Date 17th Sep 2023

NS 1001 Applied Physics
Assignment #2

1a. Max velocity

Accelerating $\longrightarrow$ Coasting $\longrightarrow$ Decelerating
$50ms^{-2}$ $0ms^{-2}$ $-3ms^{-2}$

$v_M = u + at$
$v_M = 0 + (50)(5)$
$v_M = 250ms^{-1}$

1b. Total distance

Total time for travel = $5.0 + 3.0 + t_d = 8 + t_d$

$v = u + at$
$0 = 250 + (-3)t_d$
$t_d = 83.3s$

Total time for travel = 91.3s
Total Distance = $s_1 + s_2 + s_3$

$$s_T = \left(ut + \frac{1}{2}at^2\right) + \left(ut + \frac{1}{2}at^2\right) + \left(ut + \frac{1}{2}at^2\right)$$

$$s_T = [(10)(5) + (\tfrac{1}{2})(50)(5)^2] + [(250)(3) + (\tfrac{1}{2})(0)(3)^2] + [(250)(83.3) + (\tfrac{1}{2})(-3)(83.3)^2]$$

$s_T = 625 + 750 + 10416.67$
$s_T = 117916.7m$
$s_T \approx 117000\ m$ rounded off.

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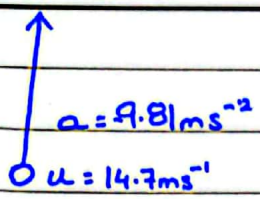
2a.



Highest Point:

$v = 0 ms^{-1}$

$v = u + at$

$0 = 14.7 + (-9.81)t$

$\frac{-14.7}{-9.81} = t$

$t = 1.498s$ → Time taken for cap to reach highst point

2b. $a = -9.81 ms^{-2}$ $t = 1.498s$

$u = 14.7 ms^{-1}$ $v = 0 ms^{-1}$

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

$s = (14.7)(1.498) + (\frac{1}{2})(-9.81)(1.498)^2$

$s = 11.013m$

2c. Time taken to reach highst point = 1.498s

Time taken to fall from highst to lowest:

$s = 11.013m$, $a = 9.81 ms^{-2}$, $u = 0 ms^{-1}$

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

$11.013 = +(\frac{1}{2})(9.81)(t)^2$

$t = 1.498s$

Total time = 2.996s

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3. $v_{ox} = 8 ms^{-1}$ for 60s. Shuts off and coasts ($a = 0 ms^{-2}$)

$v_x = \frac{v_{ox} t_1^2}{t^2}$, where $t_1 = 60s$. Displacement for $0 < t < \infty$?

$$v_x = \frac{(8)(60)^2}{t^2} = \frac{28800}{t^2}$$

Displacement for first 60 seconds:

$$s_1 = (8)(60) = 480m$$

Displacement for 60s to ∞:

$$s_2 = \int_{60}^{\infty} v_x \, dt$$

$$s_2 = \int_{60}^{\infty} 28800 t^{-2} \, dt$$

$$s_2 = 28800 \int t^{-2} \, dt$$

$$s_2 = (28800) \int \left(\frac{t^{-1}}{-1}\right) dt$$ Ans.

$$s_2 = -\frac{28800}{t}$$

Total = $480 + \left| -\frac{28800}{t} \right|_{60}^{\infty}$

$$\text{Total} = 480 + \left[\frac{-28800}{\infty} - \left(\frac{-28800}{60} \right) \right]$$

Total = 480 + 0 + 480

Total = 960m. Ans.

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4. Fred running with $a = 6 ft/s^2$. Tommy 20 yards or 60ft away heading towards Fred with speed 15 ft/s

$s_F = \frac{1}{2} 6t^2$ $\quad s_T = 60 - 15t$

$s_F = 3t^2$

$3t^2 = 60 - 15t$

$3t^2 + 15t - 60 = 0$

$t^2 + 5t - 20 = 0$

$t_1 = 2.62 s$ $\quad$ ~~$t_2 = -7.62 s$~~ Reject.

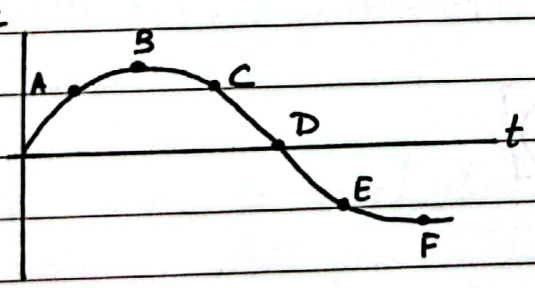
Tommy tackles Fred at $t = 2.6s$

$s_T = 60 - 15(2.6)$

$s_T = 21$ ft

Tommy tackles Fred 21ft forward from the goal line.

5.



a. Max velocity at A and C as steepest slope

b.

a. Moving fastest at D because steepest gradient

b. Moving to left at C, D, E, F

c. Speeding up at A, C, D, E while slowing at B, F

d. B is turning point as gradient = 0.

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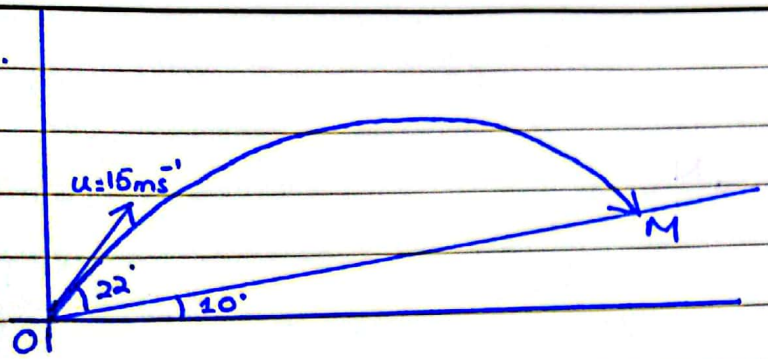
6.



a) $v = 0 ms^{-1}$ at max height

Time for reaching max height.

$v = u + at$

$0 = 15 \sin 22 + (-9.81 \cos 10)t$

$t = 0.58s$

Time to reach max height and come back down:

$t_T = 0.58 + 0.58 = 1.16 s$

b) ~~$R = \frac{15^2 \sin(22) \cos 32}{9.81 \cos^2 10}$~~ $R = \frac{u^2}{g\cos^2\alpha}\left[\sin(2\theta - \alpha) - \sin\alpha\right]$

~~Range = Time of travel = 0.58s~~

~~$u = 15$~~ $R = \frac{15^2}{9.81\cos^2(10)}\left[\sin(66 - 10) - \sin 10\right]$

$R = (23.65)(0.6554)$

$R = 15.5m$ → Distance OM

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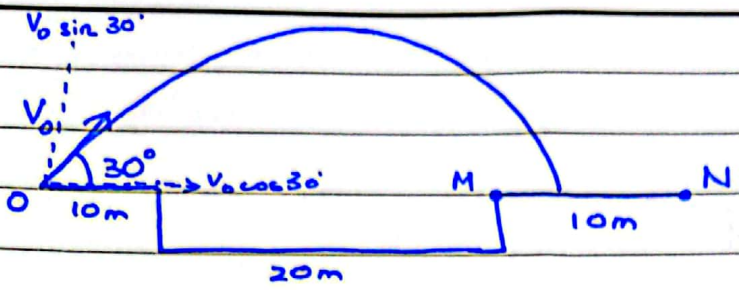
7.



$S_{H_1} = 30m$ $S_{H_2} = 40m$

$u = V_0 \cos 30°$ $u = V_0 \cos 30°$

Time of flight:

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

~~$0 = V_0 + (-9.8t)$~~

~~$V_0 = +9.8t$~~

~~Total time of flight = 19.62 s~~ 19.62 ts

$$R = \frac{V_0^2 \sin 2\theta}{g}$$

$OM = 30m$ $ON = 40m$

$$30 < \frac{V_0^2 \sin 2\theta}{g} < 40$$

$$\sqrt{\frac{30g}{\sin 2\theta}} < \sqrt{V_0^2} < \sqrt{\frac{40g}{\sin 2\theta}}$$

$$18.4 ms^{-1} < V_0 < 21.2 ms^{-1}$$

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8.i $y = (\tan\theta)x - \left(\frac{1}{2}\right)\left(\frac{g}{(V_0\cos\theta)^2}\right)x^2$, $y = -0.025x^2 + 0.5x$

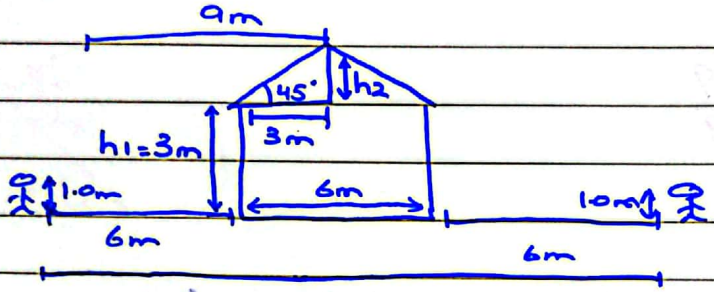
$\tan\theta = 0.5x$

$\theta = 26.5°$

$-0.025 = \left(-\frac{1}{2}\right)\left(\frac{9.8}{(V_0\cos 26.5)^2}\right)$

$V_0 = 15.6\ ms^{-1}$

9(a)



$a_y = -9.81\ ms^{-2}$

$a_x = 0\ ms^{-2}$

$\Delta x = 18m$

$\Delta x = 18m$

h2: $\tan\theta = \frac{y}{x}$

$\tan 45 = \frac{h_2}{3}$

$h_2 = 3\tan 45$

$h_2 = 3m$

Total height = 6m

Taking point of view at 1.0m so total height = 5m

Minimum speed (u) ↦ $v = 0\ ms^{-1}$, $s_y = 5$, $s_x =$ [illegible], $a_y = 9.81$, $a_x = 0\ ms^{-2}$

u_x

$s = \cancel{s_0} + u_x\cancel{\Delta t} + \cancel{\frac{1}{2}a_x t^2}$

$(9) = (u_x)(1.0)$

$u_x = 8.9\ ms^{-1}$

u_y

$2as = v^2 - u^2$

$(2)(-9.81)(5) = 0^2 - u_y^2$

$u_y = \sqrt{98}$

$u_y = 9.9\ ms^{-1}$

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$v_y = u_y + a_y t$

$0 = 9.9 - 9.8t$

$t = 1.01s$

$u = \sqrt{v_x^2 + v_y^2}$

$u = \sqrt{8.9^2 + 9.9^2}$

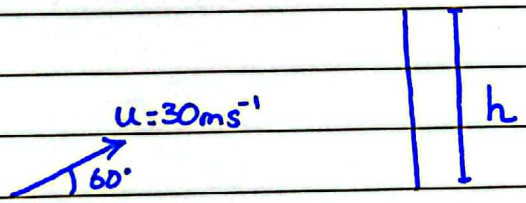
$u = 13.3 ms^{-1}$

(b) $\tan\theta = \frac{u_y}{u_x} = \frac{9.9}{8.9}$

$\theta = \tan^{-1}\left(\frac{9.9}{8.9}\right)$

$\theta = 48.0°$ above the horizontal anticlockwise from +ve x-axis

10.



$a = -9.81 ms^{-2}$

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

$h = (30\sin 60)(4) + \left(\frac{1}{2}\right)(-9.81)(4)^2$

$h = 25.4 m$

(b) $v = 0 ms^{-1}$

$2as = v^2 - u^2$

$(2)(9.81)s = 0^2 - (30\sin 60)^2$

$s = 34.4m$ max height.

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c) $t = 4.0s$, $v = 60ms^{-1}$, $s = 25.4m$, $a = -9.81ms^{-2}$

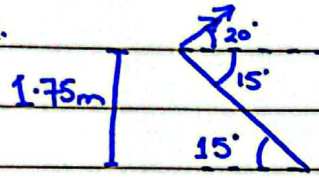
$s = vt - \frac{1}{2}at^2$

$25.4 = (4)(v) - (\frac{1}{2})(-9.81)(4)^2$

$25.4 - 78.48 = 4v$

$v = -13.27\ ms^{-1}$ is final impact speed.

11.



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

$\Delta y = 1.75m$

$1.75 = ut + \frac{1}{2}at^2$

$1.75 = (50\sin 35)(t) - (\frac{1}{2})(9.8\cos 15)(t^2)$

$4.73t^2 - 28.68t - 1.75 = 0$

$t = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$

$t = 6.12s$ ~~$t = -0.06s$~~ ← Rejected

$R = u_x t + \frac{1}{2}a_x t^2$

$R = (50\cos 35)(6.12) + (\frac{1}{2})(9.8\sin 15)(6.12)^2$

$R = 298.14m$ ← Answer