Wave Energy Transfer - Teacher Notes

Seismic waves are energy waves released during earthquakes. When seismic waves pass through rock, particles are moved to release stress. Shock waves travel in all directions away from the source and are impeded and deflected by the materials (media) they travel through. NB Although "media" commonly refers to mass communications (radio, TV internet etc.) it is used in Science when referring to more than one intervening substance through which energy is transmitted.

Teacher Demonstration 1

AIM **To demonstrate that energy waves move in all directions away from source**

Materials

- A large container of water
- A marble or small stone

Method

1. Drop the stone into the water and ask students to note that waves move away from source in all directions.

Student observations

1. Describe what happened when the falling object hit the water surface.

When the stone hit the surface of the water waves moved away from the point of impact.

2. What form of energy form was the potential energy of the stone converted to?

Potential energy from the stone was converted into kinetic energy of the water (waves).

Teacher Demonstration 2 (or student activity)

AIM **To demonstrate that waves travel in pulses through a medium**

Materials

- A table, desk or concrete path
- A slinkie (coiled steel or plastic). *Slinkies can easily become tangled and distorted if students do not take care. A little directed practice prior to the activity or a teacher demonstration may be advisable.*
- Two students or one teacher and a student

Method

Bunch up a handful of coils at one end of the slinkie.
Ask another to stretch (but not overstretch) the slinkie and hold the other end firmly.
Lower the slinkie until it just touches the hard surface below.
Release the bunched coils and watch the compressed zone (rarefaction) travel along the slinkie to the other end.
Repeat and discuss.

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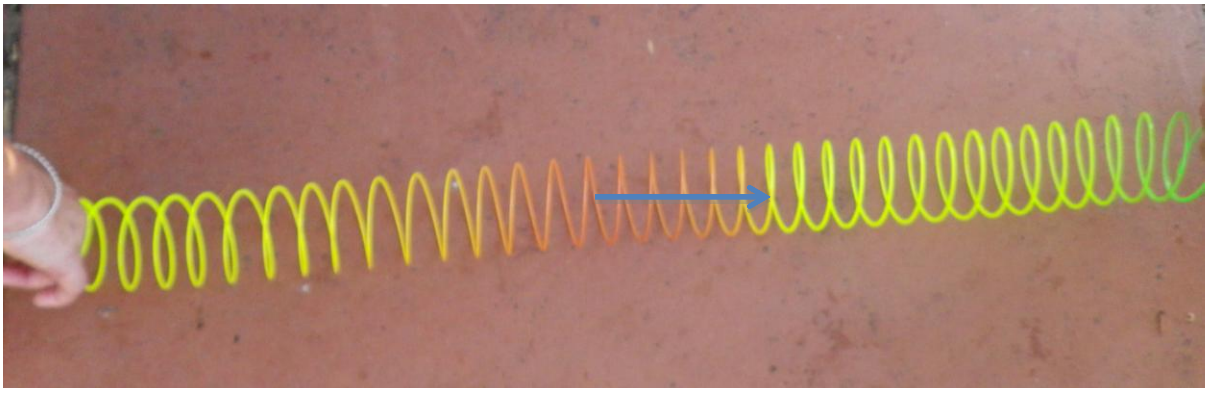

Student observations

3. When the bunch of coils was released from one end, what happened to the slinkie?
The energy travelled as a zone of compacted coils away from the released end.

4. Energy travels as a zone of compaction within the extended coil. Repeat the experiment and check if this statement agrees with your observation. Does it? YES

5. Did the length of the slinkie increase or decrease as the energy pulse travelled along it?
The length remained constant.

A medium is the material that energy waves can pass through. E.g. Light waves pass through the media of air and water. What medium did the elastic energy of compression travel through?
The slinkie, a solid.

Student Activity

Waves are energy passed on through movement of molecules (vibration). Solids are denser than liquids and liquids are denser than gasses. Waves travel faster through solids than air because the molecules are closer together because the forces of attraction between their molecules are stronger than their kinetic energy. A common student misconception is that compression waves only travel through the air. The simple activity below will demonstrate to students that compression waves can pass through solids.

AIM **To demonstrate that energy waves travel through solid media such as the Earth**

Materials

- A wooden desk
- A ruler

Method

1. Lay the ruler to the bone behind your ear (mastoid process)
2. Lay the other end of the ruler onto your desk
3. Scratch underside of desk directly below the ruler
4. Repeat scratching without the ruler

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Student Observations

6. What did you observe?

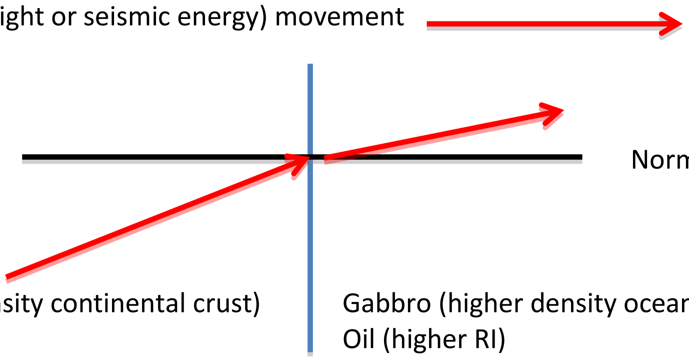
When the ruler made a solid connection between the ear and the desk scratching could be heard. When the only connection between the desk and the ear was a gas (air) no sound could be heard.

7. Why do compression waves such as sound travel more easily in a solid than a liquid?

Kinetic Energy theory, learned in Year 8 suggests that molecules are more closely bound together in a solid as the forces of attraction exceed kinetic energy. It is therefore easier to pass movement energy from one molecule to another.

When a wave passes from one medium into another with a higher refractive index, RI (generally a more dense medium) the wave is bent or refracted towards the normal (a plane at right angles to the interface between the two media)

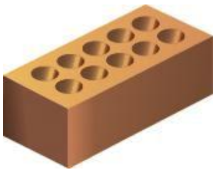
Direction of wave (light or seismic energy) movement



Normal

Sandstone (low density continental crust)
Water (Low RI)

Gabbro (higher density oceanic crust)
Oil (higher RI)



In the school laboratory light energy is easier to manipulate than seismic energy. You may wish to hit one end of a brick with a hammer. Students can feel the compression energy transmitted through the solid brick to their fingers.

Teacher Demonstration 3

<u>AIM</u> To demonstrate refraction of light at the interface of two different media

Materials

- Tall glass beaker or measuring cylinder
- Pencil, knitting needle, pencil or metal rod
- Water
- Cooking oil

Method

1. Place a narrow rod or pencil into a container with two liquids of different densities.

Student Observations

8. Draw what the pencil looks like before it is placed into the liquids in the glass.

9. Draw what the pencil looks like when it is partially immersed in liquids with different refractive indices (different media)

10. What appears different when the pencil is viewed through different media?
Parts of the pencil appear both displaced and wider than it is in air. The greatest displacement and distortion was through oil.

11. Name the different media through which light energy was transmitted.
Water, oil and air.

12. Earthquakes energy (seismic waves) is transmitted through different density layers in the Earth. Would you expect it to be refracted (bent) Yes. The different layers would refract the waves.

Interesting Fact

When Aboriginal or other hunting people spear fish, they must compensate for refraction. Light rays are bent passing from water to air. The apparent position of a fish will not be its actual position. After a period of learning, a hunter's brain makes habitual adjustments.
This skill is not necessary when spearfishing underwater as both the hunter and the prey are in the same medium.

Beautiful petroglyph of a fish from Murujuga (Burrup Peninsula) on the Pilbara coast.

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Refraction of light can also be demonstrated by adding a little milk to cloud some water in a large beaker. A narrow beam of light from a torch or Hodgekin's Light Box will be refracted at the milk/air interface.

Fun Extension - Teacher Demonstration

Laboratory glass and glycerol have almost the same refractive indices. There are two glass prisms in this photograph. One is outside the glass but the other is invisible within the liquid. Clear colourless glass marbles will also disappear in glycerol.

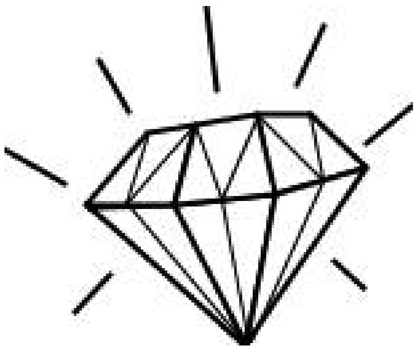
Suggested **materials**

- Two glass beakers
- Water
- Glycerol (sometimes sold as glycerine)
- Two glass objects (stirring rod, lens, broken fragment)
-

Ask students to view what happens when one object is placed in a beaker with water and another placed in the beaker with glycerol

What happened when the glass object was placed in water? The object was clearly visible.

What happened if you placed the glass object in glycerol? The object seems to disappear.



In movies people hide diamonds in ice cubes in their freezers. Does this work? Explain your answer using the data below.
No. The RI of diamond is 2.42, which is very different to the RI of ice 1.31. Diamonds would be obvious within the ice.

Refractive indexes of various transparent materials

Air	1.00	Plain glass	1.45
Ice	1.31	Lab. glass	1.47
Water	1.33	Diamond	2.42
Glycerol	1.47	Methylene iodide	1.74

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How could a sneaky science student find out find out if cheaper stones such as cubic zirconium or spinel had replaced diamonds in a damaged bracelet? (This might require some Internet searching).

Spinel (RI 1.7) will “disappear” when the bracelet is immersed in methylene iodide.
Few liquids have RIs as high as diamond. However another diamond will scratch spinel, as it is harder. The softer stones are fakes.