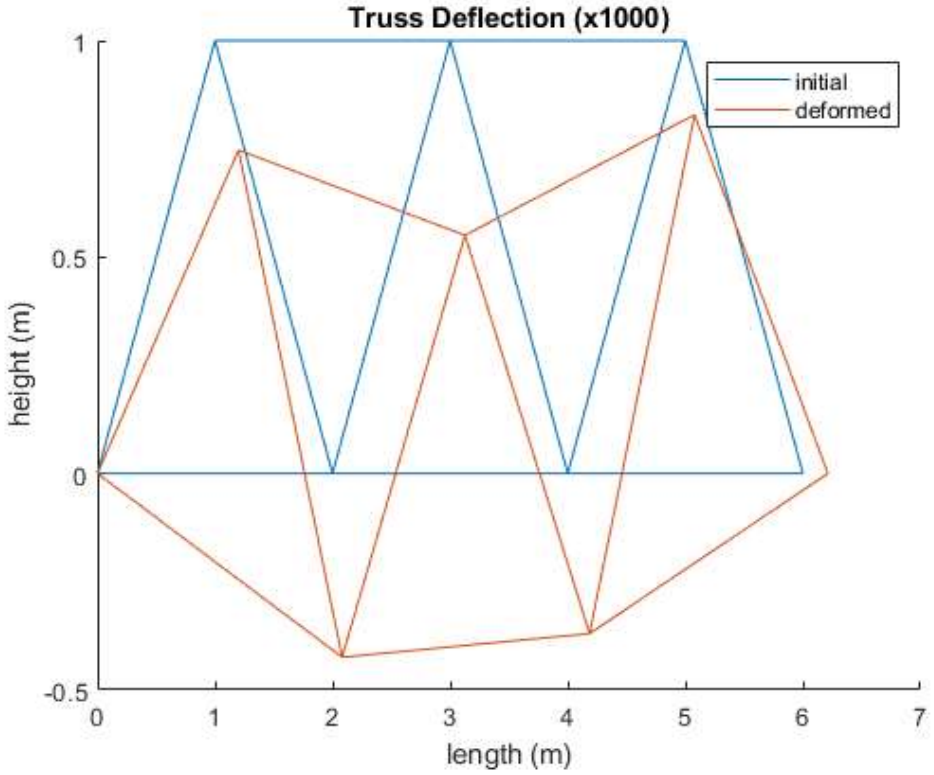
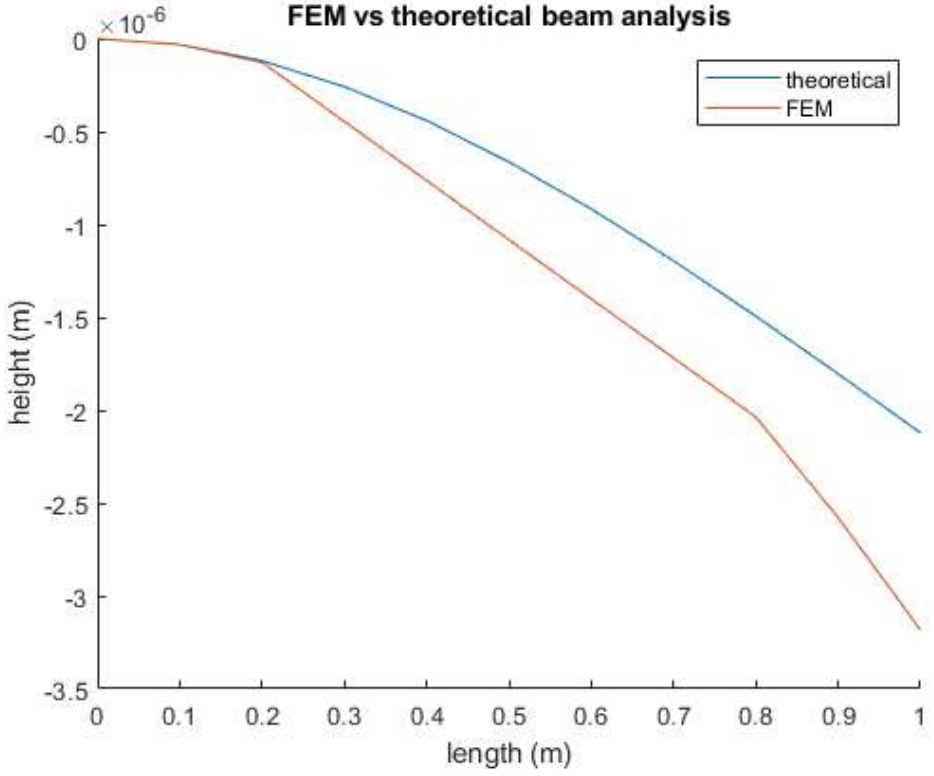
```
clear all;
close all;
clc;
format long;

name = 'Natalie Ratzlaff';
id = 'A17091327';
hw_num = 5;

A1 = pi()*0.025^2;
E = 200000000000;
La = 2;
Lb = sqrt(2);

p1a(:,:,1) = E*A1/La * [1 0 -1 0; 0 0 0 0; -1 0 1 0; 0 0 0 0];
p1a(:,:,2) = p1a(:,:,1);
p1a(:,:,3) = p1a(:,:,1);
p1a(:,:,4) = E*A1/Lb * [0.5 0.5 -0.5 -0.5; 0.5 0.5 -0.5 -0.5; -0.5 -0.5 0.5 0.5; -0.5 -0.5 0.5 0.5];
p1a(:,:,5) = E*A1/Lb * [0.5 -0.5 -0.5 0.5; -0.5 0.5 0.5 -0.5; -0.5 0.5 0.5 -0.5; 0.5 -0.5 -0.5 0.5];
p1a(:,:,6) = p1a(:,:,4);
p1a(:,:,7) = p1a(:,:,5);
p1a(:,:,8) = p1a(:,:,4);
p1a(:,:,9) = p1a(:,:,5);
p1a(:,:,10) = p1a(:,:,1);
p1a(:,:,11) = p1a(:,:,1);

K = zeros(14,14,11);
K(1:4,1:4,1) = p1a(:,:,1);
K(3:6,3:6,2) = p1a(:,:,2);
K(5:8,5:8,3) = p1a(:,:,3);
K([1:2,9:10],[1:2,9:10],4) = p1a(:,:,4);
K([3:4,9:10],[3:4,9:10],5) = p1a(:,:,5);
K([3:4,11:12],[3:4,11:12],6) = p1a(:,:,6);
K([5:6,11:12],[5:6,11:12],7) = p1a(:,:,7);
K([5:6,13:14],[5:6,13:14],8) = p1a(:,:,8);
K([7:8,13:14],[7:8,13:14],9) = p1a(:,:,9);
K(9:12,9:12,10) = p1a(:,:,10);
K(11:14,11:14,11) = p1a(:,:,11);

p1b = sum(K,3);

p1c = p1b;
p1c(:,8) = [];
p1c(8,:) = [];
p1c(:,1:2) = [];
p1c(1:2,:) = [];

F = [0;-10000;0;-10000;0;0;0;0;0;15000/sqrt(3);15000/2];
dis = inv(p1c)*F;

disp = zeros(14,1);
disp(3:7) = dis(1:5);
disp(9:14) = dis(6:11);
p1d = zeros(7,2);
p1d(:,1) = disp([1,3,5,7,9,11,13]);
p1d(:,2) = disp([2,4,6,8,10,12,14]);

force = p1b*disp;
p1e = zeros(7,2);
```

```
p1e(:,1) = force([1,3,5,7,9,11,13]);
p1e(:,2) = force([2,4,6,8,10,12,14]);

i = [0 0; 2 0; 4 0; 6 0; 1 1; 3 1; 5 1];
f = i + 1000*p1d;

figure(1);
hold on;
plot(i([5,1,2,3,4,7,3,6,2,5,6,7],1),i([5,1,2,3,4,7,3,6,2,5,6,7],2));
plot(f([5,1,2,3,4,7,3,6,2,5,6,7],1),f([5,1,2,3,4,7,3,6,2,5,6,7],2));
title('Truss Deflection (x1000)');
ylabel('height (m)');
xlabel('length (m)');
legend('initial','deformed')

p1f = 'See figure 1'

I2 = pi()*0.04^2/64;
L1 = 0.1;
L2 = 0.6;

p2a(:,:,1) = E*I2/L1^3*[12 6*L1 -12 6*L1; 6*L1 4*L1^2 -6*L1 2*L1^2; -12 -6*L1 12 -6*L1; 6*L1 2*L1^2 -6*L1 4*L1^2];
p2a(:,:,2) = p2a(:,:,1);
p2a(:,:,3) = E*I2/L2^3*[12 6*L2 -12 6*L2; 6*L2 4*L2^2 -6*L2 2*L2^2; -12 -6*L2 12 -6*L2; 6*L2 2*L2^2 -6*L2 4*L2^2];
p2a(:,:,4) = p2a(:,:,1);
p2a(:,:,5) = p2a(:,:,1);

k2 = zeros(12,12,5);
k2(1:4,1:4,1) = p2a(:,:,1);
k2(3:6,3:6,2) = p2a(:,:,2);
k2(5:8,5:8,3) = p2a(:,:,3);
k2(7:10,7:10,4) = p2a(:,:,4);
k2(9:12,9:12,5) = p2a(:,:,5);

p2b = sum(k2,3);

p2c = p2b;
p2c(1:2,:) = [];
p2c(:,1:2) = [];

f2 = [0;0;0;0;0;0;0;0;0;-100];

ans = inv(p2c)*f2;
dth = zeros(12,1);
dth(3:12) = ans;
p2d = zeros(6,2);
p2d(:,1) = dth([1,3,5,7,9,11]);
p2d(:,2) = dth([2,4,6,8,10,12]);

fm = p2b*dth;
p2e = zeros(6,2);
p2e(:,1) = fm([1,3,5,7,9 11]);
p2e(:,2) = fm([2,4,6,8,10,12]);

x = 0:0.1:1;
thr = -100.*x.^2./(6*E*I2).*(3-x);

figure(2);
hold on;
plot(x,thr);
plot([0,0.1,0.2,0.8,0.9,1.0],p2d(:,1));
```

```
title('FEM vs theoretical beam analysis');
xlabel('length (m)');
ylabel('height (m)');
legend('theoretical','FEM');

p2f = 'See figure 2'
```

```
p1f =

    'See figure 1'


p2f =

    'See figure 2'
```





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SOLIDWORKS

Truss *

Search Commands

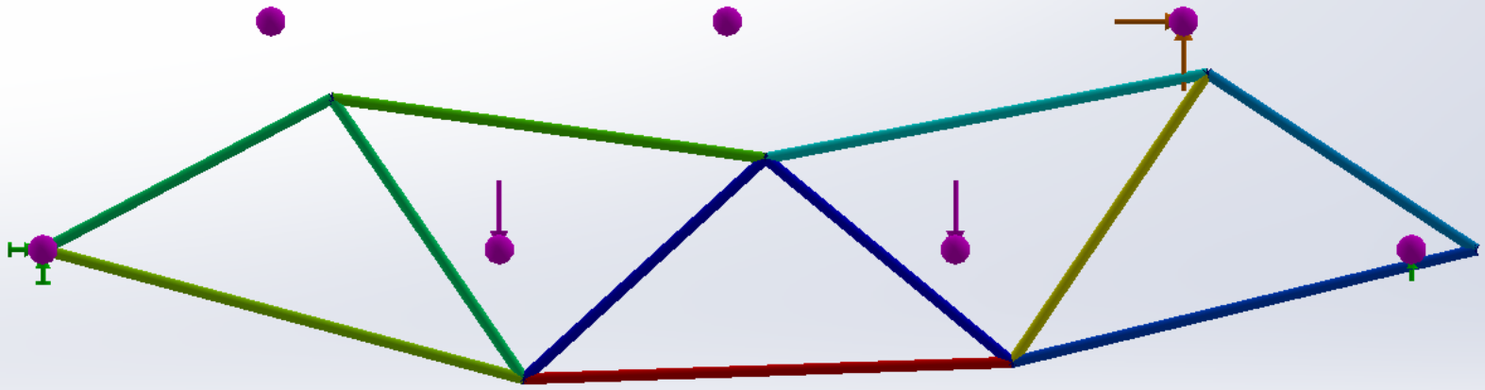
New Study | Apply Material | Fixtures Advisor | External Loads ... | Connections Advisor | Shell Manager | Diagnostic Tools | Run This... | Results Advisor | Deformed Result | Compare Results | Design Insight | Plot Tools | Report | Include Image for Report

Features | Sketch | Weldments | Markup | Evaluate | MBD Dimensions | SOLIDWORKS Add-Ins | Simulation | MBD | SOLIDWORKS CAM | SOLIDWORKS CAM TBM | Analysis Preparation

Top Plane
Right Plane
Origin
Weldment

Static 1* (-Default<As Machi
Part1
Joint group
Connections
Fixtures
Fixed-3
Reference Geometry
Reference Geometry
External Loads
Force-1 (:Per item: -
Force-2 (:Per item: v
Mesh
Mesh Quality Plot
Quality1 (-Mesh
Result Options
Results
Stress1 (-STRMAX

Model name: Truss
Study name: Static 1(-Default<As Machined>-)
Plot type: Upper bound axial and bending Stress1
Deformation scale: 1,334.65



Upper bound axial and bending (N/
1.048e+07
9.627e+06
8.773e+06
7.919e+06
7.065e+06
6.211e+06
5.357e+06
4.502e+06
3.648e+06
2.794e+06
1.940e+06
Yield strength: 1.723e+08

*Front

Model | 3D Views | Motion Study 1 | Static 1

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Editing Part | MMGS

10:17 PM
5/20/2024

SOLIDWORKS File Edit View Insert Tools Simulation Window — Truss * — Search Commands

New Study | Apply Material | Fixtures Advisor | External Loads ... | Connections Advisor | Shell Manager | Diagnostic Tools | Run This... | Results Advisor | Deformed Result | Compare Results | Design Insight | Plot Tools | Report | Include Image for Report

Features | Sketch | Weldments | Markup | Evaluate | MBD Dimensions | SOLIDWORKS Add-Ins | **Simulation** | MBD | SOLIDWORKS CAM | SOLIDWORKS CAM TBM | Analysis Preparation

Probe Result

Options

- (•) At location
- ( ) From sensors
- ( ) At Element number

Results

Element	Value (N/m^2)	X (mm)	Y (mm)	Z (mm)
11	8.131e+06	-13.49595451	0.00000000	-0.00000000
8	7.442e+06	1,001.27673340	1,000.00000000	0.00000000
4	5.263e+06	2,000.00000000	0.00000000	-0.00000000
10	1.940e+06	3,000.00000000	1,000.00000000	-0.00000000
3	3.741e+06	5,989.33105469	10.66874123	-0.00000000
7	9.142e+06	4,000.00000000	0.00000000	-0.00000000
5	4.699e+06	4,993.52587891	1,000.00000000	-0.00000000

Summary

	Value	Unit
Sum	4.036e+07	N/m^2
Avg	5.765e+06	N/m^2
Max	9.142e+06	N/m^2
Min	1.940e+06	N/m^2
RMS	6.241e+06	N/m^2

Truss (Default...

Model name: Truss
Study name: Static 1(-Default<As M...ned>-)
Plot type: Upper bound axial and b...g Stress1

Element:	10
X, Y, Z Location:	3e+03, 1e+03, -9.88e-12 mm
Value:	1.940e+06 N/m^2

Element:	5
X, Y, Z Location:	4.99e+03, 1e+03, -3.19e-14 mm
Value:	4.699e+06 N/m^2

Element:	8
X, Y, Z Location:	1e+03, 1e+03, 9.86e-12 mm
Value:	7.442e+06 N/m^2

Element:	11
X, Y, Z Location:	-13.5, 1.78e-12, -3.45e-15 mm
Value:	8.131e+06 N/m^2

Element:	3
X, Y, Z Location:	5.99e+03, 10.7, -9.77e-12 mm
Value:	3.741e+06 N/m^2

Element:	4
X, Y, Z Location:	2e+03, 2.7e-12, -3.45e-15 mm
Value:	5.263e+06 N/m^2

Element:	7
X, Y, Z Location:	4e+03, 0, -3.45e-15 mm
Value:	9.142e+06 N/m^2

Upper bound axial and bend
1.048e+07
9.627e+06
8.773e+06
7.919e+06
7.065e+06
6.211e+06
5.357e+06
4.502e+06
3.648e+06
2.794e+06
1.940e+06
Yield strength: 1.723e+08

*Front

Model | 3D Views | Motion Study 1 | Static 1

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10:16 PM 5/20/2024

Problem 4: (10 points)

Consider the truss structure and
increase by a factor of two in magn
mm) of the circular cross section su
node 2 does **not** increase (with resp

$$F = K \cdot x \rightarrow K = \frac{EA}{L}$$

$\downarrow$ $\quad$ $\downarrow$

$\times 2$ $\quad$ constant

$\therefore \rightarrow A \times 2$

$A = \pi r^2$

$r_1 = 2.5\,cm$

$D_2 = 7\,cm$

$2A = 2\pi r_1^2 = \pi r_2^2 \rightarrow r_2 = r_1\sqrt{2} \therefore r_2 = 3.5\,cm$