EM In-Semester Exam Solution

Sem - II, Jan - May - 2024.

Q.1 a) Statement of Varignon's Theorm ---- 02 marks.

Suitable example with any force system .... 03 marks.

b) Given $a = -v$

$$v\frac{dv}{dx} = -v \quad \text{------} \quad (02) \text{ marks.}$$

$$dv = -dx$$

$$\therefore \int_{v=30m/s}^{v=0} dv = -\int_{x=0}^{x} dx$$

$$[v]_{30}^{0} = [-x]_{0}^{x} \Rightarrow x = 30m$$

(03) marks

$\Rightarrow$ Dist. travelled by particle = 30m.

c) $v = u + a_t \times t$

$v = 10 m/s$, $t = 90$ sec., $u = 0$ ... given.

$a_t = 0.111 \; m/s^2$ ------- (02) marks

To find speed when $t = 30$ sec.

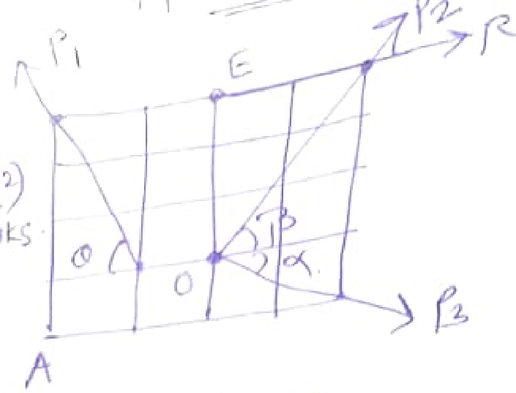
$v = u + a_t t$

$\therefore v = 3.33 \; m/s.$ -------- (02) marks

$a_N = \frac{v^2}{\rho} = \frac{3.33^2}{200} = 0.056 \; m/s^2$ ... (01) marks

Q.2 (i) $\tan\theta = \frac{3\times10}{10} \Rightarrow \theta = 71.57^\circ$

$P_1 = 1580$



$\tan\beta = \frac{3\times10}{2\times10} \Rightarrow \beta = 56.31^\circ$

$\tan\alpha = \frac{10}{2\times10} \Rightarrow \alpha = 26.57^\circ$

(02) marks

$\Sigma F_x = R$, $\Sigma F_y = 0$

By applying Varignon's theorm at some point "O".

$\Sigma M_O = R\times(3\times10)$

$\therefore \quad P_1 \sin\theta \times 10 = R\times(3\times10) \Rightarrow R = 499.28\text{ N } (\rightarrow)$ ... (02) marks

$\Sigma F_x = R$

$\Rightarrow -P_1\cos\theta + P_2\cos\beta + P_3\cos\alpha = 499.28$

$0.554\,P_2 + 0.894\,P_3 = 998.56$

$\Sigma F_y = 0$

$\Rightarrow P_1\sin\theta + P_2\sin\beta - P_3\sin\alpha = 0$

$0.832P_2 - 0.447P_3 = -1498.96$

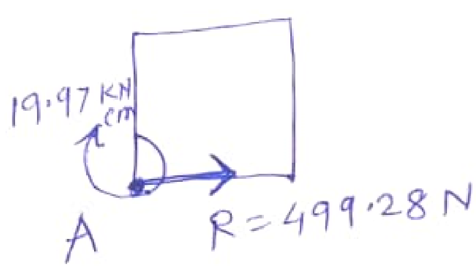
(04) marks.

$\boxed{P_2 = -901\text{ N}}$ & $\boxed{P_3 = 1675.55\text{ N}}$ $\longrightarrow$ (01) mark

(ii) To convert given system into single force & couple system at point A,

couple $= -R\times(4\times10) = -19.971$ kN·cm $= 19.97$ kN·cm (↻)

$R = 499.28$ N $(\longrightarrow)$



for part (ii)
↳ (01) mark

Q.3 (a)

For a - t curve :

$t = 0 - 3$ sec.

$a = \frac{dv}{dt} = \frac{150 - 0}{3 - 0} = 50 \, m/s^2$

$t = 3 - 6$ sec.

$a = \frac{dv}{dt} = \frac{0 - 150}{3} = -50 \, m/s^2$

$t = 6 - 12$ sec.

$a = \frac{dv}{dt} = 0$

$t = 12 - 17$ sec.

$a = \frac{-200 - 0}{17 - 12} = -40 \, m/s^2$

For x - t curve :

area under (v - t) curve = change in displacement

$t = 0 - 3$ sec.

$x_3 - x_0 = \frac{1}{2} \times 150 \times 3$

$x_3 = 225$ m.

$t = 3 - 6$ sec,

$x_6 - x_3 = \frac{1}{2} \times 150 \times 3$

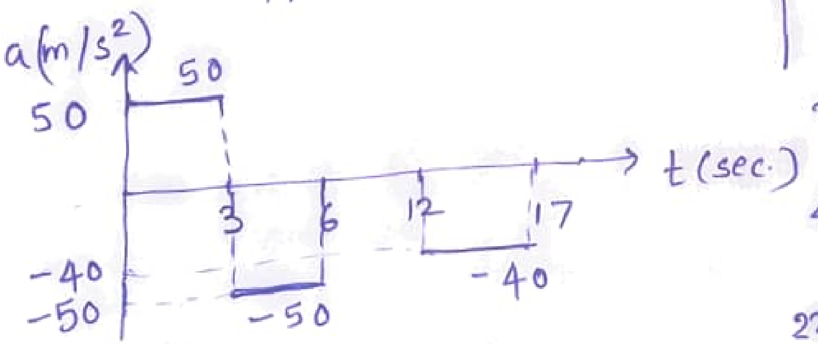
$x_6 = 450$ m,

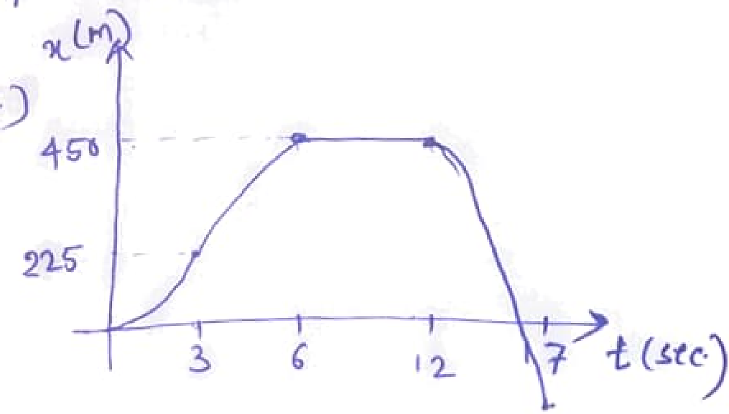
$t = 12 - 17$ sec.

$x_{17} - x_{12} = \frac{1}{2} \times 200 \times 5$

$x_{12} = 450$ m

$\therefore x_{17} = -50$ m





Calculations

a - t curve ---- 03 marks

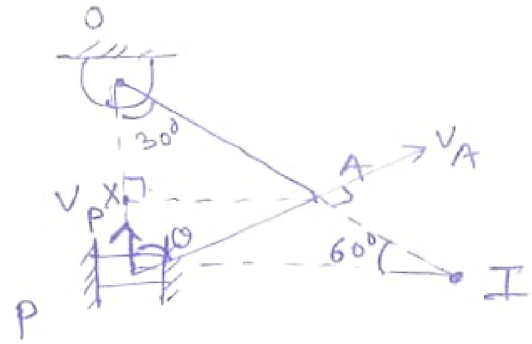
x - t curve ---- 03 marks

Graphs -

a - t curve ----- 02 marks

x - t curve ---- 02 marks.

Q.3 (b)



$\omega_{OA} = 90\,rpm$

$= 2\pi\left(\frac{90}{60}\right) rad/s$

$= 9.42\ rad/s.$

... Location of ICR

.... (0~~2~~ 4) marks

link OA

$V_A = (OA)\,\omega_{OA}$

$= (100)(9.42)$

$= 0.942\ m/s.$

From ΔAXO,

$\cos 30 = \frac{OX}{OA}$

$OX = 86.6\ mm.$

$\sin 30 = \frac{AX}{OA}$

$AX = 50\ mm.$

from ΔAXP

$\sin\theta = \frac{AX}{AP} = \frac{50}{400}$

$\Rightarrow \theta = 7.18°.$

$\cos(7.18) = \frac{XP}{AP}$

$\Rightarrow XP = 396.86\ mm.$

$OP = OX + XP = 483.46\ mm$

Calculations (01) Mark.

from ΔOPI,

$\frac{OP}{\sin 60} = \frac{IO}{\sin 90} = \frac{IP}{\sin 30} \Rightarrow IP = 279.12\ mm$

$IO = 558.25\ mm$

$IA = 458.25\ mm.$

... (03) marks.

link AP

$V_A = (IA)\,\omega_{AP}$

$(0.942) = (0.458)\,\omega_{AP}$

$\Rightarrow \boxed{\omega_{AP} = 2.057\ r/s.}$

(0~~2~~) marks
01

$V_P = (IP)\,\omega_{AP}$

$= (0.279)(2.057)$

$\boxed{V_P = 0.574\ m/s}$

(0~~2~~ 1) marks.