What Is Energy?

A. Introduction

What is always present but never visible? **ENERGY!** Energy is a difficult concept to understand because it is not a concrete object that you can see or touch. To understand what energy is, you must first understand what it does. That is, although energy isn't visible, you can detect evidence of energy. Jumping, moving a wheelchair, eating, and singing all require energy. Nonliving things also use energy—a clock, vacuum cleaner, and mechanical toys all require energy to move. Work is involved whenever anything moves a distance, and energy is needed to do work. **Therefore, energy is defined as the ability to do work.**

Much like mass or volume, energy is a property of an object. It's just that energy is more abstract than some other properties. Although energy itself isn't visible, you can detect evidence of energy.

Movement, sound, heat, and *light* provide evidence that energy is present and being used. Sound is produced when we strike something. But does sound do work? Yes, sound can move things. Sound waves move the tiny bones in your ears and shake windows when a loud truck passes by. Sound waves are also evident in the vibrations from playing a radio.

Our body is working even when it appears to be still. Breathing, blinking, and digesting food all require energy. For us to do these activities, our bodies burn the energy in food. We know this is happening because we feel warm (burning generates thermal energy, or heat). Therefore, heat is evidence that energy is being used.

If energy is the ability to do work, how does thermal energy fit into this definition? Thermal energy can melt an ice cube or make water boil. Therefore, the definition of energy can be amended to **energy is the ability to do work or to organize or change matter.**

Light is another observable form of energy. Light can change things. When light shines on your arm, it makes it feel warm. When light shines on a green plant, the plant can make food.

Since energy is a property of matter, scientists have discovered ways to measure and quantify energy. Measuring energy helps to understand how it is used, how it changes forms, and how to increase energy efficiency.

B. Two Main Forms of Energy

Kinetic energy is motion energy.

Potential energy is energy stored in matter.

In strict scientific terms, energy is classified into two main forms: kinetic and potential energy. **Kinetic energy is defined as the energy of a moving object.** A thrown football, a speeding automobile, a waterfall, or a rock falling from a cliff are examples of objects that have kinetic energy.

Potential energy appears in many different forms, and is defined as **the energy in matter due to its position or the arrangement of its parts.** The various forms of potential energy include gravitational potential energy, elastic potential energy, chemical potential energy, and electrical potential energy.

Potential Energy is often referred to as stored energy. Some scientists avoid the use of the word "stored" because it inaccurately depicts energy as a substance that is contained within a substance. In other words, some scientists and energy educators believe saying energy is "stored" is a misconception.

Various Forms of Potential Energy

Gravitational Potential Energy

When something is lifted or suspended in air, work is done on the object against the pull of gravity. This work is converted to a form of potential energy called gravitational potential energy. When the item succumbs to the force of gravity, falling towards Earth like an apple from a tree, it converts potential energy into kinetic energy.

Elastic Potential Energy

A stretched rubber band has the potential to do work or change things. This form of energy is called elastic potential energy. It occurs when an object (such as our skin, a spring, a trampoline, or a rubber band) resists being stretched out of shape. The elastic potential energy in a rubber band can be used to do work. For example, toy airplanes fly when a rubber band untwists and spins a propeller. The elastic potential energy in the rubber band was converted into kinetic energy.

Chemical Potential Energy

It would take millions of rubber bands to move a real airplane, so gasoline is used instead. But you don't stretch gasoline to make it work, you burn it. The chemical makeup (arrangement of molecules) of gasoline makes it a good fuel source. All nonliving and living things, from automobiles to zebras, are made up of molecules. It takes energy to make these molecules and hold them together. The energy stored in molecules is called chemical potential energy. During combustion, bonds are broken and reformed creating new products. The energy stored in gasoline is released by burning it (combustion). During combustion, chemical bonds are broken and reformed (changing gasoline into byproducts such as water and carbon dioxide), releasing energy. The airplane motor uses this released energy to turn a propeller. There are many examples of chemical potential energy being converted to kinetic energy to do work. The chemical energy in food is used by our bodies to move. In a lighted firecracker, chemical energy is used to make a loud sound and to scatter pieces of the firecracker all over.

Electrical (Electromagnetic) Potential Energy

A battery has chemical potential energy along with electrical potential energy. When you turn on a device that is battery operated, such as a flashlight or a toy, the electrical potential energy stored in the battery is converted into other forms of energy such as sound, mechanical motion, thermal energy, and light. For an electrical appliance you plug in, the electrical potential energy is maintained by a spinning generator of a power plant, a hydroelectric dam, or a windmill. A solar cell stores electrical potential energy similar to a battery as long as the sun is shining on it.

Thermal Energy

When you feel a warm object, you are actually feeling thermal energy, which is the movement of molecules that make up the object. All objects possess thermal energy (even

cold ones) since they have a temperature above absolute zero. Evidence of thermal energy can be detected by measuring the temperature of an object.

Although technically incorrect, the word "heat" is often used to mean thermal energy. A way to think about this distinction is objects possess thermal energy, while heat is transferred from one object to another.

The Evidence of Energy Is All Around Us!

Sound, mechanical motion, thermal energy, and light are not easily classified as kinetic and potential energy. **They are evidence of energy.**

Light is an example of electromagnetic radiation and has no mass, so it has neither kinetic nor potential energy. The remaining forms have qualities of both kinetic and potential energy. Sound is made up of vibrations (put your hand on a stereo speaker), thermal energy consists of moving molecules in air or in an object, and mechanical energy is the combination of kinetic and potential energy of a moving object. A pendulum has mechanical energy; it continually converts kinetic energy into gravitational potential energy and back into kinetic energy as it swings back and forth.

A note about thermal energy and heat. In strict scientific terms, there is a distinct difference between heat and thermal energy. Thermal energy pertains to the kinetic energy of the molecules within an object. Heat is the transfer of energy between two objects. Wherever possible, we have tried to remain true to these distinctions. However, since heat is the more familiar term, we often use that to facilitate understanding.