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Thermodynamic Work

Sign Convention

Work done **on** a system is considered to be **positive** because it increases the internal energy and **work** done **by** a system is considered to be **negative** because it decreases the internal energy of the system. Other sign conventions are used in other text books.

Definition of Work

The work W done by a force F when the point of application of the forced undergoes a displacement dx from x_1 to x_2 is defined as

$$W_{12} = \int_{x_1}^{x_2} F\, dx$$

Work Done on a Simple Compressible System

Consider a simple compressible system defined by a simple compressible substance confined in the volume of a piston-cylinder. The volume has a circular cross-section of area A and its length is L. The pressure in the volume is P acting over all boundaries. The force at the piston surface is $F = P\,A$. If the piston is displaced a distance dx, the volume increase is $dV = A\,dx$ and the work done by the system during the expansion process $V_1 \le V \le V_2$

$$W_{12} = -\int_{V_1}^{V_2} P\, dV$$

The negative sign is required to ensure that the sign convention is satisfied. The process can be shown on a $P - V$ diagram. The integral is the area under the $P - V$ curve between the states 1 and 2. Since many different paths can join the end states 1 and 2, the amount of work involved in each case is a function of the path and the end states. For this reason work is called a path function.

Work is energy which crosses (enters or leaves) the system boundaries when the system undergoes changes of state. Systems never possess work.