OR			
11	A thin cylindrical shell 90 cm long, 20 cm diameter is filled with fluid at atmospheric pressure. If the pressure is 20KN /cm^2 of fluid into the cylinder, find (i) the longitudinal stress (ii) the hoop stresses induced. (iii) Change in length (iv) Change in diameter Take E = 2.1x10^5 N/mm^2 and Poisson's ratio = 0.30.	L4	CO5	10 M

PVP 23

Code: 23CE3302

II B.Tech - I Semester – Regular / Supplementary Examinations
NOVEMBER 2025

STRENGTH OF MATERIALS
(CIVIL ENGINEERING)

Duration: 3 hours   Max. Marks: 70

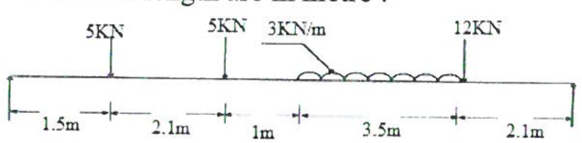
Note: 1. This question paper contains two Parts A and B.
2. Part-A contains 10 short answer questions. Each Question carries 2 Marks.
3. Part-B contains 5 essay questions with an internal choice from each unit. Each Question carries 10 marks.
4. All parts of Question paper must be answered in one place.

BL – Blooms Level   CO – Course Outcome

PART – A

		BL	CO
1.a)	Write the relationship between Young's modulus, bulk modulus and modulus of rigidity.	L2	CO1
b)	What is a composite bar? Give one example.	L1	CO1
c)	What is the point of contra flexure?	L1	CO2
d)	Draw the S.F. diagram for a simply supported beam with a central point load.	L2	CO2
e)	What is the difference between solid and hollow sections?	L1	CO3
f)	What is the shear stress distribution in a circular section?	L2	CO3
g)	Write the equation for slope of a beam using double integration method.	L3	CO4
h)	What is Macaulay's method used for?	L2	CO4
i)	Mention one limitation of Euler's theory.	L2	CO5
j)	Write the formula for longitudinal stress in a thin cylinder.	L1	CO5

PART – B

	Question	BL	CO	Max. Marks
	UNIT-I			
2	A tensile test was conducted on a specimen of 30 mm diameter and 200 mm length. Elongation with 40 kN load = 0.054 mm Yield load = 140 kN ; Length at fracture = 241 mm Determine: i) Young's modulus of elasticity ii) Yield stress iii) Ultimate stress iv) Percentage of elongation	L2	CO1	10 M
	OR			
3	A copper flat (60 mm × 30 mm) is brazed to a mild steel flat (60 mm × 60 mm). Heated to 120°C and the initial temperature is 25^0 C. Determine the stress in each bar. Given: $\alpha_1 = 18.5 \times 10^{-6}$ /°C, $\alpha_2 = 12 \times 10^{-6}$ /°C, $E_1 = 110$ GN/m², $E_2 = 220$ GN/m² , Length = 400 mm	L3	CO1	10 M
	UNIT-II			
4	Analyse the beam and draw SF and BM diagrams for the beam loaded as shown in figure below. All loads are in kN and length are in metre : 	L4	CO2	10 M
	OR			
5	Draw shear force and bending moment diagram for a simply supported beam of length 6 m and carries a point load of 40 kN at a distance of 1.75 m from left end support.	L3	CO2	10 M

	Question	BL	CO	Max. Marks
	UNIT-III			
6	A timber cantilever 200 mm wide and 300 mm deep is 3m long. It is loaded with a U.D.L of 3kN/m over the entire length. A point load of 2.7 kN is placed at the free end of the cantilever. Find the maximum bending stress produced.	L3	CO3	10 M
	OR			
7	The cross section of joist is a tee section 150 mm x 100 mm x 13 mm with 150 mm side horizontal. Find the maximum intensity of shear stress and sketch the distribution of stress across the section, if it has to resist a shear force of 45KN along the section.	L3	CO3	10 M
	UNIT-IV			
8	Find the slope and deflection of simply supported beam of span L, carrying (i) a point load P at the centre, (ii) a U.D.L of w KN/m over the entire span, using the moment area method.	L4	CO4	10 M
	OR			
9	A simply supported beam of span 6m loaded point load of 12 kN at its centre, in addition to the UDL of 6kN/m for the whole span. Find slopes at the supports and maximum deflection. Use double integration method.	L4	CO4	10 M
	UNIT-V			
10	A cast iron column 4 m long, 200 mm external diameter, 20 mm thick) carries 150 kN load at 25 mm eccentricity. Both ends are fixed. Determine: (i) Extreme stress on column section (ii) Maximum eccentricity to avoid tension Given: $E = 9.4 \times 10^4$ MPa.	L3	CO5	10 M

II B.Tech. I sem - Regular / supplymentary Examinations
November - 2025.

23CE3302

Strength of Materials.

PVP23

(Civil Engg)

70 marks.

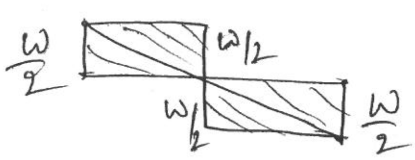
Scheme of Valuation

Part - A

1a) $E = \frac{9KG}{3K+G}$ — 2m.

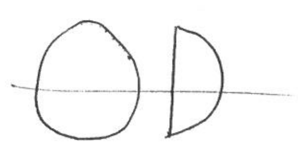
b) Definition. — 1m
examplee — 1m.

c) Definition — 2m.

d) 

— 2M.

e) Solid section — 1m.
Hollow section — 1m.

f) 
— 2m.

g) $EI \frac{dy}{dx} = \int M(x)dx + C_1$ — 2m.

h) • finding deflection.
• unified bending moment expression. } 2m.
Consider any other.

i) Any one limitation — 2m.

j) $\sigma_L = \frac{Pd}{4t}$ — 1m.
terms explanation — 1m.

Consider procedure for 70% of marks $\boxed{7m}$ for all problems

② Given data — 1m.

i) Youngs modulus formula — 1m.
Calculation — 1m.

ii) Yield stress formula — 1m
Calculation — 1m.

iii) Ultimate stress formula — 1m.
Calculation — 1m.

iv) Elongation formula — 1m.
Calculation — 1m.
% Elongation calculation — 1m.

—o—

③ Given data — 1m.

Strain in copper formula — 1m.
Strain in steel formula — 1m.
$\sigma_1 A_1 + \sigma_2 A_2 = 0$ — 1m.
Rigid connection — 1m.
Calculation of stresses — 2m.
stress in copper — 1m
stress in steel — 1m.

—o—

④ Given data — 1m.

Step-1:- Calculation of reaction forces — 3m.
Step-2:- Calculation of bending moment — 2m
BMD diagram — 1m.
Step-3:- Calculation of shear forces — 2m.
SFD diagram — 1m.

Consider procedure of 70% of marks $\boxed{7m}$ for all problems.

(5) Given data 1m.

Step-1:- Calculation of reaction forces - 3m.

Step-2:- Calculation of bending moment - 2m.

BMD - 1m.

Step-3:- Calculation of shear force - 2m.

SFD - 1m.

——o——

(6) Given data — 1m

Calculation of moment — 3m

Calculation of moment of inertia — 2m.

Eq $\boxed{\frac{M}{I} = \frac{\sigma}{y}}$ — 1m

$y = d/2$. — 1m

Calculation of σ_{max} — 2m.

——o——

(7) Calculation of Total Area - 2m.

Calculation of $\bar{y}$ — 2m.

Calculation of I_1 & I_2 & I. — 2m.

Shear stress formula. — 1m

Calculation of shear stress — 2m

diagram — 1m.

——o——

(8) Consider procedure for 70% of marks $\boxed{7m}$

i) SSB with a point load - 5m. for all problems

Slope formula - 1m

deflection formula - 1m

Calculations - 3m.

ii) SSB with UDL over entire span - 5m.

slope formula - 1m.

deflection formula - 1m.

Calculations - 3m.

---

(9) Given data diagram - 1m. $\boxed{\text{Procedure - 7m}}$

Calculation of reactions - 1m.

Moment at any section - 2m.

differential equation - 1m.

Calculation of ~~slope~~ Boundary condition - 2m

Calculation of deflection - 2m.

final deflection answer - 1m.

---

(10) Given data - 1m. $\boxed{\text{Procedure - 7m}}$

Calculation A & I - 2m.

Calculation of axial stress - 2m

bending stress - 2m.

i) Extreme stress calculation max 1m.

min - 1m.

ii) Eccentricity calculation - 1m.

---

(11) Given data - 2m. $\boxed{\text{Procedure - 7m}}$

Calc of longitudinal stress - 2m.

Hoop stress - 2m.

Calc of change in length - 2m.

Calc of change in diameter - 2m

II B.Tech – I Sem – Regular / Supplymentary Examinations
November – 2025

Strength of Materials

23CE3302 (Civil Engg) PVP23

Detailed Scheme 70 marks

Part-A

1a)

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

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

$$E = \frac{3KG}{9K+G} \quad \text{— 1m.}$$

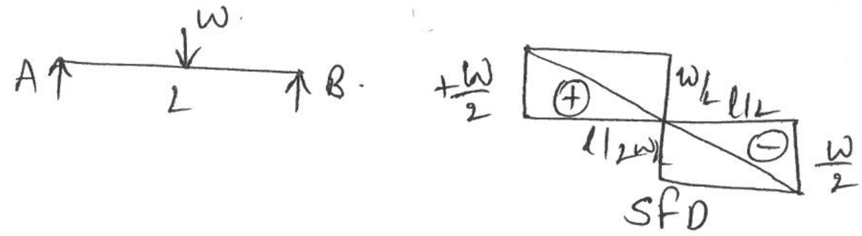
1b) Composite bar:-

A bar made from two or more materials rigidly connected so they deform together under load. } 1m
Ex:- Copper wire in plastic insulation etc. — 1m.

1c) Point of contra-flexure:-

It is the point on beam where the bending moment changes sign. } 2m

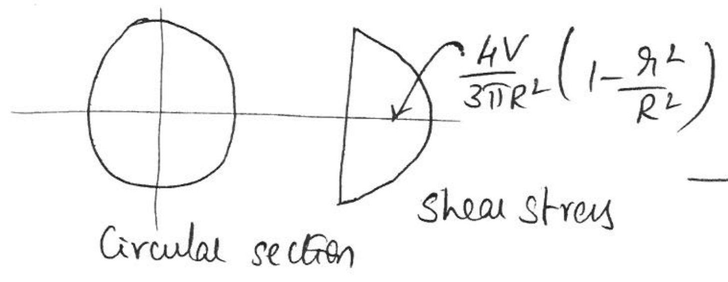
1d)



} 2m

1e) Solid section:- Material filled throughout, and it is heavier. — 1m
Hollow section:- It is empty core, lighter weight. — 1m.

1f)



— 2m.

---o---

1g)

$$M = EI\frac{d^2y}{dx^2}$$

$$EI\frac{dy}{dx} = \int M(x)dx + C_1 \Rightarrow \text{Slope equation.}$$ — 2m.

---o---

1h) <u>Macaulay's</u> <u>method</u>:-

i) for finding deflection of beams.
ii) It is a single unified bending moment expression

} Any two 2m.

---o---

1i) <u>limitation</u> <u>of Euler's theory</u>:-

i) It applies to long, slender columns
ii) Short columns fail by failing through crushing instead of buckling.

} Any one 2m.

---o---

1j) <u>longitudinal</u> <u>stress</u>:-

$$\sigma_L = \frac{Pd}{4t}$$ — 1m

P = internal pressure
d = diameter
t = thickness.

} 1m.

Part–B

(2)

2\. Given data:- Consider procedure for 70% of marks [7M]

diameter = 30 mm,

length = 200 mm,

Elongation with 40 KN load = 0.054 mm = δL

Yield load = 140 KN.

length at fracture = 241 mm

$\}$ 1M.

Cross-sectional area = $A = \frac{\pi d^2}{4} = \frac{\pi (30)^2}{4} = 225\pi$

$= 706.9\ mm^2$

i) Young's modulus:-

$\boxed{\text{stress } \sigma = \frac{P}{A}} = \frac{40 \times 10^3}{706.9} = 56.6\ N/mm^2$

Strain $\varepsilon = \frac{\delta L}{L_o} = \frac{0.054}{200} = 0.00027$

$\boxed{E = \frac{\sigma}{\varepsilon}} = \frac{56.6}{0.00027} = 2.1 \times 10^5\ N/mm^2$

$\}$ 2M

ii) Yield stress:-

$\boxed{\sigma_y = \frac{P_y}{A}} = \frac{\text{yield load}}{\text{Area}} = \frac{140 \times 10^3}{706.9} = 198\ N/mm^2$ $\}$ 2M.

iii) Ultimate stress:-

$\boxed{\sigma_u = \frac{P_u}{A}} = \frac{241 \times 10^3}{706.9} = 341\ N/mm^2$ $\}$ 2M.

iv) Percentage Elongation:-

$\boxed{\Delta L = L_f - L_o} = 241 - 200 = 41\ mm$. – 1M

$\boxed{\%\ \text{Elongation} = \frac{\Delta L}{L_o} \times 100} = \frac{41}{200} \times 100 = 20.5\%$ $\}$ – 2M.

3. Given data:- Consider procedure for 70% marks $\boxed{7m}$

Copper flat : 60mm x 30mm.

Steel flat : 60mm x 60mm.

Final temp: 120°c

Initial temp: 25°c.

$\alpha_1 = 18.5 \times 10^{-6}/°C$

$\alpha_2 = 12 \times 10^{-6}/°C$. $\Delta T = 120 - 25 = 95°C$ — 1m.

$E_1 = 110\ GN/m^2 = 110 \times 10^3\ N/m^2$

$E_2 = 220\ GN/m^2 = 220 \times 10^3\ N/m^2$

length = 400mm.

Strain in each bar:-

$A_1 = 60 \times 30 = 1800$

$A_2 = 60 \times 60 = 3600$

$\varepsilon_1 = \alpha_1 \Delta T + \frac{\sigma_1}{E_1}$ —— 1m.

$\varepsilon_2 = \alpha_2 \Delta T + \frac{\sigma_2}{E_2}$ —— 1m.

$\sigma_1 A_1 + \sigma_2 A_2 = 0.$ —— 1m.

$\sigma_2 = -\sigma_1 \frac{A_1}{A_2} = -\sigma_1 \left(\frac{1800}{3600}\right) = -\frac{\sigma_1}{2}$

$\varepsilon_1 = \varepsilon_2$. – Rigidly connected. — 1m.

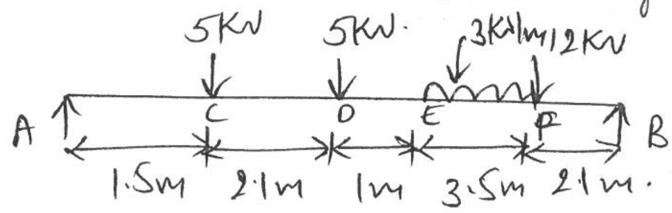
$$\left.\begin{aligned}\alpha_1 \Delta T + \frac{\sigma_1}{E_1} &= \alpha_2 \Delta T + \frac{\sigma_2}{E_2}\\ \alpha_1 \Delta T + \frac{\sigma_1}{E_1} &= \alpha_2 \Delta T - \frac{\sigma_1}{2E_2}\\ \sigma_1\left(\frac{1}{E_1} + \frac{1}{2E_2}\right) &= (\alpha_2 - \alpha_1)\Delta T\end{aligned}\right\} 2m.$$

$\sigma_1 = -54.3\ N/mm^2$. (compressive stress in copper) — 1m

$\sigma_2 = \frac{-\sigma_1}{2} = +\frac{54.3}{2} = 27.2\ N/mm^2$ (tensile stress in steel) — 2m.

(4). Consider procedure for 70% marks $\boxed{7m}$

(3)



—— 1m.

Step-1:- Calculation of Reaction forces

$\Sigma M_B = 0.$

$R_A(1.5+2.1+1+3.5+2.1) - 5(2.1+1+3.5+2.1)$
$-5(1+3.5+2.1) - 3\times3.5\left(\frac{3.5}{2}+2.1\right) - 12\times2.1 = 0.$

$R_a = 13.93\ KN$

3m.

$R_a + R_b = 5+5+3\times3.5+12 = 22.5.$

$R_b = 22.5 - 13.93 = 8.57\ KN.$

Step-2:- Calculation of BMD.

At A

$M_A = 0.$

At C

$M_c = R_a(1.5) = 20.895\ KN$

At D

$M_D = R_a(3.6) - 5(2.1) = 39.648\ KN.$

2m

At E

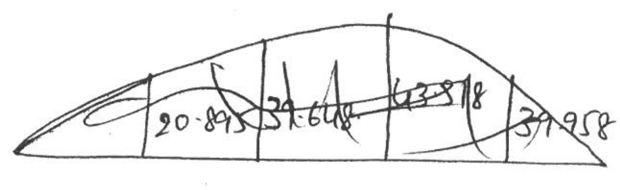
$M_E = R_a(4.6) - 5(3.1) - 5(1) = 43.578\ KN.$

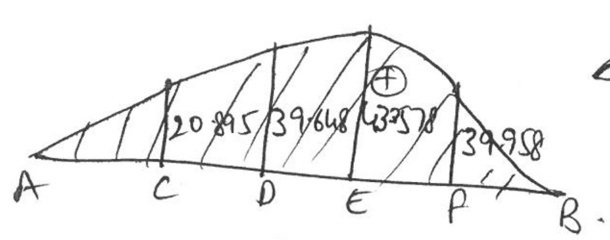
At F

$M_F = R_a(8.1) - 3\times3.5\left(\frac{3.5}{2}\right) - 5(6.6) - 5(4.5) = 39.958\ KN$

At B

$M_B = 0.$





BMD

—— 1m.

Step-3:- Calculation of shear forces.

At A

$V_A = +R_a = +13.93\,kN.$

At C

$(V_C)_{left} = +R_a = +13.93\,kN.$

$V_{C\,right} = +R_a - 5 = 8.93\,kN.$

At D

$(V_D)_{left} = 8.93\,kN.$

$(V_D)_{right} = 8.93 - 5 = 3.93\,kN.$

At E

$(V_E) = 3.93\,kN.$

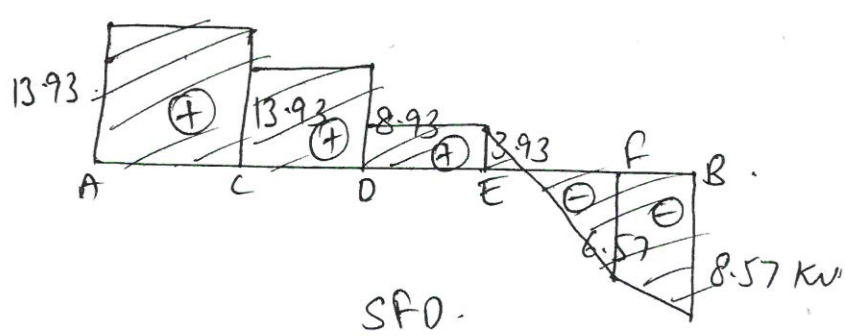
2m

At F

$V_F = 3.93 - 3 \times 3.5 = -6.57\,kN.$

At B

$V_B = -6.57\,kN + 12 = 8.57\,kN.$

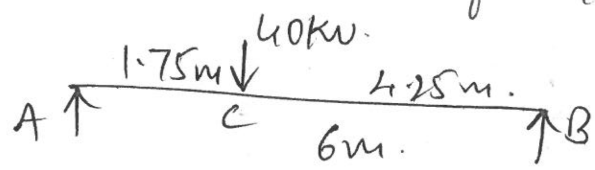


1m.

SFD.

(5)

Consider procedure for 70% marks $\boxed{7M}$



— 1m.

Step-1 Calculation of Reaction forces.

$\Sigma M_B = 0.$

$R_a(6) - 40(4.25) = 0.$

$R_a = 28.333$ KN.

$R_a + R_b = 40$ KN

$R_b = 40 - 28.333 = 11.667$ KN.

3m.

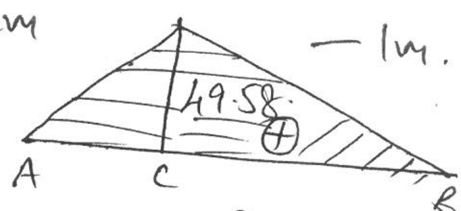
Step-2:- Calculation of bending moments.

$M_A = 0.$

$M_C = R_a(1.75) = 49.58275$

$M_B = 0$

2m



— 1m.

BMD

Step-3:- Calculation of ~~simply supported~~ shear forces

At A

$V_A = +R_a = 28.333$ KN.

At C

$(V_C)_{left} = +R_a = 28.333$ KN.

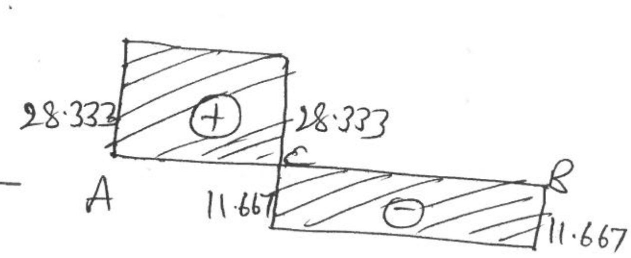
$(V_C)_{right} = +R_a - 40 = -11.667$ KN.

2m

At B

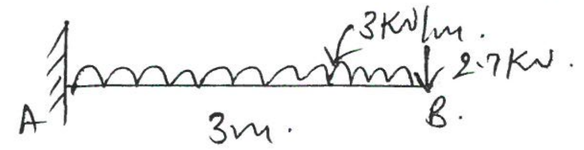
$V_B = -11.667$ KN.

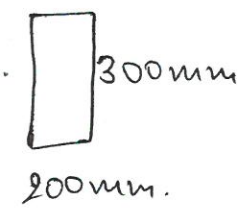
1m. —



SFD

(6) Consider procedure for 70% marks [7m]





— 1m.

$b = 200mm$
$d = 300mm$

Moment at fixed end $= 2.7 \times 3 + 3 \times 3 \times \frac{3}{2}$

$= 8.1 + 13.5 = 21.6$ KN-m. $\Rightarrow 21.6 \times 10^6$ N-mm } 3m.

$I = \frac{bd^3}{12} = \frac{200 \times 300^3}{12} = 450 \times 10^6 \ mm^4$. — 2m.

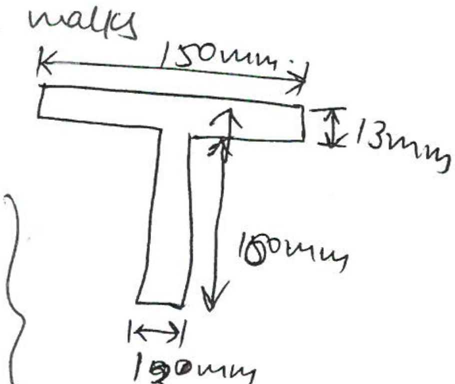
$$\boxed{\frac{M}{I} = \frac{\sigma}{y}}$$ — 1m

$y = d/2 = \frac{300}{2} = 150$ mm. — 1m.

$\frac{21.6 \times 10^6}{450 \times 10^6} = \frac{\sigma}{150} \Rightarrow 7.2 = \sigma$

$\boxed{\therefore \ \sigma_{max} = 7.5 \ N/mm^2}$ } 2m.

(7) Procedure - 70% marks



Shear force $F = 45KN = 45 \times 10^3 N$.

$A_1 = \cancel{100 \times 100} \ (100-13) \times 13 = 1131 \ mm^2$.

$A_2 = 150 \times 13 = 1950 \ mm^2$

$\boxed{A = A_1 + A_2} = 1131 + 1950 = 3081 \ mm^2$ } 2m.

$y_1 = \frac{87}{2} = 43.5$ mm

$y_2 = 87 + \frac{13}{2} = 93.5$ mm.

5

$$\boxed{\bar{y} = \frac{A_1 y_1 + A_2 y_2}{A_1 + A_2}} = \frac{1131 \times 43.5 + 1950 \times 93.5}{1131 + 1950} = 75.15\ mm$$ — 2m.

(from bottom)

Distance of NA from top = 100 − 75.15 = 24.85 mm.

<u>Web:-</u>

$$I_1 = \frac{bh^3}{12} = \frac{13 \times 87^3}{12} = 7.13 \times 10^5\ mm^4$$

<u>Flange</u> $I_2 = \frac{bh^3}{12} = \frac{150 \times 10^3}{12} = 2.75 \times 10^4\ mm^4.$

$$\boxed{I = (I_1 + A_1 h_1^2) + (I_2 + A_2 h_2^2)}$$

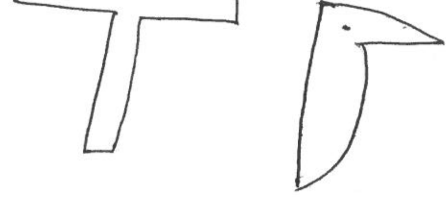
$$= (7.13 \times 10^5 + 1.13 \times 10^6) + (2.75 \times 10^4 + 6.84 \times 10^5)$$

$$= 2.53 \times 10^6\ mm^4.$$

2m.

<u>Maximum shear stress</u> — 1m.

$$\boxed{\tau_{max} = \frac{VA\bar{y}}{Ib}} = \frac{45 \times 10^3 \times 3.67 \times 10^4}{2.53 \times 10^6 \times 13} = 50\ N/mm^2$$ — 2m



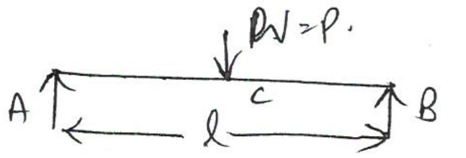
— 1m.

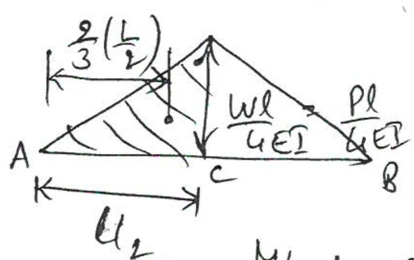
Shear stress distribution

Consider procedure for 70% marks — 7m.

(8) i) SSB with a point load 'P' at centre.

Using moment area method





$\frac{ML}{EI}$ diagram.

— 1m.

Slope at A $= \boxed{\theta_A = \text{Area between } \frac{M}{EI} \text{ diagram, } A \,\&\, C.}$

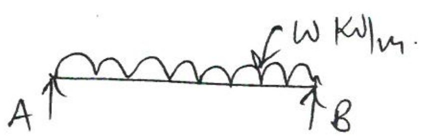
$= \frac{1}{2} \times \frac{L}{2} \times \frac{WL}{4EI} = \boxed{\frac{Wl^2}{16EI} = \theta_A} = \frac{Pl^2}{16EI}$ } 1.5m,

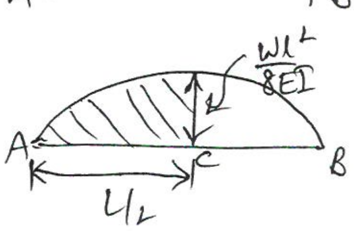
deflection at C $= \boxed{y_c = \text{Moment of } \frac{M}{EI} \text{ diagram between } A \,\&\, C.}$ — 1m

$y_c = \frac{1}{2} \times \frac{L}{2} \times \frac{WL}{4EI}\left(\frac{2}{3}\left(\frac{L}{2}\right)\right)$

$\boxed{\therefore y_c = \frac{WL^3}{48EI}} = \frac{PL^3}{48EI}$ } 1.5m.

ii) SSB with UDL w KN/m over entire span.





— 1m.

$\boxed{\text{Slope at } A = \theta_A = \text{Area of } \frac{M}{EI} \text{ diagram between } A \,\&\, C}$

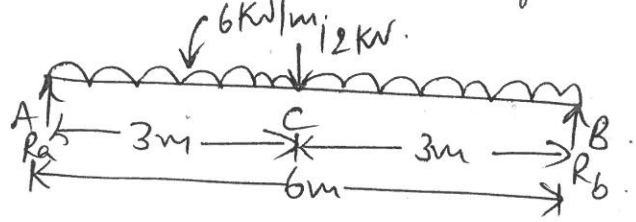
$\theta_A = \frac{2}{3} ab = \frac{2}{3} \times \frac{L}{2} \times \frac{Wl^2}{8EI}$

$\boxed{\theta_A = \frac{WL^3}{24EI}}$ } 1.5m

deflection at C $= \boxed{y_c = \text{moment of } \frac{M}{EI} \text{ diagram between } A \,\&\, C.}$ — 1m

$y_c = \frac{2}{3} \times \frac{L}{2} \times \frac{Wl^2}{8EI}\left[\frac{5}{8}\left(\frac{L}{2}\right)\right] \boxed{= \frac{5WL^4}{384EI} = y_c}$ — 1.5m.

(9) Consider procedure for 70% marks — $\boxed{7m}$ (6)



— 1m.

$R_a + R_b = 12 + 6\times 6 = 48$

$R_a = R_b = \frac{48}{2} = 24\,kN$ } 1m. (Symmetric beam)

Moment at any section x.

$M_x = R_a x - w\frac{x^2}{2} - 12(x-3)$

$= 24x - 3x^2 - 12x + 36$

$= 12x - 3x^2 + 36$ } 2m.

$24x - 3x^2 - 12(x-3)$

differential equation $M = -EI\frac{d^2y}{dx^2}$.

$EI\frac{d^2y}{dx^2} = -M = -24x + 3x^2 + 12(x-3)$ — 1m.

For slope integrate on both sides.

$\int EI\frac{d^2y}{dx^2} = +\int -24x + 3x^2 + 12(x-3)$

$EI\frac{dy}{dx} = -24\frac{x^2}{2} + C_1 \;|\; + \frac{3x^3}{3} \;|\; + 12\frac{(x-3)^2}{2}$ — (1)

For deflection equation integrate on both sides eq (1).

$EIy = -24\frac{x^3}{6} + C_1 x + C_2 \;|\; + \frac{3x^4}{12} \;|\; + 12\frac{(x-3)^3}{6}$ — (2)

Boundary conditions

At A, $x=0$, $y=0$.

At B, $x = l = 6$. $y=0$ } 2m.

$x=0$, $y=0$

$0 = 0 + C_2 \;|$

$\boxed{\therefore C_2 = 0}$

At $x=6$, $y=0$.

$$0 = -4x^3 + C_1 x \,\big|\, + 0.25(x^4) \,\big|\, + 2(x-3)^3$$

$$0 = -4 \times 6^3 + 6C_1 \,\big|\, + 0.25(6)^4 \,\big|\, + 2(3)^3$$

$$= -864 + 6C_1 \,\big|\, + 324 \,\big|\, + 54$$

$$6C_1 = -486$$

$$\boxed{\therefore C_1 = -81}$$

2m

$\therefore$ Slope at support

At $x=0$, $\theta_A =$

$$EI\,y = -81$$

$$\boxed{y_A = \frac{-81}{EI}}$$

$\therefore$ Deflection at centre (max deflection occurs at centre)

At $x=3$,

$$EI\,y_c = -4(3)^3 - 81(3) \,\big|\, + \frac{(3)^4}{4}$$

$$= -108 - 243 + 6.75$$

$$\boxed{y_c = -\frac{344.25}{EI}}$$

— 1m.

(10) Consider procedure for 70% marks – $\boxed{7m}$

Given data :-

Length = 4m.

External dia = D = 200 mm.

thickness = t = 20 mm.

load = 150 KN.

Eccentricity = e = 25 mm.

Both ends are fixed.

} 1m.

Internal diameter = $d = D - 2t = 200 - 2 \times 20 = 160\,mm$.

Area $A = \frac{\pi}{4}(D^2 - d^2) = \frac{\pi}{4}(200^2 - 160^2) = 11309\,mm^2$.

$I = \frac{\pi}{64}(D^4 - d^4) = \frac{\pi}{4}(200^4 - 160^4) = 4.636 \times 10^7\,mm^4$.

} 2m.

Axial stress $\sigma_0 = \frac{P}{A} = \frac{150 \times 10^3}{11309} = 13.26\,MPa$. — 2m

Bending stress $\sigma_b = \frac{My}{I} = \frac{Pe \cdot y}{I} = \frac{150 \times 10^3 \times 25 \times \frac{200}{2}}{4.636 \times 10^7}$ — 2m

$= 8.09\,MPa$.

i) Extreme stresses

$\sigma_{max} = \sigma_0 + \sigma_b = 13.26 + 8.09 = 21.35\,N/mm^2$ (comp)

$\sigma_{min} = \sigma_0 - \sigma_b = 13.26 - 8.09 = 5.17\,N/mm^2$ (comp).

} 1m.

ii) Max eccentricity to avoid tension.

$\sigma_0 = \sigma_b \Rightarrow \frac{P}{A} = \frac{Pe}{Z}$.

$e = \frac{Z}{A} = \frac{I/y}{A} = \frac{4.636 \times 10^5}{11309} = 40.99\,mm$.

} 1m.

∴ Max eccentricity = 40.99 mm = e_{nom}

(11) Consider procedure for 70% marks $\boxed{7m}$.

Given data:-

$$\left.\begin{aligned} \text{length} &= 90\text{ cm} = l \\ \text{dia} &= 20\text{ cm} = d \\ \text{Pressure} &= P = 20\text{ KN/cm}^2 \end{aligned}\right\} 2m$$

$\boxed{\text{Assume } t = 1\text{ cm}}$ Consider any other thickness also, answers may vary consider right procedure.

i) Longitudinal stress:-

$$\sigma_l = \frac{Pd}{4t} = \frac{20 \times 20}{4 \times 1} = 100\text{ N/mm}^2 \quad \text{— } 2m$$

ii) Hoop stress:-

$$\sigma_h = \frac{Pd}{2t} = \frac{20 \times 20}{2 \times 1} = 200\text{ N/mm}^2 \quad \text{— } 2m$$

iii) Change in length:-

$$\boxed{\varepsilon_l = \frac{\sigma_l}{E} - \mu \cdot \frac{\sigma_h}{E}} = \frac{100}{2.1 \times 10^7} - 0.3\left(\frac{200}{2.1 \times 10^7}\right)$$

$$\varepsilon_l = 19.047 \times 10^{-7}$$

change in length $\boxed{\Delta l = \varepsilon_l \times l} = 19.047 \times 10^{-7} \times 90$ } 2m

$$\boxed{\Delta l = 0.1714 \times 10^{-3}\text{ cm}}$$

iv) Change in diameter:-

$$\boxed{\varepsilon_d = \frac{\sigma_h}{E} - \mu \cdot \frac{\sigma_l}{E}} = \frac{200}{2.1 \times 10^7} - 0.3\left(\frac{100}{2.1 \times 10^7}\right) = \frac{170}{2.1 \times 10^7}$$

$$= 0.8095 \times 10^{-5}$$

Change in diameter $\boxed{\Delta d = \varepsilon_d \times d} = 0.8095 \times 10^{-5} \times 20$ } 2m

$$= 16.19 \times 10^{-5}$$

$$\boxed{\Delta d = 0.1619 \times 10^{-3}\text{ cm}}$$