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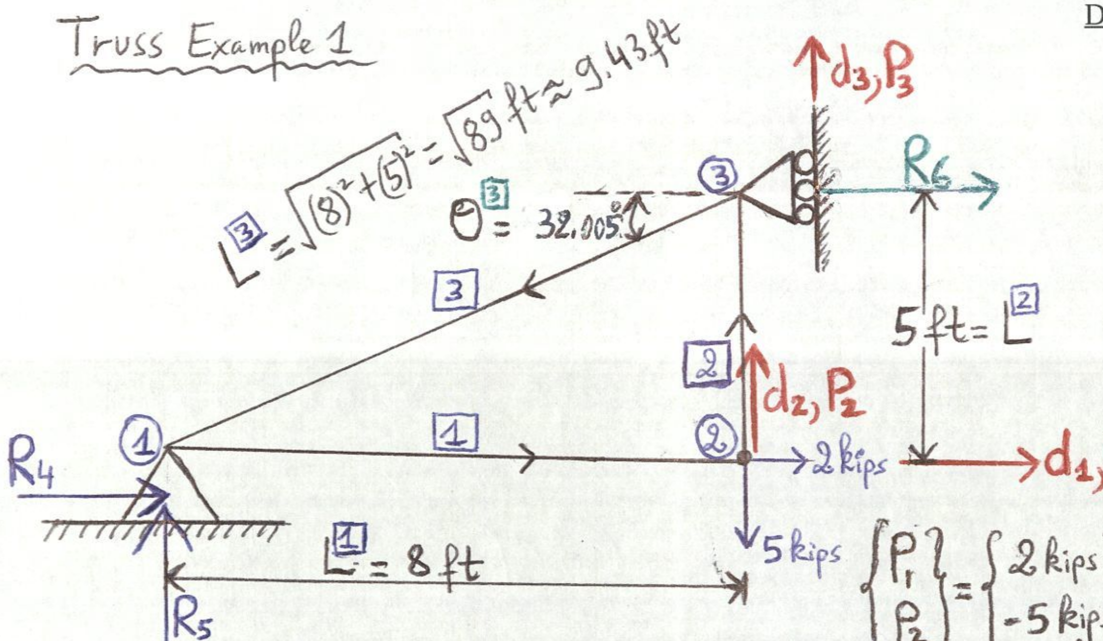
Truss Example 1

Date: 2nd October 2018



$E = 29{,}000\,ksi$

$A = 9\,in^2$

Member	Code #
1	[4 5 1 2]
2	[1 2 6 3]
3	[6 3 4 5]

$$\begin{Bmatrix} P_1 \\ P_2 \\ P_3 \end{Bmatrix} = \begin{Bmatrix} 2\,kips \\ -5\,kips \\ 0\,kips \end{Bmatrix}$$

$$[k]^{\boxed{1}} = \frac{EA}{L^{\boxed{1}}}\begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} = \frac{\left(29{,}000\frac{kips}{in^2}\right)(9\,in^2)}{(8\,ft)\left(\frac{12\,in}{1\,ft}\right)}\begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} = \begin{array}{c} \begin{array}{cccc} 4 & 5 & 1 & 2 \end{array} \\ \begin{bmatrix} 2{,}718.75 & 0 & -2{,}718.75 & 0 \\ 0 & 0 & 0 & 0 \\ -2{,}718.75 & 0 & 2{,}718.75 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \end{array} \begin{array}{c} 4 \\ 5 \\ 1 \\ 2 \end{array} \frac{kips}{in}$$

$$[k]^{\boxed{2}} = \frac{EA}{L^{\boxed{2}}}\begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} = \frac{\left(29{,}000\frac{kips}{in^2}\right)(9\,in^2)}{(5\,ft)\left(\frac{12\,in}{1\,ft}\right)}\begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} = \begin{array}{c} \begin{array}{cccc} 1 & 2 & 6 & 3 \end{array} \\ \begin{bmatrix} 4{,}350 & 0 & -4{,}350 & 0 \\ 0 & 0 & 0 & 0 \\ -4{,}350 & 0 & 4{,}350 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \end{array} \begin{array}{c} 1 \\ 2 \\ 6 \\ 3 \end{array} \frac{kips}{in}$$

$$[k]^{\boxed{3}} = \frac{EA}{L^{\boxed{3}}}\begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} = \frac{\left(29{,}000\frac{kips}{in^2}\right)(9\,in^2)}{(\sqrt{89}\,ft)\left(\frac{12\,in}{1\,ft}\right)}\begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} = \begin{array}{c} \begin{array}{cccc} 6 & 3 & 4 & 5 \end{array} \\ \begin{bmatrix} 2{,}305.5 & 0 & -2{,}305.5 & 0 \\ 0 & 0 & 0 & 0 \\ -2{,}305.5 & 0 & 2{,}305.5 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \end{array} \begin{array}{c} 6 \\ 3 \\ 4 \\ 5 \end{array} \frac{kips}{in}$$

$$[K]^{\boxed{1}} = \frac{(29{,}000\,ksi)(9\,in^2)}{(8\,ft)\left(\frac{12\,in}{1\,ft}\right)}\begin{bmatrix} (\cos(0))^2 & (\cos(0)\sin(0)) & -(\cos(0))^2 & -\cos(0)\sin(0) \\ \cos(0)\sin(0) & (\sin(0))^2 & -\cos(0)\sin(0) & -(\sin(0))^2 \\ -(\cos(0))^2 & -\cos(0)\sin(0) & (\cos(0))^2 & \cos(0)\sin(0) \\ -\cos(0)\sin(0) & -(\sin(0))^2 & \cos(0)\sin(0) & (\sin(0))^2 \end{bmatrix} = [k]^{\boxed{1}}$$

$\theta^{\boxed{1}} = 0°$

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$$[K]^{\boxed{2}} = \frac{(29{,}000\,ksi)(9\,in^2)}{(5\,\cancel{ft})\left(\frac{12\,in}{1\,\cancel{ft}}\right)} \begin{bmatrix} (\cos(90))^2 & \cos(90)\sin(90) & -(\cos(90))^2 & -\cos(90)\sin(90) \\ \cos(90)\sin(90) & (\sin(90))^2 & -\cos(90)\sin(90) & -(\sin(90))^2 \\ -(\cos(90))^2 & -\cos(90)\sin(90) & (\cos(90))^2 & \cos(90)\sin(90) \\ -\cos(90)\sin(90) & -(\sin(90))^2 & \cos(90)\sin(90) & (\sin(90))^2 \end{bmatrix}$$

$$\theta^{\boxed{2}} = 90^\circ$$

$$[K]^{\boxed{2}} = \begin{array}{c} \\ \\ \\ \\ \\ \end{array}\begin{array}{cccc} 1 & 2 & 6 & 3 \\ \end{array}$$

$$[K]^{\boxed{2}} = \begin{array}{cc} \begin{array}{cccc} 1 & 2 & 6 & 3 \end{array} & \\ \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 4{,}350 & 0 & -4{,}350 \\ 0 & 0 & 0 & 0 \\ 0 & -4{,}350 & 0 & 4{,}350 \end{bmatrix} & \begin{array}{c} 1 \\ 2 \\ 6 \\ 3 \end{array} \end{array} \frac{kips}{in}$$

$$[K]^{\boxed{3}} = \frac{(29{,}000\,ksi)(9\,in^2)}{(\sqrt{89}\,\cancel{ft})\left(\frac{12\,in}{1\,\cancel{ft}}\right)} \begin{bmatrix} (\cos(\theta^{\boxed{3}}))^2 & \cos(\theta^{\boxed{3}})\sin(\theta^{\boxed{3}}) & -(\cos(\theta^{\boxed{3}}))^2 & -\cos(\theta^{\boxed{3}})\sin(\theta^{\boxed{3}}) \\ \cos(\theta^{\boxed{3}})\sin(\theta^{\boxed{3}}) & (\sin(\theta^{\boxed{3}}))^2 & -\cos(\theta^{\boxed{3}})\sin(\theta^{\boxed{3}}) & -(\sin(\theta^{\boxed{3}}))^2 \\ -(\cos(\theta^{\boxed{3}}))^2 & -\cos(\theta^{\boxed{3}})\sin(\theta^{\boxed{3}}) & (\cos(\theta^{\boxed{3}}))^2 & \cos(\theta^{\boxed{3}})\sin(\theta^{\boxed{3}}) \\ -\cos(\theta^{\boxed{3}})\sin(\theta^{\boxed{3}}) & -(\sin(\theta^{\boxed{3}}))^2 & \cos(\theta^{\boxed{3}})\sin(\theta^{\boxed{3}}) & (\sin(\theta^{\boxed{3}}))^2 \end{bmatrix}$$

$$\theta^{\boxed{3}} = 32.005^\circ$$

$$= 2{,}305.5 \begin{bmatrix} 0.719107 & 0.449435 & -0.719107 & -0.449435 \\ 0.449435 & 0.2808929 & -0.449435 & -0.2808929 \\ -0.719107 & -0.449435 & 0.719107 & 0.449435 \\ -0.449435 & -0.2808929 & 0.449435 & 0.2808929 \end{bmatrix}$$

$$K_{22}^{\boxed{3}}$$

$$[K]^{\boxed{3}} = \begin{array}{cc} \begin{array}{cccc} 6 & 3 & 4 & 5 \end{array} & \\ \begin{bmatrix} 1{,}657.9 & 1{,}036.17 & -1{,}657.9 & -1{,}036.17 \\ 1{,}036.17 & 647.59858 & -1{,}036.17 & -647.59858 \\ -1{,}657.9 & -1{,}036.17 & 1{,}657.9 & 1{,}036.17 \\ -1{,}036.17 & -647.59858 & 1{,}036.17 & 647.59858 \end{bmatrix} & \begin{array}{c} 6 \\ 3 \\ 4 \\ 5 \end{array} \end{array} \frac{kips}{in}$$

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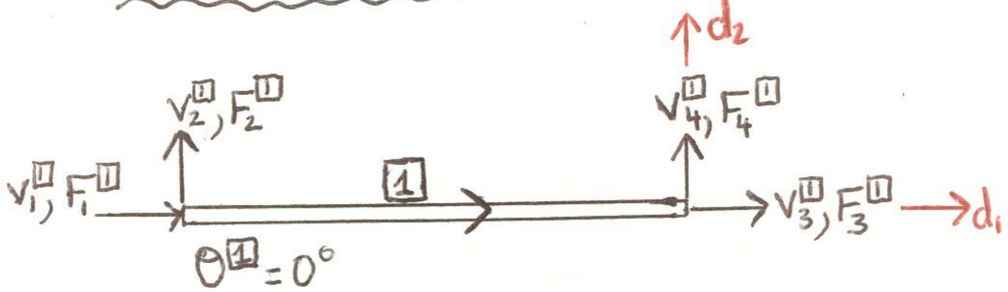
Member $\boxed{1}$ FBD



Compatibility conditions

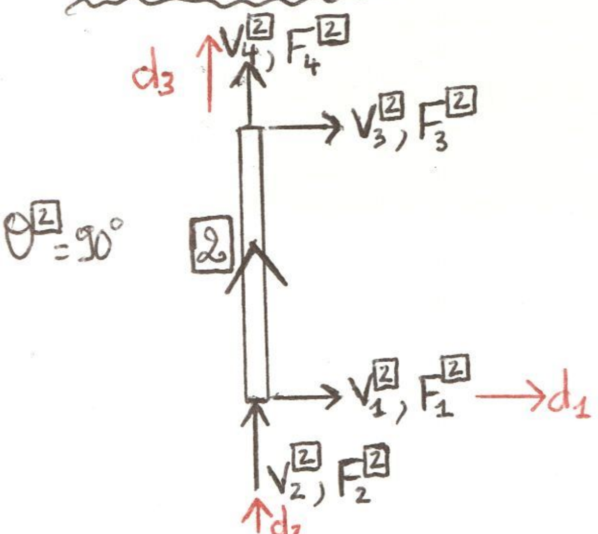
$V_1^{\boxed{1}} = 0$

$V_2^{\boxed{1}} = 0$

$V_3^{\boxed{1}} = d_1$

$V_4^{\boxed{1}} = d_2$

Member $\boxed{2}$ FBD



Compatibility conditions

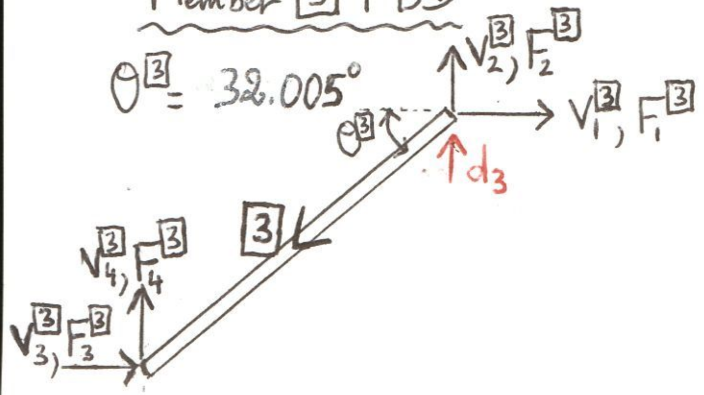
$V_1^{\boxed{2}} = d_1$

$V_2^{\boxed{2}} = d_2$

$V_3^{\boxed{2}} = 0$

$V_4^{\boxed{2}} = d_3$

Member $\boxed{3}$ FBD



Compatibility conditions

$V_1^{\boxed{3}} = 0$

$V_2^{\boxed{3}} = d_3$

$V_3^{\boxed{3}} = 0$

$V_4^{\boxed{3}} = 0$

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Joints FBD & Assemble $[S]$ using Rigorous Method

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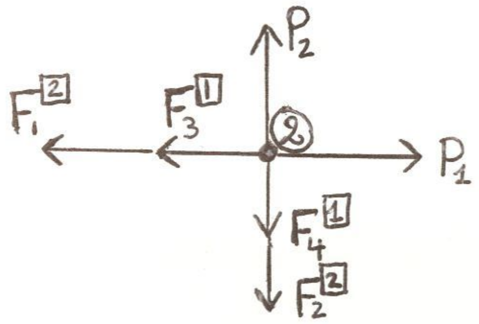
Joint (2) FBD



$$\overset{+}{\rightarrow}\sum F_x = 0 \; ; \quad P_1 = F_3^{\boxed{1}} + F_1^{\boxed{2}}$$

$$+\uparrow\sum F_y = 0 \; ; \quad P_2 = F_4^{\boxed{1}} + F_2^{\boxed{2}}$$

$$P_1 = \left(K_{31}^{\boxed{1}}\cancelto{0}{V_1^{\boxed{1}}} + K_{32}^{\boxed{1}}\cancelto{0}{V_2^{\boxed{1}}} + K_{33}^{\boxed{1}}\cancelto{d_1}{V_3^{\boxed{1}}} + K_{34}^{\boxed{1}}\cancelto{d_2}{V_4^{\boxed{1}}}\right) +$$

$$\left(K_{11}^{\boxed{2}}\cancelto{d_1}{V_1^{\boxed{2}}} + K_{12}^{\boxed{2}}\cancelto{d_2}{V_2^{\boxed{2}}} + K_{13}^{\boxed{2}}\cancelto{0}{V_3^{\boxed{2}}} + K_{14}^{\boxed{2}}\cancelto{d_3}{V_4^{\boxed{2}}}\right)$$

$$P_1 = \underbrace{\left(K_{33}^{\boxed{1}} + K_{11}^{\boxed{2}}\right)}_{S_{11}} d_1 + \underbrace{\left(K_{34}^{\boxed{1}} + K_{12}^{\boxed{2}}\right)}_{S_{12}} d_2 + \underbrace{\left(K_{14}^{\boxed{2}}\right)}_{S_{13}} d_3$$

$$P_2 = \left(K_{41}^{\boxed{1}}\cancelto{0}{V_1^{\boxed{1}}} + K_{42}^{\boxed{1}}\cancelto{0}{V_2^{\boxed{1}}} + K_{43}^{\boxed{1}}\cancelto{d_1}{V_3^{\boxed{1}}} + K_{44}^{\boxed{1}}\cancelto{d_2}{V_4^{\boxed{1}}}\right) +$$

$$\left(K_{21}^{\boxed{2}}\cancelto{d_1}{V_1^{\boxed{2}}} + K_{22}^{\boxed{2}}\cancelto{d_2}{V_2^{\boxed{2}}} + K_{23}^{\boxed{2}}\cancelto{0}{V_3^{\boxed{2}}} + K_{24}^{\boxed{2}}\cancelto{d_3}{V_4^{\boxed{2}}}\right)$$

$$P_2 = \underbrace{\left(K_{43}^{\boxed{1}} + K_{21}^{\boxed{2}}\right)}_{S_{21}} d_1 + \underbrace{\left(K_{44}^{\boxed{1}} + K_{22}^{\boxed{2}}\right)}_{S_{22}} d_2 + \underbrace{\left(K_{24}^{\boxed{2}}\right)}_{S_{23}} d_3$$

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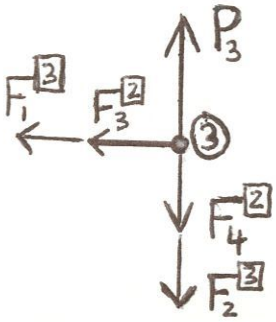
Joint ③ FBD



$$+\uparrow \sum F_y = 0 \; ; \quad P_3 = F_4^{\boxed{2}} + F_2^{\boxed{3}}$$

$$P_3 = F_4^{\boxed{2}} + F_2^{\boxed{3}}$$

$$= \left(K_{41}^{\boxed{2}} \cancelto{d_1}{V_1^{\boxed{2}}} + K_{42}^{\boxed{2}} \cancelto{d_2}{V_2^{\boxed{2}}} + K_{43}^{\boxed{2}} \cancelto{0}{V_3^{\boxed{2}}} + K_{44}^{\boxed{2}} \cancelto{d_3}{V_4^{\boxed{2}}} \right) +$$

$$\left(K_{21}^{\boxed{3}} V_1^{\boxed{3}} + K_{22}^{\boxed{3}} \cancelto{d_3}{V_2^{\boxed{3}}} + K_{23}^{\boxed{3}} \cancelto{0}{V_3^{\boxed{3}}} + K_{24}^{\boxed{3}} \cancelto{0}{V_4^{\boxed{3}}} \right)$$

$$P_3 = \underbrace{\left(K_{41}^{\boxed{2}} \right)}_{S_{31}} d_1 + \underbrace{\left(K_{42}^{\boxed{2}} \right)}_{S_{32}} d_2 + \underbrace{\left(K_{44}^{\boxed{2}} + K_{22}^{\boxed{3}} \right)}_{S_{33}} d_3$$

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Assembling [S]

Using Rigorous method

$$[S] = \begin{bmatrix} \overbrace{K_{33}^{\boxed{1}} + K_{11}^{\boxed{2}}}^{S_{11}} & \overbrace{K_{34}^{\boxed{1}} + K_{12}^{\boxed{2}}}^{S_{12}} & K_{14}^{\boxed{2}} \\ K_{43}^{\boxed{1}} + K_{21}^{\boxed{2}}, & K_{44}^{\boxed{1}} + K_{22}^{\boxed{2}} & K_{24}^{\boxed{2}} \\ K_{41}^{\boxed{2}} & K_{42}^{\boxed{2}} & K_{44}^{\boxed{2}} + K_{22}^{\boxed{3}} \end{bmatrix}$$

Using Code Number method

$$[S] = \begin{array}{c} \\ 1 \\ 2 \\ 3 \end{array} \begin{array}{c} \begin{array}{ccc} 1 & 2 & 3 \end{array} \\ \begin{bmatrix} K_{33}^{\boxed{1}} + K_{11}^{\boxed{2}} & K_{34}^{\boxed{1}} + K_{12}^{\boxed{2}} & K_{14}^{\boxed{2}} \\ K_{43}^{\boxed{1}} + K_{21}^{\boxed{2}} & K_{44}^{\boxed{1}} + K_{22}^{\boxed{2}} & K_{24}^{\boxed{2}} \\ K_{41}^{\boxed{2}} & K_{42}^{\boxed{2}} & K_{44}^{\boxed{2}} + K_{22}^{\boxed{3}} \end{bmatrix} \end{array}$$

$$[S] = \begin{array}{c} \begin{array}{ccc} 1 & 2 & 3 \end{array} \\ \begin{bmatrix} (2{,}718.75)+(0) & (0)+(0) & (0) \\ (0)+(0) & (0)+(4{,}350) & (-4{,}350) \\ (0) & (-4{,}350) & (4{,}350)+(647.59858) \end{bmatrix} \end{array} \begin{array}{c} \\ 1 \\ 2 \\ 3 \end{array}$$

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Compute displacements

$$\{P\} = [S]\{d\}$$

$$\{d\} = [S]^{-1}\{P\}$$

$$= \begin{bmatrix} 2{,}718.75 & 0 & 0 \\ 0 & 4{,}350 & -4{,}350 \\ 0 & -4{,}350 & 4{,}997.598 \end{bmatrix}^{-1} \begin{Bmatrix} 2 \text{ kips} \\ -5 \text{ kips} \\ 0 \text{ kips} \end{Bmatrix}$$

$$\boxed{\begin{Bmatrix} d_1 \\ d_2 \\ d_3 \end{Bmatrix} = \begin{Bmatrix} 0.000735632 \text{ in} \\ -0.00887026 \text{ in} \\ -0.00772083 \text{ in} \end{Bmatrix}}$$

Compute Member Forces (Global coordinate system)

$$\{F\}^{\boxed{1}} = [K]^{\boxed{1}}\{v\}^{\boxed{1}} = \begin{bmatrix} 2{,}718.75 & 0 & -2{,}718.75 & 0 \\ 0 & 0 & 0 & 0 \\ -2{,}718.75 & 0 & 2{,}718.75 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \begin{Bmatrix} 0 \\ 0 \\ 0.000735632 \text{ in} \\ -0.00887026 \end{Bmatrix}$$

$$\{F\}^{\boxed{1}} = \begin{array}{c} \begin{Bmatrix} -2 \\ 0 \\ 2 \\ 0 \end{Bmatrix} \text{kips} \end{array} \begin{array}{c} 4 \\ 5 \\ 1 \\ 2 \end{array}$$

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$$\{F\}^{\boxed{2}} = [K]^{\boxed{2}}\{v\}^{\boxed{2}} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 4{,}350 & 0 & -4{,}350 \\ 0 & 0 & 0 & 0 \\ 0 & -4{,}350 & 0 & 4{,}350 \end{bmatrix} \begin{Bmatrix} 0.000735632 \\ -0.00887026 \\ 0 \\ -0.00772083 \end{Bmatrix}$$

$$\{F\}^{\boxed{2}} = \begin{array}{l} \begin{Bmatrix} 0 \\ -5.00002 \\ 0 \\ 5.00002 \end{Bmatrix} \end{array} \begin{array}{l} 1 \\ 2 \\ 6 \\ 3 \end{array} \text{ kips}$$

$$\{F\}^{\boxed{3}} = [K]^{\boxed{3}}\{v\}^{\boxed{3}}$$

$$= \begin{bmatrix} 1{,}657.9 & 1{,}036.17 & -1{,}657.9 & -1{,}036.17 \\ 1{,}036.17 & 647.59858 & -1{,}036.17 & -647.59858 \\ -1{,}657.9 & -1{,}036.17 & 1{,}657.9 & 1{,}036.17 \\ -1{,}036.17 & -647.59858 & 1{,}036.17 & 647.59858 \end{bmatrix} \begin{Bmatrix} 0 \\ -0.00772083 \\ 0 \\ 0 \end{Bmatrix}$$

$$\{F\}^{\boxed{3}} = \begin{Bmatrix} -8.00009 \\ -5 \\ 8.00009 \\ 5 \end{Bmatrix} \begin{array}{l} 6 \\ 3 \\ 4 \\ 5 \end{array} \text{ kips}$$

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Find Reactions from $\{F\}$

$$\{F\}^{\boxed{1}} = \begin{array}{c} \begin{Bmatrix} -2 \text{ kips} \\ 0 \text{ kips} \\ 2 \text{ kips} \\ 0 \text{ kips} \end{Bmatrix} \end{array} \begin{array}{c} 4 \\ 5 \\ 1 \\ 2 \end{array}$$

$$\{F\}^{\boxed{2}} = \begin{array}{c} \begin{Bmatrix} 0 \text{ kips} \\ -5.00002 \text{ kips} \\ 0 \text{ kips} \\ 5.00002 \text{ kips} \end{Bmatrix} \end{array} \begin{array}{c} 1 \\ 2 \\ 6 \\ 3 \end{array}$$

$$\{F\}^{\boxed{3}} = \begin{array}{c} \begin{Bmatrix} -8.00009 \text{ kips} \\ -5 \text{ kips} \\ 8.00009 \text{ kips} \\ 5 \text{ kips} \end{Bmatrix} \end{array} \begin{array}{c} 6 \\ 3 \\ 4 \\ 5 \end{array}$$

$$\{R\} = \begin{array}{c} \begin{Bmatrix} (-2k) + (8.00009k) \\ (0k) + (5k) \\ (0k) + (-8.00009k) \end{Bmatrix} \end{array} \begin{array}{c} 4 \\ 5 \\ 6 \end{array}$$

Reactions

$$\{R\} = \begin{Bmatrix} R_4 \\ R_5 \\ R_6 \end{Bmatrix} = \begin{Bmatrix} 6.00009 \text{ kips} \\ 5 \text{ kips} \\ -8.00009 \text{ kips} \end{Bmatrix}$$

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Compute Transformation matrix

$$[T]^{\boxed{1}} = \begin{bmatrix} \cos(0) & \sin(0) & 0 & 0 \\ -\sin(0) & \cos(0) & 0 & 0 \\ 0 & 0 & \cos(0) & \sin(0) \\ 0 & 0 & -\sin(0) & \cos(0) \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$(\theta^{\boxed{1}} = 0°)$

$$[T]^{\boxed{2}} = \begin{bmatrix} \cos(90) & \sin(90) & 0 & 0 \\ -\sin(90) & \cos(90) & 0 & 0 \\ 0 & 0 & \cos(90) & \sin(90) \\ 0 & 0 & -\sin(90) & \cos(90) \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & -1 & 0 \end{bmatrix}$$

$(\theta^{\boxed{2}} = 90°)$

$$[T]^{\boxed{3}} = \begin{bmatrix} \cos(\theta^{\boxed{3}}) & \sin(\theta^{\boxed{3}}) & 0 & 0 \\ -\sin(\theta^{\boxed{3}}) & \cos(\theta^{\boxed{3}}) & 0 & 0 \\ 0 & 0 & \cos(\theta^{\boxed{2}}) & \sin(\theta^{\boxed{3}}) \\ 0 & 0 & -\sin(\theta^{\boxed{3}}) & \cos(\theta^{\boxed{3}}) \end{bmatrix}$$

$(\theta^{\boxed{3}} = -32.005°)$

$$= \begin{bmatrix} 0.8480018487 & -0.5299932684 & 0 & 0 \\ 0.5299932684 & 0.8480018487 & 0 & 0 \\ 0 & 0 & 0.8480018487 & -0.5299932684 \\ 0 & 0 & 0.5299932684 & 0.8480018487 \end{bmatrix}$$

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Member Forces (Local Coordinate System)

$$\{Q\}^{\boxed{1}} = [T]^{\boxed{1}} \{F\}^{\boxed{1}} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{Bmatrix} -2 \\ 0 \\ 2 \\ 0 \end{Bmatrix} = \begin{array}{c} \begin{Bmatrix} -2 \text{ kips} \\ 0 \text{ kips} \\ 2 \text{ kips} \\ 0 \text{ kips} \end{Bmatrix} \end{array} \begin{array}{c} 4 \\ 5 \\ 1 \\ 2 \end{array}$$

$$\{Q\}^{\boxed{2}} = [T]^{\boxed{2}} \{F\}^{\boxed{2}} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & -1 & 0 \end{bmatrix} \begin{Bmatrix} 0 \\ -5.00002 \\ 0 \\ 5.00002 \end{Bmatrix} = \begin{Bmatrix} -5.00002 \text{ kips} \\ 0 \text{ kips} \\ 5.00002 \text{ kips} \\ 0 \text{ kips} \end{Bmatrix} \begin{array}{c} 1 \\ 2 \\ 6 \\ 3 \end{array}$$

$$\{Q\}^{\boxed{3}} = [T]^{\boxed{3}} \{F\}^{\boxed{3}}$$

$$= \begin{bmatrix} 0.8480018487 & -0.5299932684 & 0 & 0 \\ 0.5299932684 & 0.840018487 & 0 & 0 \\ 0 & 0 & 0.8480018487 & -0.5299932684 \\ 0 & 0 & 0.5299932684 & 0.8480018487 \end{bmatrix} \begin{Bmatrix} 8.00009 \\ -5 \\ -8.00009 \\ 5 \end{Bmatrix}$$

$$\{Q\}^{\boxed{3}} = \begin{Bmatrix} 9.43406 \\ 0.0399014 \\ -9.43406 \\ 0.0000153969 \end{Bmatrix} \begin{array}{c} 6 \\ 3 \\ 4 \\ 5 \end{array} \text{ kips}$$

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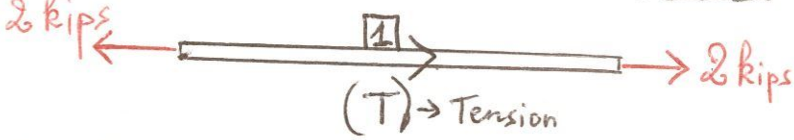
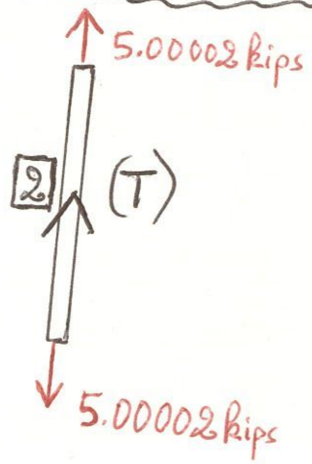
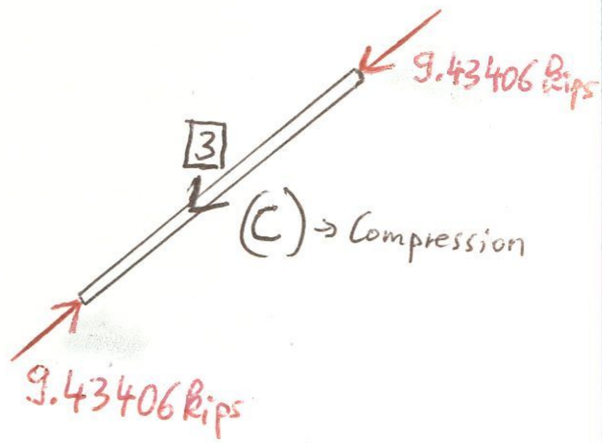
Member forces member $\boxed{1}$ FBD



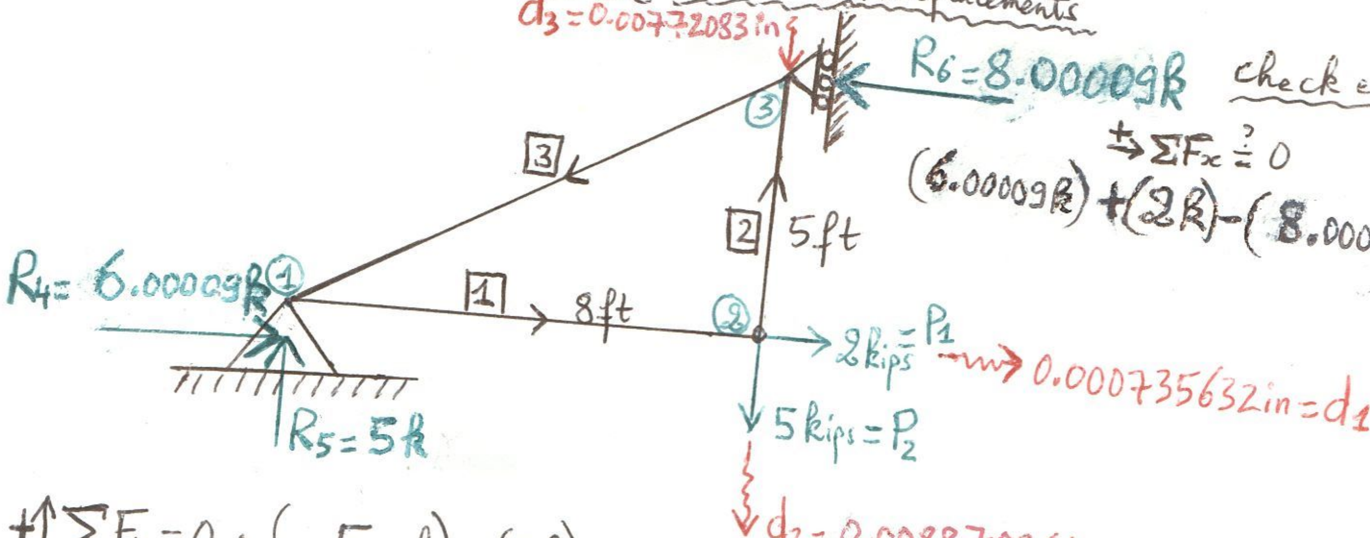
Member forces member $\boxed{2}$ FBD



Member forces member $\boxed{3}$ FBD



FBD with all the reactions & displacements



check equilibrium

$\overset{+}{\rightarrow}\Sigma F_x \overset{?}{=} 0$

$(6.00009k) + (2k) - (8.00009k) \overset{?}{=} 0$ ✓

$+\uparrow \Sigma F_y = 0 ; \; (5k) - (5k) \approx 0$ ✓

$+\circlearrowleft \Sigma M_{1} = 0 ; \; (-5\text{ kips})(8\text{ ft}) + (8.00009\text{ kips})(5\text{ ft}) \approx 0$ ✓

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Truss Example 1 (Structural Analysis)

Date: 2nd October 2018

Steps

1. Draw FBD.
2. Label all joints in circle ○ & the members in square □.
3. Label all Degrees Of Freedom (DOFs) & Reactions.
4. Write down the code number for each member.
5. Calculate the global stiffness matrix $[K_{ij}]$ for each member & assemble the stiffness matrix $[S_{ij}]$ either using Rigorous method (by drawing the joint FBD and writing down the equilibrium conditions of $\{P\}$ in terms of $[K]\{v\}$) or using Code number method (recommended).
6. Draw the FBD for each member & write down the compatibility conditions for each member.
7. Draw the FBD for each joint and write down the equilibrium conditions equations to find $\{P\}$ in terms of $[K]$ & $\{v\}$.
8. Assemble $\{P\}$ using Code number method.
9. Calculate the displacements, $\{d\} = \{P\}[S]^{-1}$.
10. Compute the member forces in the global coordinate system, $\{F\} = [K]\{v\}$
11. Assemble the Reactions using Code Number method from the member forces $\{F\}$ from each member.
12. Compute Transformation matrix $[T]$ for each member.
13. Calculate the member forces in the local coordinate system, $\{Q\} = [T]\{F\}$ and indicate whether the member is in Compression (C) or Tension (T).
14. Check equilibrium in order to make sure that it is satisfied: $\Sigma F_x = \Sigma F_y = \Sigma M = 0$.