



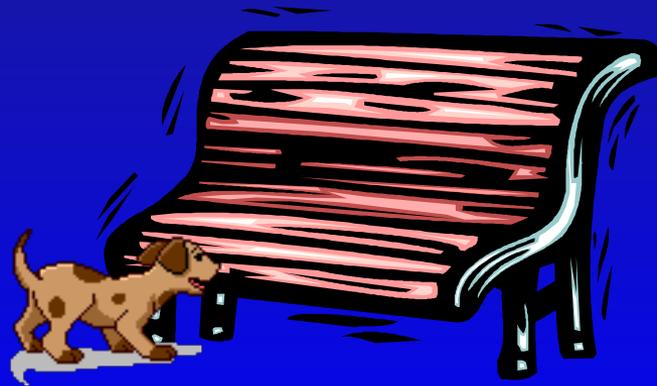
Motion & Newton's Laws

State Objectives 2.c. & 2.f.

What is MOTION?

All matter is in constant motion

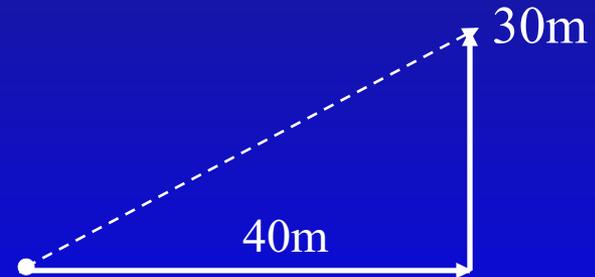
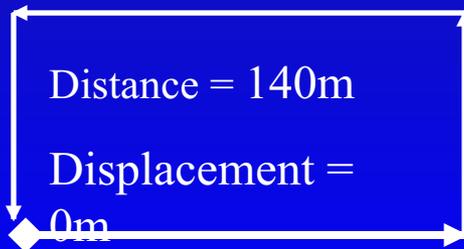
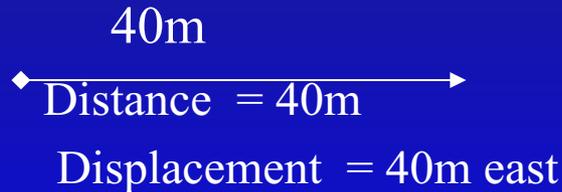
- Motion is any change in position
- Relative Motion is used to recognize a change in position by using a point of reference
 - An object changes positions if it moves relative to a reference point



Measuring Motion

- Distance is the total length of the route an object travels when it moves
- Displacement includes distance from the starting point to the stopping point and the **direction** traveled

• Ex.



Distance = 70m

Displacement = 50m northeast



Speed

- Speed is the distance traveled divided by the time taken to travel the distance
- Formula: Speed = distance ÷ time ($S=D/T$)
- SI Unit: meters per second (m/s)
- Ex. In the 100m dash the fastest runner finished in 10s.
 $S= 100m/10s= 10m/s$
- 3 Types of Speed
 - Average speed is found by dividing the total distance by the total time taken to reach that distance
 - Speeds can vary from instant to instant
 - Ex. Walking in a crowded hallway
 - Instantaneous Speed is the speed of an object at a particular moment
 - Constant Speed is when an object is moving at a steady rate throughout the entire distance.

Practice Problem

- Calculate the Average Speed. Round to the nearest 0.1m/s
 - A swimmer swam 100m in 56s.
- Answer: $S=100\text{m}/56\text{s}$
 - 1.8m/s

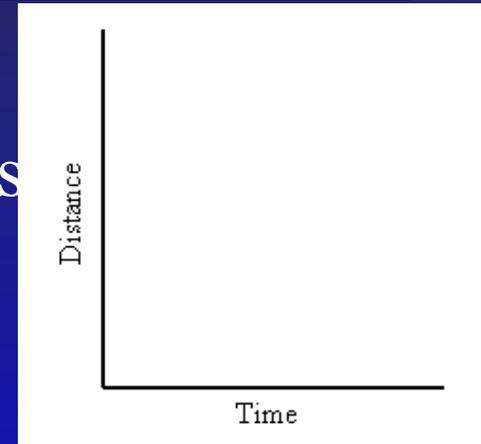


Graphing Motion

- Motion can be graphed on a distance-time graph

- Time on the horizontal (X) axis

- Distance on the vertical (Y) axis

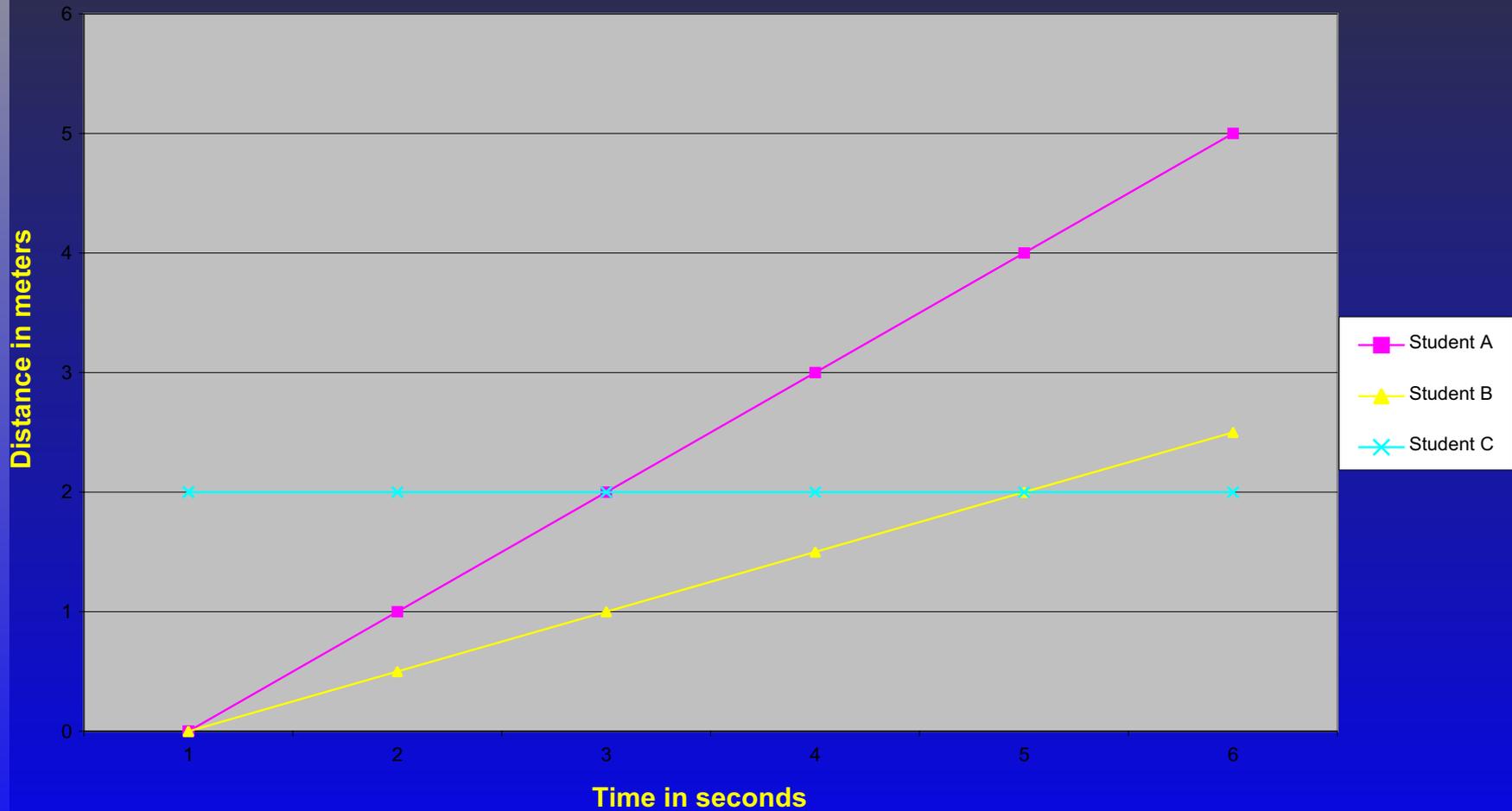


- The steeper the line on a distance-time graph, the greater the speed

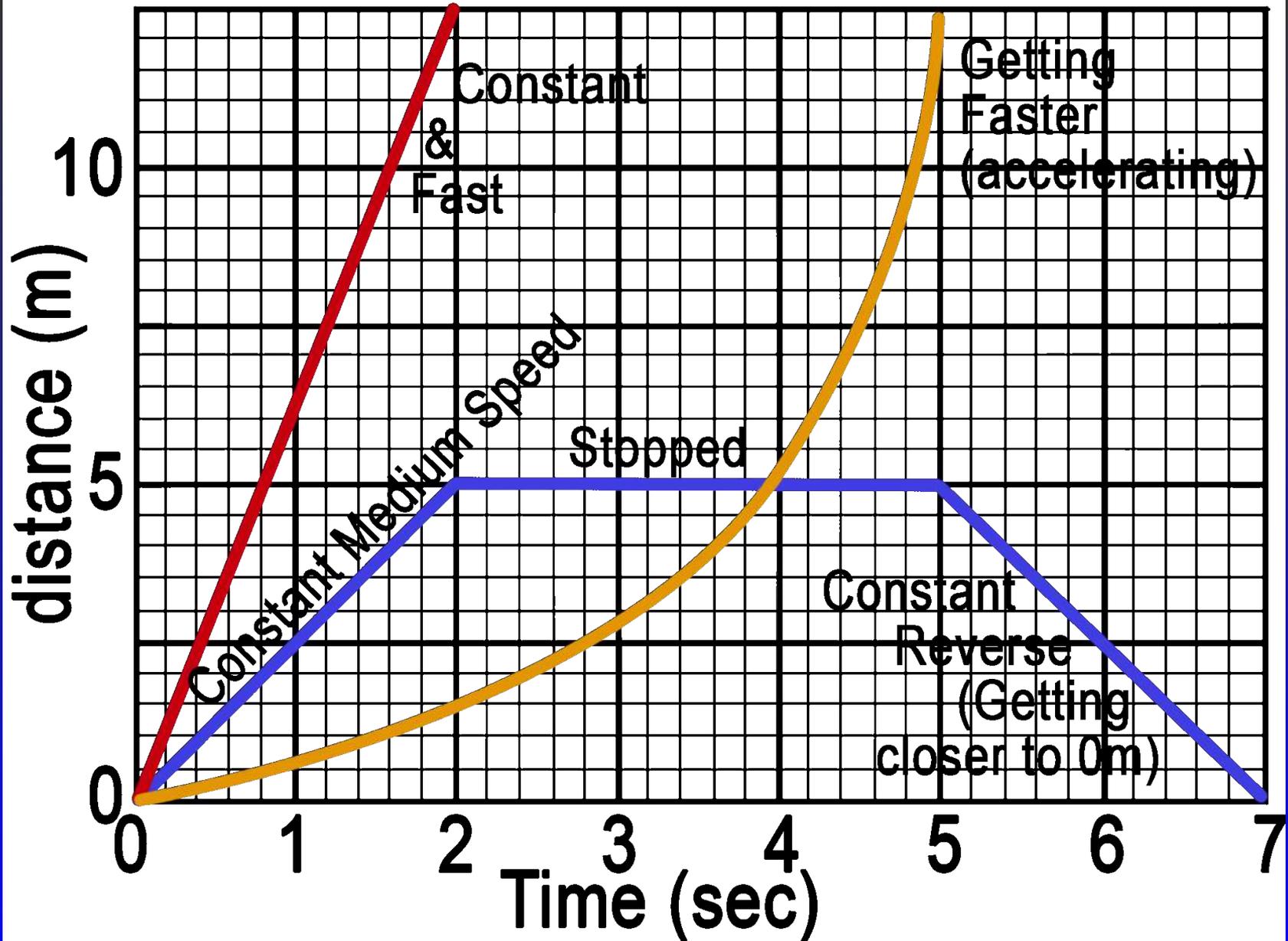
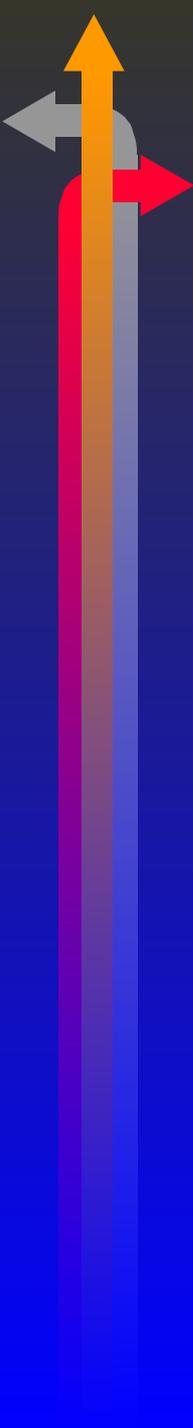
- A horizontal line means no change in position, which makes the speed “zero” at anytime on the graph

Example Graph

Distance Versus Time



- Which student is moving fastest?
- Which student has no motion?



Velocity

- Velocity is the speed of an object and the direction of its motion.
- Unit is same as speed, but includes direction
 - 10km/h east



Example: A hiker needs to know how far away the camp is & in what direction to determine the necessary velocity to get back to camp before nightfall

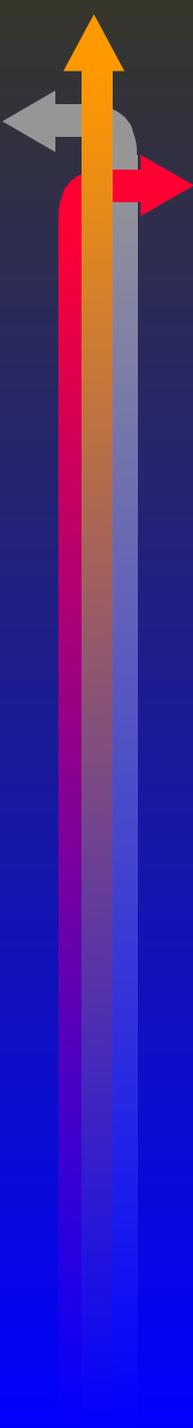


Acceleration



- Acceleration occurs when an object changes its motion (velocity changes)
 - Speed up - 50mi/h to 60mi/h (positive)
 - Slow down – 45mi/h to 40mi/h (negative)
 - Acceleration is in the opposite direction of the motion
 - Change in direction – north to east
 - Basketball thrown from the free-throw line

Can you think of examples of situations that have positive or negative acceleration?



Calculating Acceleration

- If an object's motion is in a straight line the acceleration can be calculated using this formula:

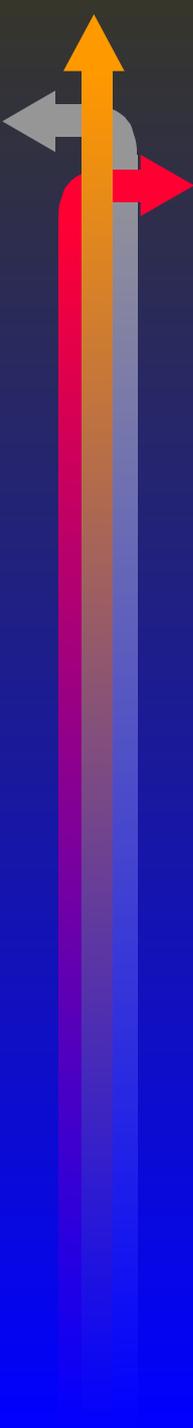
$$(a) \text{Acceleration} = \frac{\text{final speed}(s_f) - \text{initial speed}(s_i)}{\text{Time}(t)}$$

- Unit for acceleration is m/s²
- Ex. Calculate the acceleration of a bus whose speed changes from 6m/s to 12m/s over a period of 3s.

- Initial speed: 6m/s
- Final speed: 12m/s
- Time: 3s

$$A = \frac{12\text{m/s} - 6\text{m/s}}{3\text{s}}$$

$$A = 2\text{m/s}^2$$

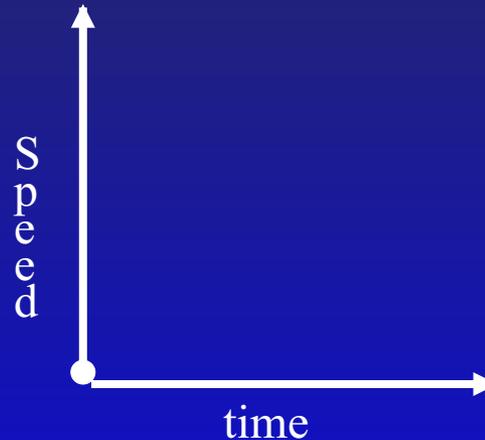


Practice Problems

1. A train's velocity increases from 7m/s to 18m/s over a period of 120s .
2. Jack was riding a bike in a straight line and sped up from 4m/s to 6m/s in 5s .
3. Sarah slowed down from 4m/s to 2m/s in 5s as she walked her last lap on the track.

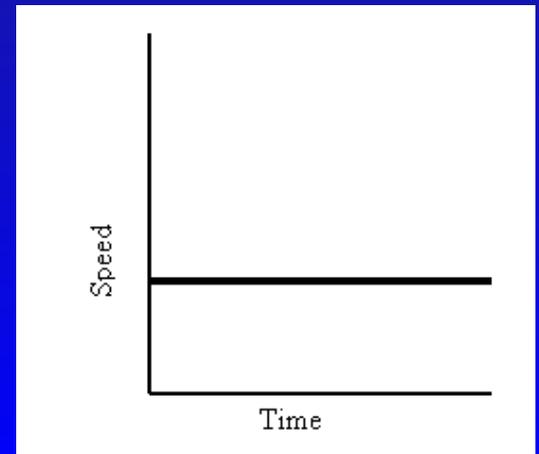
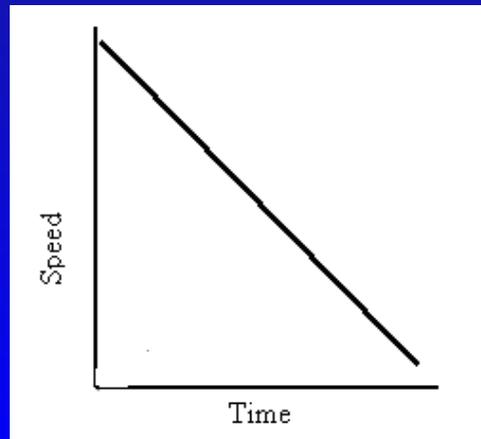
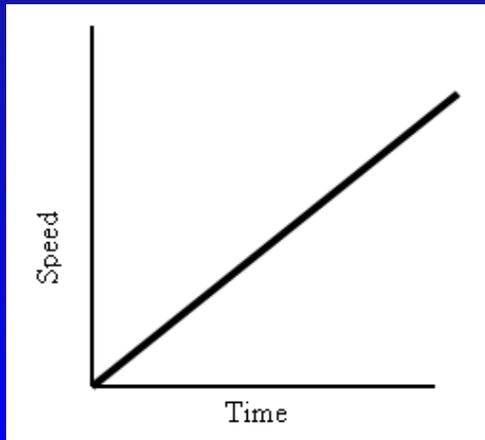
Graphing Acceleration

- Accelerated motion can be graphed by putting speed on the vertical axis and time on the horizontal axis

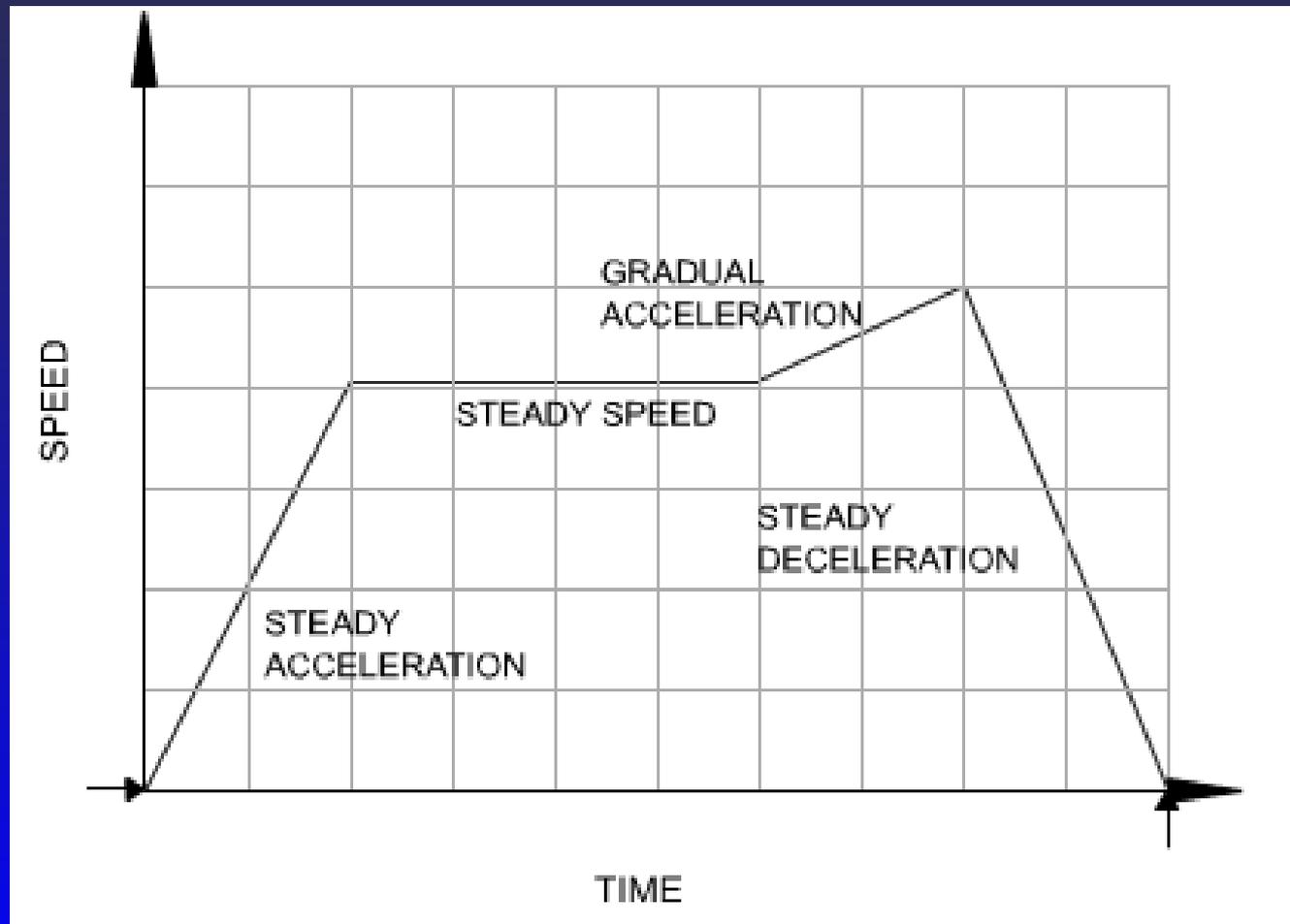


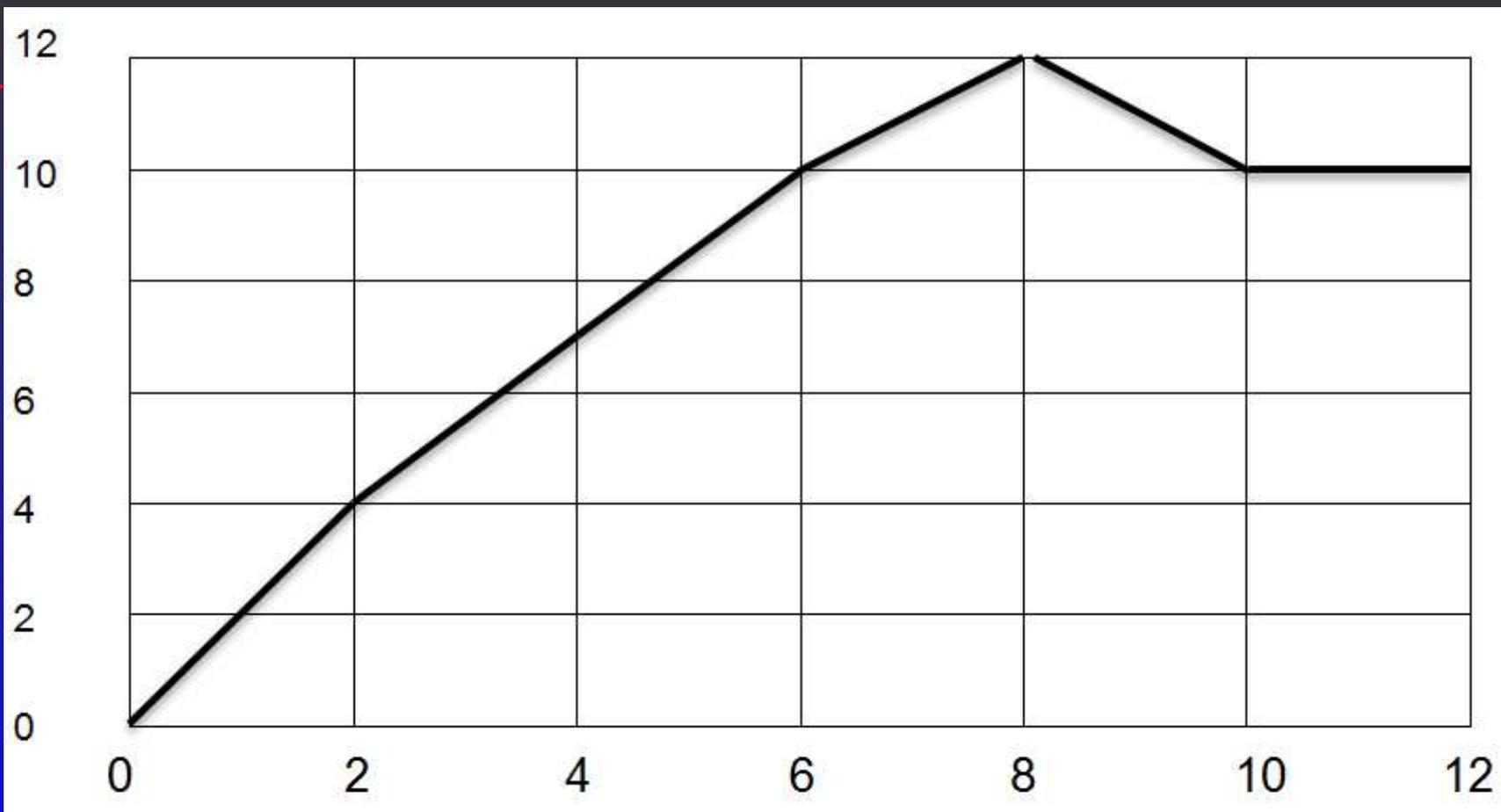
Graphing Acceleration

- An object that is speeding up will have a line that will slope upwards (positive line)
- An object that is slowing down will have a line that will slope downward (negative line)
- A horizontal line would indicate an acceleration of zero, or a constant speed



Example Graph



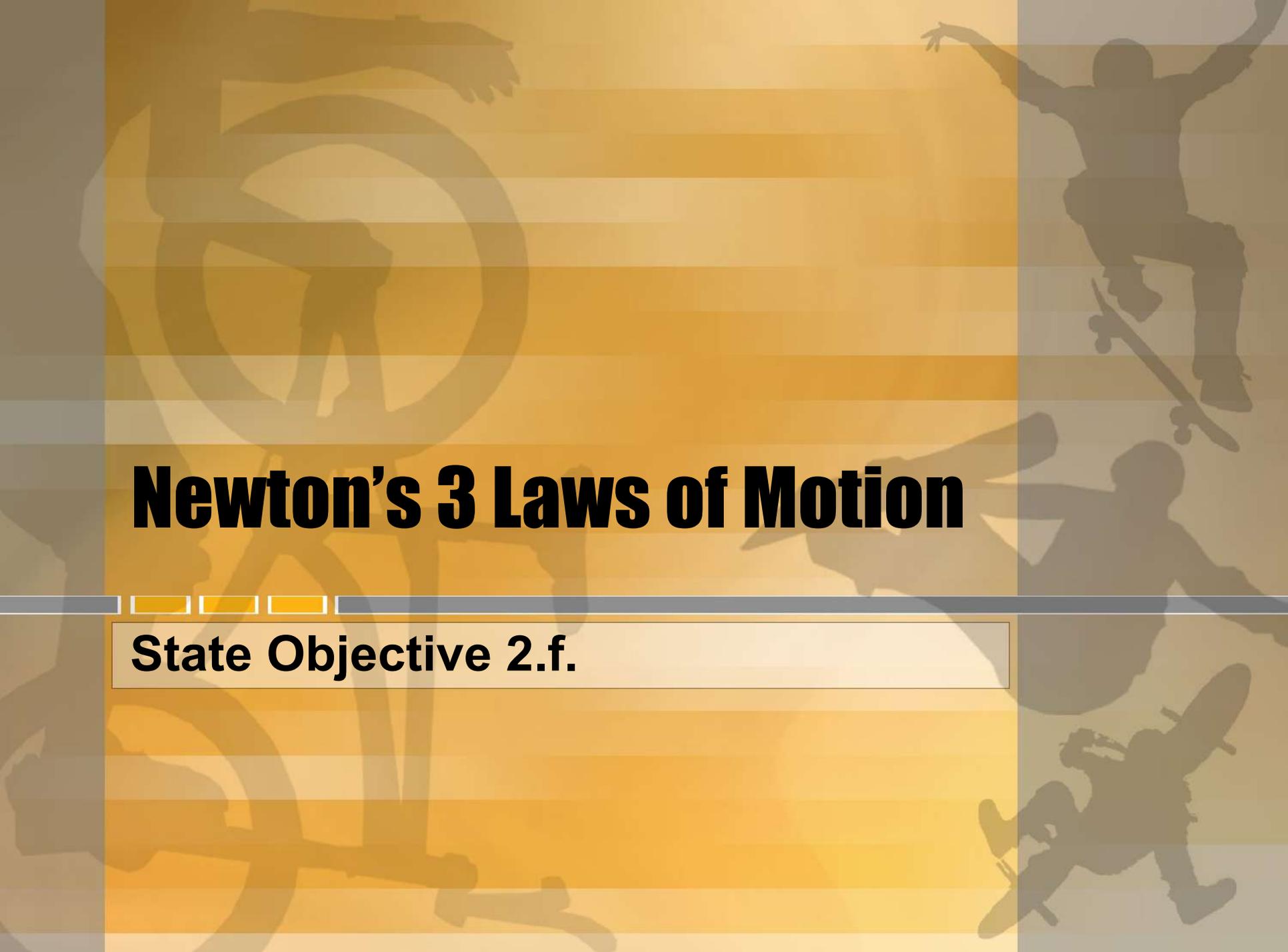


1. During what interval is the acceleration positive?
2. Negative?
3. Is the acceleration ever zero? Explain.



Simulation Review

- <http://phet.colorado.edu/en/simulation/moving-man>



Newton's 3 Laws of Motion

State Objective 2.f.

What is a Force?

- Force is defined as a push or a pull
 - Ex. Pushing a grocery cart or pulling a wagon
- Net force is the combination of all forces acting on an object at the same time.
- Ex: Identify all the forces acting on a paper clip, sitting on a table, near a magnet.



Balanced verses Unbalanced

- **Balanced forces occur when two or more forces exerted on an object cancel each other out causing no change in motion (no acceleration)**
 - Ex. Lean back to back with a partner with no motion or hold a book in your hand very still
- **Unbalanced forces occur when the combined forces acting on an object do not cancel each other out causing a change in motion (acceleration)**
 - Ex. Push a chair with wheels or when someone wins tug-a-war

Decide if the situation is Balanced or Unbalanced

1. Push a box till it moves **U**
2. Pedal a bike at a constant speed **B**
3. Apply brakes to a bike in order to pop a wheelie **U**
4. Push a car that never moves **B**
5. Two people push a box in opposite directions causing the box to go nowhere **B**
6. Two people push a box in opposite directions causing the box to slide slightly to the right. **U**

Newton's First Law of Motion

- **An object at rest will remain at rest until an unbalanced force is applied.**
 - Ex: A football player kicking a ball
- **An object in motion will remain in motion until an unbalanced force is applied.**
 - Ex: A rocket in space will move in a straight line.
- **Known as the “law of inertia”**
 - Inertia is the tendency of an object to resist change in its motion
 - Ex. Coach Brown slamming on the brakes and your body goes forward.

Friction

- **Friction is a force that resists sliding between two touching surfaces or through air or water.**
- **Example: A baseball player sliding into second base.**
 - Friction slows down an object's motion.
 - Friction produces heat and wears on objects.
 - Friction always acts against the direction of motion.
 - What are some examples of friction?

Gravity

- Gravity is the force of attraction between two objects.
- The strength of gravity depends on an object's mass and distance.
- For example, the moon's gravity is $1/6$ of the Earth's gravity because it is much smaller.
- Where would gravity be less, at sea level or on top of a mountain?

Newton's 2nd Law

- Newton's second law of motion states that an object acted upon by a force will accelerate in the direction of the force.
- Force equals mass times acceleration.
 - Ex. A baseball or a bowling ball: Which one requires more force to throw the same distance?
 - Formula: $a = f \div m$ or $f = m \times a$
 - Forces are measured in Newtons (N)
 - $1\text{N} = 1\text{kg} \times 1\text{m/s}^2$

Practice Newton's 2nd law

- Suppose you pull a 10kg sled with a force of 5N. What is the acceleration of the sled?

$$A = 5\text{N} \div 10\text{kg} = \underline{0.5\text{m/s}^2}$$

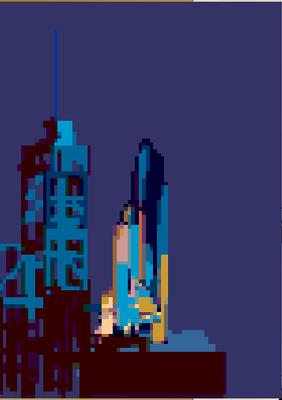
- You throw a baseball with a mass of .5 kg so it has an acceleration of 40m/s². How much force did you exert on the baseball?

Answer: 20 N

- Explain the connection between motion, 1st law, & 2nd law.

Newton's 3rd Law

- **Newton's third law of motion states that for every action, there is an equal but opposite reaction.**
- **Forces always act in pairs.**
 - Bounce a ball on the ground or playing pool
- **Action-reaction forces are always the same size but are in opposite directions and act on different objects.**
 - When the mass of one object is considerably larger than the mass of another object, the action-reaction force is not noticeable.
 - When you push a wall or walk on the earth.



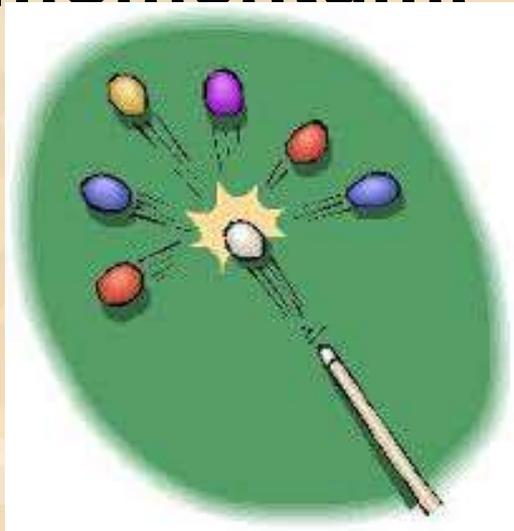
Action/Reaction Forces

- When one object exerts a force on another object the 2nd object exerts the same size force on the 1st object
- Forces act on different objects, so they do not cancel each other out
 - http://www.school-for-champions.com/science/newtons_cradle.htm
 - <https://youtu.be/BiLq5Gnp08Q> (myth buster's clip)



Collision

- **Two or more objects that come in contact with each other in which each exerts a force upon the other, causing the exchange of energy or momentum.**



Action/ Reaction Examples

Underline the object

Action

- Wings push air down & back
- Hands push water back
- Foot pushes down and back on earth
- Rocket engine pushed gas molecules downward

Reaction

- Air pushes wings up and forward
- Water pushes swimmer forward
- Earth pushes foot up &forward
- Gas molecules push rocket up

Why does the reaction not always appear to be the same?

- The greater the mass the greater the inertia

Nasa Video for Review

- <https://youtu.be/KvPF0cQUW7s>

Which law?

1. Using an oar to move a canoe

3rd

2. Pushing a swing with more force to move your big brother than you did with your little sister

2nd

3. A rock is sitting on a hill until you push it causing it to roll

1st

Quiz

Momentum

- Momentum is a measure of how hard it is to stop an object.
- Momentum increases if either mass or velocity increases.
- Formula for momentum
 - $P=mv$. P is symbol for momentum. Mass is in kg. Velocity is in m/s.
 - The unit for momentum is $\text{kg}\cdot\text{m/s}$.

Momentum

- **What is the momentum of a 5 kg bowling ball traveling 15 m/s?**
- **What is the momentum of a 0.4 kg baseball moving at 50 m/s?**
- **Which would be harder to stop if moving at the same velocity, a 2,000 kg car or a 4,000 kg truck?**

Conservation of Momentum

- The law of conservation of momentum states that the total momentum of two objects that collide is the same before and after a collision.
- For example, 3000 kg truck moving at 10 m/s hits a 1000 kg parked car. The impact causes the car to move 15 m/s. Determine the velocity of the truck after the collision.