

The Electric Field Intensity Measured At A Point From A Source Charge Is 50kN/C. What Would Be The Electric

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This question leads us into the fundamental principles of electrostatics, specifically focusing on electric field intensity, its calculation, and the factors influencing it. Understanding the electric field and how it relates to a source charge is crucial for many applications in physics, engineering, and electronics. In this article, we will explore the concept of electric field intensity, how it is measured, its mathematical representation, and the implications of knowing the electric field at a particular point due to a source charge.

Understanding Electric Field Intensity

Electric field intensity, also known as electric field strength, is a vector quantity that represents the force experienced per unit positive charge placed at a point in space due to a source charge or distribution of charges. It provides insight into how the electric force propagates through space and influences other charges.

Definition and Units

Electric field intensity (E) is defined as the force (F) experienced by a small positive test charge (q) placed at a point in space, divided by that test charge:

- **Mathematical expression:** $E = F / q$
- **Units:** Newton per Coulomb (N/C) or Volt per meter (V/m)

Since the force and charge are vector quantities, electric field intensity also has direction, which points away from positive charges and towards negative charges.

Relationship with Source Charges

The electric field at a point due to a point charge (Q) is governed by Coulomb's Law:

- **Magnitude:** $E = (1 / (4\pi\epsilon_0)) |Q| / r^2$
- **Direction:** Radially outward from the charge if Q is positive, inward if Q is negative

where:

- ϵ_0 is the permittivity of free space ($\sim 8.854 \times 10^{-12}$ F/m)
- r is the distance from the source charge to the point of measurement

Given Data and What It Tells Us

In the given problem, the electric field intensity at a point from a source charge is 50 kN/C. This value indicates the strength and magnitude of the electric field at that specific point.

Converting Units

Before proceeding, it's helpful to convert units for easier calculations:

- 50 kN/C = 50,000 N/C

This large value suggests a strong electric field, which is typical near small or highly charged sources.

Calculating the Magnitude of the Source Charge

Knowing the electric field intensity at a point allows us to determine the magnitude of the source charge, provided we know the distance from the charge to the point where the measurement was made.

Formula for Electric Field Due to a Point Charge

The fundamental equation relates the electric field to the source charge:

$$E = (1 / (4\pi\epsilon_0)) |Q| / r^2$$

Rearranged to solve for Q:

$$Q = E 4\pi\epsilon_0 r^2$$

Where:

- E is the electric field intensity at the point

- r is the distance from the source charge to the point

Determining the Source Charge

Suppose the distance r is known; then the source charge can be calculated directly:

1. Identify the measured electric field intensity: $E = 50,000 \text{ N/C}$
2. Plug in the known constants: $\epsilon_0 \approx 8.854 \times 10^{-12} \text{ F/m}$
3. Use the distance r (provided or assumed) to compute Q

For example, if $r = 1 \text{ meter}$, then:

$$Q = 50,000 \cdot 4\pi \cdot 8.854 \times 10^{-12} \cdot (1)^2$$

Calculating:

$$Q \approx 50,000 \cdot (4\pi \cdot 8.854 \times 10^{-12})$$

$$Q \approx 50,000 \cdot (1.11265 \times 10^{-10})$$

$$Q \approx 5.563 \times 10^{-6} \text{ Coulombs (approximately } 5.56 \text{ } \mu\text{C)}$$

This demonstrates that the source charge would be approximately 5.56 microcoulombs if the measurement point is 1 meter away.

Implications and Practical Applications

Understanding the electric field intensity and calculating the source charge are vital in various fields, including designing electronic components, understanding electrostatic phenomena, and safety considerations.

Designing Electric Fields in Devices

Engineers use these principles to manipulate electric fields in capacitors, sensors, and other electronic devices. Precise knowledge of electric field distribution helps optimize device performance and safety.

Electrostatic Safety

High electric field intensities can pose safety hazards, such as sparks or electric shocks. Knowing the field strength helps in designing insulation and

safety measures, especially in high-voltage environments.

Scientific Research

In research laboratories, measuring the electric field at various points allows scientists to study charge distributions, conduct experiments involving electric potentials, and validate theoretical models.

Factors Affecting Electric Field Intensity

While the basic formula provides a direct relationship, real-world applications often involve additional factors:

- **Distance from the source charge:** E decreases with the square of the distance
- **Presence of other charges:** Superposition principle applies; total field is vector sum of individual fields
- **Medium properties:** Dielectric materials can alter the electric field distribution

Summary and Key Takeaways

- Electric field intensity at a point is a measure of the force experienced by a test charge placed at that point.
- The magnitude of the source charge can be calculated if the electric field and distance are known, using Coulomb's Law.
- The formula $Q = E \cdot 4\pi\epsilon_0 \cdot r^2$ is essential for such calculations.
- Practical applications range from electronic device design to safety protocols and scientific research.
- Understanding the factors influencing electric field helps in accurate modeling and application.

Conclusion

The measured electric field intensity of 50 kN/C at a point from a source charge offers valuable information about the charge's magnitude and the spatial distribution of the electric field. By applying fundamental principles of electrostatics and Coulomb's Law, one can determine the source charge's magnitude, predict the behavior of electric fields in various environments, and utilize this knowledge across multiple scientific and engineering disciplines. Whether in designing high-voltage equipment or conducting research, understanding electric field intensity is foundational

to mastering the principles of electrostatics and ensuring safe, effective, and innovative technological solutions.

Frequently Asked Questions

What is the significance of measuring electric field intensity at a point from a source charge?

Measuring the electric field intensity helps determine the strength and direction of the electric field created by a charge at a specific location, which is essential for understanding electrostatic interactions and designing electrical systems.

If the electric field intensity at a point is 50 kN/C, how can we find the electric potential at that point?

The electric potential can be found if the distance from the source charge is known using the relation $V = E \times r$, where E is the electric field intensity and r is the distance from the charge.

What is the relation between electric field intensity and source charge magnitude?

Electric field intensity (E) at a point due to a point charge is given by $E = k \times |Q| / r^2$, where Q is the source charge, r is the distance from the charge, and k is Coulomb's constant.

How does knowing the electric field intensity help in practical applications?

Knowing the electric field intensity aids in designing electrical devices, understanding forces between charges, predicting particle behavior in electric fields, and ensuring safety in electrical installations.

Can the electric field intensity be negative or positive, and what does the sign indicate?

Electric field intensity is a vector quantity; its sign indicates the direction of the field relative to a reference direction. The magnitude is always positive, but the vector points toward or away from the source charge depending on its sign.

What additional information is needed to determine the electric potential at the point where the field is 50 kN/C?

The distance from the source charge to the point is needed to calculate the electric potential, using the relation $V = E \times r$, assuming the charge and position are known.

Additional Resources

The Electric Field Intensity Measured At A Point From A Source Charge Is 50 kN/C. What Would Be The Electric?

Understanding electric fields is fundamental to the study of electromagnetism and plays a crucial role in various scientific and engineering applications. When we are told that the electric field intensity at a specific point due to a source charge is 50 kN/C, it prompts us to explore what that implies about the electric properties of the source charge itself, as well as the surrounding environment. This article delves into the concept of electric field intensity, how it relates to source charges, and the calculations and interpretations involved in such a scenario.

Introduction to Electric Field Intensity

The electric field intensity, often denoted as E , is a vector quantity that represents the force per unit positive test charge placed at a point in space due to a source charge or distribution of charges. It is expressed in units of Newtons per Coulomb (N/C) or kiloNewtons per Coulomb (kN/C). The magnitude of the electric field provides insight into how strong the electric influence of a charge is at a particular location.

Mathematically, the electric field E at a point due to a point charge Q is given by Coulomb's law:

$$E = \frac{k |Q|}{r^2}$$

where:

- k = Coulomb's constant, approximately $(9 \times 10^9 \text{ Nm}^2/\text{C}^2)$
- Q = magnitude of the source charge
- r = distance from the source charge to the point where the electric field is measured

This relation indicates that the electric field's magnitude diminishes with the square of the distance from the charge, emphasizing the inverse-square nature of electrostatic fields.

Understanding the Given Data: Electric Field Intensity of 50 kN/C

Given that the electric field intensity E at a point is 50 kN/C, or 50,000 N/C, it suggests a relatively strong electric influence at that specific location. To understand what this means about the source charge, we need to examine the relationship between electric field, charge, and distance.

Key points:

- The magnitude of the electric field is directly proportional to the source charge.
- The electric field diminishes with increasing distance from the charge.
- Without additional information about the position, such as the distance from the source charge, we cannot directly determine the charge value; vice versa, knowing the charge and position allows us to determine the electric field.

Calculating the Source Charge or Distance

To proceed, two common scenarios are considered:

Scenario 1: The Distance from the Source Charge is Known

Suppose the distance r from the source charge Q to the point where the electric field is measured is known. Using Coulomb's law:

$$Q = \frac{E r^2}{k}$$

For example, if the measurement point is 1 meter from the source charge:

$$Q = \frac{50,000 \times 1^2}{9 \times 10^9}$$

$$Q \approx 5.56 \times 10^{-6} \text{ C}$$

This indicates that a charge of approximately 5.56 microcoulombs produces an electric field of 50 kN/C at 1 meter.

Scenario 2: The Source Charge is Known

If the source charge Q is known, the distance r can be calculated:

$$r = \sqrt{\frac{k Q}{E}}$$

Suppose the source charge is $1 \mu\text{C}$ (microcoulomb):

$$r = \sqrt{\frac{9 \times 10^9 \times 1 \times 10^{-6}}{50,000}}$$

$$r = \sqrt{\frac{9000}{50,000}}$$

$$r \approx \sqrt{0.18}$$

$$r \approx 0.424 \text{ meters}$$

This suggests the point is approximately 42.4 centimeters from a $1 \mu\text{C}$ microcoulomb charge to experience an electric field of 50 kN/C .

Implications for the Electric Field Calculation

The calculation or determination of the source charge depends heavily on knowing either the distance or the charge itself. Without this information, the problem remains incomplete but serves as a valuable exercise in understanding the relationships involved.

Key takeaways:

- The electric field value alone tells us about the intensity of the charge's electric influence at a point.
- Additional data such as distance or source charge magnitude are necessary for precise calculations.
- The inverse-square law applies, meaning small changes in distance significantly affect the electric field.

Features and Practical Considerations

Understanding electric field intensity and its measurement is essential in various practical applications:

Features:

- Non-contact Force Measurement: Electric fields allow the measurement of charges without physical contact.
- Design of Electric Devices: Knowledge of electric field strength aids in designing capacitors, insulators, and shielding.
- Electrostatic Safety: Recognizing high electric field areas helps prevent static discharge hazards.

Pros:

- Enables precise calculation and prediction of electric forces.
- Critical in designing electronic components and systems.
- Useful in medical applications like electrotherapy and imaging.

Cons:

- Sensitive to environmental factors such as humidity and nearby charges.
- Measurement accuracy can be impacted by external electromagnetic interference.
- Requires careful calibration and understanding of the spatial relationships involved.

Applications of Electric Field Measurements

Electric field intensity measurements are vital in numerous contexts:

- Electronics and Circuit Design: Ensuring components operate within safe electric field limits.
- Electrostatic Precipitation: Controlling pollution by charging particles and directing them via electric fields.
- Medical Diagnostics: Techniques like electroencephalograms (EEGs) and electrocardiograms (ECGs) rely on electric field detection.
- Research and Education: Demonstrating fundamental principles of electromagnetism.

Conclusion

The scenario where the electric field intensity measured at a point from a source charge is 50 kN/C offers a rich context for understanding electrostatics. Although the problem does not specify the distance or the magnitude of the source charge, it highlights the fundamental relationships dictated by Coulomb's law. By exploring the inverse-square law, the impact of distance, and the magnitude of the source charge, we appreciate how electric

fields characterize the influence of charges in space.

In practical terms, measuring electric field intensities allows engineers and scientists to design safer, more efficient devices, and to understand phenomena ranging from static electricity to complex electromagnetic interactions. The key takeaway is that electric field measurements serve as a bridge between theoretical physics and practical applications, enabling precise control and utilization of electric forces in countless technological advancements.

In summary:

- The electric field intensity of 50 kN/C indicates a significant electric influence at the measurement point.
- To determine the source charge or the distance, additional information is necessary.
- The inverse-square law governs the relationship between charge, distance, and electric field.
- Practical applications of electric field measurements span multiple fields, emphasizing their importance in science and engineering.

Understanding these principles allows for the effective analysis and application of electrostatic phenomena, making electric field intensity a cornerstone concept in electromagnetism.

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