9.3 Interference

Question Paper

Course	DP IB Physics
Section	9. Wave Phenomena (HL only)
Topic	9.3 Interference
Difficulty	Hard

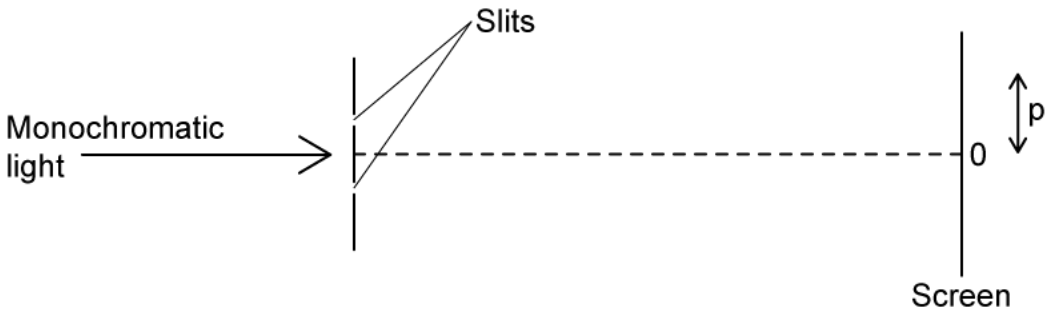
Time allowed: 60

Score: /42

Percentage: /100

Question 1a

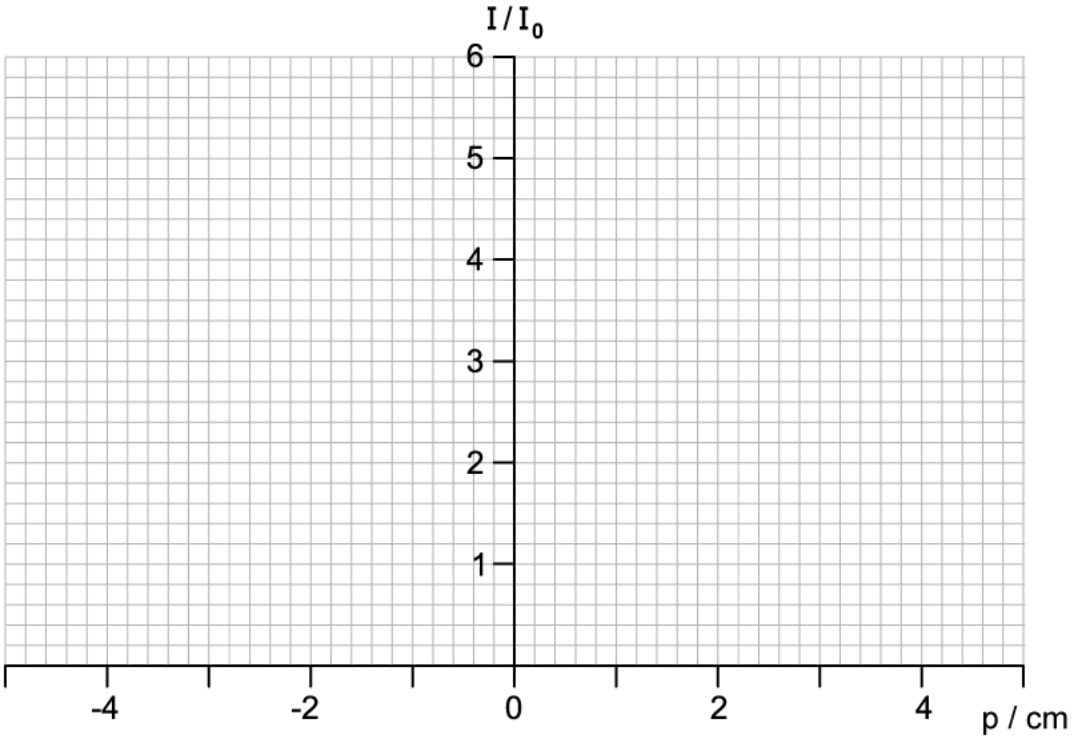
Monochromatic light from a single source is incident on two thin parallel slits.



The following data are available:

- Distance from slits to screen = 4.5 m
- Wavelength = 690 nm
- Slit separation = 0.14 mm

The intensity, I of the light on the screen from each slit separately is I_0.



(a)
Sketch, on the axis, a graph to show variation with distance p on the screen against the intensity of light detected on the screen for this arrangement.

[3]

[3 marks]

Question 1b

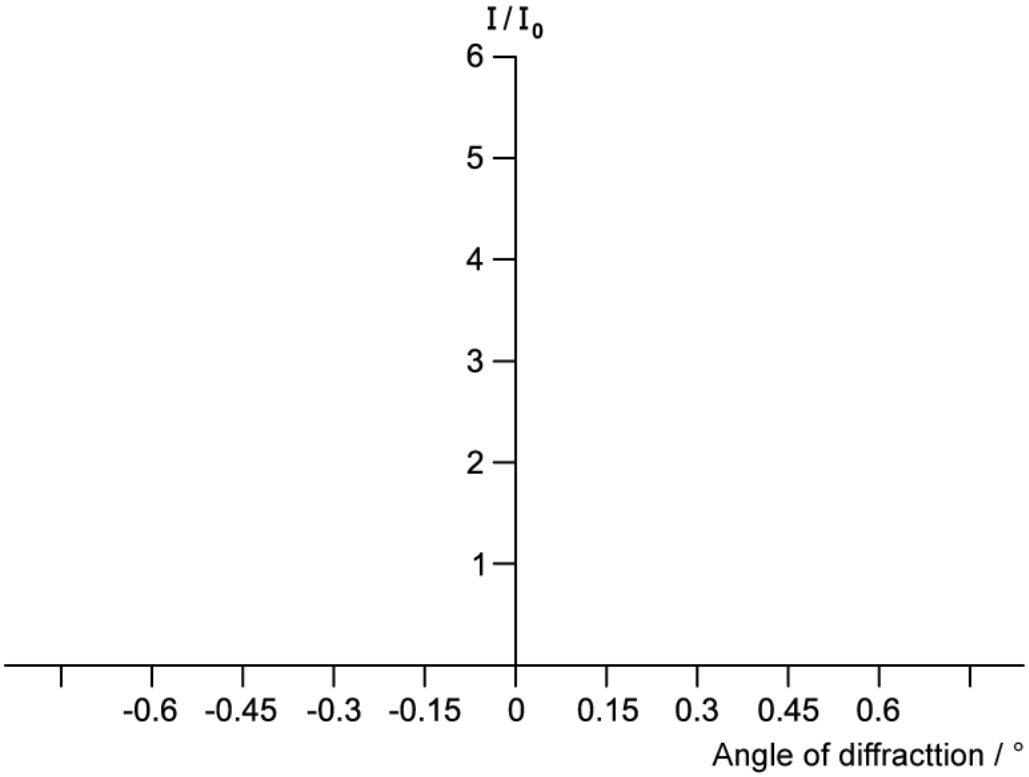
(b)
Calculate the angle of diffraction of the central and subsequent two bright fringes that would appear on the screen.
Give your answer in degrees to one significant figure.

[3]

[3 marks]

Question 1c

The relative intensity I_1 for the first bright fringe is $0.75I_0$ and for the second bright fringe I_2 is $0.25I_0$.



(c)
Plot, on the axis, a graph to show this diffraction pattern.

[4]

[4 marks]

Question 1d

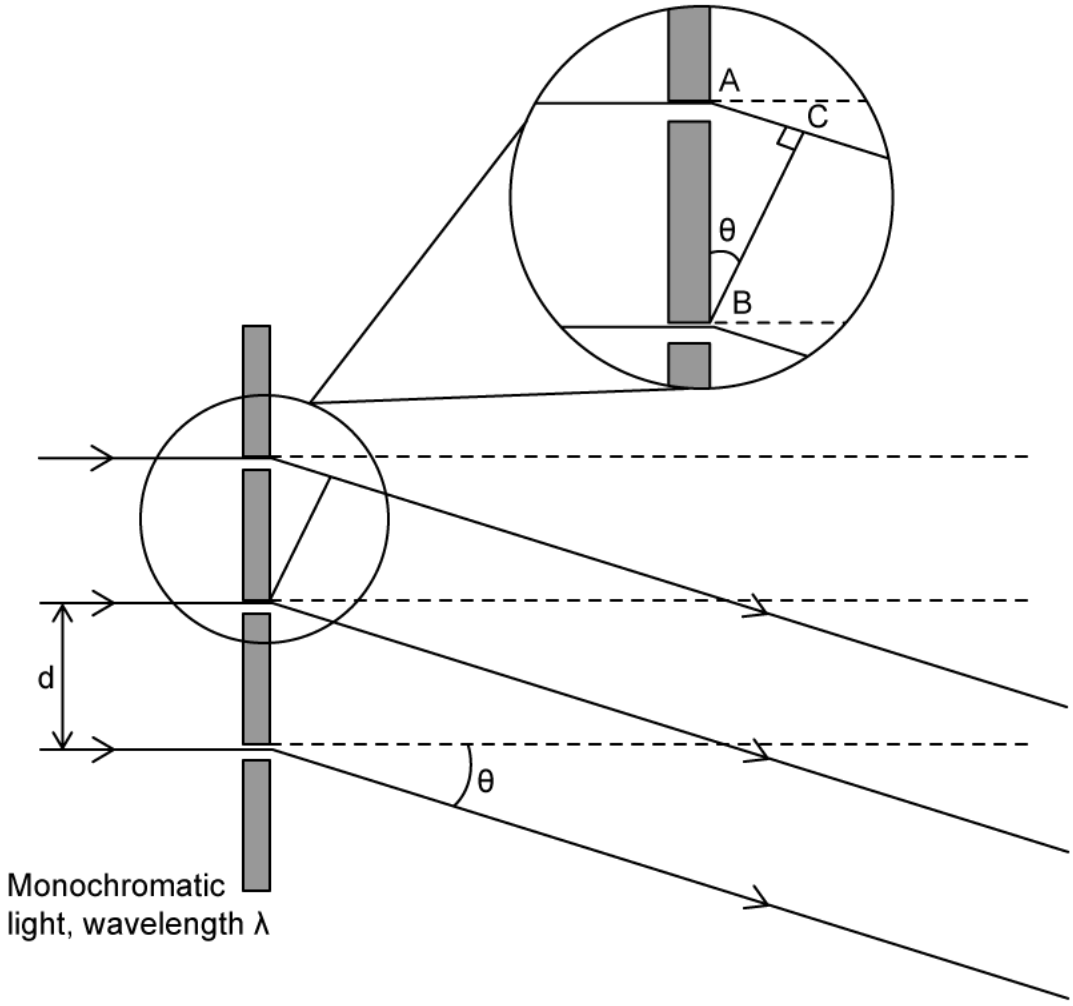
(d)
State and explain the changes that will occur to the diffraction pattern when the number of slits is increased from two to three.

[4]

[4 marks]

Question 2a

Students in a laboratory have created the following set-up. Parallel rays of monochromatic light from two adjacent slits A and B of wavelength λ are incident normally on a diffraction grating with a slit separation d.



(a)

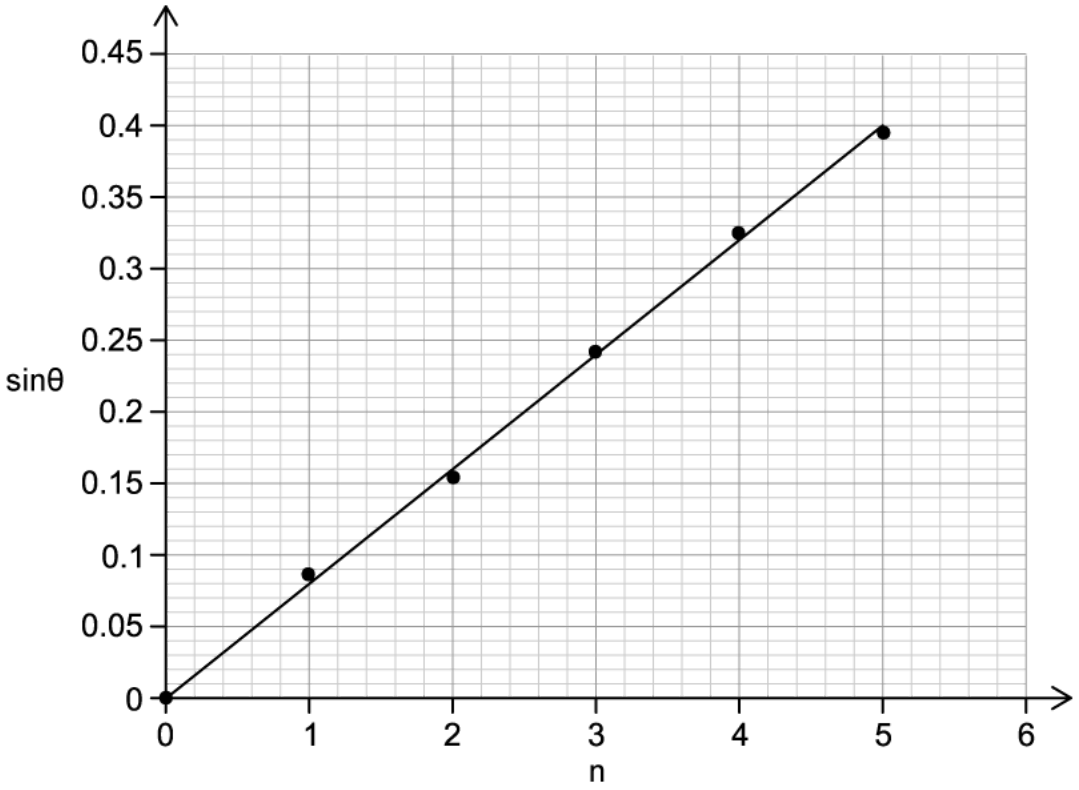
Use the diagram to derive the equation $n\lambda = d\sin\theta$ where θ is the angle of diffraction of a maxima order n visible on a screen.

[6]

[6 marks]

Question 2b

The monochromatic light in the set-up in part (a) has a wavelength of 545 nm. The graph shows the variation of sinθ with the order n of the maximum. The central order corresponds to $n = 0$.



(b)

Determine a mean value for the number of slits per mm of the grating.

[5]

[5 marks]

Question 2c

The grating is 40 mm wide.

(c)
Determine the number of slits required to obtain a maximum of six bright fringes on the screen.

[3]

[3 marks]

Question 2d

The students claim that they observed the following diffraction pattern on the screen for the grating from part (c).

(d)
State two reasons why the interference pattern obtained cannot be correct.

[2]

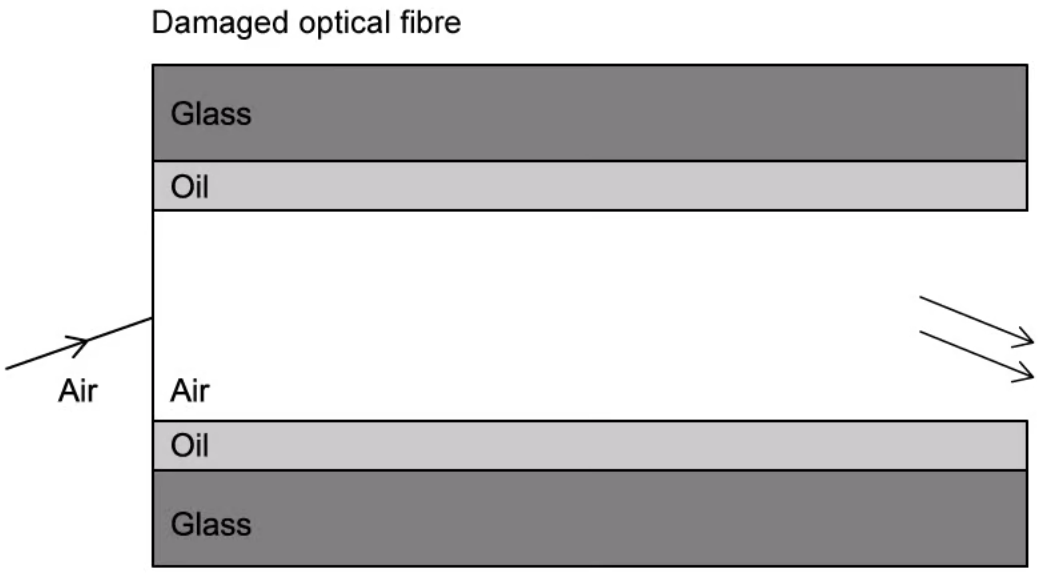
[2 marks]

Question 3a

An internet company is looking to improve the amount of light transmitted through its optical fibres. The fibres are made of glass and have a refractive index n_g.

The proposed solution has been to spread a thin film of oil on the inside surface with a refractive index n_o. The air inside the fibre has a refractive index n_a and the air outside has a refractive index n.

$$n < n_a < n_o < n_g$$



(a)
Complete the ray diagram to show the path of the incident light ray along the optical fibre.

You do not need to indicate any angles of refraction.

[3]

[3 marks]

Question 3b

(b)
Outline the conditions for constructive interference to occur as two light rays travel down in an optical fibre with oil on the inside.
You may include a diagram in your answer.

[3]

[3 marks]

Question 3c

The oil has a thickness of 100 nm and a refractive index of 1.4.

(c)
Determine the longest possible wavelength of light that can be incident on the oil to obtain constructive interference.

[2]

[2 marks]

Question 3d

(d)
Analyse whether the oil improves the amount of light transmitted through the optical fibres.
(i)
Describe the path of the ray with the presence of oil.

[1]

(ii)
Describe the path of the ray without the presence of oil.

[1]

(iii)
State and explain whether the oil improves the amount of light transmitted through the optical fibres.

[2]

[4 marks]