Mechanics of Materials
CIVL 3322 / MECH 3322

Torsion Problems

CHECK OUT MY NEW HDTV — A BEAUTIFUL, HIGH-DEF 1080p.
WOW, THAT’S OVER TWICE THE HORIZONTAL RESOLUTION OF MY CELL PHONE.
IN FACT, IT ALMOST BEATS THE LCD MONITOR I GOT IN 2004.

IT BAFFLES ME THAT PEOPLE FIND HDTV IMPRESSIVE.

Homework

- P 6.17
- P 6.18
- P 6.20
For the material properties shown in Figure 1, what is the Modulus of Elasticity of the material?

- 260 GPa
- 110 GPa
- 800 GPa
- 358 GPa

For the material properties shown in Figure 1, what is the ultimate strength of the material?

- 210 MPa
- 290 MPa
- 320 MPa
- 380 MPa
For the material properties shown in Figure 1, what is the yield strength of the material?

- 210 MPa
- 290 MPa
- 320 MPa
- 380 MPa

For the material properties shown in Figure 1, what is the fracture stress of the material?

- 210 MPa
- 290 MPa
- 320 MPa
- 380 MPa
The rigid bar shown in Figure 2 is supported by the pin at A and the rod from B to D (1). The rod (1) has a cross sectional area of 500 mm$^2$, an elastic modulus of $E = 80$ GPa, and a coefficient of thermal expansion of $\alpha = 22 \times 10^{-6}/\text{C}$. Initially the bar ABC is in a horizontal position, then the temperature of the rod (1) is reduced by 40°C. What is the deflection of point C after the temperature is reduced if the load P is equal to 0?

When rod (1) is cooled, point B will

1. Move Up
2. Move Down
3. Not Move
4. Don’t Know
The magnitude of the deflection of point C will be ______ than the magnitude of the deflection of point B when Rod (1) is cooled.

1. Equal to
2. Less than
3. Greater than
4. Don’t Know

The rigid bar shown in Figure 2 is supported by the pin at A and the rod from B to D (1). The rod (1) has a cross sectional area of 500 mm², an elastic modulus of \( E = 80 \text{ GPa} \), and a coefficient of thermal expansion of \( \alpha = 22 \times 10^{-6}/\text{C} \). Initially the bar ABC is in a horizontal position, then the temperature of the rod (1) is reduced by 40°C. What is the deflection of point C after the temperature is reduced if the load \( P \) is equal to 0?

\[
\delta_C = \frac{(\delta_B)(L_{AC})}{L_{AB}} = \frac{(-3.3 \times 10^{-3} \text{ m})(3.0 \text{ m})}{1.75 \text{ m}} = -5.66 \text{ mm}
\]
The rigid bar shown in Figure 2 is supported by the pin at A and the rod from B to D (1). The rod (1) has a cross sectional area of 500 mm², an elastic modulus of $E = 80$ GPa, and a coefficient of thermal expansion of $a = 22 \times 10^{-6}/\text{C}$. Initially the bar ABC is in a horizontal position, then the temperature of the rod (1) is reduced by 40°C. What magnitude would $P$ have to be to return the rod to a horizontal orientation after the temperature is reduced?

To solve for $P$, you would most likely

1. Sum forces in the y-direction
2. Sum forces in the x-direction
3. Sum moments about A
4. Don’t Know
To find the force in rod (1) directly, you would most use

1. The deflection at C
2. The deflection at A
3. The deflection at B
4. Don’t Know

The rigid bar shown in Figure 2 is supported by the pin at A and the rod from B to D (1). The rod (1) has a cross sectional area of 500 mm$^2$, an elastic modulus of $E = 80$ GPa, and a coefficient of thermal expansion of $\alpha = 22 \times 10^{-6}$/°C. Initially the bar ABC is in a horizontal position, then the temperature of the rod (1) is reduced by 40°C. What magnitude would $P$ have to be to return the rod to a horizontal orientation after the temperature is reduced?

$$P = \frac{-(F_i)(L_{AB})}{(L_{AC})} = \frac{-(35.2kN)(1.75m)}{(3.0m)} = 20.53kN$$
Two cylindrical rods, one of steel and the other of brass, are joined at C and restrained by rigid supports at A and E. $E_{\text{STEEL}} = 200 \text{ GPa}$ and $E_{\text{BRASS}} = 105 \text{ GPa}$.

What is the magnitude of the support reaction at point A?

$$R_A = \frac{(60\omega N)L_{CD} - (100\omega N)L_{D\ell}}{E_{\text{STEEL}}A_{\text{STEEL}} + E_{\text{BRASS}}A_{\text{BRASS}}} = \frac{(60\omega N)(120\text{mm}) - (100\omega N)(100\text{mm})}{(200\text{GPa})(1257\text{mm}^2) + (105\text{GPa})(708.9\text{mm}^2)} = 62.81\omega N$$

What is the magnitude of the support reaction at point E?

$$R_E = 60kN + 40kN - R_A = 60kN + 40kN - 62.81kN = 37.19kN$$
Two cylindrical rods, one of steel and the other of brass, are joined at C and restrained by rigid supports at A and E. $E_{\text{STEEL}} = 200 \text{ GPa}$ and $E_{\text{BRASS}} = 105 \text{ GPa}$.

What is the deflection of point C?

\[
\delta_c = \frac{F_{AB}L_{AB}}{E_{\text{Steel}}A_{\text{Steel}}} + \frac{F_{AC}L_{AC}}{E_{\text{Brass}}A_{\text{Brass}}} = \frac{(62.81 \text{kN})(180 \text{mm})}{(200 \text{GPa})(1257 \text{mm}^2)} + \frac{(2.81 \text{kN})(120 \text{mm})}{(200 \text{GPa})(1257 \text{mm}^2)} = 0.046 \text{mm}
\]

What is the stress in the Steel rod in the section between points A and B?

\[
\sigma_{AB} = \frac{F_{AB}}{A_{\text{Steel}}} = \frac{62.81 \text{kN}}{1257 \text{mm}^2} = 49.98 \text{MPa}
\]
Two cylindrical rods, one of steel and the other of brass, are joined at C and restrained by rigid supports at A and E. $E_{\text{steel}} = 200$ GPa and $E_{\text{brass}} = 105$ GPa.

What is the stress in the Brass rod in the section between points D and E?

$$\sigma_{DE} = -\frac{F_{DE}}{A_{\text{brass}}} = -\frac{37.19kN}{706.86mm^2} = -52.62MPa$$

The rigid bar AD is supported by two steel wires of 1/16-in. diameter ($E = 29 \times 10^6$ psi) and a pin at D. The bar is horizontal before the load P is applied. The load P has a magnitude of 120-lb. After P is applied, what is the tension in the wire from A to E?
The relationship between the deflections at A and C is

1. $w_{EA} > w_{FC}$
2. $w_{EA} = w_{FC}$
3. $w_{EA} > w_{FC}$
4. Don’t Know
Torsion Problems

The rigid bar AD is supported by two steel wires of 1/16 -in. diameter (E = \(29 \times 10^6\) psi) and a pin at D. The bar is horizontal before the load \(P\) is applied. The load \(P\) has a magnitude of 120-lb. After \(P\) is applied

What is the tension in the wire from A to E?

\[
F_{CF} = \frac{5}{8} F_{AE}\\
(16\text{ in})(120\text{ lb}) = (24\text{ in})(F_{AE}) + (8\text{ in})(\frac{5}{8} F_{AE})\\
F_{AE} = 66.21\text{ lb}
\]

What is the tension in the wire from C to F?

\[
F_{AE} = 66.21\text{ lb}\\
F_{CF} = \frac{5}{8} F_{AE} = \frac{5}{8} \times 66.21\text{ lb} = 41.38\text{ lb}
\]
The rigid bar AD is supported by two steel wires of 1/16 -in. diameter (E = 29x10^6 psi) and a pin at D. The bar is horizontal before the load P is applied. The load P has a magnitude of 120-lb. After P is applied
What is the strain in the wire from A to E?

\[ \varepsilon_{AE} = \frac{\delta_{AE}}{L_{AE}} = \frac{0.11 \text{ in}}{15 \text{ in}} = 0.0067 \text{ in} / \text{ in} \]

What is the deflection of point B from the original unloaded horizontal position?

\[ \delta_B = \delta_{AE} \frac{BD}{AD} = (0.11 \text{ in}) \left( \frac{16 \text{ in}}{24 \text{ in}} \right) = 0.073 \text{ in} \]
Problem 6.4

6.4 A compound shaft consists of two pipe segments. Segment (1) has an outside diameter of 200 mm and a wall thickness of 10 mm. Segment (2) has an outside diameter of 150 mm and a wall thickness of 10 mm. The shaft is subjected to torques $T_B = 42$ kN-m and $T_C = 18$ kN-m, which act in the directions shown in Fig. P6.4. Determine the maximum shear stress magnitude in each shaft segment.

Fig. P6.4

Problem 6.12

6.12 A hollow steel shaft with an outside diameter of 85 mm and a wall thickness of 10 mm is subjected to a pure torque of $T = 7,000$ N-m. The shear modulus of the steel is $G = 80$ GPa. Determine:
(a) the maximum shear stress in the shaft.
(b) the magnitude of the angle of twist in a 2.5-m length of shaft.
Problem 6.16

6.16 A compound steel \( G = 80 \text{ GPa} \) shaft (Fig. P6.16) consists of a solid 55-mm-diameter segment (1) and a solid 40-mm-diameter segment (2). The allowable shear stress of the steel is 70 MPa, and the maximum rotation angle at the free end of the compound shaft must be limited to \( \phi \leq 3^\circ \). Determine the magnitude of the largest torque \( T_C \) that may be applied at C.