National 5 Physics
Waves
Summary Notes

Contents

Learning Outcomes

Wave Parameters and Behaviours

- ☐ Know that waves transfer energy.
- ☐ Define transverse and longitudinal waves.
- ☐ Know that sound is an example of a longitudinal wave and electromagnetic radiation and water waves are examples of transverse waves.
- ☐ Determine the frequency, period, wavelength, amplitude and wave speed for longitudinal and transverse waves.
- ☐ Use appropriate relationships to solve problems involving wave speed, frequency, period, wavelength, distance, number of waves and time.

$$d = vt \quad ; \quad v = f\lambda \quad ; \quad T = \frac{1}{f} \quad ; \quad f = \frac{N}{t}$$

- ☐ Know that diffraction occurs when waves pass through a gap or around an object.
- ☐ Compare long wave and short wave diffraction.
- ☐ Draw diagrams using wavefronts to show diffraction when waves pass through a gap or around an object.

Electromagnetic Spectrum

- ☐ Know that all radiations in the electromagnetic spectrum are transverse and travel at the speed of light.
- ☐ Know the relative frequency and wavelength of bands of the electromagnetic spectrum.
- ☐ Know of typical sources, detectors and applications for each band in the electromagnetic spectrum.

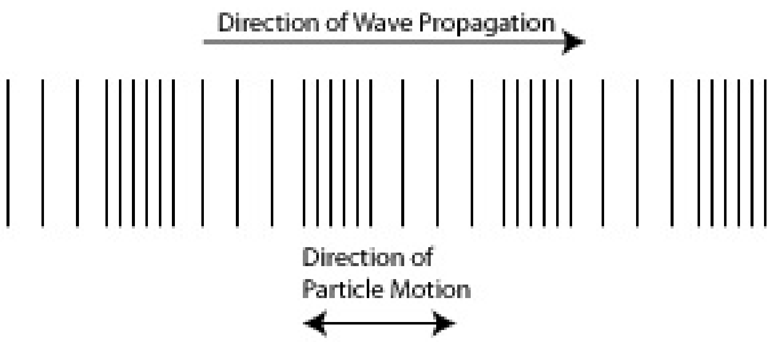
Refraction of Light

- ☐ Know that refraction occurs when waves pass from one medium to another.
- ☐ Describe refraction in terms of change of wave speed, change in wavelength and change of direction (where the angle of incidence is greater than 0°), for waves passing into both a more dense and a less dense medium.
- ☐ Identify the normal, angle of incidence and angle of refraction in ray diagrams showing refraction.

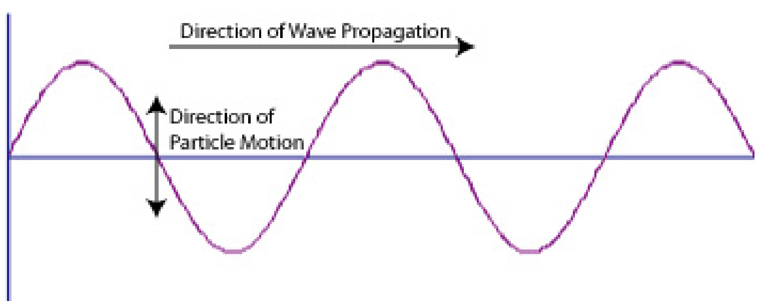
1 Wave Parameters and Behaviours

1.1 Longitudinal and Transverse Waves

- Waves transfer (carry) **energy** from one point to another.
- Examples: sound waves, heat waves, water waves, light waves.
- A **longitudinal wave** is one where the particles vibrate along the **same direction** as the wave. E.g. sound waves.



- A **transverse wave** is one where the particles move at **right angles (90°)** to the direction of travel of the wave. E.g. light, water waves and all members of the electromagnetic spectrum (i.e. x-rays, gamma rays etc).



1.2 Wave Frequency

- Frequency is the **number of waves per second**.

$$\boxed{f = \frac{N}{t}}$$

where

- f is frequency measured in hertz (Hz)
- N is number of waves (no units)
- t is time measured in seconds (s).

- $1\ Hz = 1\ s^{-1}$.

1.3 Wave Period

- Period is the **time** taken for one wave to pass a point. It is also known as the inverse of the frequency.

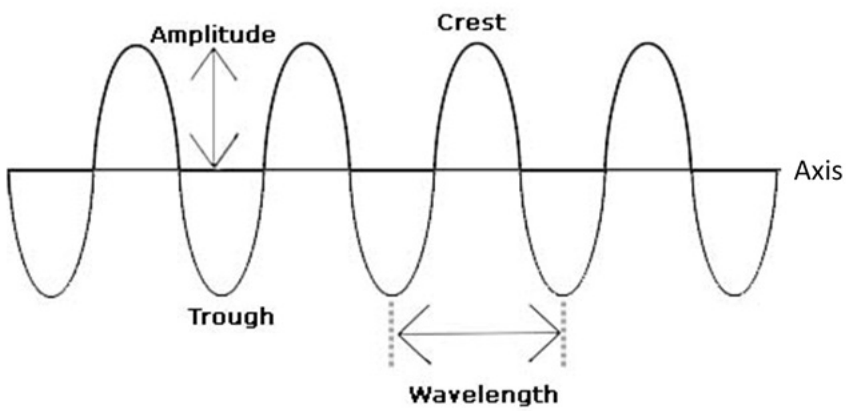
$$\boxed{T = \frac{1}{f}}$$

where

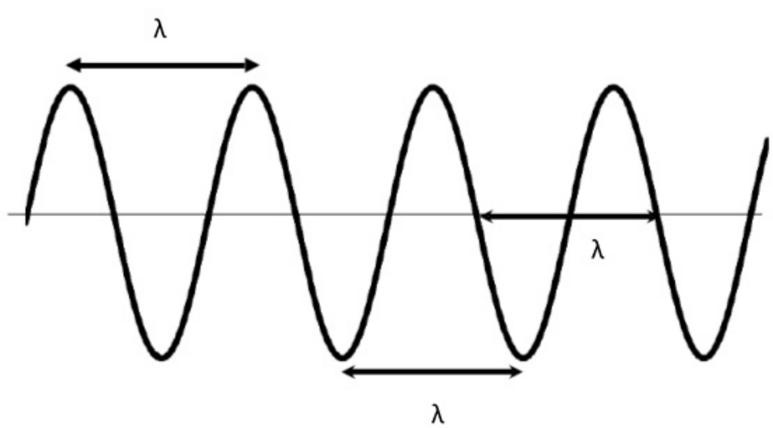
- T is period measured in seconds (s)
- f is frequency measured in hertz (Hz).

1.4 Wave Properties

- The **crest** is the top point of a wave.
- The **trough** is the bottom point of a wave.
- The **vertical distance** from the axis to the top of the wave (crest) or bottom of the wave (trough) is called the **amplitude**. It is half the vertical height of the wave.
- The **energy of a wave** depends on its **amplitude** - the **greater** the amplitude, the **greater** the energy that is transferred by the wave.



- The **horizontal distance** from one crest to the next crest, one trough to the next trough or one point on a wave to the same point on the next wave is called the **wavelength**. It is given the symbol λ and is measured in **metres (m)**.



1.5 Wave Speed

- The **speed** of a wave is the distance travelled per second.

$$v = \frac{d}{t}$$

or

$$\boxed{d = vt}$$

where

- d is distance measured in metres (m)
- v is speed measured in metres per second (ms^{-1})
- t is time measured in seconds (s).

- Sound and light waves travel at different speeds.
- Examples demonstrating this include thunder and lightning, fireworks and slamming a door shut.

Sound

Material	*Speed* in $m\,s^{-1}$
Aluminium	5200
Air	340
Bone	4100
Carbon dioxide	270
Glycerol	1900
Muscle	1600
Steel	5200
Tissue	1500
Water	1500

Light

Material	*Speed* in $m\,s^{-1}$
Air	$3{\cdot}0 \times 10^8$
Carbon dioxide	$3{\cdot}0 \times 10^8$
Diamond	$1{\cdot}2 \times 10^8$
Glass	$2{\cdot}0 \times 10^8$
Glycerol	$2{\cdot}1 \times 10^8$
Water	$2{\cdot}3 \times 10^8$

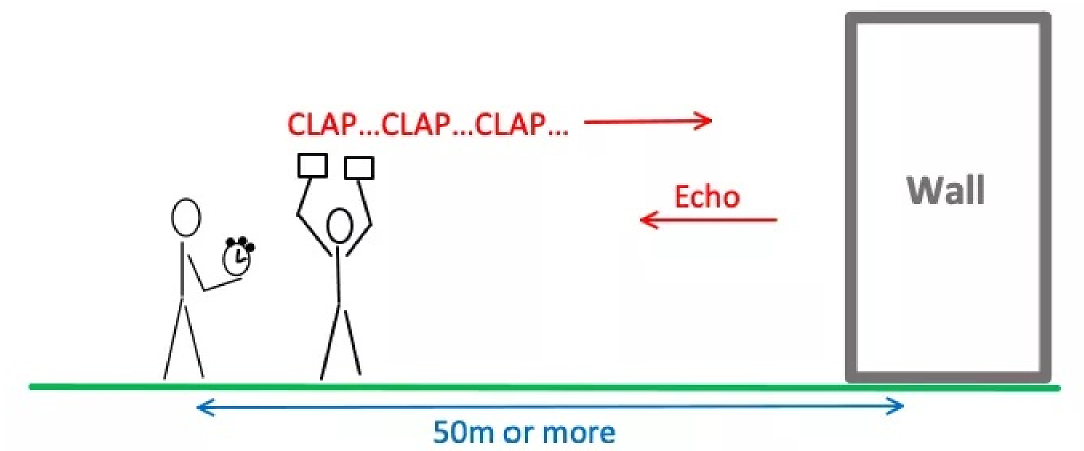
- Note: both tables are given on the data sheet in the exam.
- From the data tables above, we can see that:
  - **Sound** in air travels at 340 ms^{-1}.
  - **Light** in air (vacuum) travels at 3×10^8 ms^{-1}.

Measuring the Speed of Sound in Air

- There are two methods we can use to measure the speed of sound in air.

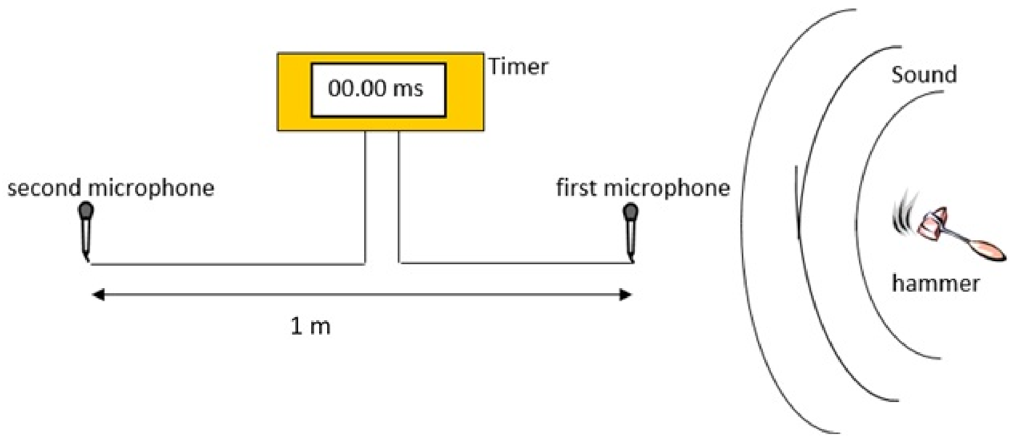
Method 1: Clap Echo

- Measure out a set distance from a wall using a trundle wheel.
- At the measured distance, make a loud noise using the clappers.
- Time how long it takes the sound to reflect off the wall (echo) using a stopwatch.
- Use $v = \frac{d}{t}$ to calculate the speed.



Method 2: Double Microphone

- Use a metre stick to set the two microphones 1 metre apart.
- At one microphone, make a loud sharp noise using a hammer.
- When the sound reaches the first microphone the timer starts. When the sound reaches the second microphone the timer stops. The timer will display the time taken, t.
- Use $v = \dfrac{d}{t}$ to calculate the speed.



The Wave Equation

- The speed of a wave can also be defined as the frequency multiplied by the wavelength. This is sometimes called the 'wave equation'.

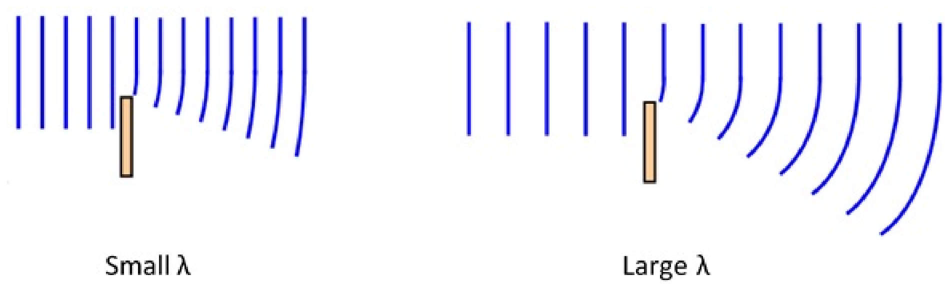
$$\boxed{v = f\lambda}$$

where

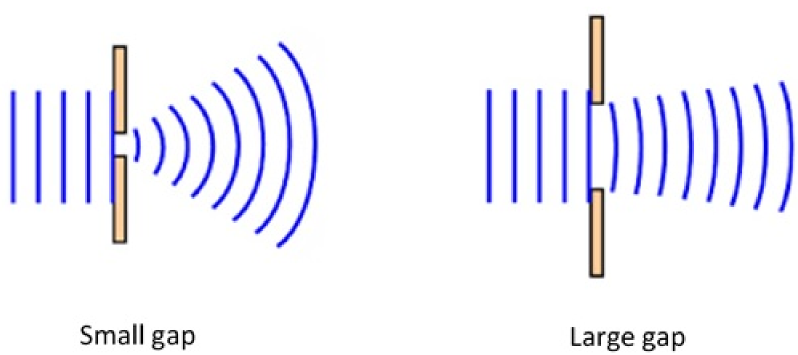
- v is speed measured in metres per second (ms^{-1})
- f is frequency measured in hertz (Hz)
- λ is wavelength measured in metres (m).

1.6 Diffraction

- **Diffraction** is the **bending of waves** through gaps or around obstacles. E.g. water waves bending around a harbour wall.
- The amount of diffraction of a wave depends on the **width of the gap** and the **wavelength of the wave** passing through it.
- The greater the wavelength, the greater the diffraction.



- The larger the gap, the smaller the diffraction.



- Note: when drawing diffraction diagrams, always make sure the spacing is the same between the wavefronts.