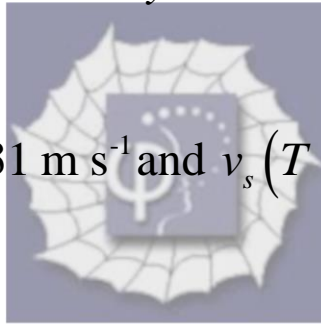


162.

**Problem 20.71 (RHK)**

*A police car sounding its siren is moving at  $27 \text{ m s}^{-1}$  and approaching a stationary pedestrian. The police in the car hear the siren at 12.6 kHz but the pedestrian hears the siren at 13.7 kHz. We have to find the air temperature. (We can assume that the speed of sound increases linearly with temperature between  $0^\circ$  and  $20^\circ \text{ C}$ ).*

$$(v_s(T = 0^\circ \text{ C}) = 331 \text{ m s}^{-1} \text{ and } v_s(T = 20^\circ \text{ C}) = 343 \text{ m s}^{-1})$$



**Solution:**

From the data we will calculate the speed of sound in air and from the speed we will find the temperature of air.

Speed of the police car,  $v_{police} = 27 \text{ m s}^{-1}$ .

Frequency of the police siren,  $f = 12.6 \times 10^3 \text{ Hz}$ .

Frequency of the siren as heard by the stationary pedestrian,  $f_{ped} = 13.7 \times 10^3 \text{ Hz}$ .

Let the speed of sound be  $v_s$ .

Relation between the frequencies is given by the Doppler shift relation

$$f_{ped} = f \frac{v_s}{v_s - v_{police}},$$

or

$$13.7 \times 10^3 = 12.6 \times 10^3 \frac{v_s}{v_s - 27 \text{ m s}^{-1}}.$$

From this equation, we get

$$v_s = 336.27 \text{ m s}^{-1}.$$

We will next calculate the coefficient of linear variation of speed of sound with temperature,  $\alpha$ . We will use the data

$$v_s(T = 0^\circ \text{ C}) = 331 \text{ m s}^{-1}$$

and

$$v_s(T = 20^\circ \text{ C}) = 343 \text{ m s}^{-1}.$$

Let us assume linear variation of  $v_s$  with temperature.

$$v_s(T) = v_s(0^\circ) + \alpha T,$$

and

$$343 = 331 + \alpha \times 20.$$

This gives

$$\alpha = \frac{12}{20} \text{ m s}^{-1} \text{ per } ^\circ\text{C}.$$

Speed of sound of  $336 \text{ m s}^{-1}$  will be at the air temperature  $T$ ,

$$T = \frac{5.27 \times 20}{12} = 8.78^\circ\text{C}.$$

