

Ph.D. Qualifying Examination

Mechanics of Materials

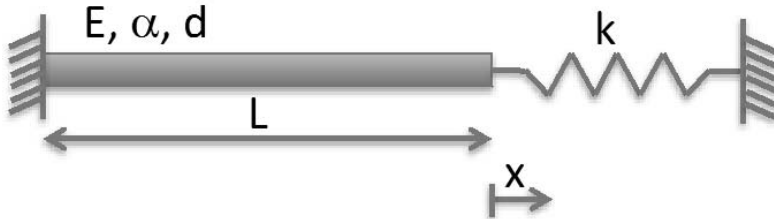
Spring 2014

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

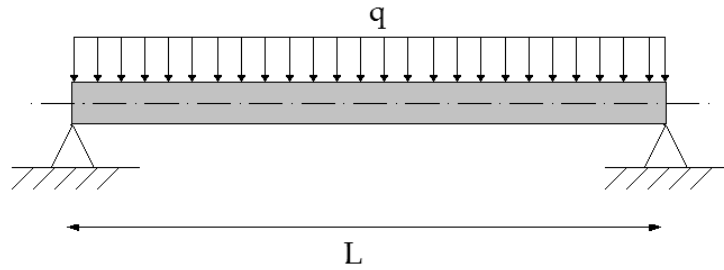
A prismatic bar with circular cross section is fixed on its left hand side and connected to a spring on its right hand side as shown in the figure below. The bar has an elastic modulus, E , coefficient of thermal expansion, α , diameter, d , and length L . A linear spring is connected in series with the bar of linear spring constant, k . Consider the scenario when the bar is uniformly heated by a temperature change, ΔT .



- Derive an equation for the displacement, x , of the connection between the spring and bar.
- When will the spring cause the bar's expansion to be significantly different than the value for free expansion of the bar (i.e. no spring).

Problem 2

Construct the shear-force and bending-moment diagrams for a prismatic beam that is simply supported at each end. A uniform load of intensity q is acting over the entirety of its span, L .

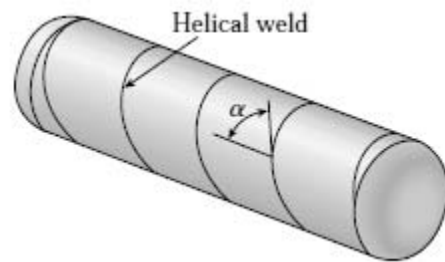


Problem 3

Consider a cylindrical pressure vessel constructed from a steel plate and welded along the edges of the plate to make a helical joint angle of α (Fig. 8-9). The helical weld makes a 50° angle with the longitudinal axis. Use the below information to find:

- The circumferential and longitudinal strains ϵ_x and ϵ_y .
- The normal stress and shear stress acting perpendicular and parallel, respectively, to the welded seam.

Inner radius of vessel = 1.0 m
Wall thickness = 10 mm
 $E = 200 \text{ GPa}$
 $\nu = 0.30$
Internal pressure = 1000 kPa



Problem 4

Consider a tubular shaft that transmits 100 kW at 5 Hz. The inside diameter of the shaft is to be one-third of the outside diameter. If the allowable shear stress in the shaft is 50 MPa, what is the minimum required outside diameter d ?