***ENERGY***

Energy – a property of an object that gives the object the ability to do work

An object does work when the object exerts a force causing itself or another object to change its momentum. An object has energy if the object can make itself or make another object change its momentum. An object cannot change its own momentum by exerting a force on itself. The object exerts a force on another object which according to Newton’s third law exerts a force on the original object. This reaction force causes the momentum of the original object to change.

There are two categories of energy:

1. kinetic energy

2. potential energy

kinetic energy – the energy of an object due to the motion of the object

It is the object which is in motion, not the energy.

The kinetic energy of an object is given by the equation:

m – mass of the object in kilograms; measure of how much matter is in the object

v – speed of the object in meters/seconds

KE – kinetic energy of the object in joules, J

The larger the moving object, the more kinetic energy the object has. The faster the object moves, the more kinetic energy the object has. Doubling the mass of the object will double the kinetic energy. Doubling the speed will make the kinetic energy four times what it was.

Since mass and speed are scalar quantities, their product will be a scalar quantity. Kinetic energy has only size and no direction. An object may have 100 J of kinetic energy. Its kinetic energy is not 100 J upward or left. Because kinetic energy is a scalar (as are all energies), you add energies using the rules for adding positive numbers in math.

Potential energy is the energy of an object that is not due to motion, but this energy could be converted into kinetic energy.

My list of types of potential energy:

1. gravitational 5. chemical 8. magnetic

2. elastic 6. electrical 9. gas pressure

3. thermal energy 7. nuclear/atomic 10. rest mass or mc2 energy

4. light

Every object has some type of potential energy. Because an object has mass it must have what I have called *mc2* energy. This is the energy equivalent of the matter in the object. This type energy is larger for an object than all the other types of energy combined, but we will not investigate **changes** in this type energy. An object in motion will have kinetic energy and also potential energy. An object that is not moving will have only potential energy.

Page 2 ENERGY

The only two kinds of potential energy we will look at this time are:

1. gravitational potential energy

2. elastic potential energy of a stretched or compressed spring

**Gravitational potential energy**

A object has gravitational potential energy if the object would move under the influence of gravity were the object not supported in some way. When the support is removed then gravity will cause the object to start moving downward. The amount of gravitational potential energy an object has is given by:



GPE = gravitational potential energy in joules

m – mass of the object in kilograms

*g* – acceleration due to gravity, 9.8 m/s2

h – how high the object is above the assigned zero PEg level in meters

The “**zero GPE level**” is a vertical position at which we will assign any object a gravitational potential energy of zero. This is a vertical position below which no object in the system will move. The “**h**” in the equation is the vertical distance an object is above this position.

The equation tells us that the higher up an object is, the more gravitational potential energy the object has. The equation also tells us that a more massive object has more gravitational potential energy than a less massive object at the same height.

Notice that gravitational potential energy is not affected by horizontal considerations.

**Elastic potential energy**

A spring has elastic potential energy if the spring is stretched or compressed. The amount of elastic potential energy of a spring is given by



EPE – potential energy of a spring in joules

k – force constant of the spring in newtons/meter; aka spring constant

X – amount by which the spring is stretched or compressed from its equilibrium length in meters

The equation tells us that the more a spring is stretched or compressed, the more elastic potential energy the spring has. The equation also tells us that a “stronger” spring has more energy than a spring with a smaller force constant when the two springs are stretched or compressed by the same amount.

The equilibrium length of a spring is the length when the spring is neither stretched nor compressed. You could think of the equilibrium length as the length of the spring if the spring were just placed on a table.

**Mechanical Energy**

Mechanical energy is not a different type of energy. For us, mechanical energy of an object is just the

sum of the kinetic energy and the gravitational energy of the object.

For a system of objects

Since our springs are ideal springs with no mass, a spring cannot have kinetic energy nor gravitational potential energy. The mechanical energy of a spring is its elastic potential energy.Page 3 ENERGY

**Law of conservation of energy**

1st Law of Thermodynamics or the Law of Conservation of Energy – The total energy of a closed system will not change. This means that one type of energy may be converted into another type of energy but the total amount of energy in the system is the same after an event as it was before the event. Energy may be transferred from one object in the system to another object in the system. The amount of energy lost by one object will be equal to the amount of energy gained by another object or objects.

A **closed system** is an identified, limited group of objects. These objects may exchange energy between themselves but can neither gain energy from an object outside the system nor lose energy to an object outside the system. The largest closed system we know is the universe itself. The law of conservation of energy states that objects within the universe may exchange and transform energy, but the total amount of energy in the universe is fixed and finite.

You can look at every event in nature as energy exchanges and conversions. Here are a few examples:

A flashlight: The chemicals in the dry cell convert chemical potential energy into electrical potential energy during chemical reactions. The electrical potential energy causes electrons to move. The electrons gain kinetic energy. The electrons move through the atoms of the wire filament causing these atoms to vibrate faster as the electrons convert their energy into heat. The heat energy of the atoms of the filament is converted into light energy.

A pole vault: Chemical reactions in the muscles of the vaulter convert chemical energy that makes the muscles contract. The contraction of muscles makes the vaulter move – kinetic energy. The vaulter puts the pole in the slot and the pole bends. The runner slows as kinetic energy is converted into elastic energy in the pole. The vaulter jumps upward converting more kinetic energy into gravitational energy. The pole straightens converting its elastic energy into more gravitational and kinetic energy. The vaulter passes over the bar and starts to fall. The vaulter speeds up as he falls – gravitational energy is converted into kinetic energy. When the vaulter lands in the pit he stops. The kinetic energy is converted into elastic energy as the foam of the pit material compresses. This elastic energy is converted into heat and warms the material of the pit. Landing in the pit also produces sound which is kinetic energy of the air molecules. When sound waves are absorbed by objects, the kinetic energy is converted into heat.

All energy conversions eventually end as thermal energy. “Eventually” may be a long way down the energy conversion path, but that is where all energy “eventually” winds up.

The origins of most of the energy on earth are either the nuclear reactions in the sun or heat generated by nuclear reactions in the material of the earth. We do get a small amount of energy from gravitational attraction due to the moon, from material that falls to the earth from space and from electromagnetic radiation from sources other than the sun.

Physics has been described as the study of energy, its transformations, and the effects produced on objects as they gain, lose, and convert energy.