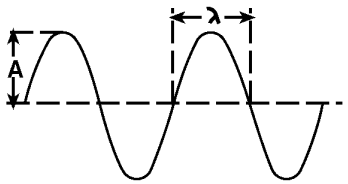
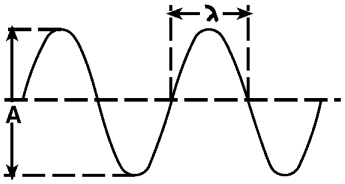
1. Which wave diagram has *both* wavelength (λ) and amplitude (A) labeled correctly?

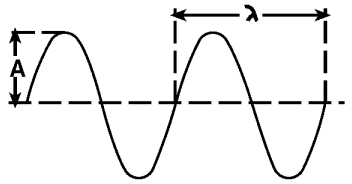
A)



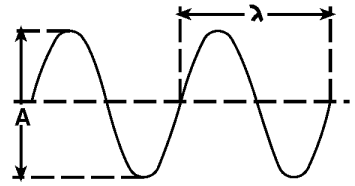
B)



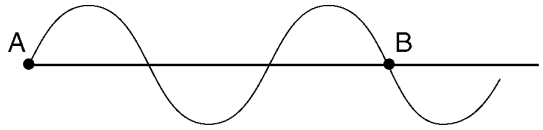
C)



D)



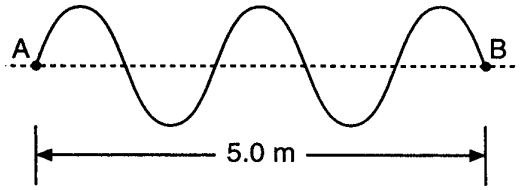
2. The diagram below shows two points, A and B, on a wave train.



How many wavelengths separate point A and point B?

A) 1.0 **B) 1.5** C) 3.0 D) 0.75

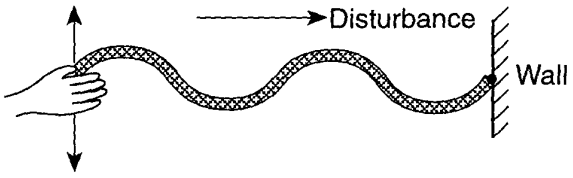
3. In the diagram below, the distance between points A and B on a wave is 5.0 meters.



The wavelength of this wave is

A) 1.0 m **B) 2.0 m** C) 5.0 m D) 4.0 m

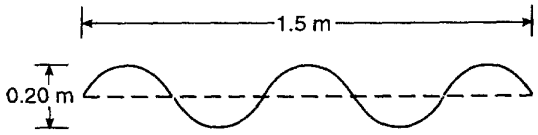
4. The diagram below shows a person shaking the end of a rope up and down, producing a disturbance that moves along the length of the rope.



Which type of wave is traveling in the rope?

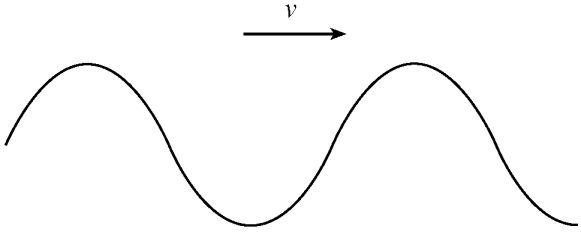
A) torsional B) longitudinal
C) transverse D) elliptical

5. What are the amplitude and wavelength of the wave shown below?



A) amplitude = 0.10 m, wavelength = 0.30 m
B) amplitude = 0.10 m, wavelength = 0.60 m
C) amplitude = 0.20 m, wavelength = 0.30 m
D) amplitude = 0.20 m, wavelength = 0.60 m

6. A transverse wave passes through a uniform material medium from left to right, as shown in the diagram below.



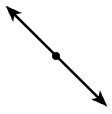
Which diagram best represents the direction of vibration of the particles of the medium?

A)

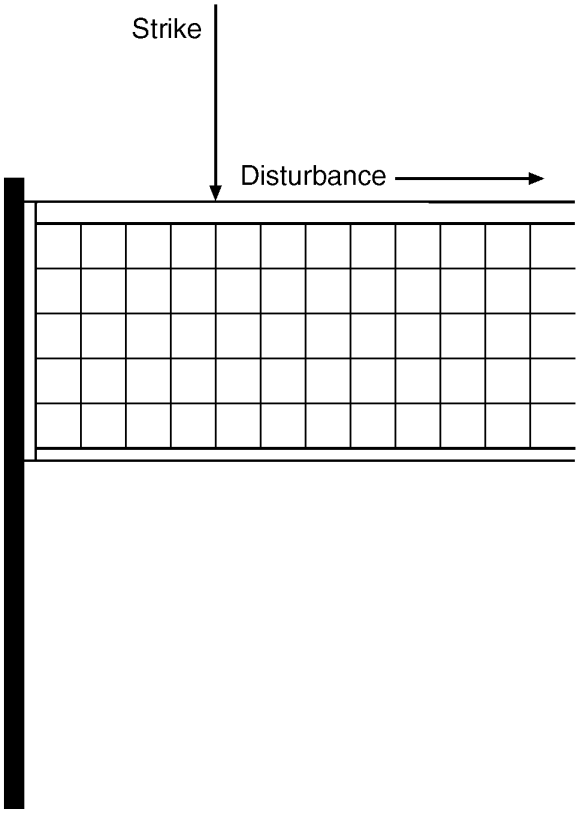
B)

C)

D)



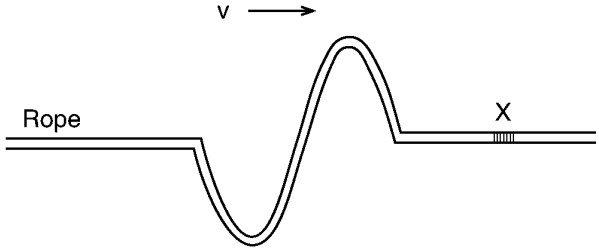
7. A student strikes the top rope of a volleyball net, sending a single vibratory disturbance along the length of the net, as shown in the diagram below.



This disturbance is best described as

A) a pulse
B) a periodic wave
C) a longitudinal wave
D) an electromagnetic wave

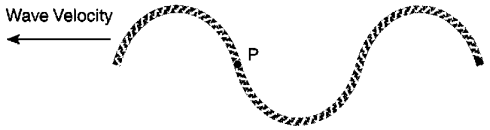
8. As shown in the diagram below, a transverse wave is moving with velocity *v* along a rope.



In which direction will segment *X* move as the wave passes through it?

A) down, only
B) up, only
C) down, then up, then down
D) up, then down, then up

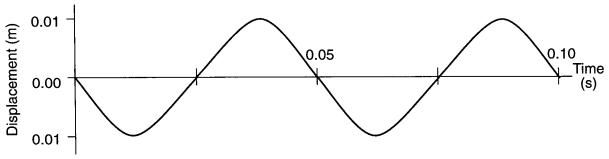
9. The diagram below shows a transverse wave moving toward the left along a rope.



At the instant shown, point *P* on the rope is moving toward the

A) bottom of the page
B) top of the page
C) left of the page
D) right of the page

10. The graph below shows displacement versus time for a particle of a uniform medium as a wave passes through the medium.



What is the frequency of the wave?

A) 10 Hz
B) 20 Hz
C) 50 Hz
D) 100 Hz

11. As a wave travels through a medium, the particles of the medium vibrate in the direction of the wave's travel. What type of wave is traveling through the medium?

A) longitudinal
B) torsional
C) transverse
D) hyperbolic

12. Which form(s) of energy can be transmitted through a vacuum?

A) light, only
B) sound, only
C) both light and sound
D) neither light nor sound

13. If the frequency of a periodic wave is doubled, the period of the wave will be

A) halved
B) doubled
C) quartered
D) quadrupled

14. What is the frequency of a wave if its period is 0.25 second?

A) 1.0 Hz
B) 0.25 Hz
C) 12 Hz
D) 4.0 Hz

15. What is the period of a wave if 20 crests pass an observer in 4 seconds?

A) 80 s **B) 0.2 s** C) 5 s D) 4 s

16. A motor is used to produce 4.0 waves each second in a string. What is the frequency of the waves?

A) 0.25 Hz B) 15 Hz
C) 25 Hz **D) 4.0 Hz**

17. A physics student notices that 4.0 waves arrive at the beach every 20. seconds. The frequency of these waves is

A) 0.20 Hz B) 5.0 Hz
C) 16 Hz D) 80. Hz

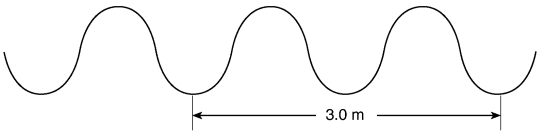
18. The hertz is a unit that describes the number of

A) seconds it takes to complete one cycle of a wave
B) cycles of a wave completed in one second
C) points that are in phase along one meter of a wave
D) points that are out of phase along one meter of a wave

19. A surfacing whale in an aquarium produces water wave crests having an amplitude of 1.2 meters every 0.40 second. If the water wave travels at 4.5 meters per second, the wavelength of the wave is

A) 1.8 m B) 2.4 m C) 3.0 m D) 11 m

20. The periodic wave in the diagram below has a frequency of 40. hertz.



What is the speed of the wave?

A) 13 m/s B) 27 m/s
C) 60. m/s D) 120 m/s

21. Which equation correctly relates the speed v, wavelength λ, and period T of a periodic wave?

A) $V = \frac{T}{\lambda}$ B) $v = T\lambda$
C) $v = \frac{\lambda}{T}$ D) $v = \lambda\frac{2}{T}$

22. A wave completes one vibration as it moves a distance of 2 meters at a speed of 20 meters per second. What is the frequency of the wave?

A) 10 Hz B) 2 Hz C) 20 Hz D) 40 Hz

23. A source of waves and an observer are moving relative to each other. The observer will detect a steadily increasing frequency if

A) he moves toward the source at a constant speed
B) the source moves away from him at a constant speed
C) he accelerates toward the source
D) the source accelerates away from him

24. A train sounds a whistle of constant frequency as it leaves the train station. Compared to the sound emitted by the whistle, the sound that the passengers standing on the platform hear has a frequency that is

A) lower, because the sound-wave fronts reach the platform at a frequency lower than the frequency at which they are produced
B) lower, because the sound-wave travels more slowly in the still air above the platform than in the rushing air near the train
C) higher, because the sound-wave fronts reach the platform at a frequency higher than the frequency at which they are produced
D) higher, because the sound-wave travels faster in the still air above the platform than in the rushing air near the train

25. A radar gun can determine the speed of a moving automobile by measuring the difference in frequency between emitted and reflected radar waves. This process illustrates

A) resonance **B) the Doppler effect**
C) diffraction D) refraction

26. A source of sound waves approaches a stationary observer through a uniform medium. Compared to the frequency and wavelength of the emitted sound, the observer would detect waves with a

A) higher frequency and shorter wavelength
B) higher frequency and longer wavelength
C) lower frequency and shorter wavelength
D) lower frequency and longer wavelength

27. An astronomer on Earth studying light coming from a star notes that the observed light frequencies are lower than the actual emitted frequencies. The astronomer concludes that the distance between the star and Earth is

A) decreasing **B) increasing**
C) unchanging

28. An astronomical body emitting high-intensity pulses of green light is moving toward Earth at high velocity. To an observer on Earth, this light may appear

A) red **B) blue**
C) orange D) yellow

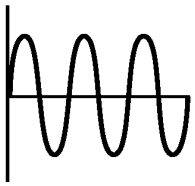
29. As a wave travels between two points in a medium, the wave transfers

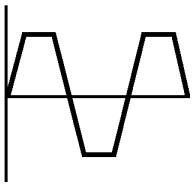
A) energy, only
B) mass, only
C) both energy and mass
D) neither energy nor mass

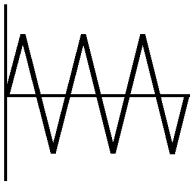
30. As a pulse travels along a rope, the pulse loses energy and its amplitude

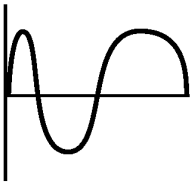
A) decreases B) increases
C) remains the same

31. Which diagram below does *not* represent a periodic wave?

A) 

B) 

C) 

D) 

32. Which phrase best describes a periodic wave?

A) a single pulse traveling at constant speed
B) a series of pulses at irregular intervals
C) a series of pulses at regular intervals
D) a single pulse traveling at different speeds in the same medium

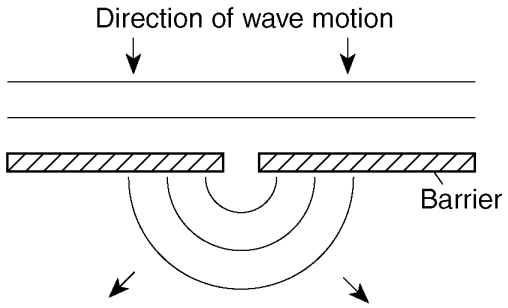
33. The spreading of a wave into the region behind an obstruction is called

A) diffraction B) absorption
C) reflection D) refraction

34. Which wave phenomenon makes it possible for a player to hear the sound from a referee's whistle in an open field even when standing behind the referee?

A) diffraction B) Doppler effect
C) reflection D) refraction

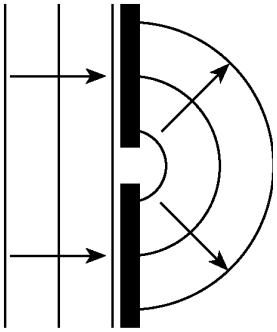
35. The diagram below shows wave fronts spreading into the region behind a barrier.



Which wave phenomenon is represented in the diagram?

A) reflection B) refraction
C) diffraction D) standing waves

36. The diagram below shows straight wave fronts passing through an opening in a barrier.



This wave phenomenon is called

A) reflection B) refraction
C) polarizaton **D) diffraction**

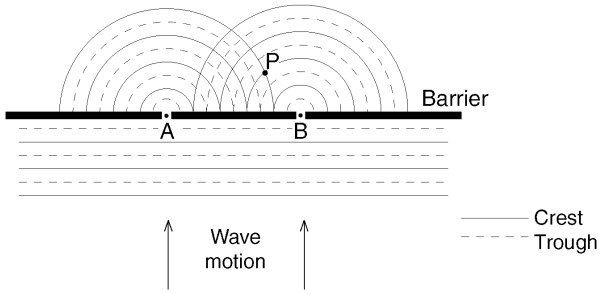
37. A wave is diffracted as it passes through an opening in a barrier. The amount of diffraction that the wave undergoes depends on both the

A) amplitude and frequency of the incident wave
B) wavelength and speed of the incident wave
C) wavelength of the incident wave and the size of the opening
D) amplitude of the incident wave and the size of the opening

38. Waves pass through a 10.-centimeter opening in a barrier without being diffracted. This observation provides evidence that the wavelength of the waves is

A) much shorter than 10. cm
B) equal to 10. cm
C) longer than 10. cm, but shorter than 20. cm
D) longer than 20. cm

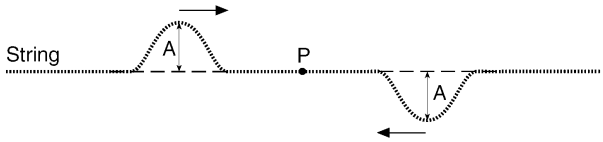
39. The diagram below represents shallow water waves of wavelength λ passing through two small openings, *A* and *B*, in a barrier.



How much longer is the length of path *AP* than the length of path *BP*?

A) 1λ **B) 2λ** C) 3λ D) 4λ

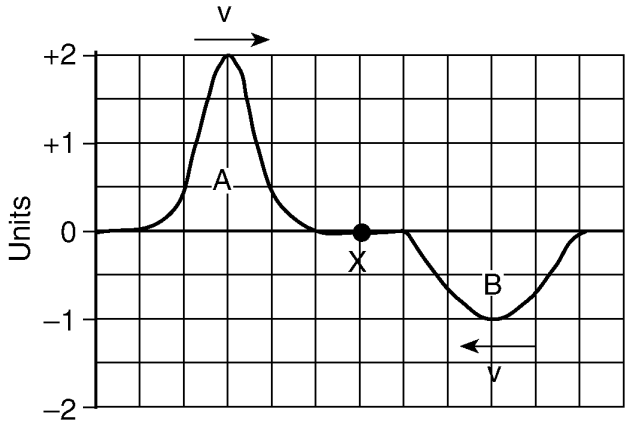
40. The diagram below shows two pulses of equal amplitude, *A*,approaching point *P* along a uniform string.



When the two pulses meet at *P*, the vertical displacement of the string at *P* will be

A) A B) 2A **C) 0** D) $\frac{A}{2}$

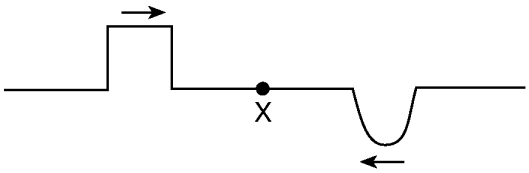
41. Two pulses, *A* and *B*, travel toward each other along the same rope, as shown below.



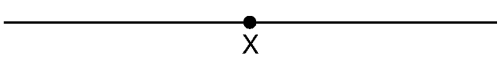
When the centers of the two pulses meet at point *X*, the amplitude at the center of the resultant pulse will be

A) +1 unit B) +2 units
C) 0 D) −1 unit

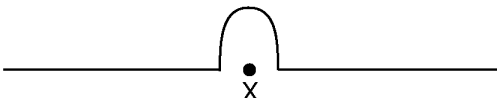
42. The diagram below shows two pulses traveling toward each other in a uniform medium.



Which diagram best represents the medium when the pulses meet at point *X*?

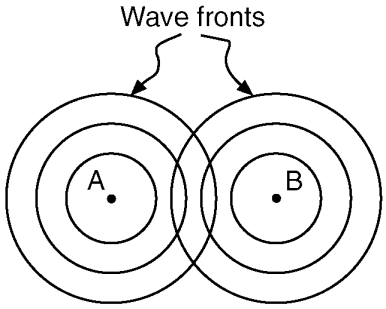
A)


B)


C)


D)

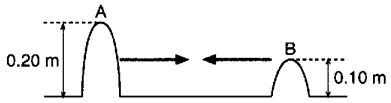

43. The diagram below represents the wave pattern produced by two sources located at points *A* and *B*.



Which phenomenon occurs at the intersections of the circular wave fronts?

A) diffraction **B) interference**
C) refraction D) reflection

44. The diagram below shows two pulses approaching each other from opposite directions in the same medium. Pulse *A* has an amplitude of 0.20 meter and pulse *B* has an amplitude of 0.10 meter.



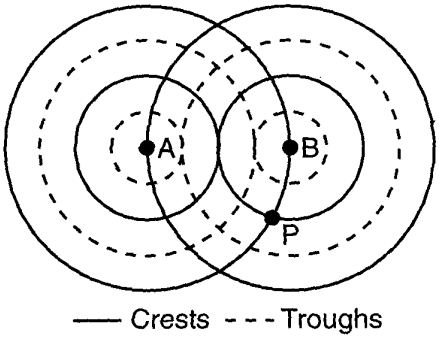
After the pulses have passed through each other, what will be the amplitude of each of the two pulses?

A) $A = 0.10$ m; $B = 0.20$ m
B) $A = 0.20$ m; $B = 0.10$ m
C) $A = 0.30$ m; $B = 0.30$ m
D) $A = 0.15$ m; $B = 0.15$ m

45. Two waves having the same amplitude and the same frequency pass simultaneously through a uniform medium. Maximum destructive interference occurs when the phase difference between the two waves is

A) 0° B) 90° **C) 180°** D) 360°

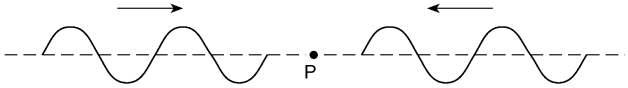
46. The diagram below shows two sources, *A* and *B*, vibrating in phase in the same uniform medium and producing circular wave fronts.



Which phenomenon occurs at point *P*?

A) destructive interference
B) constructive interference
C) reflection
D) refraction

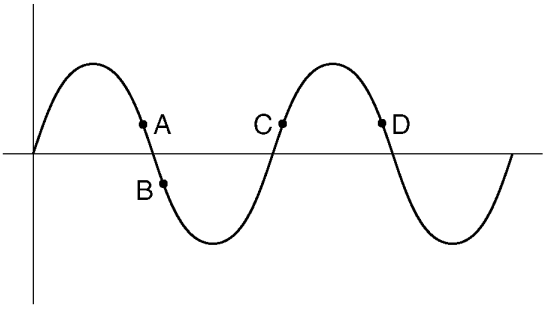
47. The diagram below represents two waves of equal amplitude and frequency approaching point *P* as they move through the same medium.



As the two waves pass through each other, the medium at point *P* will

A) vibrate up and down
B) vibrate left and right
C) vibrate into and out of the page
D) remain stationary

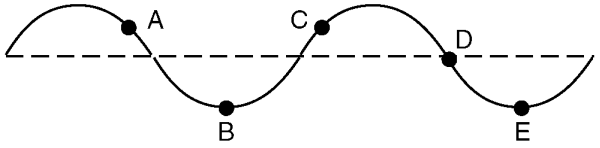
48. The diagram below shows a periodic wave.



Which points are in phase with each other?

A) *A* and *C*
B) *A* and *D*
C) *B* and *C*
D) *C* and *D*

49. The diagram below represents a periodic wave.



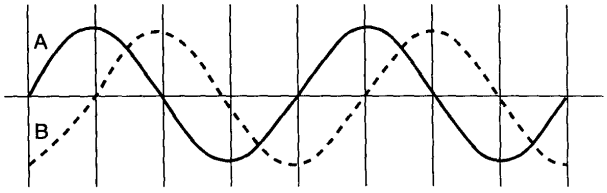
Which two points on the wave are in phase?

A) *A* and *C*
B) *B* and *D*
C) *A* and *D*
D) *B* and *E*

50. Two points on a transverse wave that have the same magnitude of displacement from equilibrium are in phase if the points also have the

A) same direction of displacement and the same direction of motion
B) same direction of displacement and the opposite direction of motion
C) opposite direction of displacement and the same direction of motion
D) opposite direction of displacement and the opposite direction of motion

51. The diagram below shows two waves, *A* and *B*.



The phase difference between *A* and *B* is

A) 0°
B) 45°
C) 90°
D) 180°

52. A tuning fork vibrating in air produces sound waves. These waves are best classified as

A) transverse, because the air molecules are vibrating parallel to the direction of wave motion
B) transverse, because the air molecules are vibrating perpendicular to the direction of wave motion
C) longitudinal, because the air molecules are vibrating parallel to the direction of wave motion
D) longitudinal, because the air molecules are vibrating perpendicular to the direction of wave motion

53. Base your answer to the following question on the information below.

A student plucks a guitar string and the vibrations produce a sound wave with a frequency of 650 hertz.

The sound wave produced can best be described as a

A) transverse wave of constant amplitude
B) longitudinal wave of constant frequency
C) mechanical wave of varying frequency
D) electromagnetic wave of varying wavelengths

54. As a sound wave passes from water, where the speed is 1.49×10^3 meters per second, into air, the wave's speed

A) decreases and its frequency remains the same
B) increases and its frequency remains the same
C) remains the same and its frequency decreases
D) remains the same and its frequency increases

55. An electric bell connected to a battery is sealed inside a large jar. What happens as the air is removed from the jar?

A) The electric circuit stops working because electromagnetic radiation can *not* travel through a vacuum.
B) The bell's pitch decreases because the frequency of the sound waves is lower in a vacuum than in air.
C) The bell's loudness increases because of decreased air resistance.
D) The bell's loudness decreases because sound waves can *not* travel through a vacuum.

56. A tuning fork oscillates with a frequency of 256 hertz after being struck by a rubber hammer. Which phrase best describes the sound waves produced by this oscillating tuning fork?

A) electromagnetic waves that require no medium for transmission
B) electromagnetic waves that require a medium for transmission
C) mechanical waves that require no medium for transmission
D) mechanical waves that require a medium for transmission

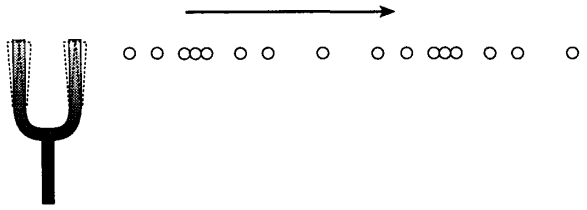
57. An electric guitar is generating a sound of constant frequency. An increase in which sound wave characteristic would result in an increase in loudness?

A) speed
B) period
C) wavelength
D) amplitude

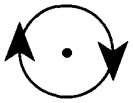
58. A standing wave pattern is produced when a guitar string is plucked. Which characteristic of the standing wave immediately begins to decrease?

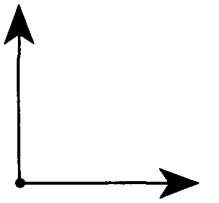
A) speed
B) wavelength
C) frequency
D) amplitude

59. The diagram below shows a tuning fork vibrating in air. The dots represent air molecules as the sound wave moves toward the right.



Which diagram best represents the direction of motion of the air molecules?

A)


B)


C)


D)


60. A student in a band notices that a drum vibrates when another instrument emits a certain frequency note. This phenomenon illustrates

A) reflection
B) resonance
C) refraction
D) diffraction

61. In a demonstration, a vibrating tuning fork causes a nearby second tuning fork to begin to vibrate with the same frequency. Which wave phenomenon is illustrated by this demonstration?

A) the Doppler effect B) nodes
C) resonance D) interference

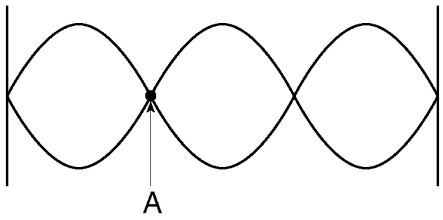
62. The superposition of two waves traveling in the same medium produces a standing wave pattern if the two waves have

A) the same frequency, the same amplitude, and travel in the same direction
B) the same frequency, the same amplitude, and travel in opposite directions
C) the same frequency, different amplitudes, and travel in the same direction
D) the same frequency, different amplitudes, and travel in opposite directions

63. Standing waves in water are produced most often by periodic water waves

A) being absorbed at the boundary with a new medium
B) refracting at a boundary with a new medium
C) diffracting around a barrier
D) reflecting from a barrier

64. The diagram below shows a standing wave.

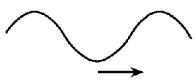
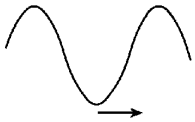
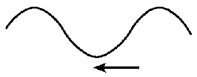
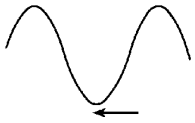


Point *A* on the standing wave is

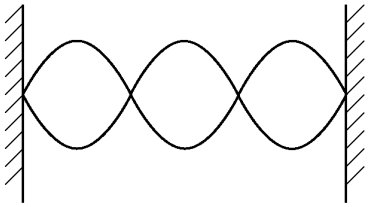
A) a node resulting from constructive interference
B) a node resulting from destructive interference
C) an antinode resulting from constructive interference
D) an antinode resulting from destructive interference

65. The diagram below represents a wave moving toward the right side of this page.

Which wave shown below could produce a standing wave with the original wave?

A) 
B) 
C) 
D) 

66. How many nodes are represented in the standing wave diagram below?

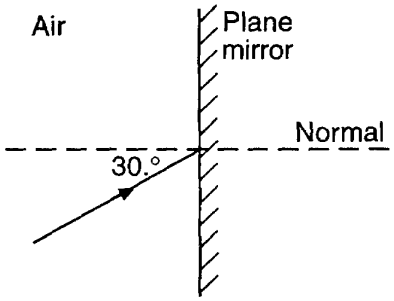


A) 1 B) 6 C) 3 **D) 4**

67. Two waves traveling in the same medium interfere to produce a standing wave. What is the phase difference between the two waves at a node?

A) 0° B) 90° **C) 180°** D) 360°

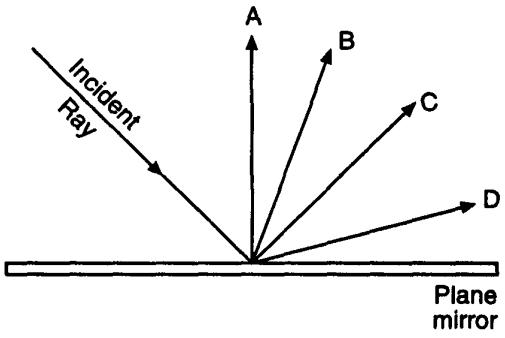
68. A ray of monochromatic light traveling in air is incident on a plane mirror at an angle of 30.°, as shown in the diagram below.



The angle of reflection for the light ray is

A) 15° **B) 30.°** C) 60.° D) 90.°

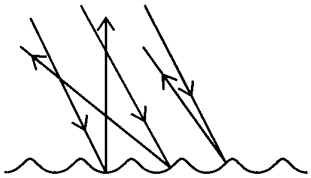
69. A light ray is incident on a plane mirror as shown in the diagram below.



Which ray best represents the reflected ray?

A) A B) B **C) C** D) D

70. The diagram below shows parallel rays of light incident on an irregular surface.



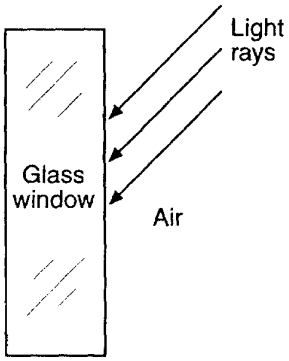
Which phenomenon of light is illustrated by the diagram?

A) diffraction B) refraction
C) regular reflection **D) diffuse reflection**

71. When a student looks into a plane mirror, she sees a virtual image of herself. However, when she looks into a sheet of paper, no such image forms. Which light phenomenon occurs at the surface of the paper?

A) regular reflection **B) diffuse reflection**
C) polarization D) resonance

72. The diagram below shows light rays in air about to strike a glass window.



When the rays reach the boundary between the air and the glass, the light is

A) totally refracted
B) totally reflected
C) partially reflected and partially diffracted
D) partially reflected and partially refracted

73. A light spring is attached to a heavier spring at one end. A pulse traveling along the light spring is incident on the boundary with the heavier spring. At this boundary, the pulse will be

A) totally reflected
B) totally absorbed
C) totally transmitted into the heavier spring
D) partially reflected and partially transmitted into the heavier spring

74. If the speed of a wave doubles as it passes from shallow water into deeper water, its wavelength will be

A) unchanged **B) doubled**
C) halved D) quadrupled

75. A change in the speed of a wave as it enters a new medium produces a change in

A) frequency B) period
C) wavelength D) phase

76. What occurs when light passes from water into flint glass?

A) Its speed decreases, its wavelength becomes shorter, and its frequency remains the same.

B) Its speed decreases, its wavelength becomes shorter, and its frequency increases.

C) Its speed increases, its wavelength becomes longer, and its frequency remains the same.

D) Its speed increases, its wavelength becomes longer, and its frequency decreases.

77. As a monochromatic beam of light passes obliquely from flint glass into water, how do the characteristics of the beam of light change?

A) Its wavelength decreases and its frequency decreases.

B) Its wavelength decreases and its frequency increases.

C) Its wavelength increases and it bends toward the normal.

D) Its wavelength increases and it bends away from the normal.

78. What happens to the frequency and the speed of an electromagnetic wave as it passes from air into glass?

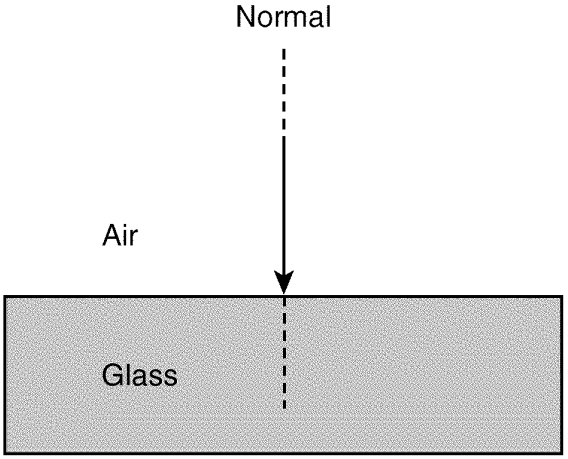
A) The frequency decreases and the speed increases.

B) The frequency increases and the speed decreases.

C) The frequency remains the same and the speed increases.

D) The frequency remains the same and the speed decreases.

79. The diagram below shows a ray of light passing from air into glass at an angle of incidence of 0°.



Which statement best describes the speed and direction of the light ray as it passes into the glass?

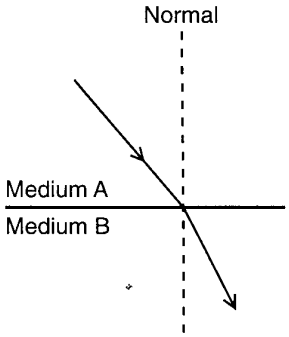
A) Only speed changes.

B) Only direction changes.

C) Both speed and direction change.

D) Neither speed nor direction changes.

80. The diagram below shows a ray of light passing through two media.



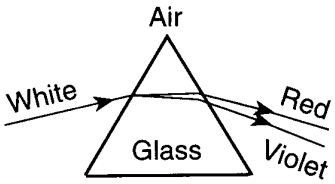
When the wave travels from medium *A* into medium *B,* its speed

A) decreases B) increases

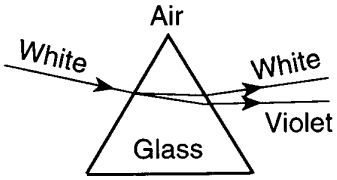
C) remains the same

81. Which diagram best represents the path of light rays passing through a glass prism?

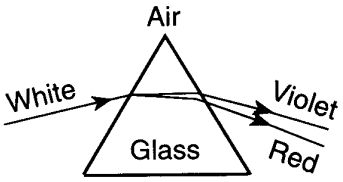
A)



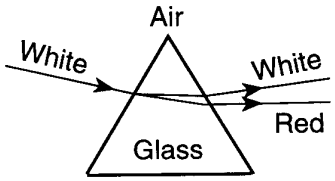
B)



C)



D)



82. In a certain material, a beam of monochromatic light ($f = 5.09 \times 10^{14}$ hertz) has a speed of 2.25×10^8 meters per second. The material could be

A) crown glass B) flint glass
C) glycerol **D) water**

83. Which quantity is equivalent to the product of the absolute index of refraction of water and the speed of light in water?

A) wavelength of light in a vacuum
B) frequency of light in water
C) sine of the angle of incidence
D) speed of light in a vacuum

84. The speed of light in a material is 2.50×10^8 meters per second. What is the absolute index of refraction of the material?

A) 1.20 B) 2.50 C) 7.50 D) 0.833

85. What is the speed of light in a medium having an absolute index of refraction of 2.3?

A) 0.77×10^8 m/s **B) 1.3×10^8 m/s**
C) 1.5×10^8 m/s D) 2.3×10^8 m/s

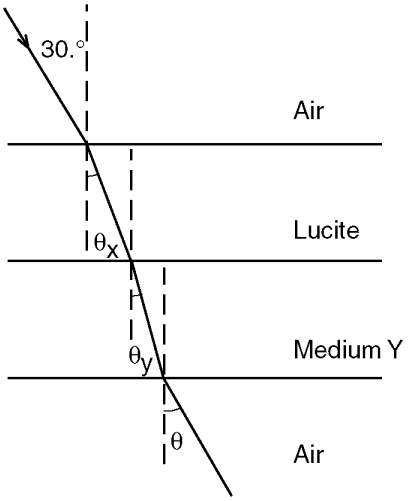
86. A ray of monochromatic light ($f = 5.09 \times 10^{14}$ hertz) in air is incident at an angle of 30.° on a boundary with corn oil. What is the angle of refraction, to the nearest degree, for this light ray in the corn oil?

A) 6° **B) 20.°** C) 30.° D) 47°

87. The speed of light ($f = 5.09 \times 10^{14}$ *Hz) in a transparent material is 0.75 times its speed in air. The absolute index of refraction of the material is approximately*

A) 0.75 **B) 1.3** C) 2.3 D) 4.0

Base your answers to questions **88** and **89** on the diagram below, which represents a light ray traveling from air to Lucite to medium *Y* and back into air.



88. Light travels *slowest* in

A) air, only
B) Lucite, only
C) medium *Y*, only
D) air, Lucite, and medium *Y*

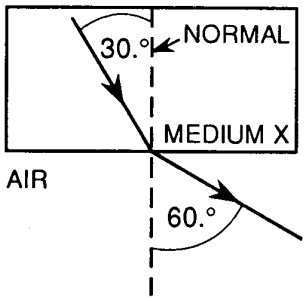
89. The sine of angle θ_x *is*

A) 0.333 B) 0.500 C) 0.707 D) 0.886

90. A monochromatic ray of light ($f = 5.09 \times 10^{14}$ hertz) traveling in air is incident upon medium A at an angle of 45°. If the angle of refraction is 29°, medium A could be

A) water **B) fused quartz**
C) Lucite D) flint glass

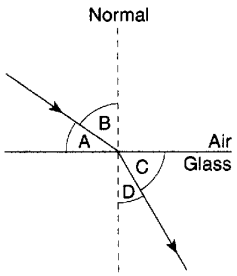
91. The diagram below shows a ray of light passing from medium *X* into air.



What is the absolute index of refraction of medium *X*?

A) 0.500 B) 2.00 **C) 1.73** D) 0.577

92. A light ray passes from air into glass as shown in the diagram below.

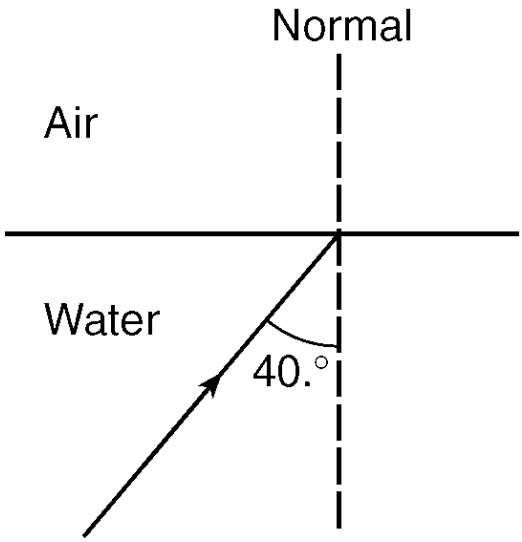


Which relationship represents the index of refraction of the glass?

A) $\frac{sinA}{sinC}$ B) $\frac{sinA}{sinD}$ C) $\frac{sinB}{sinC}$ **D)** $\frac{sinB}{sinD}$

Base your answers to questions **93** and **94** on the information and diagram below.

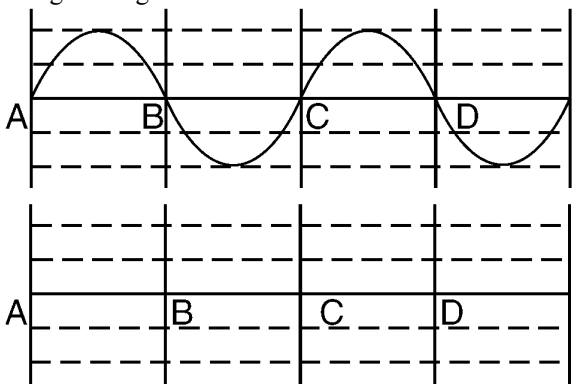
A ray of light of frequency 5.09×10^{14} hertz is incident on a water-air interface as shown in the diagram below.



93. Calculate the angle of refraction of the light ray in air. [Show all work, including the equation and substitution with units.]

94. Calculate the speed of the light while in the water. [Show all work, including the equation and substitution with units.]

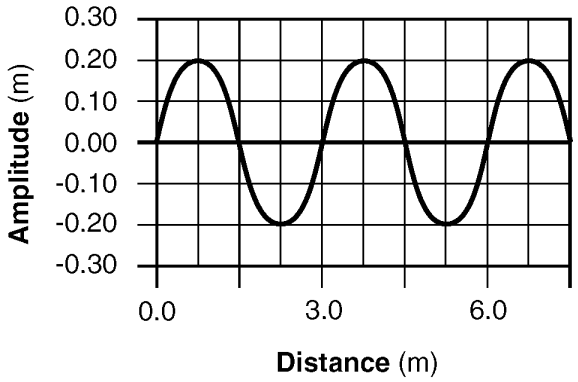
95. The diagram below represents a transverse wave moving along a string.



On the diagram draw a transverse wave that would produce complete destructive interference when superimposed with the original wave.

96. Base your answer to the following question on the information below.

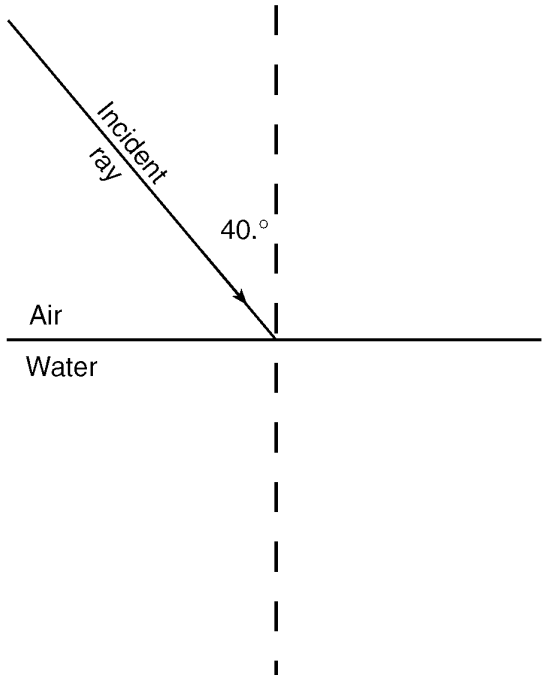
A transverse wave with an amplitude of 0.20 meter and wavelength of 3.0 meters travels toward the right in a medium with a speed of 4.0 meters per second.



Calculate the period of the wave.

Base your answers to questions **97** through **99** on the information and diagram below.

A light ray with a frequency of 5.09×10^{14} hertz traveling in air is incident at an angle of 40.° on an air-water interface as shown. At the interface, part of the ray is refracted as it enters the water and part of the ray is reflected from the interface.



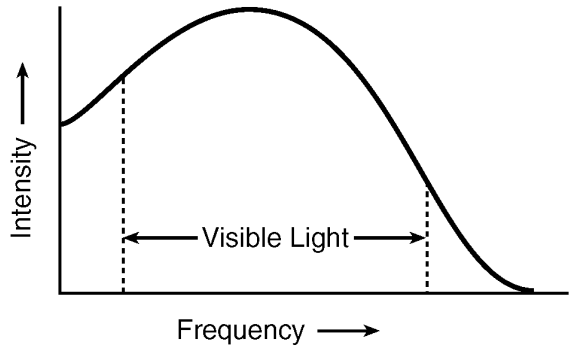
97. Calculate the angle of refraction of the light ray as it enters the water.

98. On the diagram, using a protractor and straightedge, draw the refracted ray. Label this ray "Refracted ray."

99. On the diagram, using a protractor and straightedge, draw the reflected ray. Label this ray "Reflected ray."

Base your answers to questions **100** and **101** on the information and graph below.

Sunlight is composed of various intensities of all frequencies of visible light. The graph represents the relationship between light intensity and frequency.



100. Based on the graph, which color of visible light has the lowest intensity?

101. It has been suggested that fire trucks be painted yellow green instead of red. Using information from the graph, explain the advantage of using yellow-green paint.

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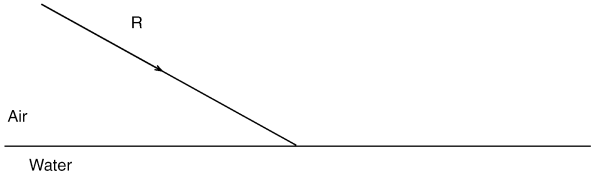
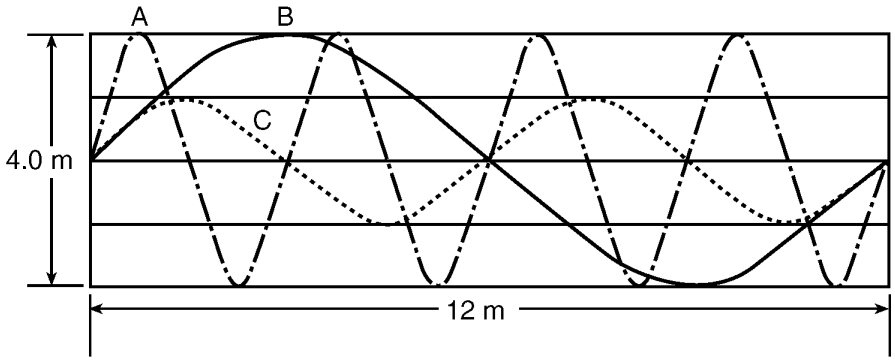
102. In the diagram, a light ray, *R*,strikes the boundary of air and water.



1 Using a protractor and straightedge, determine the angle of incidence *and* draw the reflected ray on the diagram.

Base your answers to questions **103** through **105** on the information and diagram below.

Three waves, *A*, *B*, and *C*, travel 12 meters in 2.0 seconds through the same medium as shown in the diagram below.



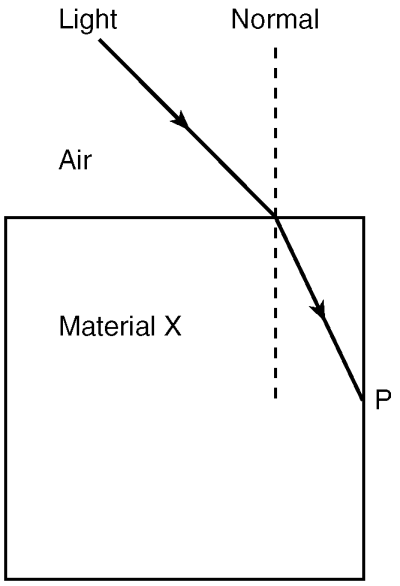
103. What is the amplitude of wave *C*?

104. What is the period of wave *A*?

105. What is the speed of wave *B*?

Base your answers to questions **106** and **107** on the information and diagram below.

A ray of light passes from air into a block of transparent material *X* as shown in the diagram below.



106. *a* Measure the angles of incidence and refraction to the nearest degree for this light ray at the air into material *X* boundary.
b Calculate the absolute index of refraction of material *X*. [Show all work, including the equation and substitution with units.]

107. The refracted light ray is reflected from the material *X*–air boundary at point *P*. Using a protractor and straightedge, on the diagram, draw the reflected ray from point *P*.

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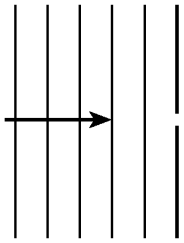
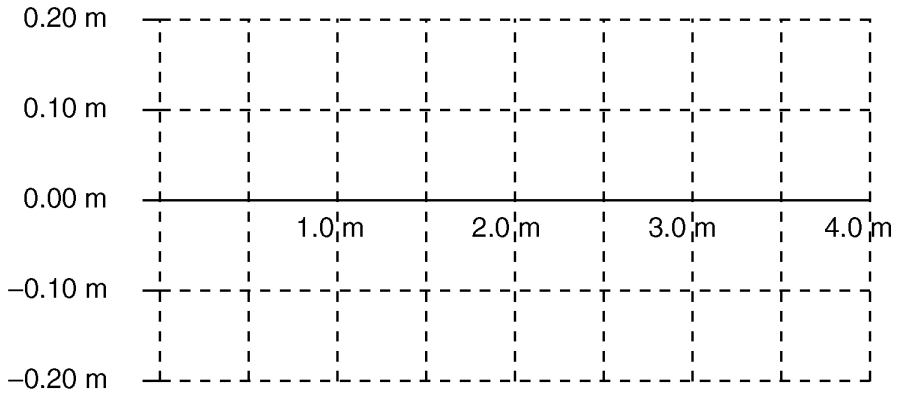
108. The diagram below shows a plane wave passing through a small opening in a barrier.



On the diagram above, sketch four wave fronts after they have passed through the barrier.

109. Base your answer to the following question on the information below.

A periodic transverse wave has an amplitude of 0.20 meter and a wavelength of 3.0 meters.



On the grid provided *above,* draw at least one cycle of this periodic wave.

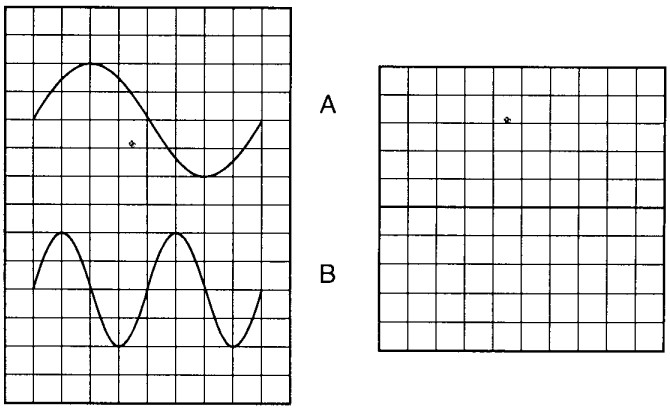
110. Base your answer to the following question on the information below.

A 0.12-meter-long electromagnetic (radar) wave is emitted by a weather station and reflected from a nearby thunderstorm.

The thunderstorm is moving toward the weather station. Using one or more complete sentences, explain how the Doppler effect could have been used to determine the direction in which the storm is moving.

Base your answers to questions **111** through **113** on the information and wave diagrams below.

Two waves, *A* and B, pass through the same medium at the same time.

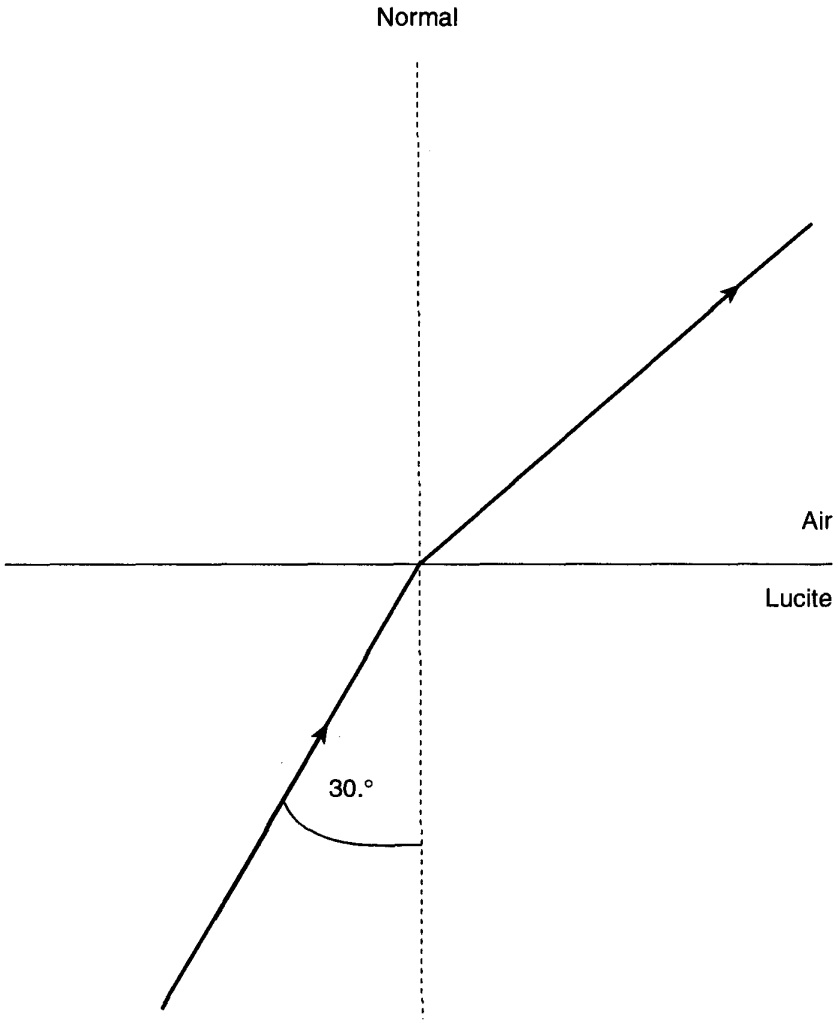


111. Name a wave characteristic that is the same for both wave *A* and wave *B.*

112. Name a wave charactertistic that is different for wave *A* and wave *B.*

113. On the grid provided above, sketch the wave pattern produced when the two waves interfere.

Base your answers to questions **114** through **116** on the diagram below which represents a beam of monochromatic light ($A = 5.9 \times 10^{-7}$ meter) traveling from Lucite into air.



(drawn to scale)

114. What is the measure of the angle of refraction?
[Use a protractor or a mathematical calculation.] If you use a calculation show all equations used with proper substitutions. Use units where they apply and circle your answer.

115. Determine the speed of the light in Lucite. Show all equations with proper substitutions. Circle your answer.

116. Determine the critical angle for the Lucite-air boundary. Show all equations used with proper substitutions. Include any units necessary and circle your answer.

Answer Key

2015-16 WAVES

1. **C**
2. **B**
3. **B**
4. **C**
5. **B**
6. **C**
7. **A**
8. **D**
9. **A**
10. **B**
11. **A**
12. **A**
13. **A**
14. **D**
15. **B**
16. **D**
17. **A**
18. **B**
19. **A**
20. **C**
21. **C**
22. **A**
23. **C**
24. **A**
25. **B**
26. **A**
27. **B**
28. **B**
29. **A**
30. **A**
31. **D**
32. **C**
33. **A**
34. **A**
35. **C**
36. **D**
37. **C**
38. **A**
39. **B**
40. **C**
41. **A**
42. **D**
43. **B**
44. **B**
45. **C**
46. **B**
47. **D**
48. **B**
49. **D**
50. **A**
51. **C**
52. **C**
53. **B**
54. **A**
55. **D**
56. **D**
57. **D**
58. **D**
59. **D**
60. **B**
61. **C**
62. **B**
63. **D**
64. **B**
65. **C**
66. **D**
67. **C**
68. **B**
69. **C**
70. **D**
71. **B**
72. **D**
73. **D**
74. **B**
75. **C**
76. **A**
77. **D**
78. **D**
79. **A**
80. **A**
81. **A**
82. **D**
83. **D**
84. **A**
85. **B**
86. **B**
87. **B**
88. **C**
89. **A**
90. **B**
91. **C**
92. **D**
93. $n_1 \sin\theta_1 = n_2 \sin\theta_2$

$\sin\theta_2 = \dfrac{n_1 \sin\theta_1}{n_2}$

$\sin\theta_2 = \dfrac{(1.33)(\sin 40.^\circ)}{1.00}$

$\sin\theta_2 = 0.855$

$\theta_2 = 59^\circ \text{ or } 58.7^\circ$

94. $\dfrac{n_2}{n_1} = \dfrac{v_1}{v_2}$

$v_1 = \dfrac{n_2 v_2}{n_1}$

$v_1 = \dfrac{1.00(3.00 \times 10^8 \text{ m/s})}{1.33}$

$v_1 = 2.26 \times 10^8 \text{ m/s}$

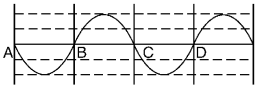
$n = \dfrac{c}{v}$

$v = \dfrac{c}{n}$

or

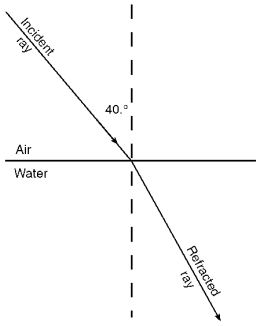
$v = \dfrac{(3.00 \times 10^8 \text{ m/s})}{1.33}$

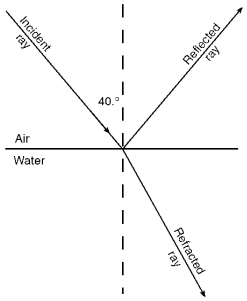
$v = 2.26 \times 10^8 \text{ m/s}$

95. 

96. 0.75 s or 0.77 s

97. $\theta = 28.9°$

98. 

99. 

100. violet, the one with the greatest frequency

101. Examples: — Yellow green has a higher intensity. —Yellow green is brighter than red.

102. Allow credit for indicating that the angle of incidence is 61° (±2°). and/or for drawing the reflected ray with θ_r = 61° (±2°).

103. Allow credit for 1.0 m or 1 m.

104. Allow credit for 0.50 s or 0.5 s.

105. Allow credit for 6.0 m/s or 6 m/s.

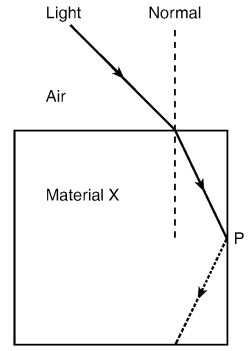
106. *a* angle of incidence $45^\circ\ (\pm 2^\circ)$,
angle of refraction $26^\circ\ (\pm 2^\circ)$

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

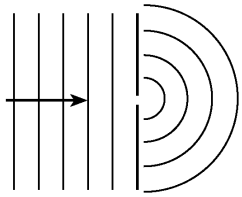
$$n_2 = \frac{(1.00)(\sin 45^\circ)}{\sin 26^\circ}$$

b $n_2 = 1.61$

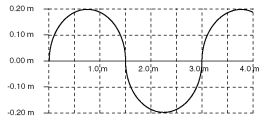
107.



108.



109.



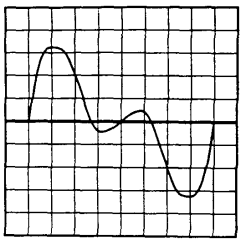
110. Examples:
– The frequency of the reflected wave is greater than the emitted waves frequency.
– The wave reflected from the thunderstorm has a higher frequency than the wave emitted by the weather station.

111. amplitude *or* speed

112. **Examples of Acceptable Responses**

wavelength *or* frequency *or* period

113.



114. 49°

115. 2.0×10^8 m/s

116. 42°