Topic 3 Waves and the Particle Nature of Light
3C More wave properties of light

3C.1 Refraction

1 (a) speed reduces

(b) wavelength reduces

(c) frequency is constant

2 The refraction of the light from the body of the giraffe causes it to appear in a false position, whilst the light from the head is unaffected.

3 16.4°

3C.2 Total internal reflection

1 The angle of incidence within a more dense medium, beyond which a ray will be totally internally reflected

2 In all cases, the angle of incidence as the light tries to leave the glass is greater than the critical angle (which is usually about 42° for glass).

3 48.8°

4 From any part of the sky, the angle the rays make underwater with the normal to the water surface must always be less than the critical angle. This limits the range of angles that the fish needs to observe and yet still be able to see everything above the water, as shown in fig F.

3C.3 Polarisation

1 Sound waves are longitudinal, and longitudinal waves cannot be polarised.

2 There are numerous waves with oscillations oriented in all planes, favouring no particular plane.

3 Light reflected from the surface of the snow is likely to be polarised in the horizontal plane, so the vertical Polaroids will absorb this glare.

4 Students' own answers:

e.g. The models show the real outcomes of the design, in order to confirm any theoretical calculations that have been done to check the design.

For large projects, it is important to be able to check the strength of the design using a cheap model before investing in building the real thing.

3C Exam practice

1 D

2 C

3 C

4 B

5 (a) Ray drawn along edge of prism (labelled X)

(b) (i) $n = \frac{3 \times 10^8}{1.96 \times 10^8}$

$n = 1.53$

(ii) sin (critical angle) $= \frac{1}{n}$ OR $\frac{\sin i}{\sin r} = \frac{v_1}{v_2} = n$

$c = 41^o$

(c) Red light: refraction towards normal at first face but less than refraction for blue light

Refracts into air at second face with angle in air > angle in glass

6 (a) Unpolarised light oscillates/vibrates in many planes/directions while polarised oscillates/vibrates in one plane/direction only

(b) Sunglasses cut out the reflected light / polarised light / glare

but not the light from the fish OR light from fish is unpolarised

(c) Sound is a longitudinal wave and only transverse waves can be polarised.

7 (a) $n = \frac{\sin 48}{\sin 30}$

$n = 1.5$ (common answer will be 1.49)

($n = 0.67$ scores 1 mark for idea of ratio of sin of angles)

(b) (i) QWC (quality of written communication) – spelling of technical terms must be correct and the answer must be organised in a logical sequence, including:

As x increases, y increases

OR at a certain angle / critical angle, $y = 90^\circ$ / the light travels along the boundary

For angles greater than the critical angle (in glass) total internal reflection occurs

(ii) $\sin c = \frac{1}{n}$

$c = 42^\circ$

8 (a) $\frac{\sin c}{1} = \frac{1.96}{2.03}$

$c = 75^\circ$

(b) It will be reflected (back into the core) / totally internally reflected

(c) Most of the light will undergo repeated (total internal) reflection and light hits the bottom at less than the critical angle.

9 (a) Refraction

(b) (i) Normal correctly added to diagram

i and r correctly labelled

(ii) Greater refraction than the red light as light enters the raindrop (must be between red light ray and centre)

Reflection followed by refraction away from normal as ray emerges from the raindrop

(c) (i) The angle of incidence (in the denser medium) for which angle of refraction is 90º OR angle of incidence for which a ray is transmitted along the boundary

(ii) $\frac{1}{\sin c} = 1.3$

$\sin c = \frac{1}{1.3}$

$c = 50.3^\circ$

(d) $\lambda = \frac{2.2 \times 10^8 \text{ m s}^{-1}}{4.2 \times 10^{14} \text{ Hz}}$

$\lambda = 5.2 \times 10^{-7}$ m

10 Award 1 mark for the (QWC) quality of written communication.

Award a maximum of 5 marks from the following expected answer points:

Fibre made of glass

Light is totally internally reflected

when it strikes the edge of the fibre at more than the critical angle

Used for decorative lighting

Used to guide light to the interior of buildings for illumination

Used to communicate information as pulses of light

e.g. broadband internet

Endoscope for medical diagnosis

Has fibre carrying light into body for illumination

and fibre carrying reflection back out to form image

Some fibres are made with core and cladding of similar refractive indices

in order to increase critical angle

and reduce fibre damage / light leakage

and reduce multimode dispersion