3.2 Sound reflection refraction and lenses

Name: _____ Class: _____ Date: _____ **Total: 20 marks**

Objective

Cover sound, ultrasound, reflection, refraction and lenses (3.3.3–3.3.6): hearing range, pitch and loudness, (P) ultrasound echo timing s = vt, the law of reflection, (P) refractive index with n = sin i/sin r, critical angle, optical fibres and lens/image basics with the eye. Original OxfordAQA practice.

1 Key knowledge and worked examples

- **(P) Ultrasound and reflection**

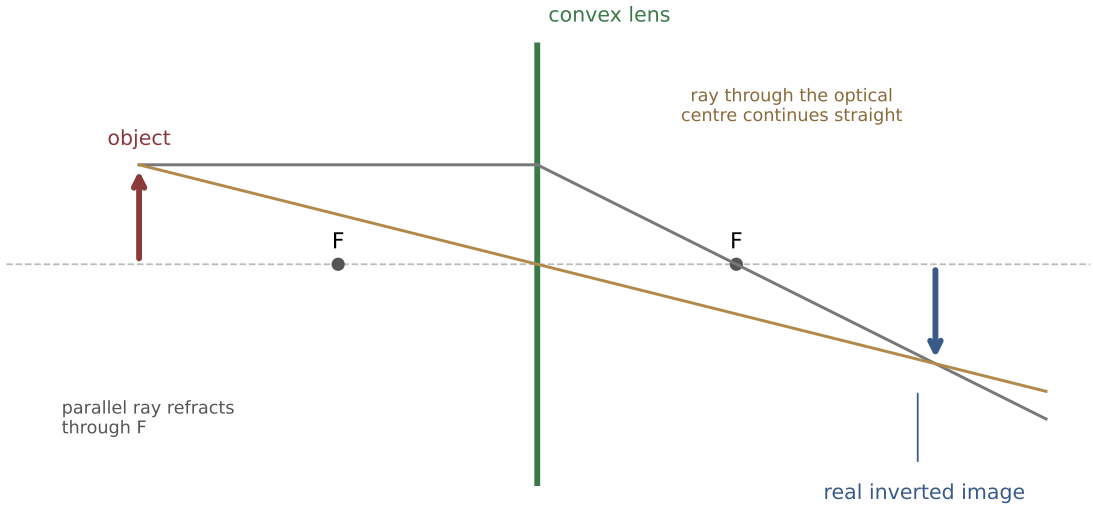
Echo time locates a boundary: $s = vt$, halved for the round trip. Plane mirror: i = r; image virtual, upright, laterally inverted.

- **(P) Refraction and lenses**

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

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

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



2 Practice

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]

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 Exam-style questions

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]

3.2 (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]

Solutions

2.1 About 20 Hz to 20 000 Hz.

2.2 Higher frequency raises pitch; larger amplitude raises loudness.

2.3 Angle of incidence = angle of reflection (measured from the normal).

2.4 (P) $\sin r = \sin 30°/1.5 = 0.5/1.5 = 0.333$; $r = 19.5°$.

2.5 (P) A convex (converging) lens.

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.

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) Magnification = 5/2 = 2.5; the real image beyond the focus is inverted and can be formed on a screen.

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.