Welcome + review syllabus

<u>prereqs</u>: multivariable calculus (230-1/2)
intro physics sequence

- syllabus overview

What is statistical mechanics?

BRIDGE between microscopic & macroscopic systems

macroscopic system: many particles (atoms, electrons, etc)

- coil of copper wire
- tank of nitrogen
- pane of window glass
- cup of coffee

most macroscopic systems have $\mathcal{O}(10^{23})$ particles, how to proceed?

Option 1: write down equations of motion & solve

<u>BAD stradegy</u>!

why - intractable
- even if doable, provides useless info

e.g. position of each particle tells you little about properties you care about

- how does P relate to V, T?
- how can I use the gas to do work?
- when & how does gas liquify?

Want to use macroscopic properties to describe our system
P, V, T, etc   gas

thermodynamics : framework for relating macroscopic properties
(ignores microscopic info)
+
processes related to heat & work
(emperical rules)

statistical mechanics:
classical mechanics + quantum mechanics
→ microscopic behavior of molecules
statistical mechanics
microscopic info ⇒ system properties
(1st principles)

NB: We will only consider equilibrium systems
time dependant phenomna give rise
to fascinating but much more difficult
to understand phenomna

ex: flow water through pipe faster & faster,
eventually create turbulent flow

<u>simple observation</u>: coffee in my cup will always <u>cool</u> until it reaches room temp

<u>two important properties</u>:

(1) temperature (familiar)

(2) arrow of time

- glass of water spontaneously heat?

NO!

<u>simple observation</u>: dropped ball bounces until it comes to rest

- why does it come to rest?

friction: energy transfered from ball → floor

consider ball + floor: energy conserved

• have you ever seen ball at rest spontaneously start bouncing?

- why not? allowed under energy conservation

new concept: <u>entropy</u>

energy conservation not sufficient!

bouncing ball energy of com motion → ball at rest + floor individual molecules total energy conserved, but transfered

one DOF $\rightarrow$ many DOF

<u>entropy</u> is a measure of how energy is distributed

Temperature & entropy are examples of quantities that discribe macroscopic systems. Also,

- pressure
- volume
- viscosity
- thermal conductivity
- etc

<u>Work & energy</u>

energy conserved, distribution of energy changes irreversibily

macroscopic viewpoint: heating a pot of water

stored energy $\rightarrow$ energy for heating

chemical energy (propane) $\rightarrow$ heating energy (open flame)

How efficient is this process? no theorethical limit!

What about stored energy → work (ex: push piston)

need an engine! limit to maximum efficiency

inefficient process / some stored energy lost to heat

The codification of these observations make up the subject of thermodynamics

1st law: conservation of energy

2nd law: entropy, arrow of time, inefficiency of stored energy → work

We will go over this in detail in the next couple of weeks!

simulation examples