt{3} = 9\sqrt{3}$ and the area of the hexagon is $6 \times 9\sqrt{3} = 54\sqrt{3}$.

25. D. Let w represent the games won and l represent the games lost. Then $w = 3 \times l = 3l$. The total number of games played is $w + l = 24$. Substituting $3l$ in for w yields $3l + l = 24$ or $4l = 24$. The number of losses is $\frac{24}{4} = 6$ and the number of wins is $24 - 6 = 18$.

Mechanical Comprehension (Practice Test 3 Answers)

1. **D.** As the person moves, his or her mass moves so that the center of mass moves also.
2. **B.** All the path analysis applies to a point mass or mass considered to be concentrated at one point, called the center of mass.
3. **B.** This is a consequence of Newton's third law of motion.
4. **D.** Mass is independent of gravity, while weight is proportional to the acceleration of gravity, which decreases with height or distance away from the center of the Earth.
5. **D.** Since only a component of the original velocity is available while turning, she must accelerate to maintain her original speed.
6. **A.** Any change in momentum or kinetic energy following a collision would mean inelastic collision.
7. **B.** Since collision involves work, or force times distance, and distance is velocity times time, the bumper offers a greater collision distance and hence greater collision time for the damage to take place.
8. **B.** Work is the product of force times distance, which is the area under the curve for the range in question.

9. A. The acceleration a of a particle (or object) moving with simple harmonic motion is minus the displacement times the square of the radian frequency ω.

10. A. Each rotation of the seconds hand amounts to 2π radians over 60 seconds. Hence, the angular velocity is $\frac{2\pi}{60}$ or 0.105.

11. A. The speed is the magnitude of the velocity, so the minus sign indicates the direction of motion but has no effect on the speed.

12. D. Acceleration is the time rate of change of the velocity.

13. C. The time required is $\frac{46.8}{9.8} \approx 4.78$.

14. C. $\frac{(8-24+48)}{160}=0.2$

15. C. Since $\omega_f = \omega_i + \alpha t$, where ω_f and ω_i are the final angular velocities, α is the angular acceleration, *t* is the time, and the torque T = Iα where I is the moment of inertia, you obtain α = 0.625 and T = 0.625 × 0.3 = 0.188.

16. C. The work done is equal to the kinetic energy of the ball, which is $\frac{1}{2}mv^2 = \frac{1}{2}(75)(4^2)=600\text{J}$.

17. B. For equilibrium, the clockwise and counterclockwise moments must be the same, in other words, $F_i \times 80 = F_o \times 40$ or $F_i = 30$ N and $\frac{F_o}{F_i} = \frac{60}{30} = 2$.

18. B. $v = \frac{\left[\frac{2(6.67\times10^{-11})(8\times10^{24})}{(5\times10^{6})}\right]^{\frac{1}{2}}}{1{,}000} = 14.6095\,\text{km/s}$

19. A. The change in momentum ΔP equals the force, F, times the time increment, *t*. Hence, you obtain F = 40/12 = 3.33 N.

20. C. The law of conservation of momentum requires that 80(3) + 0 = 120 *v* and hence *v* = −2m/s.

21. A. Period $T = 2\pi[m/k]^{1/2}$. Hence, k = 40.

22. C. Since $\frac{1}{2}mv^2 = mgh$, $m = 5$, and $h = 10$, we obtain $v = 14$ m/s. Also, the downward force on the block is mg (sin θ) where θ is the slope angle of the inclined plane. Hence, the downward force = 5(9.8)(10/40) = 12.25 N.

23. D. Because momentum is mass × velocity and acceleration is velocity/time, the product equals (mass)(velocity)^2/time, which is proportional to (kinetic energy)/time or output power.

24. C. If there is a net force acting on the box, then there will be acceleration which contradicts the condition of constant speed.

25. D. Since the mass and speed of the object are constant, it is the kinetic energy that is constant.

Electronics Information (Practice Test 3 Answers)

1. **D.** For the lamp to be on, switches (1 or 3) must be closed, and switches (2 or 4) must be closed to allow the current to flow in the circuit.
2. **C.** A wattmeter is a device used to measure electrical power. An ammeter is used to measure current. A voltmeter is used to measure a voltage difference. Electrical charge cannot be measured by a wattmeter.
3. **C.** The total resistance in the circuit can be calculated as follows:
$$\frac{1}{\frac{1}{50+50}+\frac{1}{50+50}} = 50\Omega$$
4. **B.** Symbol 2 represents a variable resistor.
5. **D.** The shown signal has a DC shift of 5 volts. Its frequency is 1 hertz, and its amplitude is 5 volts.
6. **A.** Capacitance is measured in farads. Inductance is measured in henrys. Resistance is measured in ohms. Diodes have identification numbers to identify them.
7. **B.** The ammeter reads the current flowing in the circuit. The current is calculated as follows:
$$I = \frac{V}{R} = \frac{10}{\frac{1}{\frac{1}{10}+\frac{1}{10}}+\frac{1}{\frac{1}{10}+\frac{1}{10}}} = 1A$$
8. **C.** An audio signal is transmitted wirelessly by being carried on a high frequency sinusoidal signal.
9. **B.** The unknown resistor value can be calculated as follows:
$$R = \frac{V}{I} = \frac{6-2}{\frac{2}{5}} = 10\Omega$$
10. **C.** A diode will pass electrical current only if the voltage applied is greater than the threshold voltage.
11. **B.** The collector current in the common emitter configuration is $I_B*\beta$, which is an amplification of the base current.
12. **B.** Electrical devices are grounded to prevent an electric shock.
13. **D.** An oscillator circuit is used to generate a high frequency sinusoidal signal that is used as a carrier signal.
14. **A.** The power dissipated in the circuit can be calculated as follows:
$$P = \frac{V^2}{R} = \frac{5^2}{\frac{1}{\frac{1}{10}+\frac{1}{10}}} = 5\ \text{W}$$
15. **A.** A capacitor can be used as a frequency filter. In some circuits it is used as a high pass filter, where it allows high frequency signals to pass and blocks lower frequency signals. In some other circuits it is used as a low pass filter, where it allows low frequency signals to pass and suppresses higher frequency signals.

16. **C.** Total capacitance of the circuit is calculated as follows:

    .25 μF + .25 μF = .5μF.

17. **B.** A square wave can be obtained from a function generator device.

18. **B.** Coils are used in electrical transformers to induce a different level of voltage.

19. **C.** Bipolar junction transistors (BJTs) can be PNP or NPN.

20. **B.** In order to reduce the total resistance of a circuit, the resistors are connected in parallel.

Assembling Objects (Practice Test 3 Answers)

The answers for the Assembling Objects questions can be found in the answer key, earlier in this section.

PART V

MILITARY CAREER OPPORTUNITIES

MILITARY CAREER OPPORTUNITIES

According to the military, the Department of Defense recruits and trains almost 220,000 enlisted members and officers each year, making it one of the largest employers in the United States. Therefore, an important section from the booklet *Military Careers* is included in the pages that follow. This material will give you some basic information about the different opportunities available to you as an enlisted person in different branches of the military. Related civilian occupations are also given. Thus, you can have an idea of not only what you can do once you've entered the military, but also how those specific jobs may be transferable when you leave the military.

Each job description is preceded by an indication of which branches of the service these jobs are available in, since not all branches of the service offer the same careers. For example, there is no career for Divers in the Air Force (for obvious reasons). Similarly, an Aircraft Launch and Recovery Specialist will find employment only in the Navy, Marine Corps, and Coast Guard.

This section has 91 different occupational descriptions for enlisted personnel, within 12 different career fields, which are:

- Human Services
- Media and Public Affairs
- Health Care
- Engineering, Science, and Technical
- Administrative
- Service
- Vehicle and Machinery Mechanic
- Electronic and Electrical Equipment Repair
- Construction Occupations
- Machine Operator and Precision Work
- Transportation and Material Handling
- Combat Specialty

There are also dozens of additional occupations and career paths for officers, but there are different requirements for officers. The ASVAB exam is currently for those applying for enlisted positions. If, however, you're planning to go on to college, there are several different ways to become an officer, including ROTC training or Officer Training School. You can, as an enlisted person, apply to the Officer Training Corp program, to follow a career path to become an officer. But that's down the road.

HOW TO USE THIS CAREERS SECTION

Because of the organization of this section, it should be easy to find a career or occupation in which you can find satisfaction. You can start by skimming this chapter, reading through the different jobs that are available. There are probably dozens that you never even thought of before.

Once you've done that, you can either go back to one of those 12 career areas and find a specific occupation within that area or merely read through all of those occupations that are described. As you do so, keep in mind not only the description of what a job entails, but also the physical demands that might be placed on you. And, of course, if you'd like to look into your future, discover how these jobs will eventually translate into civilian jobs. You may, of course, end up choosing the military as a full-time career, and you can anticipate advancement within your career area. If, however, you only stay for the initial enlistment period, it's important to have an idea of what you'll do when you get out. That's why the section on civilian opportunities is included.

Because you've purchased this book, it's safe to assume that you're studying for the exam. This section can help you make some decisions about whether the military is for you.

Enlisted Occupational Descriptions

HUMAN SERVICE OCCUPATIONS

Caseworkers and Counselors

Army
Navy
Air Force
Marine Corps
Coast Guard

Just like some civilians, some military personnel can develop problems with drug or alcohol abuse. Others may develop depression or other emotional problems. Caseworkers and counselors help military personnel and their families to overcome social problems. They work as part of a team that may includes social workers, psychologists, medical officers, chaplains, personnel specialists, and commanders.

What They Do

Caseworkers and counselors in the military perform some or all of the following duties:

Interview personnel who request help or are referred by their commanders

Identify personal problems and determine the need for professional help

Counsel personnel and their families

Administer and score psychological tests

Teach classes on human relations

Keep records of counseling sessions and give reports to supervisors

Where They Work

Caseworkers and counselors usually work in offices or clinics.

Opportunities in Civilian Life

Civilian caseworkers and counselors work in rehabilitation centers, hospitals, schools, and public agencies. Their duties are similar to duties in the military. Civilian caseworkers and counselors, however, are usually required to have a college degree in social work, psychology, or counseling. They may be called group workers, human relations counselors, or drug and alcohol counselors.

Physical Requirements

Caseworkers and counselors need to speak clearly and distinctly in order to teach classes and work with personnel who have problems.

Religious Program Specialists

Army
Navy
Air Force

The military has personnel from many religions and faiths. The military provides chaplains and religious program specialists to help meet the spiritual needs of its personnel. Religious program specialists assist chaplains with religious services, religious education programs, and related administrative duties.

What They Do
Religious program specialists in the military perform some or all of the following duties:

- Assist chaplains in planning and preparing religious programs and activities
- Assist chaplains in conducting religious services
- Prepare religious, educational, and devotional materials
- Organize charitable and public service volunteer programs
- Maintain relations with religious communities and public service organizations
- Perform administrative duties for chaplains, such as scheduling appointments, handling correspondence, maintaining files, and handling finances

Where They Work
Religious program specialists in the military usually work indoors. They also serve aboard ships or with land and air units in the field.

Opportunities in Civilian Life
Civilian religious program specialists help manage churches and religious schools. Their duties are similar to those performed by military religious program specialists, including planning religious programs and preparing religious educational materials. They are also called directors of religious activities.

Physical Requirements
The ability to speak clearly and distinctly is required to enter this occupation.

MEDIA AND PUBLIC AFFAIRS OCCUPATIONS

Audiovisual and Broadcast Technicians

Army
Navy
Air Force
Marine Corps
Coast Guard

Television and film productions are an important part of military communications. Films are used for training in many military occupations. They are also used to record military operations, ceremonies, and news events. These productions require the teamwork of many technicians. Audiovisual and broadcast technicians perform many specialized tasks, ranging from filming to script editing to operating audio recording devices.

What They Do
Audiovisual and broadcast technicians in the military perform some or all of the following duties:

- Work with writers, producers, and directors in preparing and interpreting scripts
- Plan and design production scenery, graphics, and special effects
- Operate media equipment and special effect devices including cameras, sound recorders, and lighting

Follow script and instructions of film or TV directors to move camera, zoom, pan, or adjust focus.

Where They Work

Audiovisual and broadcast technicians work in studios or outdoors on location. They sometimes work from aircraft or ships. They travel and work in all climates.

Opportunities in Civilian Life

Civilian audiovisual and broadcast technicians work for film production companies, government audiovisual studios, radio and television stations, and advertising agencies. Their duties are similar to those performed by military journalists and newswriters. They may be called motion picture camera operators, audiovisual production specialists, sound mixers, recording engineers, and broadcasting and recording technicians.

Physical Requirements

Normal color vision and the ability to speak clearly are required for some specialties in this area.

Broadcast Journalists and Newswriters

Army

Navy

Air Force

Marine Corps

Coast Guard

The military publishes newspapers and broadcasts television and radio programs for its personnel and the public. These services are an important source of general information about people and events in the military. Broadcast journalists and newswriters write and present news programs, music programs, and radio talk shows.

What They Do

Broadcast journalists and newswriters in the military perform some or all of the following duties:

Gather information for military news programs and publications

Write radio and TV scripts

Develop ideas for news articles

Arrange and conduct interviews

Collect information for commercial media use

Select photographs and write captions for news articles

Write news releases, feature articles, and editorials

Where They Work

Broadcast journalists and newswriters work in broadcasting studios on land or aboard ships, or sometimes outdoors, depending upon the research needed for their articles.

Opportunities in Civilian Life

Broadcast journalists and newswriters work for newspapers, magazines, wire services, and radio and television stations. Their duties are similar to those performed by military journalists and newswriters. They may be employed as newscasters, disc jockeys, writers, directors, producers, editors, or correspondents.

Physical Requirements

Normal color vision and the passing of a voice audition are required for some specialties in this area.

Graphic Designers and Illustrators

Army

Navy

Air Force

Marine Corps

The military produces many publications, such as training manuals, newspapers, reports, and promotional materials. Graphic artwork is used in these publications and for signs, charts, posters, and TV and motion picture productions. Graphic designers and illustrators produce graphic artwork, drawings, and other visual displays.

What They Do

Graphic designers and illustrators in the military perform some or all of the following duties:

Produce computer-generated graphics

Draw graphs and charts to represent budgets, numbers of troops, supply levels, and office organization

Develop ideas and design posters and signs

Help instructors design artwork for training courses

Draw illustrations of parts of the human body for medical training

Draw cartoons for filmstrips and animation for films

Make silkscreen prints

Work with TV and film producers to design backdrops and props for film sets

Where They Work

Graphic designers and illustrators usually work in offices on land or aboard ships.

Opportunities in Civilian Life

Civilian graphic designers and illustrators work for government agencies, advertising agencies, print shops, and engineering firms. They also work for many large organizations that have their own graphics departments. Their duties are similar to military graphic designers and illustrators. They may be known as commercial artists or graphic artist technicians.

Interpreters and Translators

Army
Navy
Air Force
Marine Corps

Some members of the military must be able to read and understand the many languages of the world. Information from foreign language newspapers, magazines, and radio broadcasts is important to the nation's defense. Interpreters and translators convert written or spoken foreign languages into English or other languages. They usually specialize in a particular foreign language.

What They Do

Interpreters and translators in the military perform some or all of the following duties:

Translate written and spoken foreign language material to and from English, making sure to preserve the original meaning

Interrogate (question) prisoners of war, enemy deserters, and civilian informers in their native languages

Record foreign radio transmissions using sensitive communications equipment

Prepare written reports about the information obtained

Translate foreign documents, such as battle plans and personnel records

Translate foreign books and articles describing foreign equipment and construction techniques

Where They Work

Interpreters and translators normally work on military bases, aboard ships, or in airplanes.

Opportunities in Civilian Life

Civilian interpreters and translators work for government agencies, embassies, universities, and companies that conduct business overseas. Their work is similar to the work of military interpreters and translators.

Physical Requirements

Normal hearing and the ability to speak clearly and distinctly are usually required to enter this occupation.

Musicians

Army

Navy

Air Force

Marine Corps

Coast Guard

Music is an important part of military life. Service bands and vocal groups have a strong tradition of performing at ceremonies, parades, concerts, festivals, and dances. Musicians and singers perform in service bands, orchestras, and small groups. They perform many types of music, including marches, classics, jazz, and popular music.

What They Do

Musicians in the military perform some or all of the following duties:

Play in or lead bands, orchestras, combos, and jazz groups

Sing in choral groups or as soloists

Perform for ceremonies, parades, concerts, festivals, and dances

Rehearse and learn new music when not performing

Play brass, percussion, woodwind, or string instruments

Where They Work

Musicians play indoors in theaters, concert halls, and at dances; outdoors at parades and open-air concerts. They also travel regularly.

Opportunities in Civilian Life

Civilian musicians work for many types of employers, including professional orchestras, bands, and choral groups. They work in nightclubs, concert halls, theaters, and recording studios.

Photographic Specialists

Army

Navy

Air Force

Marine Corps

Coast Guard

The military uses photographs for many purposes, such as intelligence gathering and news reporting. The services operate photographic laboratories to develop the numerous photos taken by the military. Photographic specialists take and develop still color or black-and-white photographs.

What They Do

Photographic specialists in the military perform some or all of the following duties:

Select camera, film, and other equipment needed for photo assignments

Determine camera angles, lighting, and any special effects needed

Take still photos of people, events, military equipment, land areas, and other subjects

Develop, duplicate, or retouch film negatives, photos, or slides

Maintain photographic equipment

Where They Work

Photographic specialists work both indoors and outdoors while photographing their subjects. They may take photos from aircraft or ships. They process photographs in photographic laboratories on bases or aboard ships.

Opportunities in Civilian Life
Civilian photographic specialists work for photography studios, newspapers, magazines, advertising agencies, commercial photograph developers, and large businesses. They perform duties similar to military specialists. Depending on the specialty, they may be known as photojournalists, aerial or still photographers, film developers, automatic print developers, or print controllers.

Physical Requirements
Normal color vision is required to produce accurate color prints.

HEALTH CARE OCCUPATIONS

Cardiopulmonary and EEG Technicians

Army

Navy

Air Force

Military health care includes medical treatment for heart, lung, and brain disorders. Physicians need sophisticated tests to help diagnose and treat these problems. Cardiopulmonary and EEG (electroencephalograph) technicians administer a variety of diagnostic tests of the heart, lungs, blood, and brain. They operate complex electronic testing equipment.

What They Do
Cardiopulmonary and EEG technicians in the military perform some or all of the following duties:

Take patients' blood pressure readings

Attach electrodes or microphones to patients' bodies

Help physicians revive heart attack victims

Adjust settings and operate test equipment

Watch dials, graphs, and screens during tests

Talk to physicians to learn what tests or treatments are needed

Keep records of test results and discuss them with medical staff

Operate electrocardiographs, electroencephalographs, and other test equipment

Where They Work
Cardiopulmonary and EEG technicians usually work in hospitals and clinics. In combat situations, they may work in mobile field hospitals.

Opportunities in Civilian Life
Civilian cardiopulmonary and EEG technicians work in hospitals, clinics, and physicians' offices. Their duties are similar to those performed in the military. They may specialize in either cardiovascular (heart), pulmonary (lungs), or electroencephalographic (brain) testing.

Physical Requirements
Normal color vision is required for some specialties in order to set up and monitor equipment.

Dental Specialists

Army

Navy

Air Force

Coast Guard

Dental care is one of the health services provided to all military personnel. It is available in military dental clinics all over the world. Dental specialists assist military dentists in examining and treating patients. They also help manage dental offices.

What They Do
Dental specialists in the military perform some or all of the following duties:

Help dentists perform oral surgery

Prepare for patient examinations by selecting and arranging instruments and medications

Help dentists during examinations by preparing dental compounds and operating dental equipment

Clean patients' teeth using scaling and polishing instruments and equipment

Operate dental X-ray equipment and process X-rays of patients' teeth, gums, and jaws

Provide guidance to patients on daily care of their teeth

Perform administrative duties, such as scheduling office visits, keeping patient records, and ordering dental supplies

Where They Work
Dental specialists in the military usually work indoors in dental offices or clinics. Some specialists may be assigned to duty aboard ships.

Opportunities in Civilian Life
Civilian dental specialists work in dental offices or clinics. Their work is similar to work in the military. They typically specialize in assisting dentists to treat patients, providing clerical support (dental assistants), or cleaning teeth (dental hygienists).

Physical Requirements
Dental specialists must sometimes stand for long periods.

Medical Care Technicians

Army

Navy

Air Force

Coast Guard

The military provides medical care to all men and women in the services. Medical care technicians work with teams of physicians, nurses, and other health care professionals to provide treatment to patients. They help give patients the care and treatment required to help them recover from illness or injury. They also prepare rooms, equipment, and supplies in hospitals and medical clinics.

What They Do
Medical care technicians in the military perform some or all of the following duties:

Provide bedside care in hospitals, including taking the body temperature, pulse, and respiration rate of patients

Feed, bathe, and dress patients

Prepare patients, operating rooms, equipment, and supplies for surgery

Make casts, traction devices, and splints according to physicians' instructions

Give medication to patients under the direction of physicians and nurses

Where They Work
Medical care technicians work in hospitals and clinics on land or aboard ships. In combat situations, they may work in mobile field hospitals.

Opportunities in Civilian Life
Civilian medical care technicians work in hospitals, nursing homes, rehabilitation centers, psychiatric hospitals, or physicians' offices. They perform similar duties to those performed in the military. They may be called nurses' aides, orderlies, operating room technicians, orthopedic assistants, or practical nurses.

Physical Requirements
Some specialties in this area require sufficient strength to lift and move patients, and some require a normal skin condition to guard against infection.

Medical Laboratory Technicians

Army
Navy
Air Force
Coast Guard

Medical laboratories are an important part of the military health care system. The staffs of medical laboratories perform clinical tests required to detect and identify diseases in patients. Medical laboratory technicians conduct tests on the tissue, blood, and body fluids of medical patients.

What They Do

Medical laboratory technicians in the military perform some or all of the following duties:

Use lab equipment to analyze specimens (samples) of tissue, blood, and body fluids

Examine blood and bone marrow under microscopes

Test specimens for bacteria or viruses

Draw blood from patients

Assist in collecting specimens at autopsies (medical examinations of the dead)

Record and file results of laboratory tests

Where They Work

Medical laboratory technicians work in medical centers, clinics, and hospitals on land or aboard ships.

Opportunities in Civilian Life

Civilian medical laboratory technicians usually work for privately owned laboratories, hospitals, clinics, or research institutions. They perform duties similar to military medical laboratory technicians.

Physical Requirements

Normal color vision is required to work with colored chemicals and dyes.

Medical Record Technicians

Army
Navy
Air Force
Coast Guard

Medical records are important for health care delivery. To provide proper treatment, physicians need complete and accurate information about patient symptoms, test results, illnesses, and prior treatments. Medical record technicians prepare and maintain patient records, reports, and correspondence.

What They Do

Medical record technicians in the military perform some or all of the following duties:

Fill out admission and discharge records for patients entering and leaving military hospitals

Assign patients to hospital rooms

Prepare daily reports about patients admitted and discharged

Organize, file, and maintain medical records

Type reports about physical examinations, illnesses, and treatments

Maintain libraries of medical publications

Where They Work

Medical record technicians work in admissions or medical records sections of hospitals and clinics. They work in land-based facilities and aboard ships.

Opportunities in Civilian Life

Civilian medical record technicians usually work for hospitals, clinics, and government health agencies. They perform duties similar to military medical record technicians. However, civilian medical record technicians tend to specialize in areas such as admissions, ward, or outpatient records. Those working in admission or discharge units are called admitting or discharge clerks.

Medical Service Technicians

Army

Navy

Air Force

Coast Guard

In emergencies or in combat, physicians are not always immediately available to treat the injured or wounded. When a physician is not available, medical service technicians provide basic and emergency medical treatment. They also assist medical officers in caring for sick and injured patients.

What They Do

Medical service technicians in the military perform some or all of the following duties:

- Examine and treat emergency or battlefield patients
- Interview patients and record their medical histories
- Take patients' temperature, pulse, and blood pressure
- Prepare blood samples for laboratory analysis
- Keep health records and clinical files up to date
- Give shots and medicines to patients

Where They Work

Medical service technicians usually work in hospitals and clinics on land or aboard ships. Medical service technicians may give emergency medical treatment in the field.

Opportunities in Civilian Life

Civilian medical service technicians work in hospitals, clinics, nursing homes, and rehabilitation centers. They perform duties similar to those performed by medical service technicians in the military. Civilian medical service technicians are known for the type of work they do: emergency medical technicians treat victims of accidents, fire, or heart attacks; medical assistants work for physicians and perform routine medical and clerical tasks; medication aides give shots and medicine under the close supervision of physicians; and physician assistants perform routine examinations and treatment for physicians.

Optometric Technicians

Army

Navy

Air Force

Coast Guard

Optometry, or vision care, is one of the many health benefits available to military personnel. The military operates its own clinics to examine eyes and fit glasses or contact lenses. Optometric technicians assist optometrists in providing vision care. They work with patients and manage clinic offices.

What They Do

Optometric technicians in the military perform some or all of the following duties:

- Perform screening tests of patients' vision and record results
- Order eyeglasses and contact lenses from prescriptions
- Measure patients for eyeglass frames
- Fit eyeglasses to patients
- Make minor repairs to glasses
- Place eye drops and ointment into patients' eyes
- Keep records in optometry offices

Where They Work

Optometric technicians normally work in optometric clinics.

Opportunities in Civilian Life
Civilian optometric technicians work in private optometry offices, clinics, and government health agencies. They perform duties similar to those performed by military optometric technicians. Optometric technicians are also called optometric assistants.

Physical Requirements
Normal color vision is required for some specialties to use optometric instruments.

Pharmacy Technicians

Army
Navy
Air Force
Coast Guard

Prescription drugs and medicines are important to medical treatment. Patients and physicians depend on military pharmacies to fill their prescriptions accurately. Pharmacy technicians prepare and dispense prescribed drugs and medicines under the supervision of pharmacists or physicians. They also maintain pharmacy supplies and records.

What They Do
Pharmacy technicians in the military perform some or all of the following duties:

Read physicians' prescriptions to determine the types and amount of drugs to prepare

Weigh and measure drugs and chemicals

Mix ingredients in order to produce prescription medications

Prepare labels for prescriptions

Dispense medications to patients

Keep records of drugs prescribed

Store shipments of drugs and medications

Where They Work
Pharmacy technicians usually work in hospitals and clinics on land or aboard ships. They may also work in field hospitals.

Opportunities in Civilian Life
Civilian pharmacy technicians work in pharmacies, drug stores, hospitals, and clinics under the direction of pharmacists. They are usually known as pharmacy helpers and generally do not have responsibility for the compounding and dispensing of drugs. They perform simple tasks, such as storing supplies, cleaning equipment, and delivering prescriptions. While military pharmacy technicians generally have more job responsibilities than civilian pharmacy helpers, they do not have the qualifications needed to become civilian pharmacists. Pharmacists must complete a college pharmacy degree program, pass a state board exam, and serve in a pharmacy internship.

Physical Requirements
Normal color vision is required as is the ability to speak clearly. Some specialties may involve heavy lifting.

Physical and Occupational Therapy Specialists

Army
Navy
Air Force
Coast Guard

Physical and occupational therapy consists of treatment and exercise for patients disabled by illness or injury. Physical and occupational therapy specialists assist in administering treatment aimed at helping disabled patients regain strength and mobility and preparing them to return to work.

What They Do
Physical and occupational therapy specialists in the military perform some or all of the following duties:

Test and interview patients to determine their physical and mental abilities

Assist physical and occupational therapists in planning therapy programs and exercise schedules

Fit artificial limbs (prostheses) and train patients in their use

Provide massages and heat treatments to patients

Teach patients new mobility skills

Set up and maintain therapeutic equipment such as exercise machines and whirlpools

Where They Work

Therapy specialists work in hospitals, clinics, and rehabilitation centers.

Opportunities in Civilian Life

Civilian therapy specialists work in hospitals, rehabilitation centers, nursing homes, schools, and community health centers. They perform duties similar to military therapy specialists. Civilian therapy specialists often specialize in treating a particular type of patient, such as children, the severely disabled, the elderly, or those who have lost arms or legs (amputees).

Physical Requirements

Therapy specialists may have to lift and support patients during exercises and treatments.

Radiologic (X-Ray) Technicians

Army
Navy
Air Force
Coast Guard

Radiology (the use of X-rays) is a health care service provided to men and women in the military. X-ray photographs help physicians detect injuries and illnesses. Radiology is also used to treat some diseases, such as cancer. Radiologic technicians operate X-ray and related equipment used in diagnosing and treating injuries and diseases. They work as part of a medical team of physicians and specialists to provide health care to patients.

What They Do

Radiologic technicians in the military perform some or all of the following duties:

Read requests or instructions from physicians to determine each patient's X-ray needs

Position patients under radiologic equipment

Operate X-ray equipment

Adjust X-ray equipment to the correct time and power of exposure

Process X-ray pictures

Prepare and administer radioactive solutions to patients

Keep records of patient treatment

Where They Work

Radiologic technicians work in hospitals and clinics. In combat situations, they may work in mobile field hospitals. They follow strict safety procedures to minimize exposure to radiation.

Opportunities in Civilian Life

Civilian radiologic technicians work in hospitals, diagnostic clinics, and medical laboratories. They perform duties similar to military radiologic technicians. They may specialize in various areas of radiology and may be called X-ray technologists or nuclear medical technologists.

ENGINEERING, SCIENCE, AND TECHNICAL OCCUPATIONS

Air Traffic Controllers

Army

Navy

Air Force

Marine Corps

Every day, hundreds of military airplanes and helicopters take off and land all over the world. Their movements are closely controlled in order to prevent accidents. Air traffic controllers direct the movement of aircraft into and out of military airfields. They track aircraft by radar and give voice instructions by radio.

What They Do

Air traffic controllers in the military perform some or all of the following duties:

- Operate radio equipment to issue takeoff, flight, and landing instructions to pilots
- Relay weather reports, airfield conditions, and safety information to pilots
- Use radar equipment to track aircraft in flight
- Plot airplane locations on charts and maps
- Compute speed, direction, and altitude of aircraft
- Maintain air traffic control records and communication logs

Where They Work

Air traffic controllers work in land-based and shipboard control centers.

Opportunities in Civilian Life

Civilian air traffic controllers work for the FAA in airports and control centers around the country. They perform duties similar to military air traffic controllers. They may specialize in specific areas, such as aircraft arrivals, departures, ground control, or en route flights.

Physical Requirements

Normal color vision, normal hearing, and a clear speaking voice are required to enter this occupation. Controllers must pass a special physical exam.

Chemical Laboratory Technicians

Army

Navy

Coast Guard

Fuels and oils must be free of water and other contaminants to be safely used in aircraft or vehicles. The same is true for chemicals and other materials used by the military. Chemical laboratory technicians test fuels, oils, chemicals, and other materials for quality, purity, and durability.

What They Do

Laboratory technicians in the military perform some or all of the following duties:

- Obtain petroleum test samples from storage tanks, barges, and tankers
- Test fuels and oils for water, sediment, and other contaminants using laboratory equipment
- Analyze chemicals for strength, purity, and toxic qualities
- Perform chemical and physical tests on clothing, food, paints, and plastics
- Keep detailed laboratory records and files

Where They Work

Chemical laboratory technicians work in laboratories on military bases and aboard ships.

Opportunities in Civilian Life
Civilian chemical laboratory technicians work for petroleum refineries, chemical companies, manufacturing firms, and government agencies. They perform duties similar to military laboratory technicians. Civilian chemical laboratory technicians specialize in particular industries, such as petroleum, food processing, or medical drugs. They also may be called fuel and chemical laboratory technicians or laboratory testers.

Physical Requirements
Normal color vision is required to perform chemical tests. Some specialties may require moderate to heavy lifting.

Communications Equipment Operators

Army

Navy

Air Force

Marine Corps

Coast Guard

The ability to link air, sea, and ground forces through communication systems is critical in the military. Communications equipment operators enable these messages to be transmitted and received.

What They Do
Communications equipment operators in the military perform some or all of the following duties:

Transmit, receive, and log messages according to military procedures

Encode and decode classified messages

Operate different types of telephone switchboards

Install, maintain, and operate communications equipment

Monitor and respond to emergency calls

Where They Work
Communications equipment operators may work either indoors or outdoors, depending on the specialty. They may be assigned to ships, aircraft, land bases, or mobile field units.

Opportunities in Civilian Life
Civilian communications equipment operators work in airports, harbors, police stations, fire stations, telephone companies, and many businesses. They may also work aboard ships. Their duties are similar to duties assigned to military communications equipment operators, although civilian communications equipment operators do not usually work in field units. They may be called radio operators, telephone operators, radiotelephone operators, switchboard operators or teletype operators, depending on their specialty.

Physical Requirements
Normal color vision, normal hearing, and the ability to speak clearly and distinctly are required to enter some specialties in this occupation. Operators must often sit for long periods.

Computer Programmers

Navy

Air Force

Marine Corps

Coast Guard

The military is one of the largest users of data processing equipment in the world. Information about communications, personnel, finance, and supply is kept in its many high-speed computers. This information is important for planning and management. Computer programmers plan and prepare instructions, called programs, that command computers to solve problems and organize data.

What They Do
Computer programmers in the military perform some or all of the following duties:

- Organize and arrange computer programs into logical steps that direct computers to solve problems
- Determine and analyze computer systems requirements
- Code programs into languages that computers can read, such as COBOL and FORTRAN
- Design, test, and debug computer programs
- Review and update old programs as new information is received or changes are needed

Where They Work

Computer programmers normally work in office settings. Some work aboard ships, in missile facilities, or in space command centers.

Opportunities in Civilian Life

Civilian computer programmers work for such organizations as manufacturing firms, banks, data processing organizations, government agencies, and private corporations. These employers handle large amounts of information that programmers help organize for convenient use. Civilian computer programmers perform duties similar to those in the military. They may also be called computer systems analysts.

Emergency Management Specialists

Army
Navy
Air Force
Marine Corps
Coast Guard

The military prepares for emergencies or natural disasters by developing detailed warning, control, and evacuation plans. Emergency management specialists prepare emergency plans and procedures for all types of disasters, such as floods, earthquakes, hurricanes, or enemy attack.

What They Do

Emergency management specialists in the military perform some or all of the following duties:

- Assist in preparing and maintaining disaster operations plans
- Train military and civilian personnel on what to do in an emergency
- Operate and maintain nuclear, biological, and chemical detection and decontamination equipment

Where They Work

Emergency management specialists work indoors when conducting training sessions and preparing disaster plans. Sometimes they work outdoors while operating decontamination equipment and monitoring disaster training.

Opportunities in Civilian Life

Civilian emergency management specialists work for federal, state, and local governments, including law enforcement and civil defense agencies. They perform duties similar to military emergency management specialists.

Physical Requirements

Normal color vision is needed to identify chemical agents.

Environment Health and Safety Specialists

Army
Navy
Air Force
Marine Corps
Coast Guard

Each military base is a small community. The health and well-being of the residents and surrounding land is a major concern of the services. Keeping military work places and living areas sanitary helps to prevent illness. Environmental health and safety specialists inspect military facilities and food supplies for the presence of disease, germs, or other conditions hazardous to health and the environment.

What They Do

Environmental health and safety specialists in the military perform some or all of the following duties:

Monitor storage, transportation, and disposal of hazardous waste

Analyze food and water samples to ensure quality

Conduct health and safety investigations of living quarters and base facilities

Provide training on industrial hygiene, environmental health, and occupational health issues

Where They Work

Environmental health specialists work indoors while inspecting food facilities and buildings. They work outdoors while inspecting waste disposal facilities and field camps.

Opportunities in Civilian Life

Most civilian environmental health and safety specialists work for local, state, and federal government agencies. Their duties are similar to the duties of military environmental health specialists. They may be called food and drug inspectors, public health inspectors, health and safety inspectors, or industrial hygienists.

Physical Requirements

Normal color vision is required to inspect foods for quality and freshness.

Intelligence Specialists

Army
Navy
Air Force
Marine Corps
Coast Guard

Military intelligence is information needed to plan for our national defense. Knowledge of the number, location, and tactics of enemy forces and potential battle areas is needed to develop military plans. To gather information, the services rely on aerial photographs, electronic monitoring using radar and sensitive radios, and human observation. Intelligence specialists gather and study the information required to design defense plans and tactics.

What They Do

Intelligence specialists in the military perform some or all of the following duties:

Study aerial photographs of foreign ships, bases, and missile sites

Study foreign troop movements

Operate sensitive radios to intercept foreign military communications

Study land and sea areas that could become battlegrounds in times of war

Store and retrieve intelligence data using computers

Study foreign military codes

Prepare intelligence reports, maps, and charts

Where They Work

Intelligence specialists work in offices on land and aboard ships, and in tents when in the field.

Opportunities in Civilian Life
Civilian intelligence specialists generally work for federal government agencies such as the Central Intelligence Agency or the National Security Agency. Their duties are similar to those performed by military intelligence specialists. The analytical skills of intelligence specialists are also useful in other fields, such as research or business planning.

Physical Requirements
Normal color vision is required for some specialties in order to work with color-coded maps.

Meteorological Specialists

Army

Navy

Air Force

Marine Corps

Coast Guard

Weather information is important for planning military operations. Accurate weather forecasts are needed to plan troop movements, airplane flights, and ship traffic. Meteorological specialists collect information about weather and sea conditions for use by meteorologists. They make visual observations and take readings from weather equipment, radar scans, and satellite photographs.

What They Do
Meteorological specialists in the military perform some or all of the following duties:

Launch weather balloons to record wind speed and direction

Identify the types of clouds present and estimate cloud height and amount of cloud cover

Take readings of barometric pressure, temperature, humidity, and sea conditions

Operate radio equipment to receive information from satellites

Plot weather information on maps and charts

Forecast weather based on readings and observations

Where They Work
Meteorological specialists usually work in offices either on land or aboard ships. They work outdoors when making visual weather observations and launching weather balloons.

Opportunities in Civilian Life
Civilian meteorological specialists work for government agencies (such as the U.S. Weather Service), commercial airlines, radio and television stations, and private weather forecasting firms. They perform duties similar to military meteorological specialists. Civilian meteorological specialists may also be called oceanographer assistants and weather clerks.

Physical Requirements
Normal color vision is required to use color-coded maps and weather charts. Some specialties may involve heavy lifting.

Non-Destructive Testers

Navy

Air Force

Marine Corps

Coast Guard

Military equipment is often placed under heavy stress. An airplane's landing gear absorbs heavy runway impact. Submarine hulls withstand tremendous pressure in the ocean depths. In time, stress may cause structural weakening or damage. Non-destructive testers examine metal parts for stress damage. They use X-rays, ultrasonics, and other testing methods that do not damage (are non-destructive to) the parts tested.

What They Do
Non-destructive testers in the military perform some or all of the following duties:

- Inspect metal parts and joints for wear and damage
- Take X-rays of aircraft and ship parts
- Examine X-ray film to detect cracks and flaws in metal parts and welds
- Operate ultrasonic, atomic absorption, and other kinds of test equipment
- Conduct oil analysis and heat damage tests to detect engine wear
- Prepare inspection reports

Where They Work
Non-destructive testers work indoors in laboratories and aircraft hangars. They also work outdoors in shipyards and in the field.

Opportunities in Civilian Life
Civilian non-destructive testers work for commercial testing laboratories, airlines, aircraft maintenance companies, and industrial plants. They perform duties similar to military non-destructive testers and may be called radiographers.

Physical Requirements
Normal color vision is required to read color-coded diagrams.

Ordnance Specialists

Army
Navy
Air Force
Marine Corps

Ordnance is a military term for ammunition and weapons. Ordnance includes all types of ammunition, missiles, toxic chemicals, and nuclear weapons. Ammunition and weapons are hazardous materials that must be handled carefully and stored properly. Ordnance specialists transport, store, inspect, prepare, and dispose of weapons and ammunition.

What They Do
Ordnance specialists in the military perform some or all of the following duties:

- Load nuclear and conventional explosives and ammunition on aircraft, ships, and submarines
- Inspect mounted guns, bomb release systems, and missile launchers to determine need for repair or destruction
- Assemble and load explosives such as torpedoes
- Defuse unexploded bombs
- Locate, identify, and dispose of chemical munitions

Where They Work
Ordnance specialists work both indoors and outdoors. They work in repair shops while assembling explosives and repairing weapons. They work outdoors while repairing equipment in the field and loading weapons on tanks, ships, or aircraft.

Opportunities in Civilian Life
There are no direct opportunities in civilian life for many of the military ordnance specialties. However, there are many occupations that are related. For example, civilians work for government agencies and private industry doing ordnance research and development. Others work for police or fire departments as bomb disposal experts. Some also work as gunsmiths or work for munitions manufacturers and firearms makers. Ordnance specialists may also be called bomb disposal experts.

Physical Requirements
Ordnance specialists may have to lift and carry artillery shells and other heavy ordnance.

Radar And Sonar Operators

Army
Navy
Air Force
Marine Corps
Coast Guard

Radar and sonar devices work by bouncing radio or sound waves off objects to determine their location and measure distance. They have many uses, such as tracking aircraft and missiles, determining positions of ships and submarines, directing artillery fire, forecasting weather, and aiding navigation. Radar and sonar operators monitor sophisticated radar and sonar equipment. They normally specialize in either radar or sonar.

What They Do

Radar and sonar operators in the military perform some or all of the following duties:

Detect and track position, direction, and speed of aircraft, ships, submarines, and missiles

Plot and record data on status charts and plotting boards

Set up and operate radar equipment to direct artillery fire

Monitor early warning air defense systems

Send and receive messages using radios and electronic communication systems

Where They Work

Radar and sonar operators in the military primarily work indoors in security-controlled areas. They work in operations centers and command posts either on land or aboard aircraft, ships, or submarines. Some may work in a mobile field radar unit.

Opportunities in Civilian Life

There are no direct opportunities in civilian life for military radar and sonar operators. However, workers in civilian occupations that use radar and sonar equipment in their jobs include weather service technicians, air traffic controllers, ship navigators, and ocean salvage specialists.

Physical Requirements

Normal color vision is required to enter this occupation.

Specialties involving flying require passing a special physical exam.

Radio Intelligence Operators

Army
Navy
Air Force
Marine Corps
Coast Guard

Knowing about the military forces of foreign governments helps our military experts plan the nation's defense. One way of learning about foreign military forces is to listen to their radio transmissions. Troop locations, battle tactics, and other secrets can be learned from listening to foreign military units sending messages to one another. Radio intelligence operators intercept, identify, and record foreign radio transmissions.

What They Do

Radio intelligence operators in the military perform some or all of the following duties:

Record radio signals coming from foreign ships, planes, and land forces

Study radio signals to understand the tactics used by foreign military forces

Tune radios to certain frequencies and adjust for clear reception

Locate the source of foreign radio signals using electronic direction-finding equipment

Translate Morse code signals into words and type them for review by superiors

Keep logs of signal interceptions

Where They Work

Radio intelligence operators may work indoors or outdoors, depending on assignment. They may also work in airplanes, ships, and land vehicles.

Opportunities in Civilian Life

Civilian radio intelligence operators work for government agencies like the National Security Agency, the Central Intelligence Agency, and the Federal Bureau of Investigation. They also work in related jobs for private electronics and communications companies. They perform duties similar to military radio intelligence operators and may also be called electronic intelligence operations specialists.

Physical Requirements

Radio intelligence operators may have to sit for long periods and listen to radio transmissions.

Space Operations Specialists

Navy

Air Force

Orbiting satellites and other space vehicles are used for communications, weather forecasting, and collecting intelligence data. In the future, more and more military operations will involve space systems. Space operations specialists use and repair spacecraft ground control command equipment, including electronic systems that track spacecraft location and operation.

What They Do

Space operations specialists in the military perform some or all of the following duties:

Transmit and verify spacecraft commands using aerospace ground equipment

Monitor computers and telemetry display systems

Analyze data to determine spacecraft operational status

Repair ground and spacecraft communication equipment

Assist in preparing spacecraft commands to meet mission objectives

Operate data-handling equipment to track spacecraft

Where They Work

Space operations specialists work in space operations centers.

Opportunities in Civilian Life

Civilian space operations specialists work for the National Aeronautics and Space Administration (NASA), the U.S. Weather Service, and private satellite communications firms. They perform duties similar to military space operations specialists.

Physical Requirements

Normal color vision is required to enter this occupation.

Surveying, Mapping, And Drafting Technicians

Army

Navy

Air Force

Marine Corps

Coast Guard

The military builds and repairs many airstrips, docks, barracks, roads, and other projects each year. Surveying, mapping, and drafting technicians conduct land surveys, make maps, and prepare detailed plans and drawings for construction projects. Surveys and maps are also used to locate military targets and plot troop movements.

What They Do
Surveying, mapping, and drafting technicians in the military perform some or all of the following duties:

Draw maps and charts using drafting tools such as easels, templates, and compasses

Make scale drawings of roads, airfields, buildings, and other military projects

Conduct land surreys and compute survey results

Draw diagrams for wiring and plumbing of structures

Build scale models of land areas that show hills, lakes, roads, and buildings

Piece together aerial photographs to form large photomaps

Where They Work
Surveying, mapping, and drafting technicians work both indoors and outdoors in all climates and weather conditions. Those assigned to engineering units sometimes work outdoors with survey teams. Those assigned to intelligence units may work on ships as well as on land.

Opportunities in Civilian Life
Civilian surveying, mapping, and drafting technicians work for construction, engineering, and architectural firms and government agencies such as the highway department. Their work is used for planning construction projects such as highways, airport runways, dams, and drainage systems. Surveyors and mapmakers are also called cartographers or cartographic technicians.

Physical Requirements
Good depth perception is required to study aerial photos through stereoscopes. Normal color vision is required to work with color-coded maps and drawings.

ADMINISTRATIVE OCCUPATIONS

Administrative Support Specialists

Army
Navy
Air Force
Marine Corps
Coast Guard

The military must keep accurate information for planning and managing its operations. Paper and electronic records are kept on equipment, funds, personnel, supplies, and all other aspects of the military. Administrative support specialists record information, type reports, and maintain files to assist in the operation of military offices.

What They Do
Administrative support specialists in the military perform some or all of the following duties:

Type letters, reports, requisition (order) forms, and official orders

Proofread written material for spelling, punctuation, and grammatical errors

Organize and maintain files and publications

Order office supplies

Greet and direct office visitors

Sort and deliver mail to office workers

Schedule training and leave for unit personnel

Answer phones and provide general information

Take meeting notes

Where They Work

Administrative support specialists work in office settings, both on land and aboard ships.

Opportunities in Civilian Life

Civilian administrative support specialists work in most business, government, and legal offices. They perform duties similar to military administrative support specialists and are called clerk typists, secretaries, general office clerks, administrative assistants, or office managers.

Computer Systems Specialists

Army

Navy

Air Force

Marine Corps

Coast Guard

The military services use computers to store and process data on personnel, weather, finances, and many other operations. Before any information can be processed, computer systems must be set up, data entered, and computers operated. Computer systems specialists ensure information is entered, stored, processed, and retrieved in a way that meets the military services' needs.

What They Do

Computer systems specialists in the military perform some or all of the following duties:

Identify computer user problems and coordinate to resolve them

Install, configure, and monitor local and wide area networks, hardware, and software

Compile, enter, and process information

Provide customer and network administration services, such as passwords, electronic mail accounts, security, and troubleshooting

Where They Work

Computer systems specialists work in offices or at computer sites on military bases or aboard ships.

Opportunities in Civilian Life

Civilian computer systems specialists work for a wide variety of employers, such as banks, hospitals, retail firms, manufacturers, government agencies, and firms that design and test computer systems. They perform duties similar to those performed in the military. They may also be called network support technicians, computer operators, or data processing technicians. Most civilian computer systems specialists require a four-year college degree.

Physical Requirements

Computer systems specialists may sit and key information for long periods.

Finance And Accounting Specialists

Army

Navy

Air Force

Marine Corps

Coast Guard

Millions of paychecks are issued and large amounts of materials are purchased by the services each year. To account for military spending, exact financial records must be kept of these transactions. Finance and accounting specialists organize and keep track of financial records. They also compute payrolls and other allowances, audit accounting records, and prepare payments for military personnel.

What They Do

Finance and accounting specialists in the military perform some or all of the following duties:

Record details of financial transactions on accounting forms

Audit financial records

Prepare pay and travel vouchers (checks), earnings and deductions statements, bills, and financial accounts and reports

Disburse cash, checks, advance pay, and bonds

Organize information on past expenses to help plan budgets for future expenses

Special Qualifications

Depending on the specialty, entry into this occupation may require courses in mathematics, bookkeeping, or accounting.

Where They Work

Finance and accounting specialists work in offices on land or aboard ships.

Opportunities in Civilian Life

Civilian finance and accounting specialists work for all types of businesses and government agencies. They perform duties similar to military finance and accounting specialists. Civilian finance and accounting specialists are also called accounting clerks, audit clerks, bookkeepers, or payroll clerks.

Flight Operations Specialists

Army

Navy

Air Force

Marine Corps

Coast Guard

The services operate one of the largest fleets of aircraft in the world. Hundreds of transport, passenger, and combat airplanes and helicopters fly missions every day. Accurate flight information keeps operations safe and efficient. Flight operations specialists prepare and provide flight information for air and ground crews.

What They Do

Flight operations specialists in the military perform some or all of the following duties:

Help plan flight schedules and air crew assignments

Keep flight logs on incoming and outgoing flights

Keep air crew flying records and flight operations records

Receive and post weather information and flight plan data, such as air routes and arrival and departure times

Coordinate air crew needs, such as ground transportation

Plan aircraft equipment needs for air evacuation and dangerous cargo flights

Check military flight plans with civilian agencies

Where They Work

Flight operations specialists work indoors in flight control centers or air terminals.

Opportunities in Civilian Life

Civilian flight operations specialists work for commercial and private airlines and air transport companies. They perform duties similar to military flight operations specialists.

Physical Requirements

The ability to speak clearly and distinctly is required.

Legal Specialists And Court Reporters

Army

Navy

Air Force

Marine Corps

Coast Guard

The military has its own judicial system for prosecuting lawbreakers and handling disputes. Legal specialists and court reporters assist military lawyers and judges in the performance of legal and judicial work. They perform legal research, prepare legal documents, and record legal proceedings.

What They Do

Legal specialists and court reporters in the military perform some or all of the following duties:

- Research court decisions and military regulations
- Process legal claims and appeals
- Interview clients and take statements
- Prepare trial requests and make arrangements for courtrooms
- Maintain law libraries and trial case files
- Type text from stenotyped records, shorthand notes, or taped records of court proceedings
- Prepare records of hearings, investigations, court-martials, and courts of inquiry

Where They Work

Legal specialists and court reporters work in military law offices and courtrooms.

Opportunities in Civilian Life

Civilian legal specialists and court reporters work for private law firms, banks, insurance companies, government agencies, and local, state, and federal courts. They perform duties similar to military legal specialists and court reporters. Civilian legal specialists and court reporters may also be called legal assistants, clerks, paralegal assistants, and court clerks or recorders.

Personnel Specialists

Army
Navy
Air Force
Marine Corps
Coast Guard

Personnel management helps individuals develop their military careers. It also serves the military's need to fill jobs with qualified workers. Personnel specialists collect and store information about the people in the military, such as training, job assignment, promotion, and health information. They work directly with service personnel and their families.

What They Do

Personnel specialists in the military perform some or all of the following duties:

- Organize, maintain, and review personnel records
- Enter and retrieve personnel information using computer terminals
- Assign personnel to jobs
- Prepare organizational charts, write official correspondence, and prepare reports
- Provide career guidance
- Assist personnel and their families who have special needs
- Provide information about personnel programs and procedures to service men and women

Where They Work

Personnel specialists normally work in office settings on land or aboard ships.

Opportunities in Civilian Life

Civilian personnel specialists work for all types of organizations, including industrial firms, retail establishments, and government agencies. They perform duties similar to military personnel clerks. However, specific jobs vary from company to company.

Postal Specialists

Army
Navy
Air Force
Marine Corps
Coast Guard

The military operates its own postal service for official military communications and messages. In addition, it delivers mail to thousands of service men and women all over the world. Postal specialists process incoming and outgoing mail between military and civilian postal systems. They also sell stamps and money orders and provide services to postal customers.

What They Do

Postal specialists in the military perform some or all of the following duties:

Process mail using metering and stamp-canceling machines

Weigh packages, using scales, to determine postage due

Examine packages to ensure that they meet mailing standards

Process and sort registered, certified, and insured mail

Receive payment for and issue money orders and stamps

Prepare postal reports and claims for lost or damaged mail

Where They Work

Postal specialists work in post offices and mailrooms on land or aboard ships.

Opportunities in Civilian Life

Civilian postal specialists work for the United States Postal Service and for private courier or express mail firms. They perform many of the same duties as military postal specialists. They are usually called postal clerks.

Preventive Maintenance Analysts

Army
Navy
Air Force
Marine Corps
Coast Guard

Regular maintenance extends the time aircraft, vehicles, and machinery can be used. To make sure military equipment is well maintained, the services prepare detailed maintenance schedules. Preventive maintenance analysts promote equipment maintenance. They watch schedules and notify mechanics about upcoming maintenance needs.

What They Do

Preventive maintenance analysts in the military perform some or all of the following duties:

Review maintenance schedules and notify mechanics about the types of service needed

Compare schedules to records of maintenance work actually performed

Prepare charts and reports on maintenance activities

Calculate how many mechanics and spare parts are needed to maintain equipment

Operate computers and calculators to enter or retrieve maintenance data

Where They Work

Preventive maintenance analysts usually work in office settings.

Opportunities in Civilian Life

Civilian preventive maintenance analysts work for government agencies, airlines, and large transportation firms. They also work for firms with large numbers of machines. They perform duties similar to military preventive maintenance analysts.

Physical Requirements

Normal color vision is required to read and interpret maintenance charts and graphs in some specialties.

Some specialties require the ability to speak clearly.

Recruiting Specialists

Army

Navy

Air Force

Marine Corps

Coast Guard

Each year, the military services enlist approximately 200,000 young men and women. Attracting young people with the kinds of talent needed to succeed in today's military is a large task. Recruiting specialists provide information about military careers to young people, parents, schools, and local communities. They explain service employment and training opportunities, pay and benefits, and service life.

What They Do

Recruiting specialists in the military perform some or all of the following duties:

Interview civilians interested in military careers

Describe military careers to groups of high school students

Explain the purpose of the ASVAB (Armed Services Vocational Aptitude Battery) and test results to students and counselors

Participate in local job fairs and career day programs

Talk about the military to community groups

Counsel military personnel about career opportunities and benefits

Where They Work

Recruiting specialists work in local recruiting offices, on high school campuses and in career centers, and in local communities. They may have to travel often.

Opportunities in Civilian Life

Civilian recruiting specialists work for businesses of all kinds searching for talented people to hire. Recruiters also work for colleges seeking to attract and enroll talented high school students.

Sales And Stock Specialists

Navy

Air Force

Marine Corps

Coast Guard

The military operates retail stores and snack bars for its personnel on bases and aboard ships in the United States and overseas. Military stores, called exchanges, sell merchandise similar to that sold in civilian stores, but at a discount. Sales and stock specialists operate retail food and merchandise stores for military personnel.

What They Do

Sales and stock specialists in the military perform some or all of the following duties:

Operate snack bars, laundries, and dry cleaning facilities

Order and receive merchandise and food for retail sales

Inspect food and merchandise for spoilage or damage

Price and mark retail sales items, using markers and stamping machines

Stock shelves and racks for the display of products

Count merchandise and supplies during inventories

Record and account for money received and prepare bank deposits

Where They Work
Sales and stock specialists work on land and aboard ships in retail stores, snack bars, and storerooms.

Opportunities in Civilian Life
Civilian sales and stock specialists work in many kinds of retail businesses, such as grocery stores and department stores. They perform duties similar to military sales and stock specialists. They may also be called sales clerks or stock clerks.

Physical Requirements
The ability to speak clearly is required. Sales and stock specialists may have to lift and carry heavy objects.

Supply And Warehousing Specialists

Army

Navy

Air Force

Marine Corps

Coast Guard

The military maintains a large inventory of food, medicines, ammunition, spare parts, and other supplies. Keeping the military's supply system operating smoothly is an important job. The lives of combat troops in the field may depend on receiving the right supplies on time. Supply and warehousing specialists receive, store, record, and issue military supplies.

What They Do
Supply and warehousing specialists in the military perform some or all of the following duties:

Perform inventory and financial management procedures, including ordering, receiving, and storing supplies

Locate and catalog stock

Give special handling to medicine, ammunition, and other delicate supplies

Select the correct stock for issue

Load, unload, and move stock using equipment such as forklifts and hand trucks

Keep records on incoming and outgoing stock

Where They Work
Supply and warehousing specialists work in large general supply centers, small specialized supply rooms, or ship storerooms.

Opportunities in Civilian Life
Civilian supply and warehousing specialists work for factories, parts departments in repair shops, department stores, and government warehouses and stockrooms. They perform duties similar to military supply and warehousing specialists. Civilian supply and warehousing specialists may also be called stock control clerks, parts clerks, or storekeepers.

Physical Requirements
Supply and warehousing specialists may have to lift and carry heavy boxes of ammunition and other supplies. Normal color vision is required for specialties that handle color-coded parts, supplies, and ammunition.

Training Specialists And Instructors

Navy

Air Force

Marine Corps

Coast Guard

The military trains new personnel in the job skills needed to begin their careers in the service. The military also offers advanced training and retraining to nearly all personnel. Instruction in electronics, health care, computer sciences, and aviation are just a few of the many vocational and technical areas for which the military has training programs. Training specialists and instructors teach classes and give demonstrations to provide military personnel with the knowledge needed to perform their jobs.

What They Do

Training specialists and instructors in the military perform some or all of the following duties:

- Prepare course outlines and materials to present during training
- Select training materials, such as textbooks and films
- Teach classes and give lectures in person, over closed-circuit TV, or on videotape
- Work with students individually when necessary
- Test and evaluate student progress

Where They Work

Training specialists and instructors in the military work either indoors or outdoors, depending on the type of training they provide and their specialty area.

Opportunities in Civilian Life

Civilian training specialists and instructors work for vocational and technical schools, high schools, colleges, businesses, and government agencies. Their duties are similar to those performed by military training specialists and instructors. Civilian training specialists and instructors may be called teachers, trainers, or training representatives.

Physical Requirements

Training specialists and instructors must be able to speak clearly and distinctly.

Transportation Specialists

Army

Navy

Marine Corps

Coast Guard

The military constantly moves passengers and cargo. Personnel often travel to meetings, training sessions, and new assignments. Supplies and equipment to support troops must be shipped regularly. Transportation specialists plan and assist in air, sea, and land transportation for people and cargo. Some assist passenger travel as gate agents and flight attendants.

What They Do

Transportation specialists in the military perform some or all of the following duties:

- Arrange for passenger travel via plane, bus, train, or boat
- Arrange for shipment and delivery of household goods
- Determine which vehicles to use based on freight or passenger movement requirements
- Determine transportation and shipping routes
- Prepare transportation requests and shipping documents
- Check in passengers and baggage for military transport flights
- Serve as military airplane flight attendants
- Inspect cargo for proper packing, loading, and marking

Where They Work

Transportation specialists usually work in offices. They may work outdoors when escorting passengers or processing shipments. Flight attendants work on land and in airplanes.

Opportunities in Civilian Life
Civilian transportation specialists work for airlines, shipping firms, and commercial freight lines. They perform duties similar to military transportation specialists. Civilian transportation specialists may also be called travel clerks, reservation clerks or transportation agents.

SERVICE OCCUPATIONS

Firefighters

Army

Navy

Air Force

Marine Corps

Coast Guard

Military bases have their own protection services, including fire departments. Military firefighting units are responsible for protecting lives and property from fire. Firefighters put out, control, and help prevent fires in buildings, aircraft, and aboard ships.

What They Do
Firefighters in the military perform some or all of the following duties:

- Operate pumps, hoses, and extinguishers
- Force entry into aircraft, vehicles, and buildings in order to fight fires and rescue personnel
- Drive firefighting trucks and emergency rescue vehicles
- Give first aid to injured personnel
- Inspect aircraft, buildings, and equipment for fire hazards
- Teach fire protection procedures
- Repair firefighting equipment and fill fire extinguishers

Where They Work
Firefighters work indoors and outdoors while fighting fires. They are exposed to the smoke, heat, and flames of the fires they fight.

Opportunities in Civilian Life
Civilian firefighters work for city and county fire departments, other government agencies, and industrial firms. They perform duties similar to those performed by military firefighters, including rescue and salvage work.

Physical Requirements
Good vision without glasses and a clear speaking voice are required to enter some specialties in this occupation. Firefighters have to climb ladders and stairs. They must also be able to lift and carry injured personnel.

Food Service Specialists

Army

Navy

Air Force

Marine Corps

Coast Guard

Every day, more than one million meals are prepared in military kitchens. Some kitchens prepare thousands of meals at one time, while others prepare food for small groups of people. Food service specialists prepare all types of food according to standard and dietetic recipes. They also order and inspect food supplies and prepare meats for cooking.

What They Do
Food service specialists in the military perform some or all of the following duties:

- Order, receive, and inspect meat, fish, fruit, and vegetables
- Prepare standard cuts of meat using cleavers, knives, and bandsaws
- Cook steaks, chops, and roasts
- Bake or fry chicken, turkey, and fish

Prepare gravies and sauces

Bake breads, cakes, pies, and pastries

Serve food in dining halls, hospitals, field kitchens, or aboard ship

Clean ovens, stoves, mixers, pots, and utensils

Where They Work
Food service specialists normally work in clean, sanitary kitchens and dining facilities. They may sometimes work in refrigerated meat lockers. Sometimes they work outdoors in tents while preparing and serving food under field conditions.

Opportunities in Civilian Life
Civilian food service specialists work in cafes, restaurants, and cafeterias. They also work in hotels, hospitals, manufacturing plants, schools, and other organizations that have their own dining facilities. Depending on specialty, food service specialists are called cooks, chefs, bakers, butchers, or meat cutters.

Physical Requirements
Food service specialists may have to lift and carry heavy containers of foodstuffs and large cooking utensils.

Law Enforcement And Security Specialists

Army
Navy
Air Force
Marine Corps
Coast Guard

The military services have their own law enforcement and security specialists. These specialists investigate crimes committed on military property or that involve military personnel. They also guard inmates in military correctional facilities.

What They Do
Law enforcement and security specialists in the military perform some or all of the following duties:

Investigate criminal activities and activities related to espionage, treason, and terrorism

Interview witnesses and question suspects, sometimes using polygraph machines (lie detectors)

Guard correctional facilities and conduct searches of inmates, cells, and vehicles

Perform fire and riot control duties

Where They Work
Law enforcement and security specialists in the military work mainly indoors; they may work outdoors while conducting investigations or guarding prisoners in exercise yards.

Opportunities in Civilian Life
Civilian law enforcement and security specialists work in federal, state, and local prisons, intelligence and law enforcement agencies, and private security companies. They perform similar duties to those performed in the military. They may be called detectives, private investigators, undercover agents, correction officers, or guards.

Physical Requirements
Normal color vision is necessary to enter some specialties in this area. Some specialties have minimum age and height requirements.

Military Police

Army
Navy
Air Force
Marine Corps
Coast Guard

The services have their own police forces for many of the same reasons that civilians do: to control traffic, prevent crime, and respond to emergencies. Military police protect lives and property on military bases by enforcing military laws and regulations.

What They Do

Military police perform some or all of the following duties:

Patrol areas on foot, by car, or by boat

Interview witnesses, victims, and suspects in the course of investigating crimes

Collect fingerprints and other evidence

Arrest and charge criminal suspects

Train and walk with police dogs

Testify in court

Guard entrances and direct traffic

Where They Work

Military police work both indoors and outdoors. They may work on foot, in cars, or in boats.

Opportunities in Civilian Life

Civilian police officers generally work for state, county, or city law enforcement agencies. Some work as security guards for industrial firms, airports, and other businesses and institutions. They perform duties similar to military police.

Physical Requirements

Normal color vision, hearing, and a clear speaking voice are usually required to enter this occupation. Some specialties have minimum height requirements.

VEHICLE AND MACHINERY MECHANIC OCCUPATIONS

Aircraft Mechanics

Army
Navy
Air Force
Marine Corps
Coast Guard

Military aircraft are used to fly hundreds of missions each day for transport, patrol, and flight training. They need frequent servicing to remain safe and ready to fly. Aircraft mechanics inspect, service, and repair helicopters and airplanes.

What They Do

Aircraft mechanics in the military perform some or all of the following duties:

Service and repair helicopter, jet, and propeller aircraft engines

Inspect and repair aircraft wings, fuselages (bodies), and tail assemblies

Service and repair aircraft landing gear

Repair or replace starters, lights, batteries, wiring, and other electrical parts

Where They Work

Aircraft mechanics work in aircraft hangars and machine shops located on air bases or aboard aircraft carriers.

Opportunities in Civilian Life

Civilian aircraft mechanics work for aircraft manufacturers, commercial airlines, and government agencies. They perform duties similar to military aircraft mechanics. They may also be called airframe or power plant mechanics.

Physical Requirements
Some specialties require moderate to heavy lifting. Normal color vision is required to work with color-coded wiring.

Automotive And Heavy Equipment Mechanics

Army

Navy

Air Force

Marine Corps

Coast Guard

Keeping automotive and heavy equipment in good working condition is vital to the success of military missions. Automotive and heavy equipment mechanics maintain and repair vehicles such as jeeps, cars, trucks, tanks, self-propelled missile launchers, and other combat vehicles. They also repair bulldozers, power shovels, and other construction equipment.

What They Do
Automotive and heavy equipment mechanics in the military perform some or all of the following duties:

Troubleshoot problems in vehicle engines, electrical systems, steering, brakes, and suspensions

Tune and repair engines

Replace or repair damaged body parts, hydraulic arms or shovels, and grader blades

Establish and follow schedules for maintaining vehicles

Where They Work
Automotive and heavy equipment mechanics usually work inside large repair garages. They work outdoors when making emergency repairs in the field.

Opportunities in Civilian Life
Civilian automotive and heavy equipment mechanics may work for service stations, auto and construction equipment dealers, farm equipment companies, and state highway agencies. They perform duties similar to military automotive and heavy equipment mechanics. They may also be called garage mechanics, carburetor mechanics, transmission mechanics, radiator mechanics, construction equipment mechanics, or endless track vehicle mechanics.

Physical Requirements
Automotive and heavy equipment mechanics may have to lift heavy parts and tools. They sometimes have to work in cramped positions. Normal color vision is required for some specialties to work with color-coded wiring and to read diagrams.

Divers

Army

Navy

Marine Corps

Coast Guard

Sometimes, military tasks such as ship repair, construction, and patrolling must be done under water. Divers in the military perform this work. They usually specialize either as scuba divers, who work just below the surface, or as deep sea divers, who may work for long periods of time in depths up to 300 feet.

What They Do
Divers in the military perform some or all of the following duties:

Inspect and clean ship propellers and hulls

Patch damaged ship hulls using underwater welding equipment

Patrol the waters below ships at anchor

Salvage (recover) sunken equipment

Assist with underwater construction of piers and harbor facilities

Survey rivers, beaches, and harbors for underwater obstacles

Use explosives to clear underwater obstacles

Where They Work

Divers work underwater. However, they plan and prepare for work on land or aboard ships. Because diving is not usually a full-time job, divers often have another job specialty in which they work.

Opportunities in Civilian Life

Civilian divers work for oil companies, salvage companies, underwater construction firms, and police or fire rescue units. They perform duties similar to divers in the military.

Physical Requirements

Divers must be good swimmers and physically strong.

Heating And Cooling Mechanics

Army
Navy
Air Force
Marine Corps
Coast Guard

Air conditioning and heating equipment is used to maintain comfortable temperatures in military buildings, airplanes, and ships. Refrigeration equipment is used to keep food cold and to keep some missile fuels at sub-zero storage temperatures. Heating and cooling mechanics install and repair air conditioning, refrigeration, and heating equipment.

What They Do

Heating and cooling mechanics in the military perform some or all of the following duties:

Install and repair furnaces, boilers, and air conditioners

Recharge cooling systems with refrigerant gases

Install copper tubing systems that circulate water or cooling gases

Replace compressor parts such as valves, pistons, bearings, and electrical motors on refrigeration units

Repair thermostats and electrical circuits

Where They Work

Heating and cooling mechanics may work inside repair shops. Frequently, they work wherever equipment is to be installed or repaired.

Opportunities in Civilian Life

Civilian heating and cooling mechanics work for contractors that install home furnaces and air conditioners or for firms that repair refrigerators and freezers in homes, grocery stores, factories, and warehouses. Heating and cooling mechanics in civilian life often specialize more than those in the military. They may be called heating, air conditioning, refrigeration, or climate control mechanics.

Physical Requirements

Heating and cooling mechanics may have to lift or move heavy equipment. They are often required to stoop, kneel, and work in cramped positions. Normal color vision is required for locating and repairing color-coded wiring.

Marine Engine Mechanics

Army
Navy
Air Force
Marine Corps
Coast Guard

The military operates many types of watercraft from small motor launches to large ships. Many of these vessels are powered by gasoline or diesel engines. Marine engine mechanics repair and maintain gasoline and diesel engines on ships, boats, and other watercraft. They also repair shipboard mechanical and electrical equipment.

What They Do

Marine engine mechanics in the military perform some or all of the following duties:

Repair and maintain shipboard gasoline and diesel engines

Locate and repair machinery parts, including valves and piping systems

Repair ship propulsion machinery

Repair and service hoisting machinery and ship elevators

Repair refrigeration and air conditioning equipment on ships

Repair engine-related electrical systems

Where They Work

Marine engine mechanics work aboard ships, normally in the engine or power rooms. Sometimes they work in repair centers on land bases. Working conditions in engine rooms tend to be noisy and hot.

Opportunities in Civilian Life

Civilian marine engine mechanics work in many industries, including marine transportation, commercial fishing, and oil exploration and drilling. They perform duties similar to military marine engine mechanics.

Physical Requirements

Normal color vision is required to work with color-coded diagrams and wiring.

Powerhouse Mechanics

Army

Navy

Coast Guard

Power generating stations (powerhouses) provide electric power for military bases, ships, and field camps. There are many types of powerhouses, from small gas generators to large nuclear reactors. Powerhouse mechanics install, maintain, and repair electrical and mechanical equipment in power generating stations.

What They Do

Powerhouse mechanics in the military perform some or all of the following duties:

Install generating equipment, such as gasoline and diesel engines, turbines, and air compressors

Repair and maintain nuclear power plants

Inspect and service pumps, generators, batteries, and cables

Tune engines using hand tools, timing lights, and combustion pressure gauges

Diagnose (troubleshoot) engine and electrical system problems

Replace damaged parts such as fuel injectors, valves, and pistons

Where They Work

Powerhouse mechanics work in equipment repair shops, power plant stations, or power generating rooms aboard ships. Sometimes they work outdoors while repairing substation generating equipment.

Opportunities in Civilian Life

Civilian powerhouse mechanics work for a wide variety of employers, such as utility and power companies, manufacturing companies, and others that operate their own power plants. They perform duties similar to military powerhouse mechanics.

Physical Requirements
Powerhouse mechanics may have to lift and move heavy electrical generators or batteries. Normal color vision is required to work with color-coded wiring and cables.

ELECTRONIC AND ELECTRICAL EQUIPMENT REPAIR OCCUPATIONS

Aircraft Electricians

Army
Navy
Air Force
Marine Corps
Coast Guard

Airplanes and helicopters have complex electrical systems. Instruments, lights, weapons, ignition systems, landing gear, and many other aircraft parts are powered by electricity. Aircraft electricians maintain and repair electrical systems on airplanes and helicopters.

What They Do
Aircraft electricians in the military perform some or all of the following duties:

Troubleshoot aircraft electrical systems using test equipment

Repair or replace defective generators and electric motors

Inspect and maintain electrical systems

Replace faulty wiring

Solder electrical connections

Repair or replace instruments, such as tachometers, temperature gauges, and altimeters

Read electrical wiring diagrams

Where They Work
Aircraft electricians usually work indoors, in aircraft hangars, airplanes, and repair shops. They may also work on aircraft parked outdoors.

Opportunities in Civilian Life
Civilian aircraft electricians work mainly for airlines and aircraft maintenance firms. They may also work for aircraft manufacturers and other organizations that have fleets of airplanes or helicopters. Their duties are similar to those of military aircraft electricians.

Physical Requirements
Normal color vision is required to work with color-coded wiring.

Communications Equipment Repairers

Army
Navy
Air Force
Marine Corps
Coast Guard

The military relies on communication equipment to link ground, sea, and air forces. This equipment allows the military to track and direct troop, aircraft, and ship movements. Communications equipment repairers ensure this equipment operates properly.

What They Do
Communications equipment repairers in the military perform some or all of the following duties:

Maintain, test, and repair communications equipment using frequency meters, circuit analyzers, and other electrical and electronic test equipment

Install and repair circuits and wiring using soldering irons and hand tools

Calibrate and align equipment components using scales, gauges, and other measuring instruments

String overhead communications and electric cables between utility poles

Where They Work
Communications equipment repairers usually work in repair shops, laboratories, and outdoors, depending on the specialty.

Opportunities in Civilian Life
Civilian communications equipment repairers often work for firms that design and make communications and electronic equipment. They may also work for the federal government. They perform duties similar to military communications equipment repairers. They may be called radio repairers, radio mechanics, teletype repairers, or station installers and repairers, depending on their specialty.

Physical Requirements
For some specialties, normal color vision is required. Some repairers may work from ladders or on tall utility poles.

Computer Equipment Repairers

Army

Navy

Air Force

Marine Corps

The military relies on computers to support weapons systems, communications, and administration. Keeping systems "up" is crucial for all military operations. Computer equipment repairers install, test, maintain, and repair computers and related data processing equipment.

What They Do
Computer equipment repairers in the military perform some or all of the following duties:

Install computers and other data processing equipment

Inspect data processing equipment for defects in wiring, circuit boards, and other parts

Test and repair data processing equipment using electrical voltage meters, circuit analyzers, and other special testing equipment

Locate defective data processing parts using technical guides and diagrams

Where They Work
Computer equipment repairers usually work indoors in repair shops or data processing centers on land or aboard ships. Some specialties involve flying.

Opportunities in Civilian Life
Civilian computer equipment repairers work for computer manufacturers, repair services, and other businesses with large computer facilities. They perform duties similar to military computer equipment repairers. They may also be called computer service technicians.

Physical Requirements
Specialties that involve flying require passing a special physical exam. Normal color vision is required to work with color-coded wiring.

Electrical Products Repairers

Army

Navy

Marine Corps

Coast Guard

Much of the military's equipment is electrically powered. Electric motors, electric tools, and medical equipment require careful maintenance and repair. Electrical products repairers maintain and repair electrical equipment. They specialize by type of equipment.

What They Do

Electrical products repairers in the military perform some or all of the following duties:

- Maintain, test, and repair electric motors in many kinds of machines, such as lathes, pumps, office machines, and kitchen appliances
- Inspect and repair electrical, medical, and dental equipment
- Inspect and repair electric instruments, such as voltmeters
- Replace worn gaskets and seals in watertight electrical equipment
- Maintain and repair portable electric tools, such as saws and drills
- Maintain and repair submarine periscopes

Where They Work

Electrical products repairers usually work in repair shops on land or aboard ships.

Opportunities in Civilian Life

Civilian electrical products repairers work in many industries, including hospitals, manufacturing firms, and governmental agencies. They also work in independent repair shops. They perform duties similar to military electrical products repairers. They may be called electric tool repairers, electrical instrument repairers, electromedical equipment repairers, or electric motor repairers.

Physical Requirements

Normal color vision is required to work with color-coded wiring.

Electronic Instrument Repairers

Army
Navy
Air Force
Marine Corps
Coast Guard

The military uses electronic instruments in many areas, including health care, weather forecasting, flight control, and combat, to name a few. Electronic instrument repairers maintain and repair electronic instruments, such as precision measuring equipment, navigational controls, photographic equipment, and biomedical instruments. Electronic instrument repairers normally specialize by type of equipment or instrument being repaired.

What They Do

Electronic instrument repairers in the military perform some or all of the following duties:

- Test meteorological and medical instruments, navigational controls, and simulators using electronic and electrical test equipment
- Read technical diagrams and manuals in order to locate, isolate, and repair instrument parts
- Replace equipment parts such as resistors, switches, and circuit boards

Where They Work

Electronic instrument repairers usually work in repair shops and laboratories.

Opportunities in Civilian Life

Most civilian electronic instrument repairers work for manufacturing, medical research, or satellite communications firms, or commercial airlines. They may also work for government agencies, such as the Federal Aviation Administration, the National Aeronautics and Space Administration, or the National Weather Service. They perform the same kind of duties as military instrument repairers. They are called electronics mechanics, dental equipment repairers, or biomedical equipment technicians, depending on their specialty.

Physical Requirements

Normal color vision is required to work with color-coded wiring. Some specialties require a minimum age of 18 to enter.

Photographic Equipment Repairers

Navy

Air Force

Marine Corps

The photographic equipment used by the military has many sensitive mechanisms. Still cameras, video cameras, and photographic processing equipment need regular attention to stay in working order. Photographic equipment repairers adjust and repair cameras, projectors, and photoprocessing equipment.

What They Do

Photographic equipment repairers in the military perform some or all of the following duties:

- Adjust and repair camera shutter mechanisms, focus controls, and flash units
- Maintain and repair aerial cameras mounted in airplanes
- Maintain aerial sensors that detect foreign military activities
- Maintain and repair motion picture cameras and sound recording equipment
- Repair photoprocessing equipment such as enlargers, film processors, and printers
- Diagnose problems in all types of cameras

Where They Work

Photographic equipment repairers work in repair shops on land or aboard ships.

Opportunities in Civilian Life

Civilian photographic equipment repairers work for photographic laboratories, engineering firms, and government agencies. They perform duties similar to those performed in the military. Depending on specialty, they may also be called camera repairers, motion picture equipment machinists, or photographic equipment technicians.

Physical Requirements

Normal color vision is required to work with color-coded wiring.

Power Plant Electricians

Army

Navy

Air Force

Marine Corps

Coast Guard

Each military base—anywhere in the world—must have its own electricity. Power plant electricians maintain and repair electricity generating equipment in mobile and stationary power plants.

What They Do

Power plant electricians perform some or all of the following duties:

- Maintain and repair motors, generators, switchboards, and control equipment
- Maintain and repair power and lighting circuits, electrical fixtures, and other electrical equipment
- Detect and locate grounds, open circuits, and short circuits in power distribution cables
- Connect emergency power to the main control board from an emergency switchboard
- Operate standard electrical and electronic test equipment
- Read technical guides and diagrams to locate damaged parts of generators and control equipment

Where They Work

Power plant electricians work in repair shops on land, aboard ships, or wherever generating equipment needing repair is located.

Opportunities in Civilian Life
Civilian power plant electricians often work for construction companies, manufacturers, and utility companies. They perform duties similar to military power plant electricians.

Physical Requirements
Normal color vision is required to work with color-coded wiring.

Precision Instrument Repairers

Army

Navy

Air Force

Marine Corps

Precision instruments are measuring devices. They can be as simple as a thermometer or as complex as a gyrocompass. Precision instruments are used by the military to measure distance, pressure, altitude, underwater depth, and many other physical properties. Precision instrument repairers keep measuring devices in good working order. They calibrate (adjust) gauges and meters to give correct readings.

What They Do
Precision instrument repairers in the military perform some or all of the following duties:

Calibrate weather instruments, such as barometers and thermometers

Repair gyrocompasses

Adjust and repair weapon-aiming devices, such as range finders, telescopes, periscopes, and ballistic computers

Calibrate engineering instruments, such as transits, levels, telemeters, and stereoscopes

Calibrate and repair instruments used in aircraft

Repair watches, clocks, and timers

Calibrate electrical test instruments

Where They Work
Precision instrument repairers usually work in repair shops on land or aboard ships.

Opportunities in Civilian Life
Civilian precision instrument repairers work for firms that manufacture or use precision instruments. These include manufacturing firms, airlines, machinery repair shops, maintenance shops, and instrument makers. Civilian precision instrument repairers perform duties similar to military precision instrument repairers. They may also be called instrument mechanics or calibration specialists.

Physical Requirements
Normal color vision is required to work with color-coded wiring and repair manuals.

Radar And Sonar Equipment Repairers

Army

Navy

Air Force

Marine Corps

Coast Guard

Radar and sonar equipment locates objects by bouncing radio and sound waves off them. This equipment is used to detect and track enemy ships, planes, and missiles. It is also used for ship and plane navigation and weather observation. Radar and sonar equipment repairers install, maintain, repair, and operate sonar and radar equipment.

What They Do
Radar and sonar equipment repairers perform some or all of the following duties:

Test radar systems using electronic and electrical test equipment

Monitor the operation of air traffic control, missile tracking, air defense, and other radar systems to make sure there are no problems

Repair sonar and radar components (parts), using soldering irons and other special hand and power tools

Install receivers, transmitters, and other components using technical manuals and guides

Read wiring diagrams, designs, and other drawings to locate parts and components of radar equipment

Where They Work
Radar and sonar equipment repairers work in repair shops and laboratories on land or aboard ships. Some specialties involve flying.

Opportunities in Civilian Life
Civilian radar and sonar equipment repairers work for engineering firms, the federal government, or aircraft and military hardware manufacturers. They perform duties similar to military radar and sonar equipment repairers. They may also be called communications technicians.

Physical Requirements
Specialties involving flying require passing a special physical exam. Normal color vision is required to work with color-coded wiring.

Ship Electricians

Navy

Coast Guard

Electrical systems supply power to operate ships and submarines. Lights, radar, weapons, laundry and cooking appliances, and machinery all need electricity. Ship electricians operate and repair electrical systems on ships. They keep electrical power plants, wiring, and machinery in working order.

What They Do
Ship electricians in the military perform some or all of the following duties:

Install wiring for lights and equipment

Troubleshoot electrical wiring and equipment using test meters

Inspect and maintain devices that distribute electricity throughout ships, such as circuits, transformers, and regulators

Monitor and maintain electrical devices connected to the ship's main engines or nuclear reactors

Repair motors and appliances

Where They Work
Ship electricians usually work indoors, aboard ships or submarines. They also work in ship repair shops on land.

Opportunities in Civilian Life
Civilian ship electricians work for shipbuilding and dry-dock firms and shipping lines. They perform duties similar to military ship electricians. Other civilian electricians, such as building electricians and electrical products repairers, also perform similar work. Civilian nuclear power plant electricians perform duties similar to ship electricians who work with nuclear plants on ships and submarines.

Weapons Maintenance Technicians

Army

Navy

Air Force

Marine Corps

Coast Guard

Combat forces use many different types of weapons from small field artillery to large ballistic missiles. Weapons may be fired from ships, planes, and ground stations. Most modern weapons have electronic components and systems that assist in locating targets, aiming weapons, and firing them. Weapons maintenance technicians maintain and repair weapons used by combat forces.

What They Do
Weapons maintenance technicians in the military perform some or all of the following duties:

Repair and maintain artillery, naval gun systems, and infantry weapons

Clean and lubricate gyroscopes, sights, and other electro-optical fire control components

Repair and maintain missile mounts, platforms, and launch mechanisms

Test and adjust weapons firing, guidance, and launch systems

Where They Work
Weapons maintenance technicians work in workshops when testing and repairing electronic components. They may work outdoors while inspecting and repairing combat vehicles, ships, artillery, aircraft, and missile silos.

Opportunities in Civilian Life
Civilian weapons maintenance technicians work for firms that design, build, and test weapons systems for the military. They perform duties similar to military weapons maintenance technicians. They may also be called electronic mechanics, avionics technicians, or missile facilities repairers.

Physical Requirements
Some specialties involve moderate to heavy lifting. Normal color vision is required to read color-coded charts and diagrams.

CONSTRUCTION OCCUPATIONS

Building Electricians

Army
Navy
Air Force
Marine Corps
Coast Guard

The military uses electricity to do many jobs, including lighting hospitals, running power tools, and operating computers. Building electricians install and repair electrical wiring systems in offices, repair shops, airplane hangars, and other buildings on military bases.

What They Do
Building electricians in the military perform some or all of the following duties:

Install and wire transformers, junction boxes, and circuit breakers, using wire cutters, insulation strippers, and other hand tools

Read blueprints, wiring plans, and repair orders to determine wiring layouts or repair needs

Cut, bend, and string wires and conduits (pipe or tubing)

Inspect power distribution systems, shorts in wires, and faulty equipment using test meters

Repair and replace faulty wiring and lighting fixtures

Install lightning rods to protect electrical systems

Where They Work

Building electricians usually work indoors while installing wiring systems. They work outdoors while installing transformers and lightning rods.

Opportunities in Civilian Life

Civilian building electricians usually work for building and electrical contracting firms. Some work as self-employed electrical contractors. They perform duties similar to military building electricians.

Physical Requirements

Normal color vision is required for working with color-coded wiring and circuits.

Construction Equipment Operators

Army

Navy

Air Force

Marine Corps

Coast Guard

Each year the military completes hundreds of construction projects. Tons of earth and building materials must be moved to build airfields, roads, dams, and buildings. Construction equipment operators use bulldozers, cranes, graders, and other heavy equipment in military construction.

What They Do

Construction equipment operators in the military perform some or all of the following duties:

Drive bulldozers, road-graders, and other heavy equipment to cut and level earth for runways and roadbeds

Lift and move steel and other heavy building materials using winches, cranes, and hoists

Dig holes and trenches using power shovels

Remove ice and snow from runways, roads, and other areas using scrapers and snow blowers

Operate mixing plants to make concrete and asphalt

Spread asphalt and concrete with paving machines

Drill wells using drilling rigs

Place and detonate explosives

Where They Work

Construction equipment operators work outdoors in all kinds of weather conditions. They often sit for long periods and are subject to loud noise and vibrations. They may work indoors while repairing equipment.

Opportunities in Civilian Life

Civilian construction equipment operators work for building contractors, state highway agencies, rock quarries, well drillers, and construction firms. Civilian construction equipment operators may also be known as operating engineers, heavy equipment operators, well drillers, or riggers.

Physical Requirements

Some specialties require normal hearing, color vision, and heavy lifting.

Construction Specialists

Army

Navy

Air Force

Marine Corps

Coast Guard

The military builds many temporary and permanent structures each year. Lumber, plywood, plasterboard, and concrete and masonry (bricks, stone, and concrete blocks) are the basic building materials for many of these projects. Construction specialists build and repair buildings, bridges, foundations, dams, and bunkers. They work with engineers and other building specialists as part of military construction teams.

What They Do

Construction specialists in the military perform some or all of the following duties:

Build foundations, floor slabs, and walls with brick, cement block, mortar, or stone

Erect wood framing for buildings using hand and power tools, such as hammers, saws, levels, and drills

Lay roofing materials, such as asphalt, tile, and wooden shingles

Install plasterboard, plaster, and paneling to form interior walls and ceilings

Lay wood and ceramic tile floors and build steps, staircases, and porches

Build temporary shelters for storing supplies and equipment while on training maneuvers

Where They Work

Construction specialists work indoors and outdoors on construction sites.

Opportunities in Civilian Life

Civilian construction specialists usually work for construction or remodeling contractors, government agencies, utility companies, or manufacturing firms. They perform duties similar to military construction specialists. They may also be called bricklayers, stonemasons, cement masons, cement finishers, carpenters, or cabinetmakers.

Physical Requirements

Construction specialists may have to lift and carry heavy building materials, such as lumber, plasterboard, and concrete. Sometimes, they climb and work from ladders and scaffolding.

Plumbers And Pipe Fitters

Army

Navy

Marine Corps

Coast Guard

Military buildings and equipment require pipe systems for water, steam, gas, and waste. Pipe systems are also needed on aircraft, missiles, and ships for hydraulic (fluid pressure) and pneumatic (air pressure) systems. Plumbers and pipe fitters install and repair plumbing and pipe systems.

What They Do

Plumbers and pipe fitters in the military perform some or all of the following duties:

Plan layouts of pipe systems using blueprints and drawings

Bend, cut, and thread pipes made of lead, copper, and plastic

Install connectors, fittings, and joints

Solder or braze pipe and tubing to join them

Install sinks, toilets, and other plumbing fixtures

Troubleshoot, test, and calibrate hydraulic and pneumatic systems

Keep accurate records of tasks completed and materials used

Where They Work

Plumbers and pipe fitters work both indoors and outdoors on land and aboard ships.

Opportunities in Civilian Life

Civilian plumbers and pipe fitters usually work for mechanical or plumbing contractors or as self-employed contractors. Some plumbers and pipe fitters work for public utilities. Civilian plumbers and pipe fitters perform duties similar to those performed in the military.

Physical Requirements
Plumbers and pipe fitters have to lift and carry heavy pipes and tubes.

MACHINE OPERATOR AND PRECISION WORK OCCUPATIONS

Compressed Gas Technicians

Navy

Marine Corps

Compressed gases have many uses in the military, such as breathing oxygen for jet pilots, divers, and medical patients and fuel for missiles and welding torches. Compressed gas technicians operate and maintain the machinery used to compress or liquefy gases.

What They Do
Compressed gas technicians in the military perform some or all of the following duties:

Operate valves to control the flow of air through machinery that compresses or liquefies gases

Remove impurities, such as carbon dioxide, from gases

Fill storage cylinders with compressed gas

Test cylinders for leaks, using pressure gauges

Operate dry ice plants

Maintain compressed gas machinery

Where They Work
Compressed gas technicians in the military normally work indoors in shops on bases or aboard ships. Working with air compressors may be noisy and hot.

Opportunities in Civilian Life
Civilian compressed gas technicians work for a wide range of industrial companies and processing plants, especially distilling and chemical firms. They perform duties similar to military compressed gas technicians. They may also be called oxygen plant operators, compressed gas plant workers, or acetylene plant operators.

Physical Requirements
Normal color vision is usually required to enter this occupation.

Dental And Optical Laboratory Technicians

Army

Navy

Air Force

Coast Guard

The military provides dental and optical care as part of its comprehensive health service program. Dental and optical laboratory technicians make and repair dental devices and eyeglasses that are provided for military personnel.

What They Do
Dental and optical laboratory technicians perform some or all of the following duties:

Make dentures, braces, and other dental or optical devices

Construct, assemble, repair, and align dental and optical devices (metal braces and retainers, eyeglass frames and lenses)

Harden and cure new dentures or lenses using high temperature ovens or other heat-treating equipment

Grind, polish, and smooth dentures or lenses using hand or power tools

Where They Work
Dental and optical laboratory technicians normally work in dental or optical laboratories and occasionally in examination and dispensing offices.

Opportunities in Civilian Life
Civilian dental laboratory technicians normally work for small dental laboratories or large dental offices. Optical laboratory technicians work in optical laboratories or for retail opticians. They perform duties similar to military technicians. Civilian optical laboratory technicians may also be called opticians or ophthalmic laboratory technicians.

Physical Requirements
Normal color vision for some specialties is required to match color of artificial teeth with natural tooth color.

Machinists

Army

Navy

Air Force

Marine Corps

Coast Guard

Sometimes when engines or machines break down, the parts needed to repair them are not available. In these cases, the broken parts must be repaired or new ones made. Machinists make and repair metal parts for engines and all types of machines. They operate lathes, drill presses, grinders, and other machine shop equipment.

What They Do
Machinists in the military perform some or all of the following duties:

- Study blueprints or written plans of the parts to be made
- Set up and operate lathes to make parts such as shafts and gears
- Cut metal stock using power hacksaws and bandsaws
- Bore holes using drill presses
- Shape and smooth parts using grinders
- Measure work, using micrometers, calipers, and depth gauges

Where They Work
Machinists work in machine shops, which are often noisy.

Opportunities in Civilian Life
Civilian machinists work for factories and repair shops in many industries, including the electrical product, automotive, and heavy machinery industries. They perform duties similar to military machinists.

Power Plant Operators

Army

Navy

Marine Corps

Coast Guard

Power plants generate electricity for ships, submarines, and military bases. The military uses many different types of power plants. Some are fueled by oil, others run on coal. Many ships and submarines have nuclear power plants. Power plant operators control power generating plants on land and aboard ships and submarines. They operate boilers, turbines, nuclear reactors, and portable generators.

What They Do
Power plant operators in the military perform some or all of the following duties:

- Monitor and operate control boards to regulate power plants
- Operate and maintain diesel generating units to produce electric power
- Monitor and control nuclear reactors that produce electricity and power ships and submarines
- Operate and maintain stationary engines, such as steam engines, air compressors, and generators

Operate and maintain auxiliary equipment, such as pumps, fans, and condensers

Inspect equipment for malfunctions

Operate the steam turbines that generate power for ships

Operate and maintain auxiliary equipment, including pumps, fans, condensers, and auxiliary boilers

Where They Work

Power plant operators usually work indoors. They are subject to high temperatures, dust, and noise.

Opportunities in Civilian Life

Civilian power plant operators work for power companies, factories, schools, and hospitals. They perform duties similar to military power plant operators. Depending on the specialty, power plant operators may also be called boiler operators, stationary engineers, nuclear reactor operators, or diesel plant operators.

Physical Requirements

Power plant operators lift heavy parts or tools when maintaining power plants. They may also have to stoop and kneel and work in awkward positions while repairing.

Printing Specialists

Army
Navy
Air Force
Marine Corps

The military produces many printed publications each year, including newspapers, booklets, training manuals, maps, and charts. Printing specialists operate printing presses and binding machines to make finished copies of printed material.

What They Do

Printing specialists in the military perform some or all of the following duties:

Reproduce printed matter using offset lithographic printing processes

Prepare photographic negatives and transfer them to printing plates using copy cameras and enlargers

Prepare layouts of artwork, photographs, and text for lithographic plates

Produce brochures, newspapers, maps, and charts

Bind printed material into hardback or paperback books using binding machines

Maintain printing presses

Where They Work

Printing specialists work indoors in print shops and offices located on land or aboard ships.

Opportunities in Civilian Life

Civilian printing specialists work for commercial print shops, newspapers, insurance companies, government offices, or businesses that do their own printing. They perform duties similar to military printing specialists. They may be called offset printing press operators, lithograph press operators, offset duplicating machine operators, lithograph photographers, or bindery workers.

Survival Equipment Specialists

Army
Navy
Air Force
Marine Corps
Coast Guard

Military personnel often have hazardous assignments. They depend on survival equipment (parachutes, rescue equipment) to protect their lives in case of emergencies. Survival equipment specialists inspect, maintain, and repair survival equipment such as parachutes, aircraft life support equipment, and air-sea rescue equipment.

What They Do

Survival equipment specialists in the military perform some or all of the following duties:

- Inspect parachutes for rips and tangled lines
- Pack parachutes for safe operation
- Repair life rafts and load them with emergency provisions
- Test emergency oxygen regulators on aircraft
- Stock aircraft with fire extinguishers, flares, and survival provisions
- Train crews in the use of survival equipment
- Repair tents, tarps, and other canvas equipment

Where They Work

Survival equipment specialists in the military work in repair shops on land or aboard ships.

Opportunities in Civilian Life

Civilian survival equipment specialists work for commercial airlines, parachute rigging and supply companies, survival equipment manufacturing firms, and some government agencies. They perform duties similar to military survival equipment specialists. Those that specialize in parachutes are called parachute riggers.

Physical Requirements

Normal color vision is required to work with color-coded wiring and repair charts.

Water And Sewage Treatment Plant Operators

Army
Navy
Air Force
Marine Corps
Coast Guard

Military bases operate their own water treatment plants when public facilities cannot be used. These plants provide drinking water and safely dispose of sewage. Water and sewage treatment plant operators maintain the systems that purify water and treat sewage.

What They Do

Water and sewage treatment plant operators in the military perform some or all of the following duties:

- Operate pumps to transfer water from reservoirs and storage tanks to treatment plants
- Add chemicals and operate machinery that purifies water for drinking or cleans it for safe disposal
- Test water for chlorine content, acidity, oxygen demand, and impurities
- Regulate the flow of drinking water to meet demand
- Clean and maintain water treatment machinery
- Keep records of chemical treatments, water pressure, and maintenance

Where They Work

Water and sewage treatment plant operators work indoors and outdoors. They may be exposed to strong odors.

Opportunities in Civilian Life

Civilian water and sewage treatment plant operators work for municipal public works and industrial plants. Their work is similar to military water and sewage treatment plant operators. Civilian plant operators usually specialize as water treatment plant operators, waterworks pump station operators, or wastewater treatment plant operators.

Physical Requirements
Normal color vision is needed to examine water for acidity and impurities.

Welders And Metal Workers

Army

Navy

Air Force

Marine Corps

Coast Guard

Sheet metal is used as a building material in many military construction projects. Ships, tanks, and aircraft are made of heavy metal armor. Welders and metal workers make and install sheet metal products, such as roofs, air ducts, gutters, and vents. They also make custom parts to repair the structural parts of ships, submarines, landing craft, buildings, and equipment.

What They Do
Welders and metal workers in the military perform some or all of the following duties:

- Weld, braze, or solder metal parts together
- Repair automotive and ship parts using welding equipment
- Measure work with calipers, micrometers, and rulers

Where They Work
Welders and metal workers work indoors in metalworking shops and aircraft hangars. They also work outdoors at construction sites, on ships, and in the field.

Opportunities in Civilian Life
Civilian welders and metal workers may work for metal repair shops, auto repair shops, construction companies, pipeline companies, aircraft manufacturing plants, shipyards, and marine servicing companies. They perform duties similar to military welders and metal workers.

Physical Requirements
Welders and metal workers may have to lift heavy metal parts and work in crouching or kneeling positions. Good color vision is required for locating and marking reference points, setting and adjusting welding equipment, and matching paints.

TRANSPORTATION AND MATERIAL HANDLING OCCUPATIONS

Air Crew Members

Army

Navy

Air Force

Marine Corps

Coast Guard

The military uses aircraft of all types and sizes to conduct combat and intelligence missions, rescue personnel, transport troops and equipment, and perform long-range bombing missions. Air crew members operate equipment on board aircraft during operations. They normally specialize by type of aircraft, such as bomber, intelligence, transport, or search and rescue.

What They Do
Air crew members in the military perform some or all of the following duties:

- Operate aircraft communication and radar equipment
- Operate and maintain aircraft defensive gunnery systems
- Operate helicopter hoists to lift equipment and personnel from land and sea

Operate and maintain aircraft in-flight refueling systems

Where They Work
Air crew members work inside all sizes and types of aircraft based on land or aboard ships. They fly in all types of weather and in both hot and cold climates.

Opportunities in Civilian Life
There are no direct civilian equivalents to military air crew members. However, some of the skills gained in the military could be useful in civilian government and private agencies that provide emergency medical services. Also, weight and load computation skills are useful for civilian air transport operations.

Physical Requirements
Air crew members must be in excellent physical condition and pass a special physical exam in order to qualify for flight duty. They must be mentally sound and have normal hearing.

Aircraft Launch And Recovery Specialists

Navy

Marine Corps

Coast Guard

The military operates thousands of aircraft that take off and land on aircraft carriers all over the world. The successful launch and recovery of aircraft is important to the completion of air missions and the safety of flight crews. Aircraft launch and recovery specialists operate and maintain catapults, arresting gear, and other equipment used in aircraft carrier takeoff and landing operations.

What They Do
Aircraft launch and recovery specialists in the military perform some or all of the following duties:

Operate consoles to control launch and recovery equipment, including catapults and arresting gear

Operate elevators to transfer aircraft between flight and storage decks

Install and maintain visual landing aids

Test and adjust launch and recovery equipment using electric and mechanical test equipment and hand tools

Install airfield crash barriers and barricades

Direct aircraft launch and recovery operations using hand or light signals

Maintain logs of airplane launches, recoveries, and equipment maintenance

Where They Work
Aircraft launch and recovery specialists work outdoors aboard ships while operating and maintaining launch and recovery equipment or holding visual landing aids for incoming aircraft. They are exposed to noise and fumes from jet and helicopter engines.

Opportunities in Civilian Life
There are no direct opportunities in civilian life for military aircraft launch and recovery specialists. However, many of the skills learned are relevant to jobs performed by ground crews at civilian airports.

Physical Requirements
Normal color vision is required to work with color-coded parts and the wiring of launch and recovery equipment.

Cargo Specialists

Army

Navy

Air Force

Coast Guard

The military delivers supplies, weapons, equipment, and mail to United States forces in many parts of the world. Military cargo travels by ship, truck, or airplane. It must be handled carefully to ensure safe arrival at the correct destination. Cargo specialists load and unload military supplies and material using equipment such as forklifts and cranes. They also plan and organize loading schedules.

What They Do

Cargo specialists in the military perform some or all of the following duties:

- Load supplies into trucks, transport planes, and railroad cars using forklifts
- Load equipment such as jeeps, trucks, and weapons aboard ships, using dockyard cranes
- Pack and crate boxes of supplies for shipping
- Inspect cargo for damage
- Plan and inspect loads for balance and safety
- Check cargo against invoices to make sure the amount and destination of material are correct

Where They Work

Cargo specialists work outdoors on loading docks and indoors in warehouses.

Opportunities in Civilian Life

Civilian cargo specialists work for trucking firms, air cargo companies, and shipping lines. They perform duties similar to military cargo specialists. Depending on specialty, they may also be called industrial truck operators, stevedores, longshoremen, material handlers, or cargo checkers.

Physical Requirements

Cargo specialists must lift and carry heavy cargo.

Flight Engineers

Navy
Air Force
Marine Corps
Coast Guard

The military operates thousands of airplanes and helicopters. Pilots and air crew members rely upon trained personnel to keep aircraft ready to fly. Flight engineers inspect airplanes and helicopters before, during, and after flights to ensure safe and efficient operations. They also serve as crew members aboard military aircraft.

What They Do

Flight engineers in the military perform some or all of the following duties:

- Inspect aircraft before and after flights, following pre- and post-flight checklists
- Plan and monitor the loading of passengers, cargo, and fuel
- Assist pilots in engine start-up and shut-down
- Compute aircraft load weights and fuel distribution
- Compute fuel consumption using airspeed data, charts, and calculators
- Monitor engine instruments and adjust engine controls following pilot orders
- Check fuel, pressure, electrical, and other aircraft systems during flight
- Inform pilot of aircraft performance problems and recommend corrective action

Opportunities in Civilian Life

Civilian flight engineers work for passenger and cargo airline companies. They perform the same duties as in the military.

Physical Requirements
Flight engineers, like pilots and navigators, have to be mentally alert and physically sound to perform their job. They must be in top physical shape and pass a special physical exam to qualify for flight duty.

Petroleum Supply Specialists

Army

Navy

Air Force

Marine Corps

Coast Guard

Ships, airplanes, trucks, tanks, and other military vehicles require large amounts of fuel and lubricants. These and other petroleum products require special storage and handling. Petroleum supply specialists store and ship petroleum products, such as oil, fuel, compressed gas, and lubricants.

What They Do
Petroleum supply specialists in the military perform some or all of the following duties:

- Connect hoses and valves and operate pumps to load petroleum products into tanker trucks, airplanes, ships, and railroad cars
- Test oils and fuels for pollutants
- Repair pipeline systems, hoses, valves, and pumps
- Check the volume and temperature of petroleum and gases in tankers, barges, and storage tanks
- Prepare storage and shipping records
- Store and move packaged petroleum products using forklifts

Where They Work
Petroleum supply specialists work outdoors in all types of weather while filling storage tanks and refueling airplanes, ships, and tankers.

Opportunities in Civilian Life
Civilian petroleum supply specialists work for oil refineries, pipeline companies, and tanker truck and ship lines. They may also refuel airplanes at large airports. They perform many of the same duties as military petroleum supply specialists.

Physical Requirements
Petroleum supply specialists may have to perform moderate to heavy lifting.

Quartermasters And Boat Operators

Army

Navy

Marine Corps

Coast Guard

The military operates many small boats for amphibious troop landings, harbor patrols, and transportation over short distances. Quartermasters and boat operators navigate and pilot many types of small watercraft, including tugboats, PT boats, gunboats, and barges.

What They Do
Quartermasters and boat operators in the military perform some or all of the following duties:

- Direct the course and speed of boats
- Consult maps, charts, weather reports, and navigation equipment
- Pilot tugboats when towing and docking barges and large ships
- Operate amphibious craft during troop landings
- Maintain boats and deck equipment
- Operate ship-to-shore radios
- Keep ship logs

Where They Work
Quartermasters and boat operators work aboard all types of boats and in all types of weather conditions. When not piloting boats, they may work on or below deck repairing boats and equipment or overseeing cargo storage. When ashore, they may work in offices that make nautical maps or in harbor management offices. Some boats are operated in combat situations.

Opportunities in Civilian Life
Civilian quartermasters and boat operators may work for shipping and cruise lines, piloting tugboats, ferries, and other small vessels. They perform duties similar to military quartermasters and boat operators. Depending upon specialty, they may also be called tugboat captains, motorboat operators, navigators, or pilots.

Physical Requirements
Quartermasters and boat operators may have to stand for several hours at a time. They must be able to speak clearly. Some specialties require normal depth perception and hearing.

Seamen

Army

Navy

Air Force

Coast Guard

All ships must have teams of individuals with "jack-of-all-trades" skills who make things run smoothly above deck. Seamen perform many duties to help operate and maintain military ships, boats, and submarines.

What They Do
Seamen in the military perform some or all of the following duties:

Operate hoists, cranes, and winches to load cargo or set gangplanks

Operate and maintain on-deck equipment and ship rigging

Supervise firefighting and damage control exercises

Handle lines to secure vessels to wharves or other ships

Stand watch for security, navigation, or communications

Supervise crews painting and maintaining decks and sides of ships

Physical Requirements
Seamen may have to climb ships' rigging and perform work at heights. Their work often involves moderate to heavy lifting.

Where They Work
Seamen and deckhands work aboard all types of ships and submarines. On ships, they often work outdoors on deck while servicing shipboard equipment.

Opportunities in Civilian Life
Civilian seamen work primarily for shipping companies, sometimes called the Merchant Marine. They also work for cruise ship lines. They perform many duties similar to military seamen. They are called able seamen, deckhands, or boatswains.

Vehicle Drivers

Army

Navy

Marine Corps

Coast Guard

The military uses numerous vehicles to transport its troops, equipment, and supplies. Together, the services own and operate about 50,000 heavy trucks and buses. Vehicle drivers operate all types of heavy military vehicles. They drive fuel or water tank trucks, semi-tractor trailers, heavy troop transports, and passenger buses.

What They Do
Vehicle drivers in the military perform some or all of the following duties:

Read travel instructions to determine travel routes, arrival dates, and types of cargo

Make sure vehicles are loaded properly

Check oil, fuel and other fluid levels, and tire pressure

Drive vehicles over all types of roads, traveling alone or in convoys

Keep records of mileage driven and fuel and oil used

Wash vehicles and perform routine maintenance and repairs

Opportunities in Civilian Life

Civilian vehicle drivers work for trucking companies, moving companies, bus companies, and businesses with their own delivery fleets. They perform duties similar to military vehicle drivers. They may specialize as tractor-trailer truck drivers, tank truck drivers, heavy truck drivers, or bus drivers.

Physical Requirements

Normal color vision is required to read road maps.

COMBAT SPECIALTY OCCUPATIONS

Artillery Crew Members

Army

Navy

Marine Corps

Coast Guard

Artillery includes weapons that fire large shells or missiles. The military uses artillery to support infantry and tank units in combat. Artillery is also used to protect land and sea forces from air attack. Artillery crew members position, direct, and fire artillery guns, cannons, howitzers, missiles, and rockets to destroy enemy positions and aircraft. They normally specialize by type of artillery.

What They Do

Artillery crew members in the military perform some or all of the following duties:

Determine target location using computers or manual calculations

Set up and load artillery weapons

Prepare ammunition, fuses, and powder for firing

Fire artillery weapons according to instructions from artillery officers

Clean and maintain artillery weapons

Drive trucks and self-propelled artillery

Where They Work

Artillery crew members work outdoors when on land maneuvers. Some work in sheltered fire control stations. At sea, they mainly work below deck.

Opportunities in Civilian Life

Although the job of artillery crew member has no equivalent in civilian life, the close teamwork, discipline, and leadership experiences it provides are helpful in many civilian jobs.

Physical Requirements

Artillery crew members must have physical stamina to perform strenuous activities for long periods without rest. They are also required to have normal color vision to identify color-coded ammunition and to read maps and charts.

Combat Engineers

Army

Navy

Marine Corps

Combat situations often require rapid travel across difficult terrain and swift flowing rivers. A combination of combat ability and building skill is necessary to do field construction for fighting forces.

What They Do

Combat engineers perform some or all of the following duties:

Construct trails, roads, and field fortifications, such as shelters, bunkers, and gun emplacements

Erect floating or prefabricated bridges

Lay and clear mine fields and booby traps

Place and detonate explosives, as needed

Erect camouflage and other protective barriers for artillery and troop positions

Load, unload, and move supplies and equipment, using planes, helicopters, trucks, and amphibious vehicles

Construct airfields and perform ground traffic control duties

Participate in combat operations as infantrymen

Where They Work

Because combat engineers must be prepared to support operations anywhere in the world, they work and train for long hours under all kinds of weather conditions and in all climates. Combat engineers work, eat, and sleep outdoors during training exercises and in real combat situations. Most of the time, combat engineers are assigned to military bases.

Opportunities in Civilian Life

Although the job of combat engineer has no direct equivalent in civilian life, experience as a combat engineer is related to occupations in several civilian fields. These include the logging, mining, construction, shipping, and landscaping industries. Civilians in these jobs are called forestry aides, loggers, blasters, and construction workers.

Physical Requirements

Combat engineers must meet very demanding physical requirements. They need agility and balance and must be able to perform strenuous physical activities over long periods of time. Combat engineers lift and move heavy objects. Some specialties require good swimming abilities.

Infantrymen

Army

Marine Corps

The infantry is the main land combat force of the military. In peacetime, the infantry's role is to stay ready to defend our country. In combat, the role of the infantry is to capture or destroy enemy ground forces and repel enemy attacks. Infantrymen operate weapons and equipment to engage and destroy enemy ground forces.

What They Do

Infantrymen perform some or all of the following duties:

Operate, clean, and store automatic weapons, such as rifles and machine guns

Parachute from troop transport airplanes while carrying weapons and supplies

Fire armor-piercing missiles from hand-held antitank missile launchers

Carry out scouting missions to spot enemy troop movements and gun locations

Operate two-way radios and signal equipment to relay battle orders

Drive vehicles mounted with machine guns or small missiles

Perform hand-to-hand combat drills that involve martial arts tactics

Set firing angles and fire mortar shells at targets

Dig foxholes, trenches, and bunkers for protection against attacks

Physical Requirements

The infantry has very demanding physical requirements. Infantrymen must perform strenuous physical activities, such as marching while carrying equipment, digging foxholes, and climbing over obstacles. Infantrymen need good hearing and clear speech to use two-way radios, and good night vision and depth perception to see targets and signals.

Where They Work

Because infantrymen must be prepared to go anywhere in the world they are needed, they work and train in all climates and weather conditions. During training exercises, as in real combat, infantrymen work, eat, and sleep outdoors. Most of the time, however, infantrymen work on military bases.

Opportunities in Civilian Life

Although the job of infantrymen has no equivalent in civilian life, the close teamwork, discipline, and leadership experiences it provides are helpful in many civilian jobs.

Special Operations Forces

Army
Navy
Air Force
Marine Corps

When the military has difficult and dangerous missions to perform, they call upon special operations teams. These elite combat forces stay in a constant state of readiness to strike anywhere in the world on a moment's notice. Special operations forces team members conduct offensive raids, demolitions, intelligence, search and rescue, and other missions from aboard aircraft, helicopters, ships, or submarines. Due to the wide variety of missions, special operations forces team members are trained swimmers, parachutists, and survival experts, in addition to being combat trained.

What They Do

Special operations forces team members in the military perform some or all of the following duties:

Go behind enemy lines to recruit, train, and equip friendly forces for guerrilla raids

Carry out demolition raids against enemy military targets, such as bridges, railroads, and fuel depots

Clear mine fields, both underwater and on land

Conduct missions to gather intelligence information on enemy military forces

Conduct offensive raids or invasions of enemy territories

Destroy enemy ships in coastal areas, using underwater explosives

Where They Work

Because special operations forces team members must be prepared to go anywhere in the world they are needed, they train and work in all climates, weather conditions, and settings. They may dive from submarines or small underwater craft. Special forces team members may also be exposed to harsh temperatures, often without protection, during missions in enemy-controlled areas. Most of the time, however, they work and train on military bases or ships and submarines.

Opportunities in Civilian Life

Although the job of special operations forces team members has no equivalent in civilian life, training in explosives, bomb disposal, scuba diving, and swimming may be helpful in such civilian jobs as blaster, police bomb disposal specialist, diver, or swimming instructor. The discipline and dependability of special operations forces are assets in many civilian occupations.

Physical Requirements

The special operations forces have very demanding physical requirements. Good eyesight, night vision, and physical conditioning are required to reach mission objectives by parachute, overland, or underwater. Also required is excellent hand-eye coordination to detonate or deactivate explosives. In most instances, special operations forces team members are required to be qualified divers, parachutists, and endurance runners.

Tank Crew Members

Army

Marine Corps

In peacetime, the role of tank and armor units is to stay ready to defend our country anywhere in the world. In combat, their role is to operate tanks and amphibious assault vehicles to engage and destroy the enemy. Tanks also conduct scouting missions and support infantry units during combat. Tank crew members work as a team to operate armored equipment and fire weapons to destroy enemy positions. Tank crew members normally specialize by type of armor, such as tanks or amphibious assault vehicles.

What They Do

Tank crew members in the military perform some or all of the following duties:

Drive tanks or amphibious assault vehicles in combat formations over roadways, rough terrain, and in heavy surf

Operate target sighting equipment to aim guns

Load and fire guns

Operate two-way radios and signaling equipment to receive and relay battle orders

Gather and report information about the terrain, enemy strength, and target location

Perform preventive maintenance on tanks, guns, and equipment

Read maps, compasses, and battle plans

Where They Work

Tank crew members, like other combat troops, work in all climates and weather conditions. During training exercises, as in real combat conditions, tank crew members work, eat, and sleep outdoors and in tanks.

Opportunities in Civilian Life

Although the job of tank crew member has no equivalent in civilian life, the close teamwork, discipline, and leadership experiences it provides are helpful in many civilian jobs.

Physical Requirements

Tank crew members must be in good physical condition and have exceptional stamina. They must be able to work inside the confined area of a tank for long periods of time. Good vision and normal color vision are required in order to read maps, drive vehicles around obstacles, and locate targets.

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