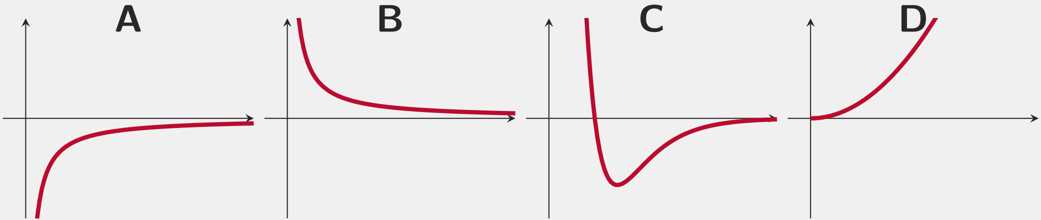
Announcements

- Homework
  - WebWork due tonight
  - Another webwork due on Friday
- Will mostly wrap up Ch 7 today, but some bits might go into Friday
- Polling: `rembold-class.ddns.net`

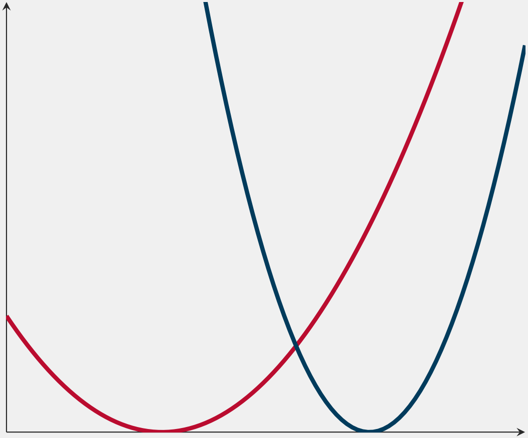
Review Question

Which image below correctly depicts the potential energy curve for two interacting electrons? The x-axis is always showing separation and the y-axis showing energy.



Effective Potentials

- Often times a system can have multiple potential energies
- We know we can just add them all up to get a total or net potential energy
  - The same works visually



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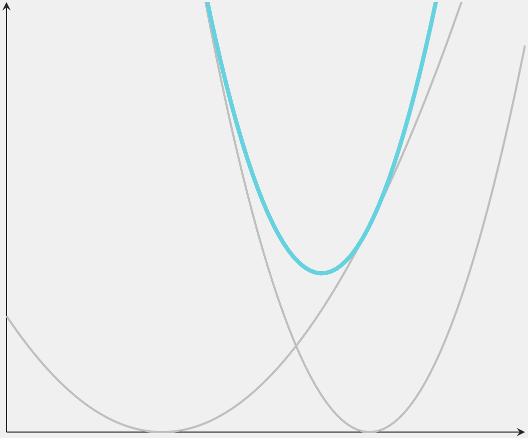
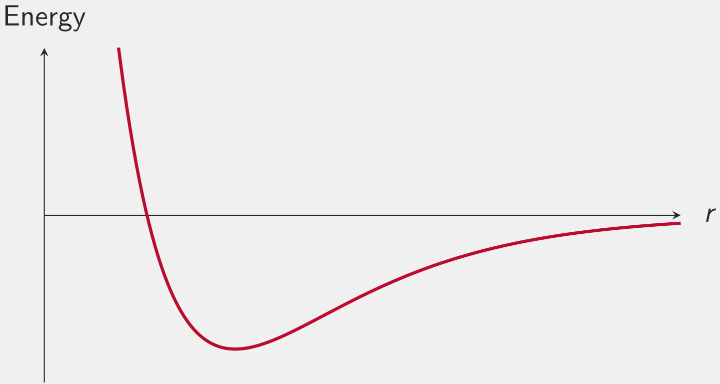


In the Darkness Bind Them

- When close to equilibrium we like to model atomic forces with springs
- Further away, we need to be a bit more careful (you can't ever escape springs!)



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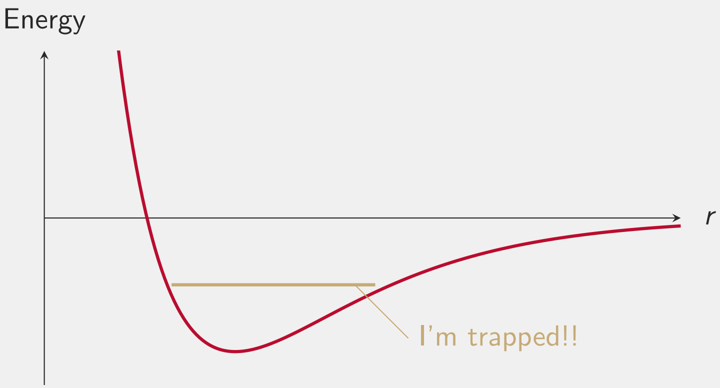

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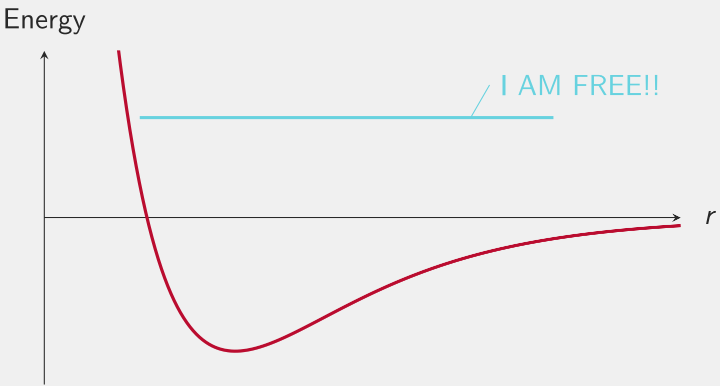
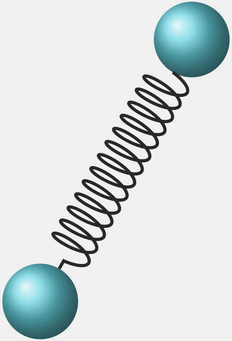


Internal Energy

- For systems of masses
- Rest mass and kinetic energy of system related to center of mass
- But what of all the other types of motion/energy about that center of mass?
- Collectively termed internal energy
  - thermal
  - rotational
  - vibrational
  - chemical
  - etc
- Still talking types of potential energy



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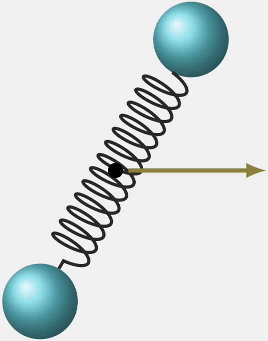

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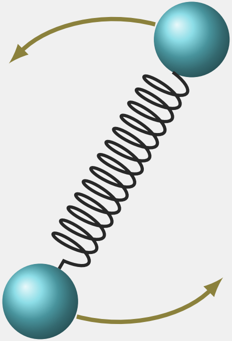

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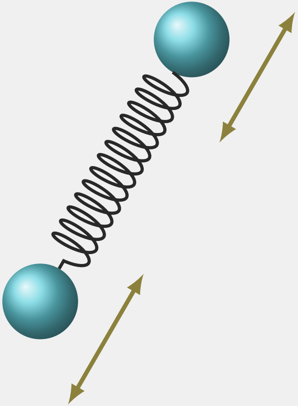

Thermal Energy

- Energy gets distributed randomly throughout the system by atomic springs
- These random bits of energy each atom possesses are what we refer to as thermal energy
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    - Could try to measure and find all the interatomic spring stretches and kinetic energies
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  - Turns out (shockingly, I know) that temperature is a good gauge of the thermal energy

Measuring Temperature

- Simple thermometers use a liquid that expands as it heats faster than the surrounding glass
  - More heat increases the chances that the spring stretch will be longer
  - Results in the material taking up slight more space, and thus expanding
- Temperature measured in SI units of degrees Kelvin
  - The Kelvin scale has the same spacing as the Celsius scale, just a different 0 point
  - $\Delta T_{\mathrm{K}} = \Delta T_{^\circ\mathrm{C}}$
- The amount of energy to raise an object's temperature by 1 K is called its heat capacity.

This Heat Specifically

- How much does a change in temperature increase the thermal energy?
  - Depends on the material in question
  - A material's specific heat determines how much energy corresponds to a change in temperature of 1 K for a given amount of material.
  - For water, this is 4.2 J/(g K)
  - For gold it is 0.129 J/(g K)
- Can be described quantitatively by:

$$\Delta E_{thermal} = mC\Delta T$$

where

  - m is the mass
  - C is the specific heat of the material in question
  - ΔT is the temperature change in units of kelvin or celsius

Getting Souper Hungry

Getting home late from school one day, you'd like to heat up some soup to enjoy for dinner. The soup has been chilling in your refridgerator all day at $2\,^{\circ}\mathrm{C}$ and you'd like it to be at a more pleasant $80\,^{\circ}\mathrm{C}$ before consumption. Assuming you have about $1\,\mathrm{L}$ of soup ($1\,\mathrm{L}{=}0.001\,\mathrm{m}^3$) and soup is mostly made of water (same density and specific heat), how much energy do you need to add to prepare your dinner?

An Iron Enriched Diet

Say you didn't have a microwave or something to just add energy to your soup. Instead, you decide to drop a superheated cube of iron into the cold $2\,^{\circ}\mathrm{C}$ soup. The iron has a mass of $500\,\mathrm{g}$, a specific heat of $0.42\,\mathrm{J/(K\,g)}$, and is initially at $150\,^{\circ}\mathrm{C}$. You allow the two to come to an equilibrium temperature (in an insulated environment) and then pull it out to enjoy. How hot is your soup?

Let's talk Heat

- Want to way to talk about energy added to a system via temperature differences (microscopic work)
- Want to distinguish it from normal work
- Call it Heat, and is symbolized with a Q (so much for things making sense)
- Lets us write:

$$\Delta E_{sys} = W + Q + \text{ other energy transfers}$$

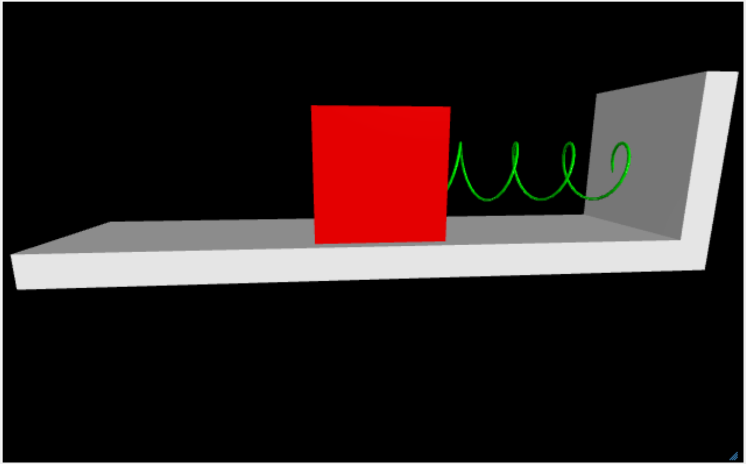
More Soup Please

Returning to our previous soup example with the iron block, suppose you instead considered just the soup as your system. How much heat (Q) has added to your soup as a result of the temperature difference between the soup and iron block?

Energy Dissipation

- We talk about energy transfer so much because certain forms of energy are generally more "useful" to us
  - Thermal energy is *not* usually one of these, unless our pure goal is to increase somethings temperature
  - Usually we are interested in movement! Motion!
- Sliding friction is our main example of kinetic or potential energy "lost" to friction
  - Not truly lost, only converted to thermal energy
- Other forms of dissipative forces include viscous friction and air resistance
  - All convert potential and kinetic energy into thermal energy
  - Energy "dissipates" only out of the useful forms we like. It is still there!

Visualizing Dissipation



Resistance is Futile!

- Sliding Friction

$$F = -\mu |F_N| \hat{v}$$

- Viscous Friction
  - For tiny objects or things moving REALLY slow

$$F = -kv\hat{v}$$

- Air Resistance
  - Dominates when objects moving fast

$$F = -\frac{1}{2}C\rho A v^2 \hat{v}$$

    where A is the cross-sectional area, ρ the density of the air and C a measure of the shape of the object
  - Fun fact: can never totally stop an object by itself!