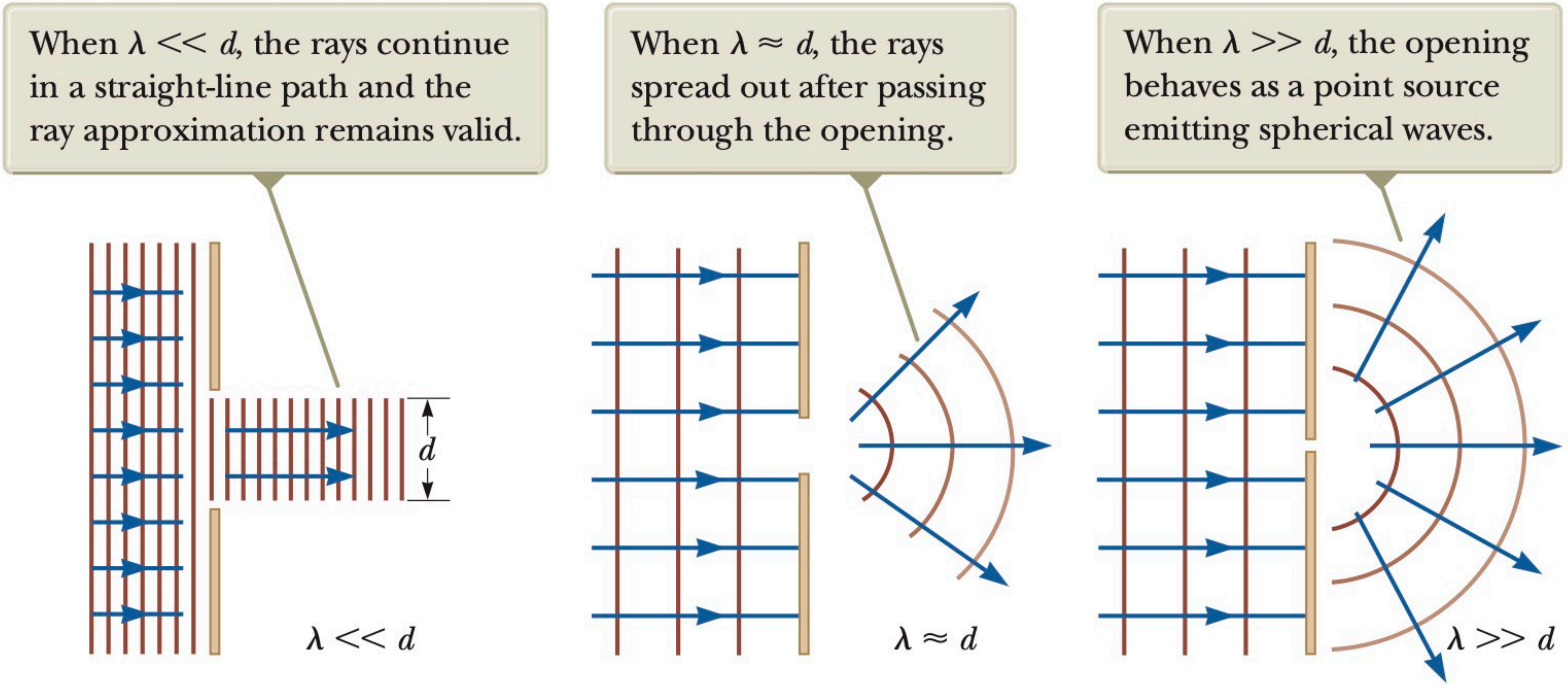
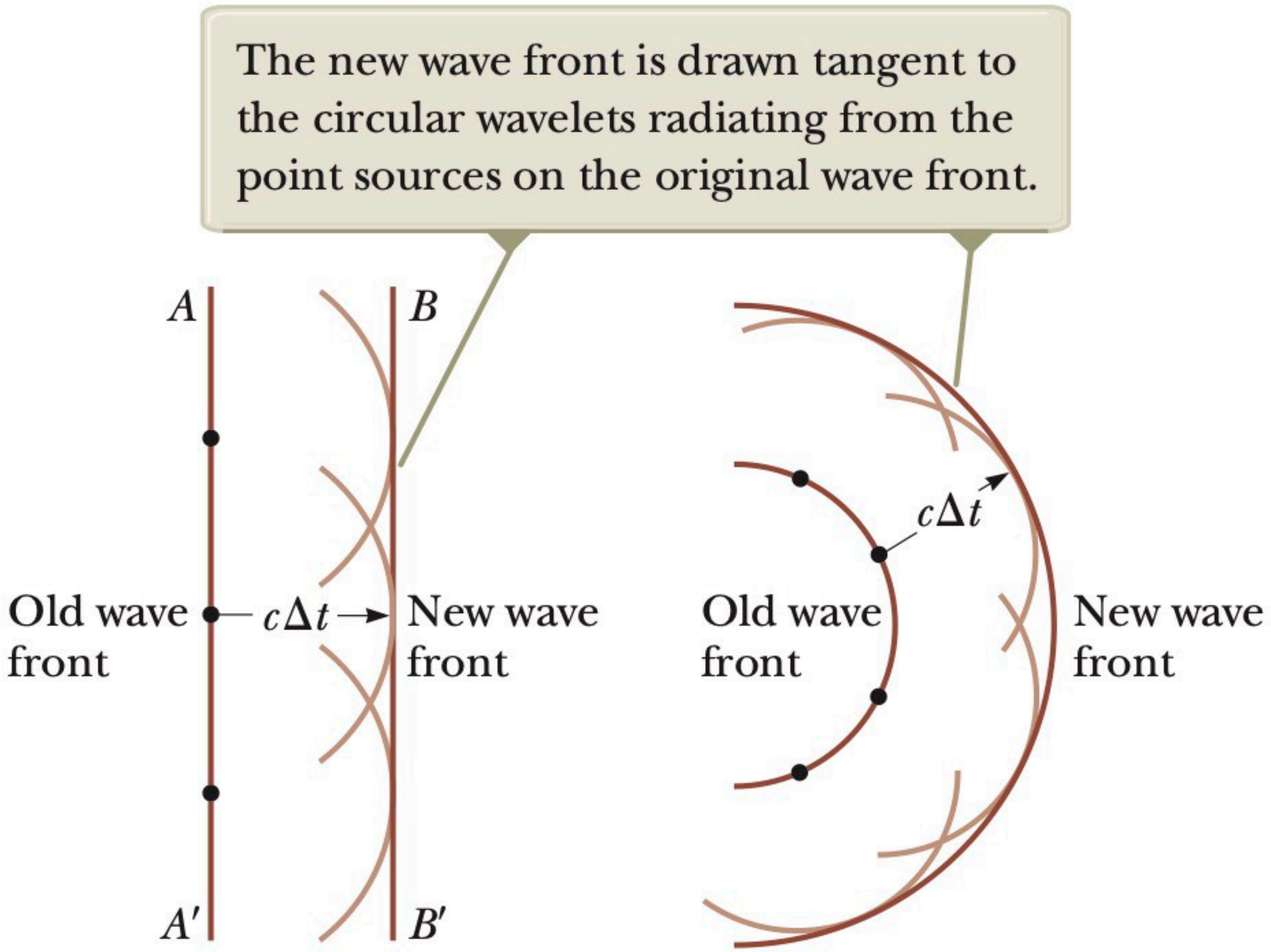
Review: The nature of light and wave optics

A plane wave of wavelength λ is incident on a barrier in which there is an opening of diameter d.



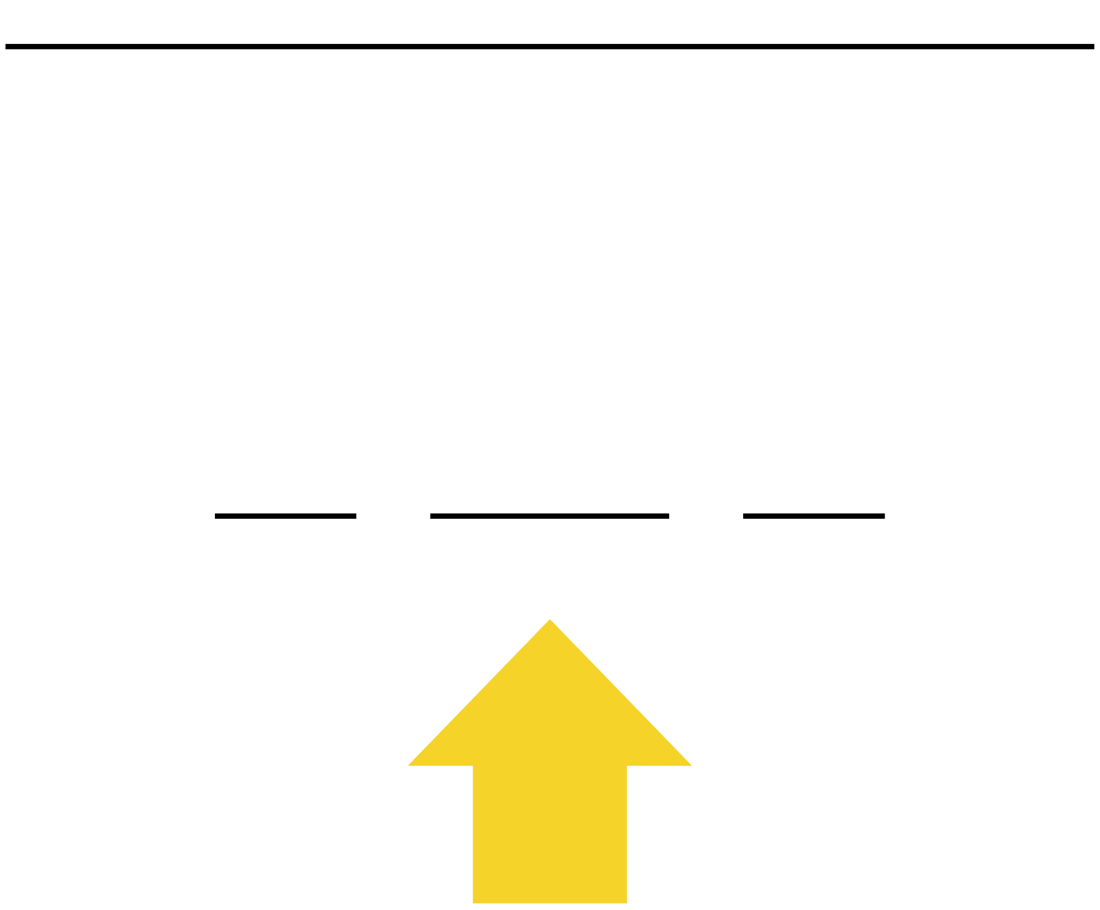
Huygens's principle

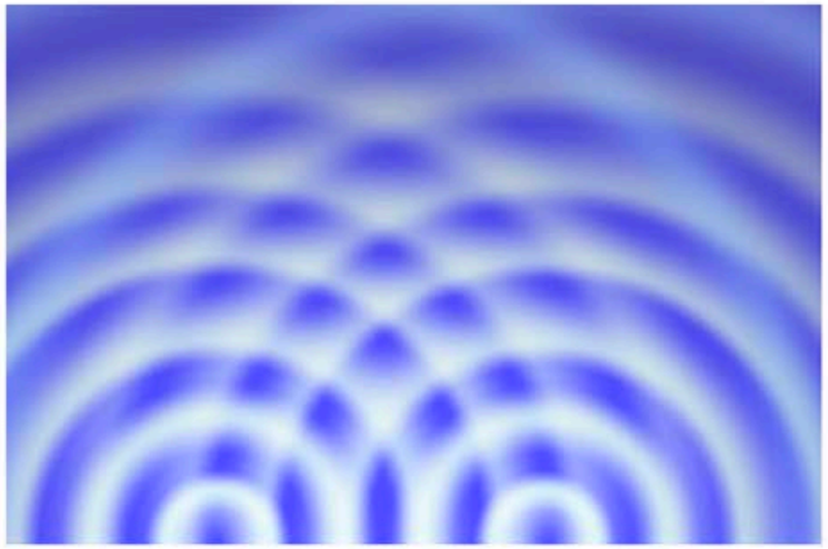


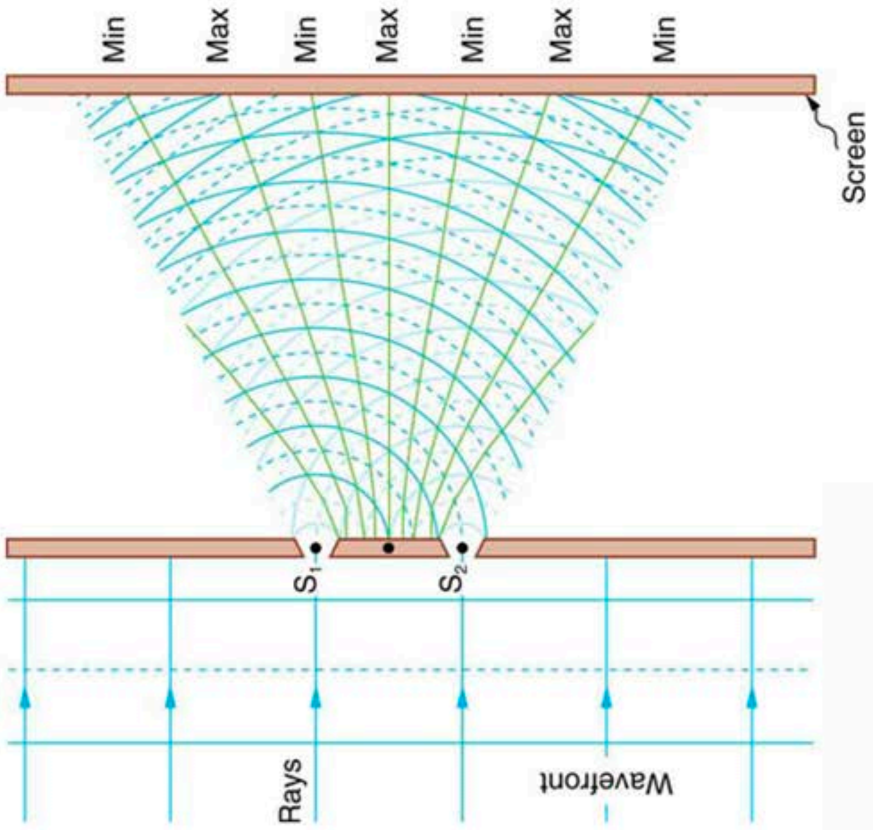
All points on a given wave front are taken as point sources for the production of spherical secondary waves, called wavelets, that propagate outward through a medium with speeds characteristic of wages in that medium. After some time interval has passed, the new position of the wave front is the surface tangent to the wavelets.

Wave equation, wave function and intensity

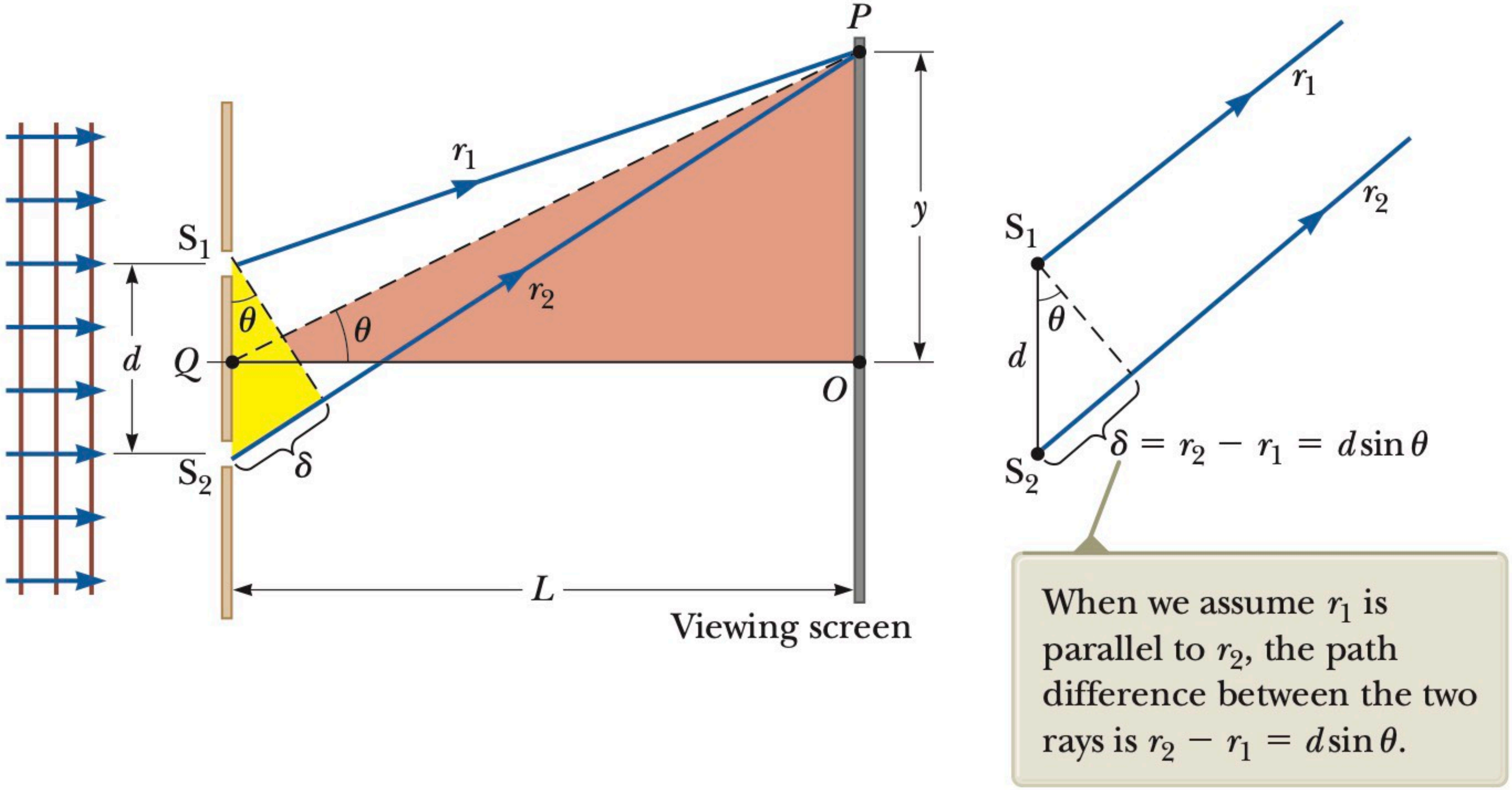
Consider the following situation, and we try to describe by using wave equation, wave function and definition of intensity we have discussed before.







Young's double-slit experiment



Exercise

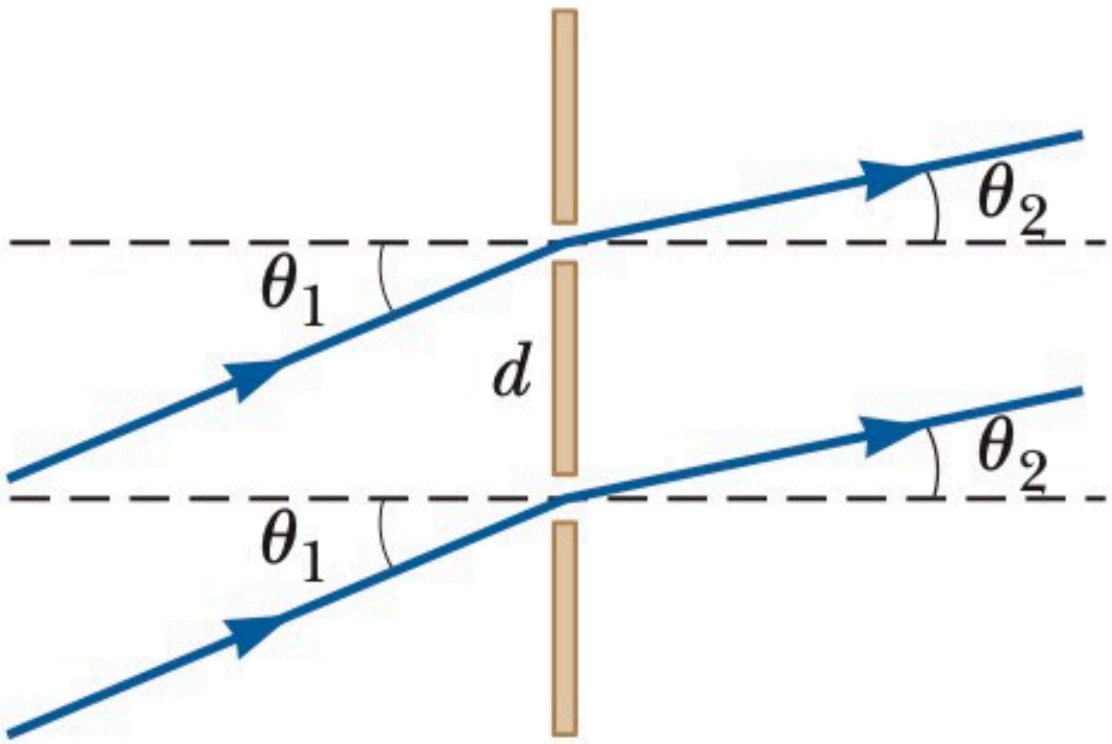
In Young’s double-slit experiment, (a) why do we use monochromatic light? (b) If white light is used, how would the pattern change?

Exercise

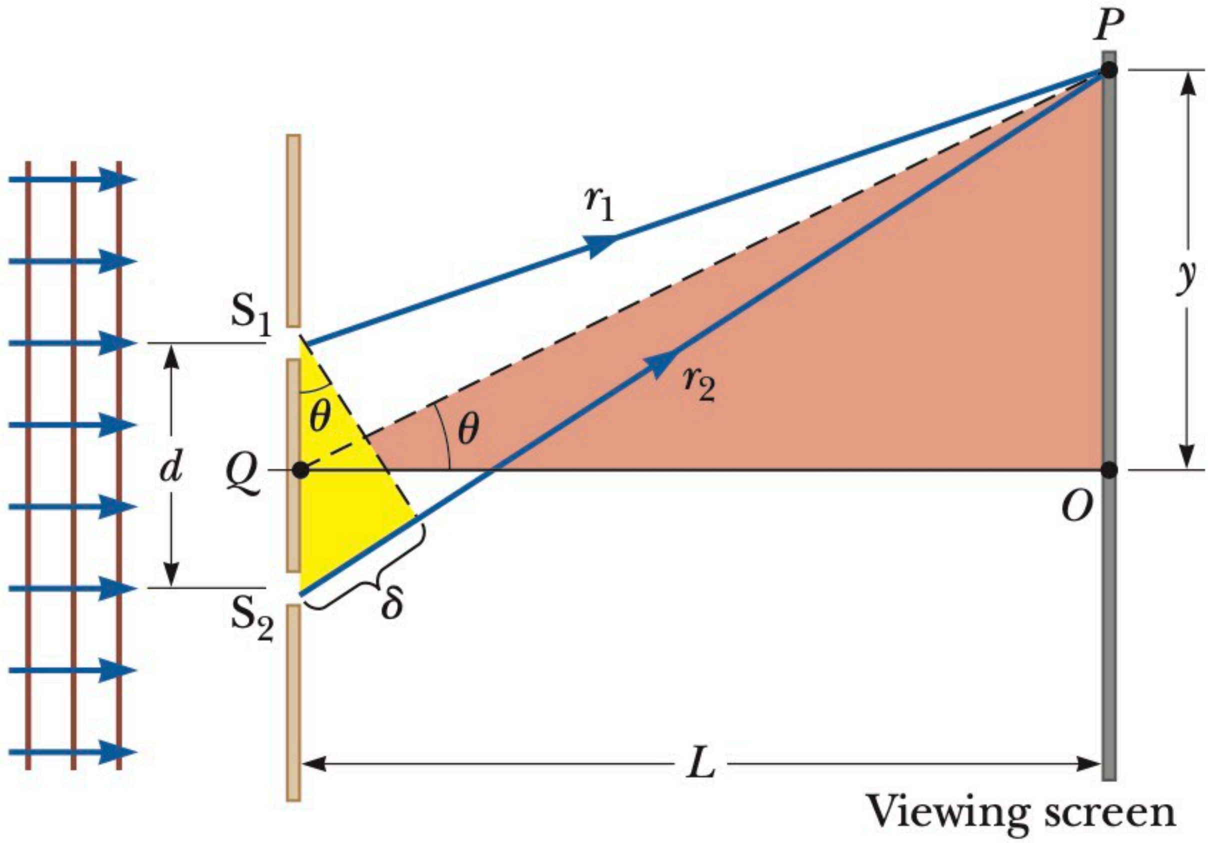
In Young's experiment, two slits are separated by $d = 0.320$ mm. A beam of 500 nm light strikes the slits, producing an interference pattern. Determine the number of maxima observed in the angular range $-45.0^{\circ} < \theta < 45.0^{\circ}$

Exercise

Coherent light rays of wavelength λ strike a pair of slits separated by distance d at an angle θ_1 with respect to the normal to the plane containing the slits as shown in the figure. The rays leaving the slits make an angle θ_2 with respect to the normal, and an interference maximum is formed by those rays on a screen that is a great distance from the slits. Show that the angle θ_2 is given by $\theta_2 = \sin^{-1}(\sin\theta_1 - \frac{m\lambda}{d})$



Exercise

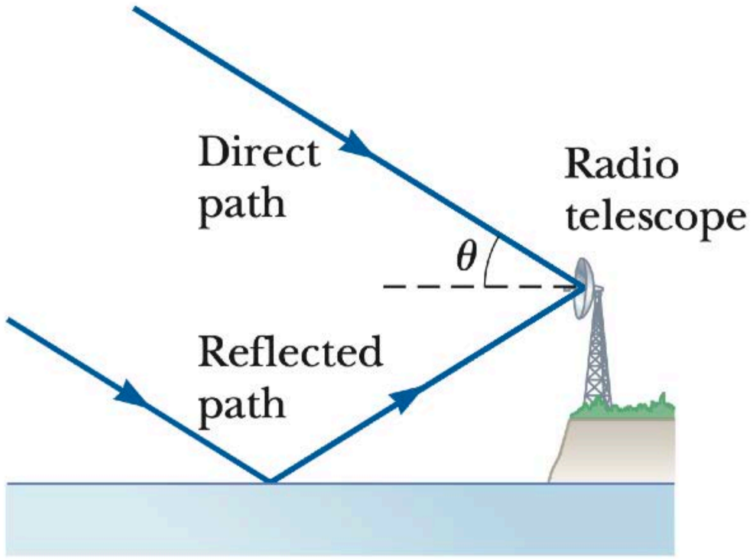


In the double slit experiment, supposed $d = 0.100$ mm and $L = 1.00$ m, and the incident light is monochromatic with a wavelength 500 nm.

1. What is the phase difference between two waves arriving at a point P on the screen with $\theta = 0.8^\circ$
2. What is the phase difference between two waves arriving at a point P on the screen when $y = 4.0$ mm
3. If the path difference is $\delta = \lambda/4$, what is the value of θ

Exercise

Radio waves of wavelength 125 m from a galaxy reach a radio telescope by two separate paths as shown in the figure. One is a direct path to the receiver, which is situated on the edge of a tall cliff by the ocean, and the second is by reflection off the water. As the galaxy rises in the east over the water, the first minimum of destructive interference occurs when the galaxy is $\theta = 25.0°$ above the horizon. Find the height of the radio telescope dish above the water.



Young's double-slit experiment: Intensity

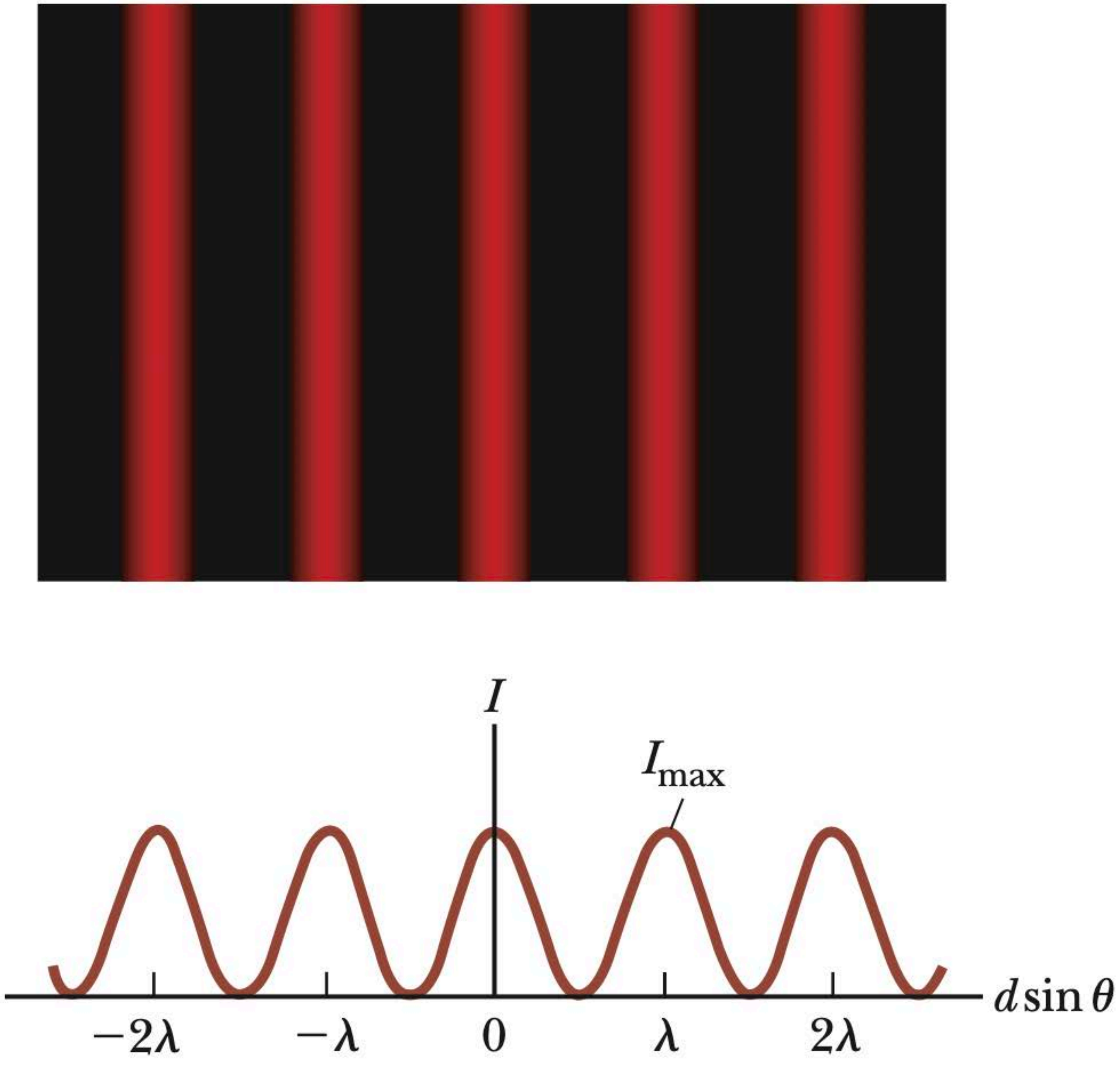


Figure 37.6 Light intensity versus $d \sin \theta$ for a double-slit interference pattern when the screen is far from the two slits ($L >> d$).

Exercise

The intensity on the screen at a certain point in a double slit interference pattern is 60% of the maximum value. (A) What minimum phase difference (in radian) between sources produces this result? (B) Express this phase difference as a path difference for 500 nm light.

Exercise

Two narrow, parallel slits separated by 0.850 mm are illuminated by 600 nm light, and the viewing screen is 2.80 m away from the slits.

1. What is the phase difference between the two interfering waves on a screen at a point 2.50 mm from the central bright fringe?
2. What is the ratio of the intensity at this point to the intensity at the center of a bright fringe?