Ph.D. Qualifying Examination

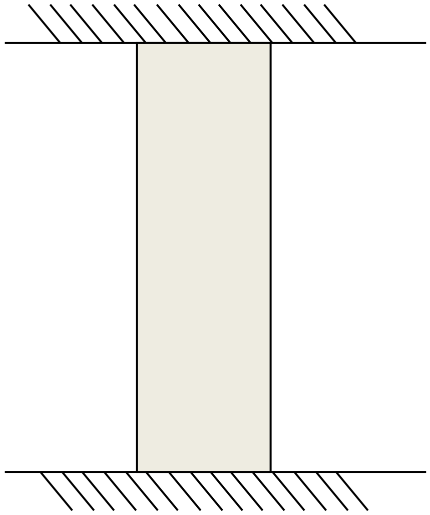
Mechanics of Materials

Summer 2022

<u>Notes:</u>

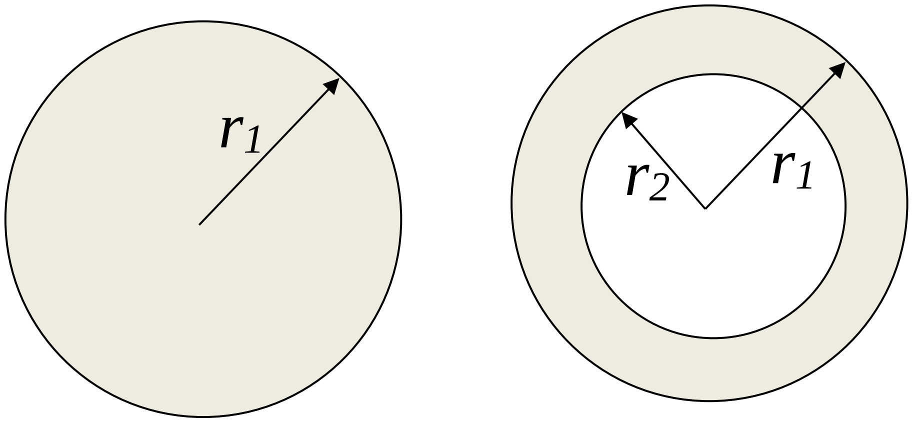
- There are a total of 4 problems.
- Time allowed: 2.5 hours.
- Exam is closed book and closed-notes (one sheet of formulas is allowed)
- Problems count 25 points each (total=100 points).
- Show your work on these exam sheets. (Add additional sheets, if needed.)
- You may use a calculator.
- Laptops and cell phones are not allowed.

Problem 1



The bar shown in the picture has a length of L and a cross-sectional area of A. The bar is being held between immoveable supports as shown in the figure. If the temperature increases uniformly by ΔT, express (in terms of any relevant parameters) any longitudinal stress, and the nature of such stress, that might develop. If no longitudinal stress will develop then state so as well. If there is longitudinal stress, is it dependent on, i.e. a function of, the cross-sectional area? Define any parameters used in your expression and assume the bar experiences no friction between its ends and the supports. Finally, what is the lateral stress in this case?

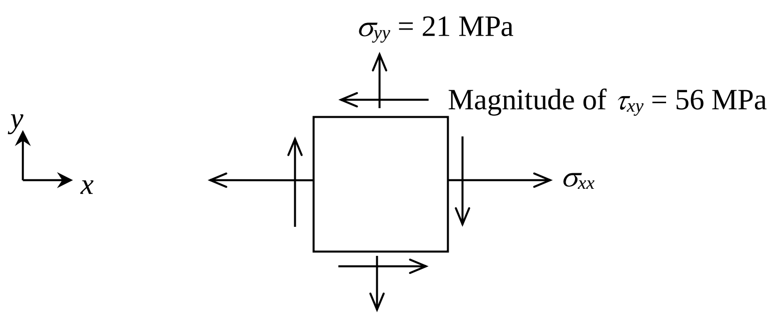
Problem 2



Consider the above two pictures. Each represents the circular cross section of a bar of length *L*. The left bar is solid while the right bar is hollow. Both bars are subjected to the same torque *T*. However, they are made of two different materials (material A for the left bar and material B for the right bar). What is the ratio of the shear modulus of elasticity for these two materials, i.e. G_B/G_A, if they were to have the same total angle of twist ϕ? Remember that the polar moment of inertia is given by $I_p = \int \rho^2 \, dA$. Finally, $r_2 = 0.5r_1$.

Problem 3

A material element is under the plane stress state as shown below. It is known that the minimum principal stress is −7 MPa. (a) Determine the stress σ_{xx}. (b) Determine the direction of the maximum principal stress (namely its angles with the *x*- and *y*-axes).



Problem 4

A simply supported beam is under a distributed load *q*, as shown below. (a) Obtain the "elastic curve" (i.e., the expression of *y* as a function of *x* for the beam in the deformed state). (b) Obtain the maximum deflection. The Young's modulus of the beam is *E* and the second moment of the cross section is *I*.