

GRADE 11 STUDY GUIDE | 2025

Waves and Sound

Physical Sciences

1. Properties of Waves

$$v = f \times \lambda$$

$$f = 1/T$$

Where: v =speed (m/s), f =frequency (Hz), λ =wavelength (m), T =period (s)

- Transverse wave: particles vibrate PERPENDICULAR to direction of energy transfer (e.g. water, light)
- Longitudinal wave: particles vibrate PARALLEL to direction of energy transfer (e.g. sound)
- Amplitude: maximum displacement from equilibrium -- determines INTENSITY/LOUDNESS
- Frequency: number of complete waves per second -- determines PITCH (for sound)

2. Sound Waves

Sound is a LONGITUDINAL mechanical wave. It requires a MEDIUM to travel (cannot travel in a vacuum). Speed of sound in air at 20 degC = 343 m/s.

- Compressions: regions of high pressure (particles close together)
- Rarefactions: regions of low pressure (particles far apart)
- Intensity (loudness) depends on amplitude
- Pitch depends on frequency: high pitch = high frequency

3. Reflection, Refraction and Diffraction

- Reflection: wave bounces off a barrier. Angle of incidence = angle of reflection.
- Refraction: wave changes speed (and direction, unless hitting normal) when entering a new medium. Frequency stays the same; wavelength and speed change.
- Diffraction: waves spread out after passing through a gap or around an obstacle. Most pronounced when gap size $\sim$ wavelength.

4. Standing Waves (Resonance)

A standing wave forms when two identical waves travelling in opposite directions superpose. The wave pattern appears stationary with NODES (zero displacement) and ANTINODES (maximum displacement).

String fixed at both ends

$$\text{Fundamental (1st harmonic): } f_1 = v/(2L)$$

$$\text{2nd harmonic: } f_2 = 2v/(2L) = v/L$$

$$\text{nth harmonic: } f_n = n \times f_1$$

Open pipe (open at both ends)

$$\text{Same harmonics as string: } f_n = n \times v/(2L)$$

Closed pipe (closed at one end)

$$\text{Only ODD harmonics: } f_n = n \times v/(4L) \text{ where } n = 1, 3, 5, \dots$$

5. The Doppler Effect

$$f_{\text{observer}} = v \pm v_{\text{observer}} / (v \mp v_{\text{source}}) \times f_{\text{source}}$$

Use + v_{observer} when observer moves TOWARD source

Use - v_{source} when source moves TOWARD observer

The Doppler effect is the apparent change in frequency (and pitch) of a wave due to relative motion between the source and the observer. Moving toward = higher pitch; moving away = lower pitch.

KEY: Applications: speed cameras (radar), ultrasound medical imaging, astronomy (red-shift/blue-shift to measure star velocities).