unit 19

Wave After Wave

mySci
hands on science for elementary students

MONSANTO
Fund
What is a wave and how does it move?

How is pendulum motion similar to wave motion?

What type of motion do waves make?

How can we create a complex wave motion using simple pendulums?

What factors affect waves?

How can a computer simulation show us about waves?

What are different types of waves?

How is a tsunami tidal wave different from the waves we have been studying?

How can we use waves to communicate?
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<th>Lesson</th>
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<th>Items you must supply:</th>
<th>Extra prep time needed:</th>
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<tr>
<td>Lesson 1</td>
<td>Waves picture cards</td>
<td>Internet access Science notebooks Chart paper/interactive white board</td>
<td>Review MySci Safety Guidelines Copy and administer pre-assessment Copies of the Compare and Contrast Diagram (Appendix i) Copies of The Swinging Pendulum pre-assessment</td>
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<tr>
<td>Lesson 2</td>
<td>(6) 50 cm stick (ruler) (1 per group) 12 Small Binder clips (2 per group) 30 washers (5 per group) String (2 pieces about 20 cm long per group) 1 roll blue painter’s tape per class</td>
<td>Science notebooks Meter sticks (optional) Safety glasses</td>
<td>Copies of Data Table (Appendix ii)</td>
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<td>Lesson 3</td>
<td>4 pre-made pendulum set-ups, at stations labeled 1 - 4 (4) 50 cm sticks from previous lesson (for measurements)</td>
<td>Science notebooks Interactive white board/chart paper</td>
<td>Pendulum Set Ups Sheet (Appendix iii) Copies of the Data Recording sheet (Appendix iv) Unpack and check pendulum set-ups OPTIONAL: Make additional pendulum set-ups if you want more than 4 groups</td>
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<td>Lesson 4</td>
<td>(12) 50 cm sticks (ruler) (2 per group) 120 washers (20 per group) 120 small sized binder clips (20 per group) 6 medium binder clips (1 per group)</td>
<td>Internet access Science notebooks Yard stick or meter stick for pulling and releasing pendulums Stopwatch Protractor (for measuring angles)</td>
<td>Copies of the Engineering Design Cycle (Appendix v) Copies of The Swinging Pendulum post-assessment Count out group materials</td>
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<td>Lesson 5</td>
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<td>Science notebooks OPTIONAL: video recorder</td>
<td></td>
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<td>Lesson 6</td>
<td>6 flat clear plastic container (ripple tank) (1 per group) 6 flashlights with batteries 6 PVC tubes 6 small plastic rulers 6 zinc strips 6 Styrofoam peanuts 6 pipettes 1 food coloring (red, blue or green)</td>
<td>Science notebooks Books or blocks - to prop up the pan about 12 cm -15 cm off the surface of the desk White paper (1 per group) Water Paper towels Safety glasses</td>
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## Unit 19 Teacher Preparation List (continued)

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<td>Lesson 7</td>
<td>6 Slinky springs (1 per group) Blue Painter’s Tape (from Lesson 2)</td>
<td>Science Notebooks Measuring tool (Use of a meter stick or tile floor helps to provide reference points that can be used in their descriptions.)</td>
<td>Copies of Frequency and Amplitude Chart (Appendix vi)</td>
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<td>Lesson 8</td>
<td>6 Long springs (1 per group) (Do not use the Slinky this time.)</td>
<td>Safety glasses Science notebooks</td>
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<td>Lesson 9</td>
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<td>Science notebooks Computers with internet access (enough for students individually or in pairs)</td>
<td>Copies of Wave Simulation Chart (Appendix vii) Verify the on-line simulations work with your computers (including sound)</td>
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<td>Lesson 10</td>
<td>6 Slinkies from Lesson 7 Blue painters’ tape (optional — for marking)</td>
<td>Safety glasses Science notebooks</td>
<td></td>
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<td>Lesson 11</td>
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<td>Science notebooks Internet access OPTIONAL (for Tsunami demo): Plastic tub, underwater obstacles (square plastic tub submerged), water, and a rock or paper-weight</td>
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<tr>
<td>Lesson 12</td>
<td>All wave-generating devices from previous lessons (flash lights, pendulums, slinkies, springs, etc.)</td>
<td>Science notebooks</td>
<td>Copies of Sending Information With Waves handout (Appendix viii-ix) OPTIONAL: Copies of Waves, Codes, and Computers Extension Activity (Appendix x and xi) Copy and administer post-assessment</td>
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</table>
Lesson 1: What is a wave?

LEARNING TARGET
Identify common characteristics of waves.

SUMMARY
This lesson assesses students’ current perceptions and understanding about different types of waves.

ENGAGE
Ask the class: What kind of waves are there? Students list the different types of waves they are familiar with in their Science notebook. Students share out with the whole class. Create a chart that lists all of the different waves they have come up with.

EXPLORE
Ask the class: What causes waves? Watch the video Tacoma Narrows Bridge Collapse News Reel http://archive.org/details/SF121. Discuss what was seen in the video. Add new ideas to list based on what students saw in the video.

EXPLAIN
Ask the class: How can we group waves that have common characteristics together? Students sort their Waves picture cards into groups that have common characteristics. The students should explain their sort, noting similarities, differences, and patterns among the groups in their science notebooks. They could use a compare and contrast graphic organizer in their notebook if this is helpful to organize their thinking.

ELABORATE
Ask the class: How have you experienced waves?
Looking at the lists they have created and thinking about the waves picture cards, have students share in small groups the different places they have experienced waves.

EVALUATE
Ask the class: What are common characteristics of waves?
- Students will complete an exit slip answering the question. (Examples answers: movement, back and forth, vibration, up and down, repeats.
Give students The Swinging Pendulum Pre-assessment http://region1rttt.ncdpi.wikispaces.net/file/view/Pendulum.pdf. This probe is from Page Keeley, Uncovering Student Ideas in Physical Science, Vol 1.

MYSCI MATERIALS:
Waves picture cards

TEACHER PROVIDES:
Copies of the Compare and Contrast Diagram (Appendix i)
Copies of The Swinging Pendulum pre-assessment (see Evaluate for link)
Internet access
Science notebooks
Chart paper/Interactive White board

Teaching Tip:
This icon highlights an opportunity to check for understanding through a formal or informal assessment.
Lesson 2: How is pendulum motion similar to wave motion?

LEARNING TARGET
Explain how pendulum motion is similar to wave motion.

SUMMARY
Students will observe the patterns in motion of a pendulum and see how that pattern of motion is similar and predictable for waves.

ENGAGE
Ask the class: What is a pendulum? Yesterday, we talked about waves. Today we will be working with a piece of scientific equipment called a pendulum. You probably have all been on a swing. Swings are pendulums.

Students should draw a picture of a swing or pendulum in their science notebooks. They should include a sentence to describe what the motion looks like.

EXPLORE
Ask the class: What would happen to the way a pendulum moves if you changed either the string or “bob” (a weight/washer) on the end?

This is a good time to talk about variables, change, and how scientists keep track of information. Student will have to be reminded to keep track of their observations and data often.

Separate students into six groups. Students will decide in their group what they will change about their pendulum. They should spend some time designing their experiment. They should include materials, what they will measure, what tools (if any) they will need for the measurement, and how they will keep track of their measurements. Once they have this, they should show the teacher. Ask them questions to lead them to find quantifiable data (i.e. How will you measure that? What tool will you use?).

At this time materials can be dispensed and students can begin their experiments. Students may need help with set up. They might also need reminders to be consistent and change only one variable so that their results are relevant and accurate.

Students should record all of their data in a data table in their notebooks. A generic one that they might use is provided in Appendix ii. Remind students often to keep track of their observations in their notebooks. They want to learn from their mistakes, but won’t if they can’t remember why they made a change.

Once students have completed their data table they can write conclusions about their data. This is also a good time to share their data and conclusion with others, providing evidence for their conclusion.

EXPLAIN
Ask the class: What are characteristics of a pendulum’s movement? Students should answer the question in their science notebooks.

MYSCI MATERIALS:
(6) 50 cm stick/ruler (1 per group)
12 small binder clips (2 per group)
30 washers (5 per group)
String (2 pieces about 20 cm long per group)
1 roll blue painter’s tape per class

TEACHER PROVIDES:
Copies of Data Table (Appendix ii)
Science notebooks
Safety glasses
Meter sticks (optional)

Teaching Tip:
50 cm sticks are used because they fit into your kit tubs. If you have 1 meter sticks, you may find them easier for your students to use.

Teaching Tip:
If students want to change something besides the length of the string or the number of bobs and can get quantifiable data from the change, let them. You might want to leave it open and just state the Explore Question as: What would happen to the way a pendulum moves if you changed something about it?
Lesson 2 continued: How is pendulum motion similar to wave motion?

ELABORATE
Ask the class: What ways are pendulums used in the real world?
Now that students have thought about the common characteristics of pendulums, they can discuss in a small group other places they have seen pendulums and what uses there are for the pendulums they know.

EVALUATE
Ask the class: How is a pendulum's motion similar to a wave's motion?
☐ Students should look back at their information about a wave's motion and compare this to the motion of a pendulum in their science notebooks.
Lesson 3: What type of motion do waves make?

LEARNING TARGETS
Explain the pattern of wave movement by collecting data and making observations.

SUMMARY
Students will observe different pendulum set-ups to understand how the motion of a pendulum can model the motion of a wave.

ENGAGE
Ask the class: How can we use a pendulum to investigate the ways waves move? Discuss with students the previous single pendulum observations.

EXPLORE
Ask the class: What would happen if we put more than one pendulum together? How can we observe all the pendulums and record what we are seeing? Record student responses on interactive white board or chart.

Hand out 1 copy of the Data Recording sheet (Appendix iv) to each student. Put students into 4 equal groups (or 8 groups if you made additional pendulum set-ups). Make sure each group assigns one or more students to record the data for that station, so that every student has a chance to be the recorder and every station is recorded by at least one student in each group.

Give each group of students 1 pendulum set-up to explore. Have them observe, measure, and draw their set-up on the Data Recording sheet. Make sure they note on the paper which station they are recording! After they have recorded this information, have them experiment with the set-up and record their observations. Teacher should rotate between groups of students to assist with observations and ask guiding questions.

Example of a guiding question: How can you make sure the pendulums are all being started at the same time? What do you notice about how your pendulums move?

Observation Notes Example: The shorter pendulum is moving faster than the longer pendulum, or, the pendulums that are the same length are moving at exactly the same time.

After each group has finished one pendulum setup, have student groups rotate to a second setup to repeat the exploration. Continue the explore/rotate sequence until each group has observed each pendulum. Encourage groups to take notes and discuss observations at each station.

EXPLAIN
Ask the class: What are the similarities and differences between each station of pendulums? What did you observe happening?

Have students refer to their data recording sheets to answer these questions. Discuss with students how the different groups of pendulums moved based on their group observations.

MYSCI MATERIALS:
4 pre-made pendulum set-ups, at stations labeled 1–4
(4) 50 cm sticks from previous lesson (for measurements)

TEACHER PROVIDES:
Pendulum Set-Ups Sheet (Appendix iii)
Copies of the Data Recording Sheet (Appendix iv)
Science notebooks
Interactive white board or chart paper

Teaching Tip:
If you would like to make more than 4 stations, you can re-create the pendulum set-ups using the directions in Appendix iii.
Lesson 3 continued: What type of motion do waves make?

ELABORATE
Ask the class: What factors affected the way the pendulums moved? Discuss how the length of the string and amount of mass (number of washers) affected the movement.

Ask: Is there anything else you noticed that changed the movement? Discuss how the distance that students may have pulled out the pendulums may have affected the swing.

EVALUATE
Ask the class: Which pendulum setup created a movement that is most like a wave?

Discuss how to modify the other setups to create repetitive movement that is most like a wave.
Lesson 4: How can we create a complex wave motion using simple pendulums?

LEARNING TARGET
Create a model and use it to explain a complex pattern of wave motion.

SUMMARY
Students will use what they have learned and observed about waves and pendulums to create a complex system of pendulums. This system will model wave motion.

ENGAGE
Ask the class: What type of motion did your pendulum make in lesson 2? (Students can refer to previous day’s notes to determine that it is a repetitive or back and forth motion.)

EXPLORE
Ask the class: What do you think would happen if you combine more than one 50 cm stick together? What would it look like? What kinds of wave motion could you create? Allow for time to make predictions in their science notebooks.

As you watch the video think about the predictions you made: Amazing Pendulum Wave Effect https://www.youtube.com/watch?v=7_AiV12XBBI

Ask students if they think their pendulum will work exactly like the video the first time they try it (they will probably say no!) Hand out or project the Engineering Design Cycle (Appendix v). Ask students why they think it is a cycle. Emphasize testing and redesign.

Attempt to replicate the Amazing Pendulum Wave Effect using prepared pendulums in the kit. Your notes from previous lessons might be really useful! Allow plenty of time for students to explore their predictions. Divide students into six groups.

1. Have one person from each group collect materials.
2. Allow students to explore combining the pendulums to create the pendulum they saw on video. The students will have to combine two 50 cm stick pendulums to make a full meter. Tape two of the 50 cm sticks together and use a medium sized binder clip to reinforce where the two sticks are combined.
3. Students will use a meter stick to pull all pendulums out to the same angle and release. Then, observe the pendulums in motion and record observations in their Science Journal.
4. After discussion, collect materials and return to bin.

EXPLAIN

MYSCI MATERIALS:
(12) 50 cm sticks (ruler) (2 per group)
120 washers (20 per group)
120 small-sized binder clips (20 per group)
6 medium binder clips (1 per group)

TEACHER PROVIDES:
Copies of the Engineering Design Cycle (Appendix v)
Copies of The Swinging Pendulum post-assessment
Science notebooks
Yard stick or meter stick for pulling and releasing pendulums
Stopwatch
Protractor (for measuring angles)
Internet access

Teaching Tip:
You may wish to show the video a number of times or even have it loaded on your students’ computers so that they may revisit it as often as they would like.
Lesson 4 continued: How can we create a complex wave motion using simple pendulums?

ELABORATE
Ask the class: How many times did you have to make changes (redesign) and what did you change? How did you decide what to change?

After students have a chance to record their answers, take a few responses from the class.

EVALUATE
Ask the class: What did you learn about the motion of waves? What is the most important thing to know about the motion of waves? Have students record their ideas in their science notebooks. Students should mention that waves are repeated or repetitive motion.

Administer The Swinging Pendulum probe as post-assessment http://region1rtti.ncdpi.wikispaces.net/file/view/Pendulum.pdf. This probe is from Page Keeley, Uncovering Student Ideas in Physical Science, Vol 1.
What happens as waves move through different matter?

Lesson 5: How can we model wave motion?

LEARNING TARGET
Explain how waves affect the particles they travel through.

SUMMARY
Students model the motion of a wave by locking elbows and observing the result.

ENGAGE
Ask the class: How can we model wave movement with our bodies?
Have students write ideas in their science notebook. They can share out and try ideas. Some of them may come up with linking elbows.

EXPLORE
Ask the class: How does your model compare to other waves we have seen?
Students model a wave. Have the students line up across the front of the room and interlock their elbows. (This is very important to do because in a wave, the adjacent parts interact but do not travel with the wave front.)

1. Have the first person in line slowly bend forward at the waist and then come back up to vertical position and continue to repeat that movement.
2. As the first person bends over, the person beside him or her will also need to bend, but with a little delay.
3. This continues down the line until all have bent over and returned to the vertical at least two or three times.

You may want to have different students from your class not be part of the wave chain but have them watch the movement from across the room and describe it to the whole class. You most likely will want to try this a few times so that students are consistent in their up and down motions and do not rush the process. Recording a video of the successful wave will also be helpful to watch later. Here are two options to show students if you cannot record:

Find a video of “The Wave” at a sporting event on YouTube.
PBS Video illustrating The Wave: http://www.pbslearningmedia.org/resource/lsp07.sci.phys.energy.waves/what-is-a-wave/

TEACHER PROVIDES:
Science notebooks
Video recorder (optional)

Teaching Tip:
Remind students that they must keep the ball on the table or desk, or on the designated spot on the carpet.
Listen for words such as “roll, toss, bounce, slide, throw.”

Teaching Tip:
If you have a video recorder, a great technique is to record the motion and then project it on your Smart Board. You can then diagram over the motion to show the wave pattern. This shows that each person (part/particle) is moving up and down as the “wave front” moves across the room. This diagramming technique helps to reinforce how actual motions and objects in life can be shown in diagrams (cartoons). The technique helps to make meaningful those lines and arrows we always see in science. Model other student ideas as well and discuss which one has the most accurate wave.
Lesson 5 continued: How can we model wave motion?

EXPLAIN
Ask the class: *Why is interlocking elbows important?* Students discuss what they saw in the video or as the wave was moving through the group of students.
Did the students move the same as the wave? How was their movement different? What can this help us understand about how a wave moves versus how the particles of matter move? Are the waves and the particles (the medium) the same thing?

ELABORATE
Ask the class: *How can we model back and forth movement in a wave?*
Students work together to come up with a process to show this type of movement, as opposed to the up and down movement shown in the other wave.

EVALUATE
☐ Ask: *What does the human wave you created show us about how waves move through a medium?* Students draw a picture of the wave and the particles a wave moves through, and explain what they learned about how a wave moves through a medium.
Lesson 6: How does water help us understand the motion of waves?

LEARNING TARGET
Describe how waves travel through water.
Describe how waves behave when they encounter obstacles.

SUMMARY
Students investigate how waves move through water, including the interactions between waves and barriers and the interaction of more than one wave.

ENGAGE
Ask the class: *What happens when waves move through water?*
Demonstrate the set-up first. In order to explore water waves, you are going to make a “ripple tank”. This is a container that shows how water waves move through water.

1. Using a few books or blocks, prop the “tank” up about 12 cm to 15 cm from the tabletop. Textbooks work well for this. Make sure that just the edges of the tank are propped on the blocks or books. That allows more of the surface to show through to the paper below.
2. Put a sheet of white paper on the table below the tank.
3. Add enough water to the tank to fill it about a third of the way.
4. Start with a few drops of food coloring to shade the water. You may need to add more coloring as you explore.
5. Hold the flashlight above the tank and shine the light through the water so that you can see it on the paper below the tank.
6. Be gentle. Do not make a splash. Dip your finger into the water and see what kind of pattern shows on the white paper. Model this for the students and then model the response to the following question on the white-board. Have them record the outcome and observation in their science notebooks.

Have students diagram a picture of a birds-eye-view of their ripple tank. Ask: *What happens when you dip your finger in a few times? What do you observe?*

EXPLORE
Ask the class: *How do different set ups of the ripple tank produce different wave movement?*
Put students into six groups. Instruct students to continue the exploration. For each different set up they should draw a picture in their science notebooks, describe the set-up, make a prediction, and then record observations.

MYSCI MATERIALS:
- 6 flat clear plastic containers (ripple tank, 1 per group)
- 6 flashlights with batteries
- 6 PVC tubes
- 6 small plastic rulers
- 6 zinc strips
- 6 Styrofoam peanuts
- 6 pipettes
- 1 food coloring (red, blue or green)

TEACHER PROVIDES:
- Science notebooks
- Books or blocks to prop up the pan about 12 cm–15 cm off the surface of the desk
- White paper (1 per group)
- Water
- Paper towels
- Safety glasses
Lesson 6 continued: How does water help us understand the motion of waves?

Set-Ups:
1. Set a PVC tube in one end of the tank so that if you roll the tube slightly, it will make a long flat ripple or wave. Remember, be gentle.
2. Put a small piece of styrofoam on top of the water. Make a prediction of what you think will happen if you make the same type of wave you made in step 1. Now make the same type of wave as in step 1. What happens to the styrofoam? Did this match your prediction? What does this tell you about the movement of waves through water?
3. What happens when two waves from different directions come together? How would you set up an exploration to observe that? Try it. What do you observe?

EXPLAIN
Ask the class: What are some characteristics of water waves we have learned from exploring the ripple tanks?

Students can work together in their groups to review their science notebooks and share what they have learned about waves so far. Each group needs to come up with what they think is the most important characteristic of water waves. They will share this with the whole class.

ELABORATE
Ask the class: How do barriers affect the motion of waves in water?

Once again instruct students to continue the exploration. For each different set up they should draw a picture in their science notebooks, describe the set-up, make a prediction, and then record observations. Always encourage them to record and sketch as much information as they can!

1. Curl one of the zinc strips into a spiral circle about the diameter of a fifty cent piece, observe what happens at the surface of the water when a wave bumps into that “obstacle”.
2. Make different shapes with the zinc strips and explore. What happens when waves bump into them?
3. What happens if two obstacles are in the tank at the same time?

EVALUATE
Ask the class: What happens to the surface of water when a wave moves through it? What happens when a wave encounters an obstacle? Do you think this applies to other materials besides water?

Students should write out their explanations of the above questions in their science notebooks. They should note that the surface of the water moves up and down but does not move back and forth.

Teaching Tip:
This activity should show that the floating styrofoam doesn’t move forward, but moves up and down. This may need to be a demonstration, as sometimes the students’ waves can be very forceful and move the styrofoam forward. We want them to see that the particles of the medium that the wave is moving through won’t necessarily move forward, but move up and down instead.
Lesson 7: How does a spring show motions of waves?

LEARNING TARGET
Identify frequency and amplitude in waves.
Create drawings of waves of various frequencies and amplitudes.

SUMMARY
Students will use small slinky springs to look for patterns that waves make.
New vocabulary terms amplitude, frequency and pulse are introduced.

ENGAGE
Ask the class: *How can you create a wave motion using a Slinky?* Allow students
time to plan a wave model using a Slinky.

EXPLORE
Model sending a pulse using a Slinky.

1. Stretch the Slinky on the floor between 2 people. Do not stretch it
   too far or it won’t “spring” back! One person holds the Slinky in
   one spot on the floor, the person on the other end of the Slinky then
   moves the Slinky out one arm’s length to his or her left across the
   floor and then brings the Slinky back to the original spot on the floor.
   Moving the Slinky out and back once is called a pulse.

2. Move the Slinky repetitively. That repetitive motion is what causes a
   wave. Describe what is observed with this repetitive motion.

3. Use pieces of blue tape on the floor to show where different parts of
   a wave occur on your Slinky. Observe the distances between those
   marks. Ask: *Can you change how big the wave is that you made with the
   Slinky? In what ways?*

   Carefully monitor how students manipulate the springs. Stretching
   springs out too far could create a safety issue, raises the potential for
   injury, and could damage the materials. A Slinky is very susceptible to
   over stretching and getting twisted if not handled carefully. Remind
   students to only move Slinky springs on the ground, not in the air.

EXPLAIN
Have students draw a picture of the waves they made. Ask: *How did
they change?*

ELABORATE
Ask the class: *Can you change the speed that a wave moves? If so, how would
you do that?* Allow time for students to change the speed of the wave and
the height of the wave.

The speed of a wave is called its “frequency”. The height is called
its “amplitude”. Have students label the frequency and amplitude on any of
the drawings that they made of their observations.
Lesson 7 continued: How does a spring show motions of waves?

EVALUATE

Have students make a Frequency and Amplitude Chart (Appendix vi) in their science notebooks, then describe how they will make a wave with the properties shown. They should also sketch each type of wave and label the frequency and amplitude of each.
Lesson 8: How does a longer spring model different motions of waves?

LEARNING TARGET
Describe how waves interact with other waves.

SUMMARY
Students will expand their experiences using a longer spring to show some forms of waves. Now that your students have explored waves from a spring with one end of the spring being held steady, see what happens when a pulse is started from both ends of the spring at the same time.

ENGAGE
Ask the class: What do you observe when you start a wave from both ends of a spring at the same time?

EXPLORE
Ask the class: What combinations of movement for the spring could you try?
Encourage students to develop multiple combinations of movement and observe the results. Have students try their combinations and record how the movement changes. After all students have made their observations, summarize all observations in one chart. Students can duplicate the chart in their notebooks.

EXPLAIN
What variables did you change to make the results you observed? Could you duplicate it? Have students try someone else’s combination and record how the movement changes. Wave interference and interactions can be confusing! The following resources can be used to help explain this topic to your students:

Physics Classroom: http://www.physicsclassroom.com/class/waves/Lesson-3/Interference-of-Waves


ELABORATE
Ask the class: Can you make a wave move down one side of the spring (that is, peaking to the left) but come back on the other side (that is, peaking to the right)? How do you make that kind of wave?

EVALUATE
Ask the class: How do your observations in working with the longer springs compare to working with the shorter Slinky springs? How are the observations the same? How are they different? How do waves behave when they run into each other?

MYSCI MATERIALS:
6 long springs (1 per group — do not use the Slinky at this time)

TEACHER PROVIDES:
Safety glasses
Science notebooks

Teaching Tip:
Remember to move these springs on the ground, not in the air.
Lesson 9: What can a computer simulation show us about waves?

LEARNING TARGET
Describe how changing the variables of amplitude and frequency can change the motion of the wave.

SUMMARY
Students will use computer simulations to better understand how amplitude and frequency affects different types of waves.

ENGAGE
Ask the class: What will waves look like on the computer?
On the Phet simulation website, demonstrate the wave on a string simulation first. Make sure that the “oscillate” option is chosen. Frequency and amplitude options will show up and be set at 50. Have the students work in pairs to make changes to the string variables. Give a limited amount of time for the students to get used to the site.

EXPLORE
Ask the class: How can the simulations help us understand waves?
After the students are familiar with how the Phet wave on a string simulation works, explain: We will be changing one variable to see the effect that variable has on the motion of a wave.
Using their science notebooks, the students write down a variable that they would like to change (i.e. amplitude) and the change to be made (i.e. 60). In their notebooks, beside the listing of the variable, have them state what they think will be the result of the change. You may also want to add a column that includes what the resulting wave will look like. They can use a chart that looks like the Wave Simulation Chart example (Appendix vii).

EXPLAIN
Ask: How does changing one variable about a wave affect the wave?
They should then write down what actually happens. Have them do that at least four times. This process should be repeated with the two other types of wave simulations as well.
Lesson 9 continued: What can a computer simulation show us about waves?

ELABORATE
Ask the class: How does adding another wave change the motion of the first wave?
Using the wave interference or sound simulation, the students can either change the number of drips to two or change the tab at the top to “Two Source Interference”, respectively. Students should write their observations in their science notebooks and share these out with others. They should see that when there are two waves there is a spot where the waves cancel each other out.

EVALUATE
Ask the class: What did the different computer simulations show us about waves?
How does changing frequency change the motion of the wave? How does changing amplitude change the motion of the wave?
✔ Assess how well they are able to predict a change by noting the third or fourth change and the outcome.
Lesson 10: What are different types of waves?

LEARNING TARGET
Identify compression waves and compare them to other types of waves.

SUMMARY
Students use a Slinky to observe a compression wave.

ENGAGE
Ask the class: Are there different ways waves can move?
Let students know that they will have a chance to use the Slinky again to see if they can get a different type of wave motion. Students should discuss the question above in small groups of three or four. They should keep track of ideas they discuss in their science notebooks so that they can try them when they get their Slinky.

EXPLORE
Ask the class: How else can we make the slinky move in a wave?
Small groups try out their different ideas of how to make the Slinky do a different wave motion. For each idea they try, the students should record what they did, draw what the resulting motion looked like, and determine whether this motion is like a wave or not and why.

EXPLAIN
Ask the class: What other ways can a wave move besides back and forth?
1. Stretch the Slinky out about 5 feet. Don't pull too far or you will ruin the Slinky, but you want it pulled out far enough to see a wave travel.
2. Starting at the middle of the Slinky, pull (bunch) the coils together into the tight pack towards you. The result should look like the Slinky before it was stretched.
3. Now let go of the bunched part and observe what happens. Observe this multiple times.
4. Record what you observe in your notebook. Draw a diagram and write an explanation of what is happening. Discuss what was observed.

ELABORATE
Ask the class: How do we measure amplitude and frequency of compression wave?
Teacher may need to review the concepts of amplitude and frequency of transverse waves with students. Students will use the Slinky.

EVALUATE
Ask the class: What is a compression wave, and how does it compare to the other wave motions we have been studying?
Students answer the question in their science notebooks, using pictures and explanations.

MYSCI MATERIALS:
6 Slinkies from Lesson 7
Blue painters’ tape (optional — for marking)

TEACHER PROVIDES:
Safety glasses
Science notebooks

Teaching Tip:
Remember to move these springs on the ground, not in the air.
Lesson 11: How is a tsunami tidal wave different from the waves we have been studying?

**LEARNING TARGET**
Describe the pattern of a Tsunami wave and how it is different than other waves.

**SUMMARY**
Students design an exploration to see how tsunami waves are different from the waves they have studying in previous lessons. A tsunami is a series of ocean waves that sends surges of water, sometimes reaching heights of over 100 feet (30.5 meters), onto land. These walls of water can cause widespread destruction when they crash ashore. These awe-inspiring waves are typically caused by large, undersea earthquakes at tectonic plate boundaries. When the ocean floor at a plate boundary rises or falls suddenly it displaces the water above it and launches the rolling waves that will become a tsunami. (Both Tsunami waves and ocean waves are formed as the land under the sea becomes shallow. This enables the wave front to “break” (curl) and concentrate energy along the shore.)

**ENGAGE**
Say to the students: *We have studied compression waves, and longitudinal waves. Today we are going to explore another different type of wave and compare it to what we have already studied.*

*What is a tsunami? (A tsunami is a giant tidal wave.)*

Engage students in a discussion on what tsunami waves are and how they affect people. Watch [2011 Tsunami in Japan video](http://www.bbc.co.uk/news/world-asia-pacific-12725646) and discuss any new information about effects of tsunamis on communities and people.

**EXPLORE**
Ask the class: *How can we model tsunami waves? What would you need to try out your exploration?* Encourage students to create an exploration to see if they can model how tsunami waves are different from the other waves studied. Allow time for trial and retrial as students test their exploration.

*Optional Exploration: Tiny Model of a Tsunami*
You can make a tiny model of a tsunami by dropping a rock into a bowl of water, causing ripples to travel outwards from the site of impact. Try it again with a submerged obstacle. The wave should increase over the shallow area.

**TEACHER PROVIDES:**
Internet access
Science notebooks

**OPTIONAL MATERIALS**
(for Tsunami demonstration):
- Plastic tub
- Under water obstacles (square plastic tub submerged)
- Water
- Rock or paper-weight

**Teaching Tip:**
If you are not going to do the demo, consider showing additional videos such as:
- [How Earthquakes Trigger Tsunamis — Bang Goes The Theory, Preview — BBC One](https://www.youtube.com/watch?v=xyK-gamjg7Q)
- [How Tsunamis Work:](https://www.youtube.com/watch?v=Wx9vPv-T51I)
Lesson 11 continued: How is a tsunami tidal wave different from the waves we have been studying?

Ask: How is your model like tsunami waves? What do they have in common? Are there any elements you would change to make it more like the tsunami you saw in the video?

Students should write their original procedure for the model they design and results they observed. If any retrials are conducted, they should note what variables were changed and what results they observed upon retrial. Allow for 2-3 trials of the exploration.

ELABORATE

Ask the class: If tsunamis are underwater earthquakes, how can scientists use technology to warn people about tsunami waves? How can scientists predict tsunami waves?

Have pairs or small groups of students discuss ideas about developing warning systems and how predictions can be made based on monitoring of earthquakes. Groups can then share with the whole class as a brainstorming activity.

EVALUATE

Ask the class: How do tsunami waves move differently from the waves we have been studying?

Students should use their observation notes to compare tsunami waves to other waves studied. They may refer back to the notes from Lesson 1 on characteristics of waves. Observations may include that tsunami waves are fast, they may extend high above the shoreline near the coast, and they can cause extensive damage when the water runs inland.
Lesson 12: How can we use waves to communicate?

LEARNING TARGETS
Identify ways that we use waves to communicate.

SUMMARY
Students will use the various wave-making materials from previous lessons to create a code and communicate with their partner.

ENGAGE
Ask the class: Have any of you ever played the game “I Spy” or “20 Questions”? Can you explain how the game is played? (One person asks questions, the other person says “yes” or “no”). To play the game, two people have to communicate. But what if you wanted to communicate a secret message?

EXPLORE
Tell the class: We have learned about several types of waves and used different materials to model them. How might we send information using waves? (Have students write in their science journals first. They can also use their previous notes to recall the different wave materials. After a few quiet moments to write, ask students to share out.)

EXPLAIN
Tell the class: There are many ways that both humans and other animals use waves to communicate. The following article contains information about how humans hear, as well as how animals use sound waves to communicate: http://www.kidsdiscover.com/spotlight/sound-and-vibration/.

This video from PBS Learning showcases an Audio Engineer: http://www.pbslearningmedia.org/resource/0a763ed5-2be9-4d47-9ed5-753c8c31e2db/0a763ed5-2be9-4d47-9ed5-753c8c31e2db/

ELABORATE
Computers use digital waves to transmit information. One little “bit” of information can either be “yes” or “no”. Ask: How would you use the wave types that we have used to create this image in a computer?

This drawing requires 8 “yes or no” questions. That is, 8 little “bits” of information. For computer programmers, this has a special meaning. 8 bits of information is one byte. Put students into pairs or groups of up to 4 students. Pass out handouts from Appendix viii and ix to each group of students. Each pair or group should select (or be given) one of the wave...

MYSCI MATERIALS:
All wave-generating devices from previous lessons (flashlights, pendulums, slinkies, springs, etc.)

TEACHER PROVIDES:
Copies of Sending Information With Waves (Appendix viii–ix)
Science notebooks
OPTIONAL: Copies of Waves, Codes, and Computers Extension Activity (Appendix x)

Teaching Tip:
Connections can be made to computers, math, area, arrays, codes, etc.
Lesson 12 continued: How can we use waves to communicate?

devices (slinky, pendulum, or spring). They will conduct several 1-byte trials to see if they can transmit information using waves. You can also do the extension activity and have students transmit secret words or phrases!

EVALUATE

☐ Ask students to list different ways that we use waves to communicate, and what the benefits of wave communication might be.

EXTEND (OPTIONAL)

If you choose to do a more involved design activity, use the handout in Appendix x to have students make up secret messages using their own code.
### NEXT GENERATION SCIENCE STANDARDS

Key to Understanding the NGSS Codes

NGSS codes begin with the grade level, then the “Disciplinary Core Idea code”, then a standard number. The Disciplinary Core Ideas are:

#### Physical Sciences
PS1: Matter and its interactions  
PS2: Motion and stability: Forces and interactions  
PS3: Energy  
PS4: Waves and their applications in technologies for information transfer

#### Life Sciences
LS1: From molecules to organisms: Structures and processes  
LS2: Ecosystems: Interactions, energy, and dynamics  
LS3: Heredity: Inheritance and variation of traits  
LS4: Biological evolution: Unity and diversity

#### Earth and Space Sciences
ESS1: Earth’s place in the universe  
ESS2: Earth’s systems  
ESS3: Earth and human activity

#### Engineering, Technology, and Applications of Science
ETS1: Engineering design  
ETS2: Links among engineering, technology, science, and society

For more information, visit [http://www.nextgenscience.org/next-generation-science-standards](http://www.nextgenscience.org/next-generation-science-standards)

<table>
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<tr>
<th><strong>NGSS PERFORMANCE EXPECTATIONS</strong></th>
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<tbody>
<tr>
<td><strong>4-PS4-1</strong></td>
<td>Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.</td>
</tr>
<tr>
<td><strong>3-5-ETS1-1</strong></td>
<td>Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.</td>
</tr>
<tr>
<td><strong>4-PS4-3</strong></td>
<td>Generate and compare multiple solutions that use patterns to transfer information.*</td>
</tr>
<tr>
<td><strong>3-5-ETS1-2</strong></td>
<td>Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.</td>
</tr>
<tr>
<td><strong>3-5-ETS1-3</strong></td>
<td>Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.</td>
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</tbody>
</table>
SCIENCE AND ENGINEERING PRACTICES

Asking Questions and Defining Problems
- Ask questions about what would happen if a variable is changed.
- Identify scientific (testable) and non-scientific (non-testable) questions.
- Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.
- Use prior knowledge to describe problems that can be solved.
- Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.

Developing and Using Models
- Identify limitations of models.
- Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events.
- Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution.
- Develop and/or use models to describe and/or predict phenomena.
- Develop a diagram or simple physical prototype to convey a proposed object, tool, or process.
- Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.

Planning and Carrying Out Investigations
- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.
- Evaluate appropriate methods and/or tools for collecting data.
- Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.
- Make predictions about what would happen if a variable changes.
- Test two different models of the same proposed object, tool, or process to determine which better meets criteria for success.

Analyzing and Interpreting Data
- Represent data in tables and/or various graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.
- Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.
- Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings.
- Analyze data to refine a problem statement or the design of a proposed object, tool, or process.
- Use data to evaluate and refine design solutions.

Using Mathematics and Computational Thinking
- Decide if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success.
- Organize simple data sets to reveal patterns that suggest relationships.
- Describe, measure, estimate, and/or graph quantities (e.g., area, volume, weight, time) to address scientific and engineering questions and problems.
- Create and/or use graphs and/or charts generated from simple algorithms to compare alternative solutions to an engineering problem.

Constructing Explanations and Designing Solutions
- Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard).
- Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.
- Identify the evidence that supports particular points in an explanation.
- Apply scientific ideas to solve design problems.
- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.

Engaging in Argument from Evidence
- Compare and refine arguments based on an evaluation of the evidence presented.
- Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation.
- Respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions.
- Construct and/or support an argument with evidence, data, and/or a model.
- Use data to evaluate claims about cause and effect.
- Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.

Obtaining, Evaluating and Communication Information
- Read and comprehend grade-appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence.
- Compare and/or combine across complex texts and/or other reliable media to support the engagement in other scientific and/or engineering practices.
- Combine information in written text with that contained in corresponding tables, diagrams, and/or charts to support the engagement in other scientific and/or engineering practices.
- Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem.
- Communicate scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts.
### DISCIPLINARY CORE IDEAS

<table>
<thead>
<tr>
<th>Concepts</th>
<th>CROSSCUTTING CONCEPTS</th>
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<tbody>
<tr>
<td>PS4.C: Information Technologies and Instrumentation</td>
<td>Patterns</td>
</tr>
<tr>
<td>People also use a variety of devices to communicate (send and receive information) over long distances. (1-PS4-4)</td>
<td>• Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products.</td>
</tr>
<tr>
<td>Waves and Information</td>
<td>• Patterns of change can be used to make predictions.</td>
</tr>
<tr>
<td>Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach. (Note: This grade band endpoint was moved from K–2). (4-PS4-1)</td>
<td>• Patterns can be used as evidence to support an explanation.</td>
</tr>
<tr>
<td>Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks). (4-PS4-1)</td>
<td>Cause and Effect: Mechanism and Prediction</td>
</tr>
<tr>
<td>PS4.C: Information Technologies and Instrumentation</td>
<td>• Cause and effect relationships are routinely identified, tested, and used to explain change.</td>
</tr>
<tr>
<td>ETS1.C: Optimizing The Design Solution</td>
<td>• Events that occur together with regularity might or might not be a cause and effect relationship.</td>
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<tr>
<td>Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (secondary to 4-PS4-3)</td>
<td>Systems and System Models</td>
</tr>
<tr>
<td>Engineering Design</td>
<td>• A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot.</td>
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<tr>
<td>ETS1.A: Defining and Delimiting Engineering Problems</td>
<td>• A system can be described in terms of its components and their interactions.</td>
</tr>
<tr>
<td>Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)</td>
<td>Energy and Matter: Flows, Cycles, and Conservation</td>
</tr>
<tr>
<td>ETS1.B: Developing Possible Solutions</td>
<td>• Energy can be transferred in various ways and between objects.</td>
</tr>
<tr>
<td>Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2)</td>
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<tr>
<td>At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2)</td>
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<tr>
<td>Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3)</td>
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<tr>
<td>ETS1.C: Optimizing the Design Solution</td>
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<td>Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)</td>
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Key to Understanding the GLE Codes

GLE codes are a mixture of numbers and letters, in this order: Strand, Big Idea, Concept, Grade Level and GLE Code.

The most important is the strand. The strands are:

1. ME: Properties and Principles of Matter and Energy
2. FM: Properties and Principles of Force and Motion
3. LO: Characteristics and Interactions of Living Organisms
4. EC: Changes in Ecosystems and Interactions of Organisms with their Environments
5. ES: Processes and Interactions of the Earth’s Systems (Geosphere, Atmosphere and Hydroshpere)
6. UN: Composition and Structure of the Universe and the Motion of the Objects Within It
7. IN: Scientific Inquiry
8. ST: Impact of Science, Technology and Human Activity

For more information, visit http://dese.mo.gov/college-career-readiness/curriculum/science

### Fourth Grade

**IN 1 A 4 a**
Formulate testable questions and explanations (hypotheses)

**IN 1 A 4 b**
Recognize the characteristics of a fair and unbiased test

**IN 1 A 4 c**
Conduct a fair test to answer a question

**IN 1 B 4 a**
Make qualitative observations using the five senses

**IN 1 B 4 b**
Make observations using simple tools and equipment (e.g., hand lenses, magnets, thermometers, metric rulers, balances, graduated cylinders, spring scale)

**IN 1 B 4 d**
Compare amounts/measurements

**IN 1 C 4 a**
Use quantitative and qualitative data as support for reasonable explanations

**IN 1 C 4 b**
Use data as support for observed patterns and relationships, and to make predictions to be tested

**IN 1 C 4 c**
Evaluate the reasonableness of an explanation

**IN 1 C 4 d**
Analyze whether evidence supports proposed explanations

**ST 1 C 4 a**
Communicate the procedures and results of investigations and explanations through: oral presentations, drawings and maps, data tables, graphs (bar, single line, pictograph), writings

**ST 1 C 4 b**
Identify how the effects of inventions or technological advances (e.g., different types of light bulbs, semiconductors/integrated circuits and electronics, satellite imagery, robotics, communication, transportation, generation of energy, renewable materials) may be helpful, harmful, or both

**ST 3 A 4 a**
Identify a question that was asked, or could be asked, or a problem that needed to be solved when given a brief scenario (fiction or nonfiction of people working alone or in groups solving everyday problems or learning through discovery)

**ST 3 A 4 b**
Work with a group to solve a problem, giving due credit to the ideas and contributions of each group member
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Compare and Contrast Diagram

Section 1, Lesson 1

Name: ___________________________ Date: ________________

ALIKE? HOW?

_______________________________

_______________________________

_______________________________

DIFFERENT? IN WHAT WAY?

_______________________________

_______________________________

_______________________________

COMPARISON SUMMARY

_______________________________

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_______________________________
# Data Table

**Section 1, Lesson 2**

Name: ____________________________  Date: __________________

<table>
<thead>
<tr>
<th>WHAT I CHANGED</th>
<th>WHAT I OBSERVED (MEASURED)</th>
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<tbody>
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Pendulum Set-Ups

Section 1, Lesson 3

To the Teacher: These directions are provided in case you want to make more of these so that students can work in smaller groups. You can use the extra 50 cm sticks or 1 meter sticks if you have them available. Use the additional binder clips and washers from your kit.

Each pendulum set up has binder clips, string and washers:

Station 1
4 pendulum bobs per 50 cm stick. Each bob has a mass of one washer and length of 20 cm. The bobs are placed at 15 cm, 25 cm, 35 cm, and 45 cm on the 50 cm stick. (The clips that hold the pendulum bobs are at 2 cm on either side of the placement. For example, the 15 cm bob has one strand of the pendulum clipped at 13 cm and its double is at 17 cm.)

Station 2
4 pendulum bobs per 50 cm strip. Each bob has a mass of one washer. The length of the bobs varies from 10 cm, 15 cm, 20 cm, and 25 cm. The bobs are placed at 15 cm, 25 cm, 35 cm, and 45 cm on the 50 cm stick. (The clips that hold the pendulum bobs are at 2 cm on either side of the placement as in (1) above.)

Station 3
4 pendulum bobs per 50 cm strip. Each bob has a mass of three washers and length of 20 cm. The bobs are placed at 15 cm, 25 cm, 35 cm, and 45 cm on the 50 cm stick. (same set-up as above)

Station 4
4 pendulum bobs per 50 cm strip. Each bob has a mass of three washers. The length of the bobs varies from 10 cm, 15 cm, 20 cm, and 25 cm. The bobs are placed at 15 cm, 25 cm, 35 cm, and 45 cm on the 50 cm stick. (same set-up as above)
Data Recording Sheet

Section 1, Lesson 3

Name: ________________________________  Date: ______________________
Station: ______________________________

Sketch the pendulum set-up for this station here. Include labels and measurements.

<table>
<thead>
<tr>
<th>WHAT WE DID</th>
<th>WHAT WE OBSERVED</th>
</tr>
</thead>
<tbody>
<tr>
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Engineering Design Cycle

Section 1, Lesson 4

1. Identify Need/Problem

2. Research & Brainstorm

3. Choose Best Ideas

4. Construct Prototype

5. Test & Evaluate

6. Communicate

7. Redesign
Frequency and Amplitude Chart

Section 2, Lesson 7

Name: ____________________________________________________________ Date: __________________

<table>
<thead>
<tr>
<th>HIGH FREQUENCY</th>
<th>LOW FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Amplitude</td>
<td></td>
</tr>
<tr>
<td>Low Amplitude</td>
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</tbody>
</table>
Wave Simulation Chart
Section 3, Lesson 9

Name: ___________________________________________ Date: __________________________

WAVE ON A STRING

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>AMOUNT OF CHANGE</th>
<th>PREDICTION</th>
<th>WHAT ACTUALLY HAPPENED</th>
</tr>
</thead>
<tbody>
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</table>

SOUND

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>DIRECTION OF CHANGE</th>
<th>PREDICTION</th>
<th>WHAT ACTUALLY HAPPENED</th>
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</thead>
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</table>

WAVE INTERFERENCE (WATER)

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>DIRECTION OF CHANGE</th>
<th>PREDICTION</th>
<th>WHAT ACTUALLY HAPPENED</th>
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</table>
Sending Information With Waves

Transmitter (front)

Section 3, Lesson 12

Name: _______________________________ Date: _________________________

My Partner is: _______________________________

Our wave device is: _______________________________

How we will send information (describe and/or draw):

For Trial one, make up a pattern in this table and then “transmit” the information to your “receiver” using your wave device. When you have finished, check your partner’s drawing and make sure they match. For Trials 2, 3, and 4, trade places. For Trials 2, 3, and 4, trade places.

Make up your own pattern here:

<table>
<thead>
<tr>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Trial 4</th>
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</table>

Both partners together:

1. How many bits of information can you send in this grid? Can you use math to find this answer without counting?

   _____________________________
   _____________________________
   _____________________________

2. How many bytes of information can you send in this grid? How could you use math to figure out how many bytes are shown without counting or outlining each byte?

   _____________________________
   _____________________________
   _____________________________
   _____________________________

   8 bits = 1 byte
   1,000 bytes = 1 _____ byte
   1,000,000 bytes = 1 _____ byte
   1,000,000,000 bytes = 1 _____ byte
Sending Information With Waves

Receiver Handout (back)

Section 3, Lesson 12

**DRAW the information you get here:**

<table>
<thead>
<tr>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Trial 4</th>
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<tbody>
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</table>

**Did it match the transmitter’s pattern exactly?**

- **Trial 1**: Yes or No
- **Trial 2**: Yes or No
- **Trial 3**: Yes or No
- **Trial 4**: Yes or No
Waves, Codes, and Computers
Extension Activity

Section 3, Lesson 12

Name: _______________________________ Date: __________________

Make a code for the alphabet using only one byte of information for each letter. A and B have been done for you.

A B EC D F G H I
J K NL M O P Q R
S T WU V X Y Z Blank
Make up a code for all of the other letters, then write a secret word or words to send in code. Figure out how many bytes of information you would need to send your secret word or words.

My secret word or words:

I would need ______ bytes of information to send this message. Explain how you figured this out:

Now, fill in the boxes to write out your secret word or words. My secret word or words:
Vocabulary
All Sections and Lessons

RECOMMENDATION
We recommend that students participate in investigations as they learn vocabulary, that it is introduced as they come across the concept. MySci students work collaboratively and interact with others about science content also increasing vocabulary. The hands-on activities offer students written, oral, graphic, and kinesthetic opportunities to use scientific vocabulary and should not be taught in isolation.

AMPLITUDE
The height from the baseline to the trough or crest of the wave.

ANGLE
The space (usually measured in degrees) between two intersecting lines or surfaces at or close to the point where they meet.

CLASSIFY
To arrange in groups, by some property or category. Examples: color, shape size.

COMPARE
Find similarities between and among different items or concepts.

COMPRESSION WAVE
A wave that moves by compressing and expanding particles as the wave moves through matter.

CONTRAST
Find differences between and among different items or concepts.

FREQUENCY
How often the period occurs in a specific amount of time (seconds).

PATTERN
A repeated movement or design.

PENDULUM
A pendulum is a moving rod or string that has something on one end and you can make it swing back and forth.

PERIOD
The movement of the pendulum out and back one time (one complete cycle).

PULSE
One wavelength moving through matter.

REPETITIVE MOTION
Persistent and continual motion.

RECEIVER
The person or device that is getting the information.

 RIPPLE
A small wave or series of waves on the surface of matter.

TRANSMITTER
The person or device that is sending information.

TRANSVERSE WAVE
A wave starts at a point and goes out over a distance, moving in a back and forth or up and down motion.

TSUNAMI
A very high, large wave in the ocean that is usually caused by an earthquake under the sea and that can cause great destruction when it reaches land.

VIBRATION
A continuous slight shaking movement: a series of small, fast movements back and forth or from side to side.

WAVE
A back and forth or up and down movement on the surface of, or through, particles of matter. Examples of waves are sound waves, ocean waves, hand waves, radio and TV waves.

WAVELENGTH
Wavelength is the distance between identical points on a single wave.