Ph.D. Qualifying Examination

Mechanics of Materials

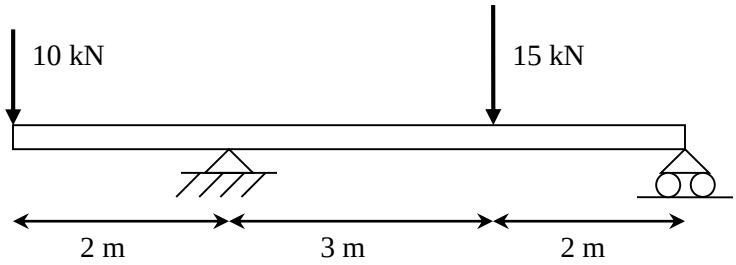
Fall 2015

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 beam is under loading as shown in the figure. Draw the shear and bending moment diagrams along the beam length. Indicate on your diagrams the values of the shear force and bending moment.

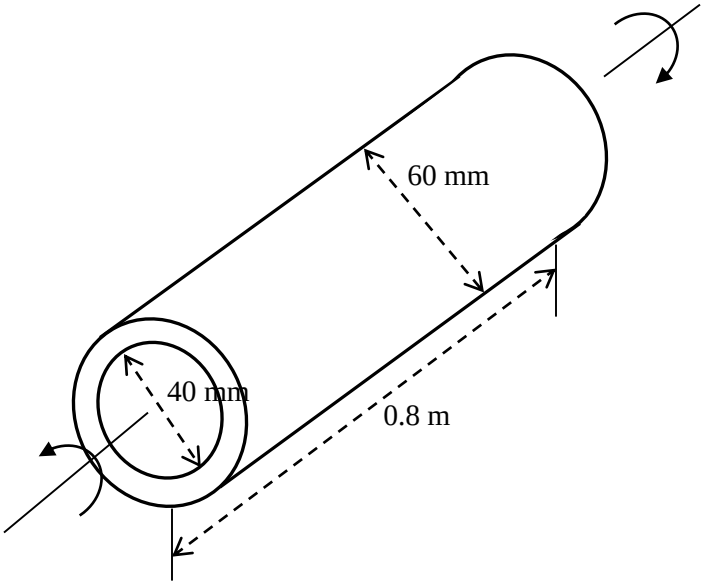


Problem 2

The preliminary design of a shaft connecting a motor to a generator calls for the use of a hollow shaft with inner and outer diameters of 40 mm and 60 mm, respectively, as shown in the figure below. The maximum allowable shearing stress is 12 MPa. Determine the maximum torque which may be transmitted

(a) by the shaft as designed,
(b) by a solid shaft of the same weight,
(c) by a hollow shaft of the same weight and of 80 mm outer diameter.

(Note the polar moment of inertia of a circle of radius c is $J = \frac{1}{2}\pi c^4$.)



Problem 3

Consider a cantilevered beam and fix-fix beam both of length L. The cantilever is loaded at its tip with a force F and the fix-fix beam is loaded with a force F at it center. Both loads act perpendicular to the length of the beams. For the following parameters how much does each beam deflect (δ) at the point of force application?

a. F = 100 μN

b. Cross sectional area of beam is a rectangle - 2 μm x 20 μm

c. E = 170 GPa

Problem 4

Consider two circular rod segments each with identical cross sectional areas and lengths. The two rods are placed end-to-end with their faces touching and their opposing sides fixed. Determine the normal stress in each bar for a ΔT of 300K if:

a. Each bar is made of the same material
b. The two bars are made of different materials