ME 331 Thermodynamics II

Prerequisite: ME 230 Thermodynamics I

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(Dept. of Mechanical Engineering)
Lecture: Tue (9.30-11.00) and Wed (13.30 – 15.00)
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Relating courses

- ME 230 Heat transfer
- ME 333 Internal combustion engine
- ME 345 Power plant engineering
- ME 434 Refrigeration and air conditioning
- ME 436 Gas turbine
- ME 438 Energy sources and conversion
- ME 439 Energy management in building and industry

Red: Compulsory courses

Objectives

- To understand the closed system and open system/ control volume concepts and be able to describe engineering problems in terms of these concepts.
- To understand the 1st and 2nd laws of thermodynamics, and learn how to apply these laws to both open and closed systems.
- To understand how the relations between the energy storage and phase change in various kinds of power cycles and refrigeration cycles.
- To understand how to analysis of performance of engineering components, systems.

Teaching schedule

Session	Topics
1 – 2	**1. Reviews of Thermodynamics I** Overviews and importance of Thermodynamics in real applications; Open-close systems; Control volume; adiabatic process; Isothermal process; Steam table; Conservation of mass; Conservation of energy
3 – 6	**2. Second law of Thermodynamics** Introduction to the second law; Refrigerators and heat pumps; Reversible and Irreversible processes; Carnot cycle; Carnot refrigerator and heat pumps
7 – 10	**3. Entropy** Entropy; increase of entropy principle; Isentropic processes; Entropy generation; T – ds Relations; Entropy change of liquids, solids, and ideal gases; Reversible Steady – flow work; Minimizing the compressor work; Isentropic efficiencies of steady – flow; Entropy balance
11 – 14	**4. Exergy: A measure of work potential** Work potential of energy; Reversible work and irreversibility; Second – law efficiency; Exergy change of a system; Exergy transfer by heat, work, and mass; Decrease of exergy principle; Exergy balance

Teaching schedule (Cont')

Session	Topics
***15 – 18**	**5. Gas power cycles** Basic considerations in the analysis of power cycle; Carnot cycle; Air standard cycle; Reciprocating engines; Otto cycle; Diesel cycle; Stirling cycle; Brayton cycle; Second – law analysis of gas power cycles
19 – 21	**6. Vapor and combined power cycles** Carnot vapor cycle; Rankine cycle; Deviation of actual vapor power cycles; Cogeneration; Combined gas – vapor power cycles
22 – 24	**7. Refrigeration cycles** Refrigerators and heat pumps; Reversed Carnot cycle; Ideal vapor – compression refrigeration cycle; Actual vapor compression refrigeration cycle

Reference

- Lecture note (powerpoint) (http://www.engr.tu.ac.th/~cchainar)
- Cengel, Y.A., and Boles, M., 2002. *Thermodynamics an engineering approach*. 4th ed., McGraw-Hill.

Tentative Evaluation

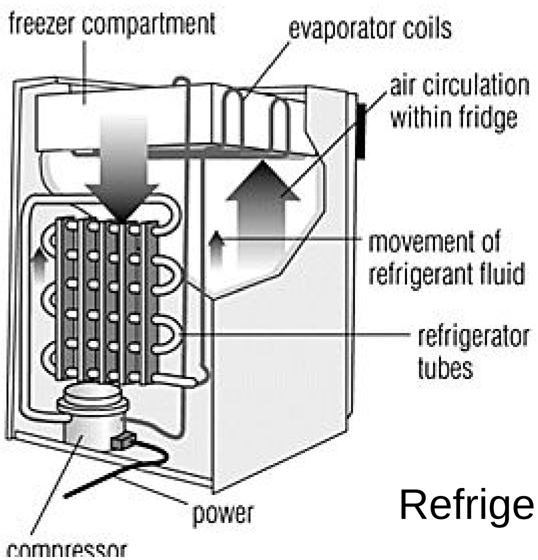
Attendance, Quiz and Assignment	20%
Mid-term Examination (topic 1 – 4)	20%
2nd Examination (topic 5)	30%
Final Examination (topic 6 – 7)	30%
Total	100%

Evaluation

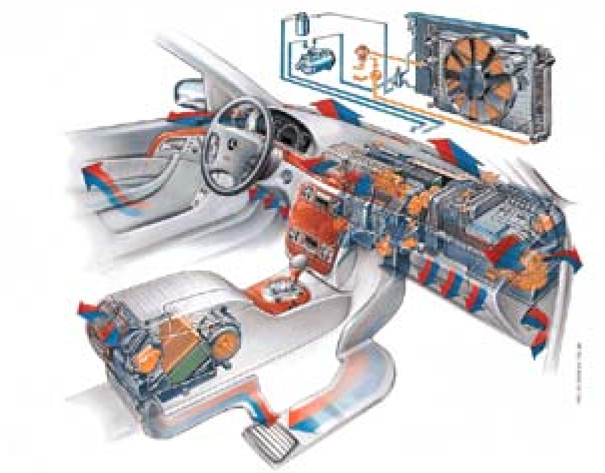
≥ 80	**A**
74 - 79	**B+**
68 – 73	**B**
62 – 67	**C+**
56 – 61	**C**
50 – 55	**D+**
44 – 49	**D**
< 44	**F**

Applications of Thermodynamics

❑ Refrigeration and air-conditioning systems

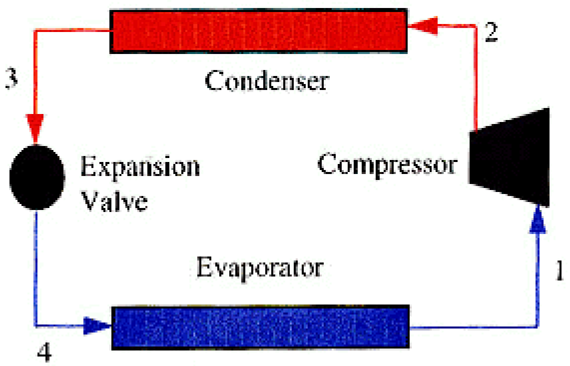


Refrigerator

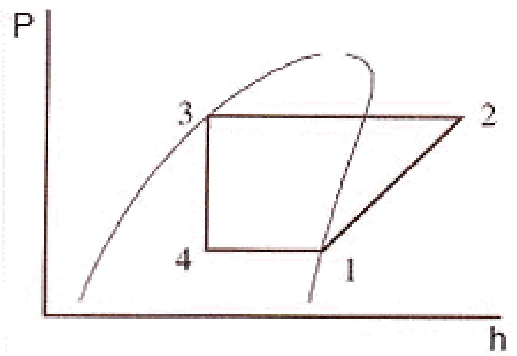


Air-conditioning system

Vapor Compression Refrigeration Cycle



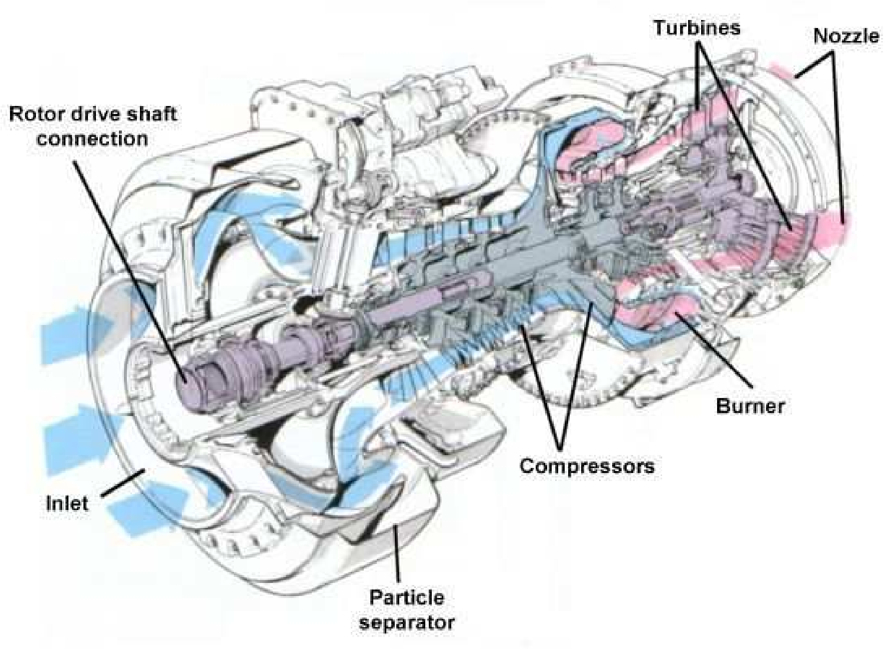
Phase diagram for vapor compression refrigeration cycle



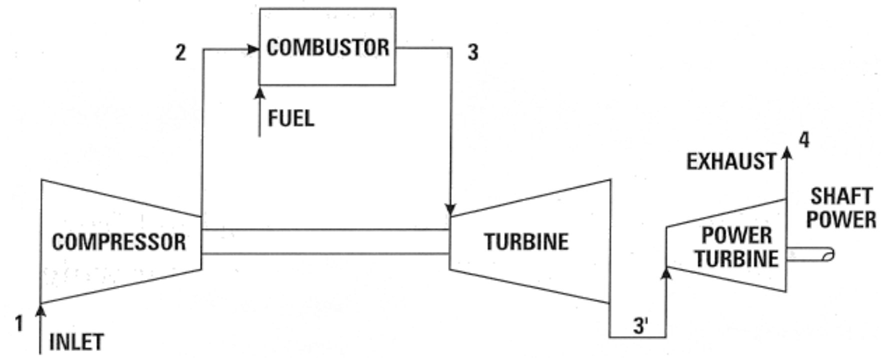
Applications of Thermodynamics

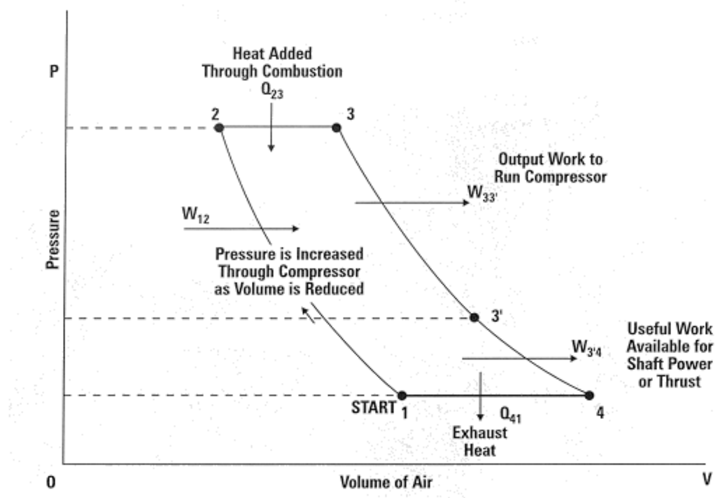
- **Gas turbine engine**

  Aircraft propulsion



Turboshaft



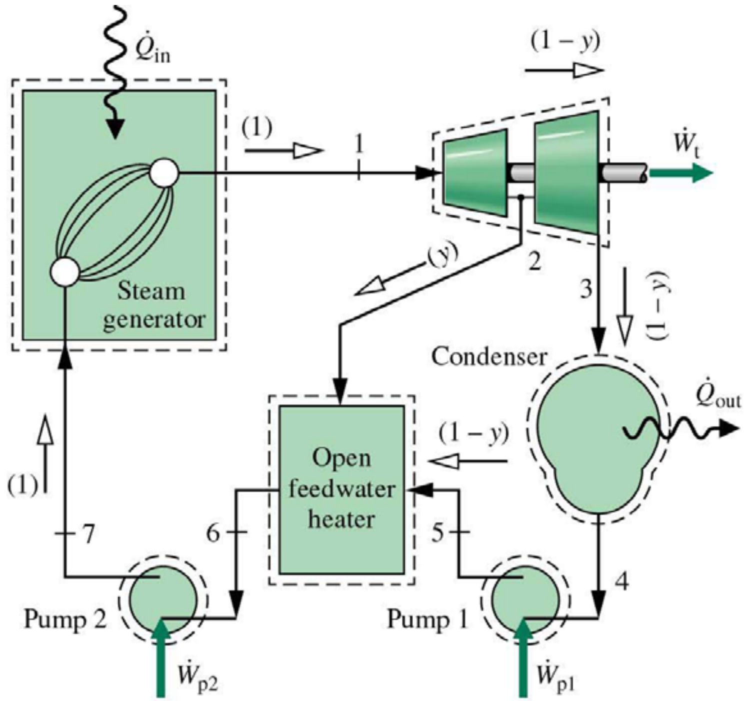


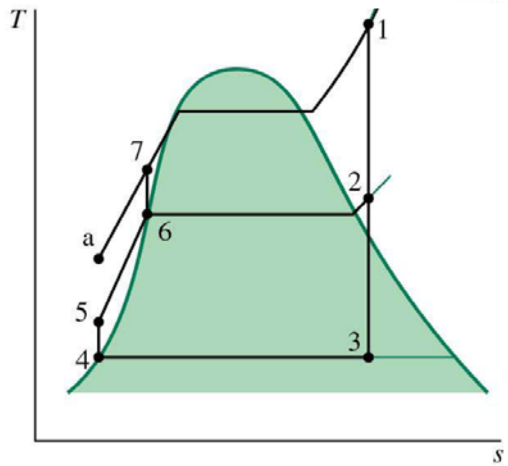
Applications of Thermodynamics

❑ Power plant

Heat → Electricity

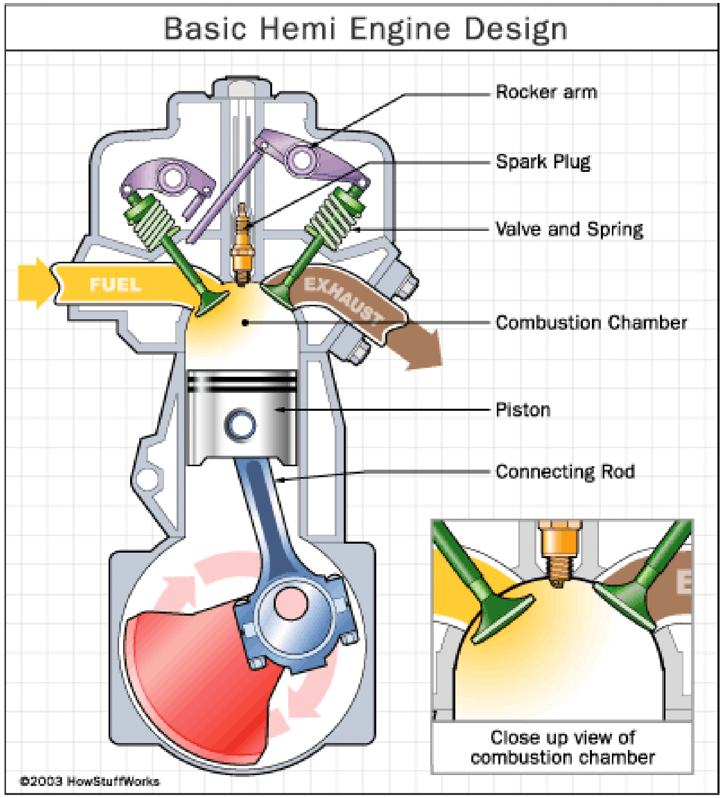
Turow Power Plant
Courtesy of Turow Plant



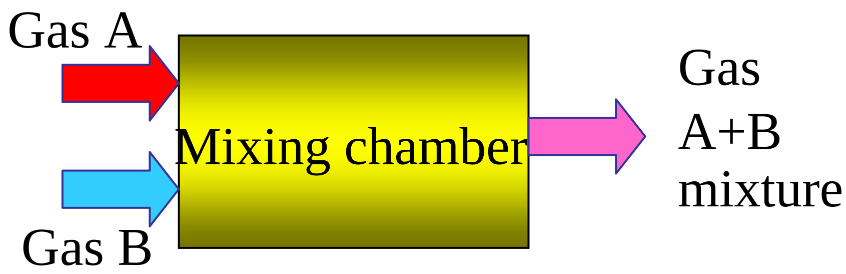


Applications of Thermodynamics

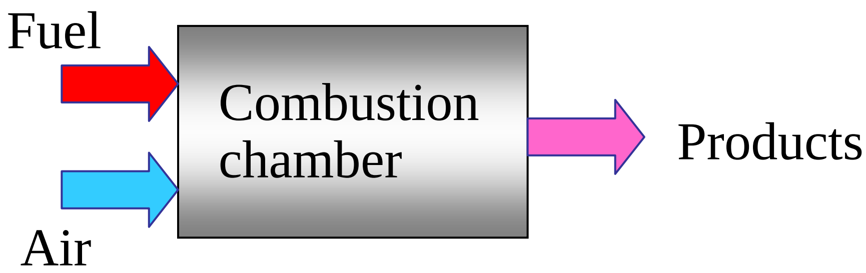
❑ Mixing w/o chemical reaction



(a) Without chemical reaction



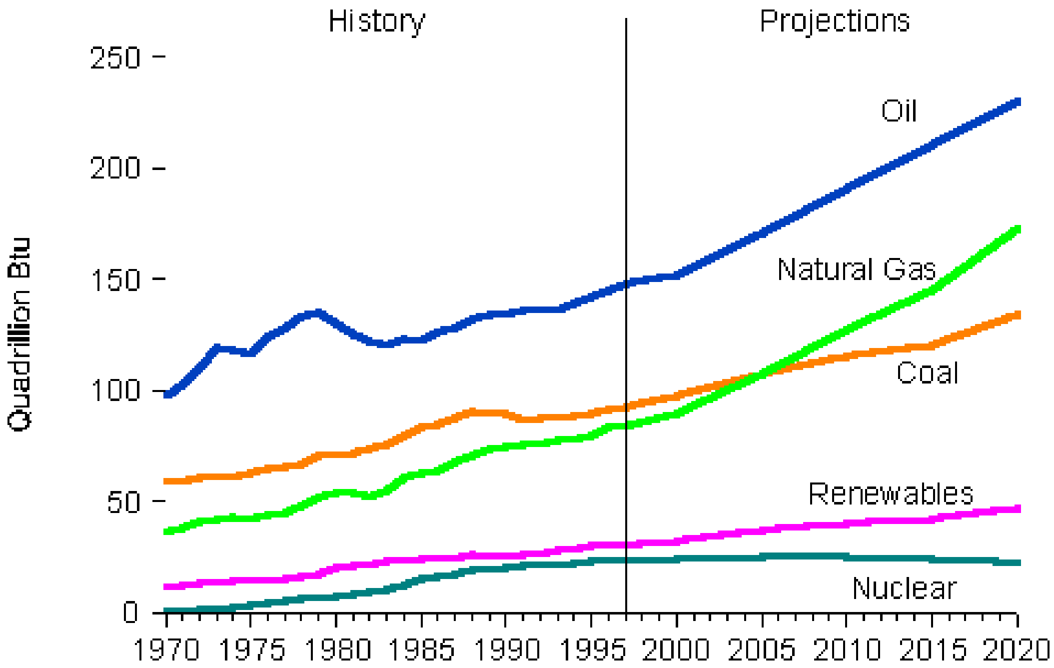
(b) Without chemical reaction



Applications of Thermodynamics

❑ Evaluation and improvement of the thermal efficiencies

World Energy Consumption by Fuel Type, 1970-2020



Source: EIA, International Energy Outlook 2000

- **Thermodynamics**
  Heat, work, energy, power cycles

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- Energy analysis
- Efficiency analysis

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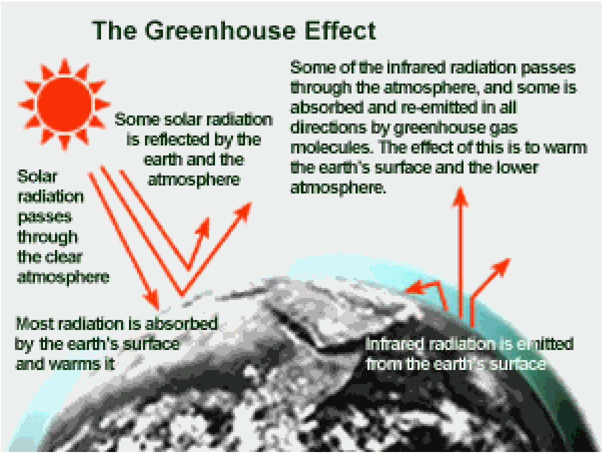
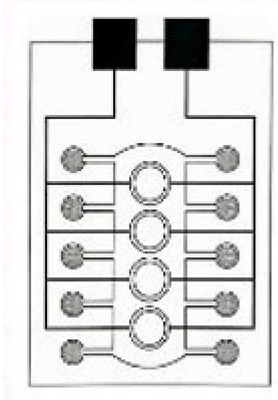
- Improvement
- Alternative energy
- New energy source

Applications of Thermodynamics

❑ Global warming



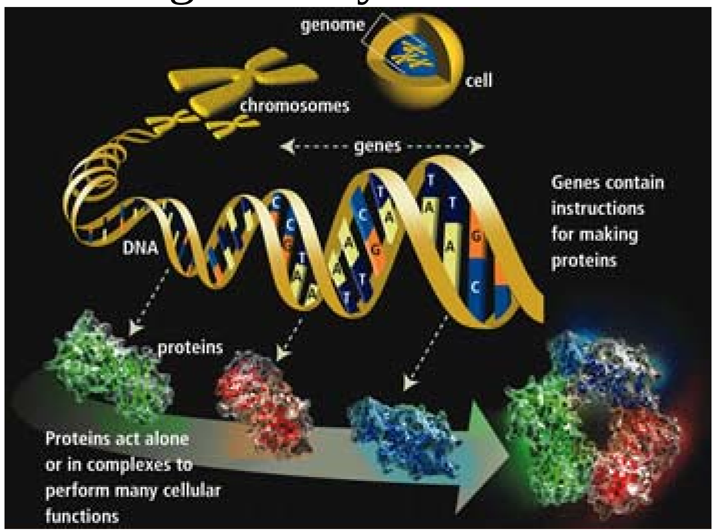
❑ Micro power generator




Heat → electricity

❑ Biological thermodynamics

- Healing illness and disease
- Drug delivery

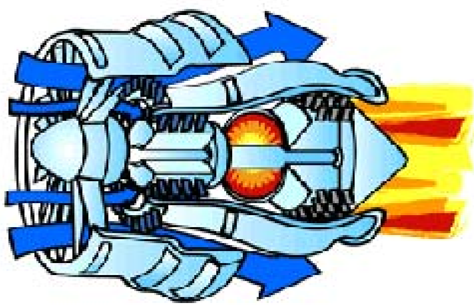


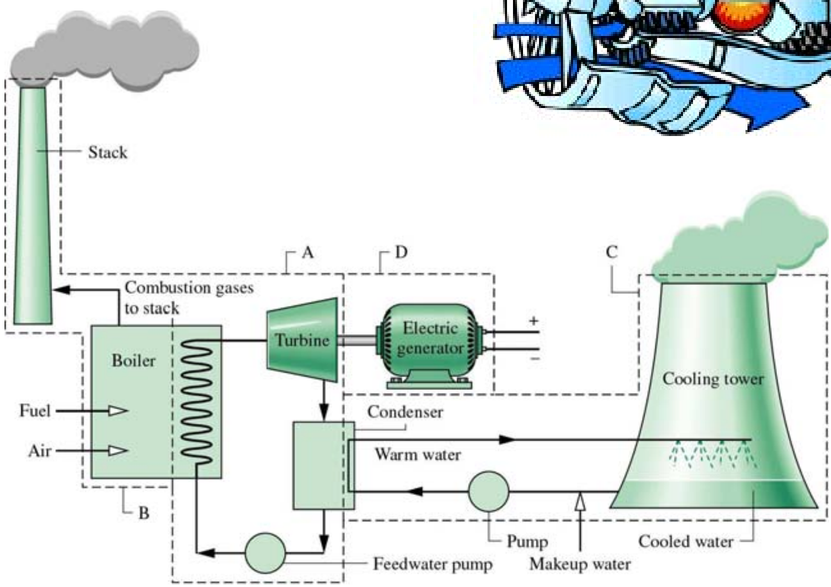
❑ Food engineering


Thermodynamics II

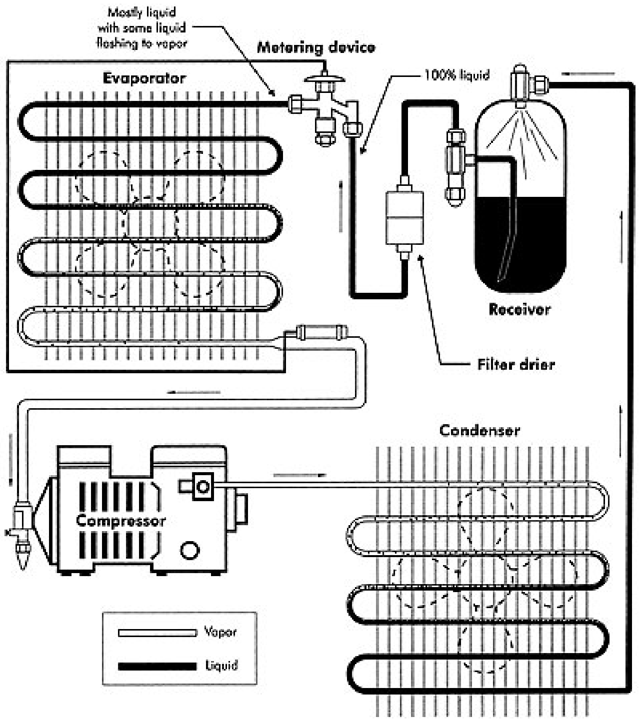
- **Principle and efficiency**
  - Power cycles
  - Principles of refrigeration and air-conditioning system
- **Reacting mixtures and combustion**

Combustion engine





Power plant diagram



Refrigeration system

Thermodynamics

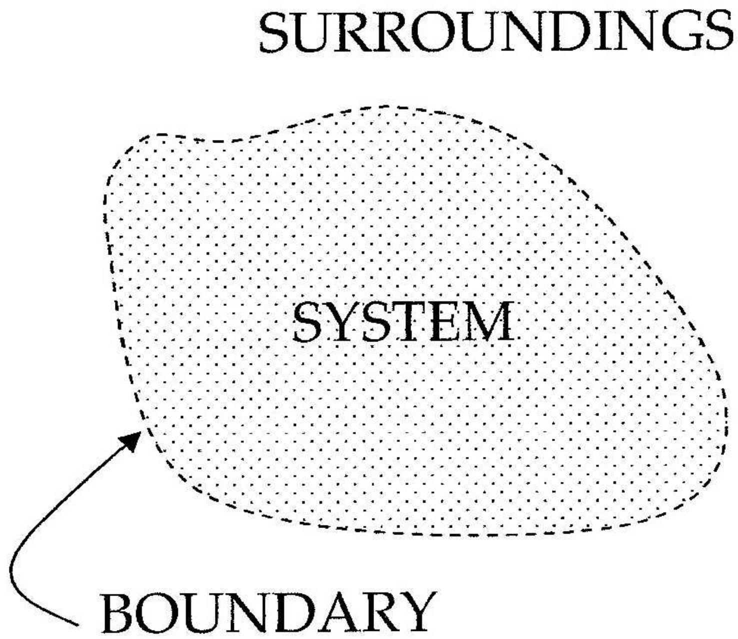
- From Greek, *thermos* = heat, and *dynamis* = power
- Describe processes that involve changes in temperature, transformation of energy, relationship between heat and work
- The results of thermodynamics are essential for other fields of physics and for chemistry, chemical engineering, cell biology, biomedical engineering, and materials science.

Thermodynamic systems

"***System***" is defined as a quantity of matter or a region in space chosen for study.

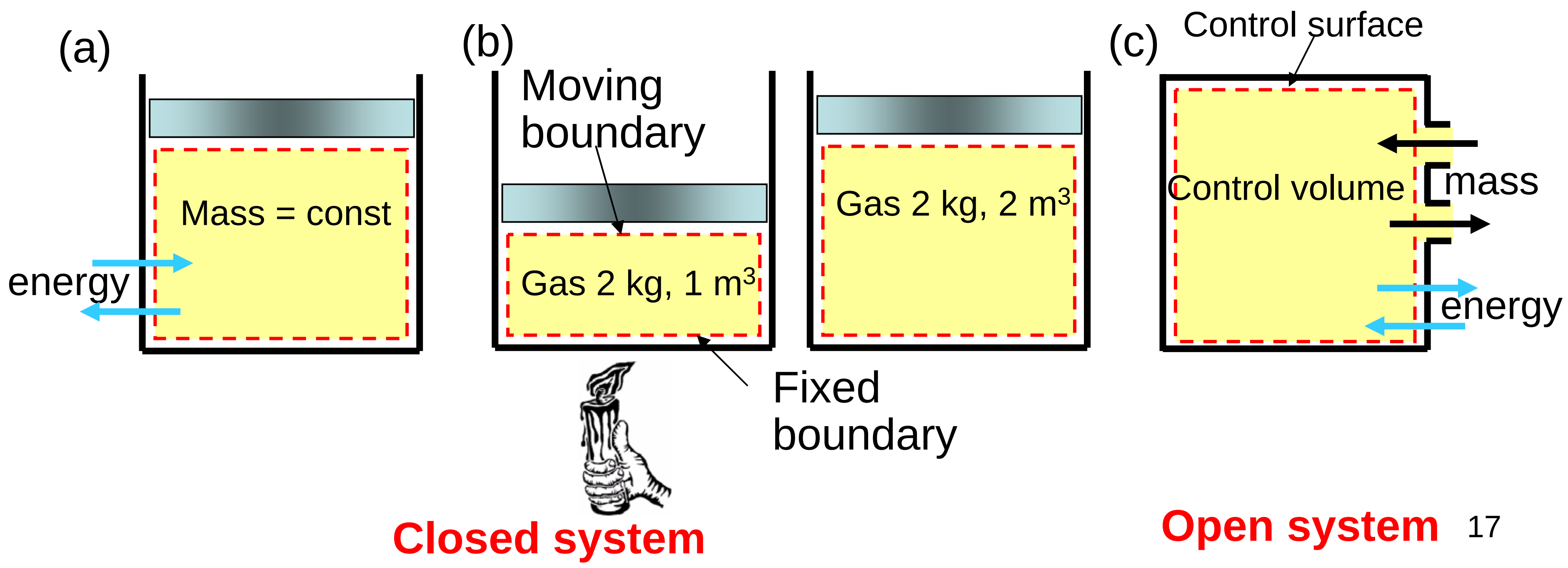
"***Surrounding***" is the mass or region outside the system.

The possible exchanges of work, heat, or matter between the system and the surroundings take place across this boundary.



Dominant classes of systems

1. **Isolated systems** – matter and energy do not cross the boundary.
2. **<u>Adiabatic systems</u>** – heat does not cross the boundary.
3. **Diathermic systems** – heat can cross the boundary.
4. **<u>Closed systems</u>** – matter does not cross the boundary.
5. **<u>Open systems</u>** – heat, work, and matter can cross the boundary.



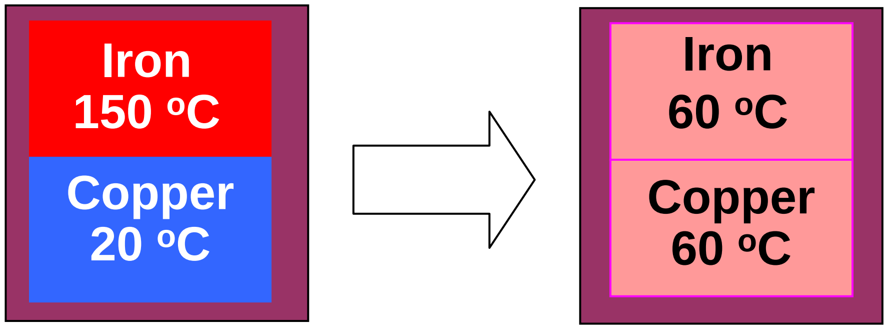
Thermodynamic processes

1. **<u>Reversible process</u>** – Both the system and surrounding can be returned to their initial states.
2. **<u>Irreversible process</u> –** System and all parts of its surrounding cannot be exactly restored to their respective initial state after the process has occurred.
3. **<u>Isothermal process</u>** – A process occurs at const temperature
4. **<u>Isentropic process</u>** – A process occurs at constant entropy.
5. **Isobaric process** – A process occurs at constant pressure.
6. **Isochoric process** – A process occurs at constant volume.

Laws of Thermodynamics

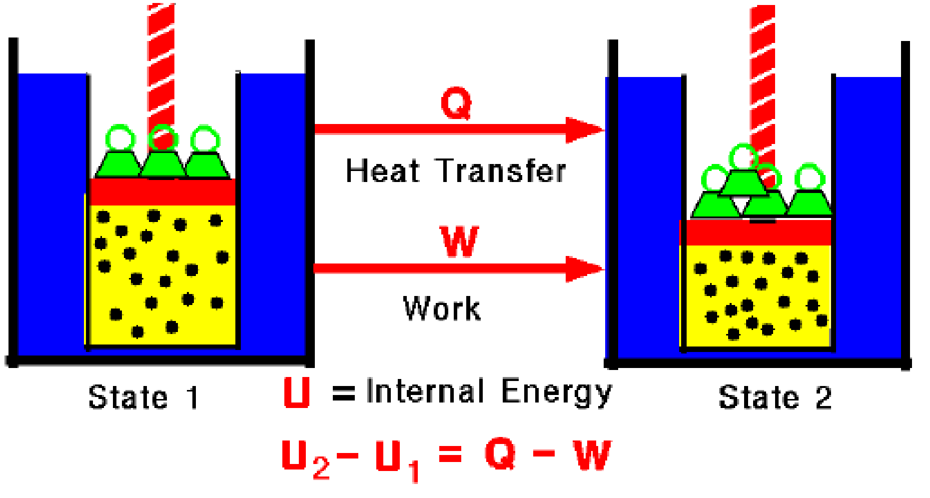
❑ **Zeroth law of Thermodynamics** (R.H. Fowler, 1931)

- "Thermal equilibrium: two bodies are in thermal equilibrium if both have the same temperature reading even if they are not in contact".
- Thermometer



Laws of Thermodynamics

- **1st law of Thermodynamics** (William Rankine, 1850s)
  - An expression of the conservation of energy
  - Assert that energy is a thermodynamic property
  - • Heat, Work, energy



Laws of Thermodynamics

- **2nd law of Thermodynamics** (William Rankine, 1850s)
  - Assert that energy has quality and quantity and
  - Actual processes occur in the direction of decreasing quality of energy
  - Entropy $\rightarrow$ Find potential work