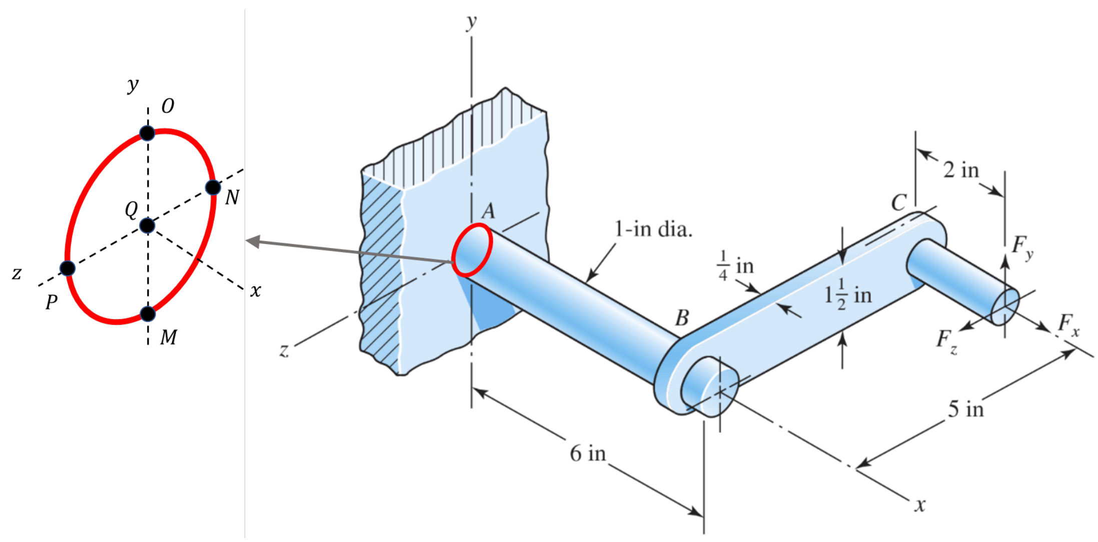
Machine Design - 1



Consider the structure shown above loaded with forces F_x, F_y, and F_z. The structure is made of AISI 1020 CD steel ($S_y = 57$ kpsi).

(a) **[10 points]** F_x generates the following types of stresses at the fixed end of the beam (select all that apply).

Axial stress / Bending Stress / Transverse Shear / Torsional Shear / None

(b) **[10 points]** F_y generates the following types of stresses at the fixed end of the beam (select all that apply).

Axial stress / Bending Stress / Transverse Shear / Torsional Shear / None

(c) **[10 points]** F_z generates the following types of stresses at the fixed end of the beam (select all that apply).

Axial stress / Bending Stress / Transverse Shear / Torsional Shear / None

Answer the following for the applied forces: $\boldsymbol{F_x = F_z = 0}$ **lbf** and $\boldsymbol{F_y = 175}$ **lbf**

(d) **[10 points]** What are the reaction forces and moments acting at the fixed end A of the structure?

(e) **[25 points]** Identify the critical point on the cross-section at the fixed end from M, N, O, P, and Q (shown above). Determine the factor of safety using maximum shear stress (MSS) theory at this critical point.

Answer the following for the applied forces: $\boldsymbol{F_y = F_z = 0}$ **lbf** and $\boldsymbol{F_x = 400}$ **lbf**

(f) **[10 points]** What are the reaction forces and moments acting at the fixed end A of the structure?

(g) **[25 points]** Identify the critical point on the cross-section at the fixed end from M, N, O, P, and Q (shown above). Determine the factor of safety using maximum shear stress (MSS) theory at this critical point.

Useful equations:

Geometry

Moment of Inertia (circular cross-section with diameter d)

$$I = \frac{\pi d^4}{64} \quad J = \frac{\pi d^4}{32}$$

Stresses

Axial:

$$\sigma = \frac{P}{A}$$

Bending:

$$\sigma = \frac{-M \cdot y}{I}$$

Transverse Shear:

$$\tau = \frac{V \cdot Q}{I \cdot b}$$

$\tau_{max} = \frac{3V}{2A}$ Rectangular beams

$\tau_{max} = \frac{4V}{3A}$ Circular beams

$\tau_{max} = \frac{2V}{A}$ Hollow circular beams

Torsion (round beam):

$$\tau = \frac{T \cdot \rho}{J}$$