BSP1153
Mechanics & Thermodynamics
Kinematics (Part 1)

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Chapter Description

Expected outcomes

- To understand the concept of kinematics.
- To solve the free fall and projectile problems.
- To solve problems in kinematics.

References

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CHAPTER 3

KINEMATICS

Motion in One Dimension

- Displacement, position, velocity, speed and acceleration
- Instantaneous Velocity and Speed
- Free Fall

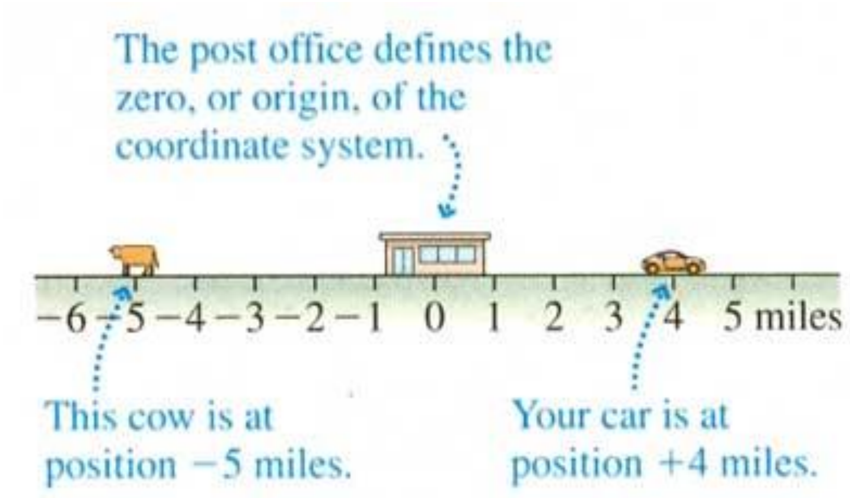
Motion in Two Dimension

- Projectile Motion

Position, displacement, velocity, speed & acceleration

Position

- A point where an object is located with respect to its reference or origin in a coordinate system.



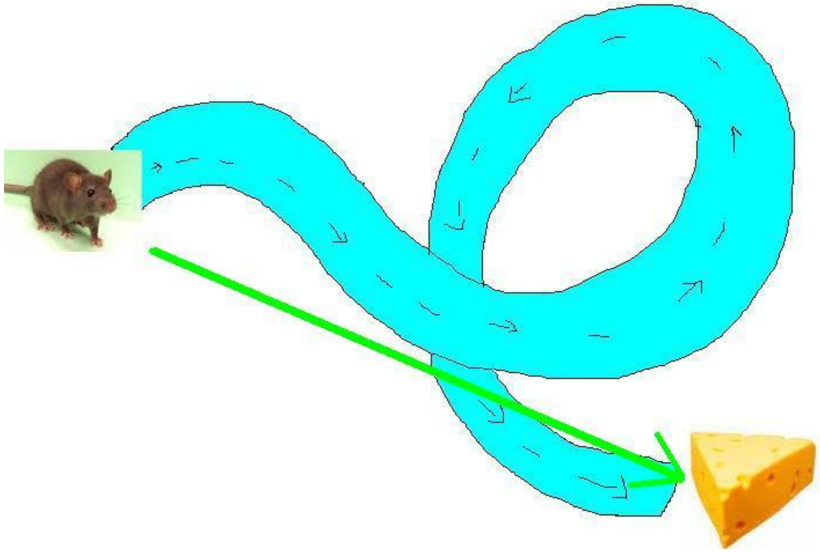
Position, displacement, velocity, speed & acceleration

Displacement

- Is the changes of position, Δx in a specified time interval.

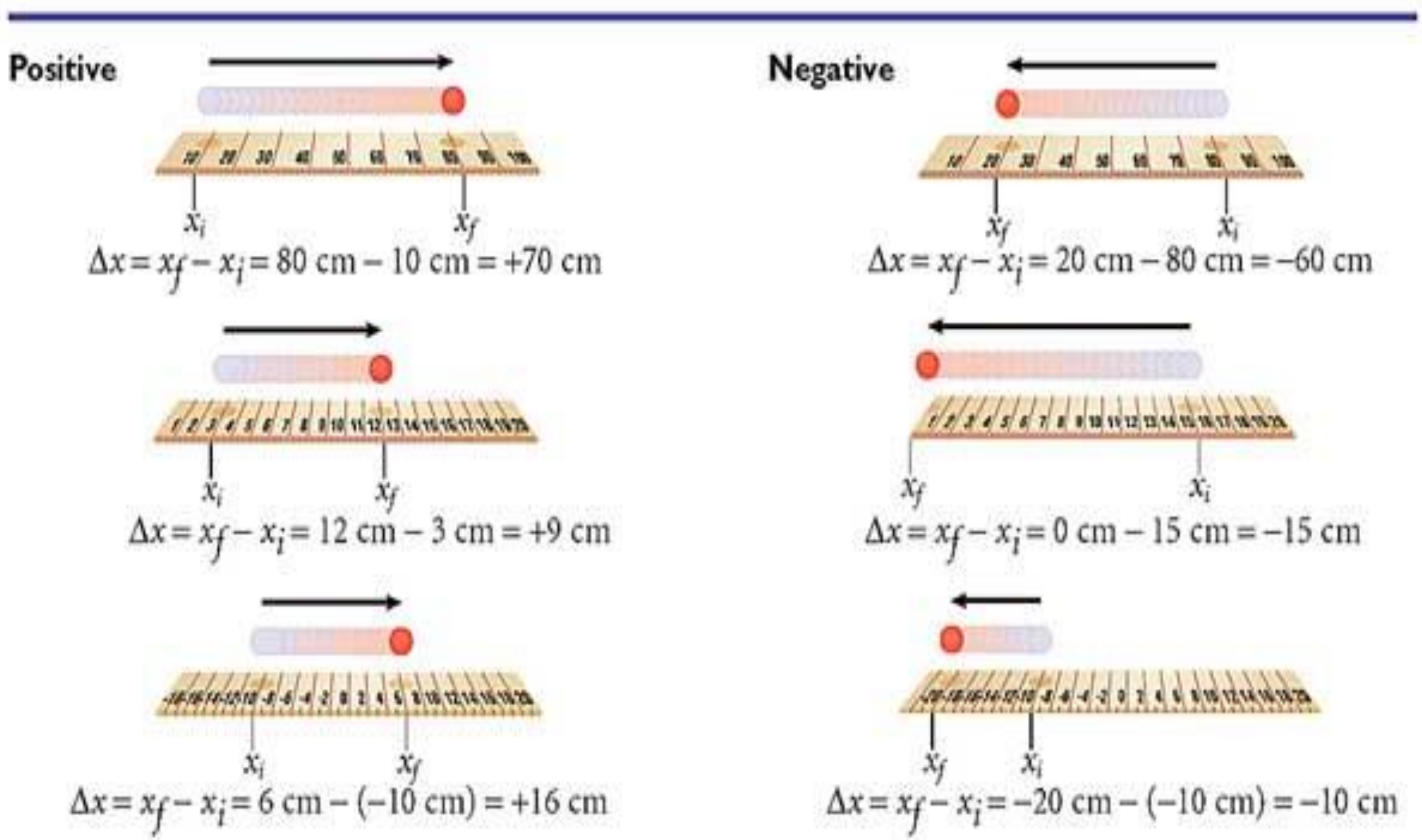
  $$\Delta x \equiv x_f - x_i$$

  Where
  - x_f is final position
  - x_i Is initial position



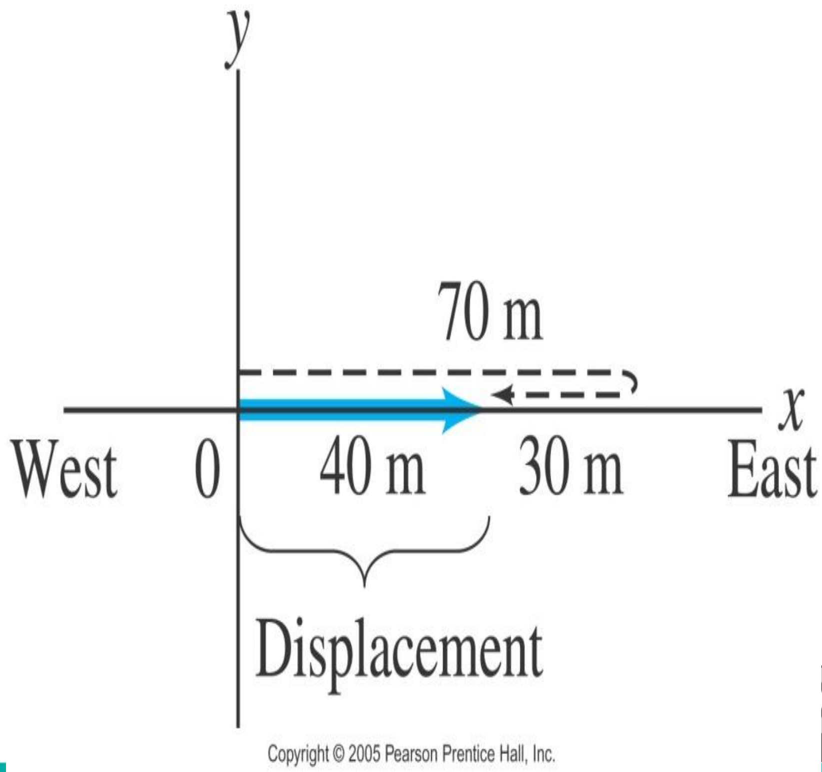
- The value can be +ve or -ve

How that the displacement value be positive or negative?



Example

- Ali walking 70m towards east and then make a U-turn at a distance of 30m to the west. Calculate the total distance and displacement for his journey.



- Total distance = 100 m
- Displacement = 40 m

Speed & Velocity

- Speed quantify a measurement of a distance travelled by an object at specific interval time.

$$\text{Speed} = \frac{\text{Distance}}{\text{Time Interval}}$$

- Velocity measure how fact an object is moving with respect to its magnitude and direction.

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time Interval}} \qquad v_{x,avg} \equiv \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{\Delta t}$$

Position, displacement, velocity, speed & acceleration

- **Acceleration**
  - Acceleration is the change of velocity.

$$\text{Acceleration} = \frac{\text{Velocity}}{\text{Time Interval}}$$

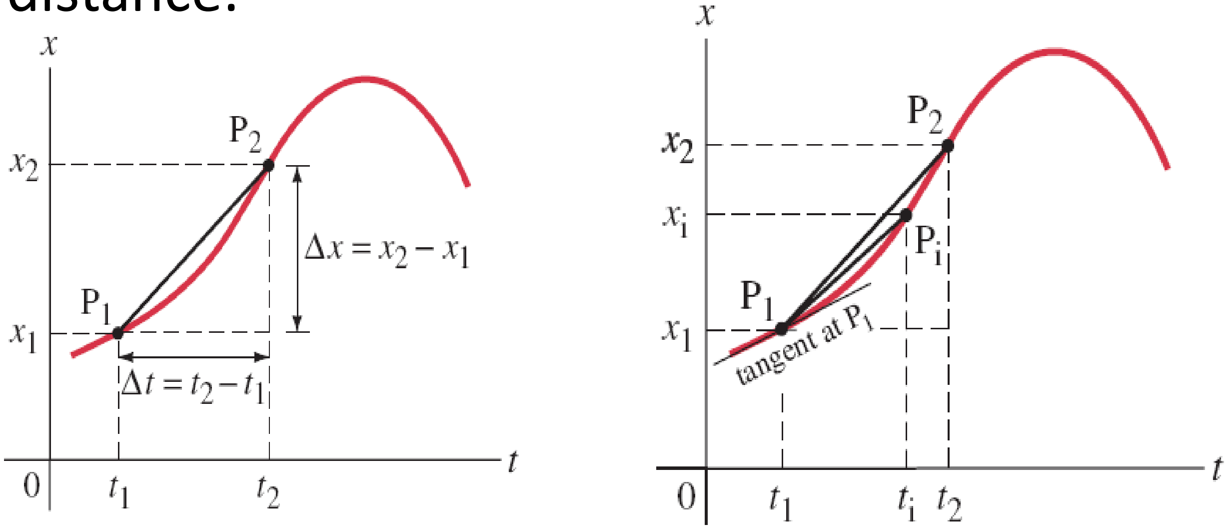
  - Average acceleration is the change of velocity at a specified time interval.

$$a_{x,avg} \equiv \frac{\Delta v_x}{\Delta t} = \frac{v_{xf} - v_{xi}}{t_f - t_i}$$

  - SI Unit for acceleration is ms^{-2}

Instantaneous Velocity

- Shows the velocity of a moving object at one point along a path distance.



Graph of particle's position vs. time

- By refer to above graph, the tangent to the curve (at any point) is denote to the instantaneous velocity.

- The instantaneous velocity could be expressed as:

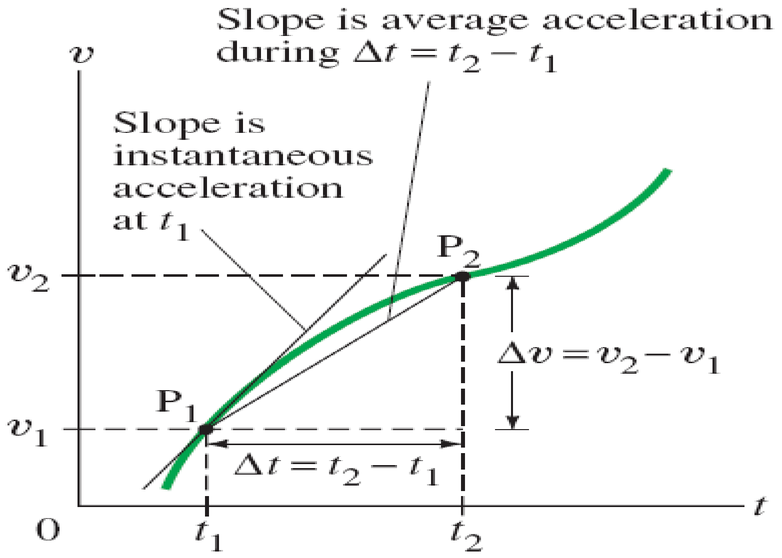
$$v_x = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

- The value can be +ve, -ve or zero.
- Meanwhile, the instantaneous speed is the magnitude of the instantaneous velocity w/o considered its direction.

Instantaneous Acceleration

- The instantaneous acceleration is the average acceleration of an object as the time interval approaches zero.

$$a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} = \frac{dv}{dt}.$$



- Both velocity as well as acceleration is a rate in which expressed in terms of time.
- Therefore, instantaneous acc. can be expressed as:

$$a = \frac{dv}{dt} = \frac{d}{dt}\left(\frac{dx}{dt}\right) = \frac{d^2x}{dt^2}$$

Freely Falling Object

- Objects is said to be fall freely when near the Earth's surface with constant acceleration.
- Galileo Galilei (1564-1642) stated that in the absence of air (due to small resistance effect), all objects fall with the same acceleration.
- This is due to the gravity, g which is equal to 9.81 ms^{-2}

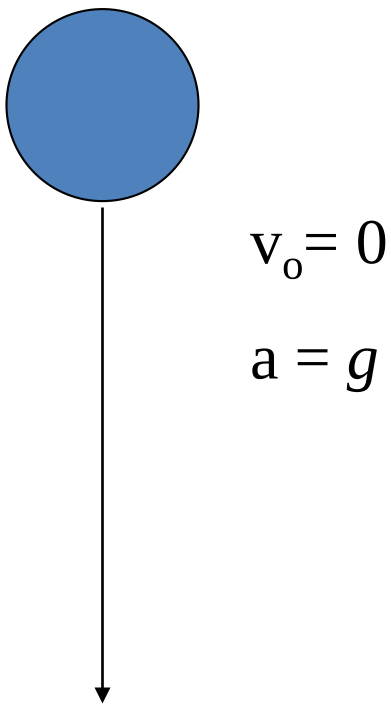
When dealing with freely falling object, we can make use of kinematics equation for constant acceleration

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

- $a = g = 9.80\ ms^{-2}$
- If the motion is vertical, substitute *y* in *x*, y_o in x_o, $y_o = 0$ (unless specified)
- v_o is initial velocity, x_o is initial position = y_o

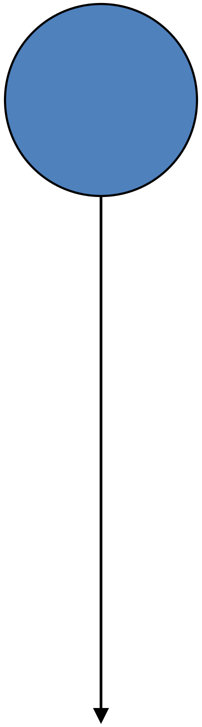
1^{st} case: An object dropped

- The initial velocity, v_o = zero.
- Let the downward be +ve.
- Refer to kinematic equations:
  - Since the motion is vertical, use y instead of x since.
  - $a_y = g = 9.81\ m/s^2$



2nd situation- An object thrown downward

- $a_y = g = 9.81\ m/s^2$
- Initial velocity $\neq 0$
- With the downward be +ve.



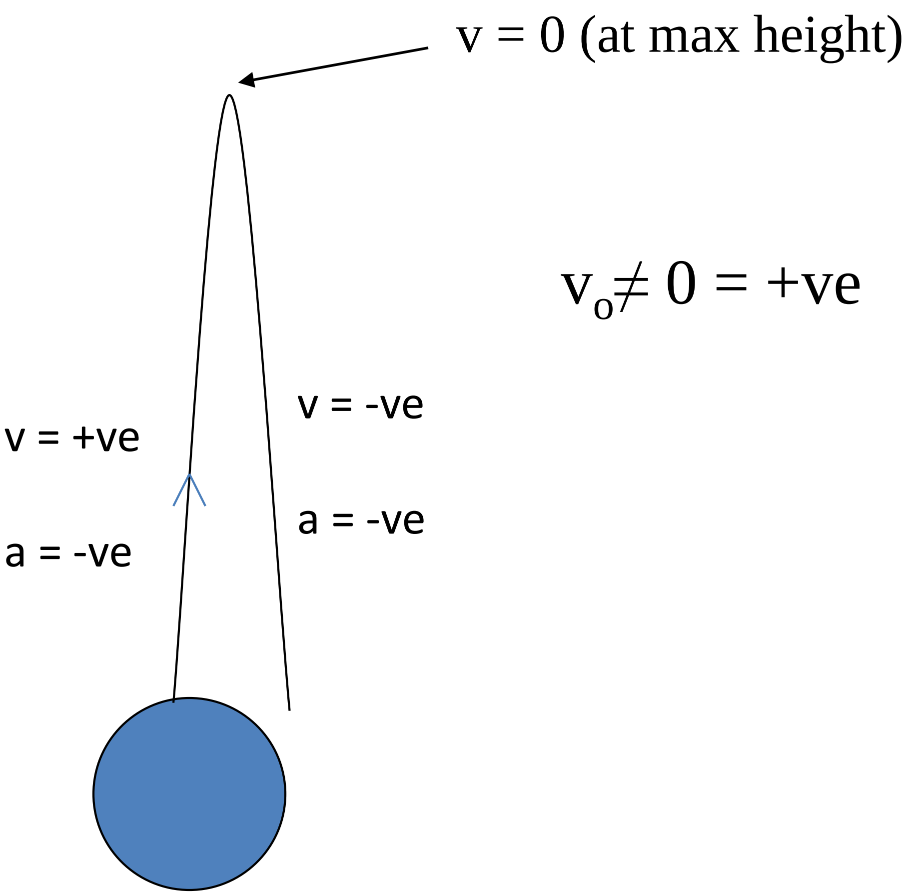
$v_o \neq 0$

$v_o = +ve$

$a = g$

3^{rd} situation : an object thrown upward

- Let direction be positive at any point above the release point and negative at any point below the release point
- The initial velocity is moving upward → so +ve
- The instantaneous velocity at the max. height, *h* = zero
- Pay attention , the $a_y = -g = -9.81\ m/s^2$ in the whole motion.



See you in Next Chapter!