Physics 101

Lecture 32.

Monday, March 24, 2003.

Topics Covered.

- Temperature / Thermal equilibrium.
- Heat.
- Thermal expansion.

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

Ch. 16. Temperature and Heat.

Up till now.

— Mechanics.

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

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 $U(T)$. ⇔)

Zeroth Law of ~~thermal dty~~ 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 into 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: $T = 10 + 273.15 = 283.15\ K$.

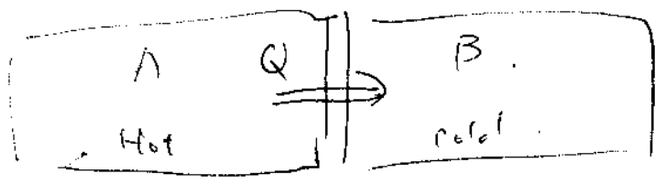
Coldest "possible" temperature: 0 K.

↑ 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.

↑ with more slow down. ⟹ Q ⟹ ↑ speed up.

Unit of heat:

Same as energy. — Joules. — 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).

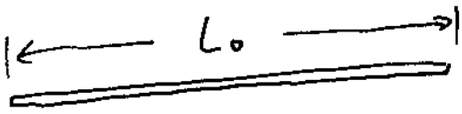
- Thermal expansion.

— size changes with temperature.

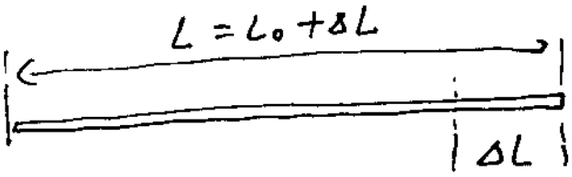
Most objects get larger when the temperature is increased, but some get smaller.

- Linear expansion — thin rod, wire, etc.

Low Temp: T



High Temp:
$T+\Delta T$.



$\Delta L \propto L_0, \Delta T$.

$\Delta L = \alpha \cdot L_0 \cdot \Delta T$.

α — coefficient of (Linear) Thermal expansion

depends on material.