14: Electrostatics

Key Physics Terms

- **Force**: A vector quantity that tends to accelerate an object; a push or a pull.
- **Charge**: A fundamental intrinsic property of matter that gives rise to the attractions and repulsions between electrons and protons.
- **Electron**: A small, light negative particle. Electrons orbit around the nucleus of the atom.
- **Nucleus**: A small, compact, heavy center of an atom that contains positively charged protons and neutrons (neutral).
- **Ion:** An atom or molecule that has net positive or negative charge resulting from losing or gaining an electron.
- **Charging by Contact**: The transfer of electric charge from one object to another by simple contact such as rubbing or conduction.
- **Charging by Induction**: Redistribution or charging of an object by bringing a charged item in close proximity to, but not touching, an uncharged object.
- **Coulomb's Law**: Mathematical relationship between electric force, charge, and distance. The electric force varies directly with the product of the charges, and inversedly to the square of the distance between the charges.
- **Polarized**: Separation or alignment of the charges in a neutral body so that like charges are grouped together, resulting in a positive and a negative region.
- **Electric Field**: A force field that fills the space near any charge.
- **Electric Field Line**: A representation of a field using a line whose direction is that of the force that a tiny positive charge would experience if placed in that field. Field lines always start at positive charge and end on negative charge.
- **Electric Potential**: The ratio of electric potential energy to electric charge at a particular spot in an electric field. Measured in Volts.
- **Electric Potential Difference:** The work done to move a 1 Coulomb charge between two points in an electric field. Measured in Volts and sometimes called **Voltage.**
- **Equipotential Line**: A line where all points have an equal electric potential, or voltage.
- **Inverse Square Law**: A relationship relating the strength of an effect to the inverse square of the distance away from the source. Gravitational and electrical forces are examples.

Variables Used

- r=distance/radius
- d = distance
- F = force
- q = charge
- E = electric field
- PE = potential energy
- V = electric potential
- V_{ba}= electric potential difference

Typical Key Metric Units

- Distance/radius: meters, m
- Force: Newtons, N
- Charge: Coulombs, C
- Energy or work: Joules, J
- Electric potential and Electric potential difference : Volts, V
- Electric Field: N/C

Key Constants

- $k = 9 \times 10^9$ N•m²/C²
- $\varepsilon_o = 8.85 \times 10^{-12}$ C²/N•m²
- $1\ C = 6.25\times10^{18}$ electrons
- Charge on an electron = -1.6×10^{-19} C
- $1eV=1.6 \times 10^{-19}$ J

Key Formulas

- $F_E = k\frac{q_1 q_2}{r^2}$
- $V = \frac{PE}{q}$
- $V = k\frac{q}{r}$, Electric potential for a single charge
- $V_{ba} = V_b - V_a = \frac{PE_b}{q} - \frac{PE_a}{q}$
- $\Delta PE = qV_{ba}$
- $\vec{E} = \frac{\vec{F}}{q}$
- $E = \frac{-V_{ba}}{d}$

Electrostatics Problem Solving Tips

These tips will make it easier to solve any physics problems.

- Thoroughly read the entire problem.
- Draw a diagram if needed. Remember that E fields point in the direction that a positive test charge would move.
- Identify all given information.
- Identify the quantity to be found.
- Select appropriate formula(s) that incorporate what you know and what you want to find.
- Convert units if needed. Use units throughout your calculations. Do any mathematical calculations carefully.

Electrostatics Diagrams

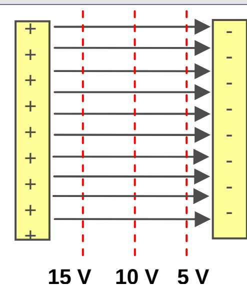

Diagram shows electric field between two oppositely charged plates. Also shown are equipotential lines that are perpendicular to the field lines.

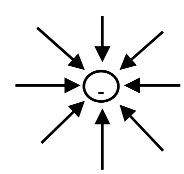

Diagram shows the electric field surrounding an area of negative charge. The E field lines always point in the direction that a small positive test charge would move in the field.

Typical Electrostatics Problem

Example: What force exists between two clumps, 2 meters apart, each of which containing one billion excess electrons?

First, convert the raw number of electrons into an appropriate charge in Coulombs.

$1\times10^9 \times -1.6 \times 10^{-19}C = -1.6 \times 10^{-10}C$

Next, substitute into Coulombs law.

$$F_E = k\frac{q_1 q_2}{r^2} = (9 \times 10^9 N\cdot m^2/C^2)\frac{(-1.6 \times 10^{-10}C)(-1.6 \times 10^{-10}C)}{(2.0\ m)^2}$$

$$F_E = 5.8 \times 10^{-11}\ N$$

A small positive force, indicating that the force is repulsive. Remember like charges repel, dislike attract.

How to Use This Cheat Sheet: These are the keys related this topic. Try to read through it carefully twice then recite it out on a blank sheet of paper. Review it again before the exams.

