Conceptual Questions

27.1 The Wave Aspect of Light: Interference

1.

What type of experimental evidence indicates that light is a wave?

2.

Give an example of a wave characteristic of light that is easily observed outside the laboratory.

27.2 Huygens's Principle: Diffraction

3.

How do wave effects depend on the size of the object with which the wave interacts? For example, why does sound bend around the corner of a building while light does not?

4.

Under what conditions can light be modeled like a ray? Like a wave?

5.

Go outside in the sunlight and observe your shadow. It has fuzzy edges even if you do not. Is this a diffraction effect? Explain.

6.

Why does the wavelength of light decrease when it passes from vacuum into a medium? State which attributes change and which stay the same and, thus, require the wavelength to decrease.

7.

Does Huygens's principle apply to all types of waves?

27.3 Young's Double Slit Experiment

8.

Young's double slit experiment breaks a single light beam into two sources. Would the same pattern be obtained for two independent sources of light, such as the headlights of a distant car? Explain.

9.

Suppose you use the same double slit to perform Young's double slit experiment in air and then repeat the experiment in water. Do the angles to the same parts of the interference pattern get larger or smaller? Does the color of the light change? Explain.

10.

Is it possible to create a situation in which there is only destructive interference? Explain.

11.

Figure 27.55 shows the central part of the interference pattern for a pure wavelength of red light projected onto a double slit. The pattern is actually a combination of single slit and double slit interference. Note that the bright spots are evenly spaced. Is this a double slit or single slit characteristic? Note that some of the bright spots are dim on either side of the center. Is this a single slit or double slit characteristic? Which is smaller, the slit width or the separation between slits? Explain your responses.

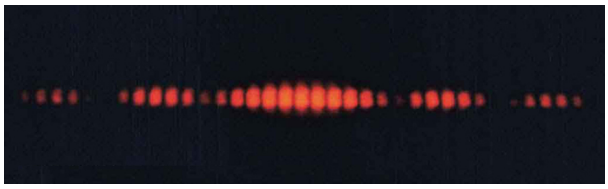

Figure 27.55 This double slit interference pattern also shows signs of single slit interference. (credit: PASCO)

27.4 Multiple Slit Diffraction

12.

What is the advantage of a diffraction grating over a double slit in dispersing light into a spectrum?

13.

What are the advantages of a diffraction grating over a prism in dispersing light for spectral analysis?

14.

Can the lines in a diffraction grating be too close together to be useful as a spectroscopic tool for visible light? If so, what type of EM radiation would the grating be suitable for? Explain.

15.

If a beam of white light passes through a diffraction grating with vertical lines, the light is dispersed into rainbow colors on the right and left. If a glass prism disperses white light to the right into a rainbow, how does the sequence of colors compare with that produced on the right by a diffraction grating?

16.

Suppose pure-wavelength light falls on a diffraction grating. What happens to the interference pattern if the same light falls on a grating that has more lines per centimeter? What happens to the interference pattern if a longer-wavelength light falls on the same grating? Explain how these two effects are consistent in terms of the relationship of wavelength to the distance between slits.

17.

Suppose a feather appears green but has no green pigment. Explain in terms of diffraction.

18.

It is possible that there is no minimum in the interference pattern of a single slit. Explain why. Is the same true of double slits and diffraction gratings?

27.5 Single Slit Diffraction

19.

As the width of the slit producing a single-slit diffraction pattern is reduced, how will the diffraction pattern produced change?

27.6 Limits of Resolution: The Rayleigh Criterion

20.

A beam of light always spreads out. Why can a beam not be created with parallel rays to prevent spreading? Why can lenses, mirrors, or apertures not be used to correct the spreading?

27.7 Thin Film Interference

21.

What effect does increasing the wedge angle have on the spacing of interference fringes? If the wedge angle is too large, fringes are not observed. Why?

22.

How is the difference in paths taken by two originally in-phase light waves related to whether they interfere constructively or destructively? How can this be affected by reflection? By refraction?

23.

Is there a phase change in the light reflected from either surface of a contact lens floating on a person's tear layer? The index of refraction of the lens is about 1.5, and its top surface is dry.

24.

In placing a sample on a microscope slide, a glass cover is placed over a water drop on the glass slide. Light incident from above can reflect from the top and bottom of the glass cover and from the glass slide below the water drop. At which surfaces will there be a phase change in the reflected light?

25.

Answer the above question if the fluid between the two pieces of crown glass is carbon disulfide.

26.

While contemplating the food value of a slice of ham, you notice a rainbow of color reflected from its moist surface. Explain its origin.

27.

An inventor notices that a soap bubble is dark at its thinnest and realizes that destructive interference is taking place for all wavelengths. How could she use this knowledge to make a non-reflective coating for lenses that is effective at all wavelengths? That is, what limits would there be on the index of refraction and thickness of the coating? How might this be impractical?

28.

A non-reflective coating like the one described in Example 27.6 works ideally for a single wavelength and for perpendicular incidence. What happens for other wavelengths and other incident directions? Be specific.

29.

Why is it much more difficult to see interference fringes for light reflected from a thick piece of glass than from a thin film? Would it be easier if monochromatic light were used?

27.8 Polarization

30.

Under what circumstances is the phase of light changed by reflection? Is the phase related to polarization?

31.

Can a sound wave in air be polarized? Explain.

32.

No light passes through two perfect polarizing filters with perpendicular axes. However, if a third polarizing filter is placed between the original two, some light can pass. Why is this? Under what circumstances does most of the light pass?

33.

Explain what happens to the energy carried by light that it is dimmed by passing it through two crossed polarizing filters.

34.

When particles scattering light are much smaller than its wavelength, the amount of scattering is proportional to $1/\lambda^4$. Does this mean there is more scattering for small λ than large λ? How does this relate to the fact that the sky is blue?

35.

Using the information given in the preceding question, explain why sunsets are red.

36.

When light is reflected at Brewster's angle from a smooth surface, it is 100% polarized parallel to the surface. Part of the light will be refracted into the surface. Describe how you would do an experiment to determine the polarization of the refracted light. What direction would you expect the polarization to have and would you expect it to be 100%?

27.9 *Extended Topic* Microscopy Enhanced by the Wave Characteristics of Light

37.

Explain how microscopes can use wave optics to improve contrast and why this is important.

38.

A bright white light under water is collimated and directed upon a prism. What range of colors does one see emerging?