Ph.D. Qualifying Examination

Mechanics of Materials

Spring 2012

Notes:

- 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

A steel shaft is to be manufactured either as a sold circular bar, of diameter d_0, or as a circular tube, with inner diameter d_1 and outer diameter d_2. The shaft is required to transmit a torque of 1200 Nm. It must also satisfy BOTH of the following design specifications simultaneously: (A) the allowable shear stress must not exceed 40 MPa; (B) the allowable rate of twist must not exceed 0.75^o/m. (G_{steel} = 78 GPa)

1) Determine the required diameter d_0 of the solid shaft.
2) Determine the required outer diameter d_2 of the hollow shaft if the thickness, t, of the shaft is specified as one-tenth of the outer diameter.
3) Determine the ratio of the diameters (d_2/d_0) and the ratio of the weights of the hollow and solid shafts.

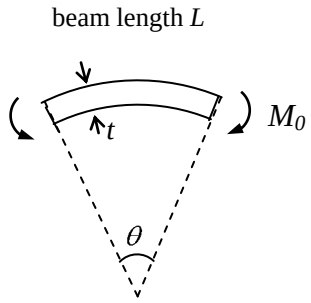
Problem 2

A prismatic bar having cross-sectional area $A = 1200$ mm^2 is compressed by an axial load $P = 90$ kN.

1) Determine the stresses acting on an inclined section cut through the bar an angle of $\theta = 25^o$ from the bar's longitudinal axis.
2) Determine the complex state of stress for $\theta = 25^o$ and show the stresses on a properly oriented stress element.

Problem 3

A thin steel rule (with Young's modulus 210 GPa) having thickness t = 4.4 mm and length L = 1200 mm is bent by couples M_0 into a circular arc subtending a central angle θ = 40° (see figure below).



(a) What is the maximum bending stress σ_{max} in the rule?

(b) By what percent does the stress increase or decrease if the central angle θ is increased by 10%?

Problem 4

Determine the equation of the deflection curve for a cantilever beam, shown below, which is subjected to a uniform distributed load of intensity *w*. Take the elastic modulus of the beam as *E* and the second area moment of its cross section as *I*. Show your procedure.