1.10.24

Tangellapalli Mohana Krishna Sushma - EE25BTECH11058

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Question

Find the direction cosines of the unit vector perpendicular to the plane

$$\mathbf{r} \cdot (6\hat{i} - 3\hat{j} - 2\hat{k}) + 1 = 0$$

passing through the origin.

given data

The plane equation:

$$\mathbf{r} \cdot (6\mathbf{i} - 3\mathbf{j} - 2\mathbf{k}) + 1 = 0$$

The normal vector to the plane:

$$\mathbf{n} = \begin{pmatrix} 6 \\ -3 \\ -2 \end{pmatrix}$$

Formula

To find the unit vector perpendicular to the plane:

$$\mathbf{u} = \frac{1}{\|\mathbf{n}\|}\mathbf{n}$$

where $\mathbf{n}$ is the normal vector of the plane.

Norm of the vector $\mathbf{n}$,

$$\mathbf{u} = \frac{1}{\|\mathbf{n}\|}\mathbf{n} = \frac{1}{7}\begin{pmatrix} 6 \\ -3 \\ -2 \end{pmatrix} = \begin{pmatrix} \frac{6}{7} \\ -\frac{3}{7} \\ -\frac{2}{7} \end{pmatrix} \tag{1}$$

The direction cosines of the unit vector perpendicular to the plane are

$$\left(\frac{6}{7}, -\frac{3}{7}, -\frac{2}{7}\right)$$

Python Code

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

# Define the plane: 6x - 3y - 2z + 1 = 0
normal = np.array([6, -3, -2]) # Normal vector to the plane

# Create grid for the plane
x = np.linspace(-5, 5, 10)
y = np.linspace(-5, 5, 10)
X, Y = np.meshgrid(x, y)
Z = (6*X - 3*Y + 1)/2 # Rearranged plane equation
```

Python Code

```
    # Plot the plane
fig = plt.figure(figsize=(10, 8))
ax = fig.add_subplot(111, projection='3d')
ax.plot_surface(X, Y, Z, alpha=0.5, color='cyan', edgecolor='k')

# Plot the normal vector from the origin
ax.quiver(0, 0, 0, normal[0], normal[1], normal[2],
          color='r', linewidth=2, label='Normal Vector (6, -3, -2)
              ')
```

Python Code

```
   # Labels
ax.set_xlabel('X-axis')
ax.set_ylabel('Y-axis')
ax.set_zlabel('Z-axis')
ax.set_title('Plane $6x - 3y - 2z + 1 = 0$ and its Normal Vector'
    )

# Legend
ax.legend()

# Show plot
plt.show()
```

C Code

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

int main() {
    // Plane equation: 6x - 3y - 2z + 1 = 0
    // Normal vector = (6, -3, -2)
    double a = 6, b = -3, c = -2;

    // Step 1: Print normal vector
    printf(Normal vector to the plane: (%.2f, %.2f, %.2f)\n, a, b
        , c);

    // Step 2: Find norm of the vector
    double norm = sqrt(a*a + b*b + c*c);
    printf(Norm of the vector = sqrt(%.2f^2 + %.2f^2 + %.2f^2) =
        %.2f\n, a, b, c, norm);

    // Step 3: Find unit vector
```

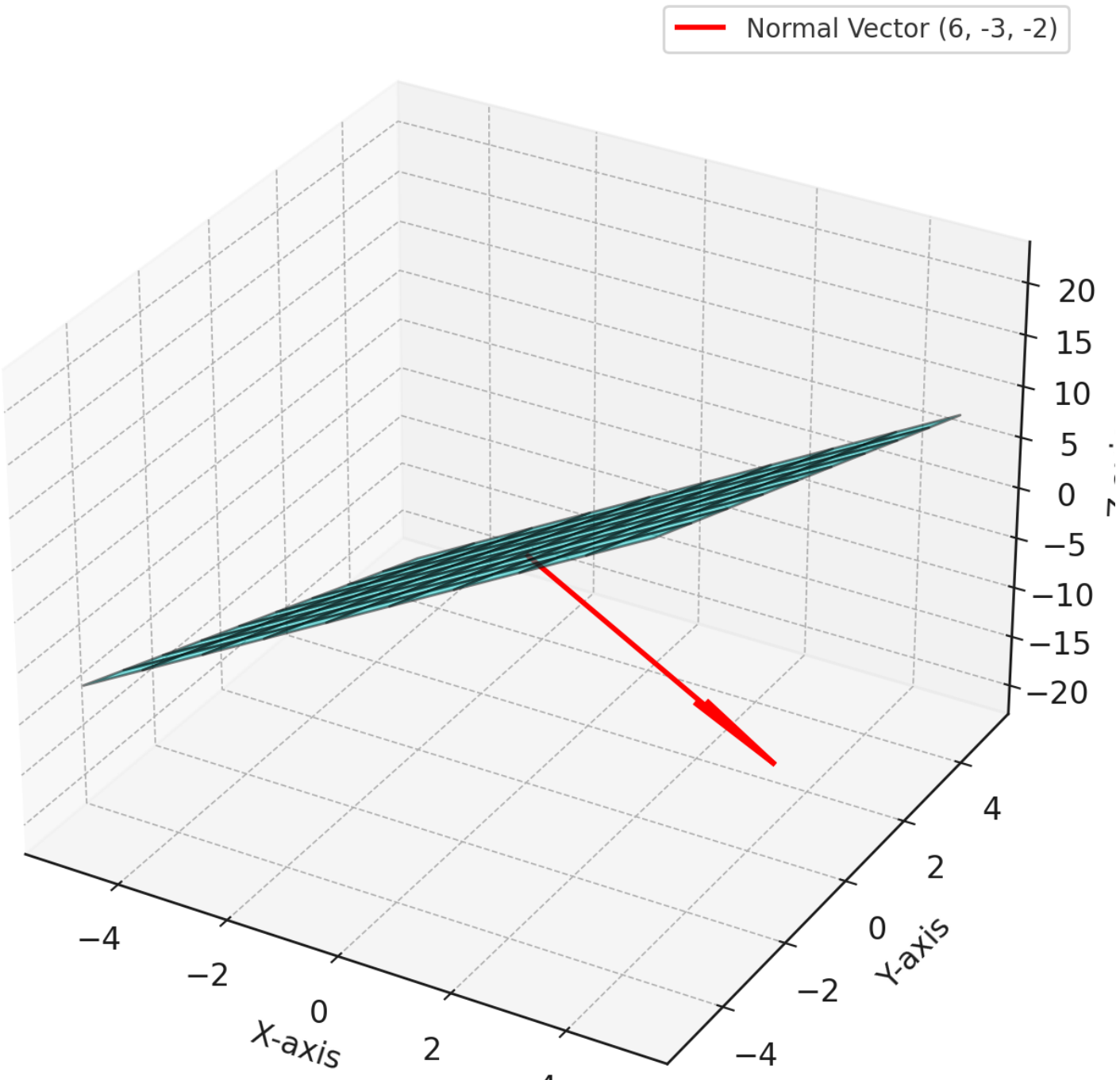
Python and C Code

```
import subprocess

# 1. Compile the C program
subprocess.run([gcc, direction cosines.c, -o, direction cosines])

# 2. Run the compiled C program
result = subprocess.run([./direction cosines], capture_output=
    True, text=True)

# 3. Print the output from the C program
print(result.stdout)
```


Plane $6x - 3y - 2z + 1 = 0$ and its Normal Vector
Normal Vector (6, -3, -2)
20
15
10
5
0
−5
−10
−15
−20
−4
−2
0
2
X-axis
4
2
0
−2
−4
Y-axis