LAB ASSIGNMENT 1

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Group Number: 37

1.Aim and Scope:

Given simple dynamic system is approximated as single degree of freedom(SDOF) system, for this system we need to understand the structure of the system.

The input signal is given by using impulse hammer, Check and document the impulse hammer and the sensitivity on the impulse hammer and accelerometer as we will use these to convert voltage signals into force/Acceleration SDOF.

Two sensors are used at input and output respectively these input and output signals are connected to channel 0 and channel 1 of data acquisition unit, we repeat this process 5times and five different values are saved, each contain four signal and response signal.

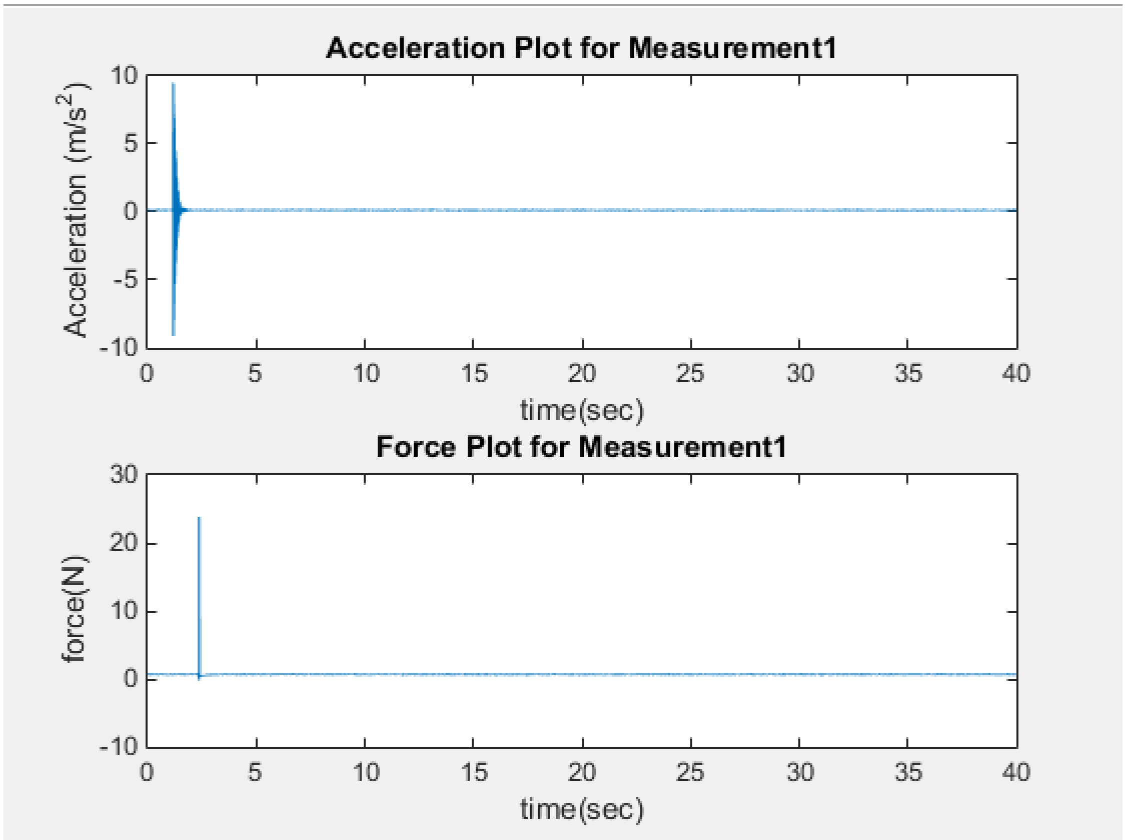
2. Experimental setup:

1) Cantilever Beam: It is a element of rigid structure, it is attached at one end as in shown in fig
2) Accelerometer: It is a sensor which used to sense the vibration and cable to connect the channel
3) Impulse hammer: It is used to hit the SDOF with certain force and used to sense the force applied to it sends the info to NID through cable.
4) National Instrument device: It is used to acquire data from channels
5) NI USB-9612 Shaker: It is used to provide vibrations.

3.Detailed Calculations and Results:

3.1 Task 1: Experimental Data.

Here we use the sensitivity to calculate the force[N] and acceleration[m/s^2] we repeat this procedure for all five experiments and plot the acceleration and force in time domain.



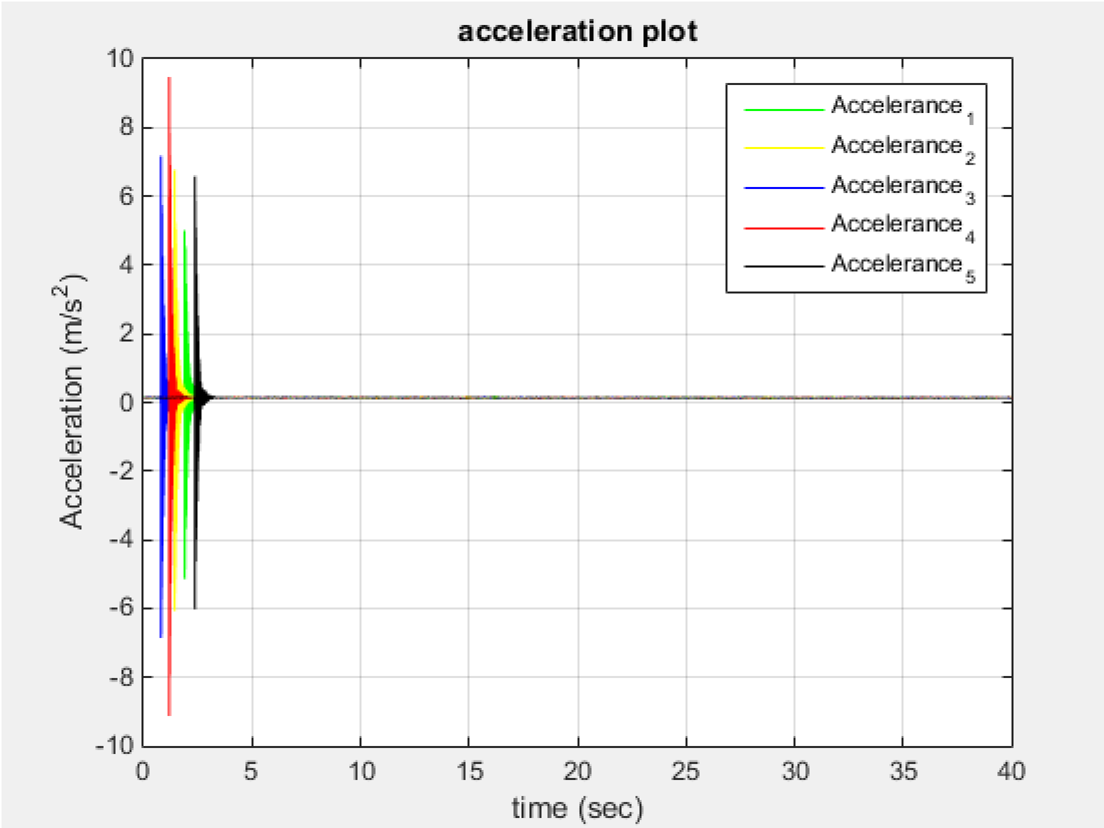
3.2 Task 2: Estimating the Natural Frequency.

In this task after plotting the acceleration signals in time domain we will obtain natural frequency.

Natural Frequency can be calculated using the formula

$$= \left((f_1 - f_2)/no\ of\ cycles\right)^{-1}$$
$$= (0.17/10)^{-1}$$

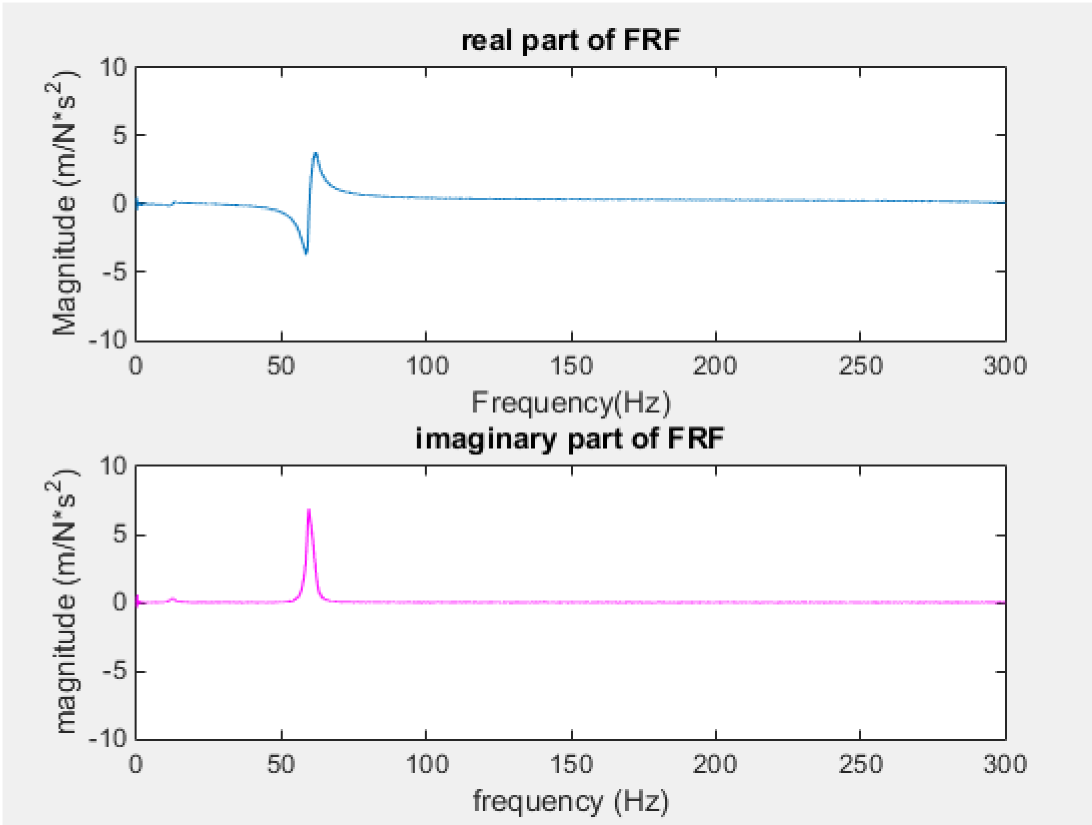
= 58.82Hz



3.3 Task 3: frequency Response Functions I.

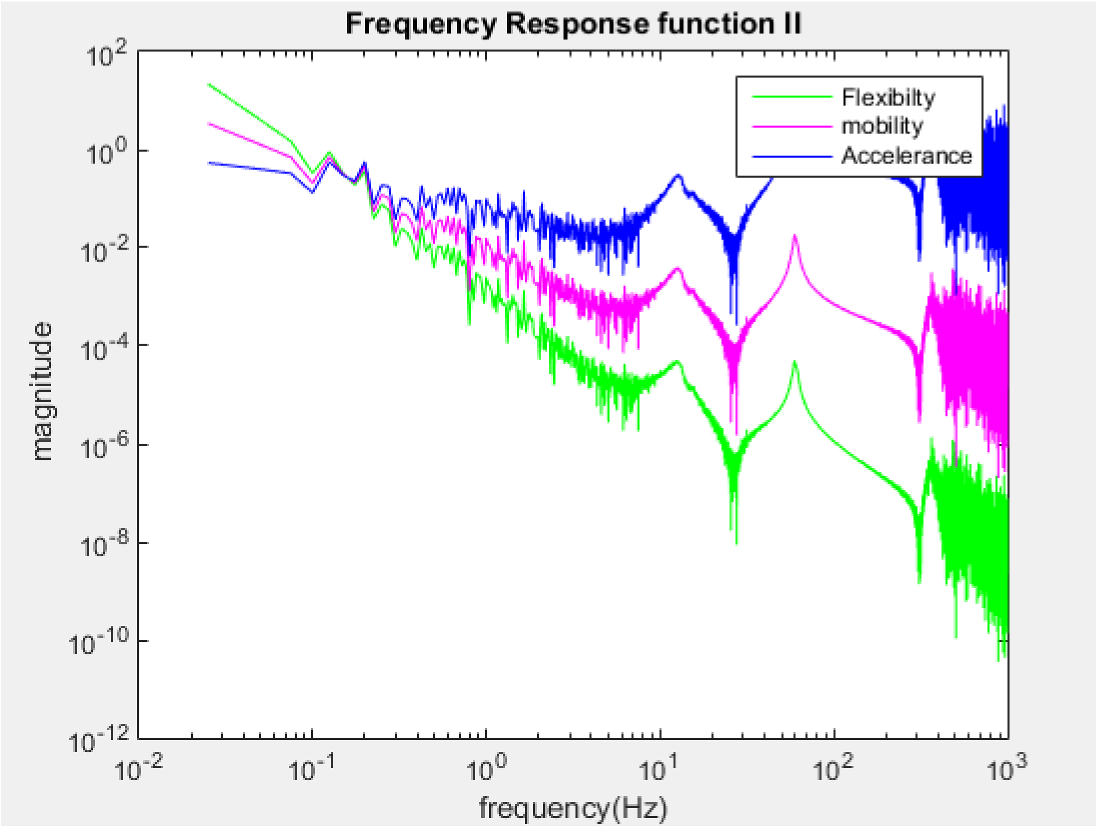
In this task we estimate the frequency response function of the system and use the matlab function fantransc function to find the spectra of the signal, for each measurement acceleration spectrum is divided with force spectrum. Then for five measurements average value is calculated.

The real and imaginary part of the transfer function are calculated and plotted as shown below.



3.4 Task 4: Frequency Response Functions II.

In this task the receptance and mobility is obtained using the frequency response function in task 3, magnitude of flexibility, mobility and accelerances are calculated and drawn in the same figure.



The above plot and figure 2.4 in "INTRODUCTORY NOISE AND VIBRATION ANAYLSIS" both are random signals taken from an accelerometer, and data plotted shows random variations in both plots.

3.5 Task 5: Resonance Frequency & Damping.

In this task resonance frequency and relative frequency are calculated.

Resonant frequency is obtained as 59.4Hz

Relative damping can be calculated as $\zeta = (f_2 - f_1)/(2f_d)$

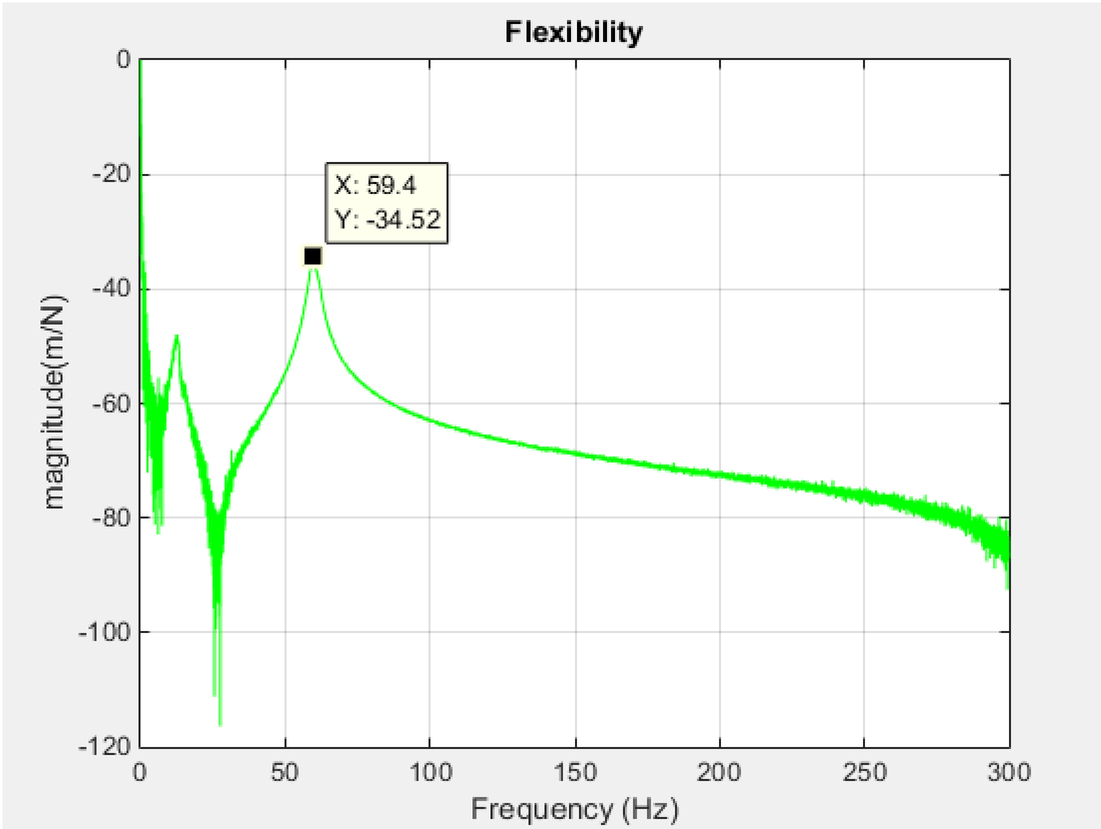
We have $f_1 = 56.4Hz$ $\quad f_2 = 63.53Hz$ $\quad f_d = 59.4Hz$

By substituting relative damping as 0.060

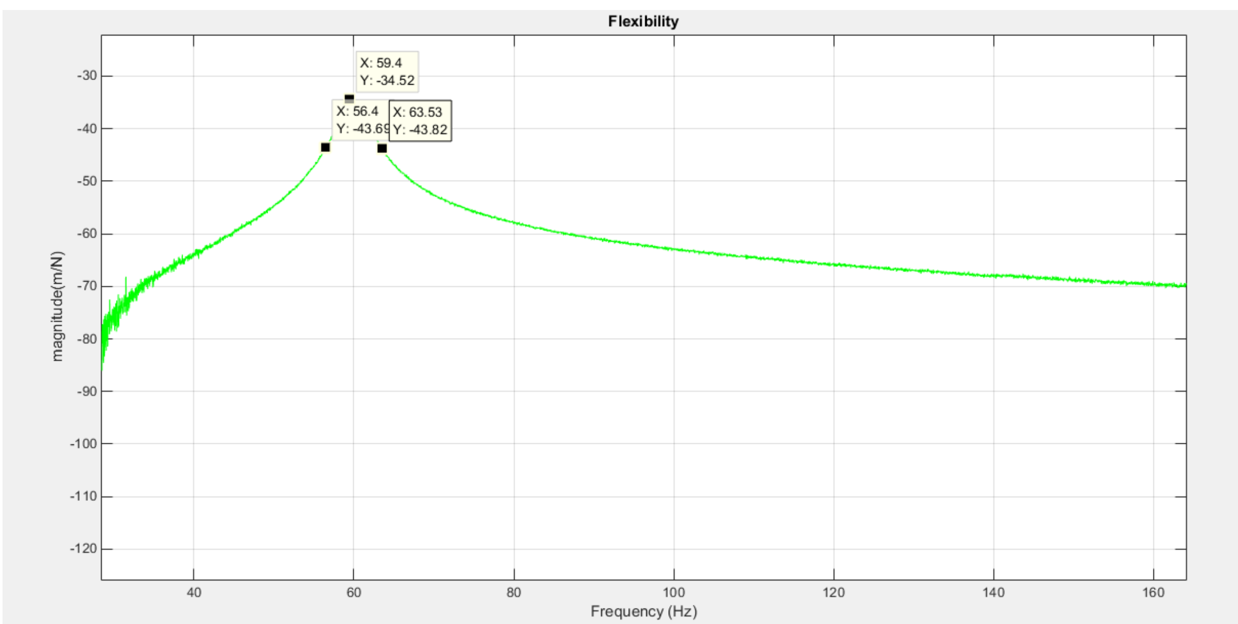
Resonant frequency can be calculated as $\frac{f_d}{\sqrt{1-\zeta^2}}$

We have $\zeta^2 = 3.60 \times 10^{-3}$

After substituting $f_n = 59.5Hz$



Flexibility
X: 59.4
Y: -34.52
magnitude(m/N)
Frequency (Hz)



Flexibility
X: 59.4
Y: -34.52
X: 56.4
Y: -43.69
X: 63.53
Y: -43.82
magnitude(m/N)
Frequency (Hz)

3.6 Task 6: Stiffness and Damping.

Stiffness and damping can be calculated by using the formulas.

Stiffness K = $(2 \times \pi \times f_n)^2 \times M$

$= (2 \times \pi \times 59.5)^2 \times 0.547$

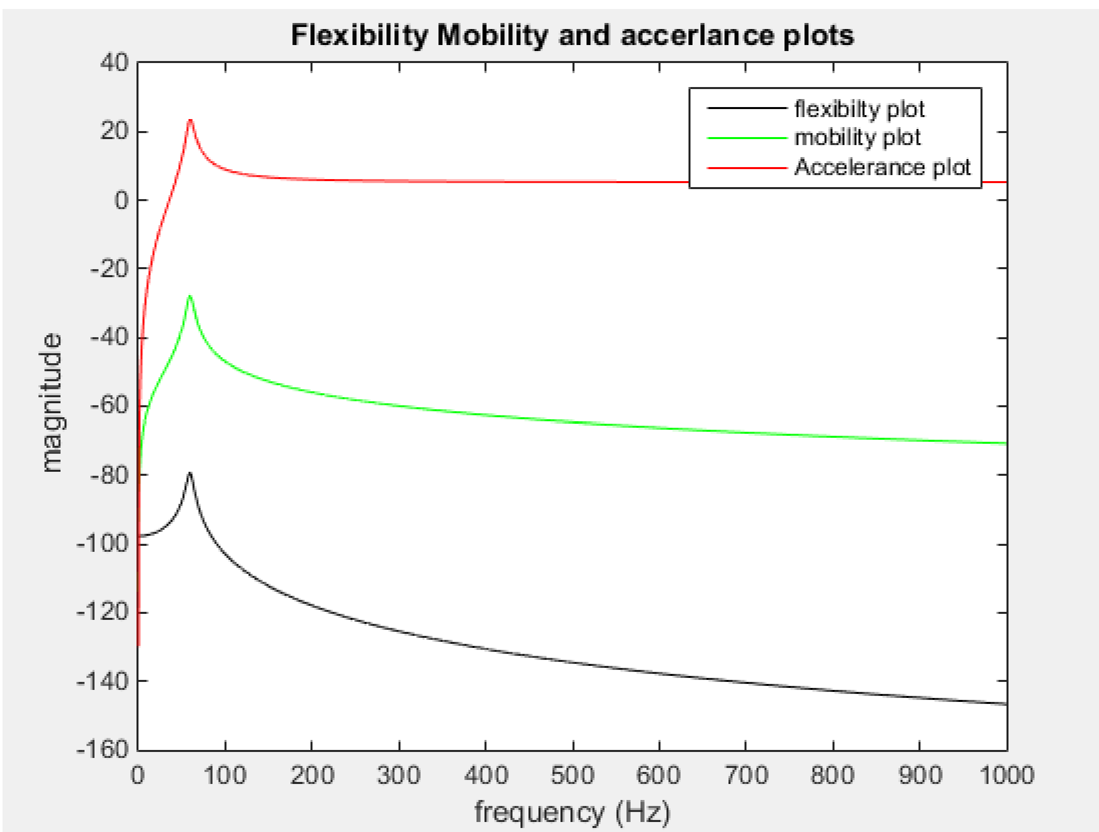
$= 7.6450 \times 10^4$

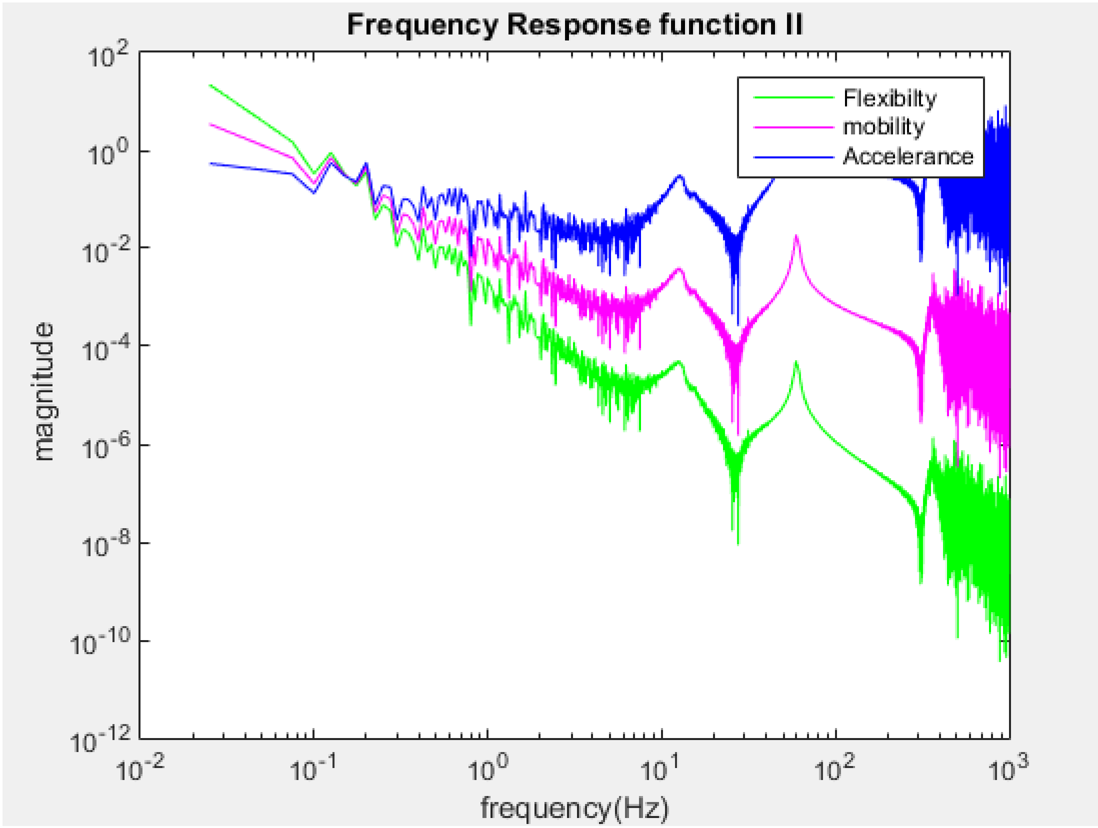
Viscous damping can be calculated by $2 \times \sqrt{M \times K} \times \zeta$

After substituting we get C_ value as 24.53

3.7 Task 7: Stiffness and Damping.

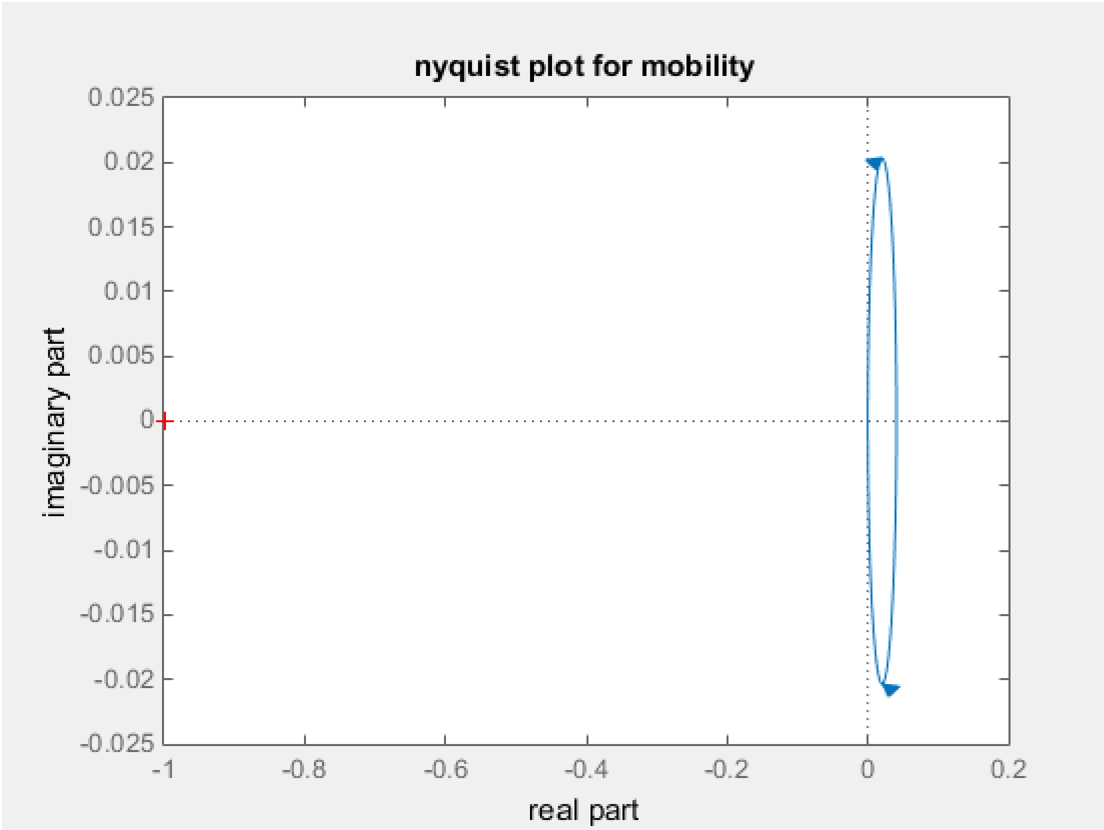
In this task we calculate analytic transfer function by using parameters M, C & K and the graphs are plotted in below figure.





3.8 Task 8: Nyquist Diagram.

In this task Nyquist diagram is plotted using mobility and it was done for measured mobility and analytical mobility.



4.Conculsion:

From this experiment we studied the structure of single degree of freedom system force and acceleration signals are produced from random excitation source, different have been done.

In the first task force and acceleration signals are calculated from voltage signals and plotted in time domain.

In the second task Natural frequency for one of the measurements taken was calculated.

In the third task the real and imaginary part of the transfer function was calculated and plotted.

In the fourth task the magnitude of flexibility mobility and accelerances are plotted in frequency domain.

In fifth task resonance frequency and damping were calculated and relative damping are calculated using 3-dB bandwidth.

In sixth task stiffness and viscous damping are calculated

In seventh task analytical transfer function was calculated for flexibility mobility and accelerances and graphs are plotted

In the last task Nyquist diagram was plotted using mobility and it was done for analytical and measured mobility

5.Refernces.

[1]. Noise and vibration analysis: signal analysis and experimental procedures 2010/2011 written by Anders Brandt.

[2]. Math works.

Appendix:

Task 1:

```
clc;
clear all;
close all;
load ('trail1lab1.mat');
s1=10.2*10^(-3);
s2=2.3*10^(-3);
Acceleration_1=(data(:,2))/s1;
Force_1=data(:,1)/s2;
load('trail2lab1.mat');
Acceleration_2= data(:,2)/s1;
Force_2=data(:,1)/s2;
load ('trail3lab1.mat');
Acceleration_3= data(:,2)/s1;
```

```
Force_3=data(:,1)/s2;
load ('trail4lab1.mat');
Acceleration_4= data(:,2)/s1;
Force_4=data(:,1)/s2;
load('trail5lab1.mat') ;
Acceleration_5= data(:,2)/s1;
Force_5=data(:,1)/s2;
subplot(2,1,1);
plot(time,Acceleration_4);
xlabel('time(sec)');
ylabel ('Acceleration (m/s^2)');
title('Acceleration Plot for Measurement1');
subplot(2,1,2);
plot (time,Force_5);
xlabel ('time(sec)');
ylabel ('force(N)');
title('Force Plot for Measurement1');
```

Task 2:

```
figure
plot(time,Acceleration_1,'g');
grid on
title('acceleration plot');
xlabel('time (sec)');
ylabel('Acceleration (m/s^2)');
```

Task 3:

```
fs=2000;
[A1,f]=fantransc(Acceleration_1,fs);
[A2,f]=fantransc(Acceleration_2,fs);
[A3,f]=fantransc(Acceleration_3,fs);
[A4,f]=fantransc(Acceleration_4,fs);
[A5,f]=fantransc(Acceleration_5,fs);
[F1,f1]=fantransc(Force_1,fs);
[F2,f1]=fantransc(Force_2,fs);
[F3,f1]=fantransc(Force_3,fs);
```

```
[F4,f1]=fantransc(Force_4,fs);
[F5,f1]=fantransc(Force_5,fs);
H=((A1./F1)+(A2./F2)+(A3./F3)+(A4./F4)+(A5./F5))/5;
r=real(H);
subplot(2,1,1);
plot(f,r);
xlabel('Frequency(Hz)');
ylabel('Magnitude (m/N*s^2)');
title('real part of FRF');
axis([0 300 -10 10]);
imagI=imag(H);
subplot(2,1,2);
plot(f,imagI,'m');
xlabel('frequency (Hz)');
ylabel('magnitude (m/N*s^2)');
title('imaginary part of FRF');
axis([0 300 -10 10]);
```

Task 4:

```
Flex=-H./((2*pi*f).^2);
mobi=H./(2*pi*1i*f);
figure
loglog(f,(abs(Flex)),'g',f,(abs(mobi)),'m',f,(abs(H)),'b');
xlabel('frequency(Hz)');
ylabel('magnitude');
title('Frequency Response function II');
legend('Flexibilty','mobility','Accelerance');
```

Task 5:

```
figure
v=-H./((2*pi*f));
plot(f,20*log10(abs(v)),'g');
grid on;
title('Flexibility');
xlabel('Frequency (Hz)');
ylabel('magnitude(m/N)');
axis([0 300 -120 0]);
```

Task 7:

```
s=(2*pi*1i*f);
Ma=0.547;
C_value=24.53;
K_value=7.6450*10^4;
h_s=(1/Ma)./(s.^2+((s*C_value)/Ma)+(K_value/Ma));
h_v=(s/Ma)./(s.^2+((s*C_value)/Ma)+(K_value/Ma));
h_a=(s.^2/Ma)./(s.^2+((s*C_value)/Ma)+(K_value/Ma));
figure
plot(f,20*log10(abs(h_s)),'k',f,20*log10(abs(h_v)),'g',f,20*log10(abs(h_a)),'r');
xlabel('frequency (Hz)');
ylabel('magnitude');
title('Flexibility Mobility and accerlance plots');
legend('flexibilty plot','mobility plot','Accelerance plot');
```

Task 8:

```
figure
tr=tf([0 1 0],[Ma C_value K_value]);
grid on
nyquist(tr);
xlabel('real part');
ylabel('imaginary part');
title('nyquist plot for mobility');
```