LAB 4: Vibrating Chladni Plates

REQUIRED READINGS: **Vibrating Systems p.74-75, Percussion instruments p. 299-306**

Theory:

This experiment is designed to show how the geometry of an object affects the patterns of waves formed when the object is vibrated. So far you have dealt mainly with vibrating columns of air or gas. No matter what is vibrating the same rules apply. For example, if the edges of a solid are not free to vibrate then they act just like the closed end of a column of air and therefore must form displacement nodes in the wave pattern. They would therefore have an anti-node at the center and a node at the edge making the smallest fraction of a wave that the plate could contain to be ¼ of a wave. If, in contrast, the edges of a solid are free to vibrate then they act just like the open end of a column of air and therefore must form displacement anti-nodes in the wave pattern. They would therefore have an anti-node at the center and an anti-node at the edge making the smallest fraction of a wave that the plate could contain to be ½ of a wave.

The main difference in this experiment from what you have previously encountered is that the source of the vibration will not be coming from one end of a column, but from the center of the plates. You know from class that sound waves, or vibrations, travel in all directions from the source. So, it should not be a surprise that the vibrations caused at the center of the plates will travel outward from the center in circles until they hit a change of medium and then bounce back. If the frequency is just right then the waves travelling out and back will create a standing wave, or resonance. We will be able to see this by watching sand bounce on the surface of the plates. Since circular plates have the same geometry as the outgoing waves, the change in medium comes as a circle and thus, the waves that bounce back are also circular. Therefore, the standing waves on a circular plate look like circles.

Equipment:

You will need a function generator, a Chladni driver with four detachable plates, some sand and two banana clips. The banana clips should lead directly from the generator to the driver. Before turning on the generator, be sure that both the amplitude and the frequency knobs are set to zero.

WARNING! The wave driver is simply a speaker with a driving rod attached. Therefore, if you place significant force on this when attaching or removing the plate, it will damage the speaker diaphragm, and BREAK the wave driver. Please be **VERY GENTLE** when attaching and removing the plates.

There is a ‘‘stop ring’’ on the shaft of the driver. If the voltage applied to the driver is too large this ring will impact against the metal plate giving an audible warning – immediately reduce the voltage to avoid damaging the wave driver. In other words, turn the amplitude knob down if you hear this warning sound!

Procedure:

Attach the circular plate to the driver by gently removing the screw from the top of the driving rod, placing the plate on the rod and then returning the screw. Make sure that the driver is sitting in the box provided for it. We want to recycle as much of the sand as possible and by keeping the driver in the box we will be able to keep a lot of the sand. Turn the generator on and turn the amplitude knob about a third of the way up. Starting with the frequency at about 100 Hz slowly increase the frequency until you hear a resonance (the point where the sound is the loudest. Reduce the amplitude and sprinkle a SMALL amount of sand onto the plate.

1) Sketch the resonance patterns and write down the frequency.

Replace the circular plate with the square plate and start again.

2) Sketch the resonance patterns and write down the frequency.
3) Increase the frequency slowly to find the next resonances. Find at least 3 more resonances. For each resonance sketch the resonance patterns and write down the frequency.

Repeat for the triangular shaped plate.

4) Sketch the resonance patterns and write down the frequency.

5) Increase the frequency slowly to find the next resonances. Find at least 3 more resonances. For each resonance sketch the resonance patterns and write down the frequency.

Repeat for the violin shaped plate.

6) Sketch the resonance patterns and write down the frequency.

7) Increase the frequency slowly to find the next resonances. Find at least **6** more resonances. For each resonance sketch the resonance patterns and write down the frequency.

Analysis:

8) Did the pattern for the circular plate come out as you expected?

9) Comment on any patterns or general features you notice for the square plate.

10) Comment on any patterns or general features you notice for the triangular plate.

11) Comment on any patterns or general features you notice for the violin shaped plate.

12) Did the sand gather at the nodes or anti-nodes of displacement?

13) Find the relationship between the resonant frequencies for the square plate.

14) Find the relationship between the resonant frequencies for the triangular plate.

15) Find the relationship between the resonant frequencies the violin shaped plate.

16) Is there any relation between the resonant frequencies and the harmonic series that we've been studying?

17) Do you think that real violins have the same nodal patterns that you observed on the plate? (Think about the fact that our plates have free edges.) If yes, why? If no, why not?

18) What are the differences that make violins more pleasing to hear than, say, a box with a hole in it? (Think about the patterns you saw and the number of resonances you found.)

19) Were you surprised to see circular patterns on non-circular plates? Why or why not?