- **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

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

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

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

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 the 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 subscript Qq and R subscript 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

$$U_{12}^{elec} = \frac{k_C Q_1 Q_2}{r_{12}}$$

No vectors!

- The potential energy between many charges is

$$U_{12\ldots N}^{elec} = \sum_{i<j=1}^{N} \frac{k_C Q_i Q_j}{r_{ij}}$$

Just add up all pairs!