

Thermodynamic state & variables

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Human motivations, constraints & semantics

- Two viewpoints: Energy conversion vs. properties of matter
- What can be measured?
- TD is about equilibrium and “quasi-static” transformation
- Approximations (e.g. surface can be neglected) vs. Idealization (e.g. adiabatic boundary)
- Thermodynamic system?

Thermodynamic system

- Thermodynamic variables: **T, P & V**
- **TD system** -Quantity of matter or a region in space containing energy converting devices where TD variables can be measured/well defined
- **Surrounding** -Rest of the “universe”
- **Boundary** -Surface that separates system and surrounding; It shares TD properties between TD system & surrounding
- **Boundary** -Imagined surface or an idealization of a real surface-Zero thickness, no mass/volume
- Depending on the objective of the analysis: Focus can be on the system or movement of the boundary

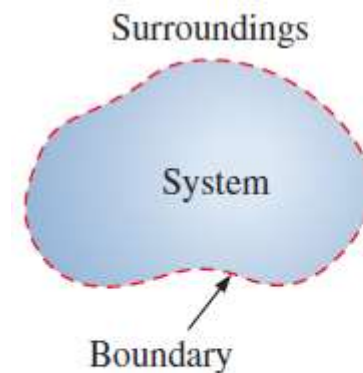


FIGURE 1-18

System, surroundings, and boundary.

Fig: C & B: TD

Control Systems-Closed: Mass & Surface...

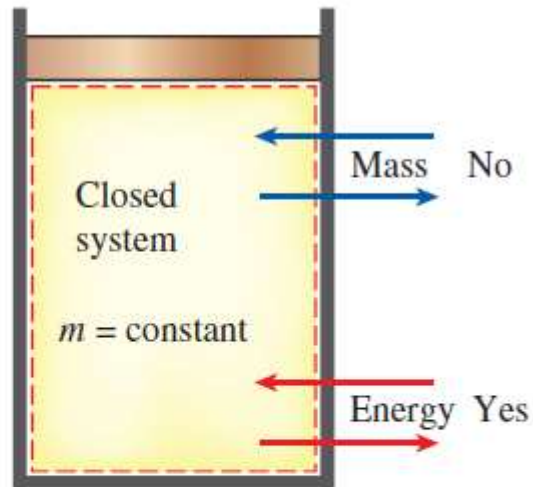


FIGURE 1-19

Mass cannot cross the boundaries of a closed system, but energy can.

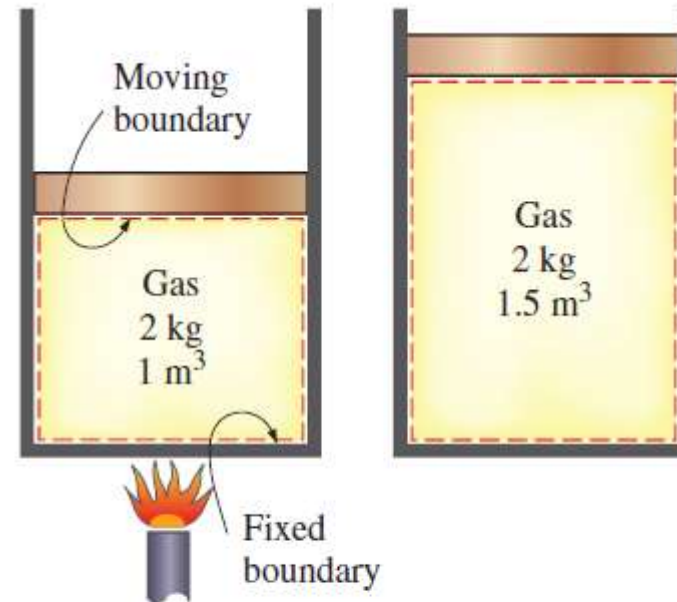
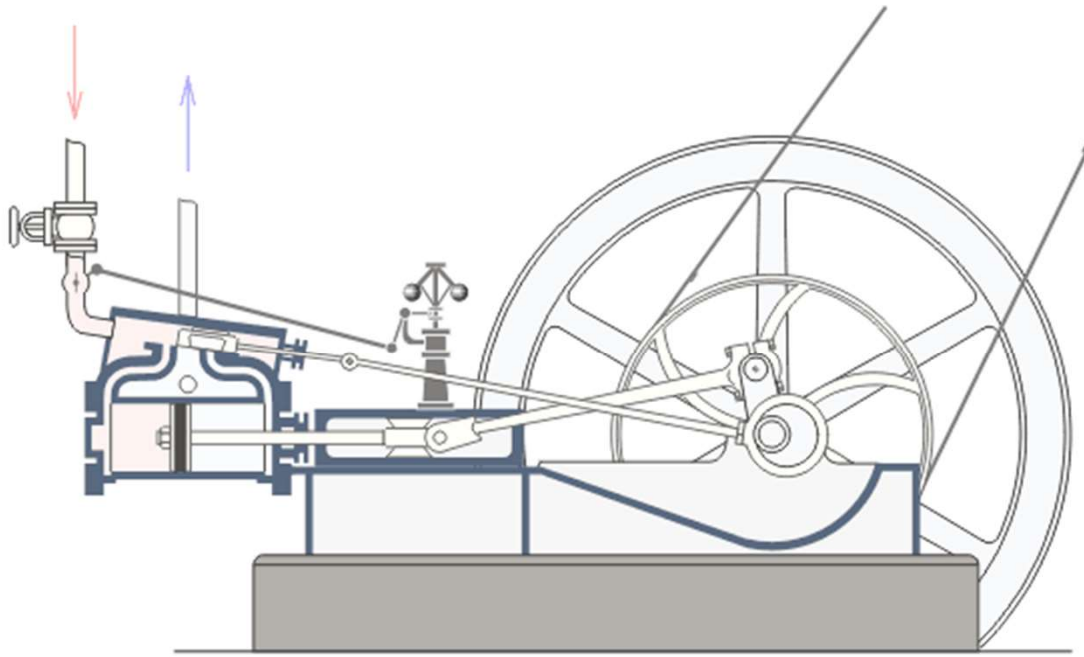


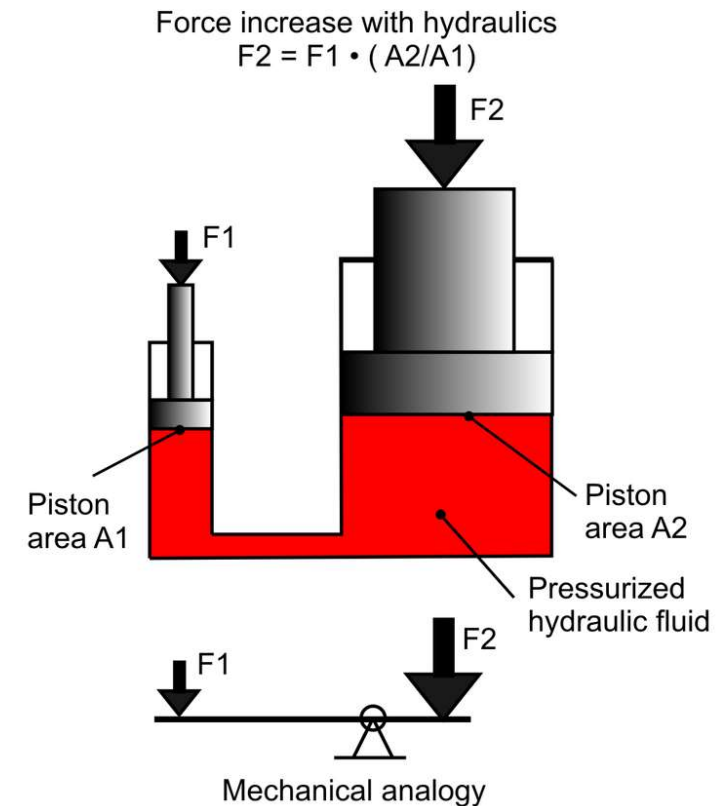
FIGURE 1-20

A closed system with a moving boundary.

Is the course title ESO: Pistons-analysis & applications?!



Cyclic linear motion of the piston → Rotatory motion

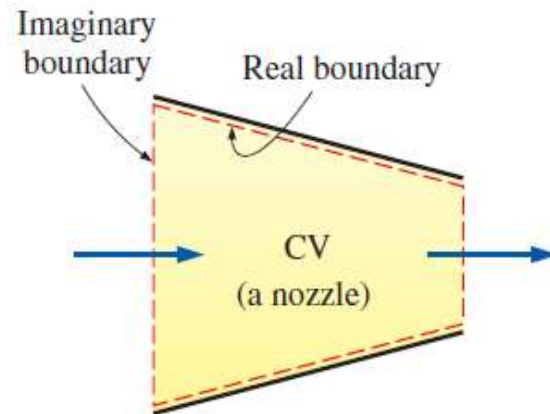


When **weights** above the piston are changed in **very small increments**, the **pressure** can be varied **infinitesimally** → **Reversible process**

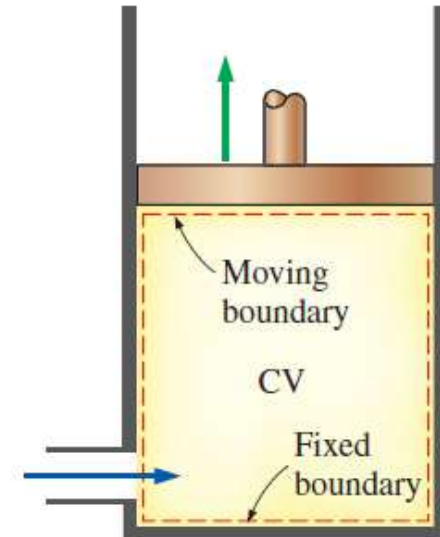
https://en.wikipedia.org/wiki/Reciprocating_motion

https://en.wikipedia.org/wiki/Hydraulic_machinery

Control Systems-Open: Volume & Surface...



(a) A control volume (CV) with real and imaginary boundaries



(b) A control volume (CV) with fixed and moving boundaries as well as real and imaginary boundaries

FIGURE 1-22

An open system (a control volume) with one inlet and one exit.

Variants in TD systems

- System open to selective components: semi-permeable membranes
- Flexible boundaries: Gas expansion in a balloon
- Adiabatic/Insulating wall Vs Diathermal/Conducting wall
- Idealization of systems encountered in reality

TD system-Emphasis starts with T & then...

- Solid mechanics: Focus on strain of charge neutral systems; Electrodynamics focusses on effects of charge in mechanically unstrained situation...
- As the focus in TD is on T , we begin with charge neutral, elastically unstrained systems...
- But TD can deal with stress & strain, electrical charges/monopoles & fields, Magnetic dipoles & fields, surface stress & strain, surface tension & area...
- Eventually you will see that TD variables come in conjugate pairs where an (Intensive quantity) * (Extensive quantity)=Energy
- Extensive quantities: mass, V , charge monopoles, magnetic dipoles, strains, area...
- Intensive quantities: gravitational potential, Pressure, fields, stress, surface tension...Specified at a given point; (extensive quantity/another exten.quan.)