Two Charged Particles Are A Distance Of 1.72 M From Each Other. One Of The Particles Has A Charge Of

Two Charged Particles Are A Distance Of 1.72 M From Each Other. One Of The Particles Has A Charge Of a certain magnitude, and understanding the interaction between such particles is fundamental to the study of electrostatics. This scenario offers an excellent opportunity to explore Coulomb's Law, the nature of electric forces, and the factors influencing the behavior of charged particles. In this article, we will delve into the principles governing their interaction, analyze how the charge magnitude affects the force, and examine related concepts such as electric potential and energy.

Understanding Coulomb's Law

The Fundamental Equation

Coulomb's Law describes the electrostatic force F between two point charges. Mathematically, it is expressed as:

$$F = k_e \frac{|q_1 q_2|}{r^2}$$

where:
- F is the magnitude of the force between the charges,
- k_e is Coulomb's constant ($8.9875 \times 10^9 \, \mathrm{Nm^2/C^2}$),
- q_1 and q_2 are the magnitudes of the two charges,
- r is the distance between the charges.

This law indicates that the force is directly proportional to the product of the charges and inversely proportional to the square of the separation distance.

Application to the Scenario

Given:
- Distance $r = 1.72\, \mathrm{m}$,
- One of the charges, say q_1, has a known magnitude,
- The other charge q_2 is either known or to be determined.

The force's magnitude depends on the specific charge values, which can vary widely. The sign of the charges (positive or negative) determines whether the force is attractive or repulsive, but Coulomb's Law calculates only the magnitude; the direction depends on charge signs.

Factors Influencing the Electrostatic Force

Charge Magnitudes

The strength of the electrostatic force increases with larger magnitudes of the charges. For example:
- If both charges are large, the force becomes significant.
- If one charge is very small, the force diminishes accordingly.

Distance Between Particles

The inverse-square relationship means that:
- Doubling the distance reduces the force to a quarter.
- Halving the distance increases the force fourfold.

This sensitivity underscores the importance of proximity in electrostatic interactions.

Medium Between Charges

While Coulomb's Law is typically considered in a vacuum or air, the presence of other media can modify the force:
- Dielectric materials decrease the effective force.
- The dielectric constant ε_r of the medium adjusts Coulomb's constant to $k_e' = \frac{k_e}{\varepsilon_r}$.

Calculating the Force for a Given Charge

Example: Known Charge Magnitude

Suppose the known charge q_1 is $+3.0 \, \mathrm{μC}$ (microcoulombs), and q_2 is unknown.

Applying Coulomb's Law:
$$F = k_e \frac{|q_1 q_2|}{r^2}$$
$$F = (8.9875 \times 10^9) \times \frac{|3.0 \times 10^{-6} \times q_2|}{(1.72)^2}$$

If the force F is measured or specified, the equation can be rearranged to find q_2:
$$q_2 = \frac{F \times r^2}{k_e \times |q_1|}$$

Determining Force for Different Charge Values

- For a positive q_2, the force is repulsive.
- For a negative q_2, the force is attractive.

The magnitude of the force varies directly with $|q_2|$.

Electric Potential and Potential Energy

Electric Potential at a Point

The electric potential V created by a point charge at a distance r is:

$$V = k_e \frac{q}{r}$$

This potential influences how other charges move in the electric field.

Potential Energy of Interaction

The potential energy U between two charges is:

$$U = k_e \frac{q_1 q_2}{r}$$

- If both charges are of opposite signs, the potential energy is negative, indicating a bound state.
- If charges are like-signed, the potential energy is positive, indicating repulsion.

Electrostatic Force in Real-World Applications

Electrostatic Forces in Technology

Understanding these forces is vital in many fields, including:
- Designing capacitors, where electric fields store energy.
- Particle accelerators, where charged particles are manipulated.
- Microelectronics, where electrostatic forces influence component behavior.

Safety Considerations

High voltages and large charges can produce significant forces, leading to:
- Sparks or discharges.
- Damage to electronic components.

- Health hazards due to static buildup.

Proper insulation and grounding are essential when dealing with substantial charges.

Advanced Topics Related to Charged Particles

Electric Field Concept

The electric field E at a point in space due to a charge q is:

$$E = k_e \frac{|q|}{r^2}$$

The direction of E depends on the sign of q.

Force on a Charge in an Electric Field

A charge q' placed in an electric field experiences a force:

$$F = q' E$$

This concept helps analyze the motion of charges under electrostatic influence.

Potential and Energy in Multiple Charges

When multiple charges are present, the net electric potential and force are vector sums, often requiring superposition principles for accurate analysis.

Concluding Remarks

Understanding the interaction between two charged particles separated by a specific distance involves applying Coulomb's Law and related electrostatic principles. The force magnitude depends on the charges' magnitudes, their signs, and the separation distance. Precise calculations require known charge values; however, the fundamental relationships remain consistent across different scenarios. This knowledge forms the foundation for many technological applications and provides insight into natural phenomena governed by electrostatics.

In practical situations, considering environmental factors such as medium dielectric constant, presence of other charges, and external fields is crucial for accurate analysis. Mastery of these concepts enables scientists and engineers to manipulate electric forces effectively, innovate new devices, and ensure safety in electrical systems.

Frequently Asked Questions

What is the electrostatic force between two charged particles separated by 1.72 meters?

The electrostatic force can be calculated using Coulomb's Law: $F = k |q_1 q_2| / r^2$, where k is Coulomb's constant, q_1 and q_2 are the charges, and r is the distance (1.72 m).

How does the distance of 1.72 meters affect the strength of the electrostatic force?

The force decreases with the square of the distance, so as the separation increases, the electrostatic force weakens significantly.

If one particle has a known charge, how can we determine the other particle's charge based on the electrostatic force?

Rearranged Coulomb's Law: $q_2 = F r^2 / (k |q_1|)$. Knowing the force, distance, and one charge allows calculation of the other charge.

What units are typically used for charge in such calculations?

Charges are typically measured in Coulombs (C).

What is Coulomb's constant, and what is its value?

Coulomb's constant, k, is approximately 8.988×10^9 $N \cdot m^2/C^2$.

How does changing the charge of one particle affect the electrostatic force at a fixed distance?

The force is directly proportional to the product of the charges; increasing one charge increases the force proportionally.

What safety considerations are important when dealing with charged particles and electrostatic

forces?

Ensure proper grounding to prevent static buildup, avoid high-voltage exposures, and handle charged objects carefully to prevent shocks or discharges.

Can the electrostatic force be attractive or repulsive, and what determines this?

Yes, the force can be attractive or repulsive depending on the signs of the charges: opposite signs attract, same signs repel.

Additional Resources

Two Charged Particles Are A Distance Of 1.72 M From Each Other. One Of The Particles Has A Charge Of

---

Introduction

In the realm of electromagnetism, the interactions between charged particles are fundamental to understanding the forces that govern the physical universe. The problem of two charged particles separated by a specific distance, especially when one of them carries a known charge, serves as a cornerstone in both theoretical and applied physics. This investigation delves into the scenario where two charged particles are separated by 1.72 meters, with one particle's charge specified, aiming to elucidate the nature of their interaction, the magnitude of the force between them, and the broader implications of such a setup.

Contextual Background

Electrostatics, a branch of classical physics, describes the forces between stationary electrical charges. Coulomb's Law, formulated by Charles-Augustin de Coulomb in the 18th century, provides the quantitative foundation for understanding these interactions. It states that the magnitude of the electrostatic force F between two point charges q_1 and q_2 separated by a distance r in a vacuum is given by:

$$
F = k_e \frac{|q_1 q_2|}{r^2}
$$

where:

- k_e is Coulomb's constant, approximately \(8.9875 \times 10^9 \,

$\mathrm{N\,m^2\,C^{-2}}$.
- q_1, q_2 are the magnitudes of the charges.
- r is the separation distance.

This fundamental law is instrumental in analyzing the current problem, where the separation distance is fixed at 1.72 meters, and one of the charges, say q_1, is known.

The Significance of Distance: Why 1.72 M?

The choice of 1.72 meters is not arbitrary. It is a distance that is large enough to observe measurable electrostatic forces without immediate complications from other physical effects such as electromagnetic radiation or quantum phenomena. At this scale, the forces are typically detectable with sensitive instrumentation, making it a practical distance for experimental validation.

From a theoretical standpoint, 1.72 meters represents a macroscopic scale at which Coulomb’s Law remains valid without significant correction factors. It also provides an illustrative example for educational settings, creating tangible insights into electrostatic interactions.

Key Variables and Assumptions

Before proceeding, it’s essential to clarify the variables and assumptions involved:

- Known Quantity:
- One of the charges, q_1, is specified. (In this hypothetical, the actual value will be discussed later.)
- Unknowns:
- The second charge, q_2, which may be positive or negative.
- The force magnitude F between the particles.
- Assumptions:
- The particles are point charges.
- The medium is vacuum or air, approximating vacuum conditions.
- There are no other external influences or fields.
- The system is static; charges are stationary.

Determining the Force Between the Particles

Given that one particle’s charge is known, and the separation is fixed at 1.72 meters, the force can be calculated directly once the other charge is specified. Conversely, if the force or effect (such as acceleration or potential energy) is known, the second charge can be deduced.

Case Study: Known Charge q_1

Suppose the known charge q_1 is +1 μC (microcoulomb), a typical value used for illustrative purposes.

- $q_1 = +1 \times 10^{-6} \, C$

If the force F is measured or specified, we can find q_2:

$$
q_2 = \frac{F r^2}{k_e |q_1|}
$$

Conversely, if q_2 is known, the force can be directly computed.

The Electrostatic Force: Quantitative Analysis

Assuming a hypothetical force magnitude, say 0.01 N (a modest force that is measurable), we can calculate the unknown charge q_2:

$$
q_2 = \frac{F r^2}{k_e |q_1|} = \frac{0.01 \times (1.72)^2}{8.9875 \times 10^9 \times 1 \times 10^{-6}}
$$

Calculations:

$$
q_2 = \frac{0.01 \times 2.9584}{8.9875 \times 10^9 \times 10^{-6}} = \frac{0.029584}{8.9875 \times 10^{3}}
$$

$$
q_2 \approx 3.293 \times 10^{-6} \, C
$$

Thus, $q_2 \approx +3.29\, \mu C$.

This numerical example illustrates how force measurements can help deduce unknown charges in a controlled environment.

Practical Implications and Applications

Understanding the forces between two charges separated by 1.72 meters has several practical implications:

- Design of Electric Field Experiments: Precise control of charge magnitudes

and distances is essential for laboratory experiments testing Coulomb’s Law.
- Electrostatic Shielding: Knowledge of force magnitudes informs the development of shielding devices where static charges could interfere with sensitive equipment.
- Charge Quantification in Micro- and Macroscopic Systems: These principles underpin technologies from particle accelerators to electrostatic precipitators.

Limitations and Considerations

While Coulomb's Law provides a robust theoretical framework, real-world applications must consider:

- Environmental Factors: Humidity, air ionization, and other environmental conditions can influence measurements.
- Charge Distribution: Actual particles may not be perfect point charges; their size and charge distribution can affect interactions.
- Quantum Effects: At extremely small scales, quantum phenomena may override classical electrostatics.
- Electromagnetic Radiation: Accelerating charges radiate energy, which can influence force calculations if charges are in motion.

Broader Scientific Context

The analysis of two charges at a distance forms the basis of many modern technologies and scientific explorations, including:

- Electrostatic Force Microscopy: Imaging surfaces at nanometer resolution.
- Charged Particle Beams: In accelerators, understanding Coulomb interactions is critical for beam stability.
- Fundamental Physics Tests: Precise measurements of Coulomb’s Law test the limits of classical physics and probe for new physics beyond the Standard Model.

Conclusion

The problem of two charged particles separated by 1.72 meters, with one particle's charge specified, exemplifies fundamental principles of electrostatics. By applying Coulomb’s Law, we can quantify the force between them, explore the relationship between charge magnitudes and distance, and understand the broader significance of electrostatic interactions. Whether for educational purposes, experimental design, or technological development, such analyses reinforce our grasp of the invisible yet powerful forces shaping our universe.

References

- Coulomb, C. A. (1785). "Premier mémoire sur l’électricité et le magnétisme." Histoire de l'Académie Royale des Sciences.
- Griffiths, D. J. (2017). Introduction to Electrodynamics. 4th Edition. Cambridge University Press.
- Tipler, P. A., & Mosca, G. (2008). Physics for Scientists and Engineers. 6th Edition. W. H. Freeman and Company.
- Serway, R. A., & Jewett, J. W. (2014). Physics for Scientists and Engineers. 9th Edition. Brooks Cole.

Note: The above analysis assumes ideal conditions. Actual experimental setups should account for measurement uncertainties, environmental influences, and the physical characteristics of the particles involved.

Two Charged Particles Are A Distance Of 1 72 M From Each Other One Of The Particles Has A Charge Of

Two Charged Particles Are A Distance Of 1 72 M From Each Other One Of The Particles Has A Charge Of

Related Articles

- The Marginal Cost Of A Corn Farmer In Dormaa Has Been Estimated By A Team Of Agricultural Economists
- What Is One Function Of Cytokinesis That Helps A Cell Grow And Reproduce?A. Making A Copy Of Each Of
- The Current Level Of Standard & Poor's Index Is 4,438. The Prospective Dividend Yield Is 2%, And

Back to Home