1.2.25

EE24BTECH11014 - DEEPAK

Question:

Rain is falling vertically with a speed of $30ms^{-1}$. A woman rides a bicycle with a speed of $10ms^{-1}$ in the north to south direction. What is the direction in which she should hold her umbrella?

Solution: :

Variable	Description	value
$\mathbf{v}_{\text{rain}}$	velocity vector of rain in vertical downwards direction	$30ms^{-1}$
$\mathbf{v}_{\text{woman}}$	velocity vector of women in north to south (Horizontal) direction	$10ms^{-1}$
$\mathbf{v}_{\text{relative}}$	velocity of rain with respect to woman	
θ	angle with vertical in which she should hold her umbrella	

TABLE 0: Variables Used

Since the rain is falling vertically, its velocity vector is along the negative y-axis (downward). We can represent this velocity vector as:

$$\mathbf{v}_{rain} = \begin{pmatrix} 0 \\ -30 \end{pmatrix} \text{m/s}$$

The woman is riding from **north to south**, which means her velocity is along the negative x-axis (horizontal). Her velocity vector is:

$$\mathbf{v}_{\text{woman}} = \begin{pmatrix} -10 \\ 0 \end{pmatrix} \text{m/s}$$

velocity of rain with respect to woman :

$$\mathbf{v}_{\text{relative}} = \mathbf{v}_{\text{rain}} - \mathbf{v}_{\text{woman}}$$

$$\mathbf{v}_{\text{relative}} = \begin{pmatrix} 0 \\ -30 \end{pmatrix} - \begin{pmatrix} -10 \\ 0 \end{pmatrix}$$

$$\mathbf{v}_{\text{relative}} = \begin{pmatrix} 10 \\ -30 \end{pmatrix}$$

So, the relative velocity of the rain with respect to the woman is:

$$\mathbf{v}_{\text{relative}} = \begin{pmatrix} 10 \\ -30 \end{pmatrix}, \text{m/s}$$

The direction in which she should hold the umbrella is the direction of the relative velocity vector.

since θ is the angle with the vertical
so,

$$\tan\theta = \frac{10}{-30} = -\frac{1}{3}$$

Thus, the angle θ is:

$$\theta = \tan^{-1}(-\frac{1}{3})$$

so, woman should hold her umbrella upwards at an angle of $\tan^{-1}(\frac{1}{3}) \approx 18.43°$south of the vertical to stay dry.

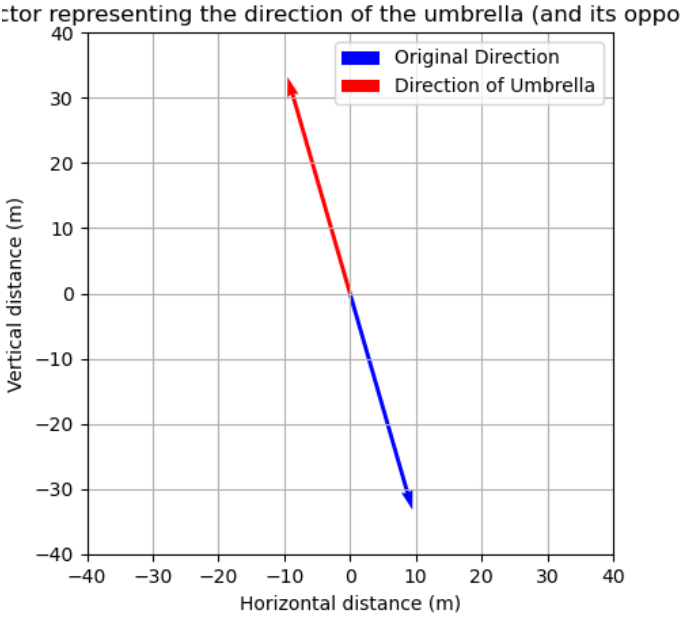

Fig. 0.1