LAB ASSIGNMENT 2

Date:2016/04/30

Name: SANA, RAJ SEKHAR 9503127210

VELURU, CHAITHANYA KUMAR REDDY 9508266450

Group Number: 37

1. Aim and Scope:

The aim of this assignment is to compute and plot relevant frequency spectra for the three signals. This analysis is performed with two different FFT record lengths for each of the three signals. To characterize the signals values are also computed in time and frequency domains.

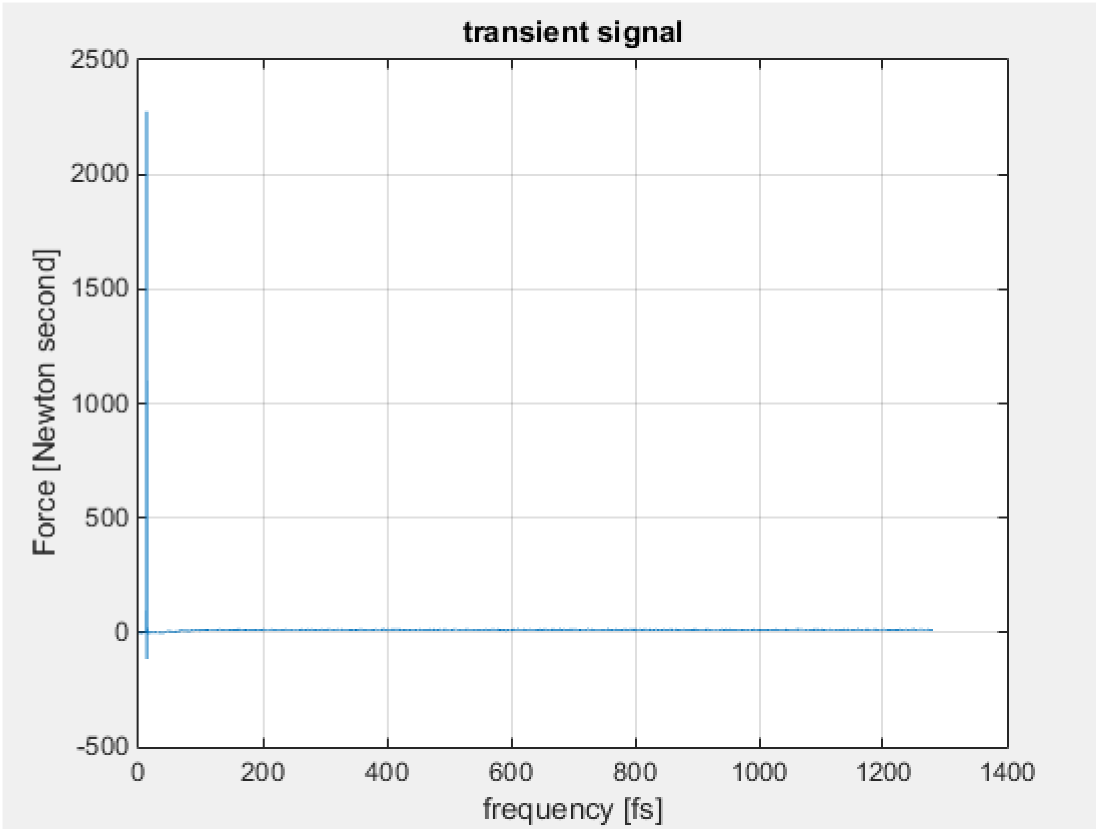
The signals given in the assignment are transient, periodic and random signals.

2. Detailed Calculations and Results:

2.1 Task 1: Transient Hammer Force.

In the first task there is a force signal from hammer impact. Two transient spectra are produced by FFT function, one is produced out of these two with analysis of the old signal and the other is produced by using 2048 samples of the signal and the spectra for these two signals are plotted.

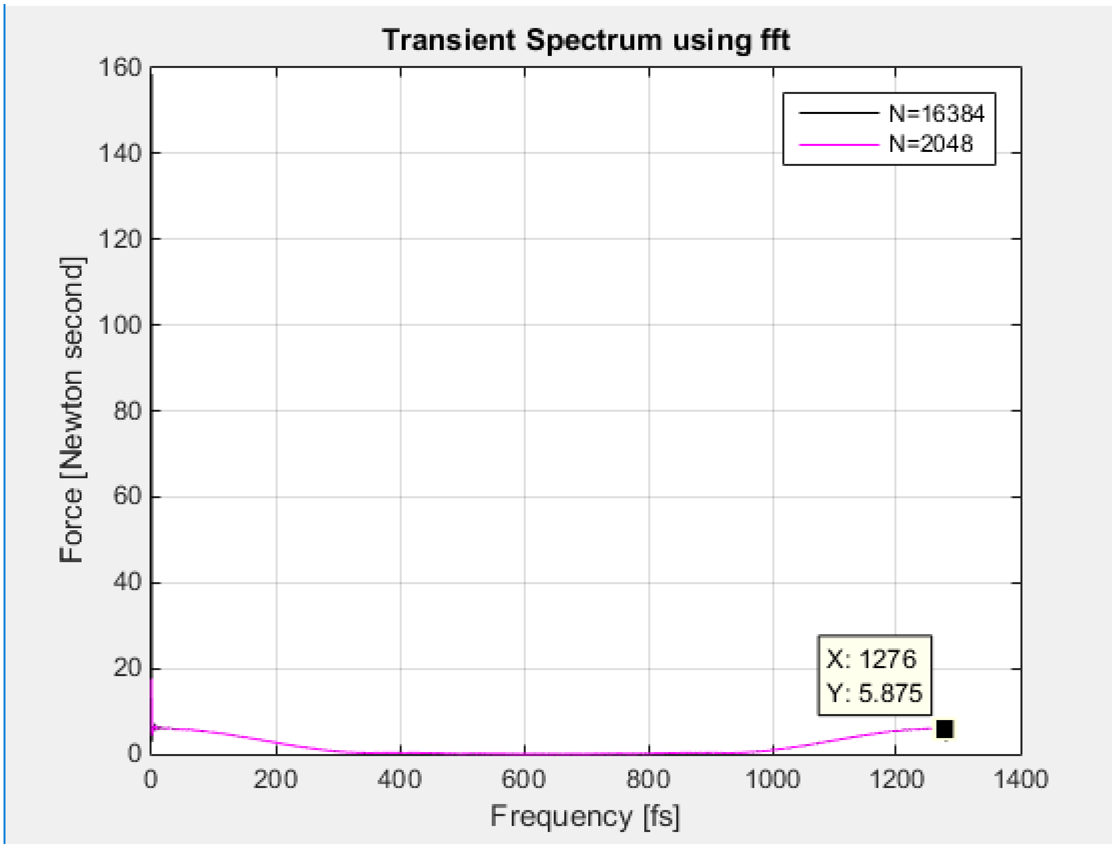
The input transient signal is shown below,



The main thing done in this task is the computation of transient spectrum. The two transient spectrum obtained, one is obtained from spectrum analysis by using the formula.

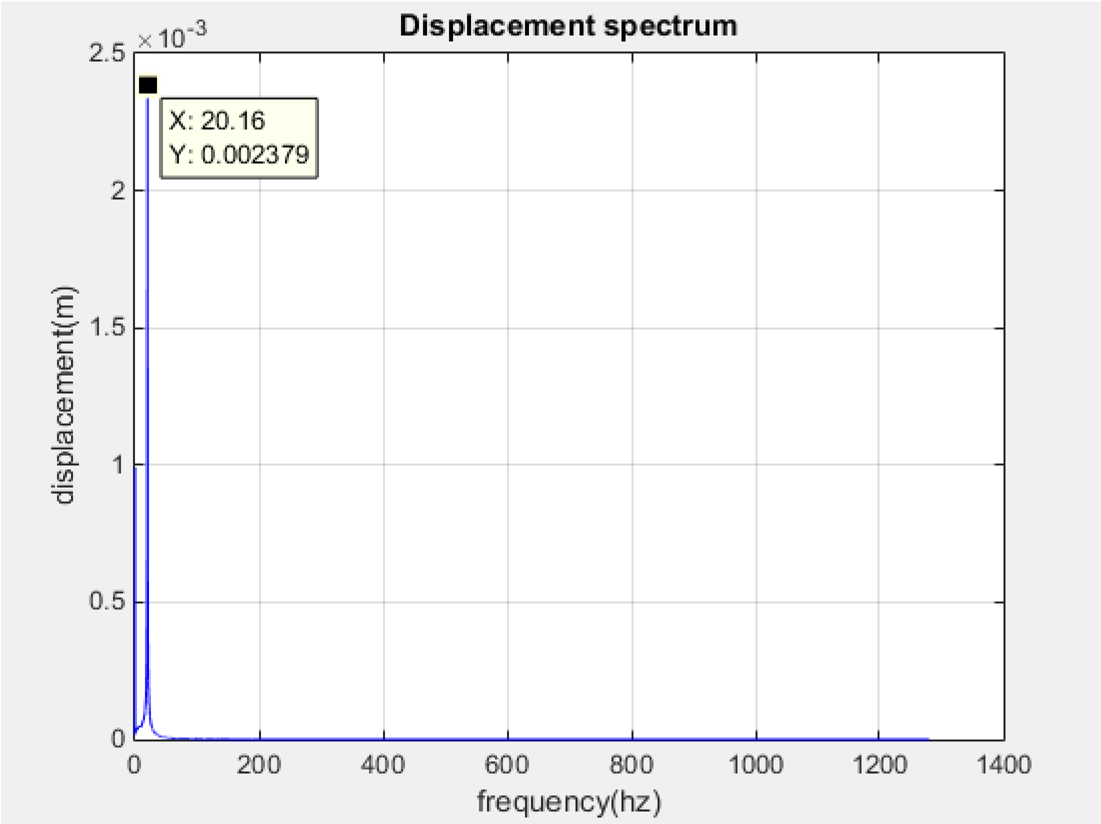
$$T_x(k) = \Delta t. |X(k)|$$

The transient spectra are plotted as shown below.



The maximum displacement response when fore applied to the mass of a SDOF system with M =10 kg, C =20 Ns/m, K =160000N/m can be calculated using the formula $F(s) = (Ms^2 + Cs + K)\big(U(s)\big)$

The Displacement spectra is shown as below.



The maximum displacement response can be calculated from the figure and the obtained value is

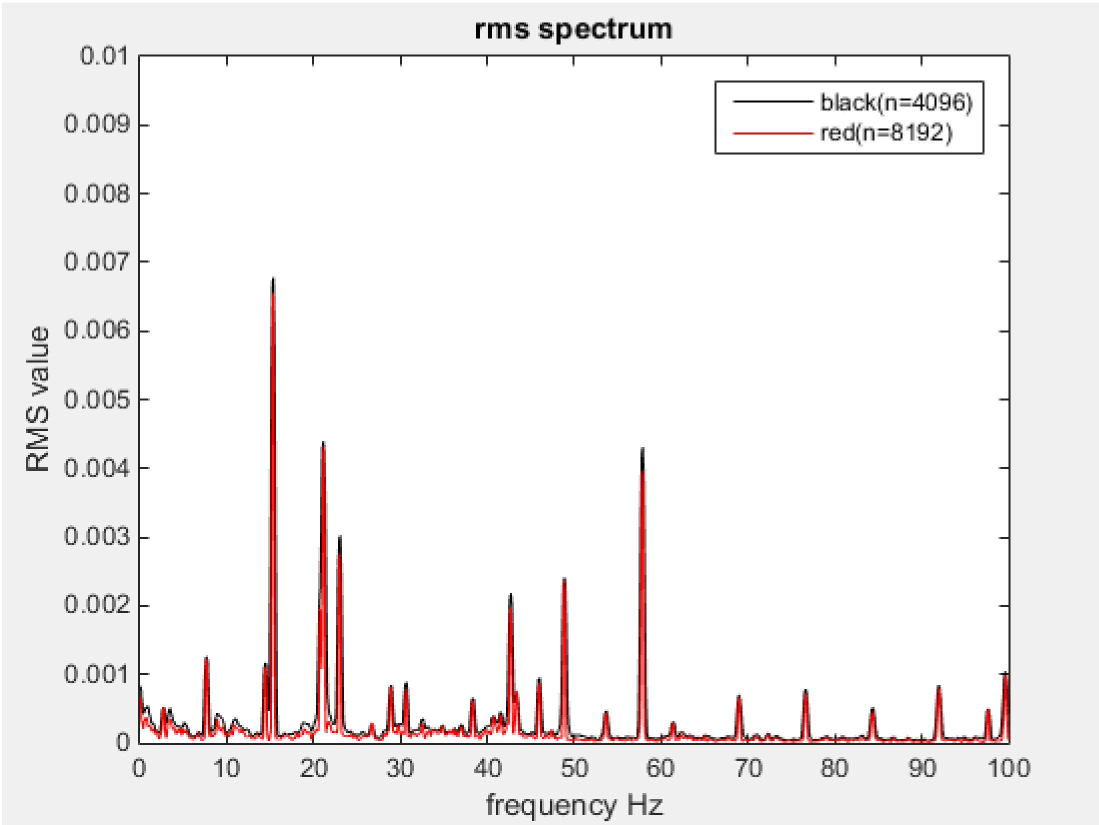
$$U(s)max=2.379\times 10^{-3}m$$

2.2 Task 2: Vibration from Rotating Machinery.

In this second task the input signal is a periodic signal two RMS spectra are plotted in matlab using FFT function. This signal is 50% overlapped and windowed using flat top window.

This following figure is RMS spectra plotted from 0-150Hz.

In figure 1 the spectrum is computed with FFT blocks size 4096 and it is plotted in black other spectrum is computed with FFT block size 8192 and plotted in red

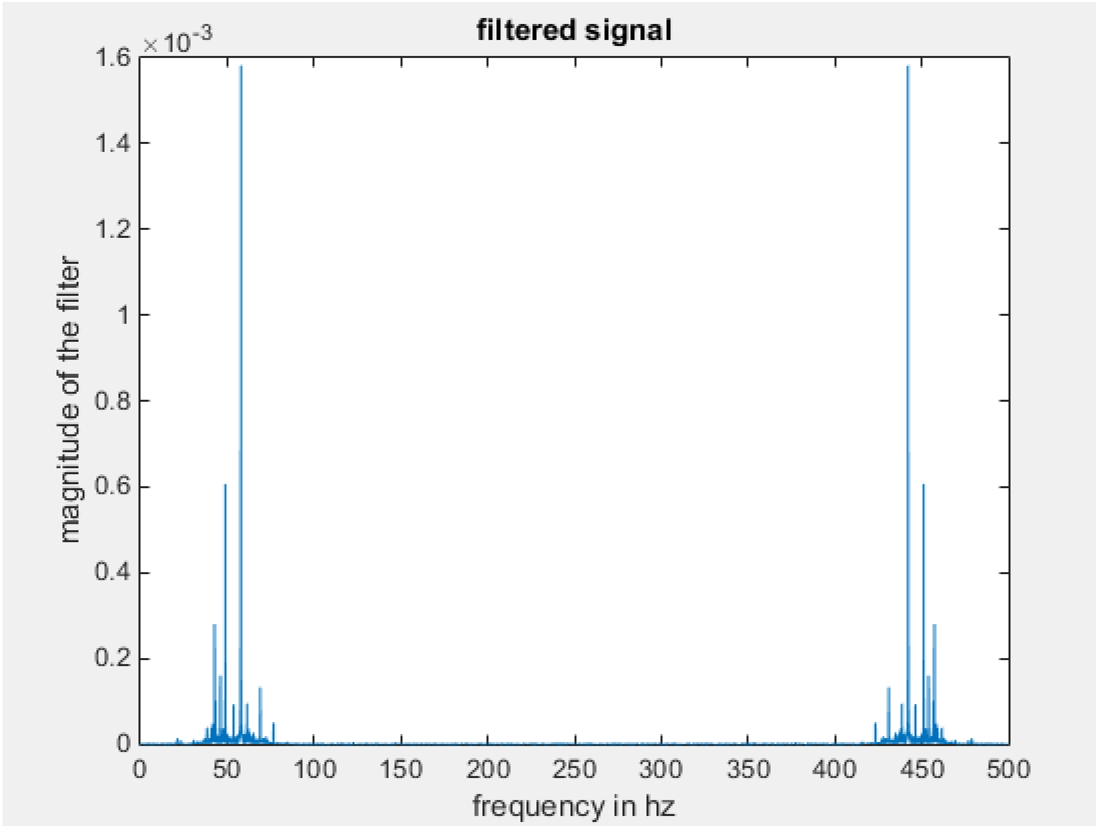


From the graph Rms values at 58hz obtained can be given as.

Rms value for n= 4096 is =0.003927m/s^2

Rms value for n= 8192 is = 0.002466m/s^2

The vibration signal is filtered in a band pass filter of range 56-60Hz, the resultant is shown in the figure.



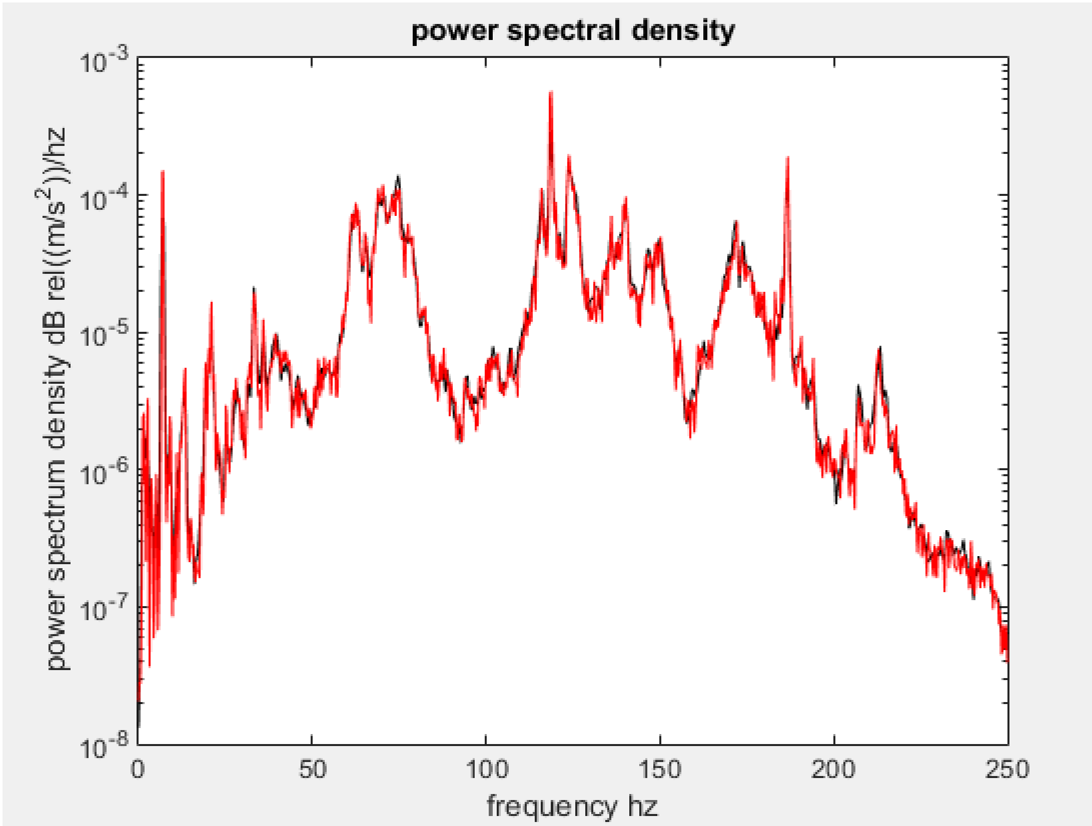
The Rms value obtained for the filtered signal = 0.0036m/s^2

2.3 Task 3: Vibration from Wind Excited Structure.

In the third task signal given is a vibration recorded inside the box containing electronics and the box was mounted at 50m height in a telecommunication.

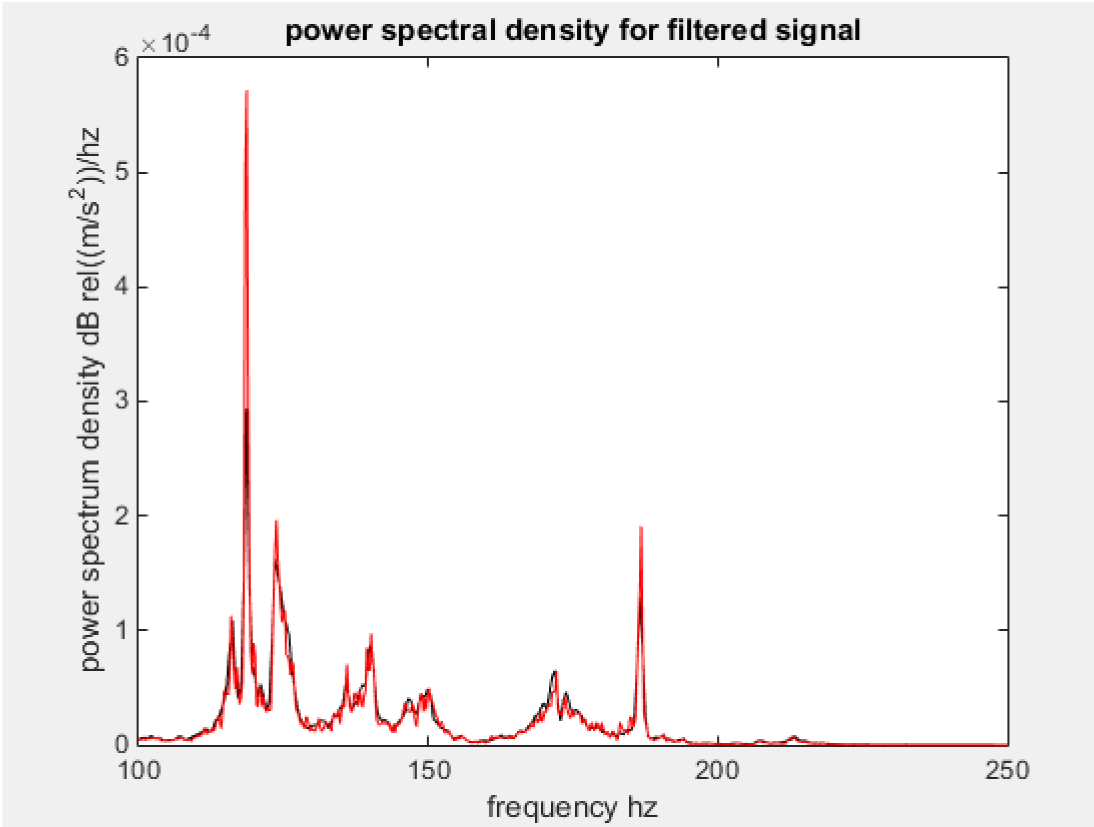
The two power spectral densities are produced and plotted. Power spectral density is computed for 50% overlapped signals and using hanning window.

In the following figure the power spectral density is plotted in the range 0-250Hz.In the following figure two power spectral densities are plotted one is calculated with FFT block size 4096 and it is plotted in black another one is calculated with FFT block size 8192 and it is plotted in red as below.



From the two spectra the Rms value of the signal is calculated in the frequency range 100-250Hz.

The figure shown below is a filtered signal in the frequency range 100-250Hz.



Rms value obtained from the spectrum in frequency domain is 0.031m/s^2

Rms value obtained in time domain is 0.0385 m/s^2

3.Conclusion:

In Task1 we calculated transient spectrum which determines the analysis between the force and the frequency we used FFT function in order to plot the transient spectrum and it is just like impulse response which decays with increase in time.

In Task2 we observed that Rms spectrum is a linear spectrum obtained from power spectrum Rms spectrum is used to determine the mean square values of the signal to overcome the noise in the signal we divided the entire signal into few blocks and computed the FFT for each block and averaged it.

In Task3 welch estimator is used to plot the power spectrum density and hanning window is used to overcome the leakage problem in spectral analysis.

4.References:

[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('ass2_signal1');
a=x;
l=0:length(a)-1;
deltaf=fs/length(a);
Res=l*deltaf;
figure;
plot(Res,a);
grid on
xlabel('frequency [fs]');
ylabel('Force [Newton second]');
title('transient signal');
figure;
z=(1/fs).*abs(fft(a));
plot(Res,z,'k ');
title('')
hold on;
n1=2048;
l1=0:n1-1;
dealtaf1=fs/n1;
Res1=l1*dealtaf1;
z1=(1/fs).*abs(fft(a(1:n1)));
plot(Res1,z1,'m -');
title('Transient Spectrum using fft');
ylabel('Force [Newton second]');
xlabel('Frequency [fs]');
grid on;
```

```
legend('N=16384','N=2048');
m=10;
c=20;
k=160000;
s= 1i*2*pi*Res;
disp=(z)./(m*(s.^2)+(c.*s)+k);
figure
plot(Res,abs(disp),'b');
grid on
xlabel('frequency(hz)');
ylabel('displacement(m)');
title('Displacement spectrum');
```

Task 2:

```
clc;
clear all;
close all;
load('ass2_signal2.mat');
L = length(x);
n_1 = 4096;
n_2= 8192;
k_1 = 0:n_1-1;
k_2 = 0:n_2-1;
f_1 = k_1*fs/n_1;
f_2= k_2*fs/n_2;
window_1 = flattopwin(n_1);
window_2=flattopwin(n_2);
q_1= n_1/sum(window_1);
q_2=n_2/sum(window_2);
block1 = L/n_1;
block2=L/n_2;
f1=n_1/2;
f2=n_2/2;
x1(1,:) = x(1:n_1).*window_1;
x2(1,:)=x(1:n_2).*window_2;
for i = 1:block1-1
    x1(2*i+1,:) = x(i*n_1+1:(i+1)*n_1).*window_1;
x1(2*i,:) = x((2*i-1)*f1+1:(2*i+1)*f1).*window_1;
end
[m,n]=size(x1);
```

```
for j = 1:m
y1(j,:) = (abs(fft(q_1*x1(j,:)/n_1))).^2;
end
for k = 1:block2-1
x2(2*k+1,:) = x(k*n_2+1:(k+1)*n_2).*window_2;
x2(2*k,:) = x((2*k-1)*f2+1:(2*k+1)*f2).*window_2;
end
[p,q]=size(x2);
for l = 1:p
y2(l,:) = (abs(fft(q_2*x2(l,:)/n_2))).^2;
end
p1 = 2*sum(y1)/block1;
p2=2*sum(y2)/block2;
rms1 = sqrt(p1);
rms2=sqrt(p2);
figure
plot(f_1,rms1,'k');
hold on
plot(f_2,rms2,'r');
axis([0 100 0 10*10^-3]);
xlabel('frequency Hz');
ylabel('RMS value');
title('rms spectrum');
legend('black(n=4096)','red(n=8192)');
b=fir1(32,[2*(56/fs) 2*(60/fs)]);
r=filter(b,1,x);
filteredrms=rms(p)
rmsvalue=rms(r);
figure
plot([0:L-1]*fs/L,abs(fft(r))/L);
title('filtered signal');
ylabel('magnitude of the filter');
xlabel('frequency in hz');
```

Task 3:

```
clc;
clear all;
close all;
load ass2_signal3.mat;
f=[0:length(x)-1]*fs/length(x);
```

```
[pwx1] = pwelch(x, hanning(4096), [50], 4096, fs);
[pwx2] = pwelch(x, hanning(8192), [50], 8192, fs);
f1=0:fs/4096:250;
f2=0:fs/8192:250;
figure(1),semilogy(f1,pwx1(1:513),'k');
xlabel('frequency hz')
ylabel('power spectrum density dB rel((m/s^2))/hz')
title('power spectral density')
hold on;
figure(1),semilogy(f2,pwx2(1:1025),'r');
b=fir1(48,[130/1000 200/1000]);
x1=filter(b,1,x);
y1=abs(fft(x1)/length(x));
f=[0:length(x1)-1]*fs/(length(x1));
rms(x1);
figure,plot(f1,pwx1(1:513),'k');
axis([100 250 0 6*10^-4]);
hold on;
plot(f2,pwx2(1:1025),'r');
area=trapz(pwx2);
xlabel('frequency hz');
ylabel('power spectrum density dB rel((m/s^2))/hz');
title('power spectral density for filtered signal');
```