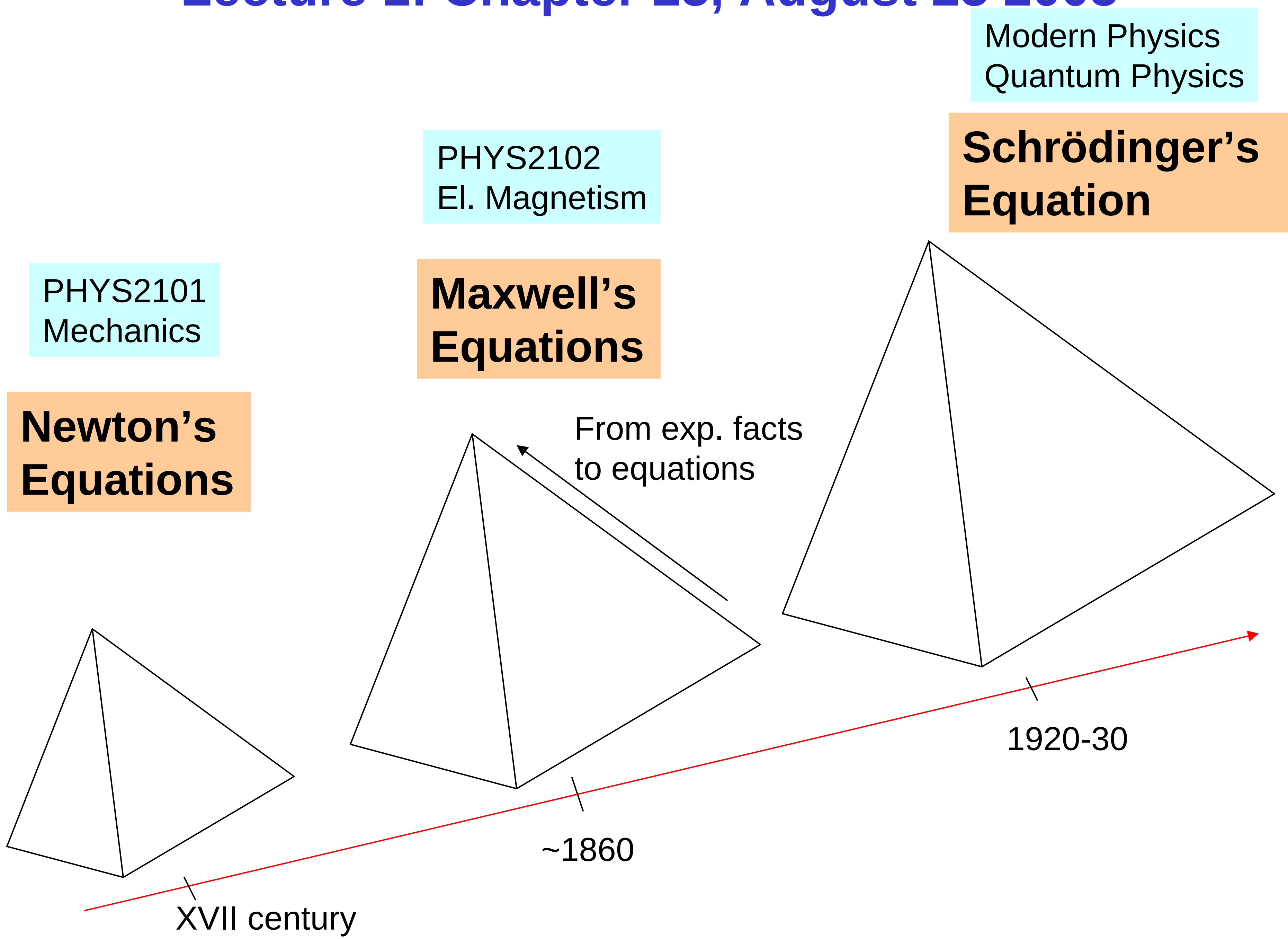
Lecture 1: Chapter 25, August 25 2005



Maxwell's Equations (Chapter 34)

GENERAL PRINCIPLES

Maxwell's Equations

These equations govern electromagnetic fields:

$\oint \vec{E} \cdot d\vec{A} = \frac{Q_{\text{in}}}{\epsilon_0}$	Gauss's law
$\oint \vec{B} \cdot d\vec{A} = 0$	Gauss's law for magnetism
$\oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi_{\text{m}}}{dt}$	Faraday's law
$\oint \vec{B} \cdot d\vec{s} = \mu_0 I_{\text{through}} + \epsilon_0 \mu_0 \frac{d\Phi_{\text{e}}}{dt}$	Ampère-Maxwell law

Maxwell's equations tell us that:

An electric field can be created by

- Charged particles
- A changing magnetic field

A magnetic field can be created by

- A current
- A changing electric field

Lorentz Force

This force law governs the interaction of charged particles with electromagnetic fields:

$$\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$$

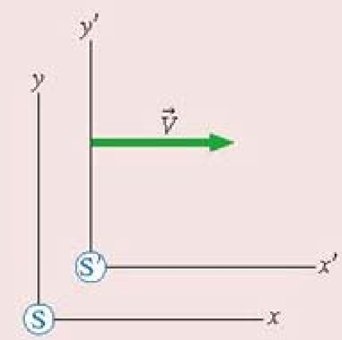
- An electric field exerts a force on any charged particle.
- A magnetic field exerts a force on a moving charged particle.

Field Transformations

Fields measured in frame S to be $\vec{E}$ and $\vec{B}$ are found in frame S′ to be

$$\vec{E}' = \vec{E} + \vec{V} \times \vec{B}$$

$$\vec{B}' = \vec{B} - \frac{1}{c^2}\vec{V} \times \vec{E}$$



Equations are too complicated to explore the EM piramide in descending way. We have to clime up!

Goals of PHYS2102

- Explore EM Piramide from the bottom to the top:

a) Experimental Facts
b) Empirical Laws
c) New quantities (charge, fields, potential, flux, etc.)
d) System of units

- Understanding Maxwell's Equations

- Problems Solving

PHYS2102

Electrostatics

Chapters
25 Charges & Forces
26 Electric Field
27 Gauss's Law
29 El. Potential
30 Potential and Field

First Exam
Thu, September 29

Circuits and Magnetism

Chapters
28 Current and Conductivity
31 Circuits
32 Magnetic Field
33 EM Induction
34 EM Fields and Waves

Second Exam
Thu, November 17

Waves and Optics

Chapters
22 Wave Optics
23 Ray Optics

Final Exam
Dec 13, 3:30-6:30pm

Chapter 25: Electric Charges

Features:

- Long history

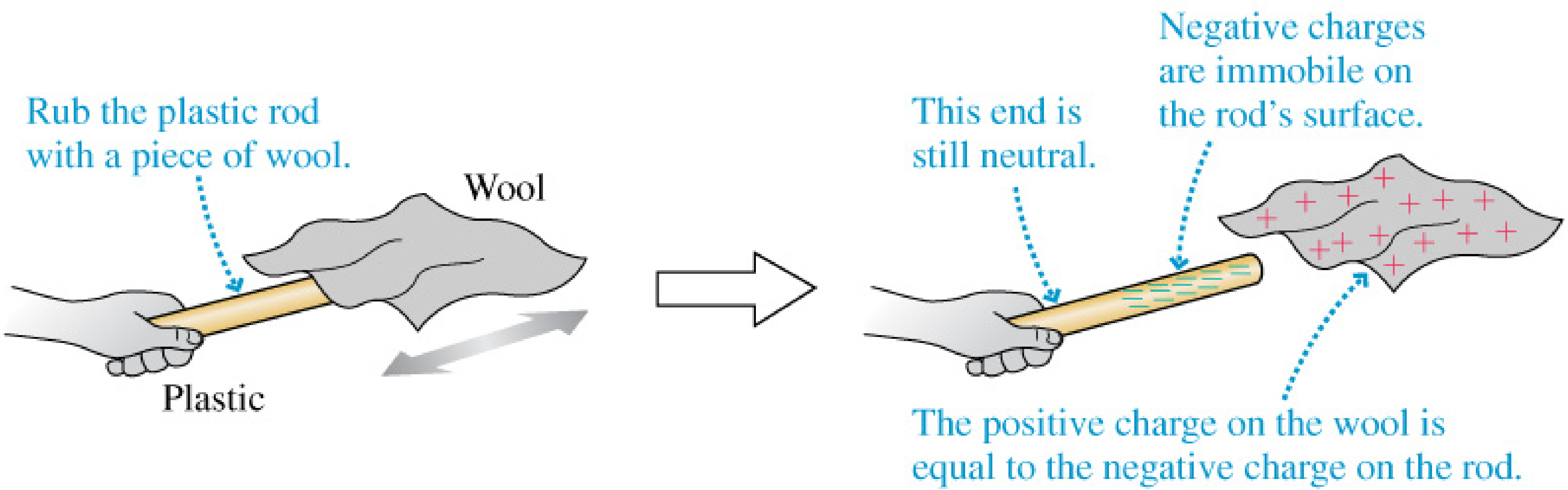
- All types of phenomena in everyday life

- Lots of applications:

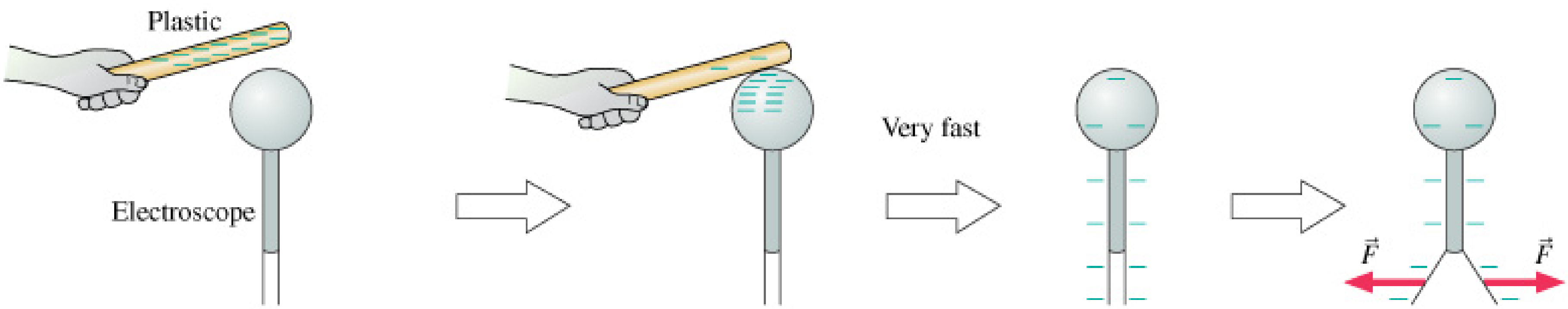
a) Electrostatic paint spraying
b) Photocopying , Xerox

- Macro and Micro-World

Chargind Plastic or Glass



Charging Metal and Electroscope

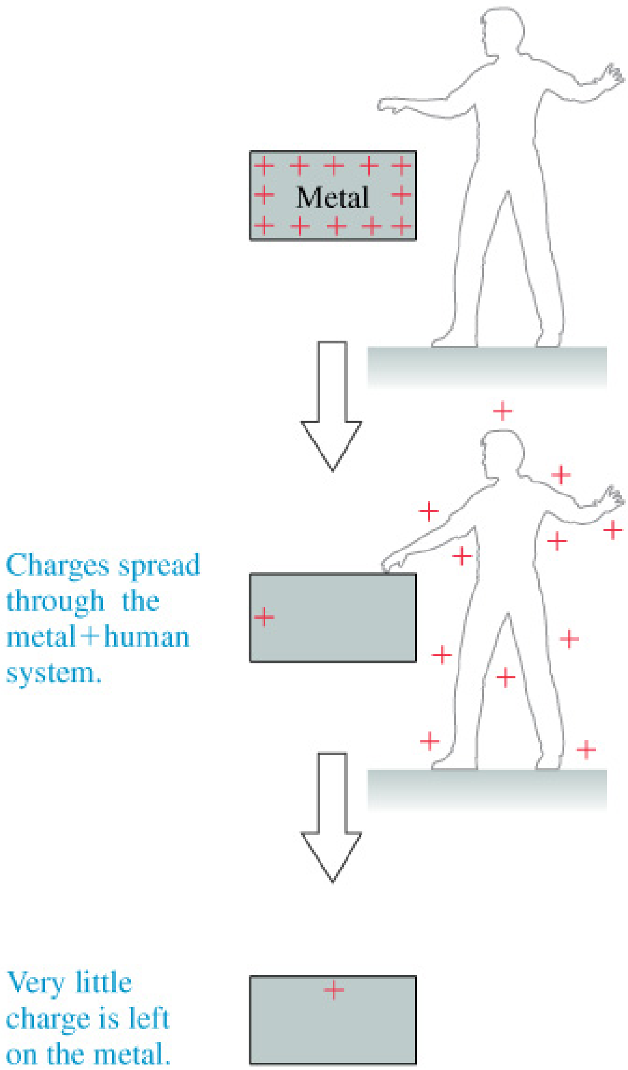


1. Negative charges (i.e., electrons) are transferred from the rod to the metal sphere upon contact.

2. Metal is a conductor. Therefore charge *very quickly* spreads throughout the entire electroscope. The leaves become negatively charged.

3. Like charges repel. The negatively charged leaves exert repulsive forces on each other, causing them to spread apart.

Discharging and Summary of Properties



- Frictional forces, such as rubbing, create charges

- There are two types of charges: “plastic charge” and “glass charge”

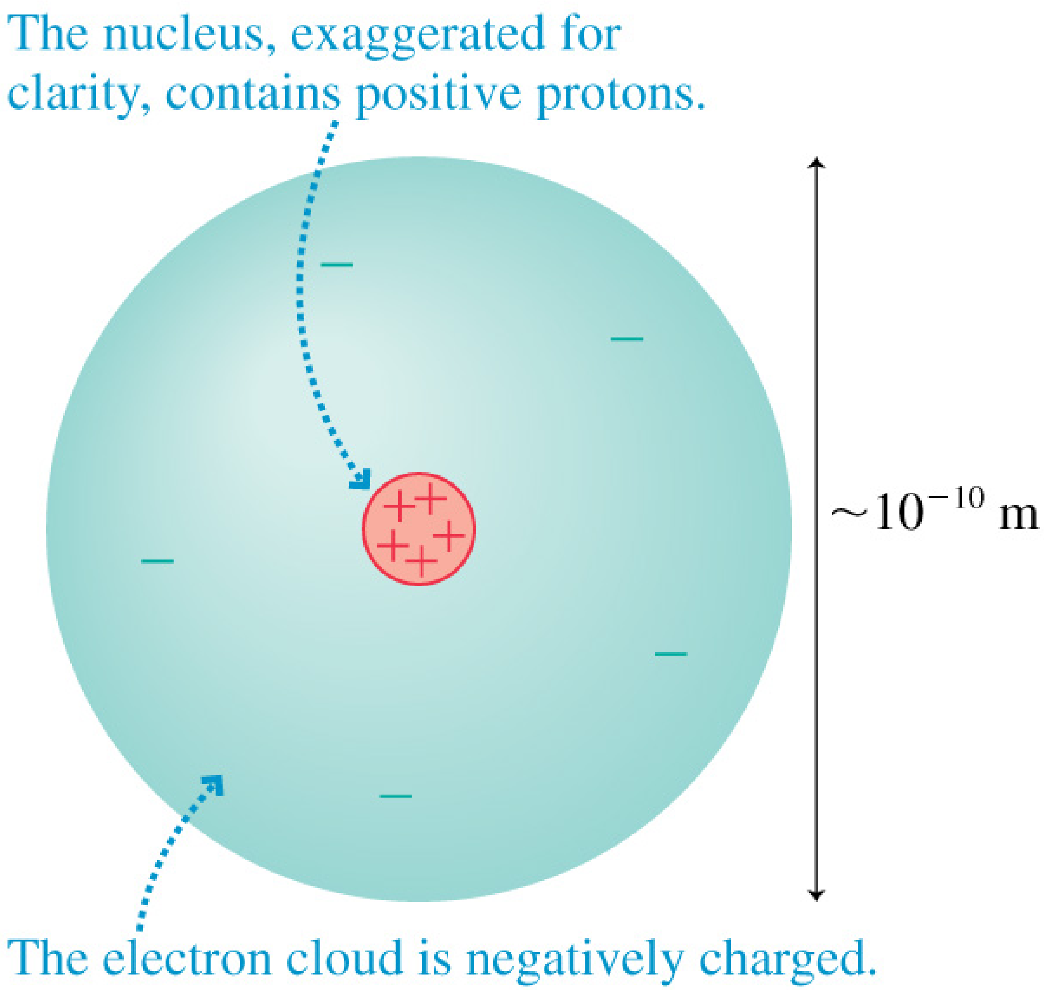
- Two like charges *repulse*, two opposite charges *attract*

- The forces are long-range

- On some materials, such as plastic or glass, the charge is immobile

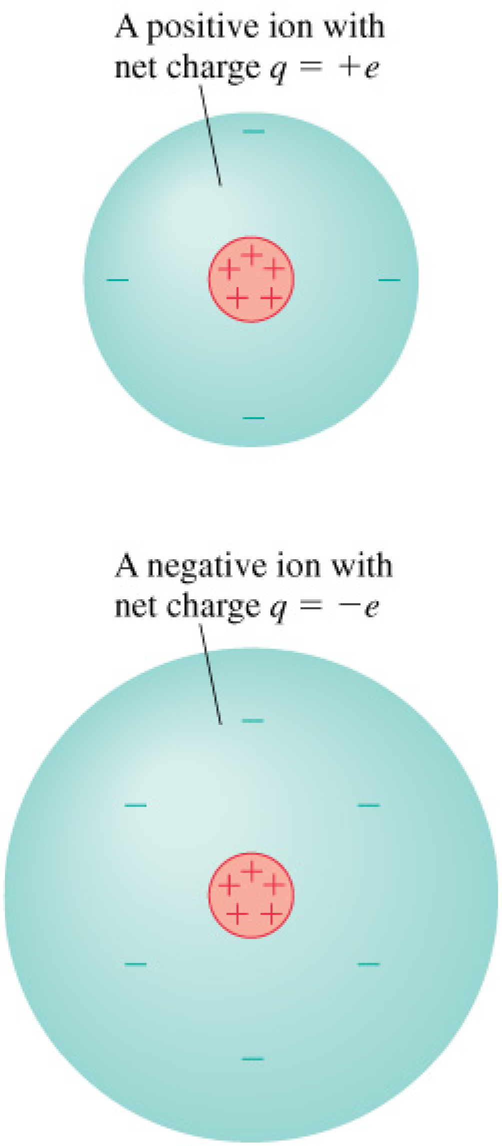
- On some materials such as metals the charge is free to move

Atoms and Electricity



- Electrons are negatively charged *particles*
- The nucleus consists of positively charged *protons* and neutral *neutrons*
- The mass of the atom is concentrated in its nucleus since the electrons are lightest particles
- Electrons and protons have charges of opposite sign but exactly equal magnitude

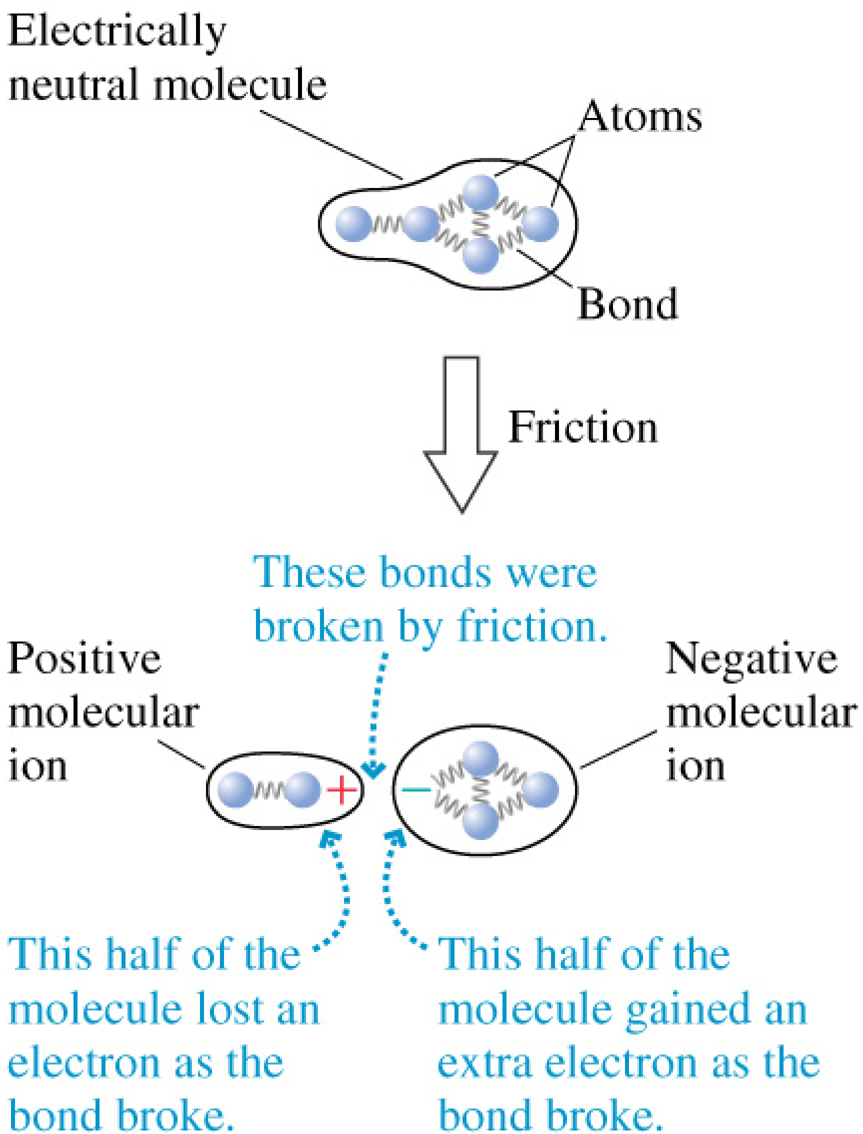
The Micro/Macro Connection



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

Neutral does not mean “no charges” but, instead, means there is not net charge.
A typical 1cm^3 solid contains ~10^{24} electrons and equal number of protons.

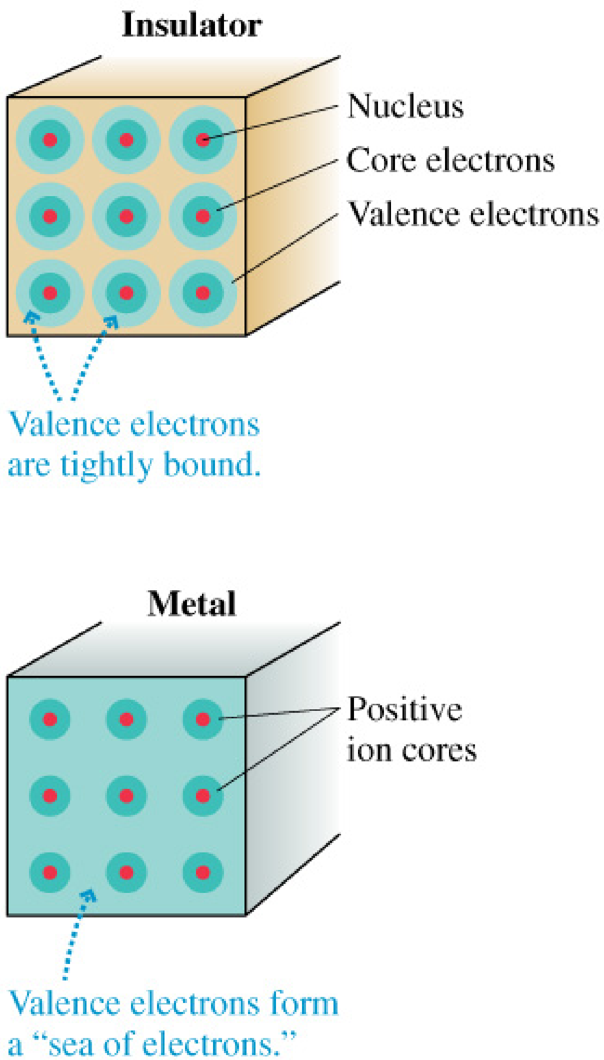
Mechanism of Charging by Friction



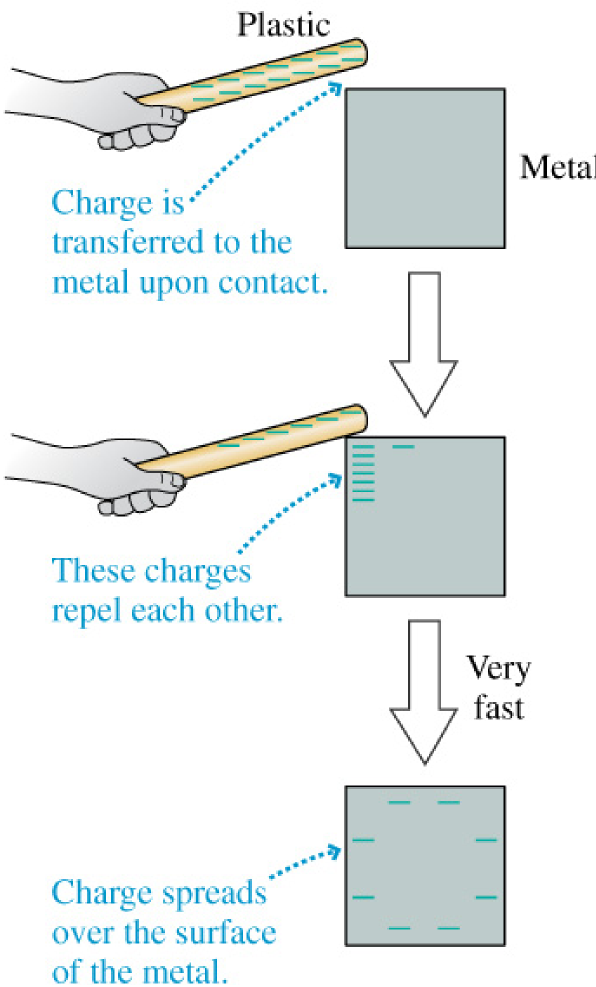
The positive molecular ions remain on one material and the negative on the other, so one of the objects being rubbed ends up with a net positive charge and the other with a negative charge.

Two Major Classes of Materials: Insulators and Conductors

Insulators and Conductors



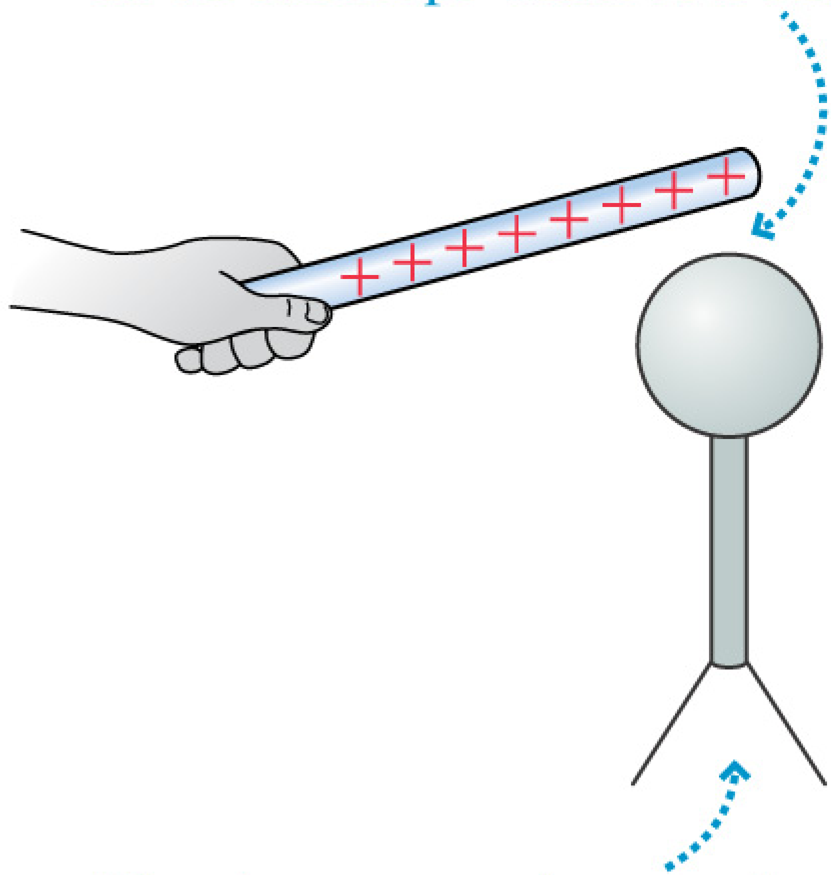
Charging Conductor



Any excess charge is located on the surface of the conductor

Charge Polarization

Bring a positively charged glass rod close to an electroscope without touching the sphere.

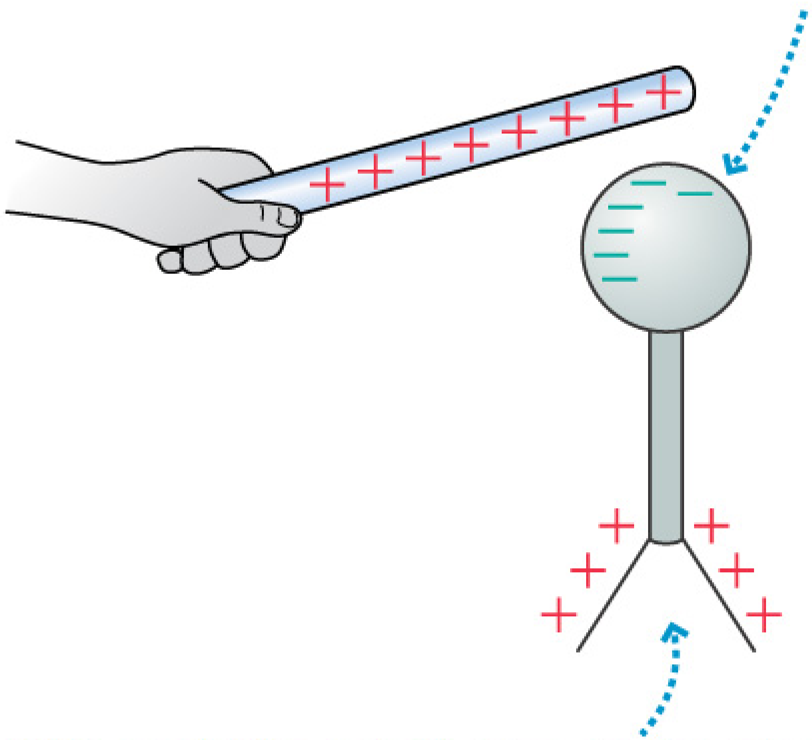


The electroscope is neutral, yet the leaves repel each other. Why?

Charge Polarization

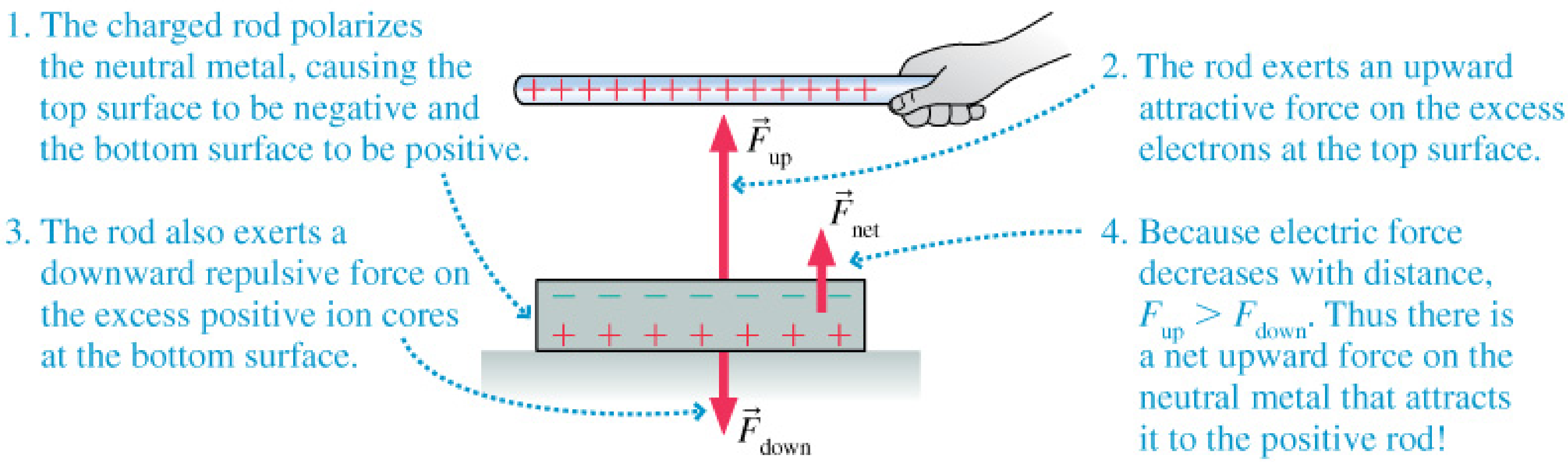
(b)

The electroscope is polarized by the charged rod.
The sea of electrons shifts toward the rod.

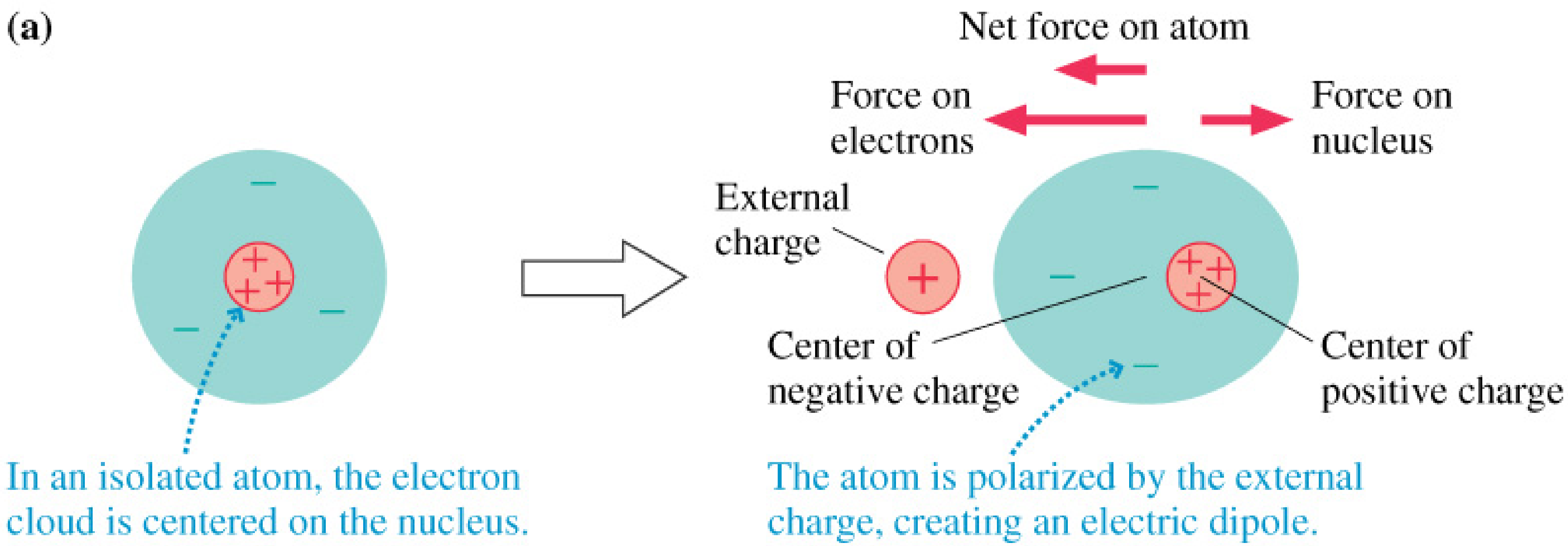


Although the net charge on the electroscope is still zero, the leaves have excess positive charge and repel each other.

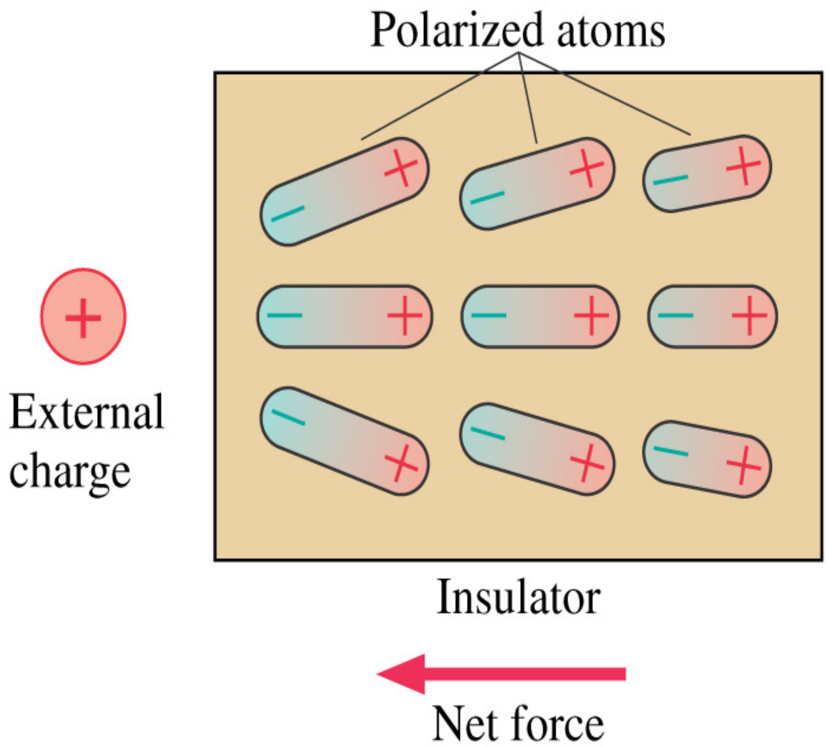
Polarization Force

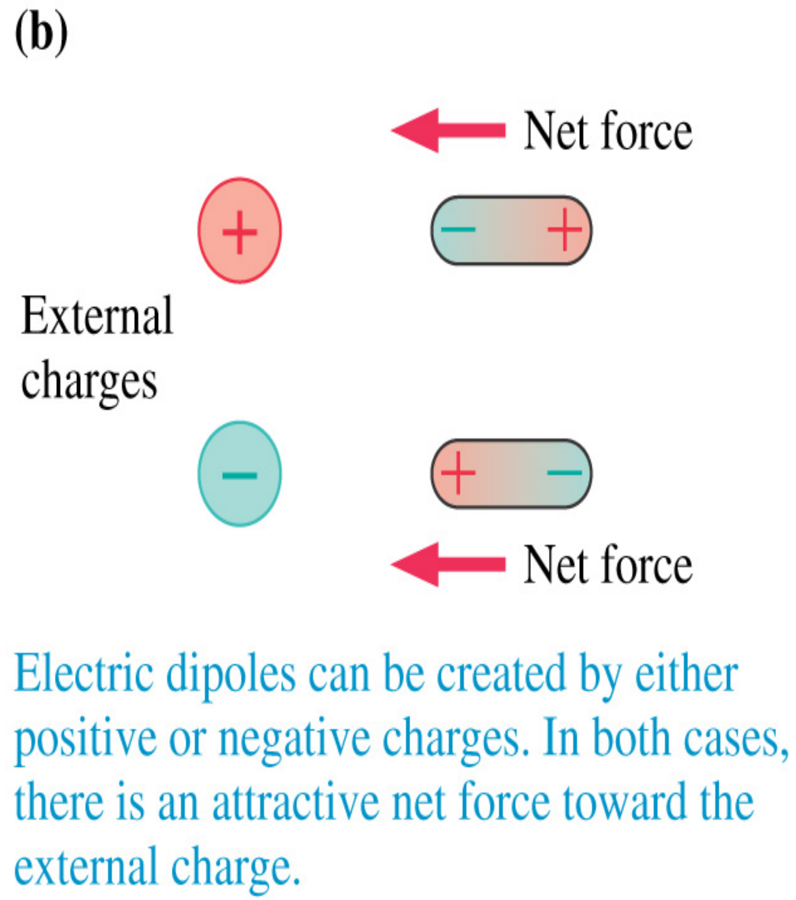


Polarization of atom



Why does a charged rod pick up paper? (Experiments with plastic and glass rods)





End of Lecture 1
Reading: Entire Chapter 25
Home Work 1 in Mastering Physics