Recitation Session 3

Achint Kumar

Duke University

September 13, 2021

Desiderata

1. Conductors
2. Electric Potential

Desiderata

1. Conductors
2. Electric Potential

Electrical Conductors: Properties

In *electrostatic equilibrium*, electric field in zero inside a conductor

- By Gauss' law, charge inside conductor is zero. So, charge is confined to surface of the conductor
- Charge distribution on conductor is stationary. So, the field lines are always perpendicular to the surface of the conductor

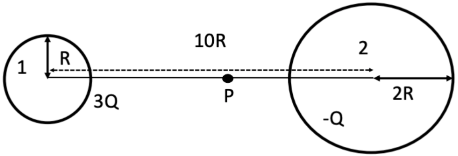
Desiderata

Electrostatic Potential

- It provides a way to calculate electric fields in an easier way because we deal with scalar instead of vector quantity
- The electric potential between two points a and b is defined as

$$V(a) - V(b) = -\int_a^b \vec{E} \cdot d\vec{r}$$

1. Consider two metallic spheres of radii R and $2R$ as shown. Their centres are a distance $10R$ apart. The spheres have charge $3Q$ and $-Q$ as shown.



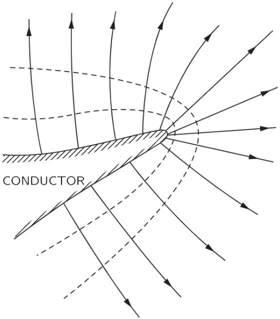
(a) Compute the direction and magnitude of the net electric field due to the two spheres at the point P which is exactly halfway between the centres. You can assume the spheres are far enough away that the charge distribution on each are spherically symmetric.Use the principle of superposition.

(b) Compute the total potential at the point P. Take the potential to be zero at infinity for each sphere.

(c) A metal wire (assumed to be infinitely thin) is used to connect the two spheres. What is the charge on each sphere once the spheres achieve electrostatic equilibrium?

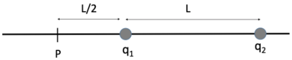
High Voltage breakdown

You're in a thunderstorm. Should you stand under a tree? Stand in an open field? Sit inside a car?



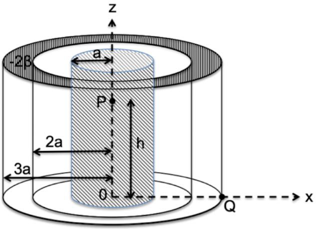
The electric field near a sharp point on a conductor is very high.

4. Two point charges q_1 and q_2 are a distance L apart. The net electric field due to the two charges is zero at the point P which is a distance $\frac{L}{2}$ to the left of q_1 as shown.



(a.) If the charge $q_1 = +Q$, find the sign and magnitude of the charge q_2.
(b.) Find the point/ points where the total electrostatic potential due to the two charges is zero.

2. An infinite cylindrical insulator has radius a and a volume charge density $\rho = \frac{\beta}{\pi a r}$ where r is the radial distance from the centre and β a positive constant. The insulator has a coaxial infinite cylindrical metal shell around it with inner radius $2a$ and outer radius $3a$. The shell has charge per unit length of -2β.

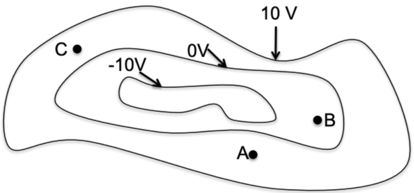


(a) What is the total charge per unit length of the cylindrical insulator? What is the induced charge per unit length on the inner and outer surface of the metal cylinder?

(b) Compute the expression for the electric field for i) $r < a$, ii) $a < r < 2a$, iii) $2a < r < 3a$, iv) $3a < r$. Your answer should be in terms of a, β, r and ϵ_0. In each of the regions indicate the direction of the electric field.

(c) Find the potential difference ΔV between the points P and Q as shown on the diagram. The point P is on the z axis at height h as shown and the point Q is on the $z = 0$ plane at $r = 3a$, i.e., on the outer surface of the conducting shell.

3. The diagram below shows the lines of equipotentials for a charge distribution. The numbers next to the lines represent the potential of each equipotential line.



On the diagram above draw a qualitative sketch of three electric field lines: one line each through the points A, B and C which intersect all three equipotential lines. You should indicate the direction of the field lines by arrows.