Properties of Waves

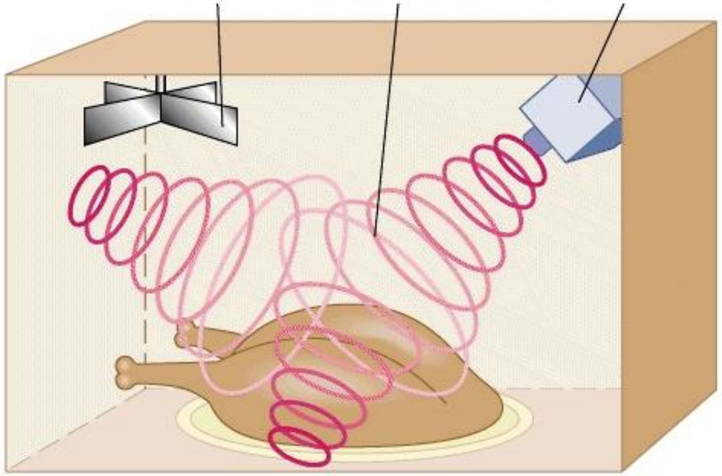
Lesson 19

Many properties of light can be understood using a wave model of light

- Imagine standing at the edge of a lake. The lake is calm and flat. It acts like a mirror, reflecting the far shore and the mountains beyond. Suddenly, a fish jumps. You hear a splash, and circles of water waves radiate out from where the fish re-entered. These waves carry the energy that the fish transferred to the water surface by its jump. The size of the waves and amount of energy they carry give you information about the size of the fish and how far out of the water it jumped. Light is also a wave that carries energy a long way, as it travels from its source, such as a flashlight or a star. All waves, including water waves and light waves, share many common characteristics.

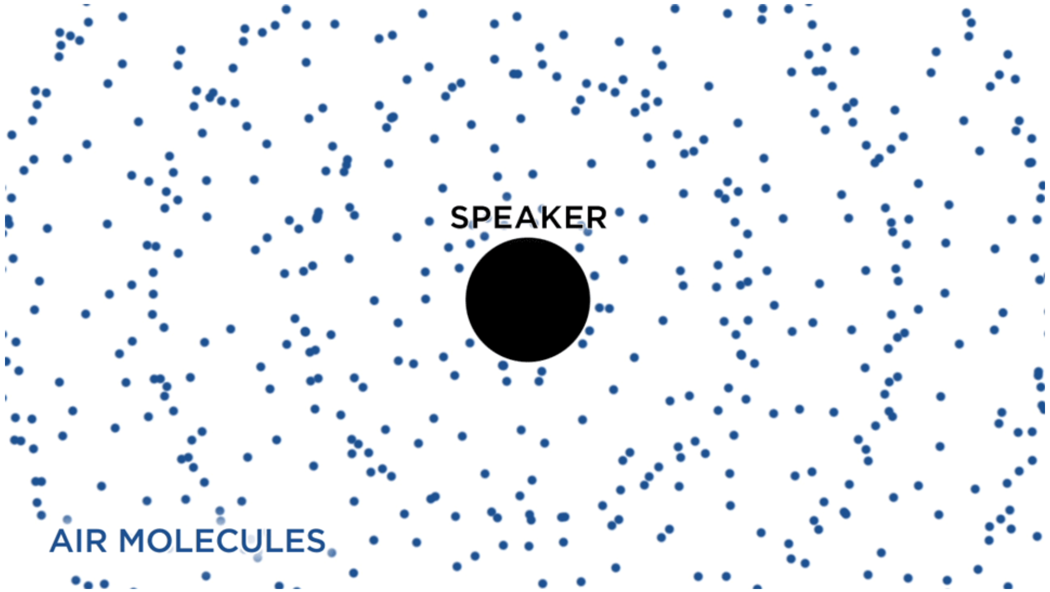
Properties of Waves

- Waves transfer energy through matter or space
  - A surfer bobs in the ocean waiting for the perfect wave
  - Microwaves warm up your leftover pizza
  - Sound waves from your device brings music to your ears
- These and other types of waves have many properties in common



Features of a Wave

- A **wave** is a disturbance or movement that transfers energy through matter or space, without causing any permanent displacement
  - Sound waves disturb the air and transfer energy through it
  - Ocean waves disturb the water and transfer energy through it
- **Energy** is the capacity to apply a force over a distance
- A **force** is a push or pull on an object



Features of a Wave

- A **crest** is the highest point in a wave
- A **trough** is the lowest point in a wave

- The dotted line shows the equilibrium or rest position
- The **<u>rest position</u>** is the level of the water when there are **<u>no waves</u>**

Wave Direction

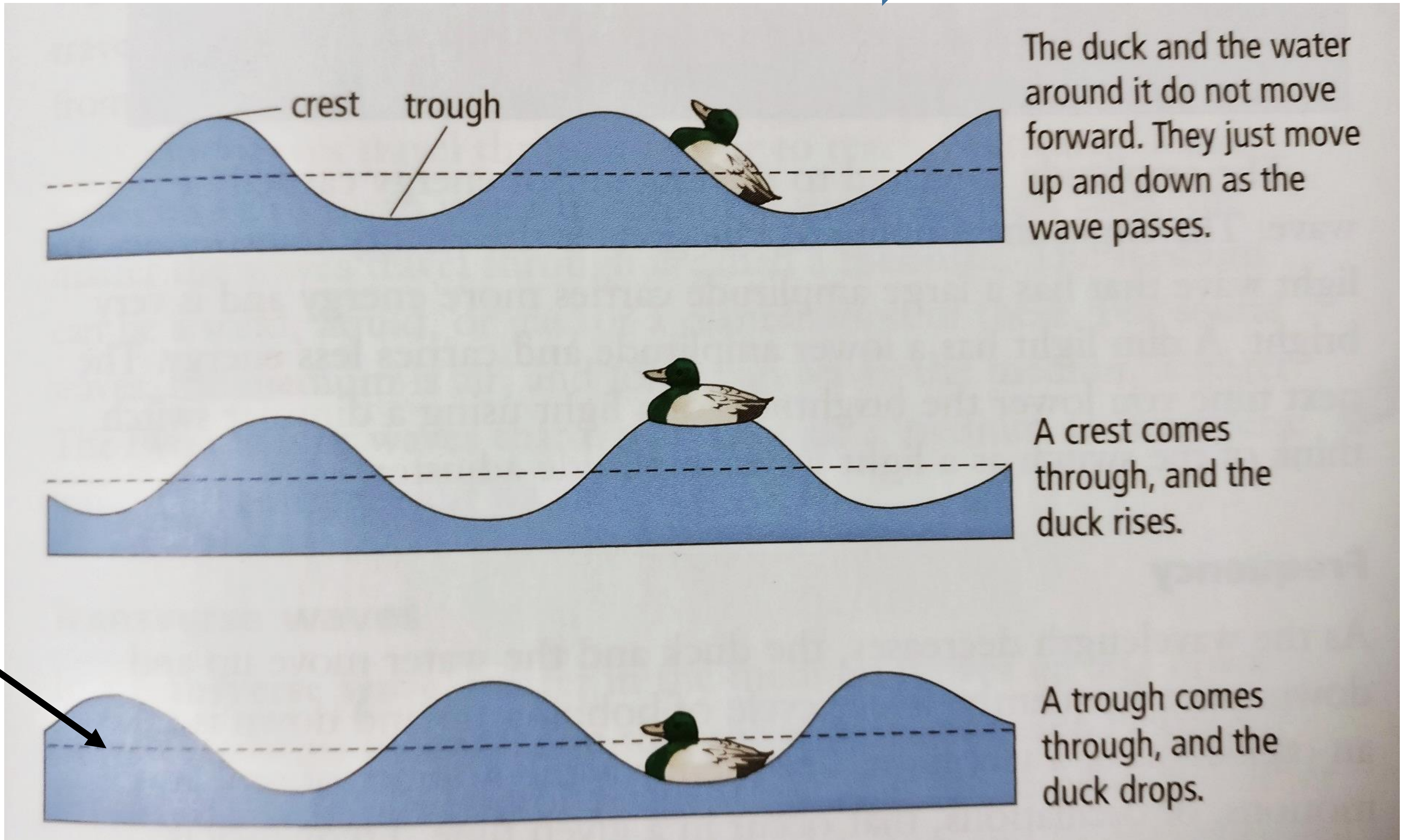
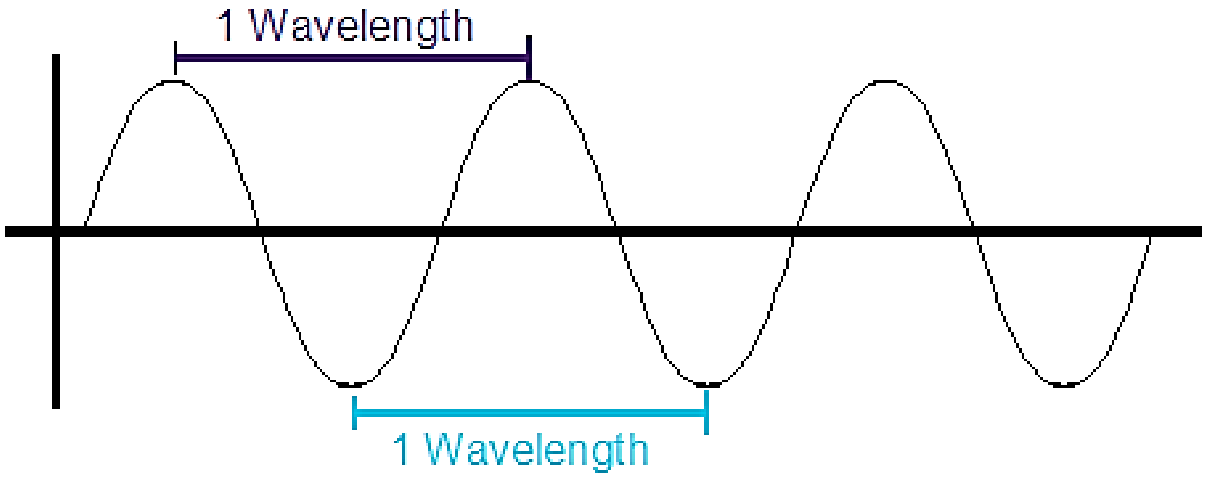


Figure 4.2 The wave is moving from left to right.

Wavelength

- The **wavelength** is the distance from *crest to crest* or from *trough to trough*
- You can also think of a wavelength as the distance covered by one complete crest plus one complete trough
- Wavelength is measured in metres



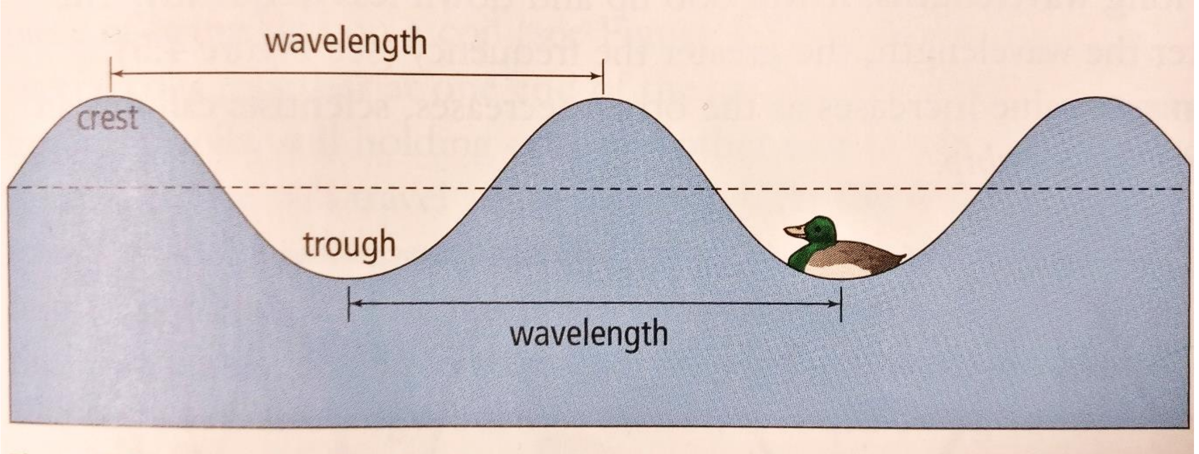
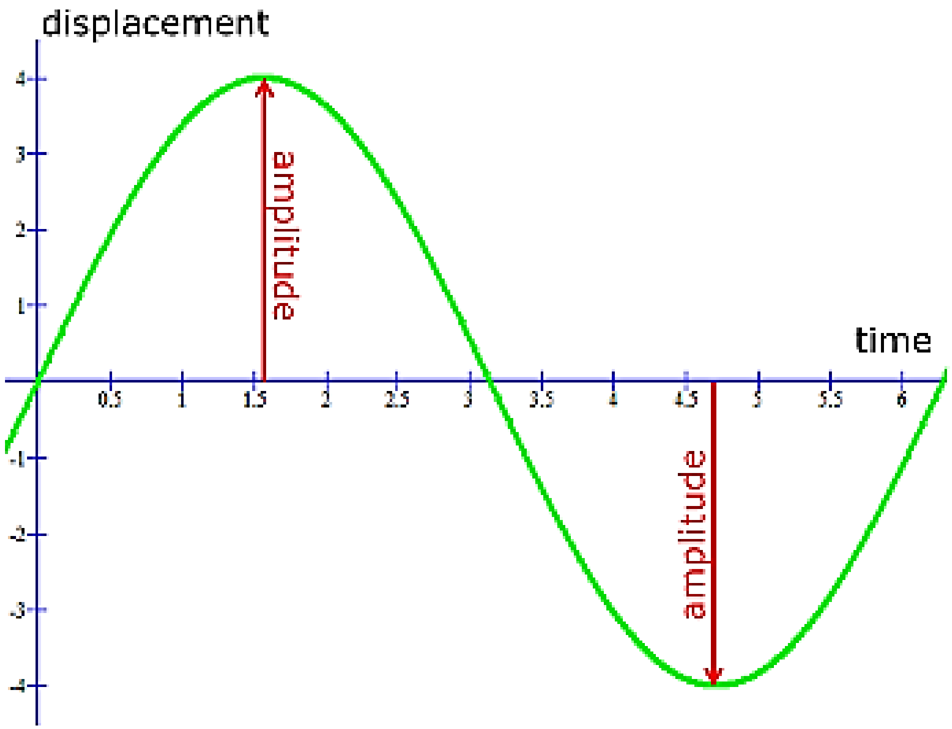


Figure 4.3 A wavelength is the distance over which the wave repeats.

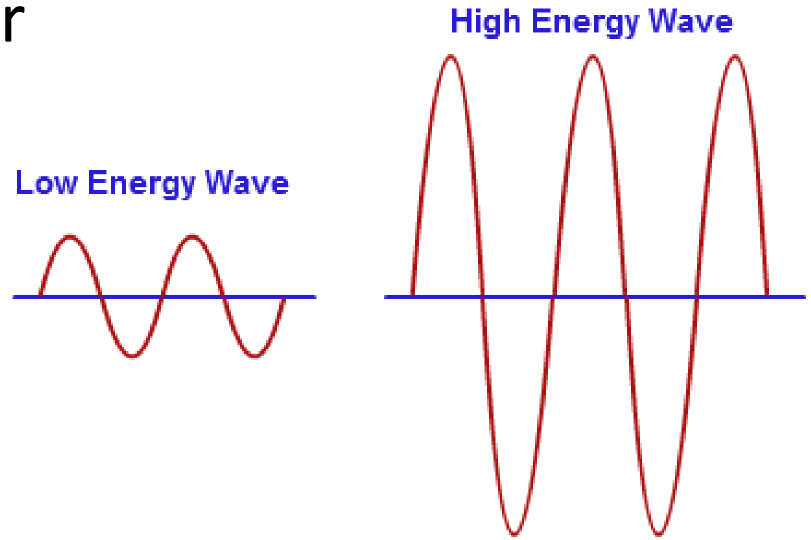
Amplitude

- The **amplitude** is the height of a wave crest or depth of a wave trough, as measured from its rest position
- If a breeze picks up on the lake where the duck is sitting, the height of the wave can increase
  - This means the duck floats higher and lower as the crests rise and the troughs deepen
  - When the crests are high and the troughs are low, we say the wave has a larger amplitude



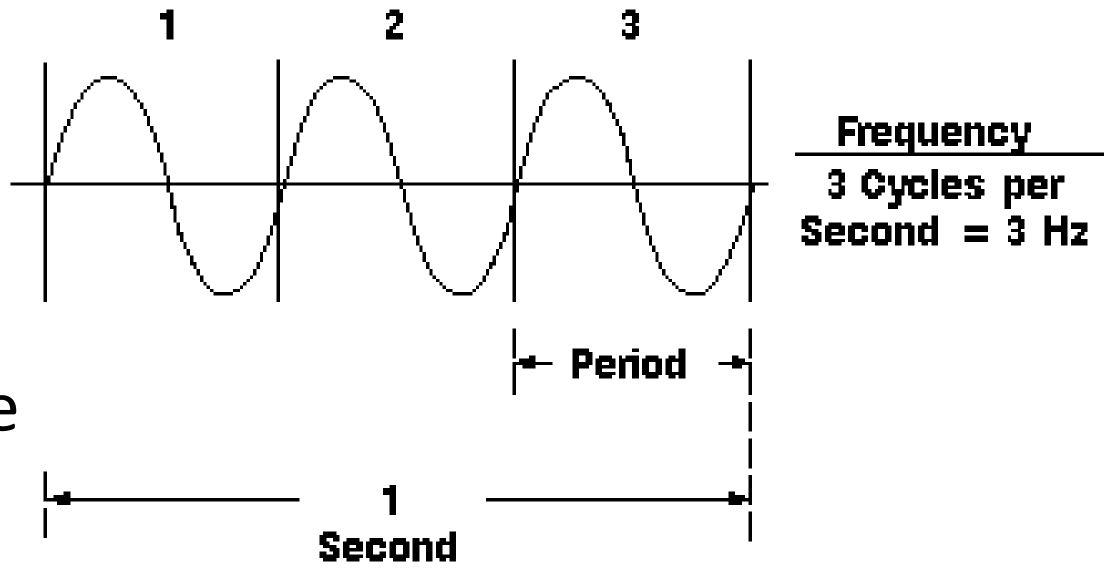
Amplitude

- The amplitude is related to the amount of energy carried by the wave
- The LARGER the amplitude, the GREATER the energy transported
    - A light wave that has a large amplitude carries more energy and is very bright
    - A dim light has a lower amplitude and carries less energy
- When you lower the brightness of a light using a dimmer switch, think of the switch as a light wave amplitude adjuster



Frequency

- As the wavelength decreases, the duck and the water move up and down more frequently
- Every cycle of bobbing up and down is called an *oscillation* or a *vibration*
- **Frequency** is the number of repetitive motions, or oscillations, that occur in a given time
  - Usually measured in **hertz (Hz),** or cycles per second



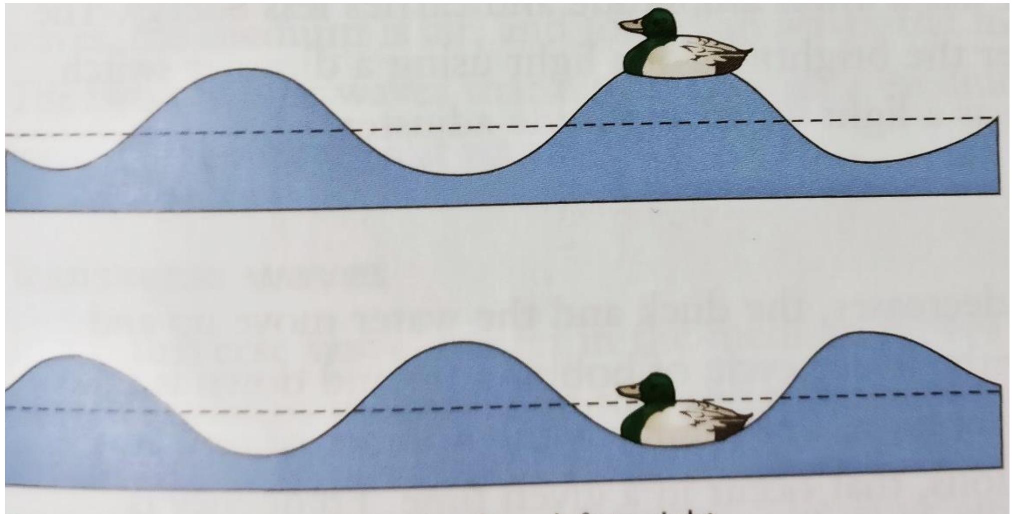
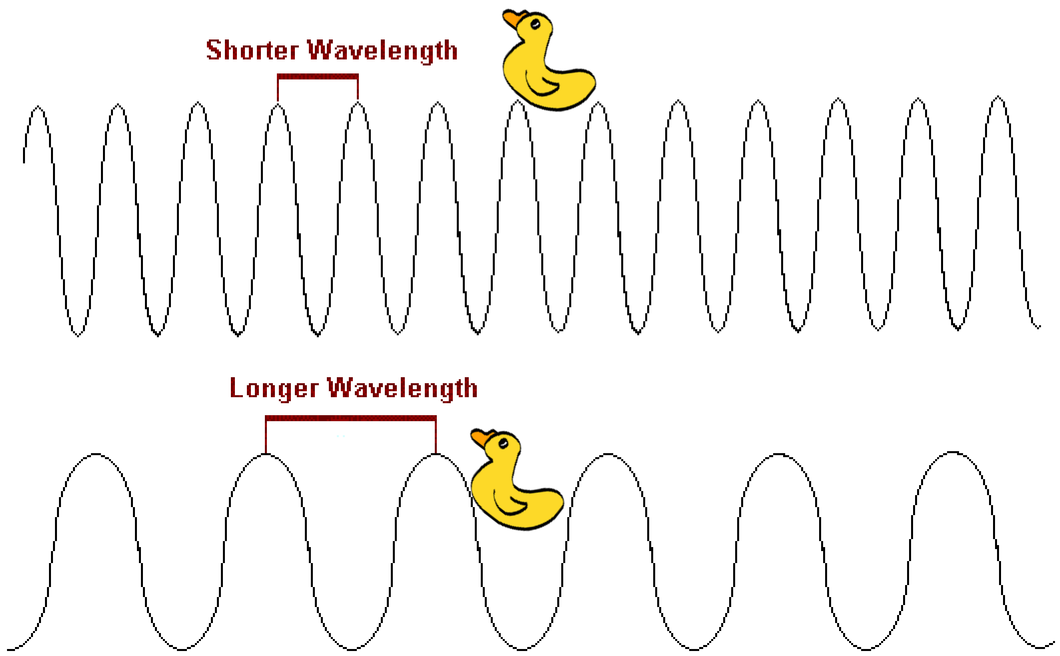


Figure 4.2 The wave is moving from left to right.

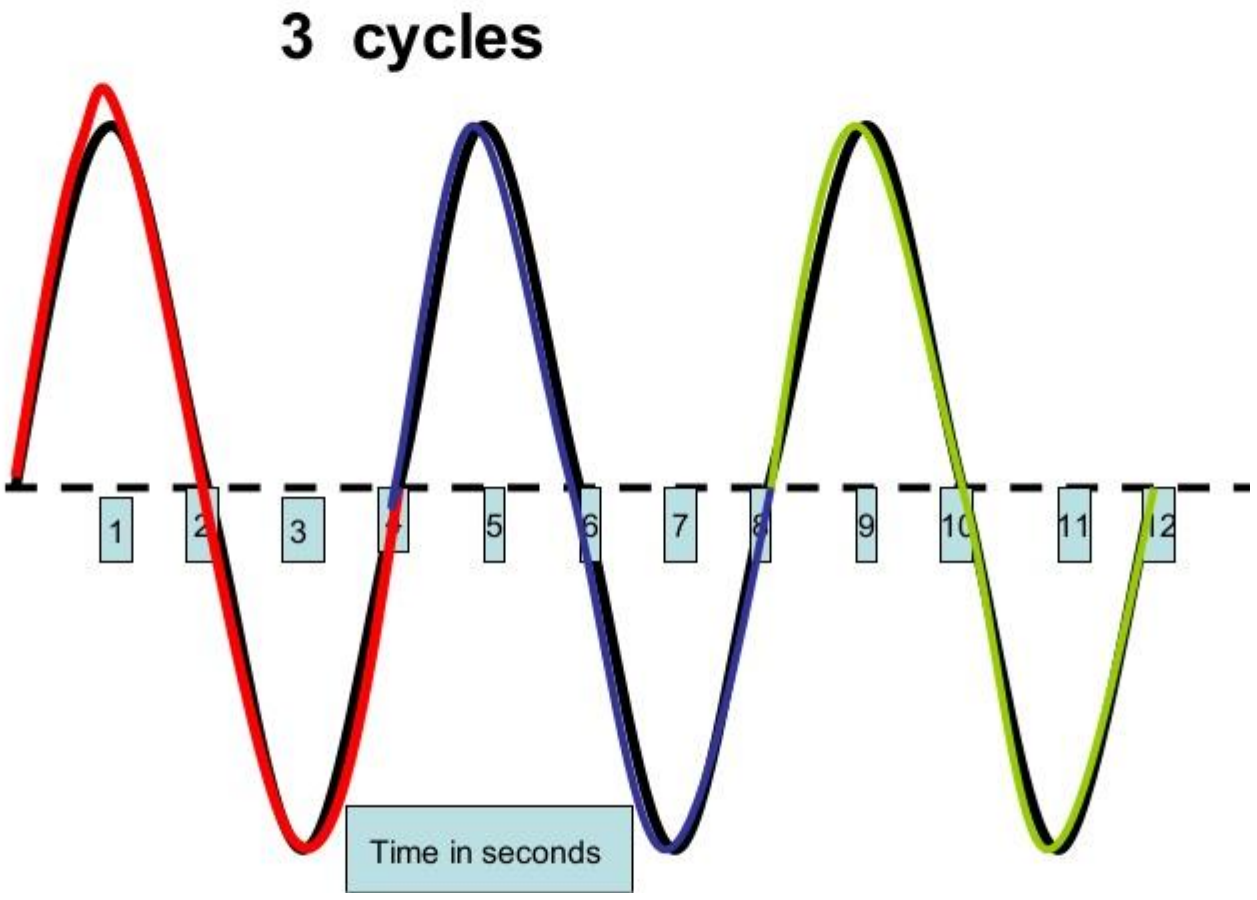
Frequency

- When the duck is sitting in water waves with short wavelengths, it will bob up and down frequently
- When the duck is sitting in water waves with long wavelengths, it will bob up and down less frequently
- The <u>**shorter the wavelength**</u>, the <u>**greater the frequency**</u>
- The ***longer the wavelength***, the ***lower the frequency***



Frequency

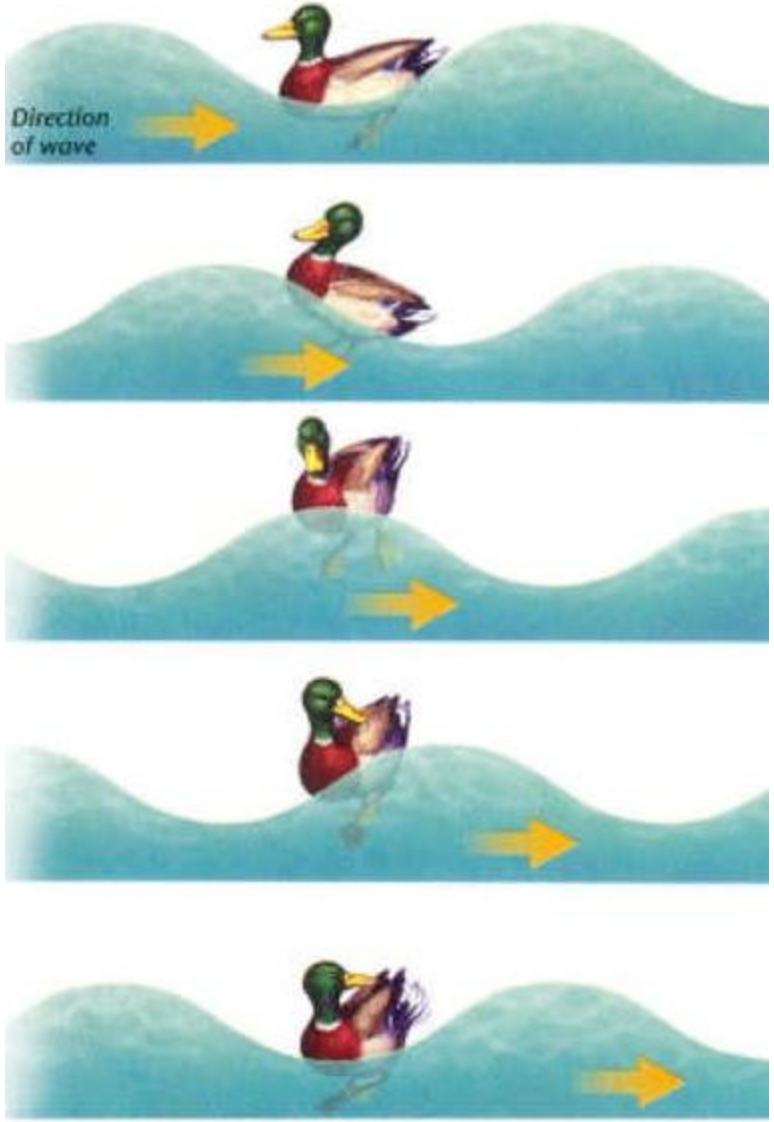
- One cycle is an up and a down
- In our duck example, **frequency** is the number of times per second the duck bobs from crest to crest
  - For example, if two wave crests were to pass under the duck every second, then the duck is said to be vibrating or oscillating at a frequency of 2 Hz



- Frequency = (# of cycles)/seconds
  - The unit for frequency = Hz
- How many Hz does the above diagram represent?

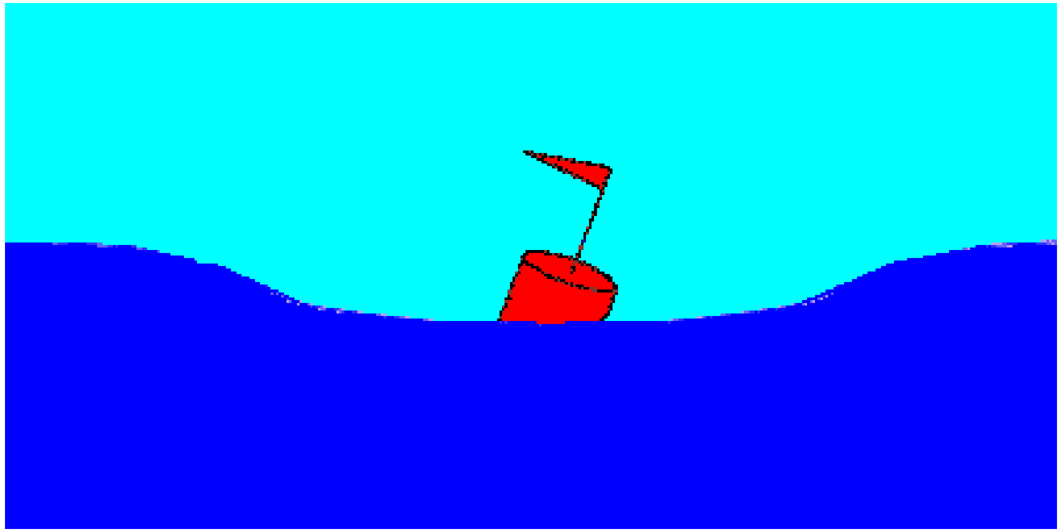
A Water Wave Moves Energy, Not Water

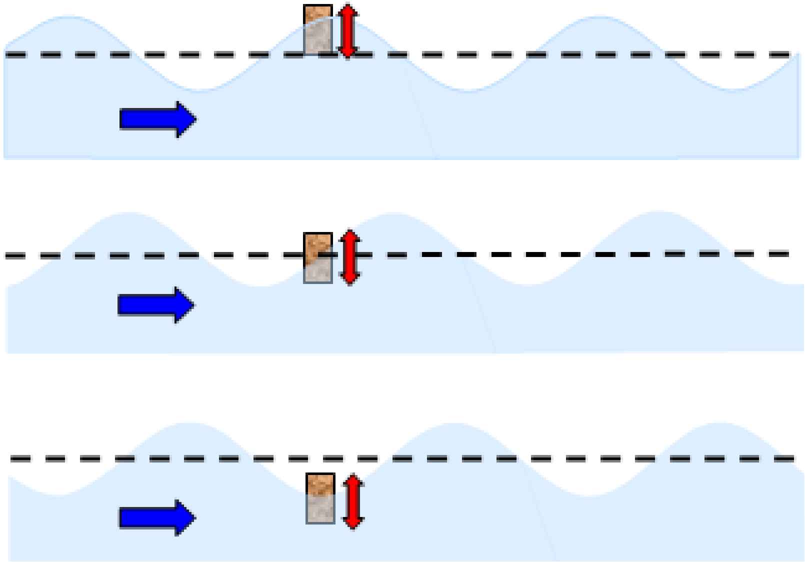
- A water wave does not carry water along with it
- Only the energy carried by the water wave moves forward
- Many important types of waves share this property – they carry energy without transporting matter



A Water Wave Moves Energy, Not Water

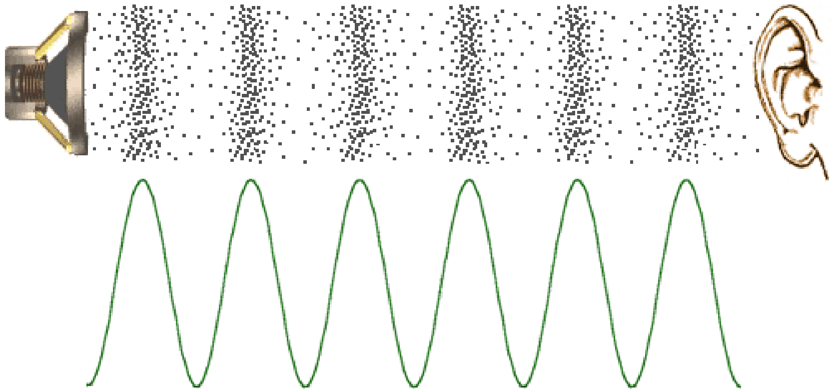
- Think of a buoy bobbing straight up and down out in the middle of a lake
  - Only the energy of the waves moves forward toward the shore
  - The buoy does not move forward and neither does the water
  - Once the waves have passed, the water returns to its original, or rest, position





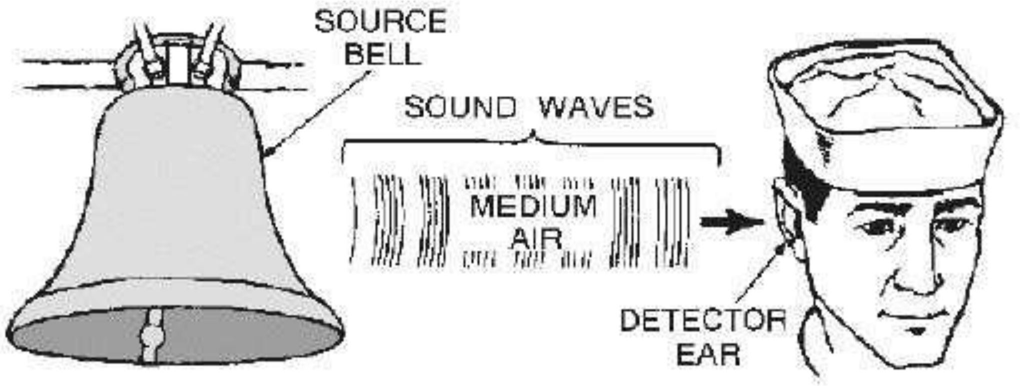
Two Types of Waves

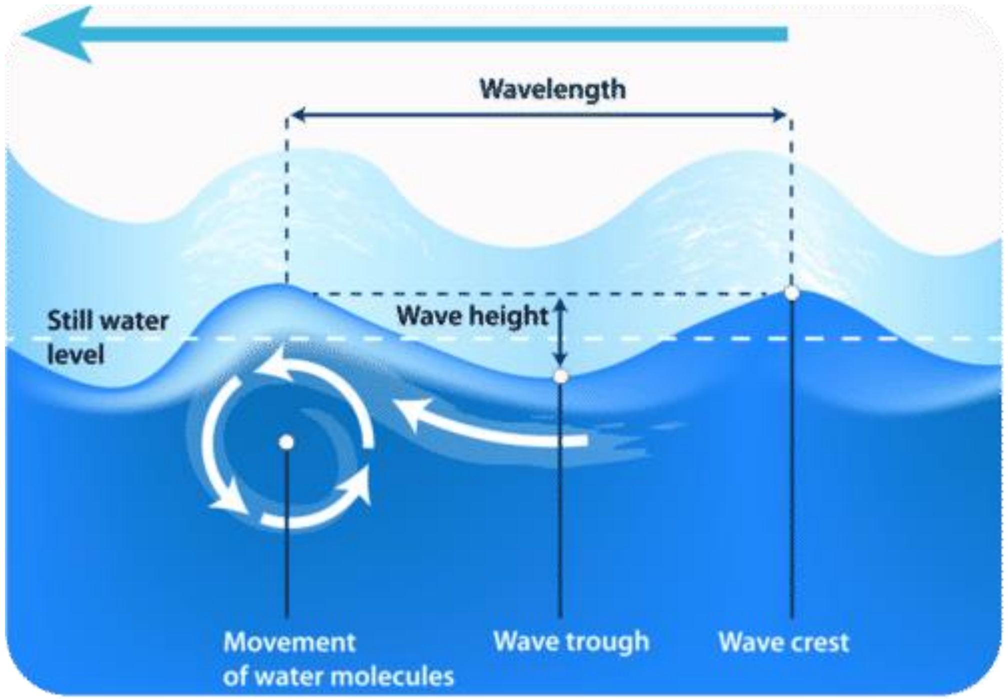
- Waves can differ in how much energy they carry and in how fast they travel
- Waves also have other characteristics that make them different from each other
  - Sound waves travel through the air to reach your ears
  - Ocean waves move through water to reach the shore
- In both cases, the matter the waves travel through is called a **medium**



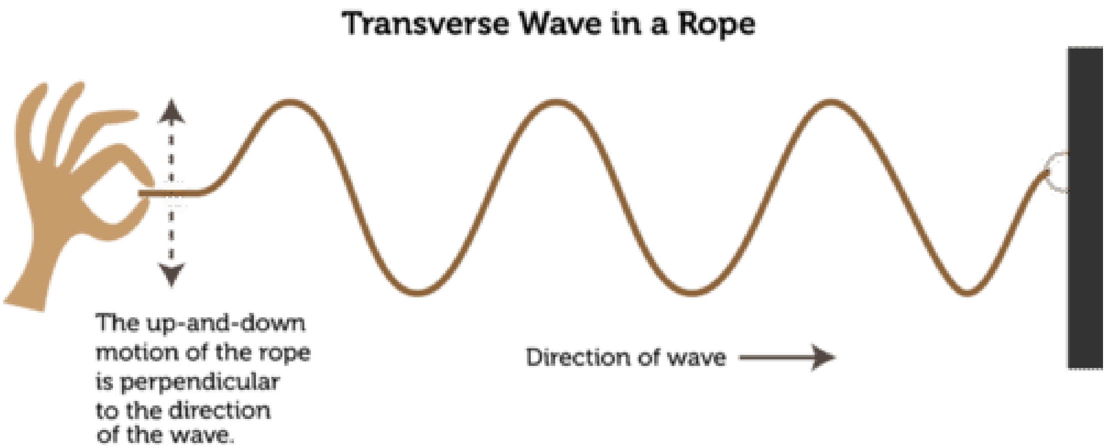
Two Types of Waves

- The **medium** can be a solid, liquid, or gas, or a combination of these
- For sound waves – the medium is air (gas)
- For ocean waves – the medium is water (liquid)





Two Types of Waves



The two types of waves that travel through a medium are ***transverse*** waves and ***compression*** (longitudinal) waves

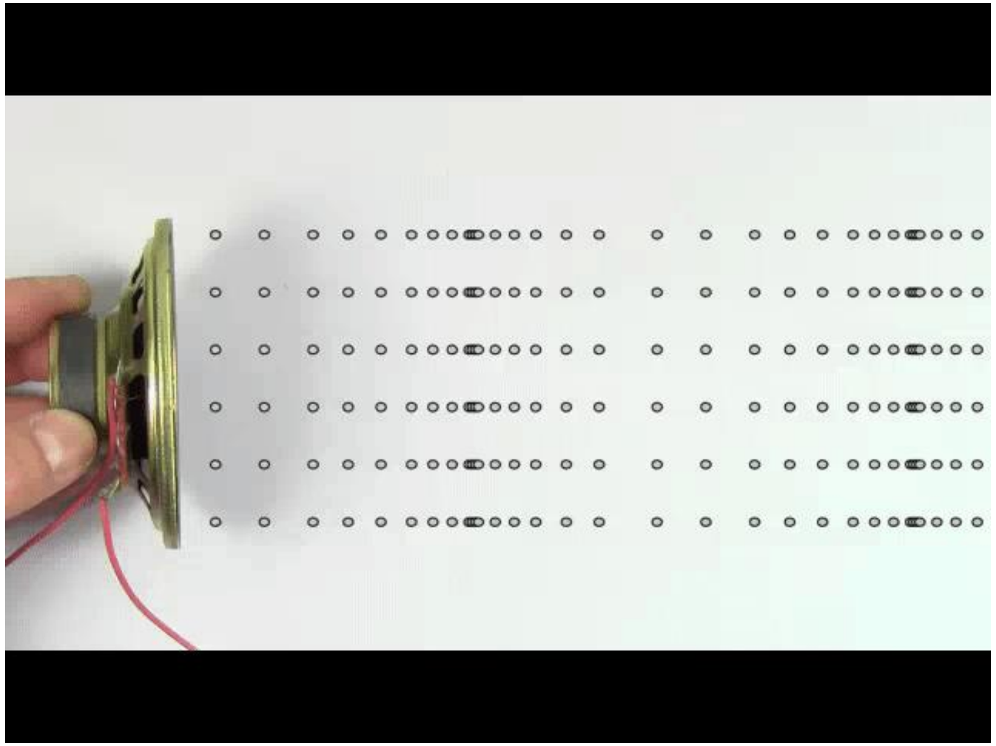
Transverse Waves:

- Matter in the medium moves up and down perpendicular to the direction that the wave travels
  - When you shake one end of a rope while your friend holds the other end, you are making **transverse waves**
  - The wave and its energy travel from you and your friend as the rope moves up and down

Two Types of Waves

Compression Waves:

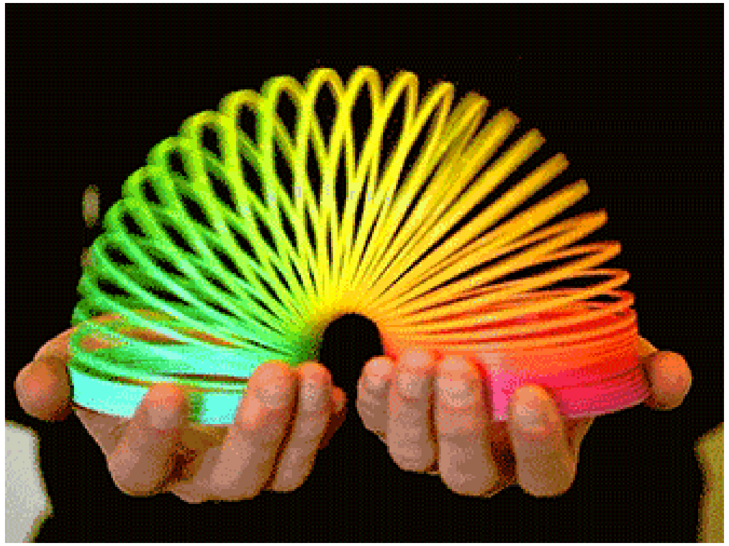
- Sound waves are compression waves
- Matter in the medium moves back and forth along the same direction that the wave travels



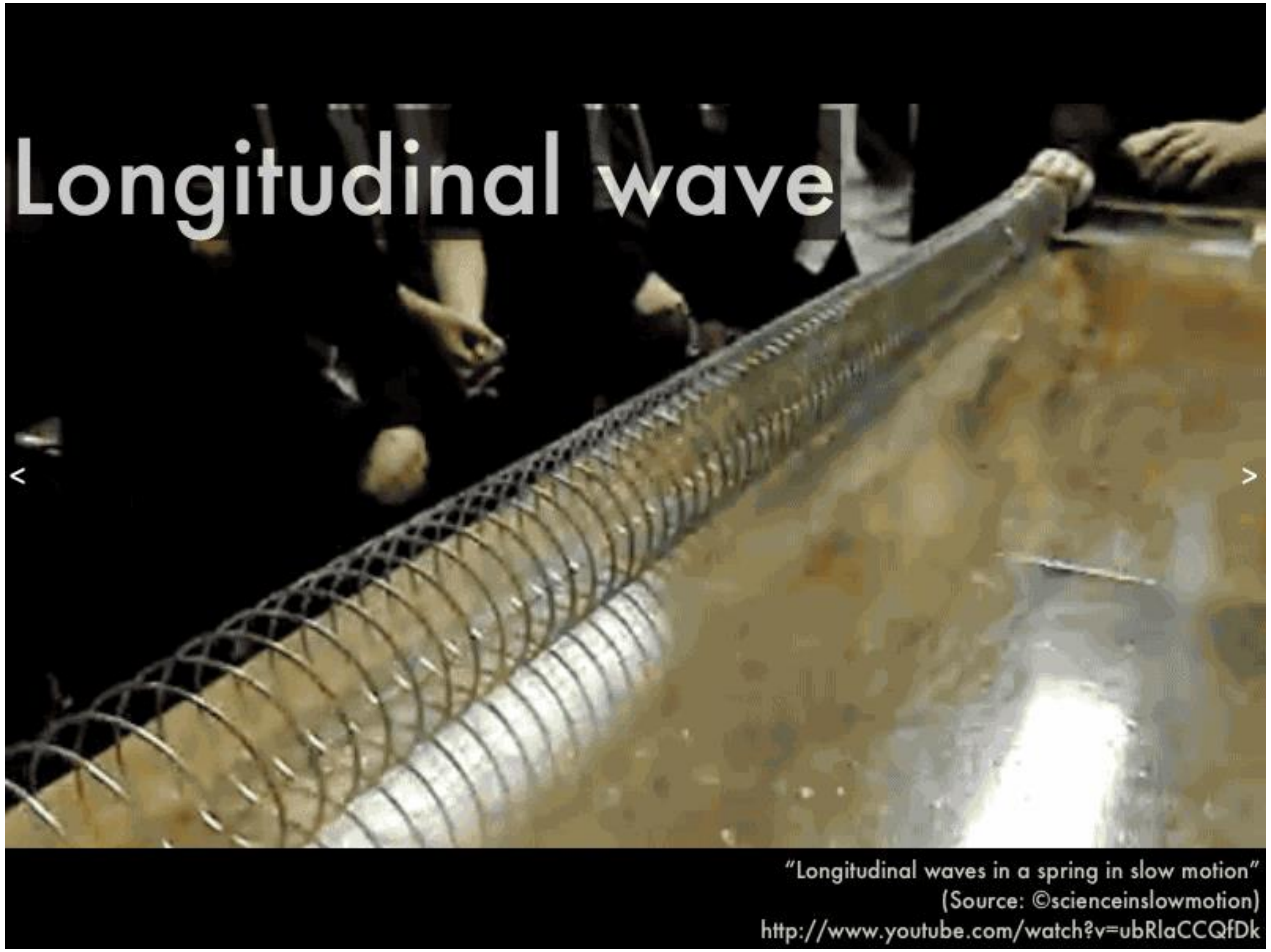
Two Types of Waves

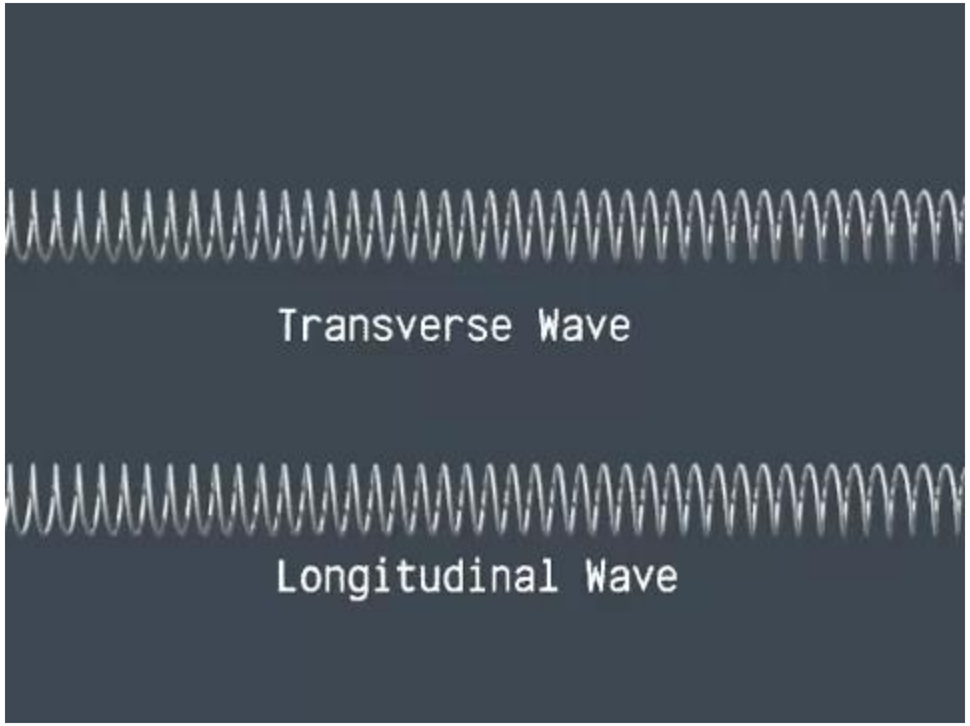
Compression Waves:

- Think of a coiled spring with a piece of string tied on a coil
- Squeeze several coils together at one end of the spring, then let go of the coils while still holding onto the other end
- A wave will travel along the spring
- As the wave moves, it looks as if the whole coil spring is moving towards one end
- The spring moves back and forth as the wave passes, and then stops moving after the wave has passed
- The wave carries energy, but not matter, forward along the spring



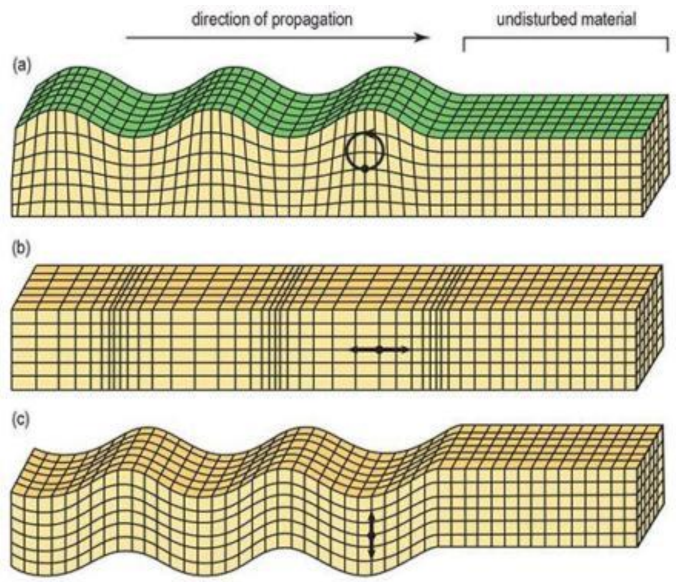
Compression vs Transverse Wave

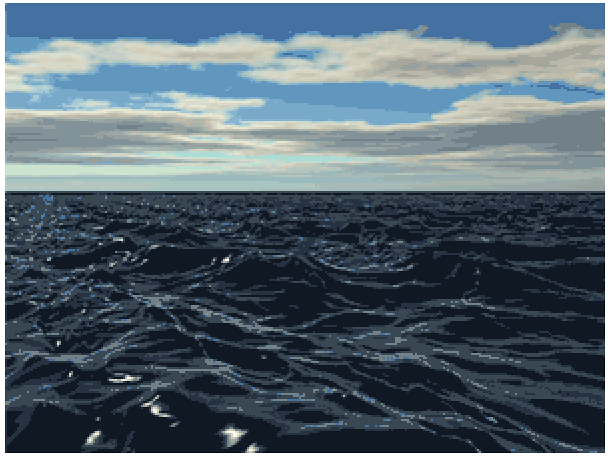




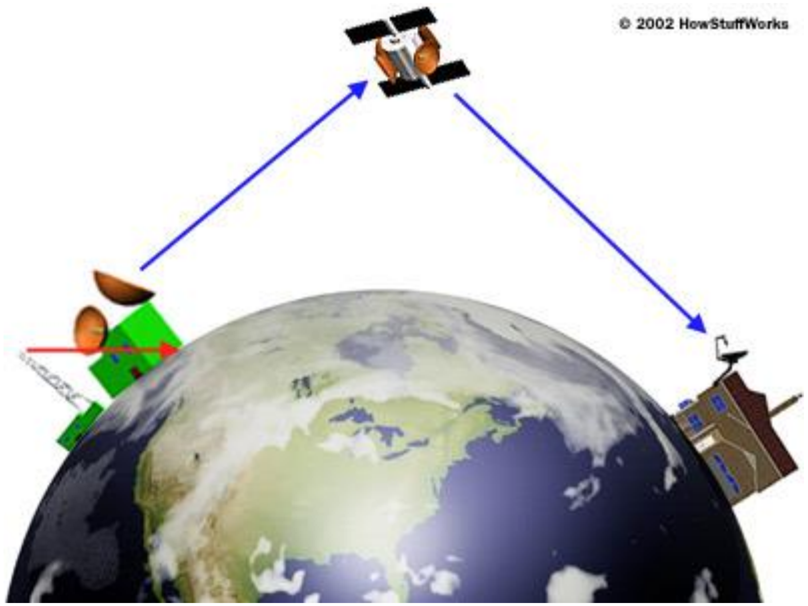
Two Types of Waves

- Water waves and seismic (earthquake) waves are a combination of transverse and compression waves
- Seismic waves can travel through Earth and along Earth's surface
  - When objects on Earth's surface absorb some of the energy carried by seismic waves, the objects move and shake

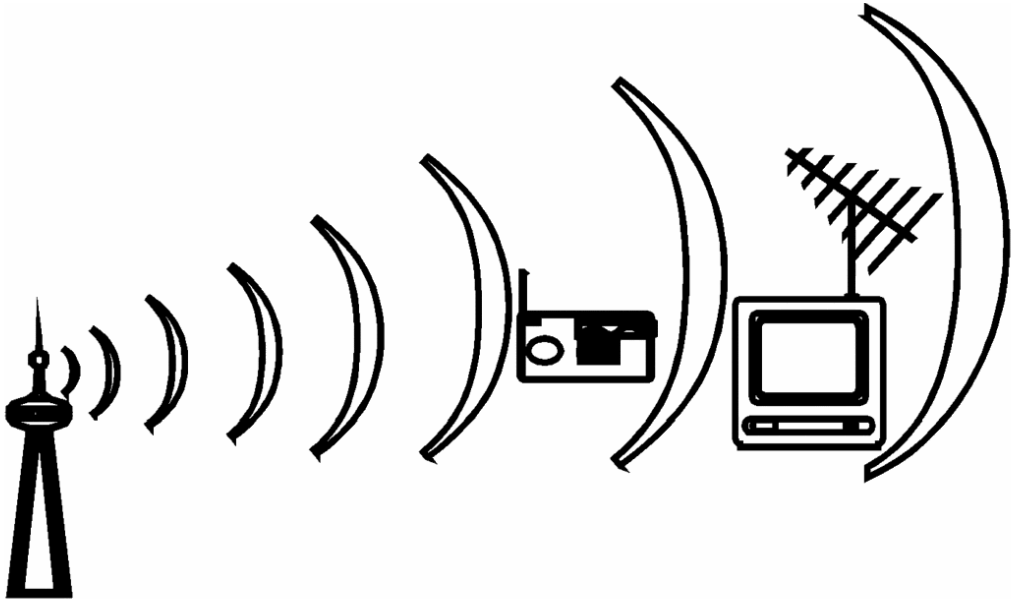




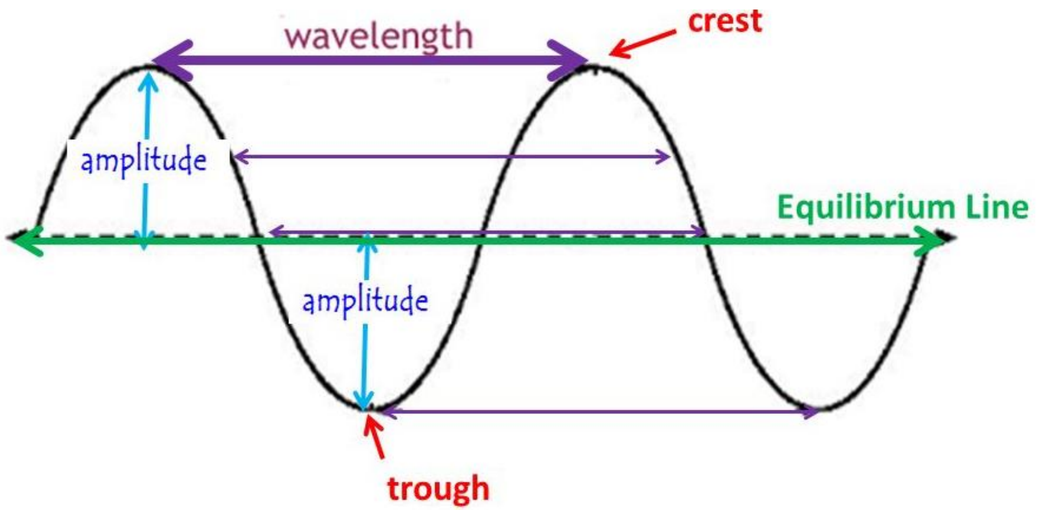
Waves



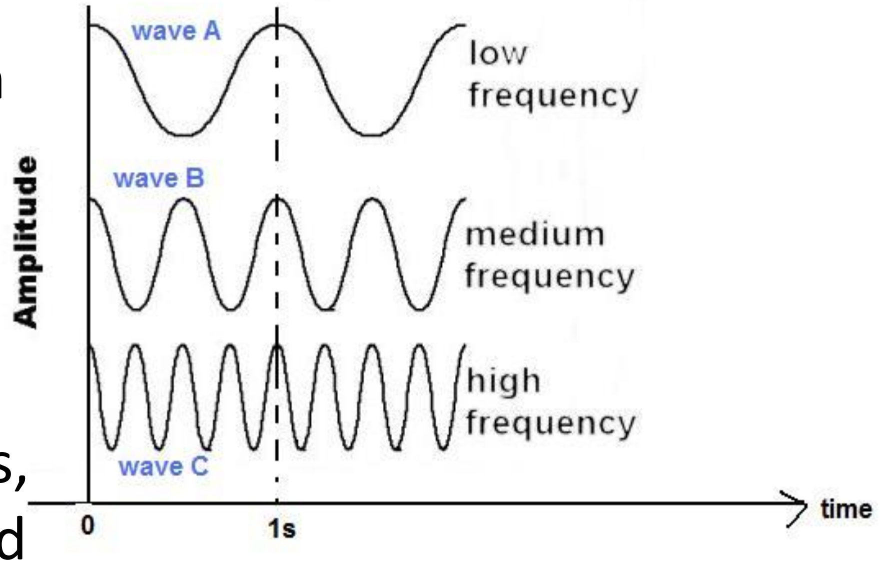
- Not all waves need a medium to travel through
- Some wave, such as visible light waves and radio waves, can travel through space where there is no material



Review - Key Terms



- **Crest** = the highest point of a wave
- **Trough** = the lowest point of a wave
- **Wavelength** = the distance from one point on a wave to the same point on the next wave. E.g. crest to crest or trough to trough.
  - A wave with a long wavelength carries less energy than a wave with a short wavelength



- **Amplitude** = the height or a wave crest from its rest position or the depth of a wave trough, as measured from its rest position
  - Large amplitude wave carries more energy than a small amplitude wave
- **Frequency** = The number of repetitive motions, or vibrations, that occur in a given time. It is measured in cycles per second or hertz (Hz)