1.2 Energy:

- Energy is the ability to do work.
- Energy is conserved: The total energy for an isolated system stays constant.
- Like momentum, energy can be transferred from one body to another.
- Unlike momentum, energy can change forms.

Figure 1: How many forms of energy can you identify in this photograph of a wind farm in Iowa? Can you identify an energy transformation from one form of energy to another? (credit: Jürgen from Sandesneben, Germany, Wikimedia Commons)

We can name many forms of energy, including that provided by our foods and petroleum (chemical potential energy), to the energy our car gains as it speeds up (kinetic energy), to the sunlight (radiant energy) that warms us (thermal energy, or microscopic kinetic energy). You can also cite examples of what people call energy that may not be physics related, such as someone having an energetic personality. Like mass, momentum, and angular momentum, energy is conserved: the total amount of energy in an isolated system is constant. Energy can be added to a system by adding heat or work. Additionally, energy can change forms and is thus more difficult to keep track of than momentum or mass. For instance, if a rock falls from a cliff, the gravitational potential energy changes to kinetic energy as the rock falls. When the rock hits the ground the kinetic energy changes to heat energy and is conducted away.
Your responsibility in reading this chapter is to become comfortable with the different kinds of energy and transitions. Part of this is to read and consider all three of the exercises.

Energy is one of the major building blocks of modern civilization. Energy resources are key limiting factors to economic growth. Global use of energy resources, especially oil, continues to grow, with economic, social, political, and environmental consequences.

We can loosely define energy as the ability to do work, admitting that we have yet to clearly define work. For now, we have to accept a circular definition because work is the ability to change energy. For instance, when a compressed spring beneath a toy rocket is released, the rocket is propelled into the air. The spring does work on the rocket as the spring potential energy is converted to the kinetic energy of the rocket, which turns to gravitational potential energy of

the rocket/earth system, as the rocket gains height and slows down.

Kinetic and **Potential** Energy

In the above example, there are two classes of energy worth distinguishing: kinetic energy and potential energy. Kinetic energy is a form of energy associated with the speed of a body. Potential energy comes from stored energy and we can think of it as having the potential to do some work. There is stored energy in the compressed spring, in the height of the rocket and in stored chemical energy. If you let the spring go, the potential energy of the spring changes to kinetic energy of the rocket.

Transformation of Energy

The transformation of energy from one form into others is happening all the time. The chemical energy in food is converted into kinetic energy and thermal energy through metabolism; light energy is converted into the chemical energy of sugar through photosynthesis in plants. The chemical energy contained in coal is converted into thermal energy as it burns to turn water into steam in a boiler. This thermal energy in the steam in turn is converted to mechanical energy as the expanding steam spins a turbine (and cools in the process), which is connected to a generator, converting the kinetic energy to electrical energy.

Another example of energy transformation occurs in a solar cell. Sunlight impinging on a solar cell (Figure 2) produces electricity, which in turn can be used to run an electric motor. Energy is converted from the primary source of solar energy into electrical energy and then into mechanical energy. Because energy is conserved, all the radiant energy absorbed by a solar cell is equal to the electrical energy produced and thermal energy, warming up the solar panel.

Figure 2: Solar energy is converted into electrical energy by solar cells, which is used to run a motor in this solar-power aircraft. (credit: NASA)

Exercise 1

In a city, a generator powered by gasoline charges a battery. At night, the charged battery is moved to a nearby village without electricity to provide lighting.

a) Starting with the chemical potential energy of the gasoline, follow the energy transformations that result in lighting.
b) What are the energy transformations that gave rise to the gasoline? Starting with prehistoric sunlight, where did the gasoline get its chemical potential energy?

Exercise 2

Consider in the above scenario, there is often more than one kind of energy produced from each transformation. In particular, thermal energy is often produced along with another energy form. Thus, the energy conversion is not considered 100% efficient because some of the energy is "lost" from the system through heat to thermal energy.

a) In the scenario represented above, all of the prehistoric sunlight didn't turn into light in the rural community. Identify the many places where energy was "lost" as thermal energy along the way, rendering much less radiant energy in the rural village than the original prehistoric radiant energy that fell upon the prehistoric plants.
b) If all the lost thermal energy from the energy transformations accumulates, the earth would get hotter very quickly. Where does all this energy eventually go?

Exercise 3

Consider two identical solar panels next to each other in the sun. One is hooked to a motor that is doing work, while the other is not hooked to anything. Which solar panel is warmer? How do you know?

Exercise 4

Suppose that you eat an "energy bar" and then ride your bike very fast up a hill. From the top of the hill, you turn around and coast downward, speeding up. You stop at the bottom using your brakes.

a) Starting with the chemical potential energy in the energy bar, please identify the energy conversions in this process.
b) Finishing with the energy bar you ate, please identify the energy transformations that gave rise to that energy bar.