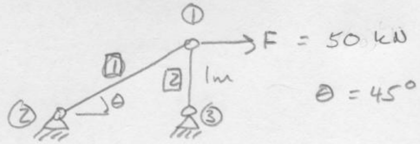


$A_1 = \sqrt{2} \times 4(10)^{-4}\ m^2$

$\theta = 45°$

$A_2 = 4(10)^{-4}\ m^2$

Member	$i \to j$	$\frac{AE}{L}$	θ	c	s
1	$1 \to 2$	$\frac{\sqrt{2} \times 4(10)^{-4}\ 210(10)^9}{\sqrt{2}}$	225	$-\frac{1}{\sqrt{2}}$	$-\frac{1}{\sqrt{2}}$
2	$1 \to 3$	$\frac{4(10)^{-4}\ 210(10)^9}{1}$	-90	0	-1

$$k^{(e)} = \frac{AE}{L}\begin{bmatrix} c^2 & cs & -c^2 & -cs \\ & s^2 & -cs & -s^2 \\ & -\text{sym}- & c^2 & cs \\ & & & s^2 \end{bmatrix}$$

$$k_1 = 8.4(10)^7 \begin{array}{c} \begin{array}{cccc} d_{1x} & d_{1y} & d_{2x} & d_{2y} \end{array} \\ \begin{bmatrix} \frac{1}{2} & \frac{1}{2} & -\frac{1}{2} & -\frac{1}{2} \\ & \frac{1}{2} & -\frac{1}{2} & -\frac{1}{2} \\ -\text{sym} & & \frac{1}{2} & \frac{1}{2} \\ & & & \frac{1}{2} \end{bmatrix} \end{array} \begin{array}{c} d_{1x} \\ d_{1y} \\ d_{2x} \\ d_{2y} \end{array}$$

$$k_2 = 8.4(10)^7 \begin{array}{c} \begin{array}{cccc} d_{1x} & d_{1y} & d_{3x} & d_{3y} \end{array} \\ \begin{bmatrix} 0 & 0 & 0 & 0 \\ & 1 & 0 & -1 \\ & -\text{sym} & 0 & 0 \\ & & & 1 \end{bmatrix} \end{array} \begin{array}{c} \\ d_{1x} \\ d_{1y} \\ d_{3x} \\ d_{3y} \end{array}$$

$$d_s = \begin{Bmatrix} d_{2x} \\ d_{2y} \\ d_{3x} \\ d_{3y} \end{Bmatrix} = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{Bmatrix} \qquad F_s = \begin{Bmatrix} F_{2x} \\ F_{2y} \\ F_{3x} \\ F_{3y} \end{Bmatrix}$$

$$d_F = \begin{Bmatrix} d_{1x} \\ d_{1y} \end{Bmatrix} \qquad F_F = \begin{Bmatrix} F_{1x} \\ F_{1y} \end{Bmatrix} = \begin{Bmatrix} 50{,}000 \\ 0 \end{Bmatrix}$$

Assemble System Matrix

$$[K]\{d\} = \{F\}$$

$$
K_{FF} \qquad K_{FS} \qquad d_F \qquad F_F\ \tfrac{3}{5}
$$

$$
8.4(10)^7
\begin{array}{cccccc}
d_{1x} & d_{1y} & d_{2x} & d_{2y} & d_{3x} & d_{3y} \\
\end{array}
\left[\begin{array}{cc|cccc}
\frac{1}{2} & \frac{1}{2} & -\frac{1}{2} & -\frac{1}{2} & 0 & 0 \\
\frac{1}{2} & 1+\frac{1}{2} & -\frac{1}{2} & -\frac{1}{2} & 0 & -1 \\
\hline
 & & \frac{1}{2} & \frac{1}{2} & 0 & 0 \\
 & & & \frac{1}{2} & 0 & 0 \\
 & K_{SF} & & & 0 & 0 \\
 & & & & & 1
\end{array}\right]
\begin{Bmatrix} d_{1x} \\ d_{1y} \\ \hline d_{2x} \\ d_{2y} \\ d_{3x} \\ d_{3y} \end{Bmatrix}
=
\begin{Bmatrix} F_{1x} \\ F_{1y} \\ \hline F_{2x} \\ F_{2y} \\ F_{3x} \\ F_{3y} \end{Bmatrix}
$$

$$
K_{SS} \qquad d_S \qquad F_S
$$

Solve for Displacements.

$$
K_{FF}\, d_F + \cancel{K_{FS}\, d_S}^{\,0} = F_F
$$

$$
8.4(10)^7 \begin{bmatrix} \frac{1}{2} & \frac{1}{2} \\ \frac{1}{2} & \frac{3}{2} \end{bmatrix} \begin{Bmatrix} d_{1x} \\ d_{1y} \end{Bmatrix} = \begin{Bmatrix} 50{,}000 \\ 0 \end{Bmatrix}
$$

$$
\begin{Bmatrix} d_{1x} \\ d_{1y} \end{Bmatrix} = \underline{\underline{\begin{Bmatrix} 1.79(10)^{-3} \\ -5.95(10)^{-4} \end{Bmatrix}}} \longleftarrow
$$

Solve for the reactions

$$K_{SF}\, d_F + \cancel{K_{SS}\, d_S}^{\,0} = F_S$$

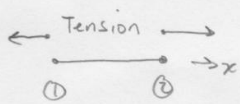
$$8.4(10)^7 \begin{bmatrix} -\frac{1}{2} & -\frac{1}{2} \\ -\frac{1}{2} & -\frac{1}{2} \\ 0 & 0 \\ 0 & -1 \end{bmatrix} \begin{Bmatrix} 1.79(10)^{-3} \\ -5.95(10)^{-4} \end{Bmatrix} = \begin{Bmatrix} F_{2x} \\ F_{2y} \\ F_{3x} \\ F_{3y} \end{Bmatrix} = \underline{\underline{\begin{Bmatrix} -5(10)^4 \\ -5(10)^4 \\ 0 \\ 5(10)^4 \end{Bmatrix}}} \leftarrow$$

Solve for the element forces

$$\begin{Bmatrix} f_{ix}^{(e)} \\ f_{iy}^{(e)} \end{Bmatrix} = \frac{AE}{L} \begin{bmatrix} c & s & -c & -s \\ -c & -s & c & s \end{bmatrix} \begin{Bmatrix} d_{ix} \\ d_{iy} \\ d_{jx} \\ d_{jy} \end{Bmatrix}$$

Element #1: $i \to j = 1 \to 2$

$$8.4(10)^7 \begin{bmatrix} -\frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \end{bmatrix} \begin{Bmatrix} 1.79(10)^{-3} \\ -5.95(10)^{-4} \\ 0 \\ 0 \end{Bmatrix} = \underline{\underline{\begin{Bmatrix} -7.07(10)^4 \\ 7.07(10)^4 \end{Bmatrix}}}$$

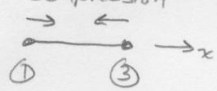


$$\sigma = \frac{7.07(10)^4}{4(10)^{-4}} = \underline{\underline{1.25(10)^8\ \text{N/m}^2}} \leftarrow$$

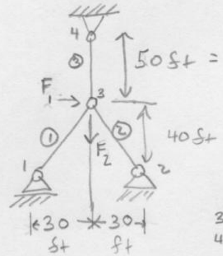
Element #2

$$8.4(10)^7 \begin{bmatrix} 0 & -1 & 0 & 1 \\ 0 & 1 & 0 & -1 \end{bmatrix} \begin{Bmatrix} 1.79(10)^{-3} \\ -5.95(10)^{-4} \\ 0 \\ 0 \end{Bmatrix} = \begin{Bmatrix} 5(10)^4 \\ -5(10)^4 \end{Bmatrix}$$

Compression



$$\sigma = \frac{5(10)^4}{4(10)^{-4}} = \underline{\underline{1.25(10)^8\ N/m^2}}$$



$A = 3 in^2$

$E = 3(10)^7$ psi

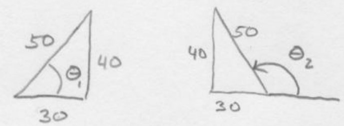
30ft = 360in
40ft = 480in

$F_1 = 5(10)^3$ lbf

$F_2 = 10(10)^3$ lbf

Element 1 & 2 length:

$\sqrt{30^2+40^2} = 50ft = 600in$



$\theta_1 = \text{atan}\ \frac{40}{30} = 53.13$

$\theta_2 = 180 - \theta_1 = 126.87$

Member	$i \to j$	$\frac{AE}{L}$	θ	c	s
1	$1 \to 3$	$\frac{3 \cdot 3(10)^7}{600}$	53.13	$\frac{3}{5}$	$\frac{4}{5}$
2	$2 \to 3$	$\frac{3 \cdot 3(10)^7}{600}$	126.87	$-\frac{3}{5}$	$\frac{4}{5}$
3	$4 \to 3$	$\frac{3 \cdot 3(10)^7}{600}$	-90	0	-1

$$k^{(e)} = \frac{AE}{L} \begin{bmatrix} c^2 & cs & -c^2 & -cs \\ & s^2 & -cs & -s^2 \\ & -\text{sym}- & c^2 & cs \\ & & & s^2 \end{bmatrix}$$

$$k_1 = 1.5(10)^5 \begin{array}{c} \begin{array}{cccc} d_{1x} & d_{1y} & d_{3x} & d_{3y} \end{array} \\ \begin{bmatrix} \frac{9}{25} & \frac{12}{25} & -\frac{9}{25} & -\frac{12}{25} \\ & \frac{16}{25} & -\frac{12}{25} & -\frac{16}{25} \\ & & \frac{9}{25} & \frac{12}{25} \\ -\text{sym}- & & & \frac{16}{25} \end{bmatrix} \end{array} \begin{array}{c} d_{1x} \\ d_{1y} \\ d_{3x} \\ d_{3y} \end{array}$$

$$k_2 = 15(10)^5 \begin{array}{cccc|c} d_{2x} & d_{2y} & d_{3x} & d_{3y} & \\ \end{array}$$

$$k_2 = 15(10)^5 \begin{array}{c} \\ \\ \\ \\ \end{array} \begin{array}{cccc} d_{2x} & d_{2y} & d_{3x} & d_{3y} \\ \left[\begin{matrix} \frac{9}{25} & \frac{-12}{25} & -\frac{9}{25} & \frac{12}{25} \\ & \frac{16}{25} & \frac{12}{25} & \frac{-16}{25} \\ & & \frac{9}{25} & \frac{-12}{25} \\ \text{-sym-} & & & \frac{16}{25} \end{matrix}\right] \end{array} \begin{array}{c} \\ d_{2x} \\ d_{2y} \\ d_{3x} \\ d_{3y} \end{array}$$

$$k_3 = 15(10)^5 \begin{array}{cccc} d_{3x} & d_{3y} & d_{4x} & d_{4y} \\ \left[\begin{matrix} 0 & 0 & 0 & 0 \\ & 1 & 0 & -1 \\ \text{- sym} & & 0 & 0 \\ & & & 1 \end{matrix}\right] \end{array} \begin{array}{c} \\ d_{3x} \\ d_{3y} \\ d_{4x} \\ d_{4y} \end{array}$$

Now Assemble System Stiffness Matrix

Example: Show Row Column Swap

Example: Show Direct Assemby with proper order

$$
\begin{array}{c|cccccccc|c}
 & d_{1x} & d_{1y} & d_{2x} & d_{2y} & d_{3x} & d_{3y} & d_{4x} & d_{4y} & \\
\hline
 & \frac{9}{25} & \frac{12}{25} & 0 & 0 & -\frac{9}{25} & -\frac{12}{25} & 0 & 0 & d_{1x} \\
 & \frac{12}{25} & \frac{16}{25} & 0 & 0 & -\frac{12}{25} & -\frac{16}{25} & 0 & 0 & d_{1y} \\
 & 0 & 0 & \frac{9}{25} & -\frac{12}{25} & -\frac{9}{25} & \frac{12}{25} & 0 & 0 & d_{2x} \\
 & 0 & 0 & -\frac{12}{25} & \frac{16}{25} & \frac{12}{25} & -\frac{16}{25} & 0 & 0 & d_{2y} \\
 & -\frac{9}{25} & -\frac{12}{25} & -\frac{9}{25} & \frac{12}{25} & 0+\frac{9}{25}+\frac{9}{25} & 0+\frac{12}{25}-\frac{12}{25} & 0 & 0 & d_{3x} \\
 & -\frac{12}{25} & -\frac{16}{25} & \frac{12}{25} & -\frac{16}{25} & 0 & 1+\frac{16}{25}+\frac{16}{25} & 0 & -1 & d_{3y} \\
 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & d_{4x} \\
 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 1 & d_{4y}
\end{array}
$$

-sym-

$\times\ 1.5(10)^5$

Interested in Node 3

First Swap Rows $1 \leftrightarrow 5$
and Rows $2 \leftrightarrow 6$

$$
\begin{array}{cccccccccc}
 & d_{1x} & d_{1y} & d_{2x} & d_{2y} & d_{3x} & d_{3y} & d_{4x} & d_{4y} & \\
\left[\begin{array}{c} \\ \\ \\ \\ \\ \\ \\ \\ \end{array}\right. & & & & & & & & & \\
\end{array}
$$

$$
\begin{array}{c}
\begin{array}{cccccccc}
d_{1x} & d_{1y} & d_{2x} & d_{2y} & d_{3x} & d_{3y} & d_{4x} & d_{4y}
\end{array}
\\
\left[\begin{array}{cccccccc}
-\frac{9}{25} & -\frac{12}{25} & -\frac{9}{25} & \frac{12}{25} & \frac{18}{25} & 0 & 0 & 0 \\
-\frac{12}{25} & -\frac{16}{25} & \frac{12}{25} & -\frac{16}{25} & 0 & \frac{57}{25} & 0 & -1 \\
0 & 0 & \frac{9}{25} & -\frac{12}{25} & -\frac{9}{25} & \frac{12}{25} & 0 & 0 \\
0 & 0 & -\frac{12}{25} & \frac{16}{25} & \frac{12}{25} & -\frac{16}{25} & 0 & 0 \\
\frac{9}{25} & \frac{12}{25} & 0 & 0 & -\frac{9}{25} & -\frac{12}{25} & 0 & 0 \\
\frac{12}{25} & \frac{16}{25} & 0 & 0 & -\frac{12}{25} & -\frac{16}{25} & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & -1 & 0 & 1
\end{array}\right]
\begin{array}{c}
d_{3x} \\ d_{3y} \\ d_{2x} \\ d_{2y} \\ d_{1x} \\ d_{1y} \\ d_{4x} \\ d_{4y}
\end{array}
\end{array}
$$

$\times\ 1.5 \times 10^5$

Next Swap Columns $1 \leftrightarrow 5$

and Columns $2 \leftrightarrow 6$

15/9

$$
\begin{array}{c|cccccccc}
 & d_{3x} & d_{3y} & d_{2x} & d_{2y} & d_{1x} & d_{1y} & d_{4x} & d_{4y} \\
\hline
d_{3x} & \frac{18}{25} & 0 & -\frac{9}{25} & \frac{12}{25} & -\frac{9}{25} & -\frac{12}{25} & 0 & 0 \\
d_{3y} & 0 & \frac{57}{25} & \frac{12}{25} & -\frac{16}{25} & -\frac{12}{25} & -\frac{16}{25} & 0 & -1 \\
d_{2x} & & & \frac{9}{25} & -\frac{12}{25} & 0 & 0 & 0 & 0 \\
d_{2y} & & & & \frac{16}{25} & 0 & 0 & 0 & 0 \\
d_{1x} & & & & & \frac{9}{25} & \frac{12}{25} & 0 & 0 \\
d_{1y} & & -\text{sym}- & & & & \frac{16}{25} & 0 & 0 \\
d_{4x} & & & & & & & 0 & 0 \\
d_{4y} & & & & & & & & 1
\end{array}
\times 1.5(10)^5
$$

K_{FF} K_{FS}

after the last swap it is symetric again

Note!

This is extremly painfull — much better to order degrees of freedom from the start & Assemble Stiffness matrix correctly without row/column swap

See following page

$$
\begin{array}{c}
\begin{array}{cccccccc} d_{3x} & d_{3y} & d_{2x} & d_{2y} & d_{1x} & d_{1y} & d_{4x} & d_{4y} \end{array} \\
\left[\begin{array}{cc|cccccc}
\frac{18}{25} & 0 & \frac{-9}{25} & \frac{12}{25} & \frac{-9}{25} & \frac{-12}{25} & 0 & 0 \\
0 & \frac{57}{25} & \frac{12}{25} & \frac{-16}{25} & \frac{-12}{25} & \frac{-16}{25} & 0 & -1 \\
\hline
 & & \frac{9}{25} & \frac{-12}{25} & 0 & 0 & 0 & 0 \\
 & & & \frac{16}{25} & 0 & 0 & 0 & 0 \\
 & & & & \frac{9}{25} & \frac{12}{25} & 0 & 0 \\
 & & & & & \frac{16}{25} & 0 & 0 \\
 & & & & & & 0 & 0 \\
 & & & & & & & 1
\end{array}\right]
\end{array}
\begin{Bmatrix} d_{3x} \\ d_{3y} \\ d_{2x} \\ d_{2y} \\ d_{1x} \\ d_{1y} \\ d_{4x} \\ d_{4y} \end{Bmatrix}
$$

K_{FF} $\quad K_{FS}$ $\quad K_{SF}$ $\quad K_{SS}$ $\quad d_F$

$\times 1.5 \times 10^5$

$$
\left[\begin{array}{c|c}
K_{FF} & K_{FS} \\
\hline
K_{SF} & K_{SS}
\end{array}\right]
\begin{Bmatrix} d_{3x} \\ d_{3y} \\ d_{2x} \\ d_{2y} \\ d_{1x} \\ d_{1y} \\ d_{4x} \\ d_{4y} \end{Bmatrix}
=
\begin{Bmatrix} F_{3x} \\ F_{3y} \\ F_{2x} \\ F_{2y} \\ F_{1x} \\ F_{1y} \\ F_{4x} \\ F_{4y} \end{Bmatrix}
$$

$$
F_F = \begin{Bmatrix} F_{3x} \\ F_{3y} \end{Bmatrix} = \begin{Bmatrix} 5(10)^3 \\ 1(10)^4 \end{Bmatrix}
$$

$$
d_S = \begin{Bmatrix} d_{2x} \\ d_{2y} \\ d_{1x} \\ d_{1y} \\ d_{4x} \\ d_{4y} \end{Bmatrix} = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{Bmatrix}
$$

Solve for Displacements

$$K_{FF} d_F + \cancel{K_{FS} d_S}^{\,0} = F_F$$

$$1.5(10)^4 \begin{bmatrix} \frac{18}{25} & 0 \\ 0 & \frac{57}{25} \end{bmatrix} \begin{Bmatrix} d_{3x} \\ d_{3y} \end{Bmatrix} + 0 = \begin{Bmatrix} 5(10)^3 \\ 1(10)^4 \end{Bmatrix}$$

$$\{d_F\} = \begin{Bmatrix} d_{3x} \\ d_{3y} \end{Bmatrix} = \underline{\underline{\begin{Bmatrix} 0.046 \\ -0.029 \end{Bmatrix}}}$$

Solve for Reactions

$$K_{SF} d_F + \cancel{K_{SS} d_S}^{\,0} = F_S$$

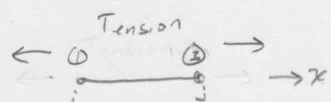
$$1.5(10)^4 \begin{bmatrix} -\frac{9}{25} & \frac{12}{25} \\ \frac{12}{25} & -\frac{16}{25} \\ -\frac{9}{25} & -\frac{12}{25} \\ -\frac{12}{25} & -\frac{16}{25} \\ 0 & 0 \\ 0 & -1 \end{bmatrix} \begin{Bmatrix} 0.046 \\ -0.029 \end{Bmatrix} = \begin{Bmatrix} -4.61(10)^3 \\ 6.14(10)^3 \\ -3.95(10)^2 \\ -5.26(10)^2 \\ 0 \\ 4.39(10)^3 \end{Bmatrix} = \begin{Bmatrix} R_{2x} \\ R_{2y} \\ R_{1x} \\ R_{1y} \\ R_{4x} \\ R_{4y} \end{Bmatrix}$$

Solve for Element forces:

$$\begin{Bmatrix} f_{ix}^{(e)} \\ f_{jx}^{(e)} \end{Bmatrix} = \frac{AE}{L} \begin{bmatrix} C & S & -C & -S \\ -C & -S & C & S \end{bmatrix} \begin{Bmatrix} d_{ix} \\ d_{iy} \\ d_{jx} \\ d_{jy} \end{Bmatrix}$$

Element 1:

$$\frac{1.5(10)^5}{5} \begin{bmatrix} 3 & 4 & -3 & -4 \\ -3 & -4 & 3 & 4 \end{bmatrix} \begin{Bmatrix} 0 \\ 0 \\ 0.046 \\ -0.029 \end{Bmatrix} = \begin{Bmatrix} -657.9 \\ 657.9 \end{Bmatrix}$$



$$\sigma = \frac{657.9 \text{ lbs}}{3 \text{ in}^2} = \underline{\underline{219.29 \text{ psi}}}$$

Element 2:

$$\frac{1.5(10)^5}{5} \begin{bmatrix} -3 & 4 & 3 & -4 \\ 3 & -4 & -3 & 4 \end{bmatrix} \begin{Bmatrix} 0 \\ 0 \\ 0.046 \\ -0.029 \end{Bmatrix} = \begin{Bmatrix} 7679.4 \\ -7679.4 \end{Bmatrix}$$

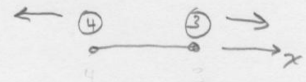
Compression

$$\sigma = \frac{-7679.4 \text{ lbs}}{3 \text{ in}^2} = \underline{\underline{-2558.48 \text{ psi}}}$$

Element #3

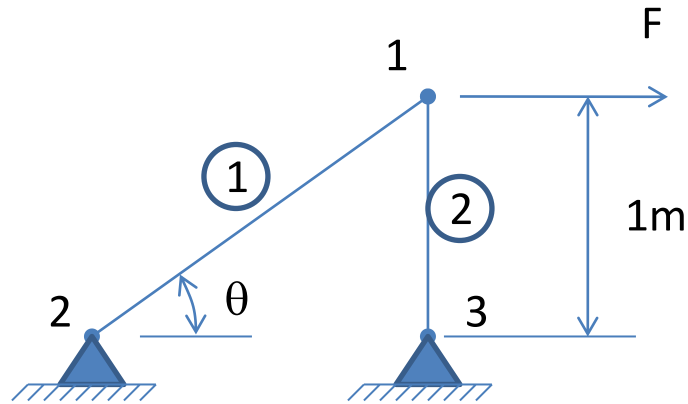
$$\frac{1.5(10)^3}{5}\begin{bmatrix} 0 & -1 & 0 & 1 \\ 0 & 1 & 0 & -1 \end{bmatrix}\begin{Bmatrix} 0 \\ 0 \\ 0.046 \\ -0.029 \end{Bmatrix} = \begin{Bmatrix} -4386 \\ 4386 \end{Bmatrix}$$

Tension



$$\sigma = \frac{4386 \text{ lbs}}{3 \text{ in}^2} = \underline{\underline{1462 \text{ psi}}} \longleftarrow$$

a) Determine ***Displacements***, ***Reactions***, ***element forces*** and ***stresses*** for the truss shown.



F=1000 N

θ = 45 deg

For Elements:

$A_1=\sqrt{2} \times 4 \times 10^{-4}\ m^2$

$A_2=4 \times 10^{-4}\ m^2$

E= 210 GPa

```
time 2
sol 101
cend
title=ME204 Homework 3
subtitle=Problem a
spc=100
disp=all
spcforces=all
subcase 1
   label=Load Set
   load=501
   forces=all
   stress=all
begin bulk
grid,11,,1.,1.
grid,12,,0.,0.
grid,13,,1.,0.
crod,21,20,11,12
crod,22,21,11,13
prod,20,40,5.657-4
prod,21,40,4.-4
mat1,40,2.1+11,,0.3
spc1,100,12,12,13
force,501,11,,50000.,1.
param,grdpnt,0
enddata
```

Problem a (Nastran Solution)

Conclusions:

Manual computation matches Nastran solution

D I S P L A C E M E N T   V E C T O R

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
11	G	1.785684E-03	-5.952381E-04	0.0	0.0	0.0	0.0
12	G	0.0	0.0	0.0	0.0	0.0	0.0
13	G	0.0	0.0	0.0	0.0	0.0	0.0

F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
12	G	-5.000000E+04	-5.000000E+04	0.0			
13	G	0.0	5.000000E+04	0.0			

Numbers match manual computation

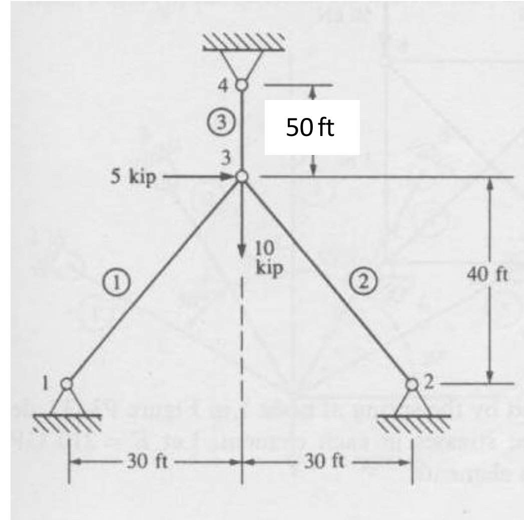
F O R C E S   I N   R O D   E L E M E N T S   (C R O D)

ELEMENT ID.	AXIAL FORCE	TORQUE	ELEMENT ID.	AXIAL FORCE	TORQUE
21	7.071068E+04	0.0	22	-5.000000E+04	0.0

S T R E S S E S   I N   R O D   E L E M E N T S   (C R O D)

ELEMENT ID.	AXIAL STRESS	SAFETY MARGIN	TORSIONAL STRESS	SAFETY MARGIN
21	1.249968E+08		0.0	
22	-1.250000E+08		0.0	

b) Determine ***Displacements***, ***Reactions***, ***element forces*** and ***stresses*** for the truss shown.



For All Elements:
$A=3\ in^2$
$E=3 \times 10^7$ psi

```
time 2
sol 101
cend
title=ME204 Homework 3
subtitle=Problem b
spc=100
disp=all
spcforces=all
subcase 1
   label=Load Set
   load=501
   forces=all
   stress=all
begin bulk
grid,11,,-360.,-480.
grid,12,,360.,-480.
grid,13,,0.,0.
grid,14,,0.,600.
crod,21,20,11,13
crod,22,20,12,13
crod,23,20,14,13
prod,20,40,3.
mat1,40,3+7,,0.3
spc1,100,12,11,12,14
force,501,13,,5000.,1.
force,501,13,,10000.,0.,-1.
param,grdpnt,0
enddata
```

Problem b (Nastran Solution)
Conclusions:
Manual computation matches Nastran solution

D I S P L A C E M E N T   V E C T O R

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
11	G	0.0	0.0	0.0	0.0	0.0	0.0
12	G	0.0	0.0	0.0	0.0	0.0	0.0
13	G	4.629629E-02	-2.923977E-02	0.0	0.0	0.0	0.0
14	G	0.0	0.0	0.0	0.0	0.0	0.0

Numbers match manual computation

F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
11	G	-3.947368E+02	-5.263158E+02	0.0			
12	G	-4.605263E+03	6.140351E+03	0.0			
14	G	0.0	4.385965E+03	0.0	0.0	0.0	0.0

F O R C E S   I N   R O D   E L E M E N T S   (C R O D)

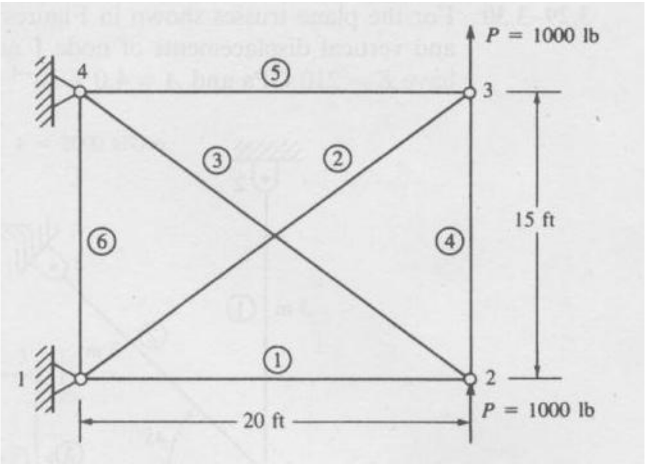
ELEMENT ID.	AXIAL FORCE	TORQUE	ELEMENT ID.	AXIAL FORCE	TORQUE
21	6.578947E+02	0.0	22	-7.675438E+03	0.0
23	4.385965E+03	0.0			

S T R E S S E S   I N   R O D   E L E M E N T S   (C R O D)

ELEMENT ID.	AXIAL STRESS	SAFETY MARGIN	TORSIONAL STRESS	SAFETY MARGIN	ELEMENT ID.	AXIAL STRESS	SAFETY MARGIN
21	2.192982E+02		0.0		22	-2.558479E+03	
23	1.461988E+03		0.0				

Problem c (Nastran Solution)
Use A=1in^2 E=10^7 psi

Conclusions:
Nastran Problem solves redundant system properly



A=1in^2, and E=10^7 psi

```
time 2
sol 101
cend
title=ME204 Homework 3
subtitle=Problem c
spc=100
disp=all
spcforces=all
subcase 1
   label=Load Set
   load=501
   forces=all
   stress=all
begin bulk
grid,11,,0.,0.
grid,12,,240.,0.
grid,13,,240.,180.
grid,14,,0.,180.
crod,21,20,11,12
crod,22,20,11,13
crod,23,20,12,14
crod,24,20,12,13
crod,25,20,13,14
crod,26,20,11,14
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,14
force,501,12,,1000.,0.,1.
force,501,13,,1000.,0.,1.
param,grdpnt,0
enddata
```

Key Results from .f06 file

D I S P L A C E M E N T   V E C T O R

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
11	G	0.0	0.0	0.0	0.0	0.0	0.0
12	G	3.200000E-02	1.260000E-01	0.0	0.0	0.0	0.0
13	G	-3.200000E-02	1.260000E-01	0.0	0.0	0.0	0.0
14	G	0.0	0.0	0.0	0.0	0.0	0.0

F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
11	G	-2.666667E+03	-1.000000E+03	0.0	0.0	0.0	0.0
14	G	2.666667E+03	-1.000000E+03	0.0	0.0	0.0	0.0

F O R C E S   I N   R O D   E L E M E N T S   (C R O D)

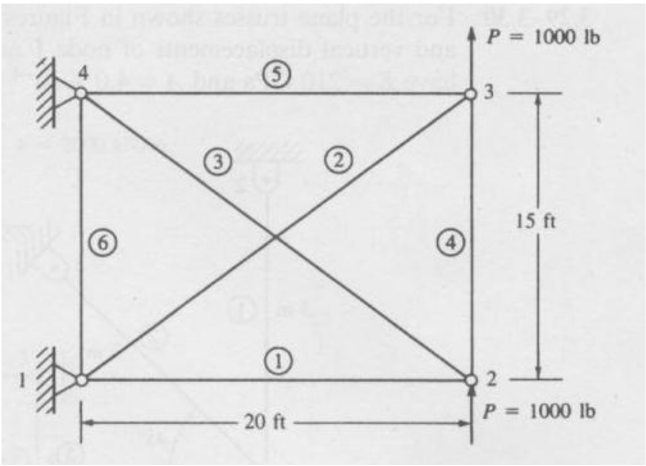
ELEMENT ID.	AXIAL FORCE	TORQUE	ELEMENT ID.	AXIAL FORCE	TORQUE
21	1.333333E+03	0.0	22	1.666667E+03	0.0
23	-1.666667E+03	0.0	24	0.0	0.0
25	-1.333333E+03	0.0	26	0.0	0.0

S T R E S S E S   I N   R O D   E L E M E N T S   (C R O D)

ELEMENT ID.	AXIAL STRESS	SAFETY MARGIN	TORSIONAL STRESS	SAFETY MARGIN	ELEMENT ID.	AXIAL STRESS	SAFETY MARGIN	TORSIONAL STRESS
21	1.333333E+03	5.0E-01	0.0		22	1.666667E+03	2.0E-01	0.0
23	-1.666667E+03	2.0E-01	0.0		24	0.0		0.0
25	-1.333333E+03	5.0E-01	0.0		26	0.0		0.0

Problem d

Conclusions: When crossbars 2 and 3 are removed, Nastran recognizes system as a singular Matrix. Produces consistent error shown on following page



A=1in^2, and E=10^7 psi

```
time 2
sol 101
cend
title=ME204 Homework 3
subtitle=Problem d
spc=100
disp=all
spcforces=all
subcase 1
   label=Load Set
   load=501
   forces=all
   stress=all
begin bulk
grid,11,,0.,0.
grid,12,,240.,0.
grid,13,,240.,180.
grid,14,,0.,180.
crod,21,20,11,12
crod,22,20,11,13
crod,23,20,12,14
crod,24,20,12,13
crod,25,20,13,14
crod,26,20,11,14
prod,20,40,1.
mat1,40,1+7,,0.3,2.6-4
,2000.,2000.
spc1,100,12,11,14
force,501,12,,1000.,0.,1.
force,501,13,,1000.,0.,1.
param,grdpnt,0
enddata
```

Key Results from .f06 file: System is singular – is a mechanism (i.e. F=ma should be used)

```
 *** USER INFORMATION MESSAGE 6137 (DFMN)
     INPUT MATRIX TO DECOMPOSITION HAS        1 SINGULARITIES.
     SEE FOLLOWING MESSAGES FOR DETAILS.

 *** USER INFORMATION MESSAGE 4158 (DFMSA)
 ---- STATISTICS FOR SPARSE DECOMPOSITION OF DATA BLOCK KLL      FOLLOW
        NUMBER OF NEGATIVE TERMS ON FACTOR DIAGONAL =      0
        MAXIMUM RATIO OF MATRIX DIAGONAL TO FACTOR DIAGONAL =  1.0E+15 AT ROW NUMBER          2

 *** SYSTEM INFORMATION MESSAGE 4159 (DFMSA)
     THE DECOMPOSITION OF KLL      YIELDS A MAXIMUM MATRIX-TO-FACTOR-DIAGONAL RATIO OF    1.000000E+15
 *** USER WARNING MESSAGE 4698 (DCMPD)
     STATISTICS FOR DECOMPOSITION OF MATRIX KLL.
     THE FOLLOWING DEGREES OF FREEDOM HAVE FACTOR DIAGONAL RATIOS GREATER THAN
     1.000000E+07 OR HAVE NEGATIVE TERMS ON THE FACTOR DIAGONAL.
     USER INFORMATION:
     THIS MESSAGE MAY BE IGNORED IF NO GRID POINT IDS OR HIGH RATIO MESSAGES APPEAR IN THE TABLE ON THE NEXT PAGE.
1   ME204 HOMEWORK 3                                                     SEPTEMBER  23, 2007   MD NASTRAN  2/16/07
PAGE    10
     PROBLEM 3.26
0    LOAD SET                                                                                              SUBCASE
1
0
         GRID POINT ID       DEGREE OF FREEDOM   MATRIX/FACTOR DIAGONAL RATIO        MATRIX DIAGONAL

              12                    T2                   1.00000E+15                    5.55556E+04
 ^^^
 ^^^ USER   FATAL   MESSAGE 9050 (SEKRRS)
 ^^^ RUN TERMINATED DUE TO EXCESSIVE PIVOT RATIOS IN MATRIX KLL.
 ^^^ USER ACTION:  CONSTRAIN MECHANISMS WITH SPCI OR SUPORTI ENTRIES OR SPECIFY PARAM,BAILOUT,-1 TO
     CONTINUE THE RUN WITH MECHANISMS.
```

This may help identifying problem if you think it ***should*** be properly posed,
i.e. this is the FIRST grid point where a problem is identified