PHYS 101

Ch. 2

Motion along a Straight Line

Chapter 2

Chapter Two

Motion along a Straight Line

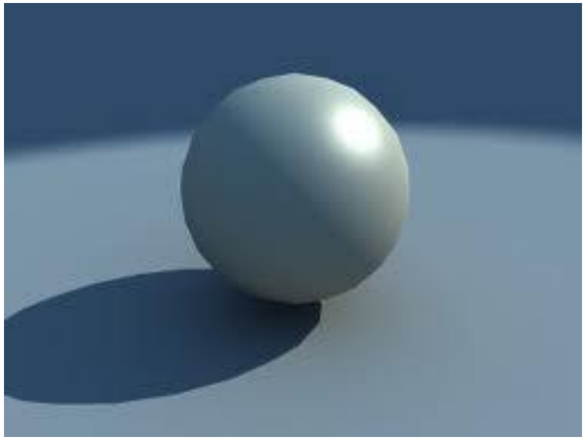
- ***Displacement, Time, and Average Velocity***
- ***Instantaneous Velocity***
- ***Average and Instantaneous Acceleration***
- ***Motion with Constant Acceleration***
- ***Free Falling Bodies***

Displc., Time, and Average Velocity

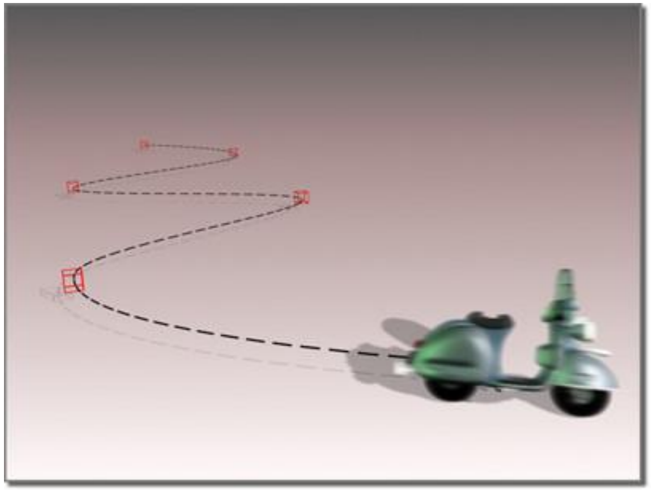
Position and Displacement

Position

- The position of a particle locates the particle with respect to the origin.
- The simple for position is x
- It has a unit of m



Displc., Time, and Average Velocity



Displacement

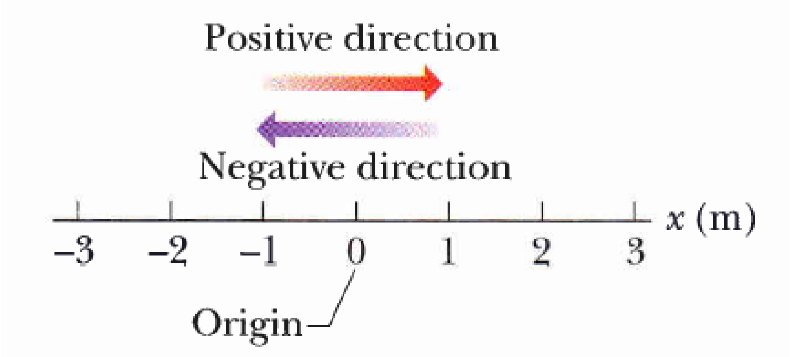
- The displacement of a particle is the change in its position.

- The simple for displacement is Δx

- It can be expressed as:

$$\Delta x = x_2 - x_1.$$

- It has a unit of m



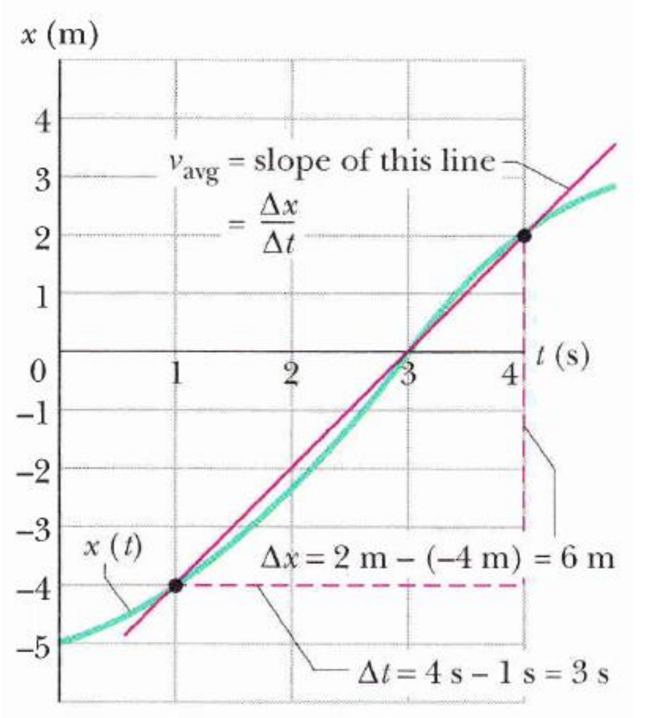
Displc., Time, and Average Velocity

Average Velocity and Average Speed

Average Velocity

- The average velocity for a particle moves from one position to another during a time interval is:

$$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1}.$$



- It depends on original and final positions not on the actual distance.

- Its has a unit of *m/s*

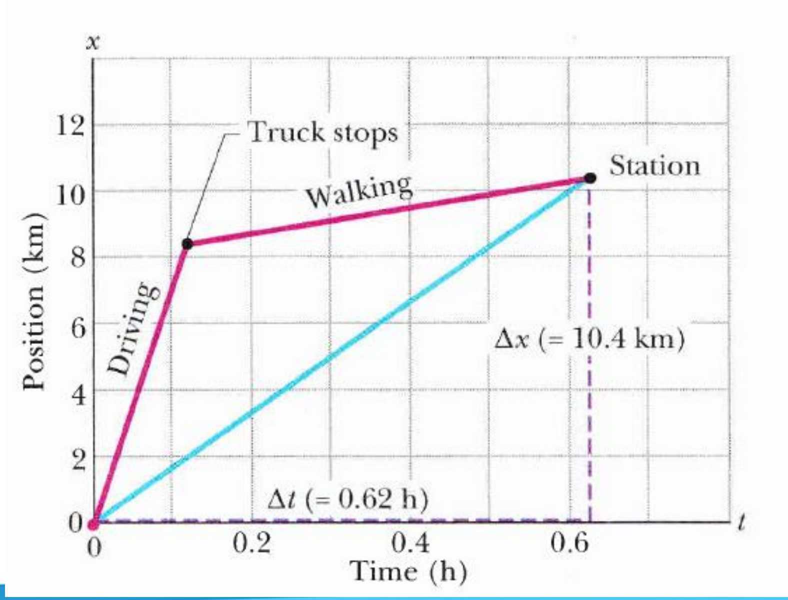
Displc., Time, and Average Velocity

Average Speed

- The average speed for a particle depends on the total distance that it moves during a time interval as

$$s_{avg} = \frac{\text{total distance}}{\Delta t}.$$

- Its has a unit of ***m/s***



Displc., Time, and Average Velocity

Example 1:

A bicycle travels 12 km in 90 min. Its average speed is:

Solution:

(A)

(A) 8 km/h
(B) 18 km/h
(C) 28 km/h
(D) 48 km/h

Instantaneous Velocity

Instantaneous Velocity and Speed

- Instantaneous velocity for a particle is given by

$$v = \frac{dx}{dt}.$$

- Instantaneous speed is the magnitude of instantaneous velocity.

- Both has a unit of ***m/s***

Instantaneous Velocity

Example 2:

The position of a particle moving on an x axis is given by
$x = 4 + 7t - t^2$, with x in (m) and t in (s). The velocity at 3 s is:

Solution:

(C)

(A) 4 m/s
(B) 2 m/s
(C) 1 m/s
(D) 0.4 m/s

Average and Instant. Acceleration

Acceleration

Acceleration

Average Acceleration

Instantaneous Acceleration

Average and Instant. Acceleration

Average Acceleration

- Average acceleration for a particle is the change in velocity during a time interval as follows:

$$a_{avg} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{\Delta v}{\Delta t},$$

- It has a unit of m/s^2

Average and Instant. Acceleration

Example 3:

A car uniformly changes its speed from 20 m/s to 5 m/s in 5 s. The average acceleration is:

Solution:

(B)

(A) 9 m/s^2
(B) -3 m/s^2
(C) 4 m/s^2
(D) -6 m/s^2

Average and Instant. Acceleration

Instantaneous Acceleration

- Instantaneous acceleration for a particle is the first time derivative of velocity $v(t)$ and the second time derivative of position $x(t)$:

$$a = \frac{dv}{dt}.$$

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

- It has a unit of m/s^2

Average and Instant. Acceleration

Example 4:

The velocity of a train is given by $v(t)=98 - 3t$, (where t in seconds and v is in m/s), has an acceleration of:

Solution:

(B)

(A) 2 m/s^2
(B) -3 m/s^2
(C) 98 m/s^2
(D) 0.3 m/s^2

Motion with Constant Acceleration

Constant Acceleration: A Special Case

- The equations used to describe the motion of a particle with constant acceleration are:

$$v = v_0 + at. \quad \text{------------} \quad (1)$$

$$x - x_0 = v_0 t + \tfrac{1}{2} a t^2. \quad \text{--------} \quad (2)$$

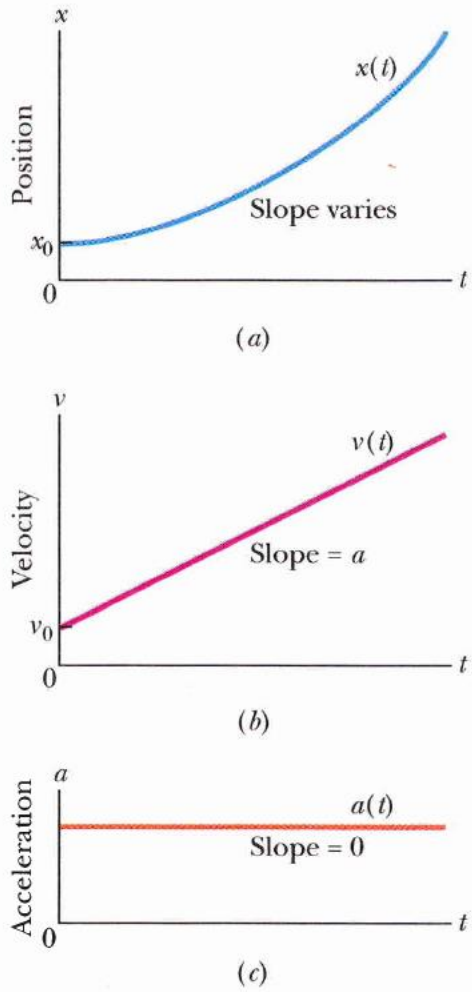
$$v^2 = v_0^2 + 2a(x - x_0). \quad \text{---------} \quad (3)$$

$$x - x_0 = \tfrac{1}{2}(v_0 + v)t. \quad \text{---------} \quad (4)$$

$$x - x_0 = vt - \tfrac{1}{2} a t^2. \quad \text{---------} \quad (5)$$

Motion with Constant Acceleration

Equation	Missing Quantity
$v = v_0 + at$	$x - x_0$
$x - x_0 = v_0 t + \frac{1}{2}at^2$	v
$v^2 = v_0^2 + 2a(x - x_0)$	t
$x - x_0 = \frac{1}{2}(v_0 + v)t$	a
$x - x_0 = vt - \frac{1}{2}at^2$	v_0



Motion with Constant Acceleration

Example 5:

A particle starts motion at 15 m/s. If it moves 20 m in 2 s, its final velocity is:

Solution:

(B)

(A) 10 m/s
(B) 5 m/s
(C) 3 m/s
(D) zero

Motion with Constant Acceleration

Example 6:

A car takes 10 s to accelerate from 0 to 50 m/s with constant acceleration. This acceleration is:

Solution:

(C)

(A) 15 m/s^2
(B) 9 m/s^2
(C) 5 m/s^2
(D) 2 m/s^2

Motion with Constant Acceleration

Example 7:

A train changes its velocity from 70 km/h to 20 km/h in 6 s. The distance it covered is:

Solution:

(A)

(A) 75.0 m
(B) 9.87 m
(C) 15.4 m
(D) 20.6 m

Motion with Constant Acceleration

Example 8:

A car moves along the x-axis with constant speed, the acceleration of the car is:

Solution:

(D)

(A) Decreasing
(B) Increasing
(C) 9.8 m/s^2
(D) Zero

Free Falling Bodies

Free-Fall Acceleration

- Important example of straight line motion with constant acceleration.

- Described by constant acceleration equations, but need to make two changes:

  1) Replace x by y .

  2) Replace a by $-g$, where $g = 9.8\ m/s^2$

Free Falling Bodies

- The equations will be as follows:

$$v = v_0 - gt \longrightarrow (1)$$

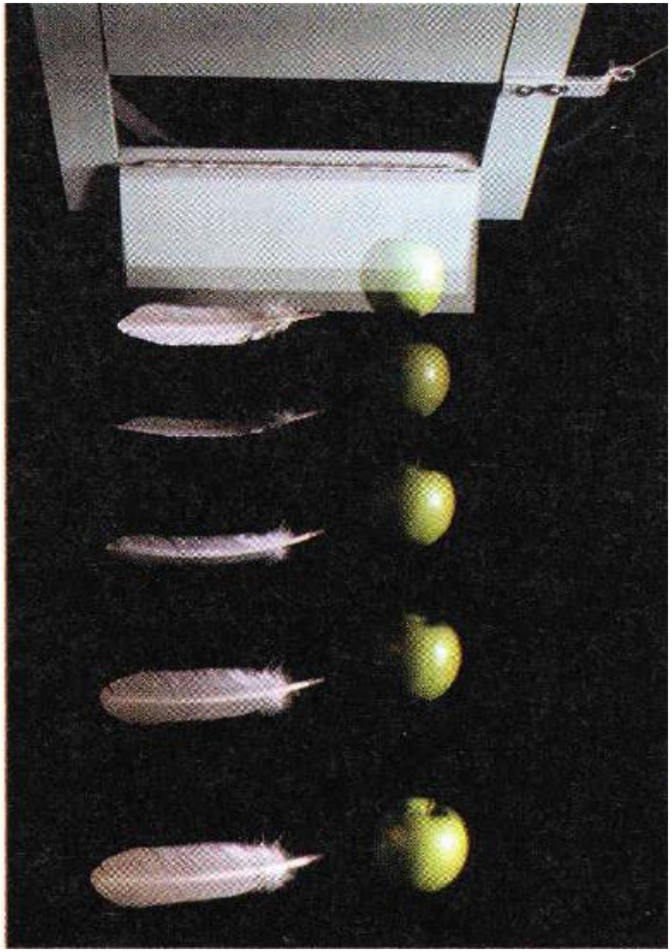
$$y - y_0 = v_0 t - \frac{1}{2} g t^2 \longrightarrow (2)$$

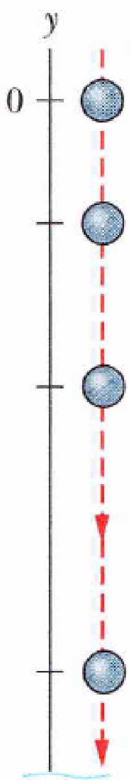
$$v^2 = v_0^2 - 2g(y - y_0) \longrightarrow (3)$$

$$y - y_0 = \frac{1}{2}(v_0 + v)t \longrightarrow (4)$$

$$y - y_0 = vt + \frac{1}{2} g t^2 \longrightarrow (5)$$

Free Falling Bodies





t	y	v	a
(s)	(m)	(m/s)	(m/s^2)
0	0	0	–9.8
1	–4.9	–9.8	–9.8
2	–19.6	–19.6	–9.8
3	–44.1	–29.4	–9.8
	–48.0		–9.8

Free Falling Bodies

Example 9:

A ball is thrown vertically upward at a speed of 12 m/s. It will reach its maximum height in:

Solution:

(A)

(A) 1.22 s
(B) 1.84 s
(C) 2.33 s
(D) 3.21 s

Free Falling Bodies

Example 10:

A stone is dropped vertically downwards from a height h. If the stone reaches a height of 10 m above the ground in 2 s, the height h is:

Solution:

(D)

(A) 4.9 m
(B) 9.6 m
(C) 19.6 m
(D) 29.6 m

Free Falling Bodies

Example 11:

A boy shot a foot ball vertically up with an initial speed v_0. When the ball was 2 m above the ground, the speed was 0.4 of the initial speed. The initial speed is:

Solution:

(C)

(A) 11.7 m/s
(B) 8.41 m/s
(C) 6.83 m/s
(D) 4.82 m/s