Problem 1: The sketch below is an idealization of the Washington monument subject to a wind load. Assuming that $I_1 = 80,000 \text{ft}^4$ in segment 1 and $I_2 = 500,000 \text{ft}^4$ in segment 2, calculate the strain energy due to bending in the monument.

Problem 2: For the cantilever beam shown below, calculate the external work done by the load and the internal strain energy due to bending moment. Verify that they are equal.

Problem 3: Revisit the stadium bridge (Now called the Southern Vermont (1906) bridge on the project website) you analyzed earlier in the semester. Use the loading
and material properties described in problem 3 of HW 3. You may use the posted solution for reference for the cross section areas and loads.

This time, though, analyze the structure as a planar frame instead of a planar truss. You will need to calculate the moments of inertia for all members to do this.

(a) Prepare a table showing the moments of inertia for all members. Follow the format used in HW 3 for cross section area reporting.
(b) Determine the maximum displacement obtained from a frame analysis. Compare to that obtained by truss analysis.
(c) Find the maximum bending moment that occurs anywhere in the structure during a frame analysis. Calculate the bending stress that results from this moment.
(d) Find the maximum axial force that occurs anywhere in the structure and calculate the resulting axial stress.
(e) Compare the magnitude of the maximum bending and axial stresses. Does one dominate? Discuss the effect the frame analysis has on displacements. Is it a large difference? In light of these results, discuss whether it is reasonable to analyze the structure as a truss even though the gusset-plated connections can certainly transmit bending moment.

**Problem 4:** Consider the frame shown in Hibbeler 16-16. Construct a MASTAN model assuming that all columns are W14x61 with $I = 640in^4$ and $A = 17.9in^2$ and depth of 13.89in, and that all beams are W16x26 with $I = 301in^4$ and $A = 7.68in^2$ with depth 15.69in. Assume all members are steel with $E = 29000ksi$. Pay careful attention to support conditions. Print and attach axial force and bending moment diagrams, and the deflected shape, appropriately scaled (deflections may be small). Calculate the maximum combined bending and axial stress for elements 3 and 7. (Note: stresses add by the principal of superposition. Please see additional notes posted to the website for an example of combined stresses.)
**Problem 5**: Consider the frame shown below. The structure is statically indeterminate, meaning that equilibrium conditions are insufficient to calculate the reactions and internal forces. In statically indeterminate structures, the reactions and internal forces are dependent on the stiffness of the members; remember that loads prefer to accumulate in structurally stiff members. Assume that the columns have $E = 29000 \text{ksi}$ and $I = 400 \text{in}^4$ and that $P = 10 \text{kips}$ and that the beam has $E = 29000 \text{ksi}$. Use MASTAN to solve the structure for the following values of $I$ for the beam: $[10, 200, 400, 800, 10000] \text{in}^4$. Assume $A = 8 \text{in}^2$ for all members. Plot the reaction force and the bending moment at the column top against the ratio of the beam moment of inertia to the column moment of inertia. Include printouts of the moment diagram and deflected shape for only the cases of the beam moment of inertia equal to $[10, 400, 10000] \text{in}^4$. Discuss your findings.