1.2.29

Abhiram Reddy-AI25BTECH11021

August 27,2025

Question

In a harbour, wind is blowing at the speed of 72 $\mathrm{km/h}$ 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 $\mathrm{km/h}$ to the north, what is the direction of the flag on the mast of the boat?

Represent given velocities as vectors

The wind velocity (ground frame) is along the NE direction with speed 72 km/h:

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

The boat velocity (ground frame) is northward with speed 51 km/h:

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

Relative wind (wind as seen from the boat)

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

Direction of the relative wind

$$\theta = \tan^{-1}\left(\frac{-0.09}{50.91}\right) \approx -0.1^\circ$$

Thus, the relative wind is almost exactly eastward, slightly south of east.

The flag on the mast points nearly East, slightly tilted South.

C Code

```c
#include <stdio.h>
#include <math.h>

int main() {
    // Wind (NE at 72 km/h)
    double W_x = 72 * cos(M_PI/4);
    double W_y = 72 * sin(M_PI/4);

    // Boat (North at 51 km/h)
    double V_x = 0;
    double V_y = 51;

    // Relative wind = Wind - Boat
    double R_x = W_x - V_x;
    double R_y = W_y - V_y;

    printf(Relative wind: (%.2f, %.2f)\n, R_x, R_y);
    return 0;
```

Python Code

```
import numpy as np
import matplotlib.pyplot as plt

# Wind velocity (ground frame), NE direction at 72 km/h
W = np.array([72/np.sqrt(2), 72/np.sqrt(2)]) # [East, North]

# Boat velocity (ground frame), north at 51 km/h
V = np.array([0, 51]) # [East, North]

# Relative wind (wind seen from boat)
R = W - V
```

Python Code

```
# Calculate angle of relative wind
angle_deg = np.degrees(np.arctan2(R[1], R[0]))

print(Wind vector W =, W)
print(Boat vector V =, V)
print(Relative wind R =, R)
print(Angle of relative wind =, angle_deg, degrees)
```

Python Code

```
# Create plot
plt.figure(figsize=(6,6))
plt.axhline(0, color='gray', linewidth=0.5)
plt.axvline(0, color='gray', linewidth=0.5)
```

Python Code

```
# Plot vectors
plt.quiver(0,0, W[0], W[1], angles='xy', scale_units='xy', scale
    =1, color='blue', label=Wind (ground))
plt.quiver(0,0, V[0], V[1], angles='xy', scale_units='xy', scale
    =1, color='green', label=Boat (ground))
plt.quiver(0,0, R[0], R[1], angles='xy', scale_units='xy', scale
    =1, color='red', label=Relative Wind)
```

Python Code

```
# Labels
plt.text(W[0], W[1],  W, fontsize=12)
plt.text(V[0], V[1],  V, fontsize=12)
plt.text(R[0], R[1],  R, fontsize=12)

plt.xlim(-10,80)
plt.ylim(-10,80)
plt.xlabel(East (+x))
plt.ylabel(North (+y))
plt.title(Relative Wind Seen from Boat)
plt.legend()
plt.grid(True)
plt.gca().set_aspect('equal', adjustable='box')
plt.show()
```

Plot

figs/python image.png