



# Module 2



## Work and Heat



# We Concentrate On Two Categories Of Heat And Work



➤ Thermodynamic definition of work:

Positive work is done by a system when the **sole effect external** to the system **could be** reduced to the rise of a weight.

➤ Thermodynamic definition of heat:

It is the **energy in transition** between the system and the surroundings by virtue of the difference in temperature.



# Traits of Engineers



- All our efforts are oriented towards how to convert heat to work or vice versa:

Heat to work ➡ Thermal power plant

Work to heat ➡ Refrigeration

- Next, we have to do it in a sustained manner (we can't use fly by night techniques!!)

- We require a combination of processes.

- Sustainability is ensured from a cycle

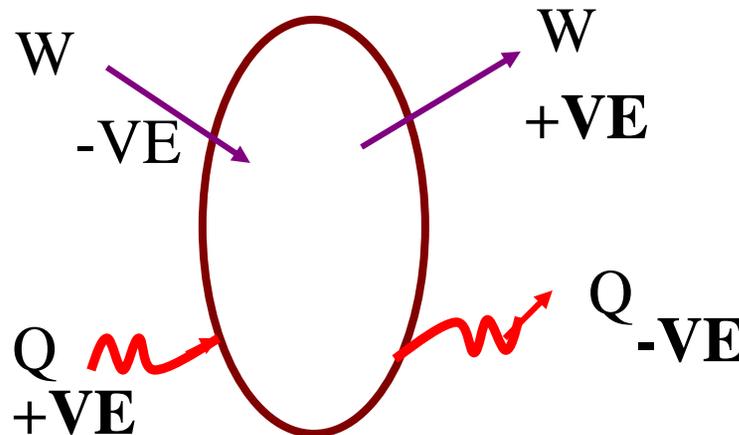
- A system is said to have gone through a cycle if the initial state has been regained after a series of processes



# Sign Conventions



- Work done BY the system is +ve
- Obviously work done ON the system is -ve
- Heat given TO the system is +ve
- Obviously Heat rejected by the system is -ve





# Types of Work Interaction



## Types of work interaction

- Expansion and compression work  
(displacement work)
- Work of a reversible chemical cell
- Work in stretching of a liquid surface
- Work done on elastic solids
- Work of polarization and magnetization



# Notes on Heat



- All temperature changes need not be due to heat alone  
eg: Friction
- All heat interaction need not result in changes in temperature  
eg: condensation or evaporation



# Various Types of Work



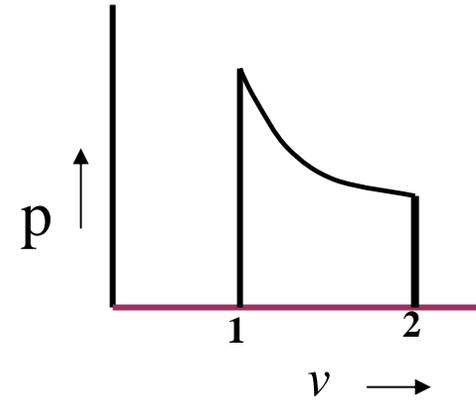
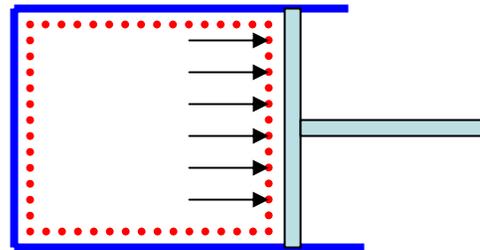
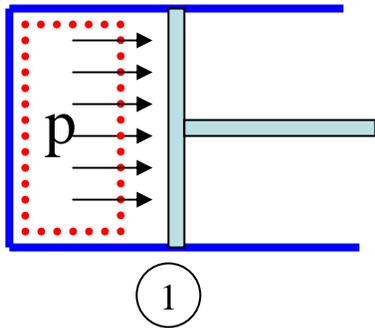
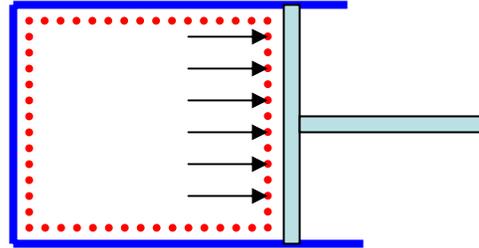
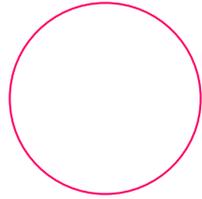
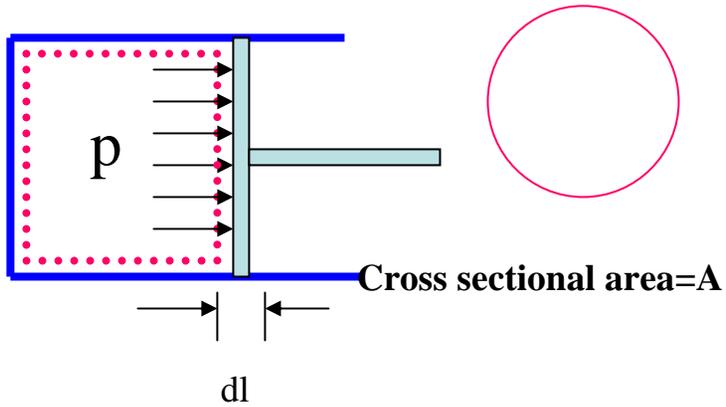
- Displacement work (pdV work)
- Force exerted,  $F = p \cdot A$
- Work done

$$dW = F \cdot dL = p \cdot A \cdot dL = p \cdot dV$$

- If the piston moves through a finite distance say 1-2, Then work done has to be evaluated by integrating  $\delta W = \int p dV$



# Work (Contd...)





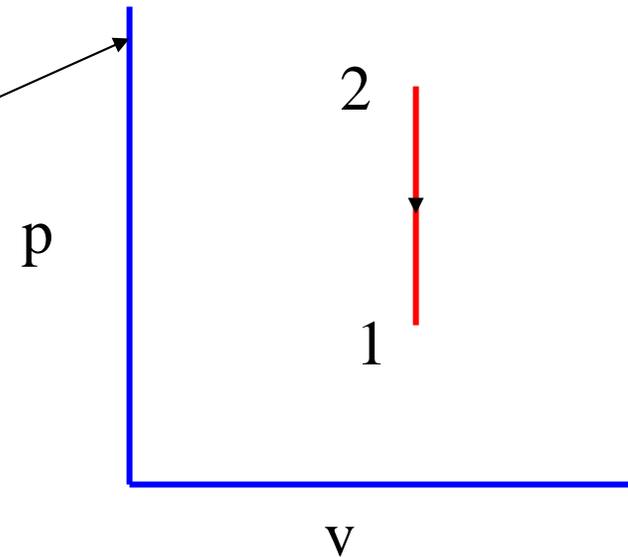
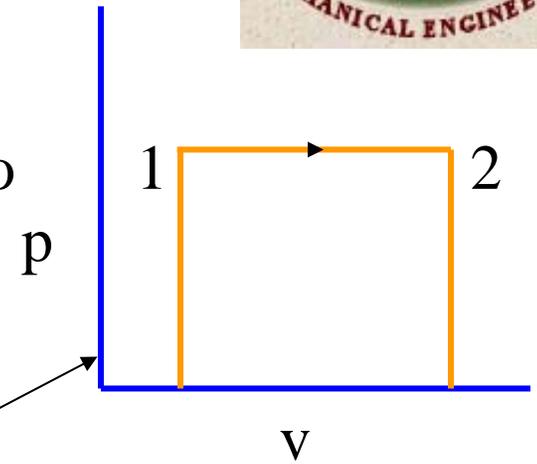
# Discussion on Work Calculation



The system (shown by the dotted line) has gone through a change of state from 1 to 2. We need to know how the pressure and volume change.

## Possibilities:

- Pressure might have remained constant  
or
  - It might have undergone a change as per a relation  $p(V)$   
or
  - The volume might have remained constant
- In general the area under the process on  $p$ - $V$  plane gives the work



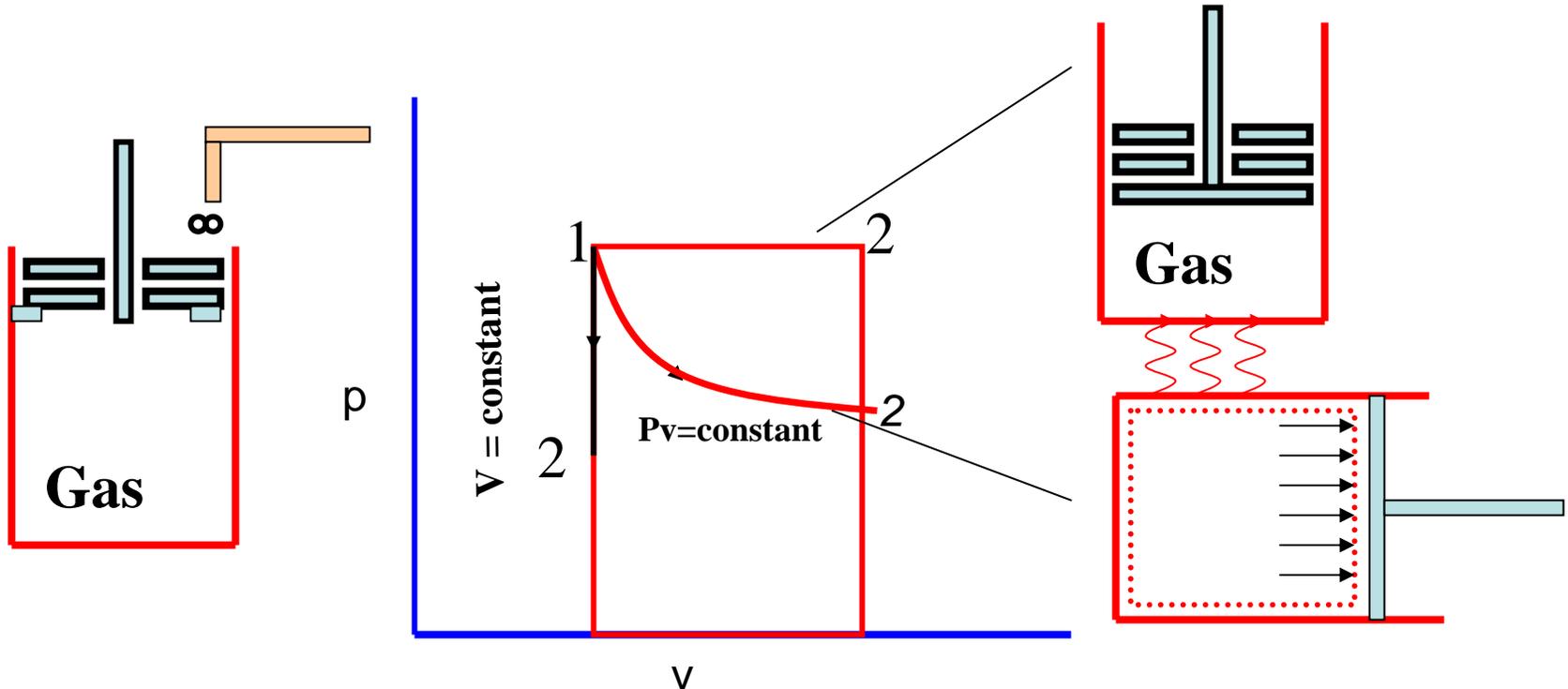


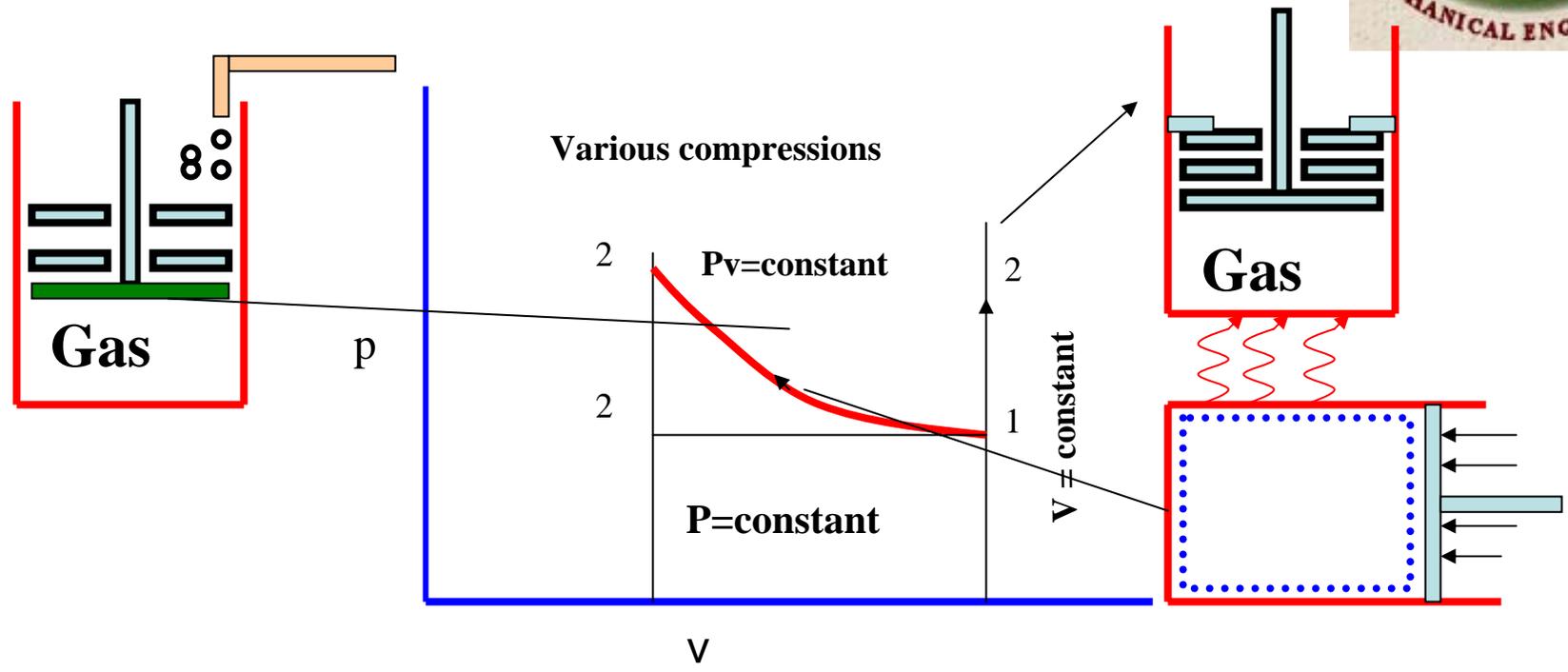
# Other Possible Process



- $p v = \text{constant}$  (it will be a rectangular hyperbola)
- In general  $p v^n = \text{constant}$

**IMPORTANT:** always show the states by numbers/alphabet and indicate the direction.





➤  $n=0$  Constant pressure

$(V_2 > V_1 - \text{expansion})$

➤  $n=1$   $pv = \text{constant}$

$(p_2 < p_1 ; V_2 > V_1 - \text{expansion})$

➤  $n = \infty$  Constant volume

$(p_2 < p_1 - \text{cooling})$



# Others Forms Of Work



## ❖ Stretching of a wire:

Let a wire be stretched by  $dL$  due to an application of a force  $F$

Work is done on the system. Therefore  $dW = -FdL$

## ❖ Electrical Energy:

Flowing in or out is always deemed to be work

$$dW = -EdC = -EIdt$$

## ❖ Work due to stretching of a liquid film due to surface tension:

Let us say a soap film is stretched through an area  $dA$

$$dW = -\sigma dA$$

where  $\sigma$  is the surface tension.