1.5.14

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Question

If a, b, c are position vectors of the points A$(2, 3, -4)$, B$(3, -4, -5)$, and C$(3, 2, -3)$ respectively, then $\|a + b + c\|$ is equal to

Theoretical Solution

Given the position vectors,

$$\mathbf{a} = \begin{pmatrix} 2 \\ 3 \\ 4 \end{pmatrix} \quad \mathbf{b} = \begin{pmatrix} 3 \\ -4 \\ -5 \end{pmatrix} \quad \mathbf{c} = \begin{pmatrix} 3 \\ 2 \\ -3 \end{pmatrix} \tag{1}$$

To find the magnitude of $\|a + b + c\|$,we can add these three vectors to find their sum, say S, and find their magnitude.

Theoretical Solution

$$\mathbf{S} = \mathbf{a} + \mathbf{b} + \mathbf{c} \tag{2}$$

$$\mathbf{S} = \begin{pmatrix} 2 \\ 3 \\ -4 \end{pmatrix} + \begin{pmatrix} 3 \\ -4 \\ -5 \end{pmatrix} + \begin{pmatrix} 3 \\ 2 \\ -3 \end{pmatrix} \tag{3}$$

$$\therefore \mathbf{S} = \begin{pmatrix} 8 \\ 1 \\ -12 \end{pmatrix} \tag{4}$$

Theoretical Solution

The magnitude of S is given by

$$\|S\|^2 = \mathbf{S}^T\mathbf{S} \tag{5}$$

$$\therefore \|S\|^2 = \begin{pmatrix} 8 & 1 & -12 \end{pmatrix} \begin{pmatrix} 8 \\ 1 \\ -12 \end{pmatrix} \tag{6}$$

$$\|S\|^2 = \begin{pmatrix} 209 \end{pmatrix} \tag{7}$$

$$\therefore \|S\| = \begin{pmatrix} 14.457 \end{pmatrix} \ \textit{units} \tag{8}$$

C Code - Internal division formula

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

double find_magnitude(int result[3])
{
        double mag;
        mag=sqrt(pow(result[0],2)+pow(result[1],2)+pow(result
            [2],2));
        return mag;

}

void sum_of_vectors(int a[3], int b[3], int c[3], int result[3])
{
    for(int i = 0; i < 3; i++)
    {
        result[i] = a[i] + b[i] + c[i];
    }
}
```

Python Code

```
import ctypes
import numpy as np
import matplotlib as mp
mp.use("TkAgg") # must come before pyplot
import matplotlib.pyplot as plt

# Load C library
lib = ctypes.CDLL('./libmagnitude_sum.so')

# C function signatures
lib.sum_of_vectors.argtypes = [
    ctypes.POINTER(ctypes.c_int),
    ctypes.POINTER(ctypes.c_int),
    ctypes.POINTER(ctypes.c_int),
    ctypes.POINTER(ctypes.c_int)
]
lib.sum_of_vectors.restype = None
```

Python Code

```
lib.find_magnitude.argtypes = [ctypes.POINTER(ctypes.c_int)]
lib.find_magnitude.restype = ctypes.c_double

# Define vectors
A = np.array([2, 3, -4], dtype=np.int32)
B = np.array([3, -4, -5], dtype=np.int32)
C = np.array([3, 2, -3], dtype=np.int32)
S = np.zeros(3, dtype=np.int32)

# Sum vectors via C
lib.sum_of_vectors(
    A.ctypes.data_as(ctypes.POINTER(ctypes.c_int)),
    B.ctypes.data_as(ctypes.POINTER(ctypes.c_int)),
    C.ctypes.data_as(ctypes.POINTER(ctypes.c_int)),
    S.ctypes.data_as(ctypes.POINTER(ctypes.c_int))
)
```

Python Code

```
print("Sum of vectors:", S)

# Magnitude via C
magnitude = lib.find_magnitude(S.ctypes.data_as(ctypes.POINTER(
    ctypes.c_int)))
print("Magnitude of sum vector: {:.3f}".format(magnitude))
```

Python Code

```
# 3D Plot
origin = np.array([0,0,0])
fig = plt.figure(figsize=(8,8))
ax = fig.add_subplot(111, projection='3d')

ax.quiver(*origin, *A, color='r', label='A')
ax.quiver(*origin, *B, color='g', label='B')
ax.quiver(*origin, *C, color='b', label='C')
ax.quiver(*origin, *S, color='k', linewidth=2, label='Sum (A+B+C)
    ')

max_val = max(np.abs(S)) + 2
ax.set_xlim([0, max_val])
ax.set_ylim([0, max_val])
ax.set_zlim([min(0, np.min(S)) - 2, max_val])
```

Python Code

```
ax.set_xlabel('X')
ax.set_ylabel('Y')
ax.set_zlabel('Z')
ax.set_title('3D Vectors and their Sum')
ax.legend()

plt.savefig("/home/user/Matrix/Matgeo_assignments/1.9.15/figs/
    Figure_1.png", dpi=300, bbox_inches='tight')
plt.show()
```

Plot