9.2 Single-Slit Diffraction

Question Paper

Course	DP IB Physics
Section	9. Wave Phenomena (HL only)
Topic	9.2 Single-Slit Diffraction
Difficulty	Easy

Time allowed: 80

Score: /59

Percentage: /100

Question 1a

(a)
State the features of a single-slit diffraction pattern using monochromatic light.

[2]

[2 marks]

Question 1b

The monochromatic light is replaced by a source of white light.

(b)
The paragraph below describes how this change would affect the interference pattern. Choose appropriate words to fill the gaps.

[3]

The central maximum would be _____, and each subsidiary maximum would be composed of a _____.
The _____ wavelength would appear nearest to the central maximum, and the _____ wavelength would appear furthest from the central maximum.
The fringe spacings would be _____ and the maxima would be _____.

[3 marks]

Question 1c

The white light source is replaced, first with red laser light and then blue laser light.

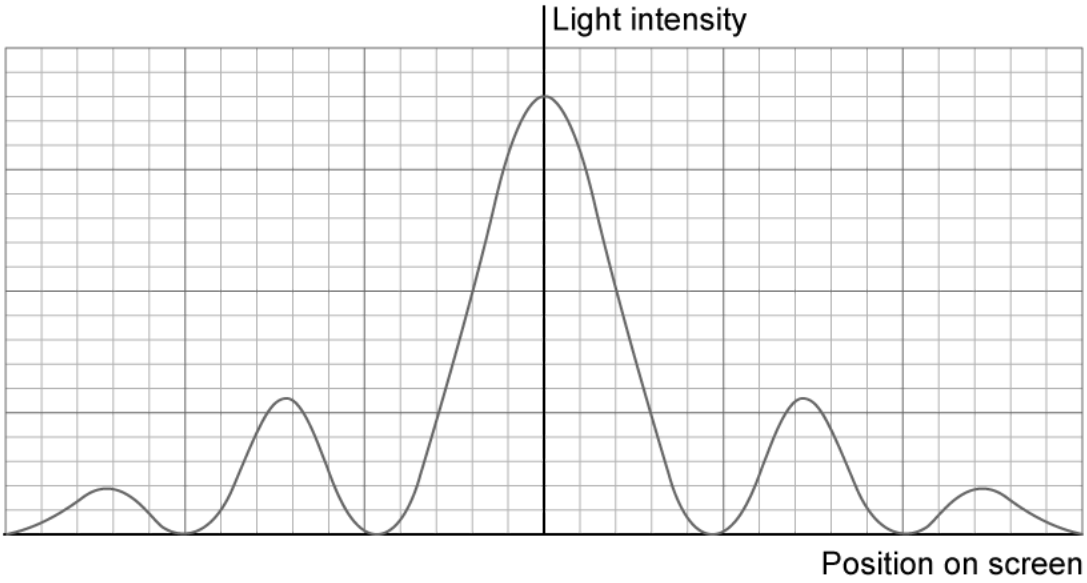
(c)
Explain the difference in the diffraction patterns between the red and blue light.

[2]

[2 marks]

Question 1d

The diagram below shows the intensity patterns for blue light.



(d)
On the same axes, sketch the intensity pattern for red light.

[2]

[2 marks]

Question 2a

The angle of diffraction of the first minima can be found using the following equation:

$$\theta = \frac{\lambda}{b}$$

(a)
State the definition of each variable and give an appropriate unit for each.

[3]

[1 mark]

Question 2b

(b)
Use the equation from part (a) to determine what will happen to the angle of diffraction if the width of slit is doubled using monochromatic light.

[3]

[3 marks]

Question 2c

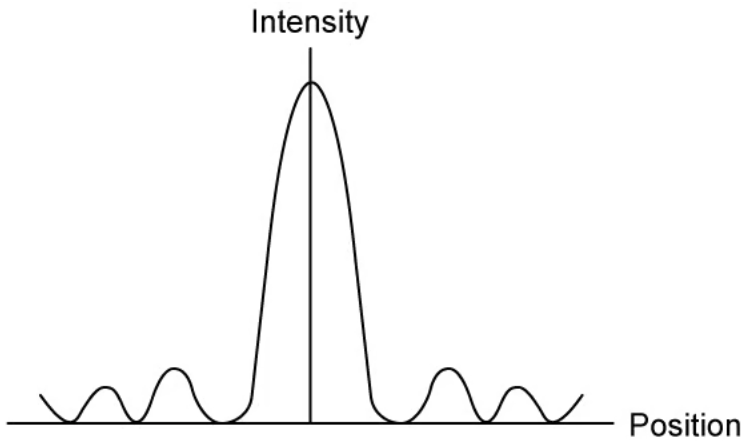
(c)
Use the equation from part (a) to explain why red light produces wider maxima than blue light.

[2]

[2 marks]

Question 2d

The graph below shows the diffraction pattern of monochromatic red light with a slit width *b*.



(d)
Sketch on the same axes the diffraction pattern if the slit width was reduced.

[2]

[2 marks]

Question 3a

(a)
For the diffraction of light through a single slit, the following equation is used:

$$\theta = \frac{\lambda}{b}$$

The equation contains some assumptions about the set up of the equipment.

(i)
Outline why the slit width has to be has to be smaller than the wavelength of the incident light.

[1]

(ii)
Explain why the screen must be placed a great distance away from the slit.

[2]

[3 marks]

Question 3b

(b)
Monochromatic light of wavelength 450 nm is incident upon a single slit of width 1.3 μm. Determine the angle of diffraction.

[4]

[4 marks]

Question 3c

(c)
State the colour of the light used in the experiment in part (b).

[1]

[1 mark]

Question 3d

(d)
Determine the angular width of the central maximum for the experiment in part (b).

[2]

[2 marks]

Question 4a

A group of students were conducting single-slit diffraction experiments with different coloured lasers.

(a)
A slit width of 0.12 mm was used, but the student forgot to note down what colour laser was used. The angle of diffraction produced was 0.0050 rad. Determine the colour of the incident light.

[4]

[4 marks]

Question 4b

(b)
The students decided to try the red laser next. Suggest, without calculation, how this would affect the diffraction pattern.

[4]

[4 marks]

Question 4c

(c)
Calculate the angle of diffraction using the red laser of wavelength 675 nm.

[3]

[3 marks]

Question 4d

(d)
Still using the same red laser, the students discussed the effect of decreasing the slit width by half.

(i)
State a prediction of the effect this would have on the diffraction pattern.

[3]

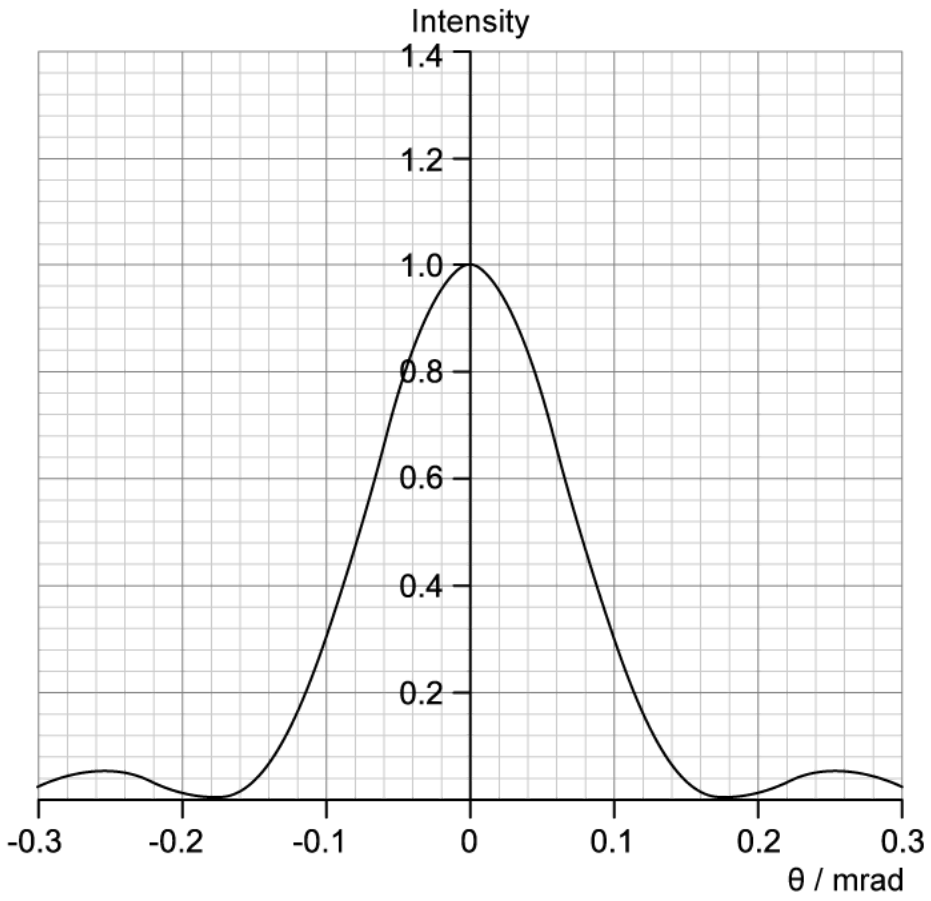
(ii)
Prove mathematically that your prediction would be correct.

[4]

[7 marks]

Question 5a

The following graph shows the diffraction pattern for monochromatic light incident on a single slit.



(a)

The wavelength of the light used is 4.5×10^{-7} m. Calculate the width of the slit.

[4]

[4 marks]

Question 5b

The investigation from part (a) was repeated. The same light was used, but the slit width was doubled.

(b)
On the same graph shown in part (a) sketch the resulting diffraction pattern for the new slit width.

[3]

[3 marks]

Question 5c

(c)
Using the same light from parts (a) and (b), determine the slit width that would give the central maximum an angular width of 0.1 mrad.

[4]

[4 marks]

Question 5d

Light with wavelength λ is incident upon a single slit of width b producing an angle of diffraction θ.

(d)

Explain the change in the diffraction pattern if light with a wavelength $\frac{\lambda}{2}$ and a slit width $\frac{b}{2}$ were used.

[3]

[3 marks]