ME 372- Metrology Lab

Exp 3B - Group 24

Page No.:
Date:

Exp-3B Vibration Measurement of structure using Accelerometer sensor.

Intro: Every structure has modal parameters such as natural frequencies and natural modes of vibration associated with it. It is important to know these characteristics to determine performance of the structure. Bridges have been known the collapse when subject to periodic vibrations such as the coordinated marching of cadets. This happens because the structure undergoes resonance if it is stimulated at its natural frequency. To avoid such mishaps, modal analysis is done.

Objective: To measure vibration of structure using an accelerometer, impact force applied using the impulse force hammer and finally to determine the modal parameters of the vibrating structure.

Principle: The vibration signals of excitation and response are measured on a complex structure and analysis is done to obtain a set of modal parameters. The parameters can by estimated using observed data by the method of curve-fitting.

Theory:

Every structure has a transfer function: $H(\omega)$ associated with it.
A Fast Fourier transform (FFT) on the measured acceleration can be done to get $A(\omega)$. Measuring the force, $F(\omega)$ can also be obtained. Then,

$$A(\omega) = H(\omega) \cdot F(\omega)$$

the structure is modelled as spring and damper in parallel connection. Thus the relationship between $h(t)$ & $F(t)$ is

$$m\frac{d^2x}{dt^2} + b\frac{dx}{dt} + Kx = F_u$$

Taking the fourier transform on both sides, we obtain:

$$\frac{A(\omega)}{F(\omega)} = \frac{1}{K}\left(\frac{C - \omega^2 \omega_n^2}{(\omega_n^2 - \omega^2 + j(2\zeta\omega\omega_n)}\right)$$

The LHS can be obtained from the exp and the modal parameters can thus be estimated using curve-fitting.

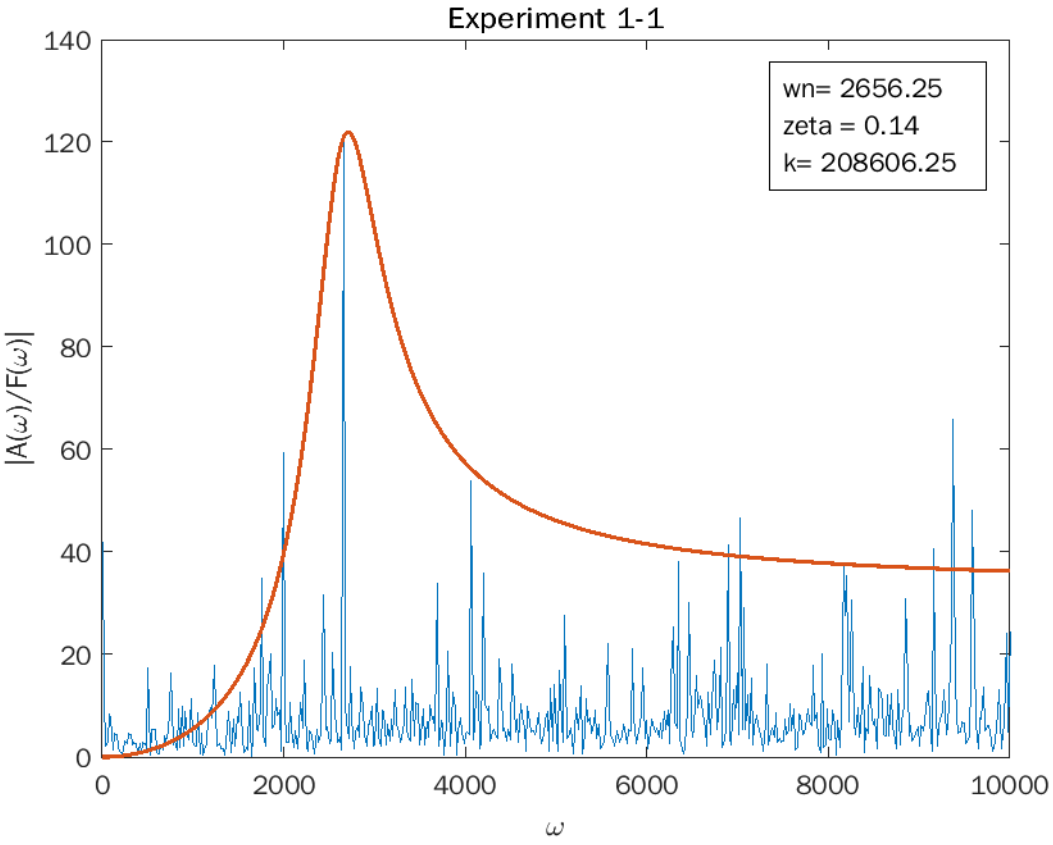
Procedure:

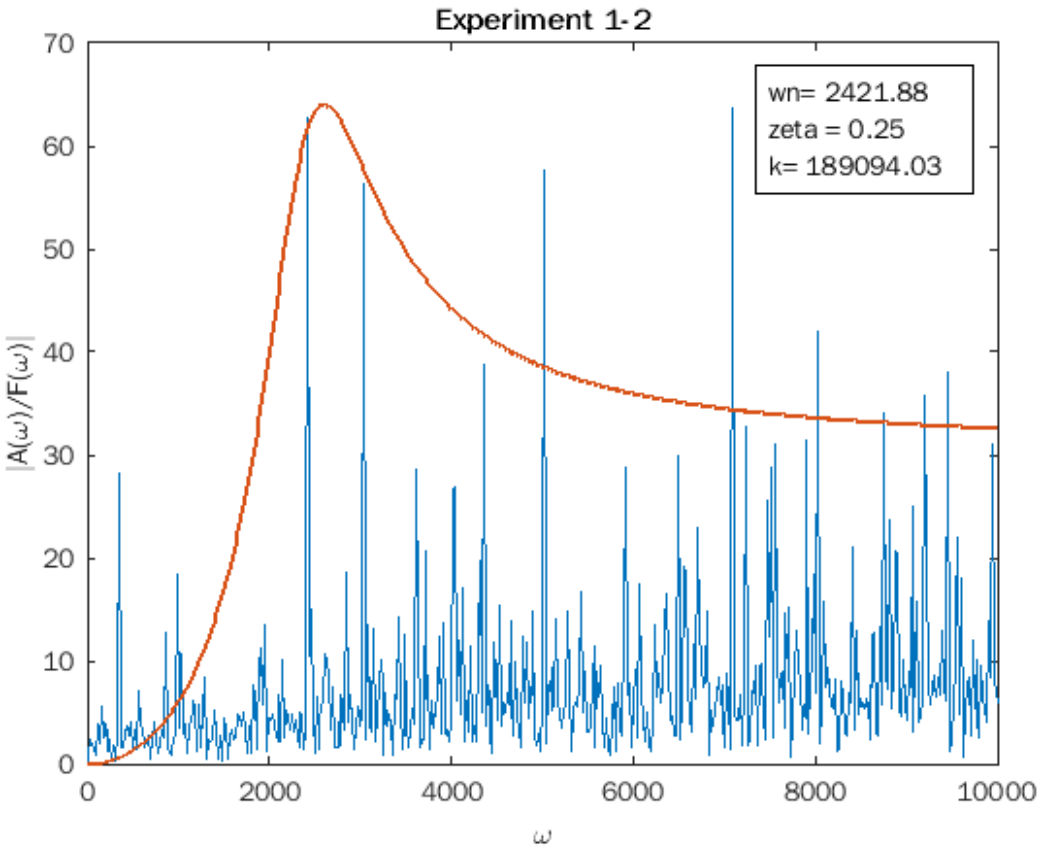
1. Divide the structure into 5 different nodes.
2. Identify the two nodes where you wand to take the measurment using impulse hammer at one node and accelerometer at another node.
3. Place the accelerometer at the node where you want to measure the response.
4. Start the data acquisitiong using the run button at the labview computer software panel.
5. Tap the impact hammer at the one of the selected nodes to excite the structure
6. Save the data of acceleration and impact fors which will be in time domain
7. Repeat the process by selecting the different nodes on the structure.

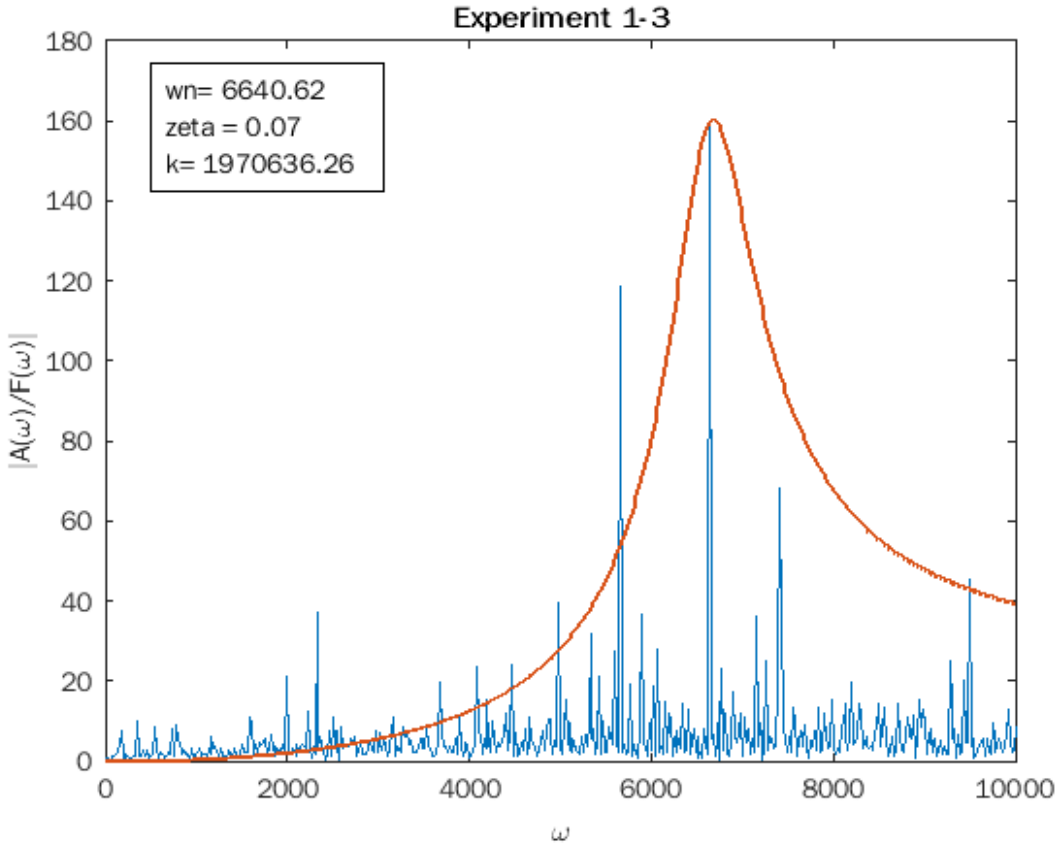
Precautions:

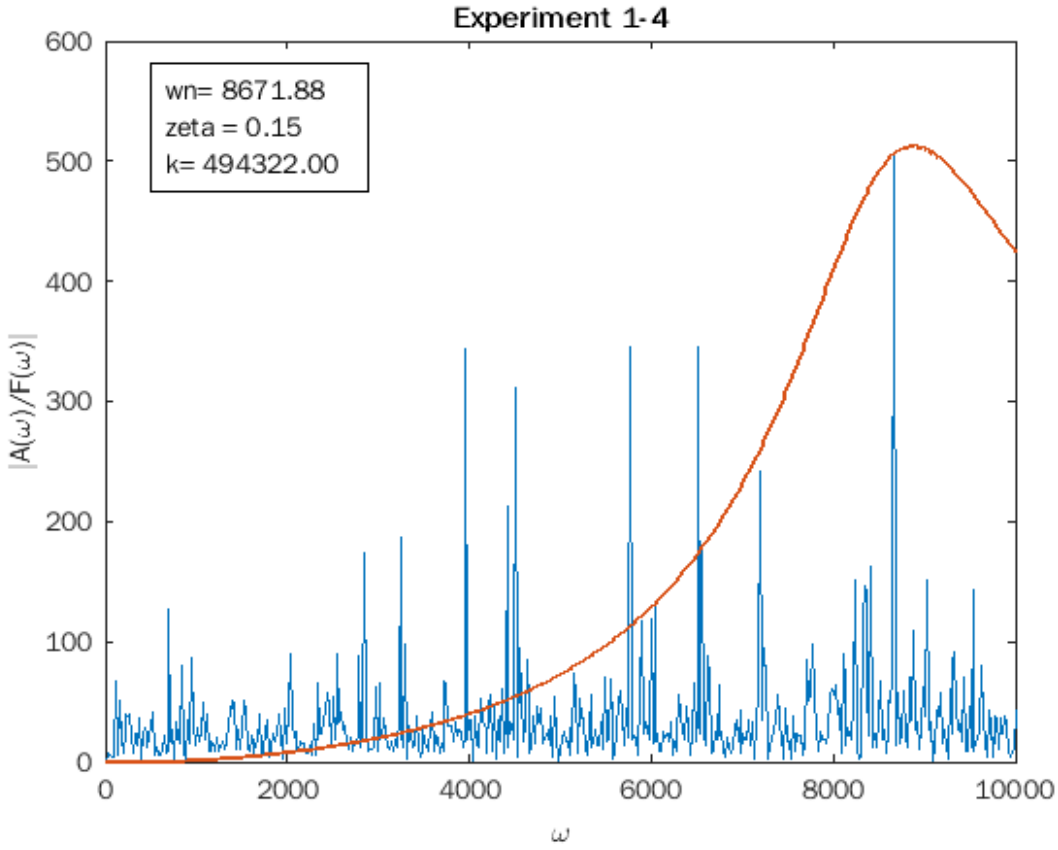
1. To avoid affecting the test result, care must be taken to ensure that the test is not disturbed by any shock or vibration.
2. Make sure that the accelerometer is fixed to the node properly for accurate measurment
3. Strike the hammer very gently on the centre as accurately as possible.

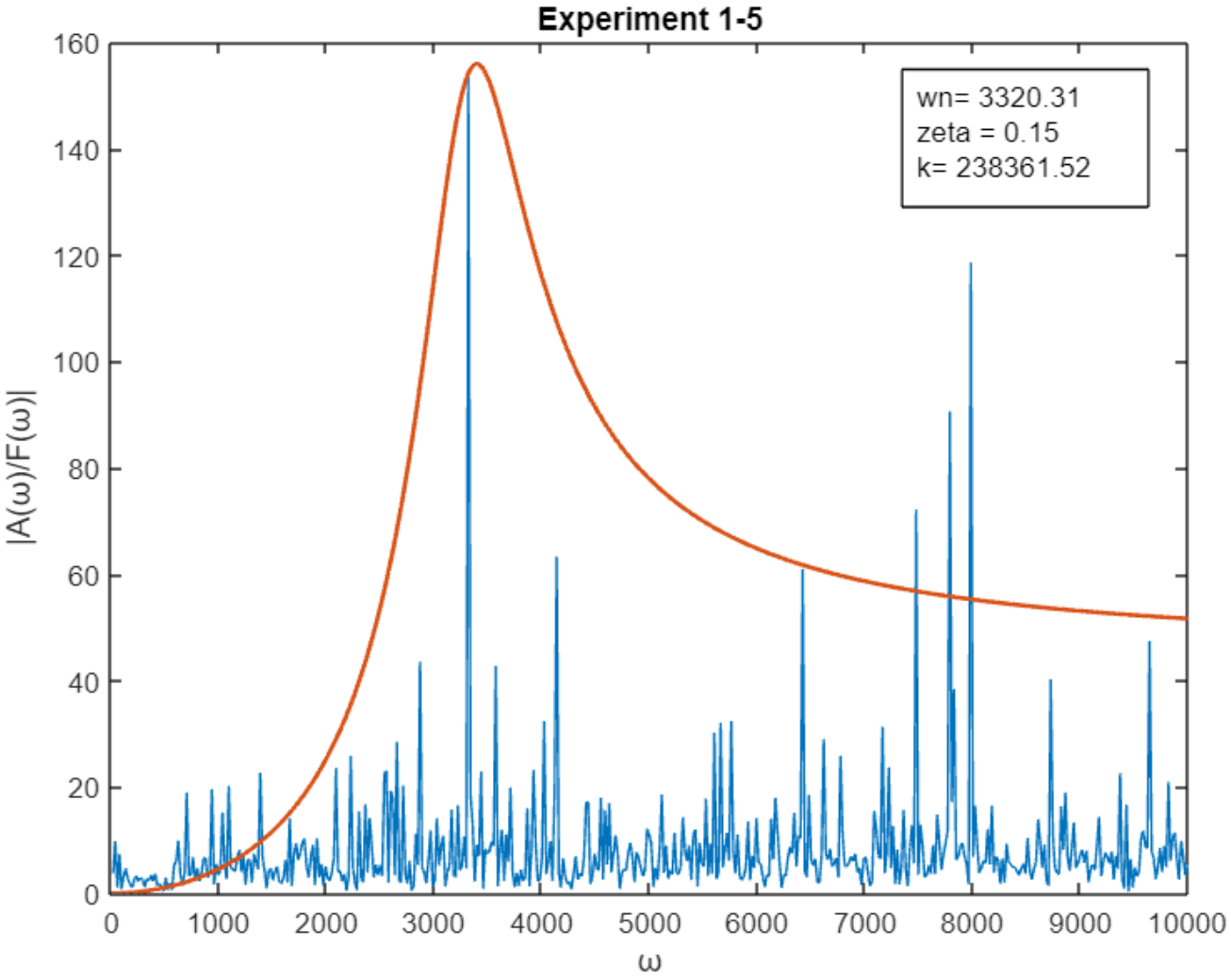
Plots for 10 different datasets:

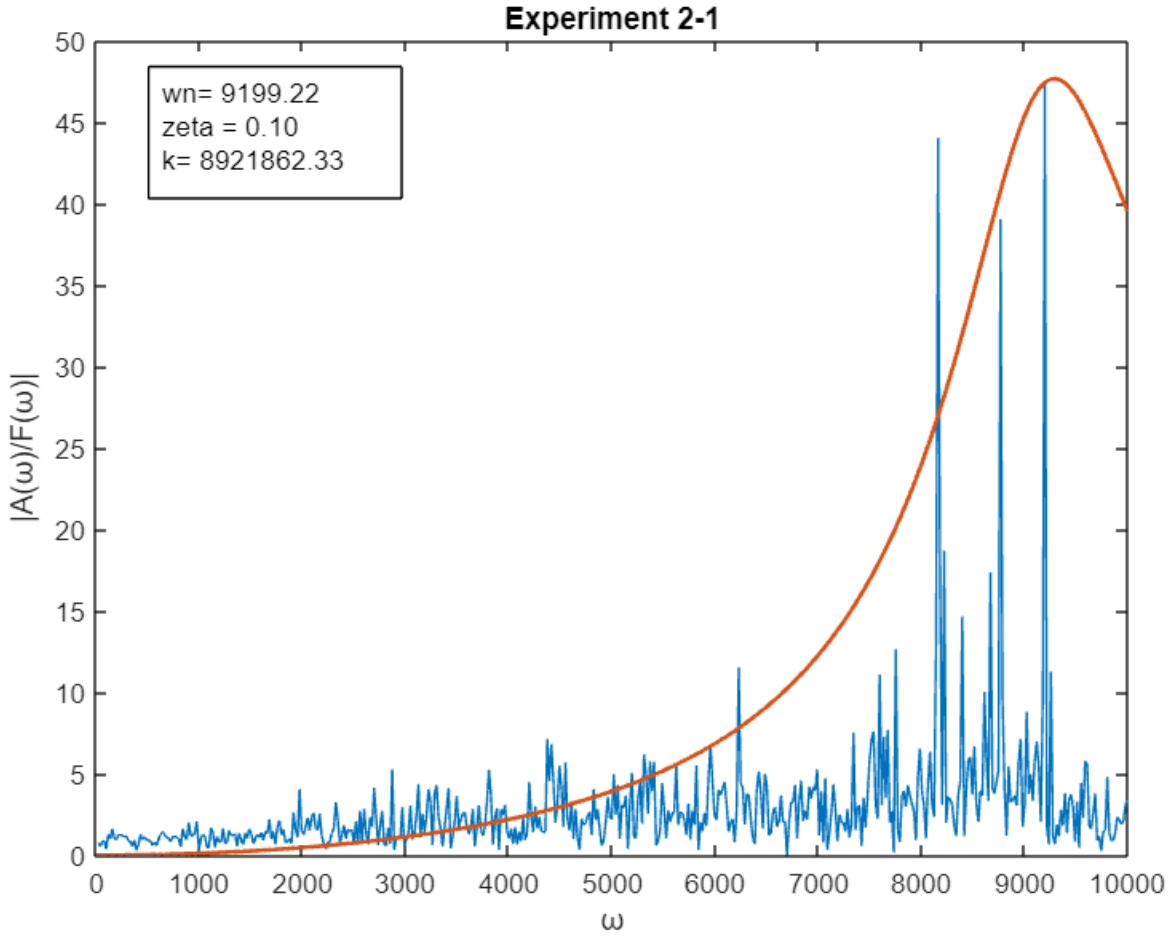


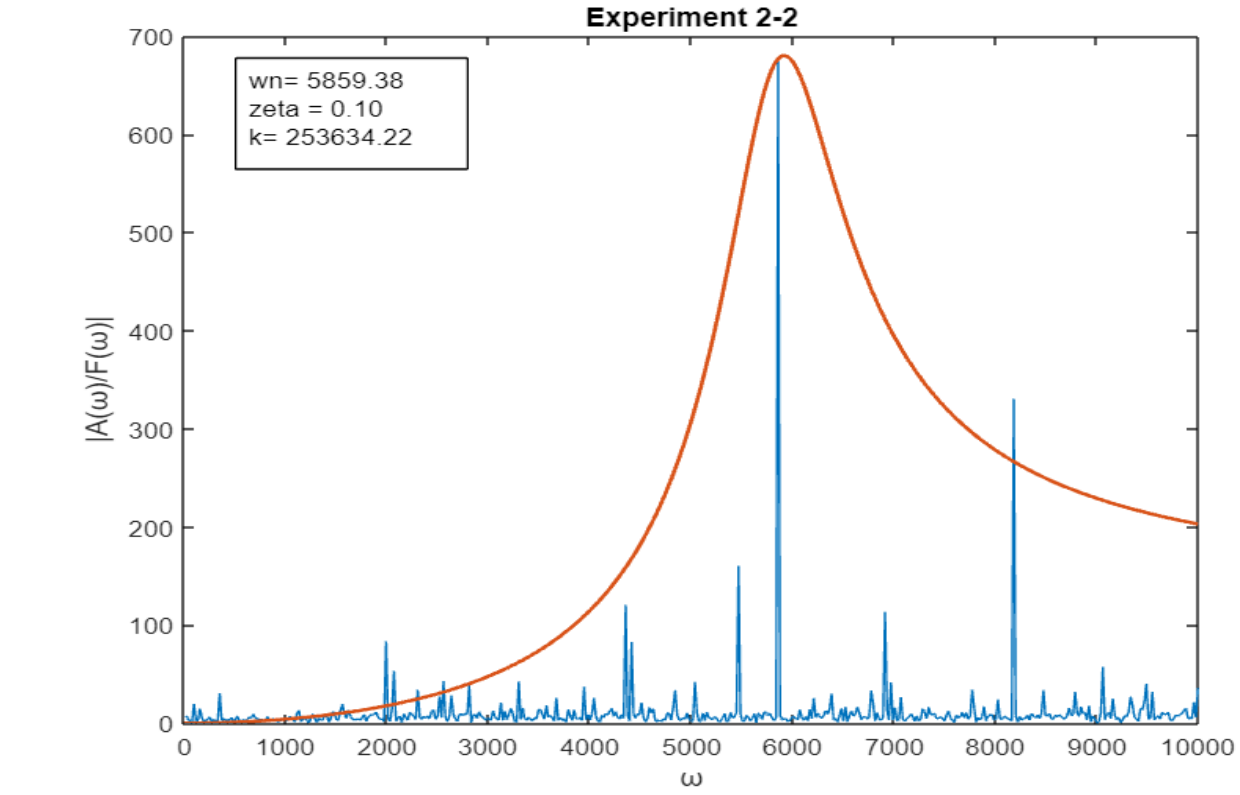


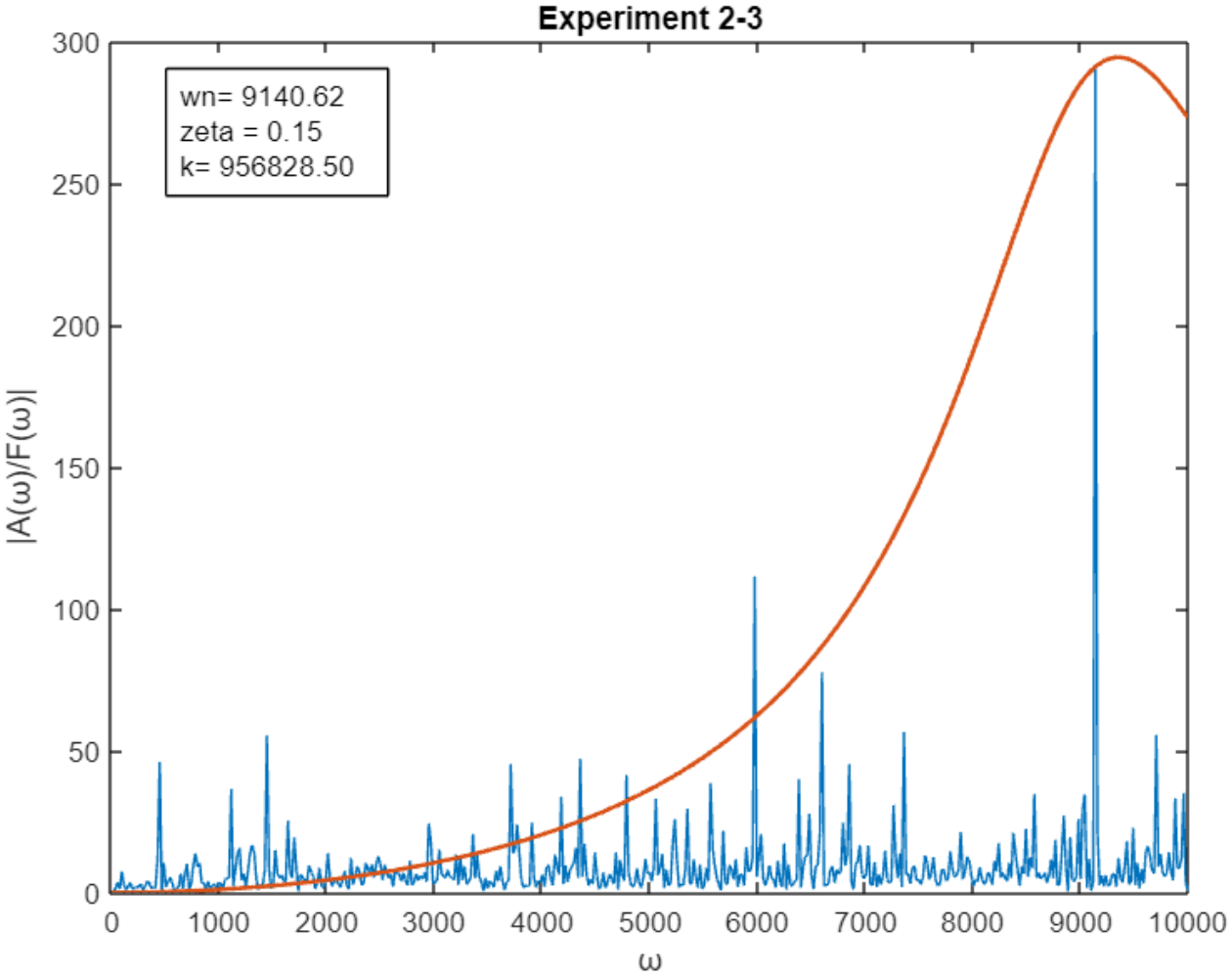

Experiment 1-3
wn= 6640.62
zeta = 0.07
k= 1970636.26
|A(ω)/F(ω)|
ω
0
20
40
60
80
100
120
140
160
180
0
2000
4000
6000
8000
10000

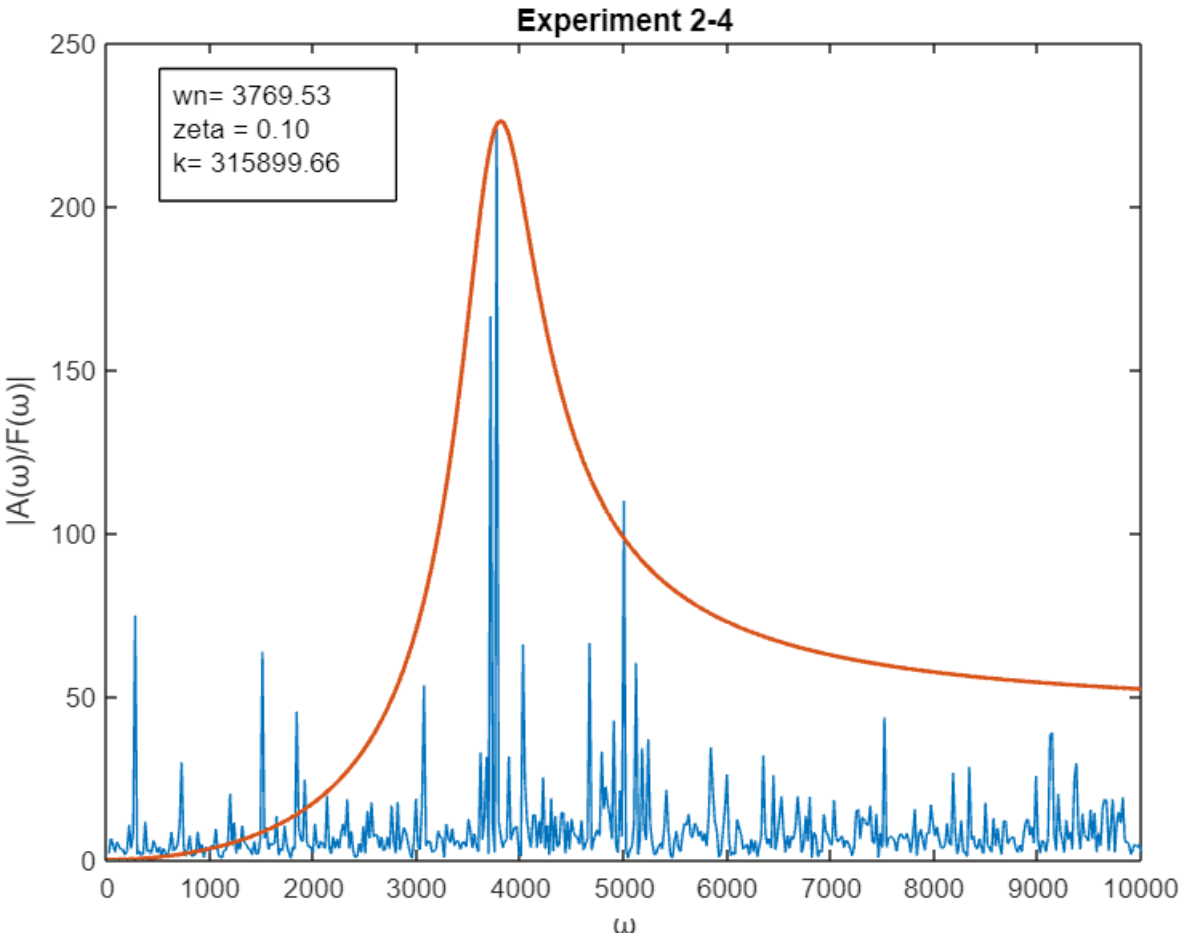

Experiment 1-4
wn= 8671.88
zeta = 0.15
k= 494322.00
|A(ω)/F(ω)|
ω
0
100
200
300
400
500
600
0
2000
4000
6000
8000
10000

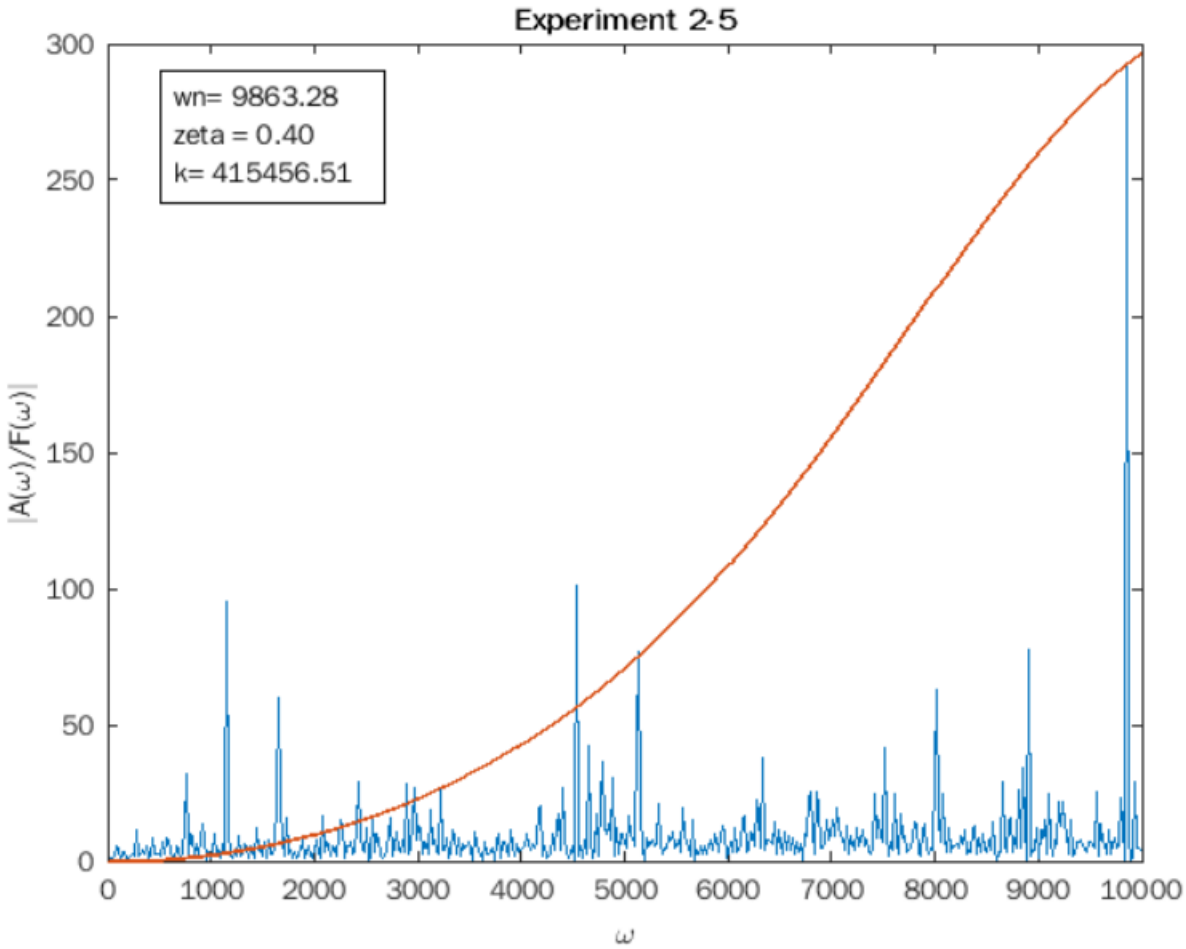

Experiment 1-5
wn= 3320.31
zeta = 0.15
k= 238361.52
|A(ω)/F(ω)|
ω
0
20
40
60
80
100
120
140
160
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000


Experiment 2-1
wn= 9199.22
zeta = 0.10
k= 8921862.33
|A(ω)/F(ω)|
ω
0
5
10
15
20
25
30
35
40
45
50
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000


Experiment 2-2
wn= 5859.38
zeta = 0.10
k= 253634.22
|A(ω)/F(ω)|
ω
0
100
200
300
400
500
600
700
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000


Experiment 2-3
wn= 9140.62
zeta = 0.15
k= 956828.50
|A(ω)/F(ω)|
ω
0
50
100
150
200
250
300
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000


Experiment 2-4
wn= 3769.53
zeta = 0.10
k= 315899.66
|A(ω)/F(ω)|
ω
0
50
100
150
200
250
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000


Experiment 2-5
wn= 9863.28
zeta = 0.40
k= 415456.51
|A(ω)/F(ω)|
ω
0
50
100
150
200
250
300
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000

Conclusions:

- The highest value of zeta is 0.4 for Exp_2-5 with corresponding omega_n= 9863.28 and k= 415456.51
- The Lowest value of zeta is 0.07 for Exp_1-3 with corresponding omega_n= 6640.62 and k= 1970636.26
- The behavior of the system subject to a known force of a known frequency distribution can be estimated.
- We know which frequencies are a danger to a longer structure life.

Sources of Error:

- The impulse force applied by hammer might not be gentle and will not give desired results.
- There might be shock due to some earthly or other disturbances.
- Accelerometser might not be attached properly with the plate.