

Chapter 36 End-of-Chapter Problems

Halliday & Resnick, 10th Edition

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Hit me where it Matters

1 Problem 1

The distance between the first and fifth minima of a single-slit diffraction pattern is 0.35 mm with the screen 40 cm away from the slit, when light of wavelength 550 nm is used. (a) Find the slit width. (b) Calculate the angle θ of the first diffraction minimum.

1.1 Solution (a)

Estimate $\sin \theta \approx \theta \approx \tan \theta = \frac{y}{D}$. $D = 40$ cm and never changes in this case. y does change, so we can create a Δy .

$$a \sin \theta = a \frac{y}{D} = m\lambda \quad (1)$$

We can create a Δy on one side and Δm on the other, for a separation between the first and fifth fringes.

$$a \frac{y}{D} = m\lambda \quad (2)$$

$$a \frac{\Delta y}{D} = \Delta m \lambda \quad (3)$$

$$a = \frac{\Delta m}{\Delta y} \lambda D = \frac{4}{0.35 \text{ mm}} * 550 \text{ nm} * 0.4 \text{ m} = \boxed{2.51 \text{ mm}} \quad (4)$$

1.2 Solution (b)

Divide the distance between fringes by four.

$$\Delta y = \frac{0.35 \text{ mm}}{4} = 87.5 \times 10^{-6} \text{ m} \quad (5)$$

Divide this by the distance to the screen to find the approximate angle.

$$\theta = \frac{87.5 \times 10^{-6} \text{ m}}{0.4 \text{ m}} = \boxed{2.2 \times 10^{-4}} \quad (6)$$

2 Problem 5

A single slit is illuminated by light of wavelengths λ_a and λ_b , chosen so that the first diffraction minimum of the λ_a component coincides with the second minimum of the λ_b component. (a) If $\lambda_b = 350 \text{ nm}$, what is λ_a ? For what order number m_b (if any) does a minimum of the λ_b component coincide with the minimum of the λ_a component in the order number (b) $m_a = 2$ and (c) $m_a = 3$?

2.1 Solution (a)

We can define a relationship between y_a and y_b .

$$y_a = y_b \quad (7)$$

Approximating $\sin \theta \approx \theta \approx \tan \theta$, we have a relationship equation between y and λ for both a and b .

$$a \sin \theta = a \frac{y_a}{D} = m_a \lambda_a \quad (8)$$

$$a \frac{y_b}{D} = m_b \lambda_b \rightarrow y_a = y_b = \frac{m_b \lambda_b D}{a} \quad (9)$$

$$a \frac{\frac{m_b \lambda_b D}{a}}{D} = m_a \lambda_a = 2m_b \lambda_b \quad (10)$$

In this case, m_a would be equal to 1, while m_b would be equal to 2.

$$\lambda_a = 2\lambda_b = 2 * 350 \text{ nm} = \boxed{700 \text{ nm}} \quad (11)$$

2.2 Solution (b)

4

2.3 Solution (c)

6

3 Problem 9

3.1 Solution

4 Problem 13

4.1 Solution

5 Problem 15

5.1 Solution

6 Problem 19

6.1 Solution

7 Problem 21

7.1 Solution

8 Problem 37

8.1 Solution

9 Problem 39

9.1 Solution

10 Problem 45

10.1 Solution

11 Problem 47

11.1 Solution

12 Problem 49

12.1 Solution

13 Problem 59

13.1 Solution

14 Problem 63

14.1 Solution

15 Problem 65

15.1 Solution

16 Problem 69

16.1 Solution

17 Problem 75

17.1 Solution

18 Problem 77

18.1 Solution

19 Problem 93

19.1 Solution

Contents

1	Problem 1	2
1.1	Solution (a)	2
1.2	Solution (b)	2
2	Problem 5	3
2.1	Solution (a)	3
2.2	Solution (b)	3
2.3	Solution (c)	3
3	Problem 9	4
3.1	Solution	4
4	Problem 13	5
4.1	Solution	5
5	Problem 15	6
5.1	Solution	6
6	Problem 19	7
6.1	Solution	7
7	Problem 21	8
7.1	Solution	8
8	Problem 37	9
8.1	Solution	9
9	Problem 39	10
9.1	Solution	10
10	Problem 45	11
10.1	Solution	11
11	Problem 47	12
11.1	Solution	12
12	Problem 49	13
12.1	Solution	13

13 Problem 59	14
13.1 Solution	14
14 Problem 63	15
14.1 Solution	15
15 Problem 65	16
15.1 Solution	16
16 Problem 69	17
16.1 Solution	17
17 Problem 75	18
17.1 Solution	18
18 Problem 77	19
18.1 Solution	19
19 Problem 93	20
19.1 Solution	20