2.5.28

Namaswi -EE25BTECH11060

August ,2025

Question

Find the projection of the vector

$$\mathbf{a} = 2\mathbf{i} + 3\mathbf{j} + 2\mathbf{k}$$

on the vector

$$\mathbf{b} = 2\mathbf{i} + 2\mathbf{j} + \mathbf{k}.$$

Given data

Vector	**i-component**	**j-component**	**k-component**
a	2	3	2
b	2	2	1

Table: Components of vectors **a** and **b**

Formulae

Projection of vector $\mathbf{A}$ on $\mathbf{B}$ is given by

$$\frac{\mathbf{A}^\top \mathbf{B}}{||\mathbf{B}^2||}\mathbf{B} \tag{1}$$

$$\frac{\begin{pmatrix} 2 & 3 & 2 \end{pmatrix}\begin{pmatrix} 2 \\ 2 \\ 1 \end{pmatrix}}{2^2+2^2+1^2}\mathbf{B} \tag{2}$$

$$\tag{3}$$

Theoretical Solution

$$= \frac{2^2 + (3)(2) + (2)(1)}{2^2 + 2^2 + 1^2} \begin{pmatrix} 2 \\ 2 \\ 1 \end{pmatrix}$$

$$= \frac{12}{9} \begin{pmatrix} 2 \\ 2 \\ 1 \end{pmatrix}$$

$$= \frac{4}{3} \begin{pmatrix} 2 \\ 2 \\ 1 \end{pmatrix} = \begin{pmatrix} \frac{8}{3} \\ \frac{8}{3} \\ \frac{4}{3} \end{pmatrix}$$

$$\textit{The projection vector is given by} \frac{8}{3}\mathbf{i} + \frac{8}{3}\mathbf{j} + \frac{4}{3}\mathbf{k}$$

C Code

```c
 #include <stdio.h>

int main() {
    double a[3] = {2, 3, 2};
    double b[3] = {2, 2, 1};
    double dot = 0.0, normB2 = 0.0;
    for(int i = 0; i < 3; i++) {
        dot += a[i] * b[i];
        normB2 += b[i] * b[i]; }
    double factor = dot / normB2;
    double proj[3];
    for(int i = 0; i < 3; i++) {
        proj[i] = factor * b[i];}
    printf("Projection of a on b = (%.2lf)i + (%.2lf)j + (%.2lf)k\n",
           proj[0], proj[1], proj[2]);
 return 0;
}
```

Python Code

```python
 import numpy as np
import matplotlib.pyplot as plt
from mpl_toolkits.mplot3d import Axes3D

# Define vectors
a = np.array([2, 3, 2])
b = np.array([2, 2, 1])
```

Python Code

```
 # Compute projection of a onto b
proj_scalar = np.dot(a, b) / np.dot(b, b)
proj = proj_scalar * b

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

# Plot origin
origin = [0, 0, 0]
```

Python Code

```


# Plot vectors
ax.quiver(*origin, *a, color='blue', label='Vector a', linewidth=2)
ax.quiver(*origin, *b, color='green', label='Vector b', linewidth=2)
ax.quiver(*origin, *proj, color='red', label='Projection of a on b', linestyle='dashed', linewidth=2)

# Labels and settings
ax.set_xlim([0, 4])
ax.set_ylim([0, 4])
ax.set_zlim([0, 4])
ax.set_xlabel('X')
ax.set_ylabel('Y')
ax.set_zlabel('Z')
ax.set_title('Projection of Vector a onto Vector b')
ax.legend()
```

Python Code

```
import ctypes

# Load the shared C library
lib = ctypes.CDLL("./libprojection.so") # use "projection.dll" on Windows

# Define argument and return types
lib.projection.argtypes = [ctypes.POINTER(ctypes.c_double),
                           ctypes.POINTER(ctypes.c_double),
                           ctypes.POINTER(ctypes.c_double)]
lib.projection.restype = None
```

Python Code

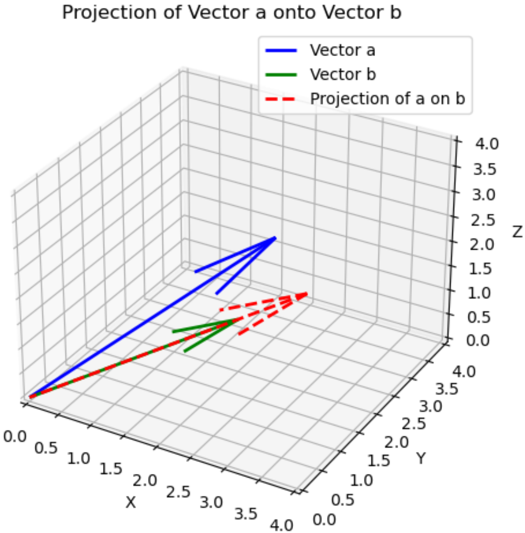
```python
 lib.projection.restype = None

# Define vectors a and b
a = (ctypes.c_double * 3)(2, 3, 2)
b = (ctypes.c_double * 3)(2, 2, 1)
proj = (ctypes.c_double * 3)()

# Call C function
lib.projection(a, b, proj)

# Print result
print(f"Projection of a on b = ({proj[0]:.2f})i + ({proj[1]:.2f})j + ({proj[2]:.2f})k")
```

Plot


Projection of Vector a onto Vector b
Vector a
Vector b
Projection of a on b
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
X
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Y
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Z