POSTAL Book Package 2021

Mechanical Engineering

Objective Practice Sets

Strength of Materials

Contents

MADE EASY Publications

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CHAPTER

Torsion in Shafts

Q.1 The theory of pure torsion is based on the following assumptions:

1. The material of the shaft is uniform throughout.
2. The torque along the shaft may not be uniform.
3. All radii which are straight before twist remain straight after twist.
4. Cross-section of the shaft remains plane even after twisting.

Which of these statements is correct?

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

Q.2 The shear stress at a point in a shaft subjected to a torque is

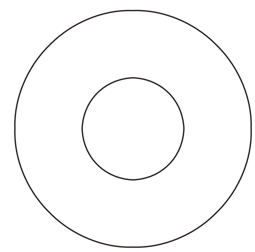
(a) directly proportional to the polar moment of inertia and to the distance of the point from the axis.
(b) directly proportion to the applied torque and inversely proportional to the polar moment of inertia.
(c) directly proportional to the applied torque and polar moment of inertia.
(d) inversely proportional to the applied torque and polar moment of inertia.

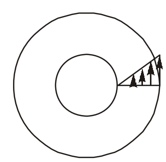
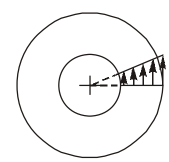
Q.3 **Statement (I):** In theory of torsion, shearing strains increase radially away from the longitudinal axis of the bar.

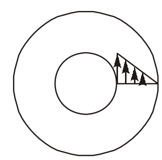
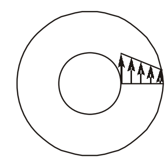
Statement (II): Plane transverse sections before loading remain plane after the torque is applied.

(a) Both Statement (I) and Statement (II) are individually true; and Statement (II) is the correct explanation of Statement (I)
(b) Both Statement (I) and Statement (II) are individually true; but Statement (II) is NOT the correct explanation of Statement (I)
(c) Statement (I) is true; but Statement (II) is false
(d) Statement (I) is false; but Statement (II) is true

Q.4 Shear stress distribution for the hollow shaft shown in the figure is:

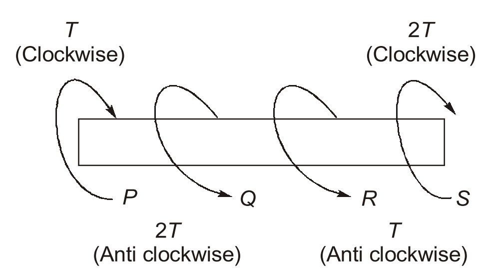


(a)  (b) 

(c)  (d) 

Q.5 A shaft *PQRS* is subjected to torques at *P*, *Q*, *R*, *S* as shown in the given figure.

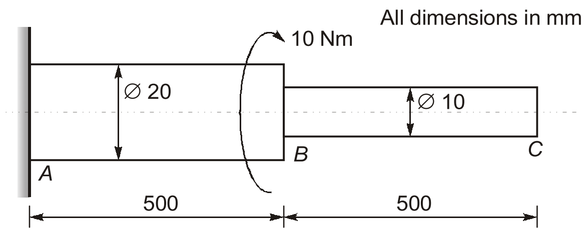
The maximum torque for the shaft section occurs between



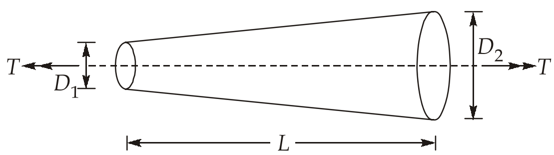
(a) *P* and *Q* (b) *P* and *R*
(c) *Q* and *R* (d) *R* and *S*

Q.6 When subjected to a torque, a circular shaft undergoes a twist of 1° in a length of 1200 mm, and the maximum shear stress induced is 80 N/mm^2. The modulus of rigidity of the material of the shaft is 0.8×10^5 N/mm^2. What is the radius of the shaft?

Q.24 Consider a stepped shaft subjected to a twisting moment applied at *B* as shown in the figure. Assume shear modulus, $G = 77$ GPa. The angle of twist at *C* (in degree) is ________.



Q.25 A tapered solid circular shaft of length *L* with its diameter varying from D_1 at one end to D_2 at the other end is as shown in figure below.



The shaft is subjected to a torque *T* which is constant throughout its length. What will be the value of angle of twist over the entire length? [The shear modulus of the material is *G*]

(a) $\dfrac{16TL}{3\pi G}\times\left(\dfrac{D_2^2+D_1^2+D_1D_2}{D_1^3\times D_2^3}\right)$

(b) $\dfrac{32TL}{5\pi G}\times\left(\dfrac{D_2^2+D_1^2+D_1D_2}{D_1^3\times D_2^3}\right)$

(c) $\dfrac{24TL}{5\pi G}\times\left(\dfrac{D_2^2+D_1^2+D_1D_2}{D_1^3\times D_2^3}\right)$

(d) $\dfrac{32TL}{3\pi G}\times\left(\dfrac{D_2^2+D_1^2+D_1D_2}{D_1^3\times D_2^3}\right)$

Q.26 A circular section rod *ABC* is fixed at ends *A* and *C*. It is subjected to torque *T* at *B*. *AB* = *BC*= *L* and the polar moment of inertia of portions *AB* and *BC* are 2*J* and *J* respectively. If *G* is the modulus of rigidity, what is the angle of twist at point *B*?

(a) $\dfrac{TL}{3GJ}$ (b) $\dfrac{TL}{2GJ}$

(c) $\dfrac{TL}{GJ}$ (d) $\dfrac{2TL}{GJ}$

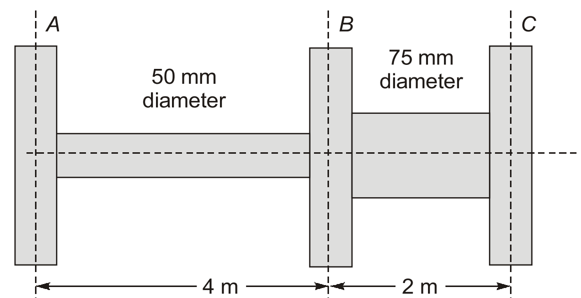
Q.27 A solid aluminium shaft 1 m long and of 50 mm diameter is to be replaced by a hollow shaft of steel of the same length and same outside diameter, so that the hollow shaft would carry the same torque and has same angle of twist. The inner diameter of hollow shaft is
[Take modulus of rigidity of aluminium as 28 GPa and that for steel as 85 GPa]

(a) 37.50 mm (b) 51.45 mm

(c) 45.25 mm (d) 58.15 mm

Q.28 A solid shaft of 200 mm diameter has the same cross – sectional area as that of a hollow shaft of the same material with inside diameter of 150 mm. The ratio of power transmitted by the hollow shaft to that of solid shaft at same speed is__________.

Q.29 The shaft as shown in figure below rotates at 200 r.p.m with 30 kW and 15 kW taken off at *A* and *B* respectively and 45 kW applied at *C*. The maximum shear stress developed in the shaft is ______ N/mm^2.



Q.30 There are two shaft of same weight and material, first one of solid circular section and second of hollow circular cross-section with a ratio of internal and external diameters of (2/3). The ratio of maximum torque carried by hollow shaft to solid shaft will be

(a) 2.85 (b) 0.75

(c) 1.94 (d) 4.60

Q.31 In a solid circular bar of diameter '*D*', a concentric hole is made of diameter $\dfrac{D}{3}$. The ratio of the torque carried by the hollow bar to that of solid bar in order to develop the same magnitude of maximum shearing stress will be

(a) $\dfrac{26}{27}$ (b) $\dfrac{81}{80}$

(c) $\dfrac{27}{26}$ (d) $\dfrac{80}{81}$

Q.47 **Statement (I):** A hollow circular shaft has more power transmitting capacity than a solid shaft of same material and same weight per unit length.
Statement (II): In a circular shaft, shear stress developed at a point due to torsion is proportional to its radial distance from the centre of the shaft.

Q.48 **Statement (I):** Hollow shafts are preferred in propeller shafts of airplanes.
Statement (II): Use of hollow shafts affords considerable reduction in the weight of the shaft for equal performance.

Q.49 **Statement (I):** Cast iron shaft subjected to torque fails with helicoidal surface at 45° to the axis of shaft.
Statement (II): Cast iron is Brittle in nature and Brittle specimen are week in tension.

Q.50 As per the maximum principal stress theory, when a shaft is subjected to a bending moment M and torque T. And σ is the allowable stress in axial tension, then the diameter d of the shaft is given by

(a) $d^3 = \dfrac{16}{\pi\sigma}\left[M + \sqrt{M^2 + T^2}\right]$

(b) $d^3 = \dfrac{4}{\pi\sigma}\left[M + \sqrt{M^2 + T^2}\right]$

(c) $d^3 = \dfrac{32}{\pi\sigma}\left[M + \sqrt{M^2 + T^2}\right]$

(d) $d^3 = \dfrac{8}{\pi\sigma}\left[M + \sqrt{M^2 + T^2}\right]$

Q.51 If a circular shaft is subjected to a torque T and a bending moment M, the ratio of the maximum shear stress to the maximum bending stress is given by

(a) $\dfrac{2M}{T}$ (b) $\dfrac{T}{2M}$

(c) $\dfrac{2T}{M}$ (d) $\dfrac{M}{2T}$

Q.52 A section of a solid circular shaft with diameter D is subjected to bending moment M and torque T. The expression for maximum principal stress at the section is

(a) $\dfrac{2M + T}{\pi D^3}$

(b) $\dfrac{16\pi}{D^3}\left(M + \sqrt{M^2 + T^2}\right)$

(c) $\dfrac{16\pi}{D^3}\left(\sqrt{M^2 + T^2}\right)$

(d) $\dfrac{16}{\pi D^3}\left(M + \sqrt{M^2 + T^2}\right)$

Q.53 A hollow shaft whose internal diameter is half the external diameter is subjected to bending and twisting moments of 54.0 kNm and 72.0 kNm, respectively. For the maximum shear stress to not exceed 96 MPa, the outer diameter of the shaft will be
(a) 172 mm (b) 205 mm
(c) 156 mm (d) 196 mm

Q.54 If a circular shaft is subjected to an axial twisting moment T and a bending moment M such that M = 1.2T. What will be the ratio of maximum shearing moment to the maximum principal stress?
(a) 1.2 (b) 0.566
(c) 0.822 (d) 1.0954

■■■■

Answers **Torsion in Shafts**

1. (c)	2. (b)	3. (b)	4. (b)	5. (d)	6. (d)	7. (c)	8. (c)	9. (d)	10. (d)
11. (b)	12. 0.8726		13. 35.343		14. 44.5212		15. (b)	16. (b)	17. (d)
18. (d)	19. (b)	20. (b)	21. (c)	22. (b)	23. (b)	24. 0.2368.		25. (d)	26. (a)
27. (c)	28. 1.7	29. 58.36		30. (c)	31. (d)	32. (d)	33. (a)	34. 0.22	35. 9
36. (a)	37. (c)	38. (a)	39. (a)	40. (a)	41. (a)	42. (a)	43. (b)	44. (d)	45. (c)
46. (c)	47. (b)	48. (a)	49. (a)	50. (a)	51. (b)	52. (d)	53. (a)	54. (c)	

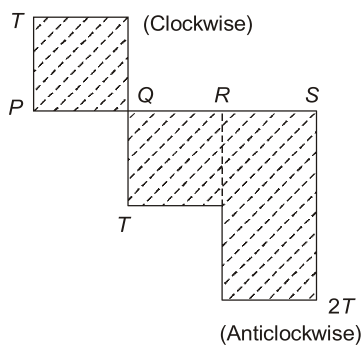
Explanations Torsion in Shafts

2. (b)

$$\frac{T}{J} = \frac{\tau}{R}$$

$$\tau = \frac{TR}{J}$$

5. (d)



Torsion Diagram

Section	Torque
PQ	*T* (clockwise)
QR	*T* (anticlockwise)
RS	2*T* (anticlockwise)

6. (d)

Using torsion formula,

$$\frac{\tau}{r} = \frac{G\theta}{L}$$

$$\Rightarrow \quad \tau = \tau \times \frac{L}{G\theta}$$

$$= \frac{80 \times 1200}{0.8 \times 10^5 \times 1} \times \frac{180}{\pi}$$

$$\Rightarrow \quad r = \frac{216}{\pi}$$

7. (c)

$$P = \frac{2\pi N}{60} \cdot T$$

$$= 20 \times 10^3 \times 150 \times \frac{2\pi}{60}$$

$$= 100\ \pi \text{ kW}$$

8. (c)

$$P = \frac{2\pi NT}{60}$$

$$\therefore \quad \frac{P_A}{P_B} = \frac{N_A}{N_B} \times \frac{T_A}{T_B} = 1.0$$

9. (d)

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

$$\therefore \quad \frac{\theta_1}{\theta_2} = \frac{J_2}{J_1} = \left(\frac{d_2}{d_1}\right)^4 = \frac{1}{16}$$

10. (d)

From torsional formula, we have

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

$$\Rightarrow \quad \frac{\tau_{max}}{D/2} = \frac{T}{\frac{\pi}{32} \times D^4}$$

$$\Rightarrow \quad \tau_{max} = \frac{16\,T}{\pi D^3} \qquad [\because \tau_{max} = f_s]$$

$$\Rightarrow \quad D^3 = \frac{16\,T}{\pi f_s}$$

$$\Rightarrow \quad D = \sqrt[3]{\frac{16\,T}{\pi f_s}}$$

11. (b)

$$D_0 = 16 \text{ mm}, \quad \frac{\tau}{r} = \frac{T}{J}$$

$$D_i = 12 \text{ mm}$$

$$T = 40 \text{ N-m}$$

$$\Rightarrow \quad \tau = \frac{T \times r}{J}$$

$$J = \frac{\pi(16^4 - 12^4)}{32}$$

$$\Rightarrow \quad \tau_0 = \frac{40 \times 10^3 \times \frac{16}{2}}{\pi \times \frac{(16^4 - 12^4)}{32}} = 72.75 \text{ N/mm}^2$$

$$\tau_i = \frac{72.7}{\left(\frac{16}{2}\right)} \times \left(\frac{12}{2}\right) = 54.54 \text{ N/mm}^2$$

12. (0.8726)