MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION
(Autonomous)
(ISO/IEC - 27001 - 2013 Certified)

WINTER – 19 EXAMINATION

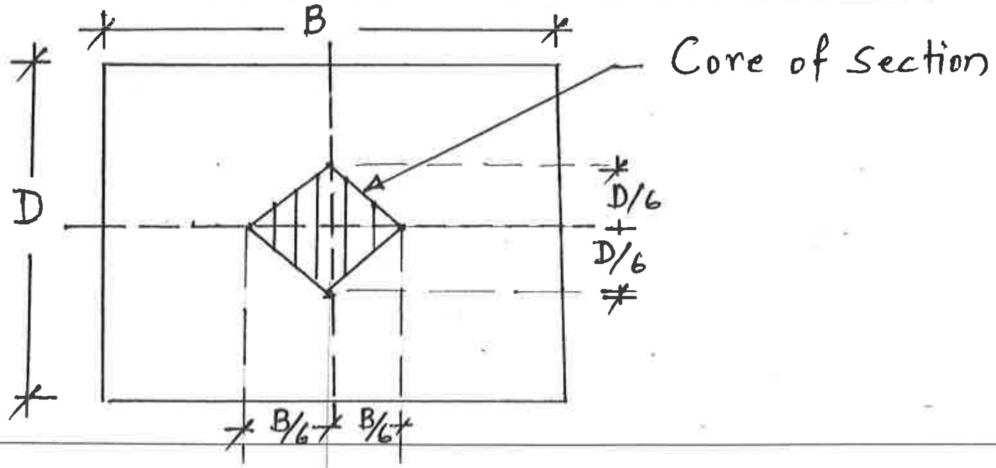
Subject Name: STRENGTH OF MATERIALS **Model Answer** **22306**

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

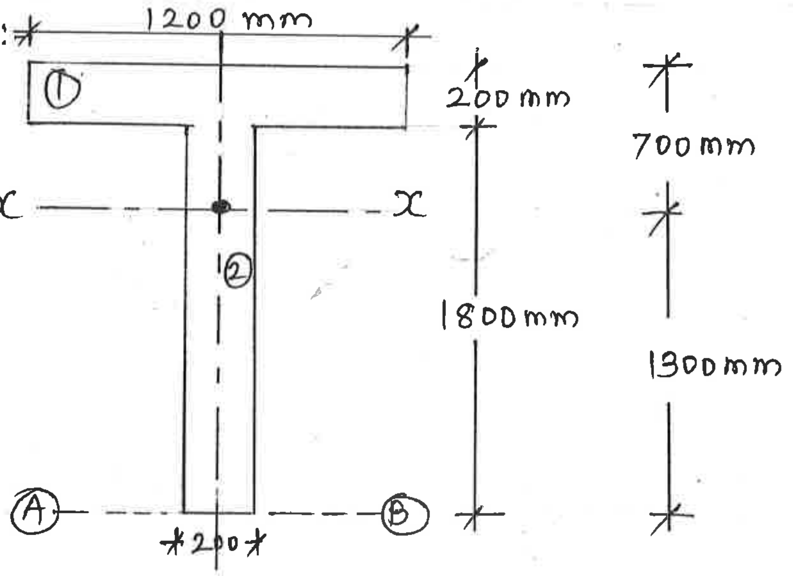
Q. No.	Sub Q.No.	Answer	Marking Scheme
1.		**Attempt any FIVE of the following:**	10
	a)	Write the formulae to find moment of Inertia of semi-circular section about its xx and yy centroidal axes.	
		Soln:- $I_{xx} = 0.11 R^4$	1
		$I_{yy} = \frac{\pi R^4}{8}$ OR $\frac{\pi D^4}{128}$	1 } 2
	b)	Differentiate between single shear and double shear.	
		Soln:- Differentiation between single shear and double shear	1 Mark for each criteria Max. 2 Marks.

Sr No	Criteria	Single shear	Double shear
1	No. of shearing planes	one	two
2.	No. of pieces of specimen after failuer in shear	two	three
3.	formula to calculate shear stress	$q = F/A$	$q = F/2A$

	c)	Define brittleness. Enlist any two names of brittle materials. Brittleness:- It is the property of material due to which it suddenly breaks without remarkable deformation when subjected to external force. Examples of brittle materials – Brass, Cast iron, Glass, chalk etc.	01 ½ mark for each example 02
	d)	Define point of contraflexure. Point of contraflexure:- It is the point along the length of beam where bending moment changes from sagging (or +ve) to hogging (or -ve) and vice-versa.	02
	e)	State the relation between maximum shear stress and average shear stress for a solid circular section. For solid circular beam section – Max. shear stress = $\frac{4}{3}$ Average shear stress OR. $q_{max} = \frac{4}{3} q_{average}$ or $1.33\ q_{average}$	02
	f)	Draw a neat sketch to show core of a rectangular section of (B × D) dimensions.  	

1.	g)	State the condition for no tension at the base of a column. Condition for no tension at the base of a column:- Direct stress shall be greater than or equal to bending stress OR. $\sigma_0 \geq \sigma_b$	02
2.		**Attempt any THREE of the following:**	12
	a)	Calculate M.I. of a T-section about the centroidal xx axis. Top flange is 1200 mm × 200 mm and web is 1800 mm × 200 mm. Total height is 2000 mm.	

Sol^n:



from fig:- $a_1 = 1200 \times 200 = 240000 \text{ mm}^2$, $y_1 = 1900 \text{ mm}$

$a_2 = 200 \times 1800 = 360000 \text{ mm}^2$, $y_2 = 900 \text{ mm}$

Position of centroid from base AB

$$\bar{Y} = \frac{a_1 y_1 + a_2 y_2}{a_1 + a_2} = \frac{240000(1900) + 360000(900)}{240000 + 360000}$$

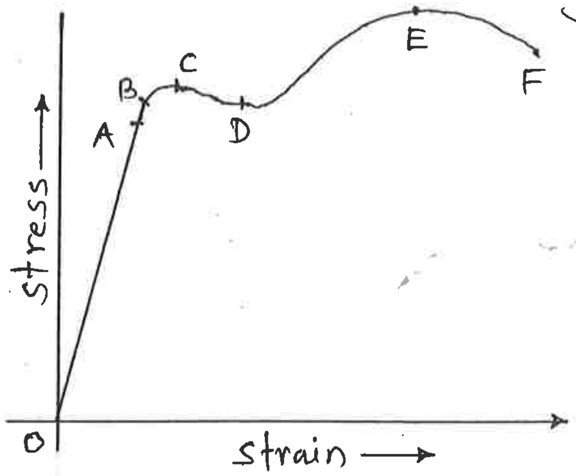
$\bar{Y} = 1300 \text{ mm}$ OR 700 mm from top of flange. 1

Using transfer formula,

$$I_{xx_1} = \left(\frac{bd^3}{12} + ah^2\right)_1 = \frac{1200 \times 200^3}{12} + 240000(1900-1300)^2$$

$I_{xx_1} = 8.72 \times 10^{10} \text{ mm}^4$ 1

$$I_{xx_2} = \left(\frac{bd^3}{12} + ah^2\right)_2 = \frac{200 \times 1800^3}{12} + 360000(1300-900)^2$$

		(Contd.... from page 3) $I_{xx_2} = 15.48 \times 10^{10}\ mm^4$ $\therefore$ I_{xx} of 'T' section $= I_{xx_1} + I_{xx_2}$ $= 8.72 \times 10^{10} + 15.48 \times 10^{4}$ $\therefore \boxed{I_{xx} = 24.20 \times 10^{10}\ mm^4}$	1 1
2	b)	Draw stress - strain diagram with all salient points on it for ductile material and explain the term ultimate stress. Soln:- stress-strain diagram for ductile material  A = Proportionality point B = Elastic limit C = Upper Yield point D = Lower Yield point E = Ultimate stress point F = Breaking stress point Ultimate Stress:- It is maximum stress developed in material. Its value is obtained by following relation. $$\text{Ultimate stress} = \frac{\text{Maximum load}}{\text{Original c/s area of body}}$$	1+1 02
2	c)	For a certain material, modulus of elasticity is 169 MPa. If Poisson's ratio is 0.32, calculate the values of modulus of rigidity and bulk modulus. Given:- $E = 169\ MPa$ $\mu = 0.32$ To find:- i) Modulus of rigidity (G) ii) Bulk Modulus (K)	

Solution:-

i) Using the relation, $E = 2G(1+\mu)$ — 1

$169 = 2G(1+0.32)$

$\therefore$ $\boxed{G = 169/2.64 = 64.02\ \text{MPa}}$ — 1

ii) Using the relation, $E = 3K(1-2\mu)$ — 1

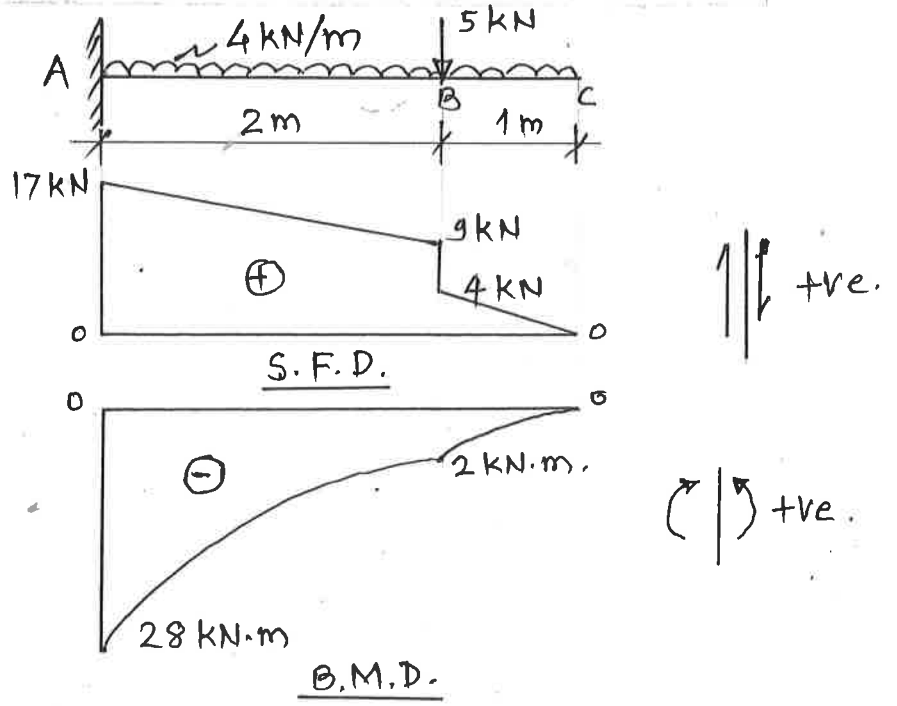
$169 = 3K(1-2\times0.32)$

$\therefore$ $\boxed{K = 169/1.08 = 156.48\ \text{MPa}}$ — 1

---

2 d) A cantilever of span 3 m carries a point load of 5kN at 2 m from the support and a u.d.l. of 4 kN/m over the entire span. Draw S.F. and B.M. diagrams.

Soln:-



(S.F.D.) — 1

(B.M.D.) — 1

S.F. Calculations,

$SF_C = 0$

$SF_{B(right)} = 4\times1 = 4\ \text{kN}.$

$S.F_B\ (left) = 4+5 = 9\ \text{kN}.$

$S.F_A = 9 + 4\times2 = 17\ \text{kN}.$ — 1

B.M. Calculations

$BM_C = 0$

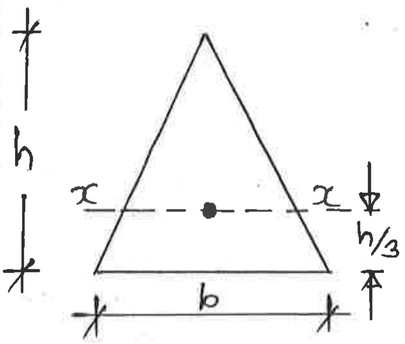
$B.M_B = 4\times1\times0.5 = 2\ \text{kN.m}.$

$B.M_A = 4\times3\times1.5 + 5\times2 = 28\ \text{kN.m}.$ — 1

3.		**Attempt any THREE of the following:**	12
	a)	State parallel axis theorem and use it to find moment of Inertia of an isosceles triangle of base 'b' and height 'h' about its base.	

Soln:- Parallel axis theorem:- Moment of inertia of a plane lamina about an axis parallel to its centroidal axis is given by sum of M.I. of that lamina about its centroidal axis and the product of area of the lamina and square of the distance between two parallel axes. 02

M.I. of an isosceles triangle about its base



Using parallel axis theorem.

$$I_{base} = I_G + Ay^2$$

$$= \frac{bh^3}{36} + \left(\frac{1}{2} \times b \times h\right) \times \left(\frac{h}{3}\right)^2$$

$$= \frac{bh^3}{36} + \frac{bh^3}{18}$$

$$= \frac{bh^3 + 2bh^3}{36}$$

$$\boxed{I_{base} = \frac{bh^3}{12}}$$ 02

3 b) A brass bar shown in Figure No. 1 is subjected to a tensile load of 40 kN. Find the total elongation of the bar if $E = 1 \times 10^5$ N/mm^2 and the maximum stress induced.

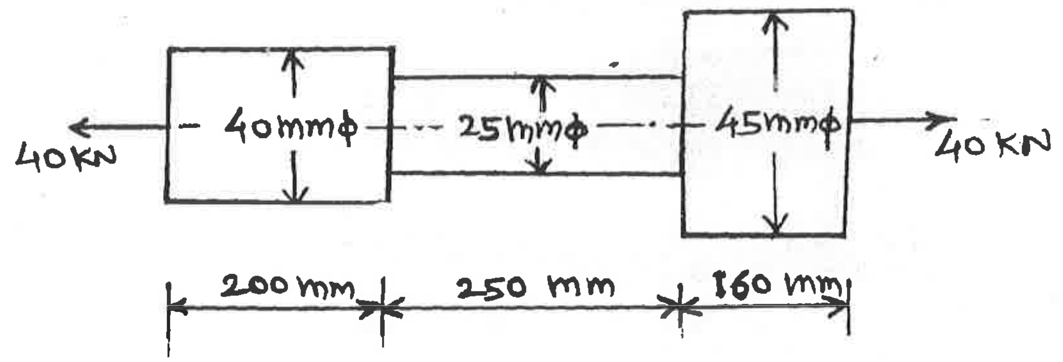


Fig. No. 1

To find :- (i) total elongation, (ii) maximum stress

Sol^n :- $a_1 = \frac{\pi}{4} \times 40^2 = 1256.63 \text{ mm}^2$

$a_2 = \frac{\pi}{4} \times 25^2 = 490.87 \text{ mm}^2$

$a_3 = \frac{\pi}{4} \times 45^2 = 1590.43 \text{ mm}^2$

Change in length $= \delta L = \frac{PL}{AE}$

$$\delta L = \frac{P}{E}\left(\frac{L_1}{a_1} + \frac{l_2}{a_2} + \frac{l_3}{a_3}\right)$$ 01

$$= \frac{40 \times 10^3}{1 \times 10^5}\left[\frac{200}{1256.63} + \frac{250}{490.87} + \frac{160}{1590.43}\right]$$

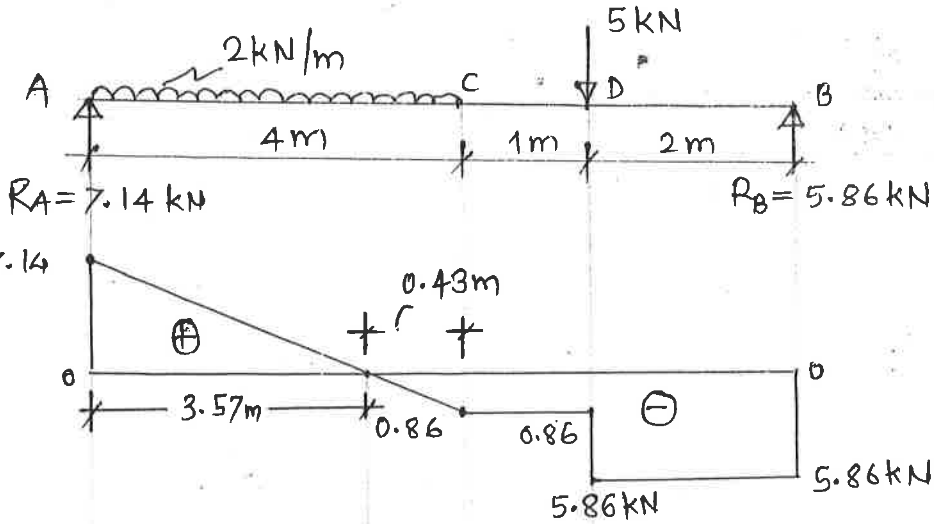
$$\boxed{\delta L = 0.308 \text{ mm}}$$ 02

$$\text{Maximum stress} = \frac{P}{a_{min}} = \frac{40 \times 10^3}{490.87}$$

$$\therefore \boxed{\sigma_{max} = 81.49 \text{ N/mm}^2}$$ 01

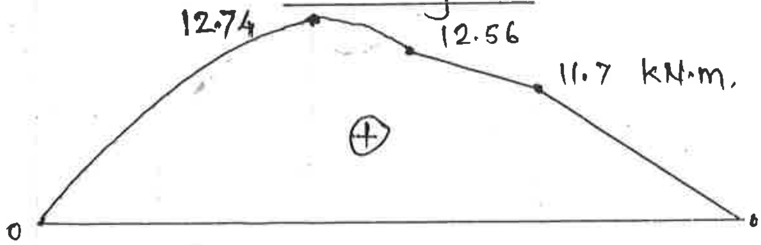
3	c)	A simply supported beam of span 7 m carries an u.d.l. of 2kN/m over 4 m length from left hand support and a point load of 5 kN at 2 m from right hand support. Draw S.F. and B.M. diagrams.	

Soln:-



S. F. Diagram.

01



B.M. Diagram.

01

(A) Reactions, $\Sigma M_A = 0$, ↻ +ve.

$2 \times 4 \times 2 + 5 \times 5 - R_B \times 7 = 0$

$\therefore R_B = 5.86$ kN

$\Sigma F_y = 0$ ↑ +ve

$R_A + R_B - (2 \times 4) - 5 = 0$

$\therefore R_A = 13 - 5.86 = 7.14$ kN

(B) S.F. values ↑↓ +ve.

$S.F_A = R_A = 7.14$ kN.

$S.F_C = 7.14 - (2 \times 4) = -0.86$ kN.

$S.F_D$ (left) $= -0.86$ kN

$S.F_D$ (right) $= -0.86 - 5 = -5.86$ kN.

$S.F_B = -5.86$ kN.

S.F. Calculations 01 Mark.

Position of point of contrashear

$$\frac{7.14}{0.86} = \frac{4-d}{d} = \frac{4}{d} - 1$$

$$8.30 + 1 = \frac{4}{d} \qquad \therefore \; d = \frac{4}{9.30} = \underline{0.43\ m.\ \text{from pt 'c'}}$$

OR $\underline{3.57\text{m from 'A'}}$

c) B.M. Values $\quad$ +ve

$BM_A = 0$

$BM_C = 7.14 \times 4 - 2 \times 4 \times 2 = 12.56$ kN.m.

$BM_D = 7.14 \times 5 - 2 \times 4 \times 3 = 11.7$ kN.m.

$BM_B = 0$

$BM_{max} = 7.14 \times 3.57 - \dfrac{2 \times 3.57^2}{2} = 12.74$ kN.m.

B.M. Calculation 01 Mark.

---

3 d) A C-clamp as shown in Figure No. 2, carries a load P = 25 kN. The cross-section of the clamp at x – x is rectangular, having width equal to twice the thickness. Assuming that the C-clamp is made of steel casting with an allowable stress of 100 N/mm^2, find its dimensions *b* and *t*.

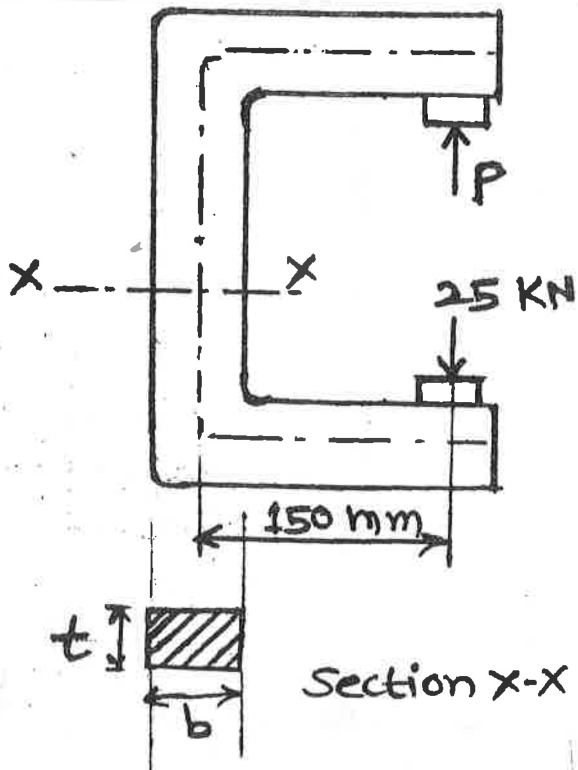


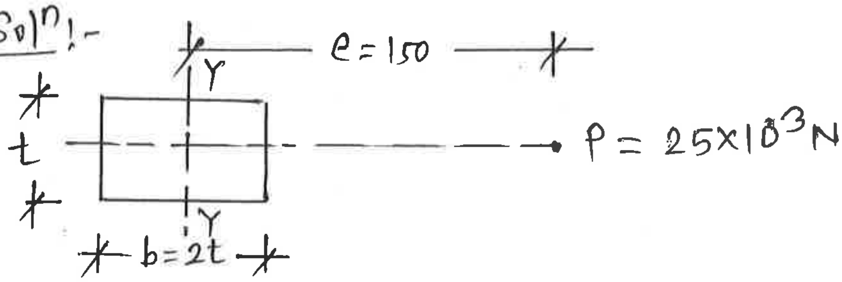
Fig. No. 2

d

<u>Given:</u> $P = 25\times10^3\,N$, $e = 150\,mm$, $\sigma_{max} = 100\,N/mm^2$
$b = 2t$

<u>To find:</u> b and t

<u>Soln:-</u>



eccentricity @ yy-axis.

$$I_{yy} = \frac{t\times(2t)^3}{12} = \frac{2}{3}t^4, \quad y_{max} = \frac{2t}{t} = t$$ 01

$$\sigma_{max} = \sigma_0 + \sigma_b = \frac{P}{A} + \frac{P.e.y_{max}}{I}$$ 01

$$100 = \frac{25\times10^3}{t\times2t} + \frac{25\times10^3\times150\times t}{\frac{2}{3}t^4}$$

$$100 = \frac{12500}{t^2} + \frac{5625000}{t^3}$$ 01

OR multiplying by $t^3/100$

$$t^3 = 125t + 56250$$

$$\therefore t^3 - 125t - 56250 = 0$$

Solving, $\underline{t = 39.41\,mm}$

$\therefore b = 2t = 2\times39.41$

$\therefore \underline{b = 78.82\,mm}$ 01

4.		**Attempt any THREE of the following:**	12
	a)	A steel rail is 12.6 m long and is laid at a temperature of 24°C. The maximum temperature expected is 44°C. Determine: (i) The minimum gap between two rails to be left so that temperature stresses do not develop. (ii) Thermal stresses developed in the rails if no expansion joint is provided. Take $E = 2 \times 10^5$ N/mm² and $\alpha = 12 \times 10^{-6}/°C$.	

Given :- $L = 12.6\,m = 12.6 \times 10^3\,m$, $t_1 = 24°c$, $t_2 = 44°c$

$\alpha = 12.6 \times 10^{-6}\,/°C$. $E = 2 \times 10^5\,N/mm^2$

To find :- 1) Minimum gap so that no temp. stress develop

ii) thermal stresses developed if no expansion is permitted.

Slo^n :- $T = t_2 - t_1 = 44 - 24 = 20°c$

i) Minimum gap for no temp. stresses $= \delta L$

δL = free expansion $= L \alpha T$

$= 12.6 \times 10^3 \times 12 \times 10^{-6} \times 20°$

$\boxed{\delta L = 3.024\,mm}$ 01+01

ii) Thermal stresses when no expansion joint is provided.

$\sigma_T = \alpha T E = 12 \times 10^{-6} \times 20 \times 2 \times 10^5$

$\boxed{\sigma_T = 48\,N/mm^2 \text{ (Compressive)}}$ 01+01

4	b)	Calculate the power a shaft of 30 mm diameter can transmit with a speed of 200 r.p.m. if the permissible shear stress is 120 N/mm². Take maximum torque as 30% more than the average torque.	

Given; for shaft, $D = 30\,mm$, $N = 200\,rpm$, $\tau = 120\,N/mm^2$

$T_{max} = 1.3\,T_{avg}$.

To find: Power of shaft

Soln:- Using the relation

$$\frac{T}{I_p} = \frac{\tau}{R}$$

$$\therefore T = \frac{I_p}{R} \times \tau = \frac{\pi}{16} D^3 \times \tau$$

$$T_{max} = \frac{\pi}{16} \times 30^3 \times 120 = 6.36 \times 10^5\ N\text{-}mm \qquad 01$$

$$\therefore T_{avg} = \frac{T_{max}}{1.3} = \frac{6.36 \times 10^5}{1.3} = \frac{6.36 \times 10^5}{1.3}$$

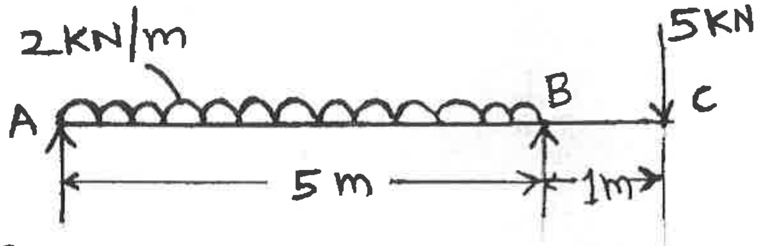
$$= 4.89 \times 10^5\ N\cdot mm = 4.89 \times 10^2\ N\cdot m. \qquad 01$$

$$\therefore \text{Power} = \frac{2\pi N\,T_{avg}}{60} = \frac{2\pi \times 200 \times 4.89 \times 10^2}{60} \qquad 01$$

$$= 10.242 \times 10^3\ \frac{N\cdot m}{sec}$$

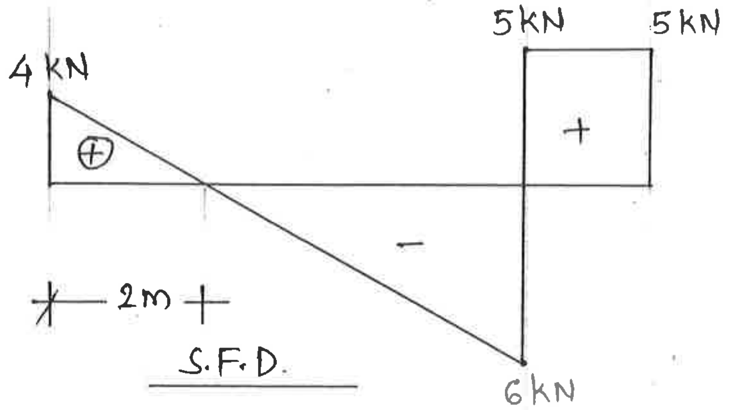
$$\boxed{P = 10.242\ kW} \qquad 01$$

4 c) An overhanging beam is as shown in Figure No. 3. Draw S.F. and B.M. diagrams and locate the point of contraflexure.



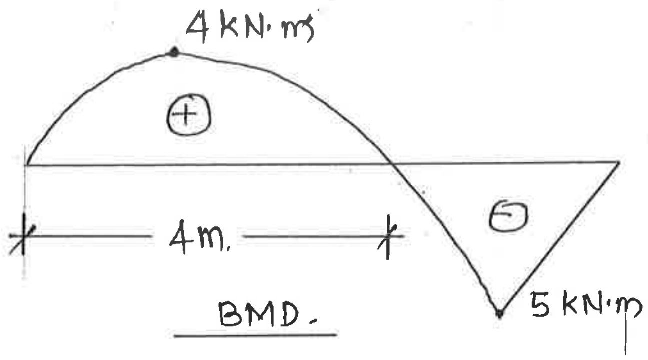
$R_A = 4$ kN **Fig No. 3** $R_B = 11$ kN

Soln:-



S.F.D.

+ve — 01



BMD.

+ve. — 01

1) Reactions $\Sigma M_A = 0$ +ve.

$2 \times 5 \times 2.5 - R_B \times 5 + 5 \times 6 = 0$

$\therefore R_B = 55/5 = 11$ kN.

$\Sigma F_y = 0$ ↑+ve, $R_A + R_B - (2 \times 5) - 5 = 0$

$\therefore R_A = 15 - 11 = 4$ kN.

2) S.F. Values:- $SF_A = 4$ kN +ve

$S.F_B(\text{left}) = 4 - (2 \times 5) = -6$ kN.

$S.F_B(\text{right}) = -6 + 11 = 5$ kN.

$S.F_C = 5$ kN.

S.F. value & Pt. of contraflexure 01

		Position of point of contrashear. $\frac{4}{d} = \frac{6}{5-d} \rightarrow d = 2m$ from 'A' 3) **B.M. Values** $\circlearrowleft | \circlearrowright$ +ve. $B.M_A = 0$ $B.M_B = 4\times5 - 2\times5\times2.5 = -5$ kN.m. $B.M_C = 0$ $B.M_{max} = 4\times2 - 2\times2\times1 = 4$ kN.m. **Position of point of contraflexure** $BM_x = 0$ $4x - \frac{2x^2}{2} = 0$ $4x = x^2$ $\therefore x = 4m$ from 'A'	BM value and position of P.C. 01
4	d)	A simply supported beam of span 8 m carries a point load of 60 kN at the centre of the span. Calculate the modulus of section required, if bending stress is not to exceed 150 MPa. **Given**, for S.S. beam, $L = 8$ m, $P = 60$ kN at midspan. $\sigma_{b,max} = 150$ MPa, **To find** :- Section Modulus, Z **Soln**:- Maximum B.M at center $= \frac{WL}{4} = \frac{60\times8}{4} = 120$ kN.m $\therefore M = 120\times10^6$ N.mm. $\sigma_{b_{max}} = M/Z$ OR $Z = M/\sigma_{b_{max}} = \frac{120\times10^6}{150} = 8\times10^5\ mm^3$ $\boxed{Z = 8\times10^5\ mm^3}$	 01 01 01 01

	e)	State the equation of torsion with the meaning of each term and use the torsional equation to find torque induced in a solid circular shaft of 50 mm diameter rotating at 100 r.p.m. The permissible shear stress is not to exceed 75 MPa.	

Soln:-

i) Equation of Torsion

$$\frac{T}{I_p} = \frac{q}{R} = \frac{G\theta}{L}$$ 01

Where, T = Torque

I_p = Polar M.I.

q = Max. shear stress

R = Radius of shaft

G = Modulus of rigidity

θ = Angle of twist.

L = Length of shaft. 01

ii) for shaft, d = 50 mm, N = 100 rpm., $q_{max} = 75\ N/mm^2$

To find :- Torque.

$$I_p = \frac{\pi d^4}{32} = \frac{\pi \times 50^4}{32} = 6.14 \times 10^5\ mm^4$$ 01

$$T = \frac{I_p}{R} \times q_{max} = \frac{6.14 \times 10^5}{25} \times 75$$

$$\therefore T = 18.42 \times 10^5\ N\text{-}mm.$$

$$\boxed{T = 1.842\ kN\cdot m}$$ 01

			Marks
5.		Attempt any **TWO** of the following:	12
	a)	A rectangular block loaded is shown in Figure No. 4. Find linear strains in X, Y and Z directions. Also find change in volume of the block. Take E = 200 GPa and Poisson's ratio. μ = 0.25	

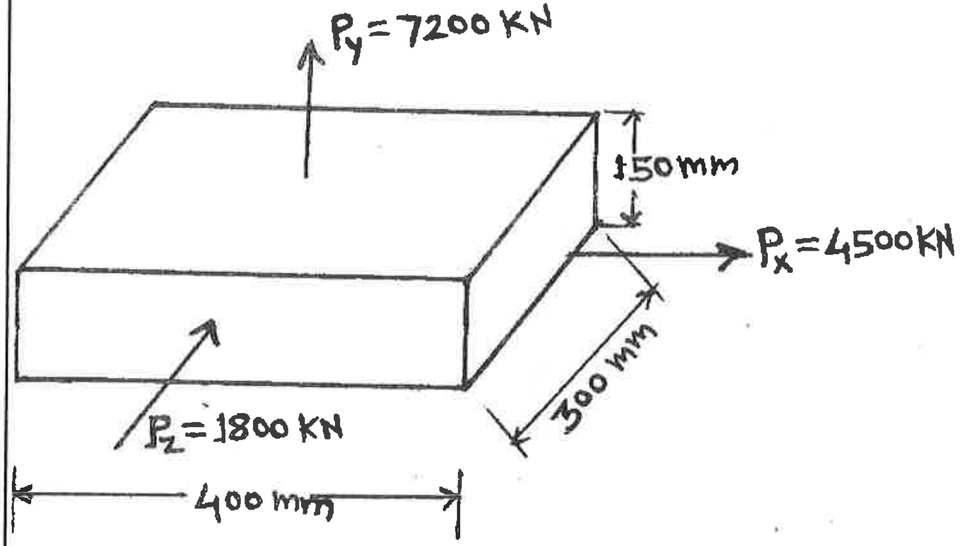


Fig No. 4

To find, i) e_x ii) e_y iii) e_z, iv) δV.

Solution:-

$$\sigma_x = \frac{4500 \times 10^3}{150 \times 300} = 100 \text{ N/mm}^2$$

$$\sigma_y = \frac{7200 \times 10^3}{400 \times 300} = 60 \text{ N/mm}^2$$

$$\sigma_z = \frac{-1800 \times 10^3}{400 \times 150} = -30 \text{ N/mm}^2$$

01

strain, $e_x = \frac{\sigma_x}{E} - \mu \frac{\sigma_y}{E} - \mu \frac{\sigma_z}{E}$

$$= \frac{1}{E}\left(\sigma_x - \mu \sigma_y - \mu \sigma_z\right)$$

$$= \frac{1}{2 \times 10^5}\left(100 - 0.25 \times 60 - (-30) \times 0.25\right)$$

$$\boxed{e_x = 4.625 \times 10^{-4}}$$

01

Strain, $e_y = -\mu \frac{\sigma_x}{E} + \frac{\sigma_y}{E} - \mu \cdot \frac{\sigma_z}{E}$

$= \frac{1}{E}\left(-0.25 \times 100 + 60 - 0.25 \times (-30)\right)$

$\boxed{e_y = +2.125 \times 10^{-4}}$ 01

Strain, $e_z = -\mu \frac{\sigma_x}{E} - \mu \cdot \frac{\sigma_y}{E} + \frac{\sigma_z}{E}$

$= \frac{1}{2 \times 10^5}\left(-0.25 \times 100 - 0.25 \times 60 + (-30)\right)$

$\boxed{e_z = -3.5 \times 10^{-4}}$ 01

$\therefore$ Volumetric strain $= e_v = e_x + e_y + e_z$

$= 4.625 \times 10^{-4} + 2.125 \times 10^{-4} - 3.5 \times 10^{-4}$

$\therefore \underline{e_v = 3.25 \times 10^{-4}}$ 01

Change in volume $= e_v \times V$

$= +3.25 \times 10^{-4} \times (400 \times 300 \times 150)$

$\boxed{\delta_v = +5850 \text{ mm}^3}$ 01

5	b)	A simply supported beam of span 8 m carries two point loads of 50 kN and 20 kN at 2 m and 6 m from the left hand support respectively. Draw bending moment diagram and also sketch the qualitative deflected shape of the beam.	

Solⁿ:- Reactions of beam.

$\underline{\Sigma M_A = 0}$ ↻+ve., $50 \times 2 + 20 \times 6 - R_B \times 8 = 0$

$\therefore \underline{R_B = 27.50 \text{ kN}}$.

$\underline{\Sigma F_y = 0}$ ↑+ve, $R_A + R_B - 50 - 20 = 0$

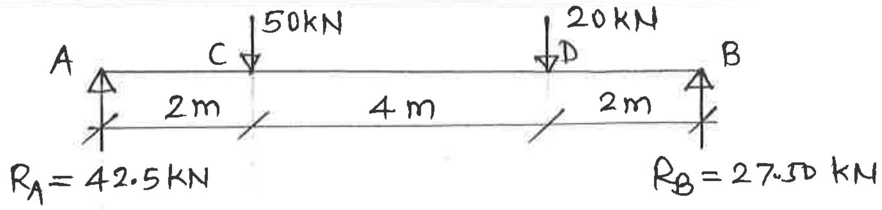
$\therefore \underline{R_A = 70 - 27.50 = 42.50 \text{ kN}}$. } 01

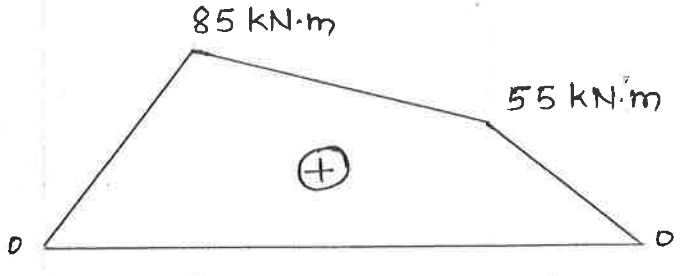
Calculations for B.M.D. (↻↺)+ve.

$BM_A = BM_B = 0$ --- Simple supports.

$B.M_C = R_A \times 2 = 42.50 \times 2 = 85$ kN·m.

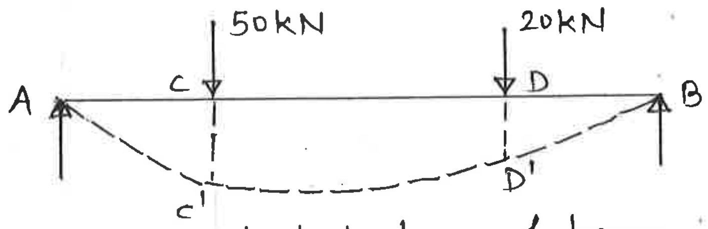
$BM_D = 42.5 \times 6 - 50 \times 4 = 55$ kN-m. } 02





B.M.D.

02



Deflected shape of beam.

$\delta_c > \delta_d$

01

5 c) State any four assumptions in the theory of simple bending and apply the bending stress equation to determine the maximum bending stress developed in a rectangular beam of cross section 50 mm × 150 mm when a bending moment of 600 N.m is applied about x-x axis.

Solⁿ:- Assumptions in the theory of simple bending

1. The section which is plane before bending will remain plane after bending.
2. The material of beam is homogeneous & isotropic.
3. Every layer is free to expand or contract as compared to the layer above or below it.
4. The beam is loaded within the elastic limit.
5. The section is subjected to pure bending only.

½ mark for each assumption (max. 2 Mk)

for rectangular beam, $b = 50$ mm, $d = 150$ mm, $M = 600 \times 10^3$ N·mm

$$I_{xx} = \frac{bd^3}{12} = \frac{50 \times 150^3}{12} = 14.06 \times 10^6 \text{ mm}^4$$ 01

$$y_{max} = d/2 = 150/2 = 75 \text{ mm.}$$ 01

Applying bending equation.

$$\frac{M}{I} = \frac{\sigma_{b max}}{y_{max}}.$$ 01

$$\therefore \sigma_{b,max} = \pm \frac{M \cdot y_{max}}{I} = \pm \frac{600 \times 10^3 \times 75}{14.06 \times 10^6}$$

$$\therefore \boxed{\sigma_{b,max} = \pm 3.20 \text{ N/mm}^2}$$ 01

6. **Attempt any <u>TWO</u> of the following:** 12

a) A beam of square cross section 100 mm × 100 mm is subjected to a shear force of 30 kN. Calculate the maximum shear stress as well as shear stress induced across the section at a layer 20 mm away from the neutral axis. Sketch the shear stress distribution diagram for the given beam.

<u>Given :- for beam section</u>

$b = d = 100$ mm.

$S = 30 \times 10^3$ N.

<u>To find:</u>

i) Max. shear stress (q_{max})

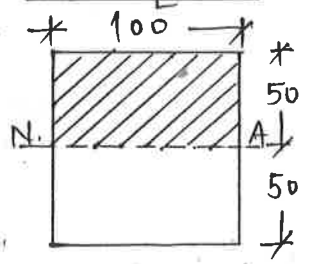
ii) Shear stress at a layer 20 mm away from N.A.

iii) Shear stress distribution

<u>Sol^n :-</u>

Shear stress is given by:- $q = \frac{S a \bar{y}}{b I}$.

i) <u>for q_{max}.</u>



$S = 30 \times 10^3$ N

$A = 100 \times 50 = 5000 \text{ mm}^2$

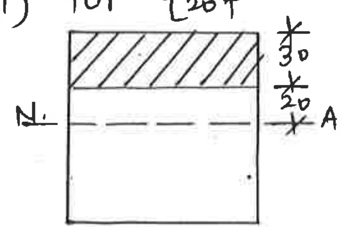
$\bar{Y} = 50/2 = 25$ mm

$b = 100$ mm., $I_{xx} = \frac{100 \times 100^3}{12} = 8.33 \times 10^6 \text{ mm}^4$

$$\therefore q_{max} = \frac{S a \bar{y}}{b I} = \frac{30 \times 10^3 \times 5000 \times 25}{100 \times 8.33 \times 10^6}$$

$$\boxed{q_{max} = 4.5 \text{ N/mm}^2}$$ 03

ii) for q_{20}



$S = 30 \times 10^3$ N, $A = 100 \times 30 = 3000 \text{ mm}^2$

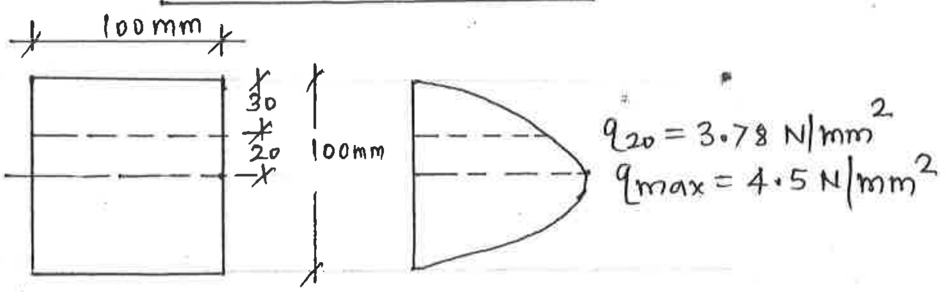
$\bar{Y} = 20 + \frac{30}{2} = 35$ mm.

$b = 100$ mm.

$I = 8.33 \times 10^6 \text{ mm}^4$

$$q_{20} = \frac{S a \bar{y}}{b I} = \frac{30 \times 10^3 \times 3000 \times 35}{100 \times 8.33 \times 10^6}$$

$$\therefore \boxed{q_{20} = 3.78 \ N/mm^2}$$ 02



01

C/s of beam — Shear stress distribution

6 b) A hollow circular shaft is required to transmit a torque of 24 kN.m. The inside diameter is 0.6 times external diameter. Calculate both the diameter, if allowable shear stress is 80 MPa.

Given, for hollow circular shaft

External dia = D,

Internal dia = d = 0.6D

$\delta_s = 80 \ N/mm^2$, $T = 24 \times 10^6 \ N \cdot mm$.

To find:-

i) D

ii) d.

Solution:-

$$I_p = \frac{\pi}{32}\left[D^4 - d^4\right] = \frac{\pi}{32}\left[D^4 - (0.6D)^4\right] = 0.0855 D^4$$ 02

$R = D/2$

Using the relation, $\frac{T}{I_p} = \frac{\delta_s}{R}$ 01

$$\frac{24 \times 10^6}{0.0855 D^4} = \frac{80 \times 2}{D}$$

$$\therefore D^3 = \frac{24 \times 10^6}{0.0855 \times 80 \times 2} = 1.75 \times 10^6 \ mm^3$$

$\therefore D = 120.61$ mm, Say 125 mm. 02

$d = 0.6 D = 0.60 \times (125) = 75$ mm. 01

6 c) A rectangular column 150 mm wide and 100 mm thick carries a load of 150 kN at an eccentricity of 50 mm in the plane bisecting the thickness. Find the maximum and minimum intensities of stress at the base section. Draw the combined stress distribution diagram showing these valves.

Given, for rectangular column

$b = 150\ mm,\ d = 100\ mm.$

$P = 150 \times 10^3\ N$

$e = 150\ mm.$

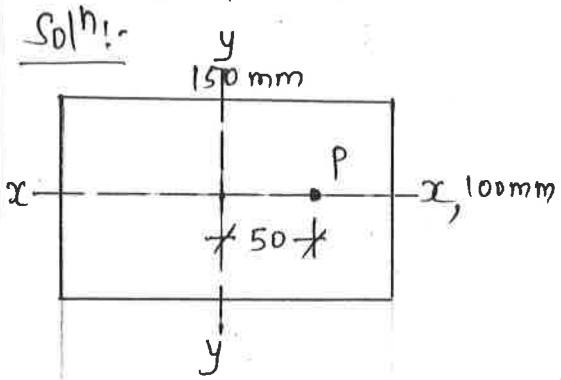
To find:-

1.) σ_{max}

2) σ_{min}

3) Stress distribution.

Soln:-



c/s of Column.

Eccentricity @ yy-axis -

$A = 150 \times 100 = 15000\ mm^2$

$\sigma_0 = \frac{P}{A} = \frac{150 \times 10^3}{15000} = 10\ N/mm^2$ 01

$I_{yy} = \frac{100 \times 150^3}{12} = 28.13 \times 10^6\ mm^4$ 01

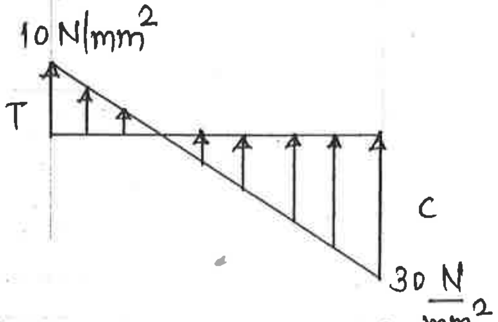
$y_{max} = 150/2 = 75\ mm.$

$\sigma_b = \pm \frac{P \cdot e \cdot y_{max}}{I}$

$= \pm \frac{150 \times 10^3 \times 50 \times 75}{28.13 \times 10^6}$

$\sigma_b = \pm 20\ N/mm^2.$ 01

01 mark for dia.



Combined stress distribution dia.

$\sigma_{max} = \sigma_0 + \sigma_b = 10 + 20$

$\therefore \boxed{\sigma_{max} = 30\ N/mm^2\ (Comp).}$ 01

$\sigma_{min} = \sigma_0 - \sigma_b = 10 - 20$

$\therefore \sigma_{min} = -10\ N/mm^2$

$\therefore \boxed{\sigma_{min} = 10\ N/mm^2\ (Tensile)}$ 01