6.4 The maths/science interface

Exercises

In the previous activity you considered waves from the mathematical perspective of the equation $y = a\sin(bx + c) + d$. In science classes waves are considered in contexts such as sound waves and light waves. Waves are formed when disturbances are propagated from place to place in a regular and organised way. The most familiar waves are surface waves that travel on water, but sound and light also exhibit wave-like properties.

In a simple wave, disturbance oscillates periodically with a fixed frequency and wavelength. Longitudinal waves, such as sound, require a material medium through which to travel, while electromagnetic waves such as light do not require a medium and can be propagated through a vacuum. The important factor about a wave is the property of energy transfer.

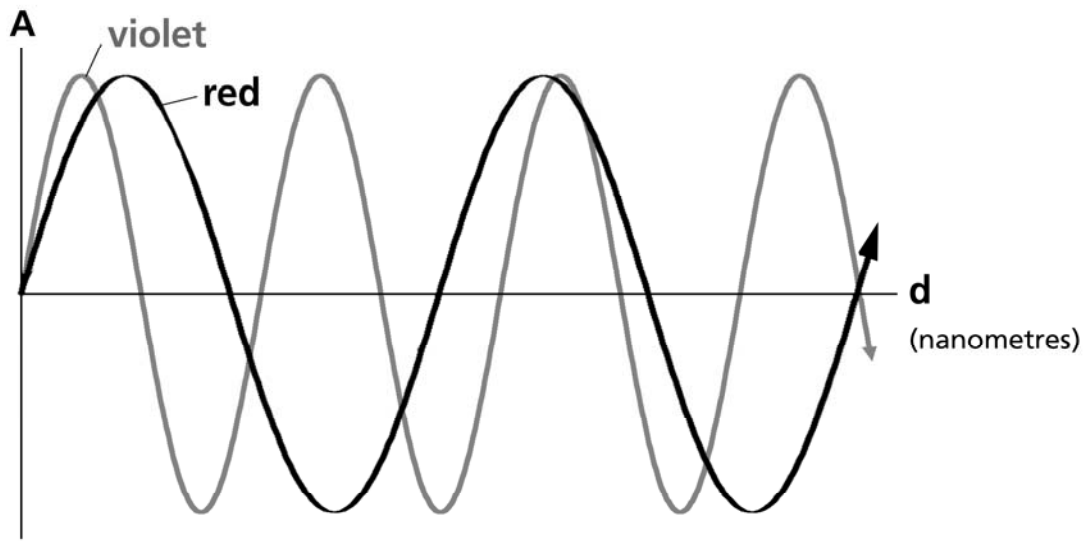
Wavelength

Light waves come in many wavelengths. Wavelength is the distance between any two corresponding points on the wave, for example successive peaks. The wavelengths of visible light range from 400 to 650 nanometres (nm), 10^{-9} m.

However, the full range of wavelengths included in the definition of electromagnetic radiation extends from 10^{-15} metres (gamma rays) to hundreds of metres (radio waves).

Visible light is only one small section of the electromagnetic spectrum.

Frequency



Light waves also come in many frequencies. Frequency is the number of waves that pass a point in space during any time interval, usually one second. It is measured in units of cycles (waves) per second, or Hertz (Hz). The frequency of visible light is referred to as colour, and ranges from 460 trillion Hz (seen as red) to 750 trillion Hz (violet).

The amount of energy in a light wave is proportionally related to its frequency: high frequency light has high energy; low frequency light has low energy. Thus gamma rays have the most energy, and radio waves have the least. Of visible light, violet has the most energy and red the least.

Light not only vibrates at different frequencies, it also travels at different speeds. Light waves move through a vacuum at their maximum speed (≈300000 kilometres per second). This means light is the fastest known phenomenon in the universe. Light waves slow down when they travel inside substances such as air, water, glass or diamond.

From our earlier definition of period $= \frac{1}{\text{frequency}}$ or $T = \frac{1}{f}$

Also

Wave speed = frequency x wavelength or $v = f \times \lambda$

1. Find an equation for period in terms of wavelength and wave speed.

2. What is the wavelength of the colours red and violet, give your answer in nanometres (nm)?

3. Radio stations broadcast via radio waves in a variety of bands such as FM, AM and shortwave. How do radio stations identify themselves enabling the listener to tune in to their station? Using this method describe three of your favourite radio stations.

4. Mobile phones also transfer your voice to particular types of radio waves. Describe the nature and range of the waves used by mobile phones.