## 14-3 Diffraction and Interference

## Vocabulary Diffraction: The spreading of a wave as it passes around an obstacle or through an opening.

Vocabulary Interference: When two waves overlap to produce one new wave.
In 1801, Thomas Young attempted to prove that light was a wave by showing that it has the ability to diffract and interfere. Young passed white light through two closely-spaced slits and noticed that the light spread out as it passed through the openings (diffracted), and overlapped on a screen a few meters away (interfered), to produce alternating bands of light and dark.


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Whether light is passed through two slits or through the multiple, closelyspaced slits of a diffraction grating, the grating equation can be written as

$$
\text { wavelength }=\frac{(\text { slit separation })(\text { space between bright bands })}{(\text { distance from slits to screen })} \text { or } \lambda=\frac{d x}{L}
$$

This equation is a good approximation when the angular separation between the bright bands is very small. When used with a diffraction grating, however, it could produce an answer with as much as $10 \%$ error. Nevertheless, to simplify calculations and avoid the use of trigonometry, the equation will be used in this form in all exercises.

The common unit for the wavelength of light is the nanometer ( $\mathbf{n m}$ ), which equals $10^{-9} \mathrm{~m}$.

## Solved Examples

Example 8: Miss McGillivray loses the specifications for her diffraction grating and must recalibrate it in order to determine the grating spacing. She shines a red helium-neon laser, whose wavelength is 633 nm , through the grating. Two bright spots that are each 1.40 m from the central maximum fall on the wall 4.00 m away. What is the space between the grooves on the diffraction grating?

Solution: First, convert nm to $\mathrm{m} . \quad 633 \mathrm{~nm}=6.33 \times 10^{-7} \mathrm{~m}$

$$
\text { Given: } \begin{array}{rlr}
\lambda=6.33 \times 10^{-7} \mathrm{~m} & \text { Unknown: } d=? \\
L & =4.00 \mathrm{~m} & \text { Original equation: } \lambda=\frac{d x}{L} \\
x=1.40 \mathrm{~m} &
\end{array}
$$

Solve: $d=\frac{\lambda L}{x}=\frac{\left(6.33 \times 10^{-7} \mathrm{~m}\right)(4.00 \mathrm{~m})}{1.40 \mathrm{~m}}=\mathbf{1 . 8 1} \times \mathbf{1 0}^{\mathbf{- 6}} \mathbf{~ m}$
Example 9: In the previous exercise, Miss McGillivray uses her newly calibrated grating to determine the wavelength of a green helium-neon laser. Keeping the laser at the same distance from the wall as before, the distance from the central maximum to the first bright fringe is 1.20 m . What is the wavelength of the green HeNe laser?

Given: $d=1.81 \times 10^{-6} \mathrm{~m}$
Unknown: $\lambda=$ ?
Original equation: $\lambda=\frac{d x}{L}$

$$
\begin{aligned}
& L=4.00 \mathrm{~m} \\
& x=1.20 \mathrm{~m}
\end{aligned}
$$

Solve: $\lambda=\frac{d x}{L}=\frac{\left(1.81 \times 10^{-6} \mathrm{~m}\right)(1.20 \mathrm{~m})}{4.00 \mathrm{~m}}=5.43 \times 10^{-7} \mathrm{~m}=543 \mathrm{~nm}$

## Practice Exercises

Exercise 13: Judy and Earl are sitting under the boardwalk one warm summer evening while the light of a low-pressure sodium vapor lamp whose wavelength is 589 nm passes through two small cracks in a board, producing fringes of light 0.0020 m apart on the ground. a) If the boardwalk is 3.0 m above the sand, what is the distance between the two cracks in the board? b) If the distance between the cracks were smaller, would the fringes of light on the ground be closer together or farther apart?

Answer: a. $\qquad$
Answer: b.
Exercise 14: Two large speakers broadcast the sound of a band tuning up before an outdoor concert. While the band plays an A whose wavelength is 0.773 m , Brenda walks to the refreshment stand along a line parallel to the speakers. If the speakers are separated by 12.0 m and Brenda is 24.0 m away, how far must she walk between the "loudspots"?

Answer: $\qquad$
Exercise 15: In an attempt to test the particle nature of matter, Claus Jönsson performed an experiment in 1961 that was very similar to Young's Double Slit experiment for light done in 1801. Jönsson sent a beam of electrons through two slits separated by $2.00 \times 10^{-6} \mathrm{~m}$ onto a fluorescent screen 0.200 m away. Due to their high speed, the electrons behaved like waves with a wavelength of $2.40 \times 10^{-11} \mathrm{~m}$. How far apart were the bright lines formed on the screen?

Answer: $\qquad$

# 13. <br> 15. $2.4 \times 10^{-6} \mathrm{~m}$ 

