

6.2 Reflection, sound and detection waves

Name: _____ Class: _____ Date: _____

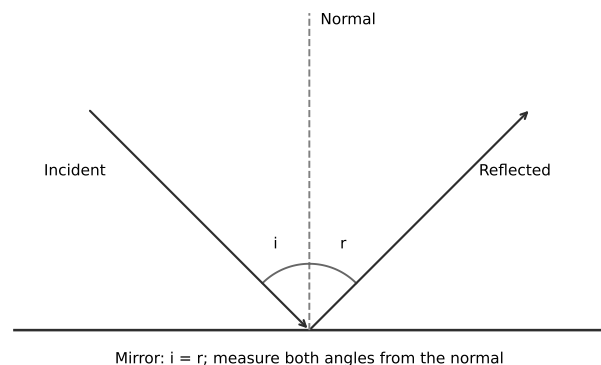
Total: 21 marks

KEY WORDS specular reflection • diffuse reflection

Objective

Construct reflection ray diagrams, describe absorption/transmission, explain the ear and hearing range, and use ultrasound and seismic waves for detection. Physics only (sound and detection HT). Original questions for spec statements 4.6.1.3–4.6.1.5 and RP9.

1 Key knowledge and worked examples



Angle of incidence = angle of reflection, measured from the normal.

At a boundary parts of a wave can be **reflected**, **absorbed** and **transmitted**. Smooth surface → **specular** reflection (one direction); rough → **diffuse** (scattered).

RP9: ray box on a plane mirror – trace incident and reflected rays, measure angles from the normal with a protractor; repeat for different angles; glass block for refraction paths.

Sound (HT): vibrations travel through solids; the ear drum vibrates; ear structures pass on the vibrations and convert them into signals for the brain. The conversion works only over a limited range: **human hearing 20 Hz to 20 kHz**.

Ultrasound (above 20 kHz): partially **reflected at boundaries** between media; echo time gives boundary distance:

$$s = vt \quad (\text{halve for a there-and-back path})$$

Uses: prenatal scans (non-ionising), industrial flaw detection. **Seismic waves:** P-waves longitudinal (pass through liquid), S-waves transverse (do not) – shadow zones reveal Earth's structure. Echo sounding maps seabeds.

Worked example. An ultrasound pulse returns from a flaw in $48 \mu\text{s}$; speed in steel 5200 m/s.

- Convert: $t = 48 \times 10^{-6} \text{ s}$; path there and back.

$$d = \frac{vt}{2} = \frac{5200 \times 48 \times 10^{-6}}{2} = 0.1248 \text{ m} \approx 0.12 \text{ m (2 s.f.)}$$

2 Practice

2.1 Draw the reflected ray for a ray hitting a plane mirror at 35° to the normal. State the reflection angle. [1]

2.2 State the frequency range of human hearing. [1]

2.3 Explain which radiation risk ultrasound avoids compared with X-rays. [2]

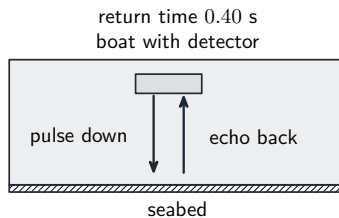
3 Exam-style questions

3.1 A student investigates reflection with a ray box and a plane mirror.

- (a) Describe how they measure the angle of incidence. [2]
- (b) Give one source of error and one improvement. [2]
- (c) The mirror is replaced by rough paper. Describe what happens to the reflected light and name the effect. [2]

3.2 Ultrasound is used to find the depth of a seabed. The pulse returns in 0.40 s; the speed in water is 1500 m/s.

- (a) Explain why the distance is halved before reporting the depth. [1]
- (b) Calculate the depth. [3]
- (c) Explain why a detectable reflected ultrasound pulse can be used to find the seabed depth. [1]



3.3 After an earthquake, a detection station records P-waves but no S-waves from a region.

- (a) State the wave types of P-waves and S-waves. [2]
- (b) Using the Earth model, explain how a liquid layer on the wave path could produce this pattern. [2]
- (c) Explain how the difference in arrival time helps locate the earthquake. [2]

Solutions

2.1 35° – the angle of reflection equals the angle of incidence.

2.2 20 Hz to 20 kHz.

2.3 Ultrasound is non-ionising; X-rays ionise and can mutate genes, so ultrasound avoids that risk – it is why it is used for prenatal scans.

3.1 (a) Draw the normal at 90° to the mirror at the point of incidence; measure the angle between the incident ray and the normal with a protractor. (b) Error: ray line too thick / mirror frame offset; improvement: use a thinner beam, mark ray points with crosses and join after, or repeat and average. (c) The light scatters in many directions; diffuse reflection.

3.2 (a) The pulse travels down and back – the time covers both legs. (b)

$$d = \frac{vt}{2} = \frac{1500 \times 0.40}{2} = \mathbf{300 \text{ m}}$$

(C1, C1, A1) (c) Some ultrasound is reflected at the water-seabed boundary, producing the timed echo.

3.3 (a) P-waves are longitudinal; S-waves are transverse. (b) S-waves cannot travel through liquid; a liquid outer core can prevent S-waves reaching the station while P-waves pass through. One missing signal alone is not proof: use the pattern across stations with the Earth model. (c) P-waves travel faster and arrive first; the time gap grows with distance from the quake, so comparing gaps at several stations triangulates the source.