2.2.13

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Question

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

Given

- $|\mathbf{a}| = \sqrt{3}$
- $|\mathbf{b}| = 4$
- $\mathbf{a} \cdot \mathbf{b} = 2\sqrt{3}$

Find the angle θ between $\mathbf{a}$ and $\mathbf{b}$.

Formula for Angle Between Vectors

$$\mathbf{a} \cdot \mathbf{b} = |\mathbf{a}||\mathbf{b}| \cos\theta$$

Substitute the given values:

$$2\sqrt{3} = \sqrt{3} \cdot 4 \cdot \cos\theta$$

$$2\sqrt{3} = 4\sqrt{3}\cos\theta$$

$$\cos\theta = \frac{2\sqrt{3}}{4\sqrt{3}} = \frac{1}{2}$$

$$\theta = \cos^{-1}\left(\frac{1}{2}\right)$$

$$\boxed{\theta = 60^\circ}$$

C Code

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

int main() {
    double dot_product = 2 * sqrt(3);
    double magnitude_a = sqrt(3);
    double magnitude_b = 4.0;

    double cos_theta = dot_product / (magnitude_a * magnitude_b);
    double theta_rad = acos(cos_theta); // angle in radians
    double theta_deg = theta_rad * (180.0 / M_PI); // convert to
        degrees

    printf(cos(theta) = %.6f\n, cos_theta);
    printf(Angle (in radians) = %.6f\n, theta_rad);
    printf(Angle (in degrees) = %.6f\n, theta_deg);

    return 0;
```

Python Code

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

# Given values
a_mag = np.sqrt(3)
b_mag = 4
dot_product = 2 * np.sqrt(3)

# Compute angle
cos_theta = dot_product / (a_mag * b_mag)
theta = np.arccos(cos_theta)

# Vector a: along x-axis
a = np.array([a_mag, 0])

# Vector b: rotated by angle theta
b = np.array([b_mag * np.cos(theta), b_mag * np.sin(theta)])
```

Python Code

```
# Plot
origin = np.array([0, 0])
plt.quiver(*origin, *a, angles='xy', scale_units='xy', scale=1,
    color='red', label=r'$\vec{a}$')
plt.quiver(*origin, *b, angles='xy', scale_units='xy', scale=1,
    color='blue', label=r'$\vec{b}$')

# Annotate the angle
angle_deg = np.degrees(theta)
plt.text(0.5, 0.5, f'$\\theta$ = {angle_deg:.1f}', fontsize=12)
```

Python Code

```
# Plot settings
plt.xlim(0, 5)
plt.ylim(0, 3)
plt.gca().set_aspect('equal')
plt.grid(True)
plt.xlabel(x)
plt.ylabel(y)
plt.title(Angle Between Vectors)
plt.legend()

# Save the plot
plt.savefig(python_plot.png)
plt.show()
```

Plot