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Applications of derivatives  
Problems involving position, velocity and acceleration

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Consider each of the following situations and answer clearly. Remember to use the appropriate mathematical notation and to frame your final answer.

1. An object is moving along a straight line, and its position (in meters) is given by the function  $s(t) = 80t - t^2$ . Determine
- a) The velocity of the object when  $t = 2$  sec  $v(t) = 80 - 2t$
  - b) The acceleration when  $t = 3$  sec  $a(t) = -2$
  - c) The time when the velocity is zero and the position of the object at that time

2. An object is moving along a straight line, and its position (in meters) is given by the function  $s(t) = 3t + \frac{48}{t+1}$ . Determine
- a) The velocity of the object when  $t = 2$  sec  $v(t) = 3 - \frac{48}{(t+1)^2}$
  - b) The acceleration when  $t = 2$  sec  $a(t) = \frac{96}{(t+1)^3}$
  - c) The time when the velocity is zero and the position of the object at that time

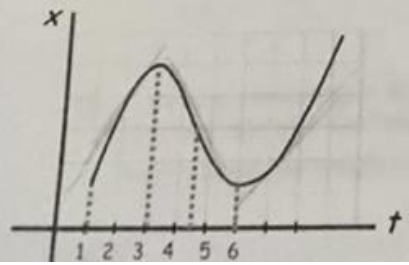
3. A dynamite charge blows a rock up with a velocity of 160 feet/sec. The height of the rock is given by  $h(t) = 160t - 16t^2$  where "h" is measured in feet and "t" in seconds. Find
- a) The equation that gives the velocity of the rock at any time  $v(t) = 160 - 32t$
  - b) The time when the velocity is zero  $5s$
  - c) The height of the rock when the velocity is zero (maximum height)  $400 ft$
  - d) The times (on the way up and on the way down) when the height is 256 feet  $3s$  and  $7s$
  - e) The velocities of the rock when the height is 256 feet  $96 ft/s$  and  $-96 ft/s$
  - f) The equation that gives the acceleration of the rock at any time  $a(t) = -32$
  - g) How long does it take the rock to fall back down?  $10s$

4. A baseball is thrown upward while being in the moon (hypothetically), with an initial velocity of 24 meters/second. The height of the ball is given by  $s = 24t - 0.8t^2$
- a) Find the equations of velocity and acceleration at any time  $v(t) = 24 - 1.6t$ ,  $a(t) = -1.6$
  - b) How long does it take the ball to reach its maximum height?  $1.5s$
  - c) Find the maximum height of the ball  $180m$
  - d) How long was the ball in the air?  $30s$

5. The position of an object is given by  $S(t) = t^3 - 6t^2 + 9t$  where "t" is measured in seconds and "s" in meters.
- a) Find the equations of velocity and acceleration as a function of time  $v(t) = 3t^2 - 12t + 9$ ,  $a(t) = 6t - 12$
  - b) Find the time when the velocity is zero  $1s$  and  $3s$
  - c) Find the acceleration when the velocity is zero.  $6 m/s^2$  and  $-6 m/s^2$
  - d) Find the time when the acceleration is zero and then give the velocity at that time.  $2s$  and  $3 m/s$

6. The height of a certain tree (starting from being 1 year old) is modeled by  $H(t) = 5\sqrt{t} + 2t^2 + 10$ , where height is measured in cm and time in years
- Find:
- a) The height of the tree in its 5th year (hint  $t=4$ )  $82 cm$
  - b) The function that models the rate of change of its height  $H'(t) = 2.5\sqrt{t} + 4t$
  - c) The rate of change when  $t=4$   $31 cm/year$
  - d) The rate of change when  $t=9$   $58.5 cm/year$
  - e) When is the tree growing faster? at  $t=4$  or  $t=9$  years? Why?  
At  $t=9$  years, because the rate of change of its height is bigger.

**CHALLENGE:** The following graph shows the position of a particle that moves along a straight line (author: Lic. Norma Patricia Salinas Martinez).



- a) In which interval or intervals is the velocity of the particle positive? (1, 4)
- b) In which interval or intervals is the velocity of the particle negative? (4, 6)
- c) In which interval or intervals of time is the position increasing faster? (1, 3)
- d) In which interval or intervals of time is the position increasing slower? (3, 4)
- e) In which interval or intervals of time is the position decreasing faster? (4, 5)
- f) In which interval or intervals of time is the position decreasing slower? (5, 6)
- g) In which interval or intervals of time is the velocity increasing? (6, infinity)
- h) In which interval or intervals of time is the velocity decreasing? (3, 6)