TOPIC I - Systems and Energy

Systems and Energy Transfer (Lecture 2/3)

Contents

5. System and its properties (some definitions)
6. Work and heat
7. Energy conservation

5. Properties of System

Closed system – space containing fluid with boundary between fluid and surroundings

Six properties – include T, p, ρ. (later u, h, s)

The **state postulate** - 'simple' equilibrium system is specified for two independent properties, e.g. {p, T} $\rightarrow$ {ρ, u, h, s}.

Pressure (in bar) - force per unit area

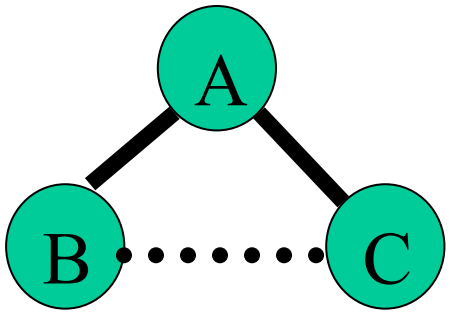
- **isotropic** - equal in all directions.
- **gauge pressure** vs **absolute pressure**
- absolute: p = 0 $\rightarrow$ vacuum
- gauge has **datum** of standard atmospheric pressure, 1 atm = 1.013 bar

Systems and Energy Transfer (Lecture 2/3)

Temperature can have **two-point** scale – e.g. Celcius (datum ≅ ice point)

Thermodynamic scale (later in course) – e.g. Kelvin. No dependence on particular substance.

The zeroth law – equilibriums AB and AC = equilibrium BC



Implication – two objects at the same temperature are at thermal equilibrium.

Systems and Energy Transfer (Lecture 2/3)

Process_transforms system from one equilibrium state to another - **path** charted by **process diagram** (e.g. p-versus-V)

quasi-equilibrium process – v. close to equilibrium along path

equilibrium - all driving forces acting on system are balanced

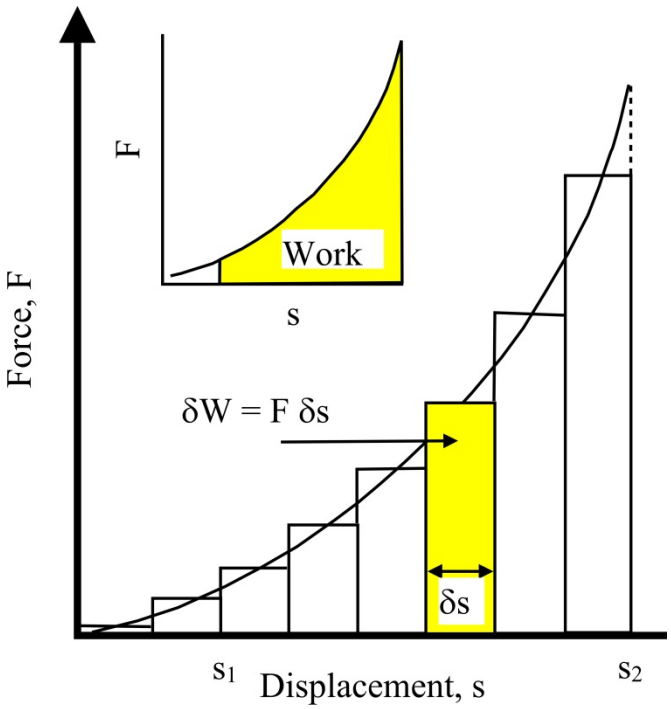
6 Work and Heat

Not system properties → energy in transit.

Work definition – product of force and displacement

$$W = \pm F\, s \qquad [3]$$

If (e.g. spring) F(s) is not constant



$$\delta W = \pm F(s)\,\delta s \qquad (3b)$$

or

$$W = \pm \int_1^2 F(s)\, ds \qquad (3c)$$

Piston cylinder - $\delta W = \pm p\,\delta V$ (6)

6 Work and Heat (continued)

Heat transferred by conduction, convection and radiation.

For our purposes, treat combustion as a means of heat addition.

$$Q = m_f \, q_{cal} \qquad [7]$$

7 Energy Conservation

Stationary system - any change in kinetic or potential energy is small.

Internal energy U: combination of all forms of microscopic energy in a fluid.

Systems and Energy Transfer (Lecture 2/3)

For a closed, stationary system energy conservation yields the Non Flow Energy Equation (NFEE)

$$U_2 - U_1 = Q + W$$

$$\Delta U = Q + W$$

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Systems and Energy Transfer (Lecture 2/3)

Conclusions

Theoretical basis; applicable throughout course

Definitions and terms – system, process, equilibrium

Subtle aspects of pressure, temperature – consider datum

Work and heat – energy in transit. Work defined as product of force and displacement

Internal Energy – system property