3.2 Light refraction and sound

Name: _____ Class: _____ Date: _____ **Total: 30 marks**

Objective

Build the skills to answer exam questions on **light and sound** : reflection and refraction, refractive index, critical angle and total internal reflection, optical fibres, sound waves, echoes, hearing and oscilloscope traces.

You must be able to:

- use the law of reflection and $n = \sin i \div \sin r$
- calculate a critical angle and explain total internal reflection
- calculate distances from echoes and frequencies from oscilloscope traces
- plan an experiment to measure refraction in a glass block

1 Key knowledge and worked examples

Light and sound

idea	equation or rule
reflection	angle of incidence = angle of reflection (both measured from the normal)
refraction	light slows down and bends towards the normal when it enters a denser material
refractive index	$n = \sin i \div \sin r$
critical angle	$\sin c = 1 \div n$; above c, total internal reflection happens inside the denser material
sound	a longitudinal wave; needs a medium; humans hear about 20–20 000 Hz
distance and speed	distance = speed × time

Worked example 1: refractive index. A ray enters a block with $i = 45°$ and $r = 28°$. Find n.

1. Known: $i = 45°$; $r = 28°$.
2. Rule: $n = \sin i \div \sin r$.
3. Numbers: $0.707 \div 0.469$.
4. Result: $n = 1.51$.

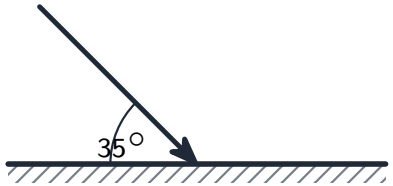
Worked example 2: critical angle. Water has $n = 1.33$. Find its critical angle.

1. Known: $n = 1.33$.
2. Rule: $\sin c = 1 \div n$.
3. Numbers: $\sin c = 0.752$.
4. Result: $c = 49°$.

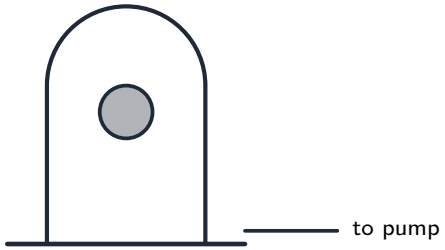
Answer shapes: measure every angle from the normal, not from the surface.

2 Practice

2.1 A ray of light hits a plane mirror at 35° to the mirror surface. Find the angle of reflection. [2]



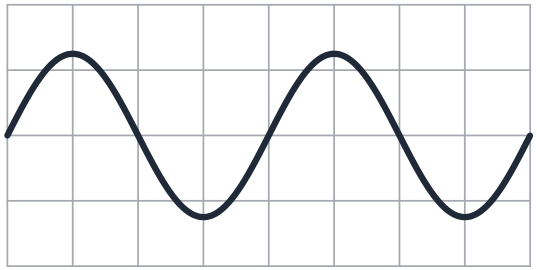
2.2 Explain why sound cannot travel through space, but light can. [2]



2.3 State the range of human hearing, and explain what ultrasound is. [2]



2.4 One complete wave on an oscilloscope covers 4 squares. Each square is 0.5 ms. Calculate the frequency. [2]

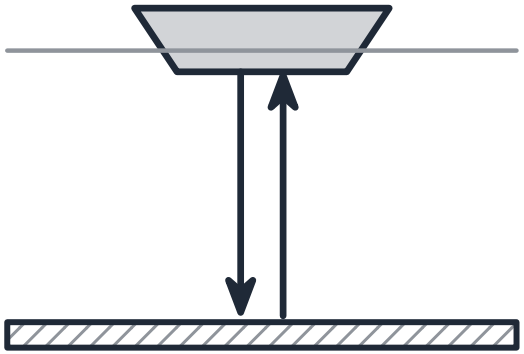


3 Exam-style questions

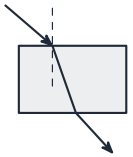
3.1 Explain how light travels along an optical fibre. [3]



3.2 A ship sends a sound pulse to the sea bed and hears the echo 0.50 s later. Sound travels at 1500 m/s in sea water. Calculate the depth of the sea. [3]



3.3 A student shines a ray of light into a glass block at different angles of incidence and measures the angle of refraction. The results are shown.



i / °	20	30	40	50	60
r / °	13	19	25	30	35

(a) Use the results for $i = 40°$ to calculate the refractive index of the glass. [3]

(b) Calculate the critical angle of the glass, and explain what happens to a ray inside the block that hits the surface at 50°. [4]

(c) Use your refractive index to predict the angle of refraction when $i = 60°$, and compare it with the result. [3]

(d) Describe how the student should measure the angles of incidence and refraction. [6]