Analog Assignment

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Question :

A train, standing in a station yard, blows a whistle of frequency 400 Hz in still air. The wind starts blowing in the direction from the yard to the station with a speed of 10 m/s. What are the frequency, wavelength, and the speed of sound for an observer standing on the station's platform? Is the situation exactly identical to the case when the air is still and the observer runs towards the yard at a speed of 10 m/s? The speed of sound in still air can be taken as 340 m/s.

Solution :

For the stationary observer:

$$\text{Frequency of the sound produced by the whistle, } v = 400\,\text{Hz} \tag{1}$$

$$\text{Speed of sound} = 340\,\text{m/s} \tag{2}$$

$$\text{Velocity of the wind, } v = 10\,\text{m/s} \tag{3}$$

As there is no relative motion between the source and the observer, the frequency of the sound heard by the observer will be the same as that produced by the source, i.e., 400 Hz.

The wind is blowing toward the observer. Hence, the effective speed of the sound increases by 10 units, i.e.,

$$\text{Effective speed of the sound, } v_e = 340 + 10 = 350\,\text{m/s}$$

The wavelength (λ) of the sound heard by the observer is given by the relation:

$$\lambda = \frac{v_e}{v} = \frac{350}{400} = 0.875\,\text{m}$$

For the running observer:

$$\text{Velocity of the observer, } v_o = 10\,\text{m/s} \tag{4}$$

$$\text{Change in frequency, } v' = \frac{v_e}{v} \cdot v_o + v \tag{5}$$

$$= \frac{350}{340} \cdot 10 + 400 \tag{6}$$

$$\approx 411.76\,\text{Hz} \tag{7}$$

Table 1: Summary of Parameters

Parameter	**Description**	**Value**
(v)	Sound frequency	400 Hz
(c)	Speed of sound in air	340 m/s
(v)	Wind velocity	10 m/s
(v_e)	Effective speed of sound	350 m/s
(λ)	Wavelength of the sound wave	0.875 m
(v_o)	Observer's velocity	10 m/s
(v')	Frequency change	411.76 Hz