

Resonance with Washers

Introduction

Have you ever heard a crystal glass hum when someone runs a finger around its rim? Do you remember the great height you could reach on a swing when you pumped your legs with proper timing? Do any objects in your home vibrate when music is playing? Although these observations seem to be unrelated, they all involve a phenomenon known as *resonance*.

Concepts

- Natural frequency
- Resonance
- Oscillation
- Vibration

Background

All objects have a natural frequency or set of natural frequencies at which they vibrate. The natural frequency of an object is dependent upon its length and composition. If an object is forced to vibrate at its natural frequency, a vigorous vibration, known as resonance, will occur. An object can be forced to vibrate by a push, pull, pluck, strum, or even from the vibrations of another object. When resonance occurs, it can often be seen, or even heard as a humming sound.

In this demonstration, resonance will be visibly shown using a series of six pendulums. One pendulum will be set into motion as the others are observed. The oscillation or vibrations of the swinging pendulum will cause any other pendulums with the same natural frequency to resonate.

Materials

- | | |
|-------------------|-------------------|
| Fishing line | Scissors |
| Marker, permanent | Support stands, 2 |
| Meter stick | Washers, ½", 6 |

Safety Precautions

The materials in this activity are considered nonhazardous. Please follow all laboratory safety guidelines.

Procedure

1. Place the support stands 50 cm apart.
2. Tie a piece of fishing line to the top of a support stand. Extend the fishing line to the other support stand and tie it so the line is horizontal (see Figure 1).
3. Use a permanent marker and label each washer with a number (1, 2, 3, 4, 5, and 6).
4. Tie a piece of fishing line to each washer and hang them from the horizontal line at the lengths listed below (see Figure 1).

- | | |
|------------------|------------------|
| Washer 1 — 20 cm | Washer 4 — 15 cm |
| Washer 2 — 15 cm | Washer 5 — 5 cm |
| Washer 3 — 20 cm | Washer 6 — 35 cm |

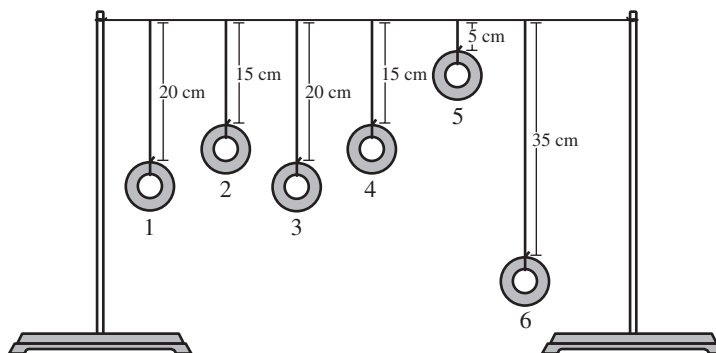


Figure 1.

5. Steady the washers so they are motionless. Gently pull washer #3 toward you and then release it. As the washer pendulum oscillates back and forth, observe the other pendulums for 1 to 2 minutes. *Note:* If nothing happens within 1–2 minutes, you may need to move the support stands slightly closer together. You do not want the horizontal

line to be extremely taut—the line should have some bounce to it.

6. Stop the washers from moving.
7. Repeat steps 5–6 using the other pendulums on the line one at a time until a pattern is observed.

Disposal

All materials can be saved for future use.

NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

Disciplinary Core Ideas: Middle School

- MS-PS2 Motion and Stability: Forces and Interactions
 - PS2.A: Forces and Motion
- MS-PS3 Energy
 - PS3.B: Conservation of Energy and Energy Transfer

Disciplinary Core Ideas: High School

- HS-PS2 Motion and Stability: Forces and Interactions
 - PS2.A: Forces and Motion
- HS-PS3 Energy
 - PS3.B: Conservation of Energy and Energy Transfer

Science and Engineering Practices

- Developing and using models
- Planning and carrying out investigations
- Constructing explanations and designing solutions

Crosscutting Concepts

- Patterns
- Cause and effect
- Structure and function
- Stability and change

Tips

- If the horizontal fishing line supporting the pendulums is too taut, the demonstration will not work. Simply move the support stands closer together to give the horizontal line some slack.
- Use this as an inquiry-based demonstration for your class. Ask the students to predict what will happen when one pendulum is set into motion. Most students will think nothing will happen. Repeat the experiment until someone recognizes a pattern.
- Set up the same pendulum demonstration but use different objects as the pendulum bobs. Have the students predict if the results will be similar to the original demonstration.
- For further concept development on resonance try the following demonstration kits from Flinn Scientific: *Open End Resonance Tube Set* (Catalog No. AP4616), *Singing Rods Demonstration Set* (Catalog No. AP7040), *Triple Singing Tubes Demonstration Kit* (Catalog No. AP6305), or *The Resonator* (Catalog No. AP7261).

Discussion

When washer #3 is set into motion, it acts as a vibrating source that, in time, will cause washer #1 to resonate. You may notice that the other washers will bounce or oscillate slightly as well, but the motion of washer #1 will swing much more dramatically. This occurs because washer #1 and #3 have the same natural frequency. They have the same natural frequency because they are made out of the same material and hang at the same length. The identical phenomenon will happen with washers #2 and #4 because they also share a common length and therefore a common natural frequency. Washers #5 and #6 will not cause other washers to swing vigorously because neither shares a common length with any other pendulum.

Materials for *Resonance with Washers* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP6938	Fishing Line, Monofilament
AP6012	Meter Stick, Hardwood
AP8228	Support Stand
AP7261	The Resonator
AP4616	Open-Ended Resonance Tube Set
AP7040	Singing Rods Demonstration Set
AP6305	Triple Singing Tubes Demonstration Kit

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.