12. For elastic materials, the ratio of lateral strain to longitudinal strain is constant and is known as *Poisson ratio* (ν).
13. Volumetric strain is the ratio of increase in volume of a body to its original volume when it is acted upon by three mutually perpendicular stresses.
14. Volumetric strain $= \dfrac{(\sigma_1+\sigma_2+\sigma_3)(1-2\nu)}{E} \approx \varepsilon_1+\varepsilon_2+\varepsilon_3.$
15. Factor of safety $= \dfrac{\text{ultimate load}}{\text{allowable load}}$ or $\dfrac{\text{ultimate stress}}{\text{allowable stress}}$
16. Relation between various elasticity constants of a material is
$$E = 2G(1+\nu) = 3K(1-2\nu)$$

Objective Type Questions

1. A material with identical properties in all directions is known as
   (a) homogeneous (b) isotropic (c) elastic (d) none of these
2. The units of stress in the SI system are
   (a) kg/m^2 (b) N/mm^2 (c) MPa (d) any one of these
3. In a lap-riveted joint, the rivets are mainly subjected to _____ stress.
   (a) shear (b) tensile (c) bending (d) compressive
4. The resistance to deformation of a body per unit area is known as
   (a) stress (b) strain
   (c) modulus of elasticity (d) modulus of rigidity
5. Stress developed due to external force in an elastic material
   (a) depends on elastic constants (b) does not depend on elastic constants
   (c) depends partially on elastic constants
6. Strain is defined as deformation per unit
   (a) area (b) length (c) load (c) volume
7. Units of strain are
   (a) mm/m (b) mm/mm (c) m/mm (d) no units
8. Hooke's law is valid up to the
   (a) elastic limit (b) yield point
   (c) limit of proportionality (d) ultimate point
9. The ratio of linear stress to linear strain is known as
   (a) bulk modulus (b) modulus of rigidity
   (c) Young's modulus (d) modulus of elasticity
10. The units of modulus of elasticity are the same as of
    (a) stress (b) modulus of rigidity (c) pressure (d) any one of these
11. The change in length due to a tensile force on body is given by
    (a) PL/AE (b) PLA/E (c) PLE/A (d) AE/PL
12. Approximate Value of Young's modulus for mild steel is
    (a) 100 GPa (b) 205 MPa (c) 205 GPa (d) 100 MPa
13. 1MPa is equal to
    (a) $1N/m^2$ (b) $1N/mm^2$ (c) $1kN/m^2$ (d) $1kN/mm^2$

14. Deformation of a bar under its own weight is ...... the deformation due to a direct load equal to the weight of the body applied at the lower end.
(a) double (b) four times (c) half (d) equal to
15. Elongation of a conical bar under its own weight is ......that of a rectangular section of the same length.
(a) two-third (b) one-third (c) half (d) equal to
16. If a bar of length L m extends by l mm under load W, the strain is
(a) $1000\ l/L$ (b) l/L (c) $0.001l/L$ (d) none of these
17. Four wires of same material are applied the same load. In which of the following cases, the elongation will be maximum (length, diameter)?
(a) 2 m, 1 mm (b) 4 m, 2 mm (c) 8 m, 4 mm (d) 12 m, 6 mm
18. If $E_s = 3E_a$, the stress in steel of a composite bar made of aluminium and steel strips each having a cross-sectional area of 300 mm^2 and subjected to an axial load of 12 kN is
(a) 10 MPa (b) 20 MPa (c) 30 MPa (d) 40 MPa
19. The ratio of modulus of rigidity to modulus of elasticity for most of the materials is
(a) 0.5 (b) > 0.5 (c) < 0.5 (d) > 1
20. Temperature stress is a function of
(a) modulus of elasticity (b) coefficient of linear expansion
(c) change in temperature (d) all of these
21. Factor of safety is defined as ratio of
(a) ultimate stress to allowable stress (b) ultimate stress to yield stress
(c) allowable stress to ultimate stress (d) allowable stress to yield stress
22. The modulus of rigidity in terms of modulus of elasticity is given by

(a) $\dfrac{E}{2(1-\nu)}$ (b) $\dfrac{E}{2(1+\nu)}$ (c) $\dfrac{2E}{(1-\nu)}$ (d) $\dfrac{2E}{(1+\nu)}$

23. The modulus of elasticity in terms of bulk modulus is given by
(a) $3K/(1+2\nu)$ (b) $3K(1+2\nu)$ (c) $3K/(1-2\nu)$ (d) $3K(1-2\nu)$
24. The ratio of Young's modulus and bulk modulus is given by
(a) $3/(1+2\nu)$ (b) $3(1-2\nu)$ (c) $3(1-\nu)$ (d) none of these
25. The modulus of elasticity in terms of bulk modulus and modulus of rigidity is

(a) $\dfrac{9KG}{3K+G}$ (b) $\dfrac{9KG}{K+3G}$ (c) $\dfrac{3K+G}{9KG}$ (d) $\dfrac{K+3G}{9KG}$

26. The bulk modulus of a material having $E = 200$ GPa and $G = 80$ GPa is
(a) 233.3 GPa (b) 133.3 GPa (c) 250 GPa (d) 160 GPa
27. For a Poisson's ratio 0.4 for a material, the ratio of the shear modulus of elasticity to modulus of elasticity is
(a) 14/5 (b) 5/7 (c) 7/5 (d) 5/14
28. The ratio of lateral strain to linear strain is known as
(a) modulus of rigidity (b) elastic limit
(c) Poisson's ratio (d) modulus of elasticity
29. The stress at which elongation of a material is quite large as compared to the increase in load is known as
(a) ultimate point (b) yield point (c) elastic limit (d) rupture point

30. The limit up to which the stress is linearly proportional to strain is ______ limit.
(a) elastic (b) plastic (c) ultimate (d) rupture

31. Poisson's ratio ν is defined as ratio of
(a) axial strain to transverse strain (b) transverse strain to axial strain
(c) shear strain to axial strain (d) axial strain to shear strain

Answers

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

Summary

1. Stresses on an inclined plane of system with direct and shear stresses are

$$\sigma_\theta = \sigma_x \cos^2\theta + \sigma_y \sin^2\theta + \tau \sin 2\theta$$

$$= \frac{1}{2}(\sigma_x + \sigma_y) + \frac{1}{2}(\sigma_x - \sigma_y)\cos 2\theta + \tau \cdot \sin 2\theta$$

$$\tau_\theta = -\frac{1}{2}(\sigma_x - \sigma_y)\sin 2\theta + \tau \cos 2\theta$$

2. Sum of direct stresses on two mutually perpendicular planes, $\sigma_\theta + \sigma_{(\theta + 90°)} = \sigma_x + \sigma_y$
3. In complex systems of loading, there exist three mutually perpendicular planes, on each of which the resultant stress is wholly normal. These are known as *principal planes* and the normal stresses across these planes as *principal stresses*.
4. The inclination of principal planes is given by $\tan 2\theta = \dfrac{2\tau}{\sigma_x - \sigma_y}$
5. The magnitude of major and minor principal stresses are given by

$$\sigma_{1,2} = \frac{1}{2}(\sigma_x + \sigma_y) \pm \frac{1}{2}\sqrt{(\sigma_x - \sigma_y)^2 + 4\tau^2}$$

6. Maximum shear stress $= \dfrac{1}{2}\sqrt{(\sigma_x - \sigma_y)^2 + 4\tau^2} = \dfrac{1}{2}(\sigma_1 - \sigma_2)$

7. A material acted upon by pure shear stresses on two perpendicular planes will have a tensile stress equal to the magnitude of the shear stress on the planes at 45° and a compressive stress of the same magnitude on the planes at 135° with no shear stress on these planes.
8. Principal stresses from principal strains for 2-D,

$$\sigma_1 = \frac{E(\nu\varepsilon_2 + \varepsilon_1)}{1-\nu^2} \quad \text{and} \quad \sigma_2 = \frac{E(\nu\varepsilon_1 + \varepsilon_2)}{1-\nu^2}$$

9. Linear strain in an inclined plane,

$$\varepsilon_\theta = \frac{1}{2}(\varepsilon_x + \varepsilon_y) + \frac{1}{2}(\varepsilon_x - \varepsilon_y)\cos 2\theta + \frac{1}{2}\varphi \sin 2\theta$$

10. Shear strain in an inclined plane,

$$\varphi_\theta = (\varepsilon_x - \varepsilon_y)\sin 2\theta - \varphi \cos 2\theta$$

11. Principal strains $= \frac{1}{2}(\varepsilon_x + \varepsilon_y) \pm \frac{1}{2}\sqrt{(\varepsilon_x - \varepsilon_y)^2 + \varphi^2}$

12. Sum of direct strains on two mutually perpendicular planes, $\varepsilon_\theta + \varepsilon_{(\theta + 90°)} = \varepsilon_x \, \varepsilon_y$

Objective Type Questions

1. Under uniaxial loading, the maximum shear stress is _____ times the uniaxial stress.
   (a) half (b) two (c) 1.5 (d) three
2. The shear stress on the principal plane is
   (a) $\frac{\sigma_x + \sigma_y}{2}$ (b) $\frac{\sigma_x - \sigma_y}{2}$ (c) $\sigma_x + \sigma_y$ (d) Zero
3. If a body is acted upon by pure shear stresses on two perpendicular planes, the planes inclined at 45° are subjected to no _____ stress.
   (a) tensile (b) compressive (c) shear
4. Normal stress on a plane, the normal to which is inclined at angle θ with the line of action of uniaxial stress σ is given by
   (a) $\sigma \sin^2 \theta$ (b) $\sigma \cos^2 \theta$ (c) $\sigma/\sin^2 \theta$ (d) $\sigma/\cos^2 \theta$
5. Shear stress on a plane the normal to which is inclined at angle θ with the line of action of uniaxial stress σ is given by
   (a) $\frac{1}{2}\sigma \sin 2\theta$ (b) $\sigma \sin^2 \theta$ (c) $\frac{1}{2}\sigma \cos 2\theta$ (d) $\sigma \cos^2 \theta$
6. In case of biaxial stresses, the maximum value of shear stress is
   (a) difference of normal stresses
   (b) half the difference of normal stresses
   (c) sum of normal stresses
   (d) half the sum of normal stresses
7. In case of biaxial stresses, the shear stress is maximum on a plane at ___ degrees to the given planes.
   (a) 45° (b) 90° (c) 135° (d) 180°
8. Normal stress on an oblique plane inclined at angle 45° to the axis of a bar of square cross-section of side s when acted upon by a tensile force P is
   (a) $\frac{P}{s^2}$ (b) $\frac{2P}{s^2}$ (c) $\frac{P}{2s^2}$ (d) $\frac{P}{4s^2}$

9. Each normal stress on two planes of maximum shear stresses are
(a) difference of normal stresses (b) half the difference of normal stresses
(c) sum of normal stresses (d) half the sum of normal stresses

10. In a Mohr's circle, the radius gives the value of
(a) minimum shear stress (b) maximum normal stress
(c) minimum normal stress (d) maximum shear stress

11. Ellipse of stress can be drawn only when a body is acted upon by
(a) one normal stress (b) two normal stresses
(c) one shear stress (d) two normal stresses and one shear stress

12. The angle between planes of principal stresses and principal strains is
(a) zero (b) 45° (c) 90° (d) 135°

13. A strain rosette consists of at least ______ strain gauges
(a) two (b) three (c) four (d) five

14. In a rectangular strain rosette, the strain gauges are set at
(a) 45° (b) 60° (c) 75° (d) 90°

15. In an equiangular strain rosette, the strain gauges are set at
(a) 45° (b) 60° (c) 75° (d) 90°

16. In a linear strain system, strain in a direction θ with x-direction is
(a) $\varepsilon_x \cdot \cos\theta$ (b) $\varepsilon_x \cdot \sin\theta$ (c) $\varepsilon_x \cdot \sin^2\theta$ (d) $\varepsilon_x \cdot \cos^2\theta$

Answers

1. (a)	2. (d)	3. (c)	4. (b)	5. (c)	6. (b)
7. (a)	8. (c)	9. (d)	10. (d)	11. (b)	12. (a)
13. (b)	14. (a)	15. (b)	16. (d)		

Objective Type Questions

1. The strain energy stored in a bar is given by

   (a) $\frac{PL}{AE}$ (b) $\frac{PL^2}{2AE}$ (c) $\frac{P^2L}{AE}$ (d) $\frac{P^2L}{2AE}$

2. Strain energy of a member is given by

   (a) $\frac{\sigma^2}{2E} \times$ volume (b) $\frac{P^2L}{2AE}$

   (c) $\frac{1}{2} \times$ stress $\times$ strain $\times$ volume (d) all of these

3. Modulus of resilience is

   (a) percentage of elongation of an elastic body

   (b) strain energy stored in the elastic body

   (c) strain energy per unit volume of the elastic body

4. Proof resilience is the maximum energy stored at

   (a) plastic limit (b) limit of proportionality (c) elastic limit

5. Modulus of toughness is the area of the stress–strain diagram up to

   (a) rupture point (b) yield point

   (c) limit of proportionality (d) none of these

6. Shear strain energy per unit volume is given by

   (a) $\frac{\tau^2}{4G}$ (b) $\frac{\tau^2}{2G}$ (c) $\frac{2\tau^2}{3G}$ (d) $\frac{\tau}{4G}$

7. Strain energy of a bar of conical section is

   (a) $\frac{P^2L}{\pi EdD}$ (b) $\frac{2PL}{\pi EdD}$ (c) $\frac{2P^2L}{EdD}$ (d) $\frac{2P^2L}{\pi EdD}$

8. Strain energy stored in a body due to suddenly applied load compared to when applied slowly is

   (a) twice (b) four times (c) eight times (d) half

Answers:

1. (d) 2. (d) 3. (c) 4. (c) 5. (a) 6. (b)
7. (d) 8. (a)

Objective Type Questions

1. Wherever the bending moment is maximum the shear force is
   (a) zero (b) also maximum (c) minimum (d) of any value
2. The point of contraflexure lies where
   (a) shear force changes sign (b) bending moment is zero or changes sign
   (c) shear force is zero (d) bending moment is maximum
3. For a moving load on a simply supported beam, the maximum bending moment occurs
   (a) at the supports (b) under the load (c) at the midspan
4. The bending moment diagram for a cantilever subjected to bending moment at the free end is
   (a) triangle (b) rectangle (c) parabola (d) elliptical
5. The variation of shear force due to a uniformly distributed load is by
   (a) cubic law (b) parabolic law (c) linear law (d) uniform law
6. The variation of bending moment due a point load is by
   (a) cubic law (b) parabolic law (c) linear law (d) uniform law
7. The variation of bending moment due uniformly distributed load is by
   (a) cubic law (b) parabolic law (c) linear law (d) uniform law

8. Maximum bending moment in a cantilever carrying a point load at the free end occurs at the
(a) free end (b) mid-span (c) fixed end

9. At the point of application of a point load on a beam there is
(a) maximum bending moment
(b) sudden change of shape of bending moment diagram
(c) maximum deflection
(d) point of contraflexure

10. Maximum bending moment in a cantilever carrying a uniformly distributed load is
(a) $\frac{wl^2}{4}$ (b) $\frac{wl^2}{8}$ (c) $\frac{wl^3}{4}$ (d) $\frac{wl^2}{2}$

11. Maximum bending moment in a simply supported beam carrying a point load at mid-span is
(a) $Wl/2$ (b) $Wl/4$ (c) $Wl/6$ (d) $Wl/8$

12. Maximum bending moment in a simply supported beam carrying a point load W at a distance a from one end of the span l is
(a) $\frac{Wa(l-a)}{l}$ (b) $\frac{Wa^2}{l}$ (c) $\frac{Wa(l-a)^2}{l}$ (d) $\frac{Wa(l-a)}{l^2}$

13. Maximum bending moment in a simply supported beam carrying a uniformly distributed load is
(a) $\frac{wl^2}{4}$ (b) $\frac{wl^2}{8}$ (c) $\frac{wl^2}{12}$ (d) $\frac{wl}{4}$

14. Variation of shear force in a cantilever carrying a load the intensity of which varies uniformly from zero at the free end to w per unit run at the fixed end is by
(a) cubic law (b) parabolic law (c) linear law (d) none of these

15. Variation of bending moment in a cantilever carrying a load the intensity of which varies uniformly from zero at the free end to w per unit run at the fixed end is by
(a) cubic law (b) parabolic law (c) linear law (d) none of these

16. A simply supported beam carries a couple at a point on its span, the shear force
(a) varies by cubic law (b) varies by parabolic law
(c) varies linearly (d) is uniform throughout

Answers

1. (a)	2. (b)	3. (c)	4. (b)	5. (c)	6. (c)
7. (b)	8. (c)	9. (b)	10. (d)	11. (b)	12. (a)
13. (b)	14. (b)	15. (a)	16. (d)		

Objective Type Questions

1. A beam is said to be loaded in pure bending if
   (a) shear force and bending moment are uniform throughout
   (b) shear force is zero and bending moment is uniform throughout
   (c) shear force can vary but bending moment is uniform throughout
2. The moment of inertia of rectangular lamina of side d and b about centroidal axis parallel to side d is
   (a) $\frac{bd^3}{12}$ (b) $\frac{bd^3}{36}$ (c) $\frac{db^3}{12}$ (d) $\frac{db^3}{36}$
3. *Neutral axis* in a beam carries ____bending stress.
   (a) maximum (b) minimum (c) zero
4. In simple bending of beams, the stress in the beam
   (a) is constant (b) varies linearly (c) varies parabolically
5. In a transversally loaded beam, the maximum tensile stress occurs at the
   (a) top edge (b) bottom edge (c) neutral axis (d) none of these
6. In a transversally loaded beam, the maximum compressive stress occurs at the
   (a) top edge (b) bottom edge (c) neutral axis (d) none of these
7. The relation governing the simple bending of beam is
   (a) $\frac{\sigma}{y}=\frac{M}{E}=\frac{I}{R}$ (b) $\frac{\sigma}{y}=\frac{M}{R}=\frac{E}{I}$ (c) $\frac{\sigma}{E}=\frac{M}{I}=\frac{y}{R}$ (d) $\frac{\sigma}{y}=\frac{M}{I}=\frac{E}{R}$
8. The diameter of kern of a circular cross-section of diameter d is
   (a) $\frac{d}{2}$ (b) $\frac{d}{3}$ (c) $\frac{d}{4}$ (d) $\frac{2d}{3}$
9. The stress in a beam is less if its section modulus is
   (a) high (b) low (c) zero
10. *Equivalent moment of inertia* of the cross-section in terms of timber of a flitched beam made up of steel and timbre is ($m = E_s/E_t$)
    (a) $(I_t + m/I_s)$ (b) $(I_t + I_s/m)$ (c) $(I_t + mI_s)$ (d) $(I_t + 2mI_t)$
11. *Equivalent moment of inertia* of the cross-section in terms of steel of a flitched beam made up of steel and timbre is ($m = E_s/E_t$)
    (a) $(I_s + mI_t)$ (b) $(I_s + I_t/m)$ (c) $(I_s + m/I_t)$ (d) $(I_s + 2mI_t)$

Answers

1. (b) 2. (c) 3. (c) 4. (b) 5. (b) 6. (a)
7. (d) 8. (c) 9. (a) 10. (c) 11. (b)

Objective Type Questions

1. Shear stress at a distance y from neutral axis of a cross-section is
   (a) $F \cdot \frac{z\bar{y}}{AI}$ (b) $F \cdot \frac{A\bar{y}}{zI}$ (c) $z \cdot \frac{FA}{I\bar{y}}$ (d) $F \cdot \frac{zI}{A\bar{y}}$
2. In a beam of I-section, the maximum shear stress is carried by the
   (a) web (b) upper flange (c) lower flange
3. Ratio of maximum to average shear stress in a rectangular section is
   (a) 1.2 (b) 1.5 (c) 2 (d) 2.5
4. Ratio of maximum to average shear stress in a triangular cross-section is
   (a) 1.2 (b) 1.5 (c) 2 (d) 2.5
5. Ratio of maximum to average shear stress in a rectangular section with a diagonal horizontal is
   (a) 5/4 (b) 4/5 (c) 8/9 (d) 9/8
6. Ratio of shear stress at neutral axis to average shear stress in a hexagonal section is
   (a) 1.2 (b) 1.5 (c) 2 (d) 2.5
7. Ratio of maximum shear stress to average shear stress is 4/3 in a ______ section.
   (a) rectangular (b) triangular (c) circular (d) hexagonal
8. The nature of shear stress distribution in a rectangular beam is
   (a) uniform (b) linear (c) parabolic (d) elliptic
9. Maximum shear stress in a rectangular beam occurs at
   (a) neutral axis (b) bottom edge (c) top edge
10. Shear centre is the point in or outside a section through which the shear force applied produces ______ in the beam
    (a) only twisting (b) only bending
    (c) twisting and bending (d) no twisting and bending
11. Shear centre of a semicircular arc is at
    (a) $4r/\pi$ (b) $3r/\pi$ (c) $2r/\pi$ (d) r/π

Answers

1. (b)	2. (a)	3. (b)	4. (b)	5. (d)	6. (a)
7. (c)	8. (c)	9. (a)	10. (b)	11. (a)	

Objective Type Questions

1. The designing of a beam based on bending and shear stress considerations is known as ________ criterion.
   (a) stiffness (b) toughness (c) strength
2. The designing of a beam based on deflection considerations is known as ______ criterion.
   (a) stiffness (b) toughness (c) strength
3. The flexural rigidity of a beam is
   (a) E/I (b) EI (c) I/E (d) E^2I
4. Deflection of the free end of a cantilever having a point load at the free-end
   (a) $\frac{Wl^3}{48EI}$ (b) $\frac{5Wl^3}{48EI}$ (c) $\frac{5Wl^3}{24EI}$ (d) $\frac{Wl^3}{3EI}$
5. Slope at the free end of a cantilever having a point load at the free end
   (a) $\frac{Wl^2}{2EI}$ (b) $\frac{Wl^2}{3EI}$ (c) $\frac{Wl^2}{4EI}$ (d) $\frac{Wl^2}{8EI}$

6. Deflection of the free end of a cantilever having a point load at the mid-span

(a) $\frac{Wl^3}{3EI}$ (b) $\frac{5Wl^3}{24EI}$ (c) $\frac{5Wl^3}{48EI}$ (d) $\frac{Wl^3}{48EI}$

7. Maximum deflection of a cantilever having a uniformly distributed load

(a) $\frac{wl^4}{2EI}$ (b) $\frac{wl^4}{4EI}$ (c) $\frac{wl^4}{8EI}$ (d) $\frac{wl^4}{24EI}$

8. Maximum slope of a cantilever having a uniformly distributed load

(a) $\frac{wl^3}{4EI}$ (b) $\frac{wl^3}{6EI}$ (c) $\frac{wl^3}{12EI}$ (d) $\frac{wl^3}{24EI}$

9. Maximum deflection of a simply supported beam with a central point load

(a) $\frac{Wl^3}{4EI}$ (b) $\frac{Wl^3}{8EI}$ (c) $\frac{Wl^3}{24EI}$ (d) $\frac{Wl^3}{48EI}$

10. Slope at the supports of a simply supported beam with a central point load

(a) $\frac{Wl^2}{8EI}$ (b) $\frac{Wl^2}{12EI}$ (c) $\frac{Wl^2}{16EI}$ (d) $\frac{Wl^2}{24EI}$

11. Maximum deflection of a simply supported beam with a total uniformly distributed load W is

(a) $\frac{Wl^3}{384EI}$ (b) $\frac{5Wl^3}{384EI}$ (c) $\frac{Wl^3}{48EI}$ (d) $\frac{5Wl^3}{48EI}$

12. Slope at the supports of a simply supported beam with a uniformly distributed load is

(a) $\frac{wl^3}{12EI}$ (b) $\frac{wl^3}{24EI}$ (c) $\frac{wl^3}{48EI}$ (d) $\frac{wl^3}{96EI}$

Answers

1. (c)	2. (a)	3. (b)	4. (d)	5. (a)	6. (c)
7. (c)	8. (b)	9. (d)	10. (c)	11. (b)	12. (b)

Review Questions

1. Maximum deflection of a fixed beam carrying a point load at the midspan

(a) $\dfrac{Wl^3}{192EI}$ (b) $\dfrac{Wl^3}{384EI}$ (c) $\dfrac{Wl^3}{48EI}$ (d) $\dfrac{Wl^3}{24EI}$

2. Maximum deflection of a fixed beam carrying a uniformly distributed load is

(a) $\dfrac{wl^4}{12EI}$ (b) $\dfrac{wl^4}{48EI}$ (c) $\dfrac{wl^4}{96EI}$ (d) $\dfrac{wl^4}{384EI}$

3. For a beam having a point load at the midspan, the ratio of the deflection when the two ends are simply supported to when they are fixed is

(a) 2 (b) 3 (c) 4 (d) 5

4. A continuous beam has

(a) one support (b) two supports

(c) more than two supports (d) very long span

5. Three–moment theorem for continuous beams was forwarded by

(a) Bernoulli (b) Clapeyron (c) Castigliano (d) Maxwell

Answers

1. (a) 2. (d) 3. (c) 4. (c) 5. (b)

Objective Type Questions

1. The curved beam theory was forwarded by
   (a) Bernoulli (b) Winkler–Bach (c) Rankine (d) Maxwell
2. The variation of bending stress in a curved beam is
   (a) linear (b) parabolic (c) hyperbolic (d) cubic
3. Usually, the cross-section of a crane hook is
   (a) square (b) rectangular (c) circular (d) trapezoidal
4. When a crane hook carries the load, the nature of stress at the inside edge is
   (a) tensile (b) compressive (c) shear
5. The maximum stress in a ring under tension occurs at ______ with the line of action of the load.
   (a) 0° (b) 30° (c) 45° (d) 90°
6. If a small cut is made at a horizontal diameter of a ring under compression, the maximum stress
   (a) decreases (b) increases (c) does not change (d) becomes zero
7. If a small cut is made at a horizontal diameter of a ring under compression, the deflection
   (a) decreases (b) increases (c) does not change (d) becomes infinite

Answers

1. (b) 2. (c) 3. (d) 4. (a) 5. (a) 6. (b)
7. (b)

Objective Type Questions

1. Magnitude of shear stress induced in a shaft due to applied torque varies from
   (a) maximum at centre to zero at circumference
   (b) maximum at centre to minimum (not–zero) at circumference
   (c) zero at centre to maximum at circumference
   (d) Minimum (not zero) at centre to maximum at circumference
2. The variation of shear stress in a circular shaft subjected to torsion is
   (a) linear (b) parabolic (c) hyperbolic (d) uniform
3. The relation governing the torsional torque in circular shafts is
   (a) $\frac{T}{r}=\frac{\tau}{l}=\frac{G\theta}{J}$ (b) $\frac{T}{J}=\frac{\tau}{r}=\frac{G\theta}{l}$ (c) $\frac{T}{J}=\frac{\tau}{l}=\frac{G\theta}{r}$ (d) $\frac{T}{l}=\frac{\tau}{r}=\frac{G\theta}{J}$
4. Torsional rigidity of a shaft is defined as
   (a) G/J (b) GJ (c) TJ (d) T/J
5. Torsional rigidity of a shaft is given by
   (a) Gl/θ (b) $T\theta$ (c) Tl/θ (d) T/l
6. A solid shaft of same cross-sectional area and of same material as that of a hollow shaft can resist
   (a) less torque (b) more torque (c) equal torque
7. Angle of twist of a circular shaft is given by
   (a) $\frac{GJ}{Tl}$ (b) $\frac{Tl}{GJ}$ (c) $\frac{TJ}{Gl}$ (d) $\frac{TG}{Jl}$
8. Maximum shear stress of a solid shaft is given by
   (a) $\frac{16T}{\pi d}$ (b) $\frac{16T}{\pi d^2}$ (c) $\frac{16T}{\pi d^3}$ (d) $\frac{16T}{\pi d^4}$
9. The ratio of maximum bending stress to maximum shear stress on the cross–section when a shaft is simultaneously subjected to a torque T and bending moment M,
   (a) T/M (b) M/T (c) $2T/M$ (d) $2M/T$
10. Maximum shear stress in a hollow shaft subjected to a torsional moment is at the
    (a) middle of thickness (b) at the inner surface of the shaft
    (c) at the outer surface of the shaft (d) none of the above
11. The ratio of strength of a hollow shaft to that of a solid shaft subjected to torsion if both are of the same material and of the same outer diameters, the inner diameter of hollow shaft being half of the outer diameter, is
    (a) 15/16 (b) 16/15 (c) 7/8 (d) 8/7
12. Ratio of diameters of two shafts joined in series is 2. If the two shafts have the same material and the same length, the ratio of their angles of twist is
    (a) 2 (b) 4 (c) 8 (d) 16
13. Ratio of diameters of two shafts joined in series is 2. If the two shafts have the same material and the same length, the ratio of their shear stresses will be
    (a) 2 (b) 4 (c) 8 (d) 16
14. For two shafts joined in series, the _____ in each shaft is the same.
    (a) shear stress (b) angle of twist (c) torque
15. For two shafts joined in parallel, the _____ in each shaft is the same.
    (a) shear stress (b) angle of twist (c) torque

Answers

1. (c)	2. (a)	3. (b)	4. (b)	5. (c)	6. (a)
7. (b)	8. (c)	9. (d)	10. (c)	11. (a)	12. (d)
13. (c)	14. (c)	15. (b)			

Review Questions

Objective Type Questions

1. The deflection of a closely coiled helical spring under an axial load is given by,
(a) $\frac{WR^3n}{Gr^4}$ (b) $\frac{2WR^3n}{Gr^4}$ (c) $\frac{4WR^3n}{Gr^4}$ (d) $\frac{8WR^3n}{Gr^4}$
2. Shear stress in a closed-coiled helical spring under an axial load is
(a) $\frac{8WD}{\pi d^3}$ (b) $\frac{4WD}{\pi d^3}$ (c) $\frac{8WD}{\pi d^2}$ (d) $\frac{16WD}{\pi d^3}$
3. The predominant effect of an axial tensile force on a helical spring is
(a) bending (b) tension (c) compression (d) twisting
4. The equivalent stiffness of two springs joined in series is
(a) $s = \frac{s_1 s_2}{s_1 + s_2}$ (b) $s = \frac{s_1 / s_2}{s_1 + s_2}$ (c) $s = s_1 + s_2$ (d) $s = s_1 \cdot s_2$
5. The equivalent stiffness of two springs joined in parallel is
(a) $s = \frac{s_1 s_2}{s_1 + s_2}$ (b) $s = \frac{s_1 / s_2}{s_1 + s_2}$ (c) $s = s_1 + s_2$ (d) $s = s_1 \cdot s_2$
6. The angle of twist of a closely coiled helical spring under an axial torque is
(a) $\frac{32TDn}{Ed^4}$ (b) $\frac{64TDn}{Ed^4}$ (c) $\frac{64Tdn}{ED^4}$ (d) $\frac{32Tdn}{ED^4}$
7. Rotation of a flat spiral spring is given by
(a) $\frac{Tl}{EI}$ (b) $\frac{1.5Tl}{EI}$ (c) $\frac{1.75Tl}{EI}$ (d) $\frac{1.25Tl}{EI}$
8. Maximum stress is a flat spiral spring is given by
(a) $\frac{12T}{bt^3}$ (b) $\frac{12T}{b^2t}$ (c) $\frac{12T}{bt^2}$ (d) $\frac{T}{12bt^2}$
9. Widely used springs in automobile industry are
(a) flat spiral springs (b) leaf springs
(c) closely-coiled helical springs (d) open-coiled helical springs

10. Proof load in a leaf spring is

(a) $\frac{8nbt^3 Ey}{3l^3}$ (b) $\frac{3nbtEy}{8l^3}$ (c) $\frac{3nbt^3 Ey}{8l}$ (d) $\frac{8nbt^2 Ey}{3l^2}$

11. The central deflection of a leaf of leaf springs is

(a) $\frac{3}{8}\frac{Wl^2}{nbt^2 E}$ (b) $\frac{8}{3}\frac{Wl^3}{nbt^3 E}$ (c) $\frac{8}{3}\frac{Wl^2}{nbt^2 E}$ (d) $\frac{3}{8}\frac{Wl^3}{nbt^3 E}$

12. Leaf springs are subjected to

(a) tensile stress (b) compressive stress (c) shear stress (d) bending stress

Answers

1. (c)	2. (a)	3. (d)	4. (a)	5. (c)	6. (b)
7. (d)	8. (c)	9. (b)	10. (a)	11. (d)	12. (d)

Objective Type Questions

1. If the load on a column is increased to a value that on its removal the deflection remains, the load is known as
   (a) critical load (b) crippling load (c) buckling load (d) all of these
2. The equivalent length of a column fixed at one end with other free is
   (a) l (b) $2l$ (c) $l/\sqrt{2}$ (d) $l/2$

3. The equivalent length of a column fixed at both ends is
(a) l (b) $2l$ (c) $l/\sqrt{2}$ (d) $l/2$

4. Euler crippling load for both ends hinged is given by,
(a) $\frac{\pi^2 EI}{l^2}$ (b) $\frac{2\pi^2 EI}{l^2}$ (c) $\frac{4\pi^2 EI}{l^2}$ (d) $\frac{\pi^2 EI}{4l^2}$

5. Euler buckling load for one end fixed and the other hinged is given by,
(a) $\frac{\pi^2 EI}{l^2}$ (b) $\frac{2\pi^2 EI}{l^2}$ (c) $\frac{4\pi^2 EI}{l^2}$ (d) $\frac{\pi^2 EI}{4l^2}$

6. Euler buckling load for one end fixed and the other free is given by,
(a) $\frac{\pi^2 EI}{l^2}$ (b) $\frac{2\pi^2 EI}{l^2}$ (c) $\frac{4\pi^2 EI}{l^2}$ (d) $\frac{\pi^2 EI}{4l^2}$

7. Euler buckling load for both ends fixed is given by,
(a) $\frac{\pi^2 EI}{l^2}$ (b) $\frac{2\pi^2 EI}{l^2}$ (c) $\frac{4\pi^2 EI}{l^2}$ (d) $\frac{\pi^2 EI}{4l^2}$

8. In a long column with one end fixed and the other free, if the slenderness ratio increases, the critical stress
(a) increases (b) decreases (c) remains same

9. The buckling load for a given material depends upon
(a) Poisson's ratio and slenderness ratio
(b) Poisson's ratio and modulus of elasticity
(c) Slenderness ratio and cross-sectional area
(d) Slenderness ratio and modulus of elasticity

10. Rankine's formula is applicable to
(a) long columns (b) short columns (c) both of these (d) none of these

11. Secant formula is applicable for
(a) short columns under axial loading
(b) long columns under axial loading
(c) short columns under eccentric loading
(d) long columns under eccentric loading

12. Perry's approximate formula is
(a) $\left(\frac{\sigma_{max}}{\sigma_o} - 1\right)\left(1 - \frac{\sigma_o}{\sigma_e}\right) = \frac{e \cdot y_c}{1.2k^2}$
(b) $\left(\frac{\sigma_e}{\sigma_o} - 1\right)\left(1 - \frac{\sigma_o}{\sigma_{max}}\right) = \frac{1.2e \cdot y_c}{k^2}$
(c) $\left(\frac{\sigma_{max}}{\sigma_o} - 1\right)\left(1 - \frac{\sigma_o}{\sigma_e}\right) = \frac{1.2e \cdot y_c}{k^2}$
(d) $\left(\frac{\sigma_{max}}{\sigma_o} - 1\right)\left(\frac{\sigma_o}{\sigma_e} - 1\right) = \frac{1.2e \cdot y_c}{k^2}$

Answers

1. (d) 2. (b) 3. (d) 4. (a) 5. (b) 6. (d)
7. (c) 8. (b) 9. (d) 10. (c) 11. (d) 12. (c)

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Objective Type Questions

1. Hoop stress σ_θ induced in a rotating ring is
   (a) $\rho \cdot r^3 \omega^2$ (b) $\rho \cdot r^2 \omega^2$ (c) $\rho \cdot r^2 \omega^3$ (d) $\rho \cdot r^3 \omega^3$
2. In a solid rotating disc, the hoop stress is maximum at the
   (a) center (b) outer surface (c) mean radial section (d) none of these
3. In a solid rotating disc, the radial stress is maximum at the
   (a) center (b) outer surface (c) mean radial section (d) none of these
4. In a solid rotating disc, the value of the hoop stress at the centre is ______ the radial stress.
   (a) greater than (b) less than (c) equal to
5. In a solid rotating disc, the radial stress at the centre is
   (a) $\frac{1-\nu}{4}\rho\omega^2R^2$ (b) $\frac{3+\nu}{8}\rho\omega^2R^2$ (c) $\frac{3-\nu}{8}\rho\omega^2R^2$ (d) zero
6. In a solid rotating disc, the radial stress at the outer surface is
   (a) $\frac{1-\nu}{4}\rho\omega^2R^2$ (b) $\frac{3+\nu}{8}\rho\omega^2R^2$ (c) $\frac{3-\nu}{8}\rho\omega^2R^2$ (d) zero
7. In a solid rotating disc, the hoop stress at the outer surface is
   (a) $\frac{1-\nu}{4}\rho\omega^2R^2$ (b) $\frac{3+\nu}{8}\rho\omega^2R^2$ (c) $\frac{3-\nu}{8}\rho\omega^2R^2$ (d) zero
8. In a hollow rotating disc, radial stress is maximum at
   (a) $r = \sqrt{R_iR_o}$ (b) $r = \sqrt{R_i^2R_o}$ (c) $r = \sqrt{R_iR_o^2}$ (d) $r = \sqrt{R_i / R_o}$

9. In a hollow rotating disc, hoop stress is maximum at

(a) inner surface (b) outer surface (c) $r = \sqrt{R_i R_o^2}$ (d) none of these

10. In a hollow rotating disc if the inner radius is very small, the hoop stress at the inner surface is ______ that for a solid shaft.

(a) same as (b) twice (c) thrice (d) 1.5 times

11. In a long rotating solid cylinder, the maximum value of radial stress is at

(a) = center (b) outer surface (c) mean radial section (d) none of these

12. In a long rotating solid cylinder, the radial stress at the centre is given by

(a) $\frac{(3-2v)}{2(1-v)}\rho\omega^2 R^2$ (b) $\frac{(3-2v)}{4(1-v)}\rho\omega^2 R^2$ (c) $\frac{(3-2v)}{8(1-v)}\rho\omega^2 R^2$ (d) $\frac{(3-2v)}{1-v}\rho\omega^2 R^2$

13. In a flat rotating disc of uniform strength σ at all radii, the thickness at a radius r is given by

(a) $t_o \cdot e^{-\rho\cdot\omega^2\cdot r^2/\sigma}$ (b) $t_o \cdot e^{\rho\cdot\omega^2\cdot r^2/2\sigma}$ (c) $t_o \cdot e^{-\rho\cdot\omega\cdot r^2/2\sigma}$ (d) $t_o \cdot e^{-\rho\cdot\omega^2\cdot r^2/2\sigma}$

14. The collapse speed of a rotating solid disc is given by

(a) $\omega = \frac{1}{R}\sqrt{\frac{3\sigma_y}{\rho}}$ (b) $\omega = \frac{1}{R}\sqrt{\frac{\sigma_y}{3\rho}}$ (c) $\omega = \frac{1}{R}\sqrt{\frac{2\sigma_y}{\rho}}$ (d) $\omega = \frac{1}{R}\sqrt{\frac{\sigma_y}{2\rho}}$

15. The collapse speed of a rotating hollow disc is given by

(a) $\sqrt{\frac{3\sigma_y(R_o - R_i)}{\rho(R_o^2 - R_i^2)}}$ (b) $\sqrt{\frac{3\sigma_y(R_o - R_i)}{\rho(R_o^3 - R_i^3)}}$ (c) $\sqrt{\frac{3\sigma_y(R_o^3 - R_i^3)}{\rho(R_o - R_i)}}$ (d) $\sqrt{\frac{3\sigma_y(R_o - R_i)}{\rho(R_o - R_i)}}$

Answers

1. (b)	2. (a)	3. (a)	4. (c)	5. (b)	6. (d)
7. (a)	8. (a)	9. (a)	10. (b)	11. (a)	12. (c)
13. (d)	14. (a)	15. (b)			

Objective Type Questions

1. Maximum normal stress theory is used for
   (a) brittle materials (b) ductile materials (c) both of these (d) none of these
2. Maximum principal stress theory of failure was postulated by
   (a) Castigliano (b) Rankine (c) Tresca (d) St. Venant

3. Maximum normal stress theory is also known as
   (a) Rankine's theory
   (b) St. Venant's theory
   (c) Guest's and Tresca's theory
   (d) Mises' and Henkey's theory
4. Maximum principal strain theory
   (a) Rankine's theory
   (b) St. Venant's theory
   (c) Guest's and Tresca's theory
   (d) Mises' and Henkey's theory
5. Maximum shear stress theory
   (a) Rankine's theory
   (b) St. Venant's theory
   (c) Guest's and Tresca's theory
   (d) Mises' and Henkey's theory

Answers

1. (a) 2. (b) 3. (a) 4. (b) 5. (c)

Review Questions

MULTIPLE CHOICE QUESTIONS

1. Design of shafts made of brittle materials is based on
   (*a*) Guest's theory (*b*) Tresca's theory (*c*) Rankine's theory (*d*) St. Venant's theory
2. Which of the following theories is suitable for ductile materials ?
   (*a*) Maximum shear stress theory (*b*) Maximum principal stress theory
   (*c*) Maximum principal strain theory (*d*) Maximum distortion energy theory.
3. Guest's theory is used for
   (*a*) brittle materials (*b*) ductile materials (*c*) elastic materials (*d*) plastic materials

4. The principal stresses σ_1, σ_2 and σ_3 at a point respectively are 80 MPa, 30 MPa and –40 MPa. The maximum shear stress is

(*a*) 20 MPa (*b*) 40 MPa (*c*) 60 MPa (*d*) 80 MPa

5. If the principal stresses corresponding to two dimensional state of stress are σ_1 and σ_2 when σ_1 is greater than σ_2 and both are tensile, then which one of the following would be correct criterion for failure by yielding, according to maximum shear stress theory?

(*a*) $\sigma_1 = \pm 2\sigma_{yp}$ (*b*) $\frac{\sigma_1}{2} = \pm\frac{\sigma_{yp}}{2}$ (*c*) $\frac{\sigma_2}{2} = \pm\frac{\sigma_{yp}}{2}$ (*d*) $\frac{\sigma_1 - \sigma_2}{2} = \pm\frac{\sigma_{yp}}{2}$

6. A rod having cross-sectional area 100×10^{-6} m^2 is subjected to a tensile load. Based on Tresca failure of criterion, if the uniaxial yield stress of the material is 200 MPa, the failure load is

(*a*) 20 MPa (*b*) 40 MPa (*c*) 60 MPa (*d*) 100 MPa

ANSWERS

1. (*c*) 2. (*a*) 3. (*b*) 4. (*c*) 5. (*b*) 6. (*a*)

Objective Type Questions

1. In circular plates, freely supported at the edges with uniformly distributed load, the deflection at the centre is

   (a) $\frac{3wR^4}{16Et^3}(5+\nu)(1-\nu)$ (b) $\frac{3wR^4}{16Et^3}\frac{(5+\nu)}{(1-\nu)}$

   (c) $\frac{3wR^4}{8Et^3}\frac{(5+\nu)}{(1-\nu)}$ (d) $\frac{3wR^4}{8Et^3}(5+\nu)(1-\nu)$

2. In circular plates, freely supported at the edges with uniformly distributed load, the radial stress at the centre is given by

   (a) $\frac{3wR^2}{16t^2}(3+\nu)$ (b) $\frac{3wR^2}{8Et^2}(3+\nu)$ (c) $\frac{3wR^2}{16Et^2}(3+\nu)$ (d) $\frac{3wR^2}{8t^2}(3+\nu)$

3. In circular plates with edges clamped and with uniformly distributed load, central deflection is given by

   (a) $\frac{3wR^4}{8Et^3}(1-\nu^2)$ (b) $\frac{3wR^4}{16Et^3}(1-\nu^2)$ (c) $\frac{3wR^4}{16Et^3}(1-\nu)$ (d) $\frac{3wR^4}{8Et^3}(1-\nu)$

4. In circular plates with edges clamped and with uniformly distributed load, the maximum radial stress occurs at the

   (a) clamped edge (b) centre (c) mean radius (d) none of these

5. In circular plates with edges clamped and with uniformly distributed load, the maximum tangential stress occurs at the

(a) clamped edge (b) centre (c) mean radius (d) none of these

6. In circular plates with central point load and edges freely supported, central deflection is given by

(a) $\dfrac{3PR^2}{4Et^3}\cdot(3+\nu)(1-\nu)$ (b) $\dfrac{3PR^2}{16Et^3}\cdot(3+\nu)(1-\nu)$

(c) $\dfrac{3PR^2}{4\pi Et^3}\cdot(3+\nu)(1-\nu)$ (d) $\dfrac{3PR^2}{16\pi Et^3}\cdot(3+\nu)(1-\nu)$

7. In circular plates having clamped edges and with central point load, the maximum radial stress is at the

(a) edges (b) centre (c) mean radius (d) none of these

8. In circular plates having clamped edges and with central point load, the maximum tangential stress is at the

(a) edges (b) centre (c) mean radius (d) none of these

9. In circular plates having clamped edges and with central point load, the radial stress at the edges is

(a) $\dfrac{2}{3}\cdot\dfrac{P}{\pi t^2}$ (b) $\dfrac{2}{3}\cdot\dfrac{P\nu}{\pi t^2}$ (c) $\dfrac{3}{2}\cdot\dfrac{P\nu}{\pi t^2}$ (d) $\dfrac{3}{2}\cdot\dfrac{P}{\pi t^2}$

10. In circular plates having clamped edges and with central point load, the maximum tangential stress is at the

(a) $\dfrac{2}{3}\cdot\dfrac{P}{\pi t^2}$ (b) $\dfrac{2}{3}\cdot\dfrac{P\nu}{\pi t^2}$ (c) $\dfrac{3}{2}\cdot\dfrac{P\nu}{\pi t^2}$ (d) $\dfrac{3}{2}\cdot\dfrac{P}{\pi t^2}$

Answers

1. (a)	2. (d)	3. (b)	4. (a)	5. (b)	6. (c)
7. (a)	8. (a)	9. (d)	10. (c)		

Objective Type Questions

1. In a rectangular beam of width b and depth h subjected to bending moment, when the yielding just commences, the moment of resistance is given by

   (a) $\frac{bh}{6} \cdot \sigma_y$ (b) $\frac{bh^3}{4} \cdot \sigma_y$ (c) $\frac{bh^2}{4} \cdot \sigma_y$ (d) $\frac{bh^2}{6} \cdot \sigma_y$

2. In a rectangular beam of width b and depth h subjected to bending moment, the moment of resistance in the fully plastic state is given by

   (a) $\frac{bh}{6} \cdot \sigma_y$ (b) $\frac{bh^3}{4} \cdot \sigma_y$ (c) $\frac{bh^2}{4} \cdot \sigma_y$ (d) $\frac{bh^2}{6} \cdot \sigma_y$

3. The ratio of M_p/M_y is known as

   (a) elastic factor (b) plastic factor (c) shape factor (d) resistance factor

4. For a rectangular section, the value of the shape factor is

   (a) 0.5 (b) 1 (c) 1.5 (d) 2

5. Load factor is

   (a) Shape factor × Factor of safety (b) Shape factor/Factor of safety
   (c) Load × Factor of safety (d) Load/Factor of safety

6. The ratio of the *collapse load* to the *working load* is termed as

   (a) load factor (b) shape factor (c) yield factor (d) factor of safety

7. For the solid circular shafts transmitting torque, the shape factor is
   (a) 1/2 (b) 2/3 (c) 4/3 (d) 3/2
8. Load factor of a built-in beam loaded with a uniformly distributed load is ______ times over the simply supported beam for the same working stress conditions.
   (a) 4/5 (b) 5/4 (c) 8/9 (d) 9/8

Answers

1. (d) 2. (b) 3. (c) 4. (c) 5. (a) 6. (a)
7. (c) 8. (d)

Objective Type Questions

1. A plane frame structure consists of
   (a) rectangular spaces
   (b) triangular spaces
   (c) rectangular and triangular spaces
   (d) any shapes
2. A plane frame structure is a system having
   (a) riveted joints (b) welded joints (c) rigid joints (d) pin joints
3. A triangle is the geometric figure for a plane frame structure because it is
   (a) strong (b) rigid (c) flexible (d) none of these
4. Hinged joints are used in frames to ensure ______ forces in the members.
   (a) axial
   (b) transverse
   (c) inclined
   (d) horizontal and vertical
5. The relationship between the number of members and the number of joints of a perfect frame can be expressed as
   (a) $m = 2j - 3$ (b) $j = 2m - 3$ (c) $m = 3j - 2$ (d) $2m = j - 3$
6. A frame in which the number of members is less than that required for a perfect frame is known as a
   (a) redundant frame (b) deficient frame (c) plane frame (d) complex frame
7. A frame in which the number of members is more than that required for a perfect frame is known as a
   (a) redundant frame (b) deficient frame (c) plane frame (d) complex frame
8. Method of joints is preferred in the analysis of plane frames if forces are required to be determined in
   (a) one member only (b) two members only (c) a few members (d) in all the members
9. Method of sections is preferred in the analysis of plane frames if forces are required to be determined in
   (a) one member only
   (b) two members only
   (c) in a few members
   (d) in all the members
10. In a plane frame, the forces in collinear members at a joint are equal if the joint is
    (a) loaded
    (b) not loaded
    (c) loaded and has three members only
    (d) not loaded and has three members only

Answers

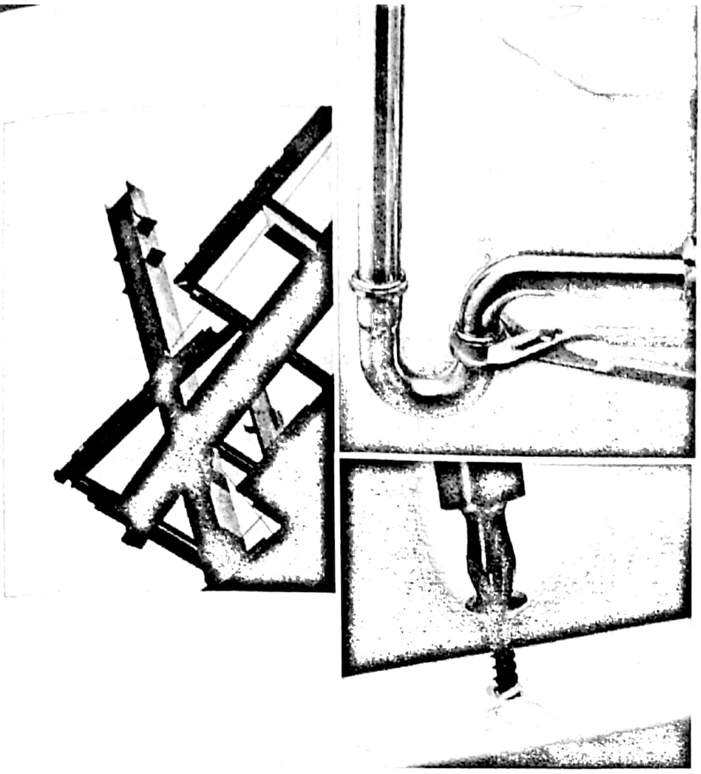
1. (b) 2. (d) 3. (b) 4. (a) 5. (a) 6. (b)
7. (a) 8. (d) 9. (c) 10. (d)

Objective Type Questions

1. The strength of a material is its ability to resist
   (a) fracture due to impact loads (b) deformation under stress
   (c) external forces without yielding (d) none of these
2. A ductile material can be drawn into
   (a) sheets (b) wires (c) none of these
3. A brittle material can be drawn into
   (a) sheets (b) wires (c) none of these
4. Malleability is the property of a material which allows it to expand in ______ directions without rupture.
   (a) one (b) two (c) all
5. Hardness is the resistance to
   (a) indentation (b) scratching (c) abrasion (d) all of these
6. The capacity of a structure to withstand an impact load is due to its property of
   (a) ductility (b) toughness (c) rigidity (d) strength
7. Endurance limit is the stress at which failure
   (a) takes place for a given number of cycles
   (b) does not take place for a given number of cycles
   (c) does not take place for any number of cycles
8. Work done on a unit volume of material on increasing the tensile force gradually from zero to the rupture value is called
   (a) modulus of toughness (b) modulus of resilience
   (c) modulus of endurance
9. Brittle materials generally fail by shearing along the planes inclined at ______ to the longitudinal axis.
   (a) 30° to 40° (b) 50° to 60° (c) 70° to 80° (d) 90°

Answers

1. (c) 2. (b) 3. (c) 4. (c) 5. (d) 6. (b)
7. (c) 8. (a) 9. (b)



Appendix

Important Relations and Results

1. Elongation of a bar, $\Delta = \dfrac{PL}{AE}$
2. Temperature stress in bar, $\sigma = \alpha\, t\, E = \alpha\, t\, \sigma/\varepsilon$
3. Net strain in the direction of σ_1, $\quad \varepsilon_1 = \sigma_1/E - \nu\sigma_2/E - \nu\sigma_3/E$
4. Relation between elastic constants, $E = 2G(1 + \nu) = 3K(1 - 2\,\nu) = \dfrac{9KG}{3K + G}$
5. Normal stress on an inclined plane $= \sigma \cos^2 \theta$
6. Shear stress on an inclined plane $= \frac{1}{2}\sigma \sin 2\theta$
7. Strain energy stored in a bar $= \dfrac{P^2L}{2AE} = \dfrac{\sigma^2}{2E} \times$ volume $= \dfrac{1}{2} \times$ stress $\times$ strain $\times$ volume
8. Shear strain energy per unit volume $= \dfrac{\tau^2}{2G}$
9. Maximum bending moments in standard cases:
   - In a cantilever with a point load at free end $= Wl$
   - In a cantilever with a uniformly distributed load $= \dfrac{wl^2}{2} = \dfrac{Wl}{2}$
   - In a simply supported beam with a point load at mid-span $= \dfrac{Wl}{4}$
   - In a simply supported beam with a point load W at a distance a from one end of the span $l = \dfrac{Wa(l - a)}{l}$
   - In a simply supported beam carrying a uniformly distributed load $= \dfrac{wl^2}{8} = \dfrac{Wl}{8}$
10. The moment of inertia of a rectangular lamina of sides b and d about centroidal axis parallel to side $b = \dfrac{bd^3}{12}$

11. The moment of inertia of circular lamina = $\dfrac{\pi d^4}{64}$

12. The relation governing the simple bending of beam is $\dfrac{\sigma}{y} = \dfrac{M}{I} = \dfrac{E}{R}$

13. The diameter of kern of a circular cross-section of diameter d is $d/4$.
14. Shear centre of a semi-circular arc is at $4r/\pi$
15. The flexural rigidity of a beam is EI
16. Deflection and slope of standard cases:

Cantilevers:

- A point load at the free-end: Deflection of free end = $\dfrac{Wl^3}{3EI}$ (maximum)

  Slope of free end = $\dfrac{Wl^2}{2EI}$ (maximum)

  A point load at the mid-span, deflection of free end = $\dfrac{5Wl^3}{48EI}$

- A uniformly distributed load, deflection of free end = $\dfrac{wl^4}{8EI}$ (maximum)

  Slope of free end = $\dfrac{wl^3}{6EI}$ (maximum)

Simply supported beam:

- Central point load, Deflection at mid-span = $\dfrac{Wl^3}{48EI}$ (maximum)

  Slope at mid-span = Zero

  Slope at the support = $\dfrac{Wl^2}{16EI}$ (maximum)

- Uniformly distributed load, Deflection at mid-span = $\dfrac{5Wl^4}{384EI}$ (maximum)

  Slope at the supports = $\dfrac{wl^3}{24EI}$

Fixed beam:

- Central point load, Maximum deflection = $\dfrac{Wl^3}{192EI}$

- Uniformly distributed load, Maximum deflection = $\dfrac{wl^4}{384EI}$

17. The relation governing the torsional torque in circular shafts is $\dfrac{T}{J} = \dfrac{\tau}{r} = \dfrac{G\theta}{l}$

18. Torsional rigidity of a shaft = $GJ = Tl/\theta$

19. Maximum shear stress of a solid shaft is given by $\dfrac{16T}{\pi d^3}$

20. Deflection of a closely coiled helical spring under axial load = $\dfrac{32WR^2l}{G\pi d^4} = \dfrac{8WD^3n}{Gd^4}$

21. Shear stress in a closed-coiled helical spring under an axial load = $\dfrac{8WD}{\pi d^3}$

22. The angle of twist of a closely coiled helical spring = $\dfrac{64TDn}{Ed^4}$

23. The equivalent stiffness of two springs joined in series, $s = \dfrac{s_1 s_2}{s_1 + s_2}$

24. The equivalent stiffness of two springs joined in parallel, $s = s_1 = s_2$

25. The equivalent lengths of columns for different types of end conditions:
    - both ends hinged, $l_e = l$
    - one end fixed and the other free, $l_e = 2l$
    - both ends fixed, $l_e = l/2$
    - one end fixed, other hinged, $l_e = l/\sqrt{2}$

26. Euler crippling load for columns with both ends hinged = $\dfrac{\pi^2 EI}{l^2}$

27. In a thin cylinder, hoop stress = $\dfrac{pd}{2t}$; longitudinal stress = $\dfrac{pd}{4t}$

28. In a thin spherical shell, hoop stress = $\dfrac{pd}{4t}$

29. The volumetric strain in a thin spherical shell = $\dfrac{3pd}{4tE}(1 - \nu)$

30. Hoop stress induced in a rotating ring, $\sigma_\theta = \rho \cdot r^2\omega^2 = \rho \cdot v^2$

31. In a solid rotating disc, at the centre of the disc, $\sigma_r = \sigma_\theta = \dfrac{3+\nu}{8}\rho\omega^2 R^2$

    At the outer surface, $\sigma_\theta = \dfrac{1-\nu}{4}\rho\omega^2 R^2$, $\sigma_r = 0$

32. In a hollow rotating disc,
    - Radial stresses are zero at inside and outside radii.
    - σ_r is maximum at $r = \sqrt{R_i R_o}$ and is $\dfrac{3+\nu}{8}\rho\omega^2(R_o - R_i)^2$
    - σ_θ is maximum at inner radius and is $\dfrac{\rho\omega^2}{4}[(1-\nu)R_i^2 + (3+\nu)R_o^2]$
    - At outer radius, $\sigma_\theta = \dfrac{\rho\omega^2}{4}[(3+\nu)R_i^2 - (1-\nu)R_o^2]$

33. In a long rotating solid cylinder, the radial stress at the centre = $\dfrac{(3-2\nu)}{8(1-\nu)}\rho\omega^2 R^2$

34. In plastic bending:
    - Moment of resistance at first yield, $M_y = (\sigma_y/\sigma_w) \cdot M_w$
    - Moment of resistance in fully plastic state, $M_p = SZ\sigma_y$
    - Load factor, $L = W_c/W = S(\sigma_y/\sigma_c)$ = Shape factor × Factor of safety