

THINGS TO NOTE

- All material related to the course is available at the course website:
<http://www.wpi.edu/Academics/Depts/Physics/Courses/ph1120b07/ph1120b07.html>

WPI Physics Homepage → Student Resources → Physics Courses Online → PH1120B08

- All questions concerning registration, exam scheduling, absence from classes, special needs etc. should be addressed to Prof. Keil.
- All questions concerning Labs (absences, makeups etc.) should be addressed to Mr. Fred Hutson, the Lab Coordinator.
- My office hours: Mon 11am-12pm, Tue/Thu 2-3pm or by appointment.
- Organization of the course is largely similar to that of PH1110:
4 Study Guides, 4 Exams, Mastering Physics homeworks, Summary homeworks, labs, etc. Same text also! See handouts for full details.
- Labs begin on **Thu, Oct 30**. Make sure you attend!
- First Mastering Physics assignment is due Wed 10/29 by midnight. Generally, a MP assignment is due every lecture day by midnight, **but no assignments are due on the four exam days**.

ELECTRIC CHARGES

The unit of electric charge is the coulomb (C)

OBJECT	CHARGE	MASS
Electron	$-1.6 \times 10^{-19}\text{C}$	$9.1 \times 10^{-31}\text{kg}$
Proton	$+1.6 \times 10^{-19}\text{C}$	$\sim 2000m_e$
Neutron	0	$\sim 2002m_e$
Charges generated by friction	1nC to 1 μC	
Lightning bolt	10C	
Copper penny	+137,000C -137,000C	3.11 gm Z = 29, A=63.5

Charge units:

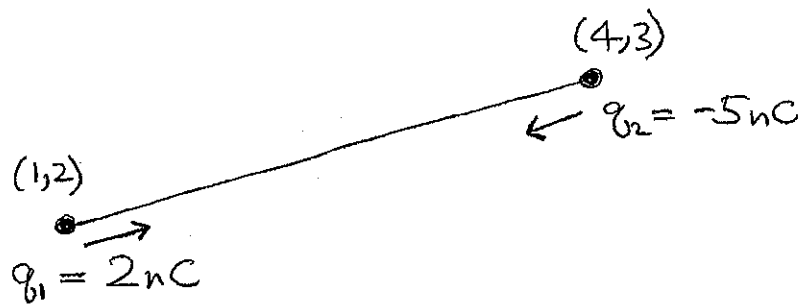
$$1 \text{ mC} = 1 \text{ milli-coulomb} = 10^{-3} \text{ C}$$

$$1 \mu\text{C} = 1 \text{ micro-coulomb} = 10^{-6}\text{C}$$

$$1 \text{ nC} = 1 \text{ nano-coulomb} = 10^{-9}\text{C}$$

$$1 \text{ pC} = 1 \text{ pico-coulomb} = 10^{-12}\text{C}$$

Coulomb's Law I



$$F_{1on2} = \frac{(9 \cdot 10^9)(2 \cdot 10^{-9})(5 \cdot 10^{-9})}{(\sqrt{(4-1)^2 + (3-2)^2})^2} = \frac{90 \cdot 10^{-9}}{10} = 9 \cdot 10^{-9} \text{ N}$$

$$\text{Unit vector from } q_2 \text{ to } q_1: \hat{n} = \frac{(1-4)\hat{i} + (2-3)\hat{j}}{\sqrt{3^2 + 1^2}} \\ = -0.947\hat{i} - 0.316\hat{j}$$

$$\vec{F}_{1on2} = (9 \cdot 10^{-9})(-0.947\hat{i} - 0.316\hat{j}) = \\ = -8.53 \times 10^{-9}\hat{i} - 2.85 \times 10^{-9}\hat{j} \text{ N}$$

$$\text{By Newton's 3rd law } \vec{F}_{2on1} = -\vec{F}_{1on2} \\ = 8.53 \times 10^{-9}\hat{i} + 2.85 \times 10^{-9}\hat{j} \text{ N}$$

One-hundredth of one percent (i.e. 10^{-4}) of the electrons in a copper penny are transferred to another penny, so that the original penny is left with a positive charge and the other acquires an equal and opposite negative charge. The pennies are then placed 100m apart (the length of a football field).

The force of attraction between the pennies is

- (a) so small as to be unnoticeable
- (b) about the weight of a penny
- (c) about the weight of a human being
- (d) about the weight of an automobile (1 auto = 2 tons = 2000kg)
- (e) about the weight of 5000 automobiles

The correct answer is closest to (e). The magnitude of the net charge on each penny is $(10^{-4})(137,000\text{C}) = 13.7\text{C}$. From Coulomb's law, the magnitude of the force between the pennies is $1.69 \times 10^8 \text{ N}$. This is the same as the weight of 8618 autos (taking each auto to have a mass of 2000kg or a weight of 19,600 N).

Moral: such large charge imbalances never arise in practice. If a penny ever has its charge balance upset significantly, large forces arise, as a result of which the penny attracts other charges (from the air or neighboring objects) and quickly neutralizes itself.