Applied Physics.

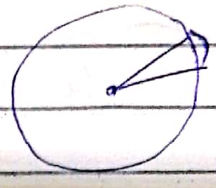
Assignment 1

BSSE23058 Section A

Q1 $1\ nt.mi = 1.151 mi$ or $1852 m$

House ——— ASTP

2.3 nt.mi



s r θ .

$2.3 \times 1.151 = 2.65$ mi

↓

$2.3 \times 1852 = 4260 m$

$$1 min = \frac{1}{60} \times \frac{\pi}{180} = \frac{\pi}{10800}$$

$$s = r\theta$$

$$= 4260 \times \frac{\pi}{10800} = 1.23$$

≈ 1.23 degrees in a minute arc.

Q2 a. $1 hr = 1.44 \times 10^{13}$ calculation steps.

$x = 1$ calculation steps

$x = 6.94 \times 10^{-14}$ hr.

It takes 6.94×10^{-14} hr to perform one calculation step

$1 hr - 1.44 \times 10^{13}$ c. steps.

$\frac{1 \times 60 \times 60}{10^{-9}} ns - 1.44 \times 10^{13}$ c. steps

$1 ns - ?$

$1 ns = 4$ calculation steps.

In one ns, 4 calculation steps can be performed.

b. 8 ft 11.1 inch ⟶ m

$8 + (11.1 \times \frac{1}{12}) = 8.925$ ft

$1 ft = 0.3048 m$

$8.925 ft = x\ m$

$2.72034\ m = x$

8 ft 11.1 inch = 2.72034 m (6 sig. fig)

1918 — 1940 22 years.

$$\text{growth rate} = \frac{2.72034}{22}$$

$$= 0.124 \text{ meter/year.}$$

Q3 a. Mr of N_2 = $2 \times \cancel{28}\, 14 = 28$

$$\text{molecular Mass of } N_2 = \% \text{ of } N_2 \times Mr$$

$$= \frac{75.5 \times 28}{100} = 21.14$$

$$\text{Molecular Mass of } O_2 = \frac{23.2}{100} \times 2 \times 16 = 7.424$$

$$\text{Molecular Mass of } Ar = \frac{1.3}{100} \times 1.8 = 0.234$$

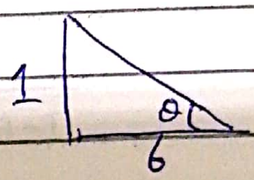
$$\text{Average Molecular Mass of air} = 21.14 + 7.424 + 0.234$$

$$= 29.02$$

$\Rightarrow$ 6.02×10^{23} molecules of air would have a mass of 29.02 grams.

b. The scientist should use second as the fundamental unit to decsibe the measuremenot. In 1 minute the bird beats its wings 3000 times, for more precise measurement the scientist should use $\frac{1}{1000} = 10^{-3}$ millisecond. (ms).

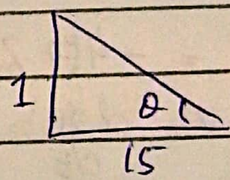
Q4 angle to use for 1 step 6 atoms.



$$\tan\theta = \frac{1}{6}$$

$$\theta = 9.46^\circ$$

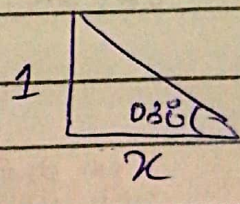
angle to use for 1 step 15 atoms



$$\tan\theta = \frac{1}{15}$$

$$\theta = 3.81^\circ$$

angle = 0.30° step = 1 atoms = x



$$\tan 0.30 = \frac{1}{x}$$

$$x = \frac{1}{\tan 0.30}$$

$x \approx 191$ atoms.

Q5 a. Displacement $= -2-0$
$0 \leq t \leq 1$ $= -2m$

Displacement $= 6-(-2)$
$1 \leq t \leq 3$ $= 8m$

b. $\bar{v} = \frac{-2-0}{1-0} = -2\,m/s$ for $0 \leq t \leq 1$

$\bar{v} = \frac{6-(-2)}{3-1} = 4\,m/s$ for $1 \leq t \leq 3$

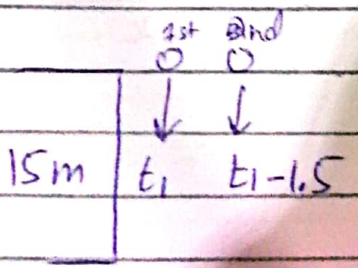
c. $x = -4t + 2t^2$

$v = \frac{dx}{dt}$

$v = -4 + 2(2)t$
$= -4 + 4t$

$v(t=2.5) = -4 + 4(2.5)$
$= 6\,m/s$

Q6

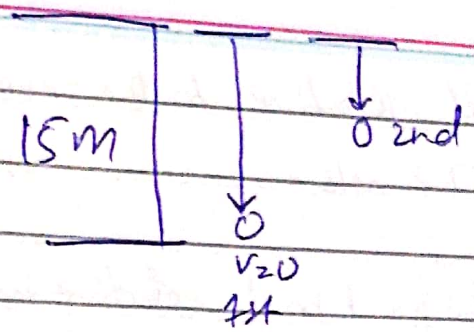


a. $t_1 = 1.5s$
$S = ?$
$a = g = 9.81\,m/s^2$
$v_0 = 0\,m/s$

$S = v_0 t + \frac{1}{2} g t_1^2$
$= 0 \times 1.5 + \frac{1}{2}(9.81)(1.5)^2$

$S \approx 11.036m$
$S \approx 11.0m$

1st ball has travelled 11.0m when the second ball is released,
1st ball is approximately 4m from ground.



$t_1 = ?$ – time taken for 1st ball to hit ground.

$S = 15m$

$V_0 = 0m/s$

$V = 0m/s$

$a = 9.81m/s^2$

$$S = V_0 t_1 + \frac{1}{2} a t_1^2$$

$$15 = 0 \times t_1 + \frac{1}{2}(9.81) t_1^2$$

$$\sqrt{\frac{15 \times 2}{9.81}} = t_1$$

$$1.75s = t_1$$

$t_2 = 1.75 - 1.5$

$t_2 = 0.25s$ – time taken for 2nd ball to reach the specific distance.

$a = 9.81m/s^2$

$V_0 = 0 m/s.$

$S_2 = ?$

$$S_2 = V_0 t + \frac{1}{2} a t^2$$

$$= 0 \times 0.25 + \frac{1}{2} \times 9.81 \times (0.25)^2$$

$S_2 = 0.31 m$ – distance travelled by 2nd ball when 1st ball hits ground,

approximately 14.7m above the ground.

b. $t_1 = 1.75s$ (1st ball)

$g = 9.81m/s^2$

$V_0 = 0m/s$

$V_{f_1} = ?$

$V_{f_1} = V_0 + at$

$= 0 + 9.81 \times 1.75$

$= 17.2 m/s$

$t_2 = 1.75 - 1.5$ (2nd ball)

$= 0.25s$

$V_0 = 0m/s$

$g = 9.81m/s^2$

$V_{f_2} = ?$

$V_{f_2} = 9.81 \times 0.25$

$= 2.6$

The instan~~t~~aneous velocity of the first ball relative to the second just before it hits the ground is 17.2 m/s.

c. The instantaneous acceleration of the first ball ~~relative to the second is the same as~~ is the acceleration due to gravity ~~which is 9.8 m/s~~. It is due to the balls being in free fall. but if seen relative to each other, it is $0\,m/s^2$.

Q7 a. $\xrightarrow{A}$ 100 km/h.

P $\quad$ after 6 s $\longrightarrow$ 110 km/h

$V = 0$ $\quad$ in 10s.

$$100\,km/h \times \frac{1000}{3600} = \frac{250}{9}\,m/s$$

$$d = \frac{250}{9} \times 6$$

$$= 166.67\,m$$

distance travelled by speeder = 166.7 m ahead of police cruiser.

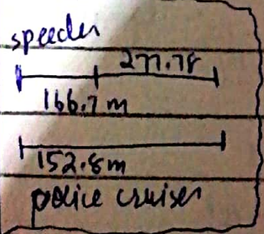
b. $110 \times \frac{1000}{3600} = 30.56\,m/s$ $\qquad$ $a = \frac{30.56 - 0}{10} = 3.056\,m/s^2$

Distance covered by police car during 10sec. $= V_0 t + \frac{1}{2} a t^2$

$$= 0 \times 10 + \frac{1}{2} \times 3.056 \times (10)^2$$

$$= 152.8\,m$$

Distance covered by speeder during 10sec $= \frac{250}{9} \times 10 = 277.78\,m$



Distance ahead of cruiser of the speeder $= (166.7 + 277.78) - 152.8$

$= 291.7\,m.$

c. Distance covered by police cruiser − Distance covered by speeder $= 30.56 - \frac{250}{9}$

$t^2 + 30.56t - \frac{250}{9}t$

$= 2.78$ or $\frac{25}{9}$

$t^2 + \frac{25}{9}t - \frac{25}{9} = 0$

Distance covered to catch $= 16.8 \times \frac{250}{9}$

$= 466.7m$

$9t^2 + 25t - 25 = 0$

$t = \frac{-25 + \sqrt{(25)^2 - 4(9)(-25)}}{2(9)} = 0.78s$

$t = 0.78 + 6 + 10 = 16.8s.$

Q8 From rest (displacement = 0) to B, object is accelerating.
At B, object is at rest.
~~A~~ from B to C, object is decelerating.

Instantaneous velocity at A, B and C = slopes of line (tangents)

$V_A = \frac{12-3}{4-0} = \frac{9}{4} = 2.25 m/s$

$V_B = 0 m/s$ (slope = 0)

$V_C = \frac{5.5-13}{15-8.5} = -1.15 m/s$

Q9 a. $x = 3.5t - 0.45t^2 + 1.5t^3$

$x_{t=0} = 3.5(0) - 0.45(0)^2 + 1.5(0)^3$

$x_{t=0} = 0 m/s.$

$x_{t=5} = 3.5(5) - (0.45)(5)^2 + 1.5(5)^3$

$x_{t=5} = 193.75$

Average speed $= \frac{193.75 - 0}{5-0}$

$= 38.75 m/s$

b. $V = \frac{V_0}{(1+At+Bt^2)}$

$= V_0(1+At+Bt^2)^{-1}$

$V = 50(1 + 2.0t + 0.5t^2)^{-1}$

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

$a = 50 \times -1 (1 + 2.0t + 0.5t^2)^{-2} \times (2.0 + 0.5 \times 2t)$

$a = \frac{-50(2.0 + t)}{(1 + 2.0t + 0.5t^2)^2}$

a when $t = 0$ $= \frac{-50(2.0 + 0)}{(1 + 2(0) + 0.5(0)^2)^2}$

$a_{t=0} = -100$

$a_{t=2} = \frac{-50(2+2)}{(1 + 2(2) + 0.5(2)^2)^2}$

$= \frac{-200}{49} = -4.08$

$a_{t=\infty} = \frac{-50(2+\infty)}{(1 + 2(\infty) + 0.5(\infty)^2)^2}$

$= -\infty$

C. $a = At + Bt^2 + Ct^3$

$\int a = \int 10t + 30t^2 + 20t^3$

$v = \frac{10t^2}{2} + \frac{30t^3}{3} + \frac{20t^4}{4} + c$

$v = 5t^2 + 10t^3 + 5t^4 + c$

$(v = 0 \; t = 0)$

$0 = c$

$\int v = \int 5t^2 + 10t^3 + 5t^4$ $\Rightarrow$ $t = 2$ $v = 5(2)^2 + 10(2)^3 + 5(2)^4$

$v = 180$ m/s

$d = \frac{5t^3}{3} + \frac{10t^4}{4} + \frac{5t^5}{5}$

$d = \frac{5t^3}{3} + \frac{5}{2}t^4 + t^5$

$d_{t=1} = \frac{5}{3} + \frac{5}{2} + 1 = \frac{31}{6}$

$$d_{t=2} = \frac{5}{3}(2)^3 + \frac{5}{2}(2)^4 + (2)^5$$

$$= \frac{256}{3}$$

distance travelled $= d_{t=2} - d_{t=1}$

$$= \frac{256}{3} - \frac{31}{6}$$

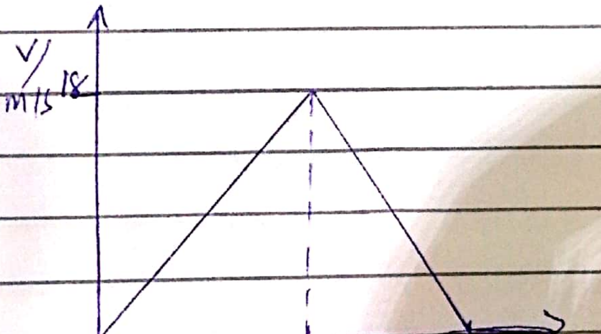
$$= 80.2\,m.$$

Q10 Acceleration-time graph.

Area between 0 to 6 $= 3 \times 6 = 18.$

Area b/w 6 to 10 $= 4.5 \times 4 = 18.$

Area: p-t, v-t, a-t; slope



velocity time graph.

Area b/w 0 to 6 $= \frac{1}{2} \times 18 \times 6 = 54$

Area b/w 6 to 10 $= \frac{1}{2} \times 4 \times 18 = 36$