12425

WINTER- 2024 EXAMINATION

Model Answer

Subject Name: Strength of Material.

Subject Code 313308

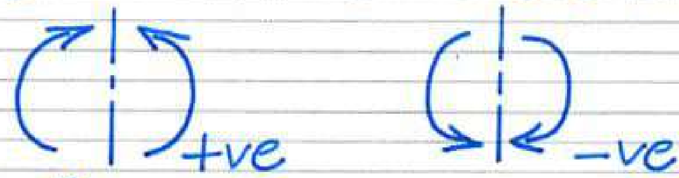
Important Instructions to STUDENTS

1) *The model answer given here are prepared from the answers from the previously uploaded model answers by Board.*
2) *These model answers are not uploaded by the MSBTE official site but MSBTE study resources website prepared it for students. This model answer has question paper also inbuilt in it, no need to download it separate.*
3) *Please remembter that answers are not checked word to word but based on keywords which must be present in your answer*
4) *The model answer and the answer written by candidate may vary but the examiner may tryto assess the understanding level of the candidate*
5) *While assessing figures, examiner may give credit for principal components indicated in thefigure. The figures drawn bycandidate and model answer may vary. The examiner may give credit for anyequivalent figure drawn*
6) *For programming language papers, credit may be given to any other program based on equivalentconcept*
7) *Students are advised to prepare all the syllabus from recommended book and use these model answers for the purpose of tests.*

Q.NO	SUB Q N	ANSWER	Marking Scheme
1.		Attempt any Five of the following	10 Marks
	a]	Define Moment of Inertia.	
	→	Moment of Inertia:- Algebric sum of product of area & square of it's perpendicular distance referance from axis is "Moment of Inertia". It is denoted by "I". It's S.I. unit is $mm^4 / cm^4 / m^4$.	
	b]	Define Radius of Gyration.	
	→	It is the distance at which area is supposed to be concentrated to give same moment of Inertia. It is denoted by "K". $k = \sqrt{\frac{I}{A}}$ S.I. unit is mm/cm/M.	
	c]	State Hook's law:-	
	→	Within elastic limit stress is directly proportional to strain. $\boxed{\sigma = e}$	
	d]	Define Shear force & Bending Moment.	
	→	Shear Force:- Algebric sum of all vertical forces acting an either side of section of a beam is known as	

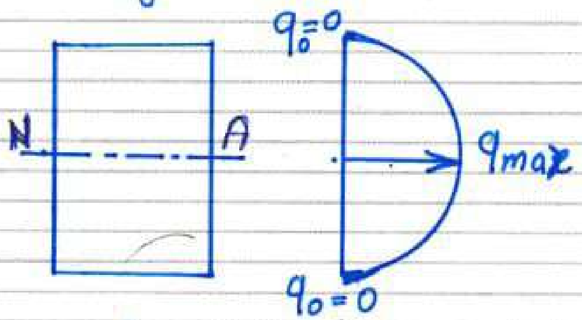
Q.NO	SUB Q N	ANSWER	Marking Scheme

Bending Moment :- It is the algebric sum of moment of all vertical forces acting on a beam on either side of section.



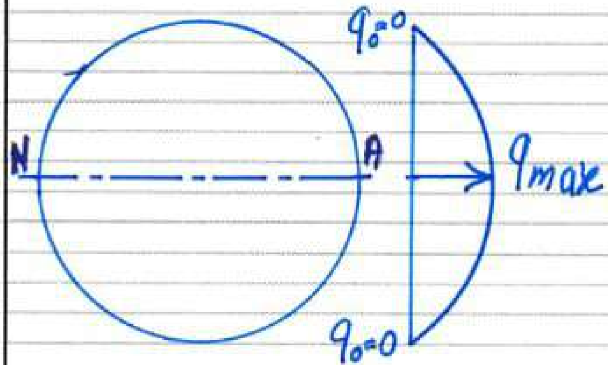
e) Give relation bet^n avarage & maximum shear stress for rectangular & circular cross section

→ Rectangular cross section:-



$$\boxed{q_{max} = 1.5\, q_{av.}}$$

Circular cross section:-



$$\boxed{q_{max} = \frac{4}{3}\, q_{av.}}$$

f] State any two assumptions in theory of pure bending.

→ i] Transverse sections of beam which are plane before bending remain plane after bending.

ii] Material of beam is homogeneous, isotropic & obeys Hook's law.

g] State middle third rule :-

→ (i) If $\sigma_o > \sigma_b$ load line falls inside core of section. (No tension at base)

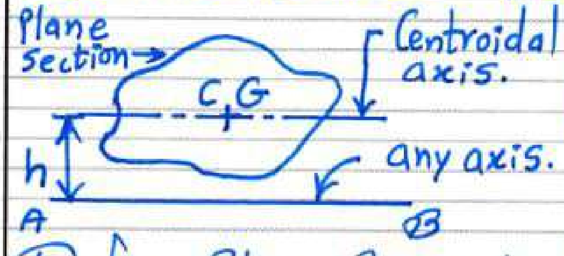
(ii) If $\sigma_o = \sigma_b$. load line falls on boundry line of core of section. (No tension at base)

(iii) If $\sigma_o < \sigma_b$ load line falls outside

Q.NO	SUB Q N	ANSWER	Marking Scheme
2.		Attempt any three	12 Marks

a] State Parallel axis theorem with mathematical formula

→ M.I. of a plane section about any axis is equal to the M.I. of plane section about a parallel axis passing through centroid plus product of area & square of perpendicular distance between two axis.

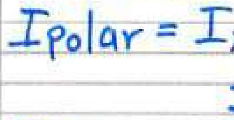


$$\boxed{I_{AB} = I_G + Ah^2}$$

b] Define Polar Moment of Inertia. Calculate Polar moment of Inertia for square lamina side 40cm

→ "Moment of inertia of a plane area w.r.t. an axis perpendicular to the plane figure" called "Polar M.I." It is denoted by = I_{polar}. [Unit is mm^4].

Polar M.I. of 40cm side square lamina —



$b = 40cm = 400mm$

$d = 40cm = 400mm.$

$$I_{xx} = \frac{bd^3}{12} = \frac{(400)(400)^3}{12} = 2.133 \times 10^9 \, mm^4$$

$$I_{yy} = \frac{db^3}{12} = \frac{(400)(400)^3}{12} = 2.133 \times 10^9 \, mm^4.$$

$$I_{polar} = I_{xx} + I_{yy} = 2.133 \times 10^9 + 2.133 \times 10^9$$

$$I_{polar} = 4.266 \times 10^9 \, mm^4.$$

c] Mild steel flat 120mm wide, 12mm thick & 5M long carries axial load of 25KN. Find stress strain & change in length. (Take $E = 2 \times 10^5 \, N/mm^2$)

→ $b = 120\,mm$, $d = 12\,mm$, $L = 5M = 5000mm.$

$\sigma = ?$ $e = ?$ & $\delta l = ?$ $P = 25 \times 10^3 N.$

(i) stress (σ)

$$\sigma = \frac{P}{A}$$

$$\sigma = \frac{25 \times 10^3}{120 \times 12}$$

stress $\sigma = 17.36 \, N/mm^2$

(ii) Change in length, (δl)

$$\delta l = \frac{P \cdot L}{A \cdot E}$$

$$\delta l = \frac{25 \times 10^3 \times 5000}{(120 \times 12)(2 \times 10^5)}$$

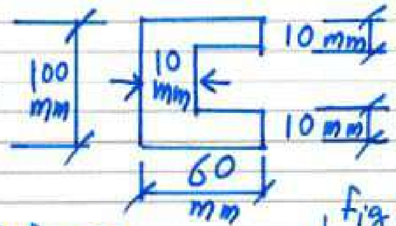
(iii) Strain (e)

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

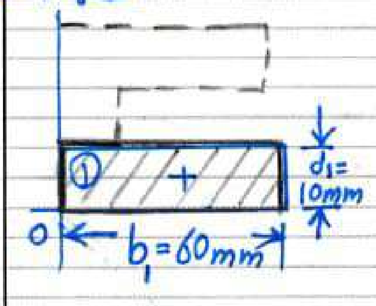
$$e = \frac{0.434}{5000}$$

Q.NO	SUB Q N	ANSWER	Marking Scheme

d] Calculate M.I. for following section:-



① Fig ①



② fig ②

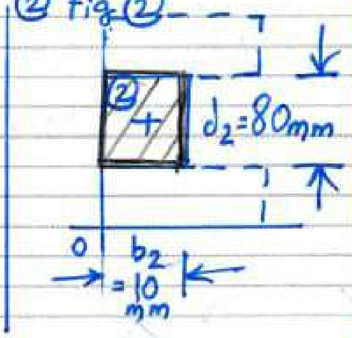
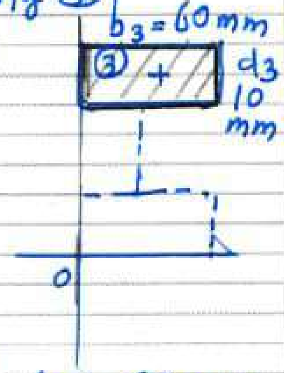


fig ③



$b_1 = 60mm$
$d_1 = 10mm$
$A_1 = b_1 \cdot d_1$
$A_1 = 600mm^2$
$y_1 = \frac{10}{2} = 5mm$

$b_2 = 10mm$
$d_2 = 80mm$
$A_2 = b_2 \cdot d_2$
$A_2 = 800mm^2$
$y_2 = 10 + \frac{80}{2} = 50mm$

$b_3 = 60mm$
$d_3 = 10mm$
$A_3 = b_3 \cdot d_3$
$A_3 = 600mm^2$
$y_3 = 10 + 80 + \frac{10}{2}$
$y_3 = 95mm$

$$\bar{y} = \frac{A_1 y_1 + A_2 y_2 + A_3 y_3}{A_1 + A_2 + A_3} = \frac{600(5) + 800(50) + 600(95)}{600 + 800 + 600}$$

$$\boxed{\bar{y} = 50mm}$$

$I_{xx_1} = \frac{b_1 d_1^3}{12} + A_1(\bar{y} - y_1)^2$
$= \frac{(60)(10)^3}{12} + (600)(45)^2$
$I_{xx_1} = 1.22 \times 10^6 mm^4$

$I_{xx_2} = \frac{b_2 d_2^3}{12} + (A_2)(\bar{y} - y_2)^2$
$= \frac{(10)(80)^3}{12} + (800)(0)$
$I_{xx_2} = 0.426 \times 10^6 mm^4$

$I_{xx_3} = \frac{b_3 d_3^3}{12} + A(\bar{y} - y)^2$
$= \frac{(60)(10)^3}{12} + (600)(45)^2$
$I_{xx_3} = 1.22 \times 10^6 mm^4$

$$\text{Total } I_{xx} = I_{xx_1} + I_{xx_2} + I_{xx_3} = 2.866 \times 10^6 mm^4$$

$x_1 = \frac{60}{2} = 30mm$ $\quad x_2 = \frac{10}{2} = 5mm$ $\quad x_3 = \frac{60}{2} = 30mm.$

$$\bar{x} = \frac{A_1 x_1 + A_2 x_2 + A_3 x_3}{A_1 + A_2 + A_3} \quad \therefore \boxed{\bar{x} = 20mm}$$

$I_{yy_1} = \frac{d_1 b_1^3}{12} + A(\bar{x} - x_1)^2$
$= \frac{10(60)^3}{12} + (600)(10)^2$
$I_{yy_1} = 240 \times 10^3 mm^4$

$I_{yy_2} = \frac{d_2 b_2^3}{12} + (A_2)(\bar{x} - x_2)^2$
$= \frac{80(10)^3}{12} + (800)(15)^2$
$I_{yy_2} = 186.67 \times 10^3 mm^4$

$I_{yy_3} = \frac{d_3 b_3^3}{12} + A(\bar{x} - x_3)^2$
$= \frac{10(60)^3}{12} + (600)(10)^2$
$I_{yy_3} = 240 \times 10^3 mm^4$

$$\text{Total } I_{yy} = I_{yy_1} + I_{yy_2} + I_{yy_3} = 666.67 \times 10^3 mm^4$$

Q.NO	SUB Q N	ANSWER	Marking Scheme
3		Attempt any three.	12 Marks

a] State relation between E, G, K.

→ $\boxed{E = 2G(1+\mu)}$ $\boxed{E = 3K(1-2\mu)}$

$$\boxed{E = \frac{9KG}{G+3K}}$$ where;

E = Modulus of Elasticity (Young's Modulus)
G = Modulus of Rigidity (Shear Modulus)
K = Bulk Modulus.
μ = Poisson's Ratio.

b] Define:- (i) Normal stress (ii) Direct stress (iii) Bending stress (iv) Shear stress.

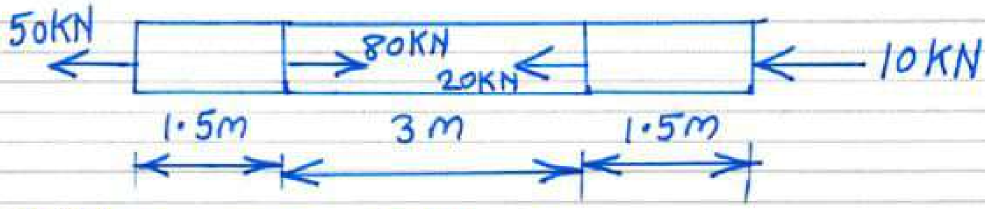
→ (i) Normal stress:- Stress which are act normal to plane on which forces act is "Normal Stress."

(ii) Direct stress:- Normal stress is "Direct stress."

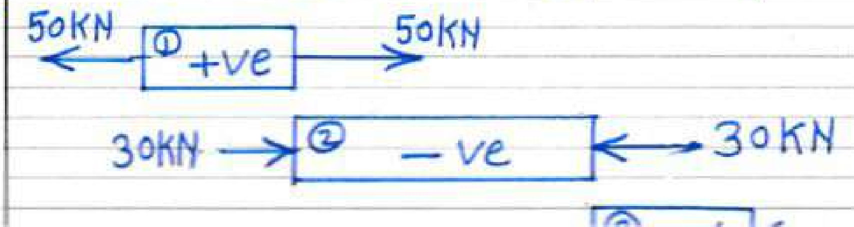
(iii) Bending stress:- Compressive stress produce on surface of body, when body exerts pressure on other body.

(iv) Shear stress:- When two equal opposite & parallel forces acting tangential to surface of body is "Shear stress."

c] A steel bar 800 mm^2 cross section is subjected to axial forces as shown. Find total change in length of bar, if $E = 2 \times 10^5$ N/mm^2.



→



Q.NO	SUB Q N	ANSWER	Marking Scheme

(i) fig ①

$P_1 = 50\times10^3 N$
$L_1 = 1500 mm$
$A_1 = 800 mm^2$
$E = 2\times10^5 N/mm^2$

(ii) fig ②

$P_2 = 30\times10^3 N$
$L_2 = 3000 mm$
$A_2 = 800 mm^2$
$E = 2\times10^5 N/mm^2$

(iii) fig ③

$P_3 = 10\times10^3 N$
$L_3 = 1500 mm$
$A_3 = 800 mm^2$
$E = 2\times10^5 N/mm^2$

$$\delta l_1 = \frac{P_1 L_1}{A_1 E} = \frac{(50\times10^3)(1500)}{(800)(2\times10^5)}$$

$$\underline{\delta l_1 = 0.468 mm} \quad (+ve)$$

$$\delta l_2 = \frac{P_2 L_2}{A_2 E} = \frac{(30\times10^3)(3000)}{(800)(2\times10^5)}$$

$$\underline{\delta l_2 = 0.562 mm} \quad (-ve)$$

$$\delta l_3 = \frac{P_3 L_3}{A_3 E} = \frac{(10\times10^3)(1500)}{(800)(2\times10^5)}$$

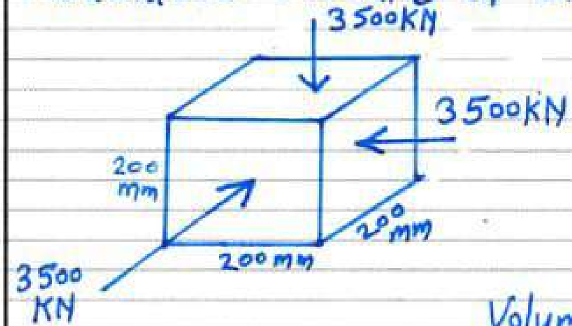
$$\underline{\delta l_3 = 0.093 mm} \quad (-ve)$$

$$\text{Total } \delta l = +\delta l_1 - \delta l_2 - \delta l_3$$
$$= +0.468 - 0.562 - 0.093$$

$$\boxed{\text{Change in length (deformation)} = \delta l = 0.187 mm}$$

d] Cube of 200mm side subjected to a compressive force of 3500KN on all it's faces. Change in volume of cube is 5000mm³. Calculate Bulk modulus & modulus of elasticity. if $\mu = 0.28$.

→



$b = 200mm$
$d = 200mm$

$A = b\cdot d$

$$\boxed{A = 40\times10^3 mm^2}$$

$\text{Volume} = V = b\cdot d\cdot l$

$V = 200\times200\times200$

$$\boxed{V = 8\times10^6 mm^3}$$

$$\sigma_x = \sigma_y = \sigma_z = \frac{3500\times10^3}{40\times10^3} = \underline{87.5 N/mm^2}$$

We know; $\text{Volumetric strain} = e_v = \frac{\delta v}{V} = \frac{5000}{8\times10^6}$

$$\therefore \boxed{e_v = 6.25\times10^{-4} \text{ No unit.}}$$

But; $e_v = \frac{\delta v}{V} = \frac{\sigma_x+\sigma_y+\sigma_z}{E}(1-2\mu)$

$$\therefore 6.25\times10^{-4} = \frac{87.5+87.5+87.5}{E}\left[1-2(0.28)\right]$$

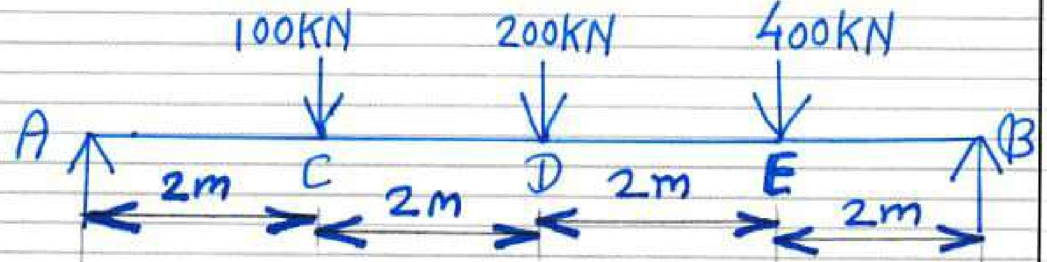
We have, $E = 3K(1-2\mu)$

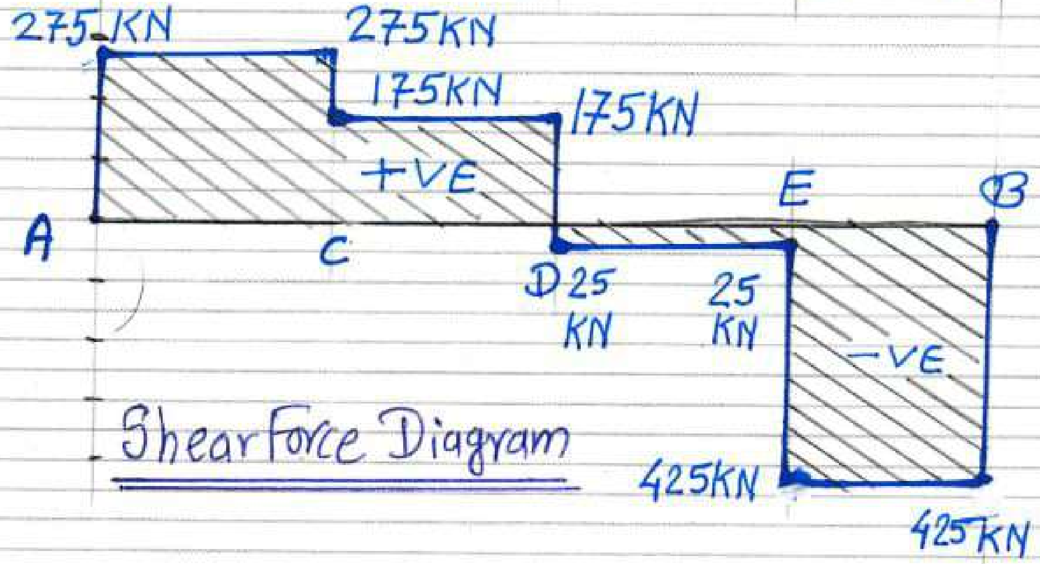
$$\frac{184.8\times10^3}{3(1-2\times0.28)} = K$$

$$\boxed{\text{Bulk Modulus} = K = 140\times10^3\ N/mm^2}$$

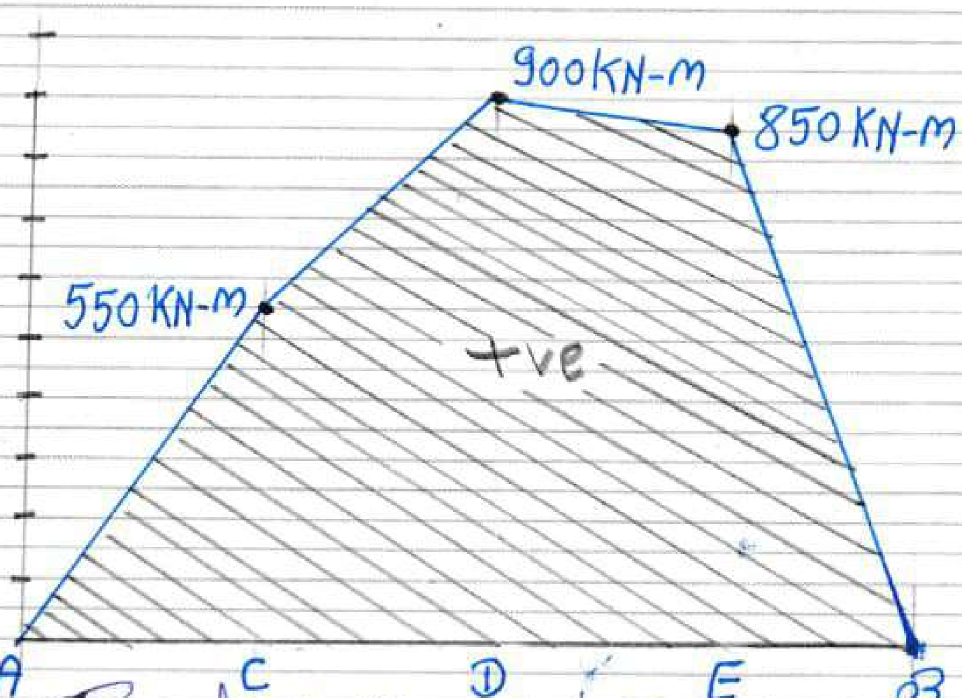
Q.4. Attempt any three. 12 Marks

a) Draw S.F.D. & B.M.D. for given S.S.B.



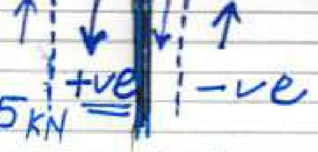


Shear Force Diagram



Bending Moment Diagram.

Shear Force Calculations:-



$SF_{B(R)} = 0\,KN$ $\quad$ $SF_{B(L)} = -425\,KN$

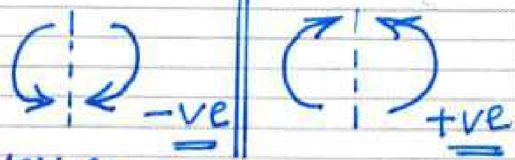
$SF_{E(R)} = -425\,KN$ $\quad$ $SF_{E(L)} = -425+400 = -25\,KN$

$SF_{D(R)} = -25\,KN$ $\quad$ $SF_{D(L)} = -25+200 = 175\,KN$

$SF_{C(R)} = 175\,KN$ $\quad$ $SF_{C(L)} = 175+100 = 275\,KN$

$SF_{A(R)} = 275\,KN$ $\quad$ $SF_{A(L)} = 275-275 = 0\,KN.$

Bending Moment Calⁿ.:-



$B.M._B = 0\,KN\text{-}m$

$B.M._E = +(425\times2) = 850\,KN\text{-}m$

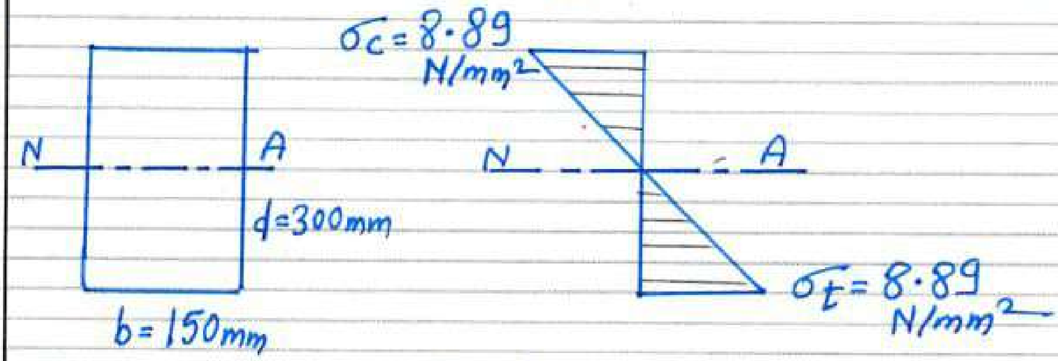
$B.M._D = +(425\times4)-(400\times2) = 900\,KN\text{-}m$

$B.M._C = +(425\times6)-(400\times4)-(200\times2) = 550\,KN\text{-}m$

$BM\ A = +(425\times8)-(400\times6)-(200\times4)-(100\times2) = 0\,KN\text{-}m.$

b] S.S.B. of rectangular section 150mm wide & 300mm deep is simply supported over a span of 4 m. It carries udl 10 KN/m over entire span. Find max. & min. bending stress induced in section. Draw bending stress distribution diagram.

→



$b = 150\,mm$ $\quad$ $L = 4\,m = 4000\,mm$

$d = 300\,mm$ $\quad$ $UdL = w = 10\left(\frac{KN}{m}\right) = 10\left(\frac{N}{mm}\right).$

$\bar{y} = \frac{d}{2} = 150\,mm.$

$$M_{max} \text{ for S.S.B.} = \frac{WL^2}{8} = \frac{10(4000)^2}{8} = \underline{20\times10^6\,N\text{-}mm}$$

$$I = \frac{bd^3}{12} = \frac{(150)(300)^3}{12} \quad \therefore \boxed{I = 337.5\times10^6\,mm^4}$$

Comp. stress $= \sigma_c = \frac{M}{I}\times\bar{y}$

$$\sigma_c = \frac{(20\times10^6)}{(337.5\times10^6)}\times150$$

$\sigma_c = 8.89\,N/mm^2$

Tensile stress $\sigma_t = \frac{M}{I}\times\bar{y}$

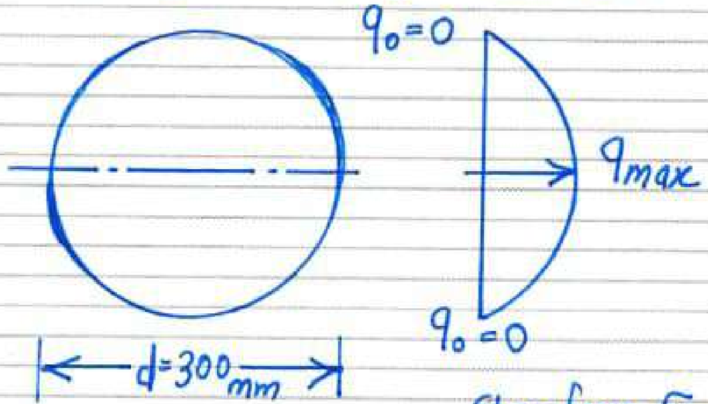
$$\sigma_t = \frac{(20\times10^6)}{(337.5\times10^6)}\times150$$

$\sigma_t = 8.89\,N/mm^2$

Q.NO	SUB Q N	ANSWER	Marking Scheme

c] Draw shear stress distribution along c/s. of circular beam for 300mm dia carrying 400KN Shear force. Determine ratio of maximum stress to avarage stress.

→



$d = 300\,mm$

$A = \frac{\pi}{4} d^2$

$A = \frac{\pi}{4} (300)^2$

$\boxed{A = 70.685 \times 10^3\ mm^2}$

Shear force $F = 400 \times 10^3\ N.$

Avarage shear stress $= q_{av} = \frac{F}{A} = \frac{400 \times 10^3}{70.685 \times 10^3}$

$\boxed{q_{av} = 5.658\ N/mm^2.}$

Max. shear stress $= q_{max} = \frac{4}{3} q_{av}$

$q_{max} = \frac{4}{3} (5.658)$

$\boxed{q_{max} = 7.544\ N/mm^2}$

Ratio $= \frac{q_{max}}{q_{av}} = \frac{7.544}{5.658} = \frac{4}{3}$ or 1.333.

d] State Rankin's formula with meaning of each term.

→ Buckling / Crippling load by Rankin's Formula:-

$$P_R = \frac{\sigma_c \cdot A}{1 + \alpha \left(\frac{Le}{K_{min}}\right)^2}$$

σ_c = Crushing stress

A = Area

α = Rankin's constant

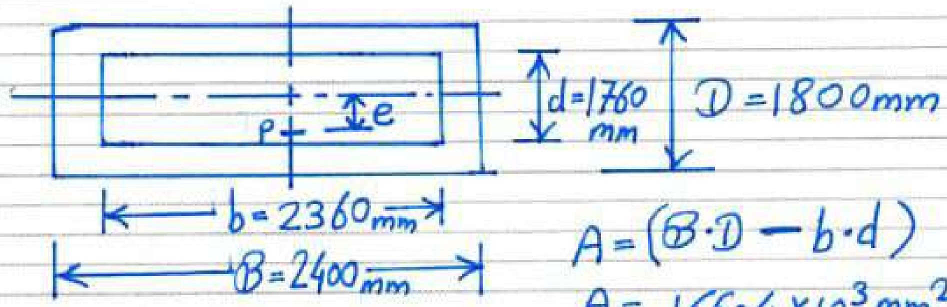
Le = Effective length

Kmin = Minimum radius of gyration.

Q.NO	SUB Q N	ANSWER	Marking Scheme

e] Short column of hollow rectangular c/s has external dimensions 2·4m × 1·8m & 20mm thick. It carries a vertical load of 500 KN at an eccentricity of 30mm from geometrical axis of section bisecting longer side. Find max & min stress.

→



$A = (B \cdot D - b \cdot d)$

$A = 166 \cdot 4 \times 10^3\ mm^2$.

$P = 500 \times 10^3 N \qquad e = 30mm$

Direct stress $= \sigma_o = \frac{P}{A} = \frac{500 \times 10^3}{166 \cdot 4 \times 10^3}$

$$\boxed{\sigma_o = 3\ N/mm^2.}$$

$$I = \frac{BD^3 - bd^3}{12} = \frac{2400(1800)^3 - (2360)(1760)^3}{12}$$

$$\boxed{I = 9 \cdot 422 \times 10^{10}\ mm^4.}$$

$\bar{y} = \frac{D}{2} = \frac{1800}{2} \qquad \boxed{\bar{y} = 900 mm.}$

Bending stress $= \sigma_b = \frac{P \cdot e \cdot \bar{y}}{I} = \frac{500 \times 10^3 \times 30 \times 900}{9 \cdot 422 \times 10^{10}}$

$$\boxed{\sigma_b = 0 \cdot 143\ N/mm^2.}$$

Max. stress $= \sigma_{max} = \sigma_o + \sigma_b$

$= 3 + 0 \cdot 143\ N/mm^2$

$\sigma_{max} = 3 \cdot 143\ N/mm^2$ (Comp.)

Min. stress $= \sigma_{min} = \sigma_o - \sigma_b$

$= 3 - 0 \cdot 143$

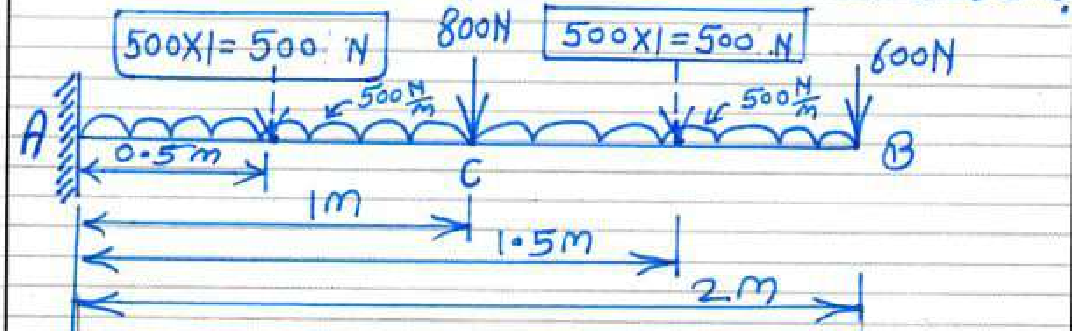
$\sigma_{min} = 2 \cdot 857\ N/mm^2$ (comp)

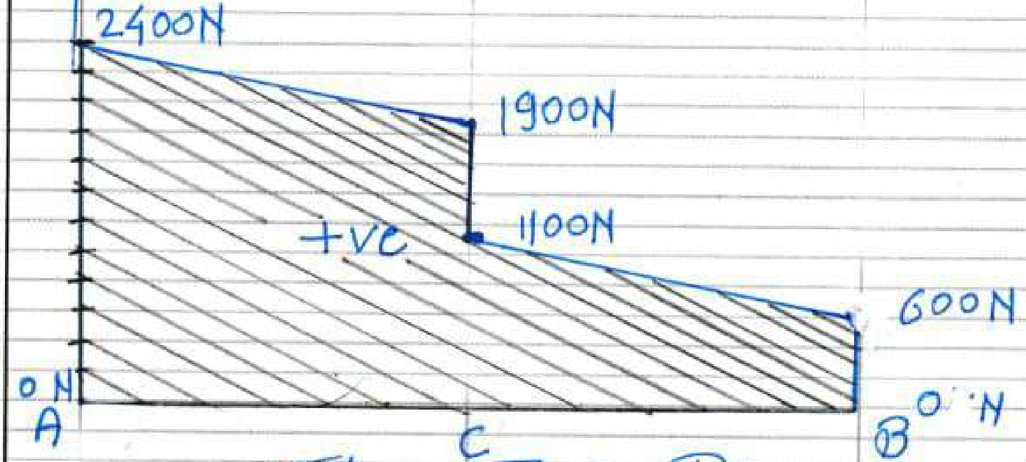
Baseline

Q.NO	Q N	ANSWER	Marking Scheme

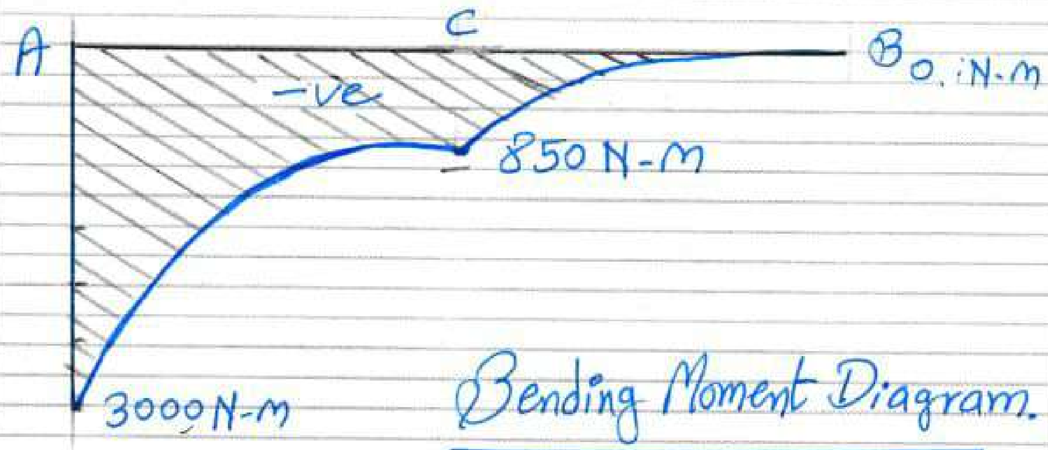
5. Attempt any two. — 12 Marks

a) Cantilever fixed at left end is 2m. long carries U.D.L. of 500N/m. A point load of 800N & 600N act at 1m & 2m from fixed end. Draw SFD & BMD.





Shear Force Diagram.



Bending Moment Diagram.

Shear Force Calculations:- ↓ +ve ↑ -ve

$SF_{B(R)} = 0N$ $\qquad SF_{B(L)} = +600N$

$SF_{C(R)} = 600+500 = 1100N$ $\qquad SF_{C(L)} = 1100+800 = 1900N$

$SF_A = 1900+500 = 2400N.$

Bending Moment:- ↻ +ve ↺ -ve

$BM_B = 0N\text{-}m.$

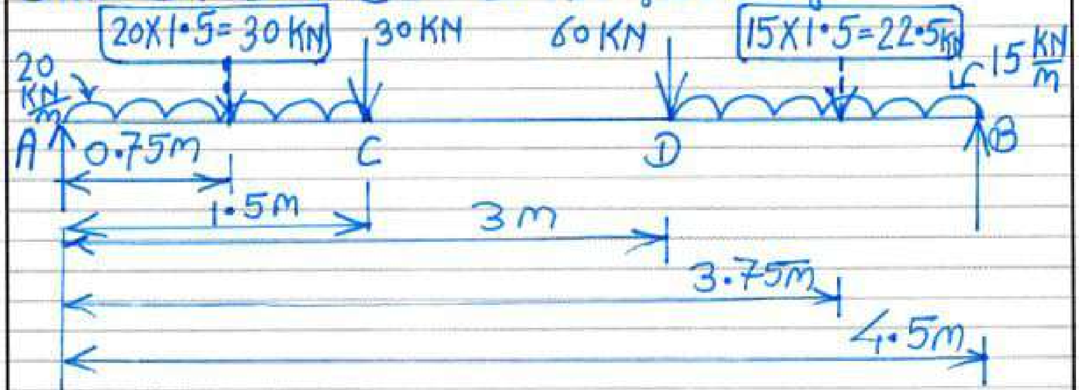
$BM_C = -(600 \times 1) - (500 \times 0.5) = -850\ N\text{-}m$

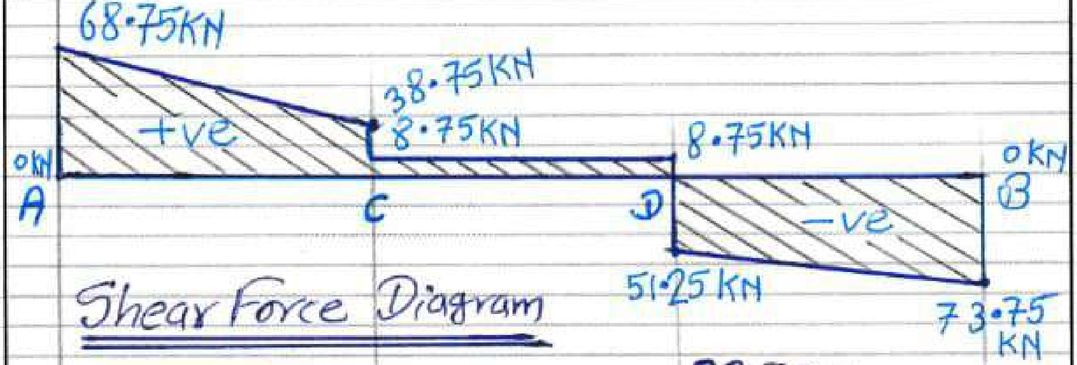
$BM_A = -(600 \times 2) - (500 \times 1.5) - (800 \times 1) - (500 \times 0.5)$

$BM_A = -3000\ N\text{-}m$

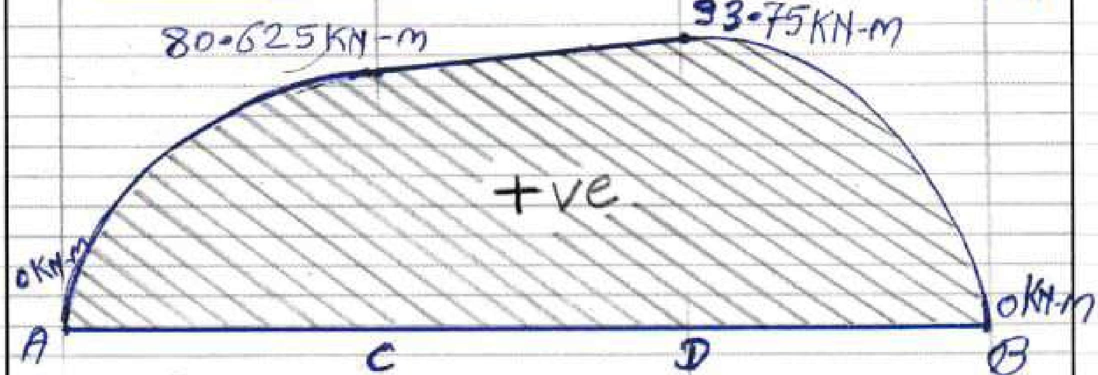
Q.NO	SUB Q N	ANSWER	Marking Scheme

b) Draw S.F.D. & B.M.D. for given fig.





Shear Force Diagram



Bending Moment Diagram.

Shear Force Calculations:- $\downarrow$ +ve $\uparrow$ -ve

$R_A + R_B = 22.5 + 60 + 30 + 30$

$R_A + R_B = 142.5$ KN ——— eq^n ①

Taking moment @ A,

$4.5 R_B = (22.5 \times 3.75) + (60 \times 3) + (30 \times 1.5) + (30 \times 0.75)$

$4.5 R_B = 331.875$

$\therefore R_B = \dfrac{331.875}{4.5}$ $\therefore \boxed{R_B = 73.75 \text{ KN}}$

But: $R_A + R_B = 142.5$

$\therefore R_A = 142.5 - 73.75$ $\therefore \boxed{R_A = 68.75 \text{ KN}}$

Shear Force Cal^n: +ve −ve

$SF_{B(R)} = 0\,KN$ $SF_{B(L)} = -73{\cdot}75\,KN$

$SF_{D(R)} = -73{\cdot}75 + 22{\cdot}5 = -51{\cdot}25\,KN$

$SF_{D(L)} = -51{\cdot}25 + 60 = +8{\cdot}75\,KN.$

$SF_{C(R)} = +8{\cdot}75\,KN$

$SF_{C(L)} = +8{\cdot}75 + 30 = +38{\cdot}75\,KN$

$SF_{A(R)} = +38{\cdot}75 + 30 = +68{\cdot}75\,KN$

$SF_{A(L)} = +68{\cdot}75 - 68{\cdot}75 = 0\,KN.$

Bending Moment Cal^n: −ve +ve.

$BM_B = 0\,KN\text{-}m$

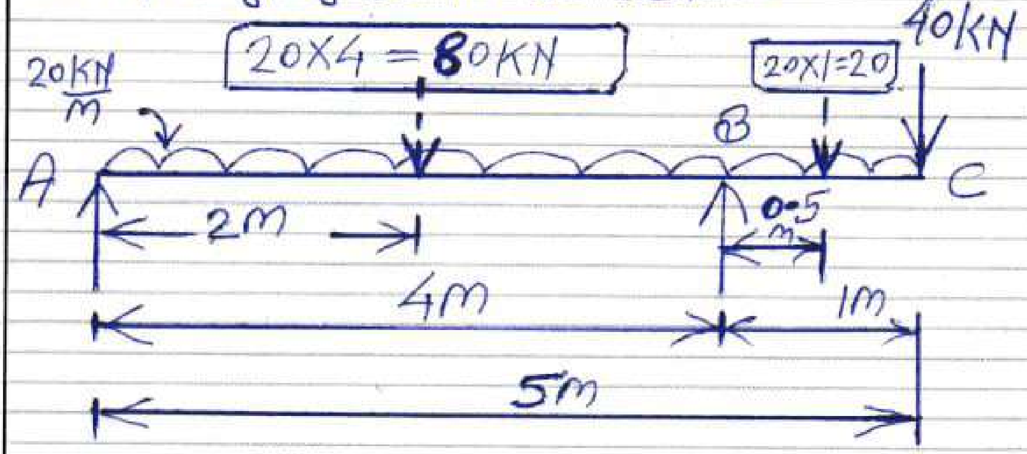
$BM_D = +(73{\cdot}75 \times 1{\cdot}5) - (22{\cdot}5 \times 0{\cdot}75) = +93{\cdot}75\,KN\text{-}m$

$BM_C = +(73{\cdot}75 \times 3) - (22{\cdot}5 \times 2{\cdot}25) - (60 \times 1{\cdot}5)$

$BM_C = 80{\cdot}625\,KN\text{-}m$

$BM_A = +(73{\cdot}75 \times 4{\cdot}5) - (22{\cdot}5 \times 3{\cdot}75)$
$\quad - (60 \times 3) - (30 \times 1{\cdot}5) - (30 \times 0{\cdot}75) = 0\,KN\text{-}m.$

c] Draw S.F. & B.M. diagram for the overhanging beam as below-



Total upward Forces = Total downward Forces

$R_A + R_B = 40 + 20 + 80$

$\therefore R_A + R_B = 140\,KN.$ — eq^n (1)

Taking Moment @ A,

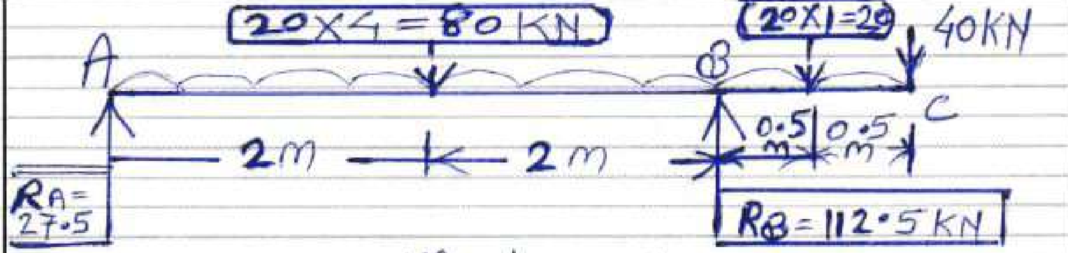
$4R_B = (40 \times 5) + (20 \times 4{\cdot}5) + (80 \times 2)$

$4R_B = 450$ $\therefore \boxed{R_B = 112{\cdot}5\,KN}$

But, $R_A + R_B = 140\,KN$

$\therefore R_A = 140 - 112{\cdot}5$ $\therefore \boxed{R_A = 27{\cdot}5\,KN.}$

Q.NO	SUB QN	ANSWER	Marking Scheme



Shear Force Cal^n: $\downarrow$ +ve $\uparrow$ −ve

$SF_{C(R)} = 0\,KN$ $\quad SF_{C(L)} = +40\,KN$

$SF_{B(R)} = +40+20$ $\quad SF_{B(L)} = +60-112.5$

$SF_{B(R)} = +60\,KN$ $\quad SF_{B(L)} = -52.5\,KN$

$SF_{A(R)} = -52.5+80$ $\quad SF_{A(L)} = 27.5-27.5$

$SF_{A(R)} = 27.5\,KN$ $\quad SF_{A(L)} = 0\,KN.$

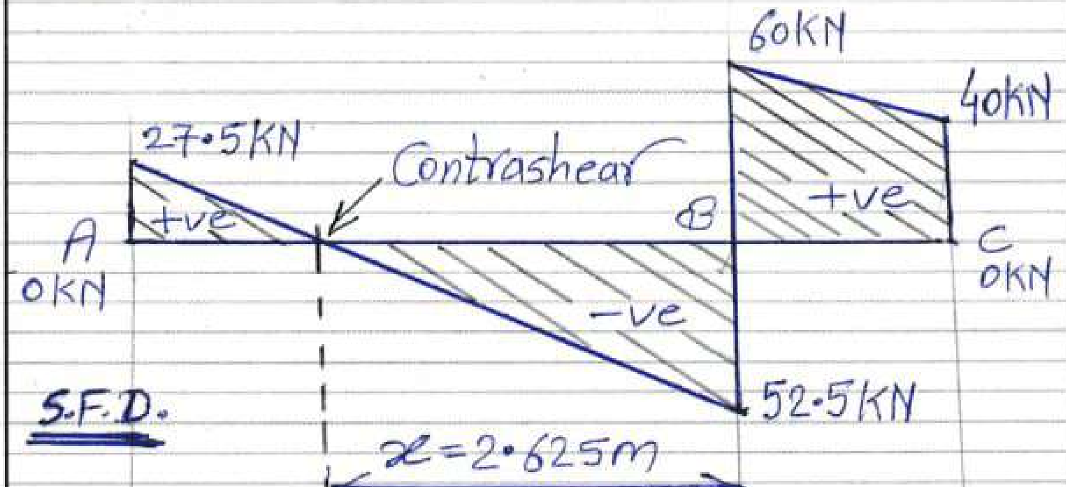
BM Calculations:- ↻ +ve ↺ −ve

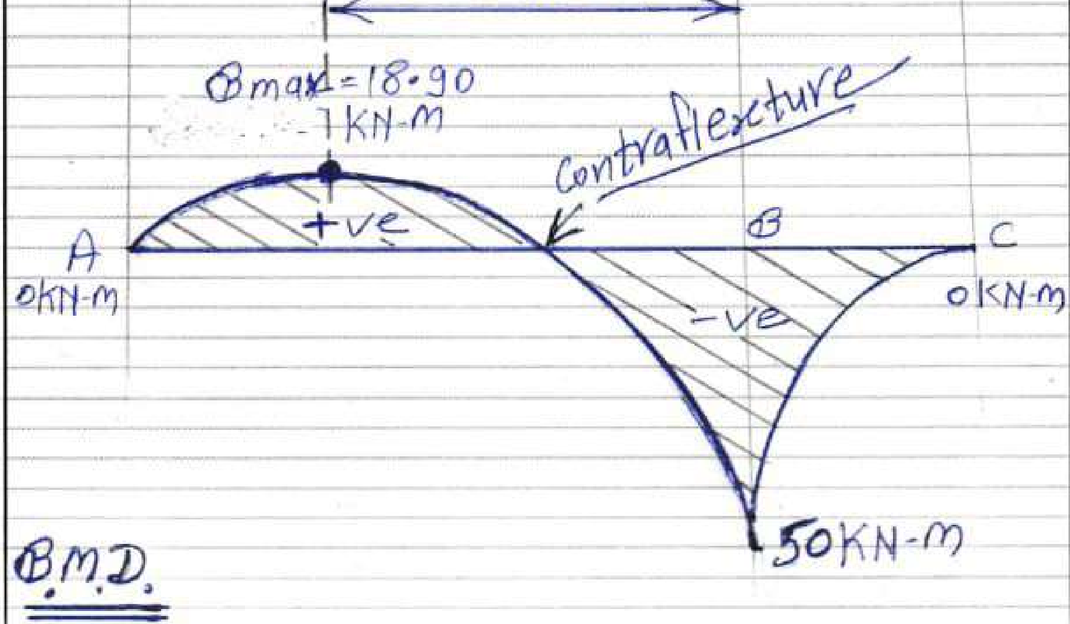
$BM_C = 0\,KN\text{-}m$

$BM_B = -(40\times1)-(20\times0.5) = -50\,KN\text{-}m$

$BM_A = -(40\times5)-(20\times4.5)+(112.5\times4)-(80\times2)$

$BM_A = 0\,KN\text{-}m.$

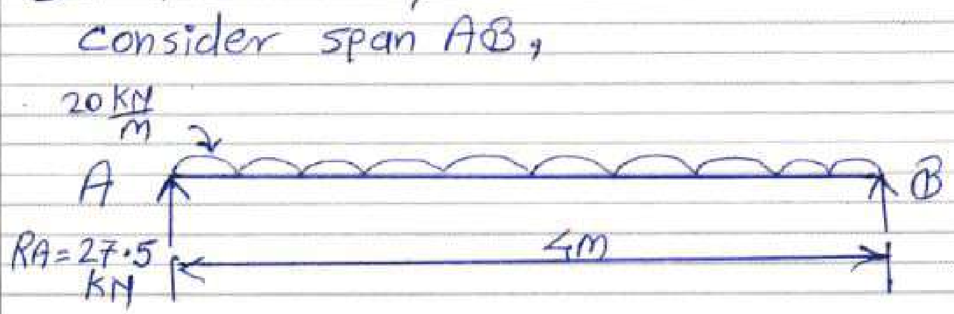


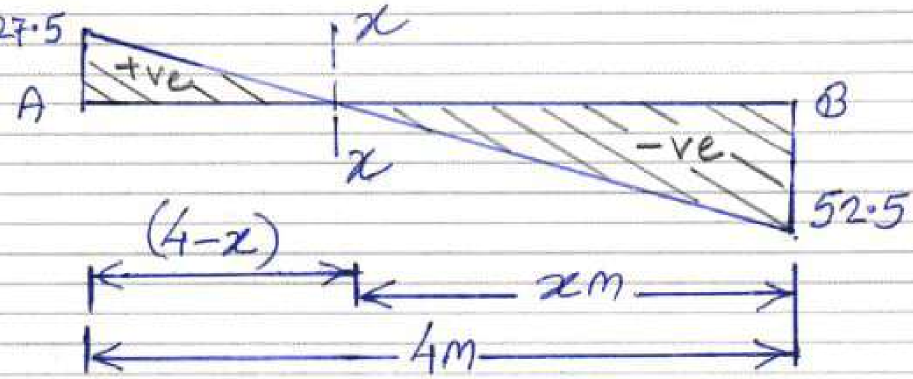


Q.NO	SUB Q N	ANSWER	Marking Scheme

Cal^n. For Bmax;

consider span AB,





$$\therefore \frac{27.5}{(4-x)} = \frac{52.5}{x}$$

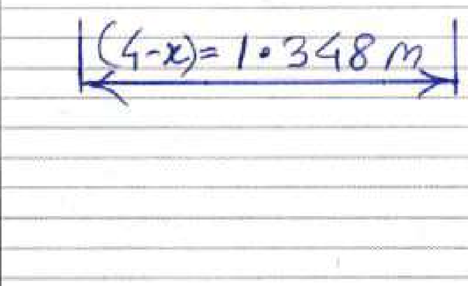
$\therefore 27.5x = 52.5(4-x)$

$\therefore 27.5x = 210 - 52.5x$

$\therefore 27.5x + 52.5x = 210$

$\therefore 80x = 210 \qquad \therefore \boxed{x = 2.625\,m}$

Considering x-x section L.H.S.



Taking Moment @ x-x

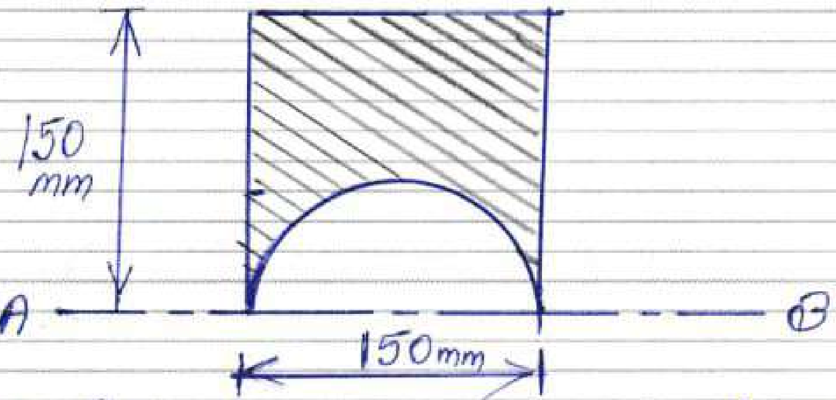
$B_{max} = +(27.5 \times 1.348) - (26.96 \times 0.674)$

$\therefore B_{max} = 18.8989\,KN\text{-}m$

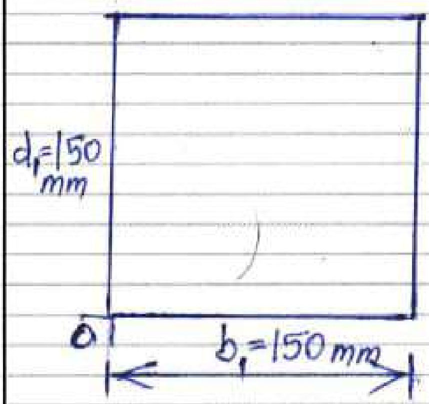
$B_{max} \cong 18.90\,KN\text{-}m$

Q.NO	SUB Q N	ANSWER	Marking Scheme
6.		Attempt any two.	12 Marks
	a)	Calculate M.I. @ base of composite lamina made up of a semicircle of 150mm base diameter is removed from base of square 150mm X 150mm such that lamina is symmetrical to y-axis.	

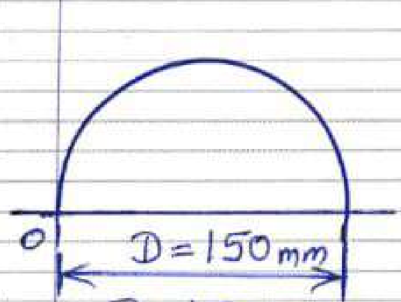
→



fig① Rectangle



fig② semicircle



$b_1 = 150mm$
$d_1 = 150mm$

$A_1 = b_1 \cdot d_1$

$\boxed{A_1 = 22500 mm^2}$

$I_1 = \frac{b_1 d_1^3}{12}$

$I_1 = \frac{(150)(150)^3}{12}$

$\boxed{I_1 = 42.1875 \times 10^6 mm^4}$

$y_1 = \frac{d_1}{2} = 75mm$

$D = 150 mm$
$R = 75mm$

$A_2 = \frac{(\pi/4)(D^2)}{2}$

$\boxed{A_2 = 8831.25 mm^2}$

$I_2 = 0.11R^4$

$I_2 = 0.11(75^4)$

$\boxed{I_2 = 3.4804 \times 10^6 mm^4}$

$y_2 = \frac{4R}{3\pi} = 31.83mm$

$$\bar{y} = \frac{A_1 y_1 + A_2 y_2}{A_1 + A_2} = \frac{(22500)(75) + (8831.25)(31.83)}{(22500) + (8831.25)}$$

$\boxed{\bar{y} = 102.89mm}$

$I_1 @ AB = I_1 + A_1 \cdot (\bar{y} - y_1)^2$

$I_1 @ AB = (42.1875 \times 10^6) + (22500)(102.89 - 75)^2$

$I_1 @ AB = 59.689 \times 10^6 mm^4.$

$I_2 @ AB = I_2 + A_2 (\bar{y} - y_2)^2$

$I_2 @ AB = (3.4804 \times 10^6) + (8831.25)(102.89 - 31.83)^2$

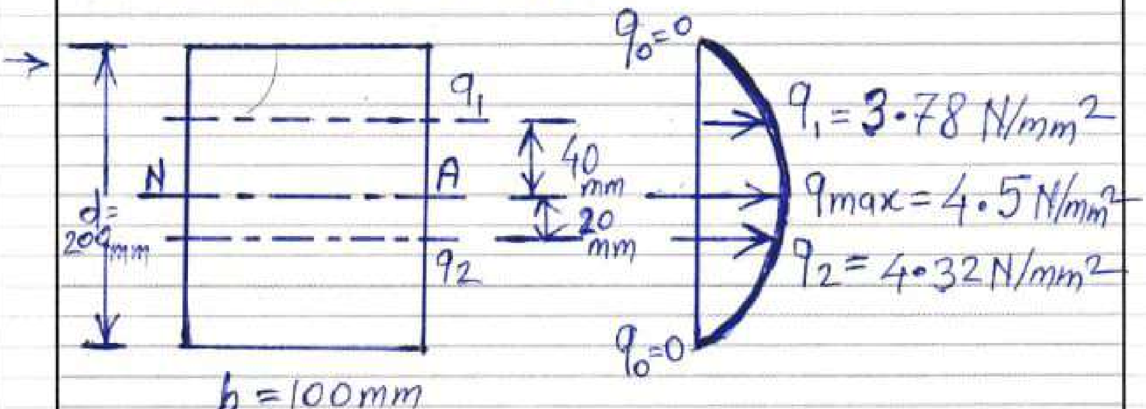
$I_2 @ AB = 48.074 \times 10^6 mm^4.$

$\text{Total } I @ AB = I_{①} @ AB - I_{②} @ AB$

$= 59.689 \times 10^6 - 48.074 \times 10^6$

$\boxed{\text{Total } I @ AB = 11.615 \times 10^6 mm^4. \text{ (Base)}}$

b) Beam 100mm X 200mm subjected to shear force of 60 KN. Determine shear stress induced on a layer at 40mm above N.A. & 20mm below N.A.



b = 100mm
d = 200mm

$A = b \cdot d$

$\boxed{A = 20 \times 10^3 mm^2}$

$q_{av} = \frac{F}{A} = \frac{60 \times 10^3}{20 \times 10^3}$

$\boxed{q_{av} = 3 N/mm^2.}$

$q_{max} = 1.5 \, q_{av}$

$q_{max} = 1.5(3)$

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

Shear force = $F = 60 \times 10^3 N$

Let, q_1 = 40mm above N.A.

$q_1 = \frac{6F}{bd^3}\left(\frac{d^2}{4} - y^2\right)$

$q_1 = \frac{6(60 \times 10^3)}{(100)(200)^3}\left(\frac{200^2}{4} - 40^2\right)$

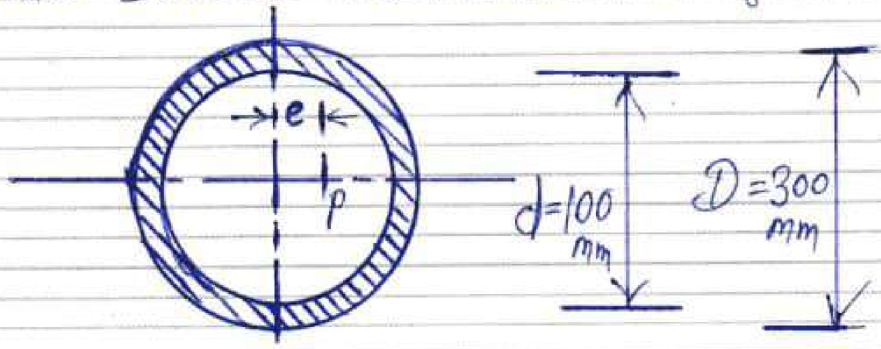
$\boxed{q_1 = 3.78 N/mm^2.}$

20mm below N.A :-

$q_2 = \frac{6(60 \times 10^3)}{(100)(200)^3}\left(\frac{200^2}{4} - 20^2\right)$

$\boxed{q_2 = 4.32 N/mm^2}$

Q.NO	SUB Q N	ANSWER	Marking Scheme
6	c]	Determine limit of eccentricity for hollow circular section having D = 300 mm & d = 100 mm draw stress distribution diagram.	



$A = \frac{\pi}{4}(D^2 - d^2)$ $I = \frac{\pi}{64}[D^4 - d^4]$

$\boxed{A = 62.831 \times 10^3 \ mm^2.}$ $\boxed{I = 392.699 \times 10^6 \ mm^4.}$

$\boxed{\bar{y} = \frac{D}{2} = \frac{300}{2} = 150 \ mm}$

For No tension at base condition;

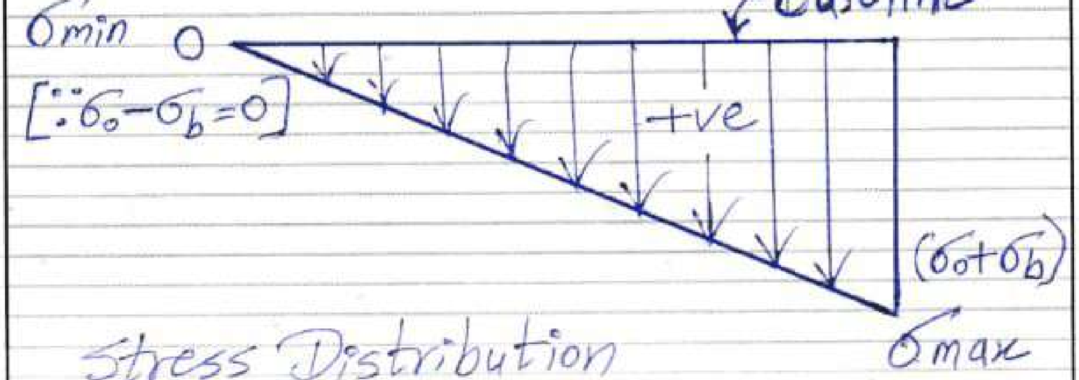
Direct stress (σ_0) = Bending stress (σ_b)

$$\frac{P}{A} = \frac{P \cdot e \cdot \bar{y}}{I}$$

$$\therefore \frac{I}{A \cdot \bar{y}} = e$$

$$\therefore \frac{(392.699 \times 10^6)}{(62.831 \times 10^3)(150)} = e$$

$\therefore$ Limit of eccentricity = e = 41.67 mm from centroidal axis.



Stress Distribution