120

USN		CMRIT

Internal Assessment Test 1 – Sept. 2017

Sub:	Basic Thermodynamics	Sub Code:	15ME33	Branch:	MECH
Date:	21/09/2017	Duration: 90 min's	Max Marks: 50	Sem / Sec: III- (A&B)	OBE

	Answer any ~~FIVE~~ 2 FULL Questions	MARKS	CO	RBT
1 (a)	Define thermodynamics. Differentiate between open system, closed system and isolated system	[05]	CO1	L2
(b)	Explain the flowing with examples : a) Microscopic thermodynamics and Macroscopic thermodynamics b) quasi-static process c) Intensive and Extensive Properties d) Point function and path function	[10]	CO1	L2
(c)	A platinum wire is used as a resistance thermometer. The wire resistance was found to be 10 ohm and 16 ohm at ice point and steam point respectively, and 30 ohm at sulphur boiling point of 444.6°C. Find the resistance of the wire at 500°C, if the resistance varies with temperature by the relation. $R=R_0(1+\alpha t+\beta t^2)$	[10]	CO1	L3
2 (a)	With help of P – V diagram explain the various regions of a pure substance	[05]		
(b)	Define the following: System, Boundary, Property, Thermal equilibrium, State	[05]	CO1	L2
(c)	Two thermometers coincide at ice point and steam point. However, at all other points, they are related by $T1 = A + BT^2 + CT_2^2$. When both are immersed in a fluid, the first thermometer registers a temperature of 11.6°C while the second registers 12.8°C. Determine the reading in the first thermometer when the second reads 36°C.	[10]	CO1	L3
(d)	Compare work energy with heat energy.	[05]	CO2	L2
3 (a)	Define the work with respect to mechanics and thermodynamics	[06]	CO2	L2
(b)	Derive a work done equation for polytropic process. show the process on P-V Diagram.	[09]	CO2	L2
(C)	A fluid is heated reversibly at a constant pressure of 1.013 bar until it has a specific volume of 0.1 m^3/kg. it is then compressed reversibly according to a law pV=C to a pressure of 4.2 bar , then allowed to expand compressed reversibly according to a law $pV^{1.3}$=C to the initial conditions. The work done constant pressure process is 515 N-m and the mass of the fluid present is 0.2kg.caluculate the net work done on or by the fluid in the process and sketch the cycle on P-V diagram.	[10]	CO2	L4

1.a) Define thermodynamics. Differentiate between Open System, Closed System & Isolated System.

Ans: It is a Science which deals with the relations among heat & work. And properties of the System when it is in equilibrium.

Open System	Closed System	Isolated System.
*Thermodynamic System in which mass & energy crosses the boundary is Called an Open System.	*Thermodynamic System in which energy crosses the boundry is Called Closed System.	*No energy & mass Crosses the boundry then the system is called Isolated System.
* Examples i) Scooter Engine. ii) Centrifugal water pump. iii) Electric pan. iv) Turbine. v) Radiator. vi) Condenser.	*Examples i) Compression of air in the Compressor. ii) Car battery. iii) Pressure Cooker. iv) Boiler. v) Steam power plant. vi) Refrigerator.	*It has a fixed mass & energy. This Concept is helpful in the study and analysis of thermodynamic principle of law. Example: Thermoplast (100% insulation is assumed)

1.b) Explain the following with Examples.

a) Microscopic thermodynamics & Macroscophic thermo-dynamics.

Particles known as 'molecule'. These molecules have different Values of velocity (s) and energy (s) that vary with time. This approach of T.D which is Concerned directly with the structure of matter is known as 'statical thermodynamics'. The properties like velocity, momentum, impact, kinetic energy, force etc are described not directly by instruments. It needs a large no of variables to describe a system. Due to this reason, macroscophic approach is Complicated to adopt.

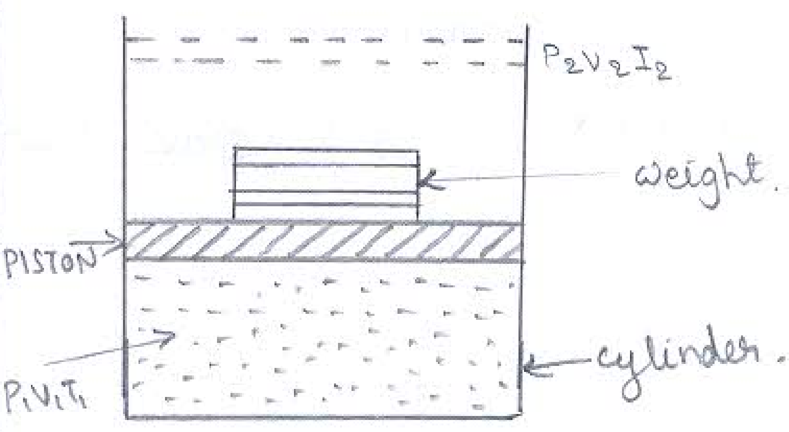
<u>Macroscophic thermodynamics</u>: The system is describe by means of measurable quantities such as temp", pressure, volume etc which are large Scale properties. Then such a system of approach called macroscophic approach. Different system may require different macroscophic properties for their description. But all macroscophic co-ordinates have the following characteristics in column.

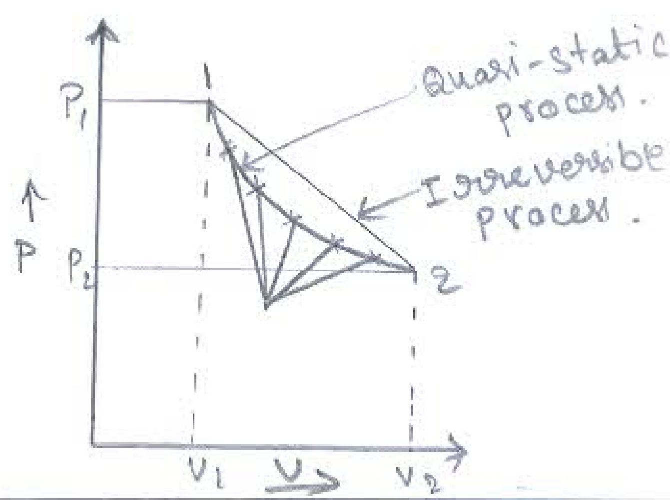
→ They don't involve Special assumptions Concering to the Structure of the matter.

→ They are readily measurable.

→ Only few properties are needed to describe a System adequeatly.

b) <u>Quasi-static process</u>





Consider a piston - cylinder arrangement in which there is a gas in the cylinder under pressure. The system initially is in equilibrium state represented by the properties P_1, V_1, T_1. The ~~equi~~ weights on the piston just balances the upward force excerted by the gas. If all the weights are removed once, the system undergoes a change of state & then becomes to the equilibrium state with the properties P_2, V_2, T_2. But intermediate states passed through the system are non-equilibrium states. This process is called irreversible process.

If the weights are removed one by one very slowly from the top of the piston then the system undergoes a change of state with successive equilibrium states during the process and it represented by the curve 1-2 on PV diagram. Such process is called Quasti - static process.

c] Intensive & Extensive property.

Intensive property: The properties which are independent of the mass of the system are called intensive properties.

eg: Density, Sp volume, Sp energy etc.

Extensive property: The properties which are dependent on the mass of the system are called Extensive properties. These are directly proportional to mass of the system.

eg: Area, volume etc.

d] Path function & Point function

Point function: Point function, when two properties locate a point on the graph then these properties are called Point function.

examples: Pressure, volume, Temperature, Enthalpy, Entropy, Internal energy.

→ Point functions are exact differentials.

ex: $\int_1^2 dV = V_2 - V_1$

Path function: These are certain quantities which cannot be located on a graph by a point but they are given by the area on the graph.

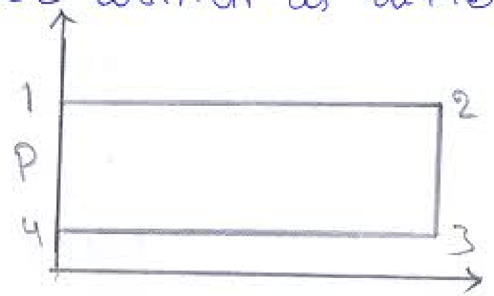
In that case the area on the graph printing to the particular process is the function of path of the process such quantities are called path function.

Examples: Heat & Work are in exact differentials.

∴ Their change cannot be written as difference b/w the end states.

$$\int_1^2 \delta W = W_2 - W$$

where, δ is in exact,



(1C) A platinum wire is used as a resistance thermometer. The wire resistance was found to be 10 ohm & 16 ohm at ice point & steam point respectively, & 30 ohm at sulphur boiling point of 444.6°C. Find the resistance of the wire at 750°C, if the resistance varies with temperature by the relation.

$$R = R_0(1 + \alpha t + \beta t^2)$$

Soln: $R = R_0(1 + \alpha t + \beta t^2)$

At ice point, $t = 0$, $R = 10\Omega$

$$10 = R_0(1+0+0)$$

$$(R_0 = 10\Omega)$$

At steam point, $t = 100°C$, $R = 16\Omega$

$$16 = 10(1 + 100\alpha + 100^2\beta)$$

$$\alpha + 100\beta = 0.006.$$

At sulphur point, $t = 444.6°C$, $R = 30\Omega$

$$30 = 10(1 + 444.6\alpha + 444.6^2\beta)$$

$$\alpha + 444.6\beta = 0.0045$$

Solving Equations (1) & (2)

$$\alpha + 100\beta = 0.006$$

$$\alpha + 444.6\beta = 0.0045$$

Sub. $-344.6\beta = 0.0015$

$$\beta = -435 \times 10^{-6}$$

$$0.006 = \alpha + 100(-4.35 \times 10^{-6})$$

$$\alpha = 6.44 \times 10^{-3}$$

$$\therefore \quad R = 10(1 + 6.44 \times 10^{-3} t - 4.35 \times 10^{-6} t^2)$$

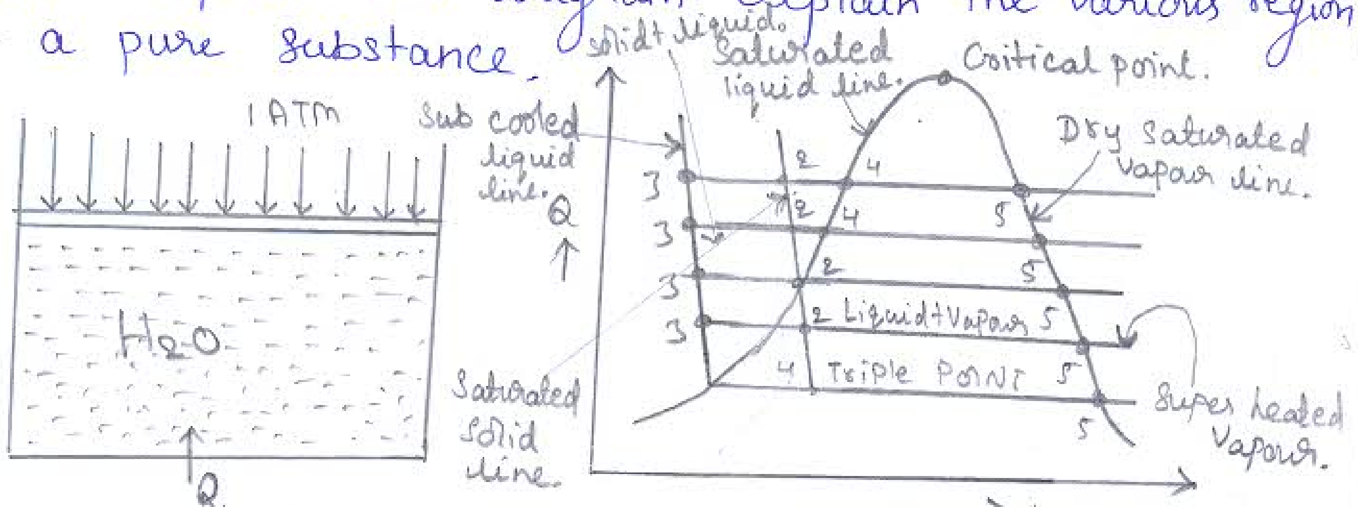
when $t = 750°C$

$$R = 10(1 + 6.44 \times 10^{-3} \times 750 - 4.35 \times 10^{-6} \times 750^2)$$

$$\boxed{R = 33.8\Omega}$$

2(a) With help of P-V diagram explain the various region of a pure substance.

Ans:



Consider Ice at $-10°C$ & 1 atm pressure contained in a cylinder & piston arrangement. Let the ice is heated slowly & change in volume are noted. The following observations are noted during heated of Ice.

Process 1-2: Temp^r of Ice increases from -10°C to 0°C. Volume of Ice increased from V_1 to V_2.

Process 2-3: Ice melts into water at a Constant temperature of 0°C. Their is decrease in volume.

Process 3-4: The temp^r of water increases from 0°C to 100°C. The volume of water increases from V_2 to V_4 because of thermal expansion.

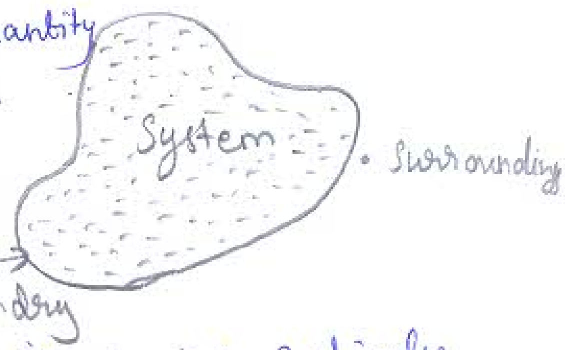
Process 4-5: The water start boiling at state 4 and boiling ends at state 5.

During the process phase change from liquid to Vapour ~~increases from~~ Occurs at Constant vapour temperature.

Process 5-6: The Vapour is heated to Superheated temp^r, the volume of Vapour increases from V_5 to V_6.

2b Define the following.

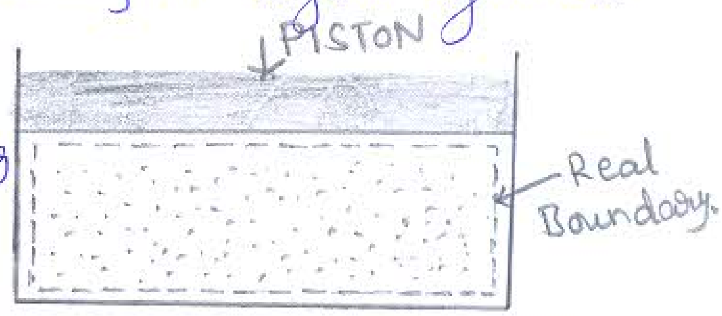
1) System: It refers to a definite quantity of matter bounded by Some closed surface. Upon which attention is Concentrated in the analysis of a problem.



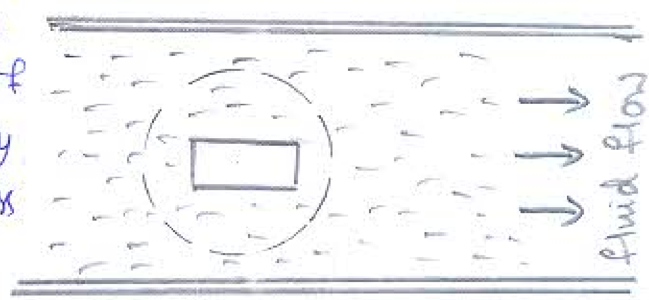
eg: Mass of gas, Vapour Containing in engine cylinder.

2) Boundary:

→ The actual envelope Enclosing the System is Called boundry of the System.



→ The boundry of the system may be real one like that of a cylinder enclosing the imaginery like the boundry of a Certain mass of the liquid as it flow along a pipe.



3] Property: A property is the characteristic which is used to identify the state of a System.
eg: Pressure, temperature, Sp volume, internal energy etc.

4] Thermal equilibrium: In this the temperature of the system does not change with time and it has some value at all the points of the system.

5] Process: When the system changes from one equilibrium state to another. It does so by means of a process.

(2C) Two thermometers Coincide at ice point & steam point. However, at all other points, they are related by $T1 = A + BT_2^2 + CT^2$. When both are immersed in a fluid, the first thermometer registers a temperature of 11.6°C. while the Second registers 12.8°C. Determine the reading in the first thermometer when the second reads 36°C

Soln

In Celsius Scale, ice point 0°C & steam point 100°C

ice point → $0 = A + B \times 0 + C \times 0$

$\therefore A = 0$

Steam point → $100 = 0 + 100^2 B + C(100^2)$

$\therefore 10000B + 10000C = 100$

$10000(B+C) = 100$

$B + C = 0.01$

While $t_A = 11.6°C$, $t_B = 12.8°C$

$$11.6 = 12.8B \times C \times 12.8$$

$$12.8B + 163.84C = 11.6$$

$$12.8B + 12.8C = 0.01 \quad \times 12.8$$

$$(-) \quad 151.04C = 11.472$$

$$C = \frac{11.472}{151.04}$$

$$C = 0.0759$$

$$B + C = 0.01$$

$$B = 0.01 - 0.0759$$

$$B = +0.0659$$

Equation becomes

$$t_A = 0.0659\, t_B - 0.0759\, t_B^2$$

$$t_B = 36^\circ C$$

$$t_A = +0.0659 \times 36 - 0.0759 \times 36^2$$

$$t_A = +122^\circ C$$

first thermometer reading is 122°C

2d. Compare Work energy with heat energy.

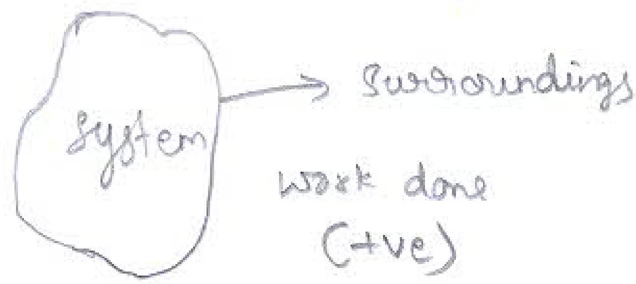
Ans: <u>Work</u>

Work is a transiant quantity which only appears at the boundry while a change of state is taking place within a system.

<u>Sign Conversion for work</u>

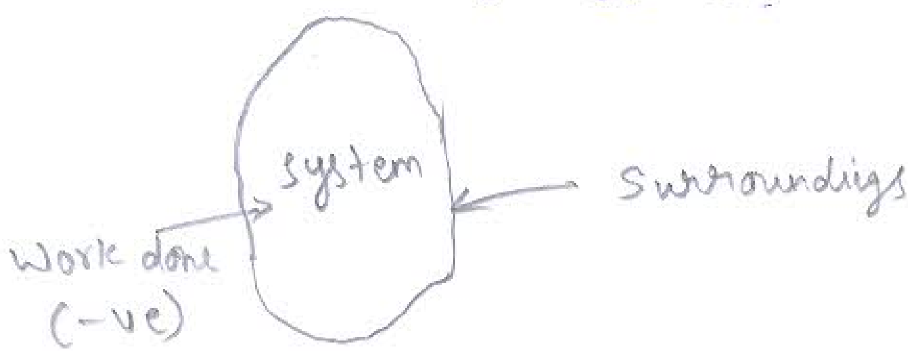
① Work done by the system on the surroundings.

<u>for eg</u>: Expansion of fluid pushing a piston outwards then the work is said to be positive.



② Work done on the system by the surroundings.

<u>for eg</u>: When a force is applied on the piston to compress to it then the work is said to be negative. Unit of work is ~~said to be~~ N-m (or) Joules.



<u>Heat energy</u>

Heat is defined as the form of energy, that is transferred across the boundry by virtue of its temp^-1 difference.

Heat is a transient quantity which only appears at the boundry while a change is taking place within the system. Heat is something which appears at the

When a system changes its state due to difference in temp^n b/w the System & its Surroundings.

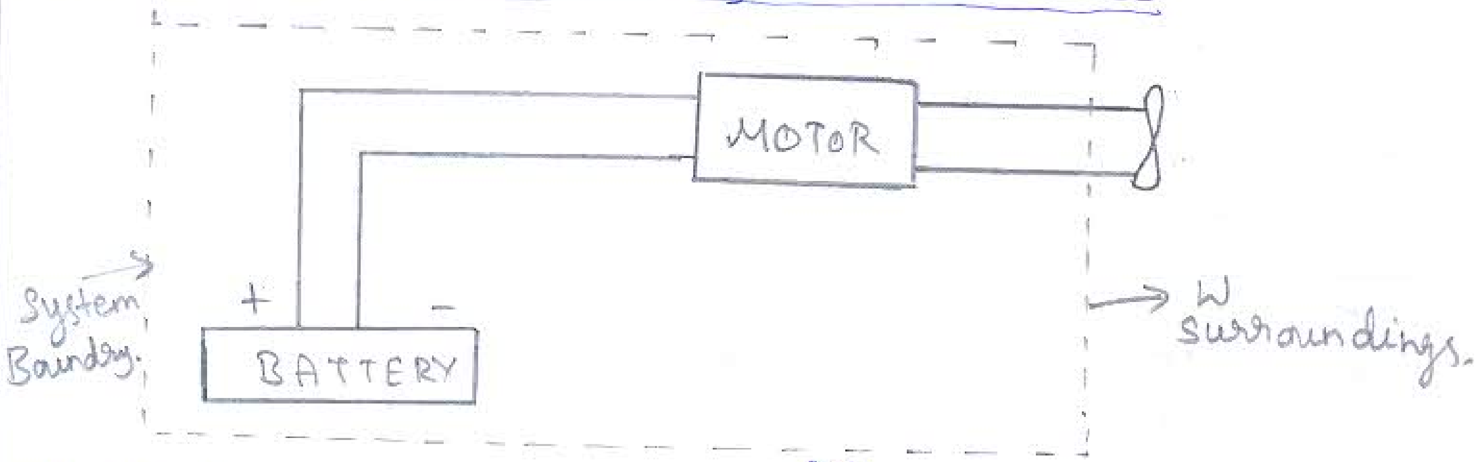
Heat is not conserved quantity & is not a property of the System. Heat is denoted by 'Q'. The S.I unit of heat is KJ (or) KN-m.

Sine Convention of heat

Heat rejected by the system is positive (+ve)
Heat rejected by the system is Negative (-ve).

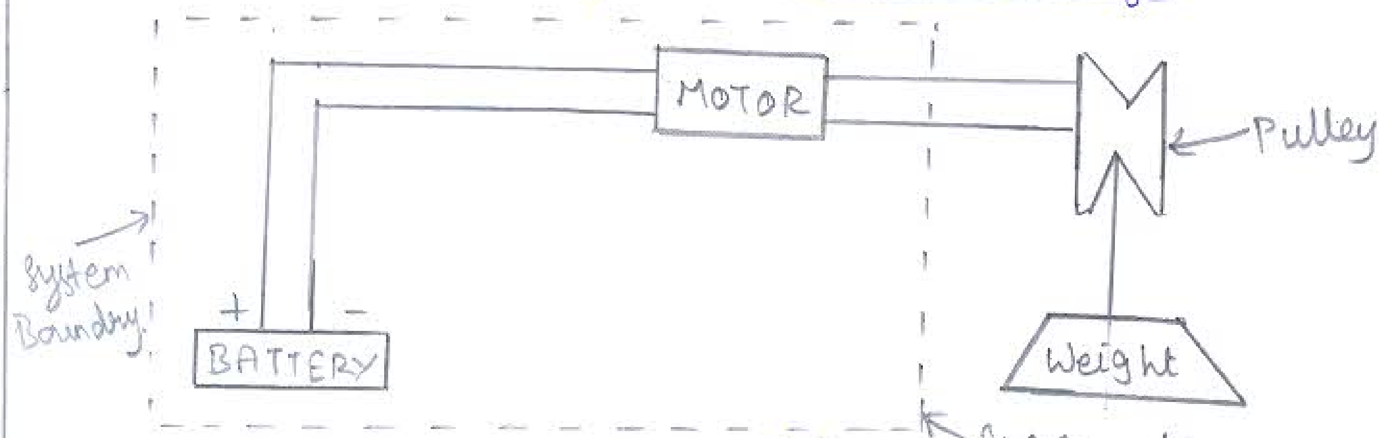
3a) Define the work with respect to mechanics and thermodynamics.

Ans: Work done according to mechanics



(a)

Work done according to the surroundings



(b)

In mechanics work is defined as a product of a force & distance moved in the direction of the force.

$\omega = f \times s$ where, f = force.
s = distance moved.

It is also called as Mechanical one.

In thermodynamics work transfer is considered as occuring b/w the system & surroundings.

The work is said to be done by system if the soul effect on things external to the system could be reduced to raising the weight. It can be represented as follows.

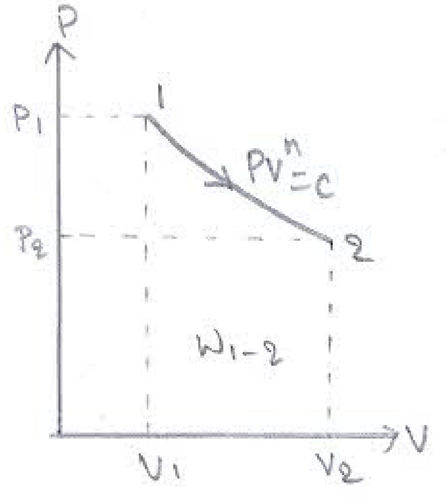
In the fig (a) the motor drives a fan. The

System is doing work upon the surroundings. When the fan is replaced by a pulley & weight as in fig(b). The weights may be raised with the pulley driven by the motor. The soul effect on things external to the system is thus raising of a weight.

Work is a transiant quantity which only appears at the boundry while a change of state is taking place within a system.

(3b) Define a work done equation for polytrophic process. Show the process on PV

Ans:



W.K.T

$$W_{1-2} = \int_{V_1}^{V_2} P\,dV$$

$$PV^n = P_1V_1^n = P_2V_2^n = C$$

$$PV^n = P_1V_1^n$$

$$P = \frac{P_1V_1^n}{V^n}$$

$$W_{1-2} = \int_{V_1}^{V_2} \frac{P_1V_1^n}{V^n}\,dV$$

$$W_{1-2} = P_1V_1^n \int_{V_1}^{V_2} \frac{dV}{V^n}$$

$$W_{1-2} = P_1V_1^n \left[\frac{V^{-n+1}}{-n+1}\right]_1^2$$

$$W_{1-2} = \frac{P_1V_1^n}{1-n}\left[V_2^{-n+1} - V_1^{-n+1}\right]$$

$$W_{1-2} = \frac{P_1V_1^n \times V_2^{-n+1} - P_1V_1^n \times V^{-n+1}}{1-n}$$

$\because P_1V_1^n = P_2V_2^n$

$P_2 = \frac{P_1V_1^n}{V_2^n}$

$$W_{1-2} = \frac{P_2V_2^n \times V_2^{-n+1} - P_1V_1^n \times V_1^{-n+1}}{1-n}$$

$$W_{1-2} = \frac{P_2V_2 - P_1V_1}{1-n}$$

$$W_{1-2} = \frac{mRT_2 - mRT_1}{1-n}$$

$$\boxed{W_{1-2} = \frac{mR[T_2 - T_1]}{1-n}}$$

(3c) A fluid is heated reversibly at constant pressure of 1.013 bar until it has a sp volume of $0.1 m^3/kg$. it is then compressed reversibly according to a law $PV=C$ to a pressure of 4.2 bar, then allowed to expand compressed reversibly according to a law $PV^{1.3}=C$ to the initial conditions. The work done constant pressure process is 515 N-m & the mass of the fluid present is 0.2 kg. Calculate the net work done on (or) by the fluid in the process & sketch the cycle on P-V diagram.