Physics 161
Lecture 20 Summary
Electric Forces and Fields

November 9, 2017

Lecture 20: learning objectives

You will be able to define the basic carriers of charge and describe conductors, insulators and semi-conductors.

You will be able to state and apply Coulomb's law for systems of charged particles.

You will be able to define an electric field, draw electric field lines, and apply these definitions to systems of charged particles. You will be able to define electric flux, and define and apply Gauss' law to distributions of charge.

You will be able to describe a Van de Graaff generator.

Conductors and insulators

Conductors:
Electric charges move freely in response to an electric force.

Insulators:
Electric charges cannot move freely in response to an electric force.

Semi-conductors:
Electric charges can move freely in certain situations, but not in others.

Transferring charge

By friction:
Electrons physically transferred by rubbing materials together. Friction provides the energy required to liberate electrons from atoms and transfer them.

By conduction:
Electrons move directly from a charged material in contact with a neutral object.

By induction:
Electrons induced to move through the presence of a charged object.

Electrical force

Coulomb's law:
The magnitude of the electric force F between charges q_1 and q_2 separated by a distance r is proportional to the product of the magnitude of the charges, divided by the distance squared.

$$F_{\mathrm{E}} = k_e \frac{|q_1||q_2|}{r^2}$$

k_e is Coulomb's constant: $k_e = 8.988 \times 10^9$ N m^2/C^2

Charge conservation:
Electric charge is conserved. Always.

Electric field

Superposition principle:
The electrical force at a single point due to multiple electric charges is the vector sum of the fields due to each charge.

Electric field:
The electric field E produced by a charge q at the location of a small "test" charge q_O is defined as the electric force F exerted by q on q_O, divided by the test charge q_O.

$$\vec{E} = \frac{\vec{F}_{\text{E}}}{q_0}$$

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

Electrical field lines

We can represent an electric field by drawing electric field lines. Field lines satisfy the following rules:

1. Field lines at a point are tangent to the electric field vector at that point.

2. Field lines of point charges begin on positive charges and end on negative charges.

3. Number of lines leaving a positive charge or ending on a negative charge is proportional to the magnitude of the charge.

Conductors

Electrostatic equilibrium:
No net motion of charge within an object.

Isolated conductors in electrostatic equilibrium have the following properties:
1. The electric field is zero everywhere inside the conducting material.
2. Any excess charge resides entirely on the surface.
3. The electric field just outside the conductor is perpendicular to the surface.
4. On an irregularly shaped conductor surface, charge collects on the sharp points.