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ME 209
Basic Thermodynamics (Lecture-3)

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First Law - I

Adiabatic process

- By definition, adiabatic process is that which involves only work interaction between system and surroundings
- Joule performed several experiments and showed that W_{ad} is a constant when a adiabatic system is taken from a given state to another given state..

$$W_{ad}\Big|_1^2 = \text{cons tan t}$$

- This is one form of first law (Caratheodory), the other common form will be seen soon

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First Law - I

- If we can define a variable φ such that,

$$W_{ad}\Big| = \Delta\varphi$$

- Then φ qualifies to be a property. Usually, this is denoted by E and is called **Energy.** Thus,

$$W_{ad}\Big| = -\Delta E$$

- The negative sign is added to have consistency of sign convention
- Note that work done on the system (which is –ve) will increase the energy of the system

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Energy

Forms of Energy

Energy	**The Associated Potential**
Potential	Energy possessed by virtue of elevation from earth
Kinetic	Energy possessed by virtue of motion
Internal	Energy Possessed by virtue of • Elasticity • Chemical Composition • Temperature

$$\Delta E = \Delta PE + \Delta KE + \Delta IE$$

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Internal Energy

- Internal Energy possessed by virtue of Temperature is called is usually denoted by U
- In this course, Unless explicitly mentioned, $\Delta IE = \Delta U$
- Since energy has the same unit as work, it will be expressed in Joules
- Some people still use Calories

  1 Calorie = 4.18 J
- Specific internal energy is denoted with **u,** and has the units J/kg

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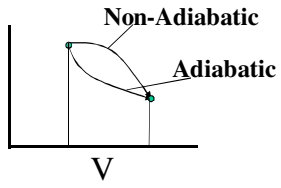
Heat Interaction - I

- For adiabatic Process

$$W_{ad}\Big|_1^2 = -\Delta E$$

- For Non-adiabatic process

$$W_{nad}\Big|_1^2 \neq -\Delta E$$



- Let

$$W_{nad}\Big|_1^2 - W_{ad}\Big|_1^2 = Q_{nad}\Big|_1^2 \quad \Rightarrow W_{nad}\Big|_1^2 + \Delta E = Q_{nad}\Big|_1^2$$

$$\Rightarrow W + \Delta E = Q$$

Or $\Delta E = dQ - dW$ **For an elemental process**

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Heat Interaction - II

The following Observations/Comments may be noted

- Q is also is energy in transit and occurs due to temperature difference between system and surroundings. It is called Heat. Will be expressed in Joules
- The highlighted equation in previous slide is the **First Law**
- In adiabatic process Q = 0
- For consistency of first law, Q into the system is positive for the system
- Only E can be stored and not Q or W

Forms of First Law for a Closed System

- We had seen that the first law for a process is

  dE = dQ-dW
- If the process were a cycle, then

$$0 = \oint dQ - \oint dW$$

- The same law can be written in the rate form as

$$\frac{dE}{dt} = \dot{E} = \dot{Q} - \dot{W}$$