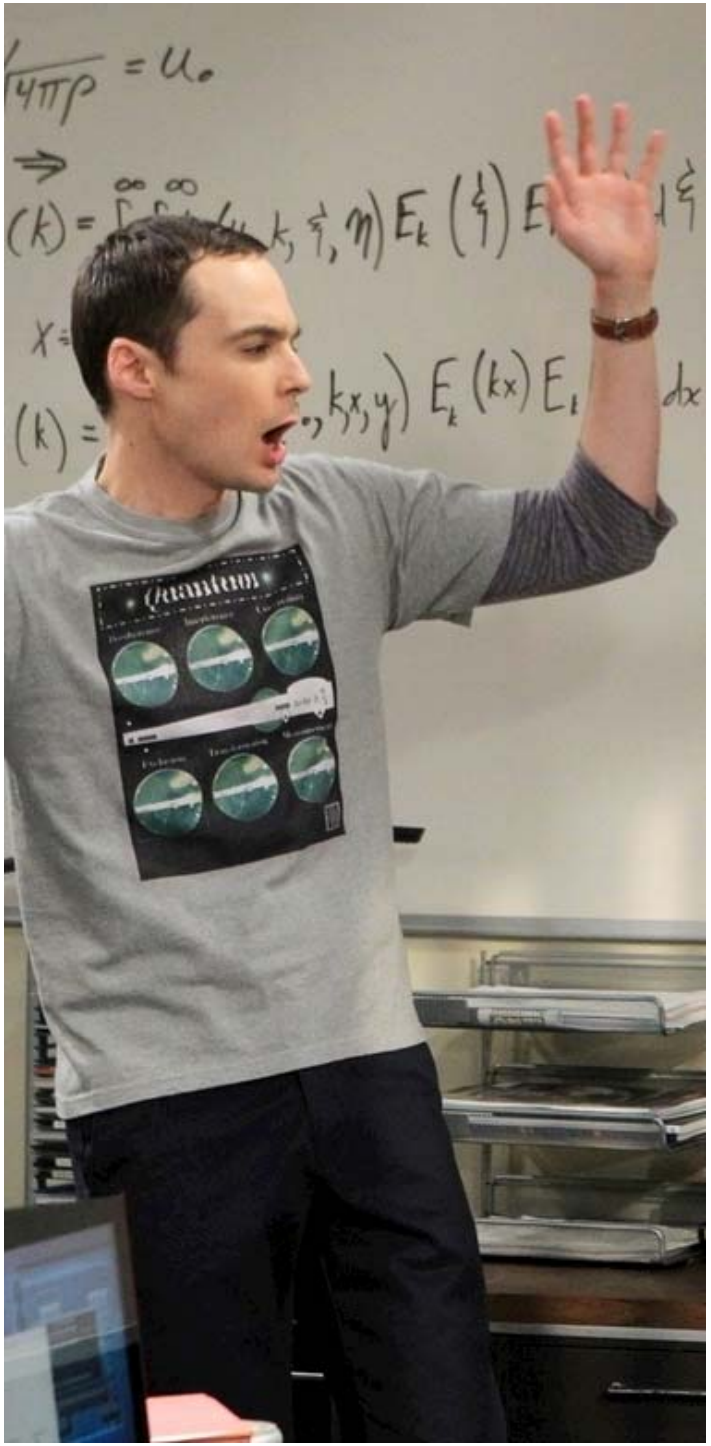
This week

- Exam on Friday!
- No quiz this week!
- No homework!
- Sample exam available in Canvas.
- Summary slides on Schedule page
- Q&A session on Thursday (here) – when?
  - 4-5 PM
  - 5-6 PM
  - 6-7 PM



The Equation of the Day

New dimensionality

$$[q] = Q$$

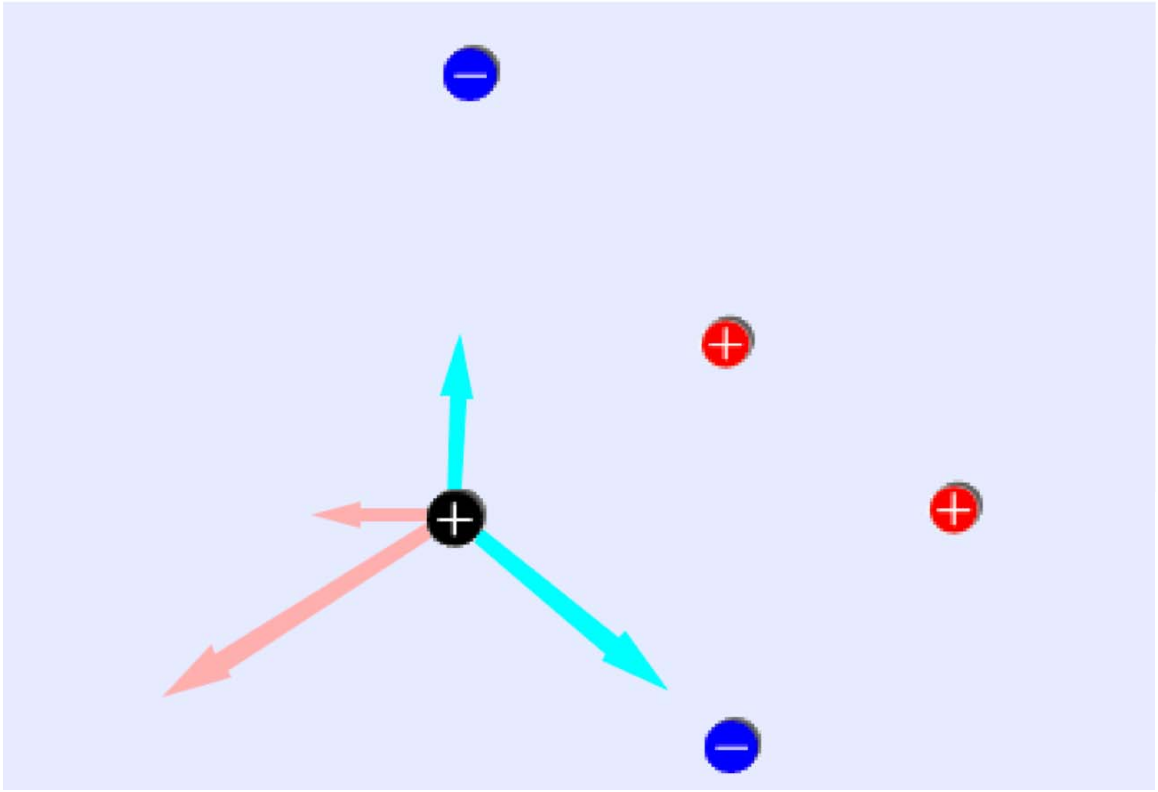
Experiencing Electrostatics

http://phet.colorado.edu/simulations/sims.php?sim=Balloons_and_Static_Electricity

Model: Charge
A hidden property of matter

- Matter is made up of two kinds of electric matter (positive and negative) that have equal magnitude and that cancel when they are together and hide matter's electrical nature.
- Matter with an equal balance is called neutral.
- Like charges repel, unlike charges attract.
- The algebraic sum of postive and negative charges is a constant (i.e, $N_+ - N_- = \text{const.}$)

Exploring charge interactions: Electric Field Hockey



https://phet.colorado.edu/en/simulation/electric-hockey

Electric forces: Foothold ideas (basic)

- There are two kinds of charges: + and -.
- Charges of the same type repel each other.
- Charges of different types attract each other.
- The force between charges gets stronger as they get closer, weaker as they get farther away.
- The electric force satisfies Newton's 3rd law.

Conductors and Insulators

- Insulators
  - In some matter, the charges they contain are tightly bound and cannot move around freely.
  - Excess charge put onto this kind of matter tends to just sit there.
- Conductors
  - In some matter, charges in it can move around throughout the object.
  - Excess charge put onto this kind of matter redistributes itself or flows off (if there is a conducting path to ground).
- Unbalanced charges attract neutral matter (polarization)

Exploring charge interactions: Polarization

https://phet.colorado.edu/sims/html/balloons-and-static-electricity/latest/balloons-and-static-electricity_en.html

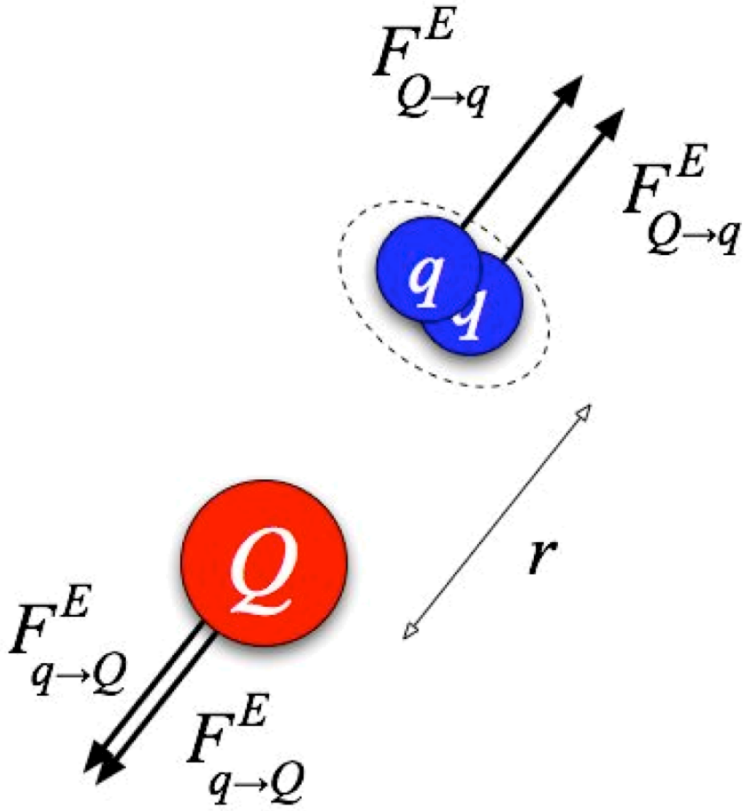
Quantifying Charge

- Need an operational definition.
- Charge is a new kind of quantity (to M, L, T, add Q).
- Choose our scale:
  A small object has a charge of 1 C (= 1 Coulomb) if two identical such charges held at a distance of 1 m exert forces of 9×10^9 N on each other.

- [This corresponds to choosing the constant $k_C = 9 \times 10^9$ N-m^2/C^2.]

Inventing an Electric Force Law

- What law should we propose?
  $F = ? / R^2$. (observed)
- What goes on top?
- We expect
  - $F_{Q\to q}$ proportional to q (Why?)
  - $F_{q\to Q}$ proportional to Q (Why?)
  - $F_{q\to Q} = F_{Q\to q}$



Foothold idea: Coulomb's Law

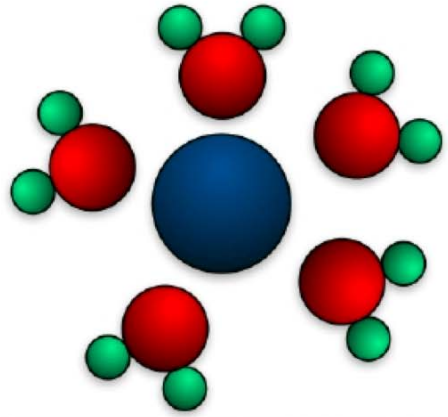
- Point charges attract each other with a force whose magnitude is given by

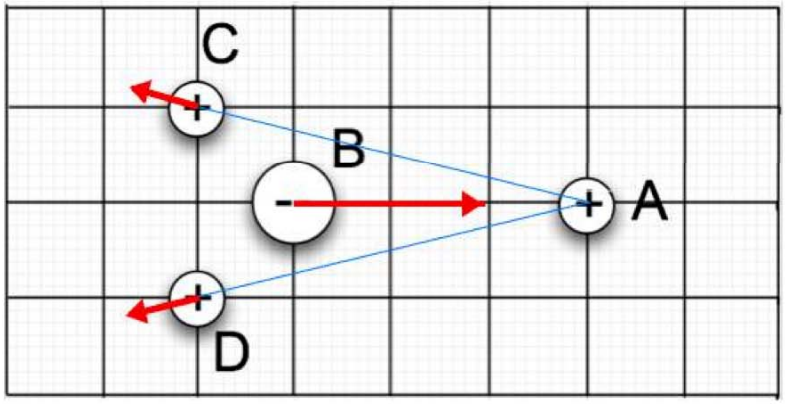
$$\vec{F}_{q\to Q} = -\vec{F}_{Q\to q} = \frac{k_C qQ}{r_{qQ}^2}\hat{r}_{q\to Q}$$

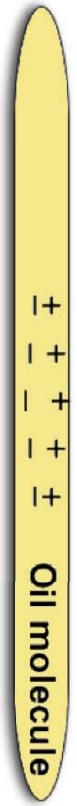
- k_C is put in to make the units come out right.

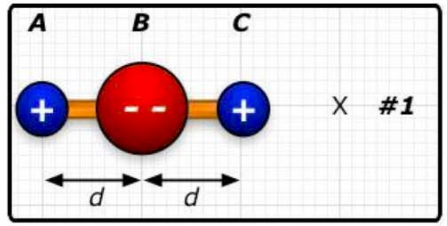
$$k_C = 9\times 10^9 \text{ N-m}^2/\text{C}^2$$

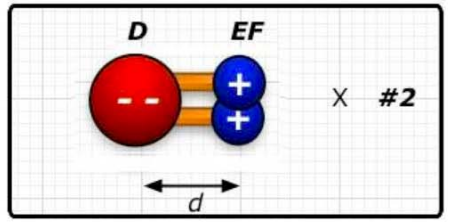
We can do lots with this!

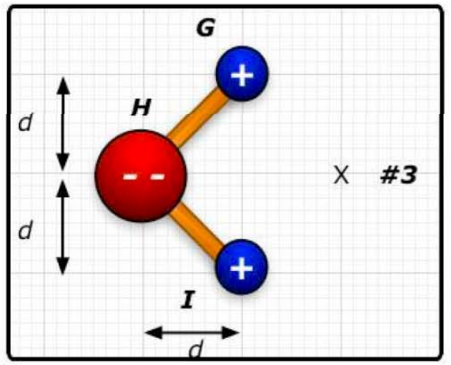












(Once we become adept at seeing how to add forces in different directions! Vectors!)