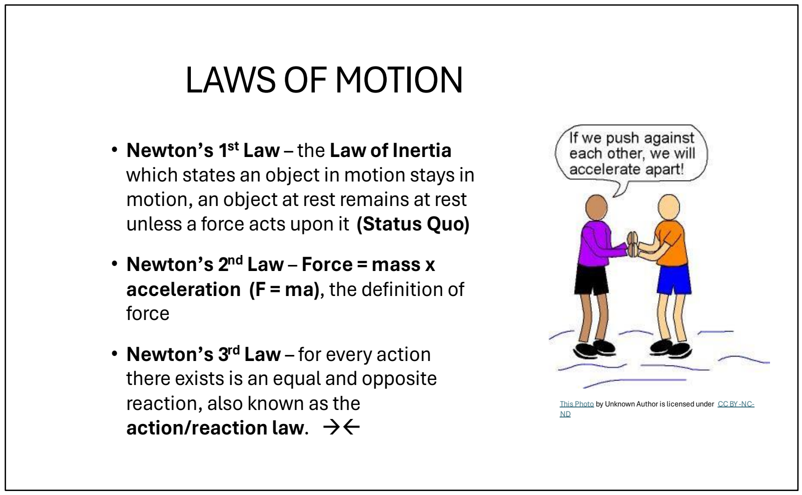
Lesson 1 Physics (All Series Combined – SS, CS, SS+, CP)
Student Challenge

Mastery Goals: Students are encouraged to test their STEM comprehension and competency levels by reviewing each section (Observe, Explore, Analyze, Apply); and by practicing math skills at specified or all levels (SS, CS, SS+, CP). Younger students may skip sections as needed.

OBSERVE: **Newton's Laws of Motion/Classical Physics**

Look at the world around you.

1. Choose a small round object, like an orange.
2. Note that once it is set on a table at rest, it remains at rest (Law 1).
3. Track the position of the Sun throughout the day. The Sun represents a celestial object – all which are in constant motion. Although the observed constant motion is caused by the Earth spinning on it's axis over 24 hrs, the Sun's provides a way to track Earth's spin. The Sun's motion around the galaxy is ~750,000 km/hr, Earth's orbital speed is ~100,000 km/hr, and its spin ~1000 km/hr at the equator.

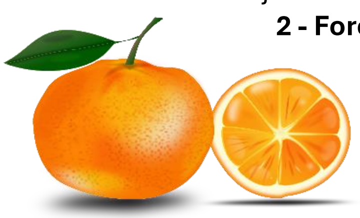


Note: Sir Isaac Newton understood the orbital motion of planets around the Sun, and moons around their respective planets, as a falling motion bound by the force of gravity. Their constant motion, combined with his understanding of gravity, helped him explain the 1st Law of Motion.

Summary: Mass/Matter has a resistance to motion, but once in motion, it has a resistance against stopping or returning to rest. *Status Quo* or stasis (remaining the same) is the norm.

EXPLORE:

Newton's Laws. Objects at rest can be put in motion. What does it require to move an object? **Law 2 - Force (ma)** Using a small round object (you can drop or roll). Let's explore:



Try moving your object with: a) Your Hand; b) A Feather, c) Your Little Finger Only, without the use of your hand!

1. *Highest mass = Hand; Lowest mass = Feather*
2. *Similar acceleration = different results with different masses; i.e., total force moves from highest with hand to lowest with a feather.*
3. *Similar/same mass = different results with different acceleration (try varying the amount of push from a slight push to a fast push).*

Summary: Force is a product of **both mass and acceleration**. Both are equally important. The greater the force, the greater the potential for change or "work" to be done.

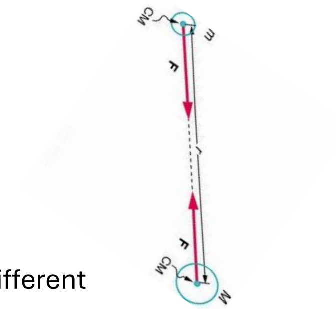
EXPERIMENT:

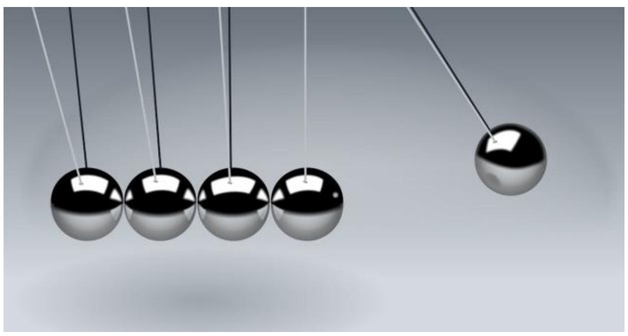
Question: What happens when a moving object hits a non-moving object, such as an orange dropped to the floor? Let's experiment by watching an orange/object drop to the floor.

1. Gravity accelerates the object DOWNWARD.
2. The Object exerts a FORCE (its mass x acceleration due to gravity) on the floor.
3. The Floor pushes back against the force, but the Floor doesn't move visibly?

Observation Results: Since the floor doesn't move, what does that mean?

1. The Object's motion is slowed (a change in motion, it's direction is changed – in this case, reversed to a sporatic bounce and roll).
2. The Floor's force is **equal and opposite** to the force of the falling object (Law 3). It's mass (m) is the greatest aspect of its force.
3. The Floor's resistance results in atoms vibrating within the floor.





Would the results be different if two masses and/or accelerations were equal? If possible, experiment with a Newtonian cradle that has equal mass balls. Lift and release one ball; then, two opposite balls.

Experiment with a variety of combinations. Remember, acceleration is caused by gravity acting on the lifted ball's mass (F = ma).

Summary: Most large objects, such as a floor, a building, a street, are capable of exerting a greater force than a smaller object can; however, only the amount of force equivalent to the object's force is exerted in response. If, or when, a large object isn't great enough to resist a smaller object's force, the result can be catastophic (image to the right). An small asteroid strike on Earth can be catastrophic because it's moving so fast. In these instances, the smaller object also visibly moves the larger object due to its greater acceleration.

ANALYZE:

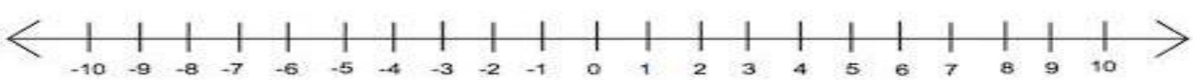
Motion (a number line sheet is included for practice)

Basic (SS)

Number Line – why is direction important when using a number line or understanding the motion of an object? Will it's ending position be different if it's direction changes? **Try moving your own vehicle 10 units with various combinations of north and south.**

Timeline numbers = hours of travel 

South **North**



hours of travel/units = 10 miles per unit of time

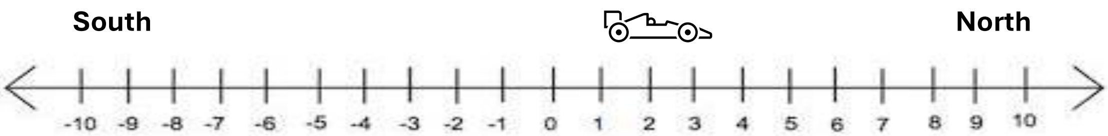
For ALL the FOLLOWING Problems:

Time = numbers on the timeline   Units = 10 mi per each unit/# on the number line
Speed = 10 mph constant (mi/hr = miles per hour)
Distance Traveled = Number of hours/units traveled x 10 = ___________ miles
Ending Position (distance N or S from starting position of 0)

Example (determine distance or position):

Travel time = 2 hrs
Units (negative South or positive North) = 2 x 10 mi = 20 mi
Distance traveled = 20 miles

South   **North**

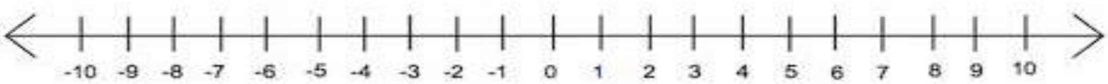


hours of travel/units = 10 miles per unit of time

PROBLEMS:

1. Your car is moving at a constant speed of 10 mph. IF it travels 5 hours north, where will it be at on the number line: (a)_________ (draw your car on the number line)
   Distance traveled: (b)________ (5 hrs x 10 = _____ mi or 10+10+10+10+10 = _____ mi)

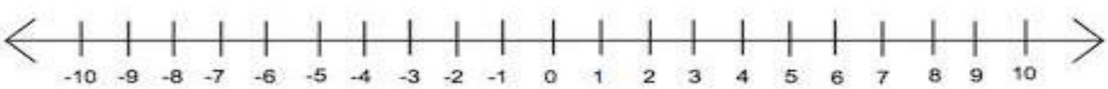
South   **North**



hours of travel/units = 10 miles per unit of time

2. Your car is moving at a constant speed of 10 mph. It travels 5 hours north, then 3 hours south. Trace your path on the number line careful to move both right and left.
   a. What is the car's speed? ________________
   b. How many total miles has the car traveled? _________________
   c. Where is the car on the number line after traveling 8 hours? ____________
   d. If the number line represents ENDING POSITION to calculate velocity, how far has your car moved from its original starting position? ___________(miles)

South   **North**



hours of travel/units = 10 miles per unit of time

Answers (BASIC):

1) a. 5; b. 50 miles
2) a. Speed: 10 mph – the same speed throughout! b. Total miles traveled: 80 mi;
   c. Position: #2 on the number line; d. Distance: 2 x 10 mi = 20 mi from starting position

Advanced (CS)

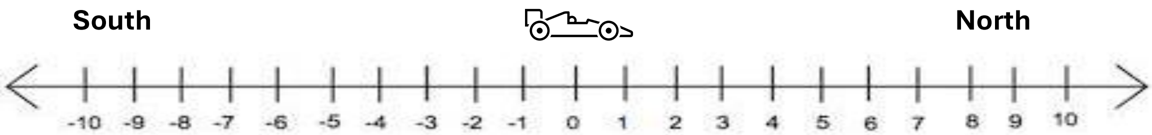
Vector Motion/Velocity (Review Basic)

VELOCITY: To determine average velocity, only the ENDING position on the number line is needed. Velocity uses BOTH speed and direction - positive (north) and a negative (south) directions for this problem.

Example 1: A car travels 2 hrs north, then 2 hrs south, ending at 0 on the number line. The car traveled 4 hrs at 10 mph covering 40 miles (20 north and 20 south).

Ending position: 0 on the number line.
The car's average velocity: 0 mph (0 x 10 mph/4 hrs = 0 mph velocity)

South **North**

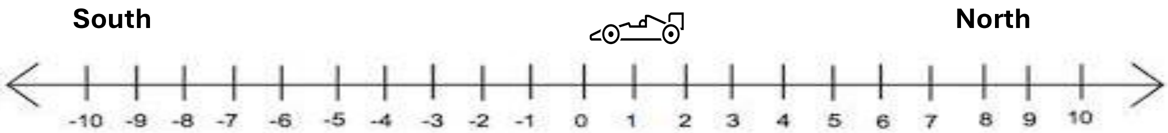


hours of travel/units = 10 miles per unit of time

Example 2: A car travels 3 hrs north, then 2 hrs south, ending at 1 on the number line. The car traveled 5 hrs at 10 mph covering 50 miles, but the car's average velocity is equal to:
Ending position: 1 unit/hr 1 x 10 mi = 10 miles from starting position

1 x 10 mi/5 hrs = 10 mi/5 hr = 2 mph or 2 mi/hr

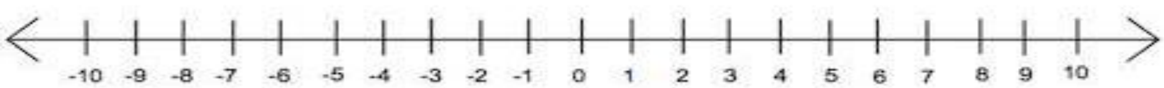
South **North**



hours of travel/units = 10 miles per unit of time

CHALLENGE PROBLEM: Your car is moving at a constant speed of 10 mph. It travels 5 hours north, then 3 hours south. What is its velocity?

South **North**



hours of travel/units = 10 miles per unit of time

3. Position/Velocity (ending position on the number line)
   a. Position on Number line: ___________
   b. Final Distance: _________ x 10 mi = ____________ miles
   c. Avg Velocity: __________ miles in 8 hours *(20 mi ÷ 8 hrs)* = _________ mph

Answers (ADVANCED):

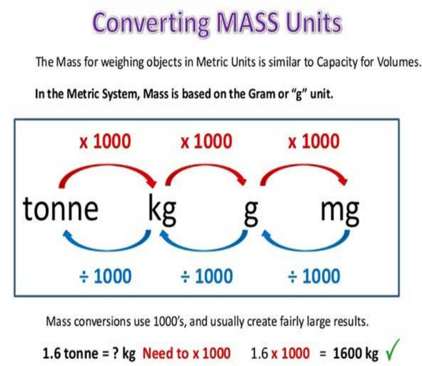
3) a. Position: 2; b. Distance: 20 mi; c. Avg Velocity: 2 ½ or 2.5 mph

Applied (SS+)

Mass (Review Advanced)

FORCE (SI) units are kilograms. Metric conversions are generally divided or multiplied by 1000's.

1 metric ton (tonne) = 1000 kilograms (kg)
1 kg = 1000 grams (g)
1 g = 1000 milligrams (mg)



PROBLEMS:

1. A sailor needs ½ metric ton weight to anchor his ship. How many grams (x) would be required?
   Write your equation:
   Solve for x:

2. To balance a scale, the miner needed ¾ kilograms of sand. How many milligrams (x) of sand would be required? Convert kilograms to grams before writing your equation.
   Write your equation:
   Solve for x:

Answers (Applied):

1) a. .5 (or ½) x 1000 kg x 1000 g/kg = x; b. x = 500,000 grams
2) a. .75 (or ¾) x 1000 g x 1000 mg/g = x: b. x = 750,000 milligrams

Compute (CP)

Force (Review Applied) Newton's Force F = ma given in **Newtons or kgm/s^2**

For each problem, use the acceleration due to gravity as 10 m/s^2

Example: How much force will a 3 kg melon (~6.6 lbs) exert on the floor if it falls 1 meter under acceleration from gravity (no initial velocity):

Equation: F = 3kg x 10 m/s^2
Answer: F = 30 kgm/s^2

PROBLEMS: Calculate the amount of Force in Newtons for the following:

1. How much force would a 5 metric ton vehicle exert if it falls 1 meter under acceleration due to gravity? Convert tons to kilograms.
   a. Equation:
   b. Answer in Newtons:

2. How much force would a 100 gram object exert if it falls 2 meters under acceleration due to gravity? Convert grams to kilograms.
   a. Equation:
   b. Answer in Newtons:

Answers (Compute):

1) a. x = 5 x 1000 kg x 10 m/s^2; b. x = 50,000 N or 50,000 kgm/s^2
2) a. x = .1 kg x 2(10 m/s^2) = x: b. x = 2 N or 2 kgm/s^2