Exercise walk-through

3.2 Sound reflection refraction and lenses

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1. Waves: carrying energy and information

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Waves move energy from a source to a receiver without moving matter — light to an eye, sound to an ear, radio to a phone

This topic builds the wave model (frequency, wavelength, speed), then applies it across the electromagnetic spectrum, to sound and (P) ultrasound, reflection, refraction with total internal reflection, and (P) lenses and the eye

2. General properties of waves

General properties of waves

Transverse : oscillations perpendicular to travel — electromagnetic and water waves

Longitudinal : oscillations parallel, as compressions and rarefactions — sound; mechanical waves may be either

6. Lenses and the eye (P)

Lenses and the eye (P)

A convex (converging) lens brings parallel rays to the principal focus (focal length from the lens); a concave (diverging) lens spreads them as if from the focus

Images are described as larger/smaller, upright/inverted, real/virtual — ray diagrams on graph paper show them, and magnification = image height ÷ object height

Exercises 2.1–2.3

2.1 State the human hearing range. [1]

2.2 What raises pitch and what raises loudness? [2]

2.3 State the law of reflection. [1]

Exercises 2.1–2.3

2.1 State the human hearing range. [1]

2.1 About 20 Hz to 20 000 Hz.

2.2 What raises pitch and what raises loudness? [2]

2.2 Higher frequency raises pitch; larger amplitude raises loudness.

2.3 State the law of reflection. [1]

2.3 Angle of incidence = angle of reflection (measured from the normal).

Exercises 2.4·3.1

2.4 (P) Light enters glass (n = 1.5) at 30°. Calculate the refraction angle. [3]

2.5 (P) Which lens corrects long sight? [1]

3.1 (P) An ultrasound pulse in tissue (v = 1500 m/s) returns from a kidney-stone boundary after 8.0×10^{-5} s. Calculate the depth, explaining the factor of two. [3]

Exercises 2.4·3.1

2.4 (P) Light enters glass (n = 1.5) at 30°. Calculate the refraction angle. [3]

2.4 (P) $\sin r = \sin 30°/1.5 = 0.5/1.5 = 0.333$; $r = 19.5°$.

2.5 (P) Which lens corrects long sight? [1]

2.5 (P) A convex (converging) lens.

3.1 (P) An ultrasound pulse in tissue (v = 1500 m/s) returns from a kidney-stone boundary after 8.0×10^{-5} s. Calculate the depth, explaining the factor of two. [3]

3.1 (P) Total distance $= 1500 \times 8.0 \times 10^{-5} = 0.12$ m; the pulse travels there and back, so depth = 0.06 m = 6 cm.

Exercises 3.2–3.4

3.2 (P) Describe, with the ray that shows it, how an optical fibre carries light around a bend. [3]

3.3 (P) An object 2 cm tall forms an image 5 cm tall through a converging lens. Calculate the magnification and state two properties of a real image formed beyond the focus. [3]

3.4 (P) A periscope uses two plane mirrors. Describe the path of a ray through it, stating the image properties at each mirror. [3]

Exercises 3.2–3.4

3.2 (P) Describe, with the ray that shows it, how an optical fibre carries light around a bend. [3]

3.2 (P) The fibre's glass core is denser than its surroundings; light strikes the fibre wall above the critical angle and is totally internally reflected at each bounce; repeated reflections carry the light along the whole fibre, even around gentle bends.

3.3 (P) An object 2 cm tall forms an image 5 cm tall through a converging lens. Calculate the magnification and state two properties of a real image formed beyond the focus. [3]

3.3 (P) Magnification $= 5/2 = 2.5$; the real image beyond the focus is inverted and can be formed on a screen.

3.4 (P) A periscope uses two plane mirrors. Describe the path of a ray through it, stating the image properties at each mirror. [3]

3.4 (P) The ray hits the first mirror at 45°, reflecting up (i = r at each mirror); it then reflects off the second mirror at 45° to travel horizontally again; each mirror forms a virtual image – the pair returns an upright, laterally correct view along the shifted path.