1.2.27

AI25BTECH11019 - MENAVATH SAI SANJANA

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:

$$\vec{v}_r = \begin{pmatrix} 0 \\ 30 \end{pmatrix} \quad \text{(rain velocity)} \tag{0.1}$$

$$\vec{v}_w = \begin{pmatrix} 10 \\ 0 \end{pmatrix} \quad \text{(woman velocity)} \tag{0.2}$$

$$\vec{v}_{r/w} = \vec{v}_r - \vec{v}_w \tag{0.3}$$

$$= \begin{pmatrix} -10 \\ 30 \end{pmatrix}. \tag{0.4}$$

Let the unit vector along the x-axis be $\hat{i} = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$.

The angle θ between $\mathbf{v}_{r/w}$ and the x-axis is given by the inner product:

$$\cos\theta = \frac{\vec{v}_{r/w} \cdot \hat{i}}{||\vec{v}_{r/w}||||\hat{i}||} \tag{0.5}$$

$$= \frac{\begin{pmatrix} -10 \\ 30 \end{pmatrix} \cdot \begin{pmatrix} 1 \\ 0 \end{pmatrix}}{\sqrt{(-10)^2 + 30^2} \cdot 1} \tag{0.6}$$

$$= \frac{-10}{\sqrt{100 + 900}} \tag{0.7}$$

$$= -\frac{1}{\sqrt{10}}. \tag{0.8}$$

$\theta = \cos^{-1}\left(-\frac{1}{\sqrt{10}}\right) \approx 108.43^\circ$

Since $90^\circ < \theta < 180^\circ$, the relative rain vector points *behind the x-axis*, i.e., slightly tilted from vertical.

Tilt of umbrella: From vertical, the tilt angle is $180^\circ - 108.43^\circ = 71.57^\circ$ from the x-axis.

This corresponds to about 18.43° forward from vertical (towards south, the direction of motion).

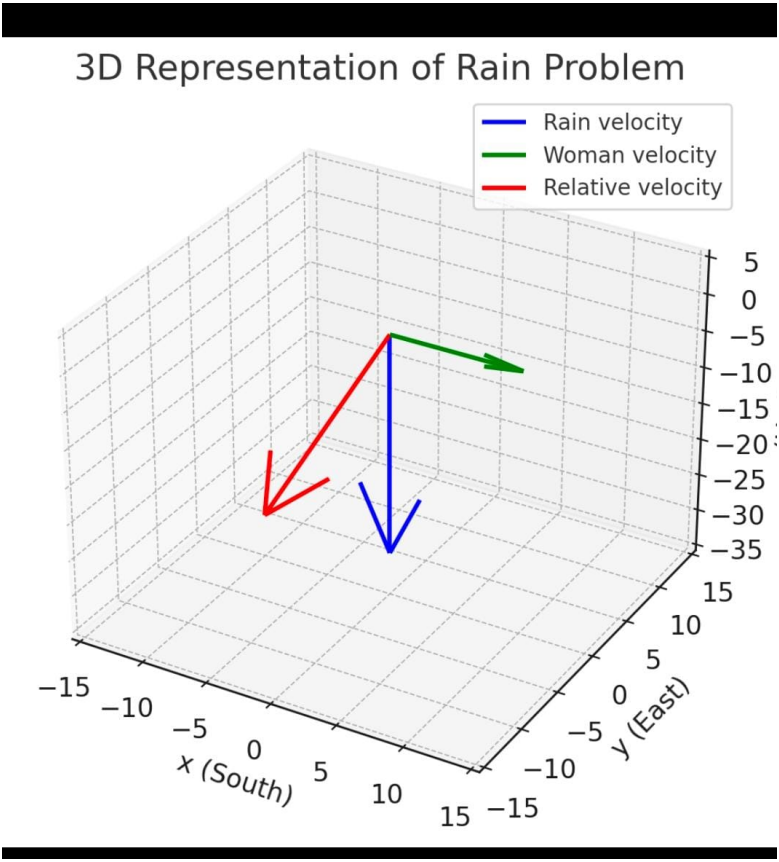
3D Representation of Rain Problem
Rain velocity
Woman velocity
Relative velocity
x (South)
y (East)

Fig. 0.1