UNIVERSITY OF CALIFORNIA, BERKELEY College of Engineering

Mechanics of Materials (CE130-II)

The First Mid-term Examination (Spring 2004)

Problem 1.

Consider the following statically indeterminate system (Fig. 1). Find the reactions forces R_1 and R_2. Hint: The flexibility is defined as

$$f = \frac{L}{EA}, \tag{1}$$

and relationship between internal force and elongation of a two force bar is $P = f\Delta$.

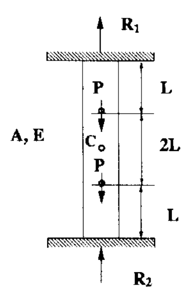

Figure 1: A Statically Indeterminate System

Problem 2

Consider the following two shaft system. Both shafts have circular cross section. Find the maximum shear stress in the system. Assuming $T_B = T$ and $T_C = 2T$. The radius of shaft AB is given as $R = C$; and the radius of shaft BC is given as $R = 2C$. Hints: torsion formula

$$\tau = \frac{T\rho}{I_\rho}, \text{ for shafts with circular cross section }, \quad I_\rho = \frac{\pi R^4}{2}. \tag{2}$$

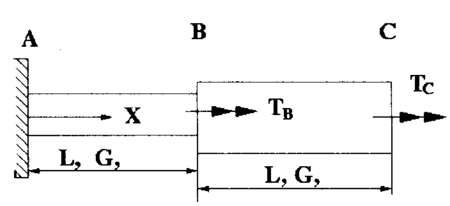

Figure 2: Torsion of a two-shaft system

Problem 3

A planar circular three-hinge arch consists of two segments as shown in Fig. 3. Determine the reaction forces at A and B caused by the application of a vertical force P.

Problem 4

Consider a long (1000 meters in z-direction) concrete block with its both ends fixed. The cross section of the concrete block (section in x-y plane) is a 5 meter square. Suppose that in x-y plane,

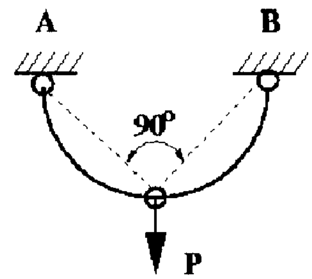

Figure 3: A two-bar truss system

the block is subjected biaxial tensile stress load, namely, $\sigma_x = 5MP_a$ and $\sigma_y = 10MP_a$. This is a typical *plane strain* state. Let $E = 100MP_a$ and Poisson's ratio $\nu = 0.3$. Find σ_z, ϵ_x, and ϵ_y. Hint: The generalized Hooke's law is

$$\begin{aligned}
\epsilon_x &= \frac{\sigma_x}{E} - \nu\frac{\sigma_y}{E} - \nu\frac{\sigma_z}{E} \\
\epsilon_y &= -\nu\frac{\sigma_x}{E} + \frac{\sigma_y}{E} - \nu\frac{\sigma_z}{E} \\
\epsilon_z &= -\nu\frac{\sigma_x}{E} - \nu\frac{\sigma_y}{E} + \frac{\sigma_z}{E}
\end{aligned}$$

Problem 5.

Consider a rectangular block with the dimension $dx \times dy \times dz$. Uniform shear stress, τ_{xy}, is acting on the surfaces normal to (+/−) x-axis and uniform shear stress, τ_{yx}, is acting on the surfaces normal to (+/−) y-axis as shown in Figure 4. Show $\tau_{xy} = \tau_{yx}$. Hint: use moment equilibrium equation about the z-axis ($\sum M_z = 0$).

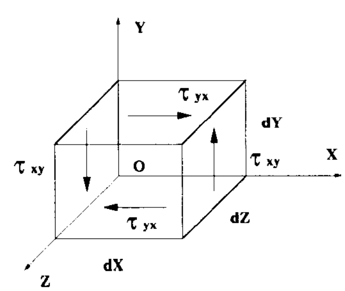

Figure 4: Infinitesimal element in pure shear