SE130B

Homework 5

Due: 11:59 pm, Monday, May 17, 2021

Attach your code (*.m file) to Canvas>Assignment>Homework 5.

Submit your code with output in a pdf file to Gradescope>Homework 5.

1. (25 Points) Given: AE=constant, $A=1000mm^2$, and E=200GPa.
   - (a) (5%) Label the structure degrees of freedom, number the elements and define a global coordinate system. For each element, define the x and y coordinates for each end node (*i* and *j*), label the element global DOFs, and map to the global structure DOFs to define the ID vector.
   - (b) (20%) In a Matlab *.m file, derive the global element stiffness matrix based on E, A values. Input the *x-y* coordinates and use them to define the length(L), and directions (cosine and sine). Show your output for each member's global element stiffness matrices.
   - (c) (25%) Continue in the *.m file to assemble the structure stiffness matrix and partition to obtain K_{ff} and show your output.
   - (d) (25%) Calculate the displacements of the free DOFs and the reactions at supports.
   - (e) (25%) Compute member forces.

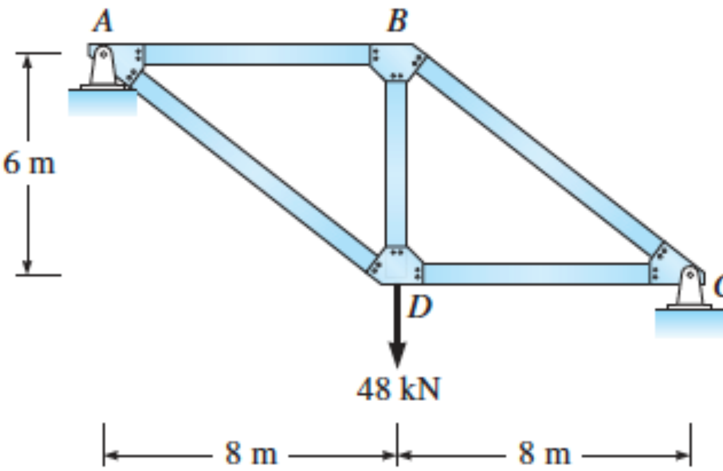


Figure 1.

Example (a):

Please be as clear as possible.

```
%Define element properties and stiffnes matrix in units of kN, m
E=200e6;  %kPa
A=1e-3;   %m^2
Grbm = [ -1 0 1 0 ];  %Gamma_RGB same for all truss
%      member id first i then j
%A is origin.
%Define
%AB 1
%AD 2
%BD 3
%BC 4
%DC 5
%Globald DOF
%A 1 2
%B 3 4
%C 5 6
%D 7 8
```

Example Output (b):

```
k1 =

      25000          0     -25000          0
          0          0          0          0
     -25000          0      25000          0
          0          0          0          0


k2 =

   1.0e+04 *

    1.2800   -0.9600   -1.2800    0.9600
   -0.9600    0.7200    0.9600   -0.7200
   -1.2800    0.9600    1.2800   -0.9600
    0.9600   -0.7200   -0.9600    0.7200


k3 =

   1.0e+04 *

         0         0         0         0
         0    3.3333         0   -3.3333
         0         0         0         0
         0   -3.3333         0    3.3333


k4 =

   1.0e+04 *

    1.2800   -0.9600   -1.2800    0.9600
   -0.9600    0.7200    0.9600   -0.7200
   -1.2800    0.9600    1.2800   -0.9600
    0.9600   -0.7200   -0.9600    0.7200


k5 =

      25000          0     -25000          0
          0          0          0          0
     -25000          0      25000          0
          0          0          0          0
```

Example Output (c):

```
Kff =

   1.0e+04 *

    3.7800   -0.9600         0         0
   -0.9600    4.0533         0   -3.3333
         0         0    3.7800   -0.9600
         0   -3.3333   -0.9600    4.0533
```

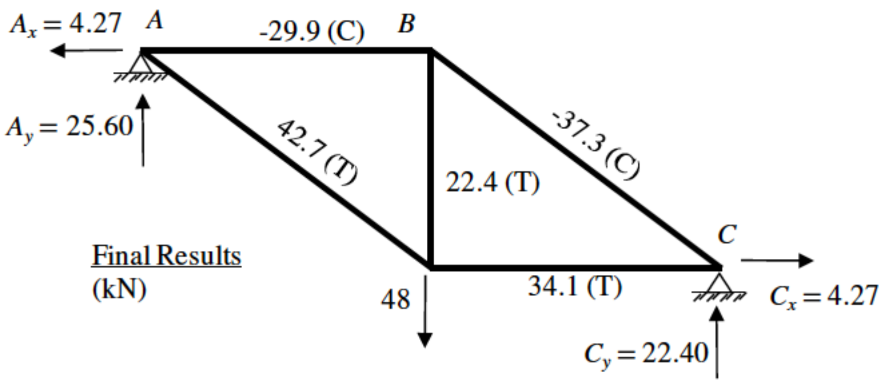
Example Output (d):

```
Uf =

   -0.0012
   -0.0047
   -0.0014
   -0.0054


Pd =

   -4.2667
   25.6000
    4.2667
   22.4000
```

Example Output (e):

```
FBP1 =

  -29.8667


FBP2 =

   42.6667


FBP3 =

   22.4000


FBP4 =

  -37.3333


FBP5 =

   34.1333
```

Exact solution to compare:



2. (25 Points) In the beam shown below, E=29,000 ksi and I =1,200 in.^{4} for all members. Use hand calculations with method of stiffness coefficients to
   (a) Identify the free DOFs. Neglect axial deformations.
   (b) Form the stiffness matrix $\underline{\boldsymbol{K}_{ff}}$ and load vector $\underline{\boldsymbol{P}_f}$.
   (c) Solve for the nodal displacement vector $\underline{\boldsymbol{U}_f}$.
   (d) Draw the shear force and bending moment diagrams.
   (e) Sketch the deflected shape.
   Hint: Put a node at point B to avoid the use of fixed-end forces.

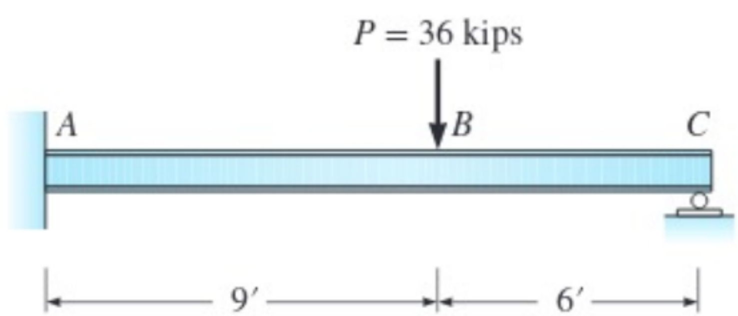


Figure 2.

3. (25 Points) In the frame shown below, E=29,000 ksi and I =550 in.^{4} Use hand calculations to
   (a) Identify the free DOFs. Neglect axial deformations.
   (b) Form the stiffness matrix $\underline{K_{ff}}$ and load vector $\underline{P_f}$.
   (c) Solve for the nodal displacement vector Uf.
   (d) Draw the shear force and bending moment diagrams.
   (e) Sketch the deflected shape.

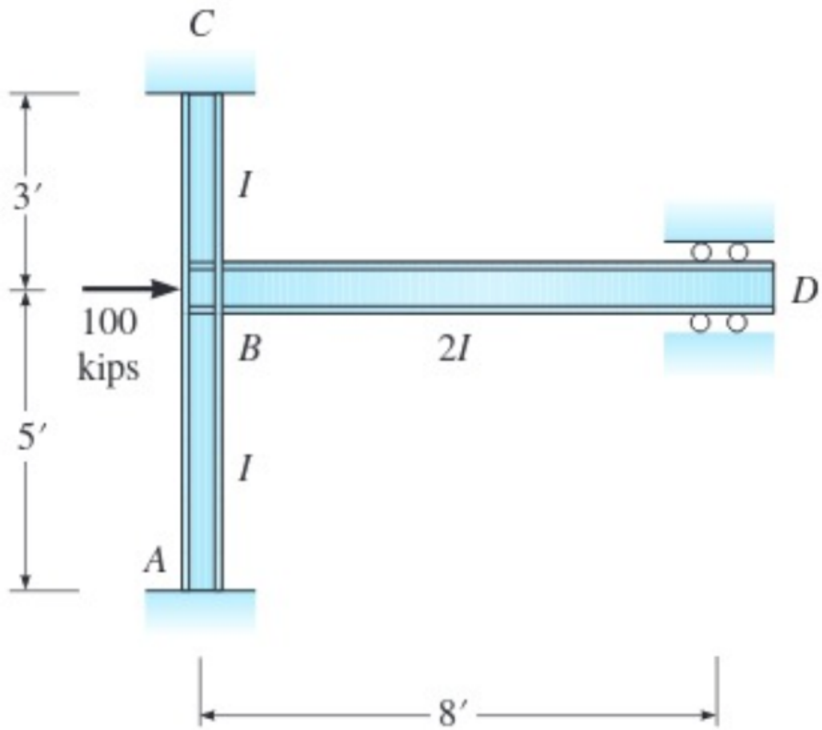


Figure 3.

4. (25 Points)
Analyze the 9-member truss shown below using Matlab to aid in the computation. Neatly report all nodal displacements, external reactions, and bar forces. Use E = 200GPa, A=3500mm^2, and $\alpha = 6 \times 10^{-6}/°F$ for all members. In addition to the indicated joint loads, distributed element loads, and temperature loads, node 1 settles downward by 3mm. For members with a non-uniform axial force, draw the axial force diagram.

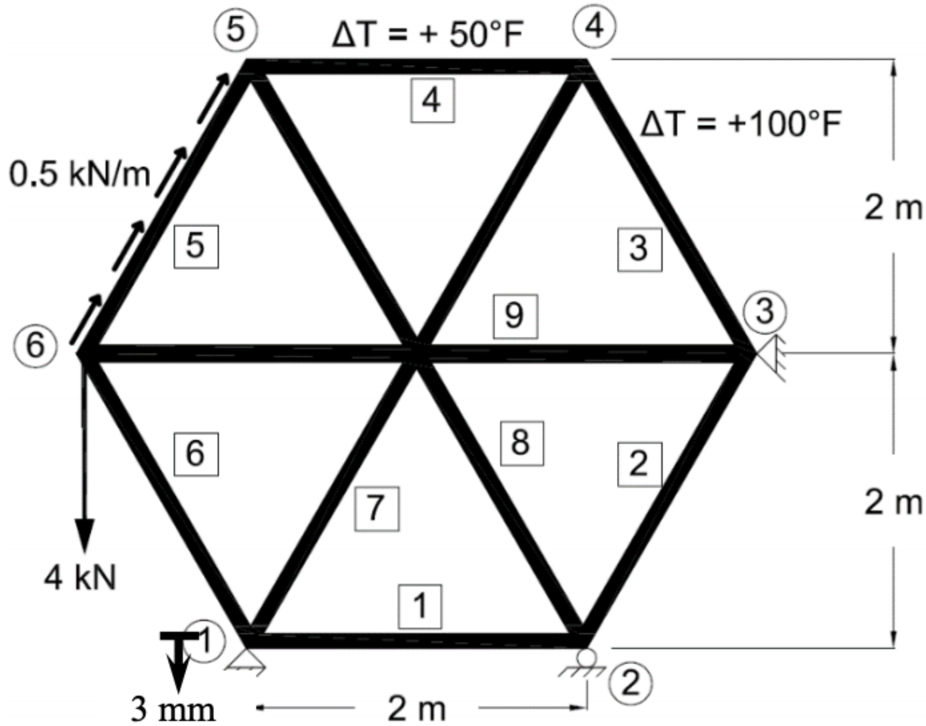


Figure 4.