Waves & Sound

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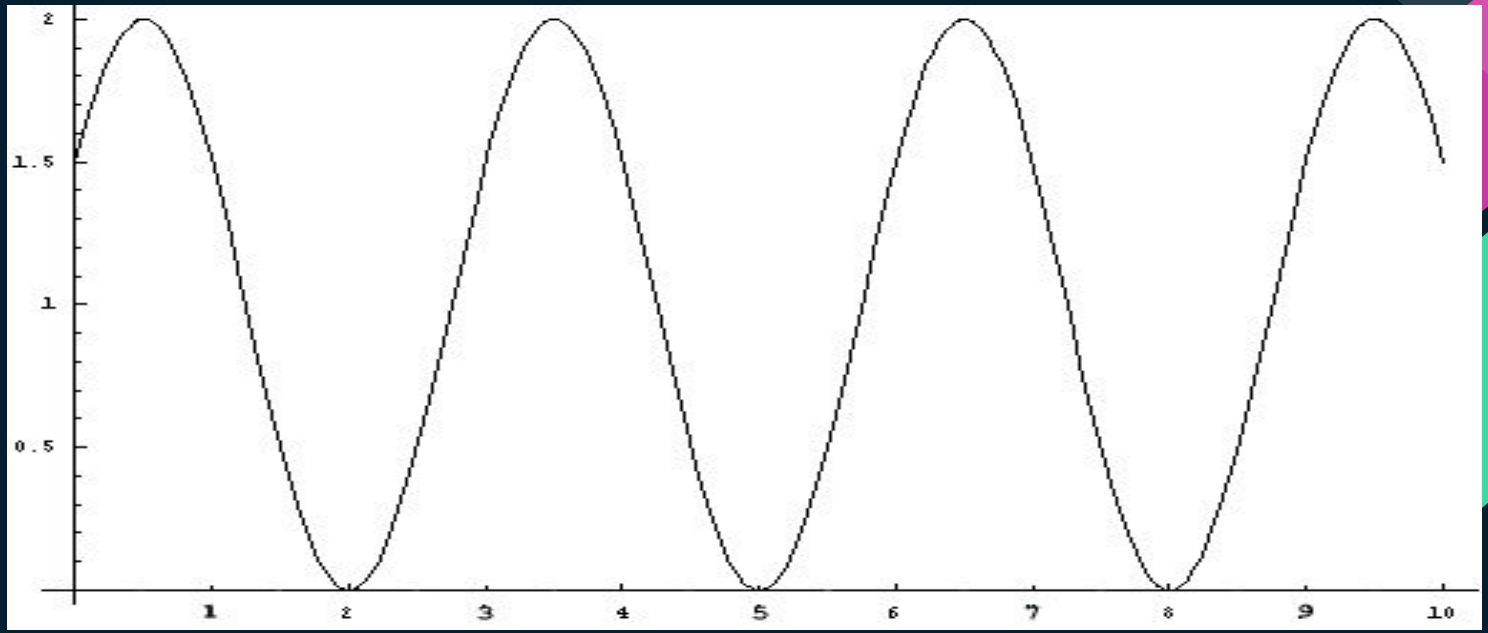
Period 2

Waves

- Travelling vibrations
- Carry energy
- Speed of Light: $c = 3.00 \times 10^8$ m/s
- Speed of sound: v = 344 m/s (in dry air at 20°C)

Wave Characteristics



$V=\lambda f$

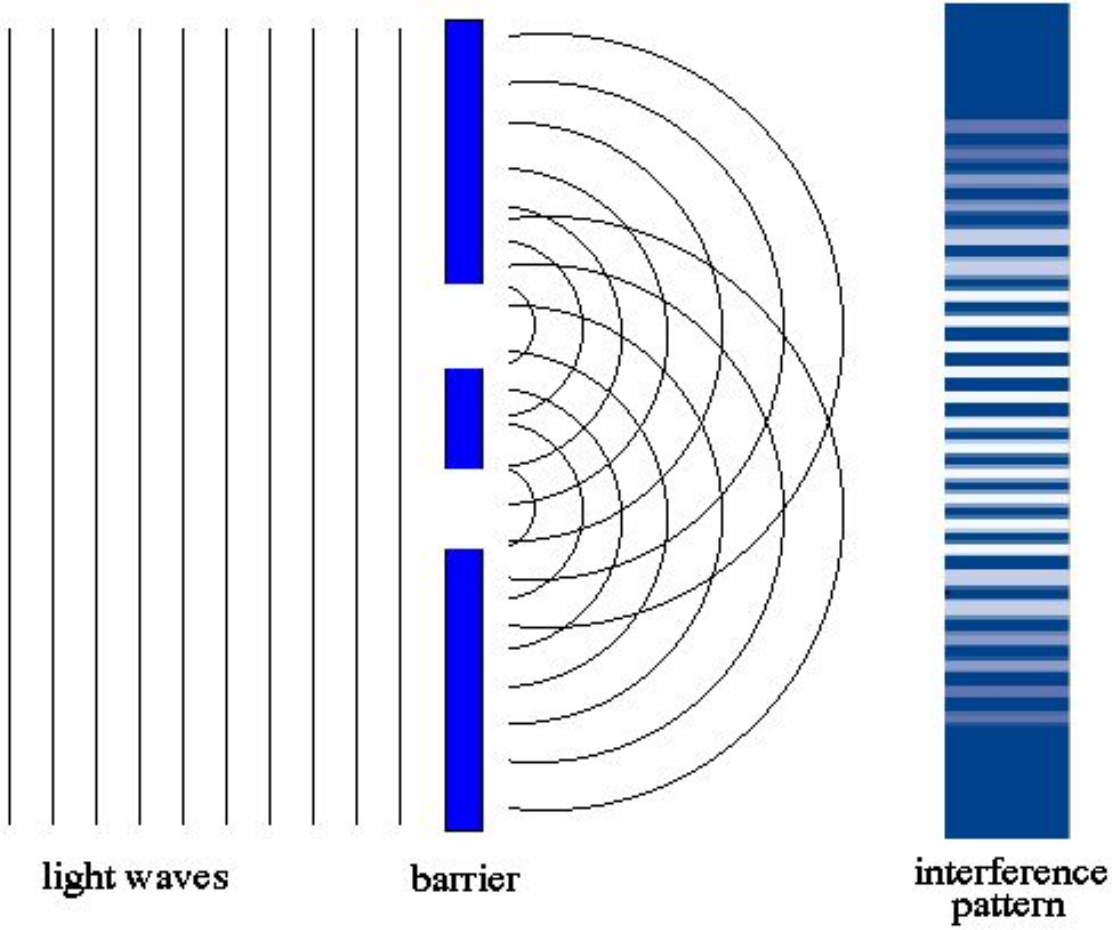
Types of Waves

- ***Longitudinal*** - Motion is in the same direction as wave propagation
  - Light, earthquake secondary waves, water ripples
- ***Transverse*** - Motion is perpendicular to wave propagation
  - Sound, earthquake primary waves

Interference

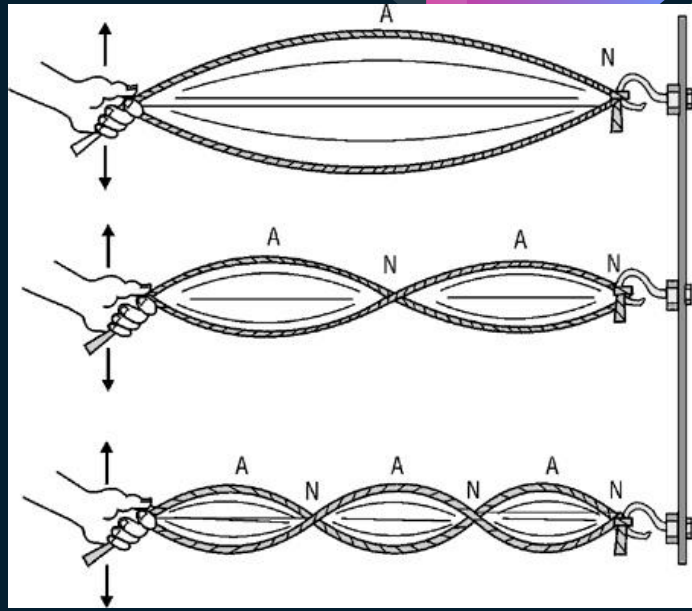
- When 2 or more waves meet
- ***Constructive Interference*** - Crest of one wave overlaps with crest of another (effects are additive)
- ***Destructive Interference*** - Crest of one wave meets trough of another (effects decrease)

Interference



Standing Waves

- Result from interference:
  - 2 oppositely moving waves of equal amplitude and wavelength pass through each other
- ***Nodes***: Fixed/stationary points,
- ***Antinodes***: Positions with the largest amplitudes (halfway between nodes)




Sound

Sound: Origin

- Sound is created by a vibrating source.
- The frequency at which the source vibrates is the same as the frequency of the sound wave
- ***Natural Frequency*** - Frequency at which minimum energy is required for vibrations
- Frequency is measured in Hz (cycles per second)

Sound:Travel and Interpretation

- Sound travels in longitudinal waves
- ***Compressions*** - compressed areas of higher pressure
- ***Rarefactions*** - decompressed areas of low pressure
- We interpret sound waves as pitch
  - ***Pitch*** - the brain's interpretation of frequency
    - Higher frequency = higher pitch (same for low)
  - Below 25 Hz - infrasonic
  - Above 20,000 Hz - Ultrasonic

Doppler Effect

- Apparent change in frequency due to the movement of the source or of the receiver
  - Moving toward = higher pitch
  - Moving away = lower pitch
- V_s = velocity of the source
- V = speed of sound
- (+) moving away
- (-) moving towards

$$f' = \frac{f}{1 \pm \frac{v_s}{v}}$$

Loudness

- Loudness: the brain's interpretation of intensity
  - Measured in Decibels (dB)

$$Intensity = \frac{Power}{Area} \qquad \beta = 10 \log \frac{I_1}{I_0}$$

- $I_0 = 10^{-12}$ W/m
  - "Threshold of Hearing"

Speed of Sound

- Sound cannot travel in a vacuum.
- Speed of sound is dependent on the elasticity
  - Elasticity: measure of a material's propensity to retain its shape
- Sound travels fastest through solids, slowest in gases
- Higher elasticity = higher speed of sound

Speed of Sound

$$v = \sqrt{\frac{E}{\rho}} \qquad v = \sqrt{\frac{B}{\rho}}$$

- E = Elastic Modulus (N/m^2) for solids
- B = Bulk Modulus (N/m^2) for liquids/gases
- ρ = density (kg/m^3)

Resonance

- The dramatic increase in amplitude that occurs when frequency of a forced vibration on an object matches the object's natural frequency

Timbre

- The character of quality of a musical sound or voice as distinct from its pitch and intensity
- Also known as tone quality or tone color

Common Mistakes

- Waves DO NOT carry MATTER
- Waves do not travel in vacuums
- Sound expands in 3 dimensions, spherically

Demo Problem

A police car is driving away from you at a speed of 50 m/s. Its siren emits a frequency of 700 Hz. What is the apparent frequency?

Practice Problem

Due to your abnormal fear of police cars, you start running away East at 10 m/s from the police car (traveling 50 m/s) that is traveling West. What is the new apparent frequency?

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Answer: 596 m/s

The End