December 5, 2013 Physics 131 Prof. E. F. Redish

- **Theme Music:** **Simon & Garfunkel**

  Homeward Bound

- **Cartoon:** **S. Harris**

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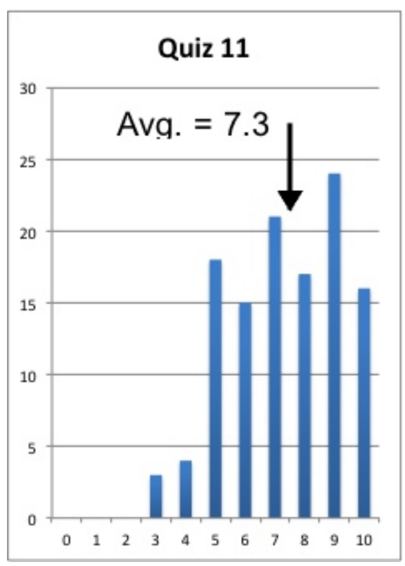
Quiz 11

	1.1	1.2	1.3	1.4	1.5
A	0%	0%	**30%**	**23%**	3%
B	**97%**	**91%**	**69%**	**72%**	**75%**
C	3%	9%	1%	5%	**23%**

	2.1	2.2	2.3	2.4	2.5
A	12%	3%	13%	**91%**	4%
B	19%	**80%**	15%	2%	**34%**
C	**54%**	2%	**22%**	7%	**55%**
D	2%	14%	**48%**	1%	7%
E	14%	1%	2%	0%	0%



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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!

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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?

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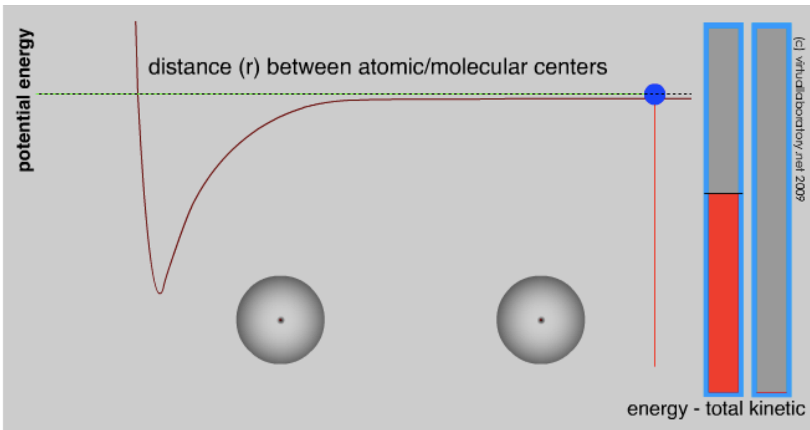
Molecular forces



http://besocratic.colorado.edu/CLUE-Chemistry/activities/LondonDispersionForce/1.2-interactions-0.html

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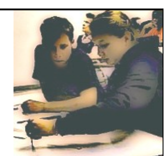
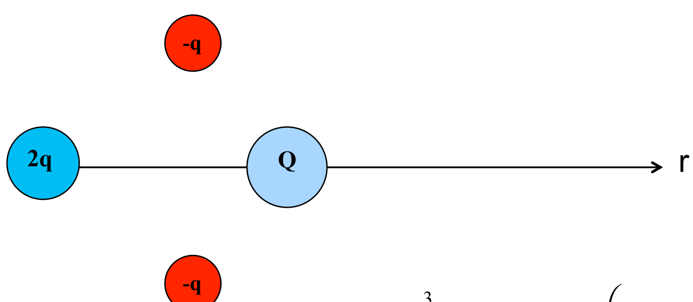


Sketch a graph of the extra potential energy from adding Q as a function of position r of charge Q



$$\Delta U = k_C Q \sum_{i=1}^{3} \frac{q_i}{r_{Q \to q_i}} = k_C Q \left(\frac{q_1}{r_1} + \frac{q_2}{r_2} + \frac{q_3}{r_3} \right)$$

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What if we move in 2D instead of 1D?

Foothold ideas: Forces from PE

- For conservative forces, PE can be defined by

$$\vec{F} \cdot \Delta\vec{r} = -\Delta U$$

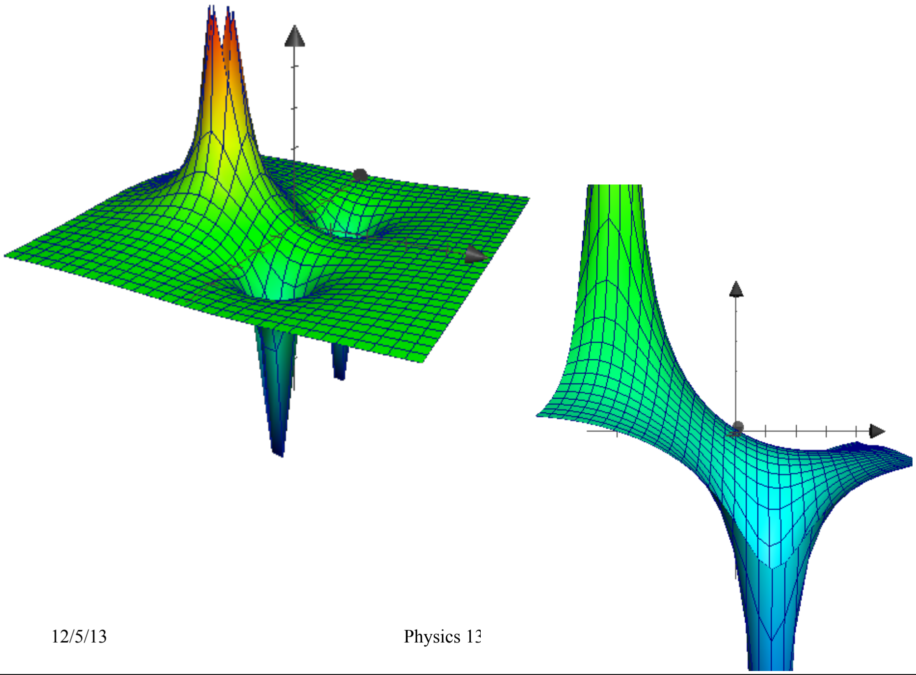
- If you know U, the force can be gotten from it via

$$F_{\parallel}^{type} = -\frac{\Delta U_{type}}{\Delta r} = -\frac{dU_{type}}{dr}$$

- In more than 1D need to use the *gradient*

$$\vec{F}^{type} = -\left(\frac{\partial U_{type}}{\partial x}\hat{i} + \frac{\partial U_{type}}{\partial y}\hat{j} + \frac{\partial U_{type}}{\partial z}\hat{k}\right) = -\vec{\nabla} U_{type}$$

- The force always points <u>down</u> the PE hill.



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Foothold ideas: Bound states

- When two objects attract, they may form a *bound state* – that is, they may stick together.
- If you have to do positive work to pull them apart in order to get to a separated state with KE = 0, then the original state was in a state with negative energy.

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