Unit 10 · Nature and Propagation of Light

HARDER PRACTICE QUESTIONS

Full marks 28

Write your answers on separate paper. Show your working. Take $c = 3.0 \times 10^8$ m/s.

1 Spot the error [3]

Find the mistake in the working and correct it.

Light of wavelength 600 nm in air enters a plastic of refractive index 1.4. Manish finds its frequency in the plastic:
"$v = c/1.4 = 2.14 \times 10^8$ m/s, and the wavelength is still 600 nm, so $f = v/\lambda = 2.14 \times 10^8/600 \times 10^{-9}$ = **3.6×10^{14} Hz**: lower than in air."

2 Show that [2]

Show that light's wavelength in a medium of refractive index μ is λ_0/μ, where λ_0 is its wavelength in a vacuum.

3 Predict, then explain [3]

Write your prediction first, then explain it.

A ray passes from glass ($\mu = 1.5$) into water ($\mu = 1.33$) at a slant. Predict: does it bend towards the normal or away from it? Explain with Huygens' wavelets, and find the angle of refraction for an angle of incidence of 40°.

4 Read the data [3]

Answer from the data.

A pulse of light is timed through a tube 1.50 m long, filled each time with a different liquid:

Liquid	Water	Ethanol	Glycerol
Time (ns)	6.65	6.80	7.35

i. Find the refractive index of each liquid.
ii. Is light slower or faster than in air in these liquids? Which theory of light does this support?

5 A real setting [3]

An optical fiber has a core of refractive index 1.48 and a cladding of 1.46 round it. Find the critical angle at the boundary between them, and the time light takes to travel 10 km straight along the core.

6 Which explanation fits? [3]

Newton explained refraction into water by saying the water pulls the corpuscles towards it as they arrive, speeding them up across the surface. Huygens explained it by the wavefront slowing down. Each predicts a speed of light in a liquid of refractive index 1.44. Find both predictions. In 1850 light was measured to travel more slowly in water than in air. Which explanation fits?

7 Estimate it [3]

Sunlight reaches us as a spherical wavefront of radius 1.5×10^{11} m. Across a lens 10 cm wide, a piece of a sphere of radius R departs from a flat plane by about $d^2/(8R)$, where d is the width. Estimate this, and compare it with a wavelength of light (500 nm). Is it right to treat sunlight as plane waves?

8 Correct the misconceptions [3]

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

> Sushma wrote: "When light enters glass, its frequency falls, which is why its wavelength gets shorter. Wavefronts and rays are parallel to each other. And a wavefront joins all the points that are the same distance from the source, whatever the medium."

9 Think [3]

A plane wavefront in glass ($\mu = 1.5$) meets the glass–air surface at an angle of incidence of 50°. Using Huygens' construction, explain why there is no refracted wavefront in the air.

10 Make your own [2]

Choose a refractive index and an angle of incidence from air so that the angle of refraction is exactly 30°.