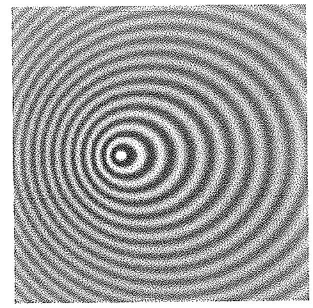
Name: Key



## Practice 17.4 – Doppler Effect

**Equations:**

$$v = 331.3\sqrt{1+\frac{T}{273.15}} \approx 331.3 + 0.606\,T \text{ m/s} \qquad f_o = f_s\frac{v \pm v_o}{v \pm v_s}$$

1. Suppose a train that has a 150-Hz horn is moving at 35.0 m/s in still air on a day when the speed of sound is 340 m/s.
   A. What frequencies are observed by a stationary person at the side of the tracks as the train approaches and after it passes?

Approaching: $f_o = (150\text{ Hz})\frac{340\ \frac{m}{s}}{340 - 35.0\ \frac{m}{s}} = \boxed{167\text{ Hz}}$

Receding: $f_o = (150\text{ Hz})\frac{340\ \frac{m}{s}}{340 + 35.0\ \frac{m}{s}} = \boxed{136\text{ Hz}}$

   B. What frequency is observed by the train's engineer traveling on the train?

$\boxed{150\text{ Hz}}$ There is no relative motion between the horn & the engineer.

2. What frequency is received by a mouse just before being dispatched by a hawk flying at it at 25.0 m/s and emitting a screech of frequency 3500 Hz? Take the speed of sound to be 331 m/s.

Hawk is approaching $\Rightarrow f_o = (3500\text{ Hz})\frac{331\ \frac{m}{s}}{331 - 25.0\ \frac{m}{s}} = \boxed{3.79\times10^3\text{ Hz}}$

3. A car passes through an intersection at $1.00 \times 10^2$ km/hr. If the air temperature is 20.0 °C and the frequency of the car's horn is $3.00 \times 10^2$ Hz, what change in frequency would a stationary observer notice as the car passes? **Note:** $\Delta f = f_{towards} - f_{away}$

$v = 331.3\sqrt{1+\frac{20.0°C}{273.15}} = 343.2\ \frac{m}{s}$

$100\frac{km}{h}\left(\frac{1\text{ h}}{3600\text{ s}}\right)\left(\frac{1000\text{ m}}{1\text{ km}}\right) = 27.78\ \frac{m}{s}$

Towards: $f_o = (3.00\times10^2\text{ Hz})\frac{343.2\ \frac{m}{s}}{343.2 - 27.78\ \frac{m}{s}} = 326.4\text{ Hz}$

Away: $f_o = (3.00\times10^2\text{ Hz})\frac{343.2\ \frac{m}{s}}{343.2 + 27.78\ \frac{m}{s}} = 277.5\text{ Hz}$

$\Delta f = \boxed{48.9\text{ Hz}}$

4. Two police cars pass each other, both moving at 80.0 km/hr. The air temperature is 25.0 °C. If each car sounds its siren with a frequency $4.00 \times 10^2$ Hz, what change in frequency will be heard by each policeman as the cars pass?

$$V = 331.3\sqrt{1 + \frac{25.0}{273.15}} = 346.1\ \frac{m}{s} \qquad 80\frac{km}{h}\left(\frac{1h}{3600}\right)\left(\frac{1000m}{1km}\right) = 22.22\frac{m}{s}$$

$$\text{Toward: } f_o = 400Hz\left(\frac{346.1 + 22.22\frac{m}{s}}{346.1 - 22.22\frac{m}{s}}\right) = 454.9\ Hz$$

$$\text{Away: } f_o = 400Hz\left(\frac{346.1 - 22.22\frac{m}{s}}{346.1 + 22.22\frac{m}{s}}\right) = 351.7\ Hz$$

$$\Delta f = \boxed{103\ Hz}$$

5. A sound meter at a race track records the frequency of the exhaust of an approaching race car to $6.00 \times 10^2$ Hz. The actual frequency is known to be $5.30 \times 10^2$ Hz. The air temperature is 20.0 °C. How fast is the car going?

$$V = 331.3\sqrt{1 + \frac{20.0}{273.15}} = 343.2\ \frac{m}{s}$$

$$f_o = f_s\frac{V}{V - V_s} \Rightarrow \frac{f_o}{f_s} = \frac{V}{V - V_s} \Rightarrow V - V_s = \frac{V}{f_o/f_s} \Rightarrow V_s = V - \frac{V}{f_o/f_s}$$

$$V_s = V\left(1 - \frac{f_s}{f_o}\right) = 343.2\left(1 - \frac{530}{600}\right) = \boxed{40.0\frac{m}{s}}$$

6. A sound meter records the exhaust frequency of a receding race car to be $4.00 \times 10^2$ Hz. The actual frequency is $4.50 \times 10^2$ Hz. If the air temperature is 15.0 °C, how fast is the car going?

$$V = 331.3\sqrt{1 + \frac{15.0}{273.15}} = 340.3\ \frac{m}{s}$$

$$f_o = f_s\frac{V}{V + V_s} \Rightarrow V + V_s = \frac{V}{f_o/f_s} \Rightarrow V_s = V\left(\frac{f_s}{f_o} - 1\right)$$

$$V_s = 340.3\frac{m}{s}\left(\frac{450}{400} - 1\right) = \boxed{42.5\frac{m}{s}}$$