Motion
Distance and Displacement

Pg. 18 DO NOW:

Motion is described with respect to a:

a. Graph

b. Displacement

c. Slope

d. Frame of reference

Pg. 18

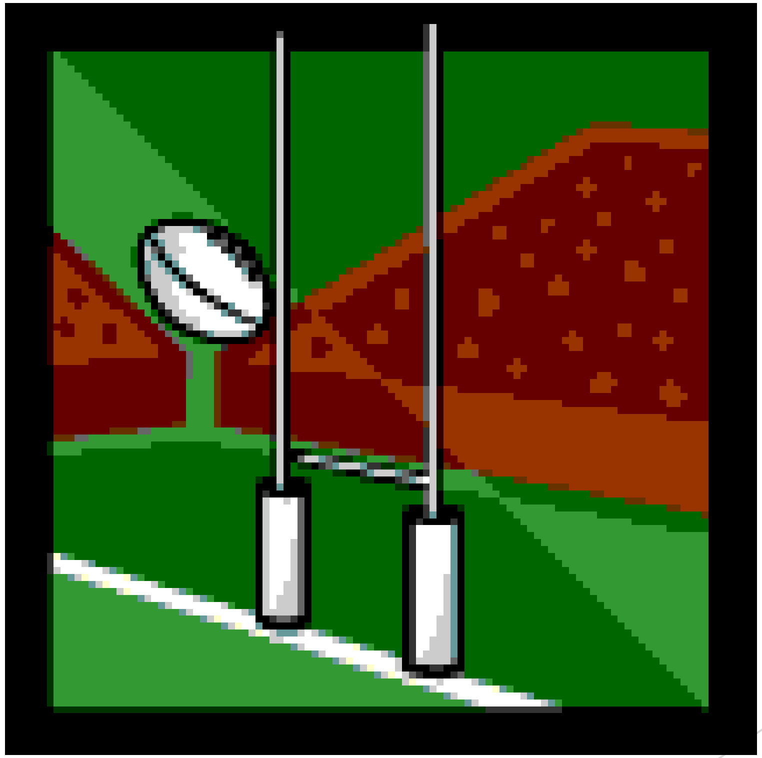
DO NOW:

Why is it necessary to choose a single reference point (frame of reference) when measuring motion?

The motion appears to be different in different frames of reference.

Motion

- **Motion** – an object's change in position relative to a reference point



Motion and Position

You don't always need to see something move to know that motion has taken place.

A **reference point** is needed to determine the position of an object.

Motion occurs when an object **changes** its position relative to a reference point.

The motion of an object depends on the reference point that is chosen.

Reference Point

- The Earth's surface is used as a common reference point

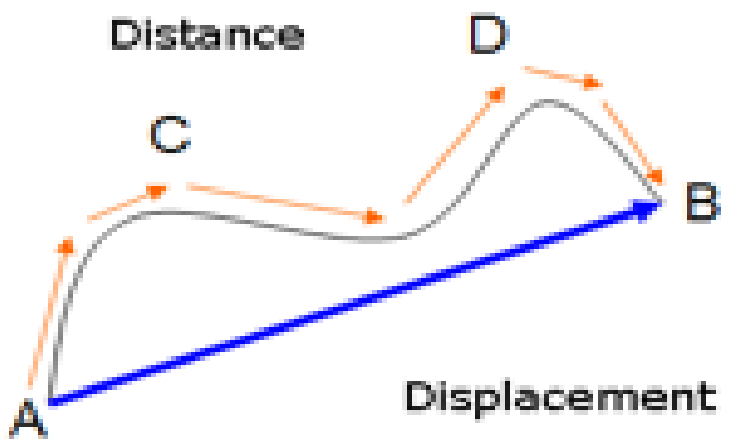
- A moving object can be used as a reference point as well

SCALAR QUANTITIES

Definition: quantities that just have **magnitude** (strength) but NO direction.

Examples:

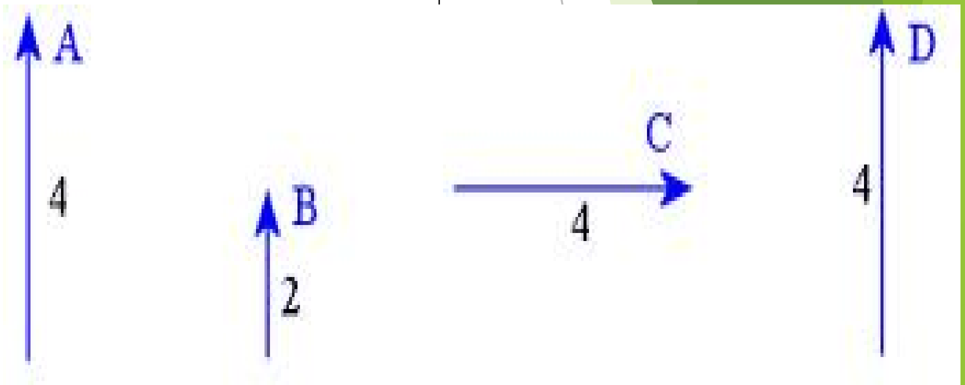
1. **Speed 60 mph**
2. Mass 42 kg
3. Volume 33 mL
4. Density 6 g/mL
5. Temperature 32°C
6. **Distance 100 m**



VECTOR QUANTITIES

Definition: quantities that have both **magnitude** (strength) and **direction.**

Examples:



1. **Velocity 60 mph East**
2. Force 8 N south
3. Acceleration 3 m/s/s (m/s^2) Left
4. Momentum 16 Kg m/s Right
5. Electric Field 112 N/C East
6. **Displacement 100 m, west**

Check For Understanding #2

Quantity	Scalar or Vector Quantity
5m	scalar
30 m/s East	vector
5 mi. North	vector
20 degrees Celsius	scalar
256 g	scalar
4000 calories	scalar
88 N south	vector

DISTANCE

An important part of describing the motion of an object is to describe how far it has moved, which is **distance**.

refers to how much ground an object has covered during its motion.

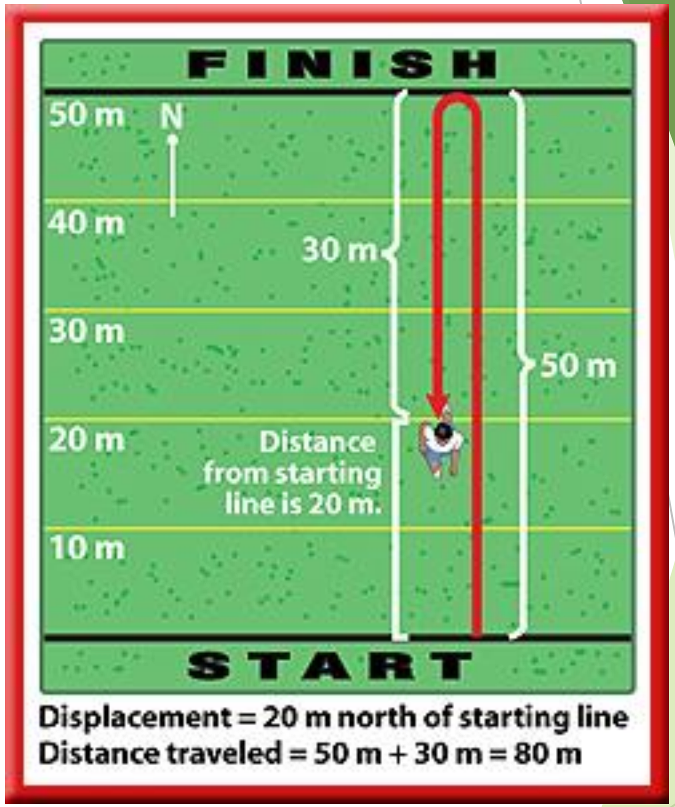
DISPLACEMENT

refers to “how far” an object is from its starting point.

Displacement

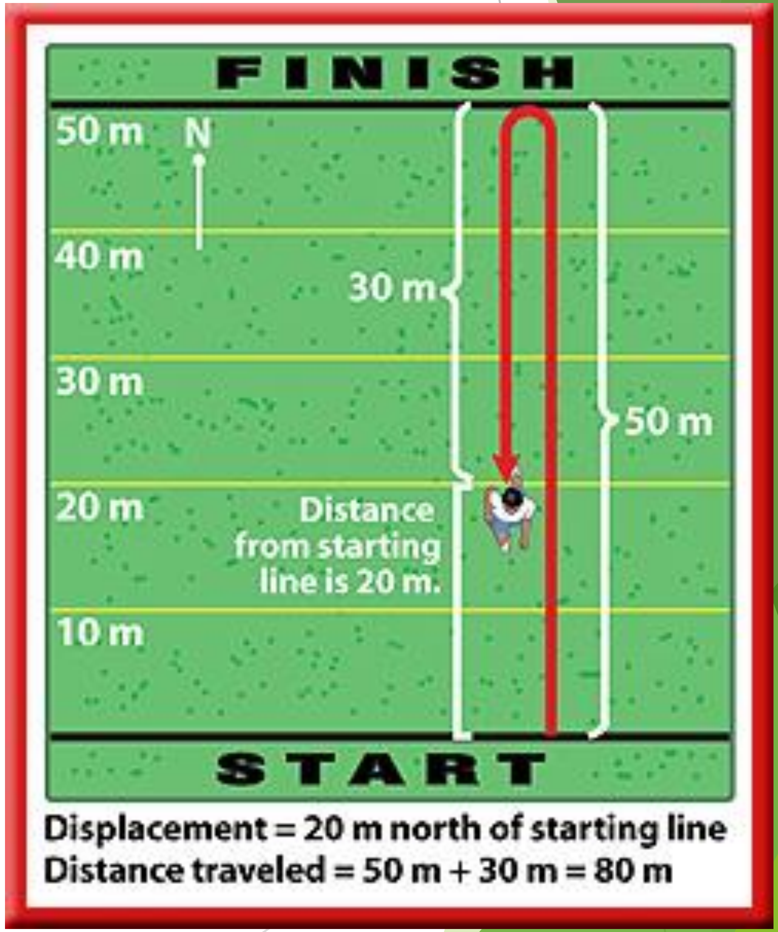
Displacement is how far you are from the starting point, as if you moved in a straight line.

The displacement and distance traveled do not have to be the same.



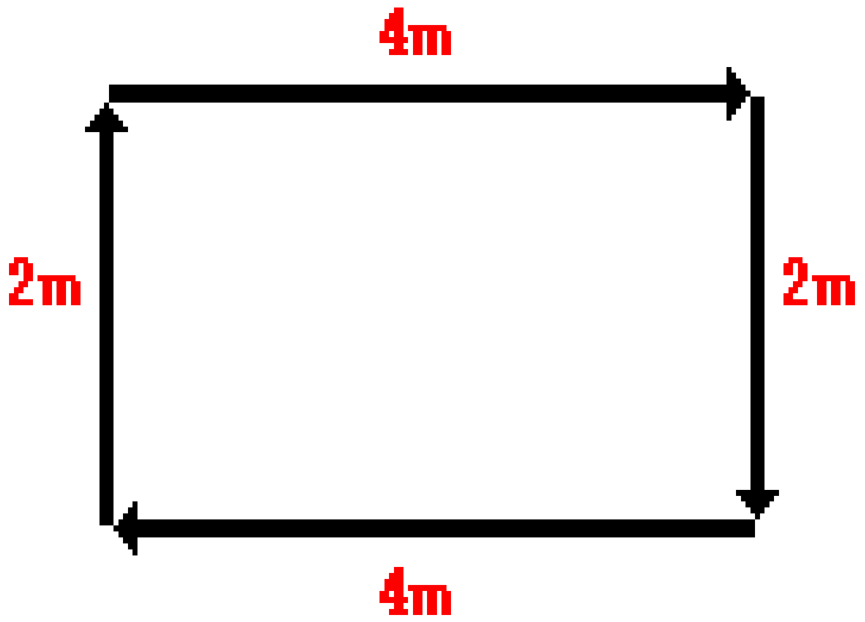
Suppose a runner jogs to the 50-m mark and then turns around and runs back to the 20-m mark.

The runner travels 50 m in the original direction (north) plus 30 m in the opposite direction (south), so the total distance she ran is 80 m.



Check for Understanding #3

A physics teacher walks 4 meters East, 2 meters South, 4 meters West, and finally 2 meters North.



Teacher's Distance: 12m

Teacher's Displacement: 0m

MEASURED IN:

The SI unit of length or distance is the meter (m).

Longer distances are measured in kilometers (km).

Shorter distances are measured in centimeters (cm).

Pg 18

Check for Understanding #4

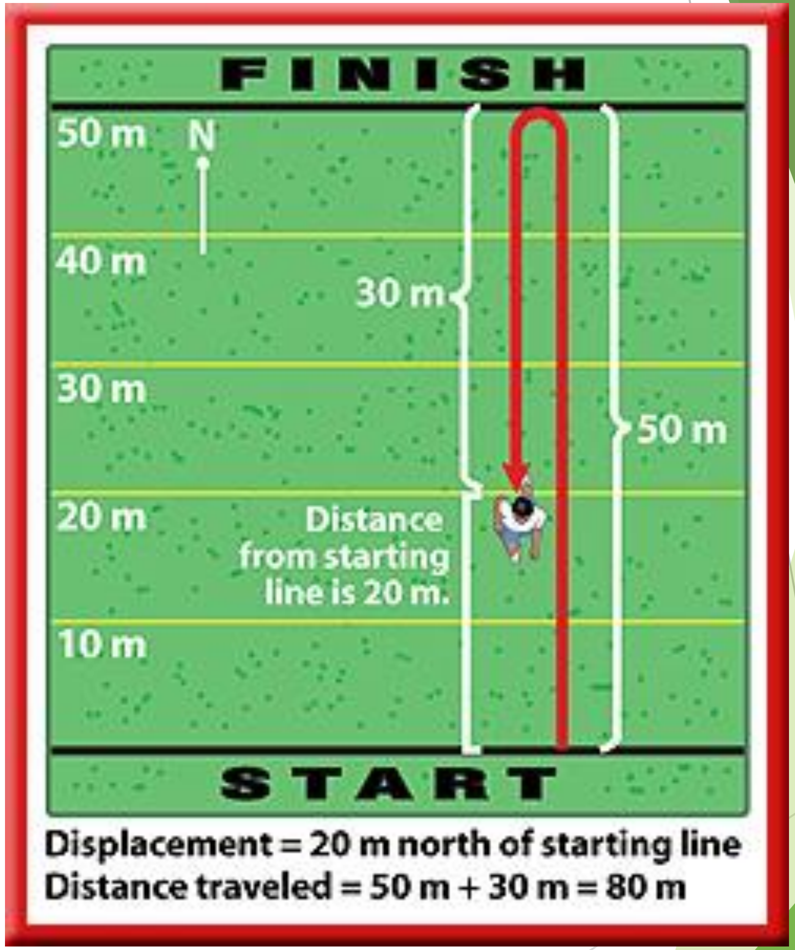
What is the difference between distance and displacement?

Check for Understanding #4

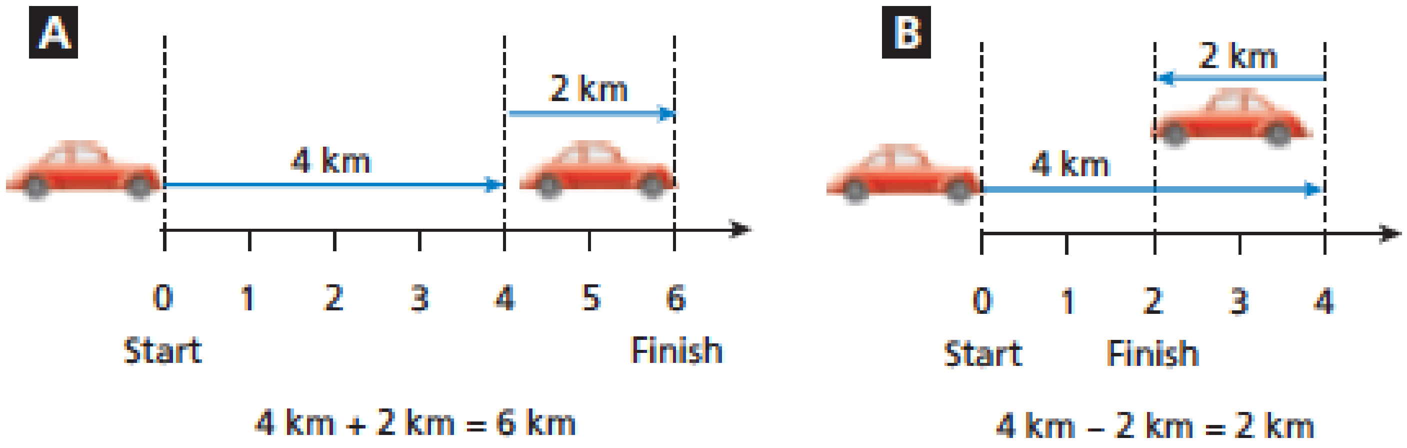
Answer

Distance describes how far (total amount) an object moves.

Displacement describes how far form the starting point an object ends up.



COMBINING DISPLACEMENTS



DISPLACEMENT THAT ISN'T A STRAIGHT LINE

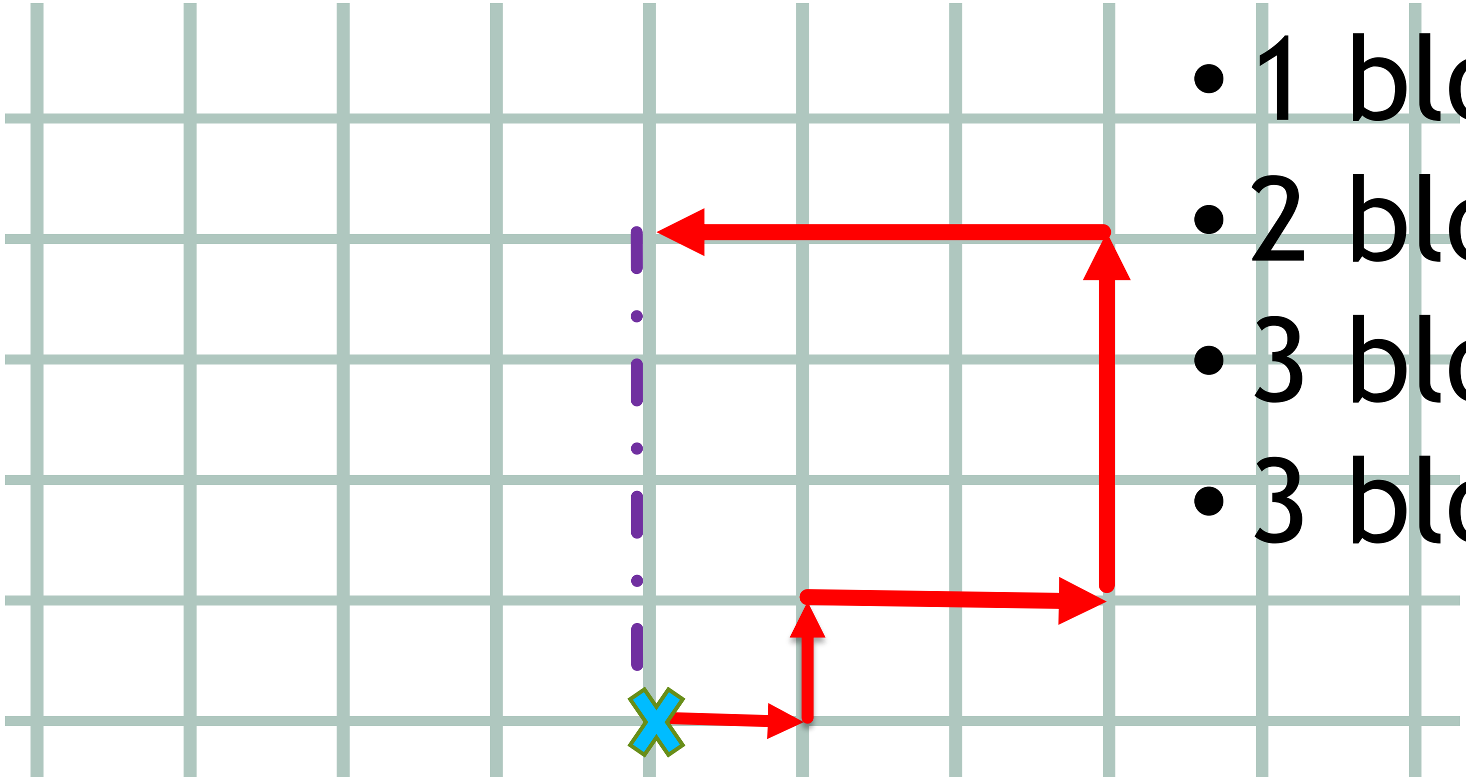
DISPLACEMENT ALONG A STRAIGHT LINE

Same direction: ADD

Opposite direction: SUBRACT

Vector Diagrams

- 1 block East Vector A
- 1 block North Vector B
- 2 blocks East Vector C
- 3 blocks north Vector D
- 3 blocks west Vector E



Calculate

Distance =

Displacement =

SCALAR

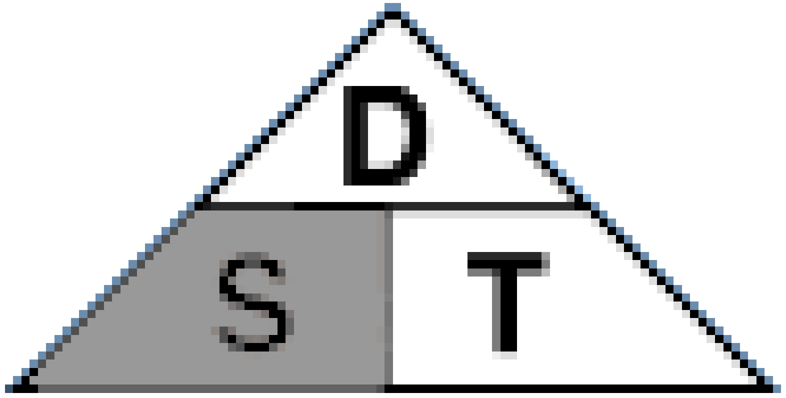
- NO direction
- Example: Distance

VECTOR

- HAS direction
- Example: Displacement

Motion
Speed and Velocity

Equation for speed is:



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

Speed Example C4U #1

A plane travels **350 mph** for north 6.5 hours. How far did it travel?

Speed Example C4U #1

A plane travels **350 mph** for 6.5 hours.
How far did it travel?

Given: S= **350 mph**

T= 6.5 hrs

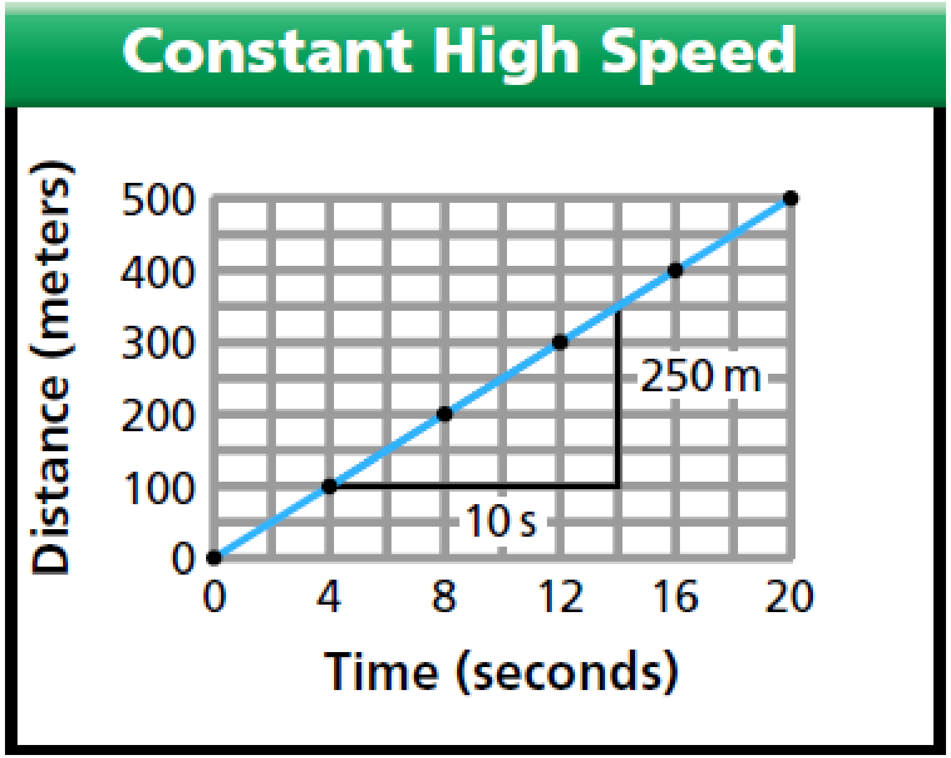
Find: D

Formula: D = S x T

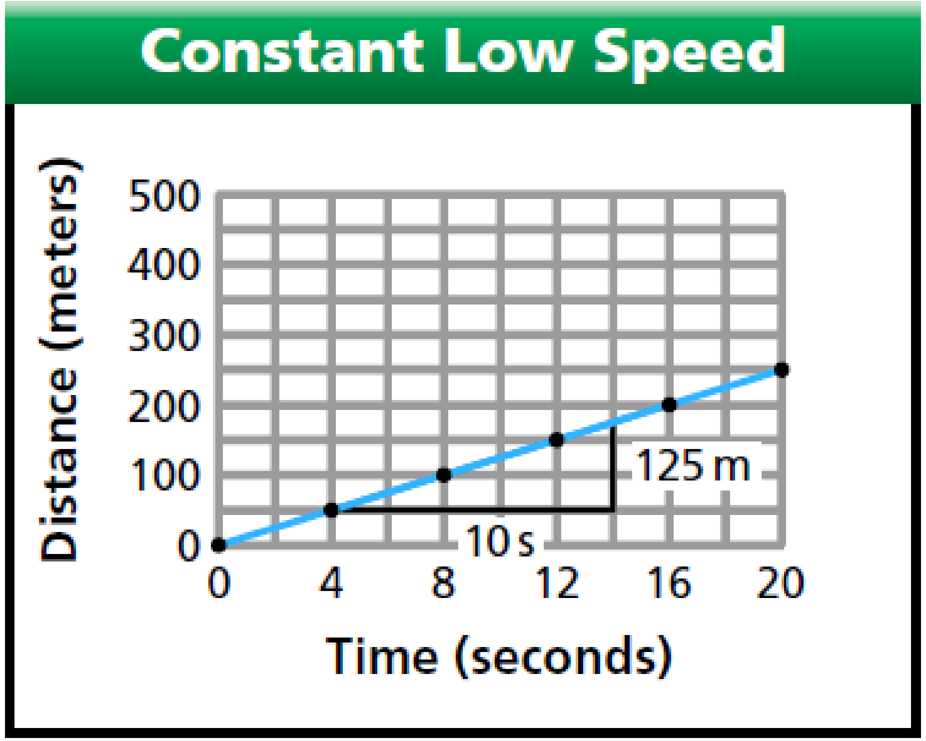
Work:

D= (350 mph) x (6.5 hours) =

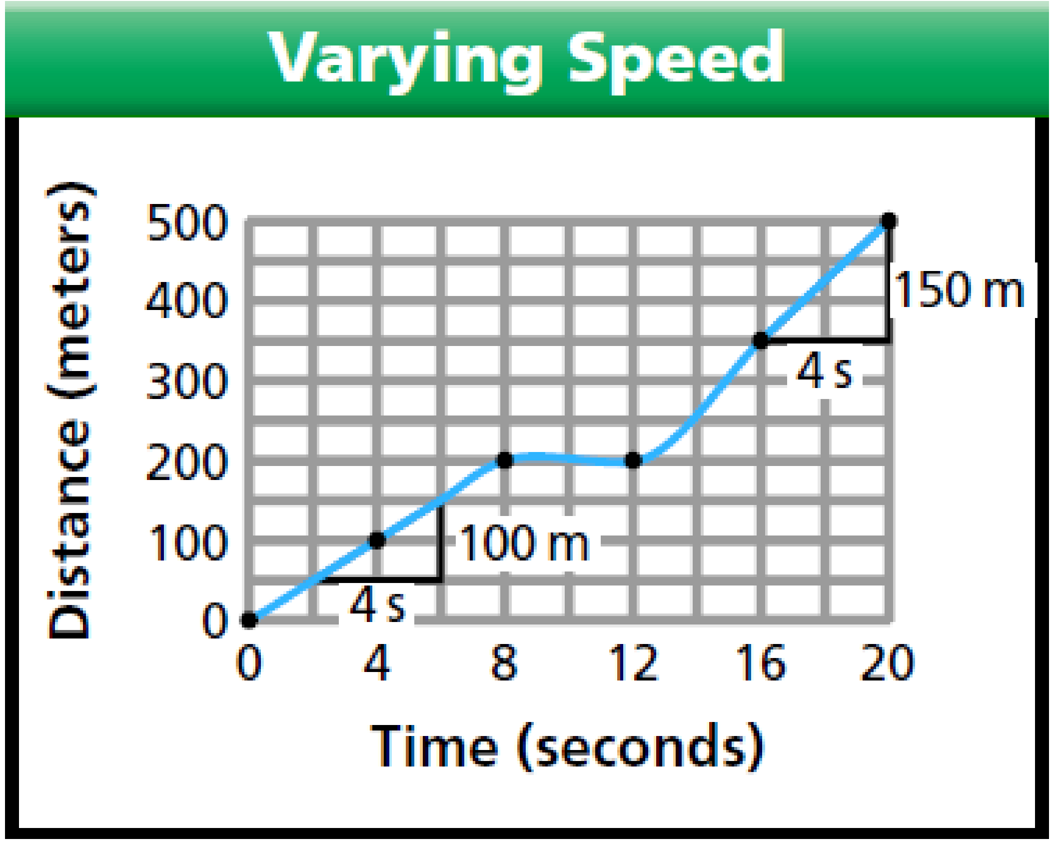
Distance-Time Graphs

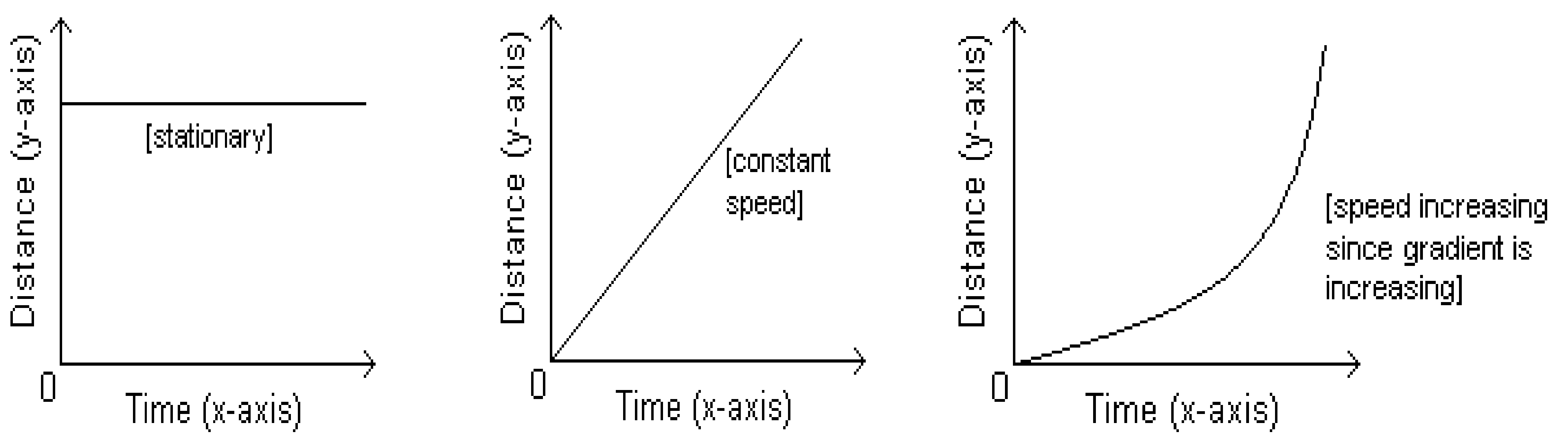


Distance-Time Graphs



Distance-Time Graphs




Distance (y-axis)
[stationary]
0
Time (x-axis)
Distance (y-axis)
[constant speed]
0
Time (x-axis)
Distance (y-axis)
[speed increasing since gradient is increasing]
0
Time (x-axis)

Distance-Time Graphs
C4U #2

- 1.Complete the graph by plotting the given data points on the graph. Each set of data points represents (time, distance).
  - Data points:

(0, 0), (2, 40), (4, 80), (6, 120), (8, 160), (10, 200)

- 2.Connect the plotted points with a straight line.
- 3. Describe the motion shown on the graph.

How are speed and velocity different?

Acceleration

Essential question: how are changes in Acceleration described?

How can we define acceleration?

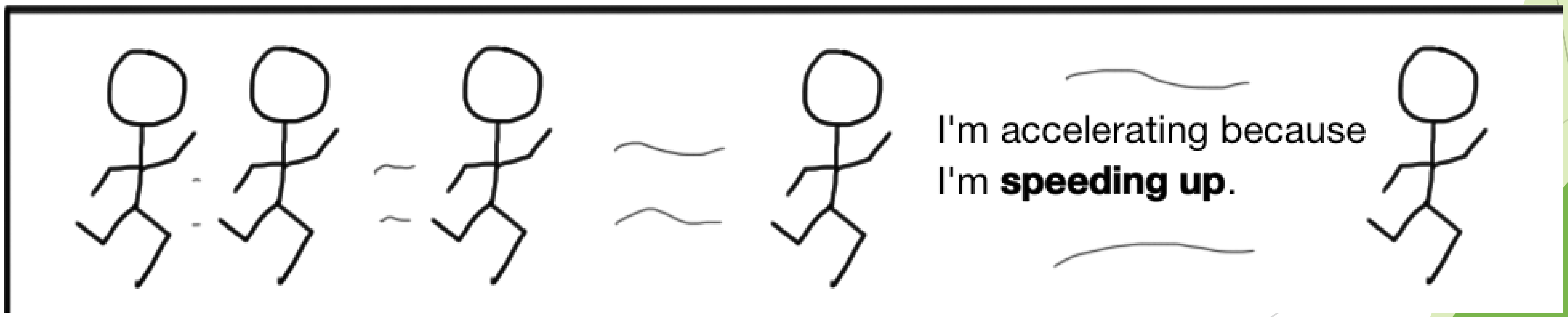
The rate at which velocity changes

The basketball constantly changes velocity as it rises and falls. Describing changes in velocity, and how fast they occur, is a part of describing motion.

3 ways to change acceleration:

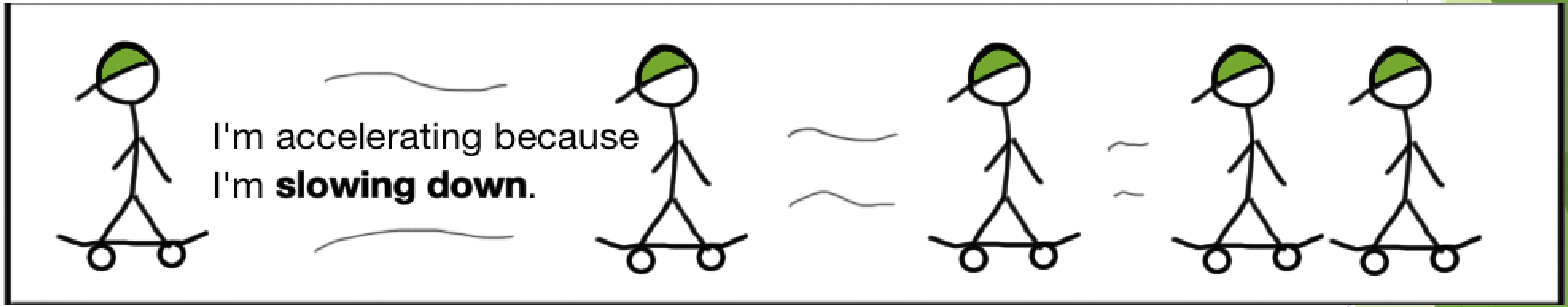
Changes in Speed

- In science, acceleration applies to any change in an object's velocity.
- Acceleration can be caused by positive (increasing) change in speed or by negative (decreasing) change in speed.



3 ways to change acceleration:

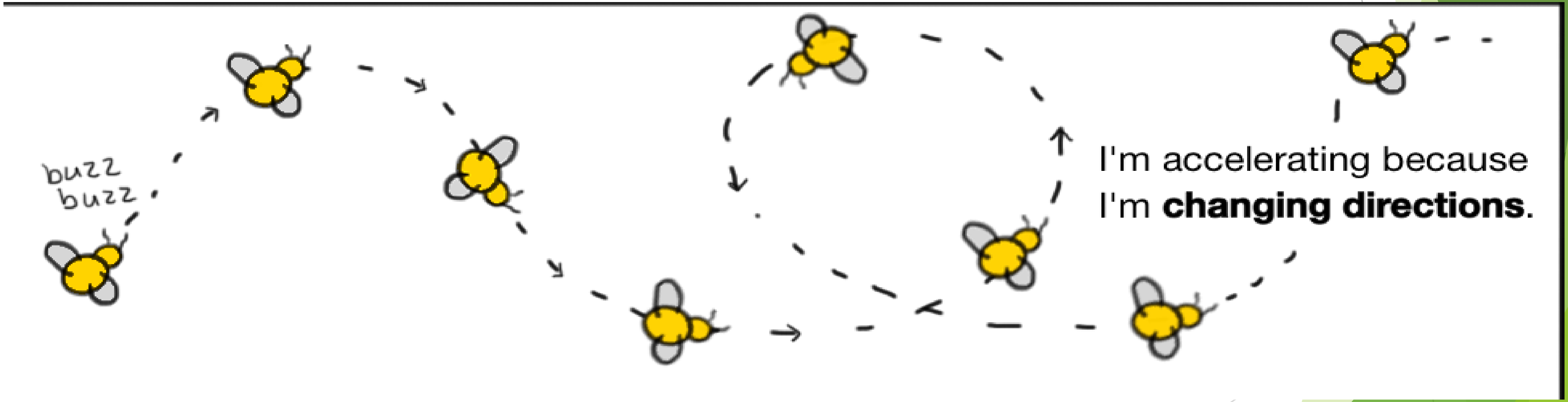
Deceleration is an acceleration that slows an object's speed.



3 ways to change acceleration:

Changes in Direction

Acceleration can be the result of a change in direction at constant speed, for example, riding a bicycle around a curve.

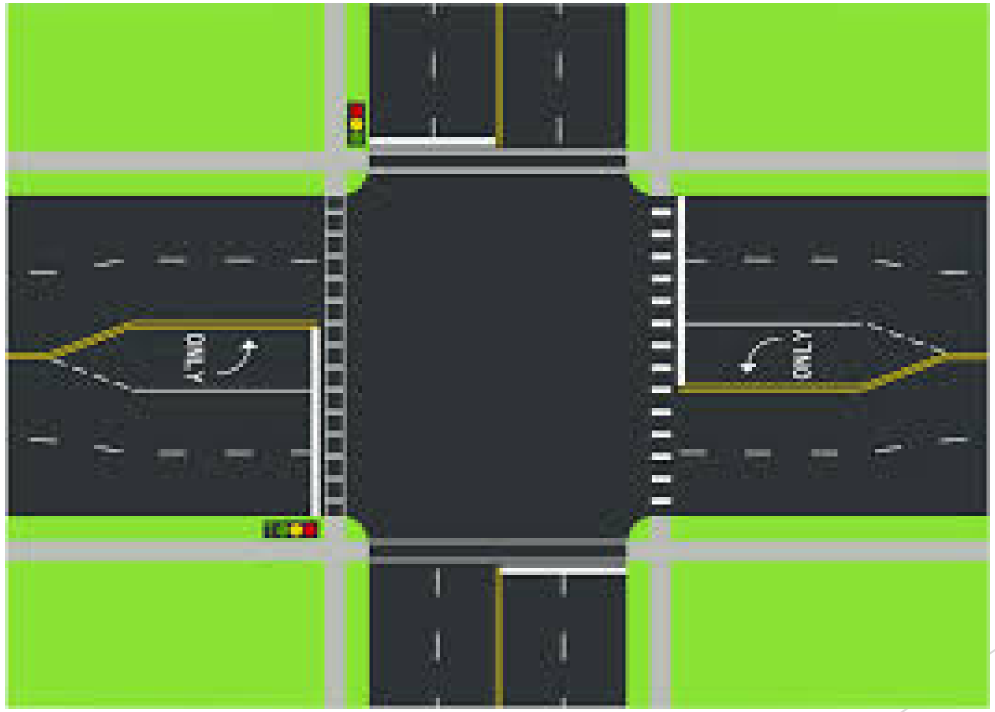


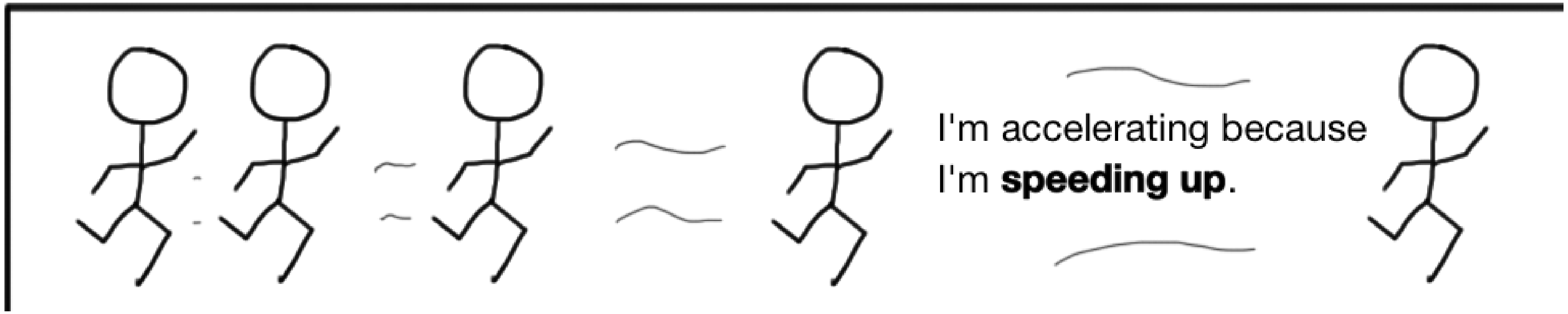
3 ways to change acceleration:

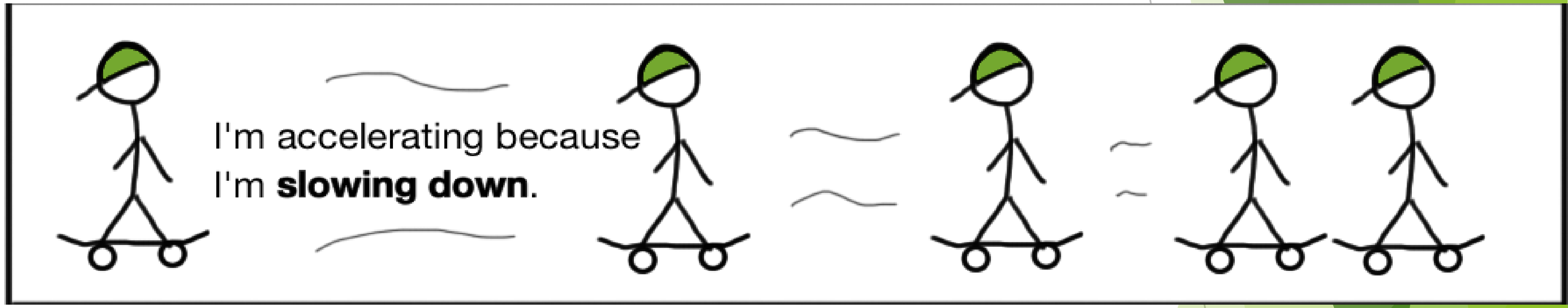
Changes in Speed and Direction

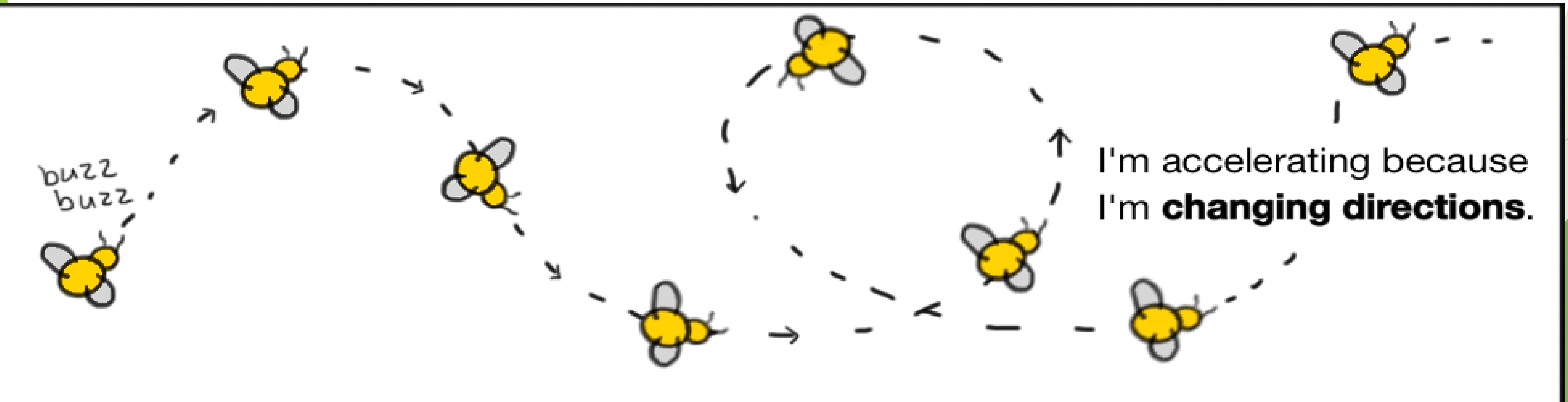
Sometimes motion is characterized by changes in both speed and direction at the same time.

For example: Turning a corner. The car is accelerating both because it is changing direction and because its speed is decreasing.




I'm accelerating because
I'm **speeding up**.


I'm accelerating because
I'm **slowing down**.


buzz
buzz
I'm accelerating because
I'm **changing directions**.

Acceleration can change in different ways:

1. Speeding up
2. Slowing down
3. Changing direction
4. Both Speed and Direction

C4U #1:

Identify the following as a change in speed, changing direction or both:

1. **Taking off when the light changes from red to green**

2. **Riding on a carousel**

3. **A roller coaster**

C4U #1:

Acceleration changes by:

A car moving after stopping at a red light is accelerating as it takes off. The acceleration is the result of an increase in speed.

C4U #1:

Acceleration changes by:

A horse on the carousel is traveling at a constant speed, but it is accelerating because its direction is constantly changing.

C4U #1:

Acceleration changes by:

A roller coaster produces acceleration due to changes in both speed and direction.

C4U #2

Is acceleration a vector or scalar quantity?

Vector

What Is Constant Acceleration?

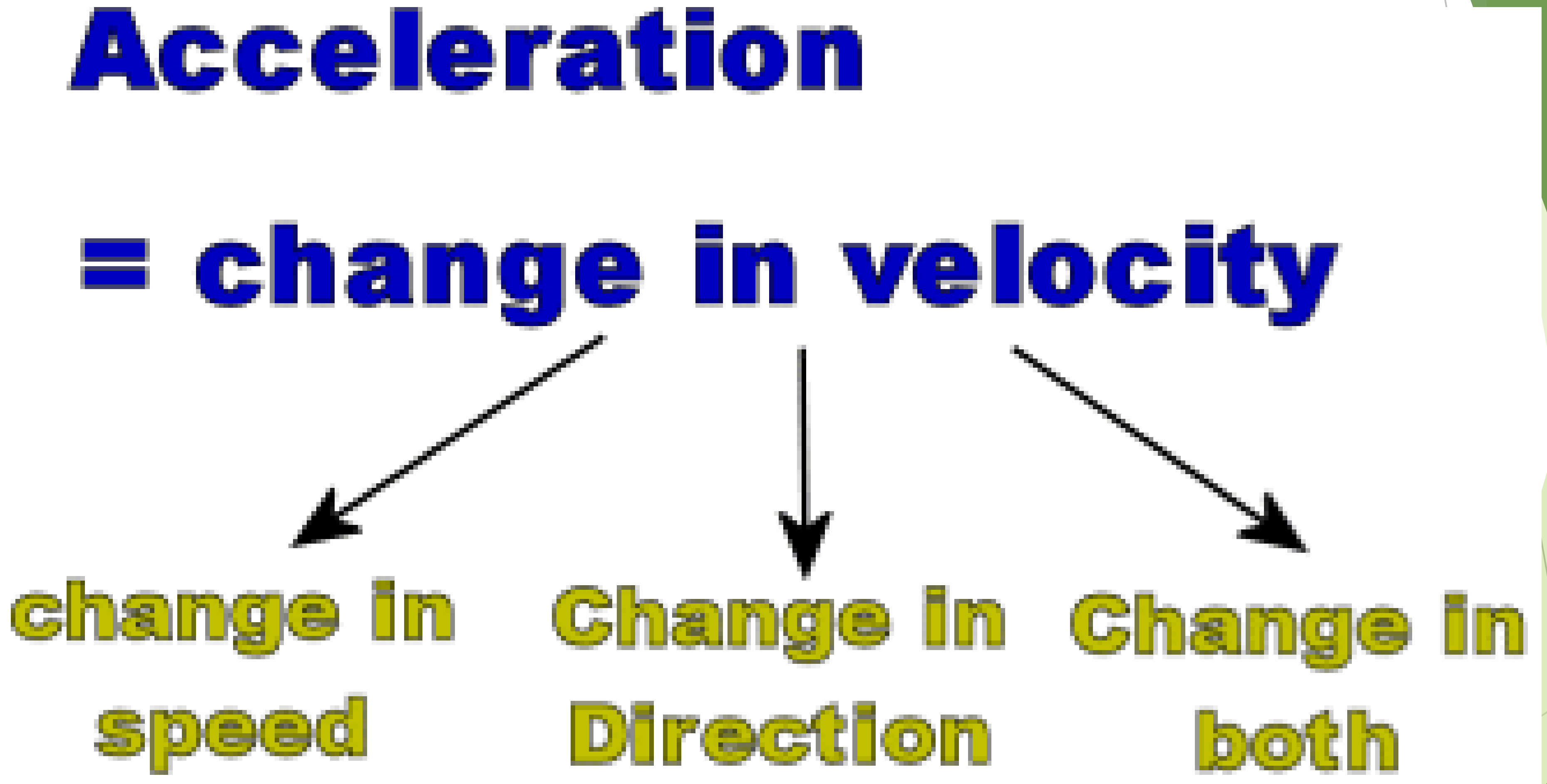
Constant Acceleration

Constant acceleration is a steady change in velocity.

Ex: An airplane’s acceleration may be constant during a portion of its takeoff.

What Is Constant Acceleration?

Constant acceleration during takeoff results in changes to an aircraft’s velocity that is in a constant direction.


Acceleration
= change in velocity
change in speed
Change in Direction
Change in both

a = acceleration

$\triangle v$= change in velocity

V_f = final velocity

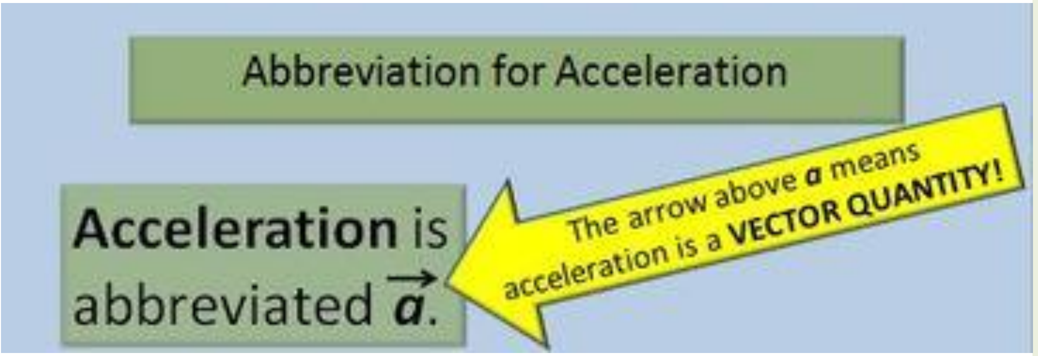
V_i= initial velocity

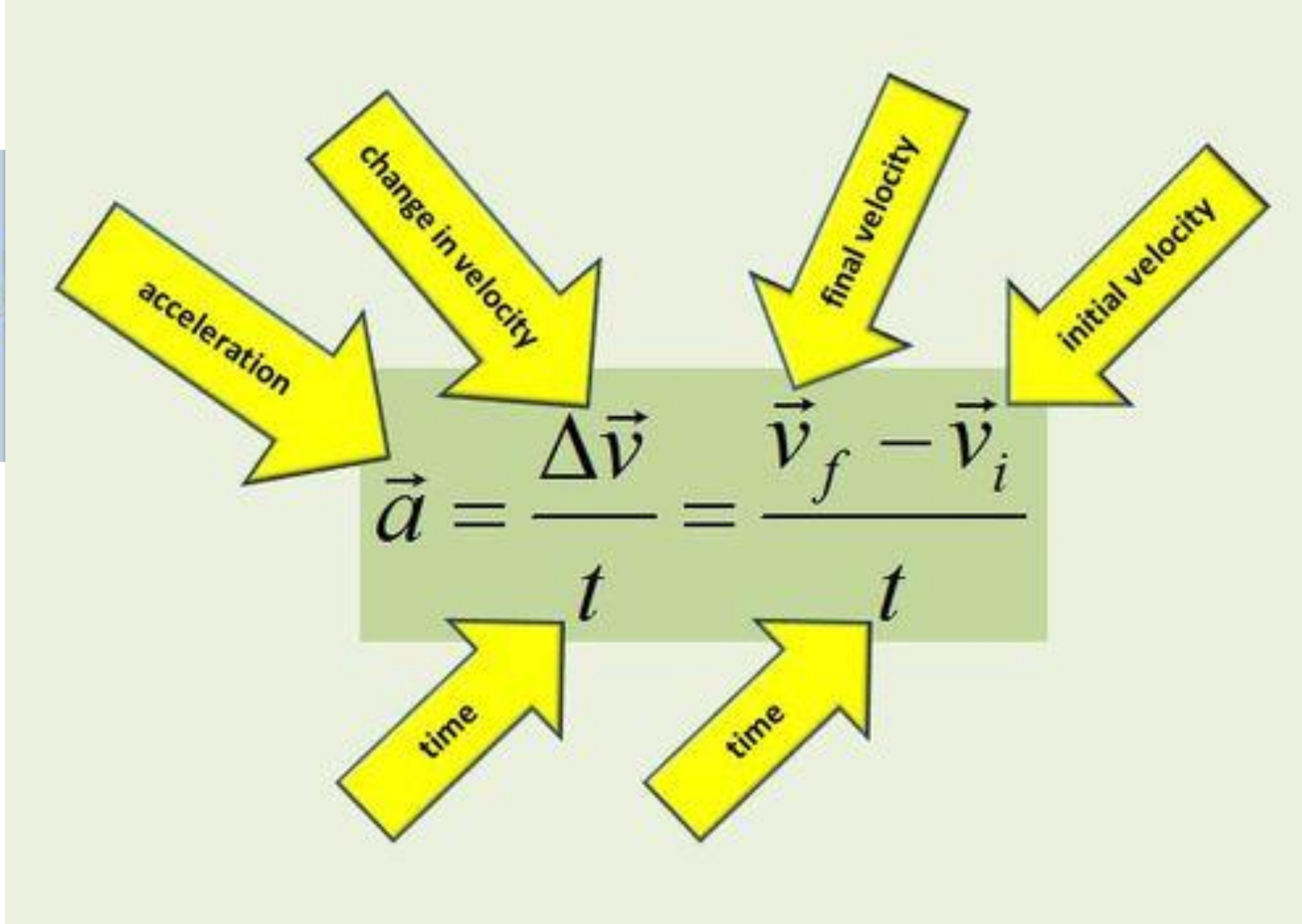
t = time

$\triangle$ = change (final - initial

How can you calculate acceleration?

Formula





Acceleration is the rate at which velocity changes. *Vi* is the initial velocity, *vf* is the final velocity, and *t* is total time.

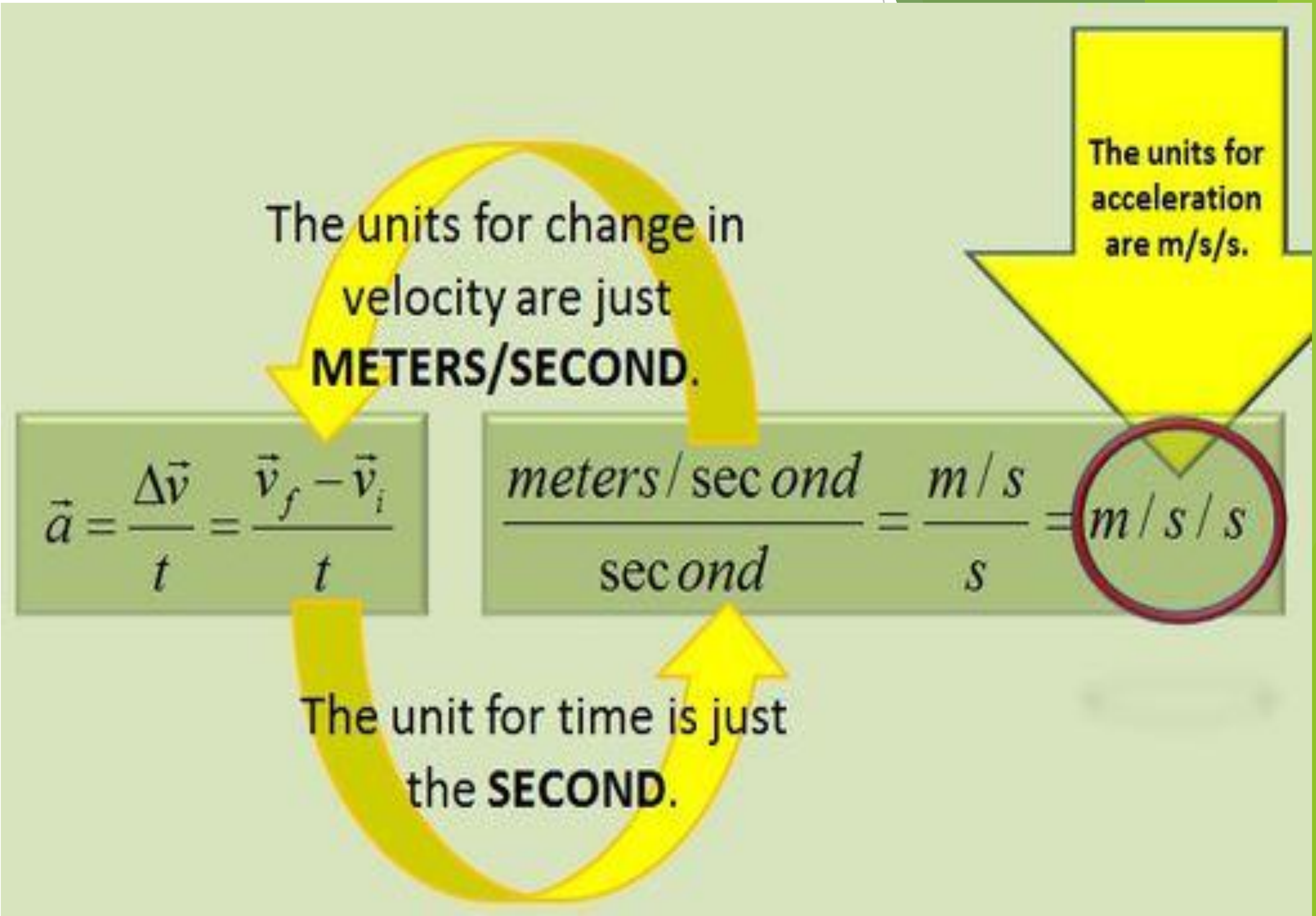
Units used:

Note: We can express the SI units for acceleration either as

m/s/s

or as

m/s^2.



Example 1:

A car moving at 35 mph comes to a stop in 5 seconds. Find the acceleration of the car. (Hint – it is actually decelerating).

C4U #3

A car is traveling at 50 mph. The driver speeds up to 70 mph in 4 seconds. Find the car's acceleration. (include units)

a =

V_f =

V_i=

t =

Formula:

BrainPop Video – Acceleration

BrainPop

C4U #4 Pg. 30

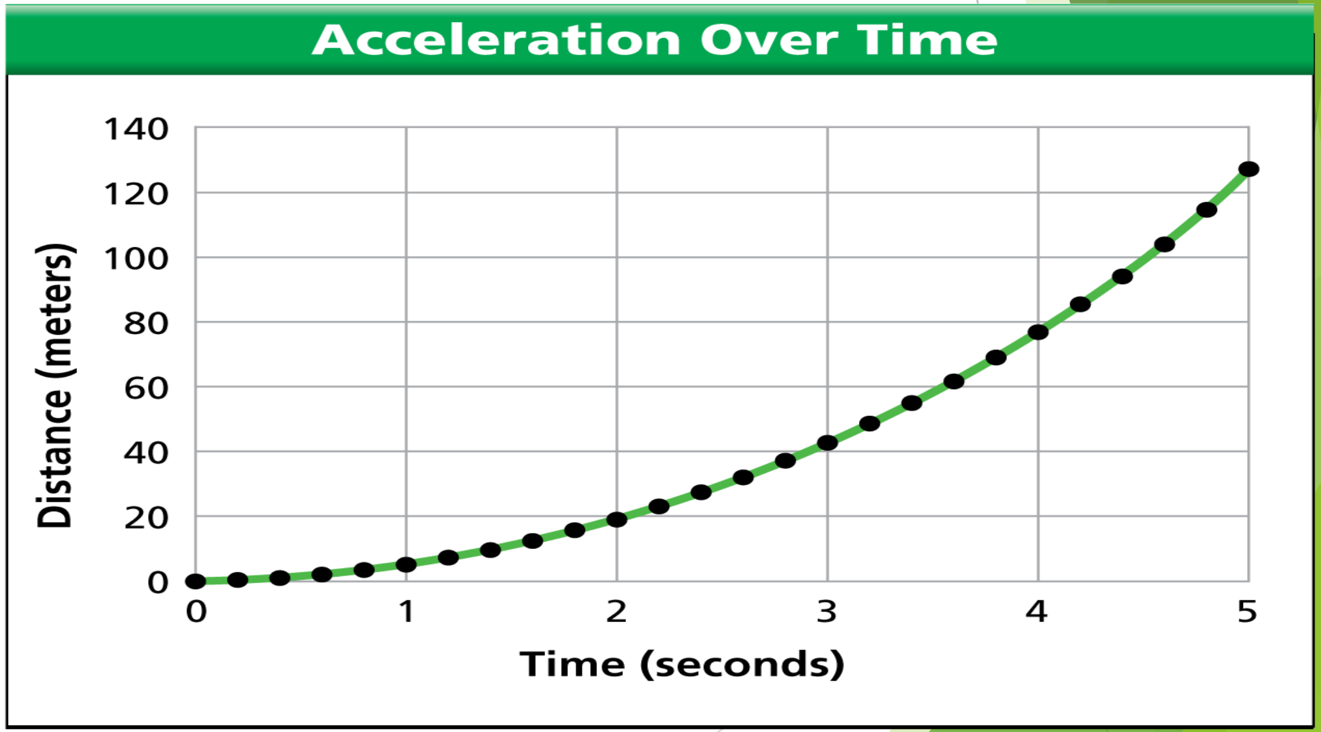
1. **What is acceleration?**
   a. **the rate at which speed increases**
   b. **the time an object's velocity increases**
   c. **the rate at which displacement changes**
   d. **the rate at which velocity changes**

D

Graphing Acceleration

A distance-time graph of accelerated motion is a curve.

Ex: The data in this graph are for a ball dropped from rest toward the ground.



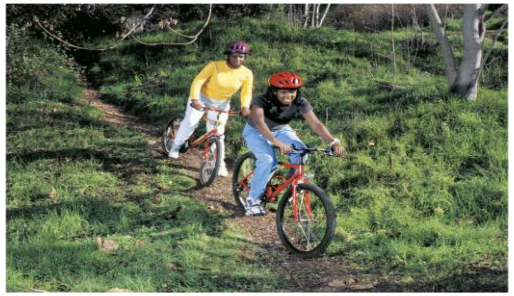
In a **nonlinear graph**, a curve connects the data points that are plotted.

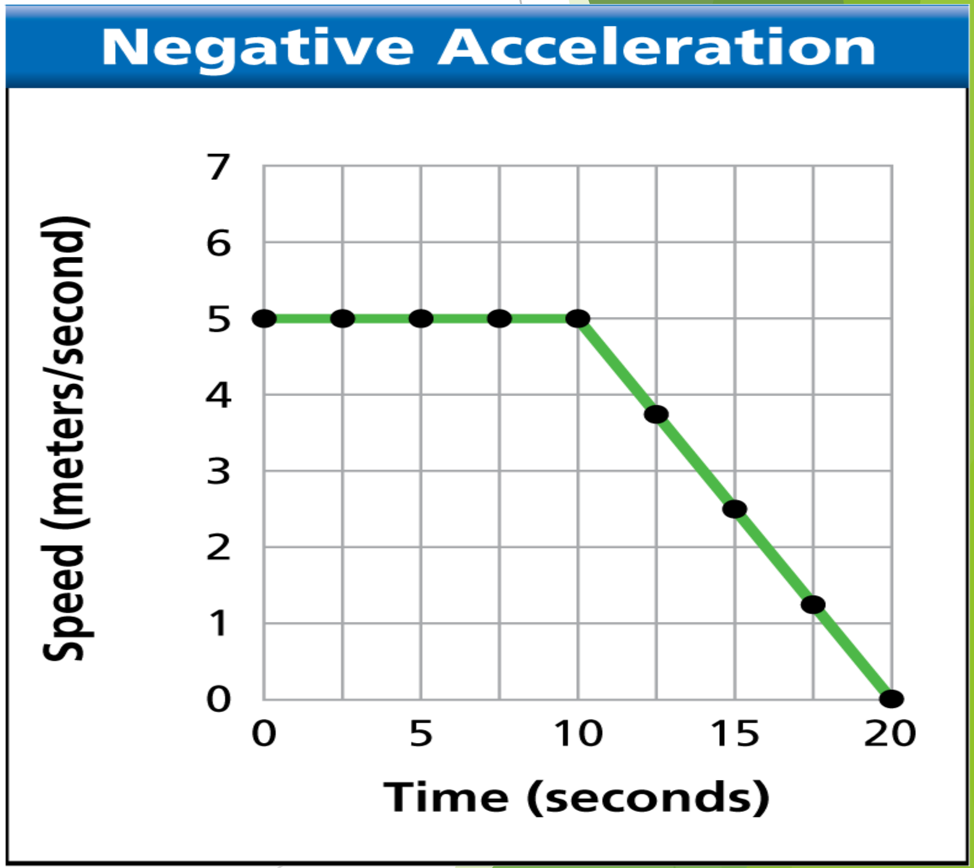
Graphing Acceleration

Ex: The biker moves at a constant speed and then slows to a stop.

Constant negative acceleration decreases speed.

- On a speed-time graph of a bicycle slowing to a stop, a line sloping downward represents the bicycle decelerating.
- The change in speed is negative, so the slope of the line is negative.





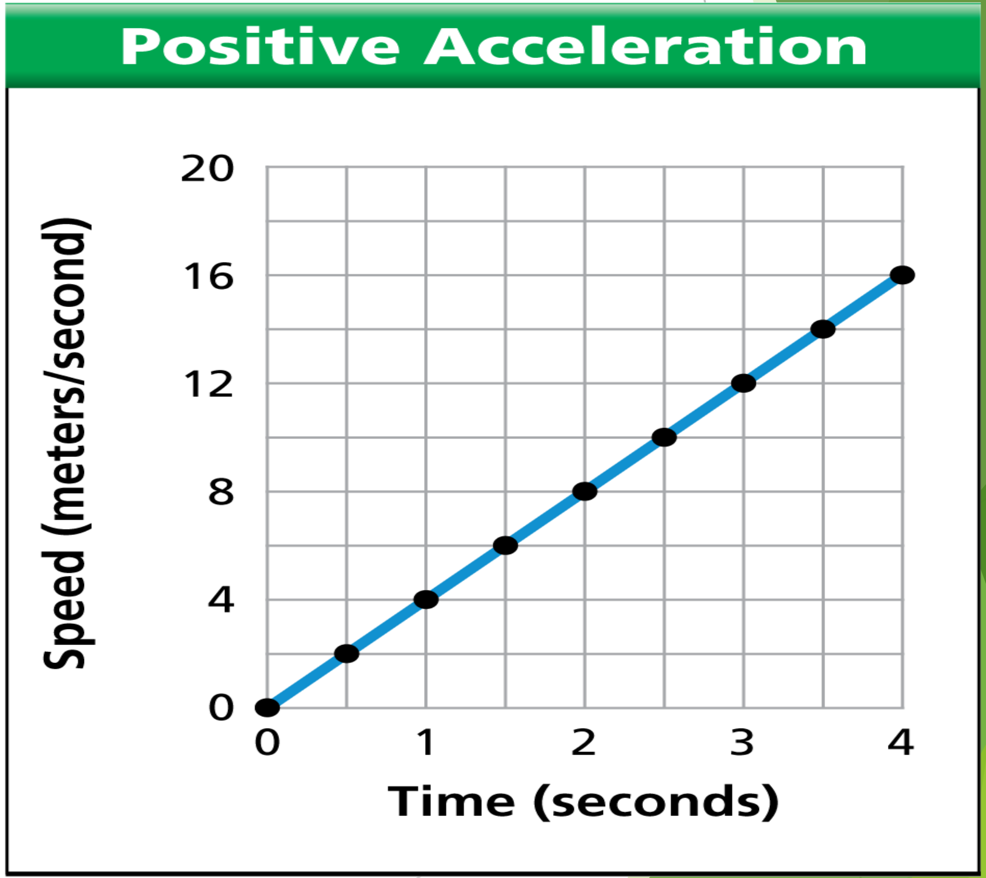
Graphing Acceleration

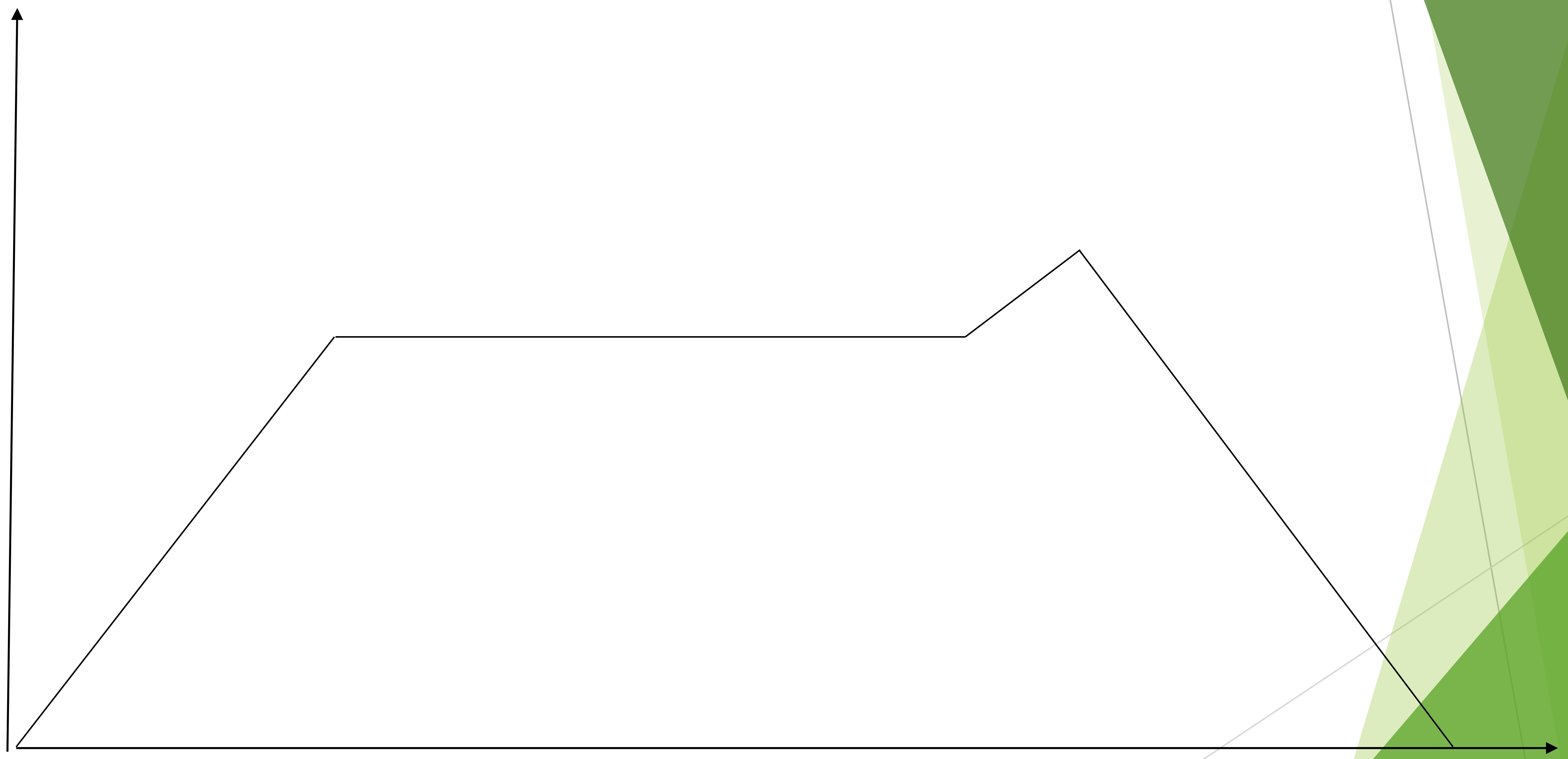
Ex: The skier’s acceleration is positive. The acceleration is 4 m/s^2.

Speed-Time Graphs

Constant acceleration is represented on a speed-time graph by a straight line. The slope of the line is the acceleration.

The graph is an example of a linear graph, in which the displayed data form straight-line parts.



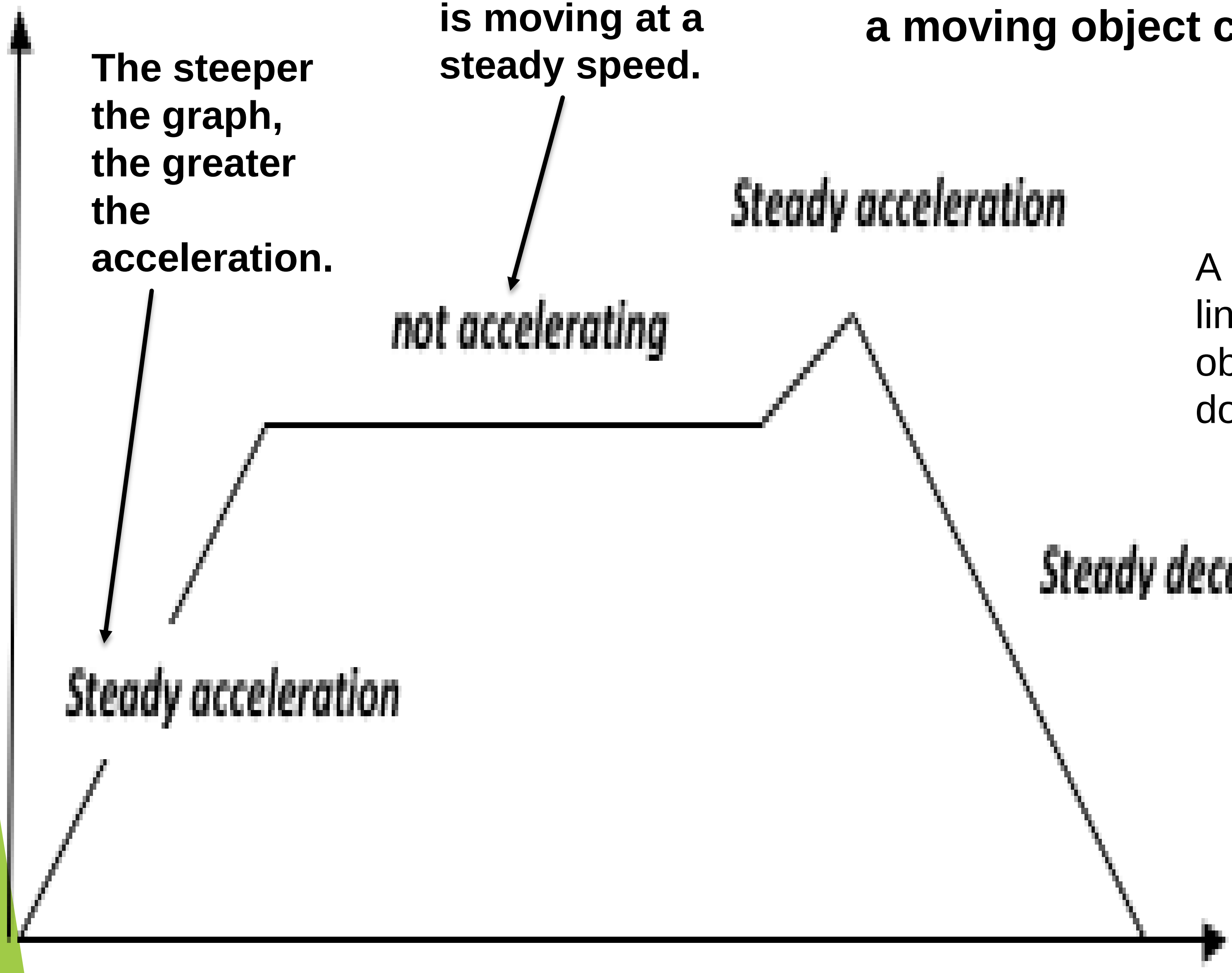


A speed- time graph shows us how the speed of a moving object changes with time.

The steeper the graph, the greater the acceleration.

A horizontal line means the object is moving at a steady speed.

A downward sloping line means the object is slowing down.



Instantaneous Acceleration

What is instantaneous acceleration?

Instantaneous acceleration is how fast a velocity is changing at a specific instant.

What Is Freefall?

Free fall is

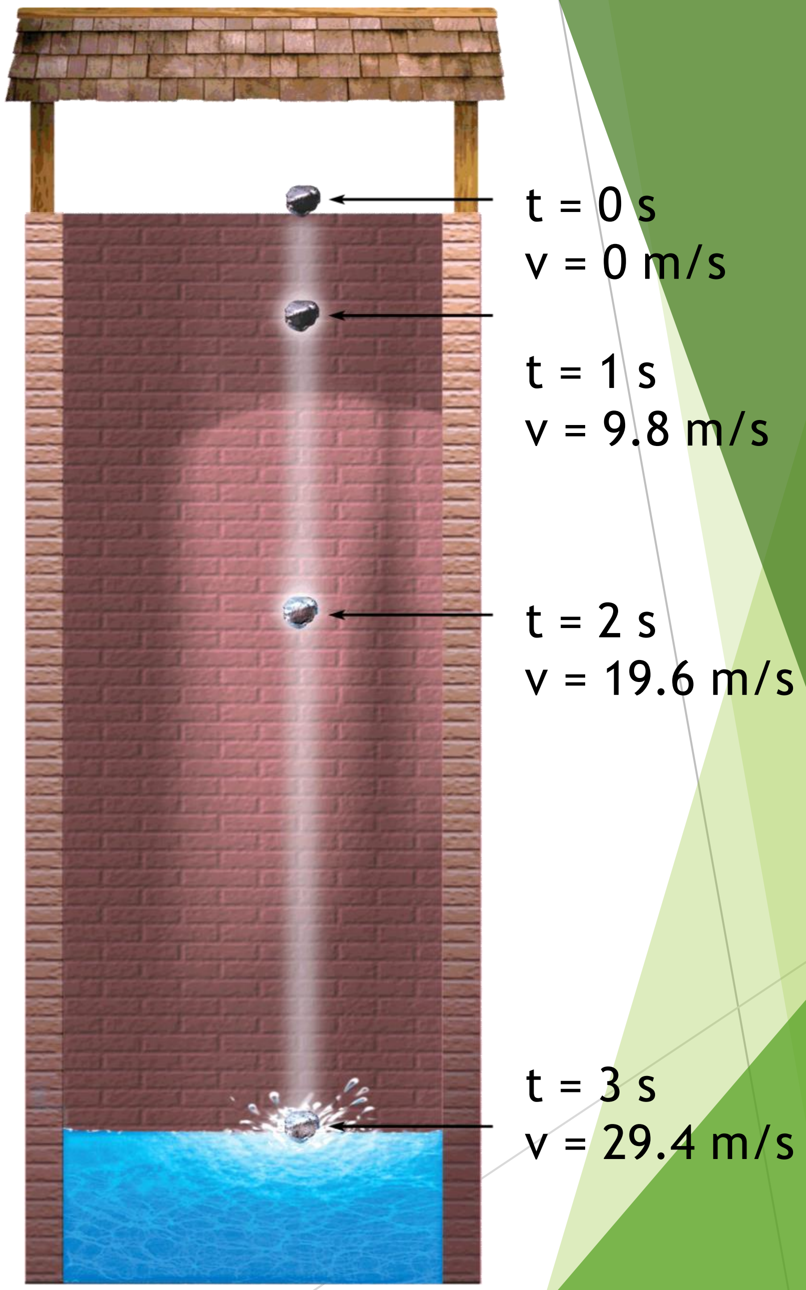
the movement of an object toward Earth solely because of gravity.

Objects falling near Earth’s surface accelerate downward at a rate of 9.8 m/s^2.

What Is Freefall?

Each second an object is in free fall, its velocity increases downward by 9.8 meters per second.

The change in the stone's speed is 9.8 m/s^2, the acceleration due to gravity.



$$\text{Acceleration} = \frac{\text{change in speed}}{\text{time interval}}$$

$$a = \frac{v_f - v_i}{t}$$

Final velocity, Initial velocity, Time

<u>ways to change your acceleration:</u>

1. Increase your speed (gas pedal) (accelerate)

2. Slow down (brake) – decelerate (negative acceleration)

3. Change your direction (steering wheel)

4. Change in both speed and direction