***Physics: Principle and Applications*, 7e (Giancoli)**
Chapter 24 The Wave Nature of Light

24.1 Conceptual Questions

1) If unpolarized light of intensity I_0 passes through an ideal polarizer, what is the intensity of the emerging light?
A) I_0
B) $I_0/2$
C) $I_0/4$
D) $I_0/\sqrt{2}$
E) $I_0/16$
Answer: B
Var: 1

2) For a beam of light, the direction of polarization is defined as
A) the beam's direction of travel.
B) the direction of the electric field's vibration.
C) the direction of the magnetic field's vibration.
D) the direction that is perpendicular to both the electric and magnetic field vectors.
Answer: B
Var: 1

3) When light travels from air into water,
A) its velocity, wavelength and frequency all change.
B) its velocity changes, but its frequency and wavelength do not change.
C) its frequency changes, but its velocity and wavelength do not change.
D) its velocity and wavelength change, but its frequency does not change.
E) its wavelength changes, but its velocity and frequency do not change.
Answer: D
Var: 1

4) Monochromatic coherent light shines through a pair of slits. If the distance between these slits is decreased, which of the following statements are true of the resulting interference pattern? (There could be more than one correct choice.)
A) The distance between the maxima stays the same.
B) The distance between the maxima decreases.
C) The distance between the minima stays the same.
D) The distance between the minima increases.
E) The distance between the maxima increases.
Answer: D, E
Var: 1

5) Monochromatic coherent light shines through a pair of slits. If the wavelength of the light is decreased, which of the following statements are true of the resulting interference pattern? (There could be more than one correct choice.)
A) The distance between the maxima stays the same.
B) The distance between the maxima decreases.
C) The distance between the minima stays the same.
D) The distance between the minima increases.
E) The distance between the minima decreases.
Answer: B, E
Var: 1

6) A double-slit interference experiment is performed in the air. Later, the same apparatus is immersed in benzene (which has an index of refraction of 1.50), and the experiment is repeated. When the apparatus is in benzene, you observe that the interference fringes are
A) more closely spaced than when the apparatus is in air.
B) equally spaced as when the apparatus is in air.
C) more widely spaced than when the apparatus is in air.
Answer: A
Var: 1

7) In a double-slit interference experiment you are asked to use laser light of different wavelengths and determine the separation between adjacent maxima. You observe that this separation is greatest when you illuminate the double slit with
A) blue light.
B) green light.
C) yellow light.
D) red light.
E) The separation is the same for all wavelengths.
Answer: D
Var: 1

8) Two light sources are said to be *coherent* if they are
A) of the same frequency.
B) of the same frequency, and maintain a constant phase difference.
C) of the same amplitude, and maintain a constant phase difference.
D) of the same frequency and amplitude.
Answer: B
Var: 1

9) What do we mean when we say that two light rays striking a screen are in phase with each other?
A) When the electric field due to one is a maximum, the electric field due to the other is also a maximum, and this relation is maintained as time passes.
B) They are traveling at the same speed.
C) They have the same wavelength.
D) They alternately reinforce and cancel each other.
Answer: A
Var: 1

10) Two beams of coherent light start out at the same point in phase and travel different paths to arrive at point P. If the maximum constructive interference is to occur at point P, the two beams must travel paths that differ by
A) a whole number of wavelengths.
B) an odd number of half-wavelengths.
C) a whole number of half-wavelengths.
Answer: A
Var: 1

11) Two beams of coherent light start out at the same point in phase and travel different paths to arrive at point P. If the maximum destructive interference is to occur at point P, the two beams must travel paths that differ by
A) a whole number of wavelengths.
B) an odd number of half-wavelengths.
C) a whole number of half-wavelengths.
Answer: B
Var: 1

12) If a sheet containing two very thin slits is heated (without damaging it), what happens to the angular location of the first-order interference minimum?
A) It moves toward the centerline.
B) It moves away from the centerline.
C) It doesn't change.
Answer: A
Var: 1

13) In a double-slit experiment, it is observed that the distance between adjacent maxima on a remote screen is 1.0 cm. What happens to the distance between adjacent maxima when the slit separation is cut in half?
A) It increases to 2.0 cm.
B) It increases to 4.0 cm.
C) It decreases to 0.50 cm.
D) It decreases to 0.25 cm.
E) None of these choices are correct.
Answer: A
Var: 1

14) In a single-slit diffraction experiment, the width of the slit through which light passes is reduced. What happens to the width of the central bright fringe in the resulting diffraction pattern?
A) It stays the same.
B) It becomes narrower.
C) It becomes wider.
Answer: C
Var: 1

15) A single-slit diffraction pattern is formed on a distant screen. Assuming the angles involved are small, by what factor will the width of the central bright spot on the screen change if the wavelength of the illuminating light is doubled?
A) It will be cut to one-quarter its original size.
B) It will be cut in half.
C) It will double.
D) It will become four times as large.
E) It will become eight times as large.
Answer: C
Var: 1

16) A single-slit diffraction pattern is formed on a distant screen. Assuming the angles involved are small, by what factor will the width of the central bright spot on the screen change if the slit width is doubled?
A) It will be cut to one-quarter its original size.
B) It will be cut in half.
C) It will double.
D) It will become four times as large.
E) It will become eight times as large.
Answer: B
Var: 1

17) If a sheet containing a single slit is heated (without damaging it) and therefore expands, what happens to the angular location of the first-order diffraction minimum?
A) It moves toward the centerline.
B) It moves away from the centerline.
C) It doesn't change.
Answer: A
Var: 1

18) If a sheet containing a single thin slit is heated (without damaging it) and therefore expands, what happens to the width of the central bright diffraction region on a distant screen?
A) It gets narrower.
B) It gets wider.
C) It doesn't change.
Answer: B
Var: 1

19) What principle is responsible for light spreading as it passes through a narrow slit?
A) refraction
B) polarization
C) diffraction
D) dispersion
Answer: C
Var: 1

20) Radio waves are diffracted by large objects such as buildings, whereas light is not noticeably diffracted. Why is this?
A) Radio waves are unpolarized, whereas light is normally polarized.
B) The wavelength of light is much smaller than the wavelength of radio waves.
C) The wavelength of light is much greater than the wavelength of radio waves.
D) Radio waves are coherent and light is usually not coherent.
E) Radio waves are polarized, whereas light is usually unpolarized.
Answer: B
Var: 1

21) Which of the following changes would *increase* the separation between the bright fringes in the diffraction pattern formed by a diffraction grating?
A) Increase the wavelength of the light used.
B) Increase the separation between the slits.
C) Immerse the apparatus in water.
D) All of these.
E) None of these.
Answer: A
Var: 1

22) Light of the same wavelength passes through two diffraction gratings. One grating has 4000 lines/cm, and the other one has 6000 lines/cm. Which grating will spread the light through a larger angle in the first-order pattern?
A) the 4000-line grating
B) the 6000-line grating
C) Both gratings spread the light the same.
Answer: B
Var: 1

23) If a diffraction grating is heated (without damaging it) and therefore expands, what happens to the angular location of the first-order maximum?
A) It moves toward the centerline.
B) It moves away from the centerline.
C) It doesn't change.
Answer: A
Var: 1

24) Light in a frozen block of ice reflects off the ice-air interface at the surface of the block. What phase shift does it undergo?
A) 0°
B) 90°
C) 180°
D) 270°
E) It does not undergo any phase shift.
Answer: A
Var: 1

25) Light reflects off the surface of Lake Superior. What phase shift does it undergo?
A) 0°
B) 90°
C) 180°
D) 270°
E) It does not undergo any phase shift.
Answer: C
Var: 1

26) When a beam of light that is traveling in glass strikes an air boundary at the surface of the glass, there is
A) a 90° phase change in the reflected beam.
B) no phase change in the reflected beam.
C) a 180° phase change in the reflected beam.
D) a 60° phase change in the reflected beam.
E) a 45° phase change in the reflected beam.
Answer: B
Var: 1

27) When a beam of light that is traveling in air is reflected by a glass surface, there is
A) a 90° phase change in the reflected beam.
B) no phase change in the reflected beam.
C) a 180° phase change in the reflected beam.
D) a 60° phase change in the reflected beam.
E) a 45° phase change in the reflected beam.
Answer: C
Var: 1

28) When a light wave enters into a medium of different refractive index,
A) only its speed and frequency change.
B) only its speed and wavelength change.
C) only its frequency and wavelength change.
D) its speed, frequency, and wavelength change.
Answer: B
Var: 1

29) When a beam of light, originally traveling in air, enters a piece of glass having an index of refraction of 3/2, its frequency
A) increases by a factor of 3/2.
B) is reduced to 2/3 its original value.
C) is unaffected.
Answer: C
Var: 1

30) When a beam of light, originally traveling in air, enters a piece of glass having an index of refraction of 3/2, its wavelength
A) increases by a factor of 3/2.
B) is reduced to 2/3 its original value.
C) is unaffected.
Answer: B
Var: 1

31) When a beam of light, originally traveling in air, enters a piece of glass having an index of refraction of 3/2, its speed
A) increases by a factor of 3/2.
B) is reduced to 2/3 its original value.
C) is unaffected.
Answer: B
Var: 1

32) The colors on an oil slick are caused by reflection and
A) diffraction.
B) interference.
C) refraction.
D) polarization.
E) ionization.
Answer: B
Var: 1

24.2 Problems

1) Unpolarized light of intensity I_0 passed through an ideal polarizing sheet with its polarizing axis at the 12 o'clock position and then through a second ideal sheet with its polarizing axis at the 1 o'clock position. What is the intensity of the emerging light in terms of I_0?

Answer: $\frac{3}{8} I_0$

Var: 1

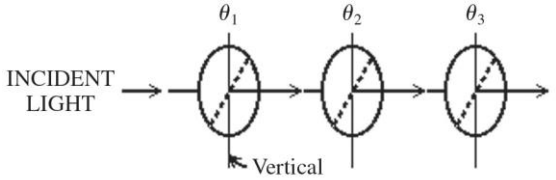
2) Three ideal polarizers are oriented as follows: The axis of the second polarizer is at an angle of 59.0° relative to the first one. The axis of the third polarizer is at an angle of 31.0° relative to the second one, so the axis of the axis of the third polarizer is perpendicular to the axis of the first one. Unpolarized light of intensity $18.6\ \text{W/m}^2$ is incident on the first polarizer.
(a) What is the intensity of the light after it passes through all three polarizers?
(b) What is the intensity of the transmitted light if the second polarizer is removed?
Answer: (a) 1.81 W/m^2 (b) 0 W/m^2
Var: 50+

3) Light passes through three ideal polarizing sheets. Unpolarized light enters the first sheet and the resultant vertically polarized beam continues through the second sheet and third sheet. The second sheet has its transmission axis at 50° with respect to the first sheet, and the third sheet is at 70° with respect to the first sheet.
(a) What percent of the original intensity emerges from filter #1?
(b) What percent of the original intensity emerges from filter #2?
(c) What percent of the original intensity emerges from filter #3?
Answer: (a) 50% (b) 21% (c) 18%
Var: 1

4) Unpolarized light of intensity I_0 passes through four ideal polarizing sheets. The polarizing angle of each sheet is rotated 30° from the one before it, so that the last sheet is aligned at 90° to the first sheet. What is the intensity of the light emerging from the fourth sheet in terms of I_0?
Answer: 0.21 I_0
Var: 1

5) An ideal polarizer with its transmission axis rotated 30° to the vertical is placed in a beam of unpolarized light of intensity 10 W/m^2. After passing through the polarizer, what is intensity of the beam?
A) 2.5 W/m^2
B) 5.0 W/m^2
C) 8.7 W/m^2
D) 7.5 W/m^2
E) 10 W/m^2
Answer: B
Var: 1

6) As shown in the figure, the orientation of the transmission axis for each of three ideal polarizing sheets is labeled relative to the vertical direction. A beam of light, polarized in the vertical direction, is incident on the first polarizer with an intensity of 1.00 kW/m^2. What is the intensity of the beam after it has passed through the three polarizing sheets when θ_1 = 30°, θ_2 = 30°, and θ_3= 60°?



A) 141 W/m^2
B) 316 W/m^2
C) 433 W/m^2
D) 563 W/m^2
E) 188 W/m^2
Answer: D
Var: 1

7) The following items are positioned in sequence: A source of a beam of natural light of intensity I_0, three ideal polarizers A, B, and C; and an observer. Polarizer axis angles are measured clockwise from the vertical, as viewed by the observer. The axis angle of polarizer A is set at 0° (vertical), and the axis angle of polarizer C is set at 50°. Polarizer B is set so that the beam intensity is zero at the observer. What are the two possible axis angle settings (less than 180°) of polarizer B?
A) 40° and 90°
B) 40° and 130°
C) 40° and 140°
D) 90° and 130°
E) 90° and 140°
Answer: E
Var: 1

8) The following items are positioned in sequence: A source of a beam of natural light of intensity I_0, three ideal polarizers A, B, and C; and an observer. Polarizer axis angles are measured clockwise from the vertical, as viewed by the observer. The axis angle of polarizer A is set at 0° (vertical), and the axis angle of polarizer C is set at 50°. Polarizer B is set so that the beam intensity at the observer is a *maximum*. What is the axis angle settings of polarizer B?
A) 0°
B) 25°
C) 50°
D) 75°
E) 100°
Answer: B
Var: 1

9) The following items are positioned in sequence: A source of a beam of natural light of intensity I_0, three ideal polarizers A, B, and C; and an observer. Polarizer axis angles are measured clockwise from the vertical, as viewed by the observer. The axis angle of polarizer A is set at 0° (vertical), and the axis angle of polarizer C is set at 50°. The axis angle of polarizer B is set at 120°. What is ratio of the intensity of the beam at the observer to the intensity I_0 of the source?
A) 0.015
B) 0.020
C) 0.025
D) 0.030
E) 0.035
Answer: A
Var: 1

10) A beam of light is polarized in a vertical plane and has an intensity I_0. The beam passes through an ideal polarizer and then through an ideal analyzer whose axis is set horizontally. If the axis of the polarizer is set at 60° with the vertical, what is the ratio of the intensity of the final beam to I_0?
A) 0.19
B) 0.25
C) 0.31
D) 0.37
E) 0.43
Answer: A
Var: 1

11) Light of intensity S_0 that is polarized horizontally passes through three ideal polarizers. The first and third are horizontal, but the second one is oriented at $0.39270\ \text{rad}$ to the horizontal. In terms of S_0, the intensity of the light that passes through the set of polarizers is closest to which one of the following choices?
A) 0.729 S_0
B) 0.125 S_0
C) 0.427 S_0
D) 0.854 S_0
Answer: A
Var: 6

12) Polarized light of intensity S_0 passes through an ideal polarizer. If the electric vector of the polarized light is horizontal what, in terms of the initial intensity S_0, is the intensity of the light that passes through a polarizer if that polarizer is tilted $0.449\ \text{rad}$ from the horizontal?
A) 0.812 S_0
B) 0.188 S_0
C) 0.217 S_0
D) 0.284 S_0
Answer: A
Var: 5

13) Unpolarized light is incident upon two ideal polarizing filters that do not have their transmission axes aligned. If 19% of the light passes through this combination, what is the angle between the transmission axes of the two filters?
A) 52°
B) 72°
C) 0°
D) 0°
Answer: A
Var: 31

14) Unpolarized light passes through a combination of two ideal polarizers. The transmission axes of the first polarizer and the second polarizer are at 30.0° to each other. What percentage of the original light gets through the combination?
A) 37.5%
B) 50%
C) 75%
D) 100%
Answer: A
Var: 1

15) Unpolarized light passes through three ideal polarizing filters. The first filter is oriented with a horizontal transmission axis, the second one has its transmission axis at 30° from the horizontal, and the third filter has a vertical transmission axis. What percent of the light gets through this combination?
A) 9.4%
B) 91%
C) 50%
D) 0%
E) 33%
Answer: A
Var: 1

16) A vertically polarized beam of light of intensity 100 W/m^2 passes through two ideal polarizers. The transmission axis of the first polarizer makes an angle of 20.0° with the vertical, and the transmission axis of the second one makes an angle of 40.0° with the vertical. What is the intensity of the light after it has passes through both polarizers?
A) 22.2 W/m^2
B) 44.4 W/m^2
C) 66.6 W/m^2
D) 78.0 W/m^2
E) 11.7 W/m^2
Answer: D
Var: 1

17) Red light with a wavelength of 650 nm travels from air into a liquid with an index of 1.33. What are the frequency and wavelength of the light in the liquid? (c = 3.0 × 10^8 m/s)
Answer: 4.61 × 10^{14} Hz, 489 nm
Var: 1

18) Light of wavelength 550 nm in air is found to travel at 1.96 × 10^8 m/s in a certain liquid. (c = 3.0 × 10^8 m/s)
(a) What is the index of refraction of this liquid?
(b) What is the frequency of the light in air?
Answer: (a) 1.53 (b) 5.45 × 10^{14} Hz
Var: 1

19) Light of wavelength 550 nm in air is found to travel at 1.96 × 10^8 m/s in a certain liquid. What are the frequency and wavelength of the light in this liquid? (c = 3.0 × 10^8 m/s)
Answer: 5.45 × 10^{14} Hz, 359 nm
Var: 1

20) Light having a frequency in vacuum of 6.0 × 10^{14} Hz enters a liquid of refractive index 2.0. What is the frequency of the light in this liquid? (c = 3.0 × 10^8 m/s)
A) 12 × 10^{14} Hz
B) 6.0 × 10^{14} Hz
C) 3.0 × 10^{14} Hz
D) 1.5 × 10^{14} Hz
E) 2.0 × 10^{14} Hz
Answer: B
Var: 1

21) Light having a wavelength in vacuum of 600 nm enters a liquid of refractive index 2.0. In this liquid, what is the wavelength of the light? ($c = 3.0 \times 10^8$ m/s)
A) 1200 nm
B) 600 nm
C) 300 nm
D) 150 nm
E) 200 nm
Answer: C
Var: 1

22) A light beam having a wavelength of 470 nm in air is directed into glycerine at an angle of 75.0° with the normal in air. Glycerine has a refractive index of 1.47. ($c = 3.0 \times 10^8$ m/s)
(a) What are the frequency and wavelength of the light in the glycerine?
(b) What angle does the light beam make with the normal in the glycerine?
Answer: (a) 6.38×10^{14} Hz, 320 nm (b) 41.1°
Var: 1

23) When unpolarized light from air (with refractive index 1.00) strikes a piece of glass with index of refraction 1.80, the reflected light is found to be completely polarized when the angle of incidence is equal to Brewster's angle. What is the angle of refraction in this case?
Answer: 29.1°
Var: 50+

24) Find Brewster's angle for light in air that is reflected from the top of a water surface. The index of refraction of the water is 1.33.
A) 53.1°
B) 36.9°
C) 56.3°
D) 60.2°
E) 90.0°
Answer: A
Var: 1

25) What is Brewster's angle for light traveling in vacuum and reflecting off a piece of glass having a refractive index of 1.52?
A) 48.9°
B) 33.3°
C) 48.1°
D) 56.7°
E) 41.1°
Answer: D
Var: 1

26) The critical angle for an air-glass interface is 42.6°. A light ray in air hits the interface, and the reflected ray is 100% polarized. What is the angle of refraction for that ray?
A) 47.4°
B) 55.9°
C) 24.3°
D) 65.7°
E) 34.1°
Answer: E
Var: 1

27) When light in air strikes the flat surface of a certain glass at 31.2° with the normal, the reflected ray is 100 percent polarized. What is the critical angle for the air-glass interface of this glass?
A) 52.7°
B) 58.8°
C) 21.4°
D) 37.3°
E) 68.6°
Answer: D
Var: 1

28) A ray of light traveling in water hits a glass surface. The index of refraction of the water is 1.33, and that of the glass is 1.50. At what angle with the plane of the surface must the incident ray strike the glass in order that the polarization of the reflected ray is the greatest?
A) 36.9°
B) 33.7°
C) 41.6°
D) 48.4°
E) 53.1°
Answer: C
Var: 1

29) Coherent light of wavelength 519 nm passes through two slits. In the resulting interference pattern on a screen 4.6 m away, adjacent bright fringes are 4.0 mm apart. What is the separation of the two slits?
Answer: 0.60 mm
Var: 50+

30) In a double-slit experiment, the slit separation is 1.75 mm, and two coherent wavelengths of light, 425 nm and 510 nm, illuminate the slits. At what angle from the centerline on either side of the central maximum will a bright fringe from one pattern first coincide with a bright fringe from the other pattern?
Answer: 0.0835°
Var: 1

31) A double-slit experiment uses coherent light of wavelength 633 nm with a slit separation of 0.100 mm and a screen placed 2.0 m away.
(a) How wide on the screen is the central bright fringe?
(b) What is the distance on the screen between first-order and second-order bright fringes?
(c) What is the angular separation (in radians) between the central maximum and the first-order maximum?
Answer: (a) 1.3 cm (b) 1.3 cm (c) 6.33 mrad
Var: 6

32) In a two-slit experiment, monochromatic coherent light of wavelength 600 nm passes through a pair of slits separated by 2.20 x 10^{-5} m. At what angle away from the centerline does the first bright fringe occur?
A) 1.56°
B) 2.22°
C) 3.12°
D) 4.70°
E) 6.24°
Answer: A
Var: 5

33) In a two-slit experiment, monochromatic coherent light of wavelength 600 nm passes through a pair of slits separated by 2.20 × 10^{-5} m. At what angle away from the centerline does the second dark fringe occur?
A) 4.70°
B) 3.51°
C) 3.94°
D) 1.17°
E) 2.34°
Answer: E
Var: 1

34) In a two-slit experiment, the slit separation is 3.00 × 10^{-5} m. The interference pattern is created on a screen that is 2.00 m away from the slits. If the 7th bright fringe on the screen is 10.0 cm away from the central fringe, what is the wavelength of the light?
A) 100 nm
B) 204 nm
C) 214 nm
D) 224 nm
E) 234 nm
Answer: C
Var: 5

35) Coherent light of wavelength 540 nm passes through a pair of thin slits that are 3.4×10^{-5} m apart. At what angle away from the centerline does the second bright fringe occur?
A) 1.8°
B) 3.7°
C) 4.3°
D) 1.5°
E) 5.0°
Answer: A
Var: 5

36) In a two-slit experiment, a third-order bright fringe is observed at an angle of 7.10° away from the centerline. If the wavelength of light is 595 nm, how far apart are the two slits?
A) 1.44×10^{-5} m
B) 1.07×10^{-5} m
C) 2.12×10^{-5} m
D) 2.53×10^{-5} m
E) 3.76×10^{-5} m
Answer: A
Var: 5

37) In a two-slit experiment using coherent light, the distance between the slits and the screen is 1.10 m, and the distance between the slits is 0.100 mm. If the first-order bright fringe is measured to be 3.40 cm from the centerline, what is the wavelength of the light?
A) 354 nm
B) 241 nm
C) 133 nm
D) 3.09 μm
E) 2.11 μm
Answer: D
Var: 1

38) A two-slit arrangement with 60.3 μm separation between the slits is illuminated with 491.0 nm coherent light. If a viewing screen is located 2.14 m from the slits, find the distance from the first dark fringe on one side of the central maximum to the second dark fringe on the other side.
A) 52.3 mm
B) 34.9 mm
C) 69.7 mm
D) 24.6 mm
Answer: B
Var: 50+

39) In a two-slit experiment using coherent light, the distance between the slits and the screen is 1.10 m, and the distance between the slits is 0.0400 mm. If the second order bright fringe is measured to be 4.20 cm from the centerline on the screen, what is the wavelength of light?
A) 200 nm
B) 381 nm
C) 401 nm
D) 620 nm
E) 763 nm
Answer: E
Var: 1

40) The distance between two slits is 1.50×10^{-5} m. A beam of coherent light of wavelength 600 nm illuminates these slits, and the distance between the slit and the screen is 2.00 m. What is the distance on the screen between the central bright fringe and the fourth-order bright fringe?
A) 0.132 m
B) 0.201 m
C) 0.324 m
D) 0.528 m
E) 0.688 m
Answer: C
Var: 5

41) A pair of narrow slits that are 1.8 mm apart is illuminated by a monochromatic coherent light source. A fringe pattern is observed on a screen 4.8 m from the slits. If there are 5.0 bright fringes/cm on the screen, what is the wavelength of the monochromatic light?
A) 550 nm
B) 600 nm
C) 650 nm
D) 700 nm
E) 750 nm
Answer: E
Var: 1

42) A pair of narrow slits that are 1.8 mm apart is illuminated by a monochromatic coherent light source. A fringe pattern is observed on a screen 4.8 m from the slits. If the wavelength of the monochromatic light is 450 nm, what is the angular separation between adjacent dark fringes on the screen, measured in milliradians?
A) 0.15 mrad
B) 0.20 mrad
C) 0.25 mrad
D) 0.30 mrad
E) 0.36 mrad
Answer: C
Var: 1

43) A double slit that is illuminated with coherent light of wavelength 644 nm produces a pattern of bright and dark fringes on a screen 6.00 cm from the slits. If the slits are 2783 nm apart, what is the distance on the screen between the 4^{th} and the 2^{nd} bright fringes on one side of the central maximum?
A) 23.0 cm
B) 17.6 cm
C) 11.5 cm
D) 3.13 cm
E) 14.7 cm
Answer: D
Var: 1

44) An optical engineer needs to ensure that the bright fringes from a double-slit are 15.7 mm apart on a detector that is 1.70 m from the slits. If the slits are illuminated with coherent light of wavelength 633 nm, how far apart should the slits be?
A) 68.5 μm
B) 74.0 μm
C) 79.5 μm
D) 63.0 μm
Answer: A
Var: 50+

45) A two-slit arrangement with 60.3 μm separation between the slits is illuminated with 537.0-nm wavelength light. If a viewing screen is located 2.14 m from the slits, find the distance on the screen from the first dark fringe on one side of the central maximum to the second dark fringe on the other side.
A) 57.2 mm
B) 38.1 mm
C) 76.3 mm
D) 26.9 mm
Answer: B
Var: 1

46) Two thin slits are 6.00 μm apart. Monochromatic coherent light falls on these slits, and produces a fifth-order bright interference fringe at an angle of 32.3° away from the centerline. What is the wavelength of the light?
A) 164 nm
B) 416 nm
C) 614 nm
D) 641 nm
Answer: D
Var: 3

47) Coherent light of wavelength 575 nm falls on a double-slit and the third-order bright fringe is seen at an angle of 6.5° away from the centerline. How far apart are the double slits?
A) 5.0 μm
B) 10 μm
C) 15 μm
D) 20 μm
Answer: C
Var: 1

48) In a double-slit experiment, the slit separation is 2.0 mm, and two wavelengths, 750 nm and 900 nm, illuminate the slits. A screen is placed 2.0 m from the slits. At what distance from the central maximum on the screen will a bright fringe from one pattern first coincide with a bright fringe from the other?
A) 1.5 mm
B) 3.0 mm
C) 4.5 mm
D) 6.0 mm
Answer: C
Var: 1

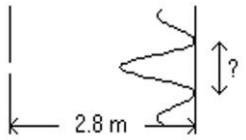
49) Two radio antennas are 130 m apart on a north-south line. The two antennas radiate in phase at a frequency of 3.6 MHz. All radio measurements are made far from the antennas. What is the smallest angle, reckoned east of north from midway between the antennas, at which constructive interference of two radio waves occurs? ($c = 3.00 \times 10^8$ m/s)
A) 50°
B) 55°
C) 45°
D) 40°
E) 35°
Answer: A
Var: 50+

50) Two radio antennas are 120 m apart on a north-south line. The two antennas radiate in phase at a frequency of 5.6 MHz. All radio measurements are made far from the antennas. What is the smallest angle, reckoned north of east from midway between the antennas, at which destructive interference of the two radio waves occurs? ($c = 3.00 \times 10^8$ m/s)
A) 13°
B) 6.4°
C) 9.7°
D) 16°
E) 19°
Answer: A
Var: 50+

51) Two radio antennas are 10 km apart on a north-south axis on high mountain tops at the seacoast. The antennas broadcast identical AM radio signals, in phase, at a frequency of 4.70 MHz. A steamship, 200 km offshore, travels toward the north at 15 km/h and passes east of the antennas. A radio on board the ship is tuned to the broadcast frequency. The reception of the radio signal on the ship is a maximum at a given instant. How much later until the *next* occurrence of maximum reception? ($c = 3.00 \times 10^8$ m/s)
A) 5.1 min
B) 3.8 min
C) 6.4 min
D) 7.7 min
E) 8.9 min
Answer: A
Var: 50+

52) At most, how many bright fringes can be formed on one side of the central bright fringe (not counting the central bright fringe) when light of 625 nm falls on a pair of slits that are 6.77×10^{-6} m apart?
A) 10
B) 9
C) 8
D) 11
E) 12
Answer: A
Var: 50+

53) The figure shows the resulting pattern when a single slit is illuminated by monochromatic light. The slit is 0.3×10^{-3} m wide and is illuminated by light of wavelength 506 nm. A diffraction pattern is seen on a screen 2.8 m from the slit. What is the linear distance on the screen between the first two diffraction minima on either side of the central diffraction maximum?



Answer: 9.4×10^{-3} m
Var: 50+

54) A single slit, which is 0.0500 mm wide, is illuminated by light of 550 nm wavelength. What is the angular separation between the first two minima on either side of the central maximum?
Answer: 0.630°
Var: 1

55) Using monochromatic light of 410 nm wavelength, a single thin slit forms a diffraction pattern, with the first minimum at an angle of 40.0° from central maximum. The same slit, when illuminated by a new monochromatic light source, produces a diffraction pattern with the second minimum at a 60.0° angle from the central maximum. What is the wavelength of this new light?
A) 276 nm
B) 293 nm
C) 309 nm
D) 326 nm
E) 342 nm
Answer: A
Var: 33

56) A single thin slit forms a diffraction pattern, with the first minimum at an angle of 40.0° from central maximum. If monochromatic light of 530.0-nm wavelength is used for the illumination, what is the width of the slit?
A) 825 nm
B) 791 nm
C) 757 nm
D) 723 nm
E) 689 nm
Answer: A
Var: 33

57) A single slit, 1400 nm wide, forms a diffraction pattern when illuminated by monochromatic light of 490-nm wavelength. What is the largest angle from the central maximum at which the intensity of the light is zero?
A) 44°
B) 41°
C) 38°
D) 35°
E) 32°
Answer: A
Var: 50+

58) A single thin slit forms a diffraction pattern when illuminated with monochromatic light. The fourth minimum of the pattern occurs at an angle of 32.0° away from the central maximum. At what angle does the fifth minimum occur?
A) 41.5°
B) 41.0°
C) 40.5°
D) 42.0°
E) 42.5°
Answer: A
Var: 40

59) A beam of monochromatic light passes through a slit that is 11.0 μm wide. If the first order dark fringe of the resulting diffraction pattern is at an angle of 4.31° away from the centerline, what is the wavelength of light?
A) 827 nm
B) 301 nm
C) 602 nm
D) 402 nm
E) 201 nm
Answer: A
Var: 5

60) A beam of light of wavelength 610 nm passes through a slit that is 1.90 μm wide. At what the angle away from the centerline does the first dark fringe occur?
A) 9.35°
B) 11.4°
C) 12.2°
D) 39.9°
E) 18.7°
Answer: E
Var: 1

61) A beam of light of wavelength 610 nm passes through a slit that is 1.90 μm wide. At what the angle away from the centerline does the second dark fringe occur?
A) 11.4°
B) 9.35°
C) 12.2°
D) 39.9°
E) 18.7°
Answer: D
Var: 1

62) A beam of light of wavelength 600 nm passes through a slit that is 3.1×10^{-5} m wide, and then goes on to a screen that is 2.2 m from the slit. On the screen, how far is the second dark fringe from the center of the diffraction pattern?
A) 3.9 cm
B) 4.2 cm
C) 6.3 cm
D) 2.1 cm
E) 8.5 cm
Answer: E
Var: 1

63) When light of wavelength 450 nm falls on a single slit of width 0.30 mm, what is the angular width of the central bright region?
A) 0.086°
B) 0.13°
C) 0.17°
D) 0.26°
E) 0.35°
Answer: C
Var: 1

64) When a single slit that is 0.050 mm wide is illuminated by light of 550-nm wavelength, what is the angular separation between the first two minima on one side of the central maximum?
A) 0.36°
B) 0.47°
C) 0.54°
D) 0.63°
E) 1.3°
Answer: D
Var: 1

65) Light of wavelength 687 nm passes through a single slit that is 0.75 mm wide. At what distance from the slit should a screen be placed so that the second dark fringe in the diffraction pattern is to be 1.7 mm from the center of the pattern?
A) 0.39 m
B) 0.93 m
C) 1.1 m
D) 1.5 m
E) 1.9 m
Answer: B
Var: 1

66) Light of wavelength 610 nm is incident on a slit 0.20 mm wide and the diffraction pattern is viewed on a screen that is 1.5 m from the slit. What is the width on the screen of the central maximum?
A) 0.34 cm
B) 0.68 cm
C) 0.92 cm
D) 1.2 cm
E) 1.5 cm
Answer: C
Var: 1

67) Light of wavelength 580 nm is incident on a slit of width 0.30 mm. An observing screen is placed 2.0 m past the slit. Find the distance on the screen of the first order dark fringe from the center of the pattern.
A) 0.26 mm
B) 1.5 mm
C) 1.9 mm
D) 3.9 mm
E) 7.7 mm
Answer: D
Var: 1

68) A beam of light of wavelength 630 nm is incident on a slit that is 0.400 mm wide. If the distance between the slit and the screen is 1.80 m, what is the width on the screen of the central bright fringe?
A) 1.94 mm
B) 2.94 mm
C) 3.54 mm
D) 5.67 mm
E) 6.94 mm
Answer: D
Var: 5

69) A diffraction grating is to be used to find the wavelength of the emission spectrum of a gas. The grating spacing is not known, but light of a known wavelength of 632.8 nm is deflected by 43.2° in the second order by this grating. Light of the wavelength to be measured is deflected by 34.9° in the second order. What is the wavelength of the light that is to be measured?
Answer: 529 nm
Var: 50+

70) When red light illuminates a grating with 7000 lines per centimeter, its second maximum is at 62.4°. What is the wavelength of this light?
Answer: 633 nm
Var: 1

71) A diffraction grating has 5150 lines per centimeter ruled on it. What is the angular separation between the first- and the third-order bright spots on the same side of the central maximum when the grating is illuminated by a beam of light with wavelength 633 nm?
Answer: 58.9°
Var: 1

72) In a diffraction grating experiment, light of 600 nm wavelength produces a first-order maximum 0.35 mm from the central maximum on a distant screen. On the same screen, a second monochromatic source produces a third-order maximum 0.87 mm from the central maximum when it passes through the same diffraction grating. What is the wavelength of the light from the second source?
Answer: 500 nm
Var: 1

73) Consider an experiment using a diffraction grating with 7000 lines/cm, a screen 2.50 m away, and a 440- nm wavelength beam of light.
(a) How many side maxima will be observed on one side of the central maximum?
(b) How far apart on the screen are the first-order and second-order maxima on the same side of the central maximum?
Answer: (a) 3 (b) 1.15 meters
Var: 5

74) What is the angular separation of two spectral lines of wavelengths 497 nm and 251 nm formed in the third order with a diffracting grating having 587 lines per millimeter?
A) 34.8°
B) 24.8°
C) 41.3°
D) 29.4°
E) 4.21°
Answer: A
Var: 1

75) A diffraction grating with 396 lines/mm is illuminated with light of wavelength 343 nm. What is the angular separation between the two second-order bright fringes?
A) 31.5°
B) 15.8°
C) 32.9°
Answer: A
Var: 1

76) Monochromatic light of wavelength 500 nm is incident normally on a diffraction grating. If the third-order maximum of the diffraction pattern is observed at 32° from the centerline, what is the distance between the slits of the grating?
A) 0.93 μm
B) 1.4 μm
C) 2.8 μm
D) 8.5 μm
Answer: C
Var: 1

77) Monochromatic light of wavelength 500 nm is incident normally on a diffraction grating. If the third-order maximum of the diffraction pattern is observed at 32.0°, what is the *total* number of maxima can be seen?
A) 5
B) 7
C) 10
D) 11
E) 8
Answer: D
Var: 1

78) An 18-mm-wide diffraction grating has rulings of 710 lines per millimieter. Monochromatic light of wavelength 506 nm wavelength is incident normally on the grating. What is the largest angle from the centerline at which an intensity maximum is formed?
A) 46°
B) 44°
C) 42°
D) 40°
E) 38°
Answer: A
Var: 50+

79) When light illuminates a diffraction grating with 7000 lines per centimeter, its second order maximum is at 62.4°. What is the wavelength of the light?
A) 336 nm
B) 363 nm
C) 633 nm
D) 752 nm
Answer: C
Var: 1

80) When a diffraction grating having 5000 lines/cmis illuminated by monochromatic light, the angle between the central maximum and the fourth order maximum is 47.2°. What is the wavelength of the light?
A) 138 nm
B) 183 nm
C) 367 nm
D) 637 nm
Answer: C
Var: 3

81) Monochromatic light is incident on a diffraction grating that is 75 mm wide and ruled with 50,000 lines. The second-order maximum is seen at 32.5°. What is the wavelength of the incident light?
A) 202 nm
B) 403 nm
C) 605 nm
D) 806 nm
Answer: B
Var: 1

82) A diffraction grating has 6.00×10^3 lines per centimeter ruled on it. What is the angular separation between the second and the third orders on the same side of the central order when the grating is illuminated with a beam of light of wavelength 550 nm?
A) 20.5°
B) 30.5°
C) 40.6°
D) 50.5°
Answer: C
Var: 1

83) A 17-mm-wide diffraction grating has rulings of 530 lines per millimeter. White light is incident normally on the grating. What is the longest wavelength that forms an intensity maximum in the fifth order?
A) 377 nm
B) 352 nm
C) 402 nm
D) 427 nm
E) 452 nm
Answer: A
Var: 50+

84) What is the slit spacing of a diffraction grating necessary so that 600-nm light will produce a first order principal maximum at 25.0° away from the centerline?
A) 1.42 μm
B) 2.01 μm
C) 3.12 μm
D) 4.12 μm
E) 5.44 μm
Answer: A
Var: 1

85) A beam of light of wavelength 600 nm is incident normally on a diffraction grating with a spacing between slits of 1.70×10^{-4} cm. At what angle away from the centerline does a first-order maximum occur?
A) 10.5°
B) 12.1°
C) 16.4°
D) 18.2°
E) 20.7°
Answer: E
Var: 1

86) The distance between the ruled lines on a diffraction grating is 1900 nm. The grating is illuminated at normal incidence with a parallel beam of white light in the 400 nm to 700 nm wavelength band. What is the angular width of the *gap* between the first order spectrum and the second order spectrum?
A) 3.3°
B) 4.3°
C) 5.3°
D) 6.3°
E) 2.3°
Answer: A
Var: 50+

87) The distance between the ruled lines on a diffraction grating is 1770 nm. The grating is illuminated at normal incidence with a parallel beam of white light in the 400 nm to 700 nm wavelength band. What is the longest wavelength that appears in the third order spectrum?
A) 590 nm
B) 570 nm
C) 550 nm
D) 530 nm
E) 610 nm
Answer: A
Var: 50+

88) A metallic sheet has a large number of parallel slits, 5.0 mm wide and 20 cm apart. This sheet is used as a diffraction grating for microwaves. A wide parallel beam of microwaves is incident normally on the sheet. If the microwave wavelength is 6.0 cm, what is the largest angle from the normal, at which an intensity maximum occurs?
A) 64°
B) 69°
C) 74°
D) 79°
E) 84°
Answer: A
Var: 1

89) A metallic sheet has a large number of parallel slits, 5.0 mm wide and 20 cm apart. This sheet is used as a diffraction grating for microwaves. A wide parallel beam of microwaves is incident normally on the sheet. What is the smallest microwave frequency for which only the central maximum will occur? ($c = 3.00 \times 10^8$ m/s)
A) 0.50 GHz
B) 0.70 GHz
C) 1.0 GHz
D) 1.5 GHz
E) 2.0 GHz
Answer: D
Var: 1

90) A metallic sheet has a large number of parallel slits, 5.0 mm wide and 20 cm apart. This sheet is used as a diffraction grating for microwaves. A wide parallel beam of microwaves is incident normally on the sheet. If the intensity maxima occur 2.0° apart in the central region, what is the wavelength of the microwaves?
A) 5.0 mm
B) 6.0 mm
C) 7.0 mm
D) 8.0 mm
E) 9.0 mm
Answer: C
Var: 1

91) A diffraction grating has 450 lines per millimeter. What is the highest order *m* that contains the entire visible spectrum from 400 nm to 700 nm?
A) $m = 2$
B) $m = 3$
C) $m = 4$
D) $m = 5$
E) $m = 6$
Answer: B
Var: 1

92) Light is incident perpendicularly from air onto a liquid film that is on a glass plate. The liquid film is 199 nm thick, and the liquid has index of refraction 1.60. The glass has index of refraction 1.50. Calculate the longest visible wavelength (as measured in air) of the light for which there will be totally destructive interference between the rays reflected from the top and bottom surfaces of the film. Assume that the visible spectrum lies between 400 nm and 700 nm.
Answer: 637 nm
Var: 50+

93) A soap bubble, when illuminated at normal incidence with light of 463 nm, appears to be especially reflective. If the index of refraction of the film is 1.35, what is the minimum thickness the soap film can be if it is surrounded by air?
Answer: 85.7 nm
Var: 50+

94) Light in air of wavelength 500 nm illuminates a soap film that has an index of refraction of 1.3 and air on both sides. What is the minimum thickness of this film that will produce cancellation in the reflected light when the light is incident normally on the film?
Answer: 96 nm
Var: 1

95) A soap bubble with air on both sides has an index of refraction of 1.33. What minimum thickness of the wall of this bubble will ensure maximum reflectance of normally incident light having a wavelength of 530 nm?
Answer: 99.6 nm
Var: 1

96) A glass plate that is 2.5 cm long is separated from another glass plate at one end by a strand of someone's hair that is 0.010 mm in diameter. How far apart are the adjacent interference bands when viewed with light of wavelength 600 nm?
Answer: 0.75 mm
Var: 1

97) The wavelength of light in a thin film is 360 nm and the wavelength of light in vacuum is 469 nm. What is the index of refraction for the film?
A) 1.10
B) 1.30
C) 1.50
D) 1.70
E) 1.90
Answer: B
Var: 1

98) Light has a wavelength of 600 nm in a vacuum. It passes into glass, which has an index of refraction of 1.50. What is the wavelength of the light in the glass?
A) 600 nm
B) 500 nm
C) 400 nm
D) 300 nm
E) 900 nm
Answer: C
Var: 1

99) Light has wavelength 600 nm in a vacuum. It passes into glass, which has an index of refraction of 1.5. What is the frequency of the light inside the glass? ($c = 3.0 \times 10^8$ m/s)
A) 3.3×10^{14} Hz
B) 5.0×10^{14} Hz
C) 3.3×10^{5} Hz
D) 5.0×10^{5} Hz
Answer: B
Var: 1

100) A 360-nm thick oil film floats on the surface of a pool of water water. The indices of refraction of the oil and the water are 1.5 and 1.33, respectively. When the surface of the oil is illuminated from above at normal incidence with white light, what are the two wavelengths of light between 400 nm to 800 nm wavelength that are most strongly reflected?
A) 410 nm and 700 nm
B) 430 nm and 720 nm
C) 450 nm and 740 nm
D) 470 nm and 760 nm
E) 490 nm and 780 nm
Answer: B
Var: 1

101) A 360-nm thick oil film floats on the surface of a pool of water. The indices of refraction of the oil and the water are 1.50 and 1.33, respectively. When the surface of the oil is illuminated from above at normal incidence with white light, what is the wavelength of light between 400 nm to 800 nm wavelength that is most weakly reflected?
A) 520 nm
B) 540 nm
C) 560 nm
D) 580 nm
E) 600 nm
Answer: B
Var: 1

102) A light beam with wavelength 500 nm is reflected constructively from a thin layer of oil having index of refraction 1.25. The oil floats on the top of water of index of refraction 1.33. What is the minimum thickness of the layer of oil?
A) 100 nm
B) 150 nm
C) 175 nm
D) 200 nm
E) 225 nm
Answer: D
Var: 1

103) A 500-nm-wavelength beam of light illuminates a soap film with air on both sides and an index of refraction 1.33. If the beam of light is incident normally on the film, what is the minimum thickness of the film to make the reflected light enhanced in brightness?
A) 47.0 nm
B) 74.0 nm
C) 94.0 nm
D) 152 nm
E) 268 nm
Answer: C
Var: 1

104) What is the minimum thickness of a soap bubble film with refractive index 1.38 that results in a constructive interference in the reflected light if this film is illuminated by a beam of light of wavelength 610 nm?
A) 222 nm
B) 111 nm
C) 333 nm
D) 444 nm
E) 555 nm
Answer: B
Var: 1

105) A soap bubble has an index of refraction of 1.33. What minimum thickness of this bubble will ensure maximum reflectance of normally-incident light having a wavelength of 530 nm?
A) 24.9 nm
B) 76.9 nm
C) 99.6 nm
D) 199 nm
E) 398 nm
Answer: C
Var: 1

106) An oil film with refractive index 1.48 and thickness 290 nm is floating on water and illuminated with white light at normal incidence. What is the wavelength of the dominant color in the reflected light?
A) green (541 nm)
B) blue-green (493 nm)
C) violet (404 nm)
D) yellow (572 nm)
E) blue (470 nm)
Answer: D
Var: 1

107) A sodium light, having wavelength 589.3 nm, is used to view a soap film to make it look black when directed perpendicular to the film. What is the minimum thickness of the soap film if the index of refraction of soap solution is 1.38?
A) 114 nm
B) 194 nm
C) 294 nm
D) 314 nm
E) 214 nm
Answer: E
Var: 1

108) A soap bubble film that is 106 nm thick and has an index of refraction of 1.42 results in constructive interference in the reflected light if this film is illuminated by a beam of light with a wavelength of 601 nm. What are the next three thicknesses of this film that will also result in constructive interference?
A) 212 nm, 318 nm, 424 nm
B) 53.0 nm, 35.3 nm, 26.5 nm
C) 212 nm, 424 nm, 636 nm
D) 67.0 nm, 42.4 nm, 22.3 nm
E) 318 nm, 530 nm, 742 nm
Answer: E
Var: 1

109) A puddle of water has a thin film of gasoline floating on it. A beam of light is shining perpendicular on the film. If the wavelength of light incident on the film is 560 nm and the indices of refraction of gasoline and water are 1.40 and 1.33, respectively, what must be the minimum thickness of the film to see a bright reflection?
A) 100 nm
B) 200 nm
C) 300 nm
D) 400 nm
E) 500 nm
Answer: A
Var: 1

110) A piece of glass has a thin film of gasoline floating on it. A beam of light is shining perpendicular on the film. If the wavelength of light incident on the film is 560 nm and the indices of refraction of gasoline and glass are 1.40 and 1.50, respectively, what is the minimum nonzero thickness of the film to see a bright reflection?
A) 500 nm
B) 400 nm
C) 300 nm
D) 200 nm
E) 100 nm
Answer: D
Var: 1

111) Two very flat glass plates, 16 cm long, are in contact at one end and separated by 0.020 mm at the other end. The space between the plates is occupied by oil with index of refraction 1.45. The refractive index of the glass plates is 1.55. The plates are illuminated at normal incidence with monochromatic light, and fringes are observed. When the monochromatic light has a wavelength of 580 nm, how many bright fringes are visible in the pattern?
A) 60
B) 70
C) 80
D) 90
E) 100
Answer: E
Var: 1

112) Two very flat glass plates, 16 cm long, are in contact at one end and separated by 0.020 mm at the other end. The space between the plates is occupied by oil with index of refraction 1.45. The refractive index of the glass plates is 1.55. The plates are illuminated at normal incidence with monochromatic light, and fringes are observed. If the spacing of the dark fringes is 2.0 mm, what is the wavelength of the monochromatic light?
A) 425 nm
B) 475 nm
C) 525 nm
D) 675 nm
E) 725 nm
Answer: E
Var: 1

113) A thin uniform film of oil that can be varied in thickness covers a sheet of glass of refractive index 1.52. The refractive index of the oil is 1.64. Light of wavelength 555 nm is shone from air at normal incidence on the film. Starting with no oil on the glass, you gradually increase the thickness of the oil film until the first interference maximum in the reflected light occurs. What is the thickness of the oil film at that instant?
A) 139 nm
B) 169 nm
C) 183 nm
D) 84.6 nm
E) 91.3 nm
Answer: D
Var: 1