Question. An alert physics student stands beside the tracks as a train rolls slowly past. He notes that the frequency of the train whistle is $489 Hz$ when the train is approaching him and $473 Hz$ when the train is receding from him. Using these frequencies, he calculates the speed of the train. What value does he find? (Assume the speed of sound in air is $343 m/s$).

Given. $\nu_1 = 489 Hz$; $\nu_2 = 473 Hz$; $v = 343 m/s$.

Find. $u - ?$

Solution.

According to the Doppler effect:

the train is approaching the student

$$\nu_1 = \nu_0 \frac{1}{1 - \dfrac{u}{v}}$$

the train is receding from the student

$$\nu_2 = \nu_0 \frac{1}{1 + \dfrac{u}{v}}.$$

We have

$$\frac{\nu_1}{\nu_2} = \frac{1 + \dfrac{u}{v}}{1 - \dfrac{u}{v}} \Rightarrow \frac{\nu_1}{\nu_2} = \frac{v + u}{v - u} \Rightarrow v\left(\nu_1 - \nu_2\right) = u\left(\nu_1 + \nu_2\right).$$

Finally

$$u = v \frac{\nu_1 - \nu_2}{\nu_1 + \nu_2} = 343 \cdot \frac{489 - 473}{489 + 473} = 5.7 m/s.$$

Answer. $u = 5.7 m/s$.