Model Question Paper-I with effect from 2022

CBCS SCHEME

First Semester B.E Degree Examination

Introduction to Civil Engineering (BESCK104A)

TIME: 03Hours **Max.Marks:100**

NOTES:

1. *Answer any **FIVE** full questions, choosing at least **ONE** question from each **MODULE.***
2. *VTU Formula Hand Book is permitted.*
3. *M – Marks, L – Bloom's Level, C – Course Outcomes*

Q No.		Module - 1	M	L	C
Q.1	a	Explain scope of the following branches of Civil Engineering Disciplines i) Structural Engineering ii) Construction Planning and Project Management	10	L2	CO1
	b	Explain the following building materials along with their application in construction i) Cement Mortar ii) Pre-Stressed Concrete	10	L2	CO1
		OR			
Q.2	a	Explain scope of the following branches of Civil Engineering Disciplines i) Environmental Engineering ii) Hydraulics and Water Resource Engineering	10	L2	CO1
	b	Explain the following structural elements of a building with their functions i) Masonry Wall ii) Staircase	10	L2	CO1
		Module – 2			
Q.3	a	Define Sustainable Development Goals. List and explain the various goals of sustainable development set by United Nations.	10	L2	CO2
	b	Explain the causes of Urban Floods. List the remedial measures to control urban floods.	10	L2	CO2
		OR			
Q.4	a	Explain different methods to manage the solid waste in Urban Areas.	10	L2	CO2
	b	Explain the methods to control sound and temperature to create a conducive atmosphere in a building.	10	L2	CO2
		Module – 3			
Q.5	a	State and Prove Parallelogram Law of Forces.	10	L2	CO3
	b	Determine the resultant of a given system of force Fig.5(b) about point A	10	L3	CO3

Model Question Paper-I with effect from 2022

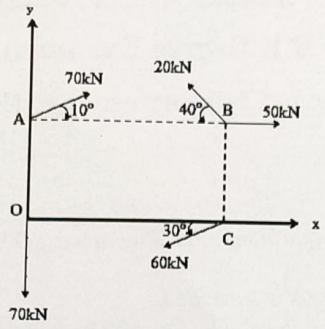


Fig. 5(b)

OR

Q.6	a	Explain the basic idealizations in Engineering mechanics.	10	L2	CO3
	b	Two cylinders are placed in a ditch as shown in Fig.6(b) Determine the reactions at all the contact surfaces (A, B, C, D).	10	L3	CO3

	Radius	Weight
Cylinder 1	100 mm	2000 N
Cylinder 2	50 mm	800 N

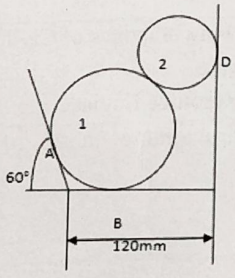


Fig.6(b)

Module – 4

Q.7	a	Derive an expression to locate the centroid of a semicircle.	8	L2	CO4
	b	Determine the centroid of the shaded region shown in Fig.7(b) about x and y axis.	12	L3	CO4

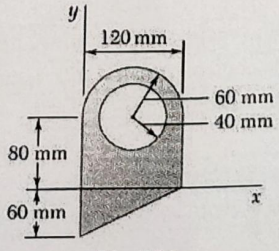


Fig.7(b)

OR

Q.8	a	Derive an expression to locate the centroid of a rectangle.	8	L2	CO4

	b	Determine the centroid of the shaded region shown in Fig.8(b) about x and y axis.	12	L3	CO4

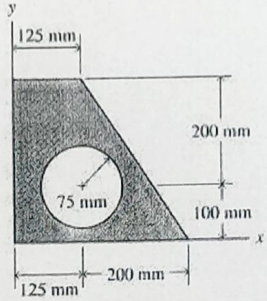


Fig.8(b)

Module – 5

Q.9	a	Derive an expression to locate the moment of inertia of a Triangle.	8	L2	CO5
	b	Determine the moment of inertia of the shaded region shown in Fig.9(b) about reference x and y axis.	12	L3	CO5

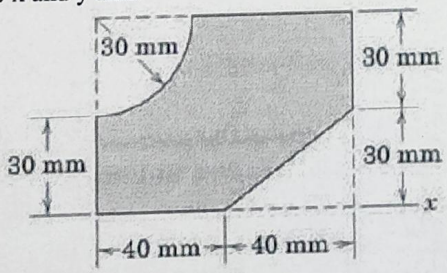
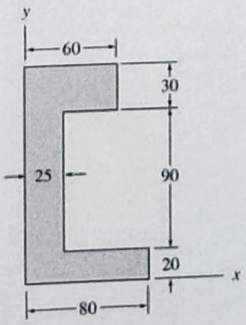


Fig.9(b)

OR

Q.10	a	Derive an expression to locate the moment of inertia of a circle.	8	L2	CO5
	b	Determine the polar moment of inertia of the shaded region shown in Fig.10(b)	12	L3	CO5



Dimensions in mm

Fig.10(b)

Solution and Scheme for award of marks

University Model QP - Set1 **AY: 2022-23(ODD)**

Department: Civil Engineering
Subject with Sub .Code: ICE(BESCK104A) **Semester / Division: I sem . C Div & A Div**
Name of Faculty: Prof. S.G.Hiremath & Dr. Ashik. B.

Q.No.	Solution and Scheme	Marks
1a)	Explain the scope of the following branches of Civil engineering Disciplines.	10M
	i) Structural Engineering ii) Construction planning & project Management.	
Ans:	i) Structural Engineering. Load acting on a structure is ultim-ately transferred to ground. In doing so, various components of the structure are subjected to internal stresses. Assessing the internal stresses in the components of a structure is known as structural analysis and finding the suitable size of the components is called design of Structures. To get economical sections mathematical optimization techniques are used. Frequent earthquakes in the recent years have brought importance of structural analysis for earthquake forces also. --- ii) Construction planning & project Management Construction is the major activity of civil engineering which is continuously improving. As land cost is going up	05M

Q.No.	Solution and Scheme	Marks
	there is a demand for the tall structures in urban areas while in rural areas need is for low cost construction. In India, contribution of Central Building Research Institute (CBRI)- Roorkie & Gaziabad & several educational institutions throughout the country and Nirmiti kendras in the development of Construction technology are note worthy.	05M
	Total	10M.
1 b)	Explain the following building Materials along with their application in Construction. i) Cement Mortar ii) Pre-stressed conc.	10M.
Ans:	i) Cement Mortar: The term, cement mortar is used to indicate a paste prepared by adding required quantity of water to a mixture of cement & fine aggregates like Sand.	— 02
	Applications 1. To form joints of RCC pipes. 2. To bind the building units such as bricks, stones etc in to a solid mass. 3. To carryout pointing & plastering works on exposed Surface of masonery.	

Q.No.	Solution and Scheme	Marks
	4. To improve the general appearance of structure. 5. To hide the open joints of brickwork and stone work. 6. To fill up the cracks detected in the structure during maintenance process.	03
	~~Total~~	~~10M~~
	ii) Pre-Stressed concrete: PSC is a form of concrete used in construction where initial compression is given in the concrete before applying the external load so that stress from external loads is counteracted in the desired ways during the service period. This initial compression is introduced by high-strength steel or alloys (called tendons) located in the concrete section.	03
	Applications: 1. PSC is used in the construction of super structure of bridges, runways. 2. It is used in the construction of water tanks, tall columns and retaining walls.	02
	Total	10M.
	OR	
2a.	Explain the scope of following branches of civil engineering Disciplines. i) Environmental engg. ii) Hydraulics & water resource engineering.	10

Q.No.	Solution and Scheme	Marks

ii) Environmental Engineering

Proper distribution of waters to rural areas, towns & cities and disposal of wastewaters and solid wastes are another fied of civil engineering which is called as environmental engineering. Industrialization and increased vehicular traffic are creating air pollution problems. Environmental engineering tackling all these problems provides healthy environment to public. 05M.

iii) Hydraulics & Water resourse engg.

Hydraulics.

Water is an important need for all living beings. Study of mechanics of water and its flow characteristics is another important field in civil engineering and it is known as "Hydraulics" 02

Water resource engineering:

Water is tobe supplied to agriculture fields and for drinking purposes. Hence suitable waters resources are to be identified and water is to be stored. Identifying, planning and building waters retaing structures like tanks, dams and carrying stored waters to the fields is known as waters resourse engg. 03

Total 10M

Q.No.	Solution and Scheme	Marks
2b	Explain the following structural elements of a building with their functions. i) Masonry wall ii) Staircase.	10M.
Ans:	**i) Masonry wall**	
	Masonry walls are vertical components constructed to devide the space into different rooms. Walls transfers load of roofs and live load above it to the foundation. - - -	01
	Functions:	
	1. Main function of masonry wall is to devide the space into rooms.	
	2. Wall support the loads from the roof / upper floors to the foundation	
	3. Help in the provision of opening like doors, windows etc.	
	4. Provides space for exterior decoration for the rooms. - - -	04
	ii) Staircase:	
	A stair is a set of steps leading from one floor of building to another, typically inside building. the room or enclosure of building in which the stair is located is known as "staircase". - - -	02

Q.No.	Solution and Scheme	Marks
	Functions:	
	1. The primary purpose of staircase is to provide a simple and easy way or means of moving between levels in a building.	
	2. In modern buildings, the structure of staircase can serve as: a partition to break up a large open plan area or even it provides space for storage of materials.	
	3. Staircase enhance the aesthetic appearance of the building in addition to providing access between floor. — — — —	03
	Total	10M
	Module 2	
3 a)	Define Sustainable development Goals. List and explain the various goals of Sustainable development set by United nation.	10M.
Ans:	The "SDGs" are the set of goals for fair & sustainable health at every level from planetary biosphere to local community. The aim is to end poverty, protect the planet and ensure that all people enjoy peace & prosperity, now and in the future.	
	The SDGs were adopted all member states of united nations	

Q.No.	Solution and Scheme	Marks

formally in 2015 for the period of 2016-30. And these are related to people, planet, prosperity, peace and partnership & the nos of 17 as follows. 03M.

List of min 08 goals among 17 goals

* People

Goal 1: No poverty
Goal 2: Zero hunger
Goal 3: Good health & well being.
Goal 4: Quality education.
Goal 5: Gender Equality
Goal 6: Clean water & sanitation.

* Prosperity:

Goal 7: Affordable clean energy.
Goal 8: Decent work and economic development.
Goal 9: Industry innovation and infrastructure
Goal 10: Reduce Unequalities.
Goal 11: Sustainable cities & Communities
Goal 12: Responsible consumption & production.

* Planet:

Goal 13: climate action
Goal 14: Life below water

Q.No.	Solution and Scheme	Marks
	Goal 15: Life on Land * Peace & partaner ships. Goal 16: Peace, justice and strong institutions. Goal 17: partnership for the goal - - - Brief explaination of any three goals.	04M 03M Total 10M.
3b)	Explain the causes of urban floods. List the remedial measures to control urban floods.	10M.
Ans:	"Floods" can be defined as submergence of usually dry areas by large of water that comes from sudden excessive rainfall, an overflowing river or lake etc. Unplanned development and encroachment by the people alongside rivers and water courses will results in the increased runoff & Ultimately results in floods - - - -	04
	* Controlling Measures: 1. Adopting innovative approaches like sponge cities, wetland restoration etc. 2. Early warning system and communi-cation with the help of weather	

Q.No.	Solution and Scheme	Marks
	Report about rain, water level in the rivers etc.	
	3. Designing & managing the urban drainage system.	
	4. Avoiding the blockage of sewerlines with solid wastes which reduces the water carrying capacity of sewers.	
	5. Rainwater harvesting should be adopted to increase the ground water table which is decreased due to urbanization.	
	6. Conserving the urban water bodies like lakes, tanks, ponds etc. - - -	06
	Total	10M.
	OR.	
4 a)	Explain different methods to manage the solid waste in urban areas - - - -	10M.
Ans:	Following are the different methods to manage the solid wastes in urban areas.	
	1. Sanitary landfill: This is the most popular solid waste disposal method used today. In this method garbage is basically spread out in thin layers compressed and covered with soil or plastic foam. When the landfill is full	

Q.No.	Solution and Scheme	Marks

it is covered with layers of sand, clay top soil and gravel to prevent seepage of water.

2. Incineration: this method involves the burning of solid wastes at high temperatures until the wastes are turned into ashes. Incinerators are made in such a way that they do not give off extreme amounts of heat when burning solid wastes. this method of SWM can be done by individuals, municipalities and even institutions.

3. Recovery & Recycling: It is the process of taking useful but discarded items for the next use. plastic bags, tin, glass and containers are often recycled automatically since, in many situations, they are likely to be scarce commodities.

4. Composting: Due to lack of adequate space for landfills, biodegradable yard waste is allowed to decompose in a medium designed for the purpose. Only biodegradable waste materials are used in composting. Good quality manure is formed in composting method.

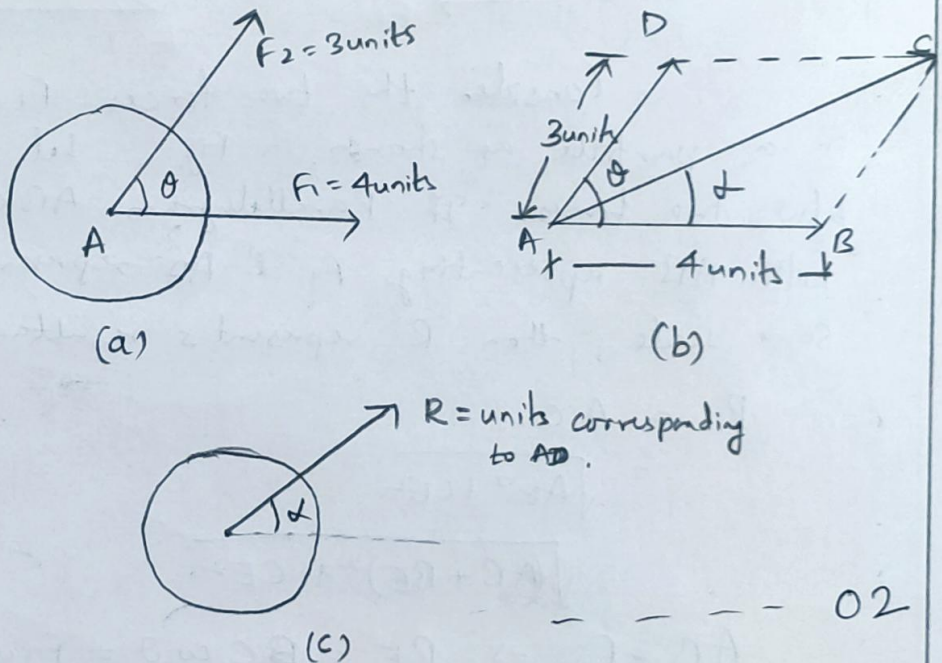
Q.No.	Solution and Scheme	Marks
	5. Pyrolysis: This is a method of SWM whereby solid wastes are chemically decomposed by heat without presence of oxygen. It usually occures under pressure and at temperatures of up to 430°c. The solid wastes are changed in to grasses, solid residue of carbon and ash and small quantity of liquid.	05x 02
	Total	10M
4b)	Explain the methods to control sound and temperature to create conducive atmosphere in a building.	10M.
	* Sound control in building:	
	Sound in a building are of two kinds those that are wanted and those that are objectionable. The unwanted sounds should be eliminated as far as possible, while the wanted sounds should be adjusted for comfortable hearing. this process is called sound control in building.	02
	Methods of sound control:	
	1. Providing air openings between rooms such as ventilators, openings under & around the door etc.	
	2. Ventilators can be equipped with baffles and lined with sound absorbing	

Q.No.	Solution and Scheme	Marks
	materials, doors & windows can be made tight fitting. 3. Using common building materials such as gypsum boards, wood, conc blocks & tile are fairly reflective do not absorb much sound. The use of sound absorbing materials such as carpet foam padding, fibre glass insulation can be helpful in controling sound in a building.	03M.
	ii) Temperature control in buildings: Temperature control in building refers to the process of keeping the interior of a building at a comfortable, uniform & regulated temperature. ---	01
	The temperature control can be achieved by the following methods. i) Air conditioning system. ii) Heating system. iii) Low budget heating & cooling systems like. a) Fans & Portable heaters b) Reflecting & screening. c) Insulating floor coverings. --- d) Insulating materials.	04
	Total	10M.

(Q.5) a). State and Prove Parallelogram Law of forces

" If two forces acting simultaneously on a body at a point are represented in magnitude and direction by the two adjacent sides of a parallelogram, their resultant is represented in magnitude and direction by the diagonal of the parallelogram which passes through the point of intersection of the two sides representing the forces." ---03M

Proof :-



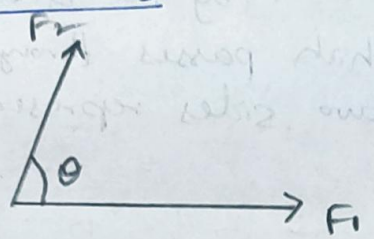
---02

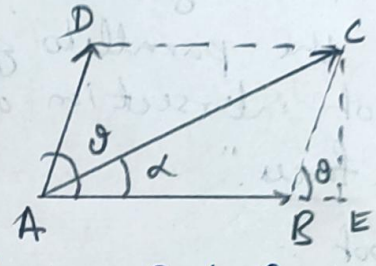
In figure, the force $F_1 = 4kN$ and $F_3 = 3kN$ are acting on a body at point A simultaneously. Then to get the resultant of these two forces, a parallelogram ABCD is constructed such that AB is equal to 4units. (say 40mm). and AC is 3units (say 30 mm).

Then according to the law the diagonal AD represents the resultant in direction & magnitude. Thus the resultant of forces F_1 & F_2 on a body is equal to units corresponding to AD (10mm = 1kN).

Hence proved graphically. ——— 02 M

Mathematically





Consider the two forces F_1 & F_2 acting on a particle as shown in Fig. Let θ be the angle b/w two forces. If Parallelogram ABCD is constructed, with AB representing F_1 & AD representing F_2 to some scale, then 'R' represents resultantants.

$$R = AC$$

$$= \sqrt{AE^2 + CE^2}$$

$$= \sqrt{(AB + BE)^2 + CE^2}$$

$AB = F_1 \Rightarrow BE = BC\cos\theta = F_1\cos\theta$

$CE = BC\sin\theta = F_2\sin\theta$

$$R = \sqrt{(F_1 + F_2\cos\theta)^2 + (F_2\sin\theta)^2}$$

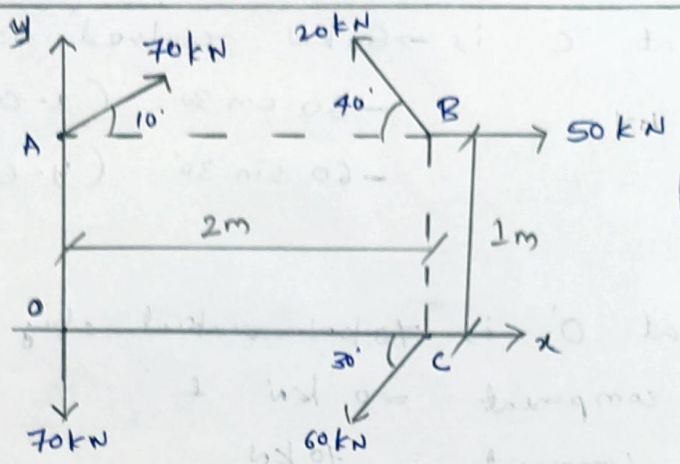
$$= \sqrt{F_1^2 + F_2^2\cos^2\theta + F_2^2\sin^2\theta + 2F_1F_2\cos\theta}$$

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

$$\alpha = \tan^{-1}\left(\frac{F_2\sin\theta}{F_1 + F_2\cos\theta}\right)$$ ——— 03 M

Total: 10M.

Q.5) b)

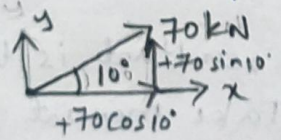


Note :- The distance OC & BC are not given in the question paper. Let us assume OC = 2 m & BC = 1 m to solve the problem.

Since the forces are not acting on a single point. This problem is a coplanar - non concurrent force system problem.

Step 1 :- Resolve the forces in x & y direction / resolve into horizontal and vertical components

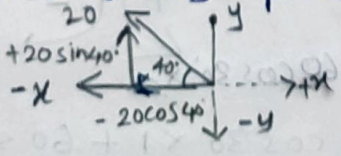
Forces at 'A' point → '70 kN' resolved into



+ 70 cos 10° — x-component

+ 70 sin 10° — y-component.

Forces at 'B' point → '20 kN' resolved into



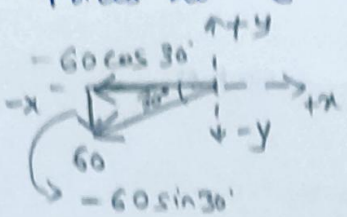
- 20 cos 40° — x-component

+ 20 cos 40° — y-component.

'50 kN' is acting along x axis

50 kN — x component & 0 — y component

Forces at 'C' is → 60 kN. resolved into.



$-60\cos 30'$ (x-component)

$-60\sin 30'$ (y-component)

Forces at 'O' is 70 kN vertical along y axis.

x component = 0 kN &

y component = 70 kN.

Step 2 :-

$\Sigma F_x = +70\cos 10' + 50 - 20\cos 40' - 60\cos 30'$

$= 51.65$ kN ——— 02 M

$\Sigma F_y = +70\sin 10' + 20\sin 40' - 60\sin 30' - 70$

$= -74.98$ kN ——— 02 M

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

$\therefore R = 91.055$ kN ——— 01 M

Step 3 :- Since in the question resultant is to be determined from point 'A'. Take moment at pint 'A'.

(+) ↙ (-) ↘

$\Sigma M_A = -20\sin 40' \times 2 + 60\cos 30' \times 1 + 60\sin 30' \times 2$

$\therefore \Sigma M_A = 86.25$ kN-m ——— 03

Note :- The forces 70 kN at point O, 70 kN at A. 20 cos 40' & 50 kN will pass through point 'A' & perpendicular distance is zero

Step 4 :-
From Varignon's theorem :-

$$R \times d = \Sigma M_A$$

$$\Rightarrow \quad d = \frac{\Sigma M_A}{R}$$

$$\therefore \quad d = 0.9472 \text{ m}$$

Step 5 :- $\tan\theta = \left|\frac{\Sigma F_y}{\Sigma F_x}\right|$

$$\theta = \tan^{-1}\left(\frac{74.98}{51.65}\right)$$

$$\therefore \quad \theta = 55.4389^\circ$$

$$\therefore \quad \theta \simeq 55.44^\circ$$

Step 6 :- x intercept $= \left|\frac{\Sigma M_A}{\Sigma F_y}\right|$

$$= \left|\frac{86.25}{74.98}\right|$$

$$= 1.15 \text{ m}$$

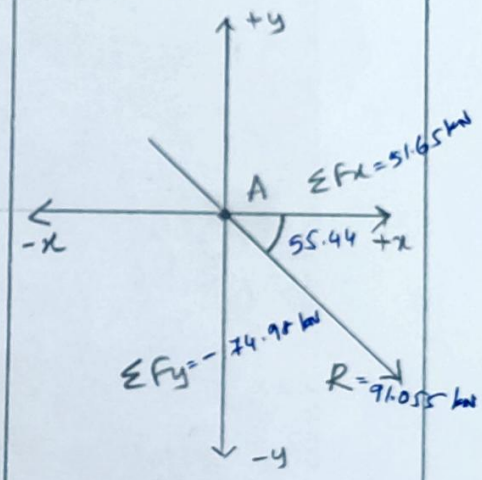
y intercept $= \left|\frac{\Sigma M_A}{\Sigma F_x}\right|$

$$= \left|\frac{86.25}{51.65}\right|$$

$$= 1.67 \text{ m} \quad - - -$$

02 M.

Step : 7



Total : 10 M.

Q.NO:- 6) a). The basic idealizations in Engineering Mechanics :-

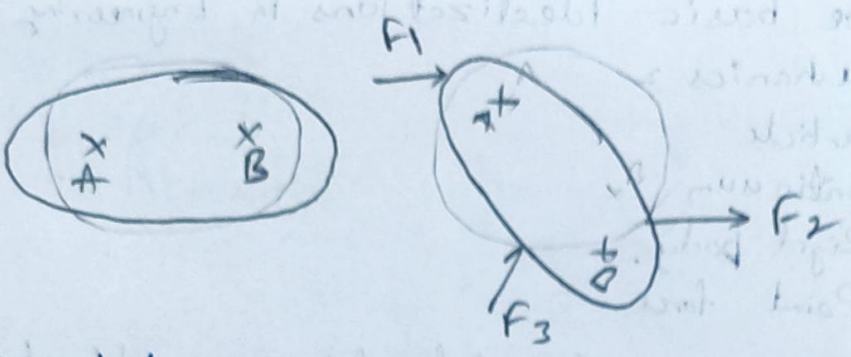
→ Particle
→ Continuum
→ Rigid body.
→ Point force

→ A particle may be defined as an object which has only mass but no size. Such body cannot exist theoretically. However, while dealing with problems involving distances considerably larger when compared to the size of the body.

Ex:- A bomber aeroplane is a particle for gunner operating from ground. ---- 03M

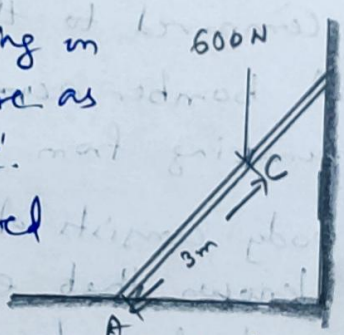
→ A body consists of several particles. It is well known that each particle can be subdivided into molecules, atoms & electrons. The body is assumed to consists of numerous continuous distribution of matter. In other words, the body is treated as a continuum. The concept of continuum of bodies enables us to simplify the problems of engineering mechanics. ---------- 02M

→ A rigid body, may be defined as a body in which relative positions of any two particles do not change under the action of forces. For example, consider a body in figure shown below.



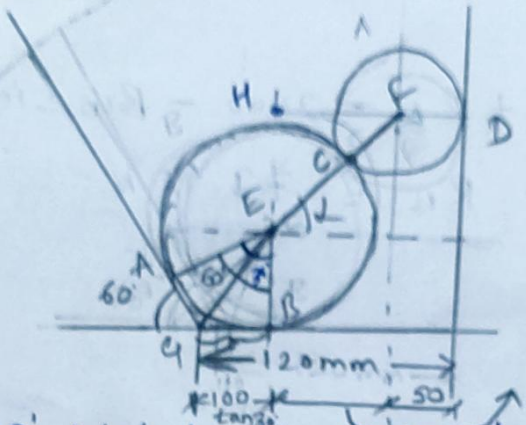
The distance between two points A & B is unaltered. ---03

→ Point force :- It is yet another idealization very commonly used in engineering mechanics problem. The weight of the man standing on a ladder is shown in figure as a force applied at point 'C'. The contact area is ignored in engineering mechanics problem. Not much accuracy is lost by treating it as point force and thereby simplifying the problem. ---02



Total: 10M.

Q. 6) b)



Δle GEH & EHF are concurrent/Conjugate Δles.

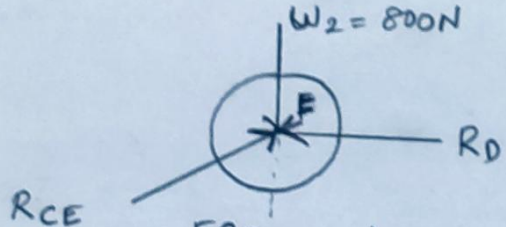
EF = 100 + 50 = 150 mm

HF = ?

120 − 50 − 100 tan 30° = 12.26 mm

Let 'E' & 'F' be the centres of circle 1 & 2 respectively

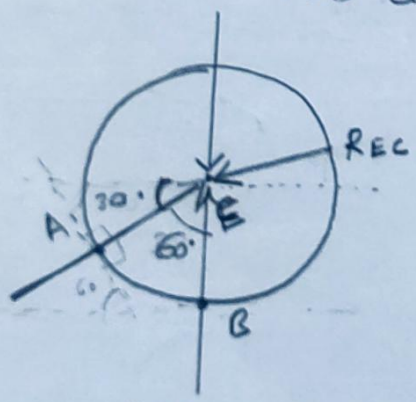
Step 1 :- Draw the FBD for circle 1 & 2



FBD circle 2

$\cos\alpha = \frac{120 - 50 - 100\tan 30°}{150}$

$\therefore \alpha = 85.3°$ — 01M



FBD Circle 1

Applying Lami's theorm to circle 1 we get

$\frac{R_{CF}}{\sin 90°} = \frac{R_D}{\sin(175.3)} = \frac{800}{\sin(180° - 85.3)}$

$\Rightarrow R_{CF} = 799\ N. = R_{CE}$

$\therefore R_D = 65.47\ N.$ — 02

Applying equilibrium eqns on circle 1.

$\Sigma F_n = 0.$

$R_A \cos 30° - R_{CE} \cos 85.3° = 0$

$\Rightarrow \therefore R_A = 75.59\ N.$ — — — — — 02M.

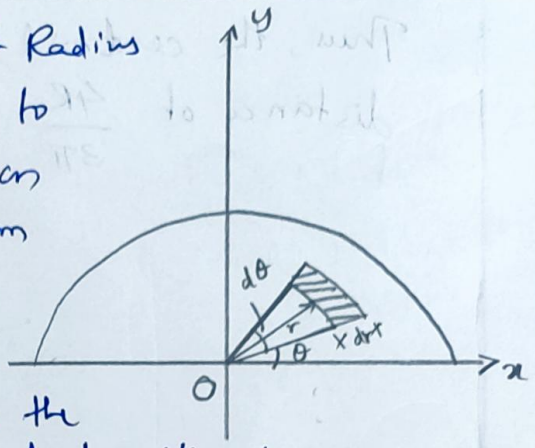
$\Sigma f_y = 0$.

$R_A \sin 30^\circ + R_B - 2000 - R_E \sin 85.3^\circ = 0$.

$\Rightarrow \therefore R_B = 73.78\ N$ ------ 02M

Total 10M.

Q.NO:- 7) a) Consider a semicircle of Radius R as shown in figure Due to symmetry centroid must lie on y-axis. Let its distance from diametrical axis be $\bar{y}$.



To find $\bar{y}$, consider an element at a distance r from the centre 'O' of the semicircle, radial width being dr and bound by radii at θ & θ + dθ

The elemental area may be treated as rectangle of sides rdθ & dr. Hence

Area of element = r dθ dr

Its moment about diametrical axis x is given by

$r d\theta \times dr \times r\sin\theta = r^2 \sin\theta \, dr \, d\theta$ ---- O&M.

∴ Total moment of area about diametrical axis,

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

$$= \frac{R^3}{3}[-\cos\theta]_0^{\pi}$$

$$= \frac{R^3}{3}[1+1] = \frac{2R^3}{3}$$

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

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

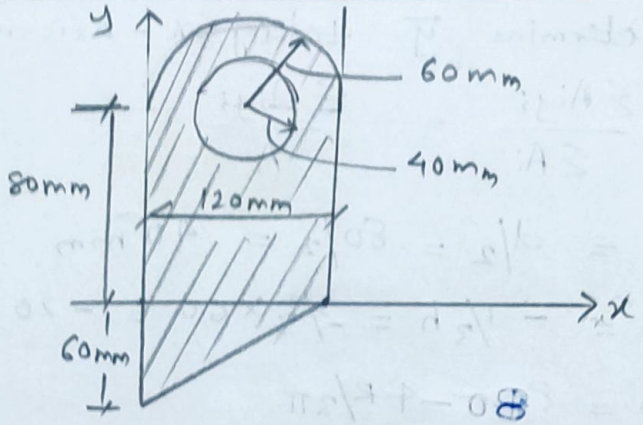
$$\Rightarrow \frac{2R^3/3}{1/2\,\pi R^2} = \frac{4R}{3\pi}$$

Thus, the centroid of the circle is at a distance of $\frac{4R}{3\pi}$ from the diametrical axis.

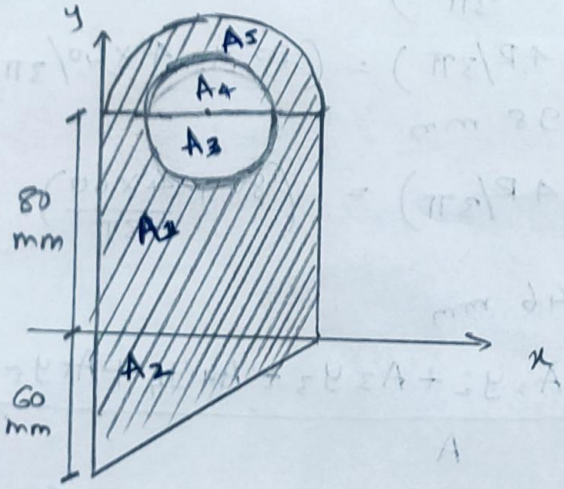
— — — 04M

Total 08M

Q.7) b)



Step 1 :- Divide the area into simple figures.



A_1 is rectangle
A_2 is a triangle.
A_3 is semicircular hole.
A_4 is semicircular hole.
A_5 is semicircle

Step 2 :- Determine the areas of simple fgue and add to get total area

$A_1 = b \times d = 120 \times 80 = 9600\ mm^2$

$A_2 = \frac{1}{2} \times b \times h = \frac{1}{2} \times 120 \times 60 = 3600\ mm^2$

$A_3 = -\frac{\pi R^2}{2} = A_4 = -\frac{\pi \times 40^2}{2} = -2513.27\ mm^2$

$A_5 = \frac{\pi R^2}{2} = \frac{\pi \times 60^2}{2} = 5654.87\ mm^2$

$\therefore \Sigma A_i = A_1 + A_2 - A_3 - A_4 + A_5$

$\therefore A = 13828.47\ mm^2$ ——— 04M

Step 3 :- Determine $\bar{y}$ taking x-axis reference.

$$\bar{y} = \frac{\Sigma A_i y_i}{\Sigma A_i} = \frac{\Sigma A_i y_i}{A}$$

$\Rightarrow$ $y_1 = d/2 = 80/2 = 40$ mm

$y_2 = -1/3\,h = -1/3 \times 60 = -20$ mm

$y_3 = 80 - 4R/3\pi$

$= \left(80 - \frac{4 \times 40}{3\pi}\right) = 63.023$ mm.

$y_4 = (80 + 4R/3\pi) = (80 + 4 \times 40/3\pi)$

$= 96.98$ mm

$y_5 = \left(80 + 4R/3\pi\right) = \left(80 + \frac{4 \times 60}{3\pi}\right)$

$= 105.46$ mm

$$\therefore \bar{y} = \frac{A_1 y_1 + A_2 y_2 + A_3 y_3 + A_4 y_4 + A_5 y_5}{A}$$

$$= \frac{9600 \times 40 + 3600 \times (-20) - 2513.27 \times 63.023 - 2513.27 \times 96.98 + 5654.87 \times 105.46}{13828.47}$$

$\therefore \bar{y} = 36.607$ mm ——— 04 M.

Step 4 :- Determine $\bar{x}$ taking y-axis reference

$$\bar{x} = \frac{\Sigma A_i x_i}{\Sigma A_i} = \frac{\Sigma A_i x_i}{A}$$

$x_1 = b/2 = 120/2 = 60$ mm

$x_2 = b/3 = 120/3 = 40$ mm

$x_3 = x_4 = x_5 = \frac{120}{2} = 60$ mm

A_3, A_4 & A_5 are symmetrical about vertical y-axis.

$$\therefore \bar{x} = \frac{\Sigma A_i x_i}{A}$$

$$= \frac{A_1x_1 + A_2x_2 + A_3x_3 + A_4x_4 + A_5x_5}{A}$$

$$= \frac{9600 \times 60 + 3600 \times 40 - 2 \times 2513.27 \times 60 + 5654.87 \times 60}{13828.47}$$

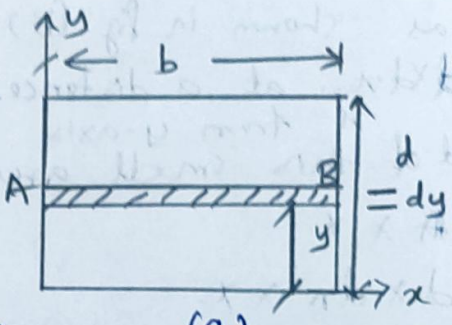
$$\therefore \bar{x} = 54.79 \text{ mm} \quad - - - - - \quad 04M$$

The centroid of shaded region is

$$(\bar{x}, \bar{y}) = (54.79, 36.61) \qquad \text{Total: 10M.}$$

Q. NO:- 8) a) Derive expression to locate the centroid of a rectangle.

Ans :-



(a)

Consider a rectangle having width 'b' & depth 'd'. Let x & y be reference axes as shown in figure 'a'.

Let us consider a small area dA - AB having width 'b' and depth 'dy' at a distance of 'y' from x - axis.

$dA = b\,dy$ ---02M

Moment of area of small strip AB is $yA = y \times b\,dy$.

By definition, $\bar{y} = \Sigma Ai yi / \Sigma Ai$.

$\therefore \Sigma Ai yi = \int_0^d y\,b\,dy$.

$= b \int_0^d y\,dy$

$= b \left[\frac{y^2}{2}\right]_0^d$

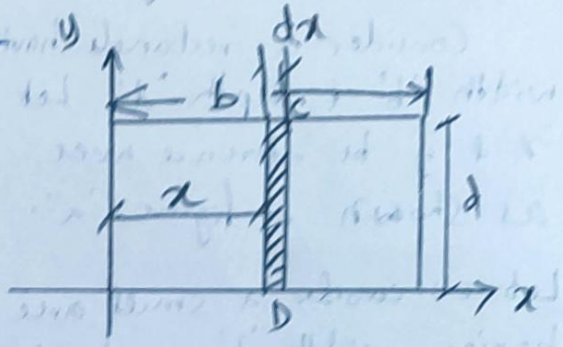
$= \frac{bd^2}{2}$

Area of rectangle $= \Sigma Ai = bd$.

$\Rightarrow \bar{y} = \frac{bd^2}{2} \Big/ bd$

$\therefore \bar{y} = \frac{d}{2}$ ---03M.

To find $\bar{x}$, Let us have an ~~vertical~~ vertical strip CD as shown in fig. (b), having an area $dA = d \times dx$, at a distance x from y-axis



Moment of this small area

$= dA \times x$

$= d \times dx \times x$

$$\bar{x} = \frac{\Sigma A_i g_i}{\Sigma A_i}$$

$$\Sigma A_i x_i = \int_0^b x \, dx \cdot d$$

$$= d \int_0^b x \, dx$$

$$= d \times \left[\frac{x^2}{2}\right]_0^b$$

$$= \frac{b^2 d}{2}$$

ΣA_i = Area of rectangle $= bd$

$$\Rightarrow \bar{x} = \frac{\frac{b^2 d}{2}}{bd}$$

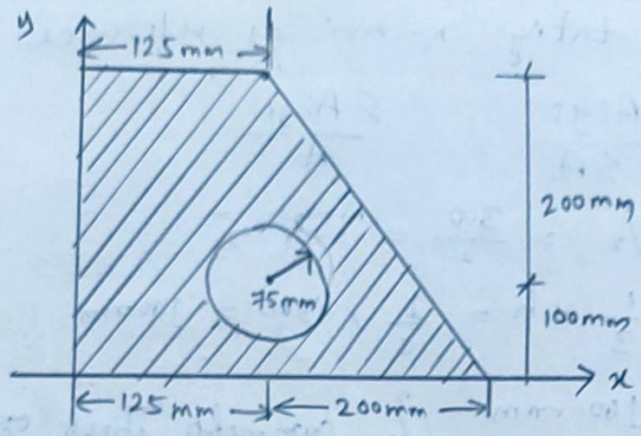
$$\therefore \bar{x} = b/2$$

Therefore, centroid of rectangle $\Rightarrow (\bar{x}, \bar{y}) = (b/2, d/2)$

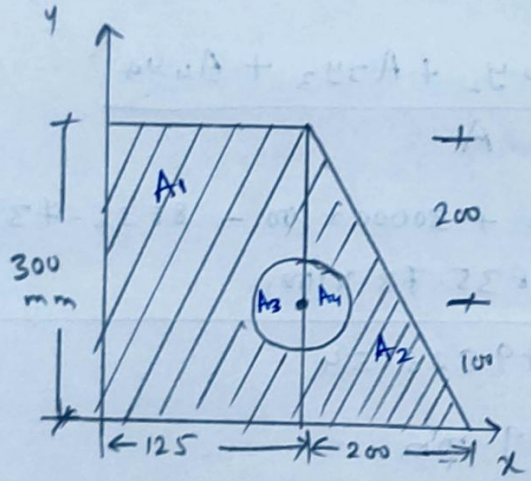
0.5M

Total 0.5M.

(Q. 8) b)



Step 1 :- Divide the area into simple figures.



A_1 is rectangle
A_2 is triangle.
$A_3 = A_4 =$ is semicircular hole.

Step 2 :- Determine areas of the simple figures and add to get total area

$$A_1 = b \times d = 125 \times 300 = 37500 \text{ mm}^2$$

$$A_2 = \frac{1}{2} \times b \times h = \frac{1}{2} \times 200 \times 300 = 30000 \text{ mm}^2$$

$$A_3 = -\frac{\pi R^2}{2} = A_4 = -\frac{\pi \times 75^2}{2} = -8835.73 \text{ mm}^2$$

$$A = A_1 + A_2 - A_3 - A_4$$

$$= 37500 + 30000 - 2 \times 8835.73$$

$$\therefore A = 49828.54 \text{ mm}^2 \quad \text{-------} \quad 04M$$

Step 3:- Determine $\bar{y}$ taking x-axis as reference.

$$\bar{y} = \frac{\Sigma A_i y_i}{\Sigma A_i} = \frac{\Sigma A_i y_i}{A}$$

$y_1 = d/2 = \frac{300}{2} = 150 mm$

$y_2 = \frac{1}{3} \times h = \frac{1}{3} \times 300 = 100 mm$

$y_3 = 100 mm$
$y_4 = 100 mm$
} Symmetric about y axis

$$\bar{y} = \frac{A_1 y_1 + A_2 y_2 + A_3 y_3 + A_4 y_4}{A}$$

$$= \frac{37500 \times 150 + 30000 \times 100 - 8835.73 \times 100 - 8835.73 \times 100}{49828.54}$$

$\therefore \bar{y} = 137.629 mm$ ---- 04M.

Step 4:- Determine $\bar{x}$ taking y-axis as reference

$$\bar{x} = \frac{\Sigma A_i x_i}{\Sigma A_i} = \frac{\Sigma A_i x_i}{A}$$

$x_1 = b/2 = 125/2 = 62.5 mm$

$x_2 = 125 + 1/3 \times 200 = 191.67 mm$

$x_3 = 125 - \frac{4R}{3\pi} = 125 - \frac{4 \times 75}{3\pi}$

$\therefore x_3 = 93.169 mm$

$x_4 = 125 + 4R/3\pi = 125 + (4 \times 75/3\pi)$

$\therefore x_4 = 156.831 mm$

$$\therefore \quad \bar{x} = \frac{\sum A_i x_i}{A}$$

$$= \frac{A_1 x_1 + A_2 x_2 + A_3 x_3 + A_4 x_4}{A}$$

$$= \frac{37500 \times 62.5 + 30000 \times 191.67 - 8835.73 \times 93.169 - 8835.73 \times 156.831}{49828.54}$$

$$= 118.10335 \text{ mm}.$$

$$\therefore \quad \bar{x} = 118.103 \text{ mm}.$$

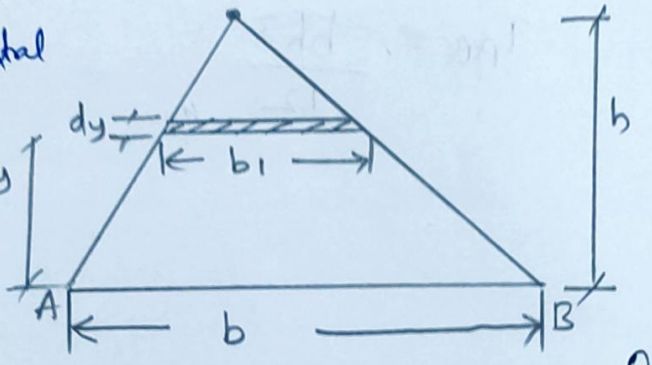
$\therefore$ The centroid of shaded region is.

$(\bar{x}, \bar{y}) = (118.103, 137.629)$ ---- 04M

Total 12M.

Q.9) a) Derive an expression to locate the moment of a triangle.

Consider an elemental strip at a distance 'y' from base AB. Let dy be the thickness of the strip and dA its area.



02

Width of the strip is given by

$$b_1 = \frac{(h-y)}{h} \times b.$$

Moment of inertia of this strip about AB.

$$= y^2 dA$$

$$= y^2 b_1 dy$$

$$= y^2 \frac{(h-y)}{h} \times b \times dy$$

∴ Moment of Inertia of the triangle about AB

$$I_{AB} = \int_0^h \frac{(y^2)(h-y)\, b\, dy}{h}$$

$$= \int_0^h \left(y^2 - \frac{y^3}{h}\right) b\, dy.$$

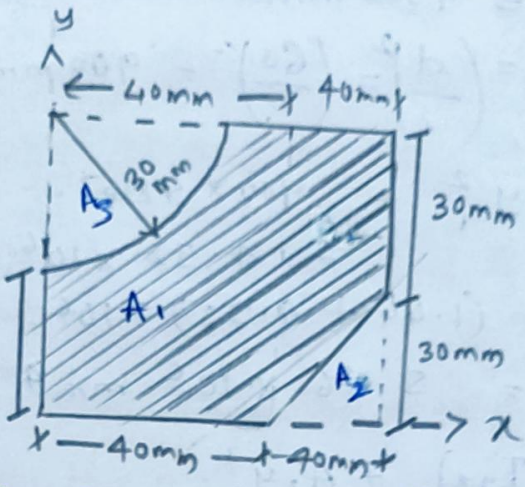
$$= b\left[\frac{y^3}{3} - \frac{y^4}{4h}\right]_0^h$$

$$= b\left[\frac{h^3}{3} - \frac{h^4}{4h}\right]$$

$$\therefore I_{AB} = \frac{bh^3}{12} \quad \text{//} \qquad \text{— — —} \qquad 06\,M$$

Total: 08M.

Q. 9) b)



Step 1 :- Divide the area into simple figures

A_1 is a rectangle with $b = 80mm$ & $d = 60mm$.

A_2 is a ~~triangle~~ with $b = 40mm$ & $h = 30mm$.

A_3 is a quarter of a O^{le} with $R = 30mm$

$$\Rightarrow \quad A_1 = b \times d = 80 \times 60 = 4800\ mm^2.$$

$$A_2 = -1/2 \times 40 \times 30 = -600\ mm^2$$

$$A_3 = -\frac{\pi R^2}{4} = -\frac{\pi \times 30^2}{4} = -706.86\ mm^2$$

$$A = A_1 - A_2 - A_3$$

$$= 4800 - 600 - 706.86$$

$$\therefore A = 3493.14\ mm^2 \text{ ---} \quad 03M.$$

Step 2 :- To determine I_{xx}.

$$I_{xx} = I_{1x} - I_{2x} - I_{3x}$$

$$I_{1x} = (I_{gx})_1 + A_1 y_{c_1}^2$$

$$(I_{gx})_1 = bd^3/12 = 80 \times 60^3/12 = 1.44 \times 10^6$$

$A_1 = 4800\ mm^2$

$y_{c_1}^2 = \left(\frac{d}{2}\right)^2 = \left(\frac{60}{2}\right)^2 = 900\ mm^2.$

$\Rightarrow A_1 y_{c_1}^2 = 900 \times 4800$

$= 4.32 \times 10^6.$

$\Rightarrow I_{1x} = (1.44 + 4.32) \times 10^6.$

$= 5.76 \times 10^6\ mm^4$

$I_{2x} = (I_{gx})_2 + A_2 y_{c_2}^2$

$(I_{gx})_2 = \frac{bh^3}{12} = \frac{40 \times 30^3}{12} = 0.09 \times 10^6\ mm^4$

$\therefore A_2 y_{c_2}^2 = 0$ since reference axis coincides with base of Δ^4.

$I_{3x} = (I_{gx})_3 + A_3 y_{c_3}^2$

$(I_{gx})_3 = \frac{\pi R^4}{4} = \frac{\pi \times 30^4}{4} = 0.636 \times 10^6\ mm^4$

$A_3 = 706.86\ mm^2$

$y_{c_3}^2 = \left(60 - \frac{4 \times 30}{3\pi}\right)^2 = 2234.26\ mm^2$

$\Rightarrow A_3 y_{c_3}^2 = 1.58 \times 10^6\ mm^4$

$I_{3x} = 2.215 \times 10^6\ mm^4.$

$\therefore I_{xx} = I_1 - I_2 - I_3$

$= (5.76 - 0.09 - 2.215) \times 10^6$

$\therefore I_{xx} = 3.455 \times 10^6 \text{ mm}^4$ — — — 04

Step 3 :- To determine I_{yy}

$I_{yy} = I_{1y} - I_{2y} - I_{3y}$

$I_{1y} = (I_{gy})_1 + A_1 x_{c_1}^2$

$(I_{gy})_1 = \frac{db^3}{12} = \frac{60 \times 80^3}{12} = 2.56 \times 10^6 \text{ mm}^4$

$A_1 = 60 \times 80 = 4800 \text{ mm}^2$.

$x_{c_1}^2 = (b/2)^2 = \left(\frac{80}{2}\right)^2 = 1600 \text{ mm}^2$.

$\Rightarrow (A_1 x_{c_1}^2) = 7.86 \times 10^6 \text{ mm}^4$.

$\Rightarrow I_{1y} = 10.1 \times 10^6 \text{ mm}^4$.

$I_{2y} = (I_{gy})_2 + A_2 x_{c_2}^2$

$(I_{gy})_2 = \frac{hb^3}{36} = \frac{30 \times 40^3}{36} = 0.053 \times 10^6 \text{ mm}^4$.

$A_2 = 600 \text{ mm}^2$

$(x_{c_2})^2 = \left(40 + 2 \times b/3\right)^2 = \left(40 + \frac{2 \times 40}{3}\right)^2$

$= 4444.44 \text{ mm}^2$.

$\Rightarrow (A_2 x_{c_2}^2) = 2.67 \times 10^6 \text{ mm}^4$

$\Rightarrow I_{2y} = 2.719 \times 10^6 \text{ mm}^4$.

$I_{3y} = (I_{gy})_3 + A_3 (x_{c_3})^2$

$\Rightarrow (I_{gy})_3 = \pi R^4/4 = 0.636 \times 10^6 \text{ mm}^4$

$A_3 = 706.86\ mm^2$

$(\bar{x}c_3)^2 = (4R/3\pi)^2 = \left(\frac{4 \times 20}{3\pi}\right)^2 = 162.11\ mm^2$

$\Rightarrow (A_3 \bar{x} c_3^2) = 0.115 \times 10^6\ mm^4$

$\Rightarrow I_{3y} = 0.751 \times 10^6\ mm^4$

$\Rightarrow I_{yy} = (10.18 - 2.719 - 0.751) \times 10^6$

$\therefore I_{yy} = 6.71 \times 10^6\ mm^4$

$\Rightarrow I_{xx} = 3.455 \times 10^6\ mm^4$ &

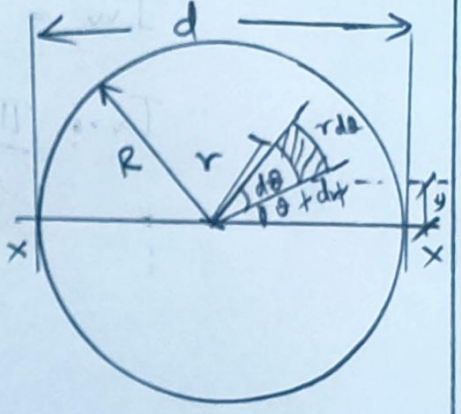
$I_{yy} = 6.71 \times 10^6\ mm^4$. ---04

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

$\therefore I_{zz} = 10.165 \times 10^6\ mm^4$. ---01

Total 12M

Q.No:- 10) a)



Consider an element sides $rd\theta$ and dr as shown in fig. Its moment of inertia about the diametral axis $x-x$:

$$= y^2 dA$$

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

$$= r^3 \sin^2\theta \, d\theta \, dr$$

---- 02M.

∴ Moment of Inertia of the circle about x-x axis is given by

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

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

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

$$I_{xx} = \frac{2\pi R^4}{8}$$

$$\therefore I_{xx} = \frac{\pi R^4}{4}$$

If 'd' is the diameter of the circle, then

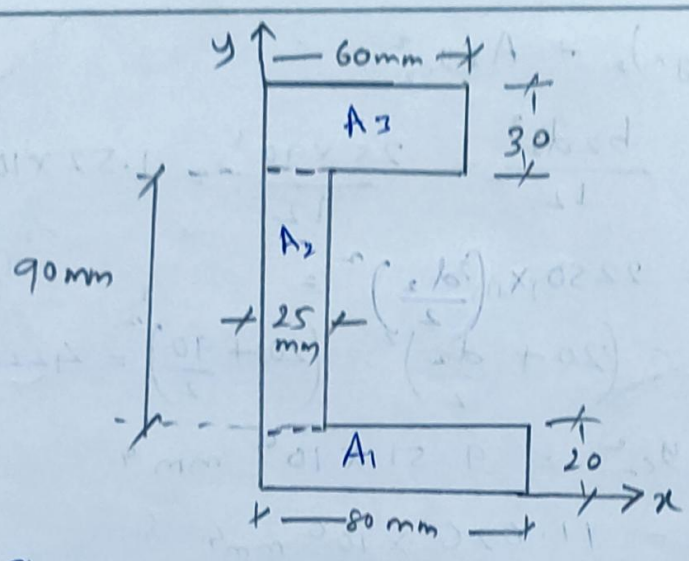
$$R = d/2$$

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

$$\therefore I_{xx} = \frac{\pi d^4}{64} = \frac{\pi R^4}{4} \quad \text{---- 06M}$$

Total: 08M.

Q.10) b)



Step 1). Divide the area into simple figures.

A_1, A_2 & A_3 are rectangles

$A_1 = b_1 \times d_1 = 80 \times 20 = 1600\ mm^2$

$A_2 = b_2 \times d_2 = 25 \times 90 = 2250\ mm^2$

$A_3 = b_3 \times d_3 = 60 \times 30 = 1800\ mm^2$

$\therefore A = A_1 + A_2 + A_3 = 5650\ mm^2$ ——— 03

Step 2 :- To determine I_{xx} about x-axis

$I_{xx} = I_{1x} + I_{2x} + I_{3x}$

$I_{1x} = (I_{gx})_1 + A_1 y_{c_1}^2$

$(I_{gx})_1 = \frac{b d_1^3}{12} = \frac{80 \times 20^3}{12} = 0.0533 \times 10^6\ mm^4$

$A_1 y_{c_1}^2 = 1600 \times (d_1/2)^2 = 1600 \times \left(\frac{20}{2}\right)^2 = 0.16 \times 10^6\ mm^4$

$\Rightarrow I_{1x} = 0.2133 \times 10^6\ mm^4$

$I_{2x} = (I_{gx})_2 + A_2 y_{c_2}^2$

$(I_{gx})_2 = \frac{b_2 d_2^3}{12} = \frac{25 \times 90^3}{12} = 1.52 \times 10^6 \text{ mm}^4$

$A_2 = 2250 \text{ mm}^2$

$y_{c_2}^2 = \left(20 + \frac{d_2}{2}\right)^2 = \left(20 + \frac{90}{2}\right)^2 = 4225 \text{ mm}^2$

$\Rightarrow A_2 y_{c_2}^2 = 9.51 \times 10^6 \text{ mm}^4$

$\Rightarrow I_{2x} = 11.026 \times 10^6 \text{ mm}^4$

$I_{3x} = (I_{gx})_3 + A_3 y_{c_3}^2$

$(I_{gx})_3 = \frac{b_3 d_3^3}{12} = 0.135 \times 10^6 \text{ mm}^4$

$A_3 = 1800 \text{ mm}^2$

$y_{c_3}^2 = (20 + 90 + d_3/2)^2 = 15625 \text{ mm}^2$

$A_3 y_{c_3}^2 = 28.125 \times 10^6 \text{ mm}^4$

$\therefore I_{3x} = 28.26 \times 10^6 \text{ mm}^4$.

$\Rightarrow I_{xx} = 0.2133 \times 10^6 + 11.026 \times 10^6 + 28.26 \times 10^6$

$\therefore I_{xx} = 39.5 \times 10^6$ ---- 04

Step 3 :- To determine I_{yy} about reference y axis

$I_{yy} = I_{1y} + I_{2y} + I_{3y}$

$I_{1y} = (I_{gy})_1 + A_1 x_{c_1}^2$

$(I_{gy})_1 = \frac{d_1 b_1^3}{12} = \frac{20 \times 50^3}{12} = 0.853 \times 10^6 \text{ mm}^4$

$A_1 = 1600\ mm^2$

$x_{c_1}^2 = (b_1/2)^2 = \left(\frac{80}{2}\right)^2 = 1600\ mm^2$

$A_1 x_{c_1}^2 = 2.56 \times 10^6\ mm^4$

$\Rightarrow I_{1y} = 3.413 \times 10^6\ mm^4$

$I_{2y} = (I_{gy})_2 + A_2 x_{c_2}^2$

$(I_{gy})_2 = \frac{d_2 b_2^3}{12} = \frac{90 \times 25^3}{12} = 0.117 \times 10^6\ mm^4$

$A_2 = 2250\ mm^2$

$x_{c_2}^2 = \left(\frac{b_2}{2}\right)^2 = \left(\frac{25}{2}\right)^2 = 156.25\ mm^2$

$\Rightarrow A_2 x_c^2 = 0.352 \times 10^6\ mm^4$

$\Rightarrow I_{2y} = 0.469 \times 10^6\ mm^4$

$I_{3y} = (I_{gy})_3 + A_3 x_{c_3}^2$

$(I_{gy})_3 = \frac{d_3 b_3^3}{12} = \frac{30 \times 60^3}{12} = 0.54 \times 10^6\ mm^4$

$A_3 = 1800\ mm^2$

$(x_{c_3})^2 = \left(\frac{b_3}{2}\right)^2 = \left(\frac{60}{2}\right)^2 = 900\ mm^2$

$\Rightarrow A_3 x_{c_3}^2 = 1.62 \times 10^6\ mm^4$

$I_{3y} = 2.16 \times 10^6\ mm^4$

$\therefore I_{yy} = I_{1y} + I_{2y} + I_{3y}$

$\therefore I_{yy} = 6.042 \times 10^6\ mm^4$ ---- 04

Step 4 :- Polar moment of Inertia. $I_p = I_{zz}$

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

$= 39.5 \times 10^6 + 6.042 \times 10^6$

$\therefore I_{zz} = 45.542 \times 10^6 \text{ mm}^4$ // ——— 01M

Total 12M.

(Staff In charge)
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28-02-2023
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