

Third exercise: (7 ½ points)

Diffraction and interference of light

A laser source emits a monochromatic cylindrical beam of light of wavelength $\lambda = 640 \text{ nm}$ in air.

A – Diffraction

This beam falls normally on a vertical screen (P) having a horizontal slit F_1 of width a . The phenomenon of diffraction is observed on a screen (E) parallel to (P) and situated at a distance $D = 4 \text{ m}$ from (P).

Consider on (E) a point M so that M coincides with the second dark fringe counted from O, the center of the central bright fringe. $\text{OIM} = \theta$ (θ is very small) is the angle of diffraction corresponding to the second dark fringe (Fig. 1).

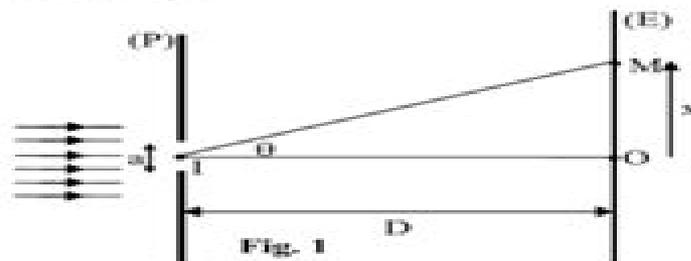


Fig. 1

- 1) Write the expression of θ in terms of a and λ .
- 2) Determine the expression of $\text{OM} = x$ in terms of a , D and λ .
- 3) Determine the value of a if $\text{OM} = 1.28 \text{ cm}$.
- 4) We replace the slit F_1 by another slit F_1' of width 100 times larger than that of F_1 . What do we observe on the screen (E)?

B – Interference

We cut in (P) another slit F_2 identical and parallel to F_1 so that the distance $F_1F_2 = a' = 1 \text{ mm}$. The laser beam falls normally on the two slits F_1 and F_2 . We observe on (E) a system of interference fringes.

O' is the orthogonal projection of the midpoint I' of F_1F_2 on (E) (Fig. 2).

- 1) a) Due to what is the phenomenon of interference?
b) Describe the fringes observed on (E).
- 2) Consider a point N on (E) so that $\text{O'N} = x$.
a) Write the expression of the optical path difference $\delta = F_2N - F_1N$ in terms of a' , x and D .
b) If N is the center of a dark fringe of order k , write the expression of the optical path difference δ at N in terms of λ and k .
c) Deduce the expression of x in terms of a' , D , k and λ .
d) Knowing that the interfringe distance i is the distance between the centers of two consecutive dark fringes, deduce then the expression of i in terms of λ , D and a' .

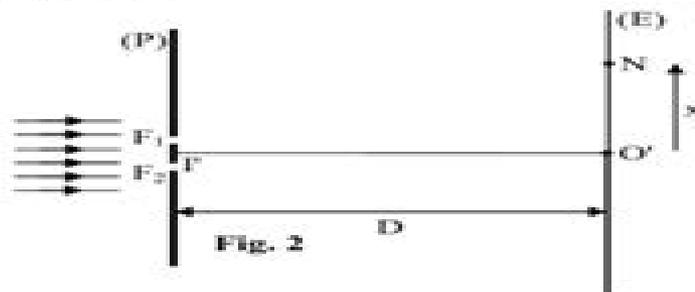


Fig. 2

- 3) The whole set up of figure 2 is immersed in water of index of refraction n .
a) i) The interfringe distance i varies and becomes i' . Why?
ii) Show that $i' = \frac{i}{n}$.
b) We move (E) parallel to (P) and away from it by a distance $d = \frac{4}{3} \text{ m}$. We notice that the interfringe distance takes again the initial value i . Deduce then the value of n .

31 Diffraction And Interference Exercise Answers

Konrad Bates Krauskopf, Arthur Beiser

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