# 2.4.41

Sai Hasini Pappula-EE25BTECH11044

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# Question

## Problem

Determine whether the points $A(3, 6, 9)$, $B(10, 20, 30)$, $C(24, -41, 5)$ are the vertices of a right-angled triangle using matrices.

# Process (Step 1)

**Step 1: Represent points as vectors**

$$\mathbf{A} = \begin{bmatrix} 3 \\ 6 \\ 9 \end{bmatrix}, \quad \mathbf{B} = \begin{bmatrix} 10 \\ 20 \\ 30 \end{bmatrix}, \quad \mathbf{C} = \begin{bmatrix} 24 \\ -41 \\ 5 \end{bmatrix} \tag{1}$$

**Step 2: Compute first difference vector**

$$\mathbf{B} - \mathbf{A} = \begin{bmatrix} 10 - 3 \\ 20 - 6 \\ 30 - 9 \end{bmatrix} = \begin{bmatrix} 7 \\ 14 \\ 21 \end{bmatrix} \tag{2}$$

# Process (Step 2)

**Step 2 (continued): Compute remaining difference vectors**

$$\mathbf{C}-\mathbf{B}=\begin{bmatrix}24-10\\-41-20\\5-30\end{bmatrix}=\begin{bmatrix}14\\-61\\-25\end{bmatrix} \tag{3}$$

$$\mathbf{C}-\mathbf{A}=\begin{bmatrix}24-3\\-41-6\\5-9\end{bmatrix}=\begin{bmatrix}21\\-47\\-4\end{bmatrix} \tag{4}$$

**Step 3: Use dot product test**

$$(\mathbf{X}-\mathbf{Y})\cdot(\mathbf{Z}-\mathbf{W})=0 \quad \Rightarrow \quad \text{Vectors are perpendicular} \tag{5}$$

# Conclusion

Dot product results:

$$(\mathbf{B}-\mathbf{A})\cdot(\mathbf{C}-\mathbf{A}) = -595 \tag{6}$$

$$(\mathbf{B}-\mathbf{A})\cdot(\mathbf{C}-\mathbf{B}) = -1281 \tag{7}$$

$$(\mathbf{C}-\mathbf{A})\cdot(\mathbf{C}-\mathbf{B}) = 3261 \tag{8}$$

Since none are zero, the points **do not form a right-angled triangle**.

# C Code

```c
#include <stdio.h>
int main() {
    double A[3] = {3, 6, 9};
    double B[3] = {10, 20, 30};
    double C[3] = {24, -41, 5};
    double dot1 = (B[0]-A[0])*(C[0]-A[0]) +
                  (B[1]-A[1])*(C[1]-A[1]) +
                  (B[2]-A[2])*(C[2]-A[2]);
    double dot2 = (B[0]-A[0])*(C[0]-B[0]) +
                  (B[1]-A[1])*(C[1]-B[1]) +
                  (B[2]-A[2])*(C[2]-B[2]);
    double dot3 = (C[0]-A[0])*(C[0]-B[0]) +
                  (C[1]-A[1])*(C[1]-B[1]) +
                  (C[2]-A[2])*(C[2]-B[2]);
    if(dot1==0 || dot2==0 || dot3==0)
        printf("Right-angled triangle\n");
    else
        printf("Not right-angled\n");
    return 0;
```

# Python Code (1/2)

```python
import numpy as np

A = np.array([3, 6, 9])
B = np.array([10, 20, 30])
C = np.array([24, -41, 5])

# Dot products computed directly
dot1 = np.dot(B-A, C-A)
dot2 = np.dot(B-A, C-B)
dot3 = np.dot(C-A, C-B)

if dot1 == 0 or dot2 == 0 or dot3 == 0:
    print("Right-angled triangle")
else:
    print("Not right-angled")
```

# Python Code (2/2: Plot)

```
import matplotlib.pyplot as plt
from mpl_toolkits.mplot3d import Axes3D
fig = plt.figure(figsize=(8,6))
ax = fig.add_subplot(111, projection='3d')
ax.scatter(*A, color='black', s=80)
ax.text(A[0]+0.5, A[1]+0.5, A[2]+0.5, "A(3,6,9)")
ax.scatter(*B, color='blue', s=80)
ax.text(B[0]+0.5, B[1]+0.5, B[2]+0.5, "B(10,20,30)")

ax.scatter(*C, color='red', s=80)
ax.text(C[0]+0.5, C[1]+0.5, C[2]+0.5, "C(24,-41,5)")

ax.plot([A[0],B[0]], [A[1],B[1]], [A[2],B[2]], color='blue')
ax.plot([A[0],C[0]], [A[1],C[1]], [A[2],C[2]], color='green')
ax.plot([B[0],C[0]], [B[1],C[1]], [B[2],C[2]], color='red',
    linestyle='--')

plt.show()
```

# Triangle in 3D