

If The Vectors $\mathbf{A} + \mathbf{B} + \mathbf{C} = \mathbf{0}$ And $\mathbf{A} = (4.6 \text{ M}) \hat{\mathbf{x}} + (3.8 \text{ M}) \hat{\mathbf{y}}$ $\mathbf{B} = (6.8 \text{ M}) \hat{\mathbf{x}} + (6.8 \text{ M}) \hat{\mathbf{y}}$ What Is The

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Understanding vector operations is fundamental in physics and engineering, especially when analyzing forces, velocities, and other directional quantities. In this article, we will explore the problem involving vectors $\mathbf{A}$, $\mathbf{B}$, and $\mathbf{C}$, where their sum equals zero, and derive the missing vector $\mathbf{C}$ based on the given information. We will break down the concepts and calculations step by step, making the topic accessible even to those new to vector algebra.

Introduction to Vectors and Their Components

What Are Vectors?

Vectors are quantities that have both magnitude and direction. Unlike scalar quantities, which are described only by their size (such as mass or temperature), vectors require both magnitude and a directional component for a complete description.

Component Form of Vectors

Vectors can be expressed in component form, especially in Cartesian coordinates. For example, a vector $\mathbf{A}$ can be written as:

$$\mathbf{A} = A_x \hat{\mathbf{i}} + A_y \hat{\mathbf{j}}$$

where:

- A_x and A_y are the components of vector $\mathbf{A}$ along the x and y axes, respectively.
- $\hat{\mathbf{i}}$ and $\hat{\mathbf{j}}$ are the unit vectors in the x and y directions.

In the problem, vector $\mathbf{A}$ is given as:

$$\mathbf{A} = 4.6 \text{ M} \hat{\mathbf{i}} + 3.8 \text{ M} \hat{\mathbf{j}}$$

and vector $\mathbf{B}$ as:

$$\mathbf{B} =$$

$$\mathbf{B} = 6.8 \text{ M} \hat{\mathbf{i}} + 6.8 \text{ M} \hat{\mathbf{j}}$$

where M denotes meters (unit of length).

Understanding the Problem Statement

Given:

- $\mathbf{A} + \mathbf{B} + \mathbf{C} = 0$
- $\mathbf{A} = 4.6 \text{ M} \hat{\mathbf{i}} + 3.8 \text{ M} \hat{\mathbf{j}}$
- $\mathbf{B} = 6.8 \text{ M} \hat{\mathbf{i}} + 6.8 \text{ M} \hat{\mathbf{j}}$

Find:

- The vector $\mathbf{C}$.

This problem involves vector addition and the concept of equilibrium, where the sum of vectors equals zero, indicating a balanced system.

Calculating Vector C

Using Vector Addition Principles

From the equation:

$$\mathbf{A} + \mathbf{B} + \mathbf{C} = 0$$

we can rearrange to find $\mathbf{C}$:

$$\mathbf{C} = -(\mathbf{A} + \mathbf{B})$$

This means vector C is the negative sum of vectors A and B.

Adding Vectors A and B

Addition of vectors in component form is straightforward:

$$\mathbf{A} + \mathbf{B} = (A_x + B_x) \hat{\mathbf{i}} + (A_y + B_y) \hat{\mathbf{j}}$$

Substituting the given components:

$$\mathbf{A} + \mathbf{B} = (4.6 + 6.8) \mathbf{i} + (3.8 + 6.8) \mathbf{j}$$

Calculating:

$$\mathbf{A} + \mathbf{B} = 11.4 \mathbf{i} + 10.6 \mathbf{j}$$

Finding Vector C

Since:

$$\mathbf{C} = -(\mathbf{A} + \mathbf{B})$$

then:

$$\mathbf{C} = -11.4 \mathbf{i} - 10.6 \mathbf{j}$$

which simplifies to:

$$\mathbf{C} = -11.4 \mathbf{i} - 10.6 \mathbf{j}$$

or in magnitude and direction form.

Magnitude and Direction of Vector C

Calculating the Magnitude

The magnitude of vector $\mathbf{C}$ is given by:

$$|\mathbf{C}| = \sqrt{C_x^2 + C_y^2}$$

where:

- $C_x = -11.4$
- $C_y = -10.6$

Calculating:

$$|\mathbf{C}| = \sqrt{(-11.4)^2 + (-10.6)^2} = \sqrt{129.96 + 112.36} = \sqrt{242.32} \approx 15.56, \text{ m}$$

So, the magnitude of vector C is approximately 15.56 meters.

Determining the Direction of Vector C

The direction (angle θ) of vector C relative to the positive X-axis can be calculated using:

$$\theta = \arctan \left(\frac{C_y}{C_x} \right)$$

Since both components are negative, the vector points into the third quadrant, where both x and y are negative.

Calculating:

$$\theta = \arctan \left(\frac{-10.6}{-11.4} \right) = \arctan \left(\frac{10.6}{11.4} \right) \approx \arctan(0.9316)$$

$$\theta \approx 43.7^\circ$$

Because both components are negative, the vector points at:

$$\theta \approx 180^\circ + 43.7^\circ = 223.7^\circ$$

from the positive X-axis, indicating the vector is directed into the third quadrant.

Practical Applications of Vector Analysis

In Physics and Engineering

Understanding vector addition and equilibrium conditions are vital in various fields, including:

- Analyzing forces in statics and dynamics

- Calculating resultant velocities
- Determining resultant forces on structures
- Navigating in aerospace engineering

In Navigation and Map Reading

Vectors help in plotting courses, determining displacements, and understanding directional relationships between different paths or forces acting on an object.

Summary of Key Steps in Solving the Problem

- Express the given vectors in component form.
- Use the vector addition formula to find the sum of vectors A and B.
- Apply the negative of this sum to find vector C, according to the equilibrium condition.
- Calculate the magnitude of vector C using the Pythagorean theorem.
- Determine the direction of vector C using the arctangent function, considering the signs of components.

Conclusion

In this detailed exploration, we have demonstrated how to determine an unknown vector in a system where vectors sum to zero. The process involved breaking vectors into components, performing vector addition, and then applying the negative to find the resulting vector. The key takeaway is that understanding the component form of vectors and their algebraic operations is essential for solving real-world problems in physics, engineering, and navigation.

By mastering these concepts, students and professionals can analyze complex systems involving multiple forces, velocities, or other vector quantities with confidence. Whether in designing structures, navigating ships, or studying motion, vector algebra remains a foundational skill.

Meta Description:

Learn how to find an unknown vector when given two vectors and the condition that their sum equals zero. Step-by-step explanation with calculations, applications, and practical insights into vector addition and equilibrium.

Frequently Asked Questions

Given vectors **A** and **B**, how do you find the vector **C** such that $\mathbf{A} + \mathbf{B} + \mathbf{C} = \mathbf{0}$?

To find vector **C**, rearrange the equation as $\mathbf{C} = -(\mathbf{A} + \mathbf{B})$. First, sum vectors **A** and **B** component-wise, then multiply each component by -1 to get **C**.

What are the components of vectors **A** and **B** in the given problem?

Vector **A** has components (4.6 M, 3.8 M), and vector **B** has components (6.8 M, 6.8 M).

How do you calculate the sum of vectors **A** and **B**?

Add their corresponding components: for the x-component, $4.6 \text{ M} + 6.8 \text{ M} = 11.4 \text{ M}$; for the y-component, $3.8 \text{ M} + 6.8 \text{ M} = 10.6 \text{ M}$. So, $\mathbf{A} + \mathbf{B} = (11.4 \text{ M}, 10.6 \text{ M})$.

What is the resulting vector **C** when $\mathbf{A} + \mathbf{B} + \mathbf{C} = \mathbf{0}$?

Vector **C** is the negative of the sum of **A** and **B**, so $\mathbf{C} = -(11.4 \text{ M}, 10.6 \text{ M}) = (-11.4 \text{ M}, -10.6 \text{ M})$.

How can this problem be visualized geometrically?

Vectors **A** and **B** can be represented as arrows from the origin. Their sum is a diagonal vector. Vector **C** is then the arrow that brings the resultant back to the origin, effectively closing the triangle formed by **A**, **B**, and **C**.

What is the significance of the equation $\mathbf{A} + \mathbf{B} + \mathbf{C} = \mathbf{0}$ in physics and vector analysis?

This equation indicates that the three vectors form a closed triangle, often representing equilibrium or conservation of momentum in physics, where the vector sum balances out to zero.

Additional Resources

Understanding the Vector Equation: $\mathbf{A} + \mathbf{B} + \mathbf{C} = \mathbf{0}$

In the realm of physics and engineering, vector analysis is fundamental in describing quantities that have both magnitude and direction. One common problem involves understanding the relationships between multiple vectors, especially when their sum equals zero. The equation $\mathbf{A} + \mathbf{B} + \mathbf{C} = \mathbf{0}$ exemplifies such a scenario, often indicating that the vectors form a closed triangle or that they are in equilibrium. This detailed review explores the nuances of this problem, focusing on the given vectors **A** and **B**, and aims to uncover

the unknown vector C through analytical methods.

Introduction to Vector Addition and Equilibrium

Before delving into the specifics of the problem, it's essential to understand the foundational concepts of vector addition and equilibrium:

- Vectors: Quantities characterized by magnitude and direction, often represented graphically with arrows.
- Vector Addition: The process of combining two or more vectors to find a resultant vector, typically using the head-to-tail method.
- Equilibrium Condition: When the sum of vectors equals zero, indicating a state of balance or closure (no net force or moment).

The equation $A + B + C = 0$ suggests that the vectors A, B, and C form a triangle when placed head-to-tail or that their vector sum cancels out, implying they are in equilibrium.

Given Data and Its Significance

The problem provides the following vectors:

- $A = (4.6 M_1) \hat{X} + (3.8 M) \hat{Y}$
- $B = (6.8 M) \hat{X} + (6.8 M) \hat{Y}$

Where M_1 and M are units of magnitude, possibly representing different measurement scales or units. However, it appears there might be a typographical inconsistency with M_1 and M ; for the purpose of analysis, we assume both are magnitudes in the same units, or M_1 is a specific known scalar.

Key Points:

1. Both vectors are expressed in Cartesian components, along the X and Y axes.
2. The components of A and B are given explicitly, allowing us to perform algebraic calculations.
3. The goal is typically to find C or analyze the relationships between A, B, and C based on the given data.

Step-by-Step Analysis of the Vectors

Component Form of Vectors A and B

Expressing the vectors explicitly:

$$\begin{aligned} - A &= (4.6 M_1) \hat{X} + (3.8 M) \hat{Y} \\ - B &= (6.8 M) \hat{X} + (6.8 M) \hat{Y} \end{aligned}$$

Assuming M_1 and M are compatible units, or that M_1 is a scalar multiple of M , the components are straightforward.

Calculating the Components of A and B

$$\begin{aligned} - A_x &= 4.6 M_1 \\ - A_y &= 3.8 M \\ - B_x &= 6.8 M \\ - B_y &= 6.8 M \end{aligned}$$

Finding Vector C

Given the vector sum:

$$\backslash [A + B + C = 0 \backslash]$$

Rearranged:

$$\backslash [C = - (A + B) \backslash]$$

This means C is the negative of the vector sum of A and B .

Calculating the Resultant of Vectors A and B

Component-wise Summation

Adding vectors A and B component-wise:

$$- A + B = (A_x + B_x) \hat{X} + (A_y + B_y) \hat{Y}$$

Plugging in the values:

$$- A + B = (4.6 M_1 + 6.8 M) \hat{X} + (3.8 M + 6.8 M) \hat{Y}$$

Dealing with Potential Unit Discrepancy

If M_1 and M are different units or scales, we need clarification. For simplicity, assume $M_1 = M$ (or that the problem intends for both to be in the same units):

$$- A + B = (4.6 + 6.8) M \hat{X} + (3.8 + 6.8) M \hat{Y}$$

Calculations:

$$- A + B = 11.4 M \hat{X} + 10.6 M \hat{Y}$$

Resultant Vector of $A + B$

The resultant vector $R = A + B$:

$$\| R = (11.4 M) \hat{X} + (10.6 M) \hat{Y} \|$$

Determining the Vector C

Since $A + B + C = 0$, then:

$$\| C = -R = -(11.4 M \hat{X} + 10.6 M \hat{Y}) \|$$

Thus,

$$\| C = -11.4 M \hat{X} - 10.6 M \hat{Y} \|$$

or, expressed component-wise:

$$- C_x = -11.4 M$$

$$- C_y = -10.6 M$$

Vector C : Magnitude and Direction

Calculating the Magnitude of C

The magnitude of C:

$$|C| = \sqrt{C_x^2 + C_y^2}$$

Plugging in the values:

$$|C| = \sqrt{(-11.4 \text{ M})^2 + (-10.6 \text{ M})^2} = \sqrt{(11.4)^2 + (10.6)^2} \text{ M}$$

Calculations:

$$\begin{aligned} - (11.4)^2 &= 129.96 \\ - (10.6)^2 &= 112.36 \end{aligned}$$

Sum:

$$129.96 + 112.36 = 242.32$$

Therefore,

$$|C| = \sqrt{242.32} \text{ M} \approx 15.56 \text{ M}$$

Determining the Direction of C

The angle θ with respect to the positive X-axis:

$$\theta = \arctan \left(\frac{C_y}{C_x} \right)$$

Since both components are negative:

$$\theta = \arctan \left(\frac{-10.6}{-11.4} \right) = \arctan \left(\frac{10.6}{11.4} \right)$$

Calculations:

$$\theta =$$

$$\frac{10.6}{11.4} \approx 0.930$$

Thus,

$$\theta \approx \arctan(0.930) \approx 43.3^\circ$$

Because both C_x and C_y are negative, C points in the third quadrant, so:

$$\boxed{\text{Direction of } C \approx 180^\circ + 43.3^\circ = 223.3^\circ}$$

or, equivalently, measured from the positive X-axis, the vector points roughly 223.3 degrees in the third quadrant.

Physical Interpretation and Applications

Understanding the vector relationships has practical implications across various fields:

Mechanical Equilibrium

- When forces acting on a body are in equilibrium, their vector sum is zero.
- The vectors A, B, and C could represent forces, moments, or velocities balancing each other.
- The calculation confirms that C is the negative resultant of A and B, maintaining equilibrium.

Electrical and Magnetic Fields

- In electromagnetism, vectors representing fields or forces often sum to zero in specific configurations.
- This analysis could be applied to magnetic vector fields or electric forces in a system.

Vector Resolution in Engineering

- Engineers frequently resolve forces or velocities into components.

- This problem exemplifies how to determine an unknown vector component when the sum is known, an essential skill in structural analysis, fluid mechanics, and robotics.

Implications of the Results

The detailed calculations provide insight into the relationships between vectors:

- The magnitude of C (~ 15.56 M) indicates the strength of the opposing force or quantity needed to balance A and B.
- The direction ($\sim 223.3^\circ$) situates C in the third quadrant, meaning it points diagonally downward-left if visualized on a coordinate plane.
- These insights are critical for designing systems where forces or influences must be balanced precisely.

Additional Considerations and Variations

Impact of Different Units or Scalars

- Clarify the units and scalars (M_1 and M) for precise calculations.
- If M_1 differs significantly from M, the components of A would need adjustment before summation.

3D Extensions

- While this analysis assumes a 2D plane, real-world problems often require

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