4.4.37

EE25BTECH11001 - Aarush Dilawri

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Question

Find the vector equation of the line passing through the point $(2, 3, -5)$ and making equal angles with the coordinate axes.

Solution

Let the line be

$$\mathbf{x} = \mathbf{h} + \kappa \mathbf{m} \tag{1}$$

where $\mathbf{m}$ is the direction unit vector of the line, $\mathbf{h}$ is any given point on the line and $|\kappa|$ is the distance of $\mathbf{x}$ from $\mathbf{h}$ along the line.

Solution

Here,

$$\mathbf{h} = \begin{pmatrix} 2 \\ 3 \\ -5 \end{pmatrix} \tag{2}$$

We are given that the line makes equal angles with the coordinate axes. Therefore,

$$\mathbf{m}^\top \mathbf{e_1} = \mathbf{m}^\top \mathbf{e_2} = \mathbf{m}^\top \mathbf{e_3} = \lambda \tag{3}$$

Solution

where,

$$\mathbf{e_1} = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}, \quad \mathbf{e_2} = \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}, \quad \mathbf{e_3} = \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix} \tag{4}$$

From (0.3),

$$\mathbf{m}^\top \begin{pmatrix} \mathbf{e_1} & \mathbf{e_2} & \mathbf{e_3} \end{pmatrix} = \lambda \begin{pmatrix} 1 & 1 & 1 \end{pmatrix} \tag{5}$$

Solution

$$\mathbf{m}^\top \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} = \lambda \begin{pmatrix} 1 & 1 & 1 \end{pmatrix} \tag{6}$$

$$\mathbf{m}^\top \mathbf{I} = \lambda \begin{pmatrix} 1 & 1 & 1 \end{pmatrix} \tag{7}$$

$$\mathbf{m}^\top = \lambda \begin{pmatrix} 1 & 1 & 1 \end{pmatrix} \tag{8}$$

Taking transpose on both sides,

$$\mathbf{m} = \begin{pmatrix} \lambda \\ \lambda \\ \lambda \end{pmatrix} \tag{9}$$

Solution

Since,

$$\|\mathbf{m}\| = 1 \tag{10}$$

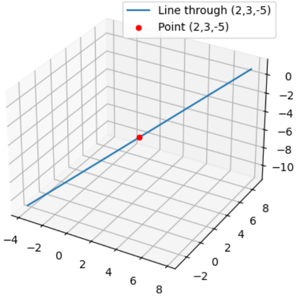
$$\lambda = \pm\frac{1}{\sqrt{3}} \tag{11}$$

Therefore the equation of the line is

$$\mathbf{x} = \begin{pmatrix} 2 \\ 3 \\ -5 \end{pmatrix} + \kappa \begin{pmatrix} \frac{1}{\sqrt{3}} \\ \frac{1}{\sqrt{3}} \\ \frac{1}{\sqrt{3}} \end{pmatrix} \tag{12}$$

Figure

From the figure, it is clearly verified that the theoretical solution matches with the computational solution.



C Code (code.c)

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

// Function to compute m vector (equal angle with axes)
void get_m(double *mx, double *my, double *mz) {
    double val = 1.0 / sqrt(3.0);
    *mx = val;
    *my = val;
    *mz = val;
}
```

Python Code (code.py)

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

# Compute m vector directly
m = np.array([1/np.sqrt(3), 1/np.sqrt(3), 1/np.sqrt(3)])
print("m vector from Python:", m)

# Point through which line passes
P = np.array([2, 3, -5])

# Line: r = P + t*m
```

Python Code (code.py)

```
t = np.linspace(-10, 10, 100)
X = P[0] + t * m[0]
Y = P[1] + t * m[1]
Z = P[2] + t * m[2]

# Plot
fig = plt.figure()
ax = fig.add_subplot(111, projection='3d')
ax.plot(X, Y, Z, label="Line through (2,3,-5)")
ax.scatter(P[0], P[1], P[2], color="red", label="Point (2,3,-5)")
ax.legend()
plt.show()
```

Python Code (nativecode.py)

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

# Load the shared object
lib = ctypes.CDLL("./code.so")

# Define the function signature
lib.get_m.argtypes = [ctypes.POINTER(ctypes.c_double),
                      ctypes.POINTER(ctypes.c_double),
                      ctypes.POINTER(ctypes.c_double)]

# Prepare variables
mx = ctypes.c_double()
my = ctypes.c_double()
mz = ctypes.c_double()
```

Python Code (nativecode.py)

```
lib.get_m(ctypes.byref(mx), ctypes.byref(my), ctypes.byref(mz))
m = np.array([mx.value, my.value, mz.value])
print("m-vector-from-C:", m)

# Point through which line passes
P = np.array([2, 3, -5])

# Line: r = P + t*m
t = np.linspace(-10, 10, 100)
X = P[0] + t * m[0]
Y = P[1] + t * m[1]
Z = P[2] + t * m[2]
```

```
# Plot
fig = plt.figure()
ax = fig.add_subplot(111, projection='3d')
ax.plot(X, Y, Z, label="Line through (2,3,-5)")
ax.scatter(P[0], P[1], P[2], color="red", label="Point (2,3,-5)")
ax.legend()
plt.show()
```