October 12, 2012 Physics 131 Prof. E. F. Redish

- **Theme Music:** MGMT
  *Electric Feel**
- **Cartoon:** Bob Thaves
  Frank & Ernest

*Thanks to Jaclyn for suggesting this song!

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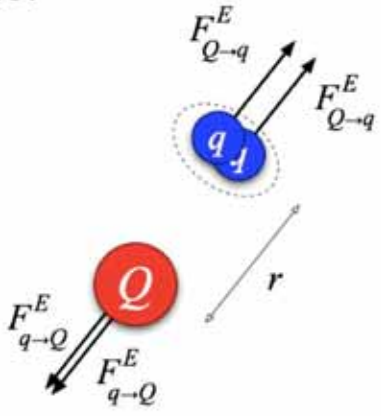
Inventing an Electric Force Law

- What law should we propose?
  $F = ? / R^2$.
- What goes on top?
- We expect
  - $F_{Q->q}$ proportional to q (Why?)
  - $F_{q->Q}$ proportional to Q (from N3)
  - $F_{q->Q} = F_{Q->q}$



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Foothold idea: Coulomb's Law

- All objects 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.

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

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Making Sense of Coulomb's Law

- Changing the test charge
- Changing the source charge
- Changing the distance
- Specifying the direction
- Interpret the sign

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

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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 x 10^9 N on each other.
- This corresponds to choosing the constant

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

Foothold ideas: Electric Forces and Fields

- When we focus our attention on the electric force on a particular charge (a test charge) we see the force it feels factors into the magnitude of its charge times a factor that depends on position (and the other charges).

$$\vec{F}_{q_0}^{E\,net} = \frac{k_C q_0 q_1}{r_{01}^2}\hat{r}_{1\to 0} + \frac{k_C q_0 q_2}{r_{02}^2}\hat{r}_{2\to 0} + \frac{k_C q_0 q_3}{r_{03}^2}\hat{r}_{3\to 0} + \ldots \frac{k_C q_0 q_N}{r_{0N}^2}\hat{r}_{N\to 0}$$

$$\vec{F}_{q_0}^{E\,net} = q_0 \vec{E}(\vec{r}_0)$$

$$\vec{E}(\vec{r}_0) = \frac{k_C q_1}{r_{01}^2}\hat{r}_{1\to 0} + \frac{k_C q_2}{r_{02}^2}\hat{r}_{2\to 0} + \frac{k_C q_3}{r_{03}^2}\hat{r}_{3\to 0} + \ldots \frac{k_C q_N}{r_{0N}^2}\hat{r}_{N\to 0}$$