Physics 101

Lecture 33

Friday. March 25. 2004

Topics: Temperature / Thermal Equilibrium.

Heat and Work.

Conduction, convection, radiation

Ref: 16 - 1. 2, 3. 4, 5. 6.

# Ch. 16. Temperature and Heat.

Up till now.

— Mechanics.

3 Basic quantities: length, mass, time.
M. K. S.

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New Quantity: Temperature.

New area of physics. — Thermodynamics.

The study of temperature, heat and exchange of energy.

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e.g.: Hot Coffee.

When you put a spoon in the hot coffee, the spoon will be warmed up.

— Spoon and coffee are in thermal contact.

After a while, the spoon will be as hot as the coffee.

— Spoon and coffee are in thermal equilibrium.

A quantity to describe thermal equilibrium:

: Temperature.

Temperature:

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

High-T — hot. (atoms, molecules move fast — more Thermal energy)

Low-T — cold. (atoms, molecules move slowly — less Thermal energy)

T — related to average kinetic energy of molecules, atoms.

[Thermal Energy $U(T)$. ⇒]

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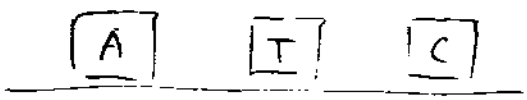
Zeroth Law of ~~thermal dy~~ Thermodynamics.

If object A is in Thermal equilibrium with object T.

and object B is also in thermal equilibrium with object T.

Then object A and B will be in thermal equilibrium if they are brought in ~~*~~ to thermal contact.

Then, object T is a measure of the common temperature — it's a thermometer.




Temperature scales.

- Celsius scale.

  definition: 0°C — water freezes.

  100°C — water boils.

- Fahrenheit scale:

$$T_F = \frac{9}{5} T_C + 32.$$

$$T_C = \frac{5}{9} (T_F - 32).$$

$T_C$ — Temperature reading in °C.

$T_F$ — Temperature reading in °F.

Today's Temperature: 10°C.

$$T_F = \frac{9}{5} \times 10 + 32 = 50°F.$$

- Kelvin scale. (Absolute Temperature).

$$T = T_C + 273.15.$$

(Today: $T = 10 + 273.15 = 283.15\,K$.

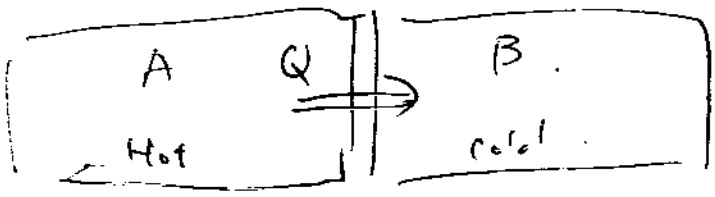
Coldest possible temperature: 0 K.

↑ can never be reached.

Now, $\sim 10^{-9}$ K

In Thermodynamics, we use K. (absolute Temperature).

What if two objects with different temperatures $T_1$, $T_2$ are brought into thermal contact?




$T_A > T_B$.

There is a "heat flow" from A (higher T) to B (lower T)

what is "this" heat flow".

wrong: heat is like a fluid that flows from one object to another.

right: Heat is the energy transfered between objects because of a temperature difference.

e.g: Molecules in A can interact with molecules in B.

↑ will move slow down. ⟹ Q ⟹ ↑ speed up.

Unit of heat:

Same as energy. — Joule. — just like work.

another unit: Calorie.

$1\,cal = 4.186\ J$.

Two ways of Transferring energy:

- work.
- heat.

Both are quantities involved in the process of energy Transfer, not a quality of the system.

(they don't describe the state of the system).

35=

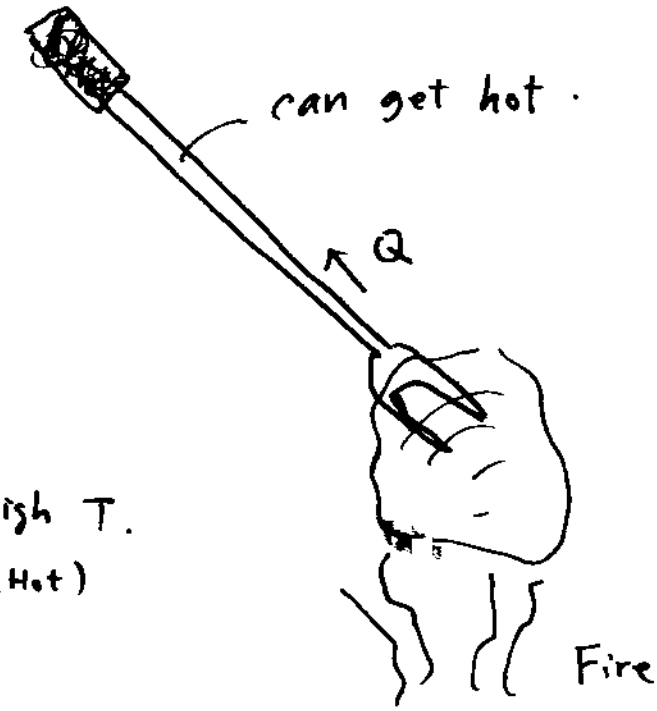
- 3 Mechanisms of Heat exchange. { conduction, convection, radiation }

  Heat exchange ↑ Thermal energy

- conduction

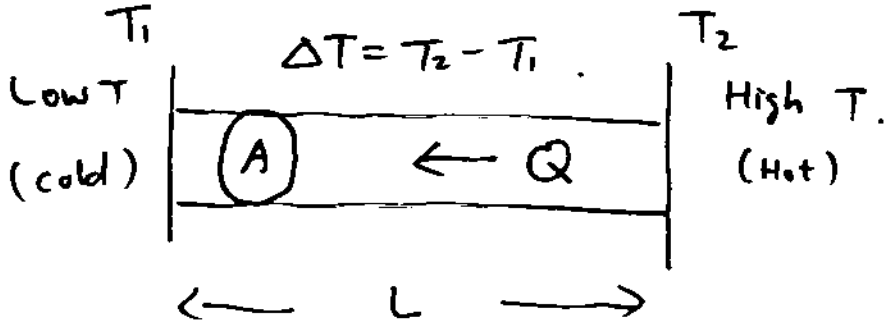
  – by interactions among atoms and molecules, but there is no transport of the atoms and molecules themselves.

e.g. BBQ




Heat flow by conduction:

$$Q = k \cdot A \cdot \left(\frac{\Delta T}{L}\right) *$$




$k$ — Thermal conductivity. steel: $k = 67\ W/m\cdot k$.

wood: $k = 0.1\ W/m\cdot k$.

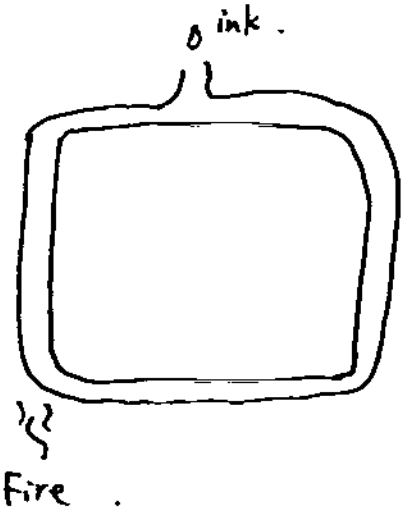
- Convection

— There is a transport of atoms and molecules.

e.g.: Warming a house by forced hot air.

How to increase the efficiency — blow!

Demo:




- Radiation.

— by electromagnetic radiation with the speed of light.

No physical contact!

Demo