NEWTON'S LAWS OF MOTION

LET US DEFINE!

- MOTION- a change with time of the position or orientation of the body.
- MASS- a measure of the amount of matter in an object.
- INERTIA- the tendency of an object to resist changes in its state of motion.
- Vector – show magnitude and direction

LET US DEFINE!

- ACCELERATION- a change in velocity, a measurement of how quickly an object changing speed, and direction.
- VELOCITY- The range of change of a position along straight line with respect to time.
- FORCE - push or pull; required to change an object's motion.

TYPES OF FORCES

FORCE

- A force is a push or pull on an object.
- An object or a person can apply a force to another object.
- Some forces are applied only when objects touch. Other forces are applied even when objects do NOT touch.
- The two types of forces are contact and noncontact forces.

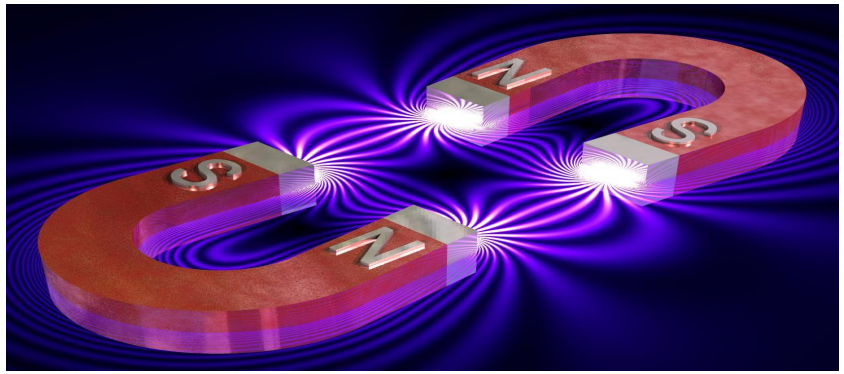
TYPES OF FORCE

CONTACT FORCE

- A contact force is a push or a pull on one object by another that is touching it.
- Contact forces can be weak or strong.

NON-CONTACT FORCE

- A noncontact force is a force that one object can apply to another object without touching it.
- Gravity, magnetism and electric force are noncontact forces.

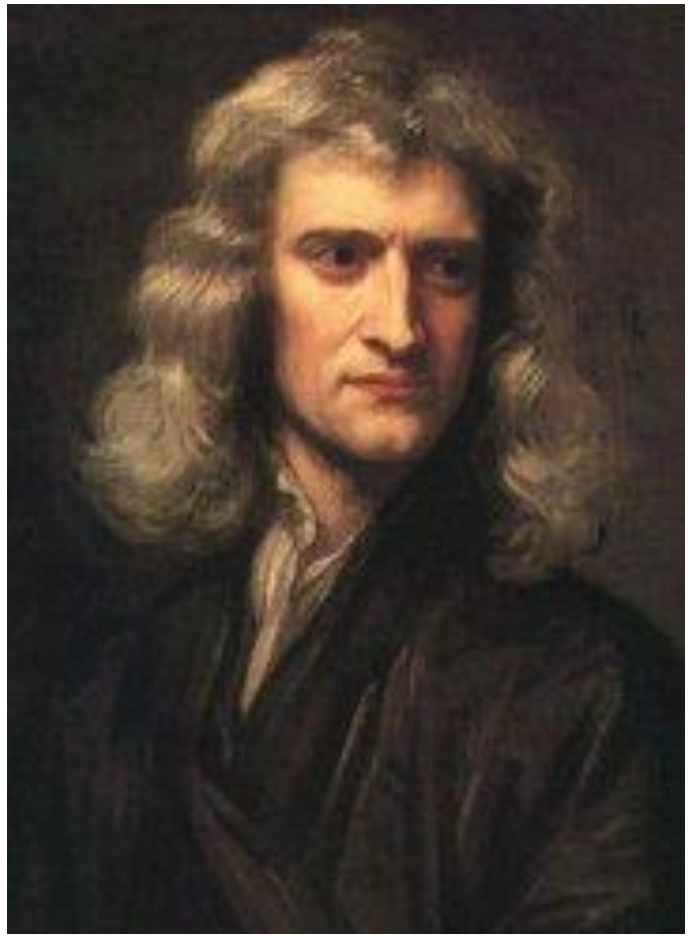


THREE LAWS OF MOTION

WHO WAS THE MAN BEHIND THE LAWS OF MOTION?

BACKGROUND

- Sir Isaac Newton (1643-1727)
- an English scientist and mathematician famous for
- his discovery of the law of
- gravity also discovered the
- three laws of motion.



- Today these laws are known as Newton's Laws of Motion and describe the motion of all objects on the scale we experience in our everyday lives.

FIRST LAW OF MOTION

INERTIA: the tendency of an object to resist changes in its state of motion

The First Law states that all objects have inertia. The more mass an object has, the more inertia it has (and the harder it is to change its motion).

"An object at rest tends to stay at rest and an object in motion tends to stay in motion unless acted upon by an unbalanced force."

WHAT DOES IT MEAN?

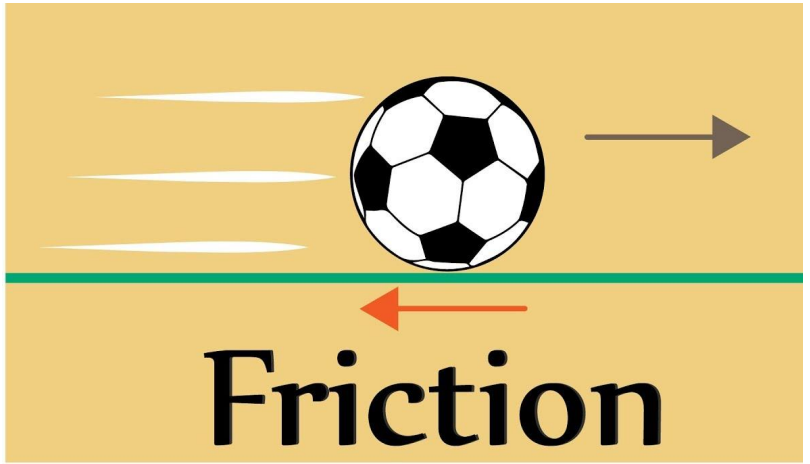
- Basically, an object will “keep doing what it was doing” unless acted on by an unbalanced force.

- If the object was sitting still, it will remain stationary. If it was moving at a constant velocity, it will keep moving.

- It takes force to change the motion of an object.

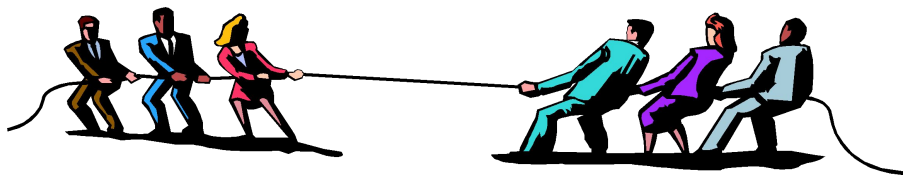
WHY DO OBJECTS STOPS MOVING?

- Friction and inertia affect an object's movement.
- An object will stop moving because of friction or if another force acts on it.
- An object will keep moving at the same speed in the same direction do to inertia. However, this is only if friction does NOT exist.
- On Earth, friction can be reduced but not totally removed.



REAL LIFE EXAMPLES

A soccer ball is sitting at rest. It takes an unbalanced force of a kick to change its motion.



Two teams are playing tug of war. They are both exerting equal force on the rope in opposite directions. This balanced force results in no change of motion.

REAL LIFE EXAMPLES

A book sliding across a table slows down and stops because of the force of *friction*.

If you throw a ball upwards it will eventually slow down and fall because of the force of *gravity*.

SECOND LAW OF MOTION

Force equals mass times acceleration.

$$F = ma$$

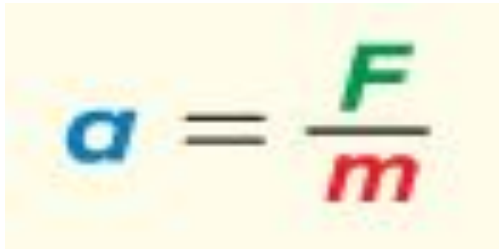
Acceleration: a measurement of how quickly an object is changing speed.

WHAT DOES IT MEAN?

- Acceleration of an object is equal to the net force acting on the object divided by the objects mass.

- The direction of acceleration is the same as the direction of the net force.

- Newton's Second Law Equation

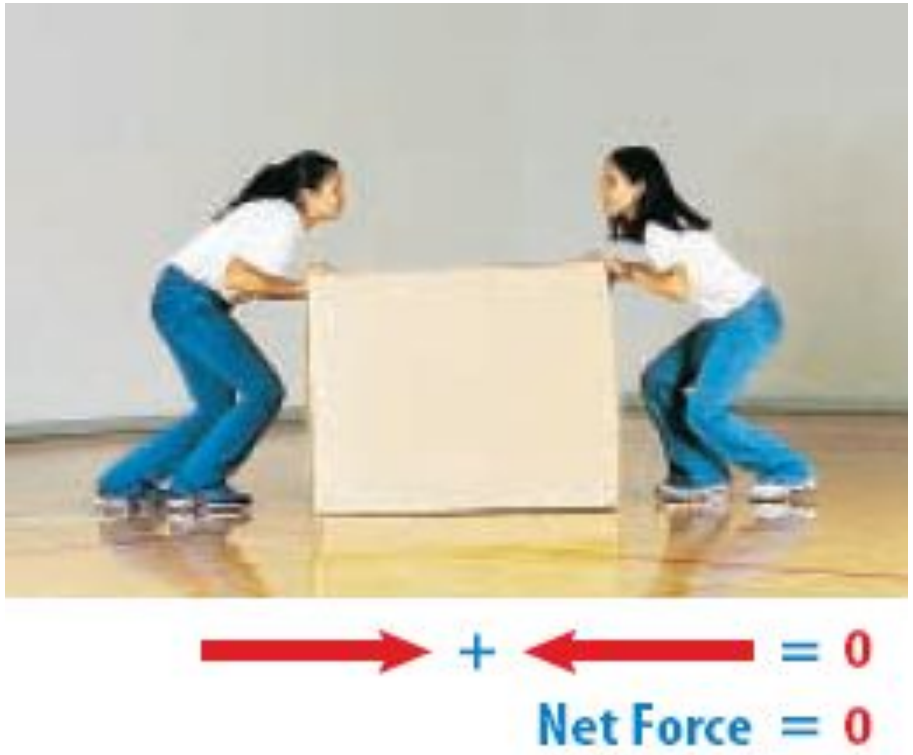


a = acceleration (in m/s^2)

F = net force (in N)

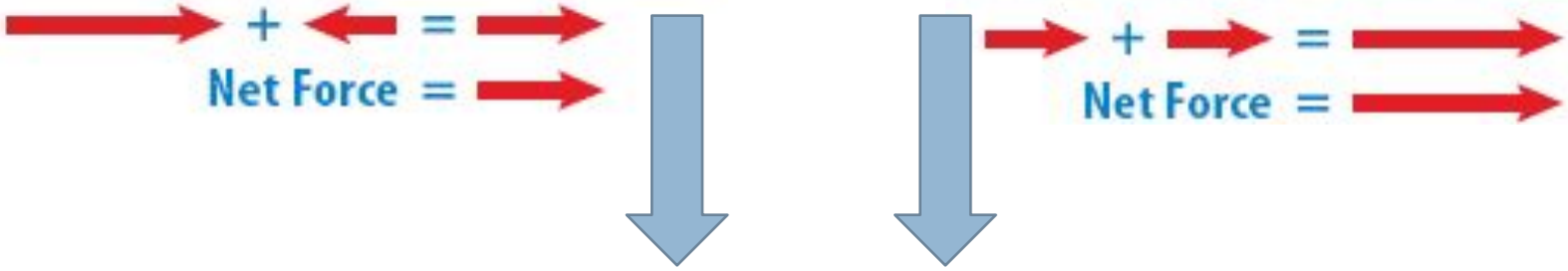
m = mass (in kg)

BALANCE VS. UNBALANCE



Balanced forces cause no acceleration.

BALANCE VS. UNBALANCE



Unbalanced forces cause acceleration.

IN OTHER WORDS…

- Small Force = Small Acceleration

IN OTHER WORDS…

Large Force = Large Acceleration

TWIST!

Acceleration is INVERSELY related to the mass of the object.

In other words…..using the same amount of force….

F →  Small acceleration →

Large Mass

a

F →  Large acceleration →

Small Mass

a

SOLVING FOR ACCELERATION

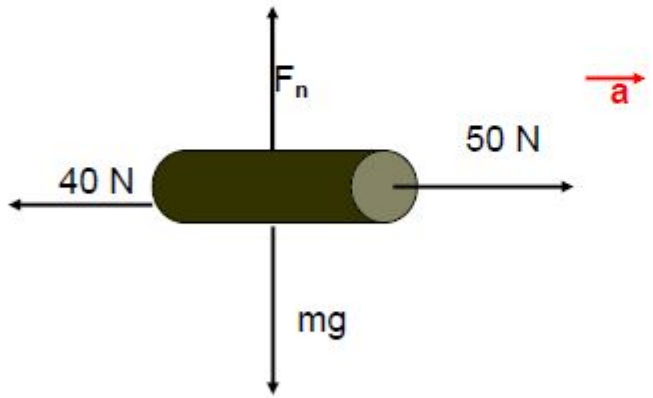
Solve for Acceleration You throw a 0.5-kg basketball with a force of 10 N. What is the acceleration of the ball?

1. **This is what you know:**
   - mass: $m = 0.5$ kg
   - force: $F = 10$ N or $10\ \text{kg}\cdot\text{m/s}^2$
2. **This is what you need to find:** acceleration: a
3. **Use this formula:** $a = \frac{F}{m}$
4. **Substitute:** the values for F and m into the formula and divide.

$$a = \frac{10\ \text{N}}{0.5\ \text{kg}} = 20\ \frac{\text{kg}\cdot\text{m/s}^2}{\text{kg}} = 20\ \text{m/s}^2$$

EXAMPLE

- A 50 N applied force drags an 8.16 kg log to the right across a horizontal surface. What is the acceleration of the log if the force of friction is 40.0 N?



$$F_{NET} = ma$$

$$F_a - F_f = ma$$

$$50 - 40 = 8.16a$$

$$10 = 8.16a$$

$$a = \text{1.23 m/s/s}$$

THIRD LAW OF MOTION

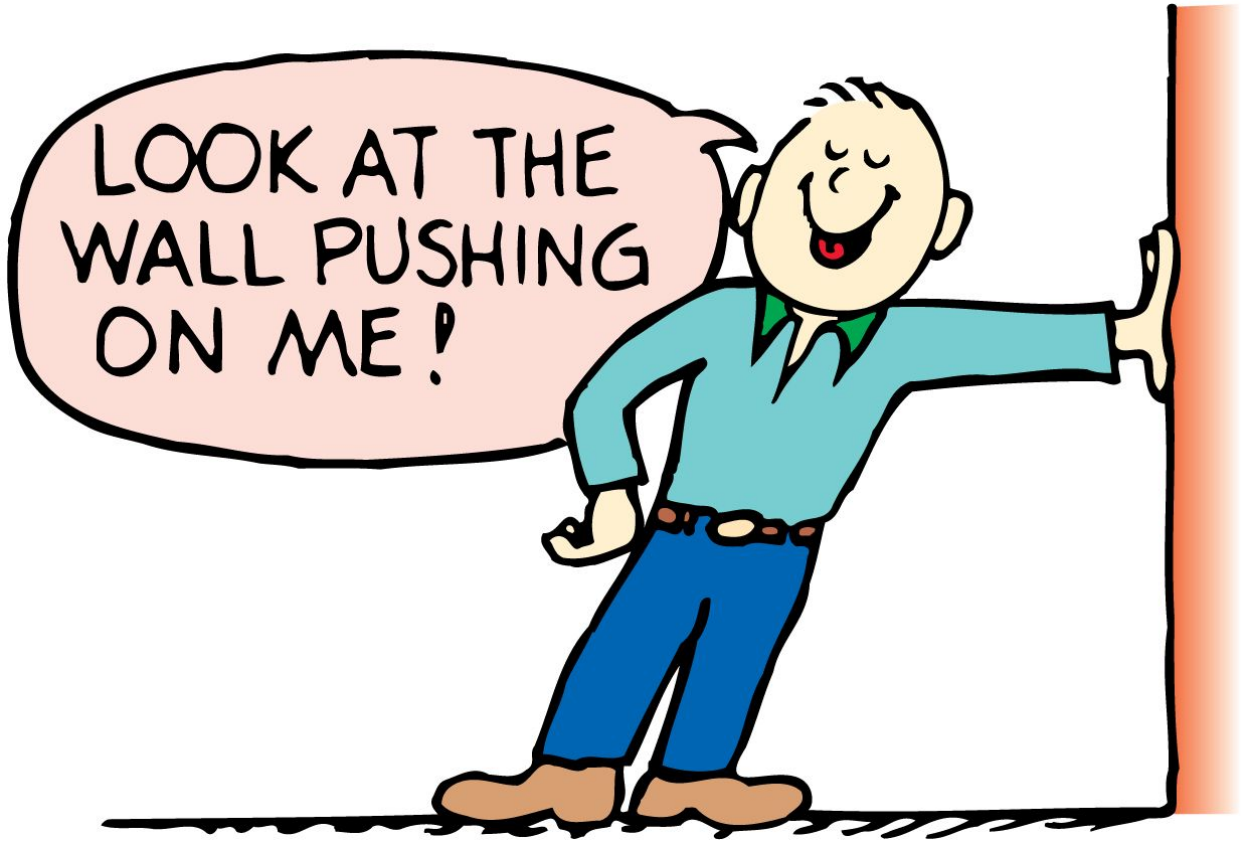
"For every action there is an equal and opposite reaction."

WHAT DOES IT MEAN?

- When an object applies a force on another object, the second object applies a force of the same strength on the first object, but the force is in the opposite direction.
- When an object exerts a force on a second object, the second object exerts an equal force in the opposite direction on the first object.

FORCES AND INTERACTIONS

- When you push on the wall, the wall pushes on you.



FORCE PAIRS

- The forces described in Newton's Third Law are force pairs.
- A force pair is the force two objects apply to each other.
- The forces do not result in a net force of zero because they act on different objects. Adding forces can only result in a net force of zero if the forces act on the same object.
- In a force pair, one force is called the action force and the other is called reaction force.
- For every action force, there is a reaction force that is equal in strength but opposite in direction.

USING THIRD LAW OF MOTION

- When the reaction force results in an unbalanced force, there is a net force, and the object accelerates.

  - Swimming – when you swim you push your arms against the water in the pool. The water in pool pushes back on you in the opposite (forward) direction.
  - Jumping – when you jump, you push down on the ground, and the ground pushes up on you.
  - Rocket Motion – the engine pushes the hot gas out in the downward direction. The gas pushes upward on the engine.

MOMENTUM

- Action and reaction forces do not cancel each other, therefore they can change the motion of objects.
- Momentum is a measure of how hard it is to stop a moving object. It is the product of an object's mass and velocity.
- An object's momentum is in the same direction as its velocity.
- Momentum Formula

$$p = m \times v$$

p = momentum (in kg*m/s) m = mass (in kg)

v = velocity (in m/s)

SOLVING FOR MOMENTUM

Solve for Momentum What is the momentum of a 12-kg bicycle moving at 5.5 m/s?

1. **This is what you know:**
   mass: $m = 12$ kg
   velocity: $v = 5.5$ m/s
2. **This is what you need to find:** momentum: p
3. **Use this formula:** $p = m \times v$
4. **Substitute:** $p = 12\ \text{kg} \times 5.5\ \text{m/s} = 66\ \text{kg}\cdot\text{m/s}$
   the values for m and v
   into the formula and multiply.

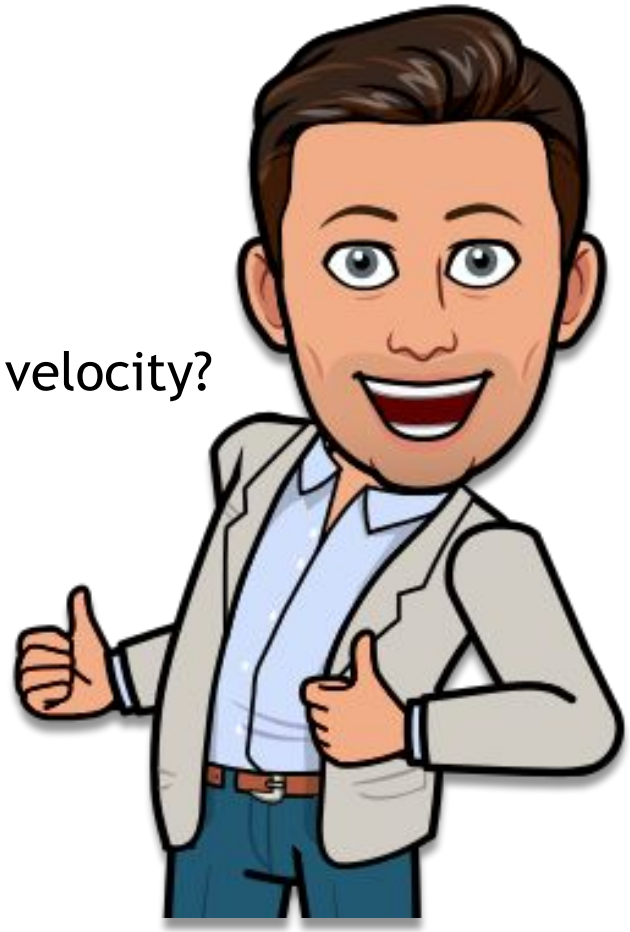
EXAMPLES

1. What is the momentum of a 1.5 kg ball rolling at 3.0 m/s?

   Answer: 4.5 kg*m/s

2. A 55 kg woman has a momentum of 220 kg*m/s. What is her velocity?

   Answer: 4.0 m/s



MOMENTUM

- The more mass an object has the more momentum.

- If objects of equal mass move at different speeds, the faster object has more momentum and is harder to stop.

Predict what will happen to the velocity and momentum of each ball when the small ball hits the heavier large ball?

LAW OD CONSERVATION OF MOMENTUM

- In any collision, one object transfers momentum to another object, however, the total momentum does NOT change.
- Law of Conservation of Momentum is the total momentum of a group of objects stays the same unless outside forces act on the objects.
- Example: outside forces include: Friction

- Types of collisions

  Elastic collision – when colliding objects bounces off each other.

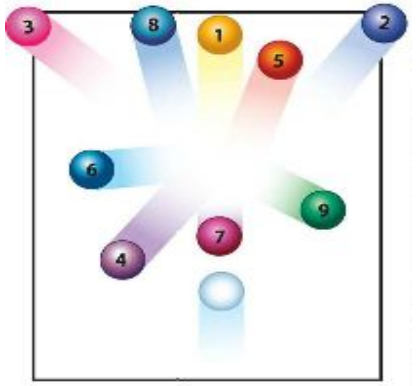
  Example: Pool, cue ball hitting a solid or stripe ball.

  Inelastic collision – when colliding objects stick together.

  Example: Football, player tackles another.
- No matter the type of collision, the total momentum will be the same before and after the collision.

BEFORE

AFTER



LET US REVIEW!

Newton's First Law:

Objects in motion tend to stay in motion and objects at rest tend to stay at rest unless acted upon by an unbalanced force.

Newton's Second Law:

Force equals mass times acceleration ($F = ma$).

Newton's Third Law:

For every action there is an equal and opposite reaction.

Reference

(2021). Retrieved 16 August 2021, from https://mrheppeardsclass.weebly.com/uploads/2/0/4/4/20448547/laws_of_motion.pptx