PRACTICE QUESTIONS

for SSC-JE : CBT-2

Strength of Materials

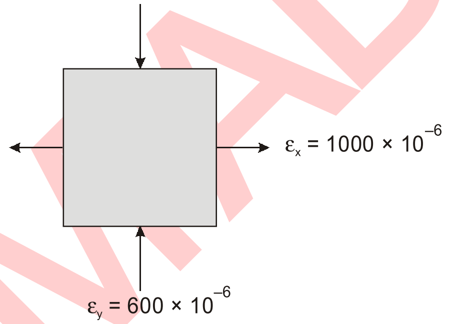
Mechanical Engineering

04 Strength of Materials

Q.1 The maximum principal strain in a thin cylindrical tank, having a radius of 25 cm and wall thickness of 5 mm when subjected to an internal pressure of 1 MPa is
[Take E = 200 GPa, μ = 0.02]
(a) 2.475×10^{-4} (b) 2475×10^{-5}
(c) 2475×10^{-6} (d) 2.475×10^{-7}

Q.2 A cantilever beam has a rectangular cross-section 1 m deep and 0.6 m thick. If the beam were to be 0.6 m deep and 1 m thick, then the beam would
(a) be weakened 0.5 times
(b) be weakened 0.6 times
(c) be strengthened 0.6 times
(d) have the same strength as the original beam as the area is same

Q.3 For the element shown below, the maximum shear strain is



(a) 400×10^{-6} (b) 800×10^{-6}
(c) 1000×10^{-6} (d) 1600×10^{-6}

Q.4 A cylindrical tank of 1.5 m diameter and 25 mm thick is subjected to a pressure of 12 N/mm^2. What is the circumferential stress induced in the tank?
(a) 78 N/mm^2 (b) 72 N/mm^2
(c) 36 N/mm^2 (d) 18 N/mm^2

Q.5 A composite rod is 1000 mm long. It is made of two members of cross-section areas 40 mm^2 and 30 mm^2 and lengths 400 mm × 600 mm, respectively. If the rod is subjected to an axial tensile load of 1000 N, what will be its total elongation? [Take E = 200 GPa]
(a) 0.130 mm (b) 0.197 mm
(c) 0.160 mm (d) 0.150 mm

Q.6 A circular shaft of diameter 30 mm is tested under torsion, the gauge length of test specimen is 300 mm. A torque of 2 kNm produces an angle of twist of 1°, then the torsional rigidity of the shaft is
(a) 0.432×10^6 N/mm^2
(b) 0.324×10^6 N/mm^2
(c) 0.460×10^6 N/mm^2
(d) 0.532×10^6 N/mm^2

Q.7 What will be the elastic modulus of a material for which the Poisson's ratio is 0.5?
(a) It will be equal to its shear modulus.
(b) It will be equal to its bulk modulus.
(c) It is four times its shear modulus.
(d) None of these

Q.8 Brittle fracture takes place without any appreciable deformation and by rapid crack propagation. The direction of the crack propagation is, nearly
(a) parallel to the direction of the applied tensile stress.
(b) perpendicular to the direction of the applied stress.
(c) at an angle of 45° to the direction of the applied tensile stress.
(d) None of the above.

Q.9 The effective length of a column of length fixed against rotation and translation at one end is

(a) 0.5 L (b) 0.717 L
(c) 1.414 L (d) 2 L

Q.10 Two bars of same material, one is circular cross-section and other is uniform tapering section, are hanged from their one end

1. Elongation due to self weight in cylinder is $\frac{\gamma L^2}{2E}$.
2. Elongation due to self weight in cone is $\frac{\gamma L^2}{6E}$.
3. If both bars have equal cross-sectional areas and have same weight, then they produce equal elongation respectively.

Which of the above statement(s) is/are correct?

(a) Only 1 (b) 1 and 2 only
(c) 2 and 3 only (d) All are correct

Q.11 A shaft subjected to torsion experiences a pause shear stress τ on surface. The maximum principal stress on the surface which is at 55° to the axis will have a value of

(a) $\tau \cos 55°$ (b) $\tau \sin 55°$
(c) $\tau \sin^2 55°$ (d) $2\tau \sin 55° \cos 55°$

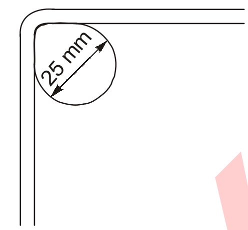
Q.12 A hollow circular shaft has an outer diameter of 100 mm and a wall thickness of 25 mm. The allowable shear stress in the shaft is 125 MPa. The maximum torque the shaft can transmit is.

(a) 11.5 kN-m (b) 24.5 kN-m
(c) 23 kN-m (d) 46 kN-m

Q.13 When a rectangular beam is loaded longitudinally, shear stress develops on

(a) Top fibre
(b) bottom fibre
(c) Middle fibre
(d) Every horizontal plane

Q.14 A 0.25 mm thick tape goes over a frictionless pulley of 25 mm diameter. If the E of material is 100 GPa, then the maximum stress induced in the tape is

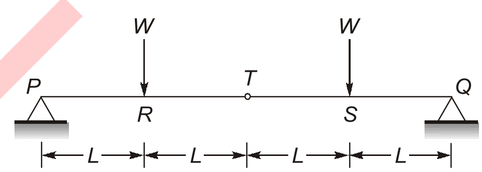


(a) 100 MPa (b) 1000 MPa
(c) 2000 MPa (d) 500 MPa

Q.15 What is the number of independent stress components in a body loaded under a general state of stress and a plane stress condition respectively in order to completely specify the state of stress at a point ?

(a) 9 and 4 (b) 6 and 4
(c) 9 and 3 (d) 6 and 3

Q.16 Consider a simply supported beam as shown below:



There is a hinge at point T. The portion of the beam which will be subjected to pure bending is/are

(a) PR (b) QS
(c) PR and QS (d) RS

Q.17 Consider the following statements regarding a simply supported beam subjected to a couple at its mid-span:

1. Bending moment will be zero at ends and maximum at centre.
2. Bending moment changes its sign at the mid span.
3. Shear force is zero over the entire length of the beam.

Which of the above statements are correct?

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

Q.18 The torque, which a shaft of 200 mm diameter can safely transmit, if shear stress is not to exceed 49 MPa, will be

(a) 51.33 kN-m (b) 77 kN-m
(c) 81.67 kN-m (d) 90 kN-m

Q.19 Consider the following statements regarding continuous beams:

1. A continuous beam is the one which has more than one span and more than two supports.
2. It is statically determinate beam.
3. The degree of indeterminacy depends on the number and type of supports.
4. Three moment theorem method can be used for analysis of a continuous beam.

Which of the above statements are correct?

(a) 1, 2 and 3 (b) 2, 3 and 4
(c) 1, 3 and 4 (d) 1, 2, 3 and 4

Q.20 The ratio of maximum shear stress to average shear stress for a circular cross-section will be

(a) 1 (b) $\frac{3}{2}$
(c) $\frac{4}{3}$ (d) $\frac{9}{8}$

Q.21 Consider the following statements regarding torsion:

1. In theory of torsion, shearing strains increases radially away from the longitudinal axis of the bar.
2. Plane transverse sections before loading remains plane after the torque applied.

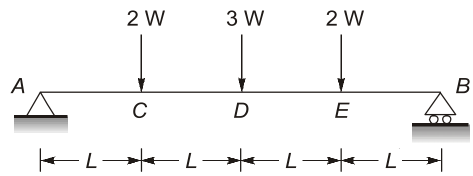
Which of the above statement(s) is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q.22 If the bulk modulus of a material is 500 GPa and Young's modulus of elasticity is 200 GPa then the modulus of rigidity of the material will be

(a) 52.15 GPa (b) 69.76 GPa
(c) 81.33 GPa (d) 105.67 GPa

Q.23 A simply supported beam is loaded as shown below:



Here, $W = 10$ N

The maximum shear force in beam will be

(a) 1.5 N (b) 3.5 N
(c) 15 N (d) 35 N

Q.24 The maximum shear stress in plane in a thin-walled cylindrical shell having an internal diameter, D and thickness, t, when subjected to an internal pressure, P, is equal to

(a) $\frac{PD}{t}$ (b) $\frac{PD}{2t}$
(c) $\frac{PD}{4t}$ (d) $\frac{PD}{8t}$

Q.25 Two shafts A and B are made of same material. The diameter of shaft A is one third to that of B. The ratio of power which can be transmitted by shaft A to that of shaft B, if the maximum shear stress is to be the same is

(a) $\frac{1}{3}$ (b) $\frac{1}{9}$
(c) $\frac{1}{27}$ (d) $\frac{1}{81}$

Q.26 In a cantilever beam, if the length is doubled and the concentrated load acting at the free end is halved, the deflection at the free end will increase by

(a) 2.66 times (b) 4 times
(c) 6 times (d) 8 times

Q.27 Consider the following statements regarding state of stress at a point:

1. When state of stress at a point is completely known then stress components on any arbitrary plane containing that point can be determined.

2. Sum of complimentary shear stress at a point is always equal to zero.
3. Mohr's construction is possible only for stress and strain.

Which of the above statements are correct?
(a) 1 and 2 (b) 2 and 3
(c) 1 and 3 (d) 1, 2 and 3

Q.28 Consider the following statements:
1. A beam subjected to end moments will be free from shearing forces.
2. The change in bending moment between two cross sections of a beam is equal to the area of the shear force diagram between the two sections.
3. The ratio of the area under the bending moment diagram to the flexural rigidity between any two points along a beam gives the change in deflection.

Which of the above statements are correct?
(a) 1 and 2 (b) 2 and 3
(c) 1 and 3 (d) 1, 2 and 3

Q.29 If bulk modulus of a material is two third of modulus of elasticity, then Poisson's ratio for the material will be
(a) 0.6 (b) 0.5
(c) 0.35 (d) 0.25

Q.30 The state of stress at a point is given by σ_x = 14 MPa, σ_y = –10 MPa and τ_{xy} = –9 MPa. The maximum tensile stress at the point is
(a) 27 MPa (b) 34 MPa
(c) 17 MPa (d) 11.22 MPa

■■■■

Answer Keys

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

Detailed Solutions

1. (a)

$$\epsilon_1 = \frac{pd}{2tE} - \frac{\mu pd}{4tE} = \frac{1\times 0.5(2-0.02)}{4\times 5\times 200}$$

$$\epsilon_1 = 2.475 \times 10^{-4}$$

2. (b)

$$\sigma_{max} = \frac{M\cdot y_{max}}{I} = \frac{M}{Z_{NA}}$$

$$\sigma_{max} \propto \frac{1}{Z_{NA}}$$

$$\frac{(\sigma_2)_{max}}{(\sigma_1)_{max}} = \frac{(Z_{NA})_1}{(Z_{NA})_2} = \frac{(1\times 0.6^2)/6}{(0.6\times 1^2)/6} = 0.6$$

3. (d)

$$\frac{\gamma_{max}}{2} = \sqrt{\left(\frac{\varepsilon_x - \varepsilon_y}{2}\right)^2 + \left(\frac{\gamma_{xy}}{2}\right)^2}$$

$$= \left(\frac{1000-(-600)}{2}\right)\times 10^{-6}$$

$$\Rightarrow \gamma_{max} = 1600 \times 10^{-6}$$

4. (c)

$$\text{Hoop stress} = \frac{pd}{2t} = \frac{1200\times 1.5}{2\times 25} = 36 \text{ N/mm}^2$$

5. (d)

$$\delta = \frac{PL}{AE} = \frac{P}{E}\left(\frac{L_1}{A_1} + \frac{L_2}{A_2}\right)$$

$$\delta = \frac{1000}{200 \times 10^{-3}}\left(\frac{400}{40 \times 10^{-3}} + \frac{600}{30 \times 10^{-3}}\right)$$

$\delta = 15 \times 10^{-4}$ m = 0.150 mm

6. (a)

$$\theta = 1° = \frac{\pi}{180} \text{ radians}$$

$$J = \frac{\pi}{32} \times 30^4 \text{ mm}^4$$

T = 2 kNm, l = 300 mm

$$\theta = \frac{TL}{GW}$$

$$G = \frac{TL}{\theta J} = \frac{2 \times 10^6 \times 300}{\frac{\pi}{180} \times \frac{\pi}{32} \times 30^4} = 0.4323 \times 10^6 \text{ N/mm}^2$$

7. (d)

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

Given that, $\mu = 0.5$

$$E = 3G$$

9. (d)

For a column with one end fixed and the other as free, the effective length is $2L$.

10. (d)

Since the weight of bar and cone is W and area A and same material having elasticity E,

elongation due to weight = $\dfrac{WL}{2AE}$

$$\Delta_{cylinder} = \Delta_{cone} = \frac{WL}{2AE}$$

11. (d)

$\sigma = \tau \sin(2 \times 55°) = 2\tau \sin 55° \cos 55°$

12. (c)

$$\frac{T}{J} = \frac{\tau_{max}}{R}$$

$$T = \tau_{max} \times \frac{J}{R} = 125 \times \frac{\pi}{32}\left(100^4 - 50^4\right) \times \frac{10^{-6}}{50}$$

= 23.0010 kN-m

13. (d)

14. (b)

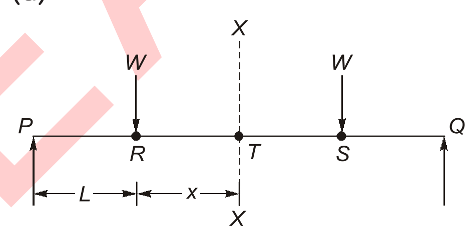
Bending formula $\dfrac{\sigma}{y} = \dfrac{E}{R} = \dfrac{M}{I}$

$$\sigma_{max} = \frac{Ey}{R} = \frac{100 \times 10^3 \times \frac{0.25}{2}}{\frac{25}{2}} = 1000 \text{ MPa}$$

15. (d)

The number of independent stress components in a body loaded under a general state of stress is 6 [σ_x, σ_y, σ_z, $\tau_{xy} = \tau_{yx}$, $\tau_{zx} = \tau_{zx}$ and $\tau_{yz} = \tau_{zy}$] and for plane stress condition is 3 [σ_x, σ_y and $\tau_{xy} = \tau_{yx}$]

16. (d)



$R_P = R_Q = W$ (Symmetrical loading)

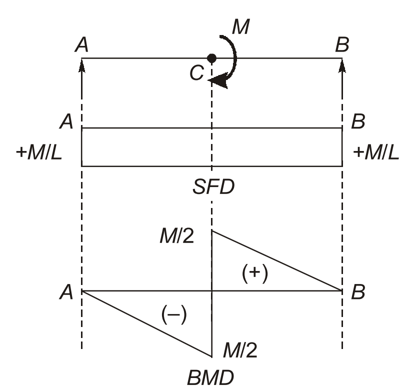
Taking moment at X-X section,

$$R_P \times (L + x) - W_x = M_{xx}$$

$M_{xx} = W(L + x) - W_x = WL$

$M_{xx} = WL$ (constant)

17. (a)



18. (b)

$$\text{Torque, } T = \frac{\pi}{16}\tau D^3 = \frac{22}{7}\times\frac{1}{16}\times 49\times 10^6\times 0.2^3$$

T = 77000 Nm = 77 kN-m

19. (d)

The methods which can be used for analysis of continuous beams are:

- Three moment theorem method.
- Method of consistent deformation.
- Slope deflection method.
- Moment distribution method.

20. (c)

For circular cross section,

$$\tau_{max} = \frac{4P}{3\pi R^2}$$

Average shear stress, $$\tau_{avg} = \frac{P}{\pi R^2}$$

$$\Rightarrow \quad \frac{\tau_{max}}{\tau_{avg}} = \frac{4}{3}$$

21. (c)

- In theory of pure torsion, the plane section before twisting remain plane after twisting, it means the radii which were straight before twisting remain straight after twisting.
- Shearing strains increase radially away from the longitudinal axis of the bar.

22. (b)

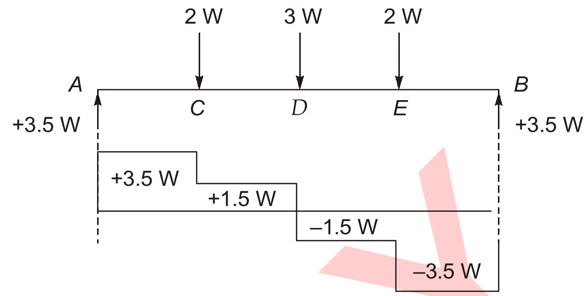
Since, $$\frac{9}{E} = \frac{1}{K}+\frac{3}{G}$$

$$\frac{9}{200\times 10^9} = \frac{1}{500\times 10^9}+\frac{3}{G}$$

$$\frac{3}{G} = \frac{0.043}{10^9}$$

G = 69.76 GPa

23. (d)



SFD

So, maximum shear force is 3.5 W = 35 N.

24. (d)

As for thin cylindrical shell,

$$\sigma_l = \frac{PD}{4t}$$

and, $$\sigma_h = \frac{PD}{2t}$$

$$\tau_{max} = \frac{\sigma_h - \sigma_l}{2} = \frac{PD}{8t}$$

25. (c)

$$\text{As power, } P = T\times\omega = \left(\frac{\pi}{16}d^3\right)\times\tau\times\omega$$

$$\Rightarrow \quad P \propto d^3$$

or, $$\frac{P_A}{P_B} = \frac{d_A^3}{d_B^3}$$

$$\frac{P_A}{P_B} = \frac{\left(\frac{1}{3}d_B\right)^3}{d_B^3}$$

$$P_A = \frac{1}{27}P_B$$

26. (b)

Deflection at free end is given by

$$\delta = \frac{WL^3}{3EI}$$

When, load is halved and length is doubled,

$$\delta = \frac{\frac{W}{2}(2L)^3}{3EI}$$

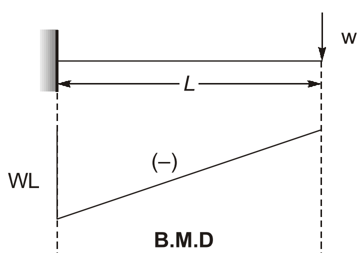
$$\delta = 4\frac{WL^3}{EI}$$

$$\delta' = 4\delta$$

27. (a)

Since Mohr's circle represents transformation of second order tensor, its construction is also possible for moment of inertia.

28. (a)



$$\text{Area of BMD} = \frac{1}{2}\times wL\times L = \frac{wL^2}{2}$$

$$\text{So,}\ \frac{\text{Area}}{\text{Flexural rigidity}} = \frac{\frac{wL^2}{2}}{EI} = \frac{wL^2}{2EI}\text{(slope)}$$

So, the ratio will not give deflection but slope.

29. (d)

Given: $K = \frac{2}{3}E$

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

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

$$0.5 = 1 - 2\mu$$

$$\mu = 0.25$$

30. (c)

$$\sigma_{max} = \sigma_1 = \frac{\sigma_x + \sigma_y}{2} + \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$= \frac{14-10}{2} + \sqrt{\left(\frac{14-(-10)}{2}\right)^2 + (-9)^2}$$

$$= 2 + \sqrt{12^2 + 9^2} = 17\ \text{MPa}$$

■■■■