CLASS TEST

S.No.:01_JP_CE__02092024

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CIVIL ENGINEERING

SOM

Duration : 1:00 hr. **Maximum Marks : 50**

Read the following instructions carefully

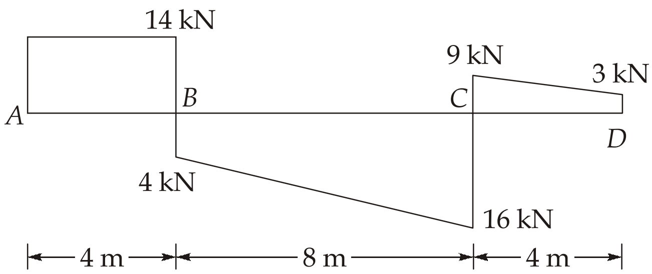
1. This question paper contains **30** objective questions. **Q.1-10** carry one mark each and **Q.11-30** carry two marks each.
2. Answer all the questions.
3. Questions must be answered on Objective Response Sheet (**ORS**) by darkening the appropriate bubble (marked **A**, **B**, **C**, **D**) using HB pencil against the question number. Each question has only one correct answer. In case you wish to change an answer, erase the old answer completely using a good soft eraser.
4. There will be **NEGATIVE** marking. For each wrong answer **1/3rd** of the full marks of the question will be deducted. More than one answer marked against a question will be deemed as an incorrect response and will be negatively marked.
5. Write your name & Roll No. at the specified locations on the right half of the **ORS**.
6. No charts or tables will be provided in the examination hall.
7. Choose the **Closest** numerical answer among the choices given.
8. If a candidate gives more than one answer, it will be treated as a **wrong answer** even if one of the given answers happens to be correct and there will be same penalty as above to that questions.
9. If a question is left blank, i.e., no answer is given by the candidate, there will be **no penalty** for that question.

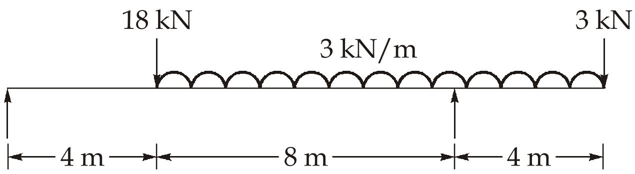
DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE ASKED TO DO SO

Q.No. 1 to Q.No. 10 carry 1 mark each

Q.1 In the Mohr's circle for strains, radius of Mohr's circle gives the
(a) Minimum value of normal strain
(b) Maximum value of normal strain
(c) Maximum value of shear strain
(d) Half of maximum value of shear strain

Q.2 For the shear force diagram shown in the figure, the loaded beam will be



(a)


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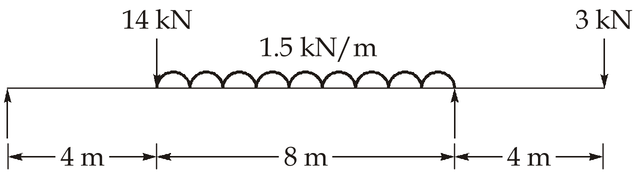

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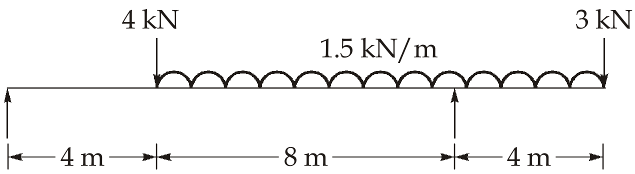

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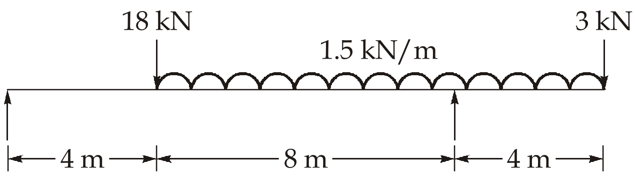


Q.3 The limit of proportionality of a certain steel specimen is 300 MPa in simple tension. It is subjected to principal tensile stresses of 150 MPa, 60 MPa and 30 MPa. According to maximum principal stress theory, the factor of safety in this case would be
(a) 10
(b) 5
(c) 4
(d) 2

Q.4 Determine the bulk modulus of a material for which Young's modulus is 1.2×10^5 N/mm^2 and modulus of rigidity is 4.8×10^4 N/mm^2.
(a) 80 kN/mm^2
(b) 0.8 N/mm^2
(c) 8×10^4 kN/mm^2
(d) 800 N/cm^2

Q.5 Which of the following statement is correct regarding assumption in Euler's column theory?
1. Initially the column is perfectly straight and load applied is truly axial.
2. The failure of column occurs due to buckling alone.
3. The length of column is small as compared to its cross-section dimensions.

(a) 1 and 2 (b) 2 and 3
(c) 1 and 3 (d) 1, 2 and 3

Q.6 Which of the given option is correct for crippling load by Rankine's formula?

(a) $P_R = \dfrac{P_{CS}}{1 + \dfrac{\sigma_{CS}}{E}\left(\dfrac{l_e}{k}\right)^2}$ (b) $P_R = \dfrac{\sigma_{CS}}{1 + \dfrac{P_{CS}}{E}\left(\dfrac{l_e}{k}\right)^2}$

(c) $P_R = \dfrac{P_{CS}}{1 + \dfrac{\sigma_{CS}}{\pi^2 E}\left(\dfrac{l_e}{k}\right)^2}$ (d) $P_R = \dfrac{\sigma_{CS}}{1 + \dfrac{P_{CS}}{A\pi^2 E}\left(\dfrac{l_e}{k}\right)}$

where P_R = Crippling load, P_{CS} = Crushing load, σ_{CS} = Crushing stress, l_e = Effective length of column, k = Radius of gyration

Q.7 A copper wire of 2 mm diameter is required to be wounded around a drum. What will be the minimum radius of drum, if the stress in the wire is not to exceed 80 MPa?
[Take modulus of elasticity for copper = 100 GPa]

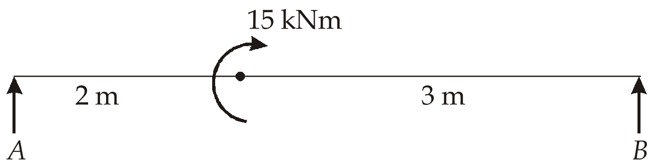
(a) 1.5 m (b) 3 m
(c) 1.25 m (d) 2.5 m

Q.8 When a body is subjected to the mutually perpendicular tensile stresses (σ_x and σ_y) then the center of the Mohr's circle from τ-axis is taken as

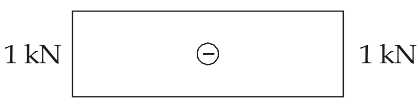
(a) $\dfrac{\sigma_x + \sigma_y}{2}$ (b) $\dfrac{\sigma_x - \sigma_y}{2}$

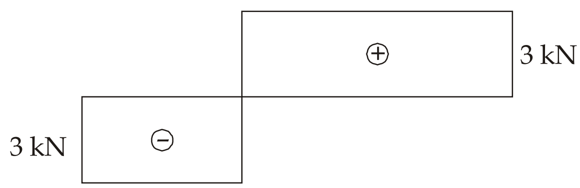
(c) $\dfrac{\sigma_x - \sigma_y}{2} + \tau_{xy}$ (d) $\dfrac{\sigma_x - \sigma_y}{2} - \tau_{xy}$

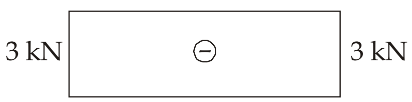
Q.9 A simply supported beam of 5 m span is subjected to a clockwise moment of 15 kN-m at a distance of 2 m from left end as shown in the figure.

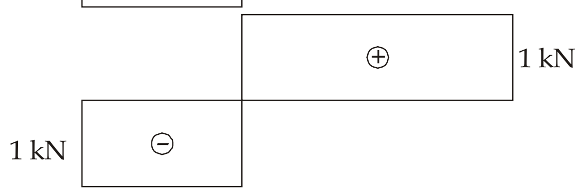


Which of the following options show correct SFD of beam AB?

(a) 

(b) 

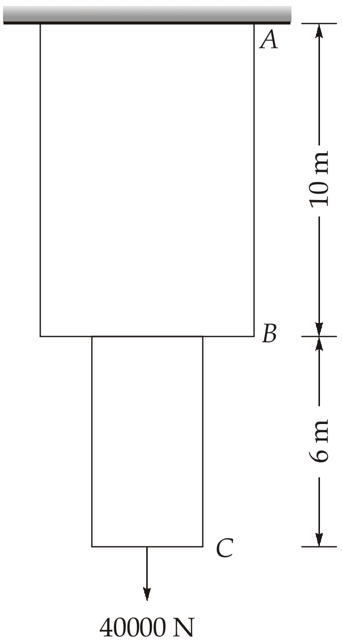
(c) 

(d) 

Q.10 In a cantilever beam of length 2 m, the shear force (in N) is given by $V(x) = 5x^2$, where x is the distance (in m) measured from fixed end. The magnitude of the load intensity at the mid-span of the beam is
(a) 0
(b) 1 N/m
(c) 5 N/m
(d) 10 N/m

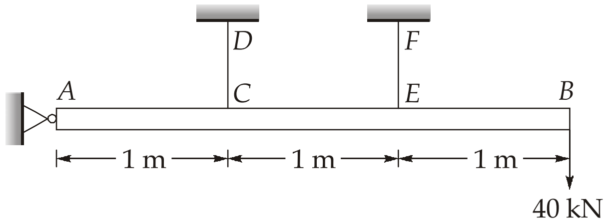
Q. No. 11 to Q. No. 30 carry 2 marks each

Q.11 Two prismatic bars are rigidly fastened together and support a vertical load of 40000 N as shown in figure. The upper bar is made of steel having specific weight 76000 N/m^3, length 10 m and cross-sectional area 60 cm^2. The lower bar is made of brass having specific weight 80000 N/m^3, length 6 m and cross-section area 50 cm^2. For steel E = 200 GPa and for brass E = 90 GPa. Determine the maximum stress in steel bar (in kN/cm^2).



(a) 0.78
(b) 0.31
(c) 0.46
(d) 0.96

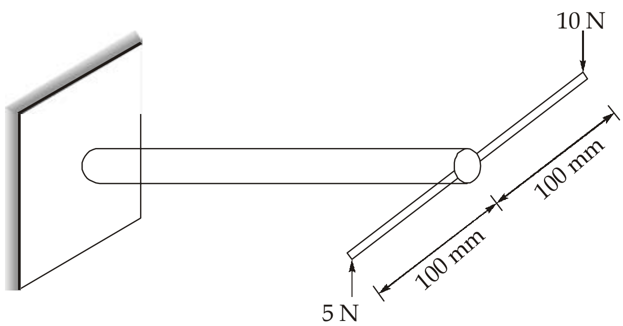
Q.12 A rigid weightless horizontal beam in supported by two identical steel bars *CD* and *EF* and a hinge at one end as shown in figure. Determine the load in the bars *CD* if a load of 40 kN is applied at end *B*.



(a) 24 kN
(b) 13.33 kN
(c) 48 kN
(d) 26.67 kN

Q.13 The normal stress on two perpendicular planes *A* and *B* are 60 MPa and 20 MPa respectively. The shear stress on these planes is 30 MPa. The plane having zero shear stress is inclined to plane *B* at
(a) 28.15° (Anticlockwise)
(b) 28.15° (Clockwise)
(c) 61.85° (Clockwise)
(d) 61.85° (Anticlockwise)

Q.14 Two vertical forces are applied at the free end of a cantilever bar of diameter 50 mm as shown in figure. Determine the maximum principal stress at the top fibre 200 mm away from the free end.



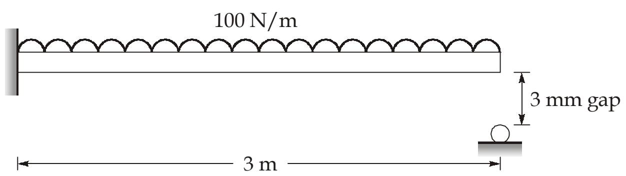
(a) 0.0815 N/mm^2
(b) 0.114 N/mm^2
(c) 0.0611 N/mm^2
(d) 0.047 N/mm^2

Q.15 A beam of square cross-section is used to carry a shear force under a certain system of loading with one side of the square kept vertical. The beam is now rotated to make one of its diagonal vertical under the same system of loading. The ratio of maximum shear intensity per unit width at neutral axis over the cross-section between the former and the latter beam is
(a) 0.58
(b) 1.33
(c) 1.89
(d) 2.67

Q.16 A compression member has one end hinged and other end rigidly fixed against rotation and sway. Its Euler's buckling load is 120 kN. What will be its critical buckling load if its both ends are fixed against sway and rotation.

(a) 60 kN
(b) 120 kN
(c) 240 kN
(d) $120\sqrt{2}$ kN

Q.17 A small gap of 3 mm exists between the beam and the roller support before application of the load as shown in figure. Determine the roller support reaction. Take $EI = 5 \times 10^{10}$ N-mm^2.



(a) 95.83 N
(b) 47.92 N
(c) 204.17 N
(d) 252.09 N

Q.18 A rectangular bar made of steel is 3 m long and 15 mm thick. The rod is subjected at an axial tensile load is 40 kN. The width of the rod varies from 80 mm at one end to 20 mm at the other. Find the extension of the rod if $E = 2 \times 10^5$ N/mm^2.

(a) 0.924 mm
(b) 0.468 mm
(c) 0.621 mm
(d) 0.729 mm

Q.19 Consider the following statements:

1. When a member is subjected to a direct stress (σ) in one plane, then the maximum shear stress acting on any plane is $\sigma/2$.
2. The planes of maximum and minimum normal stress are at an angle of 90° to each other.
3. Mohr's circle of stresses is a graphical method of finding normal, tangential and resultant stresses on an oblique plane.

Which of these statements are correct?

(a) 1, 2 and 3
(b) 1 and 2
(c) 1 and 3
(d) 2 and 3

Q.20 Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

List-I

A. Partial derivative of total strain energy with respect to load.
B. Derivative of deflection.
C. Derivative of slope.
D. Derivative of moment.

List-II

1. Expression for shear force.
2. Expression for slope.
3. Expression for bending moment.
4. Deflection under the load.

Codes:

	A	B	C	D
(a)	4	3	2	1
(b)	4	2	3	1
(c)	2	1	3	4
(d)	2	3	1	4

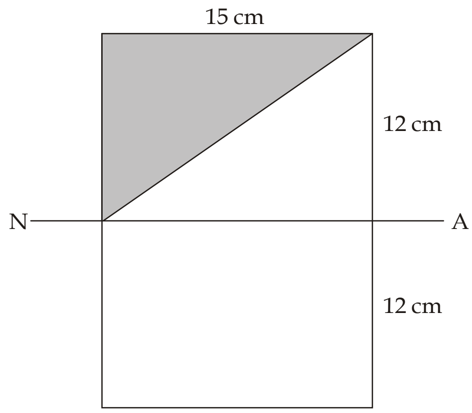
Q.21 A hollow steel shaft is having external and internal diameter as 80 mm and 60 mm respectively. Volume of shaft is 10^6 mm^3. What will be maximum strain energy stored in the shaft if maximum allowable shear stress is 80 MPa?
[Take shear modulus (G) = 100 GPa]

(a) 25 N-m
(b) 50 N-m
(c) 20 N-m
(d) 40 N-m

Q.22 A closely-coiled helical spring of round steel wire 5 mm in diameter having 12 complete coils of 50 mm mean diameter is subject to an axial load of 100 N. What will be deflection of the spring. [Take modulus of rigidity (G) = 80 GPa.]

(a) 192 mm
(b) 24 mm
(c) 42 mm
(d) 252 mm

Q.23 The beam section as shown in figure is subjected to a maximum bending stress of 90 kg/cm^2. What will be the force on the shaded area?

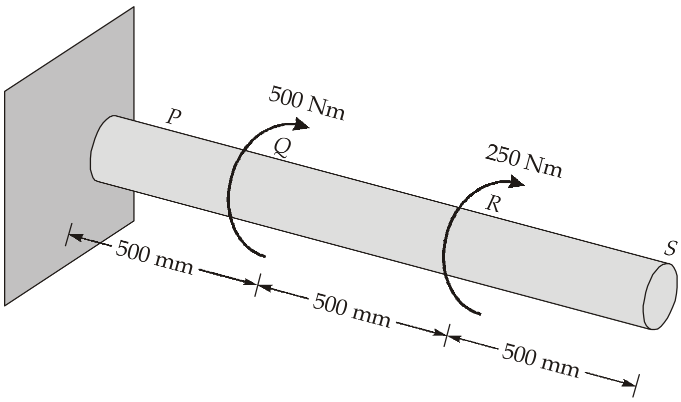


(a) 2700 kg
(b) 10800 kg
(c) 5400 kg
(d) 1350 kg

Q.24 A section of shaft of 100 mm diameter is subjected to combined bending and twisting moments of 8 kNm and 6 kNm respectively. What will be the maximum shear stress induced on the section?
(a) 50.93 MPa
(b) 30.56 MPa
(c) 40.74 MPa
(d) 60.36 MPa

Q.25 The state of plane strain at a point is $\varepsilon_x = 800 \times 10^{-6}$, $\varepsilon_y = 200 \times 10^{-6}$ and $y_{xy} = -600 \times 10^{-6}$. If material properties are E = 200 GPa and μ = 0.30, then the major principal stress is
(a) 308 MPa
(b) 208 MPa
(c) 104 MPa
(d) 154 MPa

Q.26 A solid circular steel shaft of 50 mm diameter, fixed at one end, is subjected to torques as shown below. The shearing modulus of the material is 80 GPa.

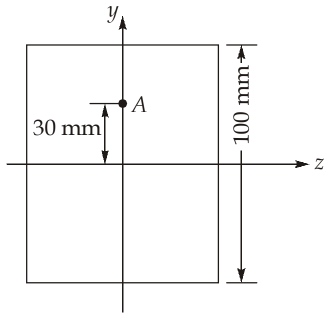


The rotation of the free end S due to torsion is
(a) 0.25°
(b) 0.58°
(c) 1.22°
(d) 1.25°

Q.27 An unspecified pure bending moment is used to bend an aluminium rod of radius 2.5 mm elastically into a circular ring of radius 2 m. If the same bending moment is used to bend elastically a copper rod of radius 2 mm, the radius of the resulting ring (in m) is ______. (Elastic modulus of aluminium is 70 GPa and elastic modulus of copper is 120 GPa).

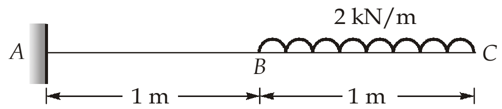
(a) 1.404 m
(b) 2.836 m
(c) 3.804 m
(d) 2.510 m

Q.28 A beam having a constant solid rectangular cross-section is subjected to pure bending. The longitudinal strain at a point A on the cross-section is 3.0×10^{-5}. If the Young's modulus of the material of the beam is 200 GPa, then the maximum tensile stress (in MPa) anywhere in the section is ______.



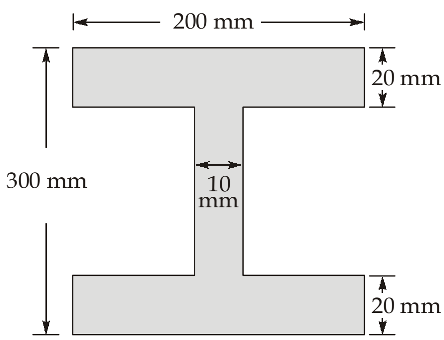
(a) 10 MPa
(b) 5 MPa
(c) 20 MPa
(d) 15 MPa

Q.29 A cantilever beam is loaded as shown in the figure below. What is the shape of bending moment diagram for portion AB?



(a) Parabolic
(b) Linearly varying with maximum bending moment at B
(c) Constant bending moment for A to B
(d) Linearly varying with maximum bending moment at A

Q.30 A beam of L meters span simply supported at end carries a central load W. The overall depth of beam section is 300 mm with horizontal flanges each of 200 mm × 20 mm and a web of 260 mm × 10 mm. If the maximum shear stress is limited to 45 N/mm^2 and maximum bending stress is limited to 150 N/mm^2, then the values of centrally applied load W and span L respectively are:



(a) 250.23 kN, 4.242 m
(b) 239.77 kN, 2.864 m
(c) 220.57 kN, 2.142 m
(d) 280.52 kN, 4.121 m

■■■■

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SOM

CIVIL ENGINEERING

Date of Test : 02/09/2024

ANSWER KEY

1.	(d)	7.	(c)	13.	(c)	19.	(a)	25.	(b)
2.	(d)	8.	(a)	14.	(b)	20.	(b)	26.	(b)
3.	(d)	9.	(c)	15.	(c)	21.	(a)	27.	(a)
4.	(a)	10.	(d)	16.	(c)	22.	(b)	28.	(a)
5.	(a)	11.	(a)	17.	(a)	23.	(c)	29.	(d)
6.	(c)	12.	(a)	18.	(a)	24.	(a)	30.	(b)

DETAILED EXPLANATIONS

1. (d)

Radius of Mohr's circle, $$R = \frac{\gamma_{max}}{2}$$

2. (d)

- Vertical drop at B shows point load on the loaded beam having magnitude equal to (14 + 4) = 18 kN.
- 1° shear force diagram between B and D represents. Uniformly distributed load. Whose magnitude is

$$\frac{(-4)-(-16)}{8} = \frac{12}{8} = 1.5 \text{ kN/m}$$

or

$$\frac{9-(+3)}{4} = \frac{6}{4} = 1.5 \text{ kN/m}$$

3. (d)

As per maximum principal stress theory

$$\sigma_{p_1} = \frac{\sigma_y}{FOS}$$

$$150 = \frac{300}{FOS}$$

$$\text{FOS} = 2$$

4. (a)

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

$$1.2 \times 10^5 = 2 \times 4.8 \times 10^4 (1+\mu)$$

$$\mu = 0.25$$

⇒ Now, Bulk modulus $$K = \frac{E}{3(1-2\mu)}$$

$$= \frac{1.2 \times 10^5}{3(1-0.25\times 2)}$$

$$= 8 \times 10^4 \text{ N/mm}^2 = 80 \text{ kN/mm}^2$$

5. (a)

The length of column is very large as compared to its cross-sectional dimensions.

6. (c)

As per Rankine theory:

$$\frac{1}{P_R} = \frac{1}{P_{CS}} + \frac{1}{P_E}$$

$$P_R = \frac{P_{CS} \times P_C}{P_{CS} + P_E} = \frac{P_{CS}}{1 + \frac{P_{CS}}{P_E}}$$

$\because$
$$P_{CS} = \sigma_{CS}A$$
$$P_E = \frac{\pi^2 EI}{Le^2}$$
$$P_R = \frac{P_{CS}}{1+\dfrac{\sigma_{CS}A}{\dfrac{\pi^2 EI}{Le^2}}} = \frac{P_{CS}}{1+\dfrac{\sigma_{CS}ALe^2}{\pi^2 EI}}$$

$\therefore$
$$k = \sqrt{\frac{I}{A}}$$

$\Rightarrow$
$$k^2 = \frac{I}{A}$$

Hence
$$P_R = \frac{P_{CS}}{1+\dfrac{\sigma_{CS}}{\pi^2 E}\left(\dfrac{Le}{k}\right)^2}$$

i.e., option (c) is correct.

7. (c)

$$d = 2 \text{ mm}$$
$$\sigma_{b(\max)} = 80 \text{ N/mm}^2$$
$$E = 100 \times 10^3 \text{ N/mm}^2$$

Distance between the neutral axis of wire and its extreme fibre

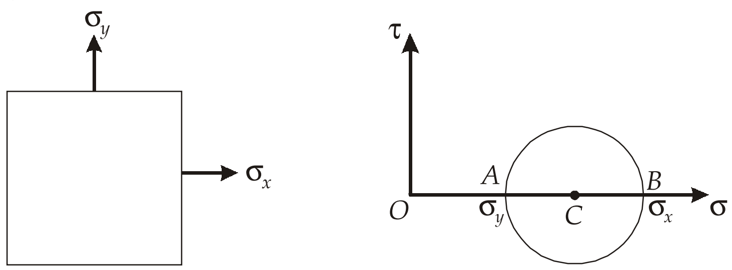
$$y = \frac{2}{2} = 1 \text{ mm}$$

So, minimum radius of the drum

$$R = \frac{y}{\sigma_{b(\max)}} E \qquad \left(\because \frac{f}{y} = \frac{E}{R}\right)$$
$$= \frac{1}{80} \times 100 \times 10^3$$
$$= 1.25 \times 10^3 \text{ mm} = 1.25 \text{ m}$$

8. (a)

Assuming ($\sigma_x > \sigma_y$)



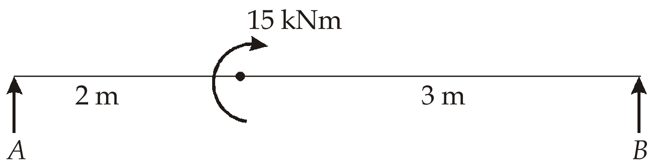
$$AB = \sigma_x - \sigma_y$$

$$AC = \frac{AB}{2} = \frac{\sigma_x - \sigma_y}{2}$$

$$\therefore \quad OC = OA + AC = \sigma_y + \frac{\sigma_x - \sigma_y}{2}$$

$$= \frac{\sigma_x + \sigma_y}{2}$$

9. (c)



$$R_A + R_B = 0$$

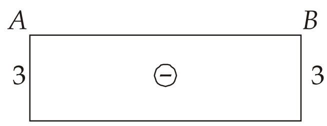
$$\Sigma M_A = 0$$

$$\Rightarrow \quad R_B \times 5 = 15$$

$$\Rightarrow \quad R_B = 3 \text{ kN}$$

$$R_A = -3 \text{ kN}$$

Now, SFD will be as shown in figure below,



10. (d)

As we know, $\frac{dV}{dx} = w$

$$\Rightarrow \quad w = \frac{d}{dx}\left(5x^2\right) = 10x$$

For midspan, $x = 1$ m

So, load intensity, $w = 10$ N/m

11. (a)

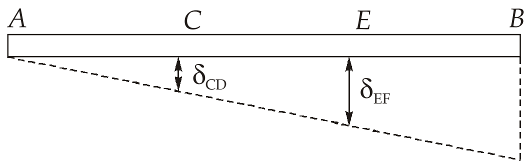
The maximum stress in the steel bar occurs at section A-A, the point of suspension because there the entire weight of steel and brass bar gives rise to normal stress whereas at any lower section only a portion of the weight and the steel would be effective in causing stress.

Weight of steel bar, $W_s = 10 \times \frac{60}{10^4} \times \frac{76000}{10^3} = 4.56$ kN

Weight of brass bar, $W_b = 6 \times \frac{50}{10^4} \times \frac{80000}{10^3} = 2.4$ kN

Stress across section A-A, $\sigma = \frac{40 + 4.56 + 2.4}{60} = 0.78$ kN/cm^2

12. (a)



From similarity of ΔS,

$$\frac{\delta_{CD}}{1} = \frac{\delta_{EF}}{2}$$

$$\delta_{EF} = 2\delta_{CD}$$

$$\frac{F_{EF} \times L}{A_{EF} \times E_s} = \frac{2 \times F_{CD} \times L}{A_{CD} \times E_s}$$

$\Rightarrow$
$$F_{EF} = 2F_{CD} \quad \text{...(i)}$$

$$\Sigma M_A = 0$$

$$F_{CD} \times 1 + F_{EF} \times 2 = 40 \times 3$$

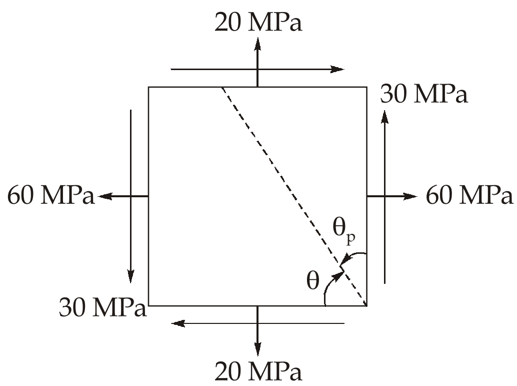
$$F_{CD} + 2 \times (2F_{CD}) = 120$$

$$5F_{CD} = 120$$

$$F_{CD} = 24 \text{ kN}$$

13. (c)

Plane having zero shear stress is called principal planes.



$$\tan 2\theta_p = \frac{2\tau_{xy}}{\sigma_x - \sigma_y}$$

$$\tan 2\theta_p = \frac{2 \times 30}{60 - 20}$$

$$\tan 2\theta_p = 1.5$$

$$2\theta_p = \tan^{-1}(1.5)$$

$$\theta_p = 28.15°$$

Required angle from plane B, $\theta = 90° - 28.15° = 61.85°$ (Clockwise)

14. (b)

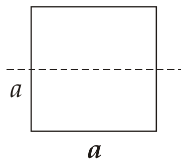
Normal stress, $$\sigma = \frac{32M}{\pi d^3} = \frac{32\times(5\times 200)}{\pi(50)^3} = 0.0815\ \text{N/mm}^2$$

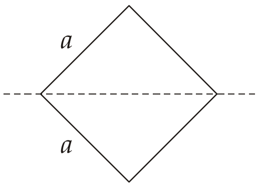
Shear stress, $$\tau_{xy} = \frac{16T}{\pi d^3} = \frac{16\times(15\times 100)}{\pi(50)^3} = 0.0611\ \text{N/mm}^2$$

$$\sigma_{p_1} = \frac{\sigma}{2} + \frac{1}{2}\sqrt{(\sigma)^2 + 4(\tau_{xy})^2}$$

$$= \frac{0.0815}{2} + \frac{1}{2}\sqrt{(0.0815)^2 + 4(0.0611)^2} = 0.114\ \text{N/mm}^2$$

15. (c)





$$\tau_{max_1} = \frac{3}{2}\tau_{avg} \qquad \tau_{max_2} = \frac{9}{8}\tau_{avg}$$

$$\tau_{max_1} = \frac{3}{2}\frac{F}{a^2} \qquad \tau_{max_2} = \frac{9}{8}\frac{F}{a^2}$$

$$\frac{\tau_{max_1}}{B_1} = \frac{\frac{3}{2}\frac{F}{a^2}}{a} = \frac{3}{2}\frac{F}{a^3} \qquad \frac{\tau_{max_2}}{B_2} = \frac{\frac{9}{8}\frac{F}{a^2}}{a\sqrt{2}} = \frac{9}{8\sqrt{2}}\frac{F}{a^3}$$

$$\therefore \quad \text{Ratio} = \frac{\frac{3}{2}}{\frac{9}{8\sqrt{2}}} = 1.89$$

16. (c)

When one end hinged and other end rigidly fixed against rotation and sway

$$P_{cr_1} = \frac{\pi^2 EI}{(L/\sqrt{2})^2}$$

$$120 = \frac{2\pi^2 EI}{L^2}$$

$$\frac{\pi^2 EI}{L^2} = 60 \qquad \text{...(i)}$$

When both ends are fixed against sway and rotation

$$P_{cr_2} = \frac{\pi^2 EI}{(L/2)^2}$$

$$P_{cr_2} = \frac{4\pi^2 EI}{L^2}$$

$$P_{cr_2} = 4 \times 60 = 240 \text{ kN}$$

17. (a)

Total deflection at free end, $\delta = \frac{wL^4}{8EI} = \frac{100(3)^4 \times 10^9}{8 \times 5 \times 10^{10}} = 20.25 \text{ mm}$

Reaction at roller support is produced due to the deflection resisted i.e., (20.25 – 3) mm = 17.25 mm

$$\Rightarrow \quad 17.25 = \frac{P \times (3)^3 \times 10^9}{3EI}$$

$$P = 95.83 \text{ N}$$

18. (a)

$$dL = \frac{PL}{Et(b-a)} \ln\left(\frac{b}{a}\right)$$

$$= \frac{40 \times 10^3 \times 3 \times 10^3}{2 \times 10^5 \times 15(80-20)} \ln\left(\frac{80}{20}\right)$$

$$= 0.924 \text{ mm}$$

19. (a)

20. (b)

21. (a)

Strain energy stored in hollow shaft, $U = \frac{\tau_{max}^2}{4G}\left[\frac{D^2 + d^2}{D^2}\right]V$

$$= \frac{80^2}{4 \times 100 \times 10^3}\left[\frac{80^2 + 60^2}{80^2}\right] \times 10^6$$

$$= \frac{10000 \times 10^6}{4 \times 10^5} = 2.5 \times 10^4 \text{ N-mm}$$

$$= 25 \text{ N-m}$$

22. (b)

We know deflection of spring,

$$\delta = \frac{64 WR^3 n}{Gd^4}$$

where, $W = 100$ N, $R = 25$ mm, $n = 12$, $G = 80$ GPa, $d = 5$ mm

So, $\delta = \frac{64 \times 100 \times (25)^3 \times 12}{80 \times 10^3 \times 5^4} = 24 \text{ mm}$

23. (c)

From bending equation, $$\frac{f}{y} = \frac{f_{max}}{y_{\max}}$$

$$\therefore \quad f = \frac{f_{max}}{y_{\max}} \times y$$

$$\therefore \quad \text{Force on shaded area} = \frac{f_{\max}}{y_{\max}} \times \Sigma Ay$$

$$= \frac{f_{max}}{y_{\max}}(A\bar{y})$$

[where A is shaded area, $\bar{y}$ = distance of centroid of shaded area from N.A.]

$$= \frac{90}{12} \times \left[\frac{15}{2} \times 12\right] \times \frac{2}{3} \times 12$$

$$= 5400 \text{ kg}$$

24. (a)

$$\tau_{\max} = \frac{16}{\pi D^3}\sqrt{M^2 + T^2}$$

$$= \left[\frac{16}{\pi(100)^3}\sqrt{(8)^2 + (6)^2}\right] \times 10^6$$

$$= \frac{16}{\pi} \times \frac{10 \times 10^6}{10^6} = 50.93 \text{ MPa}$$

25. (b)

Principal strains, $$\varepsilon_{1/2} = \frac{\varepsilon_x + \varepsilon_y}{2} \pm \sqrt{\left(\frac{\varepsilon_x - \varepsilon_y}{2}\right)^2 + \left(\frac{\gamma_{xy}}{2}\right)^2}$$

$$= \left[\frac{800 + 200}{2} \pm \sqrt{\left(\frac{800 - 200}{2}\right)^2 + \left(\frac{-600}{2}\right)^2}\right] \times 10^{-6}$$

$$\varepsilon_1 = 924.264 \times 10^{-6}$$

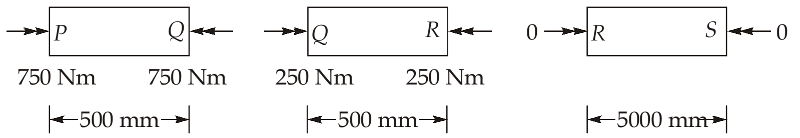
$$\varepsilon_2 = 75.74 \times 10^{-6}$$

Thus major principal stress is,

$$\sigma_1 = \frac{E}{1 - \mu^2}(\varepsilon_1 + \mu\varepsilon_2) = \frac{200 \times 10^3}{1 - 0.3^2}(924.264 + 0.3 \times 75.74) \times 10^{-6}$$

$$= 208.13 \text{ MPa} \simeq 208 \text{ MPa}$$

26. (b)



$$\text{Angle of twist } \phi = \frac{Tl}{GJ}$$

$$\phi_{PS} = \phi_{PQ} + \phi_{QR} + \phi_{RS}$$

$$= \frac{750 \times 10^3 \times 500}{80 \times 10^3 \times \frac{\pi}{32} \times 50^4} + \frac{250 \times 10^3 \times 500}{80 \times 10^3 \times \frac{\pi}{32} \times 50^4} + 0$$

$$= 10 \times 10^{-4} \times \frac{32}{\pi} \text{ rad}$$

$$= 0.58°$$

27. (a)

In pure bending case,

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

So, $$R = \frac{EI}{M}$$

When same M is applied,

$$\frac{R_1}{R_2} = \frac{(EI)_1}{(EI)_2}$$

$$\Rightarrow \quad \frac{2}{R_2} = \frac{70 \times \frac{\pi}{4} \times 2.5^4}{120 \times \frac{\pi}{4} \times 2^4}$$

$$\Rightarrow \quad R_2 = 1.404 \text{ m}$$

28. (a)

As it is given that, $$\varepsilon = \frac{\sigma}{E} = \frac{y}{R} = 3.0 \times 10^{-5}$$

So, $$\frac{1}{R} = \frac{3.0 \times 10^{-5}}{30} \text{mm}^{-1} = 10^{-6} \text{mm}^{-1}$$

Also, in pure bending, $$\frac{\sigma}{y} = \frac{M}{I} = \frac{E}{R} = \text{constant}$$

For σ_{max}, y_{max} has to be used

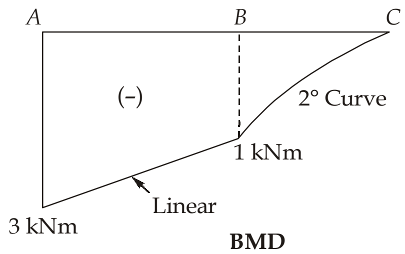
So, $\sigma_{max} = \frac{E}{R} y_{max} = \frac{200 \times 10^3}{R} \text{MPa} \times y_{max}$

$\Rightarrow \sigma_{max} = 200 \times 10^3 \times 10^{-6} \times 50$ MPa

$\Rightarrow \sigma_{max} = 10$ MPa

29. (d)

There is no load on portion AB, so shear force remains constant throughout AB. Therefore, the shape of BMD between AB will be linearly varying with maximum value at A.



BMD

30. (b)

$$I_{NA} = \frac{200 \times 300^3}{12} - \frac{190 \times 260^3}{12} = 1.717 \times 10^8 \text{ mm}^4$$

Let point load at midspan $= W$ N

$\therefore$ Maximum shear force $= \frac{W}{2}$ N

$\therefore \tau_{max} = \frac{Va\bar{y}}{Ib} = 45 \text{ N/mm}^2$

$a\bar{y}$ = Moment of area above NA portion about NA

$= (200 \times 20) \times (130 + 10) + 10 \times 130 \times 65$

$= 644500 \text{ mm}^3$

$\therefore \tau_{max} = \frac{W}{2} \times \frac{644500}{1.717 \times 10^8 \times 10} = 45$

$\Rightarrow W = 239.77$ kN

$$M_{max} = \frac{WL}{4}$$

$\because \sigma_{max} = \frac{M_{max}}{Z}$

$\Rightarrow 150 = \frac{WL}{4} \times \frac{y}{I}$

$\Rightarrow 150 = \frac{239.77 \times 10^3 \times L \times 10^3 \times 150}{4 \times 1.717 \times 10^8}$

$\Rightarrow L = 2.864$ m

■■■■