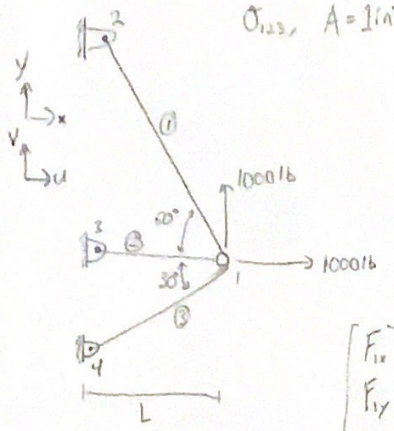
AEM 4502 — Homework 2 — Colton Davies — 5631935

1.] Solve 3.22, U_1, V_1 $E = 10\times10^6$ psi

σ_{123}, $A = 1\text{in}^2$, $L = 100\text{in}$

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



Element	θ	c	s	c^2	s^2	cs
1	120	$-\frac{1}{2}$	$\frac{\sqrt{3}}{2}$	$\frac{1}{4}$	$\frac{3}{4}$	$-\frac{\sqrt{3}}{4}$
2	0	1	0	1	0	0
3	210	$-\frac{\sqrt{3}}{2}$	$-\frac{1}{2}$	$\frac{3}{4}$	$\frac{1}{4}$	$\frac{\sqrt{3}}{4}$

$\cos(60) = \frac{1}{2}$, $\cos(30) = \frac{\sqrt{3}}{2}$

$$\begin{bmatrix} F_{1x}\\ F_{1y}\\ F_{2x}\\ F_{2y}\\ F_{3x}\\ F_{3y}\\ F_{4x}\\ F_{4y}\end{bmatrix} \begin{matrix}\rightarrow 1000\text{lb}\\ \rightarrow 1000\text{lb}\\ \\ \\ \\ \\ \\ \end{matrix} = [K]\begin{bmatrix} U_1\\ V_1\\ U_2\\ V_2\\ U_3\\ V_3\\ U_4\\ V_4\end{bmatrix}$$

$$[K^{(1)}] = \frac{EA}{L/\cos 60}\begin{bmatrix} 1/4 & -\frac{\sqrt{3}}{4} & -1/4 & -\frac{\sqrt{3}}{4}\\ & 3/4 & \frac{\sqrt{3}}{4} & -3/4\\ & & 1/4 & \sqrt{3}/4\\ \text{sym} & & & 3/4\end{bmatrix}\begin{matrix}U_1\\V_1\\U_2\\V_2\end{matrix}$$

$$[K^{(2)}] = \frac{EA}{L}\begin{bmatrix} 1 & 0 & -1 & 0\\ & 0 & 0 & 0\\ & & 1 & 0\\ \text{Sym} & & & 0\end{bmatrix}\begin{matrix}U_1\\V_1\\U_3\\V_3\end{matrix}$$

$$[K^{(3)}] = \frac{EA}{L/\cos 30}\begin{bmatrix} 3/4 & \frac{\sqrt{3}}{4} & -3/4 & -\frac{\sqrt{3}}{4}\\ & -\frac{1}{2} & -\frac{\sqrt{3}}{4} & -\frac{1}{4}\\ & & \frac{3}{4} & \frac{\sqrt{3}}{4}\\ \text{sym} & & & -\frac{1}{2}\end{bmatrix}\begin{matrix}U_1\\V_1\\U_4\\V_4\end{matrix}$$

$F_{1x} = 1000$

$F_{4y} = 1000$

$$\frac{EA}{L}\begin{bmatrix} 1+\frac{3}{8}+\frac{\sqrt{3}}{8} & \frac{\sqrt{3}}{8}-\frac{\sqrt{3}}{8} & -\frac{1}{8} & \frac{\sqrt{3}}{8} & -1 & 0 & \frac{\sqrt{3}}{8} & \frac{\sqrt{3}}{8}\\ -\frac{\sqrt{3}}{8}+\frac{\sqrt{3}}{8} & \frac{3}{8}+\frac{\sqrt{3}}{8} & \frac{\sqrt{3}}{8} & -\frac{3}{8} & 0 & 0 & -\frac{\sqrt{3}}{8} & -\frac{\sqrt{3}}{8}\\ -\frac{1}{8} & \frac{\sqrt{3}}{8} & \frac{1}{8} & -\frac{\sqrt{3}}{8} & 1 & 0 & 0 & 0\\ \frac{\sqrt{3}}{8} & -\frac{3}{8} & -\frac{\sqrt{3}}{8} & \frac{3}{8} & 0 & 0 & 0 & 0\\ -1 & 0 & 1 & 0 & 1 & 0 & 0 & 0\\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\ \frac{\sqrt{3}}{8} & -\frac{\sqrt{3}}{8} & 0 & 0 & 0 & 0 & \frac{3}{8} & -\frac{\sqrt{3}}{8}\\ \frac{\sqrt{3}}{8} & -\frac{\sqrt{3}}{8} & 0 & 0 & 0 & 0 & -\frac{\sqrt{3}}{8} & \frac{3}{8}\end{bmatrix}\begin{bmatrix} U_1\\V_1\\U_2\\V_2\\U_3\\V_3\\U_4\\V_4\end{bmatrix} = \begin{bmatrix} F_{1x}\\F_{1y}\\F_{2x}\\F_{2y}\\F_{3x}\\F_{3y}\\F_{4x}\\F_{4y}\end{bmatrix}$$

$$\frac{EA}{L}\begin{bmatrix} \frac{9+3\sqrt{3}}{8} & \frac{3-\sqrt{3}}{8} \\ \frac{3-\sqrt{3}}{8} & \frac{3+\sqrt{3}}{8} \end{bmatrix}\begin{bmatrix} u_1 \\ v_1 \end{bmatrix} = \begin{bmatrix} 1000\,lb \\ 1000\,lb \end{bmatrix}$$

$$\frac{EA}{L}\left(\frac{3-\sqrt{3}}{8}u_1 + \frac{3+\sqrt{3}}{8}v_1\right) = 1000$$

$$\frac{3-\sqrt{3}}{8}u_1 = \frac{1000L}{EA} - \frac{3+\sqrt{3}}{8}v_1$$

$$u_1 = \left(\frac{1000L}{EA} - \frac{3+\sqrt{3}}{8}v_1\right)\left(\frac{8}{3-\sqrt{3}}\right)$$

$$\frac{EA}{L}\left(\frac{9+3\sqrt{3}}{8}u_1 + \frac{3-\sqrt{3}}{8}v_1\right) = 1000$$

$$\frac{9+3\sqrt{3}}{8}\left(\frac{1000L}{EA} - \frac{3+\sqrt{3}}{8}v_1\right)\left(\frac{8}{3-\sqrt{3}}\right) = 1000$$

solve for v_1

$$\boxed{v_1 = 0.01577\,in}$$

$$\boxed{u_1 = 0.00423\,in}$$

$$\sigma_{1,2,3} = \frac{E}{L}\begin{bmatrix} -C & -S & C & S \end{bmatrix}\begin{bmatrix} u_1 \\ v_1 \\ \cancel{u_2}\,0 \\ \cancel{v_2}\,0 \end{bmatrix}$$

$$\sigma_1 = \frac{E}{L\cos(60)}\begin{bmatrix} \frac{1}{2} & \frac{-\sqrt{3}}{2} & \frac{-1}{2} & \frac{\sqrt{3}}{2} \end{bmatrix}$$

$$\boxed{\sigma_1 = -577\,\frac{lb}{in^2}}\ \text{Compression}$$

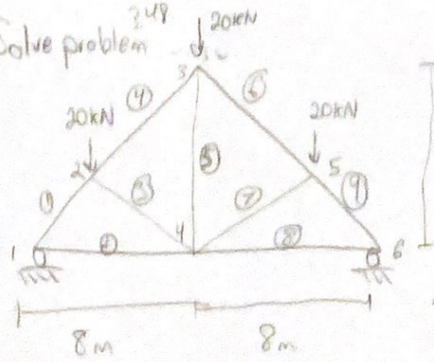
$$\sigma_2 = \frac{E}{L}\begin{bmatrix} -1 & 0 & 1 & 0 \end{bmatrix}\begin{bmatrix} u_1 \\ v_1 \\ 0 \\ 0 \end{bmatrix} \Rightarrow$$

$$\boxed{\sigma_2 = -422\,\frac{lb}{in^2}}\ \text{Compression}$$

$$\sigma_3 = \frac{E}{L\cos(30)}\begin{bmatrix} \frac{\sqrt{3}}{2} & \frac{1}{2} & \frac{-\sqrt{3}}{2} & \frac{-1}{2} \end{bmatrix}\begin{bmatrix} u_1 \\ v_1 \\ 0 \\ 0 \end{bmatrix} \Rightarrow$$

$$\boxed{\sigma_3 = 999.8\,\frac{lb}{in^2}}\ \text{Tension}$$

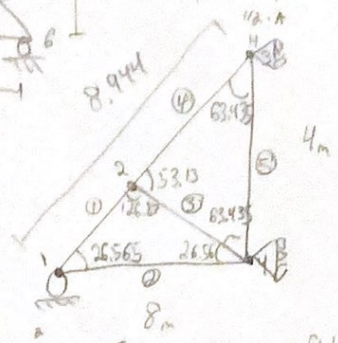
2.] Solve problem 3.49



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

$E = 210\ GPa$

Symmetry Down Middle



20kN ↓ •2

10kN ↓ •3

$L_1 = 4.47$ $L_4 = 4.47$

$L_2 = 8$ $L_5 = 4$

$L_3 = 4.47$

Element	θ	C	S	C^2	S^2	CS
1	26.565	.894	.447	.8	.199	0.399
2	0	1	0	1	0	0
3	153.435	-.894	.447	.8	.199	-0.399
4	26.565	.894	.447	.8	.199	0.399
5	90	0	1	0	1	0

$$\begin{bmatrix} U_1 \\ V_1 \\ U_2 \\ V_2 \\ U_3 \\ V_3 \\ U_4 \\ V_4 \end{bmatrix}$$

$$[k^{(1)}] = \frac{EA}{4.47} \begin{array}{c} \\ \\ \\ \\ \\ \\ \\ \\ \end{array} \begin{array}{c} \begin{array}{cccc} U_1 & V_1 & U_2 & V_2 \end{array} \\ \begin{bmatrix} 0.8 & 0.399 & -0.8 & -0.399 \\ & 0.199 & -0.399 & -0.199 \\ & & 0.8 & 0.399 \\ \text{Sym} & & & 0.199 \end{bmatrix} \end{array} \begin{array}{c} U_1 \\ V_1 \\ U_2 \\ V_2 \end{array}$$

$$[k^{(2)}] = \frac{EA}{8} \begin{array}{c} \begin{array}{cccc} U_1 & V_1 & U_4 & V_4 \end{array} \\ \begin{bmatrix} 1 & 0 & -1 & 0 \\ & 0 & 0 & 0 \\ & & 1 & 0 \\ \text{Sym} & & & 0 \end{bmatrix} \end{array} \begin{array}{c} U_1 \\ V_1 \\ U_4 \\ V_4 \end{array}$$

$$[k^{(3)}] = \frac{EA}{447} \begin{array}{c} \begin{array}{cccc} U_4 & V_4 & U_2 & V_2 \end{array} \\ \begin{bmatrix} 0.8 & -0.399 & -0.8 & 0.399 \\ & 0.199 & -0.399 & -0.199 \\ & & 0.8 & -0.399 \\ \text{Sym} & & & 0.199 \end{bmatrix} \end{array} \begin{array}{c} U_4 \\ V_4 \\ U_2 \\ V_2 \end{array}$$

$$[k^{(4)}] = \frac{EA}{4.47} \begin{array}{c} \begin{array}{cccc} U_2 & V_2 & U_3 & V_3 \end{array} \\ \begin{bmatrix} 0.8 & 0.399 & -0.8 & -0.399 \\ & 0.199 & -0.399 & -0.199 \\ & & 0.8 & 0.399 \\ \text{Sym} & & & 0.199 \end{bmatrix} \end{array} \begin{array}{c} U_2 \\ V_2 \\ U_3 \\ V_3 \end{array}$$

$$[k^{(5)}] = \frac{EA}{4} \begin{array}{c} \begin{array}{cccc} U_4 & V_4 & U_3 & V_3 \end{array} \\ \begin{bmatrix} 0 & 0 & 0 & 0 \\ & 1 & 0 & -1 \\ & & 0 & 0 \\ \text{Sym} & & & 1 \end{bmatrix} \end{array} \begin{array}{c} U_4 \\ V_4 \\ U_3 \\ V_3 \end{array}$$

$$EA(0.399 U_1 - 0.179 U_2 - 0.089 V_2) = 0$$

$$EA(-0.179 U_1 + 0.586 U_2 + 0.089 V_2 - 0.089 V_3 - 0.089 V_4) = 0$$

$$EA(-0.089 U_1 + 0.089 U_2 + 0.1335 V_2 - 0.0445 V_3 - 0.089 V_4) = -20$$

$$EA(-0.089 U_2 - 0.0445 V_2 + 0.295 V_3 - 0.25 V_4) = -20$$

$$EA(-0.089 U_2 - 0.089 V_2 - 0.25 V_3 + 0.25 V_4) = 0$$

$$EA \begin{bmatrix} 0.399 & -0.179 & -0.089 & 0 & 0 \\ -0.179 & 0.586 & 0.089 & -0.089 & -0.089 \\ -0.089 & 0.089 & 0.1335 & -0.0445 & -0.089 \\ 0 & -0.089 & -0.0445 & 0.295 & -0.25 \\ 0 & -0.089 & -0.089 & -0.25 & 0.295 \end{bmatrix} \begin{bmatrix} U_1 \\ U_2 \\ V_2 \\ V_3 \\ V_4 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ -20 \\ -20 \\ 0 \end{bmatrix}$$

$U_1 = -1.13 \times 10^{-3}\ m = U_6$

$U_2 = 3.93 \times 10^{-4}\ m = U_5$

$V_2 = -4.61 \times 10^{-3}\ m = V_5$

$V_3 = -5.09 \times 10^{-3}\ m$

$V_4 = -5.13 \times 10^{-3}\ m$

$\sigma_1 = \frac{E}{L}\begin{bmatrix} -C & -S & C & S \end{bmatrix}\begin{bmatrix} u_1 \\ v_1 \\ u_2 \\ v_2 \end{bmatrix}$ $\begin{matrix} 0 \\ 0 \end{matrix} \Rightarrow$ $\frac{210\times10^9}{4.47}\left(-0.894(-1.13\times10^{-3}) + 0.894(3.93\times10^{-4}) + 0.447(-4.61\times10^{-3})\right)$

$\boxed{\sigma_1 = \sigma_4 = -31.36\ MPa}$ Compression

$\sigma_2 = \frac{E}{L}\begin{bmatrix} -1 & 0 & 1 & 0 \end{bmatrix}\begin{bmatrix} u_1 \\ v_1 \\ u_2 \\ v_2 \end{bmatrix}$ $\begin{matrix} 0 \\ 0 \end{matrix}$ $\frac{210\times10^9}{8}\left(-1 \times -1.13\times10^{-3}\right)$

$\sigma_8 = \boxed{\sigma_2 = 29.66\ MPa}$ Tension

$\sigma_3 = \frac{E}{L}\begin{bmatrix} +0.894 & .447 & -0.894 & .447 \end{bmatrix}\begin{bmatrix} u_4 \\ v_4 \\ u_2 \\ v_2 \end{bmatrix}$ 0 $\frac{210\times10^9}{4.47}\left(.447(-5.13\times10^{-3}) - 0.894(3.93\times10^{-4}) + .447(-4.61\times10^{-3})\right)$

$\boxed{\sigma_3 = \sigma_3 = -5.67\ MPa}$ Compression

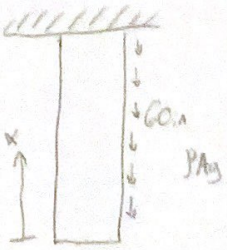
$\sigma_4 = \frac{E}{L}\begin{bmatrix} -.894 & -.447 & .894 & .447 \end{bmatrix}\begin{bmatrix} u_3 \\ v_3 \\ u_3 \\ v_3 \end{bmatrix}$ 0 $\frac{210\times10^9}{4.47}\left(-.894(3.93\times10^{-4}) - 0.447(-4.61\times10^{-3}) + 0.447(-5.09\times10^{-3})\right)$

$\boxed{\sigma_c = \sigma_4 = -32.08\ MPa}$ Compression

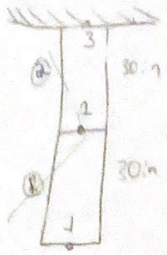
$\sigma_5 = \frac{E}{L}\begin{bmatrix} 0 & -1 & 0 & 1 \end{bmatrix}\begin{bmatrix} u_4 \\ v_4 \\ u_3 \\ v_3 \end{bmatrix}$ $\begin{matrix} 0 \\ 0 \end{matrix}$ $\frac{210\times10^9}{4}\left(-1(-5.13\times10^{-3}) + 1(-5.09\times10^{-3})\right)$

$\boxed{\sigma_5 = 2.1\ MPa}$ Tension

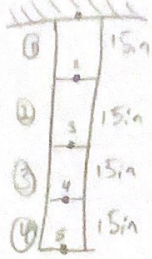
3.]



a.)



b.)



$A = 2\,in^2$ $\quad g = 2.683\ \frac{in}{s^2}$

$E = 30\times10^6\ psi$

$\rho_v = 0.283\ lb/in^3$

$\downarrow \rho A g$ (force/length)

$= 0.566\ \frac{lb}{in}$

$= -33.96\ lb$

$T(x) = -0.566$

$\frac{d\Pi^*}{d\{\delta\}^T} = 0 \Rightarrow \frac{\delta U}{\delta\{\delta\}^T} + \cancel{\frac{\delta\Omega_B}{\delta\{\delta\}^T}} + \cancel{\frac{\delta\Omega_S}{\delta\{\delta\}^T}} + \frac{\delta\Omega_B}{\delta\{\delta\}^T} = 0$ Internal Force is a function of x

Determine nodal displacements

a.)

$[k]\{\delta\} = \{f_S\} + \{f_B\} \Rightarrow [K]\{\delta\} = \{f_B\}$ $\quad 0 = \frac{\delta U}{\delta\{\delta\}^T} + \frac{\delta\Omega_B}{\delta\{\delta\}^T}$

$\Omega_B = -\int_0^L T(x)\,u(x)\,dx \rightarrow \{f_B\} = \int_0^L \begin{Bmatrix} N_1(x)\,T(x) \\ N_2(x)\,T(x) \\ N_3(x)\,T(x) \end{Bmatrix} dx$

$$\int_0^L \begin{Bmatrix} (1-\frac{x'}{L})(0.5663) \\ (\frac{x'}{L})(0.5663) \\ (1-\frac{x'}{L})(0.5663) \\ (\frac{x'}{L})(0.5663) \end{Bmatrix} dx$$

$F_1^{(1)} = -(0.5663)\left(x' - \frac{x'^2}{2L}\right)\Big|_0^{L^{(1)}} = -8.4945\ lb$

$F_2^{(1)} = -(0.5663)\left(\frac{x'^2}{2L}\right)\Big|_0^{L^{(1)}} = -8.4945\ lb$

$F_2^{(2)} = -8.4945\ lb$

$F_3^{(2)} = -8.4945\ lb$

$\frac{EA}{L^{(1)}} = 2\times10^6$

$[K]\{\delta_B\} = \{\delta\}$

$k = \frac{EA}{L}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$

$k^{(1)} = \begin{matrix} \\ u_1 \\ u_2 \end{matrix}\begin{matrix} \begin{matrix} u_1 & u_2 \end{matrix} \\ \begin{bmatrix} 2\times10^6 & -2\times10^6 \\ -2\times10^6 & 2\times10^6 \end{bmatrix} \end{matrix}$

$k^{(2)} = \begin{matrix} \\ u_2 \\ u_3 \end{matrix}\begin{matrix} \begin{matrix} u_2 & u_3 \end{matrix} \\ \begin{bmatrix} 2\times10^6 & -2\times10^6 \\ -2\times10^6 & 2\times10^6 \end{bmatrix} \end{matrix}$

$$\begin{matrix} \\ u_1 \\ u_2 \\ u_3 \end{matrix}\begin{matrix} \begin{matrix} u_1 & u_2 & u_3 \end{matrix} \\ \begin{bmatrix} 2\times10^6 & -2\times10^6 & 0 \\ -2\times10^6 & 4\times10^6 & -2\times10^6 \\ 0 & -2\times10^6 & 2\times10^6 \end{bmatrix} \end{matrix} \begin{bmatrix} u_1 \\ u_2 \\ u_3 = 0 \end{bmatrix} = \begin{bmatrix} -8.4945 \\ -16.989 \\ -8.4945 \end{bmatrix}$$

$u_1 = -1.6989\times10^{-5}\ in$

$u_2 = -1.6989\times10^{-5}\ in$

$u_3 = 0$

b.) $\{f_B\} = \int_0^L N(x)\, T(x)\, dx$

$$\int_0^L \begin{Bmatrix} \left(1 - \frac{x'}{L}\right)(0.566) \\ \left(\frac{x'}{L}\right)(0.566) \\ \left(1 - \frac{x'}{L}\right)(0.566) \\ \left(\frac{x'}{L}\right)(0.566) \\ \left(1 - \frac{x'}{L}\right)(0.566) \\ \left(\frac{x'}{L}\right)(0.566) \end{Bmatrix} \begin{matrix} N_1 T \\ N_2 T \\ N_3 T \\ N_4 T \\ N_5 T \end{matrix} dx' \Rightarrow \text{All equal values}$$

$\therefore$

$$\{f_B\} = \begin{bmatrix} -4.245 \\ -8.49 \\ -8.49 \\ -8.49 \\ -4.245 \end{bmatrix} = \begin{bmatrix} F_1 \\ F_2 \\ F_3 \\ F_4 \\ F_5 \end{bmatrix}$$

$$\begin{bmatrix} 2\times10^6 & -2\times10^6 & 0 & 0 & 0 \\ -2\times10^6 & 4\times10^6 & -2\times10^6 & 0 & 0 \\ 0 & -2\times10^6 & 4\times10^6 & -2\times10^6 & 0 \\ 0 & 0 & -2\times10^6 & 4\times10^6 & -2\times10^6 \\ 0 & 0 & 0 & -2\times10^6 & 2\times10^6 \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \\ u_5 \end{bmatrix} = \begin{bmatrix} -4.245 \\ -8.49 \\ -8.49 \\ -8.49 \\ -4.245 \end{bmatrix}$$

$u_5 = 0$

$u_1 = -1.6989 \times 10^{-5}$

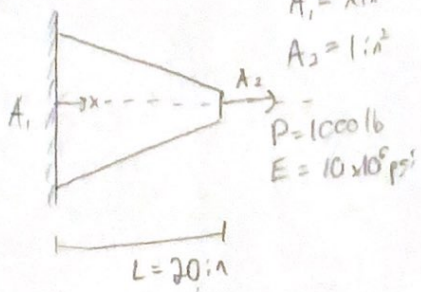
$u_2 = -1.593 \times 10^{-5}$

$u_3 = -1.274 \times 10^{-5}$

$u_4 = -7.432 \times 10^{-6}$

$u_5 = 0$

4.]



$A_1 = 2\ in^2$

$A_2 = 1\ in^2$

$P = 1000\ lb$

$E = 10 \times 10^6\ psi$

Point collocation method at $x = \frac{L}{3}, \frac{2L}{3}, L$

$A(\frac{L}{3}) = 1\frac{2}{3}$

$A(\frac{2L}{3}) = 1\frac{1}{3}$

$A(L) = 1$

$$u(x) = C_1 x + C_2 x^2 + C_3 x^3$$

$$R(C, x = \tfrac{L}{3}) = 0 = AE\left[C_1 + 2C_2(\tfrac{L}{3}) + 3C_3(\tfrac{L}{3})^2\right]$$

$$R(C, x = \tfrac{2L}{3}) = 0 = AE\left[C_1 + 2C_2(\tfrac{2L}{3}) + 3C_3(\tfrac{2L}{3})^2\right]$$

$$R(C, x = L) = 0 = AE\left[C_1 + 2C_2(L) + 3C_3(L)^2\right] - 1000$$

$$AE\left(C_1 \tfrac{L}{3} + C_2 \tfrac{L^2}{9} + C_3 \tfrac{L^3}{27}\right) = 0$$

Solve $u(\frac{L}{3})$, $u(\frac{2L}{3})$, $u(L)$

$C_1 = 5.5 \times 10^{-5}$

$C_2 = 1 \times 10^{-18}$

$C_3 = 3.75 \times 10^{-8}$

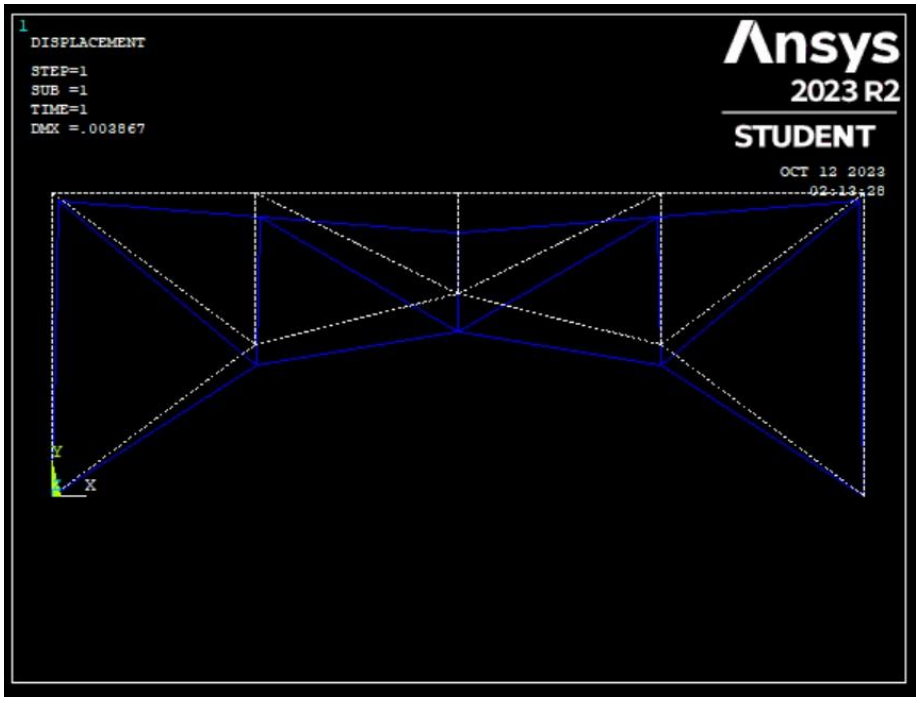
$$u(x) = (5.5 \times 10)x + (1 \times 10^{-18})x^2 + (3.75 \times 10^{-8})x^3$$

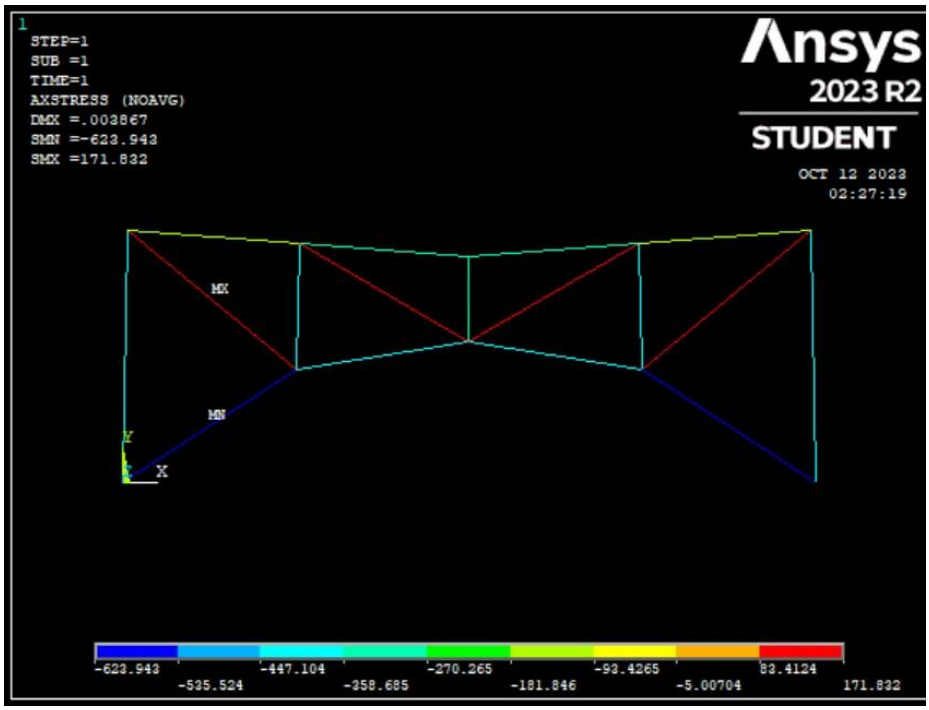
$$u(\tfrac{L}{3}) = 3.77 \times 10^{-4}$$

$$u(\tfrac{2L}{3}) = 8.22 \times 10^{-4}$$

$$u(L) = 1.4 \times 10^{-3}$$

Problem 5


1
DISPLACEMENT
STEP=1
SUB =1
TIME=1
DMX =.003867
Ansys
2023 R2
STUDENT
OCT 12 2023
02:13:28
Y
X


1
STEP=1
SUB =1
TIME=1
AXSTRESS (NOAVG)
DMX =.003867
SMN =-623.943
SMX =171.832
Ansys
2023 R2
STUDENT
OCT 12 2023
02:27:19
MX
MN
Y
X
-623.943
-535.524
-447.104
-358.685
-270.265
-181.846
-93.4265
-5.00704
83.4124
171.832

```
PRINT ELEMENT TABLE ITEMS PER ELEMENT

 ***** POST1 ELEMENT TABLE LISTING *****

   STAT      CURRENT
   ELEM      AXSTRESS
      1   -421.41
      2    171.83
      3   -623.94
      4   -387.04
      5   -137.47
      6   -274.93
      7   -318.31
      8    153.69
      9   -372.82
     10   -274.93
     11   -372.82
     12   -387.04
     13    153.69
     14    171.83
     15   -137.47
     16   -421.41
     17   -623.94

MINIMUM VALUES
ELEM            3
VALUE     -623.94

MAXIMUM VALUES
ELEM            2
VALUE      171.83


PRINT U     NODAL SOLUTION PER NODE

 ***** POST1 NODAL DEGREE OF FREEDOM LISTING *****

 LOAD STEP=     1  SUBSTEP=     1
  TIME=    1.0000       LOAD CASE=   0

 THE FOLLOWING DEGREE OF FREEDOM RESULTS ARE IN THE GLOBAL COORDINATE SYSTEM

   NODE        UX            UY            UZ            USUM
      1    0.0000        0.0000        0.0000        0.0000
      2   0.56882E-003-0.87188E-003   0.0000       0.10410E-002
      3   0.37921E-003-0.23589E-002   0.0000       0.23892E-002
      4   0.12418E-003-0.19585E-002   0.0000       0.19624E-002
      5  -0.24068E-018-0.36473E-002   0.0000       0.36473E-002
      6  -0.18191E-018-0.38668E-002   0.0000       0.38668E-002
      7  -0.12418E-003-0.19585E-002   0.0000       0.19624E-002
      8  -0.37921E-003-0.23589E-002   0.0000       0.23892E-002
      9  -0.56882E-003-0.87188E-003   0.0000       0.10410E-002
     10    0.0000        0.0000        0.0000        0.0000

MAXIMUM ABSOLUTE VALUES
NODE            2             6             0             6
VALUE    0.56882E-003-0.38668E-002   0.0000       0.38668E-002
```

```
/FILNAM,P1-6
/title, P1-6_Truss /prep7
et, 1, link180

! Material 1
mp, ex, 1, 3.e7
mp, prxy, 1, 0.28

r, 1, 3.141592
```

```
n, 1, 0.0, 0.0, 0.0
n, 2, 0.0, 60.0, 0.0
n, 3, 40.0, 60.0, 0.0
n, 4, 40.0, 30.0, 0.0
n, 5, 80.0, 60.0, 0.0
n, 6, 80.0, 40.0, 0.0
n, 7, 120.0, 60.0, 0.0
n, 8, 120.0, 30.0, 0.0
n, 9, 160.0, 60.0, 0.0
n, 10, 160.0, 0.0, 0.0

! Set properties before creating elements
mat, 1 real, 1
en, 1, 1, 2
en, 2, 2, 3

d, 1, all, 0.
d, 10, all, 0.

f, 2, fy, -1000.
f, 3, fy, -1000.
f, 5, fy, -1000.
f, 7, fy, -1000.
f, 9, fy, -1000.

finish
/solu
antype, static
solve
save
finish
```

Problem 6

```
PRINT U    NODAL SOLUTION PER NODE

 ***** POST1 NODAL DEGREE OF FREEDOM LISTING *****

 LOAD STEP=     1  SUBSTEP=     1
  TIME=    1.0000       LOAD CASE=   0

 THE FOLLOWING DEGREE OF FREEDOM RESULTS ARE IN THE GLOBAL COORDINATE SYSTEM

   NODE        UX            UY            UZ          |   USUM
      1 -0.22857E-002  0.0000        0.0000       0.22857E-002
      2  0.89383E-003-0.95535E-002  0.0000       0.95952E-002
      3   0.0000      -0.98954E-002  0.0000       0.98954E-002
      4   0.0000      -0.10276E-001  0.0000       0.10276E-001

MAXIMUM ABSOLUTE VALUES
NODE          1             4             0            4
VALUE  -0.22857E-002-0.10276E-001  0.0000       0.10276E-001
```

```
PRINT S    ELEMENT SOLUTION PER ELEMENT

***** POST1 ELEMENT NODAL STRESS LISTING *****

 LOAD STEP=     1  SUBSTEP=     1
  TIME=    1.0000       LOAD CASE=   0

 THE FOLLOWING X,Y,Z VALUES ARE IN GLOBAL COORDINATES

 ELEMENT=      10        LINK180
   NODE      SX            SY            SZ            SXY           SYZ           SXZ
      1 -0.67082E+008  0.0000        0.0000        0.0000        0.0000        0.0000
      2 -0.67082E+008  0.0000        0.0000        0.0000        0.0000        0.0000

 ELEMENT=      11        LINK180
   NODE      SX            SY            SZ            SXY           SYZ           SXZ
      1  0.60000E+008  0.0000        0.0000        0.0000        0.0000        0.0000
      4  0.60000E+008  0.0000        0.0000        0.0000        0.0000        0.0000

 ELEMENT=      12        LINK180
   NODE      SX            SY            SZ            SXY           SYZ           SXZ
      2 -0.22361E+008  0.0000        0.0000        0.0000        0.0000        0.0000
      4 -0.22361E+008  0.0000        0.0000        0.0000        0.0000        0.0000

 ELEMENT=      13        LINK180
   NODE      SX            SY            SZ            SXY           SYZ           SXZ
      2 -0.44721E+008  0.0000        0.0000        0.0000        0.0000        0.0000
      3 -0.44721E+008  0.0000        0.0000        0.0000        0.0000        0.0000

 ELEMENT=      14        LINK180
   NODE      SX            SY            SZ            SXY           SYZ           SXZ
      3  0.20000E+008  0.0000        0.0000        0.0000        0.0000        0.0000
      4  0.20000E+008  0.0000        0.0000        0.0000        0.0000        0.0000
```

Problem 7

```
PRINT ELEMENT TABLE ITEMS PER ELEMENT

 ***** POST1 ELEMENT TABLE LISTING *****

   STAT      CURRENT
   ELEM      AXSTRESS
      1    -67082040.
      2     49081504.
      3    -22360680.
      4    -44721360.
      5     20000000.
      6    -44721360.
      7    -22360680.
      8     49081504.
      9    -67082040.

MINIMUM VALUES
ELEM          1
VALUE  -0.67082E+008

MAXIMUM VALUES
ELEM          2
VALUE   0.49082E+008
```

```
 ***** POST1 NODAL DEGREE OF FREEDOM LISTING *****

 LOAD STEP=     1  SUBSTEP=     1
  TIME=    1.0000       LOAD CASE=   0

 THE FOLLOWING DEGREE OF FREEDOM RESULTS ARE IN THE GLOBAL COORDINATE SYSTEM

   NODE       UX            UY            UZ            USUM
      1   0.0000        0.0000        0.0000         0.0000
      2  0.25935E-002-0.83813E-002  0.0000       0.87734E-002
      3  0.15295E-002-0.83830E-002  0.0000       0.85214E-002
      4  0.18698E-002-0.87640E-002  0.0000       0.89612E-002
      5  0.80581E-003-0.77008E-002  0.0000       0.77429E-002
      6  0.37395E-002 0.13610E-002  0.0000       0.39795E-002

MAXIMUM ABSOLUTE VALUES
NODE          6             4             0             4
VALUE   0.37395E-002-0.87640E-002  0.0000       0.89612E-002
```