Answer on Question 49809, Physics, Mechanics | Kinematics | Dynamics

Question:

The temperature outside is $0^{\circ}C$ when you are watching a football game. The referee blows his whistle when he is 110 meters away from your seat. How long does it take before you hear this whistle? How long would it take if the temperature was $35^{\circ}C$ and it had to travel the same distance?

Solution:

Let's calculate the speed of sound in air:

$$c = \sqrt{\gamma \cdot \frac{R \cdot T}{M}},$$

where c is the speed of sound, γ is the adiabatic index, for air $\gamma = 1.402$, $R = 8.3145 \frac{J}{mol \cdot K}$ is the molar gas constant, T is the temperature in Kelvin, $M = 0.0289645 \frac{kg}{mol}$ is the molar mass for air.

So, the speed of sound in air at $0^{\circ}C$ would be:

$$c_{0^{\circ}C} = \sqrt{\frac{1.402 \cdot 8.3145 \frac{J}{mol \cdot K} \cdot 273.15K}{0.0289645 \frac{kg}{mol}}} = 331.56 \frac{m}{s}.$$

We can obtain the time that sound take before we hear this whistle:

$$t_{0^{\circ}C} = \frac{s}{c_{0^{\circ}C}} = \frac{110m}{331.56 \frac{m}{s}} = 0.33s.$$

Similarly, we can obtain the time that sound take before we hear this whistle at temperature $35^{\circ}C$:

$$c_{35^{\circ}C} = \sqrt{\frac{1.402 \cdot 8.3145 \frac{J}{mol \cdot K} \cdot 308.15K}{0.0289645 \frac{kg}{mol}}} = 352.16 \frac{m}{s}.$$

$$t_{35^\circ C} = \frac{s}{c_{35^\circ C}} = \frac{110m}{352.16\frac{m}{s}} = 0.31s.$$

Answer:

a) $t_{0^\circ C} = 0.33s.$

b) $t_{35^\circ C} = 0.31s.$