CIVE 2320   Structural Analysis I

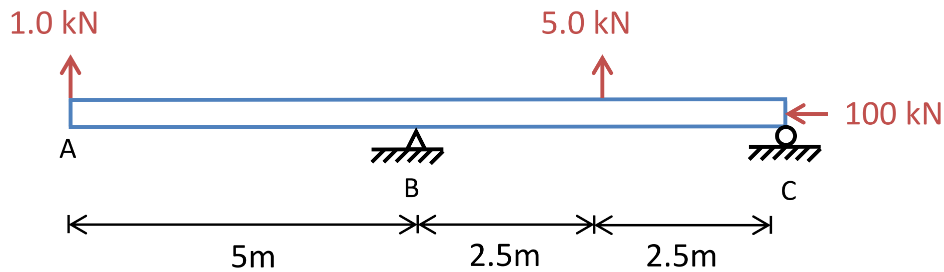
Homework #3 – Combined Beam Loading and Torsion

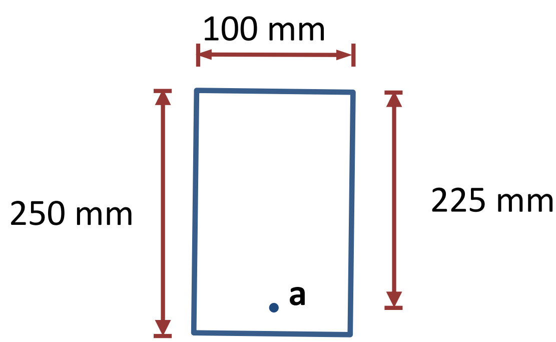
February 8, 2017   **Due date: February 16, 2017**

Submit completed assignments through Blackboard.

Problem #1 – Combined Beam Loading [30 points]

For the 100mm x 250mm rectangular beam defined below and made from a material with E = 200 GPa.





1. Solve for the reactions at B and C.
2. Draw the shear diagram for the beam, indicating numerical values. Note that axial force does not influence the shear diagram.
3. Draw the moment diagram for the beam, indicating numerical values. Note that the axial force does not influence the moment diagram.
4. For the cross-section located immediately to the left of midspan between B and C, calculate the following:
    a. The shear stress at point 'a' caused by the shear force. Note that Q can be calculated base don the first moment of área above or below point a. See Gere 5.8, pg 443 for more info.
    b. The normal stress at point 'a' caused by bending moment and axial force
    c. The principal stresses at point 'a' caused by bending moment and axial force

Problem #2 – Pure Torsion [30 points]

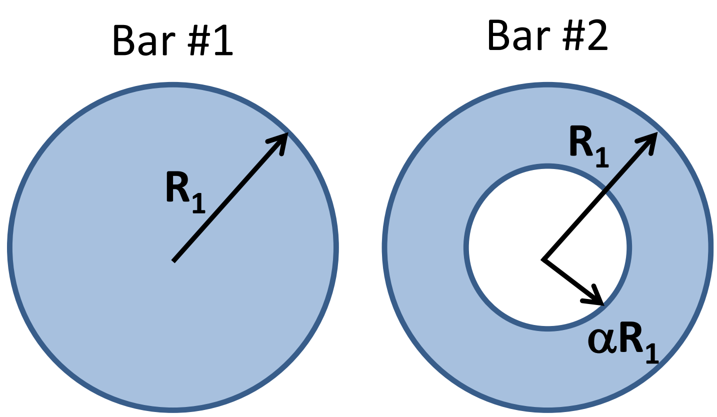
Shown below are two cross-sections of bars, one solid and one hollow, with the same length L and made from the same material with shear modulus G. Both bars are subjected to pure torsion with magnitude T. For the hollow section, the parameter α represents that ratio of the inner to the outer radius. For values of α between 0.25 and 0.75, plot the following:

1. The ratio of I_p for bar #1 to I_p in bar #2 versus α
2. The ratio of τ_{max} in bar #1 to the τ_{max} in bar #2 versus α
3. The ratio of ϕ in bar #1 to ϕ in bar #2 versus α
4. The weight of bar #1 to the weight of bar #2 versus α

Now asume that both bars are subjected to different torques, but that the torques yield the same value of τ_{max} in each bar (i.e. $\tau_{max} = \beta$). For values of α between 0.25 and 0.75, plot:

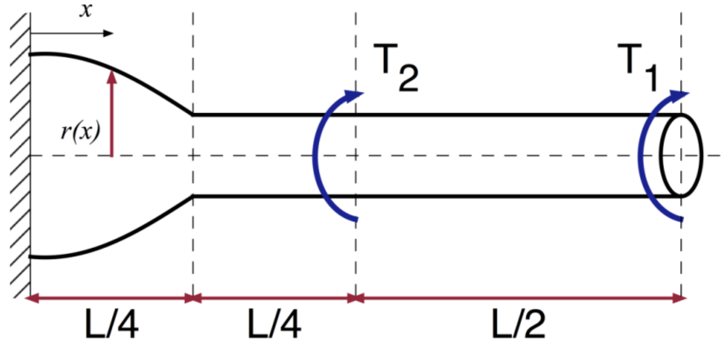
1. The strength-to-weight ratio for bar #1 divided by the strenght-to-weight ratio of bar #2 versus α. For each bar, the strength-to-weight ratio is the ratio of the torque corresponding to a maximum shear stress equal to β divided by the weight of the bar.

Comment on each of your results.



Problem #3 – Nonuniform Torsion [40 points]

Consider the following circular rod subject to two torques:

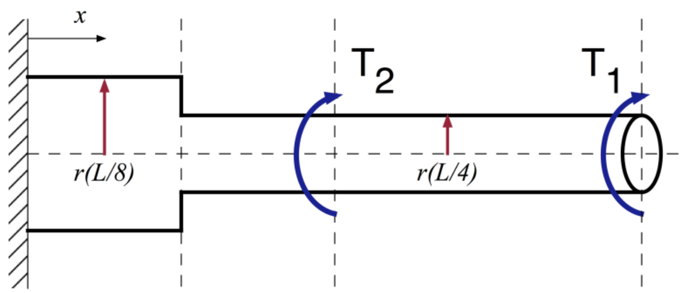


T_1 = 100 kN-m, T_2 = 50 kN-m, G = 70 GPa, L = 0.8 m, r_0= 0.2m

$$r(x) = \begin{cases} r_0\sqrt{\cos(\pi x/L)} & , \quad 0 \leq x < L/4 \\ r_0\sqrt{\cos(\pi/4)} & , \quad x > L/4 \end{cases}$$

I. Approximate Solution:

1. Solve for the reaction at x = 0 and draw the torsion diagram, T(x).
2. Approximate the radius of the nonlinear section (x < L/4) to be the midpoint value, i.e. at x = L/8, as illustrated below:



3. Calculate ϕ at x = L/4, x = L/2, and x = L.
4. Calculate τ_{max} at x = 0, x = L/8 and x = L/4.

II. Exact Solution:

1. Determine $I_P(x)$ for the nonlinear section.
2. Calculate ϕ at x = L/4, x = L/2, and x = L.
3. Calculate τ_{max} at x = 0, x = L/8 and x = L/4.
4. Calculate the error between the approximate and exact solutions for ϕ and τ_{max}. Is the approximate solution a good engineering approach?