⊛ Class tests to be graded out of 10, HW out of 5.

11th January 2024

Thermal Equilibrium:

- System connected to its surroundings by a diathermic wall
  → wait (Associated timescale)
  → Thermal equilibrium

Based on this logic, we will create laws of equilibrium thermodynamics

→ When these laws are violated, we will say that the system is not in equilibrium.

In prev example, this means $\exists F(P_1, V_1, P_2, V_2) = 0$
↳ Holds for more complex systems

□ Zeroth Law of Thermodynamics →

If systems A and B are separately / individually in thermal equilibrium with system C; then ~~they are in~~ A and B are also in thermal equilibrium.

(Found empirically - from experience)

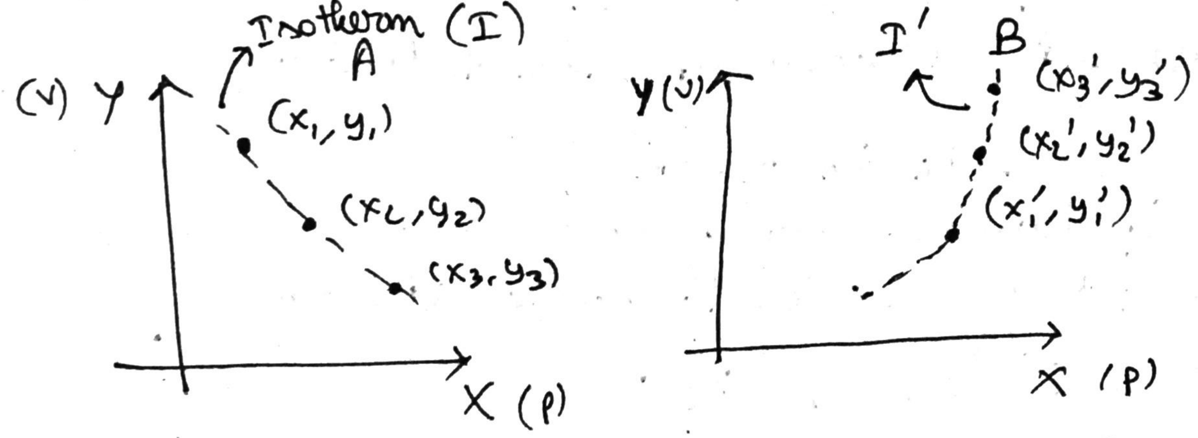
⇒ 'Suggests' that there must be a physical quantity that is same for two systems in thermal equilibrium. We are going to call this quantity 'temperature'

⊛ This idea of equilibrium can be generalised - any system that 'exchanges' something akin to energy (chemical eq, mechanical eq)

⇒ Temperature (T)

$$\left.\begin{aligned} T_A &= T_C \\ T_B &= T_C \end{aligned}\right\} \Rightarrow T_A = T_B$$

Two systems, where the system is described by two independent variables X and Y. (could be anything - P and V for gas)



A and B are ~~connected by~~ are in thermal equilibrium

Make (x_1, y_1) to (x_2, y_2) but still in thermal equilibrium with (x_1', y_1')

<u>Self Note</u>: Think in terms of P and V.

In thermal eq of ideal gas, $P_1V_1 = P_2V_2$

⇒ P_2V_2 held const, there are infinitely many pairs (P_1, V_1) s.t $P_1V_1 = P_2V_2$

We ~~again~~ again move $(x_2, y_2) \to (x_3, y_3)$ s.t (x_3, y_3) is in therm eq. with (x_1', y_1')

⇒ (x_1, y_1), (x_2, y_2), (x_3, y_3) are all in thermal eq with each other. (By zeroth law – as they are individually in therm eq with (x_1', y_1'))

⊗ Locus of all points that represents states at which a system is in thermal equilibrium with <u>one</u> state of another system.

Note that we can also take states (x_2', y_2'), (x_3', y_3') which are in thermal equilibrium with each other.

→ All points on I and I' are in thermal equilibrium

⇒ They are <u>conjugate isotherms</u>

We can construct any such isotherm pairs.

Formally, common properties of I and I'

$\Rightarrow$ Temperature

o A and B are two systems, there will be a function,

$$F_1(x_A, y_A, x_B, y_B) = 0$$

if they are in thermal equilibrium.

Say B and C are in thermal equilibrium,

$$F_2(x_B, y_B, x_C, y_C) = 0$$

By ~~Zeroth~~ Zeroth law, there ~~was~~ must be,

$$F_3(x_A, y_A, x_C, y_C) = 0$$

Try to show that,

$$f_1(x_A, y_A) = f_2(x_B, y_B) = f_3(x_C, y_C)$$
$$= \theta \rightarrow \text{Temperature}$$

☐ Heat $\rightarrow$

people originally thought of this as a fluid, some ~~caloric~~ caloric fluid.

Later we accepted that this was a form of energy.

o Internal Energy : K.E + P.E $\rightarrow$ Binding, etc.

In non relativistic systems, we subtract rest energies. (mc^2)

(*) In context of thermodynamics, KE is calculated in rest frame of system.

So Internal Energy is not relativistic energy.

(*) ~~Also~~ Also it is not related to overall motion.