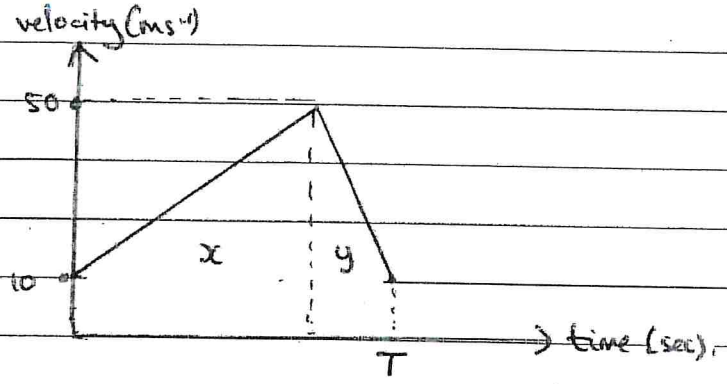
Mechanics Homework 3 solutions

Vertical motion

Section 1

a)



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

c) $x + y = 30T$

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

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

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

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

Section 2

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

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

$= 0 + \frac{1}{2} \times 9.8 \times 1.8^2 = 15.9 \text{ m}$ ✓ (3)

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

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

$15^2 = 7^2 + 2 \times 9.8h$ ✓

$225 = 49 + 19.6h \Rightarrow 19.6h = 176 \Rightarrow h = 8.98 \text{m}$ ✓ (3)

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

$= -9.8 ms^{-2}$

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

$\Rightarrow$ Height of cliff $= 98 \text{m}$ ✓

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

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

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

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

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

$= 176 \text{m}$ to 3sf ✓

c.) $v = u + at$

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

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

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

$v = 58.8 ms^{-1}$ ✓

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

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

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

(10)

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

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

$87.5 = 42t + \frac{1}{2}(-9.8)t^2$ ✓

$4.9t^2 - 42t + 87.5 = 0$ ✓ $t = 5$ or 3.57 ✓

Time above $87.5\,m = 1.43$ sec ✓ (4)

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

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

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

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

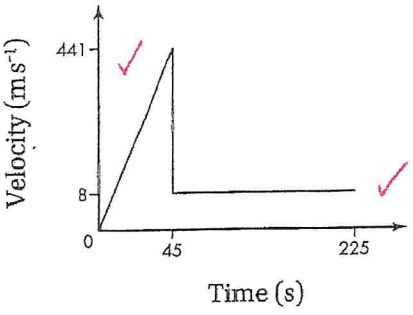
$4.9T^2 + 9.8T + 4.9 = 14T + 4.9T^2$

$4.9 = 4.2T$

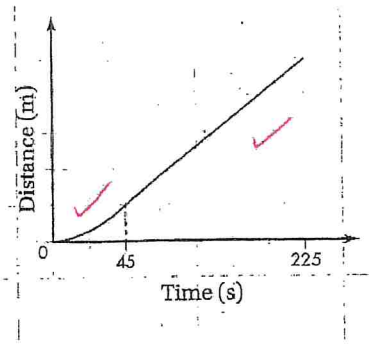
$T = 7/6$ ✓

$\therefore h = 14(7/6) + 4.9(7/6)^2 = 23.0\,m$ ✓ (5)

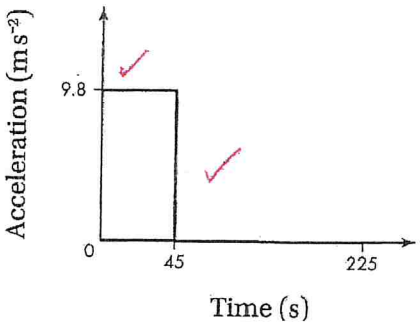
6) a)



b)



c)



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

$= 11{,}362.5\,m$ ✓

$= 11{,}400\,m$ to 3sf ✓

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

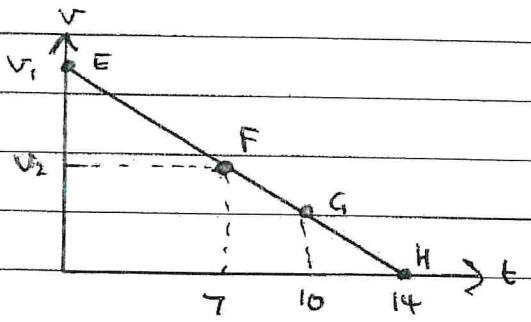
(10)

Mechanics Homework 4 solutions

Vertical Motion

Section 3

1.)



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

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

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

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

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

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

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

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

$0 = 400 - 8s \Rightarrow 8s = 400 \Rightarrow s = 50m$

He will stop $\underline{30m}$ from the debris

b.) For the 2 sec before he engages brakes

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

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

$s = ut + 1/2\, at^2 = 20\times 2 + 1/2 \times 2 \times 2^2 = 44m \Rightarrow 80 - 44 = 36m$ from debris

Once brakes engaged:

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

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

$v = 17.0 ms^{-1}$ when he hit debris