SEE MODEL QUESTION PAPER

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21CIV14

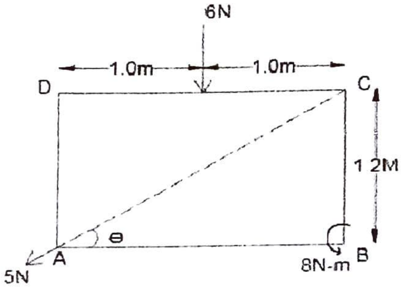
First Semester B.E Degree Examination, March- 2022

Engineering Mechanics

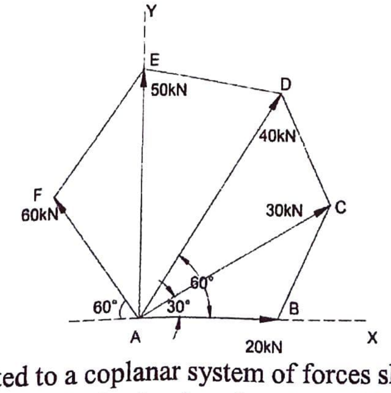
Time: 3 hrs. Max. Marks: 100

Note: Answer any Five full questions, choosing ONE full question from each module.

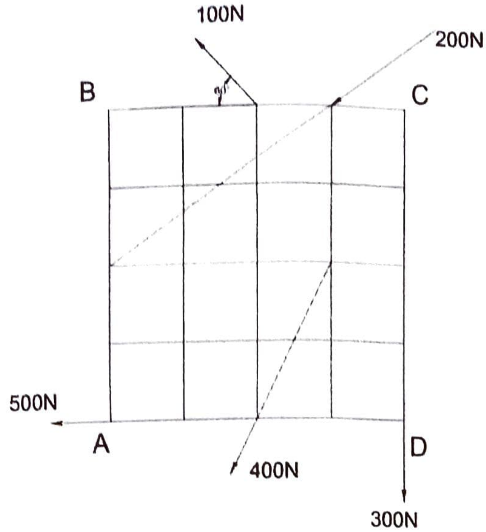
Q. No.		Questions	Marks
		Module 1	
1	a	Explain the Following. i) Composition of forces and Resolution of forces ii) Moment of a force and Couple	8
	b	Determine the magnitude, direction and the point of appliction of the resultant force for the given sysem of forces as shown in figure.	6



	c	State and prove Varignon's theorem.	6
		OR	
2	a	Forces of 20 KN, 30 KN, 40 KN, 50 KN, and 60 KN act from the vertex 'A' of rectangulr hexagon ABCDEF towards other vertices B, C, D, E and F respectively as shown in figure. Determine the magniude and direction of reultatant of forces.	8



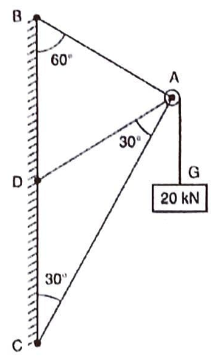
	b	A flat plate is subjected to a coplanar system of forces shown in figure. Each square of the inscribed grid is having length of 1.0 m. Determine the resultant with respect to A.	8



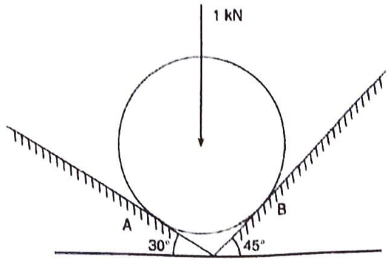
c Explain transmissibility of force. 4

Module – 2

3 a The frictionless pulley 'A' shown in figure. is supported by two bars AB and AC which are hinged at 'B' and 'C' to a vertical wall. The flexible cable DG hinged at 'D', goes over the pulley and supports a load of 20 kN at 'G'. The angles between the various members are shown in the figure. Determine the forces in the bars AB and AC. Neglect the size and weight of the pulley. 10



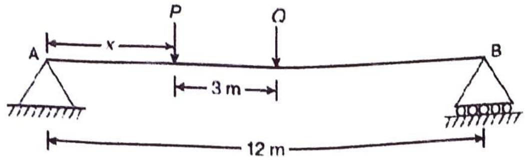
b Determine the reactions at the point of contact for the sphere shown in figure. 6



c Explain the types of loading on the beams. 4

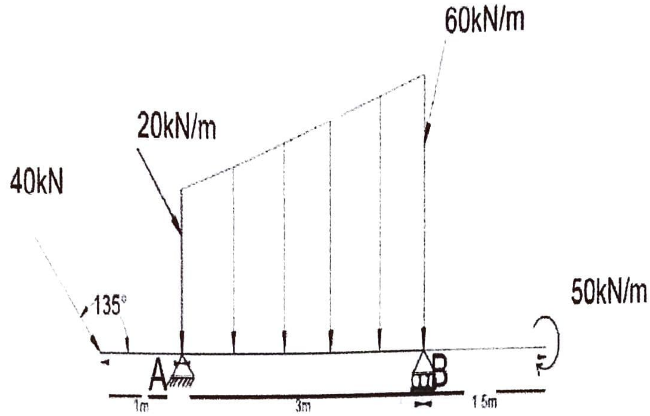
OR

4 a Determine the distance x of the load P from the support A, if the reaction R_A is twice as great as reaction R_B. Take P = 2 kN, Q = 1kN 8



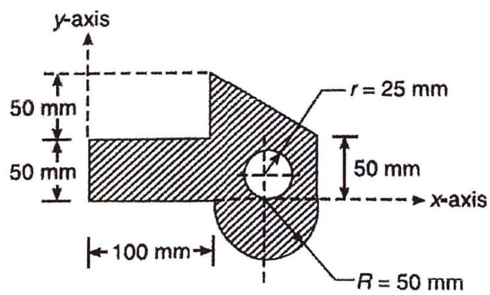
b With neat sketches, explain various types of supports. 6

c Find the support reactions R_A and R_B for the beam loaded as shown in figure. 6



Module – 3

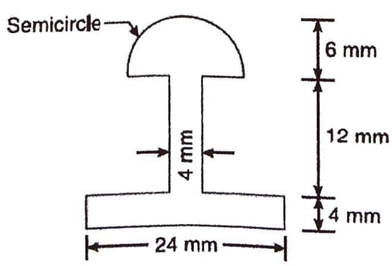
5 a Locate the centroid of a given composite area shown in figure. 14



b Derive the position of centroid of a semi-circular lamina of radius "R". 06

OR

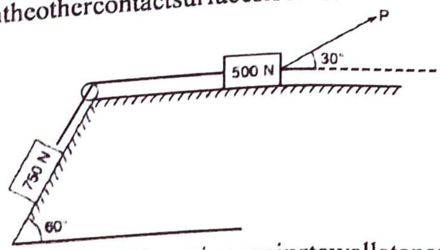
6 a The cross-section of a cast iron beam is shown in Fig. Determine the moment of Inertia about the centroidal axes. 12



b Derive an expression for moment of inertia of a semicircle with respect to its diameter line and also w.r.t centroidal axis parallel to diameter line. 08

Module 4

7 a What is the value of 'P' in the system shown in Figure, to cause the motion to impend to the right? Assume the pulley is smooth and coefficient offrictionbetweentheothercontactsurfacesis0.20. 10



b Aladder7mlongweighing300Nisrestingagainstawallatanangleof60° to the horizontal ground. A man weighing 700 N climbs the ladder, atwhatpositiondoesheinduceslipping.Take μ =0.25forallcontactsurfaces. 10

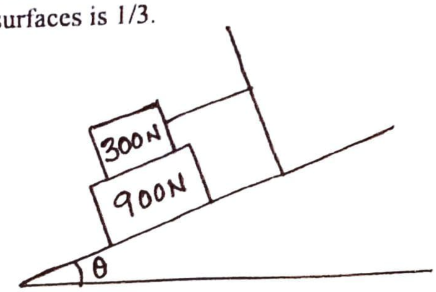
OR

8 a Explain different types of friction. 4

b Define the terms: 8

a. Angle of friction
b. Angle of Repose
c. Limiting Friction
d. Coefficient of friction

c What should be the value of Θ as shown in the figure which will make the motion of 900 N block down the plane to impend? The coefficient of friction for all the contact surfaces is 1/3. 8



Module 5

9 a Explain with neat sketch for projectile motion: 10

i) Range.
ii) Time of flight.
iii) Maximum height.
iv) Angle of projection.
v) Projectile.

b A stone is dropped into a well and a sound of splash is heard after 4seconds. Find the depth of well if velocity of sound is 320m/s. 10

OR

10 a A burglar's car starts with an acceleration of 2 m/sec^2. A police vigilant party came after 5seconds and continued to chase the burgler's car with uniform velocity of 20m/sec. Find the time taken in which the police van will overtake the car. 10

b A cricket ball is thrown by a fielder in ground from a height of 3m at an angle of 40^0 with horizontal. The velocity with which the ball is thrown is 30m/sec. The ball hits the wicket at a height of 0.3m from ground. Determine the distance of fielder from the wicket when the ball is thrown. 10

SOLUTION AND SCHEME:

Name of Subject & code: ECE & M (21CIV14)

Staff Incharge: S. G. Hiremath.

Q.No. 1 a) Explain the following.
i) Composition of forces & Resolution of forces.
ii) Moment of force & Couple.

Ans: i) Composition of forces & Resolution of forces.

The process of combining no of forces to get a single force is called "Composition of forces". And the single force will have same effect as no of forces is have on the body. This single force is called resultant force.

The composition can be done by the following methods.

i) Graphical methods. like

a) law of parallelogram of forces
b) Triangle law of forces.
c) polygon law of forces.

ii) Analytical methods. like

$$R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

with the help of parallelogram law of forces

where

R = magnitude of resultant force

F_1, F_2 = Any two forces.

θ = Inclination between F_1 & F_2

02M

ii) Resolution of forces.

The process of splitting the given single forces into no of forces is called "Resolution of forces. The no of forces after splitting the single force are called component forces.

As per Principle of Superposition of forces, these component forces will have same effect as single forces having on the body. We can find any no of component forces but in solving the numericals usually, the components of forces along two mutually ⊥[er] axis are found out. — 02M.

Total 04M.

Q.No. 1 b) Numerical problem on composition of coplanar non concurrent forces.

From the given fig $\theta = \tan^{-1}\frac{1.2}{2} = 30.96°$

$\Sigma F_x = -5\cos 30.96° = -4.28\,N$ — 01M.

$\Sigma F_y = -5\sin 30.96° -6 = -8.57\,N$ — 01M

$R = \sqrt{(-4.28)^2 + (-8.57)^2} = 9.58\,N$ — 01M

$\Sigma M_A = +6\times1 - 8 = -2\,N\cdot m$

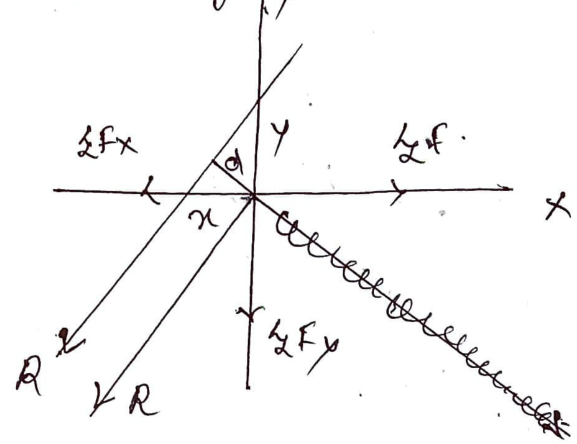
$d = \frac{\Sigma M_A}{R} = 0.20\,m$

$x = \frac{\Sigma M_A}{\Sigma F_y} = 0.23\,m.$

(2)

$$y = \frac{\Sigma M_A}{\Sigma F_x} = \frac{2}{4.28} = 0.46\,m$$ — 02M.

The results can be shown with the help of following fig.



— 01M

Total 06M.

Q.No.1 c) State & Prove Varignon's theorem

Varignon's theorem or varignon's principle of moments or Principle of moments

Statement: It states the the algebraic sum of moments of coplanar forces about a moment centre in the plane is equal to the moment of their resultant force about the same moment centre.

Mathematically

$$R \cdot d = F_1 d_1 + F_2 d_2$$

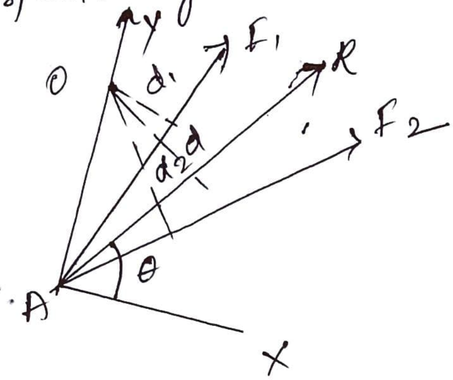
where

F_1, F_2 = Two Coplanar forces

R = Resultant of F_1 & F_2

d, d_1 & d_2 = moment arms of R, F_1 & F_2 resply. — 02M.

Proof: Consider two forces F_1 & F_2 which are acting at point A as shown below in fig. Let R be the resultant of F_1 & F_2 and let d, d_1 & d_2 be the moment arms of R, F_1 & F_2 respectively as shown.



Let O be the moment centre, join OA & consider it as Y-axis and per to it draw X-axis as shown. Let θ be the inclination of R with X-axis.

As per Varignon's then we have to prove

$$R \cdot d = F_1 d_1 + F_2 d_2 \quad \text{—} \ (1)$$

$$R \cdot d = OA \cdot R_x \quad \text{—} \ (2)$$

Illy we can prove

$$F_1 d_1 = OA \cdot F_{1x} \quad \text{and} \ \text{—} \ (3)$$

$$F_2 d_2 = OA \cdot F_{2x} \quad \text{—} \ (4)$$

Adding (3) & (4)

$$F_1 d_1 + F_2 d_2 = OA\, F_{1x} + OA \cdot F_{2x}$$

$$= OA\,(F_{1x} + F_{2x})$$

$$F_1 d_1 + F_2 d_2 = OA\, R_x \quad (\text{from } (2))$$

$$F_1 d_1 + F_2 d_2 = R \cdot d$$

04M

Total 06M.

(4)

Q. No. 2 a) Numerical problem on composition of Coplanar Concurrent forces.

$\Sigma F_x = +20 + 30\cos 30 + 40\cos 60 - 60\cos 60$ — 03 M

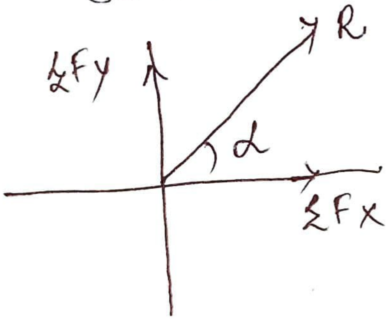
$= 35.98$ KN

$\Sigma F_y = +30\sin 30 + 40\sin 60 + 50 + 60\sin 60$ — 03 M

$= 151.60$ KN

$R = \sqrt{35.98^2 + 151.60^2} = 155.81$ KN

$\alpha = \tan^{-1}\frac{151.60}{35.98} = 76.64^\circ$ — 02 M



Total 08 M.

Q. No. 2 b) Numerical problem on composition of Coplanar non Concurrent forces.

Let θ_1 & θ_2 be the inclinations of 200N & 400N forces shown in fig. Then from given fig.

$\theta_1 = \tan^{-1}\frac{2}{3} = 33.69^\circ$

$\theta_2 = \tan^{-1}\frac{2}{1} = 63.43^\circ$

$\Sigma F_x = -500 - 200\cos 33.69^\circ - 100\cos 60 - 400\cos 63.43^\circ$ — ② M.

$= -895.32$ N

$\Sigma F_y = +100 \sin 60 - 200 \sin 33.69$
$- 400 \sin 63.43 - 300$

$= -682.09\,N$ ———— 02 M

$R = \sqrt{895.32^2 + (-682.09)^2}$

$R = 1125.54\,N$ ———— 01 M

$\alpha = \tan^{-1} \dfrac{682.09}{895.32} = 37.30^\circ$

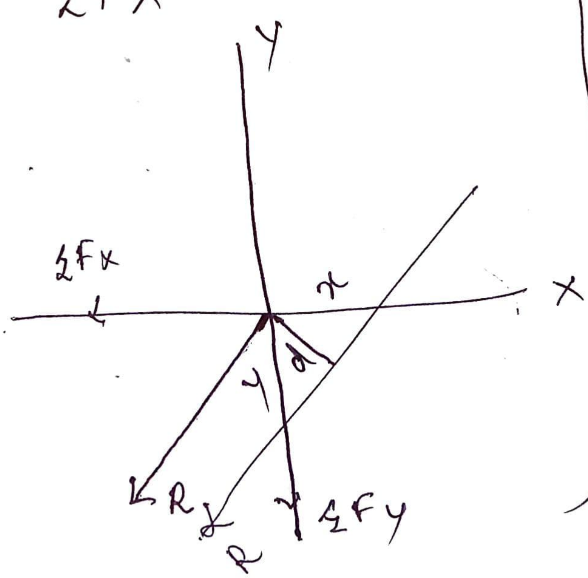
$\Sigma M_A = +400 \sin 63.43^\circ \times 2 + 300 \times 4$
$- 200 \cos 33.69^\circ \times 2 - 200 \sin 60 \times 2$
$- 100 \cos 60 \times 4$ ———— 02 M.

$= 1036.28\,N \cdot m$

$d = \dfrac{\Sigma M_A}{R} = 0.92\,m$

$x = \dfrac{\Sigma M_A}{\Sigma F_y} = 1.52\,m$

$y = \dfrac{\Sigma M_A}{\Sigma F_x} = 1.16\,m$



———— 01 M

Total 08 M.

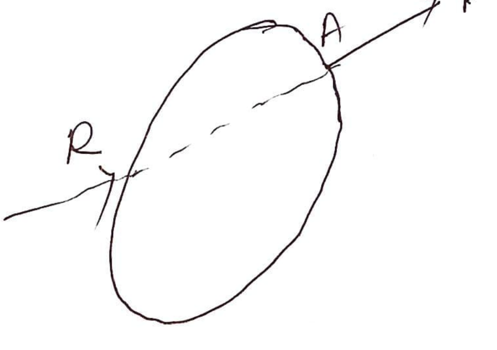
(6)

2 c) Principle of transmissibility of force

Statement: It states that "the state of rest or uniform motion of the body is unaltered, if a force acting on a body is replaced by another force of same magnitude & in the same direction anywhere on the body but along the ~~same~~ line of action of replace force. ---- 02M

Explaination:

Consider a rigid body as shown below in fig. Let F be the force acting at point A.



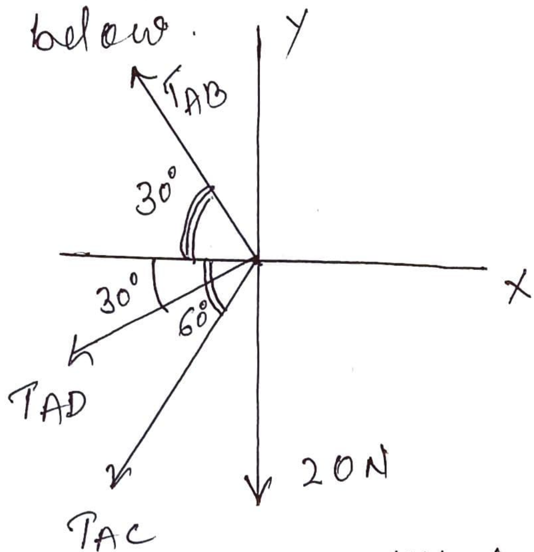
As per principle of transmissibility the state of rest is unaltered if F is replaced by R but R should in the same direction & it should be along the line of action of F as shown in fig. 02

Total 04M.

7

3 a) Numerical problem on equillibrium of connected bodies.

FBD for point A is as shown below.



04

Applying eqn of equillibrium.

$\sum F_x = 0$

$\Rightarrow -T_{AB}\cos 30 - T_{AC}\cos 60 = 0$ --- 02

$\Rightarrow T_{AB} = -\dfrac{T_{AC}\cos 60}{\cos 30}$ --- ①

$\sum F_y = 0$

$\Rightarrow +T_{AB}\sin 30 - T_{AC}\sin 60 - 20 = 0$

$T_{AB} = \dfrac{T_{AC}\sin 60 + 20}{\sin 30}$ --- ② 02

equaling ① & ②

$-\dfrac{T_{AC}\cos 60}{\cos 30} = \dfrac{T_{AC}\sin 60 + 20}{\sin 30}$

$-0.577\,T_{AC} = 1.732\,T_{AC} + 40$

$-2.309\,T_{AC} = 40$

$T_{AC} = -17.32\,N$ --- 02

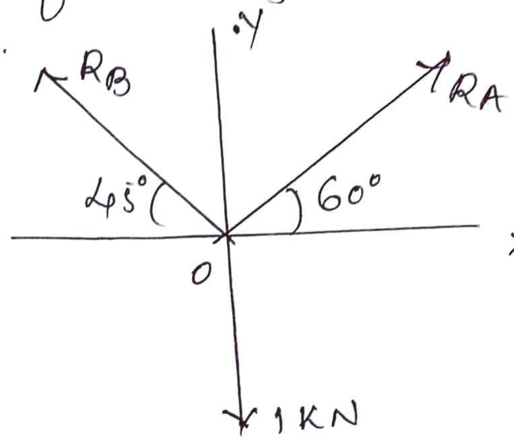
$\Rightarrow T_{AB} = 10\,N$ from ①

Total 10M

⑧

3 b) Numerical problem on Equillibrium of Coplanar Concurrent forces.

FBD for the sphere is as shown below.



Let RA & RB be the reactions at contact points A & B respectively

Applying Lami's thm.

$$\frac{R_A}{\sin(90+45)} = \frac{R_B}{\sin(90+60)} = \frac{1}{\sin 75°}$$ — 04M

$R_A = \frac{\sin 135}{\sin 75°} = 0.732\ KN$

$R_B = \frac{\sin 150}{\sin 75°} = 0.518\ KN$ — 02M

Total 06M.

3 c) The beams can be loaded with the loads like.

i) Concentrated load.
ii) Uniformly distributed load (UDL)
iii) " Varying load (UVL)
iv) External moments.

i) Concentrated load.

These are the load which will have a point of contact with the axis of beam. These may be vertical or inclined to the axis of the beam.

ii) UDL

These are the loads which will have same magnitude for a given length of the beam. The unit for UDL is N/m or KN/m.

iii) UVL

These are the loads which will have some minimum magnitude & have maximum magnitude at some other point on the beam for a given length of the beam.

iv) External moments.

Beams can also be loaded with external moments at a point on the beam. These may be in clockwise or anticlockwise in direction.

=0AM

4 a) Numerical problem on anlalysis of beams.

$\Sigma F_y = 0$

$\Rightarrow R_A + R_B - 2 - 1 = 0$ — (i)

Given $R_A = 2R_B$

∴ eqn (i) becomes.

$2R_B + R_B = 3$

$3R_B = 3 \Rightarrow R_B = 1 \Rightarrow R_A = 2$ — 04

$\Sigma M_A = 0$

$\Rightarrow +2 \times x + 1(x+3) - 1 \times 12 = 0$

$\Rightarrow 2x + x + 3 - 12 = 0.$

$3x = 12 - 3$

$x = \frac{9}{3} \Rightarrow x = 3m.$ — 04

Arithmetic check

$\Sigma F_y = 0$

$\Rightarrow 2 \times 3 + 6 - 12 = 0$

$0 = 0$

Total 08M.

4 b) The various types of supports are

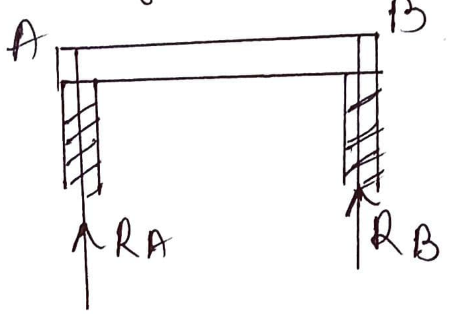
i) Simple support

ii) Roller support

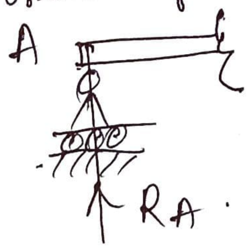
iii) Hinged or pinned support

iv) Fixed support.

i) Simple support It is a support in which ends simply rest over rigid support. In this type the ends are free to move in vertical direction. The reaction developed is normal to to axis of the structural member.

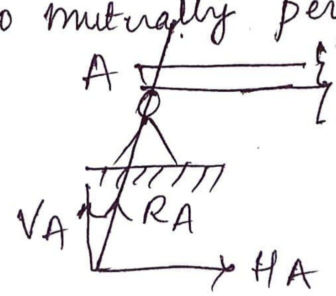


ii) Roller Support: It is a support in which the ends are free to roll on support, there is no resisting moment developed. the reaction is normal to the axis of the structural member.



iii) Hinged or pinned support:

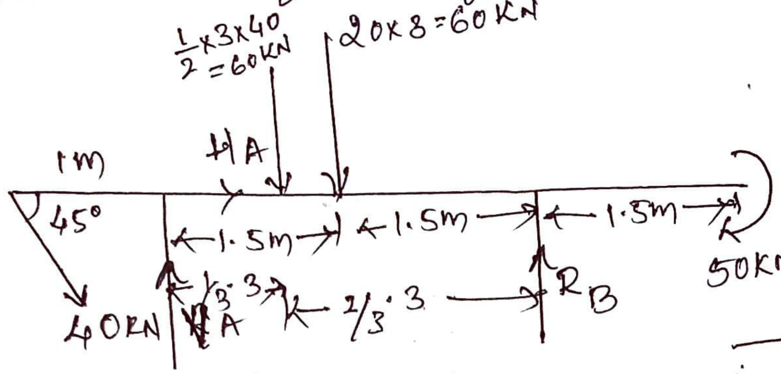
It is a support in which the ends are free to move in vertical or horizontal direction. there is resisting moment. The reaction developed may be in any direction which can be conviniently represented by its components along two mutually perpendicular axis.



02×3=06M

4 c) Numerical problem on support reaction of beam.

Consider the following figure.



→ 01 M

Let V_A & H_A be the vertical & horizontal components of reaction in any direction due to hinged support at point A & R_B be the normal reaction due to roller support at pt B.

$\Sigma M_A = 0$

$\Rightarrow -R_B\times3 - 40\sin45\times1 + 60\times\frac{1}{3}\cdot3 + 60\times1.5 + 50 = 0$ — 03

$\Rightarrow R_B = 57.24\,KN$

$\Sigma F_x = 0$

$\Rightarrow +H_A + 40\cos45 = 0.$

$\Rightarrow H_A = -28.28\,KN$

$\Sigma F_y = 0$ — 01

$\Rightarrow -40\sin45 + V_A - 60 - 60 + 57.24 = 0$

$\Rightarrow V_A = 91.04\,KN$

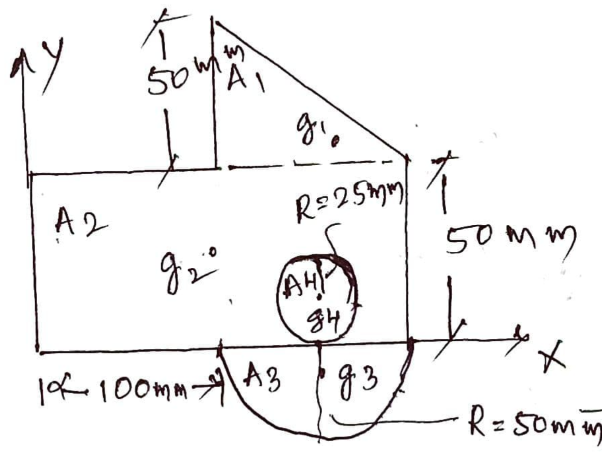
Let R_A be the reaction due to hinged support

$R_A = \sqrt{28.28^2 + 91.04^2} = 95.33\,KN$ — 01

Total 06 M

5 a) Numerical on determination of Centroid.

Consider the following fig.



01M

Let A_1, A_2, A_3 & A_4 be the segmental areas of given composite section. Let g_1, g_2, g_3 & g_4 be the positions of centroids of A_1, A_2, A_3 & A_4 respectively.

$$\Sigma A = 200 \times 50 + \frac{1}{2} \times 100 \times 50 + \frac{\pi (50)^2}{2} - \pi (25)^2$$

03

$$= 14463.49 \text{ mm}^2.$$

Let $\bar{x}$ & $\bar{y}$ be the coordinates of centroid of given composite area.

$$\bar{x} = \frac{A_1\bar{x}_1 + A_2\bar{x}_2 + A_3\bar{x}_3 - A_4\bar{x}_4}{\Sigma A}$$

$$= \frac{200 \times 50 \times 100 + \frac{1}{2} \times 100 \times 50 \times (100 + \frac{2}{3} \cdot 100) + \frac{\pi (50)^2}{2} \cdot \frac{4 \times 50}{3\pi} - \pi (25)^2 \times 125}{14463.49}$$

$$= \frac{1000000 + 416666.67 + 83333.33 - 245436.92}{14463.49}$$

$$\boxed{\bar{x} = 86.74 \text{ mm.}}$$

05

(14)

$\bar{x} = 86.74 \text{ mm}.$

$$\bar{y} = \frac{A_1\bar{y}_1 + A_2\bar{y}_2 + A_3\bar{y}_3 - A_4\bar{y}_4}{\Sigma A}$$

$$= \frac{200 \times 50 \times 25 + \frac{1}{2} \times 100 \times 50 \times \frac{2}{3} \cdot 50 + 50 - \frac{\pi 50^2}{2} \times \frac{4 \times 50}{3\pi} - \pi (25)^2 \times 25}{14463.49}$$

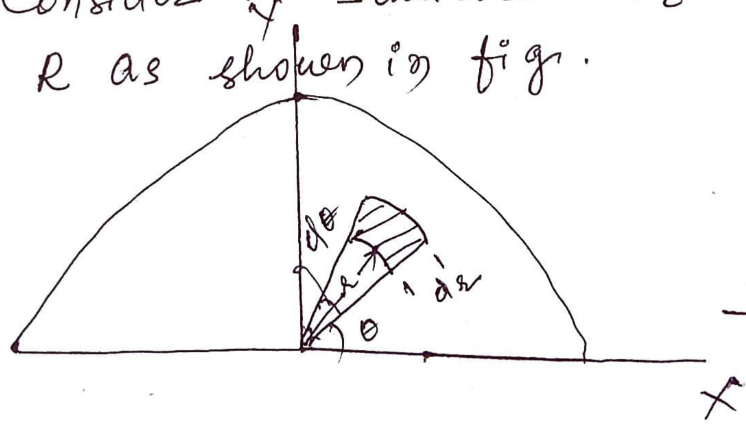
$$= \frac{250000 + 208,325 - 83333.33 - 49087.38}{14463.49}$$

$= 22.532 \text{ mm}$

$$\boxed{\bar{y} = 22.532 \text{ mm.}}$$

5b Position of Centroid of a semi circular lamina of Radius R.

Consider the semicircle of radius R as shown in fig.



02

Due to symmetry centroid must lie on the y-axis. Let its distance from diametral axis by $\bar{y}$. To find $\bar{y}$, consider an element at a dist. r from the centre O of the semicircle, radial width being dr and bound by radii at θ & $(d\theta + \theta)$.

Area of element $= r\, d\theta\, dr$

Its moment about diametral axis x is given by

$r\, d\theta \times dr \times r\sin\theta = r^2 \sin\theta\, d\theta\, dr$.

$\therefore$ Total moment of area about diametral axis

$$\int_0^{\pi}\int_0^{R} r^2 \sin\theta\, dr\, d\theta = \int_0^{\pi} \left[\frac{r^3}{3}\right]_0^R \sin\theta$$

$$= \frac{R^3}{3}\left(-\cos\theta\right)_0^{\pi}$$

$$= \frac{R^3}{3}(1+1)$$

$$= \frac{2R^3}{3}$$

Area of semicircle $= A = \frac{\pi R^2}{2}$

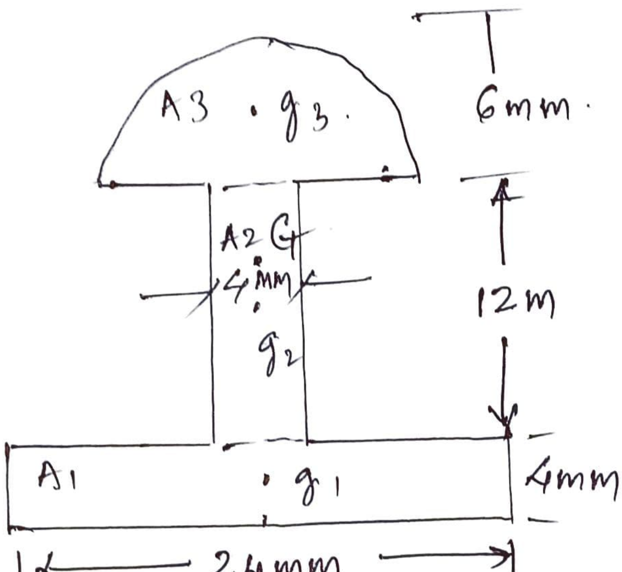
$$\therefore \bar{y} = \frac{\text{Moment of Area}}{\text{Total area}}$$

$$= \frac{\frac{2R^3}{3}}{\frac{\pi R^2}{2}} \Rightarrow \boxed{\bar{y} = \frac{4R}{3\pi}}$$ — 04M

Total 06M

6a) Numerical problem on determination of Moment of Inertia.

Consider the following figure.



Let A_1, A_2 & A_3 be the segmental areas & g_1, g_2 & g_3 be the positions of centroids of A_1 & A_2 & A_3 as shown in figure.

Due to symmetry the centroid lies along y axis. i.e

$$\bar{X} = 0$$

$$\bar{y} = \frac{A_1\bar{y}_1 + A_2\bar{y}_2 + A_3\bar{y}_3}{\Sigma A} \quad \text{—— (1)}$$ → 04M

where $A_1 = 24 \times 4 = 96\ mm^2$

$A_2 = 12 \times 4 = 48\ mm^2$

$A_3 = \pi\, 6^2 = 113.09\ mm^2$ → 01M

$\Rightarrow \Sigma A = 257.09\ mm^2$

(17)

$\bar{y}_1 = 2mm$, $\bar{y}_2 = 10mm$ $\bar{y}_3 = 4 + 12 + \frac{4 \times 6}{3\pi}$

$= 18.546 mm$.

sub in eqn (i)

$$\Rightarrow \bar{y} = \frac{96 \times 2 + 48 \times 10 + 113.09 \times 18.546}{257.09}$$

$= 10.772 mm$.

$\therefore G \equiv (0, 10.772)$ —— 01

$$I_{xx} = \frac{24 \times 4^3}{12} + 24 \times 4 (8.772)^2 + \frac{4 \times 12^3}{12} + 4 \times 12 (0.772)^2 + \frac{\pi (6)^4}{4} + \frac{\pi 6^2}{} (7.774)^2$$

$I_{xx} = 7515 + 604.60 + 7852.92$

$= 15972.52 mm^4$. —— 03

$$I_{yy} = \frac{4(24)^3}{12} + \frac{12(4)^3}{12} + \frac{\pi 6^4}{4}$$

$I_{yy} = 4608 + 64 + 1017.87$

$= 5689.88 mm^4$. —— 03

Total: 12M.

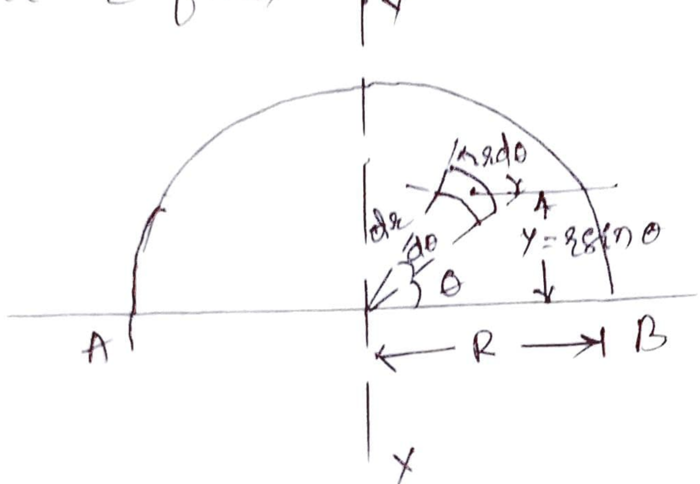
6b) Derivation of expression for MI for semi ck about diametral axis & the axis parallel to diameter.

(18)

Marks

Q.No.

Consider a semicircle of radius R as shown below in fig. Choose differential element of angular width dθ at an angle θ and radial width dr at distance r from the centre. ~~the~~



The area of differential element will be

$dA = r d\theta \cdot dr$

$= r dr \cdot d\theta$

The distance of this element from the diameter AB is

$y = r \sin\theta$ 02

∴ MI of element about AB is

$dI_{AB} = y^2 \cdot dA$

$= (r \sin\theta)^2 \cdot r dr\, d\theta$

$dI_{AB} = r^3 \sin^2\theta\, dr \cdot d\theta$

$\Rightarrow \quad I_{AB} = \int_0^R \left[\int_0^{\pi} \sin^2\theta\, d\theta \right] r^3 dr$

19

$$\Rightarrow = \int_0^R \left[\int_0^\pi \left(\frac{1 - \cos 2\theta}{2} \right) d\theta \right] r^3 dr.$$

$$= \frac{1}{2} \int_0^R \left[\theta - \frac{\sin 2\theta}{2} \right]_0^\pi r^3 dr.$$

$$= \frac{1}{2} \int_0^R \pi r^3 dr$$

$$I_{AB} = \frac{\pi r^4}{8}$$ — 03M

The centroid is at a distance of $\frac{4R}{3\pi}$ from AB

$$I_{AB} = I_G + Ad^2$$

$$\Rightarrow I_G = I_{AB} - Ad^2$$

$$A = \frac{\pi R^2}{2} \text{ and } d = \frac{4R}{3\pi}$$

$$I_G = \frac{\pi R^4}{8} - \frac{\pi R^2}{2} \left(\frac{4R}{3\pi} \right)^2$$

$$= R^4 \left(\frac{\pi}{8} - \frac{8}{9\pi} \right)$$

$$I_G = 0.11 R^4$$

As $R = D/2$ we have — 03M

$$I_G = 0.00686 D^4.$$

Total 08M

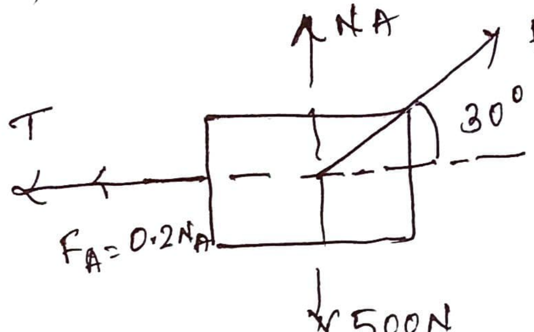
Marks

Q.No.

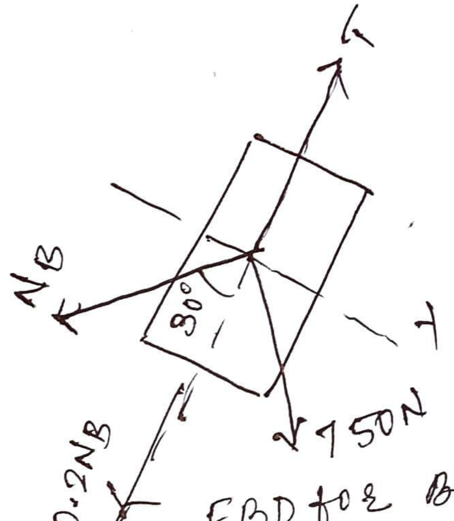
7 a)

Numerical problem on friction.

FBDs for the two blocks are as shown below.



FBD for Block A



FBD for Block B

02 M

Considering FBD for Block B

$\Sigma F_y = 0 \Rightarrow N_B - 750 \sin 30 = 0 \Rightarrow N_B = 375N$

$\Sigma F_x = 0 \Rightarrow T - 0.2 N_B - 750 \cos 30 = 0 \Rightarrow T = 724.52N$

04 M

Considering FBD for Block A

$\Sigma F_y = 0 \Rightarrow N_A + P \sin 30 - 500 = 0 \Rightarrow N_A = 500 - P \sin 30$ — ①

$\Sigma F_x = 0 \Rightarrow P \cos 30 - T - 0.2 N_A = 0 \Rightarrow N_A = \frac{P \cos 30 - T}{0.2}$ — ②

Equating ① & ② solving for P

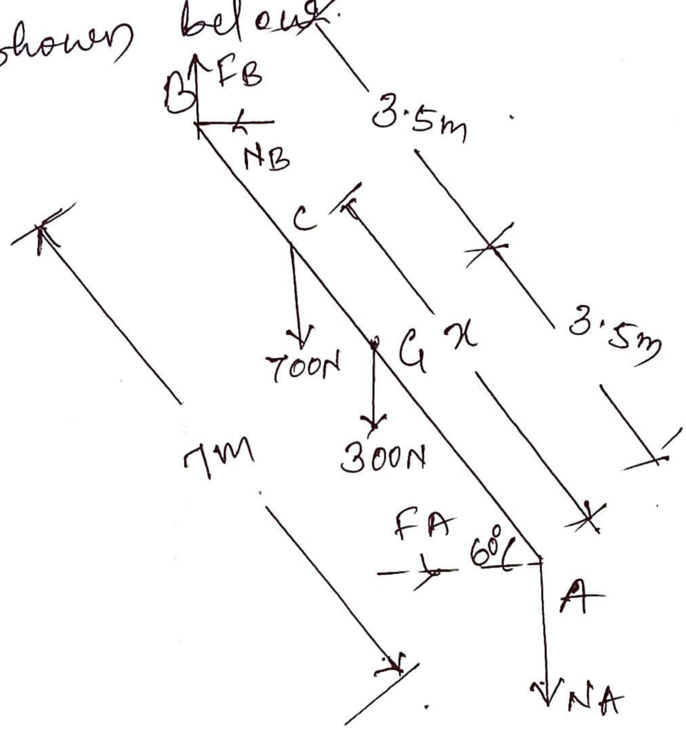
$P = 853.52N$

04

Total 10M

7 b) Numerical problem on friction & application of eqns of equilibrium for coplanar non concurrent forces.

Soln — FBD for the ladder is as shown below.



From friction law

$F_A = 0.25 N_A$

$F_B = 0.25 N_B$ ——— 04

$\Sigma F_y = 0$

$\Rightarrow +N_A + F_B - 300 - 700 = 0$ — (1)

$+N_A + 0.25 N_B - 1000 = 0$

$\Sigma F_x = 0$

$\Rightarrow +F_A - N_B = 0 \Rightarrow F_A = N_B$

$\Rightarrow 0.25 N_A = N_B$ — (2)

From (1) & (2)

$+N_A + 0.25 \times 0.25 N_A - 1000 = 0.$

$\Rightarrow N_A = \frac{1000}{1.06} = 943.39N$

$\Rightarrow N_B = 250N$ from (2). 03

(22)

Marks

Q.No.

Let x be the dist where person induces slipping from A.

$\sum M_A = 0$

$\Rightarrow -250 \times 7 \sin 60 + 62.5 \times 7 \cos 60 - 700 \cos 60 x - 300 \cos 60 \times 3.5 = 0$.

$\Rightarrow x = -5.20$ m

$\Rightarrow \boxed{x = 5.20 m}$ ($\because$ dist cannot be $-ve$) — 03

Total 10M.

8a) Types of friction

i) Static friction: The friction between the two bodies which are in contact with each other at rest is called Static friction — ①

ii) Limiting friction: This is a friction at impending motion of one body over the other. — 1

iii) Dynamic friction: This is a friction developed, when one body moves over the other. Depending on motion we have two types of dynamic friction those are i) Rolling friction ii) ~~Dynam~~ ii) Sliding friction. — 02

Total 04 M

(23)

8 b) Defi^ns of the terms.

i) Angle of friction: The inclination of resultant of normal & frictional force with the normal reacting force is defined as "Angle of friction".

ii) Angle of repose: The maximum inclination of the plane on which the body, free from external forces, can repose is called "angle of repose"

iii) Limiting friction: the maximum value of frictional force, which comes into play when the motion is impending is known as "Limiting friction".

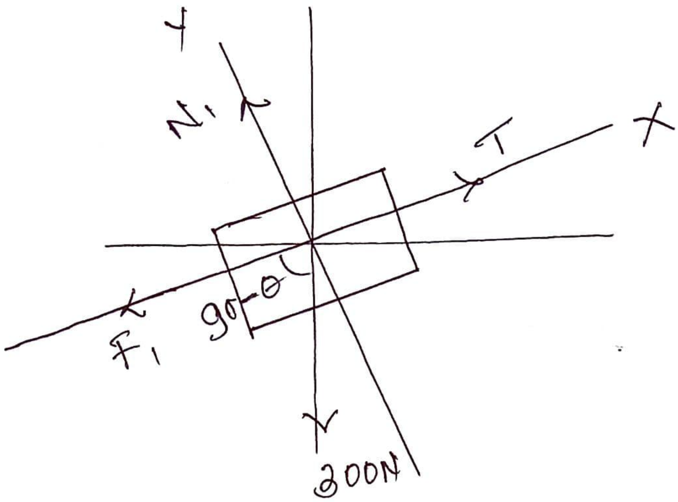
iv) Coefficient of friction: The constant ratio between the frictional force & normal reaction can be defined as "Coefficient of friction". —— 02×04 = 08M.

8 c) Numerical problem on friction.

FBD for the 300N & 900N blocks are as shown below.

(24)

Q.No. | Marks

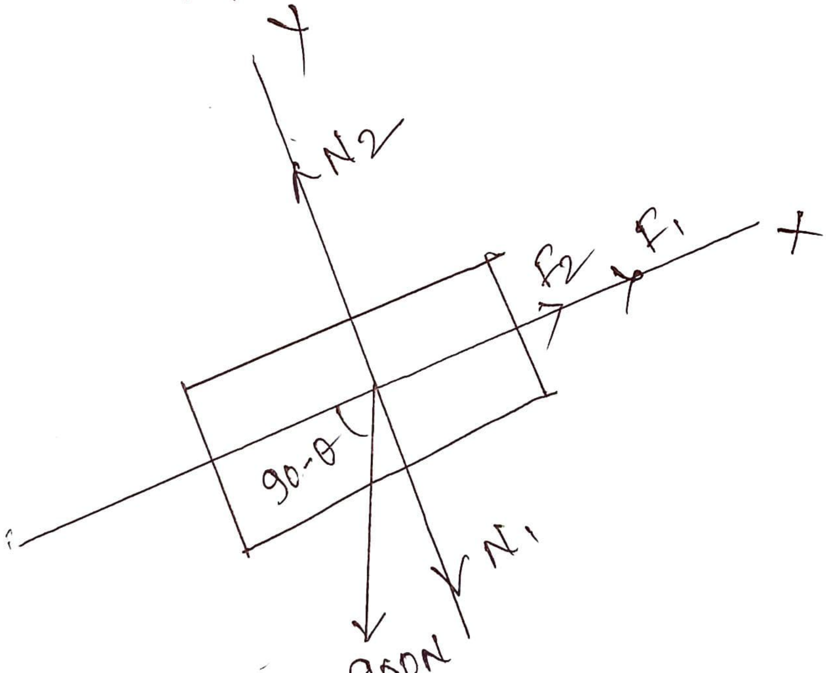


Applying eq^n of equillibrium.

$\Sigma F_y = 0 \Rightarrow N_1 - 300\cos\theta = 0$

$\Rightarrow N_1 = 300\cos\theta$.

Given $\frac{F_1}{N_1} = \frac{1}{3} \Rightarrow F_1 = \frac{300\cos\theta}{3} = 100\cos\theta$ —— 03M



~~Applying~~ eq^n of equillibrium.

$\Sigma F_y = 0 \Rightarrow N_2 - N_1 - 900\cos\theta = 0$.

$N_2 = 1200\cos\theta$

(25)

Given: $\frac{F_2}{N_2} = \frac{1}{3}$

$\Rightarrow F_2 = \frac{1200 \cos\theta}{3} = 400\cos\theta.$ 03

$\Sigma F_x = 0$

$\Rightarrow F_1 + F_2 = 900 \sin\theta.$

$100\cos\theta + 400\cos\theta = 900\sin\theta.$

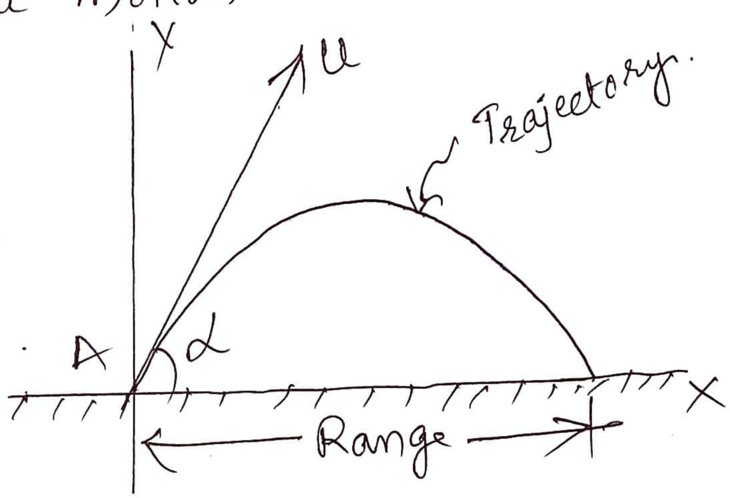
$500\cos\theta = 900\sin\theta$

$\Rightarrow \tan\theta = \frac{500}{900}$ 02

$\Rightarrow \theta = 29.05°.$

Total 08M.

9 a) Projectile motion.



v) Projectile:

Freely projected particles in the air which are having the combined effect of a vertical & horizontal motion are called projectiles.

i) Range or horizontal range: The horizontal distance through which the projectile travels in its flight is called the horizontal range or simply "Range".

ii) Time of flight: The time interval during which the projectile is in motion is called time of flight.

iii) Maximum height: It is the maximum height reached by the particle when it is projected freely in air.

iv) Angle of projection: This is the angle between the direction of projection & horizontal direction. —— $02 \times 05 = 10M$.

9b) Numerical problem on rectilinear motion.

Sol: Let x be the depth of well.

Then displacement of stone $= S = -x$

-ve sign is for downward displacement

$a = -g = -9.81\ m/sec^2$, $t =$ time &

$u = 0$ for the stone.

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

$$-x = 0 + \frac{1}{2}(-9.81)t^2$$

$$\Rightarrow x = 4.905t^2$$ —— 04

As total time is 4 second for stone to reach the water surface and sound to come up, the time for sound will be 4-t.

Using distance = x = Velocity × time

$$x = 330 \times (4-t)$$

$$x = 1320 - 330t$$

$$\Rightarrow 4.905t^2 = 1320 - 330t$$

$$\Rightarrow 4.905t^2 - 330t - 1320 = 0 \quad \text{—(1)}$$ 04

Solving the quadratic eqⁿ (1) we have

$t = 3.78685$ or $t = 71.065$ sec.

Time for stone can not be greater than 4.

$\therefore t = 3.7868$ sec.

$$\therefore \Rightarrow x = 4.905(3.7868)^2$$

$$x = 70.34\,m$$

02

10 a Numerical problem on rectilinear motion.

Total 10M

Given:

Initial velocity of burglar's car = $u = 0$.

Acceleration of " " = $a = 2\,m/sec^2$

Uniform velocity of van = 20 m/sec

Let t = Time taken by police van to overtake burglar's car. 02

(28)

As the police party came after 5 seconds hence the burglar's car will be in motion for $(t+5)$ secs.

When the police party will overtake the burglar's car, then the distance travelled by police van (say s') & dist travelled by ~~poli~~ burglar car (say s) will be same. — 02

$\therefore$ s' = Uniform velocity × time. — (1) — 02

$s' = 20 \times t$

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

$s = 0(t+5) + \frac{1}{2} \times 2(t+5)^2$

$s = (t+5)^2$ — (2)

$s = t^2 + 25 + 10t$ — 02

Equating (1) & (2)

$20t = t^2 + 25 + 10t$

$t^2 - 10t + 25 = 0$

$\Rightarrow (t-5)^2 = 0$ — 02

$\Rightarrow t = 5$ secs.

Total 10M.

(29)

10b) Numerical problem on projectiles.

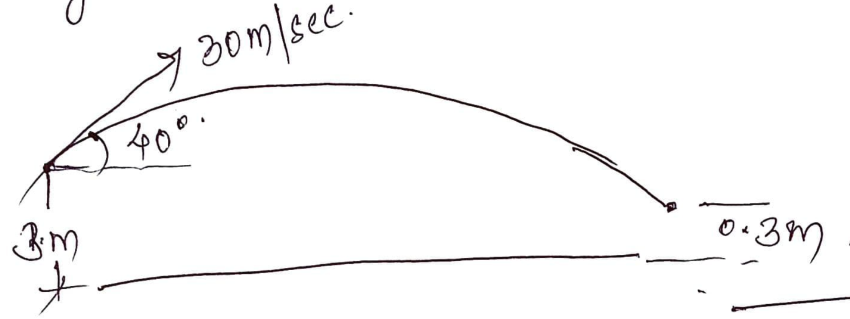
Soln Given.

Height of the ball from ground when it is thrown = 3m

Angle of projection = 40°.

velocity of ball = 30m/sec.

height of wicket from gr = 0.3m



03

The equation of path is.

$$y = x\tan\alpha - \frac{gx^2}{2u^2\cos^2\alpha} \quad \text{--- (1)}$$ 02

here $y = -3+0.3 = -2.7m.$, $x = ?$.

$g = 9.81$ $\alpha = 40°$ $u = 30m/sec$.

from (1)

$$-2.7 = x\tan 40 - \frac{9.81x^2}{2\times 40^2\cos^2 40}.$$

$$\frac{9.81x^2}{2\times 40^2\cos^2 40} - x\tan 40 - 2.7 = 0.$$

$5.224\times 10^{-3}x^2 - 0.839x - 2.7 = 0$ --- (2) 03

(2) is a quadratic eqn

(30)

in which

$a = 5.224 \times 10^{-3}$

$b = -0.839$

$c = -2.7$

We have

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$= \frac{-(-0.839) \pm \sqrt{(-0.839)^2 - 4 \times 5.224 \times 10^{-3} \times (-2.7)}}{2 \times 5.224 \times 10^{-3}}$$

$$= \frac{0.839 \pm \sqrt{0.704 + 0.056}}{0.010}$$

$$= \frac{0.839 \pm 0.8718}{0.010}$$

$\Rightarrow x = 171.08\,m$ or $x = -3.28\,m$.

x can not be negative

$\therefore x = 171.08\,m$. — 02

Total 10M.

Q.No.1a) ii) Moment of force & Couple.

* Moment of force:

The rotational effect of force can be defined as moment of force & also it can be defined as the product of magnitude of force & the perpendicular distance betn the point in the plane about

(31)

which the moment of force has to be Calculated, ~~is called~~ & the the line of action of force.

The point about which the moment of force has to be Calculated is called "moment Centre" & the ⊥er distance between the moment centre & the line of action of force is called the "moment arm". — 02M

* Couple:

Two parallel forces which are equal in ~~in~~ magnitude & opposite in direction are said to form "Couple".

Charactoristics of Couple:

i) Couple consists of two parallel forces which are equal in magnitude & opposite in direction.

ii) The moment of Couple about any point in the plane is same & is equal to the product of one of the parallel force & the ⊥er distance between the two // forces.

iii) The translatory effect of Couple on the body is nill or zero. — 02M

Total 04M

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