Student ID_____

Department of Mechanical Engineering
Michigan State University
East Lansing, Michigan

Ph.D. Qualifying Exam in Solid Mechanics

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

Exam prepared by

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August 2020

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Problem 1

A strain rosette is attached to a point on the surface of a pump as shown. The pump is made of steel. Due to the loading, the strain gauges give a reading of:

$\varepsilon_a = -250\,E-6$

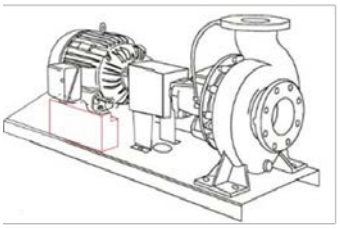
$\varepsilon_b = \ \ 300\,E-6$

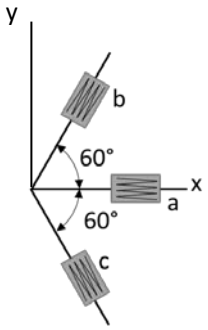
$\varepsilon_c = -200\,E-6$

Determine:

a) the complete *strain state* at the point,

b) the *shear stress* τ_{xy} at the point.





	Steel	Cupronickel	Aluminum
Young's Modulus	30x10^6 psi *(210 GPa)*	20x10^6 psi *(140 GPa)*	10x10^6 psi *(70 GPa)*
Shear Modulus	11 x 10^6 psi *(80 GPa)*	7.5 x 10^6 psi *(52 GPa)*	4 x 10^6 psi *(28 GPa)*
Coefficient of Thermal Expansion	6.5 x 10^{-6} 1/°F *(12 x 10^{-6} 1/℃)*	9.75 x 10^{-6} 1/°F *(18 x 10^{-6} 1/℃)*	13 x 10^{-6} 1/°F *(24 x 10^{-6} 1/℃)*

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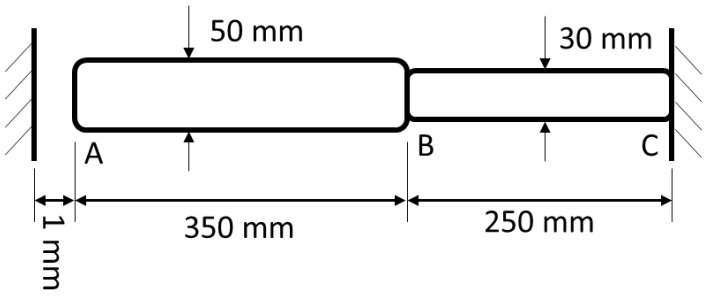
Problem 2

The circular aluminum rods AB and BC are attached to a rigid support at C and are initially unstressed. At room temperature (20C) a 1 mm gap exists between the end of the rod and the rigid support at A.

If the temperature is increased to 140C, determine:

a) the normal stress in the rod AB

b) the change in length of the rod AB



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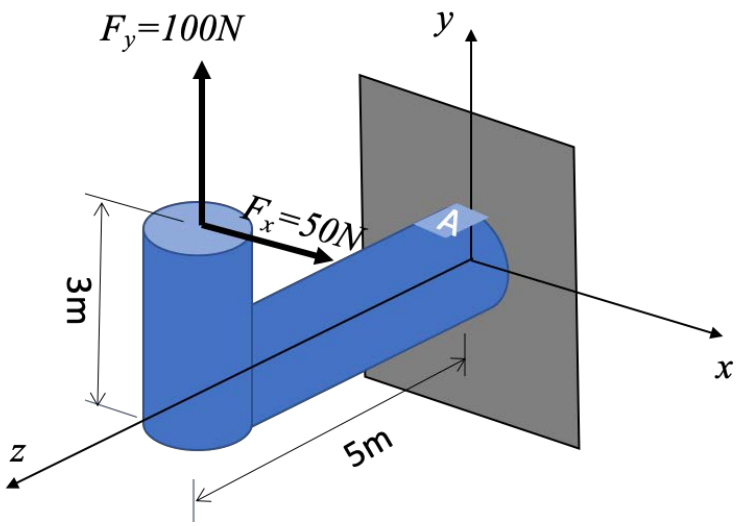
Problem 3

A structure has a 90-degree elbow made of solid cylinder coming out of rigid wall. The radius of the solid cylinder is 2cm. The forces are given in two directions, $F_y=100N$ and $F_x=50N$. *(a)* Determine the stresses on A presented in the picture. *(b)* Determine the complete stress state at the most critical location where yielding is most likely to occur.



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Problem 4

The beam whose dimensions and cross-section are also shown below is loaded with a distributed load and a concentrated load as shown below. Determine the maximum shear stress and the maximum normal stress in the beam.