Chapter 4, 5 & 6
Work, Energy and Power
Lecture Notes

I. 5.1 The Nature of Energy
   a. **Energy** – the ability to do work or cause a change.
      i. work is the transfer of energy
      ii. SI unit for energy is the same as the SI unit for work – Joule
   b. Two main types of energy: **Kinetic and Potential**
      i. **Kinetic Energy**: the energy of motion
         1. The amount of kinetic energy depends on the objects **mass and velocity**
         2. Energy is transferred during work – the more work one does on an object, the more energy one imparts on the object.
         3. Calculating Kinetic Energy
            a. **Kinetic energy** = $\frac{\text{Mass} \times \text{Velocity}^2}{2}$ K.E = $\frac{10\text{ kg} \times (10\text{m/s})^2}{2}$

               K.E. = $\frac{10 \times 100}{2}$ = $\frac{1000}{2}$ = 500

            b. **When mass is doubled; Kinetic Energy is doubled** (from 500 to 1000)

               $\frac{\text{Mass} \times \text{Velocity}^2}{2}$ K.E = $\frac{20\text{ kg} \times (10\text{m/s})^2}{2}$

               K.E. = $\frac{20 \times 100}{2}$ = $\frac{2000}{2}$ = 1000

            c. **When velocity is doubled; Kinetic Energy is quadrupled!!** (from 500 to 2000)

               $\frac{\text{Mass} \times \text{Velocity}^2}{2}$ K.E = $\frac{10\text{ kg} \times (20\text{m/s})^2}{2}$

               K.E. = $\frac{10 \times 400}{2}$ = $\frac{4000}{2}$ = 2000

      ii. **Potential Energy:** Energy stored for use at a later time
         1. **Elastic Potential Energy:**
            a. Energy stored in springs, bow and arrow, stretched elastic or rubber bands.
            b. Associated w/ objects that can be stretched or compressed.
         2. **Gravitational Potential Energy**:
            a. **Height** and **weight** dependant
            b. GPE = work done to lift and object to a height
            c. Joules = Newtons x Meters
            d. **GPE = Weight x Height**
            e. Weight = Mass x Aceleration$_g$ = mass x 9.8 m/s^2
            f. Therefore….. **GPE = mass x 9.8 m/s2 x height**
      iii. Different Forms of Energy
         1. **Mechanical** – associated w/ the motion or position of an object

2. **Thermal Energy**– associated w/ the total energy of the particles (atoms and Molecules) in an object. As thermal energy increases, the particles increase in speed and the thermal energy (temperature) of the object increases.
3. **Chemical Energy** – the energy stored in chemical bonds. The potential energy stored in compounds.
4. **Electrical Energy** – moving electrical charges. Electricity!!
5. **Electromagnetic energy** – Travels in waves, associated w/ light, infrared, ultraviolet, microwaves, x-rays, etc.
6. **Nuclear Energy** – Associated w/ the fusion or fission of nuclear atoms.

iv. 5.2 Energy Conversion and Conservation

1. Most forms of **energy can be converted from one type to another**.
    a. Water falling onto a water turbine: mechanical energy converting into electrical energy
    b. A Toaster: Converts electrical energy into thermal energy to toast bread
    c. Striking a match: Converts mechanical energy (rubbing the match on a surface) into chemical energy (breaking chemical bonds to form fire) which is converted into thermal energy (heat from the fire) and Electromagnetic energy (see light coming from the fire on the match)
2. **Conservation of energy**
    a. **Law of the Conservation of Energy** states that energy cannot be created or destroyed. It simply changes from one form into another
    b. Part of Einstein's theory of Relativity tells us that a small amount of mass can be changed directly into a tremendous amount of energy
        i. **E = mc2**
            1. E = **the energy produced**
            2. m = **the mass being converted**
            3. c = **the speed of light (186,000 miles/second)**

v. 5.4 Power: the rate at which work is done

1. Power = work / time

2. Power = $\frac{\textbf{Force x Distance}}{\text{Time}}$

3. SI Unit for Power is the **Watt**
4. 1 **Watt = 1Joule / 1 Second**
5. 1 Watt is approx the power required to raise a glass of water to your mouth in 1 second.
6. **1000 watts = 1 kilowatt**
7. Power can also be described as the rate energy is transferred from one object to another or the rate energy is converted.
8. H**orsepower** : An American unit of power
    a. The amount of work a horse does when it lifts 33,000 ponds of coal to a height of 1 foot in 1 minute.
    (1) **1** horsepower = 746 watts