MECHANICS OF MATERIALS–3

The column shown has a cross-sectional area of 13 m². What can the approximate maximum load be if the compressive stress cannot exceed 9.6 kPa?

(A) 120 kN  (B) 122 kN  (C) 125 kN  (D) 130 kN

MECHANICS OF MATERIALS–4

A copper column of annular cross section has an outer diameter, \(d_2\), of 5 m, and is subjected to an axial loading of 200 kN. The allowable compressive stress is 14.4 kPa. The wall thickness, \(t\), should be most nearly

(A) 0.5 m  (B) 0.8 m  (C) 1 m  (D) 2 m
What is most nearly the stress at surface S of the cylindrical object shown? The specific weight of the material is $\gamma = 76.9 \text{ kN/m}^3$.

(A) 100 kPa  (B) 150 kPa  (C) 200 kPa  (D) 250 kPa
MECHANICS OF MATERIALS—12

A 2 m long aluminum bar (modulus of elasticity = 70 GPa) is subjected to a tensile stress of 175 MPa. Find the elongation.

(A) 3.5 mm  (B) 5.0 mm  (C) 7.5 mm  (D) 9.0 mm

MECHANICS OF MATERIALS—13

A 600 mm tall thin plate is placed in tension by a 5000 kN force as shown. What is the height (y direction) of the plate while tension is applied? The modulus of elasticity, $E$, is 200 GPa, and Poisson’s ratio, $\nu$, is 0.3. Assume the load is distributed uniformly across the plate and the yield strength is not exceeded.

(A) 599.7 mm  (B) 599.9 mm  (C) 600.2 mm  (D) 600.5 mm
MECHANICS OF MATERIALS—14

What is most nearly the lateral strain, \( \varepsilon_y \), of the steel specimen shown if \( F_x = 3000 \text{ kN} \), \( E = 193 \text{ GPa} \), and \( \nu = 0.29 \)?

\[
(F_x) = 4 \times 10^{-4} \quad (B) = -1 \times 10^{-4} \quad (C) = 1 \times 10^{-4} \quad (D) = 4 \times 10^{-4}
\]

MECHANICS OF MATERIALS—17

A 150 mm diameter rivet resists a shear force of \( V = 8 \text{ kN} \). Find the average shear stress in the rivet.

\[
(A) = 230 \text{ kPa} \quad (B) = 370 \text{ kPa} \quad (C) = 430 \text{ kPa} \quad (D) = 450 \text{ kPa}
\]
MECHANICS OF MATERIALS—19

What is most nearly the maximum allowable load, \( F \), if the factor of safety is 1.5 and the compressive yield stress, \( \sigma_{\text{yield}} \), is 20,670 kPa?

(A) 220 kN  (B) 240 kN  (C) 300 kN  (D) 420 kN
MECHANICS OF MATERIALS—20

The allowable tensile stress for a 6.25 mm diameter bolt with a thread length of 5.5 mm is 207 MPa. The allowable shear stress of the material is 103 MPa. Where and how will such a bolt be most likely to fail if placed in tension? (Assume threads are perfectly triangular and that the force is carried at the mean thread height.)

(A) at the root diameter due to tension
(B) at the threads due to shear
(C) at the root diameter due to shear
(D) at the threads due to tension

MECHANICS OF MATERIALS—21

Hexagonal nuts for 6.25 mm diameter bolts have a height of 5.5 mm. If the ultimate strength of the nut material in shear is 103 MPa, what is most nearly the maximum allowable shear force on the nut threads using a safety factor of 5?

(A) 0.72 kN  (B) 0.8 kN  (C) 1.0 kN  (D) 1.1 kN
MECHANICS OF MATERIALS–24
What is most nearly the total elongation of the rod shown if \( E = 69 \) GPa? Neglect bending.

\[ D_1 = 300 \text{ mm} \quad \text{and} \quad L_1 = 2.5 \text{ m} \]
\[ D_2 = 150 \text{ mm} \quad \text{and} \quad L_2 = 1.75 \text{ m} \]
\[ F = 27 \text{ kN} \]

(A) 0.01 mm  (B) 0.05 mm  (C) 0.2 mm  (D) 1.2 mm

MECHANICS OF MATERIALS–25
What is most nearly the total elongation of this composite body under a force of 27 kN? \( E_1 = 70 \) GPa, and \( E_2 = 100 \) GPa.

\[ D_1 = 0.12 \text{ m} \quad \text{and} \quad D_2 = 0.08 \text{ m} \]
\[ F = 175 \text{ kN} \]

(A) 0.075 mm  (B) 0.73 mm  (C) 1.2 mm  (D) 3.0 mm
MECHANICS OF MATERIALS – 26

A 200 m cable is suspended vertically. At any point along the cable, the strain is proportional to the length of the cable below that point. If the strain at the top of the cable is 0.001, determine the total elongation of the cable.

(A) 0.050 m  (B) 0.10 m  (C) 0.15 m  (D) 0.20 m
MECHANICS OF MATERIALS—28

The two bars shown are perfectly bonded to a common face to form an assembly. The bars have moduli of elasticity and areas as given. If a force of $F = 1300 \text{ kN}$ compresses the assembly, what is most nearly the reduction in length?

\[
\begin{align*}
E_2 &= 207 \text{ GPa} \\
A_2 &= 8500 \text{ mm}^2 \\
E_1 &= 200 \text{ GPa} \\
A_1 &= 7700 \text{ mm}^2 \\
\text{uncompressed length} &= 3 \text{ m}
\end{align*}
\]

(A) 1.2 mm  (B) 1.4 mm  (C) 1.5 mm  (D) 1.6 mm
MECHANICS OF MATERIALS–29

A rigid weightless bar is suspended horizontally by cables 1 and 2 as shown. The cross-sectional areas of the cables are given in the figure. The modulus of elasticity, $E$, is the same for both cables. If a concentrated load of $F = 1500 \text{ kN}$ is applied between points A and B, what is most nearly the distance, $x$, for the bar to remain horizontal?

(A) 1300 mm  (B) 1600 mm  (C) 1900 mm  (D) 2300 mm
MECHANICS OF MATERIALS–30
A prismatic bar at 10°C is constrained in a rigid concrete wall at both ends. The bar is 1000 mm long and has a cross-sectional area of 2600 mm². What is most nearly the axial force in the bar if the temperature is raised to 40°C?

\[ A = 2600 \text{ mm}^2 \]

\[ E = \text{modulus of elasticity} = 200 \text{ GPa} \]
\[ \alpha = \text{coefficient of thermal expansion} = 9.4 \times 10^{-6}\text{°C} \]

(A) 115 kN  (B) 125 kN  (C) 134 kN  (D) 147 kN

MECHANICS OF MATERIALS–33
A 3 m diameter bar experiences a torque of 280 N-m. What is most nearly the maximum shear stress in the bar?

\[ T \]

(A) 2.2 Pa  (B) 31 Pa  (C) 42 Pa  (D) 53 Pa
What is most nearly the angle of twist, $\phi$, for the aluminum bar shown? The shear modulus of elasticity, $G$, is 26 GPa.

\[ T = 11 \text{ kN-m} \]
\[ d = 0.8 \text{ m} \]
\[ L = 17 \text{ m} \]

(A) 0.00055°  (B) 0.0055°  (C) 0.032°  (D) 0.082°
MECHANICS OF MATERIALS–36

Determine the maximum torque that can be applied to the shaft, given that the maximum angle of twist is 0.0225 rad. Neglect bending.

\[
\begin{align*}
(A) & \quad 0.000625 \frac{\pi G}{L} \\
(B) & \quad 0.0500 \frac{\pi G}{L} \\
(C) & \quad 0.250 \frac{\pi G}{L} \\
(D) & \quad 0.525 \frac{\pi G}{L}
\end{align*}
\]
For the given shaft, what is most nearly the largest torque that can be applied if the shear stress is not to exceed 110 MPa?

\[ r_1 = 0.015 \text{ m} \]
\[ r_2 = 0.025 \text{ m} \]

(A) 1700 N-m  (B) 1900 N-m  (C) 2400 N-m  (D) 3400 N-m
MECHANICS OF MATERIALS—38

A hollow circular bar has an inner radius \( r_1 \) and an outer radius \( r_2 \). If \( r_1 = \frac{r_2}{2} \), most nearly what percentage of torque can the shaft carry in comparison with a solid shaft?

(A) 25%  (B) 55%  (C) 75%  (D) 95%
MECHANICS OF MATERIALS—40

A beam supports a distributed load, w, as shown. Find the shear force at x = 2 m from the left end.

\[ w = 5 \text{ kN/m} \]

\[ x = 2 \text{ m} \]

\[ L = 10 \text{ m} \]

(A) 11 kN  (B) 12 kN  (C) 13 kN  (D) 15 kN
MECHANICS OF MATERIALS—43

Which of the following is the shear force diagram for this beam?

(A) 4 kN

(B) 3 kN

(C) 1 kN

(D) 1 kN
Which of the following is the bending moment diagram for this beam?

(A) \(3 \text{kN}\cdot\text{m}\)  
(B) \(3 \text{kN}\cdot\text{m}\)  
(C) \(3 \text{kN}\cdot\text{m}\)  
(D) \(2 \text{kN}\cdot\text{m}\)
Which of the following bending moment diagrams corresponds to the simply supported beam shown? The beam is subjected to a distributed load, \( w \), between points B and C.
MECHANICS OF MATERIALS-47

What is most nearly the maximum allowable load, $F$, on the cantilever? The maximum compressive stress is 7000 kPa, and the maximum tensile stress is 5500 kPa. The moment of inertia about the centroidal axis, $I_{NA}$, is $20.6 \times 10^6 \text{ mm}^4$.

![Diagram of cantilever with dimensions and moment of inertia](image)

(A) 540 N  (B) 600 N  (C) 610 N  (D) 640 N
A simply supported beam with the cross section shown supports a concentrated load, $F = 10 \text{ kN}$, at its center, C. What is most nearly the maximum bending stress in the beam?

\[ F = 10 \text{ kN} \]

\[ \begin{array}{c}
A \\
\hline
C \\
\hline
B
\end{array} \]

\[ \text{2 m} \quad \text{2 m} \]

\[ \begin{array}{c}
\text{25 mm} \\
\hline
\text{30 mm} \\
\hline
\text{600 mm} \\
\hline
\text{NA} \\
\hline
\text{25 mm} \\
\hline
\text{200 mm} \\
\hline
\text{cross section}
\end{array} \]

(A) 2300 kPa  (B) 3200 kPa  (C) 3800 kPa  (D) 4600 kPa
MECHANICS OF MATERIALS-40

For the cantilever beam shown, what is the maximum tensile bending stress?

\[ w = 10 \text{ kN/m} \]

(A) 230 MPa  (B) 320 MPa  (C) 480 MPa  (D) 550 MPa
MECHANICS OF MATERIALS - 50

A composite beam made of steel and wood is subjected to a uniform distributed load, \( w \). Determine the maximum compressive stress in the steel.

\[ w = 26 \text{ kN/m} \]

(A) 620 MPa  (B) 850 MPa  (C) 1100 MPa  (D) 1200 MPa
MECHANICS OF MATERIALS – 52
An I-beam is loaded as shown. What is most nearly the maximum shear stress, \( \tau \), in the web at point C along the beam?

\[
\begin{align*}
&\text{2 kN} \quad \text{1 kN} \\
&A \quad C \quad B
\end{align*}
\]

(A) 160 kPa  (B) 370 kPa  (C) 400 kPa  (D) 750 kPa

MECHANICS OF MATERIALS – 53
An I-beam is made of three planks, each 20 mm \( \times \) 100 mm in cross section, nailed together with a single row of nails on top and bottom as shown. If the longitudinal spacing between the nails is 25 mm, and the vertical shear force acting on the cross-section is 600 N, what is most nearly the load in shear per nail, \( F \)?

\[
\begin{align*}
&\text{100 mm} \\
&\text{20 mm} \quad \text{20 mm} \\
&\text{100 mm}
\end{align*}
\]

(A) 56 N  (B) 76 N  (C) 110 N  (D) 160 N
MECHANICS OF MATERIALS—54
Considering the orientation of shear force $\tau_{xy}$ in the illustration, find the direction of the shear stress on the other three sides of the stress element.

(A) \hspace{1cm} (B) \hspace{1cm} (C) \hspace{1cm} (D)

MECHANICS OF MATERIALS—55
If the principal stresses on a body are $\sigma_1 = 400$ kPa, $\sigma_2 = -700$ kPa, and $\sigma_3 = 600$ kPa, what is the maximum shear stress?

(A) $150$ kPa \hspace{1cm} (B) $250$ kPa \hspace{1cm} (C) $550$ kPa \hspace{1cm} (D) $650$ kPa
MECHANICS OF MATERIALS—56
For the element of plane stress shown, find the principal stresses.

![Stress Diagram](image)

(A) \(\sigma_{\text{max}} = 35 \text{ MPa}, \sigma_{\text{min}} = -25 \text{ MPa}\)
(B) \(\sigma_{\text{max}} = 45 \text{ MPa}, \sigma_{\text{min}} = 55 \text{ MPa}\)
(C) \(\sigma_{\text{max}} = 70 \text{ MPa}, \sigma_{\text{min}} = -30 \text{ MPa}\)
(D) \(\sigma_{\text{max}} = 85 \text{ MPa}, \sigma_{\text{min}} = 15 \text{ MPa}\)

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MECHANICS OF MATERIALS—57
What are the principal (maximum and minimum) stresses of the stress element shown?

![Stress Diagram](image)

(A) \(\sigma_{\text{max}} = 1.16 \text{ kPa}, \sigma_{\text{min}} = -6.16 \text{ kPa}\)
(B) \(\sigma_{\text{max}} = 2.00 \text{ kPa}, \sigma_{\text{min}} = -4.00 \text{ kPa}\)
(C) \(\sigma_{\text{max}} = 3.24 \text{ kPa}, \sigma_{\text{min}} = -5.24 \text{ kPa}\)
(D) \(\sigma_{\text{max}} = 5.24 \text{ kPa}, \sigma_{\text{min}} = -3.24 \text{ kPa}\)
MECHANICS OF MATERIALS-61

A steel ($\sigma_{\text{yield}} = 200 \text{ MPa}$) pressure tank is designed to hold pressures up to 7 MPa. The tank is cylindrical with a diameter of 1 m. If the longitudinal stress must be less than 20% of the yield stress of the steel, what is the necessary wall thickness, $t$?

(A) 22 mm \hspace{1cm} (B) 44 mm \hspace{1cm} (C) 88 mm \hspace{1cm} (D) 120 mm

MECHANICS OF MATERIALS-62

In designing a cylindrical pressure tank 1 m in diameter, a factor of safety of 2.5 is used. The cylinder is made of steel ($\sigma_{\text{yield}} = 200 \text{ MPa}$), and will contain pressures up to 7 MPa. What is the required wall thickness, $t$, based on circumferential stress considerations?

(A) 22 mm \hspace{1cm} (B) 44 mm \hspace{1cm} (C) 88 mm \hspace{1cm} (D) 120 mm
What is the deflection at point B for the beam shown?

(A) 17 mm    (B) 25 mm    (C) 36 mm    (D) 48 mm
MECHANICS OF MATERIALS—66

What is the Euler buckling load for a 10 m long steel column pinned at both ends and with the given properties and cross section?

\[ I_{x'x'} = 3.70 \times 10^6 \text{ mm}^4 \]
\[ E = 200 \text{ GPa} \]

(A) 15 kN  (B) 24 kN  (C) 43 kN  (D) 73 kN
1. The element is subjected to the plane stress condition shown.

\[ \sigma_x = -140 \text{ MPa} \]
\[ \sigma_y = 205 \text{ MPa} \]
\[ \tau_{xy} = 100 \text{ MPa} \]

What is the maximum shear stress?
(A) 100 MPa
(B) 160 MPa
(C) 200 MPa
(D) 210 MPa

2. A plane element in a body is subjected to a normal tensile stress in the x-direction of 84 MPa, as well as shear stresses of 28 MPa, as shown.

Most nearly, what are the principal stresses?
(A) 70 MPa; 14 MPa
(B) 84 MPa; 28 MPa
(C) 92 MPa; -8.5 MPa
(D) 112 MPa; -28 MPa
3. What is most nearly the lateral strain, $\varepsilon_y$, of the steel specimen shown if $F_x = 3000$ kN, $E = 193$ GPa, and $\nu = 0.29$?

\[(A) \ -4.0 \times 10^{-4} \]
\[(B) \ -1.1 \times 10^{-4} \]
\[(C) \ 1.0 \times 10^{-4} \]
\[(D) \ 4.0 \times 10^{-4} \]

4. The elements are subjected to the plane stress condition shown. The maximum shear stress is $109.2$ MPa.

$\sigma_x = -75$ MPa
$\sigma_y = 110$ MPa
$\tau_{xy} = 58$ MPa

What are the orientations of the stress planes (relative to the x-axis)?

\[(A) \ -74^\circ; 15^\circ \]
\[(B) \ -58^\circ; 32^\circ \]
\[(C) \ -32^\circ; 58^\circ \]
\[(D) \ -16^\circ; 74^\circ \]
5. What is most nearly the elongation of the aluminum bar (cross section of 3 cm x 3 cm) shown when loaded to its yield point? The modulus of elasticity is 69 GPa, and the yield strength in tension is 255 MPa. Neglect the weight of the bar.

\[ L = 2.5 \text{ m} \]

\( F \)

(A) 3.3 mm  
(B) 9.3 mm  
(C) 12 mm  
(D) 15 mm

6. The column shown has a cross-sectional area of 13 m².

What is the approximate maximum load if the compressive stress cannot exceed 9.6 kPa?

(A) 120 kN  
(B) 122 kN  
(C) 125 kN  
(D) 130 kN
7. The element is subjected to the plane stress condition shown. The maximum shear stress is 300 MPa.

\[
\begin{align*}
\sigma_x &= -310 \text{ MPa} \\
\sigma_y &= 250 \text{ MPa} \\
\tau_{xy} &= 110 \text{ MPa}
\end{align*}
\]

The principal stresses are most nearly

(A) 250 MPa; -310 MPa
(B) 270 MPa; -330 MPa
(C) 330 MPa; -270 MPa
(D) 310 MPa; -250 MPa

8. Given a shear stress of \( \tau_{xy} = 35 \text{ MPa} \) and a shear modulus of \( G = 75 \text{ GPa} \), the shear strain is most nearly

(A) \( 2.5 \times 10^{-5} \) rad
(B) \( 4.7 \times 10^{-4} \) rad
(C) \( 5.5 \times 10^{-4} \) rad
(D) \( 8.3 \times 10^{-4} \) rad
9. Which of the following could be the Poisson ratio of a material?

(A) 0.35  
(B) 0.52  
(C) 0.55  
(D) 0.60

10. A plane element in a body is subjected to the stresses shown.

What is most nearly the maximum shear stress?

(A) 50 MPa  
(B) 64 MPa  
(C) 72 MPa  
(D) 78 MPa
1. The maximum torque on a 0.15 m diameter solid shaft is 13500 N·m. What is most nearly the maximum shear stress in the shaft?
   (A) 20 MPa
   (B) 23 MPa
   (C) 28 MPa
   (D) 34 MPa

2. The unrestrained glass window shown is subjected to a temperature change from 0°C to 50°C. The coefficient of thermal expansion for the glass is $8.8 \times 10^{-6} \text{ 1/C}$.

What is most nearly the change in area of the glass?
   (A) 0.00040 m²
   (B) 0.0013 m²
   (C) 0.0021 m²
   (D) 0.0028 m²
3. The cylindrical steel tank shown is 3.5 m in diameter, 5 m high, and filled with a brine solution. Brine has a density of 1198 kg/m³. The thickness of the steel shell is 12.5 mm. Neglect the weight of the tank.

What is the approximate hoop stress in the steel 0.65 m above the rigid concrete pad?

(A) 1.2 MPa
(B) 1.4 MPa
(C) 7.2 MPa
(D) 11 MPa

4. A steel shaft is shown. The shear modulus is 80 GPa.

Most nearly, what torque should be applied to the end of the shaft in order to produce a twist of 1.5°?

(A) 420 N·m
(B) 560 N·m
(C) 830 N·m
(D) 1100 N·m
5. For the shaft shown, the shear stress is not to exceed 110 MPa. 

\[ r_1 = 0.015 \text{ m} \]
\[ r_2 = 0.025 \text{ m} \]

What is most nearly the largest torque that can be applied?

(A) 1700 N-m  
(B) 1900 N-m  
(C) 2300 N-m  
(D) 3400 N-m

6. An aluminum (shear modulus = 2.8 \times 10^{10} \text{ Pa}) rod is 25 mm in diameter and 50 cm long. One end is rigidly fixed to a support. Most nearly, what torque must be applied at the free end to twist the rod 4.5° about its longitudinal axis?

(A) 26 N-m  
(B) 84 N-m  
(C) 110 N-m  
(D) 170 N-m
7. A circular bar at 10°C is constrained by rigid concrete walls at both ends. The bar is 1000 mm long and has a cross-sectional area of 2600 mm².

![Diagram of a circular bar with dimensions and cross-sectional area labeled.]

\[ E = \text{modulus of elasticity} = 200 \text{ GPa} \]
\[ \alpha = \text{coefficient of thermal expansion} = 9.4 \times 10^{-6} \text{ 1/°C} \]

What is most nearly the axial force in the bar if the temperature is raised to 40°C?

(A) 92 kN  
(B) 110 kN  
(C) 130 kN  
(D) 150 kN

8. A 3 m diameter bar experiences opposing torques of 280 N·m at each end.

![Diagram of a circular bar with opposing torques labeled.]

What is most nearly the maximum shear stress in the bar?

(A) 2.2 Pa  
(B) 31 Pa  
(C) 42 Pa  
(D) 53 Pa
9. A 12.5 mm diameter steel rod is pinned between two rigid walls. The rod is initially unstressed. The rod’s temperature subsequently increases 50°C. The rod is adequately stiffened and supported such that buckling does not occur. The coefficient of linear thermal expansion for steel is \(11.7 \times 10^{-6}\) °C. The modulus of elasticity for steel is 210 GPa.

What is the approximate axial force in the rod?  
(A) 2.8 kN  
(B) 15 kN  
(C) 19 kN  
(D) 58 kN

10. 10 km of steel railroad track are placed when the temperature is 20°C. The linear coefficient of thermal expansion for the rails is \(11 \times 10^{-6}\) 1/°C. The track is free to slide forward. Most nearly, how far apart will the ends of the track be when the temperature reaches 50°C?  
(A) 10.0009 km  
(B) 10.0027 km  
(C) 10.0033 km  
(D) 10.0118 km
11. A deep-submersible diving bell has a cylindrical pressure hull with an outside diameter of 3.5 m and a wall thickness of 15 cm constructed from a ductile material. The hull is expected to experience an external pressure of 50 MPa. The hull should be designed as a

- (A) thin-walled pressure vessel using the outer radius in the stress calculations
- (B) thin-walled pressure vessel using the logarithmic mean area in stress calculations
- (C) thin-walled pressure vessel using factors of safety of at least 4 for ductile materials and at least 8 for brittle components such as viewing ports
- (D) thick-walled pressure vessel

12. A cantilever horizontal hollow tube is acted upon by a vertical force and a torque at its free end.

Where is the maximum stress in the cylinder?

- (A) at the upper surface at midlength ($L/2$)
- (B) at the lower surface at the built-in end
- (C) at the upper surface at the built-in end
- (D) at both the upper and lower surfaces at the built-in end
13. One end of the hollow aluminum shaft is fixed, and the other end is connected to a gear with an outside diameter of 40 cm as shown. The gear is subjected to a tangential gear force of 45 kN. The shear modulus of the aluminum is $2.8 \times 10^{10}$ Pa.

What are most nearly the maximum angle of twist and the shear stress in the shaft?

(A) 0.016 rad, 14 MPa  
(B) 0.025 rad, 220 MPa  
(C) 0.057 rad, 67 MPa  
(D) 0.25 rad, 200 MPa

14. A compressed gas cylinder for use in a laboratory has an internal gage pressure of 8 MPa at the time of delivery. The outside diameter of the cylinder is 25 cm. If the steel has an allowable stress of 90 MPa, what is the required thickness of the wall?

(A) 0.69 cm  
(B) 0.35 cm  
(C) 1.1 cm  
(D) 1.9 cm
1. For the beam shown, what is most nearly the maximum compressive stress at section D-D, 1.5 m from the left end?

(A) 63 MPa  
(B) 110 MPa  
(C) 230 MPa  
(D) 330 MPa

2. Refer to the beam shown. The beam is fixed at one end. The beam has a mass of 46.7 kg/m. The modulus of elasticity of the beam is 200 GPa; the moment of inertia is 4680 cm$^4$.

The upward force at B is 1500 N. What is most nearly the net deflection of the beam at a point 1.2 m from the fixed end?

(A) −0.32 mm (downward)  
(B) −0.29 mm (downward)  
(C) 0.12 mm (upward)  
(D) 0.17 mm (upward)
3. Refer to the simply supported beam shown.

What is most nearly the maximum bending moment?
(A) 340 N·m
(B) 460 N·m
(C) 660 N·m
(D) 890 N·m

4. Refer to the cantilevered structural section shown.
The beam is manufactured from steel with a modulus of elasticity of 210 GPa. The beam’s cross-sectional area is 37.9 cm²; its moment of inertia is 2880 cm⁴. The beam has a mass of 45.9 kg/m. A 6000 N compressive force is applied at the top of the beam, at an angle of 30° from the horizontal. Neglect buckling.

What is most nearly the maximum shear force in the beam?
(A) 3000 N
(B) 3900 N
(C) 5200 N
(D) 6100 N
5. For the cantilever steel rod shown, what is most nearly the force, $F$, necessary to deflect the rod a vertical distance of 7.5 mm?

(A) 6900 N
(B) 8800 N
(C) 11000 N
(D) 17000 N

6. Refer to the simply supported beam shown.

What is most nearly the maximum shear?

(A) 500 N
(B) 1000 N
(C) 1500 N
(D) 2000 N
7. Refer to the cantilevered structural section shown. The beam is manufactured from steel with a modulus of elasticity of 200 GPa. The beam's cross-sectional area is 74 cm$^2$; its moment of inertia is 8700 cm$^4$. The beam has a mass of 60 kg/m. A 2500 N compressive force is applied at the top of the beam, at an angle of 22° from horizontal. Neglect buckling.

What is most nearly the approximate maximum bending moment in the beam?

(A) 5000 N·m
(B) 5200 N·m
(C) 5900 N·m
(D) 6100 N·m

8. A rectangular beam has a cross section of 5 cm wide x 10 cm deep and experiences a maximum shear of 2250 N. What is most nearly the maximum shear stress in the beam?

(A) 450 kPa
(B) 570 kPa
(C) 680 kPa
(D) 790 kPa
9. A simply supported beam supports a triangular distributed load as shown. The peak load at the right end of the beam is 5 N/m.

What is the approximate bending moment at a point 7 m from the left end of the beam?

(A) 15 N·m  
(B) 17 N·m  
(C) 28 N·m  
(D) 30 N·m

10. Refer to the cantilevered structural section shown. The beam is manufactured from steel with a modulus of elasticity of 205 GPa. The beam’s cross-sectional area is 86 cm²; its moment of inertia is 24400 cm⁴. A 3700 N compressive force is applied at the top of the beam, at an angle of 40° from horizontal. A counterclockwise moment of 600 N·m is applied to the free end. Neglect beam self-weight, and neglect buckling.

What is most nearly the deflection at the tip of the beam due to the external force alone (i.e., neglecting the beam’s own mass)?

(A) 0.63 mm  
(B) 0.82 mm  
(C) 1.2 mm  
(D) 2.5 mm
10. Refer to the cantilevered structural section shown. The beam is manufactured from steel with a modulus of elasticity of 205 GPa. The beam's cross-sectional area is 86 cm$^2$; its moment of inertia is 24400 cm$^4$. A 3700 N compressive force is applied at the top of the beam, at an angle of 40° from horizontal. A counterclockwise moment of 600 N-m is applied to the free end. Neglect beam self-weight, and neglect buckling.

What is most nearly the deflection at the tip of the beam due to the external force alone (i.e., neglecting the beam's own mass)?

(A) 0.63 mm  
(B) 0.82 mm  
(C) 1.2 mm  
(D) 2.5 mm

1. A steel column with a cross section of 12 cm $\times$ 16 cm is 4 m in height and fixed at its base. The column is pinned against translation in its weak direction at the top but is unbraced in its strong direction. The column's modulus of elasticity is $2.1 \times 10^5$ MPa.

What is most nearly the maximum theoretical vertical load the column can support without buckling?

(A) 1.3 MN  
(B) 5.2 MN  
(C) 6.1 MN  
(D) 11 MN
2. A 10 cm × 10 cm square column supports a compressive force of 9000 N. The load is applied with an eccentricity of 2.5 cm along one of the lines of symmetry. What is most nearly the maximum tensile stress in the column?

(A) 450 kPa
(B) 900 kPa
(C) 1400 kPa
(D) 2300 kPa

3. A square column with a solid cross section is placed in a building to support a load of 5 MN. The maximum allowable stress in the column is 350 MPa. The column reacts linearly to all loads. If the contractor is permitted to load the column anywhere in the central one-fifth of the column’s cross section, what are most nearly the smallest possible dimensions of the column?

(A) 12 cm × 12 cm
(B) 14 cm × 14 cm
(C) 16 cm × 16 cm
(D) 18 cm × 18 cm
4. What is most nearly the maximum resultant normal stress at A for the cantilever beam shown?

(A) 7.2 MPa
(B) 9.4 MPa
(C) 9.8 MPa
(D) 9.9 MPa

5. A rectangular steel bar 37.5 mm wide and 50 mm thick is pinned at each end and subjected to axial compression. The bar has a length of 1.75 m. The modulus of elasticity is 200 GPa. What is most nearly the critical buckling load?

(A) 60 kN
(B) 93 kN
(C) 110 kN
(D) 140 kN