9.3 Interference

Question Paper

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

Time allowed: 20

Score: /10

Percentage: /100

Question 1

A layer of oil with a refractive index of 1.5 coats the outside of a perspex cover with a refractive index of 1.75. The layer of oil is used to eliminate reflection from the lens at wavelength λ in air.

What is the phase change at the top of the air-oil interface and at the oil-perspex interface and the minimum thickness of the oil layer?

	Phase change air-oil	Phase change oil-perspex	Oil thickness
A.	π	0	$\frac{\lambda}{4}$
B.	π	π	$\frac{\lambda}{6}$
C.	π	π	$\frac{2\lambda}{7}$
D.	0	0	$\frac{\lambda}{4}$

[1 mark]

Question 2

Monochromatic light of wavelength λ is incident on a double slit. The resulting interference pattern is observed on a screen a distance p from the slits. The distance between consecutive fringes in the pattern is 21 mm when the slit separation is q.

λ and q are tripled and p is doubled.

What is the new distance between consecutive fringes?

A. 7 mm

B. 21 mm

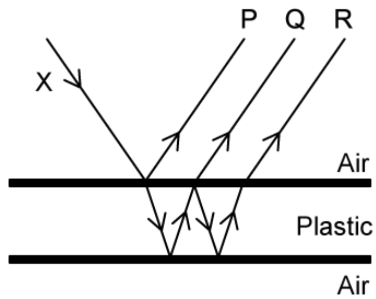
C. 42 mm

D. 63 mm

[1 mark]

Question 3

A transparent plastic forms a parallel-sided thin film in air. A ray X is incident on the upper-air plastic boundary at a normal incidence is shown on the diagram.



Reflections from the top and bottom surface of the film result in three rays P, Q and R. An observer can see a whole spectrum of colours at the point PQR.

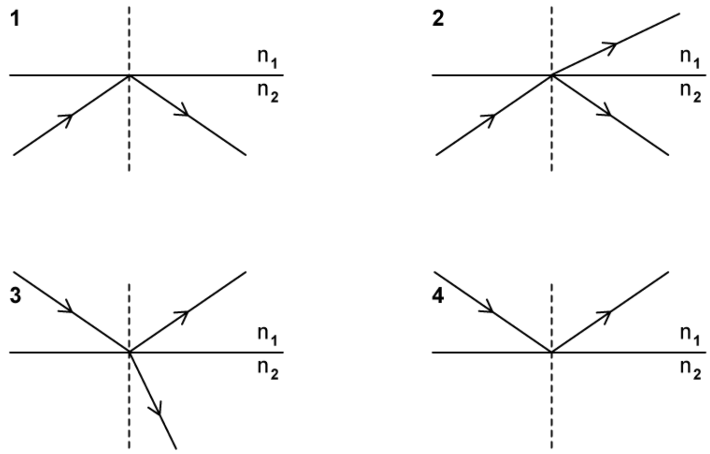
Which path differences are correct for the minimum thickness of the plastic?

	X – P	X – Q	P – R
A.	$\frac{\lambda}{2}$	$\frac{\lambda}{2}$	0
B.	$\frac{\lambda}{2}$	0	λ
C.	0	$\frac{\lambda}{2}$	$\frac{\lambda}{2}$
D.	$\frac{\lambda}{2}$	$\frac{\lambda}{2}$	λ

[1 mark]

Question 4

A ray of light is incident on the boundary between two materials n_1 and n_2 where $n_1 < n_2$.



Which diagrams show the correct behaviour of this ray of light at the boundary?

A. All diagrams are correct

B. No diagrams are correct

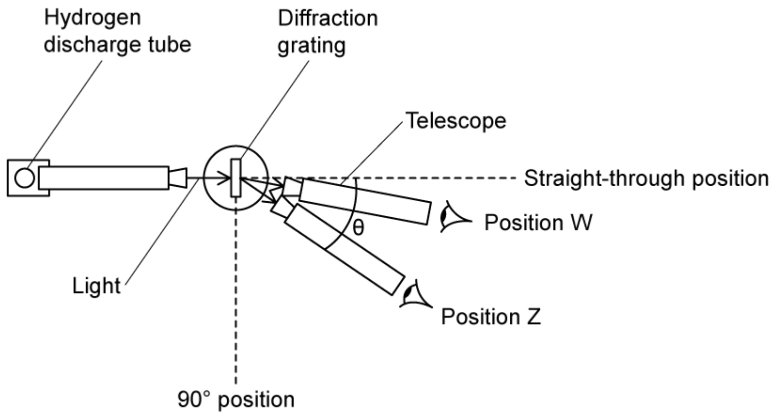
C. Diagrams 2 and 3 are correct

D. Diagrams 1 and 3 are correct

[1 mark]

Question 5

The figure below shows a spectrometer that uses a diffraction grating to split a beam of light into its constituent wavelengths and enables the angles of the diffracted beams to be measured.



Light with a particular wavelength is passed through the diffraction grating. The angle of diffraction θ at the centre of the observed beam at Z in the image above is 45^0 where sin(45) = $\frac{\sqrt{2}}{2}$ and the grating has 1000 lines per mm.

A dark fringe is observed at position W, with the central maximum at the straight-through position.

How many orders of maxima of this light are present at this wavelength?

A. 1

B. 2

C. 3

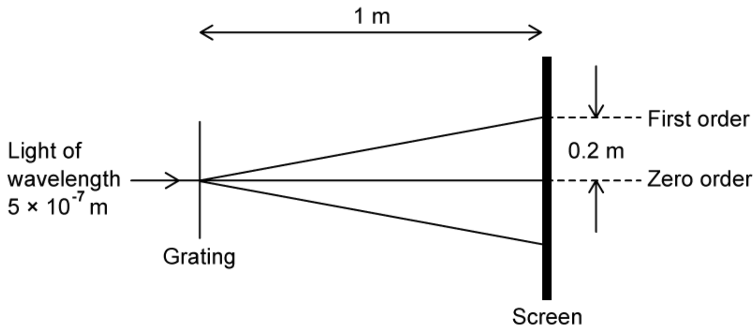
D. 4

[1 mark]

Question 6

A diffraction grating is illuminated normally with light of wavelength 5×10^{-7}m.

When a screen is 1 m from the grating, the distance between the zero and first-order maxima on the screen is 0.20 m.



You may need to use the following values in your calculation:

$$tan^{-1}\left(\frac{1}{5}\right) = 11°$$

$$sin^{-1}\left(\frac{1}{5}\right) = 11°$$

$$cos^{-1}\left(\frac{1}{5}\right) = 78°$$

What is the number of lines per mm of the diffraction grating?

A. 100

B. 400

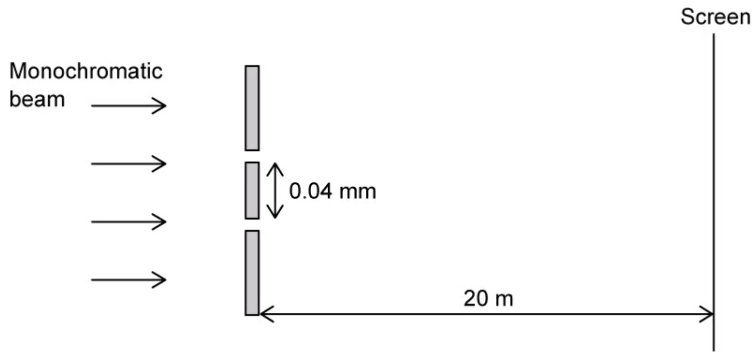
C. 1000

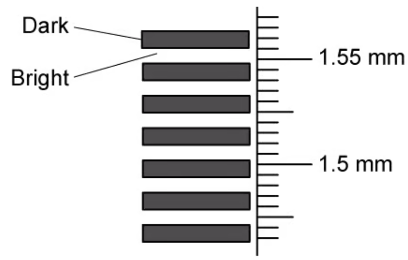
D. 2500

[1 mark]

Question 7

A Physicist carried out Young's double slit experiment using a monochromatic beam. The diagram shows the equipment set-up and the pattern produced with a ruler next to it.





What is the wavelength of the monochromatic beam?

A. 0.03 nm

B. 3 nm

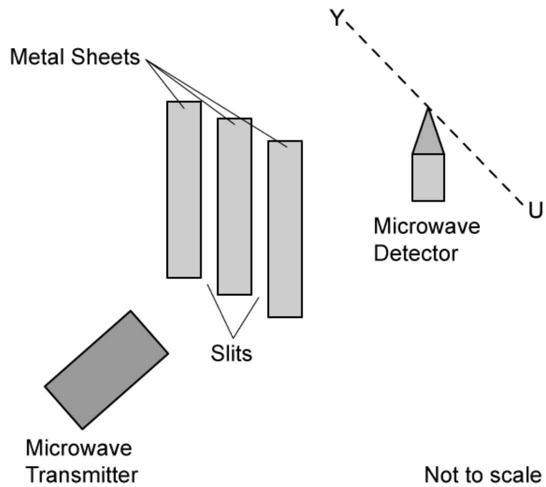
C. 6 μm

D. 9 μm

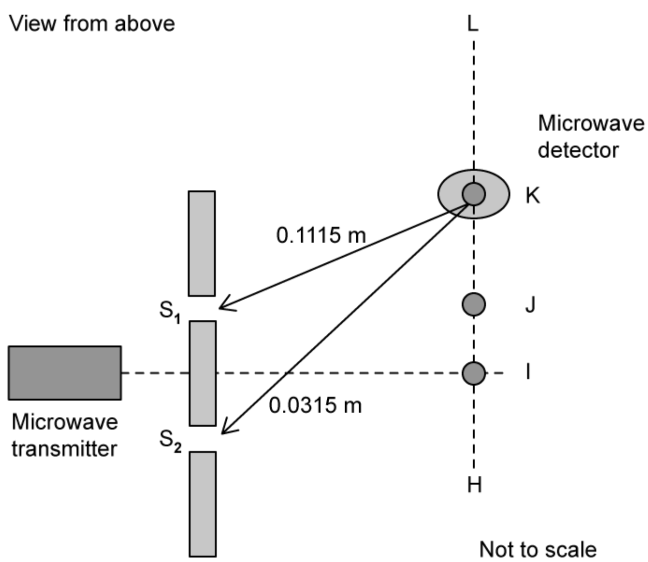
[1 mark]

Question 8

The diagram below shows an arrangement used to investigate double-slit interference using microwaves.



The diagram below shows the view from above.



The microwaves from the transmitter are polarised. These waves are detected by the aerial in the microwave detector. The aerial is a vertical metal rod.

The detector is moved along the dotted line HL. As it is moved, maximum and minimum signals are detected. Maximum signals are first detected at points I and J. The next maximum signal is detected at position K.

The distances between each of the two slits, S_1 and S_2 and the microwave receiver when the aerial is in position K are S_1K = 0.1115 m and S_2K = 0.0315 m

Which of the following reasons explains why the signal strength falls to a minimum between H and I, and between I and J?

	Reason 1	Reason 2	Reason 3

A.	Waves are out of phase	Gives rise to a path difference	Destructive interference occurs
B.	Waves are out of phase	Gives rise to a path difference	Constructive interference occurs
C.	Path difference for the two waves	Gives rise to a phase difference	Constructive interference occurs
D.	Path difference for the two waves	Gives rise to a phase difference	Destructive interference occurs

[1 mark]

Question 9

White light is passed through a double slit and an interference pattern is observed on a screen 2.0 m away. The separation between the slits is 0.5 mm. The first violet and red fringes are formed 2.0 mm and 3.0 mm respectively away from the central white fringe.

What are the wavelengths of the violet and red light?

A. Violet light wavelength = 0.5 m and red light wavelength = 0.75 m

B. Violet light wavelength = 500 nm and red light wavelength = 750 nm

C. Violet light wavelength = 750 nm and red light wavelength = 500 nm

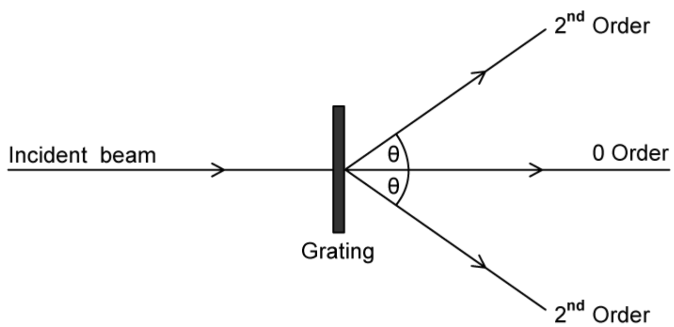
D. Red light wavelength = 250 nm and violet light wavelength = 250 nm

[1 mark]

Question 10

A parallel beam of monochromatic light is directed normally at a plane of transmission grating which has *N* slits per meter.

The second-order diffracted beam is at an angle θ to the zero-order transmitted beam.



The grating is then replaced by a plane transmission grating which has 5*N* slits per meter.

Which one of the following statements is correct?

A. With the second grating, the first order beam is at an angle of θ to the zero-order transmitted beam

B. With the second grating, the second order beam is at an angle θ to the zero-order transmitted beam

C. With the second grating, the second order beam is at an angle of 0.2θ to the zero-order transmitted beam

D. With the first grating, the first order beam is at an angle of 0.2θ to the zero-order transmitted beam

[1 mark]