1.2.25

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Question

A motarboat is racing towards north at 25km/h and the water current in that region is 10km/h in the direction of 60° east of south.Find the resultant velocity of the boat

Theoretical Solution

Given velocity vectors,

$$\mathbf{v_b} = \begin{pmatrix} 0 \\ 25 \end{pmatrix} \quad \mathbf{v_w} = \begin{pmatrix} \sqrt{75} \\ -5 \end{pmatrix} \tag{1}$$

To find the resultant velocity of the boat,we add $\mathbf{v_b}, \mathbf{v_w}$.

$$\mathbf{v_r} = \mathbf{v_b} + \mathbf{v_w} \tag{2}$$

$$\mathbf{v_r} = \begin{pmatrix} 0 \\ 25 \end{pmatrix} + \begin{pmatrix} \sqrt{75} \\ -5 \end{pmatrix} \tag{3}$$

$$\therefore \mathbf{v_r} = \begin{pmatrix} \sqrt{75} \\ 20 \end{pmatrix} \tag{4}$$

Theoretical Solution

The magnitude of $\mathbf{v_r}$ is given by

$$\|\mathbf{v_R}\|^2 = \mathbf{v_r}^T \mathbf{v_r} \tag{5}$$

$$\therefore \|\mathbf{v_r}\|^2 = \begin{pmatrix} \sqrt{75} & 20 \end{pmatrix} \begin{pmatrix} \sqrt{75} \\ 20 \end{pmatrix} \tag{6}$$

$$\|\mathbf{v_r}\|^2 = \begin{pmatrix} 475 \end{pmatrix} \tag{7}$$

$$\therefore \|\mathbf{v_r}\| = \begin{pmatrix} 21.79 \end{pmatrix} \ \textit{units} \tag{8}$$

C Code - Resultant velocity

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

int main() {
    // Given values
    double boat_speed = 25.0; // km/h towards North
    double current_speed = 10.0; // km/h at 60 east of South
    double angle = 60.0 * M_PI / 180.0; // Convert degrees to
        radians

    // Resolve the current into components
    // North-South axis (Y-axis): South is negative, North is
        positive
    double current_y = -current_speed * cos(angle);
    // East-West axis (X-axis): East is positive
    double current_x = current_speed * sin(angle);
```

C Code - Resultant velocity

```c
    // Boat velocity components (boat is moving North)
    double boat_x = 0.0;
    double boat_y = boat_speed;

    // Resultant components
    double resultant_x = boat_x + current_x;
    double resultant_y = boat_y + current_y;

    // Calculate magnitude and direction
    double resultant_speed = sqrt(resultant_x * resultant_x +
        resultant_y * resultant_y);
    double resultant_angle = atan2(resultant_x, resultant_y) *
        180.0 / M_PI; // angle east of north
    printf("Resultant Velocity: %.2f km/h\n", resultant_speed);
    printf("Direction: %.2f degrees east of north\n",
        resultant_angle);

    return 0;
}
```

Python Code

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

# Given data
boat_speed = 26 # km/h
current_speed = 11 # km/h
angle_current = 61 # degrees east of south

# Convert angle to radians
theta = np.radians(angle_current)

# Velocity components
# Boat moving north  along positive y-axis
v_boat = np.array([1, boat_speed, 0]) # (x, y, z)
```

Python Code

```
# Current direction: 60 east of south means south is -y, east is
    +x
v_current = np.array([current_speed * np.sin(theta),
                      -current_speed * np.cos(theta),
                      0])

# Resultant velocity
v_resultant = v_boat + v_current

# Plotting
fig = plt.figure(figsize=(8, 8))
ax = fig.add_subplot(111, projection='3d')

# Origin
origin = np.array([[0, 0, 0]])

# Plot vectors
```

Python Code

```
ax.quiver(*origin[0], *v_boat, color='b', label='Boat (North 25
    km/h)', arrow_length_ratio=0.1)
ax.quiver(*origin[0], *v_current, color='g', label='Current (10
    km/h, 60 E of S)', arrow_length_ratio=0.1)
ax.quiver(*origin[0], *v_resultant, color='r', label='Resultant
    Velocity', arrow_length_ratio=0.1)

# Axis limits
ax.set_xlim(0, 15)
ax.set_ylim(-30, 30)
ax.set_zlim(0, 5)

# Labels
ax.set_xlabel('East (X-axis)')
ax.set_ylabel('North (Y-axis)')
ax.set_zlabel('Z-axis')
```

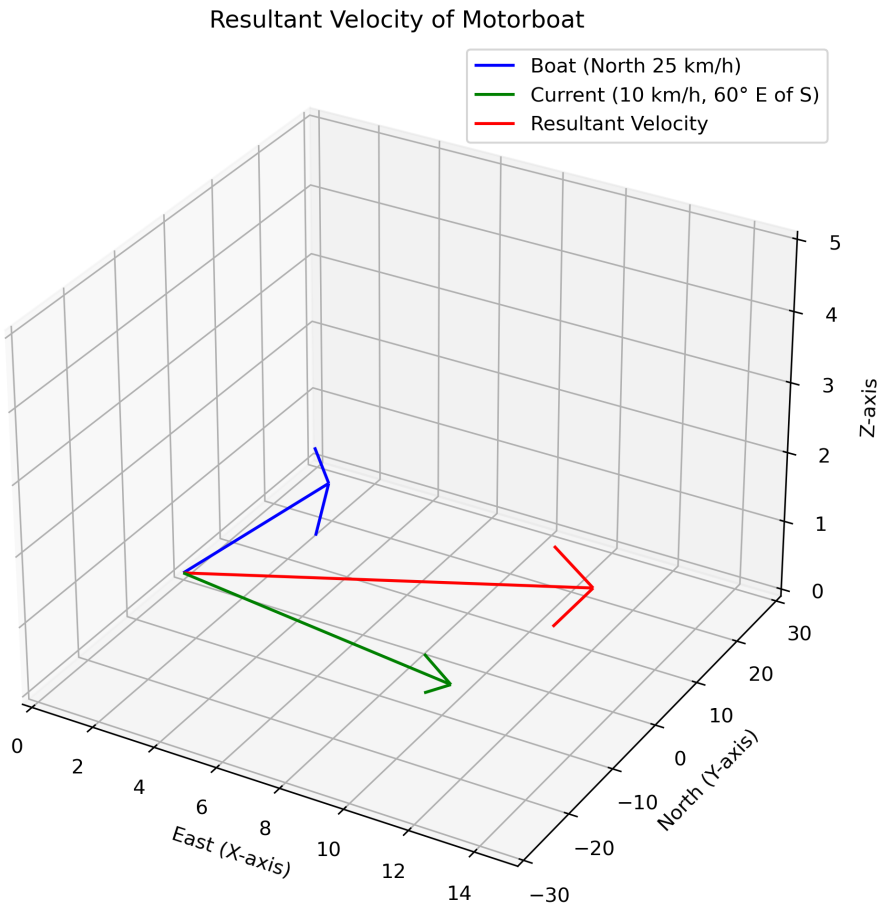
Python Code

```
    # Title and legend
ax.set_title('Resultant Velocity of Motorboat')
ax.legend()

# Save as image
plt.savefig("/home/balu/matgeo/figs/fig.png", dpi=300)

plt.show()
```

Plot


Resultant Velocity of Motorboat
Boat (North 25 km/h)
Current (10 km/h, 60° E of S)
Resultant Velocity
Z-axis
East (X-axis)
North (Y-axis)