Physics 208: Fundamentals of Physics II

Asst. Prof. Matthew DeCamp

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Office Hours: Tues 2-5pm in Phys. Help Center (SHL 101A)

Welcome Back!

Students on "wait-list" please see me after class

Discussion section TAs:
Sec: 020, 021, 022, 023 Fariah Nasir
Sec: 024, 025, 026, 027 Nagitha Ekanayake

Lab section TAs:
Sec: 020, 025, 026 Brendan Harris
Sec: 022, 023, 027 Aaron Loether
Sec: 021, 024 Peng Cao

Prior material assumed for course

- Sakai access
  - All announcements/class notes will be available via Sakai
- I will assume you have mastered all material in Physics 207 (e.g. Forces, Energy, Vectors)
- Co-requisite is Math 242.
  - I will assume that you can differentiate and/or integrate simple functions (e.g. x, x^2, $\sin(x)$, $\ln(x)$)
  - We will also use simple "multi-dimensional calculus"
    - Including Cartesian, cylindrical, and spherical coordinates
    - Dot product/Cross product
  - First discussion section will be dedicated to a math refresher

Course requirements

- **Weekly Homework Assignments (15%)**
  - WileyPLUS
  - Due Wednesdays at noon
  - Late homework will receive 25% penalty
  - Lowest homework score will be dropped at the end of the semester
- **Weekly Homework Quizzes (15%)**
  - In discussion section
  - Lowest Quiz score will be dropped at the end of the semester
- **Laboratories (15%)**
  - **Labs start week of Sept. 10**
- **Two in class Midterm Exams (15% each)**
  - Tuesday **Oct. 9** and Thursday **Nov. 8**
  - Closed Book/Closed Note
  - Only covers recent material
- **Cumulative Final Exam (25%)**
  - Closed Book/Closed Note
  - Scheduled by Registrars office

Approximate Grading Scale (subject to change)

A	90-100
A-	86-90
B+	82-86
B	78-82
B-	74-78
C+	71-74
C	67-71
C-	64-67
D+	60-64
D	57-60
D-	53-57
F	<53

WileyPLUS

Registration Tutorial:

https://www.wileyplus.com/WileyCDA/Section/id-406168.html

UD student policy on academic honesty

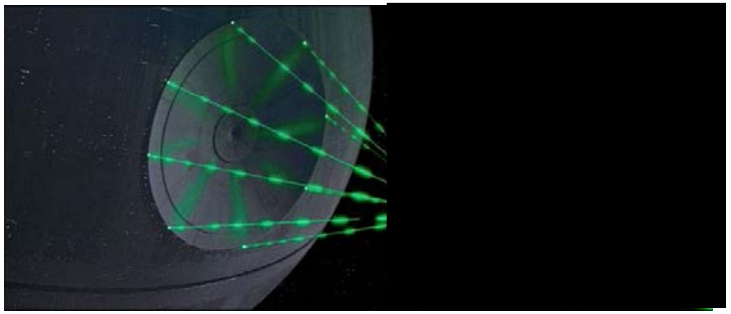
"All students must be honest and forthright in their academic studies. To falsify the results of one's research, to steal the words or ideas of another, to cheat on an assignment, or to allow or assist another to commit these acts corrupts the educational process. Students are expected to do their own work and neither give nor receive unauthorized assistance.

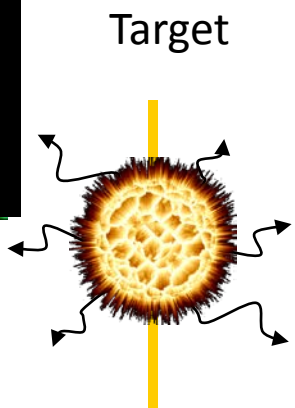
Any violation of this standard must be reported to the Office of Student Conduct. The faculty member, in consultation with a representative from the Office of Student Conduct, will decide under which option the incident is best filed and what specific academic penalty should be applied."

- For Physics 208, this will be strictly applied for exams and laboratory reports. In particular, any use of unauthorized materials or assistance will be reported.
  - Including smart phones, calculators, tablets, etc.

My interest in Physics 208

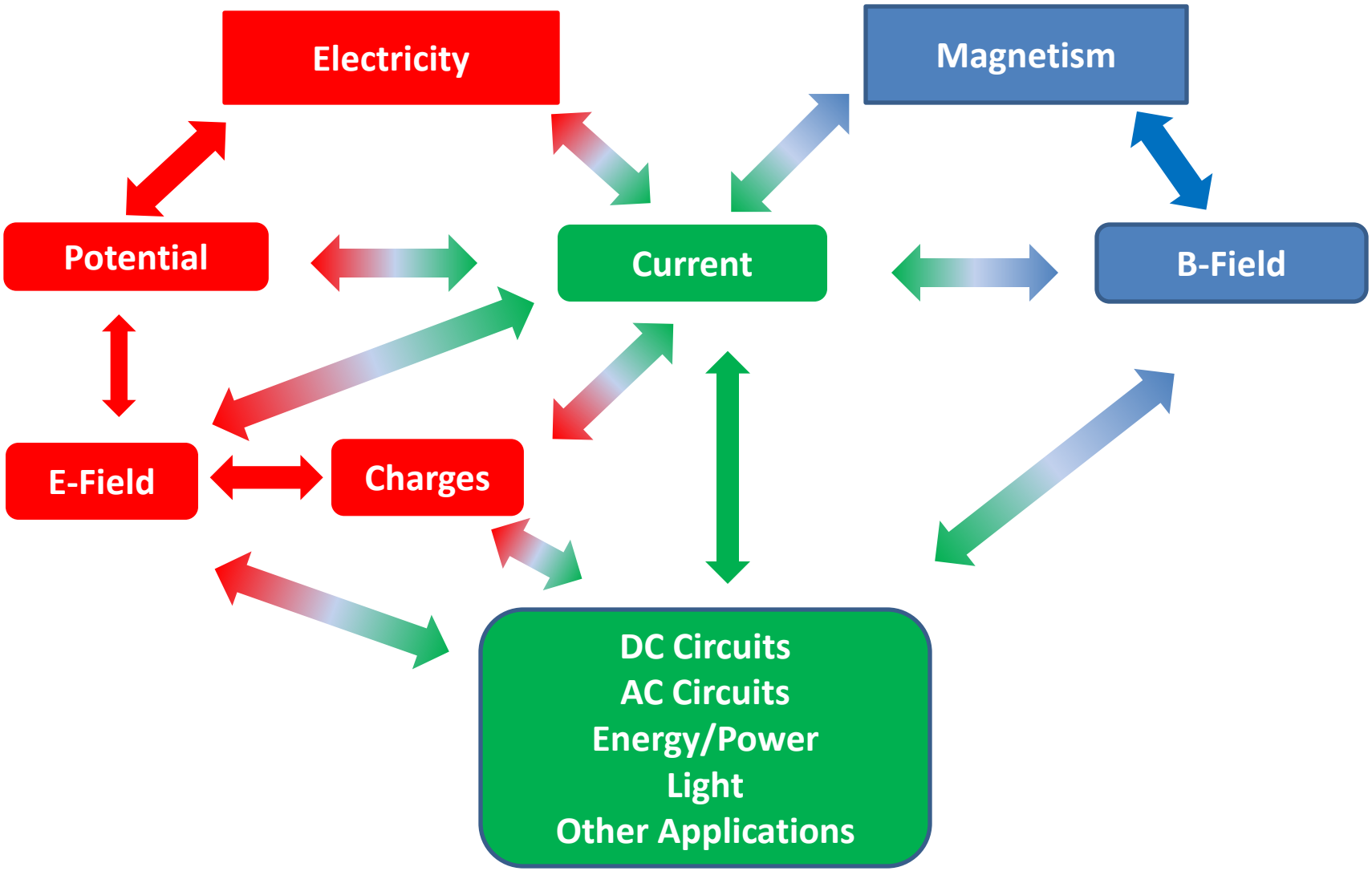
- Experimental Atomic, Molecular, and Optical Physicist
  - Atomic/molecular bonds dictated by electric/magnetic interactions
  - Ultrafast Laser Science
- Research is to “build big lasers and blow things up”
- Light is an “electromagnetic wave”





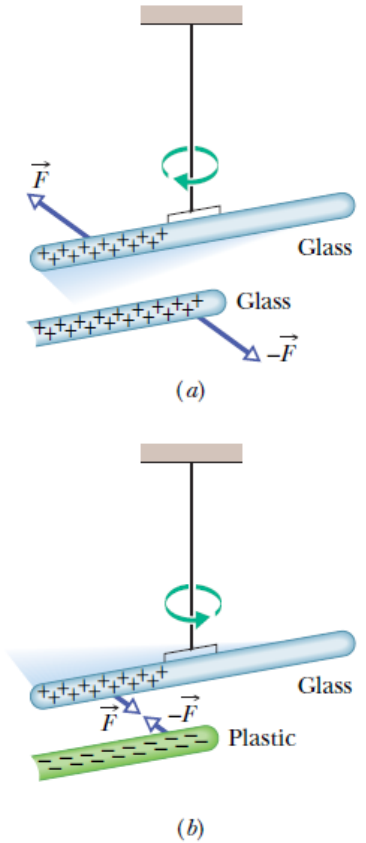
Uses: Protein Folding, light induced chemistry, photovoltaic devices, laser fusion

Electromagnetism



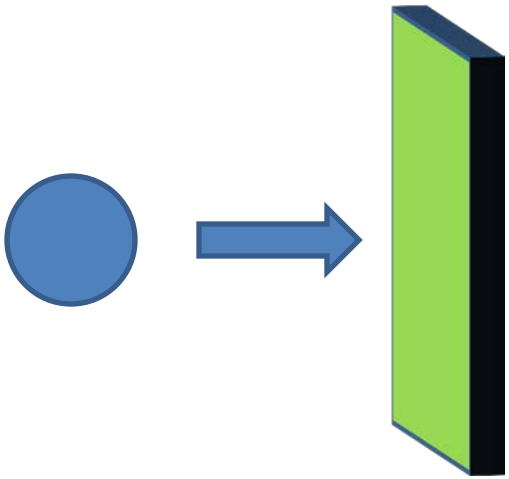
What is Electric Charge?

- Fundamental property of particles (Like Mass)
  - Can be “positive” or “negative”
  - Unit is the “Coulomb”
- Quantized amount
  - Smallest stable charge is the charge of one electron “e”=1.6x10^{-19} Coulomb
    - fundamental physical constant
    - Proton =+e
    - Electron =-e
    - Neutron = +e+(-e)=0
  - Charge on material is integer number of e
  - “Neutral” particles have equal number of positive and negative charges
- Charges interact with each other.
  - Opposites attract
  - Likes repel
- Charges cannot be created or destroyed. They can only be transferred.



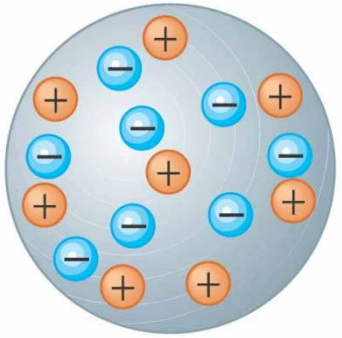
What is electrical current?

$$i = \frac{dq}{dt}$$

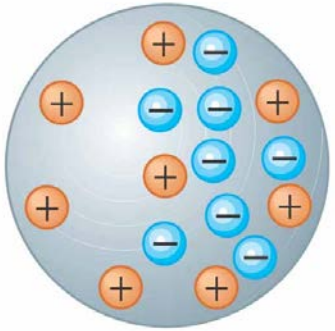


The amount of charge that passes through a particular point.
While charge is a scalar, current is a vector (i.e. direction of flow).

Conductors/Insulators



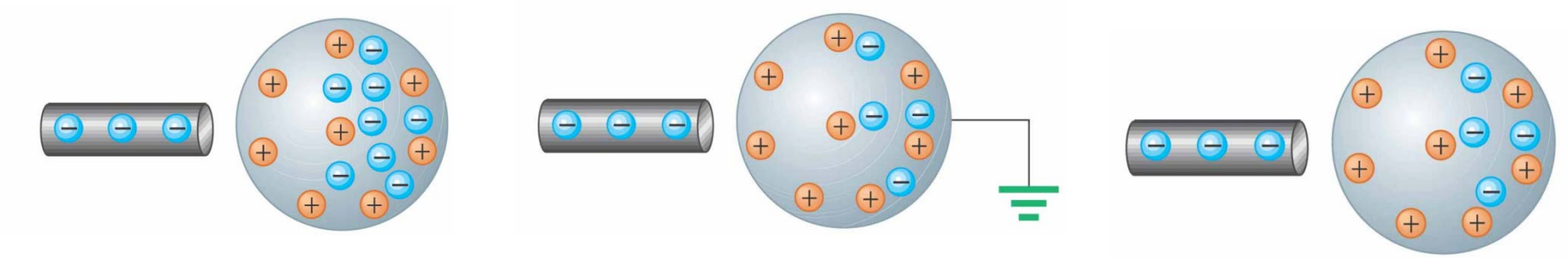
- Conductors
  - Materials through which charges can move freely
    - Metals
    - Superconductors (perfect conductors)
    - Electrons that can move are called “conduction electrons”
- Insulators
  - Materials through which movement of charges is hindered
    - Rubber
    - Plastic
    - Glass
  - Very few (if any) free electrons available
  - Can be polarized



- Semiconductors
  - Materials that can behave as both an insulator and a conductor
    - Silicon
    - Germanium

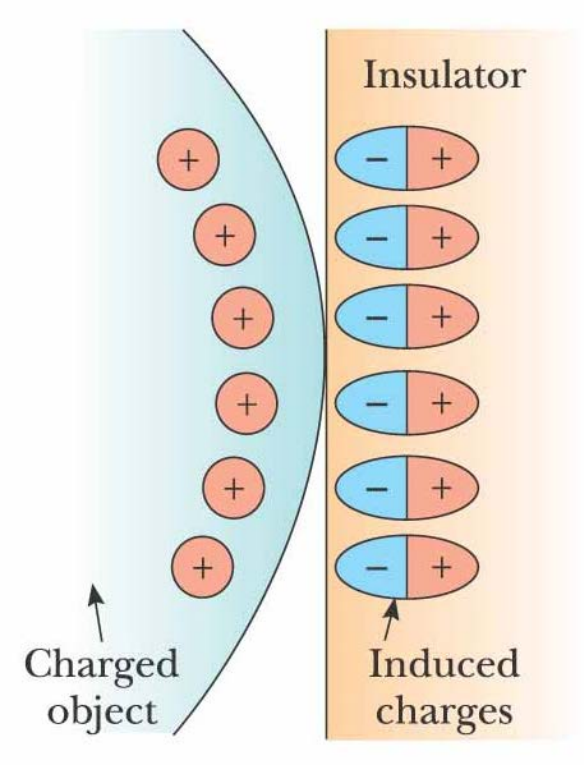
Transferring Charge

- Direct Contact
  - A charged conductor in contact with a neutral conductor will cause charges to move
  - “Direct contact” can be through intermediary
    - “Arcing”
- Charging by induction
  - Charged object can induce charge with out touching



Charge Rearrangement in Insulators

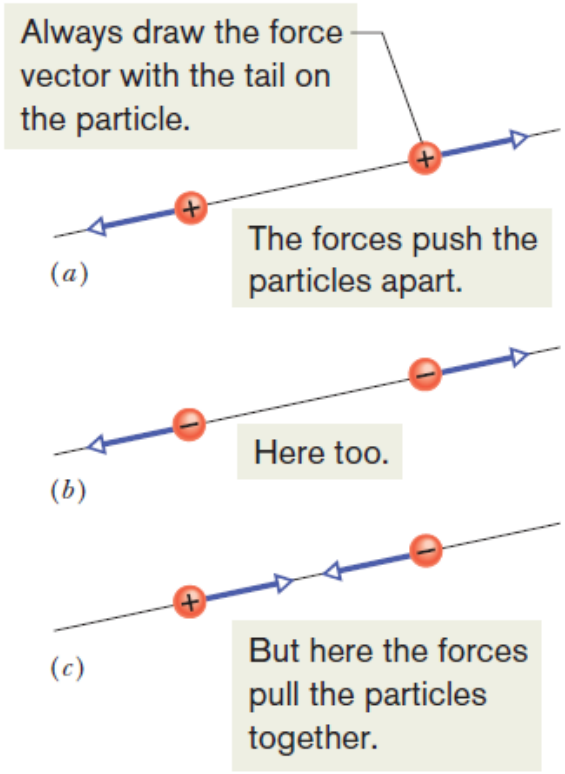
- Similar to charging by induction
  - Like charges repel



Object is now “polarized”

Forces on charges

- We know that charges can move, what determines the “dynamics”?
- Coulomb’s Law



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

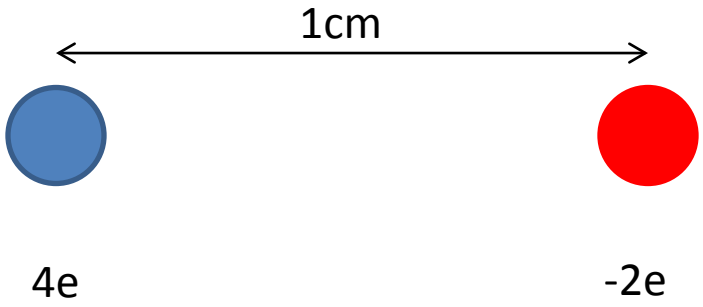
$$k = \frac{1}{4\pi\epsilon_o} = 8.99x10^9\, Nm^2/C^2 \qquad \epsilon_o = 8.85x10^{-12}\, C^2/Nm^2$$

Permittivity of free space

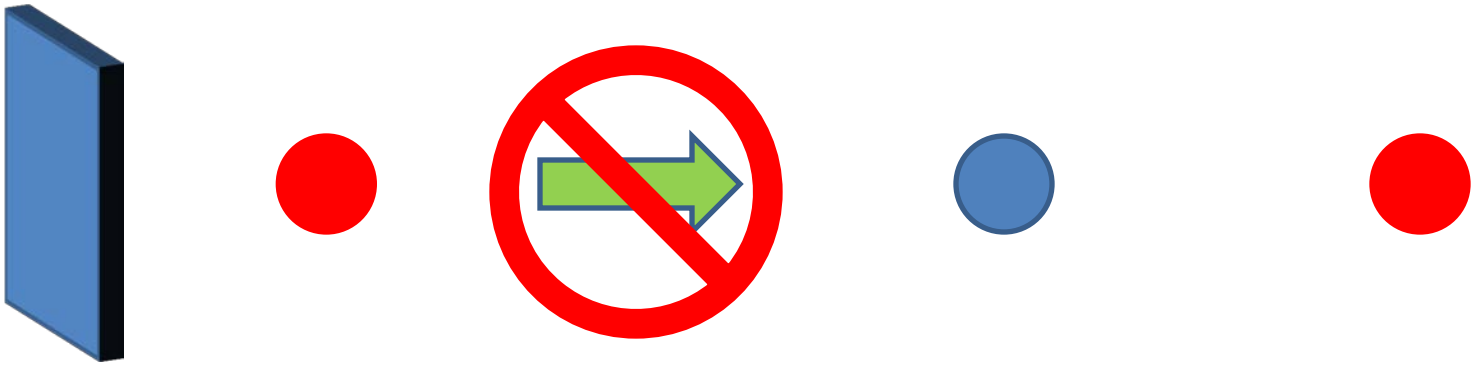
Looks like Newton’s Law of gravity.
Acts like Newton’s law of gravity
Note: if force is positive (negative) it is repulsive (attractive)

Coulomb's Law

- Example: What is the electrical force between these particles



- This only works for point charges!

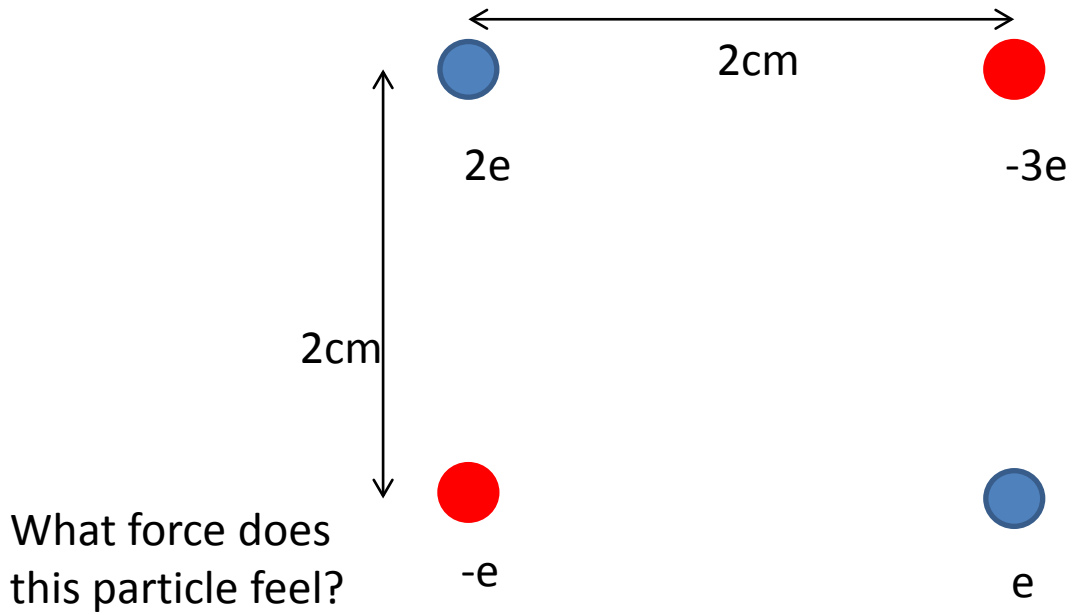


However, if the charge distribution is spherical, you can treat the object as a point particle outside the sphere. (we will prove this later)

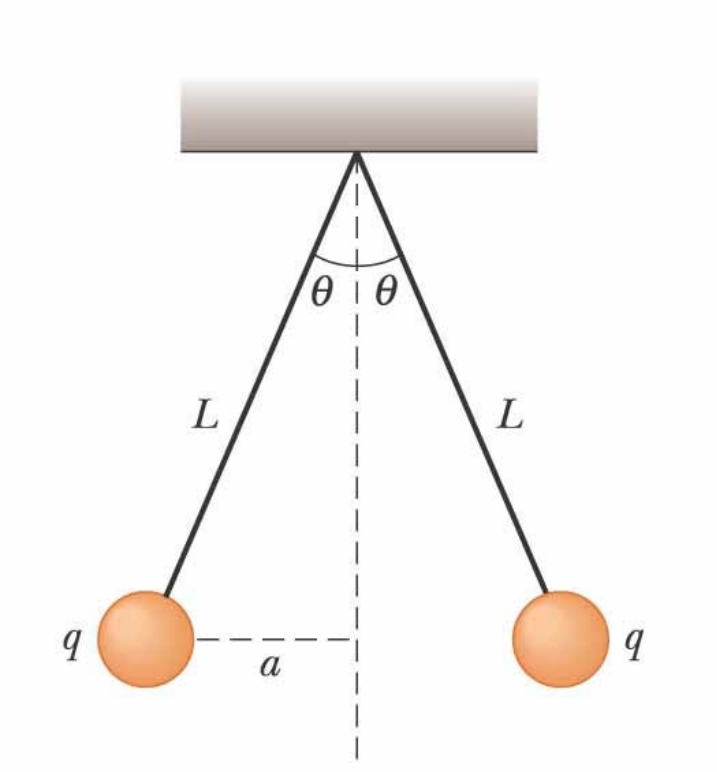
Vector nature of Electric forces

- Just like gravity, superposition holds

$$\overrightarrow{F_{tot}} = \overrightarrow{F_1} + \overrightarrow{F_2} + \ldots + \overrightarrow{F_n}$$



Electrical vs other forces

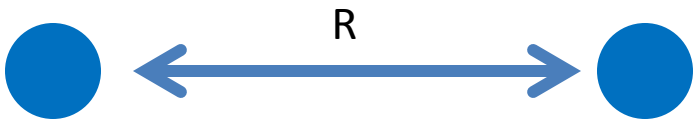


If the two spherical masses (mass m) with equal charge are hanging from two massless wires (length L) at equilibrium, what is the charge on the two particles?

Electrical force vs Gravitational Force: Who Wins?

$$F_{grav} = \frac{GMm}{r^2}\hat{r}$$

$$F_{elec} = \frac{1}{4\pi\epsilon_o}\frac{Qq}{r^2}\hat{r}$$



Two protons (Mass=1.67x10^{-27}kg, Charge 1.6x10-^{19} C) are separated by R. What is the ratio of the gravitational force to the electric force between the two particles

G=6.67x10^{-11}m^3/kgs^2

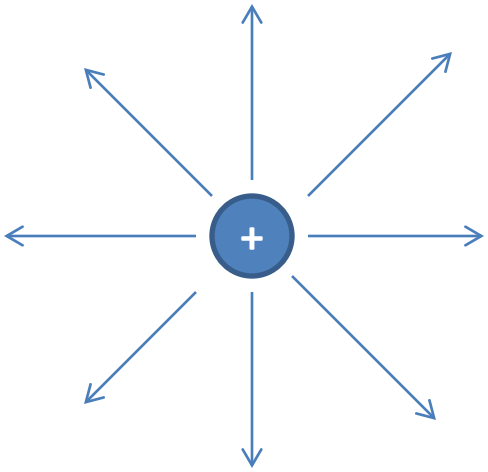
$$k = \frac{1}{4\pi\epsilon_o} = 8.99x10^9\ Nm^2/C^2$$

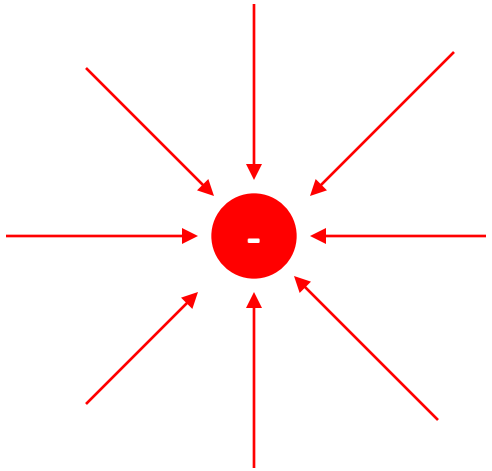
The Electric Field

$$\vec{F}_{12} = \frac{1}{4\pi\epsilon_o}\frac{q_1 q_2}{r^2}\hat{r}$$

Define the electric field due to charge 1 as:

$$\vec{E} = \frac{\vec{F}}{q_2} = \frac{1}{4\pi\epsilon_o}\frac{q_1}{r^2}\hat{r}$$



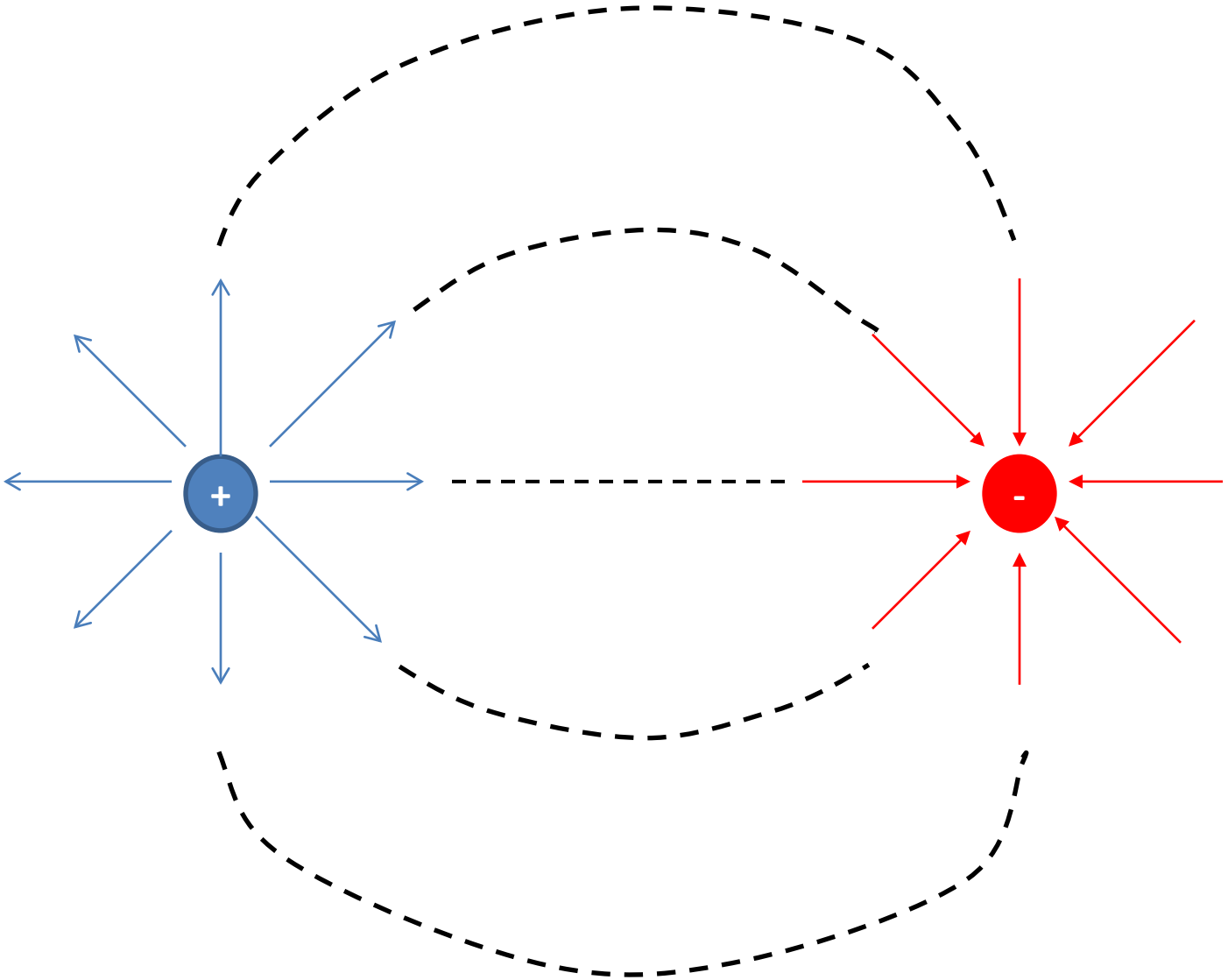


Still only valid for point like charges

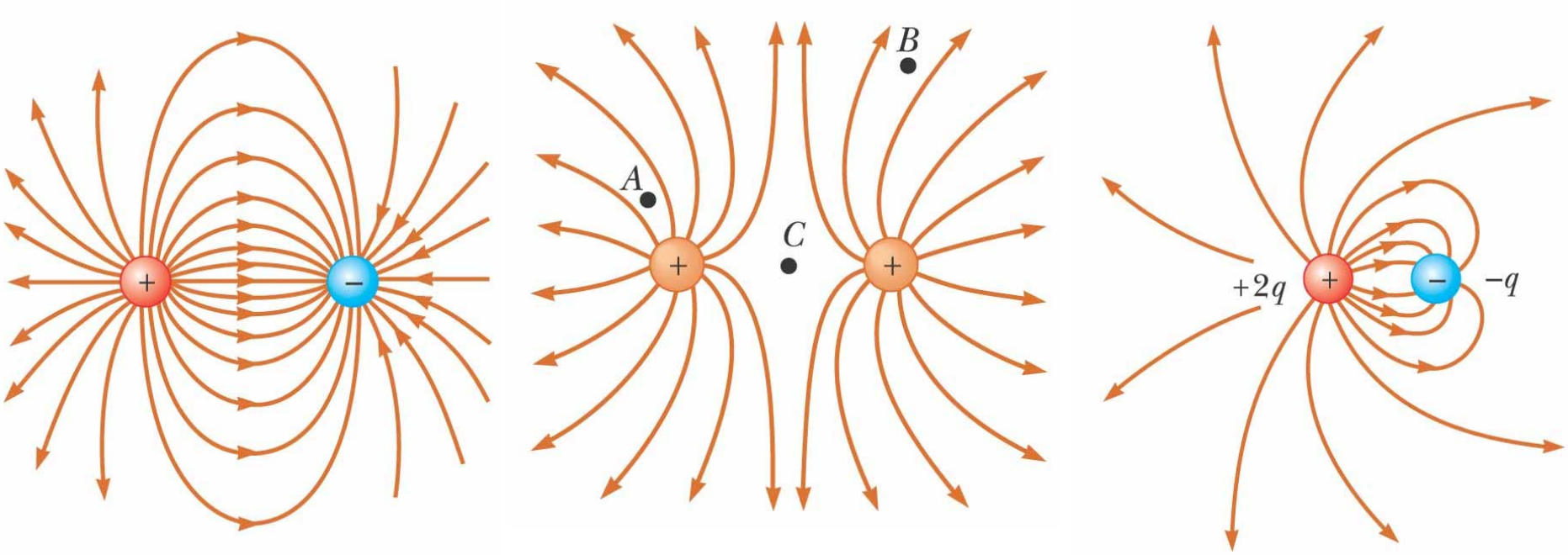
E-Field II

E-field is a vector, so the field adds like a vector

$$\overrightarrow{E_{tot}} = \overrightarrow{E_1} + \overrightarrow{E_2}$$

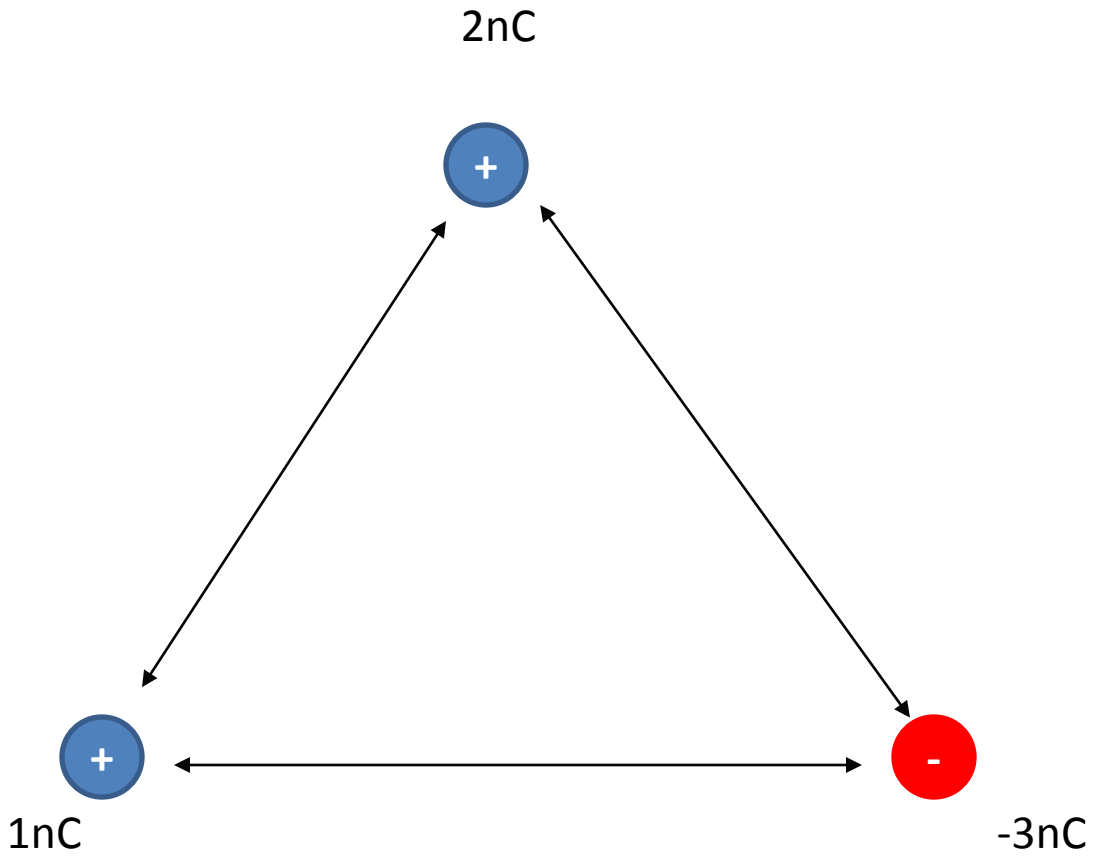


Field patterns



- All field lines start from positive charges, end at negative charges
- Number of lines proportional to charge
- Field lines cannot cross in free space

Example



If three equal mass point charges are arranged in equilateral triangle, what is the electric field at the center of mass?