

2.4.20

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Question

Find the value of λ such that the vectors $\mathbf{a} = 2\mathbf{i} + \lambda\mathbf{j} + \mathbf{k}$ and $\mathbf{b} = \mathbf{i} + 2\mathbf{j} + 3\mathbf{k}$ are orthogonal.

Given Vectors

$$\mathbf{a} = \begin{pmatrix} 2 \\ \lambda \\ 1 \end{pmatrix}, \mathbf{b} = \begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix} \quad (1)$$

Finding Lambda(λ)

For two vectors to be orthogonal their dot product should be equal to zero which is equal to product of transpose of column matrix **a** and column matrix **b**:

$$\mathbf{a}^T \mathbf{b} = 0 \quad (2)$$

$$\begin{pmatrix} 2 & \lambda & 1 \end{pmatrix} \begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix} = 0 \quad (3)$$

$$2 + 2\lambda + 3 = 0 \quad (4)$$

$$\lambda = \left(\frac{-5}{2} \right) \quad (5)$$

Therefore, the final vectors are:

$$\mathbf{a} = \begin{pmatrix} 2 \\ \left(\frac{-5}{2}\right) \\ 1 \end{pmatrix} \quad (6)$$

$$\mathbf{b} = \begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix} \quad (7)$$

```
#include <stdio.h>
void make_data(double *points){
    points[0] = 1;
    points[1] = 2;
    points[2] = 3;
    double lambda_val;
    lambda_val = -2.5;
    points[3] = lambda_val;
}
```

Python Code 1

```
import ctypes as ct
def give_data():
    lib = ct.CDLL("./problem.so")
    entry = ct.c_double*4
    lib.make_data.argtypes = [ct.POINTER(ct.c_double)]
    data = entry()
    lib.make_data(data)
    return data[1], data[3], data[0], data[0], data[1], data[2]
```

Python Code 2

```
import numpy as np
import matplotlib.pyplot as plt
from call import give_data
Ax, Ay, Az, Bx, By, Bz = give_data()
lambda_val = -2.5
a = np.array([Ax, Ay, Az])
b = np.array([Bx, By, Bz])
fig = plt.figure()
ax = fig.add_subplot(111, projection='3d')
ax.quiver(0, 0, 0, a[0], a[1], a[2], color='r', label='Vector a')
ax.quiver(0, 0, 0, b[0], b[1], b[2], color='b', label='Vector b')
```


Python Code 2

```
ax.text(a[0], a[1], a[2], 'a', fontsize=12)
ax.text(b[0], b[1], b[2], 'b', fontsize=12)
ax.set_xlabel('X')
ax.set_ylabel('Y')
ax.set_zlabel('Z')
ax.set_title("Orthogonal Vectors a and b")
ax.legend()
plt.savefig("../figs/plot.png")
plt.show()
```

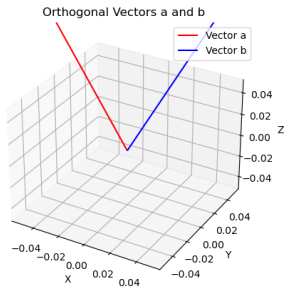


Figure: Plot of orthogonal vectors \mathbf{a} and \mathbf{b} .