

# Welcome + review syllabus

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prereqs: 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

BAD strategy!

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?

(2)

Want to use macroscopic properties to describe our system  
 gas  
 $P, V, T, \text{etc}$

thermodynamics : framework for relating macroscopic properties  
 (ignores microscopic info)

+  
 processes related to heat & work  
 (empirical rules)

statistical mechanics:

classical mechanics + quantum mechanics

→ microscopic behavior of molecules

statistical mechanics

microscopic  
info

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system  
properties

(1st principles)

NB: We will only consider equilibrium systems

time dependant phenomena give rise  
 to fascinating but much more difficult  
 to understand phenomena

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

simple observation: coffee in my cup will always cool until it reaches room temp

two important properties:

(1) temperature (familiar)

(2) arrow of time

- glass of water spontaneously heat?  
NO!

simple observation: dropped ball bounces until it comes to rest

- why does it come to rest?

friction: energy transferred from ball  $\rightarrow$  floor

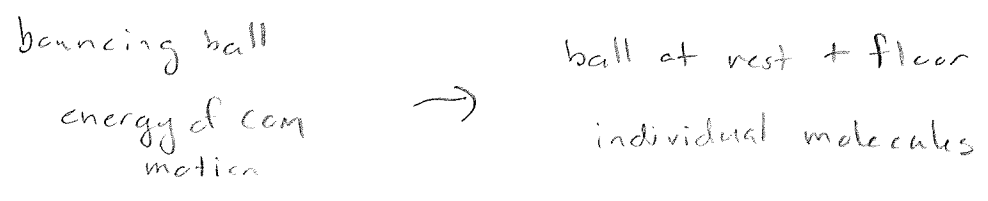
consider ball + floor: energy conserved

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

- why not? allowed under energy conservation

new concept: entropy

energy conservation not sufficient!



total energy conserved, but transferred

one DOF  $\rightarrow$  many DOF

entropy is a measure of how energy is distributed

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

- pressure
- volume
- viscosity
- thermal conductivity
- etc

Work & energy

energy conserved, distribution of energy changes irreversibly

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 theoretical limit!

What about stored energy  $\rightarrow$  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  $\rightarrow$  work

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

simulation examples