4.4 Wave Behaviour

Question Paper

Course	DP IB Physics
Section	4. Waves
Topic	4.4 Wave Behaviour
Difficulty	Medium

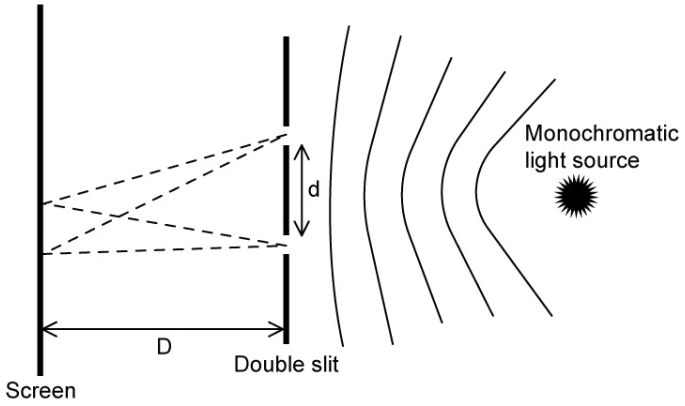
Time allowed: 60

Score: /49

Percentage: /100

Question 1a

A beam of monochromatic light is incident upon two slits. The distance between the slits is 0.4 mm.



(a)

A series of bright and dark fringes appear on the screen. Explain how a bright fringe is formed.

[2 marks]

Question 1b

(b)

Monochromatic light is incident on the double-slits and the distance from the screen is 0.64 m. The distance between the bright fringes is 9.3×10^{-4} m. Determine the wavelength of the incident light.

[2 marks]

Question 1c

(c)

If the wavelength of the incident light is halved and the distance between the slits is doubled, outline the effect on the separation of the fringes of the interference pattern.

[2 marks]

Question 1d

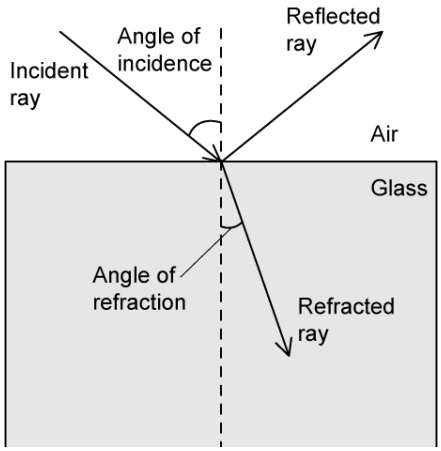
One of the slits is covered so it emits no light.

(d)
Describe how this changes the pattern's appearance and the intensities observed on the screen.

[2 marks]

Question 2a

Light is incident upon a piece of glass.



The angle of incidence is less than that of the critical angle. The refractive index of the glass is 1.50.

(a)
Explain what is meant by the 'critical angle' and what will occur at angles that are above and below the critical angle.

[3 marks]

Question 2b

The angle of incidence for this situation is 34°.

(b)
Determine the angle of refraction to the nearest degree.

[2 marks]

Question 2c

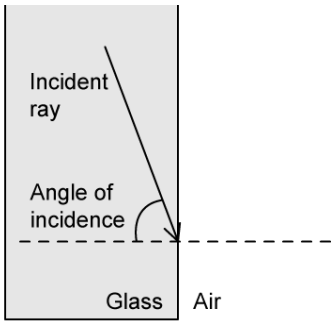
The refracted light travels within the glass for 5 m.

(c)
Determine the time that the light will take to travel this distance in the glass.

[2 marks]

Question 2d

The light continues within the glass until it strikes the side perpendicular to the original side of entry.

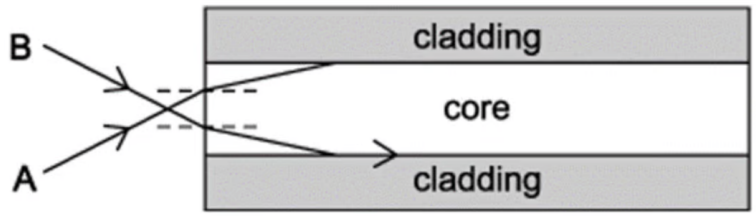


(d)
Show that the light will not emerge from the side of the glass.

[3 marks]

Question 3a

The diagram shows a cross-section through a step-index optical fibre.



Beam A is incident at the end of the optical fibre at an angle of 12.6° to the normal and refracts into the core at 6.89° to the normal.

(a)
Calculate the refractive index of the core.

[2 marks]

Question 3b

Beam A travels through the air-core boundary and experiences total internal reflection.

(b)
On the diagram, show the path of this ray down the fibre and label the angle of reflection.

[2 marks]

Question 3c

Beam **B** is incident at the same end of the fibre. It refracts through the air-core boundary and then refracts again when it hits the core-cladding boundary at an angle of 51.8°, traveling along the boundary.

(c)
Calculate the refractive index of the cladding.

[2 marks]

Question 3d

A different step-index optical fibre is built with the same core as that in part (a) but with a different material used for the cladding.

The speed of light in the new cladding material is 1.54×10^{8} m s^{-1}.

(d)
Explain why this new cladding material would not be suitable for sending signals through the step-index optical fibre. Use a calculation to support your answer.

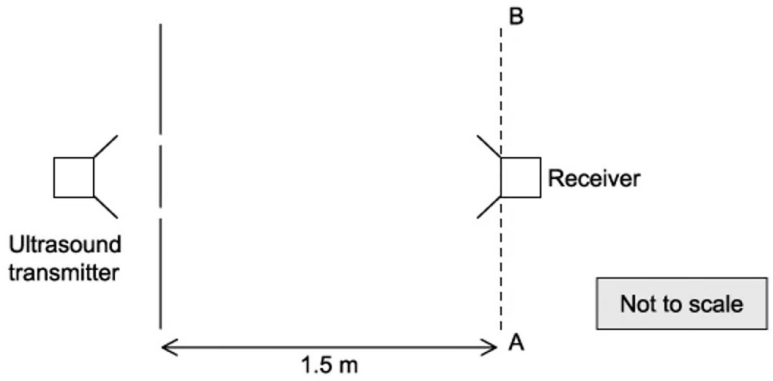
[3 marks]

Question 4a

A laboratory ultrasound transmitter emits ultrasonic waves of wavelength 0.7 cm through two slits. A receiver, moving along line AB, parallel to the line of the slits, detects regular rises and falls in the strength of the signal.

A student measures a distance of 0.39 m between the first and the fourth maxima in the signal when the receiver is 1.5 m from the slits.

Figure 1



The ultrasound transmitter is a coherent source.

(a)
Explain what is meant by the term coherent source.

[2 marks]

Question 4b

(b)
Explain why the receiver detects regular rises and falls in the strength of the signals as it moves along the line AB.

[4 marks]

Question 4c

(c)
Calculate the distance between the two slits.

[3 marks]

Question 4d

One of the slits is now covered. No other changes are made to the experiment.

(d)
State and explain the difference between the observations made as the receiver is moved along AB before and after one of the slits is covered.

[3 marks]

Question 5a

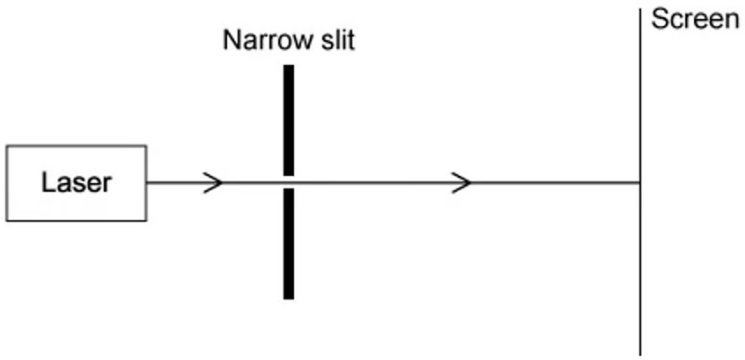
White light is passed through a single narrow slit and illuminates a screen.

(a)
Describe the patten observed on the screen.

[2 marks]

Question 5b

Blue light from a laser is now passed through a single narrow slit. A pattern of bright and dark regions can be observed on the screen which is placed several meters beyond the slit.



(b)
Describe the effect on the diffraction pattern if the width of the narrow slit is decreased.

[2 marks]

Question 5c

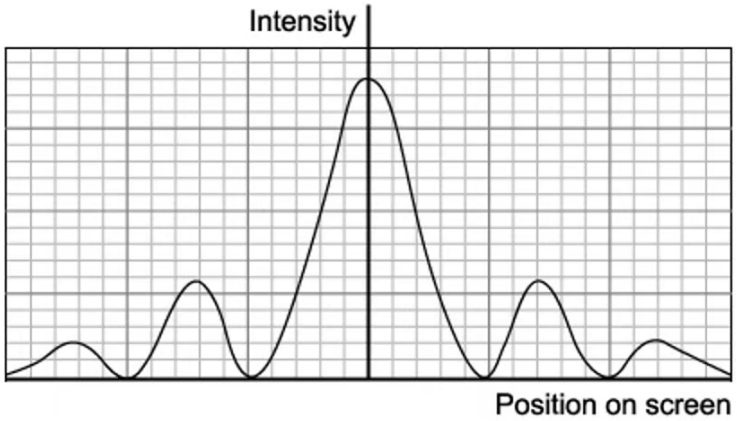
(c)
With the original slit width, state and explain the effect on the width of the fringes on the diffraction pattern if the blue light is replaced with a red light of the same intensity.

[3 marks]

Question 5d

(d)

The intensity graph for the diffracted blue light is shown in the diagram below.



On the axes of the diagram, sketch the intensity graph for the laser emitting red light.

[3 marks]