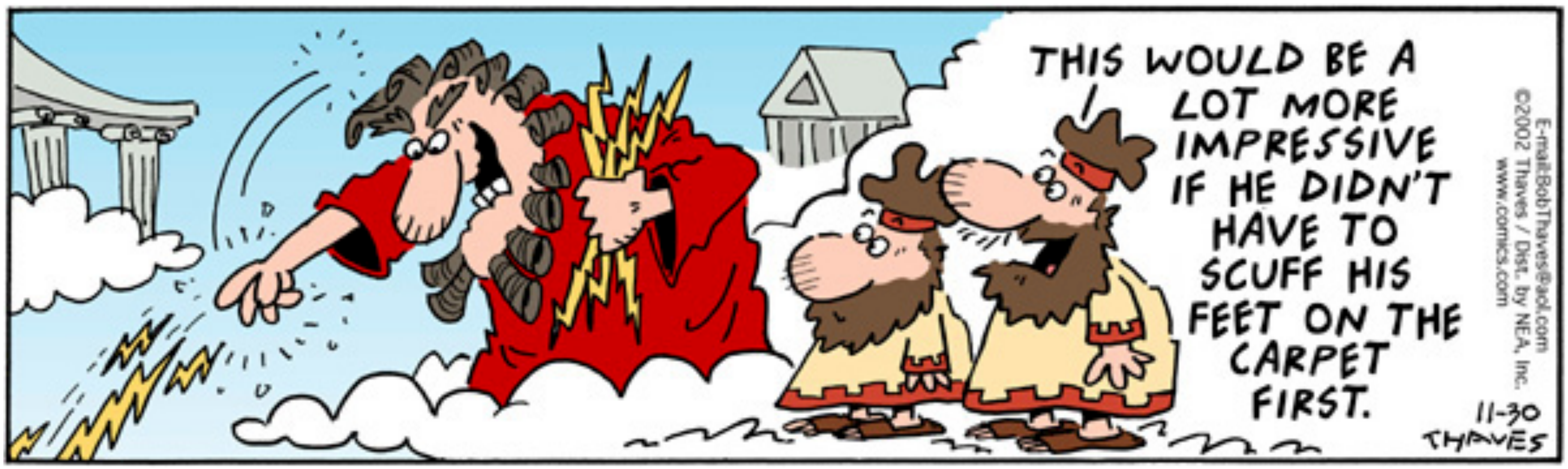
- **<u>Theme Music:</u> MGMT**
  Electric Feel*

Thanks to Jaclyn for suggesting this song!

- **<u>Cartoon:</u> Bob Thaves**
  Frank & Ernest

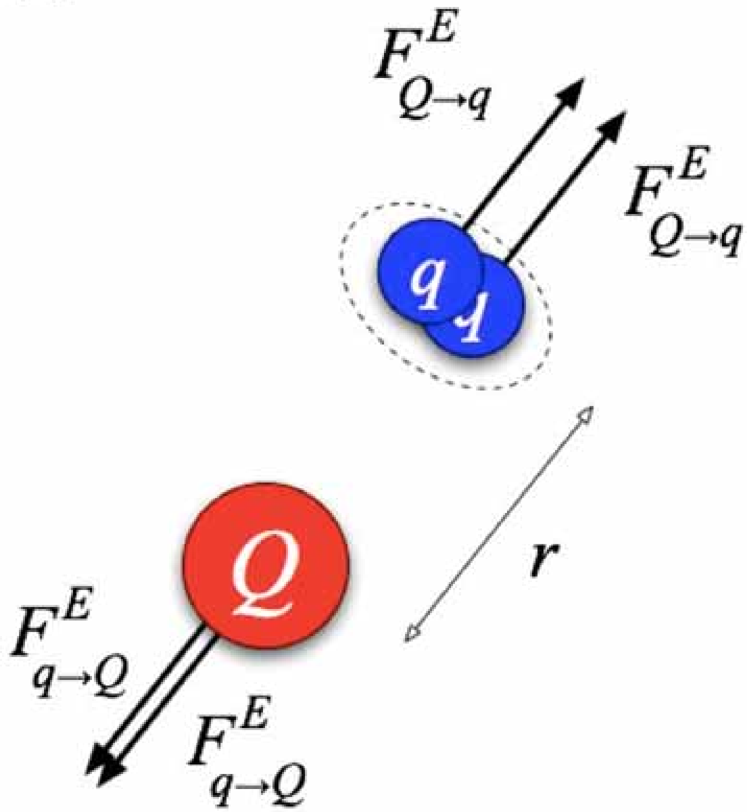


Reading question

- I don’t quite understand why we need to include the product of the two charges in our formula for force. The charge of interest only feels the force from the other charge, and when considering the motion of an object, we only consider forces that directly affect the object. Why, then, does the formula utilize the product of both charges if the one charge only feels one force?

Inventing an Electric Force Law

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



Foothold idea: Coulomb's Law

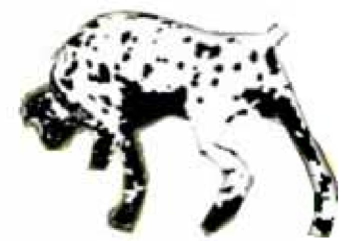
- All objects attract each other with a force whose magnitude is given by

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

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

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

Making Sense of Coulomb's Law



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

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

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

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

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).

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

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

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