# Chapter 2

I. 2-1: Reference Frames and Displacement:
   a. Reference Frame: The "perspective"
      i. If you are on a train that is moving 50mph, a person outside the train would say you are going 50 mph (Frame of Ref: The earth)
      ii. If you are on a train that is moving 50mph, a person inside the train would say you are not moving (Frame of Ref: In the train)
   b. Displacement: How far the object moved from its starting point to endpoint
      $d = x - x_0$ i.e [Distance Traveled - Starting Distance]
   c. Vectors represent magnitude and direction
   d. Δ (Delta) stands for change in

II. 2-2: Average Velocity
   a. Speed: How far an object travels in a given time interval (regardless of direction)
      Average speed: The total distance traveled along its path divided by the time it takes to travel this distance
      $\bar{s} = \frac{distance \quad traveled}{time \ elapsed} = \frac{d_2 - d_1}{t_2 - t_1} = \frac{\Delta d}{\Delta t}$
   b. Average velocity: The total displacement along its path divided by the time it takes to travel
      $\bar{v} = \frac{displacement}{time \ elapsed} = \frac{d}{t_2 - t_1} = \frac{d}{\Delta t}$
   c. Speed vs. Velocity:
      i. Speed is simply a positive number
      ii. Velocity is the Magnitude of how fast the object is going and the direction in which it is moving

III. 2-3: Instantaneous Velocity
   a. Instantaneous Velocity: The average velocity during an infinitesimally short time interval
      $v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$
   b. The instantaneous speed always equals the magnitude of the instantaneous velocity
   c. If an object moves at a constant velocity during a particular time interval,

IV. 2-4: Acceleration
   a. Average Acceleration:
      $\bar{a} = \frac{change \quad in \quad velocity}{time \ elapsed} = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1}$
   b. Instantaneous Acceleration: The average acceleration during an infinitesimally short time interval
      $a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t}$
   c. Acceleration tells us how quickly velocity changes, whereas velocity tells us how quickly the position changes
   d. Deceleration: When an object is slowing down
      i. Deceleration means the magnitude of velocity is decreasing; it does not necessarily mean acceleration is negative
      ii. We have deceleration whenever the magnitude of the velocity is decreasing, and then the velocity and acceleration point in the opposite directions

V. 2-5: Motion at a Constant Acceleration:
   a. Finding the constant acceleration:
      $a = \frac{velocity - starting \quad velocity}{time \ elapsed}$
   b. Determining the velocity of an object after any elapsed time
      $v = initial \ velocity + acceleration \times time \quad elapsed$
      i. Example:
         Given: $(a = \frac{4.0m}{s^2}, t = 6.0s)$
         Starts from Rest $(v_0 = 0, t_0 = 0)$
         $v = \frac{4.0m}{s^2} \times 6.0s = \frac{24m}{s}$
   c. Calculating position of an object after a certain time when it is undergoing constant acceleration
      $x = starting \quad position + starting \quad velocity \times time \quad elapsed + \frac{acceleration \times time^2}{2}$
   d. Calculating $velocity^2$ without given time
      $velocity^2 = (initial \quad velocity)^2 + 2 \times acceleration(displacement)$
   e. Average Velocity
      $average \quad velocity = \frac{initial \quad velocity + final \ velocity}{2}$
   f. Variables
      i. Initial Velocity ($v_0$)
      ii. Final Velocity ($v_f$)
      iii. Displacement $(\Delta x) = (x - x_0)$
      iv. Acceleration $(a)$
      v. Time $(t)$
   g. If you know the values of 3 variables, you can solve for the other 2

VI. 2-7: Falling Objects
   a. Without air resistance, All objects fall with the same constant acceleration
      (Weight) (Size) (Shape) don't change the acceleration
   b. Free Fall: No air resistance
   c. Gravitational Acceleration: g=9.8 m/s^2

VII. 2-8: Graphical Analysis
   a. Sketching vs. Graph
      i. Sketch is rough, Graph is precise
   b. Setting up a Graph
      i. x-axis (independent variable)
      ii. y-axis (dependent on x-axis)

Important Equations (For Motion at a constant Acceleration):

- $v = \frac{d}{t}$
- $v = v_0 + at$
- $x = x_0 + v_0 t + \frac{1}{2}at^2$
- $v^2 = v_0^2 + 2a(x - x_0)$
- $\bar{v} = \frac{v + v_0}{2}$

General Things to keep in mind:

- If position...
  - Remains constant: The velocity is 0, therefore the acceleration remains at 0
  - Is Linear: The velocity remains a constant number, therefore acceleration is 0
  - Is a curve: The velocity is increasing/decreasing, therefore the object is accelerating
- Velocity: The rate of change of the objects position with respect to its frame of reference (aka direction)
  - Velocity changes if
    - Displacement changes
    - Direction changes
- Acceleration: How fast the object's velocity is changing

Linearizing Graphs:

- So we can see the change in velocity (aka see the acceleration)
- How to:
  - x-axis: $t^2$
  - y-axis: $v$

$t_0$ is basically the moment where you start a stopwatch
$t$ is basically the total time $(t_2 - t_1)$