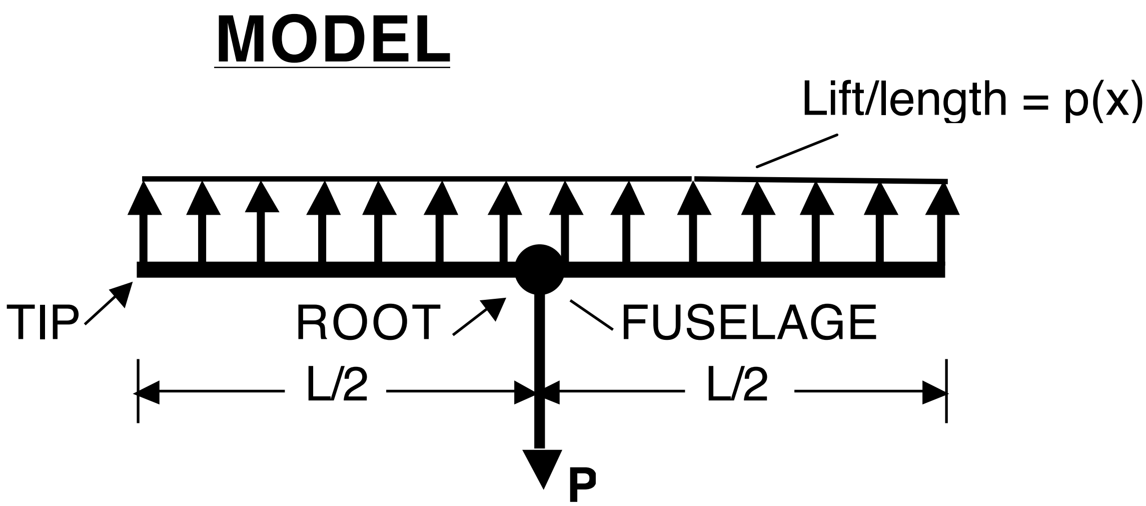
Unified Engineering Problem Set **Lectures: M7, M8, M9**
Week 4 Spring, 2008 **Units: M4.4, M4.5**

M4.1 ***(10 points)*** Let's continue exploring our simple model of how wings carry load in level flight. We now expand this to consider stress distributions and deflections. The four models of the load configuration continue to be considered here. The model for the constant value load configuration is again shown below. Use the results from the solution for the problem set for Week #3 for the axial force, shear force, and bending moment as appropriate. Assume that the wing has constant cross-sectional properties of I and A and is made of an isotropic material with a modulus of E and Poisson's ratio of ν.



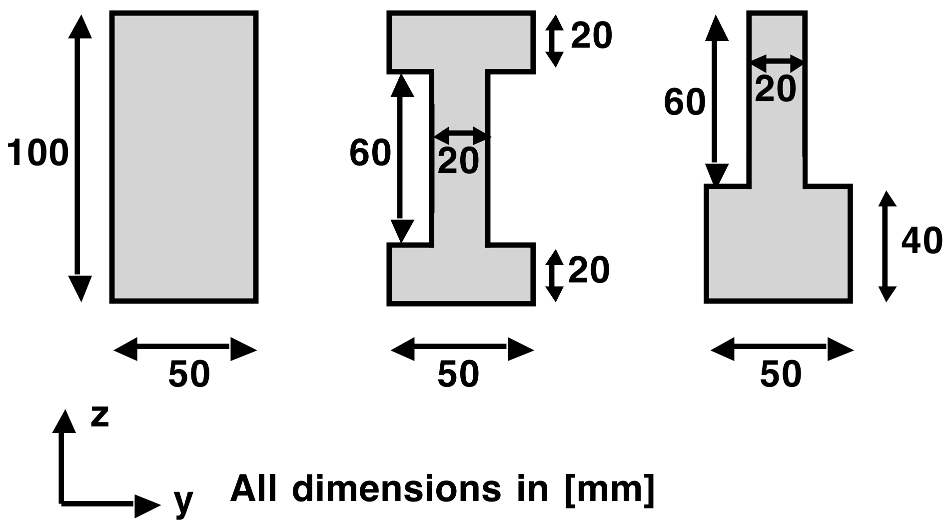
Do the following for each case and compare the results:

(a) Determine and sketch the distribution of the axial stress, σ_{xx}, along the wing; and find the location of the maximum magnitude along the wing.

(b) Determine and sketch the distribution of the shear stress, τ_{xz}, along the wing; and find the location of the maximum magnitude along the wing.

(c) Determine and sketch the deflection of the wing, w; and find the location of the maximum magnitude along the wing.

M4.2 ***(10 points)*** Consider the three beam cross-sections of a solid rectangle, an I-beam, and a T-beam with the dimensions as shown.



(a) Determine the beam cross-section properties (A, I, Q). For Q, also determine its maximum value and the location for such.

(b) Determine I/A for each case and compare these results.

M4.3 ***(10 points)*** You are asked to design the cross-section of a 40-foot long statically determinate cantilevered beam to be made out of steel. The beam is loaded by a constant distributed downward load of as yet undetermined magnitude. In each case, the cross-sectional area of the beam equals 30 in^2 and the in-plane dimensions must not exceed 12 inches in height and 6 inches in width.

In all cases, determine the shape. Final values of dimensions are not needed.

(a) Design a cross-section that will minimize the beam deflection.

(b) Design a cross-section that will minimize the maximum magnitude of the axial stress σ_{xx}. Indicate the location of this stress in the cross-sectional plane of your design.

(c) Design a cross-section that will minimize the maximum magnitude of the shear stress τ_{xz}. Indicate the location of this stress in the cross-sectional plane of your design.

(*Note:* One way to start is to consider known different cross-sections such as a solid rectangle, a rectangular tube, a T-beam, and an I-beam. There are, however, more efficient means to the solutions.)