## Position (Distance), Velocity, and Acceleration

**Position Function:** $s(t)$ or $x(t)$ motion along the x-axis or $y(t)$ motion along the y-axis.

**Average Velocity:** $m_{sec} = \dfrac{s(t_2) - s(t_1)}{t_2 - t_1}$

**Instantaneous Velocity:** $v(t) = s'(t) = \dfrac{ds}{dt}$

- Motion to the right or up is considered positive →, then $v(t) > 0$ and distance $s$ is increasing

- Motion to the left or down is considered negative ←, then $v(t) < 0$ and distance $s$ is decreasing.

**Acceleration:** $a(t) = v'(t) = \dfrac{dv}{dt}$ or $a(t) = s''(t) = \dfrac{d^2 s}{dt^2}$

- If $a(t)$ and $v(t)$ have same signs, then speed of $P$ is increasing or speeding up

- If $a(t)$ and $v(t)$ have opposite signs, then speed of $P$ is decreasing or slowing down.

- If $s$ is a continuous function of $t$, then $P$ reverses direction whenever $v$ is zero and $a$ is different from zero. NOTE: zero velocity does not necessarily imply a reversal in direction.

**Instantaneous speed:** $|v(t)|$

1. If the position of a particle is $s(t) = \dfrac{t^3}{3} - 3t^2 + 4$, find the velocity and position of the particle when its acceleration is zero.

2. A particle moves along the x-axis so that at time $t \geq 0$ its position is given by $x(t) = 2t^3 - 21t^2 + 72t - 53$. At what time $t$ is the particle at rest?

3. The acceleration of a particle moving along the x-axis at time $t$ is given by $a(t) = 6t - 2$. If the velocity is 25 when $t = 3$ and the position is 10 when $t = 1$, Find the position function, $x(t)$.

4. A particle moves along a straight line is given by the position function $s(t) = 2t^3 - 9t^2 + 12t - 4$, where $t \geq 0$.

    A. Find all $t$ for which the velocity is increasing.

    B. Find where the speed of the particle is increasing.

    C. Find the speed when $t = 1.5$

    D. Find the total distance traveled between $t = 0$ and $t = 4$.

5. A particle moves in a straight line with velocity $v(t) = 4t^2$. How far does the particle move between times $t = 1$ and $t = 2$ ?

6. The graph of the position function of a moving particle is shown at right.
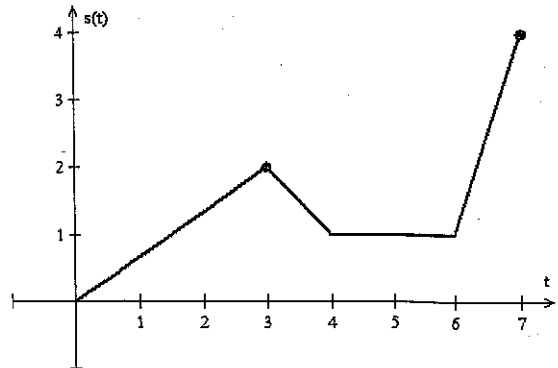
    A. What is the particle's position at $t = 5$ ?

    B. When is the particle moving to the left? Justify.

    C. When is the particle standing still?

    D. When does the particle have the greatest speed? Justify.

    E. What is the net change in position of the particle?

7. The velocity function of a particle is shown, at right.
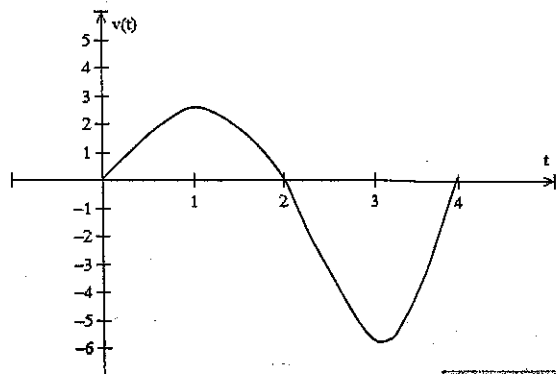
    A. When does the particle reverse direction? Justify.

    B. When is the acceleration zero? Justify.

    C. When is the speed the greatest? Justify.