

Third exercise: (7 ½ points)

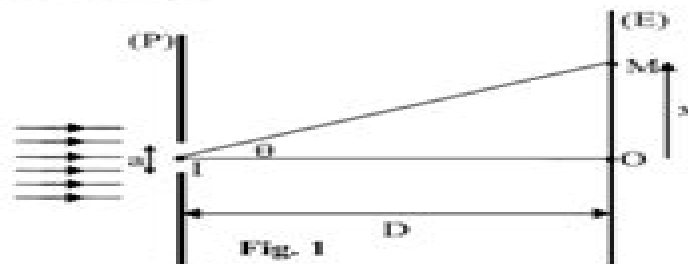
Diffraction and interference of light

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).



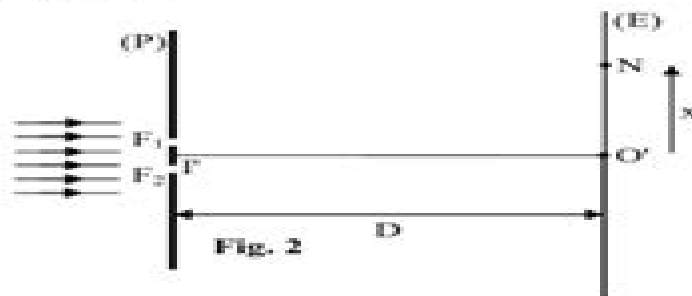
- 1) Write the expression of θ in terms of a and λ .
- 2) Determine the expression of $OM = x$ in terms of a , D and λ .
- 3) Determine the value of a if $OM = 1.28$ cm.
- 4) We replace the slit F_1 by another slit F_1' of width 100 times larger than that of F_1 . What do we observe on the screen (E)?

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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Table of Contents 31 Diffraction And Interference Exercise Answers

1. Understanding the eBook 31 Diffraction And Interference Exercise Answers
 - The Rise of Digital Reading 31 Diffraction And Interference Exercise Answers
 - Advantages of eBooks Over Traditional Books
2. Identifying 31 Diffraction And Interference Exercise Answers
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an 31 Diffraction And Interference Exercise Answers
 - User-Friendly Interface
4. Exploring eBook Recommendations from 31 Diffraction And Interference Exercise Answers
 - Personalized Recommendations
 - 31 Diffraction And Interference Exercise Answers User Reviews and Ratings
 - 31 Diffraction And Interference Exercise Answers and Bestseller Lists
5. Accessing 31 Diffraction And Interference Exercise Answers Free and Paid eBooks
 - 31 Diffraction And Interference Exercise Answers Public Domain eBooks
 - 31 Diffraction And Interference Exercise Answers eBook Subscription Services
 - 31 Diffraction And Interference Exercise Answers Budget-Friendly Options

6. Navigating 31 Diffraction And Interference Exercise Answers eBook Formats
 - ePub, PDF, MOBI, and More
 - 31 Diffraction And Interference Exercise Answers Compatibility with Devices
 - 31 Diffraction And Interference Exercise Answers Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of 31 Diffraction And Interference Exercise Answers
 - Highlighting and Note-Taking 31 Diffraction And Interference Exercise Answers
 - Interactive Elements 31 Diffraction And Interference Exercise Answers
8. Staying Engaged with 31 Diffraction And Interference Exercise Answers
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers 31 Diffraction And Interference Exercise Answers
9. Balancing eBooks and Physical Books 31 Diffraction And Interference Exercise Answers
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection 31 Diffraction And Interference Exercise Answers
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine 31 Diffraction And Interference Exercise Answers
 - Setting Reading Goals 31 Diffraction And Interference Exercise Answers
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of 31 Diffraction And Interference Exercise Answers
 - Fact-Checking eBook Content of 31 Diffraction And Interference Exercise Answers
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
 - Integration of Multimedia Elements

- Interactive and Gamified eBooks

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