

Math of waves

The energy transferred by a wave often depends on the **speed** of the wave **and** its **frequency**.

The higher the frequency, the **higher** energy the wave passes along.

The higher the frequency the **shorter** the wavelength

The **wave equation** tells us the relationship between frequency, speed, and wavelength:

$$V = f \times \lambda$$

Frequency = cycles per **second!** = Hertz (Hz)

v = speed (for light, it's always 3×10^8 m/s)

Ex. 40 cycles in 2 min

f = frequency (Hz or 1/s)

$$= 40 / 120$$

λ = wavelength (m)

$$= 0.33 \text{ Hz}$$

Ex 1. Red light has a wavelength of 700 nm. If its frequency is 4.2827×10^{14} Hz, what is the calculated SPEED OF LIGHT? *[always need convert to wavelength into metres]*

$$v = f \times \lambda$$

$$v = (4.2827 \times 10^{14} \text{ Hz})(700 \times 10^{-9} \text{ m})$$

$$v = 2.99789 \times 10^8 \text{ m/s} \quad \Rightarrow 3.0 \times 10^8 \text{ m/s}$$

Ex 2. Using the speed of light (3.0×10^8 m/s) determine the frequency of some X-rays have a wavelength of 5.25 nm.

$$v = f \times \lambda$$

$$f = v / \lambda$$

$$f = (3.0 \times 10^8 \text{ m/s}) / (5.25 \times 10^{-9} \text{ m})$$

$$f = 5.71 \times 10^{16} \text{ Hz}$$

$$v = f \times \lambda$$

$$f = v / \lambda$$

$$\lambda = v / f$$

$$f = \text{cycles} / \text{second}$$

Homework: Using the Wave Equation / frequency calculation

All final answers should be rounded to 2 decimal places

1. A pendulum goes through 100 cycles in 2.5 minutes. Determine its frequency.
2. While sitting on a dock, a boat passes by you and produces a wave. You estimate the distance from the first crest to the fifth crest is 12 m.
 - a) Use a diagram to determine the number of cycles and the wavelength of the wave.
 - b) You measure that it takes 3.4 s for 6 waves to pass your dock. Determine the frequency of the wave.
 - c) Using your answers from part a) and b) determine the speed of the wave.
3. What is the speed of a wave with a wavelength of 1.75 m and a frequency of 800Hz?
4. A light wave passes through a transparent wall. It has a wavelength of 0.3m and travels at 2000m/s. What is its frequency?
5. Red light has a wavelength of 680 nm. What is its frequency?
6. Radiation from a distant galaxy has a frequency of 3.2×10^{22} Hz. What is the wavelength of the light? What type of ray is it?
7. A light ray from a laser has a frequency of 6.7×10^{14} Hz. What is the wavelength of the light? What colour is the light?

MORE PRACTICE

$$\text{speed of light} = 3 \times 10^8 \text{ m/s}$$

$$v = f\lambda$$

$$f = \frac{\text{\#cycles}}{\text{seconds}}$$

8. The Team Pursuit record in speed skating is 8 laps in 3 min 35 sec. What is this team's frequency?
9. If the speed of great surfing waves is 52 m/s and the frequency is 34 Hz, what is the wavelength?
10. Orange light has a wavelength of 603 nm. What is the frequency?
11. A wave travels with a wavelength of 2.3×10^8 nm and a frequency of 1200 Hz. What speed is the wave traveling at?
12. What is the speed of a wave with a wavelength of 1.5m and a frequency of 4000 Hz?
13. What is the wavelength of a radio wave with a frequency of 10^6 Hz?
14. A light wave passes through a transparent wall. It has a wavelength of 0.1m and travels at 2000m/s. What is its frequency?
15. Owen runs around a 400 m track 6 times in 14 minutes and 12 seconds. What is his frequency?
16. A light ray from a laser has a frequency of 4.3×10^{12} Hz. What is the wavelength of the light?

