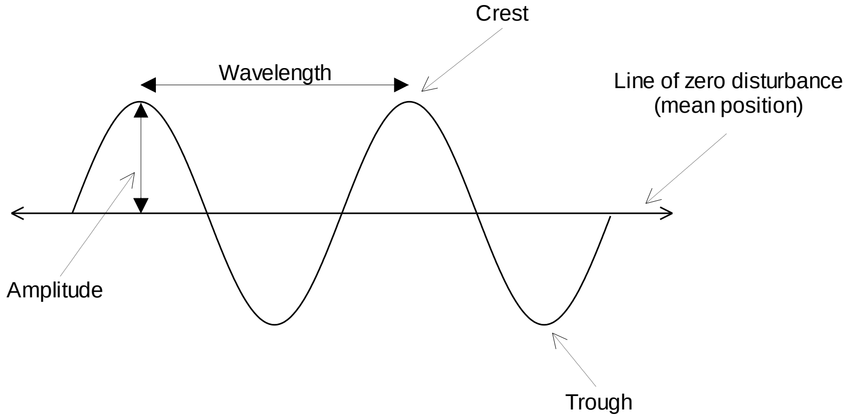
Physics with Synno – Waves-Light – Lesson 2

LW.5 Features of a Transverse Wave



- Crest – the highest point on a wave.
- Trough – the lowest point on a wave.
- Wavelength – the distance between two corresponding points on a wave. The symbol used is the Greek letter lambda, λ.

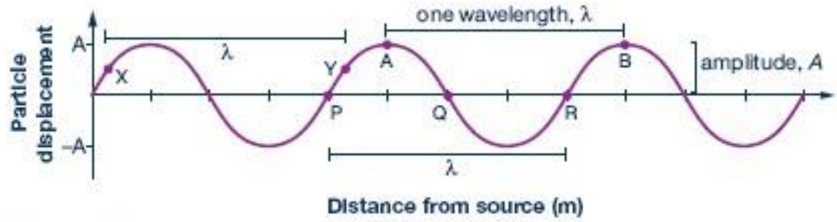


Figure 1.13 When determining the wavelength of a wave directly from a displacement-distance graph it does not matter at which part of the cycle you begin the wavelength measurement.

- Amplitude – the maximum displacement of a particle from its **mean** position.

LW.6 Period and Frequency

Frequency is the number of vibrations or cycles completed every second. The symbol used is f, it is measured in cycles per second (s^{-1}) and the unit used is hertz (Hz). Named after Heinrich Hertz (1857 – 1894). Thus 1 cycle per second (s^{-1}) equals 1 hertz (Hz).
Frequency can be calculated as follows:

$$f = \frac{number\ of\ waves}{time}$$

Period is the time for the completion of one cycle. The symbol use is T and the unit is second (s).
Period and Frequency are linked by the following equation

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

Example

A student lays a long heavy rope in a straight line across a smooth floor. She holds one end of the rope and shakes it sideways, to and fro, with a regular rhythm. This sends a transverse wave along the rope. Another student standing halfway along the rope notices that two crests and troughs travel past him each second.

a) What is the frequency of the wave in the rope?
b) What is the frequency of vibration of the source of the wave?
c) How long does it take for the student to produce each complete wave in the rope?

a) $f = \frac{number\ of\ waves}{time} = \frac{2}{1} = 2\ Hz$

b) 2 HZ

c) $f = \frac{1}{T} \ \rightarrow\ T = \frac{1}{f} = \frac{1}{2} = 0.5\ sec$

LW.7 The Wave Equation

Video: Wave Equation

The speed of a wave is the distance travelled in a certain time or

$$speed = \frac{distance\ travelled}{time\ taken}$$

$$speed = \frac{\lambda}{T}$$

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

$\therefore$ $$v = \lambda f$$

The speed of the wave is measured in metres per second (ms^{-1})

Note: The ***medium*** that a wave travels through is the ***determining factor for the speed***. If the wave travels into another medium then the **speed will** change.

The ***frequency*** of a wave is ***determined by the thing making the wave***. i.e. the source. After they are produced the **frequency does not** change.

Example

A person standing on a pier notices that every 4.0 seconds the crest of a wave travels past a certain pole that sticks out of the water. The crests are 12 metres apart from one another. Calculate:

a) the frequency of the waves
b) the speed of the waves.

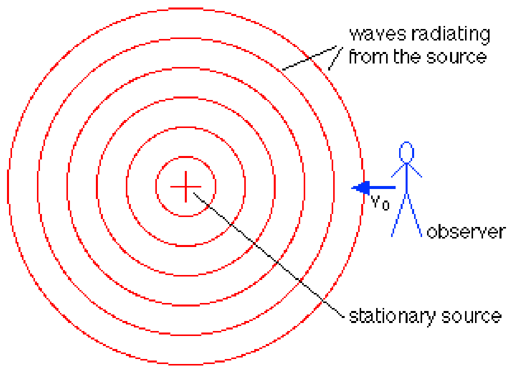
a) $f = \frac{number\ of\ waves}{time} = \frac{1}{4} = 0.25\ Hz$

b) $v = \lambda f = 12 \times 0.25 = 3\ m/s$

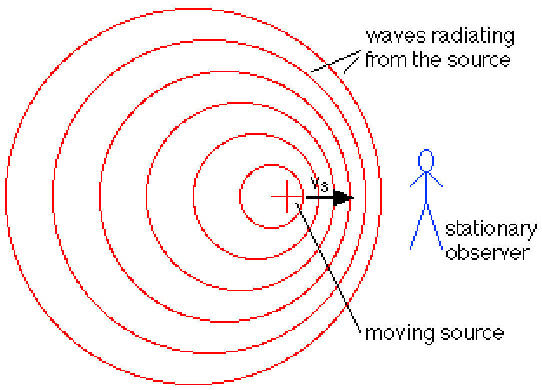
LW.8 The Doppler Effect

Video: Car Horn Doppler Effect
The Doppler Effect: what does motion do to waves?
Conceptual Physics: The Doppler effect
Doppler Effect
Doppler Effect, Big Bang Theory Style

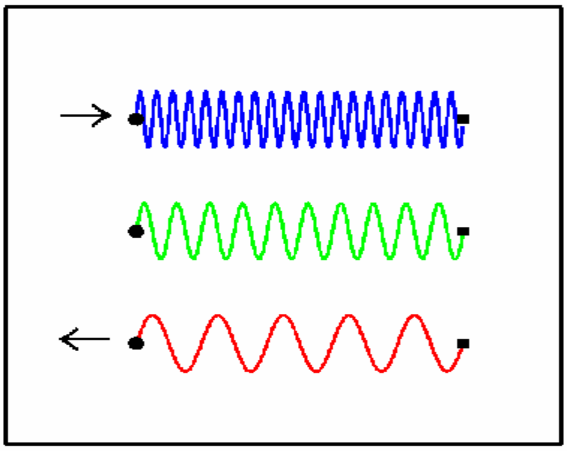
The Doppler effect describes the shift in the frequency of a wave sound when the wave source and/or the receiver is moving. Consider first the case of a stationary source, and an observer (you, for example) moving toward the source. As shown in the diagram, the waves are emitted by the source uniformly.



If the observer is stationary, the frequency received by the observer is the frequency emitted by the source. If the observer moves toward the source at a speed v_o, more waves are intercepted per second and the frequency received by the observer goes up. Effectively, the observer's motion shifts the speed at which the waves are received.
If the observer is stationary but the source moves toward the observer at a speed v_s, the observer still intercepts more waves per second and the frequency goes up.



The same principle applies for light as well as for sound. In detail the amount of shift depends a little differently on the speed, since we have to do the calculation in the context of special relativity. But in general it's just the same: if you're approaching a light source you see shorter wavelengths (a blue-shift), while if you're moving away you see longer wavelengths (a red-shift).



Distant galaxies are moving away from us extremely fast. So fast in fact that it is relatively easy to measure the shift in their spectral lines. This is evidence that the Universe is expanding, which is one of the most important pieces of evidence in support of the Big Bang picture.

Text Questions: Text Page 281 Ex 8.2 All Questions