Sound of Science
Study Guide

Sound

Sound is a form of energy produced and transmitted by vibrating matter. All sounds originate with some kind of vibrating object or substance.

Early Elementary:

Pitch/frequency
High
Low

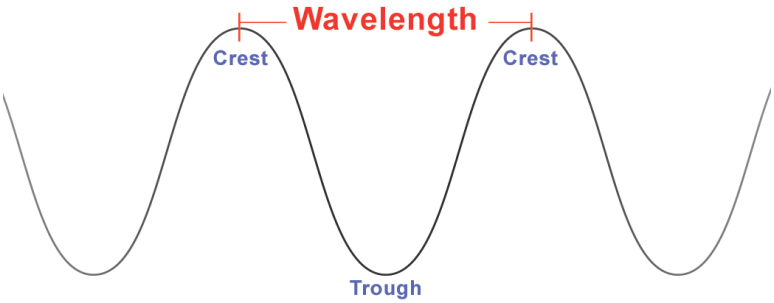
Loudness/amplitude
High
Low

- Try making a variety of high pitched, low pitched and loud and quiet sounds.
- What are things that make sounds?

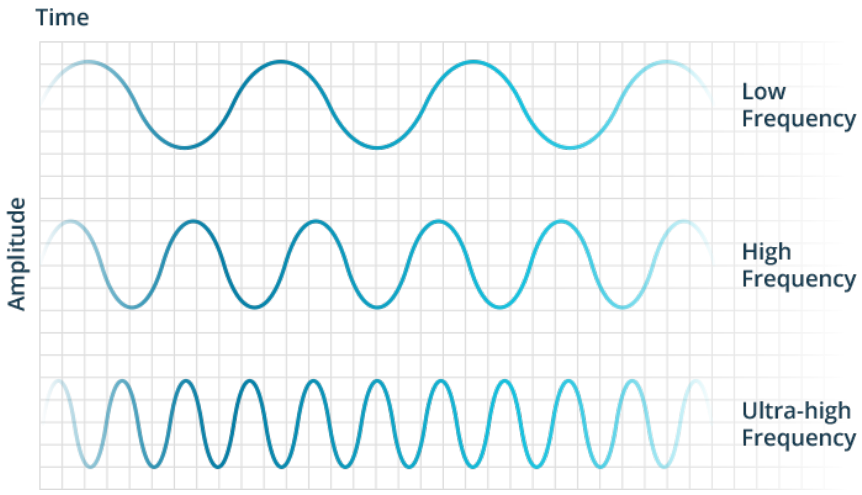
Elementary:

- Sound travels in waves and can be described by the wavelength and frequency of the waves.
- A wave is a vibration moving through a medium such as a solid, liquid, or gas.

What is a wavelength?
The distance between the top (crest) of one wave and another is the wave length (T)

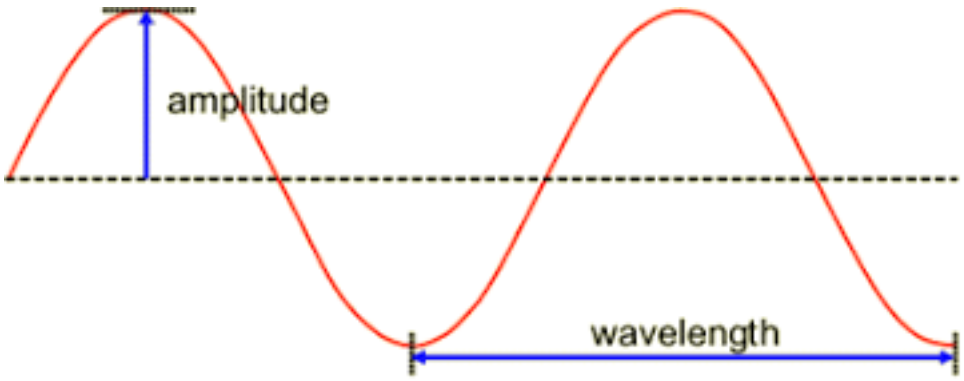


What is frequency?
The frequency of sound is the number of vibrations in a given unit of time.



- **Pitch** is determined by the frequency of a vibrating object. Objects vibrating faster have a higher pitch than objects vibrating slower.
- Loudness and quietness of sound is determined by the height or **amplitude** of the sound wave.

Taller waves (higher amplitude) show louder sounds and shorter waves (lower amplitude) show quieter sounds.



How do different materials affect the way sound travels?
Sound is caused by a vibration of matter. Sound travels through a medium such as air, water, or glass. Sound cannot travel through a vacuum. Sound travels more quickly through solids than through liquids and gases because the molecules of a solid are closer together. Sound moves most slowly through gases because the molecules of a gas are farthest apart.

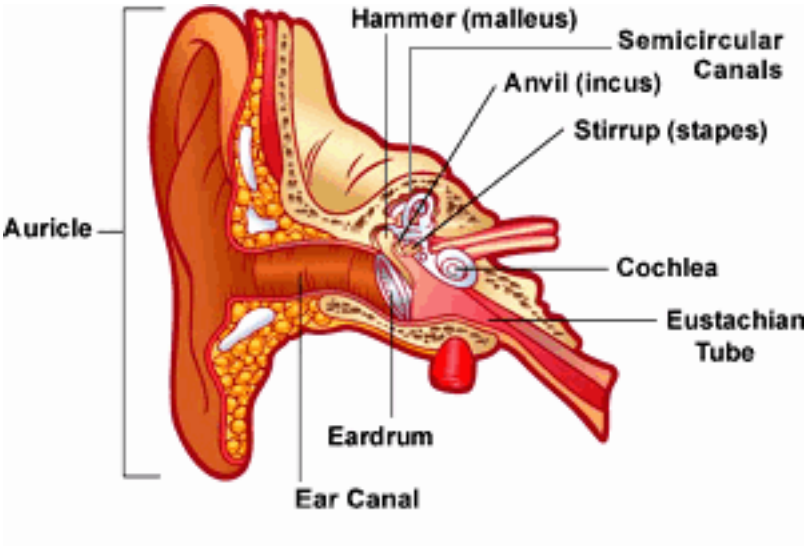
The Ear

Elementary:

The ear is made up of three different sections: the outer ear, the middle ear, and the inner ear. These parts all work together so you can hear and process sounds.

The Outer Ear
The outer ear is called the pinna or auricle. It is designed to collect sound waves. The outer ear also includes the ear canal, where wax is produced. Earwax catches and protects against infections that could hurt the the more delicate middle and inner ear. It also collects dirt to help keep the ear canal clean.

The Middle Ear
After sound waves enter the outer ear, they travel through the ear canal to the middle ear, where they reach the eardrum, a thin piece of skin stretched tight.



The eardrum separates the outer ear from the middle ear and the ossicles, the three tiniest, most delicate bones in your body. The ossicles are the malleus, incus and stapes. Those are Latin words for hammer, anvil, and stirrup.

When sound waves reach the eardrum, they cause it to vibrate and move the tiny ossicles, first the hammer, then the anvil and finally the stirrup. These bones send the vibrations into the inner ear.

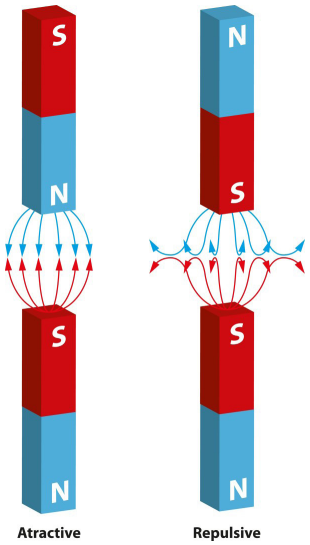
The Inner Ear
Next, the vibrations enter the cochlea, a small, curled tube in the inner ear. The cochlea is filled with liquid, which is set into motion, like a wave, when the ossicles vibrate.

The cochlea is also lined with tiny cells covered in microscopic hairs called cilia. The vibrations cause the cilia to move, creating nerve signals that the brain understands as sound.

Electricity & Magnetism

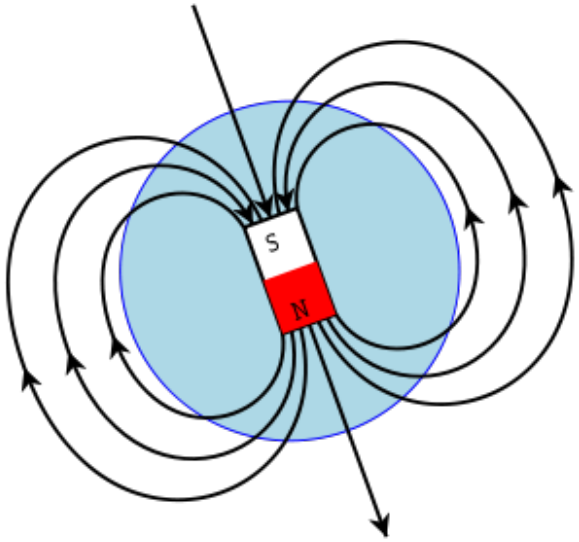
Early Elementary and Elementary:

Magnets
Magnets have a north and south pole.
Unlike poles attract and like poles repel.



Magnetic Field

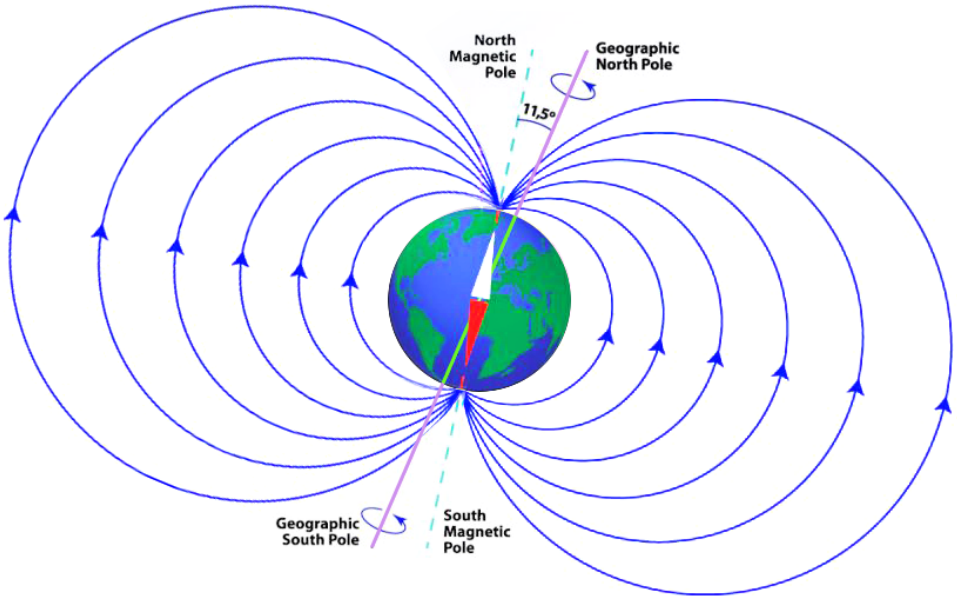
- A magnet creates an invisible area of magnetism all around it called a magnetic field.



- A magnet is strongest at its poles.
- Magnets can attract objects made of iron, nickel or cobalt.
- Magnets can be naturally or artificially made. A natural magnet is called a lodestone and is composed of a mineral called magnetite.
- Magnets are used by all of us in our everyday lives, from smart phones to toys and tools.

Elementary:

- The earth has a magnetic field.



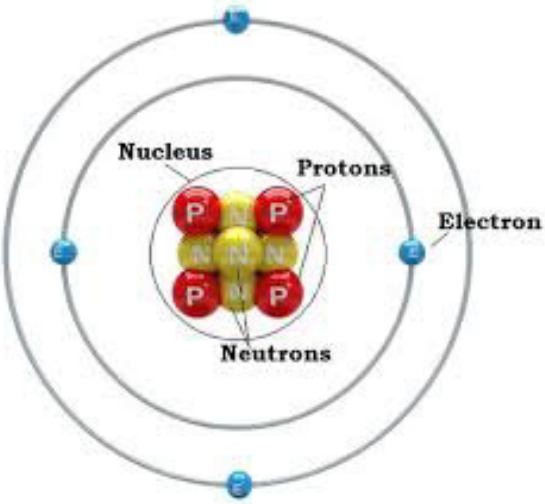
Earth's **inner core** and **outer core** are metal. The outer core is liquid but pressure keeps the inner core solid. The liquid metal outer core is always moving and this generates a magnetic field around the planet. This magnetic field is the reason a compass points north. It also protects the planet from the Sun's radiation.

Heat and the spin of the Earth causes the outer core to move continuously. This constant movement causes electrical currents in the core, which is mostly iron. Iron is attracted to magnets. These electrical currents create a magnetic field around the earth that extends into outer space.

- Electricity and magnetism go hand in hand.
- Electricity always produces a magnetic field.
- When you spin magnets they create electricity.
- All electricity is made from magnets except for solar.
- Magnets are one of the four fundamental forces that control everything that happens in the universe.

How are electricity and magnetism related?
Flowing electrons produce a magnetic field, and spinning magnets cause an electric current to flow. **Electromagnetism** is the interaction of these two important forces.

- A simple electromagnet can be created by wrapping a wire around an object that contains iron. The more coils, the stronger the electromagnet.
- All **matter** is made up of tiny invisible particles called **atoms**.
- **Atoms** are the baseline for static electricity and consist of **protons**, **neutrons** and **electrons**.



- **Electrons** (E) have a negative charge.
- **Protons** (P) have a positive charge.
- **Neutrons** (N) are neutral and add weight.
- **Unlike** charged particles always attract, **like** charged particles always repel.

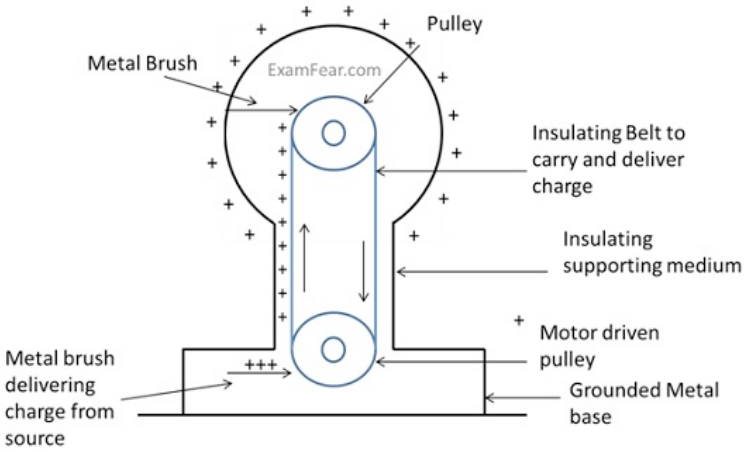
When two different materials come close or touch, electrons may be transferred from one material to the other.

- **Electricity** can take two forms, **Static** or **Current**.

Static electricity
Static electricity is an imbalance of positive and negative charges within or on the surface of a material. Electrons build up on the material and the material will remain charged until the extra electrons leave it through an electric current or discharge.

Current electricity
Current electricity flows uninterrupted through wires or other conductors and transmits energy. A **Van de Graaff Generator** is a fun way to demonstrate electricity. If you stand on a neutral object between you and the floor and touch the generator, your hair will stand up.

This happens because the Van de Graaff Generator fills with positive charges. When you are connected to it, then you charge up with positive charges as well.



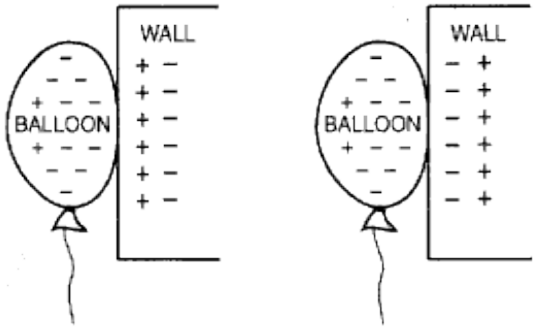
Construction of Van de Graaff generator

Balloon Experiment

When you rub two different materials together, one material loses electrons, leaving it positively charged, while the other one gains electrons, leaving it negatively charged.

When you rub a balloon against your hair, electrons jump from your head to the balloon and the balloon becomes negatively charged. When you bring the negatively-charged balloon close to a neutral object such as a wall, the balloon will attract the positive charges of the wall. The balloon will remain stuck to the wall as long as the balloon is negatively charged. This is **static electricity**.

The balloon's negative charges repel negative charges in the wall. This leaves a row of positive charges on the outside edge of the wall. The negatively charged balloon is attracted to the wall's positive charges and sticks to it.



Lightning

Lightning is the discharge of static electricity in the air. When warm air rises and meets cold air, water droplets in the warm air rub against ice crystals in the cold air. This causes friction and creates an electrical charge. Positive charges (protons) gather at the top of the cloud and negative charges (electrons) gather at the bottom of the cloud. A positive charge builds up on the ground beneath the electrically charged cloud. The positive charge on the ground gathers on anything that sticks up, like a tree, a lightning rod or even a person. When a cloud system gathers enough charge relative to the earth's ground, the charges will try to equalize. When they do this, massive charges run through the air from ground to the cloud and then the cloud fires a massive lightning bolt back to the ground.

Plasma ball demonstration

Plasma is a state of matter in which a gaseous substance becomes highly electrically charged (ionized) to the point that long-range electric and magnetic fields dominate the behavior of the matter. Plasma has a nearly equal amount of positively charged ions and negatively charged electrons. Plasma is the fourth state of matter, the others being solids, liquids and gases.

- **Alternating current**
  An alternating electric current periodically reverses direction. The outlets on your wall use alternating currents (AC). Batteries in your toys use direct current (DC) and do not change direction. This is where the heavy metal band AC/DC got its name.

The alternating voltage at the centre of the ball creates electromagnetic waves, and the arcs of plasma are like antennas. The magnetic field goes far past the glass surface of the ball. When you touch the glass, energy immediately flows to your finger because the human body is more conductive and more easily polarized than the gas inside the globe. Just like lightning, the energy in the ball flows to the most attractive spot.

The invisible magnetic field surrounding the globe can turn on a fluorescent light bulb held in midair!