Shaikh Sir's Diploma Classes

Sub:Strength of Material (313308)

UNIT 1. Moment of Inertia

1.1 Concept of Moment of Inertia, M.I. of plane lamina and radius of gyration of a given lamina.

1.2 Parallel and perpendicular axes theorems (without derivation).

1.3 M.I. of standard basic figures like square, rectangle, triangle, circle, semi-circle, quarter- circle and Hollow Rectangular & Circular sections. (without derivation).

1.4 M.I. of Composite plane figures such as symmetrical and unsymmetrical I-section, channel section, T-section, angle section. Numerical on composite figure consisting of maximum 03 standard shapes.

1.5 Introduction to M.I. for built-up sections. (No numerical). (

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Websites : www.msbte.engg-info.website, www.mechdiploma.com,

Theory questions and answers

Q.1. Define Moment of Inertia and state its SI unit.

ANS : Moment of inertia is defined as,

“Second moment of an area about an axis is called Moment of inertia.”

or

” A quantity expressing the body’s tendency to resist angular acceleration, it is equal to sum of product of mass of particles to the square of distances from the axis of rotation.”

Moment of inertia = $area \times (distance\ from\ axis)^2$

SI unit of moment of inertia is $m^4\ (\ or\ mm^4)$

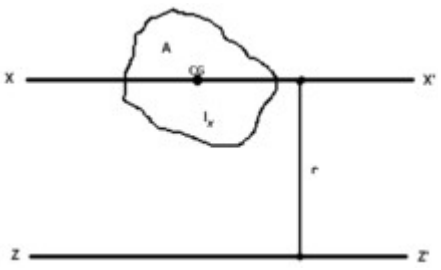
Q.2. Define radius of Gyration.

ANS : Moment of inertia is defined as,

“Radius of gyration of a body about an axis is a distance such that when square of that distance is multiplied by the area of that body gives Moment of inertia of that body.”

$$k = \sqrt{\frac{I}{A}}$$

Q.3. State Parallel axis theorem.

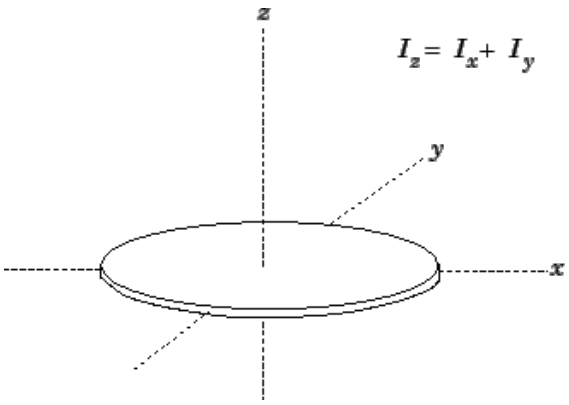


It states that,

*“ **The moment of inertia of a lamina about any axis parallel to the centroidal axis is equal to the Moment of inertia of the body about its centroidal axis plus the product of the area and square of distance between these two axes.**”*

$$Izz = Ixx + A.d^2$$

Q.3. State Perpendicular axis theorem.



It states that,

" ***The moment of inertia of a lamina about an axis perpendicular to plane of lamina about an axis perpendicular to the lamina and passing through its centroid is equal to sum of its moment of inertia about two mutually perpendicular axes lying in the plane.***"

Iz = Ixx+Iyy

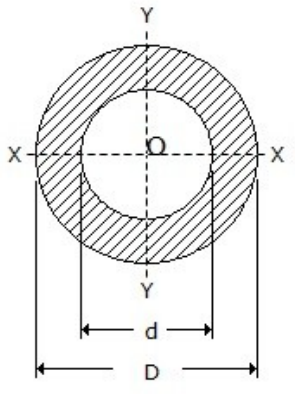
Q.4. Define Polar moment of Inertia.

"It is defined as the moment of inertia of body about its centroidal axis which is perpendicular to the plane of the body."

Ip = Ixx+Iyy

Q.5. Write the equation for MI of Hollow circular section.

Ans: Moment of inertial of a hollow circular section is given by ,

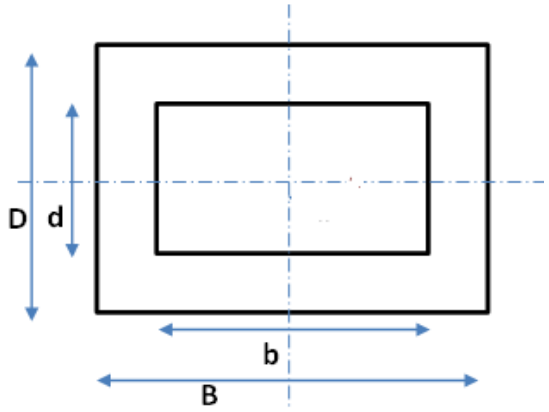


$$I=\frac{\pi}{64}(D^4-d^4)$$

D = Outer diameter of Hollow cylinder
d= Inner diameter of internal cylinder

Q.6. Write the equation for MI of Hollow rectangular section.

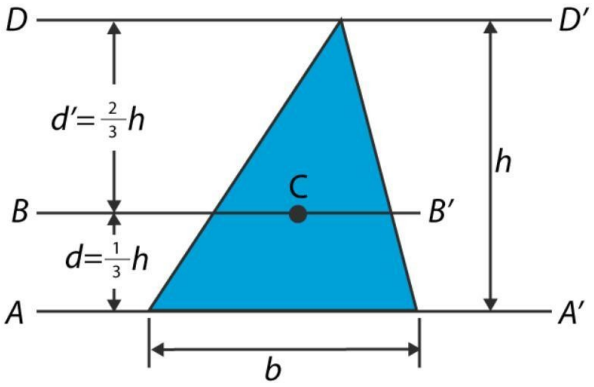
Ans: Moment of inertial of a hollow circular section is given by ,



$$I=\frac{BD^3}{12}-\frac{bd^3}{12}$$

B = Outer width of section
b= Inner width of section
D = Outer depth of section
d = Inner depth of section

Q.7. Write the equation for MI of triangle about its base and apex.

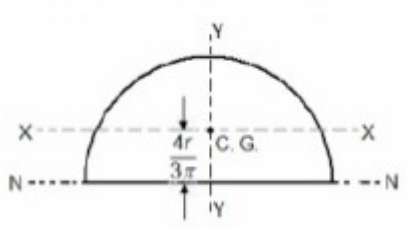


$$I_{xx}=\frac{b\times h^3}{36}$$

$$I_{AA}=\frac{b\times h^3}{12}$$

$$I_{DD}=\frac{b\times h^3}{4}$$

Q.7. Write the equation for MI of semicircle about its base.



Moment of inertia about centroidal axis

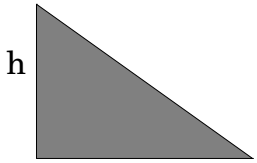
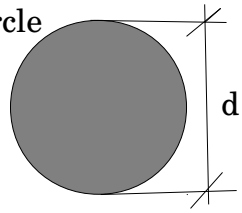
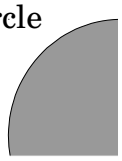
$$I_{xx}=0.11\,r^4$$

Moment of inertia about base,

Using parallel axis theorem

$$I_{nn}=I_{xx}+Area\times(distance)^2$$

$$I_{nn}=0.11\times r^4+\frac{(\pi\times r^2)}{2}\times\left(\frac{4r}{3\pi}\right)^2$$

FIGURE	Area mm^2	X	Y	Ixx mm^4	Iyy mm^4
Rectangle 	$A = b \times d$	x=b/2	y=d/2	$I_{xx} = \frac{bd^3}{12}$	$I_{xx} = \frac{db^3}{12}$
Triangle 	$A = \frac{1}{2} b \times h$	$x_1 = b/3$ From side $x_2 = 2b/3$ From right side	$y_1 = h/3$ From bottom $y_2 = 2h/3$ From Apex	$I_{xx} = \frac{bh^3}{36}$	
Circle 	$A = \frac{\pi}{4} \times d^2$	$x = d/2$	$y = d/2$	$I_{xx} = \frac{\pi}{64} d^4$	$I_{yy} = \frac{\pi}{64} d^4$
Semicircle 	$A = \frac{\frac{\pi}{4} \times d^2}{2}$	$x = d/2$	$y1 = 0.42 \times r$ from base $y2 = 0.58 \times r$ from top	$I_{xx} = 0.11 \times r^4$	$I_{yy} = \frac{\frac{\pi}{64} d^4}{2}$
Quarter circle 	$A = \frac{\frac{\pi}{4} \times d^2}{4}$	$x1 = 0.42 \times r$ from base $x2 = 0.58 \times r$ from corner	$y1 = 0.42 \times r$ from base $y2 = 0.58 \times r$ from top	$I_{xx} = \frac{0.11 \times r^4}{2}$	$I_{xx} = \frac{0.11 \times r^4}{2}$

Parallel axis theorem

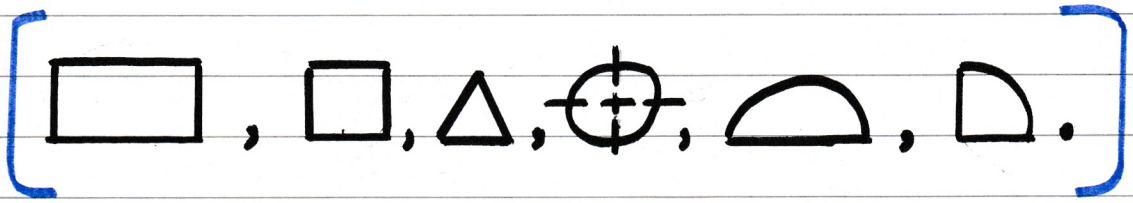
$$I_{PQ} = I_{xx} + A\,y^2$$

Perpendicular Axis theorem

Polar moment of inertia

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

Type-I] Problems on Moment of Inertia on Standard figures]



Q.1. Find polar moment of inertia of a square having side 40 mm?

$I_p = 426.66 \times 10^3$ mm^4.

Q.2. Find polar moment of inertia of a circular lamina having diameter 100 mm?

$I_p = 9.817 \times 10^6$ mm^4.

Q.3. Find polar M.I. of a rectangle having width 200mm & depth 100 mm?

$I_p = 83.333 \times 10^6$ mm^4.

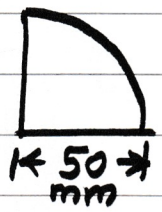
Q.4. Find polar moment of inertia of a semi-circle having diameter 200mm?

$I_p = 50.263 \times 10^6$ mm^4.

Q.5 Find polar moment of inertia of square lamin having size 30 mm ?

$I_p = 0.135 \times 10^6 \text{ mm}^4$.

Q.6. Find polarmoment of Quater circle of radius 50 mm ?



$I_p = 687.6 \times 10^3 \text{ mm}^4$.

Type-II) Problems on Parallel axis Theorem:-

Q.1. Find M.I. of a rectangle about axis passing throug base (PQ) if width is 200mm & depth 150mm?

$I_{PQ} = 58.56 \times 10^6 \text{ mm}^4$.

Q.2. Find M.I. of a triangle having base 200mm & height 300mm about axis passing throug base?

$I_{PQ} = 450 \times 10^6 \text{ mm}^4$

Q.3. A triangle has base 150mm & height 200mm Find M.I. @ -
i) Centroidal axis -
ii) About base -
iii) About axis passing through apex -

$I_{CG} = 33.33 \times 10^6 \text{ mm}^4$
$I_{base} = 100 \times 10^6 \text{ mm}^4$
$I_{apex} = 300 \times 10^6 \text{ mm}^4$.

Q.4. Circular lamina has diameter 200mm. Find M.I. about any tangent to circle?

$I_{PQ} = 392.63 \times 10^6 mm^4$

Q.5. A semi-circle has diameter 100mm. Find M.I. @ it's diameter?

$I_{PQ} = 2.45 \times 10^6 mm^4$

Q.6. A circle has radius 50mm. Find M.I. @

i) Centroidal axis - $I_{CG} = 4.908 \times 10^6 mm^4$

ii) Tangent to circle - $I_{PQ} =$

iii) Axis at distance of 150 mm from centre:- $I_{AB} =$

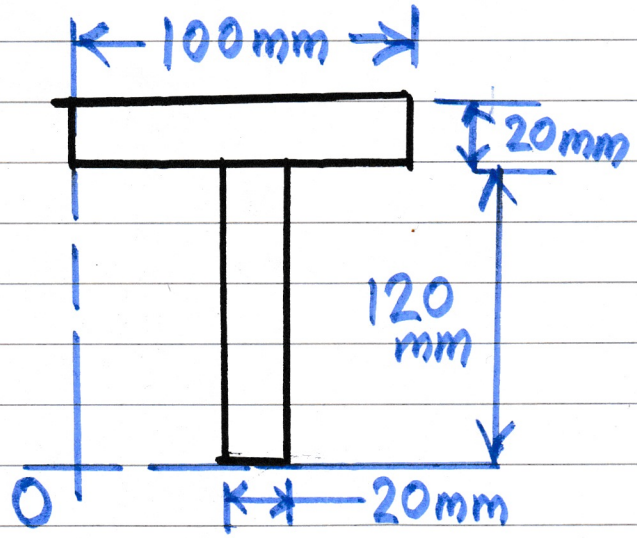
Q.7. Find M.I. about x-x axis of Hollow rectangular section having Outer dimensions 300 x 150 mm & inner dimensions 200 x 50 mm.?

Q.8. Find M.I. of Hollow circular section havi I.D. 150mm & O.D. = 250mm?

Type III] Problems on M.I. of standard sections.

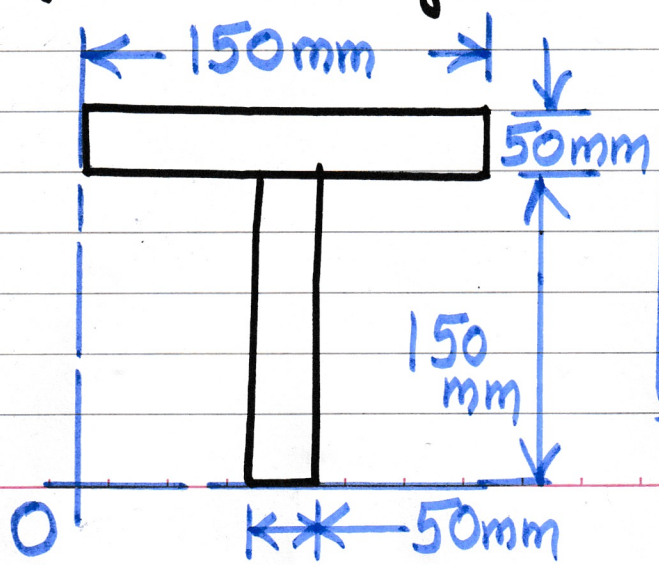
[T, ⊥, L, I, ⌶, [, ⊏,]

Q.1. A T- section has flange 100mm X 20mm & web dimension 120mm X 20mm Find M.I. about Ixx axis?



I_{xx} =

Q.2. Find M.I. of T section with flange 150mm X 50mm & web 150mm X 50mm about x-x & y-y axis through C.G. of section?



$I_{xx} = 53.125 \times 10^6 mm^4$

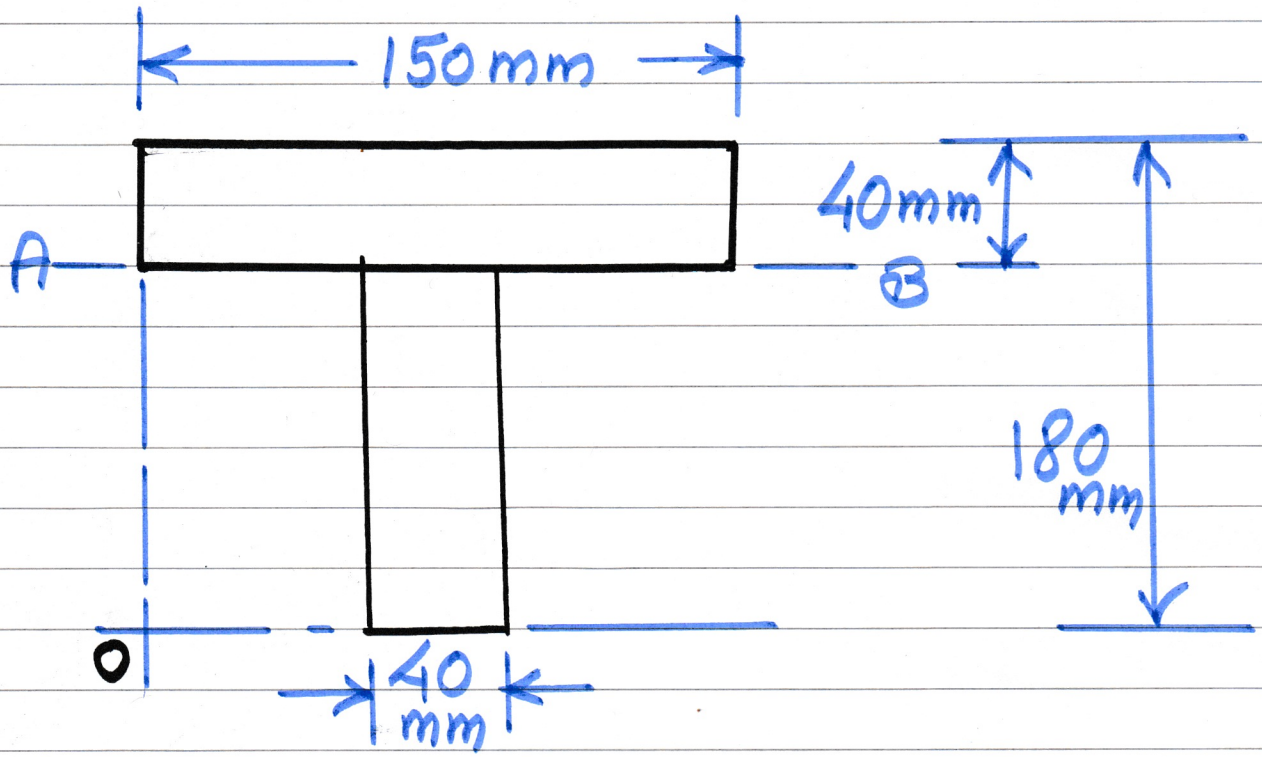
$I_{yy} = 15.625 \times 10^6 mm^4$.

Q.3. Find M.I. of a T section 150mmX180mmX40 about :-

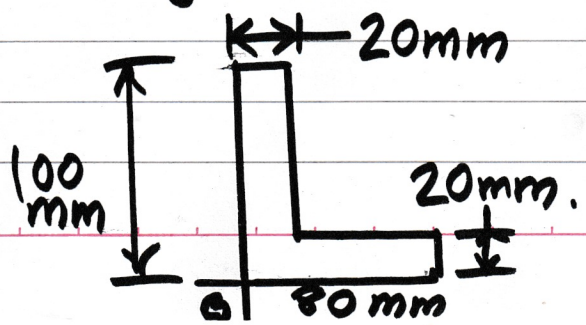
i] Centroidal x-x axis :- $I_{xx} = 33.40 \times 10^6 mm^4$.

ii] Centroiday Y-Y axis :- $I_{yy} = 12 \times 10^6 mm^4$

iii] Horizontal axis passing through junction of flange & web. :- $I_{AB} = 39.79 \times 10^6 mm^4$.



Q4. Find M.I. @ Centroidal X-X & Y-Y axis of angle section as shown :-



$I_{xx} = 2.907 \times 10^6 mm^4$

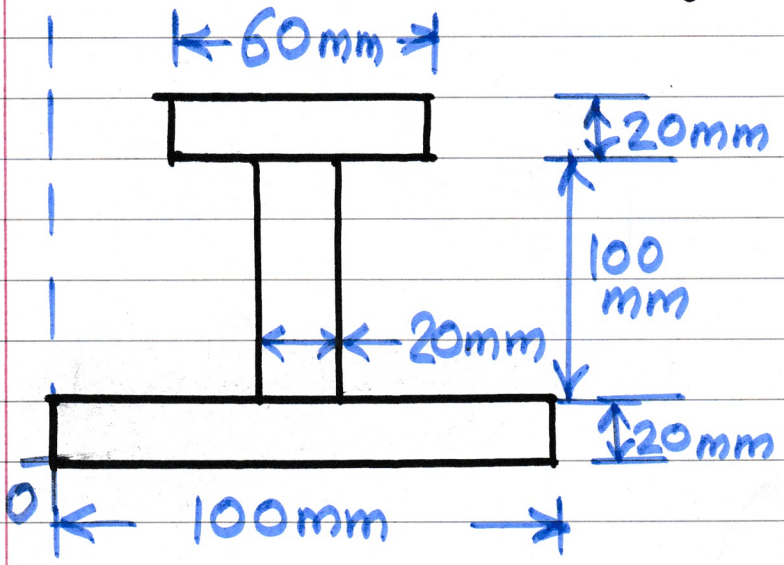
$I_{yy} = 1.627 \times 10^6 mm^4$

Q.5. Calculate I_{xx} & I_{yy} for an unequal angle section 70mm x 50mm x 10mm. Take 70mm leg as vertical.?

$I_{xx} = 5.18 \times 10^5 mm^4$.

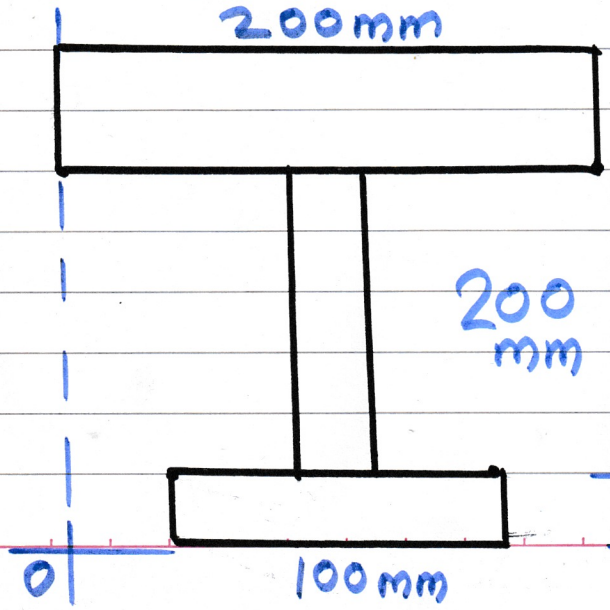
$I_{yy} = 2.18 \times 10^5 mm^4$.

Q6. I section shown in fig. Find I_{xx}.?



$I_{xx} = 12.850 \times 10^3 mm^4$

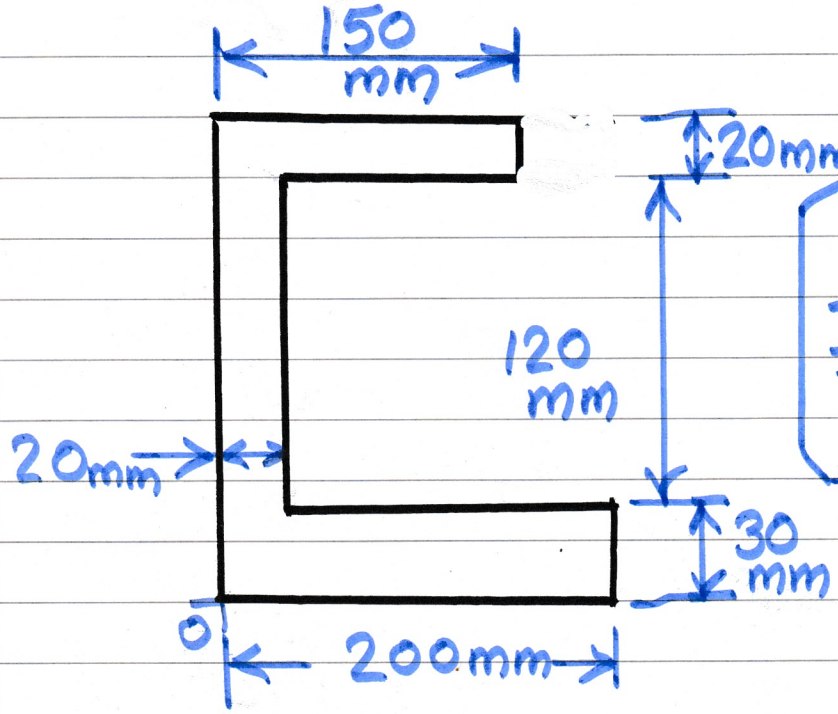
Q.7. An Unsymmetrical I section with top flange 200mm x 20mm, bottom flange 100mm x 10mm is 230mm deep. with thickness of web is 10mm. Find I_{xx} & I_{yy}



$I_{xx} = 50.19 \times 10^6 mm^4$

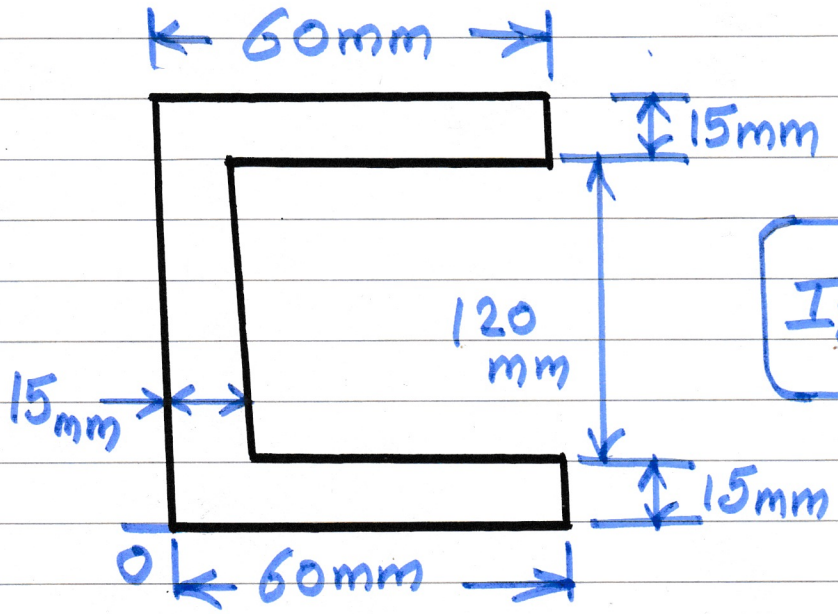
$I_{yy} = 14.18 \times 10^6 mm^4$

Q.8. Find M.I. about x-x section.?



$I_{xx} = 46.8 \times 10^6 mm^4$

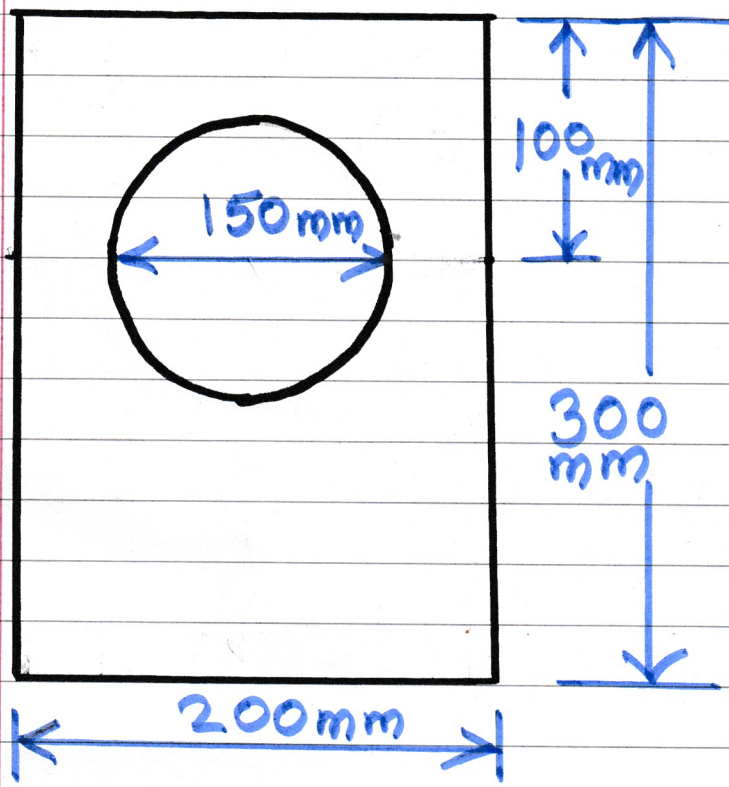
Q.9. Find Ixx about C-chanel?



$I_{xx} =$

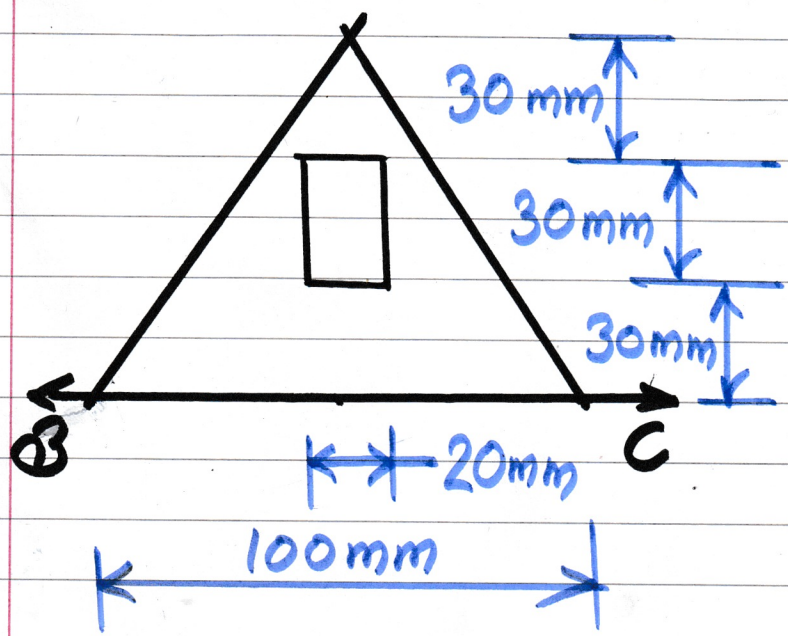
Type-IV Problems on Cut section :-

Q.1. Find M.I. of given section about axis Centroidal x-x axis ?



$I_{xx} = 362.54 \times 10^6 mm^4$

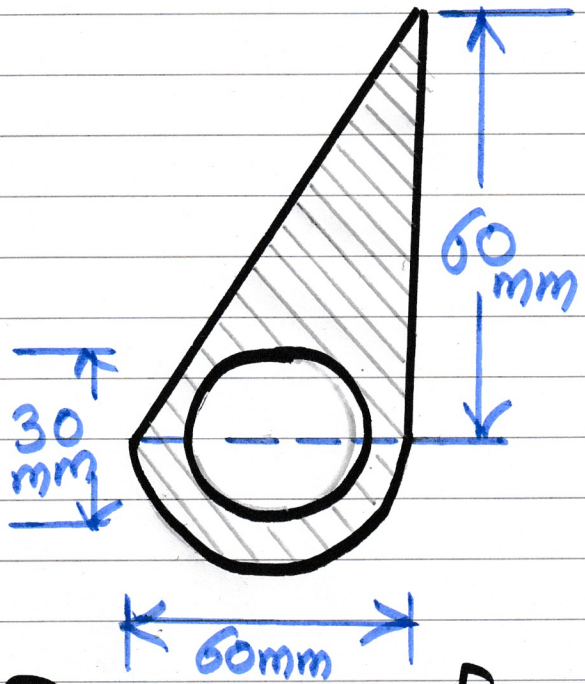
Q.2. A rectangular hole in a triangular section Determine C.G., M.I. about base BC



$I_{xx} = 1824.2 \times 10^3 mm^4$

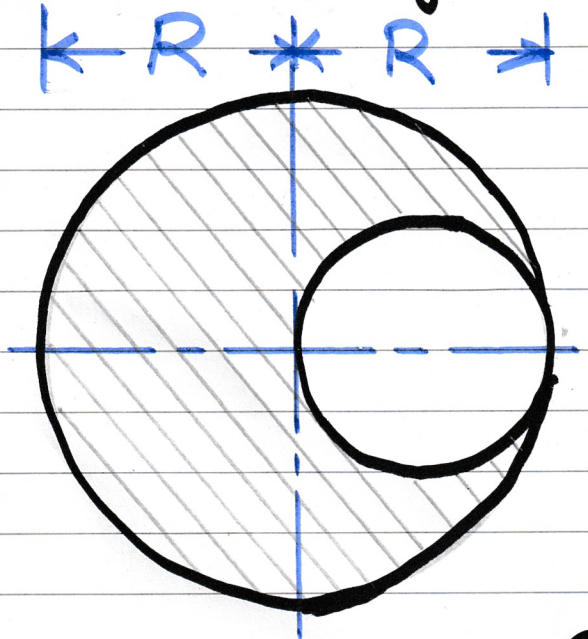
$I_{BC} = 4815 \times 10^3 mm^4$

Q.3. Find M.I. of given section.?



I_{xx} =

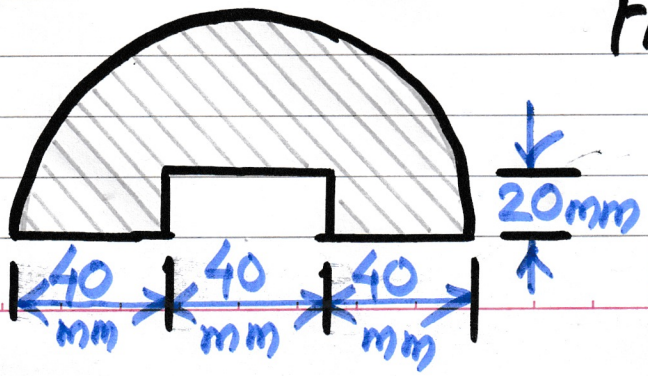
Q4. Find M.I. of given cut section ?



$$I_{xx} = \frac{15\pi R^4}{64}$$

$$I_{yy} = \frac{29\pi R^4}{192}.$$

Q5. Find M.I. @ horizontal centroidal axis?



$I_{CG} = 1.354 \times 10^6 \text{ mm}^4$.