Shaikh Sir's Diploma Classes

Sub:Strength of Material (22306)

UNIT 1. Moment of Inertia

1.1 Concept of Moment of Inertia (MI). Effect of MI in case of beam and column.

1.2 MI about axes passing through centroid.
Parallel and Perpendicular axes theorem.
Polar MI, radius of gyration.

1.3 MI of standard basic shapes.

1.4 MI of Composite plane figures.

Prepared By : Sameer V. shaikh {Engr.sameer@gmail.com} {9765158158}

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.”

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

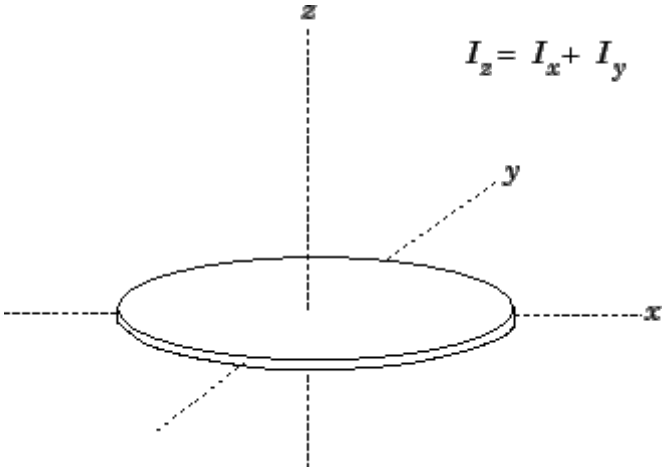
Q.3. State Parallel axis theorem.

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.



$$I_z = I_x + I_y$$

It states that,

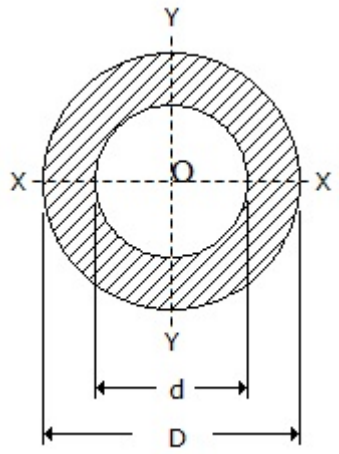
“ ***The moment of inertia of a lamina about an axis perpendicular to plane of lamina about and axis perpendicular to the lamina and passing through its centroidal is equal to sum of its moment of inertia about two mutually perpendicular axes lying in the plane.***”

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."

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

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

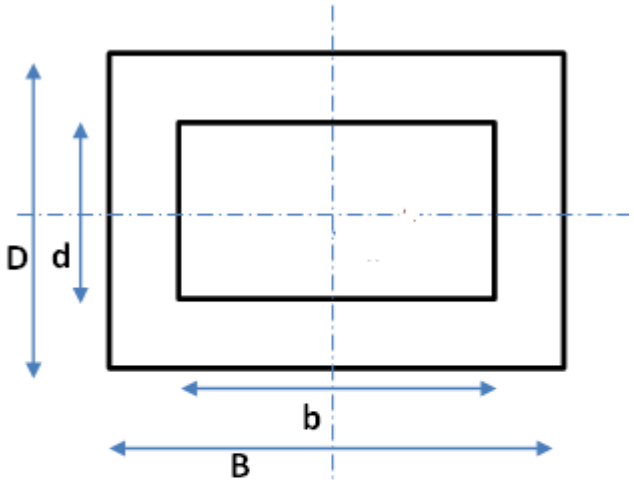


$$I = \frac{\pi}{64}(D^4 - d^4)$$

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

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

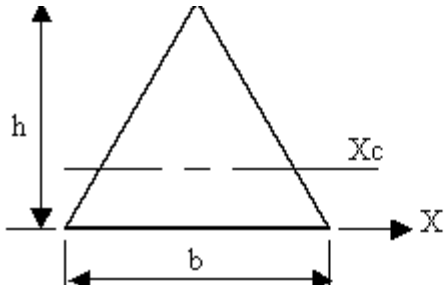
Ans: Moment of inertial of a hollow circular section is given by ,



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

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

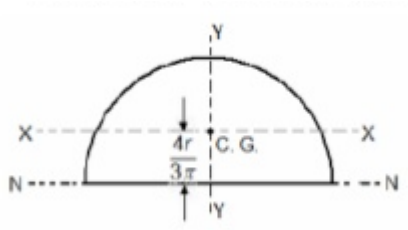
Q.7. Write the equation for MI of triangle about its base and apex.



$$I_{xc} = \frac{bh^3}{36}$$

$$I_x = \frac{bh^3}{12}$$

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



Ans :

Moment of inertia about centroidal axis

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

Moment of inertia about base,

Using parallel axis theorem

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

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

Numerical Problems on Moment of inertia

Type 1 : Moment of Inertia of Standard section
Type 2 : Moment of inertia of Standard sections (I,L,T,C)
Type 3 : Moment of inertia of Composite section

Type 1 : Moment of Inertia of Standard section

1.Determine the MI of a triangular section having base 5 cm and 6 cm height about its base.

{Ans: $I_{base} = 900 \times 10^3 mm^4$ }

2.A triangular section has base 100 mm and 300 mm height determine moment of inertia about 1)MI about axis passing through base 2)MI about axis passing through apex

{Ans: $I_{base} = 225 \times 10^6 mm^4, I_{gg} = 75 \times 10^6 mm^4, I_{apex} = 675 \times 10^6 mm^4$ }

3.Find the moment of inertia of a hollow circular section having external diameter 100 mm and internal diameter 80mm about,
1) Axis passing through center 2) About tangent to the outer circle and parallel to xx axis.

{$I_{xx} = 2.89 \times 10^6 mm^4, I_{pq} = 9.94 \times 10^6 mm^4$}

4.Find the moment of inertia of a hollow rectangular section about its centre of gravity, if the external dimensions are 40 mm deep and 30 mm wide and internal dimension are 25 mm and 15 mm wide.

{$I_{xx} = 140470\ mm^4, I_{yy} = 82970\ mm^4$}

5. An isosceles triangular section ABC has base width 80 mm and height 60mm. Determine the moment of inertia of the section about the centre of gravity of the section and the base BC.

{$I_{xx} = 480 \times 10^3 mm^4, I_{pq} = 1440 \times 10^3\ mm^4$}

6.A hollow C.I. pipe with external diameter 100 mm and thickness of metal 10 mm is used as a strut. Calculate the moment of inertia and radius of gyration about its diameter.

{$I_{xx} = 2.89 \times 10^6 mm^4, K_{xx} = 32.017\ mm$ }

7.A circular disc has M.I. about its any tangent is $6.283 \times 10^5 mm^4$***. Find the diameter of the disc.***

{$d = 40\ mm$}

8.An equilateral triangle has a side of 150 mm. Find the moment of inertia about any of its sides.

{$I_{pq} = 27.404 \times 10^6 mm^4$}

9.Find MI of an equilateral triangle of side 2m about its base.

{$I_{pq} =$ mm^4}

10.A semicircular lamina has a base diameter 140mm. Calculate the moment of inertia
1) about centroidal axis 2) about base.

{$I_{xx} = 2.64 \times 10^6 mm^4, I_{pq} = 9.428 \times 10^6 mm^4$}

11.Calculate Polar MI of a square section having 200mm as side.

{ }

12.Calculate polar moment of inertia for a circle having diameter 250 mm.

{ }

Type 2 : Moment of inertia of Standard sections (I,L,T,C)

1. Find MI of a "T" section about its centroidal axis having following dimensions,
1) Flange=200 mm ×40 mm 2) Web= 200 mm × 40 mm

$\{I_{xx} = 85.33 \times 10^6 mm^4, I_{yy} = 27.733 \times 10^6 mm^4\}$

2) Find Ixx and Iyy for an unequal angle 100 × 80×10 mm. 100 mm leg is horizontal.

$\{I_{xx} = 0.952 \times 10^6 mm^4, I_{yy} = 1.672 \times 10^6 mm^4\}$

3) Find MI of a T section 200 × 20 mm flange and 180× 20 mm web about x axis.

$\{I_{xx} = \quad mm^4\}$

4}A symmetrical I section has the following dimensions,
Flanges=100mm × 10mm, Web=10 mm × 100 mm. Calculate Polar MI of the section.

$\{I_P = 8.575 \times 10^6 mm^4\}$

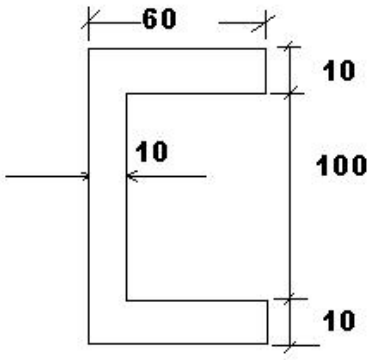
5)Calculate Ixx and Iyy for an unequal angle section 70 × 50×10 mm. Take 70 mm leg vertical

$\{I_{xx} = 0.952 \times 10^6 mm^4, I_{yy} = 1.672 \times 10^6 mm^4\}$

6)Determine Moment of inertia about xx and yy axis of I section having following dimensions
Top flange : 20 × 80 mm, Web : 10 × 280 mm, Bottom Flange : 120 × 20 mm

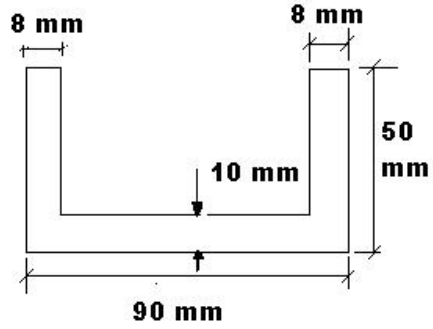
{Ixx=106.4 $\times 10^6 mm^4$*, Iyy = 3.756* $\times 10^6 mm^4$ *}*

7) A c Channel is shown below find its Moment of inertia about xx and yy axis.



{Ixx = 4.4733 $\times 10^6 mm^4$**, Iyy = 0.7097** $\times 10^6 mm^4$**}**

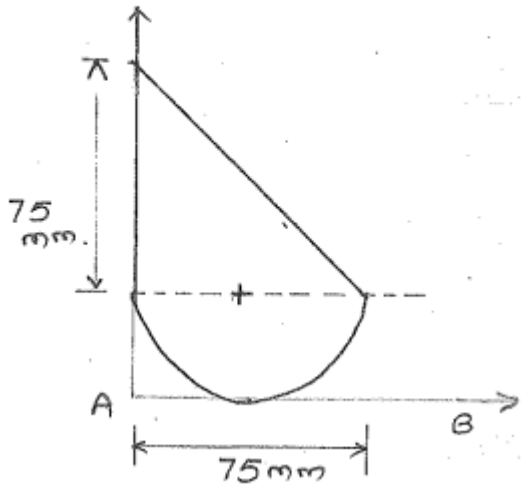
8. Find the radius of gyration of the channel section about the centroidal axis as shown below



{Ixx=327.05 $\times 10^3 mm^4$*}*

Type 3 : Moment of inertia of Composite section

1) A composite section is shown below. Find the moment of inertia of the section about base AB.



2) A square hole is punched out of a circular lamina as shown in figure below. Find the moment of inertia of the composite section.