Chapter 3
Linear Motion

Describing motion…

but not accounting for it

(yet).

Describing Motion

How far?

- Position

  Where something is relative to some defined origin.

- Path

  The total length of the trajectory an object takes.

- Displacement

  The straight-line distance from start to end.

Describing Motion

How fast (on average)?

- Average Speed

Path per unit time $= \frac{Path}{Unit\ Time}$

- Average Velocity

Displacement per unit time $= \frac{Displacement}{Unit\ time} = \frac{\Delta x}{\Delta t}$

Describing Motion

How fast?

- Instantaneous Speed

  How fast at a given instant.

- Instantaneous Velocity

  How fast AND which direction at a given instant.

Describing Motion

How fast are you getting faster?

- Average Acceleration

$$a_{ave} = \frac{\Delta v}{\Delta t}$$

- Instantaneous Acceleration

Examining 1-Dimensional Motion

If we wish to determine where something is and how fast it is going at various times in its motion, we're going to have to do some math.

Position will be designated by x.

Displacement is a CHANGE in position and is denoted by Δx, where the "Δ" means "change in…" That is:

$$\Delta x = x_{final} - x_{initial}$$

Question

You start at the 2 m mark on the x-axis and you walk to the –1 m mark. What is your displacement?

A) 3 m

B) 1 m

C) –1 m

D) –3 m

Examining 1-Dimensional Motion

Average velocity is the RATE as which position changes. That is,

$$v_{ave} = \frac{Displacement}{Unit\ time} = \frac{\Delta x}{\Delta t}$$

A *change in velocity* would be: $\Delta v = v_{final} - v_{initial}$

Average acceleration is the RATE as which velocity changes. That is,

$$a_{ave} = \frac{\Delta v}{\Delta t}$$

Question

How does the average speed of a cheetah that sprints 100 meters in 4 seconds compare to one that sprints 50 meters in 2 seconds?

A) The cheetah that sprints for 4 seconds has a smaller average speed.

B) The cheetah that sprints for 4 seconds has a larger average speed.

C) Both have the same speed.

D) Not enough information to answer.

Constant Acceleration

If we are given that an objects accelerates at a constant rate ($a = a_{ave}$ = constant), then:

$$\Delta v = a\Delta t$$

$$v_{final} - v_{initial} = a(t_{final} - t_{initial})$$

If object starts from rest at time $t_{initial} = 0$, then:

$$v = at$$

Constant Acceleration (cont'd)

With a = constant, then:

$$v_{ave} = \frac{v_{final} + v_{initial}}{2} = \frac{\Delta x}{\Delta t}$$

Again, if the object starts from rest ($v_{initial} = 0$), then:

$$v_{ave} = \frac{v_{final}}{2} = \frac{at}{2}$$

Let the object start at the origin ($x_{initial} = 0$). So, $\frac{\Delta x}{\Delta t} = \frac{d}{t} = \frac{at}{2}$.

Now solve for d:

$$d = \frac{1}{2}at^2$$

Free Fall

When gravity is the <u>only</u> force acting on an object, then the object is said to be in a state of free fall.

With a = constant = g, where $g = 10\ \text{m/s}^2$. near the surface of the Earth.

Assuming that the object falls from rest, then in the absence of air drag:

$$v = gt \quad \text{and} \quad d = \frac{1}{2}gt^2$$

Question

If you fire a projectile straight up at 40 m/s, how much time will it take to return to its launch point?

A) 4 s

B) 8 s

C) 10 s

D) 40 s

E) 80 s

Question

If you fire a projectile straight up at 40 m/s, how high will it go?

A) 10 m

B) 10 m/s

C) 40 m

D) 40 m/s

E) 80 m

Question

If you fire a projectile straight up at 40 m/s, how high will it be 6 s after the launch?

A) 180 m

B) 60 m

C) 20 m

D) 10 m

E) It will have already hit the ground.

Question

An object is tossed vertically into the air. It slows down on the way up, stops for an instant, then speeds up on the way down. What are the magnitudes of the velocity and the acceleration at the very top of the trajectory?

A) v = 10 m/s and a = 10 m/s^2.

B) v = zero and a = 10 m/s^2.

C) v = 10 m/s and a = zero.

D) Both are zero.