

## Tap 318-4: Questions involving total internal reflection

1. Explain why substances with a high refractive index like diamond, sparkle.
2. A pulse of white light is sent straight down a fibre optic cable 1 km long. The refractive index for blue light is 1.639 and for red light 1.621. What time interval will there be between the two components when they reach the far end?
3. Calculate the critical angle of an optical fibre:
  - a) without cladding if the glass has a refractive index of 1.56.
  - b) when cladding is added of  $n = 1.49$
  - c) what advantage is this?

The refractive index for light of wavelength 400 nm passing through a type of glass is 1.470; when light of wavelength 750 nm passes through the glass the measured refractive index is 1.455.

4. To what colours do these wavelengths correspond?
5. Which of these kinds of light travels faster in the glass?
6. What is the ratio of the speeds of the two colours in air?

### Practical advice

Choose the type of questions suitable for your specification.

### Answers and worked solutions

1. As any angle larger than critical is totally internally reflected, the smaller the critical angle the easier it is to get internal reflections which cause the sparkle. As  $c$  is inversely proportional to  $n$ , high  $n$ , low  $c$ .
2.  $n_b = c/c_b$ ,  $n_r = c/c_r$   
So the speed of the blue light,  $c_b = c/1.639 = 1.830 \times 10^8 \text{ m s}^{-1}$   
and the speed of the red,  $c_r = c/1.621 = 1.851 \times 10^8 \text{ m s}^{-1}$   
speed = distance / time so time = distance / speed  
So the time taken by the blue light =  $1.0 \times 10^3 / 1.830 \times 10^8 = 5.46 \mu\text{s}$  and the time taken by the red =  $1.0 \times 10^3 / 1.851 \times 10^8 = 5.40 \mu\text{s}$

so the time lag is  $0.06 \mu\text{s}$ .

3. a)  $\sin C = 1/n_{\text{glass}} = 1/1.56 = 0.641$  so  $C = 39.9^\circ$

b)  $n_{\text{core}} \sin \theta_{\text{core}} = n_{\text{cladding}} \sin \theta_{\text{cladding}}$   $\theta_{\text{core}} = C$  when  $\sin \theta_{\text{cladding}} = 1.0$   
so  $\sin C = 1.49/1.56$  and  $C = 72.8^\circ$ .

c) paths which would reflect many times at a fairly small angle are eliminated. This reduces time lag. Most rays travel close to the centre of the cable.

4. Violet; red

5. 750 nm

6. 1.01 ratio of speeds is equal to the inverse of the ratio of the refractive indices.

### External references

Questions 1-3 are taken from Resourceful Physics

Questions 4-6 are taken from Advancing Physics chapter 4, 60S