Physics 114 - January 14, 2010

This is an introduction to electromagnetism, optics and modern physics for science majors who are not majoring in physics or engineering.

- electrostatics
- electric potential
- magnetostatics
- electric and magnetic fields in matter
- current
- capacitors
- energy in electric and magnetic fields
- DC circuits
- induction
- Maxwell's equations
- electromagnetic waves
- geometric and physical optics
- quantum mechanics
- atomic physics
- nuclear physics
- relativity
- possibly a bit of cosmology + particle physics

Preregs - P113 (or equivalent)
Math 142 or 162 (or equivalent)

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Tues. 2-3pm or email for appt.

The essence of chemistry is
electromagnetism + quantum mechanics

X-rays, mass spectroscopy, visible light spectroscopy, IR spectroscopy, nature of the chemical bond, CAT scans, NMR of all sorts, EKG, nerve function, cell phones, elevator motors, ambulance lights, microscopes, dental drills, surgical lights, electrophoresis, carbon-14 dating, LASIK, laser surgery, radionuclide labeling, radiation treatments of cancer with beams and with implanted sources, mp3 players, radios, televisions, cathode ray tubes of all sorts, defibrillators, computers, digital imaging, cameras, copy machines, refrigerators, heaters, power from the wall, heating espresso, PIXUS, automatic toilets, microwaves, CD's, DVD's, streaming video, Napster, Ipods, any aspect of the internet, optical fibers, telephones, electric power transformers, credit card information stored in magnetic strips, bar code scanning, signal cables, eye glasses, MRI, contact lenses ….

Plus some serious practice on

Problem Solving

Plus some really cool things . . .

For example

Maxwell's Equations

1873

James Clerk Maxwell

1831 - 1879 (Edinburgh)

integral Form of Maxwell's eqns

$$\oint_s \vec{E} \bullet d\vec{a} = \frac{Q_{encl}}{\varepsilon_o}$$

$$\int_s \vec{B} \bullet d\vec{a} = 0$$

$$\int_c \vec{E} \bullet d\vec{l} = -\frac{d\int_s B \bullet d\vec{a}}{dt}$$

$$\int_c \vec{B} \bullet d\vec{l} = \mu_o I_{encl} + \mu_o \varepsilon_o \frac{d\int_s \vec{E} \bullet d\vec{a}}{dt}$$

"E" is symbol for electric field

"B" is symbol for Magnetic Field

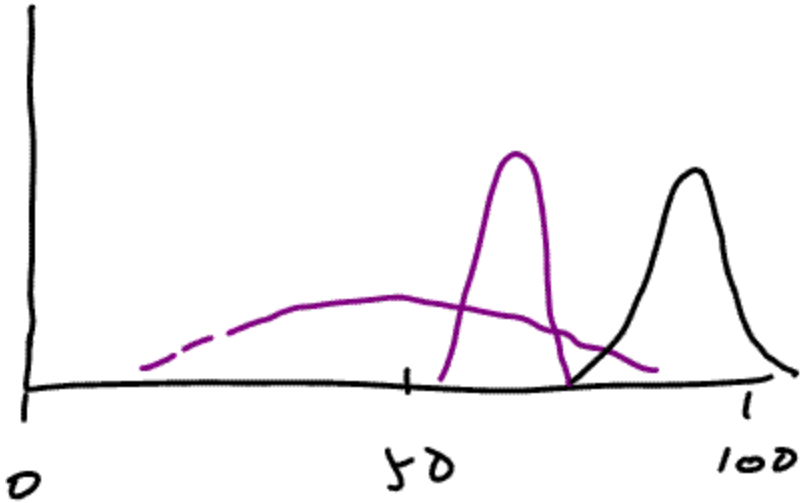
Lectures
↳ conceptual
some demos
some problems

Workshops
↳ learn how to think your way thru the problems

Problem Sets
↳ Make sure you know how to start problems

Text
↳ Different approach + discussion
useful examples

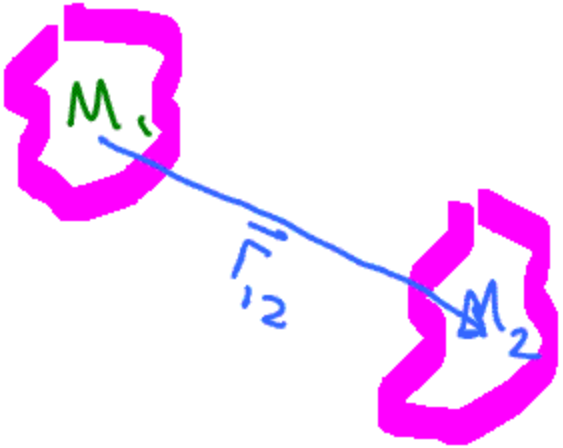
labs



Must Normalize exam means to the same number to remove exam-to-exam difficulty variations

Gravitation

$$\vec{F} = -\frac{G M_1 M_2}{r_{12}^2}\,\hat{r}_{12}$$



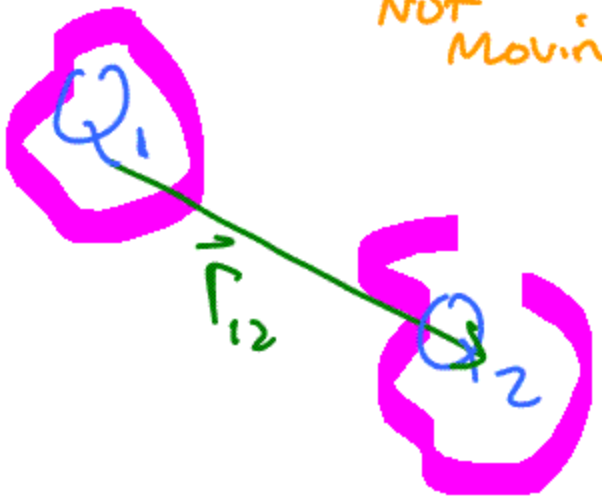
$$G = 6.67 \times 10^{-11}\ \frac{N \cdot M^2}{kg^2}$$

always Attractive

Electromagnetism

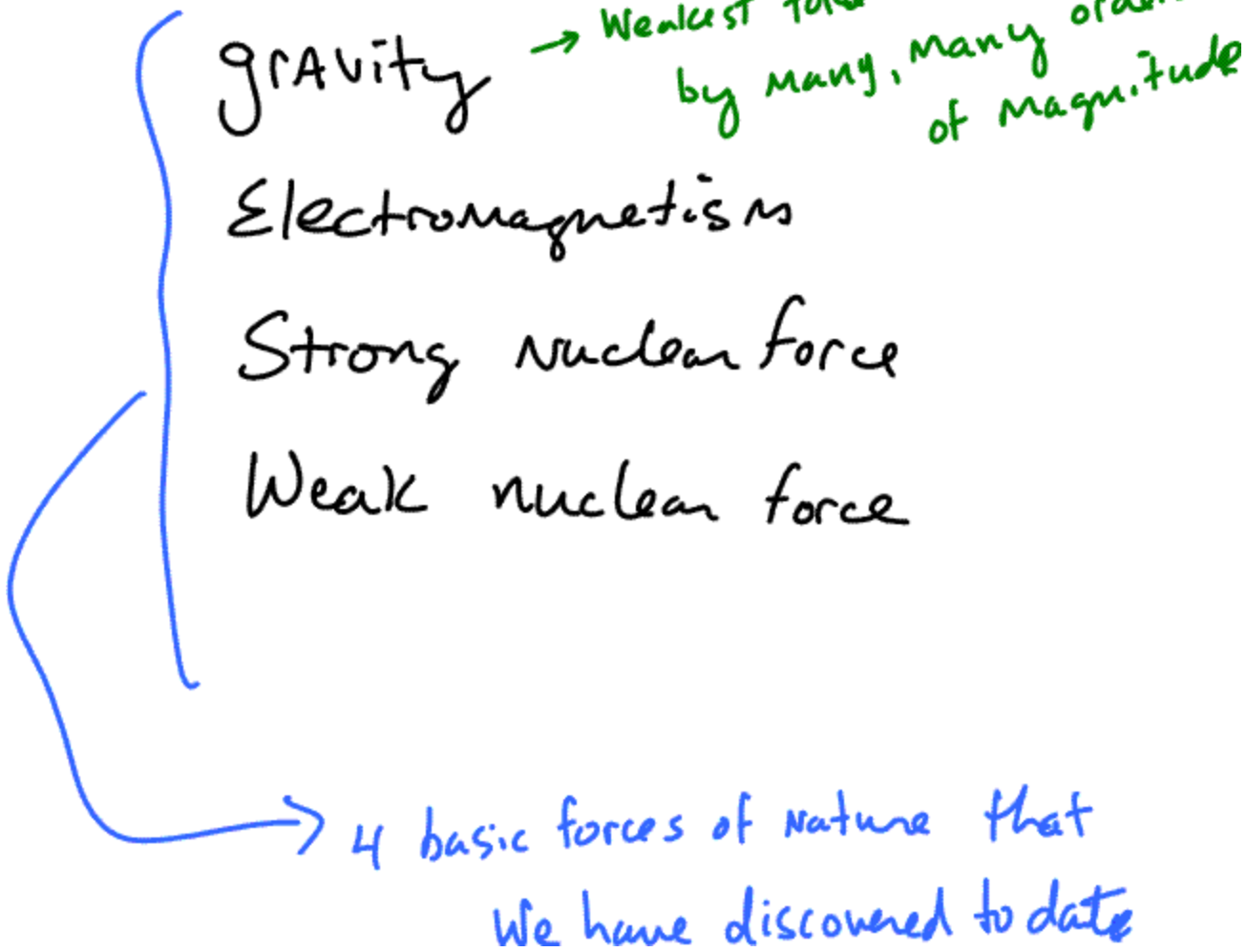
Electrostatics

Not Moving



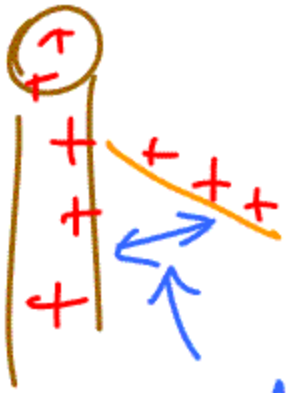
$$\vec{F} = \frac{k Q_1 Q_2}{r_{12}^2}\,\hat{r}_{12}$$

Attractive or repulsive depending on relative signs of the charge

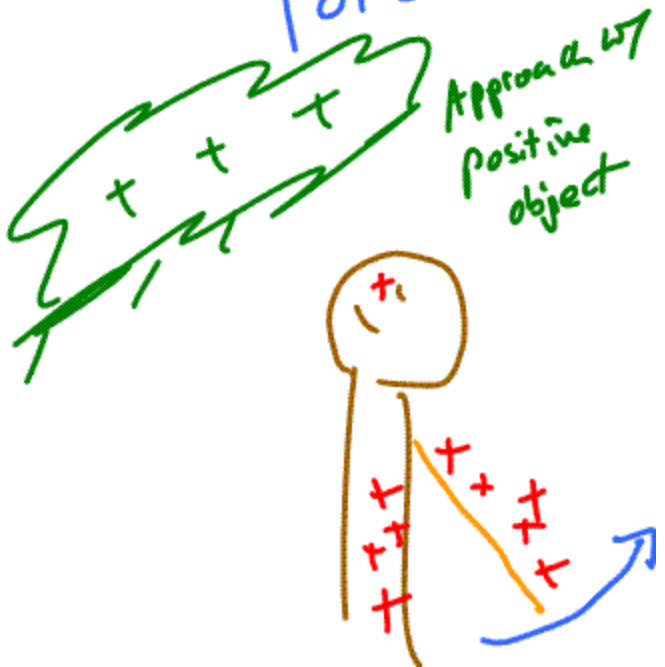

gravity
Weakest force by many, many orders of magnitude
Electromagnetism
Strong nuclear force
Weak nuclear force
4 basic forces of nature that we have discovered to date

Electroscope

"Conducting" means that charge flows freely



repulsive force

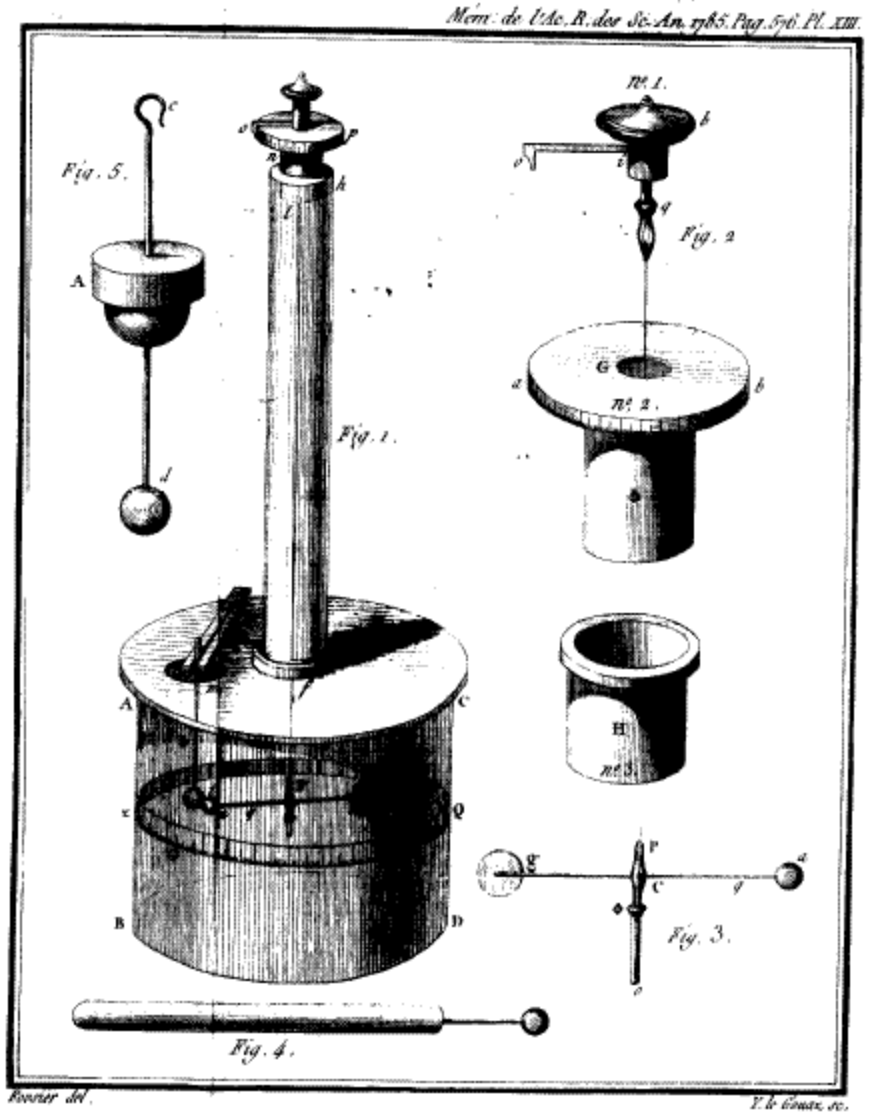


Charles
Augustin
Coulomb

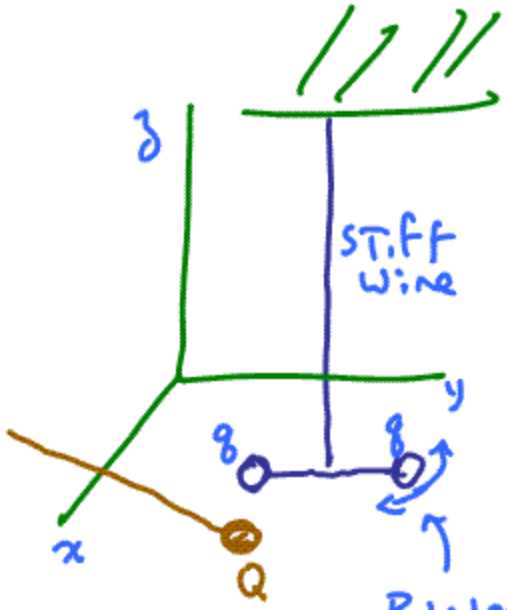
(1736 – 1806)

Coulomb's Law ~1785

French Military engineer



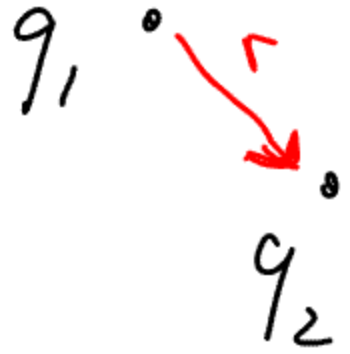
Torsion Balance



Rotates in x-y plane

$F \propto \frac{q_1 q_2}{r^2}$

Period of oscillation depends on force



$$\vec{F} = \frac{k q_1 q_2 \hat{r}}{r^2}$$

MKS unit

F in Newtons

r in meters

q in Coulombs

Coulomb $\equiv$ C $\equiv$ Coul

$k \equiv$ constant $\equiv$ set scale

$\Downarrow$

$8.99 \times 10^9 \frac{N m^2}{C^2}$

$$k \equiv \frac{1}{4\pi\epsilon_0}$$

$\epsilon_0 = 8.85 \times 10^{-12} \frac{C^2}{N m^2}$

ϵ_0 ↳ Permittivity of free space

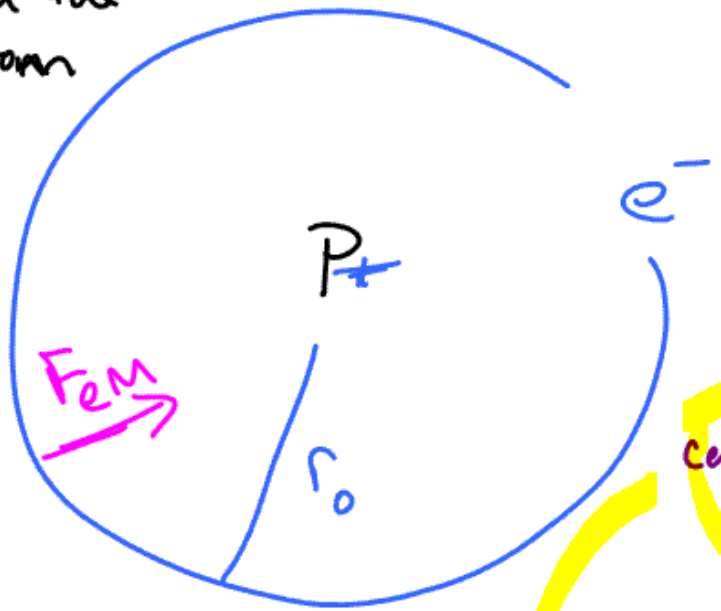
Electric charge is conserved

Electric charge is quantized

$\pm|e| = \pm 1.6\times10^{-19}$ Coulombs

quarks have $\pm\frac{1}{3}|e|$ or $\pm\frac{2}{3}|e|$ ... but
never seen freely in nature
seen only in combinations with integral charge

Consider the H atom



r_0 = Bohr radius

5.3×10^{-11} M

centripetal force is force of electromagnetism

$$F_{EM} = \frac{m_e v_e^2}{r_0} = \frac{k\, q_p\, q_e}{r_0^2}$$

$$v_e = 2.2 \times 10^6 \text{ M/s} \sim 1\% \text{ speed of light}$$