3. WORK & HEAT

THERMODYNAMIC ANALYSIS OF WORK:

General Definition of Work	$Work = F\ dx$	F= Force	dx = Distance

Thermodynamic Work: External to the system can be reduced to raising of weights. In Actual, Weight may be raised may not be raised. But the effect is equivalent to raising of weight.

Boundary Phenomena	It's Transit.
Transient Form of energy	If no Energy crosses the boundary no work.

CLOSED SYSTEM WORK/ MOVING BOUNDARY WORK/ DISPLACEMENT WORK:

Note:		$W_{1-2}(in\ \mathbf{J}) = \int_1^2 P\ dV$	It's Derived from piston movement in cylinder.
Closed System	Reversible Process		Where, P =Pressure inside cylinder, $V =$ volume of the Cylinder.

Work Done by The System	**Work Done on The System**
$+ve$ (Expansion Process)	$-ve$ (Compression Process)

WORK TRANSFER IN VARIOUS NON-FLOW PROCESSES:

Processes	**Work Done/ Work Transfer**		
Constant Volume or Isochoric or Isometric	0		
Constant Pressure or Isobaric or Isopiestic	$P(V_2 - V_1)$	$mR(T_2 - T_1)$	
Constant Temperature or Isothermal	$P_iV_i \ln\left(\frac{V_2}{V_1}\right)$	$P_iV_i \ln\left(\frac{P_1}{P_2}\right)$	$P_iV_i = mRT_i$
Adiabatic Process or Polytropic Process	$\frac{P_1V_1 - P_2V_2}{n-1}$	$\frac{mR(T_1 - T_2)}{n-1}$	$\frac{mRT_1}{n-1}\left(1 - \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}}\right)$

Isochore: Constant Volume line in P-V Diagram. **Isobar:** Constant Pressure line in P-V Diagram.	**Isotherm:** Constant Temperature line in P-V Diagram.

Closed System Work Transfer on P-V Diagram: Area under the process when projected to volume axis represents closed system reversible work transfer.

$W_1 \neq W_2$ (Depends on the path)	Work transfer is path function	$\int_1^2 W = W_{1-2}$
Work transfer is inexact differential.	It denoted by $đW$ or δW	
Work transfer is not property.		

TYPES OF WORK TRANSFERS:

Moving Boundary Work	**Electrical Work Transfer**	**Paddle Wheel Work Transfer**	**Spring Work Transfer**
$W_{1-2}(in\ \mathbf{J}) = \int_1^2 P\ dV$	$W_{ele}(in\ \mathbf{W}) = VI$ $W_{ele}(in\ \mathbf{J}) = VIt$	$W_{pad}(in\ \mathbf{W}) = T \times \omega = 2\pi NT$ $W_{pad}(in\ \mathbf{J}) = T \times \omega = 2\pi NTt$ Where, N =RPM or No. of Revolution	$W_{Sp}(in\ \mathbf{J}) = \frac{1}{2}[x_2^2 - x_1^2]$

Net Work Transfer: $W_{net} = \sum W_i$

Net Work Transfer on P-V diagram: The Area Enclosed in the cycle on P-V diagram represents Net Work Transfer.

SPECIAL CASE OF WORK TRANSFERS:

Free Expansion Process	**Paddle Wheel Work**	**Work Transfer in increasing P&V**
It's gas expansion against vacuum. No Resistance from vacuum. $W_{net} = 0$, But $P\ dV \neq 0$ It's irreversible process.	It's Paddle Wheel work in closed rigid chamber filled with fluid. $W_{net} \neq 0$, But $P\ dV = 0$. It's irreversible process.	It's arrangement of spring-loaded Piston Cylinder Arrangement. Here, Spring is liner. hence, PV diagram is like linear curve because of increasing P&V. $Area = W_{net} = (1/2)\,(P_1 + P_2)(V_2 - V_1)$

THERMODYNAMIC ANALYSIS OF HEAT:

Heat: Heat is a form of energy which crosses the boundary due to temperature difference.

Boundary Phenomena	It's Transit.
Transient Form of energy.	No ΔT across the boundary no Heat Flow.
Heat Supplied to The System	**Heat Supplied by The System**
$+ve$ (Expansion Process)	$-ve$ (Compression Process)

Generalised Equation of Heat Transfer: $Q = mc\Delta T$	**Specific Heats of Substances:** $C = Q/m\Delta T$

Generalised form of heat transfer can be applied to Solid, Gas & Liquid.

Specific Heat $(\boldsymbol{c})(\boldsymbol{in\ J/kg\ K\ or\ \ J/kg\ °C})$**:**

It's Amount of heat required to raise unit mass of substance through one-degree temperature difference.

c_P = Specific Heat at constant Pressure	c_P = Specific Heat at constant Temperature
For Gases: $c_P \geq c_V$	**For Solid & Liquid:** $c_P \cong c_V \cong c$

Heat Capacity $(\boldsymbol{C})(\boldsymbol{in\ J/K\ or\ \ J/°C})$	$C = cm$

HEAT GENERATION:

Electrical energy directly converts into heat energy (100% conversion). Hence, $Q_{gen} = W_{ele}$

HEAT EXCHANGING PROCESS:

Due to Temperature Difference, Heat Flows from higher energy to low energy region.

DIFFERENCE BETWEEN HEAT & WORK TRANSFER	**SIMILARITIES BETWEEN HEAT & WORK**
It's completely depends on the selection of the boundary. E.g. Arrangement of insulated vessel filed with fluid and putting heater inside.	• Both are Boundary Phenomena. • Both are Transit. • Both are Transient Form of energy. • Both are Path function. • Both are not properties. • Both are inexact differentials.