Work, Energy and the Work Energy Theorem:

Part 1:

Among the most well known (although not necessarily understood) scientific principles is the ***law of conservation of energy***. Most commonly it is stated as

*Energy can neither be created nor destroyed, it may only change form.*

This is a nice, tidy little statement but what does it mean? In this form it does little to tell us what energy IS. It also fails to mention what FORMS the energy may take, not to mention that the term **work** does not show up in the theorem in this form.

Using the knowledge you already have make a list of as many types of energy as you can.

Well done.

Above was only one of many statements of the theorem. Below are two others:

* *“Besides the 54 known chemical elements there is in the physical world one agent only, and this is called Kraft [energy or work]. It may appear, according to circumstances, as motion, chemical affinity, cohesion, electricity, light and magnetism; and from any one of these forms it can be transformed into any of the others.”*

*1837, Karl Friedrich Mohr*

* *The energy of an isolated system is fixed. The energy of any system can change from one value to another only as the result of work done to the system, or by heat into or out of the system.*

We can summarize these with the following:

*Initial Energy + Work1 + Heat2= Final Energy*

1: Work here is work done to the object/system by EXTERNAL forces.

2: Heat is the transfer of thermal energy from/to the surroundings.

As we move through this unit we will develop our own version of the theorem. We will also develop language to describe what is going on. For now let’s work with what we have.

A few other details:

* The SI unit for energy (in any form), as well as for work or heat is the **Joule (J)**. In MKS units a Joule is one kilogram-metre squared per second squared.

1J$≡$1$\frac{kg∙m^{2}}{s^{2}}$

* Other common units are calories (cal), British thermal units (Btu), ergs (erg), kilowatt-hours (kWh) and electron-volts (eV)
* Three main types of energy are *KINETIC ENERGY* , *POTENTIAL ENERGY and THERMAL ENERGY*.
* The *TOTAL MECHANICAL ENERGY* of an object or system is the sum of the kinetic energy and potential energies. It does not include internal energies like nuclear, chemical or thermal.
* Work and energy are SCALAR QUANTITIES
* Work is *change in energy*. (W=∆E)
* Work can be negative! If you do ***negative work*** to an object you will ***decrease its energy***. If you do ***positive work*** to an object you will ***increase its energy***.
* In order to do work to an object a force must have a component parallel to the motion of the object.
* If work is done by a **conservative force** (Force of gravity, electrostatic force, spring force among others) the total mechanical energy of an object will remain constant. Think of a pendulum in a frictionless environment oscillating back and forth.
* If work is done by a **non-conservative force** (Force of friction, normal force, among others) the total mechanical energy of an object will change (Either increase or decrease). Think of a car accelerating away from a stoplight, or a book sliding to a stop across the top of a desk.

**Questions:**

1. A system has 155J of kinetic energy, 236J of potential energy, 69J of thermal energy and 412J of chemical energy. What is the total energy of the system? What is the total mechanical energy of the system?
2. A system has 1225J of kinetic energy, 644J of gravitational potential energy, 1452J of spring potential energy, 1.7x109J of nuclear energy, 6847J of thermal energy and polka-dots. What is the total energy of the system? What is the total mechanical energy of the system?
3. A small napkin that has been carefully folded to conceal an unwanted hor d’oeuvre has 2.4J of kenetic energy, -9.4J of gravitational potential energy, and 1.8J of elastic potential energy. What is the total mechanical energy?
4. A system has 1450J of potential energy and 922J of kinetic energy. The system then has 260J of work done to it. What is the final energy of the system?
5. A system has 1450J of potential energy and 922J of kinetic energy. The system then has -260J of work done to it. What is the final energy of the system?
6. A system has 1450J of potential energy and 922J of kinetic energy. The system then has 260J of work done to it and 430J of heat removed from it. What is the final energy of the system?
7. A system has 22500J of kinetic energy and 13200J of potential energies, and is acted upon by only gravity.
8. What is the total mechanical energy of the system?
9. If the system loses 950J of potential energy, how much kinetic energy will it gain?
10. A massive system has 63425J of total mechanical energy. The mass has 28643J of kinetic energy, how much potential energy does it have?
11. A massive system has 1689J of mechanical energy. The mass undergoes a process in which 780J of heat is released to the surroundings. What is the final energy of the mass?
12. A ball is thrown straight into the air. At the moment it is released it has 260J of kinetic energy. How much gravitational potential energy and kinetic energy does it have when it is half way to its maximum height?
13. A car has 14500J of kinetic energy and is traveling on level ground. The driver then accelerates. In the process the cars engine burns gasoline releasing 38700J of chemical energy. 22400J of that energy is released as heat, 960J is released as sound. Over the acceleration friction does -6850J of work to the car. What is the final kinetic energy?
14. A person needs to do 888J of work to increase the kinetic energy of a mass, on level ground, from 222J to 999J. How much work was done by friction?
15. A mass slides down a frictionless ramp. Initially the mass has 25.0J of kinetic energy. As it slides down hill it loses 125J of gravitational potential energy. What is the final kinetic energy of the mass?
16. A small statue of Honore de Balzac in a fistfight with a penguin, has 59J of kinetic energy and shares 167J of gravitational potential energy with Earth. The statue then falls, decreasing the gravitational potential energy by 94J. During the process 14J of heat is produced (and lost to the surroundings). What is the final kinetic energy of the system?
17. A framed photo of Pierre Trudeau sitting beside Fidel Castro, eating a Montreal smoked meat sandwich while wearing a t-shirt with the slogan “It’s Always Time for TACOTIME” sits on a 4.0m high shelf. The picture then tragically falls. It falls to the ground where the frame and the glass are shattered before it finally comes to rest on the floor.
18. What type of energy does the system have as the picture sits on the shelf? (be specific)
19. What type of energy does it have when it is mid-fall?
20. What type of energy does have when it is at rest on the floor?
21. Where did the energy go?

**These next questions are a little more abstract:**

1. When does an object have energy?
2. What are you like when you have lots of energy vs. when you have low energy?
3. Does a baseball flying through the air at 160km/h have energy? Why or why not?
4. Does the element on a stove top have energy when it is on and is glowing orange? Why or why not?
5. Does a 12500kg boulder have energy when it is sitting perched precariously at the top of a steep hill? Why or why not?
6. Does a baseball, at rest on the floor, in the basement have energy? Why or why not?
7. Does a firecracker with its fuse lit have energy? Why or why not?
8. Does a firecracker with its fuse unlit have energy? Why or why not?
9. What is energy?
10. What does it mean for an object to have energy?
11. What does it look like?
12. How can energy change form?
13. What does energy smell like?
14. What does it feel like?
15. What does it taste like?
16. What does it sound like?
17. What IS energy?

Write down some thoughts about these questions in the space below. Challenge yourself, really think!