Year 13 Science: Physics applied to a context: fibre-optic broadband

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

Practice

1. Find the critical angle for light going from glass (n = 1.50) into water (n = 1.33).

2. Find the speed of light in glass with n = 1.50.

3. Find the energy of a photon of wavelength 1310 nm. Use h = 6.63×10^{-34} J s.

4. Explain why a fibre's cladding must have a lower refractive index than its core.

5. How long does light take to travel 25.0 km along a fibre core with n = 1.468?

Fix the mistake

6. Correct this statement: "Total internal reflection happens when light goes from the cladding into the core."

7. Correct this statement: "The critical angle is measured from the surface of the boundary."

8. Correct this statement: "Light travels through the fibre at 3.00×10^{8} m s^{-1}."

9. Correct this statement: "My report lists refraction, photons and dispersion, so it is comprehensive."

Answer key (for parents and tutors)

1. Find the critical angle for light going from glass (n = 1.50) into water (n = 1.33).
   $\sin\theta c = 1.33 \div 1.50 = 0.8867$, so $\theta c = 62.5°$.

2. Find the speed of light in glass with n = 1.50.
   $v = c \div n = 3.00 \times 10^{8} \div 1.50 = 2.00 \times 10^{8}$ m s^{-1}.

3. Find the energy of a photon of wavelength 1310 nm. Use h = 6.63 × 10^{-34} J s.
   $E = hc/\lambda = (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) \div (1310 \times 10^{-9}) = 1.52 \times 10^{-19}$ J.

4. Explain why a fibre's cladding must have a lower refractive index than its core.
   Total internal reflection only happens when light meets a boundary into a lower refractive index at more than the critical angle, so a lower-index cladding keeps the light in the core.

5. How long does light take to travel 25.0 km along a fibre core with n = 1.468?
   $v = 3.00 \times 10^{8} \div 1.468 = 2.044 \times 10^{8}$ m s^{-1}, $t = 25.0 \times 10^{3} \div 2.044 \times 10^{8} = 1.22 \times 10^{-4}$ s, which is 122 µs.

6. Correct this statement: "Total internal reflection happens when light goes from the cladding into the core."
   It only happens going from higher index to lower, so from the core into the cladding.

7. Correct this statement: "The critical angle is measured from the surface of the boundary."
   Angles in Snell's law are measured from the normal, so $\theta c = 84.8°$ means the ray almost grazes the boundary.

8. Correct this statement: "Light travels through the fibre at 3.00 × 10^{8} m s^{-1}."
   That is its speed in a vacuum; in the core it is $c \div n = 2.04 \times 10^{8}$ m s^{-1}.

9. Correct this statement: "My report lists refraction, photons and dispersion, so it is comprehensive."
   Excellence needs the ideas linked: say how each one depends on or affects the others in the device.