Energy

I. Energy

A. Definition

Energy is the **ability** of an object to do **______________.**

This definition is somewhat vague and misleading, but it useful in helping you working problems till you get enough experience for us to discuss the deeper philosophical questions of work and energy.

B. Types:

1. **Kinetic Energy** is the **energy** a body has due to its **Motion**.

   This is the only true definition of kinetic energy!

If a particle is moving much slower that the speed of light (i.e. v << $3.0\text{x}10^{-8}$ m/s) then we have a useful formula for find the particle's kinetic energy:

$$K = \frac{1}{2} M v^2 = \frac{1}{2} M (\vec{v} \cdot \vec{v})$$

2. **Potential Energy** is the energy a body has due only to its **<u>Position</u>**.

We will be able to give a more precise definition for potential energy once we learn about conservative forces.

Inside a material, there are atoms which can have both

________________ ________________ and _______________

____________________ due to their motion and their internal

arrangements.

This energy is called ______________________ _______________.

The **kinetic energy of atoms** in a material is what **we call**

_____________________________!!!

The **<u>average</u> kinetic energy of the atoms** of a material is <u>proportional</u> to the quantity _______________________ !!!

We will ignore this discussion about the __________________

________________________ of real objects till Chapter 13 and limit

our discussion to particles.

II. Energy and Work

1. If a force causes the **SPEED** and **Kinetic Energy** of a body to **INCREASE** then the force does ______________ ______________________

2. If a force causes the **SPEED** and **Kinetic Energy** of a body to **DECREASE** then the force does _____________ _________________________

3. If a force **DOES NOT** change the **SPEED** and **Kinetic Energy** of a body then the force does ________ __________

4. Several forces act on a body in most problems, thus we are concerned with the **net work** done on the body if we are to determine **how its speed changes**.

III. Work Energy Theorem

The work-energy theorem is one of the **central concepts** in this section.

You Must Be Able To Quote The Work-Energy Theorem

The **Work** done by the **Net External Force** is equal to the **Change** in the **Kinetic Energy** of the body.

$$W_{Net} = \Delta K$$

V. Definition of Potential Energy

The negative of the work done by a conservative force upon an object is the

Change in **Potential Energy**

Note: Only **Change** in **Potential Energy** is **Meaningful**!

You can NOT talk about potential energy at a **Point** in **Space** unless you have specified your **Zero Potential Energy Reference** point!

Only Change in Potential Energy Has Meaning!!

POTENTIAL ENRGY IS JUST A TOOL TO MAKE IT EASIER TO CALCULATE THE WORK BY A CONSERVATIVE FORCE!!

VI. Conservation of Mechanical Energy (Work-Energy Revisited)

We can break up the NET Work upon an object into two work components:

i) Work by Conservative Forces

ii) Work by Non-Conservative Forces

Thus, the work-energy theorem becomes

$$W_{NET} = W_{conservative} + W_{non-conservative} = \Delta K$$

But according to the definition of potential energy,

$$W_{conservative} = -\Delta U$$

Thus, we have the following where I have used W_{nc} as a short-hand for work by non-conservative forces.

$$W_{nc} = \Delta K + \Delta U$$

Conservation of Energy Equation

This equation is usually written in a slightly different form. If we write out the individual energy changes, we get

$$W_{nc} = (K_f - K_i) + (U_f - U_i)$$

We can now group energy terms according to the time (initial or final) instead of being grouped according to energy type (kinetic or potential). Doing this we have

$$W_{nc} = (K_f + U_f) - (K_i + U_i)$$

We now define a new type of energy.

$$\text{Total Mechanical Energy} \equiv E \equiv K + U$$

Thus, the Conservation of Energy Equation becomes

$$W_{nc} = E_f - E_i = \Delta E$$

So where does the work by non-conservative forces go?

It goes into the kinetic and potential energy of objects that we are not considering in our system. For instance, the work by friction might go into the kinetic energy of the atoms of a block (heat). Thus, we say that the negative of the work by non-conservative forces equals the change in the internal energy of the system.

VII. Conservation of Mechanical Energy

If the total work by non-conservative forces is **Zero** then the total mechanical energy of the system is **CONSERVED** (ie **Constant**).

$$\mathbf{E_f = E_i}$$

VII. Types of Potential Energy In Our Problems

A. Gravitational Potential Energy (Near Earth's Surface) -

The gravitational potential energy of an object of mass M at a height h is given by

$$\mathbf{U_g = M\,g\,y}$$

where the zero point potential energy reference point is y = 0.

B. Hooke Spring Potential Energy -

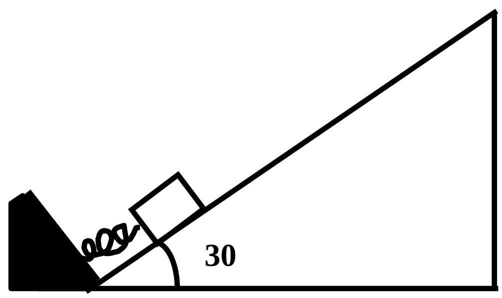
The potential energy of a Hooke spring displaced a distance **x** from its un-stretched position is given by

$$\mathbf{U_s = (1/2)\,k\,x^2}$$

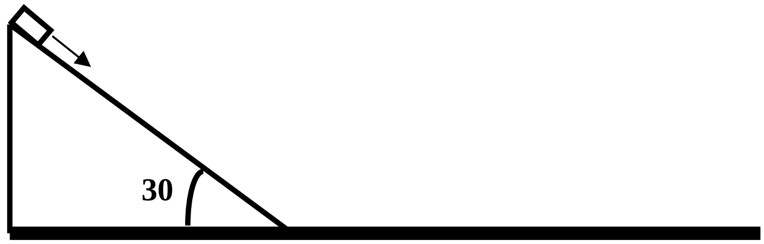
where the zero potential energy reference point is for **x** =0 (un-strectched position).

C. Potential energy functions are useful because someone else has done the Calculus integral for you! However, the price you pay for having a pre-done formula is that you must know the assumptions that were used in the derivation of the formula including the zero potential energy reference point location.

Problem: A 5.00 kg block is placed on a frictionless incline plane. The block is pushed back until it compresses a spring 0.600 m as shown below. Assuming the spring has a spring constant of 200 N/m, how far up the incline plane will the block travel when it is released?



Problem: A postal employee throws an 8 kg package off the airplane and onto the top of a 12 m long frictionless ramp. The package is traveling at 7 m/s at the top of the ramp. After sliding down the ramp, the package slides across a level runway with a 0.25 coefficient of kinetic friction until the package comes to rest.



A) How much work was done by gravity on the package?

B) How much work was done by friction on the package?

C) How far along the runway did the package slide before it stopped?