Lec #9: Thermal Energy (Chaps. 3 & 4)

LAST: Mechanical Energy

- Laws of Motion; Forces
- Work, Kinetic Energy, Potential Energy, Power

TODAY: Thermal Energy. I.

- Internal Kinetic and Potential Energy
- Temperature and Heat
- Laws of Thermodynamics
- Specific Heat & Phase Transitions

WEDNESDAY: Thermal Energy. II.

- Heat Transfer (conduction, convection, radiation)
- Heat Engines & Efficiency

Recap

- Work = Force x Distance x (cos θ)
- Power=d/dt (Work) (instantaneous)
- KE = (1/2) m v^2
  - change in speed -> change in KE
  - note: can change **v**elocity w/out change in KE
- PE = Force x Distance (e.g. mgh for gravity)
- If forces are "conservative":
  - Mechanical KE + Mechanical PE = constant
  - Work = change in Mechanical Energy
- If *not* conservative, where does the energy go?

How Do We Measure Total Energy?

- Total Energy = External (M.E.) + Internal
- Internal *Kinetic*: Thermal
- Internal *Potential*: Chemical; Nuclear
  - molecular bonds
  - atomic bonds
  - nuclear bonds
- We can't measure Total Energy, but we know that it's huge and takes many forms
- We can, however, measure *changes*....

First Law of Thermodynamics

- ΔE = ΔExternal + ΔInternal = Work + Heat
- In practice, "**heat**" usually refers only to a **change** in internal (thermal) energy, not a basic property of a substance.
  - objects don't contain *heat*, but they do contain *energy*
- "Thermal energy" usually refers only to internal *kinetic* energy, though this is only a small fraction of the total internal energy
- To measure thermal energy, we use "temperature"

Temperature

- Temperature **not** measure of **total** internal energy!
- Temperature **is** a measure of **average** kinetic energy of the molecules
- Internal K.E. -> 0 at "absolute zero", increases with temperature (but must use absolute scale)
- When 2 objects are brought into contact
  - if $T_1 > T_2$, "thermal energy" transfer (heat) from T_1 to T_2
  - If $T_1 = T_2$, no energy transfer
- "Heat" is the transfer of thermal energy

  from higher Temp ---> lower Temp

Table 4.1 TEMPERATURES OF SOME COMMON PHENOMENA*

	°C	°F	K
Water, ice point	0	32	273
Water, boiling point	100	212	373
Absolute zero	−273	−460	0
Liquid nitrogen boiling point	−196	−319	77
Liquid helium boiling point	−269	−454	4
Zinc, melting point	420	787	693
Gold, melting point	1063	1945	1336
Solid CO_2 (Dry Ice) sublimation**	−78	−109	195

*At atmospheric pressure
**Process of going from a solid directly to a gas phase

You should know how to convert between F & C.
Absolute scales: Kelvin (°C) and Rankine (°F).