

3.2 Light refraction and sound

Name: _____ Class: _____ Date: _____

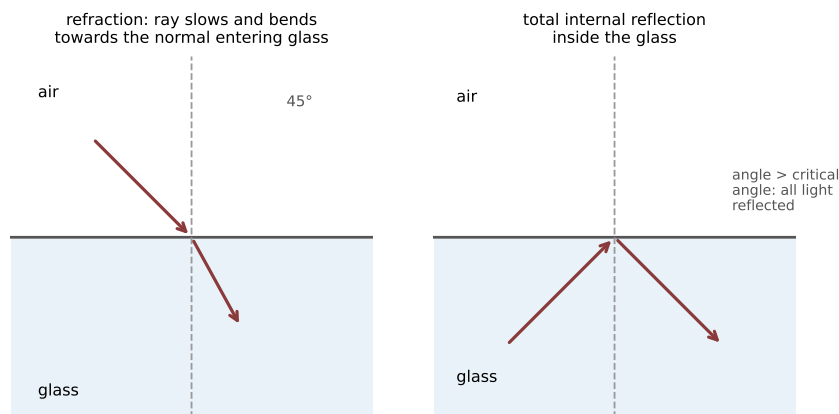
Total: **23** marks

Objective

Cover light and (P) sound (3.14–3.29P): reflection, refraction and ray diagrams, refractive index, critical angle and total internal reflection in fibres and prisms; sound as a longitudinal wave, hearing range, oscilloscope traces, pitch and loudness. Original IGCSE-level practice.

1 Key knowledge and worked examples

■ n, c and TIR



$$n = \frac{\sin i}{\sin r} \quad \sin c = \frac{1}{n}$$

Worked check. Light hits a glass block ($n = 1.5$) at 45° : $\sin r = \sin 45^\circ / 1.5 = 0.707 / 1.5 = 0.471$, $r \approx 28^\circ$ – bent towards the normal. Critical angle $\sin c = 1 / 1.5$, $c \approx 41.8^\circ$.

■ (P) Sound on the screen

Loudness $\uparrow \rightarrow$ amplitude $\uparrow$; pitch $\uparrow \rightarrow$ frequency $\uparrow$. Oscilloscope: louder = taller trace; higher pitch = more cycles across the screen.

2 Practice

2.1 State the law of reflection. [1]

2.2 Which way does light bend entering glass from air, and why? [2]

2.3 Calculate the refractive index if $\sin i = 0.866$ and $\sin r = 0.5$. [2]

2.4 State the two conditions needed for total internal reflection. [2]

2.5 (P) State what raises the pitch of a sound and what raises its loudness. [2]

3 Exam-style questions

3.1 Light travels from air into water ($n = 1.33$) at an incident angle of 40° . Calculate the angle of refraction. [3]

3.2 Explain how an optical fibre uses total internal reflection to carry information, and why the light must strike the fibre wall above the critical angle. [3]

3.3 (P) Describe how to measure the speed of sound in air using an echo method, stating the measurements taken and the calculation. [4]

3.4 (P) An oscilloscope shows a sound trace with 4 complete waves across the screen; the time base is 5 ms per division and the screen is 10 divisions wide. Calculate the frequency, and describe the trace if the sound becomes louder at the same pitch. [4]

Solutions

2.1 The angle of incidence equals the angle of reflection.

2.2 Towards the normal; light slows in the denser medium, and the change of speed changes its direction.

2.3 $n = 0.866/0.5 = 1.73$.

2.4 Light must travel in the denser medium towards the boundary at an angle greater than the critical angle.

2.5 (P) Higher frequency raises pitch; larger amplitude raises loudness.

3.1 $\sin r = \sin 40^\circ / 1.33 = 0.643 / 1.33 = 0.483$; $r = 28.9^\circ \approx 29^\circ$.

3.2 The fibre is thin glass (dense) surrounded by air/cladding (less dense); a ray entering along the axis strikes the wall above the critical angle, so it reflects repeatedly along the fibre without escaping; pulses of light carry the information from end to end.

3.3 (P) Stand a measured distance d from a large wall; clap and time the echo's return t with a stopwatch over several claps for accuracy; speed $v = 2d/t$ – total distance there and back divided by the time; repeat and average to reduce error.

3.4 (P) Screen time = $10 \times 5 \text{ ms} = 50 \text{ ms}$ for 4 waves; period = $50/4 = 12.5 \text{ ms}$; $f = 1/0.0125 = 80 \text{ Hz}$. Louder at the same pitch: the trace peaks grow taller with unchanged waves-per-screen (frequency constant).