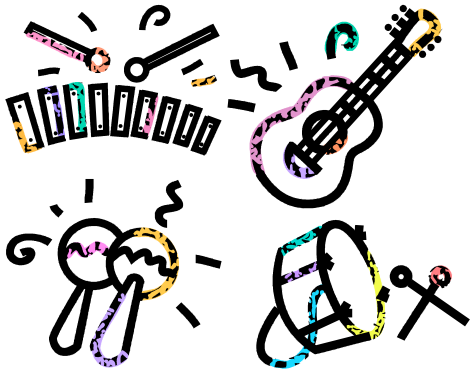
centre de développement pédagogique
pour la formation générale en science et technologie

Working document

THEORETICAL AND PRACTICAL CAPSULE

(This document is addressed to adults.)



Sound

September 2008

Objective

The objective of this capsule is to allow the teaching personnel the opportunity to acquire a quick and correct comprehension of what sound is. A few simple demonstrations, usable in class, are suggested in order to illustrate the concepts.

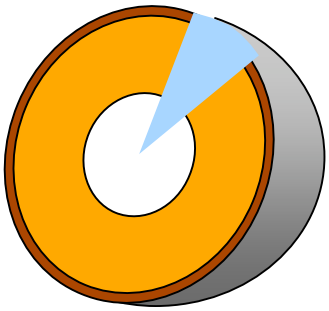
What is sound?

To begin with, a more scientific way of referring to sound is to use the expression "sound waves". This type of wave is in fact a deformation of the center that spreads starting from one point and that transports a certain amount of energy.

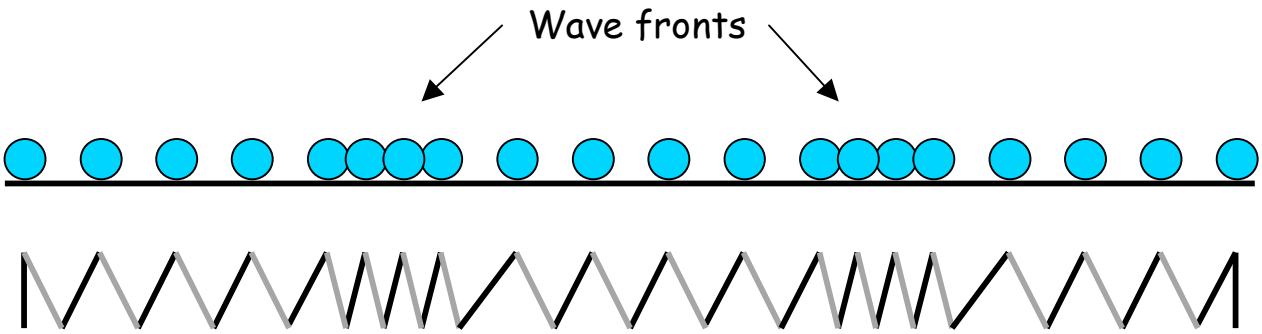
We often use analogies to capture the essence of what this wave truly is. The most popular analogy refers to waves on the surface of water. This way of imagining sound waves is not without interest. Indeed, the sound emitted from a source spreads in the air somewhat like circular waves created by an object dropped into water. Another interesting analogy between the two phenomena is that matter is not displaced with the wave. In the case of the wave in the water, water molecules go up and down without any horizontal displacement. In the case of sound, the particles of matter gently oscillate in a certain position and also do not move with the sound wave.



This analogy is, however, limited. In fact, waves at the surface of the water are displaced on a surface (in two dimensions). Sound in the air is propagated in space (in three dimensions). In two dimensions, the waves are represented by concentric circles (having the same center), while in three dimensions, they are represented by concentric spheres.



The most important limitation of the analogy with waves in the water comes from the fact that the sound wave is a compression wave. The matter which supports the sound wave does not go up and down as is the case with waves in water. Rather, the particles of matter move closer and farther from one another. An interesting analogy to imagine this phenomenon is the propagation of waves in a compressed spring. On the drawing below, the zones where the spring is compressed represents the areas where, in the air, the particles are very close to one another. These zones are called "wave fronts" and by analogy with the water these fronts are represented by the top of the waves.



We could also enlarge the air molecules and represent them with marbles.

A few demonstrations

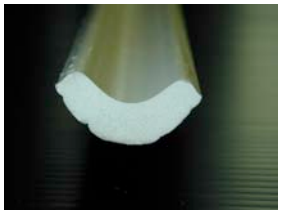
It is precisely this last analogy with marbles that will serve as a base for the following five demonstrations. They will allow you to understand the phenomenon of sound waves in the air even better. The five themes broached are as follows:

1- The propagation of a sound wave between two points;
2- The absorption of a sound wave;
3- The energy transported by a sound wave;
4- The reflection of a sound wave (formation of an echo);
5- The speed of a sound wave.

Concretely, we will simply align several glass marbles on a quarter-round that serves as a ramp. This assembly allows us to simulate a sound wave front in the air, in a single direction. The simplicity of the demonstrations allows them to be easily used in class and should captivate the students – and maybe even you - who knows!

Necessary material

- 1 package of adhesive gum (blue sticky tack used to stick drawings on the wall);
- 24 glass marbles (about 1.5 cm. in diameter);
- 3 photos: a mouth, an ear, a mountain (see photos 1, 2 and 3 attached);
- 2 meters (8 feet) of concave quarter-round (see photo 4 attached);
- 1 piece of duct tape;
- 1 large heavy filing cabinet (as a support for the system);
- 1 piece of solid metal (a mass of 500 grams used for a scale).

Photo 1	Photo 2	Photo 3	Photo 4
			

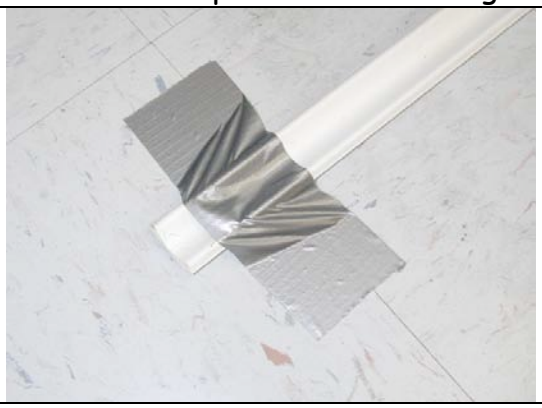
Assembly of the ramp

1. Jam one extremity of the quarter-round in to the upper handle of the filing cabinet. The concave part of the quarter-round should point upwards in such a way that it forms a ramp where the marbles will roll.

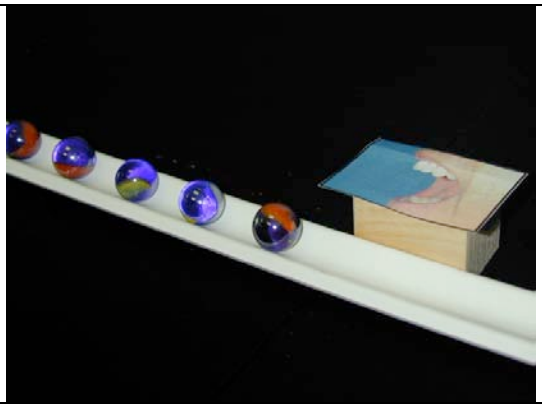




2. Affix the other end of the ramp to the floor using the duct tape.

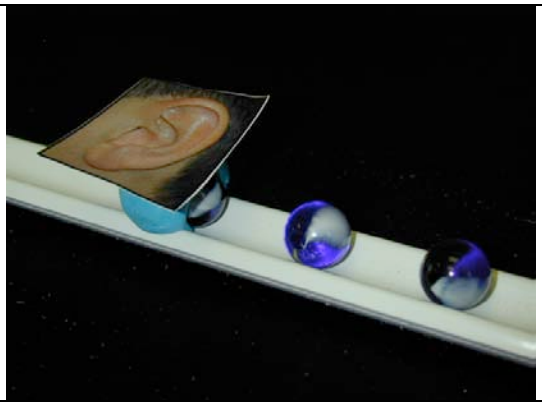


3. Install the mouth at the base of the slope, where the ramp first touches the floor. The opening of the mouth must face the bottom of the slope so that a marble rolling down the slope seems to come out of the mouth. This is our way of simulating the emission of a sound.



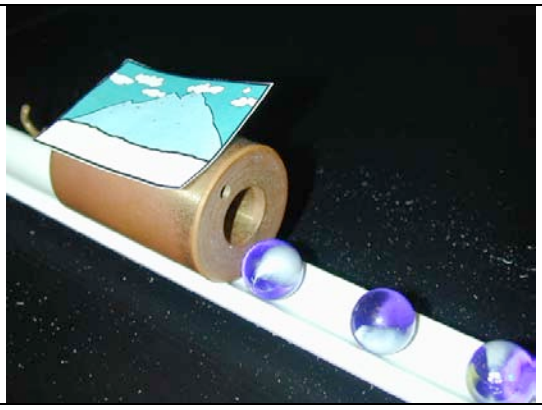
4. Install the ear, further along, on the ramp. Its position will vary depending on the demonstration. The sticky tack should be shaped so as to retain a marble that collides with it. This is our way of simulating the reception of a sound.



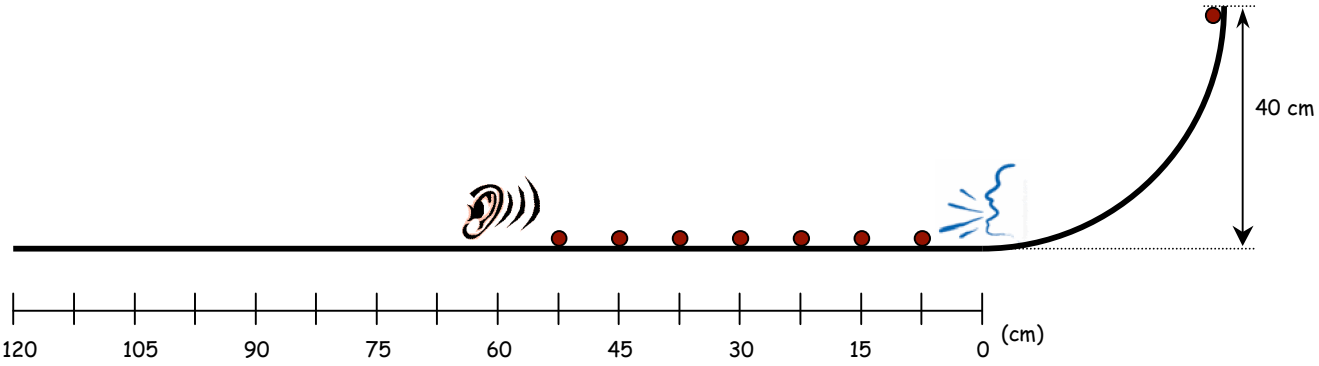


5. Finally, for the fourth demonstration, you will simply need to replace the ear with a metal mass acting as a mountain.





First demonstration: propagation of a sound wave between two points



Description

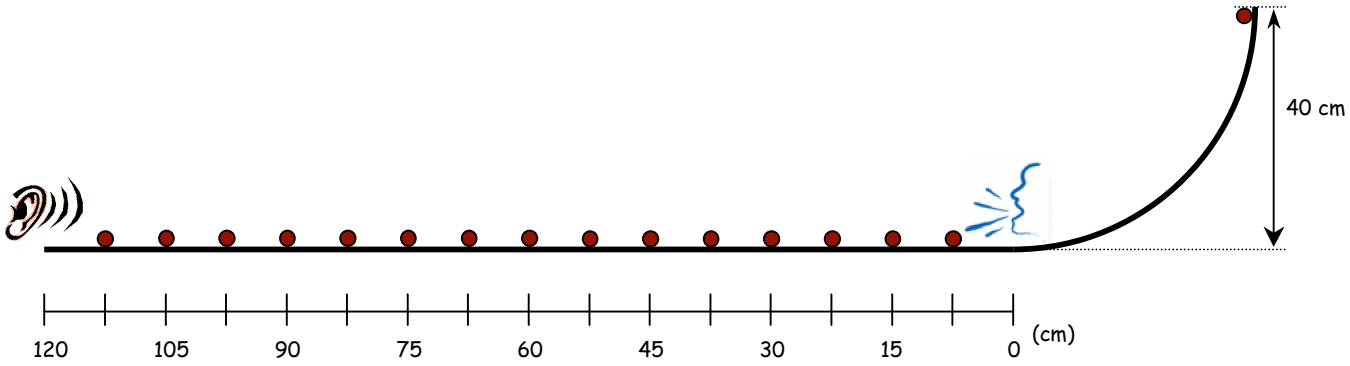
The marble placed at the top of the ramp, 40cm. above the ground, has potential gravitational energy. This energy will gradually be transformed into kinetic energy (energy of movement) while rushing down the slope. When the marble passes the level of the mouth, this energy of movement will simulate the sound energy emitted by a yell. The marbles will collide like air particles upon passage of a compression sound wave. The last marble, which is the furthest to the left, will be projected onto the sticky tack and will stay there. This adhesive gum simulates the absorption of the sound energy by the ear.

Manipulations

1. Install the photo of the mouth at the base of the ramp.
2. Install the photo of the ear 60 cm. from the mouth.
3. Place 7 marbles at the positions indicated on the diagram above.
4. Hold the 8th marble at the top of the ramp at a height of 40 cm. from the floor.
5. Release the 8th marble: it rushes down the ramp and picks up speed.
6. Observe the collisions.

N. B. Video documents of these demonstrations are available on the CPD's website.

Second demonstration: the absorption of a sound wave



Description

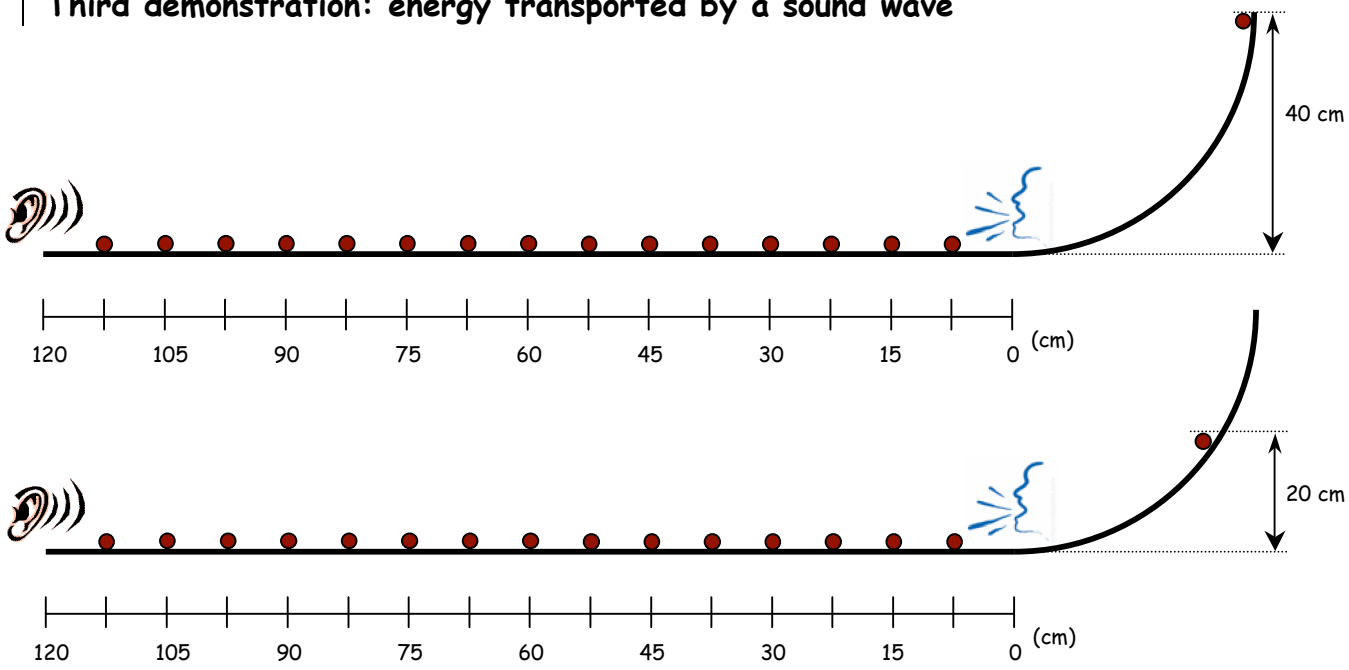
As in the previous demonstration, the marbles will also collide. Each collision entails a loss of energy. The wave will therefore not travel to the ear. A person's yell into the air has a limited range as well. The sound energy is also dissipated because of the distance.

Manipulations

1. Install the photo of the mouth at the base of the ramp.
2. Install the photo of the ear 120 cm. from the mouth.
3. Place 15 marbles at the positions indicated on the diagram above.
4. Hold the 16th marble at the top of the ramp at a height of 40 cm. from the floor.
5. Release the 16th marble: it rushes down the ramp and picks up speed.
6. Observe the collisions.

N. B. Video documents of these demonstrations are available on the CPD's website.

Third demonstration: energy transported by a sound wave



Description

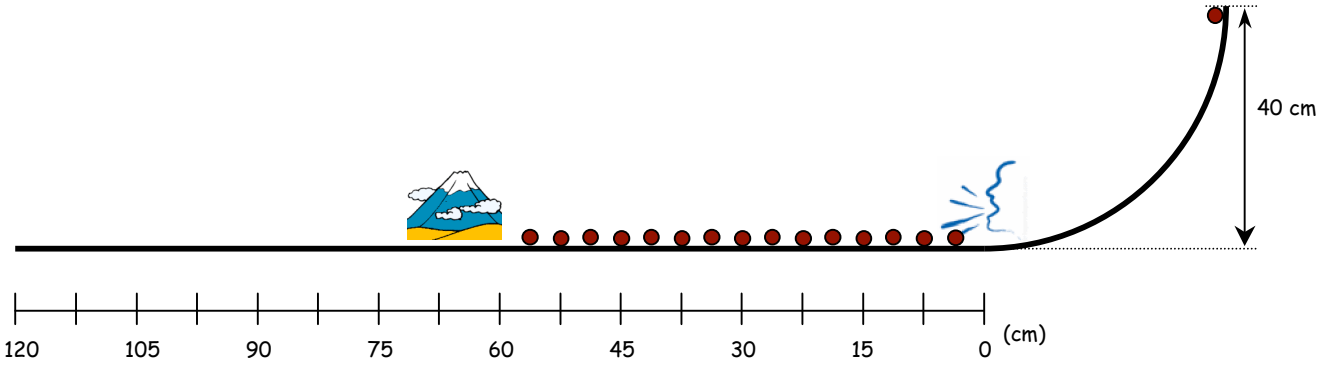
The preceding demonstration is started over here, while varying the height at which the marble is released. This height corresponds to the energy transported by the sound wave. The higher the marble is released, the louder the simulated sound will be. The propagation of collisions should stop sooner in the case of a release from a height of 20 cm.

Manipulations

1. Install the photo of the mouth at the base of the ramp.
2. Install the photo of the ear 120 cm. from the mouth.
3. Place 15 marbles at the positions indicated on the diagram above.
4. Hold the 16th marble at the top of the ramp at a height of 40 cm. from the floor.
5. Release the 16th marble: it rushes down the ramp and picks up speed.
6. Observe the collisions.
7. Begin these manipulations again, placing the 16th marble at a height of 20cm.

N. B. Video documents of these demonstrations are available on the CPD's website.

Fourth demonstration: The reflection of a sound wave



Description

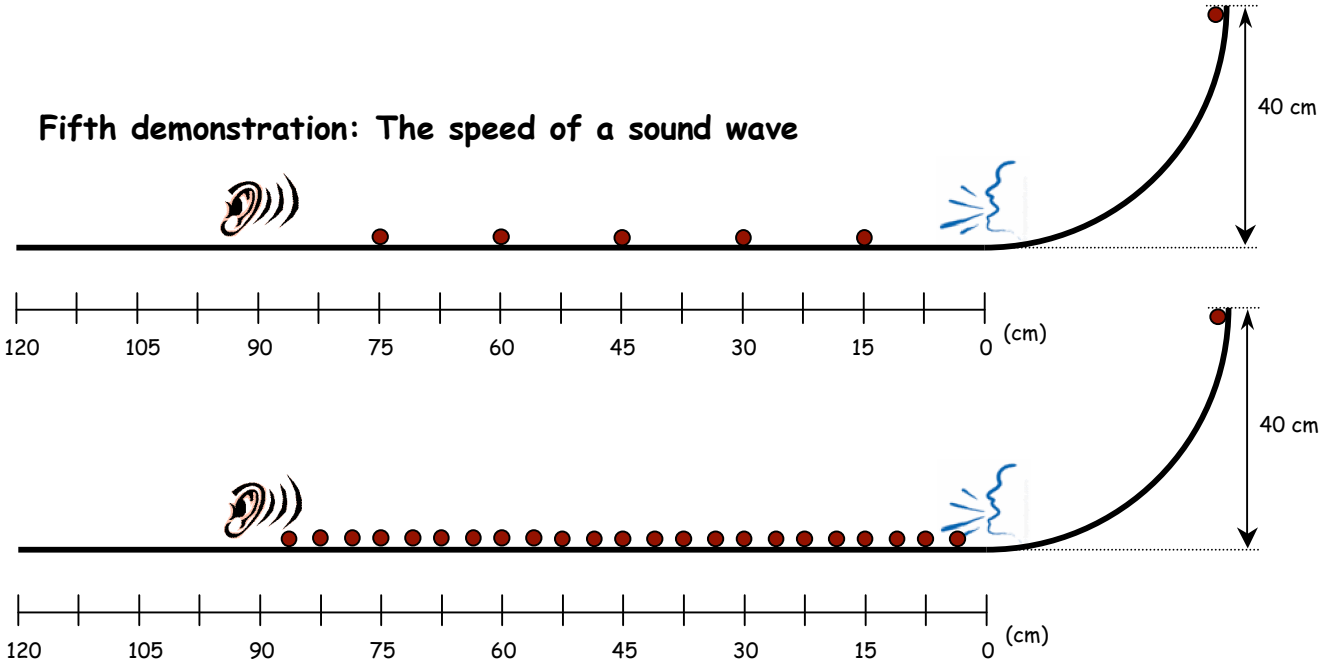
Here, the collisions will spread from the mouth to the mountain. Then, like the formation of an echo, the marbles will come back in the opposite direction. The absorption effect will certainly also make itself felt. In fact, the echo will probably not come back to its emitter.

Manipulations

1. Install the photo of the mouth at the base of the ramp.
2. Install the piece of solid metal with the photo of the mountain 60 cm. from the mouth.
3. Place 15 marbles at the positions indicated on the diagram above.
4. Hold the 16th marble at the top of the ramp at a height of 40 cm. from the floor.
5. Release the 16th marble: it rushes down the ramp and picks up speed.
6. Observe the collisions.

N. B. Video documents of these demonstrations are available on the CPD's website.

Fifth demonstration: The speed of a sound wave



Description

Sound waves can spread in locations containing more or less particles. In solids, for instance, the density of particles is greater. Under certain conditions, the density of the air may also be greater:

- High humidity (presence of water molecules in the air);
- Low temperature (air molecules get closer together);
- High atmospheric pressure (air molecules get closer together).

The speed of the compression wave is greater if there are more molecules. That is why cowboys heard the train coming when they pressed their ear to the iron track. The sound came to them more quickly and gave them time to prepare themselves. Sound therefore travels more quickly at sea level, in the damp cool air.

Manipulations

1. Install the photo of the mouth at the base of the ramp.
2. Install the photo of the ear 90 cm. from the mouth.
3. Place 5 marbles at the positions indicated on the diagram above.
4. Hold the 6th marble at the top of the ramp at a height of 40 cm. from the floor.
5. Release the 6th marble: it rushes down the ramp and picks up speed.
6. Observe the collisions.
7. Begin these manipulations again, using 23 marbles.

N. B. Video documents of these demonstrations are available on the CPD's website.

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