Homework exercise 5 – Interference

Total = 30 marks

Question 1:

Marks

Light from a helium-neon laser is incident on a double slit. A pattern of light and dark fringes is observed on a screen 3·50 m beyond the slits as shown in Figure 20.

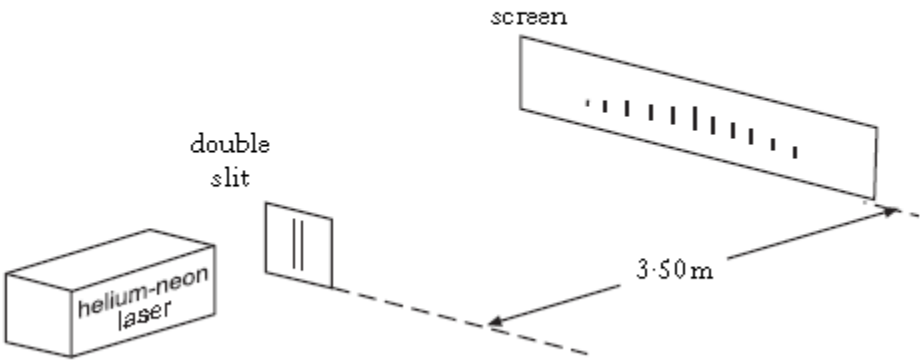

Figure 20

(*a*) State whether these fringes are caused by division of amplitude or division of wavefront. **1**

(*b*) The distance between two adjacent bright fringes on the screen is 7·20 mm. Calculate the separation of the two slits. 2

(*c*) The distance between the double slit and screen is increased to 5·50 m. The distance between the fringes is remeasured and the calculation of the slit separation is repeated.

(i) Explain **one** advantage of moving the screen further away from the double slit. 2

(ii) State **one** disadvantage of moving the screen further away from the double slit. **1**

(6)

Question 2:

Marks

A series of coloured LEDs are used in the Young's slit experiment as shown in Figure 12. The distance from the slits to the screen is $(2{\cdot}50 \pm 0{\cdot}05)$m. The slit separation is $(3{\cdot}0 \pm 0{\cdot}1) \times 10^{-4}$ m.

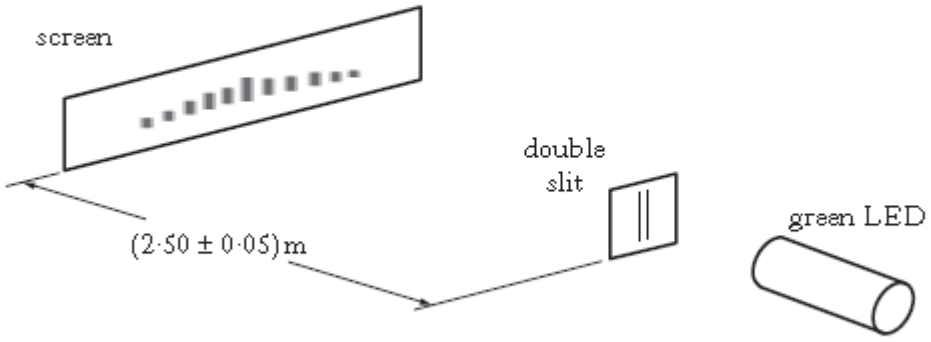

Figure 12

Colour of LED	*Wavelength* (nm)
Red	650 ± 2
Green	510 ± 2
Blue	470 ± 2

(*a*) State whether the pattern on the screen is caused by the division of wavefront or the division of amplitude. **1**

(*b*) (i) Calculate the fringe separation observed on the screen when the green LED is used. **2**

(ii) Calculate the absolute uncertainty in the fringe separation. **3**

(iii) Which measurement has the most significant impact on the absolute uncertainty?

Justify your answer. **1**

(7)

Question 3:

Marks

(*a*) A thin coating of magnesium fluoride is applied to the surface of a camera lens.

Figure 15 shows an expanded view of this coating on the glass lens.

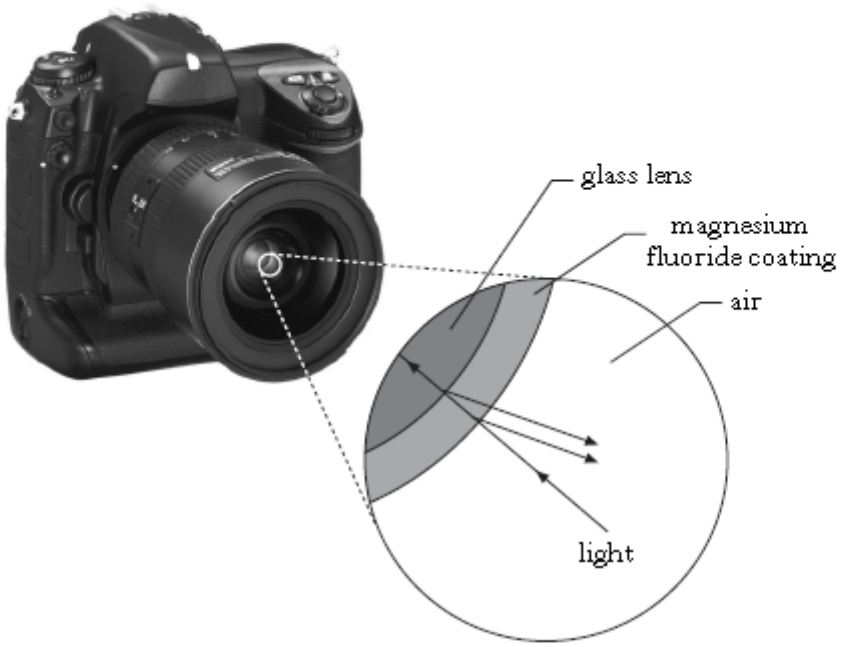

Figure 15

Monochromatic light is incident on the lens and some light reflects from the front and rear surfaces of the coating as shown in Figure 15.

(i) State the phase change undergone by the light reflected from:

(A) the front surface of the coating;

(B) the rear surface of the coating. **1**

(ii) Explain, in terms of optical path difference, why this coating can make the lens non-reflecting for a particular wavelength of light. **2**

(iii) Why is it desirable that camera lenses should reflect very little light? **1**

(iv) A particular lens has a magnesium fluoride coating of thickness $1{\cdot}05 \times 10^{-7}$m.

Calculate the wavelength of light for which this lens is non-reflecting. **2**

(*b*) A thin air wedge is formed between two glass plates which are in contact at one end and separated by a thin metal wire at the other end.

Figure 16 shows sodium light being reflected down onto the air wedge. A travelling microscope is used to view the resulting interference pattern.

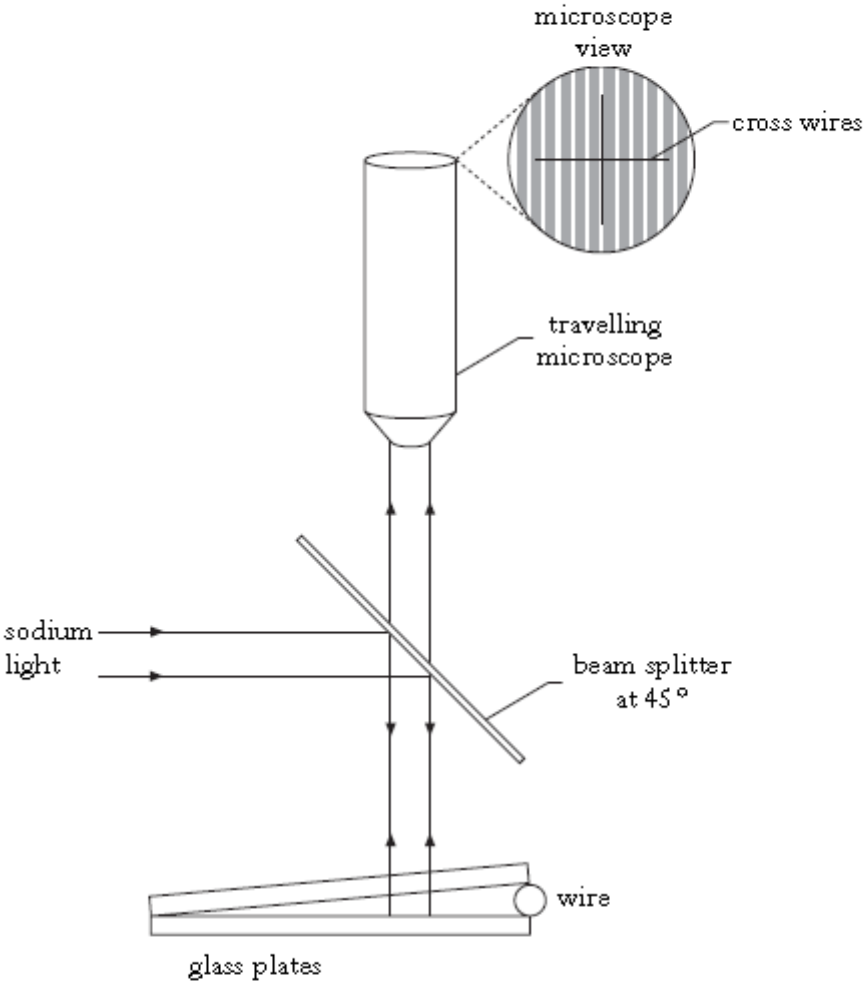

Figure 16

Explain how the diameter of the wire is determined using measurements obtained with this apparatus.

Assume the sodium light is monochromatic.

Your answer should include:

- the measurements required
- any data required
- the equation used. 2

Question 4:

Marks

(*a*) (i) State the condition for two light sources to be coherent.

(ii) Describe, with the aid of a diagram, how two coherent light sources can be produced in practice. 3

(*b*) The thickness of a very thin cylindrical optical fibre may be checked using "thin wedge fringes". Figure 15 shows two optically flat glass plates. The upper plate is resting on two cylindrical optical fibres A and B, 0·120m apart. The diameter of fibre A is 0·20mm.

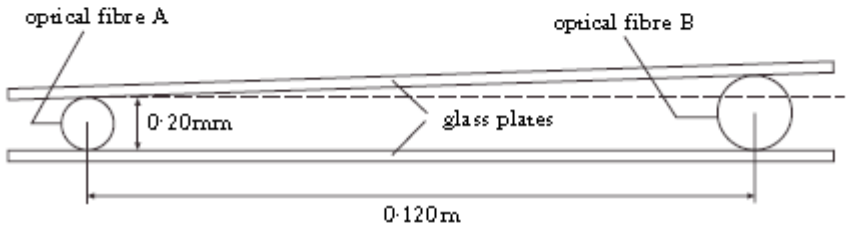

Figure not to scale

Figure 15

This apparatus is illuminated, from above, by light of wavelength 590nm. Thin wedge fringes of separation 4·4mm are observed.

(i) Calculate the difference in diameter between fibre A and fibre B.

(ii) The manufacturer of the fibre claims a tolerance of ±5% in the diameter.
Does fibre B meet with the manufacturer's specification?
You must justify your answer by calculation. 6

(9)