**Thursday 23, 2014**

**Forms of Energy**

**I can explain the different forms of energy and give examples of each.**

**What are the different forms of energy?**

**Energy has a number of different forms, all of which measure the ability of an object or system to do work on another object or system*.***

**In other words, there are *different ways* that an object or a system can possess energy.**

**Thermal Energy**

**Thermal Energy is the total energy of the particles that make up an object.**

**The higher the temperature of an object, the faster the particles move, so the more kinetic energy an object has the greater the thermal energy.**

**Consider a hot cup of coffee. The coffee is said to possess "thermal energy", or "heat energy" which is really the collective, microscopic, kinetic and potential energy of the molecules in the coffee (the molecules have kinetic energy because they are moving and vibrating, and they have potential energy due their mutual attraction for one another - much the same way that the book and the Earth have potential energy because they attract each other).** Temperature is really a measure of how much thermal energy something has. The higher the temperature, the faster the molecules are moving around and/or vibrating, i.e. the more kinetic and potential energy the molecules have.

**Chemical Energy**

**Chemical energy is a form of potential energy. Food has chemical energy. Gasoline has many atoms bonded together and has a lot of chemical energy.**

**Consider the ability of your body to do work. The glucose (blood sugar) in your body is said to have "chemical energy" because the glucose releases energy when chemically reacted (combusted) with oxygen.** Your muscles use this energy to generate mechanical force and also heat. Chemical energy is really a form of *microscopic potential energy*, which exists because of the electric and magnetic forces of attraction exerted between the different parts of each molecule - the same attractive forces involved in thermal vibrations. These parts get rearranged in chemical reactions, releasing or adding to this potential energy.

**Electrical Energy**

**Electrical energy is the energy of moving electrons. Electrical energy is a form of kinetic energy.**

All matter is made up of atoms, and atoms are made up of smaller particles, called protons (which have positive charge), neutrons (which have neutral charge), and electrons (which are negatively charged). Electrons orbit around the center, or nucleus, of atoms, just like the moon orbits the earth. The nucleus is made up of neutrons and protons.

**Some material, particularly metals, have certain electrons that are only loosely attached to their atoms. They can easily be made to move from one atom to another if an electric field is applied to them. When those electrons move among the atoms of matter, a *current* of electricity is created.**

**This is what happens in a piece of wire when an electric field, or *voltage*, is applied. The electrons pass from atom to atom, pushed by the electric field and by each other (they repel each other because like charges repel), thus creating the electrical current. The measure of how well something conducts electricity is called its *conductivity*, and the reciprocal of conductivity is called the *resistance*.** Copper is used for many wires because it has a lower resistance than many other metals and is easy to use and obtain. Most of the wires in your house are made of copper. Some older homes still use aluminum wiring.

**The energy is really transferred by the chain of repulsive interactions between the electrons down the wire - not by the transfer of electrons per se. This is just like the way that water molecules can push on each other and transmit pressure (or force) through a pipe carrying water. At points where a strong resistance is encountered, its harder for the electrons to flow - this creates a "back pressure" in a sense back to the source. This back pressure is what really transmits the energy from whatever is pushing the electrons through the wire. Of course, this applied "pressure" is the "voltage".**

**Sound Energy**

**Sound energy is caused by an object’s vibrations.**

**Sound energy is a form of potential and kinetic energy.**

Sound waves are compression waves associated with the potential and kinetic energy of air molecules. When an object moves quickly, for example the head of drum, it compresses the air nearby, giving that air potential energy. That air then expands, transforming the potential energy into kinetic energy (moving air). The moving air then pushes on and compresses other air, and so on down the chain. A nice way to think of sound waves is as "shimmering air".

**Light Energy**

**Light Energy is produced by vibrations of electrically charged particles. The vibrations that transmit light energy don’t cause other particles to vibrate.**

**Consider the energy transmitted to the Earth from the Sun by light (or by any source of light). Light, which is also called "electro-magnetic radiation"**. **Why the fancy term? Because light really can be thought of as oscillating, coupled electric and magnetic fields that travel freely through space (without there having to be charged particles of some kind around).**

**It turns out that light may *also* be thought of as little packets of energy called *photons* (that is, as particles, instead of waves). The word "photon" derives from the word "photo", which means "light".**  Photons are created when electrons jump to lower energy levels in atoms, and absorbed when electrons jump to higher levels. Photons are also created when a charged particle, such as an electron or proton, is accelerated, as for example happens in a radio transmitter antenna.

Radio waves, and the radiant heat you feel at a distance from a campfire, for example, are also forms of electro-magnetic radiation, or light, except that they consist of low energy photons (long wavelength and high frequencies - in the infrared band and lower) that your eyes can't perceive. This was a great discovery of the nineteenth century - that radio waves, x-rays, and gamma-rays, are just forms of light, and that light is electro-magnetic waves

**Nuclear Energy**

**Nuclear energy is produced in two ways-when two or more nuclei join together or when the nucleus of an atom splits. The sun’s hydrogen nuclei join to form a larger helium nucleus. Uranium atoms split and release a lot of potential energy.**

**The Sun, nuclear reactors, and the interior of the Earth, all  have "nuclear reactions" as the source of their energy, that is, reactions that involve changes in the structure of the nuclei of atoms.** In the Sun, hydrogen nuclei fuse (combine) together to make helium nuclei, in a process called **fusion**, which releases energy. In a nuclear reactor, or in the interior of the Earth, Uranium nuclei (and certain other heavy elements in the Earth's interior) split apart, in a process called **fission**. If this didn't happen, the Earth's interior would have long gone cold! The energy released by fission and fusion is not just a product of the potential energy released by rearranging the nuclei. **In fact, in both cases, fusion or fission, some of the *matter* making up the nuclei is actually converted into *energy*. How can this be?** The answer is that ***matter itself is a form of energy!***This concept involves one of the most famous formula's in physics, the formula,

**E=mc2.**

This formula was discovered by Einstein as part of his "Theory of Special Relativity". In simple words, this formula means:

**The energy intrinsically stored in a piece of matter at rest equals its mass times the speed of light squared.**

When we plug numbers in this equation, we find that there is actually an incredibly huge amount of energy stored in even little pieces of matter (the speed of light squared is a very very large number!). For example, it would cost more than a million dollars to buy the energy stored intrinsically stored in a single penny at our current (relatively cheap!) electricity rates. To get some feeling for how much energy is really there, consider that nuclear weapons only release a small fraction of the "intrinsic" energy of their components.