1. Introduction to Waves, Sound and Light

	Topic	Heinemann		
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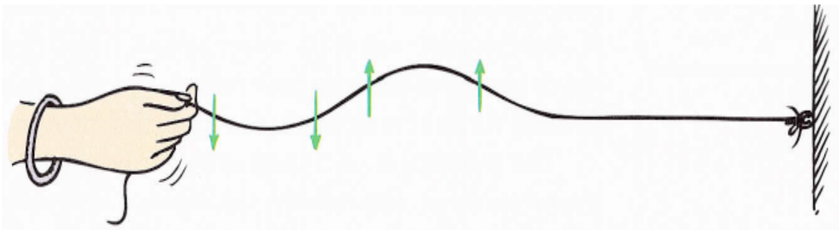
Waves Transfer Energy

Most information about our surroundings comes to us in some form of waves. It is through wave motion that

- sounds come to our ears,
- light comes to our eyes, and
- electromagnetic signals come to our radios and television sets.

Example: String



Consider the simple case of a horizontally stretched rope. If one end of such a rope is shaken up and down, a rhythmic disturbance travels along the rope.

Each part of the rope moves up and down, while the wave moves along the rope from left to right. The rope returns to its initial condition after the disturbance has passed.

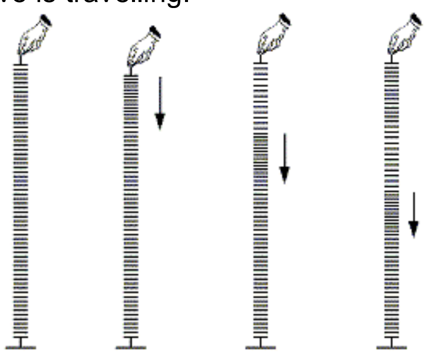
Example: Water

If a stone is dropped into a quiet pond, waves will travel outward in expanding circles. In this case, we might think that water is being transported with the waves, since water is splashed onto previously dry ground when the waves meet the shore. Remember, though, that the water will flow back into the pond, and things will be much as they were in the beginning. The surface of the water will have been disturbed, but the water itself will finish in its original position. A leaf on the surface will bob up and down as the waves pass, but will end up where it started.

Categories of Waves

Longitudinal Waves

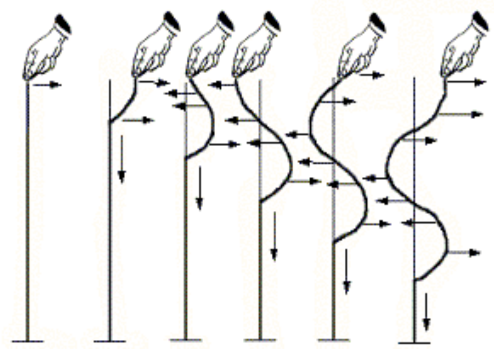
In a longitudinal wave, such as a pulse down a slinky as illustrated in the diagram below, the wave disturbance is in the same direction as the wave is travelling.



Examples: sound, pulses in slinkies.

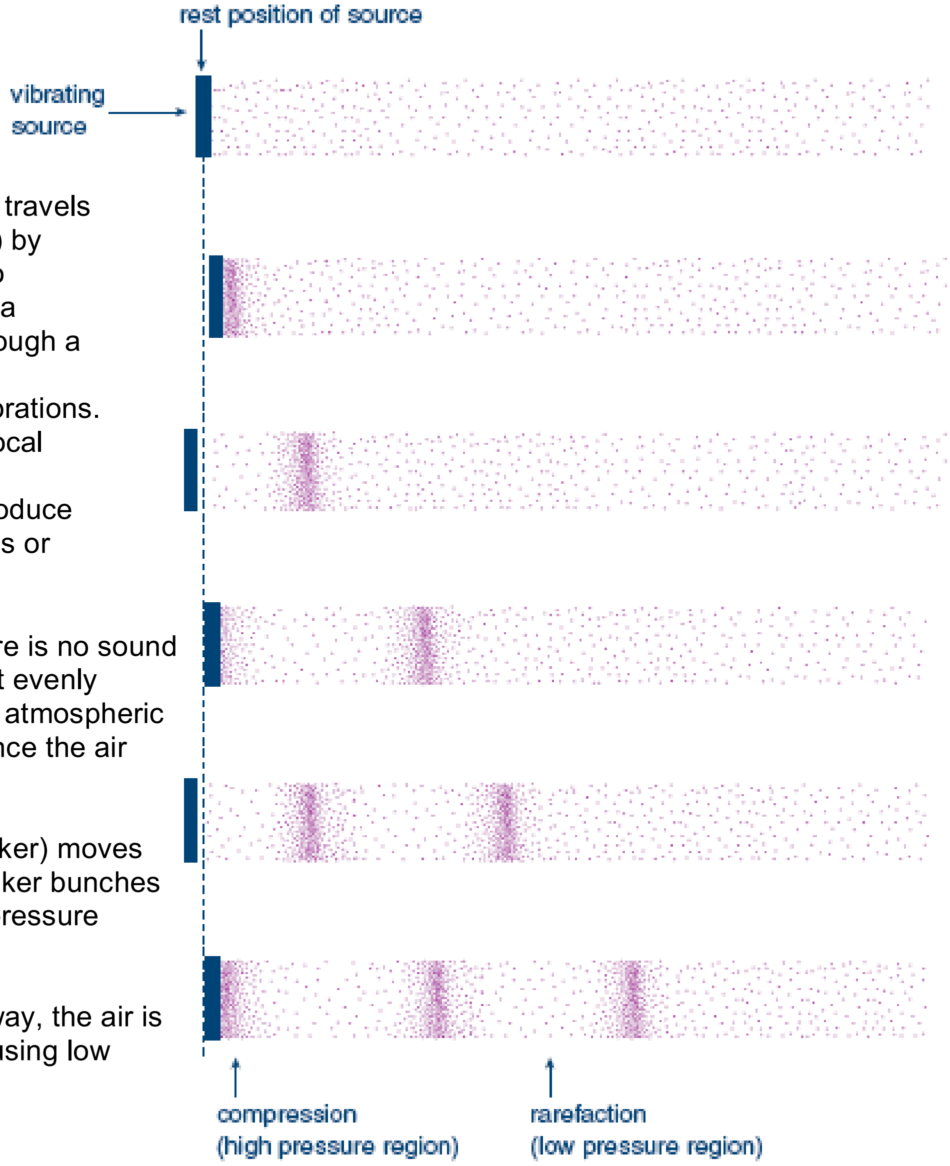
Transverse Waves

In a transverse wave, such as a pulse down a spring as illustrated in the diagram below, the wave disturbance is perpendicular to the direction as the wave is travelling.



Examples: Light, water waves, mexican wave

Sound Waves are Longitudinal



Sound is a form of energy that travels through any medium (material) by causing parts of the medium to vibrate. Sound waves require a medium, they do not travel through a vacuum.
All sounds are produced by vibrations.

- When we speak, our vocal cords vibrate.
- Musical instruments produce vibrations in their strings or pipes

In the top diagram, initially there is no sound and the air particles are almost evenly spaced. (Note: there is normal atmospheric pressure, temperature and hence the air molecules **are** moving)

As the source (such as a speaker) moves forwards, the air near the speaker bunches up (high pressure). This high pressure travels away from the speaker.

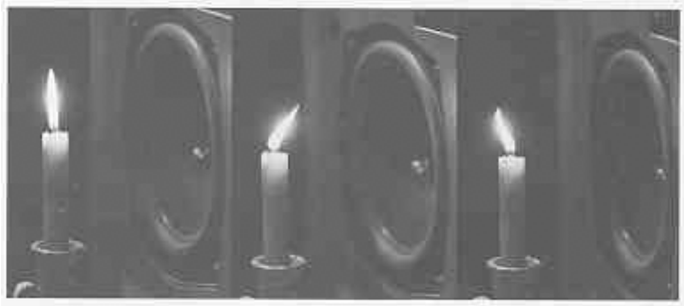
As the speaker then moves away, the air is pulled back, or spread out, causing low pressure.

- This is repeated, and a wave of high and low pressure regions moves to the right, away from the speaker
- Note that the air particles do not move with the high or low pressure regions, but simply back and forth.
- Once the speaker stops vibrating, the particles return to their original positions.

Question

A very light bit of fluff floats in the air a short distance in front of a speaker. Michelle thinks that when the speaker is turned on, the fluff will be pushed slowly away from the speaker. Kim thinks that the piece of fluff will vibrate backwards and forwards. Who is correct and why?

If we place a candle in front of a speaker, the sound from the speaker causes the flame to move backwards and forwards.



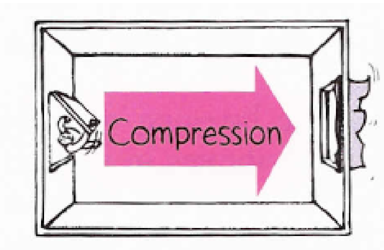
Question

Explain in more detail why the candle is moving backwards and forwards

Parts of Sound Waves – Compressions and Rarefactions

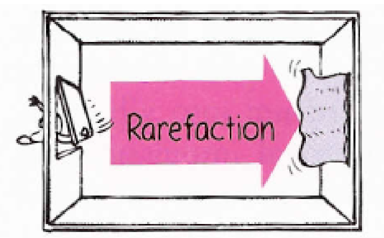
The high pressure regions of sound waves are called compressions and the low pressure regions are called rarefactions. Let us look more closely at these.

Compressions – High Pressure



Consider a room with a door at the left end and an open window with a curtain at the right end. When the door is opened, the door pushes the molecules next to it away from their initial positions and into their neighbors. The neighboring molecules also push into their neighbors, and so on, like a compression traveling along a spring, until the curtain flaps out the window. A pulse of compressed air has moved from the door to the curtain. This pulse of compressed air is called a compression.

Rarefactions – Low Pressure

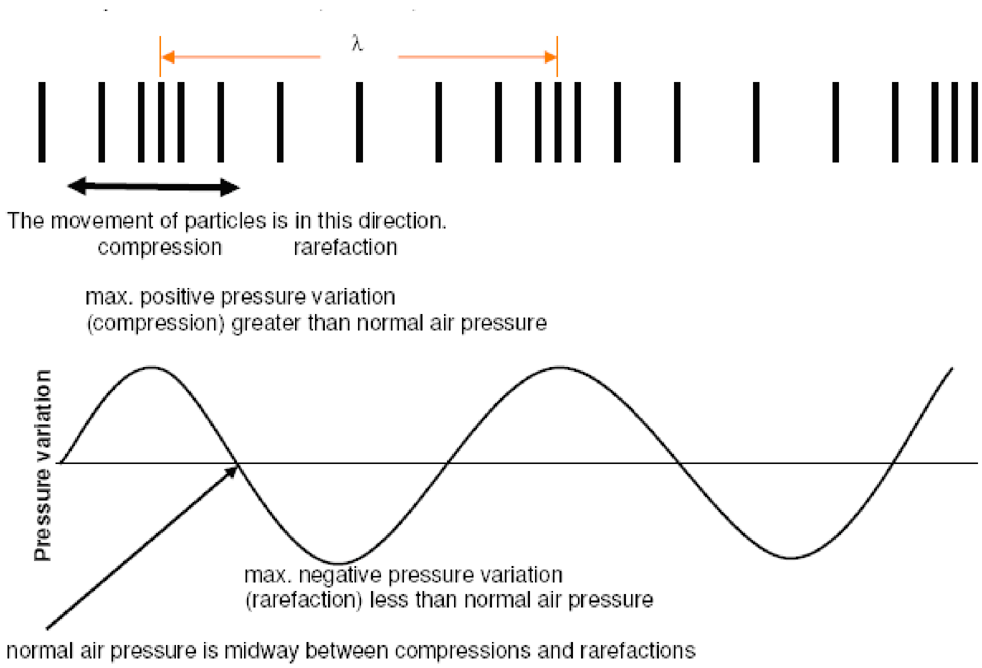


When the door is closed, the door pulls some air molecules back towards the door. This produces an area of low pressure to the right of the door. Molecules then move into it, leaving a zone of lower pressure to the right of them. Other molecules farther away from the door also move, and a wave again travels across the room. This is evidenced by the curtain, which flaps inward. This time the disturbance is a rarefaction.

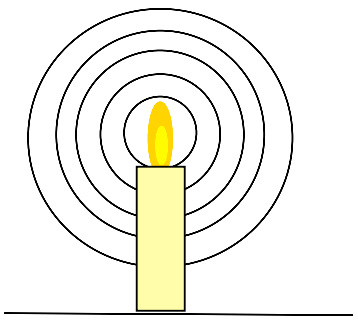
In both cases, the pulse travels from the door to the curtain. We know this because, in both cases, the curtain moves after the door is opened or closed. If you continually swing the door open and closed in periodic fashion, you can set up a wave of periodic compressions and rarefactions that will cause the curtain to swing in and out of the window.

On a much smaller but more rapid scale, this is what happens when a tuning fork is struck. The periodic vibrations of the tuning fork and the waves produced are considerably higher in frequency and lower in amplitude than those caused by the swinging door. You don't notice the effect of sound waves on the curtain, but you are well aware of them when they meet your sensitive eardrums.

Note that compressions are regions where the pressure is high. Rarefactions are regions where the pressure is low. In between there are regions where the pressure is normal (atmospheric pressure). The pressure is never actually zero or negative although it might look like it on the graph



Light – A Transverse Wave?



Like ripples created when a stone is thrown in a pool, electromagnetic waves radiate from sources of light. This can be represented by a series of wavefronts. In the case of the candle shown, light is radiating evenly in all directions, so the wavefronts are spherical. The electric and magnetic waves are both perpendicular to the direction of the light wave. Hence light can best be described as a transverse wave.

Sometimes we wish to indicate the direction in which light is travelling. It is often cumbersome to draw wavefronts to represent this. A simpler representation is to draw *light rays*. A light ray is drawn perpendicular to the wavefronts. Some *light rays* are drawn on the diagrams below.