1.11.15

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Question

Write the direction ratios of the vector $3\mathbf{a} + 2\mathbf{b}$ where $\mathbf{a} = \overrightarrow{i} + \overrightarrow{j} - 2\overrightarrow{k}$ and $\mathbf{b} = 2\overrightarrow{i} - 4\overrightarrow{j} + 5\overrightarrow{k}$.

Theoretical Solution

The given vectors $\mathbf{a}$ and $\mathbf{b}$ are

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

$$\mathbf{b} = \begin{pmatrix} 2 \\ -4 \\ 5 \end{pmatrix} \tag{2}$$

The direction ratios of the vector $3\mathbf{a} + 2\mathbf{b}$ are

Theoretical Solution

$$3\mathbf{a} + 2\mathbf{b} = \begin{pmatrix} a & b \end{pmatrix} \begin{pmatrix} 3 \\ 2 \end{pmatrix} \tag{3}$$

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

$$3\mathbf{a} + 2\mathbf{b} = \begin{pmatrix} 3(1) + 2(2) \\ 3(1) + 2(-4) \\ 3(-2) + 2(5) \end{pmatrix} \tag{5}$$

$$3\mathbf{a} + 2\mathbf{b} = \begin{pmatrix} 7 \\ -5 \\ 4 \end{pmatrix} \tag{6}$$

C Function

```c
#include <stdio.h>

// Function to compute 3a + 2b and return direction ratios
void compute_vector_sum(double a_i, double a_j, double a_k,
                        double b_i, double b_j, double b_k,
                        double *result_i, double *result_j, double *result_k) {
    // Calculate 3a + 2b
    *result_i = 3 * a_i + 2 * b_i;
    *result_j = 3 * a_j + 2 * b_j;
    *result_k = 3 * a_k + 2 * b_k;
}

// Function to print vector components
void print_vector(const char *name, double i, double j, double k) {
    printf("%s = %.1fi + %.1fj + %.1fk\n", name, i, j, k);
}
```

Main C Code

```c
 #include <stdio.h>

// Function declarations
void compute_vector_sum(double a_i, double a_j, double a_k,
                        double b_i, double b_j, double b_k,
                        double *result_i, double *result_j, double *
                            result_k);
void print_vector(const char *name, double i, double j, double k)
    ;
int main() {
    // Given vectors
    double a_i = 1.0, a_j = 1.0, a_k = -2.0; // a = i + j - 2k
    double b_i = 2.0, b_j = -4.0, b_k = 5.0; // b = 2i - 4j + 5k

    // Result vector
    double result_i, result_j, result_k;
```

Main C Code

```c

    // Compute 3a + 2b
    compute_vector_sum(a_i, a_j, a_k, b_i, b_j, b_k,
                       &result_i, &result_j, &result_k);

    // Print results
    printf("Vector Operations:\n");
    printf("==================\n");
    print_vector("a", a_i, a_j, a_k);
    print_vector("b", b_i, b_j, b_k);
    print_vector("3a + 2b", result_i, result_j, result_k);

    printf("\nDirection ratios of 3a + 2b:\n");
    printf("x-component: %.1f\n", result_i);
    printf("y-component: %.1f\n", result_j);
    printf("z-component: %.1f\n", result_k);
    return 0;
}
```

Python Code

```
from ctypes import CDLL, c_double, POINTER
import matplotlib.pyplot as plt
import numpy as np
from mpl_toolkits.mplot3d import Axes3D

lib = CDLL('./libvector.so')
lib.compute_vector_sum.argtypes = [
    c_double, c_double, c_double, # a components
    c_double, c_double, c_double, # b components
    POINTER(c_double), POINTER(c_double), POINTER(c_double) #
        result components
]
lib.compute_vector_sum.restype = None
a = [1.0, 1.0, -2.0] # i + j - 2k
b = [2.0, -4.0, 5.0] # 2i - 4j + 5k
result_i = c_double()
result_j = c_double()
result_k = c_double()
```

Python Code

```python
# Call the C function
lib.compute_vector_sum(
    c_double(a[0]), c_double(a[1]), c_double(a[2]),
    c_double(b[0]), c_double(b[1]), c_double(b[2]),
    result_i, result_j, result_k
)
result_vector = [result_i.value, result_j.value, result_k.value]
print("Vector Operations using Python and C Library")
print("============================================")
print(f"Vector a = {a[0]}i + {a[1]}j + {a[2]}k")
print(f"Vector b = {b[0]}i + {b[1]}j + {b[2]}k")
print(f"3a + 2b = {result_vector[0]:.1f}i + {result_vector[1]:.1f
    }j + {result_vector[2]:.1f}k")
print(f"\nDirection ratios of 3a + 2b:")
print(f"x-component: {result_vector[0]:.1f}")
print(f"y-component: {result_vector[1]:.1f}")
print(f"z-component: {result_vector[2]:.1f}")
```

Python Code

```
# Create a detailed 3D plot
fig = plt.figure(figsize=(14, 10))
ax = fig.add_subplot(111, projection='3d')
origin = [0, 0, 0]
ax.quiver(*origin, *a, color='red', arrow_length_ratio=0.1,
    linewidth=3,
          label=f'a = {a[0]}i + {a[1]}j + {a[2]}k')
ax.quiver(*origin, *b, color='blue', arrow_length_ratio=0.1,
    linewidth=3,
          label=f'b = {b[0]}i + {b[1]}j + {b[2]}k')
ax.quiver(*origin, *result_vector, color='green',
    arrow_length_ratio=0.1, linewidth=4,
          label=f'3a + 2b = {result_vector[0]:.1f}i + {
              result_vector[1]:.1f}j + {result_vector[2]:.1f}k')
```

Python Code

```python
ax.plot([0, result_vector[0]], [0, 0], [0, 0], 'g--', alpha=0.7, linewidth=2, label='X-component')
ax.plot([0, 0], [0, result_vector[1]], [0, 0], 'g--', alpha=0.7, linewidth=2, label='Y-component')
ax.plot([0, 0], [0, 0], [0, result_vector[2]], 'g--', alpha=0.7, linewidth=2, label='Z-component')

ax.quiver(0, 0, 0, 8, 0, 0, color='black', arrow_length_ratio=0.05, alpha=0.5, linestyle=':')
ax.quiver(0, 0, 0, 0, 8, 0, color='black', arrow_length_ratio=0.05, alpha=0.5, linestyle=':')
ax.quiver(0, 0, 0, 0, 0, 8, color='black', arrow_length_ratio=0.05, alpha=0.5, linestyle=':')

ax.text(8.5, 0, 0, 'X (i)', fontsize=12, color='black')
ax.text(0, 8.5, 0, 'Y (j)', fontsize=12, color='black')
ax.text(0, 0, 8.5, 'Z (k)', fontsize=12, color='black')
```

Python Code

```
# Add text labels for vector endpoints
ax.text(a[0], a[1], a[2], ' a', fontsize=10, color='red')
ax.text(b[0], b[1], b[2], ' b', fontsize=10, color='blue')
ax.text(result_vector[0], result_vector[1], result_vector[2], ' 3
    a+2b', fontsize=12, color='green')

# Add text for direction ratios
ax.text(2, -6, 6, f'Direction Ratios:\nX: {result_vector[0]:.1f}\
    nY: {result_vector[1]:.1f}\nZ: {result_vector[2]:.1f}',
        fontsize=11, bbox=dict(boxstyle="round,pad=0.3",
            facecolor="yellow", alpha=0.7))

# Set plot limits with some padding
max_val = max(max(abs(x) for x in a + b + result_vector), 1) + 2
ax.set_xlim([-max_val, max_val])
ax.set_ylim([-max_val, max_val])
ax.set_zlim([-max_val, max_val])
```

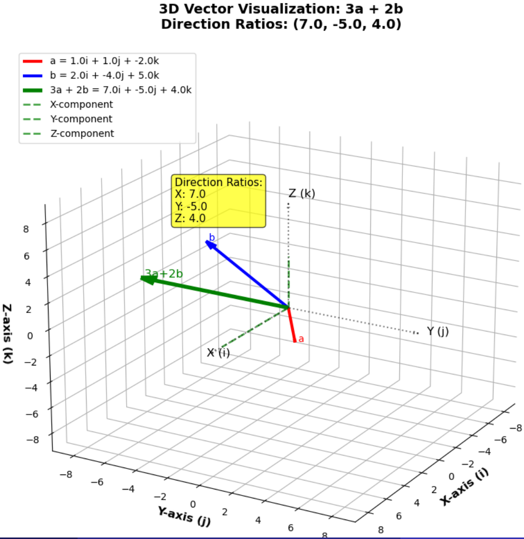
Python Code

```
# Labels and title
ax.set_xlabel('X-axis (i)', fontsize=12, fontweight='bold')
ax.set_ylabel('Y-axis (j)', fontsize=12, fontweight='bold')
ax.set_zlabel('Z-axis (k)', fontsize=12, fontweight='bold')
ax.set_title('3D Vector Visualization: 3a + 2b\nDirection Ratios:
    (7.0, -5.0, 4.0)',
            fontsize=14, fontweight='bold', pad=20)

# Add grid with better visibility
ax.grid(True, alpha=0.3)
ax.xaxis.pane.fill = False
ax.yaxis.pane.fill = False
ax.zaxis.pane.fill = False
ax.xaxis.pane.set_edgecolor('w')
ax.yaxis.pane.set_edgecolor('w')
ax.zaxis.pane.set_edgecolor('w')
```

Python Code

```
# Set view angle for better visualization
ax.view_init(elev=20, azim=30)

# Add legend
ax.legend(loc='upper left', bbox_to_anchor=(0, 1))
plt.savefig("/home/gauthamp/ee1030-2025/ai25btech11013/matgeo
    /1.11.15/figs/fig1.png")
plt.show()
```

Plot



3D Vector Visualization: 3a + 2b
Direction Ratios: (7.0, -5.0, 4.0)
a = 1.0i + 1.0j + -2.0k
b = 2.0i + -4.0j + 5.0k
3a + 2b = 7.0i + -5.0j + 4.0k
X-component
Y-component
Z-component
Direction Ratios:
X: 7.0
Y: -5.0
Z: 4.0
Z (k)
Y (j)
X (i)
b
a
3a+2b
Z-axis (k)
Y-axis (j)
X-axis (i)