

Exercise walk-through

3.2

Sound reflection refraction and lenses

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The method

Method — (P) Ultrasound and reflection

Echo time locates a boundary: $s = vt$, halved for the round trip.
Plane mirror: $i = r$; image virtual, upright, laterally inverted.

Method — (P) Refraction and lenses

$$n = \frac{\sin i}{\sin r} \quad \sin c = \frac{1}{n} \quad \text{magnification} = \frac{\text{image height}}{\text{object height}}$$

Denser medium $\rightarrow$ bend towards the normal; beyond the critical angle $\rightarrow$ total internal reflection – optical fibres.

Long sight: convex lens; short sight: concave lens.

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 ($v = 1500 \text{ m/s}$) returns from a kidney-stone boundary after $8.0 \times 10^{-5} \text{ s}$. 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) $\sin r = \sin 30^\circ / 1.5 = 0.5 / 1.5 = 0.333$; $r = 19.5^\circ$.

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.