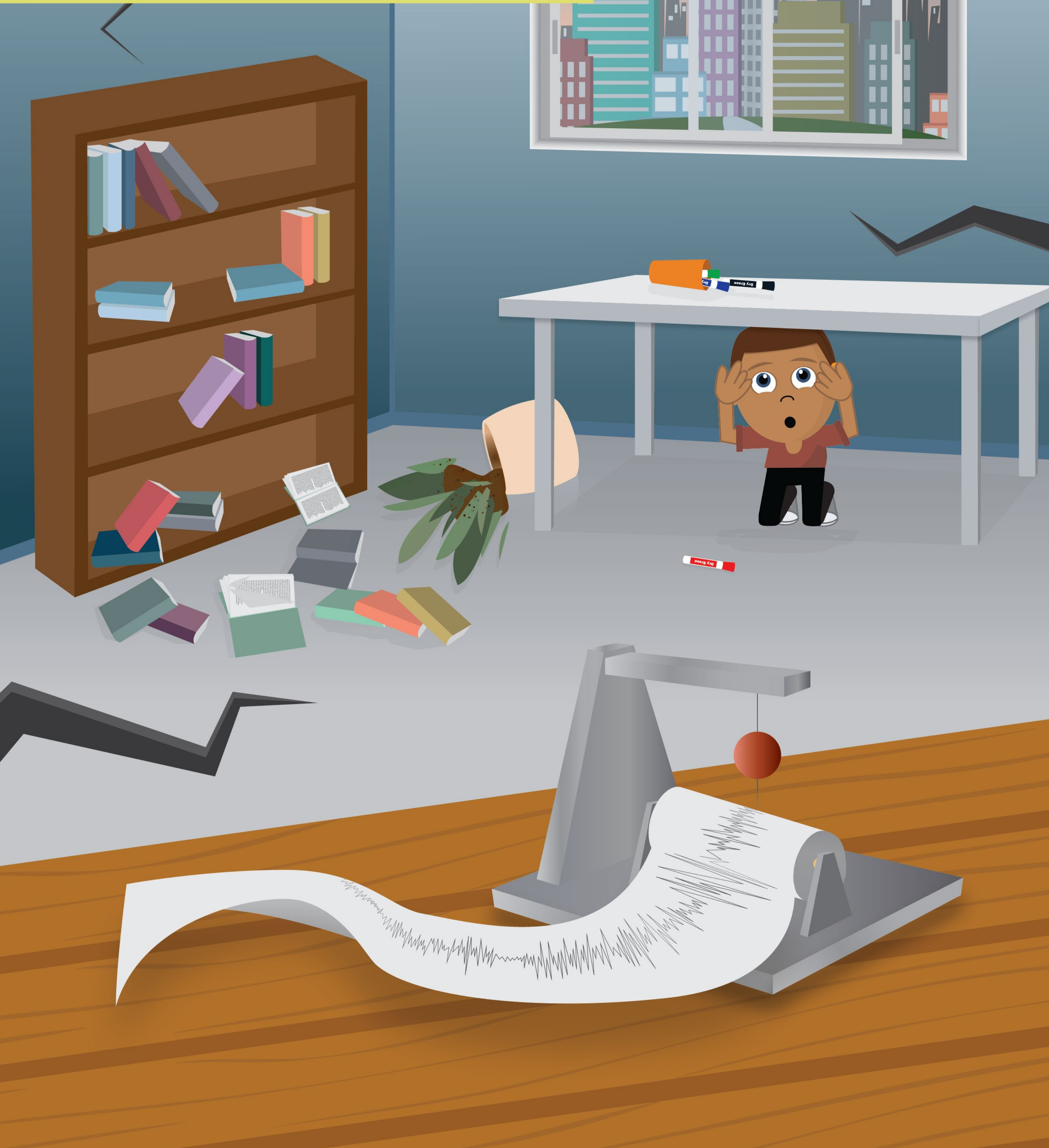
GEOLOGY

Seismology and Earthquakes



NGSS

2-ESS2-2; 4-ESS3-2

Objective

The student will understand seismology and how earthquakes affect people and the world around them. The importance of good engineering will play a major role in demonstrating how structures withstand the forces of earthquakes.

The student will be able to explain the differences between seismic waves, describe the two scales used to measure the strength of an earthquake, and replicate the effects of an earthquake on their own marshmallow buildings - all while working as a team!

Vocabulary

Epicenter: The point on the Earth's crust directly above the origin of an earthquake.

Body Wave: Type of seismic wave from an earthquake that travels through the ground.

Surface wave: Type of seismic wave from an earthquake that travels along the surface of the Earth.

Aftershock: Smaller earth-quakes or tremors that occur after an earth-quake.

Seismograph: Instrument that records how powerful an earthquake is by recording how much the ground shakes.

Seismogram: Graphical record of an earthquake produced by a seismograph.

Richter Scale: Scale used to measure the magnitude of an earthquake, expressed from 1 to 9, with 9 being the strongest.

Mercalli Scale: Scale used to measure the intensity of an earthquake, expressed from I to XII, with XII being the most intense and damaging.

Background

Earthquakes typically happen around tectonic plates. Earthquakes produce waves, called seismic waves, which can be divided into two main types. Surface waves travel along the surface of the earth, and body waves travel below the surface, causing major damage. Waves can be further categorized into P waves (primary waves) and S waves (secondary waves). P waves are the first to occur, and are fast. These waves are compression waves (like sound), which can be demonstrated by a slinky. When the slinky is pulled far apart, it springs back into place. The energy travels along the rings of the outstretched slinky. S waves are slower, but cause the most damage. S waves travel back and forth in a sheering motion. This can be demonstrated by a rope on the ground moving like a snake. Smaller tremors, called aftershocks, can follow after the original earthquake is over. These aftershocks can occur for days or even longer after the earthquake has passed. In the first demonstration, you will be able to see how these waves affect a building (i.e. your toothpicks and marshmallow stuctures). When you tap on the pan, the vibrations travel through the Jell-O, and into the buildings. The buildings may just shake or fall over completely, depending on on the strength of the vibration and how well the buildings are constructed.

To measure how strong an earthquake is, scientists created seismology. Seismology records the vibrations created by an earthquake, and measures their strength using an instrument called a seismograph. The first seismograph was invented in 132 A.D. in China. This was called a seismoscope. When an earthquake occurred, the waves would dislodge the bronze ball, and it would fall into the mouth of a toad positioned below. This allowed people to estimate which direction the wave came from, and locate the epicenter of an earthquake. Today, earthquakes are measured according to a numerical scale called the Richter scale. The Richer scale ranges from 1 (weaker) to 9 (stronger). Although often undetected by humans, a seismograph can detect earthquakes with magnitudes as low as 1-2 on the Richter Scale. Each value on the Richter Scale represents a 10-fold increase in strength (i.e. a logarithmic scale). Earthquakes are also measured using the Mercalli Scale. This scale ranges from I (not felt at all) to XII (nearly total damage caused). In the second demonstration, you will build a seismograph using a pen suspended from a ruler onto a piece of paper. When vibrations occur, the pen will move and leave marks on the paper. This resulting marked-up piece of paper represents a seismogram, or graphical record of an earthquake.

Materials

For each group (2-3 students):

Marshmallow Building:

- 1 box toothpicks
- 1 bag mini marshmallows
- 2 baking pans with Jell-O (prepared according to package directions and set up in advance)

Seismograph Building:

- 2 12" rulers
- 2 fine line markers (e.g. Sharpies)
- 1 roll of adding machine paper
- 1 small box approximately 6" L x 3" W x 2" H to fit the adding machine paper roll
- Several rubber bands
- Strip of tag board or cardboard (about 1.5'' by 3'')
- Cork or square eraser
- 2 pencils or a thin wooden dowel that can fit through the holes in the rulers

For the class

- 4-6 large, heavy books
- Tape
- Scissors

Procedure

Procedure: Jell-O Earthquakes

1. Before handing out experiment materials, explain that the students will be pretending to be engineers by building marshmallow structures.
2. Show the students an example of marshmallow building blocks: cubes, triangles, pyramid, and explain any building restrictions that may increase the difficulty or excitement level. Provide appropriate guidelines based on grade level.
3. Pass out 30 toothpicks and 30 marshmallows to each student and limit students to building one large structure or two smaller stuctures. Keep in mind that every student should have space in the Jell-O pans for their structures.
4. Once complete, place the marshmallow structures on top of the Jell-O surface. If you decide to only test a few student's structures at a time, make sure that the Jell-O is still

relatively intact.

5. Test each structure with different types of forces such as: shaking from side to side, shaking forwards and backwards, tapping the pie pan from below, wave like motions, etc. Discuss and relate each motion to the forces described in the vocabulary.
6. Allow students to re-engineer and test their own structures again if time permits.

Procedure: Seismograph

1. Place a pen/pencil through the middle of the paper roll and place the paper roll on the end of the table. When running the seismograph, have a student secure the roll of paper (while still allowing it to unroll) by holding onto either side of the pen/pencil without touching the paper.
2. Place a cork between two rulers at the 6" mark and tape it in place.
3. Wrap a rubber band around the 1" mark of both rulers together.
4. Place a marker/Sharpie just past the rubber bands so that it is at the very end of the rulers.
5. At the opposite end of the rulers (away from the marker), wedge a pencil into each ruler hole so that the tips of the pencils touch (erasers facing away from the rulers).
6. Suspend the seismograph using 6-8 textbooks, 8 inches apart.
7. Tape a strip of paper to the table on top of the roll of paper to act as a guide for the machine paper.
8. After the apparatus is prepared, have one student hold the seismograph in place by adding pressure on the books, while another student intermittently shakes the paper roll, and a third student (or instructor) pulls the end of the paper in a smooth, gradual motion.
9. Make sure to explain what this experiment is simulating and see if the students can relate the seismograph readings to the Jell-O earthquake experiment.
10. All students should participate in cleaning up the workspace/room.

If time permits, students can go through another round of building using the same materials to see if they can improve the integrity of their buildings.

Guiding Questions

- Ask: What kinds of shapes can you make with the materials provided to withstand an earthquake?
- Can you make your building better? How?
- What do the lines on the seismograph represent?
- Why are some lines on the seismograph taller than others and what does the size of the peaks on the seismograph mean (look at picture above)?

Career/Future Application

Civil, structural, mechanical, and materials engineers ensure the structures we rely upon are built strong enough to keep us safe. To reduce the number of human injuries and casualties, these engineers research and test new and improved techniques and materials that help structures withstand the tremendous forces of an earthquake. For example, engineers have developed shock absorbers and structure sliders, which isolate the foundation of a building from the ground so the building and the earth move independently. Engineers also create monitoring equipment to predict and measure earthquakes and warn surrounding communities when an earthquake is coming.

Sources

https://www.teachengineering.org/view_lesson.php?url=collection/cub_/lessons/cub_natdis/cub_natdis_lesson03.xml

https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_natdis/cub_natdis_lesson03_activity1.xml

https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_natdis/cub_natdis_lesson03_activity2.xml

http://earthscience.stackexchange.com/questions/352/how-to-distinguish-p-s-love-and-rayleigh-waves-in-a-seismogram