Phys 344 Thermal Physics

Lecture 1. Introduction

- Instructor:

  Michael CHEN: office hours: TF 11:30 – 12:20 P9442.
  + by appointment.

- Course website:

  http://www.sfu.ca/~mxchen/phys344l121/info344.htm.

- Class time / locations

  Lectures: MWF 10:30 – 11:20 WMC 2503
  Tutorials: T 10:30 11:20 WMC 3220.

  Note: Tutorials are mandatory.
  We will swap some Tutorials with lectures.

- Guest lectures: Dr. John Jones (school of Engineering Science)
  Tuesdays: March 6, 13, 20.

- Text book:

  Daniel V. Shroeder: An Introduction to Thermal Physics.

- References:

  Gerald Carrington: Basic Thermodynamics.
  Mark W. Zemansky: Heat and Thermodynamics.

• Thermal Physics.

— The study of bulk properties of matter and the processes that change these properties.

"bulk" — many particles ($\gtrsim 10^{23}$)

e.g. The air in a tire. ($> 10^{23}$ molecules)

Can we just use Newtonian mechanics ?

each molecule obeys Newton's law: $\vec{F} = m\vec{a}$

$\sim 10^{23}$ initial conditions: when $t=0$, $\vec{x} = \vec{x}_0$
$\vec{v} = \vec{v}_0$.

* It's extremely difficult to solve!

* The solution wouldn't tell you anything meaningful!

Who cares about the position and velocity of individual molecules!

Instead, we are interested in pressure, temperature, volume, etc. (bulk properties)
(represented by macroscopic variables)

• 2 parts of Thermal Physics — 2 very different approaches.

① Thermodynamics.

② statisticall mechanics.

of course they are closely related.

- Thermodynamics
  - Based on a few fundamental Laws
  - To find general relationship among macroscopic variables.
    - └ system-independent.
  - No microscopic mechanism.

e.g. Heat flows spontaneously from a hot object to a cold one.

- Statiscal mechanics.
  - Built from microscopic mechanics
  - Use statistical methods to determine bulk properties
    - └ connects 1 with 10^{23}.
  - Often needs system-specific models / approximations.

- Temperature, T — Hard to give an accurate definition now.
  The concept will become clearer later.

  — Common Sense: A measure of hot and cold.

  But, what does "hot" or "cold" mean? objectively.

More molecular motion.
↑
random.

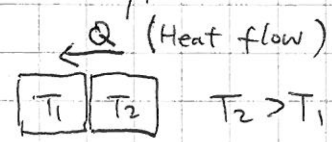
The temperature represents the average kinetic energy of the molecules $\overline{\varepsilon}_k$ (ε_k — kinetic energy of a molecule).

Hot — large $\overline{\varepsilon}_k$ — high T

cold — small $\overline{\varepsilon}_k$ — low T

- Heat flow — Be careful when you use this term!

  "Heat flow" refers to the spontaneous energy transfer from a hot object to a colder object due to the difference in temperature.



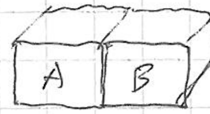
$T_2 > T_1$

But heat is not a fluid that can flow!

- Thermal Contact.

When spontaneous energy transfer between two objects can occur without doing macroscopic work, wa say that the two objects are in thermal contact.

examples: conduction.
convection
Radiation.



- Thermal equilibrium

After a long enough time, there will be no net energy transfer between the two objects. Then, we say that the two objects are in thermal equilibrium.

the "long enough time" — relaxation time

- Temperature.

When two objects are in thermal equilibrium, they have the same temperature.

(Temperature is the quantity that has the same value when two objects are in thermal equilibrium)

Textbook. p.3:

Temperature is a measure of the tendancy of an object to spontaneously give up energy to its surroundings.

- Temperature scales

— Celsius (centigrade) (°C)

freezing point of water : $0°C$

boiling point of water : $100°C$

— Absolute temperature (kelvin) (K)

$T_k = 273.15 + T_c$ Note: $\Delta T_k = \Delta T_c$

T_k — kelvin reading

T_c — Celsius reading

e.g: freezing point of water: $T_c = 0°C$

$T_k = 273.15$ kelvin

— Fahrenheit (°F)

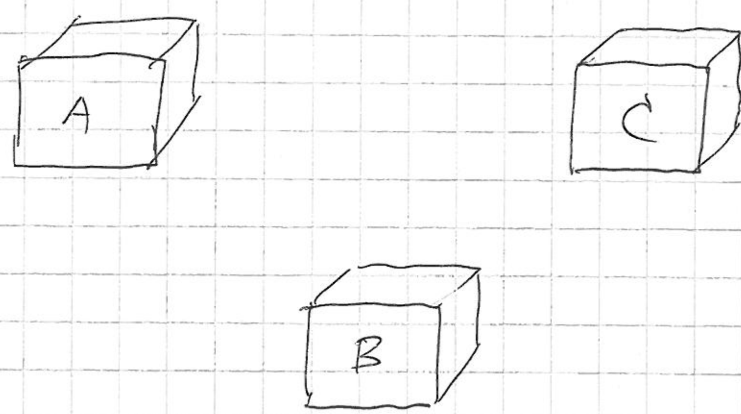
$$T_F = 32 + \frac{9}{5} \cdot T_c$$

e.g: boiling point of water : $T_c = 100°C$

$$T_F = 32 + \frac{9}{5} \times 100 = 212 °F$$

- Zeroth Law of thermodynamics

If object A is in thermal equilibrium with object B, and object B is in thermal equilibrium with object C, then object A is in thermal equilibrium with object C.



This forms the basis of making a thermometer.

Here B is the thermometer.

A is a known temperature standard.

C is the object of interest.