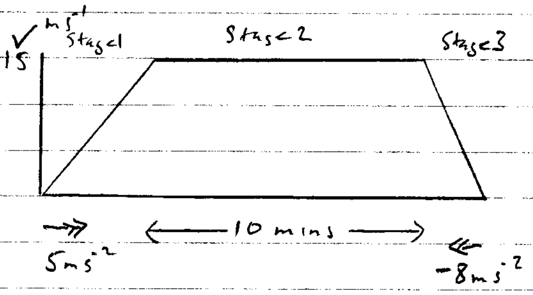
MECHANICS 1 — SUVAT MEI — EXERCISE 2B

1)



Stage1

Let time for Stage1 be t_1

Using $a = \frac{(v-u)}{t}$ $\quad 5 = \frac{15-0}{t_1}$

$\Rightarrow 5t_1 = 15$

$t_1 = 3$ s

Stage2 Let time be t_2

Given $t_2 = 10$ mins

$t_2 = 600$ s

Stage3 Let time be t_3

Using $a = \frac{(v-u)}{t}$ $\quad -8 = \frac{0-15}{t_3}$

$-8t_3 = -15$

$t_3 = \frac{15}{8} = 1.875$ s

Total time $= t_1 + t_2 + t_3$

$= 3 + 600 + 1.875$

$= 605$ s (to n'est s)

or 10 mins 5 secs

Stage 1 distance = avge velocity × time

$= \frac{(0+15)}{2} \times 3$

$= 22.5$ m

Stage 2 distance = constant vely × time

$= 15 \times 600 = 9000$ m

Stage 3 distance = average vely × time

$= \frac{(15+0)}{2} \times 1.875$

$= 14.0625$ m

Total distance $= 22.5 + 9000 + 14.0625$

$= 9037$ m (to n'est m)

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2)

$u = 2 ms^{-1}$

Let constant acceleration $= a$

When $t = 10$ s, $v = 6 ms^{-1}$

Using $v = u + at$

$6 = 2 + 10a$

$4 = 10a$

$\Rightarrow a = 0.4 ms^{-2}$

i) $\therefore$ $v = 2 + 0.4t$ ms^{-1}

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

$s = 2t + 0.2t^2$ m

iii) Using $v^2 = u^2 + 2as$

$v^2 = 2^2 + 2 \times 0.4 \times 400$

$v^2 = 324$

$v = \sqrt{324}$

$v = 18 ms^{-1}$

3) Sabina 100 m to run at $5\,ms^{-1}$

Time until finish $= \frac{100}{5} = 20\,s$

Daniel has 140 m to run, running at $4\,ms^{-1}$, accelerates at $0.25\,ms^{-2}$. If time required $= t$

$s = 140$, $u = 4$, $a = 0.25$

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

$$140 = 4t + 0.125t^2$$

$$1120 = 32t + t^2$$

Solve $t^2 + 32t - 1120 = 0$

$$t = \frac{-32 \pm \sqrt{32^2 + 4\times1120}}{2}$$

$$t = \frac{-32 \pm 74.19}{2}$$

$t = \cancel{-53.09}$ impossible

or $t = 21.095$ s

Daniel takes longer than 20 s so he does not catch Sabina

3) Alternative solution

Sabina 100 m to run at $5\,ms^{-1}$

Time to finish $= \frac{100}{5} = 20\,s$

Where will Daniel be when Sabina reaches finish?

For Daniel $u = 4$, $a = 0.25$, take $t = 20$

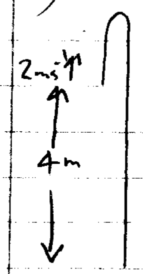
Using $s = ut + \frac{1}{2}at^2$

$$s = 4\times20 + \tfrac{1}{2}\times0.25\times20^2$$

$$s = 130\ m$$

Daniel will run 130 m in next 20 s but he is 140 m from finish so he will not catch Sabina.

4)



i) using $s - s_0 = ut + \frac{1}{2}at^2$

$$h - 4 = 2t - \tfrac{1}{2}\times9.8t^2$$

$$h - 4 = 2t - 4.9t^2$$

$$\underline{h = 4 + 2t - 4.9t^2}$$

ii) When ball hits ground $h = 0$

$$0 = 4 + 2t - 4.9t^2$$

$$4.9t^2 - 2t - 4 = 0$$

$$t = \frac{2 \pm \sqrt{4 + 4\times4\times4.9}}{2\times4.9}$$

$$t = \frac{2 \pm 9.077}{2\times4.9}$$

$t = \cancel{-0.72}$ or $\underline{t = 1.13\ s}$

iii) Using $v = u + at$

$$v = 2 - 9.8\times1.13$$

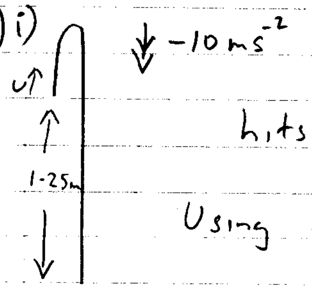
$$v = -9.07\ ms^{-1}$$

Ball is moving at $\underline{9.07\ ms^{-1}}$

iv) t greater

v less

5) i)



hits ground after 2.5 s

Using $s - s_0 = ut + \frac{1}{2}at^2$

$s - 1.25 = ut - 5t^2$

When ball hits ground $s = 0$, $t = 2.5$

$0 - 1.25 = u \times 2.5 - 5 \times 2.5^2$

$-1.25 = 2.5u - 31.25$

$30 = 2.5u$

$\underline{u = 12\ ms^{-1}}$

ii) Greatest height when $v = 0$

Using $v = u + at$

$0 = 12 - 10t$

$10t = 12$

$t = 1.2\ s$

Using $s - s_0 = ut + \frac{1}{2}at^2$

$s - 1.25 = 12 \times 1.2 - 5 \times 1.2^2$

$\underline{s = 8.45\ m}$

iii) Ball hits ground after 2.5 s

Using $v = u + at$

$v = 12 - 10 \times 2.5$

$v = -13\ ms^{-1}$

<u>Ball hits ground at $13\ ms^{-1}$</u>

iv) Measure now from after ball hits ground.

Given it loses 0.2 of speed

$\therefore u = 13 \times 0.8 = 10.4\ ms^{-1}$

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

At greatest height $v = 0$

$\therefore\ 0 = 10.4^2 - 2 \times 10s$

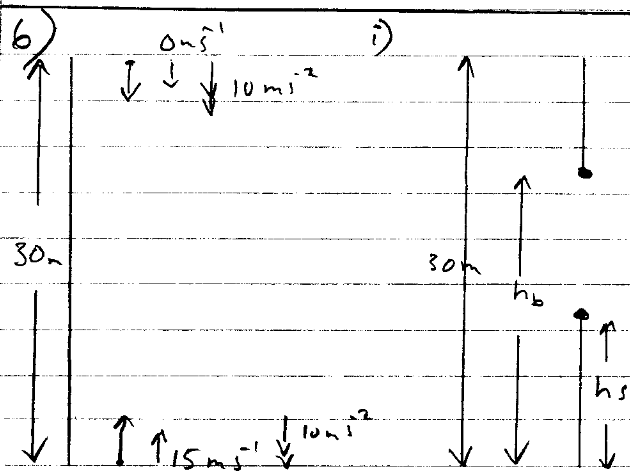
$20s = 108.16$

$\underline{s = 5.408\ m}$

v) Under-estimate

He will have hit the ball harder to stay in the air 2.5 s

6) i)



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

$\underline{h_s = 15t - 5t^2}$

iii) Using $s - s_0 = ut + \frac{1}{2}at^2$

$h_b - 30 = 0 - 5t^2$

$\underline{h_b = 30 - 5t^2}$

iv) Collide when $h_s = h_b$

$15t - \cancel{5t^2} = 30 - \cancel{5t^2}$

$\Rightarrow\ \underline{t = 2\ s}$

6 cont) v) Collide when $t = 2$ s

Subst for t in

$h_b = 30 - 5t^2$

$h_b = 30 - 5 \times 2^2$

$h_b = 10$ m

Collide at height of 10 m

7) i) 3 s accelerating at $1.8\ ms^{-2}$

Change in speed $3 \times 1.8 = 5.4\ ms^{-1}$

ii) 2 s decelerating at $-2.2\ ms^{-2}$

Change in speed 2×-2.2
$= -4.4\ ms^{-1}$

iii) In 5 sec cycle

Change in speed $= 5.4 - 4.4$
$= 1\ ms^{-1}$ increase

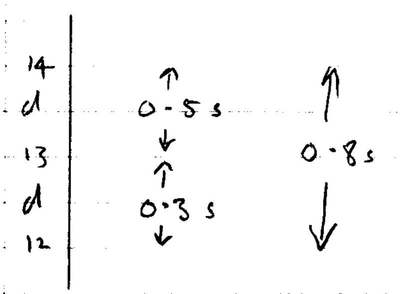
iv) 9 cycles of 5 secs

Speed increases from rest at $1\ ms^{-1}$ every 5 sec.

Final speed $= 9 \times 1 = 9\ ms^{-1}$

v) Much too quick to row a boat - more like top class sprinter.

8)



Let distance between floors $= d$

From 14 to 13

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

$d = 0.5u + 5 \times 0.5^2$

$d = 0.5u + 1.25$ ①

From 14 to 12

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

$2d = 0.8u + 5 \times 0.8^2$

$2d = 0.8u + 3.2$ ②

① × 0.8

$0.8d = 0.4u + 1$ ③

② × 0.5

$d = 0.4u + 1.6$ ④

④ − ③

$0.2d = 0.6$

$\Rightarrow d = 3$ m

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

Clay Pigeon 1

$s_1 = 30t - 5t^2$

Clay Pigeon 2

$s_2 = 30(t-1) - 5(t-1)^2$

provided $t \geq 1$

Collide when $s_1 = s_2$

$30t - 5t^2 = 30(t-1) - 5(t-1)^2$

$\cancel{30t} - 5t^2 = \cancel{30t} - 30 - 5(t^2 - 2t + 1)$

$\cancel{-5t^2} = -30 \cancel{-5t^2} + 10t - 5$

$35 = 10t \Rightarrow t = 3.5$ s

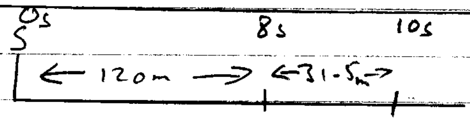
9 cont) When $t = 3.5$

$$s_1 = 30 \times 3.5 - 5 \times 3.5^2$$

$$s_1 = 43.75\text{ m}$$

Collide 43.75 m above ground

10)



i) Initial velocity u
acceleration a

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

$$120 = 8u + \tfrac{1}{2}a \times 8^2$$

$$120 = 8u + 32a$$

$$\Rightarrow \quad \underline{u + 4a = 15} \quad (1)$$

ii) From station to far side of bridge

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

$$151.5 = 10u + \tfrac{1}{2}a \times 10^2$$

$$151.5 = 10u + 50a$$

$$\underline{15.15 = u + 5a} \quad (2)$$

iii) (2) − (1)
gives $\underline{a = 0.15}$

Subst for a in (1)

$$u + 4 \times 0.15 = 15$$

$$u + 0.6 = 15$$

$$\underline{u = 14.4\text{ ms}^{-1}}$$

iv) Travels 167 m in 10s after crossing bridge

Has therefore travelled
$120 + 31.5 + 167 = 318.5\text{ m}$
in 20 seconds

According to model

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

$$s = 14.4 \times 20 + \tfrac{1}{2} \times 0.15 \times 20^2$$

$$s = 318\text{ m}$$

This means that the model is a good fit to the actual data and there is no evidence to reject the assumption of constant acceleration.