Welcome to Physics 202

Today's Topics

- The Physics 202 Team
- Course Formality and Overview

- Ch. 23-I: Electric Charge, Coulomb's Law

Text: Serway and Jewett,
Physics for Scientists and Engineers, 6th ed.

Physics 202 Homepage

http://www.icecube.wisc.edu/~karle/courses/phys202/

(linked from http://www.physics.wisc.edu/undergrads/undergrad.html)

Physics 202 Team

➢ Faculty (lectures):

- ☻ Prof. Albrecht Karle albrecht.karle@icecube.wisc.edu
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➢ Teaching Assistants (labs, discussion):

- ☺ Shusaku Horibe horibe@wisc.edu
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Physics 202 Course Composition

- **Lectures:** TR 1:20pm (Lec. 1), 2:25pm (Lec. 2)
  Honors: 12:05pm (w/ Physics 208)
- **Labs:** mandatory! Each missing lab = - 0.5 grade pt.
- **Discussion Sections**
- **Exams**: 3 midterms + final exam
- **Homework:** ~10 problems/week, web-based

  Online homework system: WebAssign
  Located at: https://www.webassign.net/login.html
  (also linked from course homepage)

  Username: your username@wisc.edu (not email address)
  Initial password: student ID

Exams and Exam Policy

- Word problems, partial credit given
- Exam Dates
  - Midterms:
    - Exam 1: Oct 1, (Ch. 23-26.3)
    - Exam 2: Oct 29 (Ch. 26.4-30)
    - Exam 3: Nov 26 (Chapters 31-33, 16,18)
  - Final: Dec 21, Cumulative

Please do not register for this course if your schedule conflicts with the exam dates!

(Exam policy details on course website)

How to Succeed …

The challenges of Physics 202:

Topics: electromagnetism, waves, quantum mech.

many new concepts, less familiar/intuitive topics, mathematics

calculus (line integrals, surface integrals, gradients), vectors

1. **Do the required reading *before* lecture**
   - the lectures assume you are familiar with the material
2. **Keep up -- don't get behind!!**
3. **Ask questions *early* if you don't understand things**
   - in lecture ask!! …also consult outside class.
   - discussion sections
   - office hours: schedule on course website.
4. **Problem solving develops and tests your conceptual understanding -- as well as your computational skill**
   - this is how you can demonstrate what you have learned…

Physics 201 and 202

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Electromagnetism

Light and Optics

Oscillation and Waves

Thermodynamics
Heat, Temperature, Pressure, Entropy,..

Classical Mechanics
Laws of motion
Force, Energy, Momentum,…

Classical

Cosmology

Sub-Sub-Atomic: Elementary Particles

Sub-Atomic: Nuclear Physics

Many-Atoms: Molecules, solids

Atomic Structure

Relativity

Quantum Theory

Modern

Physics 201

Mechanics **Gravitation**

- **Mechanics: Motion and Force**
  - **Fundamental Laws:**
    - **Newton's laws of motion ("Classical" view)**
    - **Conservation laws (energy/momentum/ang. momentum) ("modern" view)**
- **Gravitation: One of four fundamental forces**
  - **Fundamental Law:**
    Newton's Law of Universal Gravitation.

Physics 202 (1)

Electromagnetism **Waves** **Light &Optics** **Quantum**

- **Electromagnetism:** (lectures mainly by Prof. Everett)
  - **Electric force+charge, electric fields Ch. 23,24**
  - **Electric potential Ch. 25**
  - **Current, capacitance & resistance Ch. 26, 27**
  - **Magnetic fields and magnetic force Ch. 29, 30, 31,32**
  - **Electromagnetic waves Ch. 34**
  - **DC and AC Circuits Ch. 28, 33**
- **Waves:** (lectures mainly by Prof. Karle)
  - **Wave motion (Ch. 16)**
  - **Superposition Principle (Ch. 18)**

Physics 202 (2)

Electro-Magnetism	Waves	Light &Optics	Quantum

- Light and Optics (lectures mainly by Prof. Karle)
  - Optics: Physics of lights
  - Lights as rays: Geometric optics, imaging Ch. 35,36
  - Light as electromagnetic waves, interference Ch. 37
  - Light as group of photons (Quantum Physics)

- Intro to Quantum Physics (lectures mainly by Prof. Karle)
  (Ch. 40, reading on reserve)
  - Wave-Particle Duality
  - Uncertainty Principle
  - Energy Quantization

Chapter 23: Electric Fields

Today:

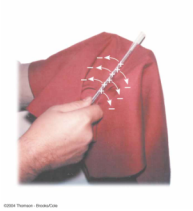
- Electric charges
- Electric force and Coulomb's Law

Thursday:

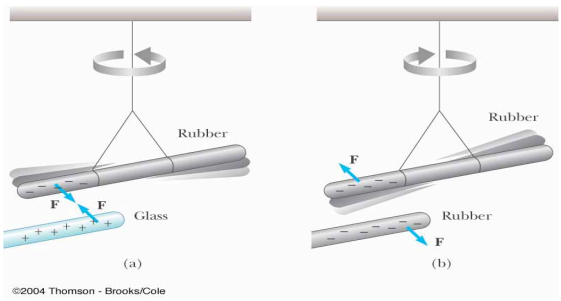
- More on Coulomb's Law
- Electric Field
- Exercises

❖ Please read Ch. 23 before Thursday's lecture

Electric Charge



Two types!



Opposite signs attract **Like signs repel**

Charges do not have to be in contact to interact

Properties of Electric Charge

- **2(+1) types: positive, negative (+ neutral*).**
- **Unit: Coulomb (C). 1 C= chg of 6.24×10^{18} protons**
- **Building blocks of matter:**

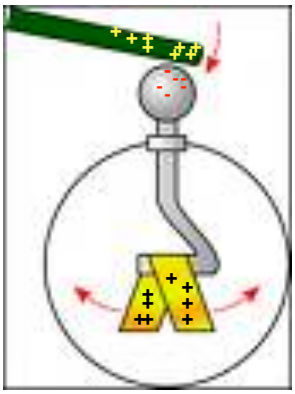
	Charge (C)	Mass (kg)
Electron	$-e=-1.602 \times 10^{-19}$	9.11×10^{-31}
Proton	$+e=+1.602 \times 10^{-19}$	1.673×10^{-27}
Neutron	0	1.675×10^{-27}

- **Electric charge is quantized: $q=\pm Ne$ ($e=1.602 \times 10^{-19}$ C)**
- **Electric charge of isolated system is conserved**

***Neutral: no charge or equal amount of + and -**

Conductors v. Insulators

Consider how charge is carried on macroscopic objects. In Physics 202, we are concerned with only 2 types:



Electroscope

Insulators (glass, plastic, rubber…):

charges NOT free to move

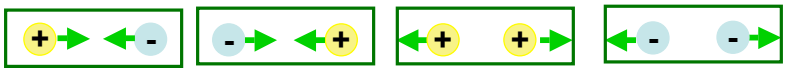
Conductors (metals…):

charges free to move

charge also by induction!
(phenomenon: polarization)

Coulomb's Law

- **Electric Force between two point charges:**
  - **Direction of force:**
    - **forces between opposite sign charges are attractive**
    - **forces between like sign charges are repulsive**



  - **Magnitude of force:**

$$F_{12} = F_{21} = k_e \frac{|q_1||q_2|}{r^2}$$ **(Coulomb's Law)**

Coulomb Constant: $k_e = 8.987 \times 10^9 Nm^2/C^2 = 1/(4\pi\varepsilon_0)$

ε_0: permitivity of free space (Ch. 26)

Gravitational v. Electric Force

- **Proton and electron in a hydrogen atom:**

$q_e = -1.6\times10^{-19}\,C \quad q_p = 1.6\times10^{-19}\,C \quad r = 5.3\times10^{-11}\,m$

→ $F_E = 8.2\times10^{-8}\,N$

➢ **The electric force is huge!**

– Compared to mass of proton: $1.673\text{x}10^{-27}$ kg

– Compared to gravitational force b/w proton+electron:

→ $F_G = 3.6\times10^{-47}\,N$ (recall: $F_G = \frac{Gm_1m_2}{r^2}$)

❖ **Four fundamental forces:**

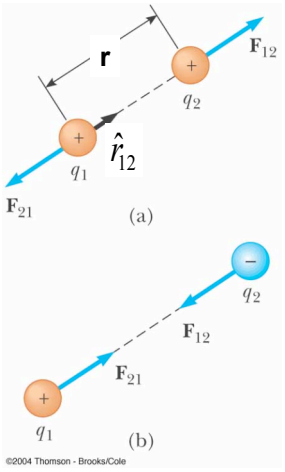
Strong > Electromagnetic > Weak >> Gravitation

Coulomb's Law: Vector Form

Force on q_2 by q_1: $\vec{F}_{12} = k_e \frac{q_1 q_2}{r^2}\hat{r}_{12}$

Force on q_1 by q_2: $\vec{F}_{21} = k_e \frac{q_1 q_2}{r^2}\hat{r}_{21} = -\vec{F}_{12}$

Exercise: use this vector form to verify attractive/repulsive feature of Coulomb's law



More than two charges:

Principle of Linear superposition

$$\vec{F}_i = \vec{F}_{1i} + \vec{F}_{2i} + \vec{F}_{3i} + \ldots$$