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# Question bank

## UNIT I
## STRESS, STRAIN AND DEFORMATION OF SOLIDS

**1. Define Poisson's Ratio.** **(April/ May 2009)**

The negative ratio of lateral strain to the longitudinal strain is known as Poisson's ratio.

**2. What is thermal Stress?** **(May/June 2009)**

If the expansion of a structural member is constrained, it will cause stresses to develop which are known as thermal Stress.

**3. State Hooke'sLaw.** **(April/May 2010)**

The Ratio of stress to the strain with in elastic limit is known as Hooke's Law.

**4. Define Bulk Modulus.** **(April/May 2010)**

The Ratio of direct stress to the corresponding volumetric strain is known as Bulk Modulus.

**5. Define Modulus of resilience.** **(April/May 2011)**

Proof resilience per unit volume is defined as Modulus of resilience.

**6. Define Elasticity**. **(May/June 2012)**

It is the property of material to regain its original shape and dimensions on removing external load acting on it.

**7. Give the relation between Modulus of Elasticity and Modulus of Rigidity.** **(May/June 2012)**

The relation between modulus of elasticity and modulus of rigidity are as follows

$E = 2G(1+v)$

**8. What is Strain Energy?** **(April/May 2011)**

The Workdone is stored in rod and is known as strain energy.

**9. Define Proof Resilience.** **(Nov/Dec 2009)**

The maximum strain energy that can be stored in a body without permanent deformation is known as Proof resilience.

**10. Define compressive stress.** **(Nov/Dec 2011)**

The Resistance offered by the section of member or body against the decrease in length due to applied pushing load.

**11. Define: Bulk-modulus**

The ratio of direct stress to volumetric strain is called as bulk modulus..

Bulk modulus, K = Direct stress / Volumetric strain



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**12. Define: Shear modulus or Modulus of rigidity (April/May 2010)**

The ratio of shear stress to shear strain is called as bulk modulus.. Shear modulus, G = shear stress / shear strain

**13. State the relationship between Young's Modulus and Modulus of Rigidity.**

$E = 2G (1+\mu)$

Where,

E - Young's Modulus

G – Modulus of rigidity

μ - Poisson's ratio

**14. Give the relationship between Bulk Modulus and Young's Modulus.**

$E = 3K (1-2\mu)$

V Where,E - Young's Modulus

K - Bulk Modulus

μ- Poisson's ratio

**15. What is principle of super position?**

The resultant deformation of the body is equal to the algebric sum of the deformation of the individual section. Such principle is called as principle of super position

**16. What is compound bar?**

A composite bar composed of two or more different materials joined together such that the system is elongated or compressed in a single unit.

**17. What you mean by thermal stresses?**

If the body is allowed to expand or contract freely, with the rise or fall of temperature no stress is developed, but if free expansion is prevented the stress developed is called temperature stress or strain.

.

**18. Define principle stresses and principle plane.**

**Principle stress:** The magnitude of normal stress, acting on a principal plane is known as principal stresses.

**Principle plane**: The planes which have no shear stress are known as principal planes.

**19. What is the radius of Mohr's circle? (April/May 2010)**

Radius of Mohr's circle is equal to the maximum shear stress.

**20. What is the use of Mohr's circle?**

To find out the normal, resultant and principle stresses and their planes.

**21. List the methods to find the stresses in oblique plane?**



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1. Analytical method
2. Graphical method

**Problem - 1:**

**A mild steel rod 2m long &3cm diameter is subjected to an axial pull of 10kN. E for Youngs modulus for steel is 2 x $10^5$ N/$mm^2$. Find the stress, strain. (Apr/May 2012)**

Sol:

Lenth (l) = 2 m = (2×1000) mm

diameter (d) = 3cm, area a = $\frac{\pi(3\times1000)}{4}$

Arial pull = 10KN = $10 \times 10^3$ N =706.5

E = $2 \times 10^5$ N/$mm^2$

Stress = $\frac{10\times10N/mm2}{706.55mm}$ = 14.15N/mm

E = $\frac{Stess}{Strain}$

Strain = $\frac{14.15}{2\times10}$ = 0.0000707

**Problem - 2:**

**A steel bar 900mm long its 2ends are 40mm &30mm in diameters &the length of each rod is 200mm. The middle portion of the bar is 15mm in diameters &500mm in long if the bar is subjected an axial tensile load of 15KN. Determine the stress in each section &total extension. Take E=200×$10^3$N/$mm^2$. (Nov/Dec 2008)**

Sol:

To find stress at each section:

Stress at **1** section AB = $\frac{Pull}{Area}$



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$$\sigma AB = \frac{15\times10^3}{\frac{\pi}{4}(40)^2}$$

$$\sigma AB = 11.94 N/mm^2.$$

Stress at section BC = $15\times10^3$

$$\sigma BC = 84.92 N/mm^2.$$

Stress at section CD = $15.10^3$

$$\sigma CD = 21.23 N/mm^2.$$

To find total Extension (or) Elangation

$$S_L = P/E\left[L_1/A_1 + L_2/A_2 + L_3/A_3\right]$$

$$= \frac{15\times10^3}{2000\times10^3}\left[\frac{/\ /}{/} + \frac{/\ /}{/} + \frac{/\ /}{/}\right]$$

$$= 0.075[3.2722]$$

**Problem – 3:**

**The following are the results of a tensile on test on a molested rod is 16 mm gaugh length is 50 mm, load at proportionality limit is 48.5 kN. Extension at the proportionally limit is 0.05mm. Load at yield point is 50.3 KN ultimate load is 90KN. Final length between gauge points is 64mm, dia of the neck at fracture is 13.7 mm. Determine the young's modules at elastic limit, Yield stress, Ultimate Stress, % of elangation & % of reduction in area. (May/Jun 2009)**

Given data:

Dia of rod d = 16mm

Dia of Fracture of rod fd = 13.7 mm

Gauge length l = 50mm

Final length $\delta$ L = 645 mm



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Load at yield point = 50.3KN

Load at ∝ limit = 48.5 KN

Extension of (∝) limit $\delta$ l = 0.05.mm

Ultimate load = 90 KN ( max load)

**Solution :**

i) Young's Modules E = $\frac{Stress}{Strain}$

$$E = \frac{P/A}{SL/L}$$

$$= \frac{48.5 \times 10^3 \left(\frac{\pi}{4}\right)(16)^2}{0.05/50}$$

$$= \frac{241.34}{0.001}$$

$$E = 241340.\ N/mm^2$$

$$= 2.41 \times 10^3\ N/mm^2$$

ii) Yield Stress = $\frac{Yiels\ Load}{Area}$

$$= \frac{50.3 \times 10^3}{\frac{\pi}{4}(16)^2}$$

$$= 250.29\ N/mm^2$$

$$= 250\ N/mm^2$$

iii) Ultimate Stress = $\frac{\text{Ultimate Stress}}{Area}$

$$= \frac{90 \times 10^3}{\frac{\pi}{4}(16)^2}$$

$$= 447.81\ N/mm^2$$

iv) % of elongation = $\frac{Change\ in\ length}{Original\ lenth} \times 100$



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$= \frac{14}{50} \times 100$

$= 28\ \%$

v) % of area reduction $= \frac{Original\ Area - Area\ of\ failure}{Original\ Area}$

$= \frac{\frac{\pi}{4}(16)^2 - \frac{\pi}{4}(13.7)^2}{\frac{\pi}{4}(16)^2}$

$= 0.2668$

$= 26.68\ \%$

**Problem - 4:**

**A Cylindrical pipe of diameter 1.5mm & thickness 1.5cm is subjected to an internal fluid pressure of 1.2 N/mm$^2$. Find the longitudinal stress & hoop stress developed in the pipe. (Apr/May 2010)**

**Solution:**

Given data :

dia (d) $= 1.5 \times 10^3$ mm

Thickness (t) $= 1.5 \times 10^1$ mm

Pressure (p) $= 1.2$ N/mm$^2$

Longitudinal Stress: $\sigma$ l $= \frac{Pd}{4t}$

$\sigma$ l $= \frac{1.2 \times 1.5\ 10^3}{15 \times 4}$

Circumferential stress:

$\sigma$ c $= \frac{1.2 \times 1.5\ 10^3}{2 \times 15}$

$= 60$N/mm$^2$



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**Problem - 5:**

**A Cyliner of internal dia 0.5m contains air at apressure of 7 N/mm$^2$.If the maximum permissible stress induced in material is 80 N/mm$^2$. Find the thickness of the cylinder . (Oct 97)**

dia (d) = $0.5 \times 10^3$mm

(p) = 7 N /mm$^2$

$\sigma$ l = 80 N/mm$^2$

t = ?

$\sigma 1 = \frac{Pd}{4t}$

$t = \frac{Pd}{4t} = 10.93$ mm

**Problem - 6:**

**Calculate change in length, change in diameters, change in volume of the thin cylinder 100cm dia & 1cm thickness, 5m long E= $2\times10^5$ N/mm$^2$ poisson's ratio (1/m) (or) $\mu$=0.3 & internal fluid pressure 3 N/mm$^2$. (Oct 97)**

**Solution**

Given :

dia (d) = 100 cm = 1000 mm

t = 1 cm = 10mm

l = 5 m = 5 x $10^3$mm

E = 2 x $10^3$ N/mm$^2$

$\vartheta$ = 0.3



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p = $3N/mm^2$

Change in length $e_2$ = $\frac{Pd}{2tE}(½ - \vartheta)$

$\frac{\delta l}{l}$ = $\frac{3 \times 1000}{2 \times 10 \times 2 \times 10^5}(^1/_2 - 0.3)$

$\delta l$ = 0.00015mmxl

= 0.75mm

Change in dia $e_1$ = $\frac{pd}{2te}(1 - l1.\,^1/_2)$

$\frac{\delta d}{d}$ = $\frac{3000}{40x10^5}(1 - \frac{0.3}{2})$

$\delta d$ = 0.0006375mm × 1000

= 0.6375mm

Change in length $e_2$ = $\frac{\delta l}{l}$

= $\frac{0.75}{5\times10^3}$ = 0.00015mm

$e_1$ = 0.0006375mm

Change in volume V = $^\pi/_4\, d^2 \times L$

= 3925000000 = $3.9L_5\times10^9mm^2$.

$e_3=\delta v$ = V $(2e_1+e_2)$

= $3.9x10^9(2\times6.375\times10^{-4}+1.5\times10^{-4})$

= $\underline{5.5}\times\underline{10^6mm^2}$

$e_3$ = $\frac{\delta v}{v}$ = $1.425\times10^{-3}$mm



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**Problem - 7:**

**A bar of 20mm diameter is tested in tension it is observed that when a lead of 40KN is applied the extension measured over a gauge length of 200mm us 0.12mm&contraction in diameter is 0.0036mm. Find poisson's ratio, young's modulas &bulk modulas &rigiditity modulas. (May/Jun2012)**

**Solution:**

Diameter D = 20mm

P = 40KN

L = 200mm

$\delta l$ = 0.12mm Contraction $\delta d$ = 0.0036mm

Asked:

M=? , E=? , K=? , G=? (or) C=?

i. Longitudinal strain $\delta l$ = $\frac{\delta l}{l}$

= $\frac{0.12}{200}$

= $0.6x10^{-3}$

ii. Lateral strain pd = $\frac{\delta d}{d}$

= $\frac{0.0036}{20}$ = $1.810^{-4}$

$\mu$ = $\frac{et}{el}$

= $\frac{1.8\times10^{-4}}{0.6\times10^{-3}}$ = 0.3



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E = $\frac{Stress}{Strain} = \frac{\rho/a}{el}$

= $\frac{/\ /}{0.6\times10^{-3}}$

= $0.212x10^{6}$

= $2.12x10^{5}N/mm^{2}$

E = $2\ G\ (1+\ ^{1}/_{m})$

Modulus of Rigidity = $2\ G\ (1+\ \mu)$

G = $\frac{E}{2(1+\mu)} = \frac{2.12\times10^{5}}{2(1+0.3)}$

= 81538.46

G(or)C = $0.815\times10^{5}N/mm^{2}$.

Bulk modulus E = $3k(1-2/m)$

K = $\frac{E}{3(1-2}$

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## UNIT II
## TRANSVERSE LOADING ON BEAMS AND STRESSES IN BEAMS

**1. State the assumptions while deriving the general formula for shear stresses.** **(May/June 2011)**

i. The material is homogenous, isotropic and elastic.
ii. The modulus of elasticity in tension and compression are same and the shear stress is constant along the beam width.

**2. Define shear stress distribution.** **(May/June 2013)**

` The variation of shear stress along the depth of beam is called shear stress distribution.

**3. Mention the different types of beams.** **(May/June 2009)**

i. Cantilever beam,
ii. Simply supported beam,
iii. Fixed beam,
iv. Continous beam and
v. Over hanging beam

**4. Write down the bending moment equation.** **(May/June 2009)**

The bending equation $M/I = \sigma/y = E/R$

Where,
M – bending moment
I – moment of inertia of the section,
$\sigma$ – bending stress at that section,
y – distance from the neutral axis,
E – Young's modulus of the material,
R – radius of curvature of the beam.

**5. What do you understand by the term point of contraflexure? (Apr/May 2010)**

The point where the shear force changes its sign or zero is called as point of contraflexure.At this point the bending moment is maximum.

**6. What is the value of bending moment corresponding to a point having a zero shear force?** **(May/June 2010)**

The value of bending moment is maximum where the shear force changes it sign or zero.

**7. Mention the types of supports.** **(Apr/May 2011)**

- Roller support
- Fixed support
- Hinged or pinned support

**8. Define bending moment in beam.** **(Nov/Dec 2012)**

The bending moment of the beam may be defined as the algebraic sum of the moments of the forces, to the right or left of the section.



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**9. Define shear force. (Apr/May 2008)**

Shear force at any section is defined as the algebraic sum of all forces acting on either side of a beam.

**10. What is meant by Neutral axis of the beam? (Nov/Dec 2012)**

It is an imaginary plane, which divides the section of the beam into the tension and compression zones on the opposite sides of the plane.

**11. What is mean by compressive and tensile force?**

The forces in the member will be compressive if the member pushes the joint to which it is connected whereas the force in the member will be tensile if the member pulls the joint to which it is connected.

**12. How will you determine the forces in a member by method of joints?**

In method of joint after determining the reactions at the supports, the equilibrium of every support is considered. This means the sum all vertical forces as well as the horizontal forces acting on a joint is equated to zero. The joint should be selected in such a way that at any time there are only two members, in which the forces are unknown.

**13. What are the benefits of method of sections compared with other methods? (April/May 2010)**

1. This method is very quick
2. When the forces in few members of the truss are to be determined, then the method of section is mostly used.

**14. Define thin cylinder?**

If the thickness of the wall of the cylinder vessel is less than 1/15 to 1/20 of its internal diameter, the cylinder vessel is known as thin cylinder.

**15. What are types of stress in a thin cylindrical vessel subjected to internal pressure? (April/May 2010)**

These stresses are tensile and are know as

- Circumferential stress (or hoop stress )
- Longitudinal stress

.

**16. What is mean by circumferential stress (or hoop stress) and longitudinal stress?**

The stress acting along the circumference of the cylinder is called circumferential stress (or hoop stress) whereas the stress acting along the length of the cylinder is known as longitudinal stress.

**17. What are the formula for finding circumferential stress and longitudinal stress?**

Circumferential stress, $f_1 = pd / 2t$

longitudinal stress, $f_2 = pd / 4t$



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**18. What are maximum shear stresses at any point in a cylinder? (April/May 2010)**

Maximum shear stresses at any point in a cylinder, subjected to internal fluid pressure is given by $(f_1 - f_2) / 2 = pd / 8t$

**19. What are the formula for finding circumferential strain and longitudinal strain?**

The circumferential strain ($e_1$) and longitudinal strain ($e_2$) are given by

$$e_1 = \frac{pd}{2tE}\left[1 - \frac{\mu}{2}\right]$$

$$e_2 = \frac{pd}{2tE}\left[\frac{1}{2} - \mu\right]$$

**20. What are the formula for finding change in diameter, change in length and change volume of a cylindrical shell subjected to internal fluid pressure p?**

$$\delta d = \frac{pd^2}{2tE}\left[1 - \frac{\mu}{2}\right]$$

$$\delta l = \frac{pdl}{2tE}\left[\frac{1}{2} - \mu\right]$$

$$\delta V = \frac{pd}{2tE}\left[\frac{5}{2} - 2\mu\right] \times Volume$$

**Problem - 1**

**Draw the shear force & bending moment diagram for given cantilever. (May/Jun 2012)**

**Solution :**

Shear force at A = 2+10 =12KN

Shear force at B = 2KN

Shear force at C = 0KN

Shear force at D = 0

Bending moment at A = $-2 \times 2 + 2 + 10 \times 1 \times 1/2$ = 3KNm

Bending moment at B = $-2 \times 1H$ = -2KNm



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Bending moment at C = 0

Bending moment at D = 0

**Problem - 2**

**Draw the shear force diagram for given cantilever. (May/Jun 2012)**

**Solution :**

To fine the support reaction:

Taking moment at A = $-R_D \times 6+6\times4+3\times2 = 0$

$R_D \times 6$ = -30

$R_D$ = -5 KN

Upward force = Downward force

$R_A+5$ = 6+3

$R_A$ = 4 KN

Shear Force Calculation:

R.H.S

Shear force at A = 4 KN

Shear force at B = 4-3 = 1 KN

Shear force at C = 4-3-6

= -5 KN

Shear force at D = -5 KN

L.H.S

Shear force at D = -5 KN



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Shear force at C = 6-5 = 1 KN

Shear force at B = 6+3-5

$R_A$ = B = 4 KN

To find the moment

Bending moment at A = 0

Bending moment at B = 4×2 = 8 KNm

Bending moment at C = (4×4) – (3×2)

= 10 KNm

**Problem - 3**

**Draw the shear force diagram for at bending moment for givern cantilever. (Nov/Dec 2012)**

**Solution :**

To fine the support reaction:

Taking moment at A = $(4\times 1) + (5 \times 2) + (6 \times 3) - (R_E \times 4)$

= $32 - 4R_E$

$R_E$ = 8 KN

$R_A + 8$ = 15

$R_A$ = 7 KNS

To fine Shear force:

Shear force at A = 7 KN

Shear force at B = 7-4 = 3 KN

Shear force at C = 7-4-5 = - 2KN



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Shear force at D = 7-4-5-6 = -8 KN

Shear force at E = - 8 KN

To find bending moment

Bending Moment at A = 0

Bending Moment at B = 4 KNm

Bending Moment at C = (7×2) – (4×2)

= 10 KNm

Bending Moment D = (7×3) – (4×2)

= 8 KNm

Bending Moment E = 0

**Problem - 4**

**A Beam of Total length 8m is freely supported at a left end & at a point 6m from left end. It carries 2 points floats of 15KN & 18KN. In which one is at the free end and another is 3m from the left support. Draw the shear force and bending moment diagram. Locate the point of contraflexture. (Nov/Dec 2012)**

**Solution :**

To fine the support reactions:

Taking moment about A,

$(R_c \times 6) – (18\times3) – (10\times8) = 0$

$6\ R_c = 54+120$

$R_c = 174/6$

$R_c = 29$ KN



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$R_A + R_c$ = 18+15

$R_A + 29$ = 33

$R_A$ = 4 KN

To fine Shear force:

Shear force at D = 15 KN

Shear force at C = 29 KN +15 = -14 KN

Shear force at B = -14+18 = 4 KN

Shear force at A = 4 KN

To find bending moment

Bending Moment at D= 0

Bending Moment at C= -(15×2) = - 30 KNm

Bending Moment at B= -(15×5)+(29×3)

Bending Moment at A= -(15×8) +(29×6)-(18×3)

= -120-54+174

= 0

**Problem-5:**

**The cross section of the beam is shown is beam is cantiliver type &carries a UDL of 16KN/m. If the span of beam is 2.5m. Determine the maximum tension & Compressible stress in the beam. (Nov/Dec 2013)**

**solution:**

**Section (1) :**



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Area ($a_1$) = l×b

= 500mm$^2$

**Section(2):**

Area ($a_2$) = l×b

To find the centroid distance:

$y_1$ = $35+\frac{10}{2}$ = 40mm

$y_2$ = $\frac{35}{2}$ = 17.5mm

$\bar{y}$ = $\frac{a1y1+a2y2}{a_{1+}a_2}$ = $\frac{500(40)+(525)(17.5)}{1025}$

$\bar{y}$ = 28.47mm

To find the moment of inertia:

$$I = \left[\frac{b_1 d_1^3}{12} + a_1(\bar{y} - y_1)^2 + \frac{b_2 d_2^3}{12} + a_2(\bar{y} - y_2)^2\right]$$

`

$$= \left[\frac{50(10)^3}{12} + (500)(28.47 - 40)^2 + \frac{15(35)^3}{12} + (525) + (28.47 - 17.5)2\right]$$

$$= \left[\frac{50000}{12} + (6879.64) + \frac{15(35)^3}{12} + (525)(1203409)\right]$$

= 187409.8392mm$^4$

To find moment (M):

M = $16\times2.5\times\frac{2.5}{2}$

= 50KNm

w.k.t,



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$$\frac{M}{I} = \frac{\sigma}{J}$$

$$\sigma = \frac{M \times \bar{y}}{I}$$

The maximum compressive bending stress is the topmost layer of the beam.

The distance from y to top layer is

$$\bar{y} = 45\text{-}28.47$$

$$= 16.53\text{mm}$$

Compressive stress $\sigma = \frac{50 \times (16.53)\ (mm^2)}{187409.83\ (mm^2)}$

$$= 4.410 \times 10^{-3} \text{mm}^{-2}. \text{KN}$$

to find the maximum tensile stress:

$$\frac{M}{I} = \frac{\sigma}{\bar{y}}$$

$$\sigma = \frac{M \times \bar{y}}{I} \qquad \bar{y} = 28.47$$

$$= \frac{50 \times 28.47}{187409.83} = 7.595 \times 10^{-3} \text{KN}$$

$$= 7.59 \times 10^{3}\ \text{KN/m}^2$$

**Problem-6:**

**The cast iron bracket subjected to bending has a cross section of I-shaped with unequal flanges as shown. If the compressive force on the top of the flanges is not to exceed 17mega pa. What is the bending moment of the section can take if the section is subjected to a shear force of 90KN. Draw the shear stress distribution over the depth of the section. (Nov/Dec 2013)**

**Solution:**

Area of section (1) = lb

$$= 250 \times 50$$



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$= 12750mm^2$

Area of section (2) = lb

$= 50 \times 250 = 12500mm^2$

Area of section (3) = lb

$= 150 \times 50 = 7500mm^2$

To find centroid distance:

$y_1 = 50+250+\frac{50}{2} = 325mm$

$y_2 = \frac{250}{2}+50 = 175mm$

$y_3 = \frac{50}{2} = 25mm$

$\bar{y} = \frac{a_1y_1+a_2y_2+a_3y_3}{a_1a_2a_3} = \frac{12500(325)+(12500)(175)+(7500)(25)}{12500+}$

$= \frac{6437500}{32500} = 199.076mm$

To find moment of inertia:

$I = \left[\frac{b_1{d_1}^3}{12} + a_1(\bar{y}-y_1)^2 + \frac{b_2{d_2}^3}{12} + a_2(\bar{y}-\right.$ $\left. y_2)^2 + a_3\frac{b_3{d_3}^3}{12} + \right.$

*a3(y−y3)2*

$= \left[\frac{250(50)^3}{12} + (12500(199.08-325)^2 + \frac{50(250)^3}{12} + \right.$ $\left. (12500(199.08-\right.$

175)2+150(50)312*7500(199.08−25)2*

$= 2604166.667 + 198198080 + 65104166.67 + 7248080$

$+ 1562500 + 22727848$



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$= 501995840.7$

$I = 5.01\times10^{8}mm^{4}.$

W.K.T,

$\frac{M}{I} = \frac{\sigma}{\bar{y}}$

$= \frac{\sigma}{\bar{y}} \times I$

$= \frac{17}{199.08}(5.01)\times10^{8}$

$= 0.4278\times10^{8}$

$= 42.78\times10^{8}Nmm$

To find shear stress:

shear force $(\tau)$ at top of the

top flange = 0

shear force $(\tau)$ at bottom of the

bottom flange = 0

$\tau$ at the bottom of the top flanges

$= \frac{FA.\bar{y}}{Ib}$

where,

$\bar{y} = 152 - \frac{50}{2} = 127mm$

A-Area-12500, I-moment of inertia, B-breath

$F = \frac{90\times10^{3}(12500)(127)}{5.01\times10^{8}(250)}$

$= 1.14071N/mm^{2}$



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$\tau$ at junction of flange and web:

$$\tau = \tau \times \frac{B}{T}$$

Where, B-breath, T-Thickness

$$= 1.14 \times \frac{250}{50} = 5.7 \text{N/mm}^2.$$

$\tau$ at the Neutral axis:

$$= \frac{FA.\bar{y}}{Ib} \qquad \bar{y} = 152 - \frac{50}{2} = 127$$

$$A\bar{y} = (250 \overset{(A)}{\times} 50 \times \overset{\bar{y}}{127}) + (102 \overset{(A)}{\times} 50 \times \overset{\bar{y}}{51})$$

$$= 1847600 = 1.8 \times 10^6 \text{mm}^3$$

b = 50.

$\tau$ at Neutral axis:

$$= \frac{(90 \times 10^3)(1.8 \times 10^6)}{(5.01 \times 10^8)(50)}$$

$$= 6.4670 \text{N/mm}^2.$$

To find shear stress:

$\tau$ at the bottom of the bottom flange is 0.

$\tau$ at the top of the bottom flange

$$= \frac{FA.\bar{y}}{Ib}$$

$$= \frac{90 \times 10^3 \ (7500)(173)}{5.01 \times 10^8 (150)}$$

$$= 1.55 \text{N/mm}^2.$$

$\tau$ at junction of flange & web:



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$= \tau \times \frac{B}{T}$

$= 1.55 \times \frac{150}{50} = 4.65 N/mm^2.$

$i_C = \frac{A1}{EI} = \frac{5}{20} = 0.25$ radians

$i_D = \frac{A2}{EI} = \frac{5}{20} = 0.25$ radians

To find Centroid distance:

$\bar{x}1 = 1/3 \times 1 = 0.33m$

$\bar{x}2 = 0.33m$

$y_C = \frac{A\bar{x}}{EI} = \frac{5(0.33)}{20} = 0.825m$

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## UNIT III – TORSION

**1. What are the assumptions made in torsion equation? (May/June 2009)**



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- The material of the shaft is homogeneous, perfectly elastic and obeys Hook's law.
- Twist is uniform along the length of the shaft and
- The stress does not exceed the limit of proportionality

**2. Write down the expression for power transmitted by a shaft. (May/June 2013)**

Power, $P = 2\pi NT/60$

Where,
T – Torque in kN.m
N – Speed in r.p.m.
P – Power in Kw

**3. Define polar modulus. (May/June 2010)**

It is the ratio between polar moment of inertia and radius of the shaft.

**4. State the differences between closed and open coil helical springs. (May/June 2009)**

| Closed coiled helical springs | Open coiled helical springs |
|---|---|
| Adjacent coils are very close to each other | Large gap between adjacent coils |
| It can carry only tensile loads . | It can carry Both tensile and Compression loads. |
| Helix angle is negligible | Helix angle is considerable |

**5.Find the torque which a shaft of 50mm diameter can transmit safely, if the allowable shear stress in 75 N/mm²? (Apr/May 2010)**

$T = \pi / 16 \times f_s \times d^3$

$T = \pi / 16 \times 75 \times (50)^3$

T = 1.840 kN.m

**6. What is mean by stiffness? (Apr/May 2011)**

The stiffness of the spring is defined as the load required to product unit deflection.

**7.Classify the types of springs. (Apr/May 2011)**

- Torsion spring and
- Bending spring

**8.What is meant by spring? (Apr/May 2010)**

Spring is a device which is used to absorb energy by taking very large change in its form without permanent deformation and then release the same when it is required.

**9.Define torsion. (Apr/May 2008)**

When a pair of forces of equal magnitude but opposite in direction acting on body, it tends to twist the body. It is known as twisting moment or simply as torque.

**10.what is meant by torsion spring? (Nov/Dec 2012)**



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A spring, which is subjected to torsion or twisting moment only is known as torsion spring.

**11. What is the ratio of maximum shear stress to the average shear stress in the case of solid circular section?**

$Q_{max}$ is 4/3 times the $Q_{avg}$.

**12. What is the shear stress distribution value of Flange portion of the I-section?**

$$q = \frac{F}{2I}\left(\frac{D^2}{4} - y\right)$$

Where, D- depth
y- Distance from neutral axis

**13. Where the shear stress is max for Triangular section?**

In the case of triangular section, the shear stress is not max at N A. The shear stress is max at a height of h/2

**14. Define: Mohr's Theorem for slope**

The change of slope between two points of a loaded beam is equal to the area of BMD between two points divided by EI.

Slope, $\theta = \frac{A}{EI}$

**15. Define: Mohr's Theorem for deflection**

The deflection of a point with respect to tangent at second point is equal to the first moment of area of BMD between two points about the first point divided by EI.

Slope, $\theta = \frac{A}{EI}$

**Problem-1:**



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**A metal bar of 10mm dia when subjected to a pull of 23.55KN gave and elongation of 0.3mm on a gauge length of 200mm. In a torsion test maximum shear stress of 40.71N/mm$^2$ was measured on a bar of 50mm dia. The angle of twist measured over a length of 300mm being 0°21'. Determine poisson's ratio. (April/May 2011)**

**Solution:**

Given data:

dia d = 10mm

pull P = 23.55KN

elongation SL = 0.3mm

Gauge length = 200mm

Torsion Test

$\tau_{max}$ (or) $(\sigma_s)_{max}$ = 40.71 N/mm$^2$

Dia = 500mm

Twist angle = 0°21'

length = 300 mm

Asked

$\lambda = ?$

Formula

$$\mu = \frac{lateral\ strain}{lengitudinal\ strain}$$

$$\mu = \frac{\frac{\delta d}{d}}{\frac{\delta l}{l}}$$

Area = $\frac{\pi}{4}(10)^2$ = 78.5mm$^2$



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$\sigma = \frac{23.55\times10^3}{78.5} = 0.3\text{N/mm}^2$

$e = \frac{\delta l}{l}$

$e = \frac{0.3}{200} = 1.5\times10^{-3}$

$E = \frac{\sigma}{l}$

$= \frac{0.3}{1.5\times10^{-3}} = 200\text{N/mm}^2$

$E = 200\text{N/mm}^2 \qquad E = 2G(1+\mu)$

$G = \frac{\sigma}{\emptyset} = \frac{40.71}{shear\ strain}$

$\frac{\sigma}{R} = \frac{G\theta}{l}$

$G = \frac{(\sigma_s)l}{R\theta}$

$= \frac{4001\times300}{25\times(0°211)=(6.105\times10^{-3})}$ G = 7.99

$= 251238\times10^3$

$E = 2(7.997)(1+\mu)$ (7.997)

$200/2(7.997)\times10 = 1+\mu$

$\mu = 1.250-1$ (0.25)

Power Transmitted by a shaft

P = mean torgue×Angle turned lsec.

$= \frac{T.N}{60}\ 2\pi w$

$P = \frac{T.N}{60}.\ \frac{2\pi}{1000}KN$



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P = $\frac{2\pi ft}{1000}$ 1f = noof revolution/time

1Hz = 1revlsec

**Problem-2:**

**A hollow shaft dia ratio 3/5 is required to transmit 450Kw at 1200pm, the shearing stress in the shaft must not exceed 60N/mm$^2$ and the twist in a length of 2.5m is not to exceed 1$^o$. Calculate the minimum external of the shaft. Take, C=8.0KN/mm$^2$. (May/Jun 2010)**

Solution:

Dia = $d/D$ = $3/5$ ⇒ d=3, D=5

P = 450Kw= $450\times10^3$W

N = $120\pi$pm

$\tau(\sigma)$ = 60N/mm$^2$

l = 2.5m = $2.5\times10^3$

$\theta$ = $1^o\times\frac{\pi}{180}$radi = 0.01745

C = 80KN/mm$^2$

D $_{min}$ = ?

T = $\frac{\pi}{16}\tau\left(\frac{D^4-d^4}{D}\right)$

P = $\frac{2N\pi T}{60}$

T = $\frac{P60}{2N\pi}$ = $35.82\times10^3$N/mm

$\frac{D^4-d^4}{D}$ = $\frac{T.16}{\pi\tau}$

= $\frac{35.82\times10^{3\times16}}{\pi\times60}$



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$= 3.0427\times10^3 N/mm$

$\frac{D^4-(3/5D)}{D} = 3.0427\times10^3$

$\frac{D^4-(1-1296)}{D} = 3.0427\times10^3$

$D^3 = \frac{3.0427\times10^3}{0.8724}$

$D = 15.17mm$

$d = 9.106mm$

**Problem-2:**

**What must be the length of a 5mm dia aluminium wine so that it can be twisted through 1 complete revolution without exceeding a shear of 42N/mm$^2$. Take, G=27 GPO. (May/Jun 2010)**

**Solution:**

Given data:

length (l) = ?

dia (d) = 5mm

Angle ($\theta$) = $360^o$ = 6.283 rod

(fs) or ($\tau$) = $42N/mm^2$

(G) = $27\times10^3 N/mm^2$

Solution:

$\frac{T}{J} = \frac{G\theta}{l}$

$T = \pi/16\ \tau d^3$

$T = \pi/16\ (42)\ (5)^3 = 1030.3125Nmm^2$



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$J = \pi/32\ d^4 = \pi/32(5)^4 = 6111.328mm^2$

$l = \frac{G\theta}{T} . J$

$= \frac{27\times10^3\times6.283\times61.328}{1030.3125} = 10097.67mm$

$= 10.09mm$

**Problem-3:**

**A solid steel shaft has to transmit 75Kw power at 200 pm. Taking allowable shear stress 70Mpo. Find suitable dia of shaft with the maximum torque transmitted on each revolutions exceeds by mean by 30%→1.3 times mean. (Apr/May 2010)**

**Solution:**

Given data:

$P = 75Kw = 75\times10^3w$

$N = 200rpm$

$\tau = 70N/mm^2$

$d = ?$

$P = \frac{2\pi NT}{60}$

$\tau$ mean $= \frac{P.60}{2\pi N} = 3.58\times10^3Nm$

$\tau$ mean $= 1.3(3.58) = 4.65\times10^3Nm$

$T = \pi/16\ (\tau)\ d^3$

$d^3 = \frac{T.16}{\pi.l} = \frac{4.65\times10^6\times16}{\pi(70)}$



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d = 6.969 = 69.69mm

## UNIT IV

## BEAMS DEFLECTION

**1. List any four methods of determining slope and deflection of loaded beam? (May/Jun2012)**

i)Double integration method,
ii)Macaulay's method,
iii)Moment area method and
iv)Conjugate beam method

**2. What is the relation between slope, deflection and radius of curvature of a beam?**
$1/R = (d^2y)/(dx^2)$ **(Nov/Dec 2012)**
Where R =radius of curvature.
Y= deflection.

**3. State two assumptions made in the Euler's column's theory (May/Jun 2012)**
i)The cross section of the column is uniform throughout its length and
ii)The length of the column is very long as compared to its cross sectional dimensions.

**4. State Slenderness ratio (May/Jun 2011)**
The ratio between actual length to least radius of gyration Slenderness ratio = L / k

**5. Write the equivalent length of column for a column. (Nov/Dec 2012)**
i)One end is fixed and other end is free Effective length L= 2l
ii)Both ends are fixed Effective length L= l/2

**6. State the limitations of Euler's formula. (May/Jun 2012)**
If the slenderness ratio is small, the crippling stress will be high. But for the column material, the crippling stress cannot be greater than the crushing stress. In the limiting case, we can find the value of slenderness ratio for which the crippling stress is equal to the crushing stress.

**7. Describe the double integration method. (May/Jun 2010)**
While integrating twice the original differential equation, we will get two constant $C_1$ and $C_2$. The value of these constants may be found by using the end conditions.

**8. Calculate the effective length of a long column, whose actual length is 4m when i)both ends are fixed ii)one end is fixed while the other end is free? (Nov/Dec 2011)**

i)Both ends are fixed Effective length L= l/2 =4/2=2m
ii)One end is fixed while the other end is free Effective length L= 2l=2x4=8m

**9. Define column (May/Jun 2010)**



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A structural member which is subjected to axial compressive load is known as column.

**10. Define crippling load (May/Jun 2011)**

The load at which the column just buckles is known as crippling load.

**11. Define shear force and bending moment?**

SF at any cross section is defined as algebraic sum of the vertical forces acting either side of beam.

BM at any cross section is defined as algebraic sum of the moments of all the forces which are placed either side from that point.

**12. When will bending moment is maximum?**

BM will be maximum when shear force change its sign.

**13. What is maximum bending moment in a simply supported beam of span 'L' subjected to UDL of 'w' over entire span?**

Max BM $=wL^2/8$

**14. In a simply supported beam how will you locate point of maximum bending moment?**

The bending moment is max. when SF is zero. Writing SF equation at that point and equating to zero we can find out the distances 'x' from one end .then find maximum bending moment at that point by taking moment on right or left hand side of beam.

**15. What is shear force and bending moment diagram?**

It shows the variation of the shear force and bending moment along the length of the beam.

**16. What are the types of beams?**

1. Cantilever beam
2. Simply supported beam
3. Fixed beam
4. Continuous beam
5. over hanging beam

**17. What are the types of loads?**

1. Concentrated load or point load
2. Uniform distributed load (udl)
3. Uniform varying load(uvl)

**18. Write the assumptions in the theory of simple bending?**

1. The material of the beam is homogeneous and isotropic.
2. The beam material is stressed within the elastic limit and thus obey hooke's law.



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3. Each layer of the beam is free to expand or contract independently about the layer, above or below.

4. The value of E is the same in both compression and tension.

**19. Write the theory of simple bending equation?**

$$\frac{M}{I} = \frac{f}{y} = \frac{E}{R}$$

Where,

M - Maximum bending moment
I - Moment of inertia
f - Maximum stress induced
y- Distance from the neutral axis
E - Young's modulus
R – Radius of neutral layer.

**20. Define: Neutral Axis**

The N.A of any transverse section is defined as the line of intersection of the neutral layer with the transverse section.

**21. Define: Moment of resistance**

Due to pure bending, the layers above the N.A are subjected to compressive stresses, whereas the layers below the N.A are subjected to tensile stresses. Due to these stresses, the forces will be acting on the layers. These forces will have moment about the N.A. The total moment of these forces about the N.A for a section is known as moment of resistance of the section.

**22. Define: Section modulus**

Section modulus is defined as the ratio of moment of inertia of a section about the N.A to the distance of the outermost layer from the N.A.

Section modulus, $$Z = \frac{I}{y_{max}}$$

Where, I – M.O.I about N.A

$y_{max}$ - Distance of the outermost layer from the N.A

**Problem – 1:**

**Determine the deflection of a given beam at the point loads. Take I = $64x10^{-4}$ $mm^4$ & its Young's modulus (E) = $210x10^6$ $N/mm^2$. (April/May 2011)**

Solution :



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To find Support reactions:

$R_B$ x 14 - 60(9.5) – 90(3) = 0

14 $R_B$ = 840

$R_B$ = 60 KN

$R_A + R_B$ = 90 + 60 ; $R_A$ = 90 KN

To find deflection in Macaulays Method:

Consider x-x section at x distance from A

$EI.\frac{d2y}{dx2}$ = 90x - 90(x-3) – 60(x-9.5) ----------> (**1**)

Integrating the equation (**1**)

$EI\frac{dy}{dx}$ = $90(\frac{x2}{2}) - 90(\frac{(x-3)2}{2}) - 60(\frac{(x-9.5)2}{2}) + c1$

= $45x^2 – 45(x-3)^2 – 30(x-9.5)^2 + c1$ ----------> (**2**)

The above equation is a slope equation

Integrating the equation (**2**)

EI y = $45(\frac{x3}{3}) - 45(\frac{(x-3)3}{3}) - 30(\frac{(x-9.5)3}{3}) + c1x + c2$

EI y = $15\ x^3 – 15\ (x-3)^3 – 10(x-9.5)^3 + c1x + c2$ ----------> (**3**)

Equation (**3**) is a deflection equation

Boundary conditions:

x = 0 , y = 0 -------(1)

x = 14, y = 0 --------(2)

Applying x = 0 , y = 0 in equation (**3**)



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$EI(0) = 15(0) + c1(0) + c2$

$c2 = 0$

Applying $x = 14$ , $y = 0$ in equation (**3**)

$EI(0) = 5(14)^3 - 15(14-3)^3 - 10(14-9.5)^3 + 14c1 + c2(0)$

$= 41160 - 19965 - 911.25 + 14c1$

$14c1 = -20283.75$

$c1 = -1448.83$

(**3**)=> $EI\,y = 15x^3 - 15(x-3)^3 - 10(x-9.5)^3 - (1448.83)x$ ----------> (**4**)

To find deflection at 'C':

put $x = 3$

(**4**)=> $EI(y) = 15(3)^3 - 15(3-3)^3 - 10(3-9.5)^3 - 1448.83(3)$

$= 405 - 4366.49$

$(210x10^6)(64x10^{-4}) = -3941.49$

$y_c = -2.932x10^{-3}$

$= -0.002932mm$

To find deflection at 'D':

put $x = 9.5$

$EI\,y = 15(9.5)^3 - 15(-3+9.5)^3 - 10(9.5-9.5)^3 - (1448.83)(9.5)$

$(210x64x10^2)y_D = 12860.625 - 4119.375 - 13763.885$

$y_D = -5022.615/(210x64x10^2)$

$= -0.00373mm$



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**Problem – 2:**

**A steel cantilever beam of 6m long carries 2 point loads 15KN at the free end and 25KN at the distance of 2.5m from the free end. To determine the slope at free end & also deflection at free end I = $1.3x10^8 mm^4$. E = $2x10^5$ $N/mm^2$ (Apr/May 2008)**

**Solution:**

Given:

Length (l) = 6m

loads (w1) = 25KN

(w2) = 15KN

I = $1.3x10^8$ $mm^4$

= $1.3x10^{-4} m^4$

E = $2x10^5$ $N/mm^2$

= $2x10^8$ $KN/m^2$

Bending moment calculation:

Bending moment at C = 0

Bending moment at B = -(15x2.5) = - 37.5 KNm

Bending moment at A = -(15x6) – (25x3.5) = -177.5KNm

To find Bending moment Area:

Area of section (1) = ½ (bh)

a1 = ½ (2.5x37.5) = 46.875 $m^2$

Area of section (2) = lb

a2 = 3.5x37.5 = 131.25$m^2$



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Area of section (3) = ½(bh)

a3 = ½(3.5x140) = $245m^2$

Total bending moment area

A = a1 + a2 + a3

= 46.8 + 131.25 + 245 = $423.125m^2$

To find the slope at free end:

According to moment area

$i_c = \frac{Area\ of\ BMD}{EI} = \frac{423.125}{2\times10^8\times1.3\times10^{-4}}$

= 0.01627 radians

To find deflection at Free end (C):

$y = \frac{A\bar{x}}{EI}$

To find $\bar{x}$: section (1) => $\frac{2}{3}$(2.5) (or) $\frac{1}{3}$( (3.5) = 1.67m

section (2) => $2.5 + (\frac{3.5}{2})$ = 4.25m

section (2) => $2.5 + (3.5 \times \frac{2}{3})$ = 4.83m

$y = \frac{A1\bar{x}1 + A2\bar{x}2 + A3\bar{x}3}{EI} = \frac{46.875(1.67) + (131.25)(4.25) + 245(483)}{EI}$

$= \frac{1820.104}{EI}$ $y_c$ = 0.07000m

**Problem – 3:**

**Determine the deflection under point load.**



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$E = 2x10^5$ KN/$m^2$

$I = 1x10^{-4}$ $m^4$ . Using moment area method.

**Solution:**

To find support reactions:

Taking moment about A,

$R_B$ x 4 – (10x 3) – 10 = 0

$4R_B$ = 40

$R_B$ = 4

$R_A + R_B$ = 20

$R_A$ = 10

$R_A$ = 10KN

$R_B$ = 10KN

Bending moment calculation:

Bending moment at B = 0

Bending moment at D = (10x1) = 10KNm

Bending moment at C = (10x3) - (10x2) = 10KNm

Bending moment at A = (10x4) - (10x3) – (10x1) = 0

To find area of bending moment:

$A_1$ = ½(bh)

= ½(1)x10 = $5m^2$



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$A_2$ = 1/2(bh) = $5m^2$

$A_3$ = lxb = 10x2 = $20m^2$

To find slope at point load:

$i_C = \frac{A1}{EI} = \frac{5}{20}$ = 0.25 radians

$i_D = \frac{A2}{EI} = \frac{5}{20}$ = 0.25 radians

To find Centroid distance:

$\bar{x}1$ = 1/3 x 1 = 0.33m

$\bar{x}2$ = 0.33m

$y_C = \frac{A\bar{x}}{EI} = \frac{5(0.33)}{20}$ = 0.825m

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## UNIT-V
## THIN CYLINDERS, SPHERES AND THICK CYLINDERS

**1. List out the modes of failure in thin cylindrical shell due to an internal pressure.**
**(May/Jun 2012)**

i)Circumferential or hoop stress and



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ii)Longitudinal stress

**2. What do you mean by principal plane? (May/Jun 2012)**

The planes which have no shear stress are known as principal planes.

**3. What are assumptions involved in the analysis of thin cylindrical shells? (April/May 2011)**

The material of the cylinder is homogeneous, isotropic and obeys Hook's law.

i)The hoop stress distribution in thin cylinder is uniform over the cross section from inner to outer surface since the thickness of the cylinder is thin and

ii)Weight of fluid and material of the cylinder is not taken into account.

**4. What are principal planes and principal stress one end is fixed and other end is free? (April/May 2011)**

Principal stress: The magnitudes of normal stress, acting on a principal plane are known as principal stresses. The plane which have no shear stress are known as principal planes.

**5. Define Circumferential and Hoop stress. (May/June 2013)**

A thin cylinder shell is subjected to an internal pressure, as a result of internal pressure, the cylinder has tendency to split up into two troughs is called circumferential stress. The same cylinder shell, subjected to the same internal pressure, the cylinder also has a tendency to split in to two ieces is known as Hoop stress.

**6. What is the use of Mohr's circle? (May/June 2009)**

It is used to find out the normal, tangential, resultant and principal stresses and their planes.

**7. What are the planes along which the greatest shear stresses occurs? (Apr/May 2008)**

Greatest shear stress occurs at the planes which is inclined at 45˚ to its normal.

**8. What is the radius of Mohr's circle? (Apr/May 2008)**

Radius of Mohr's circle is equal to the maximum shear stress.

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**9. In case of equal like principal stresses what is the diameter of the Mohr's circle? (Apr/May 2010)**

In case of equal like principal stresses what is the diameter of the Mohr's circle is zero.

**10. What is mean by position of principal planes? (Apr/May 2010)**

The planes on which shear stress is zero are known as principal planes. The position of principal planes are obtained by equating the tangential stress to zero.

**11. What is solid length?**

The length of a spring under the maximum compression is called its solid length. It is the product of total number of coils and the diameter of wire.

Ls = nt x d

Where, nt = total number of coils.

**12. Define spring rate (stiffness). (Apr/May 2008)**



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The spring stiffness or spring constant is defined as the load required per unit deflection of the spring.

$K = W/y$

Where , W - load

y- Deflection

**13. Define pitch.**

Pitch of the spring is defined as the axial distance between the adjacent coils in uncompressed state. Mathematically

Pitch=free length n-1

**14. Define helical springs.**

The helical springs are made up of a wire coiled in the form of a helix and are primarily intended for compressive or tensile load.

**15. What are the differences between closed coil & open coil helical springs?**

**Closed coil spring**

The spring wires are coiled very closely, each turn is nearly at right angles to the axis of helix . Helix angle is less ($7^0$ to $10^o$)

**Open coil spring**

The wires are coiled such that there is a gap between the two consecutive turns. Helix angle is large (>10o)

**16. Write the assumptions in the theory of pure torsion.**

1. The material is homogenous and isotropic.

2. The stresses are within elastic limit

3. C/S which are plane before applying twisting moment remain plane even after the application of twisting moment.

4. Radial lines remain radial even after applying torsional moment.

5. The twist along the shaft is uniform

**17. Define : Polar Modulus**

Polar modulus is defined as the ratio of polar moment of inertia to extreme radial distance of the fibre from the centre.

**18. Write the equation for the polar modulus for solid circular section**

$$Z_p = \frac{\pi d^3}{16}$$

**Problem -1:**



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**The mild steel block has cross-section of 50x50mm carries an axial load of 35KN which is compressive in nature. Find the normal, tangential stresses across the plane through the point of 30° to the axis of the block. Also find the maximum shear stress in the block. (Apr/May 2008)**

Solution:

Given data:

$l = 50mm$

$b = 50mm$

$P = 35x10^3N$

$\theta = 30°$

Formula:

$\sigma_n = 0.014(\cos 60°) = 10.5N/mm^2$

$\sigma_t = \frac{0.014}{2}(\sin 60°) = 6.06N/mm^2$

$(\sigma_t)_{max} = 7N/mm^2$

**Problem -2:**

**A member subjected to a pull of two pieces wooden frame of cross section (35x15)mm connected by bolts joints. Calculate the maximum permissible value of P which can withstand if the permissible normal, tangential stresses is 13N/mm$^2$ and 8N/mm$^2$. Angle of cross section is 40°. (Apr/May 2005)**

**Solution:**

$\sigma_n = \sigma\cos^2\theta$

$\sigma_n = \frac{P}{A}(\cos 80°)$



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$P = \frac{13x(35x15)}{0.5868}$

$P_n = 11630.87x10^{-3}$

$\sigma_t = \frac{\sigma}{2} \sin 2\theta$

$8 = \frac{P}{(35\times15)\times2} \sin 80°$

$P = \frac{8400}{(0.9848)}$

$P_t = 8529.508N$

Tangential load $P_t$ is minimum

The same axial load is 8529.508N (or) 8.5K

**Problem-3:**

**A 5mm thick aluminium plate has a width of 300mm and a length of 600mm subjected to pull of 15000N,9000N respectively in axial transverse directions. Determine the normal, tangential and resultant stresses on a plate 50°. (May/Jun 2003)**

**Solution:**

$d = 5mm$

$b = 300mm$

$l = 600mm$

$P_1 = 15000N$

$P_2 = 9000N$

$\theta = 50°$

Axial stress $(\sigma_1) = \frac{15000}{(5\times300)} = 10N/mm^2$



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Transverse stress $(\sigma_2)$ = $\frac{9000}{(5\times600)}$ = $3N/mm^2$

Normal stress $(\sigma_n)$ = $\frac{\sigma_1+\sigma_2}{2}+\frac{\sigma_1-\sigma_2}{2}(\cos 2\theta)$

= $\frac{10+3}{2}+\frac{10-3}{2}\cos 100°$

= $5.892N/mm^2$

Tangential stress $(\sigma_t)$ = $\frac{\sigma_1-\sigma_2}{2}\sin 2\theta$

= $3.4468N/mm^2$

Resultant stress $(\sigma_{res})$= $\sqrt{{\sigma_n}^2+{\sigma_t}^2}$

= $6.82N/mm^2$

**Problem – 4:**

**The principle stresses at a point in the section of a heat exchanger shell are 18MPa (Tensile) and 10MPa (Compressive). Acting mutually perpendicular to each other. Determine the normal, shear, resultant stress on a plane whase normal is inclilned at 60° to 10MPa stress. Find also the maximum shear stress. (Nov/Dec 2001)**

**Solution:**

$\sigma_1$ = 18MPa = $18N/mm^2$

$\sigma_2$ = -10MPa = $-10N/mm^2$

$\theta$ = 60°

Normal stress $\sigma_n$ = $\frac{\sigma_1+\sigma_2}{2}+\frac{\sigma_1-\sigma_2}{2}\cos 2\theta$

= $\frac{8}{2}+\frac{28}{2}(\cos 120°)$



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$= -3\ N/mm^2$

Shear stress $\sigma_t = \frac{\sigma_1 - \sigma_2}{2} \sin 2\theta$

$= 12.12 N/mm^2$

Resultant stress $\sigma_{res} = \sqrt{(-3)^2 + (12.12)^2}$

$= 12.489 N/mm^2$

Maximum shear stress

$(\sigma_t)_{max} = \frac{\sigma_1 + \sigma_2}{2}$

$= 14 N/mm^2$

**Problem -5:**

**A steel bar is under a tensile stress of 65N/mm$^2$ at the same time it is accompanied by a shear stress of 22.5N/mm$^2$. Find the normal, shear stress and resultant stress across a plane at an angle of 45° with the axis of major tensile stress and also find the maximum shear stress. (Nov/Dec 2013)**

**Solution:**

$\sigma = 65 N/mm^2$

$q = 22.5\ N/mm^2$

$\theta = 45°$

Normal stress $\sigma_n = \frac{\sigma}{2}(1+\cos 90°) + 22.5 \sin 90°$

$= 55 N/mm^2$

Tangential stress $\sigma_t = \frac{\sigma}{2} \sin 2(45°) - 22.5 \cos 90°$



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$= 32.5 N/mm^2$

Resultant stress $\sigma_{res} = \sqrt{(55)^2 + (32.5)^2}$

$= 63.88 N/mm^2$

Maximum shear stress

$(\sigma_t)_{max} = \frac{1}{2}\sqrt{(65)^2 + 4(22.5)^2}$

$= 39.52 N/mm^2$

**Problem -6:**

**A rectangular block of material is subjected to a tensile stress of 110N/mm$^2$, one plate and a tensile stress of 47N/mm$^2$ on another plate at right angle to each other and the above stress is accomplished by a shear stress of 63N/mm$^2$. Determine the principle stress, principle plane and maximum shear stress. (May/June 2002)**

**Solution:**

$\sigma_1 = 110 N/mm^2$

$\sigma_2 = 47 N/mm^2$

$q = 63 N/mm^2$

$\theta = 45°$

To find principle planes:

$\sigma_{n1} = \frac{110+47}{2} + \frac{1}{2}\sqrt{(110-47)^2 + 4(63)^2}$

$= 148.93 N/mm^2$

Minor principle stress:

$\sigma_{n2} = \frac{110+47}{2} - \frac{1}{2}\sqrt{(110-47)^2 + 4(63)^2}$

$= 8.093 N/mm^2$



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To find principle planes:

$$\tan 2\theta = \frac{2q}{\sigma_1 - \sigma_2}$$

$$2\theta = 63°43'$$

$$\theta = 31°71'$$

Maximum shear stress

$$(\sigma_t)_{max} = \frac{1}{2}\sqrt{(\sigma_1 - \sigma_2)^2 + (4q)^2}$$

$$= 70.43 N/mm^2$$

**Problem -7:**

**Two planes AB,AC, which are right angles carries a shear stress of intensity 17.5N/mm$^2$ while this plane also carrying a tensile stress of 70N/mm$^2$ at a compressive stress of 35N/mm$^2$ respectively. Determine the normal tangential & resultant stress, principle planes and principle stress and also determine the maximum shear stress. ((May/June 2012)**

Solution:

$$\sigma_1 = 70N/mm^2$$

$$\sigma_2 = 35N/mm^2$$

$$q = 17.5N/mm^2$$

$$\theta = \frac{\tan^{-1}\left(\frac{2(17.5)}{70+35}\right)}{2}$$

$$\theta = 9°2'$$

Normal stress

$$\sigma_n = \frac{70-35}{2} + \frac{70+35}{2}\cos(2 \times 9°.2') + 17.5 \sin(2 \times 9°.2')$$



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$= 72.839\ N/mm^2$

Tensile stress

$\sigma_t = \frac{70+35}{2} \sin(2 \times 9°.2') + 17.5 \cos(2 \times 9°.2')$

$= -0.0337 N/mm^2$

Resultant stress $\sigma_{res} = \sqrt{(\sigma_n)^2 + (\sigma_t)^2}$

$= 72.839 N/mm^2$

Major principle stress

$\sigma_{n1} = \frac{70-35}{2} + \frac{1}{2}\sqrt{(70+35)^2 + 4(17.5)^2}$

$= 72.839 N/mm^2$

Minor principle stress

$\sigma_{n2} = \frac{70-35}{2} - \frac{1}{2}\sqrt{(70+35)^2 + 4(17.5)^2}$

$= -37.83 N/mm^2$

Maximum shear stress

$(\sigma_t)_{max} = \frac{1}{2}\sqrt{(70+35)^2 + 4(17.5)^2}$

$= 55.33 N/mm^2$



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