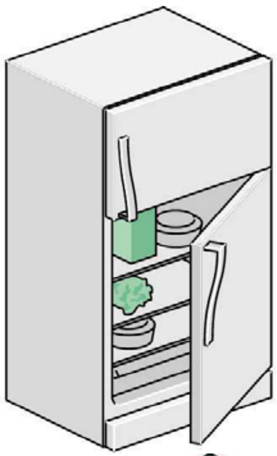
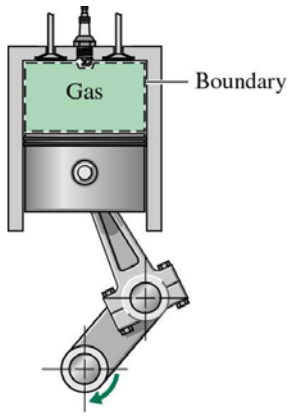
We will learn,

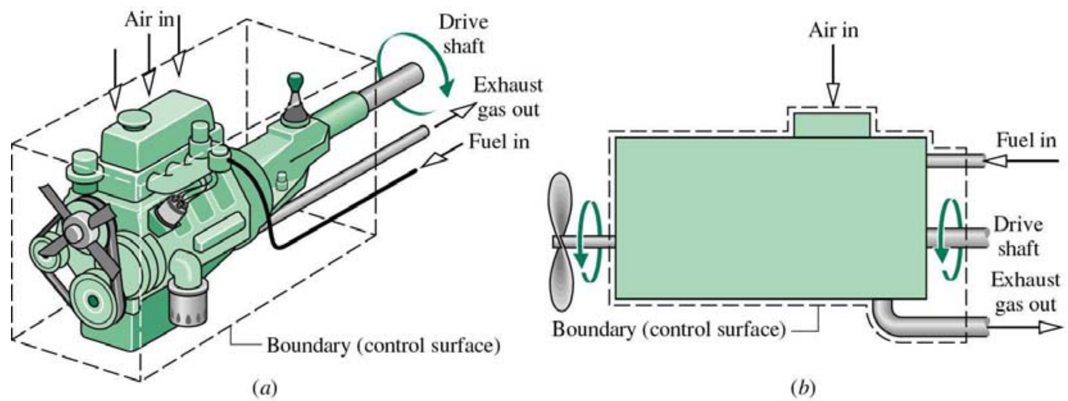
- ***Thermodynamics***, what is it?
- ***System***, ***Surrounding*** and ***Boundary***
- ***State, Property*** and ***Process***
- ***Equilibrium***, ***Quasi-Equilibrium***, and ***Actual***
- ***SI*** and ***English*** Units
- Thermodynamics Properties

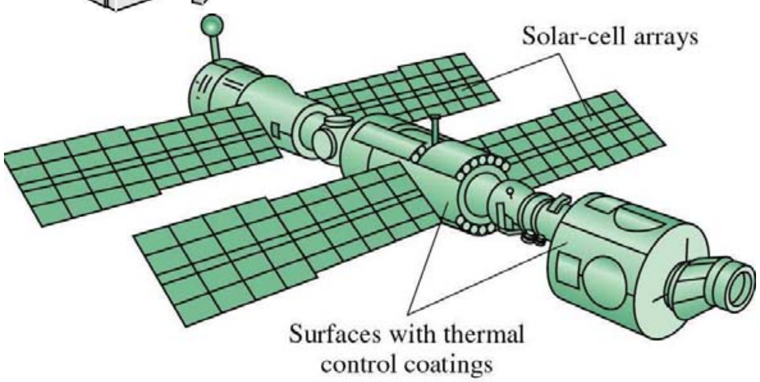
Thermodynamics, what is it?

Thermodynamics deals with the science of “motion” (*dynamics*) and/or the transformation of “heat” (*thermo*) and energy into various other energy–containing forms. The flow of energy is of great importance to engineers involved in the design of the power generation and process industries. Thermodynamics provides an understanding of the nature and degree of energy transformations, so that these can be understood and suitably utilized.

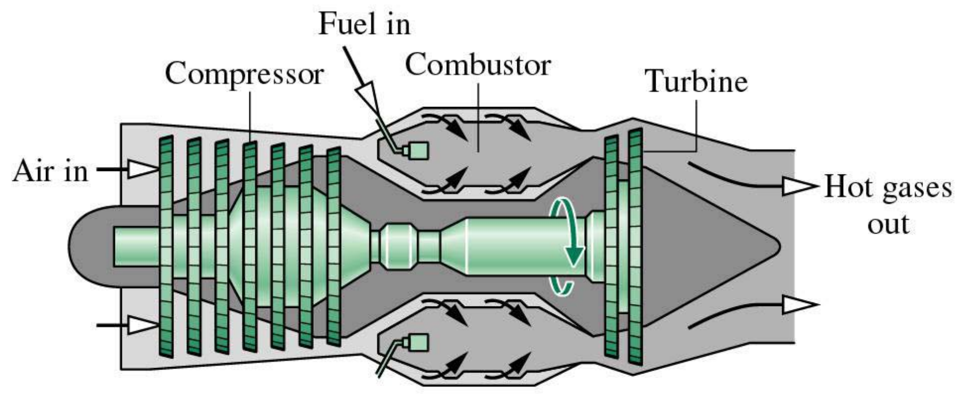








International Space Station



Turbojet engine

There are three mechanics:

- ***Continuum Mechanics***
  (Classical Thermodynamics)
- ***Quantum Mechanics***
  (Quantum Thermodynamics)
- ***Statistical Mechanics***
  (Statistical Thermodynamics)

Classical Thermodynamics

- *is the observational science dealing with heat and work*
- *is developed based on empirical observations*
- *describes macroscopic quantities, such as heat, work, internal energy, enthalpy, entropy, Gibbs free energy, etc.*
- *does not contain any information about the state or even existence of molecules!*
- *assumes that the world is made up of a continuum*

Quantum Thermodynamics

- *deals with microscopic properties, i.e., length scales on the order of 10e-9 m.*
- *is based on the idea that every particle behaves as a wave and vice versa*
- *is not continuous, but discrete!*
- *Is limited to isolated molecules or perfect crystals, usually at absolute zero temperature*
- *does not tell us anything about the thermodynamics of a macroscopic system*

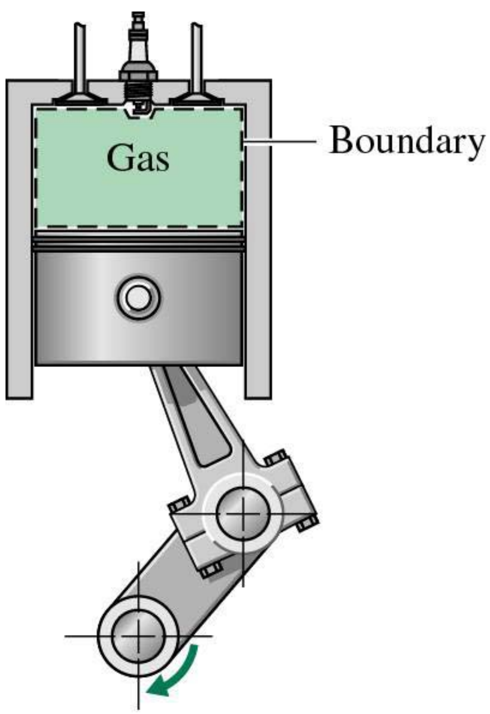
Statistical Thermodynamics

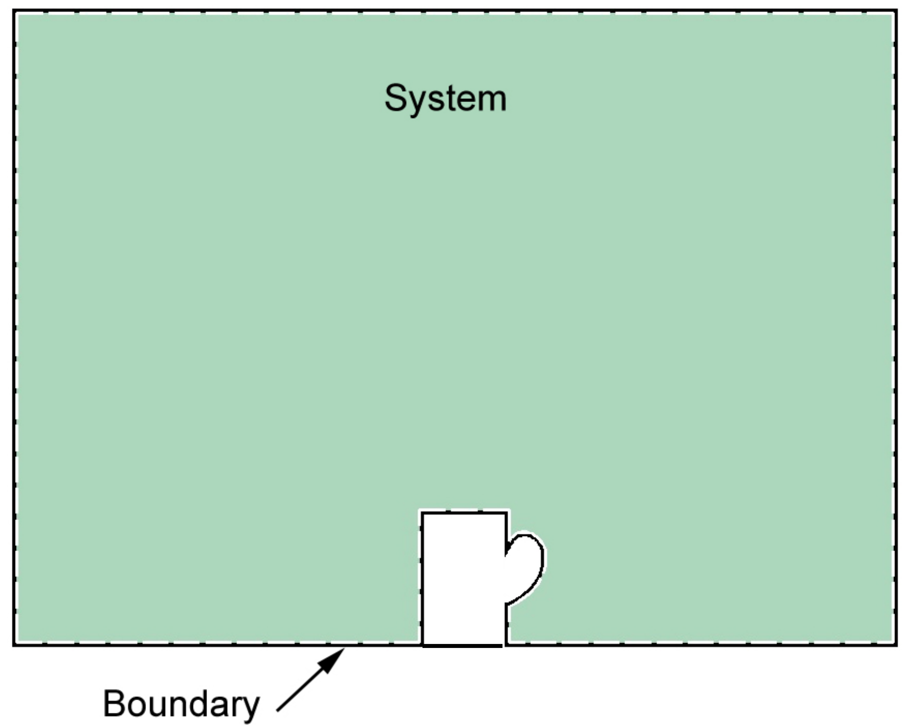
- *is the bridge between quantum mechanics and continuum*
- *deals with individual molecules*
- *averages properties, energy levels, and probabilities of individual molecules*

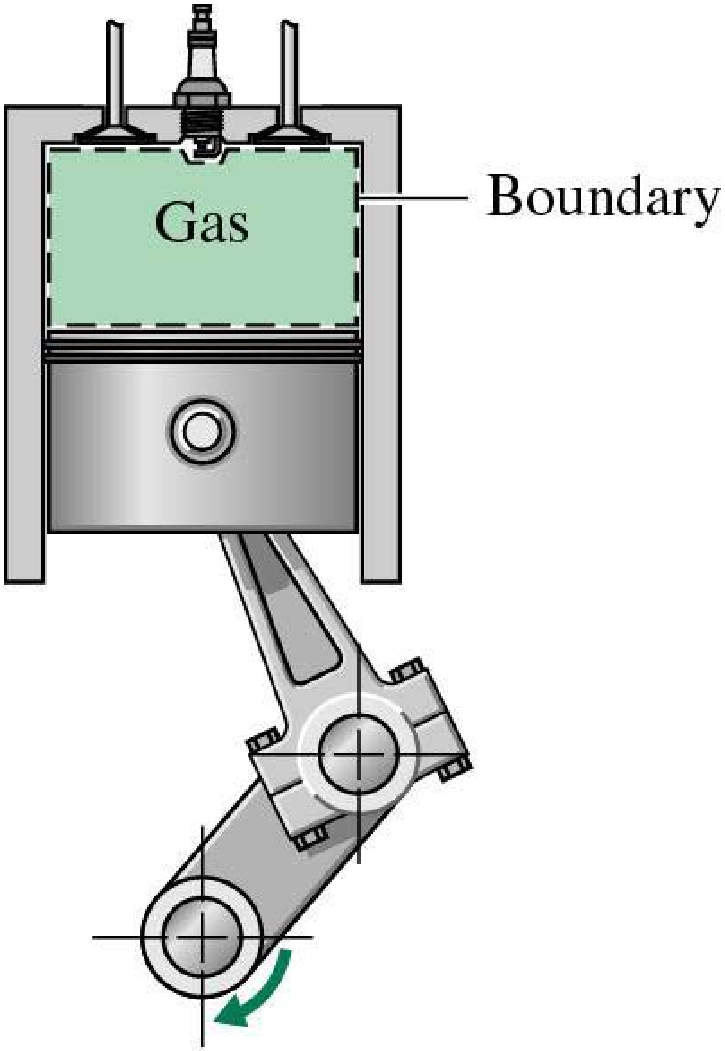
A ***system*** is a region containing energy and/or matter that is separated from its surroundings by arbitrarily imposed walls or boundaries. In a thermodynamic analysis, the ***system*** *is* the subject of the investigation.

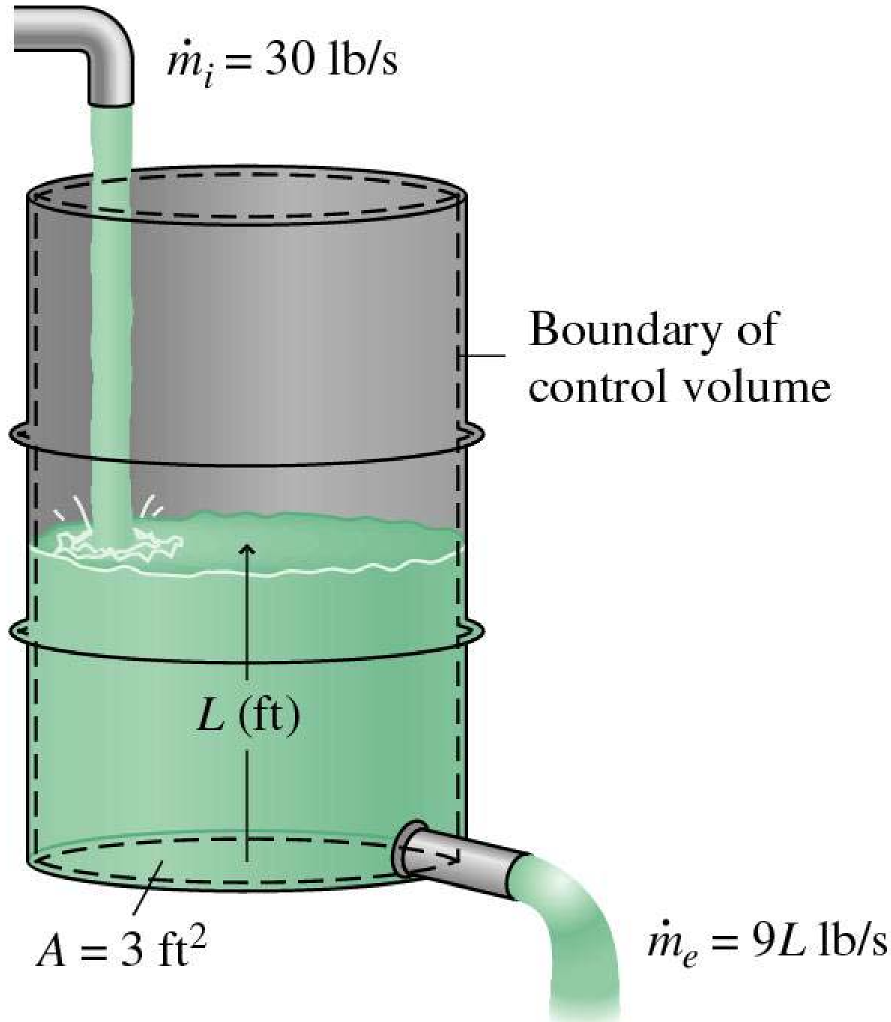
A ***boundary*** is a closed surface surrounding a system through which energy and mass may enter or leave the system.

Everything external to the ***system*** is the ***surroundings****.*









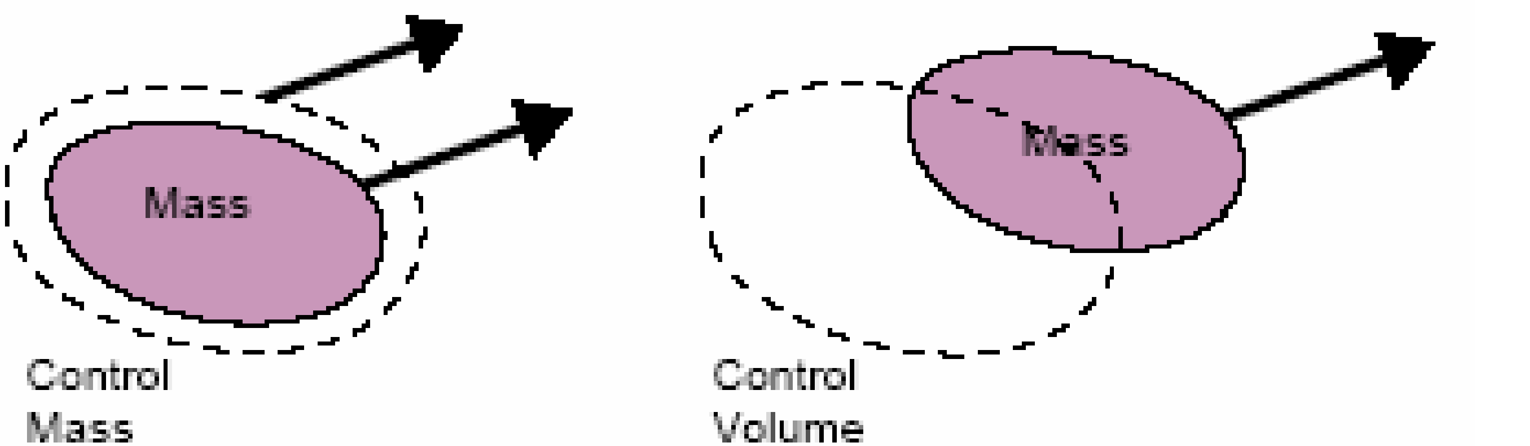
Closed System

Open System

closed system (control mass): energy, but not matter, can be exchanged with the environment.
Examples: a tightly capped cup of coffee.

open system (control volume): Both energy and matter can be exchanged with the environment.
Example: an open cup of coffee.

isolated system: Neither energy nor mass can be exchanged with the environment. In fact, no interactions with the environment are possible at all.
Example: coffee in a closed, well-insulated thermos bottle.



The condition of a system at any instant of time is called its ***state.*** The state at a given instant of time is described by the ***properties*** of the system.

A ***property*** *is any* quantity whose numerical value depends on the state but not the history of the system. The value of a property is determined in principle by some type of physical operation or test.

> ***Extensive*** properties depend on the size or extent of the system. Volume, mass, energy, and entropy are examples of extensive properties. An extensive property is additive in the sense that its value for the whole system equals the sum of the values for its parts.
>
> ***Intensive*** properties are independent of the size or extent of the system. Pressure and temperature are examples of intensive properties.

Two states are identical if, and only if, the properties of the two states are identical. When any property of a system changes in value there is a change in state, and the system is said to undergo a ***process****.*

Phase and Pure Substance

The term ***phase*** refers to a quantity of matter that is homogeneous throughout in both chemical composition and physical structure. Homogeneity in physical structure means that the matter is all *solid,* or all *liquid*, or all *vapor* (or equivalently all *gas). A* system can contain one or more phases.

A ***pure substance*** is one that is uniform and invariable in chemical composition. *A* pure substance can exist in more than one phase, but its chemical composition must be the same in each phase. For example, if liquid water and water vapor form a system with two phases, the system can be regarded as a pure substance because each phase has the same composition. The nature of phases that coexist in equilibrium is addressed by the *phase rule.*

Equilibrium means a condition of balance. In thermodynamics the concept includes not only a balance of forces, but also a balance of other influences. Each kind of influence refers to a particular aspect of thermodynamic (complete) equilibrium.

Thermal equilibrium = an equality of temperature
mechanical equilibrium = an equality of pressure
phase and ***chemical equilibrium*** = an equality of chemical potentials

For thermodynamic equilibrium the several types of equilibrium must exist individually.

To determine if a system is in thermodynamic equilibrium, isolate the system from its surroundings watch for changes in its properties. If there are no changes, it may be concluded that the system was in ***equilibrium*** at the moment it was isolated. The system can be said to be at an ***equilibrium*** *state.*

Quasiequilibrium process means the departure of the system from a thermodynamic equilibrium is infinitesimal.

International System of Units (SI) and English Units

	SI	English
Mass	Kg	lb
Length	m	ft
Time	s	s
Temperature	C	F

	SI	English
Velocity = Distance/Time	m/s	ft/s
Force = Mass*Acceleration	N	lbf
Pressure = Force / Area	N/m^2 (Pa)	lbf/ft^2
Work/Heat = Force*Distance	J	BTU

Density $$\rho = \lim_{V \to V'} \left(\frac{m}{V} \right)$$ Units: kg/m^3, lb/ft^3

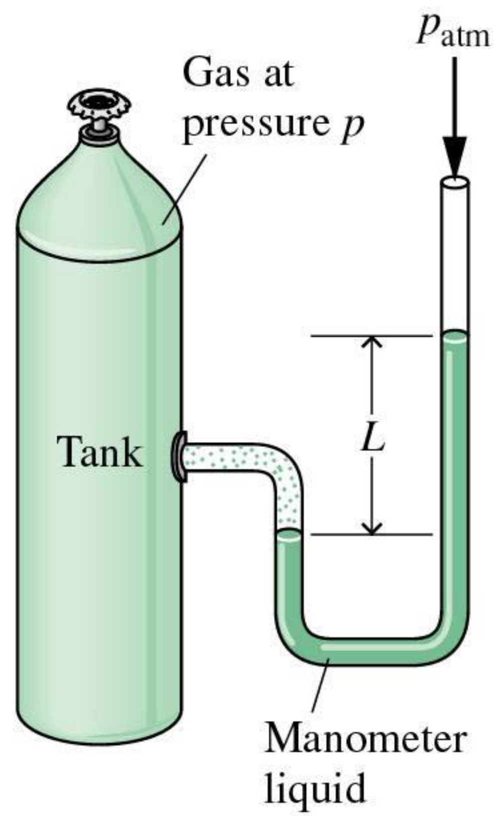
Specific Volume $$\nu = \frac{1}{\rho}$$ Units: m^3/kg, ft^3/lb

Pressure (abs.) $$P = \lim_{A \to A'} \left(\frac{F_N}{A} \right)$$

P (gage) = P (abs)- P_{atm} (abs) = ρg*L*

Units: N/m^2 or Pascal (Pa), lbf/ft^2

1 atmosphere = 101.325 kPa



Temperature

Units: Kelvin, Rankine
Fahrenheit, and Celsius

$$T(K) = T(°C) + 273.15$$

$$T(°R) = 1.8T(K)$$

$$T(°F) = T(°R) - 459.67$$

$$T(°F) = 1.8T(°C) + 32$$