Student Code Number:_____

Ph.D. Qualifying Exam

INTERMEDIATE SOLID & STRUCTURAL MECHANICS

Spring 2013

Prof. D. Liu
Prof. R. Averill

Directions: Open Book, one book and one notebook allowed.

Answer all four questions

All questions have equal weight

Time: 3.0 hrs.

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- If you make any assumption to reach a solution, state it clearly.
- Assume and state the approximate values for properties, if needed and used.

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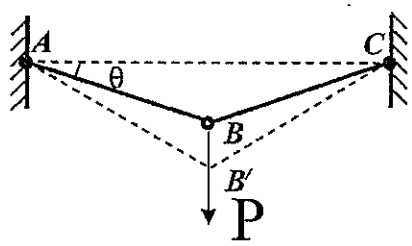
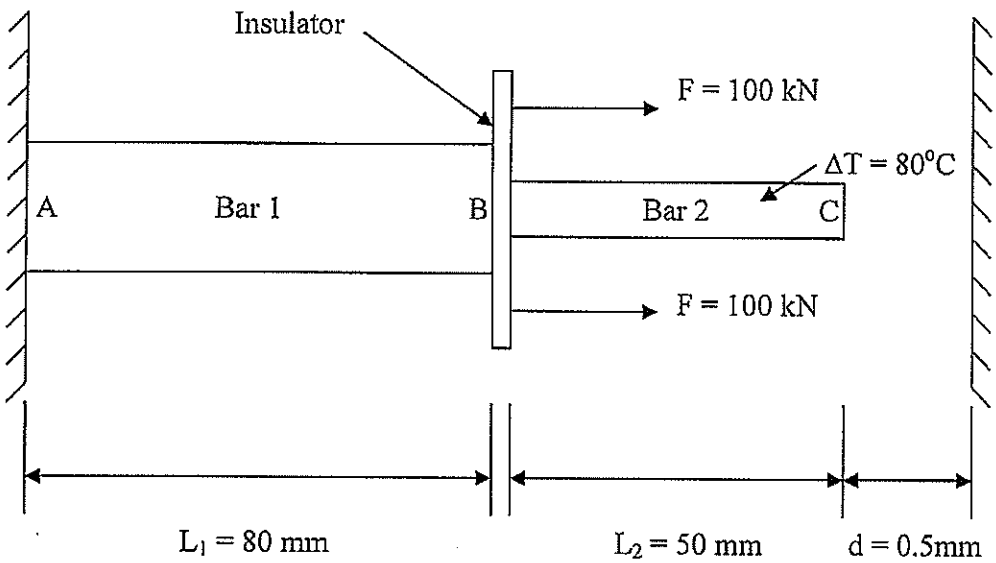
1. A structure consisting of two equal steel bars 15 feet long and with hinged ends is subjected to the action of a vertical load P. Assume Young's modulus of the bars is 29 Msi. Determine the cross sectional areas of the bars and the vertical deflection of point B when P=5000 lbs. The allowable stress is σ_{all}=10,000 lbs/in^2, and the initial angle of inclination of the bars $\theta = 30°$.



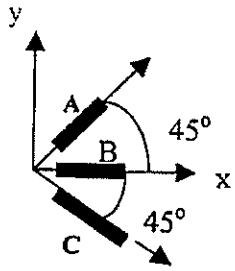
2. The stepped bar shown below is fixed at point A and is initially free at point C. At point B, a thin, rigid insulator separates bar 1 from bar 2. Bar 1 is made of steel, with Young's modulus E_1 = 200 GPa, cross-sectional area A_1 = 100 mm^2, and length L_1 = 80 mm. Bar 2 is made of aluminum, with Young's modulus E_2 = 72 GPa, coefficient of thermal expansion $\alpha_2 = 23 \times 10^{-6}$ per degree C, cross-sectional area A_2 = 60 mm^2, and length L_2 = 50 mm. Two mechanical loads F = 100 kN are applied at point B, and a thermal load ΔT = 80 degrees C is applied to bar 2 only. After the loading is applied:

(a) determine whether or not point C contacts the fixed wall to the right,
(b) determine the stresses in bar 1 and bar 2, and
(c) decide if the stresses in part (b) seem reasonable.

Hooke's law for one-dimensional thermo-mechanical loading: $\sigma = E(\varepsilon - \alpha\Delta T)$



The readings from a strain gage rosette are as follows: $\epsilon_A = 520 \times 10^{-6}$, $\epsilon_B = 360 \times 10^{-6}$ and $\epsilon_c = -80 \times 10^{-6}$. Determine the principal strains and the maximum shear strain.



$$\varepsilon_x' = \frac{\varepsilon_x + \varepsilon_y}{2} + \frac{\varepsilon_x - \varepsilon_y}{2}\cos 2\theta + \frac{\gamma_{xy}}{2}\sin 2\theta$$

$$\varepsilon_y' = \frac{\varepsilon_x + \varepsilon_y}{2} - \frac{\varepsilon_x - \varepsilon_y}{2}\cos 2\theta - \frac{\gamma_{xy}}{2}\sin 2\theta$$

$$\gamma_{xy}' = -\frac{\varepsilon_x - \varepsilon_y}{2}\sin 2\theta + \frac{\gamma_{xy}}{2}\cos 2\theta$$

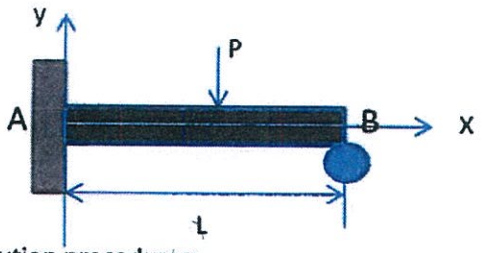
Suggested solution procedures:

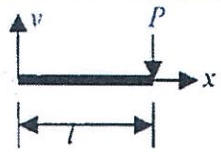
(A) Express the three strain components in the x-y coordinate system, i.e. ϵ_x, ϵ_y and γ_{xy}, in terms of ϵ_A, ϵ_B and ϵ_C.

(B) Find the values of the strain components ϵ_x, ϵ_y and γ_{xy}.

(C) Find the principal strain and the maximum shear strain based on Mohr's circle analysis.

The beam AB shown below is fixed at point A and simply supported at point B.
Based on the formula given inside the block, determine the reaction forces at A and B.





$$v = \frac{-Px^2}{6EI}(3l-x)$$

Suggested solution procedures:

(A) Give a free-body diagram.
(B) Present the equilibrium equations based on loading P and reaction forces.
(C) Show principle of superposition for linear analysis with diagrams.
(D) Give the compatibility equation.
(E) Find the deflection at point B due to the concentrated force P.
(F) Find the reaction forces at A and B.