Dynamics
- The branch of physics involving the motion of an object and the relationship between that motion and other physics concepts
  - Kinematics is a part of dynamics
    - In kinematics, you are interested in the description of motion
    - *Not* concerned with the cause of the motion

Quantities in Motion
- Any motion involves three concepts
  - Displacement
  - Velocity
  - Acceleration
- These concepts can be used to study objects in motion

Displacement
- Defined as the change in position
  - $\Delta x = x_f - x_i$
    - f stands for final and i stands for initial
  - May be represented as $\Delta y$ if vertical
  - Units are meters (m) in SI, centimeters (cm) in cgs or feet (ft) in US Customary

Velocity
- It takes time for an object to undergo a displacement
- The average velocity is the rate at which the displacement occurs
  \[ v_{\text{average}} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i} \]

Average Velocity, Constant
- The straight line indicates constant velocity
- The slope of the line is the value of the average velocity

Average Velocity, Non Constant
- The motion is non-constant velocity
- The average velocity is the slope of the blue line joining two points
### Instantaneous Velocity
- The limit of the average velocity as the time interval becomes infinitesimally short, or as the time interval approaches zero:
\[ v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} \]
- The instantaneous velocity indicates what is happening at every point of time.

### Instantaneous Velocity on a Graph
- The slope of the line tangent to the position-vs.-time graph is defined to be the instantaneous velocity at that time.
- **The instantaneous speed** is defined as the magnitude of the instantaneous velocity.

### Average Speed
- The **average speed** of an object is defined as the total distance traveled divided by the total time elapsed:
\[ \text{Average speed} = \frac{\text{total distance}}{\text{total time}} \]
\[ v = \frac{d}{t} \]
- Speed is a scalar quantity.

### Acceleration
- Changing velocity (non-uniform) means an acceleration is present.
- **Acceleration** is the rate of change of the velocity.
- Units are m/s² (SI), cm/s² (cgs), and ft/s² (US Cust).

### Average Acceleration
- **Vector quantity**
  - When the sign of the velocity and the acceleration are the same (either positive or negative), then the speed is increasing.
  - When the sign of the velocity and the acceleration are in the opposite directions, the speed is decreasing.

### Instantaneous Acceleration
- The limit of the average acceleration as the time interval goes to zero.

### Uniform Acceleration
- **Velocity vs. time curve is a straight line**.