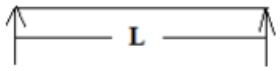
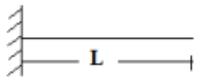
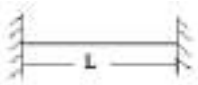
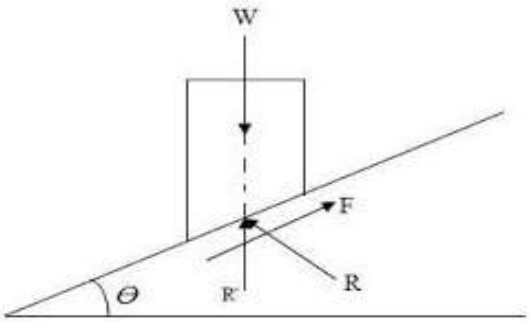
Subject Name: Applied Mechanics **Subject Code: 22203**

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.
8) As per the policy decision of Maharashtra State Government, teaching in English/Marathi and Bilingual (English + Marathi) medium is introduced at first year of AICTE diploma Programme from academic year 2021-2022. Hence if the students write answers in Marathi or bilingual language (English +Marathi), the Examiner shall consider the same and assess the answer based on matching of concepts with model answer.

Q No	Sub Q. No	Answer	Marking Scheme
1	a	**State the SI unit of force and momentum.** • SI Unit of Force: **N (Newton)** • SI Unit of Momentum: **kg m/s**	1 mark for each correct unit
1	b	**What is law of machine.** Law of Machine: - The relation between load lifted and effort applied is called the law of machine. Mathematically, P = mW + C Where P – effort applied, W – load lifted, m – slope, C - Constant	1 1
1	c	**Define funicular polygon.** The polygon is so constructed by drawing the lines in the respective spaces of space diagram; parallel to the rays of polar diagram by maintaining the order is called as 'funicular polygon.'	2
1	d	**Write the condition of equilibrium for non-concurrent coplanar force system.** 1. Sum of all the horizontal forces is equal to zero i.e. $\sum F_X = 0$ 2. Sum of all the vertical forces is equal to zero i.e. $\sum F_Y = 0$ 3. Sum of the moments of all the forces about any point is equal to zero i.e. $\sum M_A = 0$	2 Marks for all three conditions
1	e	**State two types of beam with diagram of each.** Following are the different types of beams :	

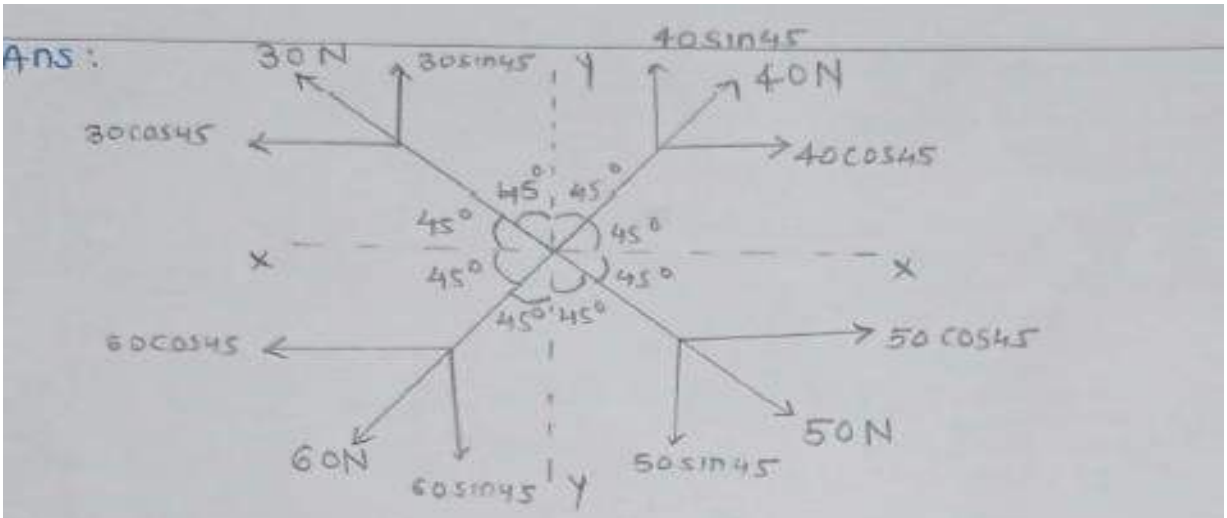
		(i) Simply supported beam  (ii) Cantilever beam  (iii)Over hanging beam  (iv)Fixed Beam  (v) Continuous beam  	1 1 (any two: 1 for each)
1	f	**What do you mean by friction?** Friction is defined as the resistance offered by the surfaces that are in contact when one or both the surfaces move relative to each other.	2
1	g	**Define Centre of gravity. How does it differ from centroid?** Centre of gravity is the point where the mass of the body or whole weight is concentrated. Centroid is defined as the point at which entire area of plane figures is supposed to be act irrespective of the position of plane figure. Centre of gravity can be calculated for 3 dimensional figures and Centroid can be calculated for 2 dimensional figures.	1 1
2	a	Sate any two properties and effects of force. **Properties of forces:** **Magnitude:T**he force of 25N or 3 kN means 25N or 3kN gives the quantity of a force is known as its magnitude. **Sense or nature:**Generally, the sense is indicated by an arrow head from which sense like pull or push can easily be understood. **Direction:**The line of action along which force acts is called as direction. **Point of application:**The point at which the force acts is known as point of application. **A force may produce** the following **effects on a body**, on which it acts: (a) It may accelerate and retard the motion of body (b) It may change the state of rest or motion of body. (c) It may change the shape and size of body. (d) It may turn or rotate the body. (e) It may keep the body in equilibrium	2 (any two: 1 for each) 2 (any two: 1 for each)

2	b	**Certain machine has a law of machine P= 0.025W + 20 N with V.R. = 50. Calculate the efficiency at a load of 1KN.** Given Data: Law of Machine - P= 0.025W + 20 N, V.R. = 50, W = 1KN = 1000N At W = 1kN =1000N, i. e. P = 0.025 X 1000 + 20 = 45N Efficiency is given by…… $\eta = \frac{MA}{VR} \times 100$ $\eta = \frac{W/P}{VR} \times 100$ $\eta = \frac{1000/45}{50} \times 100$ $\eta = 44.44\%$	1 1 1 1
2	c	**Define effort lost in friction and load lost in friction. Give expression for them.** Effort lost in friction: It is the additional effort required to overcome the friction. Effort lost in friction is given by $P_f = P - P_i$ Where, P = Effort & P_i = W/VR = Ideal effort, VR = Velocity Ratio **OR** $Effort\ lost\ in\ friction = Pf = P - \frac{W}{VR}$ Load Lost in friction: It is the additional load that might have been lifted by machine for given effort when there would have no friction. Load lost in friction is given by… $W_f = W_i - W$ Where, W = Load & W_i = P x VR = Ideal load **OR** $Load\ lost\ in\ friction = Wf = P \times VR - W$	1 1 1 1 1
2	d	**Define angle of repose with diagram.** Angle of repose is defined as the angle made by the inclined plane with the horizontal plane at which the body placed on an inclined plane is just on the point of moving down the plane, under the action of its own weight.  θ :- is angle of repose	2 2

Attempt any THREE of the following.

3 a Find magnitude and direction of resultant force, If 30N, 40N, 50N and 60N, forces are acting the line joining the centre of square of its Vertices as shown in fig no. 1.

Ans:



1) Resolving all forces

$\Sigma F_x = +40\cos45 + 50\cos45 - 60\cos45 - 30\cos45$

$= 0\ N$ 1

$\Sigma F_y = +40\sin45 - 50\sin45 - 60\sin45 + 30\sin45$

$= -28.28\ N$ 1

2) Magnitude of Resultant

$R = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}$

$= \sqrt{0^2 + (-28.28)^2}$

$R = 28.28\ N$ 1

		3) Direction of Resultant $\theta = \tan^{-1}\left(\frac{\Sigma F_y}{\Sigma F_x}\right)$ $= \tan^{-1}\left(\frac{28.28}{0}\right)$ $= \tan^{-1}(\infty)$ $\theta = 90^\circ$ 4) As, $F_x = 0N$, $F_y = -ve$, Resultant is on Y-axis (-ve) lies **Note: : If problem is solved by using another concept or method with correct answers give full marks**	1
3	b	State any Four properties of couple. Following are the properties of couple. 1. The algebric sum of the forces consisting the couple is zero. 2. The algebric sum of the moment of the forces constituting the couple about any point is the same and equal to the moment of the couple itself. 3. A couple cannot be balanced by a single force but can be balanced only by a couple but of opposite sense. 4. Any number of coplanar couples can be reduced to a single couple whose magnitude will be equal to the algebric sum of the moments of all the couples.	1 1 1 1

3	c	**For three sheave pulley block an effort of 40 N can lift a load of 180 N. Calculate the effort lost in friction and load lost in friction along with efficiency.** **Given: P= 40 N, W = 180 N** **For three sheave pulley block VR = 2 X Number of sheave = 2x 3 = 6** M. A. = W/P = 180/40 = 4.5 Efficiency is given by…… $\eta = \frac{MA}{VR} \times 100$ **Hence ή = (4.5 / 6) x 100 = 75%** Effort lost in friction is given by… $P_f = P - P_i$ Where, P = 40 N, & P_i = W/VR = Ideal effort = 180/6 = 30 N **P_f = 40 – 30 = 10 N** Load lost in friction is given by… $W_f = W_i - W$ Where, W=180 N & W_i = P x VR = Ideal load = 40 x 6 = 240N **W_f = 240 – 180 = 60 N**	1 1 1 1
3	d	**In a lifting machine an effort of 110 N raised a load of 1100 N and an effort 500 N raised a load of 5800 N. Find the law of machine.** Given**:Reading 1:** P_1= 110 N, W_1 = 1100 N and **Reading 2:** P_2 = 500 N , W_2 = 5800 N Find :Law of Machine i. e. P = mW + C….Values of slope (m) & C in this equation. We know that Law of Machine is given by P = mW + C Preparing two equations for readings… 110 = m x 1100 + C…….(1) 500 = m x 5800 + C…….(2) By subtracting Eq (1) from (2) we get…..390 = 4700 m Hence …..**m = 0.083** Put this in equation (1) 110 = 0.083 x 1100 + C hence **C = 110 – 91.3 = 18.7 N** **Hence** Law of Machine is **P = 0.083W + 18.7 N**	1 1 1 1
4		**Attempt any THREE of the following**	12

4 a

a) Find analytically the resultant of coplaner concurrent force system as shown in Fig. no. 2. Also locate its position on figure.

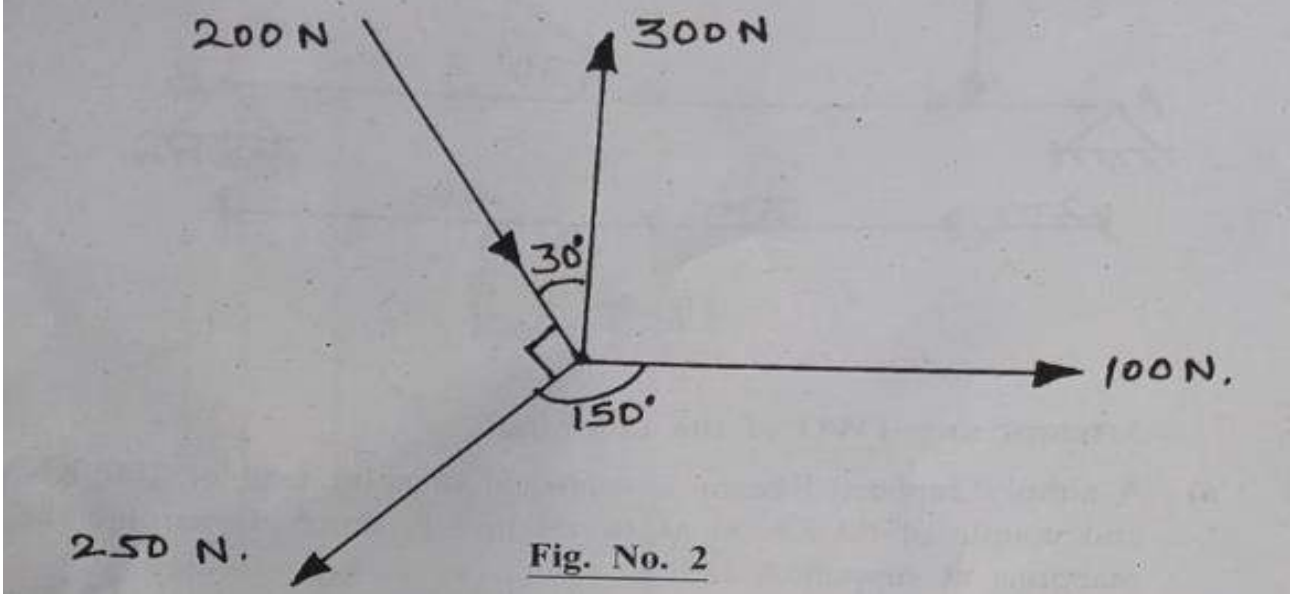
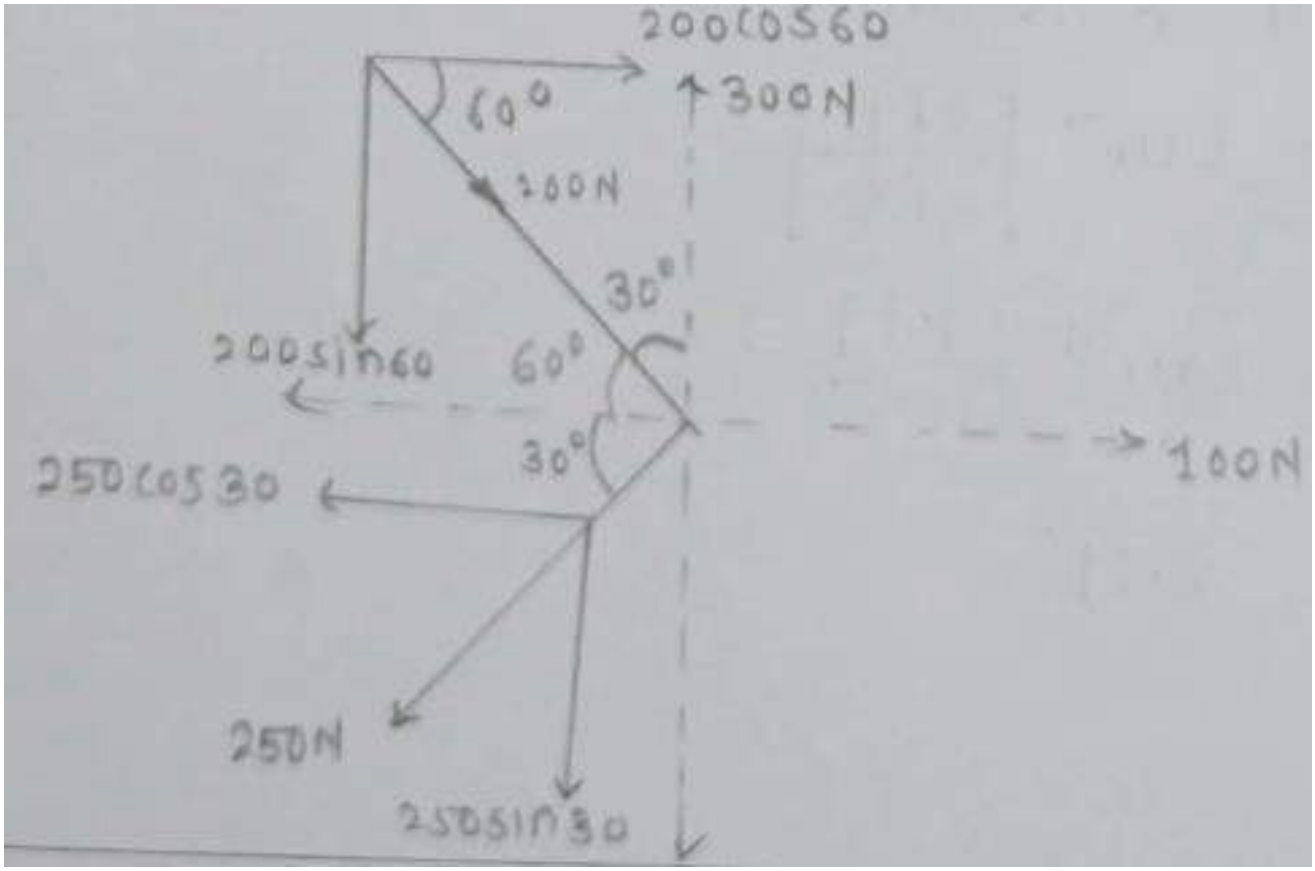


Fig. No. 2

Solution:



1) Resolving all forces

$\Sigma F_x = +100 + 200\cos 60 - 250\cos 30$

$= 16.50\ N$ — 1

$\Sigma F_y = +300 - 200\sin 60 - 250\sin 30$

$= 1.79\ N$ — 1

2) Magnitude of Resultant

$R = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}$

$= \sqrt{(16.50)^2 + (1.79)^2}$

$R = 16.59\ N$ — 1

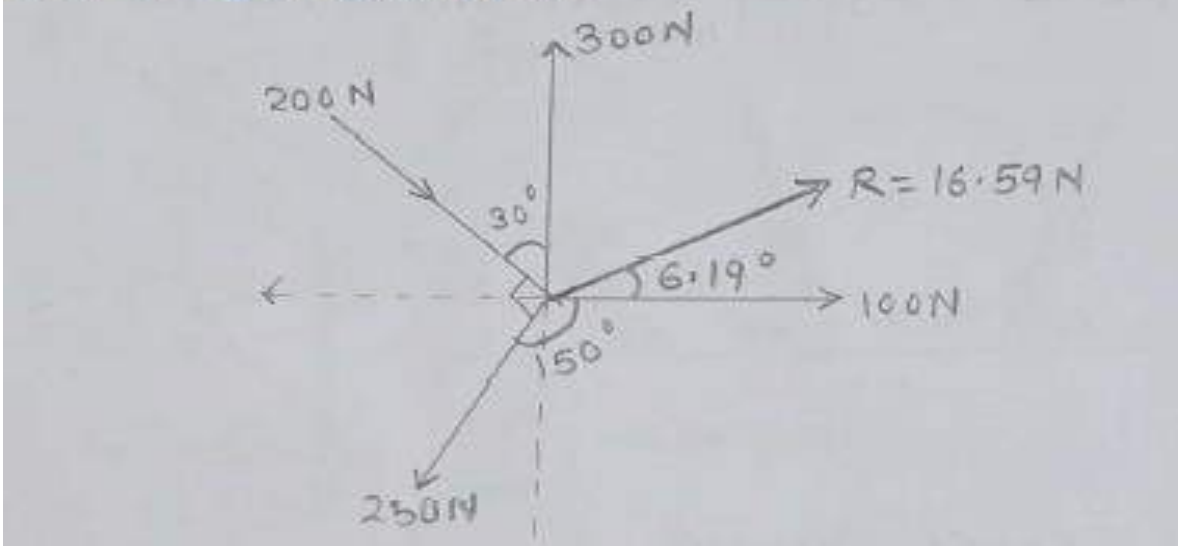
3) Direction of Resultant

$\theta = \tan^{-1}\left|\frac{\Sigma F_y}{\Sigma F_x}\right|$

$= \tan^{-1}\left(\frac{1.79}{16.50}\right)$

$\theta = 6.19°$ — ½

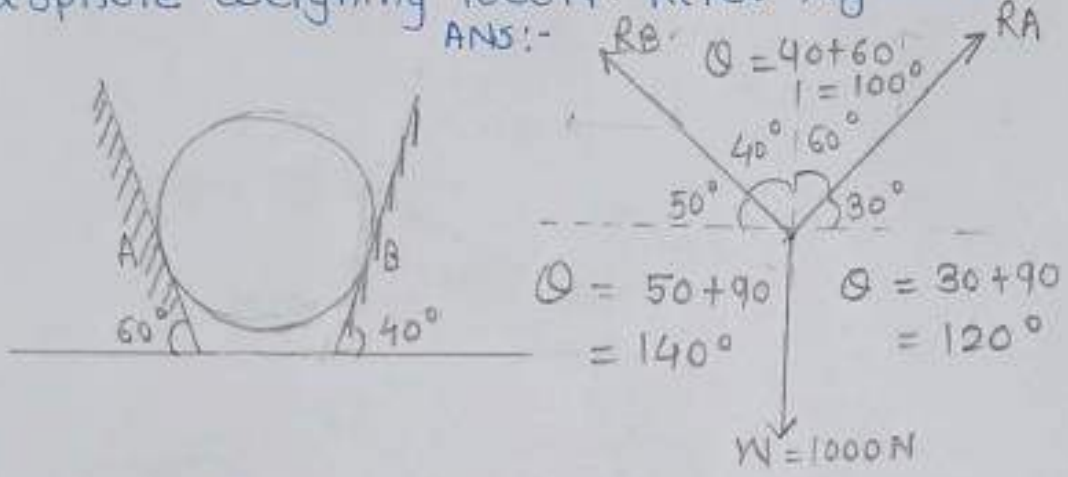
As ΣF_x is +ve and ΣF_y is +ve, Resultant lies in Ist Quadrant.



½

4	b	Find the reactions offered by two surfaces of a sphere weighing 1000 N. Refer Fig No. 3.	

ANS:-



1

Using Lami's Theorem,

$$\frac{1000}{\sin 100} = \frac{R_A}{\sin 140} = \frac{R_B}{\sin 120}$$

(1) (2) (3)

1

Using term (1) and (2)

$$\frac{1000}{\sin 100} = \frac{R_A}{\sin 140}$$

$$R_A = 1000 \times \frac{\sin 140}{\sin 100}$$

$$R_A = 652.70\ N$$

1

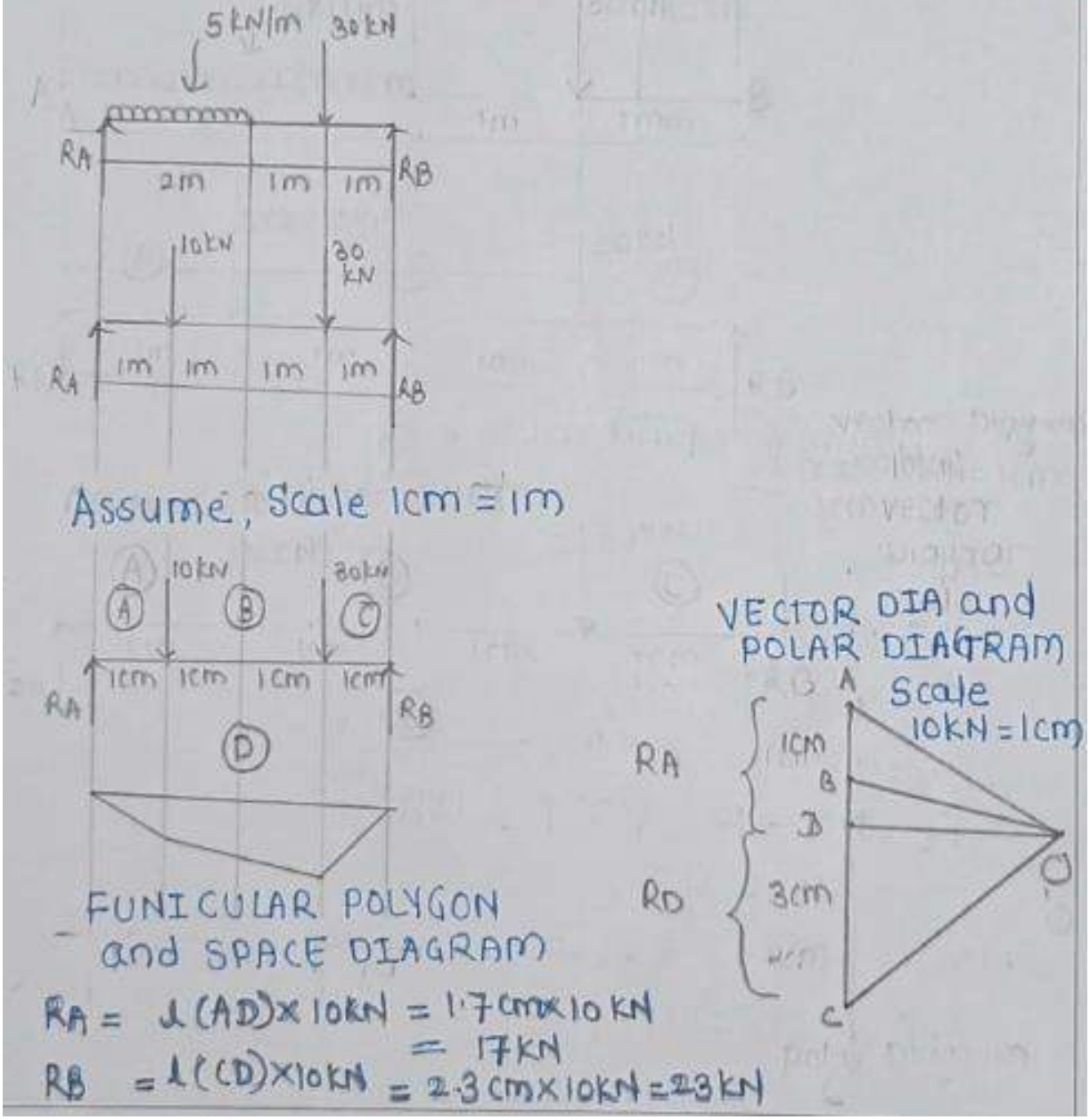
Using term (1) and (3),

$$\frac{1000}{\sin 100} = \frac{R_B}{\sin 120}$$

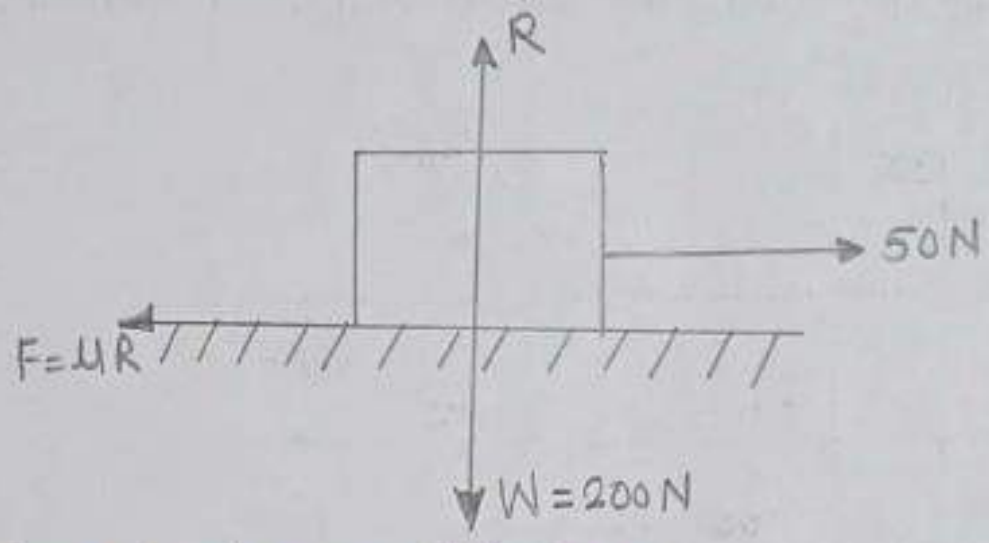
$$R_B = 1000 \times \frac{\sin 120}{\sin 100}$$

$$R_B = 879.38\ N$$

1

4	c	A simply supported beam of 4m span is loaded with an UDL of 5kN/m for 2m from left end and a point load of 30kN at 1m from right end. Find support reactions using graphical method.  **Note: If the answers are R_B= 25 kN & R_A = 15 kN with + OR – 3 kN Give marks**	1 2 1

4	d	A parcel weighing 200N is just on the point of moving horizontally by a horizontal force of 50N. What is the coefficient of friction.	



1

For limiting equilibrium,

(↑+ve, ↓-ve)

1

$\Sigma F_y = 0$

$+R_B - W = 0$

$R_B = 200N$ —(i)

1

$\Sigma F_x = 0$ ($\rightarrow$ +ve, $\leftarrow$ -ve)

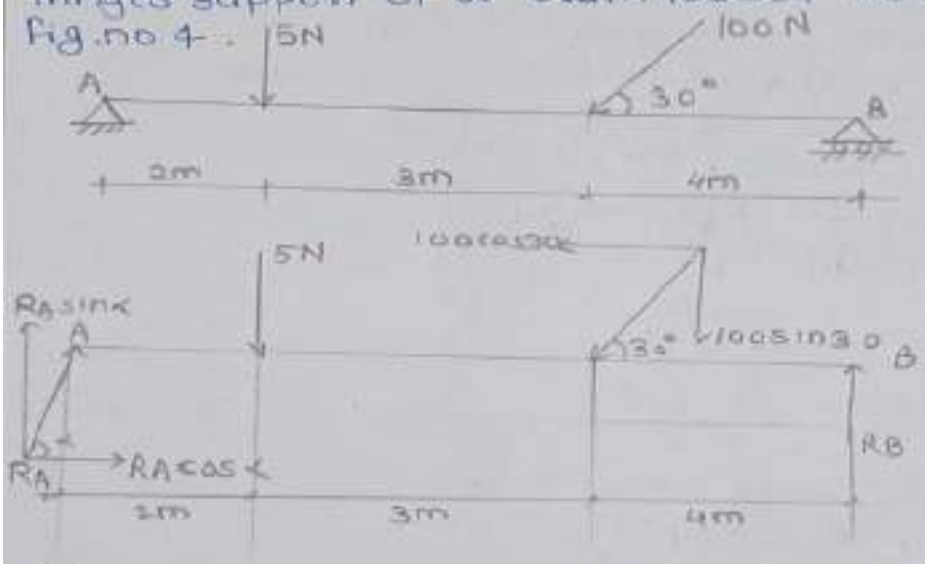
$\Sigma F_x = 50 - F$ ($\because F = \mu R$)

$0 = 50 - \mu R$

From eqn (i) $R = 200N$

$\therefore 0 = 50 - \mu(200)$

i.e. μ = 50/200 = 0.25 **……..Hence Coefficient of friction (μ) = 0.25** 1

4	e	Find analytically the reactions at roller and hinges support of a beam loaded as shown in fig. no 4.  $\Sigma MA = 0$ $0 = +(5\times2) + (100\sin30)(5) - RB\times9$ $= 10 + 250 - RB\times9$ $RB = 28.88\ N \longrightarrow (i)$	1
		$\Sigma Fx = 0$ $= RA\cos\alpha - 100\cos30$ $0 = RA\cos\alpha - 100\cos30$ $RA\cos\alpha = 86.60\ N \longrightarrow (ii)$	½
		$\Sigma Fy = 0$ $= RA\sin\alpha - 5 - 100\sin30 + RB$ $0 = RA\sin\alpha - 55 + RB$ from eqn (i) $RB = 28.88\ N$ $= RA\sin\alpha - 55 + 28.88$ $RA\sin\alpha = 26.12\ N \longrightarrow (iii)$	½
		Divide eqn (iii) by (ii) $\frac{RA\sin\alpha}{RA\cos\alpha} = \frac{26.12}{86.60}$ $\tan\alpha = 0.3016$ $\alpha = 16.78°$ Putting $\alpha = 16.78$ in eqn (ii) $RA\cos(16.78) = 86.60$ $RA = 90.45\ N$	1

			1
5		**Attempt any TWO of the following:**	**12**
	a	**A simply supported beam is subjected to a point load of 100 KN and couple of 50 KN.m as shown in figure no. 5. Determine the reactions at support A and B.**	

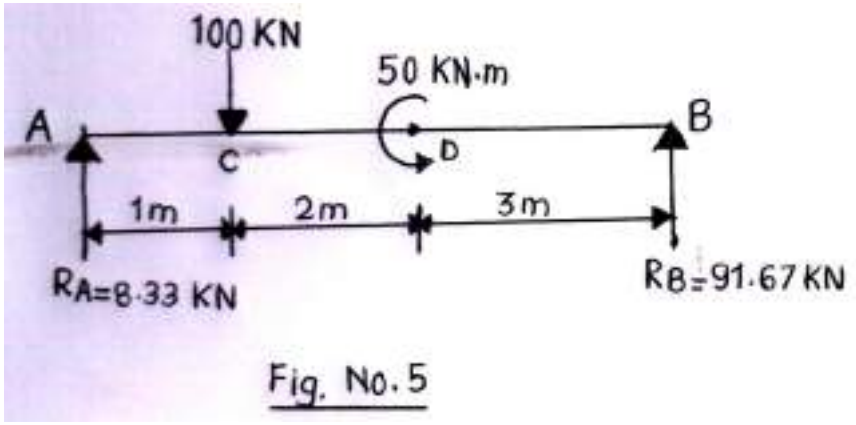


Fig. No. 5

Given: Simply Supported Beam as shown in Fig. no. 5

Find: $R_A = ?;\ R_B = ?$

Solution: Applying equlibrium conditions,

$\sum F_y = 0 \ (\uparrow +ve, \downarrow -ve)$

$+R_A + R_B - 100 = 0$

$R_A + R_B = 100$ kN ----------(Equ.1) **2**

$\sum M_A = 0$

$+(100 \times 1) - 50 - (R_B \times 6) = 0$

$+50 = +6R_B$

$\therefore R_B = \frac{50}{6}$ **2**

$\boxed{R_B = 8.33\,kN\ (\uparrow)}$

Putting value of R_B in equation 1

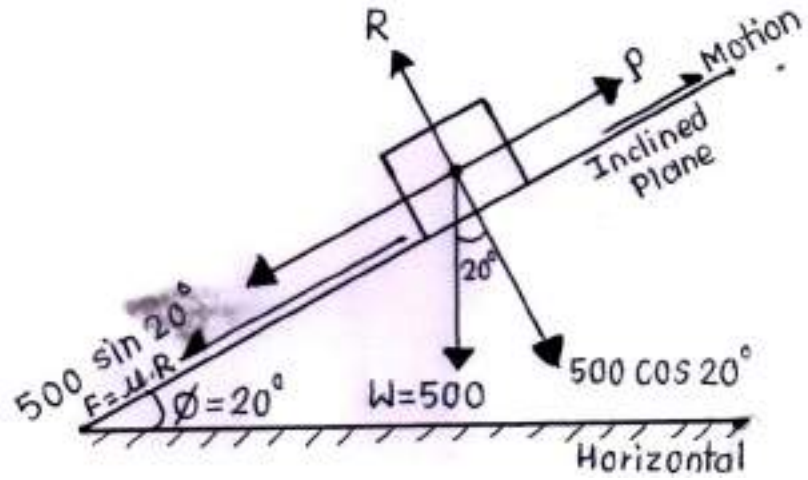
$R_A + R_B = 100$

$R_A + 8.33 = 100$

$R_A = 100 - 8.33$

$\boxed{R_A = 91.67\,kN\ (\uparrow)}$ **2**

5	b	**A block of weight 500 N is placed on a inclined plane at an angle of 20^0 with horizontal. If coefficient of friction is 0.15. Find the force P applied parallel to the plane, just to move the body up the plane.**	.



Given: Weight of block W=500 N, Angle of inclined plane=20^0 with horizontal, μ=0.15

Find: Force required to just move up the plane, P=?

Solution: By considering inclined plane as horizontal plane,

Apply $\sum Fy = 0, \uparrow +ve, \downarrow -ve$ **1**

$+R - 500 \cos 20^0 = 0$

$+R - 469.84 = 0$

$\boxed{R = 469.84 \text{ N}}$

Apply $\sum Fx = 0, \rightarrow +ve, \leftarrow -ve$ **1**

$+P - F - 500 \sin 20^0 = 0$

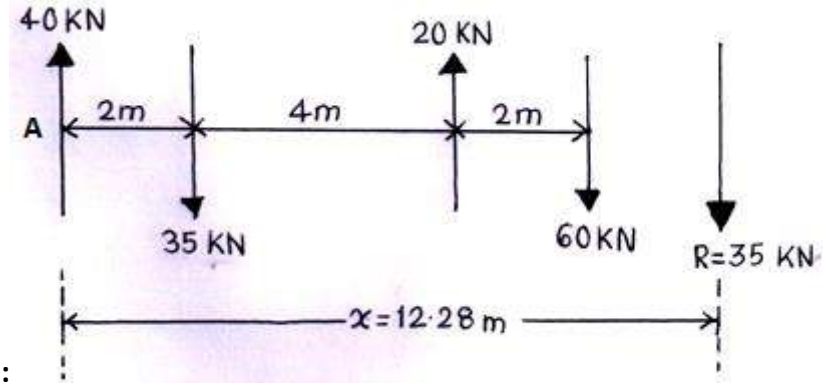
$+P - \mu R - 500 \sin 20^0 = 0$

$+P - 0.15 \times 469.84 - 500 \sin 20^0 = 0$ **2**

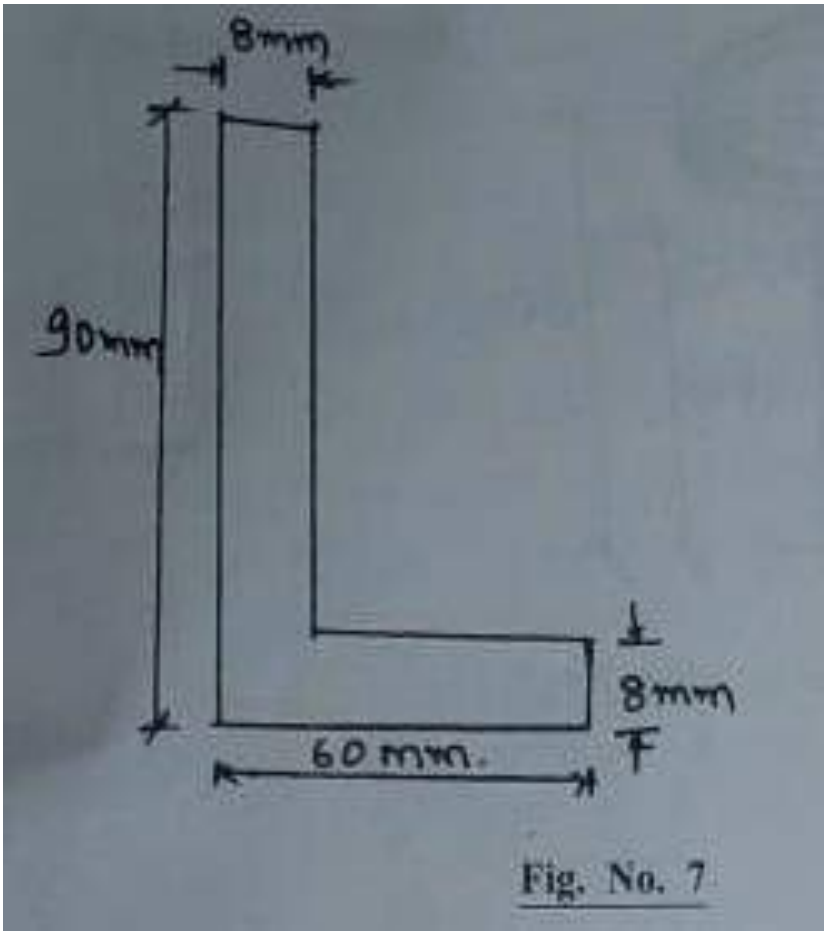
$+P - 241.48 = 0$

$\boxed{P = 241.48 \text{ N}}$ **1**

5 c **Locate the resultant with magnitude and direction for the force system shown in fig. no. 6 w.r.t. pt. A.** **1**



Solution: **Figure no. 6**

		$R = \sum Fy = 0, \uparrow +ve, \downarrow -ve$ $R = +40 - 35 + 20 - 60$ $\boxed{R = -35\ KN(\downarrow)}$	1
		Let, x be the distance of R from 40 N force. Applying Varignon's theorem of moment about point 'A' $-(35\times2) - (20\times6) - (60\times8) = (R\times x)$ $+430 = (35\times x)$ $x = (430/35)$ $\boxed{x = 12.28\ m}$ $\boxed{R = 35\ N \text{ lies at } 12.28\ cm \text{ from } 40\ N \text{ force vertically downward.}}$	1 1 1 1
6		**Attempt any TWO of the following:**	12
	a	**Find centroid for ISA 90x60x8 mm (L section) as shown in fig. no. 7.**  Fig. No. 7	

Given: ISA 90 ×60 ×8 mm as shown in Fig. no. 7

Find: Position of centroid, G $(\bar{x}, \bar{y}) = ?$

Solution: To find $\bar{x}, \bar{y}$ of given section,

Calculation of areas :

$A_1 = L \times B = 60 \times 8 = 480\,mm^2$

$A_2 = L \times B = 82 \times 8 = 656\,mm^2$ **1**

Calculation of horizontal distances of centroids from Y-axis :

$x_1 = \frac{L}{2} = \frac{60}{2} = 30$ mm

$x_2 = \frac{B}{2} = \frac{8}{2} = 4$ mm **1**

Calculation of vertical distances of centroids from X-axis :

$y_1 = \frac{B}{2} = \frac{8}{2} = 4\,mm$

$y_2 = 8 + \frac{L}{2} = 8 + \frac{82}{2} = 49\,mm$ **1**

Calculation of $\bar{x}$:

$$\bar{x} = \frac{(A_1 \times x_1) + (A_2 \times x_2)}{A_1 + A_2} = \frac{(480 \times 30) + (656 \times 4)}{480 + 656} = \boxed{\bar{x} = 14.98 \text{ mm}}$$ **1**

Calculation of $\bar{y}$:

$$\bar{y} = \frac{(A_1 \times y_1) + (A_2 \times y_2)}{A_1 + A_2} = \frac{(480 \times 4) + (656 \times 49)}{480 + 656} = \boxed{\bar{y} = 29.98 \text{ mm}}$$ **1**

Note: Figure No. 7 with location of centroid is given below

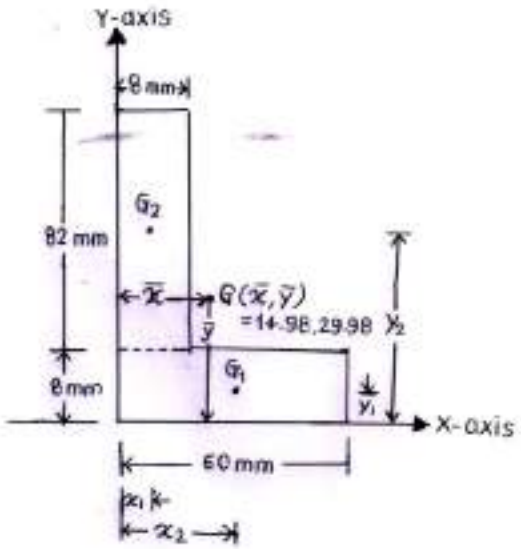


Fig. No. 7 **1**

6	b	**Locate the position of centroid for the lamina shown in fig. no. 8**	

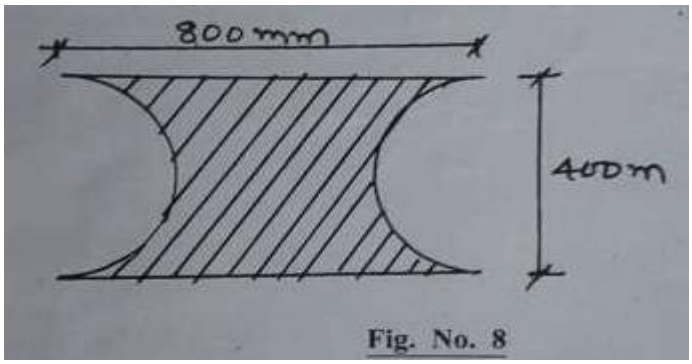


Fig. No. 8

Given: Lamina as shown in Fig. no. 8

Find: Centroid, G $(\bar{x}, \bar{y}) = ?$

Solution: Calculation of areas:

$A_1 = L \times B = = 800 \times 400 = 320000\,mm^2$

$A_2 = \frac{\pi}{8} \times d^2 = \frac{\pi}{8} \times 400^2 = 62831.85\,mm^2$

$A_3 = \frac{\pi}{8} \times d^2 = \frac{\pi}{8} \times 400^2 = 62831.85\,mm^2$ 1

Calculation of distances of centroids from y-axis.

$x_1 = \frac{L}{2} = \frac{800}{2} = 400\,mm$

$x_2 = \frac{4.R}{3.\pi} = \frac{4 \times 200}{3 \times \pi} = 84.88\,mm$ 1

$x_2 = 800 - \frac{4.R}{3.\pi} = 800 - \frac{4 \times 200}{3 \times \pi} = 715.12\,mm$

$\bar{x} = \frac{(A_1 \times x_1) - (A_2 \times x_2) - (A_3 \times x_3)}{A_1 - A_2 - A_3} = \frac{(320000 \times 400) - (62831.85 \times 84.88) - (62831.85 \times 84.88)}{320000 - 62831.85 - 62831.85}$ 1

$\boxed{\bar{x} = 400\,mm}$

Calculation of distances of centroids from x-axis.

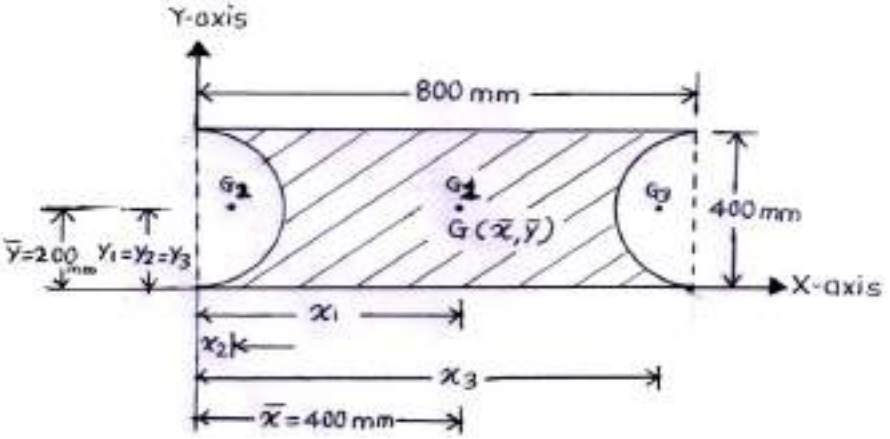
$y_1 = \frac{B}{2} = \frac{400}{2} = 200\,mm$

$y_2 = \frac{D}{2} = \frac{400}{2} = 200\,mm$

$y_3 = \frac{D}{2} = \frac{400}{2} = 200\,mm$ 1

$\bar{y} = \frac{(A_1 \times y_1) - (A_2 \times y_2) - (A_3 \times y_3)}{A_1 - A_2 - A_3} = \frac{(320000 \times 200) - (62831.85 \times 200) - (62831.85 \times 200)}{320000 - 62831.85 - 62831.85}$

$\boxed{\bar{y} = 200\,mm}$ 1



1

OR

Alternative solution: As the figure is symmetrical about X-X & Y-Y axes

$\boxed{\bar{x} = 400\,\text{mm}}$ **and** $\boxed{\bar{y} = 200\,\text{mm}}$

6

Note: Above figure with location of centroid is given.

6 c Find the y of the composite body given in Fig. no. 9. .

Given: Composite body as shown in Fig. no. 9

Find: $\bar{y} = ?$

Solution: To find $\bar{y}$ of given section,

Calculation of volumes :

$V_1 = \pi \times r^2 \times h = \pi \times 1^2 \times 6 = 18.85\,\text{cm}^2$ **1**

$V_2 = \pi \times r^2 \times h = \pi \times 2.5^2 \times 2 = 39.27\,\text{cm}^2$ **1**

Calculation of vertical distances of centroids from X-axis :

$y_1 = \frac{B}{2} = \frac{6}{2} = 3\,\text{cm}$ **1**

$y_2 = 6 + \frac{2}{2} = 6 + \frac{2}{2} = 7\,\text{cm}$ **1**

Calculation of $\bar{y}$:

$$\bar{y} = \frac{(V_1 \times y_1) + (V_2 \times y_2)}{V_1 + V_2} = \frac{(18.85 \times 3) + (39.27 \times 7)}{18.85 + 39.27}$$

$\boxed{\bar{y} = 5.702\ \text{mm}}$ **2**

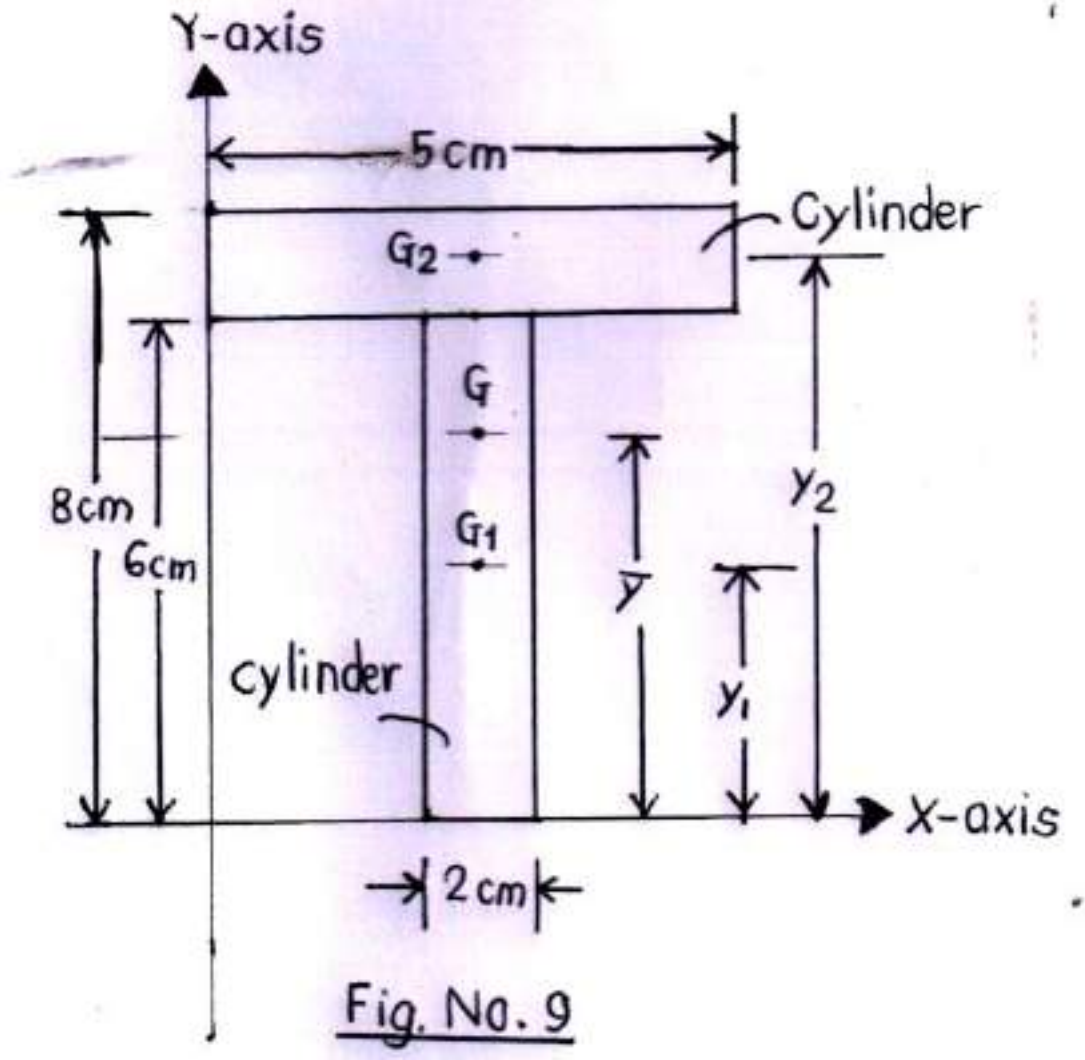


Fig. No. 9

(1.. Not neces sarry)