2.1: Where Are We Headed?

This page is a draft and is under active development.

Overview

In this second chapter we continue to work with the *Energy-Interaction Model*. We add all kinds of *mechanical* interactions to the thermal interactions we treated in Chapter 1. The term term "mechanical" is typically used to imply everything other than thermal. Since the *Energy-Interaction Model* literally applies to every kind of *interaction* that scientists have ever encountered, we will be just scratching the surface of the realm of applications of this powerful model. We will, however, devote some attention to one area of application that occurs frequently in many phenomena–all kinds of things vibrate, from atoms and molecules to bridges and skyscrapers; that is, they move back and forth or oscillate in very predictable ways. A fundamental understanding of *vibrational* (or *oscillatory* as it is often called) motion is very useful. Therefore, we introduce the *Intro Spring-Mass Oscillator Model* in this chapter as an application of the *Energy-Interaction Model*. The *Intro Spring-Mass Oscillator Model* will also play an important role in Chapter 3 when we develop particle models of matter.

In Chapter 2 we continue our focus on interacting systems. We intentionally focus on the systems as they exist *before* the interaction and then immediately *following* the interaction; we stay away from the *details* of what happens during the interaction itself. This is a very general and a very powerful approach. We saw in Chapter 1 that energy transfers are fundamentally related to interactions.

When one physical system interacts with another, or when parts of the same physical system interact, we were able to identify different *types of energy* that either increased or decreased. If the physical system is closed, i.e., we have included all of the energies that change during the interaction, then energy conservation tells us that the total of all the increases equals the total of all the decreases. If the physical system is open, then the net change in all of the energies of the system equals the net energy *added* to the physical system from the outside or *removed* from the physical system to the outside. We continue this approach in Chapter 2 with non-thermal types of energies. A surprising result for many of us is that when we consider typical activities such as driving a car or riding a bike, most of the energies involved ultimately end up being transferred to various thermal systems. Thermal energy seems to have a way of "grabbing and hanging on to" most of the energy. (This tendency has to do with the vast number of particles involved in thermal systems. We explicitly discuss this in Chapter 4.)

Thermal energies are associated with the *random* or *disordered* motions of the particles making up matter. In this chapter we turn our attention to energies in which the *common motion* all of the particles making up the matter is important. We can often describe this common motion with just two variables: a position variable (x) and a speed variable (v). These energies (ones that can be described by position and speed of the *entire object*) are commonly called *mechanical energies*.

As you begin reading this chapter, you might be tempted to ask, "How many kinds of energy can there be?". The answer is simple and reassuring: there are only *two* fundamental kinds: these are energies that depend on the square of the speed of a particle or object (kinetic energy, abbreviated KE) and energies that depend on the positions or configurations of particles or objects (potential energy, abbreviated PE). All energies, no matter what names we give them, are either a kinetic energy or a potential energy or some combination of the two. This is true for the two energies we have discussed up to this point: bond energy and thermal energy. Bond energy depends on the positions of the atoms making up the molecules, so it is a potential energy. Thermal energy is a *combination* of the kinetic energies of the individual atoms *and* the potential energies associated with the motions of the atoms about their equilibrium positions. We will discuss these relations in much greater detail in Chapter 3.

Where are we going with this energy stuff and why? You will begin to see that using the *Energy-Interaction Model* allows us to answer many interesting questions about sports, bikes, objects falling off buildings, and other common (or not so common) everyday activities. Mechanical energies involve position and speed variables, and because transfers of mechanical energy involve work (instead of heat), we need to understand a little more about *work*. Work involves the notion of forces acting through distances, which means we will have to know a little more about *force* itself. The payoff is that we will be able to calculate or predict many unknown distances, speeds, and forces *without ever having to know the details* of the interactions. And the beauty of this approach is that it works for all kinds of physical situations. We do not have to learn lots of different ways of approaching questions that depend on the particulars of the situation!

Another significant benefit of starting the way we did in Chapter 1 with thermal phenomena is that we can also look much more realistically at *real-world phenomena* where *friction* is always present. If you look at a conventional introductory physics text, you will find that for the first third of the book, it seems everyone just *pretends* that there is no friction! It is as if we lived in a distant galaxy where friction didn't exist. But that is a pretty idealized galaxy. Because we are treating energy within a general model that works for mechanical energies as well as thermal energies, rather than from a purely mechanics approach. We can deal directly with the transfers of energy to thermal systems and treat a lot of phenomena much more realistically than we could if we narrowly focused on the mechanics of *frictionless* systems.
