ME 635: Modeling and Simulation   
Homework 5

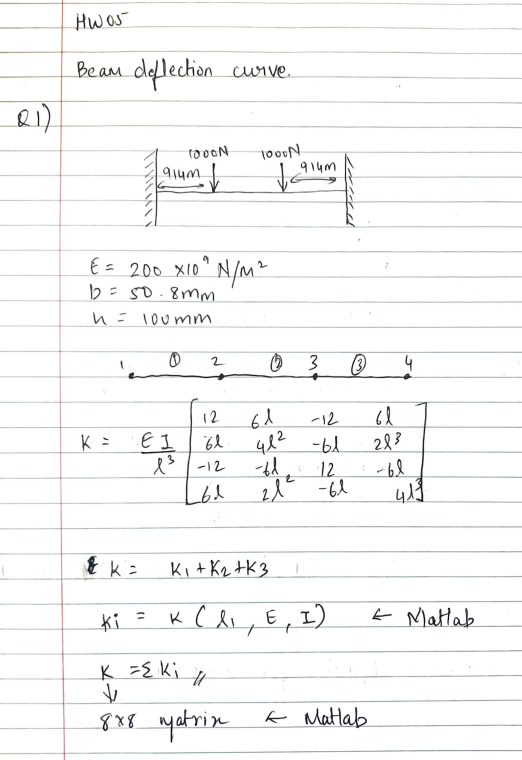
Finite Element method

10/11/2022

I pledge my honor that I have abided by the Stevens Honor System

Submitted by,

Viral Panchal



# **Q1 MATLAB program:**

%ME635 - HW05 - Q1  
%Viral Panchal  
  
close all  
clear all  
clc  
  
l = 3048\*(10^-3);  
x = 0:0.001:l;  
E = 200\*(10^9);  
I = (50.8\*(10^-3))\*((100\*(10^-3))^3)/12;  
l1 = 914\*(10^-3);  
l3 = 914\*(10^-3);  
l2 = l-l1-l3;  
  
p2 = -1000;  
m2 = 0;  
p3 = -1000;  
m3 = 0;  
  
k1 = global\_stiff(l1,E,I);  
fprintf('k1 = \n');  
disp(k1)  
k2 = global\_stiff(l2,E,I);  
fprintf('k2 = \n');  
disp(k2)  
k3 = global\_stiff(l3,E,I);  
fprintf('k3 = \n');  
disp(k3)  
  
fprintf('K = k1 + k2 + k3 \n\n');  
k\_final = zeros(8);  
k\_final(1:4,1:4) = k1;  
k\_final(3:6,3:6) = k\_final(3:6,3:6) + k2;  
k\_final(5:8,5:8) = k\_final(5:8,5:8) + k3;  
fprintf('K =\n');  
disp(k\_final)  
  
% Calculation forces and displacements  
force\_vec = [p2 m2 p3 m3]';  
displacement\_vec = [0; 0; k\_final(3:6,3:6)\force\_vec; 0;0];  
force\_vec = k\_final\*displacement\_vec;  
fprintf('Force = \n');  
disp(force\_vec)  
  
% Caculating the points on the equation  
eq\_1 = displacement(displacement\_vec(1),displacement\_vec(2),displacement\_vec(3),displacement\_vec(4),l1,0:0.01:1);  
eq\_2 = displacement(displacement\_vec(3),displacement\_vec(4),displacement\_vec(5),displacement\_vec(6),l2,0:0.01:1);  
eq\_3 = displacement(displacement\_vec(5),displacement\_vec(6),displacement\_vec(7),displacement\_vec(8),l3,0:0.01:1);  
plot(linspace(0,l1,101),eq\_1)  
hold on  
plot(linspace(l1,l1+l2,101),eq\_2)  
hold on  
plot(linspace(l1+l2,l1+l2+l3,101),eq\_3)  
legend('Eq\_1','Eq\_2','Eq\_3')  
grid on

## **Global\_stiff – function**

function K = global\_stiff(l,E,I)

K = ((E\*I)/(l^3))\* [12 6\*l -12 6\*l

6\*l 4\*l^2 -6\*l 2\*l^2

-12 -6\*l 12 -6\*l

6\*l 2\*l^2 -6\*l 4\*l^2];

end

## **Displacement – function**

function V = displacement(V1,tet1,V2,tet2,Lin,zet)

V = (1-3\*zet.\*zet+2\*zet.\*zet.\*zet)\*V1 + Lin\*(zet-2\*zet.\*zet+zet.\*zet.\*zet)\*tet1+(3\*zet.\*zet-2\*zet.\*zet.\*zet)\*V2+Lin\*(zet.\*zet.\*zet-zet.\*zet)\*tet2;

end

## **Matlab Output:**

k1 =   
 1.0e+07 \*  
  
 1.3306 0.6081 -1.3306 0.6081  
 0.6081 0.3705 -0.6081 0.1853  
 -1.3306 -0.6081 1.3306 -0.6081  
 0.6081 0.1853 -0.6081 0.3705  
  
k2 =   
 1.0e+06 \*  
  
 5.5952 3.4131 -5.5952 3.4131  
 3.4131 2.7760 -3.4131 1.3880  
 -5.5952 -3.4131 5.5952 -3.4131  
 3.4131 1.3880 -3.4131 2.7760  
  
k3 =   
 1.0e+07 \*  
  
 1.3306 0.6081 -1.3306 0.6081  
 0.6081 0.3705 -0.6081 0.1853  
 -1.3306 -0.6081 1.3306 -0.6081  
 0.6081 0.1853 -0.6081 0.3705  
  
K = k1 + k2 + k3   
  
K =  
 1.0e+07 \*  
  
 Columns 1 through 7  
  
 1.3306 0.6081 -1.3306 0.6081 0 0 0  
 0.6081 0.3705 -0.6081 0.1853 0 0 0  
 -1.3306 -0.6081 1.8901 -0.2668 -0.5595 0.3413 0  
 0.6081 0.1853 -0.2668 0.6481 -0.3413 0.1388 0  
 0 0 -0.5595 -0.3413 1.8901 0.2668 -1.3306  
 0 0 0.3413 0.1388 0.2668 0.6481 -0.6081  
 0 0 0 0 -1.3306 -0.6081 1.3306  
 0 0 0 0 0.6081 0.1853 -0.6081  
  
 Column 8  
  
 0  
 0  
 0  
 0  
 0.6081  
 0.1853  
 -0.6081  
 0.3705  
  
Force =   
 1.0e+03 \*  
  
 1.0000  
 0.6399  
 -1.0000  
 0.0000  
 -1.0000  
 0  
 1.0000

-0.6399

Chart, line chart

Description automatically generated

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**Letter

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# **Q2 MATLAB Program:**

% ME635 - HW05 - Q2  
% ViralPanchal  
  
close all  
clear all  
clc  
  
l = 3048\*(10^-3);  
x = 0:0.001:l;  
E = 200\*(10^9);  
I = (50.8\*(10^-3))\*((100\*(10^-3))^3)/12;  
l1 = 914\*(10^-3);  
l3 = 914\*(10^-3);  
l2 = l - l1 - l3;  
  
q = -1640;  
p2 = q\*l2/2;  
m2 = q\*l2^2/12;  
p3 = q\*l2/2;  
m3 = -q\*l2^2/12;  
  
k1 = global\_stiff(l1,E,I);  
fprintf('k1 = \n');  
disp(k1)  
k2 = global\_stiff(l2,E,I);  
fprintf('k2 = \n');  
disp(k2)  
k3 = global\_stiff(l3,E,I);  
fprintf('k3 = \n');  
disp(k3)  
  
fprintf('K = k1 + k2 + k3 \n\n');  
k\_final = zeros(8);  
k\_final(1:4,1:4) = k1;  
k\_final(3:6,3:6) = k\_final(3:6,3:6) + k2;  
k\_final(5:8,5:8) = k\_final(5:8,5:8) + k3  
  
% Calculation forces and displacements  
force\_vec = [p2 m2 p3 m3]';  
displacement\_vec = [0; 0; k\_final(3:6,3:6)\force\_vec; 0;0];  
force\_vec = k\_final\*displacement\_vec;  
fprintf('Force = \n');  
disp(force\_vec)  
  
% Caculating the points on the equation  
eq\_1 = displacement(displacement\_vec(1),displacement\_vec(2),displacement\_vec(3),displacement\_vec(4),l1,0:0.01:1);  
eq\_2 = displacement(displacement\_vec(3),displacement\_vec(4),displacement\_vec(5),displacement\_vec(6),l2,0:0.01:1);  
eq\_3 = displacement(displacement\_vec(5),displacement\_vec(6),displacement\_vec(7),displacement\_vec(8),l3,0:0.01:1);  
plot(linspace(0,l1,101),eq\_1)  
hold on  
plot(linspace(l1,l1+l2,101),eq\_2)  
hold on  
plot(linspace(l1+l2,l1+l2+l3,101),eq\_3)  
legend('Eq\_1','Eq\_2','Eq\_3')  
grid on  
  
% Slope  
slope\_eq = zeros();  
for r = 1:(length(eq\_1)-1)  
 slope\_eq(r,1) = ((eq\_1(1,r+1)-eq\_1(1,r))/l1)\*100;  
 slope\_eq(r,2) = ((eq\_2(1,r+1)-eq\_2(1,r))/l2)\*100;  
 slope\_eq(r,3) = ((eq\_3(1,r+1)-eq\_3(1,r))/l3)\*100;  
end  
  
figure  
plot(linspace(0,l1,100),slope\_eq(:,1))  
hold on  
plot(linspace(l1,l1+l2,100),slope\_eq(:,2))  
hold on  
plot(linspace(l1+l2,l1+l2+l3,100),slope\_eq(:,3))  
legend('eq\_1','eq\_2','eq\_3')  
grid on  
title('Slope plot');

## **Global\_stiff – function**

function K = global\_stiff(l,E,I)

K = ((E\*I)/(l^3))\* [12 6\*l -12 6\*l

6\*l 4\*l^2 -6\*l 2\*l^2

-12 -6\*l 12 -6\*l

6\*l 2\*l^2 -6\*l 4\*l^2];

end

## **Displacement – function**

function V = displacement(V1,tet1,V2,tet2,Lin,zet)

V = (1-3\*zet.\*zet+2\*zet.\*zet.\*zet)\*V1 + Lin\*(zet-2\*zet.\*zet+zet.\*zet.\*zet)\*tet1+(3\*zet.\*zet-2\*zet.\*zet.\*zet)\*V2+Lin\*(zet.\*zet.\*zet-zet.\*zet)\*tet2;

end

## **Matlab Output:**

k1 =   
 1.0e+07 \*  
  
 1.3306 0.6081 -1.3306 0.6081  
 0.6081 0.3705 -0.6081 0.1853  
 -1.3306 -0.6081 1.3306 -0.6081  
 0.6081 0.1853 -0.6081 0.3705  
  
k2 =   
 1.0e+06 \*  
  
 5.5952 3.4131 -5.5952 3.4131  
 3.4131 2.7760 -3.4131 1.3880  
 -5.5952 -3.4131 5.5952 -3.4131  
 3.4131 1.3880 -3.4131 2.7760  
  
k3 =   
 1.0e+07 \*  
  
 1.3306 0.6081 -1.3306 0.6081  
 0.6081 0.3705 -0.6081 0.1853  
 -1.3306 -0.6081 1.3306 -0.6081  
 0.6081 0.1853 -0.6081 0.3705  
  
K = k1 + k2 + k3   
  
  
k\_final =  
  
 1.0e+07 \*  
  
 Columns 1 through 7  
  
 1.3306 0.6081 -1.3306 0.6081 0 0 0  
 0.6081 0.3705 -0.6081 0.1853 0 0 0  
 -1.3306 -0.6081 1.8901 -0.2668 -0.5595 0.3413 0  
 0.6081 0.1853 -0.2668 0.6481 -0.3413 0.1388 0  
 0 0 -0.5595 -0.3413 1.8901 0.2668 -1.3306  
 0 0 0.3413 0.1388 0.2668 0.6481 -0.6081  
 0 0 0 0 -1.3306 -0.6081 1.3306  
 0 0 0 0 0.6081 0.1853 -0.6081  
  
 Column 8  
  
 0  
 0  
 0  
 0  
 0.6081  
 0.1853  
 -0.6081  
 0.3705  
  
Force =   
 1.0e+03 \*  
  
 1.0004  
 0.7216  
 -1.0004  
 -0.2034  
 -1.0004  
 0.2034  
 1.0004  
 -0.7216

Chart, line chart

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