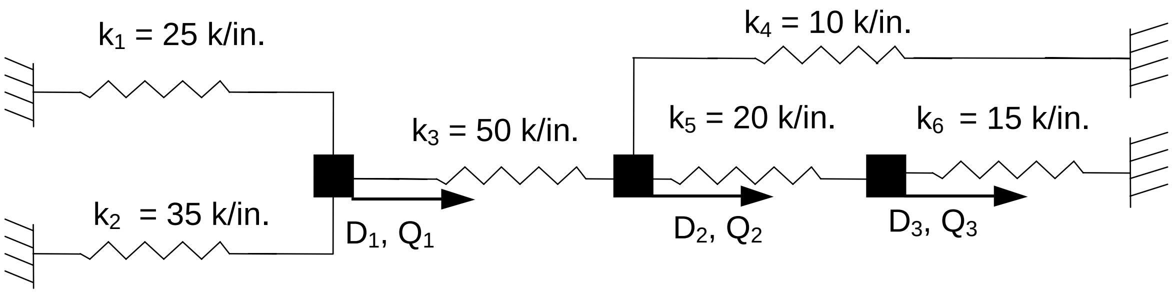
CEE 379 | Problem Set 2 | Autumn 2007

(Due October 15, in class or 4:30 PM in 233 More)

Problem 1.

Consider the six-spring system shown below. Four joints (nodes) are fixed (displacements constrained to be 0.0) and three joints are free to move (unconstrained).



Forces Q_1 = -15 k, Q_2 = 25 k, and Q_3 = 20k are applied at the free joints.
Use only pencil and paper on this problem (i.e., no spreadsheet calculations), except for solving the simultaneous equations. Identify each answer by enclosing it in a box.

a) What is the degree of external static indeterminacy for this system?

b) What is the degree of internal static indeterminacy?

c) What is the degree of kinematic indeterminacy?

d) Determine the spring stiffness matrix, **k'**, for each of the springs.

e) Draw free-body diagrams of all of the springs and nodes, annotating all spring end forces an reactions with the notation and sign convention discussed in class.

f) Based on these free-body diagrams, write the equations of equilibrium at each of the nodes. Number your nodes beginning with the unconstrained nodes, followed by the constrained nodes.

g) By substituting the force-deformation relationships into the equations of equilibrium and by enforcing compatibility, write the equations of equilibrium in terms of the spring stiffnesses, the joint displacements, and the applied forces and reactions.

h) Determine the system stiffness equations in matrix form (i.e., **K D** = **Q**) for this spring system. What are the dimensions of $\mathbf{K}_{11}$, $\mathbf{D}_u$ and $\mathbf{Q}_k$? How does the size of $\mathbf{K}_{11}$ compare to the degree of kinematic indeterminacy?

i) Considering only the equations at the free degrees of freedom, solve for the unknown displacements (i.e., $\mathbf{D}_u = \mathbf{K}_{11}^{-1}\,\mathbf{Q}_k$) at the free joint. You may use your calculator or a spreadsheet to invert the K_{11} matrix.

j) Using the spring stiffness matrices, compute the end spring forces (i.e., **q** = **k'd**) for all the springs.

k) On a neat sketch of the structure, show the calculated internal spring forces (T). Tension forces should be shown as positive and compressive forces should be shown as negative.

Problem 2.

a) Repeat Problem 1 using a spreadsheet analysis similar to the one presented at the end of the 1D-spring class notes. Submit your spreadsheet, and draw a neat sketch of the spring system showing the nodal displacements (as arrows) and the spring tension or compression. Tension forces should be shown as positive and compressive forces should be shown as negative. Do your results make sense when compared with the results of Problem 1? Explain.

b) Using the same spreadsheet, compute the displacements at the free nodes (D_1, D_2, D_3) and spring forces if Q_1 = -20k, while Q_2 = -25k and Q_3 = -20k. The spring stiffnesses should be the same as in Problem 1, except that k_1 is increased to 200 k/in. Draw a neat sketch of the spring system showing the nodal displacements (as arrows), and the spring tension or compression (T). Are your results reasonble? Explain.