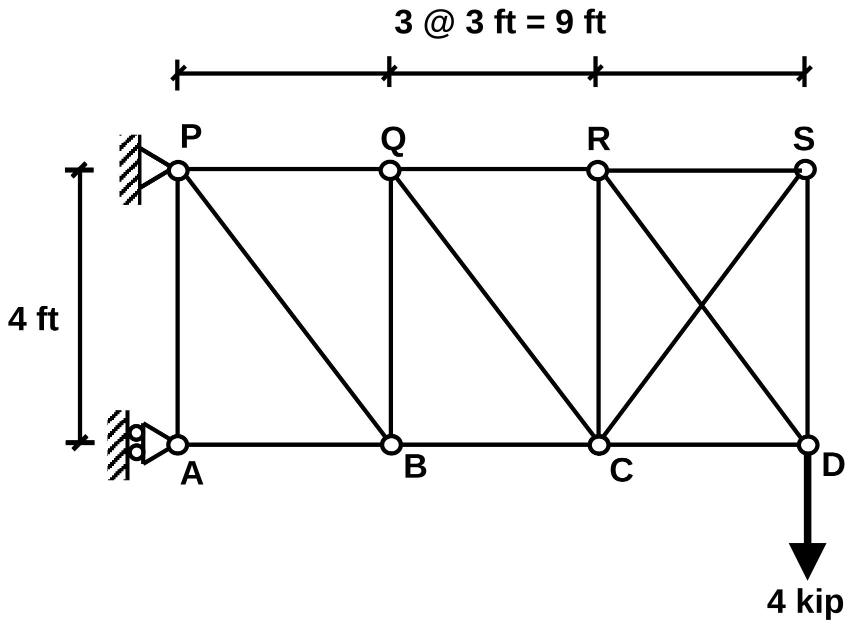
1) A truss structure is loaded as shown below. All members are made out of steel (modulus of elasticity, E = 30,000 ksi) and have identical cross-sectional area of 0.5 in^2.

How much does point B displace horizontally and vertically?

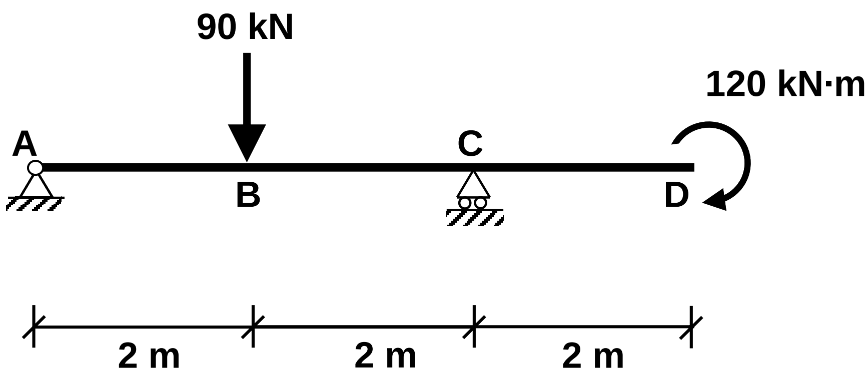


2) On a 6-m long prismatic beam, shown below, an external moment of 120 kN·m is applied at point D (the free end of the beam) and a 90 kN point load is applied at point B (the mid-span point of the supported span).

Assume that the beam has EI = 4×10^4 kN·m^2.

Considering flexural response only

a. Find the vertical displacement of point B.
b. Find the rotation of point B.
c. Sketch the deflected shape.

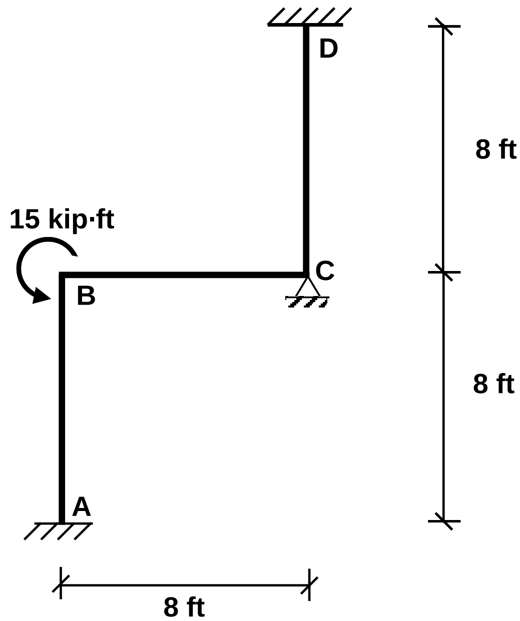


3) The continuous steel frame structure shown below has fixed-supports at A and D. At C, a support that prevents planar displacements is installed. The frame elements are prismatic and have identical section properties (i.e. constant EI throughout).

The structure is loaded externally with a 15 kip·ft moment at node B.

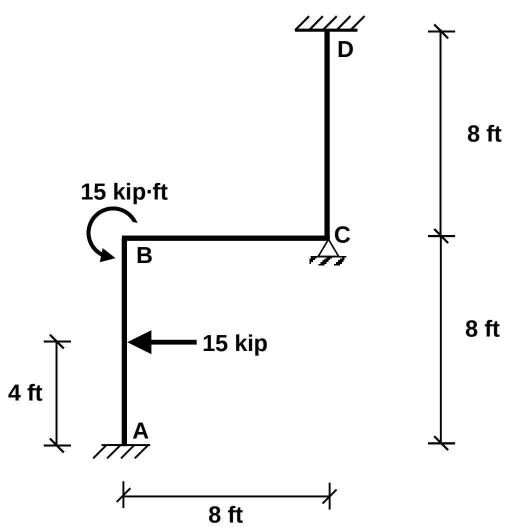
Ignore axial deformations and consider flexural response only.

a. What is the minimum number of degrees of freedom one should choose for this structure? Mark it/them on a sketch of the structure.
b. How much would the frame rotate at nodes B and C under the given load?
c. Sketch the deflected shape of the structure.
d. Draw the bending moment diagram.



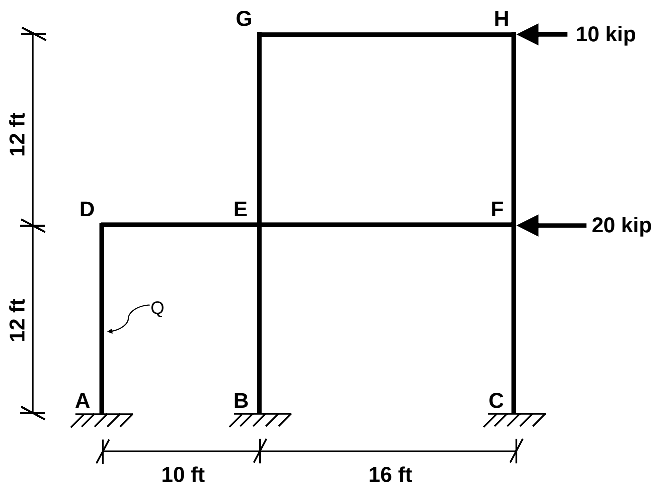
e. [Bonus] In addition to the 15 kip·ft moment at node B, an external point load of 15 kip is applied on the structure as shown below.

    i. Draw the bending moment diagram.
    ii. Sketch the deflected shape.



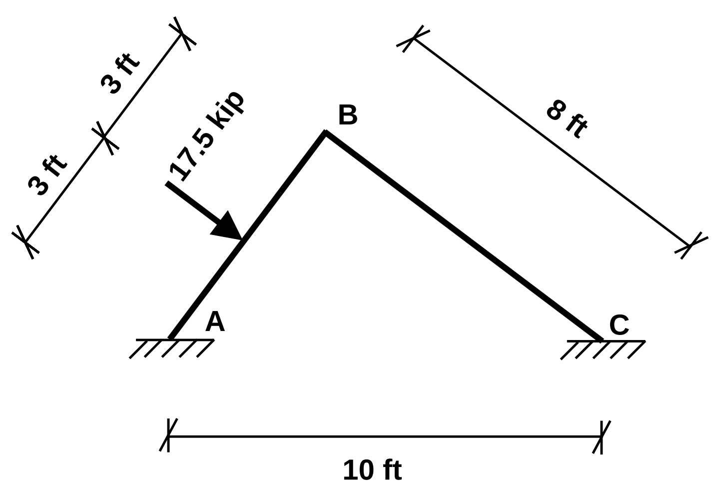
4) Using the portal method, carry out an approximate analysis of the two story frame structure shown below. The structure is loaded laterally with a 10 kip point load at roof level and a 20 kip point load at second floor level. Note that supports *A*, *B*, and *C* are fixed. Assume all joints to be rigid.

   a. Draw the bending moment diagram for the whole structure.
   b. [*Bonus*] Considering flexural behavior only and using your results, find the horizontal deflection of the column *AD* at its mid-height. In other words, how much does point *Q*, which is 6 ft from the base of column *AD*, move horizontally?



5) The continuous frame *ABC* shown below is fixed at supports *A* and *C*, and has a 90-degree bent at *B*. It has uniform material and section properties with modulus of elastic $E = 30 \times 10^3$ ksi and moment of inertia $I = 540\ in^4$. Ignore axial deformations. Analyze the system using stiffness method and find the following:

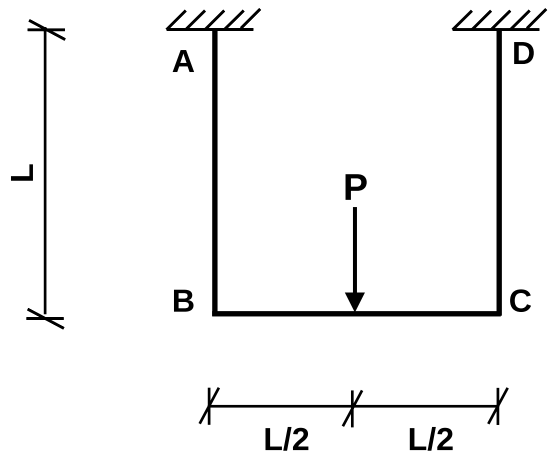
   a. the rotation of the frame at node *B*;
   b. the bending moment diagram for the whole frame;
   c. [*Bonus*] the rotation of a point on segment *BC* half-way between nodes *B* and *C*.



6) The continuous frame *ABCD* shown below has uniform material and section properties throughout (i.e. constant modulus of elasticity *E*, and constant moment of inertia *I*).

The frame is loaded with a point load *P* acting downward at the mid-span of the horizontal segment *BC*. Ignore axial deformations.

a. Indicate the minimum number of independent degrees of freedom one may choose for this frame.
b. Is it possible for the frame to sway under the given loading condition?
c. Analyze the system using the stiffness method and draw the bending moment diagram.



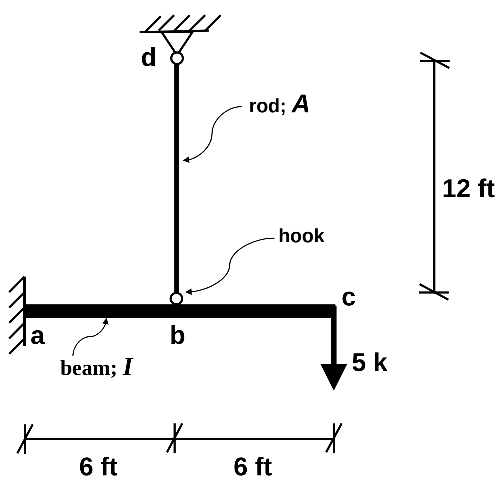
7) The rod-and-beam planar structure shown below is loaded with a 5 k downward load at the free-end of the beam. The other end of the beam is fixed. The rod is attached to the beam with a hook and is pin-supported at its other end. Dimensions are given in the figure.

Elements are made out steel with $E = 4.0 \times 10^6$ ksf. Moment of inertia of the beam is $I = 3.0 \times 10^{-2}$ ft^4. Cross-sectional area of the rod is $A = 0.75 \times 10^{-2}$ ft^2.

Use virtual force approach, and consider flexural behavior in the beam (i.e. consider bending behavior only) and axial behavior in the rod (i.e. consider axial behavior only) to analyze the system.

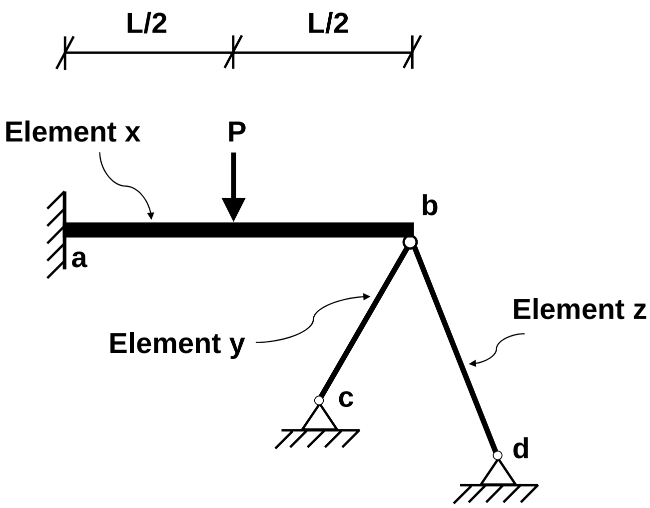
a) Find the internal force in the rod.
b) Draw the bending moment diagram for the beam.

Hint: You may want to use a constraint condition (i.e. a boundary condition or a compatibility condition existing in the given system) of your choice to help solve this system which is indeterminate to first degree.

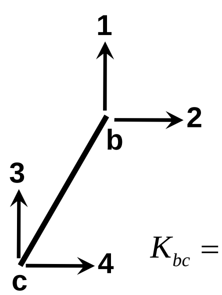


8) A simple cantilever beam supported by two inclined struts is shown below. The beam is loaded at mid-span with a downward concentrated load of magnitude P. The transformed stiffness matrix (i.e. transformed to a common global coordinate system) for each element and for the indicated degrees of freedom is also given. Assume that the axial deformations in the beam are negligible.

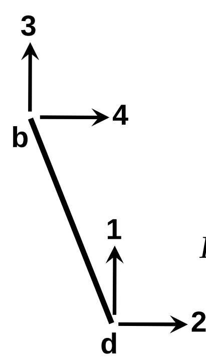
a) Choose and indicate on the figure an appropriate set of degrees of freedom for the full structure.
b) Write the corresponding equilibrium equations for the full structure. You may choose to give the equilibrium equations in matrix form (i.e. use assembled stiffness matrix, generalized displacements vector, and corresponding generalized forces vector).



$$K_{ab} = \begin{bmatrix} x_{11} & x_{12} & x_{13} & x_{14} \\ x_{21} & x_{22} & x_{23} & x_{24} \\ x_{31} & x_{32} & x_{33} & x_{34} \\ x_{41} & x_{42} & x_{43} & x_{44} \end{bmatrix}$$



$$K_{bc} = \begin{bmatrix} y_{11} & y_{12} & y_{13} & y_{14} \\ y_{21} & y_{22} & y_{23} & y_{24} \\ y_{31} & y_{32} & y_{33} & y_{34} \\ y_{41} & y_{42} & y_{43} & y_{44} \end{bmatrix}$$



$$K_{cd} = \begin{bmatrix} z_{11} & z_{12} & z_{13} & z_{14} \\ z_{21} & z_{22} & z_{23} & z_{24} \\ z_{31} & z_{32} & z_{33} & z_{34} \\ z_{41} & z_{42} & z_{43} & z_{44} \end{bmatrix}$$