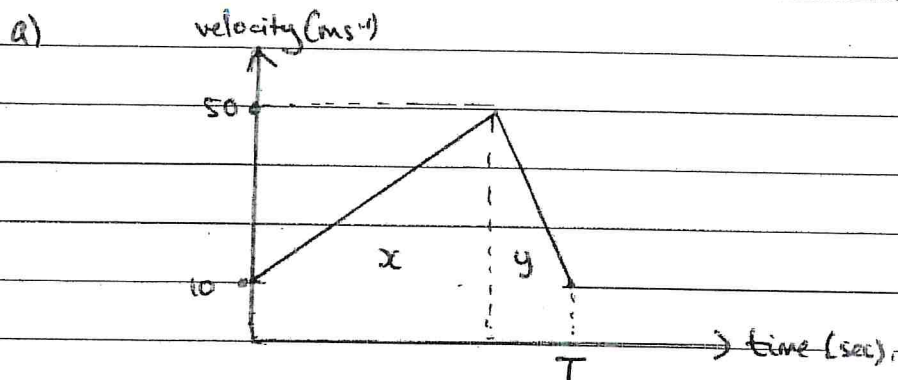


Mechanics Homework 4 solutions

Vertical motion

Section 1



b) Area = $10T + \frac{1}{2} \times T \times 40 = \underline{\underline{30T}}$

c) $x + y = 30T$

Time to accelerate = $\frac{50-10}{4} = 10 \text{ sec.}$

$\Rightarrow x = (10 \times 10) + \frac{1}{2} \times 10 \times 40 = \underline{\underline{300 \text{ m}}}$

Time to decelerate = $\frac{50-10}{10} = 4 \text{ sec}$

$\Rightarrow y = (4 \times 10) + \frac{1}{2} \times 4 \times 40 = \underline{\underline{120 \text{ m}}}$ $T = \underline{\underline{14 \text{ sec}}}$

Section 2

1) $u = 0$ $t = 1.8 \text{ sec}$ $a = 9.8 \text{ ms}^{-2}$ $s = ?$ ✓

$$s = ut + \frac{1}{2}at^2$$

$$= 0 + \frac{1}{2} \times 9.8 \times 1.8^2 = \underline{15.9 \text{ m}}$$
 ✓

(3)

2) $u = 7 \text{ ms}^{-1}$ $v = 15 \text{ ms}^{-1}$ $a = 9.8 \text{ ms}^{-2}$ $s = h$ ✓

$$v^2 = u^2 + 2as$$

$$15^2 = 7^2 + 2 \times 9.8 h$$
 ✓

$$225 = 49 + 19.6h \Rightarrow 19.6h = 176 \Rightarrow h = \underline{8.98 \text{ m}}$$
 ✓

(3)

3) a) $u = 39.2 \text{ ms}^{-1} \uparrow$ $t = 10 \text{ sec}$ $a = 9.8 \text{ ms}^{-2} \downarrow$
 $= -9.8 \text{ ms}^{-2}$

b) $s = ut + \frac{1}{2}at^2 = 39.2 \times 10 + \frac{1}{2} \times (-9.8) \times 10^2 = -98 \text{ m}$ ✓

\Rightarrow Height of cliff = 98 m ✓

b) $v = 0$ $u = 39.2 \text{ ms}^{-1}$ $a = -9.8 \text{ ms}^{-2}$

$$v^2 = u^2 + 2as$$

$$0 = 39.2^2 + 2 \times (-9.8)s \Rightarrow 0 = 1536.64 - 19.6s$$
 ✓

$$19.6s = 1536.64 \Rightarrow s = 78.4 \text{ m}$$

$$\Rightarrow \text{Total height} = 98 + 78.4 = 176.4 \text{ m}$$
 ✓

$$= \underline{176 \text{ m to 3sf}}$$
 ✓

c) $v = u + at$

$$0 = 39.2 - 9.8t \quad 9.8t = 39.2 \Rightarrow \underline{t = 4 \text{ sec}}$$
 ✓

d) $s = 98 \text{ m} \downarrow = -98 \text{ m}$ $u = 39.2 \text{ ms}^{-1}$ $a = -9.8 \text{ ms}^{-2}$

$$v^2 = u^2 + 2as = 39.2^2 + 2(-9.8)(-98) = 3457.44$$
 ✓

$$v = \underline{58.8 \text{ ms}^{-1}}$$
 ✓

e) $s = 0$ $u = 39.2 \text{ ms}^{-1}$ $a = -9.8 \text{ ms}^{-2}$

$$s = ut + \frac{1}{2}at^2 \quad 0 = 39.2t + \frac{1}{2}(-9.8)t^2 \quad 0 = t(39.2 - 4.9t)$$
 ✓

$$39.2 = 4.9t \Rightarrow t = \underline{8 \text{ sec}}$$
 ✓

(10)

4) $u = 42 \text{ ms}^{-1} \uparrow$ $a = 9.8 \text{ ms}^{-2} \downarrow = -9.8 \text{ ms}^{-2}$ $s = 87.5 \text{ m}$ $t = ?$

$$s = ut + \frac{1}{2} at^2$$

$$87.5 = 42t + \frac{1}{2}(-9.8)t^2$$

$$4.9t^2 - 42t + 87.5 = 0 \quad t = 5 \text{ or } 3.57$$

Time above 87.5m = 1.43 sec

(4)

5.) Stone 1: $u = 0$ $a = 9.8 \text{ ms}^{-2}$ $s = h$ $t = T + 1$

Stone 2: $u = 14 \text{ ms}^{-1}$ $a = 9.8 \text{ ms}^{-2}$ $s = h$ $t = T$

$$s = ut + \frac{1}{2} at^2 \quad ; \quad h = \frac{1}{2}(9.8)(T+1)^2 = 4.9T^2 + 9.8T + 4.9$$

$$h = 14T + \frac{1}{2}(9.8)T^2 = 14T + 4.9T^2$$

$$4.9T^2 + 9.8T + 4.9 = 14T + 4.9T^2$$

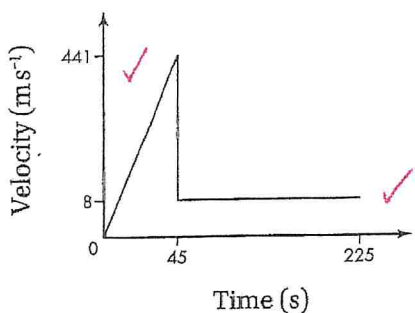
$$4.9 = 4.2T$$

$$T = \frac{7}{6}$$

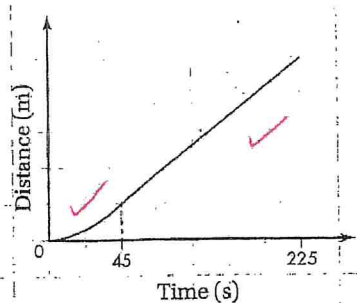
$$\Rightarrow h = 14\left(\frac{7}{6}\right) + 4.9\left(\frac{7}{6}\right)^2 = \underline{\underline{23.0 \text{ m}}}$$

(5)

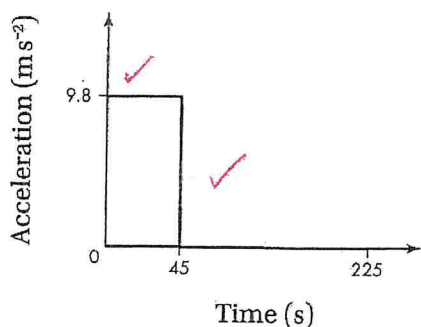
5.) a)



b.)



c.)



$$d) \left(\frac{1}{2} \times 45 \times 441\right) + (180 \times 8)$$

$$= 11,362.5 \text{ m}$$

$$= \underline{\underline{11,400 \text{ m}}} \text{ to 3sf}$$

e) Not realistic. The skydiver will not descend in freefall because of air resistance.

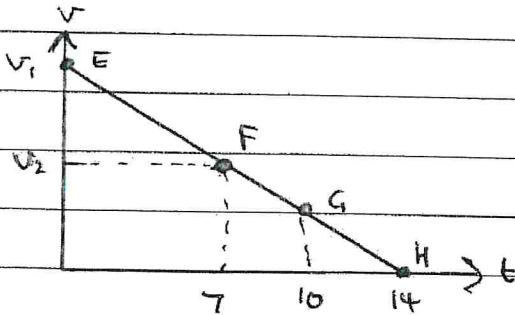
(10)

Mechanics Homework 4 solutions

Vertical Motion

Section 3

1.)



$$a) \text{ Deceleration} = \frac{v_3}{4} = \frac{v_2}{7} = \frac{v_1}{14}$$

$$\text{Area between F and G} = 66 \Rightarrow \frac{1}{2}(v_2 + v_3) \times 3 = 66 \Rightarrow v_2 + v_3 = 44$$

$$\frac{v_3}{4} = \frac{v_2}{7} \Rightarrow v_3 = \frac{4}{7}v_2 \Rightarrow v_2 + \frac{4}{7}v_2 = 44 \Rightarrow \frac{11}{7}v_2 = 44 \Rightarrow v_2 = 28 \text{ ms}^{-1}$$

$$\text{Deceleration} = 28/7 = \underline{4 \text{ ms}^{-2}}$$

$$b) \frac{v_1}{14} = 4 \Rightarrow v_1 = \underline{56 \text{ ms}^{-1}}$$

2.) a) $u = 20 \text{ ms}^{-1}$ $a = -4 \text{ ms}^{-2}$ $v = 0$ $s = ?$

$$v^2 = u^2 + 2as$$

$$0 = 20^2 + 2(-4)s$$

$$0 = 400 - 8s \Rightarrow 8s = 400 \Rightarrow s = 50 \text{ m}$$

He will stop 30m from the debris

b.) For the 2 sec before he engages brakes

$$u = 20 \text{ ms}^{-1} \quad a = 2 \text{ ms}^{-2} \quad t = 2 \text{ sec} \quad v = ? \quad s = ?$$

$$v = u + at = 20 + 2 \times 2 = 24 \text{ ms}^{-1}$$

$$s = ut + \frac{1}{2}at^2 = 20 \times 2 + \frac{1}{2} \times 2 \times 2^2 = 44 \text{ m} \Rightarrow 80 - 44 = 36 \text{ m}$$

from debris

Once brakes engaged:

$$u = 24 \text{ ms}^{-1}, \quad a = -4 \text{ ms}^{-2}, \quad s = 36 \text{ m} \quad v = ?$$

$$v^2 = u^2 + 2as = 24^2 - 2 \times 4 \times 36 = 288$$

$$\underline{v = 17.0 \text{ ms}^{-1}} \text{ when he hits debris}$$