WEEK 13

Physics of Engineer

Chapter 12: Vibration and Wave

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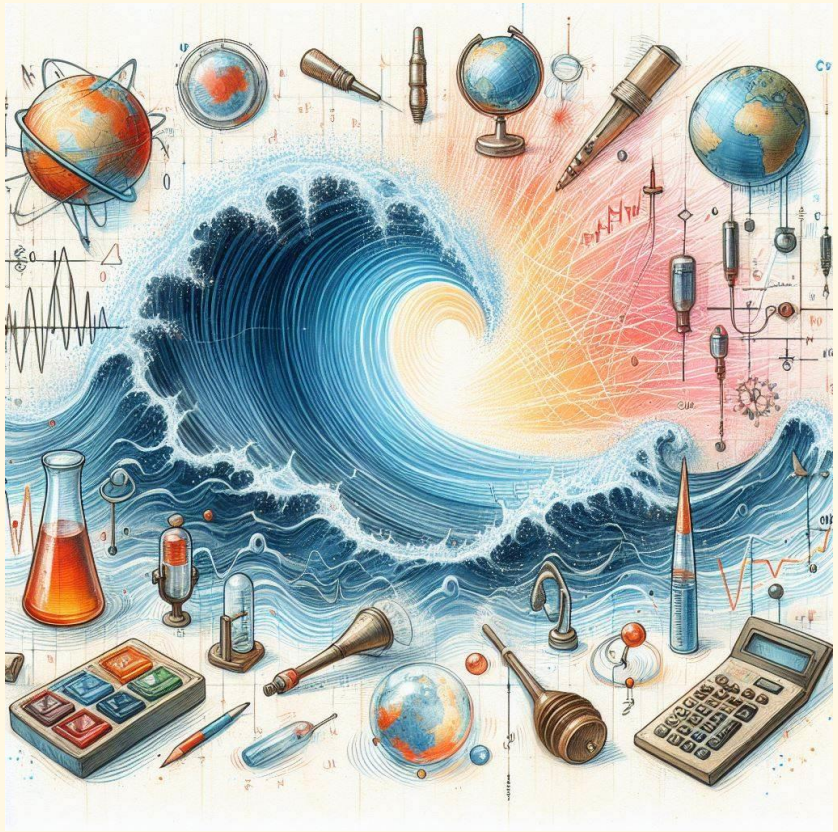
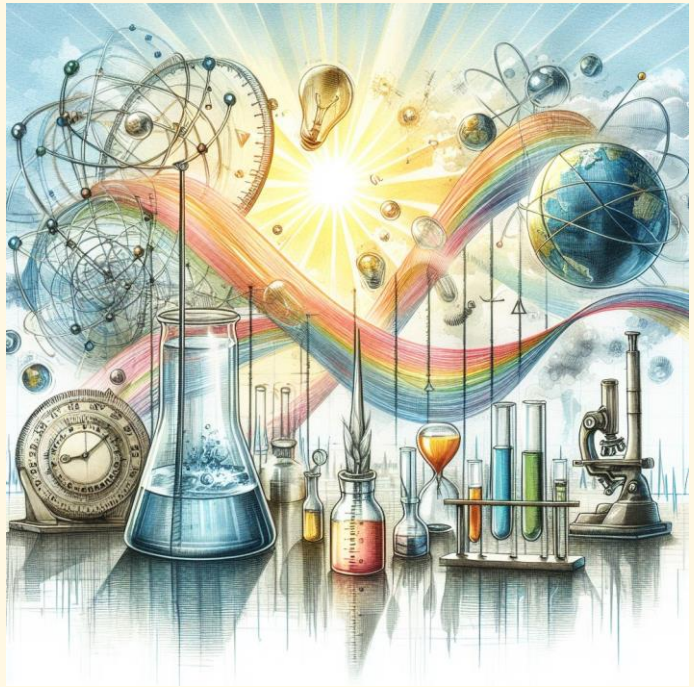
Outline

- Vibration and wave
- What is vibration?
- Properties of vibration
- Parameters of vibration
- Wave calculation
- Example of Density
- What is wave?



Outline

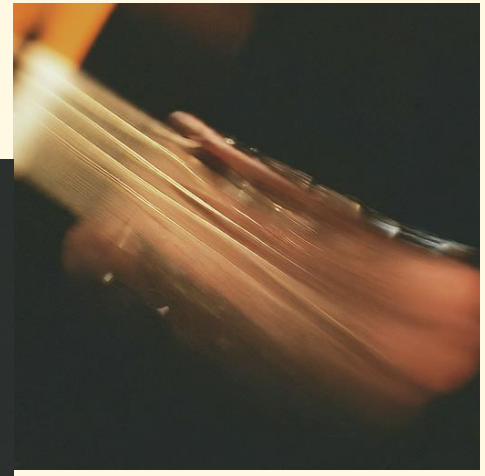
- Component of wave
- Type of waves
- Continuous vs. impulse waves
- Properties of waves
- Relation between vibration and wave
- Application of wave in daily life
- Conclusion
- Exploring resource and reference



Vibration and Waves

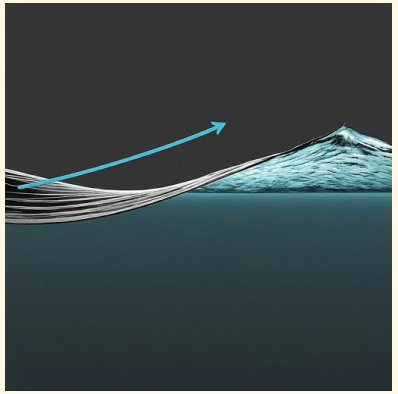
What is Vibration?

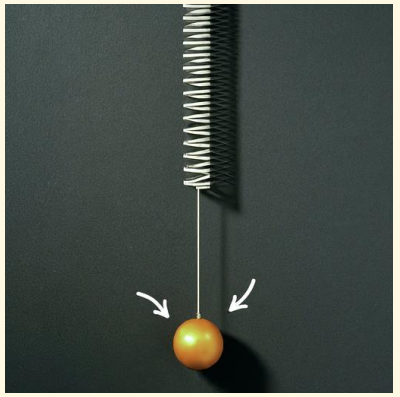
- A periodic disturbance or motion about a fixed position.
- Examples: A guitar string plucked, a swing moving back and forth.



Properties of Vibration

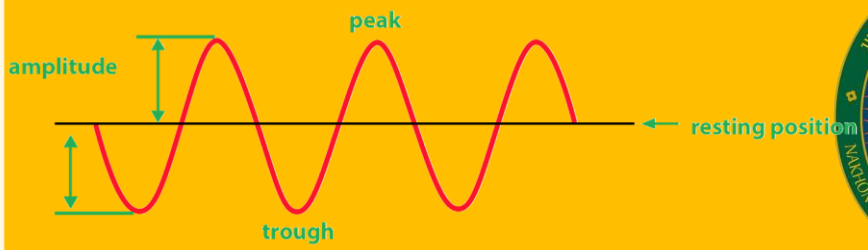
- **Equilibrium Position:** The point where the object experiences no net force.
- **Amplitude:** The maximum displacement of the object from its equilibrium position.
- **Period:** The time taken for one complete cycle of oscillation.
- **Frequency:** The number of oscillations per unit time.
- **Restoring Force:** The force that pulls the object back towards its equilibrium position.

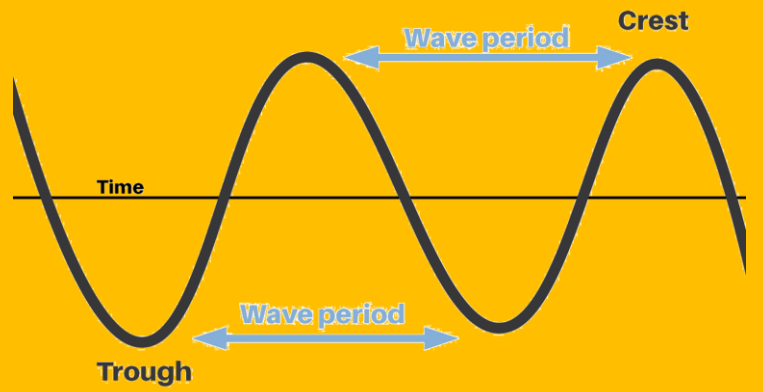


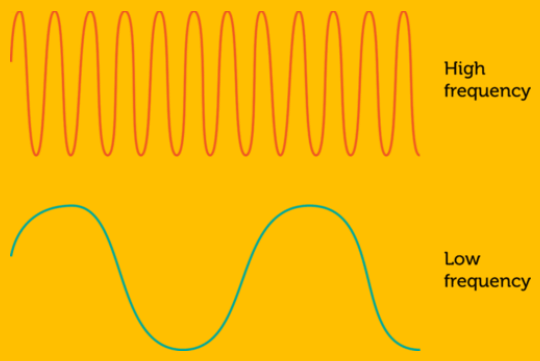


Parameters of Vibration

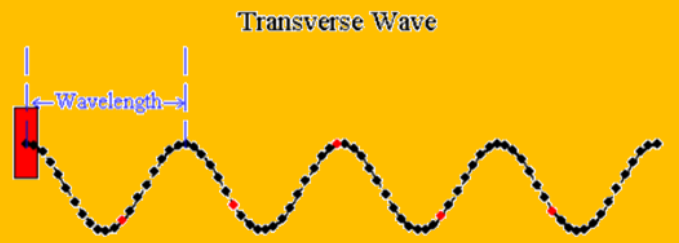
- **Amplitude (A)**: Maximum displacement of the vibrating object from its equilibrium position. (Unit: meter)
- **Period (T)**: Time taken for one complete cycle of vibration. (Unit: second)
- **Frequency (f)**: Number of vibrations per unit time. (Unit: Hertz (Hz))







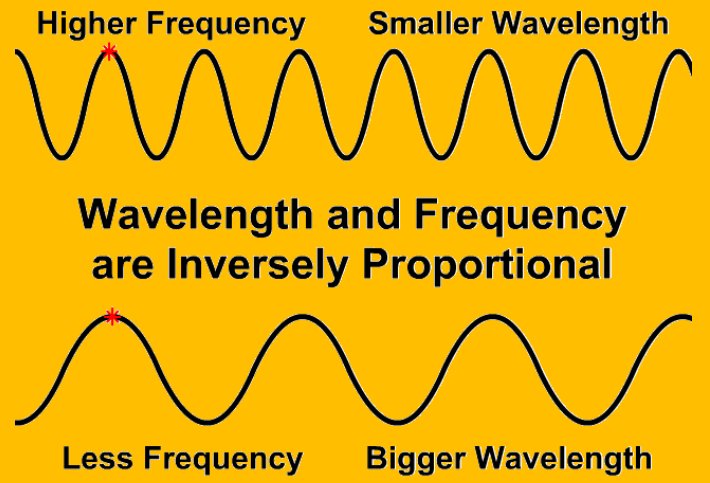
Wave Calculations



Wavelength (λ) : This is the distance between two consecutive peaks (crests) or troughs of a wave.

Formula: **λ =** v / f

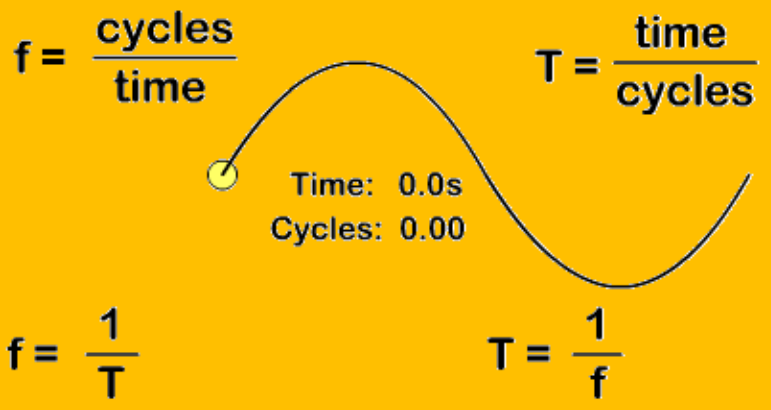
- **λ** (lambda) is the wavelength in meters (m)
- v (velocity) is the wave speed in meters per second (m/s)
- f (frequency) is the wave frequency in Hertz (Hz)



Frequency (f): This is the number of wave cycles that pass a point in one second.

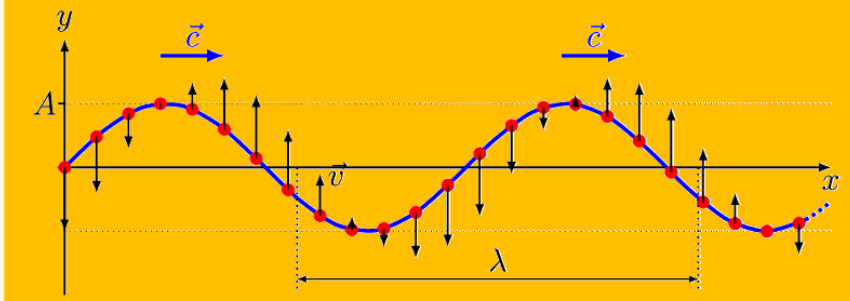
Formula: f = v / **λ**

Wave Calculations



Period (T): This is the time it takes for one complete wave cycle to pass a point. It's the reciprocal of frequency.

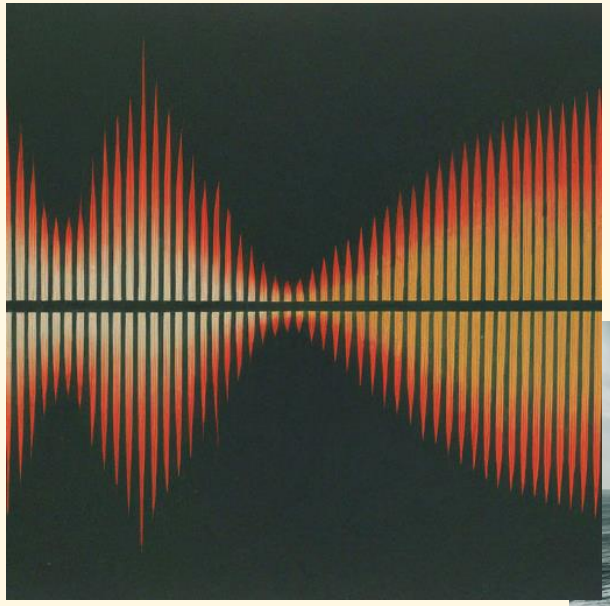
Formula: T = 1 / f

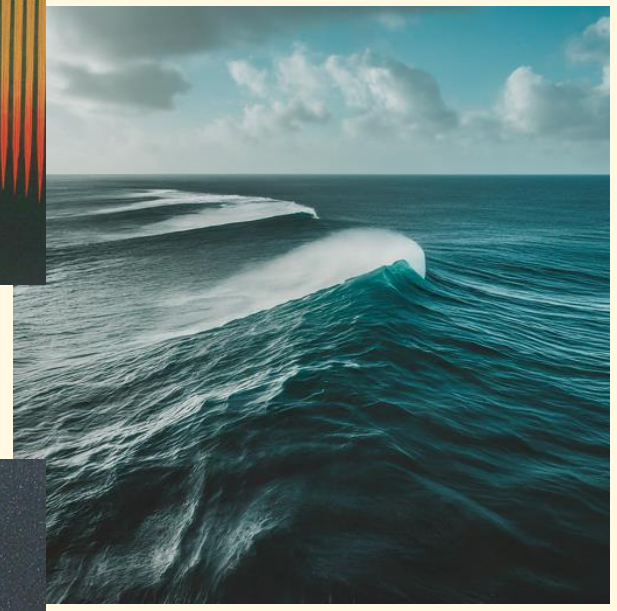


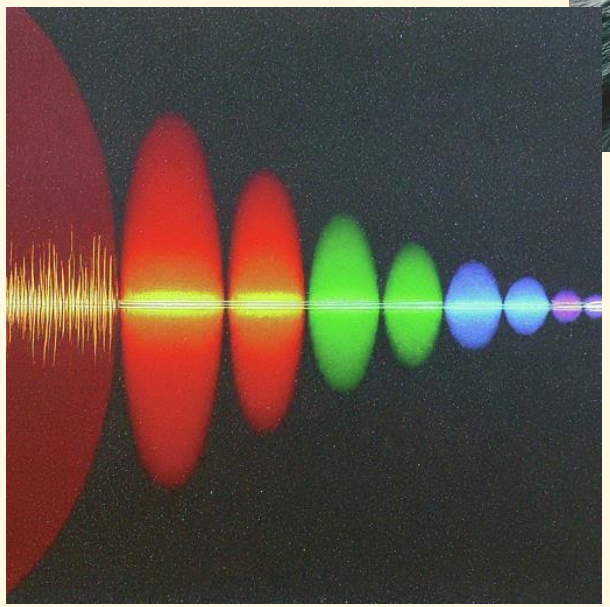
Wave Speed (v): This depends on the medium the wave travels through. For example, the speed of sound in air is about 343 meters per second (m/s) at room temperature, while the speed of light in a vacuum is constant at 299,792,458 meters per second (m/s).

What is a Wave?

- A disturbance that travels through space or a medium, transferring energy from one point to another without transporting matter itself.
- Examples: Sound waves, water waves, light waves.







Components of a Wave

- Crest: The highest point of the wave.
- Trough: The lowest point of the wave.
- Wavelength (λ): The distance between two consecutive crests (or troughs) of the wave. (Unit: meter)
- Equilibrium Position: The undisturbed position of the medium particles.

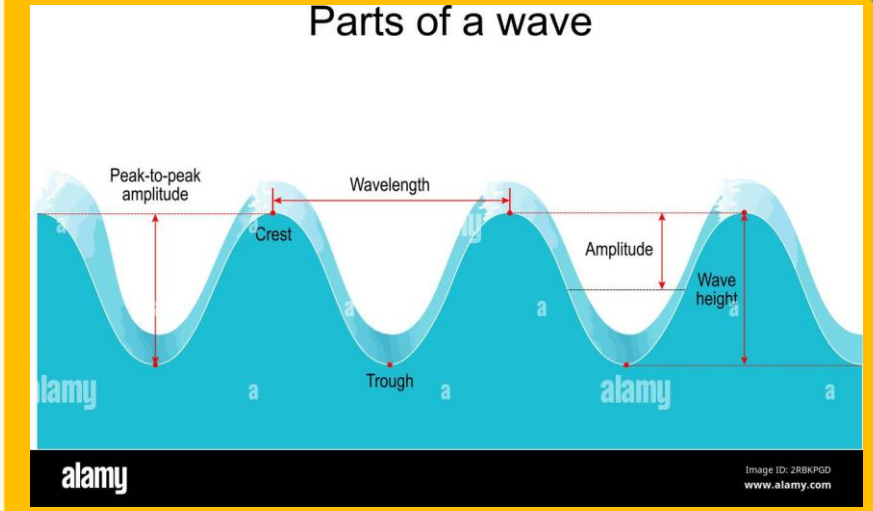
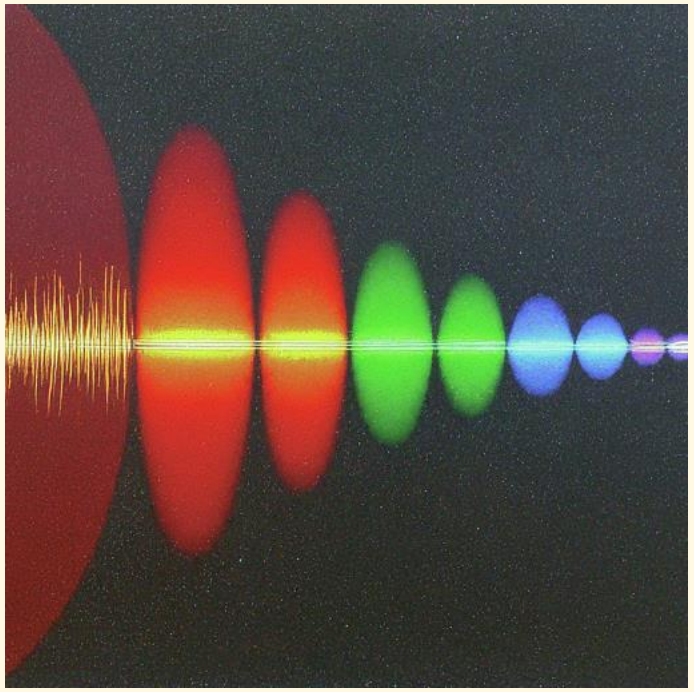


Image: https://www.alamy.com/stock-photo/wave-crest-trough.html?cutout=1&sortBy=relevant

Types of Waves

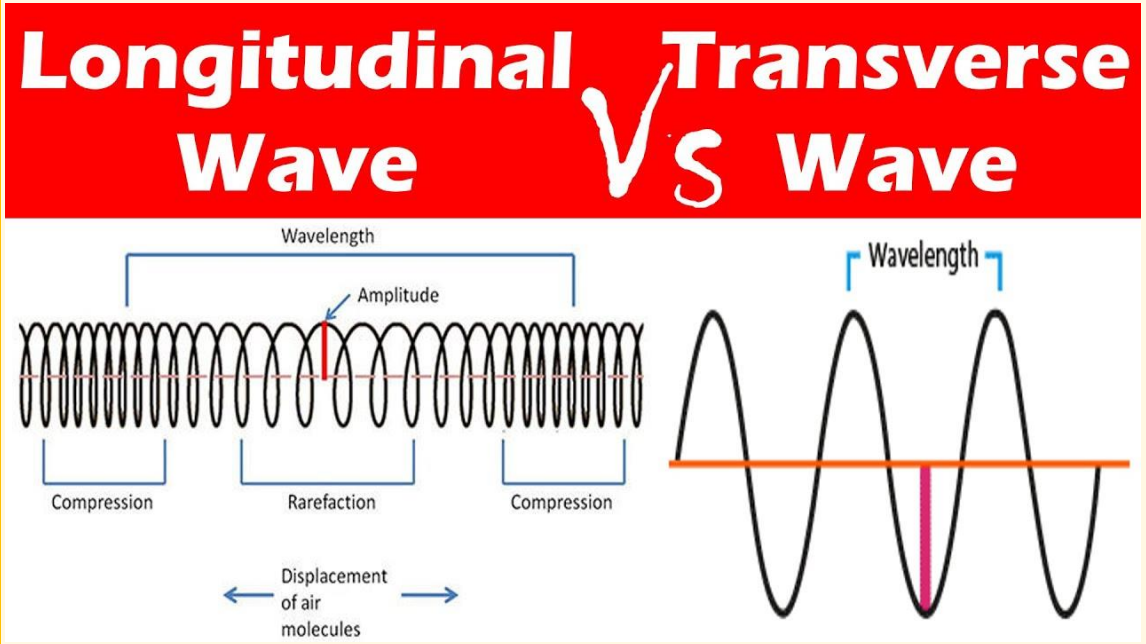
- **Mechanical Waves:** Require a medium to propagate. The particles of the medium vibrate, transferring energy. (e.g. Sound waves, water waves, seismic waves

- **Electromagnetic Waves:** Do not require a medium to propagate. They consist of oscillating electric and magnetic fields that travel through space. (e.g. Light waves, radio waves, X-rays)



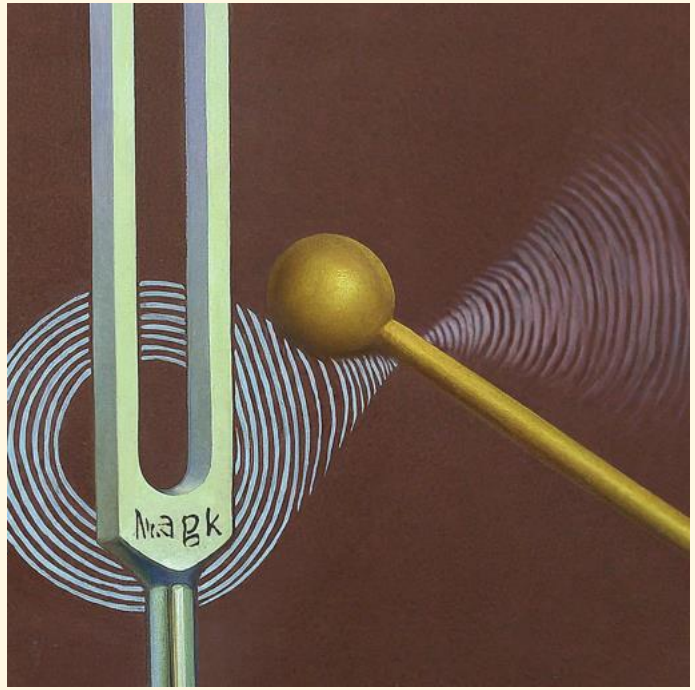
Types of Waves (continued)

- **Transverse Waves:** Particles of the medium vibrate perpendicular to the direction of wave propagation. (e.g. Water waves)
- **Longitudinal Waves:** Particles of the medium vibrate parallel to the direction of wave propagation. (e.g. Sound waves)



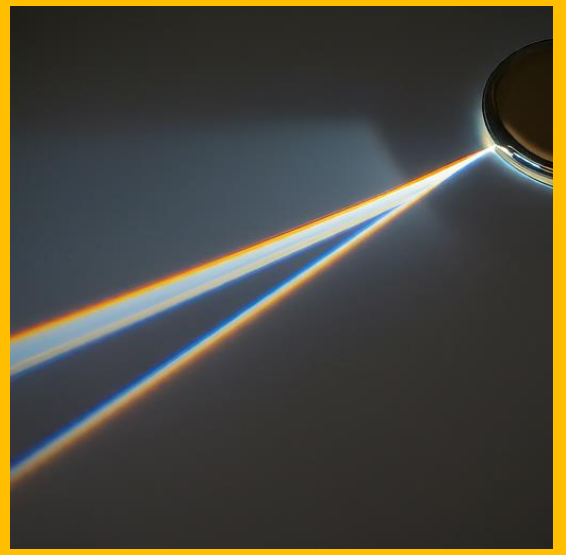
Continuous vs. Impulse Waves

- **Continuous Waves:** Waves that have a repeating pattern and carry energy for a sustained period. (e.g. Sine wave, sound waves from a tuning fork)
- **Impulse Waves:** Non-repeating waves with a localized disturbance that carries energy for a short duration. (e.g. A single ping from a sonar, a tap on a drum)



Properties of Waves

- **Reflection:** When a wave encounters a barrier, it bounces back in a different direction. (e.g. Echo)
- **Refraction:** When a wave travels from one medium to another with a different density, it bends. (e.g. Light bending through a prism)

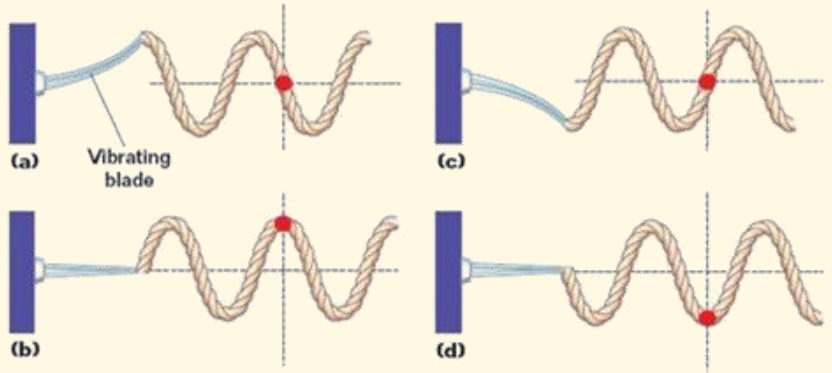


Properties of Waves

- **Diffraction:** When a wave spreads out after passing through a narrow opening or around an obstacle. (e.g. Water waves spreading after passing through a gap)
- **Interference:** The superposition of two or more waves, resulting in a new wave pattern. (e.g. Sound waves cancelling each other out)

Relationship between Vibration and Waves

- Periodic waves can be considered a collection of particles undergoing SHM.
- The displacement of a point on a wave can be described by the equation of SHM.



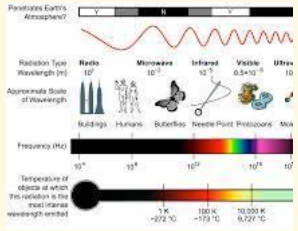
As the sine wave created by this vibrating blade travels to the right, a single point on the string vibrates up and down with simple harmonic motion.

Applications of Waves in Daily Life

- **Sound Waves:** Communication (phones, music), medical imaging (ultrasound)
- **Light Waves:** Vision, communication (fiber optics), medical treatment (lasers)
- **Radio Waves:** Wireless communication (radio, Wi-Fi)
- **Water Waves:** Navigation, recreation (surfing)

Conclusion

- We explored the concepts of vibration and waves, their properties, and different types.
- We learned about wave calculations, simple harmonic motion, and their relationship.
- We saw real-world



Exploring Resources and References

Online Resources:

- **Khan Academy - Waves:** https://www.khanacademy.org/science/physics/mechanical-waves-and-sound/mechanical-waves/v/introduction-to-waves (Interactive tutorials and practice problems)
- **The Physics Classroom - Wave Basics:** https://www.physicsclassroom.com/class/waves (Explanations and animations)
- **MIT OpenCourseware - Vibrations and Waves:** https://ocw.mit.edu/courses/8-03sc-physics-iii-vibrations-and-waves-fall-2016/resources/lecture-1-video/ (Video lectures and course materials)

Books:

- Vibrations and Waves by A.P. French (Dover Publications)
- The Physics of Waves by Richard Feynman (W. W. Norton & Company)
- Introduction to Waves and Oscillations by Frederick S. Crawford (Holt Rinehart and Winston)

Documentaries:

- **The Elegant Universe** (Explores the concept of waves in relation to string theory)
- **Sonic Seas** (Investigates the underwater world of sound waves)
- **Light in the Dark** (Explores the science and history of light waves)

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