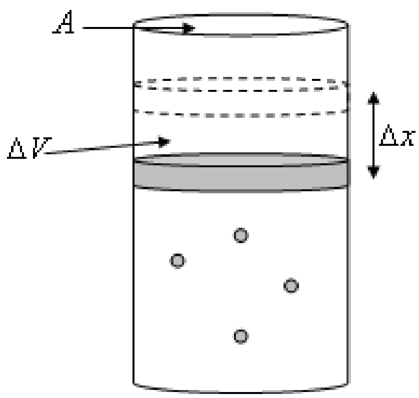
Work is an energy transfer between a system and its surroundings that is a result of organized motion in the surroundings. You can increase the internal energy of a wood block by rubbing it vigorously. You can increase the internal energy of a glass of water by stirring it rapidly. You can decrease the internal energy of a gas by letting it expand against some external pressure applied by a piston. In each example, the surroundings (rubbing cloth, stirrer, piston) are systems consisting of many particles that are all undergoing an organized motion as a whole to facilitate the energy transfer.

The system consisting of an ideal gas enclosed in a container with a moveable piston is commonly used to illustrate many of the concepts of thermodynamics. Let's look at it in more detail. Suppose the gas is allowed to expand slowly in such a way that at any point in the process the pressure is well defined and the system can be thought of as being close to equilibrium every step of the way. Such a process is said to be quasi-static. Since the gas is always in equilibrium, the gas pressure is always equal to the external pressure exerted by the piston, and the work done by the gas on the piston is just the negative of the work done on the gas by the piston. Let us further assume that while the gas expands, the pressure P remains constant, an isobaric process. This could be achieved by immersing the gas container in consecutively warmer water baths. After a time, the piston with cross-sectional area A would have expanded a distance Δx.

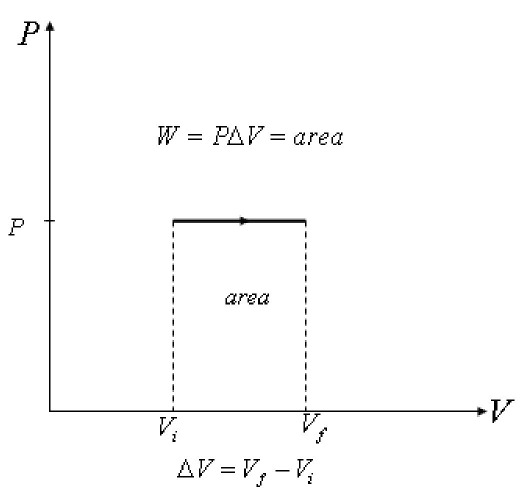


Since $P = \frac{F}{A}$, the force that the gas exerts on the piston is given by $F = PA$. Then the work done by the gas during the expansion is given by:

$$W_{by} = F\Delta x = PA\Delta x = P\Delta V$$

.

It is a simple matter to display this process on a graph that plots pressure versus volume with an arrow to show the sequence of the process.



Note that the work done by the gas is just the area under the "curve," i.e., between the graph and the V-axis. By convention, this area is positive for positive work done *by* the gas, as in this example. For our quasi-static process, this would correspond to negative work done *on* the gas. The distinction between work done on the gas and work done by the gas is one that is often made on the AP Exam, so a teacher should make this distinction clear at this point. As long as the process is quasi-static so that the pressure is well defined at each step of the way, the area under the P-V curve will always be the work done by the gas during the process. This follows from the fact that any curve can be approximated by a series of steps over which the pressure is constant. In the limit of infinitesimal steps, you get the exact answer, the sum of all the infinitesimal areas, the area under the curve.