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Rushil Shanmukha Srinivas
EE25BTECH11057
Electrical Engineering ,
IIT Hyderabad.

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1 Problem

2 Solution

- Echelon Form and Column Operations
- Norm and Direction Cosines
- Plots

3 C Code

4 Python Code

Problem Statement

Find the direction cosines of the line passing through the two points $(-2, 4, -5)$ and $(1, 2, 3)$.

Variable	Description	Values
A	Point	$(-2, 4, -5)$
B	Point	$(1, 2, 3)$

Table: Variables Used

Echelon Form and Column Operations

Let

$$\mathbf{A} = \begin{pmatrix} -2 \\ 4 \\ -5 \end{pmatrix}, \quad \mathbf{B} = \begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix}. \quad (3.1)$$

Thus the direction (difference) vector of the line is

$$\mathbf{v} = \mathbf{B} - \mathbf{A} = \begin{pmatrix} 3 \\ -2 \\ 8 \end{pmatrix}. \quad (3.2)$$

Norm and Direction Cosines

The length of \mathbf{v} is

$$\begin{aligned}\mathbf{v}^T \mathbf{v} &= (3 \quad -2 \quad 8) \begin{pmatrix} 3 \\ -2 \\ 8 \end{pmatrix} \\ &= 3^2 + (-2)^2 + (8)^2 \\ &= 9 + 4 + 64 = 77\end{aligned}$$

Therefore, the norm of \mathbf{v} is

$$\|\mathbf{v}\| \triangleq \sqrt{\mathbf{v}^T \mathbf{v}} = \sqrt{77}$$

The unit vector in the direction of \mathbf{v} is

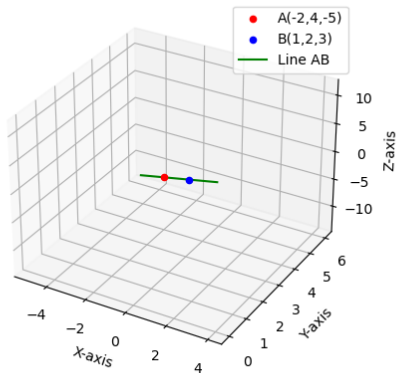
$$\frac{\mathbf{v}}{\|\mathbf{v}\|} = \frac{1}{\sqrt{77}} \begin{pmatrix} 3 \\ -2 \\ 8 \end{pmatrix}$$

Let α, β, γ be the angles made by the line with the x, y, z axes respectively. Then, the direction cosines are the elements of the above direction vector

$$\cos \alpha = \frac{3}{\sqrt{77}}, \quad \cos \beta = -\frac{2}{\sqrt{77}}, \quad \cos \gamma = \frac{8}{\sqrt{77}}$$

Plots

Line passing through A and B with direction cosines



Figure

C Code

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

// Function to compute direction cosines between two 3D points
void direction_cosines(double x1, double y1, double z1,
double x2, double y2, double z2,
double *l, double *m, double *n) {
    double dx = x2 - x1;
    double dy = y2 - y1;
    double dz = z2 - z1;
    double mag = sqrt(dx*dx + dy*dy + dz*dz);

    *l = dx / mag;
    *m = dy / mag;
    *n = dz / mag;
}
```


// For testing in C directly

```
int main() {  
  double l, m, n;  
  direction_cosines(-2,4,-5, 1,2,3, &l,&m,&n);  
  printf(" Direction-cosines:-(%lf,-%lf,-%lf)\n", l, m, n);  
  return 0;  
}
```

Python: call_c.py

```
import ctypes
```

```
# Load the shared object
```

```
lib = ctypes.CDLL("./direction_cosines.so")
```

```
# Define argument and return types
```

```
lib.direction_cosines.argtypes = [  
    ctypes.c_double, ctypes.c_double, ctypes.c_double,  
    ctypes.c_double, ctypes.c_double, ctypes.c_double,  
    ctypes.POINTER(ctypes.c_double),  
    ctypes.POINTER(ctypes.c_double),  
    ctypes.POINTER(ctypes.c_double)  
]
```

```
# Prepare variables
```

```
l = ctypes.c_double()
```

```
m = ctypes.c_double()
```

```
n = ctypes.c_double()

# Call the function
lib.direction_cosines(-2, 4, -5, 1, 2, 3, ctypes.byref(l), ctypes.byref(m),
    ctypes.byref(n))

print("Direction-cosines-(C-via-.so):", (l.value, m.value, n.value))
```

Python Code for Plotting

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

# Given points
A = np.array([-2, 4, -5])
B = np.array([1, 2, 3])

# Direction ratios
AB = B - A
print("Direction-ratios:", AB)

# Direction cosines
magnitude = np.linalg.norm(AB)
direction_cosines = AB / magnitude
print("Direction-cosines:", direction_cosines)
```

```
# Plotting
fig = plt.figure()
ax = fig.add_subplot(111, projection='3d')

# Plot points A and B
ax.scatter(*A, color='red', label='A(-2,4,-5)')
ax.scatter(*B, color='blue', label='B(1,2,3)')

# Plot line passing through A and B
t = np.linspace(-1, 2, 100) # parameter for line
line = A.reshape(3,1) + np.outer(AB, t)
ax.plot(line[0], line[1], line[2], color='green', label='Line AB')

# Labels
ax.set_xlabel('X-axis')
ax.set_ylabel('Y-axis')
ax.set_zlabel('Z-axis')
```

```
ax.legend()  
ax.set_title("Line passing through A and B with direction cosines")  
  
plt.savefig("../figs/fig_vector.png")  
  
plt.show()
```