TED (15) – 3013

(REVISION — 2015)

Reg. No...

Signature ....

DIPLOMA EXAMINATION IN ENGINEERING/TECHNOLOGY/ MANAGEMENT/COMMERCIAL PRACTICE — OCTOBER, 2018

THEORY OF STRUCTURES - I

[*Time* : 3 hours

(Maximum marks : 100)

[*Note* :—Sketches on 4th page.]

PART — A

(Maximum marks : 10)

Marks

I Answer *all* questions in one or two sentences. Each question carries 2 marks.

1. Define a force.
2. What do you mean by factor of safety ?
3. Define the term neutral layer of a section.
4. Classify the types of loading on the beam.
5. Define moment of resistance of a section in a beam. (5×2 = 10)

PART — B

(Maximum marks : 30)

II Answer any *five* of the following questions. Each question carries 6 marks.

1. Two forces 80 N and 70 N acts simultaneously act at a point O with angle between them is 90°. Find the magnitude and direction of resultant of force.
2. A simply supported beam AB of span 4 meter carries three point loads of 4 kN, 10 kN and 8 kN at a distance 1m, 2m and 3m respectively from the left hand support. Calculate the support reactions.
3. A member formed by connecting a steel bar to an aluminium bar of cross sectional area 2500 mm^2 is shown in the figure -1. Calculate the magnitude of the load P which will cause the total length of the member to decrease 0.25 mm. Take E for steel = 2.1×10^5 N/mm^2 and E for aluminium = 7×10^4 N/mm^2.
4. Explain resilience, proof resilience and modulus of resilience.
5. A cantilever beam 3 meter long carries UDL of 2 kN/m over the entire span and a point load of 3kN at the free end. Draw the shear force and bending moment diagram.

Marks

6. A shaft has to transmit power of 105 kW at 160 rpm. If the shear stress is not to exceed $65 N/mm^2$, and the twist in a length of 3.5 meter must not exceed 1°, find a suitable diameter. Take $C = 8 \times 10^4 N/mm^2$.

7. Write the assumptions made in the theory of simple bending. (5×6 = 30)

PART — C

(Maximum marks : 60)

(Answer *one* full question from each unit. Each full question carries 15 marks.)

Unit — I

III (a) A simply supported beam PQ of span 5 meter carries three point loads of 5 kN, and 10 kN at a distance 2m and 4m respectively from the left hand support. In addition to this a udl of 2kN/m over the entire span. Calculate the support reactions. 7

(b) Find the position of center of gravity of L section shown in figure - 2. 8

Or

IV (a) A weight of 15 N hangs on two chains as shown in figure - 3. Determine the tension in each chain. 6

(b) Find the moment of inertia of T section about x-x axis is shown in figure - 4. 9

Unit — II

V (a) A load of 300 kN is applied on a short column 250 mm × 250 mm. The column is reinforced by steel bars of total area $5600 mm^2$. If modulus of elasticity for steel is 15 times that of concrete, find the stresses in steel and concrete. 7

(b) Explain mechanical properties of material. 8

Or

VI (a) Draw and explain the salient features of stress strain curve of a mild steel bar. 8

(b) A steel bar 4 meter long, 35 mm wide and 20 mm thick is subjected to a pull of 30 kN in the direction of its length. Find the change in volume of bar, if poisson's ratio is 0.25. Take E = 200 GPa. 7

Unit — III

VII (a) Classify the types of beam depending on the type of supports. 5

(b) A simply supported beam of 10 m long carries a UDL 2 kN/m over entire length and point loads 1 kN and 2 kN at distance 2m and 5m from the left support. Draw shear force and bending moment diagram. 10

Or

Marks

VIII (a) Find the maximum torque, that can be transmitted safely to a shaft of diameter 30 cm diameter. The permissible angle of twist is 1.5 degree in a length of 8.0 meter length and the shear stress is not to exceed 40 N/mm^2.
Take C = 8 × 104 N/mm^2. 7

(b) The vessel of 530 mm external diameter and 10 mm thick, the length being 1800 mm. Find the change in external diameter and the length when the internal pressure of 10.5 N/mm^2. Take E = 2.1 × 105 N/mm^2 and Poisson's ratio of 0.3. 8

Unit — IV

IX (a) Derive the equation of simple bending. 9

(b) An I section has the following dimensions : Flanges 150 mm × 20 mm, web 300 mm × 10 mm. Find the maximum shear stress developed in the beam for a shear force of 50 kN. 6

Or

X (a) A rolled steel joist of I section has the following dimensions : Flange width 250 mm wide and 24 mm thick, Web 12 mm thick, Overall depth 600 mm. If this beam carries a UDL of 50 kN per meter run on a span of 8 meters, calculate the maximum stress produced due to bending. 6

(b) A beam of 100 mm × 150 mm in size is simply supported at its ends carries UDL over the span of 2 meter. If the safe stress are 28 N/mm^2 in bending and 2 N/mm^2 in shear. Calculate the safe load which can be supported by the beam. 9

Marks

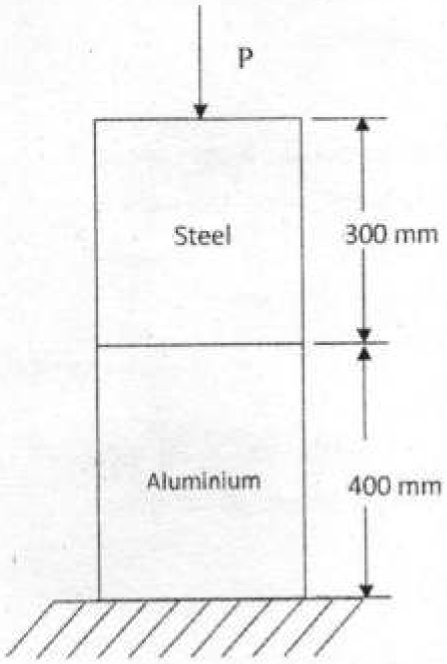

Figure -1

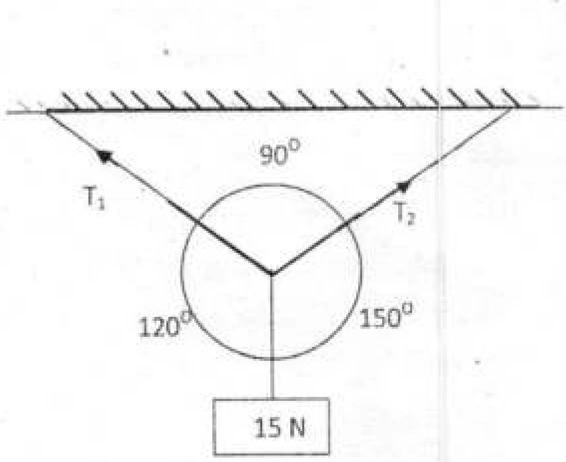

Figure -3

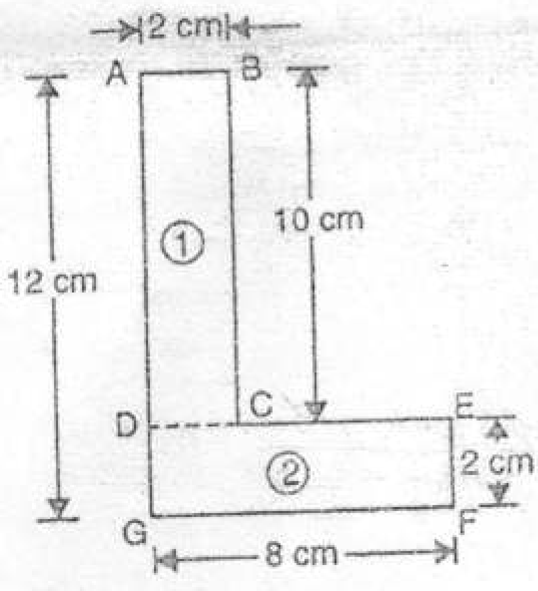

Figure -2

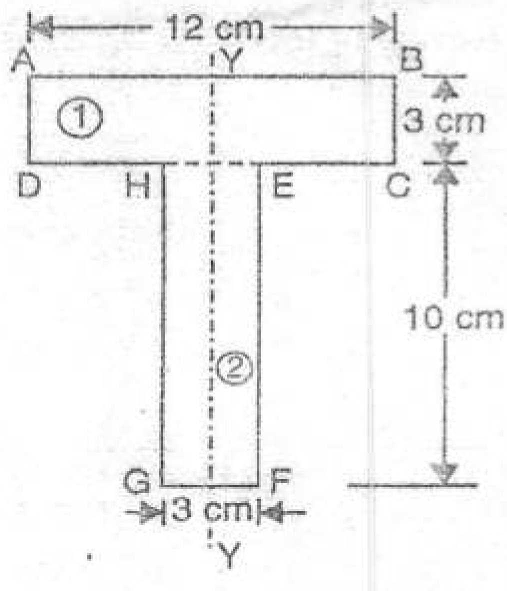

Figure -4

D · (15)

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DIPLOMA EXAMINATION IN ENGINEERING /TECHNOLOGY/MANAGEMENT

CORRECTION NOTE

Revision & Sub code: TED(15) - 3013
Subject: THEORY OF STRUCTURES - I
Verified by:

PART - B   This can also be considered.

II, 1

Resultant, $R = \sqrt{P^2 + Q^2}$

$= \sqrt{70^2 + 80^2} = 106.3\,N$

$\phi = \tan^{-1} \frac{Q}{P}$

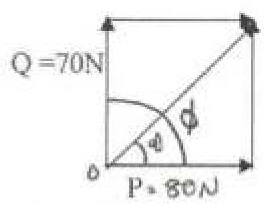
$= \tan^{-1} \frac{70}{80} = 0.875 = 41.18^\circ$

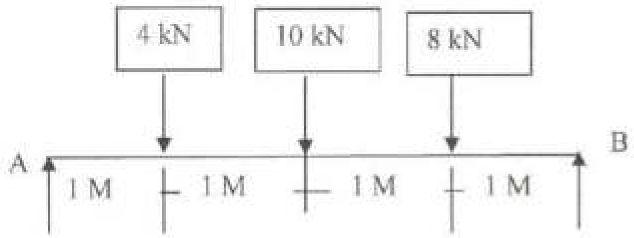
Scheme of valuation

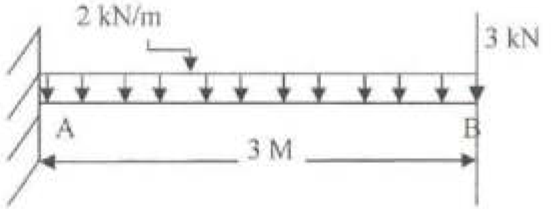
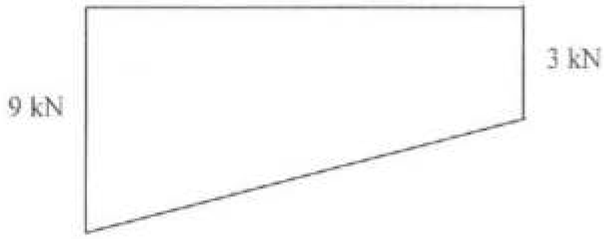
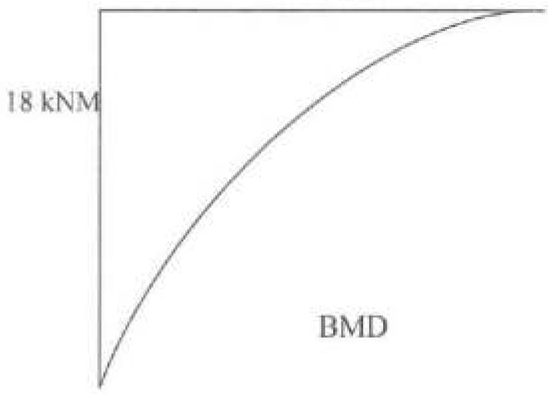
(scoring indicator)

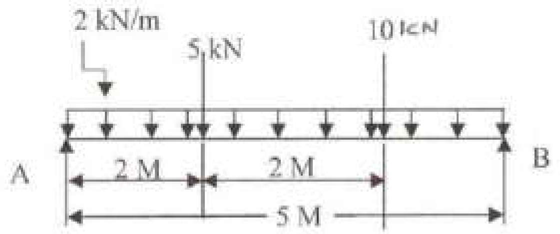
Revision Course code **TED (15) – 3013**

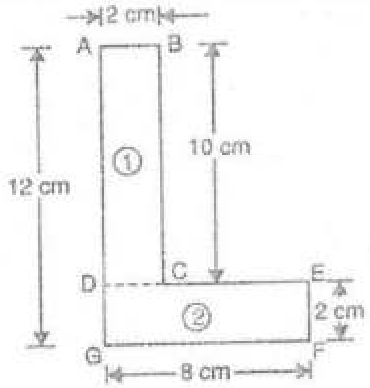
Course title **THEORY OF STRUCTURES – I**

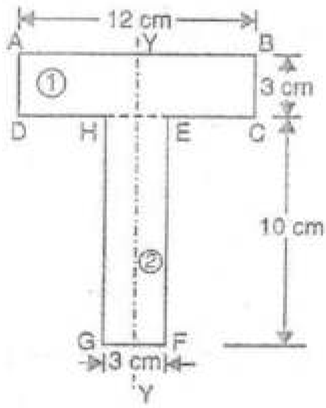
Q. No	Scoring indicator	Split up	Sub total	Total
I	Part A			
(1)	An effort which produces or tends to produce, destroys or tends to destroy motion	2	2	
(2)	The ratio between ultimate stress and working stress OR factor of safety = ultimate stress / working stress	2	2	
(3)	a layer in which neither tension nor compression	2	2	
(4)	Point load, UDL, Gradually varying load	2	2	
(5)	When beam subjected to BM, internal forces or stresses are developed in the section above and below NA, which are in opposite in nature. This form a couple and the moment couple is known as MOMENT OF RESISTANCE	2	2	10
II	Part B			
1.	(Maximum marks : 30)			
		1		
	$R = \sqrt{P^2 + Q^2 + 2PQ\cos\emptyset}$	2		
	$R = \sqrt{70^2 + 80^2 + 2 \times 70 \times 80 \times \cos 90} = 106.3\,N$	1		

	$\tan\propto = \frac{Q\sin\emptyset}{P+Q\cos\emptyset}$	1		
	$= \frac{70\sin 90}{80+70\cos 90} = 0.875 = 41.18^0$	1	6	
2.	 	1 (fig)		
	$R_A + R_B = 22\ kN$	1		
	$4R_B = 4\,X\,1 + 10\,X\,2 + 8\,X\,3$	2		
	$R_B = 12\ kN$	1		
	$R_A = 10\ kN$	1	6	
3.	$A = 2500mm^2$ $E_s = 2.1X10^5\ N/mm^2$ $E_a = 7X10^4\ N/mm^2$ $dl = 0.25mm$			
	$dl = ds + da$	1		
	$dl = \frac{P_S l_s}{AE} + \frac{P_a l_a}{AE}$	2		
	$0.25 = \frac{P\times 300}{2500\times 2.1\times 10^5} + \frac{P\times 400}{2500\times 7\times 10^4}$	2		
	$P = 87500N$	1	6	
4.	RESILIENCE:- The total energy stored in a body OR The capacity of a strained body for doing work on the removal of the straining force.	2		
	PROOF RESILIENCE:- The maximum strain energy stored in a body	2		
	MODULUS OF RESILIENCE:- Proof resilience per unit volume	2	6	

5.	SF at A =3kN	1		
	SF at B = 3+2*3=9kN	1		
	BM at ~~A~~ B = 0	1		
	BM at ~~B~~ A = 3*3+2*3*3/2=18 kNm	1		
				
	 SFD	1 (fig)		
	 BMD	1 (fig)		
6.	$POWER\ ,P=\frac{2\pi NT}{60}$	1		
	$105\ \times 10^3=\frac{2\pi 160\,T}{60}$			
	$T=6266.73\ Nm$	1		
	$From\ shear\ stress\ consideration\ T=\frac{\pi f_s D^3}{16}$	1		

	$6266.73 \times 1000 = \frac{\pi\, 65\, D^3}{16}$	1		
	$D = 78.89\, mm$	1		
	From stiffness consideration, $\frac{T}{J} = \frac{C\theta}{L}$			
	$\frac{6266.73 \times 1000}{\frac{\pi D^4}{32}} = \frac{8 \times 10^4 \times \pi}{3.5 \times 1000 \times 180}$	1	6	
	$D = 112.5\, mm$			
7.	1. Material is homogeneous and isotropic. 2. Material is within elastic limit, Obeys Hooke's law. 3. The transverse section plane before bending remain plane after bending. 4. Each layer of the beam is free to expand or contract independently of the layer above or below it. 5. E is same in tension and compression.		6	30
	PART – C (Maximum marks : 60) (Answer one full question from each unit. Each full question carries 15 marks) UNIT-1			
III (a)		1 (fig)		
	~~**Error! Reference source not found.**~~ $R_A + R_B = 5 + 10 + 2\times5 = 25\,kN$	2		
	$5R_B = 5 * 2 + 10 * 4 + 2 * 5 * 2.5 = 75$	2		
	$R_B = 15\, kN$	1		
	$R_A = 10\, kN$	1	7	

(b)				
	$A_1 = 8 \times 2 = 16cm^2$	1		
	$A_2 = 10 \times 2 = 20cm^2$	1		
	$X_1 = 4cm$	1/2		
	$X_2 = 1cm$	1/2		
	$y_1 = 1cm$	1/2		
	$y_2 = 5 + 2 = 7cm$	1/2		
	CG about y-axis			
	$\bar{X} = \frac{A_1X_1 + A_2X_2}{A_1 + A_2}$	1		
	$\bar{X} = \frac{16\times4+20\times7}{16+20} = 2.33$	1		
	CG about x-axis			
	$\bar{Y} = \frac{A_1Y_1 + A_2Y_2}{A_1 + A_2}$	1		
	$\bar{Y} = \frac{8\times2\times1+10\times2\times7}{8\times2+10\times1} = 4.33cm$	1	8	
IV				
(a)	$\frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{R}{\sin\gamma}$	2		
	$\frac{15}{\sin 90} = \frac{T_1}{\sin 150} = \frac{T_2}{\sin 120}$	2		

	$T_1 = 7.5N$	1		
	$T_2 = 12.99N$	1	6	
	OR			
(b)				
	CG ABOUT X AXIS			
	$A_1 = 3\times10 = 30cm^2, Y_1 = 5cm$			
	$A_2 = 3\times12 = 36cm^2, Y_2 = 10+1.5 = 11.5cm$	1		
	$\overline{Y} = \dfrac{A_1Y_1 + A_2Y_2}{A_1 + A_2}$	1		
	$\overline{Y} = \dfrac{30\times5+36\times11.5}{30+36} = 8.55cm$	1		
	$I_{xx1} = \dfrac{b_1d_1^3}{12} + A_1h_1^2$	1		
	$I_{xx1} = \dfrac{3\times10^3}{12} + 10\times3\times3.55^2 = 628.07cm^4$	1		
	$I_{xx2} = \dfrac{b_2d_2^3}{12} + A_2h_2^2$	1		
		1		
	$I_{xx2} = \dfrac{12\times3^3}{12} + 12\times3\times2.95^2 = 340.29cm^4$	1		
	$I_{xx} = I_{xx1} + I_{xx2} = 628.07 + 340.29 = 968.36cm^4$	1	9	

	UNIT-II			
V	$P = 300kN, A_S = 5600mm^2, \dfrac{E_s}{E_c} = 15$			
(a)	$A = 250 \times 250 = 62500mm^2$	½		
	$A_c = 62500 - 5600 = 56900mm^2$	½		
	$\dfrac{P_c}{E_c} = \dfrac{P_s}{E_s}$	1		
		1		
	$P_s = \dfrac{P_c}{E_c} E_s = 15P_c$	1		
	$P = P_s A_S + P_c A_c$	1		
	$300000 = 5600 \times 15P_c + 56900P_c$	1		
	$P_c = 2.14N/mm^2$	1		
	$P_s = 15 \times 2.14 = 31.94N/mm^2$		7	
(b)	1. Strength :-capacity of materials to withstanding the breaking, bowing or deforming under the action of load.	1		
	2. Elasticity :-property of a material to come back to its original size and shape after removal of load.	1		
	3. Plasticity:-property of a material that makes it to be in the deformed size and shape even after the withdrawal of load.	1		
	4. Ductility:-property of a material that allows it to deform or make into thin wires under the action of tensile load.	1		
	5. Malleability:-property in which a thin sheet can be easily formed without breaking by hammering or rolling or pressing.			
	6. Stiffness:-it is the resistance of an elastic body to deflection or deformation by the applied load	1		
	7. Toughness:-ability of a material to absorb energy and plastic deformation without fracture. Or energy per unit volume that a material can be absorb before rupture.	1		
	8. Brittleness:-material subjected to stress, it breaks without significant			

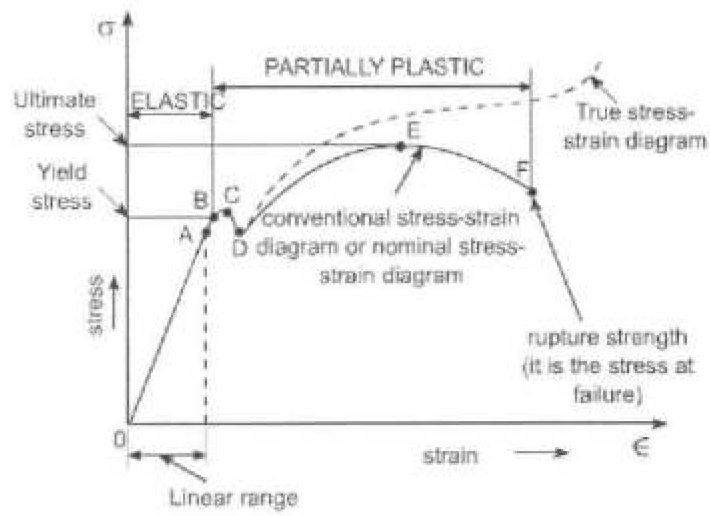
plastic deformation. It is the property of a material that fractures when subjected to stress but has a little tendency to deform before rupture. 1

9. Hardness:-the property of a material to resist pressing or scratch of a sharp object. 1 8

(any eight)

OR

VI (a)



2 (fig)

SALIENT POINTS OF THE GRAPH:

(A) So it is evident form the graph that the strain is proportional to strain or elongation is proportional to the load giving a st.line relationship. This law of proportionality is valid upto a point A. Or we can say that point A is some ultimate point when the linear nature of the graph ceases or there is a deviation from the linear nature. This point is known as **the limit of proportionality or the proportionality limit**. 1

(B) For a short period beyond the point A, the material may still be elastic in the sense that the deformations are completely recovered when the load is removed. The limiting point B is termed as **Elastic Limit** . 1

(C) and (D) - Beyond the elastic limit plastic deformation occurs and strains are not totally recoverable. There will be thus permanent deformation or permanent set when load is removed. These two points are termed as upper and lower yield 2

	points respectively. The stress at the yield point is called the yield strength.			
	(E) A further increase in the load will cause marked deformation in the whole volume of the metal. The maximum load which the specimen can with stand without failure is called the load at the ultimate strength.	1		
	The highest point 'E' of the diagram corresponds to the ultimate strength of a material.			
	(F) Beyond point E, the bar begins to forms neck. The load falling from the maximum until fracture occurs at F	1	8	
(b)	$l = 4m = 4000mm$			
	$b = 35mm$			
	$d = 20mm$			
	$P = 30kN = 30000N$			
	$\frac{1}{m} = 0.25$			
	$E = 200GPa = 200000N/mm^2$			
	$A = 35\times 20 = 700mm^2$			
	$dl = \frac{Pl}{AE} = \frac{30000\times 4000}{700\times 200000} = 0.857mm$	1		
	$linearstrain = \frac{\delta l}{l} = \frac{0.857}{4000} = 0.00021$	1		
	$lateralstrain = \frac{1}{m} linearstrain = 0.25\times 0.00021 = 0.000054$	1		
	$volume V = 4000\times 35\times 20 = 2800000$	1		
	$\frac{dv}{V} = \frac{P}{bdE}(1-\frac{2}{m}) = \frac{30000}{35\times 20\times 200000}(1-2\times 0.25)$	1		
	$= 1.07\times 10^{-4}$	1		
	$dv = 2800000\times 1.07\times 10^{-4} = 300mm^3$	1	7	
VII	1. Simply Supported Beam			
(a)	when the ends of a beam are formed to stand freely on supports beam, it is known as a simple (freely) supported beam. It contains pinned support at one end and roller support at the other end.			

2. Fixed Beam

If a beam is inflexible at both ends in order that the slope at the ends become zero, it is known as fixed beam. It is also called a built-in beam. The fixed ends produce fixing moments there other than the reactions.

3. Cantilever Beam

If a beam is fixed at one end whereas the other end is free, it is termed as cantilever beam.

4. Continuously Supported Beam

If a beam supports more than two supports are arranged to the beam, it is described as continuously supported beam.

5. overhanging beam

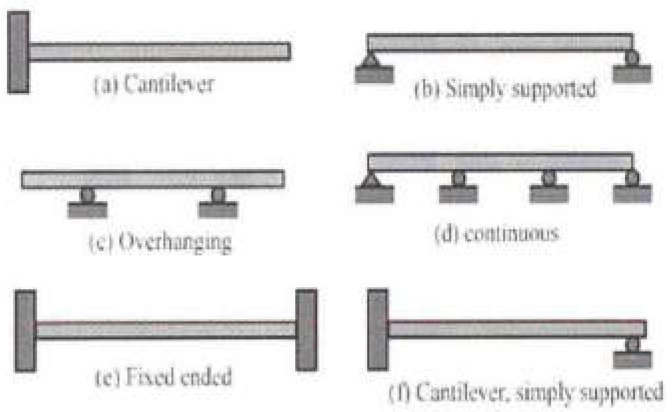
If the ends of the beams are project beyond the ends of the support.

6. Propped cantilever

One end of the beam is fixed and other end is simply supported.

OR

Types of Beams



Any five — 5x1 — 5

(b)

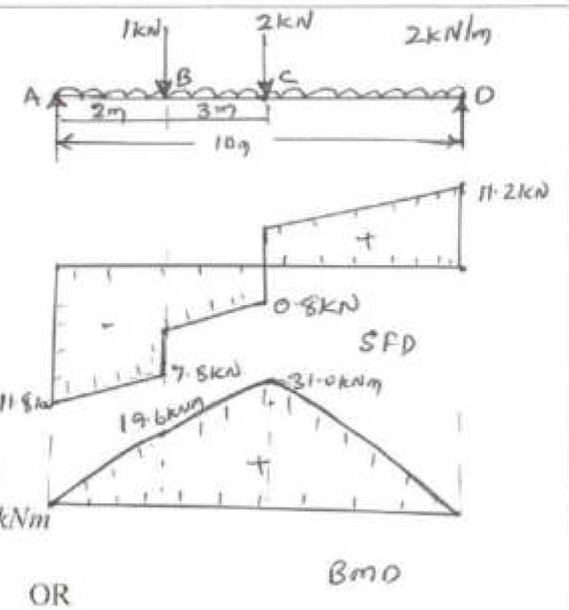
$$R_A + R_D = 1 + 2 + 2\times 10 = 23kN \quad 1$$

$$10R_D = 1\times 2 + 2\times 5 + 2\times 10\times 5 \quad 1$$

$$R_D = 11.2kN$$

$$R_A = 11.8kN \quad 1$$

	Shear force			
	$F_D = 11.2kN$	1		
	$F_C = 11.2 - 2\times5 - 2 = 0.8kN$	1		
	$F_B = 11.2 - 2\times8 - 2 - 1 = 7.8kN$	1		
	$F_A = 11.8kN$	1 (fig)		
	Bending moment	1 (fig)		
	$M_A = M_D = 0$			
	$M_C = 11.2\times5 - 2\times5\times2.5 = 31.0kNm$	1		
	$M_B = 11.2\times8 - 2\times8\times4 - 2\times3 = 19.6kNm$	1	10	
	OR			
VIII (a)	$d = 30cm, \theta = 1.5^o = 1.5\times\frac{\pi}{180} rad, L = 8m = 8000mm$			
	$f_s = 40N/mm^2, C = 8\times10^4 N/mm^2$			
	$J = \frac{\pi D^4}{32} = \frac{\pi 30^4}{32}$	1		
	$\frac{T}{J} = \frac{C\theta}{L}$	1		
	$\frac{T}{\frac{\pi 30^4}{32}} = \frac{8\times10^4\times\pi/180}{8\times1000}$	1		
		1		
	$T = 20818.69Nmm$	1		
	$T = \frac{\pi f_s D^3}{16} = \frac{\pi\times40\times30^3}{16} = 212057.5Nmm$	1		
	$\therefore Maximum \cdot torque T = 20818.69Nmm$	1	7	



(b)

$$d = 530 - 2\times 10 = 510mm$$

$$circumferential \cdots stress = \sigma_1 = \frac{pd}{2t} = \frac{10.5\times 510}{2\times 10} = 267.75N/mm^2$$ 1

$$Longitudinal \cdots stress = \sigma_2 = \frac{\sigma_1}{2} = 133.875N/mm^2$$ 1

$$circumferential \cdots strain = \varepsilon_1 = \frac{1}{E}(\sigma_1 - \frac{\sigma_2}{m})$$ 1

$$\varepsilon_1 = \frac{1}{2.1\times 10^5}(267.75 - 133.875\times 0.3) = 0.00108$$ 1

$$Increase.in.ex..dia = \varepsilon_1 \times D = 530\times 0.00108 = 0.5745mm$$ 1

$$longitudinal \cdots strain = \varepsilon_2 = \frac{1}{E}(\sigma_2 - \frac{\sigma_1}{m})$$ 1

$$\varepsilon_2 = \frac{1}{2.1\times 10^5}(133.875 - 267.75\times 0.3) = 0.000255$$ 1

$$Increase.in.length = \varepsilon_2 \times L = 1800\times 0.000255 = 0.459mm$$ 1 — 8

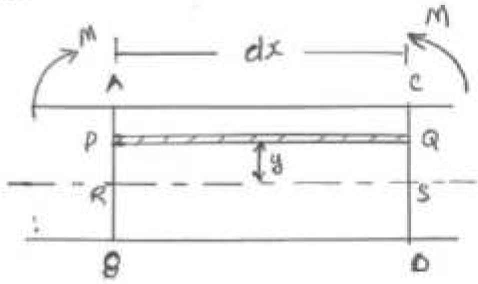
UNIT-IV

IX (a)

M=bending moment at the beam

Θ= angle subtended at the centre of the arc

R= radius of curvature of the beam

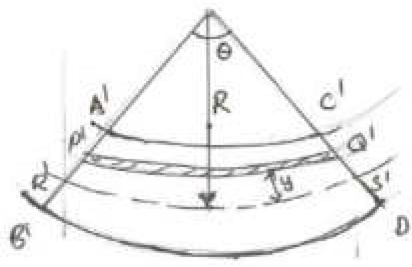


1 (fig)

$$\delta l = PQ - P^1Q^1$$

$$\text{Strain} = \varepsilon = \frac{\delta l}{l} = \frac{PQ - P^1Q^1}{PQ}$$

From geomerty $\frac{P^1Q^1}{R^1S^1} = \frac{R-y}{R}$



Bending of beam

$$1 - \frac{P^1Q^1}{R^1S^1} = 1 - \frac{R-y}{R}$$ 1

$$\frac{R^1S^1 - P^1Q^1}{R^1S^1} = \frac{y}{R}$$

$$\because R^1S^1 = PQ$$

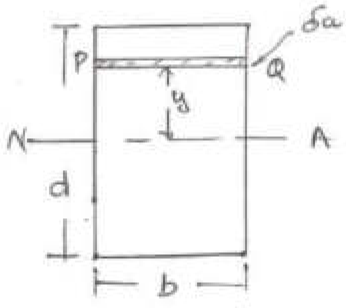
$$\frac{PQ - P^1Q^1}{PQ} = \frac{y}{R}$$

$\varepsilon = \frac{y}{R}$ 1

$\sigma = \varepsilon \times E$

$\sigma = \frac{y}{R} \times E$

$\therefore \frac{\sigma}{y} = \frac{E}{R}$ 1



Moment of Resistance

Let δa =area of layer PQ

Stress in layer PQ $\sigma = \frac{y}{R} \times E$

Force in layer PQ= $y \times \frac{E}{R} \delta a$ 1

Moment of these force about NA= $y^2 \times \frac{E}{R} \delta a$

Algebraic sum of all such moments about NA $M = \sum \frac{E}{R} y^2 \delta a = \frac{E}{R} \sum y^2 \delta a$ 1

$\sum y^2 \delta a$ represents the MI of whole section about NA

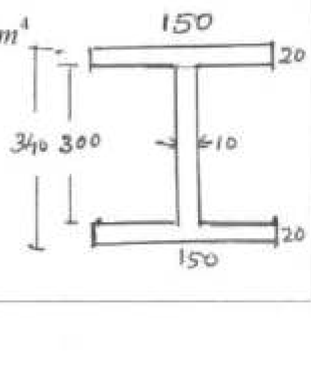
$M = \frac{E}{R} I$ 1

$\frac{M}{I} = \frac{E}{R}$ AND $\frac{\sigma}{y} = \frac{E}{R}$ 1 9

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

(b) $SF = 50kN = 50000N$

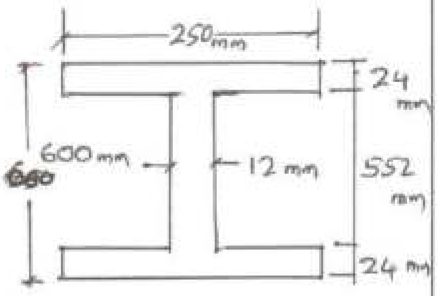
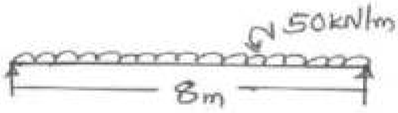
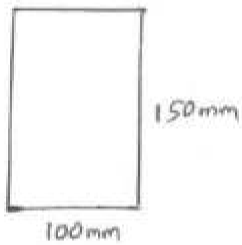
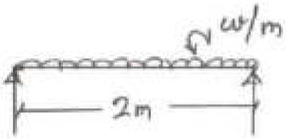
$I = \frac{B^3 D^3 - b^3 d}{12} = \frac{150 \times 340^3 - 140 \times 300^3}{12} = 176300000 mm^4$ 2



1-(fig)

$A\bar{y} = 150 \times 20 \times 160 + 150 \times 10 \times 75 = 592500$ 1

$q = \frac{FA\bar{y}}{Ib} = \frac{50000 \times 592500}{176300000 \times 10} = 16.8 N/mm^2$ 2 6

	OR			
X	$I_{xx}=\frac{BD^3-bd^3}{12}$	1		
(a)		1 (fig)		
	$I_{xx}=\frac{250\times600^3-238\times552^3}{12}=1164100mm^4$	1		
	$M=\frac{wl^2}{8}=\frac{50\times8^2}{8}=400kNm=400\times10^6$	1		
	$\frac{M}{I}=\frac{f}{y}$	1		
	$\frac{400\times10^6}{1164100}=\frac{f}{300}$ 	1	6	
	$f=103.08N/mm^2$			
	$f_s 28N/mm^2, \tau=2N/mm^2$			
(b)		1 (fig)		
	$I=\frac{bd^3}{12}=\frac{100\times150^3}{12}=28125000mm^4$	1		
	$M=\frac{wl^2}{8}=\frac{w\times10^6}{2}Nmm$	1		
	$\frac{M}{I}=\frac{f_s}{y}$	1		
	$\frac{\frac{w\times10^6}{2}}{28125000}=\frac{28}{75}$	1		
	$w=21kN/m$	1		
	$SF=\frac{wl}{2}=\frac{w2}{2}=wkN$ 			
	$A\bar{y}=100\times75\times\frac{75}{2}=281250$	1		
	$\tau=\frac{FA\bar{y}}{Ib}$	1		
	$2=\frac{w\times10^3\times281250}{28125000\times100}$	1	9	60
	$w=20kN/m$			
	$\therefore w=20kN/m$			