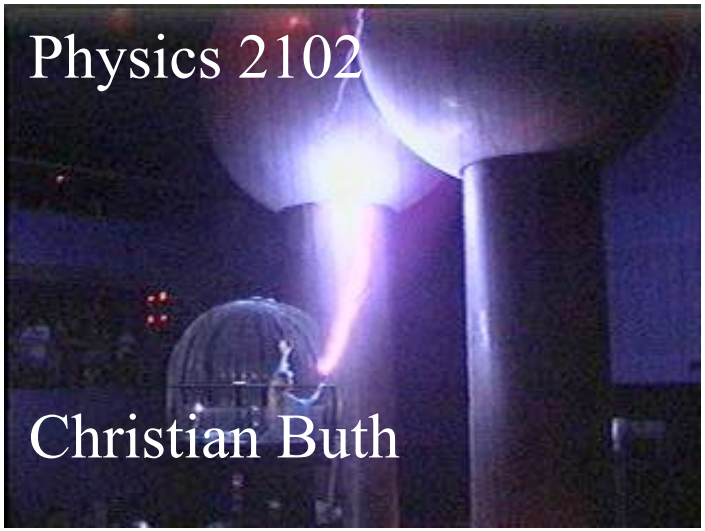

Physics 2102
Lecture 1
Electric Charge

Version: 01/12/2009

Charles-Augustin
de Coulomb
(1736-1806)

Who Am I?

Dr. Christian Buth, Postdoctoral Researcher

Since 2008: Louisiana State University, Baton Rouge, LA
2006–2008: Argonne National Laboratory, Argonne, IL
2005–2006: Max-Planck-Institute, Dresden, Germany

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My Research:
Theoretical Atomic, Molecular, and Optical Physics
X-rays, lasers, electrons

Course Details

• **Class Website**:
www.phys.lsu.edu/classes/spring2009/phys2102
Syllabus, schedule, grade policy, …

• **Lectures** will be posted in this sections' website:
www.christianbuth.name/PHYS2102_2009/PHYS2102_2009.html

• **Text:**
Fundamentals of Physics, Halliday, Resnick, and Walker, extended, 8th edition. We will cover chapters 21-36 in this class.

• **Exams:**
Three midterms: 05 Feb, 03 Mar, 02 Apr, 6-7 p.m.
Final Exam: 08 May, 5:30-7:30 p.m.

Course details: Homework

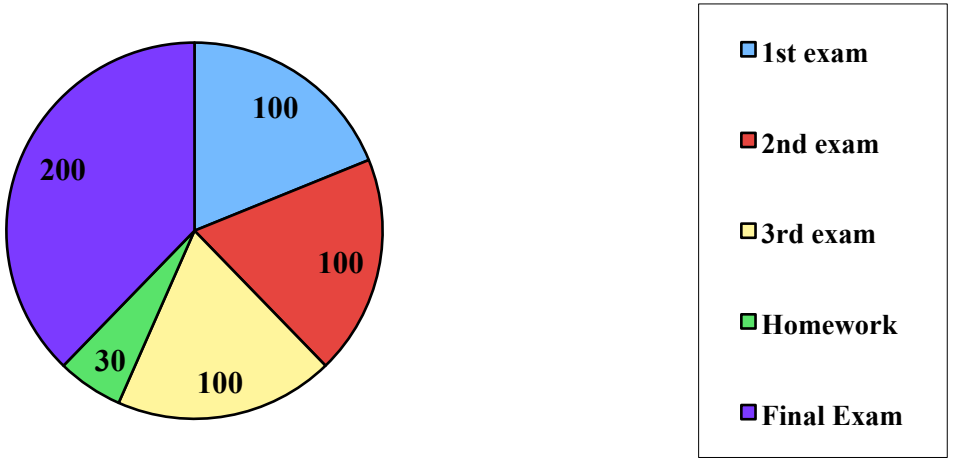
Web-based system: Web Assign

To register:

- Go to **www.webassign.net/student.html**
- On the left frame, "student login"
    - *Username*: your_id@lsu.edu
    - *Institution*: lsu
    - *Password*: LSUID

There will be one assignment per week due 2:00AM Wednesday.

Course details: Grading



A	B	C	D	F
90-100%	80–89%	60–79%	50–59%	<50%

What are we going to learn in electromagnetism?

- **Electricity**
- **Magnetism**
- **Optics**

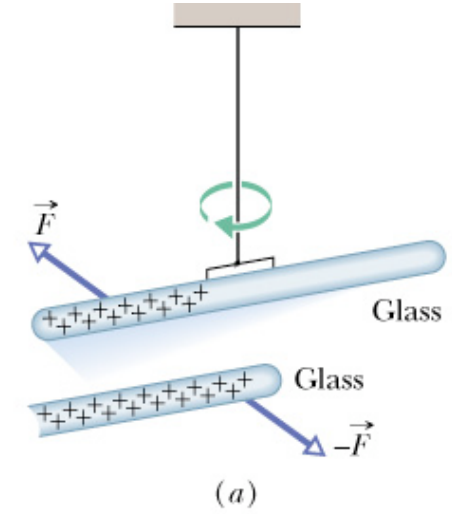
- **What is electromagnetism good for?**

- **Manifestations: man made? natural?**

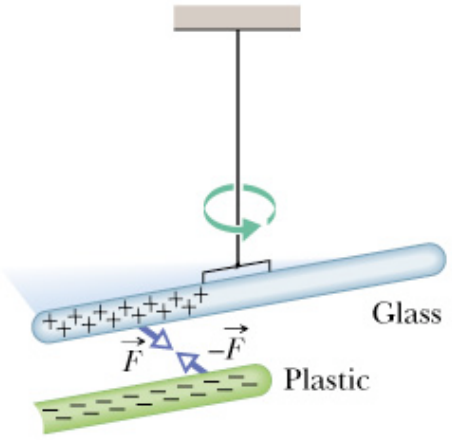
Electric charge

- Electric charge is an new, intrinsic property
- You have some sensory experience with its effects

Characteristics of charge



(a)



(b)

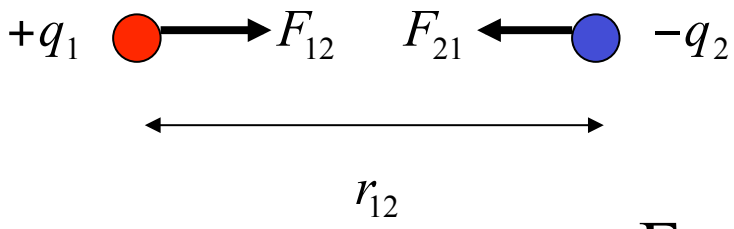
- How do we charge an object?
- By adhesion (helped by friction), or by contact with other charged objects

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

Conductors and insulators

- In an insulator, each electron cloud is tightly bound to the protons in a nucleus. Wood, glass, rubber
- The electrons stay where they are put
- In a conductor, electrons move around freely. This is why metals conduct electricity
- Charges can be “induced” (moved around) in conductors

Coulomb's law



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

For charges in a vacuum

$$k = 8.99\times10^{9}\ \frac{N\,m^2}{C^2}$$

Often, we write k as:

$$k = \frac{1}{4\pi\varepsilon_0} \text{ with } \varepsilon_0 = 8.85\times10^{-12}\ \frac{C^2}{N\,m^2}$$

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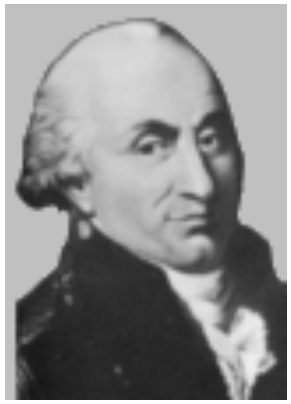
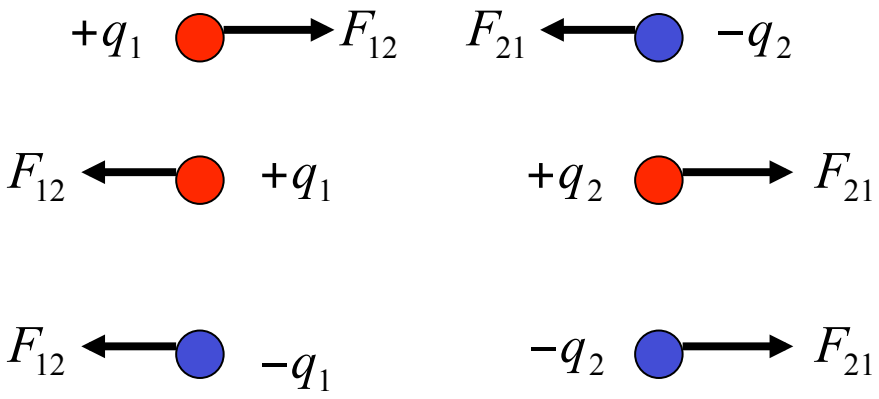


Force between pairs of point charges: Coulomb's law



or

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

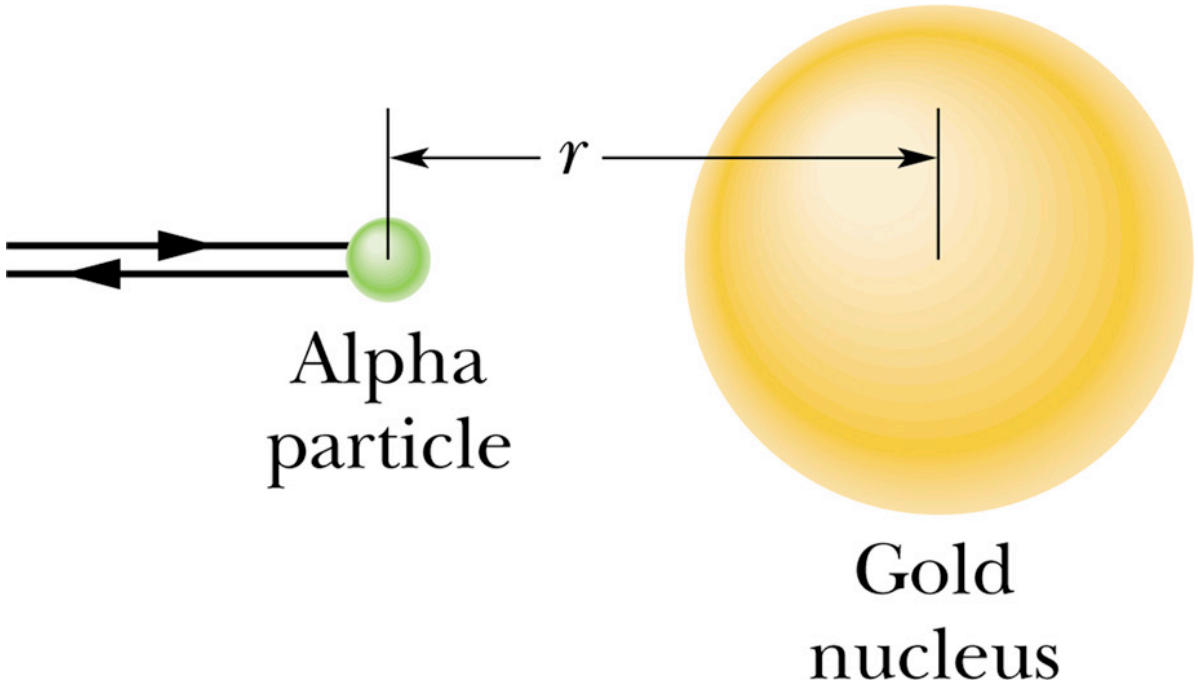
- Lies along the line connecting the charges
- Is proportional to the magnitude of each charge
- Is inversely proportional to the distance squared
- Note that Newton's third law says $|F_{12}| = |F_{21}|$!!

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")

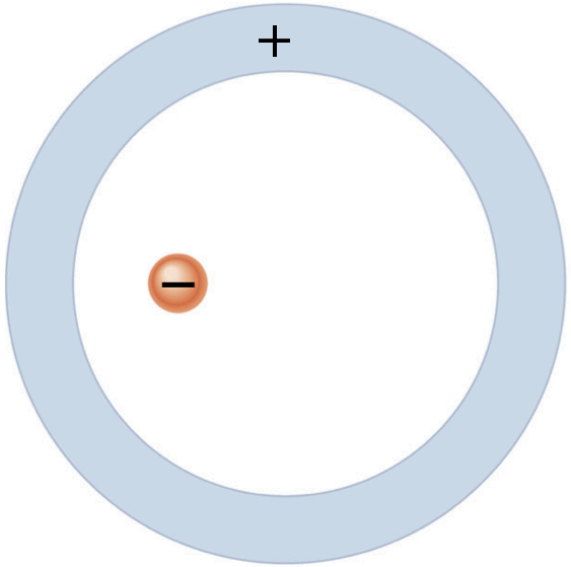
First shell theorem

- A shell of uniform charge effects an outside charge as if the shell was a point charge



Second shell theorem

- If a charged particle is in a shell of uniform charge then there is no electrostatic effect due to the shell on the particle



Summary

- **Electric charges** come with two signs: **positive and negative**

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

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

- **Superposition**: forces from charges add vectorially

- Two **shell theorems**: outside a charged shell, it behaves like a point charge; inside there is no effect