Mechanics of Materials II:

Thin-Walled Pressure Vessels and Torsion

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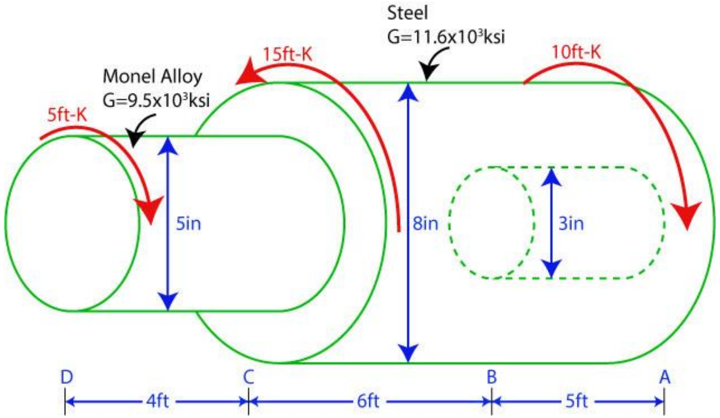
Module 17 Learning Outcome

- Solve for the maximum shear stress for elastic torsion of a straight cylindrical shaft that is non-prismatic

Elastic Torsion of Straight Cylindrical Shafts that are non-prismatic

(prismatic is a straight engineering member with the same cross-section throughout its length)

A simple model of the torsion bar of a tracked vehicle is shown below.



Elastic torsion of Straight Cylindrical Shafts that are non-prismatic

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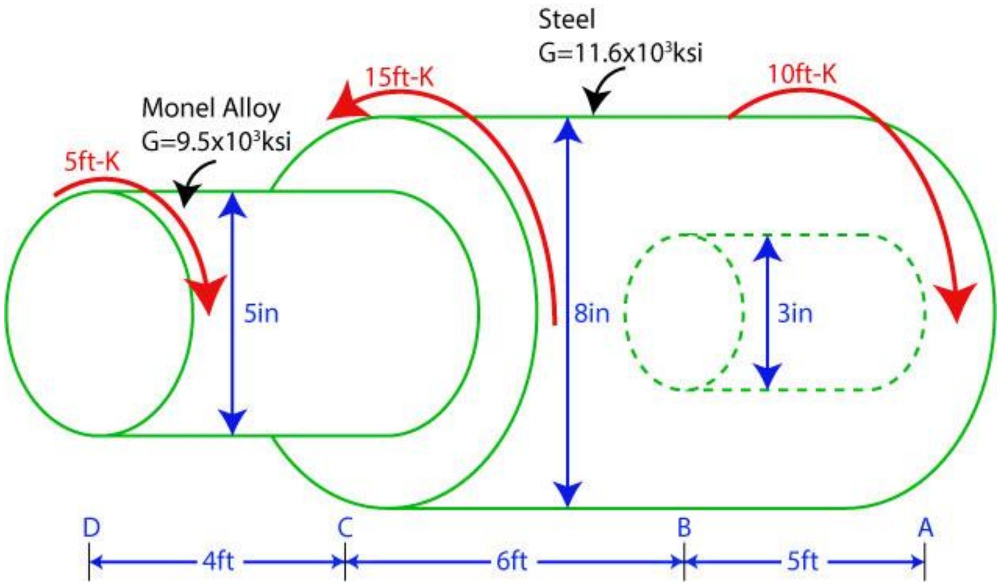
Worksheet:

The non-prismatic cylindrical bar below is subject to torques as shown.

A portion of the steel section is hollow.

a) Determine the maximum shear stress in each section.

b) Determine the angle of twist of end D with respect to end A.



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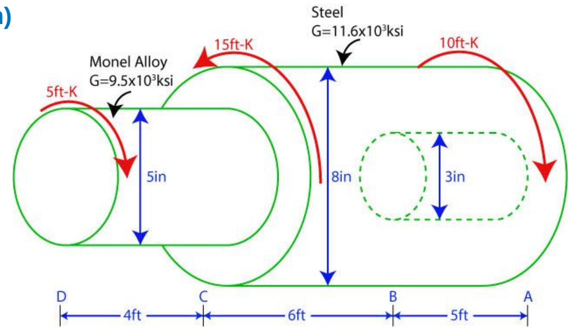

FBD – Section CD

FBD – Section BC

$$\sum M_z = 0$$

$$T_{BC} + 15 - 5 = 0$$

$$T_{BC} = -10$$

$$\vec{T}_{BC} = -10\ ft \cdot k\ \ \hat{k}$$

FBD – Section AB

$$\sum M_z = 0$$

$$T_{AB} + 15 - 5 = 0$$

$$T_{AB} = -10$$

$$\vec{T}_{AB} = -10\ ft \cdot k\ \ \hat{k}$$

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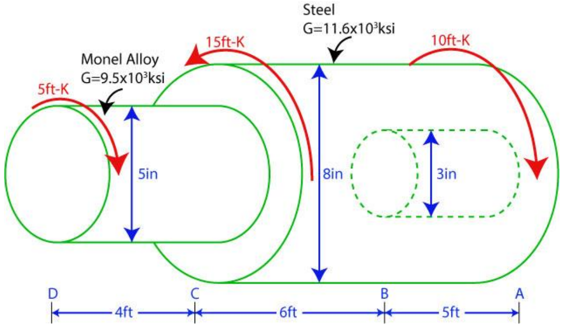

$$\vec{T}_{CD} = 5\ ft \cdot k\ \ \hat{k}$$

$$\vec{T}_{BC} = -10\ ft \cdot k\ \ \hat{k}$$

$$\vec{T}_{AB} = -10\ ft \cdot k\ \ \hat{k}$$

$$\tau_{BC_{MAX}} = \frac{10\ \ ft \cdot k\left(\frac{12\ in}{ft}\right)4\ in}{\left[\frac{\pi(4\ in)^4}{2}\right]} = 1.194\ ksi$$

ANS

$$\tau_{AB_{MAX}} = \frac{10\ \ ft \cdot k\left(\frac{12\ in}{ft}\right)4\ in}{\left[\frac{\pi(4\ in)^4}{2} - \frac{\pi(1.5\ in)^4}{2}\right]} = 1.218\ ksi$$

ANS

Both shear stresses are below the shearing proportional limit of steel, so the elastic torsion formula applies