Waves Homework

Assignment #1

Textbook: Read Section 11-7 and 11-8

Online: Waves Lesson 1a, 1b, 1c
http://www.physicsclassroom.com/Class/waves

* **problems are for all students**
** **problems are for honors physics**

1. * (a) What is a feature *common* to all waves? (b) What is a feature *that is not the same for* all waves? (There are many examples.)

2. * Describe how a single point on a slinky coil moves as (a) a transverse wave passes by that point and (b) a longitudinal wave passes by that point.

3. * What kind of waves travel down a horizontal metal rod if you strike its end (a) vertically from above and (b) horizontally parallel to its length? Explain with definitions.

4. * Give three examples of mechanical waves. In each case, state the medium in which the wave propagates. How are these different from electromagnetic waves?

5. * If we knew that energy was being transferred from one place to another, how might we determine whether the energy was being carried by particles or waves?

6. ** Describe two advantages of transferring energy via electromagnetic waves.

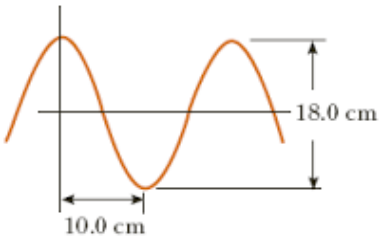
Assignment #2

Online: Waves Lesson 2a, 2b, 2c, 2d, 2e
http://www.physicsclassroom.com/Class/waves

7. * A fisherman notices that wave crests pass the bow on his anchored boat every 3.0 s. He estimates the distance between two crests to be 6.5 m. How fast are the waves traveling?
2.16 m/s

8. * You dip your finger into a pan of water twice each second, producing waves with crests that are separated by 0.15 m. Determine (a) the frequency (b) the period and (c) the speed of these water waves.
2.0 Hz, 0.50 s, 0.30 m/s

9. * A wave traveling in the positive x direction with a frequency of 25.0 Hz is shown below.



Find the following values for this wave.
(a) amplitude (c) period
(b) wavelength (d) speed
9.0 cm, 20.0 cm, 0.040 s, 5.0 m/s

10. * (a) A sound wave in air has a frequency of 262 Hz and travels with a speed of 345 m/s. How far apart are the wave compressions?
(b) TV remote controls often have a wavelength of about 69 cm. Determine the frequency and period for this EM wave, which travels at a speed $c = 3.00 \times 10^8$ m/s
1.32 m; 4.35 x 10^8 Hz, 2.30 x 10^{-9} s

11. * (a) AM radio wave signals (EM waves) with frequencies between 550 kHz and 1600 kHz (kilohertz), travel at speed $c = 3.00 \times 10^8$ m/s. What is the range of wavelengths for these radio wave signals?
(b) Repeat for FM radio wave signals that have frequencies between 88.0 MHz and 108 MHz (megahertz).
188 m to 545 m, 2.78 m to 3.41 m

12. ** P and S waves from an earthquake travel at different speeds, and this difference helps in locating the earthquake epicenter. Assuming speeds of 8.5 km/s and 5.5 km/s for P and S waves, how far away did the earthquake occur if a seismograph detects the arrival of these two types of waves 2.0 minutes apart? (Solve two simultaneous equations, where the distance is equal in each equation.)
1870 km

Assignment #3

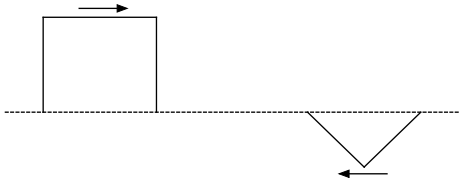
Textbook: Read Section 11-11 and 11-12

Online: Waves Lesson 3a, 3c
http://www.physicsclassroom.com/Class/waves

13. * Describe the difference between constructive interference and destructive interference of waves.

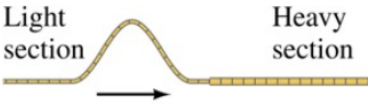
14. * For the wave pulses shown below, (a) draw the pulses before they meet, (b) draw the resultant wave when the pulses meet in the middle, and (c) draw the pulses after they have passed each other.

15. * For the wave pulses shown below, (a) draw the pulses before they meet, (b) draw the resultant wave when the pulses meet in the middle, and (c) draw the pulses after they have passed each other.



16. * A wave pulse is sent down the length of a stretched string. Describe what happens to the pulse when it reflects off the end of the string if (a) the string is tied tightly to a support rod and (b) the string is looped loosely around a support rod.

17. * A wave pulse approaches a boundary between two sections of cord, as shown below. Draw a diagram showing what happens after the wave passes the boundary.



18. ** Referring to the previous question, when a sinusoidal wave crosses the boundary, the frequency does not change (although velocity and wavelength do change). Explain why.

Assignment #4

Textbook: Read Section 12-1

Online: Sound Lesson 1a, 1b, 2a, 2c
http://www.physicsclassroom.com/class/sound

19. * Why are sound waves in air characterized as longitudinal? (Why can't they be transverse?)

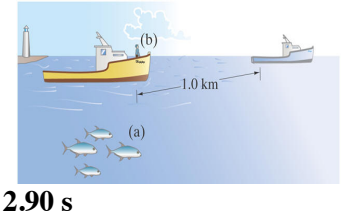
20. * Children sometimes play with a homemade "telephone" by attaching a string to the bottoms of two paper cups, as shown below. Explain clearly how the sound wave travels from one cup to the other.

21. * (a) What is the difference between frequency and pitch? (b) What is the difference between amplitude and loudness?

22. * Calculate the wavelengths in air at 20°C for sounds in the maximum range of human hearing, 20 Hz to 20,000 Hz.
17.2 m, 0.0172 m

23. * A sound wave travels in air with a frequency of 500 Hz. (a) If part of the wave travels from air to water, does its frequency and/or its wavelength change? (b) Calculate the wavelength in air (speed is 345 m/s) and in water (speed is 1440 m/s).
0.69 m, 2.88 m

24. ** An ocean fishing boat is drifting just above a school of fish as shown below. An engine backfire occurs on another boat 1.0 km away. How much time elapses before the backfire is heard (a) by the fish (b) by the fisherman? (The speed of sound in *sea water* is given in the textbook.)



0.641 s, 2.90 s

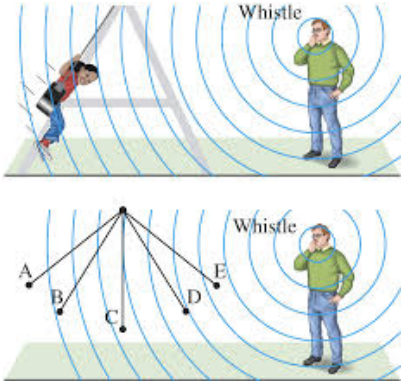
Assignment #5

Textbook: Read Section 12-7

Online: Sound Lesson 3b
http://www.physicsclassroom.com/class/sound

25. * A fire engine is moving at 40 m/s and sounding its horn. A car in front of the fire engine is moving at 30 m/s, and a van in front of the car is moving at 15 m/s. Describe the horn's frequency heard by the car driver and the van driver. Which hears a higher pitch?

26. * A child in motion on a swing hears a whistle, as shown below. Describe the Doppler effect of whistle sound heard by the child moving from position A to E.



27. * The predominant frequency of a certain fire engine's siren is 1550 Hz when at rest. What frequency does an observer hear when moving with a speed of 30.0 m/s (a) toward the fire engine, and (b) away from it?
1685 Hz, 1415 Hz
28. * A truck traveling east at 28 m/s sounds a 2200-Hz horn. What frequency is heard by (a) an approaching driver headed west at 38 m/s? (b) an approaching driver headed east toward the truck at 38 m/s?
2658 Hz, 2259 Hz
29. * In the previous question, for both parts (a) & (b), determine the Doppler shift in frequency heard by the car driver when the vehicles pass each other. (Doppler shift is the difference between an increase in frequency and a decrease in frequency.)
847 Hz, 129 Hz
30. ** A bat flies toward a wall at a speed of 15.0 m/s. As it flies, the bat emits an ultrasonic sound wave with frequency 30,000 Hz. What frequency does the bat hear in the reflected wave?
32,730 Hz
31. ** The frequency of a steam train whistle as it approaches a stationary observer is measured as 538 Hz. After the train passes the observer, its frequency is measured as 486 Hz by the observer. How fast was the train moving (assume constant velocity)?
17.5 m/s

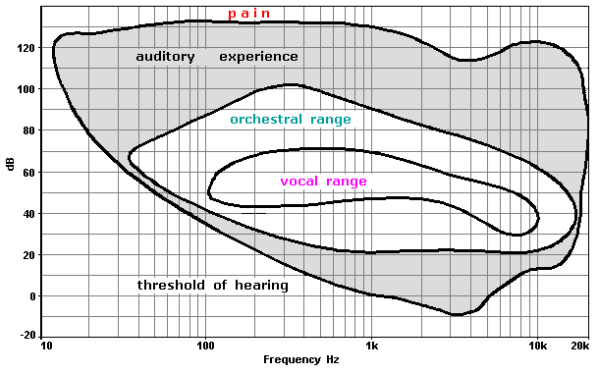
Assignment #6

Textbook: Read Section 12-2, 12-3

Online: Sound Lesson 2b
http://www.physicsclassroom.com/class/sound

32. *What is the difference between sound intensity, sound level, and loudness?

33. * The human hearing spectrum shown below has a logarithmic *x*-axis. Why is this scale used, and how does it relate to human hearing?



34. * Referring to the last questions, what does the curve at the bottom (called "threshold of hearing") suggest about human hearing of various frequencies?

35. * A bank of speakers at a concert emits sound waves with a power output of 85 watts. (a) What is the intensity of the sound waves at a distance of 2.4 meters? (b) What is the decibel level at this distance? (c) Is the sound level dangerous for human hearing?
1.17 W/m^2, 121 dB

36. * The sound level of an orchestra is 90 dB, while a single violin achieves a sound level of 70 dB. How do the intensity and loudness of the sound of the full orchestra compare with those of the violin's sound?

37. ** If two firecrackers produce a sound level of 95 dB when fired simultaneously at a certain place, what will be the sound level if only one is exploded?
92 dB
38. ** The sound level 6.0 m from a loudspeaker is 104 dB. What is the power output of the speaker assuming it radiates equally in all directions?
11.4 W

Assignment #7

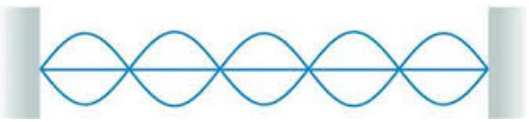
Textbook: Read Section 11-6, 11-13

Online: Sound Lesson 4a, 4b, 4d, 5b
http://www.physicsclassroom.com/class/sound

39. * A wineglass is lightly rubbed with a finger around the top rim of the glass and makes a noticeable "singing" sound. Explain this phenomenon (called resonance) and give several other everyday examples.

40. * Why does a vibrating guitar string sound louder when it is on the instrument than when it is stretched between fixed points on a workbench?

41. * A violin string that is 32.0 cm long has a fundamental frequency of 440 Hz. (a) What is the speed of the waves on this string? (b) What are the next two harmonic frequencies?
282 m/s, 880 Hz, 1320 Hz
42. * A 1.4 m long string is fixed at both ends and tightened until the wave speed is 42 m/s. What is the frequency of the standing wave shown below?



75.0 Hz

43. * A stretched string fixed at both ends is 1.2 m long. What are the three longest wavelengths that will produce standing waves on this string?
2.4 m, 1.2 m, 0.8 m
44. * If two successive harmonic frequencies of a vibrating string are 280 Hz and 350 Hz, what is the frequency of the fundamental?
70 Hz
45. ** The speed of waves on a string is 194 m/s. If the frequency of standing waves is 475 Hz, how far apart are two adjacent nodes?
0.204 m
46. ** A guitar string is 90 cm long and has a mass of 3.6 g. The distance from the bridge to the nut is 62 cm, and the string is under a tension of 520 N. What are the frequencies of the first three harmonics?
291 Hz, 582 Hz, 873 Hz

Assignment #8

Online: Sound Lesson 5a, 5c, 5d
http://www.physicsclassroom.com/class/sound

47. * How does the air temperature in a room affect the pitch of a wind instrument like a flute or trumpet?

48. * What is the purpose of the slide on a trombone and the valves on a trumpet in terms of harmonic frequencies?

49. * A typical flute is about 66 cm long. A piccolo is a very similar instrument, though it is smaller, with a length of about 32 cm. How does the pitch of the piccolo compare to that of the flute? Explain using harmonic equation, and draw a diagram to scale for each instrument playing the fundamental frequency.

50. * An aluminum rod held near the midpoint is struck on its end with a hammer produces a loud, ringing sound. (a) If the rod is 90 cm long, this fundamental frequency is measured as 2800 Hz. Determine the speed of these longitudinal sound waves in aluminum.
(b) At what distance from the ends of the rod must it be held to produce the 2^{nd}, 3^{rd}, and 4^{th} harmonics?
5040 m/s, 22.5 cm, 15.0 cm, 11.25 cm

51. * (a) The lowest note on a grand piano is 27.5 Hz, created by a vibrating string 1.90 m long. Determine the wave speed on the string.
** (b) What is the string tension if the entire string is 2.0 m long and mass of 40 g?
105 m/s, 218 N

52. * A pipe that is open at both ends has a fundamental frequency of 320 Hz when the speed of sound is 335 m/s. (a) What is the length of this pipe? (b) What are the next two harmonics? (c) What is the fundamental frequency of this pipe when the speed of sound is 355 m/s?**0.523 m; 640, 960 Hz; 339 Hz**

53. ** A guitar string with a linear density of 2.0 g/m is stretched between supports that are 60 cm apart. The string is observed to form a standing wave with three antinodes when driven at a frequency of 420 Hz. What are (a) the frequency of the fifth harmonic of this string and (b) the tension in the string?
700 Hz, 56.4 N

Assignment #9

54. * Some air columns on a pipe organ are open at both ends, others are closed at one end. For air columns that play low-frequency notes (like 30 Hz), what is one advantage of using air columns that are closed at one end?

55. * (a) What harmonic frequency would you expect from blowing across the top of an empty soda bottle that is 18 cm tall? (b) How would that change if it were one-third full of soda?
479 Hz, 719 Hz

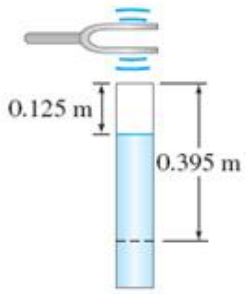
56. * An organ pipe is 112 cm long. What are the fundamental and next two frequencies if the pipe is (a) open at one end, closed at the other end (b) open at both ends?
77.0, 231, 385 Hz; 154, 308, 462 Hz

57. * A particular organ pipe can resonate at 264 Hz, 440 Hz, and 616 Hz, but not at any other frequencies in between. (a) Show why this is an open or a closed pipe. (b) What is the fundamental frequency of this pipe?
88.0 Hz

58. * An acoustic guitar string is 650 mm long and is tuned to play the note A_2 of 110 Hz. (a) How far from the end of this string must a fret (and your finger) be placed to play the note G_3 of 196 Hz? (b) What is the wavelength on the string of the 196 Hz wave? (c) What is the wavelength in air?
0.285 m; 0.730 m; 1.76 m

59. ** An open-open organ pipe is 78.0 cm long. An open-closed pipe has a fundamental frequency equal to the third harmonic of the open-open pipe. How long is the open closed pipe? Draw a scaled diagram for each case.
0.13 m

60. ** A tuning fork is set into vibration above a vertical open tube filled with water as shown below. The air in the tube resonates with the tuning fork when the distance from the opening to the water level is 0.125 m (n=1) and again at 0.395 m (n=3). What is the frequency of the tuning fork?
639 Hz



Assignment #10

Textbook: Read Section 12-5, 12-6

Online: Sound Lesson 3a
http://www.physicsclassroom.com/class/sound

61. * Explain why two instruments (for example a flute and a clarinet) sound different from each other, even when they make the same fundamental frequency at the same decibel level. Draw a wave diagram for each to show similarities and differences.

62. * Standing waves can be said to be due to "interference in space," whereas beats can be said to be due to "interference in time." Explain these statements.

63. * What is the beat frequency if middle C (262 Hz) and $C^{\sharp}$ (277 Hz) are played together? What if each is played two octaves lower (each frequency reduced by a factor of 4)?
15 Hz, 3.75 Hz

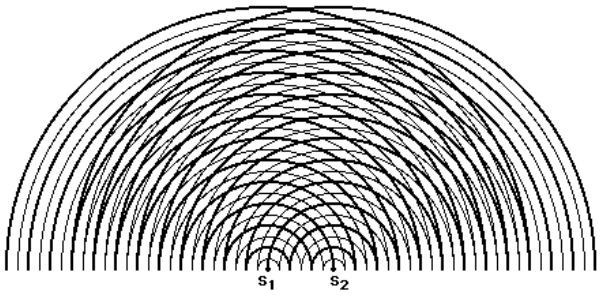
64. * Two open organ pipes, sounding together, produce a beat frequency of 11 Hz. The shorter one is 2.40 m long. How long is the other one? **2.83 m**
65. * You have three tuning forks, A, B, and C. Fork B has a frequency of 441 Hz; when A and B are sounded together, a beat frequency of 3 Hz is heard. When B and C are sounded together, the beat frequency is 4 Hz. (a) What are the possible frequencies of A and C? (b) What beat frequencies are possible when A and C are sounded together?
438 or 444 Hz; 437 or 445 Hz; 1 or 7 Hz
66. * A speaker emits a wavelength of 2.64 m and another speaker emits a wavelength of 2.76 m. how many beats per second will be heard?
5.68 Hz
67. ** Two trains emit 424-Hz whistles. One train is stationary. The conductor on the stationary train hears a 3.0-Hz beat frequency when the other train approaches. What is the speed of the moving train?
2.42 m/s

Assignment #11

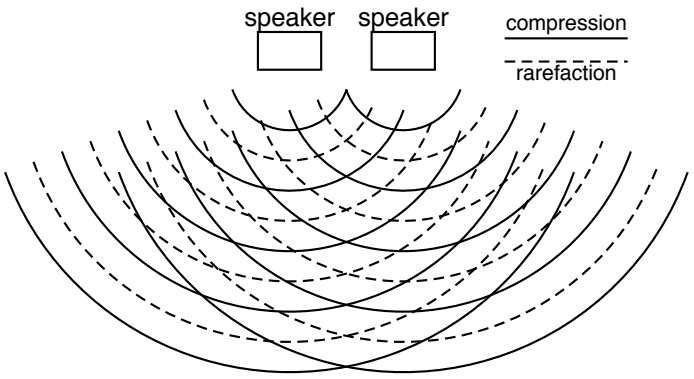
Textbook: Read Section 24-1, 24-2

Online: Light Waves Lesson 3a, 3b
http://www.physicsclassroom.com/class/light

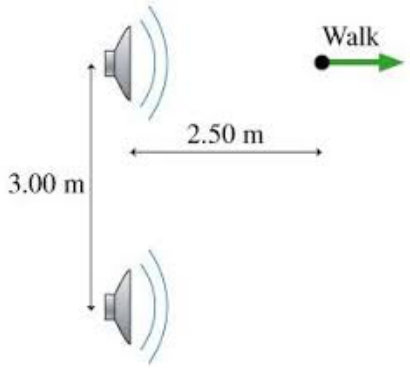
68. * For the interference pattern of water waves shown below, waves crests are 2.2 cm apart and the wave sources are 11.8 cm apart. Determine the angles for the first, second, and third order maxima. **10.7˚, 21.9˚, 34.0˚**



69. * (a) Referring to the previous diagram, what will happen to the pattern if the space between the sources S_1 and S_2 is increased? (Hint: how does changing d affect θ?) (b) What will happen to the pattern if the frequency of both sources S_1 and S_2 is decreased? (Hint: how does changing f affect λ and θ?)
70. * In the diagram below, each speaker creates compressions and rarefactions, in phase. After you finish this problem, cut out the drawing and paste it in your homework. (a) Draw a solid line through the central maximum, and through each first-order maximum. (b) Draw a dashed line through each zero-order minimum and each first-order minimum. (c) Explain the conditions for a point on the first-order maximum. (d) Explain the conditions for a point on the first-order minimum.



71. * In the previous question, the two speakers are 4.0 m apart, and connected to frequency generator set to 250 Hz, in phase. (a) What is the wavelength of these waves? (b) At what angles are interference maxima possible? (c) At what angles are interference minima possible?
20.2˚, 43.6˚; 9.9˚, 31.2˚, 59.6˚
72. ** You are standing 2.50 m directly in front of one of the two loudspeakers shown below, that are 3.0 m apart and both playing a 575 Hz tone in phase. As you begin to walk directly away from the speaker, at what distances from the speaker do you hear a minimum sound?

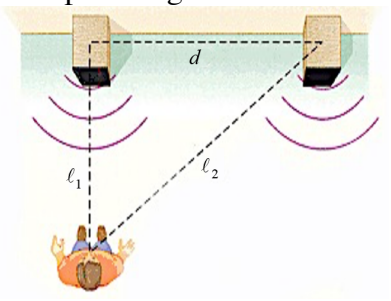


4.55 m, 14.85 m

Assignment #12

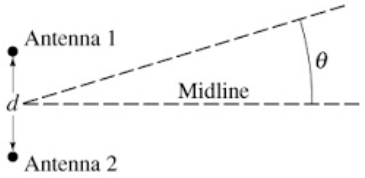
73. * Two ripple generators make water waves the leave points S_1 and S_2, and arrive at point P. What conditions are necessary for point P to be on the (a) 3rd maximum? (b) 3rd minimum?

74. * Two speakers are separated by a distance of $d = 2.10$ m, as shown below, emit the same tone, in phase. A person listens from a location $\ell_1 = 1.50$ m in front of one of the speakers. (a) What is the lowest frequency (longest wavelength) that causes constructive interference? (b) What is the lowest frequency that causes destructive interference? (Hint: think about path length difference $\ell_2 - \ell_1$.)



319 Hz, 160 Hz

75. * A radio station broadcasts FM radio waves of 102.1 MHz from two identical antennae separated by 8.0-m as shown below. A central maximum signal occurs along the midline. (a) At what other angles from the midline is a maximum signal detected? (b) At a distance of 850 m along the midline, a person walks perpendicular to the midline. How far do they walk to arrive at the maxima?



21.6°, 47.3°; 336 m, 921 m

76. * Repeat part (a) in last problem for AM radio waves of 740 kHz, with antennae 900 m apart.
26.8°, 64.3°

77. ** Two identical speakers, separated by distance d, emit 230 Hz sound waves in phase along the x-axis. As an observer walks along the x-axis, away from the speakers, a quiet spot is noticed even though both speakers are on. What are the first three possible values for the distance d?
0.75 m, 2.25 m, 3.75 m

Assignment #13

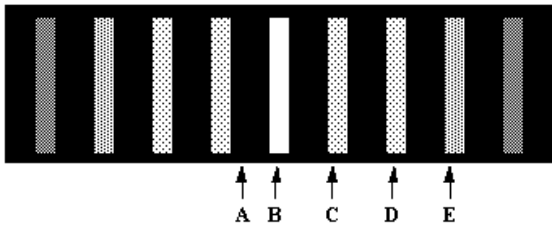
Textbook: Read Section 24-3, Honors: 24-5

Online: Light Waves Lesson 3a, 3b
http://www.physicsclassroom.com/class/light

78. * Explain the conditions for light rays to interfere (a) constructively, and (b) destructively.

79. * White light is incident on a single slit, and the interference pattern is viewed on a screen some distance away. Draw the central maximum, and the first and second order pairs maxima, labeling the location of Red, Green and Blue colors with the letters R,G,B.

80. * For next three questions, a double-slit experiment with monochromatic light produces an interference pattern shown below. Explain, using $d\sin\theta = m\lambda$, what will happen to the pattern if the distance between the double slits is decreased. Draw the two patterns, and label them with "higher d" vs. "lower d" for distance between double slits.



81. * (a) If the light used is 500 nanometers and the central maximum is at point **B**, by what distance is bright fringe **D** closer to one slit than the other, and (b) by what distance is dark fringe **A** closer to one slit than the other? (c) What are the order numbers for fringes A,B,C,D, and E?
1000 nm, 250 nm; A (m = 0), B (m = 0), C (m = 1), D (m = 2), E (m = 3)

82. * If the experiment above uses light of a smaller wavelength, how would the fringe pattern change? Explain, using $d\sin\theta = m\lambda$.

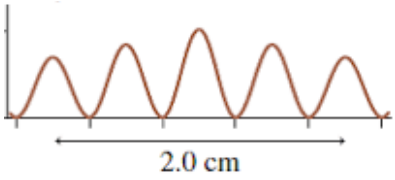
83. ** For diffraction by a single slit, what is the effect of increasing (a) the slit width, and (b) the wavelength?

Assignment #14

Online: Light Waves Lesson 3c, 3d
http://www.physicsclassroom.com/class/light

84. * We can hear sounds around corners, but we cannot see around corners; yet both sound and light are waves. Explain.

85. * Monochromatic light falling on two slits 0.016 mm apart produces the fifth order bight fringe at an 8.8° angle. What is the wavelength of light in meters and in nanometers?
4.90×10^{-7} m, 490 nm
86. * The third-order bright fringe of 610 nm light is observed at an angle of 18.0° when the light falls on two slits. How far apart are the slits?
5.92×10^{-6} m
87. * Light is incident on double slits spaced 0.15 mm apart, and produces an interference pattern on a screen 1.25 m away. The intensity of light on the screen is shown below. What is the wavelength of light in nanometers?



600 nm
88. * In a double-slit experiment, the third-order maximums for light of wavelength 500 nm are located 12 mm from the central bright spot on a screen 1.6 m from the slits. Light of wavelength 650 nm is then projected through the same slits. How far from the central bright spot will the second-order maximums of this light be located?
0.0104 m
89. ** Laser light, with wavelength of 633 nm illuminates a *single slit* of width 2.7×10^{-3} mm Determine the angle to the second minimum.
28.0°
90. ** When blue light of wavelength 440 nm falls on a *single slit*, the first dark bands on either side of center are separated by 55.0°. Determine the slit width in micrometers (μm).
0.953 μm

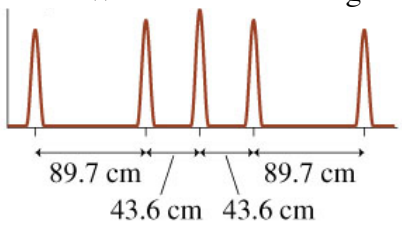
Assignment #15

Textbook: Read Section 24-6

91. * Why is white light separated into a spectrum of colors when it is passed through a diffraction grating?

92. * For a diffraction grating, what is the advantage of (a) many slits, and (b) closely spaced slits?

93. * A 3500-line/cm diffraction grating produces a third-order bright fringe at a 28.0° angle. What wavelength of light is being used?
4.47×10^{-7} m or 447 nm
94. * How many lines per centimeter does a diffraction grating have if the third-order bright fringes occur at 18.0° for 630 nm light.
1640 lines/cm
95. * The two most prominent wavelengths in the light emitted by a hydrogen discharge lamp are 656 nm (red) and 486 nm (blue). Light from a hydrogen lamp illuminates a diffraction grating with 500 lines/mm, and the light is observed on a screen 1.50 m behind the grating. What is the distance between the first-order red and blue fringes?
0.145 m
96. ** The interference pattern on a screen 1.0 m behind an 800-line/mm diffraction grating is shown below. What is the wavelength of light?



5.00×10^{-7} m or 500 nm