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Applied Physics

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ASSIGNMENT # 01

Applied Physics:

Assignment: 01

Name: Malik Zaryab Awan
Roll no: 24K-3055
Section: BSE-1A

Problem: 01

Data:

$v_1 = 30\,km/h$

$S_1 = 40\,km$

$S_2 = 40\,km$

$v_2 = 60\,km$

Sol

$T_1 = \frac{S_1}{v_1}$ $\qquad$ $T_2 = \frac{S_2}{V_2}$

$T_1 = 40/30$ $\qquad$ $T_2 = 40/60$

$T_1 = 1.33$ $\qquad$ $T_2 = 0.67$

$T = 1.33 + 0.67$

$T = 2\,hrs$

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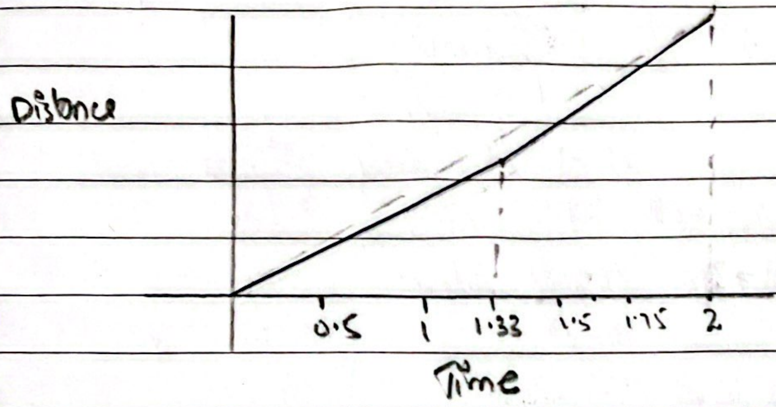
$$V_{avg} = \frac{\text{total distance}}{\text{total time}} \Rightarrow \frac{80}{2}$$

$V_{avg} = 40\ km/h$



Problem: 02

Data:

$v_i = 30 m/s$

(time to reach max height) $t_1 = ?$

(total time) $t = ?$

$g = 9.8 m/s^2$

Sol:

FOR t_1:

$v_f = v_i + gt$

$0 = 30 - 9.8t$

$9.8t = 30$

$t = \frac{30}{9.8}$

$\boxed{t_1 = 3.06 sec}$

FOR t:

$\because$ time going to max height = time to reach ground from max height

$t = 2 \times t_1$

$t = 2 \times 3.06$

$\boxed{t = 6.12\ sec}$

Problem: 03

Data:

$x = 3t - 4t^2 + t^3$

t: (a) 1s

(b) 2s

(c) 3s

(d) 4s

x at t=4s = ?

x at t=0 = ?

v_{avg} from t=2 to t=4 = ?

graph for t=0 and t=4

Sol:

at t=0s

$x = 3(0) - 4(0)^2 + (0)^3$

$\boxed{x = 3\,m}$

at t=1s

$x = 3(1) - 4(1)^2 + 1^3$

$= 3 - 4 + 1$

$\boxed{x = 0\,m}$

at t=2s

$x = 3(2) - 4(2)^2 + (2)^3$

$= 6 - 16 + 8$

$\boxed{x = -2\,m}$

at t=3s

$x = 3(3) - 4(3)^2 + (3)^3$

$\boxed{x = 0\,m}$

at t=4s

$x = 3(4) - 4(4)^2 + (4)^3$

$\boxed{x = 12\,m}$

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displacement b/w $t \to 0$ & $t \to 4$

$x_0 = 0$, $x_4 = 12$

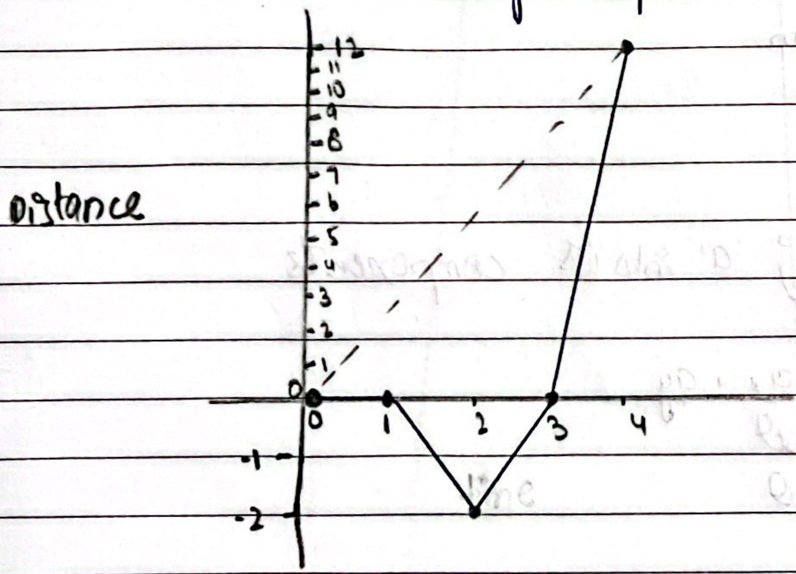
$x = x_2 - x_1$
$= 12 - 0$
$\boxed{x = 12m}$

Avg velocity from t_2 to t_4

$t_2 = -2$, $t_4 = 12$

$v_{avg} \Rightarrow \frac{x_2 - x_1}{t_2 - t_1} \Rightarrow \frac{12 - (-2)}{4 - 2} = \frac{14}{2}$

$\boxed{v_{avg} = 7m/s}$



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Problem: 04

Data:

$V_A = 3 m/s$

$y_A = 30 m$

$a_b = 0.40 m/s^2$

$\theta = ?$

Sol:

for Particle A:

$x_A = V_A t$ $\because S = vt$

$x_A = 3t$

$x_b = 30 m$

for Particle B:

$a_b = 0.40 m/s^2$

Resolving 'a' into its components

$a_{bx} = a_b \sin\theta = 0.40 \sin\theta$

$a_{by} = a_b \cos\theta = 0.40 \cos\theta$

$\because$ initial velocity of 'b' $= 0$

$S = v_i t + \frac{1}{2} a t^2$

$S = 0 + \frac{1}{2} a t^2$

$x_b = \frac{1}{2}(0.40 \sin\theta) t^2$

$x_b = \frac{1}{2}(0.40 \cos\theta) t^2$

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$X_b = 0.20 \sin\theta t^2$

$Y_b = 0.20 \cos\theta t^2$

~~INOAP~~ INorder for collision to happen

$X_A = X_b$

$3\cancel{t} = 0.20 \sin\theta t^{\cancel{2}}$

$t = \dfrac{3}{0.20\sin\theta}$

$t = \dfrac{15}{\sin\theta}$ —(1)

$Y_A = Y_b$

$30 = 0.20 \cos\theta t^2$

$150 = \cos\theta t^2$

subsitute value of 't' from (1)

$150 = \cos\theta \left(\dfrac{15}{\sin\theta}\right)^2$

$150 = \dfrac{225 \cos\theta}{\sin^2\theta}$

$\because \sin^2\theta + \cos^2\theta = 1$

$150 = \dfrac{225\cos\theta}{1-\cos^2\theta}$

$\dfrac{150}{225} = \dfrac{\cos\theta}{1-\cos^2\theta}$

$\dfrac{3}{2} = \dfrac{\cos\theta}{1-\cos^2\theta}$

$3(1-\cos^2\theta) = 3\cos\theta$

$3 - 3\cos^2\theta + 2\cos\theta = 0$

$3\cos^2\theta - 2\cos\theta - 3 = 0$

Applying quadratic formula

$\cos\theta = \dfrac{1}{2}$

$\boxed{\theta = 60°}$

Problem:5

Data:

$\vec{r} = (2t^3 - 5t)\hat{i} + (6 - 7t^4)\hat{j}$

$\vec{r}$ at $t=2$.

v at $t=2$

a at $t=2$

Sol

for $\vec{r}$ at $t=2$

$$\vec{r} = \{2(2)^3 - 5(2)\}\hat{i} + \{6 - 7(2)^4\}\hat{j}$$

$$= (16 - 10)\hat{i} + (6 - 112)\hat{j}$$

$$\vec{r} = 6\hat{i} - 106\hat{j}$$

for vel at $t=2$

diff w.r.t 't' on eq $\vec{r}$

$$\frac{d}{dt}\vec{r} = \frac{d}{dt}(2t^3 - 5t)\hat{i} + \frac{d}{dt}(6 - 7t^4)\hat{j}$$

$$= (6t^2 - 5)\hat{i} + (-28t^3)\hat{j}$$

$$\vec{v} = (6t^2 - 5)\hat{i} - 28t^3\hat{j}$$

at $t=2$

$$\boxed{\vec{v} = 19\hat{i} - 224\hat{j}}$$

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* FOR acc at t=2

diff wrt 't' on '$\vec{v}$' eq

$$\frac{d}{dt}\vec{v} = \frac{d}{dt}(6t^2 - 5)\hat{i} - 28t^3\hat{j}$$

$$\vec{a} = 12t\,\hat{i} - 84t^2\hat{j}$$

at t=2

$$\boxed{\vec{a} = 24\hat{i} - 336\hat{j}}$$

* for angle b/w velocity vector & positive x axis

$$\tan\theta = \frac{v_y}{v_x}$$

$$\theta = \tan^{-1}\left(\frac{-224}{19}\right)$$

$$\boxed{\theta = -85^\circ}$$

Problem: 6

Data:

$r = 1.5m$

$h = 2m$

$x = 10m$

$a_c = 2$

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Sol:

$\because \quad a = \frac{v^2}{r}$

* For v:-

$S = v_i t + \frac{1}{2} g t^2$

$y = v_i t + \frac{1}{2} g t^2$

$2 = 0 + \frac{1}{2}(9.8) t^2$

$t^2 = \frac{4}{9.8}$

$t = 0.64 s$

$\because S = vt$

$v = \frac{s}{t}$

$v = \frac{10}{0.64}$

$\boxed{v = 15.625 \, m/s}$

$\because \quad a_c = \frac{v^2}{r}$

$a_c = \frac{(15.625)^2}{1.5}$

$\boxed{a_c = 162.76 \, m/s^2}$

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Problem: 07

Data:-

$a(t) = At - Bt^2$

where $A = 1.5\ m/s^3$

$B = 0.12\ m/s^4$

$t = 0$

$x = ?$

$v = ?$

max vel = ?

Sol:

$a t = (1.5t - 0.12t^2)$

integrating for velocity

$$\int a(t)dt = 1.5\int t\,dt - 0.12\int t^2\,dt$$

$$= \frac{1.5t^2}{2} - \frac{0.12t^3}{3}$$

$$\boxed{v(t) = 0.75t^2 - 0.04t^3}$$

Integrating again for position vector

$$\int v(t)\,dt = 0.75\int t^2\,dt - 0.04\int t^3\,dt$$

$$= \frac{0.75t^3}{3} - \frac{0.04t^4}{4}$$

$$\boxed{x = 0.25t^3 - 0.01t^4}$$

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* FOR max velocity ⇒

∵ max velocity can be attained at $a=0$

$$1.5t - 0.12t^2 = 0$$
$$0.12t^2 = 1.5t$$
$$\boxed{t = 12.5s}$$

putting in velocity eq

$$v_{max} = 0.75(12.5)^2 - 0.04(12.5)^3$$
$$\boxed{v_{max} = 39.06\,m/s}$$

Problem:8

Data:

$v_i = 6m/s$

$t = 2s$

$v_f = ?$

$h = ?$

v after $10m = ?$

$g = 9.8\,m/s$

Sol:

$$v_f = v_i + gt$$
$$v_f = 6 + (9.8)(2)$$
$$\boxed{v_f = 25.6\,m/s}$$ → speed after 2 s

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$S = vit + \frac{1}{2} gt^2$

$S = 6(2) + \frac{1}{2}(9.8)(2)^2$

$S = 31.68m$ distance gaine after 2sec.

* for ehel at d=10
* $2gs = vf^2 - vi^2$

$2(9.8)(10) = vf^2 - 6^2$

$vf^2 = \sqrt{2 \times 9.8 \times 10 + 36}$

$\boxed{vf = \sqrt{232}\ m/s}$ OR $\boxed{vf = 15.23\ m/s}$

Problem: 09

Data: $S_2 = 25m$
$S_1 = 25m$
$t_1 = 20s$
$t_2 = 15s$
for first 25m $v = ?$
for return $v = ?$
Vavg = ? for whole round

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Sol:

* for velocity of first 25m

$$V = \frac{S}{t}$$

$$V_1 = \frac{S_1}{t_1}$$

$$V_1 = \frac{25}{20}$$

$$\boxed{V_1 = 1.25 m/s}$$

* for velocity of return 25m

$$V_2 = \frac{S_2}{t_2}$$

$$V_2 = \frac{25}{15}$$

$$\boxed{V_2 = 1.67 m/s}$$

* Avg velocity:

$$V_{avg} = \frac{\text{total displacement}}{\text{total time}}$$

$$= \frac{S_2 - S_1}{20 + 15}$$

$\boxed{V_{avg} = 0 \rightarrow \text{because there is zero displacement}}$

* Avg Speed

$$V_{avg} = \frac{\text{total distance}}{\text{total time}}$$

$$= \frac{25 + 25}{20 + 15}$$

$$\boxed{V_{avg} = 1.43 m/s}$$

Problem: 10

Sol:

(1) $x = -3t^2 + 4t - 2$

$y = 6t^2 - 4t$

differentiating with respect to t

first derivative

$V_x = -6t + 4$

first derivative

$V_y = 12t - 4$

Second derivative

$a_x = -6$

Second derivative

$a_y = 12$

// Acceleration is constant

(2) $x = -3t^3 - 4t$

$y = -5t^2 + 6$

diff wrt t

First derivative

$V_x = -9t^2 - 4$

First derivative

$V_y = -10t$

Second derivative

$a_x = -18t$

second derivative

$a_y = -10$

// acceleration const in y axis but not in x.

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(3) $r = 2t^2\hat{i} + (4t+3)\hat{j}$

diff wrt t

First derivative

$v = 4t\hat{i} + 4\hat{j}$

second derivative

$a = 4\hat{i} + 0\hat{j}$

// Acceleration is const

(4) $r = 4(t^3 - 2t)\hat{i} + 3\hat{j}$

diff wrt t

1st derivative

$v = (12t^2 - 2)\hat{i} + 0\hat{j}$

2nd Derivative

$a = 24t\hat{i} + 0\hat{j}$

// Acceleration is not constant

PROBLEM :11

*

$t = 2s$

$v_1 = 60 \text{ km/h} = 16.67 \text{ m/s}$

$v_2 = 50 \text{ km/h} = 13.89 \text{ m/s}$

Sol

$$V_{avg} = \sqrt{v_1^2 + v_2^2}$$

$$= \sqrt{(16.67)^2 + (13.89)^2}$$

$$\boxed{V_{avg} = 21.73 \text{ m/s}}$$

$$a_{vg} = \frac{V_{avg}}{\Delta t}$$

$$= \frac{21.73}{2}$$

$$\boxed{a_{vg} = 10.8 \text{ m/s}^2}$$

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Problem: 12

Data:

$S = 15km = 4.166$

$t_1 = 30min = 1800\ sec = 1/2\ hour$

$t_2 = 20min = 1200sec = 1/3\ hour$

$V_{avg} = ?$ → avg speed

$V_{avg} = ?$ avg velocity

$V_{avg} = ?$ → avg speed on his college

Sol:

* Way to school

$V_1 = \frac{S}{t}$

$V_1 = \frac{15}{1/2}$

$\boxed{V_1 = 30\ km/h}$

OR

$\boxed{V_1\ 8.33\ m/s}$

* Returning from school

$V_2 = \frac{S_2}{t_2}$

$V_2 = \frac{15}{(1/3)}$

$\boxed{V_2 = 45\ km/h}$

OR

$\boxed{V_2 = 12.5\ m/s}$

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* $V_{avg} = \frac{\text{total displacement}}{\text{total time}}$

∴ displacement = 0

$V_{avg} = 0$ m/s ⇝ avg velocity

* $V_{avg} = \frac{\text{total distance}}{\text{total time}}$

$= \frac{15+15}{1/2+1/3}$

$$\boxed{\begin{aligned} V_{avg} &= 36 \text{ km/h} \\ V_{avg} &= 10 \text{ m/s} \end{aligned}}$$

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Problem: 13

Data:

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

x at $t=0$

$t=1$

$t=1$ to $t=3$

~~v from 1~~

V_{avg} from ~~t=1~~ to $t=3$

v_{inst} at $t=2.5$

Sol:

* x at $t=0$

$x = -4(0) + 2(0)^2$

$\boxed{x = 0 \text{ m}}$

x from to to t_1

$x = x_0 - x_1$

$\boxed{x = -2\text{m}}$

* x at $t=1$

$x = -4(1) + 2(1)^2$

$\boxed{x = -2 \text{ m}}$

* x from t_1 to t_3:

$x = x_3 - x_1$

$= 6 - (-2)$

$\boxed{x = 8\text{m}}$

* x at $t=3$

$x = -4(3) + 2(3)^2$

$= -12 + 18$

$\boxed{x = 6 \text{ m}}$

* ~~[illegible]~~ Vavg from to to t_1

$V_{avg} = \frac{\text{total displacement}}{\text{total time}}$

$= \frac{-2}{1}$

$V_{avg} = -2$

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v_{avg} from t_1 to t_3

$$v_{avg} = \frac{8}{3-1} = \frac{8}{2}$$

$$\boxed{v_{avg} = 4 m/s}$$

* Instantaneous velocity at $t = 2.5$

$$v = -4t + 2t^2$$

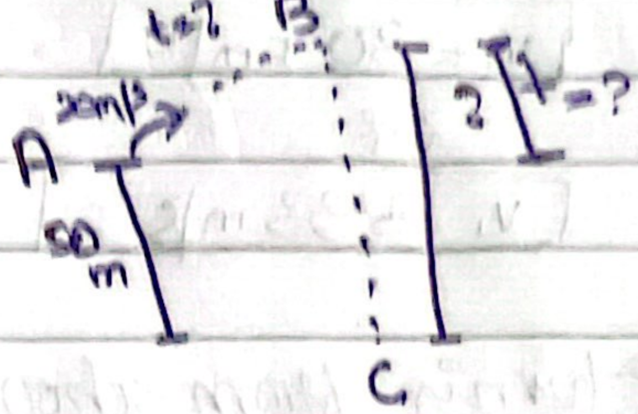
$$v = \lim_{t \to (2.5)} -4t + 2t^2$$

Applying limit

$$= -4(2.5) + 2(2.5)^2$$

$$\boxed{v = 2.5 m/s}$$

Problem: 14



Data

$v_i = 20 m/s$

$h_i = 50m$

$g = 9.8 m/s^2$

Sol: FROM A to B

$$v_f = v_i + gt$$

$$0 = v_i - 9.8t$$

$$t = \frac{20}{9.8}$$

$$\boxed{t = 2.04 s}$$ time to Reach max height

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* FOR max height

$h = vit + \frac{1}{2}gt^2$

$= 20(2.04) + \frac{1}{2}(9.8)(2.04)^2$

$\boxed{h = 20.42}$ m

max height = 20.40 + height of building
= 20.40 + 50
$\boxed{\text{height}_{max} = 70.40m}$

* total time till initial position

$t = 2t$ (time for up + time for down)
$= 2(2.04)$
$\boxed{t = 4.08 \text{ se}}$

Problem: 15

Data:

$v_x = 40 m/s$
$H = 100 m$
$g = 9.8 m/s^2$

Sol:

$\because S = vit + \frac{1}{2}gt^2$

$y = vit + \frac{1}{2}gt^2$

$$100 = 0 + \frac{1}{2}(9.8)t^2$$

$$t^2 = \frac{100 \times 2}{9.8}$$

$$\boxed{t = 4.52s}$$

$$\therefore S = vt$$

$$S = V \times t$$

$$S = 40 \times 4.52$$

$$\boxed{S = 180.66m}$$