AP Physics 1 Unit 11 Notes **Name:__________________ #:____**

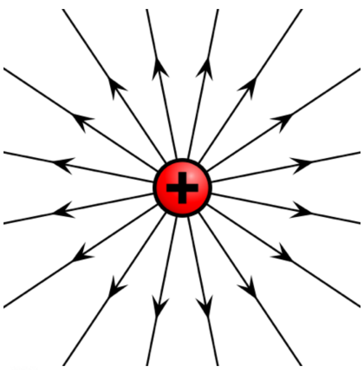
Electric Forces and Fields

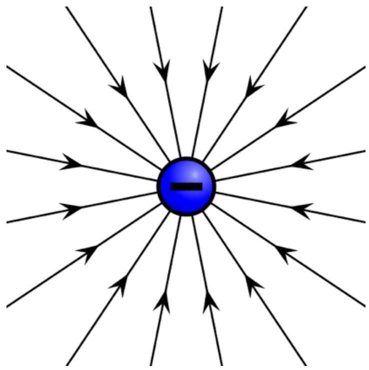
Properties of Electric Charge

→ Objects can become **electrically charged** by either **gaining or losing electrons**

→ Objects will tend to **hold an electric charge** better on a dry day because excessive **moisture can provide a pathway for charge to leak off** a charged object.

→ There are two kinds of electric charge--**Positive and Negative**
--additionally, **Like charges repel each other and Unlike charges attract**.





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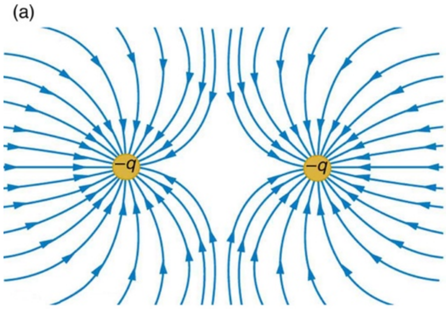
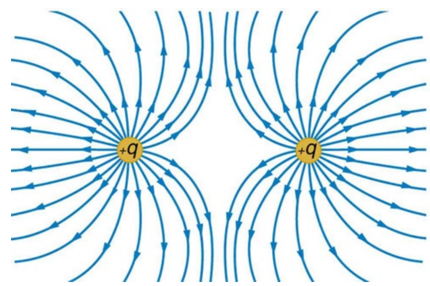


Like charges Repel
Field lines DO NOT Cross.
Notice negative charges are different from positive but both have ZERO field between them.



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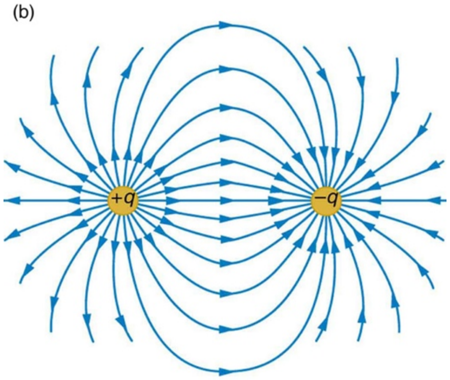

Opposite charges Attract
Field lines DO NOT Cross, a field line leaving a positive charge will come back into a negative charge.

→ The stronger the charge the MORE field lines around the charge. The closer the field lines are to each other the stronger the field.

→ By convention, when you rub a balloon across your hair, the **charge on your hair is positive (electrons have been removed)** and that on the **balloon** is **negative (electrons have been gained)**.

→ **Positive and negative** charges are said to be **opposite** because an object with an **equal amount of positive and negative charge has NO net charge**.

→ <u>**Electric Charge is conserved**</u>**.**

→ **Positively charged particles**, called **protons**, and **neutral particles**, called **neutrons**, are located in the **center of the atom**, called the **nucleus**. **Negatively charged particles**, known as **electrons**, are located **outside the nucleus** and **move around it**.

→ Protons and neutrons are relatively fixed in the nucleus of the atom, but electrons are easily transferred from one atom to another. When the electrons in an atom are balanced by an equal number of protons, the atom has no net charge.

→ When an electron is transferred from one atom to another, **one of the atoms gains a negative charge** and **the other loses a negative charge, thereby becoming positive**. Atoms that are **positively or negatively** charged are called **ions**.

→ When a balloon is rubbed against your hair, some of your hair's electrons are transferred to the balloon.

→ The **principle of conservation of charge** is one of the **fundamental laws of nature**.

→ Electric Charge is quantized. -- Milikan oil drop experiment

→ In modem terms, charge is said to be quantized. This means that charge occurs as discrete amounts in nature. Thus, an object may have a charge of **±e, or ±2e, or ±3e**, and so on.

→ An electron has a charge of **-e** and the proton has an equal and opposite charge, **+e**. The value of **e** has since been determined to be **1.60×10^{-19} C**, where the **coulomb (C)** is the **SI unit of electric charge**.

→ A total charge of **-1.0 C contains 6.2×10^{18} electrons (l/e).** Comparing this with the number of free electrons in **1 cm^3 of copper**, which is on the **order of 10^{23}**, shows that **1.0 C** is a **substantial amount** of charge.

Transfer of Electric Charge

→ Materials in which electric **charges (electrons) move freely**, such as copper and aluminum, are called **conductors**. **Most metals are conductors**. Materials in which **electric charges do not move freely**, such as glass, rubber, silk, and plastic, are called **insulators**.

→ **Semiconductors** are a third class of materials characterized by electrical properties that are somewhere between those of insulators and conductors.

→ Certain metals belong to a fourth class of materials, called **superconductors**. **Superconductors** become **perfect conductors** when they are at or below a certain temperature.

→ Insulators and conductors can be charged by contact. e.g. When the balloon was rubbed on your hair, this was charging by contact.

→ Insulators can easily be charged by contact. Conductors can ***<u>only</u>*** be charged by contact if they are not attached to the ground (grounded).

→ Conductors can be charged by **INDUCTION**. When a conductor is connected to Earth by means of a conducting wire or copper pipe, the conductor is said to be **grounded**.

→ The repulsive force between the electrons in the rod and those in the sphere causes a redistribution of negative charge on the sphere. As a result, the region of the sphere nearest the negatively charged rod has an excess of positive charge (**electron deficient)**.

→ **Induction** is the process of charging a conductor by bringing it near another charged object and grounding the conductor.

→ **A surface charge** can be induced on insulators by polarization.

17-2 -- Electric Force

→ Both attractive and repulsive electric charges can exert a force on each other. This force is called the **electric force.**

→ The closer two charges are, the greater the force between them.

→ The distance between two objects affects the magnitude of the electric force between them.

→ **Coulomb's Law** $F_e = k\frac{q_1 q_2}{r^2}$

$$F_{elecric} = Coulomb'sConstant\ \frac{Charge\ 1 * Charge\ 2}{separation\ distance^2}$$

k_c → Coulomb constant – SI unit – $N*m^2/C^2$ = 9.0 x 10^9 $N*m^2/C^2$

Sample Problem 17 A, pg. 635 Holt Physics: The electron and proton of a hydrogen atom are separated, on average, by a distance of about 5.3 x 10^{-11} m. Find the magnitudes of the electric force and the gravitational force that each particle exerts on the other.

$$F_e = k\frac{q_1 q_2}{r^2} \qquad F_g = G\frac{m_1 m_2}{r^2}$$

$$F_e = 9.0x10^9 \frac{N*m^2}{C^2}\ \frac{(1.6x10^{-19})^2}{(5.3x10^{-11}m)^2} = 8.2x10^{-8}N$$

$$F_g = 6.67x10^{-11} \frac{N*m^2}{kg^2}\ \frac{(9.109x10^{-31})(1.673x10^{-27})}{(5.3x10^{-11}m)^2} = 3.6x10^{-47}N$$

Sample Problem Practice 17A, pg. 636, #4 Holt Physics: Two identical conducting spheres are place with their centers 0.30 m apart. One is given a charge of +12 x 10^{-9} C and the other is given a charge of -18x10^{-9} C.

a) Find the electric force exerted on one sphere by the other.

Formula **Set-Up (with Units)**

Answer ________________

b) The spheres are connected by a conducting wire. After equilibrium has occurred, find the electric force between the two spheres. Set-Up (with Units)

Formula **Set-Up (with Units)**

Answer ________________

Electric Force is a field force:

→ This is a second example of a force that is exerted by one object on another even though there is not physical constant between the two objects.

→ Some important differences between electric and gravitational forces are:
1) Electric forces can be either attractive or repulsive. Gravitational forces are always attractive. This is because objects can have either a positive or a negative charge, while mass is always positive.
2) The electric force is significantly stronger than the gravitational force.
3) In the large-scale world, the relative strength of these two forces can be seen by noting that the amount of charge required to overcome the gravitational force is relatively small.

→ Resultant force on a charge is the vector sum of the individual forces on that charge. We saw this when we went outside in the fall and followed the vector directions that other teams had prepared to lead you to their hidden goal.

→ Coulomb quantified electric force with a torsion balance. A torsion balance consists of two small spheres fixed to the ends of a light horizontal rod. The rod is made of an insulating material and is suspended by a silk thread.

17-3 -- The Electric Field

→ **An Electric Field** is a field that permeates the space around a charged object and in which another charged object experiences an electric force.

→ Electric field strength is a ratio of force to charge, the SI units of **E** are **newtons per coulomb (N/C).** The electric field is a vector quantity. By convention, the direction of **E** at a point is defined as the direction of the electric force that would be exerted on a small positive charge (called a **test charge**) placed at that point.

→ The direction of **E** depends on the **sign of the charge** producing the field.

→ **Electric Field strength depends on charge and distance.**

Electric Field strength from a point charge $\boldsymbol{E = k\frac{q}{r^2}}$

$$\boldsymbol{Electric\ Field\ Strength = Coulomb's\ Constant\ \frac{Charge\ Producing\ the\ Field}{Separation\ Distance^2}}$$

→ Electric field, **E**, is a vector. If **q** is **positive**, the field due to this charge is directed **outward** radially from **q**. If **q** is **negative**, the field is directed **toward q**.

→ **Electric Field Lines are lines** representing both the magnitude and the direction of the electric field.

→ The number of field lines is proportional to the electric field strength.

→ How to draw electric field lines:

https://www.slideshare.net/linwenquan1982/drawing-electric-field-lines/6

→ The electric field lines for two point charges of equal magnitudes but opposite signs give the charge configuration for an **electric dipole**.

→ a Van de Graaff Generator collects electric charge.