Doppler effect

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Solution: *a. In the system where the air is at rest the speaker is moving away with the speed v. Therefore, the frequency that would be perceived by a listener moving along with the wind is,*

$$f_{medium} = \frac{f_0}{1+v/c} \ .$$

In the system where the air is at rest the microphone is moving away in the same direction as the speaker with the speed $u - v < 0$. Hence,

$$f_{micro} = f_{medium}\left(1 - \frac{u-v}{c}\right) = f_0 \frac{1-(u-v)/c}{1+v/c} = f_0\left(1 + \frac{-u/c}{1+v/c}\right) \ .$$

Alternatively, we calculate the Doppler shift first disregarding the wind,

$$f_{rep} = f_0\left(1 - \frac{u}{c}\right) \ ,$$

and transforming to the wind system by, $c \to c + v$, giving the same result,

$$f = f_0\left(1 - \frac{u}{c+v}\right) \ .$$

b. (i) With the microphone fixed to the ground $u = 0$, we observe $f = f_0$.
(ii) In case where the microphone reaches the wind speed, $u = v$, we observe $f = f_0 \frac{1}{1+v/c}$, which is the Doppler effect of a moving source.
(iii) Without wind $v = 0$ but with a microphone velocity u we observe $f = f_0\left(1 - \frac{u}{c}\right)$, which is the Doppler of a moving receiver.