# PHYS 1444 – Section 003
# Lecture #2

*Tuesday August 28, 2012*

*Dr. Andrew Brandt*

1. Introduction (longish) and Syllabus
2. Chapter 21

   --Coulomb's Law

   --Electric Field

   --Electric Dipole

# Announcements

a)more than 1/2 the class has gotten started on mastering physics HW due this Tues 28th. Next Hw due Sep. 4 is no posted, we will cover most of the material for it on Tuesday.

2)make sure you get the one associated with Giancoli for Scientists and engineers. if you dont get it with a new physical textbook it is $60.50 without the etext and $110 with the etext

c)Lab starts week of Sep. 3. If you have lab on Sep. 3 you start Sep. 10 there is a link from my webpage to lab, I don't know what you need to buy for lab, but i'm sure some of your colleagues do. my only association with the lab is I get your final lab grade at end of semester.

d) I am investigating clickers, will let you know on Tuesday

# So, What's New in the World of Physics?

http://www.youtube.com/watch?v=7LVA2qeSqwQ

# Higgs!

NY Times says it so it must be true!

Media Highlights

Storify

# Why Do Physics?

Exp.
- To understand nature through experimental observations and measurements (**Research**)

Theory
- Establish limited number of fundamental laws, usually with mathematical expressions
- Explain and predict nature

⇒Theory and Experiment work hand-in-hand

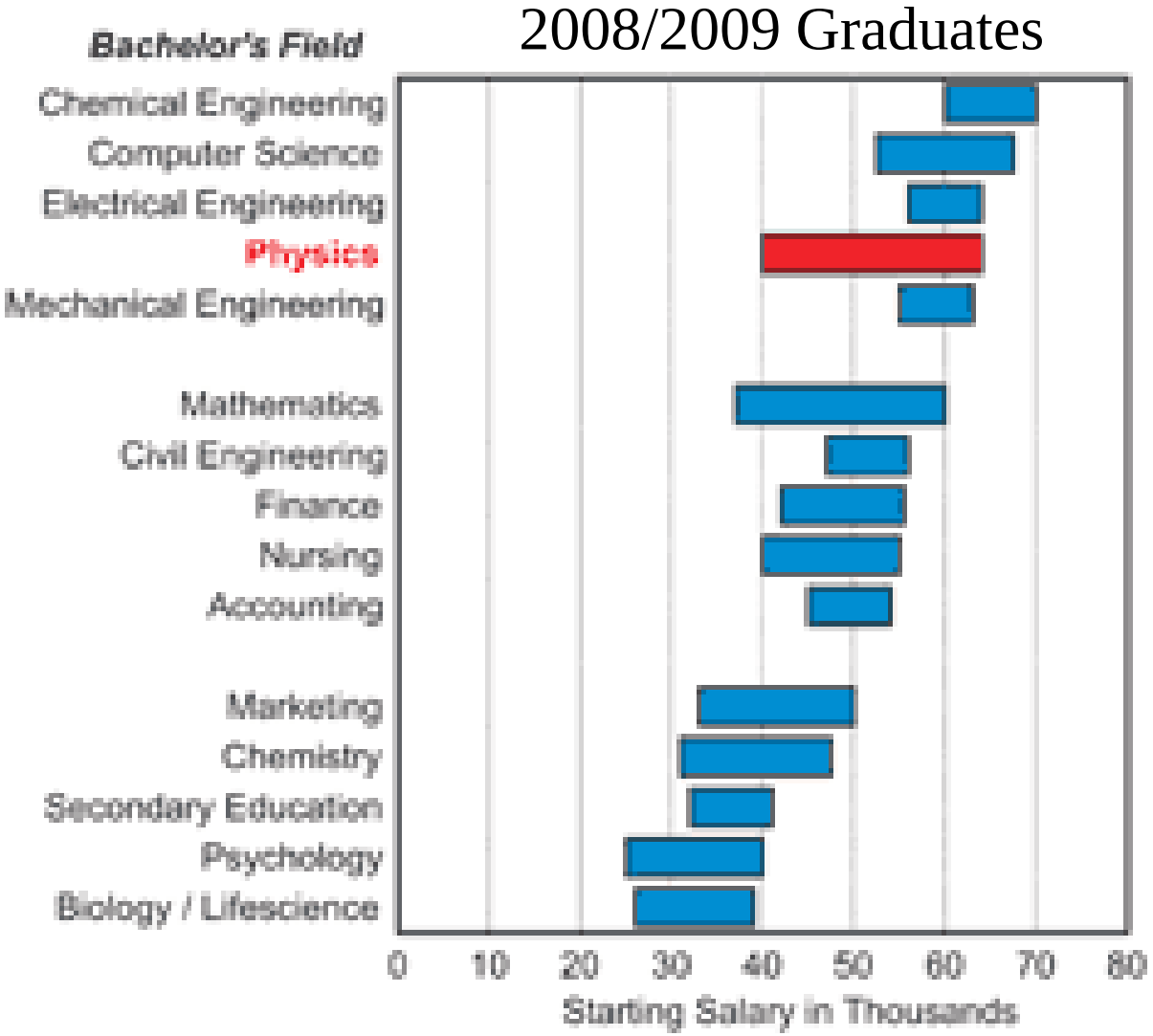
⇒Theory generally works under restricted conditions

⇒Discrepancies between experimental measurements and theory are good for improvement of theory

⇒Modern society is based on technology derived from detailed understanding of physics

# Why Do Physics Part Deux

http://www.aps.org/publications/apsnews/200911/physicsmajors.cfm




1.7% unemployment

While engineering starting salaries are typically higher than physicists, mid-career salaries are virtually identical 101k$ for engineering 99k$ for physics

# What Do Physicists Do?

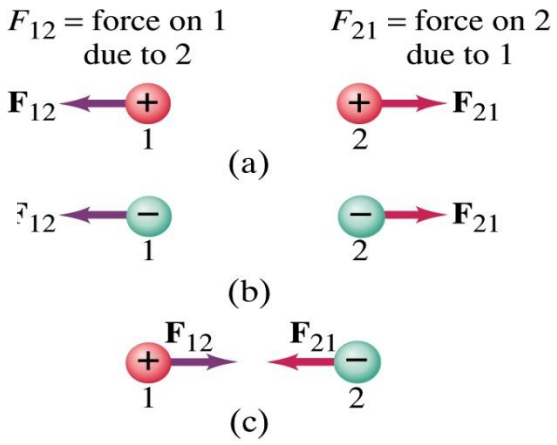
# Coulomb's Law

- Charges exert force on each other. What factors affect the magnitude of this force?
- Charles Coulomb figured this out in 1780's.
- Coulomb found that the electrical force is
  - Proportional to the product of the two charges
    - If one of the charges is doubled, the force doubles.
    - If both of the charges are doubled, the force quadruples.
  - Inversely proportional to the square of the distances between them.
  - Electric charge is a fundamental property of matter, just like mass.
- How would you put this into a formula?

# Coulomb's Law – The Formula

$$F \propto \frac{Q_1 \times Q_2}{r^2} \quad \text{Formula} \quad F = k\frac{Q_1 Q_2}{r^2}$$

- Is Coulomb force a scalar quantity or a vector quantity? Unit?
  - A vector quantity. Newtons
- Direction of electric (Coulomb) force is always along the line joining the two objects.
  - If two charges have the same sign: forces are directed away from each other.
  - If two charges are of opposite sign: forces are directed toward each other.
- Coulomb's Law is accurate to 1 part in $10^{16}$.
- Unit of charge is called Coulomb, C, in SI.
- The value of the proportionality constant, $k$, in SI units is $k = 8.988 \times 10^9 \ \ \mathrm{N \cdot m^2/C^2}$
- Thus, if two 1C charges were placed 1m apart the force would be **9x10$^9$N**.



# Coulomb's Law – The Movie

Just kidding?

# Electric Force and Gravitational Force

$$F = k\frac{Q_1 Q_2}{r^2} \quad \text{Extremely Similar} \quad F = G\frac{M_1 M_2}{r^2}$$

- Does the electric force look similar to another force? What is it?
  - **Gravitational Force**
- What are the sources of the forces?
  - Electric Force: Charge, fundamental property of matter
  - Gravitational Force: Mass, fundamental property of matter
- What else is similar?
  - Inversely proportional to the square of the distance between the sources of the force ➔ What is this kind law called?
    - Inverse Square Law
- What is different?
  - Gravitational force is always attractive.
  - Electric force depends on the sign of the two charges.
  - Magnitude

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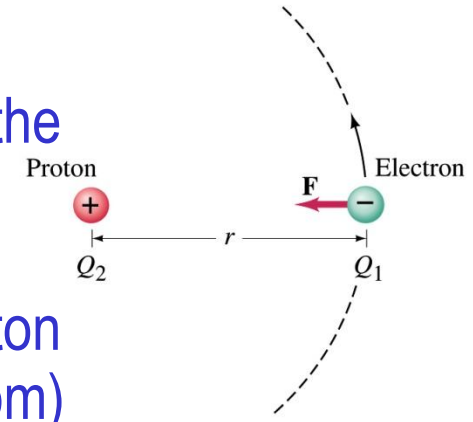
# The Elementary Charge and Permittivity

- Elementary charge, the smallest charge, is that of an electron: $e = 1.602 \times 10^{-19} C$
  - Since electron is a negatively charged particle, its charge is $-e$.
- Object cannot gain or lose fraction of an electron.
  - Electric charge is quantized.
    - It always occurs in integer multiples of $e$.
- The proportionality constant k is often written in terms of another constant, $\varepsilon_0$, the permittivity of free space. They are related $k = 1/4\pi\varepsilon_0$ and $\varepsilon_0 = 1/4\pi k = 8.85 \times 10^{-12} C^2/N \cdot m^2$.
- Thus the electric force can be written: $F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1 Q_2}{r^2}$
- Note that this force is for "point" charges at rest.

# Example 21 – 1

- **Electric force on electron due to proton**. Determine the magnitude of the electric force on the electron in a hydrogen atom exerted by the single proton ($Q_2$=+e) that is its nucleus. Assume the electron "orbits" the proton at its average distance of r = 0.53 x$10^{-10}$ m. (0.5 Angstrom)




Using Coulomb's law $$F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1 Q_2}{r^2} = k\frac{Q_1 Q_2}{r^2}$$

Each charge is $Q_1 = -e = -1.602\times10^{-19}\,C$ and $Q_2 = +e = 1.602\times10^{-19}\,C$

So the magnitude of the force is

$$F = \left|k\frac{Q_1 Q_2}{r^2}\right| = 9.0\times10^{9}\ N\cdot m^2/C^2\ \frac{1.6\times10^{-19}\,C \quad 1.6\times10^{-19}\,C}{0.53\times10^{-10}\,m^{\ 2}}$$

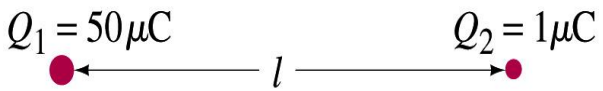
$$= 8.2\times10^{-8}\,N$$

Which direction? Towards each other…

Example on board

# Example 21 – 2

- **Which charge exerts greater force?** Two positive point charges, $Q_1$=50μC and $Q_2$=1μC, are separated by a distance L. Which is larger in magnitude, the force that $Q_1$ exerts on $Q_2$ or the force that $Q_2$ exerts on $Q_1$?




What is the force that $Q_1$ exerts on $Q_2$? $$F_{12} = k\frac{Q_1 Q_2}{L^2}$$

What is the force that $Q_2$ exerts on $Q_1$? $$F_{21} = k\frac{Q_2 Q_1}{L^2}$$

Therefore the magnitudes of the two forces are identical!

Is there any difference? The direction.

What is the direction? Opposite to each other!

What is this law? Newton's third law, the law of action and reaction

# Solving Problems

- Read and re-read problems carefully
- Draw a diagram using arrows to represent vectors
- Choose a convenient coordinate system
- Note the known and unknown quantities
- Write down the relevant relationships
- Do an approximate calculation
- Solve, substituting numbers only at the end
- Keep track of units
- Consider if answer is reasonable

# Vector Problems

- Calculate magnitude of vectors
- Split vectors into x and y components and add these separately, using diagram to help determine sign
- Calculate magnitude of resultant $|F|=\sqrt{(F_x^2+F_y^2)}$
- Use $\theta = \tan^{-1}(F_y/F_x)$ to get angle

Example on board

# Announcements

- Monday is a holiday so next class is Weds. Sep. 7
- Read Ch. 21 before next class
- Enroll in Mastering Physics and do first "welcome" assignment
- Labs start week of Sep. 5 (if you have Monday lab you start the 12th)
- Read Book, Do HW, Go to Lab, Learn Physics
- Good grade will follow

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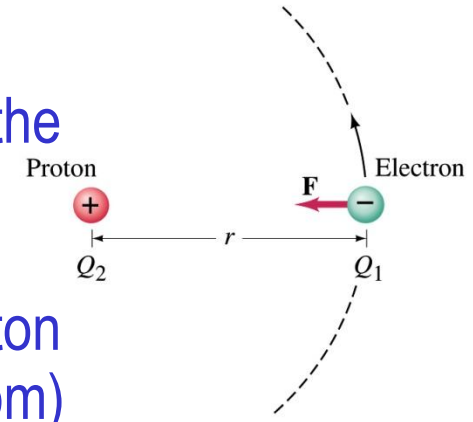


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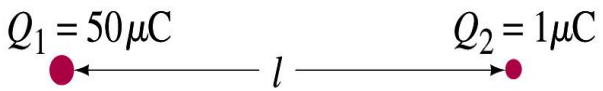


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# Advice

- Read Book, Do HW,  Go to Lab, Learn Physics
- Good grade will follow

# Quiz

1) Where can you find my lecture notes?

2) Have you used Clickers before?

3) Do you think we should get them for this class?

4) Is the cost a “hardship for you?

5) If you double the charge on each of two equal magnitude charges and also double the distance between them, what happens to the electric force between them?

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