Matgeo-1.2.27

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Question

Rain is falling vertically with a speed of (30 , m/s). A woman rides a bicycle with a speed of (10 , m/s) in the north to south direction. What is the direction in which she should hold her umbrella?

Solution

Choose axes: x (south, $+$), y (downward, $+$).

$$\overrightarrow{v}_r = \begin{pmatrix} 0 \\ 30 \end{pmatrix} \quad \text{(rain velocity: 30 m/s downward)} \qquad (1)$$

$$\overrightarrow{v}_w = \begin{pmatrix} 10 \\ 0 \end{pmatrix} \quad \text{(woman velocity: 10 m/s south)} \qquad (2)$$

$$\overrightarrow{v}_{r/w} = \overrightarrow{v}_r - \overrightarrow{v}_w \qquad (3)$$

$$= \begin{pmatrix} 0 \\ 30 \end{pmatrix} - \begin{pmatrix} 10 \\ 0 \end{pmatrix} \qquad (4)$$

$$= \begin{pmatrix} -10 \\ 30 \end{pmatrix}. \qquad (5)$$

Solution(continuation)

Horizontal component (north) $=10$ m/s,
Vertical component (down) $=30$ m/s.

$$\tan\theta = \frac{10}{30} = \frac{1}{3} \quad \Rightarrow \quad \theta = \arctan\left(\frac{1}{3}\right) \approx 18.43^\circ.$$

Conclusion: In her frame the rain comes from slightly ahead (from the south and above), so she should tilt the umbrella forward (toward the direction of motion, i.e. south) by $\theta = \arctan(1/3) \approx 18.43^\circ$.

Graphical Representation

3D Relative Velocity Diagram with Tilt Angle