Hyndland Secondary School

National 4/5

Physics

Waves and Radiation

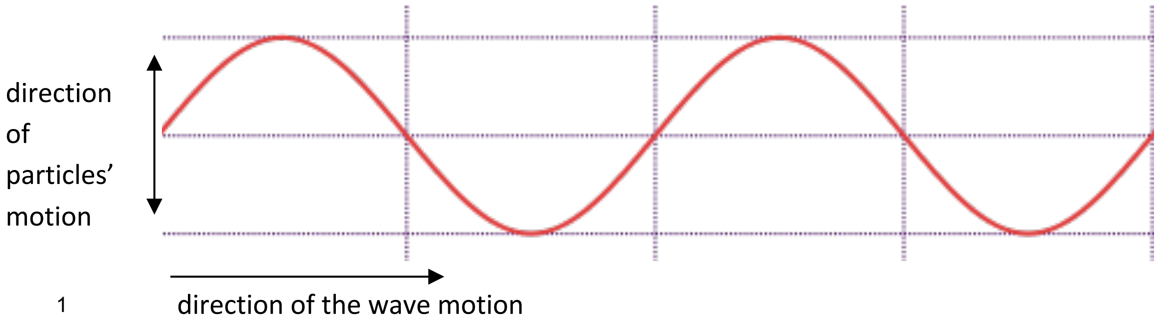
Summary Notes

Wave characteristics, parameters and behaviours

Types of wave

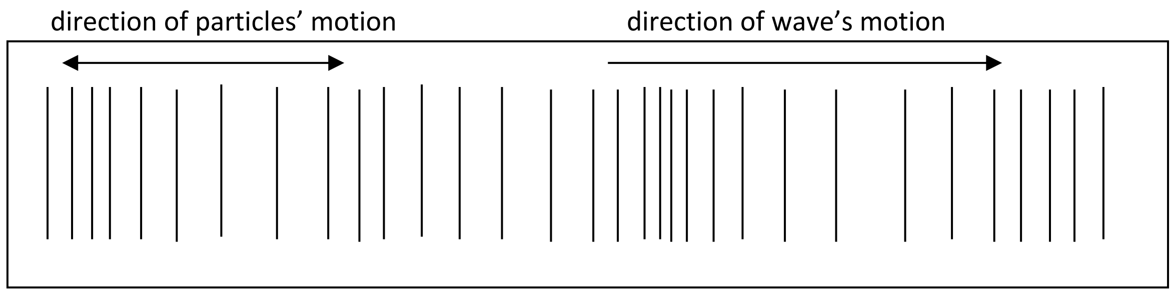
There are two different types of waves you will meet in this course, **transverse** waves and **longitudinal** waves

In transverse waves the particles oscillate (vibrate) at right angles to the motion of the wave



[1]

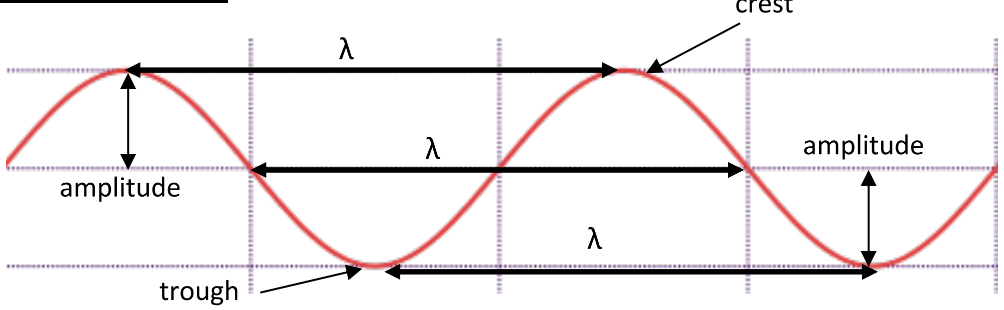
In longitudinal waves the particles oscillate in the same direction as the motion of the wave



Examples of transverse waves include light waves, radio waves, microwaves.

Sound is an example of a longitudinal wave

Properties of waves



Waves are used to transfer energy. The particles oscillate around a fixed position but the energy travels along the wave.

[1] http://upload.wikimedia.org/wikipedia/commons/7/77/Waveforms.svg

Several important features of a wave are shown in the diagram. These are explained in the following table

Wave property	Symbol	Definition	Unit	Unit symbol
crest		highest point of a wave		
trough		lowest point of a wave		
frequency	f	number of waves produced in one second	hertz	Hz
wavelength	λ	horizontal distance between successive crests or troughs	metre	m
amplitude	A	half the vertical distance between crest and trough	metre	m
wave speed	*v*	*distance travelled per unit time*	*metres per second*	*m/s*

Distance, speed and time

One of the most important equations you will meet in Physics concerns the relationship between distance, speed and time. This means that the speed of an object (or wave) is a measure of how much distance is covered in a certain time.

Another way of looking at this is that the distance travelled depends on how fast you travel and for how long. We represent this as shown below

$$distance = speed \times time$$
$$d = \bar{v}t$$

where d is the distance travelled in metres (m)

$\bar{v}$ is the average speed in metres per second (m/s)

and t is the time in seconds (s)

Example A wave travels 90 m in 30 s. Calculate the speed of the wave

Solution

d = 90m

t = 30s

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

$$90 = \bar{v} \times 30$$

$$\frac{90}{30} = \bar{v} \qquad \bar{v} = \underline{3ms^{-1}}$$

Wave speed, frequency and wavelength

By multiplying the frequency and wavelength we find that this is equal to the speed of the wave. We therefore say that:

$$wave\ speed = frequency \times wavelength$$

$$v = f\lambda$$

Example: A wave has a wavelength of 0.5 m and a frequency of 4 Hz. What is its speed?

Solution:

λ = 0.5m

f = 4Hz

$$v = f\lambda$$

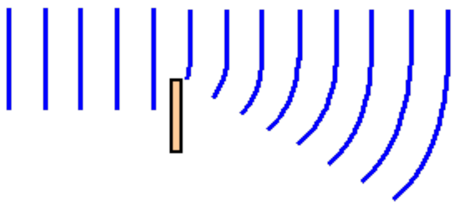
$$v = 4 \times 0.5$$

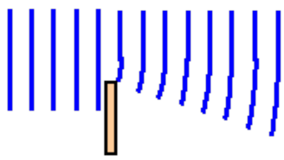
$$v = \underline{2ms^{-1}}$$

Diffraction

*Waves are able to bend around obstacles. This bending of waves around corners is called **diffraction**.*

Long wavelength waves diffract more than short wavelength waves.





[2]

Long wavelength Short wavelength

[2] http://www.schoolphysics.co.uk/age14-16/glance/Waves/Diffraction_/index.html?PHPSESSID=43cdadeaf8c0a5aeacf88cced9468bab

Electromagnetic spectrum and light

The electromagnetic spectrum

There are a number of waves which travel at the speed of light. They are all part of the ***electromagnetic spectrum****. These waves are all transverse waves and travel at 3000000000 m/s (3 x 10^8m/s) in a vacuum.*

The different parts of the electromagnetic spectrum differ in wavelength and frequency

increasing wavelength ↓

Gamma rays

X-rays

Ultraviolet

Visible light

Infrared

Microwaves

Radio and TV

increasing frequency ↑

The different parts of the electromagnetic spectrum can also be distinguished by their energy. Higher frequency electromagnetic radiation has a greater amount of energy than lower frequency electromagnetic radiation.

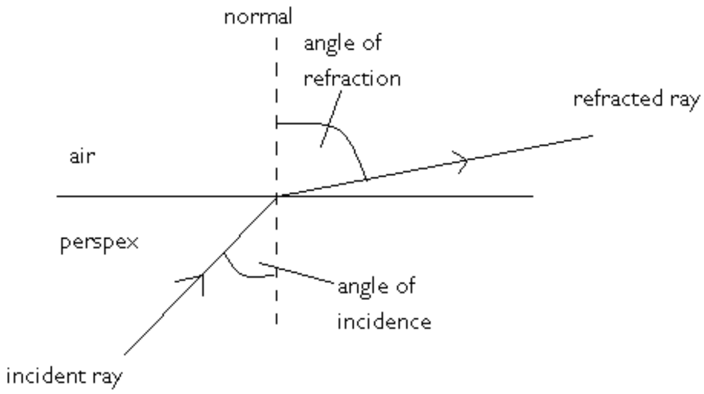
Some information on each part of the spectrum is given below

Type of e-m radiation	Typical source	Application	Detector	Possible hazard
Radio & TV	Electrical antennae	Telecommunications	Aerial	Potential increased cancer risk
Microwaves	Cosmic sources, magnetron	Cooking, telecommunications	Diode probe	Heating of body tissues
Infra-red	Heat-emitting objects	Thermograms	Phototransistor, blackened thermometer	Heating of body tissues
Visible light	Stars	Vision	Eye, photographic film	Intense light can damage the retina
Ultraviolet	Sunlight	Treating skin conditions	Fluorescent paint	Skin cancer
X-rays	X-ray tube, cosmic sources	Medical imaging	Photographic plates	Destroys cells which can lead to cancer
Gamma rays	Nuclear decay	Treating tumours	Geiger–Müller tube and counter	Destroys cells which can lead to cancer

Light

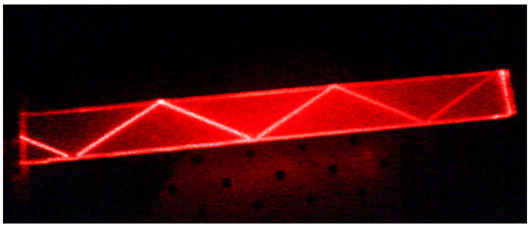
At the boundary between different types of materials, the speed of the light wave changes. This results in a change in wavelength, and can often cause the direction of a wave to change.

*The change in light speed when going from one medium into another is known as **refraction**.*



*This effect is used in **lenses**.*

*Above a certain angle of incidence, refraction no longer occurs, and instead the wave is reflected back into the first medium. This is known as **total internal reflection**. The angle of incidence that causes an angle of refraction of 90° is called the **critical angle**.*

 [3]

*Total internal reflection is used in optical fibres. Optical fibres can be used for communication or in medical applications to allow doctors to see into the body. One bundle of fibres carries light into the body whilst another carries the light back out of the body. This is known as an **endoscope**.*

[3] Sai2020 taken from http://en.wikipedia.org/wiki/File:TIR_in_PMMA.jpg