Matgeo Presentation - Problem 1.10.19

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Problem Statement

If a line has direction ratios $2, -1, -2$, determine its direction cosines.

Given Data

Symbol	Value	Description
a	$\begin{pmatrix} 2 \\ -1 \\ -2 \end{pmatrix}$	vector

Table : Vector

Solution

The direction vector of the line is

$$\mathbf{a} = \begin{pmatrix} 2 \\ -1 \\ -2 \end{pmatrix}$$

The length of $\mathbf{a}$ is

$$\begin{aligned} a^\top a &= \begin{pmatrix} 2 & -1 & -2 \end{pmatrix} \begin{pmatrix} 2 \\ -1 \\ -2 \end{pmatrix} \\ &= 2^2 + (-1)^2 + (-2)^2 \\ &= 4 + 1 + 4 = 9 \end{aligned}$$

Therefore, the norm of a is

$$\|a\| \stackrel{\Delta}{=} \sqrt{a^\top a} = \sqrt{9} = 3$$

Solution

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

$$\frac{\mathbf{a}}{\|\mathbf{a}\|} = \frac{1}{3}\begin{pmatrix} 2 \\ -1 \\ -2 \end{pmatrix}$$

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

$$\cos\alpha = \frac{2}{3}, \quad \cos\beta = -\frac{1}{3}, \quad \cos\gamma = -\frac{2}{3}$$

Graph

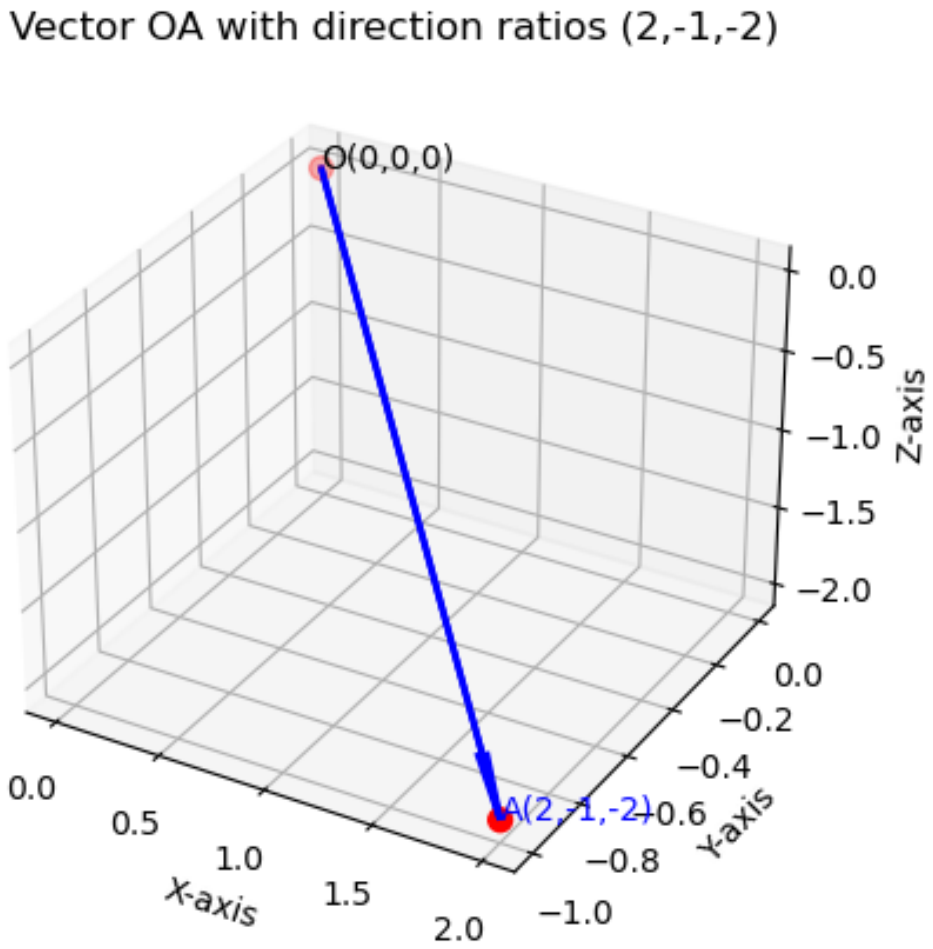

Fig : Vector a

C Code: points.c

```c
#include <stdio.h>

int main() {
  FILE *fp;

  // Endpoint of the vector with direction ratios (2, -1, -2)
  int x = 2, y = -1, z = -2;

  // Save origin and endpoint into file
  fp = fopen("points.dat", "w");
  fprintf(fp, "%d,%d,%d\n", 0, 0, 0); // Origin
  fprintf(fp, "%d,%d,%d\n", x, y, z); // Endpoint
  fclose(fp);

  return 0;
}
```

Python: call_c.py

```
import subprocess

# Compile C program
subprocess.run(["gcc", "points.c", "-o", "points"], check=True)

# Run the compiled program
subprocess.run(["./points"], check=True)
```

Python: plot.py

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

# Load points from file
points = np.loadtxt("points.dat", delimiter=',')
x, y, z = points[:,0], points[:,1], points[:,2]

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

# Plot points O and A
ax.scatter(x, y, z, color="red", s=50)
ax.text(0, 0, 0, "O(0,0,0)", color="black")
ax.text(x[1], y[1], z[1], f"A({int(x[1])},{int(y[1])},{int(z[1])})", color="blue")

# Draw line OA
ax.plot([x[0], x[1]], [y[0], y[1]], [z[0], z[1]], color="blue", linewidth=2)

# Add arrowhead at A
ax.quiver(x[0], y[0], z[0], x[1], y[1], z[1],
          color="blue", arrow_length_ratio=0.1, linewidth=2)

# Axis labels
ax.set_xlabel("X-axis")
ax.set_ylabel("Y-axis")
ax.set_zlabel("Z-axis")
ax.set_title("Vector OA with direction ratios (2,-1,-2)")

# Save and show
plt.savefig("fig_vector.png")
plt.show()
```