Consider A 20C Spherical Positive Charge Distribution Of Radius 10 Cm(0.1 M). Using Microsoft Excel Plot

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Understanding the electric field generated by a spherical charge distribution is fundamental in electrostatics. Visualizing how the electric field varies with distance from the center of the sphere helps in comprehending concepts such as Coulomb's law, Gauss's law, and the behavior of electric fields within and outside charged objects. Using tools like Microsoft Excel allows for a clear, visual representation of these fields, making complex theoretical concepts more accessible. In this comprehensive guide, we will explore how to model, calculate, and visualize the electric field of a uniformly charged sphere with a total charge of 20 Coulombs and a radius of 10 centimeters (0.1 meters) using Excel.

Understanding the Physical Setup

Charge Distribution and Geometry

- The sphere has a total positive charge (Q) of 20 Coulombs.
- The radius (R) of the sphere is 10 centimeters or 0.1 meters.
- The charge distribution is uniformly distributed throughout the volume of the sphere.

Relevance of the Model

- This scenario helps in understanding electric fields inside and outside a charged sphere.
- It demonstrates the principles of Gauss's law and how the electric field behaves in different regions relative to the sphere.

Mathematical Foundations

Electric Field Inside the Sphere (r < R)

- The electric field at a point inside the sphere (distance r from the center, where r < R) is given by:

$$E_{inside}(r) = (1 / (4\pi\varepsilon_0)) \ (Q_{enc}(r) / r^2)$$

- Since the charge is uniformly distributed, the encapsulated charge (Qenc(r)) within a sphere of radius r is:

$$Q_{enc}(r) = Q \cdot (r^3 / R^3)$$

- Substituting:

$$E_{inside}(r) = (1 / (4\pi\varepsilon_0)) \cdot (Q \cdot (r^3 / R^3) / r^2) = (1 / (4\pi\varepsilon_0)) \cdot (Q / R^3) \cdot r$$

- Using Coulomb's constant $k = 1 / (4\pi\varepsilon_0) \approx 8.99 \times 10^9$ N·m²/C², the expression simplifies to:

$$E_{inside}(r) = k \cdot (Q / R^3) \cdot r$$

Electric Field Outside the Sphere (r ≥ R)

- For points outside the sphere:

$$E_{outside}(r) = (1 / (4\pi\varepsilon_0)) \cdot (Q / r^2) = k \cdot Q / r^2$$

- The electric field behaves as if all the charge were concentrated at the center, following an inverse-square law.

Calculating and Plotting the Electric Field in Excel

Step-by-Step Guide to Setup Your Excel Sheet

1. Define Constants
- Coulomb's constant, $k = 8.99 \times 10^9$ N·m²/C²
- Total charge, Q = 20 C
- Sphere radius, R = 0.1 m

2. Create a Range of Distance Values
- Generate a column "r" with values from 0 to 0.2 meters (twice the radius) to observe behaviors inside and outside the sphere.
- Use small increments, e.g., 0.005 meters for fine resolution.

3. Calculate Electric Field Values
- For each r, compute:
- If r = 0, the electric field is 0 (to avoid division by zero).

- If $r < R$, use $E = k (Q / R^3) r$.
- If $r \geq R$, use $E = k Q / r^2$.

4. Implement Formulas in Excel
- Use IF statements to differentiate between inside and outside calculations.
- Example formula in Excel:
```excel
=IF(r_cell
```