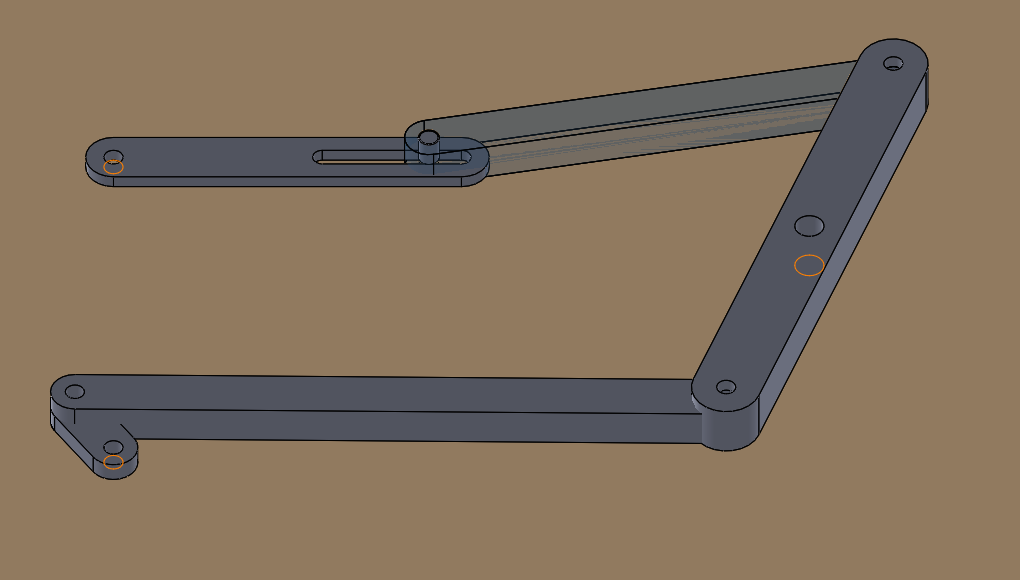
Prof. Knezevic

ME 643

4/17/19

Deliverable 2



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# Beam Equations

## Maximum and Minimum Axial Stress:

## Maximum and Minimum Bending Stress:

## Maximum and Minimum Combined Stress:

## Mean & Alternating Stress:

## Buckling

## Deflection

## Factor of Safety’s

# Pin Equations

## Pin Shear Stress

## Pin Bearing Stress

## Pin Tear-Out Stress

## Factor of Safety’s

# Beam Dimensions

Table 1 - Beam Dimensions

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Link | Length (in) | Base (in) | Height (in) | Schematic Drawing |
| OA | 0.5 | 0.35 | 0.15 | h |
| AB | 4.68 | 0.35 | 0.3 | h  b  b |
| BD | 3.5 | 0.5 | 0.4 | h |
| DE | 3.4 | 0.35 | 0.3 | h  b  b |

# Beam Calculations and Values

Table 2 - Beam Stresses and Factor of Safety's

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Member OA** | **Member AB** | **Member BD** | **Member DE** |
| **Maximum Stress (psi)** | 434.3 | 14.2 | 76.9 | 14.3 |
| **Minimum Stress (psi)** | 418.9 | 5.0 | 20.6 | 5.1 |
| **Mean Stress (psi)** | 426.6 | 9.6 | 48.7 | 9.7 |
| **Alternating Stress (psi)** | 7.7 | 4.6 | 28.2 | 4.6 |
| **Tearout Stress (psi)** | 6.6 | 12.3 | 1.6 | 12.4 |
|  | 6.5 | 98.7 | 17.0 | 98.4 |
|  | 85.6 | 144.4 | 23.4 | 144.4 |
|  | 6.0 | 495.3 | 121.7 | 486.1 |
|  | 5.8 | 176.2 | 32.5 | 175.0 |
|  | 117.3 | 5.7 | 274.5 | 10.8 |
|  | 3.5 | Infinite | 2.8 | Infinite |
|  | 270.6 | 145.3 | 1283.0 | 144.3 |
| **Failure Mode** | **Deflection** | **Buckling** | **Deflection** | **Buckling** |

# Pin Calculations and Values

Table 3 - Pin Dimensions, Forces, and Factor of Safety's

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Pin** | **A** | **B** | **C** | **D** | **E** |
| **Diameter (in)** | 0.1 | 0.1 | 0.2 | 0.1 | 0.1 |
| **Length (in)** | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| **Max Force (lb)** | 1.5 | 1.5 | 3.0 | 1.5 | 1.5 |
| **Shear Stress (psi)** | 10.8 | 10.8 | 9.3 | 10.9 | 10.9 |
| **Bending Stress (psi)** | 69.9 | 69.9 | 91.5 | 70.4 | 70.4 |
|  | 231.1 | 231.1 | 269.3 | 229.6 | 229.6 |
|  | 35.7 | 35.7 | 27.3 | 35.5 | 35.5 |
| **Failure Mode** | **Bearing** | **Bearing** | **Bearing** | **Bearing** | **Bearing** |

# Solidworks Drawings of Members

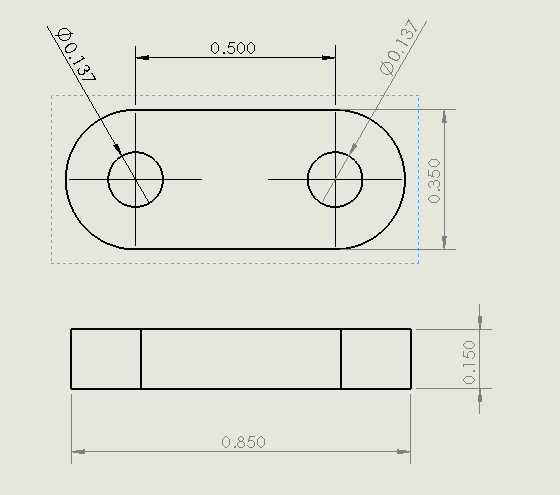


Figure 1 - Drawing of Member OA

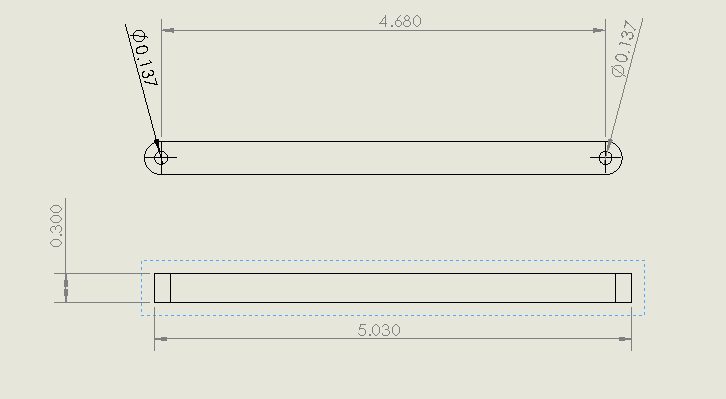


Figure 2 - Drawing of Member AB

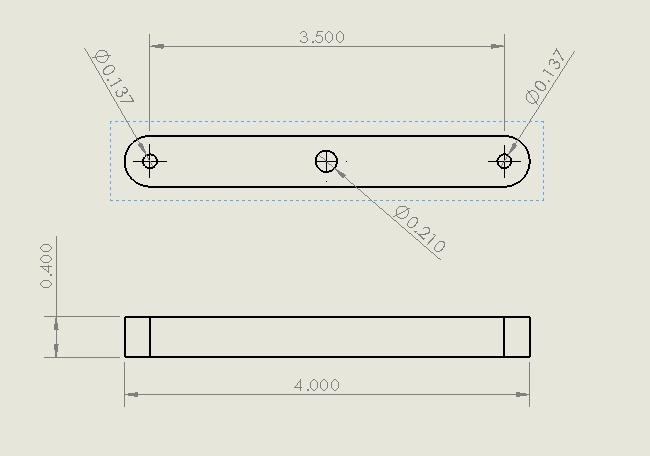


Figure 3 - Drawing of Member BD

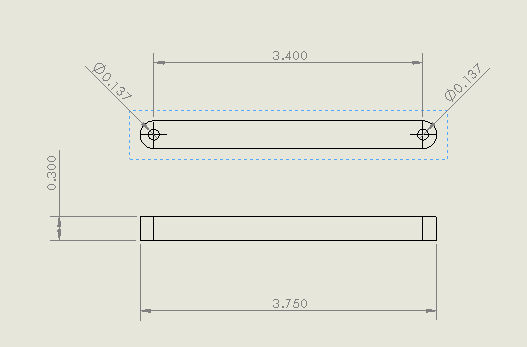


Figure 4 - Drawing of Member DE

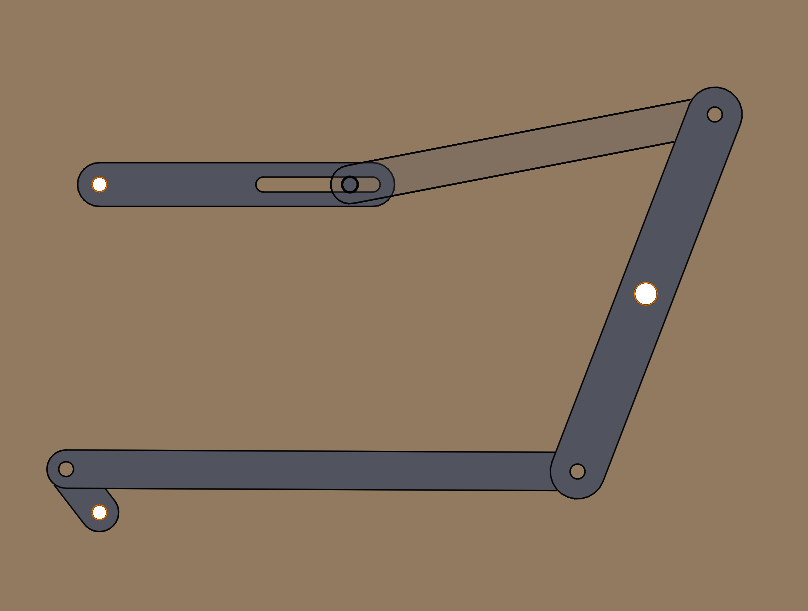


Figure 5 - 2D Figure of Full Assembly

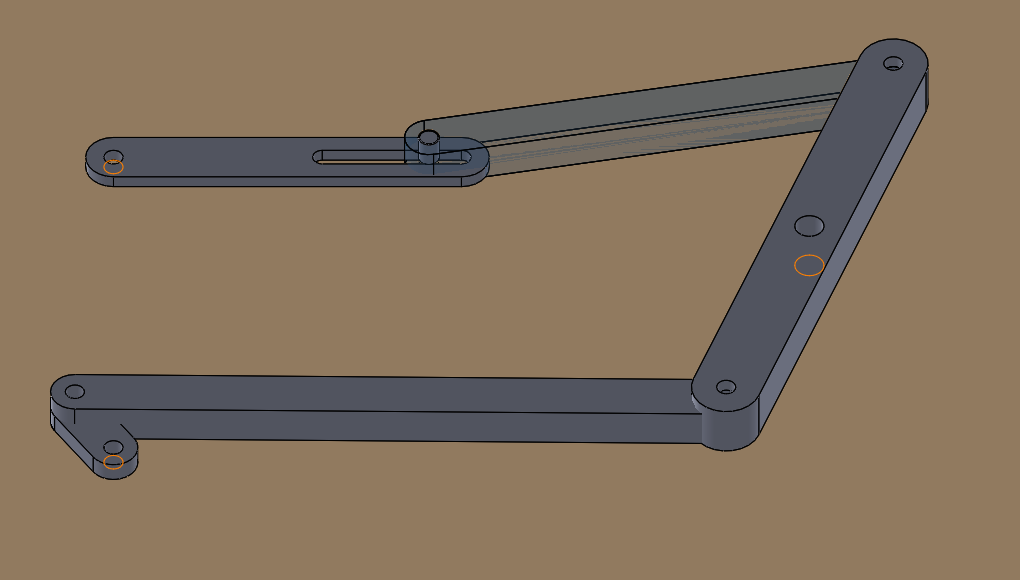


Figure 6 - 3D Figure of Full Assembly

# Appendix

## MATLAB Code

clear all; close all; clc

%Plastic Properties Given

Mod\_El=230000; %Modulus of Elasticity E = 230000psi

Sig\_y=2500; %Yeild Strength Sig\_y = 2500psi

Sig\_uts=3000; %Ultamate Tensile Strength Sig\_uts = 3000psi

Density=0.0376; %Density = 0.0376lb/in^3

%Extra Definitions

w=50; %Omega = 50rpm

theta=(0:1:360).\*(pi/180); %Singular Rotation

k=1; %lbf/in

%Lengths Determined

r\_AB = 4.68;

r\_BD = 3.5;

r\_DE = 3.4;

%Lengths Defined

r\_OA = 0.5;

r\_EF = 2.5;

%Geometry of Each Segment

%Base = b

%Height = h

%Base

dimb = .35;

dimh = .30;

b\_AB=dimb;

b\_DE=dimb;

b\_EF=dimb;

%Height

h\_AB=dimh;

h\_EF=dimh;

h\_DE=dimh;

% member BD 3

dim2b = .5;

dim2h = .4;

h\_BD=dim2h;

b\_BD=dim2b;

%Member OA

dim3b = .35;

dim3h = .15;

b\_OA=dim3b;

h\_OA=dim3h;

%Dimentions [In Inches]

Width=dimh/2;

Width2=dim2h/2;

Width3=dim3h/2;

Thickness=0.125;

Area=[b\_OA\*h\_OA,b\_AB\*h\_AB,b\_BD\*h\_BD,b\_EF\*h\_EF];

%Y values for Bending Calculations

y\_OA=h\_OA/2;

y\_AB=h\_AB/2;

y\_BD=h\_BD/2;

y\_DE=h\_DE/2;

%Inertia Calculations

I\_OA=(b\_OA\*(h\_OA^3))/12;

I\_AB=(b\_AB\*(h\_AB^3))/12;

I\_BD=(b\_BD\*(h\_BD^3))/12;

I\_DE=(b\_DE\*(h\_DE^3))/12;

%Inertia Matrix

I=[I\_OA,I\_AB,I\_BD,I\_DE];

%Moment Table from Deliverable 1 Solution

%Values in lb\*in

Mmax\_OA=0.56;

Mmin\_AB=0.00;

Mmax\_BD=2.67;

Mmin\_DE=0.00;

Mmin\_OA=0.54;

Mmax\_AB=0.00;

Mmin\_BD=0.72;

Mmax\_DE=0.00;

Mmin\_Bending=[Mmin\_OA,Mmin\_AB,Mmin\_BD,Mmin\_DE];

Mmax\_Bending=[Mmax\_OA,Mmax\_AB,Mmax\_BD,Mmax\_DE];

Min\_Bending\_Stress=zeros(1,4);

Max\_Bending\_Stress=zeros(1,4);

for i=1:4

if i == 3

Min\_Bending\_Stress(i)=(Mmin\_Bending(i)\*(Width2/2)/I(i));

Max\_Bending\_Stress(i)=(Mmax\_Bending(i)\*(Width2/2)/I(i));

end

Min\_Bending\_Stress(i)=(Mmin\_Bending(i)\*(Width/2)/I(i));

Max\_Bending\_Stress(i)=(Mmax\_Bending(i)\*(Width/2)/I(i));

end

%Axial Forces Table from Deliverable 1 Solution

%Values in lb

Ax\_Mmax\_OA=0.4;

Ax\_Mmax\_AB=1.49;

Ax\_Mmin\_BD=0.06;

Ax\_Mmax\_DE=1.50;

Ax\_Mmin\_OA=0.39;

Ax\_Mmin\_AB=0.53;

Ax\_Mmax\_BD=0.36;

Ax\_Mmin\_DE=0.54;

% %Maxiumum Compression Table from Deliverable 1 Solution

% %Values in lb

% CMax\_OA=-1.49;

% CMax\_AB=-1.49;

% CMax\_BD=-0.46; %Located in BC Region

% CMax\_DE=-1.5;

%Maxiumum Force in each Pin Table from Deliverable 1 Solutions

%Values in lb

FMax\_A=1.49;

FMax\_B=1.49;

FMax\_C=2.97;

FMax\_D=1.5;

FMax\_E=1.5;

F = [FMax\_A,FMax\_B,FMax\_C,FMax\_D,FMax\_E]

%Bending Calculations

%Bending values calulated by (M\*y)/I

%Maximum

Bending\_Max\_OA=(Mmax\_OA\*y\_OA)/I\_OA;

Bending\_Max\_AB=(Mmax\_AB\*y\_AB)/I\_AB;

Bending\_Max\_BD=(Mmax\_BD\*y\_BD)/I\_BD;

Bending\_Max\_DE=(Mmax\_DE\*y\_DE)/I\_DE;

%Minimum

Bending\_Min\_OA=(Mmin\_OA\*y\_OA)/I\_OA;

Bending\_Min\_AB=(Mmin\_AB\*y\_AB)/I\_AB;

Bending\_Min\_BD=(Mmin\_BD\*y\_BD)/I\_BD;

Bending\_Min\_DE=(Mmin\_DE\*y\_DE)/I\_DE;

%Bending Stress Matrix

%Max\_Bending\_Stress=[Bending\_Max\_OA,Bending\_Max\_AB,Bending\_Max\_BD,Bending\_Max\_DE];

%Min\_Bending\_Stress=[Bending\_Min\_OA,Bending\_Min\_AB,Bending\_Min\_BD,Bending\_Min\_DE];

%Axial Calculations

%Axial Stress Matrix

Max\_Axial=[Ax\_Mmax\_OA,Ax\_Mmax\_AB,Ax\_Mmax\_BD,Ax\_Mmax\_DE];

Min\_Axial=[Ax\_Mmin\_OA,Ax\_Mmin\_AB,Ax\_Mmin\_BD,Ax\_Mmin\_DE];

Max\_Axial\_Stress=Max\_Axial./Area;

Min\_Axial\_Stress=Min\_Axial./Area;

%Combined Stress Calculations

Max\_Comb\_Stress=zeros(1,4);

Min\_Comb\_Stress=zeros(1,4);

for i=1:4

Max\_Comb\_Stress(i)=Max\_Bending\_Stress(i)+Max\_Axial\_Stress(i);

Min\_Comb\_Stress(i)=Min\_Bending\_Stress(i)+Min\_Axial\_Stress(i);

end

%Mean and Alternating Stress

Mean\_Stress=(Max\_Comb\_Stress+Min\_Comb\_Stress)./2;

Alt\_Stress=(Max\_Comb\_Stress-Min\_Comb\_Stress)./2;

%Buckling & Deflection

L=[r\_OA,r\_AB,r\_BD,r\_DE];

Buckling = (pi^2\*Mod\_El\*I)./(L.^2);

Max\_Deflection=L./360;

Actual\_Deflection=(Mmax\_Bending.\*(L.^2))./(9\*sqrt(3)\*Mod\_El.\*I);

%Fatigue

Sf\_prime=Sig\_uts/2;

Cload=1;

Csize=1;

a\_surf=4.511;

b\_surf=-0.265;

Csurf=a\_surf\*Sig\_uts^b\_surf;

Creliab=0.814;

Ctemp=1;

Sf=Cload\*Csize\*Csurf\*Ctemp\*Creliab\*Sf\_prime;

%Factor of Safety Calculations

%Fatigue

FOS\_Fatigue\_N1=(Sf\*Sig\_uts)./((Alt\_Stress.\*Sig\_uts)+(Mean\_Stress.\*Sf));

%Yeild

FOS\_Yeild\_Tension=Sig\_y./abs(Alt\_Stress - Mean\_Stress);

FOS\_Yeild\_N\_2=Sf./Alt\_Stress;

FOS\_Yeild\_N\_4=Sig\_y./(Alt\_Stress + Mean\_Stress);

%Deflection

FOS\_Deflection=Max\_Deflection./Actual\_Deflection;

%Buckling

FOS\_Buckling=Buckling./Max\_Axial\_Stress;

%Shear Calculations

%Pin Values and Calculations

%Diameter = d [Values in Inches]

d\_A=0.137795;

d\_B=0.137795;

d\_C=0.21;

d\_D=0.137795;

d\_E=0.137795;

Length=0.19685;

d = [d\_A,d\_B,d\_C,d\_D,d\_E]

%Shear Stress Calculations per Pin

Shear\_Stress\_A=sqrt(3)\*FMax\_A/(pi\*d\_A^2)/4;

Shear\_Stress\_B=sqrt(3)\*FMax\_B/(pi\*d\_B^2)/4;

Shear\_Stress\_C=sqrt(3)\*FMax\_C/(pi\*d\_C^2)/4;

Shear\_Stress\_D=sqrt(3)\*FMax\_D/(pi\*d\_D^2)/4;

Shear\_Stress\_E=sqrt(3)\*FMax\_E/(pi\*d\_E^2)/4;

%Shear Stress Array

Shear\_Stress=[Shear\_Stress\_A,Shear\_Stress\_B,Shear\_Stress\_C,Shear\_Stress\_D,Shear\_Stress\_E];

%Bearing Stress Calculations per Pin

Bearing\_Stress\_A=FMax\_A/((pi\*d\_A\*Length)/4);

Bearing\_Stress\_B=FMax\_B/((pi\*d\_B\*Length)/4);

Bearing\_Stress\_C=FMax\_C/((pi\*d\_C\*Length)/4);

Bearing\_Stress\_D=FMax\_D/((pi\*d\_D\*Length)/4);

Bearing\_Stress\_E=FMax\_E/((pi\*d\_E\*Length)/4);

%Bearing Stress Array

Bearing\_Stress=[Bearing\_Stress\_A,Bearing\_Stress\_B,Bearing\_Stress\_C,Bearing\_Stress\_D,Bearing\_Stress\_E];

%Factor of Safety Pin Calculations

FOS\_Shear=Sig\_y./Shear\_Stress;

FOS\_Bearing=Sig\_y./Bearing\_Stress;

%Tearout Calculations

Tearout\_Stress\_OA=sqrt(3)\*Max\_Axial(1)/(2\*b\_OA\*h\_OA);

Tearout\_Stress\_AB=sqrt(3)\*Max\_Axial(2)/(2\*b\_AB\*h\_AB);

Tearout\_Stress\_BD=sqrt(3)\*Max\_Axial(3)/(2\*b\_BD\*h\_BD);

Tearout\_Stress\_DE=sqrt(3)\*Max\_Axial(4)/(2\*b\_DE\*h\_DE);

%Tearout Array

Tearout\_Stress=[Tearout\_Stress\_OA,Tearout\_Stress\_AB,Tearout\_Stress\_BD,Tearout\_Stress\_DE];

%Factor of Safety for Tearout

FOS\_Tearout=Sig\_y./Tearout\_Stress;

% Creating FOS Table

t = table(FOS\_Fatigue\_N1',FOS\_Yeild\_Tension',FOS\_Yeild\_N\_2'...

,FOS\_Yeild\_N\_4',FOS\_Deflection',FOS\_Buckling',FOS\_Tearout');

t2 = table(FOS\_Bearing',FOS\_Shear');