**Year 10 Physical Science Week 5 and 6**

**Work, Energy and Transformations**

**Objectives:**

* Define energy as the ability to do work
* The unit of measurement for energy is the Joule (J)
* Define work as the energy transformed during an action, frequently one of the energy forms produced is heat

W = F s = m a s = m g h = ∆E

* Realise that work is a type of energy
* Define kinetic energy and use the kinetic energy formula 
* Define gravitational potential energy as the energy required to change the position of an object relative to the earth and use the potential energy formula 
* State that energy can be transformed without loss
* Apply energy transformation to simple situations
* Use calculations to solve energy transfer problems for pendulums and falling object problems (Ep lost = Ep gained)
* Qualitative description of efficiency (heat loss)

**Work**

Work is done when a force (in Newtons) moves an object over a distance (in metres) in the direction of the force. So when, for instance, you push your baby brother or sister in a pram around the shops, you make the pram move and you therefore do work. If you push on something and do not move it, for instance a brick wall, no matter how much force you exert no work is done. Therefore:

Where:

W = F s

* W is work measured in joules (J)
* F is force measured in newtons (N)
* s is displacement measured in metres (m)

Example 1

If we were to push the family car along the driveway into the garage, a distance of 12.0 m, by applying a constant horizontal force of 2.50 x 102 N, the work done is:

s = 12.0 m W = Fs

F = 250 N W = 250 x 12

W = 3000 = 3.00 x 103 J

Example 2

What work is required to lift a 5.00 kg bag of potatoes from the floor to a shelf 1.50 m above the ground?

F = mg

= 5.00 x 9.8

= 49 N

s = 1.50 m

W = F s

W = 49 x 1.50

W = 73.5 J

**Energy**

Work and energy are related. Energy can be defined as the ability or capacity to do work. Whenever work is done, some energy is transferred from one object to another. The unit of energy is the same as that of work, namely the joule (J).

**Kinetic Energy**

Kinetic energy is the energy an object has because it is moving. A moving bus has kinetic energy whereas a stationary bus does not.

The kinetic energy is defined as the amount of work it could do in coming to rest. The faster an object moves, the greater its kinetic energy. Also the greater the mass of the object, the greater its kinetic energy.

Where

EK = ½ m v2

* EK is kinetic energy measured in joules (J)
* m is mass measured in kilograms (kg)
* v is velocity measured in metres per second (m s-1)

Example 3

A car of mass 1.50 tonne is moving at 20.0 ms-1. What is its kinetic energy?

Ek = 0.5 mv2

= 0.5 x 1500 x (20)2

= 3.00 x 105 J

**Gravitational Potential Energy**

A car at the top of a hill has energy because of its position. If allowed to roll down the hill, the car could do work because it could exert a force on another object and hence move it. We call the energy an object has because of its height above Earth, its (gravitational) potential energy.

EP = mgh

Ep = potential energy (J)

m = mass (kg)

g = acceleration due to gravity (ms-2)

h = height above earth (m)

Example 4

What is the potential energy of a small car of mass 1.00 x 103 kg at the top of a hill of height 50.0 m?

Ep = mgh

= 1000 x 9.8 x 50

= 4.90 x 105 J

**Law of Conservation of Energy**

Kinetic energy and potential energy are usually classified as types of mechanical energy. There are many other types of energy, such as chemical, heat, light and sound.

The amount of energy within a system is constant in all conversions and this is stated in the Law of Conservation of Energy:

Energy is neither created nor destroyed,

but can be readily converted from one form to another.

Chemical energy in a car is burned (thermal energy) and turned into kinetic energy. Other energies involved in this system are light and sound energy released during the explosion of fuel. All of these energies together add up to the original energy in the fuel.

**Energy transformations between kinetic and potential energy**

A car at the top of a hill has potential energy. If it starts to roll it loses potential energy and starts to gain potential energy. By the time it reaches the bottom of the hill it has lost all its potential energy and gained it as kinetic energy (for this section we will ignore other forms of energy involved e.g. heat from friction).

Ep lost = Ek gained

mgh = 0.5 mv2 masses cancel so

gh = 0.5 v2

Example 5

A ball is thrown into the air with an initial velocity of 15.0 ms-1. What is the maximum height it can reach?

gh = 0.5 v2

h = 0.5 x (15)2

9.8

h = 11.5 m

**Efficiency**

In all practical energy transformations, a fraction of energy is lost as it is converted from one type to another. For example, when a ball is dropped from a height it does not bounce back to the height it was dropped from. The ball has lost some of its potential energy to heat energy which is a less useful form of energy. The effectiveness with which one kind of energy is transformed to another is called *efficiency.* Some forms of energy easily transform into other forms with a high efficiency – these are called *high grade energy forms* e.g. mechanical, chemical, solar and electrical. Forms of energy that transform into other forms of energy with a low efficiency are called *low grade energy forms e.g. heat.* All forms of energy eventually end up as low grade thermal energy which will be of little use.

Efficiency can be calculated using the following formula:

Efficiency =  x *100%*

**Questions**

1. Two boys are using a force of 1.00 x 102 N to move a bed 3.00 m across a bedroom. What is the work done?

s = 3.00 m W = Fs

F = 100 N W = 100 x 3

W = 300 = 3.00 x 102 J

1. If the mass of the AK47 bullet is 7.95 g, calculate the kinetic energy of the bullet as it emerges from the barrel at 701 m s-1.

m = 7.95 g Ek = 0.5 mv2

= 0.00795 kg = 0.5 x 0.00795 x (701)2

v = 701 ms-1 = 3.91 x 103 J

1. A man is running at 5.00 ms-1 and using 937 J of energy, what was his mass?

Ek = 937 J Ek = 0.5 mv2

= 0.00795 kg 937 = 0.5 x m x (5)2

v = 5.00 ms-1 m = 937 ÷ 12.5

= 74.96 = 75.0 kg

1. A ball is thrown into the air. Just before it starts its downward journey (velocity equal to zero) it is at a height of 2.50 m above the ground. If it has a mass of 0.500 kg, what is its potential energy?

m = 0.500 kg Ep = mgh

g = 9.8 ms-2 = 0.5 x 9.8 x 2.5

h = 2.50 m = 12.2 J

1. A girl is on a diving board 3.00 m above the water below. With what velocity will she hit the water when she dives?

h = 3.00 m Ep lost = Ek gained

g = 9.8 ms-2 mgh = 0.5 mv2 masses cancel so

gh = 0.5 v2

9.8 x 3 = 0.5 v2

v2 = 29.4 ÷ 0.5

v =

= 7.67 ms-1 down

1. A car has an initial velocity of 90.0 kmh-1 when it slows to 54.0 kmh-1 in 2.30 s. If the car has a mass of 8.00 x 102 kg, what work was done in slowing the car down?

m = 800 kg W = ΔE

u = 90 kmh-1 = 25 ms-1  = ⏐0.5mv2 – 0.5mu2⏐

v = 54 kmh-1 = 15 ms-1 = ⏐(0.5 x 800 x 152) – (0.5 x 800 x 252)⏐

= ⏐90000 – 250000⏐

= 1.60 x 105 J