Gravitational potential energy

* We have been discussing the relationship between **WORK** and **ENERGY** and have so far established that if work is done to an object there will be a change in energy.
* So far that work has always caused a change in the object’s speed and so a change in its **KINETIC ENERGY**.
* However what if you lift an object straight up into the air at *constant speed*?
* You are definitely doing positive work to the object (You apply an upward force and the object is displaced upward), but there is no change in the kinetic energy.
* What kind of energy is the object gaining in this case? Let’s look at the situation a little more closely.

**F**

**F** h

**d**

ho (not necessarily the ground)

W = **F**|| **d**

W= (mg) d

W= (mg) (h-ho)

W= mgh – mgho

So here we have work is equal to the change in the quantity *m g h* , we know work is a change in energy, therefore *m g h must be a form of energy.***This form of energy is named GRAVITATIONAL POTENTIAL ENERGY (Epg)**. The object at its new position has the potential to fall down and to gain kinetic energy.

Ug=mgh

m: mass in kg g: gravitational field strength in N/kg h: height in m

**(magnitude only!)** (from some chosenzero point)

Kinetic Energy, Potential Energy

And

The conservation of mechanical energy

We have discussed what energy is and a few of its forms.

There are two main forms of energy:

* 1. Kinetic energy, the energy of motion.

K=Uk=½mv2

m: mass in kg v: SPEED of the object in m/s

Energy is a scalar quantity (we will discuss why later), this means it has no direction!

The units for energy are

* 2. Potential energy, the energy of position. An object has *potential energy* if its position relative to some other object gives the potential to move, or to gain kinetic energy.

The simplest example is to think of a massive object held above the surface of the Earth. If I simply drop that object it will fall toward Earth, gaining kinetic energy. Because of its position above Earth it has some energy “stored up” that can be released and become kinetic energy.

This particular kind of potential energy is called GRAVITATIONAL POTENTIAL ENERGY:

Ug=mgh

m: mass in kg g: gravitational field strength in N/kg h: height in m (from some chosen

**magnitude only!** zero point)

The units are:

**Using Ug in Calculations (Conservation of Mechanical Energy).**

Now we will see how the idea of gravitational potential energy can be used in calculations. We will explore this by using an example.

**EX1:** A 1.40kg ball is dropped from rest 11.0m

above the ground. Find the speed of the ball

when it is 1.00m above the ground, using

kinematics.

11.00m

1.00m

**v**2= (0m/s)2 + 2(9.80m/s2)(10.0m)

**vo**=0m/s **v**2= 196m2/s2

**a**=9.80m/s2

**d**=10.0m **v**2=**v**o2 + 2**ad v**=14.0m/s

**v**= ?

\*Note : I made down the (+) direction.

Okay, now some follow up questions for you. Use the results of the above calculations to solve.

(DO THESE ON A SEPARATE PAGE)

1. Find the initial kinetic energy (Ko) of the mass.

2. Find the final kinetic energy (K) of the mass (at 1.00m).

3. Find the initial gravitational potential energy (Ugo) of the mass.

4. Find the final gravitational potential energy (Ug) of the mass (at 1.00m).

5. Find the total initial mechanical energy (Ko + Ugo) of the mass.

6. Find the total final mechanical energy (K + Ug) of the mass.

**7. Compare your answers to 5 & 6.**

8. Find the change in kinetic energy (ΔK) of the mass.

9. Find the change in gravitational potential energy (ΔUg) of the mass.

**10. Compare your answers to 8 & 9.**

Hopefully we have noticed something. When the mass is dropped it falls down and gains kinetic energy while losing gravitational potential energy. The amount of lost potential energy is equal to the gained kinetic energy. The other thing to notice is that the total mechanical energy is the same at the beginning and the end.

Consider the next example:

**EX2:** A 680g mass is thrown straight upward at 16.0m/s. Answer parts a. through d. using kinematics:

a. Find the speed of the mass after it has risen 6.00m

b. Find the speed after it has risen 8.00m.

c. Find the speed after is has risen 10.0m.

d. Find the maximum height reached by the mass.

Use the answers from a. through d. to solve the following.

e. Find the initial kinetic energy of the mass.

f. Find the kinetic energy at 6.00m, 8.00m, 10.0m and at maximum height.

g. Find the initial gravitational potential energy.

h. Find the gravitational potential energy at 6.00m, 8.00m, 10.0m and maximum height.

i. Find the total mechanical energy at 0.00m. 6.00m, 8.00m, 10.0m and at maximum height.

j. Find the change in gravitational potential energy from 6.00m to 10.0m.

k. Find the change in kinetic energy from 6.00m to 10.0m.

Use the space below to answer:

Hopefully we have noticed something again. As the mass rises and slows down it loses kinetic energy and gains gravitational potential energy. The amount of lost kinetic energy is equal to the gained gravitational potential energy. So in both of the examples we should see that the energy simply changes from on from to another. The total mechanical energy (E, the sum of the K and U ) is the same at the beginning and the end, and at all points in between.

This is true if the only forces present are CONSERVATIVE FORCES (gravity, electrostatic, magnetic, spring). If there are NON-CONSERVATIVE FORCES (friction, normal, tension…)the total energy of the object may change as we will see.