Physics 6C
Introduction to Physics III
Electricity and Magnetism

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Forces of Interaction in Nature

- **Strong**
  - Binds the atomic nucleus together
  - Very short range, but powerful
  - Source of nuclear energy; Powers the Sun and stars
- **Weak**
  - Even shorter range and weak
  - Nuclear beta decay (source of much natural radioactivity)
- ***Electro-magnetic***
  - *Long range; attractive or repulsive*
  - *All of chemistry, including the chemistry of life*
  - *All of material science*
  - *Light (visible, IR, UV), radio waves, microwaves, x-rays, etc.*
  - *Nearly all of modern technology*
- **Gravity**
  - Weakest of all the forces, by far
  - But, long range (across the universe) and always attractive

Electricity & Magnetism

- Probably the best understood and verified *theory* in all of science.
  - Complete mathematical description of the classical theory by the mid 19th century (Maxwell's Equations). *Physics 6C!*
  - Fully understood for the first time by Einstein in the early 20th century (his 1905 Theory of Relativity).
  - Combined with quantum theory by the mid 20th century and tested to exquisite precision in the following decades.
    - Measured magnetic moment of the electron:

$$\mu = 1.001159652187 \ \frac{e\hbar}{2m_e}$$

    - Agrees with the theoretical prediction to the last decimal place!
- Readily measured, manipulated, and used by modern technology.

But despite our everyday familiarity with electro-magnetic phenomena, our "intuition" about electricity and magnetism tends to be based on misconceptions.

It's not what you don't know that hurts you. It's what you know that ain't so!

Mark Twain

Curing Cancer with Magnets?

According to the WWW, here is how it works:

Blood carries charged ion particles ... [which] when blood passes through a magnetic field, the charged ion particles . . . separate [known as the Hall Effect]. The particles, once separated, adhere to different sides of the blood vessels. The positively charged particles migrate to the negative side and the negative particles to the positive side of the vessels. As blood flows through the alternative poles, the charged particles migrate to opposite sides of the blood vessels. The Alternating Bi-Polar pattern forces the ion particles into a stage of continuous movement. The persistent movement of these charged ion particles produces thermal energy ... [thereby increasing blood flow rate, increased oxygen and nutrients, and the removal of toxins].

My hope is that by teaching you some basics about charges, fields, and Hall Effect you will be better prepared, not to write mumbo-jumbo like the above but rather to judge such ideas critically, realizing that such postulated process can be evaluated quantitatively *and* verified *through* measurement!

Course Information

- Lecture Enrollment
  - I will not drop anybody from lecture.
  - If you have not yet been able to enroll in the lecture, please obtain a permission code from the Physics Department office.
- Discussion Section Enrollment:
  - Not necessary, just show up at your convenience.
- Lab Enrollment
  - If you are enrolled, be sure to show up to that section, or you will be dropped.
  - If you are not enrolled or need to swap, please contact Hua Vang in the Physics Department Office: 459-2329; hvang@ucsc.edu

Course Information

Items that you must provide for this course:

- Textbook: Randall D. Knight, University Physics, Volume 4.
  - Only the 4th volume is needed for 6C
  - Available at Bay Tree
- Physics 6N Lab Manual.
  - Should be at Bay Tree by Monday
- Laboratory notebook.
  - Bound, with *quad ruling* (graph paper)
  - Available at Bay Tree
- Mastering Physics Student Access Kit.
  - Most of you already have this from 6A and/or 6B
  - Available at Bay Tree or online
- Scientific calculator *without alphanumeric input, display, and memory.*
  - Should cost no more than $10 to $12
  - Fancy calculators with alphanumeric memory not allowed on exams

Course Information

Course web page:

http://scipp.ucsc.edu/~johnson/phys6c/Physics_6C.htm

Course Information

- **Discussion Sections**:
  - Led by graduate teaching assistant Jeff Jones:
  - Tuesdays 5:00–6:30 pm, ISB room 235
  - Thursdays 6:00–7:30 pm, ISB room 235
  - Attendance is voluntary
- **Labs:**
  - Starting the week of October 3 (week after next)
  - Arrive with lab manual and lab notebook
  - Read the lab and answer the pre-lab questions on a sheet of paper to be turned in *at the beginning of the lab session*
  - Do not switch lab sections without prior permission
  - At least 7 of 8 labs must be completed to pass 6N
    - Labs *cannot* be made up the following week!

Course Information

- Homework
  - Mastering Physics class ID: MPJOHNSON6C02
  - Due Fridays, but the system will accept your work until 11:00 Monday morning.
  - 10% of the course grade, overall
  - Collaboration is allowed, but remember
    - *You need to work on your own problem solving skills*
    - *You will be by yourself on the exams*
    - *Problems will use randomized numerical data where possible*
- Office Hours:
  - 9:00 to 10:30 am, Mondays
  - 10:30 am to noon, Wednesdays & Fridays
  - I also will post the TA office hours when available

Exams

- Two midterm exams, each 25% of your grade
- Final exam: 40% of your grade
- My exam policy:
  - *Closed book*
  - *No notes*
  - *No calculators capable of storing notes and equations*

- I will supply all numerical constants and some equations with the exam
- Some equations and definitions must be memorized
  - I will provide a complete list prior to the exams

Course Information

- Grading: I do not grade on a "curve"
  - ~82% or greater is an *A*
  - ~64% or greater for a *B*
  - ~46% or greater for a *C*
  - I may adjust these break points slightly, but I do not, for example, assign an *A* to a fixed percentage of the class
  - I would be happy to give A's to 100% of you!

- Time commitment: for 6 hours of UCSC credit, I expect from you per week at *least:*
  - 4 hours in lecture
  - 3 hours in lab
  - 9 hours study and homework
  - *16 hours total*

Class Courtesy

This should not be necessary, but from experience, it is:

- If you arrive late or plan to leave early, sit near the back of the lecture hall and use the upper doors.
- Do not park your bicycle at the front of the lecture hall while I am lecturing.

- On the other hand, please *do* interrupt the lecture at any time to ask questions.

Static Charge

- A charged object generally will attract an uncharged object.

- Acrylic plastic rubbed with silk acquires a "positive" charge.
- Rubber rubbed with fur acquires a "negative" charge.

- Two objects with identical charge will repel each other.
- Opposite charges will attract each other.

Concept Test

- How can we detect for certain whether a ball is negatively charged?
  - A. See whether it is attracted to a neutral object.
    - No, this will tell us whether the ball is charged but will not tell us the sign of the charge.
  - B. See whether it is attracted to acrylic plastic rubbed with silk (positive).
    - No, the ball would be attracted even if it were neutral.
  - C. See whether it is repelled by rubber rubbed with fur (negative).
    - *Yes, the ball would be repelled only if it were negatively charged.*

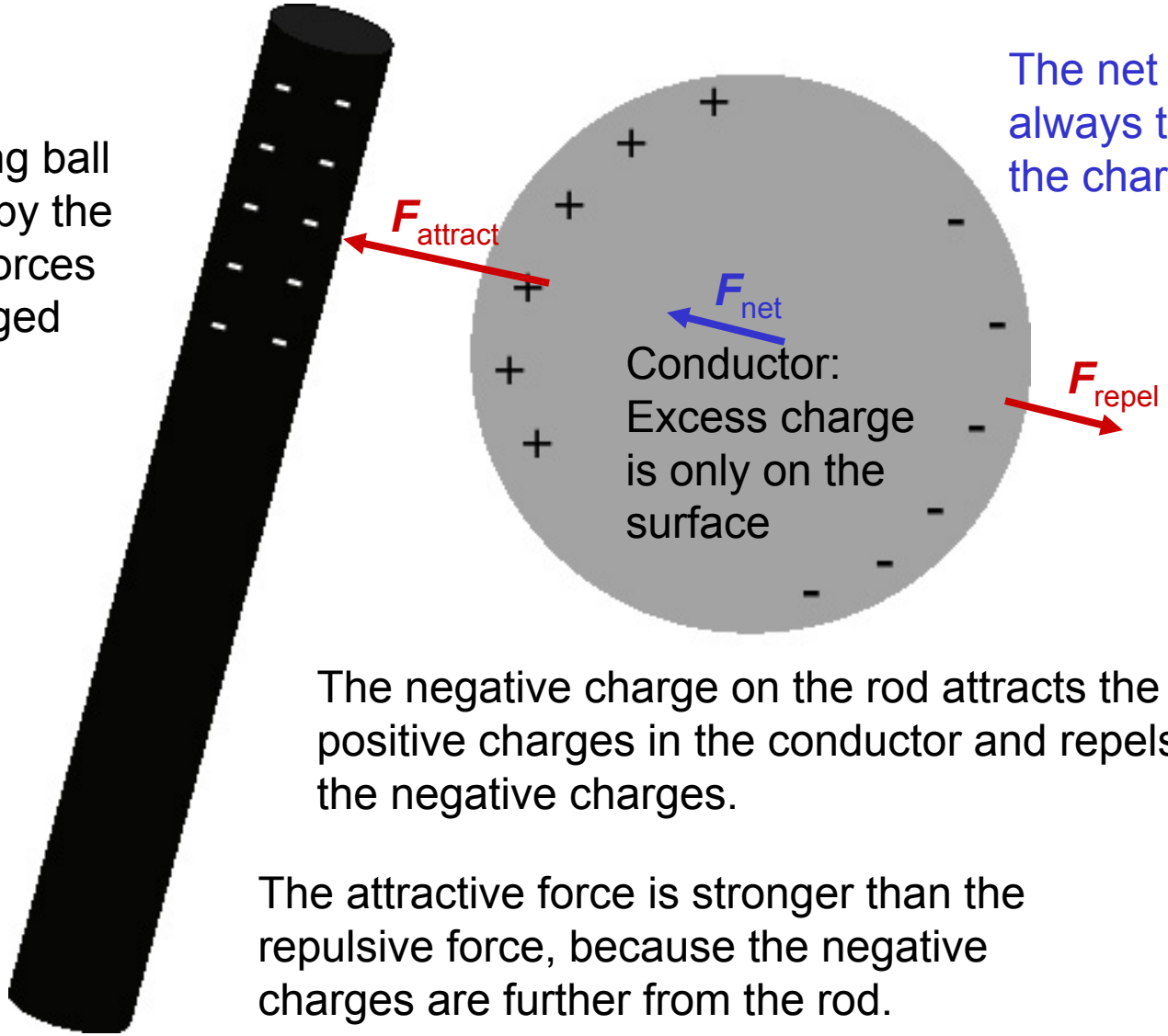
Conductors & Insulators

- Good conductors:
  - Metals
  - Ionic solutions (e.g. salt water)
- Good insulators:
  - Plastics
  - Glass
  - Many nonmetallic crystalline substances (rock, diamond, etc.)

- We will quantify the concept of conductivity later…

Electrostatic Attraction of Neutral Objects

The conducting ball is “polarized” by the electrostatic forces from the charged rod.



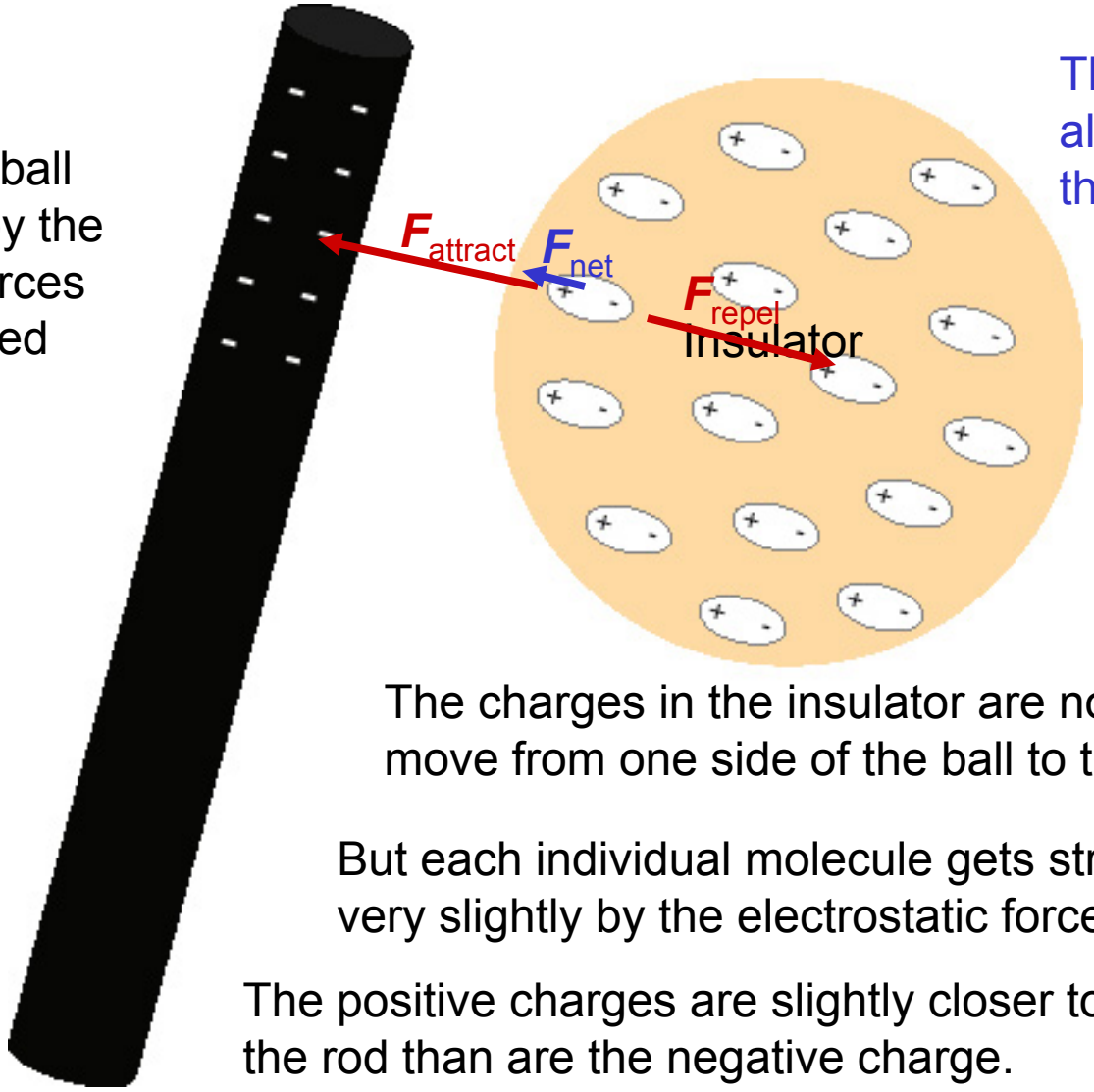
The net force is always toward the charged rod.

The negative charge on the rod attracts the positive charges in the conductor and repels the negative charges.

The attractive force is stronger than the repulsive force, because the negative charges are further from the rod.

Electrostatic Attraction of Neutral Objects

The insulating ball is "polarized" by the electrostatic forces from the charged rod.



The net force is always toward the charged rod.

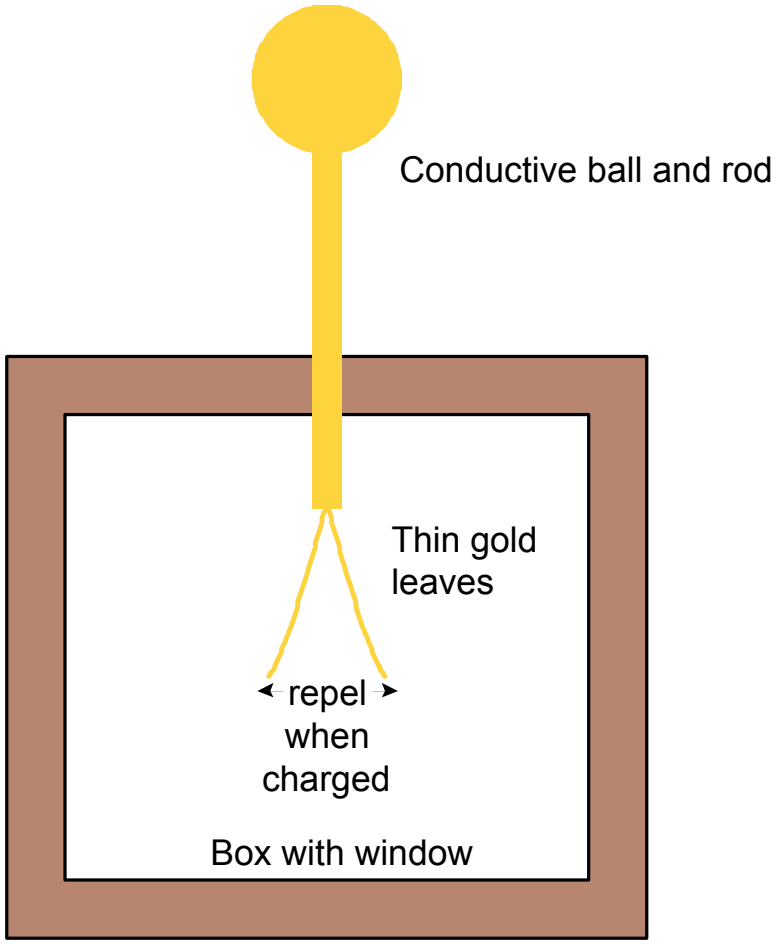
The charges in the insulator are not free to move from one side of the ball to the other.

But each individual molecule gets stretched very slightly by the electrostatic forces!

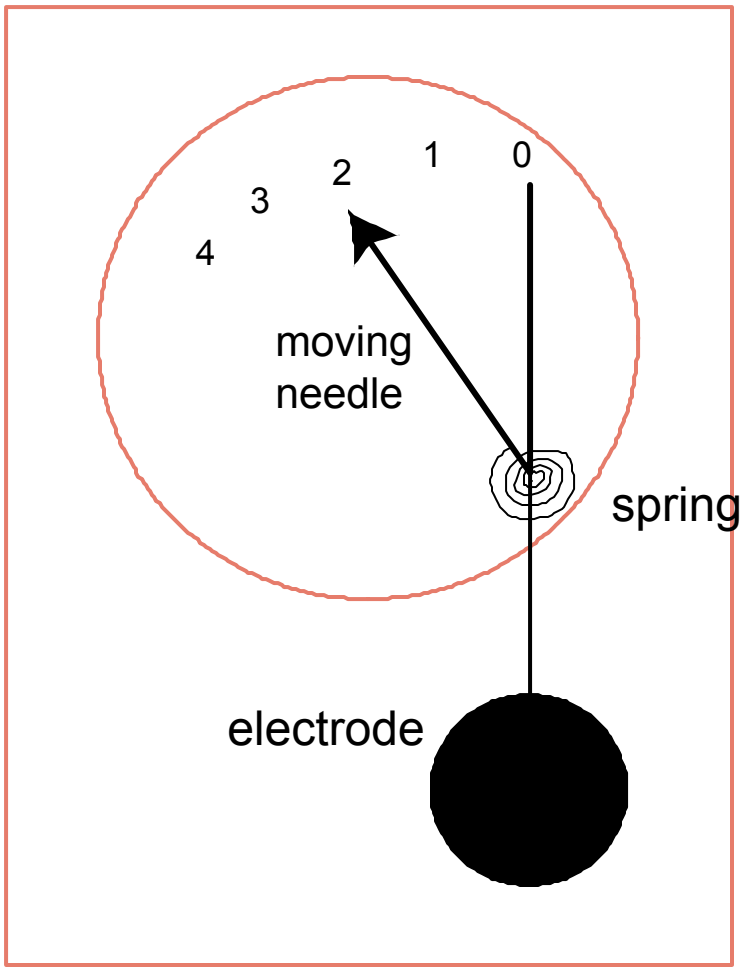
The positive charges are slightly closer to the rod than are the negative charge.

Electroscopes

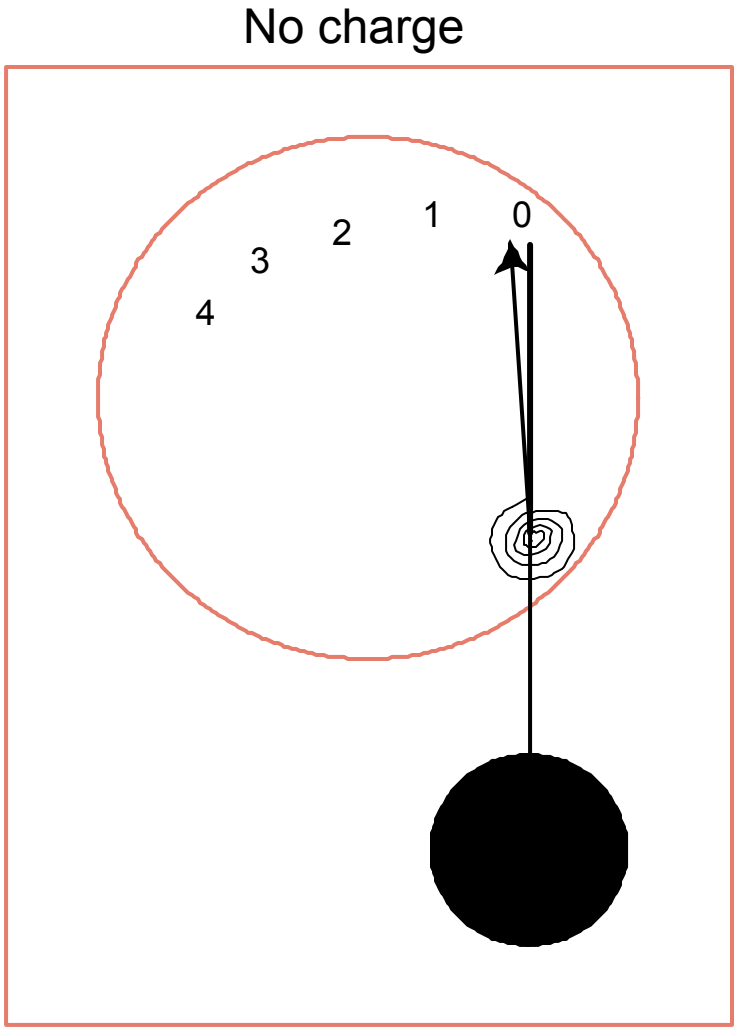
Gold Leaf Electroscope



UCSC Demo Electroscope

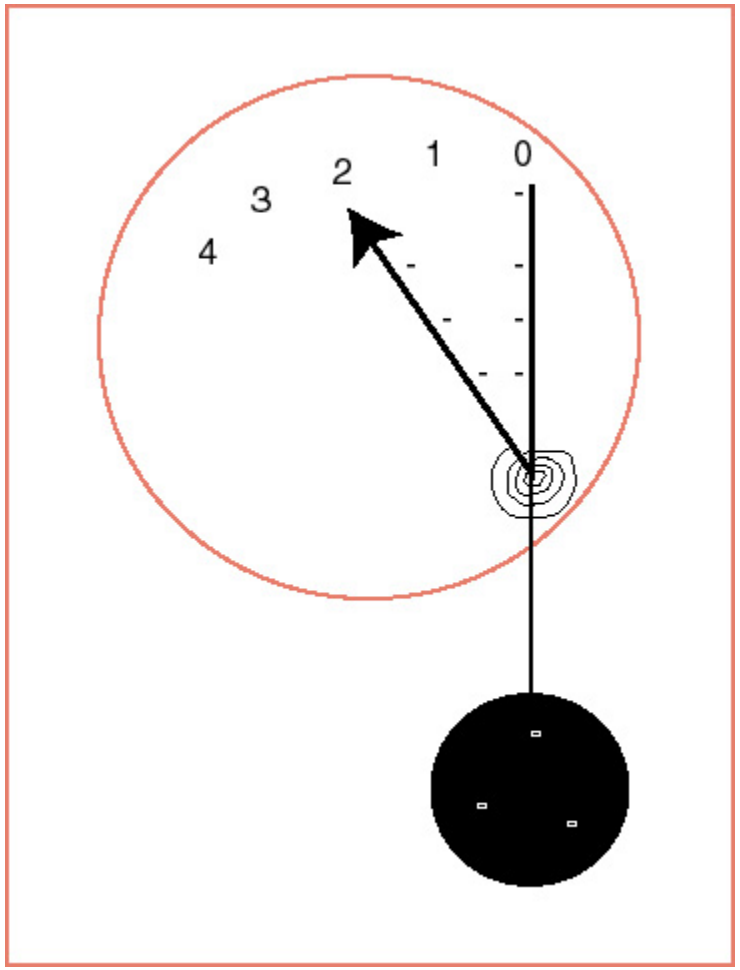


Demo Electroscope

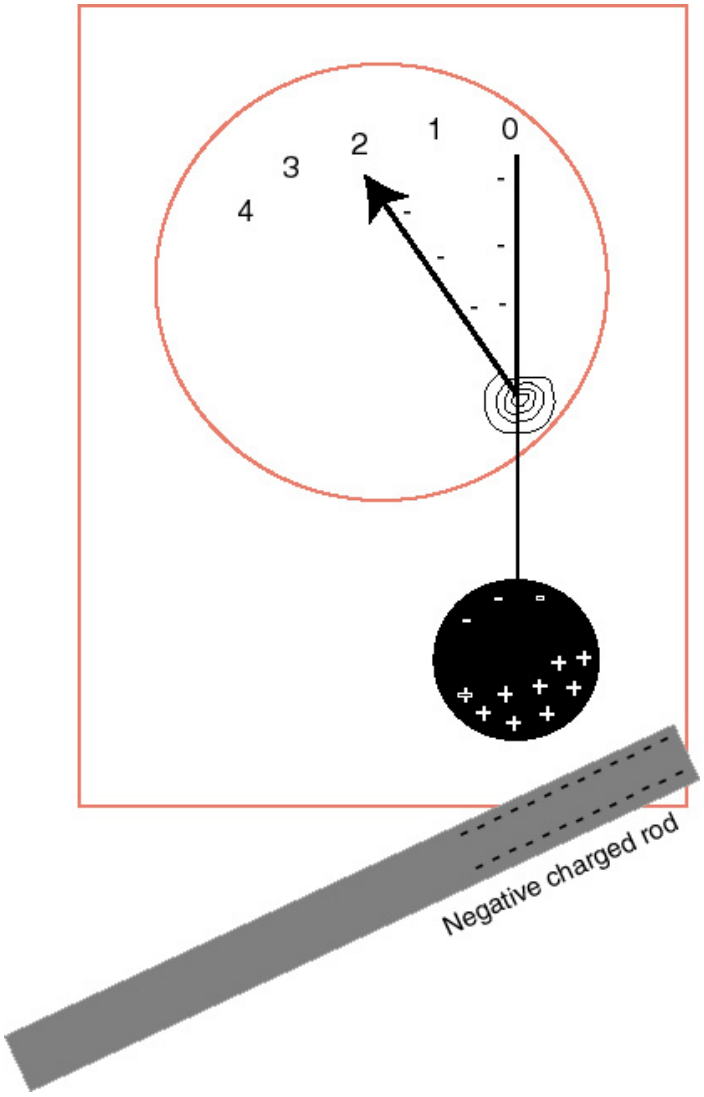


Demo Electroscope

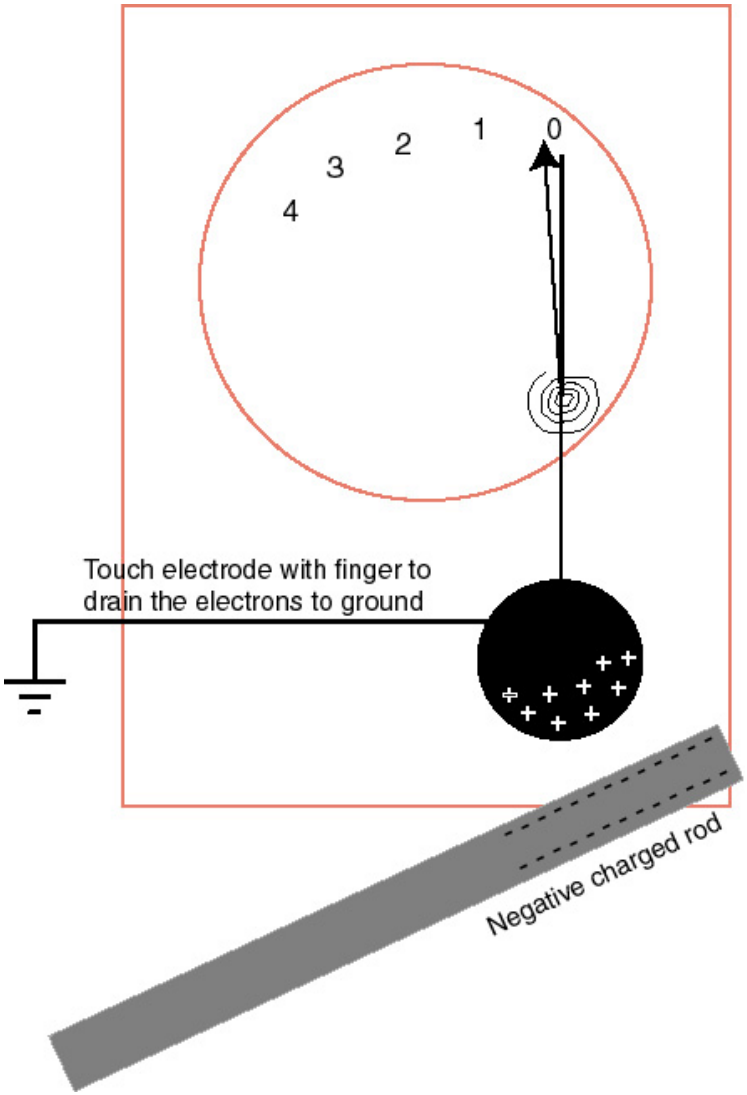
Charged by touching with charged rod



Charge by Induction



Charge by Induction



Charge by Induction