كلية المستقبل الجامعة

قسم هندسة تقنيات الأجهزة الطبية

MEDICAL CHEMISTRY

Lec. 4: Reversible of irreversible expansion

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Irreversible processes

"All naturally occurring processes proceed in one direction only. Such spontaneous one-way processes are "irreversible".

Irreversible: hydrocarbon combustion like the burning of wood or oil, radioactive decay

Reversible process

In reversible process, the system and environment will return to their original conditions.

Reversible: dissolution of a salt into water, reaction of O_2 and H_2 to form water, phase changes like freezing or boiling of water

More examples

Processes that are usually idealized as reversible include:

- Frictionless movement
- Restrained compression or expansion
- Energy transfer as heat due to infinitesimal temperature non-uniformity
- Electric current flow through a zero resistance
- Restrained chemical reaction
- Mixing of two samples of the same substance at the same state.

Processes that are irreversible include:

- Movement with friction
- Unrestrained expansion
- Energy transfer as heat due to large temperature non uniformities
- Electric current flow through a non-zero resistance
- Spontaneous chemical reaction
- Mixing of matter of different composition or state.

Reversible and irreversible Processes

- intuitive approach to reversible and irreversible processes

later

introduce entropy and the 2nd law → foundation of thermodynamics

Reversible process: can be defined as one whose "direction" can be reversed by an infinitesimal small change in some property of the system.

1. Make a video recording of a process
2. Run the recording backwards

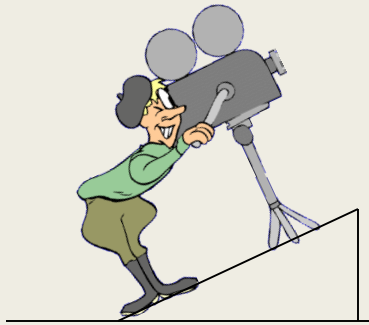
Observable process → reversible

Process impossible to observe → irreversible

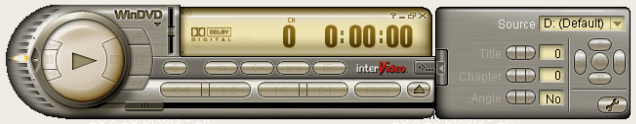
Examples:

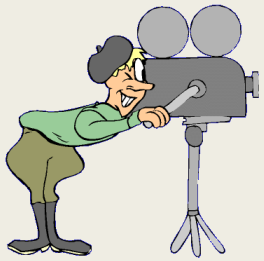
Process is possible

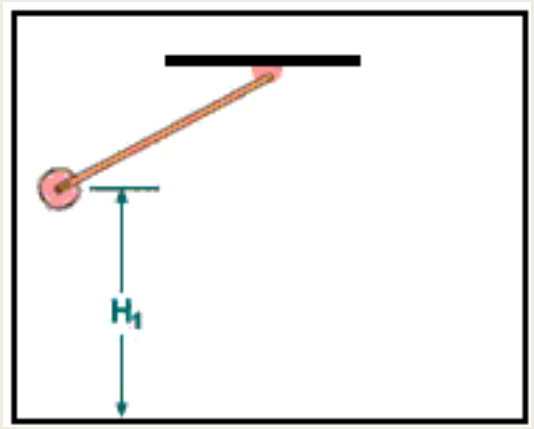
reversible

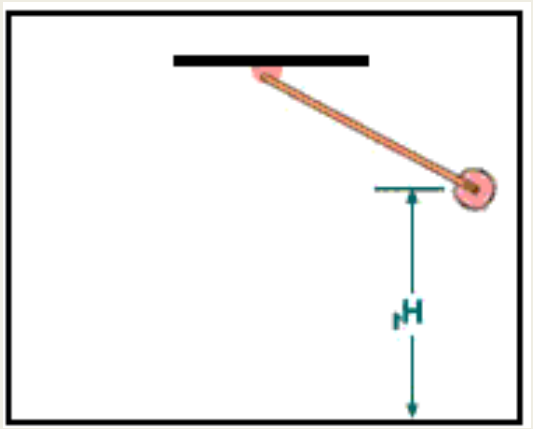


Backward recording



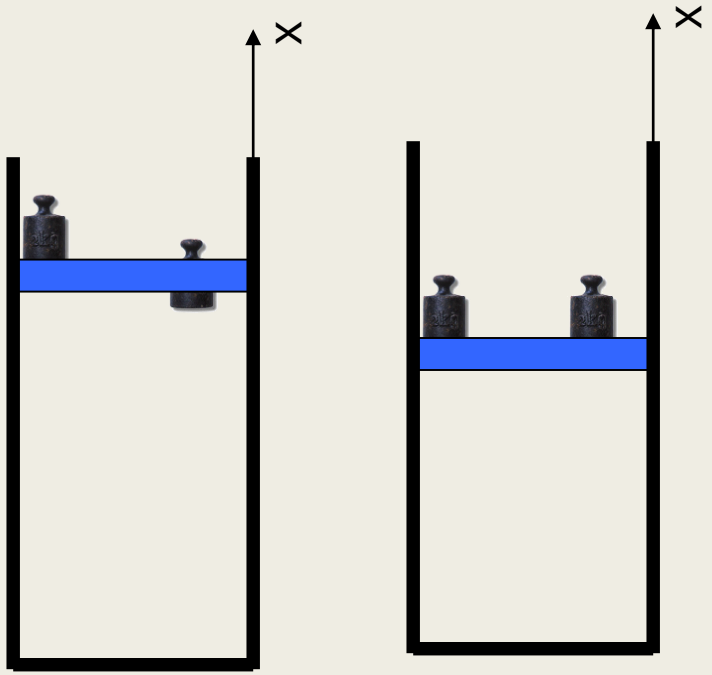






reversible

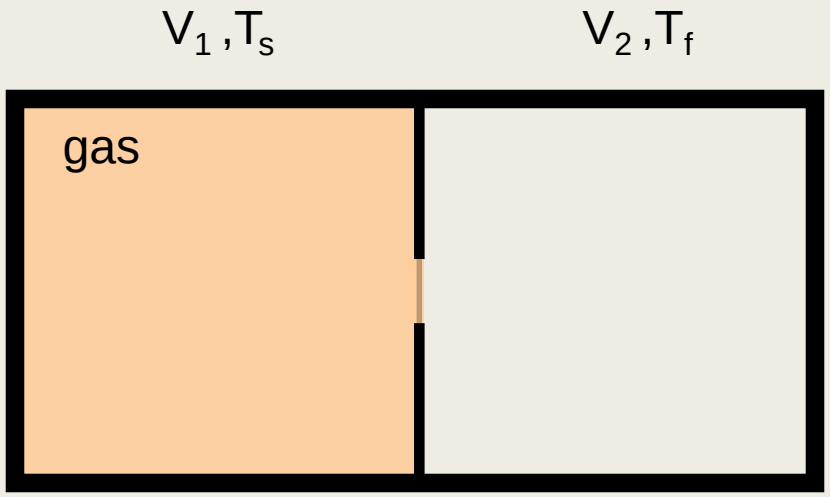
Backward recording



Small changes can be reversed

→ reversible

but

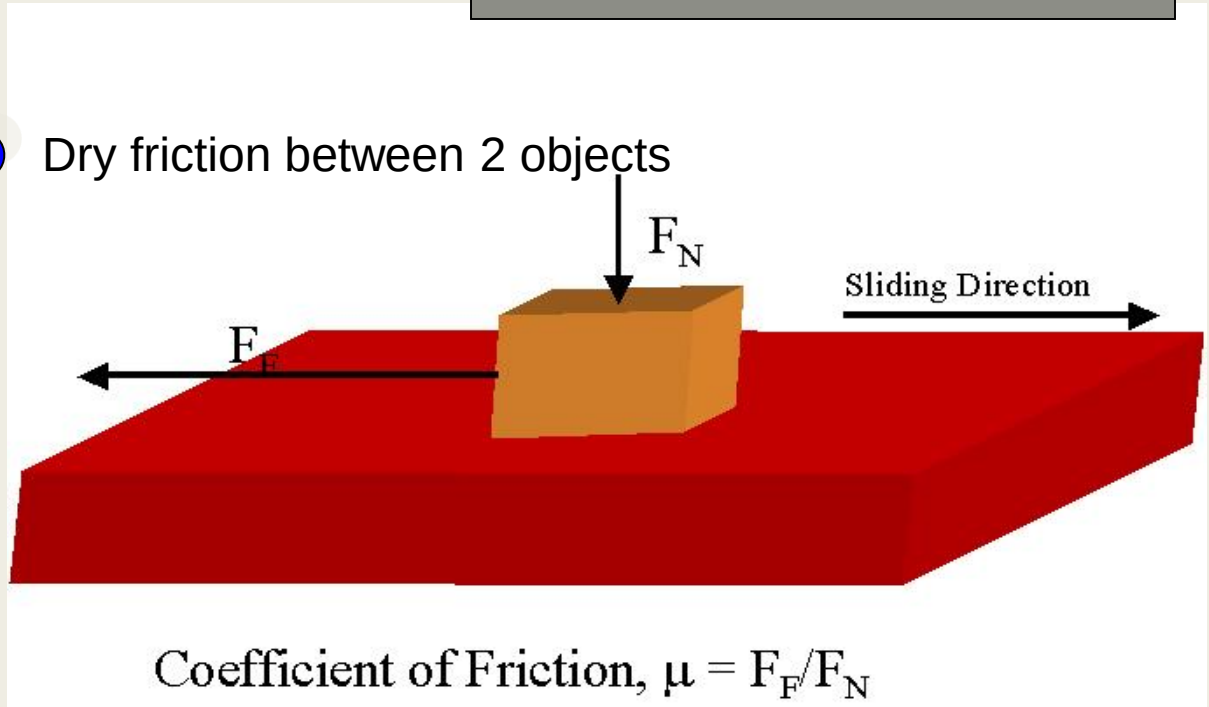


You never observe reversed process of free expansion

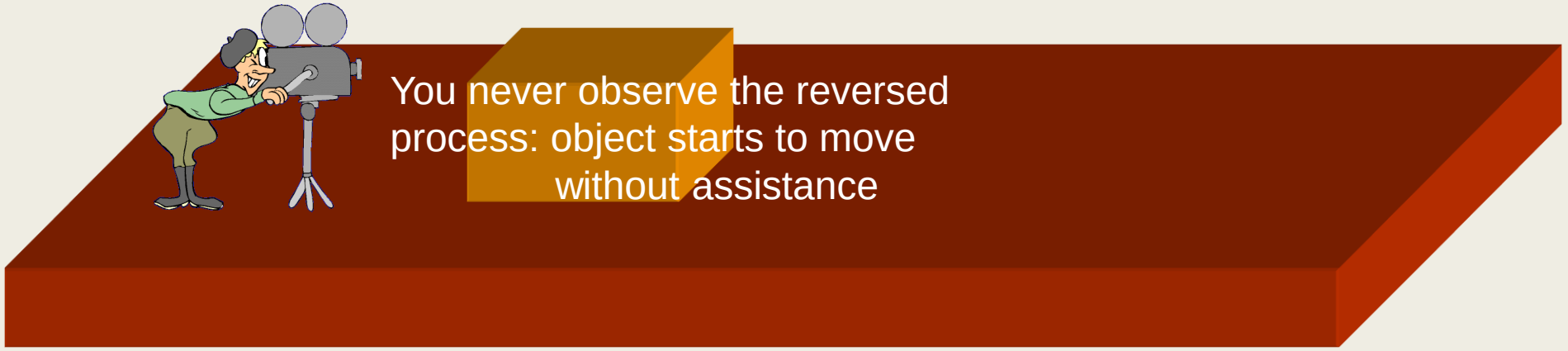
→ irreversible

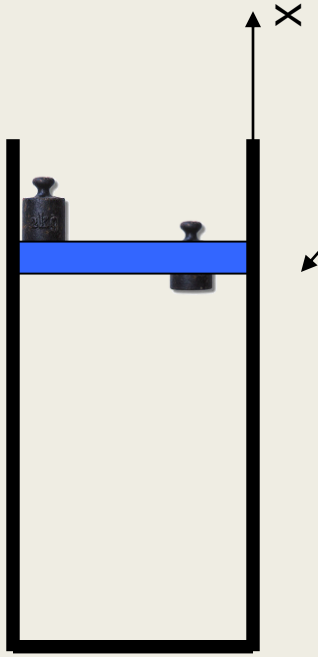
Reversibility is an idealization

- Dry friction between 2 objects



- Reversibility is an idealization (in strictest sense, almost all real processes are irreversible)

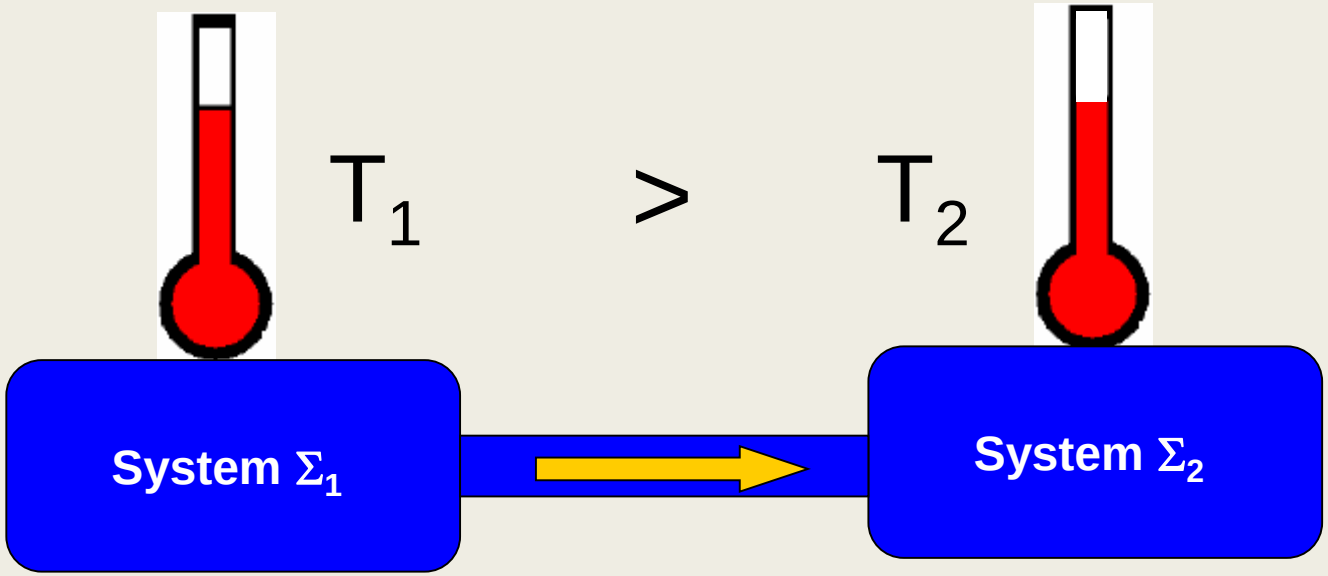




Friction between piston and cylinder ➡ irreversibility

Heat Conductivity in Solids (an example for irreversibility)

Remember: Heat is an energy transferred from one system to another because of temperature difference



Heat Q flows from

Σ_1 to Σ_2

Details:

Expansion-compression work W for all processes is calculated from

$$W = -\int P_{ext}\, dV$$

where P_{ext} is the external pressure and W is in units of kJ/mol. The external pressure and the gas pressure are equal for a reversible process, whereas for an irreversible process the external pressure is the final pressure.

Initial state:

$$V_1 = \frac{R\,T_1}{P_1}$$

where the subscript 1 refers to the initial state, R is the ideal gas constant (kJ/(mol K)), V is volume (m^3/mol), T is temperature (K) and P is pressure (Pa).

For an isothermal process:

$$V_2 = \frac{R T_1}{P_2},$$

where the subscript 2 refers to the final condition.

Reversible work:

$$W = -R T_1 \ln\left(\frac{V_2}{V_1}\right).$$

Irreversible work:

$$W = -P_2 (V_2 - V_1).$$

For an adiabatic process on an ideal diatomic gas:

$$\gamma = \frac{7}{5},$$

$$\mathrm{Cv} = \frac{5R}{2},$$

$$W = \mathrm{Cv}(T_2 - T_1),$$

where $\gamma = Cp/Cv$, Cv is the constant volume heat capacity, and Cp is the constant pressure heat capacity (kJ/(mol K)).

Reversible process:

$$V_2 = V_1 \left(\frac{P_1}{P_2}\right)^{\frac{1}{\gamma}},$$

$$T_2 = T_1 \left(\frac{V_1}{V_2}\right)^{\gamma-1}.$$

Irreversible process:

$$T_2 = T_1 - \frac{P_2 (V_2 - V_1)}{Cv},$$

$$V_2 = \frac{R (Cv\, T_1 + P_2\, V_1)}{P_2 (Cv + R)}.$$

Physical properties of matter are categorized as either Intensive or Extensive:

- **Intensive** - Properties that do not depend on the amount of the matter present.
  - **Color**
  - **Odor**
  - **Luster** - How shiny a substance is.
  - **Malleability** - The ability of a substance to be beaten into thin sheets.
  - **Ductility** - The ability of a substance to be drawn into thin wires.
  - **Conductivity** - The ability of a substance to allow the flow of energy or electricity.
  - **Hardness** - How easily a substance can be scratched.
  - **Melting/Freezing Point**.
  - **Boiling Point**.
  - **Density**.

- **Extensive** - Properties that do depend on the amount of matter present.
  - **Mass** - A measurement of the amount of matter in a object (grams).
  - **Weight** - A measurement of the gravitational force of attraction of the earth acting on an object.
  - **Volume** - A measurement of the amount of space a substance occupies.
  - **Length**
  - **Entropy**

Thank you for listening.....