

1.2.22

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Question:

Rain is falling vertically at a speed of $35ms^{-1}$. Winds start blowing after sometime with a speed of $12ms^{-1}$ in east to west direction. In which direction should a boy waiting at a bus stop hold his umbrella ?

Solution:

Term	Description
\mathbf{V}_1	velocity vector of Rain
\mathbf{V}_2	velocity vector Wind
\mathbf{V}_3	Resultant velocity vector of Rain and Wind
θ	Angle made by umbrella with horizontal

TABLE 1: Terms used

Velocity vector of rain:

$$\mathbf{V}_1 = \begin{pmatrix} 0 \\ -35 \end{pmatrix} \quad (0.1)$$

Velocity vector of Wind:

$$\mathbf{V}_2 = \begin{pmatrix} -12 \\ 0 \end{pmatrix} \quad (0.2)$$

The trajectory of Rain Drops is along the resultant velocity vectors of Rain and Wind.

The resultant velocity vector:

$$\mathbf{V}_1 + \mathbf{V}_2 = \begin{pmatrix} 0 \\ -35 \end{pmatrix} + \begin{pmatrix} -12 \\ 0 \end{pmatrix} \quad (0.3)$$

$$\mathbf{V}_3 = \begin{pmatrix} -12 \\ -35 \end{pmatrix} \quad (0.4)$$

Let the origin be O:

$$O = \begin{pmatrix} 0 \\ 0 \end{pmatrix} \quad (0.5)$$

The direction vector of AB is defined as:

$$\mathbf{M} = \mathbf{B} - \mathbf{A} = k \begin{pmatrix} 1 \\ m \end{pmatrix} \quad (0.6)$$

Where m is the slope of AB. we can also say that

$$\mathbf{m} \equiv k \begin{pmatrix} 1 \\ m \end{pmatrix} \quad (0.7)$$

So the direction vector of O and v_3 is:

$$\mathbf{D} = \mathbf{V}_3 - \mathbf{O} = \begin{pmatrix} -12 \\ -35 \end{pmatrix} = -12 \begin{pmatrix} 1 \\ \frac{35}{12} \end{pmatrix} \quad (0.8)$$

From equation 0.9 slope of direction vector OV_3 is

$$\text{Slope} = \frac{35}{12} \quad (0.9)$$

The required angle(θ) made by umbrella axis with the horizontal is;

$$\theta = \tan^{-1} \left(\frac{35}{12} \right) = 71.075^\circ \quad (0.10)$$

\therefore The boy hold the umbrella at an angle 71.075° with horizontal direction

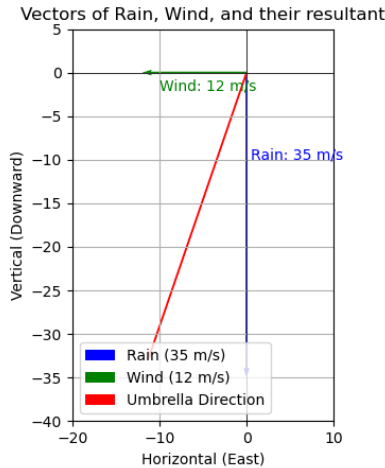


Fig. 0.1: Plot showing the velocity vectors