	b)	A simply supported beam of 10 m span carries two point loads of 4 kN and 6 kN at 3 m and 7 m. Determine the deflection under each load (Take E = 200 GPa, $I = 400 \times 10^6$ mm^4).	L3	CO3	7 M
OR					
9	a)	State Moment Area theorems.	L2	CO1	2 M
	b)	A cantilever beam of length 2.5 m carries a point load of 20 kN at the free end. Find the deflection and slope at the free end.	L3	CO3	8 M

UNIT-V

10	a)	Derive expressions for change in diameter and volume of thin cylindrical shells.	L2	CO4	2 M
	b)	A thin cylinder of internal diameter 1.25 m and thickness 12 mm is subjected to internal pressure of 1.8 N/mm^2. Find the hoop and longitudinal stresses.	L3	CO4	8 M
OR					
11		A column 2.5 m long has a circular section of 150 mm diameter. Find the crippling load using Euler's formula for following end conditions if $E = 2 \times 10^5$ N/mm^2 i) Fixed – Fixed ii) Pinned – Pinned	L3	CO4	10 M

Code: 23ME3301

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

MECHANICS OF SOLIDS
(MECHANICAL 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)	Define Hooke's law.	L1	CO1
1.b)	What is Factor of Safety?	L1	CO1
1.c)	Define torsion.	L1	CO1
1.d)	What do you mean by fixed end moment?	L2	CO1
1.e)	Define section modulus.	L1	CO1
1.f)	What is shear flow in T-beam?	L2	CO1
1.g)	Define radius of curvature of a beam.	L1	CO1
1.h)	State the boundary conditions for simply supported beams.	L2	CO1
1.i)	Define hoop stress.	L1	CO1
1.j)	State Rankine's formula for columns.	L2	CO1

PART – B

			BL	CO	Max. Marks
		UNIT-I			
2	a)	Explain the stress strain diagram for mild steel.	L2	CO2	5 M
	b)	A bar of 20 mm diameter is subjected to a tensile load of 50 kN. If the extension in 200 mm gauge length is 0.25 mm and change in diameter is 0.003 mm, find stress, strain, Poisson's ratio and modulus of elasticity.	L3	CO2	5 M
		OR			
3	a)	Explain the concept of principal stresses with suitable examples.	L2	CO2	2 M
	b)	At a point in a strained material, the principal stresses are 100 N/mm^2 (tensile) and 60 N/mm^2 (compressive) and shear stress is 30 N/mm^2. Determine i) Principal Stresses ii) Maximum shear stress iii) The normal stress and shear stress on a plane inclined at 45°.	L3	CO2	8 M
		UNIT-II			
4	a)	Construct the shear force and bending moment diagrams for a cantilever beam of span 5 m carrying a point load of 20 kN at the free end.	L3	CO2	8 M

	b)	Explain the concept of "point of contraflexure" with an example.	L2	CO2	2 M
		OR			
5	a)	Differentiate between solid shaft and hollow shaft.	L2	CO1	3 M
	b)	A solid shaft of 100 mm diameter transmits 150 kW at 200 rpm. Determine the shear stress and angle of twist for a length of 2 m. Take G = 80 GPa.	L3	CO2	7 M
		UNIT-III			
6	a)	Draw the bending stress distribution for T – cross section.	L2	CO1	3 M
	b)	A simply supported beam of span 8 m carries a UDL of 10 kN/m. Determine maximum bending stress if $I = 6 \times 10^8$ mm^4 and depth = 500 mm for a rectangular cross section.	L3	CO3	7 M
		OR			
7	a)	Explain the shear stress distribution for an I-section.	L2	CO1	3 M
	b)	A rectangular section beam 200 mm × 300 mm is subjected to a shear force of 60 kN. Compute maximum shear stress.	L3	CO3	7 M
		UNIT-IV			
8	a)	Explain the procedure for slope and deflection using Macaulay's method.	L2	CO1	3 M

PRASAD V POTLURI SIDDHARTHA INSTITUTE OF TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

MECHANICS OF SOLIDS – 23ME3301 – II B. TECH – I SEM

SCHEME OF EVALUATION – NOVEMBER 2025

Part – A: **1.** Each question carries 2 marks 10 X 2 = 20 Marks

Part – B:

		Unit – I:		
2	**a**	Stress strain diagram	3 M	
		Description	2 M	5 M
	b	Given data	1 M	
		Calculation of stress	1 M	
		Calculation of strain	1 M	
		Calculation of Poisson's ratio	1 M	
		Calculation of Modules of Elasticity	1 M	5 M
		OR		
3	**a**	Definition or formula of principal stresses	2 M	2 M
	b	Given data	2 M	
		Calculation of Principal stresses	2 M	
		Calculation of Maximum shear stresses	2 M	
		Normal stress on inclined plane	1 M	
		Shear stress on inclined plane	1 M	8 M
		Unit – II:		
4	**a**	Cantilever beam with point load	2 M	
		Shear force diagram	3 M	
		Bending Moment diagram	3 M	8 M
	b	Point of contra-flexure	2 M	2 M
		OR		
5	**a**	Any difference like definition/Area/MI/diagram etc;	3 M	3 M
	b	Given data	2 M	
		Shear stress formula	1 M	
		Calculation of Polar MI	1 M	
		Calculation of Shear stress	1 M	
		Angle of twist formula	1 M	
		Calculation of Angle of twist	1 M	7 M
		UNIT – III		
6	**a**	T – Cross section	1 M	
		Bending stress distribution diagram	2 M	3 M
	b	SSB diagram and given data	2 M	
		Maximum Bending moment equation	1 M	
		Calculation of Maximum Bending moment	1 M	
		Bending stress formula	1 M	
		Calculation of bending stress	2 M	7 M
		OR		

7	a	I – Cross section	1 M	
		Shear stress distribution diagram	2 M	3 M
	b	Rectangular diagram / Given data	2 M	
		Shear stress equation	1 M	
		Moment of Inertia formula	1 M	
		Moment of Inertia calculation	1 M	
		Shear stress calculation	2 M	7 M
		UNIT – IV		
8	a	Macaulay's method explanation with either example or with differential equation or in words	3 M	3 M
	b	Simply supported beam/Given data	1 M	
		Bending Moment equation	1 M	
		First Integration - Slope	1 M	
		Second Integration – Deflection	1 M	
		Applying Boundary conditions	1 M	
		Calculation of deflection under loads	2 M	7 M
		OR		
9	a	Moment Area theorem – I: Definition or formula	1 M	
		Moment Area theorem – II: Definition or for	1 M	2 M
	b	Cantilever beam or given data	1 M	
		Bending Moment equation	2 M	
		First Integration - Slope	1 M	
		Second Integration – Deflection	1 M	
		Applying Boundary conditions	1 M	
		Calculation of deflection and slope at free end	2 M	8 M
		UNIT – V		
10	a	Change in Diameter	1 M	
		Change in volume	1 M	2 M
	b	Given data	2 M	
		Hoop Stress formula	2 M	
		Hoop Stress Calculation	1 M	
		Longitudinal Stress formula	2 M	
		Longitudinal stress calculation	1 M	8 M
		OR		
11		Given data	2 M	
		Calculation of MI	2 M	
		Euler's Equation	2 M	
		Fixed – Fixed equivalent length	1 M	
		Crippling load for Fixed – Fixed end condition	1 M	
		Pinned – Pinned equivalent length	1 M	
		Crippling load for Pinned – Pinned end condition	1 M	10 M

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DEPARTMENT OF MECHANICAL ENGINEERING

MECHANICS OF SOLIDS – 23ME3301 – II B. TECH – I SEM

DETAILED SOLUTIONS – NOVEMBER 2025

PART – A

1.

a. Hooks law states that Stress is directly proportional to strain with elastic or proportional limit

$$\sigma = E.\varepsilon$$

b. The ratio between maximum permissible stress to working stress is Factor of safety

$$FoS = \frac{\sigma_y}{\sigma}$$

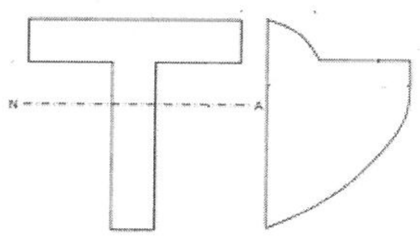
c. The moment acts along the axis or twisting of an object is torsion

d. The moment reaction developed at fixed support is known as fixed end moment

e. The ratio between distance from neutral axis to moment of Inertia is known as section modulus

$$Z = \frac{I}{y}$$

f.



g. The square root of ratio between Moment of Inertia and cross sectional area

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

h. At x = 0; y =0 and at x = l; y = 0; Or the deflection at the supports is Zero

i. The hoop stress $\sigma = \frac{PD}{2t}$ or $\sigma = \frac{Pr}{t}$

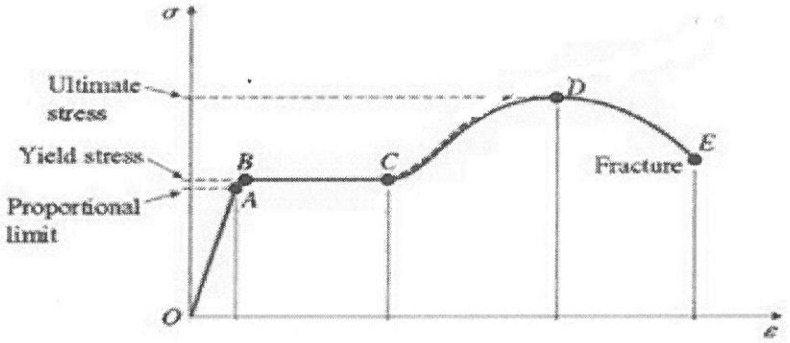
j. $\frac{1}{P} = \frac{1}{P_c} + \frac{1}{P_E}$, P = Rankine's load, P_c = Compressive load, P_E = Euler's load

PART – B

UNIT – I

2.

a.



- A uniform cross section prismatic bar is loaded in UTM and apply tensile force.
- A stress-strain diagram for mild steel is a plot of stress (σ) on the y-axis against strain (ε) on the x-axis.
- Proportional Limit (Point A): The point where the stress-strain curve is a straight line, indicating stress is directly proportional to strain.
- Elastic Limit: (Point A): The point up to which the material will return to its original shape after the load is removed.
- Yield Point (Point B): The point where the material begins to deform plastically, and a large increase in strain occurs with little to no increase in stress.
- Ultimate Tensile Strength (Point D): The highest point on the curve, representing the maximum stress the material can withstand before it begins to neck.
- Breaking Point (Point E): The point at which the material finally fractures.

b. Given Data:

Diameter	d = 20mm
Tensile force	P = 50 x 10^3 N
Gauge length	L = 200 mm
Change in length	δL= 0.25 mm
Change in diameter	δd = 0.003 mm

(i) Stress $\sigma = \frac{P}{A} = \frac{50x10^3}{\frac{\pi}{4}(20)^2} = \frac{50x10^3}{314.16} = \mathbf{159.15\ MPa}$

(ii) Strain $\varepsilon = \frac{\delta L}{L} = \frac{0.25}{200} = 1.25X10^{-3} = \mathbf{0.00125}$

(iii) Lateral strain $\varepsilon_l = \frac{\delta d}{d} = \frac{0.003}{20} = 0.00015$

Poisson's ratio $\mu = \frac{\varepsilon_l}{\varepsilon} = \frac{0.00015}{0.00125} = \mathbf{0.12}$

(iv) Modulus of elasticity $E = \frac{\sigma}{\varepsilon} = \frac{159.15}{0.00125} = 127320 = \mathbf{1.27X10^5 MPa}$

OR

3.

a.

- An element inside a body subjected to combined loading, is subjected to different stresses depending upon the angle of inclination of the element
- The maximum normal stress and minimum normal stresses are known as principal stresses (OR) the normal stresses on a plane where shear stress is zero are known as principal stresses.

b. Given data:

σx = 100 MPa, σy = – 60 MPa, τ = 30 MPa.

(i) Principal stresses $\sigma_{1,2} = \frac{\sigma_x+\sigma_y}{2} \pm \sqrt{\left[\frac{\sigma_x-\sigma_y}{2}\right]^2 + \tau^2}$

$= \frac{100-60}{2} \pm \sqrt{\left[\frac{100+60}{2}\right]^2 + 30^2}$

$= 20 \pm \sqrt{6400 + 900} = 20 \pm 85.44$

= **105.44** and **– 65.44 MPa**

(ii) Maximum shear stress $= \frac{\sigma_1-\sigma_2}{2}$

$= \frac{105.44+65.44}{2}$

= **85.44 MPa**

(iii) Stresses on 45^0 inclined plane:

Normal stresses $= \frac{\sigma_x+\sigma_y}{2} \pm \frac{\sigma_x-\sigma_y}{2}\cos 2\theta \pm \tau \sin 2\theta$

$= \frac{100-60}{2} \pm \frac{100+60}{2}\cos 2(45) \pm 30 \sin 2(45)$

$= 20 \pm 0 \pm 30$

Normal stresses = **50, – 10 MPa**

Shear stresses $= \frac{\sigma_y-\sigma_x}{2}\sin 2\theta \pm \tau \cos 2\theta$

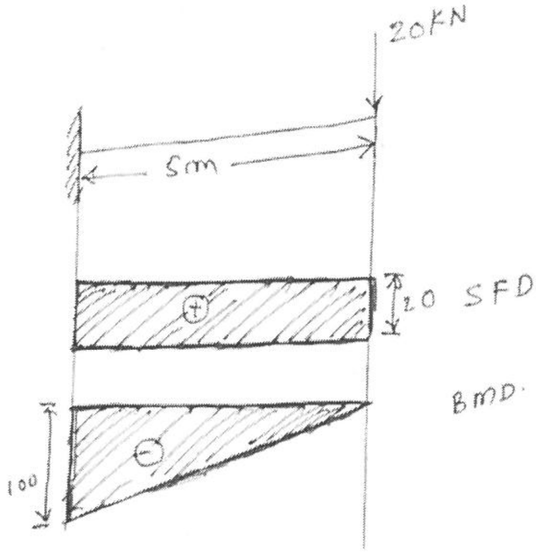
$= \frac{-60-100}{2}\sin 2(45) \pm 30(45)$

= **– 90 MPa**

UNIT – II

4.

a.



b. Point of Contra-flexure means, the point at which the bending moment is changes its sign (OR) the point at which the bending moment is zero

OR

5.

a. A shaft with full material across its cross-section is known as solid shaft and A shaft with material removed at the center, forming a hollow (tube-like) section is hollow shaft Lower strength-to-weight ratio for solid shaft but Higher strength-to-weight ratio.

b. Given data:

Diameter	d = 100 mm
Power	P = $150X10^3$ W
Speed	N = 200 rpm
Length	L = 2m
	G = $80X10^3$ MPa

Now, Torque $T = \frac{P*60}{2\pi N} = \frac{150X10^3*60}{2\pi(200)} = 7.16X10^3$ W

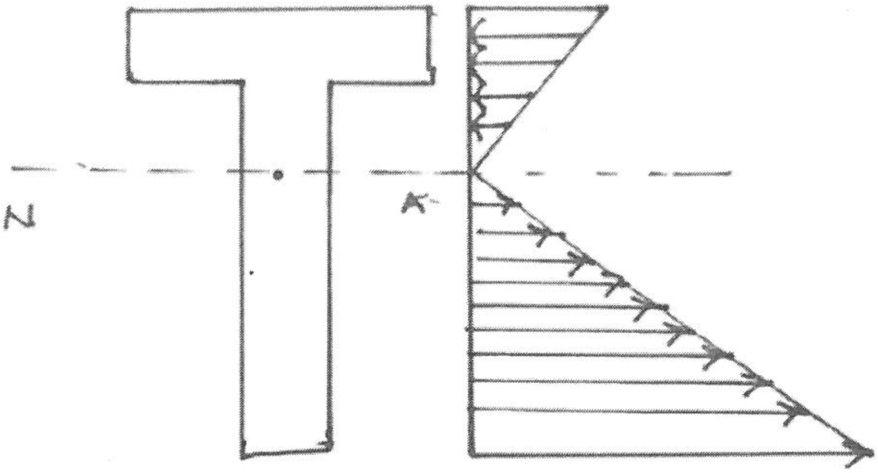
Shear stress $\tau = \frac{Tr}{J} = \frac{7.16X10^3X50}{\frac{\pi}{32}(100)^4} = \frac{7.16X10^6X50}{\frac{\pi}{32}(100)^4} = \frac{358000}{9817477.04} = \mathbf{36.47\ MPa}$

Angle of twist $\theta = \frac{TL}{GJ} = \frac{(7.16.X10^6)(2000)}{(80X10^3)(9817477.04)} = \mathbf{0.018^c}$

UNIT – III

6.

a.



b. Given data:

Beam = Simply supported beam

Length L = 8m

UDL w = 10 kN/m = 10 N/mm

Moment of Inertia I = 6×10^8 mm^4

Depth d = 500 mm

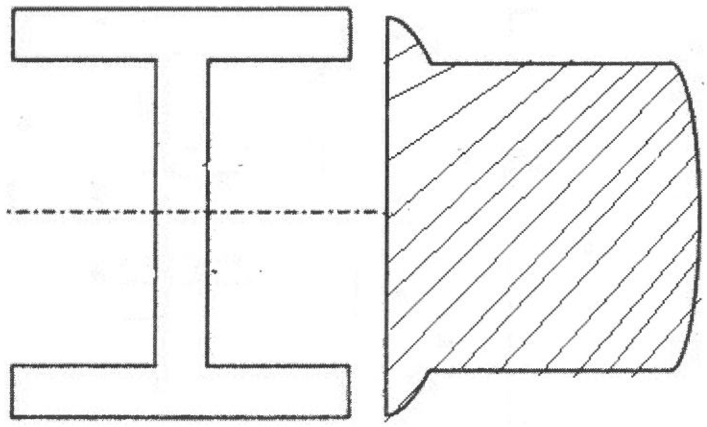
Bending moment $M = \frac{wl^2}{8} = \frac{(10)(8000)^2}{8} = 80 \times 10^6$ Nmm

Bending stress $\sigma = \frac{My}{I} = \frac{80 \times 10^6 \times 250}{6 \times 10^8}$ = **33.33 MPa**

OR

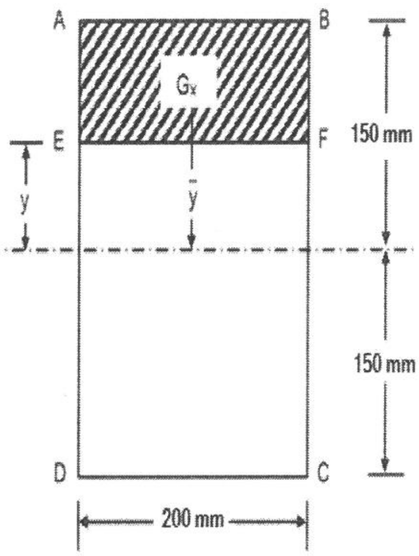
7.

a.



b. Given data:

Shear force $V = 60x10^3$ N



Shear Stress $\tau = \frac{VA\bar{y}}{Ib}$

Where $A = (200)(150 - y)$

$\bar{y} = y + \frac{150-y}{2}$

$I = \frac{(200)(300)^3}{12} = 450x10^6\ mm^4$

b = 200 mm

Shear Stress $\tau = \frac{60X10^3(200)(150-y)(y+\frac{150-y}{2})}{450x10^6x200}$

For maximum shear stress y = -

Max. shear stress = $\frac{60X10^3(200)(150)75}{450x10^6x200}$ =

= 1.5 MPa

UNIT – IV

8.

a. The basic equation for Macaulay's

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

By Integrating the above equation we can find the equation for Slope

$EI\frac{dy}{dx} = -\int M dx$

By Integrating the above equation we can find the equation for Defection

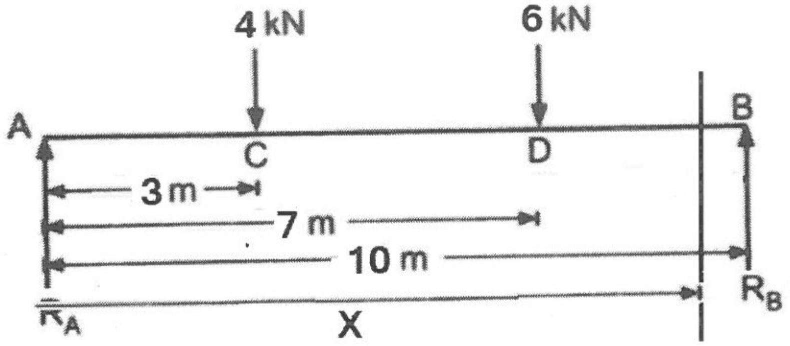
$EI\,y = -\int[\int Mdx]\,dx$

The constants can be calculated by using boundary conditions.

While substituting boundary conditions, the value inside the brackets is negative will be considered as ZERO.

That is <X – a> = 0; if X – a is negative

b.



Reactions:

$\Sigma F_y = 0$

$\Rightarrow R_A + R_B = 10$ kN

$\Rightarrow \Sigma M_A = 0$

$\Rightarrow 4(3) + 6(7) = R_B(10)$

$\Rightarrow R_B = 5.4$ kN and $R_A = 4.6$ kN

Moment equation at section X

$\Rightarrow M = 4.6x10^3x - 4x10^3 <x - 3> - 6x10^3<x - 7>$

$\Rightarrow EI\,\frac{d^2y}{dx^2} = -4.6x10^3x + 4x10^3 <x - 3> + 6x10^3<x - 7>$

$\Rightarrow EI\,\frac{dy}{dx} = -4.6x10^3\,\frac{x^2}{2} + 4x10^3\,\frac{<x-3>^2}{2} + 6x10^3\,\frac{<x-7>^2}{2} + C_1$

$\Rightarrow EI\,y = -4.6x10^3\,\frac{x^3}{6} + 4x10^3\,\frac{<x-3>^3}{6} + 6x10^3\,\frac{<x-7>^3}{6} + C_1x + C_2$

Boundary conditions are at x = 0; y = 0

$\Rightarrow 0 = C_2$

Second boundary condition at x = 10; y = 0

$\Rightarrow 0 = -4.6x10^3\,\frac{10^3}{6} + 4x10^3\,\frac{7^3}{6} + 6x10^3\,\frac{3^3}{6} + 10C_1$

$\Rightarrow C1 = 51.1x10^3$

Hence

$EI\,y = -4.6x10^3\,\frac{x^3}{6} + 4x10^3\,\frac{<x-3>^3}{6} + 6x10^3\,\frac{<x-7>^3}{6} + 51.1x10^3x$

Deflection at x = 3

$EIy_{x=3} = -4.6x10^3\,\frac{3^3}{6} + 0 + 0 + 51.1x10^3(3)$

$\Rightarrow EIy_{x=3} = -4.6x10^3\,\frac{3^3}{6} + 0 + 0 + 51.1x10^3(3)$

$\Rightarrow y_{x=3} = 132600/EI$

$\Rightarrow$ $y_{x=3}$ = 132600/80X10^6

$\Rightarrow$ **$y_{x=3}$ = 1.66x10^{-3} m = 1.66 mm**

Deflection at x = 7

$EIy_{x=7} = -4.6x10^3 \frac{7^3}{6} + 4x10^3 \frac{4^3}{6} + 0 + 51.1x10^3(7)$

$\Rightarrow$ $EIy_{x=7}$ = 137400

$\Rightarrow$ $y_{x=7}$ = 137400/EI

$\Rightarrow$ $y_{x=7}$ = 137400/80X10^6

$\Rightarrow$ **$y_{x=7}$ = 1.72x10^{-3} m = 1.72 mm**

OR

9.

a.

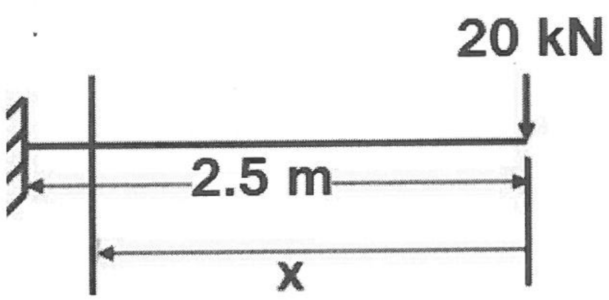
- The first theorem states that the change in slope between two points on the curve is equal to the area under the M/EI diagram between those points.

$\theta_B - \theta_A = \frac{1}{EI}$[Area of Bending moment diagram between points B and A]

- The second theorem states that the vertical deviation of a point on the curve relative to the tangent at another point is equal to the moment of the M/EI area between the two points, taken about the first point.

$y_B - y_A = \frac{1}{EI}$[First moment of Area of Bending moment diagram between points B and A]

b.



The bending moment equation M = – wx

$\Rightarrow EI\frac{d^2y}{dx^2} = 20x10^3x$

$\Rightarrow EI\frac{dy}{dx} = \frac{20x10^3x^2}{2} + C_1$

$\Rightarrow EI\ y = \frac{20x10^3x^3}{6} + C_1x + C_2$

Boundary conditions are at x = 2.5; $\frac{dy}{dx} = 0$

$\Rightarrow 0 = \frac{20x10^3(2.5)^2}{2} + C_1$

$\Rightarrow C_1 = -62{,}500$

Second boundary condition is at x = 2.5; y = 0

$\Rightarrow 0 = \frac{20x10^3(2.5)^3}{6} - 62500(2.5) + C_2$

$\Rightarrow C_2 = 104.17X10^3$

Hence equations are

$\Rightarrow EI\ y = \frac{20x10^3x^3}{6} - 62500\ x + 104.17x10^3$

And $EI\frac{dy}{dx} = \frac{20x10^3x^2}{2} - 62500$

Now at free end means x = 0;

Slope = **– 62500/EI**

Deflection = **104.17x10³/EI**

UNIT – V

10.

a. Hoop Stress $\sigma_h = \frac{Pr}{t}$

Axial Stress $\sigma_a = \frac{Pr}{2t}$

Hoop strain $\varepsilon_h = \frac{\delta d}{L} = \frac{1}{E}[\sigma_h - \mu\sigma_a]$

$\Rightarrow$ Change in diameter $\delta d = \frac{Pr}{2tE}[2 - \mu]$

and

$\Rightarrow$ Change in volume $\delta v = \frac{Pr}{2tE}[5 - 4\mu]$

b.

Given data:

Internal diameter	d = 1.25m =1250 mm
Thickness	t = 12mm
Pressure	P =1.8 MPa
Hoop stress	$\sigma_h = \frac{Pr}{t} = \frac{(1.8)(625)}{12}$ = **93.75 MPa**
Longitudinal stress	$\sigma_l = \frac{Pr}{2t} = \frac{(1.8)(625)}{2X12}$ = **46.875 MPa**

OR

11.

Given data:

Length of the column $L = 2.5\text{ m} = 2500\text{ mm}$

Diameter $d = 150\text{ mm}$

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

Now, $I = \frac{\pi d^4}{64} = \frac{\pi (150)^4}{64} = 24.85 \times 10^6\ \text{mm}^4$

(i) Fixed – Fixed end condition $L_e = L/2 = 1250\text{ mm}$

Crippling load $P_{cr} = \frac{\pi^2 EI}{L_e^2} = \frac{\pi^2 (2 \times 10^5)(24.85 \times 10^6)}{1250^2} =$ **31.39×10^6 N**

(ii) Pinned – Pinned end condition $L_e = L = 2500\text{ mm}$

Crippling load $P_{cr} = \frac{\pi^2 EI}{L_e^2} = \frac{\pi^2 (2 \times 10^5)(24.85 \times 10^6)}{2500^2} =$ **7.85×10^6 N**