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11.2: Using differentiation

1) a) $s = 4t^3 - t$
 $v = 12t^2 - 1 \quad t = 2$
 $v = 12(2)^2 - 1$
 $v = 47 \text{ ms}^{-1}$

b) $s = 2t + t^2 - 1$
 $v = 2 + 2t$
 $v = 2 + 2(2)$
 $v = 6$

c) $s = t + t^{-1}$
 $v = 1 - t^{-2}$
 $v = 1 - (2)^{-2}$
 $v = \frac{3}{4}$

2) a) $s = \frac{3}{4}t^4 - t^{-2}$

i) $v = \frac{ds}{dt} = 3t^3 + 2t^{-3}$

ii) $a = \frac{d^2s}{dt^2} = 9t^2 - 6t^{-4}$

b) i) $s = 6t^3 + 3t - 10t^2 - 5$

$v = \frac{ds}{dt} = 18t^2 + 3 - 20t$

ii) $a = \frac{d^2s}{dt^2} = 36t - 20$

c) i) $\frac{2}{4}t^3 - \frac{3}{4}t + 2t^{-1}$

$v = \frac{ds}{dt} = \frac{3}{2}t^2 - \frac{3}{4} - 2t^{-2}$

ii) $a = \frac{d^2s}{dt^2} = 3t + 4t^{-3}$

3) $x = 2t^3 - 5t^2 + 8$

$v = 6t^2 - 10t \quad t = 4$

$v = 6(4)^2 - 10(4)$

$v = 56$

b) $v = 0 \rightarrow 6t^2 - 10t = 0$

$t(6t - 10) = 0$

$t = 0$

$6t - 10 = 0$

$6t = 10$

$t = \frac{5}{3}$

c) $a = \frac{d^2s}{dt^2} = 12t - 10 \quad t = 2$

$12(2) - 10$

$a = 14 \text{ ms}^{-2}$

4) $y = 20 + t - t^2$

$20 + t - t^2 = 0$

$t = 5$ $t = -4$
 \uparrow
 can't be negative

$a = \frac{dv}{dt} = 1 - 2t \quad t = 5$

$1 - 2(5) = -9 \text{ ms}^{-2} = 9 \text{ ms}^{-2}$

5) a) $s = \frac{1}{3}(2t^3 - 21t^2 + 60t + 90)$

$s = \frac{2}{3}t^3 - 7t^2 + 20t + 30$

$v = 2t^2 - 14t + 20$

$t = 5 \quad t = 2$

$\left[\frac{2}{3}t^3 - 7t^2 + 20t \right]_2^5$

$\left(\frac{115}{3} \right) - \left(\frac{142}{3} \right)$

$= -9 \rightarrow 9 \text{ cm}$

b) $a = \frac{dv}{dt} = 4t - 14 \rightarrow 4(5) - 14 = 6$

$a = \sqrt{(6)^2} = 6 \text{ ms}^{-2}$

6) a) $v = 0 \rightarrow 2t^2 - 17t + 21 = 0$

$t = 7 \quad t = \frac{3}{2}$

b) $a = 4t - 17$

$a = 0 \quad 4t - 17 = 0$

$4t = 17$

$t = \frac{17}{4}$

$v(0) = 2(0)^2 - 17(0) + 21 = 21$

$v(4.25) = -15.125$

$v(6) = -9$

$-15.125, -9 \rightarrow 15, 9, 21$

Greatest speed: 21 m/s.

$$7a) s = kt^3 - 5t^2 + 12$$

$$v = \frac{ds}{dt} = 3kt^2 - 10t$$

$$\text{When } t=1, v=8$$

$$8 = 3k(1)^2 - 10(1)$$

$$8 = 3k - 10$$

$$k = \underline{\underline{6}}$$

$$7b) v = 3(6)t^2 - 10t$$

$$v = 18t^2 - 10t$$

Instantaneously at rest $\Rightarrow v=0$

$$0 = 18t^2 - 10t$$

$$0 = t(18t - 10)$$

$$t=0 \text{ or } 18t - 10 = 0$$

$$t = \frac{10}{18}$$

$$a = \frac{dv}{dt} = 36t - 10$$

$$\text{When } t = \frac{10}{18}$$

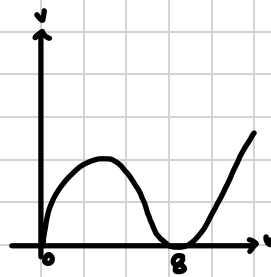
$$a = 36\left(\frac{10}{18}\right) - 10$$

$$a = \underline{\underline{10 \text{ ms}^{-2}}}$$

$$8 \text{ a. } v = \frac{1}{10} t (8 - t)^2$$

cubic graph

$$\text{roots } t = 0 \\ t = 8 \text{ (repeated)}$$



$$\text{y intercept} = 0$$

$$8 \text{ b. } v = \frac{1}{10} t (8 - t)^2$$

$$v = \frac{1}{10} t (64 - 16t + t^2)$$

$$v = 6.4t - 1.6t^2 + 0.1t^3$$

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

$$a = 6.4 - 3.2t + 0.3t^2$$

$$\text{when } a = 0$$

$$0 = 6.4 - 3.2t + 0.3t^2 \\ t = 8, \quad t = 8/3$$

$$\text{when } t = 8, \quad v = \frac{1}{10} (8)(8-8)^2 = 0 \text{ ms}^{-1}$$

$$\text{when } t = 8/3, \quad v = \frac{1}{10} (8/3)(8-8/3)^2 = \frac{1024}{135} = 7.59 \text{ ms}^{-1}$$

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