Waves
Tab 1: Waves transfer energy

- Most waves are caused by vibrations or a disturbance of matter.
- Medium - matter that waves travel through.
- Waves transfer energy from one place to another.
  - They can do work
  - They move objects
What are the parts of a wave?

1 wave is made up of 1 crest & 1 trough
Parts of a wave

- **Crest** - Highest point of wave
- **Trough** - Lowest Point of wave
- **Compression** - area where particles are crammed together.
- **Rarefaction** - area where particles are far apart.
- **Amplitude** (aka : wave height) - measure from resting point of wave to crest or trough
  - the amount of energy a wave has. More energy = higher amplitude
- **Wavelength** \((\lambda)\) - The distance from any point on one wave to a corresponding point on an adjacent wave.
  - Usually crest to crest or trough to trough

- **Frequency** \((f)\) - the number of waves that pass through a point in one second (rate). Unit= Herts (Hz) = 1 wave/sec
**Mechanical Waves**
- Must have a medium
- Cannot travel through space or a vacuum.
- Travels fastest in solids; slowest in gasses
- Examples: water waves, sound waves, earthquake (Seismic) waves

**Electromagnetic waves**
- Does not have to have a medium
- Made up of changing electric and magnetic fields
- Can travel through space & vacuum
- Travels the fastest in space; slowest in solids
- Examples: Light waves, microwaves, Ultraviolet, x-rays, gamma rays, radio waves
The subsequent direction of motion of individual particles of a medium is the same as the direction of vibration of the source of the disturbance.

**Longitudinal wave** the matter in the wave moves back and forth parallel to the direction of the wave.

**Transverse wave** the matter in the wave moves up and down at a right angle to the direction of the wave.
Tab: 3 How are frequency & wavelength related?

- **Wavelength** ($\lambda$) - The distance from any point on one wave to a corresponding point on an adjacent wave.
  - Usually crest to crest or trough to trough
- **Frequency** ($f$) - The number of waves that pass through a point in one second (rate). Unit = Hertz (Hz) = 1 wave/sec
- **Wavelength** and **frequency** are **inversely** related
  - High frequency = short wavelengths
  - Low frequency = long Wavelengths.
  - The greater the number of waves per second, the higher the frequency – the more energy carried by the wave.
  - The smaller the wavelength, the more times it will pass through a point in one second.
  - The larger the wavelength, the fewer times it will pass through a point in one second.
7. Which wave has the lowest amplitude?
8. What is the frequency for wave 3, if the resting point represents 1 second?
9. Which wave has the highest frequency?
10. Which wave has the longest wavelength?
11. Which wave has the shortest wavelength?
12. Which wave has the shortest frequency?
13. Wavelength is (directly or inversely) related.
Tab 4: Wave Speed

1. Wave speed - How fast a wave moves.
2. Units - m/s
3. Wave speed depends on the type of medium.
   1. Mechanical waves - travel faster in solids & slowest in gases
   2. Electromagnetic waves - travel fastest in empty space and slowest in solids.
4. Waves can change speeds when going from 1 type of medium to a different type
5. In a same type of medium the speed of waves is constant.
Wave Speed

\[ S = \frac{d}{t} \quad \text{or} \quad v = f \times \lambda \]

speed = frequency x wavelength

- \( V = \) speed
- \( f = \) frequency \quad \text{unit} = \text{Hz}
- \( \lambda = \) wavelength \quad \text{unit} = \text{m (meter)}
Example Problem

A wave is traveling at a velocity of 12 m/s and its wavelength is 3 m. Calculate the wave frequency.

Solution

1. This is what you know:
   - velocity \( (v) = 12 \text{ m/s} \)
   - wavelength \( (\lambda) = 3 \text{ m} \)

2. This is what you want to find:
   - wave frequency \( (f) \)

3. This is the equation you need to use:
   \[ v = \lambda \times f \]

4. Solve for \( f \) and then substitute the known values in the equation.
   \[ f = \frac{v}{\lambda} \]
   \[ f = \frac{12 \text{ m/s}}{3 \text{ m}} = 4 \times 1/\text{s} = 4 \text{ Hz} \]

Check your answer by substituting the frequency and given wavelength into the original equation. Do you calculate the velocity that was given?
- Mechanical waves travel faster through denser mediums.
- Electromagnetic waves travel faster through mediums that are less dense.
Tab 5: Wave Interactions
The Behavior of Waves

What is reflection?

When a wave bounces off an object and changes direction – this is reflection.
The angle of incidence (angle it hits) = angle of reflection (angle it reflects)
What is refraction?

- Refraction is the bending of a wave as it passes from one medium to another.

- A wave travels at different speeds in different things.

- When a wave traveling a certain speed moves into another medium, it will either slow down or speed up, resulting in a change in direction.

The pencil looks like it is broken at the surface of the water because of refraction.
Light travels slower in water than in air.

To the observer on the side of the pool, the swimmer's foot looks closer to the surface than it actually is.
What is diffraction?

Diffraction occurs when an object causes a wave to change direction and bend around it.

Ocean waves change direction as they pass a group of islands.
Diffraction also occurs when passing through a small opening. They diffract and spread out as they pass through the hole.
• Wave absorption- waves that cannot travel through an object
  • Colors that we see are being reflected
  • Colors we do not see are being absorbed
  • black= all colors of light being absorbed
  • White= all colors of light being reflected
• Wave Transmission- waves that can travel through an object
What is wave interference?

Waves interfere in one of two ways: Constructive Interference and Destructive Interference.

**Constructive**—two waves meet crest to crest and create a larger wave.

**Destructive**—two waves meet crest to trough and cancel each other out.

![Wave interference diagram](image)
Tab 6: What is the *Doppler Effect*?

The *Doppler Effect* is the apparent change in frequency detected when the sound is moving relative to the hearer.

![Diagram of the Doppler Effect](www.bramboroson.com/astro/feb11.html)

Video- [Excellent example of Doppler Effect with car horn](#) (26 seconds)

Video- [A Motorcycle does the Doppler Effect](#) (27 seconds)
How is *frequency* related to *pitch*?

The *pitch* of a sound wave is directly related to *frequency*. (Frequency determines the pitch)

- A high-pitched sound has a high frequency
- A low-pitched sound has a low frequency
- A healthy human ear can hear frequencies in the range of **20 Hz to 20,000 Hz**. Humans cannot hear below 20 Hz.
**Tab 7: Electromagnetic Spectrum**

**Electromagnetic spectrum** - all the electromagnetic waves organized from **high frequency** to **low frequency**.

**The visible spectrum** =

- **R-O-Y-G-B-I-V**
- Red, orange, yellow, green, blue, indigo, violet