NAME _____

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Topic 6A: Standard Model of Particle Physics

Skill 47 – Relating Particles to the Fundamental Forces (Using the Standard Model Charts)

1. ANTI-PARTICLES have the same mass but _____.

2. The symbol for the up quark is _____

   The symbol for the anti-up quark is _____

3. Complete the chart for each of the following particles:

	Particle category	Charge	Composition (quarks composition/charge)	
Proton				
Neutron				
Electron				

4. Fill-in the blanks

Quarks have a partial charge of _____ or _____ but combine to form elementary particles such as _____ and _____. The other common elementary particle is the electron which is a _____ and NOT made of quarks.

For every particle there exists a corresponding _____ which contains the same mass and structure but opposite electric charge. An anti-particle is symbolized by a line over the letter for the particle. For example the symbol for the up quark is _____ so the anti-up quark is symbolized by _____. A proton is made of _____ quarks so an anti-proton is made of _____.

Sub atomic particles such as the electron, proton and neutron are the smallest independent particle that can exist, they are called the elementary particles. Quarks are not elementary particles because they have _____ charge. Quarks must be combined to form a zero charge or whole number charge.

A proton is composed of "uud" and has a charge of _____; an antiproton is composed of _____ with a charge of _____. A neutron is composed of _____ with a charge of _____; an anti-neutron is composed of _____ with a charge of _____. (A neutron is its own anti-particle).

An elementary particle with a charge of 1e has a charge in coulombs of _____. To convert by elementary charge to coulombs _____.

USE THE FLOW CHART ON THE PHYSICS REFERENCE TABLE TO GROUP PARTICLES ACCORDING TO COMPOSITION OF QUARKS AND LEPTONS

5. Classify each of the following particles as a quark, lepton, anti-lepton, baryon, and anti-baryon or meson
   a. udd _____
   b. Electron _____
   c. $t\bar{t}$ _____
   d. $\overline{uud}$ _____
   e. s _____
   f. anti-neutrino _____
   g. css _____
   h. $u\bar{d}$
6. Determine the charge on each of the following particles
   a. ttb _____
   b. uts _____
   c. uuu_____
   d. $u\bar{u}$ _____
   e. ddb _____
   f. $b\bar{t}$ _____

7. Give two examples of baryons that add up to a charge of +1

_____ _____

8. Which particles are *not* affected by the strong force?

A) hadrons B) protons
C) neutrons D) electrons

9. The particles in a nucleus are held together primarily by the

A) strong force
B) gravitational force
C) electrostatic force
D) magnetic force

Base your answers to questions **10** and **11** on the table below, which shows data about various subatomic particles.

Subatomic Particle Table

Symbol	Name	Quark Content	Electric Charge	Mass (GeV/c^2)
p	proton	uud	+1	0.938
$\bar{p}$	antiproton	$\bar{u}\bar{u}\bar{d}$	−1	0.938
n	neutron	udd	0	0.940
λ	lambda	uds	0	1.116
Ω^-	omega	sss	−1	1.672

10. All the particles listed on the table are classified as

A) mesons B) hadrons C) antimatter D) leptons

11. Which particle listed on the table has the opposite charge of, and is more massive than, a proton?

A) antiproton B) neutron C) lambda D) omega

12. Baryons may have charges of

A) +1e and $+\frac{4}{3}$e B) +2e and +3e
C) −1e and +1e D) −2e and $-\frac{2}{3}$e

13. What is the total number of quarks in a helium nucleus consisting of 2 protons and 2 neutrons?

A) 16 B) 12 C) 8 D) 4

14. What fundamental force holds quarks together to form particles such as protons and neutrons?

A) electromagnetic force
B) gravitational force
C) strong force
D) weak force

15. A top quark has an approximate charge of

A) -1.07×10^{-19} C B) -2.40×10^{-19} C
C) $+1.07 \times 10^{-19}$ C D) $+2.40 \times 10^{-19}$ C

16. According to the Standard Model of Particle Physics, a meson is composed of

A) a quark and a muon neutrino
B) a quark and an antiquark
C) three quarks
D) a lepton and an antilepton

17. What are the sign and charge, in coulombs, of an antiproton?

18. The tau neutrino, the muon neutrino, and the electron neutrino are all

A) leptons B) hadrons
C) baryons D) mesons

19. A meson may *not* have a charge of

A) +1e B) +2e C) 0e D) −1e

20. Protons and neutrons are examples of

A) positrons B) baryons
C) mesons D) quarks

21. Compared to the mass and charge of a proton, an antiproton has

A) the same mass and the same charge
B) greater mass and the same charge
C) the same mass and the opposite charge
D) greater mass and the opposite charge

22. A particle that is composed of two up quarks and one down quark is a

A) meson B) neutron
C) proton D) positron

23. A particle unaffected by an electric field could have a quark composition of

A) *css* B) *bbb* C) *udc* D) *uud*

24. A baryon may have a charge of

A) −1/3 e B) 0 e
C) + 2/3 e D) + 4/3 e

25. A particle is known to only contain down and strange quarks, what can be its charge?

A) +2 e B) +1 e C) 0 e D) −1 e

26. Which of the following is the boson (force carrier) of the electromagnetic force

A) photon
B) graviton
C) electron
D) quark

27. Which of the following pair interactions will result in annihilation

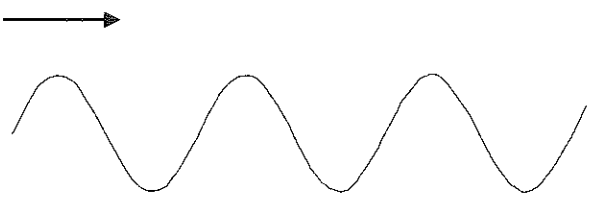
A) a charm quark and anti bottom quark
B) a charm quark and top quark
C) a charm quark and anti-charm quark
D) a top quark and a bottom quark

Topic 6B: Describing Waves

Skill 48: Applying Basic Wave Vocabulary

28. Pulse – a vibratory disturbance in a medium that carries _____ but NOT _____.

29. Periodic Wave - a set of regularly repeating pulses.



1. Add an equilibrium line
2. Label the crest and trough
3. Mark two location one wavelength apart with an "X"

30. Periodic waves do everything that pulses do but since they repeat they also have:

- Frequency – (f) measured in _____ Equation
- Period – (T) measured in _____ Equation
- Wavelength – (λ) measured in _____ Equation

31. Speed is the measure of a distance a "pulse" travels over time

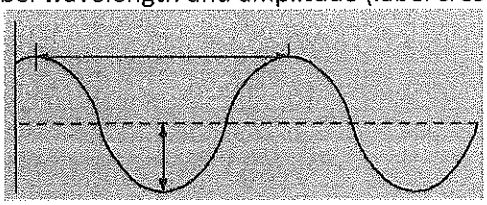
In waves distance is measured by _____ and time is measured by _____ or period

32. Write an equation for speed using λ and T

33. Summarize concepts we have learned so far in terms of variables, units and equations

	Variable	Unit of measurement	Important Equations/Notes
Wavelength			
Frequency			
Period			
Speed of wave			

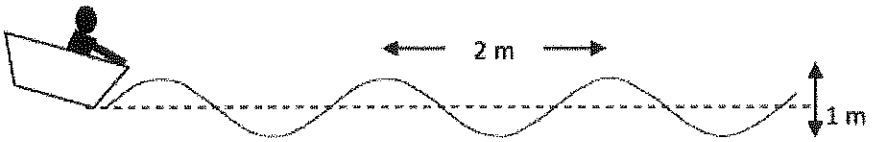
34. On the diagram below label wavelength and amplitude (label crest and trough)



35. A wave completes a cycle 3 times per second.
    a. What is the frequency of the wave?

    b. What is the period of the wave?

A person sitting in a rowboat produces a set of waves by rocking the boat back and forth. He pushes the side of the boat downward once every 2.5 seconds.



36. What is the amplitude of the wave? _____

37. What is the wavelength of the wave? _____

38. What is the period of the wave? _____

39. Calculate the frequency of the wave.

40. Calculate the speed of the wave.

Topic 6B: Wave Vocabulary
Skill 48

41. While sitting in a boat, a fisherman observes that two complete waves pass by his position every 4 seconds. What is the period of these waves?

A) 0.5 s B) 2 s C) 8 s D) 4 s

42. What is the period of a water wave if 4.0 complete waves pass a fixed point in 10. seconds?

A) 0.25 s B) 0.40 s
C) 2.5 s D) 4.0 s

43. The time required for a wave to complete one full cycle is called the wave's

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

44. The product of a wave's frequency and its period is

A) one
B) its velocity
C) its wavelength
D) Planck's constant

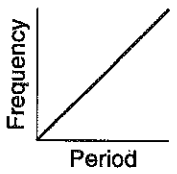
45. If the frequency of a periodic wave is doubled, the period of the wave will be

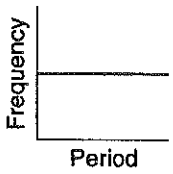
A) halved B) doubled
C) quartered D) quadrupled

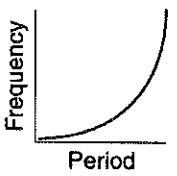
46. What is the frequency of a wave if its period is 0.25 second?

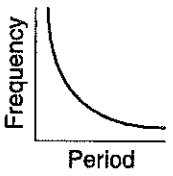
A) 1.0 Hz B) 0.25 Hz
C) 12 Hz D) 4.0 Hz

47. Which graph best represents the relationship between the frequency and period of a wave?

A)


B)


C)


D)


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

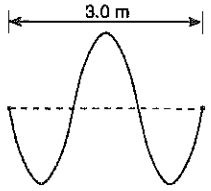
A) 0.25 Hz B) 15 Hz
C) 25 Hz D) 4.0 Hz

49. **Note that the question below has only three choices.**
If the amplitude of a wave is increased, the frequency of the wave will

A) decrease B) increase
C) remain the same

Topic 6B: Wave Vocabulary

50. The diagram below represents a periodic wave generated during a 1.5-second interval.



The frequency of the wave is

A) 1.0 Hz B) 2.0 Hz
C) 0.50 Hz D) 4.5 Hz

51. 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

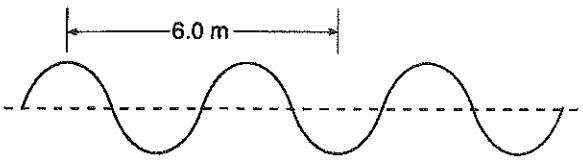
52. The number of water waves passing a given point each second is the wave's

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

53. A distance of 1.0×10^{-2} meter separates successive crests of a periodic wave produced in a shallow tank of water. If a crest passes a point in the tank every 4.0×10^{-1} second, what is the speed of this wave?

A) 2.5×10^{-4} m/s B) 4.0×10^{-3} m/s
C) 2.5×10^{-2} m/s D) 4.0×10^{-1} m/s

54. The diagram below represents a periodic wave traveling through a uniform medium.



If the frequency of the wave is 2.0 hertz, the speed of the wave is

A) 6.0 m/s B) 2.0 m/s
C) 8.0 m/s D) 4.0 m/s

55. A periodic wave having a frequency of 5.0 hertz and a speed of 10. meters per second has a wavelength of

A) 0.50 m B) 2.0 m
C) 5.0 m D) 50. m

56. **Note that the following question has only three choices.**
If the amplitude of a wave traveling in a rope is doubled, the speed of the wave in the rope will

A) decrease B) increase
C) remain the same

57. 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

58. 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

59. If the velocity of a constant-frequency wave increases, the wavelength

A) decreases
B) increases
C) remains the same

60. The rate at which a wave travels from one point to another determines the wave's

A) frequency B) period
C) amplitude D) velocity

61. A pulse traveled the length of a stretched spring. The pulse transferred

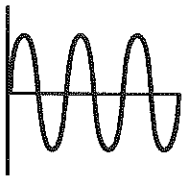
A) energy, only
B) mass, only
C) both energy and mass
D) neither energy nor mass

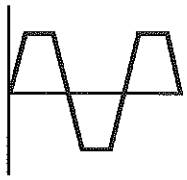
62. As a pulse travels along a rope, the pulse loses energy and its amplitude

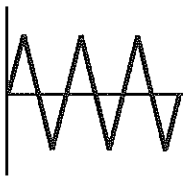
A) decreases
B) increases
C) remains the same

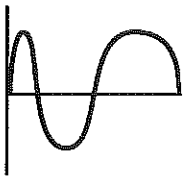
Topic 6B: Wave Vocabulary

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

A) 

B) 

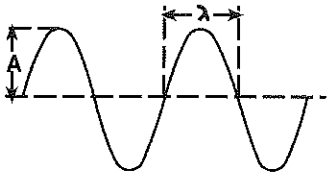
C) 

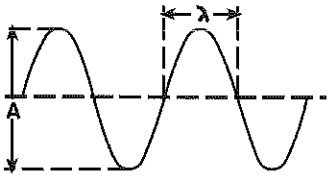
D) 

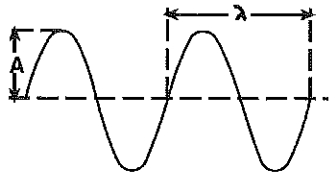
64. Which phrase best describes a periodic wave?

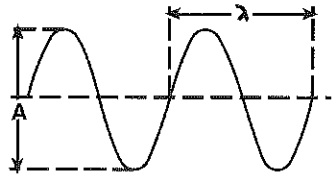
A) a single pulse traveling at constant speed
B) a series of pulses at irregular intervals
C) a series of pulses at regular intervals
D) a single pulse traveling at different speeds in the same medium

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

A) 

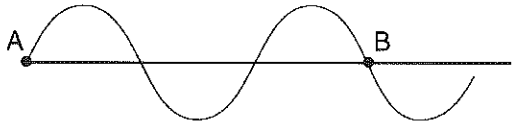
B) 

C) 

D) 

Topic 6B: Wave Vocabulary

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



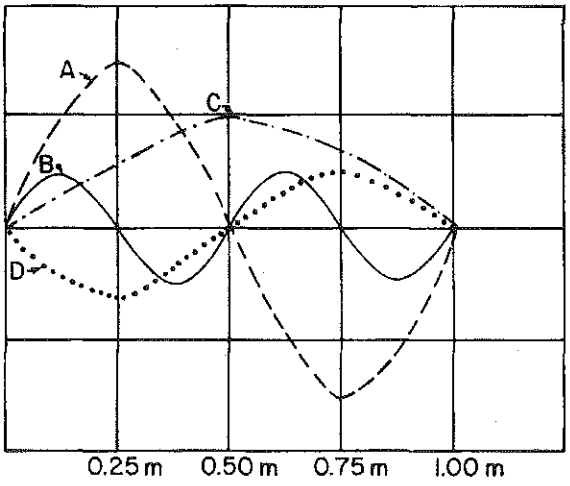
How many wavelengths separate point *A* and point *B*?

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

67. Which is a unit of wavelength?

A) cycles/second B) meters/second
C) seconds D) meters/cycle

Base your answers to questions **68** and **69** on the diagram below which represents four waves traveling to the right in the same transmitting medium.



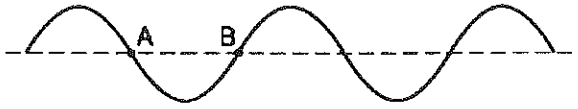
68. Which wave has the greatest frequency

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

69. What is the wavelength of wave *A*?

A) 1.00 m B) 0.75 m
C) 0.50 m D) 0.25 m

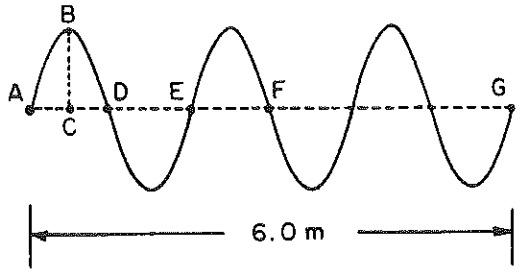
70. In the diagram below, the distance between points *A* and *B* on a wave is 0.10 meter.



This wave must have

A) an amplitude of 0.10 m
B) an amplitude of 0.20 m
C) a wavelength of 0.10 m
D) a wavelength of 0.20 m

Base your answers to questions **71** and **72** on the diagram below which represents a vibrating string with a periodic wave originating at *A* and moving to G a distance of 6.0 meters.



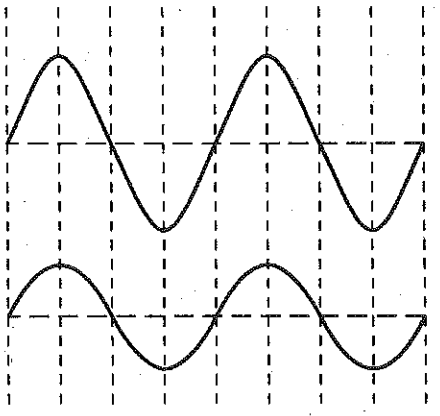
71. If the waves were produced at a faster rate, the distance between points *D* and *E* would

A) decrease B) increase
C) remain the same

72. What is the wavelength of this wave?

A) 1.0 m B) 2.0 m
C) 3.0 m D) 6.0 m

73. The diagram below shows two waves traveling in the same medium for the same length of time.



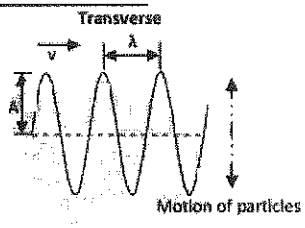
The two waves have different

A) amplitudes B) frequencies
C) speeds D) wavelengths

Skill 49: Describing Waves by Cycle

74. One complete oscillation is known as a wave cycle which can be considered _____ degrees.

75. **Transverse Motion** (Vibration) - the vibration and the propagation of energy are _____

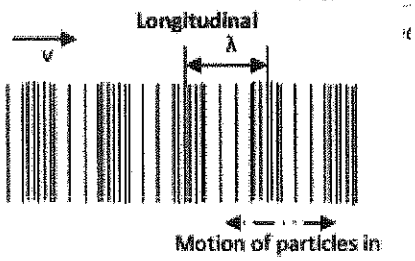


All EM waves are transverse

Some mechanical waves are transverse.

High point of a transverse wave is known as a _____
Low point of a transverse wave is known as a _____

76. **Longitudinal Motion** (Vibration)– The vibration and the propagation of energy are _____



Some mechanical waves are longitudinal

Ex: Sound, Earthquake p-waves etc

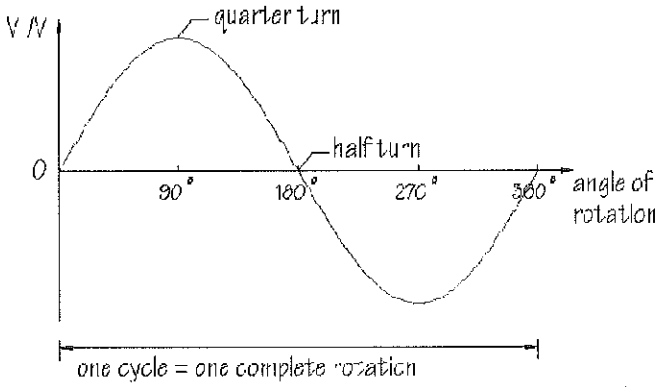
The area where the wave is "squeezed" together is known as a _____

The area where the wave is "stretched" apart is known as _____

77. For either type of wave – longitudinal or transverse

A cycle can be broken down into 4 parts each representing _____ degrees each

78. Cycles are easier to represent in transverse waves. On the image below indicate by placing an A and B on the wave indicating positions ½λ out of phase.

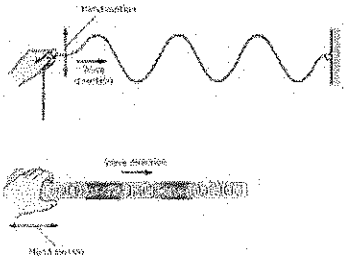


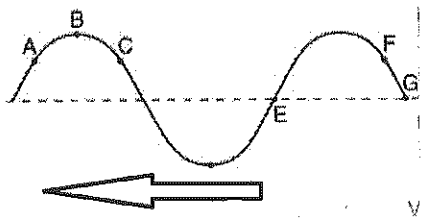
79. Waves are described by the type particle vibration. The two main types of particle motion are (define each)

a. Transverse

b. Longitudinal

80. Label the following as Longtidunal or Transverse and then label crest/trough or compression/rarefaction as appropriate.





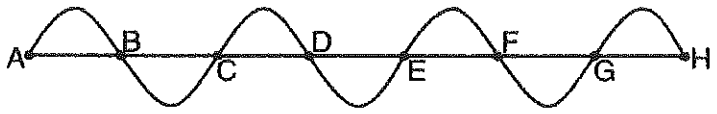
81. Which two points are "in phase"?

82. What is the phase difference between points A and C?

83. As the wave passes through point "C" its immediate motion will be _____

Topic 6B: Wave Cycle and Phase
Skill 49

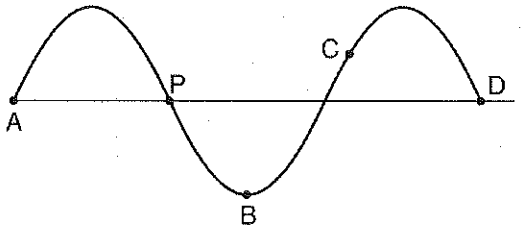
84. The diagram below represents a periodic wave.



Which two points on the wave are out of phase?

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

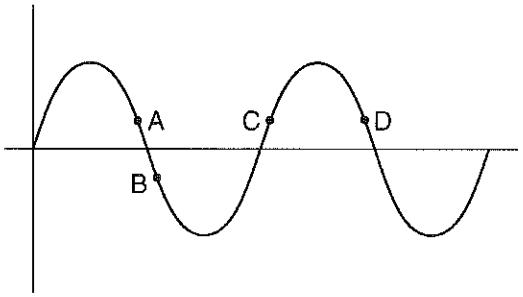
85. The diagram below represents a periodic wave.



Which point on the wave is 90° out of phase with point *P*?

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

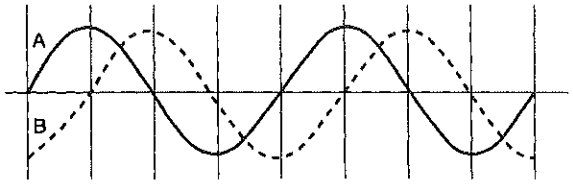
86. The diagram below shows a periodic wave.



Which points are in phase with each other?

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

87. 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°

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

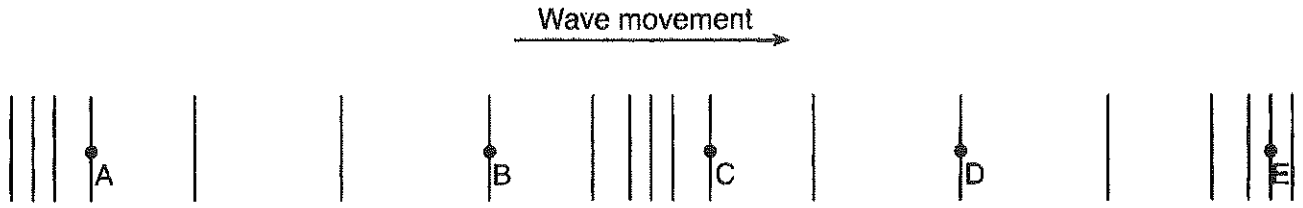
A) same direction of displacement and the same direction of motion
B) same direction of displacement and the opposite direction of motion
C) opposite direction of displacement and the same direction of motion
D) opposite direction of displacement and the opposite direction of motion

Topic 6B: Wave Cycle and Phase

89. Base your answer to the following question on the information and diagram below.

A longitudinal wave moves to the right through a uniform medium, as shown below.

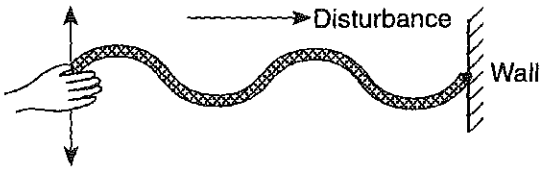
Point *A*, *B*, *C*, *D*, and *E* represent the positions of particles of the medium



The energy of this wave is related to its

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

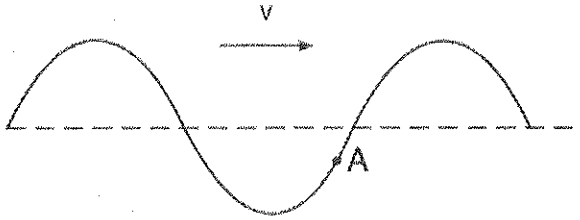
90. The diagram below shows a person shaking the end of a rope up and down, producing a disturbance that moves along the length of the rope.



Which type of wave is traveling in the rope?

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

91. The diagram below represents a transverse wave traveling to the right through a medium. Point A represents a particle of the medium.



In which direction will particle A move in the next instant of time?

A) up B) down
C) left D) right

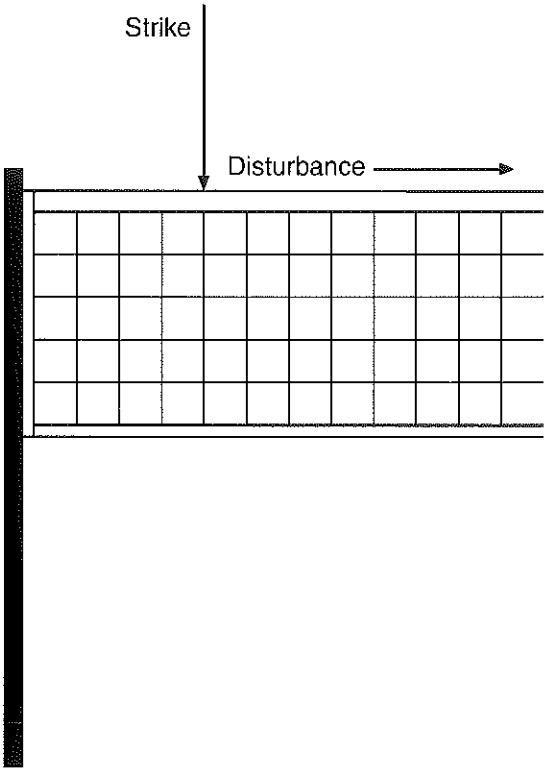
92. As a transverse wave travels through a medium, the individual particles of the medium move

A) perpendicular to the direction of wave travel
B) parallel to the direction of wave travel
C) in circles
D) in ellipses

93. An earthquake is traveling from the west to east through rock. If the particle are vibrating in a north-south direction, the wave must be classified as

A) transverse
B) longitudinal
C) a microwave
D) a radio wave

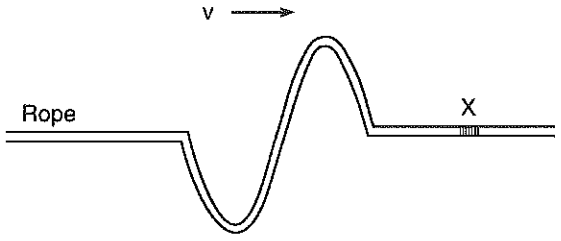
94. A student strikes the top rope of a volleyball net, sending a single vibratory disturbance along the length of the net, as shown in the diagram below.



This disturbance is best described as

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

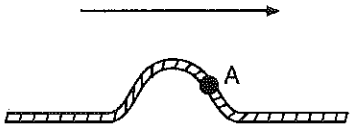
95. As shown in the diagram below, a transverse wave is moving with velocity v along a rope.



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

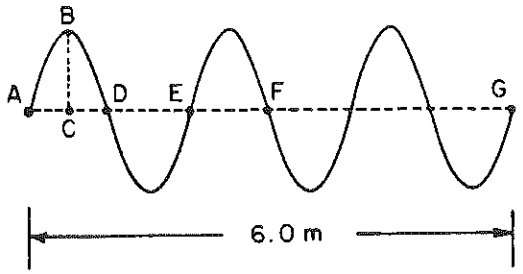
96. The diagram below shows a pulse moving to the right in a rope A is a point on the rope.



Which arrow best shows the direction of movement of point A at this instant?

A) 
B) 
C) 
D) 

97. Base your answer to the following question on the diagram below which represents a vibrating string with a periodic wave originating at A and moving to G a distance of 6.0 meters.



What type of wave is represented by the diagram?

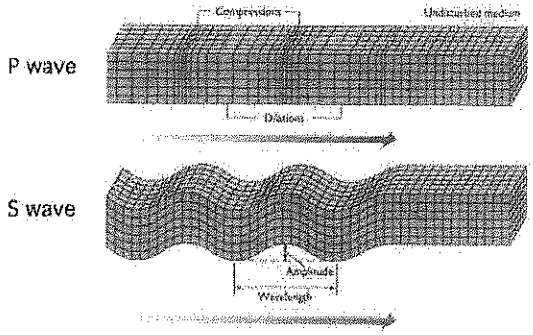
A) elliptical
B) longitudinal
C) torsional
D) transverse

98. When a transverse wave is moving through a medium, what is the action of the particles of the medium?

A) They travel through the medium with the wave.
B) They vibrate in a direction parallel to the direction in which the wave is moving.
C) They vibrate in a direction perpendicular to the direction in which the wave is moving.
D) They remain at rest.

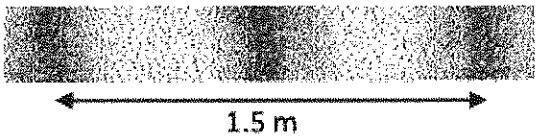
Skill 50: Mechanical Waves

99. Mechanical waves can either be transverse or longitudinal. Label the earthquake "S wave" and "P wave" as transverse or longitudinal accordingly



100. A mechanical wave is defined as a wave that _____

Use the information and diagram below to answer questions 101 and 102



A sound wave with a frequency of 440 hertz is traveling through a tube.

101. What is the wavelength of the sound wave? _____ (Hint: How many wavelengths are represented?)

102. Calculate the speed of this wave.

103. What is the frequency of a sound wave with a wavelength of 0.04 meter in air at STP? Is this a mechanical or electromagnetic wave? Is this a longitudinal or transverse wave?

104. A bat is using sound waves to locate an insect (assume air is at STP). The bat produces sounds with a frequency of 120 kilo-hertz and notes that the sound it transmits echo's back in 0.02 second.

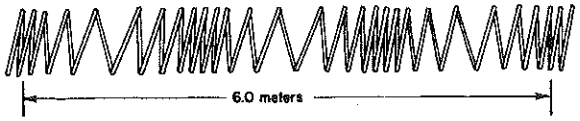
a. What is the total distance the sound travels in 0.02 seconds? What is the bat's distance to its prey?

b. What is the wavelength of the bat's radar?

105. As a longitudinal wave travels horizontally, the particles of the medium vibrate

A) in a circle B) in a spiral
C) vertically D) horizontally

106. Base your answer to the following question on the diagram below which represents waves generated in a spring.



What is the wavelength of the waves produced in the spring?

A) 1.5 m B) 2.0 m
C) 3.0 m D) 6.0 m

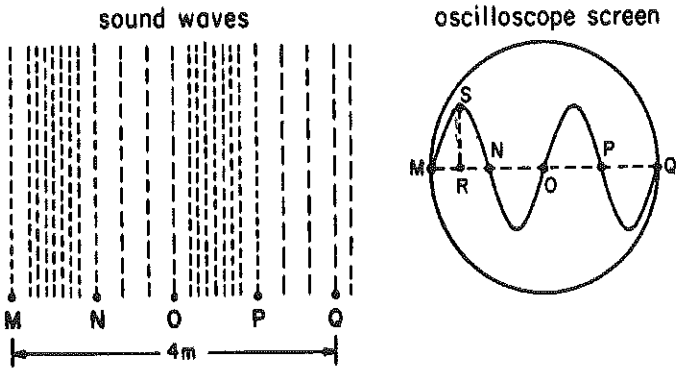
107. Which is an example of a longitudinal wave?

A) gamma ray B) X-ray
C) sound wave D) water wave

108. As a longitudinal wave passes through a medium, the particles of the medium move

A) in circles
B) in ellipses
C) parallel to the direction of wave travel
D) perpendicular to the direction of wave travel

109. Base your answer to the following question on the accompanying diagram which represents a sound wave and its corresponding pattern on an oscilloscope screen.



What is the wavelength of the sound wave?

A) 1 m B) 2 m C) 8 m D) 4 m

110. The energy of a sound wave is most closely related to the wave's

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

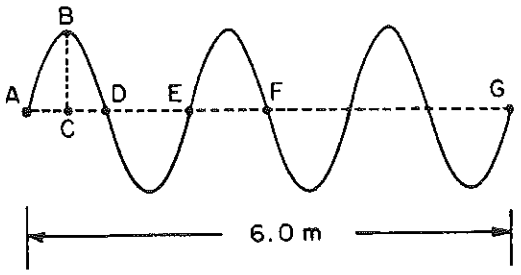
111. The energy of a water wave is most closely related to its

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

112. In which type of wave is the disturbance of the medium perpendicular to the direction of travel of the wave?

A) longitudinal B) transverse
C) latitudinal D) tangential

113. Base your answer to the following question on the diagram below which represents a vibrating string with a periodic wave originating at *A* and moving to G a distance of 6.0 meters.



What type of wave is represented by the diagram?

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

114. A transverse wave moves to the right (→) through a medium. Which diagram best represents the motion of the molecules of the medium due to the wave motion?

A) 

B) 

C) 

D) 

115. As the energy imparted to a mechanical wave increases, the maximum displacement of the particles in the medium

A) decreases
B) increases
C) remains the same

116. If the frequency of a sound wave in air at STP remains constant, its energy can be varied by changing its

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

117. A tuning fork vibrates at a frequency of 512 hertz when struck with a rubber hammer. The sound produced by the tuning fork will travel through the air as a

A) longitudinal wave with air molecules vibrating parallel to the direction of travel
B) transverse wave with air molecules vibrating parallel to the direction of travel
C) longitudinal wave with air molecules vibrating perpendicular to the direction of travel
D) transverse wave with air molecules vibrating perpendicular to the direction of travel

118. Which statement correctly describes one characteristic of a sound wave?

A) A sound wave can travel through a vacuum.
B) A sound wave is a transverse wave.
C) The amount of energy a sound wave transmits is directly related to the wave's amplitude.
D) The amount of energy a sound wave transmits is inversely related to the wave's frequency.

119. A periodic wave is produced by a vibrating tuning fork. The amplitude of the wave would be greater if the tuning fork were

A) struck more softly
B) struck harder
C) replaced by a lower frequency tuning fork
D) replaced by a higher frequency tuning fork

120. Which type of wave requires a material medium through which to travel?

A) sound B) radio
C) television D) x ray

121. Which type of wave requires a material medium through which to travel?

A) radio wave
B) microwave
C) light wave
D) mechanical wave

122. Increasing the amplitude of a sound wave produces a sound with

A) lower speed
B) higher pitch
C) shorter wavelength
D) greater loudness

123. A ringing bell is located in a chamber. When the air is removed from the chamber, why can the bell be seen vibrating but *not* be heard?

A) Light waves can travel through a vacuum, but sound waves cannot.
B) Sound waves have greater amplitude than light waves.
C) Light waves travel slower than sound waves.
D) Sound waves have higher frequency than light waves.

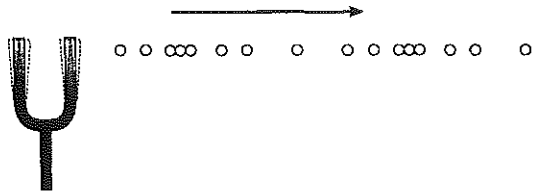
124. As a sound wave passes from water, where the speed is 1.49×10^3 meters per second, into air, the wave's speed

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

125. 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?

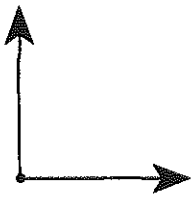
A) electromagnetic waves that require no medium for transmission
B) electromagnetic waves that require a medium for transmission
C) mechanical waves that require no medium for transmission
D) mechanical waves that require a medium for transmission

126. 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) 

127. The frequency of a sound wave determines its

A) amplitude B) loudness
C) speed D) pitch

128. Increasing the amplitude of a sound wave will make it

A) louder
B) have a higher pitch
C) travel faster
D) produce beats

129. A point in a sound wave at which the particles of the transmitting medium are farther apart than when at the rest position is called a

A) compression B) crest
C) trough D) rarefaction

130. Sound is a form of

A) thermal energy
B) mechanical energy
C) radiant energy
D) electrical energy

131. Compared to the speed of a sound wave in air, the speed of a radio wave in air is

A) less B) greater
C) the same

132. As a sound wave passes from air into steel, its velocity

A) decreases
B) increases
C) remains the same

133. In which medium does sound have the greatest speed?

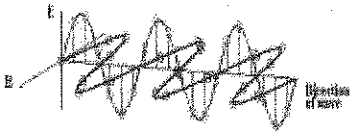
A) vacuum
B) air
C) water
D) steel

134. As the temperature of air increases, the speed of sound in air

A) decreases
B) increases
C) remains the same

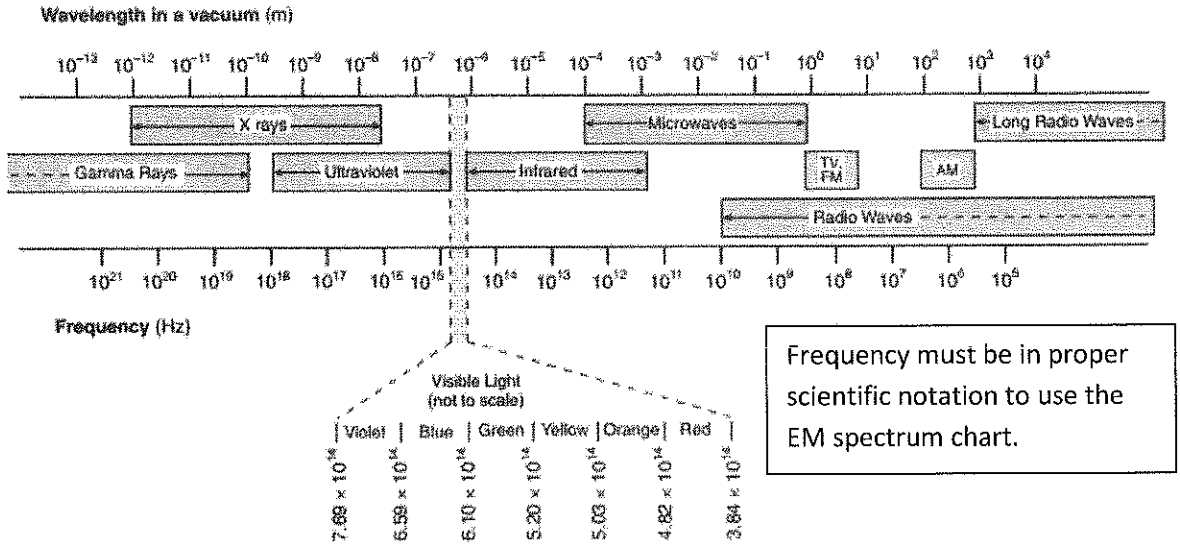
Skill 51: EM Waves

135. Electromagnetic (EM Wave)– produced by the _____ (oscillation) of a charged particle. EM waves are able to travel through a _____. (A PLACE WITHOUT MATTER.)



A _____charge has an electric field and also creates a perpendicular magnetic field. This in turn creates an electric field

136. EM SPECTRUM CHART FROM REFERENCE TABLE: VALUES GIVEN FOR A VACUUM, THEREFORE THE SPEED OF EVERY WAVE ON THIS CHART IS _____ known as "c". If you know wavelength and speed you can find frequency.



Frequency must be in proper scientific notation to use the EM spectrum chart.

137. When an EM wave enters a medium the speed of the wave will depend on the index of refraction "n" of the medium. The speed in the new medium can be calculated using the equation $n = c/v$ which means $v = c/n$

Index of refraction and speed of EM wave in a medium have a(n) _____ relationship.

138. The _____ of an EM does not change if it enters a new medium.

139. EM Waves are photons. They behave as both _____ and _____.

140. A wave traveling through a vacuum has a wavelength of 100 nm. What type of wave is this?

141. A wave traveling through a vacuum has a wavelength of 4.70×10^{-8}m. What type of wave is this?

142. A wave has a wavelength of 50×10^{-6}m. What type of wave is this?

143. An electromagnetic wave with a wavelength of 5×10^{-9} m is traveling through outer space.

a. What is the speed of this wave? _____

b. Determine the frequency of this wave

c. In what part of the electromagnetic spectrum is this wave found? _____

144. An electromagnetic wave with a frequency of 6.2×10^{14} Hz is passing through unknown substance that has an index of refraction of 2.4

a. In what part of the electromagnetic spectrum is this wave found? _____

b. Determine the speed of the wave in this medium.

c. Calculate the wavelength of this wave in this medium.

145. Bees have specially adapted eyes that can detect electromagnetic radiation outside of what humans refer to as 'visible light'. Some flowers that bees visit have colorations that are invisible to humans, and yet match this amazing evolutionary development in bees! Bees also use these specially adapted eyes to aid them in navigation when it is cloudy. This type of radiation has a somewhat higher frequency than that of visible light.

What part of the electromagnetic spectrum are these bee eyes able to see?

_____

146. An electromagnetic wave traveling through a vacuum has a wavelength of 1.5×10^{-1} meter. What is the period of this electromagnetic wave?

(1) 5.0×10^{-10} s (2) 1.5×10^{-1} s (3) 4.5×10^{7} s (4) 2.0×10^{9} s

147. The speed of a ray of light traveling through a substance having an absolute index of refraction of 1.1 is

(1) 1.1×10^{8} m/s (2) 2.7×10^{8} m/s (3) 3.0×10^{8} m/s (4) 3.3×10^{8} m/s

148. A microwave and an x-ray are traveling in a vacuum. Compared to the wavelength of the microwave, the x-ray has a wavelength that is

(1) longer and a period that is shorter (2) longer and a period that is longer

(3) shorter and a period that is longer (4) shorter and a period that is shorter

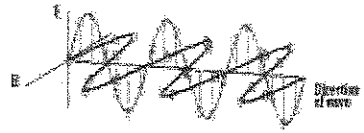
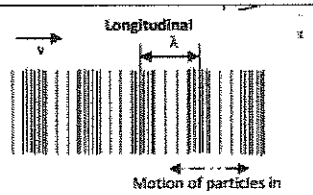
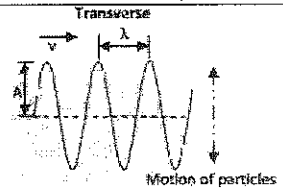
149. Which wavelength is in the infrared range of the electromagnetic spectrum?

(1) 100 nm (2) 100 mm (3) 100 m (4) 100 μm

150. To determine the type or category of a wave on the EM spectrum you can use either the wavelength or frequency if traveling in a _____ unless it is _____. If the wave is traveling through a substance you must solve for _____, because it does not change when an EM wave enters a new medium.

Radio waves are categorized as _____ because they can travel through the vacuum of space. The type of particle vibration for radio waves is _____ which means the particles move _____ to the motion of the wave. Visible light (such as Red, Orange..) is similar to a radio wave in type of wave and type of particle vibration but it has a _____ energy, a smaller _____and a _____ frequency. In a vacuum the _____ of a radio wave and a visible light are the same (which is _____m/s).

Sound waves are categorized as _____ because they cannot travel through a vacuum. The type of particle vibration for sound waves is _____. Mechanical waves other than sound can also have _____ particle vibration. The speed of a sound wave in air at STP is _____. The speed of sound in air is _____than water because the particles are less dense.

151. Fill in Blanks on Chart	**Sound Waves**	**Electromagnetic Waves**
What do they do?	Transfer _____	Transfer _____
Where do they come from?	Vibration within a medium. (Sound is a pressure wave)	Vibration (acceleration) of a charged particle. The motion of the charged particle causes the electric field to oscillate. The oscillation of the electric field causes the oscillation of the magnetic field.  EM waves are photons that behave as _____.
Types of Vibration		
Speed	Speed of sound at STP:	Speed of light (EM waves) in a vacuum Equals _____ equation in a medium
How speed changes with medium	Can only move (propagate) through a medium. Speed up with density. CANNOT propagate through a vacuum	Move at 3×10^8 m/s in a vacuum (or air n=1) Speed in a medium is inversely related to index of refraction. v=c/n
Energy of a propagating wave is related to...	Amplitude	Frequency
To compare the energy of two different types of wave consider	Amplitude	Frequency
Amplitude is related to...	Loudness	Brightness
Increasing frequency is related to....	Increasing pitch	Increasing energy (See EM spectrum)
Wavelength is the distance	Between two	Between two .....

Topic 6B: Electromagnetic Waves
Skill 51

152. Which color of light has a wavelength of 5.0×10^{-7} meter in air?

A) blue B) green
C) orange D) violet

153. An electromagnetic AM-band radio wave could have a wavelength of

A) 0.005 m B) 5 m
C) 500 m D) 5 000 000 m

154. A microwave and an x ray are traveling in a vacuum. Compared to the wavelength and period of the microwave, the x ray has a wavelength that is

A) longer and a period that is shorter
B) longer and a period that is longer
C) shorter and a period that is longer
D) shorter and a period that is shorter

155. Which wavelength is in the infrared range of the electromagnetic spectrum?

A) 100 nm B) 100 mm
C) 100 m D) 100 μm

156. Electromagnetic radiation having a wavelength of 1.3×10^{-7} meter would be classified as

A) infrared B) orange
C) blue D) ultraviolet

157. Radio waves are propagated through the interaction of

A) nuclear and electric fields
B) electric and magnetic fields
C) gravitational and magnetic fields
D) gravitational and electric fields

158. Compared to the period of a wave of red light the period of a wave of green light is

A) less B) greater
C) the same

159. Which pair of terms best describes light waves traveling from the Sun to Earth?

A) electromagnetic and transverse
B) electromagnetic and longitudinal
C) mechanical and transverse
D) mechanical and longitudinal

160. Electrons oscillating with a frequency of 2.0×10^{10} hertz produce electromagnetic waves. These waves would be classified as

A) infrared B) visible
C) microwave D) x-ray

161. A photon of which electromagnetic radiation has the most energy?

A) ultraviolet B) x-ray
C) infrared D) microwave

162. Compared to the wavelength of red light, the wavelength of yellow light is

A) shorter B) longer
C) the same

163. A beam of green light may have a frequency of

A) 5.0×10^{-7} Hz B) 1.5×10^{2} Hz
C) 3.0×10^{8} Hz D) 6.0×10^{14} Hz

164. A monochromatic beam of light has a frequency of 6.5×10^{14} hertz. What color is the light?

A) yellow B) orange
C) violet D) blue

165. Which electromagnetic radiation has the *shortest* wavelength?

A) infrared B) radio
C) gamma D) ultraviolet

166. Which of the following electromagnetic waves has the lowest frequency?

A) violet light B) green light
C) yellow light D) red light

167. Which of the following electromagnetic radiations has the shortest wavelength?

A) radio B) infrared
C) visible D) ultraviolet

168. Which is not in the electromagnetic spectrum?

A) light waves B) radio waves
C) sound waves D) x-rays

169. Which color of light has the greatest period?

A) violet B) green
C) orange D) red

170. To which part of the electromagnetic spectrum will a photon belong if its wavelength in a vacuum is 5.6×10^{-7} meters?

A) X-ray B) ultraviolet
C) visible light D) infrared

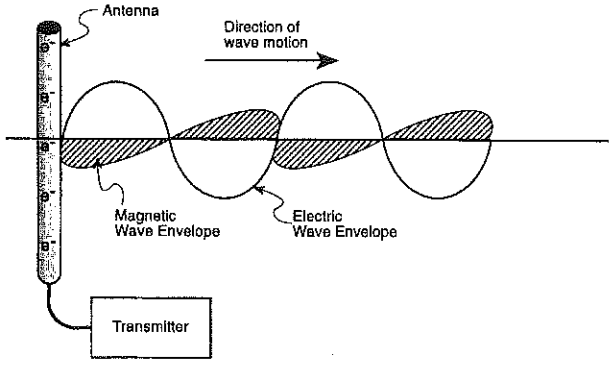
171. The color of visible light is determined by its

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

172. Which statement best describes a proton that is being accelerated?

A) It produces electromagnetic radiation.
B) The magnitude of its charge increases.
C) It absorbs a neutron to become an electron.
D) It is attracted to other protons.

173. The diagram below shows an antenna emitting an electromagnetic wave.



In what way did the electrons in the antenna produce the electromagnetic wave?

A) by remaining stationary
B) by moving at constant speed upward, only
C) by moving at constant speed downward, only
D) by accelerating alternately upward and downward

174. Electromagnetic waves can be generated by accelerating

A) a hydrogen atom B) photon
C) a neutron D) an electron

175. An accelerating particle that does not generate electromagnetic waves could be

A) a neutron B) a proton
C) an electron D) an alpha particle

176. When electrical charges are accelerated in a vacuum, they may generate

A) sound waves B) water waves
C) light waves D) torsional waves

177. Radiations such as radio, light, and gamma are propagated by the interchange of energy between

A) magnetic fields, only
B) electric fields, only
C) electric and gravitational fields
D) electric and magnetic fields

178. Orange light has a frequency of 5.0×10^{14} hertz in a vacuum. What is the wavelength of this light?

A) 1.5×10^{23}m B) 1.7×10^{6}m
C) 6.0×10^{-7} m D) 2.0×10^{-15} m

179. What is the wavelength. of X-rays with a frequency 1.5×10^{18} hertz traveling in a vacuum?

A) 4.5×10^{26} m B) 2.0×10^{-10} m
C) 5.0×10^{-10} m D) 5.0×10^{9} m

180. The time required for light to travel a distance of 1.5×10^{11} meters is closest to

A) 5.0×10^{2} s B) 2.0×10^{-3} s
C) 5.0×10^{-1} s D) 4.5×10^{19} s

181. The distance from the Moon to Earth is 3.9×10^{8} meters. What is the time required for a light ray to travel from the Moon to Earth?

A) 0.65 s B) 1.3 s
C) 2.6 s D) 3.9 s

182. A typical microwave oven produces radiation at a frequency of 1.0×10^{10} hertz. What is the wavelength of this microwave radiation?

A) 3.0×10^{-1} m B) 3.0×10^{-2} m
C) 3.0×10^{10} m D) 3.0×10^{18} m

183. How long will it take a light wave to travel a distance of 100. meters?

A) 3.00×10^{10} s B) 3.00×10^{8} s
C) 3.33×10^{-7} s D) 3.33×10^{7} s

184. When x-ray radiation and infrared radiation are traveling in a vacuum, they have the same

A) speed B) frequency
C) wavelength D) energy per photon

185. Which characteristic is the same for every color of light in a vacuum?

A) energy B) frequency
C) speed D) period

186. How much time does it take light from a flash camera to reach a subject 6.0 meters across a room?

A) 5.0×10^{-9} s B) 2.0×10^{-8} s
C) 5.0×10^{-8} s D) 2.0×10^{-7} s

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

A 2.00×10^{6}-hertz radio signal is sent a distance of 7.30×10^{10} meters from Earth to a spaceship orbiting Mars.

Approximately how much time does it take the radio signal to travel from Earth to the spaceship?

A) 4.11×10^{-3} s B) 2.43×10^{2} s
C) 2.19×10^{8} s D) 1.46×10^{17} s

188. As the wavelength of a visible light beam is increased from violet to red, the speed of the light in a vacuum

A) decreases B) increases
C) remains the same

189. As the frequency of an electromagnetic wave increases, its speed in a vacuum

A) decreases B) increases
C) remains the same

190. All frequencies of light have the same speed when traveling through

A) a vacuum B) glass
C) water D) alcohol

191. 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

192. 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.

193. What is the speed of light ($f = 5.09 \times 10^{14}$ Hz) in ethyl alcohol?

A) 4.53×10^{-9} m/s B) 2.43×10^{2} m/s
C) 1.24×10^{8} m/s D) 2.21×10^{8} m/s

194. The wavelength of a wave doubles as it travels from medium *A* into medium *B*. Compared to the wave in medium *A*, the wave in medium *B* has

A) half the speed
B) twice the speed
C) half the frequency
D) twice the frequency

195. As a wave travels into a different medium with a change in direction, there will be a change in the wave's

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

196. What is the speed of light ($f = 5.09 \times 10^{14}$ Hz) in flint glass?

A) 1.81×10^8 m/s B) 1.97×10^8 m/s
C) 3.00×10^8 m/s D) 4.98×10^8 m/s

197. What is the speed of a ray of light ($f = 5.09 \times 10^{14}$ hertz) traveling through a block of sodium chloride?

A) 1.54×10^8 m/s B) 1.95×10^8 m/s
C) 3.00×10^8 m/s D) 4.62×10^8 m/s

198. 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

199. If the speed of light in a medium is 2.0×10^8 meters per second, the index of refraction for the medium is

A) 1.0 B) 2.0 C) 1.5 D) 0.67

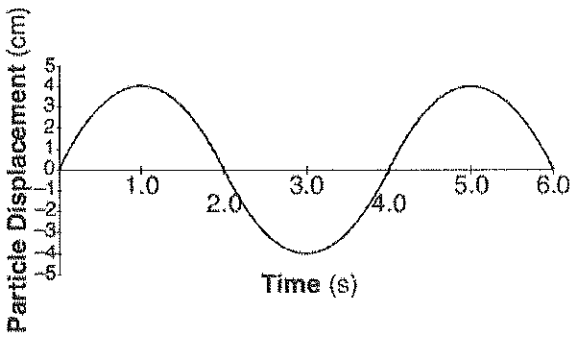
200. In which of the following materials is the speed of light the greatest?

A) quartz B) alcohol
C) glycerol D) lucite

Name _____ Topic 6AB Quiz

201. A pulse travels the length of a stretched spring. The pulse transfers
   a. Energy, only
   b. Mass, only
   c. Both energy and mass
   d. Neither energy nor mass

202. The graph below represents the displacement of a particle in a medium over a period of time.

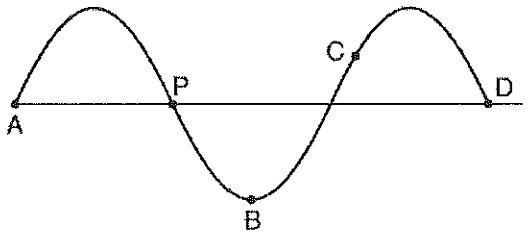


The amplitude of the wave is

   a. 0.04m
   b. 4m
   c. 8 cm
   d. 4 s

203. What is the period of a water wave if 4 complete waves pass a fixed point in 10 seconds?
   a. 0.25s
   b. 0.40s
   c. 2.5 s
   d. 4.0 s

204. The diagram below represents a periodic wave.



Which point on the wave is 90^0 out of phase with point P?

   a. A
   b. B
   c. C
   d. D

205. What is the wavelength of a 256-hertz sound wave in air at STP?

a. 1.17×10^{6}m
b. 1.29m
c. 0.773m
d. 8.53×10^{-7}m

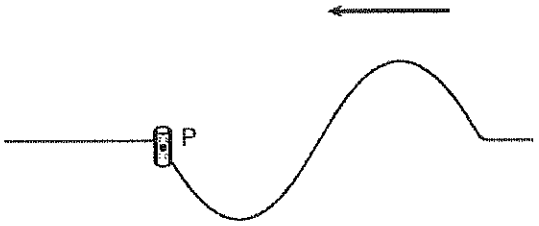
206. Which statement correctly describes one characteristic of a sound wave?

a. A sound wave can travel through a vacuum
b. A sound wave is a transverse wave
c. The amount of energy in a sound wave is directly related to the wave's amplitude.
d. The amount of energy a sound wave transmits is inversely related to the wave's frequency.

207. Which particles are not affected by the strong force?

a. Hadrons
b. Protons
c. Neutrons
d. Electrons

208. The diagram below represents a transverse water wave propagating toward the left. A cork is floating on the water's surface at point P.



In which direction will the cork move as the wave passes point P?

a. Up, then down, then up
b. Down , then up, then down
c. Left, then right, then left
d. Right, the left, then right

209. A deuterium nucleus consists of one proton and one neutron. The quark composition of a deuterium nucleus is

a. 2 up quarks and 2 down quarks
b. 2 up quarks and 4 down quarks
c. 3 up quarks and 3 down quarks
d. 4 up quarks and 2 down quarks

210. Which color of light has a wavelength of 5.0×10^{-7}m in air?

a. Blue b. Green c. Orange d. violet

211. What is the speed of light with a frequency of 5.09×10^{14}Hz when traveling through water?
   a. 5.6×10^{14}m/s
   b. 3.0×10^{8}m/s
   c. 2.25×10^{8}m/s
   d. 4.4×10^{8} m/s

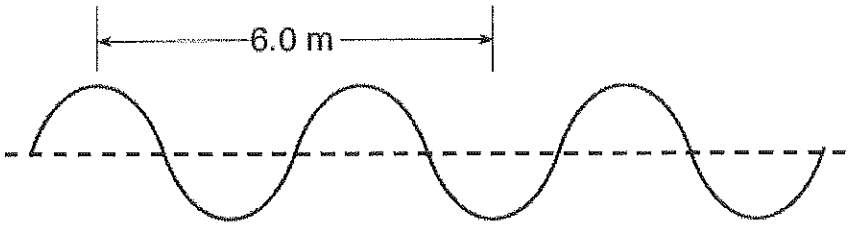
212. Determine the frequency of a radio wave with a wavelength of 1875m moving in air at STP
   a. 1.6×10^{5} Hz
   b. 1.77×10^{-1}Hz
   c. 1.5×10^{11}Hz
   d. 6.1×10^{5}Hz

213. Which of the following waves has the highest frequency?
   a. Infrared b. Green Light c. blue light d. yellow light

214. Compared to the speed of a microwave in air, the speed of a radio wave in air is
   a. Greater b. less c. the same

215. Compared to the speed of a radio wave in air, the speed of a sound wave in air at STP is
   a. Greater b. less c. the same

216.



a) For the wave pictured above, determine the wavelength of a single cycle [1]

b) If the entire wave train above took 12 seconds to pass, what is the frequency of the wave? (show work including equation, substitution and units) [2]

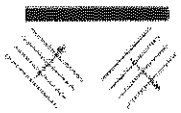
c) Determine the speed of the wave (show all work including equation, substitution and units)? [2]

Topic 6C: Wave Phenomena

Skill 52: When Waves Encounter Boundaries, Barriers and New Mediums they can ..... (217. Fill in the blanks)

_____

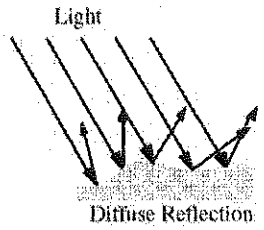
When a wave hits a surface at least some of the energy is always reflected back. **The angle of reflection is always _____to the incoming angle.**



Regular Reflection

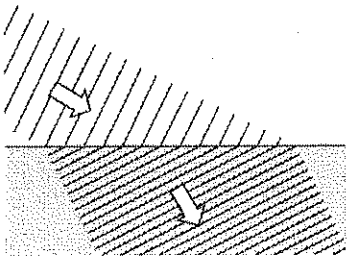
$\theta_i = \theta_r$

-Regular reflection occurs when you see the image in its clear form (glassy surface)
-Diffuse reflection occurs on rough surfaces when you can see an image but without clarity.

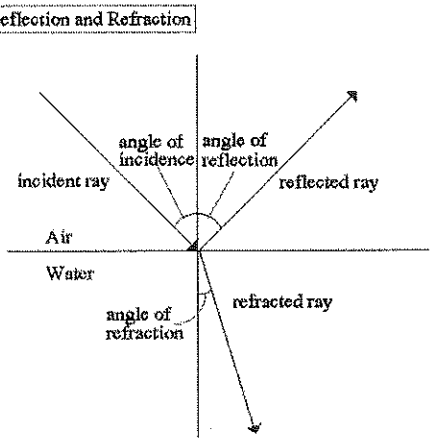


_____

When a wave encounter a new medium they often change direction (bend) due to a change in speed and/or wavelength. (Frequency does not change)



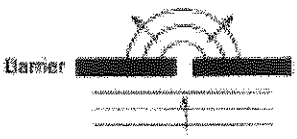
If the wave enters straight on you just get a change in _____.



For transparent surface light is usually partially transmitted/refracted and partially reflected

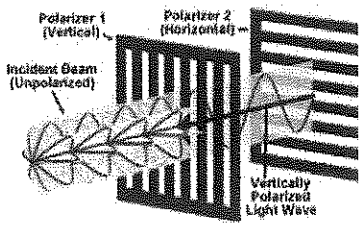
_____

Bending of wave fronts and wave rays **around barriers** and through openings



_____

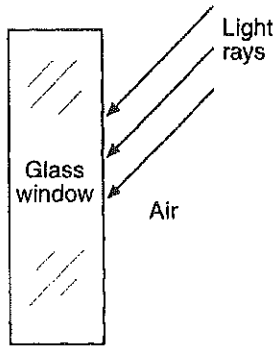
When waves of one orientation are selected.



ONLY HAPPENS TO TRANSVERSE WAVES

Topic 5C: Wave Boundaries
Skill 52

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



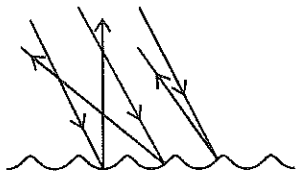
When the rays reach the boundary between the air and the glass, the light is

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

219. 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

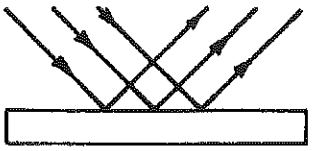
220. The diagram below shows parallel rays of light incident on an irregular surface.



Which phenomenon of light is illustrated by the diagram?

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

221. Which phenomenon of light is illustrated by the diagram below?

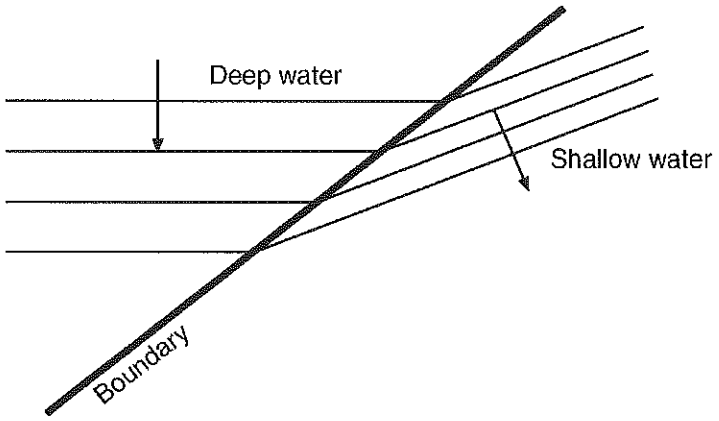


A) regular reflection B) diffuse reflection
C) diffraction D) refraction

222. 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

223. The diagram below represents straight wave fronts passing from deep water into shallow water, with a change in speed and direction.

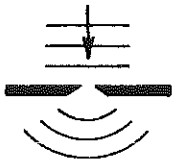


Which phenomenon is illustrated in the diagram?

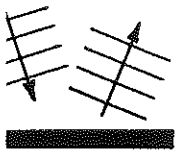
A) reflection B) refraction C) diffraction D) interference

224. Which diagram best illustrates wave refraction?

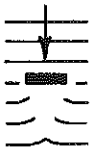
A)



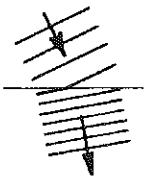
B)



C)



D)



225. The change in the direction of a wave when it passes obliquely from one medium to another is called

A) diffraction B) interference
C) refraction D) superposition

226. 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

227. 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

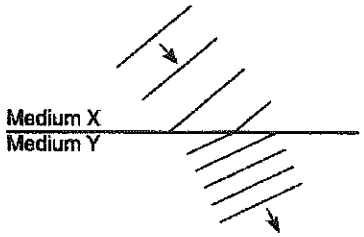
228. Compared to the wavelength of a wave of green light in air, the wavelength of this same wave of green light in Lucite is

A) less B) greater
C) the same

229. 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.

230. The diagram below represents wave fronts traveling from medium *X* into medium *Y*.



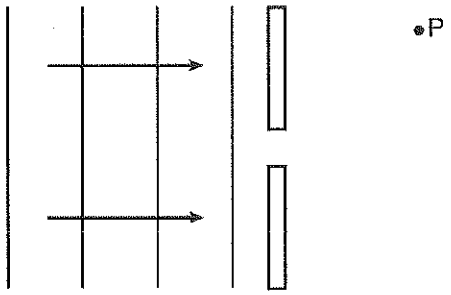
All points on any one wave front shown must be

A) traveling with the same speed
B) traveling in the same medium
C) in phase
D) superposed

231. 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.

232. The diagram below shows a series of wave fronts approaching an opening in a barrier. Point *P* is located on the opposite side of the barrier.



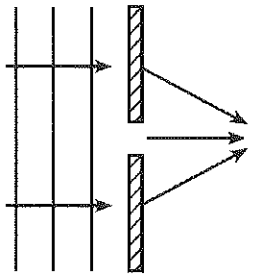
The wave fronts reach point *P* as a result of

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

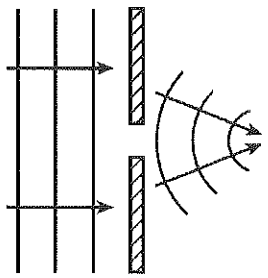
Topic 5C: Wave Boundaries

233. Which diagram best represents the shape and direction of a series of wave fronts after they have passed through a small opening in a barrier?

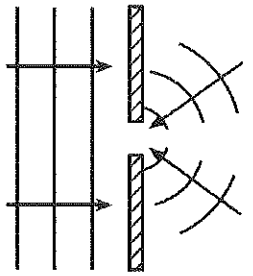
A)



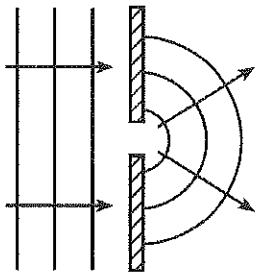
B)



C)



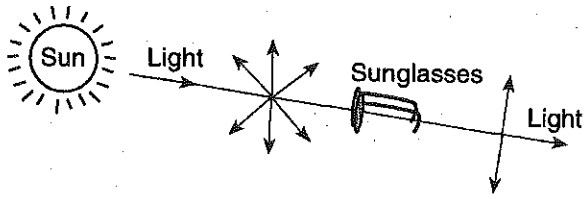
D)



234. Which phenomenon can *not* be exhibited by longitudinal waves?

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

235. The diagram below shows sunglasses being used to eliminate glare.



Which phenomenon of light is represented in the diagram?

A) dispersion B) diffraction
C) internal reflection D) polarization

236. Which phenomenon can not be exhibited by longitudinal waves?

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

237. Which two characteristics of light can best be explained by the wave theory of light?

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

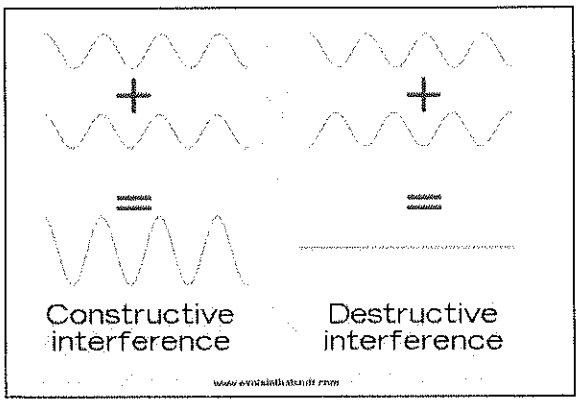
Skill 53: Interference - When waves meet

238. Fill in the blanks

Interference: When two waves superimpose (same place same time)

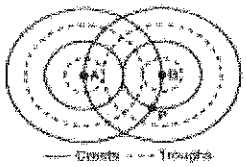
When two waves that are in phase (0 or 360 degrees) meet it results in a crest plus crest → Maximum _____**interference.**

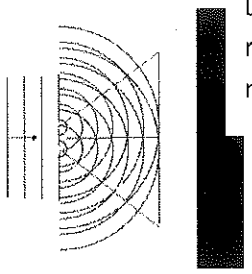
When two waves that are out of phase (180 degrees) meet it results in a crest plus a trough → Maximum _____ **interference.**



Interference

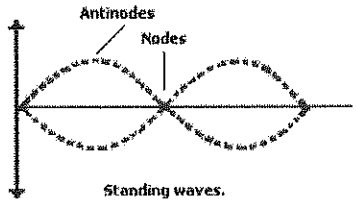
May be constructive or destructive





Diffraction with interference results in a pattern of maximum and minimums.

Standing waves result from the combination of _____ and _____ when two waves are moving in opposite directions with the same frequency and amplitude.

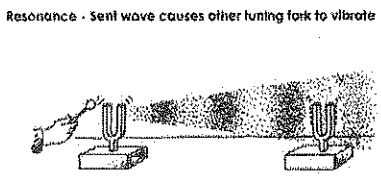


Node – (NO DispEment) _____ interference (always 180° out of phase)

Anti-node – _____ interference

maximum motion (in phase)

Resonance – Standing waves produced at or near a medium's natural frequency.



When an object oscillates in response to a wave

239. **Define or describe each of the following things that occur with the meeting of wave.**

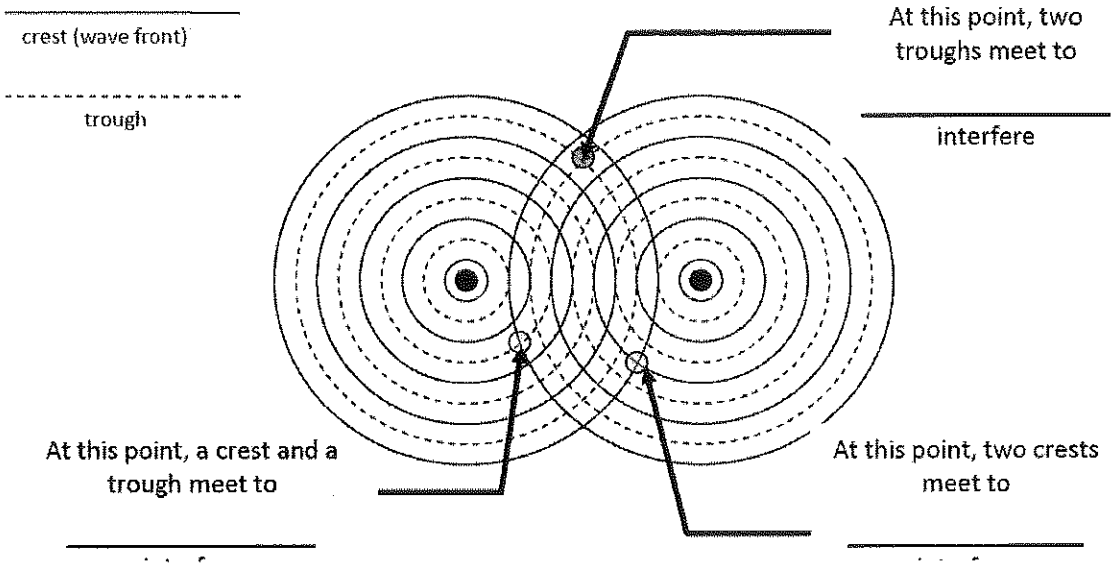
a) **Superposition**

b) **Constructive Interference**

c) **Destructive Interference**

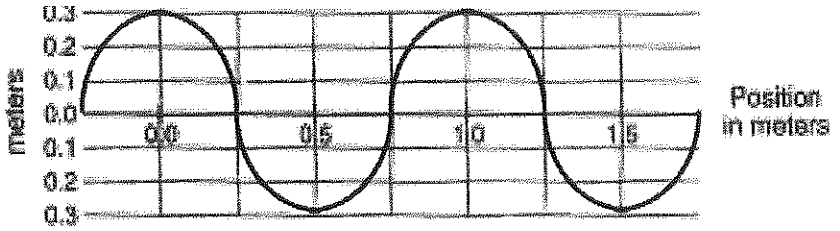
240.

When viewed from above, a wave source makes a circular pattern

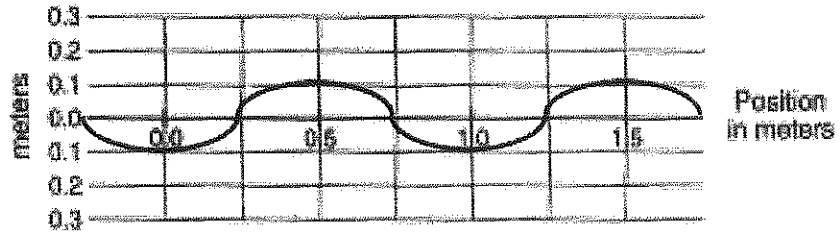


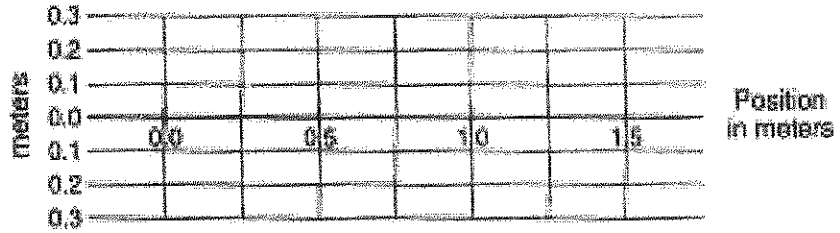
241. **Sketch the wave interference pattern for the combination of wave A and wave B**

Wave A

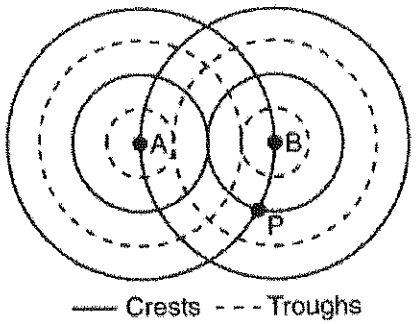


Wave B





242.

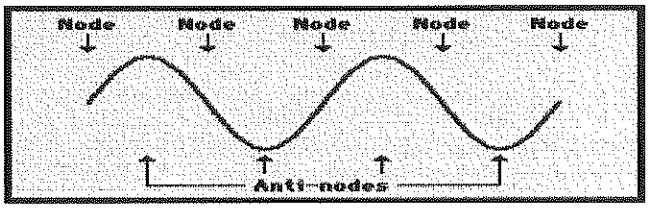


What phenomenon occurs at point P?

_____

243. **Standing Waves result from a combination of _____ and _____.**

Standing waves contain a pattern of _____ and _____.



Where crests meet crest or troughs meet troughs _____ are formed.

Where crests meet troughs _____ are formed.

244. Standing waves are produced by the interference of two waves with the same:

(1) frequency and amplitude, but opposite directions
(2) frequency and direction, but different amplitudes
(3) amplitude and direction, but different frequencies
(4) frequency, amplitude, and direction

245. What is the phase difference between two standing waves at a node?

(1) 0° (3) 90°
(2) 180° (4) 360°

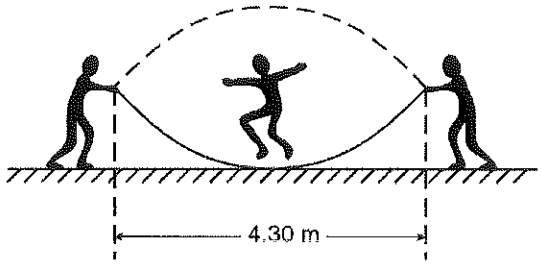
246. **Describe or define Resonance –**

247. The diagram below represents a standing wave.

The number of nodes and antinodes shown in the diagram is

A) 4 nodes and 5 antinodes
B) 5 nodes and 6 antinodes
C) 6 nodes and 5 antinodes
D) 6 nodes and 10 antinodes

248. While playing, two children create a standing wave in a rope, as shown in the diagram below. A third child participates by jumping the rope.

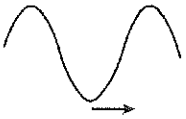
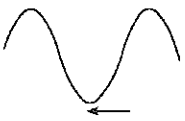


What is the wavelength of this standing wave?

A) 2.15 m
B) 4.30 m
C) 6.45 m
D) 8.60 m

249. 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) 

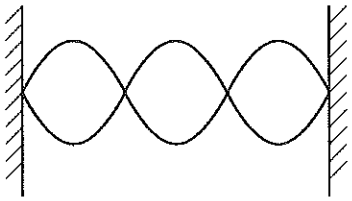
250. The superposition of two waves traveling in the same medium produces a standing wave pattern if the two waves have

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

251. 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

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



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

253. 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°

254. In order for standing waves to form in a medium, two waves must

A) have the same frequency
B) have different amplitudes
C) have different wavelengths
D) travel in the same direction

255. When an opera singer hits a high-pitch note, a glass on the opposite side of the opera hall shatters. Which statement best explains this phenomenon?

A) The frequency of the note and natural vibration frequency of the glass are equal.
B) The vibrations of the note are polarized by the shape of the opera hall.
C) The amplitude of the note increases before it reaches the glass.
D) The singer and glass are separated by an integral number of wavelengths.

256. One vibrating 256-hertz tuning fork transfers energy to another 256-hertz tuning fork, causing the second tuning fork to vibrate. This phenomenon is an example of

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

257. Resonance occurs when one vibrating object transfers energy to a second object causing it to vibrate. The energy transfer is most efficient when, compared to the first object, the second object has the same natural

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

258. The phenomenon in which one vibrating object causes another to vibrate is called

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

259. After a guitar string is set into vibration, it causes a string on a nearby guitar to begin to vibrate. This characteristic of sound waves is known as

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

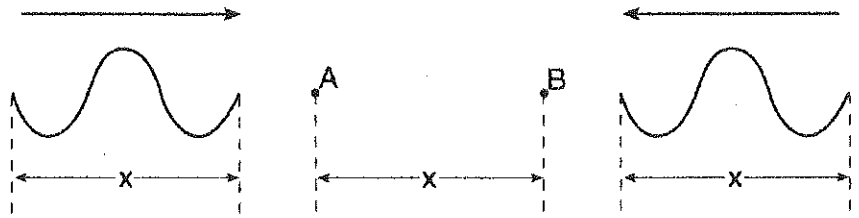
260. There are places where the reflected sound waves reinforce each other as well as places where the reflected sound waves produce near silence. This phenomenon is known as

A) refraction B) diffraction
C) amplitude D) interference

261. The distance between two consecutive nodes in a standing sound wave is

A) one wavelength
B) two wavelengths
C) one-half wavelength
D) one-quarter wavelength

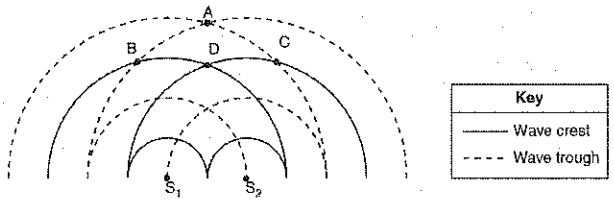
262. The diagram below shows two waves traveling toward each other at equal speed in a uniform medium.



When both waves are in the region between points *A* and *B*, they will undergo

A) diffraction
B) the Doppler effect
C) destructive interference
D) constructive interference

263. Two speakers, S_1 and S_2, operating in phase in the same medium produce the circular wave patterns shown in the diagram below.



At which two points is constructive interference occurring?

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

264. The diagram below shows two pulses approaching each other in a uniform medium.

Which diagram best represents the superposition of the two pulses?

A) 

B) 

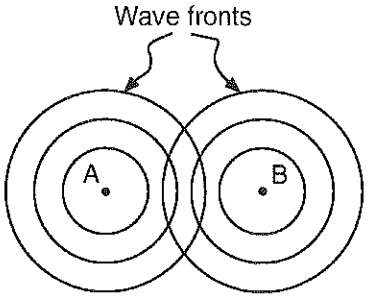
C) 

D) 

265. Two waves having the same frequency and amplitude are traveling in the same medium. Maximum constructive interference occurs at points where the phase difference between the two superposed waves is

A) 0° B) 90° C) 180° D) 270°

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



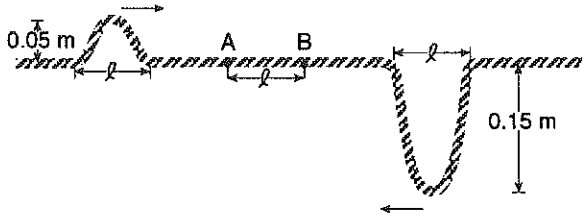
Which phenomenon occurs at the intersections of the circular wave fronts?

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

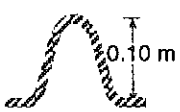
267. Two waves having the same amplitude and the same frequency pass simultaneously through a uniform medium. Maximum destructive interference occurs when the phase difference between the two waves is

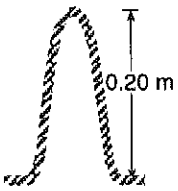
A) 0° B) 90° C) 180° D) 360°

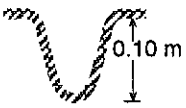
268. The diagram below shows two pulses, each of length l, traveling toward each other at equal speed in a rope.

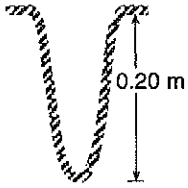


Which diagram best represents the shape of the rope when both pulses are in region AB?

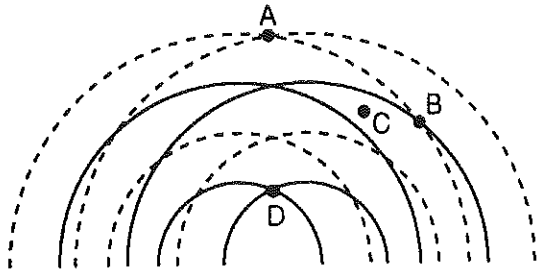
A) 

B) 

C) 

D) 

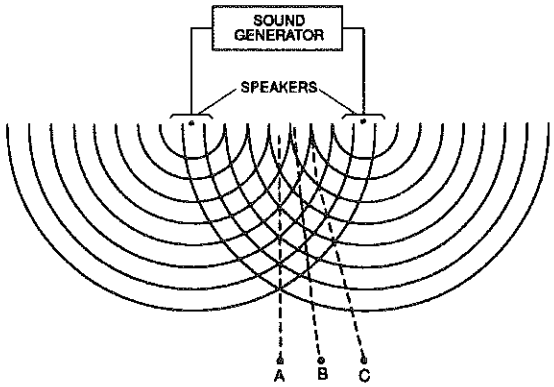
269. Two wave sources operating in phase in the same medium produce the circular wave patterns shown in the diagram below. The solid lines represent wave crests and the dashed lines represent wave troughs.



Which point is at a position of maximum destructive interference?

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

270. In the diagram below, two speakers are connected to a sound generator. The speakers produce a sound pattern of constant frequency such that a listener will hear the sound very well at A and C, but not as well at point B.

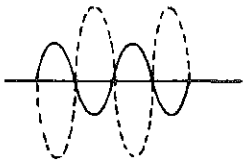


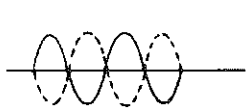
Which wave phenomenon is illustrated by this experiment?

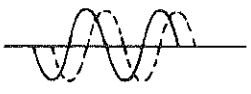
A) interference B) polarization
C) reflection D) refraction

271. Which pair of waves will produce a resultant wave with the smallest amplitude?

A) 

B) 

C) 

D) 

SKILL 54: Other Phenomena

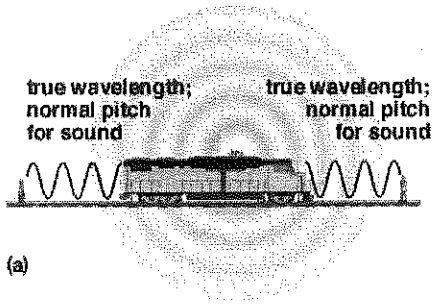
272. **Doppler Effect**: Apparent shift in the frequency of a wave due to the relative motion of the source and or observer

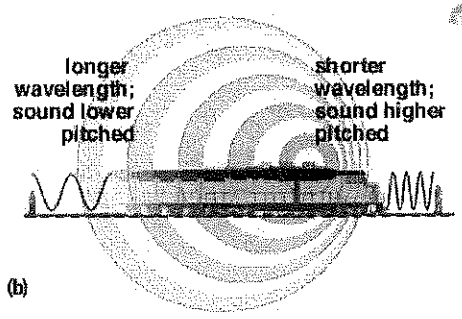
If the object is getting closer the frequency will _____ in relation to the speed (constant speed will be constant frequency, increasing speed will be increasing frequency, decreasing speed will be decreasing frequency)

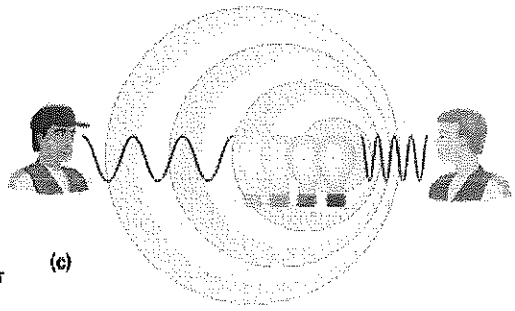
If the object is getting further away the frequency will _____ in relation to the speed

For SOUND the Doppler Effect will be observed as a change in _____

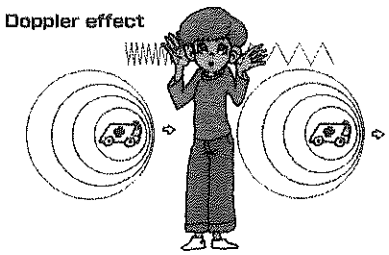
For LIGHT the Doppler Effect will be observed as a shift in the _____. A shift toward high frequency is called _____ shift. A shift toward low frequency is called _____ shift.







273. Doppler Effect



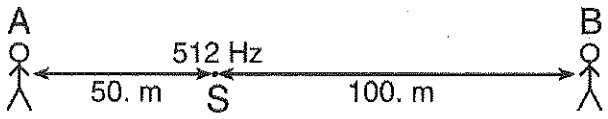
If the wave source and the observer are approaching one another the perceived frequency will _____

If the wave source and the observer are moving further apart the perceived frequency will _____

We use the Doppler Effect to analyze sound, light and the motion of objects. Analyzing light from distant celestial objects allows us to determine their relative motion to Earth and satellites. If a planetary object is moving away from us the spectrum of light will be _____ shifted. If a planetary object is moving toward us the spectrum of light will be _____ shifted.

274. Moving from one substance to another is called _____. If waves change speed as they enter a new medium they bend. This is known as _____
Some waves can't move from one boundary to the other and they bounce off the boundary. This is called _____
Some waves are absorbed when they interact with a boundary.

275. In the diagram below, a stationary source located at point S produces sound having a constant frequency of 512 hertz. Observer A, 50. meters to the left of S, hears a frequency of 512 hertz. Observer B, 100. meters to the right of S, hears a frequency lower than 512 hertz.



Which statement best describes the motion of the observers?

A) Observer A is moving toward point S, and observer B is stationary.
B) Observer A is moving away from point S, and observer B is stationary.
C) Observer A is stationary, and observer B is moving toward point S.
D) Observer A is stationary, and observer B is moving away from point S.

276. Astronauts traveling toward Earth in a fast-moving spacecraft receive a radio signal from an antenna on Earth. Compared to the frequency and wavelength of the radio signal emitted from the antenna, the radio signal received by the astronauts has a

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

277. A car's horn produces a sound wave of constant frequency. As the car speeds up going away from a stationary spectator, the sound wave detected by the spectator

A) decreases in amplitude and decreases in frequency
B) decreases in amplitude and increases in frequency
C) increases in amplitude and decreases in frequency
D) increases in amplitude and increases in frequency

278. A car's horn is producing a sound wave having a constant frequency of 350 hertz. If the car moves toward a stationary observer at constant speed, the frequency of the car's horn detected by this observer may be

A) 320 Hz
B) 330 Hz
C) 350 Hz
D) 380 Hz

279. A police car traveling at a speed of 30.0 meters per second sounds its siren, which has a frequency of 1.00×10^3 hertz. As the police car approaches a stationary pedestrian, the pedestrian detects a siren frequency of

A) 30.0 Hz
B) 9.19×10^2 Hz
C) 1.00×10^3 Hz
D) 1.10×10^3 Hz

280. 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

281. 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

282. 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

283. 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

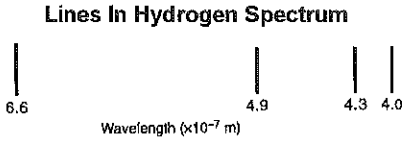
284. The driver of a car blows the horn as the car approaches a crosswalk. Compared to the actual pitch of the horn, the pitch observed by a pedestrian in the crosswalk is

A) lower B) higher
C) the same

285. Light from the star Betelgeuse displays a Doppler red shift. The shift is best explained by assuming that Betelgeuse is

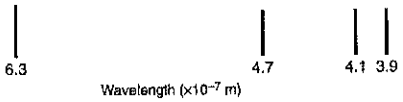
A) decreasing in temperature
B) increasing in temperature
C) moving toward Earth
D) moving away from Earth

286. The four-line Balmer series spectrum shown below is emitted by a hydrogen gas sample in a laboratory. A star moving away from Earth also emits a hydrogen spectrum.



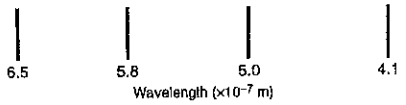
Which spectrum might be observed on Earth for this star?

A)

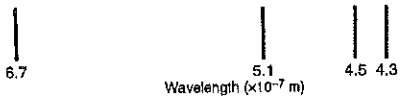


B)

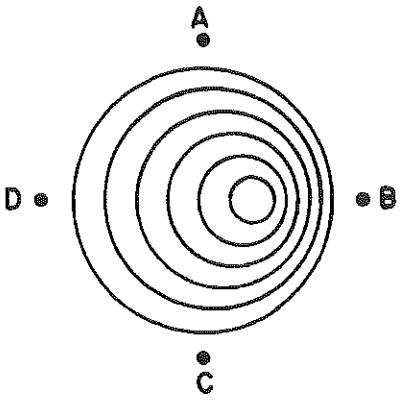
C)



D)



Base your answers to questions **287** and **288** on the diagram below which represents the wave pattern produced by a vibrating source moving linearly in a shallow tank of water. The pattern is viewed from above and the lines represent wave crests.



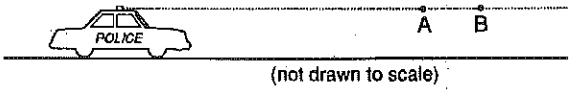
287. The velocity of the source is increased. The wavelength of the waves observed at point *D* will

A) decrease B) increase
C) remain the same

288. The wave pattern is an illustration of

A) diffraction B) interference
C) dispersion D) the Doppler effect

289. Base your answer to the following question on the diagram below which shows a parked police car with a siren on top. The siren is producing a sound with a frequency of 680 hertz, which travels first through point *A* and then through point *B*, as shown. The speed of the sound is 340 meters per second.



(not drawn to scale)

If the car were to accelerate toward point *A*, the frequency of the sound heard by an observer at point *A* would

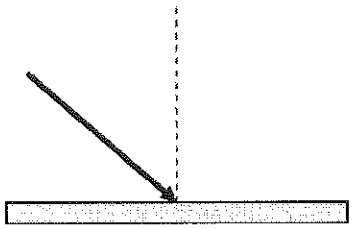
A) decrease B) increase
C) remain the same

Skill 55: Law of Reflection

Reflection

Regular Reflection

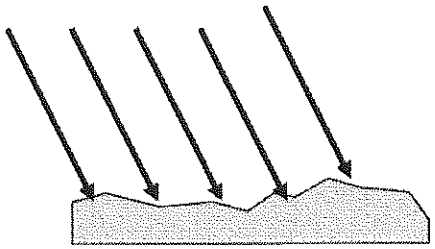
Normal – perpendicular to surface



Law of Reflection

$\theta_i = \theta_r$

Diffuse Reflection



Reflection from an irregular surface

When a light ray approaches a surface, the angle is measured between the light ray and the normal line.

Remember that "normal" means perpendicular to the surface.

In reflection the incident angle (incoming angle) is equal to the reflected angle.
-Since the light does not change medium in reflection it does not speed up or slow down, therefore the angle relative to the normal line does not change.

290. Use a protractor to measure the angle of incidence in the diagram to the left above. Draw in the angle of reflection.

Skill 56- Snell's Law

291. REFRACTION – Bending of light upon entering a new medium

The frequency of a wave does not change once it is produced, even if it enters a new medium. When it enters a new medium it will change speed and wavelength

$$v = f\lambda \qquad \frac{n_2}{n_1} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2} \qquad n = \frac{c}{v}$$

-Velocity/speed is _____ related to wavelength.

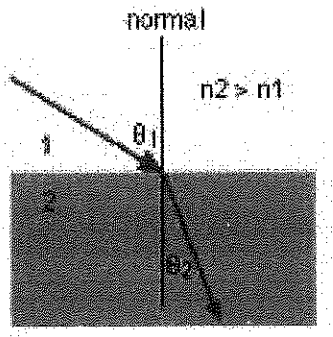
- Index of refraction is _____ related to both velocity/speed and wavelength.

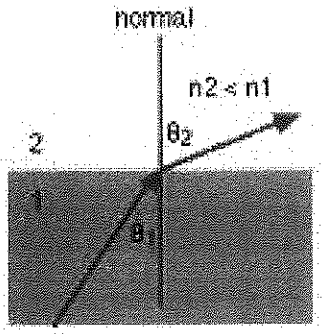
-The angle of incidence (θ_1 or θ_i) is a measure of the number of degrees between "straight on" (entering on the normal line) and the angle of the incoming ray upon the surface.

-The angle of the refraction (θ_2 or θ_r) is a measure of the number of degrees between "straight out" and the angle departing the surface in the new medium.

If the index of refraction increases it will bend "toward the normal" after entering new medium

If the index of refraction decreases it will bend "_____ _____ the normal after entering new medium

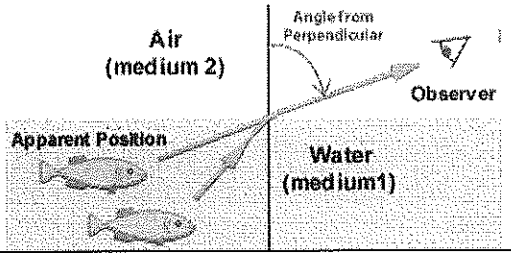




Refraction is a reversible process

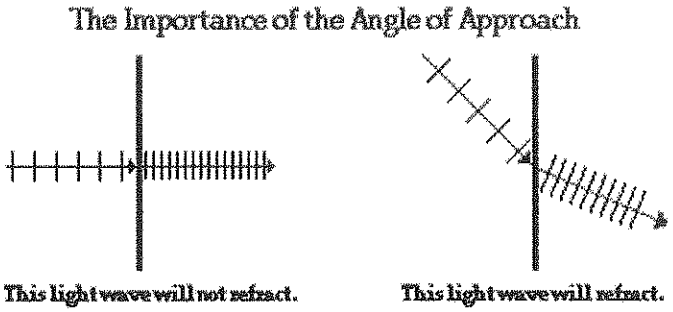
Snell's law: $n_1 \sin\theta_1 = n_2 \sin\theta_2$ or, equivalently, $\sin\theta_1 / \sin\theta_2 = v_1 / v_2$

Refraction causes you to see an image in a different position than the actual position.



SNELL'S LAW:

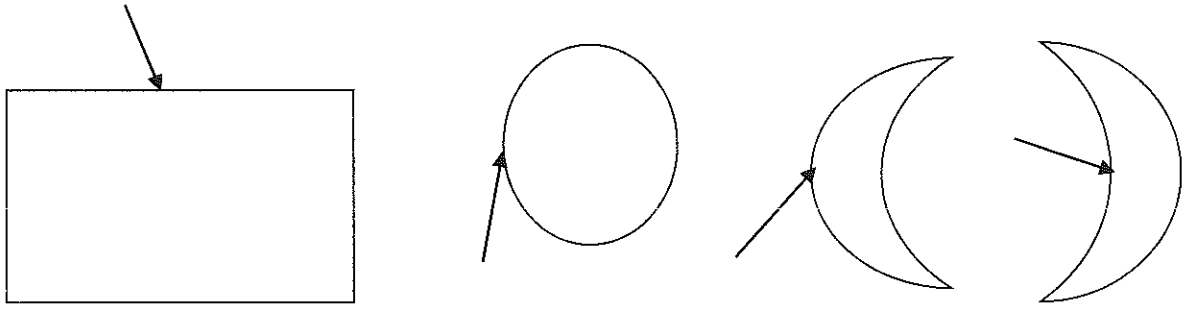
292. If the light ray enters a new medium at an angle of zero (_____) then the speed changes and the wavelength changes according to an _____ relationship with index of refraction "n". The _____ remains the same.



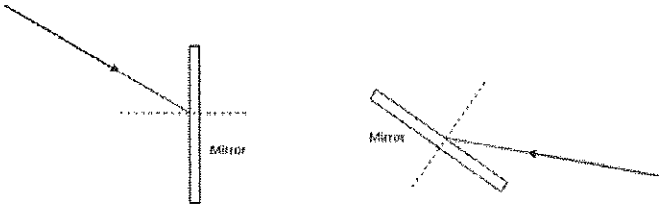
Practice: Reflection and Refraction

293. In order to study reflection or refraction we need a tool that allows us to analyze all surface shapes. This tool is the _____ line, which is an imaginary line perpendicular to the surface at the point the ray hits.

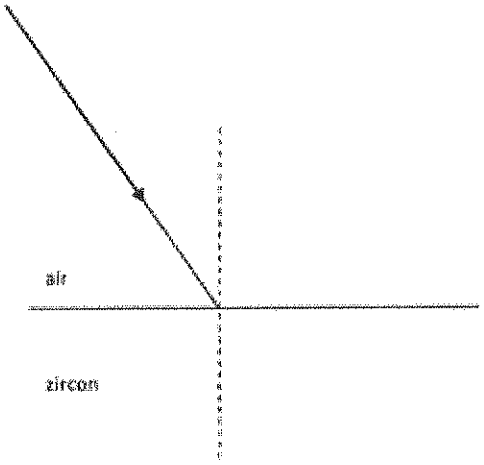
294. Given the light ray and the surface shape draw in a normal line. If the point is curved you can draw in a tangent line for help

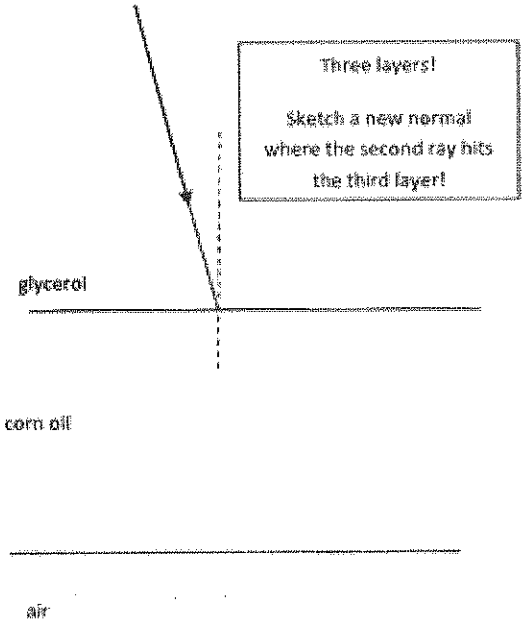


295. Use a protractor to draw in the reflected ray.

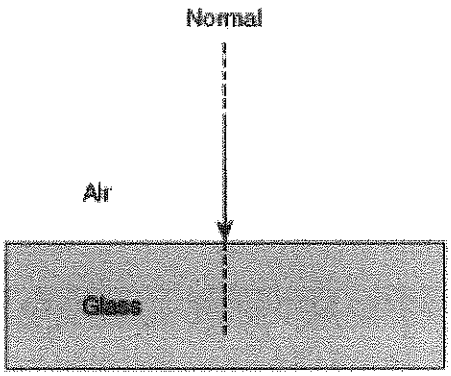


296. For each boundary below, draw the reflected and refracted ray. (Show work for any calculations)





297.



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

(1) Only speed changes.
(2) Only direction changes.
(3) Both speed and direction change.
(4) Neither speed nor direction change.

298. Briefly summarize each of the following wave phenomena

Reflection

Refraction

Diffraction

Polarization

Interference

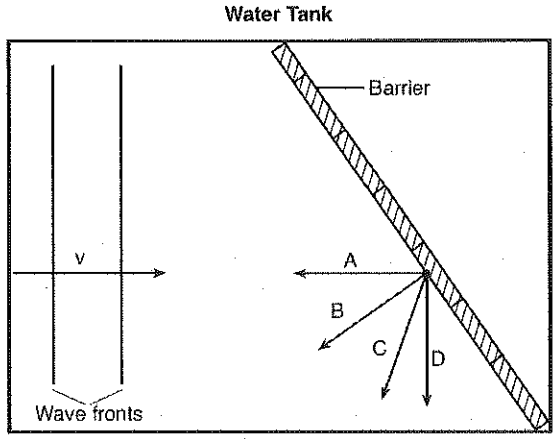
Standing Wave

Resonance

Doppler Effect

Topic 5C: Law of Reflection/Snell's Law
Skill 55 and 56

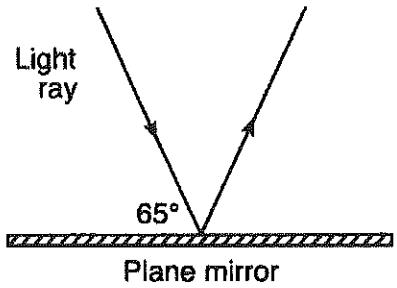
299. The diagram below represents a view from above of a tank of water in which parallel wave fronts are traveling toward a barrier.



Which arrow represents the direction of travel for the wave fronts after being reflected from the barrier?

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

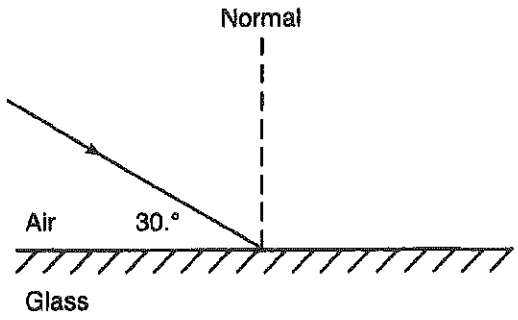
300. The diagram below represents a light ray reflecting from a plane mirror.



The angle of reflection for the light ray is

A) 25° B) 35° C) 50.° D) 65°

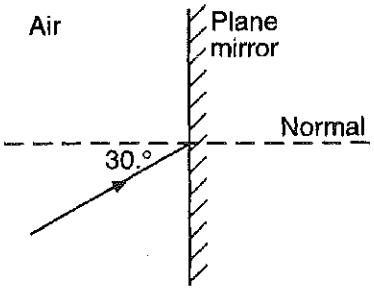
301. The diagram below represents a light ray striking the boundary between air and glass.



What would be the angle between this light ray and its reflected ray?

A) 30.° B) 60.° C) 120.° D) 150.°

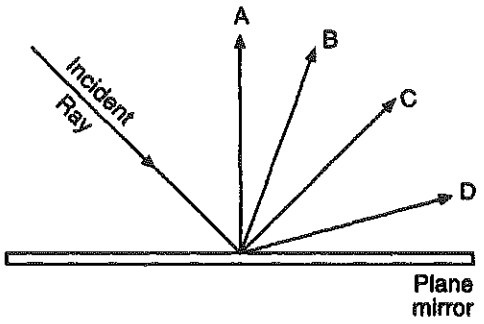
302. A ray of monochromatic light traveling in air is incident on a plane mirror at an angle of 30.°, as shown in the diagram below.



The angle of reflection for the light ray is

A) 15° B) 30.° C) 60.° D) 90.°

303. 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

304. A ray of light strikes a plane mirror at an angle of incidence equal to 35°. The angle between the incident ray and the reflected ray is

A) 0° B) 35° C) 55° D) 70°

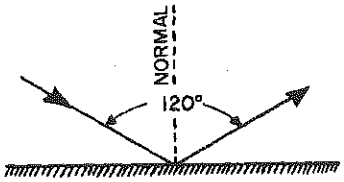
305. When a ray of light strikes a mirror perpendicular to its surface, the angle of reflection is

A) 0° B) 45° C) 60° D) 90°

306. A light ray is incident upon a plane mirror. If the angle of incidence is increased, the angle of reflection will

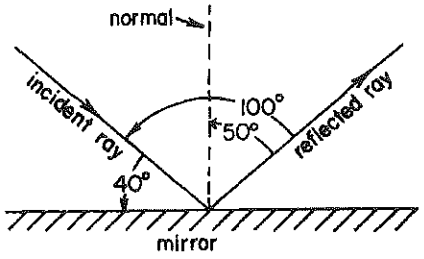
A) decrease B) increase
C) remain the same

307. What is the angle of incidence of the light ray shown below?



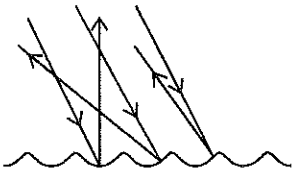
A) 30° B) 60° C) 90° D) 150°

308. The diagram below represents a light ray being reflected from a plane mirror. From the data given in the diagram, what is the angle of reflection?



A) 10 B) 40 C) 50 D) 100

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



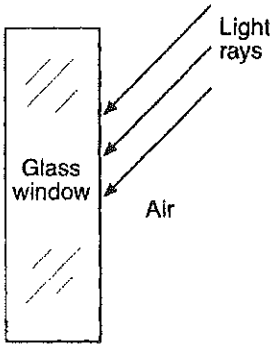
Which phenomenon of light is illustrated by the diagram?

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

310. Which phenomenon of light is illustrated by the diagram below?

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

311. 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

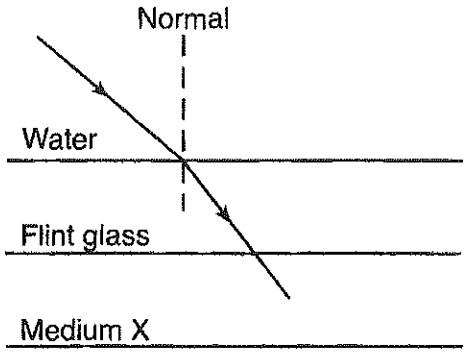
312. A light spring is attached to a heavier spring at one end. A pulse traveling along the light spring is incident on the boundary with the heavier spring. At this boundary, the pulse will be

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

313. Which will generally occur when a pulse reaches a boundary between two different media?

A) The entire pulse will be reflected.
B) The entire pulse will be absorbed.
C) The entire pulse will be transmitted.
D) Part of the pulse will be transmitted and part will be reflected.

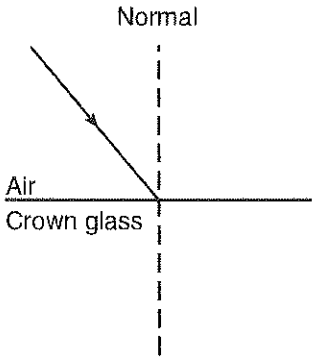
314. A ray of monochromatic yellow light ($f = 5.09\ 10^{14}$ Hz) passes from water through flint glass and into medium X, as shown below.



The absolute index of refraction of medium X is

A) less than 1.33
B) greater than 1.33 and less than 1.52
C) greater than 1.52 and less than 1.66
D) equal to 1.66

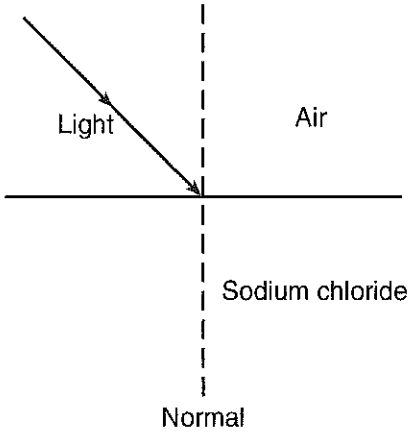
315. A ray of light ($f = 5.09\ 10^{14}$ Hz) traveling in air is incident at an angle of 40.° on an air-crown glass interface as shown below.



What is the angle of refraction for this light ray?

A) 25° B) 37° C) 40° D) 78

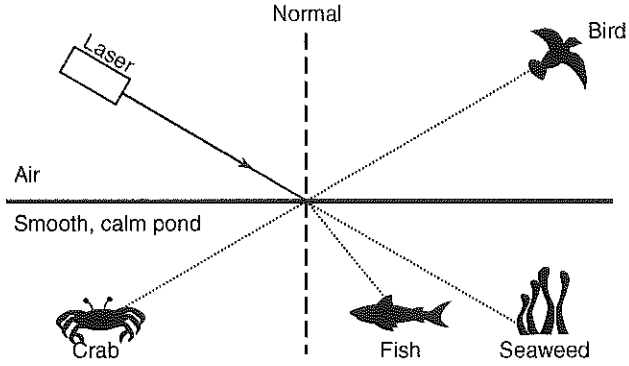
316. A ray of monochromatic light is incident on an air-sodium chloride boundary as shown in the diagram below. At the boundary, part of the ray is reflected back into the air and part is refracted as it enters the sodium chloride.



Compared to the ray's angle of refraction in the sodium chloride, the ray's angle of reflection in the air is

A) smaller B) larger
C) the same

317. A laser beam is directed at the surface of a smooth, calm pond as represented in the diagram below.



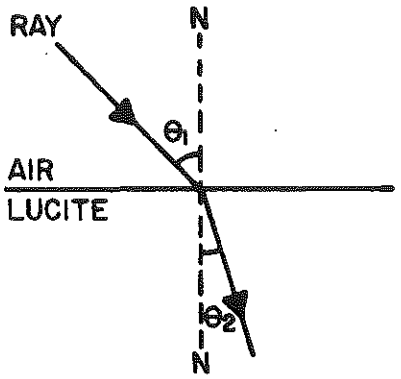
Which organisms could be illuminated by the laser light?

A) the bird and the fish
B) the bird and the seaweed
C) the crab and the seaweed
D) the crab and the fish

318. A pencil appears to be bent at a point where it enters the water in a beaker. This phenomenon is called

A) refraction B) reflection
C) dispersion D) rarefaction

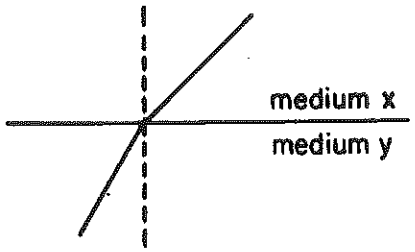
319. Base your answer to the following question on the diagram below which represents a ray of yellow light ($\lambda = 5.9 \times 10^{-7}$ meter in air) passing from air into Lucite. Angle θ_1 is 45°.



If the light ray were reversed in direction with the angle in the Lucite remaining the same, the angle in the air would be

A) less than 45°
B) 45°
C) between 45° and 72°
D) between 72° and 90°

320. The accompanying diagram represents a light ray passing from one medium into another.

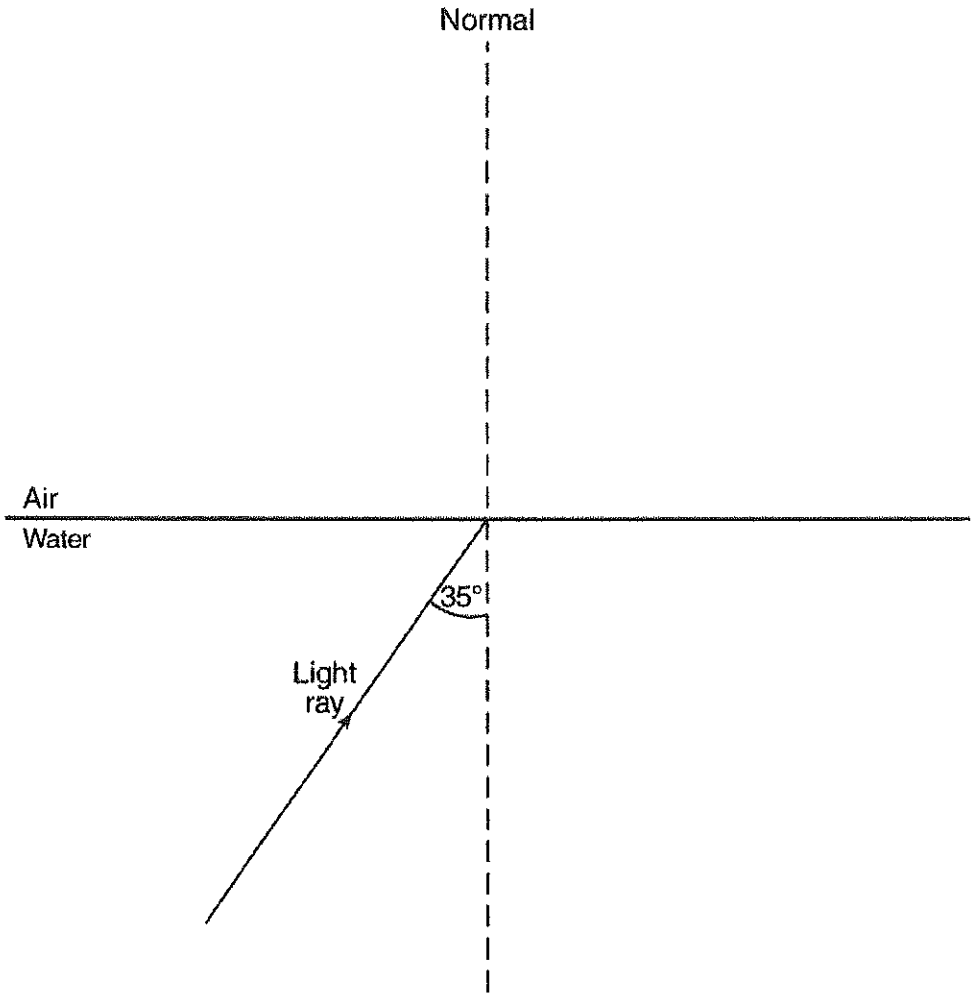


The light ray must be traveling

A) from medium x into medium y
B) from medium y into medium x
C) faster in medium x than in medium y
D) faster in medium y than in medium x

Base your answers to questions **321** and **322** on the information below.

A light ray with a frequency of 5.09×10^{14} hertz traveling in water has an angle of incidence of 35° on a water-air interface. At the interface, part of the ray is reflected from the interface and part of the ray is refracted as it enters the air.

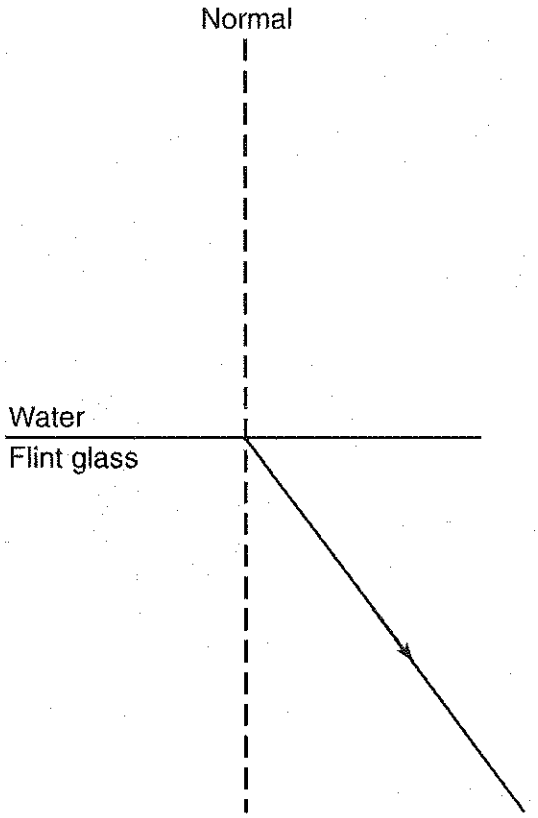


321. Identify *one* characteristics of this light ray that is the same in *both* the water and the air.

322. Calculate the angle of refraction of the light ray as it enters the air. [Show all work, including the equation and substitution with units.]

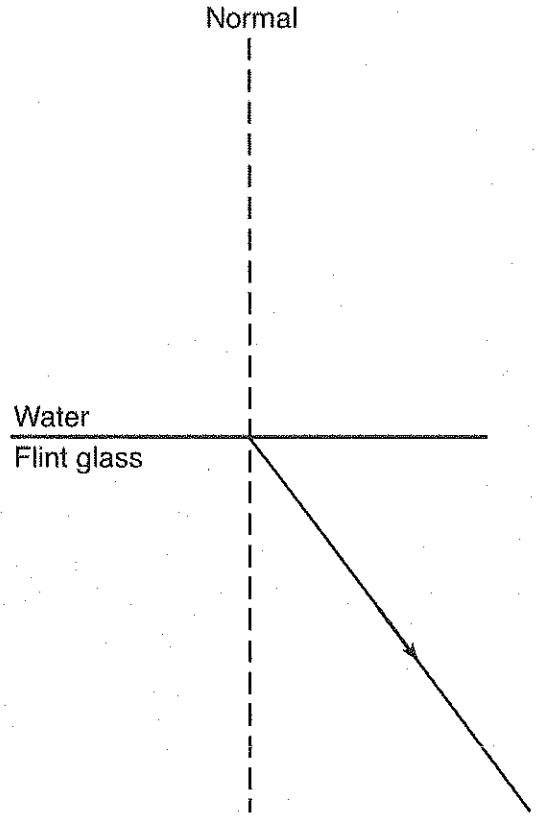
Base your answers to questions **323** and **324** on the information below.

A light ray ($f = 5.09 \times 10^{14}$ Hz) is refracted as it travels from water into flint glass. The path of the light ray in the flint glass is shown in the diagram below.

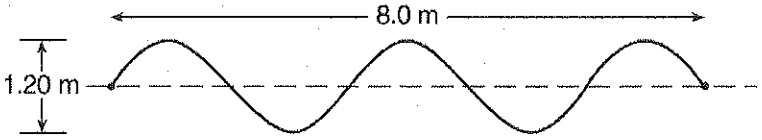


323. Identify *one* physical event, other than transmission or refraction, that occurs as the light interacts with the water-flint glass boundary.

324. Using a protractor and straightedge, on the diagram below, draw the path of the incident light ray in the water.



Base your answers to questions **325** and **326** on the diagram below, which shows a wave in a rope.

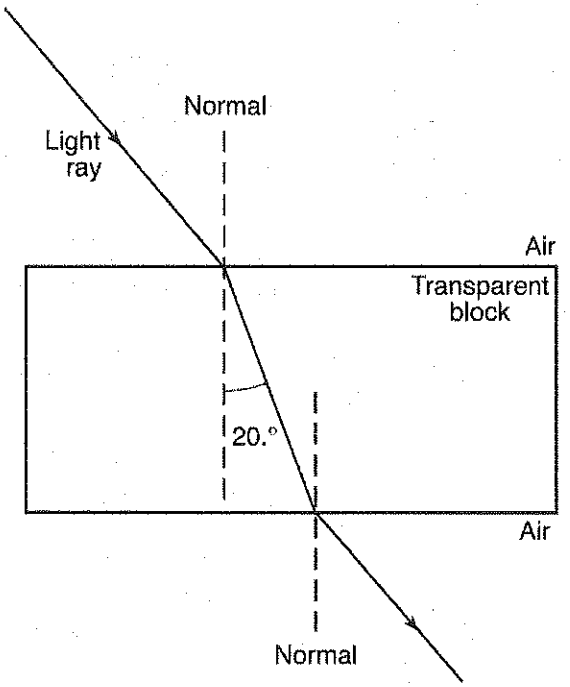


325. Determine the amplitude of the wave.

326. Determine the wavelength of the wave.

Base your answers to questions **327** and **328** on the information below.

A ray of monochromatic light ($f = 5.09 \times 10^{14}$ Hz) passes through air and a rectangular transparent block, as shown in the diagram below.

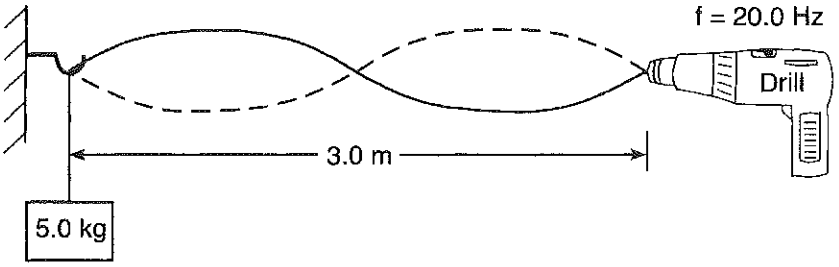


327. Calculate the absolute index of refraction for the medium of the transparent block. [Show all work, including the equation and substitution with units.]

328. Using a protractor, determine the angle of incidence of the light ray as it enters the transparent block from air.

Base your answers to questions **329** and **330** on the information below.

One end of a rope is attached to a variable speed drill and the other end is attached to a 5.0-kilogram mass. The rope is draped over a hook on a wall opposite the drill. When the drill rotates at a frequency of 20.0 Hz, standing waves of the same frequency are set up in the rope. The diagram below shows such a wave pattern.

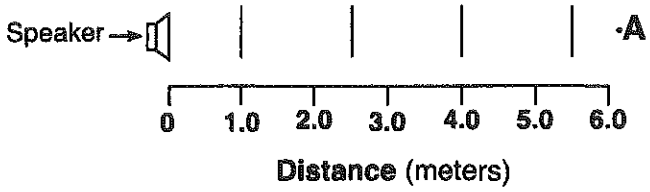


329. Calculate the speed of the wave in the rope. [Show all work, including the equation and substitution with units.]

330. Determine the wavelength of the waves producing the standing wave pattern.

Base your answers to questions **331** and **332** on the information and diagram below.

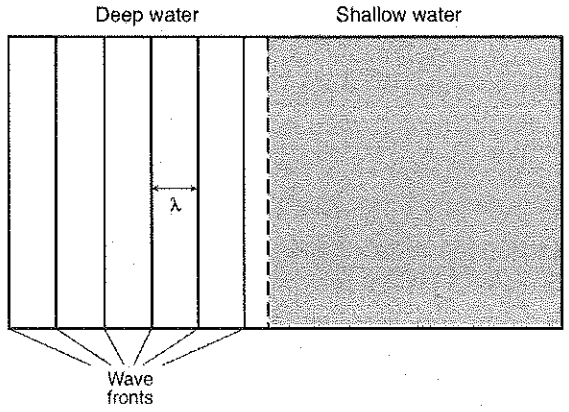
The vertical lines in the diagram represent compressions in a sound wave of constant frequency propagating to the right from a speaker toward an observer at point A.



331. The speaker is then moved at constant speed toward the observer at A. Compare the wavelength of the sound wave received by the observer while the speaker is moving to the wavelength observed when the speaker was at rest.

332. Determine the wavelength of this sound wave.

333. A wave generator having a constant frequency produces parallel wave fronts in a tank of water of two different depths. The diagram below represents the wave fronts in the deep water.



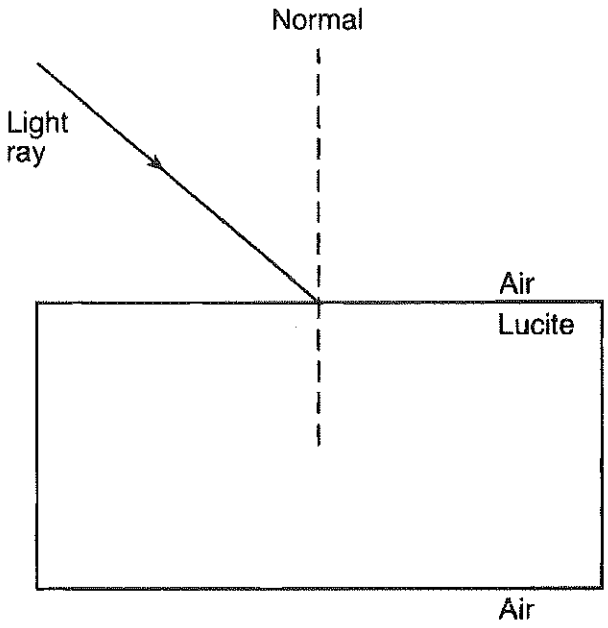
As the wave travels from the deep water into the shallow water, the speed of the waves decreases. On the diagram above, use a straightedge to draw *at least three* lines to represent the wave fronts, with appropriate spacing, in the shallow water.

334. A student and a physics teacher hold opposite ends of a horizontal spring stretched from west to east along a tabletop. Identify the directions in which the student should vibrate the end of the spring to produce transverse periodic waves.

335. A beam of monochromatic light has a wavelength of 5.89×10^{-7} meter in air. Calculate the wavelength of this light in diamond. [Show all work, including the equation and substitution with units.]

Base your answers to questions **336** through **338** on the information and diagram below.

A monochromatic light ray ($f = 5.09 \times 10^{14}$ *Hz*) *traveling in air is incident on the surface of a rectangular block of Lucite.*



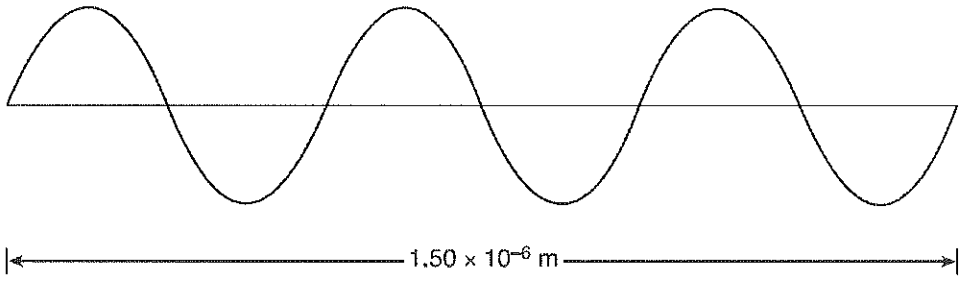
336. What is the angle of refraction of the light ray as it emerges from the Lucite block back into air?

337. Calculate the angle of refraction of the light ray when it enters the Lucite block. [Show all work, including the equation and substitution with units.]

338. Measure the angle of incidence for the light ray to the *nearest degree.*

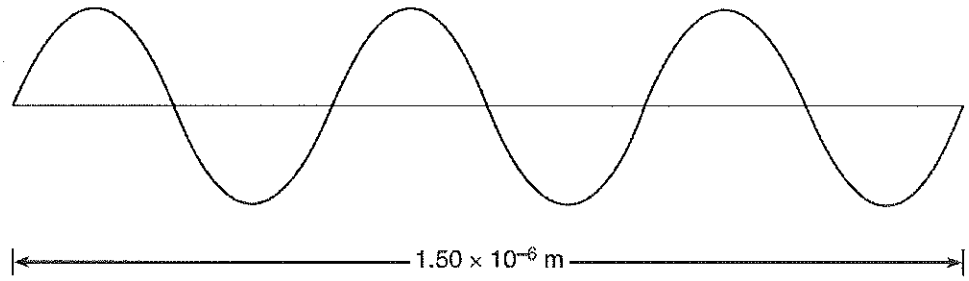
Base your answers to questions **339** and **340** on the information below.

A 1.50×10^{-6}-meter-long segment of an electromagnetic wave having a frequency of 6.00×10^{14} hertz is represented below.

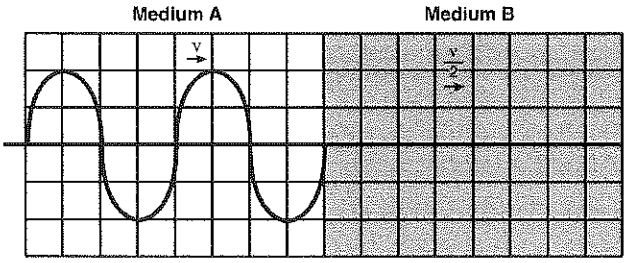


339. According to the *Reference Tables for Physical Setting/Physics*, which type of electromagnetic wave does the segment in the diagram represent?

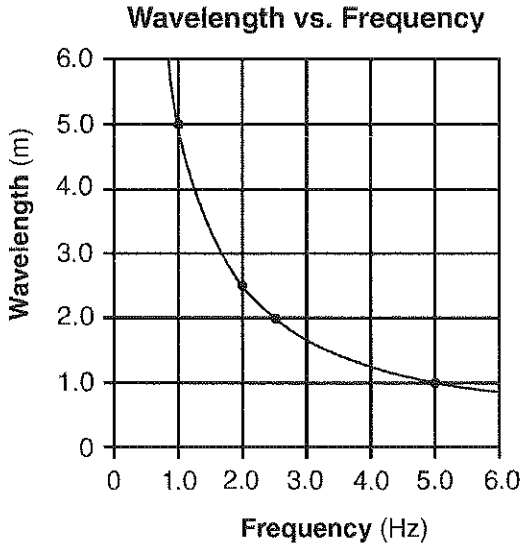
340. On the diagram below, mark *two* points on the wave that are in phase with each other. Label each point with the letter *P*.



341. A periodic wave travels at speed v through medium A. The wave passes with all its energy into medium B. The speed of the wave through medium B is $\frac{v}{2}$. On the diagram below draw the wave as it travels through medium B. [Show at least one full wave.]

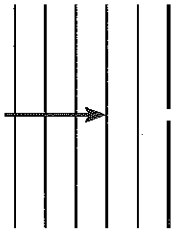


342. The graph below represents the relationship between wavelength and frequency of waves created by two students shaking the ends of a loose spring.



Calculate the speed of the waves generated in the spring. [Show all work, including the equation and substitution with units.]

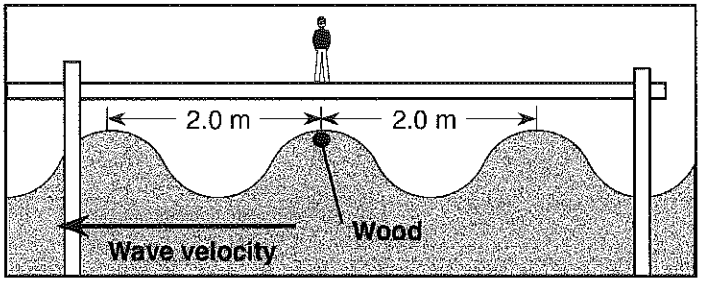
343. The diagram below shows a plane wave passing through a small opening in a barrier.



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

Base your answers to questions **344** and **345** on the information and diagram below.

A student standing on a dock observes a piece of wood floating on the water as shown below. As a water wave passes, the wood moves up and down, rising to the top of a wave crest every 5.0 seconds.



(Not drawn to scale)

344. Calculate the speed of the water waves. [Show all work, including the equation and substitution with units.]

345. Calculate the frequency of the passing water waves. [Show all work, including the equation and substitution with units.]

Skill 57: Energy of Photons – Absorption and Emission

Energy of photons:

Photons have the following properties:

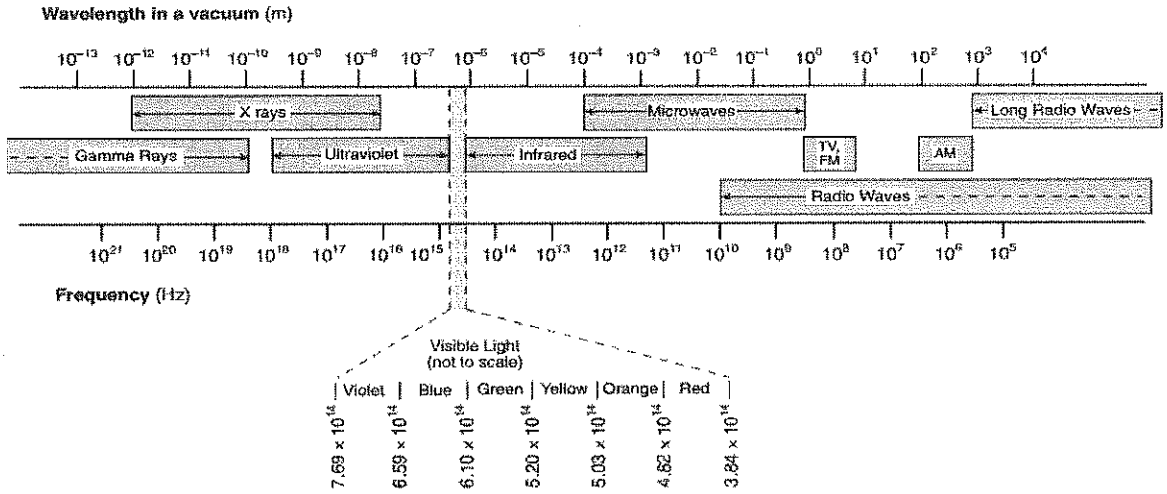
- Travel at the speed of light (c)
- Have no mass
- Carry energy and momentum
- Undergo particle-like collisions

$$E_{photon} = hf = \frac{hc}{\lambda}$$

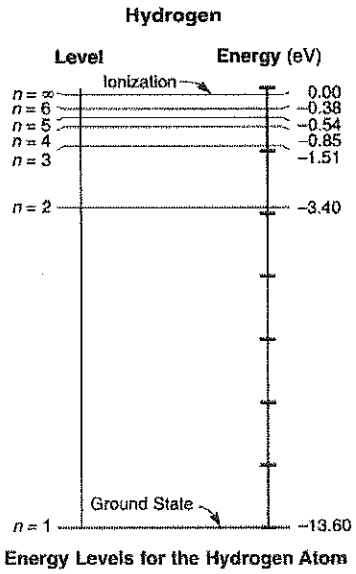
The Energy of a photon is directly related to the frequency of vibration of a charged particle by a constant known as Planck's constant. (E_{photon} and wavelength (λ) are inversely proportional)

Planck's constant	h	6.63×10^{-34} J•s

Using this equation the energy of a photon is measured in Joules.



An atom can emit or absorb energy related to the specific energy levels within an atom.



Energy Levels for the Hydrogen Atom

An absorbed photon can have an effect on electrons in an atom:

- If a photon with a corresponding energy to one of the "energy gaps" is available the photon will be absorbed and the electron will jump to that level (n).

$$E_{photon} = E_i - E_f$$

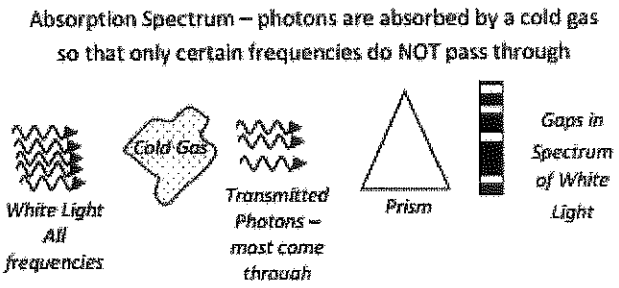
- If energy of the photon is greater than the ionization energy, the electron will be liberated
- If the energy of the photon is not the right energy for either of the above conditions then nothing happens.

A photon can be emitted when an excited electron falls from a higher energy level to a lower level. The energy of the emitted photon will be equal to the energy drop.

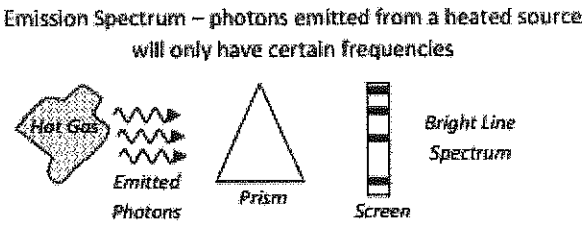
The energy of an electron and corresponding photon (emitted or absorbed) is expressed in electron-volts (eV's). To convert between eV's and Joules use the conversion ($1eV = 1.6 \times 10^{-19}J$). If energy is given in eV's multiply by 1.6×10^{-19}J; if in Joules divide by 1.6×10^{-19}J

Each atom can be identified by the absorption or emission spectrum for each element.

Absorption Spectrum: when an atom absorbs energy, it causes an electron to jump to a higher energy level. These energy levels are limited to specific "quanta".



Emission Spectrum: photons emitted from a heated source will only have certain frequencies



Light has both
A wave nature (diffraction, interference, Doppler effect, "double slit experiment)
AND a particle nature (collisions, momentum, photoelectric effect, blackbody radiation etc).

346. An atom of hydrogen has an electron in its excited, n = 4 state. The electron spontaneously drops to the n = 1 state, emitting a photon as it does so.

a. Calculate the energy of this photon in electron-volts.

b. Convert this energy into joules.

c. Determine the frequency of this photon.

d. Use the electromagnetic spectrum chart to determine the photon's type. _____

347. A hydrogen atom has an electron in its n = 2 state is hit by a photon with a frequency of $6.90 \times 10_{14}$ hertz.

a. Determine the wavelength of this photon.

b. Determine the energy of the photon in joules.

c. Convert this energy into electron volts.

d. Determine which energy level the electron will move to when hit by this photon.

348. A photon with a frequency of $7.5 \times 10_{14}$ hertz is traveling thorough empty space.

a. Determine the wavelength of this photon.

b. Calculate the energy of this photon in joules.

349. Calculate the frequency of the following set of photons:

a. 4.0×10^{-10} meter

b. 5.3×10^{-20} joules

c. 3.0 electron-volts.

350. The energy of a photon varies
(1) directly with wavelength
(2) directly with frequency
(3) inversely with frequency
(4) inversely with the square of frequency

351. What is the energy of a photon with a frequency of 5.0×10^{15} hertz?
(1) 3.3×10^{-18} J
(2) 2.0×10^{-16} J
(3) 1.5×10^{24} J
(4) 7.5×10^{48} J

352. Which of the photons given would have the greatest energy?
(1) red
(2) yellow
(3) green
(4) blue

353. Which phenomenon can only be explained by assuming that light is quantized?
(1) polarization
(2) diffraction
(3) interference
(4) photoelectric effect

354. Experiments performed with light indicate that light exhibits
(1) particle properties only
(2) wave properties only
(3) both particle and wave properties
(4) neither particle nor wave properties

355. The energy needed to ionize a hydrogen atom in the ground state is
(1) 2.9 eV
(2) 3.2 eV
(3) 13.06 eV
(4) 13.6 eV

356. Photons incident upon hydrogen atoms in the n = 2 level raise the energy of the atoms to the n = 4 level. What is the energy of the incident photons?

(1) 1.89 eV (3) 3.40 eV

(2) 2.55 eV (4) 4.25 eV

357. Several hydrogen atoms are supplied with sufficient energy to excite them to the n = 3 energy level. As the atoms return to the ground state, how many different energy-level transitions are possible?

(1) 1 (3) 3

(2) 2 (4) 4

358. A photon with 15.5 electron volts of energy is incident upon a hydrogen atom in the ground state. If the photon is absorbed by the atom, it will

(1) ionize the atom

(2) excite the atom to n = 2

(3) excite the atom to n = 3

(4) excite the atom to n = 4

Topic 6D: Energy of Photons
Skills 57

359. Moving electrons are found to exhibit properties of

A) particles, only
B) waves, only
C) both particles and waves
D) neither particles nor waves

360. Light demonstrates the characteristics of

A) particles, only
B) waves, only
C) both particles and waves
D) neither particles nor waves

361. Which phenomenon best supports the theory that matter has a wave nature?

A) electron momentum
B) electron diffraction
C) photon momentum
D) photon diffraction

362. Which phenomenon can best be explained by the wave model of light rather than the particle model of light?

A) interference
B) reflection
C) energy transfer
D) photoelectric effect

363. Which phenomenon can be explained by both the particle model and wave model?

A) reflection
B) polarization
C) diffraction
D) interference

364. Which phenomenon is most easily explained by the particle theory of light?

A) photoelectric effect
B) constructive interference
C) polarization
D) diffraction

365. A monochromatic beam of light has a frequency of 7.69×10^{14} hertz. What is the energy of a photon of this light?

A) 2.59×10^{-40} J
B) 6.92×10^{-31} J
C) 5.10×10^{-19} J
D) 3.90×10^{-7} J

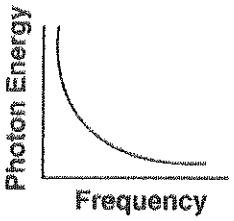
366. A variable-frequency light source emits a series of photons. As the frequency of the photon increases, what happens to the energy and wavelength of the photon?

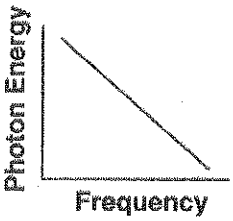
A) The energy decreases and the wavelength decreases.
B) The energy decreases and the wavelength increases.
C) The energy increases and the wavelength decreases.
D) The energy increases and the wavelength increases.

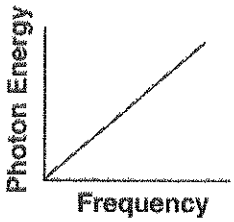
367. A photon of light traveling through space with a wavelength of 6.0×10^{-7} meter has an energy of

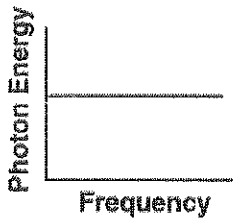
A) 4.0×10^{-40} J
B) 3.3×10^{-19} J
C) 5.4×10^{10} J
D) 5.0×10^{14} J

368. Which graph best represents the relationship between photon energy and photon frequency?

A) 

B) 

C) 

D) 

369. All photons in a vacuum have the same

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

370. Light of wavelength 5.0×10^{-7} meter consists of photons having an energy of

A) 1.1×10^{-48} J B) 1.3×10^{-27} J
C) 4.0×10^{-19} J D) 1.7×10^{-5} J

371. The energy of a photon is inversely proportional to its

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

372. Compared to a photon of red light, a photon of blue light has a

A) greater energy
B) longer wavelength
C) smaller momentum
D) lower frequency

373. Which characteristic of electromagnetic radiation is directly proportional to the energy of a photon?

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

374. What is the energy of a photon with a frequency of 5.00×10^{14} hertz?

A) 3.32 eV B) 3.20×10^{-6} eV
C) 3.00×10^{48} J D) 3.32×10^{-19} J

375. What is the energy of a quantum of light having a frequency of 6.0×10^{14} hertz?

A) 1.6×10^{-19} J B) 4.0×10^{-19} J
C) 3.0×10^{8} J D) 5.0×10^{-7} J

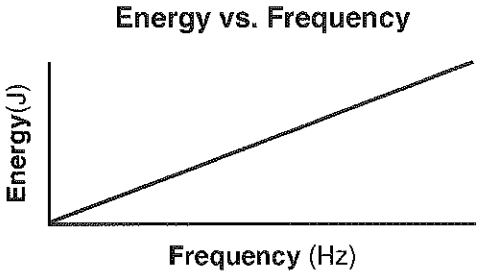
376. In which part of the electromagnetic spectrum does a photon have the greatest energy?

A) red B) infrared
C) violet D) ultraviolet

Topic 6D: Energy of Photons

377. Base your answer to the following question on the data table and graph below. The data table lists the energy and corresponding frequency of five photons. The graph represents the relationship between the energy and the frequency of photons.

Photon	Energy (J)	Frequency (Hz)
A	6.63×10^{-15}	1.00×10^{19}
B	1.99×10^{-17}	3.00×10^{16}
C	3.49×10^{-19}	5.26×10^{14}
D	1.33×10^{-20}	2.00×10^{13}
E	6.63×10^{-26}	1.00×10^{8}



The slope of the graph would be

A) 6.63×10^{-34} J•s
B) 6.67×10^{-11} N•m^2/kg^2
C) 1.60×10^{-19} J
D) 1.60×10^{-19} C

378. Electrons in excited hydrogen atoms are in the n = 3 energy level. How many different photon frequencies could be emitted as the atoms return to the ground state?

A) 1 B) 2 C) 3 D) 4

379. The momentum of a photon, p, is given by the equation $p = \frac{h}{\lambda}$ where h is Planck's constant and λ is the photon's wavelength. Which equation correctly represents the energy of a photon in terms of its momentum?

A) $E_{photon} = phc$
B) $E_{photon} = \frac{hp}{c}$
C) $E_{photon} = \frac{p}{c}$
D) $E_{photon} = pc$

380. What is the minimum energy needed to ionize a hydrogen atom in the n = 2 energy state?

A) 13.6 eV
B) 10.2 eV
C) 3.40 eV
D) 1.89 eV

381. A photon of light carries

A) energy, but not momentum
B) momentum, but not energy
C) both energy and momentum
D) neither energy nor momentum

382. On the atomic level, energy and matter exhibit the characteristics of

A) particles, only
B) waves, only
C) neither particles nor waves
D) both particles and waves

383. A photon is emitted as the electron in a hydrogen atom drops from the n = 5 energy level directly to the n = 3 energy level. What is the energy of the emitted photon?

A) 0.85 eV
B) 0.97 eV
C) 1.51 eV
D) 2.05 eV

384. An electron in the c level of a mercury atom returns to the ground state. Which photon energy could *not* be emitted by the atom during this process?

A) 0.22 eV B) 4.64 eV
C) 4.86 eV D) 5.43 eV

385. An electron in a mercury atom drops from energy level f to energy level c by emitting a photon having an energy of

A) 8.20 eV B) 5.52 eV
C) 2.84 eV D) 2.68 eV

Base your answers to questions **386** and **387** on the statement below.

The spectrum of visible light emitted during transitions in excited hydrogen atoms is composed of blue, green, red, and violet lines.

386. What characteristic of light determines the amount of energy carried by a photon of that light?

A) amplitude B) frequency
C) phase D) velocity

387. Which color of light in the visible hydrogen spectrum has photons of the shortest wavelength?

A) blue B) green
C) red D) violet

---

388. After electrons in hydrogen atoms are excited to the $n = 3$ energy state, how many different frequencies of radiation can be emitted as the electrons return to the ground state?

A) 1 B) 2 C) 3 D) 4

389. A photon having an energy of 9.40 electronvolts strikes a hydrogen atom in the ground state. Why is the photon *not* absorbed by the hydrogen atom?

A) The atom's orbital electron is moving too fast.
B) The photon striking the atom is moving too fast.
C) The photon's energy is too small.
D) The photon is being repelled by electrostatic force.

390. Which type of photon is emitted when an electron in a hydrogen atom drops from the $n = 2$ to the $n = 1$ energy level?

A) ultraviolet B) visible light
C) infrared D) radio wave

391. A hydrogen atom with an electron initially in the $n = 2$ level is excited further until the electron is in the $n = 4$ level. This energy level change occurs because the atom has

A) absorbed a 0.85-eV photon
B) emitted a 0.85-eV photon
C) absorbed a 2.55-eV photon
D) emitted a 2.55-eV photon

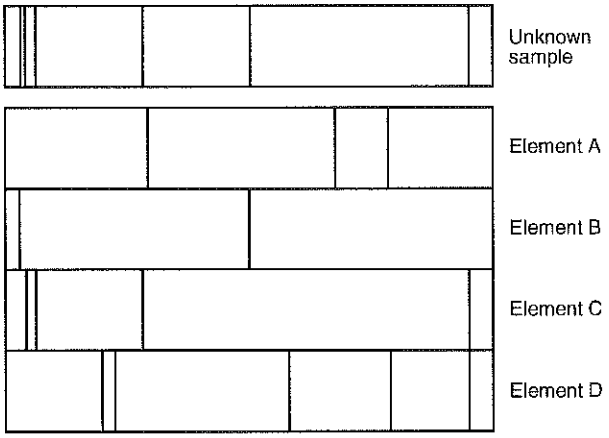
392. White light is passed through a cloud of cool hydrogen gas and then examined with a spectroscope. The dark lines observed on a bright background are caused by

A) the hydrogen emitting all frequencies in white light
B) the hydrogen absorbing certain frequencies of the white light
C) diffraction of the white light
D) constructive interference

393. A mercury atom in the ground state absorbs 20.00 electronvolts of energy and is ionized by losing an electron. How much kinetic energy does this electron have after the ionization?

A) 6.40 eV B) 9.62 eV
C) 10.38 eV D) 13.60 eV

394. The diagram below represents the bright-line spectra of four elements, *A*, *B*, *C*, and *D*, and the spectrum of an unknown gaseous sample.



Based on comparisons of these spectra, which two elements are found in the unknown sample?

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

395. How much energy is required to move an electron in a mercury atom from the ground state to energy level *h*?

A) 1.57 eV B) 8.81 eV
C) 10.38 eV D) 11.95 eV

396. The bright-line emission spectrum of an element can best be explained by

A) electrons transitioning between discrete energy levels in the atoms of that element
B) protons acting as both particles and waves
C) electrons being located in the nucleus
D) protons being dispersed uniformly throughout the atoms of that element

Skill 58: Mass-energy equivalence

The source of all energy in the universe is the conversion of mass into energy.

The Law of Conservation of Mass and the Law of Conservation of Energy can be combined to the Law of Conservation of Mass-Energy. Mass and energy are the same thing.

Energy and mass are the same thing. Neither can be created or destroyed.

Mass can be converted to energy. Energy can be converted to mass.

The equation $E=mc^2$ is used to relate a quantity of mass to the amount of energy it contains when mass is given in kg.

If mass is given in Universal mass units use the conversion from the reference table.

1 universal mass unit (u)		9.31×10^2 MeV
Rest mass of the electron	m_e	9.11×10^{-31} kg
Rest mass of the proton	m_p	1.67×10^{-27} kg
Rest mass of the neutron	m_n	1.67×10^{-27} kg

397. A 60 kilogram mass is converted completely into energy.

a. Calculate the amount of energy released in joules.

b. Convert this energy from joules into electron-volts.

398. a) Determine the amount of energy (in MeV) released when 2 universal mass units are converted to energy.

b) Convert this energy to joules

399. If a deuterium nucleus has a mass of 1.53×10^{-3} universal mass units (u) less than its components, how much energy does its mass represent?

400. The energy produced by the complete conversion of 2×10^{-5}kg of mass into energy is

a) 1.8 TJ b) 6 GJ c) 1.8 MJ d) 6.0 kJ

Topic 6D: Mass Energy Equivalence
Skills 58

401. What is the minimum total energy released when an electron and its antiparticle (positron) annihilate each other?

A) 1.64×10^{-13}J B) 8.20×10^{-14}J
C) 5.47×10^{-22}J D) 2.73×10^{-22}J

402. What total mass must be converted into energy to produce a gamma photon with an energy of 1.03×10^{-13} joule?

A) 1.14×10^{-30} kg
B) 3.43×10^{-22} kg
C) 3.09×10^{-5} kg
D) 8.75×10^{29} kg

403. The total conversion of 1.00 kilogram of the Sun's mass into energy yields

A) 9.31×10^{2} MeV B) 8.38×10^{19} MeV
C) 3.00×10^{8} J D) 9.00×10^{16} J

404. The energy produced by the complete conversion of 2.0×10^{-5} kilogram of mass into energy is

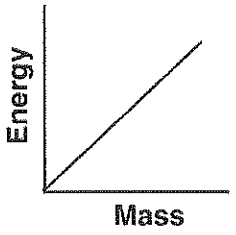
A) 1.8 TJ B) 6.0 GJ
C) 1.8 MJ D) 6.0 kJ

405. A tritium nucleus is formed by combining two neutrons and a proton. the mass of this nucleus is 9.106×10^{-3} universal mass unit less than the combined mass of the particles from which it is formed. Approximately how much energy is released when this nucleus us formed.

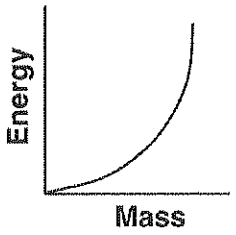
A) 8.48×10^{-2} MeV B) 2.73 MeV
C) 8.48 MeV D) 273 MeV

406. Which graph best represents the relationship between energy and mass when matter is converted into energy?

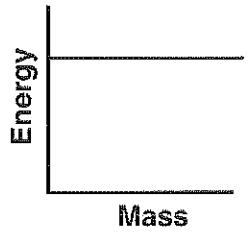
A)



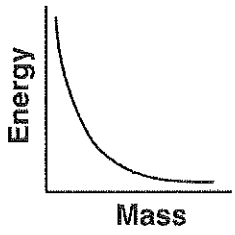
B)



C)



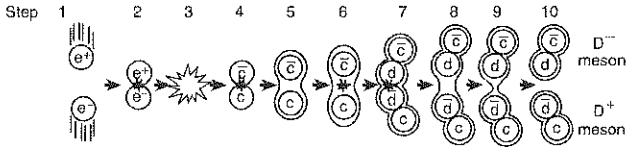
D)



407. The energy equivalent of the rest mass of an electron is approximately

A) 5.1×10^{5} J B) 8.2×10^{-14} J
C) 2.7×10^{-22} J D) 8.5×10^{-28} J

408. The diagram below represents the sequence of events (steps 1 through 10) resulting in the production of a D– meson and a D+ meson. An electron and a positron (antielectron) collide (step 1), annihilate each other (step 2), and become energy (step 3). This energy produces an anticharm quark and a charm quark (step 4), which then split apart (steps 5 through 7). As they split, a down quark and an antidown quark are formed, leading to the final production of a D– meson and a D+ meson (steps 8 through 10).



Adapted from: Electon/Positron Annihilation http://www.particleadventure.org/frameless/eedd.html 7/23/2007

Which statement best describes the changes that occur in this sequence of events?

A) Energy is converted into matter and then matter is converted into energy.
B) Matter is converted into energy and then energy is converted into matter.
C) Isolated quarks are being formed from baryons.
D) Hadrons are being converted into leptons.

409. The energy equivalent of 5.0×10^{-3} kilogram is

A) 8.0×10^{5} J B) 1.5×10^{6} J
C) 4.5×10^{14} J D) 3.0×10^{19} J

410. If a deuterium nucleus has a mass of 1.53×10^{-3} universal mass units less than its components, this mass represents an energy of

A) 1.38 MeV B) 1.42 MeV
C) 1.53 MeV D) 3.16 MeV

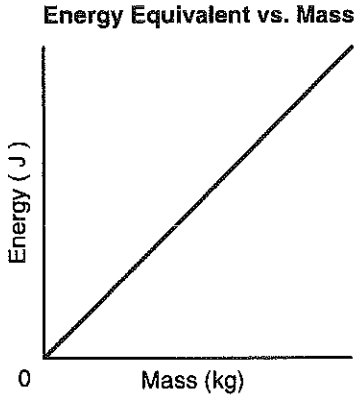
411. What is the energy equivalent of a mass of 0.026 kilogram?

A) 2.34×10^{15} J B) 2.3×10^{15} J
C) 2.34×10^{17} J D) 2.3×10^{17} J

412. How much energy would be generated if a 1.0×10^{-3}-kilogram mass were completely converted to energy?

A) 9.3×10^{-1} MeV B) 9.3×10^{2} MeV
C) 9.0×10^{13} J D) 9.0×10^{16} J

413. The graph below represents the relationship between mass and its energy equivalent



The slope of the graph represents

A) the electrostatic constant
B) gravitational field strength
C) the speed of light squared
D) Planck's constant

414. Approximately how much energy would be generated if the mass in a nucleus of a $^{2}_{1}H$ atom were completely converted to energy? [The mass of $^{2}_{1}H$ is 2.0 atomic mass units.]

A) 3.2×10^{-19} J B) 1.5×10^{-10} J
C) 9.3×10^{2} MeV D) 1.9×10^{3} MeV

415. What is the energy equivalent of a mass of 1 kilogram?

A) 9×10^{16} J
B) 9×10^{13} J
C) 9×10^{7} J
D) 9×10^{7} J

Topic 6D: Long Answer
Skills 57 and 58

Base your answers to questions **416** through **418** on the information below.

Auroras over the polar regions of Earth are caused by collisions between charged particles from the Sun and atoms in Earth's atmosphere. The charged particles give energy to the atoms, exciting them from their lowest available energy level, the ground state, to higher energy levels, excited states. Most atoms return to their ground state within 10. nanoseconds.

In the higher regions of Earth's atmosphere, where there are fewer interatom collisions, a few of the atoms remain in excited states for longer times. For example, oxygen atoms remain in an excited state for up to 1.0 seconds. These atoms account for the greenish and red glows of the auroras. As these oxygen atoms return to their ground state, they emit green photons $(f = 5.38 \times 10^{14}\ \text{Hz})$ and red photons$(f = 4.76 \times 10^{14}\text{Hz})$. These emissions last long enough to produce the changing aurora phenomenon.

416. Explain what is meant by an atom being in its ground state.

417. Calculate the energy of a photons, in joules, that accounts for the red glow of the aurora. [Show all work, including the equation and substitution with units.]

418. What is the order of magnitude of the time, in seconds, that most atoms spend in an excited state?

Base your answers to questions **419** through **421** on the information below.

A photon with a wavelength of 2.29×10^{-7} meter strikes a mercury atom in the ground state.

419. Based on your answer to the question above, state if this photon can be absorbed by the mercury atom. Explain your answer.

420. Determine the energy, in electronvolts, of this photon.

_____ eV

421. Calculate the energy, in joules, of this photon. [Show all work, including the equation and substitution with units.]

422. The energy required to separate the 3 protons and 4 neutrons in the nucleus of a lithium atom is 39.3 megaelectronvolts. Determine the mass equivalent of this energy, in universal mass units.

_____ u

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

In a mercury atom, as an electron moves from energy level *i* to energy level *a*, a single photon is emitted.

Determine the energy, in electron volts, of this emitted photon.

424. If a proton were to combine with an antiproton, they would annihilate each other and become energy. Calculate the amount of energy that would be released by this annihilation. [Show all work, including the equation and substitution with units.]

Base your answers to questions **425** and **426** on the information and data table below.

In the first nuclear reaction using a particle accelerator, accelerated protons bombarded lithium atoms, producing alpha particles and energy. The energy resulted from the conversion of mass into energy. The reaction can be written as shown below.

$${}_{1}^{1}H + {}_{3}^{7}Li \rightarrow {}_{2}^{4}He + {}_{2}^{4}He + \text{energy}$$

Data Table

Particle	Symbol	Mass (u)
proton	${}_{1}^{1}H$	1.007 83
lithium atom	${}_{3}^{7}Li$	7.016 00
alpha particle	${}_{2}^{4}He$	4.002 60

425. Determine the energy in megaelectronvolts produced in the reaction of a proton with a lithium atom.

426. Determine the difference between the total mass of the reactants (the proton and lithium atom), and the total mass of the products (the two alpha particles), in universal mass units.

427. A tau lepton decays into an electron, an electron antineutrino, and a tau neutrino, as represented in the reaction below.

$\tau \rightarrow e + \overline{\nu}_e + \nu_\tau$

On the equation below, show how this reaction obeys the Law of Conservation of Charge by indicating the amount of charge on each particle.

_____e → _____e + _____e + _____e

428. Base your answer to the following question on the statement below.

The spectrum of visible light emitted during transitions in excited hydrogen atoms is composed of blue, green, red, and violet lines.

What characteristic of light determines the amount of energy carried by a photon of that light?

A) amplitude B) frequency
C) phase D) velocity

429. The alpha line in the Balmer series of the hydrogen spectrum consists of light having a wavelength of 6.56×10^{-7} meter.

a Calculate the frequency of this light.

b Determine the energy in joules of a photon of this light.

c Determine the energy in electronvolts of a photon of this light.

Base your answers to questions **430** through **432** on the passage below.

For years, theoretical physicists have been refining a mathematical method called lattice quantum chromodynamics to enable them to predict the masses of particles consisting of various combinations of quarks and antiquarks. They recently used the theory to calculate the mass of the rare B_c particle, consisting of a charm quark and a bottom antiquark. The predicted mass of the B_c particle was about six times the mass of a proton.

Shortly after the prediction was made, physicists working at the Fermi National Accelerator Laboratory, Fermilab, were able to measure the mass of the B_c particle experimentally and found it to agree with the theoretical prediction to within a few tenths of a percent. In the experiment, the physicists sent beams of protons and antiprotons moving at 99.999% the speed of light in opposite directions around a ring 1.0 kilometer in radius. The protons and antiprotons were kept in their circular paths by powerful electromagnets. When the protons and antiprotons collided, their energy produced numerous new particles, including the elusive B_c.

These results indicate that lattice quantum chromodynamics is a powerful tool not only for confirming the masses of existing particles, but also for predicting the masses of particles that have yet to be discovered in the laboratory.

430. Explain how it is possible for a colliding proton and antiproton to produce a particle with six times the mass of either.

431. Identify the class of matter to which the B_c particle belongs.

432. Determine both the sign and the magnitude of the charge of the B_c particle in elementary charges.

433. More Sci- Than Fi, Physicists Create Antimatter

Physicists working in Europe announced yesterday that they had passed through natures looking glass and had created atoms made of antimatter, or antiatoms, opening up the possibility of experiments in a realm once reserved for science fiction writers. Such experiments, theorists say, could test some of the basic tenets of modern physics and light the way to a deeper understanding of nature.
By corralling [holding together in groups] clouds of antimatter particles in a
cylindrical chamber laced with detectors and electric and magnetic fields, the physicists assembled antihydrogen atoms, the looking glass equivalent of hydrogen, the most simple atom in nature. Whereas hydrogen consists of a positively charged proton circled by a negatively charged electron, in antihydrogen the protons counterpart, a positively charged antiproton, is circled by an antielectron, otherwise known as a positron. According to the standard theories of physics, the antimatter universe should look identical to our own. Antihydrogen and hydrogen atoms should have the same properties, emitting the exact same frequencies of light, for example. . . .Antimatter has been part of physics since 1927 when its existence was predicted by the British physicist Paul Dirac. The antielectron, or positron, was discovered in 1932. According to the theory, matter can only be created in particle-antiparticlepairs. It is still a mystery, cosmologists say, why the universe seems to be overwhelmingly composed of normal matter.

Dennis Overbye, More Sci- Than Fi, Physicists Create Antimatter, New York Times, Sept. 19, 2002

Identify *one* characteristic that antimatter particles must possess if clouds of them can be corralled by electric and magnetic fields.

Base your answers to questions **434** and **435** on the passage below.

More Sci- Than Fi, Physicists Create Antimatter

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Dennis Overbye, "More Sci- Than Fi, Physicists Create Antimatter," New York Times, Sept. 19, 2002

434. How should the emission spectrum of antihydrogen compare to the emission spectrum of hydrogen?

435. The author of the passage concerning antimatter incorrectly reported the findings of the experiment on antimatter. Which particle mentioned in the article has the charge incorrectly identified?

NAME _____ Unit 6 Practice Test

436 A sound wave is best described by the terms

a) Electromagnetic and transverse
b) Electromagnetic and longitudinal
c) Mechanical and longitudinal
d) Mechanical and transverse

437 Which of the following waves listed has the highest frequency?

a) Infrared
b) Green Light
c) Blue light
d) Yellow Light

438 Three quarks cannot have a combined charge of

a) 1
b) 2
c) -2
d) -1

439 As a fire truck moves away from a person standing on a side walk, the frequency of the siren heard by the person will

a) Remain the same
b) Decrease
c) Increase
d) Increase then decrease

440 A photon is best classified as a

a) Quark
b) Boson
c) Lepton
d) Baryon

441 As a light wave in water moves into air at an incident angle of 10^0 the light will

a) Reflect and speed up
b) Reflect and slow down
c) Refract inward and slow down
d) Refract outward and speed up

442 Which of the following particles produces an electromagnetic wave when oscillated?

a) electron
b) Neutron
c) Hydrogen atom
d) Tau neutrino

443 Determine the frequency of a radio wave with a wavelength of 1875 m moving in air.

a) 1.6×10^5 Hz
b) 6.75×10^{-1} Hz
c) 1.5×10^{11} Hz
d) 6.1×10^5 Hz

444 A particle consisting of 2 protons and 2 neutrons contains

a) 15 leptons
b) 15 quarks
c) 12 quarks
d) 5 quarks

445 A tau neutrino is classified as which type of particle?

a) Quark
b) Baryon
c) Lepton
d) Hadron

446 A wave cycle takes 4 seconds. Determine the frequency of the wave.

a) 4Hz
b) 0.25 Hz
c) 1 Hz
d) 25 Hz

447 The combination of an up quark and an anti up quark produces

a) A baryon
b) A lepton
c) A meson
d) Energy from annihilation

448 A wave completes 15 waves cycles in 37.5 m. What is the wavelength?

a) 0.33m
b) 45 m
c) 675 m
d) 2.5 m

449 Which fundamental force holds the particles in the nucleus together

a) Gravity
b) Electromagnetic force
c) Strong force
d) Weak Force

450 A wave moving from one material to another with a different index of refraction

a) Resonance
b) refraction
c) Diffraction
d) Polarization

451 Compared to the speed of a sound wave in air at STP, the speed of a radio wave is

a) Less
b) More
c) The same

452 Which of the following wave categories is a type of mechanical wave

a) Radio c) Ultrasound
b) Microwave d) Ultraviolet

453 What is the speed of a wave with a wavelength of 0.3 m and a frequency of 12 Hz?

a) 27 m/s c) 3.6 m/s
b) 60 m/s d) 3.0×10^8 m/s

454 What is the speed of light with a frequency of 5.09×10^{14}Hz when traveling through water?

a) 5.9×10^{14} m/s c) 2.25×10^8 m/s
b) 3.0×10^8 m/s d) 4.4×10^8 m/s

455 Which color of light has a wavelength of 5.0×10^{-7}m in air?

a) Blue c) Orange
b) Green d) Violet

456 Which characteristic is the same for every color of light in a vacuum?

a) Frequency c) Speed
b) wavelength d) Period

457 In which way does blue light change as it travels from crown glass into diamond?

a) Its frequency decreases
b) Its frequency increases
c) Its speed decreases
d) Its speed increases

458 The slope of a graph of photon energy vs. frequency equals

a) Photon speed
b) Wavelength
c) Planck's constant
d) Speed of light squared

459 How much energy is produced from the complete conversion of an electron into energy?

a) 1.6×10^{-19}J c) 3.2×10^{-19}J
b) 2.7×10^{-22} d) 8.2×10^{-14} J

460 Compared to the speed of a radio wave in air, the speed of a microwave in air is

a) Less c) The same
b) More

461 Determine the energy of photon with a frequency of 5.09×10^{14} Hz.

a) 1.6×10^{-19}J c) 3.4×10^{-19}J
b) 3.0×10^8 J d) 5.9×10^{-7}J

462 Determine the energy in electronvolts of photon with a wavelength of 5×10^{-7}m

a) 4.0×10^{-19}eV c) 2.5 eV
b) 6×10^{-14}eV d) 3.8×10^{33}eV

463 Light with a frequency of 5.09×10^{14} Hz in air is incident on a boundary with water at an angle of 30^0. What is the angle of refraction?

a) 15.4^0 c) 0^0
b) 45^0 d) 22^0

464 Light with a frequency of 5.09×10^{14} Hz in air is incident on a boundary with another substance. The angle of incidence is 45^0 and the angle of refraction is 30^0. What is the index of refraction for the substance?

a) 1.4 c) 1.66
b) 0.7 d) 1.33

465 What is the minimum amount of energy required to ionize an electron in the ground state of a **mercury** atom?

a) 13.6 eV c) 4.64 eV
b) 10.38 ev d) 20 eV

466 Determine the energy emitted by an electron as it falls from n=3 to n=2 in a hydrogen atom.

a) 12.09 eV c) 15.11 eV
b) 1.89 eV d) 1.51 eV

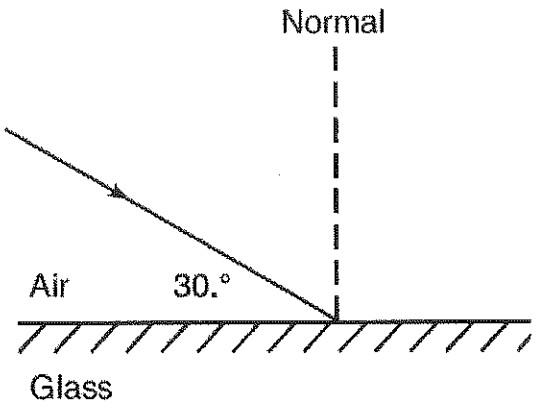
467 A singer breaking a glass by hitting a specific frequency is known as the phenomena of

a) Diffraction c) Interference
b) Doppler effect d) Resonance

468 How much energy is produced when 2 universal mass units are converted into energy?

a) 1.86×10^3 MeV
b) 2.8×10^3MeV
c) 3.0×10^8 MeV
d) 1.6×10^{-19} MeV

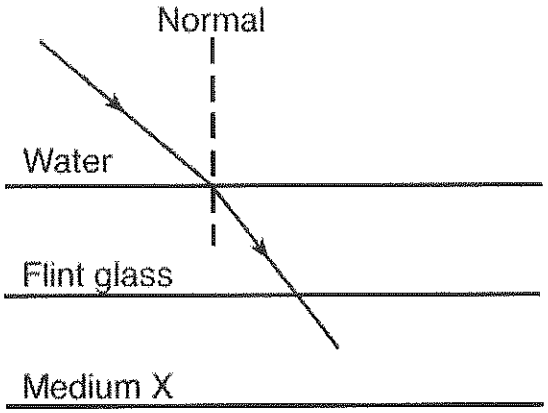
469 Draw the reflected ray on the diagram below. Label the angle of reflection including value of angle



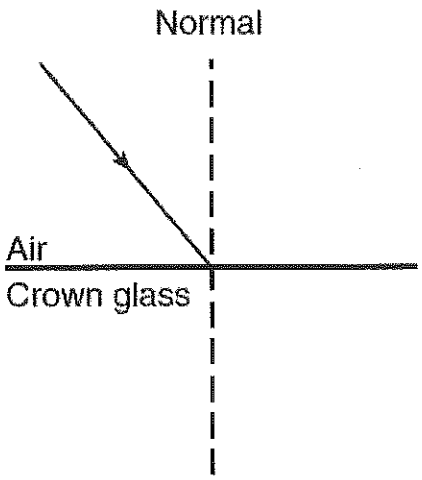
470 Maximum constructive interference occurs when two waves

a) Are in phase
b) Out of phase by 90^0
c) Out of phase by 180^0
d) Out of phase by 45^0

471 What happens to the speed of the light wave as it moves from water to flint glass?



472.



For the light ray to the left

a) Use a protractor to determine the angle of incidence [1]

b) Determine the angle of refraction (show all work including equation, and substitution with units) [2]

c) Draw in the angle of refraction on the diagram at left [1]

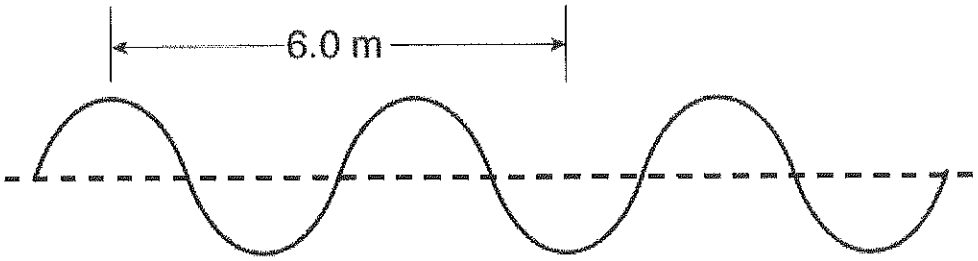
473 A photon with a frequency of 6.0×10^{14} hertz is absorbed by an excited hydrogen atom. This causes the electron to be ejected from the atom, forming an ion.

a) Calculate the energy of this photon in joules. [Show all work, including the equation and substitution with units.] [2]

b) Determine the energy of this photon in electronvolts. [1]

c) What was the initial energy level of the electron before being ejected from the atom by the photon?

474



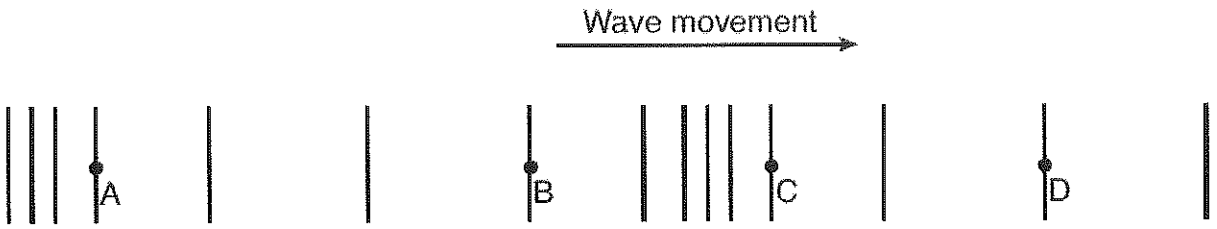
d) For the wave pictured above, determine the wavelength of a single cycle [1]

e) If the entire wave train above took 12 seconds to pass, what is the frequency of the wave? (show work including equation, substitution and units) [2]

f) Determine the speed of the wave (show all work including equation, substitution and units)? [2]

g) What type of wave motion is pictured in the diagram above? [1]

475 A sound wave moving through STP is pictured below.



a) What type of wave motion is represented in the picture above?

b) List two points (by letter) that are one wavelength apart.

c) What is the speed of this wave at STP?

d) What is the speed of this wave in a vacuum?