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:
  
  \[ \text{Heat to work} \rightarrow \text{Thermal power plant} \]

  \[ \text{Work to heat} \rightarrow \text{Refrigeration} \]

- 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
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

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

**IMPORTANT:** always show the states by numbers/alphabet and indicate the direction.
- $n= 0$ Constant pressure  \( (V_2 > V_1 \text{ - expansion}) \)
- $n=1$ \( pV \) 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.