2.1. (a) Use three 1-D bar elements,

For element 1 (connecting nodes 1 and 2),

$$\begin{array}{cc} & \begin{array}{cc} u_1 & u_2 \end{array} \\ \mathbf{K_1} = \dfrac{EA}{L} & \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \end{array}$$

For element 2 (connecting nodes 2 and 3),

$$\begin{array}{cc} & \begin{array}{cc} u_2 & u_3 \end{array} \\ \mathbf{K_2} = \dfrac{2EA}{L} & \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \end{array}$$

For element 3 (connecting nodes 3 and 4),

$$\begin{array}{cc} & \begin{array}{cc} u_3 & u_4 \end{array} \\ \mathbf{K_3} = \dfrac{EA}{L} & \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \end{array}$$

We can assemble the global FE equation as follows:

$$\begin{array}{cc} & \begin{array}{cccc} u_1 & u_2 & u_3 & u_4 \end{array} \\ \dfrac{EA}{L} & \begin{bmatrix} 1 & -1 & 0 & 0 \\ -1 & 3 & -2 & 0 \\ 0 & -2 & 3 & -1 \\ 0 & 0 & -1 & 1 \end{bmatrix} \end{array} \begin{bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \end{bmatrix} = \begin{bmatrix} F_1 \\ F_2 \\ F_3 \\ F_4 \end{bmatrix}$$

Load and boundary conditions are

$$u_1 = 0, \quad F_2 = 0, \quad F_3 = 0, \quad F_4 = P$$

FE equations become:

$$\frac{EA}{L} \begin{bmatrix} 3 & -2 & 0 \\ -2 & 3 & -1 \\ 0 & -1 & 1 \end{bmatrix} \begin{bmatrix} u_2 \\ u_3 \\ u_4 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ P \end{bmatrix}$$

$$\therefore \begin{bmatrix} u_2 \\ u_3 \\ u_4 \end{bmatrix} = \frac{PL}{EA} \begin{bmatrix} 1 \\ 1.5 \\ 2.5 \end{bmatrix}$$

(b) Stress in element 1:

$$\sigma_1 = E\varepsilon_1 = E\left[-\frac{1}{L} \quad \frac{1}{L}\right] \begin{bmatrix} u_1 \\ u_2 \end{bmatrix}$$

$$= \frac{E}{L}(u_2 - u_1) = \frac{E}{L}\left(\frac{PL}{EA} - 0\right) = \frac{P}{A}$$

Stress in element 2:

$$\sigma_2 = E\varepsilon_2 = E\begin{bmatrix}-\frac{1}{L} & \frac{1}{L}\end{bmatrix}\begin{bmatrix}u_2\\u_3\end{bmatrix}$$

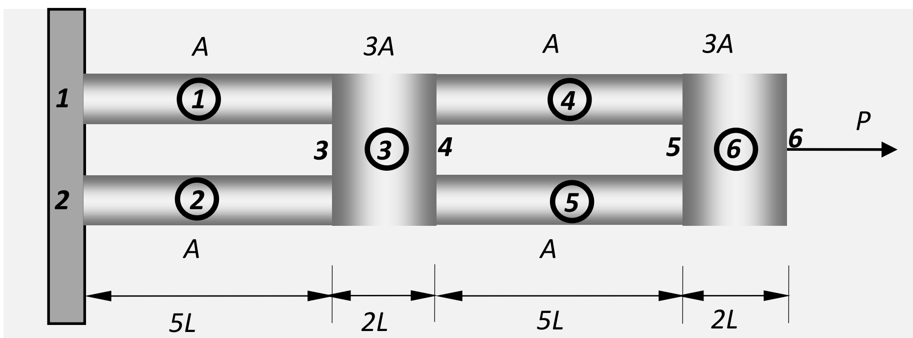
$$= \frac{E}{L}(u_3 - u_2) = \frac{E}{L}\left(\frac{1.5PL}{EA} - \frac{PL}{EA}\right) = \frac{P}{2A}$$

Stress in element 3:

$$\sigma_3 = E\varepsilon_3 = E\begin{bmatrix}-\frac{1}{L} & \frac{1}{L}\end{bmatrix}\begin{bmatrix}u_3\\u_4\end{bmatrix}$$

$$= \frac{E}{L}(u_4 - u_3) = \frac{E}{L}\left(\frac{2.5PL}{EA} - \frac{1.5PL}{EA}\right) = \frac{P}{A}$$

2.2. Use six 1-D bar elements to discretize the simple structure as shown below:



For element 1:

$$\boldsymbol{K_1} = \frac{EA}{5L}\begin{array}{c}\begin{matrix}u_1 & u_3\end{matrix}\\ \begin{bmatrix}1 & -1\\-1 & 1\end{bmatrix}\end{array}$$

For element 2:

$$\boldsymbol{K_2} = \frac{EA}{5L}\begin{array}{c}\begin{matrix}u_2 & u_3\end{matrix}\\ \begin{bmatrix}1 & -1\\-1 & 1\end{bmatrix}\end{array}$$

For element 3:

$$\boldsymbol{K_3} = \frac{3EA}{2L}\begin{array}{c}\begin{matrix}u_3 & u_4\end{matrix}\\ \begin{bmatrix}1 & -1\\-1 & 1\end{bmatrix}\end{array}$$

For element 4:

$$\boldsymbol{K_4} = \frac{EA}{5L} \begin{array}{c} \begin{matrix} u_4 & u_5 \end{matrix} \\ \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \end{array}$$

For element 5:

$$\boldsymbol{K_5} = \frac{EA}{5L} \begin{array}{c} \begin{matrix} u_4 & u_5 \end{matrix} \\ \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \end{array}$$

For element 6:

$$\boldsymbol{K_6} = \frac{3EA}{2L} \begin{array}{c} \begin{matrix} u_5 & u_6 \end{matrix} \\ \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \end{array}$$

The assembled global FE equations are:

$$\begin{array}{c} \begin{matrix} u_1 & u_2 & u_3 & u_4 & u_5 & u_6 \end{matrix} \\ \begin{bmatrix} 0.2 & 0 & -0.2 & 0 & 0 & 0 \\ 0 & 0.2 & -0.2 & 0 & 0 & 0 \\ -0.2 & -0.2 & 1.9 & -1.5 & 0 & 0 \\ 0 & 0 & -1.5 & 1.9 & -0.4 & 0 \\ 0 & 0 & 0 & -0.4 & 1.9 & -1.5 \\ 0 & 0 & 0 & 0 & -1.5 & 1.5 \end{bmatrix} \end{array} \begin{bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \\ u_5 \\ u_6 \end{bmatrix} = \begin{bmatrix} F_1 \\ F_2 \\ F_3 \\ F_4 \\ F_5 \\ F_6 \end{bmatrix}$$

Load and boundary conditions are:

$u_1 = 0, \quad u_2 = 0, \quad F_3 = 0, \quad F_4 = 0, \quad F_5 = 0, \quad F_6 = P$

FE equations become:

$$\frac{EA}{L} \begin{bmatrix} 1.9 & -1.5 & 0 & 0 \\ -1.5 & 1.9 & -0.4 & 0 \\ 0 & -0.4 & 1.9 & -1.5 \\ 0 & 0 & -1.5 & 1.5 \end{bmatrix} \begin{bmatrix} u_3 \\ u_4 \\ u_5 \\ u_6 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ P \end{bmatrix}$$

$$\therefore \begin{bmatrix} u_3 \\ u_4 \\ u_5 \\ u_6 \end{bmatrix} = \frac{PL}{EA} \begin{bmatrix} 2.500 \\ 3.167 \\ 5.667 \\ 6.333 \end{bmatrix}$$

The stress in element 1:

$$\sigma_1 = E\varepsilon_1 = E[-1/5L \;\; 1/5L] \begin{bmatrix} u_1 \\ u_3 \end{bmatrix} = \frac{E}{5L}(u_3 - u_1) = \frac{E}{5L} \times \frac{PL}{EA}(2.5 - 0) = \frac{P}{2A}$$

The stress in element 2:

$$\sigma_2 = E\varepsilon_2 = E[-1/5L \;\; 1/5L]\begin{bmatrix} u_2 \\ u_3 \end{bmatrix} = \frac{E}{5L}(u_3 - u_2) = \frac{E}{5L} \times \frac{PL}{EA}(2.5 - 0) = \frac{P}{2A}$$

The stress in element 3:

$$\sigma_3 = E\varepsilon_3 = E[-1/2L \;\; 1/2L]\begin{bmatrix} u_3 \\ u_4 \end{bmatrix} = \frac{E}{2L}(u_4 - u_3) = \frac{E}{2L} \times \frac{PL}{EA}(3.167 - 2.5) = 0.33\frac{P}{A}$$

The stress in element 4:

$$\sigma_4 = E\varepsilon_4 = E[-1/5L \;\; 1/5L]\begin{bmatrix} u_4 \\ u_5 \end{bmatrix} = \frac{E}{5L}(u_5 - u_4) = \frac{E}{5L} \times \frac{PL}{EA}(5.667 - 3.167) = \frac{P}{2A}$$

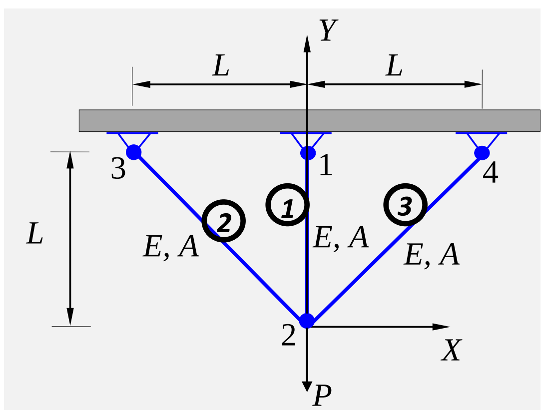
The stress in element 5:

$$\sigma_5 = E\varepsilon_5 = E[-1/5L \;\; 1/5L]\begin{bmatrix} u_4 \\ u_5 \end{bmatrix} = \frac{E}{5L}(u_5 - u_4) = \frac{E}{5L} \times \frac{PL}{EA}(5.667 - 3.167) = \frac{P}{2A}$$

The stress in element 6:

$$\sigma_6 = E\varepsilon_6 = E[-1/2L \;\; 1/2L]\begin{bmatrix} u_5 \\ u_6 \end{bmatrix} = \frac{E}{2L}(u_6 - u_5) = \frac{E}{2L} \times \frac{PL}{EA}(6.333 - 5.667) = 0.33\frac{P}{A}$$

2.3.



Element 1: $1 - 2,\ \theta = 90°,\ l = 0,\ m = L$

$$\boldsymbol{K_1} = \frac{EA}{L} \begin{array}{c} \begin{array}{cccc} u_2 & v_2 & u_1 & v_1 \end{array} \\ \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 \end{bmatrix} \end{array}$$

Element 2: $2-3$, $\theta = 135°$, $l = -\sqrt{2}/2$, $m = \sqrt{2}/2$

$$\boldsymbol{K_2} = \frac{EA}{\sqrt{2}L}\begin{array}{c} \begin{array}{cccc} u_2 & v_2 & u_3 & v_3 \end{array} \\ \begin{bmatrix} 1/2 & -1/2 & -1/2 & 1/2 \\ -1/2 & 1/2 & 1/2 & -1/2 \\ -1/2 & 1/2 & 1/2 & -1/2 \\ 1/2 & -1/2 & -1/2 & 1/2 \end{bmatrix} \end{array}$$

Element 3: $2-4$, $\theta = 45°$, $l = \sqrt{2}/2$, $m = \sqrt{2}/2$

$$\boldsymbol{K_3} = \frac{EA}{\sqrt{2}L}\begin{array}{c} \begin{array}{cccc} u_2 & v_2 & u_4 & v_4 \end{array} \\ \begin{bmatrix} 1/2 & 1/2 & -1/2 & -1/2 \\ 1/2 & 1/2 & -1/2 & -1/2 \\ -1/2 & -1/2 & 1/2 & 1/2 \\ -1/2 & -1/2 & 1/2 & 1/2 \end{bmatrix} \end{array}$$

Assemble the global FE system:

$$\frac{EA}{2\sqrt{2}L}\begin{array}{c} \begin{array}{cccccccc} u_1 & v_1 & u_2 & v_2 & u_3 & v_3 & u_4 & v_4 \end{array} \\ \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 2\sqrt{2} & 0 & -2\sqrt{2} & 0 & 0 & 0 & 0 \\ 0 & 0 & 2 & 0 & -1 & 1 & -1 & -1 \\ 0 & -2\sqrt{2} & 0 & 2\sqrt{2}+2 & 1 & -1 & -1 & -1 \\ 0 & 0 & -1 & 1 & 1 & -1 & 0 & 0 \\ 0 & 0 & 1 & -1 & -1 & 1 & 0 & 0 \\ 0 & 0 & -1 & -1 & 0 & 0 & 1 & 1 \\ 0 & 0 & -1 & -1 & 0 & 0 & 1 & 1 \end{bmatrix} \end{array} \begin{bmatrix} u_1 \\ v_1 \\ u_2 \\ v_2 \\ u_3 \\ v_3 \\ u_4 \\ v_4 \end{bmatrix} = \begin{bmatrix} F_{1X} \\ F_{1Y} \\ F_{2X} \\ F_{2Y} \\ F_{3X} \\ F_{3Y} \\ F_{4X} \\ F_{4Y} \end{bmatrix} \qquad (1)$$

B.C.: $u_1 = v_1 = u_3 = v_3 = u_4 = v_4 = 0$, $F_{2X} = 0$, $F_{2Y} = -P$,

Reduced global FE equation:

$$\frac{EA}{2\sqrt{2}L}\begin{bmatrix} 2 & 0 \\ 0 & 2\sqrt{2}+2 \end{bmatrix}\begin{bmatrix} u_2 \\ v_2 \end{bmatrix} = \begin{bmatrix} 0 \\ -P \end{bmatrix}$$

$$\therefore \quad \begin{bmatrix} u_2 \\ v_2 \end{bmatrix} = \frac{PL}{EA}\begin{bmatrix} 0 \\ -0.5858 \end{bmatrix} \qquad (2)$$

Substituting (2) into (1), we have the following reduced equation:

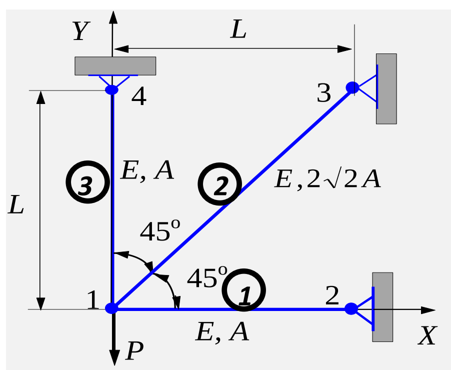
$$\begin{bmatrix} F_{1X} \\ F_{1Y} \\ F_{3X} \\ F_{3Y} \\ F_{4X} \\ F_{4Y} \end{bmatrix} = \frac{EA}{2\sqrt{2}L}\begin{bmatrix} 0 & 0 \\ 0 & -2\sqrt{2} \\ -1 & 1 \\ 1 & -1 \\ -1 & -1 \\ -1 & -1 \end{bmatrix}\begin{bmatrix} u_2 \\ v_2 \end{bmatrix} = P\begin{bmatrix} 0 \\ 0.5858 \\ -0.2071 \\ 0.2071 \\ 0.2071 \\ 0.2071 \end{bmatrix}$$

$$\sigma_1 = \frac{E}{L}\begin{bmatrix} 0 & -1 & 0 & 1 \end{bmatrix}\begin{bmatrix} u_2 \\ v_2 \\ u_1 \\ v_1 \end{bmatrix} = 0.5858\frac{P}{A}$$

$$\sigma_2 = \frac{E}{\sqrt{2}L}\begin{bmatrix} \frac{\sqrt{2}}{2} & -\frac{\sqrt{2}}{2} & -\frac{\sqrt{2}}{2} & \frac{\sqrt{2}}{2} \end{bmatrix}\begin{bmatrix} u_2 \\ v_2 \\ u_3 \\ v_3 \end{bmatrix} = 0.2929\frac{P}{A}$$

$$\sigma_3 = \frac{E}{\sqrt{2}L}\begin{bmatrix} -\frac{\sqrt{2}}{2} & -\frac{\sqrt{2}}{2} & \frac{\sqrt{2}}{2} & \frac{\sqrt{2}}{2} \end{bmatrix}\begin{bmatrix} u_2 \\ v_2 \\ u_3 \\ v_3 \end{bmatrix} = 0.2929\frac{P}{A}$$

2.4.



Element 1: $1-2,\ \theta = 0°,\ l = 1,\ m = 0;$

$$\boldsymbol{K_1} = \frac{EA}{L}\begin{array}{c} \begin{array}{cccc} u_1 & v_1 & u_2 & v_2 \end{array} \\ \begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \end{array}$$

Element 2: $1-3,\ \theta = 45°,\ l = m = \sqrt{2}/2,\ L = \sqrt{2}L;$

$$\boldsymbol{K_2} = \frac{E\left(2\sqrt{2}A\right)}{\sqrt{2}L}\begin{bmatrix} 1/2 & 1/2 & -1/2 & -1/2 \\ 1/2 & 1/2 & -1/2 & -1/2 \\ -1/2 & -1/2 & 1/2 & 1/2 \\ -1/2 & -1/2 & 1/2 & 1/2 \end{bmatrix} = \frac{EA}{L}\begin{array}{c} \begin{array}{cccc} u_1 & v_1 & u_3 & v_3 \end{array} \\ \begin{bmatrix} 1 & 1 & -1 & -1 \\ 1 & 1 & -1 & -1 \\ -1 & -1 & 1 & 1 \\ -1 & -1 & 1 & 1 \end{bmatrix} \end{array}$$

Element 3: $1-4,\ \theta = 90°,\ l = 0,\ m = l;$

$$
\boldsymbol{K_3} = \frac{EA}{L} \begin{array}{cccc} u_1 & v_1 & u_4 & v_4 \end{array}
$$
$$
\boldsymbol{K_3} = \frac{EA}{L}\begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 \end{bmatrix}
$$

Assemble the global FE system:

$$
\frac{EA}{L}\begin{bmatrix} 2 & 1 & -1 & 0 & -1 & -1 & 0 & 0 \\ 1 & 2 & 0 & 0 & -1 & -1 & 0 & -1 \\ -1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -1 & -1 & 0 & 0 & 1 & 1 & 0 & 0 \\ -1 & -1 & 0 & 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} u_1 \\ v_1 \\ u_2 \\ v_2 \\ u_3 \\ v_3 \\ u_4 \\ v_4 \end{bmatrix} = \begin{bmatrix} F_{1X} \\ F_{1Y} \\ F_{2X} \\ F_{2Y} \\ F_{3X} \\ F_{3Y} \\ F_{4X} \\ F_{4Y} \end{bmatrix} \qquad (1)
$$

B.C.s: $u_2 = v_2 = u_3 = v_3 = u_4 = v_4 = 0, \quad F_{1X} = 0, \quad F_{2Y} = -P$

$$
=> \quad \frac{EA}{L}\begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix}\begin{bmatrix} u_1 \\ v_1 \end{bmatrix} = \begin{bmatrix} 0 \\ -P \end{bmatrix}
$$

Solving,

$$
\begin{bmatrix} u_1 \\ v_1 \end{bmatrix} = \frac{PL}{3EA}\begin{bmatrix} 1 \\ -2 \end{bmatrix} \qquad (2)
$$

Reaction forces:

From (1)

$$
\begin{bmatrix} F_{2X} \\ F_{2Y} \\ F_{3X} \\ F_{3Y} \\ F_{4X} \\ F_{4Y} \end{bmatrix} = \frac{EA}{L}\begin{bmatrix} -1 & 0 \\ 0 & 0 \\ -1 & -1 \\ -1 & -1 \\ 0 & 0 \\ 0 & -1 \end{bmatrix}\begin{bmatrix} u_1 \\ v_1 \end{bmatrix} = \frac{P}{3}\begin{bmatrix} -1 \\ 0 \\ 1 \\ 1 \\ 0 \\ 2 \end{bmatrix},
$$

$$
i.e. \quad \begin{bmatrix} F_{2X} \\ F_{2Y} \\ F_{3X} \\ F_{3Y} \\ F_{4X} \\ F_{4Y} \end{bmatrix} = \begin{bmatrix} -P/3 \\ 0 \\ P/3 \\ P/3 \\ 0 \\ 2P/3 \end{bmatrix}.
$$

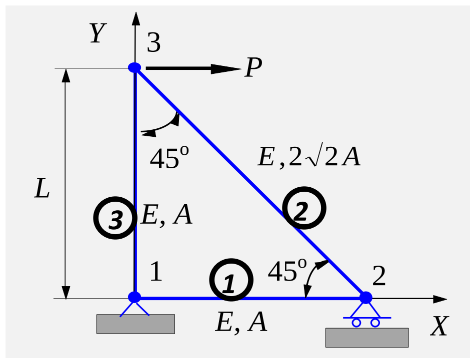
Stresses:

$$
\sigma_1 = \frac{E}{L}\begin{bmatrix} -l & -m & l & m \end{bmatrix}\begin{bmatrix} u_1 \\ v_1 \\ u_2 \\ v_2 \end{bmatrix} = \frac{E}{L}\begin{bmatrix} -1 & 0 & 1 & 0 \end{bmatrix}\begin{bmatrix} 1 \\ -2 \\ 0 \\ 0 \end{bmatrix}\frac{PL}{3EA} = -\frac{P}{3A}
$$

$$\sigma_2 = \frac{E}{\sqrt{2}L}\begin{bmatrix} -\frac{\sqrt{2}}{2} & -\frac{\sqrt{2}}{2} & \frac{\sqrt{2}}{2} & \frac{\sqrt{2}}{2} \end{bmatrix}\begin{bmatrix} 1 \\ -2 \\ 0 \\ 0 \end{bmatrix}\frac{PL}{3EA} = \frac{P}{6A}$$

$$\sigma_1 = \frac{E}{L}[0 \quad -1 \quad 0 \quad 1]\begin{bmatrix} 1 \\ -2 \\ 0 \\ 0 \end{bmatrix}\frac{PL}{3EA} = \frac{2P}{3A}$$

2.5.



Element 1: 1-2, $\theta = 0, l = 1, m = 0$

$$\boldsymbol{K_1} = \frac{EA}{L}\begin{array}{c} \begin{matrix} u_1 & v_1 & u_2 & v_2 \end{matrix} \\ \begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \end{array}$$

Element 2: 2-3, $\theta = 135°, l = -\frac{\sqrt{2}}{2}, m = \frac{\sqrt{2}}{2}$

$$\boldsymbol{K_2} = \frac{E(2\sqrt{2}A)}{\sqrt{2}L\cdot(2)}\begin{array}{c} \begin{matrix} u_2 & v_2 & u_3 & v_3 \end{matrix} \\ \begin{bmatrix} 1 & -1 & -1 & 1 \\ -1 & 1 & 1 & -1 \\ -1 & 1 & 1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix} \end{array}$$

Element 3: 1-3, $\theta = 90°, l = 0, m = 1$

$$\boldsymbol{K_3} = \frac{EA}{L}\begin{array}{c} \begin{matrix} u_1 & v_1 & u_3 & v_3 \end{matrix} \\ \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 \end{bmatrix} \end{array}$$

Global stiffness matrix:

$$\mathbf{K} = \frac{EA}{L} \begin{array}{c} \begin{matrix} u_1 & v_1 & u_2 & v_2 & u_3 & v_3 \end{matrix} \\ \begin{bmatrix} 1 & 0 & -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & -1 \\ -1 & 0 & 2 & -1 & -1 & 1 \\ 0 & 0 & -1 & 1 & 1 & -1 \\ 0 & 0 & -1 & 1 & 1 & -1 \\ 0 & -1 & 1 & -1 & -1 & 2 \end{bmatrix} \end{array}$$

Applying B.C., where:

$$u_1 = v_1 = v_2 = 0, F_{2x} = 0, F_{3x} = P, F_{3Y} = 0$$

$$\frac{EA}{L} \begin{array}{c} \begin{matrix} u_2 & u_3 & v_3 \end{matrix} \\ \begin{bmatrix} 2 & -1 & 1 \\ -1 & 1 & -1 \\ 1 & -1 & 2 \end{bmatrix} \end{array} \begin{bmatrix} u_2 \\ u_3 \\ v_3 \end{bmatrix} = \begin{bmatrix} 0 \\ P \\ 0 \end{bmatrix}$$

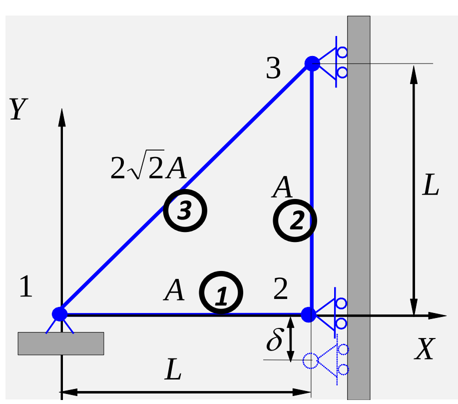
$$\begin{bmatrix} u_2 \\ u_3 \\ v_3 \end{bmatrix} = \frac{PL}{EA} \begin{bmatrix} 1 \\ 3 \\ 1 \end{bmatrix}$$

$$\sigma_1 = \frac{E}{L} [-1 \quad 0 \quad 1 \quad 0] \begin{bmatrix} u_1 \\ v_1 \\ u_2 \\ v_2 \end{bmatrix} = \frac{E}{L} u_2 = \frac{P}{A}$$

$$\sigma_2 = \frac{E}{\sqrt{2}L} \left[\frac{\sqrt{2}}{2} \quad -\frac{\sqrt{2}}{2} \quad -\frac{\sqrt{2}}{2} \quad \frac{\sqrt{2}}{2} \right] \begin{bmatrix} u_2 \\ v_2 \\ u_3 \\ v_3 \end{bmatrix} = \frac{E}{2L} (1 - 3 + 1) \frac{PL}{EA} = -\frac{P}{2A}$$

$$\sigma_3 = \frac{E}{L} [0 \quad -1 \quad 0 \quad 1] \begin{bmatrix} u_1 \\ v_1 \\ u_3 \\ v_3 \end{bmatrix} = \frac{E}{L} v_3 = \frac{P}{A}$$

2.6.



Element stiffness matrices are

Element 1: $\theta = 0, l = 1, m = 0$

$$k_1 = \frac{EA}{L}\begin{array}{c} \begin{matrix} u_1 & v_1 & u_2 & v_2 \end{matrix} \\ \begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \end{array}$$

Element 2: $\theta = 90°, l = 0, m = 1$

$$k_2 = \frac{EA}{L}\begin{array}{c} \begin{matrix} u_2 & v_2 & u_3 & v_3 \end{matrix} \\ \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 \end{bmatrix} \end{array}$$

Element 3: $\theta = 45°, l = 1\sqrt{2}/, m = 1\sqrt{2}$

$$k_1 = \frac{E(2\sqrt{2}A)}{2\sqrt{2}L}\begin{array}{c} \begin{matrix} u_1 & v_1 & u_3 & v_3 \end{matrix} \\ \begin{bmatrix} 1 & 1 & -1 & -1 \\ 1 & 1 & -1 & -1 \\ -1 & -1 & 1 & 1 \\ -1 & -1 & 1 & 1 \end{bmatrix} \end{array}$$

Global FE equation

$$\frac{EA}{L}\begin{array}{c} \begin{matrix} u_1 & v_1 & u_2 & v_2 & u_3 & v_3 \end{matrix} \\ \begin{bmatrix} 2 & 1 & -1 & 0 & -1 & -1 \\ 1 & 1 & 0 & 0 & -1 & -1 \\ -1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & -1 \\ -1 & -1 & 0 & 0 & 1 & 1 \\ -1 & -1 & 0 & -1 & 1 & 2 \end{bmatrix} \end{array}\begin{bmatrix} u_1 \\ v_1 \\ u_2 \\ v_2 \\ u_3 \\ v_3 \end{bmatrix} = \begin{bmatrix} F_{1X} \\ F_{1Y} \\ F_{2X} \\ F_{2Y} \\ F_{3X} \\ F_{3Y} \end{bmatrix}$$

Boundary Conditions:

$$u_1 = v_1 = u_2 = u_3 = 0, F_{3Y} = 0, v_2 = -\sigma$$

$$\frac{EA}{L}\begin{array}{c} \begin{matrix} v_2 & v_3 \end{matrix} \\ \begin{bmatrix} 1 & -1 \\ -1 & 2 \end{bmatrix} \end{array}\begin{bmatrix} v_2 \\ v_3 \end{bmatrix} = \begin{bmatrix} F_{2Y} \\ 0 \end{bmatrix}$$

Or $\quad -v_2 + 2v_3 = 0$

$$v_3 = \frac{1}{2}v_2 = -\frac{1}{2}\sigma$$

$$\therefore \begin{bmatrix} v_2 \\ v_3 \end{bmatrix} = \begin{bmatrix} -\sigma \\ -\sigma/2 \end{bmatrix}$$

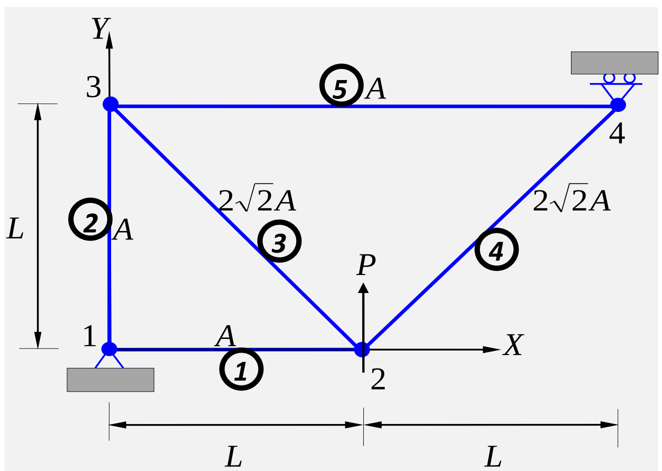
Stresses:

$$\sigma_1 = \frac{E}{L}[-1 \quad 0 \quad 1 \quad 0]\begin{bmatrix} u_1 \\ v_1 \\ u_2 \\ v_2 \end{bmatrix} = 0$$

$$\sigma_2 = \frac{E}{L}[0 \quad -1 \quad 0 \quad 1]\begin{bmatrix} u_2 \\ v_2 \\ u_3 \\ v_3 \end{bmatrix} = \frac{E}{L}\left(\sigma - \frac{\sigma}{2}\right) = \frac{E\sigma}{2L}$$

$$\sigma_3 = \frac{E}{\sqrt{2}L}\left[-\frac{1}{\sqrt{2}} \quad -\frac{1}{\sqrt{2}} \quad \frac{1}{\sqrt{2}} \quad \frac{1}{\sqrt{2}}\right]\begin{bmatrix} u_1 \\ v_1 \\ u_3 \\ v_3 \end{bmatrix} = \frac{E}{2L}\left(-\frac{\sigma}{2}\right) = -\frac{E\sigma}{4L}$$

2.7.



Element stiffness matrices:

Element 1: $1 - 2,\ \theta = 0°,\ l = 1,\ m = 0$

$$k_1 = \frac{EA}{L}\ \begin{array}{c} \begin{array}{cccc} u_1 & v_1 & u_2 & v_2 \end{array} \\ \begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \end{array}$$

Element 2: $1 - 3,\ \theta = 90°,\ l = 0,\ m = 1$

$$k_2 = \frac{EA}{L}\ \begin{array}{c} \begin{array}{cccc} u_1 & v_1 & u_3 & v_3 \end{array} \\ \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 \end{bmatrix} \end{array}$$

Element 3: $2-3,\ \theta = 135°,\ l = -2\sqrt{2},\ m = \sqrt{2}/2$

$$k_3 = \frac{E(2\sqrt{2}A)}{\sqrt{2}L} \begin{array}{c} \begin{array}{cccc} u_2 & v_2 & u_3 & v_3 \end{array} \\ \begin{bmatrix} 1/2 & -1/2 & -1/2 & 1/2 \\ -1/2 & 1/2 & 1/2 & -1/2 \\ -1/2 & 1/2 & 1/2 & -1/2 \\ 1/2 & -1/2 & -1/2 & 1/2 \end{bmatrix} \end{array}$$

Element 4: $2-4,\ \theta = 45°,\ l = \sqrt{2}/2,\ m = \sqrt{2}/2$

$$k_4 = \frac{E(2\sqrt{2}A)}{\sqrt{2}L} \begin{array}{c} \begin{array}{cccc} u_2 & v_2 & u_4 & v_4 \end{array} \\ \begin{bmatrix} 1/2 & 1/2 & -1/2 & -1/2 \\ 1/2 & 1/2 & -1/2 & -1/2 \\ -1/2 & -1/2 & 1/2 & 1/2 \\ -1/2 & -1/2 & 1/2 & 1/2 \end{bmatrix} \end{array}$$

Element 5: $3-4, \theta = 0°,\ l = 1,\ m = 0$

$$k_5 = \frac{EA}{2L} \begin{array}{c} \begin{array}{cccc} u_3 & v_3 & u_4 & v_4 \end{array} \\ \begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \end{array}$$

Assemble the global FE system:

$$\begin{array}{c} \begin{array}{cccccccc} u_1 & v_1 & u_2 & v_2 & u_3 & v_3 & u_4 & v_4 \end{array} \\ \begin{bmatrix} 1 & 0 & -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0+1 & 0 & 0 & 0 & -1 & 0 & 0 \\ -1 & 0 & 1+1+1 & 0-1+1 & -1 & 1 & -1 & -1 \\ 0 & 0 & 0-1+1 & 0+1+1 & 1 & -1 & -1 & -1 \\ 0 & 0 & -1 & 1 & 0+1+0.5 & 0-1 & -0.5 & 0 \\ 0 & -1 & 1 & -1 & 0-1 & 1+1 & 0 & 0 \\ 0 & 0 & -1 & -1 & -0.5 & 0 & 1+0.5 & 1 \\ 0 & 0 & -1 & -1 & 0 & 0 & 1 & 1 \end{bmatrix} \end{array} \begin{bmatrix} u_1 \\ v_1 \\ u_2 \\ v_2 \\ u_3 \\ v_3 \\ u_4 \\ v_4 \end{bmatrix} = \begin{bmatrix} F_{1X} \\ F_{1Y} \\ F_{2X} \\ F_{2Y} \\ F_{3X} \\ F_{3Y} \\ F_{4X} \\ F_{4Y} \end{bmatrix} \quad 1$$

B.C.: $u_1 = v_1 = v_4 = 0,\ F_{2X} = F_{3X} = F_{3Y} = 0,\ F_{2Y} = P,\ F_{4X} = 0,$

Applying B.C. to equation 1, we have:

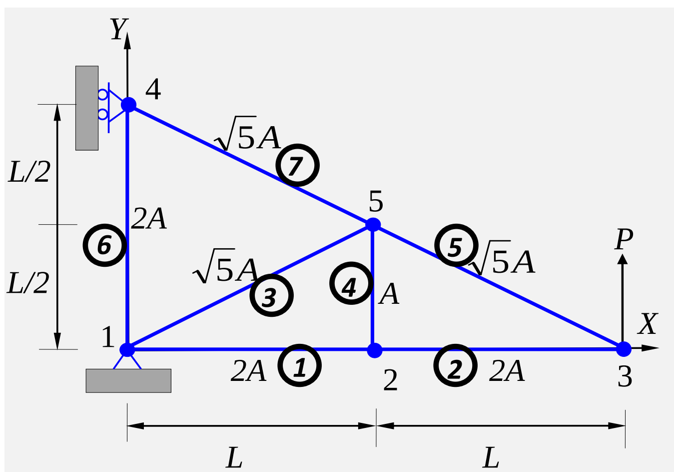
$$\frac{EA}{L} \begin{array}{c} \begin{array}{ccccc} u_2 & v_2 & u_3 & v_3 & u_4 \end{array} \\ \begin{bmatrix} 3 & 0 & -1 & 1 & -1 \\ 0 & 2 & 1 & -1 & -1 \\ -1 & 1 & 1.5 & -1 & -0.5 \\ 1 & -1 & -1 & 2 & 0 \\ -1 & -1 & -0.5 & 0 & 1.5 \end{bmatrix} \end{array} \begin{bmatrix} u_2 \\ v_2 \\ u_3 \\ v_3 \\ u_4 \end{bmatrix} = \begin{bmatrix} 0 \\ P \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$\therefore \begin{bmatrix} u_2 \\ v_2 \\ u_3 \\ v_3 \\ u_4 \end{bmatrix} = \frac{PL}{EA} \begin{bmatrix} 0 \\ 1.25 \\ -0.25 \\ 0.5 \\ 0.75 \end{bmatrix} \qquad (2)$$

Substituting (2) into (1), we have:

$$\begin{bmatrix} F_{1X} \\ F_{1Y} \\ F_{4Y} \end{bmatrix} = \frac{EA}{L} \begin{bmatrix} -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 0 \\ -1 & -1 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} u_2 \\ v_2 \\ u_3 \\ v_3 \\ u_4 \end{bmatrix} = P \begin{bmatrix} 0 \\ -0.5 \\ -0.5 \end{bmatrix}$$

2.8.



Element stiffness matrices:

Element 1: 1-2, $\theta = 0, l = 1, m = 0$

$$k_1 = \frac{E(2A)}{L} \begin{array}{c} \begin{array}{cccc} u_1 & v_1 & u_2 & v_2 \end{array} \\ \begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \end{array}$$

Element 2: 2-3, $\theta = 0, l = 1, m = 0$

$$\begin{array}{cc} & \begin{array}{cccc} u_2 & v_2 & u_3 & v_3 \end{array} \\ k_2 = \frac{E(2A)}{L} & \begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \end{array}$$

Element 3: 1-5, $l = \frac{2}{\sqrt{5}}, m = \frac{1}{\sqrt{5}}$

$$\begin{array}{cc} & \begin{array}{cccc} u_1 & v_1 & u_5 & v_5 \end{array} \\ k_3 = \frac{E(\sqrt{5}A)}{(\frac{\sqrt{5}L}{2})} & \begin{bmatrix} \frac{4}{5} & \frac{2}{5} & -\frac{4}{5} & -\frac{2}{5} \\ \frac{2}{5} & \frac{1}{5} & -\frac{2}{5} & -\frac{1}{5} \\ -\frac{4}{5} & -\frac{2}{5} & \frac{4}{5} & \frac{2}{5} \\ -\frac{2}{5} & -\frac{1}{5} & \frac{2}{5} & \frac{1}{5} \end{bmatrix} \end{array}$$

Element 4: 2-5, $\theta = 90°, l = 0, m = 1$

$$\begin{array}{cc} & \begin{array}{cccc} u_2 & v_2 & u_5 & v_5 \end{array} \\ k_4 = \frac{EA}{(\frac{L}{2})} & \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 \end{bmatrix} \end{array}$$

Element 5: 3-5, $l = -\frac{2}{\sqrt{5}}, m = \frac{1}{\sqrt{5}}$

$$\begin{array}{cc} & \begin{array}{cccc} u_3 & v_3 & u_5 & v_5 \end{array} \\ k_5 = \frac{E(\sqrt{5}A)}{(\frac{\sqrt{5}L}{2})} & \begin{bmatrix} \frac{4}{5} & -\frac{2}{5} & -\frac{4}{5} & \frac{2}{5} \\ -\frac{2}{5} & \frac{1}{5} & \frac{2}{5} & -\frac{1}{5} \\ -\frac{4}{5} & \frac{2}{5} & \frac{4}{5} & -\frac{2}{5} \\ \frac{2}{5} & -\frac{1}{5} & -\frac{2}{5} & \frac{1}{5} \end{bmatrix} \end{array}$$

Element 6: 1-4, $\theta = 90°, l = 0, m = 1$

$$\begin{array}{cc} & \begin{array}{cccc} u_1 & v_1 & u_4 & v_4 \end{array} \\ k_6 = \frac{E(2A)}{L} & \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 \end{bmatrix} \end{array}$$

Element 7: 5-4, $l = -\frac{2}{\sqrt{5}}, m = \frac{1}{\sqrt{5}}$

$$
\begin{array}{cc}
 & \begin{array}{cccc} u_5 & v_5 & u_4 & v_4 \end{array} \\
k_7 = \dfrac{E(\sqrt{5}A)}{(\frac{\sqrt{5}L}{2})} & \begin{bmatrix} \frac{4}{5} & -\frac{2}{5} & -\frac{4}{5} & \frac{2}{5} \\ -\frac{2}{5} & \frac{1}{5} & \frac{2}{5} & -\frac{1}{5} \\ -\frac{4}{5} & \frac{2}{5} & \frac{4}{5} & -\frac{2}{5} \\ \frac{2}{5} & -\frac{1}{5} & -\frac{2}{5} & \frac{1}{5} \end{bmatrix}
\end{array}
$$

Assemble the global FE system:

$$
\begin{array}{cc}
 & \begin{array}{cccccccccc} u_1 & v_1 & u_2 & v_2 & u_3 & v_3 & u_4 & v_4 & u_5 & v_5 \end{array} \\
\dfrac{2EA}{L} & \begin{bmatrix} 1.8 & 0.4 & -1 & 0 & 0 & 0 & 0 & 0 & -0.8 & -0.4 \\ 0.4 & 1.2 & 0 & 0 & 0 & 0 & 0 & -1 & -0.4 & -0.2 \\ -1 & 0 & 2 & 0 & -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & -1 \\ 0 & 0 & -1 & 0 & 1.8 & -0.4 & 0 & 0 & -0.8 & 0.4 \\ 0 & 0 & 0 & 0 & -0.4 & 0.2 & 0 & 0 & 0.4 & -0.2 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0.8 & -0.4 & -0.8 & 0.4 \\ 0 & -1 & 0 & 0 & 0 & 0 & -0.4 & 1.2 & 0.4 & -0.2 \\ -0.8 & -0.4 & 0 & 0 & -0.8 & 0.4 & -0.8 & 0.4 & 2.4 & -0.4 \\ -0.4 & -0.2 & 0 & -1 & 0.4 & -0.2 & 0.4 & -0.2 & -0.4 & 1.6 \end{bmatrix} \begin{bmatrix} u_1 \\ v_1 \\ u_2 \\ v_2 \\ u_3 \\ v_3 \\ u_4 \\ v_4 \\ u_5 \\ v_5 \end{bmatrix} = \begin{bmatrix} F_{1X} \\ F_{1Y} \\ F_{2X} \\ F_{2Y} \\ F_{3X} \\ F_{3Y} \\ F_{4X} \\ F_{4Y} \\ F_{5X} \\ F_{5Y} \end{bmatrix}
\end{array}
$$

Boundary Conditions:

$$u_1 = v_1 = u_4 = 0, F_{2X} = F_{2Y} = F_{3X} = F_{4Y} = F_{5X} = F_{5Y} = 0, F_{3Y} = P$$

Applying BCs to the global FE system, we have:

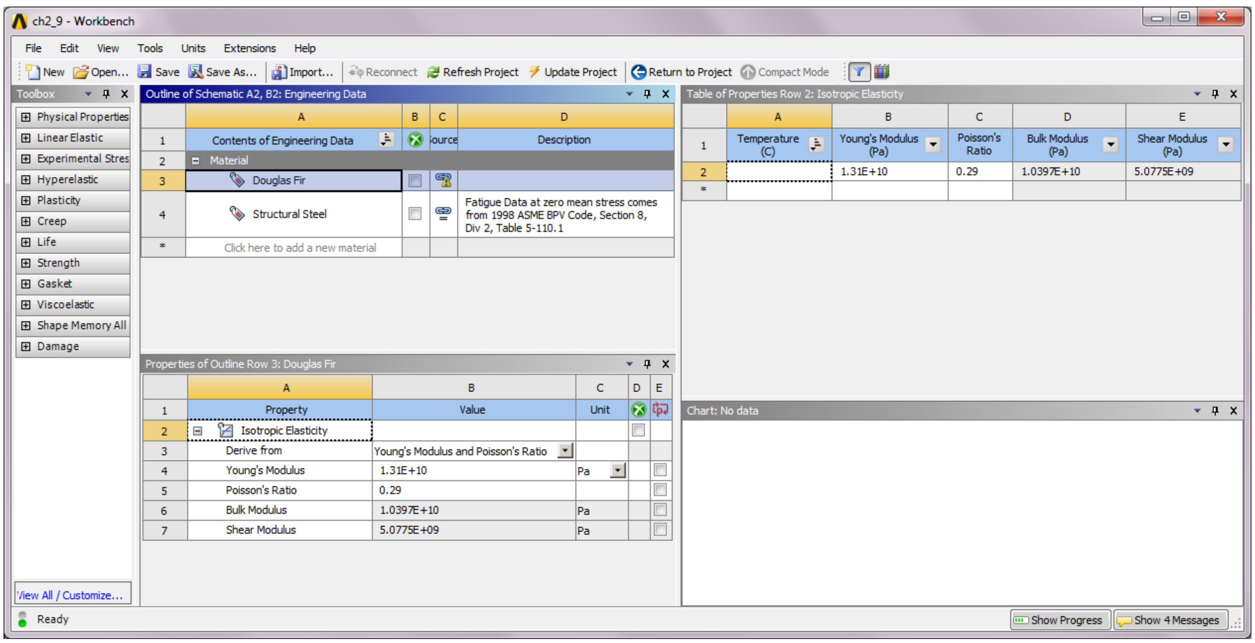
$$
\begin{array}{cc}
 & \begin{array}{ccccccc} u_2 & v_2 & u_3 & v_3 & v_4 & u_5 & v_5 \end{array} \\
\dfrac{2EA}{L} & \begin{bmatrix} 2 & 0 & -1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & -1 \\ -1 & 0 & 1.8 & -0.4 & 0 & -0.8 & 0.4 \\ 0 & 0 & -0.4 & 0.2 & 0 & 0.4 & -0.2 \\ 0 & 0 & 0 & 0 & 1.2 & 0.4 & -0.2 \\ 0 & 0 & -0.8 & 0.4 & 0.4 & 2.4 & -0.4 \\ 0 & -1 & 0.4 & -0.2 & -0.2 & -0.4 & 1.6 \end{bmatrix} \begin{bmatrix} u_2 \\ v_2 \\ u_3 \\ v_3 \\ v_4 \\ u_5 \\ v_5 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ P \\ 0 \\ 0 \\ 0 \end{bmatrix}
\end{array}
$$

$$
\begin{bmatrix} u_2 \\ v_2 \\ u_3 \\ v_3 \\ v_4 \\ u_5 \\ v_5 \end{bmatrix} = \frac{PL}{2EA} \begin{bmatrix} 2 \\ 3 \\ 4 \\ 19 \\ 1 \\ -1 \\ 3 \end{bmatrix}
$$

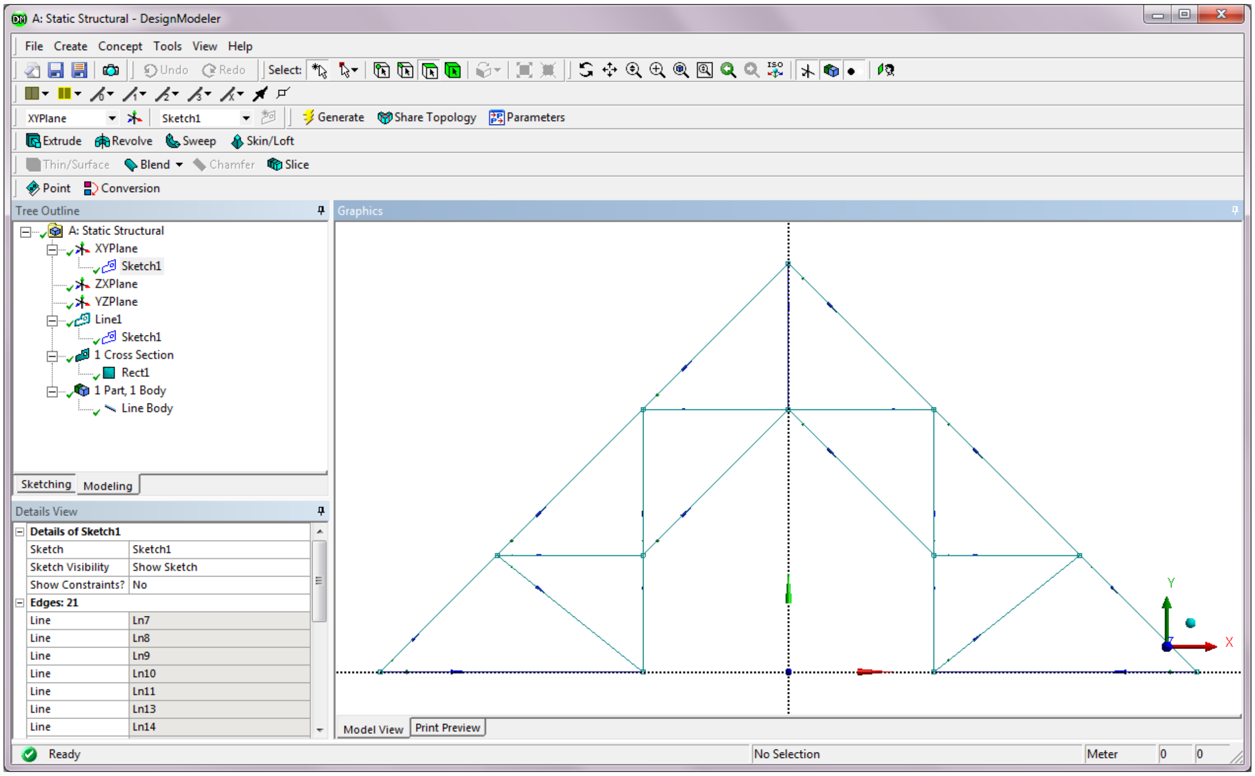
The reaction forces are:

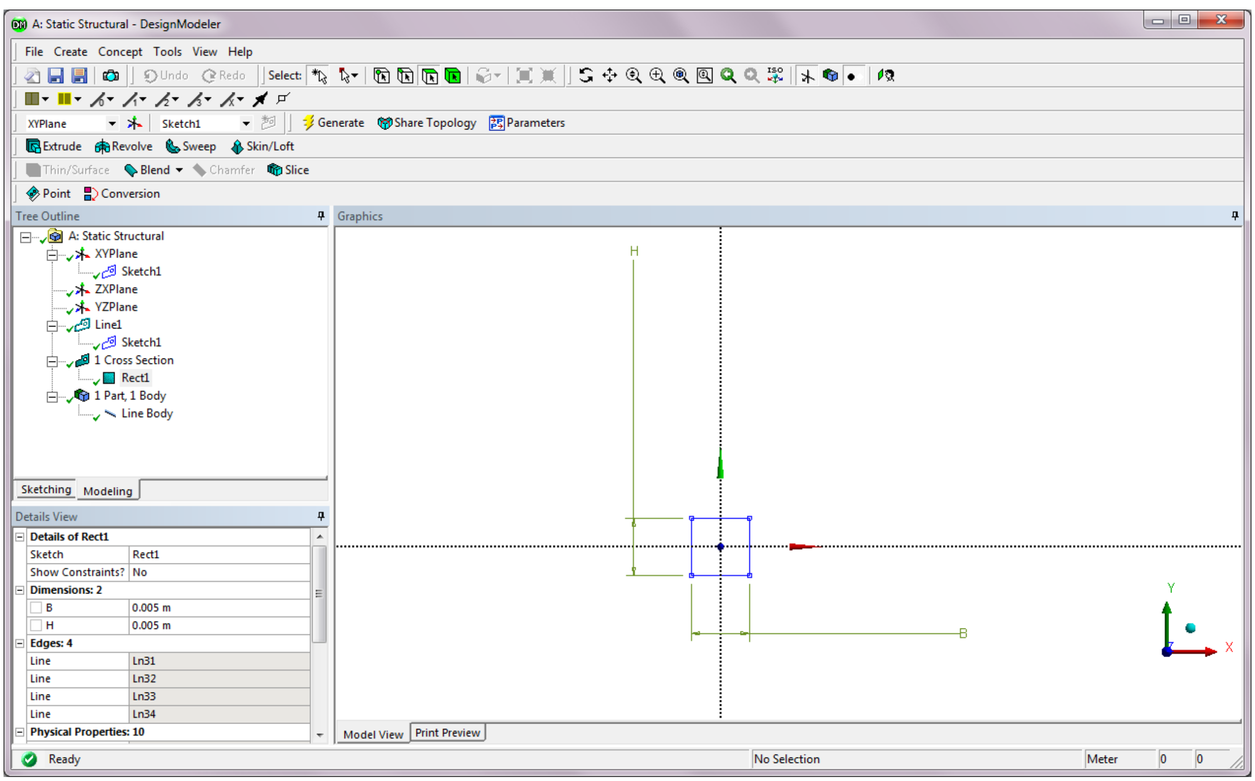
$$
\begin{bmatrix} F_{1X} \\ F_{1Y} \\ F_{4X} \end{bmatrix} = \frac{2EA}{L} \begin{bmatrix} -1 & 0 & 0 & 0 & 0 & -0.8 & -0.4 \\ 0 & 0 & 0 & 0 & -1 & -0.4 & -0.2 \\ 0 & 0 & 0 & 0 & -0.4 & -0.8 & 0.4 \end{bmatrix} \begin{bmatrix} u_2 \\ v_2 \\ u_3 \\ v_3 \\ v_4 \\ u_5 \\ v_5 \end{bmatrix} = \begin{bmatrix} -2P \\ -P \\ 2P \end{bmatrix}
$$

2.9. In the Engineering Data table, add material properties of Douglas Fir:

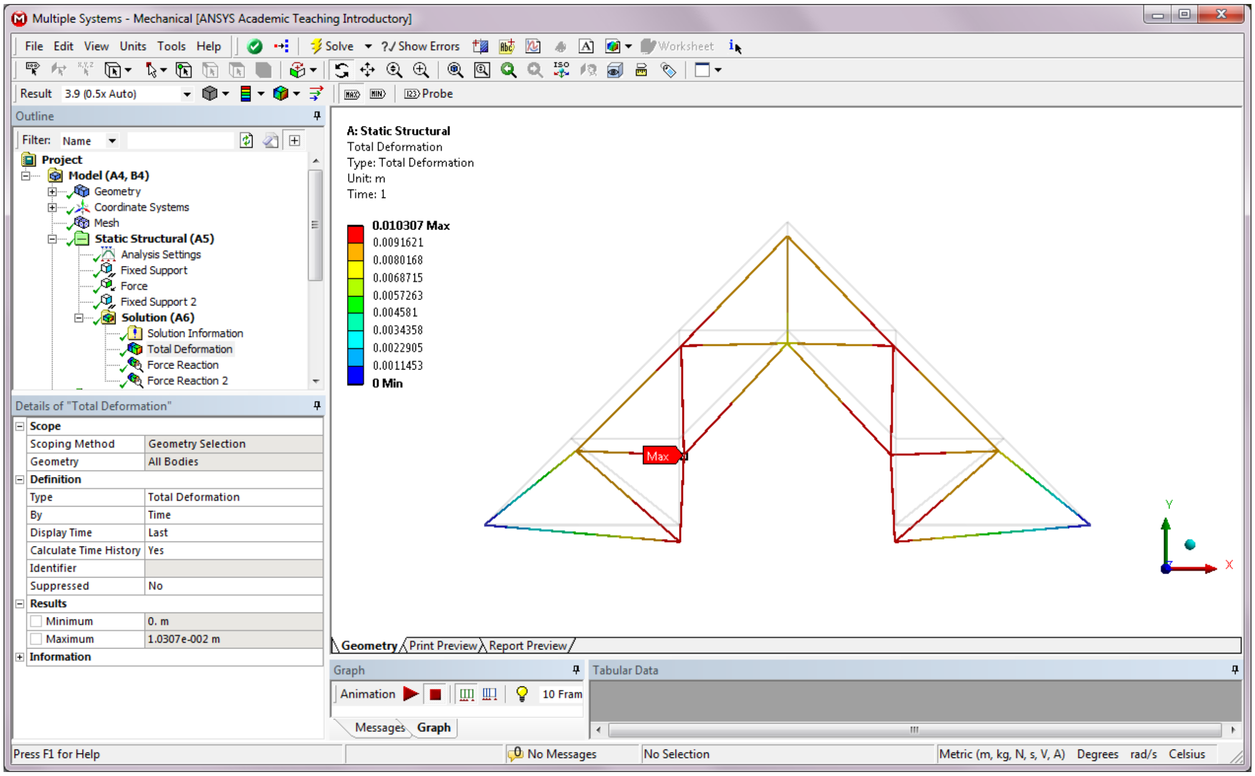


In the DesignModeler program, create a line sketch of the roof truss and a cross section definition of the truss member. Then create a line body concept model from the sketch:





In the Multiple Systems – Mechanical program, retrieve results after applying loads and boundary conditions:


Multiple Systems - Mechanical [ANSYS Academic Teaching Introductory]
File Edit View Units Tools Help
Solve
Show Errors
Worksheet
Result 3.9 (0.5x Auto)
Probe
Outline
Filter: Name
Project
Model (A4, B4)
Geometry
Coordinate Systems
Mesh
Static Structural (A5)
Analysis Settings
Fixed Support
Force
Fixed Support 2
Solution (A6)
Solution Information
Total Deformation
Force Reaction
Force Reaction 2
Details of "Total Deformation"
Scope
Scoping Method Geometry Selection
Geometry All Bodies
Definition
Type Total Deformation
By Time
Display Time Last
Calculate Time History Yes
Identifier
Suppressed No
Results
Minimum 0. m
Maximum 1.0307e-002 m
Information
A: Static Structural
Total Deformation
Type: Total Deformation
Unit: m
Time: 1
0.010307 Max
0.0091621
0.0080168
0.0068715
0.0057263
0.004581
0.0034358
0.0022905
0.0011453
0 Min
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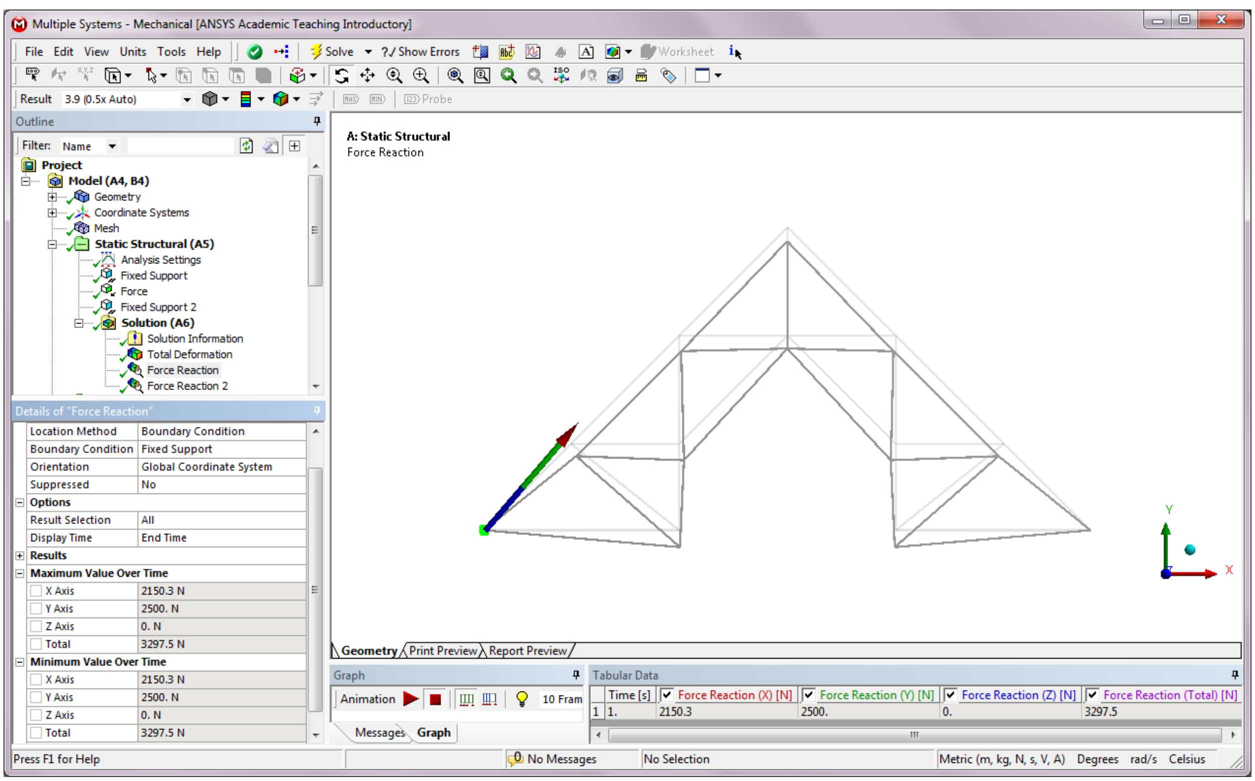
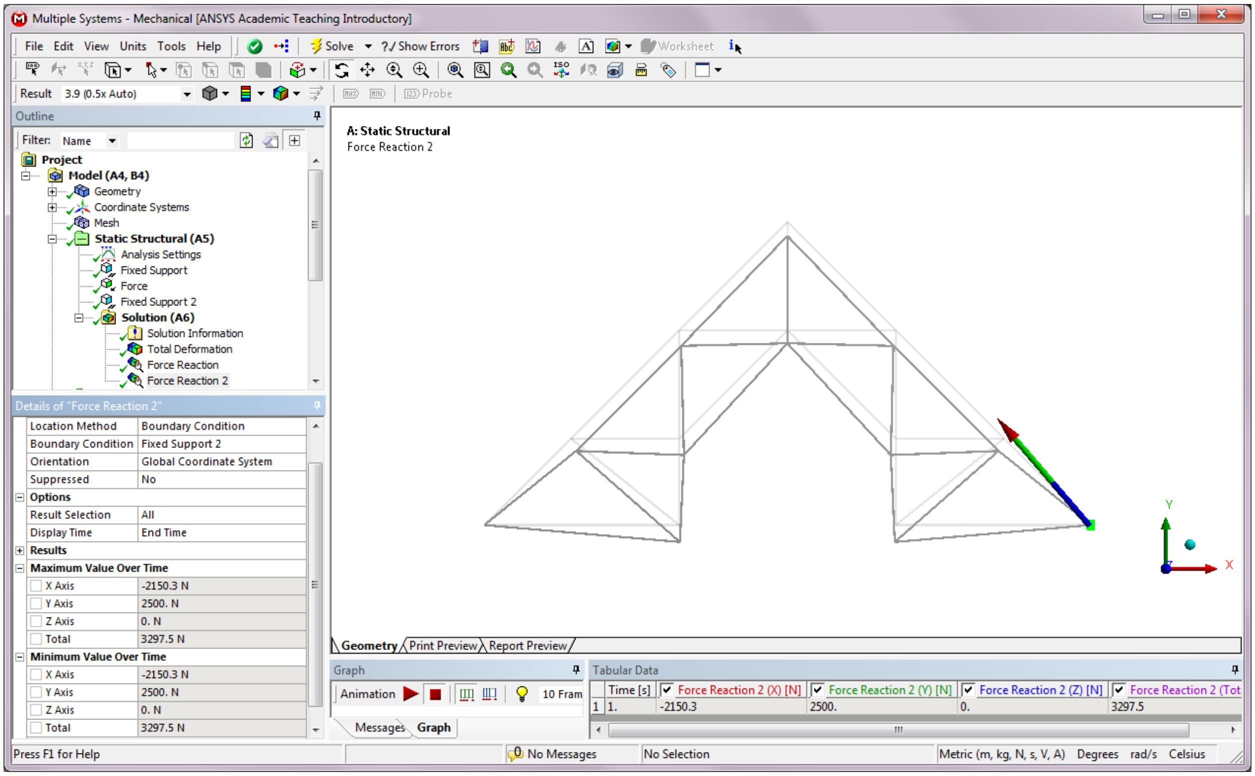
Geometry
Print Preview
Report Preview
Graph
Tabular Data
Animation
10 Fram
Messages
Graph
Press F1 for Help
No Messages
No Selection
Metric (m, kg, N, s, V, A) Degrees rad/s Celsius


Multiple Systems - Mechanical [ANSYS Academic Teaching Introductory]
File Edit View Units Tools Help
Solve
Show Errors
Worksheet
Result 3.9 (0.5x Auto)
Probe
Outline
Filter: Name
Project
Model (A4, B4)
Geometry
Coordinate Systems
Mesh
Static Structural (A5)
Analysis Settings
Fixed Support
Force
Fixed Support 2
Solution (A6)
Solution Information
Total Deformation
Force Reaction
Force Reaction 2
Details of "Force Reaction"
Location Method Boundary Condition
Boundary Condition Fixed Support
Orientation Global Coordinate System
Suppressed No
Options
Result Selection All
Display Time End Time
Results
Maximum Value Over Time
X Axis 2150.3 N
Y Axis 2500. N
Z Axis 0. N
Total 3297.5 N
Minimum Value Over Time
X Axis 2150.3 N
Y Axis 2500. N
Z Axis 0. N
Total 3297.5 N
A: Static Structural
Force Reaction
Y
X
Geometry
Print Preview
Report Preview
Graph
Tabular Data
Animation
10 Fram
Messages
Graph
Time [s] Force Reaction (X) [N] Force Reaction (Y) [N] Force Reaction (Z) [N] Force Reaction (Total) [N]
1 1. 2150.3 2500. 0. 3297.5
Press F1 for Help
No Messages
No Selection
Metric (m, kg, N, s, V, A) Degrees rad/s Celsius

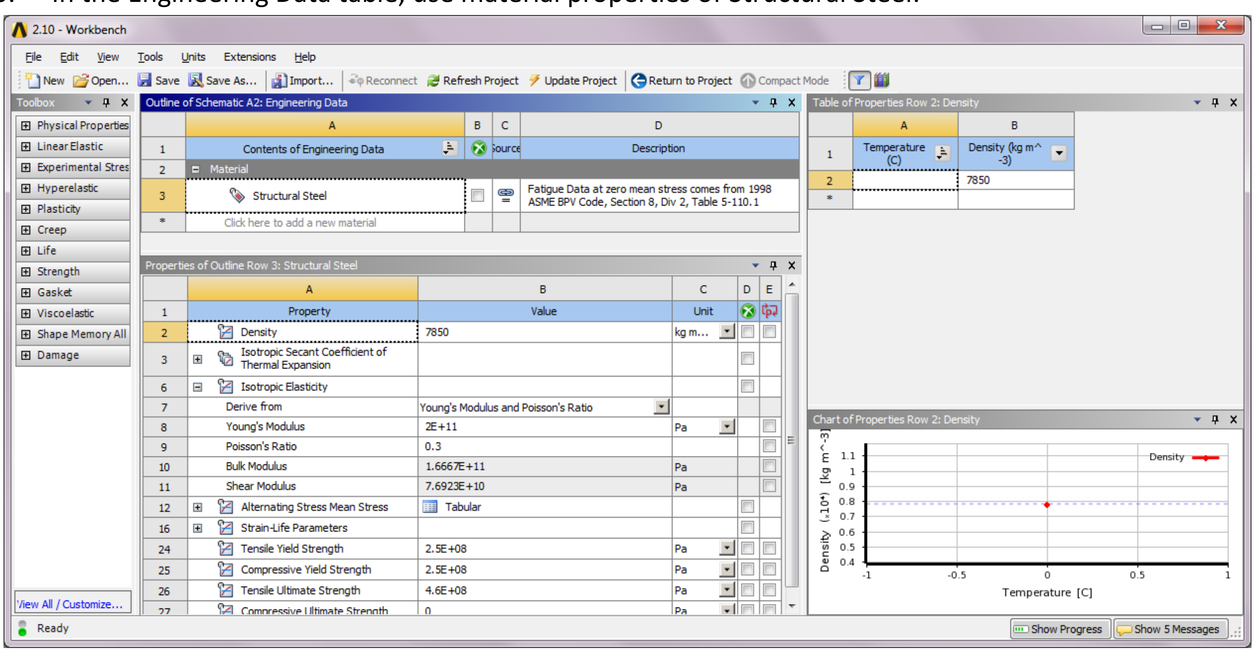


The maximum total deformation of the roof truss is: ***10.307 mm***

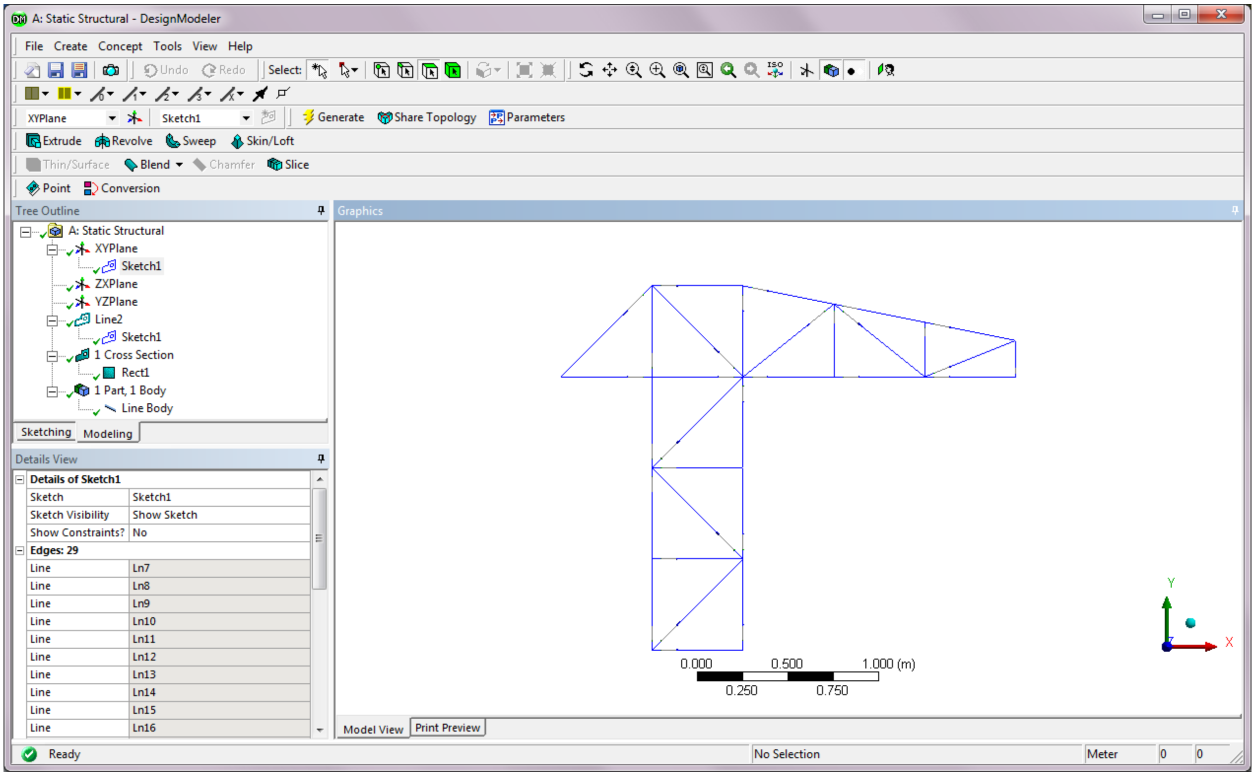
X, Y and Z components of the reaction force at the left support are: ***(2150.3 N, 2500 N, 0)***

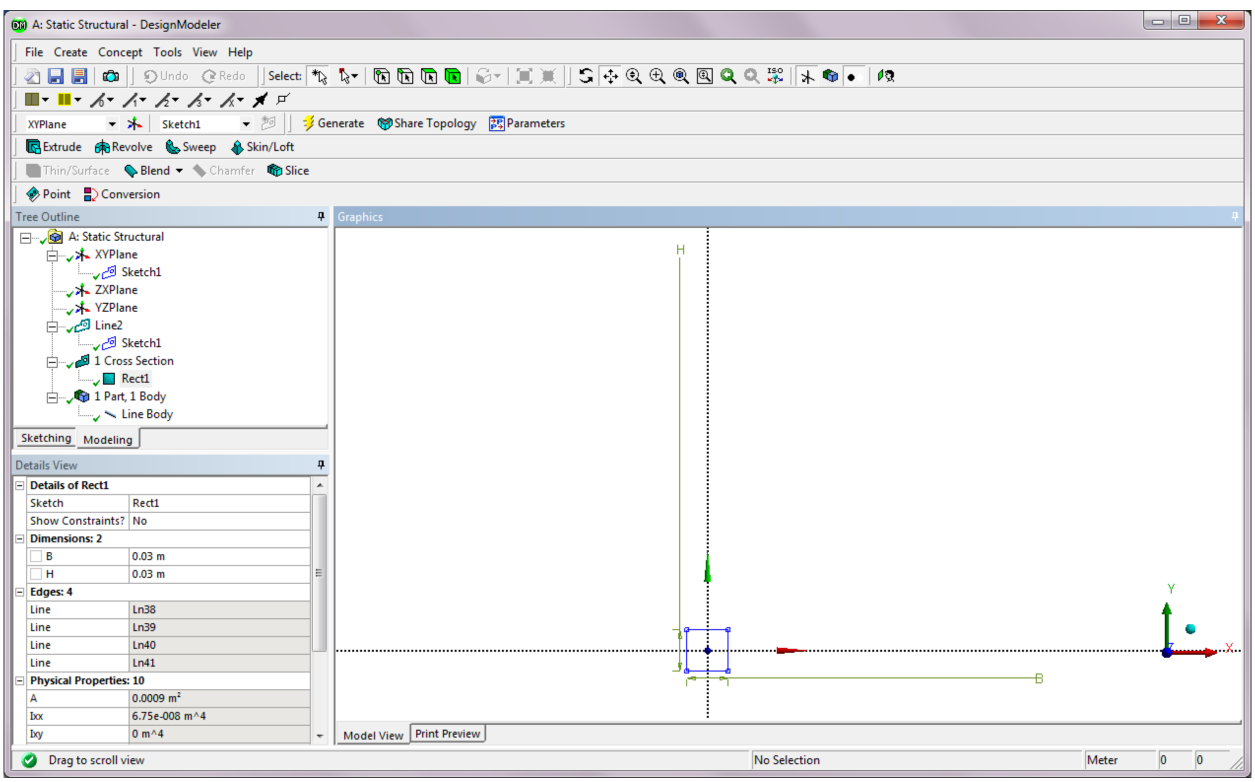
X, Y and Z components of the reaction force at the right support are: ***(-2150.3 N, 2500 N, 0)***

2.10. In the Engineering Data table, use material properties of Structural Steel:

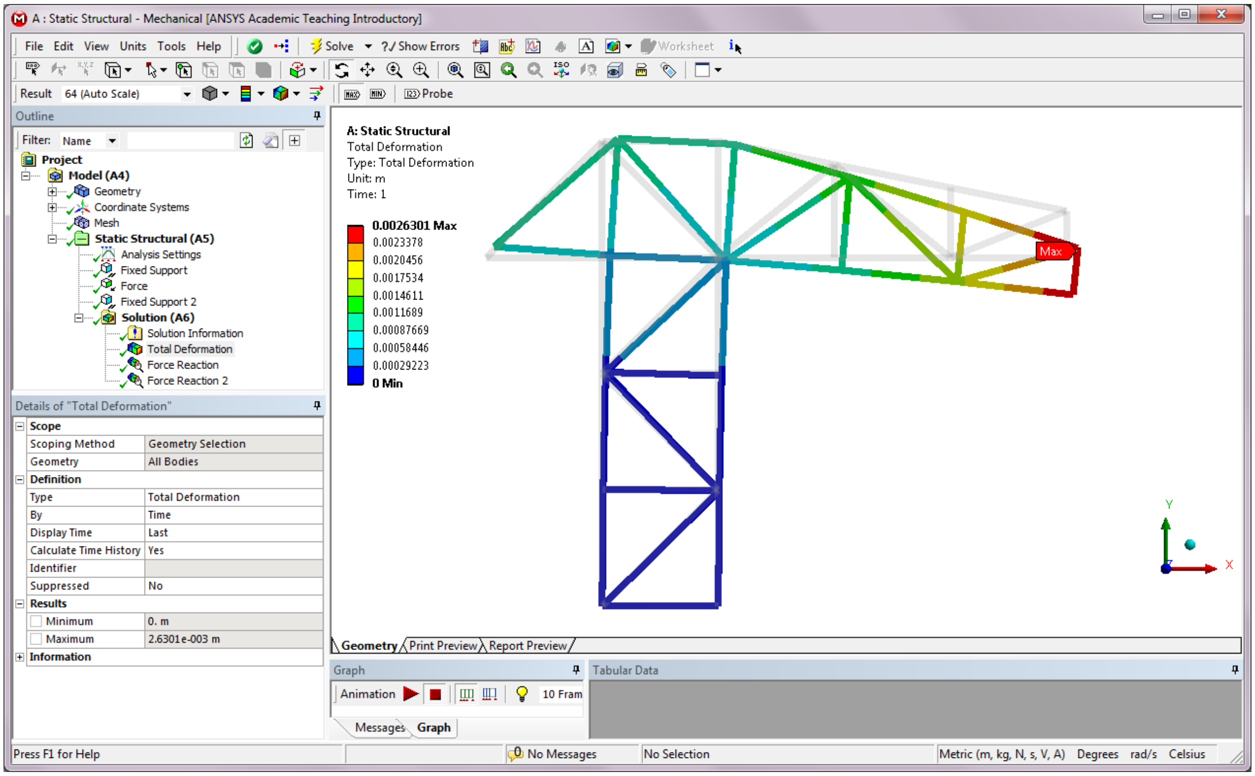


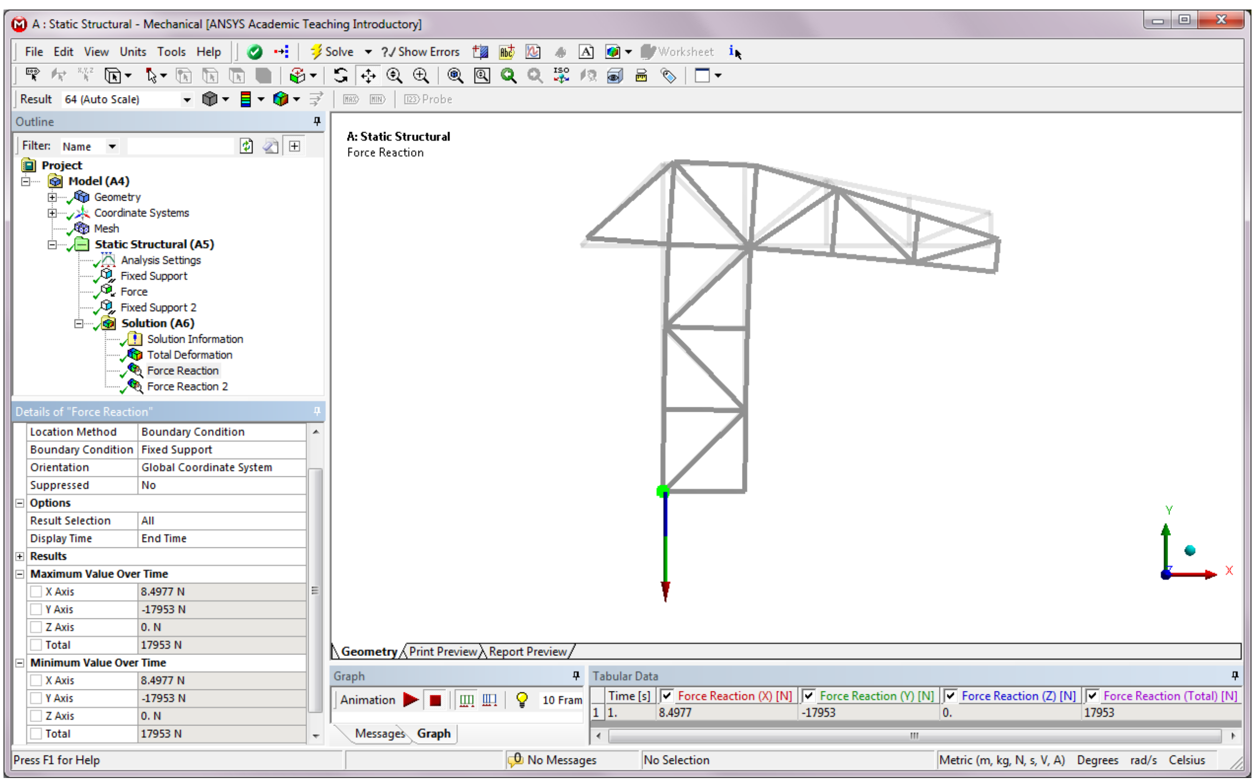
In the DesignModeler program, create a line sketch of the truss tower crane and a cross sectional definition of the truss member. Then create a line body concept model from the sketch:

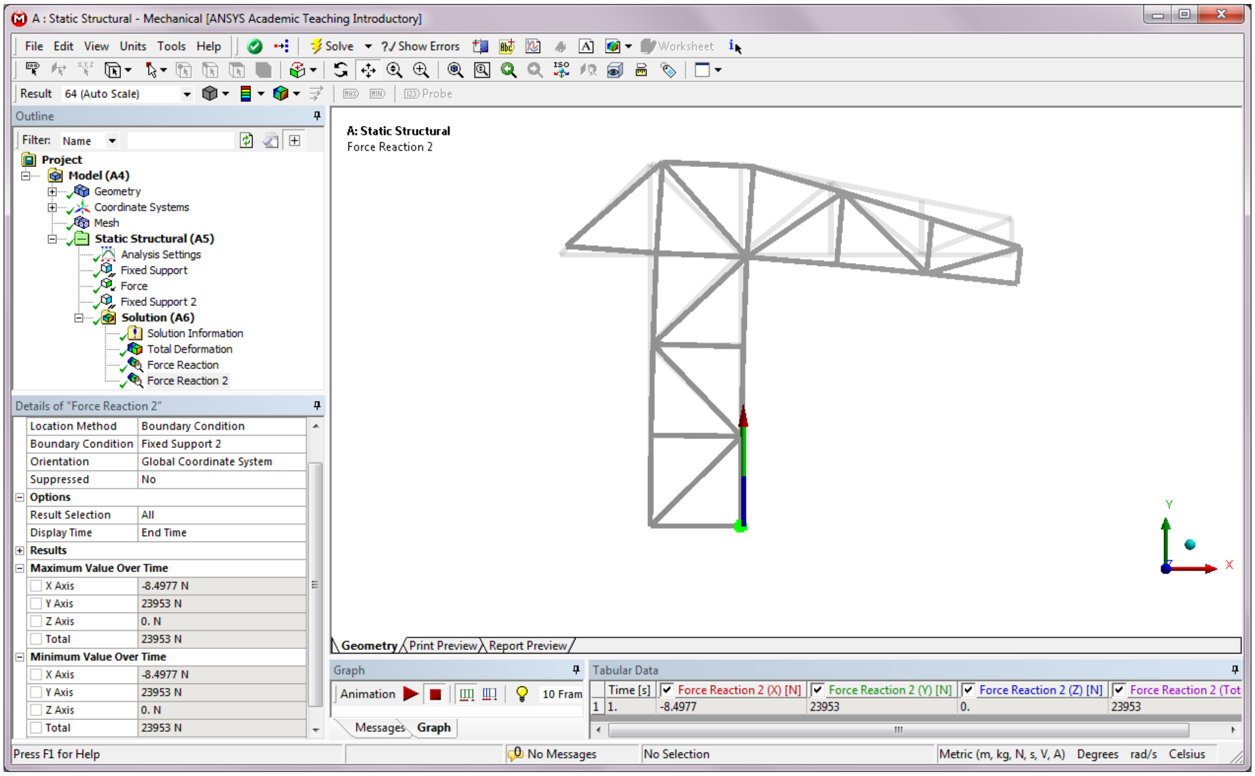




In the Multiple Systems – Mechanical program, retrieve results after applying loads and boundary conditions:





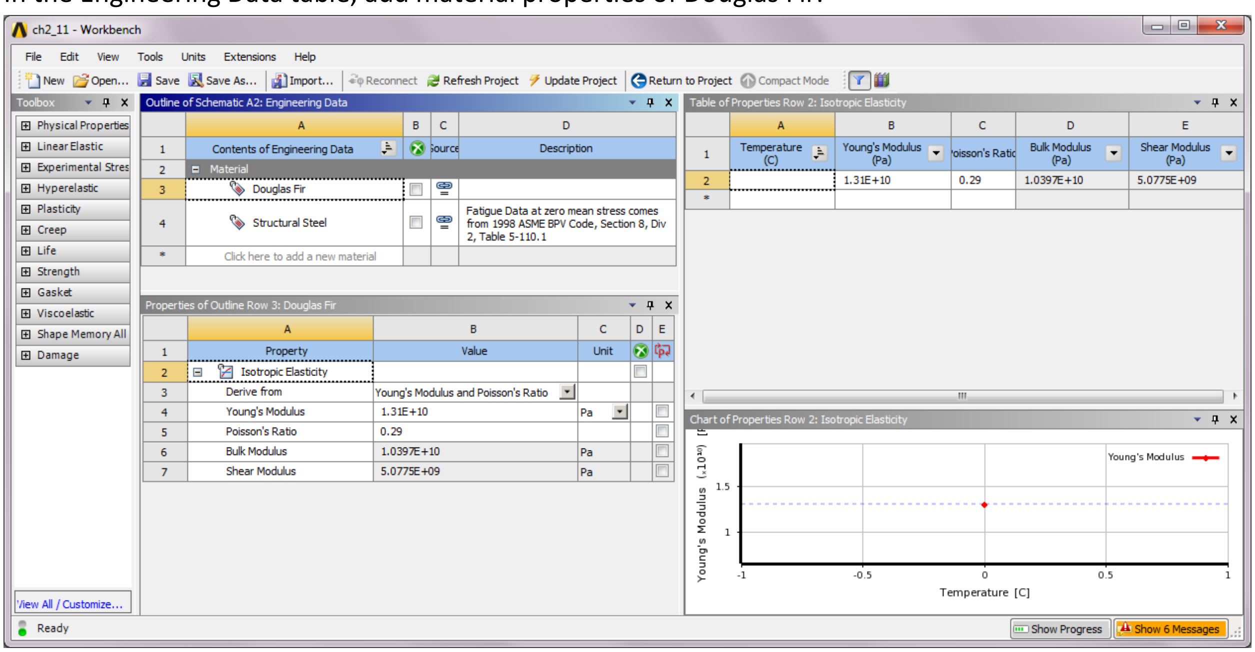


The maximum total deformation of the truss tower crane is: ***2.6301 mm***

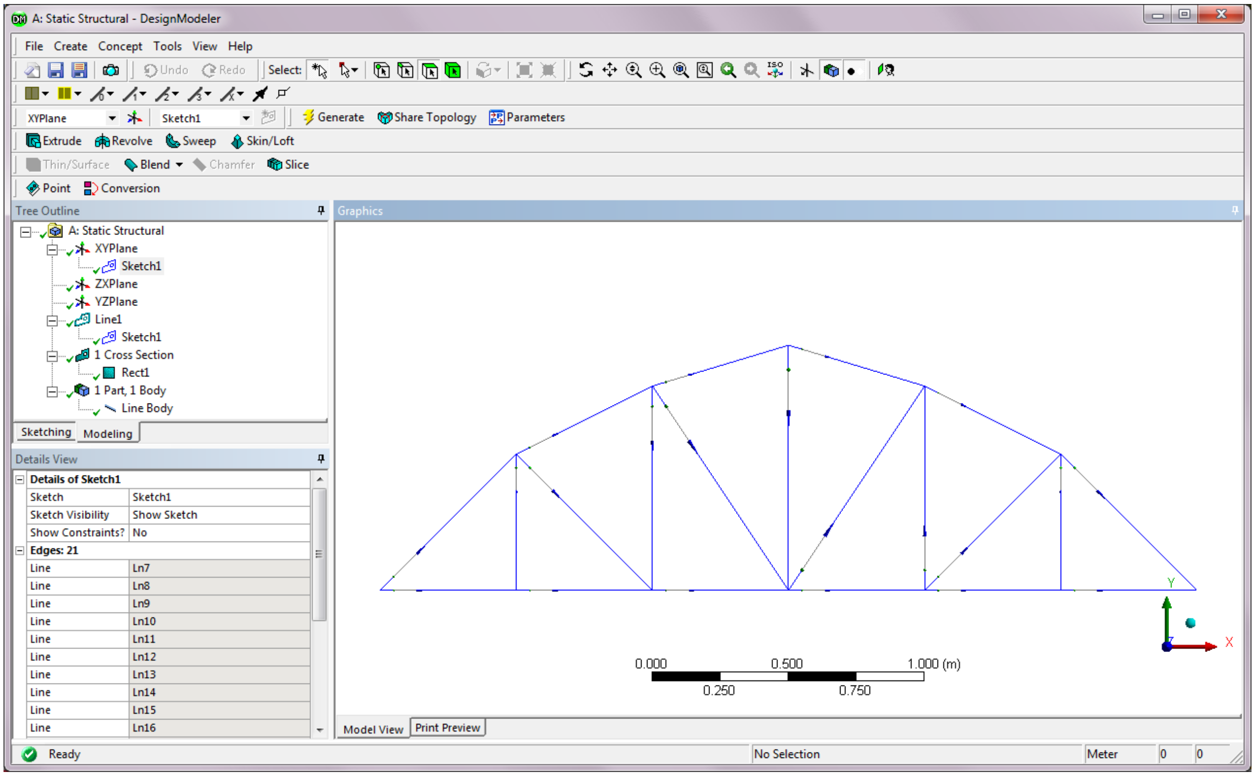
X, Y and Z components of the reaction force at the left support are: ***(8.4977 N, -17953 N, 0)***

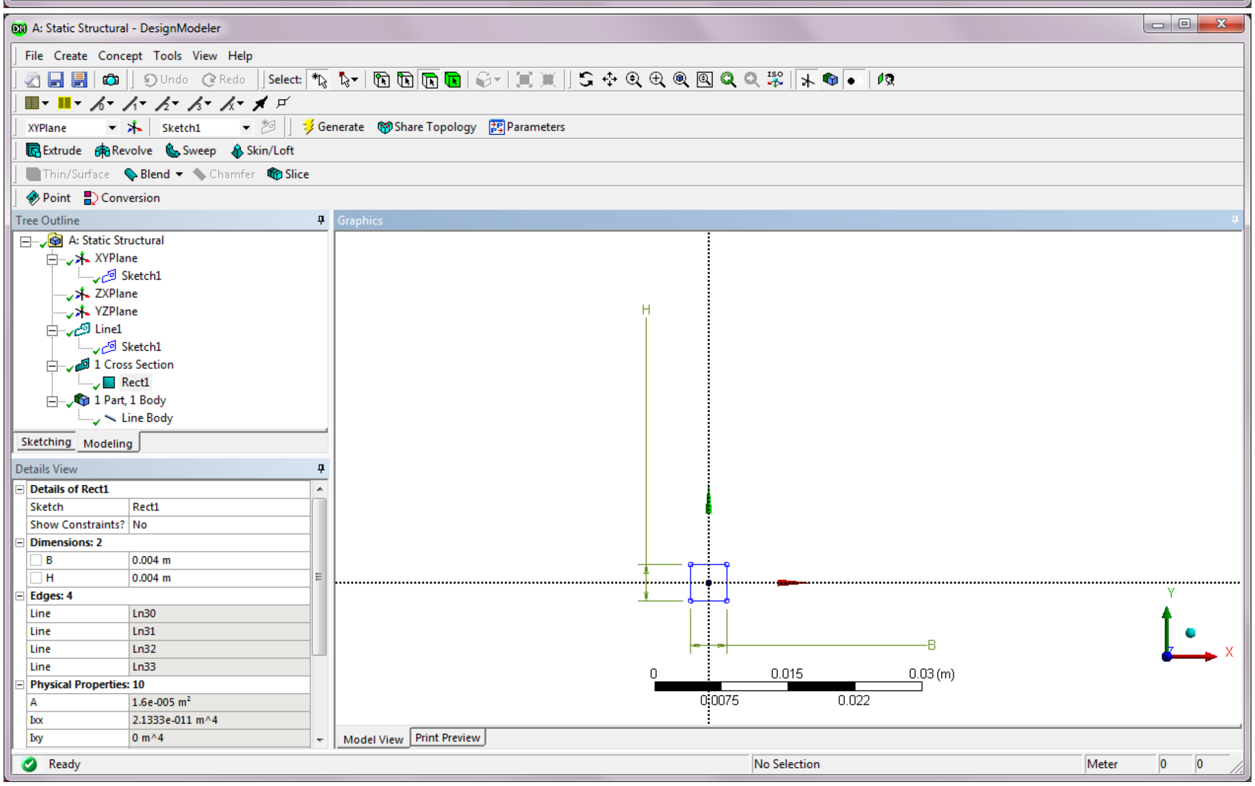
X, Y and Z components of the reaction forces at the right support are: ***(-8.4977 N, 23953 N, 0)***

2.11. In the Engineering Data table, add material properties of Douglas Fir:

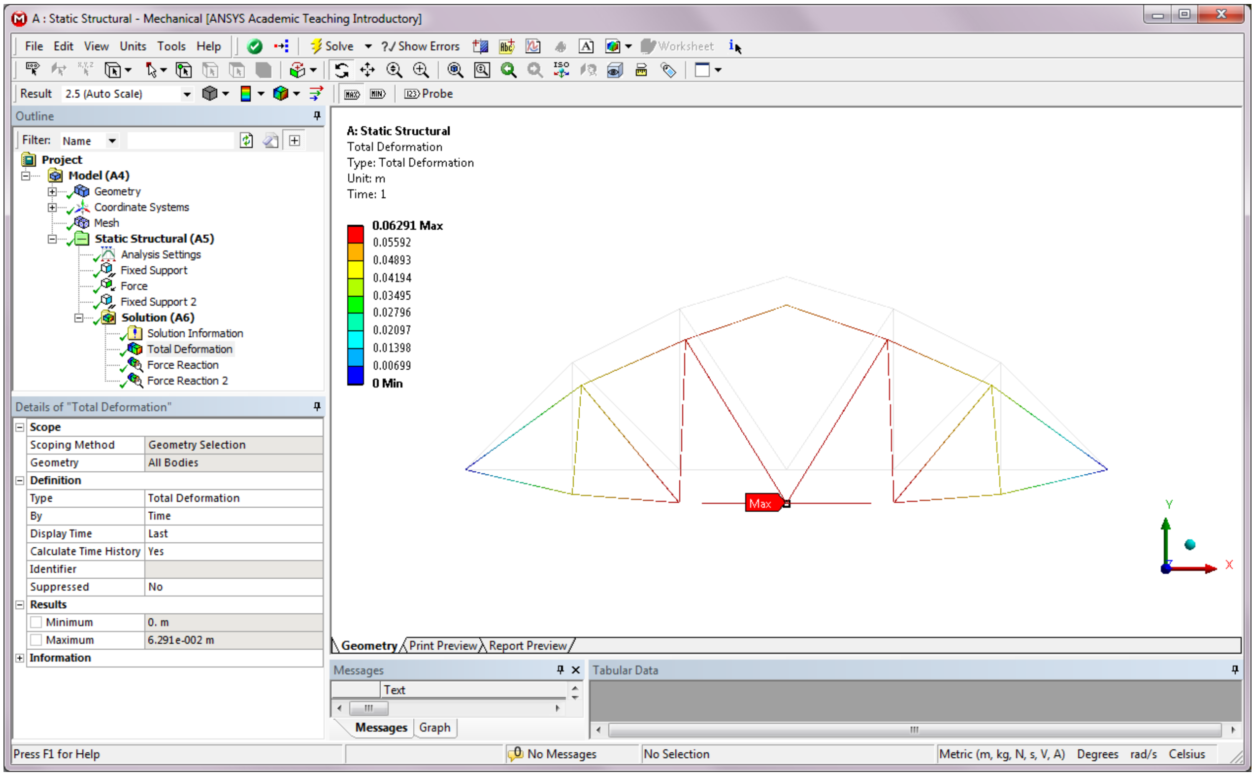


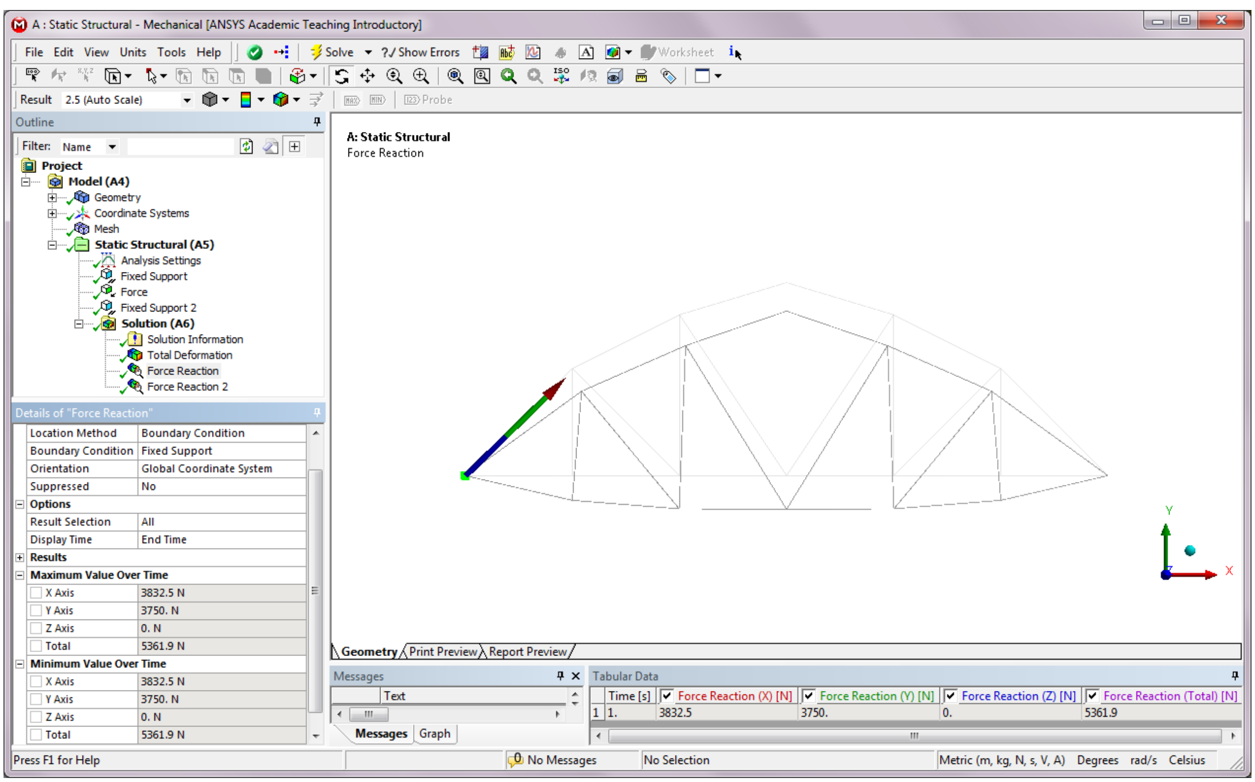
In the DesignModeler program, create a line sketch of the truss bridge and a cross section definition of the truss member. Then create a line body concept model from the sketch:

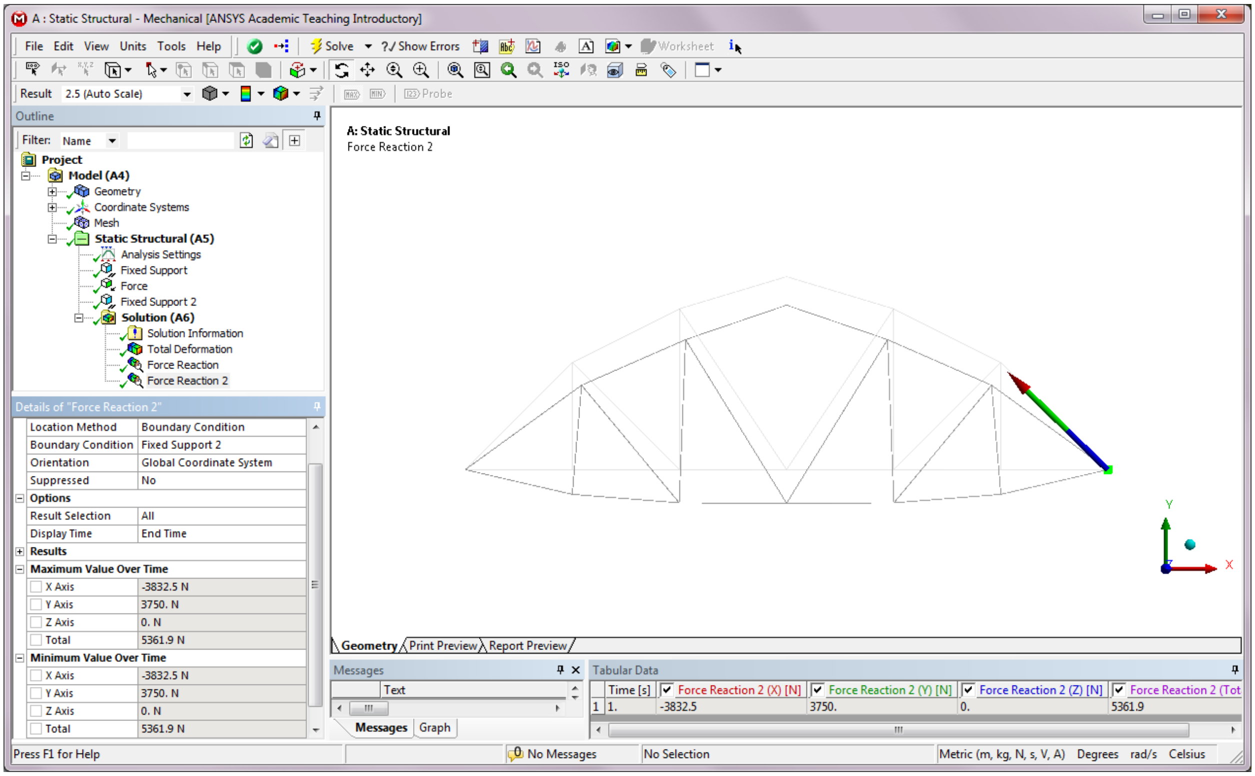




In the Multiple Systems – Mechanical program, retrieve results after applying loads and boundary conditions:





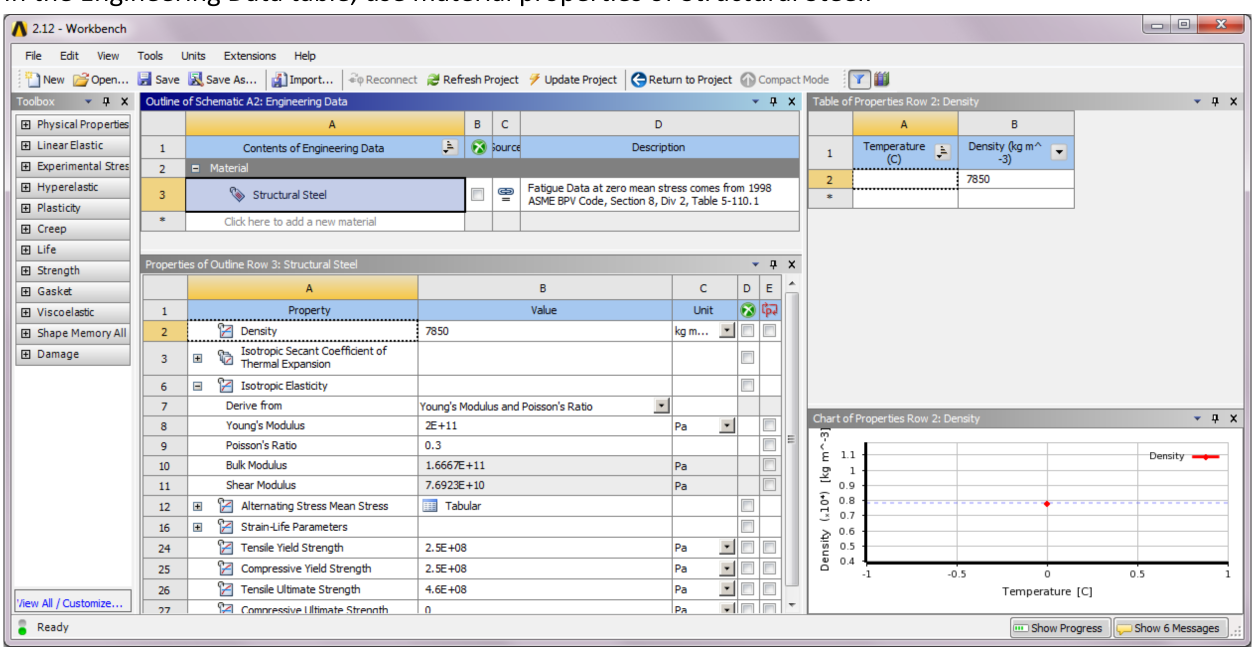


The maximum total deformation of the truss tower crane is: ***62.91 mm***

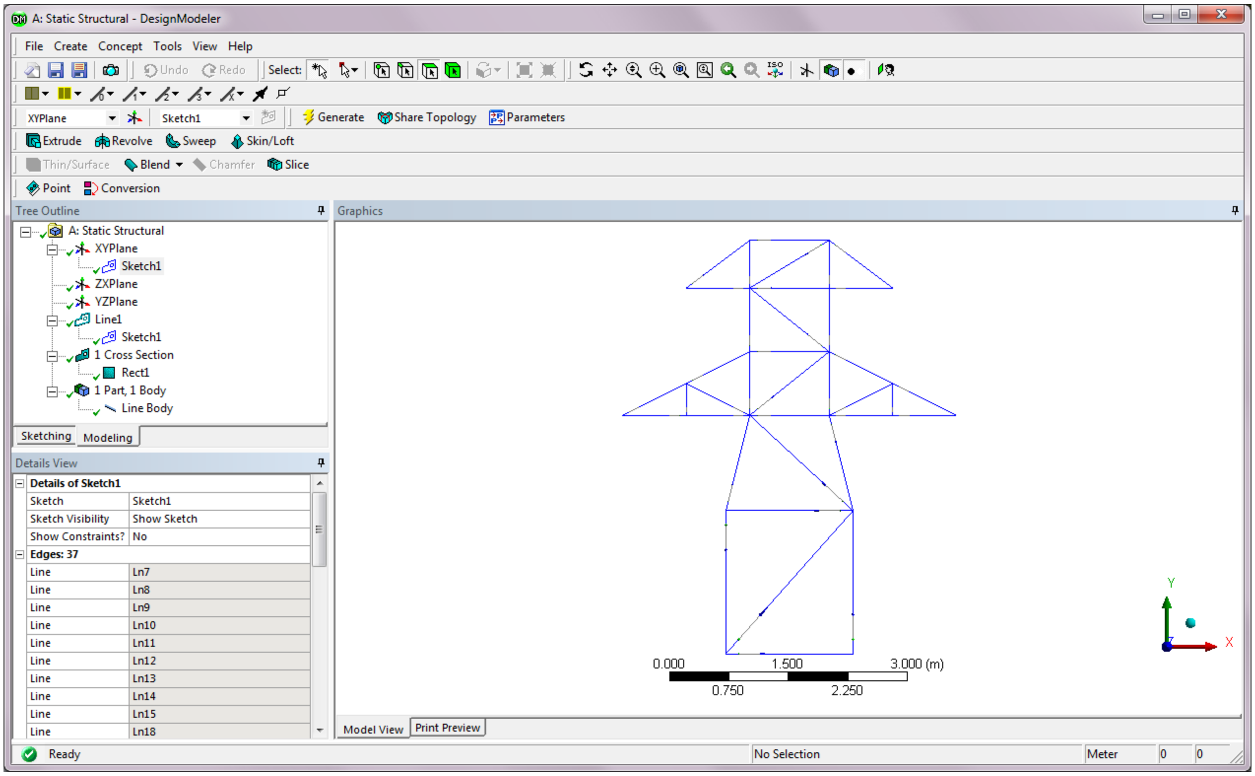
X, Y and Z components of the reaction force at the left support are: ***(3832.5 N, 3750 N, 0)***

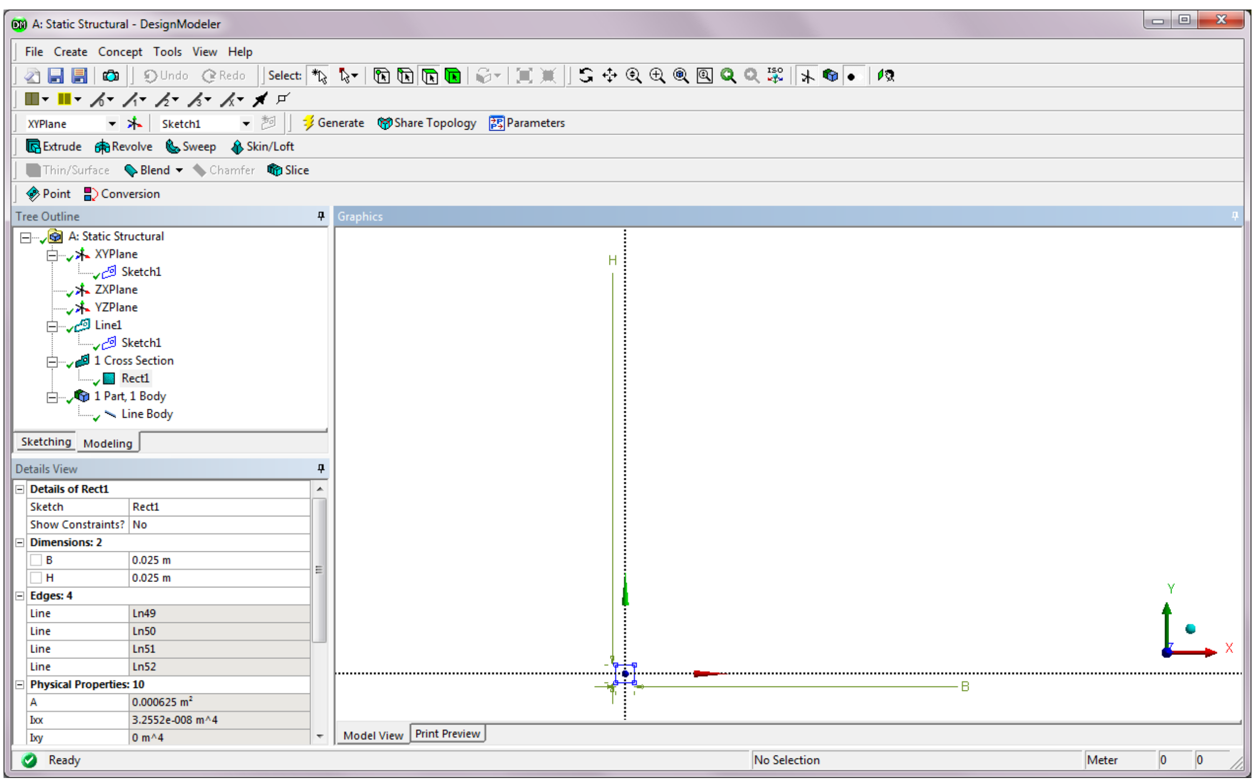
X, Y and Z components of the reaction forces at the right support are: ***(-3832.5 N, 3750 N, 0)***

2.12. In the Engineering Data table, use material properties of Structural Steel:

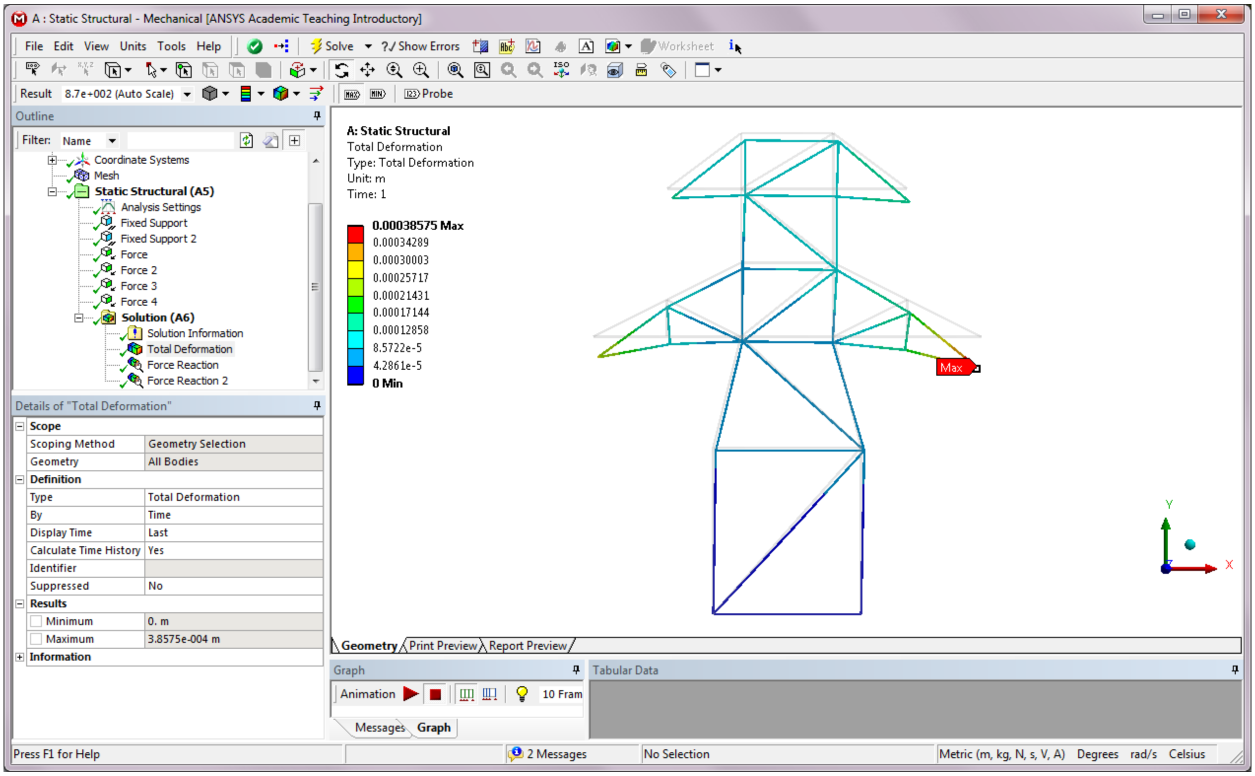


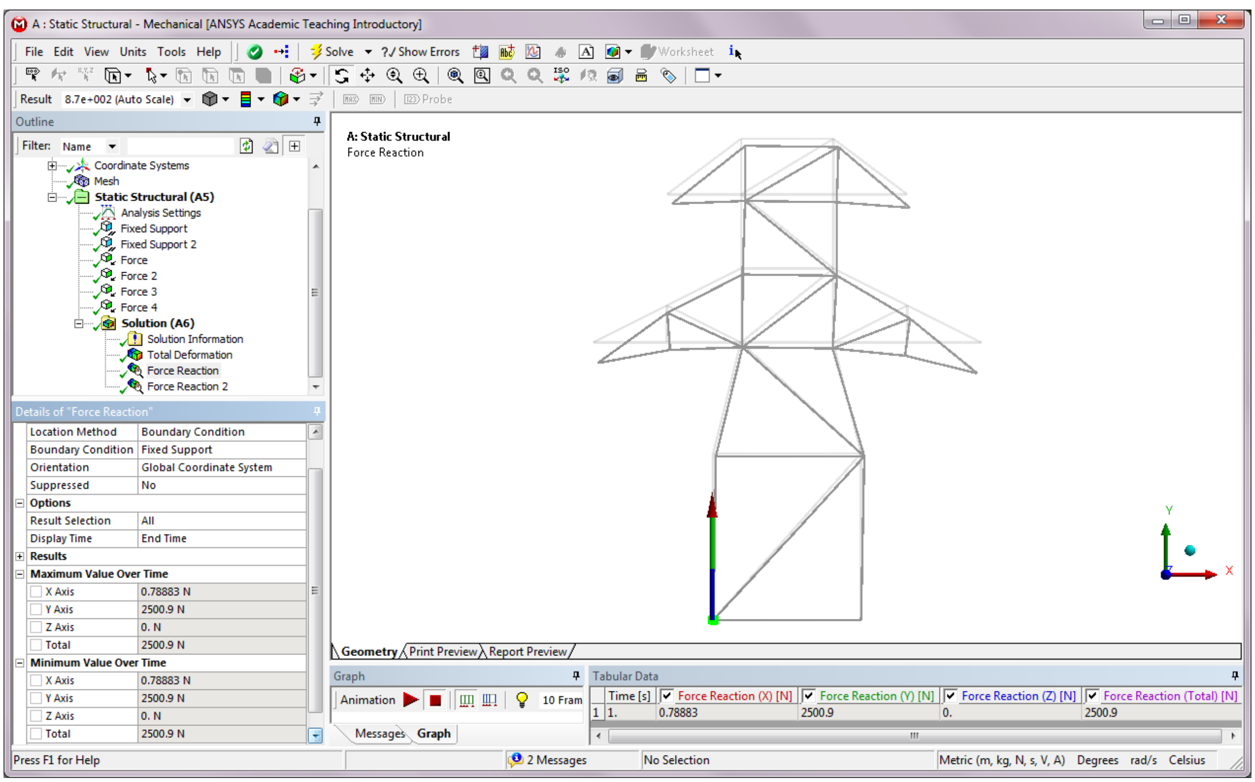
In the DesignModeler program, create a line sketch of the truss transmission tower and a cross sectional definition of the truss member. Then create a line body concept model from the sketch:

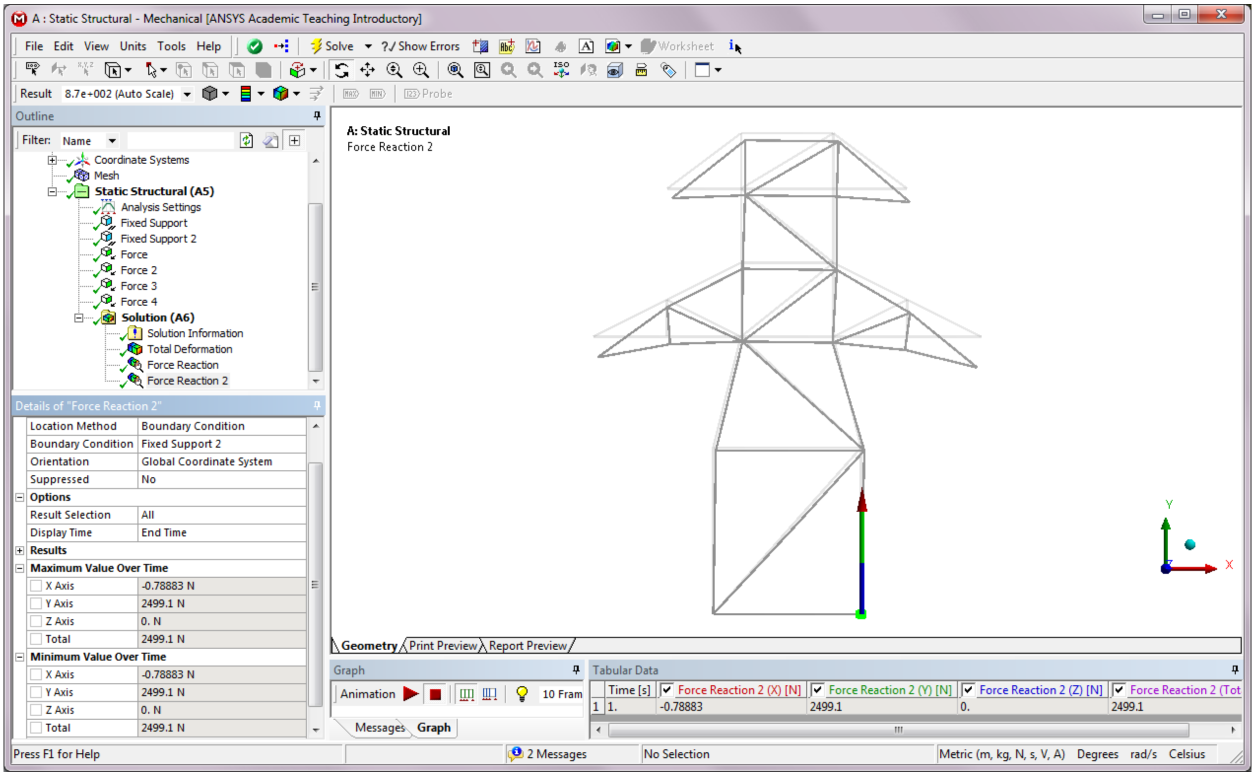




In the Multiple Systems – Mechanical program, retrieve results after applying loads and boundary conditions:







The maximum total deformation of the truss transmission tower is: ***0.38575 mm***

X, Y and Z components of the reaction force at the left support are: ***(0.78883 N, 2500.9 N, 0)***

X, Y and Z components of the reaction forces at the right support are: ***(-0.78883 N, 2499.1 N, 0)***