November 16, 2011 Physics 131 Prof. E. F. Redish

- **Theme Music: John Williams**

  Learn about the force *from Star Wars*

- **Cartoon: Mike Peters**

  Mother Goose & Grimm

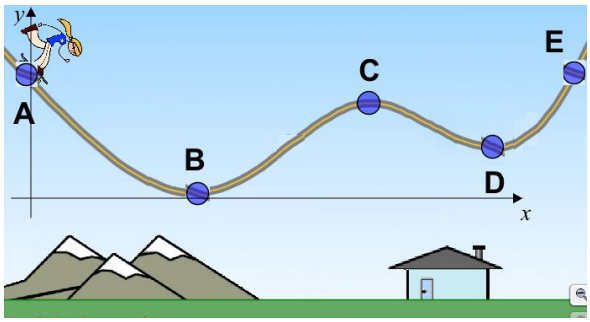
Moving to molecules

- Apply our Newtonian framework and results to atoms and molecules.
- See what goes over directly, what we have to add.
- Can we integrate what we know about atoms and molecules from chemistry with the physics we have learned?

Reading questions

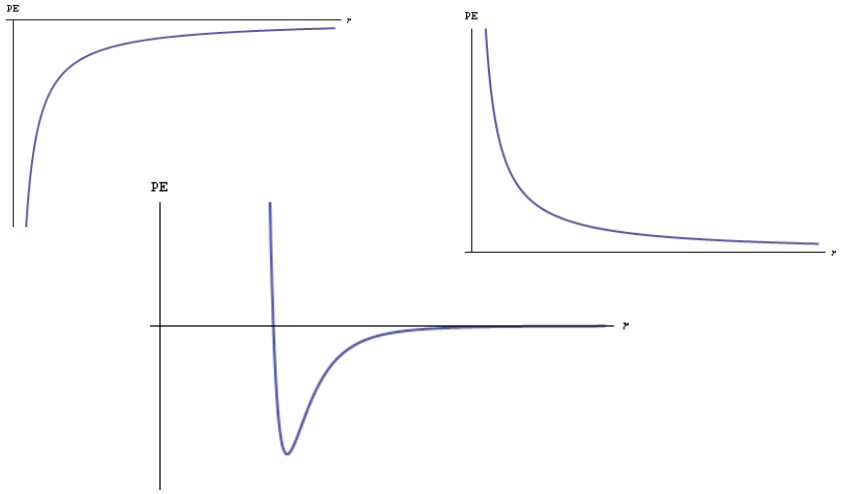
- How can electrons be found in a region where the kinetic energy is negative and still have movement if when kinetic energy reach 0 the object stops moving?
- For the second description, you stated that as the charges repel, the sign of the product of the charge is now positive. However, following that statement it says that as the charges are pushed closer together, their PE increases. I do not understand how charges that are repelling each other would be moving closer together without being pushed. Which situation is this describing?

If we have a complicated potential energy – and a mass at rest in it – can we tell where it will go when released?



How do you know?
What are the conditions under which this works?

Figures



Foothold ideas: Energies between charge clusters

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

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

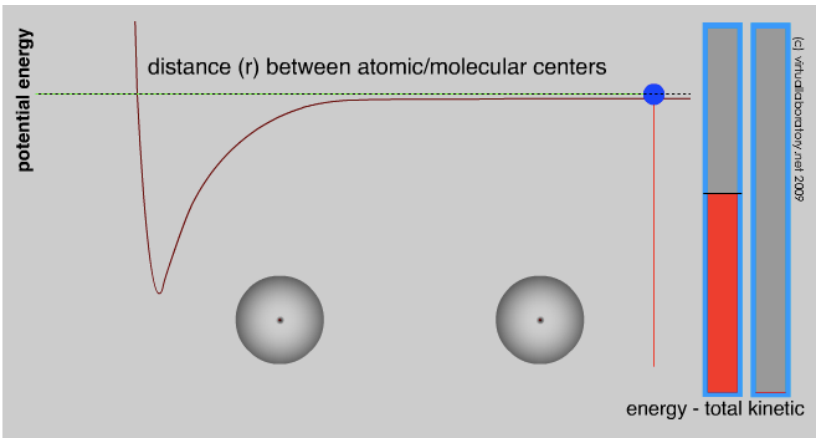
No vectors!

- The potential energy between many charges is

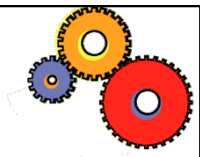
$$U_{12\ldots N}^{elec} = \sum_{i<j=1}^{N} \frac{k_C Q_i Q_j}{r_{ij}}$$

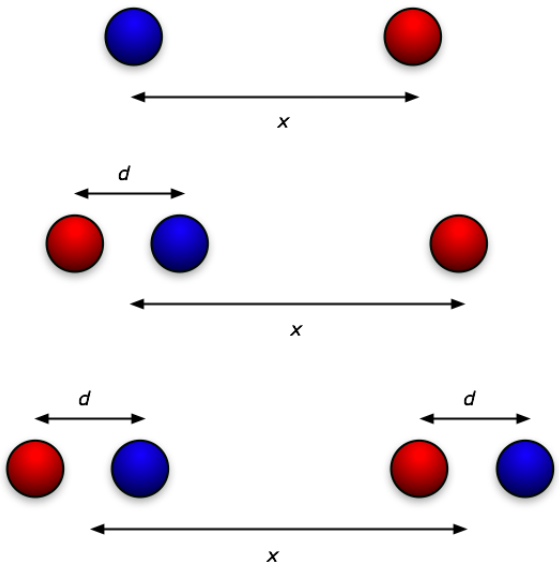
Just add up all pairs!

Molecular forces



What are the implications?

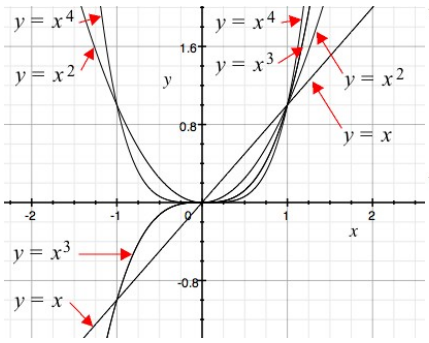




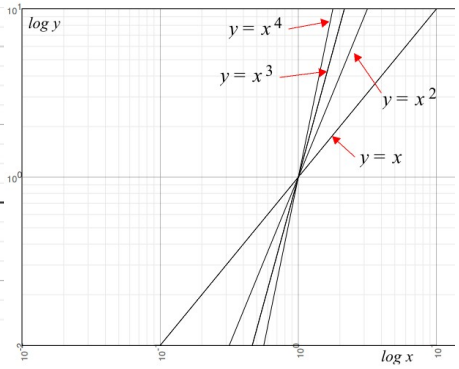
Log-log plots (positive powers)

$y = x$ $y = x^2$
$y = x^3$ $y = x^4$

Linear plot



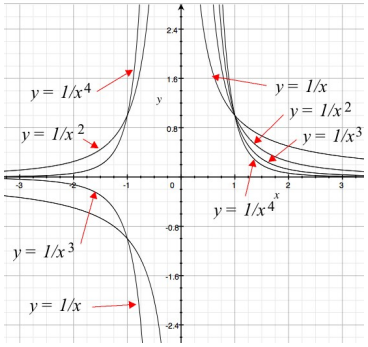
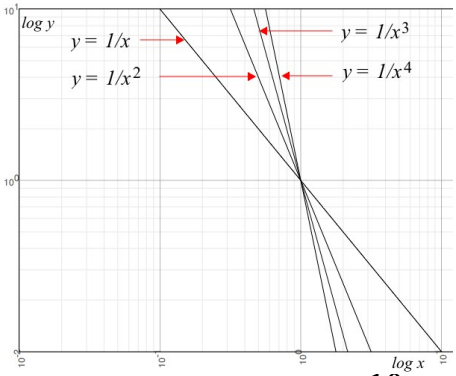
Log-log plot



Log-log plots (negative powers)

$y = 1/x$ $y = 1/x^2$
$y = 1/x^3$ $y = 1/x^4$

Linear plot



Log-log plot