9.3 Interference

Question Paper

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

Time allowed: 70

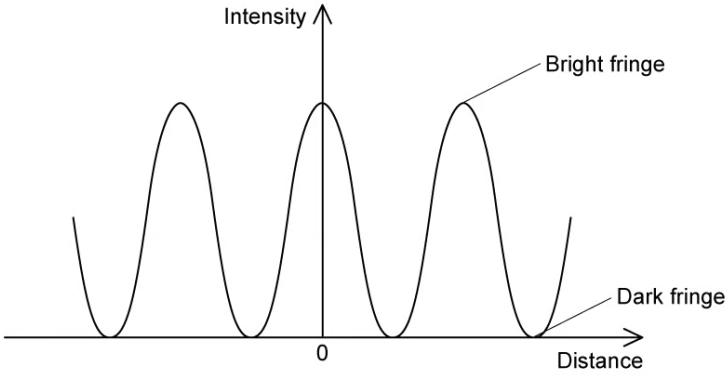
Score: /57

Percentage: /100

Question 1a

Several students are conducting investigations with Young's Double Slit Experiment.

In the first investigation, monochromatic light passes through a double-slit arrangement. The intensity of the fringes varies with distance from the central fringe. This is observed on a screen, as shown in the diagram below.



The intensity of the monochromatic light passing through one of the slits is reduced.

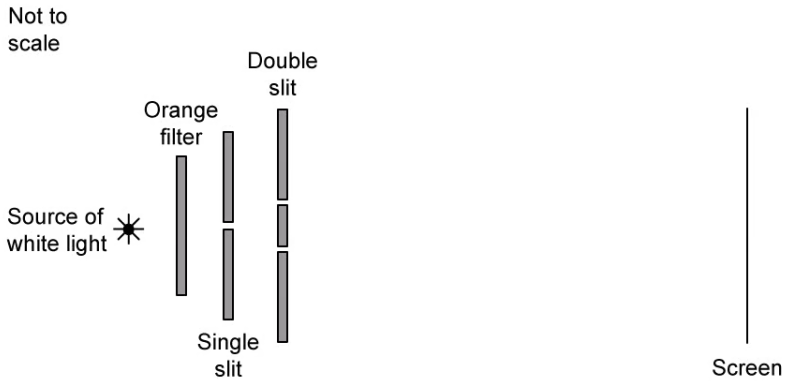
(a)
Explain the effect of this change on the appearance of the dark and bright fringes.

[2]

[2 marks]

Question 1b

In investigation, two white light is incident on an orange filter, a single slit, and then a double-slit. An interference pattern of light and dark fringes is observed on the screen.



(b)

(i)

The orange filter is now replaced by a green filter. State and explain the change in appearance, other than the change in colour, of the fringes on the screen.

[1]

(ii)

The green filter is now removed. State and explain the change in appearance of the central maximum fringe, as well as the fringes away from this central position.

[3]

[4 marks]

Question 1c

In a third experiment, the white light is replaced by orange light of wavelength 600 nm. The double-slit has a separation of 0.350 mm and the screen is 6.35 m away.

(c)
Calculate the distance between the central and first maximum as seen on the screen.

[2]

[2 marks]

Question 1d

The light source is now changed to a blue LED of wavelength 450 nm.

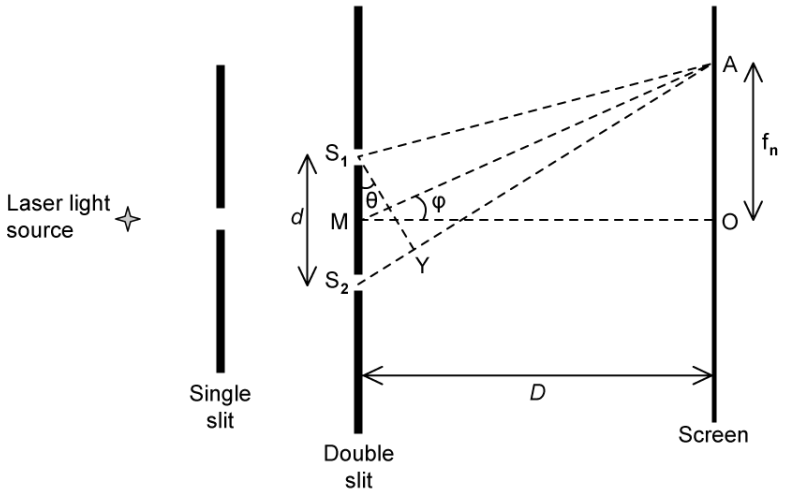
(d)
Explain the features of the interference pattern that will now be observed on the screen.

[3]

[3 marks]

Question 2a

The diagram below shows an arrangement for observing the interference pattern produced by laser light passing through two narrow slits S_1 and S_2.



The distance S_1S_2 is d, and the distance between the double slit and the screen is D where $D \gg d$, so angles θ and ϕ are small. M is the midpoint of S_1S_2 and it is observed that there is a bright fringe at point A on the screen, a distance f_n from point O on the screen. Light from S_1 travels a distance S_2Y further to point A than light from S_1.

(a)

The wavelength of light from the laser is 650 nm and the angular separation of the bright fringes on the screen is 5.00×10^{-4} rad. Calculate the distance between the two slits.

[3]

[3 marks]

Question 2b

A bright fringe is observed at A.

(b)
(i)
Explain the conditions required in the paths of the rays coming from S_1 and S_2 to obtain this bright fringe.

[2]

(ii)
State an equation in terms of wavelength for the distance S_2Y.

[1]

[3 marks]

Question 2c

(c)
Deduce expressions for the following angles in the double-slit arrangement shown in part a:

(i)
θ in terms of S_2Y and d

[2]

(ii)
ϕ in terms of D and f_n

[2]

[4 marks]

Question 2d

(d)

The separation of the slits S_1 and S_2 is 1.30 mm. The distance MO is 1.40 m. The distance f_n is the distance of the ninth bright fringe from O and the angle θ is 3.70×10^{-3} radians.

Calculate the wavelength of the laser light.

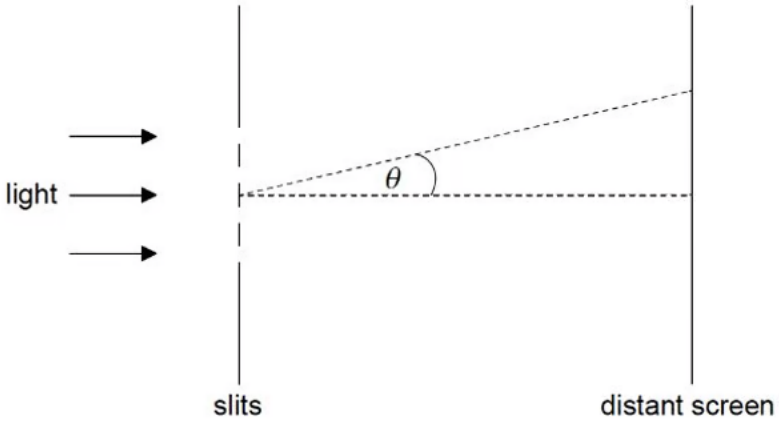
[2]

[2 marks]

Question 3a

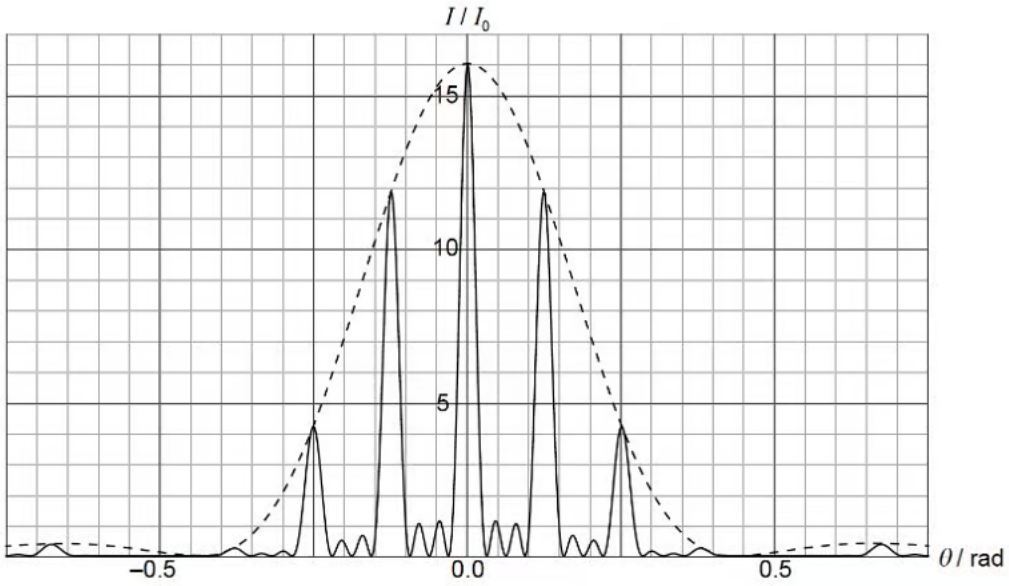
Monochromatic light is incident normally on four, thin, parallel, rectangular slits.

IMAGE



The graph shows the variation with diffraction angle θ of the intensity of light I on a distant screen.

IMAGE



I_0 is the intensity of the light at the middle of the screen from one slit.

(a)
State the value of the light intensity in terms of I_0 when $\theta = 0$ and explain where this value comes from.

[4]

[4 marks]

Question 3b

The width of each slit is 2.0 μm.

(b)
Use the graph to estimate the wavelength of the light.

[2]

[2 marks]

Question 3c

(c)
Use the graph to calculate the number of lines per meter on the diffraction grating.

[3]

[3 marks]

Question 3d

The four slits are now changed for a grating where the number of slits becomes very large. The separation of the slits and their width stays the same.

(d)

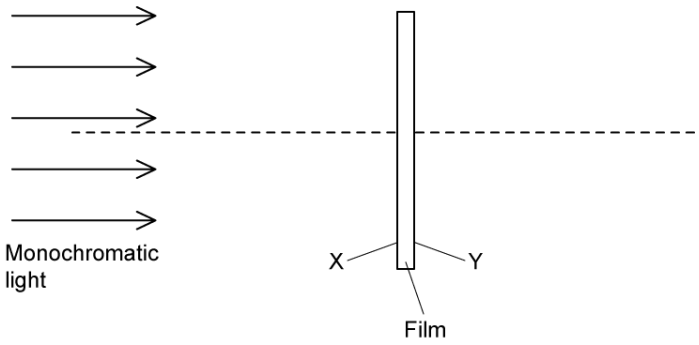
State two changes to the graph that will appear as a result of this modification.

[2]

[2 marks]

Question 4a

Monochromatic light is incident on a thin film of transparent plastic as shown below.



The plastic film is in the air.

Light is partially reflected at both surfaces X and Y on the film.

(a)
State and explain the reasons for the phase change that occurs when light is reflected from:

(i)
Surface X

[2]

(ii)
Surface Y

[2]

[4 marks]

Question 4b

The red light incident on the transparent plastic has a wavelength of 630 nm. The refractive index of the plastic is 1.50.

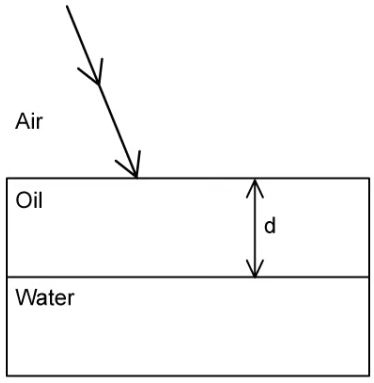
(b)
Calculate the minimum thickness of the plastic for the light reflected from surface X and surface Y to undergo constructive interference.

[2]

[2 marks]

Question 4c

In the second investigation, a thin film of colourless oil floats on water as shown in the diagram below. The refractive index of the oil is 1.47 and the water is 1.52. The same red light is now incident on the oil.



(c)
Complete the diagram to show the two light rays reflected from the two surfaces of the oil and label them P and Q.

[3]

[3 marks]

Question 4d

The observer notices that the red light reflected from the oil is now darker than that reflected from the transparent plastic.

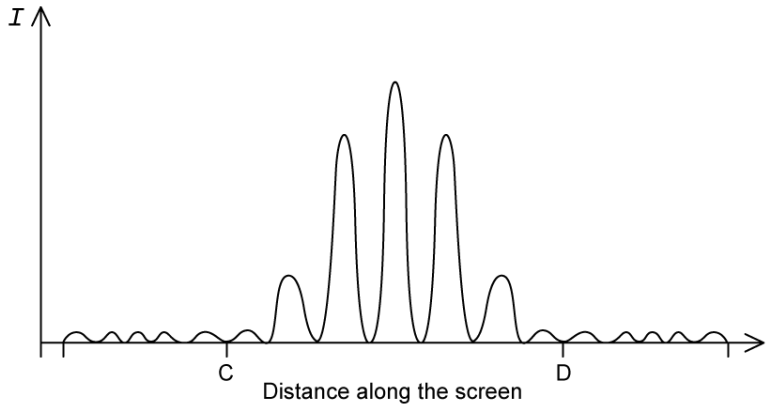
(d)
Calculate how many times thicker the thinnest film of oil is compared to the thinnest film of transparent plastic.

[4]

[4 marks]

Question 5a

Monochromatic light is incident on a double-slit diffraction grating. After passing through the slits the light is brought to a focus on a screen. The intensity distribution of the light on the screen is shown in the diagram below.



The double-slit diffraction grating is now changed to a grating with many narrower slits, the same widths as the slits above.

(a)
Sketch the new intensity pattern for the light between points C and D on the screen.

[3]

[3 marks]

Question 5b

The wavelength of the monochromatic light incident on the diffraction grating is 550 nm. The slit spacing of the diffraction grating is 1.34×10^{-6} m.

(b)
Calculate the angle between the two second-order maxima.

[2]

[2 marks]

Question 5c

(c)
Calculate the total number of orders of diffracted light that can be observed on the screen.

[2]

[2 marks]

Question 5d

Two sources of light now replace the light incident on the diffraction grating. One is the same as the wavelength of the previous source and the other has a slightly longer wavelength.

(d)
Compare and contrast the new intensity pattern with the original. Comment on the intensity of the central maxima and the width of all maxima.

[3]

[3 marks]