Interference

Revised AH Physics 2013

8. High quality *optical flats* made from glass are often used to test components of optical instruments. A high quality optical flat has a very smooth and flat surface.

(*a*) During the manufacture of an optical flat, the quality of the surface is tested by placing it on top of a high quality flat. This results in a thin air wedge between the flats as shown in Figure 8A.

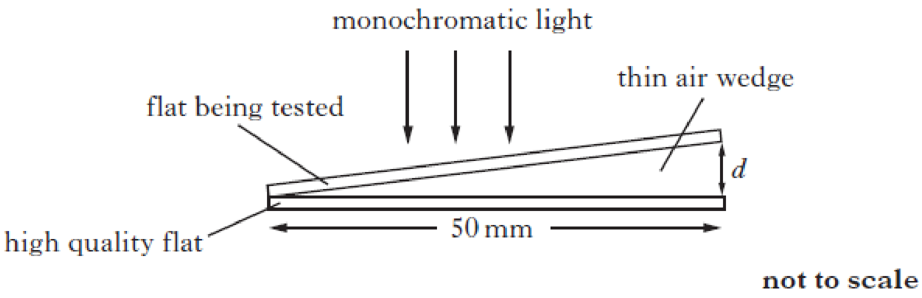

Figure 8A

The thickness d of the air wedge is $6{\cdot}2 \times 10^{-5}$ m.

Monochromatic light is used to illuminate the flats from above. When viewed from above using a travelling microscope, a series of interference fringes is observed as shown in Figure 8B.

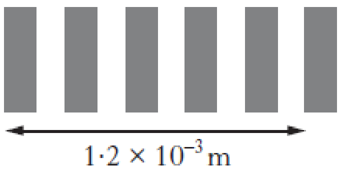

Figure 8B

Calculate the wavelength of the monochromatic light. **3**

(*b*) A second flat is tested using the same method as in part (*a*). This flat is slightly curved as shown in Figure 8C.

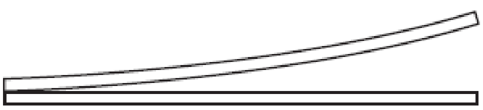

Figure 8C

Draw the fringe pattern observed. **1**

8. (continued)

(*c*) Good quality optical flats often have a non-reflecting coating of magnesium fluoride applied to the surface as shown in Figure 8D.

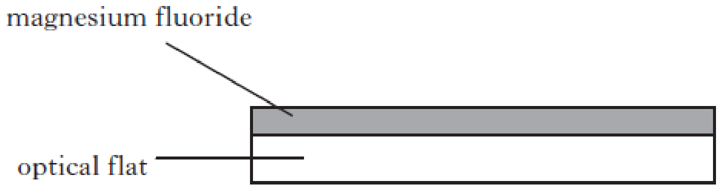

Figure 8D

(i) With the aid of a diagram explain fully how the coating reduces reflections from the flat for monochromatic light. **2**

(ii) Calculate the minimum thickness of magnesium fluoride required to make the flat non-reflecting for yellow light from a sodium lamp. **2**

(8)

Revised AH Physics 2014

9. A series of coloured LEDs are used in the Young's slit experiment as shown in Figure 9. The distance from the slits to the screen is (2·50 ± 0·05)m. The slit separation is $(3{\cdot}0 \pm 0{\cdot}1) \times 10^{-4}$ m.

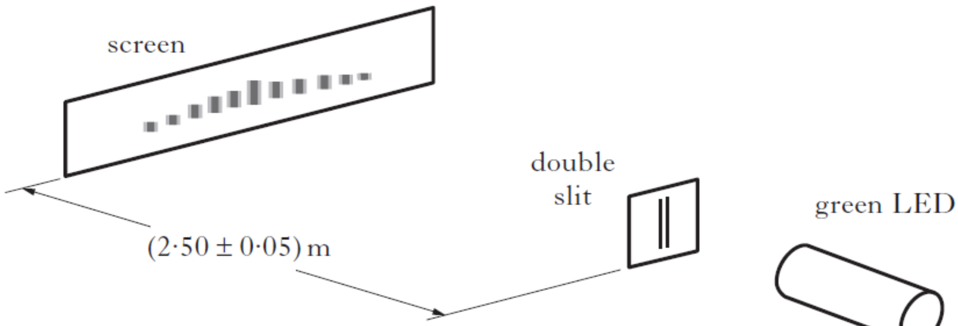

Figure 9

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**

(6)

10. (*a*) When sunlight hits a thin film of oil floating on the surface of water, a complex pattern of coloured fringes is observed.

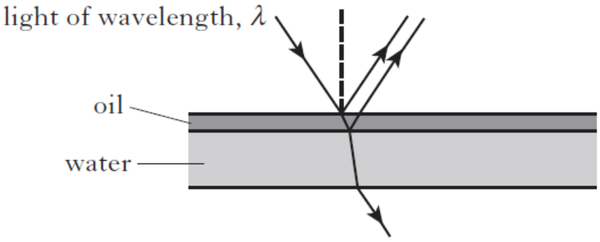

Figure 10

Explain how these fringes are formed. **2**

(*b*) The surface of a lens is coated with a thin film of magnesium fluoride.

Calculate the minimum thickness required to make the lens non-reflecting at a wavelength of 555 nm. **2**

(*c*) The lens of a digital camera appears to be purple in white light.

Explain this observation. **2**

(6)

8. A student carries out a Young's double slit experiment in order to determine the wavelength of monochromatic red light.

The student uses the apparatus shown in Figure 8 to produce an interference pattern on the screen.

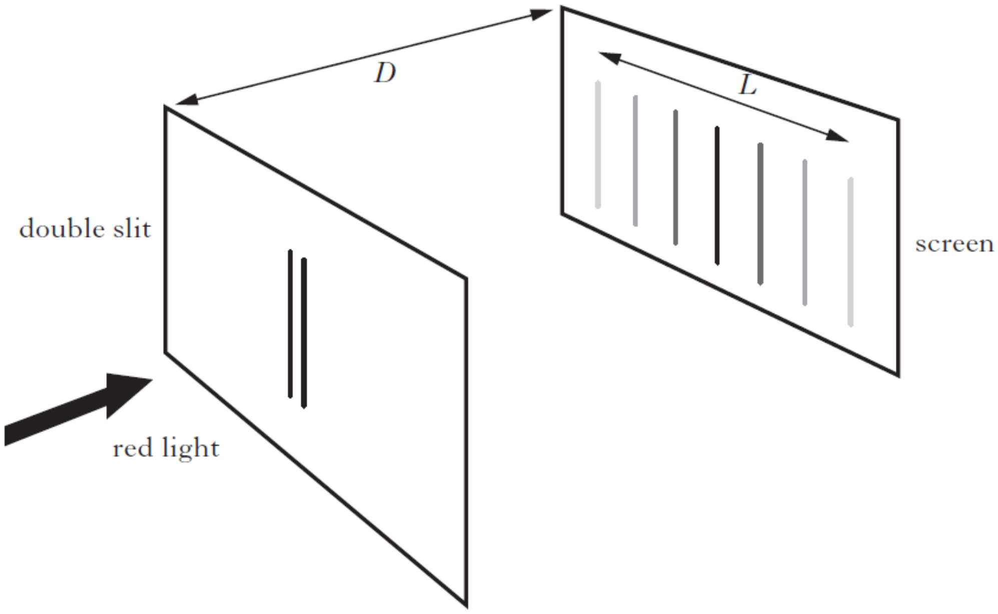

Figure 8

The double slit separation d is measured using a travelling microscope. The distance D between the double slit and the screen is measured using a steel measuring tape. The length L of the interference pattern is measured using a plastic ruler.

The student records the following data.

$D = (4 \cdot 250 \pm 0 \cdot 005)\,\text{m}$
$L = (67 \pm 2)\,\text{mm}$
$d = (0 \cdot 25 \pm 0 \cdot 01)\,\text{mm}$

(*a*) (i) State why it is possible to produce an interference pattern using only a single light source. **1**

(ii) Calculate the wavelength of the light from the source. **3**

(iii) Calculate the absolute uncertainty in the wavelength. **3**

(*b*) The student repeats the experiment with the same apparatus but uses a monochromatic blue light source. D remains fixed.

State the effect this will have on the percentage uncertainty in the calculated value for the wavelength of the blue light.

You must justify your answer. **2**

(9)

10. The internal structure of some car windscreens produces an effect which can be likened to that obtained by slits in a grating.

A passenger in a car observes a distant red traffic light and notices that the red light is surrounded by a pattern of bright spots.

This is shown in Figure 10A.

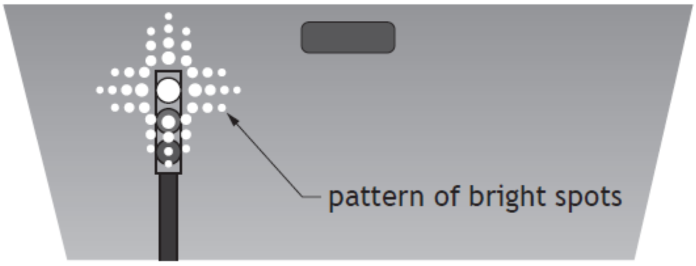

Figure 10A

(a) Explain how the **two-dimensional** pattern of bright spots shown in Figure 10A is produced. **2**

(b) The traffic light changes to green. Apart from colour, state a difference that would be observed in the pattern of bright spots.

Justify your answer. **2**

(c) An LED from the traffic light is tested to determine the wavelength by shining its light through a set of Young's double slits, as shown in Figure 10B.

The fringe separation is $(13{\cdot}0 \pm 0{\cdot}5)$ mm and the double slit separation is $(0{\cdot}41 \pm 0{\cdot}01)$ mm.

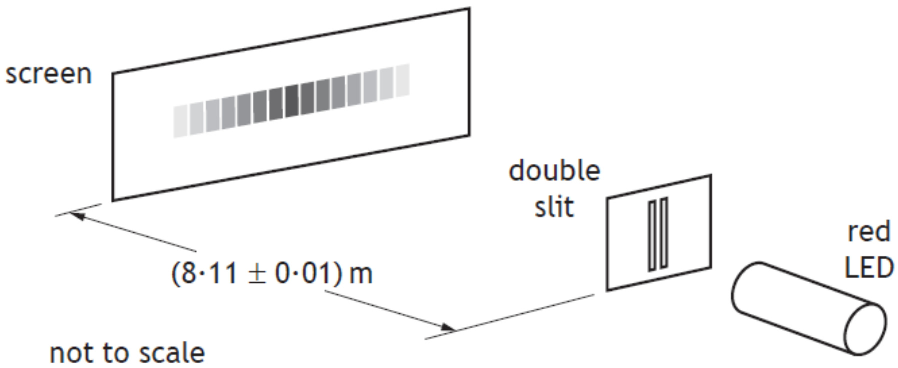

Figure 10B

(i) Calculate the wavelength of the light from the LED. **3**

10. (c) (continued)

(ii) Determine the absolute uncertainty in this wavelength. **5**

(iii) The experiment is now repeated with the screen moved further away from the slits.

Explain why this is the most effective way of reducing the uncertainty in the calculated value of the wavelength. **1**