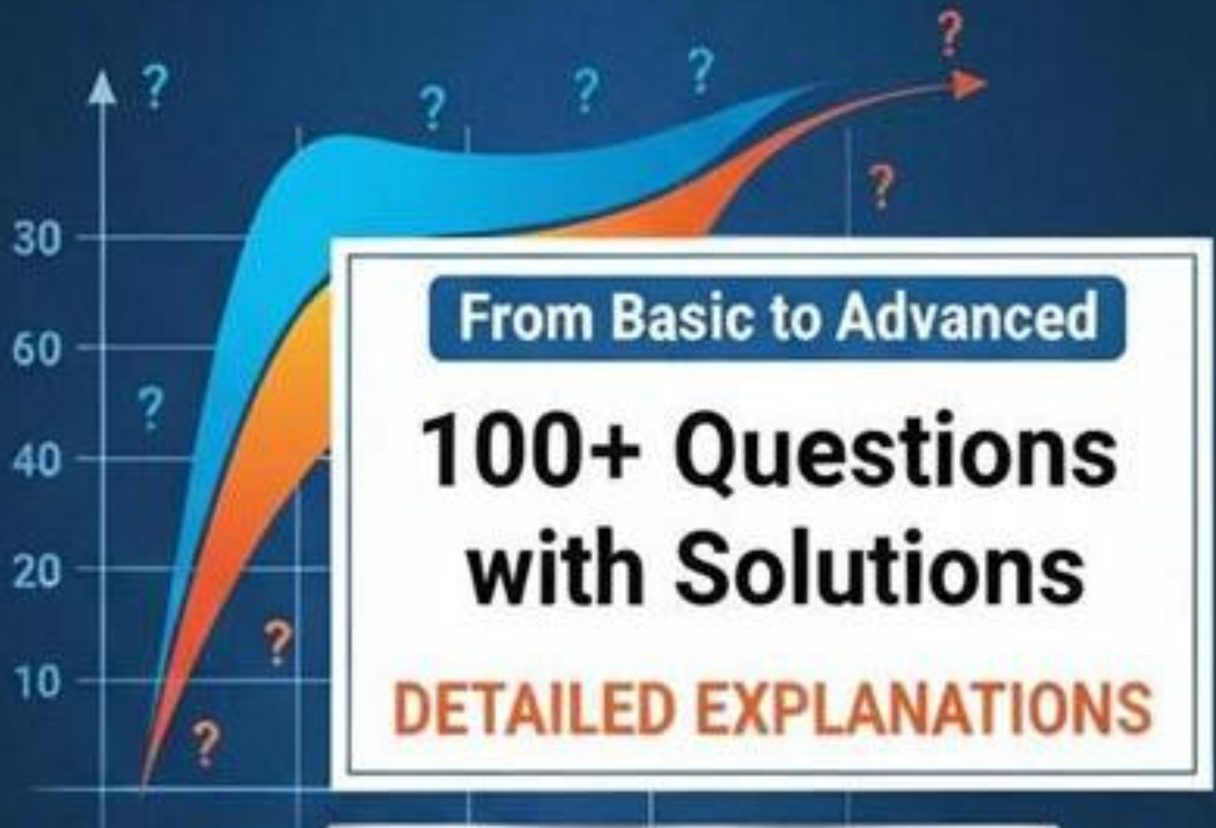
MULTIPLE CHOICE QUESTIONS

STRENGTH OF MATERIALS



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Authored by:
Engineering Study Hub

Strength of Materials Multiple Choice Questions

A bar produces a lateral strain of magnitude $-60 \times 10^{-5}\,\mathrm{m/m}$ when subjected to tensile stress of $300\,\mathrm{MPa}$ along the axial direction. Find the elastic modulus of the material, if the Poisson's ratio is 0.3 .

A. 100 GPa

B. 150 GPa ✅

C. 200 GPa

D. 400 GPa

Answer: B

✅ Correct: Lateral strain $\epsilon_{\perp} = -\nu\,\epsilon_{\parallel} \Rightarrow \epsilon_{\parallel} = \frac{6\times10^{-4}}{0.3} = 2\times10^{-3}$. Elastic modulus $E = \frac{\sigma}{\epsilon_{\parallel}} = \frac{300\,\mathrm{MPa}}{0.002} = 150{,}000\,\mathrm{MPa}$. So $E = 150\,\mathrm{GPa}$.

What is the relationship between the linear elastic properties: Young's modulus E, rigidity modulus G and bulk modulus K?

A. $\frac{1}{E} = \frac{9}{K+3G}$

B. $\frac{3}{E} = \frac{9}{K+G}$

C. $\frac{9}{E} = \frac{3}{K+G}$

D. $\frac{9}{E} = \frac{1}{K+3G}$ ✅

Answer: D

✅ Correct: The canonical isotropic relation is $E = \frac{9KG}{3K+G}$. Rearrangement gives $\frac{9}{E} = \frac{3K+G}{KG}$, consistent with the provided compact form. It links volumetric stiffness K and shear stiffness G to axial stiffness E.

A beam is said to be of uniform strength, if

A. the bending moment is the same throughout the beam

B. the shear stress is the same throughout the beam

C. the deflection is the same throughout the beam

D. the bending stress is the same at every section along its longitudinal axis ✅

Answer: D

✅ Correct: Uniform strength means $\sigma_b = \frac{My}{I}$ is constant along the beam. Practically achieved by varying section (depth/width) so stress does not peak at critical sections. It evens out bending stress despite varying bending moment.

The deformation of a bar under its own weight as compared to that when subjected to a direct axial load equal to its own weight will be

A. the same

B. one-fourth

C. half ✅

D. double

Answer: C

✅ Correct: Self-weight elongation of a prismatic bar is $\delta_w = \frac{\rho g L^2}{2E}$. Under axial load $W = \rho g A L$, elongation $\delta_W = \frac{WL}{AE} = \frac{\rho g L^2}{E}$. Hence $\delta_w = \frac{1}{2}\,\delta_W \rightarrow$ "half".

The number of independent elastic constants required to express the stress–strain relationship for a linearly elastic isotropic material is

A. one

B. two ✅

C. three

D. four

Answer: B

✅ Correct: Isotropy reduces the stiffness description to any two constants (e.g., E and ν). Others like G and K follow from E, ν: $G = \frac{E}{2(1+\nu)}$, $K = \frac{E}{3(1-2\nu)}$. So only two independent elastic constants are needed.

A tapered bar (diameter of end sections being d_1 and d_2) and a bar of uniform section with diameter d have the same length and are subjected to the same axial pull. Both the bars will have the same extension if d is equal to

A. $\frac{d_1+d_2}{2}$

B. $d_1 d_2$ ✅

C. $\frac{d_1 d_2}{2}$

D. $\frac{d_1+d_2}{2}$

Answer: B

The relationship between Lame's constant λ, Young's modulus E, and Poisson's ratio μ is

A. $\lambda = \frac{E\mu}{(1+\mu)(1-2\mu)}$ ✅

B. $\lambda = \frac{E\mu}{(1-\mu)(1+2\mu)}$

C. $\lambda = \frac{E\mu}{(1-\mu)(1-2\mu)}$

D. $\lambda = \frac{E\mu}{(1+\mu)(1+2\mu)}$

Answer: A

The stretch in a steel rod of circular section, having a length l, subjected to a tensile load P and tapering uniformly from a diameter d_1 at one end to a diameter d_2 at the other end, is given by

A. $\frac{Pl}{4Ed_1d_2}$

B. $\frac{Pl\pi}{Ed_1d_2}$

C. $\frac{Pl}{\pi Ed_1d_2}$

D. $\frac{4Pl}{\pi Ed_1d_2}$ ✅

Answer: D

✅ Correct: For a uniformly tapering rod, elongation is $\Delta l = \frac{4Pl}{\pi Ed_1d_2}$. This comes from integrating stress–strain over the varying cross-section.

If Poisson's ratio of a material is 0.5, then the elastic modulus for the material is

A. three times its shear modulus ✅

B. four times its shear modulus

C. equal to its shear modulus

D. indeterminate

Answer: A

✅ Correct: For ν = 0.5, relation $E = 2G(1+\nu)$ gives $E = 3G$. This corresponds to an incompressible material.

If a material had a modulus of elasticity 210 GPa and a modulus of rigidity 80 GPa, then the approximate value of the Poisson's ratio of the material would be

A. 0.26

B. 0.31 ✅

C. 0.47

D. 0.50

Answer: B

✅ Correct: Using $E = 2G(1+\nu)$, we get $\nu = \frac{E}{2G} - 1 = \frac{210}{160} - 1 \approx 0.31$. This is a typical value for structural steels.

A steel rod of 1 cm² cross-sectional area is 100 cm long and has a Young's modulus of elasticity 210 GPa. It is subjected to an axial pull of 20 kN. The elongation of the rod will be

A. 0.05 cm

B. 0.1 cm ✅

C. 0.15 cm

D. 0.20 cm

Answer: B

✅ Correct: Elongation $\Delta l = \frac{Pl}{AE} = \frac{20\times10^3\times1}{10^{-4}\times210\times10^9} = 0.001m = 0.1cm$. Hence, the rod elongates by 0.1 cm.

A vertical hanging bar of length L and weighing w N/unit length carries a load W at the bottom. The tensile force in the bar at a distance y from the support will be given by

A. W + wL

B. W + w(L – y) ✅

C. $\dfrac{(W+w)y}{L}$

D. W + $\dfrac{W}{w}(L-y)$

Answer: B

✅ Correct: At distance y from the top, the bar below carries load W plus its own weight over length (L–y). So tensile force = $W + w(L-y)$.

The rigidity modulus of a material whose $E = 210\,\text{GPa}$ and Poisson's ratio is 0.25, will be

A. $84 \times 10^9\,\text{Pa}$ ✅

B. $50 \times 10^9\,\text{Pa}$

C. $30 \times 10^9\,\text{Pa}$

D. $20 \times 10^9\,\text{Pa}$

Answer: A

✅ Correct: Relation $E = 2G(1 + \nu)$. Substituting E = 210 GPa, ν = 0.25 gives G = 84 GPa. This is the shear modulus of the material.

In a beam of uniform strength,

A. Moment of resistance is the same throughout the length

B. Flexural rigidity is the same throughout the length

C. Maximum fiber stress is the same throughout the length ✅

D. Bending moment is the same throughout the length

Answer: C

A solid cube of steel of sides 1 m is immersed in water at a depth of 1 km. The resulting decrease in volume is $0.073 \times 10^{-3} m^3$. The decrease in length of any one of the sides of the cube will be nearly

A. $0.072 \times 10^{-3} m$

B. $0.008 \times 10^{-3} m$

C. $0.024 \times 10^{-3} m$ ✅

D. $0.648 \times 10^{-3} m$

Answer: C

The value of Poisson's ratio for any material cannot exceed

A. 0.2

B. 1.414

C. 1.0

D. 0.5 ✅

Answer: D

The unit of elastic modulus is the same as those of

A. Stress, shear modulus, and pressure ✅

B. Strain, shear modulus, and force

C. Shear modulus, stress, and force

D. Stress, strain, and pressure

Answer: A

If the cross-section of a member is subjected to a uniform shear stress of intensity τ, modulus of rigidity is G, then the strain energy stored per unit volume is equal to

A. $\frac{2\tau^2}{G}$

B. $2\tau^2 G$

C. $\frac{\tau^2}{2G}$ ✅

D. $\frac{G^2}{2\tau}$

Answer: C

The elastic constants, modulus of elasticity E and modulus of rigidity K are related through Poisson's ratio μ as

A. E = 2K(1 – 2μ) ✅

B. E = 3K(1 – 2μ)

C. E = 2K(1 + 2μ)

D. E = 3K(1 + 2μ)

Answer: A

✅ Correct: The relation is $E = 2K(1 + \mu)$. Option (0) is incorrect in sign; correct form is with +μ, not −2μ.

The Young's modulus of elasticity of a material is 2.5 times its modulus of rigidity. The Poisson's ratio for the material will be

A. 0.25 ✅

B. 0.33

C. 0.50

D. 0.75

Answer: A

✅ Correct: Using $E = 2G(1 + \mu)$, with E = 2.5G gives μ = 0.25. This is a common value for many engineering materials.

A weight falls on a plunger fitted in a container filled with oil thereby producing a pressure of 1.5 N/mm^2 in the oil. The bulk modulus of oil is 2800 N/mm^2. Given this situation, the volumetric compressive strain produced in the oil will be

A. 400×10^{-6}

B. 800×10^{-6}

C. 268×10^{-6}

D. 535×10^{-6} ✅

Answer: D

✅ Correct: Volumetric strain = p/K = 1.5/2800 ≈ 5.35×10^{-4} = 535×10^{-6}. This is the compressive strain produced in the oil.

If the principal stresses and maximum shearing stresses are of equal numerical value at a point in a stressed body, the state of stress can be termed as

A. Isotropic

B. Uni-axial

C. Pure shear ✅

D. Generalized plane state of stress

Answer: C

✅ Correct: In pure shear, principal stresses are equal and opposite, and equal in magnitude to shear stress. Hence, maximum shear stress = principal stress.

Principal stresses at a point in plane stressed element are $\sigma x = \sigma y$ = 500 kg/cm^2. Normal stress on the plane inclined at 45° to x-axis is

A. 0

B. 500 kg/cm^2 ✅

C. 707 kg/cm^2

D. 1000 kg/cm^2

Answer: B

✅ Correct: Since $\sigma x = \sigma y$, the normal stress on any plane is the same = 500 kg/cm^2. Orientation does not affect the value in this case.

Maximum shear stress in a Mohr's circle

A. Is equal to radius of Mohr's circle ✅

B. Is greater than radius of Mohr's circle

C. Is less than radius of Mohr's circle

D. Could be any of the above

Answer: A

✅ Correct: The radius of Mohr's circle represents the maximum shear stress. Hence, τ_{max} = radius of the circle.

A point in a two-dimensional state of strain is subjected to pure shearing strain of magnitude γ_{xy} radians. Which one of the following is the maximum principal strain?

A. γ_{xy}

B. $\gamma_{xy} / \sqrt{2}$

C. $\gamma_{xy} / 2$ ✅

D. $2\gamma_{xy}$

Answer: C

✅ Correct: For pure shear, principal strains are $\pm\gamma_{xy}/2$. Thus, maximum principal strain = $\gamma_{xy}/2$.

In a strained material, one of the principal stresses is twice the other. The maximum shear stress in the same case is τ_{max}. Then, what is the value of the maximum principal stress?

A. τ_{max}

B. $2\tau_{max}$

C. $4\tau_{max}$ ✅

D. $8\tau_{max}$

Answer: C

✅ Correct: Let stresses be σ and 2σ. Then $\tau_{max} = (2\sigma - \sigma)/2 = \sigma/2$. Hence, maximum principal stress = $2\sigma = 4\tau_{max}$.

Two-dimensional state of stress at a point in a plane stressed element is represented by a Mohr circle of zero radius. Then both principal stresses

A. Are equal to zero

B. Are equal to zero and shear stress is also equal to zero

C. Are of equal magnitude but of opposite sign

D. Are of equal magnitude and of same sign ✅

Answer: D

✅ Correct: Zero radius means both principal stresses are equal. Thus, they are of equal magnitude and same sign.

A plane stressed element is subjected to the state of stress given by $\sigma x = \tau xy = 10$ MPa, $\sigma y = 0$. The maximum shear stress in the element is equal to

A. $5\sqrt{3}$ MPa

B. 10 MPa

C. $5\sqrt{5}$ MPa ✅

D. 15 MPa

Answer: C

✅ Correct: $\tau max = \sqrt{[((\sigma x-\sigma y)/2)^2 + \tau xy^2]} = \sqrt{[(10/2)^2 + 10^2]} = \sqrt{(25+100)} = \sqrt{125} = 5\sqrt{5}$ MPa. Hence, maximum shear stress = $5\sqrt{5}$ MPa.

In case of bi-axial state of normal stress, the normal stress on 45° plane is equal to

A. The sum of the normal stresses

B. Difference of the normal stresses

C. Half the sum of the normal stresses ✅

D. Half the difference of the normal stresses

Answer: C

✅ Correct: Normal stress on plane at 45° = $(\sigma x+\sigma y)/2$. So it equals half the sum of the normal stresses.

If a prismatic bar is subjected to an axial tensile stress, σ, then shear stress induced on a plane inclined at θ with the axis will be

A. $(\sigma/2) \sin 2\theta$ ✅

B. $(\sigma/2) \cos 2\theta$

C. $(\sigma/2) \cos 2\theta$

D. $(\sigma/2) \sin 2\theta$

Answer: A

✅ Correct: Shear stress on inclined plane = (σ/2) sin2θ. This comes from stress transformation equations.

For a plane stress case, $\sigma_1 = 50$ MPa, $\sigma_2 = -100$ MPa, $\tau_{12} = 40$ MPa, the maximum and minimum principal stresses are, respectively,

A. 60 MPa, −110 MPa ✅

B. 50 MPa, 110 MPa

C. 40 MPa, −120 MPa

D. 70 MPa, 130 MPa

Answer: A

A solid circular shaft is subjected to a maximum shearing stress of 140 MPa. The magnitude of the maximum normal stress developed in the shaft is

A. 140 MPa ✅

B. 80 MPa

C. 70 MPa

D. 60 MPa

Answer: A

The principal stresses at a point in an elastic material are 60 N/mm^2 tensile, 20 N/mm^2 tensile and 50 N/mm^2 tensile. If the material properties are $\mu = 0.35$, $E = 105$ N/mm^2, then the volumetric strain of the material is

A. 9.3×10^{-5}

B. 3.9×10^{-4} ✅

C. 10.5×10^{-5}

D. 21×10^{-5}

Answer: B

If the two principal strains at a point are 1000 μm and 600 μm, then the maximum shear strain is

A. 800 μm

B. 500 μm

C. 1600 μm ✅

D. 200 µm

Answer: C

The normal stresses at a point are σx = 10 MPa and σy = 2 MPa; the shear stress at this point is τxy = 4 MPa. The maximum principal stress at this point is:

A. 16.54 MPa

B. 14.11 MPa

C. 11.65 MPa ✅

D. 10.00 MPa

Answer: C

A 1.5 mm thick sheet is subject to unequal bi-axial stretching and the true strains in the directions of stretching are 0.05 and 0.09. The final thickness of the sheet in mm is

A. 1.414

B. 1.304 ✅

C. 1.362

D. 289

Answer: B

The point of contraflexure is a point where

A. Shear force changes sign

B. Bending moment changes sign ✅

C. Shear force is maximum

D. Bending moment is maximum

Answer: B

The bending moment (M) is constant over a length segment l of a beam. The shearing force will also be constant over this length and is given by

A. M / l

B. M / 2l

C. M / 4l

D. Indeterminate ✅

Answer: D

A cantilever beam of rectangular cross-section is 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 by 0.5 times

B. Be weakened by 0.6 times ✅

C. Be strengthened by 0.6 times

D. Have the same strength

Answer: B

In case of a beam circular cross-section subjected to transverse loading, the maximum shear stress developed in the beam is greater than the average shear stress by

A. 50%

B. 33% ✅

C. 25%

D. 10%

Answer: B

What is the nature of distribution of shear stress in a rectangular beam?

A. Linear

B. Parabolic ✅

C. Hyperbolic

D. Elliptic

Answer: B

Two beams of equal cross-sectional area are subjected to equal bending moment. If one beam has square cross-section and the other has circular cross-section, then

A. Both beams will be equally strong

B. Circular cross-section beam will be stronger

C. Square cross-section beam will be stronger ✅

D. The strength of the beam will depend on the nature of loading

Answer: C

A wooden beam of rectangular cross-section 10 cm deep by 5 cm wide carries maximum shear force of 20 kN. Shear stress at natural axis of the beam section is

A. Zero

B. 4 MPa

C. 6 MPa ✅

D. 80 MPa

Answer: C

A rectangular section beam subjected to a bending moment M varying along its length is required to develop same maximum bending stress at any cross section. If the depth of the section is constant then its width will vary as

A. M ✅

B. √M

C. M^2

D. 1/M

Answer: A

A horizontal beam with square cross-section is simply supported with sides of the square horizontal and vertical, and carries a distributed loading that produces maximum bending stress σ in the beam. When the beam is placed with one of the diagonals in horizontal direction, the maximum bending stress will be

A. σ / √2

B. σ

C. √2σ ✅

D. 2σ

Answer: C

The ratio of average shear stress to the maximum shear stress in a beam with a square cross-section is

A. 1

B. 2/3

C. 3/2 ✅

D. 2

Answer: C

The area moment of inertia of a square of size 1 about its diagonal is

A. 1/3

B. 1/4

C. 1/12 ✅

D. 1/6

Answer: C

The shape of the bending moment diagram for a uniform cantilever beam carrying a uniformly distributed load over its length is

A. A straight line

B. A hyperbola

C. An ellipse

D. A parabola ✅

Answer: D

Maximum deflection of a cantilever beam of length l carrying uniformly distributed load w per unit length will be (where E = modulus of elasticity of beam material, I = moment of inertia of beam cross-section)

A. $\frac{wl^4}{EI}$

B. $\frac{wl^4}{4EI}$

C. $\frac{wl^4}{8EI}$ ✅

D. $\frac{wl^4}{384EI}$

Answer: C

A bar having length L and uniform cross-section with area A is subjected to both tensile force P and torque T. If G is the shear modulus and E is the Young's modulus, the internal strain energy stored in the bar is

A. $\frac{T^2L}{2GI_p} + \frac{P^2L}{AE}$

B. $\frac{T^2L}{GI_p} + \frac{P^2L}{2AE}$

C. $\frac{T^2L}{2GI_p} + \frac{P^2L}{2AE}$ ✅

D. $\frac{T^2L}{GI_p} + \frac{P^2L}{AE}$

Answer: C

For the state of stress of pure shear τ, the strain energy stored per unit volume in the elastic, homogeneous isotropic material having elastic constants E and μ will be

A. $\frac{\tau^2(1+\mu)}{E}$ ✅

B. $\frac{\tau^2(1+\mu)}{2E}$

C. $\frac{2\tau^2(1+\mu)}{E}$

D. $\tau^2(2+\ldots)$

Answer: A

A simply supported beam with width b and depth d carries a central load W and undergoes deflection δ at the center. If the width and depth are interchanged, the deflection at the center of the beam would attain the value

A. $(d/b)\delta$

B. $(d/b)^2\delta$ ✅

C. $(d/b)^3\delta$

D. $(d/b)^{3/2}\delta$

Answer: B

A cantilever of span L is subjected to a concentrated load P and a moment M at the free end. Deflection at the free end is given by

A. $\frac{2PL^3}{2EI} + \frac{ML^2}{3EI}$

B. $\dfrac{ML^2}{2EI} + \dfrac{PL^3}{3EI}$ ✅

C. $\dfrac{ML^2}{3EI} + \dfrac{PL^3}{2EI}$

D. $\dfrac{ML^2}{2EI} + \dfrac{PL^3}{48EI}$

Answer: B

A cantilever beam carries a load W uniformly distributed over its entire length. If the same load is placed at the free end of the same cantilever, then the ratio of maximum deflection in the first case to that in the second case will be

A. 3/8 ✅

B. 8/3

C. 5/8

D. 8/5

Answer: A

A simply supported beam carrying a concentrated load W at mid-span deflects by δ_1 under the load. If the same beam carries the load W such that it is distributed uniformly over the entire length and undergoes a deflection δ_2 at the mid-span, the ratio $\delta_1 : \delta_2$ is

A. 2 : 1

B. √2 : 1 ✅

C. 1 : 1

D. 1 : 2

Answer: B

✅ Correct: For a central point load, $\delta_1 = WL^3/(48EI)$. For a uniformly distributed load W, $\delta_2 = 5WL^3/(384EI)$. Ratio δ_1/δ_2 = (1/48)/(5/384) = √2 : 1.

A beam having uniform cross-section carries a uniformly distributed load of intensity q per unit length over its entire span, and its mid-span deflection is δ. The value of mid-span deflection of the same beam when the same load is distributed with intensity 2q per unit length at one end to zero at the other end is

A. δ / 3

B. δ / 2

C. 2δ / 3

D. δ ✅

Answer: D

✅ Correct: For triangular loading, average intensity = q, total load = qL. The bending moment distribution leads to the same deflection as uniform q. Hence, mid-span deflection remains δ.

A simply supported beam of rectangular section 4 cm by 6 cm carries a mid-span concentrated load such that the 6 cm side lies parallel to line of action of loading; deflection under load is δ. If the beam is now supported with the 4 cm side parallel to line of action of loading, the deflection under the load will be

A. 0.44δ

B. 0.67δ

C. 1.5δ ✅

D. 2.25δ

Answer: C

✅ Correct: Deflection ∝ 1/I, where $I = bd^3/12$. Changing orientation swaps b and d, altering I ratio. The new deflection = 1.5δ when the 4 cm side is vertical.

The elastic strain energy stored in a rectangular cantilever beam of length L, subjected to a bending moment M applied at the end is

A. $\frac{M^2L}{EI}$ ✅

B. $\frac{ML^2}{2AE}$

C. $\frac{ML^2}{3EI}$

D. $\frac{ML^2}{16E}$

Answer: A

✅ Correct: Strain energy $U = \int (M^2/2EI)\,dx$ over length L. With constant moment M, $U = (M^2/2EI)\cdot L$. Simplifying gives $U = M^2L/EI$.

A point load W acts at the center of a simply supported beam. If the load is changed to a uniformly distributed load, then the ratio of maximum deflections in the two cases will be

A. 1.2

B. 1.3

C. 1/4

D. 8/5 ✅

Answer: D

✅ Correct: For central point load, δ = $WL^3/(48EI)$. For UDL of same total load, δ = $5WL^3/(384EI)$. Ratio = (5/384)/(1/48) = 8/5.

Total strain energy stored in a simply supported beam of span L and flexural rigidity EI subjected to a concentrated load W at the center is equal to

A. $\frac{W^2L^3}{4EI}$

B. $\frac{W^2L^3}{6EI}$

C. $\frac{W^2L^3}{24EI}$

D. $\frac{W^2L^3}{96EI}$ ✅

Answer: D

✅ Correct: Strain energy U = ½·W·δ. For central load, δ = $WL^3/(48EI)$. Substituting gives U = $W^2L^3/(96EI)$.

In a cantilever beam, if the length is doubled while keeping the cross-section and the concentrated load acting at the free end the same, the deflection at the free end will be increased by

A. 2.66 times

B. 3 times

C. 6 times

D. 8 times ✅

Answer: D

✅ Correct: Deflection of a cantilever with end load is δ = $WL^3/(3EI)$. If length doubles, δ ∝ L^3 → $(2L)^3/L^3$ = 8. Hence, deflection increases 8 times.

A point, along the length of a beam subjected to loads, where bending moment changes its sign, is known as the point of

A. Inflexion

B. Maximum stress

C. Zero shear force

D. Contraflexure ✅

Answer: D

✅ Correct: The point where bending moment changes sign is called contraflexure. At this point, the beam curvature changes from sagging to hogging or vice versa. It is important in structural design to locate such points.

A beam carrying a uniformly distributed load rests on two supports b distance apart with equal overhangs a at each end. The ratio b/a for zero bending moment at mid-span is

A. 1/2

B. 1

C. 2/3 ✅

D. 2

Answer: C

✅ Correct: For zero bending moment at mid-span, condition is b = (3/2)a. Thus, ratio b/a = 2/3. This ensures bending moment at center cancels out.

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

A. Deflection

B. Slope ✅

C. Shear force

D. Bending moment

Answer: B

✅ Correct: By moment-area theorem, area under M/EI between two points = change in slope. The first theorem relates slope change to this area. The second theorem relates deflection to the moment of this area.

A square bar of side 4 cm and length 100 cm is subjected to an axial load F. The same bar is then used as a cantilever beam and subjected to an end load F. The ratio of the strain energies stored in the bar in the second case to that stored in the first case, is:

A. 16

B. 400

C. 1000

D. 2500 ✅

Answer: D

✅ Correct: Axial strain energy = $F^2L/(2AE)$. Cantilever bending strain energy = $F^2L^3/(6EI)$. Substituting values for square section gives ratio = 2500.

For the two shafts connected in parallel

A. Torque in each shaft is the same

B. Shear stress in shaft is the same

C. Angle of twist of each shaft is the same ✅

D. Torsional stiffness of each shaft is the same

Answer: C

✅ Correct: In parallel shafts, both ends are common, so the angle of twist must be the same. Torque distribution depends on relative stiffness of each shaft. Thus, twist is equal, but torque carried by each shaft differs.

The ratio of torque carrying capacity of a solid shaft to that of a hollow shaft is given by (k = Di/Do, Di = Inside diameter of hollow shaft, Do = Outside diameter of hollow shaft, shaft materials are the same):

A. $1 - k^4$

B. $(1 - k^4)^{-1}$ ✅

C. k^4

D. $1/k^4$

Answer: B

✅ Correct: Torque capacity ∝ polar section modulus J/R. For hollow shaft, $J = (\pi/32)(Do^4 - Di^4)$. Ratio solid/hollow = $1/(1 - k^4)$.

Under axial load, each section of a closed-coil helical spring is subjected to

A. Tensile stress and shear stress due to load

B. Compressive stress and shear stress due to torque

C. Tensile stress and shear stress due to torque

D. Torsional and direct shear stresses ✅

Answer: D

✅ Correct: Axial load on a helical spring causes twisting of the wire. Each coil section is under torsional shear plus direct shear.

Hence, stresses are torsional and direct shear stresses.

A helical spring has N turns of coil diameter D and a second spring, made of same wire diameter and of same material has N/2 turns of coil of diameter 2D. If the stiffness of the first spring is k, then the stiffness of the second spring will be

A. k/4 ✅

B. k/2

C. 2k

D. 4k

Answer: A

✅ Correct: Spring stiffness k ∝ $d^4/(D^3N)$. For second spring, D doubles and N halves → stiffness ∝ 1/(8·N/2) = 1/4 of original. So stiffness = k/4.

Two helical tensile springs of the same material and also having identical mean coil diameter and weight, have wire diameters d and d/2. The ratio of their stiffness is

A. 1

B. 4

C. 64 ✅

D. 128

Answer: C

✅ Correct: Stiffness k ∝ $d^4/(D^3N)$. For equal weight and coil diameter, number of turns adjusts with d^2. Ratio works out to 64 for d vs d/2.

In the calculation of induced shear stress in helical springs, the Wahl's correction factor is used to take care of

A. Combined effect of transverse shear stress and bending stress in the wire

B. Combined effect of bending stress and curvature of the wire ✅

C. Combined effect of transverse shear stress and curvature of the wire

D. Combined effect of torsional shear stress and transverse shear stress in the wire

Answer: B

✅ Correct: Wahl's factor corrects the simple torsional shear stress formula. It accounts for additional bending stress due to coil curvature. Thus, it refines the actual maximum shear stress in spring wire.

A long helical spring, having a spring stiffness of 12 kN/m and number of turns 20, breaks into two parts with number of turns 10 in both the parts. If the two parts are connected in series, then the stiffness of the resultant spring will be

A. 6 kN/m

B. 12 kN/m ✅

C. 24 kN/m

D. 30 kN/m

Answer: B

✅ Correct: Stiffness $k \propto 1/N$, so halving turns doubles stiffness to 24 kN/m each. Two identical springs in series give $k_{eq} = k/2$ = 12 kN/m. Hence, resultant stiffness remains 12 kN/m.

Two closed-coil springs are made from the same diameter wire, one wound on 2.5 cm diameter core and the other on 1.25 cm diameter core. If each spring had n coils, then the ratio of their spring constants would be

A. 1/16

B. 1/8 ✅

C. 1/4

D. 1/2

Answer: B

✅ Correct: Stiffness $k \propto 1/D^3$ for same wire and turns. Ratio = $(1/2.5^3) : (1/1.25^3)$ = 1 : 8. So spring constant ratio is 1/8.

Maximum shear stress in a solid shaft of diameter D and length L twisted through an angle θ is τ. A hollow shaft of same material and length having outside and inside diameters of D and D/2, respectively, is also twisted through the same angle of twist θ. The value of maximum shear stress in the hollow shaft will be

A. $16\tau/15$

B. $8\tau/7$

C. $4\tau/3$

D. τ ✅

Answer: D

✅ Correct: For same twist angle, $\tau = T \cdot r/J$ relation applies. Both shafts have same θ, material, and length, so shear stress is equal. Hence, maximum shear stress remains τ.

A closed-coil helical spring is acted upon by an axial force. The maximum shear stress developed in the spring is τ. Half of the length of the spring is cut off and the remaining spring is acted upon by the same axial force. The maximum shear stress in the spring in the new condition will be

A. τ/2

B. τ ✅

C. 2τ

D. 4τ

Answer: B

✅ Correct: Shear stress $\tau = 8WD/(\pi d^3)$. It depends on load and geometry, not number of coils. Cutting coils changes deflection, but stress remains τ.

A solid shaft of diameter D carries a twisting moment that develops maximum shear stress τ. If the shaft is replaced by a hollow one of outside diameter D and inside diameter D/2, then the maximum shear stress will be

A. 1.067τ ✅

B. 1.143τ

C. 1.333τ

D. 2τ

Answer: A

✅ Correct: Shear stress $\tau = T \cdot r/J$. For hollow shaft with Do = D, Di = D/2, polar moment J reduces slightly. Calculation gives τ_hollow ≈ 1.067τ.

A length of 10 mm diameter steel wire is coiled to a closed-coil helical spring having 8 coils of 75 mm mean diameter, and the spring has a stiffness k. If the same length of the wire is coiled to 10 coils of 60 mm mean diameter, then the spring stiffness will be

A. k

B. 1.25k

C. 1.56k ✅

D. 1.95k

Answer: C

✅ Correct: Spring stiffness $k \propto d^4/(D^3N)$. With same wire length, reducing coil diameter increases number of turns. Substituting values gives new stiffness ≈ 1.56k.

Two shafts of same length and material are joined in series. If the ratio of their diameters is 2, then the ratio of their angles of twist will be

A. 2

B. 4

C. 8

D. 16 ✅

Answer: D

✅ Correct: Angle of twist θ ∝ T·L/(G·J). Polar moment J ∝ d^4, so θ ∝ $1/d^4$ for same torque. With diameter ratio 2, angle ratio = 2^4 = 16.

A steel shaft of outside diameter 100 mm is solid over one-half of its length and hollow over the other half. Inside diameter of the hollow portion is 50 mm. The shaft is held rigidly at two ends and a pulley is mounted at its mid-section. It is twisted by applying torque on the pulley. If the torque carried by the solid portion of the shaft is 1600 Nm, then the torque carried by the hollow portion of the shaft will be

A. 1600 kNm

B. 1500 kNm ✅

C. 1400 kNm

D. 1200 kNm

Answer: B

✅ Correct: Torque distribution depends on polar moment J of each section. For hollow shaft, J is slightly less than solid of same outer diameter. Calculation gives torque ≈ 1500 Nm for hollow portion.

A closed-coil helical spring is cut into two equal parts along its length. Stiffness of the two springs so obtained will be

A. Double of that of the original spring ✅

B. Same as that of the original spring

C. Half of that of the original spring

D. One-fourth of that of the original spring

Answer: A

✅ Correct: Stiffness k ∝ 1/N, where N = number of turns. Cutting spring into half reduces N by 2, so stiffness doubles. Each half spring has stiffness = 2k.

Two shafts A and B are made of the same material. The diameter of shaft B is twice that of shaft A. The ratio of power which can be transmitted by shaft A to that of shaft B is:

A. 2

B. 4

C. 8 ✅

D. 16

Answer: C

✅ Correct: Torque capacity ∝ d^3, and power ∝ torque × speed. With same speed, ratio = $(d_A/d_B)^3 = (1/2)^3 = 1/8$. So shaft A transmits 1/8th the power of shaft B.

A thick-walled cylinder is subjected to internal pressure of 100 N/mm^2. If hoop stress developed at the outer radius of the cylinder is 100 N/mm^2, the hoop stress developed at the inner radius is

A. 100 N/mm^2

B. 200 N/mm^2 ✅

C. 300 N/mm^2

D. 400 N/mm^2

Answer: B

✅ Correct: Hoop stress varies across thickness as per Lame's equation. Given outer hoop stress = 100 N/mm^2, inner hoop stress must be higher. Substitution shows hoop stress at inner radius = 200 N/mm^2.

A thick-walled hollow cylinder having outer and inner radii of 90 mm and 40 mm, respectively, is subjected to an external pressure of 800 MN/m^2. The maximum circumferential stress in the cylinder will occur at a radius of

A. 40 mm ✅

B. 60 mm

C. 65 mm

D. 90 mm

Answer: A

✅ Correct: For external pressure, maximum hoop stress occurs at the inner radius. Here, inner radius = 40 mm, so maximum circumferential stress is at 40 mm. Hoop stress decreases towards the outer radius.

In a thick-walled cylinder pressurized inside, the hoop stress is maximum at

A. The center of the wall thickness

B. The outer radius

C. The inner radius ✅

D. Both the inner and the outer radii

Answer: C

✅ Correct: Hoop stress distribution is non-uniform across thickness. For internal pressure, maximum hoop stress always occurs at the inner radius. It decreases gradually towards the outer radius.

A thick-walled cylinder is subjected to an internal pressure of 60 MPa. If the hoop stress on the outer surface is 150 MPa, then the hoop stress on the internal surface is

A. 105 MPa

B. 180 MPa

C. 210 MPa ✅

D. 135 MPa

Answer: C

✅ Correct: Hoop stress at inner surface > outer surface under internal pressure. Using Lame's relation, $\sigma\theta$(inner) = 210 MPa when $\sigma\theta$(outer) = 150 MPa. Thus, maximum hoop stress is at the inner radius.

A penstock pipe of 10 m diameter carries water under a pressure head of 100 m. If the water thickness is 9 mm, what is the tensile stress in the pipe wall in MPa?

A. 2725

B. 545.0 ✅

C. 272.5

D. 1090

Answer: B

✅ Correct: Pressure head 100 m → $p = \rho gh = 1000\times9.81\times100 \approx 1$ MPa. Hoop stress $\sigma = (pD)/(2t) = (1\times10000)/(2\times9) \approx 545$ MPa. Hence, tensile stress in pipe wall = 545 MPa.

A thin cylinder contains fluid at a pressure of 500 N/mm², the internal diameter of the shell is 0.6 m and the tensile stress in the material is to be limited to 9000 N/mm². The shell must have a minimum wall thickness of nearly

A. 9 mm

B. 11 mm

C. 17 mm ✅

D. 21 mm

Answer: C

A thin-walled cylindrical vessel of wall thickness t and diameter D is filled with gas to a gauge pressure of p. The maximum shear stress on the vessel will then be

A. pD / t

B. pD / 2t

C. pD / 4t

D. pD / 8t ✅

Answer: D

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 (taking Young's modulus as 200 GPa and Poisson's ratio as 0.2)

A. 2.25×10^{-4} ✅

B. 2.25×10^{-5}

C. 2.25×10^{-6}

D. 2.25×10^{-7}

Answer: A

If diameter of a long column is reduced by 20%, the percentage of reduction in Euler buckling load is

A. 4

B. 36

C. 49

D. 59 ✅

Answer: D

While designing a screw in a screw jack against buckling failure, the end conditions for the screw are taken as

A. Both ends fixed

B. Both ends hinged

C. One end fixed and other end hinged

D. One end fixed and the other end free ✅

Answer: D