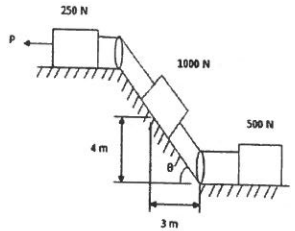
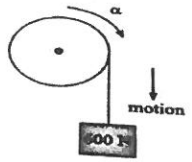
	m/s^2 reaching their maximum speeds of 90 kmph and 72 kmph respectively. If they cross each other midway between the stations, find the distance between the stations and the time taken by each other.			
	OR			
9	Determine the constant force 'P' that will give the system of bodies shown in **Fig. 7**, a velocity of 5 m/sec after moving 8 m from rest. Coefficient of friction between the block and the plane is 0.25. Pulleys are smooth.  Fig. 7	L3	CO4	10 M
	UNIT-V			
10	A pulley of weight 400N has a radius of 0.6m. A block of 600N is suspended by a rope wound round the pulley as shown in **Fig. 8.** Determine the resulting acceleration of the weight and tension in the rope.  Fig. 8	L3	CO5	10 M
	OR			
11	The motion of a flywheel around its geometrical axis is described by the equation: $\omega=15t^2+3t+2$ rad/s and angular displacement is 160 radians at t=3 seconds. Find the angular acceleration, velocity, displacement at t = 1 second.	L3	CO5	10 M

PVP 23

Code: 23CE3201, 23ME3201

I B.Tech - II Semester – Regular Examinations - JULY 2024

ENGINEERING MECHANICS

(Common for CE, ME)

Duration: 3 hours Max. Marks: 70

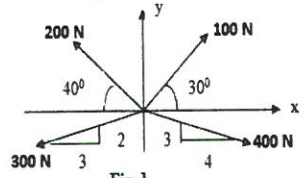
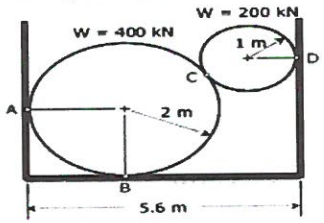
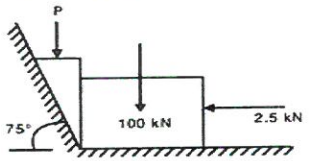
Note: 1. This question paper contains two Parts A and B.
2. Part-A contains 10 short answer questions. Each Question carries 2 Marks.
3. Part-B contains 5 essay questions with an internal choice from each unit. Each Question carries 10 marks.
4. All parts of Question paper must be answered in one place.

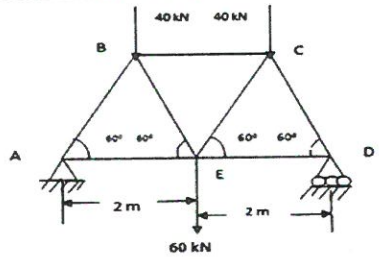
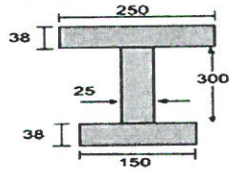
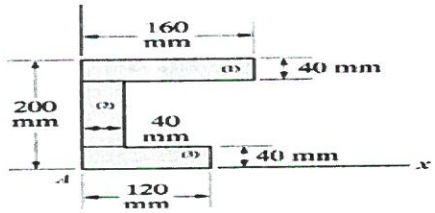
BL – Blooms Level CO – Course Outcome

PART – A

		BL	CO
1.a)	What is meant by non-coplanar concurrent system? Give an example.	L1	CO1
1.b)	What is a Free Body Diagram (FBD)? Draw FBD of a cylinder of weight 'W' resting on a floor.	L1	CO1
1.c)	Recall coefficient of friction.	L1	CO2
1.d)	Define truss. List out the types of trusses.	L1	CO2
1.e)	Define the term Area Moment of inertia.	L1	CO3
1.f)	Show the positions of centroid of semicircle and quarter circle from the base.	L1	CO3
1.g)	What are the differences between kinematics and kinetics?	L1	CO4
1.h)	State D'Alembert's principle? How it is applied in solving problems relating to dynamics?	L1	CO4
1.i)	Explain the difference between linear and angular velocity.	L2	CO5
1.j)	What is instantaneous axis of rotation?	L1	CO5

PART – B

			BL	CO	Max. Marks
		UNIT-I			
2	a)	Determine the resultant of the coplanar concurrent force system shown in **Fig.1.**  Fig. 1	L2	CO1	5 M
	b)	State and Prove Lami's theorem.	L2	CO1	5 M
		OR			
3		The cylinders shown in **Fig. 2** have the indicated weights and dimensions. Assuming smooth contact surfaces, determine the reactions at A, B, C and D on the cylinders.  Fig. 2	L2	CO1	10 M
		UNIT-II			
4		Calculate the force P required to start the wedge as shown in **Fig. 3.** The angle of friction for all surfaces of contact is 15°.  Fig. 3	L3	CO2	10 M
		OR			

5		Determine the forces in all the members of the truss shown in **Fig. 4.** and indicate the magnitude and nature of forces on the diagram of the truss. All inclined members are at 60^0 to the horizontal and length of each member is 2 m.  Fig. 4	L3	CO2	10 M
		UNIT-III			
6		Calculate the positions of centroid of the given I - Section shown in **Fig. 5**. All dimensions are in mm.  Fig. 5	L3	CO3	10 M
		OR			
7		Solve the Moment of Inertia for the section shown in **Fig.6** about the centroidal axis x-x and y-y.  Fig. 6	L3	CO3	10 M
		UNIT-IV			
8		Two trains R and S start from rest simultaneously from stations A and B facing each other with accelerations 0.5 m/s^2 and 2/3	L3	CO4	10 M

I. B.Tech - II Semester - Regular examinations - July 20

Engineering Mechanics (23ME3201)

Scheme of evaluation

PART - A

1. a) Meaning of non-Coplanar Concurrent System - 2M
   b) Definition of FBD - 1M
      FBD of cylinder resting on ground - 1M
   c) Definition of coefficient of friction - 2M
   d) Definition of truss - 1M
      Types of trusses - 1M
   e) Definition of Area moment of Inertia - 2M
   f) Centroid coordinates of semi-circle - 1M
      centroid coordinates of quarter circle - 1M
   g) Any one difference ~~differ~~ between Kinematics & Kinetics - 2
   h) D'Alembert's principle - 2M
   i) Any one difference between linear and angular velocity - 2M
   j) Definition of instantaneous axis of rotation - 2M

PART - B

UNIT - I

2. a) Finding the angles - 1M
      Determining ΣF_x, ΣF_y, Resultant & its angle - 4M
   b) Statement of Lami's theorem - 2M
      Proof - 3M

   (OR)

3. FBD of both cylinders - 4M
   Determining reactions R_A, R_B, R_C & R_D - 6M

UNIT - II

4. FBD of wedge and the block - 4M
   Determining reaction at all contact surfaces - 4M
   Determining force P - 2M

   (OR)

5. Determining Tensions in 7 members of truss - 10M

UNIT-III

6. Determining x & y coordinates – 10M (5M each)

(OR)

7. Determining centroid – 5M
   Determining moment of Inertia – 5M. ($2\frac{1}{2}$ M each) about x & y axis

UNIT-IV

8. Determining the time taken to cross – 5M
   Determining the distance between stations – 5M

(OR)

9. FBD of ~~each~~ all blocks – 6M (2M each)
   Determining the force 'P' – 4M

UNIT-V

10. FBD of weight and pulley – 4M
    Determining acceleration – 3M
    Determining Tension – 3M

(OR)

11. Determining angular velocity – 2M
    Determining angular acceleration – 3M
    Determining angular displacement – 5M

X

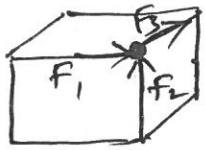
I B.Tech - II Semester - Regular examinations - July 202

Engineering Mechanics (23ME3201)

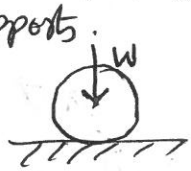
Key

PART - A

1. a) Non-coplanar concurrent system. - Two or more forces acting in different planes but their line of actions will intersect at one point.



b) Free Body Diagram (FBD) - A diagram showing the forces acting on a body together with reactions at the supports but not showing the supports.



c) Coefficient of friction - is defined as the ratio of the maximum value of limiting friction to the Normal reaction

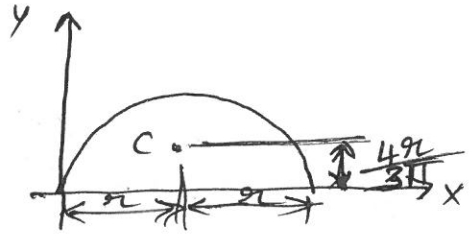
$$\mu = \frac{F}{N}$$

d) Truss - is a structure, which is a combination of three or more members, connected their edges by pin joints and subjected to loading at joints only.

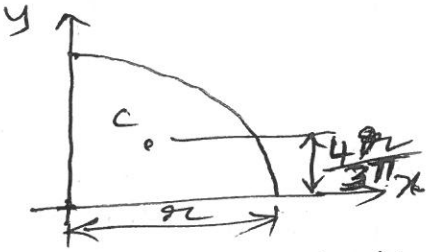
Types of trusses - perfect, deficient and redundant trusses.

e) Area moment of Inertia - It is the concept that gives quantitative estimation of relative distribution of area with respect to some reference axis.

f) semicircle



Quarter circle



g) Kinematics - Branch of mechanics, deals with the motion parameters of a moving body without considering the forces acting on it.

Kinetics - Branch of mechanics, deals with the study of motion of a moving body under the effect of forces acting on it

h) D'Alembert's principle - A body is said to be in dynamic equilibrium when the algebraic sum of external forces along with inertia force is zero.

$$\Sigma F + (-ma) = 0$$

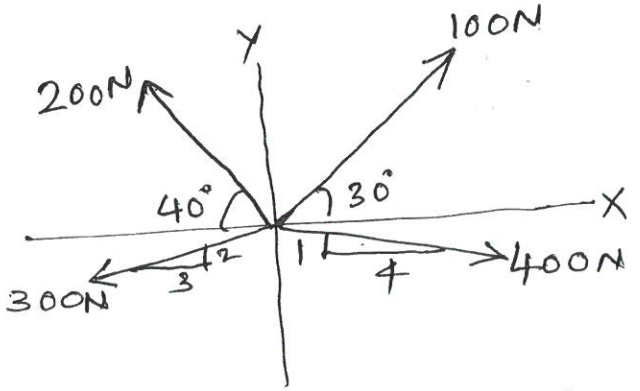
i) The velocity of a body moving in straight line path is linear velocity. The velocity of a body moving in a curved or circular path is angular velocity.

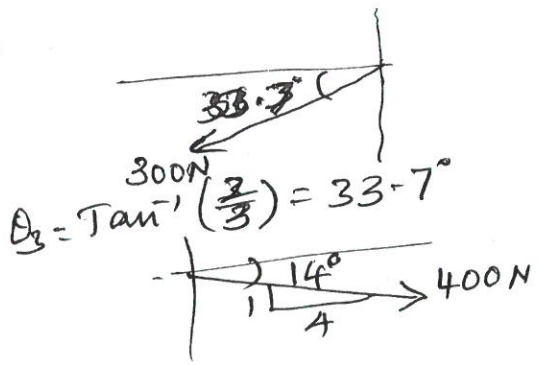
j) Instantaneous axis of rotation. - While analysing a plane body motion a point can be located in the plane which has zero velocity. The plane motion of all the particles constituting the body may then be considered as pure motion about that point. Such a point is called instantaneous centre. The axis passing through that point Normal to the plane of motion is called instantaneous axis of rotation.

PART - B

UNIT - I

2. a)





$\theta_2 = \tan^{-1}\left(\frac{3}{4}\right) = 33.7°$

$\Sigma F_x = 100\cos 30° + 400\cos 14° - 200\cos 40° - 300\cos 33.7°$

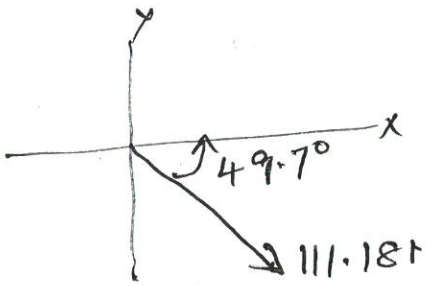
$= 71.9\ N$

$\Sigma F_y = 100\sin 30° + 200\sin 40° - 300\sin 33.7° - 400\sin 14°$

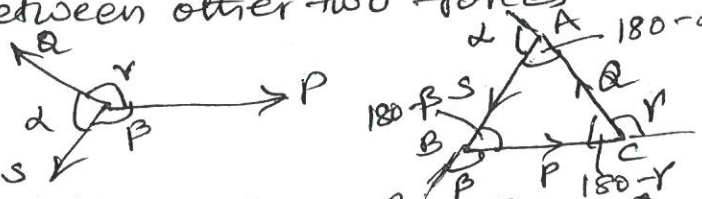
$= -84.8N$

$\text{Resultant} = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2} = \underline{111.18N}$

$\theta = \tan^{-1}\left(\frac{\Sigma F_y}{\Sigma F_x}\right) = \underline{49.7°}$



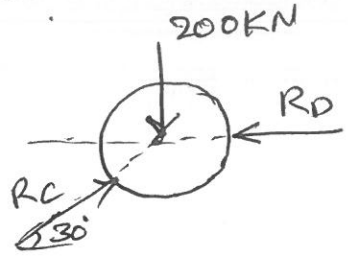
b) Lami's theorem - "If three coplanar forces acting at a point are in equilibrium, each force is proportional to the sine of the angle between other two forces

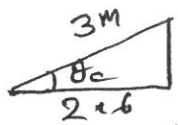


By triangular law of forces, $\frac{P}{BC} = \frac{Q}{AC} = \frac{S}{AB}$ — (1)

By sine rule, $\frac{BC}{\sin(180-\alpha)} = \frac{CA}{\sin(180-\beta)} = \frac{AB}{\sin(180-\gamma)}$ — (2)

3. FBD of 200KN (OR)





$\theta_C = \cos^{-1}\left(\frac{2.6}{3}\right)$

$= 30^\circ$

$\Sigma F_x = 0;$

$\Rightarrow R_C \cos 30^\circ - R_D = 0$

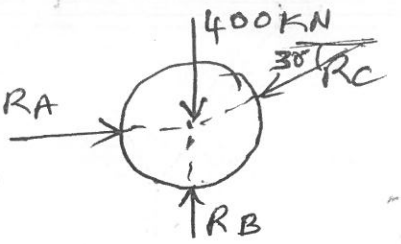
$\Rightarrow R_D = 346$ KN

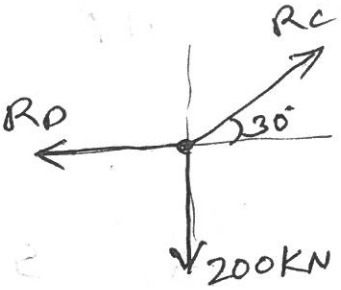
$\Sigma F_y = 0$

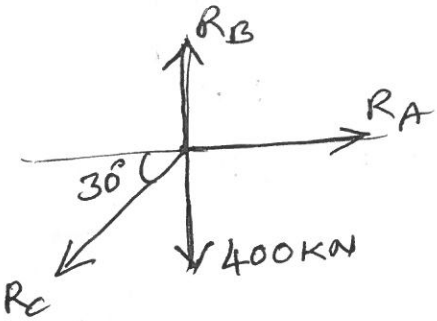
$\Rightarrow R_C \sin 30^\circ - 200 = 0$

$\Rightarrow R_C = 400$ KN

FBD of 400KN







$\Sigma F_x = 0;$

$\Rightarrow R_A - R_C \cos 30^\circ = 0$

$\Rightarrow R_A = 346$ KN

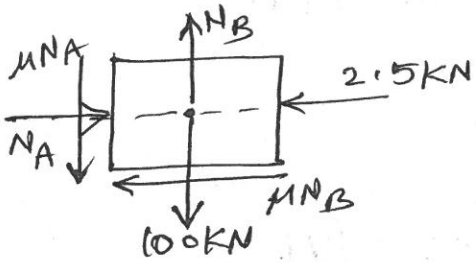
$\Sigma F_y = 0$

$\Rightarrow R_B - R_C \sin 30^\circ - 400 = 0$

$\Rightarrow R_B = 600$ KN

UNIT-II

4.



$\Sigma F_x = 0;$

$\Rightarrow N_A - 2.5 - 0.27(N_B) = 0$

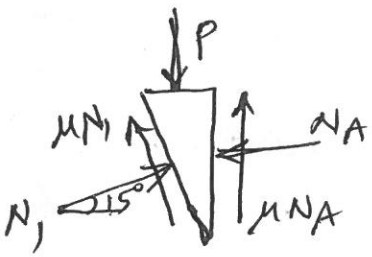
$\Sigma F_y = 0;$

$\Rightarrow N_B - 100 - 0.27(N_A) = 0$

Solving both the equations, we have

$N_A = 31.85$ KN

$N_B = 108.6$ KN



$\mu = \tan(15^\circ)$

$= 0.27$

$\Sigma F_x = 0;$

$\Rightarrow N_1 \cos 15^\circ - N_A - 0.27(N_1)\sin 15^\circ = 0$

$\Sigma F_y = 0;$

$\Rightarrow 0.27(N_A) + 0.27(N_1)\cos 15^\circ + N_1 \sin 15^\circ - P = 0$

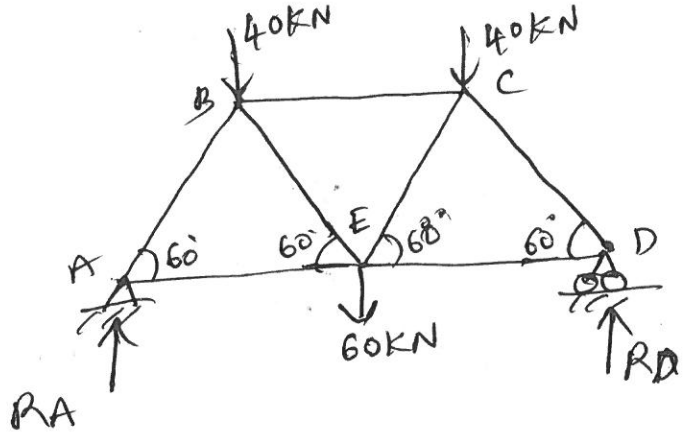
Solving both the equations, we have

$N_1 = 159.1$ KN

$P = 464.8$ KN

(OR)

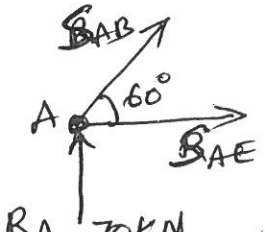
5.



By symmetry,

$R_A = R_D = 70\ KN.$

Equilibrium of Joint - A



$\Sigma F_x = 0;$

$\Rightarrow S_{AE} + S_{AB}\cos 60^\circ = 0$

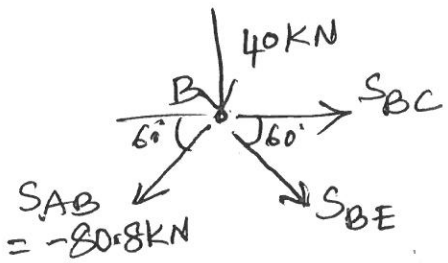
$\Rightarrow \underline{S_{AE} = 40.4\ KN}$

$\Sigma F_y = 0;$

$\Rightarrow R_A + S_{AB}\sin 60^\circ = 0$

$\Rightarrow \underline{S_{AB} = -80.8\ KN}$

Equilibrium of Joint - B



$\Sigma F_x = 0;$

$\Rightarrow S_{BC} + S_{BE}\cos 60^\circ - S_{AB}\cos 60^\circ = 0$

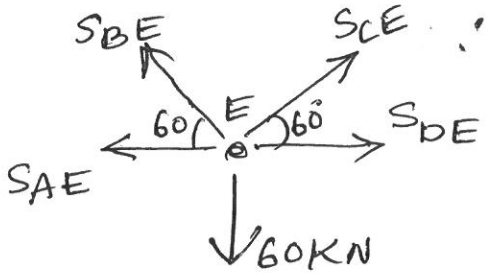
$\Rightarrow \underline{S_{BC} = -57.7\ KN}$

$\Sigma F_y = 0$

$\Rightarrow -40 - S_{BE}\sin 60^\circ - S_{AB}\sin 60^\circ = 0$

$\Rightarrow \underline{S_{BE} = 34.64\ KN}$

Equilibrium of Joint - E



$\Sigma F_x = 0;$

$\Rightarrow S_{DE} + S_{CE}\cos 60^\circ - S_{AE} - S_{BE}\cos 60^\circ = 0$

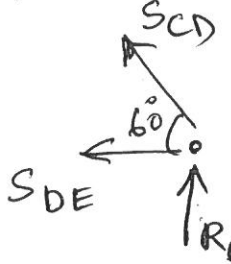
$\Rightarrow \underline{S_{DE} = 40.4\ KN.}$

$\Sigma F_y = 0$

$\Rightarrow S_{CE}\sin 60^\circ + S_{BE}\sin 60^\circ - 60 = 0$

$\Rightarrow \underline{S_{CE} = 34.64\ KN}$

Equilibrium of Joint - D



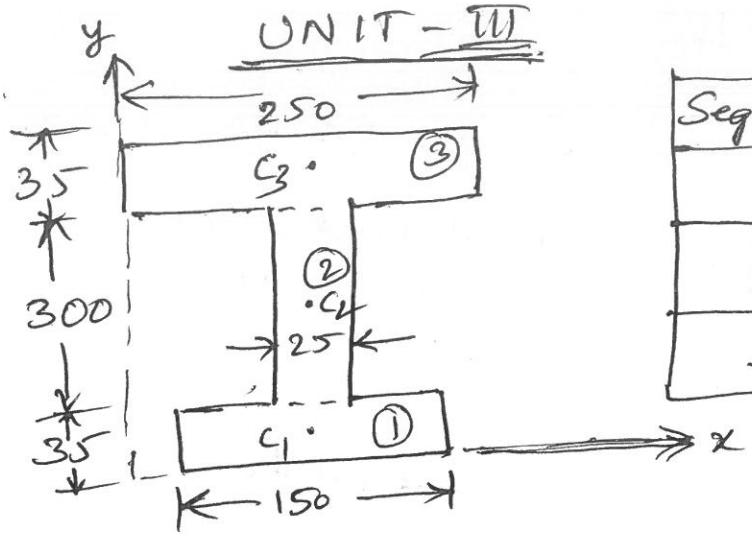
$\Sigma F_y = 0;$

$\Rightarrow R_D + S_{CD}\sin 60^\circ = 0$

$\Rightarrow \underline{S_{CD} = -80.8\ KN.}$

UNIT - III

6.

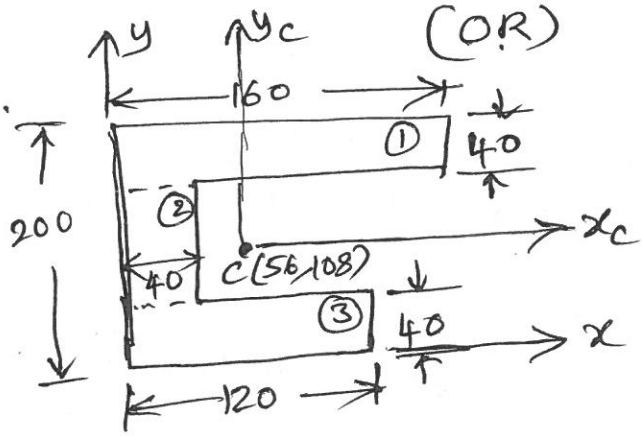


Segment	Area	x	y
1	5250	125	17.5
2	7500	125	185
3	8750	125	352.5

$$x_c = \frac{A_1x_1 + A_2x_2 + A_3x_3}{A_1 + A_2 + A_3} = 125 \text{ mm}$$

$$y_c = \frac{A_1y_1 + A_2y_2 + A_3y_3}{A_1 + A_2 + A_3} = 212.5 \text{ mm}$$

I.



Segment	Area	x	y
1	6400	80	180
2	4800	20	100
3	4800	60	20

(OR)

$$x_c = \frac{A_1x_1 + A_2x_2 + A_3x_3}{A_1 + A_2 + A_3} = 56 \text{ mm}$$

$$y_c = \frac{A_1y_1 + A_2y_2 + A_3y_3}{A_1 + A_2 + A_3} = 108 \text{ mm}$$

Moment of Inertia about centroidal x-axis:

$$I_{xx} = \left\{\frac{160(40)^3}{12} + (6400 \times 72^2)\right\} + \left\{\frac{40(120)^3}{12} + (4800 \times 8^2)\right\} + \left\{\frac{120(40)^3}{12} + (4800 \times 88^2)\right\}$$

$$= 77909333 \text{ mm}^4$$

Moment of Inertia about centroidal y-axis:

$$I_{yy} = \left\{\frac{40(160)^3}{12} + (6400 \times 24^2)\right\} + \left\{\frac{120(40)^3}{12} + (4800 \times 36^2)\right\} + \left\{\frac{40(120)^3}{12} + (4800 \times 8^2)\right\}$$

$$= 20037333 \text{ mm}^4$$

UNIT - IV

8. Let 't' is the time in seconds when both trains meet each other

Final speed of train R,

$v = u + at$

$90 \times \frac{5}{18} = 0 + (0.5)t$

$\Rightarrow t = 50$ sec

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

$= 625$ m

Distance covered in 't' seconds

$= (90 \times \frac{5}{18})(t-50) + \frac{1}{2}(0.5)(50^2)$

$= 25t + 625$

Final speed of train S,

$v = u + at$

$72 \times \frac{5}{18} = 0 + (\frac{2}{3})t$

$\Rightarrow t = 30$ sec

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

$= 300$ m

Distance covered in 't' seconds

$= (72 \times \frac{5}{18})(t-30) + \frac{1}{2}(\frac{2}{3})(30)^2$

$= 20t - 300$

As both trains meet midway, so both distances are equal,

$25t - 625 = 20t - 300$

$\Rightarrow \underline{t = 65 \text{ sec}}$

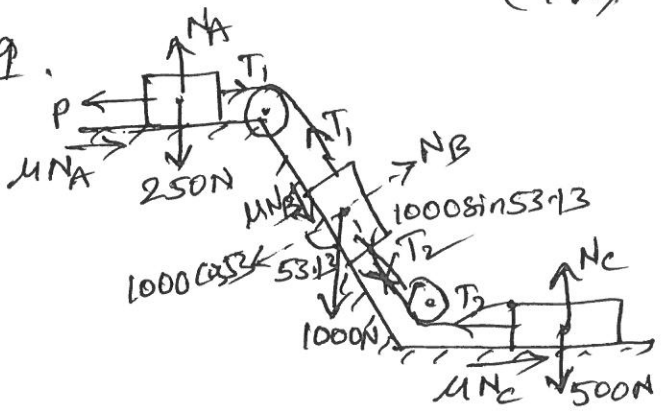
Distance covered by train R in 65 sec $= 25(65) - 625 = 1000$ m

Distance covered by train S in 65 sec $= 20(65) - 300 = 1000$ m

∴ Total distance between A and B $= 1000 + 1000 = \underline{2000 \text{ m}}$.

(OR)

9.



$\mu = 0.25$ $\quad \theta = \tan^{-1}(\frac{4}{3}) = 53.13^\circ$

$v = 5$ m/s

$s = 8$ m; $\quad N_A = 250$ N

$\mu N_A = 0.25 \times 250 = 62.5$ N

$\mu N_B = 0.25 \times 600 = 150$ N

$N_B = 1000 \cos 53.13 = 600$ N

$\mu N_C = 0.25 \times 500 = 125$ N

$N_C = 500$ N

Applying work-energy principle,

$W = KE_2 - KE_1$

$8[P - T_1 - 62.5 + T_1 - 800 - T_2 - 150 + T_2 - 125]$

$= \frac{1}{2}\left[\frac{250}{9.81} + \frac{1000}{9.81} + \frac{500}{9.81}\right](5)^2$

$P - 1137.5 = \frac{1}{8 \times 2} \times \left\{\frac{1750}{9.81}\right\} \times 25$

$\Rightarrow \underline{P = 1416.2 \text{ N}}$

UNIT – VI

10.

$\Sigma F = ma \Rightarrow W - T = \frac{W}{g} \cdot a$ — (1)

$M = T \times r$; $\alpha = \frac{a}{r}$

$\Sigma M = I\alpha \Rightarrow T \times r = I \cdot \frac{a}{r}$ where $I = \frac{M_0 r^2}{2}$

$\Rightarrow T = I \times \frac{a}{r^2} = \frac{W_0}{g} \cdot \frac{r^2}{2}$

$\Rightarrow T = \frac{W_0}{g} \cdot \frac{r^2}{2} \times \frac{a}{r^2}$

$= \frac{W_0}{2g} \cdot a$ — (2)

From equations (1) and (2),

$W - \frac{W_0}{2g} \cdot a = \frac{W}{g} \cdot a$

$W = \frac{a}{g}\left[W + \frac{W_0}{2}\right]$

$\Rightarrow a = \frac{gW}{W + \frac{W_0}{2}} = \frac{9.81 \times 400}{600 + \frac{400}{2}} = 7.35 \text{ m/s}^2$

From equation (1)

$W - T = \frac{W}{g} \times \frac{gW}{W + \frac{W_0}{2}} = \frac{2W^2}{2W + W_0}$

$\Rightarrow T = W - \frac{2W}{2W + W_0} = \frac{2W^2 + WW_0 + 2W^2}{2W + W_0}$

$= \frac{WW_0}{2W + W_0} = \frac{600 \times 400}{2(600) + 400}$

$= 150 \text{ N.}$

(OR)

11. $\omega = 15t^2 + 3t + 2$

$\alpha = \frac{d\omega}{dt} = \frac{d}{dt}(15t^2 + 3t + 2) = 30t + t$

when $t = 1$; $\alpha = 30 \text{ rad/s}^2$

$\omega = 20 \text{ rad/s}$

$\omega = \frac{d\theta}{dt} \Rightarrow d\theta = \omega \cdot dt = (15t^2 + 3t + 2)\,dt$

$\int d\theta = \int (15t^2 + 3t + 2)\,dt$

$\theta = \frac{15t^3}{3} + \frac{3t^2}{2} + 2t + c_1$

$\Rightarrow 160 = \frac{15(3)^3}{3} + \frac{3(3)^2}{2} + 2(3) + c_1 \Rightarrow c_1 = 5.5$

when $t = 1$; $\theta = 14$ radians.