Physics Stage 3: Exploring Physics Set 9 Answers

1. *The speed of sound varies with temperature according to the equation v = 331 + 0.6 T, 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, what was the the temperature difference between the days?*

$\Delta v = 343 - 340 = 3 \text{ m s}^{-1}$

there is a change of 0.6 m s^{-1} for each °C change in temperature

thus temperature change $= \dfrac{3}{0.6} = 5°C$

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

$v = \lambda f$

$$\lambda = \frac{c}{f} = \frac{3.00\times10^{8}}{720\,000} = 417 \text{ m}$$

3. *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, 0.30 s apart. If the speed of sound is 330 m s^{-1} in air and 1310 m s^{-1} in this metal pipe, what is the radius of the fence?*

r is the radius of the fence

the sound travels 2r across the park

this takes $\dfrac{2r}{330}$ s

the sound travels round the pipe

this takes $\dfrac{\pi r}{1310}$ s

the difference in time is $\dfrac{2r}{330} - \dfrac{\pi r}{1310} = 0.30$ s

thus $2r \times 1310 - \pi r \times 330 = 0.30 \times 330 \times 1310$

$2620r - 1037r$

$1583r = 129690$

$r = 82$ m

4. *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 records 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 m from where the stone entered the water. What is*

   a. *the wavelength*

   b. *the speed*

   c. *the frequency*

   of the ripples or waves?

   a. 42 ripples in 2m

      thus $\frac{2}{42}$ m per ripple or λ = 0.048 m

   b. 2 m in 5 seconds

      thus $\frac{2}{5}$ m s^{-1} = 0.4 m s^{-1}

   c. 42 ripples in 5 seconds

      thus $\frac{42}{5}$ = 8.4 Hz

5. *While sitting on the beach you notice water waves hitting the shore at the rate of 1 wave every 2 s.*

   a. *What is the frequency of the waves?*

   b. *What is the period of the waves?*

   a. 1 wave in 2 s
      thus ½ wave in 1 s or f = 0.5 Hz

   b. $T = \frac{1}{f}$ or T = $\frac{1}{0.5}$ = 2 s

6. *The graph below shows how a particle vibrates. You can produce such a wave by using a cathode ray oscilloscope.*

   a. *What is the amplitude of the wave?*

   b. *What is the period of the wave?*

   c. *What is the frequency of the wave?*

   a. amplitude = 10 mm

   b. T = 8 μs

   c. f = $\frac{1}{T}$ = $\frac{1}{8 \times 10^{-6}}$ = 1.25 x 10^5 Hz

7. *In major athletics events 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 in a staggered start. Why do they do this?*

   The athletes in the outside lanes are some distance from the starter. It will take significant time for the sound of the gun to reach them. This would give an advantage to athletes in the inside lanes who would hear the gun first and start earlier. The louspeakers are close to each athlete and the time delay for the propagation of electromagnetic waves to the speakers is insignificant, thus meaning that each athlete will hear the starter's instructions and gun at the same time.

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

   a. constant loudness (amplitude) but increasing pitch (frequency)

   b. constant pitch (frequency) but increasing loudness (amplitude)

9. *If the speed of sound in air is 342 m s^{-1}, calculate the 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 kHz

   c. a cat's upper level of hearing, which is 70 kHz

   d. a pigeon's lower level of hearing, which is 0.1 Hz

$$c = \lambda f$$

a. $\lambda = \frac{c}{f} = \frac{342}{256} = 1.34\text{ m}$

b. $\lambda = \frac{c}{f} = \frac{342}{20000} = 0.0171\text{ m}$

c. $\lambda = \frac{c}{f} = \frac{342}{70000} = 4.89 \times 10^{-3}\text{ m}$

d. $\lambda = \frac{c}{f} = \frac{342}{0.1} = 3420\text{ m}$

10. *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 the speed of sound?*

The speed of sound initially decreased until it reaches a certain depth then it increases with further depth.
(The speed of sound decreases with decreasing temperature. Thus the early drop in speed with depth is due to the decrease in temperature. The effect of increasing depth is to increase the speed of sound.)

11. *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 of this?*

{On hot days the molecules in the air vibrate and move faster. As sound is transmitted by molecules passing on the sound energy, then sound will travel slightly faster on hot days than on colder days.}

As the temperature increases, so does the speed of the molecules in the air. As a result, the molecules collide more often, and a disturbance (sound) is transmitted more quickly to neighbouring molecules. [Wilson p. 283]

Velocity of sound is inversely proportional to the density of the medium. As the temperature rises the gas becomes less dense causing the velocity of sound to increase.

12. *Why do ships and lighthouses usually use low frequency warning sounds?*

Low frequency sounds have a large wavelength. Waves diffract around objects of sizes equal to or less than the wavelength of the wave. The large wavelength foghorn sound will bend around most objects enabling it to be clearly heard even if there are obstructions.

13. *The timekeeper in a 100 m race stands at the finish and starts the 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 be too long or too short?

c. Calculate the error in her time measurement.

a. It takes time for the sound to travel the 100 m from the gun to the timekeeper.

b. The time measured will be too short because the stopwatch will start late.

c. $t = \frac{s}{v} = \frac{100}{342} =$ 0.29 s

14. *Jane whistles into a microphone connected to a cathode ray oscilloscope. Figure 1 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?

a. George (greater amplitude)

b. Jane (greater wavelength)

c. George (greater frequency)