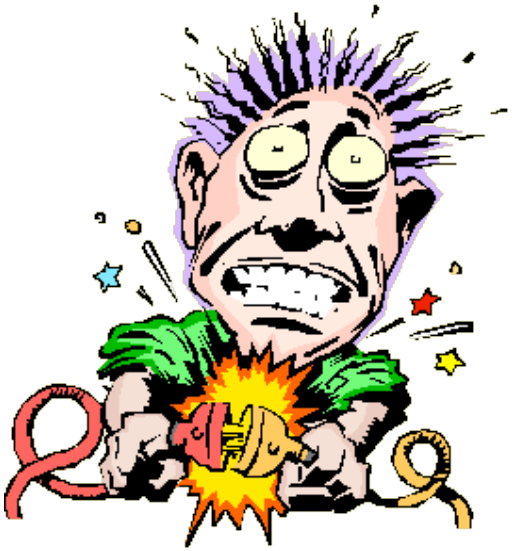
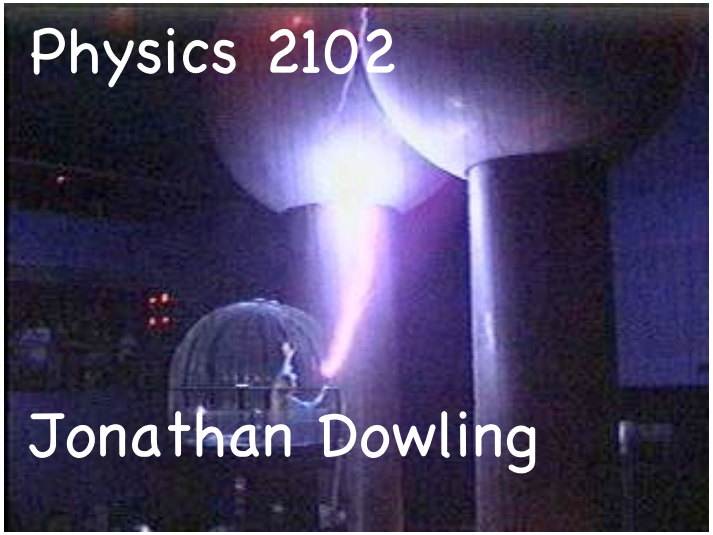




Benjamin Franklin
(1705–1790)

Physics 2102
Lecture 01: MON 12 JAN
Electric Charge I

Version: 1/12/09

Charles-Augustin
de Coulomb
(1736–1806)

Who am I & Why am I Here?

Prof. Jonathan P. Dowling

1994–98: Research Physicist, US Army Aviation & Missile Command
1998–2004: Principal Scientist, NASA Jet Propulsion Laboratory
2004–Present: Director, Hearne Institute for Theoretical Physics, LSU

Office hours: Nicholson Hall 453, MWF
10:30–11:30AM (or by appointment)

Phone: 225-578-0887

Email: jdowling@lsu.edu

My Own Research:
Quantum Optics
Quantum Computing
Photonic Crystals

Hearne Institute for Theoretical Physics
Quantum Sciences & Technologies Group

Course Details

- Main **Class Website for All Sections:**
http://www.phys.lsu.edu/classes/spring2009/phys2102/
Syllabus, Schedule, Grading Policy, Exam Solutions, …

- **Lectures** will be posted in this section's website:
http://phys.lsu.edu/~jdowling/PHYS21022SP09/

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

- **Exams:** Midterms 6-7PM: THU **05 FEB, THU 05 MAR, THU 02 APR;** Final Exam 5:30-7:30PM: **FRI 08 MAY**

- **Lab: Meets This Week! Show up or be dropped!**

- **Tutoring: Free Tutors in 102 Nicholson Hall.**

Course Details: Homework

Web-based system: Web Assign

To register:

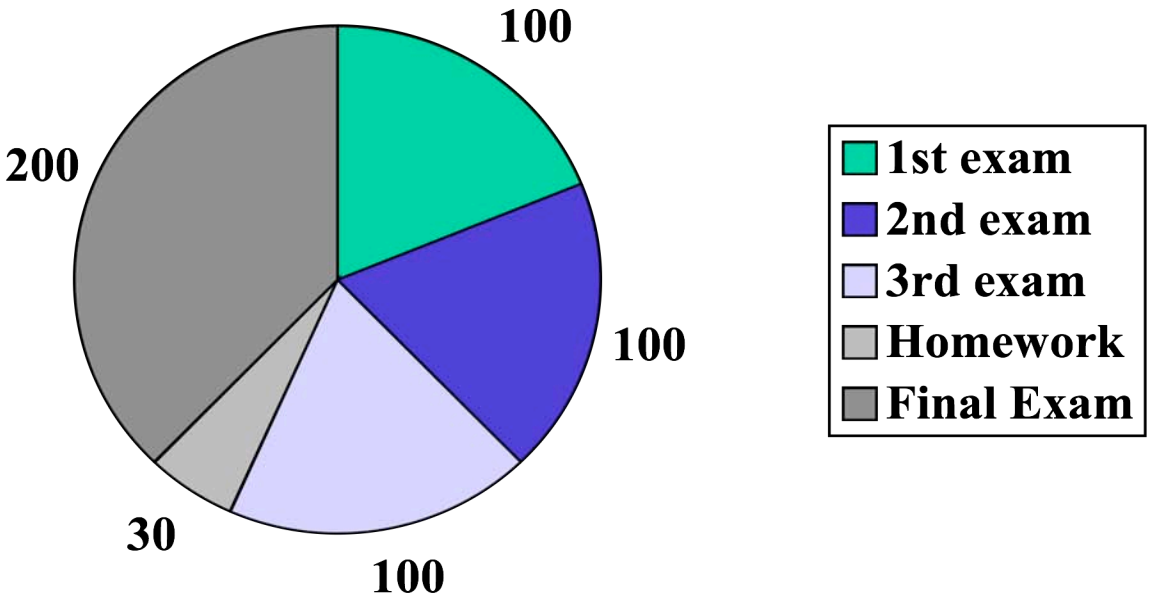
- Go to **http://www.webassign.net/student.html**
- On the left frame, "student login"
  - *Username*: pawsusername@lsu
  - *Institution*: lsu
  - *Password*: lsuidnumber

- Choose "credit card registration" ($$$) or FREE with Purchase of PHYS2102 Book from Bookstore

- One Assignment Per Week Due 2AM Wednesdays.

- First HW Is Posted This Week Due Next WED 2AM.

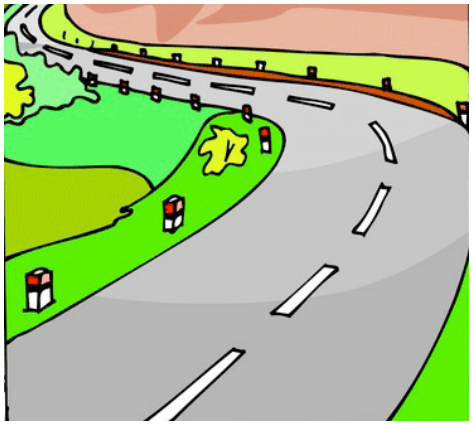
Course Details: Grading



A: ≥90 B: 80-89 C: 60-79 D: 50-59 F: <50

Borderline Cases Decided by Class Attendance!

What Are We Going to Learn? A Roadmap!



- 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, AC Circuits.
- Maxwell's Equations & Electromagnetic Waves & Light Waves
- Geometrical Optics (Light Rays).
- Physical Optics (Light Waves): Interference, Diffraction.

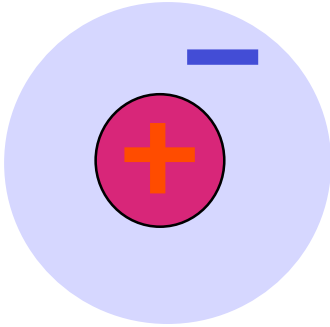
Let's Get Started! Electric Charges...

- Two Types of Charges: Positive/Negative
- Like Charges Repel
- Opposite Charges Attract

Atomic Structure:

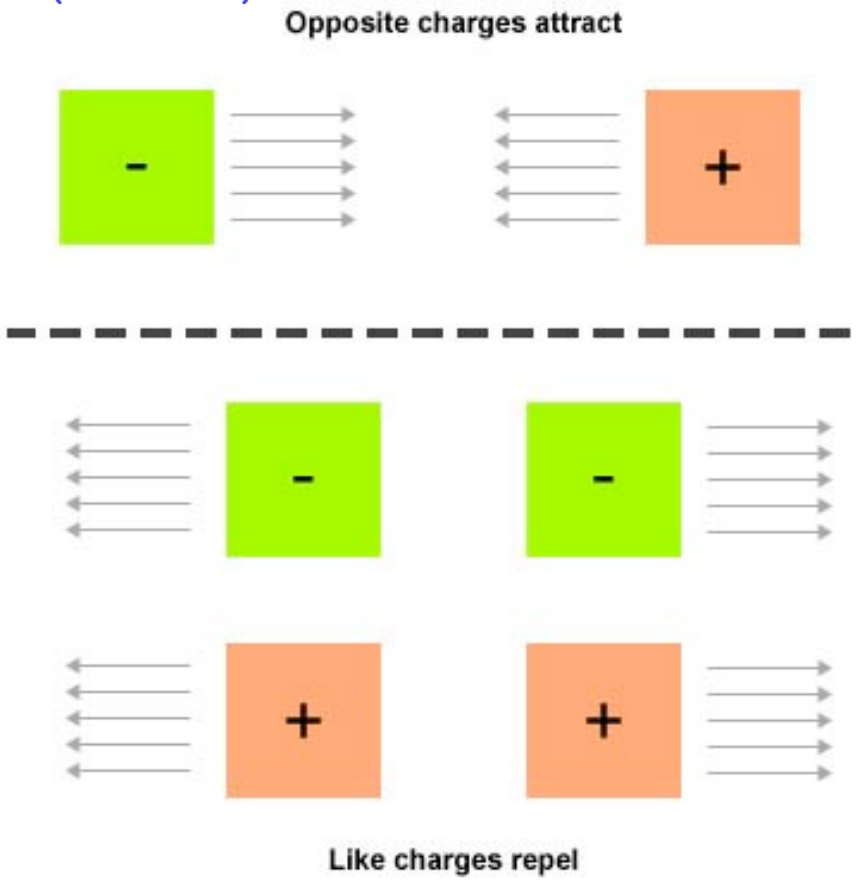
- Negative Electron Cloud
- Nucleus of Positive Protons, Uncharged Neutrons

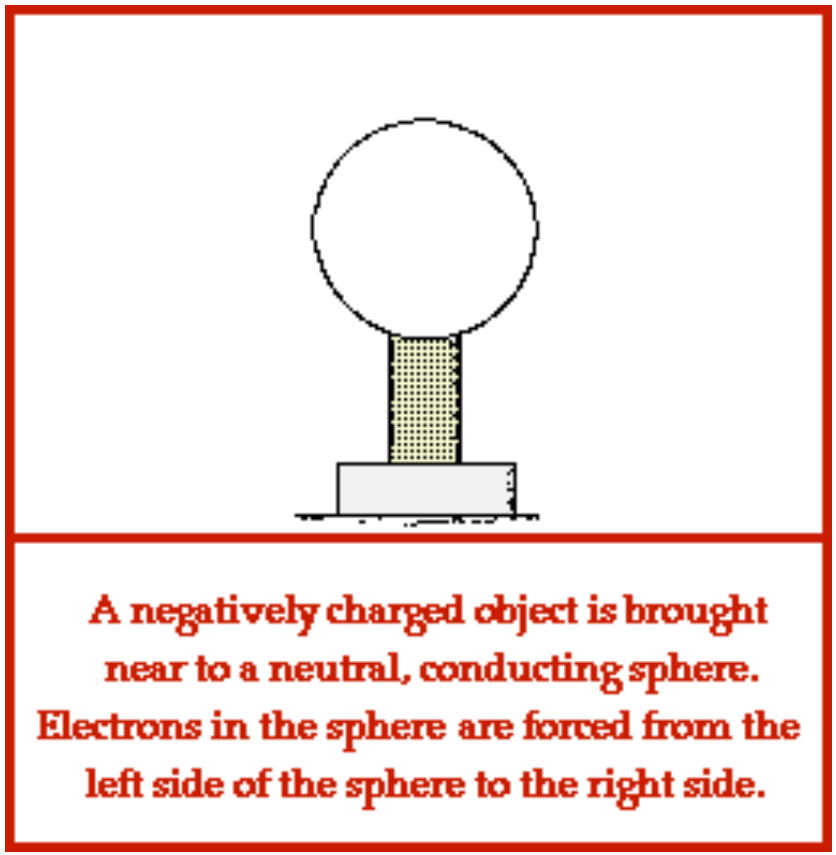
The Unit of Electric Charge is the "Coulomb" which is "C".
Proton Charge: $e = 1.60 \times 10^{-19}$ C



Rules of Attraction and Repulsion Discovered by Benjamin Franklin

Benjamin Franklin
(1705–1790)

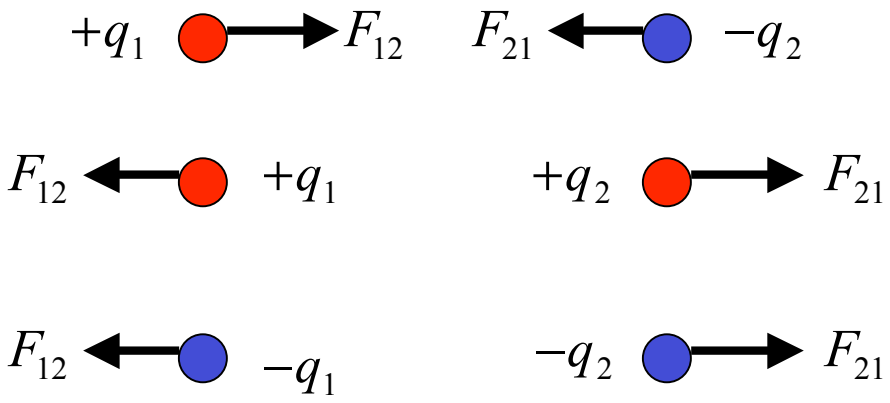




A negatively charged object is brought near to a neutral, conducting sphere. Electrons in the sphere are forced from the left side of the sphere to the right side.

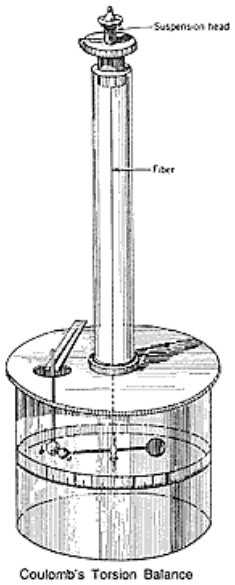
Force Between Pairs of Point Charges: Coulomb's Law

Charles-Augustin
De Coulomb
(1736–1806)



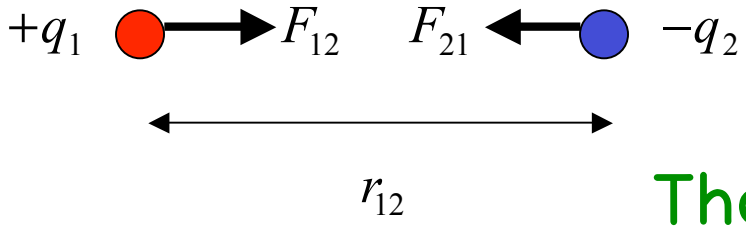
Coulomb's Law — the Force Between Point Charges:

- 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 Torsion Balance

Coulomb's Law



The "k" is the electric constant of proportionality.

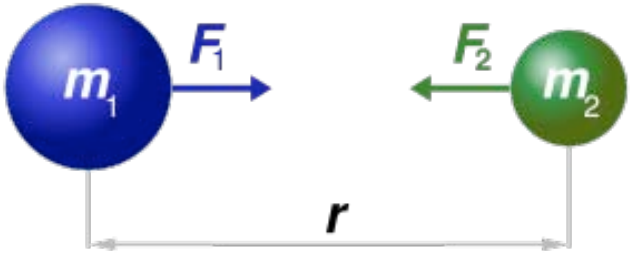
$$|F_{12}| = \frac{k\ |q_1|\ |q_2|}{r_{12}^2}$$

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

Usually, we write: $k = {}^{1}\!/_{4\pi\varepsilon_0}$ with $\varepsilon_0 = 8.85 \times 10^{-12}\ \frac{\mathrm{C^2}}{\mathrm{N\,m^2}}$

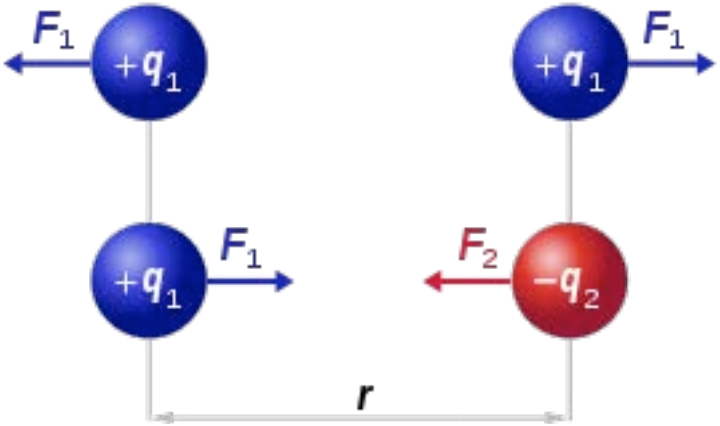
Units: F = [N] = [Newton]; r = [m] = [meter]; q = [C] = [Coulomb]

Two Inverse Square Laws



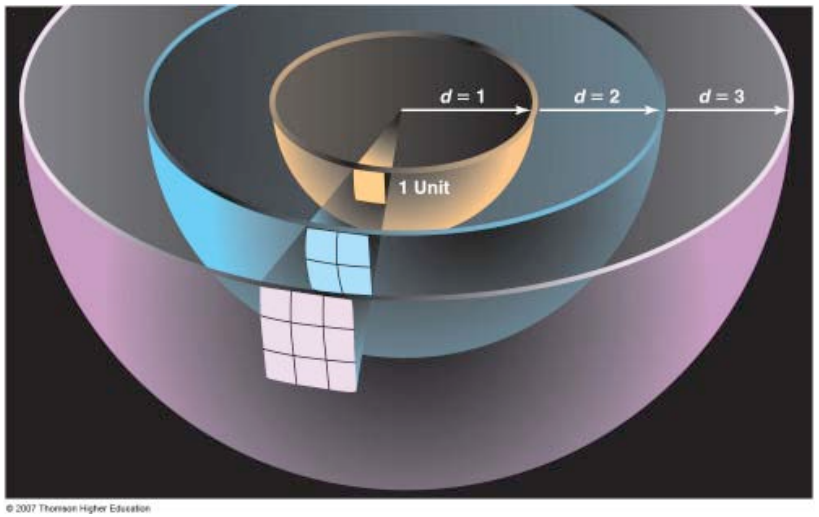
$$F_1 = F_2 = G\frac{m_1 \times m_2}{r^2}$$

Newton's Law of Gravitational Force



$$F_1 = F_2 = k_c\frac{q_1 \times q_2}{r^2}$$

Coulomb's Law of Electrical Force



Area of Sphere = $4\pi r^2$

Number of Lines of Force is Constant.

Hence Force Per-Unit-Area is Proportional to $1/r^2$

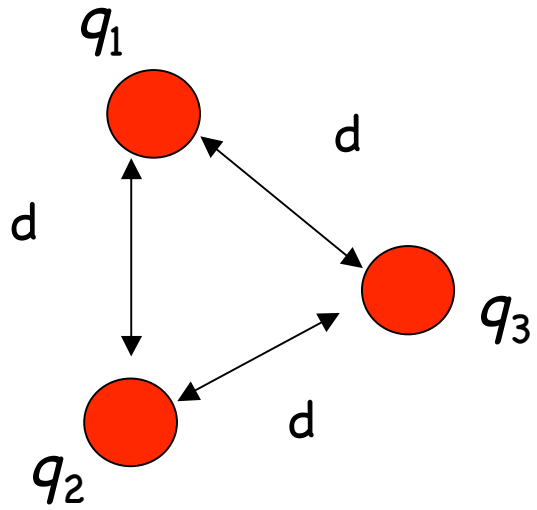
Superposition

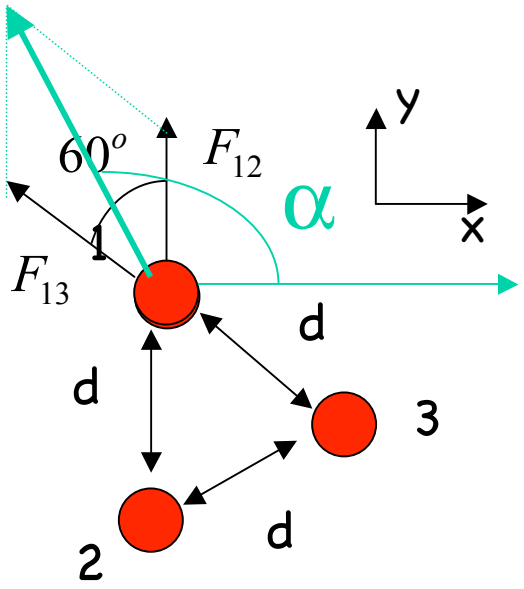
- **Question**: How Do We Figure Out the Force on a Point Charge Due to Many Other Point Charges?
- **Answer**: Consider One Pair at a Time, Calculate the Force (a Vector!) In Each Case Using Coulomb's Law and Finally Add All the Vectors! ("Superposition")
- Useful To Look Out for SYMMETRY to Simplify Calculations!

Feel the Force: Example

$q_1 = q_2 = q_3 = 20$ mC

- Three Equal Charges Form an Equilateral Triangle of Side 1.5 m as Shown
- Compute the Force on q_1
- What are the Forces on the Other Charges?

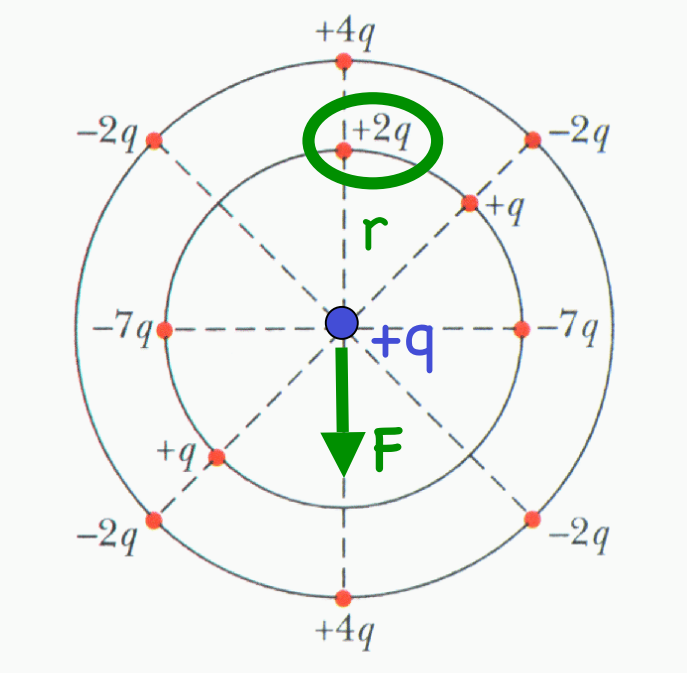




Solution: Set up a Coordinate System, Compute Vector Sum of F_{12} and F_{13}

Another Example With Symmetry

$$\left|\vec{F}\right| = \frac{k\ \left|+2q\right|\ \left|+q\right|}{r^2}$$



Charge +q
Placed at Center

What is the Force on Central Particle?

All Forces Cancel Except From +2q!


E=mc²
E=mb²