CBCS SCHEME

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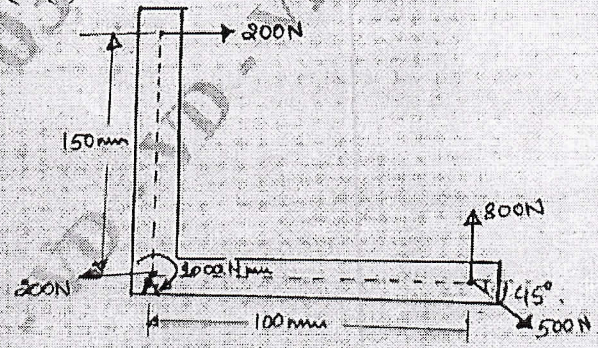
BESCKA204/BESCK204A

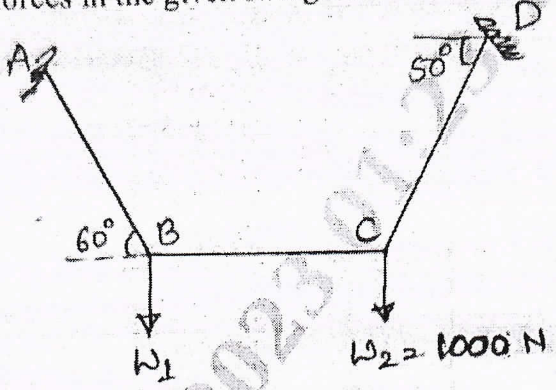
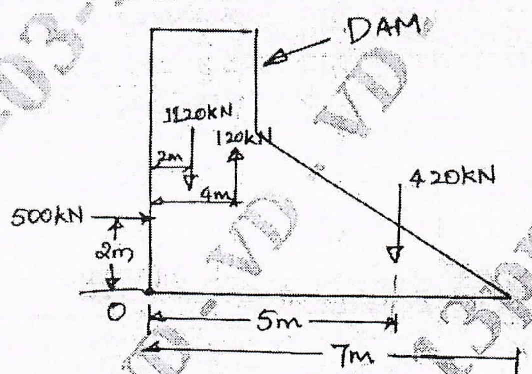
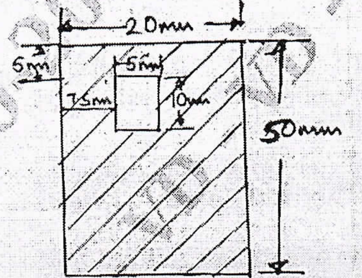
Second Semester B.E./B.Tech. Degree Examination, June/July 2023

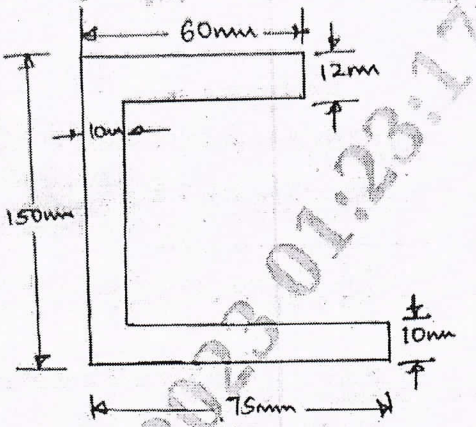
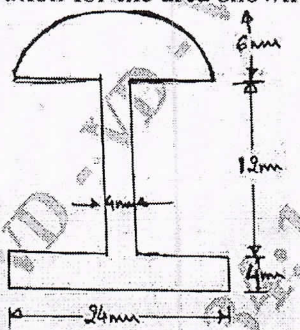
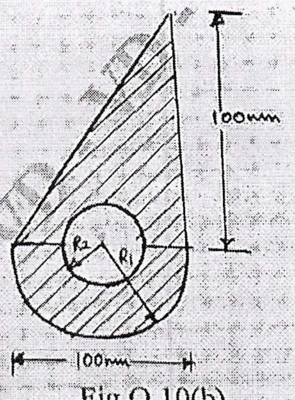
Introduction to Civil Engineering

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. VTU Formula Hand Book is permitted.
3. M : Marks , L: Bloom's level , C: Course outcomes.

		Module – 1	M	L	C
Q.1	a.	Briefly explain any 4 branches of Civil Engineering.	10	L1	CO1
	b.	What is RCC? Explain its advantages and disadvantages.	10	L1	CO1
		OR			
Q.2	a.	Explain the classification of bricks. Also mention the properties of good bricks.	10	L1	CO1
	b.	What is PSC? Explain its advantages and disadvantages.	10	L1	CO1
		Module – 2			
Q.3	a.	What are the major sustainable development goals Enumerate few?	10	L1	CO2
	b.	Define solid waste management. Explain its importance.	10	L1	CO2
		OR			
Q.4	a.	Write a note on smart city concept. Explain the core elements of smart city infrastructure.	10	L1	CO2
	b.	Explain the measures taken to control air pollution.	10	L1	CO2
		Module – 3			
Q.5	a.	Define: i) Resolution and composition of forces. ii) Principle of superposition and principle of transmissibility of forces.	5	L4	CO4
	b.	State and prove Lami's theorem.	5	L2	CO3
	c.	Find the equilibrium of forces with respect to point 'A' for given system of forces in Fig.Q.5(c).  Fig.Q.5(c)	10	L3	CO3

			Marks	Level	CO
		OR			
Q.6	a.	State and prove Varignon's theorem of moments.	5	L2	CO3
	b.	Find the tension forces in the given strings. Also find W_1 in Fig.Q.6(b).  Fig.Q.6(b)	7	L3	CO3
	c.	Find the resultant magnitude and direction with respect to point '0' in Fig.Q6(c).  Fig.Q.6(c)	8	L3	CO3
		Module – 4			
Q.7	a.	State and prove parallel axis theorem.	5	L2	CO4
	b.	Find the centroid of a triangle using first principle.	7	L3	CO4
	c.	Locate the centroid for the given shaded area in Fig.Q.7(c).  Fig.Q.7(c)	8	L3	CO4
		OR			
Q.8	a.	Define centroid and polar moment of inertia.	4	L1	CO4
	b.	Define: i) Perpendicular axis theorem. ii) Radius of gyration.	4	L1	CO4

	c.	Locate the centroid for the given 'C' section in Fig.Q.8(c).  Fig.Q.8(c)	12	L3	CO4
		Module – 5			
Q.9	a.	Find the moment of inertia of a circle along its centroidal axis. (I_{XX} and I_{YY}).	10	L2	CO5
	b.	Find the polar radius of gyration for the area shown in Fig.Q.9(b).  Fig.Q.9(b)	10	L3	CO5
		OR			
Q.10	a.	Derive an expression for moment of inertia of a quarter circle with radius 'R'.	10	L3	CO5
	b.	Determine the moment of inertia in Fig.Q.10(b) about horizontal centroidal axis for the shaded area. Also find the radius of gyration. Take R_1 = 50mm and R_2 = 20mm.  Fig.Q.10(b)	10	L3	CO5

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June | July 2023

INTRODUCTION TO CIVIL ENGINEERING (BESCK 104/204A)

Q.No.1a) Briefly explain Any four branches of civil Engineering.

Ans: 1. Structural Engineering:

Structural engineering is concerned with the analysis & design of various components of structure for the possible forces that are coming on it. This involves identifying the loads which act upon a structure and the forces and stresses which arise within the structure due to those loads, and then designing the structure to successfully support and resist these loads.

2. Geotechnical Engineering:

All the structures have to finally transfer the load acting on them to soil or earth safely. Hence it becomes essential for a civil engineer to properly investigate soil and decide the safe load that can be spread on the soil.

3. Transportation Engineering:

For the growth of a nation, the transportation facility forms an important requirement. It is concerned with provision of safe and economic communication for the movement of people and goods.

4. Environmental Engineering:

Environmental engineering deals with the study of supply of potable water to the people, disposal of properly treated waste and control of environmental pollution.

$2\frac{1}{2} \times 4 = 10M$.

Q.1 b What is RCC? Explain its advantages & disadvantages.

The long form of RCC is "Reinforced Cement Concrete". The homogeneous mixture of coarse aggregates (stone jelly), fine aggregates (sand or M sand) and a binding material (cement or lime) with appropriate quantity of water.

---- 02 M.

Advantages of RCC:

1. Durability: RCC can last for over 100 years.
2. Fire resistance: RCC is fire resistant and won't catch fire.
3. Tensile stress: RCC can withstand a lot of tensile stress.
4. Shape: RCC can be molded into any shape.

---- 04 M

Disadvantages of RCC:

1. Environmental conditions: The longevity

KLS's V.D. Institute of Tech. Dept of Civil Engg. HALIYAL of RCC depends upon the environmental conditions it's in.

2. Permeability: RCC has low ~~permeability~~ permeability, but it can still be affected by substances like CO_2, sulphates and chlorides.

3. The cost of the forms used for casting RCC is relatively higher.

4. Shrinkage causes crack development and strength loss - - - - - 04M

Total: 10M

OR

Q.2 a) Explain the classification of bricks. Also mention the properties of good bricks.

Ans. Bricks are classified by their quality, shape and intended use.

* Quality:

a) First Quality: Also known as Grade A, these bricks are high quality and have standard shape, smooth surfaces and sharp edges. They are used in permanent structures.

b) Second Class: Also known as Grade B, these bricks are similar to first-class bricks but may have minor defects.

c) Third class: Also known as Grade C, these bricks are lumpy and are good for old style walls.

- - - 05M.

Properties of good quality bricks:

1) Compressive strength: The ability of a brick to resist Compression. This is important for load bearing walls.

2) Hardness: Hard bricks are more durable and can with stand wear and tear.

3) Water absorption: A good brick should not absorb more than 15 to 20% of it's dry weight when submerged in water for 24 hours.

4) Good bricks should be uniform in size and have sharp edges.

5) Color: Good bricks should be uniform in color.

--- 05M

Total - 10M.

Q.2 b What is PSC? Explain its advantages & disadvantages.

Ans The long form of PSC is "PreStressed Concrete". PSC is a type of Concrete that has been reinforced with steel to increase its strength and load capacity. It is used in many applications, including bridges and Commercial spaces.

--- 04M.

Advantages:

1) Use of PSC ~~needs expodu~~ is best suited to increase floor space and parking faility.

2) The span length is larger, fewer joints are needed than in traditional RC structures.

3) It requires smaller amounts of Construction materials.

---- 03M

Disadvantages:

1) It requires high strength concrete and high tensile strength steel wires.

2) It requires skilled workers under skilled supervision.

3) Construction cost is little higher than RCC structures.

---- 03 M

Total: 10M.

Module 2

Q.3 a) What are the major Sustainable Development Goals Enumerate few.

Ans: I People:

Goal 1.: No poverty.
Goal 2.: Zero hunger
Goal 3: Good health and well being.
Goal 4: Quality education

II Prosperity:

Goal 7: Affordable clean energy.
Goal 10: Reduce unequalities.
Goal 11: Sustainable cities & communities.

III Planet:

Goal 13: Climate action
Goal 14: Life below water.

IV Peace & Partership:

Goal 17: Partership for the goal.

--- 1x10 = 10M.

Q.3 b) Define Solid Waste Management, Explain its importance.

Ans: Solid waste Management (SWM) is the process of managing waste from it's creation to its final disposal. It involves, collecting, transporting, treating and disposing of waste. ---- 04M.

Importance:

1) SWM is an important part of environmental management.

2.) It can help to protect the environment and promote economic efficiency.

3.) It can help to create jobs and generate income.

4.) SWM can prevent the spread of diseases and improve hygiene.

5.) SWM Can reduce the impact of pollution on ecosystems and help to mitigate climate change.

6.) SWM Can promote recycling and reuse of materials, which can help to conserve resources. ---- 06M.

Total 10M.

OR.

Q.4 a) Write a note on smart city concept. Explain the core elements of smart city infrastructure.

Ans. A smart city is a city or municipality that uses information & communication Technologies (ICT) to increase operational efficiency, share information with public and improve both the quality of government services and citizen welfare.

* Features of smart city:

The smartness of the city is determined using a set of charectoristics including

i) An infrastructure based around technology.

ii) Environmental initiatives.

iii) Confident and progressive city plans.

---- 05M.

The core elements of smart city infrastructure.

i) Adequate water supply.

ii) Assured electricity supply.

iii) Sanitation including SWM.

iv) Public transport system.

v) Affordable housing. ---- 05M

Total 10M.

Q.4 b) Explain the measures taken to control air pollution.

Ans: Measure taken to control air pollution.

1) Reduce driving: Drive less, and use Public transportation.

2) Use clean fuels: Use clean fuels like LPG & CNG instead of diesel or petrol.

3) Plant Trees: Plant and care for trees.

4) Reduce burning: Avoid burning garbage, and limit backyard fires.

5) Reduce smoking: Avoid smoking cigarettes.

---- 05×2 = 10M

Module 3

Q.5 a) Define: i) Resolution & composition of forces.
ii) Principle of super position and Principle of transmissibility of forces.

Ans: i) Resolution: Process of splitting the single force into no of forces which will have same effect as single force have on the body.

Composition: process of combining no of forces to get single force which will have same effect on body as no of forces have. ---- 02M.

ii) Principle of super position.

Statement: It states that the effect of resultant force is same as its component forces. ---- 01M.

* Principle of transmissibility of forces.

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

Total 10M.

Q. 5 b) State and prove Lami's theorem.

Ans: Statement: It states that if a body is in equillibrium under the action of three coplanar concurrent forces then each force is proportional to sine of the angle between other two forces. - - - - 02M

Proof: Consider three forces F_1, F_2 & F_3 as shown in fig. 1

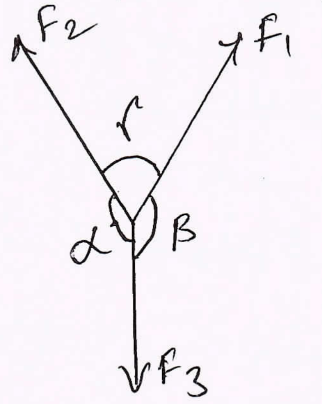


Fig 1

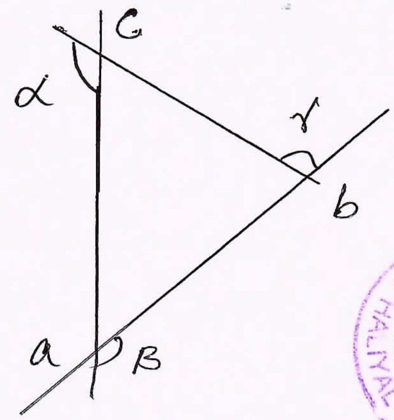


Fig. 2:

Draw the three forces F_1, F_2 & F_3 one after the other in direction and magnitude starting from point a. Since the body is in equillibrium the resultant should be zero, which means the last point of force diagram should coinside with a. Thus, it results in a Δ^{le} of forces abc as shown in fig. 2. Now the external angles at a, b, c are equal to β, γ & α, since ab, bc & ca are || to F_1, F_2, F_3 respectively

In Δ^{le} of forces abc

$$ab = F_1, \quad bc = F_2, \quad ca = F_3$$

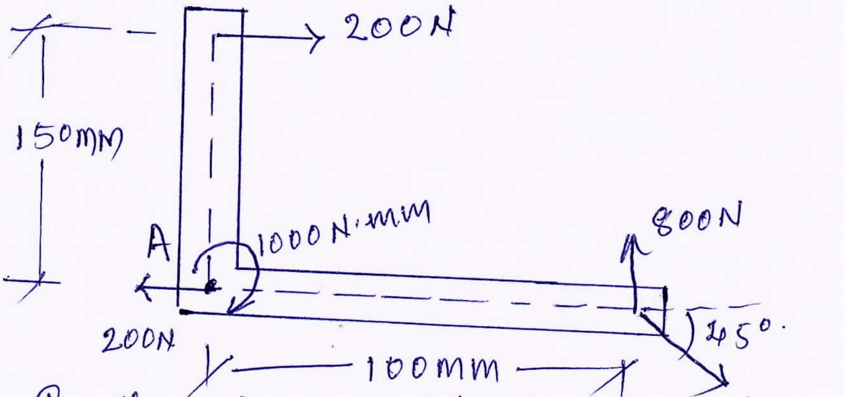
Applying sine rule.

$$\frac{ab}{\sin(180-\alpha)} = \frac{bc}{\sin(180-\beta)} = \frac{ca}{\sin(180-\gamma)}$$

$$\Rightarrow \frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\beta} = \frac{F_3}{\sin\gamma}$$ - - - 03M

Total 05M.

Q.5c Find the "equillibrium" of forces with respect to point A for the given system of forces in fig. Q.5c



Note: In the given problem use "Resultant" instead of equillibrium.

Soln

$\Sigma F_x = +200 - 200 + 500\cos 45 = +353.55\,N$ —— 02M

$\Sigma F_y = +800 - 500\sin 45 = +446.45\,N$ —— 02M

$\Sigma M_A = +1000 + 200\times150 - 800\times100 + 500\sin45\times100$

$= -13644.66\ N\cdot mm.$ —— 03M

$R = \sqrt{353.55^2 + 446.45^2}$

$R = \sqrt{324315.21}$

$R = 569.49\,N$ $\alpha = \tan^{-1}\frac{446.45}{353.55} = 51.62°$ —— 01M

$d = \frac{\Sigma M}{R} = 23.96\,mm$

$x = \frac{\Sigma M}{\Sigma F_y} = 30.56\,mm$ - - - - 01M.

$y = \frac{\Sigma M}{\Sigma F_x} = 38.59\,mm$

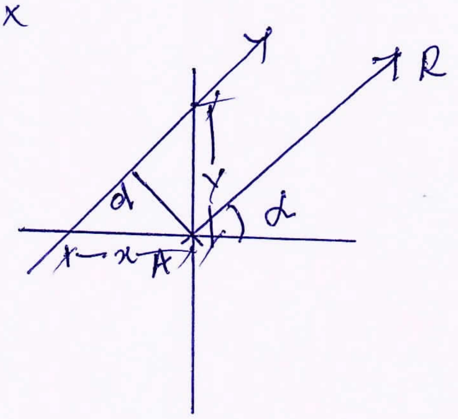


Fig. 01M

Total 10M.

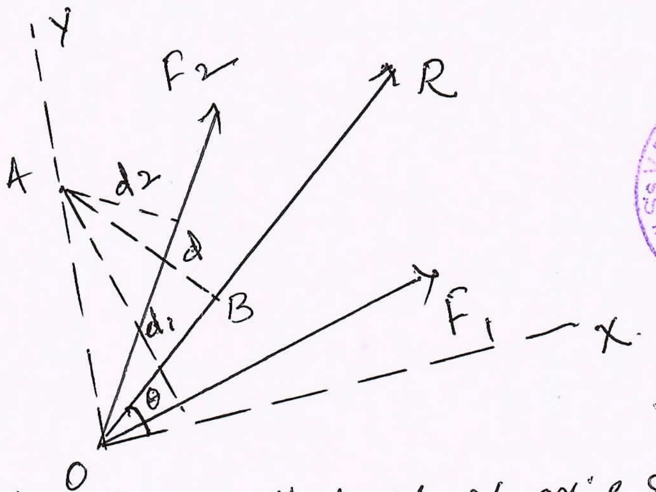
OR

Q.6 a) State and prove Varignon's principle of moments.

Ans: Statement: It states that "the algebraic sum of moments of a coplanar forces is equal to the moment of their resultant force about any moment centre in the plane. --- 01M

Mathematically: $R \cdot d = F_1 d_1 + F_2 d_2$.

where F_1 & F_2 are the two coplanar forces & R is resultant of F_1 & F_2 & d_1, d_2 & d are the moment arms of F_1, F_2 & R respectively. as shown below in fig.



--- 01M

Join OA and consider that as y-axis & draw x axis ⊥er to it as shown in fig. Let θ be the inclination of R w.r.to x-axis as shown in fig.

From Fig:

$$Rd = R \cdot OA \cos\theta$$
$$= OA\ R\cos\theta$$
$$= OA\ R_x \quad \text{--- (1)}$$

Similarly we can prove

$$F_1 d_1 = OA\ F_1x \quad \text{--- (2)}$$
$$F_2 d_2 = OA\ F_2x \quad \text{--- (3)}$$

(2) + (3)

$$F_1 d_1 + F_2 d_2 = OA\ F_1x + OA\ F_2x$$
$$= OA\,(F_1x + F_2x)$$
$$F_1 d_1 + F_2 d_2 = OA\ R_x$$

from (1)

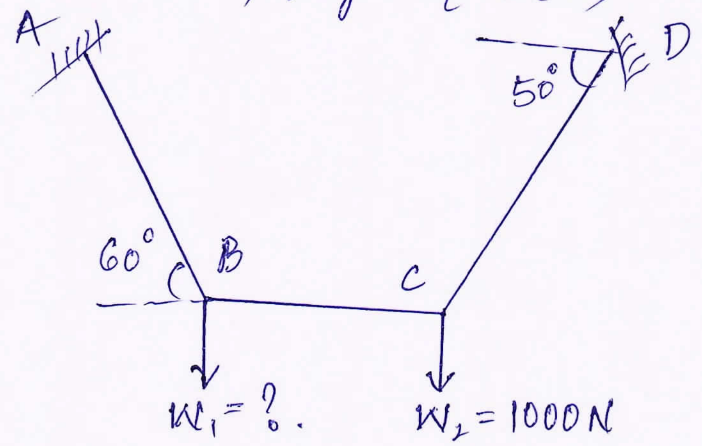
$$R \cdot d = F_1 d_1 + F_2 d_2 \quad \text{thus proved.}$$

03

Total: 5M

Q.6 b)

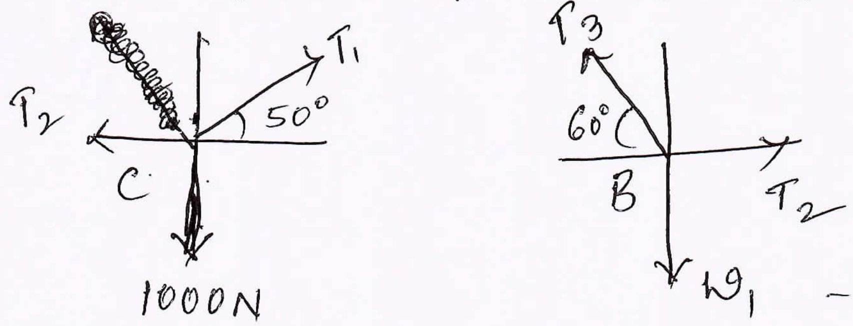
Find the tension forces in the given strings. Also find W_1 in fig Q.6(b)



Soln

Let T_1, T_2 & T_3 be the tension forces developed in string segments CD, BC & AB respectively.

FBD for the points C & B are as shown



--- 02 M

Applying Lami's thm. for C

$$\frac{T_1}{\sin 90} = \frac{T_2}{\sin 140} = \frac{1000}{\sin 130} \quad \text{---- 01 M}$$

$$\Rightarrow \quad T_1 = \frac{1000 \sin 90}{\sin 130} = 1305.41N$$

$$T_2 = \frac{1000 \sin 140}{\sin 130} = 839.1N$$

} 01 M

Applying Lami's thm for pt B

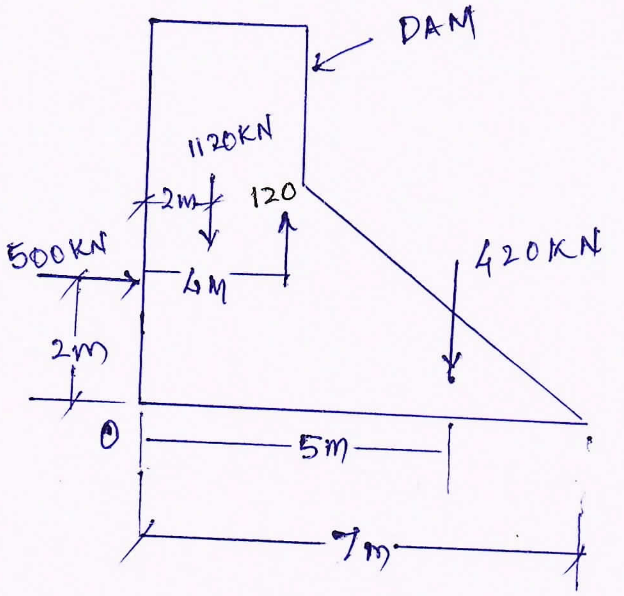
$$\frac{W_1}{\sin 120} = \frac{T_3}{\sin 90} = \frac{T_2}{\sin 150} \quad \text{--- 01 M}$$

$$\Rightarrow \quad W_1 = \frac{839.1 \sin 120}{\sin 150} = 1453.36N$$

$T_3 = 839.1 \sin 90 / \sin 150 = 1678.2N$ } 02 M

Total 07M.

Q.6.c Find the resultant magnitude and direction with respect to point O in fig. Q6(c).



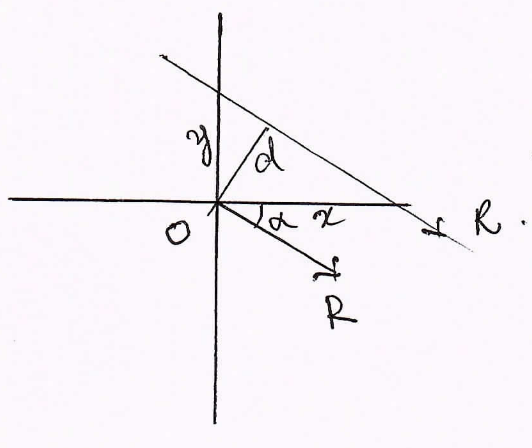
Soln

$\Sigma F_x = +500\ KN$
$\Sigma F_y = 120 - 420 - 1120 = -1420\ KN$ } 02 M

$R = \sqrt{500^2 + 1420^2} = \sqrt{2266400} = 1505\ KN$
$\alpha = \tan^{-1}\frac{1420}{500} = 70.60°$ } 01 M

$\Sigma M_O = +420 \times 5 + 500 \times 2 + 1120 \times 2 - 120 \times 4$
$= 4860\ KN \cdot m.$ —— 03 M

$d = \frac{\Sigma M_O}{R} = \frac{4860}{1505} = 3.23\ m$
$x = \frac{\Sigma M_O}{\Sigma F_y} = \frac{4860}{1420} = 3.42\ m$ } 01 M
$y = \frac{\Sigma M_O}{\Sigma F_x} = \frac{4860}{500} = 9.72\ m.$



—— 01 M

Total 08 M

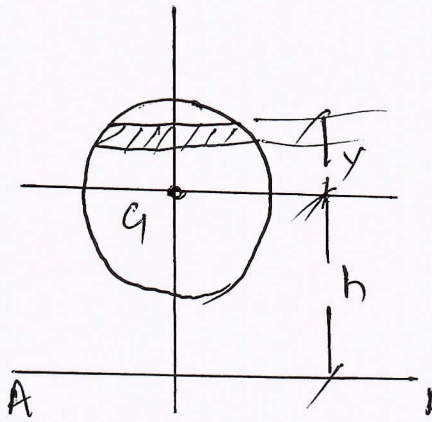
Module - 04

Q.7 a) State and prove parallel axis theorem.

Ans: **Statement:** If the MI of a plane area about an axis through it's centroid is denoted by I_{GG}, then the MI about any other axis AB parallel to the first and a distance h from the centroidal axis is given by.

$$I_{AB} = I_{GG} + Ah^2 \quad \text{—— 02M}$$

Proof: Consider a strip of cle whose MI is required to be found out about a line AB as shown in fig.



Let δa = Area of the strip.
y = dist of δa from G
h = dist betn G & AB

MI of strip about axis of G
$= \delta a y^2$

MI of whole cle about axis passing through G

$$I_G = \Sigma \delta a y^2$$

∴ MI of the section about AB

$$I_{AB} = \Sigma \delta a (h+y)^2 = \Sigma \delta a (h^2 + y^2 + 2hy)$$

$$= \Sigma h^2 \cdot \delta a + \Sigma y^2 \delta a + \Sigma 2hy \delta a$$

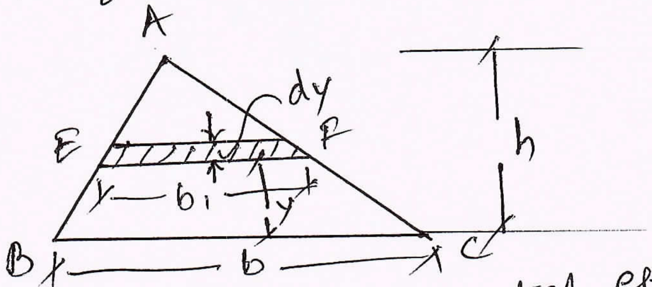
$$I_{AB} = ah^2 + I_G + 0$$

$$\therefore I_{AB} = I_G + Ah^2$$ Thus proved. 03M

Total 05M.

Q.7.b. Find the centroid of Δ^{le} using first principle.

Ans: Consider the Δ^{le} ABC of base width b and height h as shown in fig. Let us locate the centroid from base b.



Let b_1 be the width of elemental strip of thickness dy at a distance of y from base.

Since ΔAEF & ΔABC are similar Δ^{les}. ---- 02M

$$\frac{b_1}{b} = \frac{h-y}{h}$$

$$b_1 = \left(\frac{h-y}{h}\right)b = \left(1-\frac{y}{h}\right)b \quad \text{---} (1)$$

∴ Area of element $= dA = b \cdot dy$

$$dA = \left(1-\frac{y}{h}\right)dy$$

Area of Δ^{le} $ABC = \frac{1}{2} \cdot b \cdot h$

$$\therefore \bar{y} = \frac{\int y\,dA}{A}$$

$$\int y\,dA = \int_0^h y\left(1-\frac{y}{h}\right) b\,dy$$

$$= b\left(\frac{y^2}{2} - \frac{y^3}{3h}\right]_0^h$$

$$= \frac{bh^2}{6}$$

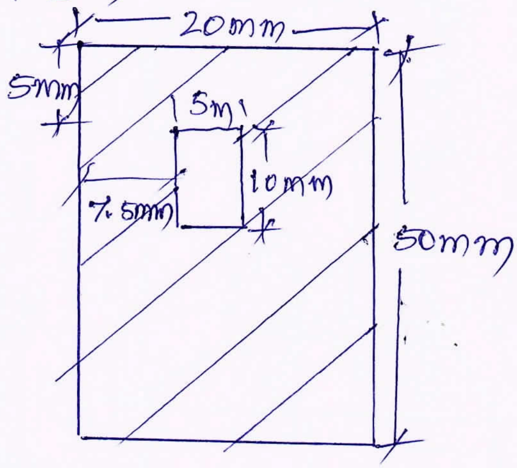
$$\therefore \bar{y} = \int \frac{y\,dA}{A} = \frac{bh^2}{6} \times \frac{1}{\frac{1}{2} b \cdot h}$$

---- 05M

$$\bar{y} = \frac{h}{3}$$

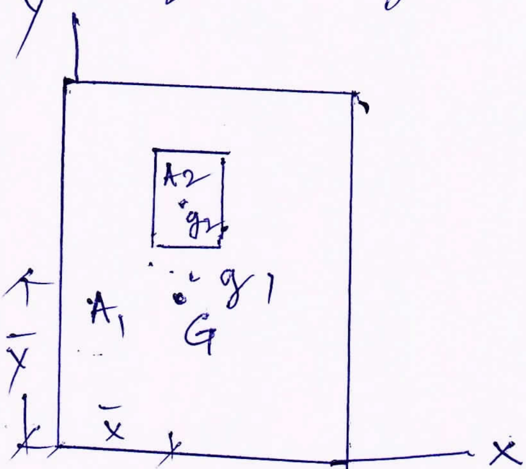
Total 07M

Q.7 c. Locate the centroid for the given shaded area in fig. 7(c)



Soln

Consider the following fig.



Let A_1 & A_2 be the segmental areas & g_1 & g_2 be their positions of centroid as shown in fig.

$A_1 = 20 \times 50 = 1000\, mm^2$

$A_2 = 5 \times 10 = 50\, mm^2$

$\Sigma A = 1000 - 50 = 950\, mm^2$

$\bar{x} = \frac{A_1 \bar{x}_1 - A_2 \bar{x}_2}{\Sigma A}$ ---- 04

$= \frac{1000 \times 10 - 50 \times 10}{950}$

$\bar{x} = 10\, mm$ ———— 02

$\bar{y} = \frac{A_1 \bar{y}_1 - A_2 \bar{y}_2}{\Sigma A}$

$= \frac{1000 \times 25 - 50 \times 40}{950}$

$\bar{y} = 24.21\, mm$ ———— 02

$G = (10, 24.21)$

08M.

OR.

Q. 8. a) Define Centroid & polar Moment of Inertia.

Ans: * Centroid: Centroid is the geometric centre of an area is it's centroid (G), the point at which the the area can be balanced if it is supported at that point. --- 02M

* Polar Moment of Inertia.

Moment of Inertia about an axis ⊥er to the plane of an area is known as "polar Moment of Inertia". It may be denoted as J or Izz. ----- 02M

Total 04M

Q. 8 b) Define: i) Perpendicular axis theorem
ii) Radius of gyration.

Ans: i) Perpendicular Axis theorem:

The moment of Inertia of an area about an axis ⊥er to it's plane (polar MI) at any point O is equal to the sum of the MI about any two mutually ⊥er axes through the same point O and lying in the plane of the area ---- 02M

ii) Radius of gyration:

Radius of gyration (k) is the distance at which the complete area is squeezed and kept as a Strip of negligible width such that there is no change in moment of Inertia. --- 02

Total 04M

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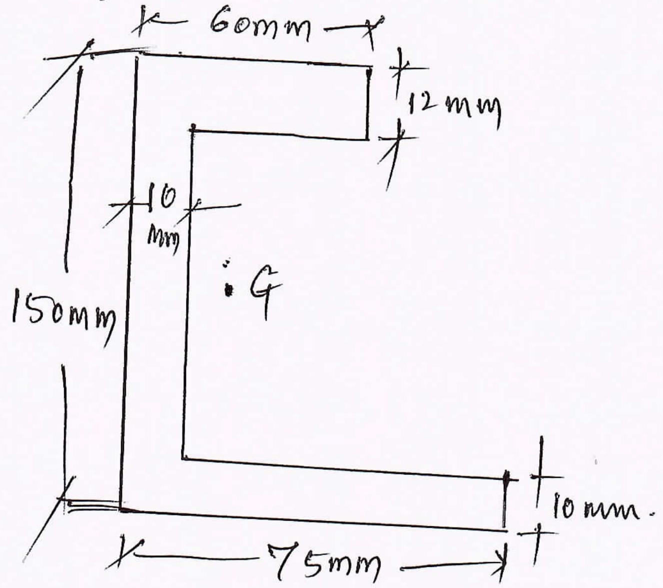
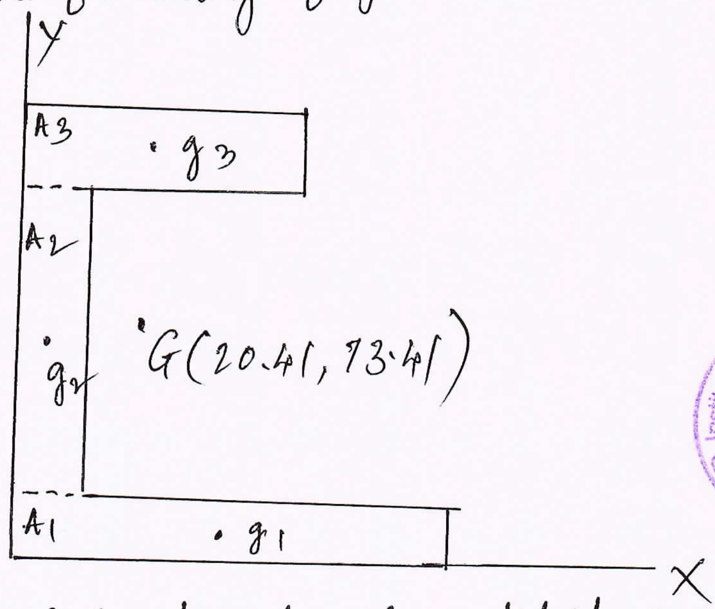
Q. 8.c

Locate the centroid for the given 'C' section in fig. Q 8(c)



Soln Consider the following figure.



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

$$A_1 = 75 \times 10 = 750 \text{ mm}^2$$

$$A_2 = 128 \times 10 = 1280 \text{ mm}^2$$

$$A_3 = 60 \times 12 = 720 \text{ mm}^2$$

$$\Sigma A = A_1 + A_2 + A_3 = 750 + 1280 + 720 = 2750 \text{ mm}^2$$

04M.

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

where $\bar{x}_1, \bar{x}_2$ & $\bar{x}_3$ are the x coordinates of g_1, g_2 & g_3 respectively.

~~$\bar{X} = \frac{750 \times 5 + 1280 \times 74 + 720 \times 144}{2750}$~~

$$\bar{X} = \frac{750 \times 37.5 + 1280 \times 5 + 720 \times 30}{2750}$$

$\bar{X} = 20.41\,mm$ ———— 04M

$$\bar{Y} = \frac{750 \times 5 + 1280 \times 74 + 720 \times 144}{2750}$$

$\bar{Y} = 73.51\,mm$

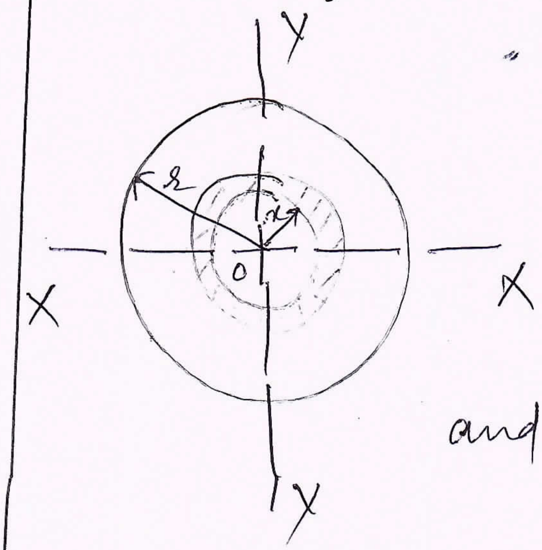
$\therefore G \equiv (20.41, 73.51)$ ———— 04M

Total 12M.

Module-5

Q.9.a) Find the moment of Inertia of a cir along its centroidal axis (I_{xx} & I_{yy}).

Ans: Consider a circular section of radius r as shown in fig, and O be the centre & X-X & Y-Y are the reference axes as shown



Now consider an elementary ring of radius x and thickness dx

$\therefore$ Area of the ring $= da = 2\pi x \cdot dx$

and the MI of ring about x-x & y-y axes

$= \text{Area} \times (\text{dist})^2$

$= 2\pi x \cdot x^2 dx$ —— (1)

Now MI of the whole section about the central axis can be found out by integrating ——— 05M eqn (1) for the radius of the ou i.e from 0 to r

$\therefore I_{zz} = \int_0^r 2\pi x^3 dx = 2\pi \int_0^r x^3 dx$

$I_{zz} = 2\pi \left[\frac{x^4}{4}\right]_0^r$

$= \frac{\pi}{2} r^4$ sub $r = d/2$

$\Rightarrow I_{zz} = \frac{\pi}{32} d^4$

we know that from ⊥er axis thm.

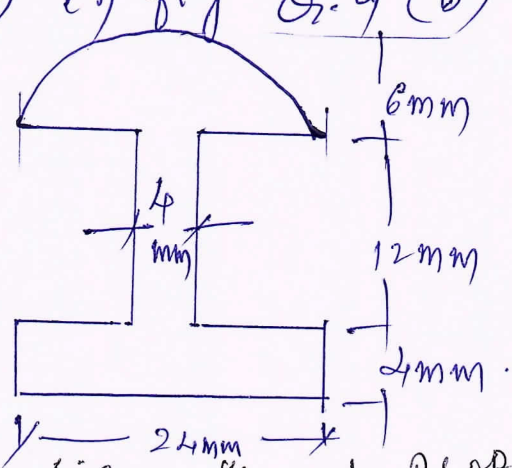
$I_{xx} + I_{yy} = I_{zz}$

$I_{xx} = I_{yy} = \frac{I_{zz}}{2} = \frac{1}{2} \cdot \frac{\pi}{32} d^4 = \frac{\pi}{64} d^4$

--- 05M

Total 10M.

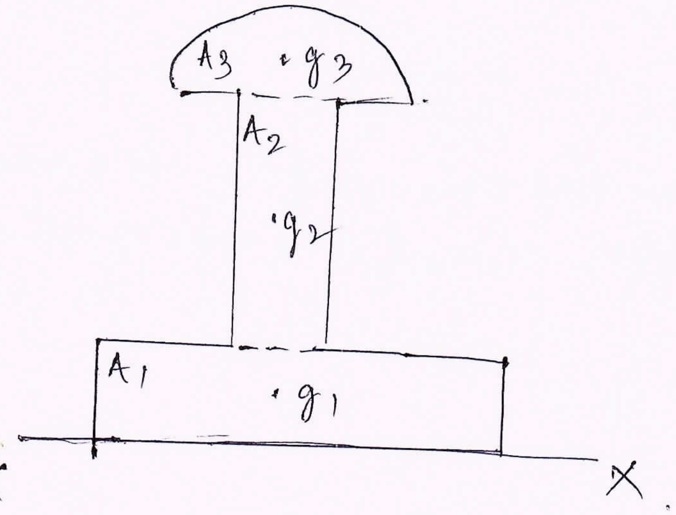
Q.9 b) Find the polar radius of gyration for the area shown in fig Q.9 (b)



Note: " The given figure is not proportional.

Soln Consider the following fig.

Let $A_1, A_2 \& A_3$ be the segmental area & $g_1, g_2 \& g_3$ be their centroids as shown in figure



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

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

$A_3 = \frac{\pi \times 6^2}{2} = 56.55\,mm^2$

$\Rightarrow \Sigma A = A_1 + A_2 + A_3 = 96 + 48 + 56.55 = 200.55\,mm^2$ — 02M

The given section is symmetric about Y-axis

$\Rightarrow \bar{X} = 0$

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

$$= \frac{96 \times 2 + 48 \times 10 + 56.55\left(16 + \frac{4 \times 6}{3\pi}\right)}{200.55}$$

$\bar{Y} = 8.58\,mm$ — 03M

Applying parallel axis theorem.

$$I_{xx} = \frac{24 \times 4^3}{12} + 96 \times 6.58^2 + \frac{4 \times 12^3}{12} + 48(1.42)^2 + 0.11 \times 6^4 + 56.55(9.97)^2$$

$I_{xx} = 10716.84\,mm^4$ — 02M

$$I_{yy} = \frac{4 \times 24^3}{12} + \frac{12 \times 4^3}{12} + \frac{\pi 6^4}{8}$$

$I_{yy} = 5180.94\,mm^4$ — 01M

$I_{zz} = I_{xx} + I_{yy} = 10716.84 + 5180.94$

$I_{zz} = 15897.78\,mm^4$ — 02M

$K = \sqrt{I_{zz}/\Sigma A} = \sqrt{15897.78/200.55}$

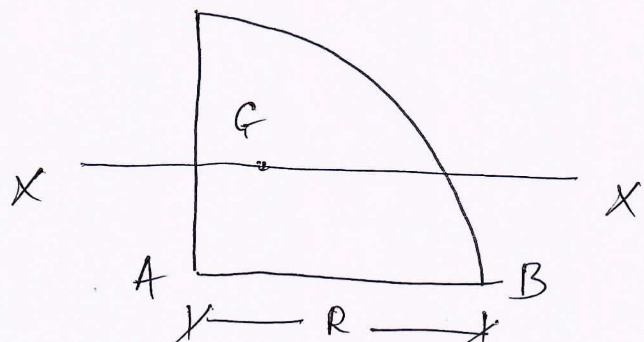
$K = 8.903\,mm$

Total 10M.

OR

Q.10 a) Derive an expression for moment of Inertia of a quarter circle with radius R.

Ans: Consider a Quarter circle as shown below in fig.



from first Principle: MI about base AB

$$I_{xx} = \int_0^R \int_0^{\pi/2} r^3 \sin^2\theta \, d\theta \, dr$$

$$= \int_0^R \int_0^{\pi/2} r^3 \left(\frac{1-\cos 2\theta}{2}\right) d\theta \, dr$$

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

$$= \left[\frac{r^4}{8}\right]_0^R [2\pi - 0 + 0 - 0]$$

$$= \frac{1}{4} \times \frac{\pi d^4}{64} = \frac{\pi d^4}{256} = \frac{\pi r^4}{16} \quad \text{---- 05M}$$

MI about centroidal axis X-X

Now the distance of centroidal axis y_c from the base is given by

and the area $A = \frac{1}{4} \frac{\pi d^2}{4} = \frac{\pi d^2}{16}$.

From the parallel axis theorem

$$I_{AB} = I_{xx} + Ay_c^2$$

$$\frac{\pi d^4}{256} = I_{xx} + \frac{\pi d^2}{16}\left(\frac{2d}{3\pi}\right)^2$$

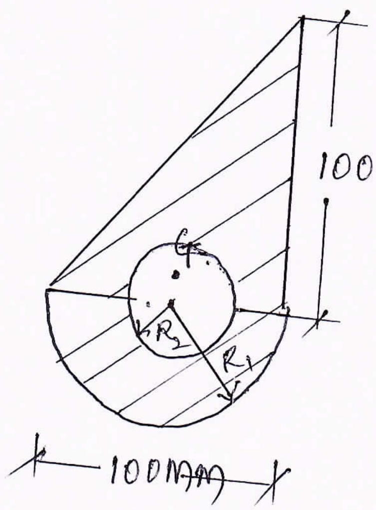
$$\Rightarrow I_{xx} = \frac{\pi d^2}{256} - \frac{\pi d^2}{36\pi}$$

$$\Rightarrow I_{xx} = 0.00343\, d^4$$

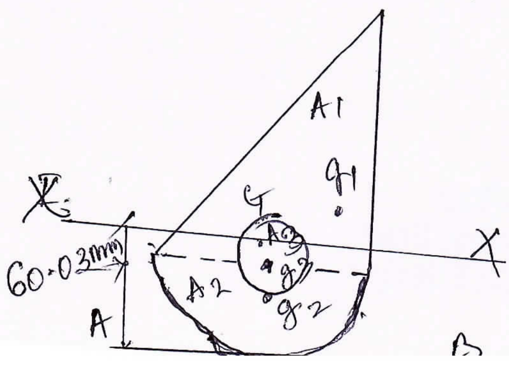
$$\Rightarrow \boxed{I_{xx} = 0.055 r^4}$$ ---- 05M

Total 10M.

Q.10 b) Determine the moment of Inertia in fig. Q.10(b) about horizontal centroidal axis. Also find the radius of gyration. Take $R_1 = 50mm$ and $R_2 = 20mm$



Sol^n Consider the following fig.



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

us determine G of given section from the axis shown in fig.

$A_1 = \frac{1}{2} \cdot 100 \times 100 = 5000\ mm^2$

$A_2 = \frac{\pi\, 50^2}{2} = 3926.99\ mm^2$

$A_3 = \frac{\pi\, 20^2}{2} = 628.32\ mm^2$

$\Sigma A = A_1 + A_2 - A_3 = 5000 + 3926.99 - 628.32$

$\Rightarrow \Sigma A = 8298.67\ mm^2$ ---- 03M

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

where $\bar{y}_1, \bar{y}_2$ & $\bar{y}_3$ be the y coordinates of g_1, g_2 & g_3 respectively.

$\bar{y} = \frac{5000 \times (50 + \frac{1}{3}100) + 3926.99 \times (50 - \frac{4 \times 50}{3\pi}) - 628.32(50)}{8298.67}$

$= \frac{416650 + 113016.18 - 31416.}{8298.67}$

$\boxed{\bar{Y} = 60.03\ mm}$ ------ 03M.

Applying parallel axis theorem.

$I_{xx} = I_{GG} + Ah^2$

$I_{xx} = \frac{100(100)^3}{36} + 5000 \times (23.3)^2 + \left[0.11(50)^4 + 3926.99(38.81)^2\right]$

$- \left[\frac{\pi\, 20^4}{4} + 628.32(10.03)^2\right]$

$= 5.4922 \times 10^6 + 6.6023 \times 10^6 - 0.1256 \times 10^6$

$- 0.06321 \times 10^6$

$\boxed{I_{xx} = 11.90569 \times 10^6\ mm^4.}$ ---- 03M

$K_{xx} = \sqrt{\frac{I_{xx}}{\Sigma A}} = \sqrt{\frac{11.9056 \times 10^6}{8298.67}}$

$\Rightarrow \boxed{K_{xx} = 37.88\ mm}$ ------ 01M

Total 10M.

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