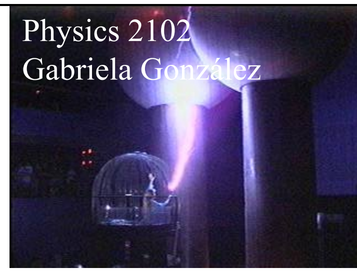
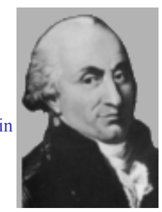


Physics 2102

Introduction to Electricity, Magnetism and Optics

Charles-Augustin de Coulomb (1736-1806)



Who Am I?

Gabriela González

Office hours:
Nicholson 271-C, Tue 5:30-6:30pm , Th 5-6pm or by appt

Phone: 578 0468

Email: gonzalez@lsu.edu

Research:
Detection of Gravitational Waves
ligo.org
einsteinmessengers.org

Course Details

- **2102 Class website:**
www.phys.lsu.edu/classes/spring2011/phys2102/
- **Our Section website**: www.phys.lsu.edu/faculty/gonzalez/Teaching/Phys2102/

Schedule, grading policy, syllabus all posted here. Check both often!!

- **Lectures** will be posted in our section's website.

- **Textbook:**
Fundamentals of Physics, Halliday, Resnick, and Walker, 9th edition.
We will cover chapters 21-38 in this class. You have access to the online textbook in WileyPlus.com

- **Exams:**
Two midterms: 6-7pm, Thursdays Feb 24 and Mar 31.
Final Exam (cumulative): Wed May 11, 3-5pm

Course details: Homework

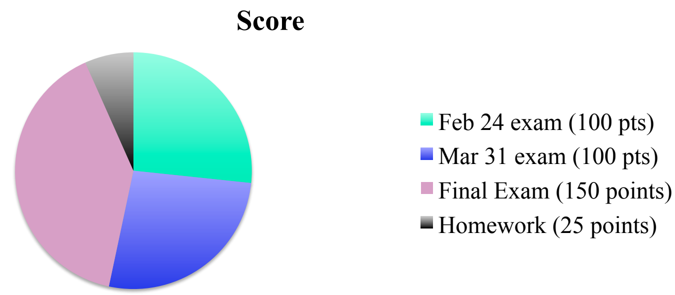
Web-based system: WileyPlus.com
To register, go to
http://edugen.wiley.com/edugen/class/cls211589/

Notice that this is only for section 5!

Email me (gonzalez@lsu.edu) ASAP if you have any trouble.
There will be one assignment per week, due Wed 2am (Tue late night)

The first assignment is due Wed Jan 26, on Ch 21.

Course details: Grading



Course grade is guaranteed to be at least as follows:

A	B	C	D	F
>85%	84-75%	74-60%	59-50%	<49%

What are we going to learn? A road map

- Electric *charge*
  - Electric *force* on other electric charges
  - Electric *field*, and electric *potential*
- Moving electric charges : current
- Electronic circuit components: batteries, resistors, capacitors
- Electric currents
  - Magnetic field
  - Magnetic force on moving charges
- Time-varying magnetic field
  - Electric Field
- More circuit components: inductors
- All together: Maxwell's equations
- Electromagnetic waves
- Optical images
- Matter waves

Let's get started!
Electric charges

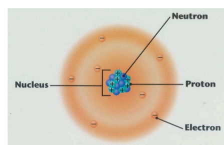
- **Two types of charges: positive/negative**
- **Like charges repel**
- **Opposite charges attract**

Atomic structure :

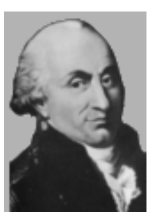
- **negative electron cloud**
- **nucleus of positive protons, uncharged neutrons**

Only electrons move, and only within conductors like metals. Negative electron clouds in insulators can get "deformed".

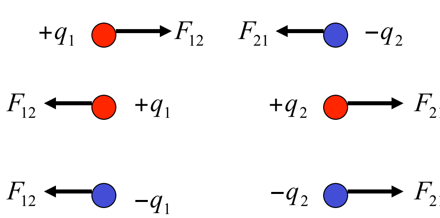
[[Why doesn't the nucleus fly apart??
Why doesn't the atom collapse??]]



Charles-Augustin de Coulomb (1736-1806)



Force between pairs of point charges: Coulomb's law

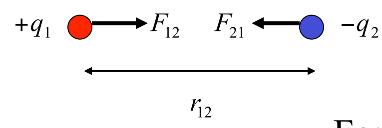


or

Coulomb's law -- the force between point charges:

- Lies along the line connecting the charges.
- Is proportional to the magnitude of each charge.
- Is inversely proportional to the distance squared.
- Note that Newton's third law says $|F_{12}| = |F_{21}|$!!

Coulomb's law



$$|F_{12}| = \frac{k\ |q_1||q_2|}{r_{12}^2}$$

For charges in a VACUUM

$$\mathrm{k} = 8.99 \times 10^9 \ \frac{N\,m^2}{C^2}$$

Often, we write *k* as:

$$k = \frac{1}{4\pi\varepsilon_0} \text{ with } \varepsilon_0 = 8.85 \times 10^{-12} \ \frac{C^2}{N\,m^2}$$

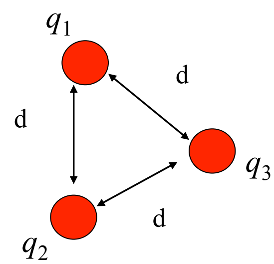
Superposition

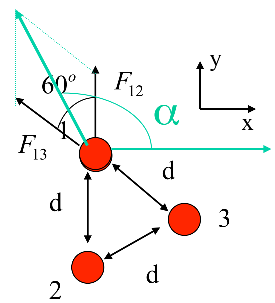
- **Question**: How do we figure out the force on a point charge due to many other point charges?
- **Answer**: consider one pair at a time, calculate the force (a vector!) in each case using Coulomb's Law and finally add all the vectors! ("superposition")
- Useful to look out for SYMMETRY to simplify calculations!

Example

$q_1 = q_2 = q_3 = 20\ \mu C$

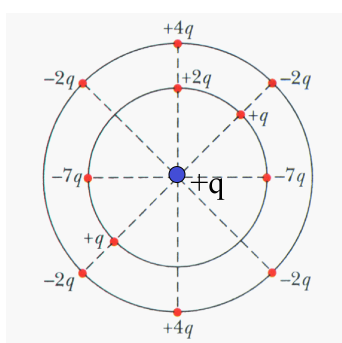
- Three equal charges form an equilateral triangle of side 1.5 m as shown
- Compute the force on q_1
- What is the force on the other charges?





Solution: Set up a coordinate system, compute vector sum of F_{12} and F_{13}

Superposition: symmetry



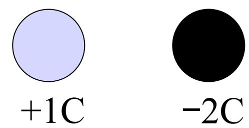
Charge +q placed at center

What is the force on central particle?

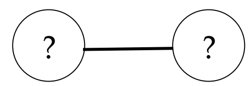
Conservation of Charge

Total amount of charge in an isolated system is fixed ("conserved")

Example: 2 identical metal spheres have charges +1C and –2C.

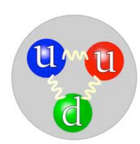


You connect these together with a metal wire; what is the final charge distribution?

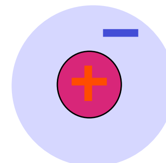


Quantization of Charge

- Charge is always found in **INTEGER** multiples of the charge on an electron/proton ([[*why*?]])
- Electron charge = e = −1.6 x 10^{-19} Coulombs
- Proton charge = p = +1.6 x 10^{-19} Coulombs
- Unit of charge: Coulomb (C) in MKS units
- One cannot ISOLATE FRACTIONAL CHARGE (e.g. −0.8 x 10^{-19} C, +1.9 x 10^{-19} C, etc.) [[but what about quarks…?]]



Atomic structure



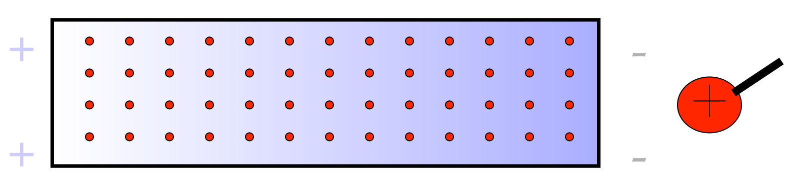
- negative electron *cloud*
- nucleus of positive protons, uncharged neutrons
- Z = atomic number = # of protons = # of electrons in a neutral atom
- A = mass number = # of protons (Z) + # of neutrons (N)
- electron charge = $e = -1.6 \times 10^{-19}$ Coulombs = − proton charge
- electron mass = $9.10938188 \times 10^{-31}$ kilograms
- proton mass = $1.67262158 \times 10^{-27}$ kilograms = neutron mass

Charges in solids

- In a conductor, electrons move around freely, forming a "sea" of electrons. This is why metals conduct electricity.
- Charges can be "induced" (moved around) in conductors.

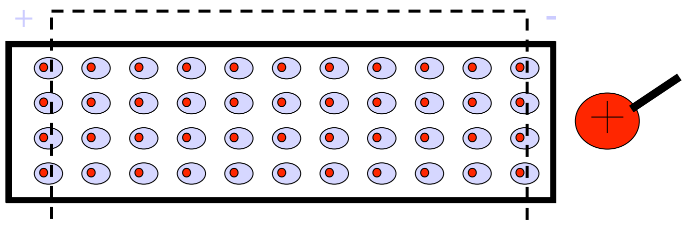
Blue background = mobile electrons

Red circles = static positive charge (nuclei)



Insulating solids

- In an insulator, each electron cloud is tightly bound to the protons in a nucleus. Wood, glass, rubber.
- Note that the electrons are not free to move throughout the lattice, but the electron cloud can "distort" locally.



How to charge an object

- An object can be given some "excess" charge: giving electrons to it (we give it negative charge) or taking electrons away (we "give" it positive charge).
- How do we do charge an object? Usually, moving charges from one surface to another by adhesion (helped by friction), or by contact with other charged objects.
- If a conductor, the whole electron sea redistributes itself.
- If an insulator, the electrons stay where they are put.

Summary

• **Electric charges** come with two signs: **positive and negative**.

• Like charges repel, opposite charges attract, with a magnitude calculated from **Coulomb's law**: $F=kq_1q_2/r^2$

• **Atoms** have a positive nucleus and a negative "cloud".

• Electron clouds can combine and flow freely in **conductors**; are stuck to the nucleus in **insulators**.

•We can **charge objects** by transferring charge, or by induction.

• Electrical charge is **conserved**, and **quantized**.