

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.

Let the line be

$$\mathbf{x} = \mathbf{h} + \kappa \mathbf{m} \quad (1)$$

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,

$$\mathbf{h} = \begin{pmatrix} 2 \\ 3 \\ -5 \end{pmatrix} \quad (2)$$

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

$$\mathbf{m}^T \mathbf{e}_1 = \mathbf{m}^T \mathbf{e}_2 = \mathbf{m}^T \mathbf{e}_3 = \lambda \quad (3)$$

Solution

where,

$$\mathbf{e}_1 = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}, \quad \mathbf{e}_2 = \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}, \quad \mathbf{e}_3 = \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix} \quad (4)$$

From (0.3),

$$\mathbf{m}^T \begin{pmatrix} \mathbf{e}_1 & \mathbf{e}_2 & \mathbf{e}_3 \end{pmatrix} = \lambda \begin{pmatrix} 1 & 1 & 1 \end{pmatrix} \quad (5)$$

Solution

$$\mathbf{m}^T \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} = \lambda \begin{pmatrix} 1 & 1 & 1 \end{pmatrix} \quad (6)$$

$$\mathbf{m}^T \mathbf{I} = \lambda \begin{pmatrix} 1 & 1 & 1 \end{pmatrix} \quad (7)$$

$$\mathbf{m}^T = \lambda \begin{pmatrix} 1 & 1 & 1 \end{pmatrix} \quad (8)$$

Taking transpose on both sides,

$$\mathbf{m} = \begin{pmatrix} \lambda \\ \lambda \\ \lambda \end{pmatrix} \quad (9)$$

Solution

Since,

$$\|\mathbf{m}\| = 1 \quad (10)$$

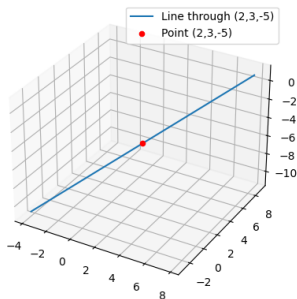
$$\lambda = \pm \frac{1}{\sqrt{3}} \quad (11)$$

Therefore the equation of the line is

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

Figure

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



C Code (code.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]
```

Python Code (nativecode.py)

```
# 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()
```