

GCSE / IGCSE Physics – Waves

GCSE / IGCSE Physics (Edexcel/AQA/Cambridge style) · Total marks: 35 · Answers on the last page

Practice questions on wave properties, sound, the electromagnetic spectrum, and reflection and refraction. A calculator may be used; take the speed of sound in air as 340 m s^{-1} and the speed of light in a vacuum as $3 \times 10^8 \text{ m s}^{-1}$ unless stated otherwise.

Section A – Wave Properties

- (a) Define what is meant by the wavelength and the frequency of a wave.
 - (b) State the wave equation linking wave speed v , frequency f and wavelength λ . [3]
2. A sound wave in air has a frequency of 2.5 kHz. The speed of sound in air is 340 m s^{-1} . Calculate the wavelength of the sound wave. [2]
3. A water wave in a ripple tank has a frequency of 4.0 Hz and a wavelength of 0.60 m. Calculate the speed of the wave. [2]
4. Describe the difference between a transverse wave and a longitudinal wave, giving one example of each. [3]

Section B – Sound and the Electromagnetic Spectrum

5. Explain how a sound wave travels through air, and state why sound cannot travel through a vacuum. [3]
6. List the seven regions of the electromagnetic spectrum in order of increasing frequency, and state one practical use each for microwaves and for gamma rays. [4]
7. A microwave has a frequency of 3.0 GHz. Calculate its wavelength in air, using $c = 3 \times 10^8 \text{ m s}^{-1}$. [2]
8. Explain the difference between ionising and non-ionising electromagnetic radiation, giving one example of each, and state one health risk associated with over-exposure to X-rays. [3]

Section C – Reflection and Refraction (Exam-style)

9. State the law of reflection, and describe how the normal is used when drawing a ray diagram for reflection at a plane mirror. [2]
10. A ray of light travels from air into glass, striking the boundary at an angle of incidence of 40° . The speed of light is $3.0 \times 10^8 \text{ m s}^{-1}$ in air and $2.0 \times 10^8 \text{ m s}^{-1}$ in the glass.
 - (a) Calculate the refractive index of the glass relative to air.
 - (b) Calculate the angle of refraction. [4]
11. A glass block has a refractive index of 1.5.
 - (a) Calculate the critical angle for the glass-air boundary.
 - (b) Explain what is meant by total internal reflection, and describe one practical application. [4]
12. A ray of light passes from air into a transparent block. The angle of incidence is 45° and the angle of refraction is 28° .

- (a) Calculate the refractive index of the block.
- (b) State, with a reason, whether this material bends light more or less than the glass in the previous question. [3]

Answers

Check your working against these. If an answer does not match, try the question again before looking for the method.

- (a) Wavelength: the distance from one point on a wave to the identical point on the next wave (e.g. crest to crest). Frequency: the number of complete waves passing a point per second.
(b) $v = f\lambda$.
- $\lambda = \frac{v}{f} = \frac{340}{2500} = 0.136 \text{ m}$.
- $v = f\lambda = 4.0 \times 0.60 = 2.4 \text{ m s}^{-1}$.
- In a transverse wave, the oscillations (vibrations) of the medium are perpendicular to the direction of energy transfer (e.g. light waves, water waves). In a longitudinal wave, the oscillations are parallel to the direction of energy transfer, producing compressions and rarefactions (e.g. sound waves).
- A vibrating source causes air particles to be pushed together (compressions) and pulled apart (rarefactions); these regions of higher and lower pressure travel outward, transferring energy without a net movement of particles. Sound cannot travel through a vacuum because there are no particles present to compress and vibrate.
- Radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, gamma rays. Microwaves: satellite communication or cooking food. Gamma rays: sterilising medical equipment or treating cancer (radiotherapy).
- $\lambda = \frac{c}{f} = \frac{3 \times 10^8}{3.0 \times 10^9} = 0.10 \text{ m}$.
- Ionising radiation (e.g. X-rays, gamma rays, and high-frequency UV) has enough energy to remove electrons from atoms and can damage or mutate DNA in living cells. Non-ionising radiation (e.g. radio waves, microwaves, infrared) does not have enough energy to ionise atoms. Over-exposure to X-rays can cause cell mutation, increasing the risk of cancer.
- The law of reflection states that the angle of incidence equals the angle of reflection. The normal is a line drawn at right angles (90^{circ}) to the reflecting surface at the point where the ray strikes it; the angle of incidence and angle of reflection are both measured from this normal.
- (a) $n = \frac{v_{\text{air}}}{v_{\text{glass}}} = \frac{3.0 \times 10^8}{2.0 \times 10^8} = 1.5$.
(b) Using $n = \frac{\sin(\text{incidence})}{\sin(\text{refraction})}$: $\sin(\text{refraction}) = \frac{\sin 40^\circ}{1.5} = 0.4285$, so the angle of refraction is 25.4° .
- (a) $\sin \theta_c = \frac{1}{n} = \frac{1}{1.5}$, so $\theta_c = 41.8^\circ$.
(b) Total internal reflection occurs when light travelling in a denser medium hits a boundary with a less dense medium at an angle greater than the critical angle, so all the light is reflected back into the denser medium with no refraction. Application: optical fibres, used in telecommunications and medical endoscopes, rely on total internal reflection to carry light along the fibre with minimal loss.
- (a) $n = \frac{\sin 45^\circ}{\sin 28^\circ} = \frac{0.7071}{0.4695} = 1.51$.
(b) This is very close to (marginally greater than) the refractive index of the glass in the previous question ($n = 1.5$), so the material bends light by almost exactly the same amount, very slightly more.

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