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Thermodynamics

Lecture 1

- **Fundamentals of Engineering Thermodynamics**

MICHAEL J. MORAN, The Ohio State University
HOWARD N. SHAPIRO, Iowa State University
DAISIE D. BOETTNER, Colonel, U.S. Army
MARGARET B. BAILEY, Rochester Institute of Technology

- **Applied Heat for Engineers**

Octave Sneeden, Samuel Vallance Kerr

- **Applied Thermodynamics for Engineering Technologists (5th Edition)**

T.D. Eastop , A. Mcconkey

- **Fundamentals of classical Thermodynamics**

Gordon John Van Wylen

- **Engineering Thermodynamics: Work and Heat Transfer**

Book by G. F. C. Rogers and Y. R. Mayhew

Definition

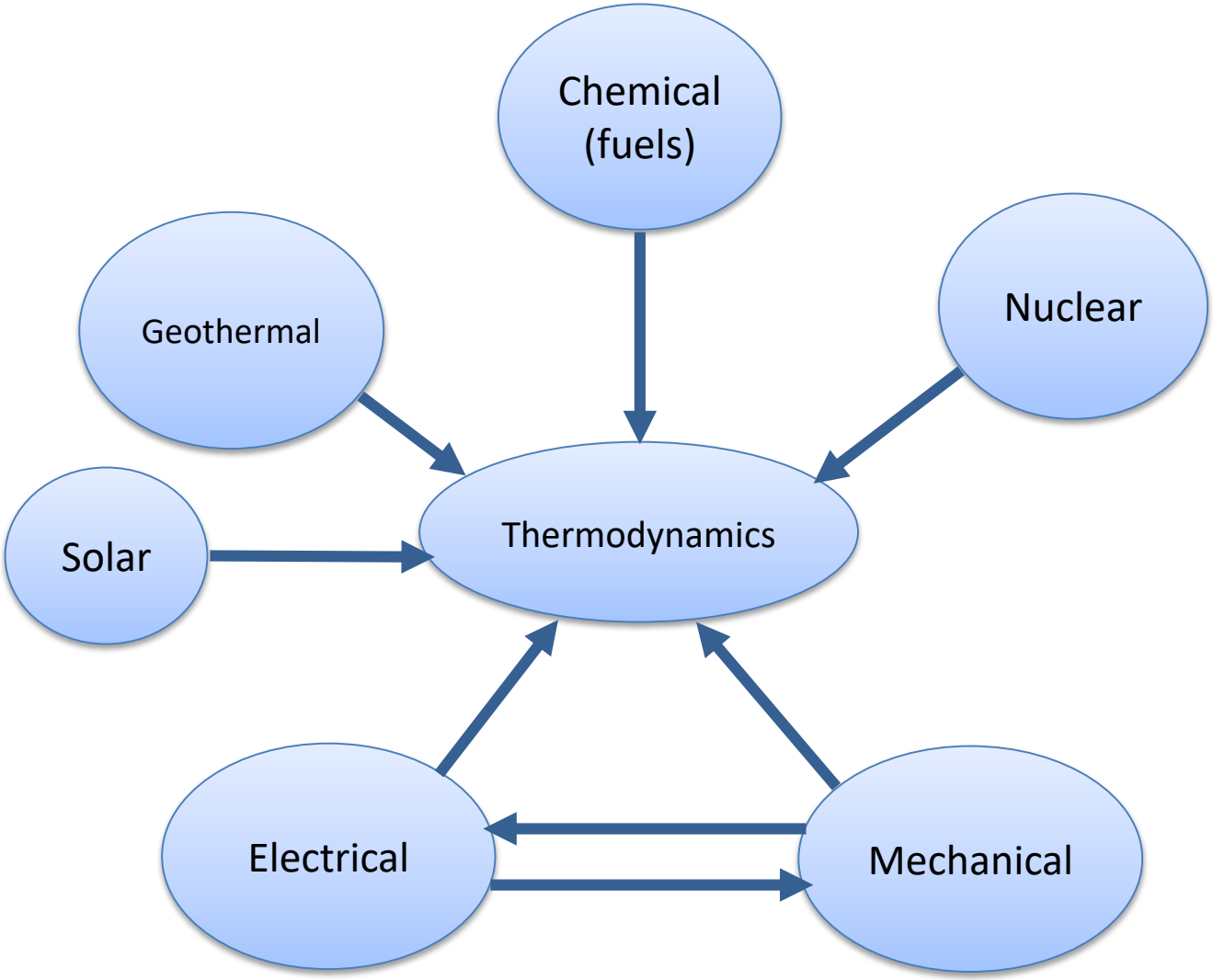
Thermodynamics: is the branch of physics that deals with heat and temperature, and their relation to energy, work, radiation, and properties of matter.

It can be defined as : the science concerned with the relations between heat and mechanical energy or work, and the conversion of one into the other.

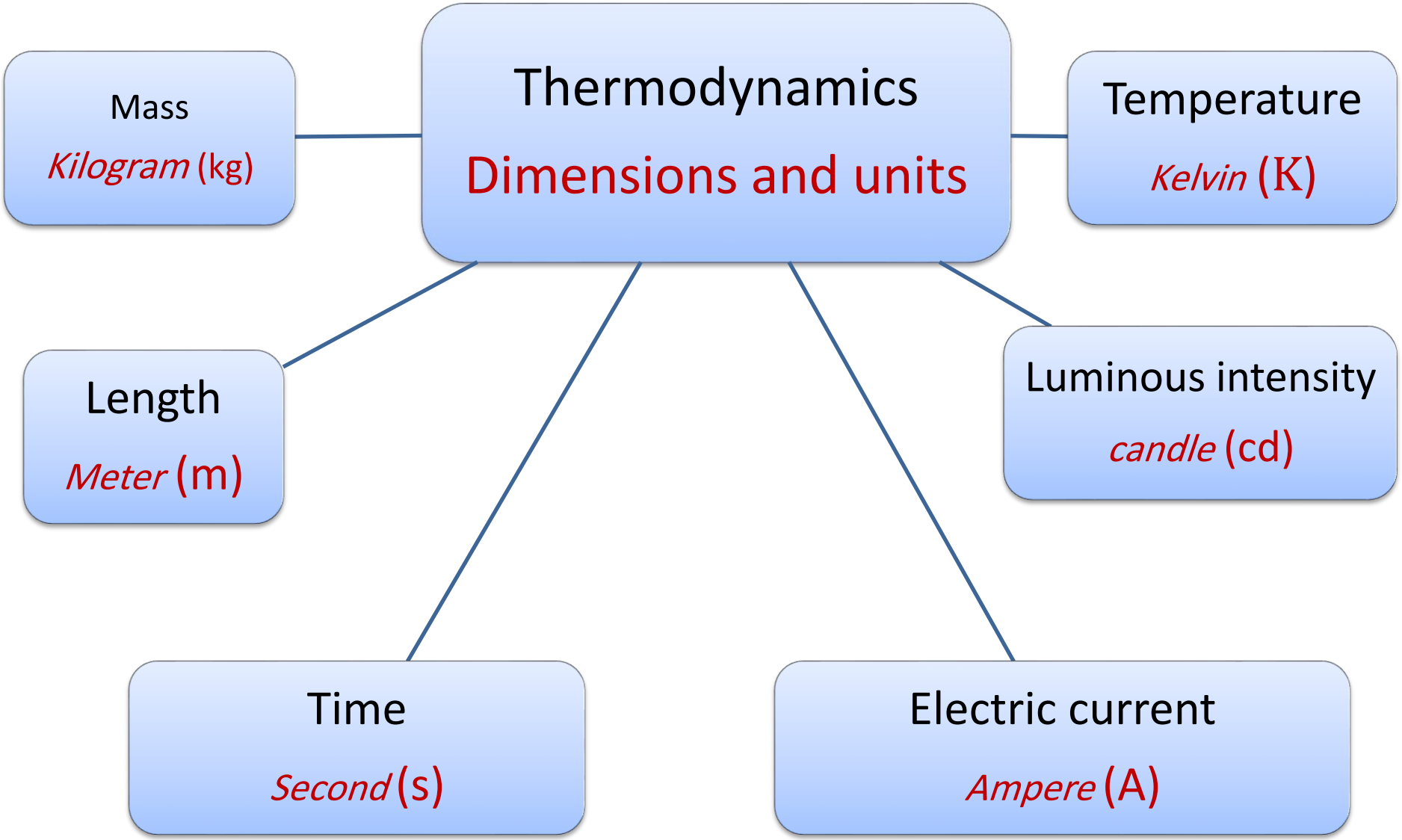
- ✓ **Heat** is the transfer of thermal energy between systems.
- ✓ **work** is the transfer of mechanical energy between two systems.

Applied thermodynamics: is the science of the relationship between heat, work, and the properties of the system.

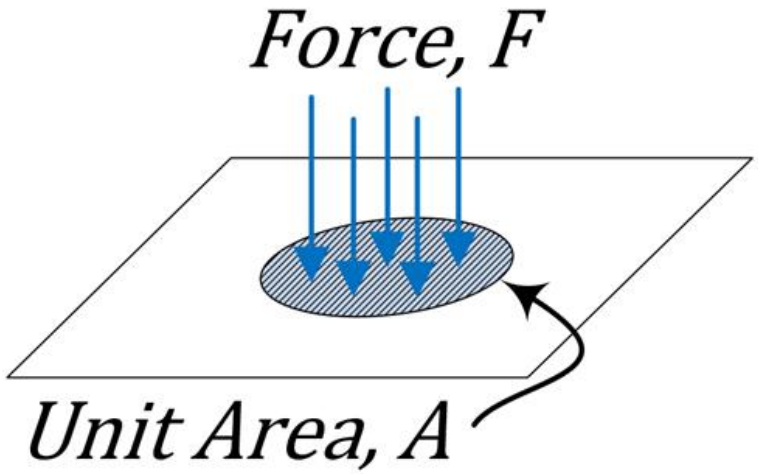
The scopes of Thermodynamics



Dimension and units:



Pressure (P)



Pressure : is the force acting on unit area normal on it. (i.e.) $P = \frac{F}{A}$

The unit of pressure is N/m^2 $(Pascal - Pa)$; KN/m^2 (KPa), Since the pressure has always has big values, lead to use bigger unit of pressure which is: bar

1 bar = 10^5 N/m^2 = 10^2 KN/m^2 = 10^2 KPa

Pressure (P)

Atmospheric pressure $P_{(atm.)}$: is the pressure within the atmosphere of Earth. The standard atmosphere is a unit of pressure defined as 1.01325 bar, equivalent to 760 mm Hg.

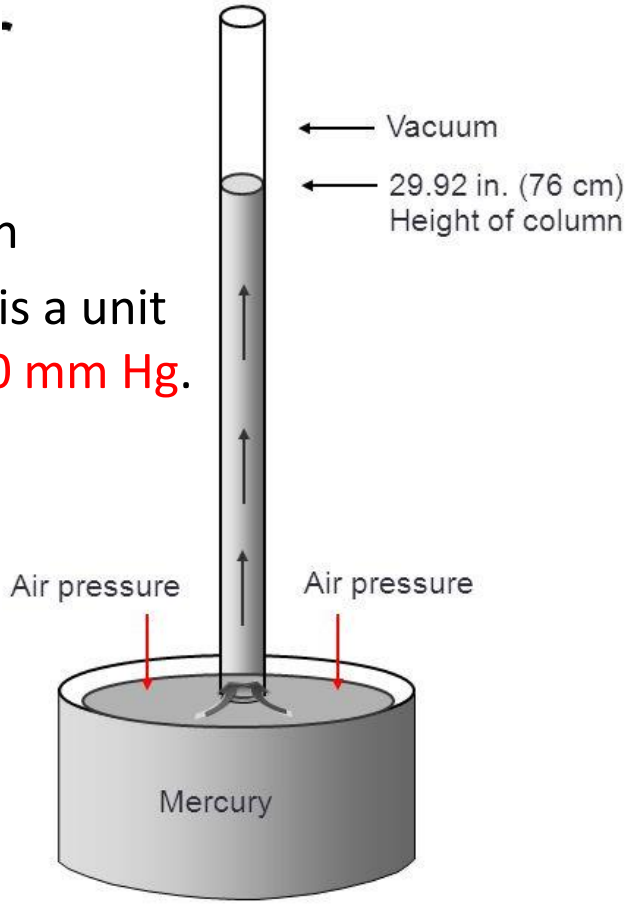
sometimes also called barometric pressure.

$P_{(atm.)} = 1\ atm$ (at sea level)

= 76 cm (Hg)

= 10.33 m (H_2o)

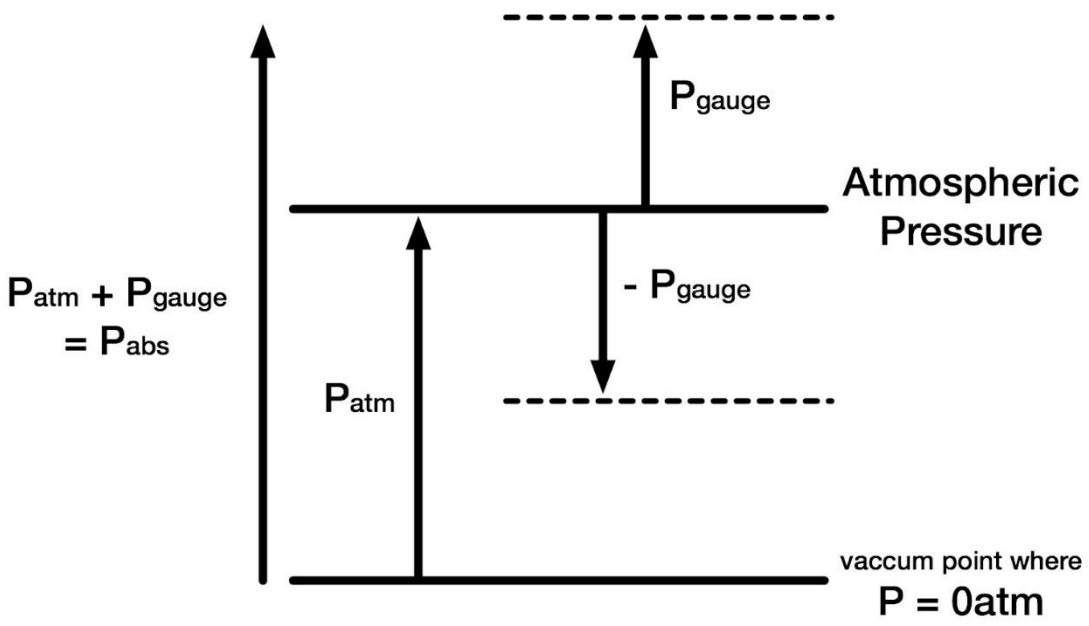
= 1.01325 bar



Barometer

Pressure (P)

- **Absolute pressure** $P_{(abs.)}$: is measured relative to a full vacuum.



Measurement of the pressure:

Manometers: use to measure the pressure (static pressure) exerted by a still liquid or gas.

If the pressure applied at one side of the U-tube, and other side is atmospheric pressure, the difference gives the gauge pressure as *h.*

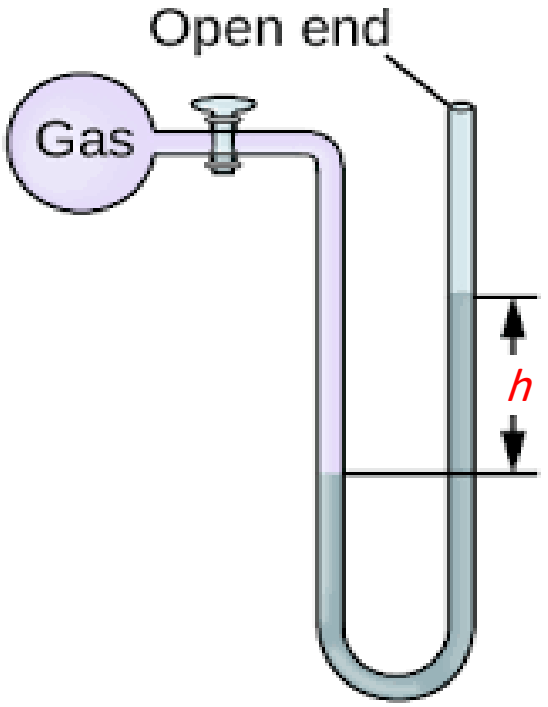
To calculate the h meaning, we use;

$$P = \rho . g . h$$

ρ: density of the liquid (kg/m^3)

g: gravitational acceleration (m/s^2)

h: the difference between the two sides (m)



Questions:

Q /1: Acceleration of gravity is 9.81 m/s^2, Find the pressure in bar for 850 mm Hg, for ρ_{Hg}= $13.6 \times 10^3 (\mathrm{kg}/m^3)$, and 1200 cm H_2o, the ρ_{H_2o}= $10^3 (\mathrm{kg}/m^3)$. (Ans. 1.134 ; 0.1177 bar)

Q /2: If the pressure of the gas is $120\ (\mathrm{KN}/m^2)$ gauge and the barometer reading is 74 cm Hg. What is the absolute pressure? (Ans. 2.187 bar)

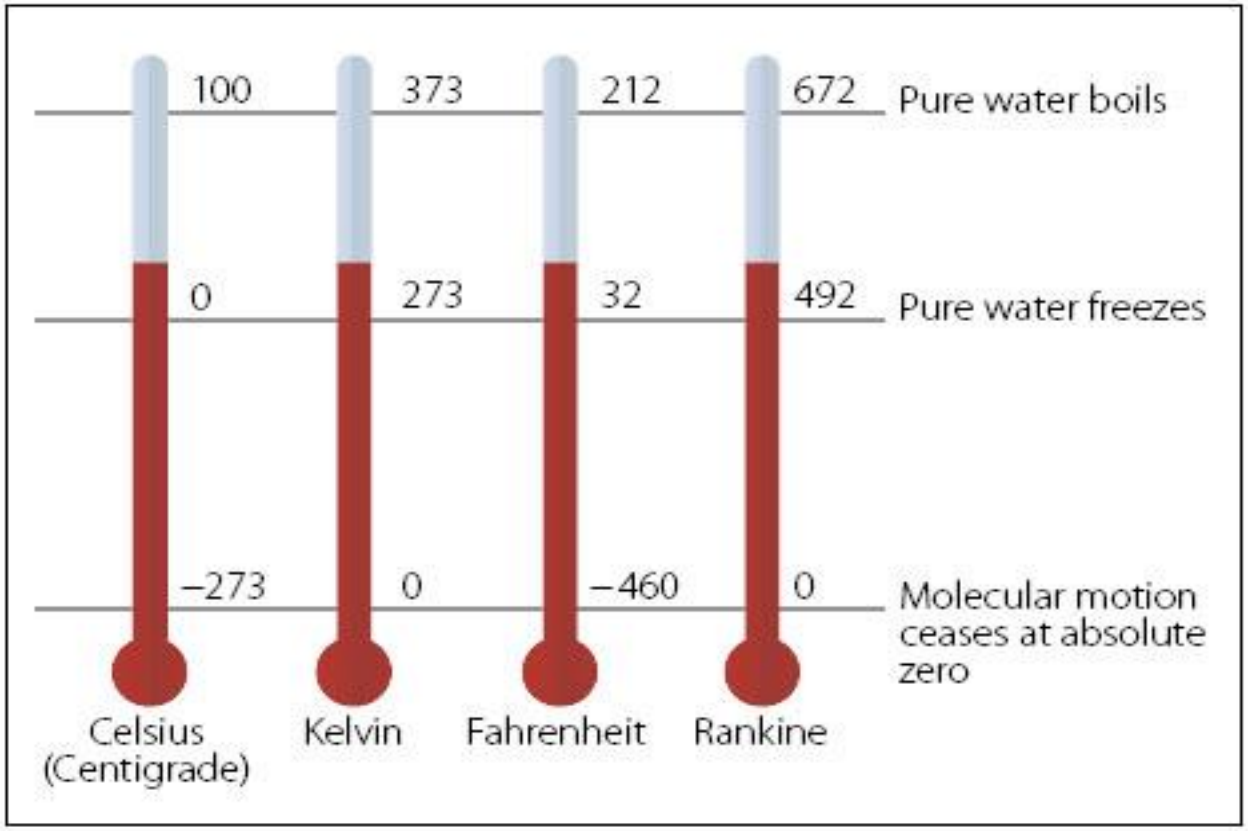
Q/3: At 27 C, a manometer filled with mercury reads 60.5 cm . The local acceleration of gravity is 9.784 m/s^2 . To what pressure does this height of mercury represent? ($\rho_{Hg} = 13.6 \times 10^3\ kg/m^3$). (Ans. 80.5 KPa)

Temperature (T):

It's defend as a sense of hotness or coldness when we touch an object. The unite of temp is ℃ $in\ sentegrate\ scale(celcius)$ and kelvin K in thermodynamic scale.

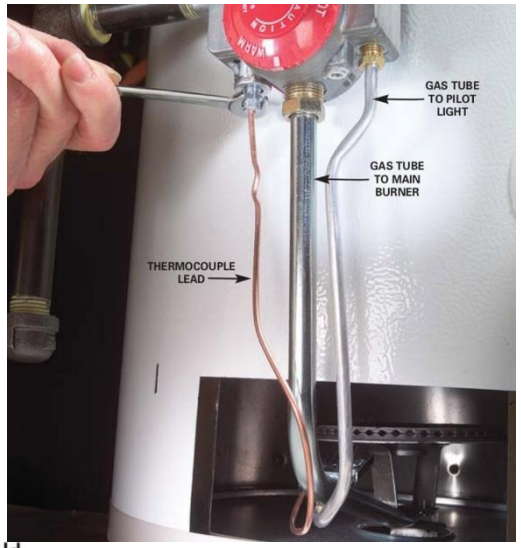
$$T(K) = t\ (℃) + 273\ \ldots\ldots\ldots 1$$

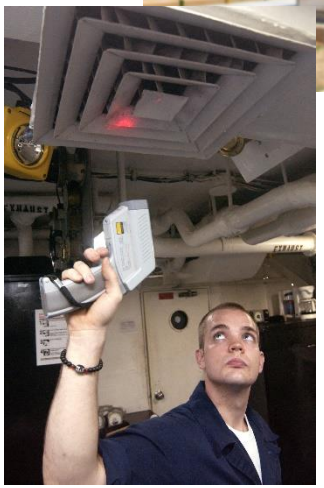
$$T(°F) = 1.8\ t\ (℃) + 32\ \ldots\ldots 2$$

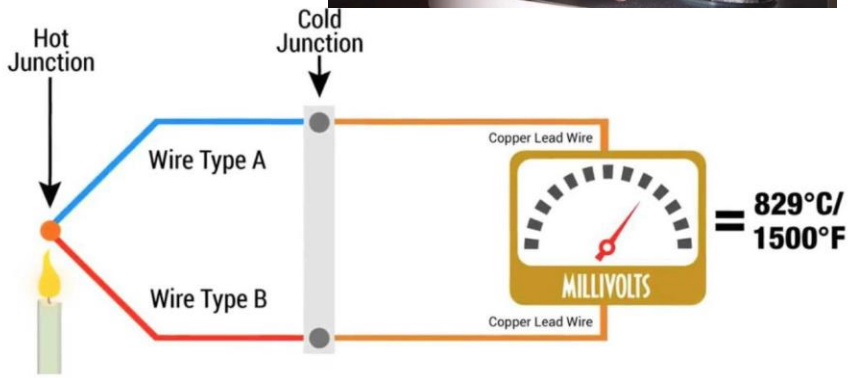


Measurement of Temperature (T):

- Thermometers
- Thermocouple
- Pyrometer





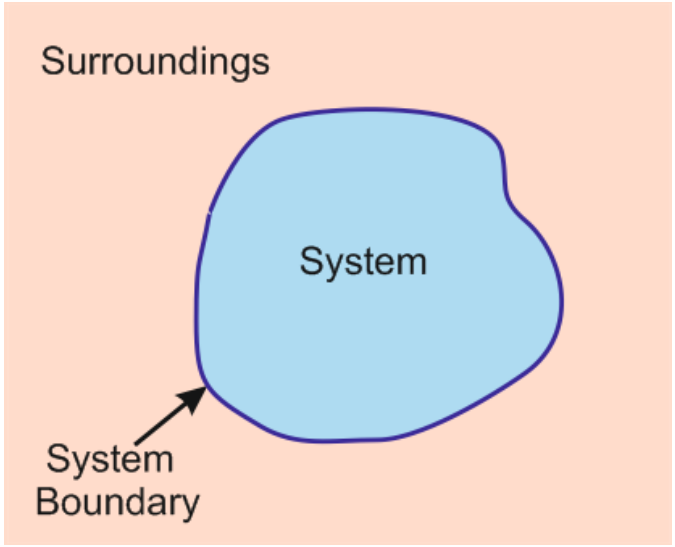


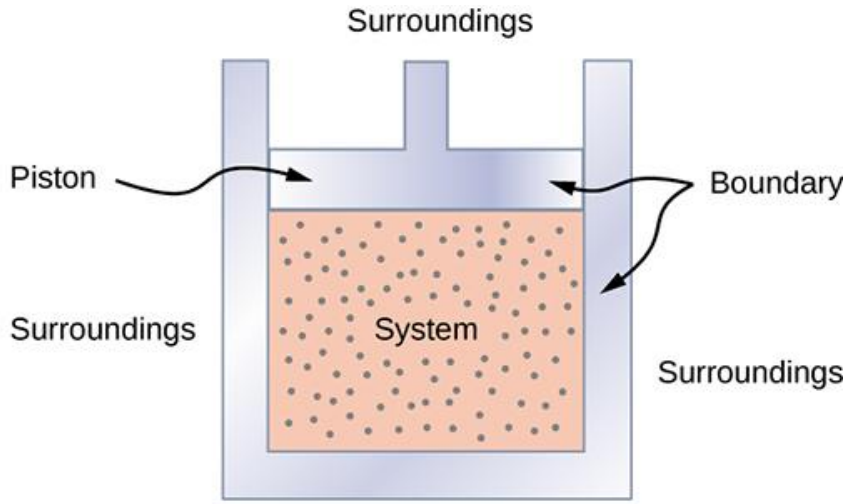
System

It is a specified region in space not necessary of constant volume, where transfers of energy and mass are to be studied.

There are two types of system:

Closed system: where no mass cross the boundary, energy may cross the boundary.

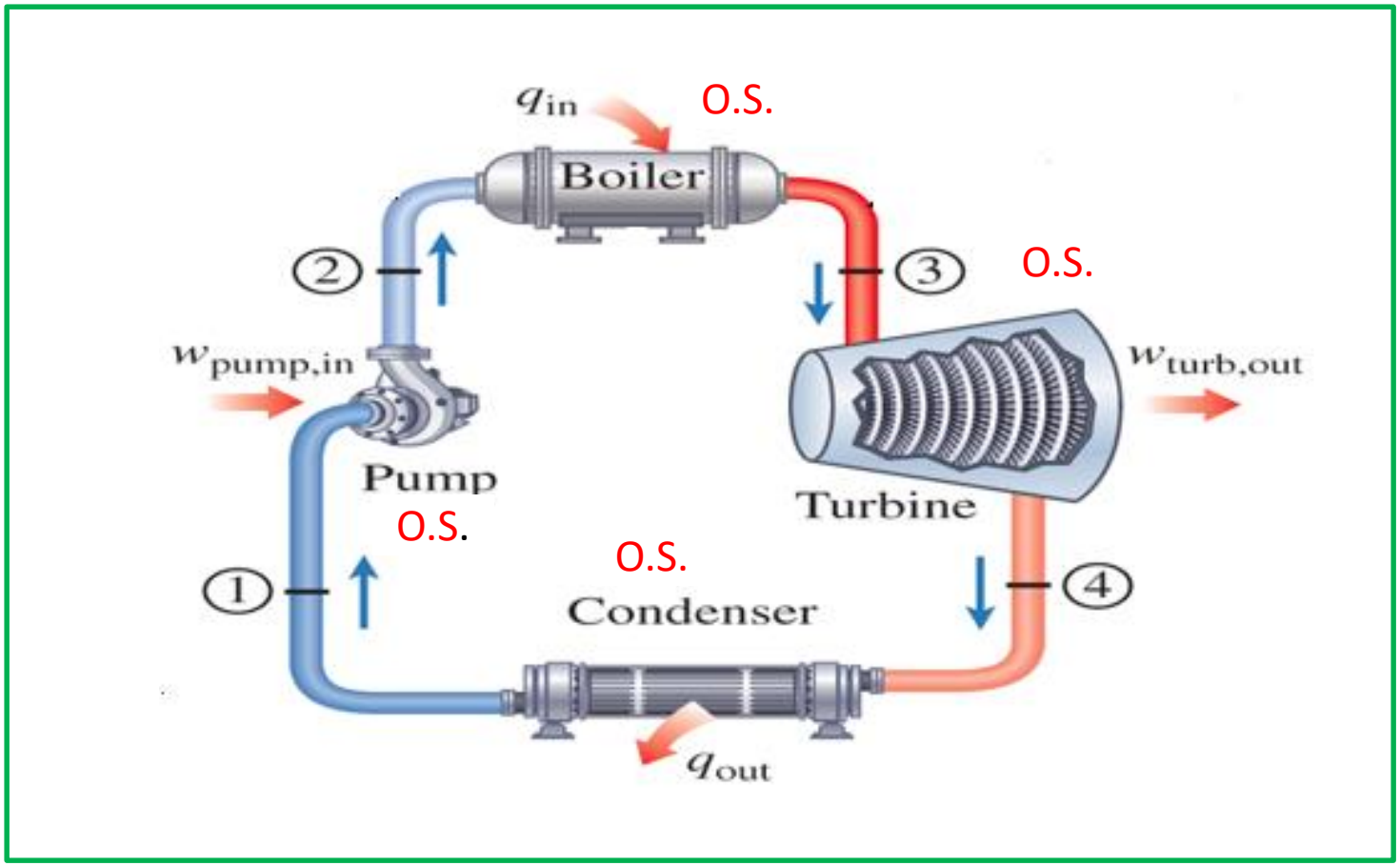




System

Open system: which is mass and energy transfer through the boundary.

(e.g.): pump, boiler, condensed, evaporator, turbine.



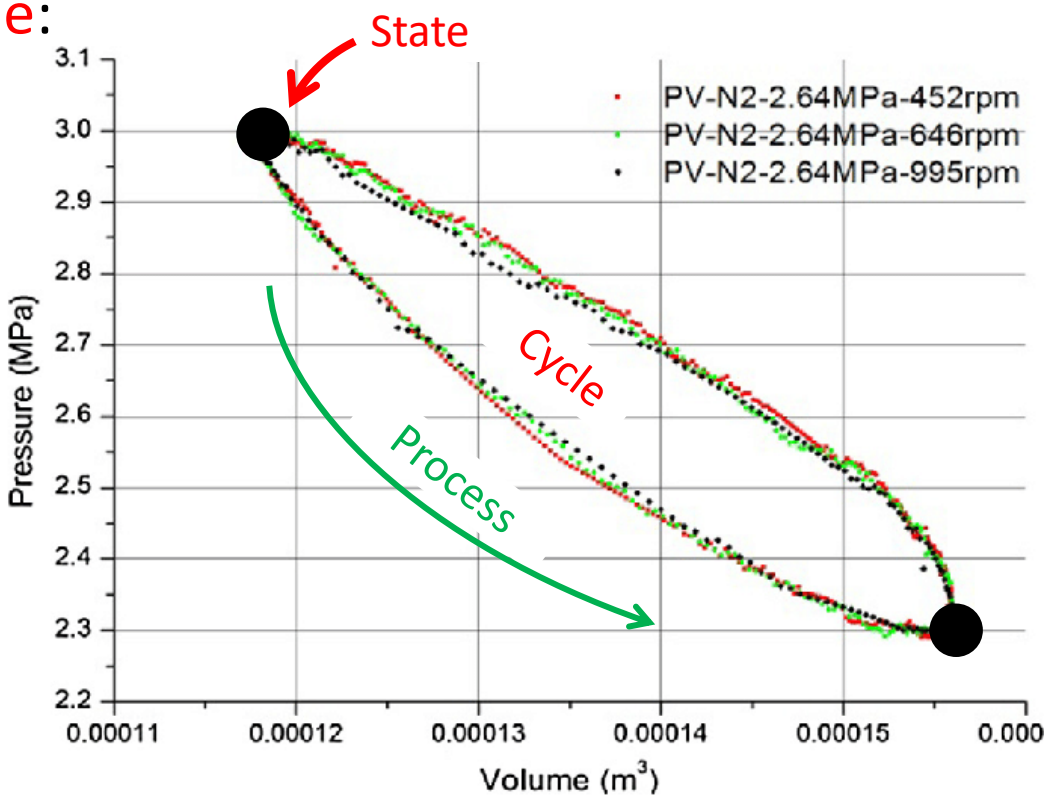
Property: it's an attribute used to describe a system, such as pressure, temperature, volume …

State: It is the system at a certain time which defined by the properties.

Process : it occurs when a system changing from state to another state.

The thermodynamic cycle:

is a sequence of processes which return the system to the first process

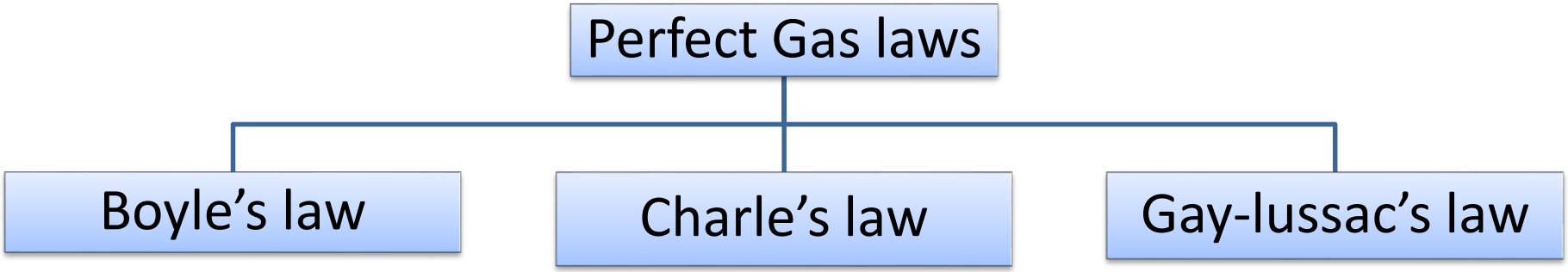


Perfect Gas……Ideal Gas

A gas at sufficiently low density such that the inter molecular forces and the associated energy are negligible small.

A perfect gas obeys all gas laws exactly under all conditions of pressure & temperature and has constant specific heats.

$$\frac{P.V}{R.T} = 1$$



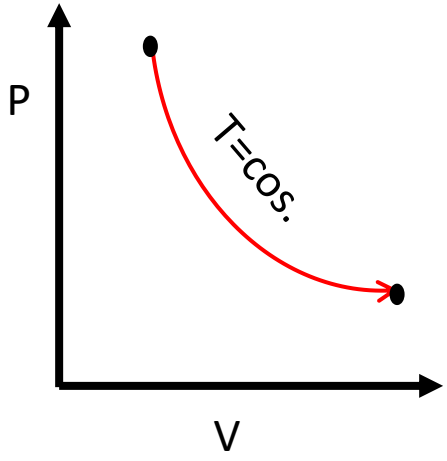
For fixed mass of gas under constant temp., the volume is inversely proportional to the absolute pressure.

For fixed mass of gas under constant Pressure., the volume is directly proportional to the absolute temperature.

For fixed mass of gas under constant volume, the pressure is directly proportional to the absolute temperature.

Perfect Gas laws

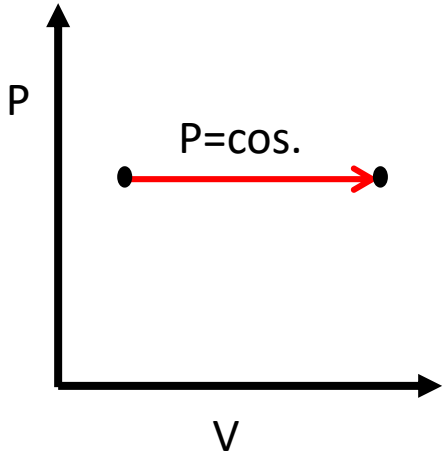
- Boyle's law
- Charle's law
- Gay-lussac's law



$$V \propto \frac{1}{P} \;\; if \;\; T = constant$$

$$\therefore V = \frac{C}{P} \Longrightarrow PV = C$$

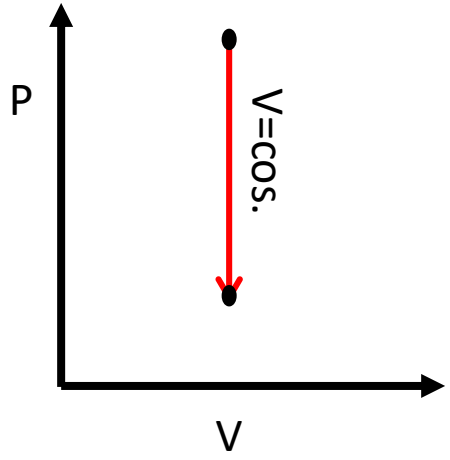
i.e. $\boldsymbol{P_1V_1 = P_2V_2 = C}$



$$V \propto T \;\; if \;\; P = constant$$

$$\therefore V = C\,T \Longrightarrow \frac{V}{T} = C$$

i.e. $\boldsymbol{V_1/T_1 = V_2/T_2 = C}$



$$P \propto T \;\; if \;\; V = constant$$

$$\therefore P = C\,T \Longrightarrow \frac{P}{T} = C$$

i.e. $\boldsymbol{P_1/T_1 = P_2/T_2 = C}$

Thank you for your attentions

Next lecture will be:
Equation of state