MASSACHUSETTS INSTITUTE OF TECHNOLOGY
13.10J/1.573J/13.014/1.052
Problem Set 9

Assigned : October 31, 2000
Due : November 7, 2000 (for 1.052/13.014)
November 8, 2000 (for 13.10J/1.573J)

- For undergraduate students (1.052) : 11.44, 11.46 and supplement 1 below.
- For undergraduate students (13.014) : 11.44, 11.46 and supplement 1 below.
- For graduate students (13.10J/1.573J) : 11.44, 11.46 and supplements 1, 2 and 3 below.

1. (Supplement 1) For all students (13.10J/1.573J/13.014/1.052)

   A bending couple of magnitude $M_0 = 1.5kN \cdot m$ acting in a vertical plane is applied to a beam having the Z-shaped cross section as shown in Figure 1. The moments and product of inertia of the section with respect to the y and z axes have been computed and are $I_{yy} = 3.25 \times 10^{-6}m^4$, $I_{zz} = 4.18 \times 10^{-6}m^4$ and $I_{yz} = 2.87 \times 10^{-6}m^4$. Find (a) the principal axes ξ, η orientation and $I_{\xi\xi}$, $I_{\eta\eta}$(with $I_{\xi\eta} = 0$), (b) the stresses (normal and shear) at point A and (c) the angle that the neutral axis forms with the horizontal plane.

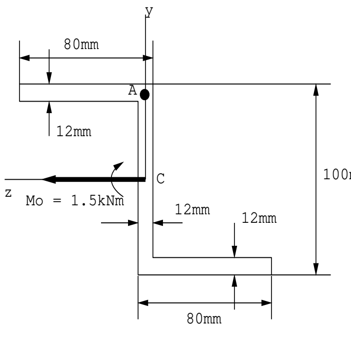

Figure 1: A diagram for problem 1

2. (Supplement 2) For graduate students (13.10J/1.573J)

   (a) A cross section of a slit square tube of constant thickness t is shown in Figure 2. Derive the distance e from the corner of the cross section to the shear center S.

(b) If load P is not applied at S but at point A, find the twisting moment about the x axis (which is normal to the plane of the figure).

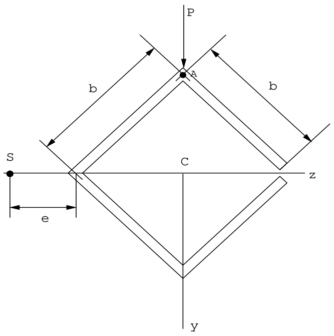

Figure 2: A diagram for problem 2

3. (Supplement 3) For graduate students (13.10J/1.573J)

   A steel beam, with Young's modulus E_s, and an aluminum beam, with Young's modulus E_a, where $E_s = 3E_a$, are joined together continuously to form a cantilever beam as shown in Figure 3. The individual beams have the same width, W, and height, H, and $W = 2H$.

   (a) To minimize the end deflection using configuration (A), does it matter whether the steel is on the top or bottom? Justify your answer.

   (b) What is the shear stress the joint must be able to withstand if the beams are oriented as in configuration (A)?

   (c) Where is the shear center if the beams are oriented as in configuration B? Assume the steel is on the left.

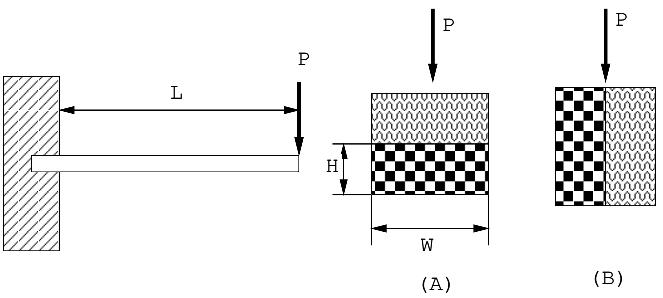

Figure 3: A diagram for problem 3