

Third exercise: (7 ½ points)

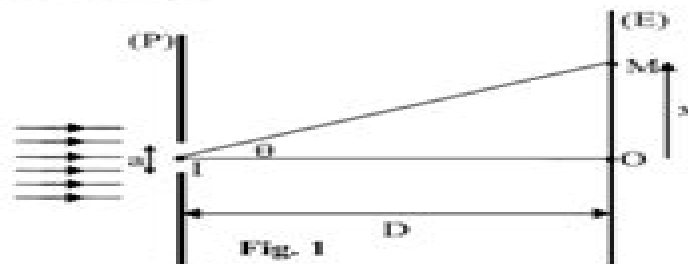
Diffraction and interference of light

A laser source emits a monochromatic cylindrical beam of light of wavelength $\lambda = 640$ 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 $D = 4$ 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. $OM = \theta$ (θ is very small) is the angle of diffraction corresponding to the second dark fringe (Fig. 1).



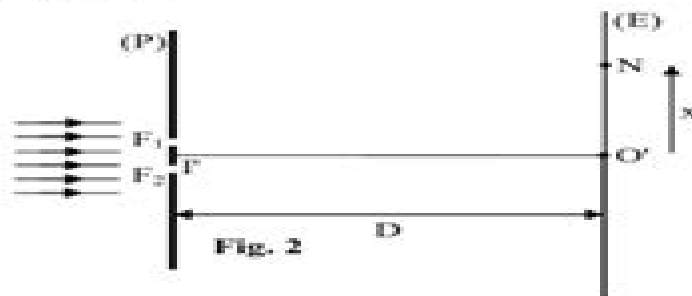
- 1) Write the expression of θ in terms of a and λ .
- 2) Determine the expression of $OM = x$ in terms of a , D and λ .
- 3) Determine the value of a if $OM = 1.28$ cm.
- 4) We replace the slit F_1 by another slit F_1' of width 100 times larger than that of F_1 . What do we observe on the screen (E)?

B – Interference

We cut in (P) another slit F_2 identical and parallel to F_1 so that the distance $F_1F_2 = a' = 1$ 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 $O'N = x$.
 - 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' .
- 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 $d = \frac{4}{3}$ 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

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