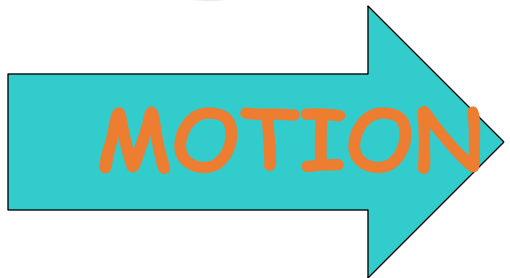
Force and Motion

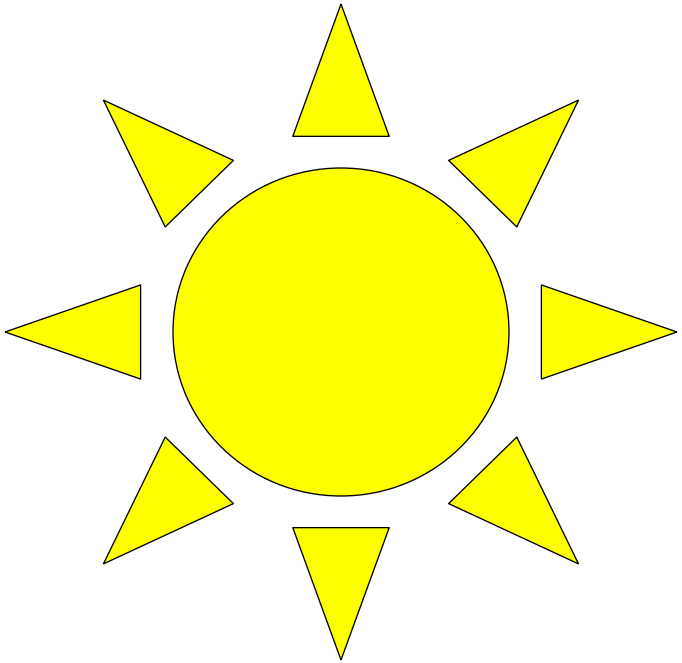
Balanced and Unbalanced Forces
Velocity and Acceleration

Motion

- What is motion?
  - A change in the position of an object over time.
- **How do you know something is in motion or has moved?**
  - You use a reference point!
    - A stationary (not moving) object such as a tree, street sign or a line on the road.

- **What causes an object to move?**
  - A FORCE!
  - ALL motion is due to forces acting on objects!
- **What is a force?**
  - A push or a pull



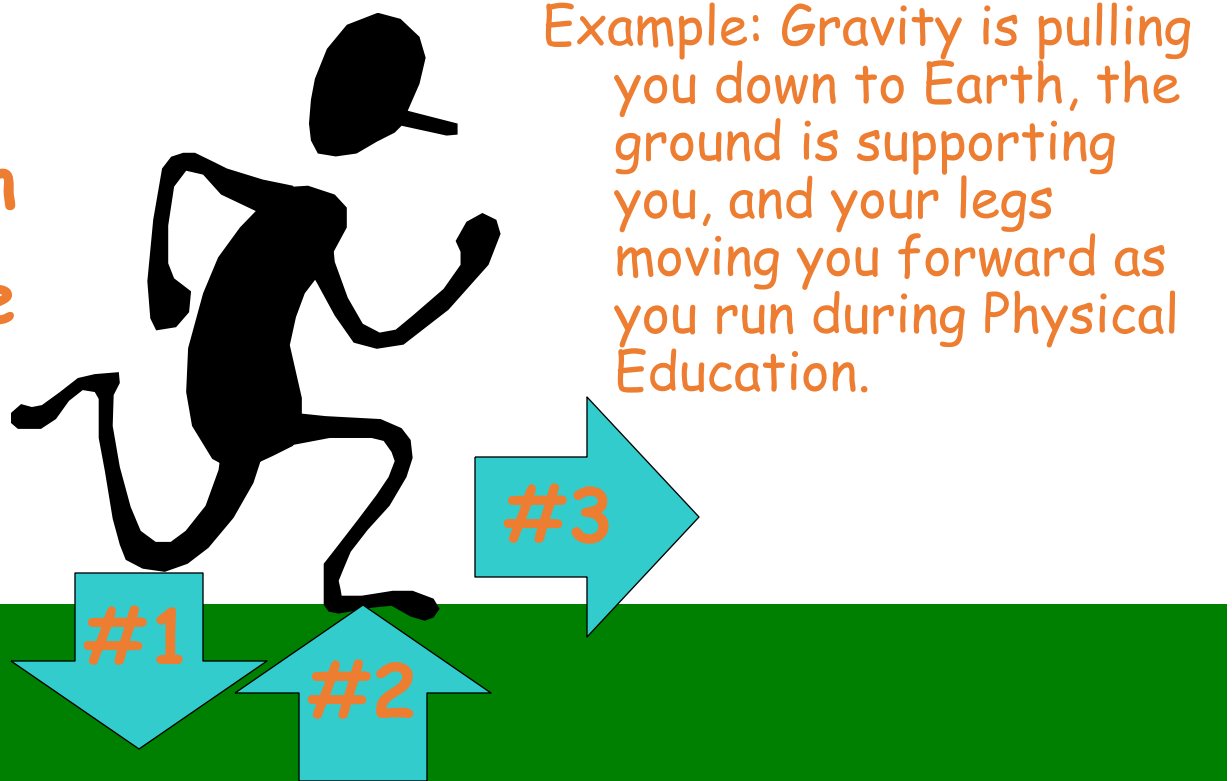


The total combination of the forces (opposites – and same direction +) acting on an object is called NET FORCE.

Can more than one force act on an object at the same time?

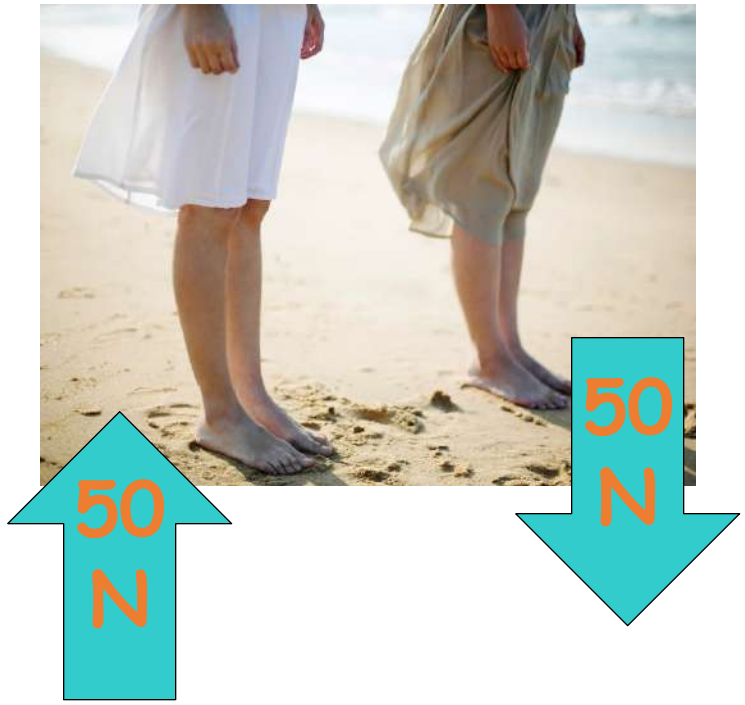
YES!

Example: Gravity is pulling you down to Earth, the ground is supporting you, and your legs moving you forward as you run during Physical Education.



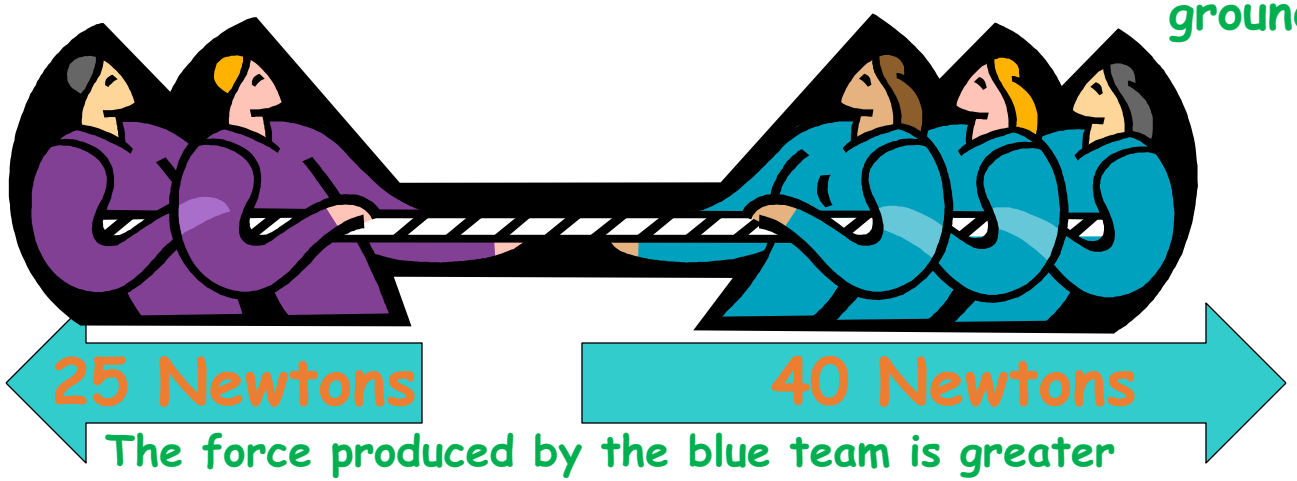
Balanced Forces

- A balanced force is one in which the net force equals ZERO.
- Do you think there will be any motion?
  - NO!
- Examples:



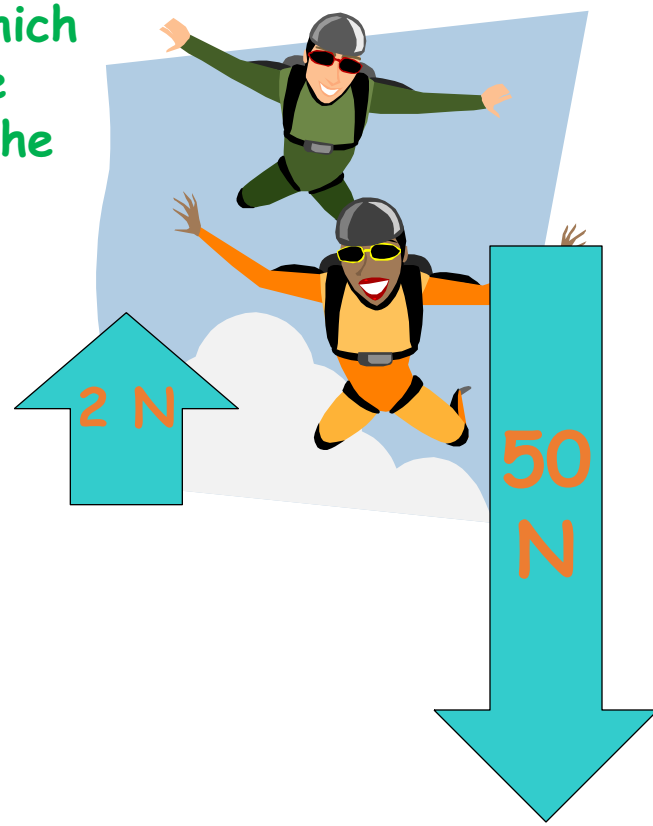
Unbalanced Forces

- An unbalanced force is one in which the **net force is <u>greater than zero</u>**.
- Do you think there will be any motion?
  - YES!
- Examples:



The force produced by the blue team is greater than that of the purple team. So the net force is 15N that would tip the ropes direction to the right.

The air resistance will negate 2 N of gravitational force which will leave 48N of net force pushing the sky divers to the ground.

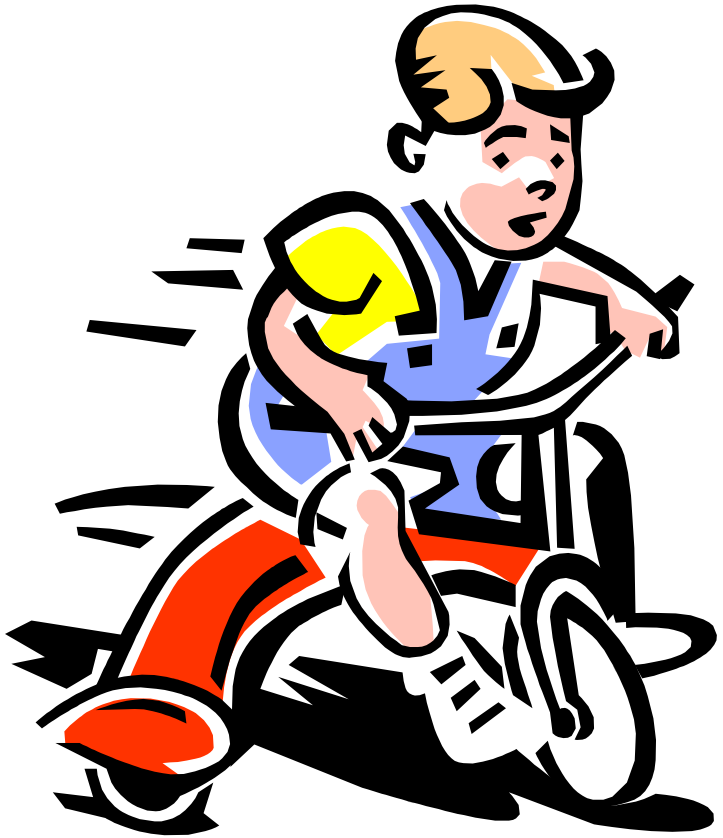


Only an unbalanced force can change the motion of an object.

- Example: Your dog can cause you to move if he pulls with enough force.
  - His force is greater than the force you're using to stay in place

What would happen if an unbalanced force acted on an object that's already in motion?

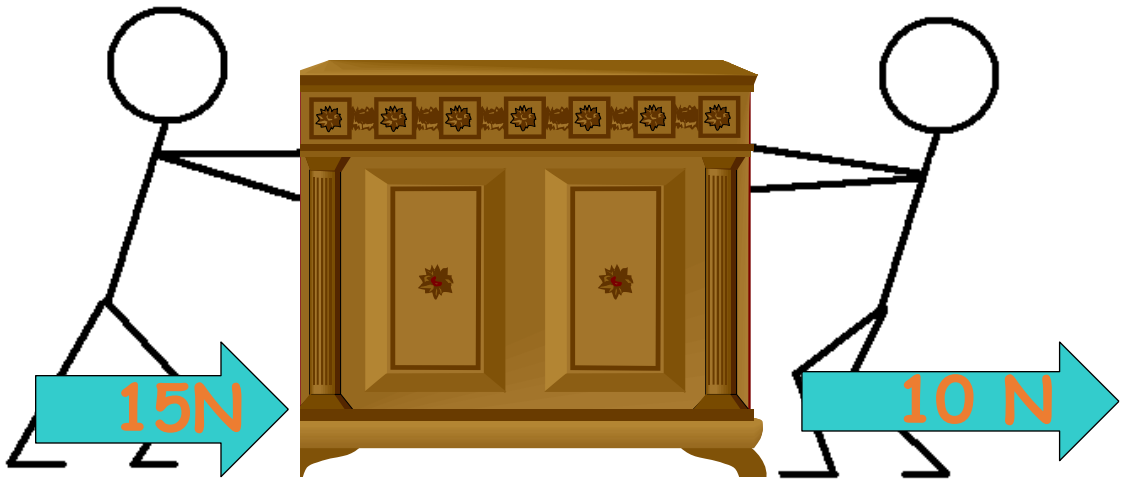
- It will change the **speed** or **direction** of the object.
- Example: Your little brother is riding his tricycle. You run up behind him and give him a push.
  - Your force adds to the existing force causing him to speed up.



Unbalanced forces can act in the same direction.

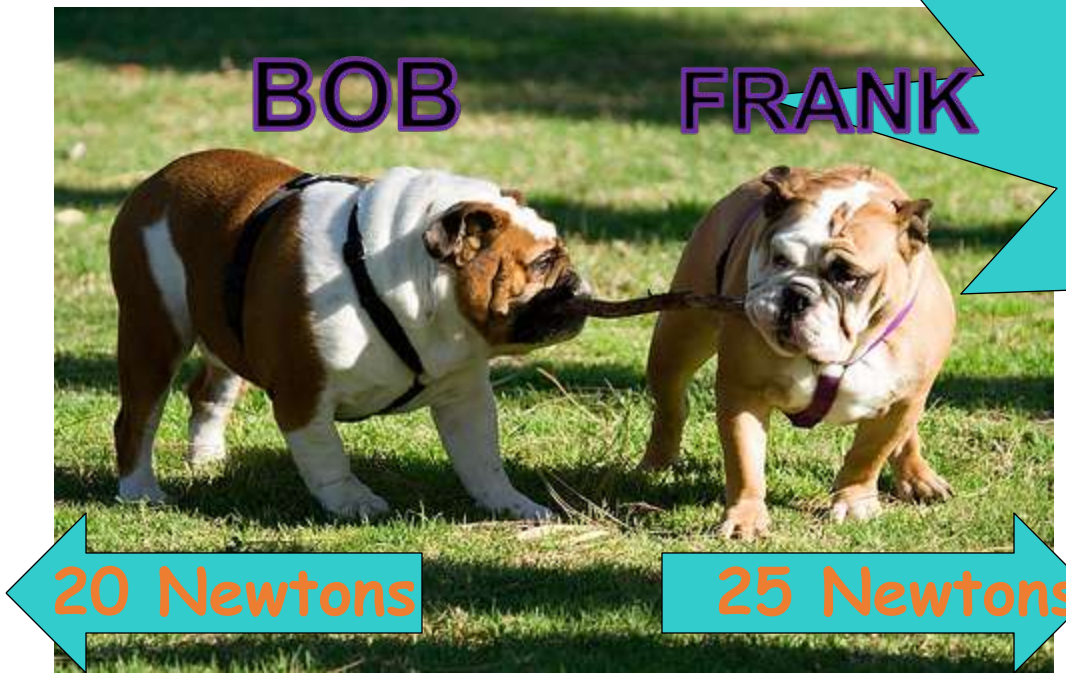
- Example: You're pushing a cabinet across the room with a force of 15 N. You're friend is pulling with a force of 10 N.
- What is the NET FORCE?
- What direction is the cabinet moving?

When two forces move in the same direction the forces are combined. Here the net force is 25N.



Unbalanced forces can act in opposite directions.

- Example: Two dogs are tugging on a rope. One dog pulls with a force of 20N and the other pulls with a force of 25N.
- What is the NET FORCE?
- What direction is the rope moving?



When you have opposing forces, the direction the object moves is in the same direction as the larger force.

Motion and Force

Motion: A change in the position of an object over time. A reference point enables a person to determine that something has moved or changed position.

*Remember Benny the beaver, we knew he moved because he got closer to our tree, the **reference point**.

ALL motion is caused by a force or forces.

Force: A force is a push or pull on an object causing a change in speed or direction.

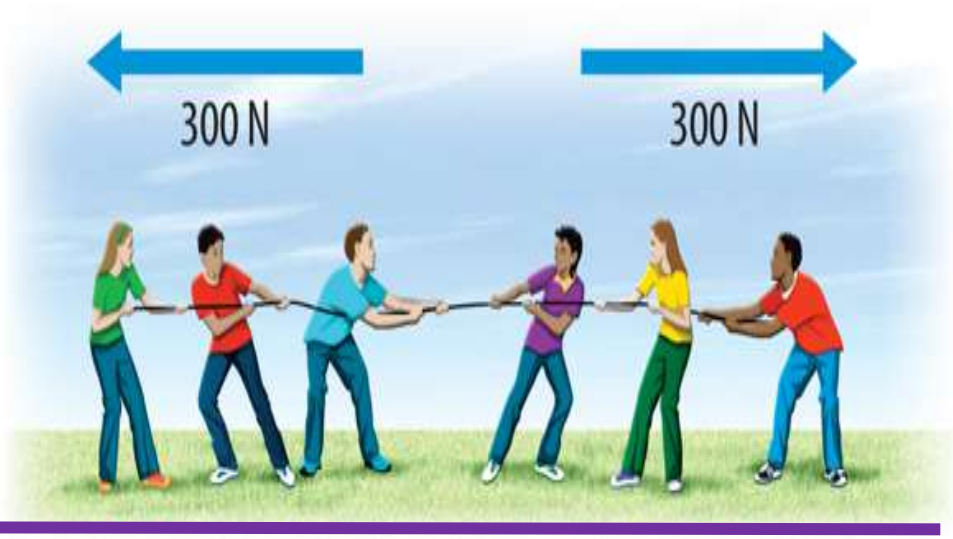
NET FORCE: The total combination of the forces acting on an object is called **NET FORCE**.

Opposites forces will take away from each other(counteract their force due to opposing direction); the larger forces newton's are always above the smaller forces newton's 50N- 40N= 10 N net force. Forces moving in the

Balanced and Unbalanced Forces

A Balanced Force: is a force in which the net force equals ZERO and there is NO MOTION.

300N of force opposing (-) 300N of force= 0N
A BALANCED force with NO MOTION



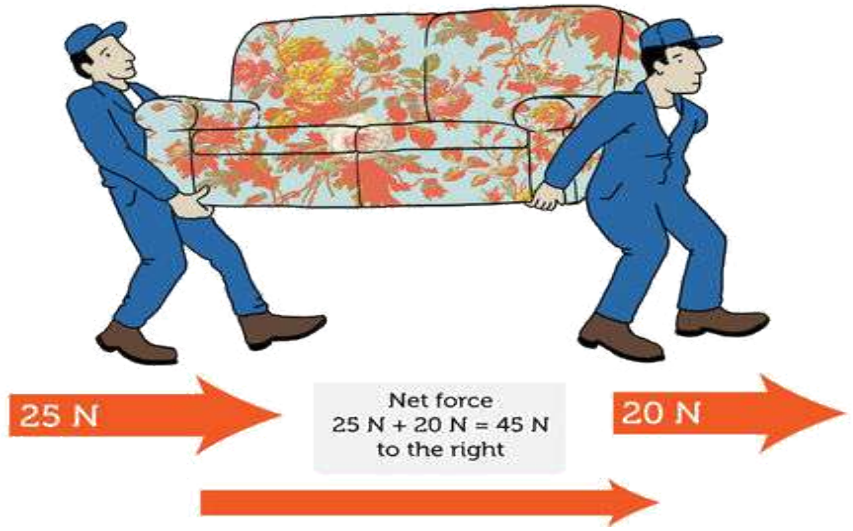
AN Unbalanced Force: is a force in which the net force is GREATER than (>) Zero causing motion.

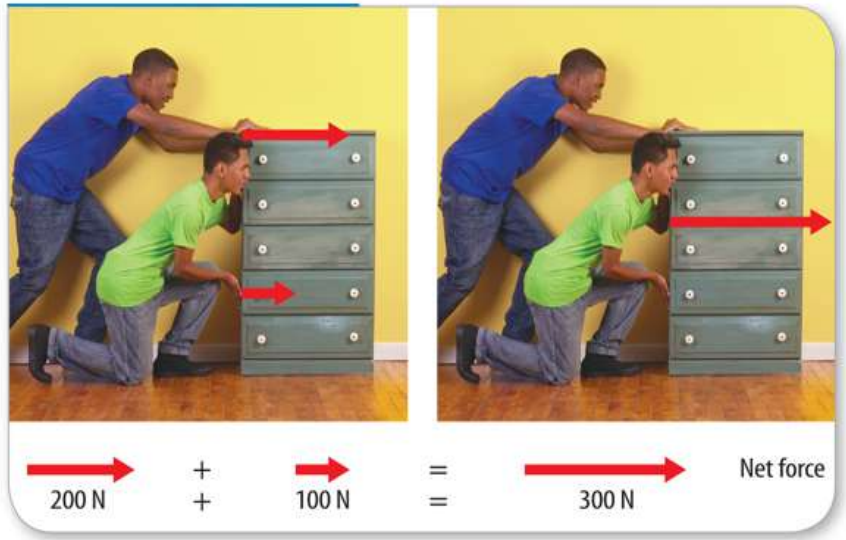
400N of force opposing (-) 300N of force= 100N an UNBALANCED force with MOTION going in the direction of the greater force in this case to the left or toward team A.

* Special information to remember about Unbalanced Forces

Unbalanced forces can act in the same direction. IF the forces are combining their efforts the Newton Force is combined (+) as well.

Unbalanced forces can be demonstrated if two people lift a couch or push a cabinet from the same side

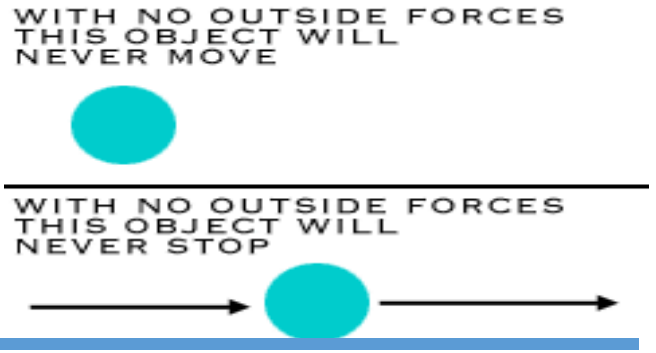




Newton's 3 Laws of Motion

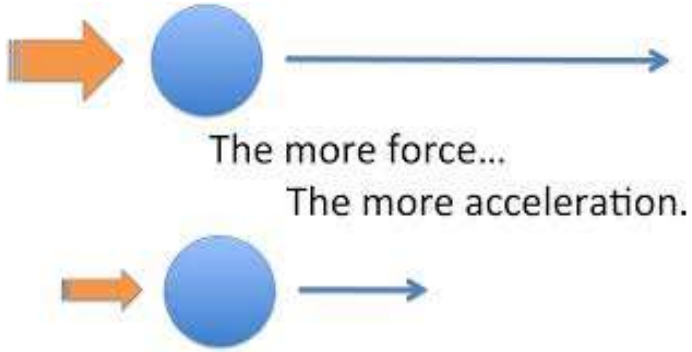
1st Law of Motion:

Things that are still stay still and things that are moving keep moving with a steady speed unless a force of some kind pushes or pulls on them.



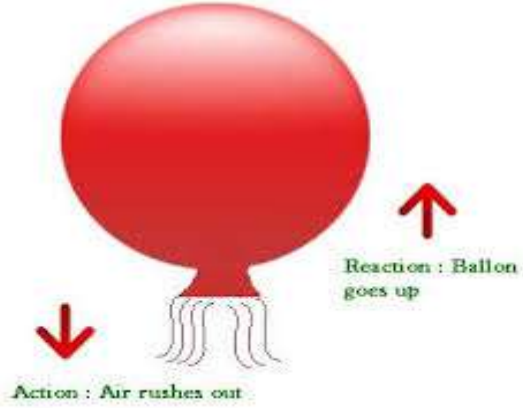
2nd Law of Motion:

When a force acts (pushes or pulls) on an object, it changes the object's speed or direction (in other words it makes the object accelerate). The bigger the force, the more the object accelerates.



3rd Law of Motion:

When a force acts on an object, there's equal force (called a reaction) acting in the opposite direction. This law is sometimes written that "actions are equal and opposite."



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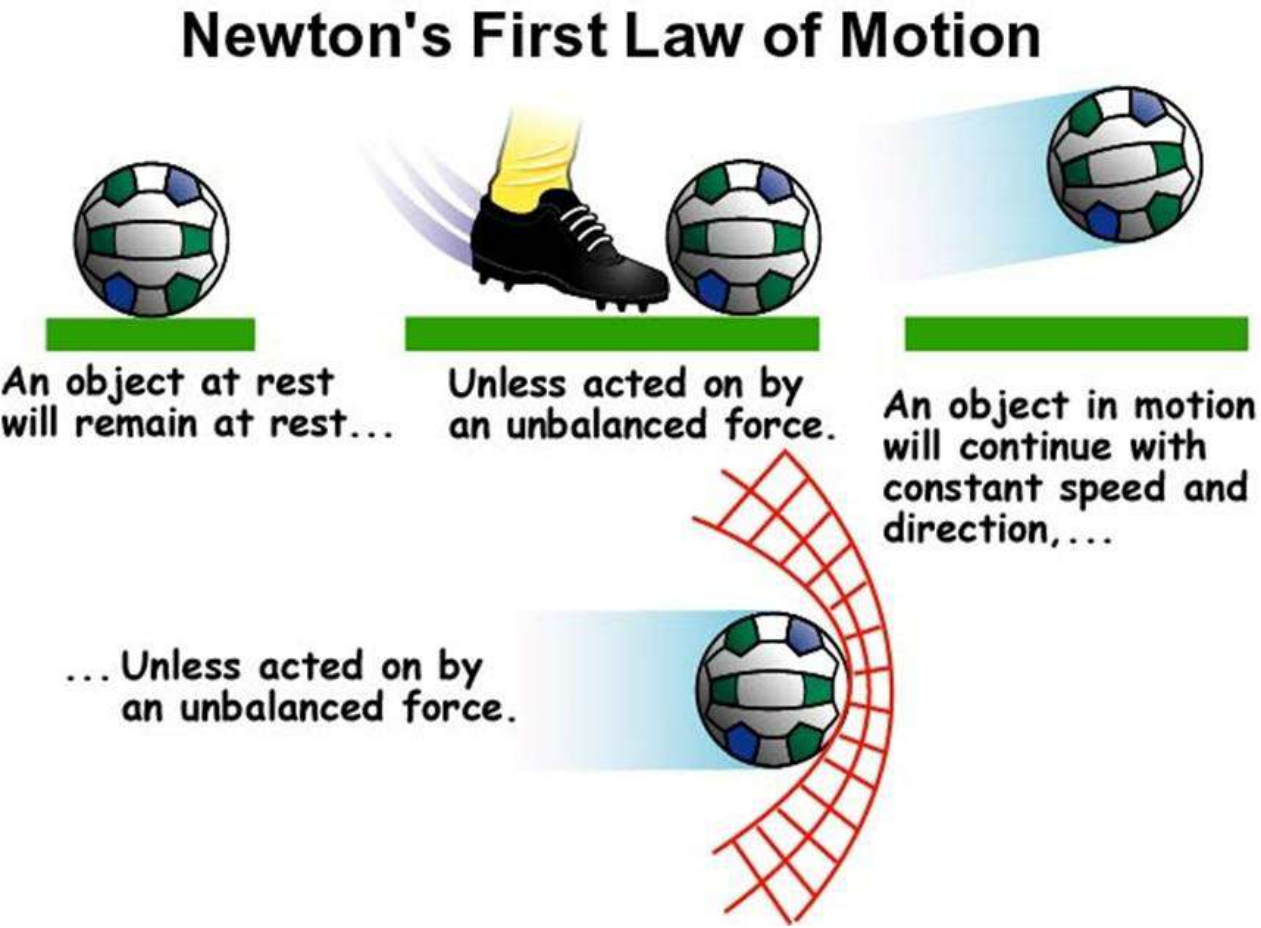

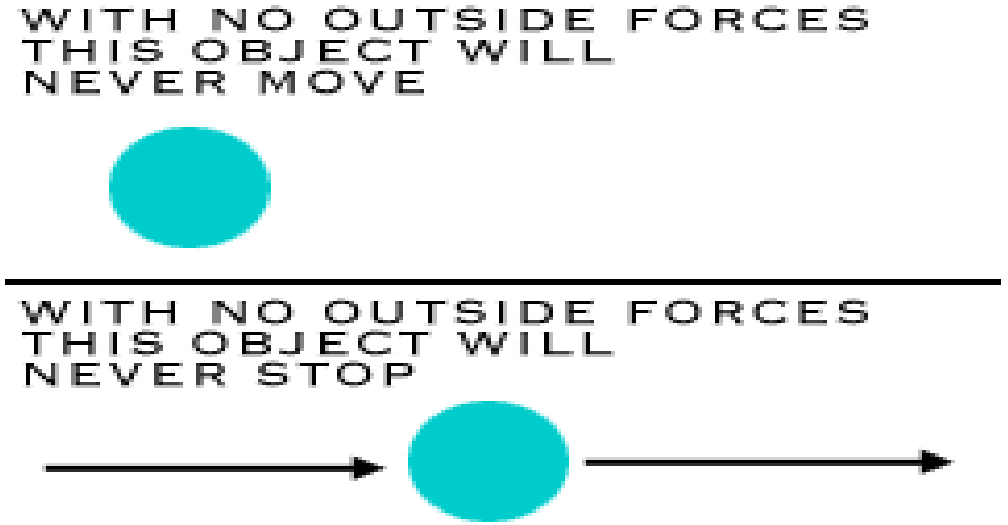

Mass and Inertia

- **Newton's 1st Law: The Law of Inertia**
  - An object at rest will remain at rest, unless acted upon by an unbalanced force
  - An object in motion will continue moving, in the same direction, at the same speed, unless an unbalanced force acts on it.

Inertia

- Inertia is the tendency of objects to resist a change in motion.
- Example: seatbelts!
- REMEMBER: Brain Pop

INERTIA

Your truck has brakes...the massive hunk of stone doesn't.

Mass and Inertia

- If a car is going 50 kilometers per hour and it comes to a sudden stop, the people inside continue moving 50 kilometers per hour unless a force prevents their forward motion through the windshield

Which is why WE wear SEATBELTS!!

Newton's 3 Laws of Motion

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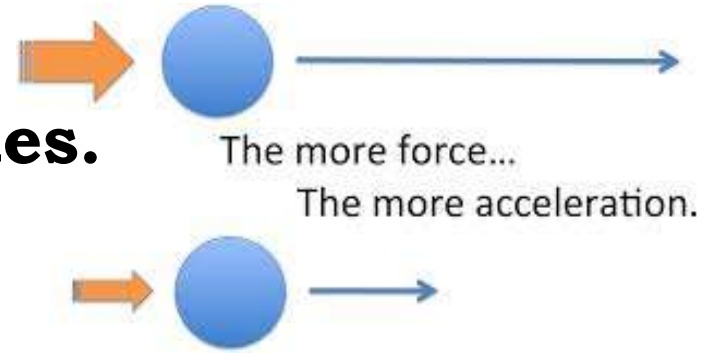
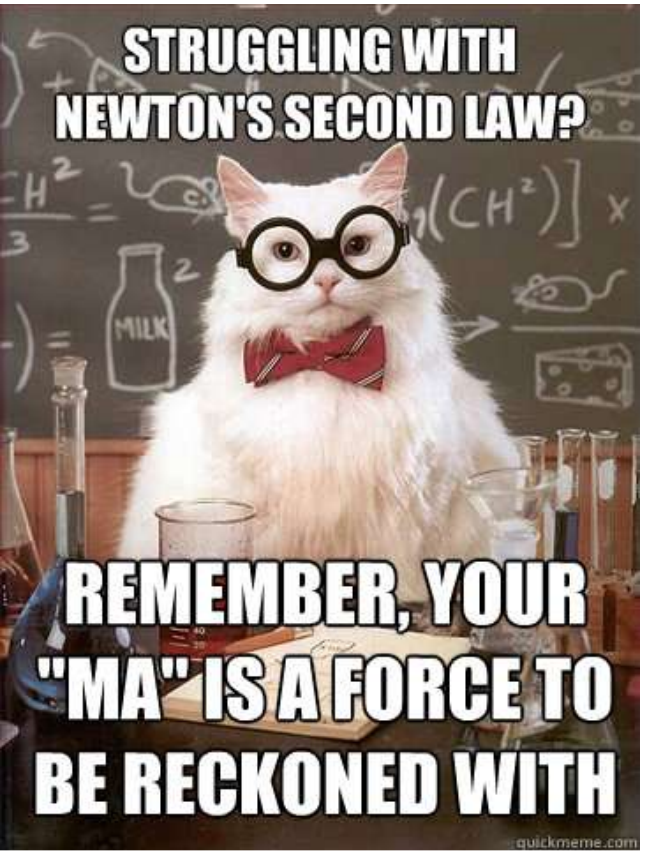
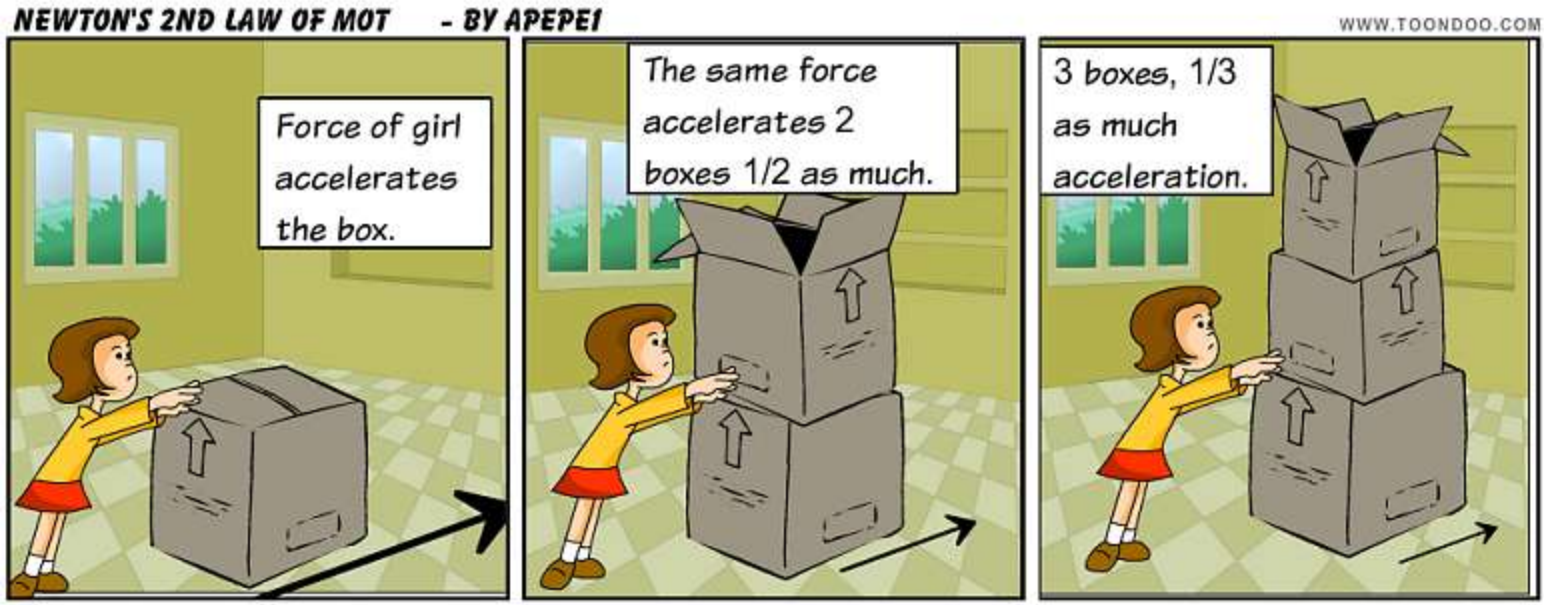
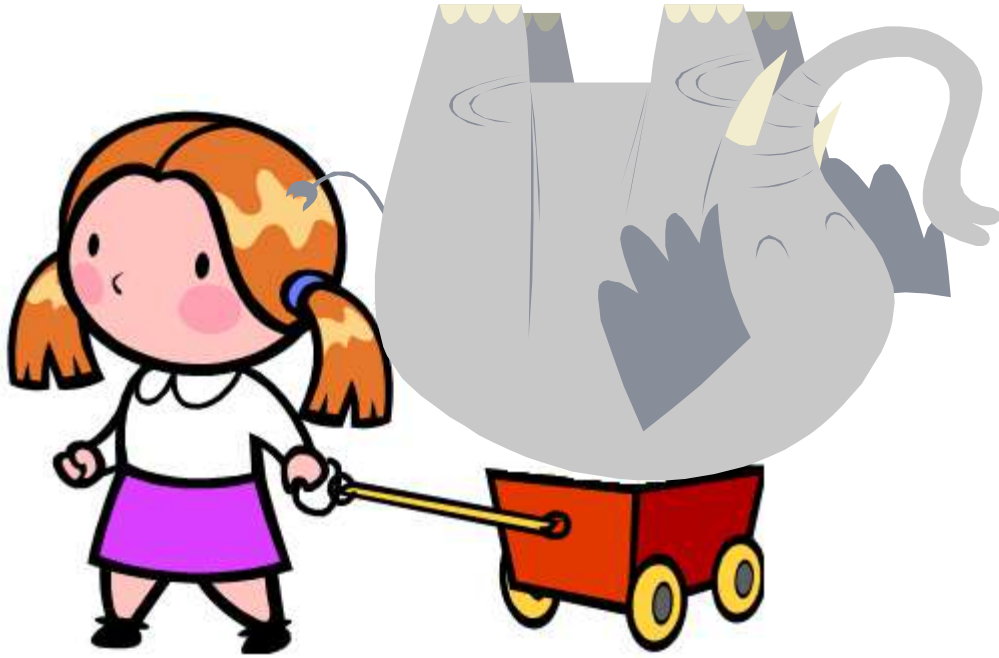






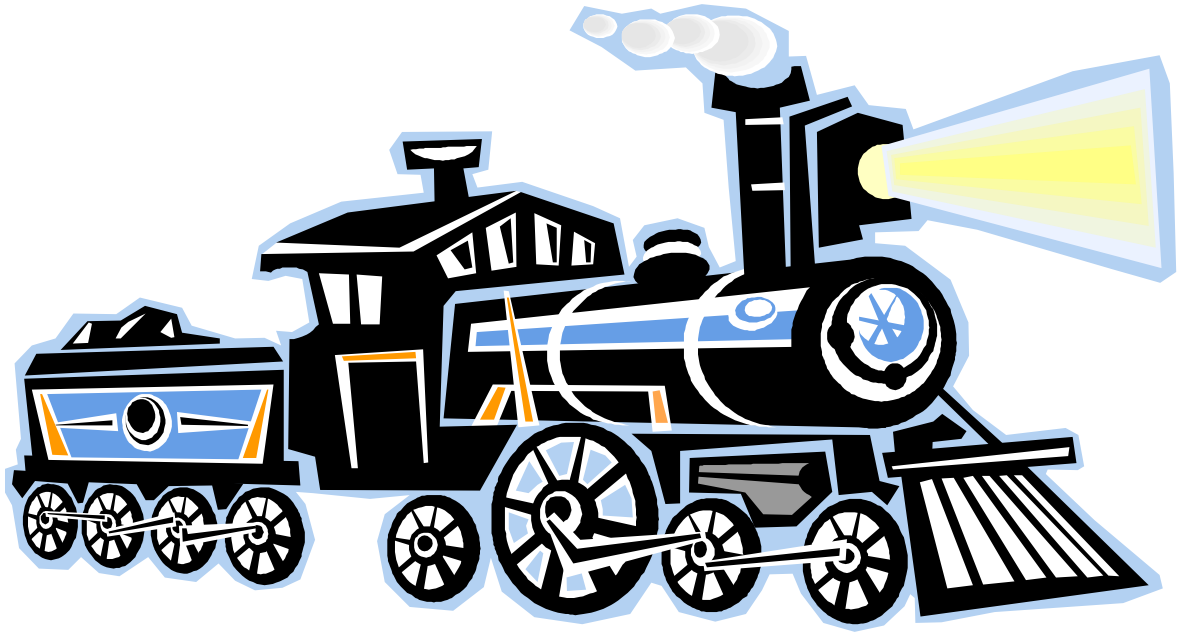
Mass

- The mass of an object affects its' inertia.
- Objects with more mass have more inertia than an object with a smaller mass.
  - It's harder to make a large object move or change the speed and direction of it when it's moving.



Another Example

- Train v. Car: Which will take longer to accelerate to 60 mph? Why?



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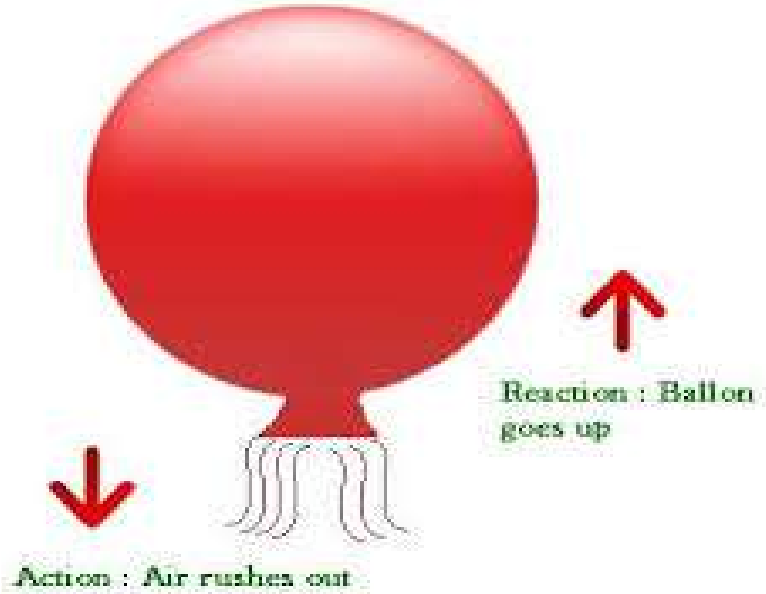
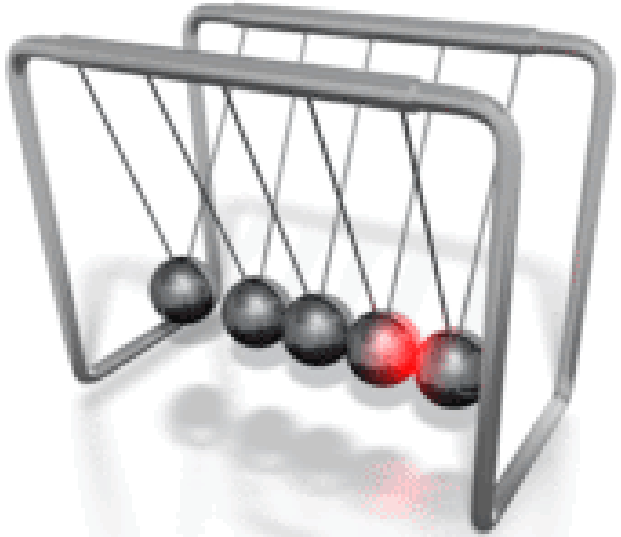
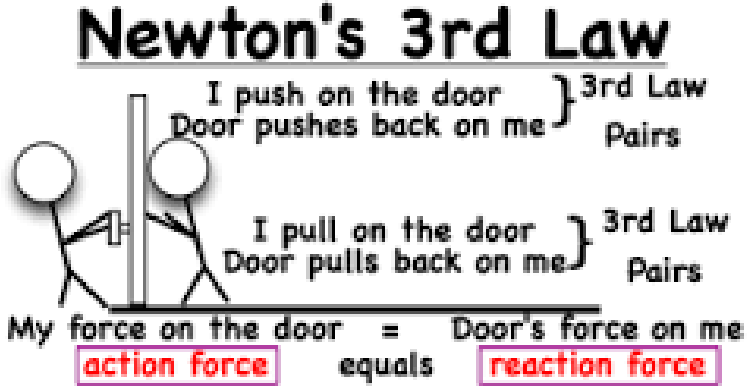






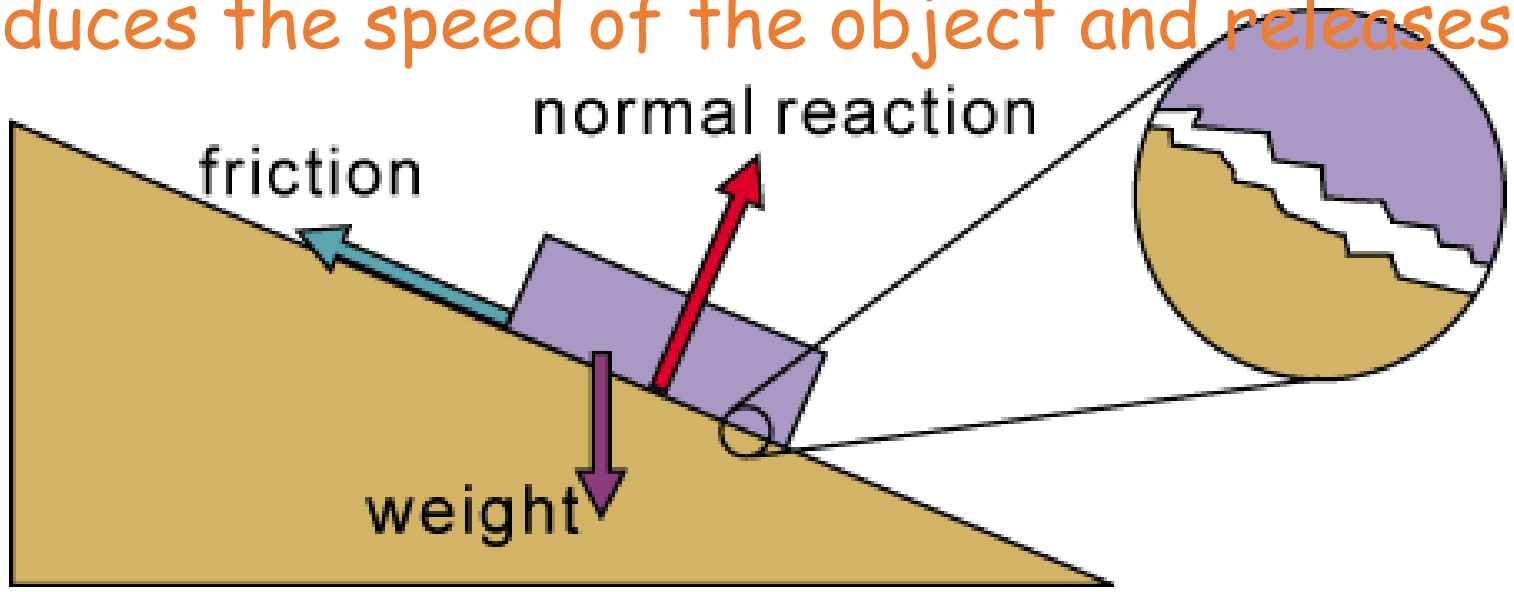
MAKE A CONNECTION

Friction and Gravity

- Two forces that can always affect
- the motion of an object are
- Friction
- Gravity

Friction and Gravity

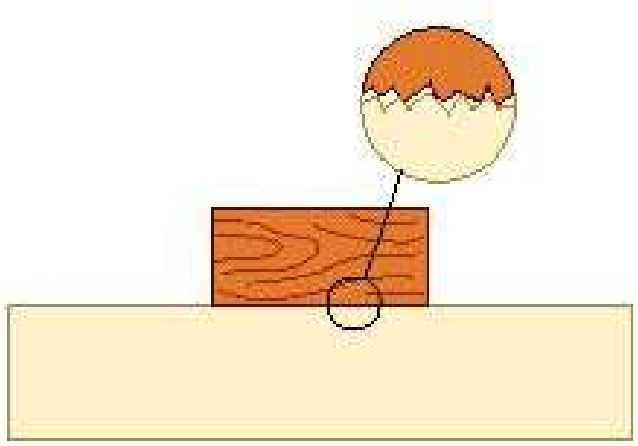
- What is friction?
  - A force that opposes the motion of an object
  - It's a "contact" force!
    - Occurs when an object in motion rubs against a surface.
    - The contact reduces the speed of the object and releases heat.



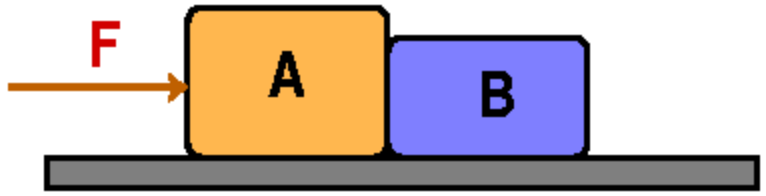
What affects the amount of friction?

- **The force of the push/pull**
  - The harder you push, the longer it's going to take friction to stop the object.

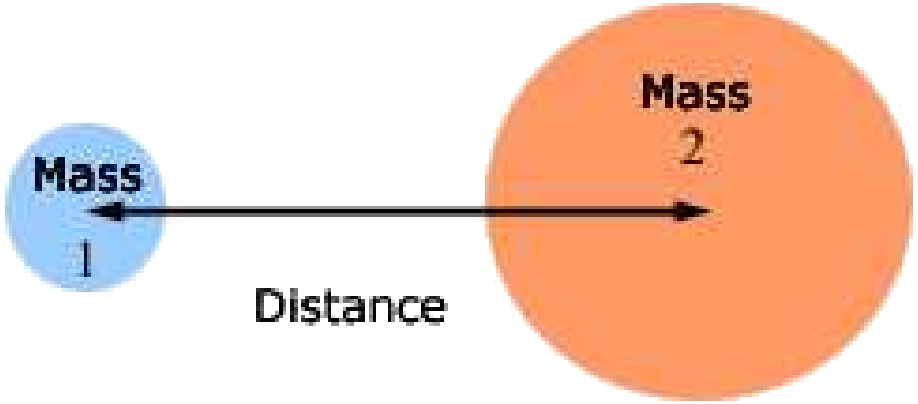
- **The roughness of the surface**
  - The rougher the surface, the more friction.



- **The weight of the object**
  - The heavier the object, the more friction.



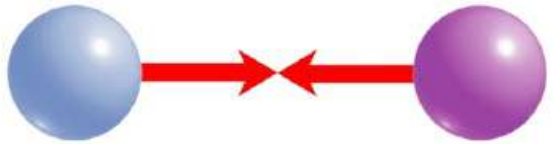
- **What is gravity?**
  - The force of attraction between all objects.
- **The amount of gravity depends on two things**
  - The objects' masses
  - The distance between the two objects



Gravity is a force that acts between any 2 masses.

Two factors affect the gravitational attraction between objects: mass and distance.

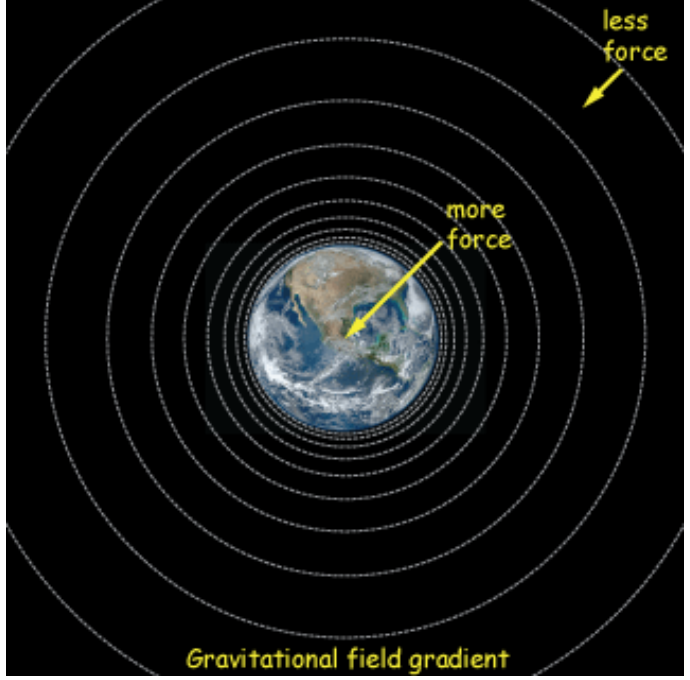
The force of gravity acts between all objects.

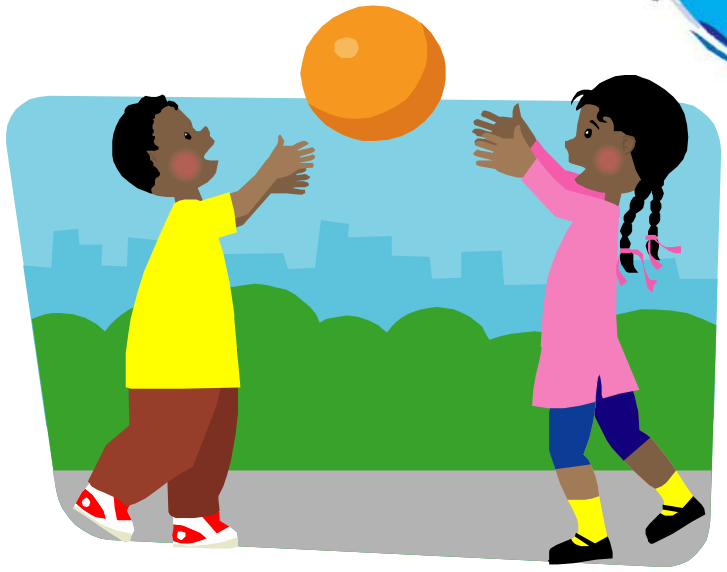


If mass increases, the force of gravity increases.

If distance increases, the force of gravity decreases.

- Since the earth is so large, everything on it is attracted to it even if they're not touching!
- Example: Throwing a ball.
  - You throw a ball up, but gravity pulls it back down to earth.
  - You can counteract gravity by catching the ball before it hits the ground (you provide the outside force!)



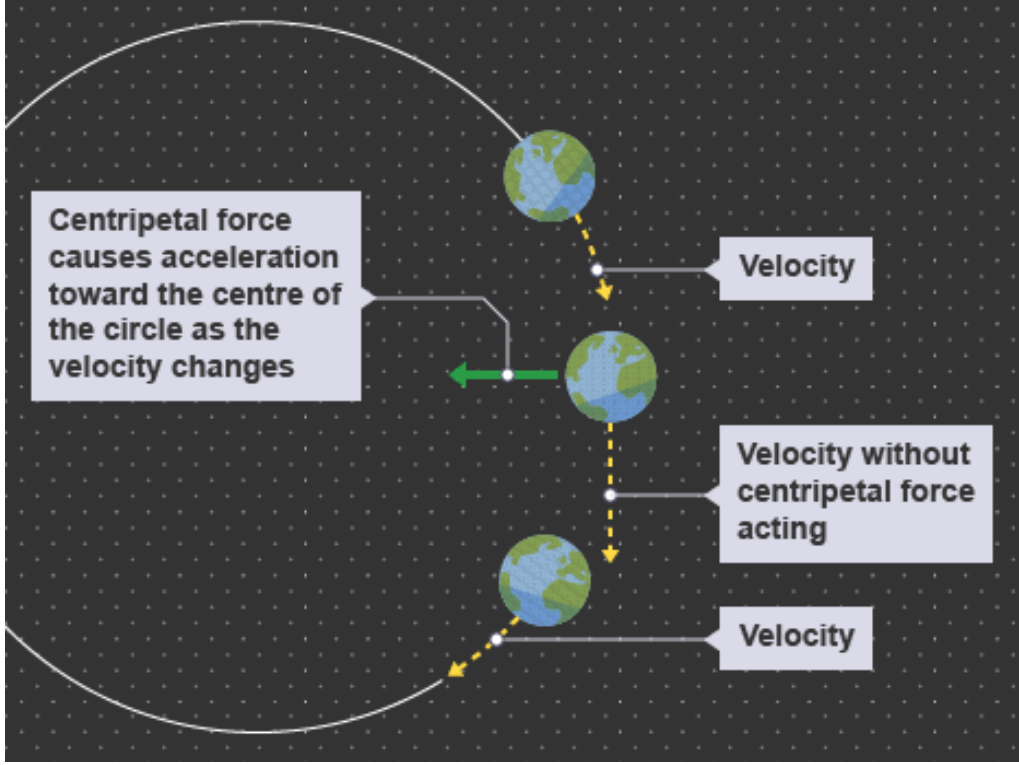


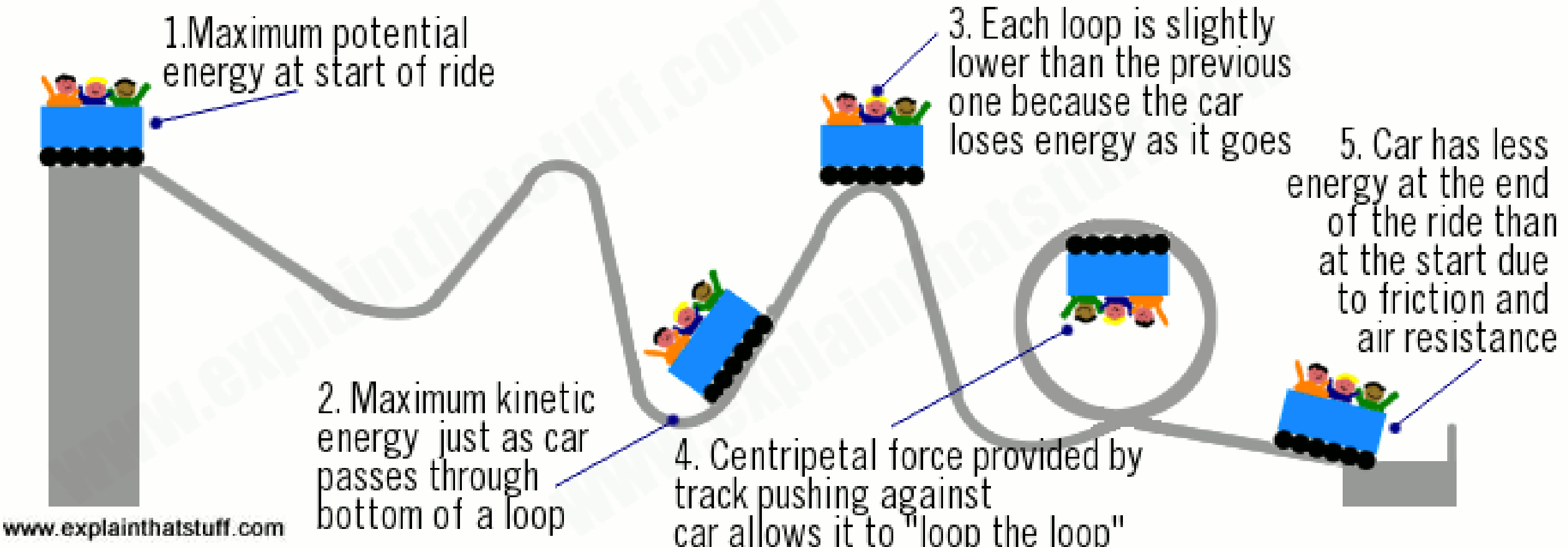
How something moves is called motion
Oooh
It's velocity, acceleration
Show you how it do
It can change if it's pushed or pulled
How something moves is called motion,
motion, motion
Oooh

An object moving in a circle is experiencing an acceleration. Even if moving around the perimeter of the circle with a constant speed, there is still a change in velocity and subsequently an acceleration. This acceleration is directed towards the center of the circle. And in accord with Newton's second law of motion, an object which experiences an acceleration must also be experiencing a net force.

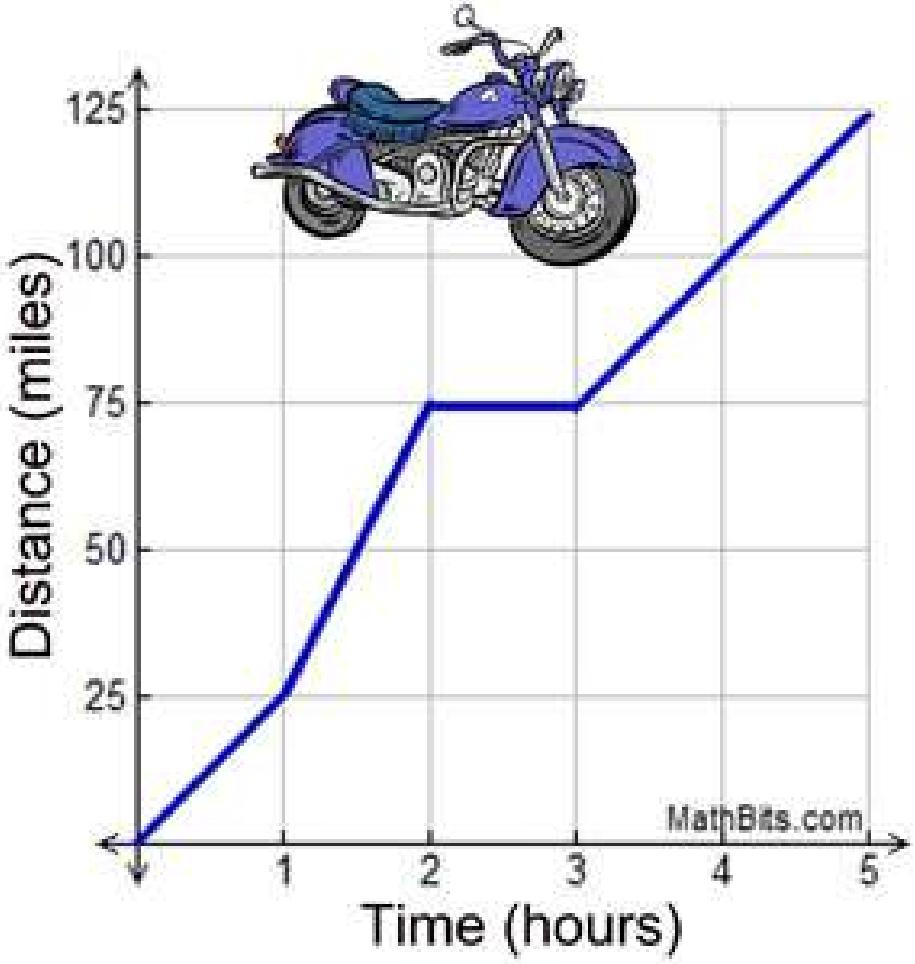
The direction of the net force is in the same direction as the acceleration. So for an object moving in a circle, there must be an inward force acting upon it in order to cause its inward acceleration.

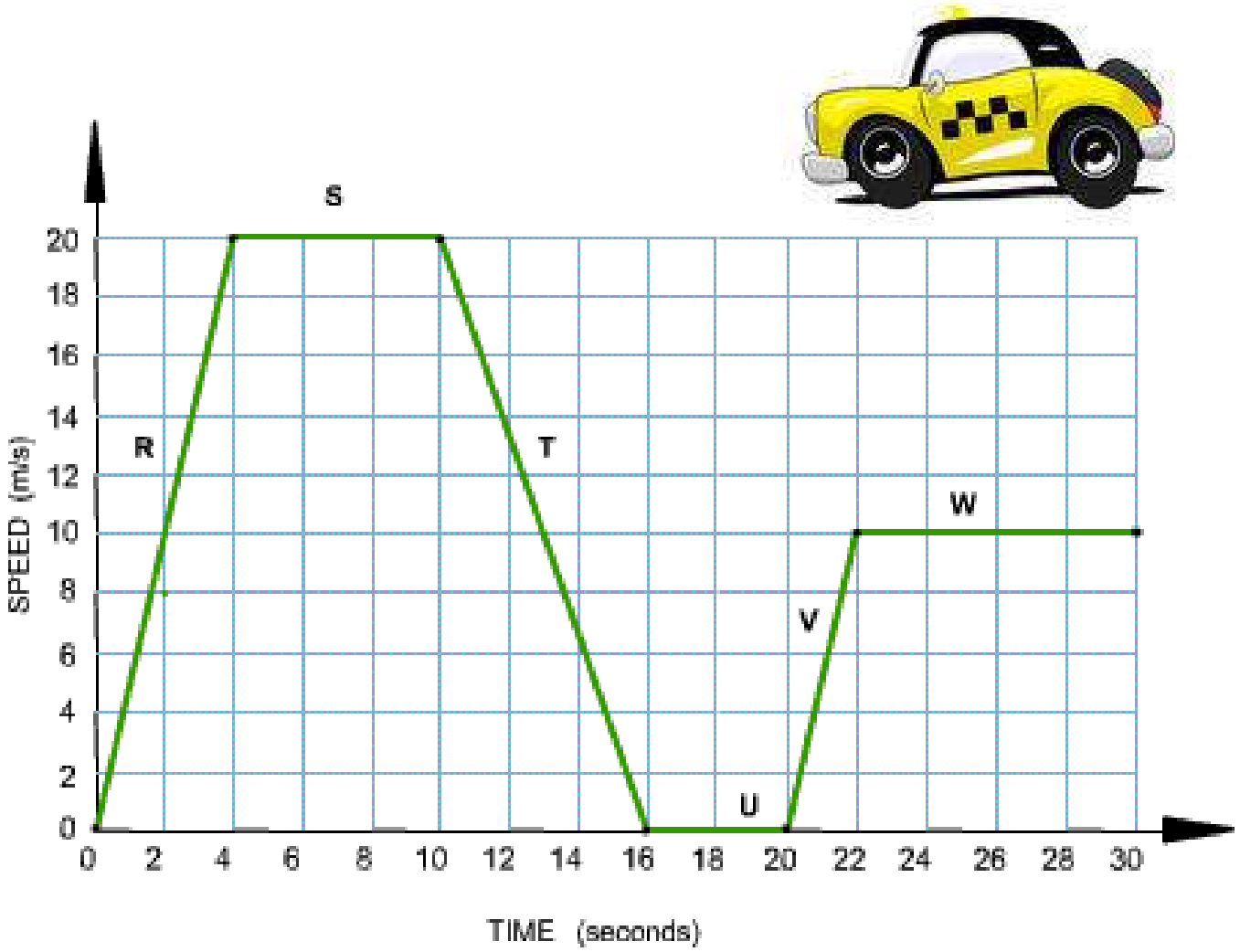
This is sometimes referred to as the **centripetal force requirement**. The word *centripetal* (not to be confused with *centrifugal*) means **center seeking**. For object's moving in circular motion, there is a net force acting towards the center



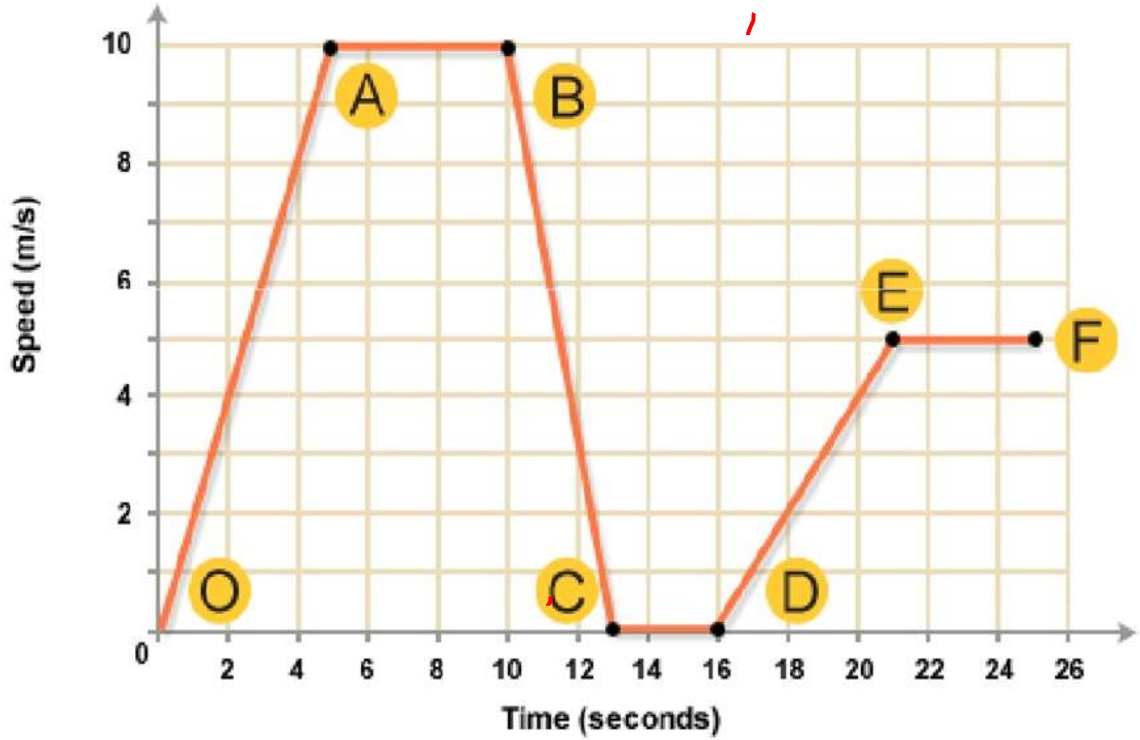

1.Maximum potential energy at start of ride
2. Maximum kinetic energy just as car passes through bottom of a loop
3. Each loop is slightly lower than the previous one because the car loses energy as it goes
4. Centripetal force provided by track pushing against car allows it to "loop the loop"
5. Car has less energy at the end of the ride than at the start due to friction and air resistance
www.explainthatstuff.com

MOTION GRAPHS





Graphs represent speeds of objects. This graph shows a bus as it travels its route.



Between what points is the bus accelerating? _____ & _____
Between what points is the bus moving at a constant speed?
_____ & _____
Between what points is the bus stopped? _____
Between what points it the bus decelerating? _____

Motion Graphs

Describing the motion of an object is occasionally hard to do with words. Sometimes graphs help make motion easier to picture, and therefore understand.

Remember:

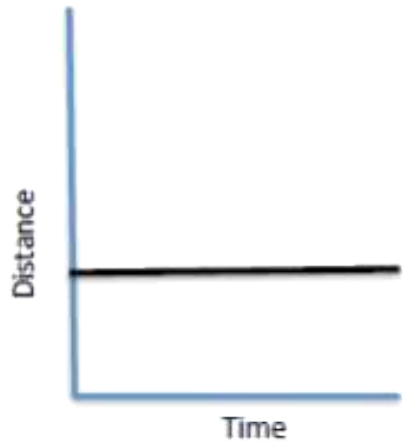
- **Motion** is a change in position measured by distance and time.
- **Speed** tells us the rate at which an object moves.
- **Velocity** tells the speed and direction of a moving object.
- **Acceleration** tells us the rate speed or direction changes.

Plotting distance against time can tell you a lot about motion. Let's look at the axes:

Time is always plotted on the X-axis (bottom of the graph). The further to the right on the axis, the longer the time from the start.

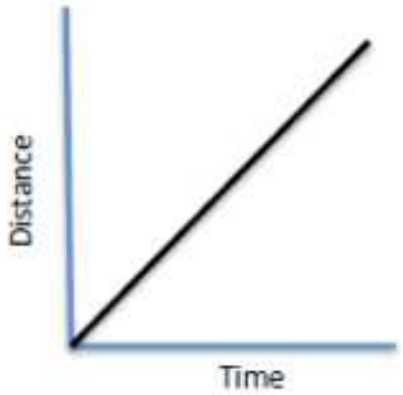
Distance is plotted on the Y-axis (side of the graph). The higher up the graph, the further from the start.

If an object is **not moving**, a horizontal line is shown on a distance-time graph.



Time is increasing to the right, but its distance does not change. It is not moving. We say it is **At Rest**.

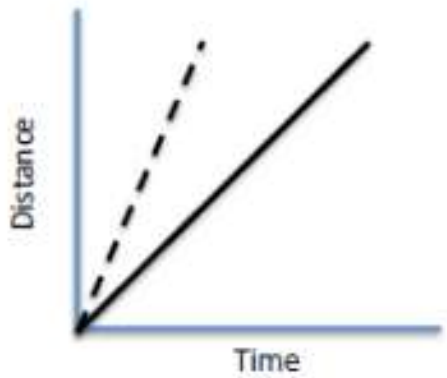
If an object is moving at a constant speed, it means it has the same increase in distance in a given time:



Time is increasing to the right, and distance is increasing constantly with time. The object moves at a **constant speed.**

Constant speed is shown by straight lines on a graph.

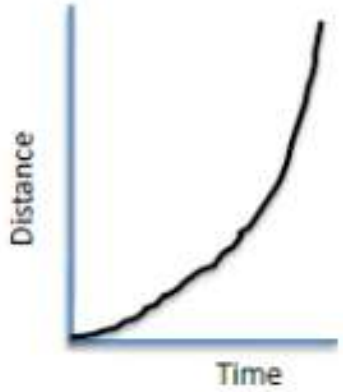
Let's look at two moving objects:
Both of the lines in the graph show that each object moved the same distance, but the steeper dashed line got there before the other one:



A steeper line indicates a larger distance moved in a given time. In other words, **higher speed.**

Both lines are **straight**, so both speeds are **constant.**

Graphs that show acceleration look different from those that show constant speed.



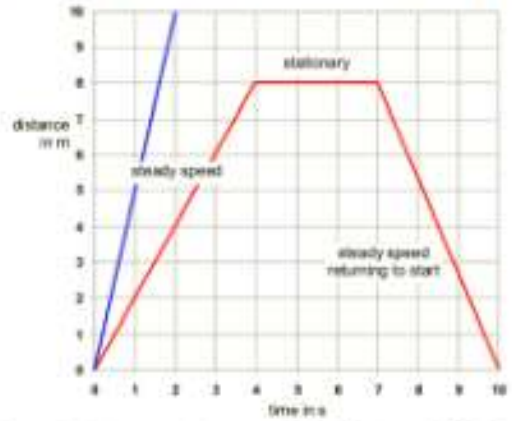
The line on this graph is curving upwards. This shows an **increase in speed**, since the line is getting steeper:

In other words, in a given time, the distance the object moves is change (getting larger). It is **accelerating.**

Summary:

A distance-time graph tells us how far an object has moved with time.

- The steeper the graph, the faster the motion.
- A horizontal line means the object is not changing its position - it is not moving, it is at rest.
- A downward sloping line means the object is returning to the start.



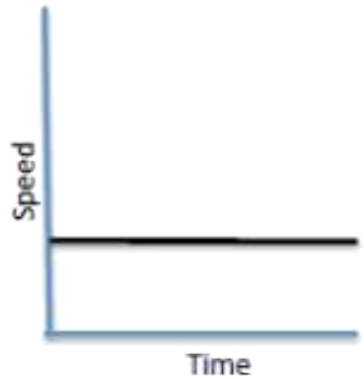
SPEED-TIME GRAPHS

Speed-Time graphs are also called Velocity-Time graphs.

Speed-Time graphs look much like Distance-Time graphs. Be sure to read the **labels**!! Time is plotted on the X-axis. Speed or velocity is plotted on the Y-axis.

A straight horizontal line on a speed-time graph means that speed is **constant**. It is **not changing** over time.

A straight line does not mean that the object is not moving!



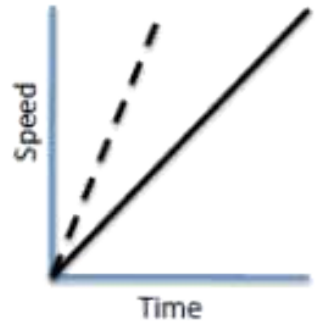
This graph shows increasing speed.

The moving object is **accelerating.**

This graph shows decreasing speed.

The moving object is **decelerating.**

What about comparing two moving objects at the same time?



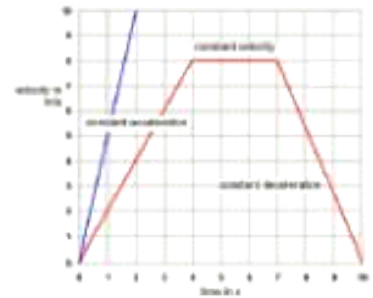
Both the dashed and solid line show increasing speed.
Both lines reach the same top speed, but the solid one takes longer.

The dashed line shows a greater acceleration.

Summary:

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 constant speed.
- A downward sloping line means the object is slowing down.

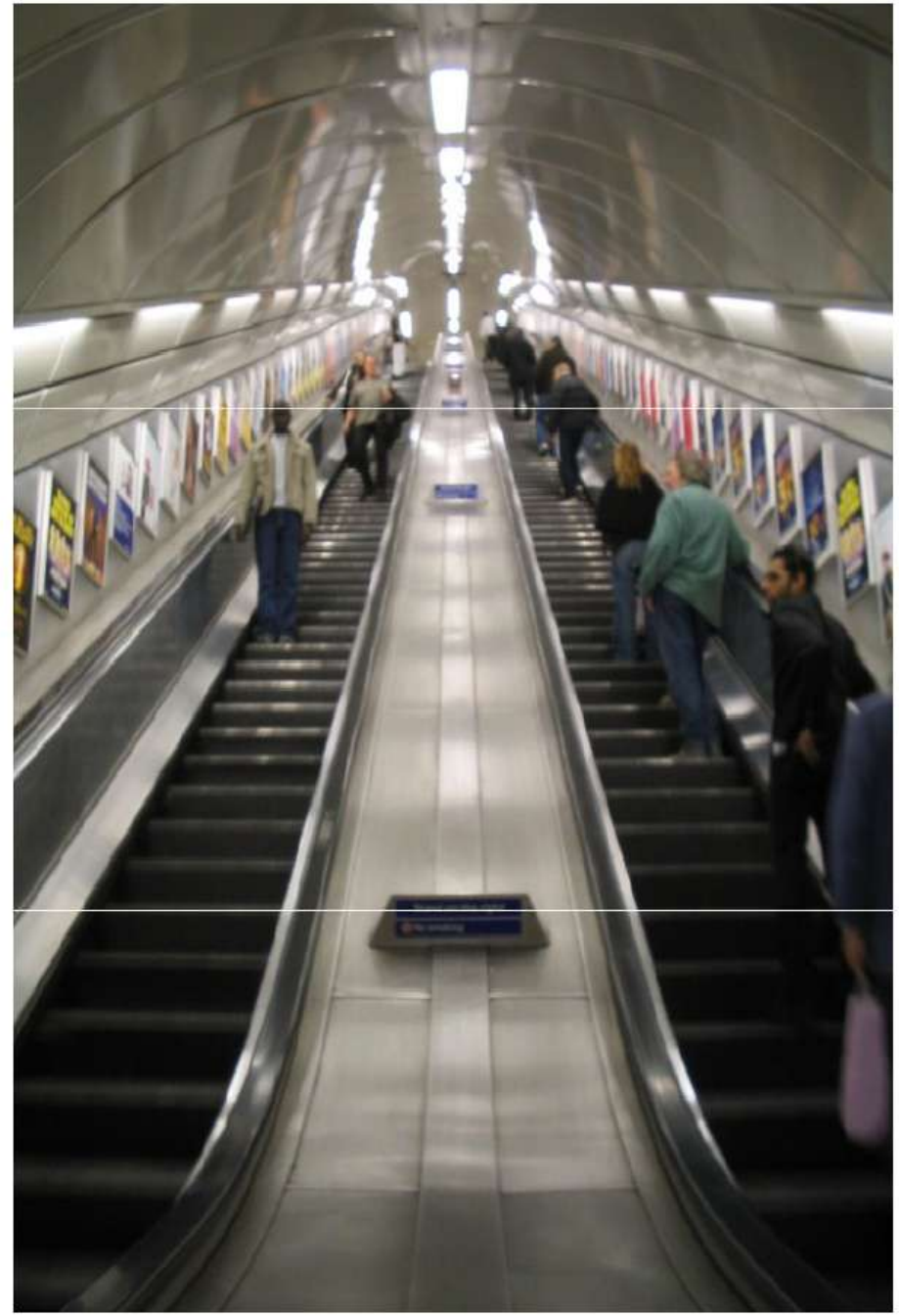


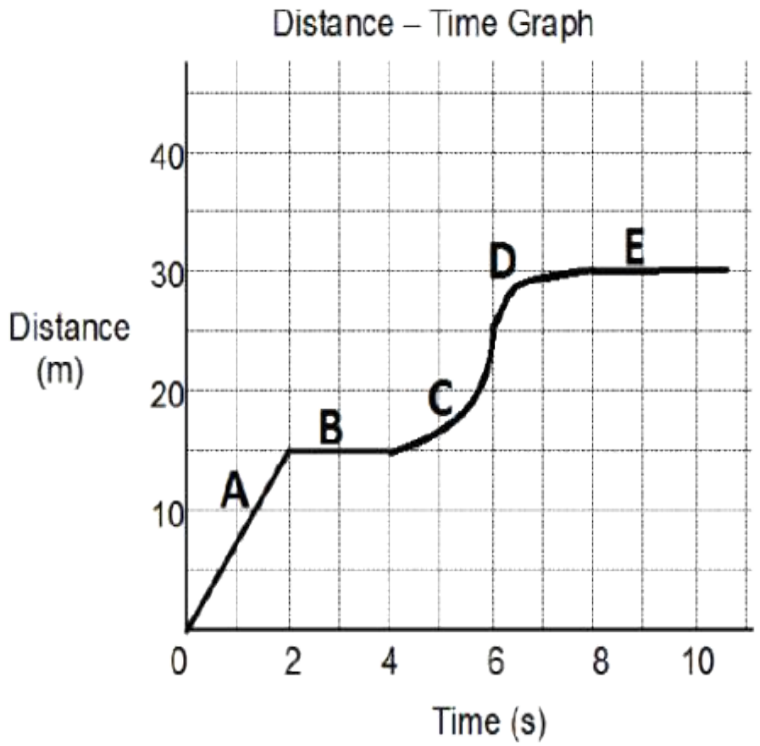
What is Velocity?

Velocity is a measure of the speed of an object AND the direction it is moving in space.

On the escalator, passengers are moving at the same constant speed, but they are moving in different directions.

Velocity can change even if speed is remaining constant (you just change direction)





1. What has happened at A? _____

2. What has happened at B? _____

3. What has happened at C? _____

4. What has happened at D? _____

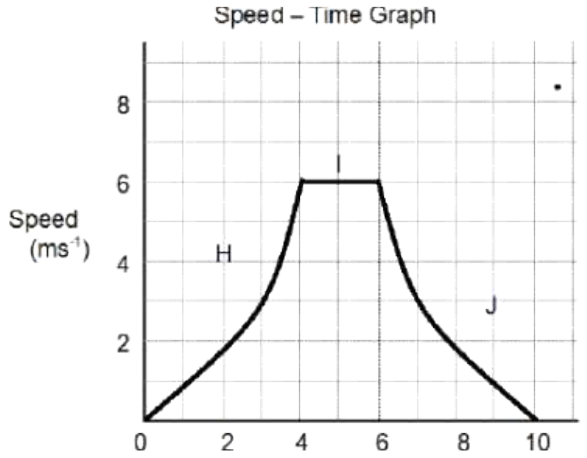
5. What has happened at E? _____

6. Calculate the speed at A?

_____

_____

_____



7. What has happened at H?

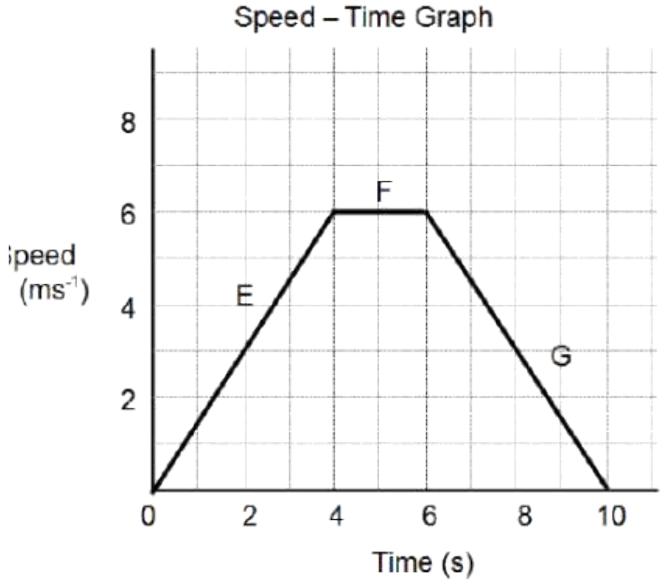
_____

8. What has happened at I?

_____

9. What has happened at J?

_____



10. What has happened at E?

_____

11. What has happened at F?

_____

12. What has happened at G?

_____

13. Calculate the acceleration at E.

_____

_____

_____

_____

_____

_____

_____

_____

14. Calculate the distance travelled during the 10 second journey. (*hint* area under the line)

_____

_____

1. Newton's first law or motion states that an object in _____ stays in _____ and an object at _____ stays at _____.

2. This Law is also called the law of what?

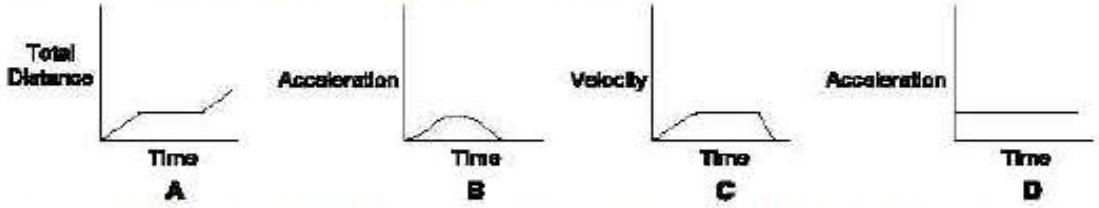
3. Newton's second law can be described by a formula. What formula is it?

4. Newton's third law explains what?

Multiple Choice:

A driver starts her car and steps on the gas pedal. The car gradually accelerates to 50 km/hr. A few minutes later, the driver suddenly slams on the brakes to avoid hitting a box in the road. As the car comes to a stop, the driver's body appears to lurch forward in the seat until it is restrained by the seatbelt.

Use the following graphs to answer the next two questions.

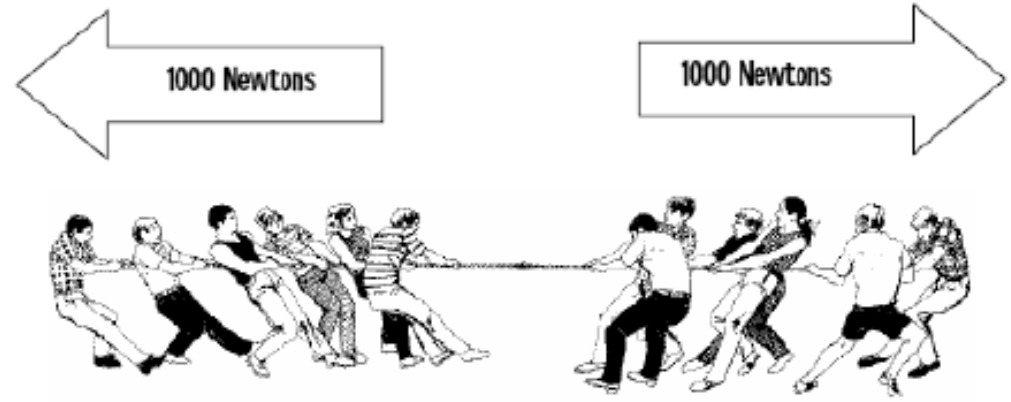


5. Which graph **best** matches the motion of the car described in the paragraph above?

   a. Graph A
   b. Graph B
   c. Graph C
   d. Graph D

6. A student rides her bicycle from her home to the library. She stays there for a while and then goes to a friend's house. Which graph **best** matches this situation?

   a. Graph A
   b. Graph B
   c. Graph C
   d. Graph D



8. **Circle the best answer:**

a. The forces shown above are **PUSHING / PULLING** forces.
b. The forces shown above are **WORKING TOGETHER / OPPOSITE FORCES**.
c. The forces are **EQUAL / NOT EQUAL**.
d. The forces **DO / DO NOT** balance each other.
e. The resultant force is **1000 N TO THE RIGHT / 1000 N TO THE LEFT /ZERO**.
f. There **IS / IS NO** motion.

Balanced and Unbalanced Forces:

9. **15N** ⇨ [ ] ⇦ **30 N**

Net Force: _____ Type of Force _____

10. **10 N** ⇦ [ ] ⇨ **10 N**

Net Force: _____ Type of Force _____

Forces make things _____ up, slow down or change _____. Without a force a still object remains still & a moving object would keep moving

Forces are constantly battling each other. Unbalanced forces move and balanced forces don't.

The more **mass** something has, the _____ force required to move it. Circle the cart that requires the *most* force to move

Gravity vs. _____

A push vs. friction and _____

A _____ vs. friction

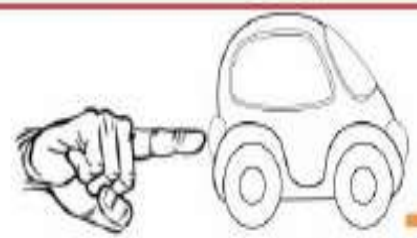
Push vs.

Types of Forces

- Magnetic force
- Pushes and _____
- Gravity
- Air resistance
- _____

Friction opposes motion between two _____ objects. Friction slows things down. Circle the

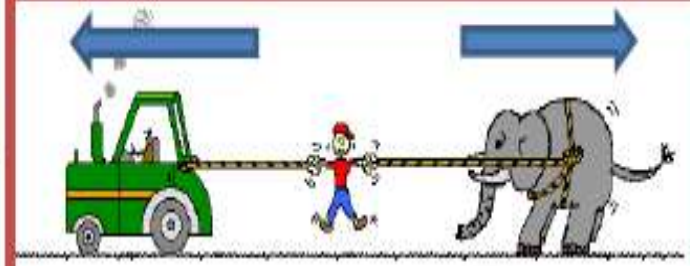
The more force that is applied, the _____ the _____ object will go. Circle the car that will *not* go as far.



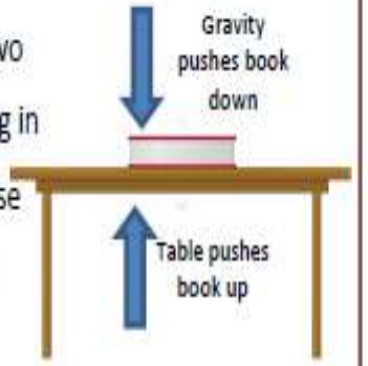
Unbalanced forces happen when one side has _____ force in one direction. This will cause the object to _____ in the direction the greater force is going.

picture with the *least* amount of friction. _____

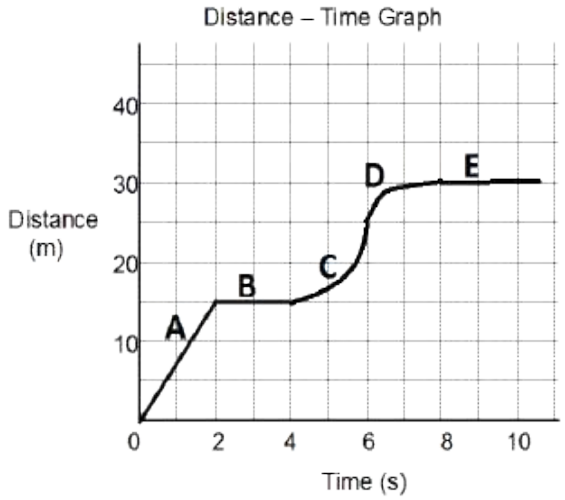
Gravity pulls everything toward _____. The more mass something has the more gravity acts on it. If you drop a bowling ball and a beach ball off a building, the _____ ball would hit the ground first because it has more _____.



Balanced forces are two _____ forces acting in opposite direction. Because it is balanced the object does_____move.

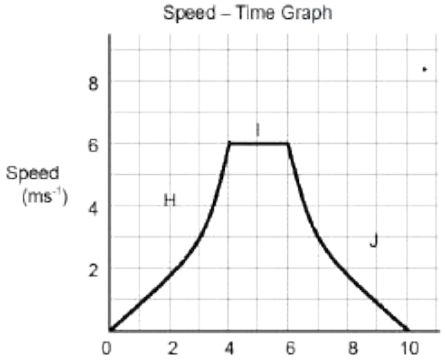


Answers

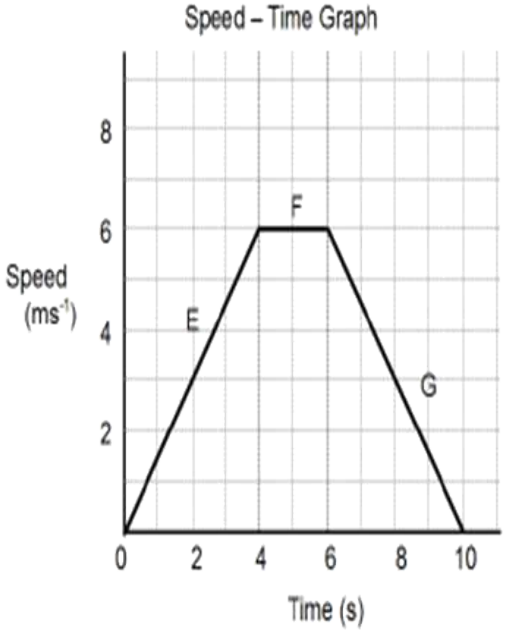


1. What has happened at A? Constant Speed
2. What has happened at B? stopped
3. What has happened at C? acceleration
4. What has happened at D? deceleration
5. What has happened at E? stopped
6. Calculate the speed at A?

Gradient = rise/run = 15m/2s = 7.5 ms^{-1}



7. What has happened at H?
   increasing acceleration
8. What has happened at I?
   constant speed (6ms^{-1})
9. What has happened at J?
   decreasing acceleration



10. What has happened at E?
    constant acceleration
11. What has happened at F?
    constant speed (6ms^{-1})
12. What has happened at G?
    constant deceleration
13. Calculate the acceleration at E.

Gradient = acceleration = rise/run

Acceleration = 6ms^{-1}/4s = 1.5 ms^{-2}

14. Calculate the distance travelled during the 10 second journey. (*hint* area under the line)

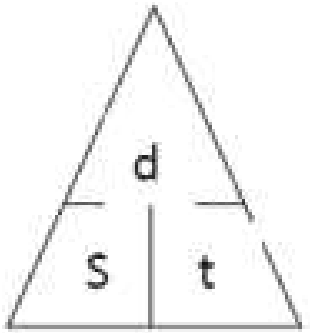
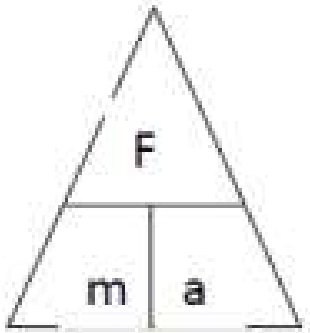
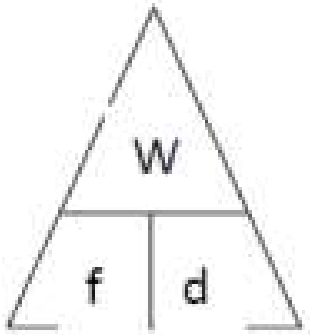
E = ½ x b x h
E = ½ x 4 x 6
E = 12 m

F = l x w
F = 6 x 2
F = 12 m

G = ½ x b x h
G = ½ x 4 x 6
G = 12 m

d = 12m + 12m + 12m

d = 36 m

Average Speed = $\frac{\text{total distance}}{\text{time}}$	$S = \frac{d}{t}$		A car travels at an average speed of 50mph on the highway to Austin, which is 200 miles away. How long did it take to get there? $t = d/s$ **200mi/50mph = 4 hours**
Net force = (mass)(acceleration)	$F = ma$		Calculate the force on a 500kg object accelerating at $3m/s^2$ $F = m \times a$ **$500kg \times 3m/s^2 = 1500N$**
Work = (force)(distance)	$W=Fd$		The work done on an object is 300J. Calculate the distance of the object if a force of 40N was applied. $d = W/f$ **300J/40N = 75m**