

## Work and Heat

### Skills to Develop

- Compare and contrast work and heat

In physics, **work** is defined as motion over some distance against an opposing force. (A force is an acceleration multiplied by a mass.) For instance, lifting an object against the force of gravity. The amount of work is the opposing force multiplied by the distance the object moved. The amount of work done in lifting an object is the force of gravity (the mass of the object times the acceleration of gravity) times the height you lifted it. There are lots of other ways systems can do work: a stretched spring can expand and lift a weight, a battery or burning gas can drive a motor and move a car up hill or forward against friction and wind.

In chemistry, work is often defined in terms of a change in volume against a pressure. (Pressure is force divided by area, so convince yourself that  $P \times V$  has the same units as  $F \times d$ .) For instance, atmospheric pressure is constant at  $\sim 1$  atm. If you have a sample of gas at higher pressure, and you let it come to mechanical equilibrium with the atmosphere, it will expand to some new volume. The work it does expanding against atmospheric pressure is  $(1 \text{ atm})(\Delta V)$ , where  $\Delta V$  is (final volume - initial volume). In general, the work done by gases expanding is called  $pV$  work, and is

$$w = \int p dV \quad (1)$$

For our purposes, we won't be dealing with integrals, so we won't calculate work this way unless the pressure is constant, in which case we can use the simpler equation

$$w = -P\Delta V \quad (2)$$

where  $P$  is the constant pressure and  $\Delta V$  is the change in volume of the system. The negative sign accounts for the fact that if the system is compressed,  $\Delta V$  is negative, and work was done to the system, so  $w$  is positive.

There are several different definitions of heat. For instance, we can heat water to make tea, or enjoy the heat when we enter a warm room in the winter. In thermodynamics the meaning of heat is more precise: it is a process, a way energy can move. **Heat** is energy that moves from a hot object to a cold object. When heat leaves the system, it has a negative sign, and when it enters the system, it has a positive sign.

Heat and work are the ways that energy can move between objects. When you think about the molecules, the difference between work and heat is very simple. Work involves an orderly motion of molecules, like all the molecules in an object moving the same direction. Heat involves disorderly or random motions of molecules.

### Outside Links

- [Khan Academy: Introduction to Work and Energy](#) (9 min)
- [Khan Academy: Work and Energy \(Part 2\)](#) (9 min)
- [Khan Academy: Conservation of Energy](#) (10 min)
- [Khan Academy: Work from Expansion](#) (13 min)

### Contributors and Attributions

- [Emily V Eames](#) (City College of San Francisco)

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