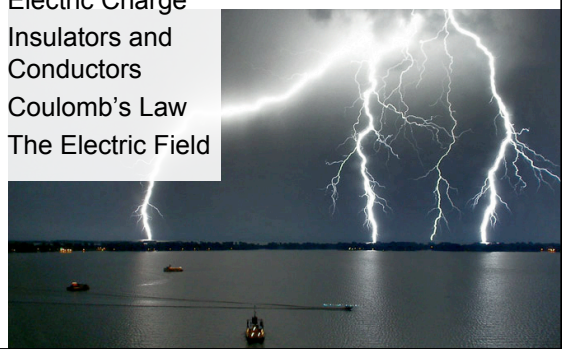
PHY132H1F Introduction to Physics II
Class 9 – **Outline:**

- Electric Charge
- Insulators and Conductors
- Coulomb's Law
- The Electric Field



Quick Ch. 26 reading quiz..

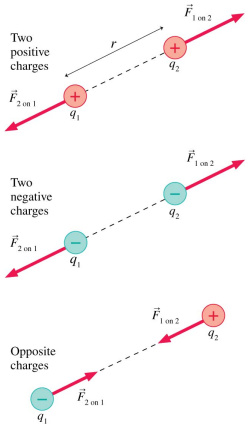
What is the SI unit of electric charge?

A. Coulomb
B. Faraday
C. Ampere
D. Ohm
E. Volt

Ch. 26 quick reading quiz #2

Two Plastic rods that have been rubbed with wool repel each other, even if they are not touching. This repulsion is

A. a fictitious force.
B. a magnetic force.
C. a gravitational force.
D. an electric force.
E. a normal force.



Coulomb's law:

1. If two charged particles having charges q_1 and q_2 are a distance r apart, the particles exert forces on each other of magnitude

$$F_{1\text{ on }2} = F_{2\text{ on }1} = \frac{K|q_1||q_2|}{r^2} \qquad (26.2)$$

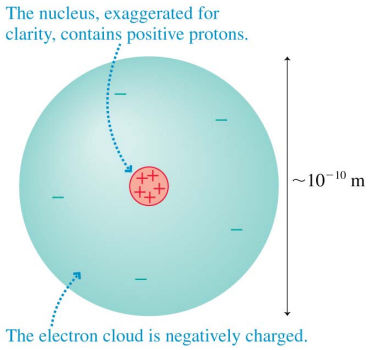
where K is called the **electrostatic constant.** These forces are an action/reaction pair, equal in magnitude and opposite in direction.
2. The forces are directed along the line joining the two particles. The forces are *repulsive* for two like charges and *attractive* for two opposite charges.

In SI units $K = 8.99 \times 10^9$ N m^2/C^2.

In-class discussion question.
Charges A and B exert repulsive forces on each other. $q_A = 4q_B$. Which statement is true?

A. $F_{A\text{ on }B} > F_{B\text{ on }A}$
B. $F_{A\text{ on }B} < F_{B\text{ on }A}$
C. $F_{A\text{ on }B} = F_{B\text{ on }A}$

FIGURE 26.1 An atom.



Atoms and Electricity

- An atom consists of a very small and dense ***nucleus*** surrounded by much less massive orbiting ***electrons***.
- The nucleus consists of ***protons*** with positive electric charge, and neutral ***neutrons***.
- The atom is held together by the attractive electric force between the positive nucleus and the negative electrons.
- Electrons and protons have charges of opposite sign but *exactly* equal magnitude. (+/- e)
- Protons and Neutrons are much more massive than electrons. That makes electrons much more free to move.

TABLE 26.1 Protons and electrons

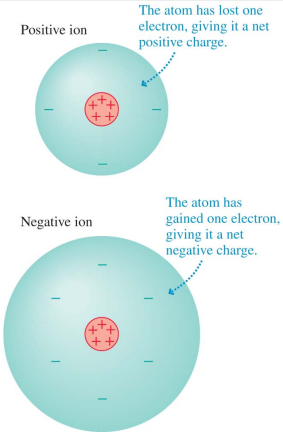
Particle	Mass (kg)	Charge
Proton	1.67×10^{-27}	$+e$
Electron	9.11×10^{-31}	$-e$

- Any object has net charge, q:

$$q = N_p e - N_e e = (N_p - N_e)e$$

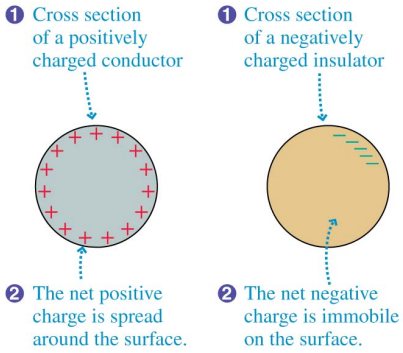
where N_p and N_e are the number of protons and electrons contained in the object.

- The process of removing or adding an electron from the electron cloud of an atom is called **ionization.**
- An atom with fewer electrons than protons is called a *positive ion.* An atom with more electrons than protons is called a *negative ion.*



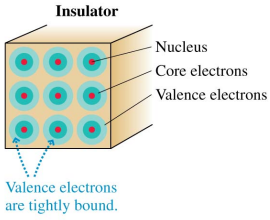
Note:
- The number of protons in an atom is very unlikely to ever change.
- Only a *nuclear process* can change the proton number, and this would change the type of element as well.
- (ie, changing Lead to Gold by removing 3 protons)
- But high orbit ("valence") electrons can come and go more easily.

FIGURE 26.4 Charge diagrams.



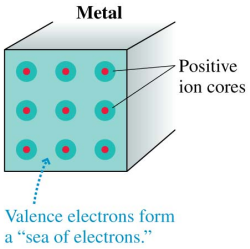
Insulators

- In an insulator, the electrons are all tightly bound to the positive nuclei and not free to move around.
- You can charge up an insulator by friction, which leaves patches of positive or negative ions on the surface, but these patches are immobile.

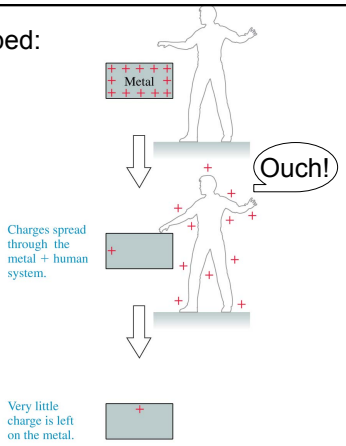


Conductors

- In a metal, the outer atomic electrons are only weakly bound to the nuclei.
- These outer electrons become detached from their parent nuclei and are free to wander about through the entire solid.
- The solid *as a whole* remains electrically neutral, but the electrons are now move around in an array of positively charged **ion cores.**

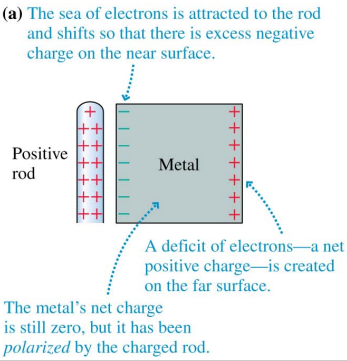


Getting zapped:



Charge Polarization

FIGURE 26.12 A charged rod polarizes a metal.



Charge Polarization

- When two small electrically charged objects are brought together, opposites attract and sames repel.
- When the objects have finite size and one of them is neutral or has very little charge on it, it will become *polarized*.
- The resulting force is *always attractive*. Both positive and negative objects tend to attract neutral objects due to *charge polarization*.

In Class Discussion Question

A sock has just come out of the dryer. You hypothesize that the sock might have a positive charge. To test your hypothesis, which of the following experiments might work?

A. see if the sock attracts a negatively charged plastic rod.
B. see if the sock repels a positively charged glass rod.
C. Both A and B.
D. Either A or B.

(Compare with Stop To Think 26.1 from your reading.)

The Electric Field

- Some charges, which we will call the **source charges,** alter the space around them by creating an *electric field.*
- A separate charge *in* the electric field experiences a force exerted *by the field.*
- Suppose probe charge q experiences an electric force $F_{\text{on } q}$ due to other charges.

$$\vec{E}(x, y, z) \equiv \frac{F_{\text{on } q} \text{ at } (x, y, z)}{q}$$

The units of the electric field are N/C. The magnitude E of the electric field is called the **electric field strength.**

The Electric Field of a Point Charge

The electric field at distance r from a point charge q is

$$\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}\hat{r} \qquad \text{(electric field of a point charge)}$$

where the unit vector for r points away from the charge to the point at which we want to know the field.
This unit vector expresses the idea "away from q".

FIGURE 26.28 The electric field of a positive charge.

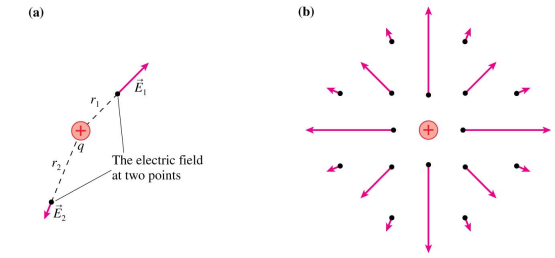
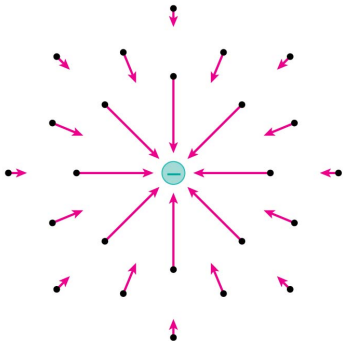


FIGURE 26.30 The electric field of a negative point charge.



Before Next Class:

- Practicals meet Friday as usual. You will be experimenting with electric charges on scotch-tape. Bring questions for your TAs if you have them!
- Try the suggested end-of-chapter problems for Chapter 26, posted on the Materials part of the web-site.
- Please read Chapter 27 on The Electric Field before Monday's class.

See you Monday!