Subject Name: Applied Mechanics (312312) Subject Code [redacted]
K-scheme.

Important Instructions to STUDENTS

1) *The model answer given here are prepared from the answers from the previously uploaded model answers by Board.*
2) *These model answers are not uploaded by the MSBTE official site but MSBTE study resources website prepared it for students. This model answer has question paper also inbuilt in it, no need to download it separate.*
3) *Please remembter that answers are not checked word to word but based on keywords which must be present in your answer*
4) *The model answer and the answer written by candidate may vary but the examiner may tryto assess the understanding level of the candidate*
5) *While assessing figures, examiner may give credit for principal components indicated in thefigure. The figures drawn bycandidate and model answer may vary. The examiner may give credit for anyequivalent figure drawn*
6) *For programming language papers, credit may be given to any other program based on equivalentconcept*
7) *Students are advised to prepare all the syllabus from recommended book and use these model answers for the purpose of tests.*

Q.NO	SUB Q N	ANSWER	Marking Scheme

1. Attempt any Five of following.

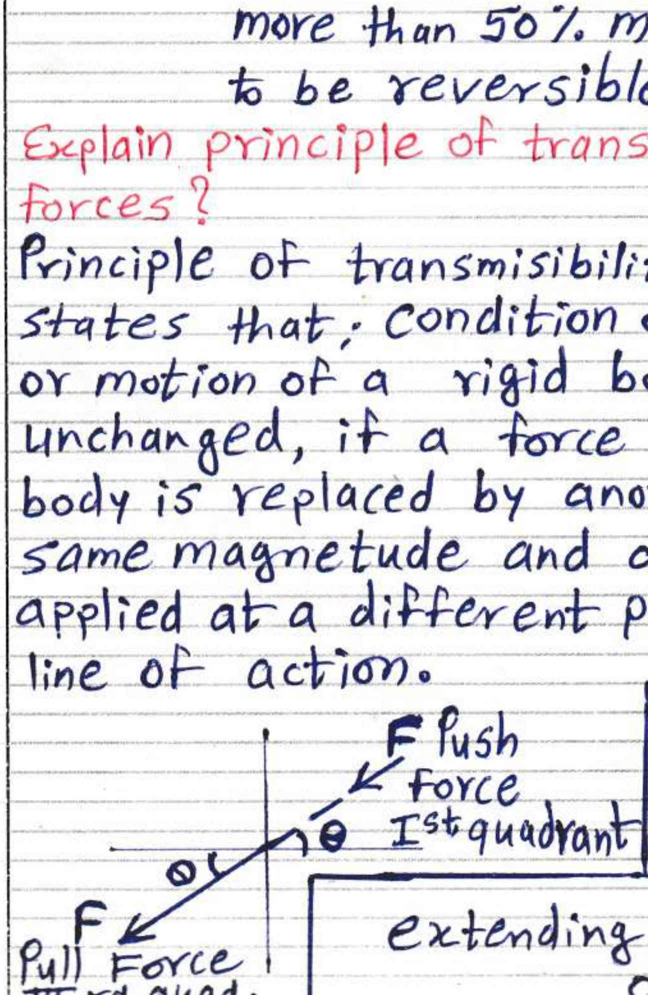
a. Define Reversible machine. what is it's condition?

When the machine moves in reverse direction, after removal of applied effort, then, the machine is said to be "reversible machine".

Condition of Reversibility:-
When the machine has efficiency more than 50% machine is said to be reversible.

b. Explain principle of transmisibility of forces?

Principle of transmisibility of forces states that; condition of equilibrium or motion of a rigid body remain unchanged, if a force acting on the body is replaced by another force of same magnetude and direction but applied at a different point along it's line of action.



As per Principle, Force of push nature can be made pull by extending line of force in opposite quadrant.

Q.NO	SUB Q.N	ANSWER	Marking Scheme

c. State analytical condition of equilibrium of co-planer, non-concurrent force system?

i] $\Sigma F_x = 0$; i.e. Algebric sum of all forces along x-axis must be equal to zero.

ii] $\Sigma F_y = 0$; i.e. Algebric sum of all forces along y-axis must be equal to zero.

iii] $\Sigma M_A = 0$; i.e. Algebric sum of moments of all the forces about any point must be equal to zero. (Say pt. A.)

d. Write any two laws of Kinetic friction?

1] Force of Kinetic friction always acts in a direction opposite to the direction of relative motion between the surfaces in contact.

2] Force of Kinetic friction is directly proportional to the normal force exerted by the surface on object.

e. Define Centroid and Centre of gravity?

Centroid:- It is the point through which the entire area of a plane figure assumed to act for all positions of lamina. ex. Triangle, Square

Centre of gravity:- It is the point through which the whole weight of body is assumed to act, ir-respective of the position of body. ex.- cone, cylinder.

f. Write formula for V.R. of Double Purchase crab using m/c. with meaning of each symbol.

$$V.R. = \frac{L}{r} \times \frac{N_1}{N_2} \times \frac{N_3}{N_1}$$

L = length of handle.

r = radius of load drum.

N_1 = No. of teeth on spur A.

N_2 = Number of teeth on pinion B.

N_3 = Number of teeth on spur C.

g. State the parallelogram law of forces?

If two forces acting at and away from point to be represented in magnetude & direction by two adjecent sides of parallelogram, then the diagonal of parallelogram passing through the point of intersection of two forces represents resultant in magnetude and direction.

2. Attempt any three of the following.

a. In a simple screw jack, the pitch of screw is 10 mm and length of handle is 450 mm. Find V.R. if an effort of 25N applied at end of handle can lift load of 3KN. Find efficiency of screw jack. Also calculate amount of effort loss in friction?

Given:- Simple screw jack,

$W = 3KN = 3 \times 10^3 N$, Pitch of screw = 10 mm

$P = 25 N$. length of handle = 450 mm

We have; $V.R. = \frac{2\pi L}{Pitch} = \frac{2 \times \pi \times 450}{10}$

$\boxed{V.R. = 282.743}$

$M.A. = \frac{W}{P} = \frac{3 \times 10^3}{25}$ $\boxed{M.A. = 120}$

$effy. = \eta = \frac{M.A.}{V.R} \times 100$

$\eta = \frac{120}{282.743} \times 100$ $\boxed{\eta = 42.44\%}$

effort lost in friction (P_f);

$P_f = P - \frac{W}{V.R.}$

$P_f = 25 - \frac{3 \times 10^3}{282.743}$ $\boxed{P_f = 14.389 N}$

b. A weston's differential pulley block is used to lift a load of 8 KN, Diameter of pulley are 26 cm & 24 cm. Calculate effort required if efficiency is 45%. Also calculate load lost in friction?

Given = $W = 8\,KN = 8 \times 10^3\,N.$

$D = 26\,cm = 260\,mm$

$d = 24\,cm = 240\,mm$

$\eta = 45\%$

machine = Weston's Differential pully block

$$V.R. = \frac{2D}{D-d} = \frac{2(260)}{[260-240]}$$

$$\boxed{V.R. = 26.}$$

$$\because \eta = \frac{M.A.}{V.R.} \times 100 \therefore \frac{\eta \times V.R.}{100} = MA.$$

$$\therefore M.A. = \frac{45 \times 26}{100}$$

$$\boxed{MA = 11.7.}$$

We have; $M.A. = \frac{W}{P}$

$$\therefore \text{effort } P = \frac{W}{M.A.} = \frac{8 \times 10^3}{11.7}$$

$$\boxed{P = 683.76\,N.}$$

load lost in friction (Wf)

$$Wf = (P \times V.R.) - W$$

$$W.F. = (683.76 \times 26) - (8000)$$

$$\boxed{Wf = 9777.76\,N.}$$

c. The law of machine = $P = \frac{W}{50} + 8$ N & V.R. = 100. Find the max. possible M.A. & max. possible efficiency while lifting load of 600N. What will be it's efficiency?

Given; law of machine $P = mW + C$ — N

$$P = \left(\frac{1}{50}\right)W + 8 \text{ — N}$$

$\therefore m = \frac{1}{50}$ $\therefore m = 0.02$.

V.R. = 100 ; W = 600 N.

Max. possible M.A. $= \frac{1}{m} = \frac{1}{(1/50)}$

Max. M.A. = 50.

Max efficiency $(\eta_{max}) = \frac{\text{max M.A.}}{\text{V.R.}} \times 100$

$\therefore \eta_{max} = \frac{50}{100} \times 100 = 50\%$

Max efficiency $(\eta_{max}) = 50\%$

Now; $P = mW + C$ ——— N.

$$P = \left(\frac{1}{50}\right)(600) + 8$$

P = 20 N.

$$\text{M.A.} = \frac{W}{P} = \frac{600}{20}$$

M.A. = 30.

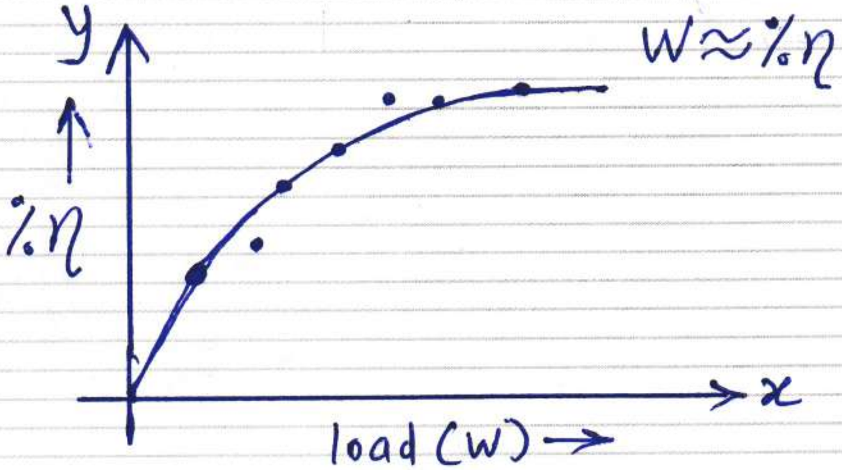
$$\text{efficiency} = \eta = \frac{\text{M.A.}}{\text{V.R.}} \times 100$$

$$\eta = \frac{30}{100} \times 100$$

efficiency = η = 30%.

d. i] Draw Nature of graph of efficiency against load for the machine?

As load increases, percentage efficiency also increases & therefore a smooth curve gradually increasing & becomes more or less parallel to x-axis.

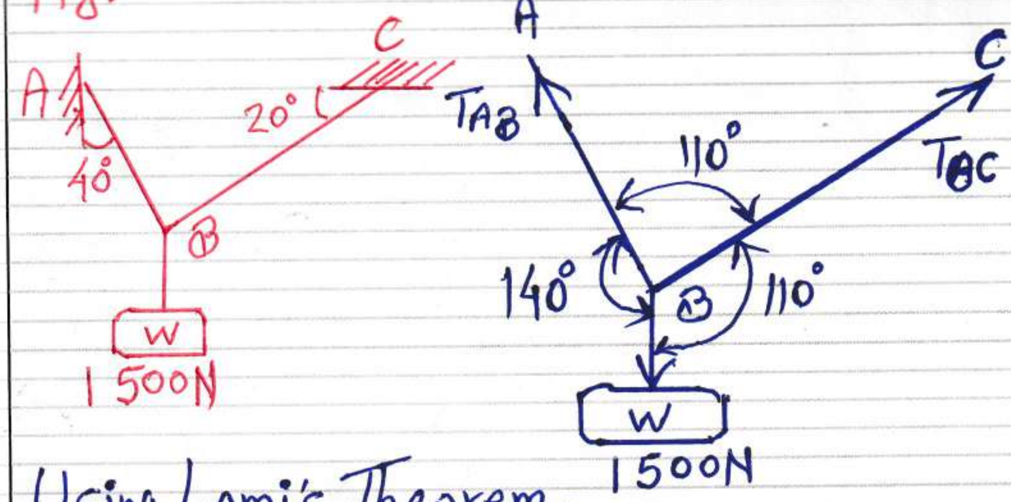


ii] Give any two point of differance between Ideal machine and actual machine.

Ideal machine	Actual machine
① An Ideal machine is considered to be 100% efficiency. i.e. No loss energy.	① An Actual machine has less than 100% effeciency due to various losses. energy.
② It operates without any friction or resistance.	② Actual machine experiance friction between two moving parts.
③ There is no maintenance.	③ Actual machine requires regular maintenance.

3 Attempt any three of following.

a. Calculate tension induced in cable used for the assembly as shown in fig.



Using Lami's Theorem;

$$\frac{1500}{\sin 110°} = \frac{T_{AB}}{\sin 110°} = \frac{T_{BC}}{\sin 140°}$$

Now; $\frac{1500}{\sin 110°} = \frac{T_{AB}}{\sin 110°}$

Tension in cable AB = T_{AB} = 1500 N.

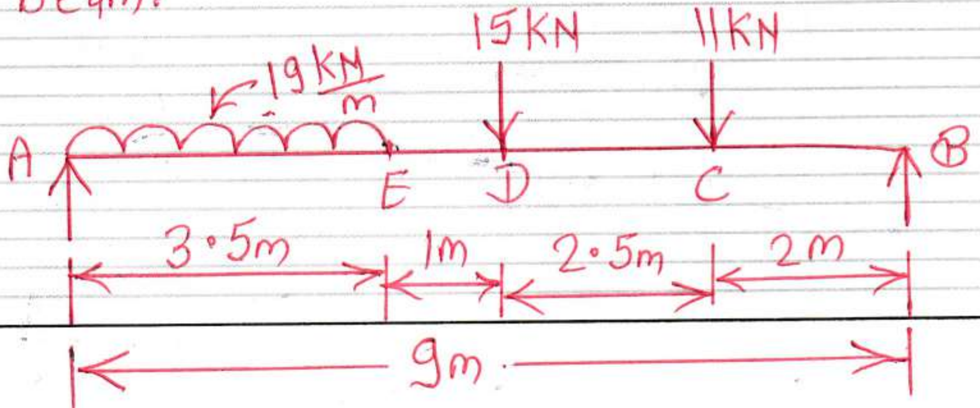
$$\frac{1500}{\sin 110°} = \frac{T_{BC}}{\sin 140°}$$

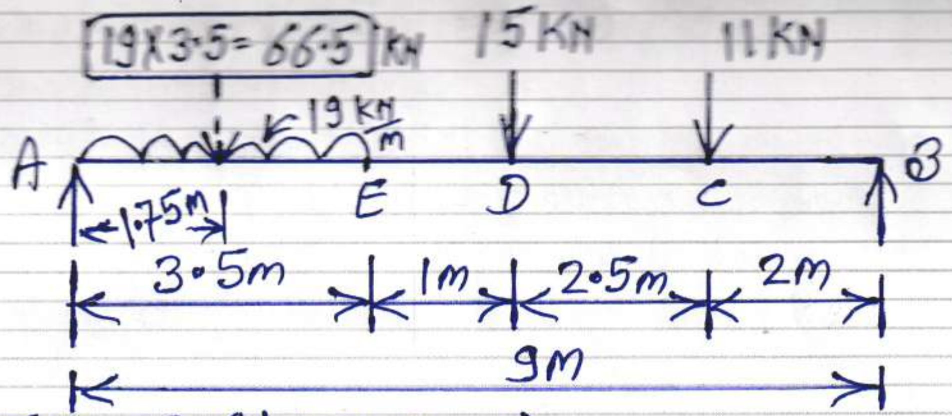
$$\frac{1500}{\sin 110°} \times \sin 140° = T_{BC}$$

$$1026.060 = T_{BC}.$$

Tension in cable BC = T_{BC} = 1026.060N

b. From following figure find support reactions for given simply supported beam.





$\Sigma f_y = 0$ ($\downarrow$ +ve, $\uparrow$ -ve)

$-R_B + 11 + 15 + 66.5 - R_A = 0$

$\therefore R_A + R_B = 11 + 15 + 66.5$

$R_A + R_B = 92.5\ KN$

$\Sigma M_A = 0.$

($\circlearrowright$ -ve, $\circlearrowleft$ +ve) Taking moment @ A;

$9R_B = (11 \times 7) + (15 \times 4.5) + (66.5 \times 1.75)$

$9R_B = 260.875$

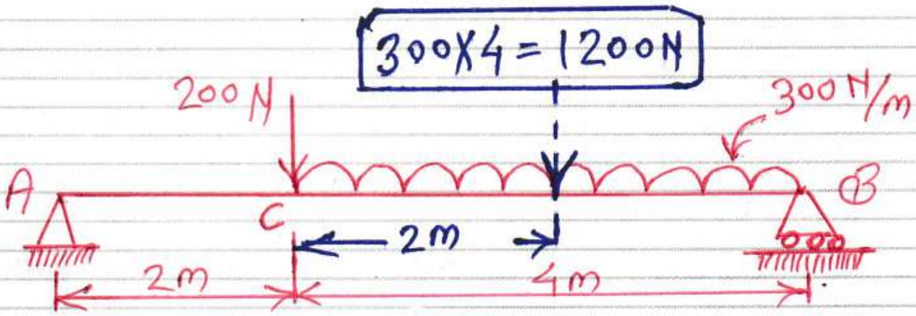
$R_B = 28.986\ KN$

But, $R_A + R_B = 92.5\ KN$

$\therefore R_A = 92.5 - 28.986$

$R_A = 63.514\ KN.$

C. Using analytical method calculate support reactions for beam as shown in fig.



$\Sigma f_y = 0$ ($\downarrow$ +ve, $\uparrow$ -ve)

$-R_B + 1200 + 200 - R_A = 0 \therefore R_A + R_B = 1400N$

Taking moment @ A;

$\Sigma M_A = 0.$ ($\circlearrowright$ -ve, $\circlearrowleft$ +ve)

$6R_B = (1200 \times 4) + (200 \times 2)$

$6R_B = 5200.$

$R_B = 866.67\ N$

But $R_A + R_B = 1400N$

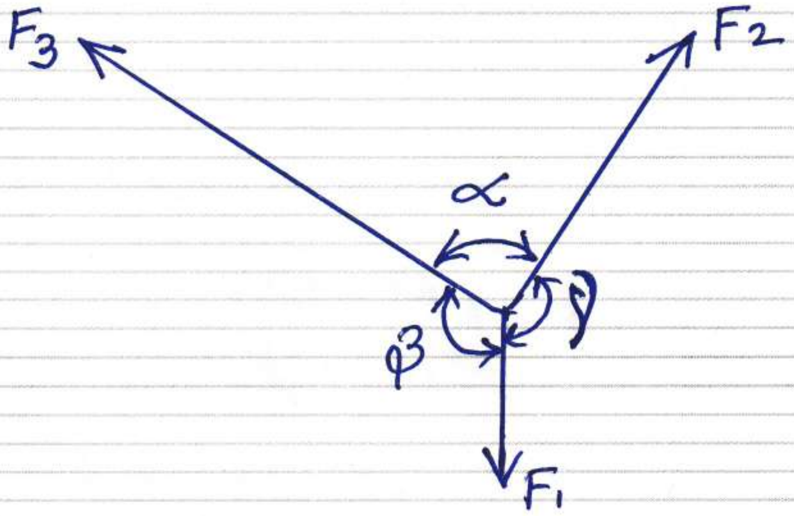
$R_A = 1400 - R_B$

$R_A = 1400 - 5200$

$R_A = 533.33\ N$

d. Explain Lami's theorem? write any three limitations of it?

Lami's theorem states that, if three forces acting at a point on a body keep it at rest, then, each force is proportional to the sin of the angle between the other two forces.



F_1, F_2 & F_3 are three concurrent forces.

α = Angle made by force F_2 & F_3.

β = Angle made by force F_1 & F_3.

γ = Angle made by force F_1 & F_2.

As per Lami's theorem,

$$\frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\beta} = \frac{F_3}{\sin\gamma}$$

Limitations of Lami's theorem:-

① Theorem is applicable if the body is in equilibrium.

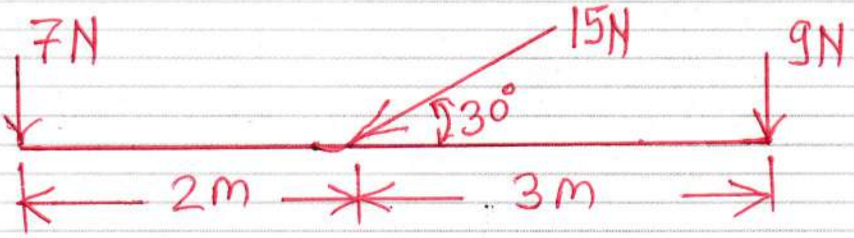
② Theorem is not applicable for parallel or non-concurrent force system.

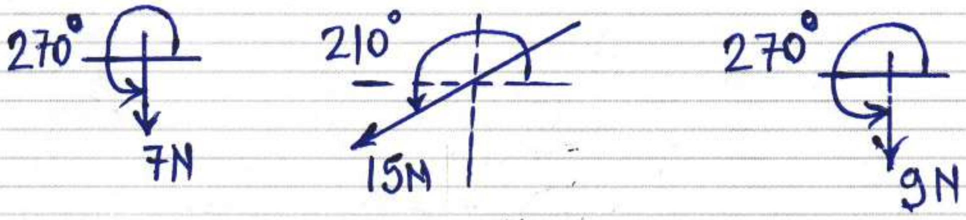
③ Theorem is not applicable for more or less than three concurrent forces.

Q.NO	SUB Q.N	ANSWER	Marking Scheme

4. Attempt any three of following.

a. Determine resultant of coplaner, non concurrent forces as shown in fig.





No.	Force	Angle	Fx Fcosθ	Fy Fsinθ
1.	7N	270°	0	−7
2.	15N	210°	−12.99	−7.5
	9 N	270°	0	−9
			Σfx = −12.99	Σfy = −23.5

Resultant $R = \sqrt{(\Sigma fx)^2 + (\Sigma fy)^2}$

$$R = \sqrt{(-12.99)^2 + (-23.5)^2}$$

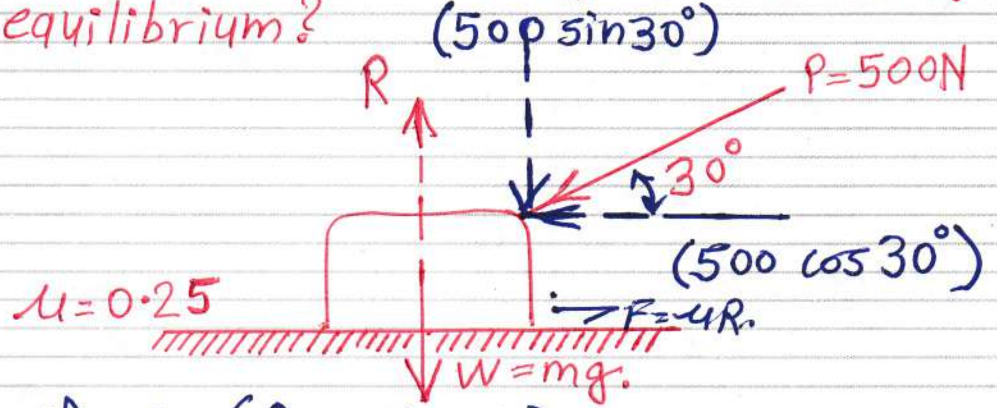
$$\boxed{R = 26.808\,N}$$

Angle; $\theta = \tan^{-1}\left|\frac{\Sigma fy}{\Sigma fx}\right|$

$$\theta = \tan^{-1}\left|\frac{23.5}{12.99}\right|$$

$$\boxed{\theta = 61.07°}$$

b. Find value of "W" of body is in limiting equilibrium?



$\Sigma f_y = 0.$ ($\uparrow$ +ve $\downarrow$ -ve)

$+R - 500\sin(30)^\circ - W = 0$

$\therefore R = 500\sin(30)^\circ + W$ —— eq^n (1)

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

$-500\cos(30)^\circ + F = 0$

$\therefore F = 500\cos(30)^\circ$

We know,

$F = \mu R$

$R = \frac{F}{\mu} = \frac{500\cos(30)^\circ}{0.25}$

$\boxed{R = 1.732\ N.}$ by putting value of R in eq^n (1)

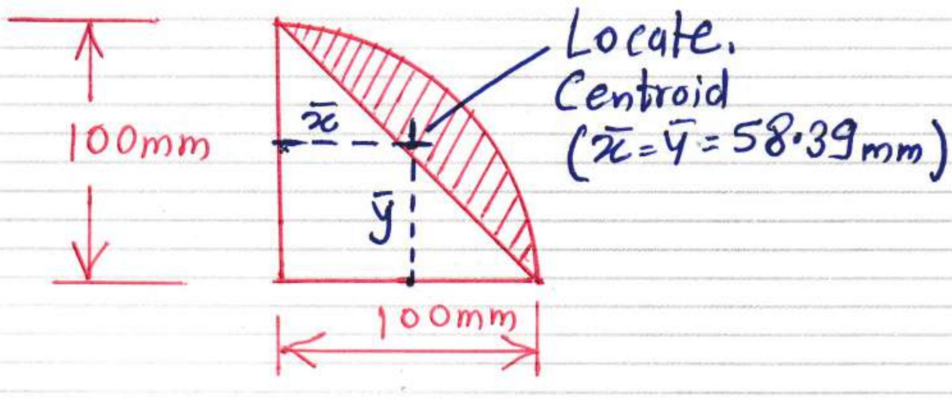
$R = 500\sin(30)^\circ + W$

$1.732 = 500\sin(30)^\circ + W$

$\therefore -W = 500\sin(30)^\circ - 1.732$

$\therefore \boxed{W = 1482\ N}$

c. Locate centroid for shaded area as shown in figure.



Q.NO	SUB Q N	ANSWER	Marking Scheme

fig ① quarter circle

$r = 100mm$

② fig ② triangle

$b = 100mm$
$h = 100mm$

$a_1 = \frac{\pi}{4} r^2$

$a_1 = 7.853 \times 10^3 mm^2$

$a_2 = \frac{1}{2} \times b \times h$

$a_2 = 5 \times 10^3 mm^2$

$x_1 = \frac{4r}{3\pi}$

$x_1 = 42.44mm.$

$y_1 = 42.44mm.$

$x_2 = \frac{b}{3}$

$x_2 = 33.33 mm.$

$y_2 = 33.33 mm.$

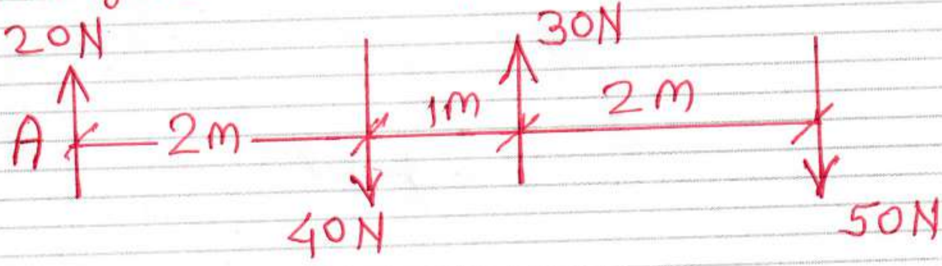
$\bar{x} = \frac{a_1 x_1 - a_2 x_2}{a_1 - a_2}$

$\bar{x} = 58.39mm$ from Y axis.

$\bar{y} = \frac{a_1 y_1 - a_2 y_2}{a_1 - a_2}$

$\bar{y} = 58.39 mm$ from x-axis.

d. Locate graphically position of resultant force for parallel force system as shown in figure with respect to point A.



Q.NO	SUB Q N	ANSWER	Marking Scheme

e. Find centre of gravity of a composite fig of solids with respect to y-axis.

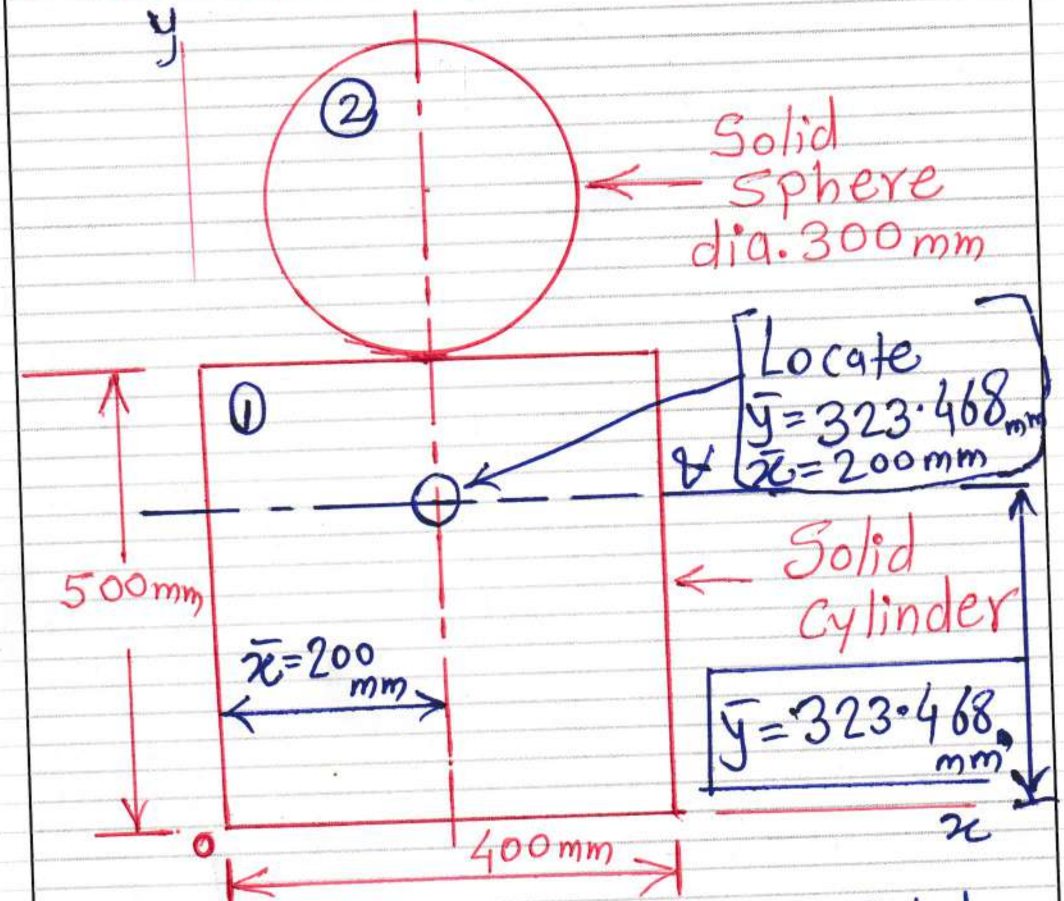


fig ① Solid Cylinder

$V_1 = \pi r^2 h$

$V_1 = \pi (200)^2 (500)$

$V_1 = 62.832 \times 10^6 \ mm^3$

$Y_1 = \frac{h_1}{2} = 250 mm$

fig ② Solid sphere

$V_2 = \frac{4}{3} \pi r^3$

$V_2 = \frac{4}{3} (\pi)(150)^3$

$V_2 = 14.137 \times 10^6 \ mm^3$

$Y_2 = 500 + 150 = 650 \ mm$

$$\bar{y} = \frac{V_1 Y_1 + V_2 Y_2}{V_1 + V_2}$$

$$\bar{y} = \frac{(62.832 \times 10^6)(250) + (14.137 \times 10^6)(650)}{(62.832 \times 10^6) + (14.137 \times 10^6)}$$

$\bar{y} = 323.468 mm$ from x axis.

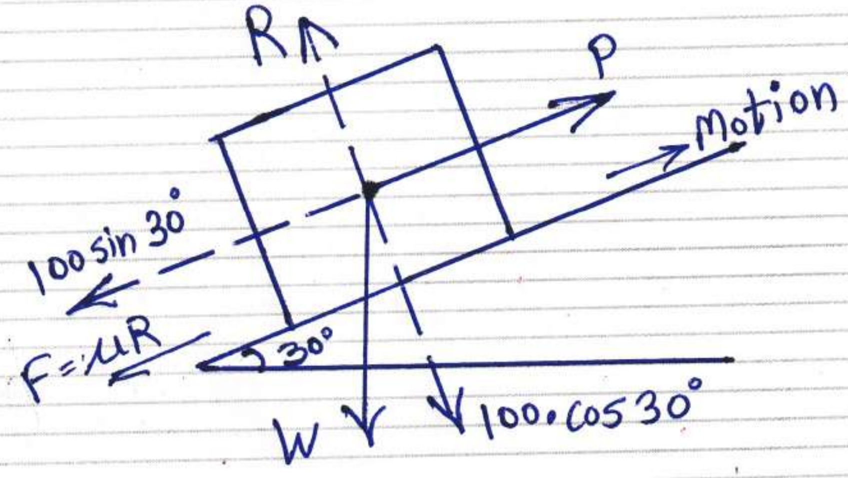
Now; $\bar{x} = x_1 = x_2 = \frac{400}{2} = 200 mm.$

From y axis.

Q.NO	SUB Q N	ANSWER	Marking Scheme

5. Attempt any two of following.

a. A block weighing 100N rests on rough inclind plane having 30° with horizontal. coefficient of friction is 0.25. Calculate force required to be applied to parallel to slope of plane to start sliding upward?



$\Sigma f_y = 0$ (↓ +ve, ↑ -ve)

$R = 100 \cos 30°$ $\quad R = 86.602N$

$\Sigma f_x = 0$. (← -ve, → +ve)

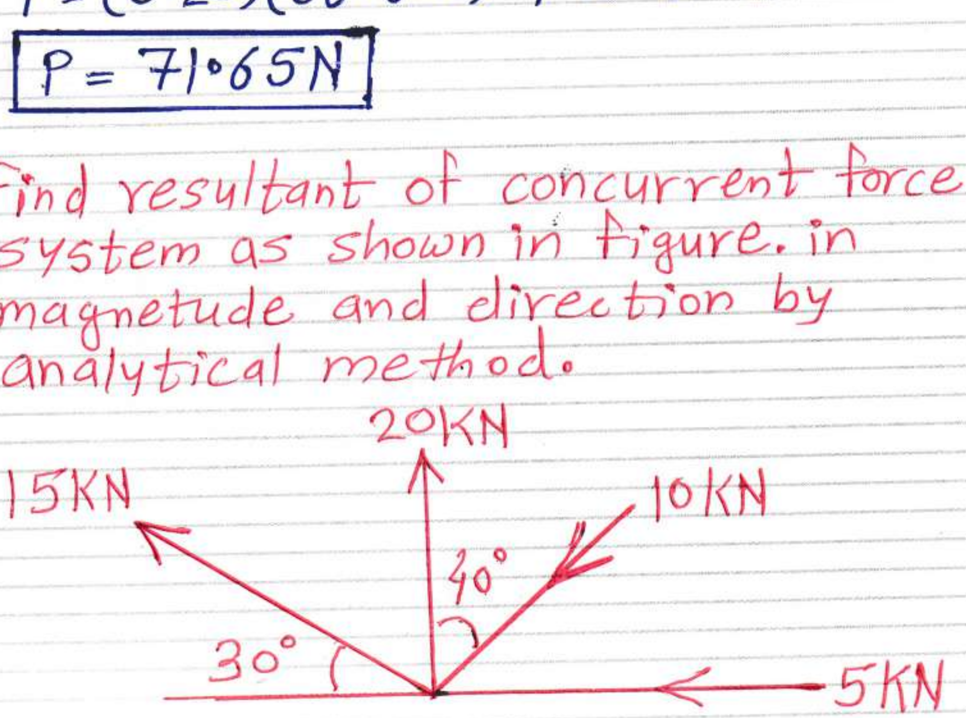
$P = F + 100 \sin 30°$

$P = (\mu \cdot R.) + 100 \sin 30°$

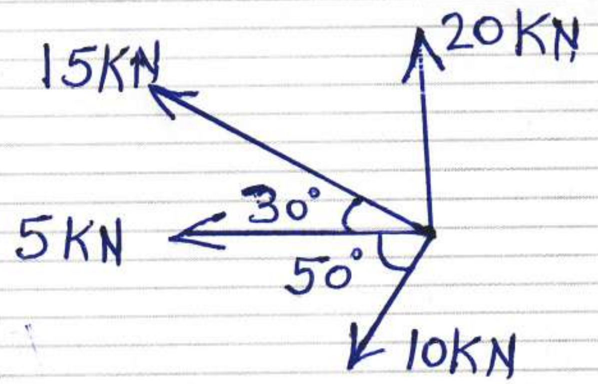
$P = (0.25)(86.602) + 100 \sin 30°$

$\boxed{P = 71.65N}$

b. Find resultant of concurrent force system as shown in figure. in magnetude and direction by analytical method.



Q.NO	SUB Q N	ANSWER	Marking Scheme



$\Sigma f_x = ?$ ($\rightarrow$ +ve, $\leftarrow$ −ve)

$\Sigma f_x = -5 - 15\cos 30^\circ - 10\cos 50^\circ$

$\boxed{\Sigma f_x = -24.417}$

$\Sigma f_y = 20 + 15\sin 30^\circ - 10 \cdot \sin 50^\circ$

$\boxed{\Sigma f_y = +19.84}$

Now; $R = \sqrt{(\Sigma f_x)^2 + (\Sigma f_y)^2}$

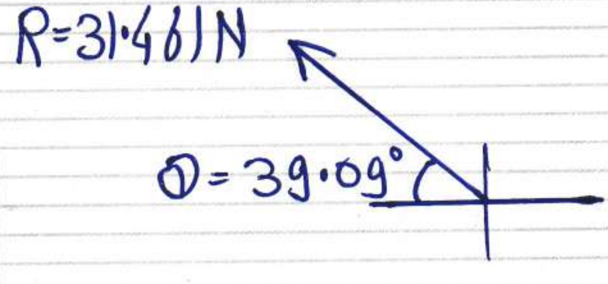
$R = \sqrt{(-24.417)^2 + (19.84)^2}$

$\boxed{R = 31.461\ N.}$

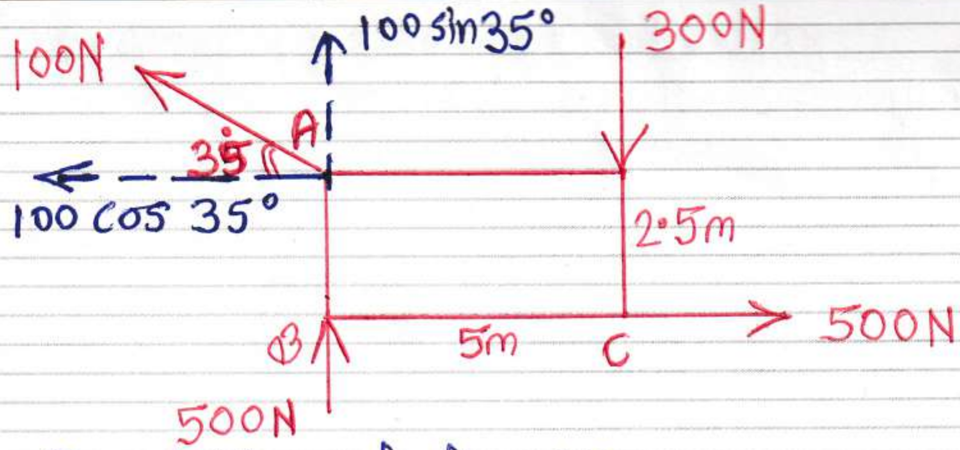
$\theta = \tan^{-1}\left(\frac{\Sigma f_y}{\Sigma f_x}\right)$

$\boxed{\theta = 39.09^\circ}$

As Σf_x is −ve & Σf_y = is +ve.



c. Calculate magnetude & direction of resultant force for a force system. as shown. Locate it w.r.t. point A.



Resolution of forces;

$\Sigma f_x = -100 \cos(35)^\circ + 500$

$\Sigma f_x = 418.08 N.$

$\Sigma f_y = +100 \sin(35)^\circ + 500 - 300$

$\Sigma f_y = 257.36 N.$

$R = \sqrt{(\Sigma f_x)^2 + (\Sigma f_y)^2} = \sqrt{(418.08)^2 + (257.36)^2}$

Resultant Force $= R = 490.94 N.$

Direction of resultant

$\theta = \tan^{-1}\left[\frac{\Sigma f_y}{\Sigma f_x}\right] = \tan^{-1}\left[\frac{257.36}{418.08}\right]$

$\theta = 31.62^\circ$ with +ve x-axis in 1st quadrant.

Distance (x) from point A;
According to Varignon's theorem,

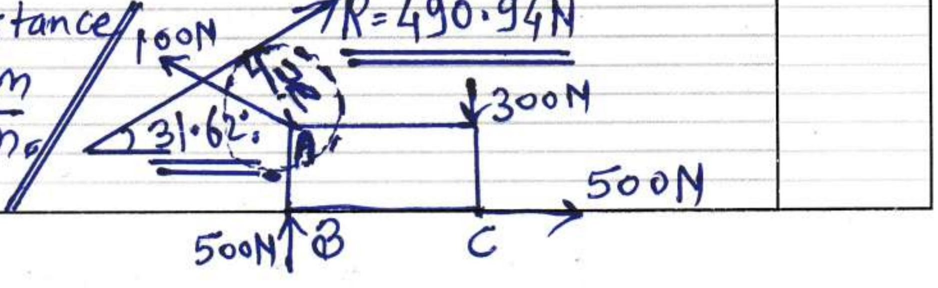
$\Sigma M_A = R_A.$

$+(300 \times 5) - (500 \times 2.5) = Rx$

$250 = 490.94 (x)$

$\therefore x = \frac{250}{490.94}$ $\boxed{x = 0.51 m}$

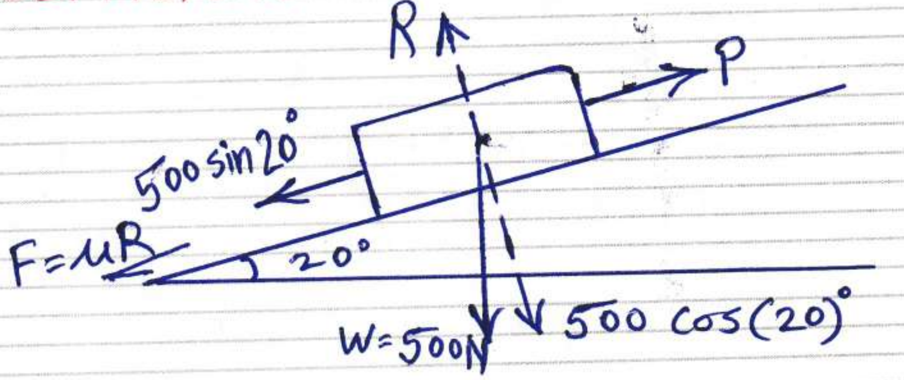
As the value of ΣM_A is +ve; resultant should produce clockwise moment @ A at ⊥er distance $x = 0.51 m$ as shown.



Q.NO	SUB Q N	ANSWER	Marking Scheme

6. Attempt any two of following.

a. Calculate force p applied parallel to plane just to move for block up the plane if block weighing 500N is placed at 20° with horizontal. Coefficient of friction is 0.14.



$\Sigma f_y = 0$ (↑+ve, ↓ -ve)

$+R - 500\cos(20)^\circ = 0$

$R = 500\cos(20)^\circ$ $\boxed{R = 469.846\,N}$

$\Sigma f_x = 0$ (⟶ +ve, ⟵ -ve)

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

$\therefore P = F + 500\sin(20^\circ)$

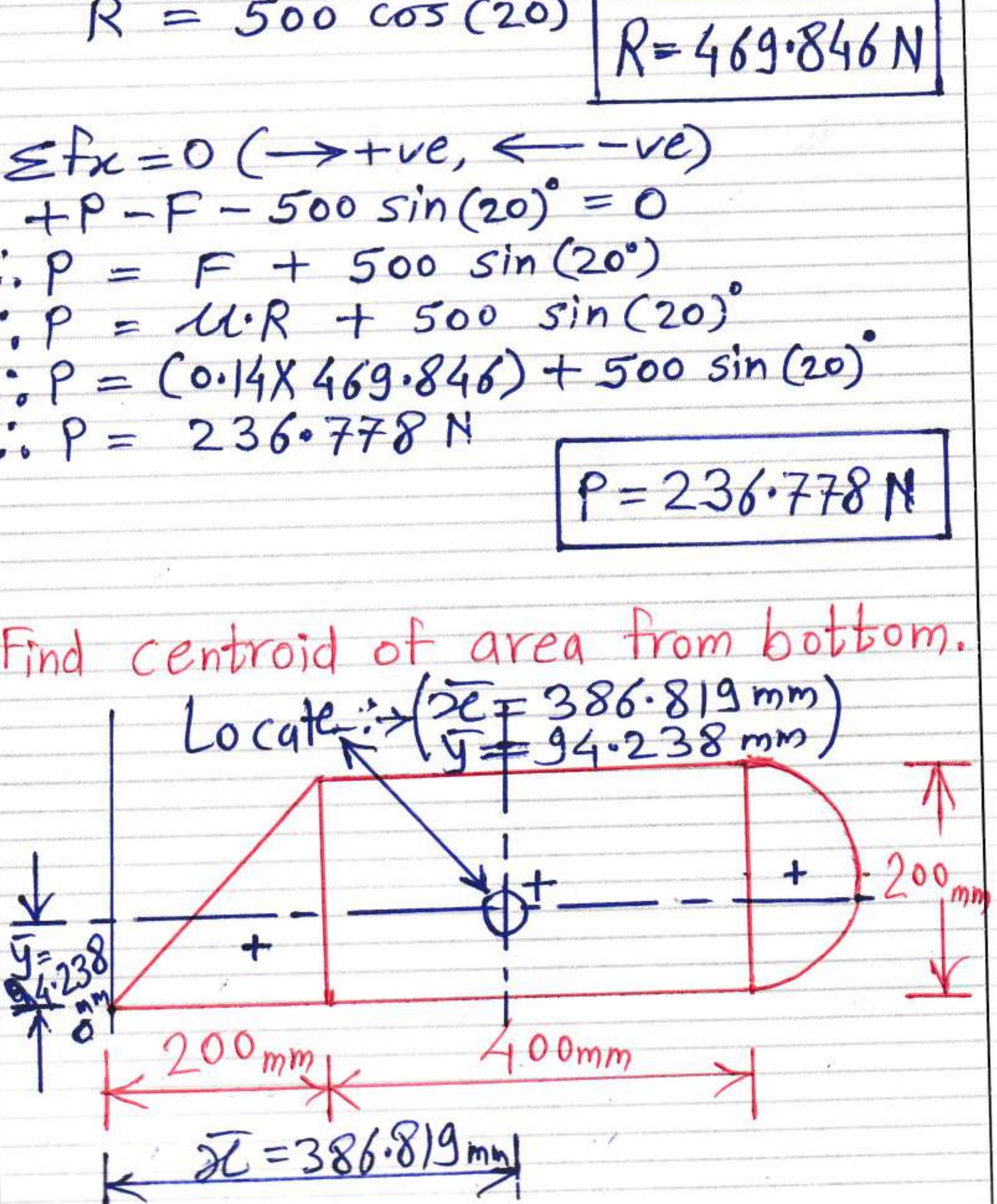
$\therefore P = \mu \cdot R + 500\sin(20)^\circ$

$\therefore P = (0.14 \times 469.846) + 500\sin(20)^\circ$

$\therefore P = 236.778\,N$

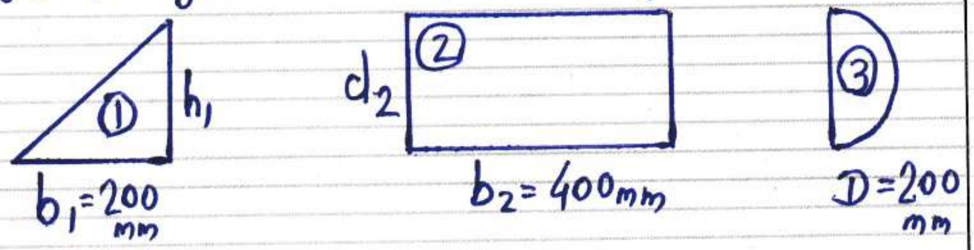
$\boxed{P = 236.778\,N}$

b. Find centroid of area from bottom.



Q.NO	SUB Q N	ANSWER	Marking Scheme

Fig① Triangle   Fig② Rectangle   Fig③ Semi circle.



$b_1 = 200$ mm, $h_1 = 200$ mm $b_2 = 400$ mm, $d_2 = 200$ mm $D = 200$ mm

$A_1 = \frac{1}{2} b_1 h_1$ $A_2 = b_2 \times d_2$ $A_3 = \frac{\frac{\pi}{4} D^2}{2}$

$A_1 = \frac{1}{2}(200)(200)$ $A_2 = (400)(200)$ $A_3 = \frac{(\pi/4)(200)^2}{2}$

$A_1 = 20 \times 10^3 \ mm^2$ $A_2 = 80 \times 10^3 \ mm^2$ $A_3 = 15.707 \times 10^3 \ mm^2$

$y_1 = \frac{h_1}{3} = \frac{200}{3}$ $y_2 = \frac{d_2}{2} = \frac{200}{2}$ $y_3 = \frac{D}{2} = \frac{200}{2}$

$y_1 = 66.67$ mm $y_2 = 100$ mm $y_3 = 100$ mm

$$\bar{y} = \frac{A_1 y_1 + A_2 y_2 + A_3 y_3}{A_1 + A_2 + A_3}$$

$$\bar{y} = \frac{(20 \times 10^3)(66.67) + (80 \times 10^3)(100) + (15.707 \times 10^3)(100)}{(20 \times 10^3) + (80 \times 10^3) + (15.707 \times 10^3)}$$

$\bar{y} = 94.238$ from bottom.

For $\bar{x}$ calculations;

$x_1 = \frac{2}{3} \times b_1$ $x_2 = 200 + \frac{d_2}{2}$ $x_3 = 200 + 400 + \left(\frac{4r}{3\pi}\right)$

$x_1 = \frac{2}{3}(200)$ $x_2 = 200 + \frac{400}{2}$ $x_3 = 600 + \left(\frac{4 \times 100}{3\pi}\right)$

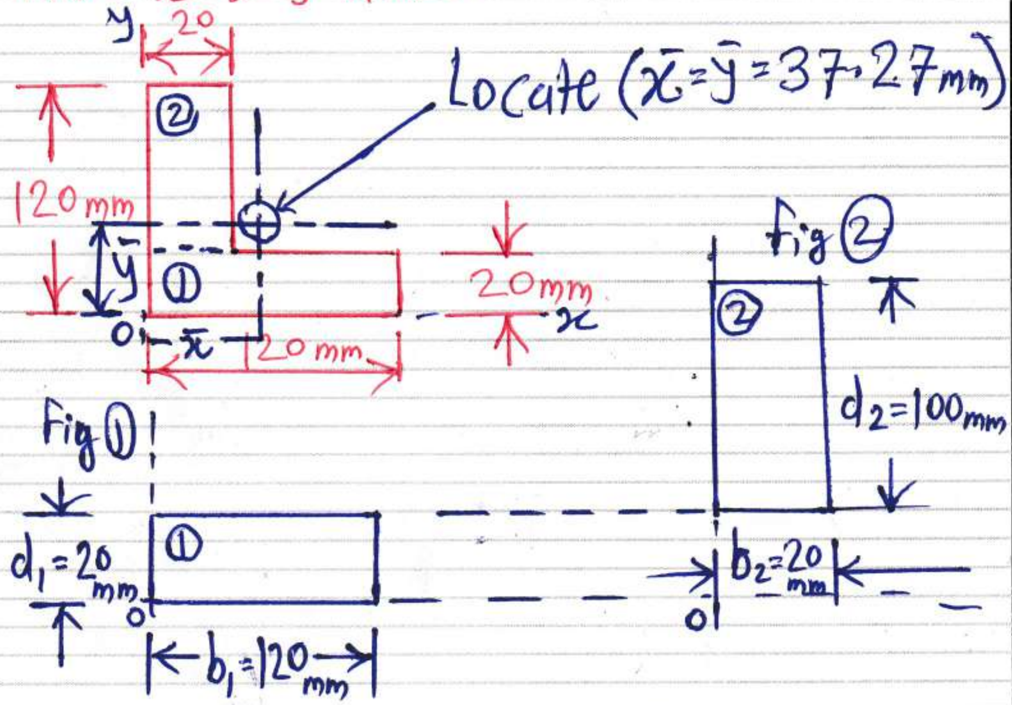
$x_1 = 133.33$ mm $x_2 = 400$ mm $x_3 = 642.44$ mm

$$\bar{x} = \frac{A_1 x_1 + A_2 x_2 + A_3 x_3}{A_1 + A_2 + A_3}$$

$$\bar{x} = \frac{(20 \times 10^3)(133.33) + (80 \times 10^3)(400) + (15.707 \times 10^3)(642.44)}{(20 \times 10^3) + (80 \times 10^3) + (15.707 \times 10^3)}$$

$\bar{x} = 38?.819$ mm from LHS.

C. A "L" section having flange 20X100mm & web 20X100mm. Overall depth is 120mm. Locate position of centroid from x & y axis.



$b_1 = 120 mm$

$d_1 = 20 mm$

$A_1 = b_1 \cdot d_1$

$A_1 = (120)(20)$

$\boxed{A_1 = 2400 mm^2}$

$y_1 = \frac{d_1}{2} = \frac{20}{2}$

$\boxed{y_1 = 10 mm}$

$b_2 = 20 mm$

$d_2 = 100 mm$

$A_2 = b_2 \cdot d_2$

$A_2 = (20)(100)$

$\boxed{A_2 = 2000 mm^2}$

$y_2 = 20 + \frac{d_2}{2} = 20 + \frac{100}{2}$

$\boxed{y_2 = 70 mm}$

$$\bar{y} = \frac{A_1 y_1 + A_2 y_2}{A_1 + A_2}$$

$$\bar{y} = \frac{(2400)(10) + (2000)(70)}{2400 + 2000}$$

$$\boxed{\bar{y} = 37.27 mm \text{ from bottom (x-axis)}}$$

$x_1 = b_1/2 = 120/2 = 60 mm \qquad x_2 = b_2/2 = 20/2 = 10 mm$

$$\bar{x} = \frac{A_1 x_1 + A_2 x_2}{A_1 + A_2} = \frac{(2400 \times 60) + (2000 \times 10)}{2400 + 2000}$$

$$\boxed{\bar{x} = 37.27 mm \text{ from L.H.S. (y-y axis)}}$$