

RME1102

Fundamentals of Mechanical Engineering

Lecture 1

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About me

Dr. Abdul Aziz Shuvo

• Education:

- Ph.D. - The Pennsylvania State University, USA (2025)
- M.Sc. - BUET (2022)
- B.Sc. - BUET (2019)

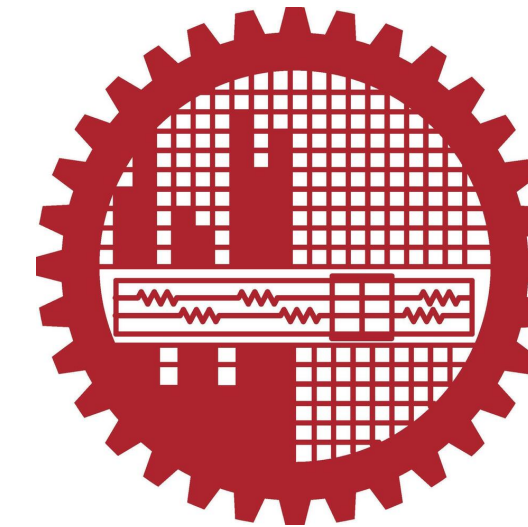


PennState
College of Engineering

**MECHANICAL
ENGINEERING**

• Professional Affiliation:

- Assistant Professor, ME, BUET (2022-present)
- Lecturer, ME, BUET (2019-2022)
- Principal Investigator, Interfacial Multiscale Physics and Transport (IMPACT) Lab at BUET



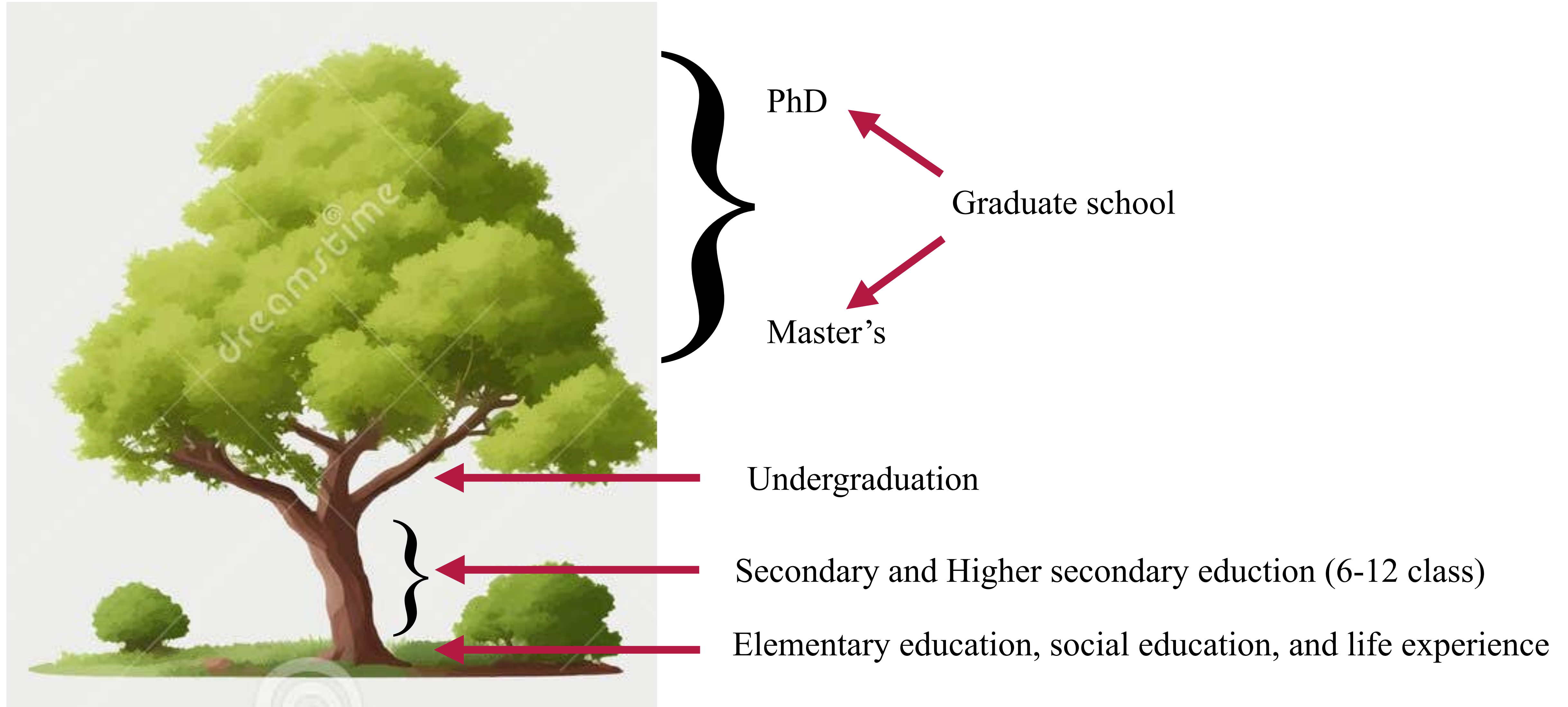
IMPACT Lab
Interfacial Multiscale
Physics and Transport

- **Email:** shuvo@me.buet.ac.bd ; **Office:** ME215, ME building, BUET; **Website:** <http://shuvo.buet.ac.bd/>

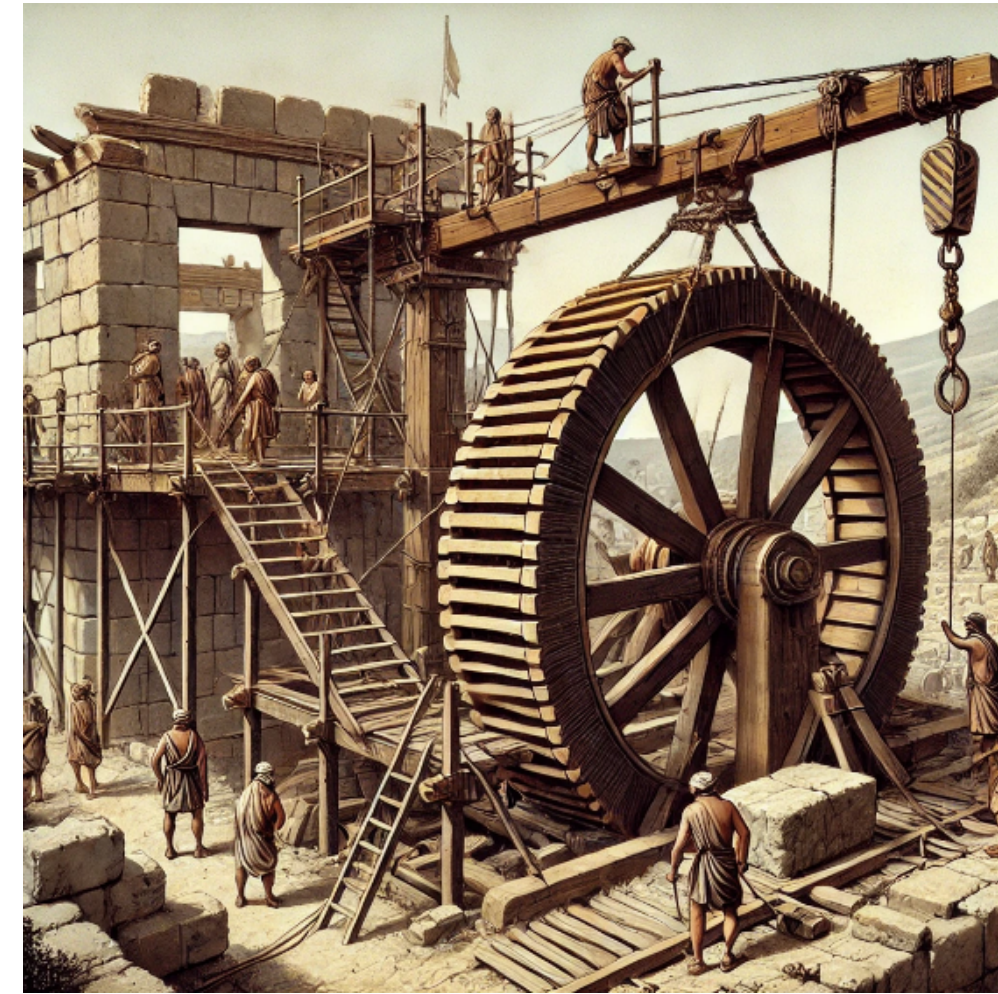
Instruction methods

- We will meet **twice** (3 hrs) in a week.
 - Lectures, video/animations, class discussion
 - Class note will be available in my website: <http://shuvo.buet.ac.bd/>
- **Do's**: interact with me, attentive to your class, keep happy.
- **Don'ts**: don't get late in the class, no talking to each other during lecture, no cheating in the exams, assignments.

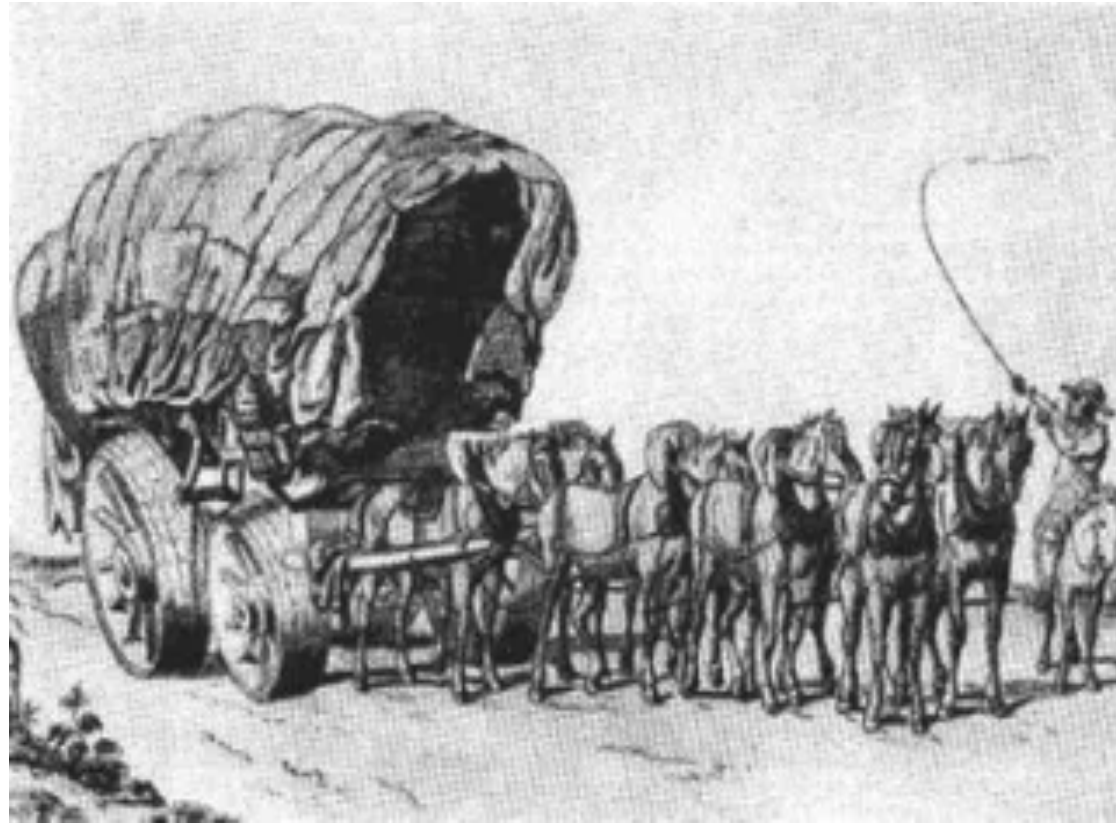
Steps of education



Evolution of Civilization



Evolution of Civilization, cont'd



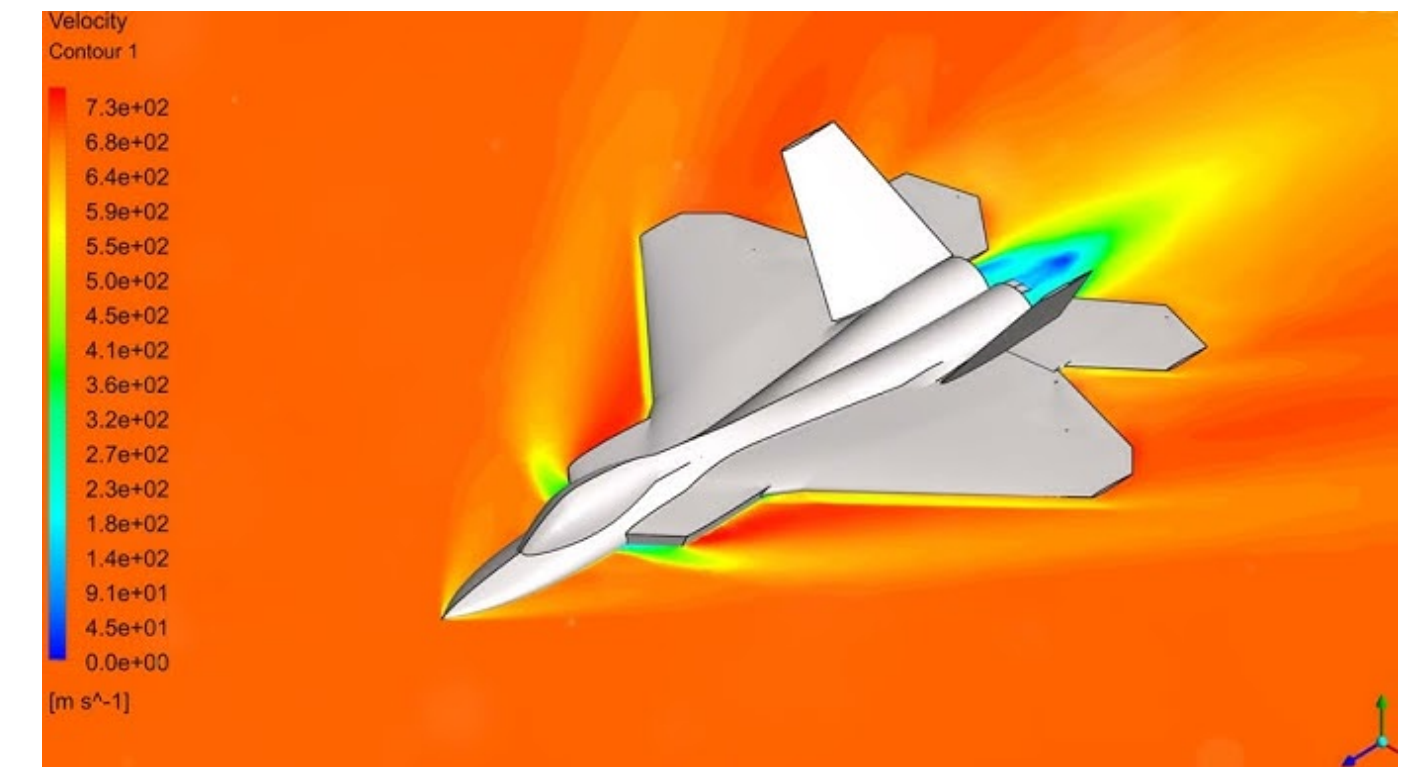
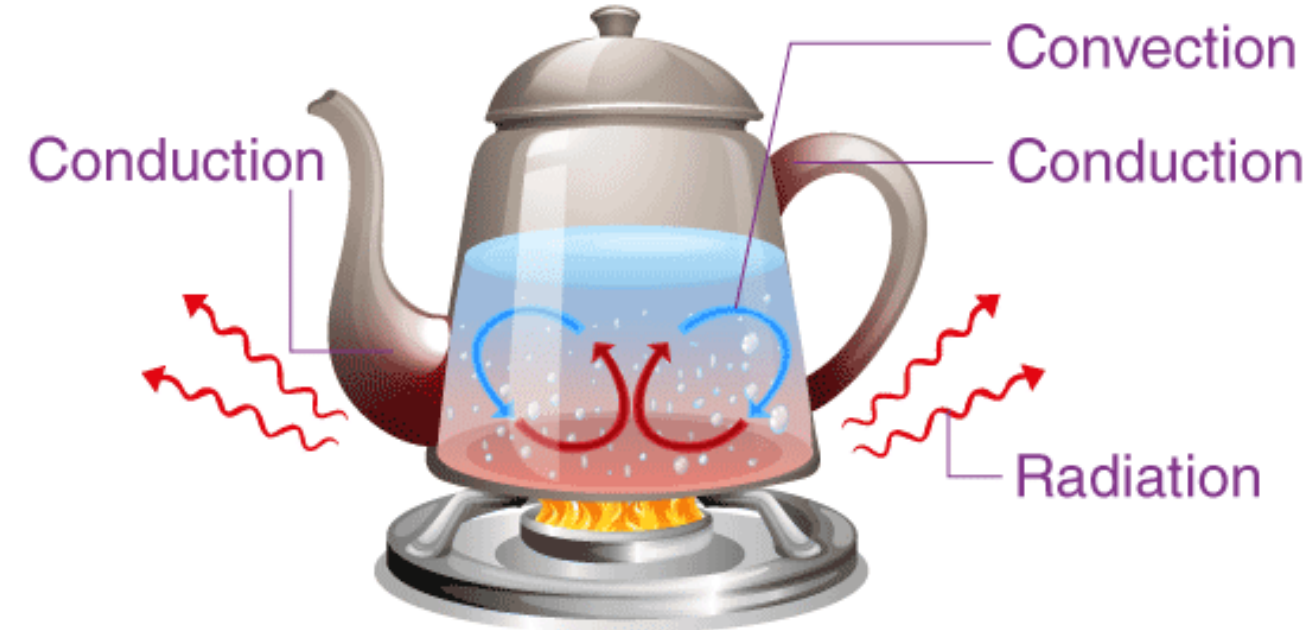
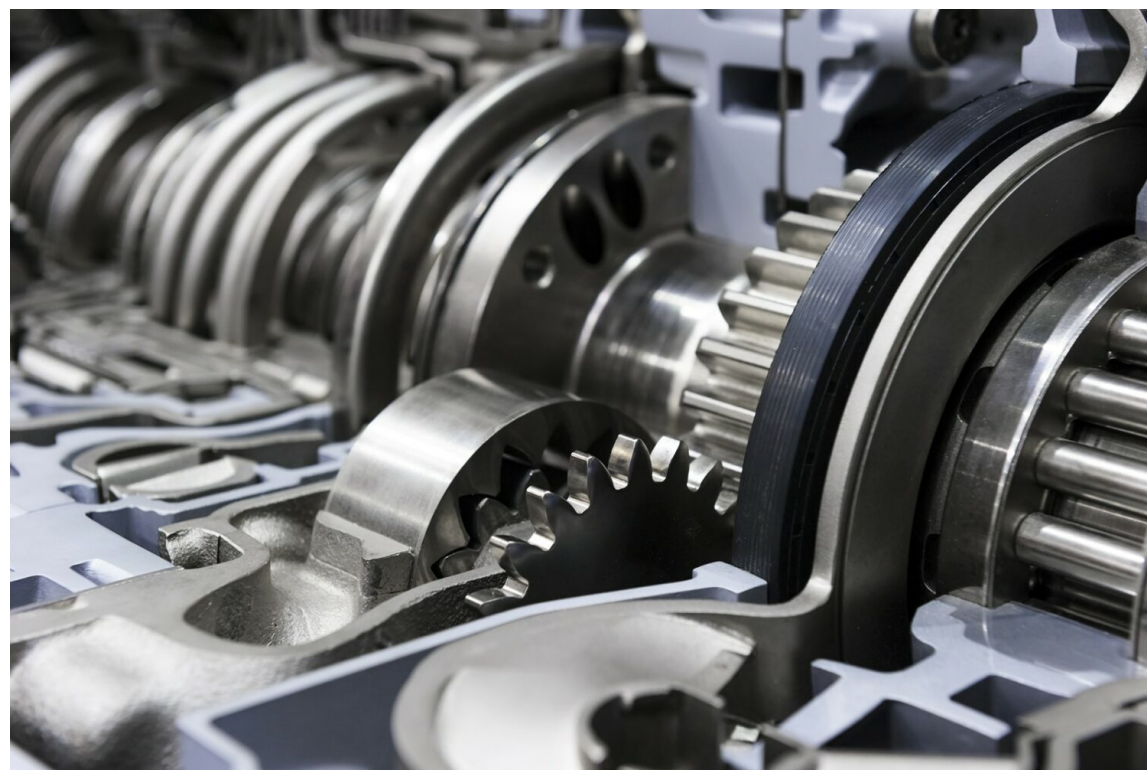
Mechanical Engineering

Mechanical Engineering

Applied Mechanics/Material Science

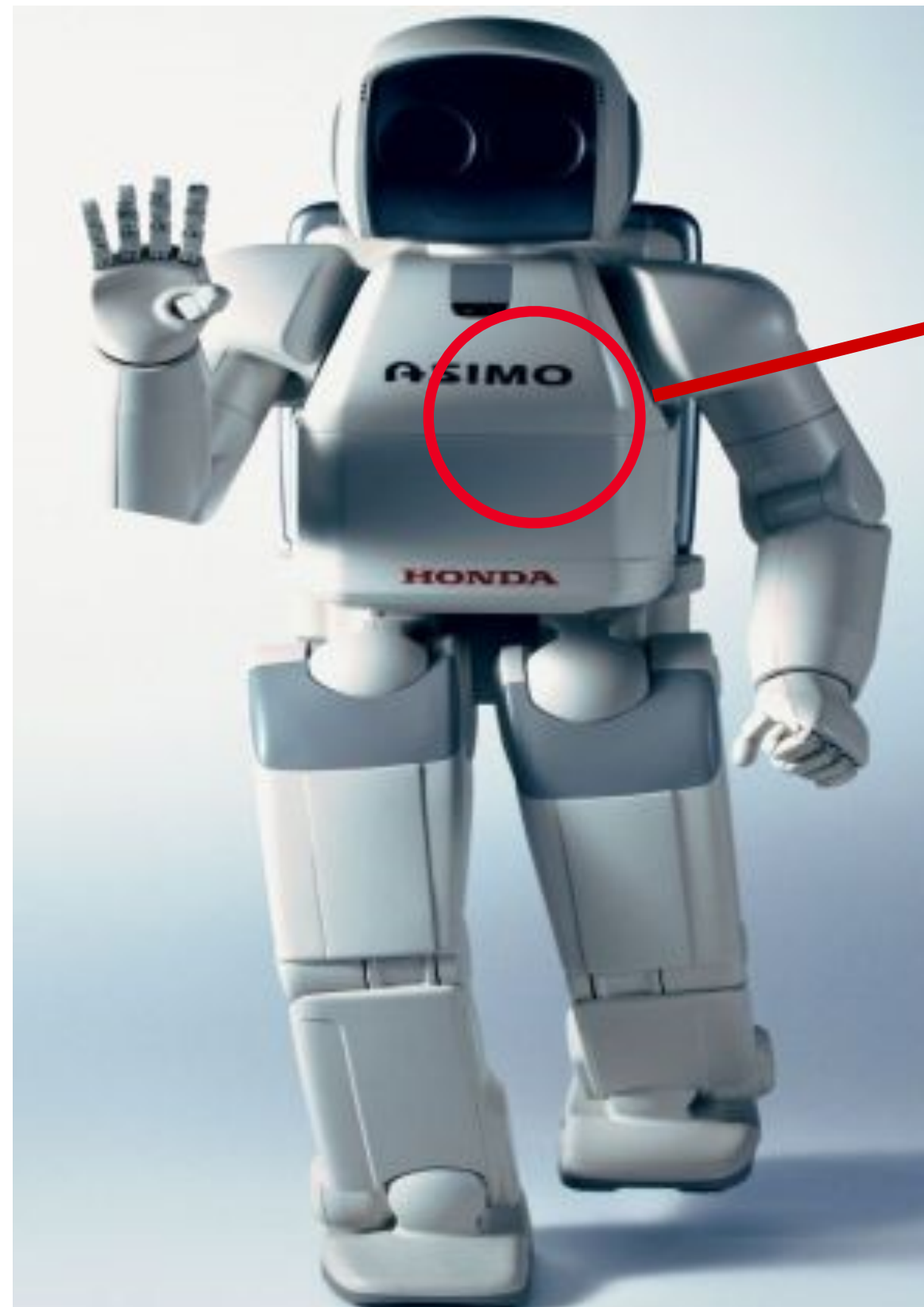
Heat Transfer

Fluid Mechanics



Mechanical Engineering: Robotics and Mechatronics

Robotics is a branch of engineering that involves the conception, design, manufacture, and operation of robots.

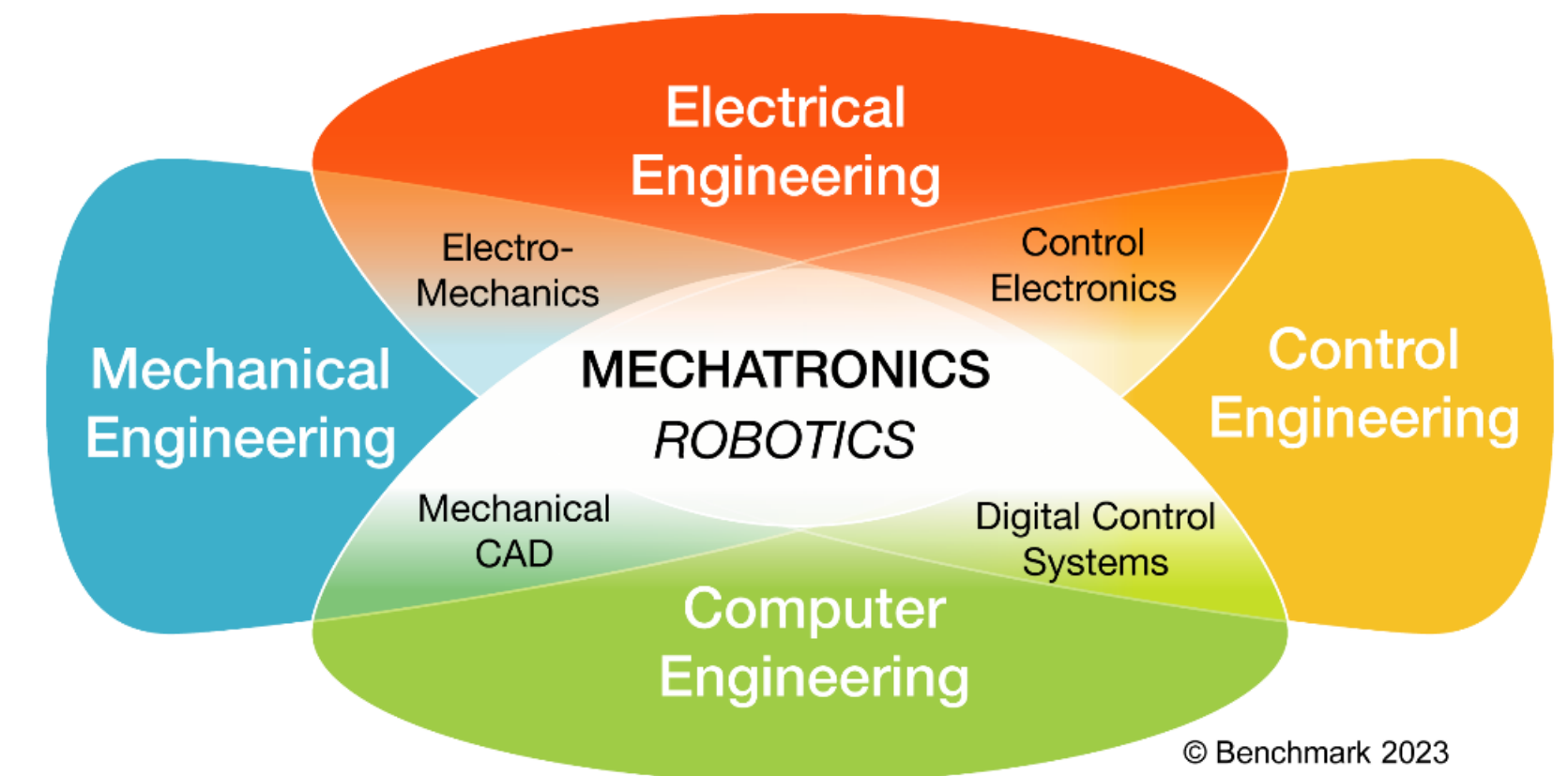


- Thermal management
- Force analysis
- Motion



Mechanical Engineering: Robotics and Mechatronics, Cont'd

- Synergistic Combination of **Mechanical, Electrical, and Computer Engineering**.
- This combination makes possible the generation of simple, more economic, and reliable systems
- Example: Self Driving Car, Lift/Elevator, Washing Machine, Engine Control Unit (ECU), Car Anti Lock Braking System (ABS), etc.



Course Syllabus

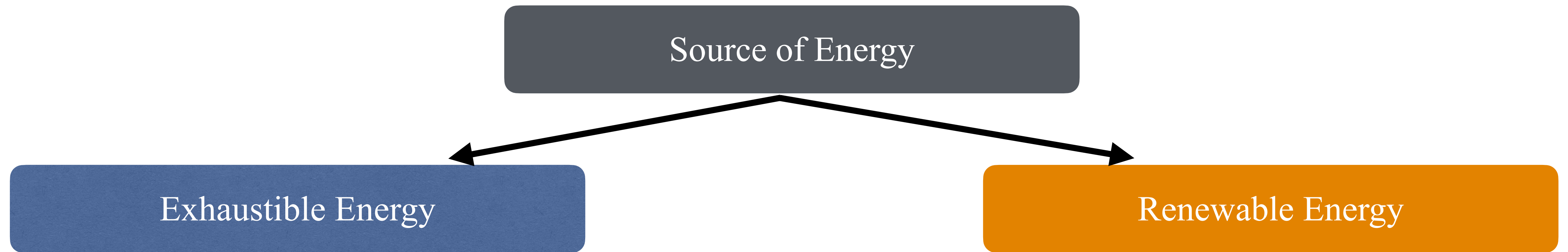
- Scope of mechanical engineering, Introduction to sources of energy
- **Thermodynamics:** Basics, Properties, 1st and 2nd Law & Entropy
- **Heat Transfer:** Fundamental of conduction, convection and radiation: one dimensional steady state, conduction in plated pipes; critical thickness of insulation
- **Major Applications:**
 - Steam generating units with accessories and mountings; Vapor Power Cycles;
 - Internal combustion engines: Introduction to internal combustion engines and their cycles; gas turbines.
 - Refrigeration and air conditioning: applications; refrigerants, different refrigeration methods.
- **Fluid Machinery:** Fluid flow, measurements of flow, friction in flow, centrifugal pumps, fans, blowers and compressor, turbines.

Tentative class schedule

Classes	Topics
1	Introduction, source of energy, and scope of mechanical engineering, Thermodynamics
2	Thermodynamics
3	Thermodynamics
4	Thermodynamics
5	Thermodynamic cycles
6	Thermodynamic cycles
7	Steam generator
8	Steam generator
9	Steam generator
10	IC engine
11	IC engine
12	IC engine
13	Refrigeration and Air conditioning
14	Refrigeration and Air conditioning
15	Refrigeration and Air conditioning
16	Heat transfer
17	Heat transfer
18	Heat transfer
19	Heat transfer
20	Fluid flow
21	Fluid flow
22	Fluid flow
23	Fluid flow
24	Fluid flow

Source of Energy

- **Energy** is defined as the capacity to do work. It isn't a physical "stuff" you can hold, but rather a property of objects and systems that can be **transferred or transformed**.
- The standard unit of energy in the International System of Units (SI) is the Joule (J).

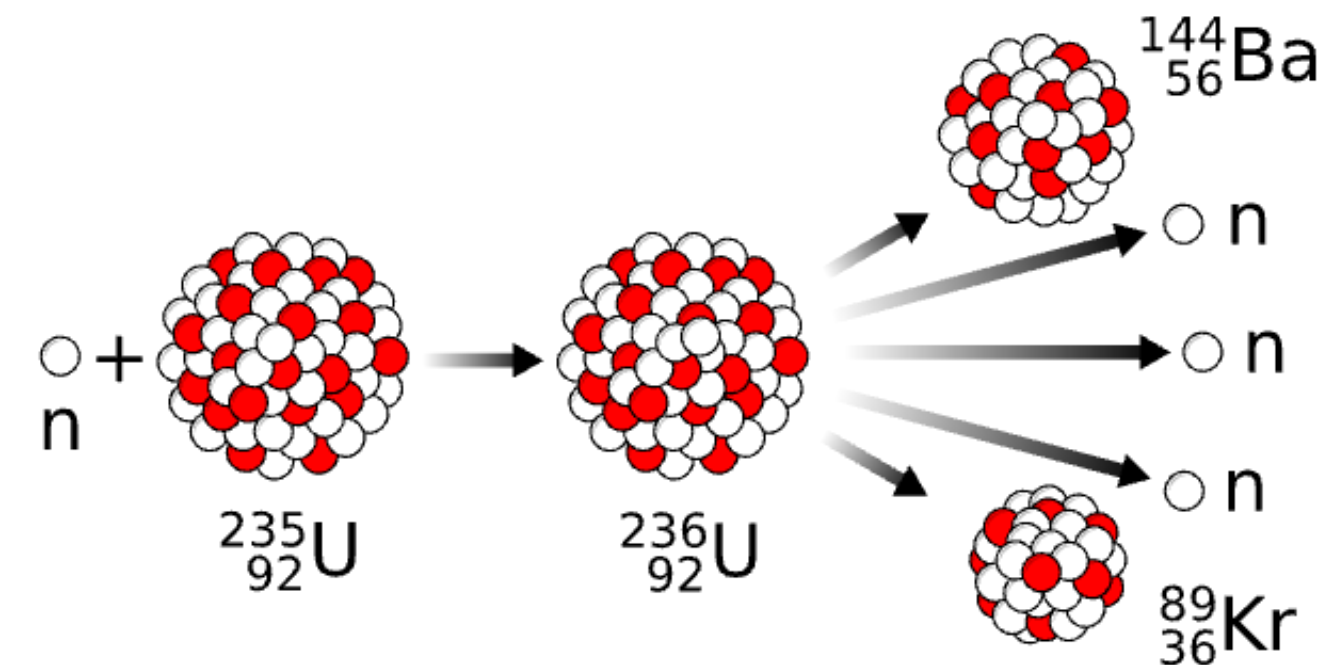
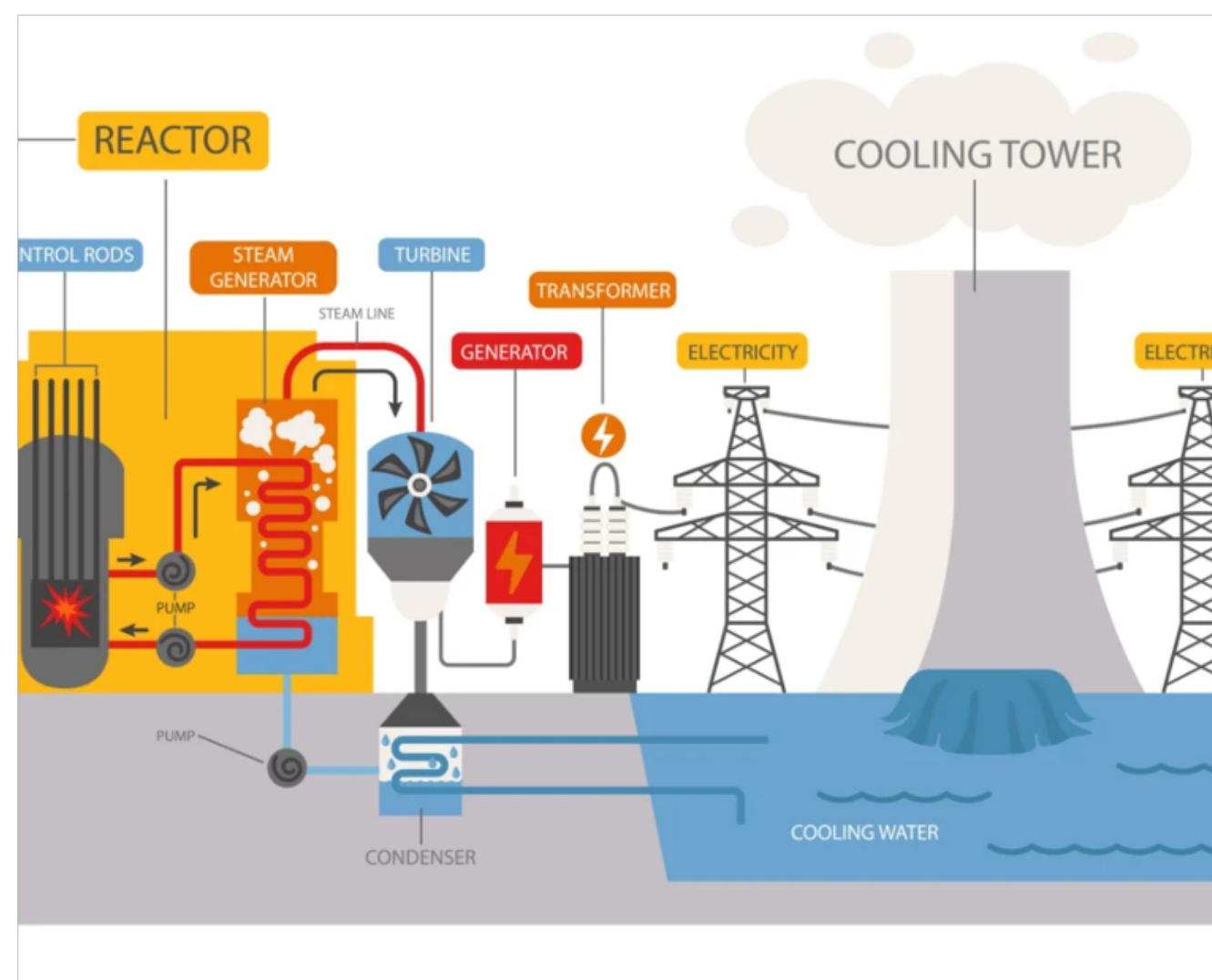


- This type of energy cannot be produced.
- Once exhausted, there is no more available source
- Example: fossil fuel, nuclear fuel, etc.

- This is a natural energy.
- There is no limitation of supply.
- Example: solar energy, wind energy, etc.

Exhaustible or Non-renewable energy source

- **Native or Indigenous** sources are available locally. In Bangladesh they are mainly used for cooking food (e.g., rice husk).
- **Fossils** are formed from the remains of plants and animals after decay and chemical decomposition. Photosynthesis that took place over the past ages has made possible large deposits of fossil fuels. When these fuels are burnt the sun's energy that has been stored for millions of years is actually released.
- **Nuclear energy** is the energy of reaction available from the atoms of radioactive materials. The energy is released basically from two types of reactions (e.g., fission and fusion reaction).

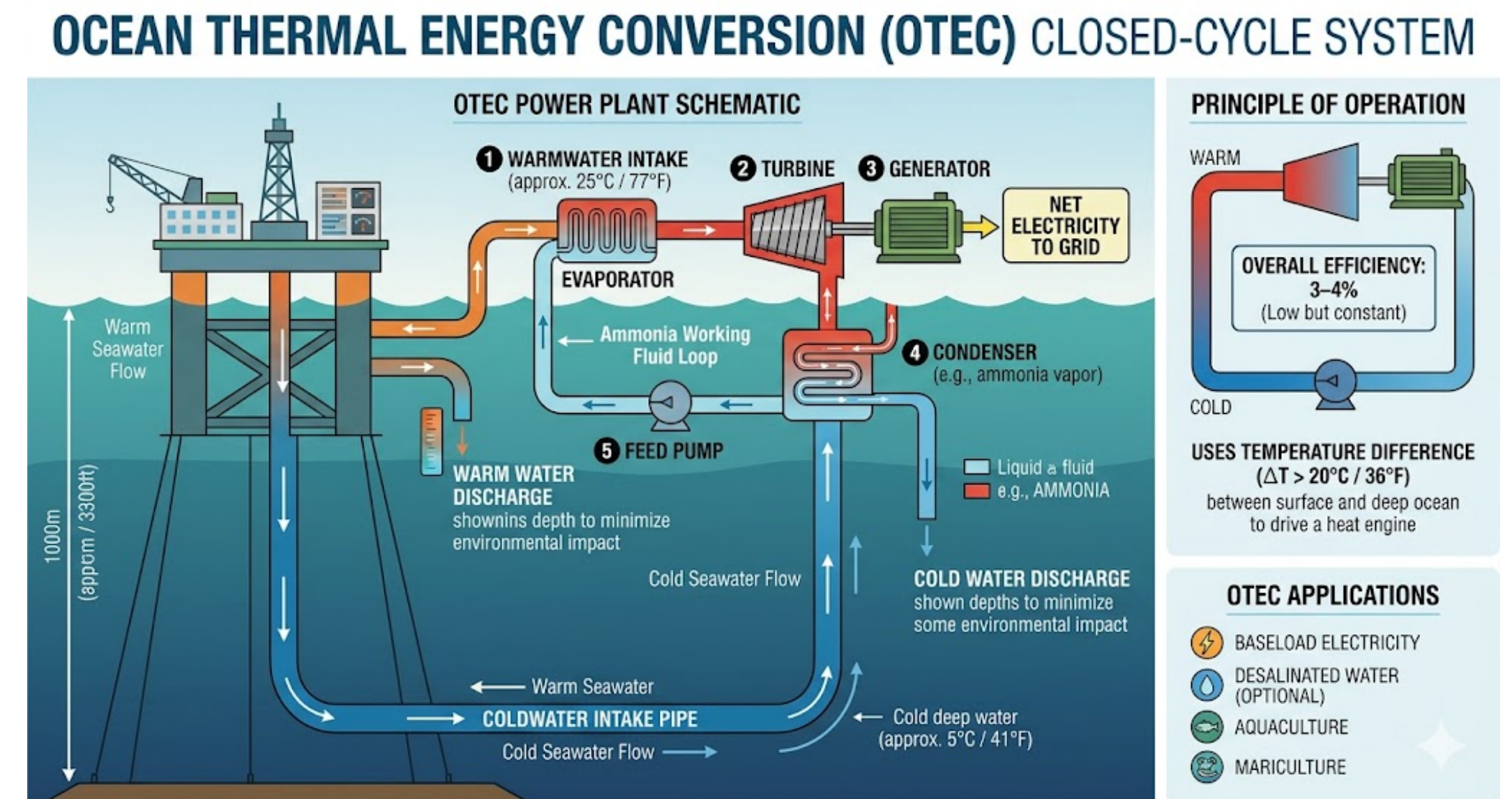
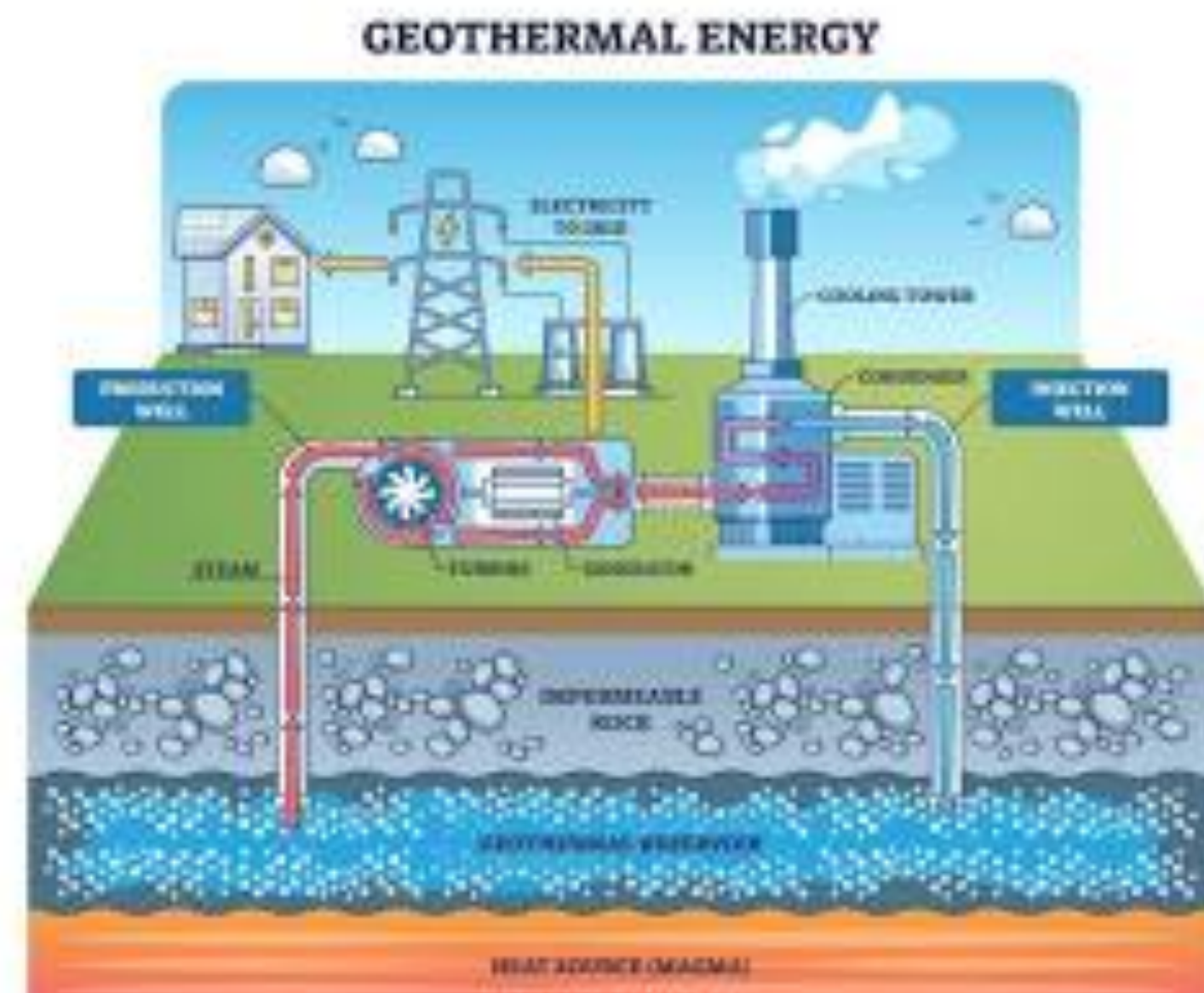


Renewable energy

- **Solar energy** is the electromagnetic radiation released by the sun. This energy is continuously released from the sun by fusion reaction, which produces 3.94×10^{26} kW of power. The earth receives only a small part of this total energy from the sun (1.73×10^{14} kW). This is equivalent to burning 6.5 million metric tons of coal per second. Solar energy can be converted into other forms of energy by 3 processes:-chemical, thermal and electrical (eg. photovoltaic cell).
- **Wind energy** is the kinetic energy of moving air mass caused by the sun's heat and by the earth's rotation. If wind is flowing at a speed of V , (m/s) through an area A (m^2), then volume flow rate is AV (m^3/s), With the density of air ρ (kg/m^3), the mass flow rate is ρAV , (kg/s). Then power of wind is $W = \frac{1}{2} \rho AV^3$, (watts). Power extracted by a wind turbine is a fraction (termed as power coefficient C_p) of this total power. C_p can never be 1.0 (i.e. 100%) since the velocity of wind behind the wind turbine rotor is not zero (e.g., WPS).
- **Geothermal:** Energy associated with vibration of atoms and molecules is termed as thermal energy. Geothermal energy is the thermal energy trapped within the solid crust of the earth in the form of magma. These magma releases heated products such as geyser, or hot springs. After a well drilled into a geothermal reservoir, the steam or hot water flow is almost continuous; which can be utilized to operate steam turbine (e.g., direct flush geothermal power plant).

Renewable energy, cont'd

- **Ocean thermal energy conversion (OTEC)** system uses the heat stored in the huge quantity of ocean water. It uses the difference between cooler deep and warmer shallow or surface ocean waters to run a heat engine and produce useful work, usually in the form of electricity.
- **Hydro:** When water drops from a height the potential energy is converted to kinetic energy, which may be transformed into electrical energy. Once the water of the high altitude has run down the slope, it is again filled up continuously by the rainfall.



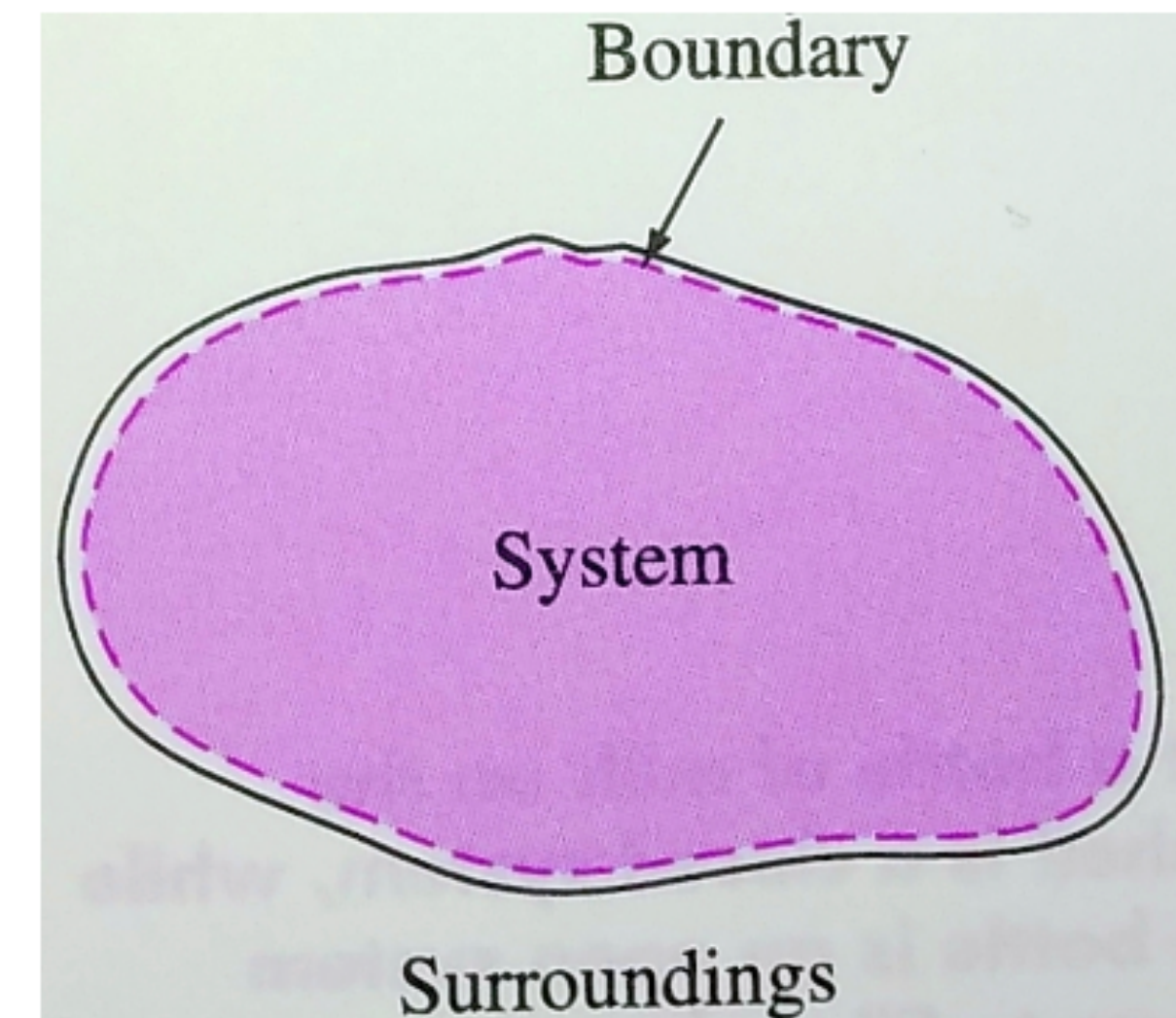
Definition of thermodynamics

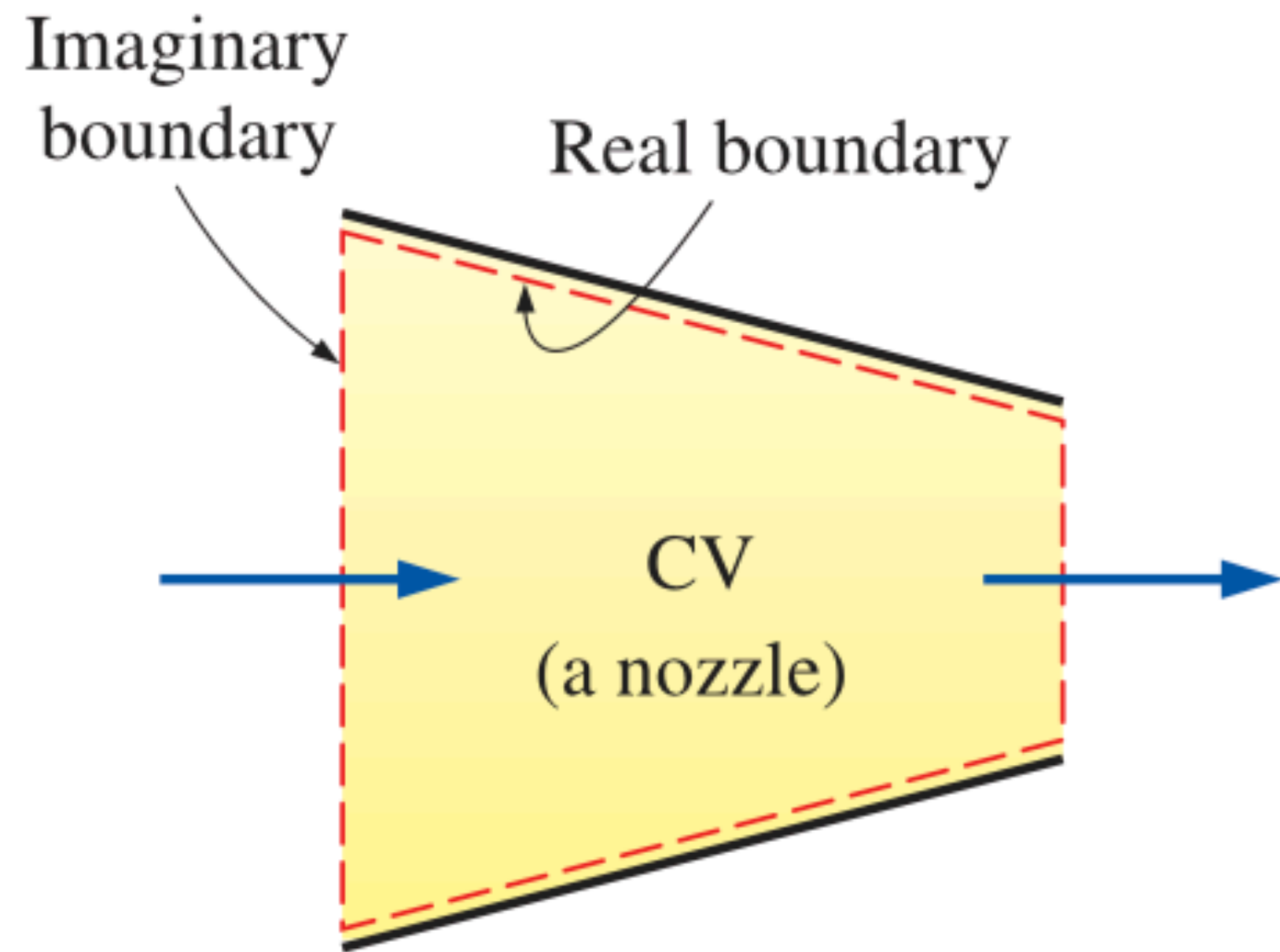
- Thermodynamics can be defined as the science of energy.
- The name thermodynamics stems from the Greek words *therme* (heat) and *dynamis* (power).
- Thermodynamics is the study of the various processes that change energy from one form into another (such as converting heat into work) and uses variables such as temperature, volume, and pressure



Thermodynamic system, boundary, and surrounding

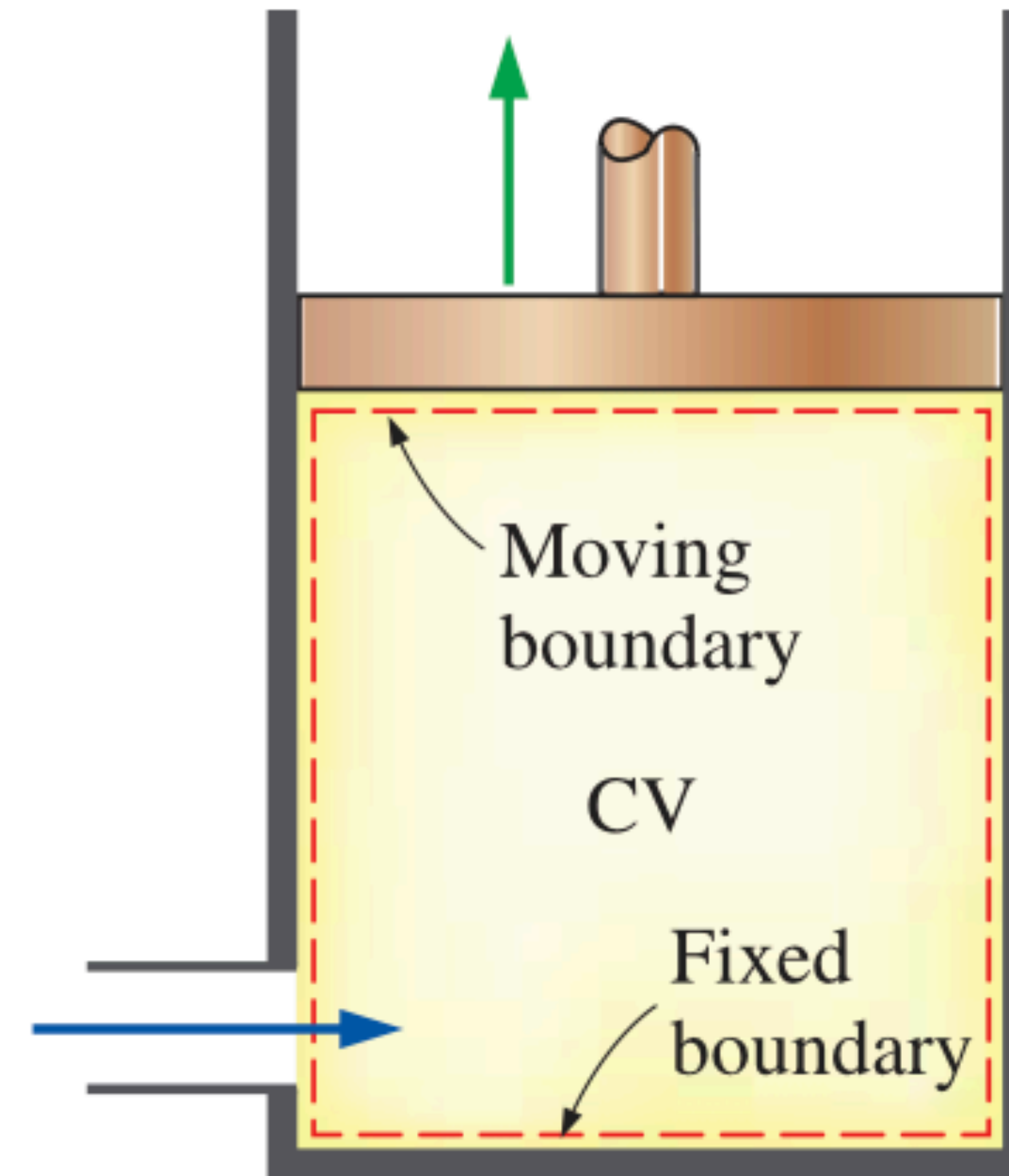
- A thermodynamic **system** is simply any object or quantity of matter or region of space that has been selected for thermodynamic study. Everything that is not part of the system is referred to as the **surroundings** or **environment**.
- **Boundary** or **control surface (CS)** separates the system from its surroundings which
 - may be real or imaginary, at rest or in motion
 - may change its shape and size
 - neither contains matter nor occupies volume
 - has zero thickness and a property value at a point on the boundary
 - is shared by both the system and its surroundings.





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

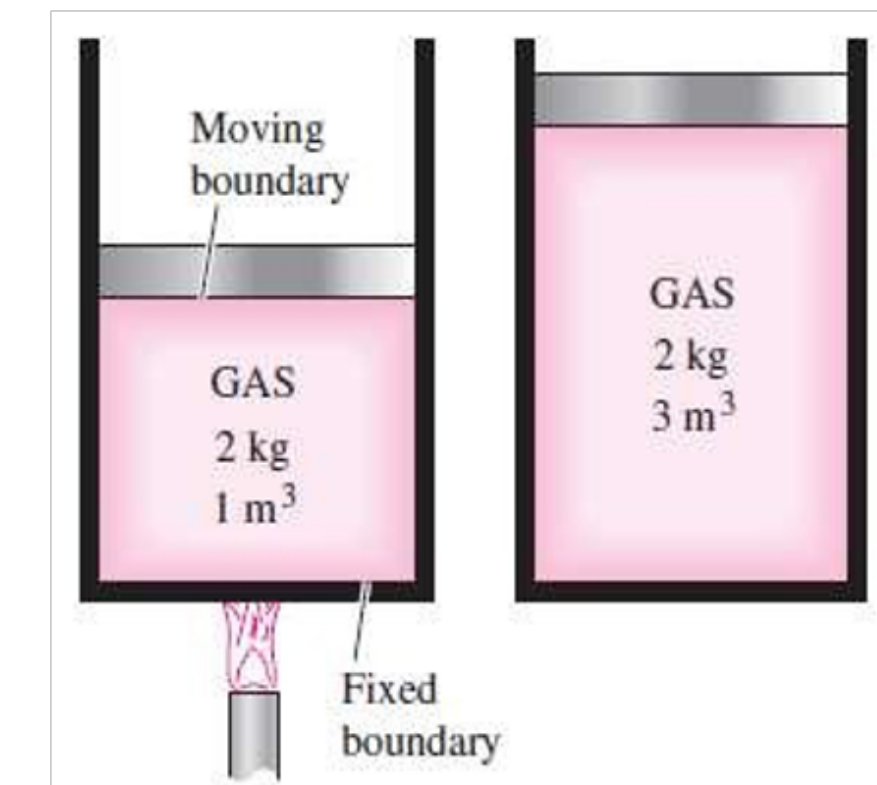
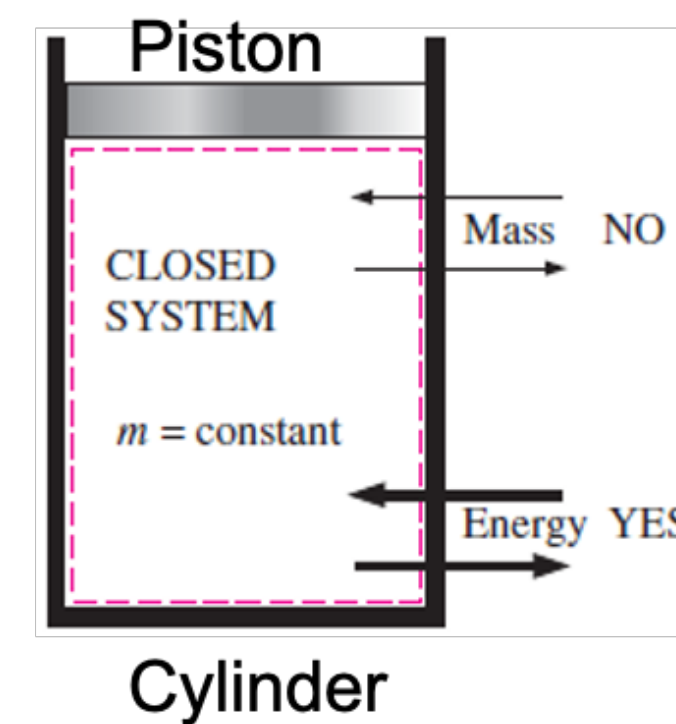
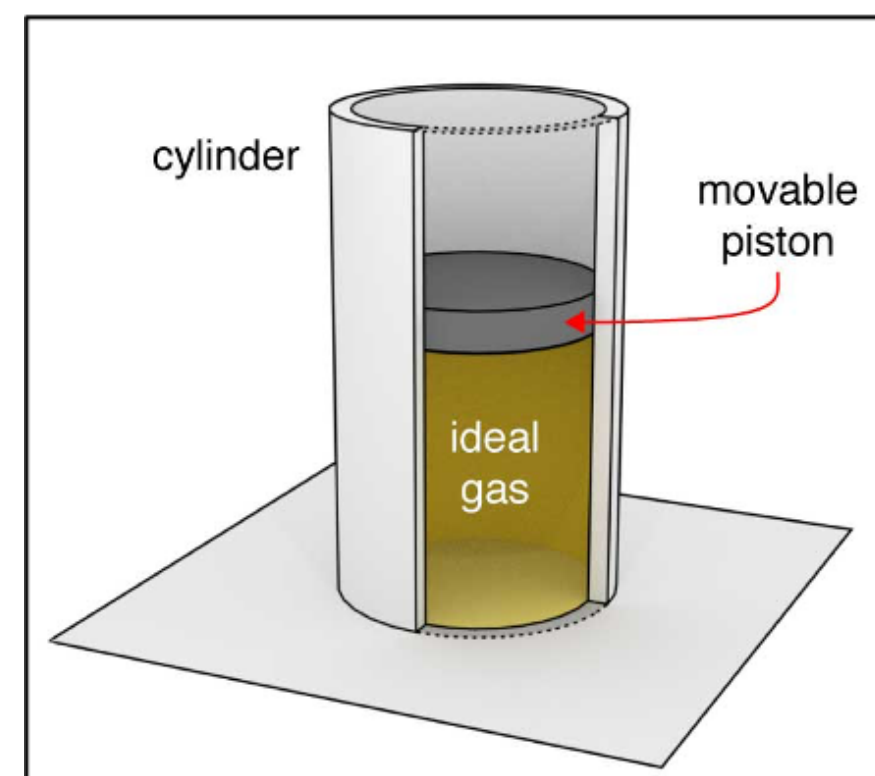
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(b) A control volume (CV) with fixed and moving boundaries as well as real and imaginary boundaries

Closed mass (CM) system or closed system

- A closed system (also known as a control mass) consists of a fixed amount of mass.
- No mass can cross its boundary, but energy, in the form of heat or work, can cross the boundary.
- The volume of a closed system does not have to be fixed.
- If, as a special case, even energy is not allowed to cross the boundary, that system is called an **isolated system**.



Hot Water Bag

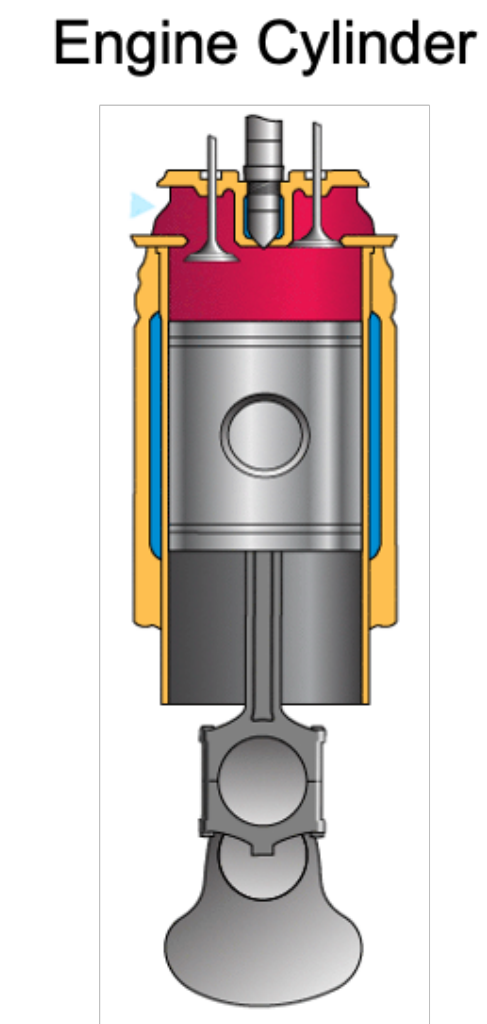
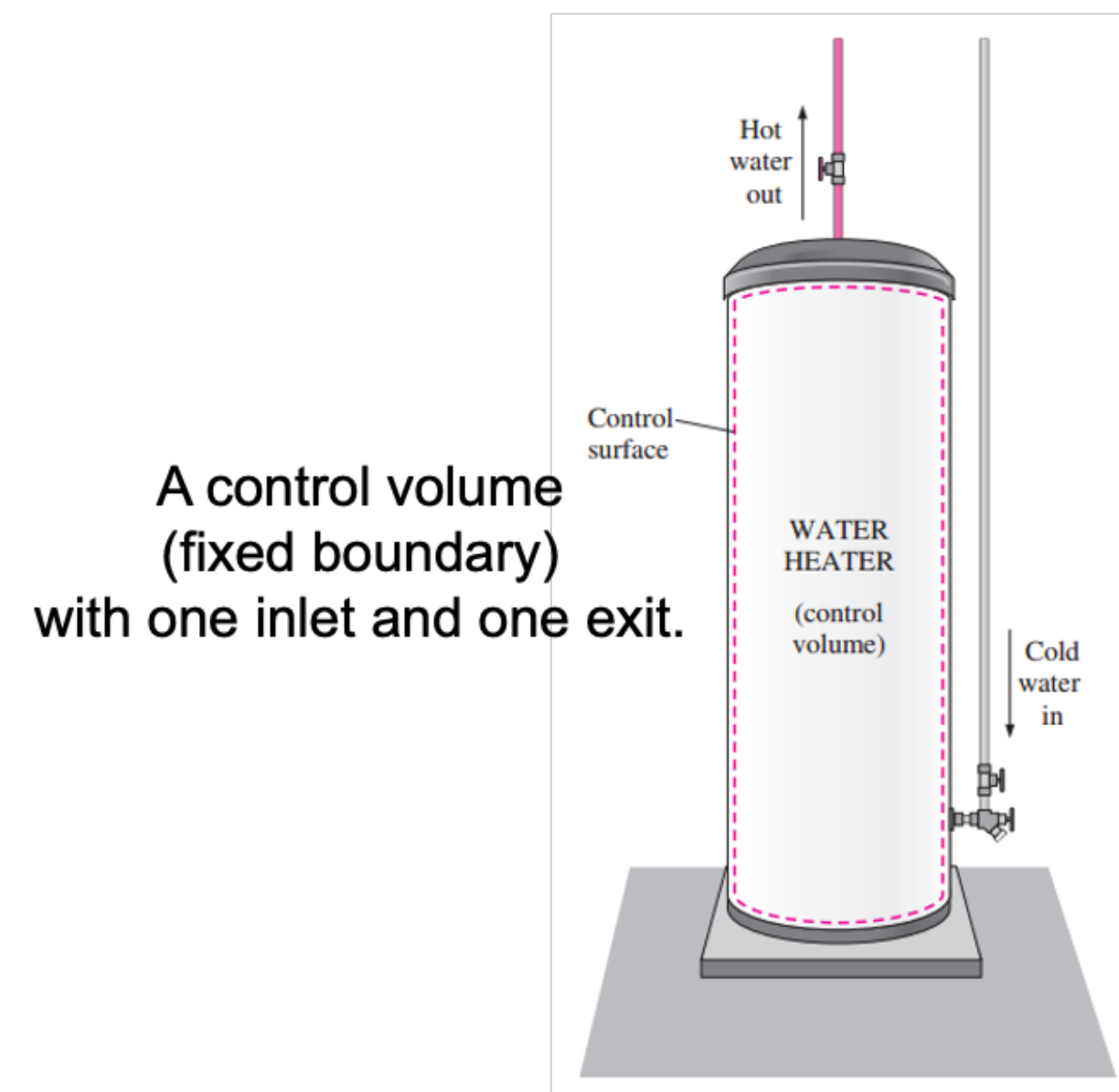
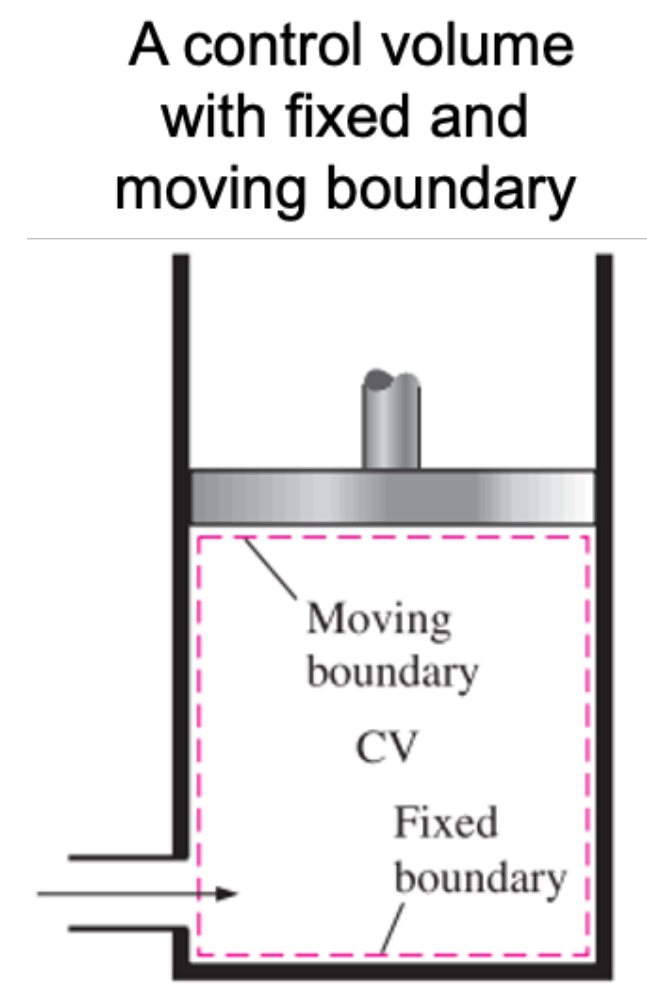


Water Flask

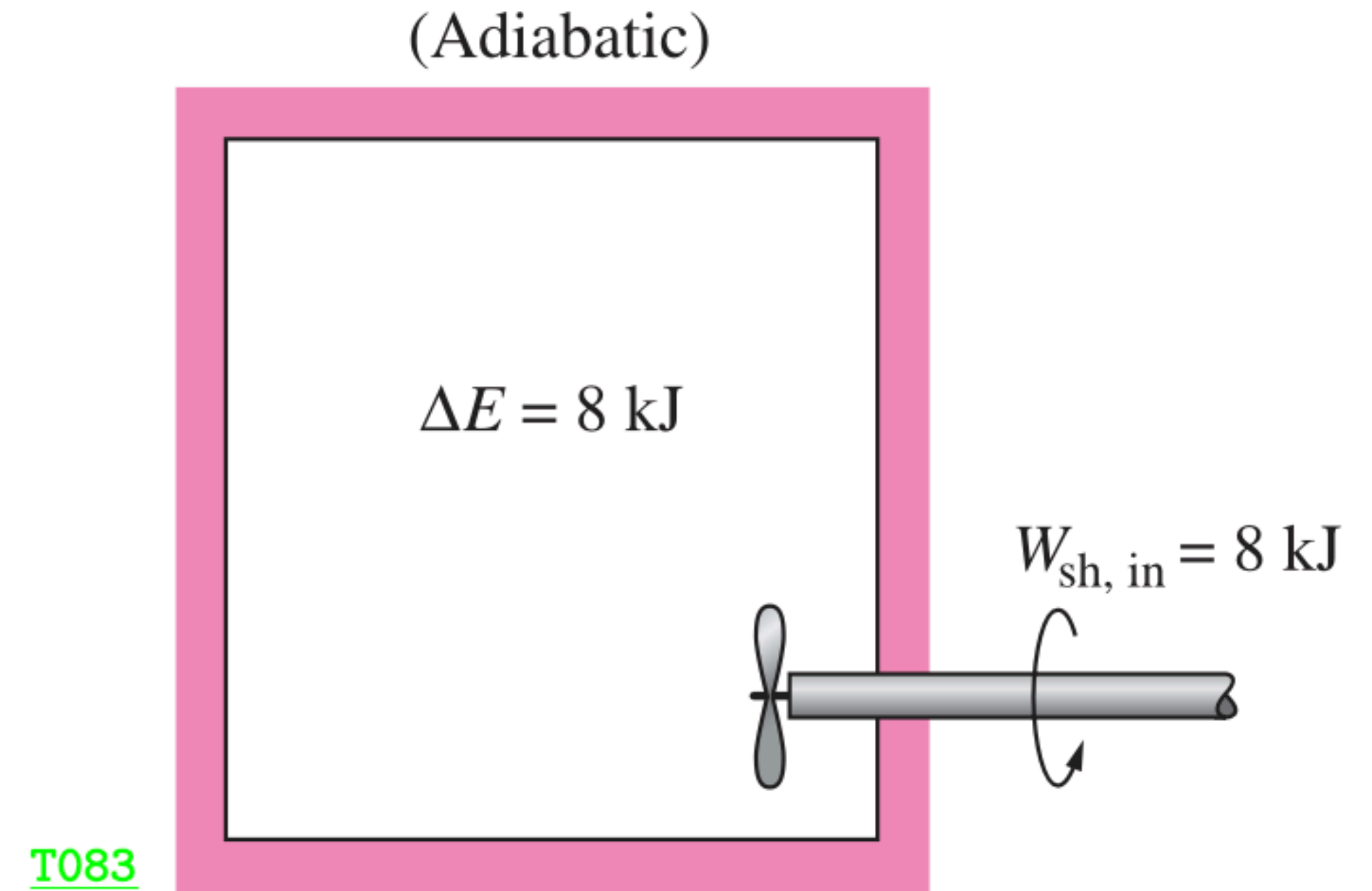
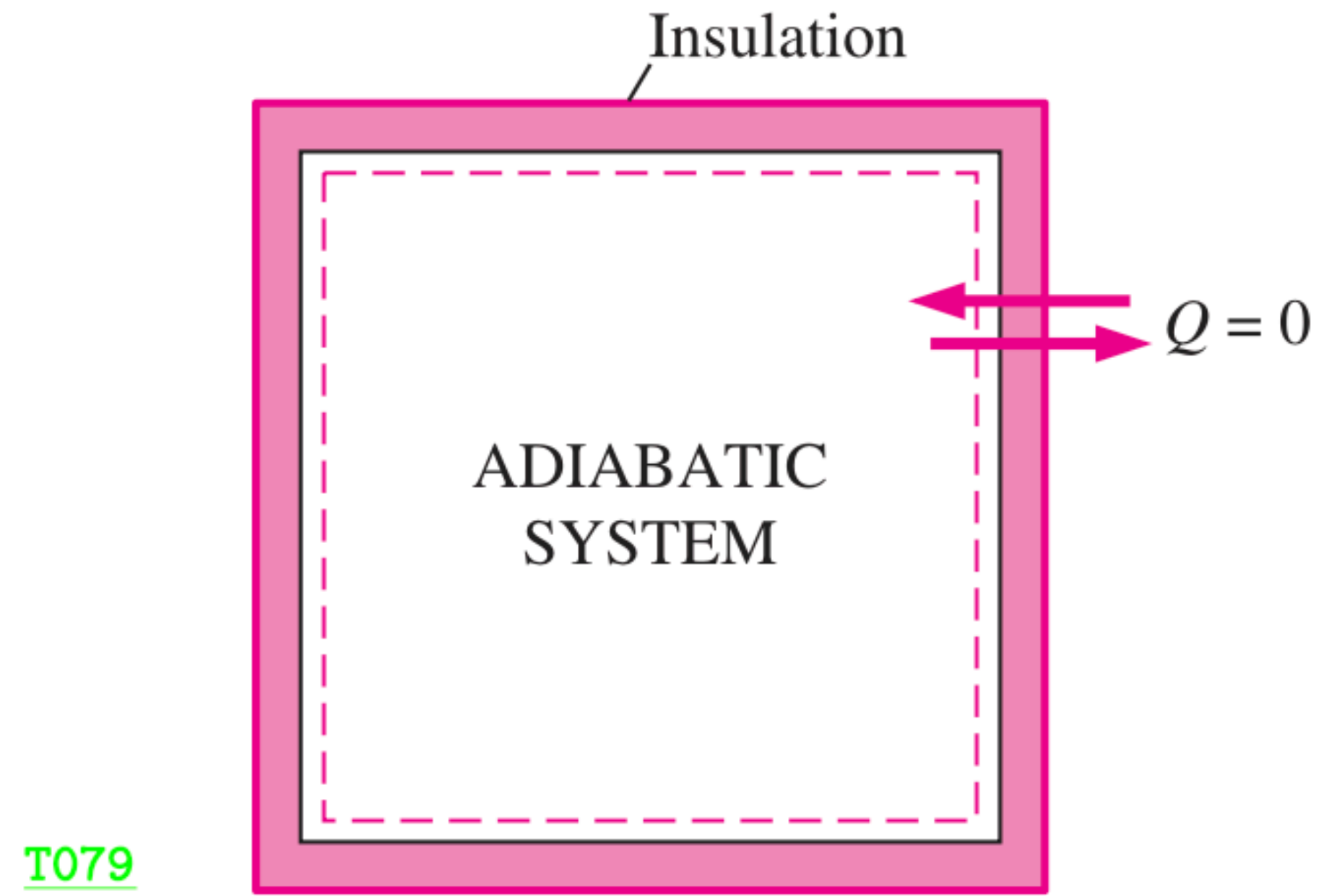


Control volume (CV) or Open system

- An open system, or a control volume, as it is often called, is a properly selected region in space.
- Both mass and energy can cross the boundary of a control volume.
- A large number of engineering problems involve mass flow in and out of a system and, therefore, are modeled as control volumes.
- It usually encloses a device that involves mass flow such as a compressor, turbine, or nozzle.



Adiabatic system



In **adiabatic system** the boundary is impermeable to heat.