TECHNICAL MEMORANDUM

Task Report Lab 7, Experimental Modal Analysis
CVEN 315 - Section 500, Sensor Technology

DATE: November 11th, 2019

TO: Sensor Lab, Texas A&M RELLIS Education and Research Campus

COPY TO:

FROM:

1. INTRODUCTION

This technical memorandum addresses Lab 7, Experimental Modal Analysis. This lab consisted of using an impact hammer to excite a suspended metal rod and record the resulting vibrations. By exciting the rod, a modal analysis could then be conducted. The modal parameters such as the eigenfrequency, damping, vibration amplitude, and phase can be determined by exciting the metal rod and analyzing the resulting vibration data. These different eigenmodes are representative of the motion of the rod when excited by the impact hammer. The raw data output from the vibration of the rod is in the time domain, which shows the behavior of a variable as a function of time. Using the Fourier transform, this data can be translated into the frequency domain. Looking at the frequency domain function, the previously mentioned modal parameters are able to be found. These eigenmodes help determine necessary modifications for structures so their natural frequency can be avoided according to Sensor Lab guideline for lab 7 Modal Analysis (2019).

2. EXPERIMENTAL PROGRAM

Lab 7 outlined a procedure for how to find modal parameters of a metal rod by clamping two ends of the rod and measuring the vibrations when the rod was excited in different locations. A sensor known as an accelerometer is attached halfway between the clamps of the metal rod. Accelerometers are devices that measure acceleration of an object. They are useful for sensing vibrations in a structure like the metal rod used in this experiment. By hitting the metal rod in different positions starting near one clamp and progressing along the rod to the second clamp, the accelerometer measures the vibration response for each hit. The data output represents the vibrational behavior of the rod as a function of time, but to gather any meaningful observations the data needs to be translated to the frequency domain. This is done by using the Fourier transform. The Fourier transform works by decomposing any waveform into sinusoidal components. In one sentence, the Fourier transform takes a time based wave, measures every possible cycle, and returns the overall characteristics of the waveform, such as amplitude, offset, & rotation speed for every cycle found ("An Interactive Guide To The Fourier Transform"). Once the Fourier transform is performed, the modal parameters can be determined using a curve fitting method. Another important characteristic measured in this lab is the damping ratio, which is a value used to describe how oscillations or vibrations dissipate after an object is excited. It is often used in structural engineering to describe how structures will oscillate in the wind or under other natural phenomenon. In Lab 7, the damping ratio of the metal rod was found using the vibrational data measured.

2.1 Experimental Setup

For this experiment, a variety of tools and equipment were necessary to perform the tests. The first item needed to perform the test is the metal rod being tested on. Two clamps were needed to secure the rod on the two ends, suspending the rod from these two points. Figure 1 below shows the set up on one of the ends of the metal rod.

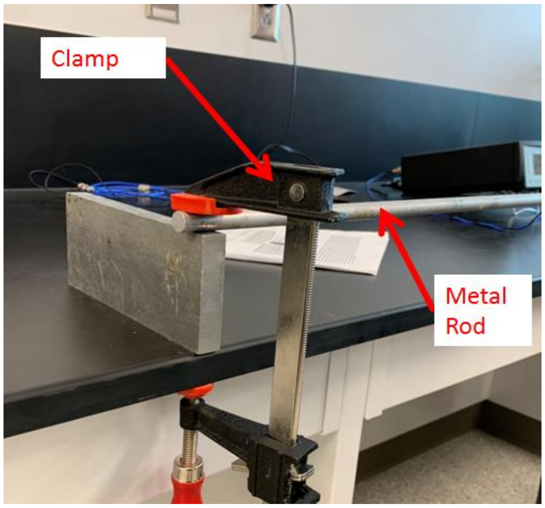

Figure 1: Metal Rod and Clamp

The next tool needed was the accelerometer to measure the vibrations of the rod. To connect the accelerometer onto the rod, tape was used to secure it. To excite the rod, an impact hammer is the tool used to hit the rod. Figure 2 below shows the impact hammer and the accelerometer placement on the rod.

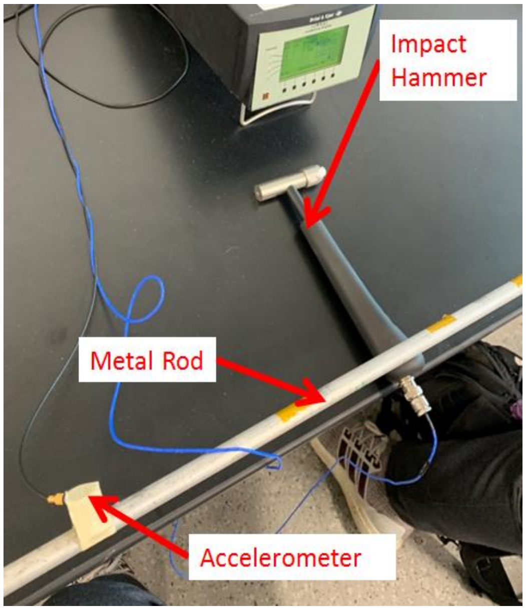

Figure 2: Impact Hammer and Accelerometer

A laptop with LabVIEW software was also needed to record the data and graph it. Matlab and excel were the software tools used to perform the Fourier transform and to analyze the data to find the modal parameters.

2.2 Experimental Procedure

The first part of the lab consisted of connecting the accelerometer onto the metal rod. This was done just by using tape and placing the accelerometer in the middle of the rod. After, the accelerometer was connected to a computer with a LabVIEW program that could record the data and graph it accordingly. Once this was done, the start of the experiment could begin.

The first step was to excite the rod at a distance L/12 (where L is the total length of the rod) from the left end where the one of the clamps was located. The way the rod was excited was to use the impact hammer to hit the same spot 10 consecutive times with a few seconds in between each hit and record the resulting vibrations. Once this was done, the data for those 10 hits was recorded and saved. There were 6 more locations excited on the rod by the hammer, each being hit 10 times and the data was recorded. The other locations tested were L/6, L/4, L/3, 5L/12, and L/2 from the left end of the rod. Each location tested resulted in vibrational data output that is shown below. Using this data, the modal parameters as well as the damping coefficient were found using the Fourier transform and other relationships. Those are summarized in the results section.

2.3 Experimental Results

Set of data was collected for each point along the beam and the values of the frequency were calculated using the formula below.

$$A = \sqrt{Re^2 + Im^2} \qquad (1)$$

where *A* is amplitude, *Re* is real part, and *Im* is imaginary part. The amplitude was then plotted against its respective frequency starting at zero and a time step of .625 Hz (Figures 3 to Figure 8).

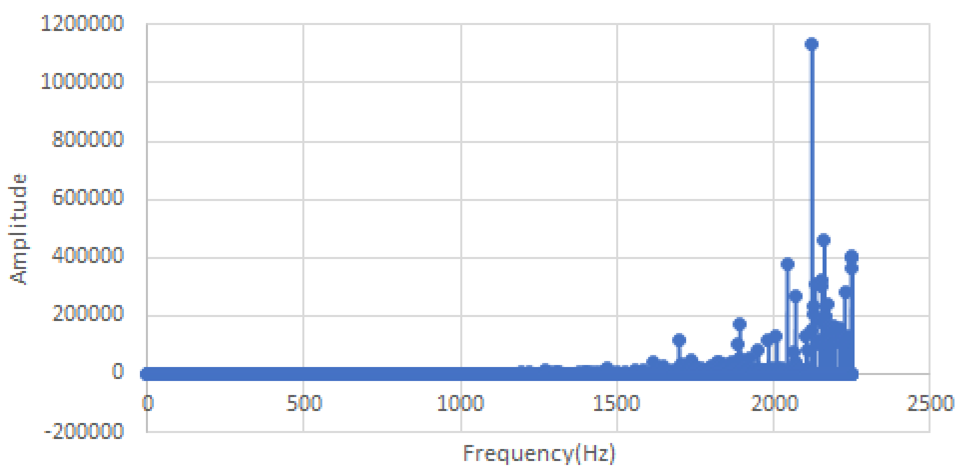

Figure 3: Frequency vs. Amplitude graph for point 1

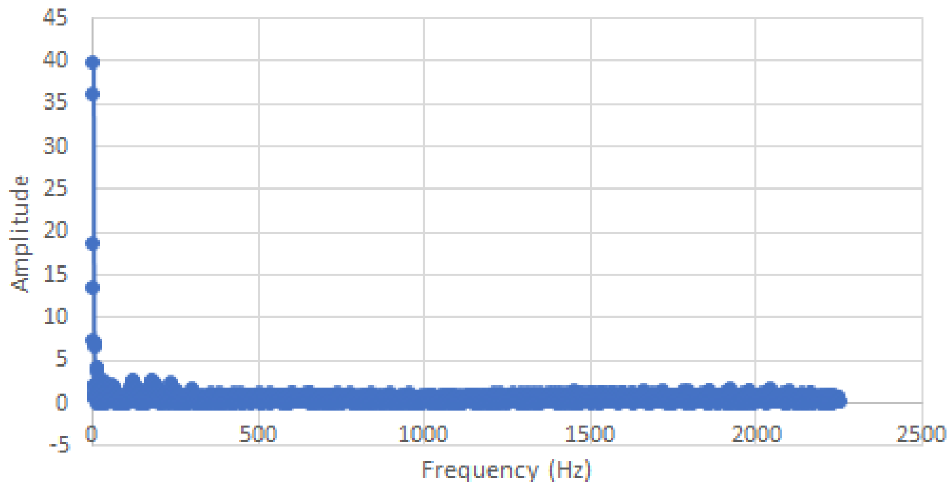

Figure 4: Frequency vs. Amplitude graph for point 2

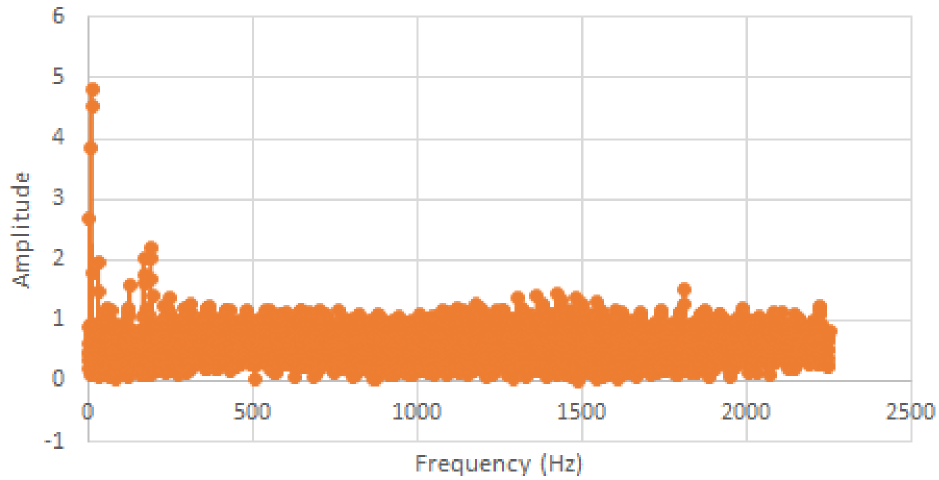

Figure 5: Frequency vs. Amplitude graph for point 3

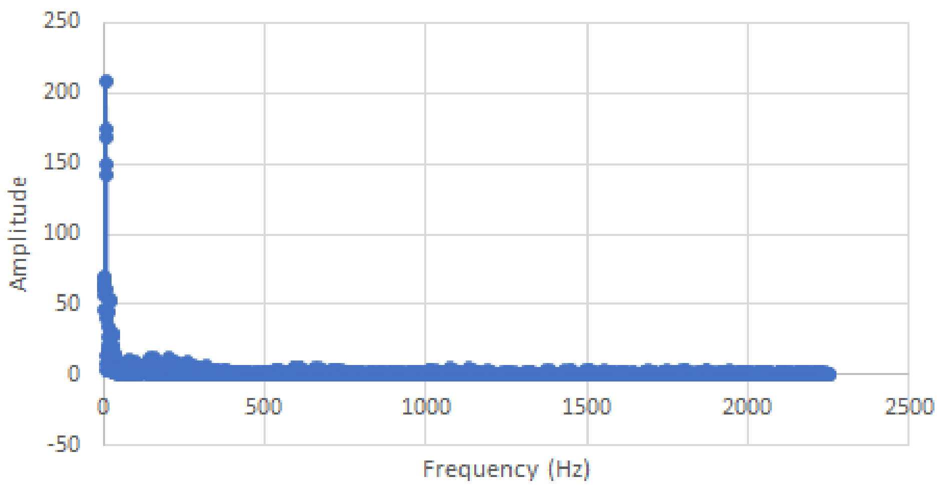

Figure 6: Frequency vs. Amplitude graph for point 4

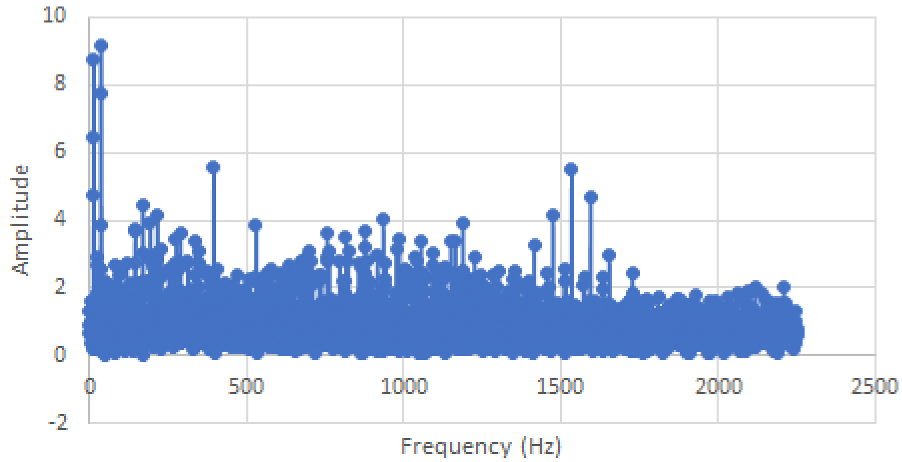

Figure 7: Frequency vs. Amplitude graph for point 5

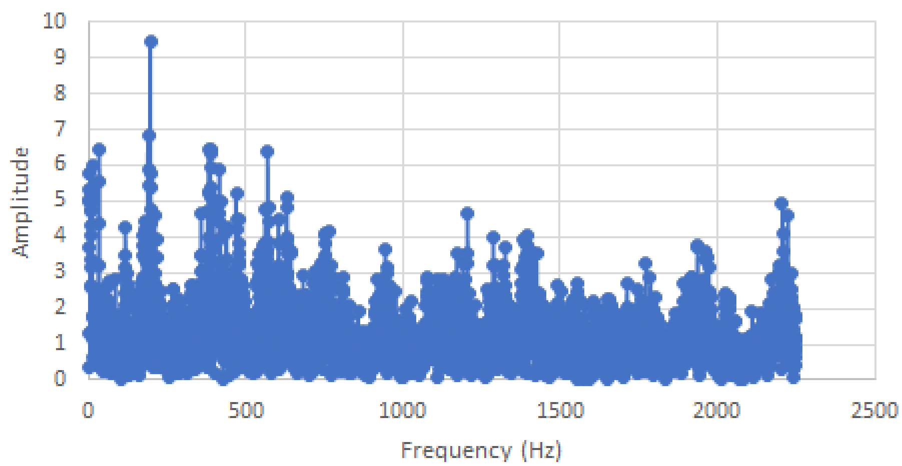

Figure 8: Frequency vs. Amplitude graph for point 6

We then identified the max amplitude for each point as well as the paired frequency which represented the natural frequency for each location, see Table 1.

Table 1: Natural Frequencies for All Point Locations

Point	Natural Frequency (Hz)	Amplitude
1	2120.6	1132040
2	0.625	39.9
3	11.2	4.82
4	6.87	209
5	35.6	9.14
6	197.5	9.43

After analyzing the data the expected frequencies for point 1 was very different and far from the rest of the data leading us to assume there is most likely a human or equipment error. Our team member could have accidentally hit the bar at a wrong position since it was the first point or because it hadn't been used since the day prior the equipment could have recorded an invalid number. The overall and trend to note is that as we move into towards the center of the beam, that is as the point location increases, so does the natural frequency in the beam.

3. CONCLUSION

- Using an impact hammer to excite a suspended metal rod and record the resulting vibrations.
- These vibrations can then be analyzed as natural frequencies.
- It is important to identify these natural frequencies so they can either be avoided or be used to diagnose the resonance of a structure.
- Resonance is the excitation of a system at its natural frequency and also deals with the vibration of a system
- Controlling this can reduce the risk of fatigue or failure of a structure.

REFERENCES

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