Biot-Savart Law

Theory and Mathematical Problem Solving

Group A

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AMPERE

Biot-Savart Law

Theory and Mathematical Problem Solving

Presented To-

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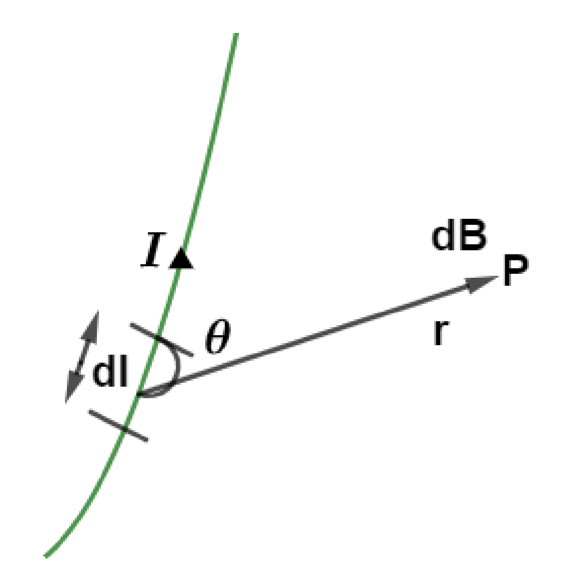
INTRODUCTION

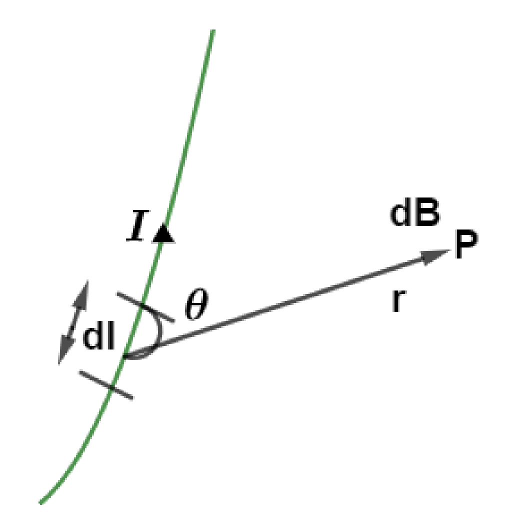
✓ **Biot-Savart Law**



Biot Savart Law states that, The magnetic field of a point for a long wire is directly proportional to the current, length of the conductor, inversely proportional to the square of the distance between the wire and the point, and proportional to the sin angle between them.

$$d\vec{B} \propto \mathrm{I}$$
$$d\vec{B} \propto \mathrm{dl}$$
$$d\vec{B} \propto \frac{1}{r^2}$$
$$d\vec{B} \propto \sin\theta$$

INTRODUCTION



✓ **What is the Formula of Biot-Savart's Law?**

Here, we consider a current carrying wire 'I' in a specific direction as shown in the figure. Take a small element of the wire of length dl. The direction of this element is along that of the current so that it forms a vector Idl.

To know the magnetic field produced at a point P, we can apply Biot-Savart's Law. Let the position vector of the point be **r** and the angle between the two be θ. Then,

$$|d\vec{B}| = \left(\frac{\mu_0}{4\pi}\right)\left(\frac{Idl\ sin\theta}{r^2}\right)$$

Where, μ_0 is the permeability of free space and is equal to $4\pi \times 10^{-7}$ TmA^{-1}.

HISTORY

✓ History of Biot-Savart Law

In 1820, French physicists Jean-Baptiste Biot and Félix Savart began investigating the magnetic field produced by a current-carrying conductor. They conducted experiments to measure the magnetic force exerted by such conductors.

Biot and Savart observed that the magnetic field around a current-carrying wire could be described by a mathematical formula. Through their experiments, they derived what is now known as the Biot-Savart Law.

Real Life Applications of BSL

✓ **Applications of Biot-Savart's Law**

The Biot-Savart Law, named after French physicists Biot and Savart, isn't just a theory in textbooks. It's important in various parts of our daily lives, like powering our homes and shaping technological advancements. This presentation will explore the practical significance and diverse applications of this fundamental law in electromagnetism.

Real Life Applications of BSL

- ✓ **Applications of Biot-Savart's Law**

Everyday items such as lightbulbs and motors use the principles of the Biot-Savart Law. When electricity flows through the filament or coils, it creates a magnetic field that interacts with charged particles, resulting in the production of light, motion, or sound.

Real Life Applications of BSL

✓ **Applications of Biot-Savart’s Law**

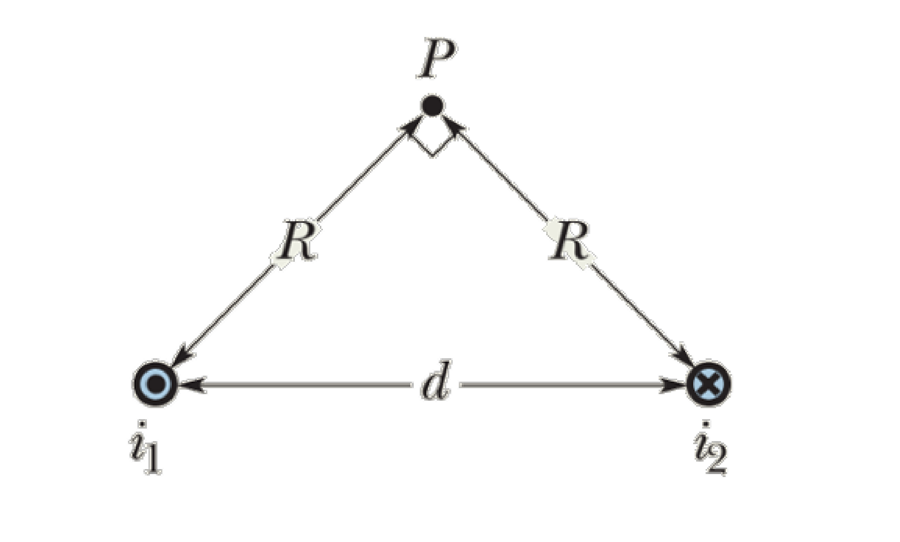
The Biot-Savart Law doesn't just apply to human-made inventions. It also affects Earth's magnetic field, which guides compasses and shields us from harmful solar radiation. Scientists also use its principles to study the magnetic fields of stars and galaxies, helping with astrophysical research.

Mathematical Problem 1

Determining magnitude and direction of the net magnetic field at a point

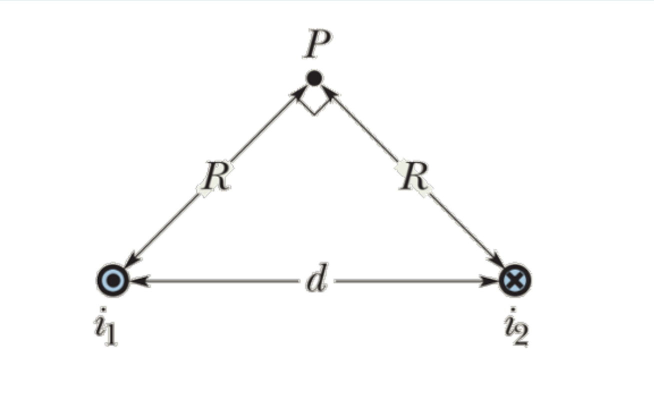
Problem 1

Figure shows two long parallel wires carrying currents i_1 and i_2 in opposite directions. What are the magnitude and direction of the net magnetic field at point P? Assume the following values: i_1 = 15 A, i_2 = 32 A, and d = 5.3 cm.



Solution

Q1: Figure shows two long parallel wires carrying currents i_1 and i_2 in opposite directions. What are the magnitude and direction of the net magnetic field at point P? Assume the following values: i_1 = 15 A, i_2 = 32 A, and d = 5.3 cm.



At first we measure the distance of point P from each wire.

As $\triangle Pi_1i_2$ is a Isosceles triangle, so -

Distance R = $\frac{d}{2\,cos\theta} = \frac{d}{2\,cos45^0}$ = 3.75cm = 3.75×10^{-2}m

The magnetic field at point P due to current i_1 is –

$$B_1 = \frac{\mu_0 i_1}{2\,\pi R}$$

$$= \frac{4\pi\times10^{-7}\times15}{2\pi(3.75\times10^{-2})}$$

$$= 8\times 10^{-5}\ T$$

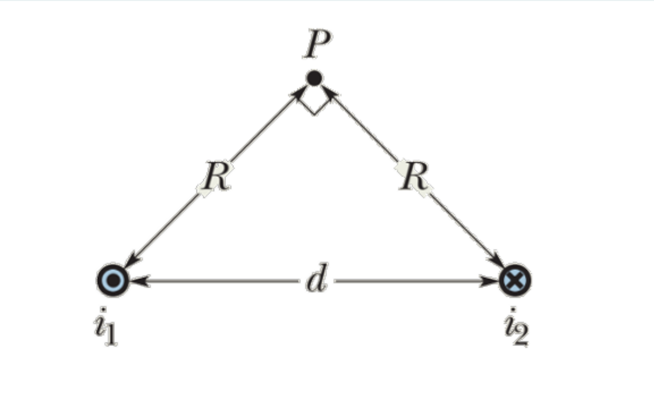
Here, $\mu_0 = 4\pi \times 10^{-7}$ TmA^{-1}

i_1 = 15 A

R = 3.75×10^{-2}m

Solution

Q1: Figure shows two long parallel wires carrying currents i_1 and i_2 in opposite directions. What are the magnitude and direction of the net magnetic field at point P? Assume the following values: $i_1 = 15$ A, $i_2 = 32$ A, and d = 5.3 cm.



Similarly, The magnetic field at point P due to current i_2 is –

$$B_2 = \frac{\mu_0 i_2}{2\,\pi R}$$

$$= \frac{4\pi \times 10^{-7} \times 32}{2\pi(3.75 \times 10^{-2})}$$

$$= 1.71 \times 10^{-4}\ \text{T}$$

Here, $\mu_0 = 4\pi \times 10^{-7}\ \text{TmA}^{-1}$

$i_2 = 32$ A

$R = 3.75 \times 10^{-2}$ m

Solution

Now, the magnetic field along X-direction is-

$B_x = (B_2 - B_1) \cos 45^0$

$= (1.71\times 10^{-4}\ T - 8\times 10^{-5}\ T) \times \cos 45^0$
$= 6.43\times 10^{-5}\ T$

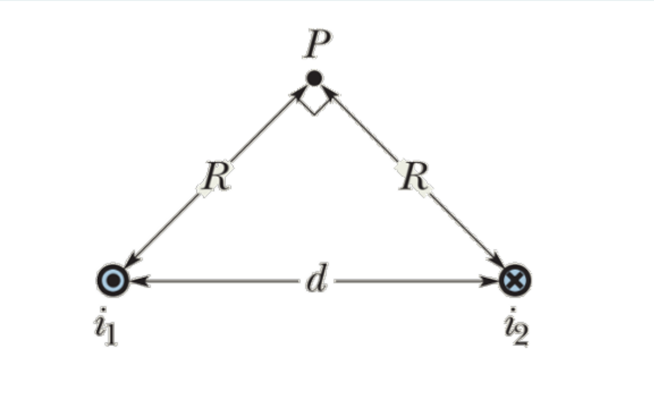
The magnetic field along Y-direction is-

$B_y = (B_1 + B_2) \sin 45^0$

$= (8\times 10^{-5}\ T + 1.71\times 10^{-4}\ T) \times \sin 45^0$

$= 1.77\times 10^{-4}\ T$

Q1: Figure shows two long parallel wires carrying currents i_1 and i_2 in opposite directions. What are the magnitude and direction of the net magnetic field at point P? Assume the following values: i_1 = 15 A, i_2 = 32 A, and d = 5.3 cm.



Solution

The magnitude of net magnetic field is

$$B = \sqrt{B_x^2 + B_y^2}$$

$$= \sqrt{(6.43 \times 10^{-5})^2 + (1.77 \times 10^{-4})^2}$$

$$= 1.88 \times 10^{-4}\ \text{T}$$

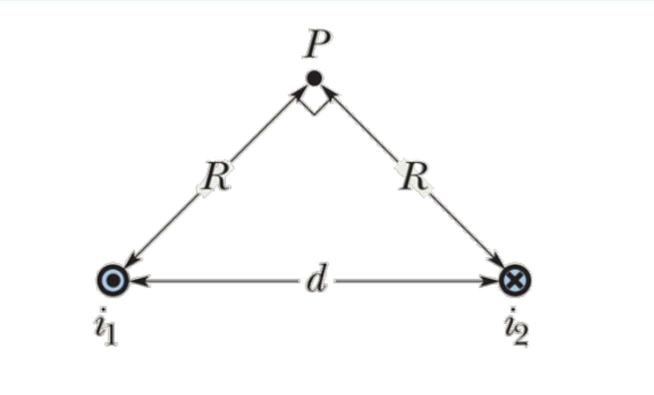
And the direction is –

$$\emptyset = tan^{-1}\left(\frac{B_y}{Bx}\right)$$

$$= tan^{-1}\ \frac{1.77\times10^{-4}}{6.43\times10^{-5}}$$

$$= 70.04°$$

Q1: Figure shows two long parallel wires carrying currents i_1 and i_2 in opposite directions. What are the magnitude and direction of the net magnetic field at point P? Assume the following values: i_1 = 15 A, i_2 = 32 A, and d = 5.3 cm.



Understandings

"In this problem, we investigated the magnetic field generated by two long parallel wires carrying currents in opposite directions. By applying the principles of the Biot-Savart Law and understanding the right-hand rule for determining the direction of magnetic fields around current-carrying wires, we were able to calculate the magnitude and direction of the net magnetic field at a specific point, P. This exercise helped us understand better how electric currents and magnetic fields interact, which are important ideas in electromagnetism."

Uses of this Problem

Electrical Engineering: Understanding the magnetic fields generated by current-carrying wires is crucial in designing electrical circuits and devices such as transformers, motors, and generators.

Medical Imaging: Techniques like Magnetic Resonance Imaging (MRI) rely on the principles of electromagnetism to produce detailed images of internal body structures, aiding in diagnosis and treatment planning.

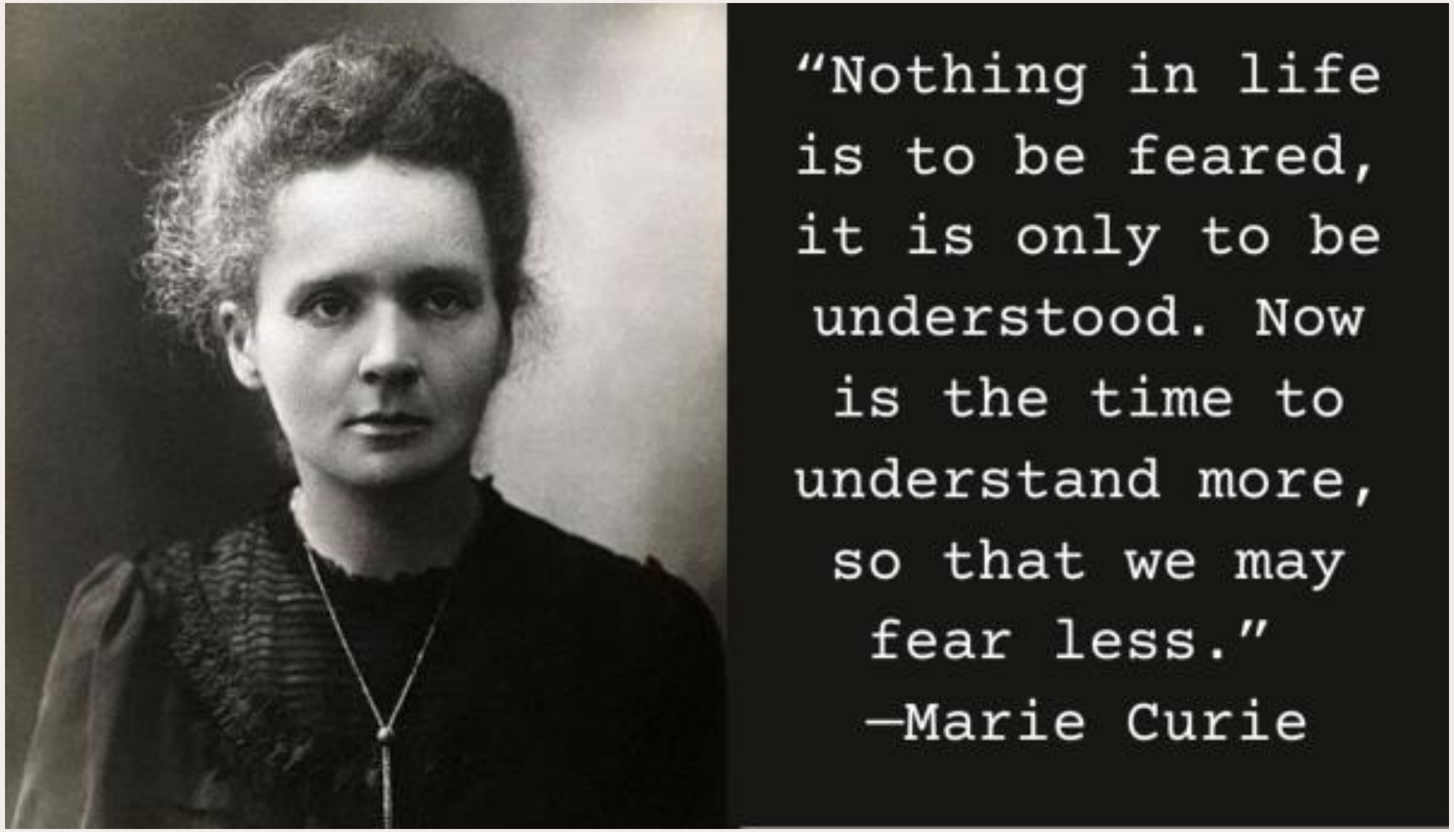
Power Distribution: Calculating magnetic fields helps optimize the design and efficiency of power distribution systems, ensuring reliable electricity supply to homes and industries.

Uses of this Problem

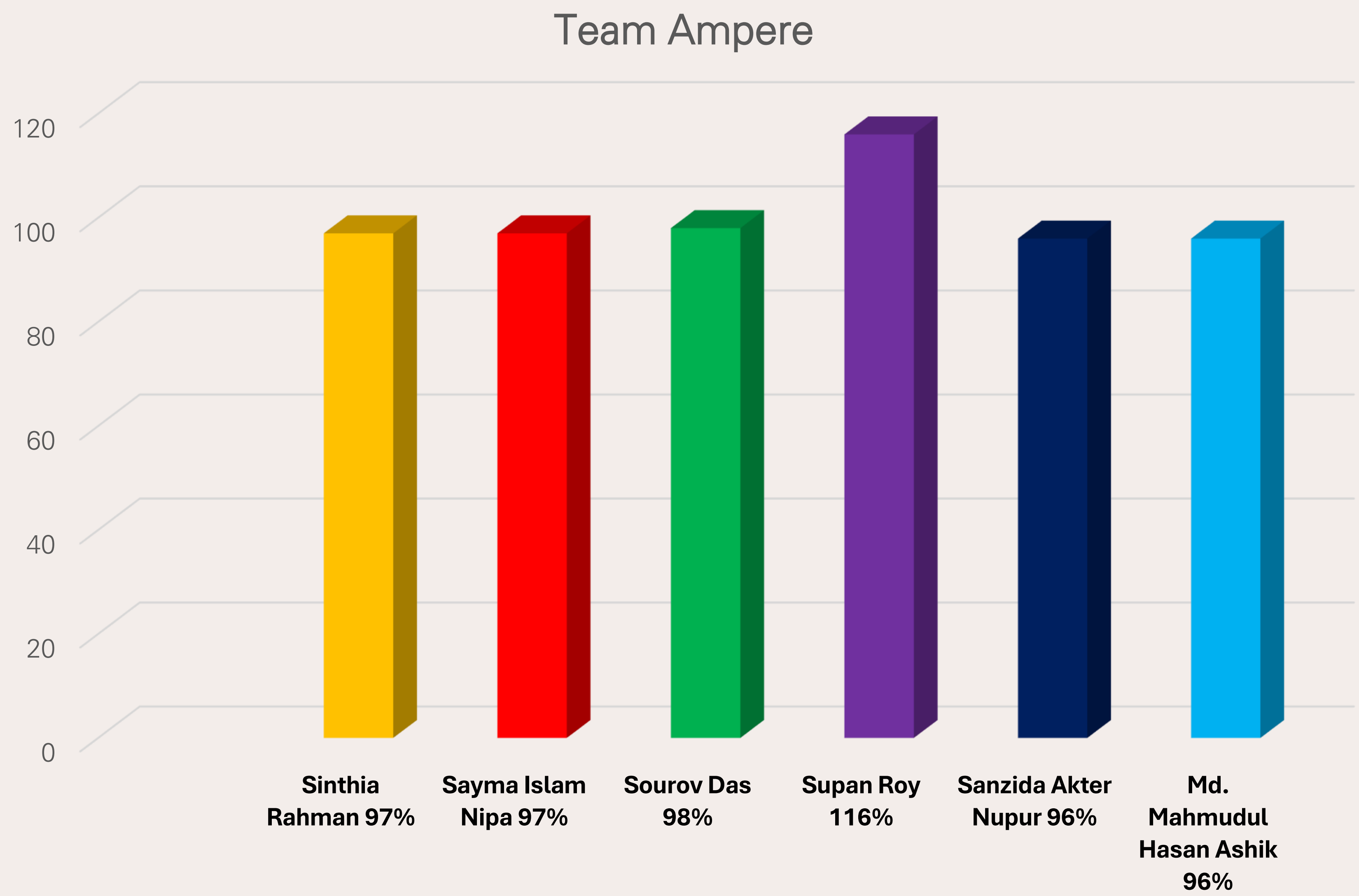
Navigation Systems: Magnetic field calculations are essential for the functioning of compasses and navigation systems, aiding in accurate orientation and navigation on land, sea, and air.

Astrophysics: Understanding magnetic fields is vital in studying celestial bodies such as stars, planets, and galaxies, providing insights into their formation, behavior, and evolution.

QUOTE


"Nothing in life
is to be feared,
it is only to be
understood. Now
is the time to
understand more,
so that we may
fear less."
—Marie Curie

Contribution




Thank You!