7.5: Power

By “power” we mean the rate at which work is done, which is to say, the rate at which energy is taken in, or given out, or converted from one form to another. The SI unit of power is the watt (W), which is equal to 1 J/s. The average power going into or coming out of a system by mechanical means, that is to say, through the action of a force applied at a point undergoing a displacement Δx, will be

$$P_{av} = \frac{\Delta E}{\Delta t} = \frac{W}{\Delta t} = F\frac{\Delta x}{\Delta t} \tag{7.5.1}$$

assuming the force is constant. Note that in the limit when Δt goes to zero, this gives us the instantaneous power associated with the force F as

$$P = Fv \tag{7.5.2}$$

where v is the (instantaneous) velocity of the point of application of the force. This one-dimensional result generalizes to three dimensions as

$$P = \vec{F} \cdot \vec{v} \tag{7.5.3}$$

using again the dot product notation.

An important goal of this chapter has been to develop a set of tools that you may use to find out where power is spent, and how much: in any practical situation, which systems are giving energy and which are taking it in, what forms of energy conversion are taking place, and where and through which means are the exchanges and conversions happening. These are extremely important practical questions; the problems and exercises that you will see here will give you a feel for the variety of situations that can already be analyzed by this “systems-based” approach, but in a way they will still do little more than scratch the surface.