PHYSICS 227

Analytical Physics 2A

"ELECTRICITY + MAGNETISM"

http://www.physics.rutgers.edu/ugrad/home.html

Google: physics 227

Preliminaries

- Website → Iclicker / mastering physics } register

- Parallel lab class 229 starts 10th Sept
- Each class will involve
  - brief quiz on reading (1 point if right)
  - 2/3 Q's (2 points for partpn)
- Recitations T/W
- Details on website.

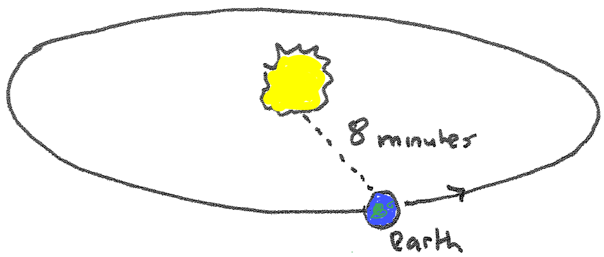
We live in a wireless age, in which almost every activity in our lives - from our toothbrush to our cell phone - everything depends on our mastery of the forces of E&M. Anyone hoping to prosper in the wireless world needs to know about the concepts & principles of electromagnetism that keep our world afloat.

In this course you will learn these concepts. You will learn that electromagnetism isn't just a nerdy paradise, but that its discovery, understanding and mastery was one of the crowning cultural & intellectual triumphs of the 19th C.

This will be a tough course in which I shall expect you to think conceptually, in which I will ask you not just to accumulate a list of equations for plugging into but to spend the time to ponder deeply about the ideas we're going to discuss together.

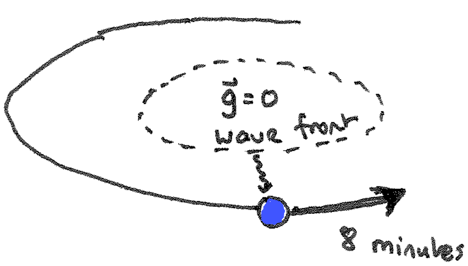
I want you above all, to go away with an understanding of the Electro-Magnetic field. You come here now with a basic grasp of Newtons picture of the universe - in which forces act "at a distance", instantaneously travelling through empty space. What we are going to learn, is that space is not empty - but instead it is full of seething electro-magnetic fields, which do not act instantaneously, but move at the speed of light. Our journey together, will take us from the age of Newton, to the dawn of the age of Einstein

Q1 : To get you thinking about fields, and to test that we can all use the PRS system.



FARADAY'S THOUGHT EXPT.

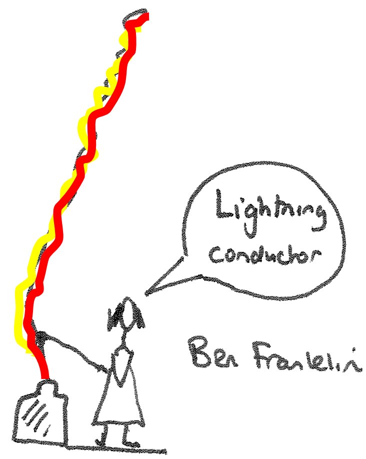
Q: What happens if the sun suddenly disappears ?



A: the earth continues to feel the gravitational field for 8 minutes until the "shockwave" of the sun's absence arrives at earth.

L1	CHARGE + COULOMB FORCE
L2	ELECTRIC FIELD

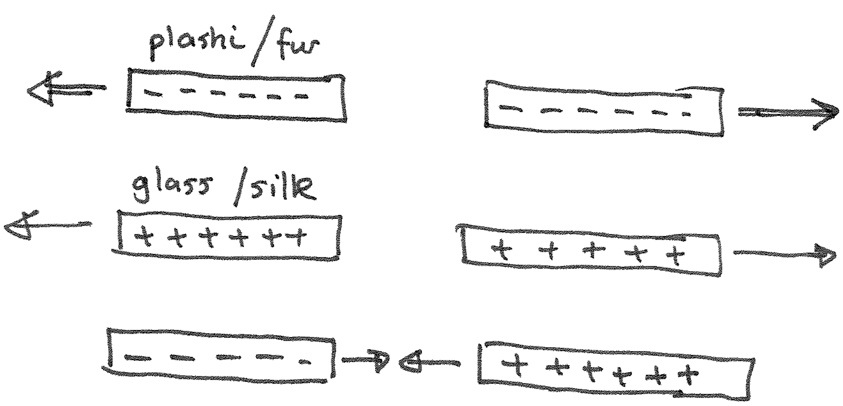
1752 Ben Franklin "collects" lightning in a Leiden jar in Philly.



- Charge +ve & -ve

LIKE CHARGES REPEL
OPPOSITES ATTRACT

- Current - electricity is the flow of charge.



- One basic unit of charge

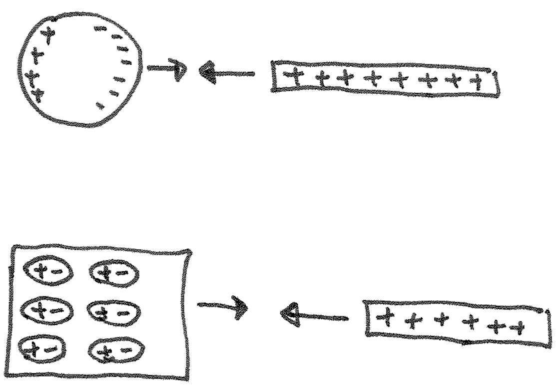
$$e = 1.602\ldots \times 10^{-19}\ C$$

$$q_e = -e \qquad q_p = +e$$

- Charge is always conserved. Depp principle of physics. Tested to incredible accuracy

Matter
- → metals — electrons are mobile
- → insulators — electrons are localized

Induced polarization → weak in insulators
→ stronger in metals



Hair; wood

Forces between charges are stronger when they are closer.

Conceptual question Q21.1 ; 21.3.

21.3 Coulombs Law

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

$k = 8.988... \times 10^9 \, N C^{-2} m^2$

$\triangleq 9 \times 10^9 \, N C^{-2} m^2$

$k = \frac{1}{4\pi\epsilon_0}$ ϵ_0 = permittivity of vacuum

$= 8.854 \times 10^{-12} \, C^2/N m^2$

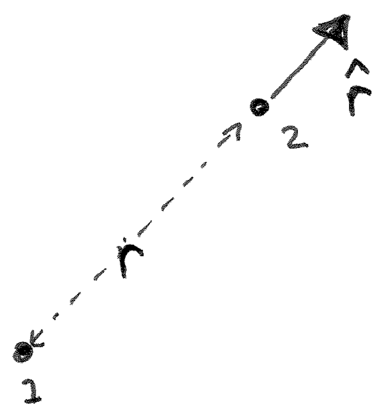
$$|F| = k \frac{|q_1 q_2|}{r^2} = \frac{9 \times 10^9 \times |10^{-6} C \times -10^{-6} C|}{(3 \times 10^{-2} m)^2}$$

$= 10 N$ BIG

attractive

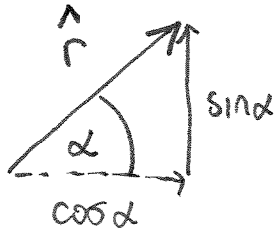
Force is a vector

$$\vec{F}_{1\,on\,2} = k \frac{q_1 q_2}{r^2} \hat{r}_{12}$$

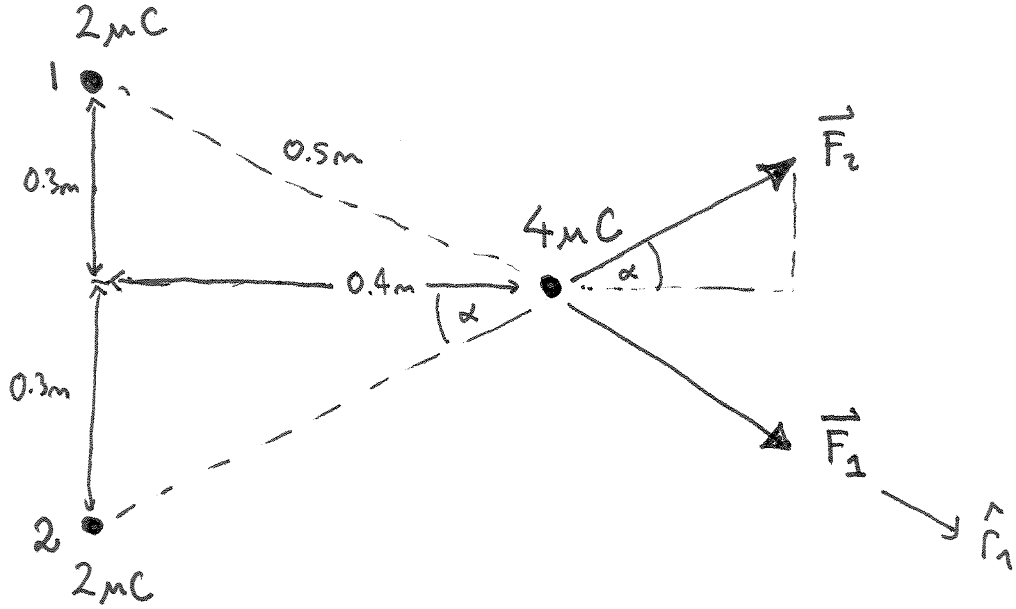


$\hat{r}_{12}$ = unit vector pointing from 1 to 2

$$= \frac{\vec{r}_{1\to 2}}{|r|}$$



$$\hat{r} = \cos\alpha\,\hat{i} + \sin\alpha\,\hat{j}$$



$$|F_1| = |F_2| = k\,\frac{(2\times10^{-6}C)(4\times10^{-6}C)}{0.3^2 + 0.4^2} = 0.288\ N$$

$\cos\alpha = 4/5$

$\sin\alpha = 3/5$

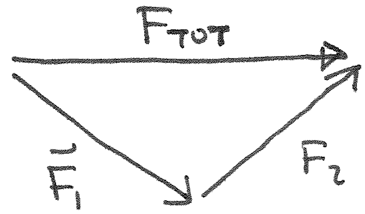
$$\hat{r}_1 = \cos\alpha\,\hat{\imath} - \sin\alpha\,\hat{\jmath} = \frac{4}{5}\hat{\imath} - \frac{3}{5}\hat{\jmath}$$

$$\hat{r}_2 = \cos\alpha\,\hat{\imath} + \sin\alpha\,\hat{\jmath} = \frac{4}{5}\hat{\imath} + \frac{3}{5}\hat{\jmath}$$

$$\vec{F}_1 = 0.288\,\hat{r}_1 = 0.288\left(\frac{4}{5}\hat{\imath} - \frac{3}{5}\hat{\jmath}\right) = 0.23\hat{\imath} - 0.173\hat{\jmath}$$

$$\vec{F}_2 = 0.288\,\hat{r}_2 = 0.288\left(\frac{4}{5}\hat{\imath} + \frac{3}{5}\hat{\jmath}\right) = 0.23\hat{\imath} + 0.173\hat{\jmath}$$

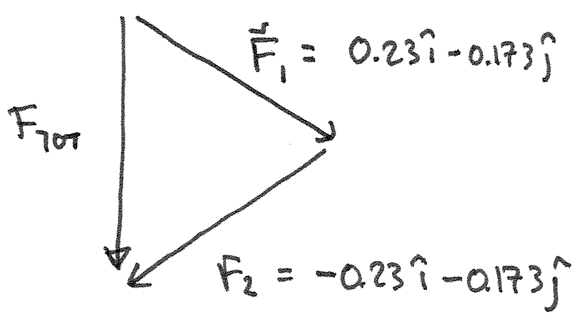
$$\vec{F}_{TOT} = \vec{F}_1 + \vec{F}_2$$



$$= 0.288 \times \frac{4}{5} \times 2\,\hat{i}$$

$$\boxed{\vec{F}_{TOT} = 0.46\,\hat{i} \quad N}$$

What happens if $q_2 = -2\mu C$



$$\vec{F}_{TOT} = -2 \times (0.173)\,\hat{j}$$

$$= -0.346\,\hat{j} \quad N$$