Lezione 2 -

Oil

Is popular for its ease of transport

Oil worsens the green-house effect but it has high energy density, they are getting easier to extract.

They have high sulfur concentration.

Natural Gas → best fossil fuels.

Very efficient energy production, difficult to transport but needs infrastructure.

It produces the least CO_2 and is relatively clean.

Easier to use in small quantities.

To ship it needs to be transported by special ships.

Until before Ukraine, the use of gas a proportional to the regional production

Coal → Worst in every way

↳ most CO_2 producing

↳ high sulfur quantity

↳ not very efficient.

Things to worry about fossil fuels: direct and indirect pollution

As engineers to help stop global warming we need to reduce the CO_2 we produce and prepare for the changed climate as it will take time to reequilibrate.

Solutions for mitigation:

↳ Nuclear
  ↳ Clean
    ↳ New ideas coming (SMR and fusion)
    ↳ Available for long periods
  ↳ Flaws:
    - High cost
    - Requires safety
    - Nuclear residue

↳ Hydroelectricity
  ↳ Merits
    ↳ Clean and renewable
    ↳ New small-scale machines
  ↳ Flaws
    ↳ limited by geography
    ↳ Some safety issues.

↳ Newer Renewables
  ↳ Improvements in old renewables in different places.
  ↳ Wind and Solar are not programmable.

↳ CO_2 capture and sequestration

↳ Hydrogen
  ↳ Can be very dangerous, so it has to be limited to certain uses.
  ↳ Hydrogen is not readily available, it needs to be produced.

↳ We have different types of hydrogen depending on the energy source we use to generate it.

↳ Possible fuel cells to produce electrical energy.

Thermodynamics describes the energy transfer between a large number of elements, this is not possible, so there are two approach to deal with that.

One is through observations and deriving phenomenological aspects. This is how the first and second principles were derived, these are statements not defined.

While we cannot study at a small scale but we can use probabilistic derivations, making assumptions we can derived macroscopic phenomena. This finds the statistical mechanics.

We use the phenomenological approach since we only care about macroscopic levels. But it is wrong since we are only looking at the macroscale, we need to place postulates, but it is top down.

We use an intermediate approach, using the postulate on statistical mechanics. From statistics we get temperature and we use the postulates on the temperature.

$\underbrace{L}_{\text{Work}} = \Delta E_k + \Delta E_p$ → This is not necessarily true (proved by Joule) as it does not consider heat which is another way

↳ Only valid for the mechanical

$E_k = \frac{1}{2} m v^2$ system. to transfer energy.

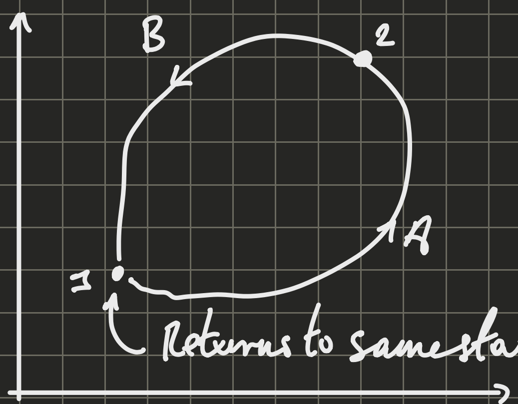
$E_p = Mgz$ E_p is irrelevant for us.

We also need a measure of the stored energy.

Microscopic changes en masse leave a macroscopic trace

Simple Thermodynamic System

State → the set of conditions which describe the system
↳ can be defined at the macroscopic level with 2 variables.



$$\oint(\delta L + \delta Q) = 0 = \int_{1A}^{2}(\delta L+\delta Q) - \int_{1B}^{2}(\delta L+\delta Q)$$

$$= f(1,2) = U_2 - U_1 = \Delta U$$

What energy enters the body is positive, while what is leaving is negative.

State function → function that only depends on the state
Difference in internal energy is 0, proving the validity of the first principal of thermodynamics.

$$\begin{cases} \Delta U = L + Q \\ dU = \delta L + \delta Q \end{cases}$$ → First Principle of Thermodynamics.

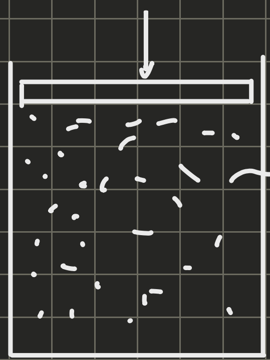
d ⇒ U is a state function
δ ⇒ not state function since they depend on the path.

We leave removed E_k, but in our system they are needed, also E_p for dams.

<u>What are L and Q ?</u>

Characterization of Work / → Heat Tomorrow

Work Modelling



The particles are in motion, they can beat the walls though momentum transfer

↳ 2 bodies

Fluid

F_{INT} → Force applied by the fluid

$$\vec{F}_{EXT} = -\vec{F}_{INT}$$

$$\vec{P} = \frac{\vec{F}_{INT}}{A} \Rightarrow \lim_{dA \to 0} \frac{\delta \vec{F}_{INT}}{dA} = P\vec{n}$$

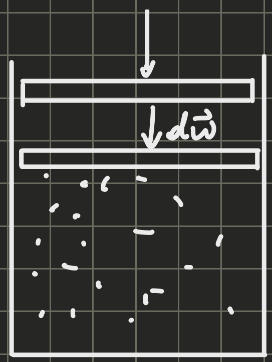
↳ Pressure

always normal to area as the only relevant ones are normal

If we consider out fluid as a continued media it allows to maintain the macro scopic proprieties while maintaining the ability for our fluid to have a microscopic gradient, while at the same time allowing us to not care about the microscopic randomness.

$$\Rightarrow \vec{F}_{INT} = \int \delta F_{INT} = \int_A P\vec{n}\, dA \Rightarrow \vec{F}_{EXT} = -\int_A P\vec{n}\, dA$$

What happens if we are able to move the piston



If $d\vec{w}$ is fast it cannot be a simple sistem since it will generate kinetic energy.
So we want it to be slow so we can have infinitesimal states of equilibria.

If we do it quick we also need more force to generate the kinematics

$$\delta L = \vec{F}_{ext} \cdot d\vec{w} = -\int_A P\vec{n}\, dA \cdot d\vec{w} = -P\int_A \vec{n}\, d\vec{w}\, dA \overset{!}{=} -PdV \Rightarrow \text{Reversible}$$

Work exchanged by a simple thermodynamic system that keeps the system the same and is reversible.

A process like this is not real since it takes an ∞ amount of time. If the velocity is high enough the force needs to be higher since we need to generate all the energy which we need for all "waste" processes that come along

If $\vec{F}_{EXT} \neq \vec{F}_{INT} \rightarrow \vec{F}_{EXT} = -\vec{F}_{INT} + \underbrace{\vec{F}_W}_{\text{Wasted}} \rightarrow \delta L = -PdV + \vec{F}_W d\vec{w} \overset{!}{=} -PdV + \underbrace{\delta L_W}_{\text{Always positive}}$

Energy is positive if it enters the fluid.

$\Rightarrow$ It is irreversible

Since we need to put more energy to put work in / less to take work out