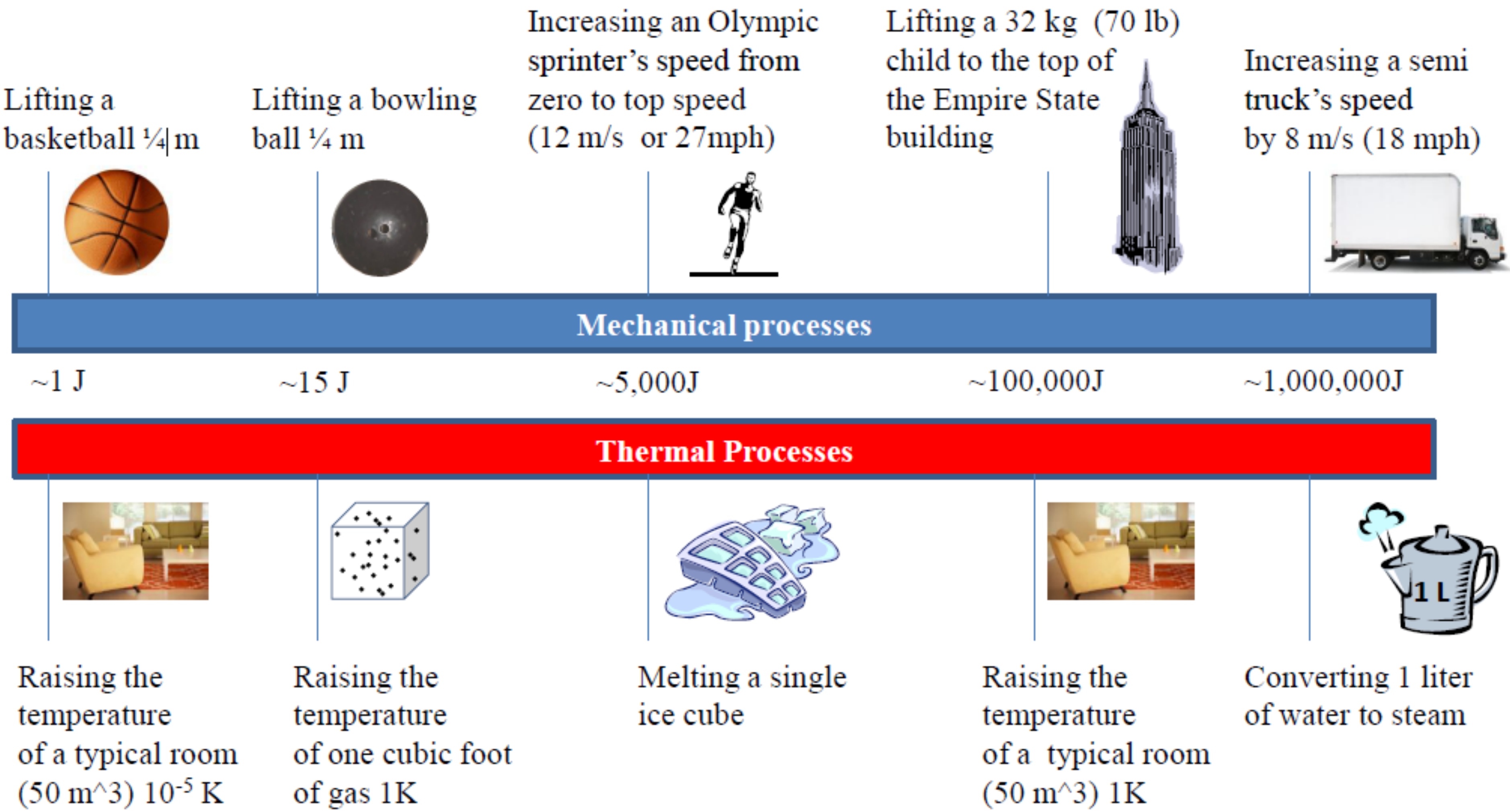
- **<u>Today's Topics:</u>** Reversible & Irreversible Processes



Used with permission from A. Daane, Paper in submission

A container of ideal gas has a fixed volume V_0. At T=10° C the pressure in the vessel is $3x10^5$ N/m^2. If we **double** the **volume** of the gas, how will the pressure change?

A. Stays the same
B. Goes down by half
C. Goes up by 2x
D. Something else

A container of ideal gas has a fixed volume V_0. At T=10° C the pressure in the vessel is $3x10^5$ N/m^2. If we increase the temperature of the gas to 20° C, what will happen to the pressure of the gas?

A. Stays the same
B. Goes down by half
C. Goes up by 2x
D. Something else

Announcements

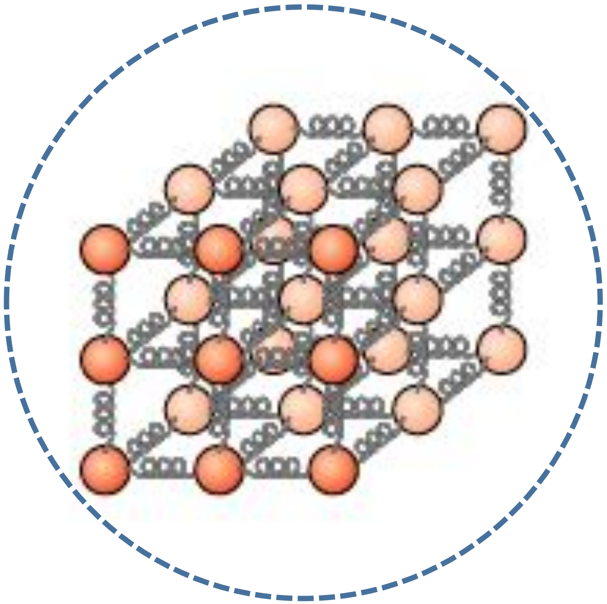
- No LAs will staff the Help Room the week of Thanksgiving
- Homework Ch13 &14 due this Friday at midnight
- Additional office hour TODAY 3:30 – 4:30pm
- Final exam times:
  - Tues, Dec 9th 9am – 11am
  - Wed, Dec 10th 10am – noon

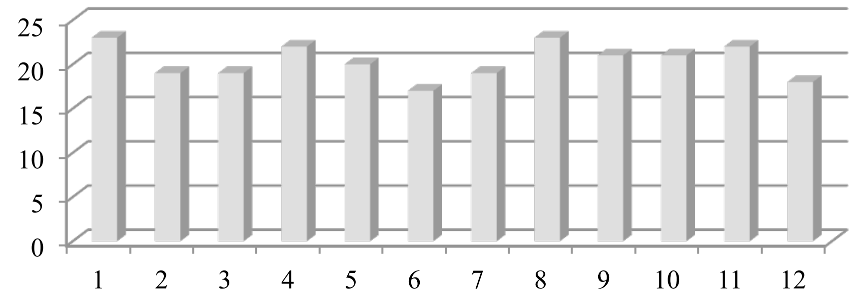
  fill out the poll on LON-CAPA to tell me which one you are going to take – you **MUST attend the session you sign up for** (Due Wed, Dec 3rd)

Temperature in any object

Object contains MANY atoms (kinetic energy) *and* interactions (potential energy)

Object A

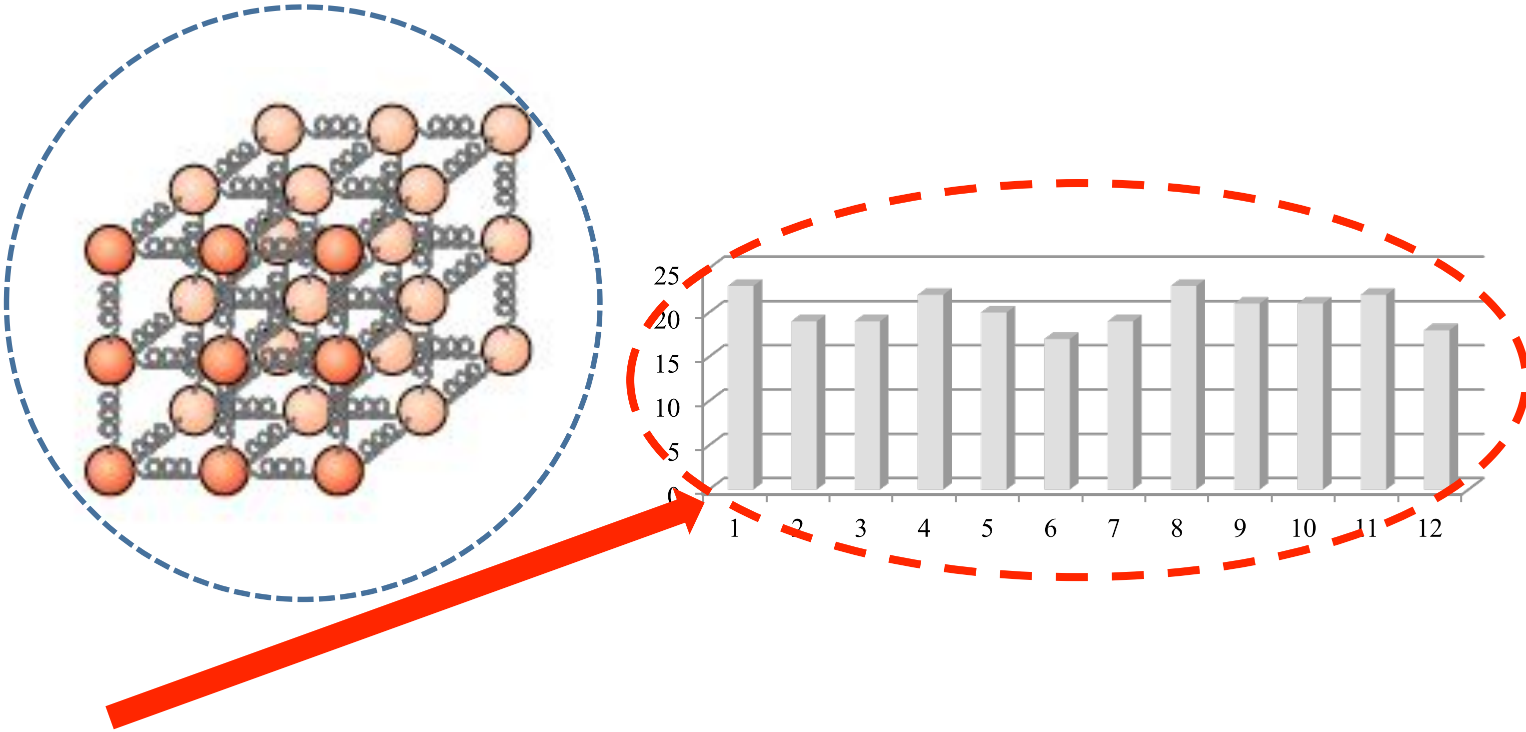




- **Temperature:** Measures the amount of energy in each atom or interaction – thermal energy is **on average** equally distributed among all these possible "bins" in which energy could reside.
- **Note: Potential energy of each bin is here defined relative to each minimum of the Potential Energy Curve.**

Thermal Energy in an object

Object A



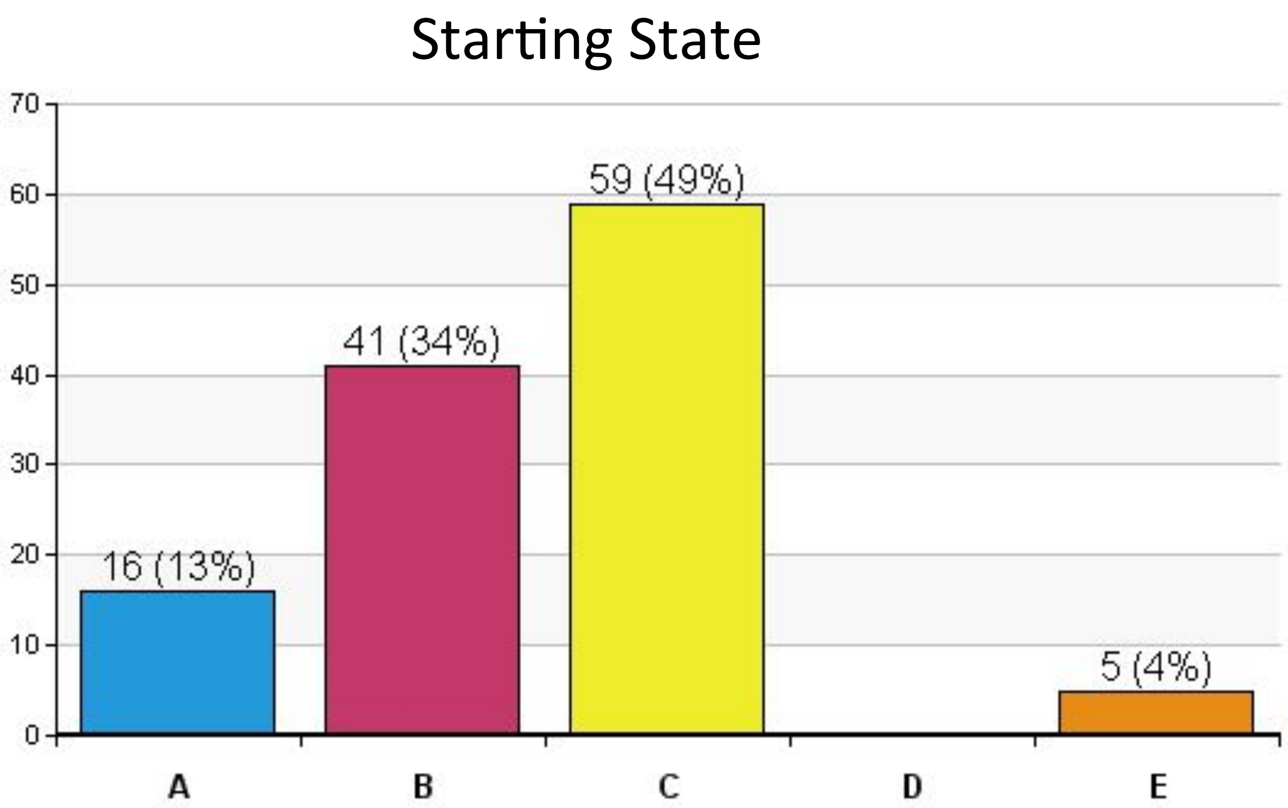
- **Thermal energy of object A :** Measures the TOTAL energy in the whole object. Depends on temperature and the number of "bins" where energy could reside.
- Energy in each bin: ½ $k_B T$

Foothold ideas: Thermal Equilibrium & Equipartition

- Degrees of freedom – where energy can reside in a system.
- Thermodynamic equilibrium is dynamic. Changes keep happening, but equal amounts in both directions.
- Equipartition – At equilibrium, the same energy density in all space and in all DoFs.

Demo – Transfer Thermal Energy

A. Hot – Front
B. Hot – Back
C. Not Hot

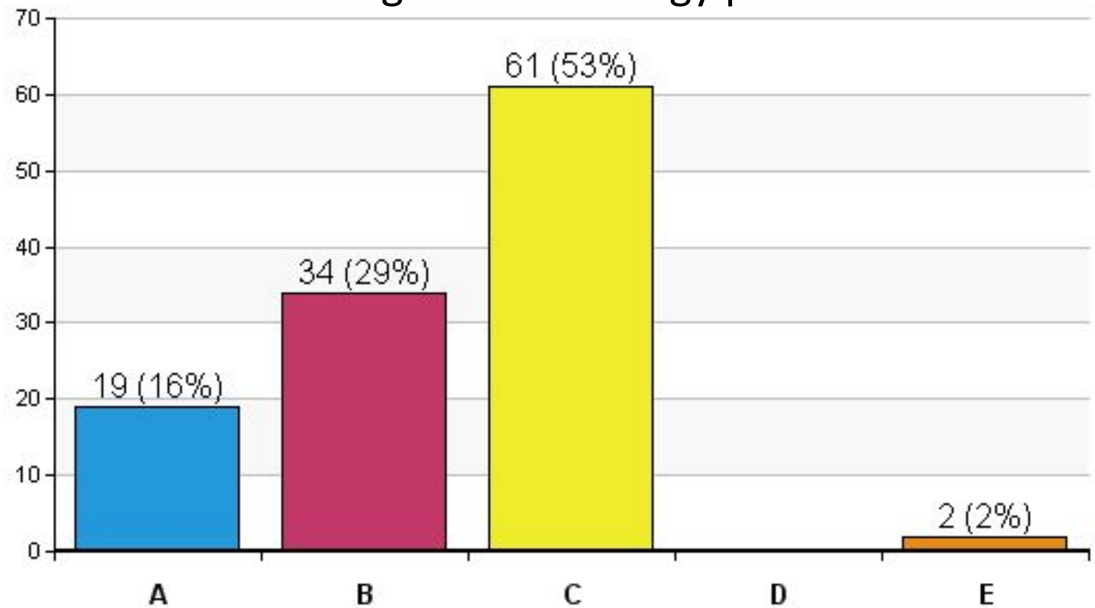


Demo – Transfer Thermal Energy

When I say "interact" play rock-paper-scissors with 6 people in the class. If you win in a game with someone who has a card – you win their card.

A. Hot – Front
B. Hot – Back
C. Not Hot

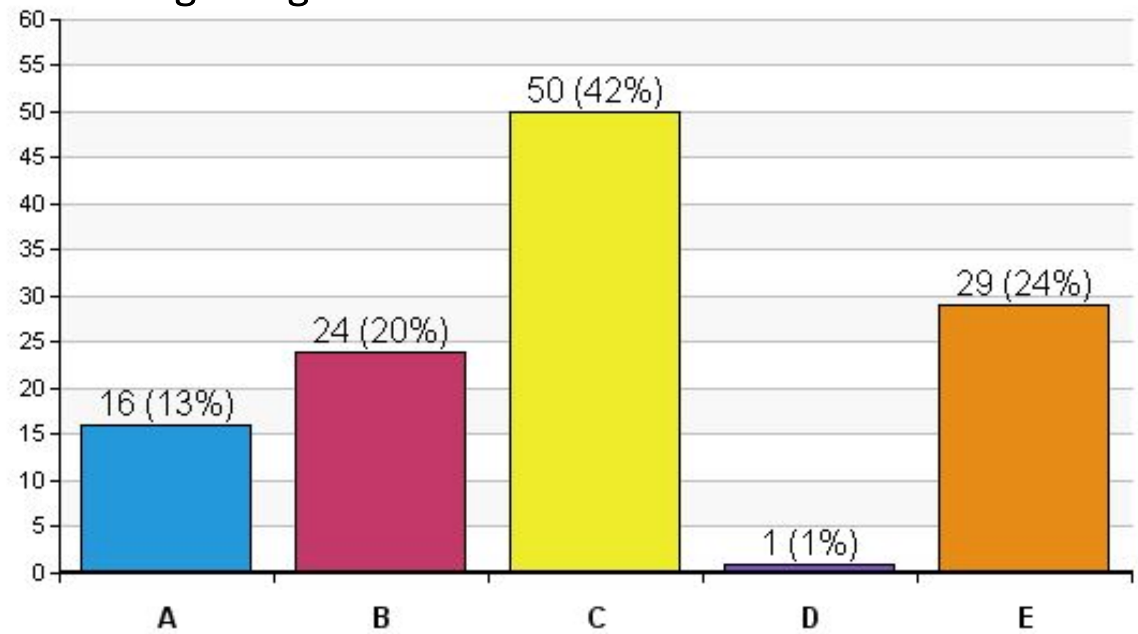
After 1 round we see more people in the front holding thermal energy packets.



Demo – Transfer Thermal Energy
If you have more than one card – give it to someone who is on the same side of the room as you.

A. Hot – Front
B. Hot – Back
C. Not Hot

I don't know who the "E"'s are, but we see the difference between the front of the room and the back of the room getting smaller.



Demo – Transfer Thermal Energy

How can random movement at a cellular level cause a unified motion on a larger scale?

- Through random interactions we see thermal energy transfer
- At the same time we see the energy distribution begin to equilibrate
- What would happen if we did this 10,000 times?

Can we get back to the original state?

If energy is conserved why do we need to worry about conserving energy?

Some kinds of energy we aren’t able to move back into our systems. We call this kind of energy “degraded”. The processes that move this kind of energy are “irreversible” because we can’t run them backwards.

Foothold ideas: Microstate and macrostates

- A *microstate* is a specific distribution of energy telling how much is in each DoF.
- A *macrostate* is a statement about some average properties of a state (pressure, temperature, density,...).
  - A given macrostate corresponds to many microstates.
- If the system is sufficiently random, each microstate is equally probable. As a result, the probability of seeing a given macrostate depends on how many microstates it corresponds to.

A small amount of heat Q flows out of a hot system A (350K) into a cold system B (250K). Which of the following correctly describes the change in number of microstate changes that result? (The systems are thermally isolated from the rest of the universe.)

A. $|\Delta\#_A| > |\Delta\#_B|$
B. $|\Delta\#_B| > |\Delta\#_A|$
C. $|\Delta\#_A| = |\Delta\#_B|$
D. It cannot be determined from the information given