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SFI GEC PALAKKAD

Reg No.:

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech SI (Special Improvement) Examination January 2021 (2019 scheme)

Course Code: EST100

Course Name: ENGINEERING MECHANICS

(2019-Scheme)

Max. Marks: 100 Duration: 3 Hours

PART A

(Answer all questions, each carries 3 marks.)

1 A traffic signal of mass 500 N is hung with the help of two strings, as shown in **fig (Q1)** below. Find the forces induced in the strings using Lami's theorem. (3)

2 State and explain the conditions of equilibrium of coplanar concurrent force system. (3)

3 Three forces 20N, 30N and 40N act along AB, BC and CA respectively, the three sides of an equilateral triangle ABC. Find the resultant. (3)

4 A block shown in **Fig** (Q2) is just moved by a force of 200 N. The weight of the block is 600 N. Determine the coefficient of static friction between the block and the floor. (3)

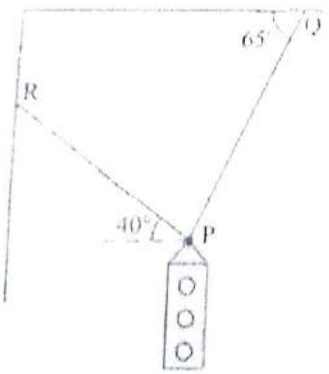


Fig. (Q1)

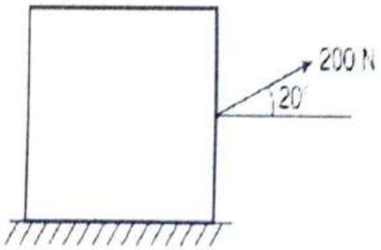


Fig. (Q2)

5 Write down the expression for centroid of a rectangle about a line passing through its base. (3)

6 A force F = $2\hat{i} + 3\hat{j} - 4\hat{k}$ is applied at the point B(1,-1.2). Find the Moment of inertia of the force about a point A. (3)

7 The angular acceleration of a particle α = 5t rad/s^2. Determine expression for angular velocity 'ω' at any instant 't' of the motion, if the particle starts from rest. (3)

8 A force of 300N acts on a body of weight 500N. Find the acceleration of the body by using D'Alembert's principle. (3)

9 A body performing Simple Harmonic Motion has an amplitude of 1m and a period of oscillation 2.05 seconds. Find the velocity and acceleration of the body (3)

4 seconds after passing the mean position.

10 A solid circular disc of mass 10 kg and radius 0.3m is rotating about its centre with constant angular acceleration of 10 rad/s^2. Determine the torque acting on the disc. (3)

PART B

(Answer one full question from each module, each question carries 14 marks)

Module-I

11 Two rollers each of weight 75 N are supported by an inclined plane and a vertical wall. Find the reaction at the points of contact A, B, C. Assume all the surfaces to be smooth. **Fig. (Q 11a)** (14)

12 ABCD is a square of side 6 m. Forces acting along AB, BC, CD, DA, AC and DB are 1.5 kN, 3 kN, 12 kN, 7.5 kN, 7.5√2 kN, 3√2 kN respectively. Find the resultant force and resultant moment about D. **Fig (Q11b)** (14)

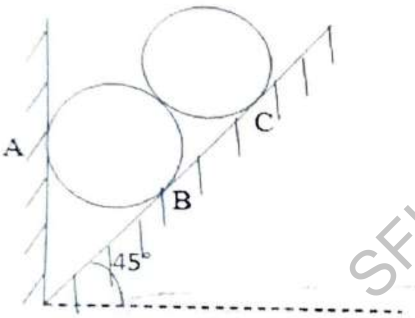


Fig. (Q 11a)

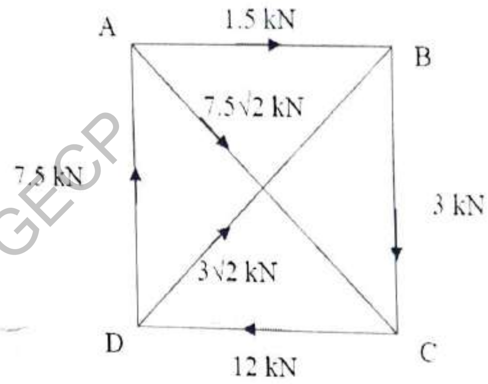
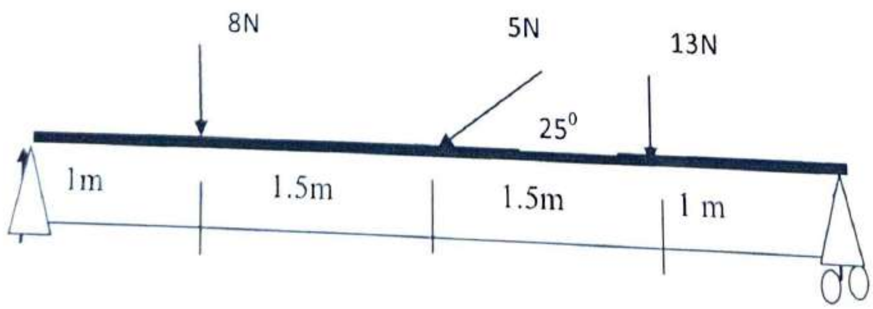


Fig. (Q 11b)

Module-II

13 a) What do you understand by the reactions at supports? (4)

Find the reactions at the supports of the beam given. A is a hinged support and B is a roller support (10)



14 Two wedges A and B are used to raise another block C weighing 1000 N as shown in figure. Assuming coefficient of friction as 0.25 for all surfaces, determine the value of P for impending upwards motion of C shown in **fig (Q14)** (14)

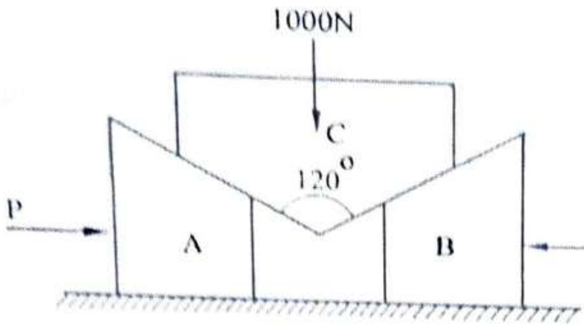
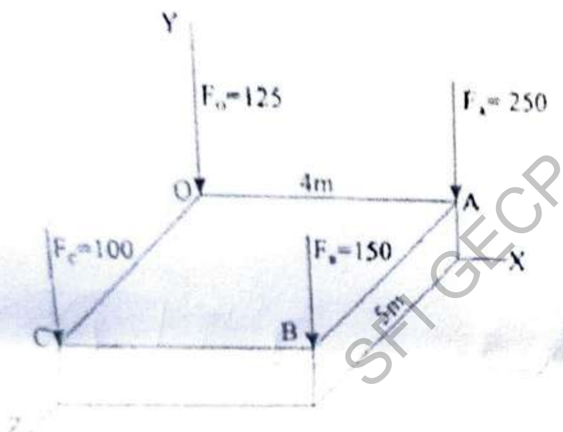


Fig. (Q14)

Module-III

15 A rectangular concrete slab supports loads in kN at its four corners as shown in Fig (Q15). Determine the resultant and the point of application of the resultant. (14)



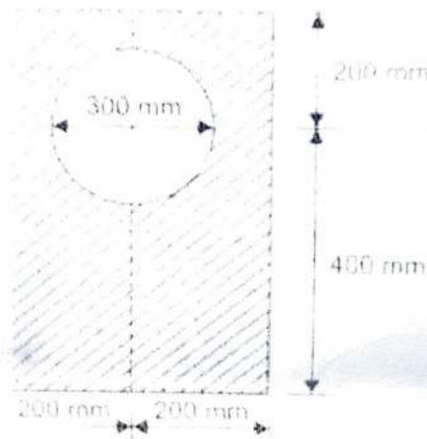


Fig (Q15) **Fig (Q16)**

16 Find the moment of inertia of a plate with a circular hole in **Fig (Q16)** about its centroidal horizontal and vertical axes. Also calculate the radius of gyration about the x-axis. (14)

Module-IV

17 a) Explain how you can apply Work – Energy Principle in Dynamics (5)

b) Two blocks of 100N (A) and 50N (B) are connected by a flexible but inextensible string as shown in **figure (Q17b)**. Assuming coefficient of friction between block 100N and horizontal surface is 0.25, find the acceleration of masses and tension in the string. (9)

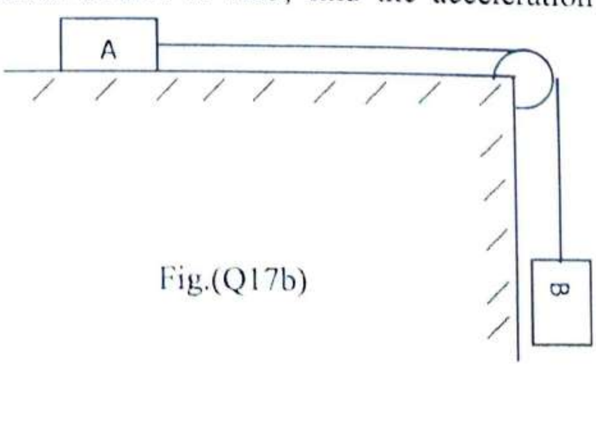
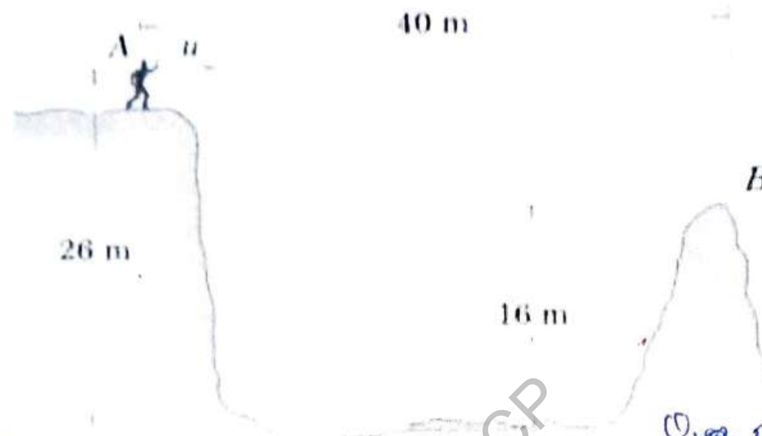


Fig.(Q17b)

18 a) A car starts from rest on a curved road of radius 600m and acquires by the end of the first 60 seconds of motion a speed of 24kmph. Find the tangential and normal acceleration at the instant, t = 30s. Also calculate the distance covered at the end of first 30 seconds. (5)

b) With what minimum horizontal velocity u can a boy through a rock at A and have it just clear the obstruction at B? (Fig Q18b) (9)



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

$600\pi = 40 \times 10 +$

θ_{1-2} θ_{2-3} θ_1 θ_2 θ_3

Fig (Q18b)

SFIGECP

Module-V

19 a) A flywheel rotates with a constant retardation due to breaking, in the first 10 seconds, it made 300 revolutions. At t = 7.5 sec, its angular velocity was 40π rad/s. Determine (7)

i) The value of constant retardation

ii) The total time taken to come to rest and

iii) The total revolutions made till it comes to rest

b) Two blocks of masses 10 kg and 25 kg are attached to the two ends of a flexible rope. The rope passes over a pulley of diameter 500mm. The mass of the pulley is 7.5 kg and its radius of gyration is 200 mm. Find the acceleration of the masses and the tension on either side of the rope. (7)

20 a) A spring stretches by 0.015m when a 1.75kg object is suspended from its end. How much mass should be attached to the spring so that its frequency of vibration is 3 Hz. (7)

b) A particle has SHM. Its maximum velocity is 6m/s and maximum acceleration is 12 m/s^2. Determine the angular velocity and amplitude. Also determine its velocity and acceleration when displacement is half of the amplitude. (7)

*****

$\omega = \frac{d\theta}{dt} = v$

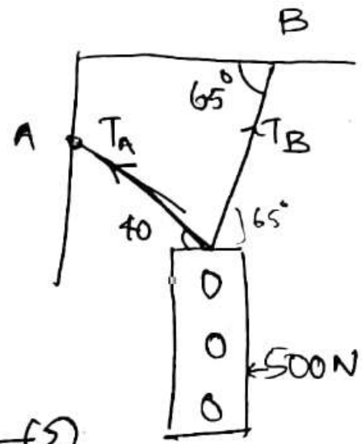
$v^2 - u^2 = 2as$

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

$10^2 - 40^2 = 2 \times -50\pi \times 5$

ENGINEERING MECHANICS

PART- A



1→

$T_A \cos 40 \pm T_B \cos 65^\circ$ —— ①

$T_A \sin 40 + T_B \sin 65 = 500N$. —— ②

from ① $T_A = T_B \dfrac{\cos 65^\circ}{\cos 40^\circ} = .551\, T_B$

substituting in ②

$.551\, T_B \sin 40 + T_B \sin 65 = 500N$

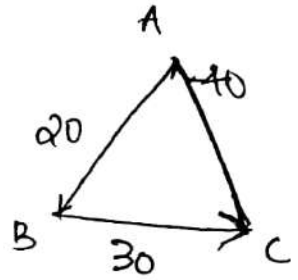
$\Rightarrow T_B = \underline{396.53\ N}$

$\Rightarrow T_A = \underline{\underline{719.66 N}}$

2→ a→ The sum of forces must be zero.

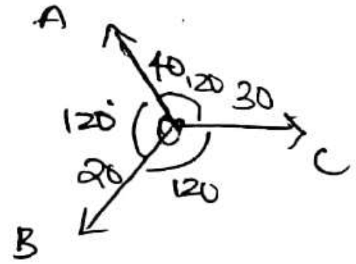
b→ The sum of moment of forces about a point in the clockwise direction & equal to the sum of the moments of forces about the same point in the clockwise direction.

3→



$F_y = \cancel{OA}\cos 30 - OB\cos 30$

$= (40-20)\cos 30 = 10\sqrt{3}$



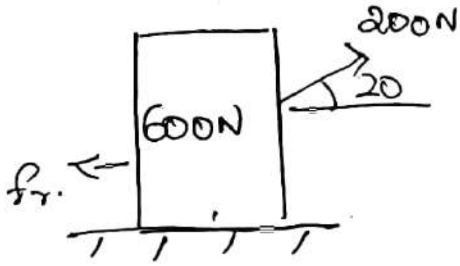
$F_x = OC - (OA\sin 30 + OB\sin 30)$

$= 30 - (40+20)\sin 30$

$= 30 - 30 = 0$

$F = \sqrt{F_x^2 + F_y^2} = \underline{10\sqrt{3}}$

4→



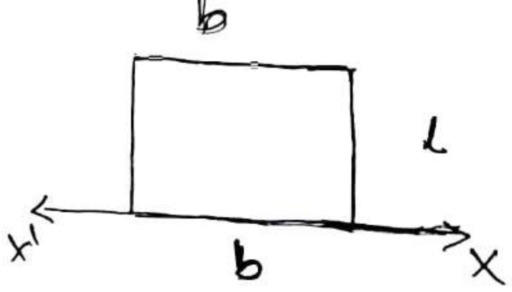
$f_r = \mu N = 200\cos 20$ — (1)

$N = 600 - 200\sin 20$ — (2)

$= 531.595\,N$

$\mu = \dfrac{200\cos 20}{N} = \underline{.3535}$

5 →



$$\bar{x} = \frac{b}{2}$$

$$\bar{y} = \frac{1}{A}\int_0^l dA \times y$$

$$= \frac{1}{l \times \cancel{b}}\int_0^l \cancel{b} \times dy \times y = \frac{1}{l}\int_0^l y\,dy = \frac{1}{l}\left[\frac{y^2}{2}\right]_0^l$$

$$= \frac{1}{\cancel{l}} \times \frac{l^{\cancel{2}}}{2} = \frac{l}{2}$$

→ centroid $= (\bar{x}, \bar{y}) = \left(\frac{b}{2}, \frac{l}{2}\right)$

6

7 → $\alpha = 5t \text{ rad } s^{-2}$. $\omega = ?$ $\omega_0 = 0$

$\omega_t = \omega_0 + \alpha t = \underline{5t^2}$

8 → $F = 300N$, $W = 500N$.

by D'Alembert's principle $\Sigma F = 0$

$\Rightarrow F - ma = 0 \Rightarrow F = ma$

$a = \frac{F}{m} = \underline{5.88 \, ms^{-2}}$ $m = \frac{W}{g} = \frac{500}{9.81}$

9 → $A = 1m$. $T = 2.05$ sec.

$x = A \sin \omega t$, $\omega = \frac{2\pi}{T}$

$x_p = -.301m$ $V = \frac{dx}{dt} = A\omega \cos\omega t = \underline{2.922 \, ms^{-1}}$

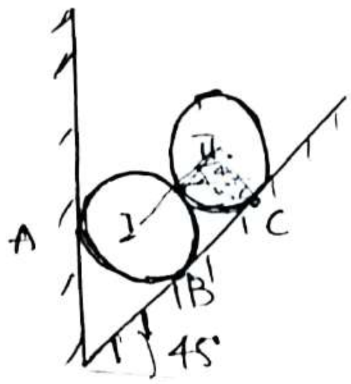
$a = \frac{d^2x}{dt^2} = -A\omega^2 \sin \omega t. = \underline{2.834 \, ms^{-2}}$

10 → $M = 10kg$, $r = .3m$, $\alpha = 10 rad\, s^{-2}$

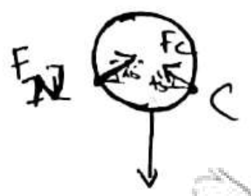
$\tau = I\alpha$. $I = \frac{Mr^2}{2} = \frac{10 \times .09}{2} = .45$

$\tau = .45 \times 10 = \underline{\underline{4.5\ Nm}}$

11 →



II^{nd} mass



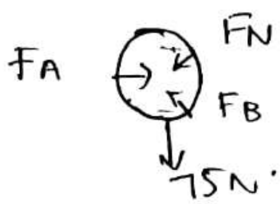
$\Sigma F_y = 0 \Rightarrow F_N \sin 45 + F_C \sin 45 = 75$ — (1)

$\Sigma F_x = 0 \Rightarrow F_N \cos 45 = F_C \cos 45$ — (2) for equilibrium

$\Rightarrow F_N = F_C \Rightarrow F_C \sqrt{2} = 75$

$F_C = \underline{\underline{53.033\ N}}$

I^{st} mass



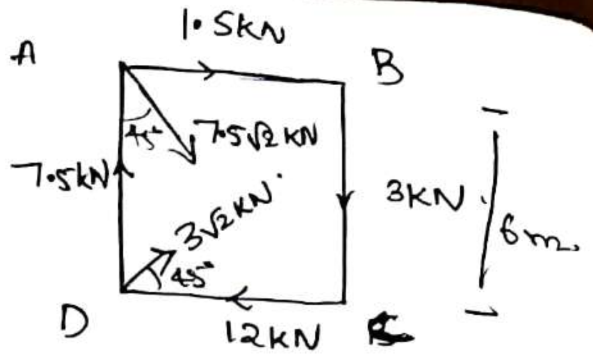
$\Sigma F_x = 0 \Rightarrow F_A = F_N \cos 45 + F_B \cos 45$

$\Sigma F_y = 0 \Rightarrow F_B \sin 45 = 75 + F_N \sin 45$

$= 75 + 37.5 = 112.5$

$\Rightarrow F_B = \underline{159.099}\ N.$, $F_A = \underline{150\ N}$

12 →



Resultant force.

$$F_y = \underset{(F_{DA})}{7.5} - \underset{(F_{BC})}{3} + \underset{3\sqrt{2}\sin 45\ (F_{DB})}{3} - \underset{7.5\sqrt{2}\cos 45\ (F_{AC})}{7.5} = 0$$

$$F_x = \underset{(F_{AB})}{1.5} + \underset{7.5\sqrt{2}\sin 45\ (F_{AC})}{7.5} + \underset{3\sqrt{2}\cos 45\ (F_{DB})}{3} - \underset{(F_{CD})}{12} = \underline{\underline{0}}$$

$M_A = (1.5 + 7.5) \times 6$ (clockwise) $= 54$ Nm

$M_B = 6\sqrt{2} \times 3/\sqrt{2} = 18$ clockwise $= 18$ Nm

$M_C = 0$

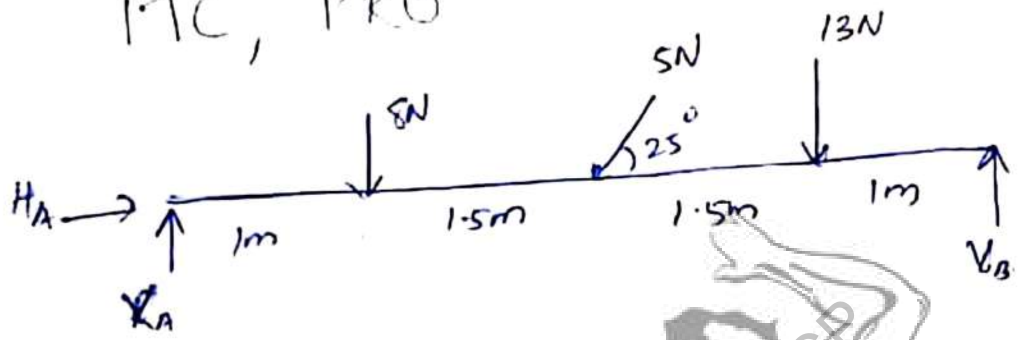
→ total moment $= \underline{\underline{72 \text{ kNm}}}$

13 → (a) Simple support → Beam simply rests on a support it is free to slide and rotate → reaction is perpendicular to the surface.

(b) Roller support → end is supported on a frictionless roller to permit contraction or expansion. The reaction is normal to surface.

EVM

MC, PRO



$\Sigma V = 0$, $V_A + V_B = 8 + 5\sin 25 + 13$

$= 23.11\ N$

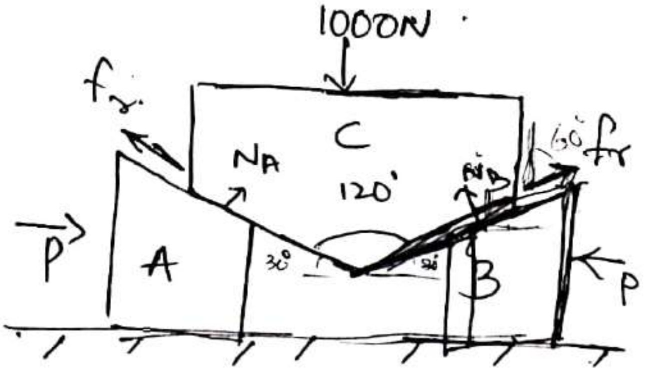
$H_A = 5\cos 25 = \underline{\underline{4.53N}}$

$\Sigma M_A = 0$. $\quad 8\times1 + 5\sin 25 \times 2.5 + 13\times 4 = V_B \times 5$

$V_B = \underline{\underline{13.056}}$

$V_A = 10.054$

14 →

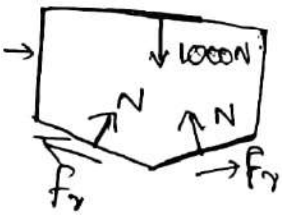


$N_B = N_A = N$

$f_r = \mu N = 0.25N$.

⇒ ~~$Q N_A \cos 30$~~

→ $\Sigma f_y = 0$ for block C.

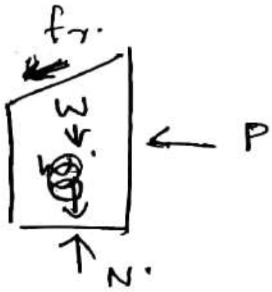


$= 2 \times N \cos 30 + 2 \times 0.25 \times N \cos 60 = 1000N$.

$(\sqrt{3} + .25) N = 1000N$.

⇒ $N = \dfrac{1000}{(\sqrt{3} + .25)} = \underline{504.527 \, N}$

→ FBD of block A or B



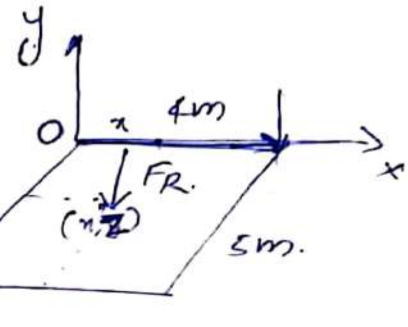
horizontal component of f_r

is provided by the external force P.

⇒ $f_r \cos 30 = P$

$f_r = .25N$ ⇒ $P = .25 \times N \times \cos 30$

$= \underline{109.233N}$



15) $F_R = 100 + 150 + 125 + 25 = \underline{\underline{625N}}$

Moment of resultant = Moment of Individual forces

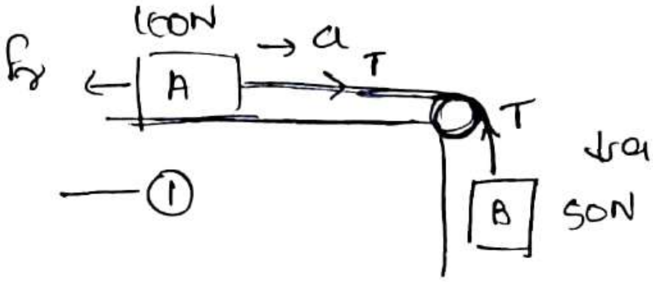
$$625\sqrt{x^2+z^2} = 250\times 4 + 150\times\sqrt{5^2+4^2} + 100\times 5$$

$$= 2460.46$$

$$\sqrt{x^2+z^2} = 3.9367$$

$F_R = 625N$ acting at a perpendicular dis of 3.9367m from O

17 (b)



$$50 - T = \frac{50}{9.81} \times a \quad \text{--- (1)}$$

$$T - 100 \times .25 = \frac{100}{9.81} \times a \quad \text{--- (2)}$$

$$50 - 25 = \frac{150}{9.81} \times a \qquad (1) + (2)$$

$$a = \frac{25 \times 9.81}{\cancel{150}\ 6} = g/6 = \underline{\underline{1.635}}$$

$$\text{from (1)} \quad T = 50 - \frac{50}{g} \times g/6$$

$$= \underline{\underline{41.667\ N}}$$

$$18(a) \rightarrow V_{60} = 24\ \text{kmph} = 24 \times \frac{5}{18} = \frac{20}{3}\ m s^{-1}$$

$$V = u + at \Rightarrow \frac{20}{3} = 60\, a_T \Rightarrow a_T = \frac{1}{9}\ m s^{-2}$$

$$V_{30} = a_T \times 30 = \frac{1}{9} \times 30 = \frac{10}{3}\ m s^{-1}$$

$$a_{normal\ 30} = \frac{v^2}{R} = \frac{100}{9 \times 600} = \underline{\frac{1}{54}\ m s^{-2}}$$

$$S_{30} = \frac{1}{2} a_T t^2 = \frac{1}{2} \times \frac{1}{9} \times 900 = \underline{\underline{50 m}}$$

19 (a) $S_{10} = 300$ rev $= 600\pi$ rads.

$V_{7.5} = 40\pi$ rad s^{-1}

$V_t = u - 7.5a = 40\pi$, $S_{10} = u \times 10 - 50a = 600\pi$

$u - 7.5a = 40\pi$ —— (1) $\Rightarrow u - 5a = 60\pi$ —— (2)

(i)

(2) − (1) $\Rightarrow 2.5a = 20\pi \Rightarrow a = 8\pi$ rad s^{-2}

$\Rightarrow u = 40 + 7.5 \times 8 = 100\pi$ rad s^{-1}

(ii) → $V_t = 0$ → $u - at$ ⇒ $100\pi - 8\pi t = 0$

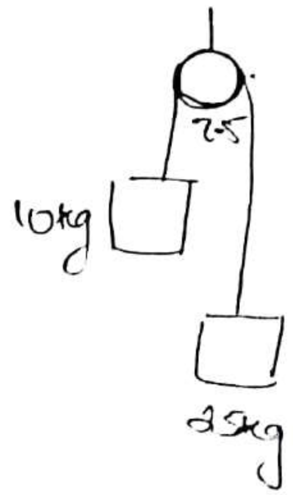
→ $t = \dfrac{100\pi}{8\pi} = 12.5$ s

(iii)

$S_{12.5} = ut - \dfrac{at^2}{2} = 100\pi \times 12.5 - 4\pi \times 156.25$

$= 625\pi$ rads $=$ 312.5 revolutions.

(b)



20 (a) $\cdot 015\,m \longrightarrow 10.75\,kg$

$\rightarrow kx = F \rightarrow k = \frac{F}{x} = \frac{10.75}{.015} = \frac{350}{3}$

$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = 3Hz.\ ,\ m = ?$

$m = \frac{k}{36\pi^2} = .328\ kg$

(b) $\rightarrow$ max velocity $= A\omega. = 6ms^{-1}$

$\rightarrow$ max accelation $= A\omega^2 = 12ms^{-2}.$

$\Rightarrow \omega = 2,\ A = 3m.$

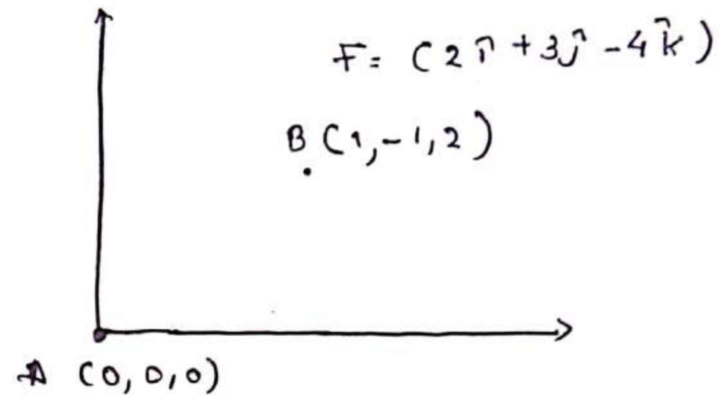
$x = A\sin\omega t = A/2 \Rightarrow \sin\omega t = 1/2$

$\rightarrow \omega t = 30^\circ$

$V_{\frac{A}{2}} = A\omega\cos\omega t = 6 \times \frac{\sqrt{3}}{2} = 3\sqrt{3}\,ms^{-1}$

$a_{A/2} = -A\omega^2 \sin\omega t = 12 \times \frac{1}{2} = \pm 6\,ms^{-2}$

6) Consider the point to be orgin



position vector of B = $(1-0)i + (-1-0)j + (2-0)\hat{k}$

$= \hat{i} - \hat{j} - 2\hat{k}$

Force vector = $2\hat{i} + 3\hat{j} - 4\hat{k}$

Moment of inertia = $\vec{r} \times \vec{F}$

$= (\hat{i} - \hat{j} + 2\hat{k}) \times (2\hat{i} + 3\hat{j} - 4\hat{k})$

$$= \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & -1 & 2 \\ 2 & 3 & -4 \end{vmatrix}$$

$\vec{M} = \hat{i}(4-6) - \hat{j}(-4-4) + \hat{k}(3+2)$

$\vec{M} = -2\hat{i} + 8\hat{j} + 5\hat{k}$