1.2.29

AI25BTECH11021 - Abhiram Reddy N

Question:
In a harbour, wind is blowing at the speed of 72 km/h and the flag on the mast of a boat anchored in the harbour flutters along the N–E direction. If the boat starts moving at a speed of 51 km/h to the north, what is the direction of the flag on the mast of the boat?

Solution:

Step 1: Represent velocities as vectors

The wind velocity vector (in ground frame) is towards NE (45°) with speed 72 km/h:

$$\mathbf{W} = \begin{bmatrix} 72\cos 45^\circ \\ 72\sin 45^\circ \end{bmatrix} = \begin{bmatrix} 50.91 \\ 50.91 \end{bmatrix} \text{ km/h}$$

The boat velocity vector (in ground frame) is towards North:

$$\mathbf{V} = \begin{bmatrix} 0 \\ 51 \end{bmatrix} \text{ km/h}$$

Step 2: Compute relative wind (wind as seen from the boat)

$$\mathbf{R} = \mathbf{W} - \mathbf{V} = \begin{bmatrix} 50.91 \\ 50.91 \end{bmatrix} - \begin{bmatrix} 0 \\ 51 \end{bmatrix} = \begin{bmatrix} 50.91 \\ -0.09 \end{bmatrix}$$

Step 3: Use cosine formula to find angle from East axis

Let θ be the angle between $\mathbf{R}$ and the East direction $\mathbf{E} = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$

$$\cos\theta = \frac{\mathbf{R}\cdot\mathbf{E}}{|\mathbf{R}||\mathbf{E}|} = \frac{50.91\cdot 1 + (-0.09)\cdot 0}{\sqrt{50.91^2 + (-0.09)^2}} = \frac{50.91}{50.9118}$$

$$\theta = \cos^{-1}\left(\frac{50.91}{50.9118}\right) \approx \cos^{-1}(0.9999646) \approx 0.1^\circ$$

So, the flag points nearly **East**, slightly tilted **South**.

Symbol	Description / value
$\mathbf{W}$	Wind vector (ground), magnitude 72 km/h, direction NE (45°)
$\mathbf{V}$	Boat velocity (ground) = (0, 51) km/h (north)
$\mathbf{R}$	Relative wind = $\mathbf{W} - \mathbf{V}$
$\|\mathbf{R}\|$	Magnitude of relative wind ≈ 50.9118 km/h
θ	Direction of flag measured from East: ≈ −0.0994° (south of east)

TABLE 0: variables and numerical values

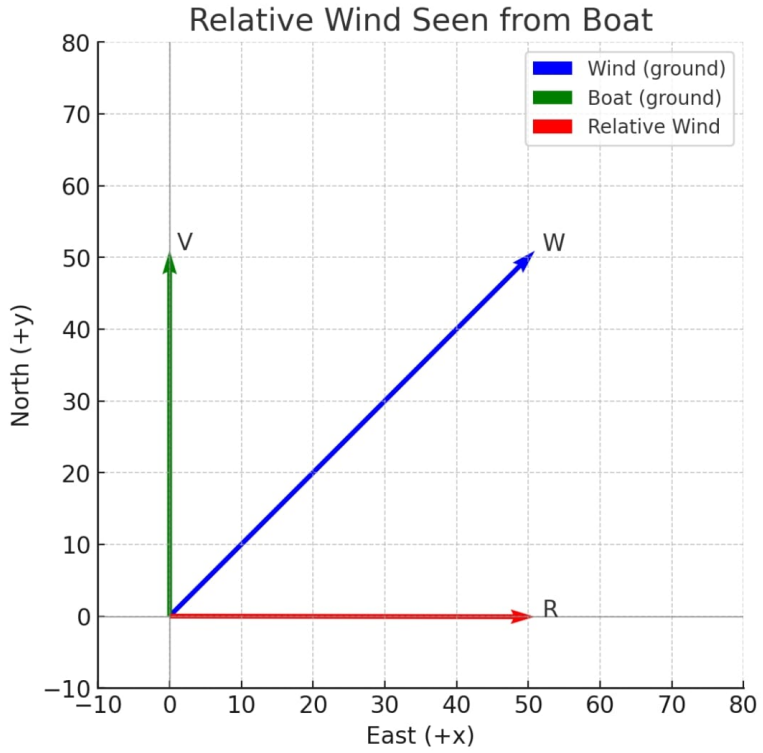

Fig. 0.1: Relative wind vector **R** obtained as **W** – **V**