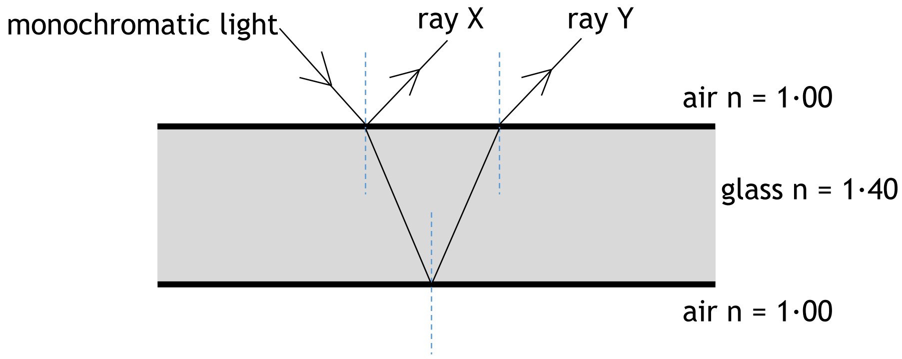
Homework – Interference

1. A source of monochromatic light is used to create an interference pattern.

(a) In order to create an interference pattern, two rays of light must be coherent.

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

Monochromatic light is directed towards a glass slide as shown in the diagram below. The glass has a refractive index of 1·40 for the frequency of light used.



Ray Y has travelled further than ray X.

(ii) State the relationship between the path difference and the optical path difference between the rays.

(iii) In terms of optical path difference, state the conditions for:

(A) Constructive interference of rays X and Y;

(B) Destructive interference of rays X and Y.

A glass slide, set up as shown in the diagram above, is observed at near normal incidence. Constructive interference is observed.

The glass slide is now placed on the surface of a liquid of refractive index greater than 1·40. Destructive interference is now observed at near normal incidence.

(iv) Explain this observed change.

(b) Good quality lenses reflect very little light.

A thing coating of magnesium fluoride on the surface of a lens reduces reflection.

(i) Explain briefly why this coating reduces reflection.

(ii) Calculate the thickness of magnesium fluoride that minimises reflection for light of wavelength 550 nm.

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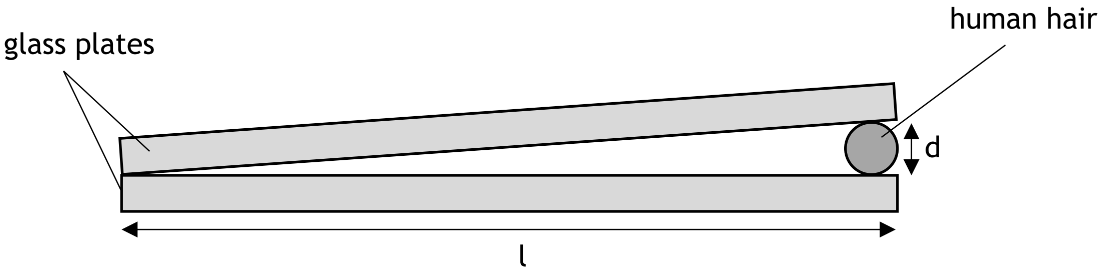
2. An air wedge is formed between two flat glass plates of length l, which are in contact at one end. They are separated by a human of diameter d at the other end, as shown in the diagram below.



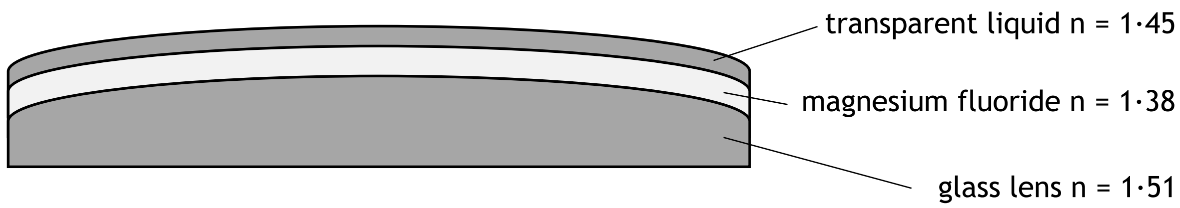
(a) The air wedge is illuminated from above by a monochromatic light source of wavelength λ. When viewed from above a series of interference fringes of separation Δx is observed.

The wavelength of the monochromatic light is 589 nm, the length of the glass plates is 75 mm and the separation between two adjacent dark fringes is $3{\cdot}4 \times 10^{-4}$ m.

Calculate the diameter of the human hair.

(b) A camera lens can be made non-reflecting by coating it with a thin layer of magnesium fluoride.

The lens has a thin film of transparent liquid placed on its surface as shown in the diagram below. The refractive index of the liquid is 1·45.

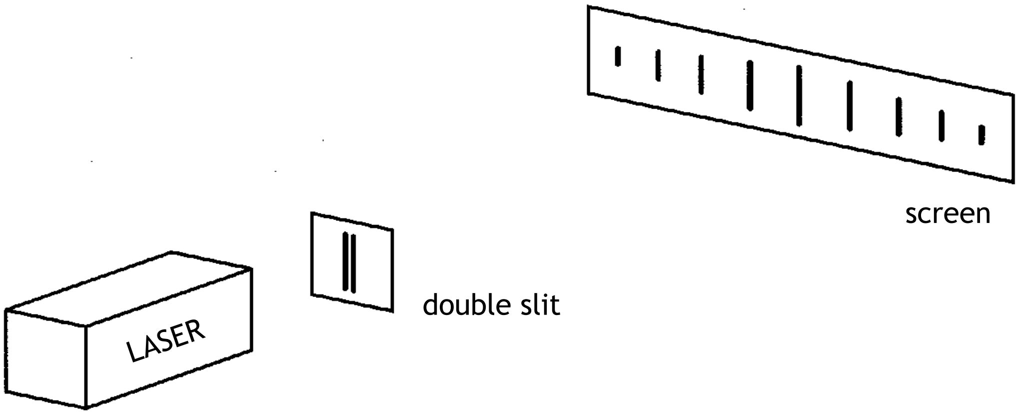


Explain why the coating is no longer non-reflective.

(c) Explain why coloured fringes can be observed when a thin film of oil forms on a puddle of water.

Homework – Interference

3. A pupil sets up a Young's slits experiment in order to measure the wavelength of monochromatic light emitted by a laser. The light from the laser passes through a double slit before reaching a screen, where a pattern of light and dark fringes is seen, as shown in the diagram below.



(a) The pupils records the following measurements:

double slit separation	(0·25 $\pm$ 0·01) mm
distance between double slits and screen	(3·91 $\pm$ 0·01) m
distance between two adjacent bright fringes	(8·0 $\pm$ 0·5) mm

(i) Calculate the wavelength of the laser light.

(ii) Show that the absolute uncertainty in the calculated wavelength is $\pm$ 4 x 10^{-8} m.

(iii) State why an answer of $\pm$ 3·78 x 10^{-8} m for part (a) (ii) would **not** be acceptable.

(b) The pupil now measures the distance between 9 bright fringes (8 spaces).

The result is

distance between 9 bright fringes (8 spaces)	(64·0 $\pm$ 0·5) mm

Calculate the new absolute uncertainty in wavelength, assuming the other measurements remain unchanged.

(c) The pupil then suggests that measuring the distance between 12 bright fringes would significantly reduce the absolute uncertainty in the wavelength.

(i) Explain why this is **not** correct.

(ii) State which measurement must be made more accurately to reduce significantly the absolute uncertainty in the wavelength.

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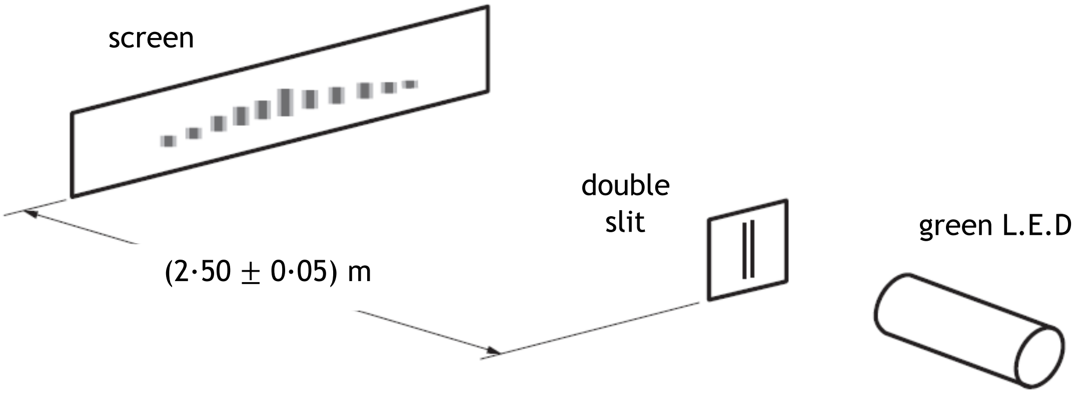
4. A series of coloured L.E.D.s are used in Young's slit experiment as shown in the diagram below. The distance from the slits to the screen is (2·50 ± 0·05) m. The slit separation is (3·0 ± 0·1) x 10^{-4} m.



colour of L.E.D.	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.

(b) Using the information given from the passage, diagram and table:

(i) Calculate the fringe separation observed on the screen when the green L.E.D. is used.

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