• **Theme Music:** Human League  
  *Together in Electric Dreams*

• **Cartoon:** Bob Thaves  
  *Frank & Ernest*
Foothold ideas:
Charge – A hidden property of matter

• Matter is made up of two kinds of electrical matter (positive and negative) that usually cancel very precisely.
• Like charges repel, unlike charges attract.
• Bringing an unbalanced charge up to neutral matter polarizes it, so both kinds of charge attract neutral matter
• The total amount of charge (pos – neg) is constant.
Foothold ideas:  
Conductors and Insulators

• Insulators
  – In some matter, the charges they contain are bound and cannot move around freely.
  – Excess charge put onto this kind of matter tends to just sit there (like spreading peanut butter).

• 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).
Foothold idea: Coulomb’s Law

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

\[
\vec{F}_{q\rightarrow Q} = -\vec{F}_{Q\rightarrow q} = \frac{k_C q Q}{r_{qq}^2} \hat{r}_{q\rightarrow Q}
\]

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

\[k_C = 9 \times 10^9 \text{ N-m}^2 / \text{C}^2\]
Reading questions

• When discussing Coulomb's Law, we don't need to worry about the direction of the force that an object with charge Q exerts on an object with charge q if the charges are right next to each other. In other words if they are separated horizontally but not vertically so they fall on the same line. Is this correct?

• I don't understand the difference between the constants: \( R_{Qq} \) and \( R_{Q->q} \). It wasn't explained very well in the webpage 'Reading the content in Coulomb's law'. I feel like the first is describing the distance between charges Q and q while the second constant is describing the distance of the force acting on q from Q. But wouldn't these distances be the same? Why are there two variables?

• Why does the force of \( r^2Qq \) fall as the square of the distance between two charges? What is the relationship that causes that to happen?
Foothold ideas:
Energies between charge clusters

• Atoms and molecules are made up of charges.
• The potential energy between two charges is

\[ U_{12}^{\text{elec}} = \frac{k_c Q_1 Q_2}{r_{12}} \]

No vectors!

• The potential energy between many charges is

\[ U_{12\ldots N}^{\text{elec}} = \sum_{i<j=1}^{N} \frac{k_c Q_i Q_j}{r_{ij}} \]

Just add up all pairs!