Physics 131- Fundamentals of Physics for Biologists I

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Outline

Review class Wed 3pm Room TBA

Office hours: Thu 5-6.30pm Course center

Fri 2pm-3pm My office rm 3341 AVW

Extending energy Conservation: The first law of thermodynamics

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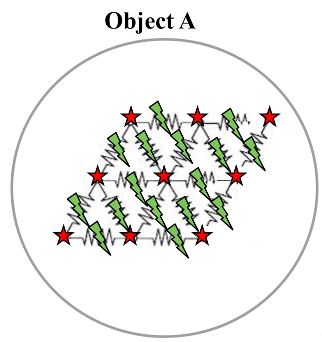
Where is thermal energy in an object?

-kinetic energy of atoms/molecules
-potential energy of their interactions



★ Kinetic Energy
Potential Energy

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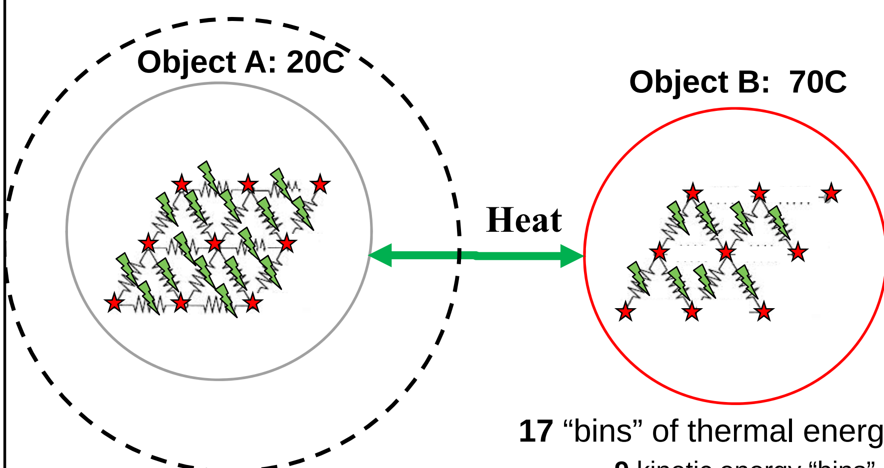
How do two objects exchange thermal energy

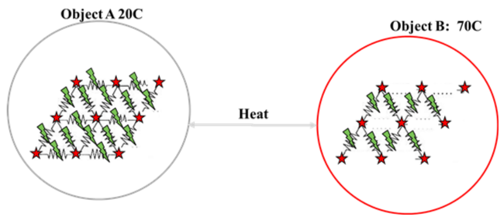


17 "bins" of thermal energy
9 kinetic energy "bins",
8 potential energy "bins"

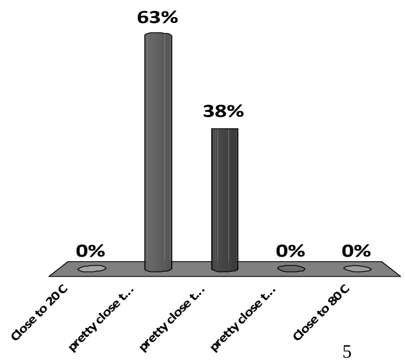
25 "bins" of thermal energy:
9 kinetic energy "bins",
16 potential energy "bins"

Potential Energy
★ Kinetic Energy

What temperature do these two small balls reach?



1. Close to 20 C
2. pretty close to 40 C
3. pretty close to 45 C
4. pretty close to 50 C
5. Close to 80 C



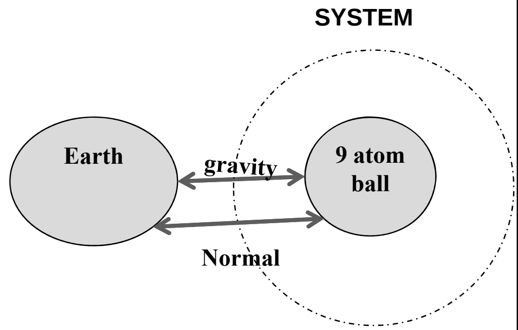
20C in 27 "bins"

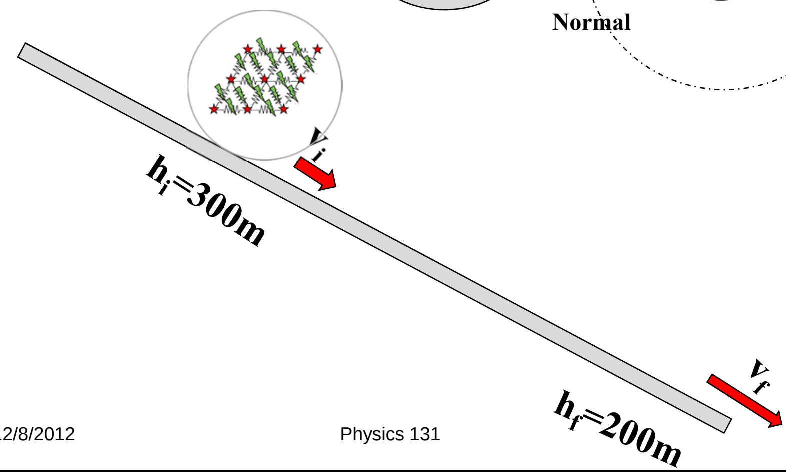
How to calculate the resulting temperature if we know the number of bins in which kinetic energy can be stored in each object?

-> Calculate the average temperature across all bins

25 "bins" at 20C
17 "bins at 70C
Average temperature of all bins:
(25 * 20C+17 * 70C) / 42 = 40.2 C

Calculate the work done on the 9 atom ball





Sources of energy for the ball

- Consider the whole ball as our system
  - Ball has thermal energy related to motion of atoms and interactions of atoms inside the ball
  - Ball has kinetic energy of motion of the whole ball
  - Ball could have potential energy due to interactions of the whole ball with objects outside the system such as the earth

Definitions: Energy

- We have expanded our idea of energy to include more forms:
  - 1. Coherent energy of motion (**kinetic**) of the center of mass of an object: ½ mv^2
  - 2. Coherent energy of location relative to other objects (**potential**) of the center of mass.
  - 3. Incoherent internal energy of motion of the parts of an object (**thermal**)
  - 4. Submolecular energy of internal structure (**chemical**)

Equations

Total energy of a system
(a set of macroscopic objects)

$$E = KE + PE + U$$

Internal energy

Exchanges of energy between the system and the rest of the universe

$$\Delta E = Q - W$$

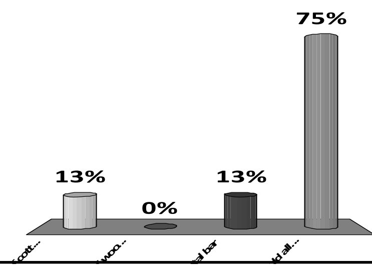
Work done by the system on "them"

Exchanges of energy between the system and the rest of the universe ignoring coherent mechanical energy

$$\Delta U = Q - W$$

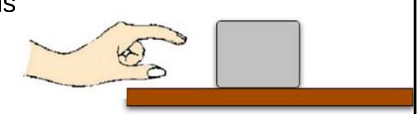
The objects listed in A-C below are placed in an oven heated to 90° C and left for a long time. Which object will have the highest temperature?

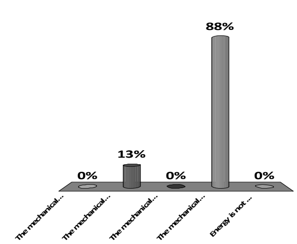
1. A ball of cotton
2. A stick of wood
3. A metal bar
4. They would all have the same temperature.



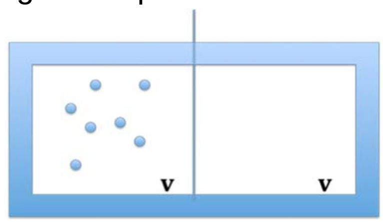
A block sitting on a smooth table was given a push. It slides across the table and comes to a stop. After the push is complete but before the block has stopped, which of the following statements are (pretty close to being) true?

1. The mechanical energy of the block is conserved.
2. The mechanical plus thermal energy of the block is conserved.
3. The mechanical energy of the block plus table is conserved.
4. The mechanical plus thermal energy of the block plus table is conserved.
5. Energy is not conserved in this process.





Suppose an isolated box of volume 2V is divided into two equal compartments. An ideal gas occupies half of the container and the other half is empty. When the partition separating the two halves of the box is removed and the system reaches equilibrium again, how does the new internal energy of the gas compare to the internal energy of the original system?



1. The internal energy increases
2. The internal energy decreases
3. The internal energy stays the same
4. There is not enough information to determine the answer

Egg placed in boiling water

	$\Delta U_{internal}$	**Q** (heat absorbed BY the system)	**W** (work done BY the system)
1	> 0	0	< 0
2	< 0	0	> 0
3	0	> 0	> 0
4	> 0	> 0	0
5	< 0	> 0	> 0
6	0	< 0	> 0
7	> 0	< 0	< 0
8	< 0	< 0	0
9	0	0	0

Man stands still holding a weight at arm's length.

	$\Delta U_{internal}$	**Q** (heat absorbed BY the system)	**W** (work done BY the system)
1	> 0	0	< 0
2	< 0	0	> 0
3	0	> 0	> 0
4	> 0	> 0	0
5	< 0	> 0	> 0
6	0	< 0	> 0
7	> 0	< 0	< 0
8	< 0	< 0	0
9	0	0	0

Flashlight left on

	$\Delta U_{internal}$	**Q** (heat absorbed BY the system)	**W** (work done BY the system)
1	> 0	0	< 0
2	< 0	0	> 0
3	0	> 0	> 0
4	> 0	> 0	0
5	< 0	> 0	> 0
6	0	< 0	> 0
7	> 0	< 0	< 0
8	< 0	< 0	0
9	0	0	0

Gas held behind a partition in an insulated chamber, the other side of the partition is vacuum. The partition breaks involving negligible energy change. What happened after equilibrium is reached?

	$\Delta U_{internal}$	**Q** (heat absorbed BY the system)	**W** (work done BY the system)
1	> 0	0	< 0
2	< 0	0	> 0
3	0	> 0	> 0
4	> 0	> 0	0
5	< 0	> 0	> 0
6	0	< 0	> 0
7	> 0	< 0	< 0
8	< 0	< 0	0
9	0	0	0