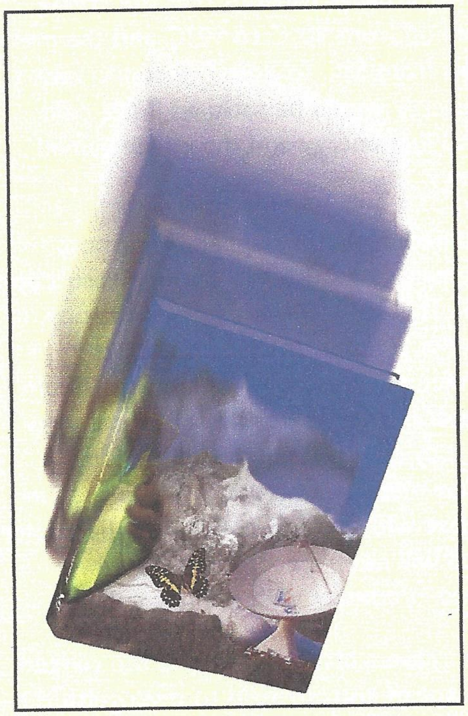
FOR YOU TO READ

Conservation of Energy

Energy is conserved. Kinetic energy can become gravitational potential energy and vice versa. When an object like a book is dropped to the ground, the gravitational



potential energy becomes kinetic energy as the book gains speed. As the book hits the ground and stops, some of the kinetic energy is converted to sound, as you hear a "thump." The rest of the kinetic energy of the book becomes heat energy and the temperatures of the book and of the ground both rise a bit.

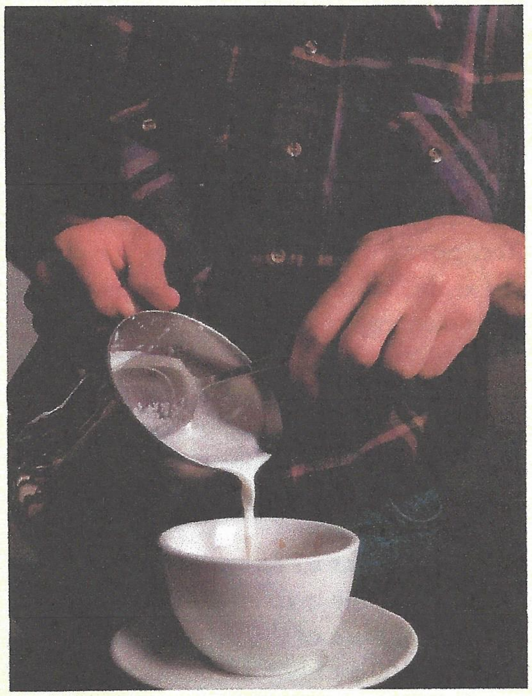
You can calculate gravitational potential energy and kinetic energy. You also now know how to calculate heat energy. Heat energy is part of the total energy picture. Conservation of energy demands that the sum of all of the energies must remain constant.

Temperature and Heat

Temperature and heat energy are not the same. Temperature is a measure of the kinetic energy of the molecules of the material. You can measure this energy with a thermometer. The temperature and the kinetic energy of the molecules change when the object touches a material of a higher or lower temperature.

Heat energy has to do with the nature of the material, the mass of the material, and the temperature of the material. For example, 100 g of hot water has more energy than 100 g of cold water because of a difference in temperature. A swimming pool of 10,000 kg of cold water will have more energy than 1 kg of hot water, mainly because of a difference in mass. If the 1 kg of hot water is poured into the swimming pool of 10,000 kg of cold water, the temperature of the pool water will rise a tiny amount. The temperature of the hot water will drop considerably.

When you mix cold milk with hot coffee, you expect the cold milk to warm a bit and the coffee to cool a bit. They will soon arrive at the same temperature. This can be explained using the conservation of energy. The milk gained some energy and the hot coffee lost some energy. It might be clearer if you look at some numbers. If the cold milk is at 5°C and the hot coffee is at 90°C, the final temperature of the milk-coffee



mixture could be 88°C. In this case the temperature of the milk rose 83°C and the temperature of the coffee fell 2°C. Energy was conserved. If you knew the mass of the coffee and the milk, you could compute the gain and loss of the energy by each substance using the relation $Q = mc\Delta t$. The change in energy of both the milk and the coffee would be the same.

This situation is quite common. If you put a piece of cold metal into the coffee, there would be a similar effect. The coffee could cool from 90°C to 88°C and the metal could warm from 5°C to 88°C. If you knew the masses of the metal and the coffee and the specific heat of the metal, you could again compute the gain and loss of the energy with the relation $Q = mc\Delta t$. Again, the change in energy would be the same for the metal and for the coffee.

When a piece of cold metal is placed in hot coffee, it never happens that the metal gets even colder and the coffee gets even hotter. It never happens that the coffee heats up from 90°C to 92°C and the metal cools from 5°C to 3°C. The conservation of energy would be satisfied if the cold metal lost energy and the coffee gained energy.

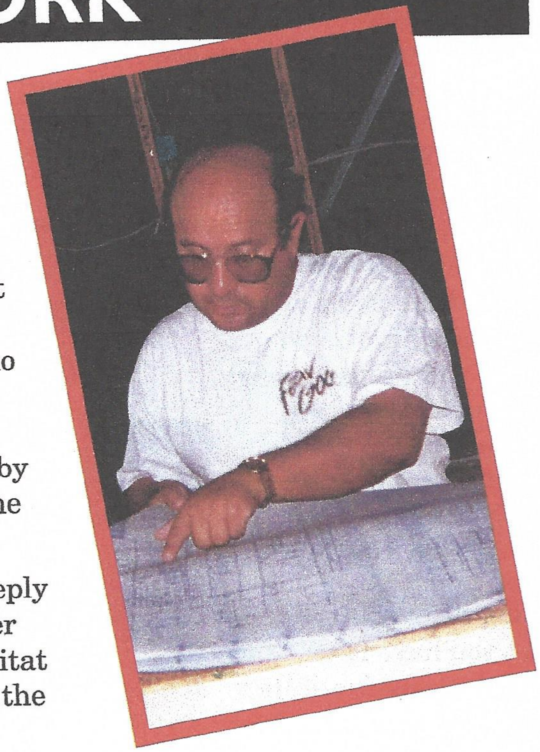
If something never happens, you must assume that nature has placed a restriction on it. This restriction is called **entropy.** It informs you that the two materials in contact will reach a common equilibrium temperature. The transfer of heat energy can only take place in one direction. A cooler metal will heat up when placed in contact with the hot coffee, but the cooler metal will never become cooler when placed in contact with the hot coffee.

This irreversibility of heat and the related concept of entropy help to distinguish the past from the future. If you watch a movie of a pendulum moving back and forth, you may not be able to tell whether the film is being played forward or backward. If you watch someone break an egg and fry it, the film would look quite silly when played backward. It doesn't make sense that the egg could get un-fried and then return to its shell.

PHYSICS AT WORK

Ray Aguilera

HABITAT FOR HUMANITY



Ray is the construction manager at the Valley in the Sun, Arizona, Habitat for Humanity branch. Habitat for Humanity International is a non-profit organization that seeks to eliminate poverty, housing, and homelessness from the world. They do this by building and selling homes for no profit, to families who cannot get conventional financing. Homeowners also become partners in the process by contributing 500 hours of "sweat equity" toward the construction of their own home.

Our former president, Jimmy Carter, has been deeply committed to Habitat since 1984. Each year former President Carter and his wife, Rosalynn, join Habitat volunteers to build homes and raise awareness of the critical need for affordable housing.

Ray Aguilera was on his way to becoming a lawyer, when one summer he got a job building homes, and he has never stopped. Ray gets a great deal of satisfaction from his work with Habitat. "I enjoy going from an empty lot and watching something magical grow out of it," he says.

Arizona has a different climate than many other places in the country and takes special considerations when planning homes. In this southwestern desert, the temperatures are often in the 100s and rarely very cold. For example, the foundations and footings for houses do not need as much concrete as other places because the soil conditions are so different. And, in Arizona, you never have to worry about winter frosts. "The most essential characteristic of building a house in Arizona," states Ray, "is to keep it energy efficient. We also strive to design houses that will blend in with the existing environment. In Arizona, we make more of an effort to keep the hot out and the cold in. To do this we use double-paned windows, and as much insulation as we can fit between the walls and in the attic."