4.2.1 In Class or Homework Exercise

1. The echo of a ship's foghorn reflected from an iceberg is heard by people on the ship 5.0 s after it is sounded. If the temperature is $-10.0^{o}C$, how far away is the iceberg?
   Since this is an echo, it takes 2.5 s for the sound to reach the iceberg.
   $t = 2.5s$
   $T = -10.0°C$
   $\Delta d = ?$

   $v_s = 331 + 0.59T$
   $= 331 + 0.59(-10.0)$
   $= 325m/s$

   $v = \frac{\Delta d}{t}$
   $325 = \frac{\Delta d}{2.5}$
   $\Delta d = \boxed{810m}$

2. Slurpy the slug and his wife Slinky are out for a sunny Sunday stroll ($25^{o}C$) along the edge of the neighborhood well. Suddenly, a strong wind comes up and blows Slurpy over the edge and into the well. 2.0 s after Slurpy hits the water, Slinky hears a splash. How deep is the well?
   $T = 25°C$
   $t = 2.0s$
   $\Delta d = ?$

   $v_s = 331 + 0.59T$
   $= 331 + 0.59(25)$
   $= 346m/s$

   $v = \frac{\Delta d}{t}$
   $346 = \frac{\Delta d}{2.0}$
   $\Delta d = \boxed{690m}$

3. A man drops a stone into a mine shaft 250.0 m deep. The temperature is $5.0^{o}C$. How many seconds pass (after he releases the stone) before he hears the sound of the stone striking the bottom?
   The stone must fall, and then the sound must come back up.

   Stone
   $\vec{v}_i = 0$
   $\Delta\vec{d} = 250.0$
   $\vec{a} = 9.80m/s^2$
   $t_1 = ?$

   $\Delta\vec{d} = \vec{v}_i t + \frac{1}{2}\vec{a}t_1^{\,2}$
   $250.0 = 0 + \frac{1}{2}(9.80)t_1^{\,2}$
   $t_1 = 7.14s$

Sound

$T = 5.0°C$

$\Delta d = 250.0m$

$t_2 = ?$

$$v_s = 331 + 0.59T$$
$$= 331 + 0.59(5.0)$$
$$= 334m/s$$

$$v = \frac{\Delta d}{t_2}$$
$$334 = \frac{250.0}{t_2}$$
$$t_2 = 0.749s$$

$$t_t = t_1 + t_2$$
$$= 7.14 + 0.749$$
$$= \boxed{7.89s}$$

4. A rifle is fired in a valley having parallel walls. The echo from one wall is heard after 2.0 s and the echo from the other wall is heard 2.0 s after the first. If the temperature is 20.0^oC, how wide is the valley?

   The echo from the wall on one side is heard after 2.0 s, while the echo from the other wall is heard after 4.0 s. It therefore takes the sound 1.0 s to reach the first wall and 2.0 s to reach the second wall – it would take 3.0 s to go across the entire valley.

   $t = 3.0s$

   $T = 20.0°C$

   $\Delta d = ?$

$$v_s = 331 + 0.59T$$
$$= 331 + 0.59(20.0)$$
$$= 343m/s$$

$$v = \frac{\Delta d}{t}$$
$$343 = \frac{\Delta d}{3.0}$$
$$\Delta d = \boxed{1\bar{0}00m}$$

5. The human ear can detect sounds between 20.0 Hz and 20.0 kHz. If the air temperature is 15^oC, what are the wavelengths of sound that the ear can detect?

   $T = 15°C$

   $f_1 = 20.0Hz$

   $f_2 = 20.0kHz = 20\bar{0}00Hz$

   $\lambda_1 = ?$

   $\lambda_2 = ?$

$$v_s = 331 + 0.59T$$
$$= 331 + 0.59(15)$$
$$= 340.m/s$$

$$v = \lambda_1 f_1 \qquad v = \lambda_2 f_2$$
$$340. = \lambda_1 (20.0) \qquad 340. = \lambda_2 (20\overline{0}00)$$
$$\lambda_1 = \boxed{17.0m} \qquad \lambda_2 = \boxed{0.0170m}$$

6. What physical characteristic of a wave would you change to increase the loudness of a sound? To change the pitch?
   The loudness of a sound can be increased by increasing the amplitude of the wave; the pitch can be changed by changing the frequency of the wave.

7. In a science fiction movie, when a spaceship explodes, the vibrations from the sound nearly destroy a nearby spaceship. If you were the science consultant for the movie, what would your advice be for the producer?
   This scenario is not possible. Sound is a mechanical wave and requires a medium to travel. Space is a vacuum, meaning that there is no medium. Sound waves cannot travel through space.

8. During a thunder storm, you hear a boom of thunder 2.4 s after a flash of lightning. How far away was the lightning from you? Assume an air temperature of 23^oC and that the time that it takes the light to reach you is negligible.
   Since we are assuming that the time that it takes for the light to reach us is negligible, we must simply find out how far the sound from the thunder travelled in 2.4 s.
   $T = 23°C$
   $t = 2.4s$
   $\Delta d = ?$

$$v_s = 331 + 0.59T \qquad v = \frac{\Delta d}{t}$$
$$= 331 + 0.59(23) \qquad 345 = \frac{\Delta d}{2.4}$$
$$= 345m/s \qquad \Delta d = \boxed{830m}$$

9. A plane is flying at a speed of Mach 3.4. If the air temperature is 17^oC, what is the speed of the airplane in m/s?

$Mach\# = 3.4$

$T = 17°C$

$v_o = ?$

$$v_s = 331 + 0.59T$$
$$= 331 + 0.59(17)$$
$$= 341 m/s$$

$$Mach\# = \frac{v_o}{v_s}$$
$$3.4 = \frac{v_o}{341}$$
$$v_o = \boxed{1200 m/s}$$

10. A person, with his ear to the ground, sees a huge stone strike the concrete pavement. A moment later two sounds are heard from the impact. One travels in the air ($18^o C$) and the other in the concrete ($30\bar{0}0$ m/s), and they are 1.1 s apart. How far away did the impact occur?

Since the sound travels slower in air, it will take longer to reach the person travelling through the air.

Air

$T = 18°C$

$t_a = t + 1.1$

$\Delta d = ?$

$$v_s = 331 + 0.59T$$
$$= 331 + 0.59(18)$$
$$= 342 m/s$$

$$v_a = \frac{\Delta d}{t_a}$$
$$342 = \frac{\Delta d}{t + 1.1}$$
$$342t + 376 = \Delta d$$

Concrete

$v = 30\bar{0}0 m/s$

$t_c = t$

$\Delta d = ?$

$$v_c = \frac{\Delta d}{t_c}$$
$$30\bar{0}0 = \frac{\Delta d}{t}$$
$$t = \frac{\Delta d}{30\bar{0}0}$$

Solving this system gives

$$342t + 376 = \Delta d$$
$$342\left(\frac{\Delta d}{3000}\right) + 376 = \Delta d$$
$$0.114\Delta d + 376 = \Delta d$$
$$376 = 0.886\Delta d$$
$$\Delta d = \boxed{424m}$$

11. A sound wave travels from the air ($22^{o}C$) to the water (v=1560 m/s). If the wavelength of the sound wave in the water is 2.17 m, what was the wavelength of the sound in the air?

The frequency will be the same in both the water and the air; therefore, we must first find the frequency in the water.

Water

$v = 1560m/s$

$\lambda = 2.17m$

$f = ?$

$$v = \lambda f$$
$$1560 = (2.17) f$$
$$f = 719Hz$$

Air

$T = 22°C$

$f = 719Hz$

$\lambda = ?$

$$v_s = 331 + 0.59T$$
$$= 331 + 0.59(22)$$
$$= 344m/s$$

$$v = \lambda f$$
$$344 = \lambda(719)$$
$$\lambda = \boxed{0.478m}$$