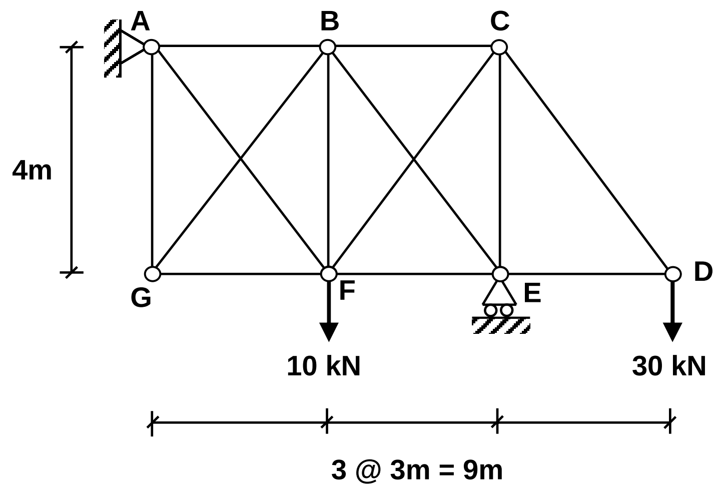
1) Determine the axial forces in the members of the steel truss shown below. Assume that the diagonal members are very slender and cannot carry compressive forces. Ignore self-weight.



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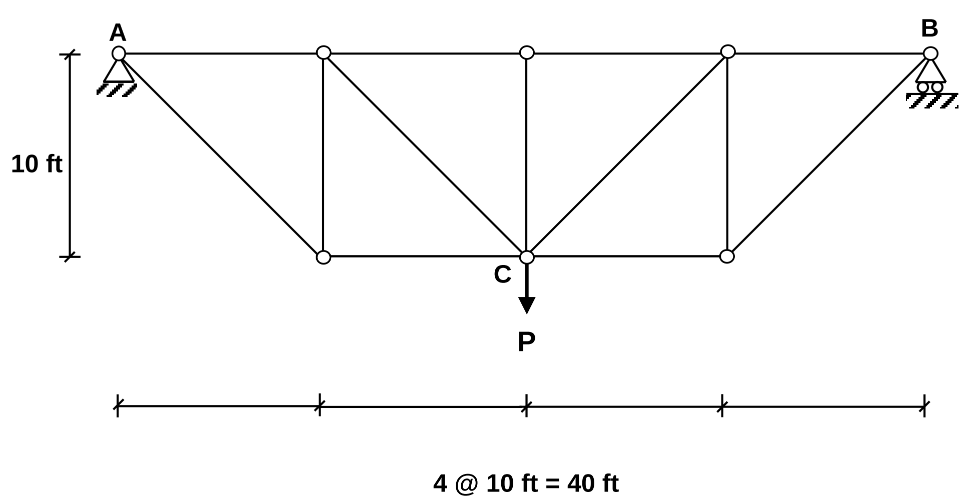
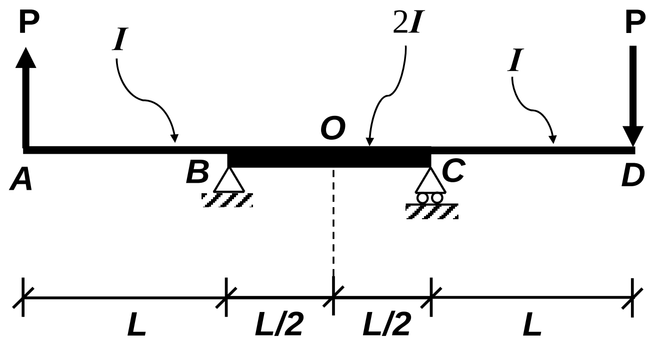
2) The truss shown below is designed to span 40 feet at 70º Fahrenheit nominal temperature. However, fluctuations in temperature cause horizontal movement at roller-support *B* in the bare structure. To compensate for the horizontal movement at *B* and keep the span at 40 feet exactly, a variable load ***P*** is applied at node *C* as illustrated in the figure.

If all truss members are made out of the same material (modulus of elasticity ***E*** and coefficient of thermal expansion ***α***) and have the same cross-sectional area A_{bar}, find how ***P*** should vary as a function of temperature change ***T*** to keep the span at 40 feet.

Assume that temperature change ***T*** applies to all truss members uniformly. Ignore self-weight of the truss.



3)



A beam of length 3***L*** is formed by welding three shorter pieces of length ***L*** as shown in the figure above. Segments *AB* and *CD* (the overhangs) have a constant cross-sectional moment of inertia ***I*** while the center piece (segment *BC*) has a constant cross-sectional moment of inertia 2***I***.

The beam is pin-supported at *B* and roller-supported at *C*.

An upward point load of amplitude **P** is applied at the left-hand tip (point *A*) and a downward point load of amplitude **P** is applied at the right-hand tip (point *D*).

Assume that the beam responds by bending (i.e. in flexure) only and has a modulus of elasticity of ***E***. Ignore the weight of the beam.

Find the vertical displacement and slope of the deflected beam at point *O*. Note that point *O* is located at the mid-span of the center piece.

Draw the deflected shape of the beam.

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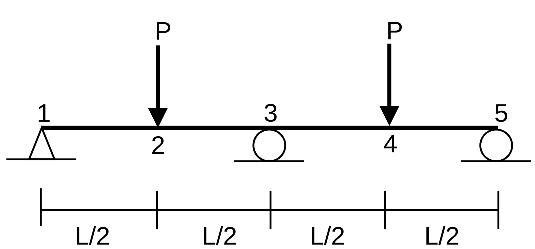
4) The continuous weightless beam shown below has two spans, each of length L. It has constant cross-sectional and material properties (i.e., constant A, A_{shear}, I, and E, G). The two point loads of magnitude P are applied at mid-spans (nodes 2 and 4).

a) Considering shear behavior only, find the reaction force at the center support (node 3). (*Hint*: use the compatibility condition that there is no vertical displacement at node 3.)

b) Considering flexural behavior only, find the reaction force at the center support (node 3). (*Hint*: use the compatibility condition that there is no vertical displacement at node 3.)

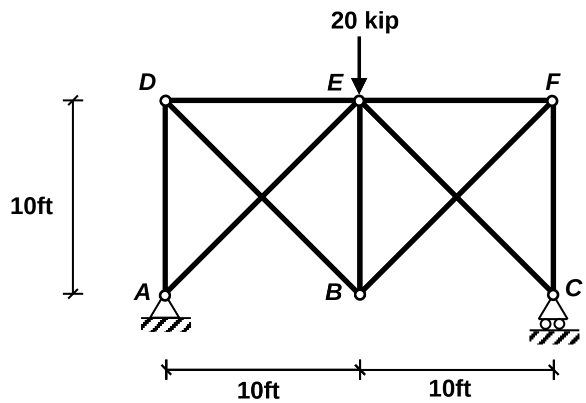
c) Considering flexural behavior only, what is the amount of reduction in displacement of node 2 caused by the presence of the center support? In other words, in comparison to the case of a simply-supported beam spanning between nodes 1 and 5 and without any center support, what is the amount of reduction in displacement of node 2 due to the reaction at center support (node 3)?



5) Each element of the truss structure shown below is made out of steel (Young's modulus of steel = 30,000 ksi) and has a cross-sectional area of 4 in^2.

a) Is the structure statically determinate? If not, what is its degree of statical indeterminacy?
b) Find the vertical displacement of node *B* (bottom center node) due to the 20 kip vertical load acting downwards at node *E* (top center node).

Note: The hollow circles at nodes *A*, *B*, *C*, *D*, *E*, and *F* indicate hinges. Support *A* is a pinned support and supprt *C* is a roller support. Note that the four diagonal members, i.e., members *AE*, *BD*, *BF*, and *CE*, are single piece elements.



6) The three-story frame structure shown below has fixed base connections at nodes *A*, *B*, and *C*. Assume that all elements are made out same material. All column sections are identical and all beam sections are identical. Beam-column connections are rigid. Ignore self-weight.

a) Consider the case of lateral loading in which two 10 kip point loads are applied on the structure: one at node *K* and another at node *G*, both acting towards right.

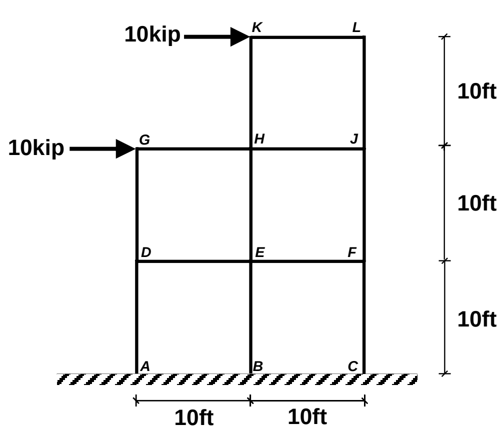
Using portal method of approximate analysis, carry out necessary calculations to draw the bending moment diagram for

i. the column *BEHK*;
ii. the beams *GH* and *DE*.
iii. [Bonus 5 points] Sketch the deflected structure.

b) Consider the case of gravity loading in which uniformly distributed vertical loads of 0.10 kip/ft are acting downwards on all beams. (No lateral loads, such as those mentioned in part a, are acting on the structure.)

Using approximate analysis, find and draw the bending moment diagram for the third floor beams, i.e., beams *GH* and *HJ*.

Note: Do not forget to write the maximum values of the bending moments on your diagrams.



7) A combined frame + truss steel structure is shown below. The structure is loaded on its truss portion with a horizontal load of 40 kN (acting towards left) at node *F* and a vertical load of 70 kN (acting downwards) at node *D*.

For all truss elements, $EA=300x10^3$ kN. The continuous frame element *ABC* has one half (segment *AB*) with 2EI and the other half (segment *BC*) with EI, where $EI = 1000x10^3 \text{ kNm}^2$.

Ignore shear and axial deformations in the frame element *ABC*.

Find the vertical displacement of point *C*.