1.10.10

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Question

The vector in the direction of the vector $\hat{i} - 2\hat{j} + 2\hat{k}$ that has magnitude 9 is

(a) $\hat{i} - 2\hat{j} + 2\hat{k}$

(b) $\hat{i} - 2\hat{j}$

(c) $3(\hat{i} - 2\hat{j} + 2\hat{k})$

(d) $9(\hat{i} - 2\hat{j} + 2\hat{k})$

Given Information

Let us assume the given vector to be vector **A**
To check whether the given vector is parallel with the vectors given in the options.
Let the vectors in the options be **B1, B2, B3, B4**. For parallel nature, the rank of (**0 A B1**) must be 1.

$$(\mathbf{0\ A\ B1}) = \begin{pmatrix} 0 & 1 & 1 \\ 0 & -2 & -2 \\ 0 & 2 & 2 \end{pmatrix} \tag{1}$$

$$(\mathbf{0\ A\ B2}) = \begin{pmatrix} 0 & 1 & 1 \\ 0 & -2 & -2 \\ 0 & 2 & 0 \end{pmatrix} \tag{2}$$

Given Information

$$(\mathbf{0\ A\ B3}) = \begin{pmatrix} 0 & 1 & 3 \\ 0 & -2 & -6 \\ 0 & 2 & 6 \end{pmatrix} \tag{3}$$

$$(\mathbf{0\ A\ B4}) = \begin{pmatrix} 0 & 1 & 9 \\ 0 & -2 & -18 \\ 0 & 2 & 18 \end{pmatrix} \tag{4}$$

Through rank manipulation we get the matrices **B1, B3 and B4** to have a rank of 1.
They are parallel to **A**

Solution

First we find the unit vector in the direction of the given vector. This is given by:

$$\hat{\mathbf{A}} = \frac{\mathbf{A}}{\|\mathbf{A}\|} \tag{5}$$

Here the magnitude(norm) of the vector $\mathbf{A}$ is given by

$$\mathbf{A}^T\mathbf{A} = \|\mathbf{A}\|^2 \implies \begin{pmatrix} 1 & -2 & 2 \end{pmatrix} \begin{pmatrix} 1 \\ -2 \\ 2 \end{pmatrix} = 9 \tag{6}$$

Continuation

$$\implies \|\mathbf{A}\| = 3 \tag{7}$$

From 7, this gives us

$$\hat{\mathbf{A}} = \frac{\mathbf{A}}{\|\mathbf{A}\|} = \frac{1}{3}\begin{pmatrix} 1 \\ -2 \\ 2 \end{pmatrix} \tag{8}$$

Continuation

From 8, the vector of magnitude 9 along this direction is given by

$$9\hat{\mathbf{A}} = 9 \times \frac{1}{3}\begin{pmatrix} 1 \\ -2 \\ 2 \end{pmatrix} \tag{9}$$

$$\implies 3\begin{pmatrix} 1 \\ -2 \\ 2 \end{pmatrix} = \mathbf{B3} \tag{10}$$

Final Answer

Therefore the required vector is **B3**. This is option (b).

C code

```c
#include<math.h>

double norm(double *A, int m){
        double norm = 0;
        for(int i=0; i<m; i++){
                norm += A[i]*A[i];
        }
        norm = sqrt(norm);
        return norm;
}
```

Python Code

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


given_vector = np.array([1, -2, 2])
final_vector = np.array([3, -6, 6])


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


ax.quiver(0, 0, 0, given_vector[0], given_vector[1], given_vector
    [2], color='b', arrow_length_ratio=0.1)
```

Python Code

```
    ax.quiver(0, 0, 0, final_vector[0], final_vector[1],
        final_vector[2], color='r', arrow_length_ratio=0.1)

ax.scatter(given_vector[0], given_vector[1], given_vector[2],
    color='b', s=50)
ax.scatter(final_vector[0], final_vector[1], final_vector[2],
    color='r', s=50)

label = f'({given_vector[0]}, {given_vector[1]}, {given_vector
    [2]})'
ax.text(given_vector[0], given_vector[1], given_vector[2], s=
    label, color='g', fontsize=10)
```

Python Code

```
label = f'({final_vector[0]}, {final_vector[1]}, {final_vector
    [2]})'
ax.text(final_vector[0], final_vector[1], final_vector[2], s=
    label, color='g', fontsize=10)

ax.set_xlim([0, 6])
ax.set_ylim([-6, 0])
ax.set_zlim([0, 6])
```

Python Code

```
ax.set_xlabel('X-axis')
ax.set_ylabel('Y-axis')
ax.set_zlabel('Z-axis')


plt.title('1.10.10')

plt.savefig('figs/fig1.png')


plt.show()
```

Plot

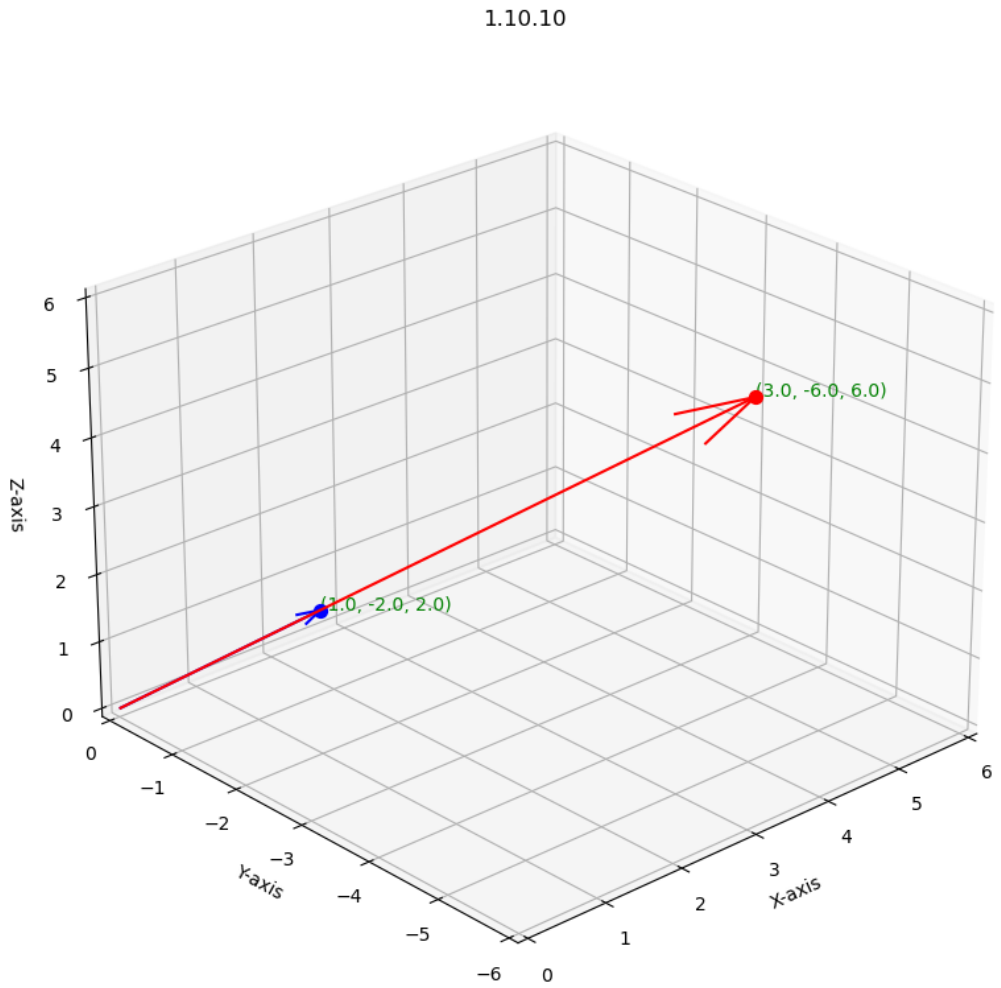

Figure: Vector along given vector with specified magnitude