Pages 90–94 Exam practice questions

1 Answer C

2 Answer B

3 Answer D

4 Answer A

5 Answer B

6 Answer B

7 Answer B

8 Answer A

9 Answer C

10 Answer C

11 a) 1/50 = 0.02 s or 20 ms

b) $2\pi/3$

c) 2/3 × 20 ms = 13 ms

12 a) wavelength = speed/frequency = $3.3 \times 10^7/82 = 4.0 \times 10^5$ m

b) $1500 \times 100 \times 10^{-3}/2$ = 75 m because the wave travels to the submarine and back to the dolphin

c) Radio waves travel much faster than sound waves underwater. The ultrasound frequency is much higher than the radio wave frequency. Other details could include: radio waves can be polarised; sound waves cannot; radio waves and sound waves travel different distances depending on how well they are absorbed in water (although a calculation is not possible, the answer may discuss how far a person can see and hear underwater).

13 a) Total internal reflection.

b) At viewing angles below the critical angle, there is no internal reflection and the block looks transparent. At viewing angles above the critical angle light reflects off the internal surface and is seen by the viewer.

14 $\sin 30^\circ = 1.5 \sin\theta_{glass}$ so angle of refraction, $\theta_{glass} = 19.5^\circ$

On the opposite face, the angle of incidence is 19.5°

$1.5 \sin \theta_{glass} = \sin \theta_{air}$ so $\theta_{air} = 30^\circ$

15 a) Total internal reflection.

b) $\sin c = 1/n$. The refractive index of the core is 1.60 and the refractive index of the cladding is 1.50.

The combined refractive index = ${}_{core}n_{air} \times {}_{air}n_{cladding}$

$\sin c = (1/1.6) \times 1.5 = 0.93$

so $c = 70^\circ$

c) i) Pulse broadening is the spreading out/longer duration of pulses travelling through an

optical fibre.

ii) A multimode optical fibre is wider than a single mode optical fibre so there are more paths for rays to take and there is modal dispersion as well as material dispersion.

iii) Pulse broadening limits the maximum frequency of pulses and therefore the bandwidth available.

d) The material for the core must be very pure to reduce scattering; it must not absorb the frequencies of light used in the fibre; it must have a higher refractive index than the core so that internal reflection occurs.

16 a) The number of decimal places in the raw data depends on the measuring instrument (protractor).

b) The calculated data has more significant figures than the raw data which implies better accuracy than the instrument can provide.

c) The graph should be a straight line going through the origin, with sin *i* on the *x*-axis and sin *r* on the *y*-axis

d) The refractive index should work out as 1.47 or 1.5.

e) The maximum uncertainty is half the range of repeated readings, i.e. 1.5 (half of 3 which is the range for the readings for 25 degrees) .

f) e.g. use black-out blinds as the ray may not be bright enough to see clearly; hard to draw lines accurately/the ray spreads out so use pencil dots and a ruler to indicate the path of the ray; protractors may be poor quality, so draw the lines first before measuring and use a transparent protractor with sharp markings.

g) The angle ranges from 20.5–19.5. The values of sin range between 0.35–0.33, so the range of sin is 0.02. The uncertainty is half the range, or 0.01.

The % uncertainty is (uncertainty / average value) × 100% = (0.01 /0.34) × 100% = 3.0%

17 a) 1.8×10^{-3} s

b) Microwave radiation can pass through the atmosphere; it can carry information; it can be sent as a narrow beam as it has a short wavelength and there is little diffraction.

c) Our atmosphere absorbs gamma rays so they will not reach an earth-based satellite; the rays travel very long distances across the Universe without losing energy so the telescope does not have to be close to the source of gamma rays.

d) Long wavelengths can pass through the atmosphere; the telescope is too heavy to launch into space.

Page 94 Stretch and challenge questions

18 a) $\theta_c = \sin^{-1} n_{cl}/n_{co}$

b) $\theta_c = \sin^{-1} 1.470/1.635$ for light of wavelength 400 nm = 64.0°

$\theta_c = \sin^{-1}1.456/1.602$ for red light = 65.34°

Difference in critical angle is 1.34°

c) All light remains inside the fibre when it is incident on the outer face at an angle less than the smallest critical angle.

d) For 400 nm light, $\sin i_c = n_{cl}/n_{co} = 1.470/1.635 = 0.899$

From the diagram, $\sin i_c = R/(R + 0.1) = 0.899$

Rearranging, $(1 - 0.899)R = 0.899 \times 0.1$

$R = 0.89$ mm

e) The cladding material increases the critical angle which reduces the smallest value of coil radius for the optic fibre for TIR to occur. (Alternative answer: cladding material can be chosen to increase protection for the optic fibre inside the body.)

19 a) Rearranging: $c^2\mu/l = k$

Substituting dimensions for μ, l and c gives dimensions for

$k = L^2T^{-2}ML^{-1}L^{-1} = MT^{-2}$

b) $\mu = 0.6$ kg/3 m = 0.2 kg m^{-1} and $k = 9$ N/3m = 3 Nm^{-1}

so substituting into $c = \sqrt{(kl/\mu)}$ gives $\sqrt{(3\times 3/0.2)} = 6.7$ ms^{-1}

c) time = speed / distance = $\sqrt{(kl/\mu)} / l$

Assuming the extension, $x = l$ and that μ is proportional to $1/l$ means that speed is proportional to l.

Time is therefore independent of l so doubling its length does not affect the time taken for the wave to travel in the spring.