Characterization of acoustic resonant nodes and antinodes on Chladni plates

Kenneth Domingo, Mary Chris Go, and Shawntel Joy Leonardo

National Institute of Physics, University of the Philippines, Diliman, Quezon City

Abstract

We qualitatively characterize the patterns formed by sand on Chladni plates by exploring the acoustic resonant modes of differently shaped plates. Three metal plates of different shapes, namely square, circular, violin, were subjected to a range of frequencies to observe the patterns generated. Different patterns were shown as the frequency is varied with constant amplitude. Visible nodes indicate how to sound waves behave while interacting with the plate.

Keywords: Chladni plates, nodes, antinodes, acoustic resonance.

1 Introduction

Sounds are produced when objects vibrate. When objects are disturbed e.g. when objects are hit, struck, plucked, or strummed, they vibrate at a particular set of frequency [1]. This particular frequency at which objects tend to vibrate is called natural frequency. On the other hand, a vibrating object can influence a second object intro vibrating at the same natural frequency and this is called resonance, the vibrations cause standing wave to be formed within the object [2].

A standing wave is a vibrational pattern created when the vibrational frequency of a source causes reflected waves from one end of the medium to interfere with incident waves from the source [3].The result of the interference is that specific points along the medium appear to be standing still (nodal points) while other points vibrated back and forth (antinodal points) [3].

In summary, the natural frequencies of an object are merely the harmonic frequencies at which standing wave patterns are established within the object[3]. In this experiment, we will visualizes sound in an object through Chladni plates. The objective of this experiment is to study the vibration of the plates and how it affects patterns on a square plate, circular plate, and a violin plate.

2 Methodology

The Chladni plate was set-up using a function generator to vary frequencies, a speaker as the audio output, an amplifier as audio booster, a metal sheets in square, circular, and violin shape as the resonant object, and sand for visualization.

The metal plate is made to vibrate by direct contact with the speaker, this was done by securing the plates in the middle rod of the speaker using bolts and nuts. The set-up was placed on a flat surface to ensure that the plates are balanced and steady. The frequency was then varied from 0Hz to 2KHz to search for normal modes where patterns develop.

3 Results and Discussion

We were able to capture different patterns. From the set up, it was made easier to see the difference per change in the amplitude. Sound travels in waves and from the experiment, we have confirmed how sound waves can travel through solids. The patterns created on the metal pan are indications of the response to the vibrations. We also saw that patterns were indications that sound waves are intact. For each pattern, areas of collected and scattered sand were seen. For the scattered part, this indicated that sound waves moved the sand away and the areas where salt were being gathered were location between waves. These are usually called nodes. As we put sprinkles of sand to the vibrating plate, the sand were being thrown off to specific regions and piled up.

We were able to try three shapes of plate. These affects the vibration patterns produced seeing more unique patterns for wider surface area. Also, we tried changing the frequency, and this made a drastic difference of the pattern given.

4 Conclusions

As the goal of this paper is to be able to showcase different sand patterns depending on the frequency given with constant amplitude, we were able to make sound waves visible (see Appendix for all the photos). These resonance patterns proved many facts about sound such as they travel in solids, the appearance of nodes, and how they travel in waves.

The problem with our set up is the imbalance plate. To make patters more visible, we recommend a more flat base. This can be achieved by using a level to check. Also, experimenters can also try to use different parts of metal plates. In addition to this, it is important that the experiment will be done inside a closed room without other loud noises as this might affect produced patterns. Thinner metal plates can be also used.

References

[1] R. Taylor, and H. Gustav MuellerYoung(2016). *Fitting and Dispensing Hearing Aids* (2nd ed.), Acoustics at the Speed of Sound.

[2] Natural Frequency. Retrieved 26 February 2019, from *Physics Classroom*: https://www.physicsclassroom.com/class/sound/Lesson-4/Forced-Vibration.

[3] Natural Frequency. Retrieved 26 February 2019, from *Physics Classroom*: https://www.physicsclassroom.com/class/sound/Lesson-4/Standing-Wave-Patterns.