Ph.D. Qualifying Exam in Solid Mechanics

- Open One Book
- Answer all questions. All questions have the same weight.

Exam prepared by

Professor G. Recktenwald
Professor S. Roccabianca

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**Problem 1**

A hollow aluminum tube is surrounding a solid steel cylinder. The tube and cylinder are fixed to the wall at A. They are both welded to a rigid plate at B. The plate can move freely. When the temperature is 45°F there are no internal stresses.

a) Find the reaction $R_A$ for the steel bar when the temperature reaches 145°F.

b) Find the internal stress in the steel bar when the temperature reaches 145°F.

Steel: Young’s Modulus = $30 \times 10^6$ psi

Coefficient of thermal expansion = $6.5 \times 10^{-6}$ $1/°F$

Aluminum: Young’s Modulus = $10 \times 10^6$ psi

Coefficient of thermal expansion = $13 \times 10^{-6}$ $1/°F$
Problem 2
The 3D structure shown in the Figure has a cross section of diameter 1 inch and is loaded with to forces shown. Find the following values.

a) Calculate the internal forces and moments at cut D (halfway between A and B).

b) Calculate the complete stress state at point g.

c) Draw the stress element for the stress at the point g.
Problem 3
The beam shown has a 10 kip/ft load across the whole beam. Find the 2D state of stress at point g, shown on the cross section at cut C.
Problem 4

Using the cut and integration method, find the piecewise function $y(x)$ for the deflection of the beam. What is the deflection at the end of the beam?

For this problem, use $EI = 5E3 \ [m^4 Pa]$

![Beam diagram with forces and lengths]