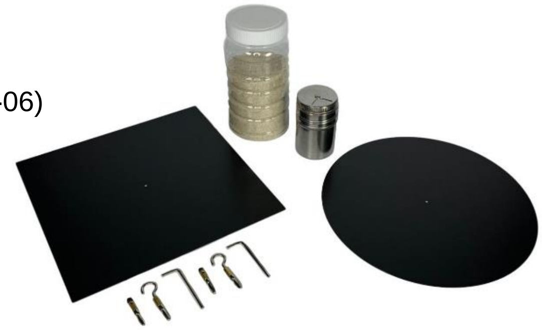
# Chladni Plates Kit

P7-1500-04

INSTRUCTIONAL GUIDE

## Contents

- Square 24 cm Plate
- Round 24 cm diameter Plate
- Two replacement allen keys and holders (P7-1500-06)
- Bottle with extra-fine sand
- Shaker bottle (empty)



**Required for activity:**

- Sine Wave Generator (P7-2000)
- Mechanical Wave Driver (P7-1000)

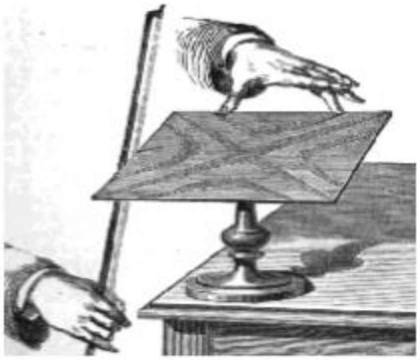
## Background

German physicist Ernest Chladni (1756-1827) observed that metal plates display patterns as they vibrate and described this result as a function of harmonic frequencies. It is a lesson in standing waves in two dimensions; vibration in the plate sets up a pattern based on the frequency and how it is reflected at the ends. However, not every frequency causes a pattern because not every wavelength fits on the plate. Resonances occur at different frequencies and that there are several possible. This is an important lesson in the Physics of Sound and violins, guitars, and pianos have to take these resonances into account in the shape of their bodies.

If you are going to reference standing waves, it is important to note that the end points are anti-nodes. You will notice that the sand never builds up along the rim of the plates because that is the location where the wave is vibrating the most. This is different from guitar strings because the ends are nodes; the process is to waves on a hanging string or waves in a double open instrument, such as an oboe, pan pipe, or **Boomwhacker**.

## Introduction

Originally the plate was driven with a violin bow. This method has its downsides, because it can be difficult, limits your frequency options, and requires a lot of practice. Now, the Chladni Plate is vibrated with a mechanical driver.



*An early illustration of a Chladni Plate. Note that the thumb and fingers are used to help place the nodal lines where little movement occurs.*

To start, secure the metal clip through the plate and attach it to the Mechanical Driver shaft. The connection must be very secure to transmit the vibrations. A medium amplitude should work for most resonances. Several patterns will be produced. These standing waves are made visible with sand because the amplitude is largest at the antinodes which pushes the sand away toward nodes to create “nodal lines.”

## Experimenting

It is helpful to secure the drive shaft and use medium amplitudes as you search for resonances. Move through a range of frequencies while adding small amounts of sand until you think you have found one. A larger amount of sand may change the effective mass of the plate and cause the frequencies to vary. Try to balance the plate and driver so that little sand pours off the edges.

The lower frequencies are further spaced, but the higher frequencies are more complex and beautiful.

The speed of sound can be measured in the plate itself. Find the frequency from the driver and then measure the wavelength as a node to node (sand to sand) distance.

A reasonable question to discover is “Is the Speed of Sound Constant in the Plate?” The reason that the speed of sound might not be constant is that at higher frequencies and higher amplitudes, the plate vibrates non-linearly. (This is similar to how a prism separates light by color; the speed of light waves is different at different frequencies.)

However, in the plate, the effect can even be complicated more by the damping of the wave. A wave that is vibrating in a medium that reduces its amplitude measurably as it travels is said to be “damped.” A good example is how a guitar string will vibrate for a long time after being plucked, unless you put your finger on it, which causes it to dampen faster. Also, some bells dampen faster than others. Higher frequencies tend to dampen more quickly, too.

If several students are performing the experiment, it might be a good idea to have the students take pictures of the various patterns they produce and note the frequency. Then they can create a (digital) portfolio of their results.

Measuring with the round plate should generate results that are more faithful to the “speed of sound is constant” model. This will be visible in the nodes (white stripes) being equally spaced.

## Conclusions

The Chladni Plate provides an opportunity to teach an advanced concept in the Physics of Sound while at the same time performing a demonstration that is visually stunning. The idea of nodes and antinodes (and the idea that these reveal wavelength) should be emphasized throughout the lesson.

A common missed opportunity is to quantify this experiment, and reinforce the $v=f$ formula. The details of the Chladni rules may only serve to over complicate this demonstration, but might be appropriate in an advanced class on the Physics of Sound. (See references for more details on these.)

## Related Products

**Longitudinal Wave Spring (P7-1500-01)** Experiment with springs, oscillations, and wave theory! A great way to demonstrate and visualize the nodes and antinodes on longitudinal waves.

**Transverse Wave String (P7-1500-03)** This Wave string is ideal for demonstrating standing waves.

**Metal Resonance Strips (P7-1500-05)** Metal Resonance Strips demonstrate resonant modes as a function of length. As vibration frequency increases, shorter length strips reach resonance and visibly oscillate.