Chapter 10: Wave Motion

- Progressive Waves
- Transverse and Longitudinal Waves
- Polarisation
- Determination of frequency and wavelength

a. Show an understanding and use the terms displacement, amplitude, phase difference, period, frequency, wavelength and speed.

(a)	**Displacement** (y):	Position of an oscillating particle from its equilibrium position.
(b)	**Amplitude** (y_0 or A):	The maximum magnitude of the displacement of an oscillating particle from its equilibrium position.
(c)	**Period** (T):	Time taken for a particle to undergo one complete cycle of oscillation.
(d)	**Frequency** (f):	Number of oscillations performed by a particle per unit time.
(e)	**Wavelength** (λ):	For a progressive wave, it is the distance between any two **successive** particles that are **in phase**, e.g. it is the distance between 2 consecutive crests or 2 troughs.
(f)	**Wave speed** (v):	The speed at which the **waveform** travels in the direction of the propagation of the wave.
(g)	**Wave front**:	A line or surface joining points which are at the same state of oscillation, i.e. in phase, e.g. a line joining crest to crest in a wave.
(h)	**Ray**:	The path taken by the wave. This is used to indicate the direction of wave propagation. Rays are always at right angles to the wave fronts (i.e. wave fronts are always perpendicular to the direction of propagation).

b. Deduce, from the definitions of speed, frequency and wavelength, the equation v = fλ

From the definition of speed, $\text{Speed} = \frac{\text{Distance}}{\text{Time}}$

A wave travels a distance of one wavelength, λ, in a time interval of one period, *T*.

The frequency, *f*, of a wave is equal to $\frac{1}{T}$

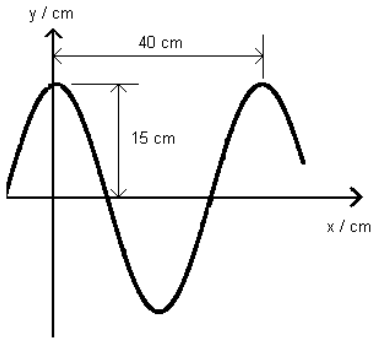
$$\text{Therefore, speed, } v = \frac{\lambda}{T}$$
$$= (\frac{1}{T})\lambda$$
$$= f\lambda$$

Hence, v = fλ

c. Recall and use the equation v = fλ

Example 10C1

A wave travelling in the positive *x* direction is showed in the figure. Find the amplitude, wavelength, period, and speed of the wave if it has a frequency of 8.0 Hz.



Amplitude (A) = 0.15 m

Wavelength (λ) = 0.40 m

Period (T) $= \frac{1}{f} = \frac{1}{8.0}$
≈ 0.125 s

Speed (v) $= f\,\lambda$
$= 8.0 \times 0.40$
$= 3.20\ m\ s^{-1}$

d. Show an understanding that energy is transferred due to a progressive wave.

A wave which results in a net transfer of energy from one place to another is known as a **progressive wave**.

e. Recall and use the relationship, intensity $\propto$ (amplitude)^2

Intensity {of a wave}: is defined as the rate of energy flow per unit time {power} per unit cross-sectional area perpendicular to the direction of wave propagation.

$$\text{ie } \textbf{Intensity} = \frac{\text{Power}}{\text{Area}} = \frac{\text{Energy}}{\text{Time x Area}}$$

For a point source (which would emit spherical wavefronts),

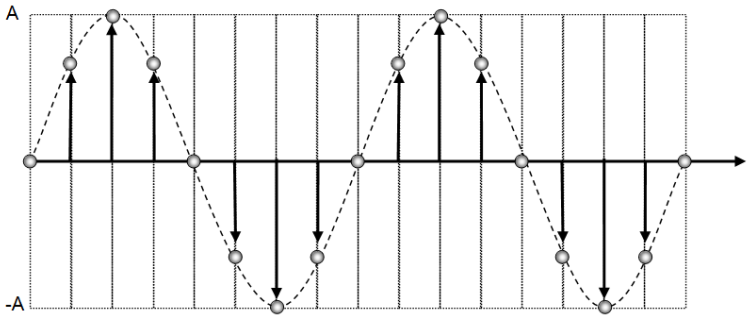
$$\text{Intensity} = \frac{\frac{1}{2}m\omega^2 x_o^{\,2}}{t \times 4\pi r^2} \qquad \text{where } x_0\text{: amplitude \& r: distance from the point source.}$$

$$\therefore \quad I \propto \frac{x_o^{\,2}}{r^2} \quad \textbf{(Pt Source)}$$

For all wave sources, **$I \propto$ (Amplitude)^2**

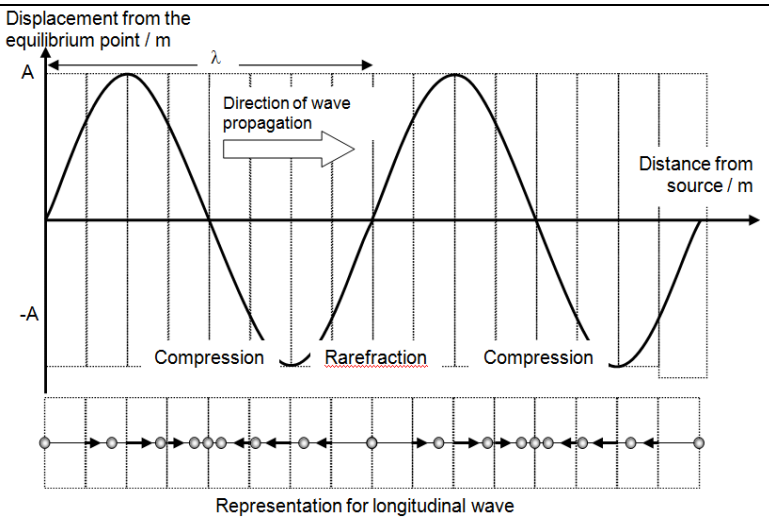
f. Analyse and interpret graphical representations of transverse and longitudinal waves.

Transverse wave: A wave in which the oscillations of the wave particles {NOT: movement} are *perpendicular* to the direction of the propagation of the wave.



Representation for transverse wave

Longitudinal wave: A wave in which the oscillations of the wave particles are *parallel* to the direction of the propagation of the wave.



Representation for longitudinal wave

g. Show an understanding that polarisation is a phenomenon associated with transverse waves.

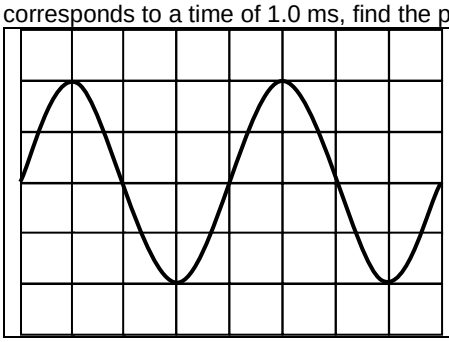
Polarisation is said to occur when oscillations are **in <u>one direction in a plane</u>**, {NOT just "in one direction"} <u>normal to the direction of propagation.</u>

{Only *transverse* waves can be polarized; ***longitudinal waves can't.***}

h. Determine the frequency of sound using a calibrated cathode ray oscilloscope.

<u>Example 10H1</u>

The following stationary wave pattern is obtained using a C.R.O. whose screen is graduated in centimetre squares. Given that the time-base is adjusted such that 1 unit on the horizontal axis of the screen corresponds to a time of 1.0 ms, find the period and frequency of the wave.



Period, T = (4 units) × 1.0
= 4.0 ms
= 4.0×10^{-3} s

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

$= \frac{1}{4 \times 10^{-3}}$

= 250 Hz

i. Determine the wavelength of sound using stationary waves.

See Chapter 11