AE-214 Thermodynamics

Sudarshan Kumar

- Lecture schedule:
  - Slot 1: Mon 1130-1230 hrs.
    - Tue 0830-0930 hrs.
    - Thu 0930-1030 hrs.
  - Venue: LCC32
- Course details will be uploaded on moodle

Course contents

- **Basic concepts**: System boundary, surroundings, state, extensive and intensive properties, energy interactions, work and heat transfers, equilibrium, quasi-static and reversible processes, non-equilibrium and irreversible processes.
- **Thermodynamic laws**: Zeroth law and temperature, first law and internal energy, first law applied to flow processes, second law, entropy and absolute temperature, third law and absolute entropy, thermodynamics of simple compressible systems, energy and exergy.
- **Applications**: Closed and open systems, polytropic processes, cyclic processes, Carnot cycle; Cycle analysis: Otto cycle, Diesel cycle, Joule-Brayton cycle; ideal and real cycles, design point analysis.

- **Special topics**: Elements of heat transfer and combustion, isentropic flow, flow with friction and heat transfer.
- **Introduction to aerospace power plants**: Piston prop, turboprop, turbojet, turbofan, turbo shaft, ramjet, rockets.
- **Text book/references**

1. P. K. Nag, Engineering thermodynamics, Tata McGraw Hill Co.
2. R. E. Sonntag, C. Borgnakke and G. J. Van Wylen, Fundamentals of Thermodynamics, 6th Ed., Wiley, 2002.
3. Cengel and Boles, Thermodynamics: an engineering approach, Tata McGraw Hill.
4. H. Cohen, G. F. C. Rogers and H. I. H. Saravanamuttoo, Gas turbine theory, 5th Ed., Pearson Education Asia, 2001.
5. Hill and Peterson, Mechanics and Thermodynamics of Propulsion, Addison Wesley.
6. J. P Holman, Heat Transfer, Tata McGraw Hill
7. H S Mukunda, Understanding Combustion, University Press/

- . Heat Tra

- **Evaluation scheme**
- End Semester: 50%
- Mid-semester exam: 25 %
- Attendance (5 % weightage for attendance greater than 95%)
    - *Anybody getting attendance equal to or less than 95% gets Zerooooooo)*
- Quizzes: 20% (dates to be announced in advance, no makeup quizzes)
- Mid-semester and end-semester exam: One **A4** formulae sheet permitted
- Assignments/homework: After each tutorial session, exercise questions to be uploaded on moodle. These questions are meant for practice.

- **Grading scheme:**
  - Total marks obtained during the semester to be added up and scaled to 100.
  - The maximum marks scored (by the topper of the class) out of 100 to be converted to 100 (if the absolute marks scored is > 90) and marks of others to be normalized based on this scaling factor.
  - If the maximum absolute marks scored is between 80-90, then the maximum grade awarded will be AB (The marks will be scaled to 95).

- Cut-offs after normalization:

    FR<40

    40<DD<45

    45<CD<55

    55<CC<65

    65<BC<75

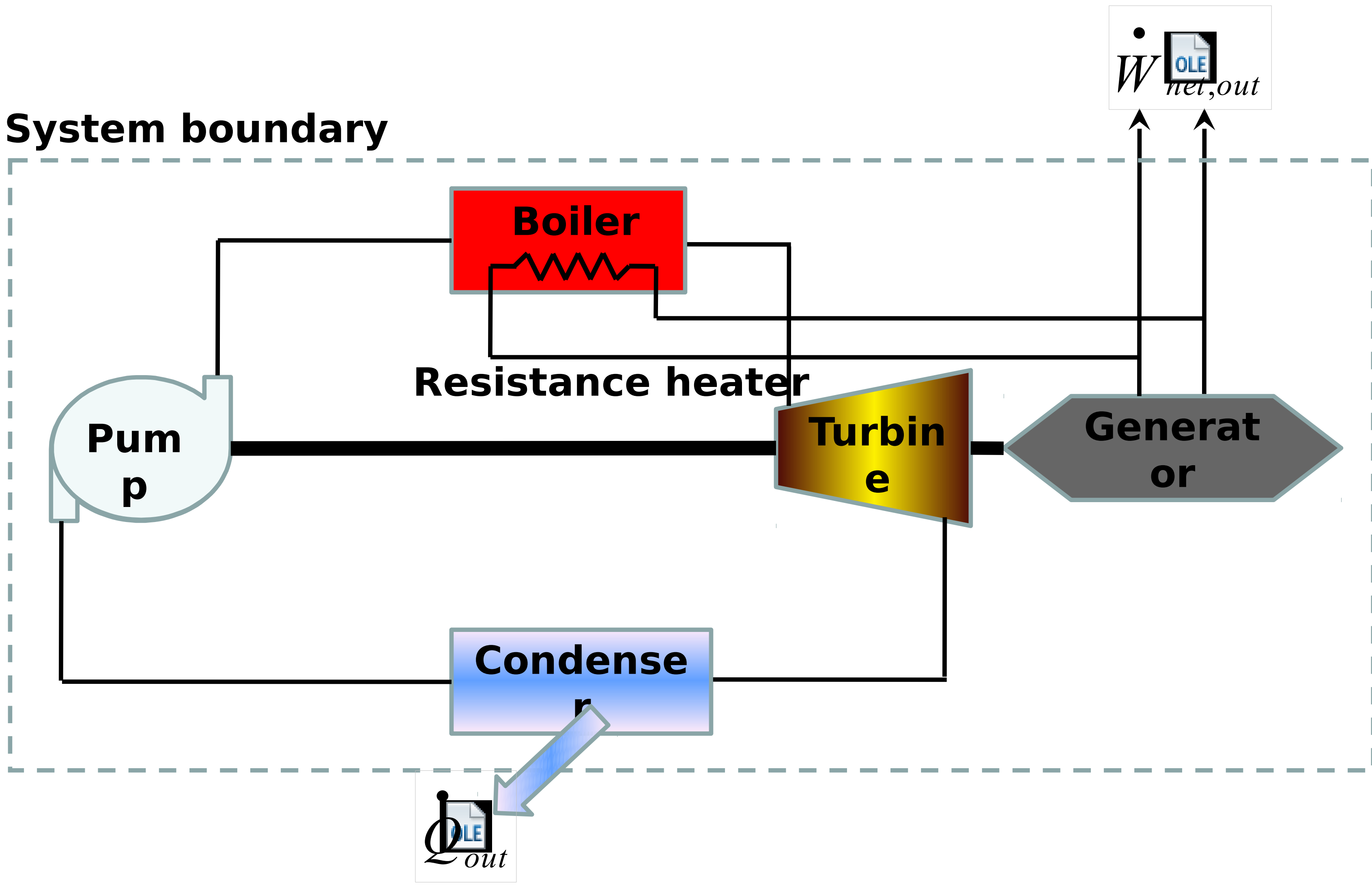
    75<BB<85

    85<AB<95

    95<AA<100

- Policy on attendance
  - Attendance to be recorded as per institute rules.
  - **An early reward in the form of DX Grade for those who have attendance less than 80% (*strictly*).**

- **Objectives of this course**
  - Understand basics of classical thermodynamics
  - Laws of thermodynamics
  - Fundamental concepts of thermodynamics
  - Applications of thermodynamic principles in engineering



System boundary
Boiler
Resistance heater
Pum
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Basic Thermodynamics

- Defined as the “science of energy”
- Originates from Greek words *therme* (heat) and *dynamis* (power)
- Conversion of heat into power
- Thermodynamics encompasses all aspects of energy and energy conversions.
- Thermodynamics provides an understanding of the nature and degree of energy transformations.
- Thermodynamic laws are fundamental laws of nature.

Examples:

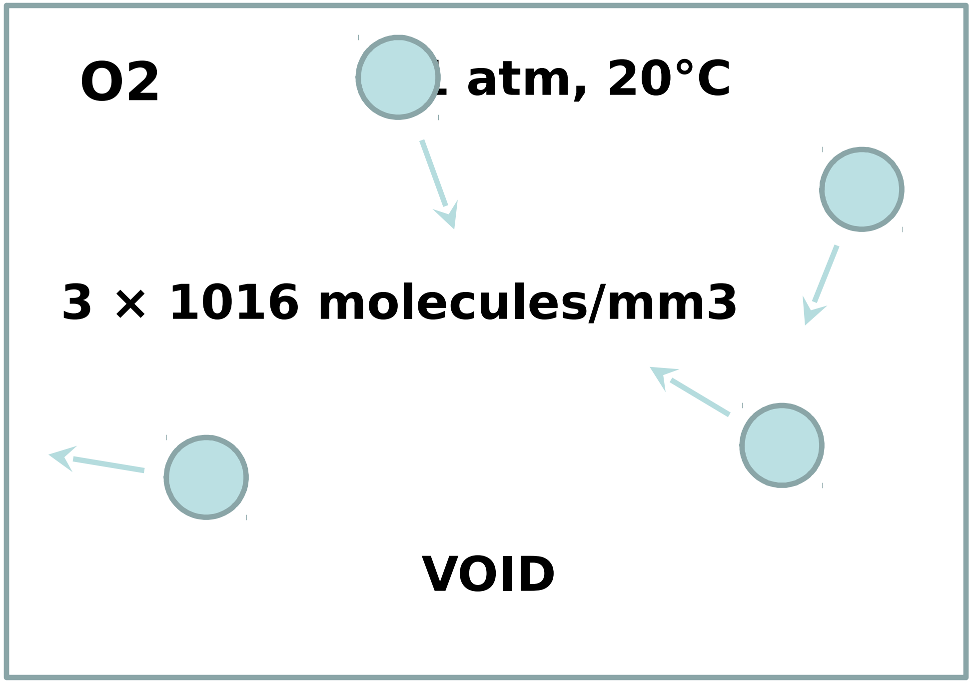
- If we would like to
  - heat water in a kettle.
  - burn some fuel in the combustion chamber of an aero engine to propel an aircraft.
  - cool our room on a hot humid day.
  - heat up our room on a cold winter night.
- What is the smallest amount of electricity/fuel needed for the above ?

- On the other hand when we burn,
  - some coal/gas in a power plant to generate electricity.
  - Petrol/Diesel in a car engine.
- What is the largest energy we can get out of these efforts?

- Thermodynamics allows us to answer some of these questions.

- Macroscopic approach: Classical thermodynamics
  - Does not require knowledge of behavior of individual molecules
  - Easier and direct approach for engineering applications
  - Will be followed in this course
- Microscopic approach: Statistical thermodynamics
  - Based on behavior of group of molecules
  - Complicated, Kinetic theory of gases

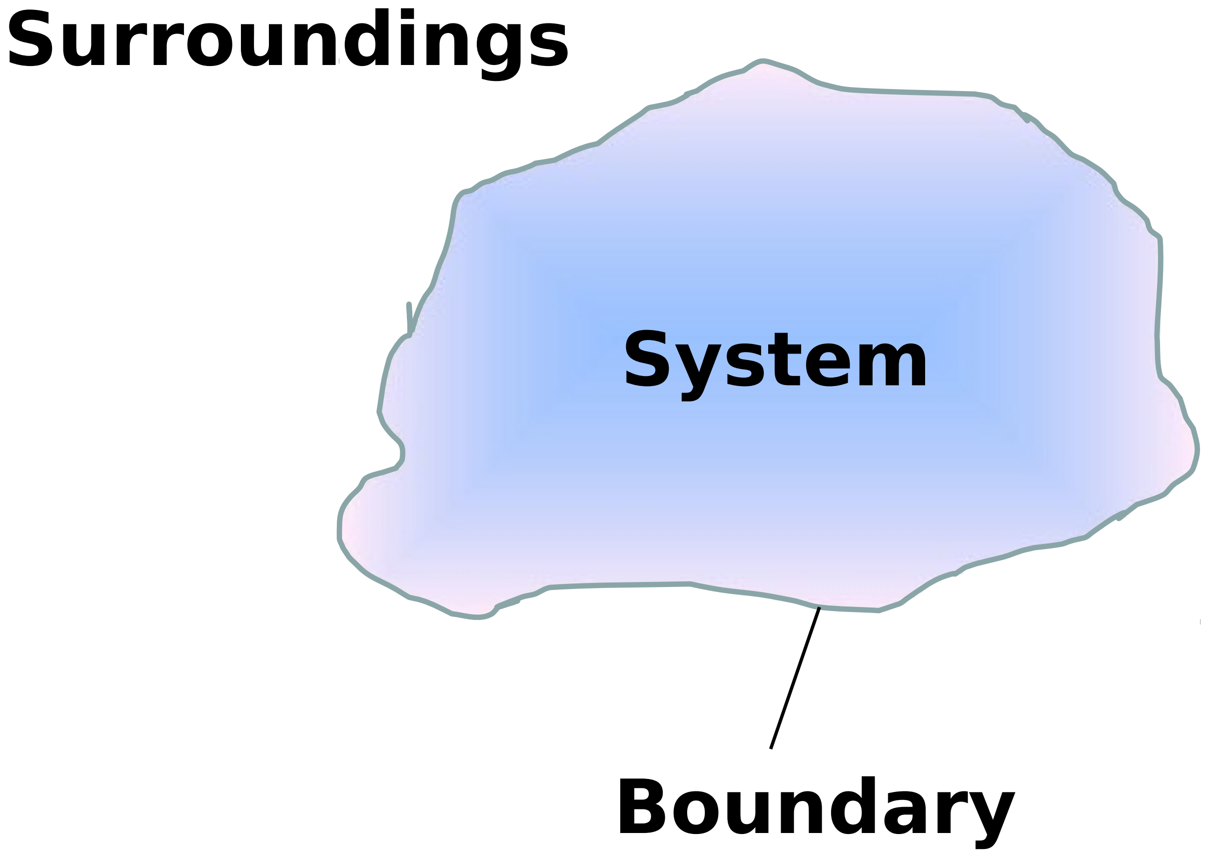
- Continuum:
  - Matter is made up of atoms that are widely spaced in the gas phase.
  - We disregard the atomic nature of a substance and view it as a continuous, homogeneous matter with no holes, that is, a continuum.
  - The continuum idealization allows us to treat properties as point functions and to assume the properties vary continually in space with no jump discontinuities.



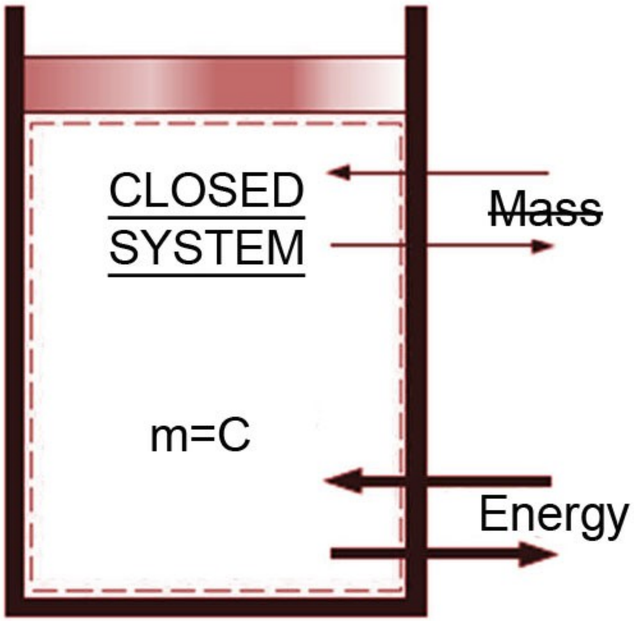
Despite the large gaps between molecules, a substance can be treated as a continuum because of the very large number of molecules

System and Control Volumes

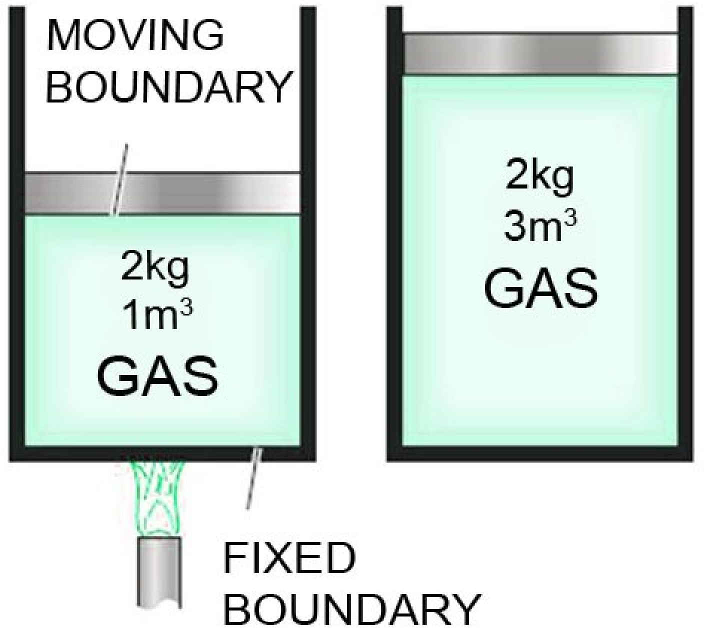
- System: a quantity of matter in space chosen for study
  - It is a macroscopically identifiable collection of matter on which we focus our attention
- Surroundings: mass or region that surrounds a system
  - Surroundings pertain to that part of the universe that is close enough to have some perceptible effect on the system
- Boundary: real or imaginary surface that separates a system from its surroundings
  - May be fixed or movable
- Universe: system and its surroundings


Surroundings
System
Boundary

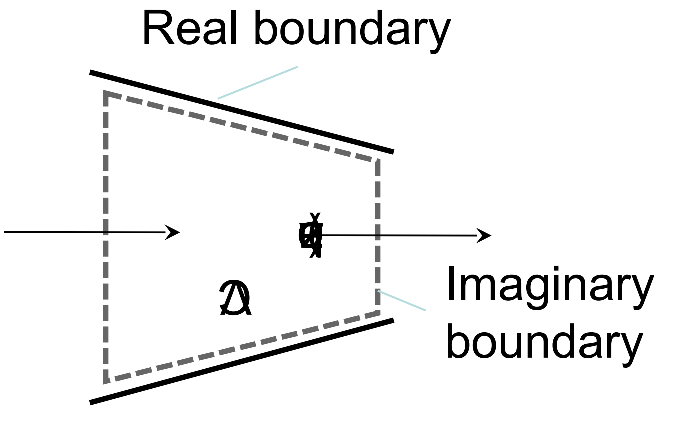
System and Control Volumes



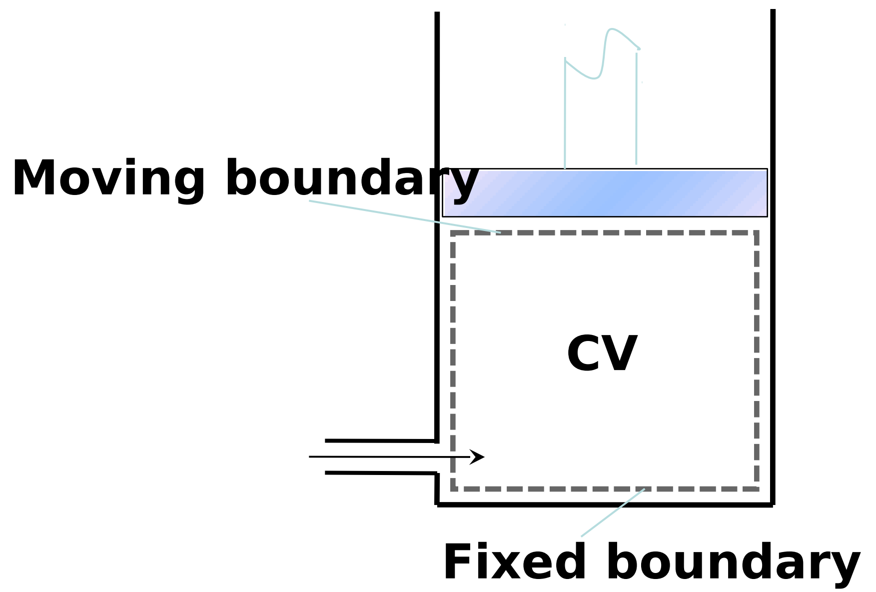
- System
  - Closed system: no mass transfer, energy transfer possible
  - Open system: also called control volume, mass and energy transfer possible
  - Isolated system: neither energy nor mass transfer possible



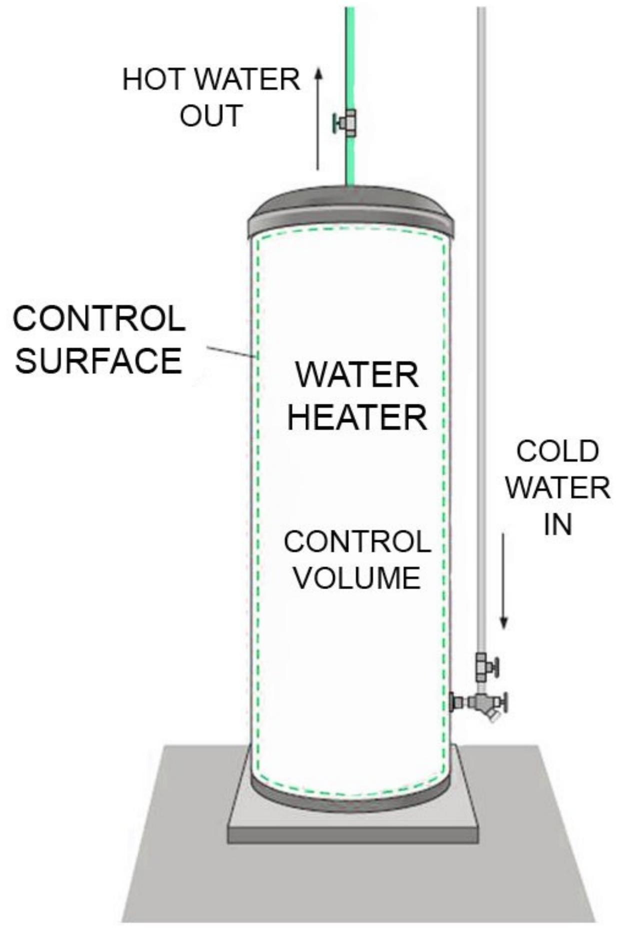
A closed system with a moving boundary



A control volume with real and imaginary boundaries



A control volume with fixed and moving boundaries



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