ESO 201A: Thermodynamics

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Introduction-part 1

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Learning objectives

1. Review of metric SI
2. Explain basic concept of :
   - *system, state, state postulate, equilibrium, and process*
3. Define intensive and extensive properties of system
4. Define density, specific gravity, and specific weight
5. Discuss temperature scale
6. Understanding pressure, barometer, manometer

Introduction to thermodynamics: definition

Thermodynamics

‘Therme’ heat

‘dynamics’ power

Conversion of heat to power!

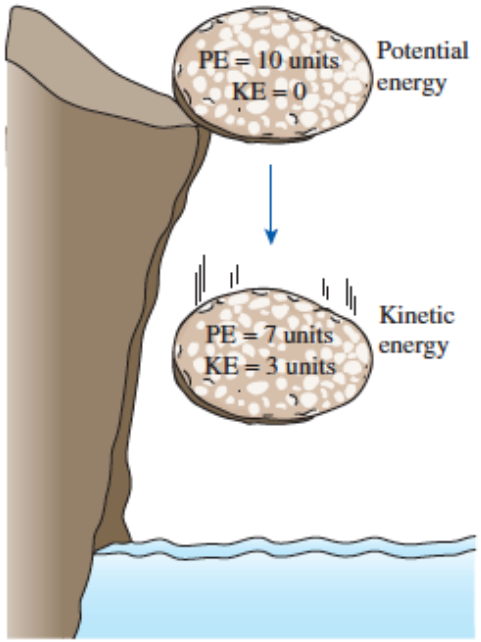
Thermodynamics: science of energy and energy transformation

Example of energy transfers, one form to another

Conversion of electrical energy into mechanical energy

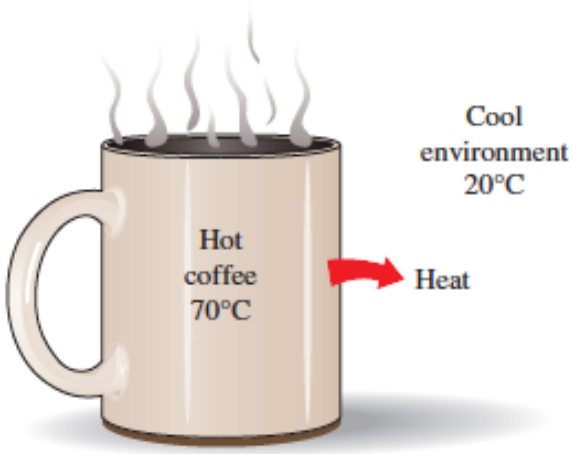
Conversion of electrical energy into Thermal energy

Fundamental laws of nature

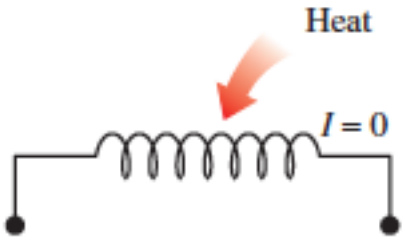


Energy cannot be created or destroyed; it can only change forms

The First Law

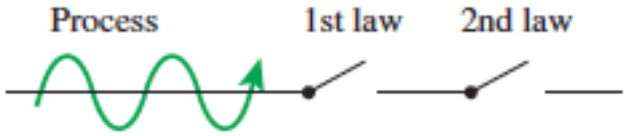


Heat flow in the direction of decreasing temperature



Transferring heat to a wire will not generate electricity.

The second law!



Processes occur in a certain direction, and not in the reverse direction.

Engineer's role

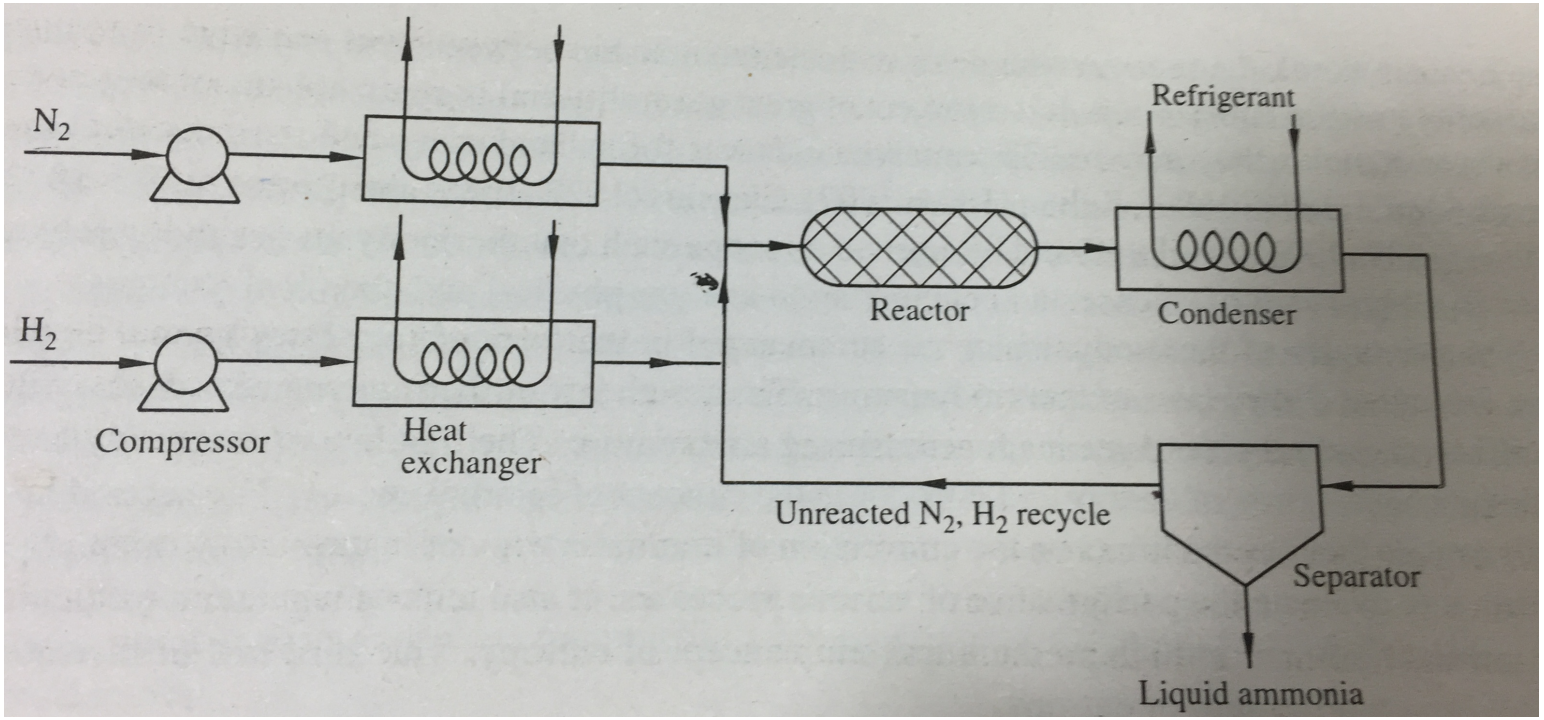
- Design and develop new systems and processes
- Improve existing systems and processes

Production *of ammonia*- basic ingredient for fertilizers

$N_2 + 3H_2 \rightarrow 2NH_3$

1. What is the source of the required raw materials? If there are several sources, which one is to be preferred?
2. What factors (pressure, temperature, ratio of reactants) govern the extent of the reaction
3. How much energy is required to compress and raise the temperature of the reactants to the desired level?
4. …

Engineer's role

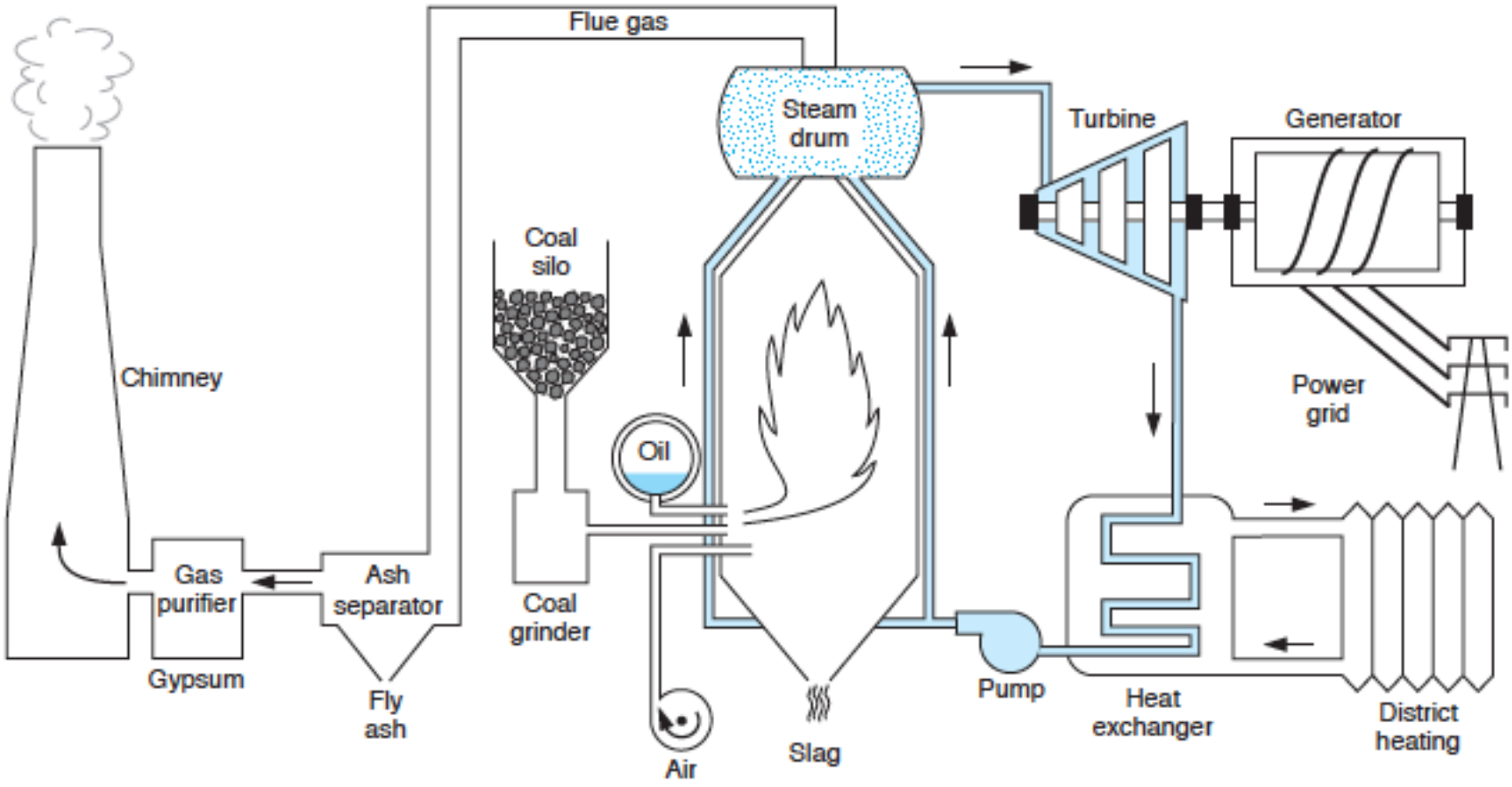


Other concerns

- How much cooling is required to condense the ammonia and to separate it from the unreacted material?
- Is a certain change, physical or chemical, feasible or not?

Thermodynamics-study of energy and its transformation- enables engineers to answers all the above questions!

Application areas

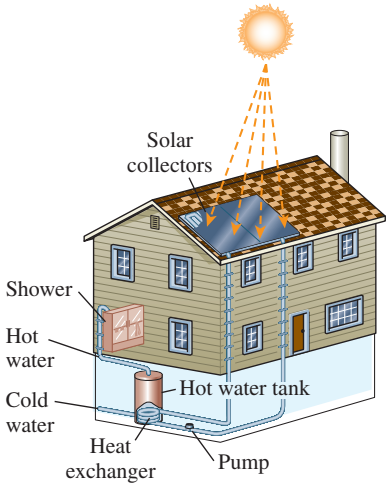


Schematic of steam power plant

Application areas

Application areas

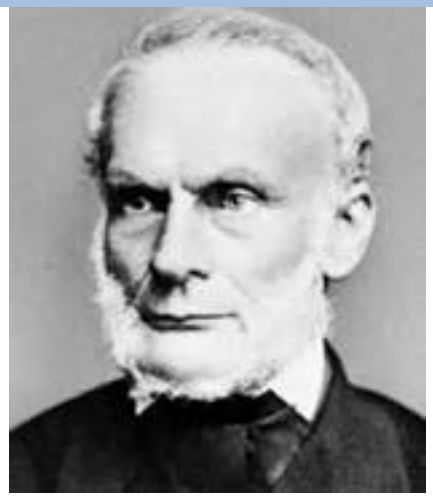
Design of many engineering systems involve thermodynamics



Laws of thermodynamic are credited to (not the exhaustive list)

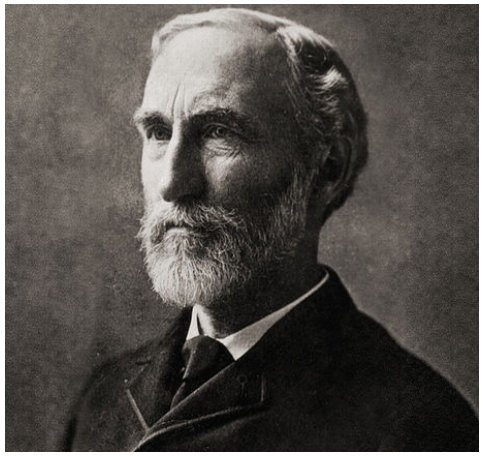
William
John
Macquorn
Rankine

(1820-1872)



Rudolf Clausius (1822-1888)

Lord Kelvin (1824-1907)



Josiah Williard Gibbs
(1839-1903)

Importance of dimension and units

- Any physical quantity can be characterized by **dimensions**.
  - The magnitudes assigned to the dimensions are called **units**.
- **Primary** or **fundamental dimensions**
  - Some basic dimensions such as mass *m*, length *L*, time *t*, and temperature *T*
- **Secondary dimensions**, or **derived dimensions**
  - velocity *V*, energy *E*, and volume *V* are expressed in terms of the primary dimensions
- Metric SI system: A simple and logical system based on a decimal relationship between the various units.

To be dimensionally homogeneous, all the terms in an equation must have the same unit.

TABLE 1–1

The seven fundamental (or primary) dimensions and their units in SI

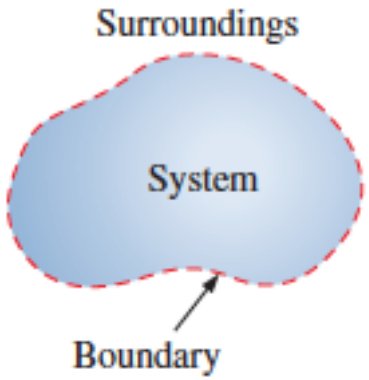
Dimension	Unit
Length	meter (m)
Mass	kilogram (kg)
Time	second (s)
Temperature	kelvin (K)
Electric current	ampere (A)
Amount of light	candela (cd)
Amount of matter	mole (mol)

TABLE 1–2

Standard prefixes in SI units

Multiple	Prefix
10^{12}	tera, T
10^{9}	giga, G
10^{6}	mega, M
10^{3}	kilo, k
10^{2}	hecto, h
10^{1}	deka, da
10^{-1}	deci, d
10^{-2}	centi, c
10^{-3}	milli, m
10^{-6}	micro, μ
10^{-9}	nano, n
10^{-12}	pico, p

System and control volume



System

- Quantity of matter or a region in space chosen for study

Surrounding

- The mass or region outside the system

Boundary

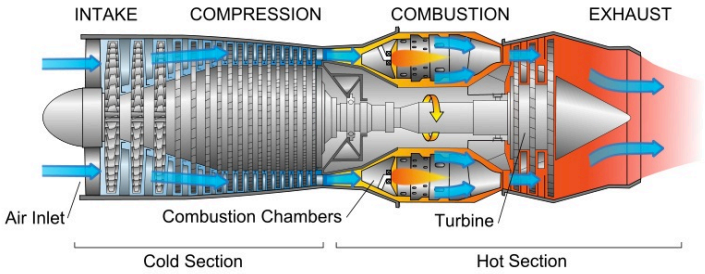
- The real or imaginary surface that separate the system and surrounding
- Fixed or movable
- Zero thickness (i.e., zero mass or volume)

Batch reactor

Soft drink

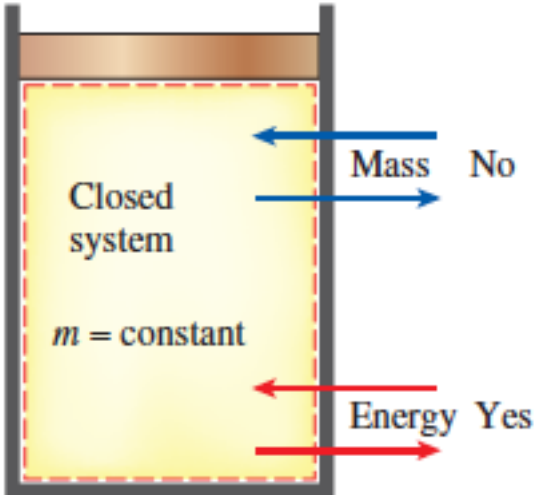
Car engine

Earth atmosphere



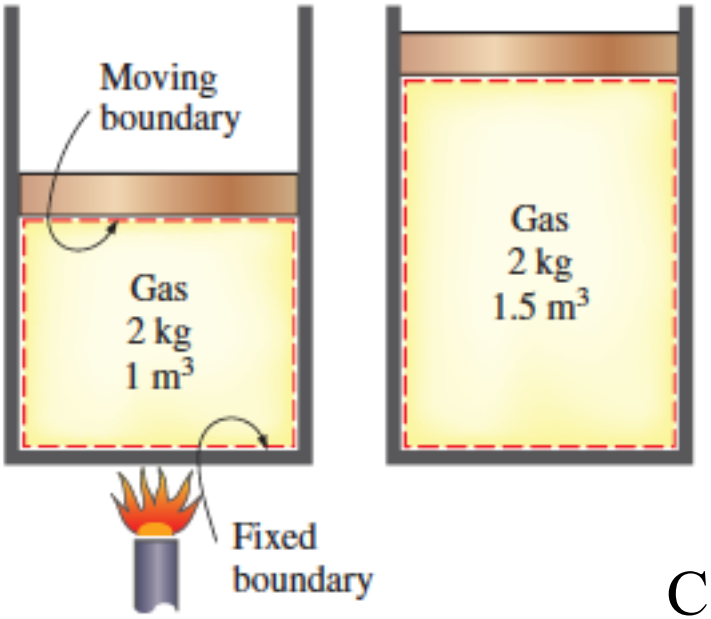
Turbine jet engine

Closed system



Closed system (control mass)

- No mass can leave or enter
- Energy can cross the boundary (work or heat)
- Volume may change (if boundary is not fixed)
- Isolated system
  - If energy is not allowed

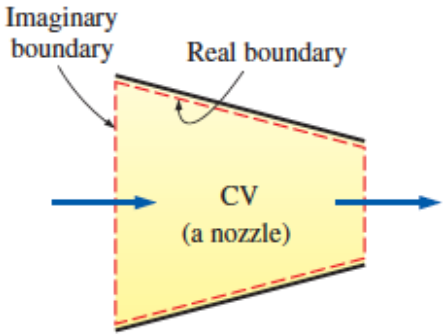


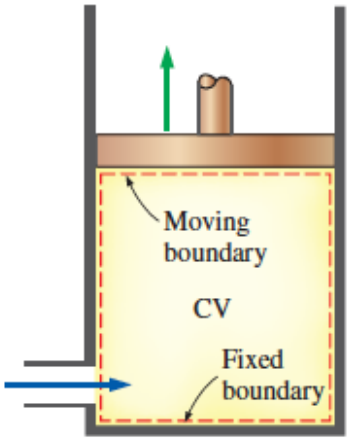
Closed system with moving boundary

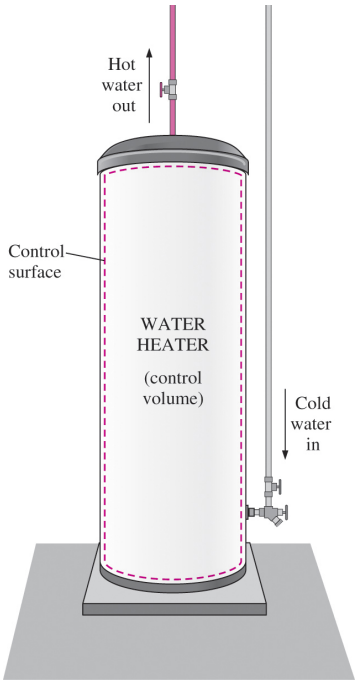
Open system

Open system(control volume)

- Usually encloses a device that involves mass flow e.g., compressor, turbine, or nozzle.
- Both mass and energy can cross the boundary of the control volume
- Any arbitrary region can be selected as control volume, though proper choice makes the analysis easier
  - Fixed in size and shape (most common), or it may have movable boundary.







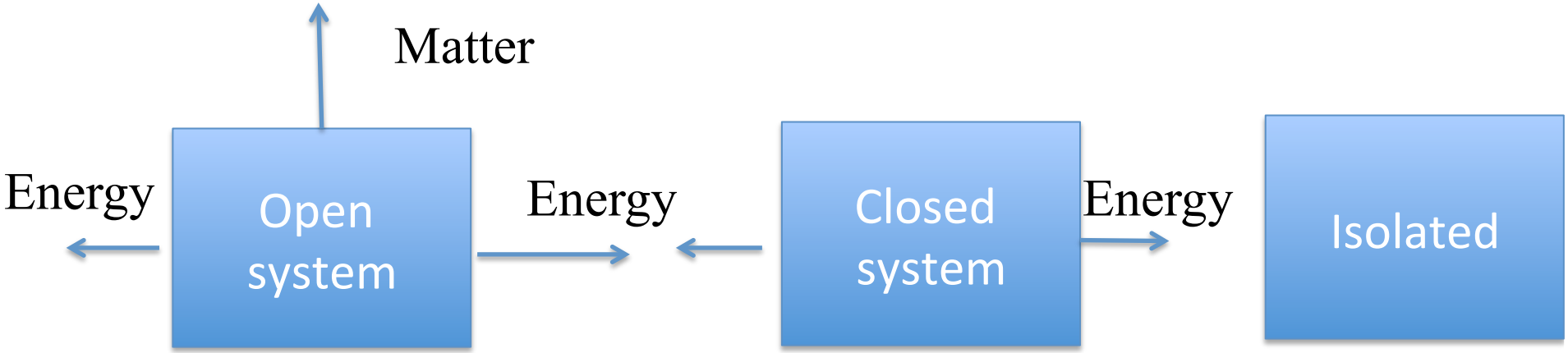
An open system (a control volume) with one inlet and one exit.

Examples

Open

Closed

Isolated



Next lecture

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