2.2.7

BALU-ai25btech11017

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Question

The angles between two vectors $\mathbf{a}, \mathbf{b}$ with magnitude $\sqrt{3}, 4$ respectively, and $\mathbf{a} \cdot \mathbf{b} = 2\sqrt{3}$ is _____

Theoretical Solution

From the given information,

$$\|\mathbf{a}\| = \sqrt{3}, \|\mathbf{b}\| = 4, \mathbf{a}^T\mathbf{b} = 2\sqrt{3} \tag{1}$$

$$\cos\theta = \frac{\mathbf{a}^T\mathbf{b}}{\|\mathbf{a}\|\|\mathbf{b}\|} \tag{2}$$

$$\cos\theta = \frac{1}{2} \tag{3}$$

$$\theta = 60^\circ \tag{4}$$

$$\tag{5}$$

Angle between two vectors is 60°

C Code

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

int main() {
    // Given values
    double mag_a = sqrt(3.0); // |a|
    double mag_b = 4.0; // |b|
    double dot_ab = 2 * sqrt(3.0); // ab

    // Formula: cos = (ab) / (|a||b|)
    double cos_theta = dot_ab / (mag_a * mag_b);

    // Find angle in radians
    double theta_rad = acos(cos_theta);

    // Convert to degrees
    double theta_deg = theta_rad * 180.0 / M_PI;
```

C Code - Resultant velocity

```
    printf("The angle between the two vectors is: %.2f degrees\n",
         theta_deg);

    return 0;
}
```

Python Code

```
import numpy as np
import matplotlib.pyplot as plt
from mpl_toolkits.mplot3d import Axes3D

# Define vectors
a = np.array([np.sqrt(3), 0, 0]) # vector a, magnitude 3
b = np.array([2*np.sqrt(3)/4, np.sqrt(3), 0]) # vector b,
    magnitude 4, dot = 23

# Verify magnitudes and dot product
mag_a = np.linalg.norm(a)
mag_b = np.linalg.norm(b)
dot_ab = np.dot(a, b)
theta = np.degrees(np.arccos(dot_ab / (mag_a * mag_b)))

# Create 3D plot
fig = plt.figure(figsize=(6,6))
ax = fig.add_subplot(111, projection='3d')
```

Python Code

```
# Plot vectors
ax.quiver(*origin, *a, color='r', label='a (|a|=3)',
    arrow_length_ratio=0.1)
ax.quiver(*origin, *b, color='b', label='b (|b|=4)',
    arrow_length_ratio=0.1)

# Annotate vectors
ax.text(*a, 'a', color='r')
ax.text(*b, 'b', color='b')

# Set axes limits
ax.set_xlim([0, 4])
ax.set_ylim([0, 4])
ax.set_zlim([0, 4])
```

Python Code

```
# Labels and title
ax.set_xlabel('X')
ax.set_ylabel('Y')
ax.set_zlabel('Z')
ax.set_title(f"Angle between a and b = {theta:.0f}")

ax.legend()
plt.tight_layout()

# Save and show figure
plt.savefig("vectors_angle.png")
plt.show()
```

Plot