Key

Waves

Basics (pg 322)

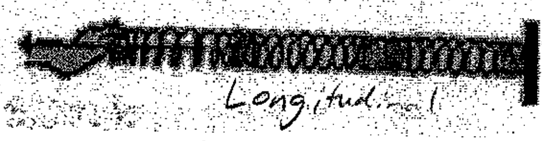
1. [✓ T]/F—Waves are created by a vibration
2. T/[✓ F]—As a wave moves, the individual particles of the medium move from the source of the wave to another location some distance away.
3. [✓ T]/F—Waves transport energy from one location to another without displacing matter from one place to another.
4. What type of wave requires a medium? Mechanical Waves
5. What type of wave is each diagram? What direction does the medium move compared to the wave?

Diagram A

Transverse

medium ↕ ↔ wave

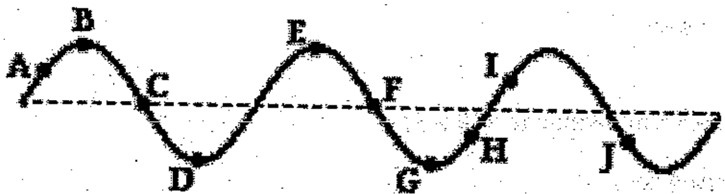
Diagram B



Longitudinal

↔ medium wave

6. Which positions represent crests? Troughs? Neither?

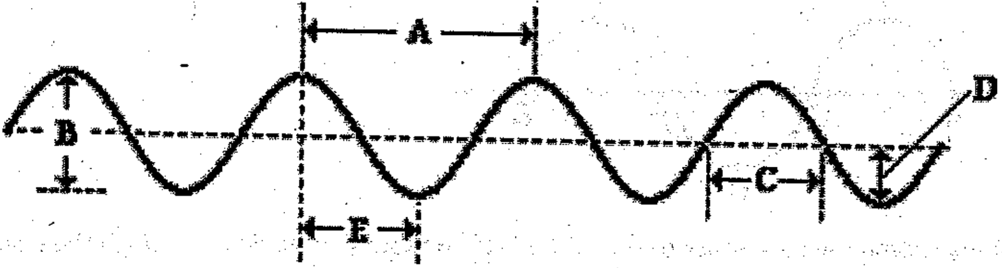


Crests = B, E

troughs = D, G

Neither = A, C F, H, I J

7. Wavelength is letter A and amplitude is letter D.



8. The number of wave cycles per second is called what? What is the unit?

Frequency ; Hz or sec^{-1}

9. What equation relates velocity, frequency, and wavelength? What equation relates frequency and period?

$V = f \cdot \lambda$

$f = \frac{1}{T}$

10. What does the term "period" mean in regards to waves?

Time for 1 complete wave

11. A pendulum makes 60 vibrations in 30 seconds. Calculate its period.

$f = \frac{60}{30} = 2\text{ Hz} = \frac{1}{T}$ $\boxed{T = 0.5\text{ sec}}$

12. A girl rides a swing in the park. She goes back and forth once every 5.0 seconds.

   a. 5.0 seconds is her... Period

   b. Her frequency is... 0.2 Hz

   c. As the frequency of a wave increases, the period... Decreases

13. Waves on a lake are 6m apart. A wave passes your boat every 2 seconds.

   a. What is the frequency of the waves?

   $\frac{1\text{ wave}}{2\text{ sec}} = 0.5\text{ Hz}$

   b. What is the speed of the waves?

   $V = \lambda \cdot f$ $v = (6)(0.5) = \boxed{3\text{ m/s}}$

14. Radio waves have a frequency of 103.5 MHz.

   a. What are their wavelengths? $103.5\times10^6\text{ Hz}$

   $3\times10^8 = (103.5\times10^6)\lambda$ $\boxed{\lambda = 2.9\text{ m}}$

   b. What is the period of the waves?

   $T = \frac{1}{F} = \frac{1}{103.5\times10^6} = \boxed{9.66\times10^{-9}\text{ sec}}$

15. The wave below has a period of 0.5 s and velocity of 8 m/s.

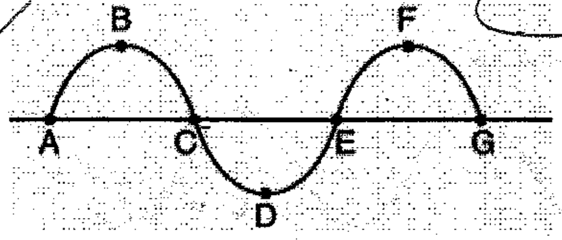
   a. What is the distance from A to E? $8 = \lambda(2)$ $\boxed{4\text{m} = \lambda}$

   b. C to E? $\boxed{2\text{m}}$

$T = \frac{1}{f}$

$0.5 = \frac{1}{f}$

$f = 2\text{ Hz}$



16. A stationary submarine uses sonar to send a 1.18×10^3 Hz sound wave down through the ocean water. The sound wave reflects off the flat ocean bottom 324 m below and is detected 0.425sec after it was sent.

   a. Calculate the speed of the sound wave.

   $V = \frac{d}{t} = \frac{324(2)}{0.425\text{ sec}} = \boxed{1524.7\text{ m/s}}$

   b. Calculate the wavelength of the sound wave.

   $1524.7 = \lambda(1.18\times10^3)$

   $\boxed{1.29\text{m} = \lambda}$

   c. Determine the period of the sound wave.

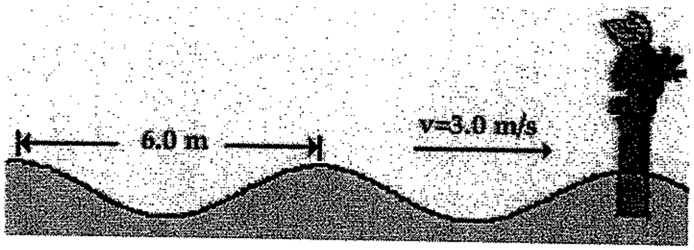
   $T = \frac{1}{f} = \frac{1}{1.18\times10^3} = \boxed{8.5\times10^{-4}\text{ sec}}$

17. A fisherman is using a fish finder (sonar). The sound wave travels at 1200 m/s through the water, and returns in 0.020 seconds. How deep is the lake?

$1200 = \frac{d}{0.01 \text{ sec}}$

$d = 12m$

18. The waves are moving at 3.0 m/s. Each crest is 6.0 meters apart. How long does the bird have between each splashing?

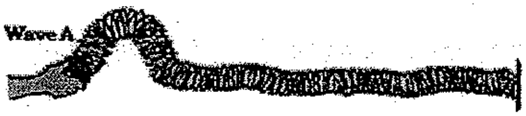


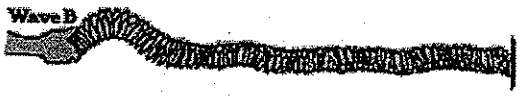
$3 = 6(f)$

$0.5 \text{ Hz} = f$

$T = 2 \text{ sec}$

19. Which pulse will take the least time to reach the wall, and why?





Same ; Same slinky

20. As the wavelength of a wave increases, its speed will... Stay constant (if mechanical)

21. As wavelength of a wave increases, its frequency will... decrease (if mechanical)

22. Wave speed depends on: (mechanical waves only)

[✓ a.] The properties of the medium

b. Wavelength

c. Frequency

d. Both b and c

23. Two boats are anchored 8.0 meters from each other. They bob up and down and return to their normal position every 10 seconds. They rise 8.0 meters between their lowest and highest points. When one is up, the other is down. There aren't any crests between them. Determine the period, frequency, wavelength, amplitude, and speed of the waves.

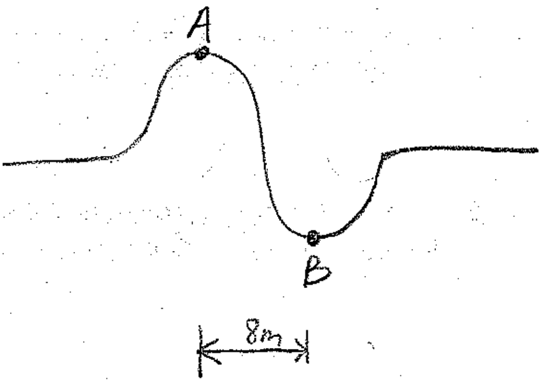
$T = 10 \text{ sec}$

$f = 0.1 \text{ Hz}$

$A = 4m$

$V = 1.6 \text{ m/s}$

$\lambda = 16 m$



24. Convert the following frequencies into periods

  a. $\frac{1}{340\text{ Hz}}$ = 0.0029 sec

  b. 20 cycles /sec 0.05 sec

  c. 0.33 s^{-1} 3.03 sec

25. A tuning fork's tines vibrate 250 times in 2.0 sec. Find

  a. The frequency of vibration

  $\frac{250}{2} =$ 125 Hz

  b. The period of vibration

  $\frac{1}{125} =$ 0.008 sec

26. The frequency of a tuning fork is 1000 Hz. If the wavelength is 35 cm, find the speed of the sound wave in

  a. m/s $v = (1000)(.35) =$ 350 m/s

  b. km/hr $\frac{350\text{ m}}{1\text{ s}} \times \frac{1\text{ Km}}{1000\text{ m}} \times \frac{3600\text{ s}}{1\text{ hr}} =$ 1260 Km/hr

27. if λ/4 is 0.85m and the frequency is 125 Hz, find

  a. the wavelength 3.4 m

  b. the period of the wave 0.008 sec

  c. the velocity of the wave $v = (125)(3.4) =$ 425 m/s

28. A source with a frequency of 20 Hz produces water waves that have a wavelength of 3.0 cm. What is the speed of the waves?

  $v = (0.03)(20) =$ 0.6 m/s

29. An FM station broadcasts radio signals with a frequency of 99.5 MHz. If these radio waves move at $3\text{x}10^8$ m/s, what is their wavelength?

  $3\times10^8 = \lambda(99.5\times10^6)$ $\lambda = 3.02$ m

30. You are shouting in a monotone voice with a frequency of 440 Hz. Your friend is 300 m away. If the speed of sound is 344 /s, how many wavelengths occur between you and your friend?

  $344 = 440\,\lambda$

  $0.782\text{ m} = \lambda$

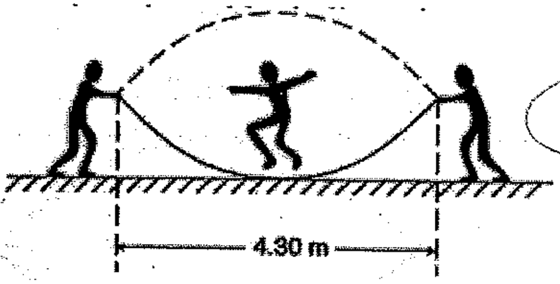
  $\frac{300\text{ m}}{0.782\text{ m}} =$ 383.7 λ

Standing Waves (pg 334 & 355)

31. What is a standing wave? What causes them? → Interference

Pattern formed by constant interference of 2 waves
↳ appears not to move

32. While playing, two children create a standing wave with a rope. A third person jumps. What is the wavelength of the wave?

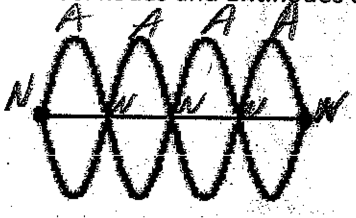


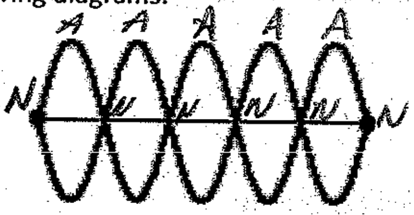
$\lambda=86$ m

33. The positions along the medium that appear stationary are called nodes.

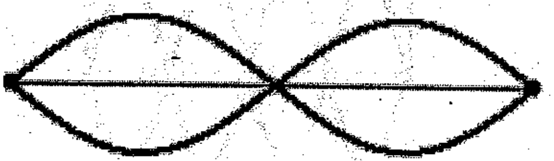
34. The positions along the medium where maximum displacement is occurring are called Antinodes.

35. Label nodes and antinodes on the following diagrams:

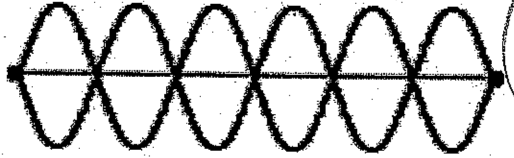




36. How many nodes/antinodes are in the following?



3N
2A



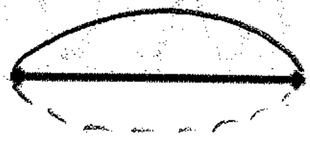
7N
6A

37. How many wavelengths apart are nodes on a standing wave?

1/2

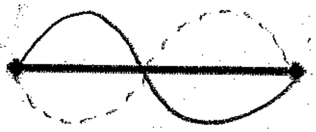
38. Draw the standing waves on the strings below:

1st Harmonic



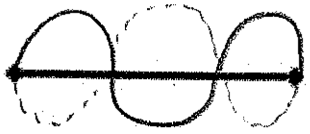
L = 1/2 λ

2nd Harmonic



L = 1 λ

3rd Harmonic



L = 3/2 λ

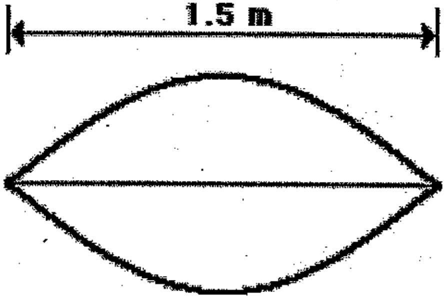
39. If the strings in the previous problem are 1.5 meters long, determine the wavelength in each string.

1st : 3m

2nd : 1.5m

3rd : 1m

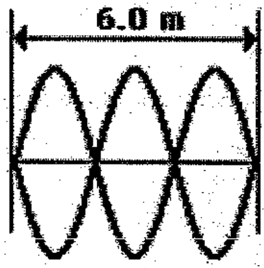
40. The string vibrates 33 cycles in 10 seconds. Find the frequency, period, wavelength, and speed of the wave.



f= 3.3 Hz λ= 3.0 m

T= 0.303 sec V= 9.9 m/s

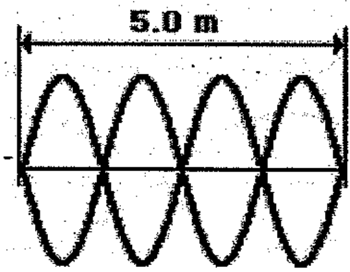
41. The string vibrates 45 cycles in 10 seconds. Find the frequency, period, wavelength, and speed of the wave.



f= 4.5 Hz λ = 4 m

T= 0.22 sec V= 18 m/s

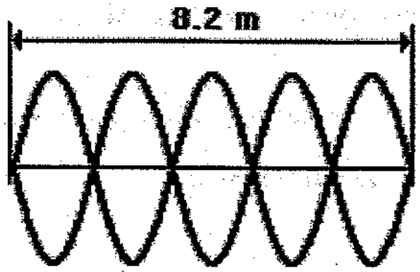
42. The string vibrates 48 cycles in 20 seconds. Find the frequency, period, wavelength, and speed of the wave.



f= 2.4 Hz λ = 2.5 m

T= 0.417 sec v = 6 m/s

43. The string vibrates 21 cycles in 5 seconds. Find the frequency, period, wavelength, and speed of the wave.



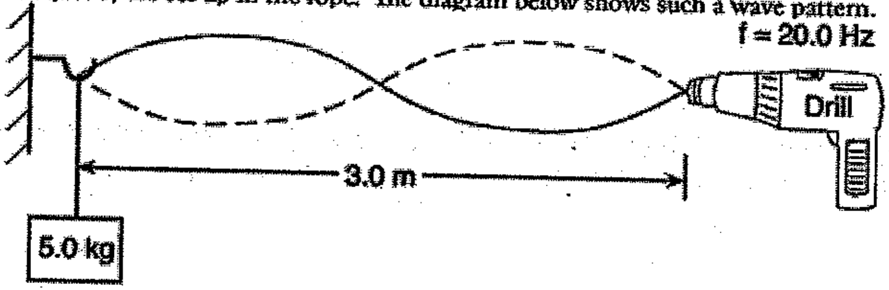
f = 4.2 Hz λ = 3.28m

T= 0.238 sec

V= 13.8 m/s

$v = \sqrt{\frac{T}{\mu}}$ $f_1 = \frac{\sqrt{\frac{T}{\mu}}}{2L}$

44. 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.



Determine the wavelength and speed of the waves.

$\boxed{\lambda = 3m}$ $\boxed{V = 60\ m/s}$

45. The speed of waves in a particular guitar string is 425 m/s. Determine the fundamental frequency (1st harmonic) of the string if its length is 76.5 cm.

$\lambda = (2)(.765) = 1.53m$

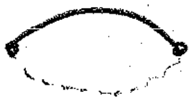
$425 = f(1.53)$

$\boxed{277.8Hz = f}$

46. Determine the length of guitar string required to produce a fundamental frequency of 256 Hz. The speed of the waves in the string are 405 m/s.

$405 = 256\ \lambda$

$1.58m = \lambda$



$\frac{1.58}{2}$ $\boxed{0.79m}$

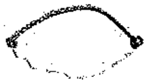
47. Why do females typically have higher pitched voices than males?

Shorter, thinner vocal cords

48. Why do bass guitars have lower pitches than regular guitars?

longer, thicker, looser strings

49. A guitar string with a length of 80.0 cm is plucked. The speed of the wave in the string is 400 m/s. Calculate the frequencies of the first, second, and third harmonics.



$\lambda = 1.6m$

$400 = (1.6)f$

$\boxed{250Hz = f_1}$ $\boxed{f_2 = 500Hz}$ $\boxed{f_3 = 750\ Hz}$

50. A pitch of Middle D (first harmonic = 294 Hz) is created by a 70.0 cm guitar string. Calculate the speed of the standing wave of the string.

$\lambda = 1.4m$

$V = (294)(1.4)$

$\boxed{V = 411.6\ m/s}$

51. The first harmonic of a vibrating guitar string is at 587 Hz (pitch D5). The waves are moving at 600 m/s. How long is the string?

$600 = 587\lambda$

$1.02m = \lambda$

String: $\frac{1.02}{2} = \boxed{0.501\ m}$

52. Waves propagate along a stretched string at 8.0 m/s. The end of the string vibrates up and down once every 1.5 seconds. What is the wavelength of the waves?

↳ T

$\frac{1}{1.5} = f = 0.67Hz$

$8 = (0.67)\lambda$

$\boxed{12m = \lambda}$

53. A 2.0 m string is stretched with a tension of 5.0 N. If the speed of the wave produced in the string is 7.0 m/s, what is the mass of the string?

$7 = \sqrt{\frac{5}{\frac{m}{2}}}$

$49 = \frac{5}{\frac{m}{2}}$

$\boxed{m = 0.204\ Kg}$

54. A string has a mass of 0.25 kg and a length of 4.0 m. What is the speed of the wave produced in the string if there is a tension of 6.7 N?

$V = \sqrt{\frac{6.7}{\frac{.25}{4}}} = \boxed{10.35\ m/s}$

55. A wave with a frequency of 50 Hz and a wavelength of 1.5 m is produced in a string. What is the tension in the string if the linear density of the string is 0.8 kg/m?

$V = (50)(1.5)$

$V = 75\ m/s$

$75 = \sqrt{\frac{T}{0.8}}$

$\boxed{T = 4500\ N}$

56. What is the length of a string that has a mass of 50.0 g and produces a wave speed of 45 m/s when there is a force of 80.0 N applied to it?

$45 = \sqrt{\frac{80}{\frac{0.05}{L}}}$

$\boxed{L = 1.26\ m}$

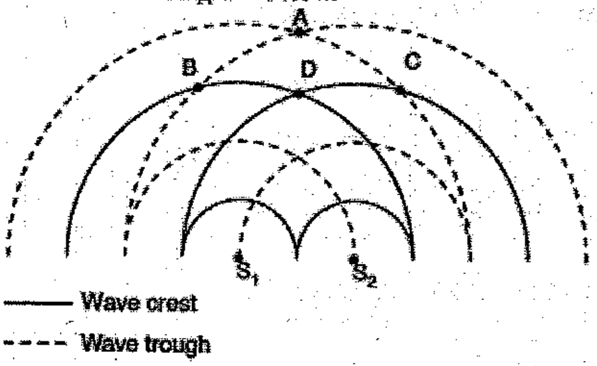
Interference (pg 333 & 362)

57. What is the principle of superposition?

Interference is constructive if the sum is an increased Amplitude & destructive if the sum is a decreased amplitude

58.

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?

1. A and B
[✓ 2. A and D]
3. B and C
4. B and D

59. T/[✓ F]—When two pulses meet up with each other while moving through the same medium, they usually bounce off each other and return to their origin.

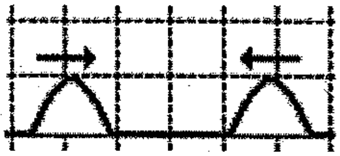
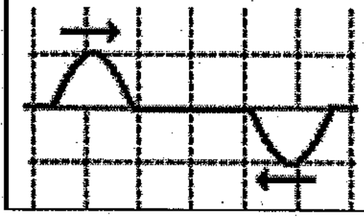
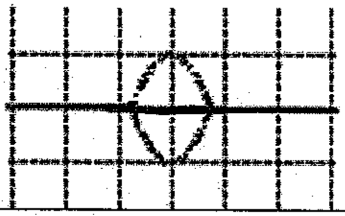
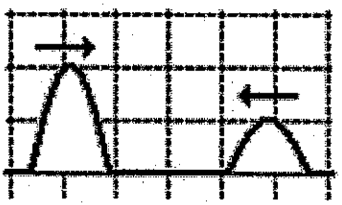
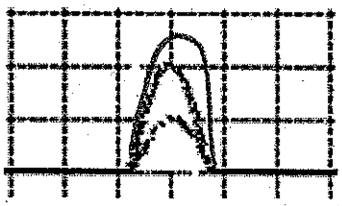
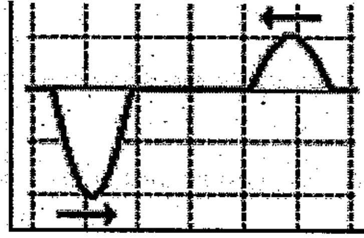
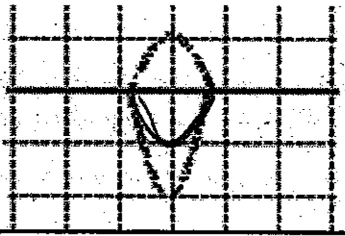
60. [✓ T]/F—Constructive interference happens when a crest meets up with another crest in the same medium.

61. [✓ T]/F—Destructive interference happens when a pulse with an amplitude of +6 units meets a pulse with an amplitude of -6 units.

62. T/[✓ F]—Destructive interference occurs when a trough meets up with another trough.

63. T/[✓ F]—Two sound waves cannot interfere and completely cancel each other out to produce silence.

64. Sketch the resultant during interference:

"Snapshot" of Two Pulses Before and During Interference		Constructive or Destructive?
BEFORE INTERFERENCE 	DURING INTERFERENCE 	C
BEFORE INTERFERENCE 	DURING INTERFERENCE 	D
BEFORE INTERFERENCE 	DURING INTERFERENCE 	C
BEFORE INTERFERENCE 	DURING INTERFERENCE 	D

Sound Basics (pg 347)

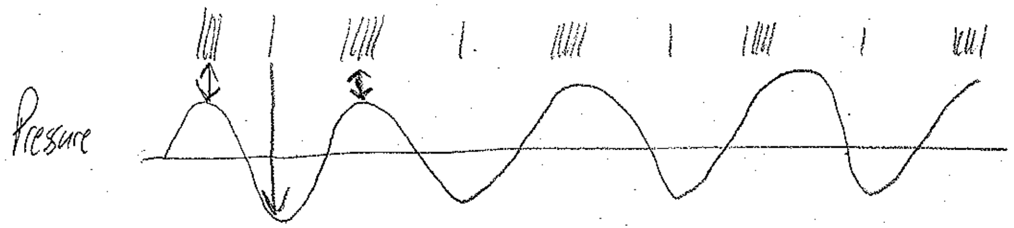
65. [✓ T]/F—Sound waves are longitudinal.

66. T/[✓ F]—As someone speaks, the listener hears the voice because particles of air move from the mouth of the speaker to the ear of the listener.

67. [✓ T]/F—Sound waves are mechanical waves.

68. [✓ T]/F—Sound waves do not have crests and troughs.

they are called compressions and rarefractions



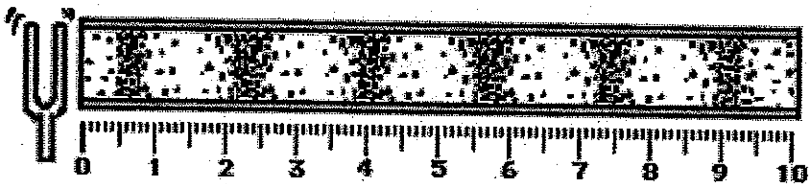
ACEGIK BDFHJ

69. Which letters represent compressions? Rarefractions?

70. In Star Wars, when a ship out in space is shot and blows up, the crew hears the explosion. Why is this incorrect?

No medium in space = no mechanical waves

71. The tuning fork below creates a sound wave with a wavelength of ~1.6 cm.



0.7 2.3

72. Pitch of a sound wave is another term for what variable?

Frequency

73. High pitch sounds have relatively large ________ and small __________.
   - a. Period, wavelength
   - [✓ b. Frequency, wavelength]
   - c. Amplitude, wavelength
   - d. Speed, period
   - e. Period, frequency
   - f. Amplitude, speed

74. As frequency of a sound wave increases, wavelength ______ and period ______.
   - a. Increases, decreases
   - b. Decreases, increases
   - c. Increases, increases
   - [✓ d. Decreases, decreases]

75. The speed of a sound wave depends on ____.
   - a. Frequency
   - b. Amplitude
   - c. Wavelength
   - [✓ d. Properties of the medium]

76. If a person yells (instead of whispers), then
   - a. The air molecules will vibrate more frequently
   - b. The sound will move faster
   - [✓ c. The air molecules will vibrate with a greater amplitude]

77. If a person yells (instead of whispers), then
   - a. The pitch will be higher
   - b. The speed will be faster
   - [✓ c. The sound will be louder]

78. What frequency of sounds are audible to humans? What do we call sounds that are above or below our audible range? $20Hz < X < 20kHz$

↳ infrasonic ↳ Ultrasonic

79. Suggest a possible explanation for why some insects produce a buzzing sound and some do not.

↓ in our audible range

↓ Outside our range

Speed of Sound

80. The speed of sound is generally greatest in [✓ SOLIDS] / LIQUIDS / GASES. Why?

81. When dogs sleep, they usually put their ear on the floor. Why do you think this is so? Is this related to people putting their ear on railroad tracks in old timey western movies?

Sound travels fastest in Solids

82. Explain why sound travels faster in warm air than cold air.

Molecules are moving faster, so collisions happen quicker

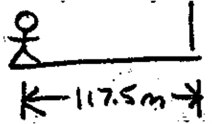
83. What equation relates the speed of sound to air temperature?

$V = 331 + 0.6T$

84. Two sounds that differ in frequency are emitted by a single loudspeaker. Which sound will reach your ear first, the low frequency or high frequency sound? Why?

Same time; Freq. doesn't affect speed

85. The person yells in the 23°C canyon. How long do they wait to hear the echo?



$V = 331 + 23(0.6)$

$V = 344.8 \text{ m/s}$

$344.8 = \frac{(2)(117.5)}{t}$

$\boxed{t = 0.68 \text{ sec}}$

86. The Count sees lightning off in the distance on a hot summer night (28°C). He immediately starts counting, He gets to 7 (ah, ah, ah). About how far away is the lightning?

Thunder

$V = 331 + (0.6)28$

$V = 347.8$

$V = \frac{d}{t}$

$347.8 = \frac{d}{7}$

$\boxed{d = 2434.6 \text{ m}}$

87. What is the wavelength of a sound made by a 256 Hz tuning fork in room HH234 (~21°C)?

$V = 331 + (0.6)(21)$

$V = 343.6 \text{ m/s}$

$343.6 = 256\ \lambda$

$\boxed{1.34\text{m} = \lambda}$

88. A person holds a rifle horizontally and fires at a target. The muzzle speed of the bullet it 200 m/s. The shooter hears the bullet hit the target 1.0 seconds after firing. The temperature is 22°C. How far is the shooter from the target?

$V_{Sound} = 331 + 0.6(22)$

$V_{Sound} = 344.2 \text{ m/s}$

$(200)t = d$

$(344.2)(1-t) = d$

$(344.2)(1-t) = 200t$

$344.2 - 344.2t = 200t$

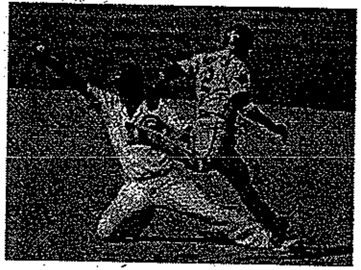
$344.2 = 544.2t$

0.13

$200(0.63) = d$

$\boxed{126.5\text{m} = d}$

89. Challenge:



$V_{Sound} = 331 + (0.6)15 = 340 \text{ m/s}$

On a cool October afternoon (air temperature = 15°C), you are sitting in the stands of Game 7 of the World Series. Your seat is 113 m from first base. With the game tied with two outs, the batter hits a ground ball and there is a play at first base. You see the runner's foot hit the base and 0.5 seconds later you hear the ball hit the first baseman's glove. The umpire signals safe, and the crowd erupts with Booooooo's". Was the call correct? Show work to prove your answer.

$$V = \frac{d}{t} = \frac{113}{t} = 340$$

$t = 0.33 \text{ sec}$

↳ time for sound of ball if it was a tie w/runner

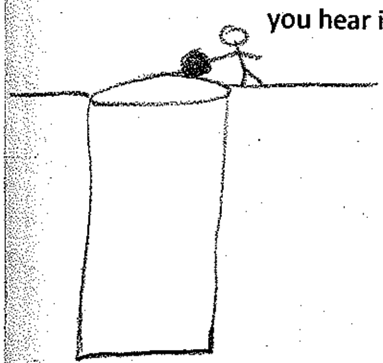
out tie safe

$\# < 0.33 < 0.5$

Good Call

90. Challenge:

You are standing at the top of a tall dark hole in the ground. You are curious to know how deep the hole is. You take a bowling ball and drop it down the hole. You can't see it hit bottom, but you hear it hit 8.0 seconds after dropping it. How deep is the hole? Temp = 26°C.



$\Delta y = v_i t + \frac{1}{2}at^2$

1.) $\Delta y = \frac{1}{2}(9.8)t^2$

2) $\Delta y = V_s(8-t)$

$V_{Sound} = 331 + 0.6(26)$

$V_{Sound} = 346.6 \text{ m/s}$

2.) $\Delta y = 346.6(8-t)$

$\Delta y = \boxed{2772.8 - 346.6t}$

$2772.2 - 346.6t = \frac{1}{2}(9.8)t^2$

$0 = 4.9t^2 + 346.6t - 2772.2$

Quadratic Eqn

$t = 7.25 \text{ sec}$

$\Delta y = (346.6)(8 - 7.25)$

$\boxed{\Delta y = 260 \text{ m deep}}$

Sound Intensity (pg 350)

91. What equation relates sound intensity to sound intensity level?

$$dB = 10 \log\left(\frac{I}{I_0}\right)$$

92. What is the more common term for sound intensity level?

decibels

93. What kind of a scale is the decibel scale? What other quantities in science are measured on these types of scales? What is the benefit of using a scale like this?

Log Scale; PH, earthquake intensity

Compresses a wide range of values into a smaller scale

94. How does sound intensity relate to distance from the sound source?

$$I = \frac{Power}{4\pi r^2}$$

95. What is the threshold of pain? What is the threshold of hearing?

$1\ W/m^2$ $\qquad$ $1\times10^{-12}\ \frac{W}{m^2}$

96. What is the sound intensity level (dB) of a sound with an intensity of 6.0×10^{-6} W/m²?

$$dB = 10 \log \frac{6\times10^{-6}}{1\times10^{-12}}$$

$$\boxed{= 67.78\ dB}$$

97. A clothing factory can have as many as eight commercial machines operating in ~~the~~ one area at the same time. Noise level measurement taken when one machine is operating gave a reading of 75.0 dB.

a. What is the sound intensity of this reading?

$$75 = 10 \log\left(\frac{I}{1\times10^{-12}}\right)$$

$$\boxed{3.16\times10^{-5}\ \frac{W}{m^2} = I}$$

b. How many decibels would the reading be if two machines were operating simultaneously?

$$\begin{array}{r} 3.16\times10^{-5} \\ \times\ 2 \\ \hline 6.32\times10^{-5}\ \frac{W}{m^2} \end{array}$$

$$dB = 10 \log\left(\frac{6.32\times10^{-5}}{1\times10^{-12}}\right)$$

$$\boxed{= 78.01\ dB}$$

c. How many decibels would the reading be if all 8 machines were operating simultaneously?

$$\begin{array}{r} 3.16\times10^{-5} \\ \times\ 8 \\ \hline 2.528\times10^{-4}\ W/m^2 \end{array}$$

$$dB = 10 \log\left(\frac{2.528\times10^{-4}}{1\times10^{-12}}\right)$$

$$\boxed{= 84.03\ dB}$$

98. A music fan at a rock concert is standing only 5.00 m away from loudspeakers and finds the sound painful to her ears. A sound level meter gave a reading of 110 dB.

a. What is the intensity of this sound?

$110 = 10 \log \frac{I}{1\times10^{-12}}$

$\boxed{0.1\ W/m^2 = I}$

b. How far away from the speakers should she stand for the intensity level to be reduced to a more comfortable 100 dB?

$100 = 10 \log \frac{I}{1\times10^{-12}}$

$0.01\ W/m^2 = I$

$I \sim \frac{1}{r^2}$

$\frac{1}{10}^{th}\ I \sim \frac{1}{r^2}$

$r^2 = 10$

$r = 3.16 \times\text{'s}\ 5.0m$

$\boxed{= 15.8m}$

99. What is the intensity of a sound at a distance of 16 feet if it was 0.004 W/m² at 4 feet away?

$I \sim \frac{1}{r^2}$

$I \sim \frac{1}{(4r)^2}$

$I \sim \frac{1}{16}$

$\frac{0.004}{16} = \boxed{2.5\times10^{-4}\ \frac{W}{m^2}}$

100. Two people are talking to you at once. One is quiet (Poythress) at 55 dB. One is loud (Jailyn) at 75 dB. How many decibels do you hear total?

$55 = 10 \log \frac{I}{1\times10^{-12}}$

$3.16\times10^{-7}\ \frac{W}{m^2} = I$

$75 = 10 \log \frac{I}{1\times10^{-12}}$

$3.16\times10^{-5}\ \frac{W}{m^2} = I$

3.16×10^{-7}
$+3.16\times10^{-5}$
3.194×10^{-5}

$dB = 10 \log \left(\frac{3.194e^{-5}}{1\times10^{-12}}\right)$

$\boxed{= 75.04\ dB}$

101. Sound produced by a jet engine measured at a distance of 10m is 95.0 dB.

a. What is the intensity of the sound?

$95 = 10 \log \frac{I}{1\times10^{-12}}$

$\boxed{I = 0.00316\ W/m^2}$

b. What is the power?

$0.00316 = \frac{P}{4\pi(10)^2}$

$\boxed{P = 3.97\ \text{Watt}}$

c. At a distance further away, 65.0 dB is detected. How far from the source is this?

$65 = 10 \log \frac{I}{I_0}$

$3.16\times10^{-6}\ \frac{W}{m^2} = I$

$\frac{1}{1000} \sim \frac{1}{r^2}$

$r^2 = 1000$

$r = 31.62 \times 5$ further

$\boxed{316.2m\ \text{away}}$

"Part Bee" next year ↳

102. One bee makes a sound that is 3 dB. How many bees at that distance would it take to reach the threshold of pain?

$3 = 10 \log \frac{I}{I_0}$

$2\times10^{-12}\ \frac{W}{m^2} = I$

$\frac{1\ W/m^2}{2\times10^{-12}\ \frac{W}{m^2}} = \boxed{5\times10^{11}\ \text{bees}!!}$

Doppler Effect and Sonic Booms (pg 365 &369)

103. What is the Doppler Effect? What equation describes this phenomena?

Apparent shift in frequency that occurs when a source & listener are moving relative to each other.

104. T/[✓ F] Doppler shifts are only observed with sound waves.

105. T/[✓ F] AS the source of a sound approaches an observer, the loudness of the sound increases. This is an example of the Doppler shift? Explain. No; frequency changes = Doppler Effect

106. The police car with its siren on is moving towards Jack and away from Jill.

a. Towards which person do the sound waves travel fastest? Same

b. Who will hear the highest frequency? Jack

107. As a sound source moves towards an observer, the pitch appears to be [✓ **HIGHER**] / **LOWER**.

108. As a sound source moves away from an observer, the pitch appears to be **HIGHER** / [✓ **LOWER**].

109. A parked car's alarm is going off and emitting a 1000 Hz sound. You are out for a jog and as you run towards the car you hear the alarm at 1003 Hz.

a. How fast are you running? $V_{sound} = 343$ m/s.

$$1003 = \left(\frac{343 + V_{obs}}{343 - 0}\right)1000$$

$$\boxed{1{,}029\ m/s = V_{obs}}$$

b. What frequency will you hear after you pass the annoying car and are running away from it?

$$f' = \left(\frac{343 - 1{,}029}{343 + 0}\right)1000$$

$$\boxed{f' = 997\ Hz}$$

110. While standing near a railroad crossing, a person hears a distant train horn. According to the train's engineer, the frequency emitted by the horn is 440Hz. The train is travelling at 20 m/s and the speed of sound is 346m/s.

a. What would be the wavelength of the train's horn if the train were at rest?

Frequency would be 440 Hz

$$346 = 440\lambda$$

$$\boxed{0.786\text{m} = \lambda}$$

b. What would be the wavelength of the train's horn as it approaches a stationary person?

$$f' = \left(\frac{346 + 0}{346 - 20}\right)440 \qquad 346 = 467\lambda$$

$$\boxed{0.74\text{m} = \lambda}$$

$$f' = 467\text{ Hz}$$

111. Westley and Buttercup are standing at the top of a hill. All of a sudden, Buttercup pushes Westley down the hill. Westley shouts "As you wish!!!!!" at a frequency of 500Hz. If Buttercup hears it his voice at 495Hz, how fast is Westley rolling down the hill?

$V_{sound} = 343$ m/s

V_{sound} 343 m/s

$$495 = \left(\frac{343 - 0}{343 + V}\right)500$$

$$0.99 = \frac{343}{343 + V} \qquad \boxed{V = 3.46\text{ m/s}}$$

112. A bat is trying to locate where the wall is in a dark cave. It emits a high frequency sound wave (30,000 Hz). This wave reflects off a wall 15m in front of the bat and returns to it in a total of 0.088 sec. What is the temperature of the cave? What is the wavelength of the bat's signal?

$$V = \frac{d}{t} = \frac{30\text{m}}{0.088\text{sec}} = 340.9\text{ m/s}$$

$$340.9 = 331 + 0.6T \qquad 340.9 = 30{,}000\lambda$$

$$\boxed{16.51°\text{C} = T} \qquad \boxed{0.01136\text{ m} = \lambda}$$

113. On a 20°C day with no wind, the frequency heard by a moving person from a 500 Hz stationary siren is 520 Hz. The person hearing the sound is

[✓ a. Moving towards the siren]
b. Moving away from the siren
c. Stationary relative to the siren

$V_{sound} = 331 + 0.6(20)$

$V_{sound} = 343$ m/s

114. In the previous problem, what is the person's speed?

$$520 = \left(\frac{343 + V}{343 - 0}\right)500$$

$$\boxed{V = 13.72\text{ m/s}}$$

115. A bystander hears a siren vary in frequency from 476 Hz to 404 Hz as a fire truck approaches, passes by, and moves away on a straight street. What is the speed of the truck? V_{sound} = 343 m/s.

See attached sheet

116. A jet flies overhead at a speed of 400 m/s. The speed of sound at that temperature is 341 m/s. What will you hear shortly after it passes?

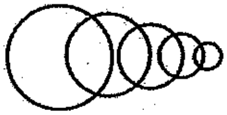
Boom $V > V_{sound}$

117. The pictures below show different sound waves being produced. Place numbers beside the pictures that will order them from the slowest speed to the fastest speed of the sound source.

2 a.


1 c.


3 b.


4 d.


Beats (pg 362)

118. What is a beat and what causes it?

Phenomena created when there is interference between 2 sounds of nearly equal frequency

119. What is the equation to find beat frequency?

$$f_{beat} = |f_1 - f_2|$$

120. A violinist and a pianist simultaneously play notes of frequencies 436 Hz and 440 Hz. What beat frequency will be heard?

4 beats/sec

121. A violinist tuning her instrument to a piano note of 264 Hz detects three beats per second. The violin could be

a. Less than 264 Hz
b. Equal to 264 Hz
c. Greater than 264 Hz
[✓ d. Both a and c]

115) ~~[illegible]~~

2 Equations, 2 unknowns

1) $404 = \left(\frac{343}{343+v}\right) f$

2) $476 = \left(\frac{343}{343-V}\right) f$

$f = \frac{476}{\left(\frac{343}{343-V}\right)}$

$$404 = \left(\frac{\cancel{343}}{343+V}\right)\left(\frac{476}{\frac{\cancel{343}}{343-V}}\right)$$

$$343+V = \frac{(476)(343-V)}{404}$$

$$(404)(343+v) = 163268 - 476v$$

$$138572 + 404V = 163268 - 476v$$

$$880V = 24696$$

$$\boxed{V = 28 \, \text{m/s}}$$

Resonance (pg 322 & 335)

122. What is resonance?

When a system is driven @ one of its natural frequencies & max displacement occurs

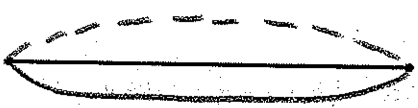
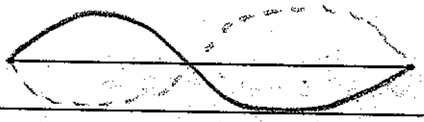
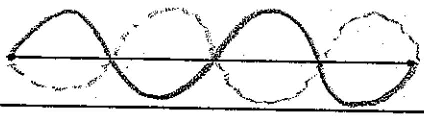
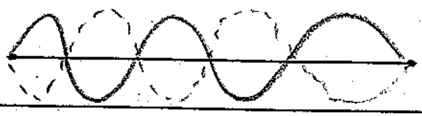
123. How can an opera singer break a wine glass using only his/her voice?

If they sing @ a resonant frequency of the glass -- energy is transferred shaking the glass until it breaks

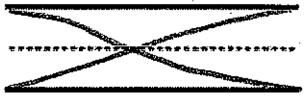
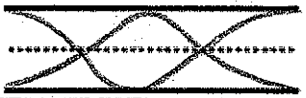
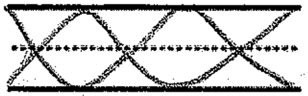
124. When soldiers march across a bridge, they are told not to march in stride with each other. Why?

In case their footsteps are @ the resonant Frequency of the bridge

125. Resonance in strings:

Harmonic #	Standing Wave Pattern	λ —> L	L —> λ
1		L = $\frac{1}{2}$ λ	λ = 2 L
2		L = 1 λ	λ = 1 L
3		L = 1.5 λ	λ = $\frac{2}{3}$ L
4		L = 2 λ	λ = $\frac{1}{2}$ L
5		L = 2.5 λ	λ = 0.4 L

126. Resonance in Open-End Tubes (pg pg 357-360):

Harmonic #	Standing Wave Pattern	λ —> L	L —> λ
1		L = ½ λ	λ = 2 L
2		L = 1.0 λ	λ = 1 L
3		L = 1.5 λ	λ = 2/3 L
4		L = 2.0 λ	λ = ½ L
5		L = 2.5 λ	λ = 0.4 L

127. Calculate the frequency of the

a. 3rd harmonic of an open tube whose 1st harmonic is 384 Hz.

$f_1 = 384$ Hz

$f_3 = 3(f_1) = \boxed{1152 \text{ Hz}}$

b. 1st harmonic of an open tube whose 4th harmonic is 1296 Hz.

$f_4 = 4(f_1) = 1296$

$\boxed{f_1 = 324 \text{ Hz}}$

c. 3rd harmonic of an open tube whose 4th harmonic is 528 Hz.

$f_4 = 4(f_1) = 528$

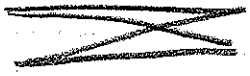
$f_1 = 132$ Hz

$f_3 = 3(f_1) = 3(132)$

$\boxed{f_3 = 396 \text{ Hz}}$

128. A flute is played at the first harmonic of 196 Hz (pitch of G₃). The length of the pipe is 89.2 cm (huge flute). Find the speed of the resonating wave.

1st Harmonic



½ λ

$\lambda = 2L$

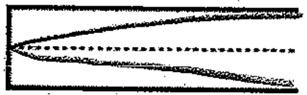
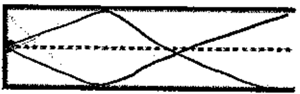
$\lambda = 2(.892) = 1.784$ m

$v = f \cdot \lambda$

$v = (196)(1.784)$

$\boxed{v = 350 \text{ m/s}}$

129. Resonance of Closed-End Tube (pg pg 357-360):

Harmonic #	Standing Wave Pattern	λ → L	L → λ
1		$L = \frac{1}{4} \lambda$	$\lambda = 4\ L$
3		$L = 3(\frac{1}{4}) \lambda$	$\lambda = 4/3\ L$
5		$L = 5(\frac{1}{4}) \lambda$	$\lambda = 4/5\ L$
7		$L = 7(\frac{1}{4}) \lambda$	$\lambda = 4/7\ L$
9		$L = 9(\frac{1}{4}) \lambda$	$\lambda = 4/9\ L$

130. Calculate the frequency of the

a. 3rd harmonic for a closed end tube whose 1st harmonic is 262 Hz.

$f_3 = 3(f_1)$

$f_3 = 786\ Hz$

b. 1st harmonic for a closed end tube whose 5th harmonic is 1700 Hz.

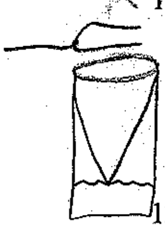
$f_5 = 5(f_1) = 1700$

$f_1 = 340\ Hz$

c. 5th harmonic for a closed end tube whose 3rd harmonic is 984 Hz.

$f_3 = 3(f_1) = 984$ $\qquad$ $f_5 = 5(f_1) = (5)328$

$f_1 = 328\ Hz$ $\qquad$ $f_5 = 1641\ Hz$



131. You have a 356 Hz tuning fork and you hold it above a 25 cm closed end tube. You hear a strong sound (fundamental frequency). What is the temperature of the room?

$25 cm = \frac{1}{4} \lambda$ $\qquad$ $V = (356)(1)$ $\qquad$ $356 = 331 + 0.6 T$

$100 cm = \lambda$ $\qquad$ $V = 356\ m/s$ $\qquad$ $41.7°C = T$

$1m = \lambda$

132. A closed end organ pipe plays its 3rd harmonic at 1100 Hz and its 5th harmonic at 1833 Hz. What is the frequency of the first harmonic?

$f_3 = 3(f_1) = 1100$

$f_1 = 366.7\ Hz$

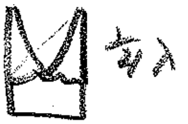
133. A talented musician pours different amounts of water into various bottles and blows across them to make sound. One of the bottles has a first harmonic of 349.2 Hz. V_{sound} = 345 m/s. What is the length of the air column?

$345 = (349.2) \lambda$

$0.99 m = \lambda$

$\div 4$

$0.25 m$



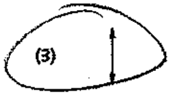
Extra Wave Practice

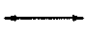
134. Waves transfer energy without transfering matter.

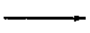
135. A single vibratory disturbance that moves from point to point in a medium is a pulse.

136. A transverse wave moves from left to right through a medium. Which diagram represents the motion of the particles of that medium?

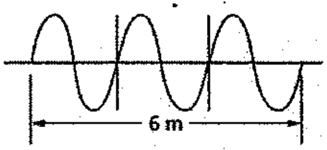
(1)


[✓ (3)]


(2)


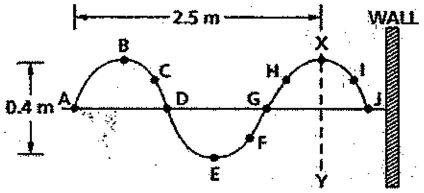
(4)


137. What is the wavelenght?



2m

138. Find the amplitude and wavelength. If a crest passes line XY every 0.4 sec, find the frequency, period, and speed.



A = 0.2m

1.25λ = 2.5

λ = 2m

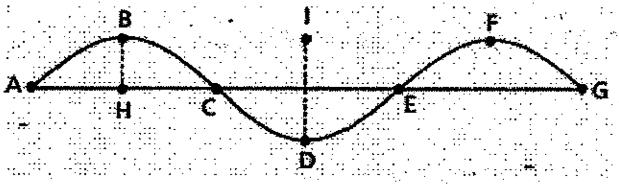
T = 0.4 sec

f = 2.5 Hz

V = (2)(2.5)

V = 5 m/s

139.



a. The amplitude of the wave is from H to B.

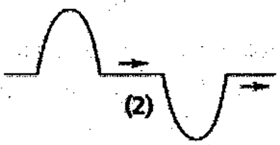
b. How many wavelenghts are shown? 1.5 λ

c. If the period of the wave is 2 seconds, its frequency is 0.5Hz

140. Which pair of moving pulses will produce destructive interference?

(1)

(3)



(2)

[✓ (4)]