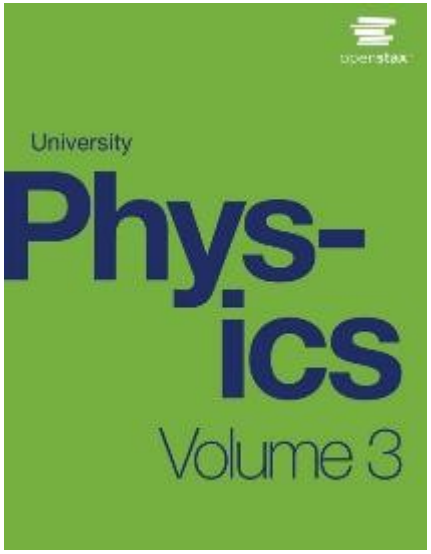
UNIVERSITY PHYSICS

Chapter 3 INTERFERENCE

PowerPoint Image Slideshow



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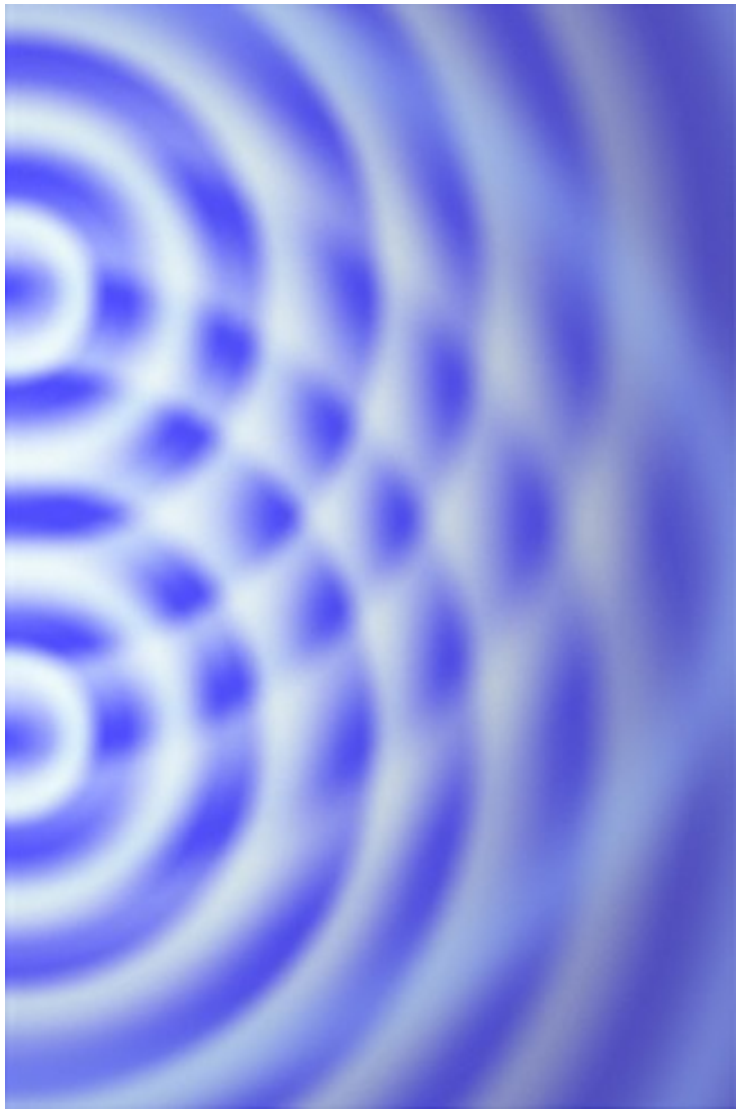
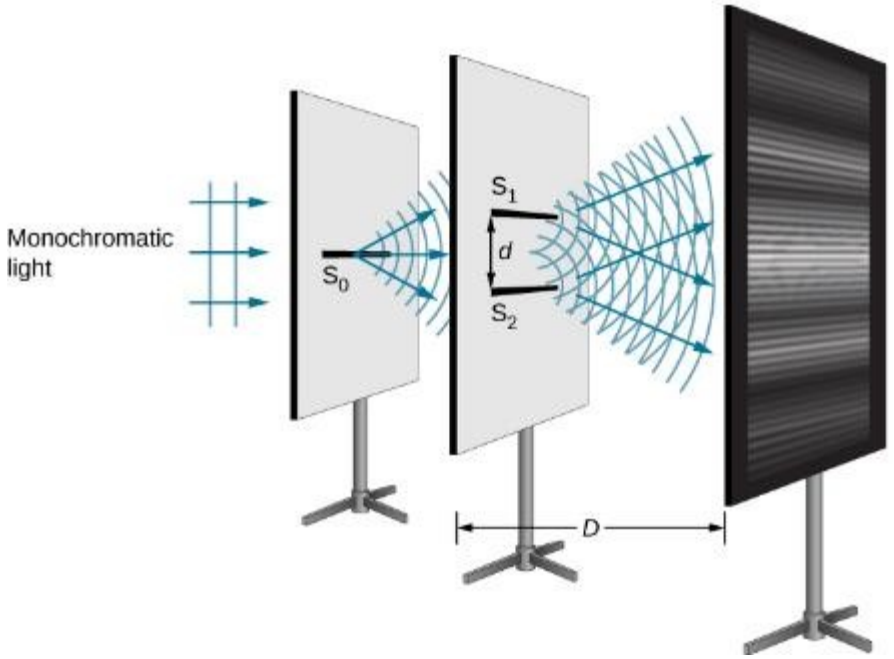
Introduction

FIGURE 3.2



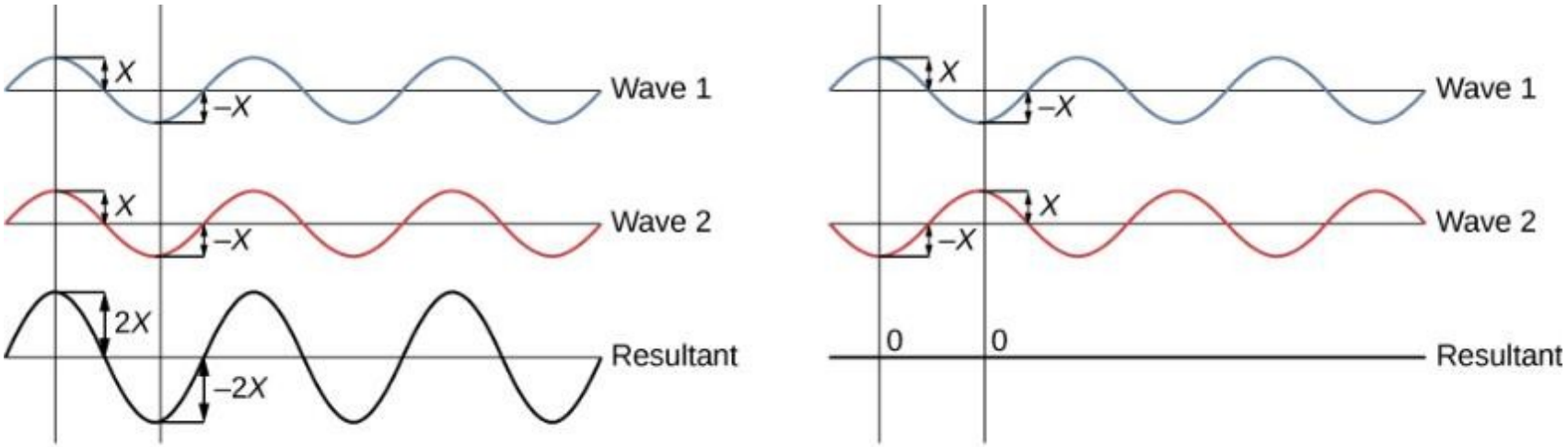
Photograph of an interference pattern produced by circular water waves in a ripple tank. Two thin plungers are vibrated up and down in phase at the surface of the water. Circular water waves are produced by and emanate from each plunger.

FIGURE 3.3



The double-slit interference experiment using monochromatic light and narrow slits. Fringes produced by interfering Huygens wavelets from slits S_1 and S_2 are observed on the screen.

FIGURE 3.4



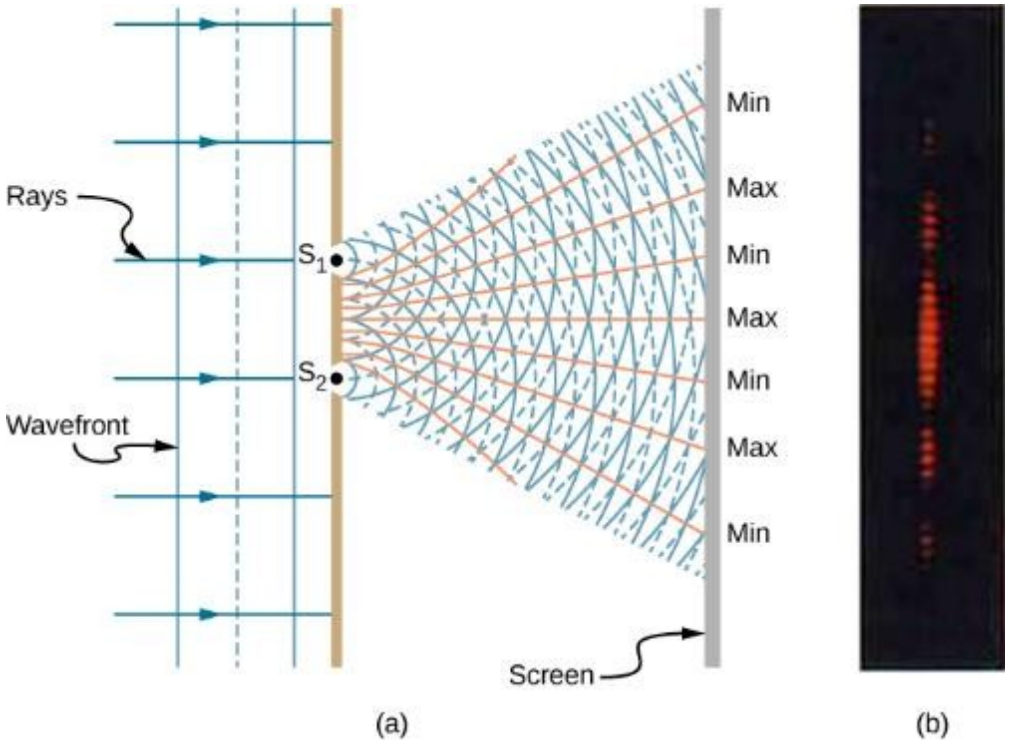
The amplitudes of waves add.

a) Pure constructive interference is obtained when identical waves are in phase.

b) Pure destructive interference occurs when identical waves are exactly out of phase, or shifted by half a wavelength.

Double slit

FIGURE 3.5



Double slits produce two coherent sources of waves that interfere.

a) Light spreads out (diffracts) from each slit, because the slits are narrow. These waves overlap and interfere constructively (bright lines) and destructively (dark regions). We can only see this if the light falls onto a screen and is scattered into our eyes.

b) When light that has passed through double slits falls on a screen, we see a pattern such as this.

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FIGURE 3.6

Waves follow different paths from the slits to a common point *P* on a screen. Destructive interference occurs where one path is a half wavelength longer than the other—the waves start in phase but arrive out of phase. Constructive interference occurs where one path is a whole wavelength longer than the other—the waves start out and arrive in phase.

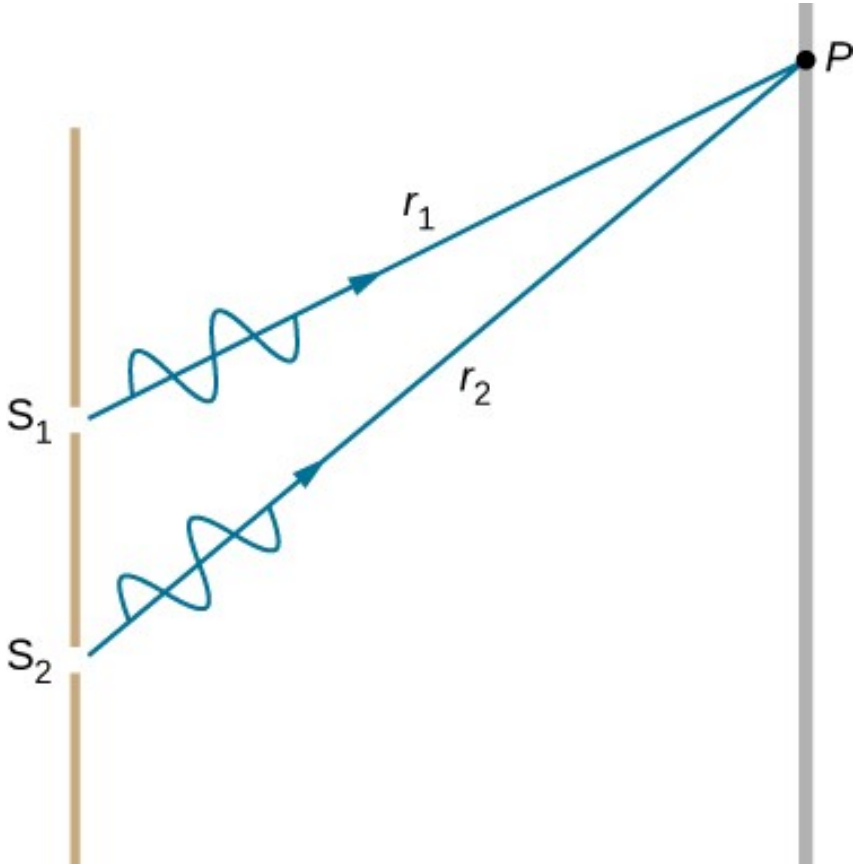
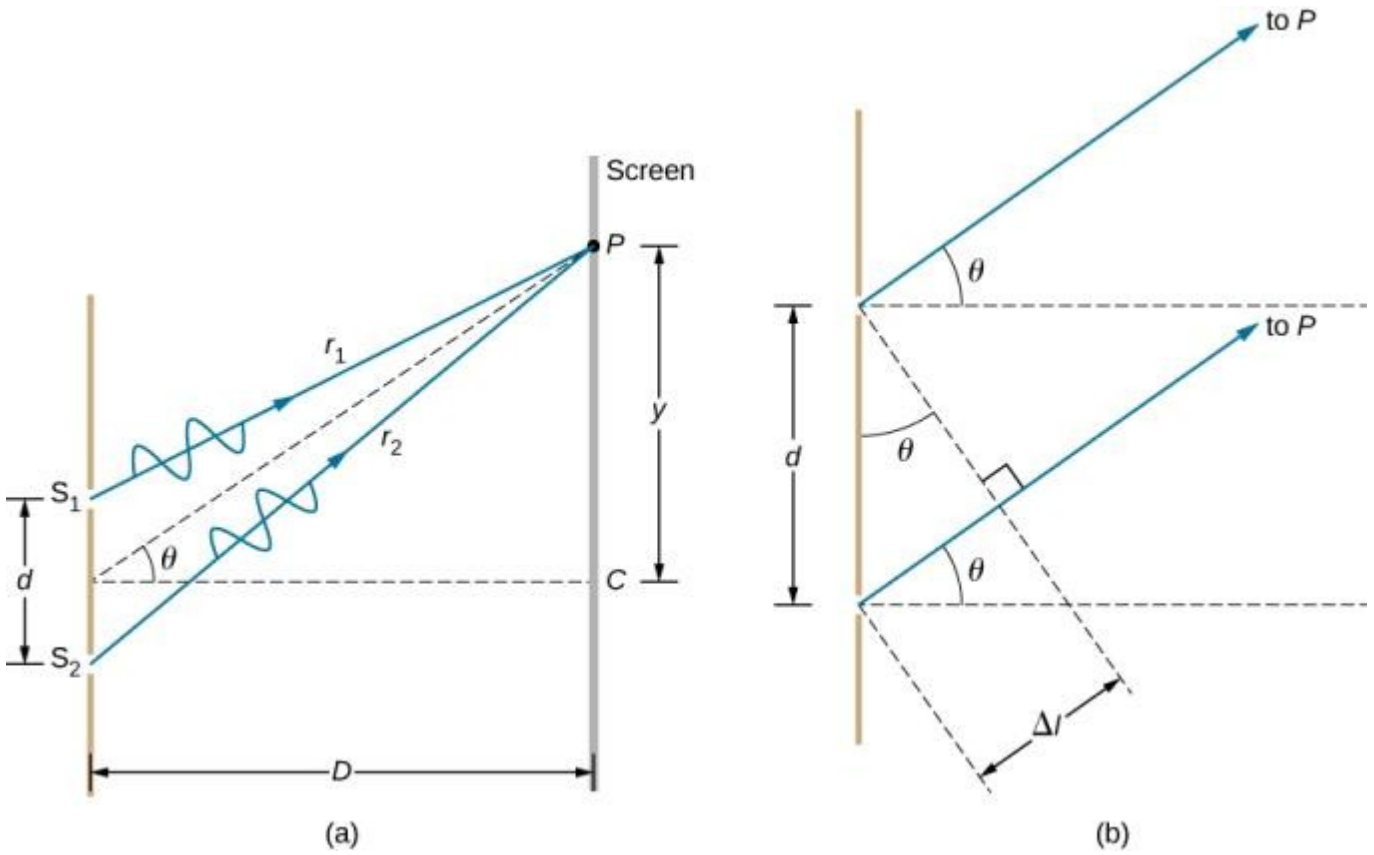


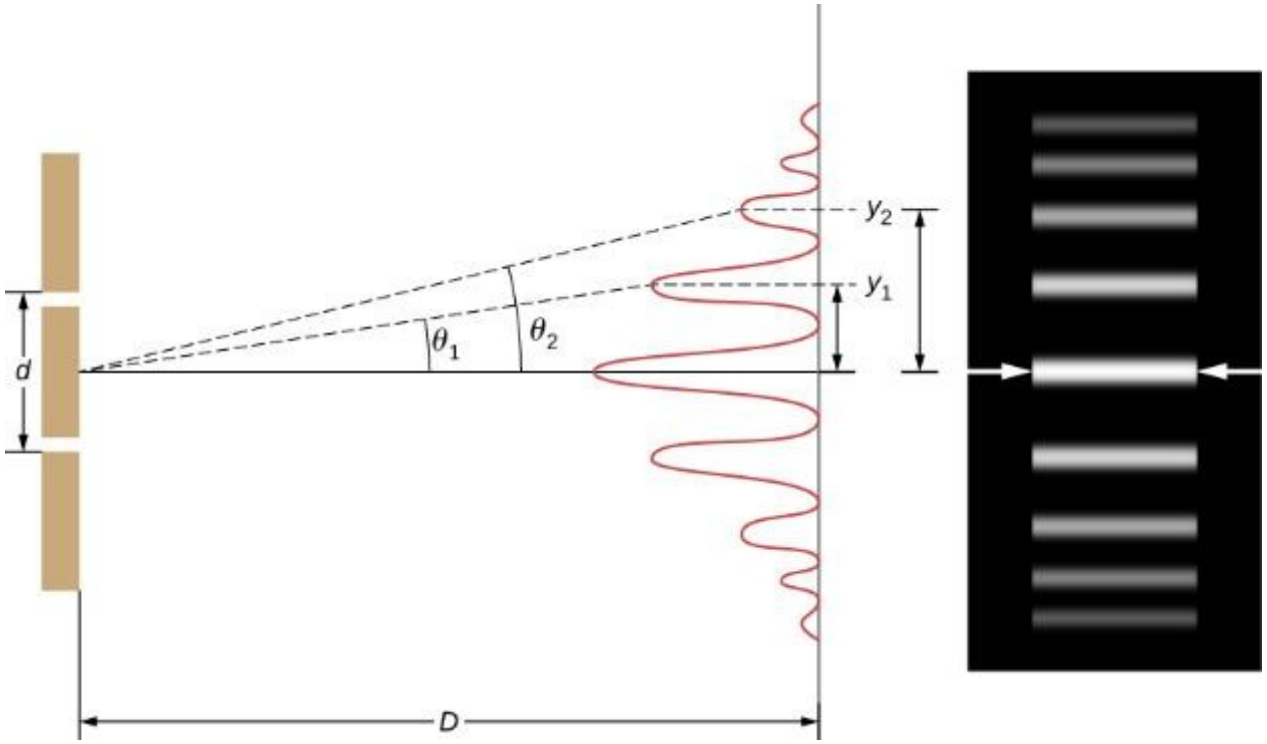
FIGURE 3.7



a) To reach *P*, the light waves from S_1 and S_2 must travel different distances.

b) The path difference between the two rays is Δl.

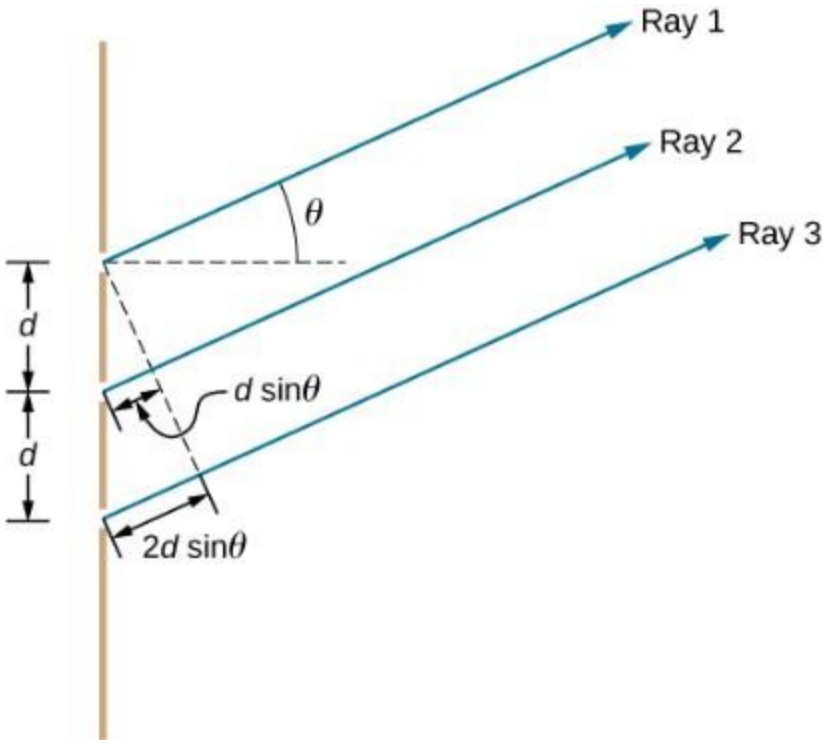
FIGURE 3.8



The interference pattern for a double slit has an intensity that falls off with angle. The image shows multiple bright and dark lines, or fringes, formed by light passing through a double slit.

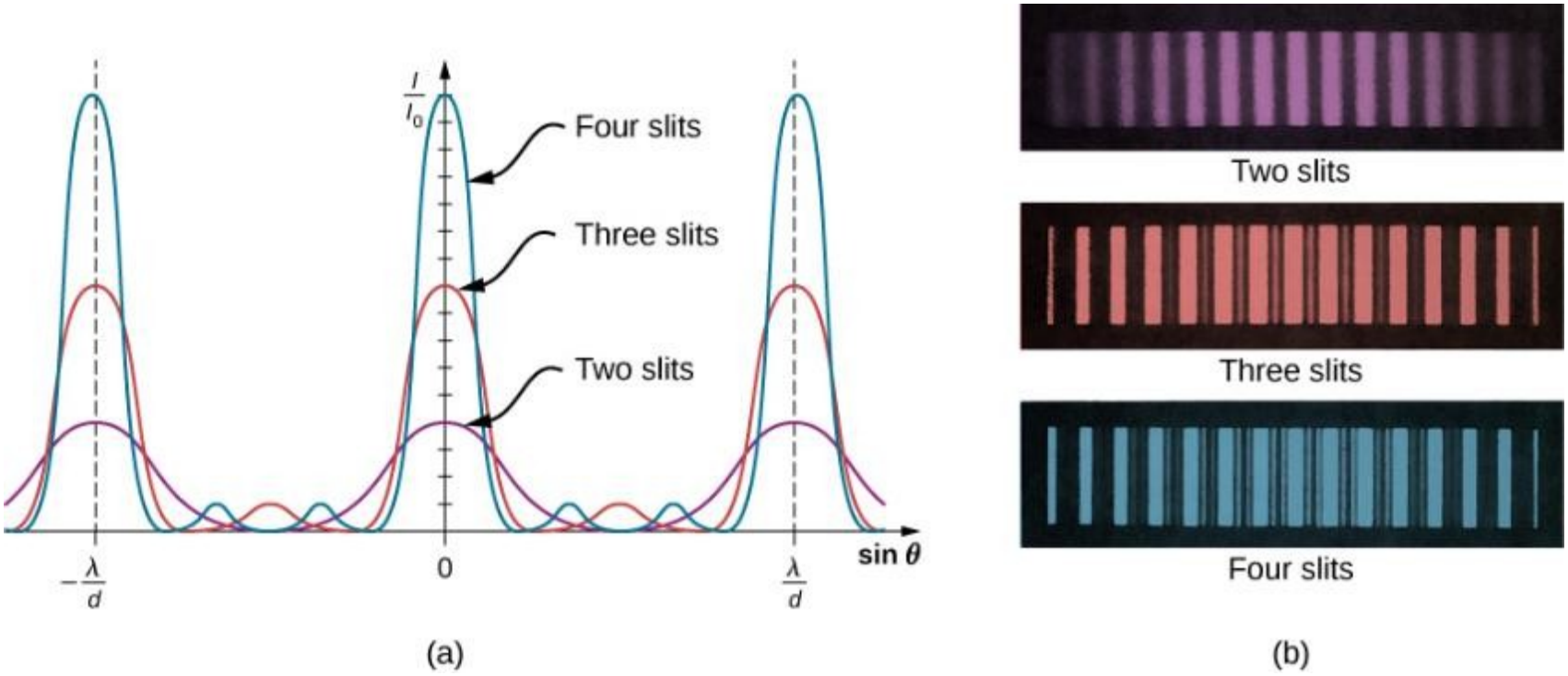
More slits

FIGURE 3.9



Interference with three slits. Different pairs of emerging rays can combine constructively or destructively at the same time, leading to secondary maxima.

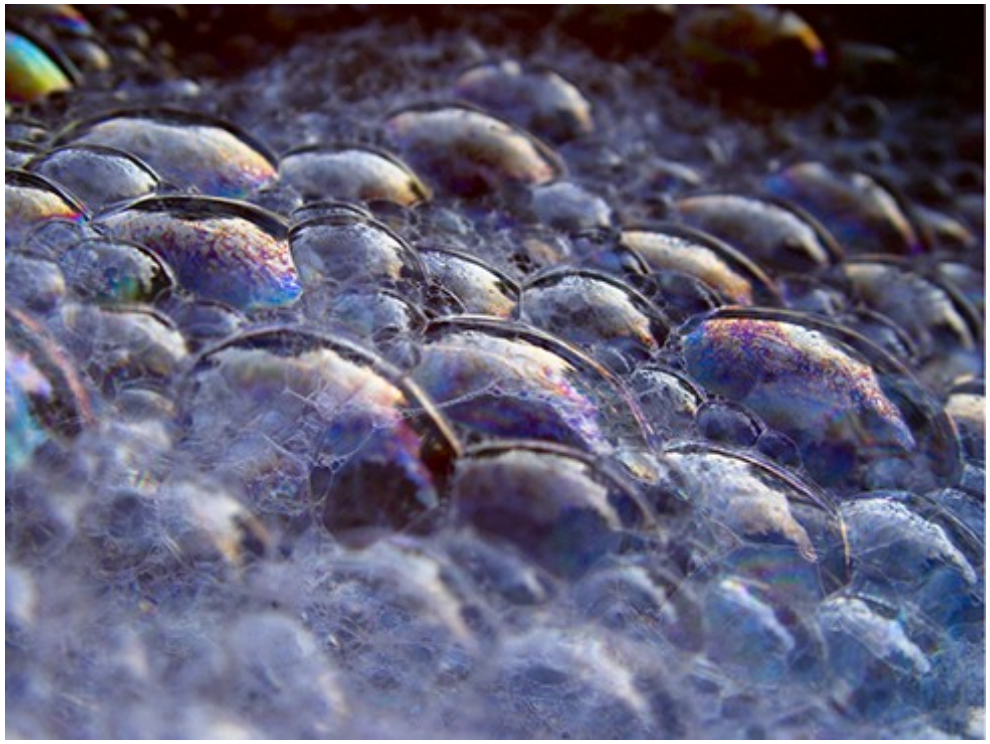
FIGURE 3.10



Interference fringe patterns for two, three and four slits. As the number of slits increases, more secondary maxima appear, but the principal maxima become brighter and narrower. (a) Graph and (b) photographs of fringe patterns.

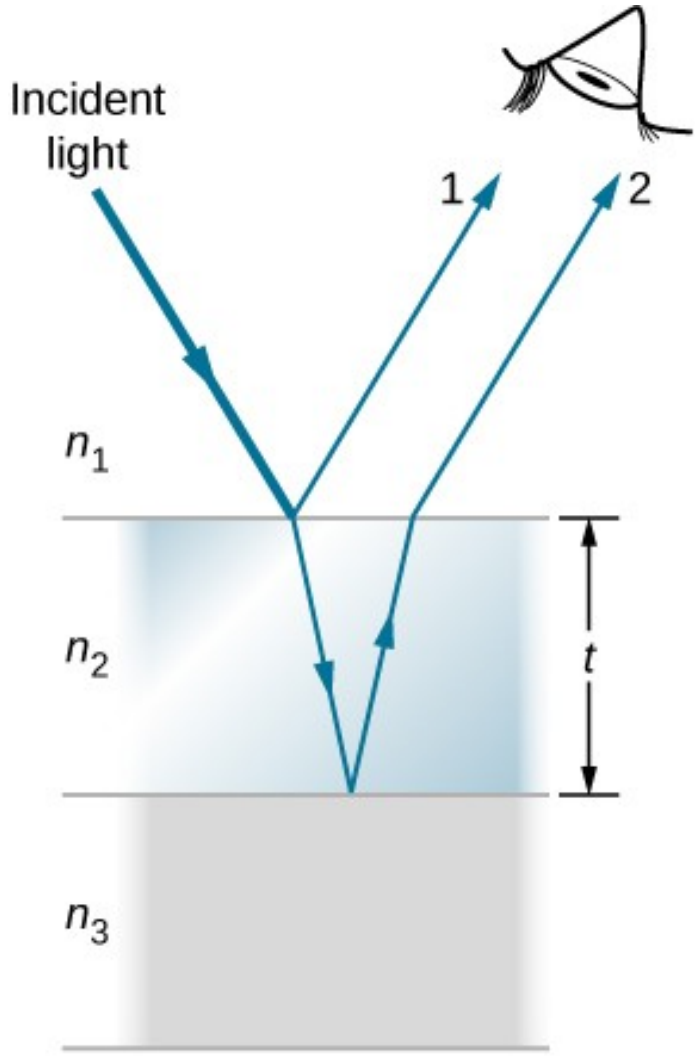
Thin films

FIGURE 3.11



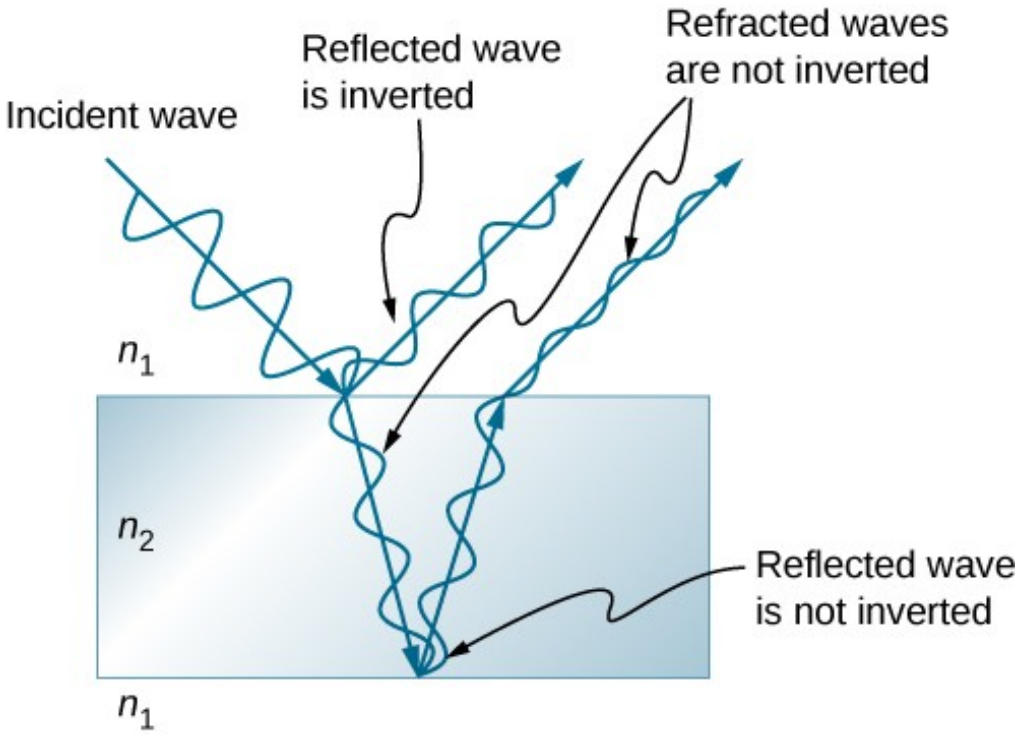
These soap bubbles exhibit brilliant colors when exposed to sunlight. (credit: Scott Robinson)

FIGURE 3.12



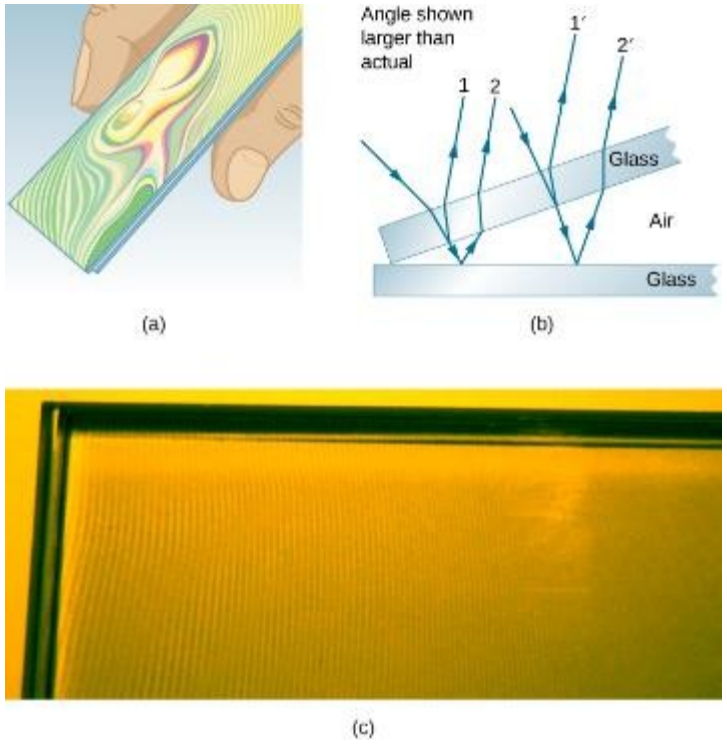
Light striking a thin film is partially reflected (ray 1) and partially refracted at the top surface. The refracted ray is partially reflected at the bottom surface and emerges as ray 2. These rays interfere in a way that depends on the thickness of the film and the indices of refraction of the various media.

FIGURE 3.13



Reflection at an interface for light traveling from a medium with index of refraction n_1 to a medium with index of refraction n_2, $n_1 < n_2$, causes the phase of the wave to change by π radians.

FIGURE 3.14

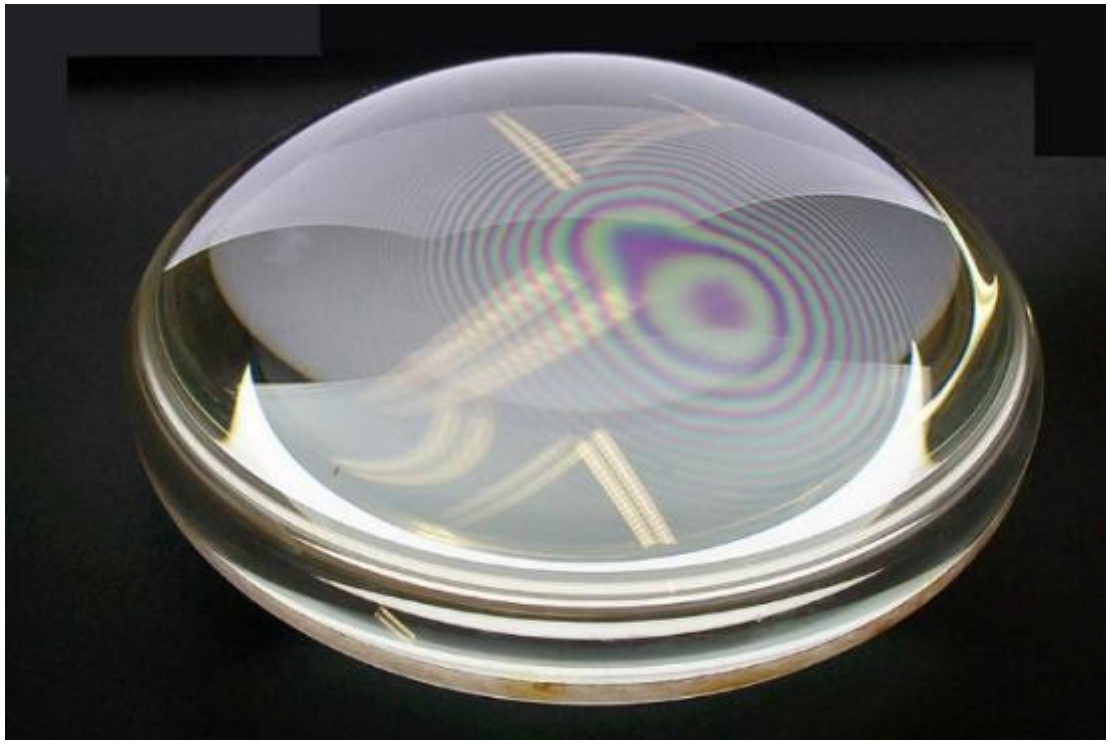


a) The rainbow-color bands are produced by thin-film interference in the air between the two glass slides.

b) Schematic of the paths taken by rays in the wedge of air between the slides.

c) If the air wedge is illuminated with monochromatic light, bright and dark bands are obtained rather than repeating rainbow colors.

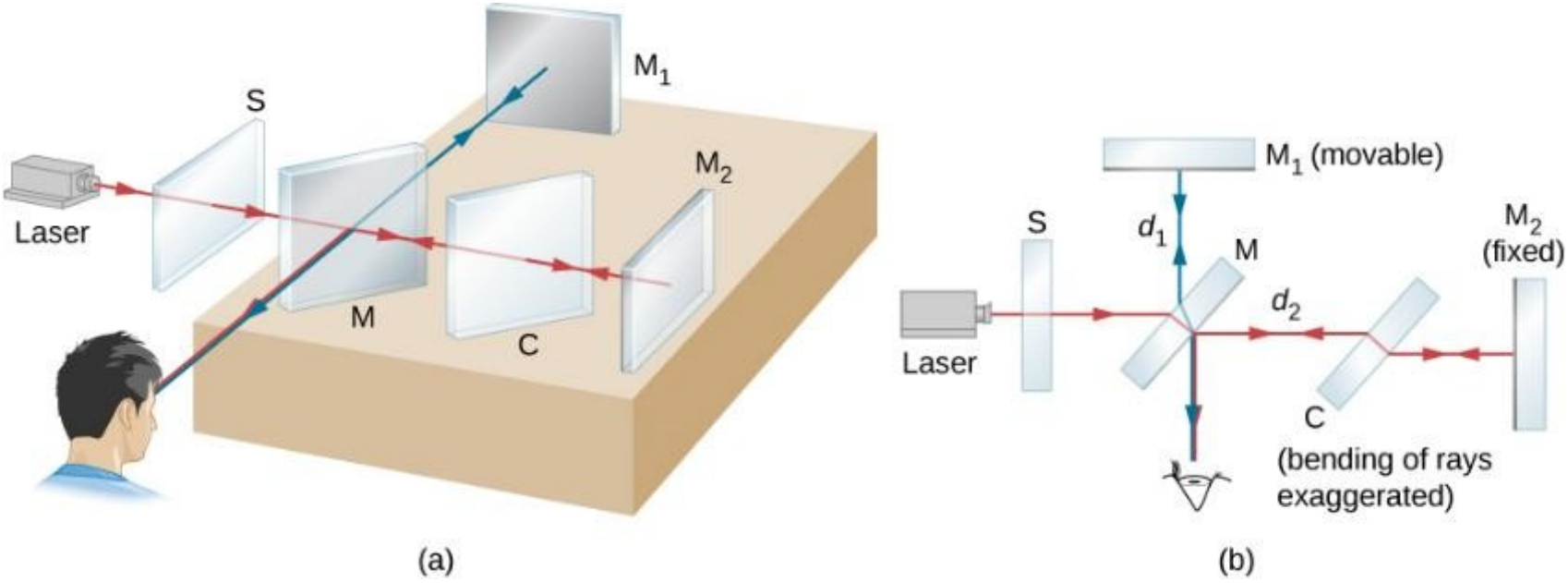
FIGURE 3.15



“Newton’s rings” interference fringes are produced when two plano-convex lenses are placed together with their plane surfaces in contact. The rings are created by interference between the light reflected off the two surfaces as a result of a slight gap between them, indicating that these surfaces are not precisely plane but are slightly convex. (credit: Ulf Seifert)

Michelson Interferometer

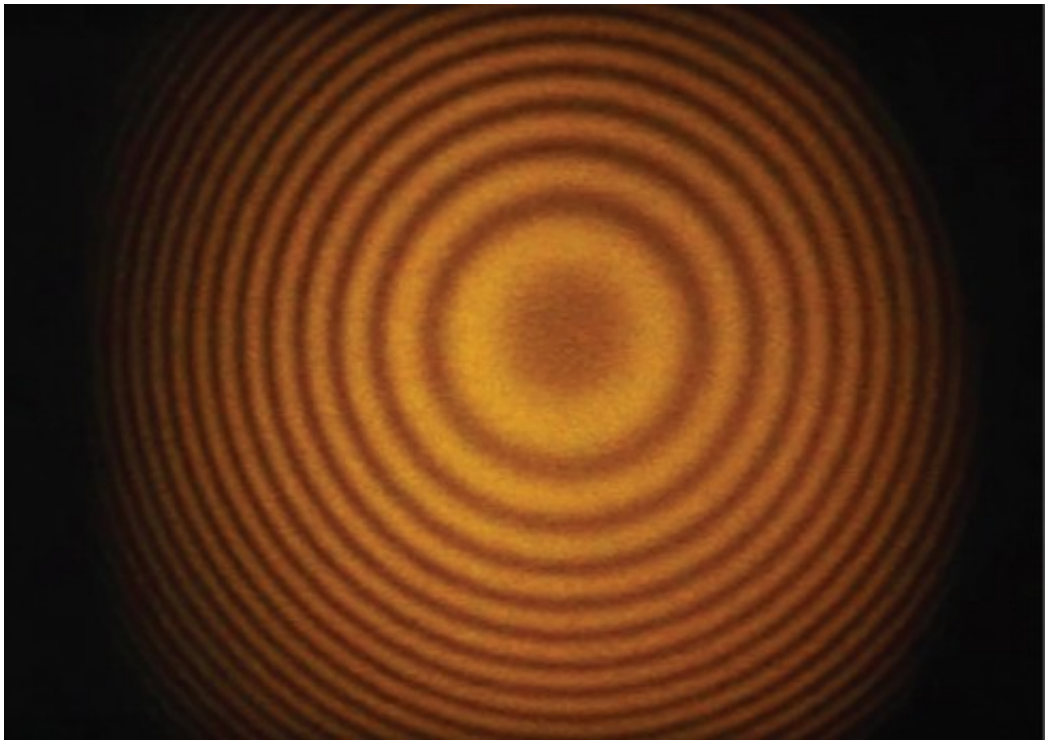
FIGURE 3.16



a) The Michelson interferometer. The extended light source is a ground-glass plate that diffuses the light from a laser.

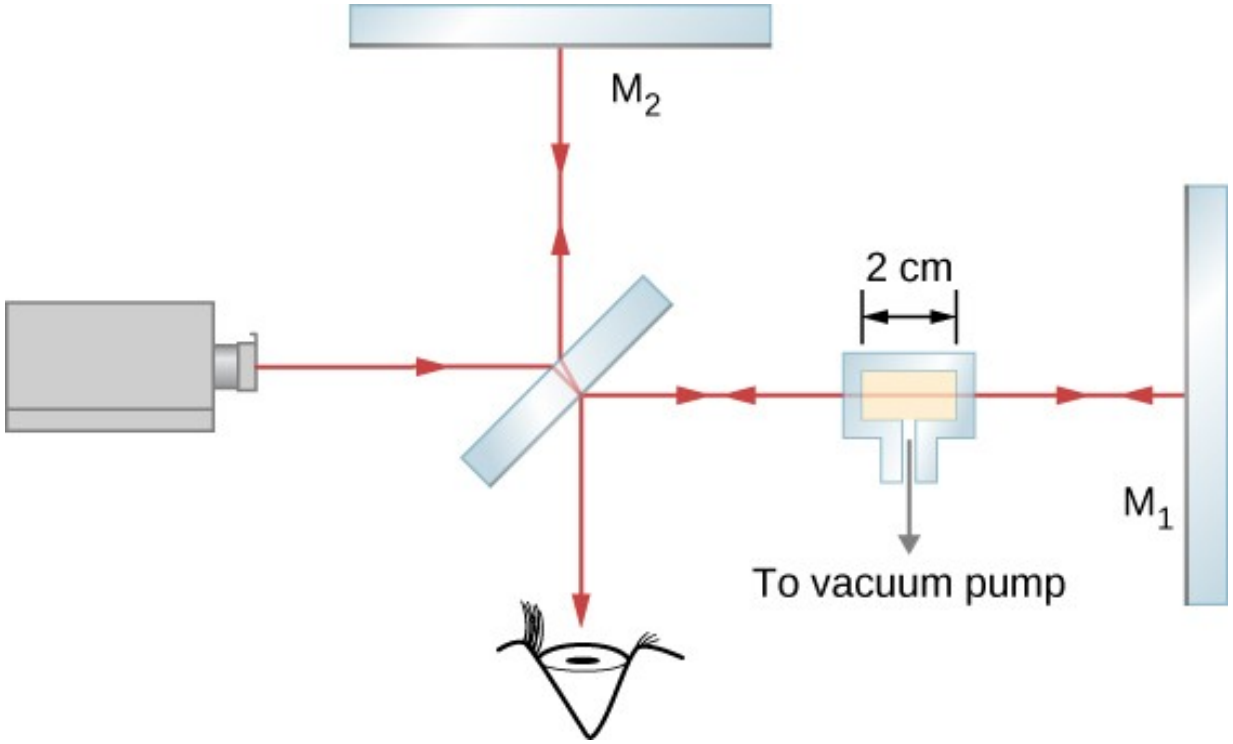
b) A planar view of the interferometer.

FIGURE 3.17



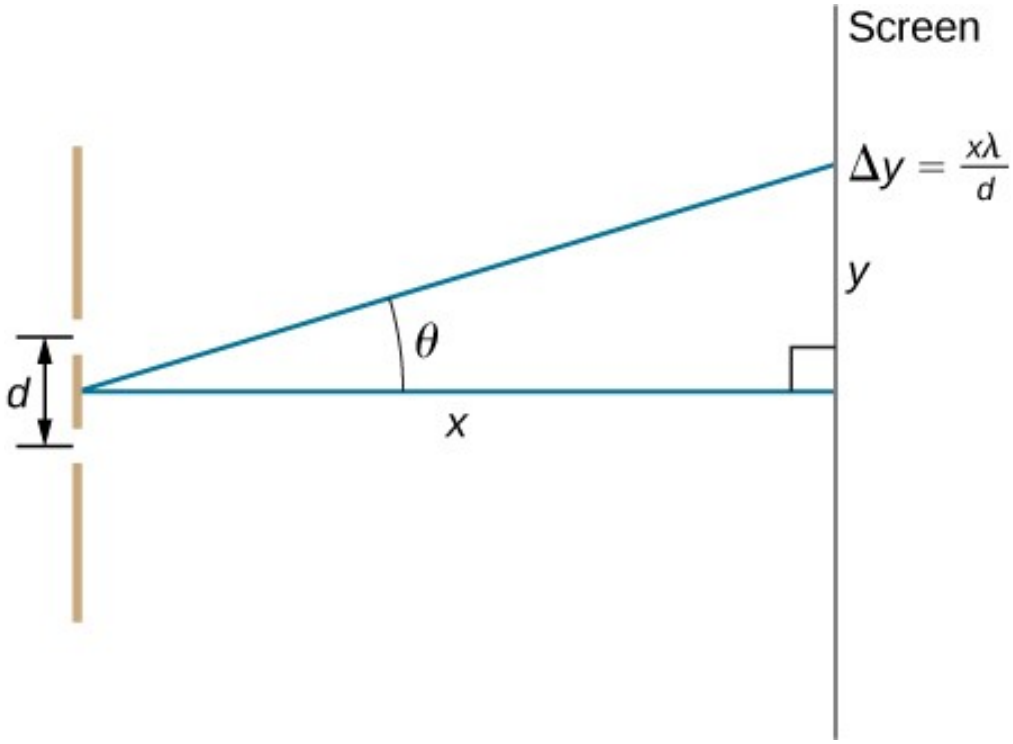
Fringes produced with a Michelson interferometer. (credit: “SILLAGESvideos”/YouTube)

EXAMPLE 3.6



Examples

EXERCISE 28



Shown below is a double slit located a distance x from a screen, with the distance from the center of the screen given by y. When the distance d between the slits is relatively large, numerous bright spots appear, called fringes. Show that, for small angles (where $\sin\theta \approx \theta$, with θ in radians), the distance between fringes is given by $\Delta y = x\lambda / d$

Exercise 35

Ten narrow slits are equally spaced 0.25 mm apart and illuminated with yellow light of wavelength 580 nm. (a) What are the angular positions of the third and fourth principal maxima? (b) What is the separation of these maxima on a screen 2.0 m from the slits?

Exercise 51

In a Michelson interferometer, light of wavelength 632.8 nm from a He-Ne laser is used. When one of the mirrors is moved by a distance D, 8 fringes move past the field of view. What is the value of the distance D?