

Exercise walk-through

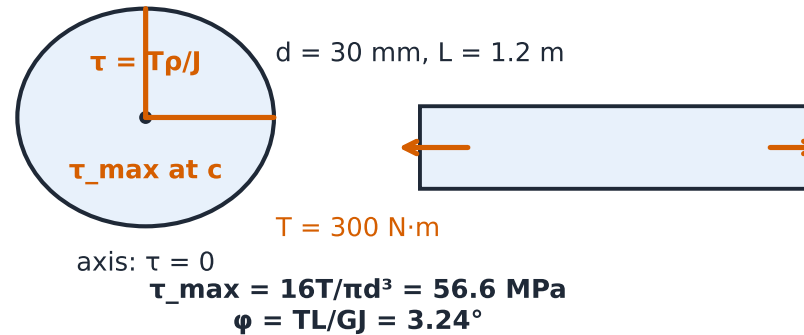
6.2

Torsion

University Mechanical Engineering

Torsion: shear to the surface, twist along L

torsion: shear grows linearly to the surface



Shaft $d = 30 \text{ mm}$, $T = 300 \text{ N} \cdot \text{m}$: $\tau_{\text{max}} = 16T/\pi d^3 = 56.6 \text{ MPa}$, $\phi = TL/GJ = 3.24^\circ$. At 180 rpm it sells $P = T\omega = 5.65 \text{ kW}$.

Exercises 2.1-2.2

2.1 A shaft of $d = 40$ mm, $L = 2.0$ m carries $T = 600$ N m (steel, $G = 80$ GPa): the maximum shear stress (one decimal, MPa) and the angle of twist (two decimals, degrees). [5]

2.2 The same torque at 240 rpm: the transmitted power (one decimal, kW). [3]

Exercises 2.1-2.2

2.1 A shaft of $d = 40$ mm, $L = 2.0$ m carries $T = 600$ N m (steel, $G = 80$ GPa): the maximum shear stress (one decimal, MPa) and the angle of twist (two decimals, degrees). [5]

2.1

- $\tau_{max} = 16T/\pi d^3 = 9600/(0.2011 \times 10^{-3}) = \mathbf{47.7}$ MPa.
- $J = \pi(0.04)^4/32 = 2.513 \times 10^{-7} \text{ m}^4$; $\phi = 1200/(2.011 \times 10^4) = \mathbf{0.0597}$ rad.
- $\phi = 0.0597 \times 180/\pi = \mathbf{3.42}^\circ$.

2.2 The same torque at 240 rpm: the transmitted power (one decimal, kW). [3]

2.2

- $\omega = 2\pi(240)/60 = 25.13$ rad/s.
- $P = T\omega = 600 \times 25.13 = \mathbf{15.1}$ kW.

Exercises 2.3·2.4

2.3 A shaft for $T = 800 \text{ N m}$ at $\tau_{allow} = 75 \text{ MPa}$: the required diameter (one decimal, mm). [3]

2.4 One sentence each: where is torsional shear zero and where is it worst, and why does a longer shaft twist more? [3]

Exercises 2.3-2.4

2.3 A shaft for $T = 800 \text{ N m}$ at $\tau_{allow} = 75 \text{ MPa}$: the required diameter (one decimal, mm). [3]

2.3

- $d^3 = 16 \times 800 \times 10^3 / (\pi \times 75) = \mathbf{54,330} \text{ mm}^3$, so $d = \mathbf{37.9} \text{ mm}$.

2.4 One sentence each: where is torsional shear zero and where is it worst, and why does a longer shaft twist more? [3]

2.4

- Zero on the axis, worst at the surface: $\tau = T\rho/J$ is linear in radius.
- $\phi = TL/GJ$ is linear in L - twist accumulates along the shaft.