MASSACHUSETTS INSTITUTE OF TECHNOLOGY
DEPARTMENT OF OCEAN ENGINEERING
AND
CIVIL AND ENVIRONMENTAL ENGINEERING
13.10J/1.573J Structural Mechanics
Fall 2001

Quiz 2

6:00pm - 8:00pm

Thursday, November 15, 2001
Room 3-370

CLOSED BOOK & NOTES, TWO SHEETS OF FORMULAS
FIRST, READ ALL THREE PROBLEMS !!!
INDIVIDUAL EFFORT

1. (**25pts**) The normal strains at a point P along directions 1,2 and 3 on the planar surface of a linearly elastic thin plate with Young's modulus of elasticity $E = 200GPa$ and Poisson's ratio $\nu = 0.3$ are measured as shown in Figure 1. Note that due to Poisson effect there may exist strain orthogonal to the xy plane.

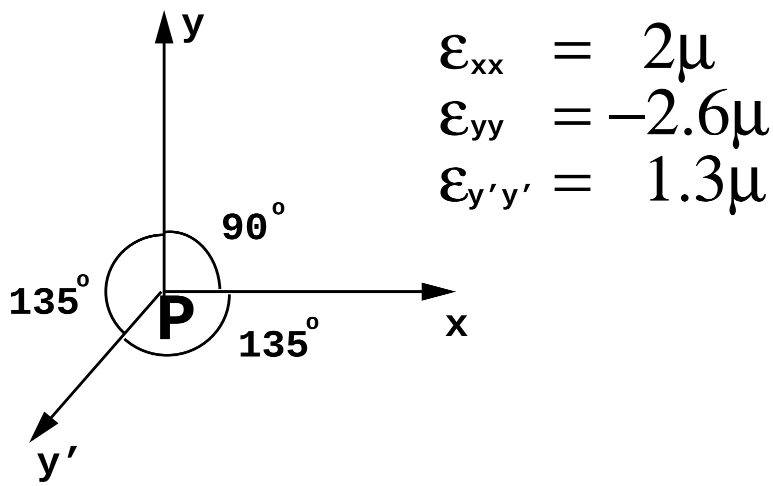

Figure 1: Problem 1

   (a) (**15pts**) Find ϵ_{xy} and then find the principal strains and their directions.

   (b) (**10pts**) Describe a method to determine the principal stresses and their directions but do not carry out the algebra.

2. (**40pts**) The structure shown in Figure 2 is proposed as a calibration fixture for an experiment. The cantilevered beam DF has an inverted "T-shape" *rigid* bracket attached to its tip F, as shown in Figure 2, allowing the placement of the point load P at any location along ABC.

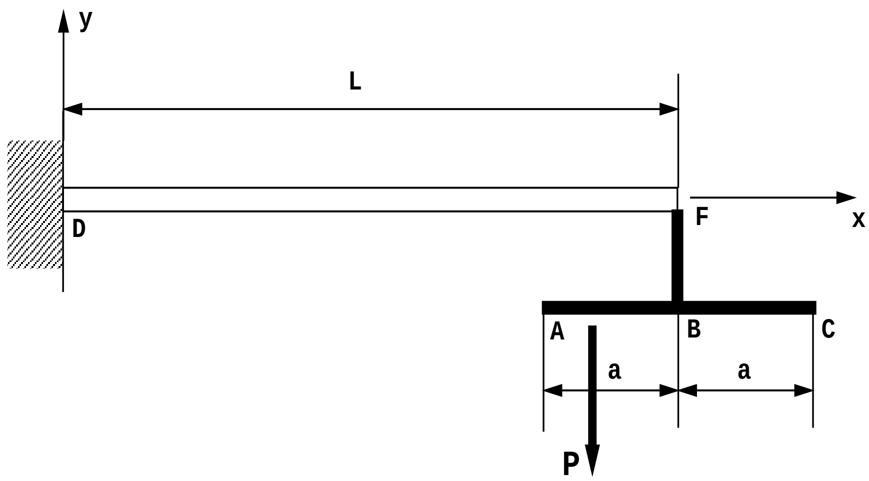

Figure 2: Problem 2-a

   (a) (**9pts**) Assuming that the bending rigidity of the beam DF is EI, sketch the resulting shear force and bending moment diagrams for the beam DF for the load placed at A, B and C. Indicate the positions and values of the maximum bending moments for each case.

   (b) (**18pts**) A point load P is acting at C in the negative y direction and another point load P is acting at F in the positive z direction, as shown in Figure 3.

      i. (**9pts**) Find the neutral axis at the position where the maximum bending moment occurs.

      ii. (**9pts**) Find the maximum normal stress τ_{xx}.

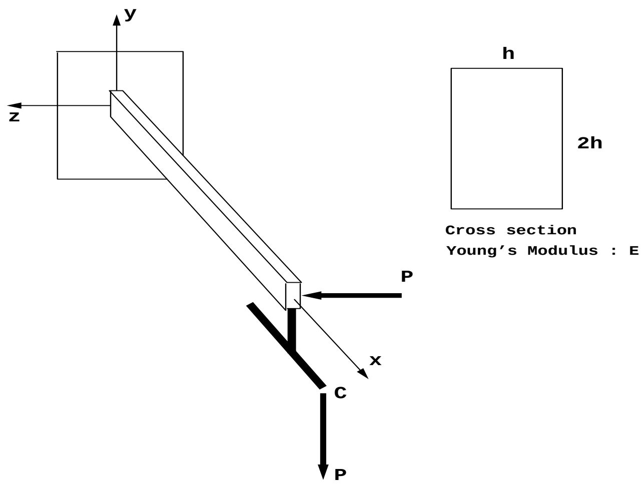

Figure 3: Problem 2-b

(c) (**23pts**) The same beam structure with the same loads as shown in Figure 3 is considered. However, the cross section of the beam DF consists of two different materials as shown in Figure 4,

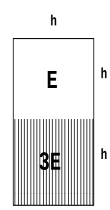

Figure 4: Problem 2-c

i. (**10pts**) Find the neutral axis at the position where the maximum bending moment occurs.

ii. (**13pts**) Find the maximum normal stress τ_{xx}.

3. (**10pts**) A rigid beam RT is supported by three steel rods as shown in Figure 5. A point load P is applied at location x on the beam RT. Assume that gravity effects can be neglected and the three bars display linearly-elastic behavior. Young's modulus of elasticity E, the cross sectional area A and the length L of the three bars are indicated in the figure, respectively. While the three rods are elastic, find the position x so that the beam remains horizontal.

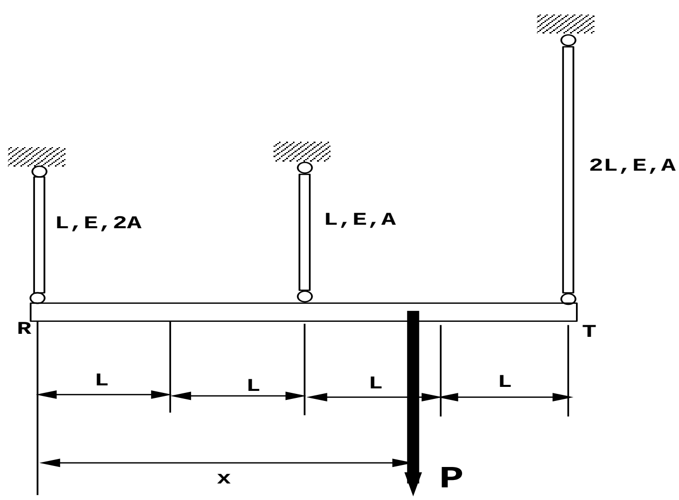

Figure 5: Problem 3

4. (**25pts**) A rigid beam RT is supported by two steel rods as shown in Figure 6. A point force P is acting downward at the position $x = \frac{8}{5}L$. The bars are idealized to be linearly-elastic, perfectly plastic as shown in Figure 6. The midpoint Q is deflected $\frac{7\tau_y L}{3E}$ downwards by the slow application of the force P, after which the force is slowly removed. (Hint: Remember that when a material becomes plastic, no increase of force is required to get additional deformation. Also when the midpoint is deflected $\frac{7\tau_y L}{3E}$ it is **NOT** necessary that both rods are plastic.)

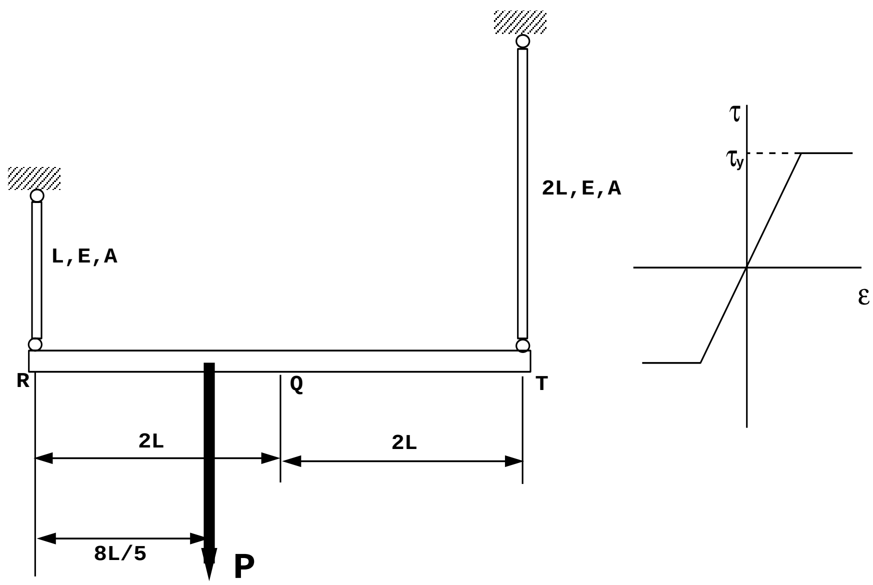

Figure 6: Problem 4

(a) (**10pts**) What is the required maximum value of P?

(b) (**15pts**) Find the final position of the beam after the force is removed.