PHYSICS NYB-10/11 Winter 2007

Electricity and Magnetism
Lecture 1: Electric charge

Instructor: Jérémie Vinet

Marianopolis College.

First class: administrative details

You should have in your possession:

- A course outline
- A detailed course outline
- A lab guidelines document

Me

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Office hours:

- Tuesday 14:15-16:15
- Wednesday 12:45-14:15
- Thursday 14:15-16:15
- Friday 11:15-12:45

Course Outline

We will be studying

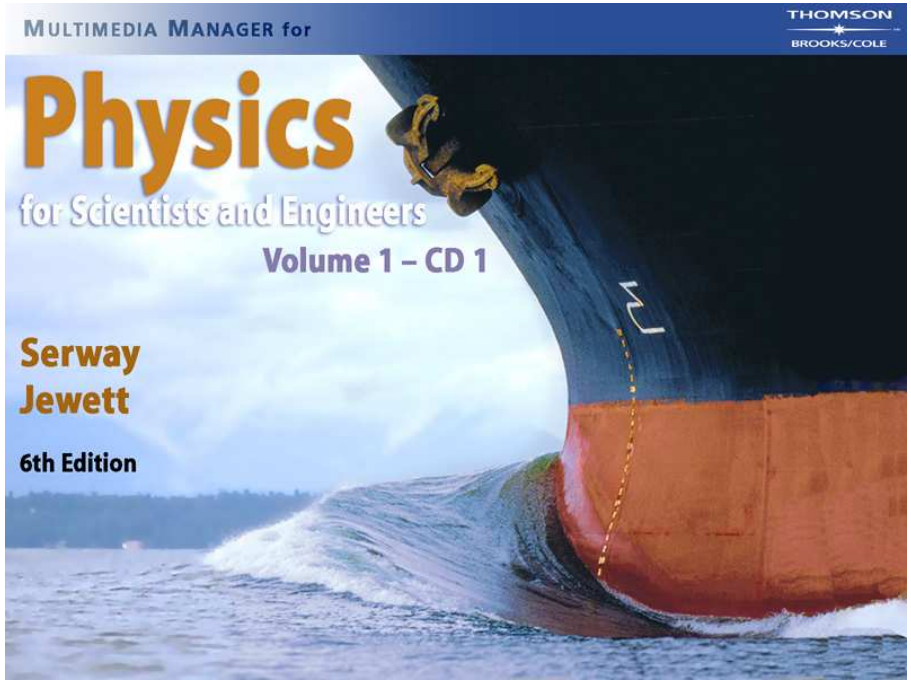
- Electric charges and electric force
- Electric field
- Electric potential and electric potential energy
- Current and resistance
- DC circuits
- Continuous charge distributions
- Electric flux and Gauss's law
- Capacitance
- Magnetic fields and their sources
- The law of induction and inductance

Book

Physics for Scientists and Engineers

With modern physics, 6th edition

Serway and Jewett



which you should already have by now...

F.A.Q.

- Is the book any good? YES!
- Should I read the book? YES!
- Is everything we're going to learn in the book? YES!*
- Are the notes going to be on the web? YES!*

Marking scheme

The following will count towards your final grade:

- Quizzes and integrative activity (11+1 over 15 week term)
- Exams (Section 10: February 21^{st} and April 4^{th}, Section 11: February 22^{nd} and April 5^{th})
- Lab reports (6, in teams of two)
- Hands-on lab (Section 10: May 2^{nd} , Section 11: May 3^{rd})
- Final exam

Marking scheme

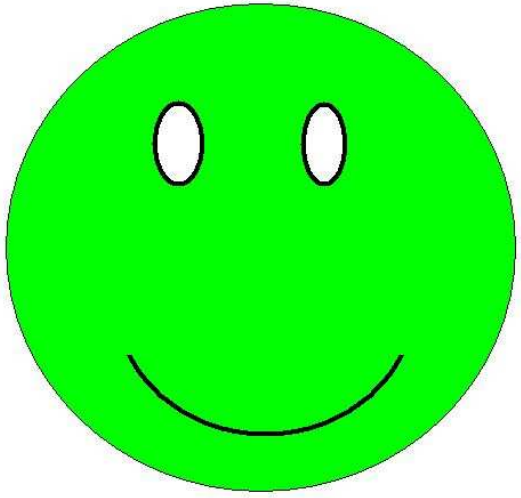
The following will count towards your final grade:

- Quizzes and integrative activity (5% or 10%)
- Exams (20% or 35%)
- Lab reports (7.5% or 7.5%)
- Hands-on lab (7.5% or 7.5%)
- Final exam (60% or 40%)

The scheme which applies to you *personally* will be the one which leads to the better final grade.

Quizzes

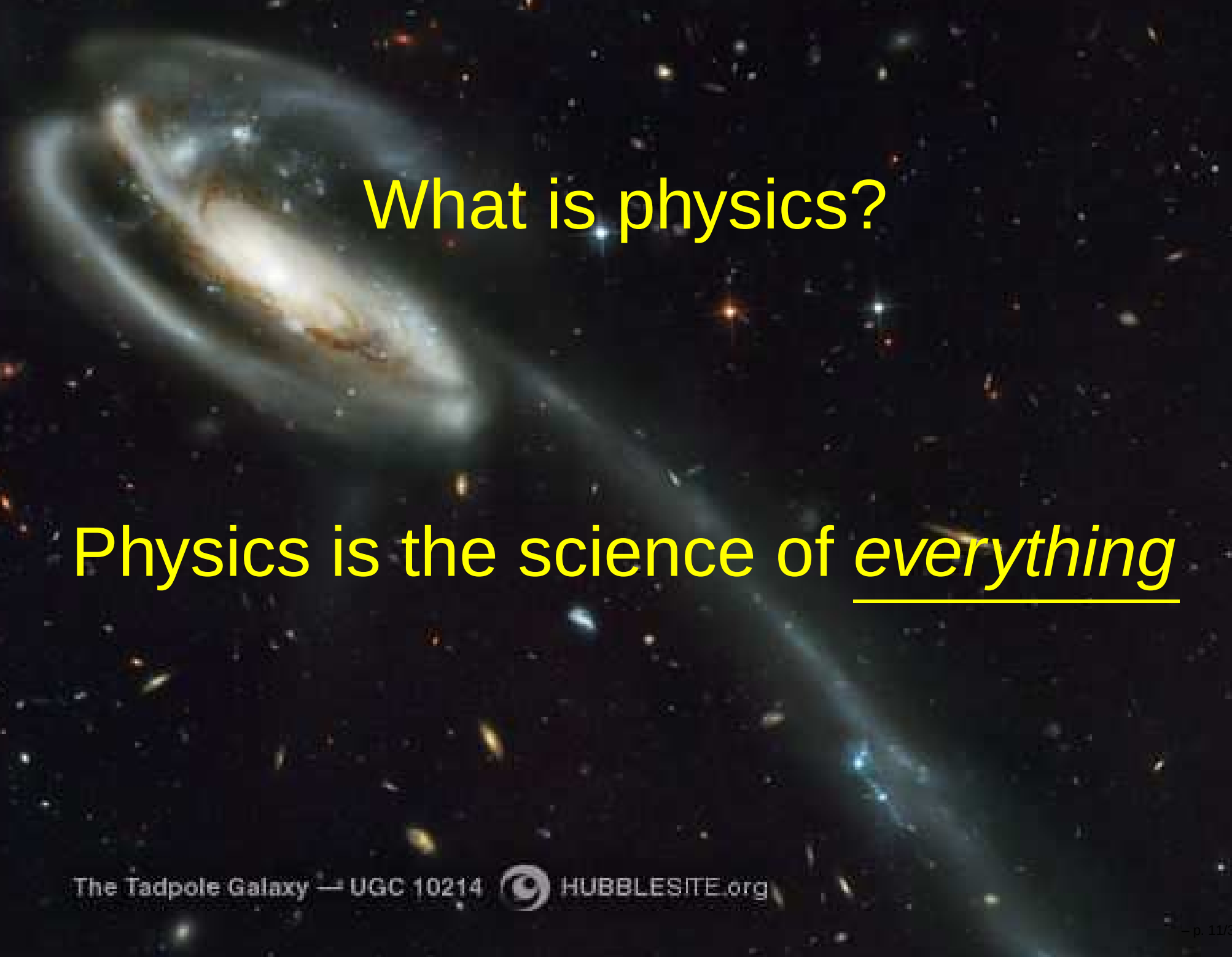
The “assignments” will be posted on Omnivox and *Cyber-Reserves* at least one week before the corresponding quiz.
Why quizzes???



Quizzes are good for you!

Exams

- There will be two exams, plus one final;
- The exams are specific to each section;
- The final is common to all sections;
- The exams are closed-book;
- There will be *no formula sheet*, except on the final;
- Only calculators allowed are the Texas Instruments Model TI-30XII (B or S);

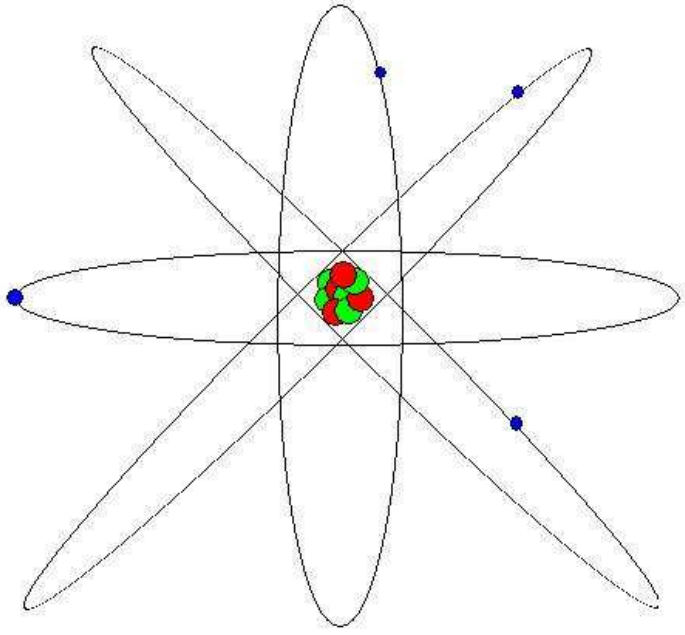

What is physics?
Physics is the science of *everything*
The Tadpole Galaxy — UGC 10214
HUBBLESITE.org

What you've learned so far

- Physics NYA:
  - There is stuff
  - Stuff moves
  - Stuff moves according to rigourous laws of nature
    - Newton's laws of motion
    - Conservation laws
- Physics NYC:
  - Stuff also oscillates when there's a restoring force
  - When bits of a medium oscillate, we can get *waves*
    - Sound is a (longitudinal) mechanical wave
    - Particles are matter waves
    - Light is a (transverse) electromagnetic wave
- Physics NYB: we'll be concentrating on *electromagnetic phenomena*.

Facts about matter

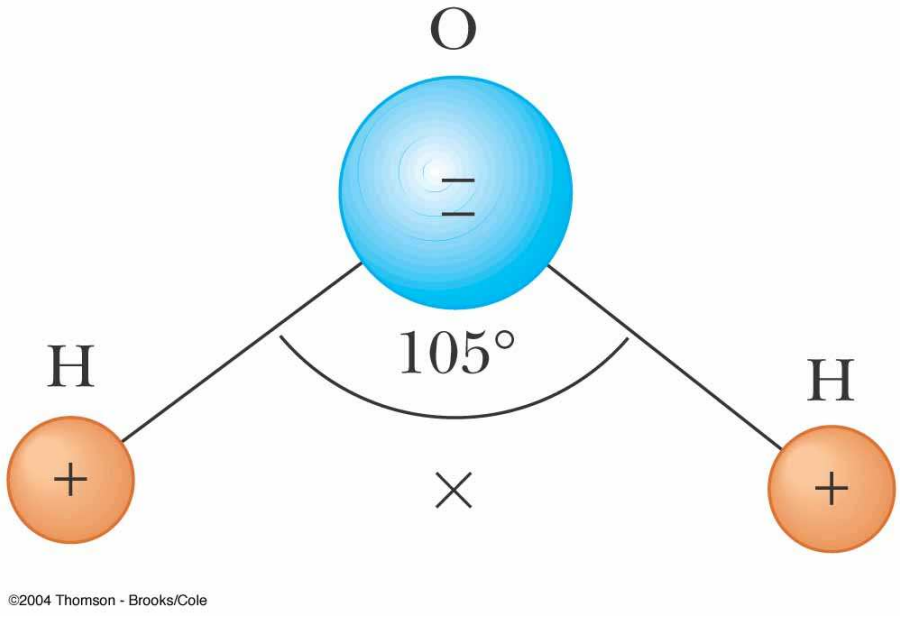
- What is matter made of?
- Matter is made of *atoms*



- Protons and neutrons in the nucleus
- Electrons in stable, quantum, orbits

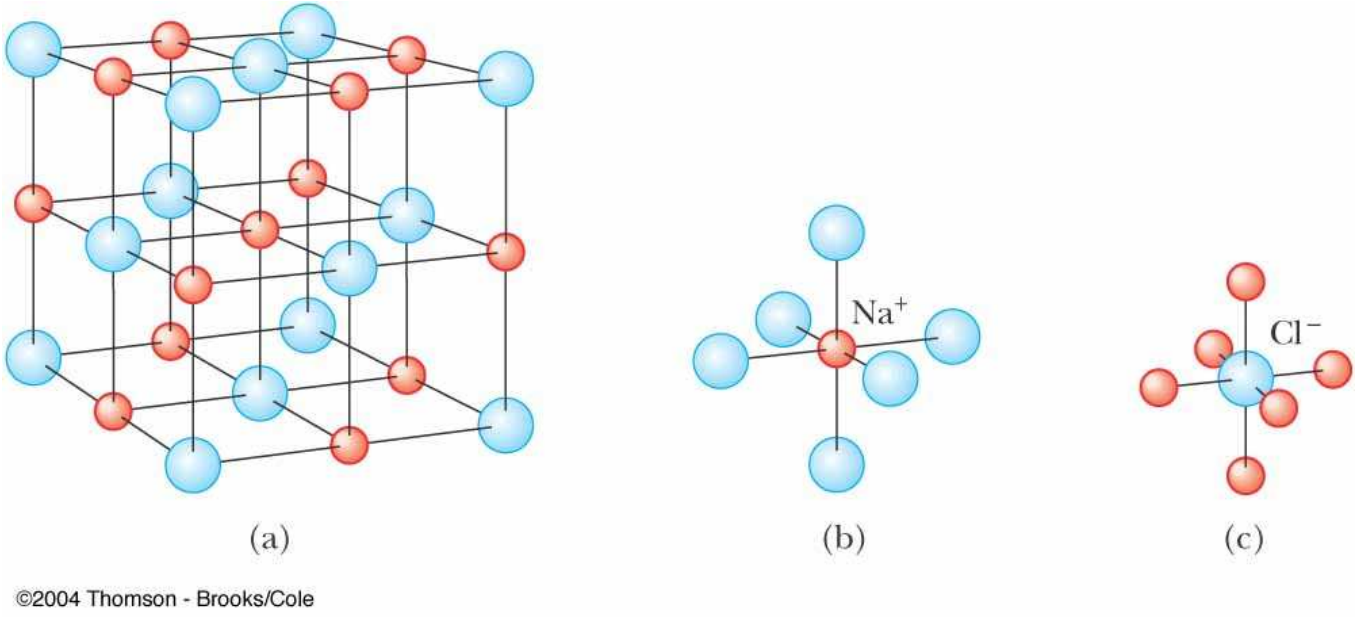
Facts about matter

- Atoms are not arranged randomly in materials
- They can group themselves to form molecules
  - For example, you don't get water just by taking two times as much hydrogen as oxygen; the atoms have to arrange themselves into water molecules, H_2O



Facts about matter

- Atoms are not arranged randomly in materials
- They can also form crystal structures
  - For example, there are no NaCl molecules making up table salt. Rather, the atoms arrange themselves in one large repeating lattice



Facts about matter

- What force holds the electron in orbit around the nucleus?
- What force holds atoms together in molecules or crystals?

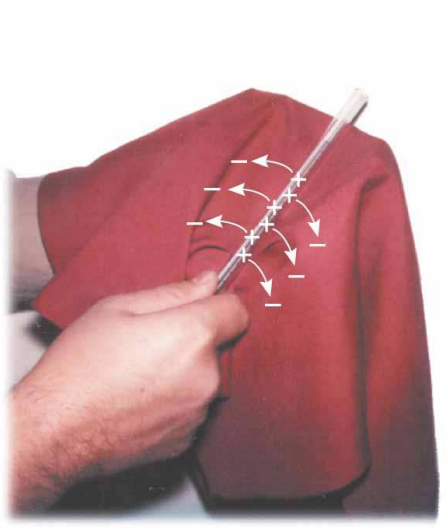
One attractive force we learned about in physics NYA is *gravity*. However, as we'll see in a later lecture, gravity is much too weak to hold atoms or molecules together.

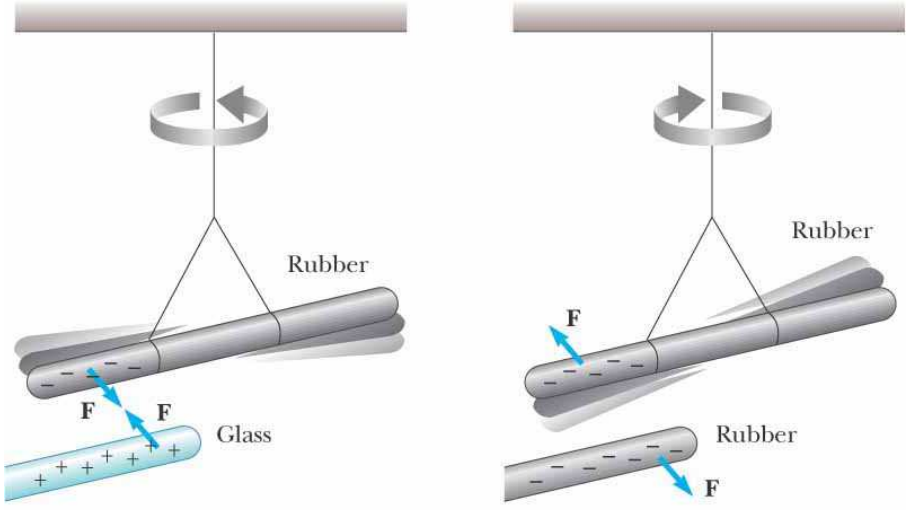
The force responsible for holding matter together is the *electric force*.

Facts about electric charge

- There are two types of electric charge: positive and negative
- The names have no deep significance
- Charge only comes in units of $\pm e$. ($e = 1.602 \times 10^{-19}$ C)
- Protons have a charge of $+e$ while electrons have a charge of $-e$. Neutrons have no electric charge.
- Net charge is a *conserved quantity*. It is never created or destroyed.
- Opposites attract. Like charges repel.
- All these facts are drawn from *experiment and observation*!

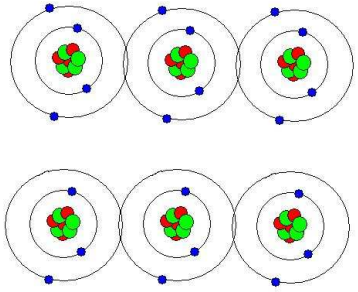
Experimenting with charges

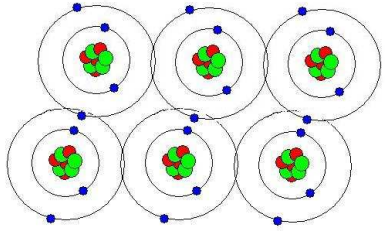


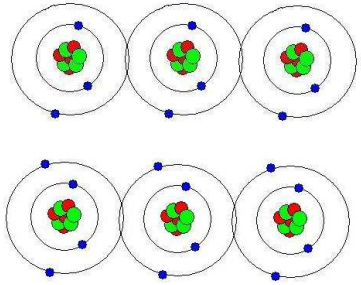


Charging objects through friction

The act of rubbing the rods has charged these objects, as can be seen from the fact that they now produce forces on other objects. At the atomic level, what can happen is that electrons move from one object to the other during the time they were rubbed together. Most of the time though, friction *breaks molecular bonds*, leaving positively charged bits on one object and negatively charged bits on the other.







Experimenting with charges

You've probably all experimented with electric charge using a comb, or a balloon.

Question: what's happening physically in these examples?

Here we have *neutral* objects and charged objects exerting an attractive force on each other... Hmmm...

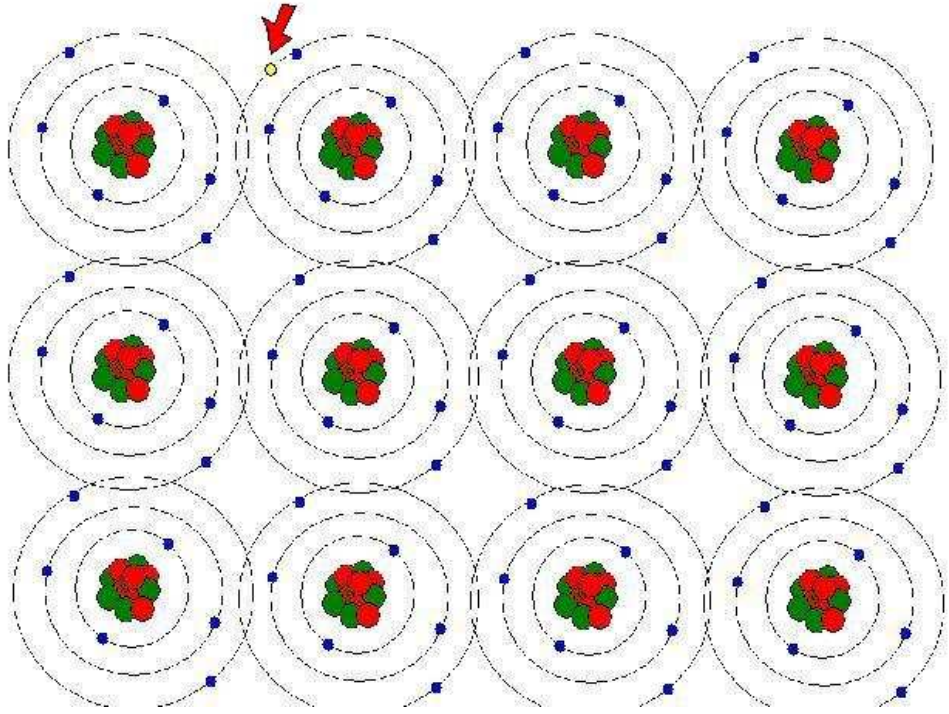
Experimenting with charges

Observations:

- Two objects with the same charge repel
- Two objects with different charges attract
- Neutral objects are attracted by both positively charged and negatively charged objects...
- How can we explain this third observation???
- We have to start using a *microscopic model* to understand these results.

Conductors and insulators

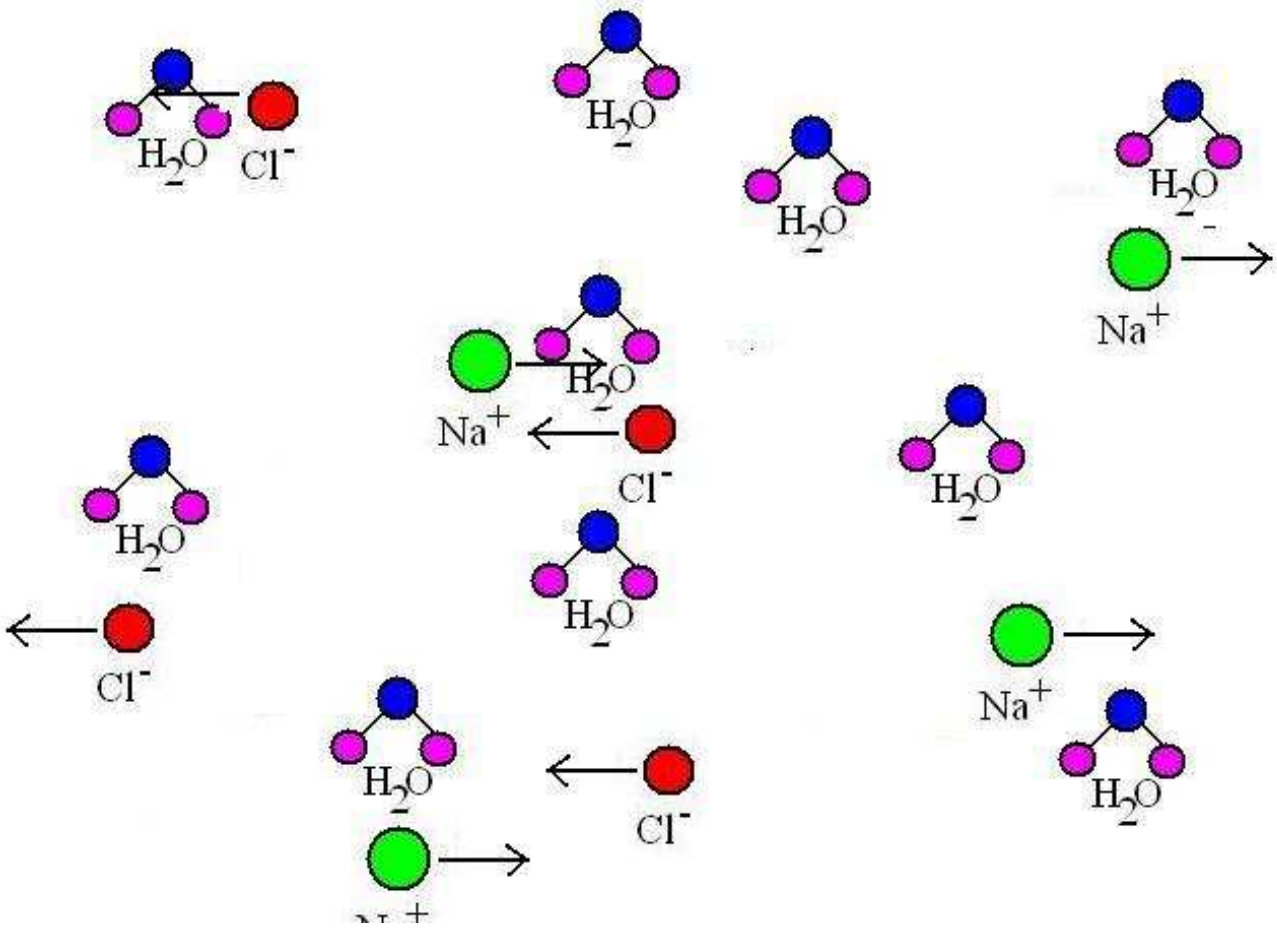
Conductors: in certain materials, like metals, the outer electrons are loosely bound to the nucleus, and are free to move around inside the material. This movement of charge is called a *current*.



Note that protons *never jump around* from one atom to another inside a material! It is only the *electrons* that can do this.

Conductors and insulators

Conductors: certain substances are conductive not because of loose electrons, but rather because *ions* are free to move around inside them.



Conductors and insulators

Insulators: in certain materials, electrons are tightly bound to the nucleus, and cannot move around inside the material. There are also no ions that can move around. Since there is no possible movement of charge, we call these materials *insulators*.

Question: which of the following materials are insulators and which are conductors?

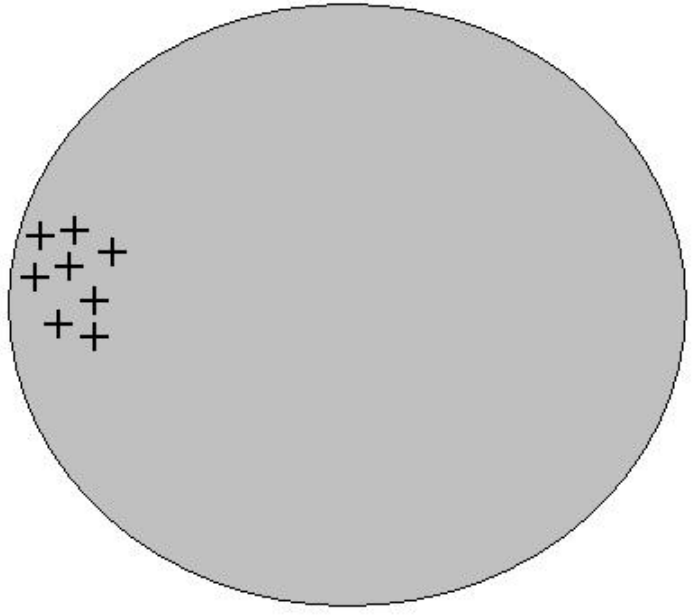
Glass, the human body, rubber, plastic, silver, gold, wood, aluminum, copper, water*

Charged conductors

Since charges are free to move inside a conductor, if a charge is deposited in a conductor, it will immediately spread out as much as possible.

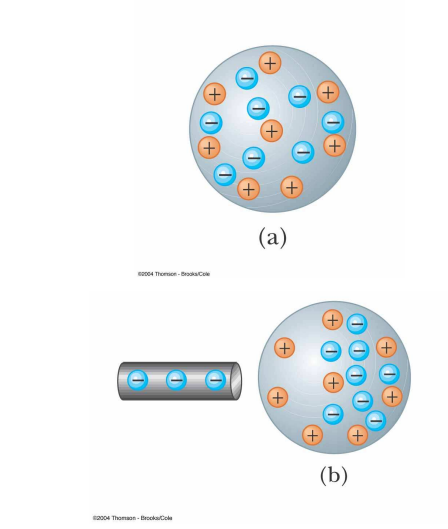
Charged insulators

Since charges are not free to move inside an insulator, if a charge is deposited in a insulator, it will remain localized.



Attracting neutral conductors

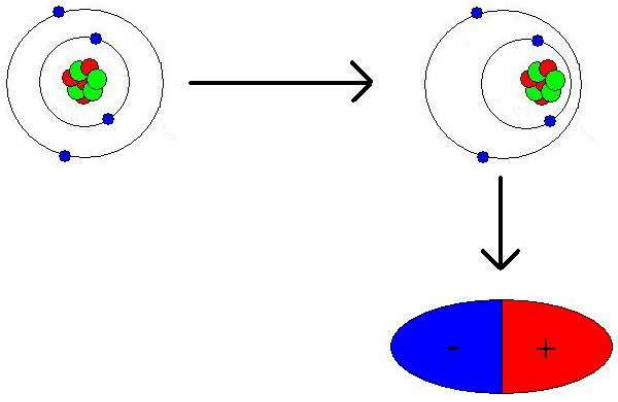
Remember that some charges are free to move inside a conductor. Therefore as a positively (negatively) charged object approaches a conductor, negative charges will move towards (away from) the object.

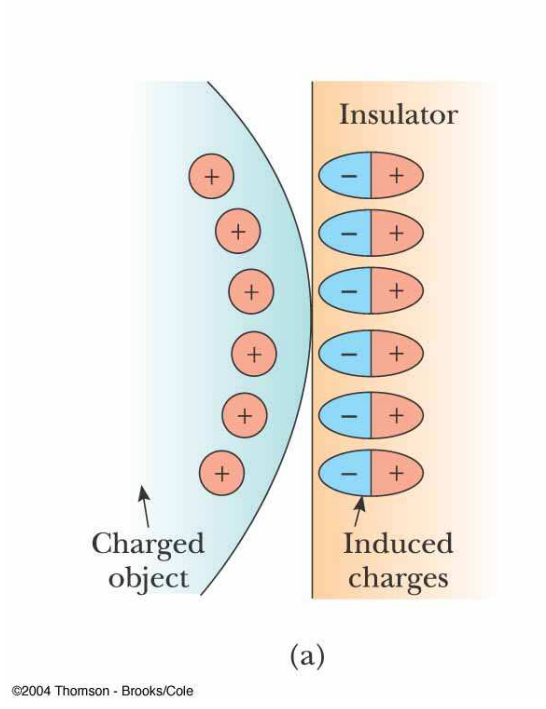


The attractive force between the closer *opposite* charges is now greater than the repulsive force between the farther apart *like* charges, so the *net force* is attractive.

Attracting neutral insulators

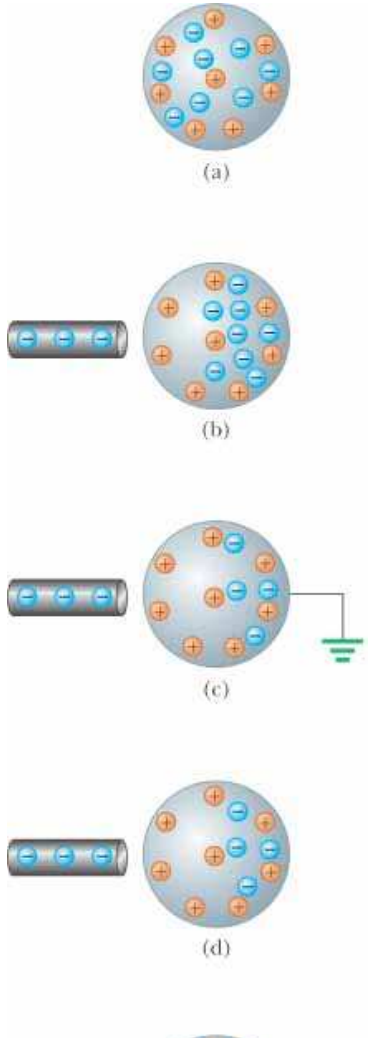
Charges can't move inside an insulator. However, the electron cloud (or the orbits) can become deformed when the electrons feel a repulsive or attractive force from a charged object. Each atom, while still neutral, now has a more negative end and a more positive end.





Charging by induction

We don’t necessarily need to rub materials together in order to charge objects. Another way to proceed is to charge by **induction** .



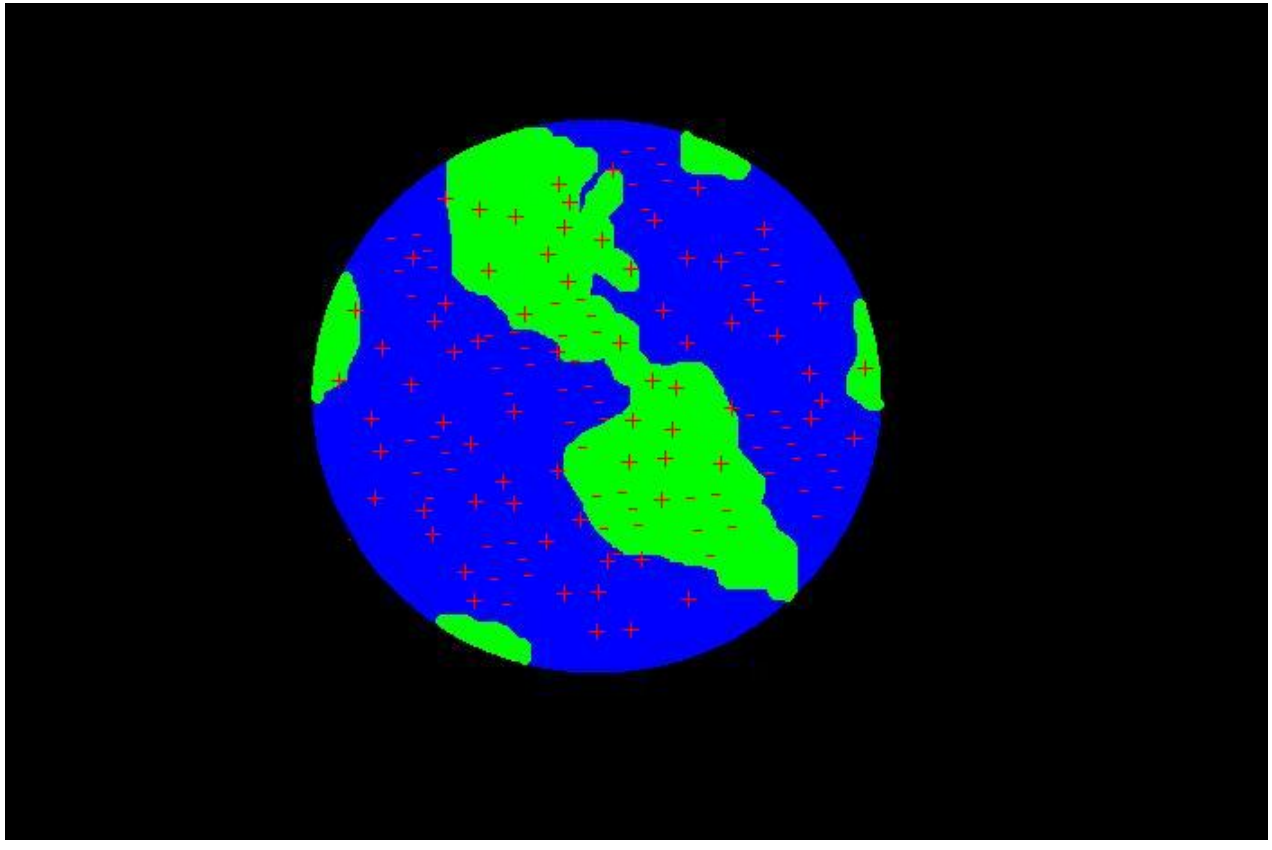
Charging by induction

We don’t necessarily need to rub materials together in order to charge objects. Another way to proceed is to charge by **induction** .

The charged rod exerts a repulsive force on the electrons in the metal. The electrons move away from the rod. If we now connect a conducting wire to the ground (this is called *grounding*), the electrons can move even further away from the rod, to the Earth. There is now an excess of positive charge in the sphere. We then disconnect the wire, and the sphere is *positively* charged.

Grounding

Note that we used a wire connected to the ground in the process of charging by induction. The Earth is very big. It can provide us with electrons, or absorb electrons in an effectively unlimited manner and never feel any difference.



What to read for next lecture

- 23.1, 23.2, 23.3