Name ____________________ Class ______________ Date __________

Summary

THE BIG IDEA **An electric field is a storehouse of energy.**

33.1 Electric Fields

The magnitude (strength) of an electric field can be measured by its effect on charges located in the field. The direction of an electric field at any point, by convention, is the direction of the electrical force on a small *positive* test charge placed at that point.

- An **electric field** is a force field that surrounds an electric charge or group of charges.
- An electric field has both magnitude and direction.
- Consider a small positive "test charge" that is placed in an electric field. Where the force is greatest on the test charge, the field is strongest. Where the force on the test charge is weak, the field is small.
- If a test charge q experiences a force F at some point in space, then the electric field E at that point is $E = \frac{F}{q}$.
- If the charge that sets up an electric field is positive, the field points away from that charge. If the charge that sets up the field is negative, the field points toward that charge.

33.2 Electric Field Lines

You can use the electric field lines (also called lines of force) to represent an electric field. Where the lines are farther apart, the field is weaker.

- Since an electric field has both magnitude and direction, it is a vector quantity and can be represented by vectors.
- In a vector representation of an electric field, the length of the vectors indicates the magnitude of the field. In a lines-of-force representation, the distance between field lines indicates magnitudes.

33.3 Electric Shielding

If the charge on a conductor is not moving, the electric field inside the conductor is exactly zero.

- The absence of electric field within a conductor holding static charge does not arise from the inability of an electric field to penetrate metals. It comes about because free electrons within the conductor can "settle down" and stop moving only when the electric field is zero.
- Consider a charged hollow metal sphere. Because of mutual repulsion, the electrons spread as far apart from one another as possible, distributing themselves uniformly over the surface of the sphere. The forces on a test charge located inside a charged hollow sphere cancel to zero.
- If a conductor is not spherical, then the charge distribution will not be uniform. The exact charge distribution over the surface is such that the electric field everywhere inside the conductor is zero.

33.4 Electrical Potential Energy

The electrical potential energy of a charged particle is increased when work is done to push it against the electric field or something else that is charged.

- A charged object can have potential energy by virtue of its location in an electric field.
- Suppose you have a small positive charge located at some distance from a positively charged sphere. If you push the small charge closer to the sphere, you expend energy to overcome electrical repulsion. The work is equal to the energy gained by the charge.
- The energy a charge has due to its location in an electric field is called **electrical potential energy**.

33.5 Electric Potential

Electric potential is *not* the same as electrical potential energy. Electric potential is electrical potential energy per charge.

- The concept of electrical potential energy per charge has a special name, **electric potential:** electric potential = electrical potential energy/charge.
- The SI unit of measurement for electric potential is the **volt.**
- Since potential energy is measured in joules and charge is measured in coulombs, 1 volt = 1 joule/coulomb.
- Since electric potential is measured in volts, it is commonly called **voltage.**

33.6 Electrical Energy Storage

The energy stored in a capacitor comes from the work done to charge it.

- Electrical energy can be stored in a common device called a **capacitor.**
- The simplest capacitor is a pair of conducting plates separated by a small distance, but not touching each other. When the plates are connected to a charging device such as a battery, charge is transferred from one plate to the other. The greater the battery voltage and the larger and closer the plates, the greater the charge that is stored.

33.7 The Van de Graaff Generator

The voltage of a Van de Graaff generator can be increased by increasing the radius of the sphere or by placing the entire system in a container filled with high-pressure gas.

- In a Van de Graaff generator, a moving rubber belt carries electrons from the voltage source to a conducting sphere.
- Van de Graaff generators in pressurized gas can produce voltages as high as 20 million volts. These devices accelerate charged particles used as projectiles for penetrating the nuclei of atoms.