Unit 13 · Light

HARDER PRACTICE QUESTIONS

Full marks 45

Write your answers on separate paper. Show your working. Take $c = 3 \times 10^8$ m/s and the refractive index of air as 1.

1 Spot the error [3]

Find the mistake in the working and correct it.

A ray in air strikes the surface of water ($\mu = 1.33$) at 30° to the surface. Nisha wrote: "sin r = sin 30° ÷ 1.33 = 0.5 ÷ 1.33 = 0.376, so the angle of refraction is **22.1**°."

2 Inside a fiber [5]

An optical fiber has a core of refractive index 1.48 and a cladding of 1.46.

i. Find the time light takes to travel 100 km along the core, ignoring the zigzag. How much longer is this than through air?
ii. Find the critical angle at the edge of the core.
iii. Two rays meet the edge of the core at 85° and at 75°. What happens to each?
iv. What if the cladding were removed and the core were left in air? Find the new critical angle, and say whether the fiber would then be better or worse at holding the 75° ray.

3 Check the readings [4]

Pasang traced rays through a glass slab and wrote these readings.

i	20°	40°	60°	80°
r	13.2°	25.4°	30.0°	41.0°

He wrote: "The angle of refraction is always a fixed fraction of the angle of incidence, about two-thirds."

i. Copy the table and add rows for i ÷ r and sin i ÷ sin r.
ii. Is his claim right? Use your table.
iii. One reading is wrong. Which one, and how can you tell?
iv. What should it have been?

4 Show that [4]

A flat layer of water ($\mu = 1.33$) lies on a flat glass plate ($\mu = 1.5$). A ray in air meets the water at i = 50°.

i. Find the angle of refraction in the water.
ii. Find the angle of refraction in the glass.
iii. Find the angle the ray would make in the glass if there were no water, and compare.
iv. Show from $\mu_1 \sin i = \mu_2 \sin r$ why the water makes no difference to the final angle.

5 A wet prism [4]

Write your prediction first, then explain it.

In a periscope, a glass prism ($\mu = 1.5$) with angles of 90°, 45° and 45° turns the light through 90°, meeting its long face at 45° from inside. Rain gets into the periscope and coats the long face with water ($\mu = 1.33$). Predict what the observer sees, then calculate what happens to the light at that face, and explain.

6 Work backwards [3]

A jar holds 16 cm of water ($\mu = 4/3$) with a layer of kerosene ($\mu = 1.44$) floating on top. A coin on the bottom looks 17 cm deep from straight above. Find the thickness of the kerosene, the coin's real depth and how far it seems to be raised.

7 The missing reading [3]

A traveling microscope focused on a mark on a table reads 2.00 cm. Through a glass slab ($\mu = 1.5$) laid on the mark, it reads 3.50 cm. What should it read when focused on chalk powder on top of the slab? How thick is the slab?

8 The floating disc [3]

A coin lies on the bottom of a still pond ($\mu = 1.33$). A flat opaque disc of radius 57 cm floats on the water, centered straight above the coin. From above the water, in no direction can anyone see the coin. Find the greatest depth of water for which this is just true, given a critical angle of 48.8° and $\tan 48.8° = 1.14$. If the pond were deeper, could the coin be seen? Explain.

9 Design a fair test [4]

Ayushma thinks that sugar dissolved in water raises its refractive index. She has a traveling microscope, a beaker with a scratch on its bottom, chalk powder, water and sugar. Plan a fair test.

i. What will she change, and what will she measure?
ii. Name three things to keep the same.
iii. How can she make her results more reliable?
iv. What result would support her idea?

10 Correct the misconceptions [3]

The paragraph has three mistakes. Write each mistake and correct it.

Riya wrote: "Kerosene floats on water, so it is optically rarer. Light bends when it goes along the normal from air into glass, because its speed changes. If you look into a swimming pool at a slant, it looks deeper than from straight above."

11 Which explanation fits the evidence? [3]

Newton thought light was a stream of particles; Huygens thought it was a wave. Two students discuss the evidence.

Lakpa: "Snell's law of sines proves that light is a wave."
Sapana: "Foucault's measurement in 1850 is what settled it."
Who is right, and why? What did each theory say about light in water?

12 Make your own [2]

From ice (1.31), water (1.33), glass (1.5) and diamond (2.42), choose one pair in which light meeting the boundary at 70° is totally reflected, and one pair in which it is not. Show the working for each.

13 Think [4]

A fish is 1 m below the surface of a pond ($\mu = 4/3$), straight below a bird 3 m above the surface. Looking straight along the normal,

i. how far below the surface does the bird see the fish?
ii. how far from itself does the bird see the fish?
iii. By reversibility, the fish sees the bird at 4/3 of its real height. How high does the fish see the bird?
iv. How far from itself does the fish see the bird, and why are the two distances not the same?