Equipotential Surfaces

• Surface on which electric potential has a constant value. Example: Point charge potential
  \[ V = \frac{kQ}{r} \]

• All points on spherical surface of radius \( r \) centered on \( Q \) have same \( V \)

• Example: \( Q=10^{-6}C \); what is the 100 V equipotential surface?

\[
r = \frac{kQ}{V} = \frac{(9 \times 10^9 \text{ Nm}^2/\text{C}^2)(10^{-6} \text{ C})}{100\text{V}} = 90m
\]

• So, 100 V equipotential surface is surface of sphere of radius 90 m. For other values of \( V \), get different radii:
$V = \text{constant}$
Relation between $\mathbf{E}$ and Equipotentials

- Remember from last time, $\mathbf{E}$ points in direction along which $V$ is *decreasing*. $\mathbf{E}$ is $\perp$ to equipotentials.

- If there is the same potential step between adjacent equipotentials, $\mathbf{E}$ is largest where equipotentials are close together.

- For which point below is $\mathbf{E}$ large and toward $+\mathbf{i}$?
Equipotentials for Set of Point Charges

- Near each charge, equipotentials \( \approx \) spheres
- Far from all charges, equipotentials \( \approx \) spheres
- Equipotentials are close together where field strong (assuming equal potential steps between equipotentials)
- System with + and - charges will have positive and negative equipotentials

- Question 2 …
- Question 3: Approximate strength of electric field at point D?
- Example equipotentials for one positive point charge and one negative point charge..
At which point is $V = 0$?:
A. $x=0$
B. $x=L/4$
C. $x=L/2$
D. $x=3L/4$
E. $x=L$
Equipotentials of Extended Objects

• For symmetric objects, use Gauss’s law to get $E$ as function of distance from object, then use

$$V[P] = -\int_\infty^P \vec{E} \cdot d\vec{l}$$

• Remember the $E$ and $V$ outside the surface of a uniformly charged sphere or spherical shell act like $E$ and $V$ for a point charge at the center

• Question: The electric potential 0.1 m from the surface of a charged sphere of radius 0.2 m is 100V. What is the total charge on the sphere?
**Electrical Conductors**

- Material in which some of the electrons move freely
- Most good conductors are metals
- “Free” electrons in conductor move until $E = 0$ everywhere within the material of the conductor

![Diagram of conductors](image-url)

- **Conducting sphere**
- Free electrons move toward external $+$ charge.
- Pos. charge (protons) left behind