

Waves and Optics

38 Wave Properties and Basic Equations

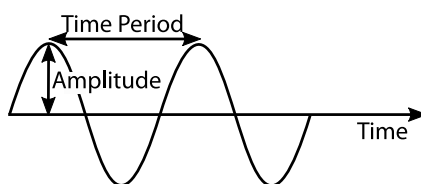
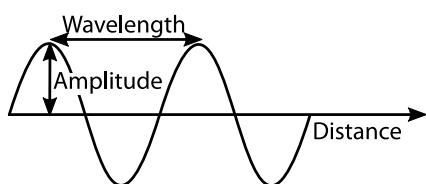
Waves can transfer **energy** (or **information**) without transferring **material**.

All waves involve **oscillations** (repeating motions back and forth).

Longitudinal Wave	Examples
Oscillations parallel to the direction of energy transfer	Sound Ultrasound Seismic P wave

Transverse Wave	Examples
Oscillations perpendicular to the direction of energy transfer	Light Other electromagnetic wave (e.g. radio) Seismic S wave

Wavelength	The distance from one peak to the next
Time period	The time for one whole wave to go past you
Amplitude	The height of the wave's peaks from the midpoint
Frequency	The number of waves going past each second
Peak	The highest point on the wave
Trough	The lowest point on the wave
Speed	How fast the wave goes



Formulae:

$$\text{wave speed} = \text{frequency} \times \text{wavelength} \quad v = f\lambda$$

Reason: Length of wave made each second = number of waves made each second \times length of each wave.

$$\text{frequency} = 1/\text{time Period} \quad f = 1/T \quad \text{so} \quad T = 1/f$$

Reason: the frequency tells you how many time periods there are in one second, so multiplying the time period by the frequency will always give the answer 1.

38.1 Use the wave equations to fill in the blanks in the tables:

Time period (s)	Frequency (Hz)	Frequency (Hz)	Speed (m/s)	Wavelength (m)
0.10	(a)	(f)	300	30
0.050	(b)	(g)	300	15
0.0050	(c)	(h)	300	1.50
2.5	(d)	0.40	(i)	420
(e)	25	20	2.0	(j)

38.2 A musical note has a frequency of 440 Hz. The speed of sound in air is 330 m/s.

- (a) What is the wavelength of the sound?
- (b) What is the time period of the sound?

38.3 An ultrasound pulse has a wavelength of 1.0 mm. Its speed in water is 1 400 m/s.

- (a) What is the frequency?
- (b) What is the time period of the sound?

38.4 A lighthouse flashes once every 7.1 s. What is its frequency?

38.5 The mains power has a frequency of 50 Hz. What is its time period?

- 38.6 When a musical note goes up one octave in pitch, its frequency doubles. What happens to its wavelength?
- 38.7 What is the period of a wave whose frequency is 4.0 Hz?

When a wave moves from one material to another, the frequency does not change. If the speed changes, the wavelength will change too.

- 38.8 Green light has a wavelength of 0.000 000 50 m, and a speed of 300 000 000 m/s.
- (a) Calculate its frequency.
- (b) When the green light goes into glass, it slows down. Its new speed is 200 000 000 m/s. What is its frequency and wavelength in glass?
- 38.9 Calculate the frequency of a water wave which has a wavelength of 1.5 m and travels a distance of 10 metres in 5.0 seconds. *[Hint: This question has two stages. You will have to work something out before you can calculate the quantity requested.]*
- 38.10 A water wave, travelling at 2.5 m/s, has a wavelength of 50 cm. What is the period of the wave? *[Hint: This question has two stages. You will have to work something out before you can calculate the quantity requested.]*

Additional Wave Properties and Basic Equations

- 38.11 On a stormy day, a girl counts the number of wave crests breaking on the shore and finds that there are 60 in 4.0 minutes. Calculate the water waves' frequency in hertz (waves per second).
- 38.12 A tuning fork makes the musical note one octave above 'middle C' (in the 'scientific designation'). What is its frequency, if its prongs vibrate 2 560 times in 5.0 s?
- 38.13 What is the wavelength of a 200 Hz sound wave in the air if the speed of sound in air is 340 m/s?
- 38.14 What is the speed of sound through an aluminium rod if a sound

vibration of frequency 13 kHz has a wavelength of 40 cm?

- 38.15** What is the frequency of a wave of red light in the air where its wavelength is 6.8×10^{-7} m?
- 38.16** Calculate the wavelength of Radio 4 which broadcasts on a frequency of 198 kHz.
- 38.17** Certain X-rays have a frequency of 1.0×10^{19} Hz. Calculate their wavelength in the air.
- 38.18** What is the wavelength of a radio station which sends out radio waves of frequency 1.15 MHz?
- 38.19** A certain radio station broadcasts on a frequency of 101.7 MHz. Calculate the wavelength of the radio wave.
- 38.20** Calculate the frequency, in kilohertz, of a radio station which broadcasts on the Medium Wave with a wavelength of 1 500 m.