# 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: $n = \sin i \div \sin r$.



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3. Numbers: $0.707 \div 0.469$.
4. Result: $n = 1.51$.

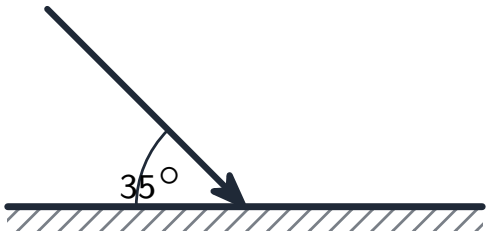
**Worked example 2: critical angle.** Water has $n = 1.33$. Find its critical angle.

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

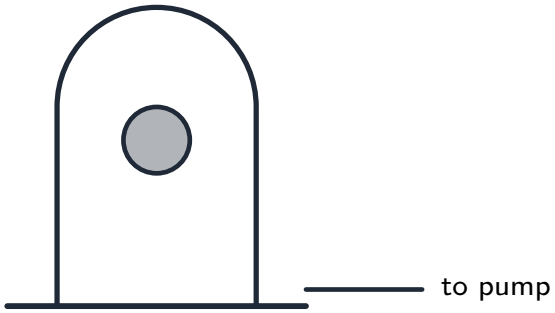
**Answer shapes:** measure every angle from the normal, not from the surface.

## 2 Practice

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



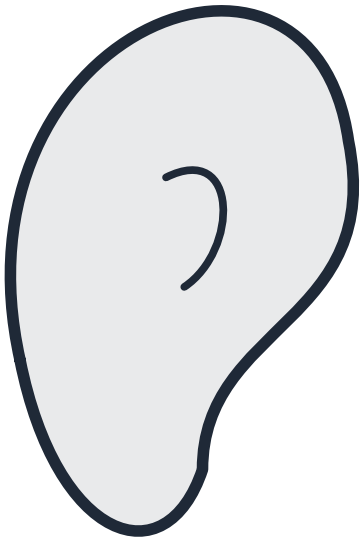

**2.2** Explain why sound cannot travel through space, but light can. [2]



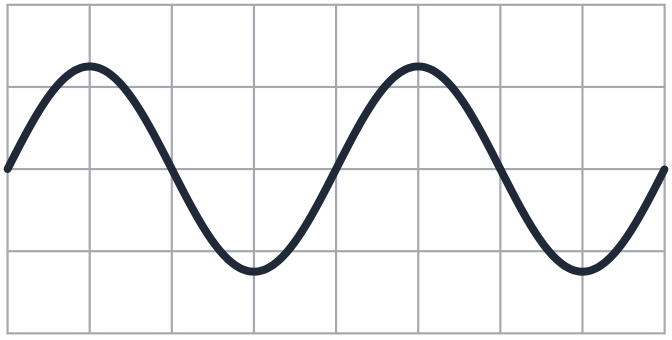



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**2.3** State the range of human hearing, and explain what ultrasound is. [2]



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





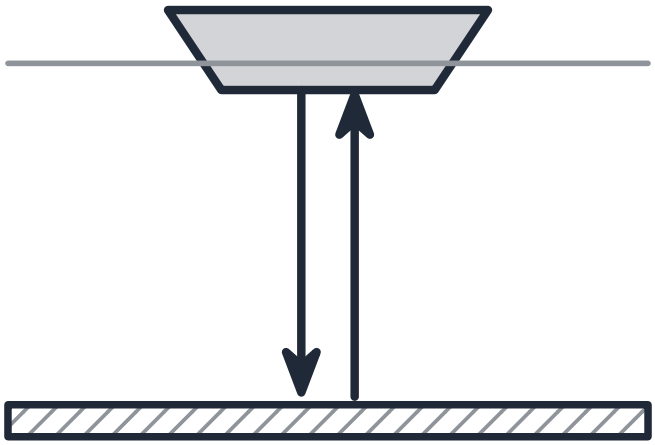
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## 3 Exam-style questions

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



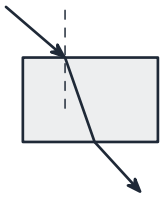
**3.2** A ship sends a sound pulse to the sea bed and hears the echo 0.50 s later. Sound travels at 1500 m/s in sea water. Calculate the depth of the sea. [3]





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**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]



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



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