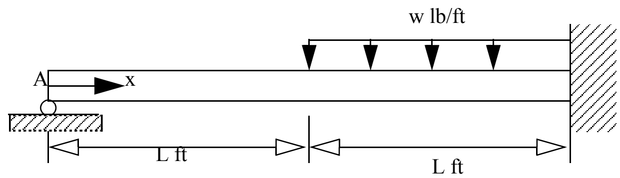
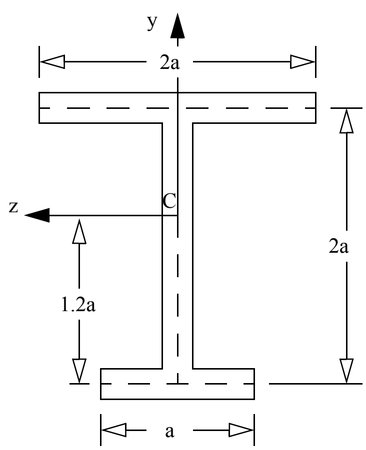
Final MEEM 4150 Dec. 15th, 2004

1. Using energy methods find the reaction force at A and the slope of the beam at A in terms of E, I, w, and L.



2. A thin walled open cross-section with a uniform thickness ‘t’ is shown. Assume that $t \ll a$, i.e., terms of t, t^2 and t^3 can be neglected in comparison to ‘a’. Determine the coordinates of the shear center e_y and e_z with respect to the centroid at C.



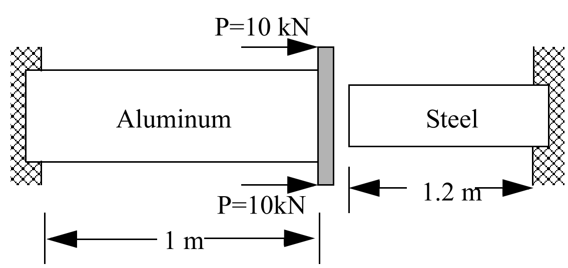
e_y = -------------------

e_z = ------------------

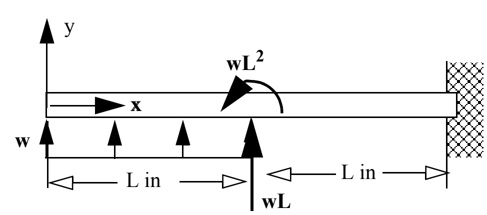
3. An aluminum rod is securely fastened to a rigid plate that does not rotate during deformation. A gap of 0.5 mm exists between the rigid plate and the steel rod in the undeformed state. The properties of the two rods are given in Table 1. In addition to the applied load the temperature of both rods is raised by 100^o. (a) Determine the movement of the rigid plate (b) The axial stress in steel.

Table 1: Properties

	diameter mm	E GPa	α $\mu/^oC$
Aluminum	20	70	22.5
Steel	10	210	12



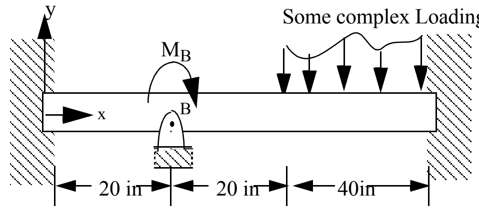
4. (a) Using Discontinuity Functions write the fourth order differential equation and the four boundary conditions. DO NOT INTEGRATE or SOLVE.



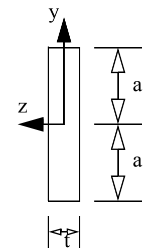
(b) The displacement of the beam in the y-direction is as given. If the bending rigidity (EI) is 135 (10^6) lbs-in^2

determine the moment M_B and reaction force R_B.

$$v_1 = 5(x^3 - 20x^2)\ (10^{-6})\ \text{in} \qquad 0 \le x \le 20$$
$$v_2 = 5(x^3 - 800x + 8000)\ (10^{-6})\ \text{in} \qquad 20 \le x \le 40$$



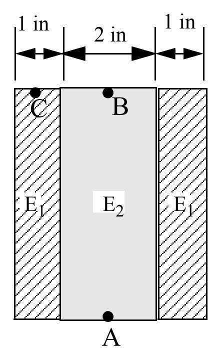
(c) For a non-linear material, the bending normal stress across the cross-section was found to be $\sigma_{xx} = \begin{cases} -K(-y)^{0.75} & y \le 0 \\ K(y)^{0.75} & y \ge 0 \end{cases}$. Determine the equivalent internal bending moment in terms.



In parts (d) and (e) below use the composite cross-section shown in which E_1=10,000 ksi and E_2= 30,000 ksi. Point A is at the bottom of the cross-section and points B and C are at the top of the cross-section.
(d) The AXIAL normal stress at A is 12 ksi (T). What are the axial stresses at points B and C?

σ_B= ------------------( )

σ_C= ------------------( )



(e) The BENDING normal stress at A is 12 ksi (T). What are the bending normal stresses at B and C?

σ_B= ------------------( )

σ_C= ------------------( )

ANSWERS

1. $R_A = 7wL/64$ $\qquad \left(\frac{dv}{dx}\right)_A = 5wL^3/(96EI)$
2. $e_y = 0.5778a$ $\qquad e_z = 0$
3. $\delta_{plate} = 1.58$ mm $\qquad \sigma_{steel} = 441$ MPa(C)

4(b)M_B = 27,000 in-lb $\qquad R_B = 0$

(c) $\boldsymbol{M_z}$= - 0.727$Kta^{2.75}$

(d) σ_B= 12 ksi(T) $\qquad \sigma_C$= 4 ksi(T)

(e) σ_B= 12 ksi (C) $\qquad \sigma_C$= 4 ksi(C)