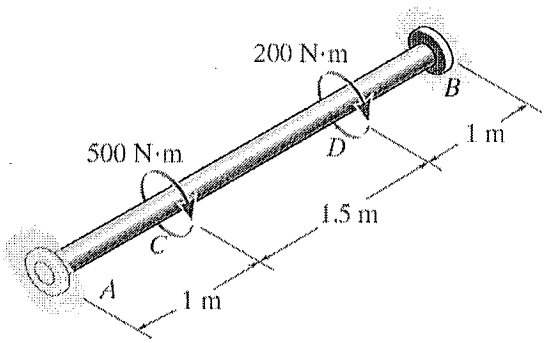
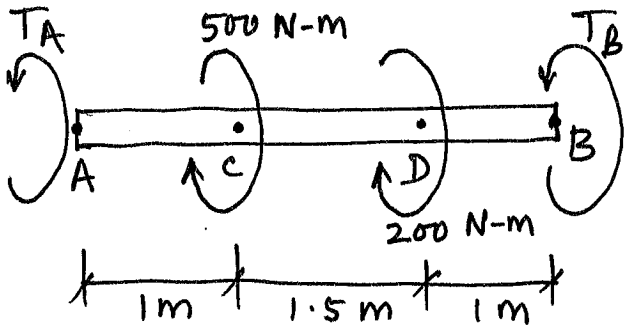
Name: Key

MECH 3130: Mechanics of Materials
Quiz-4
Spring 2012

The A-36 steel shaft has a **diameter** of 60 mm and is fixed at its ends A and B. If it is subjected to torques as shown, determine the absolute maximum shear stress in the shaft. Given, shear modulus for A-36 steel is 75 GPa.





FBD

$\Sigma T = 0 \Rightarrow -T_A + 500 + 200 - T_B = 0$

$T_A + T_B = 700$ N-m —①

Compatibility $\Rightarrow \phi_{A/B} = 0 \Rightarrow \phi_{A/C} + \phi_{C/D} + \phi_{D/B} = 0$

$\Rightarrow \left(\frac{Tl}{GJ}\right)_{AC} + \left(\frac{Tl}{GJ}\right)_{CD} + \left(\frac{Tl}{GJ}\right)_{DB} = 0$ —②

For various segments AC, CD, DB $\Rightarrow$

$T_{AC} = T_A$
$T_{CD} = T_A - 500$
$T_{DB} = T_A - 700$

Using these in eq. ② $\Rightarrow$

$\frac{1}{GJ}\left[T_A \times 1 + (T_A - 500) \times 1.5 + (T_A - 700) \times 1\right] = 0$

$\therefore T_A = 414.3$ N-m
and $T_B = 285.7$ N-m ⟸

Recall, $\tau = \frac{Tr}{J}$; max. torque is T_{AC}.

$\tau = \frac{414.3 \times 0.03}{\frac{\pi}{2}(0.03)^4} = \underline{9.77 \text{ MPa}}$