Phys.12-Q3W3-interference-Qs.Bank

Multiple Choice
Identify the choice that best completes the statement or answers the question.

____ 1. In a double-slit interference pattern, the path length from one slit to the first dark fringe of a double-slit interference pattern is longer than the path length from the other slit to the fringe by
- a. three-quarters of a wavelength.
- b. one-half of a wavelength.
- c. one-quarter of a wavelength.
- d. one full wavelength.

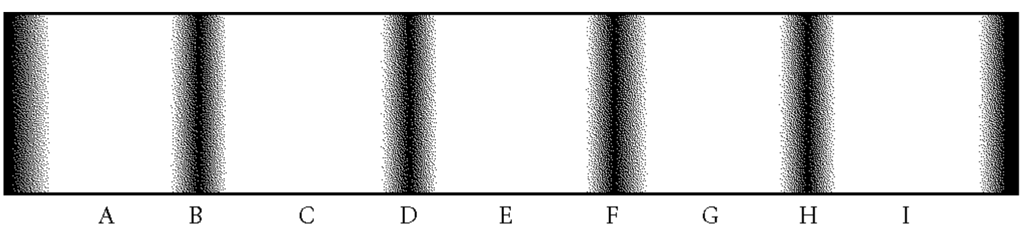
____ 2. In a double-slit interference experiment, a wave from one slit arrives at a point on a screen one wavelength behind the wave from the other slit. What is observed at that point?
- a. dark fringe
- b. bright fringe
- c. multicolored fringe
- d. gray fringe, neither dark nor bright

____ 3. In a double-slit interference experiment, a wave from one slit arrives at a point on a screen one-half wavelength behind the wave from the other slit. What is observed at that point?
- a. dark fringe
- b. bright fringe
- c. multicolored fringe
- d. gray fringe, neither dark nor bright

____ 4. In a double-slit interference pattern, the path length from one slit to the first bright fringe of a double-slit interference pattern is longer than the path length from the other slit to the fringe by
- a. three-quarters of a wavelength.
- b. one-half of a wavelength.
- c. one-quarter of a wavelength.
- d. one full wavelength.

____ 5. If two lightbulbs are placed side by side, no interference is observed because
- a. each bulb produces many wavelengths of light.
- b. each bulb produces only one wavelength of light.
- c. incandescent light is incoherent.
- d. incandescent light is coherent.

____ 6. Coherence is the property by which two waves with identical wavelengths maintain a constant
- a. amplitude.
- b. frequency.
- c. phase relationship.
- d. speed.



The figure above shows the pattern of a double-slit interference experiment. The center of the pattern is located at E.

____ 7. In the figure above, for which of the following fringes is the path length of the light wave from one slit more than one wavelength greater than the path length of the light wave from the other slit?
- a. A and B
- b. A, B, and C
- c. B and C
- d. B, C, D, and E

____ 8. In the figure above, which fringe represents a second-order minimum?
- a. E
- b. F
- c. G
- d. H

____ 9. In the figure above, θ_1 is the angle between the central maximum and the first-order maximum. What is the angle between fringes D and F?

a. $\frac{\theta_1}{2}$ c. $\frac{3\theta_1}{2}$

b. θ_1 d. $2\theta_1$

____ 10. In the double-slit interference experiment that produced the figure above, the same slits are illuminated with light of greater wavelength. Which of the following would occur to the pattern shown in the figure?

a. E would shift to the right. c. F would shift to the right.

b. E would shift to the left. d. F would shift to the left.

____ 11. In the double-slit interference experiment that produced the figure above, the two slits are moved closer. Which of the following would occur to the pattern shown in the figure?

a. E would shift to the right. c. F would shift to the right.

b. E would shift to the left. d. F would shift to the left.

____ 12. Interference effects observed in the early 19th century were instrumental in supporting a concept of the existence of which property of light?

a. polarization c. wave nature

b. particle nature d. electromagnetic character

____ 13. To produce a sustained interference pattern by light waves from multiple sources, which condition or conditions must be met?

a. Sources must be coherent.

b. Sources must be monochromatic.

c. Sources must be coherent and monochromatic.

d. Sources must be neither coherent nor monochromatic.

____ 14. Two beams of coherent light are shining on the same sheet of white paper. When referring to the crests and troughs of such waves, where will darkness appear on the paper?

a. where the crest from one wave overlaps the crest from the other

b. where the crest from one wave overlaps the trough from the other

c. where the troughs from both waves overlap

d. Darkness cannot occur because the two waves are coherent.

____ 15. For stable interference to occur, the phase difference must be

a. incoherent. c. $\frac{1}{2}\lambda$.

b. monochromatic. d. constant.

____ 16. The distance between the two slits in a double-slit interference experiment is 0.040 mm. The second-order bright fringe ($m = 2$) is measured on a screen at an angle of 2.2° from the central maximum. What is the wavelength of the light?

a. 560 nm c. 750 nm

b. 630 nm d. 770 nm

____ 17. The distance between two slits in a double-slit interference experiment is 2.9×10^{-6} m. The first-order bright fringe is measured on a screen at an angle of 12° from the central maximum. What is the wavelength of the light?

a. 1.2×10^{2} nm c. 4.6×10^{2} nm

b. 3.0×10^{2} nm d. 6.0×10^{2} nm

____ 18. The distance between two slits in a double-slit interference experiment is 0.0050 mm. What is the angle of the third-order bright fringe ($m = 3$) produced with light of 550 nm?

a. 5.0° c. 12°

b. 9.9° d. 19°

____ 19. At the first dark band in a single-slit diffraction pattern, the path lengths of selected pairs of wavelets differ by
a. one wavelength.
b. more than one wavelength.
c. one-half wavelength.
d. less than half of one wavelength.

____ 20. Monochromatic light shines on the surface of a diffraction grating with 5.3×10^3 lines/cm. The first-order maximum is observed at an angle of 17°. Find the wavelength.
a. 420 nm
b. 520 nm
c. 530 nm
d. 550 nm

____ 21. Monochromatic light shines on the surface of a diffraction grating with 5.0×10^3 lines/cm. The first-order maximum is observed at an angle of 20.0°. Find the wavelength.
a. 360 nm
b. 480 nm
c. 520 nm
d. 680 nm

____ 22. Light with a wavelength of 400.0 nm passes through a 1.00×10^4 lines/cm diffraction grating. What is the second-order angle of diffraction?
a. 21.3°
b. 53.1°
c. 56.5°
d. 72.1°

____ 23. Light with a wavelength of 500.0 nm passes through a 3.39×10^5 lines/m diffraction grating. What is the first-order angle of diffraction?
a. 9.73°
b. 23.5°
c. 36.9°
d. 53.1°

____ 24. Light with a wavelength of 546.1 nm passes through a 6.62×10^3 lines/cm diffraction grating. What is the first-order angle of diffraction?
a. 21.2°
b. 34.6°
c. 39.2°
d. 41.6°

____ 25. The angle between the first-order maximum and the central maximum for monochromatic light of 2300 nm is 27°. Calculate the number of lines per centimeter on this grating.
a. 1600 lines/cm
b. 2000 lines/cm
c. 2500 lines/cm
d. 4500 lines/cm

____ 26. Monochromatic light (λ = 632.8 nm) from a helium-neon laser shines at a right angle onto the surface of a diffraction grating that contains 531 001 lines/m. Find the angles at which one would observe the first-order and second-order maxima.
a. θ_1 = 19.63°; θ_2 = 39.26°
b. θ_1 = 19.63°; θ_2 = 42.20°
c. θ_1 = 21.10°; θ_2 = 42.20°
d. θ_1 = 33.60°; θ_2 = 67.20°

____ 27. A diffraction grating that contains 650 472 lines/m is illuminated by monochromatic light (λ = 632.8 nm) from a helium-neon laser directed perpendicular to the surface of the grating. At what angles would one observe the first-order and second-order maxima?
a. θ_1 = 2.358°; θ_2 = 4.719°
b. θ_1 = 24.30°; θ_2 = 55.38°
c. θ_1 = 29.37°; θ_2 = 55.38°
d. θ_1 = 55.38°; θ_2 = 83.078°

____ 28. A helium-neon laser shines monochromatic light (λ = 632.8 nm) perpendicular to the surface of a diffraction grating that contains 146 230 lines/m. Find the angles at which one would observe the second-order and third-order maxima.
a. θ_1 = 5.307°; θ_2 = 10.66°
b. θ_1 = 10.66°; θ_2 = 16.11°
c. θ_1 = 10.66°; θ_2 = 18.43°
d. θ_1 = 13.25°; θ_2 = 26.50°

____ 29. For high resolution in optical instruments, the angle between resolved objects should be
a. as small as possible.
b. as large as possible.
c. 1.22°.
d. 45°.

____ 30. If light waves are coherent,
- a. they shift over time.
- b. their intensity is less than that of incoherent light.
- c. they remain in phase.
- d. they have less than three different wavelengths.

____ 31. In a laser, energy is added to a(n)
- a. mirror.
- b. active medium.
- c. partially transparent mirror.
- d. light wave.

____ 32. Which of the following is the process of using a light wave to produce more waves with properties identical to those of the first wave?
- a. stimulated emission
- b. active medium
- c. hologram
- d. bandwidth

____ 33. Which of the following is a device that produces an intense, nearly parallel beam of coherent light?
- a. spectroscope
- b. telescope
- c. laser
- d. diffraction grating

____ 34. The acronym *laser* stands for light amplification by ____ emission of radiation.
- a. similar
- b. simultaneous
- c. spontaneous
- d. stimulated

____ 35. In a laser, all of the following forms of energy can be converted into coherent light *except*
- a. chemical energy.
- b. electrical energy.
- c. light.
- d. nuclear energy.

____ 36. A laser can be used
- a. to treat glaucoma.
- b. to measure distance.
- c. to read bar codes.
- d. All of the above

Short Answer

1. The dark lines in a double-slit interference pattern are due to what type of interference?
2. The bright lines in a double-slit interference pattern are due to what type of interference?
3. If two light waves are out of phase, what is the smallest amount by which their phases can differ?
4. If two light waves are in phase, what is the smallest amount by which their phases can differ?
5. A double slit is illuminated by monochromatic light with a wavelength of λ shining perpendicular to the screen. The path lengths of the waves from each slit that form the central maximum differ by what amount?
6. A double slit is illuminated by monochromatic light of wavelength λ shining perpendicular to the screen. The path lengths of the waves from each slit that form the first dark fringe differ by what amount?
7. A double slit is illuminated by monochromatic light of wavelength λ shining perpendicular to the screen. The path lengths of the waves from each slit that form the first bright fringe differ by what amount?
8. What is diffraction?
9. How does diffraction occur?
10. Describe the pattern that results from the single-slit diffraction of monochromatic light.
11. A diffraction grating is illuminated by monochromatic light shining perpendicular to its surface. How many dark fringes will appear between the central maximum and either third-order maximum?

12. What instrument uses a diffraction grating to separate light from a source into its monochromatic components?
13. If the number of lines per unit length of a diffraction grating is increased, what happens to the separation of the individual slits?
14. What is the function of a spectrometer?
15. If the number of lines per unit length of a diffraction grating is increased, what happens to the separation of the individual wavelengths of the diffracted light?
16. What is resolving power?
17. What term describes the ability of an instrument to separate two images that are close together?
18. Why is the resolving power for optical telescopes on Earth limited?
19. How does an increase in the wavelength of light reaching an optical instrument with a set aperture affect the resolving power of the instrument?
20. Why does an increase in the aperture of an optical instrument increase its resolving power for the same wavelength of light?
21. What device produces an intense, nearly parallel beam of coherent light?
22. What is meant by the statement that a laser produces a narrow beam of coherent light?
23. How does a laser produce coherent light?
24. What are the advantages of using a “laser knife” in surgical procedures?
25. How is a laser used in a CD player?
26. How are lasers used to determine the distance from Earth to the moon?
27. What property of the cornea and lens of an eye allows laser light to be transmitted through them?

Problem

1. The distance between the two slits in a double-slit experiment is 0.0034 mm. The third-order bright fringe ($m = 3$) is measured on a screen at an angle of 22° from the central maximum. What is the wavelength of the light?
2. The distance between two slits in a double-slit experiment is 3.1×10^{-6} m. The first-order bright fringe is measured on a screen at an angle of 9.6° from the central maximum. What is the wavelength of the light?
3. The distance between two slits in a double-slit experiment is 0.0016 mm. What is the angle between the central maximum and the second dark fringe in the interference pattern produced with light having a wavelength of 520 nm?
4. Monochromatic light shines on the surface of a diffraction grating with 6.7×10^{3} lines/cm. The angle between the central maximum and the first dark fringe is 11.5°. Find the wavelength of the light.
5. Monochromatic light shines on the surface of a diffraction grating with 7.9×10^{3} lines/cm. The angle between the central maximum and the third dark fringe is measured as 64.6°. Find the wavelength of the light.

6. A laser placed perpendicular to a diffraction grating that contains 138 566 lines/m illuminates the grating's surface with monochromatic light with a wavelength of 637.3 nm. At what angle will the second-order maximum appear?
7. Monochromatic light from a laser (λ = 426.9 nm) shines at a right angle onto the surface of a diffraction grating that contains 134 749 lines/m. Find the angle at which one would observe the first-order maximum.
8. Monochromatic light from a laser (λ = 445.9 nm) shines at a right angle onto the surface of a diffraction grating that contains 651 645 lines/m. At what angles would you observe the first-order and second-order maxima?
9. Monochromatic light from a laser (λ = 589.5 nm) shines at a right angle onto the surface of a diffraction grating that contains 157 591 lines/m. At what angles would you observe the first-order and second-order maxima?
10. The surface of a diffraction grating that contains 736 324 lines/m is illuminated by monochromatic light (λ = 615.1 nm) perpendicular to the grating. At what angles would one observe the first-order and second-order maxima?
11. Monochromatic light (λ = 798.7 nm) shines at a right angle onto the surface of a diffraction grating that contains 397 645 lines/m. Find the angles at which one would observe the first-order and second-order maxima.
12. A laser shines monochromatic light (λ = 754.3 nm) at a right angle onto the surface of a diffraction grating that contains 451 652 lines/m. What are the angles of the first-order and second-order maxima?

Phys.12-Q3W3-interference-Qs.Bank
Answer Section

MULTIPLE CHOICE

1.	ANS: B	PTS: 1	DIF: I	OBJ: 15-1.1
2.	ANS: B	PTS: 1	DIF: I	OBJ: 15-1.1
3.	ANS: A	PTS: 1	DIF: I	OBJ: 15-1.1
4.	ANS: D	PTS: 1	DIF: I	OBJ: 15-1.1
5.	ANS: C	PTS: 1	DIF: I	OBJ: 15-1.1
6.	ANS: C	PTS: 1	DIF: I	OBJ: 15-1.1
7.	ANS: A	PTS: 1	DIF: II	OBJ: 15-1.1
8.	ANS: D	PTS: 1	DIF: I	OBJ: 15-1.2
9.	ANS: B	PTS: 1	DIF: II	OBJ: 15-1.2
10.	ANS: C	PTS: 1	DIF: II	OBJ: 15-1.3
11.	ANS: C	PTS: 1	DIF: II	OBJ: 15-1.3
12.	ANS: C	PTS: 1	DIF: II	OBJ: 15-1.1
13.	ANS: C	PTS: 1	DIF: I	OBJ: 15-1.2
14.	ANS: B	PTS: 1	DIF: I	OBJ: 15-1.2
15.	ANS: D	PTS: 1	DIF: II	OBJ: 15-1.2

16. ANS: D

Given

d = 0.040 mm = 4.0 × 10^{-3} m
m = 2
θ = 2.2°

Solution

$d \sin\theta = m\lambda$

$$\lambda = \frac{d \sin\theta}{m} = \frac{(4.0\times10^{-5}\ \text{m})(\sin 2.2°)}{2} = 7.7\times10^{-7}\ \text{m} = 7.7\times10^{2}\ \text{nm}$$

PTS: 1 DIF: IIIA OBJ: 15-1.3

17. ANS: B

Given

d = 2.9 × 10^{-6} m
m = 1
θ = 12°

Solution

$d \sin\theta = m\lambda$

$$\lambda = \frac{d \sin\theta}{m} = \frac{(2.9\times10^{-6}\ \text{m})(\sin 12°)}{2} = 3.0\times10^{-7}\ \text{m} = 3.0\times10^{2}\ \text{nm}$$

PTS: 1 DIF: IIIA OBJ: 15-1.3

18. ANS: D

Given

d = 0.0050 mm = 5.0×10^{-6} m
m = 3
λ = 550 nm = 5.5×10^{-6} m

Solution
$d \sin\theta = m\lambda$

$$\theta = \sin^{-1}\left(\frac{m\lambda}{d}\right) = \sin^{-1}\left(\frac{(3)(5.5 \times 10^{-7}\ \text{m})}{(5.0 \times 10^{-6}\ \text{m})}\right) = 19°$$

PTS: 1 DIF: IIIB OBJ: 15-1.3

19. ANS: C PTS: 1 DIF: II OBJ: 15-2.1

20. ANS: D

Given

$$d = \frac{1}{5.3 \times 10^{3}\ \frac{\text{lines}}{\text{cm}}} = \frac{1}{5.3 \times 10^{3}}\ \text{cm}$$

m = 1
θ = 17°

Solution
$d \sin\theta = m\lambda$

$$\lambda = \frac{d\sin\theta}{m} = \frac{\left(\frac{1}{5.3 \times 10^{3}}\ \text{cm}\right)(\sin 17°)}{1} = 5.5 \times 10^{-5}\ \text{cm} = 5.5 \times 10^{2}\ \text{nm}$$

PTS: 1 DIF: IIIA OBJ: 15-2.2

21. ANS: D

Given

$$d = \frac{1}{5.0 \times 10^{3}\ \frac{\text{lines}}{\text{cm}}} = \frac{1}{5.0 \times 10^{3}\ \text{lines}}\ \text{cm}$$

m = 1
θ = 20.0°

Solution
$d \sin\theta = m\lambda$

$$\lambda = \frac{d\sin\theta}{m} = \frac{\left(\frac{1}{5.0 \times 10^{3}}\ \text{cm}\right)(\sin 20.0°)}{1} = 6.8 \times 10^{-5}\ \text{cm} = 6.8 \times 10^{2}\ \text{nm}$$

PTS: 1 DIF: IIIA OBJ: 15-2.2

22. ANS: B

Given

$$d = \frac{1}{1.0 \times 10^{4}\ \frac{\text{lines}}{\text{cm}}} = \frac{1}{1.0 \times 10^{4}}\ \text{cm} = \frac{1}{1.0 \times 10^{4}}\ \text{cm}\left(\frac{1\ \text{m}}{100\ \text{cm}}\right) = \frac{1}{1.0 \times 10^{6}}\ \text{m}$$

$m = 2$

$\lambda = 400.0 \text{ nm} = 4.000 \times 10^{-7} \text{ m}$

Solution

$d \sin \theta = m\lambda$

$$\theta = \sin^{-1}\left(\frac{m\lambda}{d}\right) = \sin^{-1}\left(\frac{(2)(4.000 \times 10^{-7} \text{ m})}{\left(\frac{1}{1.00 \times 10^{-6}} \text{ m}\right)}\right) = 53.1°$$

PTS: 1 DIF: IIIB OBJ: 15-2.2

23. ANS: A

Given

$$d = \frac{1}{3.39 \times 10^5 \frac{\text{lines}}{\text{m}}} = \frac{1}{3.39 \times 10^5} \text{ m}$$

$m = 1$

$\lambda = 500.0 \text{ nm} = 5.000 \times 10^{-7} \text{ m}$

Solution

$d \sin \theta = m\lambda$

$$\theta = \sin^{-1}\left(\frac{m\lambda}{d}\right) = \sin^{-1}\left(\frac{(5.000 \times 10^{-7} \text{ m})}{\left(\frac{1}{3.39 \times 10^{5}} \text{ m}\right)}\right) = 9.73°$$

PTS: 1 DIF: IIIB OBJ: 15-2.2

24. ANS: A

Given

$$d = \frac{1}{6.62 \times 10^3 \frac{\text{lines}}{\text{cm}}} = \frac{1}{6.62 \times 10^3} \text{ cm}\left(\frac{1 \text{ m}}{100 \text{ cm}}\right) = \frac{1}{6.62 \times 10^5} \text{ m}$$

$m = 1$

$\lambda = 546.1 \text{ nm} = 5.461 \times 10^{-7} \text{ m}$

Solution

$d \sin \theta = m\lambda$

$$\theta = \sin^{-1}\left(\frac{m\lambda}{d}\right) = \sin^{-1}\left(\frac{(5.461 \times 10^{-7} \text{ m})}{\left(\frac{1}{6.62 \times 10^{5}} \text{ m}\right)}\right) = 21.2°$$

PTS: 1 DIF: IIIB OBJ: 15-2.2

25. ANS: B

Given

λ = 2300 nm = 2.3×10^{-6} m
m = 1
θ = 27°

Solution
$d \sin \theta = m\lambda$

$$d = \frac{m\lambda}{\sin\theta} = \frac{2.3 \times 10^{-6}\ \text{m}}{\sin 27°} = 5.1 \times 10^{-6}\ \text{m} = 5.1 \times 10^{-4}\ \text{cm}$$

$$d = 5.1 \times 10^{-4}\ \text{cm/line}$$

$$\frac{1}{d} = \frac{1}{5.1 \times 10^{-4}\ \frac{\text{cm}}{\text{line}}} = 2.0 \times 10^{3}\ \text{lines/cm}$$

PTS: 1 DIF: IIIB OBJ: 15-2.2

26. ANS: B
Given
λ = 632.8 nm = 6.328×10^{-7} m

$$d = \frac{1}{5.310\,01 \times 10^{5}\ \frac{\text{lines}}{\text{m}}} = \frac{1}{5.310\,01 \times 10^{5}}\ \text{m}$$

m = 1, 2

Solution
$d \sin \theta = m\lambda$

$$\theta_1 = \sin^{-1}\left(\frac{m\lambda}{d}\right) = \sin^{-1}\left(\frac{(6.328 \times 10^{-7}\ \text{m})}{\left(\frac{1}{5.310\,01 \times 10^{5}}\ \text{m}\right)}\right) = 19.63°$$

$$\theta_2 = \sin^{-1}\left(\frac{m\lambda}{d}\right) = \sin^{-1}\left(\frac{(2)(6.328 \times 10^{-7}\ \text{m})}{\left(\frac{1}{5.310\,01 \times 10^{5}}\ \text{m}\right)}\right) = 42.20°$$

PTS: 1 DIF: IIIC OBJ: 15-2.2

27. ANS: B
Given

$$d = \frac{1}{6.504\,72 \times 10^{5}\ \frac{\text{lines}}{\text{m}}} = \frac{1}{6.504\,72 \times 10^{5}}\ \text{m}$$

λ = 632.8 nm = 6.328×10^{-7} m
m = 1, 2

Solution

$$d \sin \theta = m\lambda$$

$$\theta_1 = \sin^{-1}\left(\frac{m\lambda}{d}\right) = \sin^{-1}\left(\frac{(6.328 \times 10^{-7}\ \text{m})}{\left(\frac{1}{6.504\ 72 \times 10^5}\ \text{m}\right)}\right) = 24.30°$$

$$\theta_2 = \sin^{-1}\left(\frac{m\lambda}{d}\right) = \sin^{-1}\left(\frac{(2)(6.328 \times 10^{-7}\ \text{m})}{\left(\frac{1}{6.504\ 72 \times 10^5}\ \text{m}\right)}\right) = 55.38°$$

PTS: 1 DIF: IIIC OBJ: 15-2.2

28. ANS: B

Given

λ = 632.8 nm = 6.328 × 10^{-7} m

$$d = \frac{1}{1.462\ 30 \times 10^5\ \frac{\text{lines}}{\text{m}}} = \frac{1}{1.462\ 30 \times 10^5}\ \text{m}$$

m = 2, 3

Solution

$$d \sin \theta = m\lambda$$

$$\theta_1 = \sin^{-1}\left(\frac{m\lambda}{d}\right) = \sin^{-1}\left(\frac{(2)(6.328 \times 10^{-7}\ \text{m})}{\left(\frac{1}{1.462\ 30 \times 10^5}\ \text{m}\right)}\right) = 10.66°$$

$$\theta_2 = \sin^{-1}\left(\frac{m\lambda}{d}\right) = \sin^{-1}\left(\frac{(3)(6.328 \times 10^{-7}\ \text{m})}{\left(\frac{1}{1.462\ 30 \times 10^5}\ \text{m}\right)}\right) = 16.11°$$

PTS: 1 DIF: IIIC OBJ: 15-2.2

29. ANS: A PTS: 1 DIF: I OBJ: 15-2.3
30. ANS: C PTS: 1 DIF: I OBJ: 15-3.1
31. ANS: B PTS: 1 DIF: I OBJ: 15-3.1
32. ANS: A PTS: 1 DIF: I OBJ: 15-3.1
33. ANS: C PTS: 1 DIF: I OBJ: 15-3.1
34. ANS: D PTS: 1 DIF: I OBJ: 15-3.1
35. ANS: D PTS: 1 DIF: I OBJ: 15-3.1
36. ANS: D PTS: 1 DIF: I OBJ: 15-3.2

SHORT ANSWER

1. ANS:
destructive

PTS: 1 DIF: I OBJ: 15-1.1

2. ANS:
constructive

PTS: 1 DIF: I OBJ: 15-1.1

3. ANS:
180°

PTS: 1 DIF: I OBJ: 15-1.1

4. ANS:
0°

PTS: 1 DIF: I OBJ: 15-1.1

5. ANS:
0

PTS: 1 DIF: I OBJ: 15-1.2

6. ANS:
$\frac{1}{2}\lambda$

PTS: 1 DIF: I OBJ: 15-1.2

7. ANS:
λ

PTS: 1 DIF: I OBJ: 15-1.2

8. ANS:
Diffraction is a change in the direction of a wave when the wave encounters an obstacle, an opening, or an edge.

PTS: 1 DIF: I OBJ: 15-2.1

9. ANS:
Diffraction occurs when waves pass through small openings, around obstacles, or around sharp edges. Wavelets in a wave front interfere with each other to produce light and dark fringes.

PTS: 1 DIF: I OBJ: 15-2.1

10. ANS:
The pattern is one of alternating light and dark bands. The brightest light band is at the center and is twice as wide as the other bands. The light bands decrease in brightness as the distance from the center increases.

PTS: 1 DIF: II OBJ: 15-2.1

11. ANS:
3

PTS: 1 DIF: II OBJ: 15-2.1

12. ANS:
spectrometer

PTS: 1 DIF: I OBJ: 15-2.2

13. ANS:
The separation of the individual slits is decreased.

PTS: 1 DIF: I OBJ: 15-2.2

14. ANS:
A spectrometer separates light from a source into its monochromatic components.

PTS: 1 DIF: I OBJ: 15-2.2

15. ANS:
The separation of the individual wavelengths of the diffracted light is increased.

PTS: 1 DIF: II OBJ: 15-2.2

16. ANS:
Resolving power is the ability of an optical instrument to separate two images that are close together.

PTS: 1 DIF: I OBJ: 15-2.3

17. ANS:
resolving power

PTS: 1 DIF: I OBJ: 15-2.3

18. ANS:
Constantly moving layers of air blur the light from objects in space and limit the resolving power.

PTS: 1 DIF: II OBJ: 15-2.3

19. ANS:
The resolving power of the instrument will decrease.

PTS: 1 DIF: II OBJ: 15-2.3

20. ANS:
As the aperture increases, the effect of diffraction decreases. Each source will be less diffracted, so the central maximum of one source will be more separated from the central maximum of the second source.

PTS: 1 DIF: II OBJ: 15-2.3

21. ANS:
laser

PTS: 1 DIF: I OBJ: 15-3.1

22. ANS:
The waves emitted by a laser do not shift relative to each other as time progresses. The individual waves behave like a single wave because they are coherent and in phase.

PTS: 1 DIF: II OBJ: 15-3.1

23. ANS:

When energy is added to the active medium, the atoms in the active medium absorb some of the energy. Later, these atoms release energy in the form of light waves that have the equivalent wavelength and phase. The initial waves cause other energized atoms to release their excess energy in the form of more light waves with the same wavelength, phase, and direction as the initial light wave. Mirrors on the end of the material return these coherent light waves into the active medium, where they emit more coherent light waves. One of these mirrors is slightly transparent so that some of the coherent light is emitted.

PTS: 1 DIF: II OBJ: 15-3.1

24. ANS:
A "laser knife" cuts through tissue like a steel scalpel; however, the energy from the laser coagulates blood, sealing the blood vessels and preventing blood loss and infection.

PTS: 1 DIF: II OBJ: 15-3.2

25. ANS:
Light from a laser passes through a glass plate and then a lens that directs it onto the CD. The reflection or lack of a reflection of the laser light is then read by a detector, and the signal is sent through electrical circuits.

PTS: 1 DIF: II OBJ: 15-3.2

26. ANS:
Astronomers direct a pulse of light toward one of several reflectors that were placed on the moon's surface by astronauts. The distance from Earth to the moon can be measured by finding the time the light takes to travel to the moon and back.

PTS: 1 DIF: II OBJ: 15-3.2

27. ANS:
The cornea and lens are transparent.

PTS: 1 DIF: II OBJ: 15-3.2

PROBLEM

1. ANS:
420 nm

Given

$d = 0.0034 \text{ mm} = 3.4 \times 10^{-6} \text{ m}$

$m = 3$

$\theta = 22°$

Solution

$d \sin\theta = m\lambda$

$$\lambda = \frac{d \sin\theta}{m} = \frac{(3.4 \times 10^{-6} \text{ m})(\sin 22°)}{3}$$

$$\lambda = \frac{(3.4 \times 10^{-6} \text{ m})(0.37)}{3}$$

$$\lambda = 4.2 \times 10^{-7} \text{ m} = 4.2 \times 10^{2} \text{ nm} = 420 \text{ nm}$$

PTS: 1 DIF: IIIA OBJ: 15-1.3

2. ANS:
530 nm

Given

$d = 3.1 \times 10^{-6}$ m
$m = 1$
$\theta = 9.6°$

Solution

$d \sin\theta = m\lambda$

$$\lambda = \frac{d\sin\theta}{m} = \frac{(3.1 \times 10^{-6}\ \text{m})(\sin 9.6°)}{1}$$

$$\lambda = \frac{(3.1 \times 10^{-6}\ \text{m})(0.17)}{1}$$

$$\lambda = 5.3 \times 10^{-7}\ \text{m} = 5.3 \times 10^{2}\ \text{nm} = 530\ \text{nm}$$

PTS: 1 DIF: IIIA OBJ: 15-1.3

3. ANS:
29°

Given

$d = 0.0016\ \text{mm} = 1.6 \times 10^{-6}$ m
$m = 1\frac{1}{2} = \frac{3}{2}$
$\lambda = 520\ \text{nm} = 5.2 \times 10^{-7}$ m

Solution

$d \sin\theta = m\lambda$

$$\theta = \sin^{-1}\left(\frac{m\lambda}{d}\right) = \sin^{-1}\left(\frac{\left(\frac{3}{2}\right)(5.2 \times 10^{-7}\ \text{m})}{(1.6 \times 10^{-6}\ \text{m})}\right)$$

$$\theta = \sin^{-1}(0.49)$$

$$\theta = 29°$$

PTS: 1 DIF: IIIB OBJ: 15-1.3

4. ANS:
5.9×10^{2} nm

Given

$$d = \frac{1}{6.7 \times 10^{3}\ \frac{\text{lines}}{\text{cm}}} = \frac{1}{6.7 \times 10^{3}}\ \text{cm}$$

$m = \frac{1}{2}$

$\theta = 11.5°$

Solution

$d \sin\theta = m\lambda$

$$\lambda = \frac{d\sin\theta}{m} = \frac{\left(\frac{1}{6.7\times 10^3}\text{ cm}\right)(\sin 11.5°)}{\frac{1}{2}} = \frac{(2)(\sin 11.5°)}{\left(6.7\times 10^3\right)}\text{ cm}$$

$$\lambda = \frac{(2)(0.199)}{\left(6.7\times 10^3\right)}\text{ cm} = 5.9\times 10^{-5}\text{ cm} = 5.9\times 10^2\text{ nm}$$

PTS: 1 DIF: IIIA OBJ: 15-2.2

5. ANS:

4.6×10^2 nm

Given

$$d = \frac{1}{7.9\times 10^3\,\frac{\text{lines}}{\text{cm}}} = \frac{1}{7.9\times 10^3}\text{ cm}$$

$m = 2\frac{1}{2} = \frac{5}{2}$

$\theta = 64.6°$

Solution

$d \sin\theta = m\lambda$

$$\lambda = \frac{d\sin\theta}{m} = \frac{\left(\frac{1}{7.9\times 10^3}\text{ cm}\right)(\sin 64.6°)}{\left(\frac{5}{2}\right)} = \frac{(2)(\sin 64.6°)}{(5)\left(7.9\times 10^3\right)}\text{ cm}$$

$$\lambda = \frac{(2)(0.903)}{(5)(7.9\times 10^3)}\text{ cm} = 4.6\times 10^{-5}\text{ cm} = 4.6\times 10^2\text{ nm}$$

PTS: 1 DIF: IIIA OBJ: 15-2.2

6. ANS:

$\theta = 10.17°$

Given

$\lambda = 637.3\text{ nm} = 6.373\times 10^{-7}\text{ m}$

$$d = \frac{1}{1.38566\times 10^5\,\frac{\text{lines}}{\text{m}}} = \frac{1}{1.38566\times 10^5}\text{ m}$$

$m = 2$

Solution

$d \sin\theta = m\lambda$

$$\theta = \sin^{-1}\left(\frac{m\lambda}{d}\right) = \sin^{-1}\left(\frac{(2)(6.373\times10^{-7}\text{ m})}{\left(\frac{1}{1.38566\times10^{5}}\text{ m}\right)}\right) = \sin^{-1}\left((2)(6.373\times10^{-7}\text{ m})\left(1.38566\times10^{5}\right)\right)$$

$$\theta = \sin^{-1}(0.1766) = 10.17°$$

PTS: 1 DIF: IIIB OBJ: 15-2.2

7. ANS:
$\theta = 3.297°$

Given
$\lambda = 426.9\text{ nm} = 4.269\times10^{-7}\text{ m}$
$$d = \frac{1}{1.34749\times10^{5}\ \frac{\text{lines}}{\text{m}}} = \frac{1}{1.34749\times10^{5}}\text{ m}$$
$m = 1$

Solution
$d\sin\theta = m\lambda$
$$\theta = \sin^{-1}\left(\frac{m\lambda}{d}\right) = \sin^{-1}\left(\frac{(1)(4.269\times10^{-7}\text{ m})}{\left(\frac{1}{1.34749\times10^{5}}\text{ m}\right)}\right) = \sin^{-1}\left((4.269\times10^{-7}\text{ m})\left(1.34749\times10^{5}\right)\right)$$

$$\theta = \sin^{-1}(0.05752) = 3.297°$$

PTS: 1 DIF: IIIB OBJ: 15-2.2

8. ANS:
$\theta_1 = 16.89°,\ \theta_2 = 35.53°$

Given
$\lambda = 445.9\text{ nm} = 4.459\times10^{-7}\text{ m}$
$$d = \frac{1}{6.51645\times10^{5}\ \frac{\text{lines}}{\text{m}}} = \frac{1}{6.51645\times10^{5}}\text{ m}$$
$m = 1, 2$

Solution
$d\sin\theta = m\lambda$

$$\theta_1 = \sin^{-1}\left(\frac{m\lambda}{d}\right) = \sin^{-1}\left(\frac{(1)(4.459 \times 10^{-7}\text{ m})}{\left(\frac{1}{6.51645 \times 10^5}\text{ m}\right)}\right) = \sin^{-1}\left((4.459 \times 10^{-7}\text{ m})\left(6.51645 \times 10^5\right)\right)$$

$$\theta_1 = \sin^{-1}(0.2906) = 16.89°$$

$$\theta_2 = \sin^{-1}\left(\frac{m\lambda}{d}\right) = \sin^{-1}\left(\frac{(2)(4.459 \times 10^{-7}\text{ m})}{\left(\frac{1}{6.51645 \times 10^5}\text{ m}\right)}\right) = \sin^{-1}\left((2)(4.459 \times 10^{-7}\text{ m})\left(6.51645 \times 10^5\right)\right)$$

$$\theta_2 = \sin^{-1}(0.5811) = 35.53°$$

PTS: 1 DIF: IIIC OBJ: 15-2.2

9. ANS:
$\theta_1 = 5.330°,\ \theta_2 = 10.71°$

Given
$\lambda = 589.5\text{ nm} = 5.895 \times 10^{-7}\text{ m}$
$d = \dfrac{1}{1.57591 \times 10^5\ \frac{\text{lines}}{\text{m}}} = \dfrac{1}{1.57591 \times 10^5}\text{ m}$
$m = 1, 2$

Solution
$d \sin\theta = m\lambda$

$$\theta_1 = \sin^{-1}\left(\frac{m\lambda}{d}\right) = \sin^{-1}\left(\frac{(1)(5.895 \times 10^{-7}\text{ m})}{\left(\frac{1}{1.57591 \times 10^5}\text{ m}\right)}\right) = \sin^{-1}\left((5.895 \times 10^{-7}\text{ m})\left(1.57591 \times 10^5\right)\right)$$

$$\theta_1 = \sin^{-1}(0.09290) = 5.330°$$

$$\theta_2 = \sin^{-1}\left(\frac{m\lambda}{d}\right) = \sin^{-1}\left(\frac{(2)(5.895 \times 10^{-7}\text{ m})}{\left(\frac{1}{1.57591 \times 10^5}\text{ m}\right)}\right) = \sin^{-1}\left((2)(5.895 \times 10^{-7}\text{ m})\left(1.57591 \times 10^5\right)\right)$$

$$\theta_2 = \sin^{-1}(0.1858) = 10.71°$$

PTS: 1 DIF: IIIC OBJ: 15-2.2

10. ANS:
$\theta_1 = 26.93°,\ \theta_2 = 64.93°$

Given

$\lambda = 615.1 \text{ nm} = 6.151 \times 10^{-7} \text{ m}$

$d = \dfrac{1}{7.36324 \times 10^5 \ \dfrac{\text{lines}}{\text{m}}} = \dfrac{1}{7.36324 \times 10^5} \text{ m}$

$m = 1, 2$

Solution

$d \sin \theta = m\lambda$

$$\theta_1 = \sin^{-1}\left(\frac{m\lambda}{d}\right) = \sin^{-1}\left(\frac{(1)(6.151 \times 10^{-7} \text{ m})}{\left(\dfrac{1}{7.36324 \times 10^5} \text{ m}\right)}\right) = \sin^{-1}\left((6.151 \times 10^{-7} \text{ m})\left(7.36324 \times 10^5\right)\right)$$

$$\theta_1 = \sin^{-1}(0.4529) = 26.93°$$

$$\theta_2 = \sin^{-1}\left(\frac{m\lambda}{d}\right) = \sin^{-1}\left(\frac{(2)(6.151 \times 10^{-7} \text{ m})}{\left(\dfrac{1}{7.36324 \times 10^5} \text{ m}\right)}\right) = \sin^{-1}\left((2)(6.151 \times 10^{-7} \text{ m})\left(7.36324 \times 10^5\right)\right)$$

$$\theta_2 = \sin^{-1}(0.9058) = 64.93°$$

PTS: 1 DIF: IIIC OBJ: 15-2.2

11. ANS:

$\theta_1 = 18.52°,\ \theta_2 = 39.43°$

Given

$\lambda = 798.7 \text{ nm} = 7.987 \times 10^{-7} \text{ m}$

$d = \dfrac{1}{3.97645 \times 10^5 \ \dfrac{\text{lines}}{\text{m}}} = \dfrac{1}{3.97645 \times 10^5} \text{ m}$

$m = 1, 2$

Solution

$d \sin \theta = m\lambda$

$$\theta_1 = \sin^{-1}\left(\frac{m\lambda}{d}\right) = \sin^{-1}\left(\frac{(1)(7.987 \times 10^{-7}\ \text{m})}{\left(\frac{1}{3.97645 \times 10^5}\ \text{m}\right)}\right) = \sin^{-1}\left((7.987 \times 10^{-7}\ \text{m})\left(3.97645 \times 10^5\right)\right)$$

$$\theta_1 = \sin^{-1}(0.3176) = 18.52°$$

$$\theta_2 = \sin^{-1}\left(\frac{m\lambda}{d}\right) = \sin^{-1}\left(\frac{(2)(7.987 \times 10^{-7}\ \text{m})}{\left(\frac{1}{3.97645 \times 10^5}\ \text{m}\right)}\right) = \sin^{-1}\left((2)(7.987 \times 10^{-7}\ \text{m})\left(3.97645 \times 10^5\right)\right)$$

$$\theta_2 = \sin^{-1}(0.6352) = 39.43°$$

PTS: 1 DIF: IIIC OBJ: 15-2.2

12. ANS:
$\theta_1 = 19.92°$, $\theta_2 = 42.95°$

Given
$\lambda = 754.3\ \text{nm} = 7.543 \times 10^{-7}\ \text{m}$

$$d = \frac{1}{4.51652 \times 10^5\ \frac{\text{lines}}{\text{m}}} = \frac{1}{4.51652 \times 10^5}\ \text{m}$$

$m = 1, 2$

Solution
$d \sin\theta = m\lambda$

$$\theta_1 = \sin^{-1}\left(\frac{m\lambda}{d}\right) = \sin^{-1}\left(\frac{(1)(7.543 \times 10^{-7}\ \text{m})}{\left(\frac{1}{4.51652 \times 10^5}\ \text{m}\right)}\right) = \sin^{-1}\left((7.543 \times 10^{-7}\ \text{m})\left(4.51652 \times 10^5\right)\right)$$

$$\theta_1 = \sin^{-1}(0.3407) = 19.92°$$

$$\theta_2 = \sin^{-1}\left(\frac{m\lambda}{d}\right) = \sin^{-1}\left(\frac{(2)(7.543 \times 10^{-7}\ \text{m})}{\left(\frac{1}{4.51652 \times 10^5}\ \text{m}\right)}\right) = \sin^{-1}\left((2)(7.543 \times 10^{-7}\ \text{m})\left(4.51652 \times 10^5\right)\right)$$

$$\theta_2 = \sin^{-1}(0.6814) = 42.95°$$

PTS: 1 DIF: IIIC OBJ: 15-2.2