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ME 646  
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Lab 3

# Part 1 – Beam/Strain Gauge Response

## 1a)

Figure 1 - Beam and strain gauge setup using a Wheatstone bridge to pull in the voltage, an amplifier to increase the readings, and a scope to record the data

Thickness = .05 in in

Wheatstone Bridge

Amplifier

Scope

Strain Gages

-5V

+5V

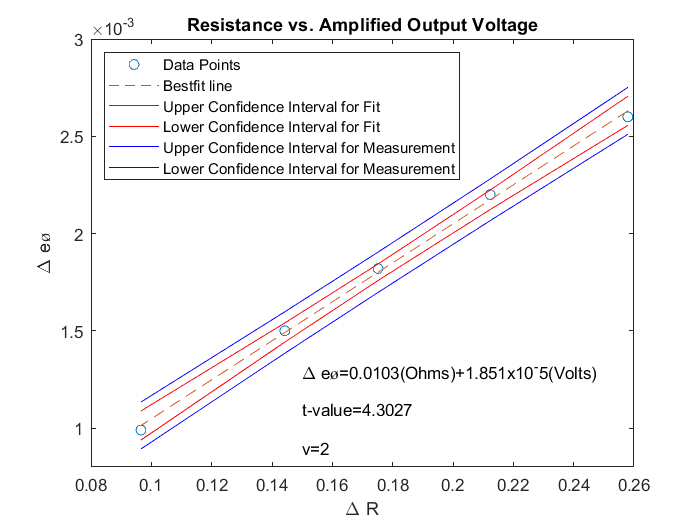
+15V

-15V

Length = 6.58 in

Width = .497 in in

## 1b)



### Solving for ΔR in the Wheatstone Bridge

and

And so reduces to

### Bridge Sensitivity

Using MATLAB, an observed bridge sensitivity of 0.01 V/Ω was calculated from the data. To calculate the expected bridge sensitivity using primarily the Wheatstone bridge setup, we must derive the equation using a quarter Wheatstone bridge.

Where R2 = R3 = R4 = R and R1 = R + .

And as approaches zero, the equation becomes:

Using this equation, an expected bridge sensitivity of 0.0104 V/Ω was found using an input voltage of 5V and knowing the resistors used were 120 Ω

## 1c)

The equation that relates the strain the beam experiences, the gage factor, the voltage gain input and the input voltage is derived from the half Wheatstone bridge by

And with the and and the equation becomes:

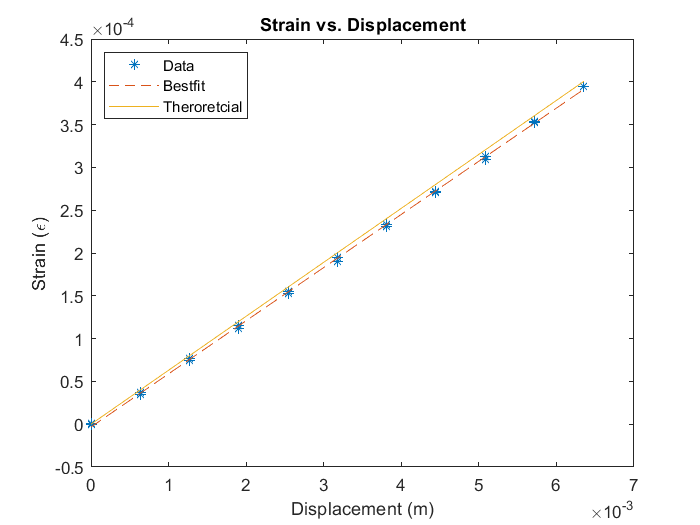
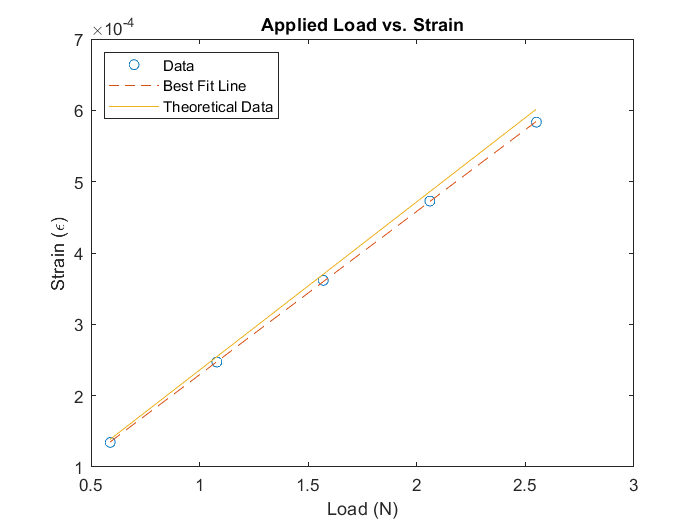
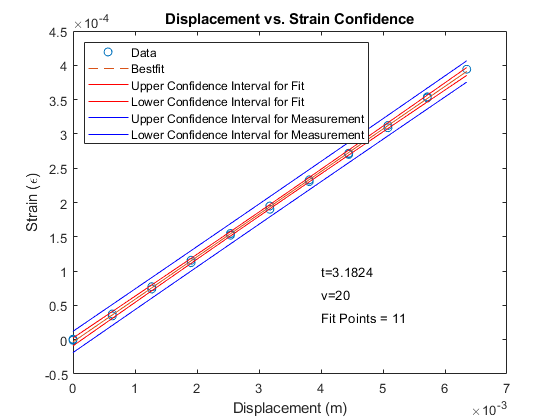
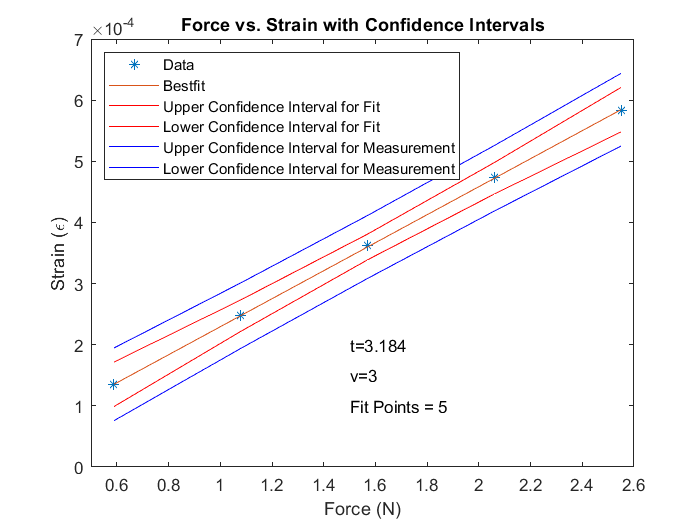
## 1d)

Using the cantilever beam equations, we see that

And

where P is the applied load, L is the length of the beam and x is the position of the strain gages on the beam. Calculating for stress we find that

Where and on the surface. With these equations, we can integrate and solve for the maximum displacement, or vice versa and get the fundamental equation for a cantilever beam

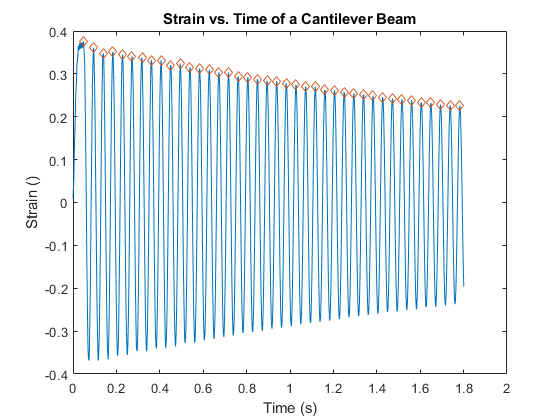
By using these formulas, strain values can then be found by the applied force and displacement of the entire beam. The two figures below show these calculation from a various force data set applied to the beam.  
  
  
  
A confidence interval of 95% was then applied to the measurements yielding the strain vs displacement and strain vs. force plots.

The hysteresis for the data was calculated to have a maximum value of 1.21% for the voltage measurement on the beam using different load values increasing then decreasing. The number was determined by calculating the difference between the corresponding loads as it was measured when the load was increasing to when it was decreasing. That difference was then divided by the total voltage difference from no load to the largest load. Please adhere to the table below that displays the data used for this calculation when increasing and decreasing load.

|  |  |  |
| --- | --- | --- |
| Displacement | Voltage | % Hysteresis |
| -0.025 | 0.0004 | 0.38 |
| -0.05 | 0.0197 | 0.72 |
| -0.075 | 0.0405 | 0.82 |
| -0.1 | 0.0608 | 0.87 |
| -0.125 | 0.0813 | 0.62 |
| -0.15 | 0.1023 | 1.21 |
| -0.175 | 0.1223 | 0.62 |
| -0.2 | 0.1427 | 0.43 |
| -0.225 | 0.164 | 0.87 |
| -0.25 | 0.1859 | 0.43 |
| 0.225 | 0.1622 |  |
| -0.2 | 0.1418 |  |
| -0.175 | 0.121 |  |
| -0.15 | 0.0998 |  |
| 0.125 | 0.08 |  |
| -0.1 | 0.059 |  |
| -0.075 | 0.0388 |  |
| -0.05 | 0.0182 |  |
| -0.025 | -0.0004 |  |
| 0 | -0.001 |  |

# Part 2 – Cantilever Beam Vibration

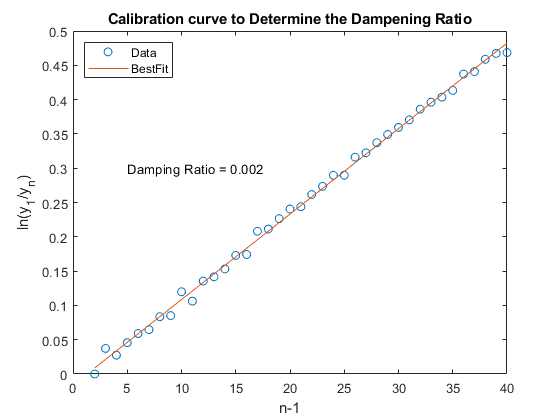
## 2a)



## 2b)

Damped Natural Frequency = 145 rad/s

## 2c)



## 2d)

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Peak 1 | Peak 2 | Peak 3 | Peak 4 | Peak 5 | Peak 6 | Peak 7 | Peak 8 | Peak 9 | Peak 10 |
| Damping Ratio | 0 | .003 | .0015 | .0018 | .0018 | .0019 | .0017 | .0019 | .0017 | .0021 |
|  | Peak 11 | Peak 12 | Peak 13 | Peak 14 | Peak 15 | Peak 16 | Peak 17 | Peak 18 | Peak 19 | Peak 20 |
| Damping Ratio | .0017 | .0020 | .0019 | .0019 | .0020 | .0018 | .0021 | .0020 | .0020 | .0019 |
|  | Peak 21 | Peak 22 | Peak 23 | Peak 24 | Peak 25 | Peak 26 | Peak 27 | Peak 28 | Peak 29 | Peak 30 |
| Damping Ratio | .0019 | .0020 | .0020 | .0020 | .0019 | .0020 | .0020 | .0020 | .0020 | .0020 |
|  | Peak 31 | Peak 32 | Peak 33 | Peak 34 | Peak 35 | Peak 36 | Peak 37 | Peak 38 | Peak 39 | Peak 40 |
| Damping Ratio | .0020 | .0020 | .0020 | .0019 | .0019 | .0020 | .0019 | .0020 | .0020 | .0019 |

Average Damping Ratio = 0.0019

Standard Deviation of the Damping Ratio: 0.0002

Comparing the two methods to calculate the damping ratio, we can see that the difference between the two methods yield very similar results, only differing by around 5%.

## 2e)

The theoretical beam stiffness was calculated to be 267 N/m. The observed beam stiffness was 271 N/m. These values differ by only 2%.

## 2f)

Using the beam equation to calculate the stiffness and using experimental data, a calculation of and can be calculated and are assumed to be nearly equal as the damping coefficient is low. The natural frequency from theoretical equations were calculated to be 145.8/s while the natural frequency obtained from observed data was 147/s. These values only differ by less than 1%!

## 2g)

The beam vibration has inherent damping in the system by just existing within the real world at sea level. The energy is dissipated as thermal energy and the natural change in momentum from air resistance with the speed of the beam against the atmospheric air.

# Part 3 – Demonstrate Understanding of FFT

The above figures Illustrate the difference the sine and triangle wave forms obtained displayed. The frequency plotted together shows that the peaks are at the same frequencies!

## 3b)

Using the equation, a frequency resolution of 20/s is calculated. This also yields a minimal and maximum detectable frequency of 50,000/s and 20/s, respectively, using the equation, with k being 1 and 2,500.

## 3c)

To adjust the frequency resolution to reach smaller frequencies, you can increase your time between data points. To increase the frequency you can detect, do the exact opposite. The number of data points collected can be manipulated as well with the same strategies and end results.

# Part 4 – String Vibration

## 4a)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Gain |  |  | Length | Linear Density | N |  |
| 100 lbf | 3,400 mv/V | 1000 | 3 V | 6 V | .73 m | 6.8 g/m | 1 to 4 | 5 V |

From our setup, the above values are constants that are used to calculate the measured force the load cell recorded from its voltage output. The equation for this value is

With these values, we were then able to calculate the first resonate frequency of each string using the equation

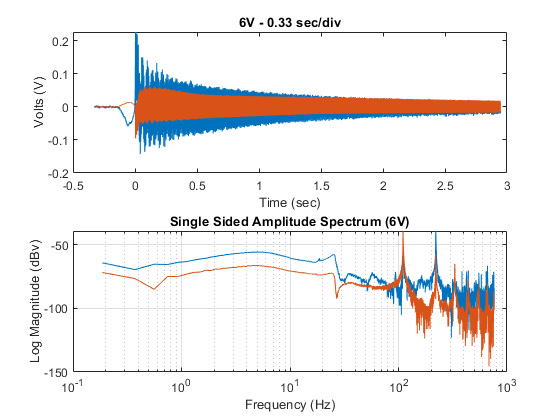
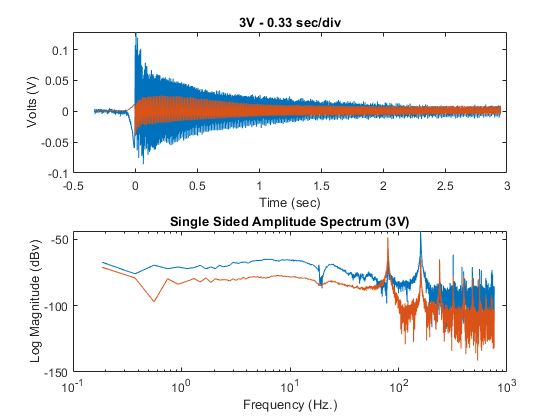
Using that equation, the first resonate frequency for the 3 Volt and 6 Volt output are

|  |  |  |
| --- | --- | --- |
| Number | Resonate Frequency 3V | Resonate Frequency 6V |
| 1 | .0194/s | .0275/s |
| 2 | .0388/s | .0549/s |
| 3 | .0583/s | .0824/s |
| 4 | .0777/s | .1099/s |

## 4b)

The below graphs are the amplitude vs frequency for each tension string with different time per division and amount of voltage input used.

## 



## 4c)

The first four resonate frequencies for both different string tension are displayed in the tables below. The fundamental frequency is the one with the largest peak from imposing initial string displacement and releasing.

**Observed Natural Frequencies: 3V**

|  |  |  |
| --- | --- | --- |
| N | Piezoelectric | Strain-Gauge |
| 1 | 79.7 | 152 |
| 2 | 160 | 298 |
| 3 | 238 | 322 |
| 4 | 319 | 445 |

**Observed Natural Frequencies: 6V**

|  |  |  |
| --- | --- | --- |
| N | Piezoelectric | Strain-Gauge |
| 1 | 110 | 226 |
| 2 | 219 | 310 |
| 3 | 329 | 528 |
| 4 | 420 | 637 |

**Calculated Natural Frequencies: 3V**

|  |  |
| --- | --- |
| N | Frequency |
| 1 | 72.2 |
| 2 | 144.3 |
| 3 | 216.5 |
| 4 | 288.7 |

**Calculated Natural Frequencies: 6V**

|  |  |
| --- | --- |
| N | Frequency |
| 1 | 102.1 |
| 2 | 204.1 |
| 3 | 306.2 |
| 4 | 408.3 |

## 4d)

The two load cells used have different fundamental frequencies attached to them because when the string is moved from its equilibrium position, the piezoelectric sensor records the minimum frequency of the test because of its placement. The other load cells record purely the maximum. One different condition is if the string does not only oscillate sideways, but downwards, they both would experience and record maximum frequencies from the compressive force the cells would experience.

# Appendix

% Lab 3

clear all

close all

%% Part 1

R\_Shunt = [55700,67700,82100,99700,149000]; % Ohms

V\_Shunt = [.260,.220,.182,.150,.099]; % Volts

R\_Strain = 120; % Ohms

V\_Gain = V\_Shunt./100; % Accounting for Amplifier

% Constant for Calculating Delta R

A = R\_Strain.\*R\_Shunt;

B = R\_Strain + R\_Shunt;

Delta\_R = R\_Strain - (A./B); % Equation for the change in R

[p1,s]=polyfit(Delta\_R,V\_Gain,1);

Fit\_Data = p1(1)\*Delta\_R+p1(2);

Nu = length(Delta\_R)-2; % First order

t\_95 = tinv(0.975,Nu); % P = 95%

x\_Bar = sum(Delta\_R)/length(Delta\_R); % Mean

Denom = sum((Delta\_R-x\_Bar).^2);

S\_yx = (sum((V\_Gain-Fit\_Data).^2)/Nu).^(0.5); % Standard Error of Fit

Con\_Fit = t\_95\*S\_yx\*(1/length(Delta\_R)+(Delta\_R-x\_Bar).^2/Denom).^(0.5);

Con\_Measure = t\_95\*S\_yx\*(1+1/length(Delta\_R)+(Delta\_R-x\_Bar).^2/Denom).^(0.5);

% Plotting

figure(1)

plot(Delta\_R,V\_Gain,'o',Delta\_R,Fit\_Data,'--',Delta\_R,Fit\_Data+Con\_Fit,'r',Delta\_R,Fit\_Data-Con\_Fit,'r',Delta\_R,Fit\_Data+Con\_Measure,'b',Delta\_R,Fit\_Data-Con\_Measure,'b');

title('Resistance vs. Amplified Output Voltage')

xlabel('\Delta R')

ylabel('\Delta e\o')

ylim([0.8\*10^-3,3\*10^-3])

legend('Data Points','Bestfit line','Upper Confidence Interval for Fit','Lower Confidence Interval for Fit','Upper Confidence Interval for Measurement','Lower Confidence Interval for Measurement','location','northwest')

text(.15,1.3e-03,strcat('\Delta e\o',' ','=',' ','0.0103(Ohms)+1.851x10^-5(Volts)'))

text(.15,1.1e-03,'t-value=4.3027')

text(.15,.9e-03,'v=2')

E\_i = 5; %Volts

G\_F = 2.1; %Strain gauge factor

St = 2.\*V\_Gain./G\_F\*E\_i;

% Strain vs. Load

Load = [.060,.110,.160,.210,.260] .\* 9.81; % N

Load\_Volts=[.0712-.000600,.130-.000250,.190-.000150,.248+.000200,.306+.000300]; % Volts accounting for the Zero shifting

Beam\_Length = 6.58\*.0254; %Length of beam in meters

Thickness = 0.050\*.0254; % Thickness of beam in meters

Width = .497\*.0254; % meters

E = 1.93e11; % Elastic Modulus

Strain\_P=(2.\*Load\_Volts./100)./(G\_F\*E\_i);

Load\_Theo=(12.\*Load.\*(Beam\_Length-Width)\*(Thickness/2))./(E\*(Width\*Thickness^3));

[h1,s]=polyfit(Load,Strain\_P,1);

Best\_Fit\_1=h1(1)\*Load+h1(2);

figure(2)

plot(Load,Strain\_P,'o',Load,Best\_Fit\_1,'--',Load,Load\_Theo)

xlabel('Load (N)')

ylabel('Strain (\epsilon)')

title('Applied Load vs. Strain')

legend('Data','Best Fit Line','Theoretical Data','Location','Northwest')

% Statistic Calculations

Nu\_1 = length(Load)-2; % First order

t\_95\_1 = tinv(0.975,Nu\_1); % P = 95%

X\_Bar\_1 = sum(Load)/length(Load); % Mean

Denom\_1 = sum((Load-X\_Bar\_1).^2);

s\_yx\_1 = (sum((Load\_Theo-Best\_Fit\_1).^2)/Nu\_1).^(0.5); % Standard Error Calculation of the Fit

Con\_Fit\_1 = t\_95\_1\*s\_yx\_1\*(1/length(Load)+(Load-X\_Bar\_1).^2/Denom\_1).^.5;

Con\_Measure\_1 = t\_95\_1\*s\_yx\_1\*(1+1/length(Load)+(Load-X\_Bar\_1).^2/Denom\_1).^.5;

% Plotting with Statistical Lines

figure(3)

plot(Load,Strain\_P,'\*',Load,Best\_Fit\_1,Load,Best\_Fit\_1+Con\_Fit\_1,'r',Load,Best\_Fit\_1-Con\_Fit\_1,'r',Load,Best\_Fit\_1+Con\_Measure\_1,'b',Load,Best\_Fit\_1-Con\_Measure\_1,'b')

xlabel('Force (N)')

ylabel('Strain (\epsilon)')

xlim([0.5,2.6])

title('Force vs. Strain with Confidence Intervals')

legend('Data','Bestfit','Upper Confidence Interval for Fit','Lower Confidence Interval for Fit','Upper Confidence Interval for Measurement','Lower Confidence Interval for Measurement','Location','Northwest')

text(1.5,2e-4,strcat('t',' ', '=' ,' ', '3.184'))

text(1.5,1.5e-4,'v=3')

text(1.5,1e-4,'Fit Points = 5')

% Strain vs. Displacement

Disp = [0,.025,.050,.075,.100,.125,.150,.175,.200,.225,.250,.250,.225,.200,.175,.150,.125,.100,.075,.050,.025,0]\*0.0254; % meters

Disp\_Volts=[.0004,.0197,.0405,.0608,.0813,.1023,.1223,.1427,.1640,.1859,.2070,.2070,.1850,.1622,.1418,.1210,.0998,.0800,.0590,.0388,.0182,-.0004];

St\_2=(2\*Disp\_Volts./100)./(G\_F\*E\_i); % Accounting for amplifier

Disp\_Theo=(3.\*Disp.\*(Thickness/2).\*(Beam\_Length-Width)./(Beam\_Length^3));

[p2,s] = polyfit(Disp,St\_2,1);

Best\_Fit\_2 = p2(1)\*Disp+p2(2);

figure(4)

plot(Disp,St\_2,'\*',Disp,Best\_Fit\_2,'--',Disp,Disp\_Theo)

title('Strain vs. Displacement')

xlabel('Displacement (m)')

ylabel('Strain (\epsilon)')

legend('Data','Bestfit','Theroretcial','Location','Northwest')

% Statistics

Nu\_2 = length(Disp)-2; % First order

t\_95\_2 = tinv(0.975,Nu\_2); %t value for P=95%

x\_Bar\_2 = sum(Disp)/length(Disp); % Mean

Denom\_2 = sum((Disp-x\_Bar\_2).^2);

s\_yx\_2 = (sum((Disp\_Theo-Best\_Fit\_2).^2)/Nu\_2).^.5; %standard error of the fit

Con\_Fit\_2 = (t\_95\_2\*s\_yx\_2\*(1/length(Disp)+(Disp-x\_Bar\_2).^2/Denom\_2).^.5);

Con\_Measure\_2 = (t\_95\_2\*s\_yx\_2\*(1+1/length(Disp)+(Disp-x\_Bar\_2).^2/Denom\_2).^.5);

figure(5)

plot(Disp,St\_2,'o',Disp,Best\_Fit\_2,'--',Disp,Best\_Fit\_2+Con\_Fit\_2,'r',Disp,Best\_Fit\_2-Con\_Fit\_2,'r',Disp,Best\_Fit\_2+Con\_Measure\_2,'b',Disp,Best\_Fit\_2-Con\_Measure\_2,'b')

xlabel('Displacement (m)')

ylabel('Strain (\epsilon)')

title('Displacement vs. Strain Confidence')

legend('Data','Bestfit','Upper Confidence Interval for Fit','Lower Confidence Interval for Fit','Upper Confidence Interval for Measurement','Lower Confidence Interval for Measurement','Location','Northwest')

text(4e-03,1e-4,strcat('t' , ' ','=',' ','3.1824'))

text(4e-03,.66e-4,'v=20')

text(4e-03,.33e-4,'Fit Points = 11')

% Hysteresis Calculations

Increasing = [0.0004,.0197,.0405,.0608,.0813,.1023,.1223,.1427,.1640,.1859,.2070];

Decreasing = [-.0004,.0182,.0388,.0590,.0800,.0998,.1210,.1418,.1622,.1850,.2070];

Y\_Range = Increasing(end)-Increasing(1);

Difference = Increasing-Decreasing;

Hysteresis\_Max = (max(abs(Difference))./(Y\_Range))\*100;

Hyst = (Difference/Y\_Range)\*100

%% Part 2

% 2a

Header=29;

Data = importdata('Beam3.lvm','\t',Header);

Col1=Data.data(:,1);

Col2=Data.data(:,2);

for i=1:length(Col1)

if Col1(i)>-0.005

Base=i;

break

end

end

Base\_Line = mean(Col2(1:Base));

Dev = std(Col2(1:Base));

Threshold = 5\*Dev;

for i=1:length(Col1)

if(abs(Col2(i)-Base\_Line)>Threshold)

Start\_Time=i;

break

end

end

New\_Time=Col1(Start\_Time:length(Col1))-Col1(Start\_Time);

New\_Strain=Col2(Start\_Time:length(Col1));

Constant=0.015;

[Locations,Values]=peakfinder(New\_Strain,Constant);

figure(6)

plot(New\_Time,New\_Strain,New\_Time(Locations),Values,'d')

xlabel('Time (s)')

ylabel('Strain ()')

title('Strain vs. Time of a Cantilever Beam')

% 2b

K = 3\*E\*Width\*Thickness^3;

Denom\_3=12\*Beam\_Length^3;

K\_Beam = K/Denom\_3;

Density\_Steel = 7700; % kg/m^3

Mass\_Hook = 0.0074; % kg

Volume\_Beam=Beam\_Length\*Thickness\*Width;

Mass\_Beam = Density\_Steel\*Volume\_Beam;

Mass\_Effective = Mass\_Beam/4 + Mass\_Hook;

Damped\_Natural\_Frequency = sqrt(K\_Beam/Mass\_Effective); % rad/s

% 2c

Log = log(Values(2)./Values(2:length(Values)));

Con = transpose(2:length(Values));

[mb,Time\_Wave] = polyfit(Con,Log,1);

Best\_Fit\_3 = mb(1)\*Con+mb(2);

alpha = mb(1);

Damp\_Ratio = (alpha/sqrt(4\*pi^2+alpha^2));

figure(7)

plot(Con,Log,'o',Con,Best\_Fit\_3)

xlabel('n-1')

ylabel('ln(y\_1/y\_n)')

title('Calibration curve to Determine the Dampening Ratio')

text(5,.3,strcat('Damping Ratio = 0.002'))

legend('Data','BestFit','Location','Northwest')

% 2d

% Using Large Equation

for n=3:length(Values)

Num = (1/(n-1))\*log(Values(2)./Values(n));

Damp(n) = Num./sqrt(4\*pi^2+Num^2);

end

Damp\_Mean = sum(Damp(3:end)./length(Damp(2:end)));

Damp\_Std = std(Damp(3:length(Damp)));

%2e

k\_Theo = (3\*E\*((Width\*Thickness^3)/12))/Beam\_Length^3;

k\_Exp = p2(1)/h1(1)

%2f

Natural\_Freq\_Theo = sqrt(k\_Theo/Mass\_Effective);

Natural\_Freq\_Actu = sqrt(k\_Exp/Mass\_Effective);

%% Part 3

Header=29;

Sin\_Wave = importdata('sinAvsF.lvm','\t',Header);

Tri\_Wave = importdata('triAvsF.lvm','\t',Header);

Time\_Wave = Sin\_Wave.data(:,1); % Shared Time Vector

Sin\_Voltage = Sin\_Wave.data(:,2);

Tri\_Voltage = Tri\_Wave.data(:,2);

% Plotting

T = Time\_Wave(2)-Time\_Wave(1); % Calculated time interval between data points

Freq = 1/T; % Sampling Frequency

Length = size(Sin\_Voltage); % Number of points in vector

Length\_2 = length(Sin\_Voltage);

Power\_2 = 2^nextpow2(Length(1)); % power of 2 from length y

Sin\_FFT = fft(Sin\_Voltage,Power\_2)./Length(1); % fft bull

Tri\_FFT = fft(Tri\_Voltage,Power\_2)./Length(1); % fft bull

Spaced\_Points = Freq/2\*linspace(0,1,Power\_2/2+1); % spaced point vector using length

Sin\_FFT\_A = 20\*log10(abs(Sin\_FFT(1:Power\_2/2+1))); % amplitude

Tri\_FFT\_A = 20\*log10(abs(Tri\_FFT(1:Power\_2/2+1))); % amplitude

figure(8)

subplot(2,1,1)

plot (Time\_Wave,Sin\_Voltage,Time\_Wave,Tri\_Voltage); grid

title('Sine vs. Triangle Wave')

xlabel ('Time (sec)')

ylabel ('Volts (V)')

xlim([0,.01])

subplot(2,1,2)

semilogx(Spaced\_Points,Sin\_FFT\_A,Spaced\_Points,Tri\_FFT\_A);grid % abs(Y) = (Re(Y)^2 + Im(Y)^2)^1/2

axis([10 10000 -110 -10])

title('Single Sided Amplitude Spectrum')

xlabel ('Frequency (Hz)')

ylabel ('Log Magnitude (dBv)')

% 3b

Freq\_Reso = 1/(Length\_2\*T);

%% Part 4

Header = 32;

Guitar\_Data\_3v = importdata('guitar1.lvm','\t',Header);

Guitar\_Data\_6v = importdata('guitar6v1.lvm','\t',Header);

Time\_Guitar = Guitar\_Data\_3v.data(:,1);

y1 = Guitar\_Data\_3v.data(:,2);

y2 = Guitar\_Data\_3v.data(:,4);

y3=Guitar\_Data\_6v.data(:,2);

y4=Guitar\_Data\_6v.data(:,4);

T1 = Time\_Guitar(2)-Time\_Guitar(1); % Time per sample

Freq1 = 1/T1; % Sampling frequency

Length1 = size(y1); % Length of signal - # of points

Power\_2\_1 = 2^nextpow2(Length1(1)); % Next power of 2 from length of y - need for FFT

Guitar\_FFT\_3\_1 = fft(y1,Power\_2\_1)./Length1(1); % this is a vector with complex number elements

Guitar\_FFT\_3\_2 = fft(y2,Power\_2\_1)./Length1(1); % this is a vector with complex number elements

Space\_Points\_1 = Freq1/2\*linspace(0,1,Power\_2\_1/2+1); % linspace generates linearly spaced points

Guitar\_3\_1\_A = 20\*log10(abs(Guitar\_FFT\_3\_1(1:Power\_2\_1/2+1)));

Guitar\_3\_2\_A = 20\*log10(abs(Guitar\_FFT\_3\_2(1:Power\_2\_1/2+1)));

figure(9)

subplot(2,1,1)

plot(Time\_Guitar,y1,Time\_Guitar,y2)

title('3V - 0.01 sec/div')

xlabel ('Time (sec)')

ylabel ('Volts (V)')

subplot(2,1,2)

semilogx(Space\_Points\_1,Guitar\_3\_1\_A,Space\_Points\_1,Guitar\_3\_2\_A);

axis([10 10000 -130 -40])

title('Single Sided Amplitude Spectrum (3V)')

xlabel ('Frequency (Hz.)')

ylabel ('Log Magnitude (dBv)')

Length2 = size(y3); % Length of signal - # of points

Power\_2\_2 = 2^nextpow2(Length2(1)); % Next power of 2 from length of y - need for FFT

Guitar\_FFT\_6\_1 = fft(y3,Power\_2\_2)./Length2(1); % this is a vector with complex number elements

Guitar\_FFT\_6\_2 = fft(y4,Power\_2\_2)./Length2(1); % this is a vector with complex number elements

Space\_Points\_2 = Freq1/2\*linspace(0,1,Power\_2\_2/2+1); % linspace generates linearly spaced points

Guitar\_6\_1\_A = 20\*log10(abs(Guitar\_FFT\_6\_1(1:Power\_2\_2/2+1)));

Guitar\_6\_2\_A = 20\*log10(abs(Guitar\_FFT\_6\_2(1:Power\_2\_2/2+1)));

figure(10)

subplot(2,1,1)

plot(Time\_Guitar,y3,Time\_Guitar,y4)

title('6V - 0.01 sec/div')

xlabel ('Time (sec)')

ylabel ('Volts (V)')

subplot(2,1,2)

semilogx(Space\_Points\_2,Guitar\_6\_1\_A,Space\_Points\_2,Guitar\_6\_2\_A);grid % abs(Y) = (Re(Y)^2 + Im(Y)^2)^1/2

axis([10 10000 -130 -30])

title('Single Sided Amplitude Spectrum (6V)')

xlabel ('Frequency (Hz)')

ylabel ('Log Magnitude (dBv)')

%% Part 4 2

Header = 32;

Guitar\_Data\_3v = importdata('guitar2.lvm','\t',Header);

Guitar\_Data\_6v = importdata('guitar6v2.lvm','\t',Header);

Time\_Guitar = Guitar\_Data\_3v.data(:,1);

y1 = Guitar\_Data\_3v.data(:,2);

y2 = Guitar\_Data\_3v.data(:,4);

y3=Guitar\_Data\_6v.data(:,2);

y4=Guitar\_Data\_6v.data(:,4);

T1 = Time\_Guitar(2)-Time\_Guitar(1); % Time per sample

Freq1 = 1/T1; % Sampling frequency

Length1 = size(y1); % Length of signal - # of points

Power\_2\_1 = 2^nextpow2(Length1(1)); % Next power of 2 from length of y - need for FFT

Guitar\_FFT\_3\_1 = fft(y1,Power\_2\_1)./Length1(1); % this is a vector with complex number elements

Guitar\_FFT\_3\_2 = fft(y2,Power\_2\_1)./Length1(1); % this is a vector with complex number elements

Space\_Points\_1 = Freq1/2\*linspace(0,1,Power\_2\_1/2+1); % linspace generates linearly spaced points

Guitar\_3\_1\_A = 20\*log10(abs(Guitar\_FFT\_3\_1(1:Power\_2\_1/2+1)));

Guitar\_3\_2\_A = 20\*log10(abs(Guitar\_FFT\_3\_2(1:Power\_2\_1/2+1)));

figure(11)

subplot(2,1,1)

plot(Time\_Guitar,y1,Time\_Guitar,y2)

title('3V - 0.33 sec/div')

xlabel ('Time (sec)')

ylabel ('Volts (V)')

subplot(2,1,2)

semilogx(Space\_Points\_1,Guitar\_3\_1\_A,Space\_Points\_1,Guitar\_3\_2\_A);

title('Single Sided Amplitude Spectrum (3V)')

xlabel ('Frequency (Hz.)')

ylabel ('Log Magnitude (dBv)')

Length2 = size(y3); % Length of signal - # of points

Power\_2\_2 = 2^nextpow2(Length2(1)); % Next power of 2 from length of y - need for FFT

Guitar\_FFT\_6\_1 = fft(y3,Power\_2\_2)./Length2(1); % this is a vector with complex number elements

Guitar\_FFT\_6\_2 = fft(y4,Power\_2\_2)./Length2(1); % this is a vector with complex number elements

Space\_Points\_2 = Freq1/2\*linspace(0,1,Power\_2\_2/2+1); % linspace generates linearly spaced points

Guitar\_6\_1\_A = 20\*log10(abs(Guitar\_FFT\_6\_1(1:Power\_2\_2/2+1)));

Guitar\_6\_2\_A = 20\*log10(abs(Guitar\_FFT\_6\_2(1:Power\_2\_2/2+1)));

figure(12)

subplot(2,1,1)

plot(Time\_Guitar,y3,Time\_Guitar,y4)

title('6V - 0.33 sec/div')

xlabel ('Time (sec)')

ylabel ('Volts (V)')

subplot(2,1,2)

semilogx(Space\_Points\_2,Guitar\_6\_1\_A,Space\_Points\_2,Guitar\_6\_2\_A);grid % abs(Y) = (Re(Y)^2 + Im(Y)^2)^1/2

title('Single Sided Amplitude Spectrum (6V)')

xlabel ('Frequency (Hz)')

ylabel ('Log Magnitude (dBv)')

%% ye

Linear\_Density=.00608; %g/m

L=.79;

Ffs = 448; %N 100 lb load cell

Gain = 1000;

mv\_V = 3.4; %mV/V

vout3 = 3000;

vout6 = 6000;

N=[1:1:4];

F\_in\_3V=(vout3\*Ffs)/(mv\_V\*5\*Gain); %tension in string

F\_in\_6V=(vout6\*Ffs)/(mv\_V\*5\*Gain); %tension in string

Rfreq1=(1/(2\*L))\*(sqrt(F\_in\_3V/Linear\_Density)).\*N;

Rfreq2=(1/(2\*L))\*(sqrt(F\_in\_6V/Linear\_Density)).\*N;