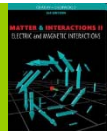
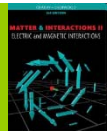


PHYSICS 272
Electric & Magnetic Interactions

Lectures:
MW 2:30-3:20PM @ PHYS 112

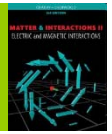
Lecturer: Prof. Yong P. Chen
yongchen@purdue.edu
Room:74, Phone:40974
http://www.physics.purdue.edu/quantum

http://www.physics.purdue.edu/academic_programs/courses/phys272/
http://phys272.blogspot.com



Schedule

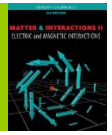
- **Lectures ---**
  - Monday, Wednesday 2:30 - 3:20PM (50 minutes)
  - Lecture Room: PHYS 112
  - Instructor: Prof. Yong P. Chen
  - Office hours: by appointment
  - Office: PHYS 74 , Phone: (49)-40947
  - Email: yongchen@purdue.edu (please use subject: PHYS 272)
- **Teaching Assistants (Rec/Lab): Jonathan Nistor (coordinator) [jnistor@purdue.edu], David Blasing, Mark Palenik**
- **Course information:**
  - **http://www.physics.purdue.edu/academic_programs/courses/phys272/**
  - Undergraduate Office - PHYS 144



Course Website

http://www.physics.purdue.edu/academic_programs/courses/phys272/ (click)

- Announcements
- Syllabus (**Outline/Policy**, **week-by-week Schedule**)
- Lectures [including iClicker questions & answers] (posted after each lecture)
- Labs/manual
- Other handouts & reading material
- Links to WebAssign, CHIP, and Phys272 blog etc



Other General Information

Room PHYS 144: Undergraduate office
Room PHYS 11: Help center
Room PHYS 290: Physics Library

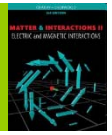
We will use WebAssign for homework and lab assignments.

You will be able to access your scores in CHIP.

See “Important Links” on course web page for details!

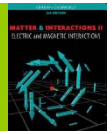
For questions concerning WebAssign contact:

V.K. Saxena: Office: PHYS 176, Phone: 49575



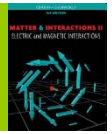
Activities and Responsibilities

- **In-class activities and responsibilities**
  - Lectures will involve projector/board writing, ppt, select demo/video, Clicker questions/survey/feedback; may not exactly follow Lec. Notes/textbook
  - You are responsible for attending all classes, and attendance will count toward your grade.
  - Bring the textbook and a scientific calculator to class.
  - If you miss class, it is your responsibility to find out what you missed. Lectures slides will be available shortly after lecture concludes.
- **Recitations and Lab Sessions**
- **Homework**
  - Homework and lab assignments will be posted on the web. See WebAssign (and Calendar section) for due dates.
- **Outside class**
  - Study assigned textbook sections
  - Studying other learning materials is encouraged
  - Participation in discussions/feedback on 272 blog also encouraged



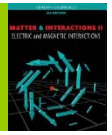
Quizzes, Exams, Grades

- Clicker Questions in Lecture:
  - Short multiple choice questions will be posed in lecture. The purpose is to assess your understanding. It will also be used to check attendance. We will start counting clicker questions towards your grade at **lecture #5**.
  - You have to purchase an **iClicker** (http://www.iclicker.com) from the bookstore.
  - **You must register your clicker ID in CHIP!!!!** **Use code "AB" for this course**
- Exams:
  - There will be two 1.5-hour evening exams and a 2-hour final exam. All exams are closed-book, but relevant formulas and constants will be provided.
  - Exam dates: 2/13; 3/27; final exam date: TBD
- Grades:
  - The final grade will be determined on the following basis (Course Total = 700 points):
    - 200 points - final exam
    - 100 points each - two 1.5-hour exams (see calendar)
    - 75 points - WebAssign homework
    - 100 points – Labs
    - 100 points -- Recitations
    - 25 points - Clicker Questions & Attendance



Summary: Who to go for help (first/quick)

Questions/issues	**Who best to ask/contact**
General course policy, syllabus	Prof. Chen
Lectures & related contents, Clicker questions and grades	Prof. Chen
Exam & final grades	Prof. Chen
Homework help & related course contents	Your TA, and Help Center staff
Recitation & Lab & their grades	Your TA
Problems with using iClicker, WebAssign (including issues of homework grades), CHIP (issues of grade calculation), course website etc.	Dr. VK Saxena
Special accommodation needs for exams	Get letter from Dean of Students and present it to Prof. Chen
Excused absences/grades (note: for lecture absences only more than 3 missed lectures need to be reported)	Follow procedure "Absences and Excused (EX) Grades" on Syllabus p.5: report to TA or Prof. in advance; fill-out EX form in Rm 144; etc,



Course Content

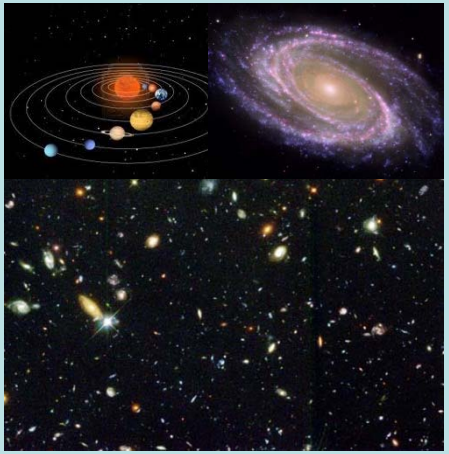
Fast paced!

This course deals with electric and magnetic interactions, which are central to the structure of matter, to chemical and biological phenomena, and to the design and operation of most modern technology [foundational to all engineering]

The main goal of this course is to have you engage in a process central to science: the attempt to model a broad range of physical phenomena using a small set of powerful fundamental principles. The specific focus of the course is an introduction to field theory, in terms of the classical theory of electricity and magnetism (E&M). The course also emphasizes the atomic structure of matter, especially the role of electrons and protons in matter.

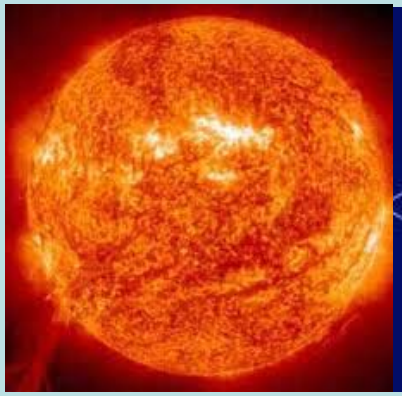
Nature's *Four* Fundamental Forces/Interactions

Gravitational

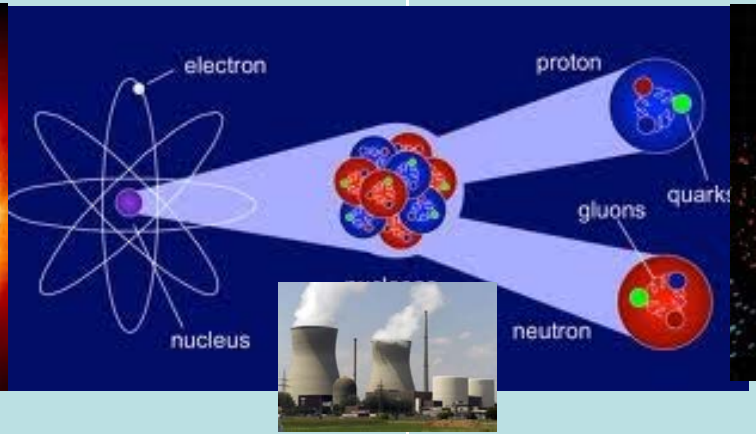


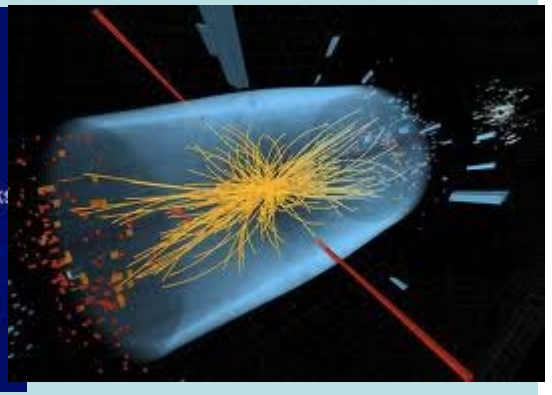
Electric/Magnetic

"Weak"



"Strong"





Electric and Magnetic Fields

Electric and magnetic fields manifest their existence through interactions with matter

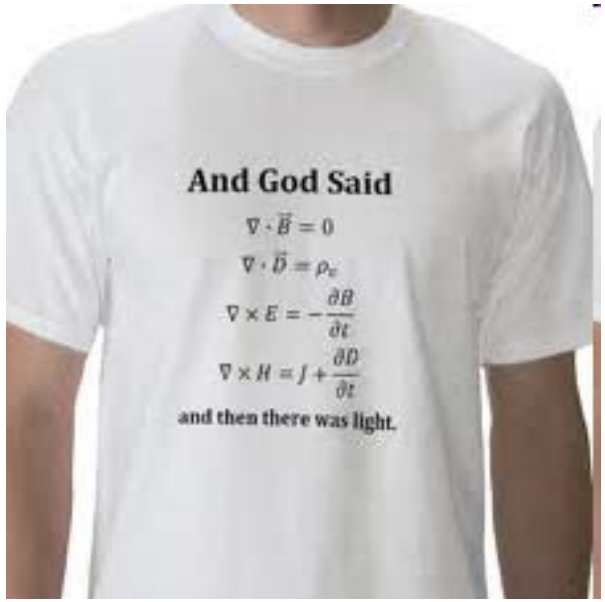
Maxwell equations:

$$\text{div}(\vec{E}) = \vec{\nabla} \cdot \vec{E} = \frac{\rho}{\varepsilon_0}$$

$$\text{div}(\vec{B}) = \vec{\nabla} \cdot \vec{B} = 0$$

$$\text{curl}(\vec{E}) = \vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\text{curl}(\vec{B}) = \vec{\nabla} \times \vec{B} = \mu_0 \left[\vec{J} + \varepsilon_0 \frac{\partial \vec{E}}{\partial t} \right]$$

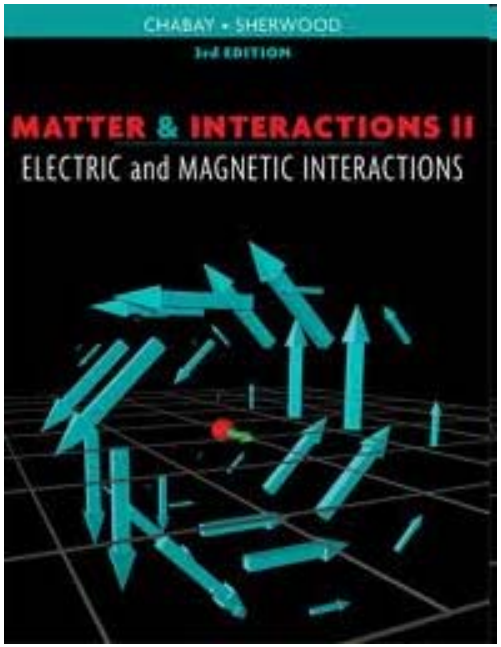


Lorentz force:

$$\vec{F} = q\vec{E} + q\vec{v} \times \vec{B}$$

We'll get to these near end of this course!

Textbook



The textbook is *Matter & Interactions, vol II: Electric & Magnetic Interactions* by R. Chabay & B. Sherwood (John Wiley & Sons 2011). We will cover almost all of the topics in this volume. See the table of contents at the front of the book (which also includes the contents of Volume I).

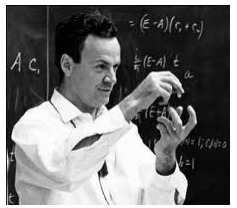
Make sure it is the **Third Edition**. The new book comes with a free coupon for WebAssign, the on-line homework service. Follow the instructions and get yourself registered.

Additional Learning Materials

Classic good books:

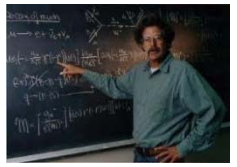
- Edward Purcell (Purdue EE'33; Nobel Prize in Physics 1952): *Electricity and Magnetism*
- Richard Feynman:

Feynman Lectures on Physics Vol 2



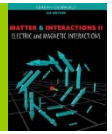
Somewhat more advanced (but very helpful):

- David Griffiths: *Introduction to Electrodynamics*



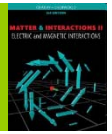
All these books are on Reserve in Physics Library

Walter Lewin's legendary online lectures (esp. demos):
http://videolectures.net/mit802s02_electricity_magnetism/
For a taste, recommend "For the love of physics:
http://www.youtube.com/watch?v=SRh75B5iotI"



This is *Your* unique Purdue-PHYS 272

- This will be a "Boilermaker" E&M with contents & style unique to Purdue, to this course, & to this class (you)
- Some features differing from many traditional E&M courses:
  - emphasize microscopic/atomic picture
  - emphasize numerical/vector/graphics [Vphython]
  - selected demo/lab (but many more online → see Lewin)
  - real-world application examples in science & engineering
  - Your ongoing feedback via in-lecture Clickers questions/survey, recitation/labs, & PHYS272-blog etc.
- Your active participation and contribution will *help tailor this course for you*!



272 Blog: http://phys272.blogspot.com (new for Spring 2013!)

This blog is meant to provide an online forum for and among PHYS 272 class members to:

- discuss topics related to electromagnetism of interests to this class
- share interesting links/articles about electromagnetism with the class
- bring up/discuss topics related to electromagnetism that you want to hear more or need more help with
- encourage peer-help and peer-discussion among the class members and facilitate an online learning community outside the classroom

[click link above for demo]

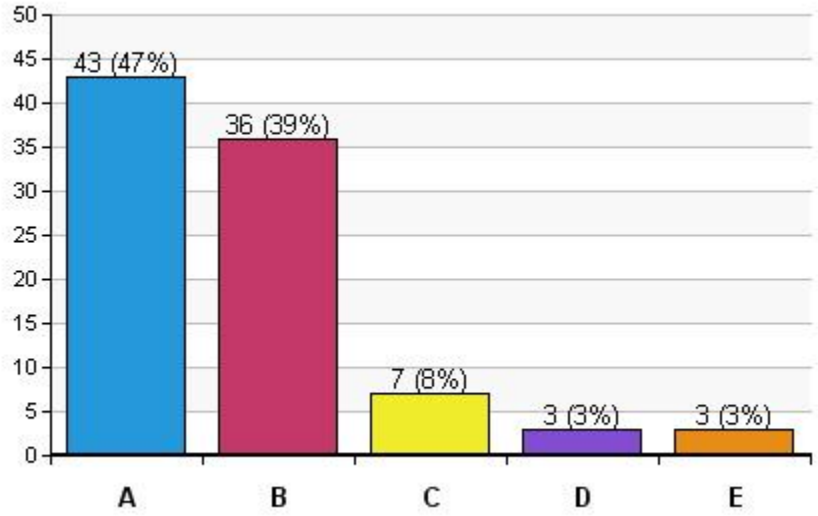
Note this blog is NOT a venue to send instructors/TAs (who may not check this blog regularly) specific or personal questions/queries/requests/complaints ---- instead please contact them directly to get faster responses.

The comments are currently un-moderated (and you can comment anonymously). Please use standard online etiquette when posting comments on this blog, and do not post contents/comments unrelated to electromagnetism and PHYS 272.

Practice Clicker Question 1

My year in college is –

A)Freshman
B)Sophomore
C)Junior
D)Senior
E)Οτηερ

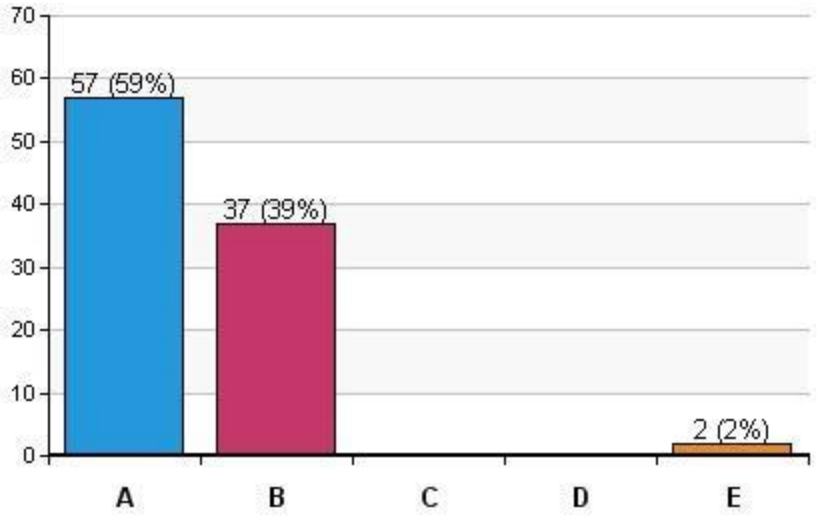


- **Use iclicker code "AB" for this course;**
- **Clicker problems, see Rm 144 or Dr. Saxena**
- **Will be graded from Lec. 5**

Clicker Question 2

My major is –

A)Engineering
B)Science
C)Liberal Arts
D)Education
E)Other



- **Use iclicker code "AB" for this course;**
- **Clicker problems, see Rm 144 or Dr. Saxena**
- **Will be graded from Lec. 5**

Clicker Question 3

Are you majoring in any of the following –

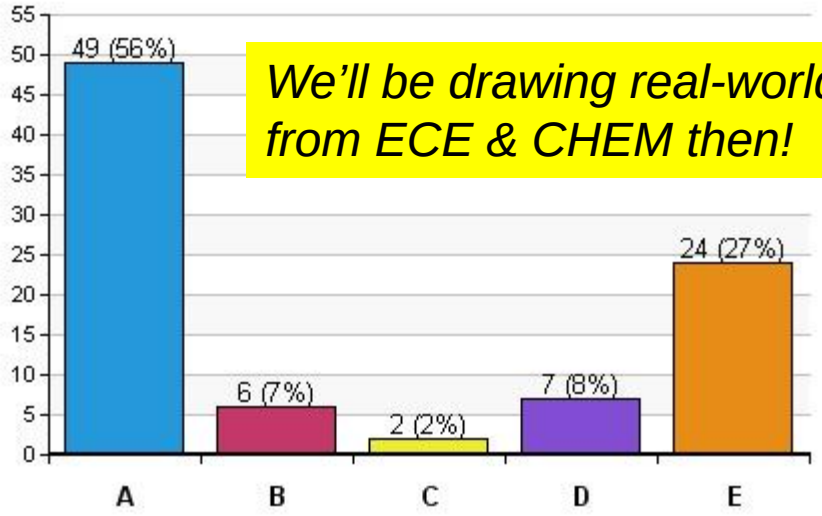
A)Electrical and Computer Engineering (ECE)

B)Physics

C)A and B

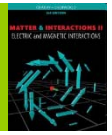
D) Computer Science

E) Chemistry



We'll be drawing real-world examples from ECE & CHEM then!

- **Use iclicker code "AB" for this course;**
- **Clicker problems, see Rm 144 or Dr. Saxena**
- **Will be graded from Lec. 5**



This Week

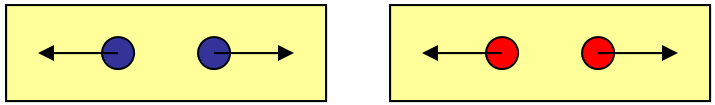
- Study chapter 14
- No Recitation/Lab this week
- Do Homework in WebAssign

Announcement

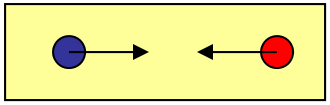
Lab Manuals no longer available in Union/BoilerCopyMaker
You will access them from course website

Point Charges

- Two types: *positive* and *negative*
- Like charges: repel



- Opposite charges: attract



- Charge is **quantized** in units of *e*

Millikan's oil drop experiment (1910-1913)

"Fractional" quantized charge (quarks, FQHE…)

[not in everyday life]

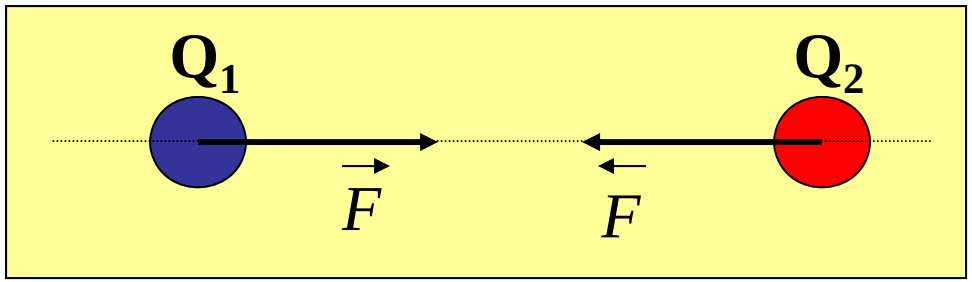
- Point charge: Size is small compared to the distance between it and other objects of interest
- Electric charge is an **intrinsic property** of the fundamental particles that everything is made of
- Universe's **Net** charge is conserved

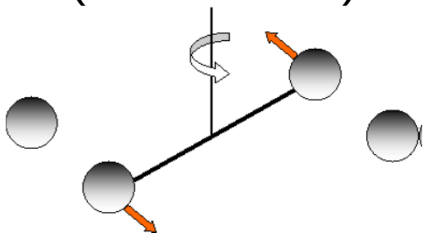
The Coulomb Force Law

$$\left|\vec{F}\right| = F = \frac{1}{4\pi\varepsilon_0}\frac{\left|Q_1 Q_2\right|}{r^2}$$

"The magnitude of the electrostatic force between two point charges is directly proportional to the magnitudes of each charge and inversely proportional to the square of the distance between the charges."

Charles-Augustin de Coulomb
(1736 - 1806)

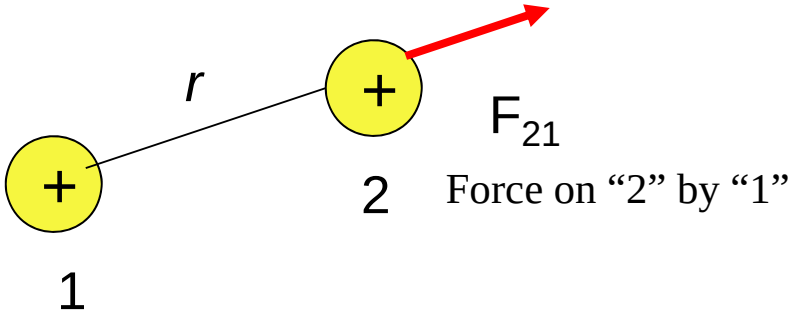




The Coulomb Force Law

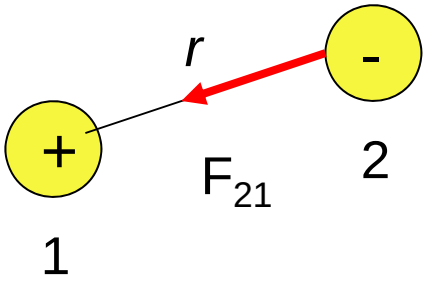
$$\vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{Q_1 Q_2}{r^2}\hat{r}$$

ε_0 = permittivity constant of vacuum (air is close)



Force on "2" by "1"

Force repulsive



Force attractive

- The force exerted by one point charge on another acts along line joining the charges.
- The force is repulsive if the charges have the same sign and attractive if the charges have opposite signs.

Units and Constants

$$\left|\vec{F}\right| = F = \frac{1}{4\pi\varepsilon_0}\frac{|Q_1 Q_2|}{r^2}$$

SI units of electric charge: Coulomb, C

Constants:

$1/4\pi\varepsilon_0 = 9\text{x}10^9\ \text{N}\cdot\text{m}^2/\text{C}^2$

$\varepsilon_0 = 8.85\text{x}10^{-12}\ \text{C}^2/\text{N}\cdot\text{m}^2$ permittivity constant of vacuum

$e = 1.602\text{x}10^{-19}$ C ("unit charge')

$1\ \text{C} = 6.24\text{x}10^{18}$ elementary charges

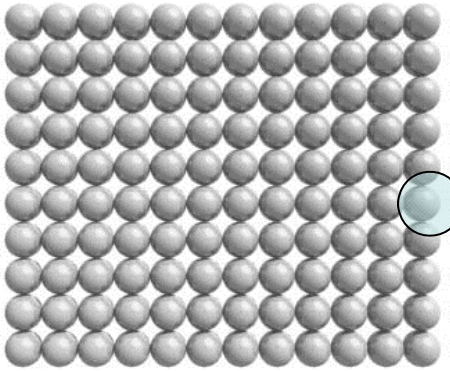
Particle	Charge
electron	$-e$
positron	$+e$
proton	$+e$
antiproton	$-e$
neutron	0
photon	0
up quark	$+(2/3)e$
down quark	$-(1/3)e$

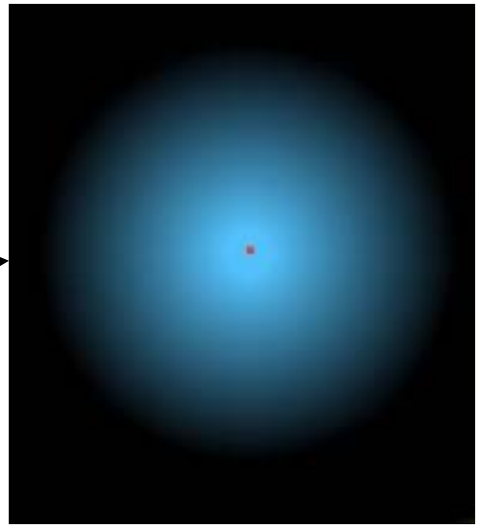
Structure of Atom

Matter consists of atoms

Coulomb force important for atom stability!

1 cm^3 : ~10^{24} atoms





Nucleus:

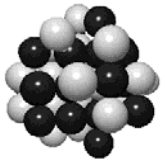
~10^4 times smaller than electron cloud,

~10^4 times heavier than electron.

1Å=0.1nm=10^{-10}m

Example: nucleus of the iron atom →

Size: ~10^{-15} m, mass: ~10^{-25} kg

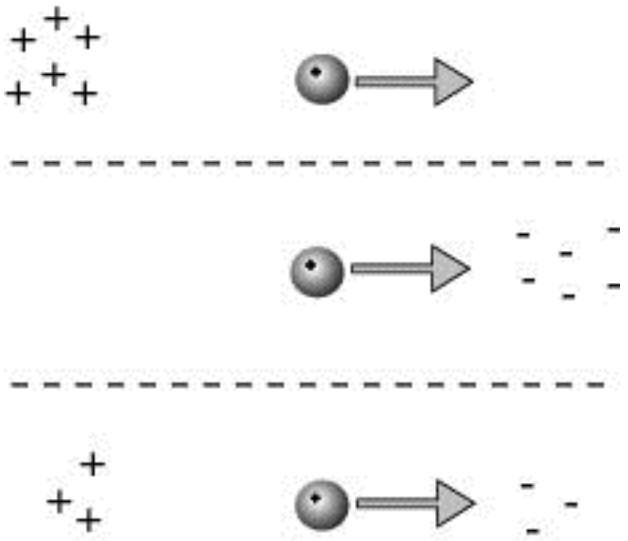


Nucleus charge = +*Ze*, atom with *Z* electrons is neutral.

The Concept of Electric Field

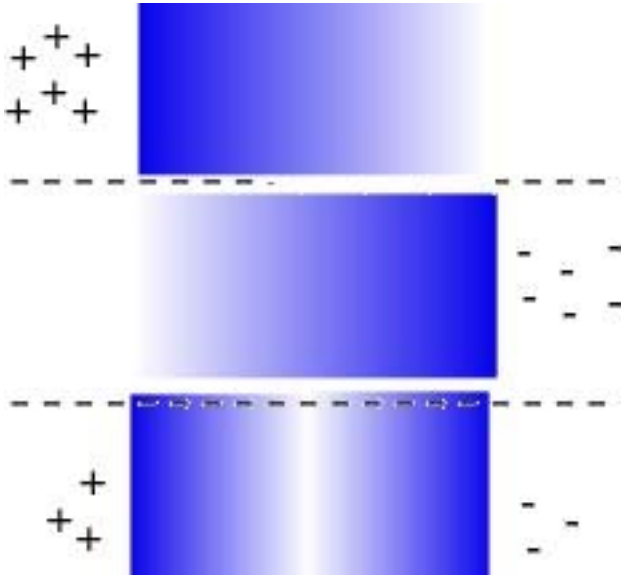
Accelerates at 9.8 m/s^2 – why?

Accelerates at 10^{11} m/s^2 – why?



There are many possible configurations of charges to produce the observed effect.

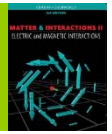
Electric Field



There is something in space waiting for a charged particle to interact with it!

This virtual force is called *electric field*.

An electric field created by charge is present throughout space at all times, whether or not there is another charge around to feel its effect.



Re-Cap (EMI 14.1-14.3)

- Course elements: lecture, recitation, lab, WebAssign…
- Coulomb's law for electric force
- Point charges and unit of charge
- Electric force → electric field

Next time (EMI 14.3-14.8)

- Electric Fields & Superposition of Electric field due to multiple charges
- Electric dipole