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## Standing Wave Demonstration Kit #WVGENKIT

### Warning:

- **Not a toy; use only in a laboratory or educational setting.**
- **California Proposition 65 Warning: This product can expose you to chemicals including lead, nickel, and acrylonitrile, which are known to the State of California to cause cancer, birth defects, or other reproductive harm. For more information go to [www.P65Warnings.ca.gov](http://www.P65Warnings.ca.gov).**



### Introduction

Waves are an essential part of physics. They are a major means of energy transfer. Mechanical waves are waves of energy traveling through matter, while electromagnetic waves are waves made of charged particles that create oscillating electromagnetic fields.

In the study of mechanical waves, Ernst Chladni and Franz Melde both made massive contributions. The work of Chladni helped pioneer the field of acoustics when he studied the movement of vibration through a stiff surface. Melde, on the other hand, put a name to the phenomena of standing waves when he observed the

vibrations of a tuning fork traveling through a taut string. Standing waves refer to waves which have one or more immobile points that the wave oscillates around. They are caused either by interference between two waves traveling in opposite directions to each other or by one wave moving through a medium that is moving in the opposite direction.

This kit allows you to replicate the famous experiments of these two revolutionary scientists so that you can follow along with their discoveries and see how standing waves work. The following pages aim to guide you through these experiments and explain the science behind them.



## Components

1. Variable Frequency Generator
2. Spool of String
3. Support Stand
4. Steel Rod
5. Power Cord
6. Chladni Plate
7. Vibration Generator
8. Connector Cords
9. Weights
10. Fastening Piece
11. Boss Head Clamp
12. Frictionless-Pulley with Clamp
13. Pan



Parts List

## Vibration Generator Operation

The Vibration Generator is an essential piece to this kit. In the original experiment with Chladni Plates, Ernst Chladni used a violin bow to produce resonating vibrations in his plate, Likewise, Franz Melde used a tuning fork to create the vibrations for his standing waves demonstration. For this kit, our vibration generator substitutes the bow and the tuning fork. In combination with the Variable Frequency Generator, you will be able to reproduce Melde's famous experiment and see some of the possible patterns that a Chladni plate can produce.

This apparatus essentially works on the same principle that runs a loudspeaker. A magnet and a bobbin within the device are able to produce steady vibrations when an alternating electric current passes through them. With the help of our Variable Frequency Generator, this Vibration Generator can produce waves with frequencies between 15Hz and 320Hz.

The generator comes equipped with two 4mm sockets for banana plugs, a lock for the piston to prevent damage to moving parts during storage, a fuse for electrical safety, and a piston with a 4mm hole on top for attaching objects to the apparatus.

## Maintenance and Precautions

- Move the locking mechanism to the LOCK position when mounting accessories or while storing.
- Move the locking mechanism to UNLOCK before turning the Variable Frequency Generator on.
- Do not use any frequency generator of your own with an input signal exceeding 1A.
- Replace the blown fuse with a similar rated fuse - 1A, 250V, slow blow. When replacing the fuse, ensure that the fuse holder is fully tightened.

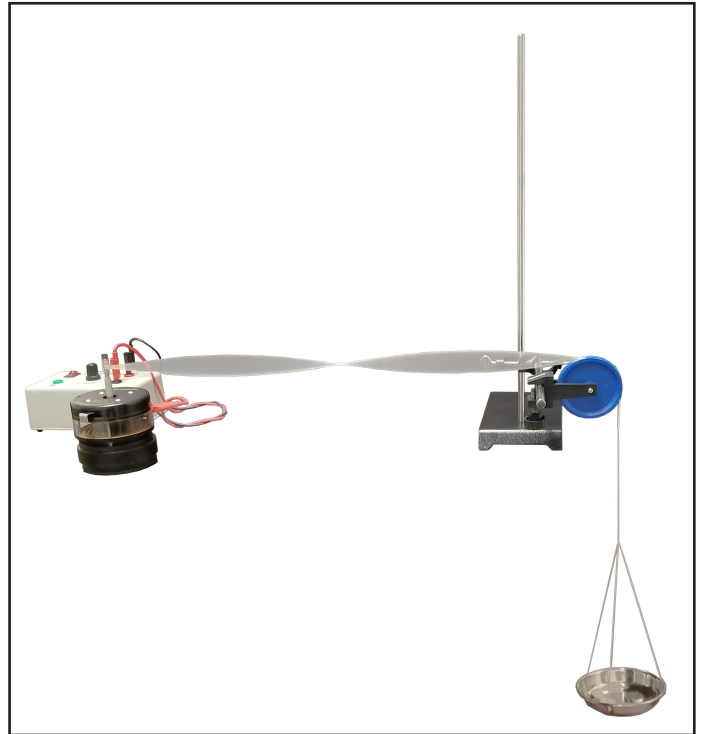


## Melde's Experiment

While standing waves were first noticed by Michael Faraday in 1831, the phenomenon didn't have a name until Franz Melde began demonstrating them with his famous experiment in the 1860s. Though our experiment uses a vibration generator to provide clear and consistent results, his original setup used a tuning fork attached to a string to create the vibrations necessary to produce demonstrable standing waves. Below you will learn how to replicate his experiment for yourself.

### Setting Up the Experiment

1. Use the picture to the right as a guide to assure you have set up your experiment properly.
2. Measure out about 4-feet of string. Tie one end to the weight pan and the other to the fastening piece included in the kit. Place the fastening piece with the string attached into the vibration generator. Don't forget to keep the generator locked until you are done with set up.
3. With its switch set to OFF, plug the variable frequency generator into the wall. Plug your connecting cords into the frequency generator and the vibration generator.
4. Screw the threaded end of the support stand rod into the base.
5. Attach your boss head clamp to the support stand, and then secure the steel rod to the other end of the boss head so that the steel rod is perpendicular to the support stand rod.
6. Attach your pulley to the steel rod. Make sure that it is lined up with the vibration generator.
7. Drape the string attached to the generator and the weight pan over the pulley. Adjust the boss head clamp so that the string is level to the table top.



### Replicating the Experiment

1. With the experiment set up as described above, turn the switch on the variable frequency generator to ON.
2. Adjust the frequency knob until you see standing waves form.
3. Experiment with different variables such as the length of the string, the weight in the pan, or the frequency of the vibrations going through the strings. Discuss the relationship between these variables.



## Performing Chladni's Plate Experiment

Ernst Chladni is famous for his plate experiment, among other things. Because of this experiment, he is often given the title of the Father of Acoustics. In his famous experiment, he was studying vibrations in a solid body by moving a violin bow across a metal plate that had been secured to a surface. He found that all objects have certain “natural frequencies” that cause vibrations to resonate within that object. These frequencies are known as “harmonics.” When an object is vibrating at a harmonic frequency, standing waves form in the object. Chladni was able to demonstrate this discovery by showing that when the resonating object is covered in a thin layer of sand, the sand will settle onto the portions of the object not vibrating because that is the location of the node in the standing wave. Rather than a violin bow, this version of the demonstration uses our vibration generator.

1. With its switch set to OFF, plug the variable frequency generator into the wall. Plug your connecting cords into the frequency generator and the vibration generator.
2. Check that your vibration generator is set to LOCK.
3. Insert the rod in the center of the plate into the piston on the vibration generator.
4. Unlock the vibration generator, check that the dial on the frequency generator is on its lowest setting, and turn the switch on the frequency generator to ON.
5. Spread an uneven layer of sand (not included) on top of the vibrating plate, and slowly turn the dial to increase the frequency of the vibrations.
6. As you turn the dial, look for a pattern to form. You should be able to produce at least two patterns on the plate using the frequency generator included with the kit. Which frequencies produce these patterns?

