Distance
- The total length of the path traveled by an object.
- Does not depend upon direction (scalar).

Displacement
- The change in position of an object.
- Depends only on the initial and final positions, not on path.
- Includes direction (vector).
- Represented by $\Delta x$.

***Problem: Distance versus Displacement***
1. A hiker hikes 25 miles due north and then all the way back to the starting point.
a) How far does the hiker hike? **Show your work.**

b) What is the hiker's displacement? **Show your work.**

Average speed
- $s_{ave} = d / t$
  d = distance
  t = elapsed time

Average Velocity
- $v_{ave} = \Delta x / t$
  $\Delta x$ = displacement ($x - x_o$)
  t = elapsed time

***Problem: Average Velocity (1988)***
62. A truck traveled 400 meters north in 80 seconds, and then it traveled 300 meters east in 70 seconds. The magnitude of the average velocity of the truck was most nearly

(A) 1.2 m/s
(B) 3.3 m/s
(C) 4.6 m/s
(D) 6.6 m/s
(E) 9.3 m/s

**Show your work:**

Acceleration
- A change in velocity.
- Acceleration can be speeding up, slowing down, or turning.
- The SI unit for acceleration is $m/s^2$.
- If the sign of the velocity and the sign of the acceleration is the same, the object speeds up.
- If the sign of the velocity and the sign of the acceleration are different, the object slows down.

Uniformly Accelerated Motion
- $a_{ave} = \Delta v / t$
  $\Delta v$ = change in velocity ($v - v_o$)
  t = elapsed time

***Problem: Acceleration (1993)***
1. In which of the following situations would an object be accelerated?

I. It moves in a straight line at constant speed.
II. It moves with uniform circular motion.
III. It travels as a projectile in a gravitational field with negligible air resistance.

(A) I only (B) III only (C) I and II only
(D) II and III only (E) I, II, and III

**Explain your answer:**

Kinematic Equations (star equations)

* $v = v_o + at$

** $\Delta x = v_o t + \frac{1}{2} a t^2$

*** $v^2 = v_o^{\,2} + 2a\Delta x$

***Problem: Kinematic Equations (1984)***

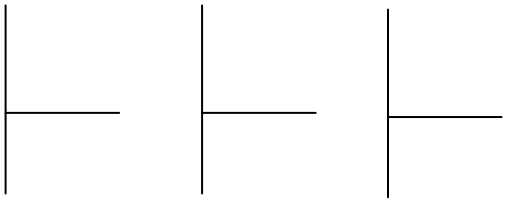
65. A body moving in the positive x direction passes the origin at time t = 0. Between t = 0 and t = 1 second, the body has a constant speed of 24 meters per second. At t = 1 second, the body is given a constant acceleration of 6 meters per second squared in the negative x direction. The position x of the body at t = 11 seconds is

(A) +99 m (B) +36 m (C) -36 m (D) -75 m (E) -99 m

**Show your work:**

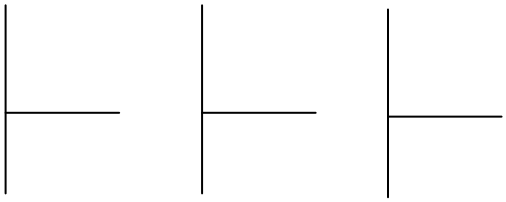
Kinematic Graphs

- Stationary particle



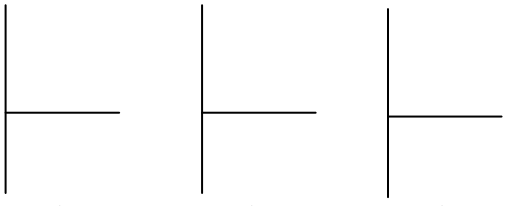
x vs t v vs t a vs t

- Particle moving with constant velocity



x vs t v vs t a vs t

- Particle moving with constant non-zero acceleration



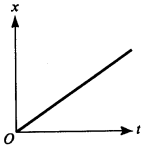
x vs t v vs t a vs t

Position-time graph
- Slope = velocity

Velocity-time graph
- Slope = acceleration
- Area under = displacement

Acceleration-time graph
- Area under = change in velocity

***Problem: Kinematic Graphs (1988)***

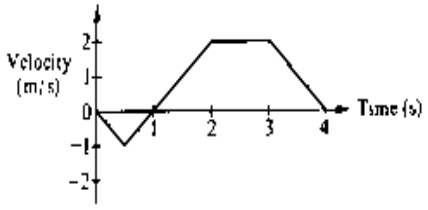



1. The displacement x of an object moving along the x axis is shown above as a function of time t. The acceleration of this object must be

(A) zero
(B) constant but not zero
(C) increasing
(D) decreasing
(E) equal to g

**Explain your answer:**

***Problem: Kinematic Graphs (1984)***




3. The graph shows the velocity versus time for an object moving in a straight line. At what time after time = 0 does the abject again pass through its initial position?

(A) Between O and 1 s
(B) 1 s
(C) Between 1 and 2 s
(D) 2 s
(E) Between 2 and 3 s

Show your work:

Free Fall

- Occurs when an object falls unimpeded.
- Gravity accelerates the object toward the earth.
- $g = 9.8\ m/s^2$ downward.
- $a = -g$ if up is positive.
- acceleration is down when ball is thrown up EVERYWHERE in the balls flight.

***Problem: Free Fall (1993)***

5. An object is released from rest on a planet that has no atmosphere. The object falls freely for 3.0 meters in the first second. What is the magnitude of the acceleration due to gravity on the planet?

(A) l .5 m/s2
(B) 3.0 m/s2
(C) 6.0 m/s2
(D) 10.0 m/s2
(E) 12.0 m/s2

**Show your work:**

Symmetry in Free Fall

- When something is thrown upward and returns to the thrower, this is very symmetric.
- The object spends half its time traveling up; half traveling down.
- Velocity when it returns to the ground is the opposite of the velocity it was thrown upward with.
- Acceleration is $-9.8\ m/s^2$ everywhere!