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% Code for AE-331 Matlab Assignment to find displacement field %
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%% Inputs and initialization

prompt = {'Length of Beam (m):','t (mm):','f (N/m):','qy (N/M):','qz (N/M):','N:'};
dlgtitle = 'Inputs';
dims = [1 35];
definput = {'2', '2', '100', '1000', '100', '4'};
input = str2double(inputdlg(prompt, dlgtitle,dims,definput));

syms x y z;
L = input(1);
t = input(2);
a = 10*t;
f = input(3);
qy = input(4);
qz = input(5);
n = input(6);

E = 70;   %Young's modulus in GPa (here: Aluminium)

%% COM and Inertia calculations

%Areas (mm^2)
A = 2*a*t+t^2;
A_1 = t*(a+t);
A_2 = a*t;

%Centroids
y1 = a+(t/2);
y2 = a/2;
z1 = (a+t)/2;
z2 = y1;
y_op = (y1*A_1 + A_2*y2)/A;
z_op = (z1*A_1 + A_2*z2)/A;

%Moment of Inertia
Izz = t^3*(a+t)/12 + ((a+(t/2)-z_op)^2)*(a+t)*t + (a^3)*(t/12) + ((a/2) - z_op)^2*a*t;
Iyy = (t/12)*(a+t)^3 +((a+t)/2 - y_op)^2*(a+t)*t + (a/12)*t^3 + a*t*(a+(t/2)- y_op)^2;
Iyz = -(A_1*(a+(t/2)- y_op)*((a+t)/2- z_op) + A_2*(a/2-y_op)*(a+t/2-z_op));

ymax = 15.76*(10^-3);
zmax = 6.24*(10^-3);

%% Custom function definitions

fun = @(s,a,b) a.*b.*s.^(a+b-2);
fun1 = @(s1,a1) (s1.^a1);
fun2 = @(s2,a2,b2) a2.*(a2-1).*b2.*(b2-1).*(s2.^(a2+b2-4));
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%% Stress and F matrix declarations
K = zeros(n,n);
K1 = zeros(2*n,2*n);
F1 = zeros(n,1);
Fnew = zeros(2*n,1);

%% Evaluating U
for i=1:(n)
   for j=1:n
      K(i,j) = E.*A.*integral(@(x)fun(x,i-1,j-1),0,L);
   end
   F1(i,1) = f.*integral(@(x)fun1(x,i-1),0,L);
end
P = K(2:n,2:n)*1000;
F2 = F1(2:n,1);
a = P\F2;
u = 0;
v = 0;
w = 0;
for k=2:n
   u = u+a(k-1,1).*(x.^(k-1));
end

%% Evaluating V and W
for l=1:n
   for m=1:n
     K1(2*l-1,2*m-1) = E.*Izz.*integral(@(x)fun2(x,l-1,m-1),0,L);
     K1(2*l-1,2*m) = E.*Iyz.*integral(@(x)fun2(x,l-1,m-1),0,L);
     K1(2*l,2*m-1) = E.*Iyz.*integral(@(x)fun2(x,l-1,m-1),0,L);
     K1(2*l,2*m) = E.*Iyy.*integral(@(x)fun2(x,l-1,m-1),0,L);

   end
   Fnew(2*l-1,1) = qy.*integral(@(x)fun1(x,l-1),0,L);
   Fnew(2*l,1) = qz.*integral(@(x)fun1(x,l-1),0,L);
end
K2 = K1(5:2*n,5:2*n)./1000;
F2 = Fnew(5:2*n,1);
d = K2\F2;
for c=5:2*n
   if mod(c,2)~=0  %Odd Even Check
      v = v + d(c-4,1).*(x.^(((c+1)./2)-1));
   else
      w = w+d(c-4,1).*(x.^((c./2)-1));
   end
end
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%% Plotting the results

xinterval = [0 2];

subplot(3,1,1);
fplot(u,xinterval);
title('u vs x');

subplot(3,1,2);
fplot(v,xinterval);
title('v vs x');

subplot(3,1,3);
fplot(w,xinterval);
title('w vs x');

%% Evaluating Stresses

dux = diff(u,x);
dvx = diff(v,x);
dvxx = diff(dvx,x);
dwx = diff(w,x);
dwxx = diff(dwx,x);
sigmaxx = vpa(E.*(dux -y.*dvxx-z.*dwxx).*(10.^6));
sigmaxxmax = sigmaxx;
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