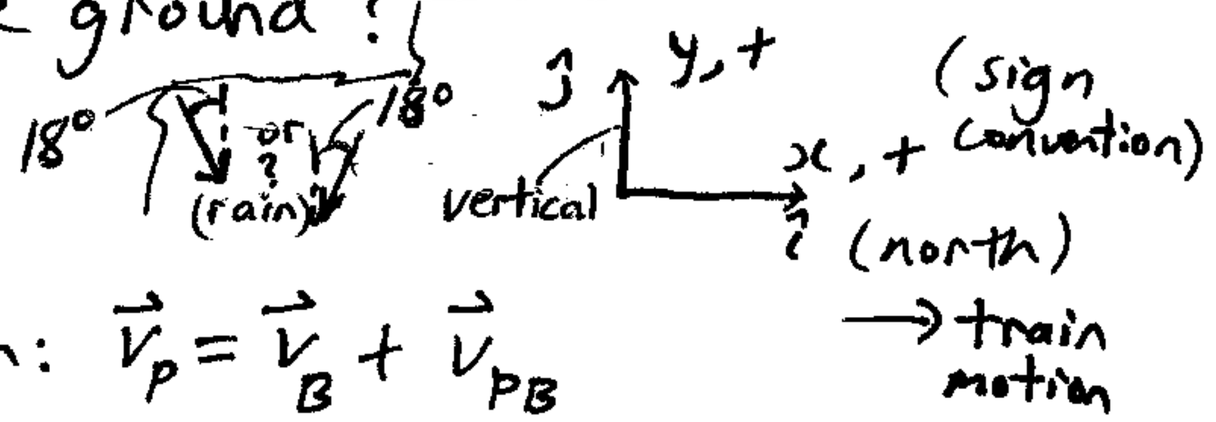
real-world-physics-problems.com
Feb. 17, 2020

This is a 2-D problem involving relative motion.

A train travels in the north direction at 25 m/s relative to the ground. At the same time it is raining. An observer on the ground sees that the raindrops make an angle of 18° with the vertical. A passenger on the train sees the rain drops fall in a perfectly vertical direction. What is the speed of the rain drops relative to the ground?



Solution:

Use the vector equation: $\vec{v}_p = \vec{v}_B + \vec{v}_{PB}$

$\vec{v}_p = \pm a\sin 18°\,\hat{i} - a\cos 18°\,\hat{j}$ (velocity of the rain drops with respect to the ground − a is the speed of the rain (magnitude of velocity) drops)

$\vec{v}_B = 25\,\hat{i}$ (velocity of the train with respect to the ground)

$\vec{v}_{PB} = -b\,\hat{j}$ (velocity of the rain drops with respect to the train − b is the magnitude of this velocity)

Substitute:

$\pm a\sin 18°\,\hat{i} - a\cos 18°\,\hat{j} = 25\,\hat{i} - b\,\hat{j}$

Solve: $-a\cos 18° = -b$, and $b = a\cos 18°$

$\pm a\sin 18° = 25$

Since $a > 0$ then only the positive sign is possible, so, $a = \frac{25}{\sin 18°}$

and, $b = a\cos 18° = \frac{25\cos 18°}{\sin 18°} = 76.94$, $a = \frac{25}{\sin 18°}$ $= 80.9$

Therefore, $\vec{v}_p = a\sin 18°\,\hat{i} - a\cos 18°\,\hat{j}$

$\vec{v}_p = 80.9\sin 18°\,\hat{i} - 80.9\cos 18°\,\hat{j}$

The speed of the rain drops is $80.9\ m/s$ (answer)