3.3.5

Abhiram Reddy-AI25BTECH11021

September 09,2025

Problem statement

Construct a $\triangle ABC$ in which

$$CA = 6\,cm, \quad AB = 5\,cm, \quad \text{and} \quad \angle BAC = 45^\circ.$$

Step 1: Define Points and Vectors

Place A at origin:

$$\mathbf{A} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}.$$

Set $\mathbf{B}$ on x-axis since $AB = 5\,cm$:

$$\mathbf{B} = \begin{pmatrix} 5 \\ 0 \end{pmatrix}.$$

Find $\mathbf{C}$ such that $|\mathbf{C} - \mathbf{A}| = 6$ and $\angle BAC = 45^\circ$.

Step 2: Calculate Coordinates of C

Using trigonometry:

$$\mathbf{C} = 6\begin{pmatrix}\cos 45^\circ \\ \sin 45^\circ\end{pmatrix} = 6\begin{pmatrix}\frac{\sqrt{2}}{2} \\ \frac{\sqrt{2}}{2}\end{pmatrix} = \begin{pmatrix}3\sqrt{2} \\ 3\sqrt{2}\end{pmatrix}.$$

Verify angle using dot product confirms $\angle BAC = 45^\circ$.

Summary of Points

$$\boxed{\mathbf{A} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \quad \mathbf{B} = \begin{pmatrix} 5 \\ 0 \end{pmatrix}, \quad \mathbf{C} = \begin{pmatrix} 3\sqrt{2} \\ 3\sqrt{2} \end{pmatrix}}$$

These points satisfy all given conditions.

C Code: Dot Product and Magnitude

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

double dotProduct(double A[], double B[]) {
    return A[0]*B[0] + A[1]*B[1];
}

double magnitude(double V[]) {
    return sqrt(V[0]*V[0] + V[1]*V[1]);
}
```

C Code: Angle Calculation and Main

```c
double angleBetweenVectors(double A[], double B[]) {
    double dot = dotProduct(A, B);
    double magA = magnitude(A);
    double magB = magnitude(B);
    double cosTheta = dot / (magA * magB);
    if (cosTheta > 1.0) cosTheta = 1.0;
    else if (cosTheta < -1.0) cosTheta = -1.0;
    return acos(cosTheta) * (180.0 / M_PI);
}

int main() {
    double AB[2] = {5.0, 0.0};
    double AC[2] = {3.0 * sqrt(2), 3.0 * sqrt(2)};
    printf(Angle: %.2f degrees\n, angleBetweenVectors(AB, AC));
    return 0;
}
```

Python Code: Setup and Points

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

A = np.array([0, 0])
B = np.array([5, 0])
C = np.array([3 * np.sqrt(2), 3 * np.sqrt(2)])
```

Python Code: Plot Triangle

```
fig, ax = plt.subplots()

triangle_points = np.array([A, B, C, A])
ax.plot(triangle_points[:, 0], triangle_points[:, 1], 'b-',
    marker='o')

ax.text(A[0], A[1], 'A', fontsize=12, ha='right', va='top')
ax.text(B[0], B[1], 'B', fontsize=12, ha='left', va='top')
ax.text(C[0], C[1], 'C', fontsize=12, ha='left', va='bottom')
```

Python Code: Final Touches and Save

```
ax.set_aspect('equal', 'box')
ax.grid(True, linestyle='--', alpha=0.6)
ax.set_xlabel('x (cm)')
ax.set_ylabel('y (cm)')
ax.set_title('Triangle ABC with CA=6 cm, AB=5 cm, BAC=45')

padding = 1
min_x, max_x = min(A[0], B[0], C[0]) - padding, max(A[0], B[0], C
    [0]) + padding
min_y, max_y = min(A[1], B[1], C[1]) - padding, max(A[1], B[1], C
    [1]) + padding
ax.set_xlim(min_x, max_x)
ax.set_ylim(min_y, max_y)

plt.savefig('python_plot.png', dpi=300)
plt.show()
```

Plot

figs/python_plot.png