SECTION 2

# The First Law of Thermodynamics

### SECTION OBJECTIVES

- **Illustrate how the first law of thermodynamics is a statement of energy conservation.**
- **Calculate heat, work, and the change in internal energy by applying the first law of thermodynamics.**
- **Apply the first law of thermodynamics to describe cyclic processes.**

## ENERGY CONSERVATION

Imagine a roller coaster that operates without friction. The car is raised against gravitational force by work. Once the car is freely moving, it will have a certain kinetic energy ($KE$) and a certain potential energy ($PE$). Because there is no friction, the mechanical energy ($KE + PE$) remains constant throughout the ride's duration. Thus, when the car is at the top of the rise, it moves relatively slowly (larger $PE$ + smaller $KE$). At lower points in the track, the car has less potential energy and so moves more quickly (smaller $PE$ + larger $KE$).

If friction is taken into account, mechanical energy is no longer conserved, as shown in **Figure 7.** A steady decrease in the car's total mechanical energy occurs because of work being done against the friction between the car's axles and its bearings and between the car's wheels and the coaster track. Mechanical energy is transferred to the atoms and molecules throughout the entire roller coaster (both the car and the track). Thus, the roller coaster's internal energy increases by an amount equal to the decrease in the mechanical energy. Most of this energy is then gradually dissipated to the air surrounding the roller coaster as heat. If the internal energy for the roller coaster (the system) and the energy dissipated to the surrounding air (the environment) are taken into account, then the total energy will be constant.


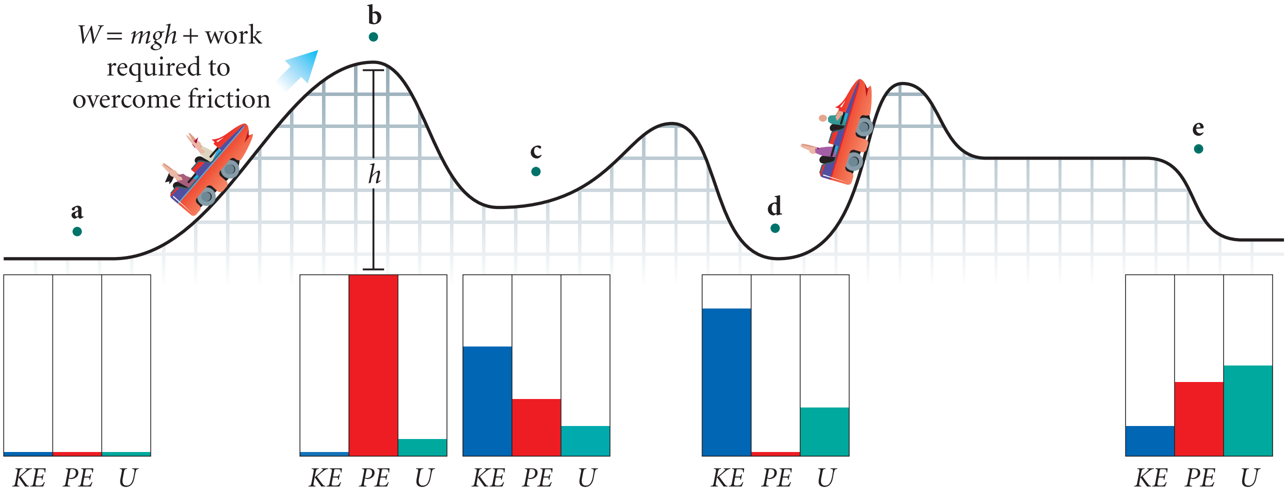


**Figure 7**
In the presence of friction, the internal energy ($U$) of the roller coaster increases as $KE + PE$ decreases.