Newton's Laws

OBJECTIVES

Students should be able to:

1. Describe Aristotle's Horse Cart theory and what was wrong with it.
2. Describe Galileo's experiment that lead to his conclusions about inertia
   (a) Describe how this experiment is exemplified in modern day amusement parks

3. Define in a sentence Galileo's Law of Inertia (Alias-Newton's first Law of Motion)

4. Describe what effects an object's inertia.

5. Characterize rotational inertia
   (a) Describe the relationship between an objects rate of spin and the object's distribution of it's mass.

6. Give examples of how inertia is demonstrated in everyday life (TOYS)

7. Write in words Newton's Second Law of Motion.
   (a) Describe a force
   (b) Give the SI and English unit of force.
   (c) Give the symbols for force in SI and English systems.
8. Describe the relationship between force and acceleration.

9. Describe the relationship between force and mass.

10. Do problems that make proportionality predictions based on Newtons Second Law of Motion. (F=ma)
11. Describe the formula for calculating weight from mass. (w=mg)
    (a) Describe what is means to experience a certain number of "g's."
    (b) Convert back and forth between g's and m/s2.

12. Write in a complete sentence Newton's Third Law of Motion.

13. Apply Newton's Third Law of Motion to Problems.

14. Be able to identify the "reaction force" in a given situation.

15. Distinguish between the concepts of mass and weight.

16. Memorize the value for the acceleration of any object near the surface of the Earth.
    (a) Describe what it means to be weightless.
17. Utilize Newton's Laws in conjunction with the Kinematics equations from chapter 1 to solve problems

Newton's Laws Worksheets

Show all work on a separate sheet of paper.

PROBLEMS

1. A little boy pushes a wagon with his dog in it. The mass of the dog and wagon together is 45 kg. The wagon accelerates at 0.85 m/s^2. What force is the boy pulling with?
2. A 1650 kg car accelerates at a rate of 4.0 m/s^2. How much force is the car's engine producing?
3. A 68 kg runner exerts a force of 59 N. What is the acceleration of the runner?
4. A crate is dragged across an ice covered lake. The box accelerates at 0.08 m/s^2 and is pulled by a 47 N force. What is the mass of the box?
5. 3 women push a stalled car. Each woman pushes with a 425 N force. What is the mass of the car if the car accelerates at 0.85 m/s^2?
6. A tennis ball, 0.314 kg, is accelerated at a rate of 164 m/s2 when hit by a professional tennis player. What force does the player's tennis racket exert on the ball?
7. In an airplane crash a woman is holding an 8.18 kg, 18 pound, baby. In the crash the woman experiences a horizontal de-acceleration of 88.2 m/s^2. How many g's is this de-acceleration? How much force must the woman exert to hold the baby in place?
8. When an F-14 airplane takes-off an aircraft carrier it is literally catapulted off the flight deck. The plane's final speed at take-off is 68.2 m/s. The F-14 starts from rest. The plane accelerates in 2 seconds and has a mass of 29,545 kg. What is the total force that gets the F-14 in the air?
9. A sports car accelerates from 0 to 60 mph, 27 m/s, in 6.3 seconds. The car exerts a force of 4106 N. What is the mass of the car?
10. A sled is pushed along an ice covered lake. It has some initial velocity before coming to a rest in 15 m. It took 23 seconds before the sled and rider come to a rest. If the rider and sled have a combined mass of 52.5 kg, what is the magnitude and direction of the stopping force? What do "we" call the stopping force?
11. A car is pulled with a force of 10,000 N. The car's mass is 1267 kg. But, the car covers 394.6 m in 15 seconds.
    (a) What is expected acceleration of the car from the 10,000 N force?
    (b) What is the actual acceleration of the car from the observed data of x and t?
    (c) What is the difference in accelerations?
    (d) What force caused this difference in acceleration?
    (e) What is the magnitude and direction of the force that caused the difference in acceleration?
12. **12.** A little car has a maximum acceleration of 2.57 m/s2. What is the new maximum acceleration of the little car if it tows another car that has the same mass?
13. 13. A boy can accelerate at 1.00 m/s2 over a short distance. If the boy were to take an energy pill and suddenly have the ability to accelerate at 5.6 m/s2, then how would his new energy-pill-force compare to his earlier force? If the boy's earlier force was 45 N, what is the size of his energy-pill-force?
14. 14. A cartoon plane with four engines can accelerate at 8.9 m/s2 when one engine is running. What is the acceleration of the plane if all four engines are running and each produces the same force?

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15. 15. While dragging a crate a workman exerts a force of 628 N. Later, the mass of the crate is increased by a factor of 3.8. If the workman exerts the same force, how does the new acceleration compare to the old acceleration?

16. 16. A rocket accelerates in a space at a rate of "1 g." The rocket exerts a force of 12,482 N. Later in flight the rocket exerts 46,458 N. What is the rockets new acceleration? What is the rocket's new acceleration in "g's?"

17. 17. A race car exerts 19,454 N while the car travels at a constant speed of 201 mph, 91.36 m/s. What is the mass of the car?

(<u>18-31 Weight and Mass</u>)

18. A locomotive's mass is 18181.81 kg. What is its weight?

19. A small car weighs 10168.25 N. What is its mass?

20. What is the weight of an infant whose mass is 1.76 kg?

21. An F-14's mass is 29,545 kg. What is its weight?

22. What is the mass of a runner whose weight is 648 N?

23. The surface gravity of the Sun is 274 m/s2. How many Earth g's is this?

24. The planet Mercury has 0.37 g's compared to the Earth. What is the acceleration on Mercury in m/s2?

25. A plane crashes with a de-acceleration of 185 m/s2. How many g's is this?

26. A baseball traveling 38 m/s is caught by the catcher. The catcher takes 0.1 seconds to stop the ball. What is the acceleration of the ball and how many g's is this?

27. A very fast car accelerates from a rest to 32 m/s, (71.68 mph), in 4.2 seconds. What is acceleration of the car and how many g's is this?

28. The Space Shuttle travels from launch to 529.2 m in 6.0 seconds. What is the acceleration of the shuttle and how many g's is this?

29. The space shuttle's mass, (with boosters) is 654,506 kg. The average force of the shuttle's engines is 25,656,635.2N. What is the acceleration of the shuttle in m/s2 and g's?

30. How can the answers to #11 and #12 <u>both</u> be correct?

31. What is the SI weight of a McDonald's Quarter Pounder sandwich?

Newton’s Laws Worksheets

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32. A little boy, mass = 40 kg, is riding in a wagon pulled by a his HUGE dog, Howard. What is the acceleration of the wagon if the dog pulls with a force of 30 N? (Assume the wagon rolls on a friction less surface).

33. The wagon and boy mentioned in the previous problem are let loose by Howard the dog. The wagon freely rolls until it hits a patch of ground that slows down the wagon until it comes to a rest. If it takes 10 seconds to come to a stop in 15 meters, what if the frictional force stopping the wagon?

34. A speed boat in the water experiences an acceleration of 0.524 m/s2. The boat's mass is 842 kg. What is the force that the boat's engine's are putting out?

35. A stalled car is pushed with a force of 342 N from rest. How far does the car travel in 12 seconds is it's mass is 989 kg?

36. How far does the car travel in the previous problem if the pushing force is doubled?

37. A little boy is pulling a wagon full of 10 bricks. The mass of the wagon is too small to be considered. If the boy later is pulling the wagon with the same force and the wagon has 45 bricks in it, then how does the acceleration of the 45 brick wagon compare to the acceleration of the 10 brick wagon?

38. A car accelerates with a given force. Later the same car accelerates with 1/6 it's original acceleration and it now has 1.4 times its earlier mass. (A) How does the car's later force compare with the its earlier force? (B) If its earlier force is 1523 N, then what is the car's later force?

39. What force does the car exert if its mass is 1201 kg and the car goes from 5.4 m/s to 16.3 m/s in 107 meters?

40. What are Newton's 3 Laws and which ones are used in shaking a Catsup bottle to get the Catsup out when it is "stuck" in the bottle.

41. An ice skater is spinning when she begins to draw in her arms. As she does this what happens to her rate of spin? Which law does this fall under?

42. A 1027 kg car is resting at a stop light. The car moves with a force of 1528 N for 22 s. Then the car travels at a constant velocity for 10 seconds. Finally, the car stops with a force of 4056 N. HOW MUCH DISTANCE IS TRAVELED BY THE CAR DURING THIS JOURNEY?

SOME ANSWERS

1) 38.25 N	2) 6600 N	3) 0.87 m/s2	4) 587.5 kg	5)1500 kg
6) 51.50 N	7) 9 g’s; 721.48 N	8) 1,007,484.5 N	9) 958.07 kg	10) 2.98 N
11a) 7.89 m/s2	11b) 2.62 m/s2	11c) 5.27 m/s2	11d) ???	11e) 6682.15 N
12) 1.285 N	13) 252 N	14) 35.6	15) New Accel = (0.26) Old Acceleration	
16) 3.72 g’s	17) ???	18) 178181.74 N	19) 1037.58 kg	20) 17.25 N
21) 289541 N	22) 66.12 kg	23) 27.96 g’s	24) 3.63 m/s2	25)18.88 g’s
26) 380 m/s2, 38.78 g’s	27) 134.4 m/s2, 13.71 g’s	28) 29.4 m/s , 3 g’s	29) 29.4 m/s , 3 g’s	30) ???
31) ???	32) 0.75 m/s2	33) 40 N (0.3 m/s2)	34) 441.21 N	35) 24.90 m, (0.34 m/s2)
36) 49.80 (twice as far)	37) accel of 45 brick wagon = (1/(4.5))[accel of the 10 brick wagon)			
38) new froce = 0.233(old force; 355.37 N		39) 1327.44 N, (1.1053 m/s2)		40) 1st
41) Spin faster (1st)	42) 360.05m + 327.32 + 135.64m = <u>823.02 m</u>			

Newton's Laws Worksheets

Show all work on a separate sheet of paper.

1 $m = 45$ kg, $a = 0.85$ m/s2, F = ?
F = ma, F = (45)(0.85) <u>F = 38.25 N</u>

2 m =1650 kg, a = 4.0 m/s2, f =?
F=ma, F = 1650 x 4.0 = <u>6600N</u>

3 m = 68 kg, F = 59 N, a =?
F = ma, 59 = 68a, <u>a = 0.87</u> m/s2

4 a = 0.08 m/s2, F =47 N, m = ?
F = ma, 47 = m(0.08), <u>m = 587.5 kg</u>

5 F = (3)425N = 1275 N, a = 0.85 m/s2, m =?
F=ma, 1275=m(0.85 m/s2), <u>m = 1500 kg</u>

6 m=0.314 kg, a = 164 m/s2, F = ?
F =ma, (0.314)(164), <u>51.50 N</u>

7 m = 8.18 kg, a = 88.2 m/s2,
g's?: 88.2/9.8 = 9 g's
F =?, F=ma, 8.18(88.3) = <u>722.29 N</u> = (162 lbs)

8 v = 68.2 m/s, vo = 0 (rest), t = 2 s, m = 29 545 kg
v=vo + at, 68.2 = 0 +a(2), a =34.1 m/s2,
F = ma, F = (29 545)34.1 =<u>1 007 484.5 N</u>

9 vo = 0, v = 27 m/s, t = 6.3 s, F = 4106 N, m=? :
v=vo + at, 27 = 0 +a(6.3), a =4.2857 m/s2,
F = ma, 4106 = (m)4.2857, <u>m= 958.07 kg</u>

10 vo = ?, v = 0, x = 15 m, t = 23 s, m =52.5 kg,

$$\frac{v+v_0}{2}=\frac{x}{t}\text{: } \frac{0+v_0}{2}=\frac{15}{23}\text{: } v_0 = 1.3043\ \frac{\text{m}}{\text{s}}$$

$$v^2 = (v_0)^2 + 2ax\text{: } 0^2 = (1.3043)^2 + 2a(15)\text{: } \text{a} = 0.0567\,\frac{\text{m}}{\text{s}^2}$$

F = ma, F = 52.5(0.0567) =<u> 2.95 N FRICTION</u>

11 SKIP

12 If it is towing a car like itself, then the cqar's engine is supplying the same force to double the mass. Therefore, (F=ma), the acceleration is half or <u>1.285</u> m/s2.

13 From F=ma: If the new acceleration is 5.6 times the old (5.6/ 1.00) then the force will also increase by <u>5.6</u>.

Newton's Laws Worksheets

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14 Now it is four times the force with the same mass means four times the acceleration, $4 \times 8.9 = \underline{35.6}$ m/s^2.

15 165N/3.8 = <u>165.26 N</u>

16 F_{new}/F_{old} = 46,458/12,482 = 3.72199968

a_{new}/a_{old} = 3.72199968
a_{new} = 3.72 g = <u>3.72 g's = 36.48</u> m/s^2.

17 SKIP

18 g = 9.80 m/s^2, m = 18181.81 kg, w = ?, w =mg w = 18181.81(9.8) = <u>178181.74 N</u>

19 g = 9.80 m/s^2, w = 10168.25 N, w=mg,
m = <u>1037.58 kg</u>

20 g = 9.80 m/s^2, m= 1.76, w=?, <u>w = 17.25 N</u>

21 g = 9.80 m/s^2, m = 29,545 kg, w=mg,
<u>w = 289541 N</u>

22 g = 9.80 m/s2, w = 648, w=mg, <u>m=66.12 kg</u>

23 g = 9.80 m/s2, g_{SUN} = 274 m/s2, 274/9.8 = <u>27.96</u> $g_{EARTH's}$

24 g = 9.80 m/s2, 0.37g_{EARTH} = 0.37(9.80) = <u>3.63</u> m/s2.

25 g = 9.80 m/s2, a = 185 m/s2, 185/g = <u>18.76 g's</u>

26 vo = 38 m/s, v = 0, t = 0.1 s, a =? in g's
v=vo + at, 0 = 38 +a(.1), a =-380 m/s2,
380 m/s2/9.80 m/s2 = <u>38.78 g's</u> !!!

27 vo = 0, v = 32 m/s, t = 4.2, a =?
v=vo + at, 32 = 0 +a(4.2), a =7.62 m/s2,
7.62 m/s2/9.80 m/s2 = <u>0.78 g's</u>

28 vo = 0, x = 529.2, t = 6.0 s, a =?
x = (vo)t + 1/2at2: 529.2 = 0 + 1/2a(6.0)2
a = 29.4 m/s2, 29.4 m/s2/9.80 m/s2 = <u>3.00 g's</u>

29 m = 654,506 kg, F = 25,656,635.2 N
F = ma : 25,656,635.2=654.506a
a = 39.2m/s2, 39.2 m/s2/9.80 m/s2 = <u>4.00 g's</u>

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30 While the thrust could produce 4 g's of acceleration one of those "g's" of thrust is used to overcome gravity. The rest are used to accelerate the rocket.

31 1 lb = 2.205 kg = 1 Newton
(Dimensional Analysis)

32 m = 40 kg, F =30 N
F = ma, 30 = (40)a, a = 0.75 m/s2

33 v = 0, t =10 s x = 15 m, m = 40 kg

$$\frac{v+v_0}{2}=\frac{x}{t}:\ \frac{0+v_0}{2}=\frac{15}{10}:\ v_0=3.00\ \frac{\mathrm{m}}{\mathrm{s}}$$

$$v^2=(v_0)^2+2ax:\ 0^2=(3)^2+2a(15):\ \mathrm{a}=0.30\frac{\mathrm{m}}{\mathrm{s}^2}$$

F = ma, F = 40(0.3) = 133.33 N

34 a = 0.524 m/s2, m = 842 kg, F = ?
F =ma, F = 0.542(842) = 441.208 N

35 F =342 N, v_o = 0, x =?, t = 12 s, m = 989 kg,
F = ma: 342 = 989a, a = 0.3458 m/s2,
x = (v_o)t + 1/2at2
x = 0 + 1/2(0.3458)(12)2
x = 24.90 m

36 If the pushing force is doubled then the acceleration is doubled. Because the relationship between x and a in linear, if the acceleration is doubled then the distance is also doubled. Therefore, the car will travel 49.80 m.