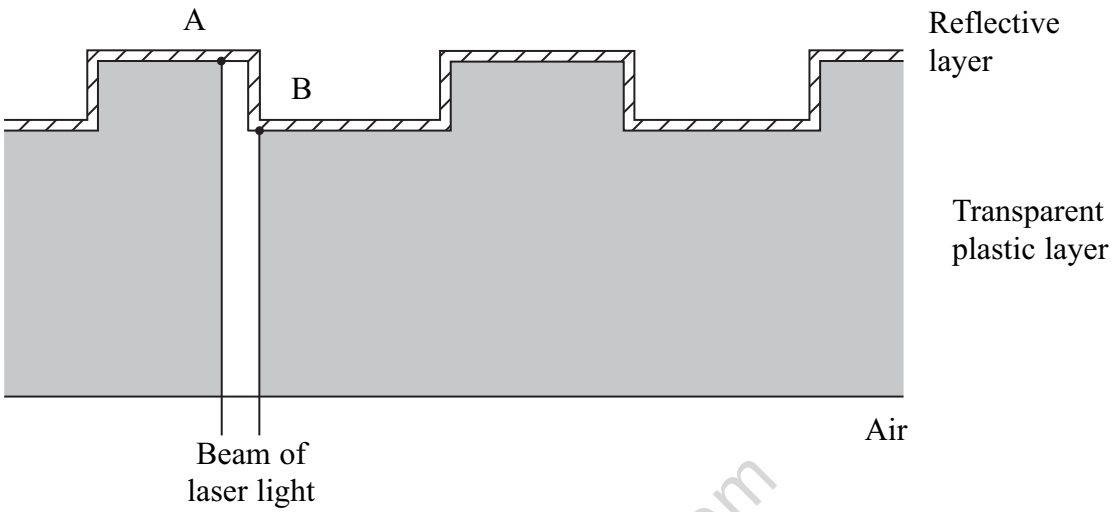
Optics QP1

1 A diagram shows the structure of a compact disc. A laser light beam is directed at right angles to the underside of the disc.



The wavelength of the laser light in the transparent plastic layer is 414 nm

refractive index of the transparent plastic layer = 1.53

(a) (i) Calculate the wavelength of the light in air.

(2)

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Wavelength = ...

(ii) Light reflected from point A is 180° out of phase with light reflected from point B.

Calculate the minimum vertical distance from A to B.

(2)

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Minimum vertical distance = ...

(iii) Explain the effect when the light reflected from A and B is combined.

(2)

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(b) Some of the reflected light will not hit the plastic-air boundary at 90°.

(i) Calculate the critical angle of the plastic-air boundary.

(2)

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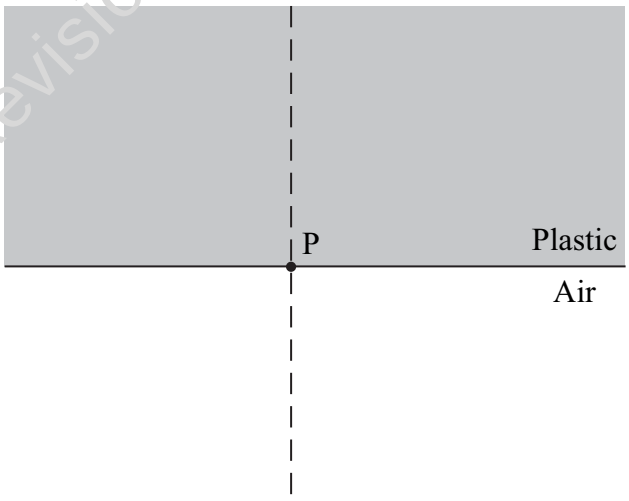
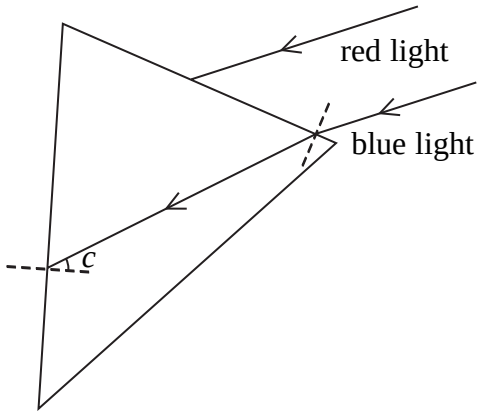
Critical angle = ...

(ii) On the diagram below, show what happens to a ray of light which hits the plastic-air boundary at point P at an angle greater than the critical angle.

(2)



2 Two parallel rays of light, one blue, one red, are travelling in air and are incident on one side of a glass prism . The blue light passes into the prism and meets the second face at the critical angle as shown in the diagram.



(a) Add to the diagram the path of the blue light after it meets the second face. Label this path X.

(1)

(b) (i) The speed of blue light in the glass prism is 1.96×10^8 m s^{-1}.

Calculate the refractive index of this glass for blue light.

(2)

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Refractive angle = ...

(ii) Calculate the critical angle for blue light in this glass prism.

(2)

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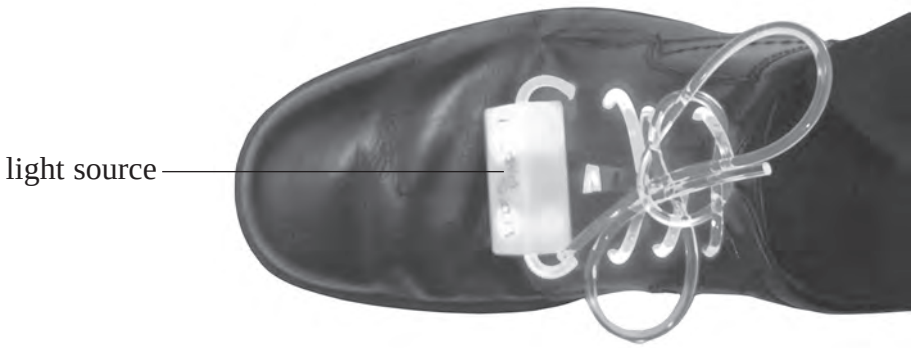
Critical angle = ...

(c) The refractive index of this glass for red light is less than for blue light. Add to the diagram to complete the path of the red light through the prism. Label this path Y.

(2)

3 The photograph shows a shoe with novelty shoelaces.



The laces are long, flexible plastic strands. Light from the light source passes through the tied laces, illuminating the ends.

(a) (i) State what is meant by critical angle.

(2)

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(ii) Show that the refractive index for the plastic used for the laces is about 1.5

speed of light in plastic = 1.97×10^8 m s^{-1}

(2)

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(iii) Calculate the critical angle for the plastic used for the laces.

(2)

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Critical angle = ...

(b) Explain how light from the source is able to reach the end of the laces.

(2)

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4 A student is asked to take measurements to determine the refractive index of a transparent plastic block.

The student uses a ray box and a protractor to obtain the following measurements:

angle of incidence in air = 40°

angle of refraction in plastic = 25°

(a) Calculate the refractive index of the plastic from which the block is made.

(2)

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Refractive index = ...

*(b) The student compares his value of refractive index with the values in the table to identify the type of plastic from which the block is made.

Type of plastic	Refractive index
A	1.494
B	1.498
C	1.509
D	1.519
E	1.531

Comment on the limitations of using this method to identify the type of plastic and suggest how the method may be improved.

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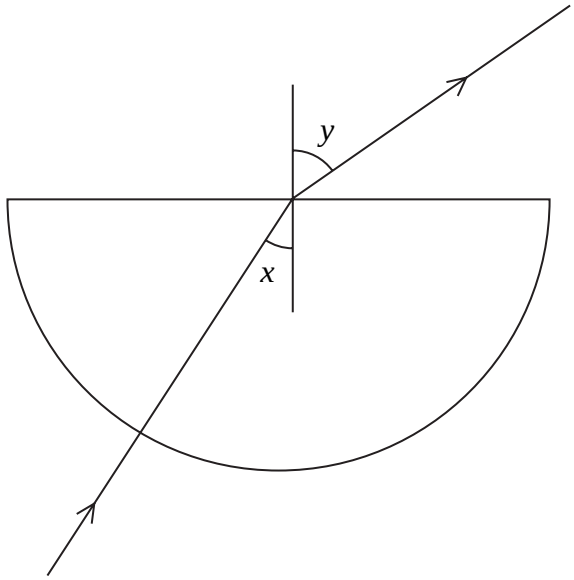
***5** A student carries out an experiment to measure the refractive index of glass. She does this by shining a ray of light through a semicircular glass block and into the air as shown.



$x = 30°$
$y = 48°$

(a) Calculate the refractive index from air to glass ${}_a\mu_g$.

(2)

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Refractive index = ...

(b) (i) The student steadily increases the angle x in glass and finds that eventually the light does not pass into the air. Explain this observation.

(3)

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(ii) Calculate the largest value of angle x that allows the light to pass out of the block into the air.

(2)

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Angle = ...