

SUMMARY

Interference in light waves occurs whenever two or more waves overlap at a given point. A sustained interference pattern is observed if (1) the sources are coherent and (2) the sources have identical wavelengths.

In Young's double-slit experiment, two slits S_1 and S_2 separated by a distance d are illuminated by a single-wavelength light source. An interference pattern consisting of bright and dark fringes is observed on a viewing screen. The condition for bright fringes (**constructive interference**) is

$$d \sin \theta = m\lambda \quad m = 0, \pm 1, \pm 2, \dots \quad (37.2)$$

The condition for dark fringes (**destructive interference**) is

$$d \sin \theta = (m + \frac{1}{2})\lambda \quad m = 0, \pm 1, \pm 2, \dots \quad (37.3)$$

The number m is called the **order number** of the fringe.

The **intensity** at a point in the double-slit interference pattern is

$$I = I_{\max} \cos^2\left(\frac{\pi d \sin \theta}{\lambda}\right) \quad (37.12)$$

where I_{\max} is the maximum intensity on the screen and the expression represents the time average.

A wave traveling from a medium of index of refraction n_1 toward a medium of index of refraction n_2 undergoes a 180° phase change upon reflection when $n_2 > n_1$ and undergoes no phase change when $n_2 < n_1$.

The condition for constructive interference in a film of thickness t and refractive index n surrounded by air is

$$2nt = (m + \frac{1}{2})\lambda \quad m = 0, 1, 2, \dots \quad (37.16)$$

where λ is the wavelength of the light in free space.

Similarly, the condition for destructive interference in a thin film is

$$2nt = m\lambda \quad m = 0, 1, 2, \dots \quad (37.17)$$

QUESTIONS

- What is the necessary condition on the path length difference between two waves that interfere (a) constructively and (b) destructively?
- Explain why two flashlights held close together do not produce an interference pattern on a distant screen.
- If Young's double-slit experiment were performed under water, how would the observed interference pattern be affected?
- In Young's double-slit experiment, why do we use monochromatic light? If white light is used, how would the pattern change?
- Consider a dark fringe in an interference pattern, at which almost no light is arriving. Light from both slits is arriving at this point, but the waves are canceling. Where does the energy go?
- An oil film on water appears brightest at the outer regions, where it is thinnest. From this information, what can you say about the index of refraction of oil relative to that of water?
- In our discussion of thin-film interference, we looked at light *reflecting* from a thin film. Consider one light ray, the direct ray, that transmits through the film without reflecting. Consider a second ray, the reflected ray, that transmits through the first surface, reflects from the second, reflects again from the first, and then transmits out into the air, parallel to the direct ray. For normal incidence, how thick must the film be, in terms of the wavelength of light, for the outgoing rays to interfere destructively? Is it the same thickness as for reflected destructive interference?
- Suppose that you are watching television connected to an antenna rather than a cable system. If an airplane flies near your location, you may notice wavering ghost images in the television picture. What might cause this?
- If we are to observe interference in a thin film, why must the film not be very thick (on the order of a few wavelengths)?
- A lens with outer radius of curvature R and index of re-