Problem Set 19: Waves

Notes

19.1 A student sends a longitudinal wave pulse down a slinky spring which is pulled tightly. It takes 0.850 s for the pulse to travel along the 12.5 m slinky spring. Determine the velocity of sound in the slinky.

19.2 A second student sends a transverse wave down a stretched rope. The student measures the wavelength of the transverse wave and finds it to be 0.662 m. If the student is producing four waves per second, determine the velocity of sound in the rope.

19.3 A tuning fork is producing a frequency of 120 Hz. The speed of sound in the air around the tuning fork is measured to be 346 ms^{-1}. Determine the period and the wavelength of the sound signal.

19.4 Transverse water waves pass the end of a pier at the rate of four crests every 6.45 s. Determine the velocity of the waves if the distance between crests is measured to be 8.00 m.

19.5 A fisherperson has a small float that is moving up and down with the motion of the sea. He is curious as to why the float does not appear to move along with the waves as they move past his float. Explain this observation.

19.6 In a transverse wave the molecules of the medium move in a plane that is 90° to the direction of energy flow. In what plane do the molecules in a longitudinal wave move?

19.7 Water can move in both a transverse and longitudinal at the same time. The Earth after a large seismic event can do the same. Identify which type of wave arrives first and which type usually does the most damage to structures.

19.8 The speed of sound varies with temperature according to the equation $v = 331 + 0.6T$, where v is the speed and T is the temperature in °C. A sound technician finds the speed of sound is 340 m s^{-1} one day and 343 m s^{-1} the following day. If the difference is due to temperature difference only, determine the temperature difference between the two days.

19.9 A radio announcer reminds listeners that the station he works for is broadcasting at 720 kHz. What is the wavelength of the transmission?

19.10 A park has a circular fence around it. The top rail of the fence is a metal pipe. A physics teacher sets a group of students the task of finding the radius of the fence by using their knowledge of sound. One member of the group hits the pipe with a hammer giving a sound of 350 Hz; a second student, standing directly opposite on the other side of the park, detects two sounds, 0.300 s apart. If the speed of sound is 330 m s^{-1} in air and 1310 m s^{-1} in this metal pipe, calculate the radius of the fence.

19.11 If you throw a stone into a still pond, ripples radiate out from where the stone enters the water. A group decides to take some measurements and record the following data to calculate the wavelength, speed and frequency of the ripples. Some five seconds after a stone entered the water, they noted that 42 ripples covered a distance of 2.00 m from where the stone entered the water.
Calculate the:
[a] wavelength [b] speed [c] frequency, of the ripples or waves.

19.12 While sitting on the beach you notice water waves hitting the shore at the rate of one wave every 2.00 s. Calculate:
[a] the frequency of the waves [b] the period of the waves.

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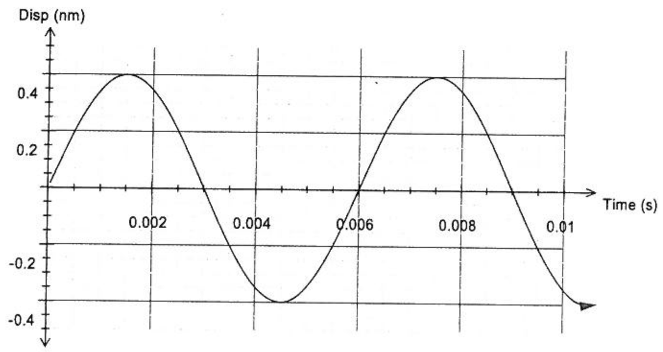
19.13 Draw the displacement vs time graphs for the following sound signals in air. Ensure that you identify the amplitude and the period clearly by selecting an appropriate scale.

[a] A 2.00 Hz sound signal in which the molecules move a maximum of 1.00 mm from their rest positions

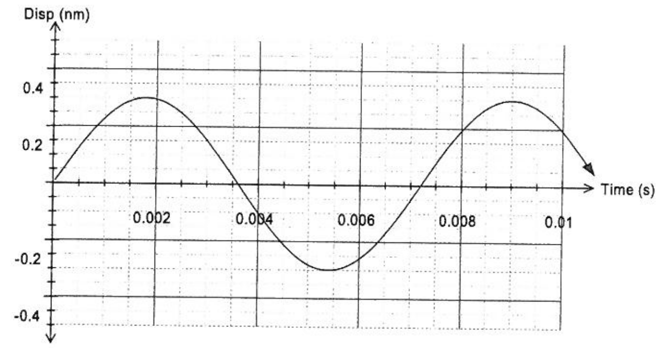
[b] A 5.00 Hz sound signal in which the molecules move a maximum of 2.00 nm from their rest position.

[c] A 0.500 Hz sound signal in which the molecules move a maximum of 5.00 nm from their rest position.

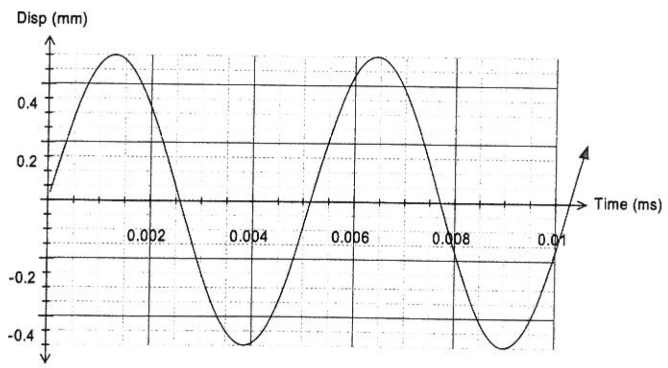
19.14 You are given the following displacement vs time graphs. Determine the period, frequency and amplitude (in nm or mm) for the sound signals, and calculate the wavelength given that the velocity of sound is 339 m s^{-1}.



Signal 1



Signal 2

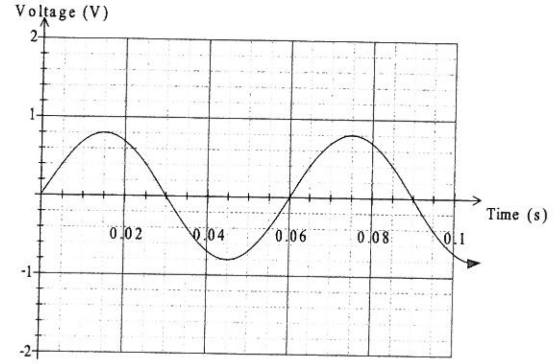


Signal 3

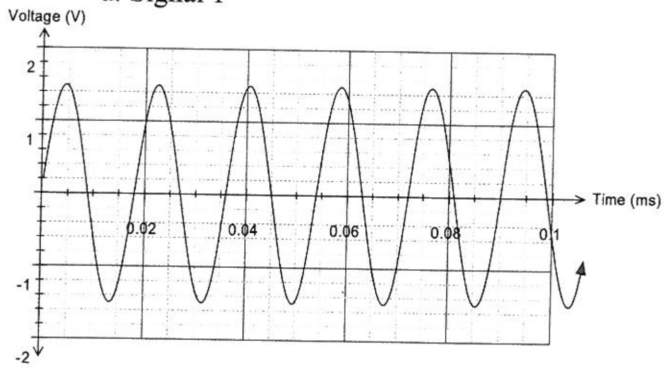
Notes

19.15 When you use a microphone to connect to a digital CRO or other analysis system the signal will often be a sound pressure vs time graph or a simple voltage vs time graph. Explain why this is the case.

19.16 You are given the following voltage vs time graphs for a simple microphone connected to computer running analysis software. Determine the period and frequency of the sound waves, and calculate the wavelength given that the velocity of sound is 349 m s^{-1}.

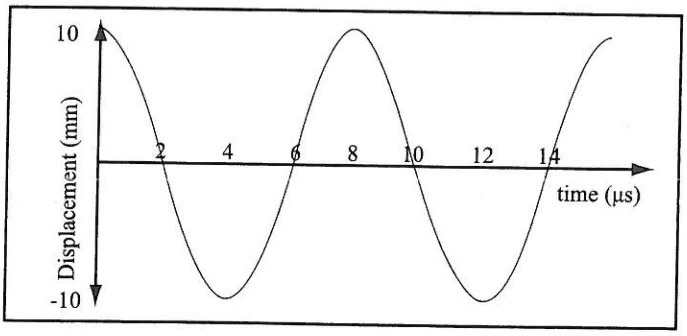


a. Signal 1



b. Signal 2

19.17 The graph below shows how a particle vibrates. You can produce such a wave by using a cathode ray oscilloscope (CRO). Determine the:
[a] amplitude of the wave;
[b] period of the wave; and
[c] frequency of the wave.



19.18 In major athletics events having a staggered start, such as the 400 m race at the Olympics, loudspeakers connected to the starter's gun are placed in each lane just behind each competitor. Explain why this is done.

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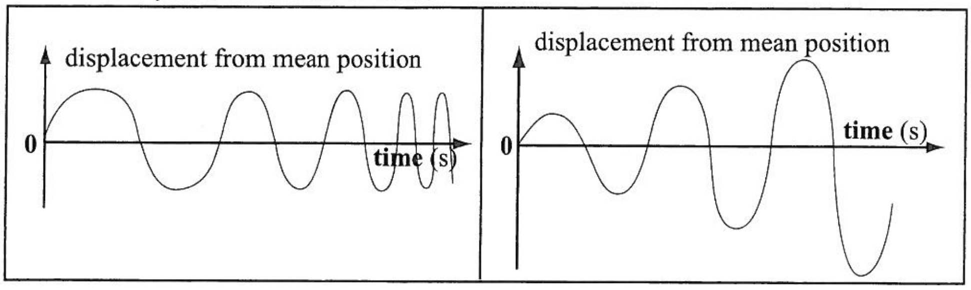
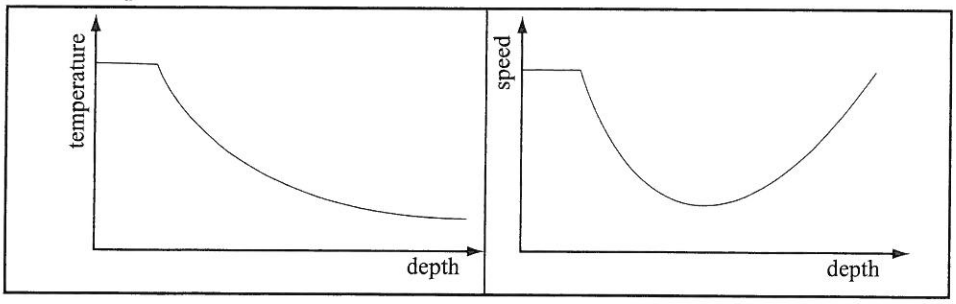
Notes

19.19 The graphs below represent two separate sounds. Describe the nature of the sound you would hear in case.



19.20 If the speed of sound in air is 342 m s^{-1}, calculate wavelength of each of the following frequencies:
[a] middle C, 256 Hz, played on the piano,
[b] the upper limit of a stereo system speaker creating a frequency of 20.0 kHz,
[c] a cat's upper level of hearing, which is 70.0 kHz,
[d] a pigeon's lower level of hearing, which is 0.100 Hz.

19.21 The two graphs below show how the temperature and speed of sound change with depth in the ocean. What is the relationship between the depth of the ocean and speed of sound?



Graphs for question 19.14

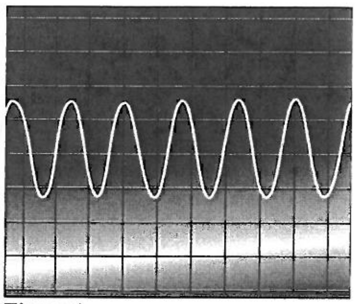


Figure 1

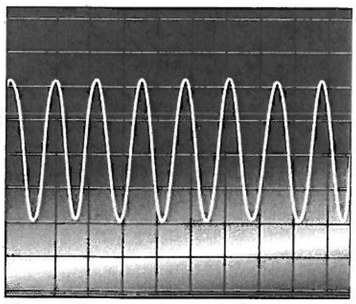


Figure 2

19.22 A group of researchers perform a sensitive experiment. They find that sound travels slightly faster on hot days than on cold days. What is the explanation for this?

19.23 Why do ships and lighthouses usually use low frequency warning sounds?

19.24 The timekeeper in a 100 m race stands at the finish and starts a stopwatch when she hears the noise from the starter's gun.
[a] Why will the time she measures for the race be wrong?
[b] Will the time she measures be too long or too short?
[c] Calculate the error in her time measurement.

19.25 Jane whistles into a microphone connected to a cathode ray oscilloscope. Figure 1 (left)shows the trace on the oscilloscope. George then whistles into the same microphone from the same distance. Figure 2 shows his whistle's oscilloscope trace.
During the experiment the controls on the cathode ray oscilloscope are unaltered.
[a] Who whistles louder?
[b] Whose note has the greater wavelength?
[c] Whose note has the greater frequency?

Set 19

19.1	14.7 m s^{-1}
19.2	2.65 m s^{-1}
19.3	T = 8.33 ms; λ = 2.88 m
19.4	4.96 m s^{-1}
19.8	5 °C
19.9	420 m
19.10	82 m
19.11	[a] 50 mm [b] 0.4 m s^{-1} [c] 8.4 Hz
19.12	[a] 0.5 Hz [b]2 s
19.14	Signal 1: T = 0.0060 s or 6.0 ms; f = 170 Hz; A = 0.40 nm; λ = 2.0 m Signal 2: T = 0.0072 s or 7.2 ms; f = 140 Hz; A = 0.35 nm; λ = 2.4 m Signal 3: T = 0.0026 ms or 2.6 μs; f = 380 kHz; A = 0.50 mm; λ = 0.88 mm
19.16	Signal 1: T = 0.06 s; f = 17 Hz; λ = 21 m Signal 2: T = 0.018 ms; f = 56 kHz; λ = 6.3 mm
19.20	[a) 1.3 m [b] 17 mm [c] 4.9 mm[d] 3.4 km
19.24	[b] too short [c] 0.29 s
19.25	[a] George [b] Jane [c] George

Set 20

20.3	[c] 34 Hz–17 kHz
20.5	[a] (i) 1.9 mm in air (ii) 8.1 mm in water
20.6	72.8 m
20.7	[a] 100 [b] 0.8° [c] 10 scans
20.12	708 Hz
20.13	[a] 512 m s^{-1} [c] 84 Hz, 168 Hz, 262 Hz
20.18	[a] 0.64 m [b] 328 m s^{-1} [c] closed
20.19	[a] violin [b] double bass
20.27	5.87 m
20.29	0.324 m, 0.108 m
20.30	175 Hz
20.31	6.21 Hz