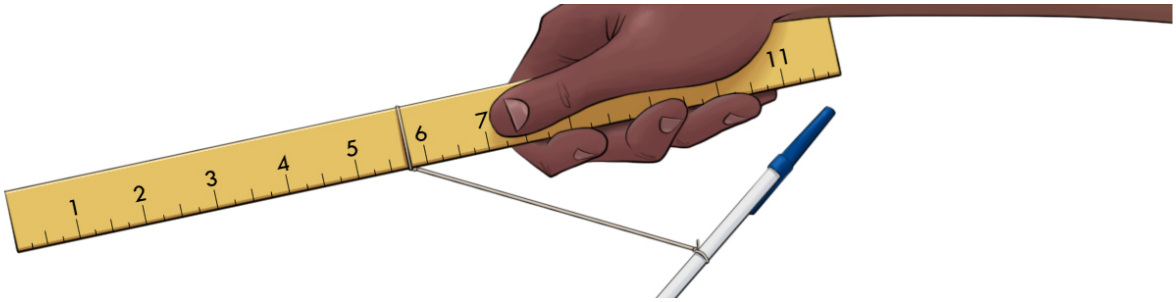


# 3.4: Conservation

*Solve conservation of energy problems, including situations where energy is dissipated.*

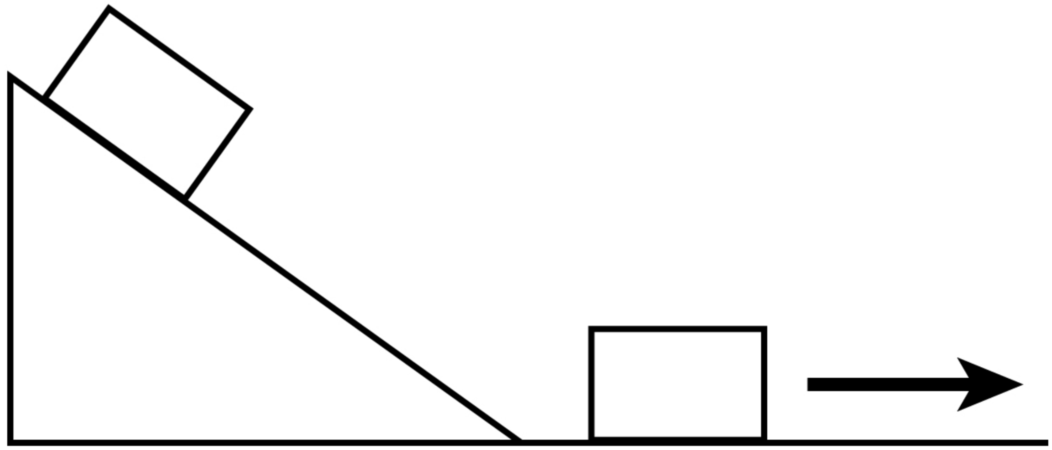
## Conservation of Energy (with no loss of mechanical energy)

You have just learned the formulas for calculating three different types of mechanical energy. You also learned that energy can be defined as a conserved quantity that an object possesses that has the capability to produce change. Now you are ready to look at how energy is conserved. Energy can be transformed from one form to another. The law of conservation of energy states that energy is neither created nor destroyed when it changes form. Thus, the amount of energy at the beginning will always equal the amount of energy at the end!

The energy bar graphs will be a very useful tool to help you identify the energy in a given system. Recall that the total mechanical energy in a system is simply the sum of its gravitational potential energy, kinetic energy, and elastic potential energy. To identify how energy changes in a system, we can draw an energy bar graph representing the initial energy of the system and another energy bar graph representing the final energy of the system. Based on the bar graphs, you can create a formula where the initial energy is equal to the final energy. If you have forgotten the formulas for calculating energy, refer to the previous objective. Once your formula is set up, plug in the given information and solve. Let’s look at an example:

### Example 3.10:

A block is dropped from a frictionless hill that is 5 m high. How fast will it be moving at the bottom of the hill if no mechanical energy is lost?



Show Answer

## Conservation of Energy (with some loss of mechanical energy)

The law of conservation of energy states that energy is neither created nor destroyed when it changes form. In the example above we looked at a case where there was no “loss” of mechanical energy. Thus, the beginning total of the KE, GPE, and EPE in the system initially will equal the total of the KE, GPE, and EPE in the end. In the real world, this is not always the case. Some of the initial energy is often changed into other forms of nonmechanical energy. This is usually in the form of heat. This heat energy dissipates (spreads out) into the environment and is referred to as dissipated energy (E-diss).

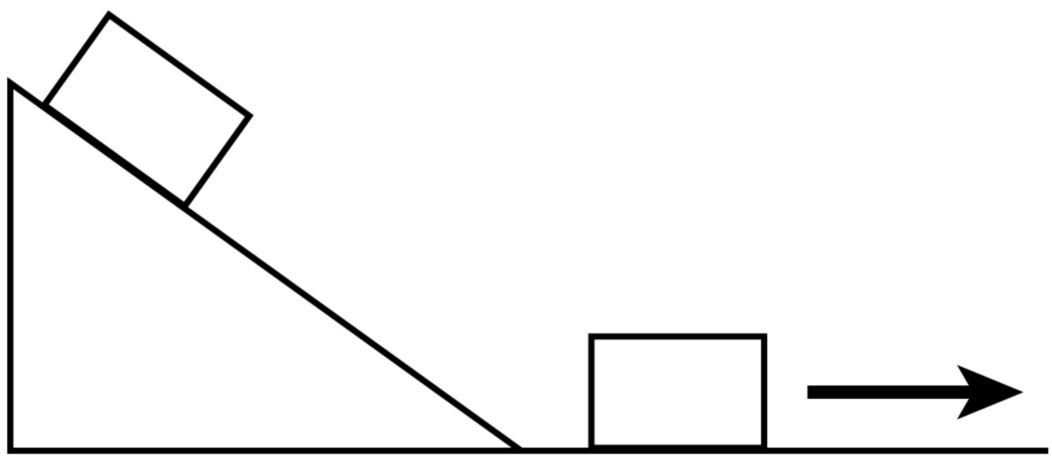
Fig. 3.12: Energy that is converted to heat and lost in the environment (like a hot engine) is called dissipated energy.

This dissipated energy can actually be calculated in many cases. To find the amount of dissipated energy, there are two different methods. The first way to calculate the amount of dissipated energy is to find the difference between the initial energy and the final energy. This difference would be the amount of dissipated energy. For example, if a system began with 100 J of mechanical energy and ended with 75 J of mechanical energy, you would know that 25 J of energy had been dissipated (simply 100 − 75).

The second way to calculate the amount of dissipated energy is to find the work done by dissipative forces. The force that usually causes energy to dissipate is the force of friction. Taking the force of friction times the distance traveled equals the work done by friction, which also equals the amount of dissipated energy. So now we can add a column to our energy bar graphs in the final energy to include dissipated energy. Let's take a look at a couple of examples.

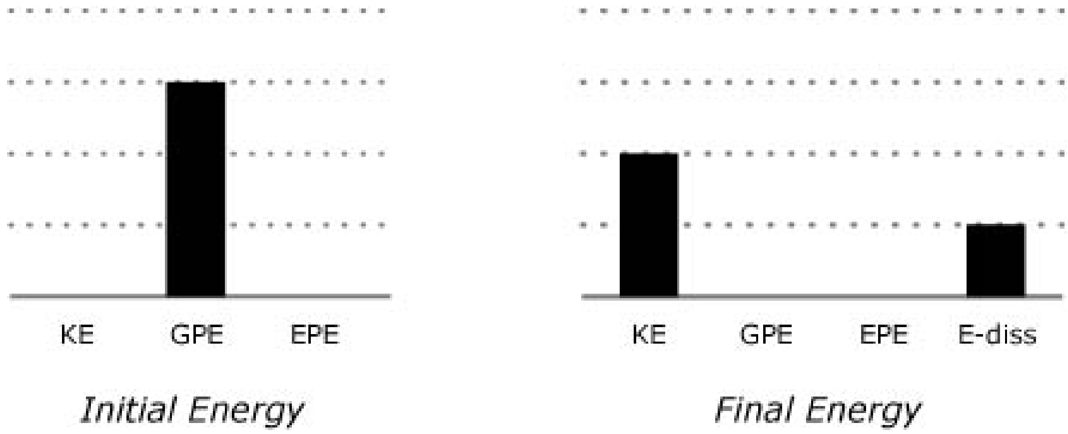
## Example 3.11:

Suppose a 0.5 kg. block at the top of a 20 m hill is allowed to slide downhill. It reaches the bottom with a speed of 16 m/s. How much energy was dissipated?



Hide Answer

Step 1: Draw the initial and final energy bar graphs. Make sure the total final energy equals the total initial energy (when you include dissipated energy).




Step 2: Write energy equations, substitute, and solve:

- $E_{initial} = E_{final}$
- $GPE_{initial} = KE_{final}$ + E-diss
- $mgh = \frac{1}{2} mv^2$ + E-diss
- $(0.5)(10)(20) = \frac{1}{2} (0.5)(16^2)$ + E-diss
- $100 = 64$ + E-diss
- **36 J = E-diss**

## Example 3.12:

A 2 kg book slid at 12 m/s across the floor. If the floor exerts a frictional force of 30 N, how far will the book slide before coming to rest?

Hide Answer

Step 1: Draw the initial and final energy bar graphs. Make sure the total final energy equals the total initial energy. (In this case, the initial energy is all kinetic, and the final energy is all dissipated.)


Step 2: Write energy equations, substitute, and solve:

- $E_{initial} = E_{final}$
- $KE_{initial}$ = E-diss
- $\frac{1}{2} mv^2 = Ff\ d$
- $(0.5)(2)(122) = (30)(d)$

- 144 = (30)(d)
- **4.8 m = d**

As you think about problems like these, remember that you must account for all the energy going into the problem as you look to see where it went. The closer you look the more you will recognize that wasted energy is a product of almost every energy system.