ENERGY

Definition

Energy can be defined as:

1) The ability to get things done or to make things go.
2) The capacity to perform work.

Types of Energy

There are many types of energy:

- Heat energy
- Electrical energy
- Stored energy (chemical energy and potential energy are stored energies)
- Kinetic energy (the energy of moving objects
- Sound energy
- Nuclear energy
- Light
- Mechanical
- Magnetic

Sources of Energy

The sun is our most important source of energy. Without it plants would not be able to photosynthesise and make food that we rely on to live. The energy stored in food is stored energy.

Most of the energy we use to generate electricity comes from

(1) Coal,
(2) Oil,
(3) Natural gas,
(4) Water (hydroelectric)
(5) Nuclear fuel.

It is interesting to note that oil and natural gas were all formed from living organisms that died millions of years ago so without the sun they were would not be in existence either. The use of these traditional fuels can be quite harmful to the environment.

Discussion

Discuss some of the effects of using fossil fuels, water and nuclear fuels on the environment, including the Green House Effect.

DANGERS OF COMBUSTION

Combustion produces carbon dioxide, which contributes to the Greenhouse effect. It also produces sulphur dioxide and nitrogen oxides. These gases cause acid rain which corrodes buildings, acidifies waterways and kills wildlife. Leaded petrol releases dangerous lead compounds into the atmosphere.

The following have been done to reduce the harmful effects of burning petrol. Carbon monoxide gas is released during combustion; carbon monoxide is poisonous. It has a greater affinity to haemoglobin than oxygen and thus replaces oxygen in the blood and tissues.

Some alternative sources of energy are far more environmentally friendly and include:

(1) Solar,
(2) Wind,
(3) Geothermal energy
(4) Waves

Conservation of Energy

The law of conservation of energy states that:
Energy cannot be created or destroyed but it can be converted from one form to another.

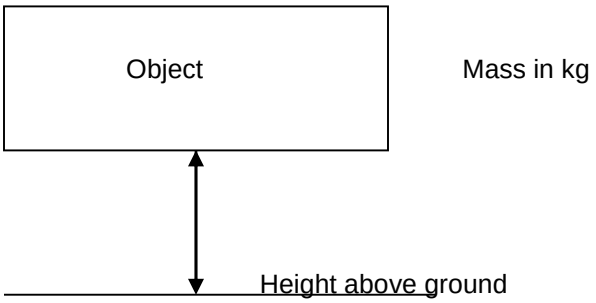
Energy Converters

Many household appliances change energy from one form to another. They are called energy converters or transducers. When energy is converted none is lost or gain even though some can be wasted (converted to a form which is not useful to us).

Examples

I
Car converts chemical energy in the petrol into mechanical energy to move the car.
However over 70% of this energy converted is wasted as heat energy in the radiator and the exhaust.
More energy is also lost due to friction in various moving parts of the car.
In general only 12% of the original energy is converted to move the car.

II



When an object is lifted against gravity work must be done. This work is stored in the lifted object. The higher the object is from its original position, the move energy it possesses.
When this object is then released the potential energy (stored energy) is converted to kinetic energy (moving energy).

III
A light bulb changes electrical energy into light and heat energy. This can be written as follows:
Electrical energy → light energy + heat energy

IV
A television: Electrical energy → light + sound + heat energy
A tractor: Chemical energy → kinetic + sound + heat energy.

In examples III and IV, heat energy is wasted energy.
A lot of money is spent on energy sources (fossil fuels). This is why energy conservation is essential in our homes and industries.

DISCUSSION

1. Why do you think humans need to reduce their reliance on fossil fuels?
2. What ways can you save energy at home?

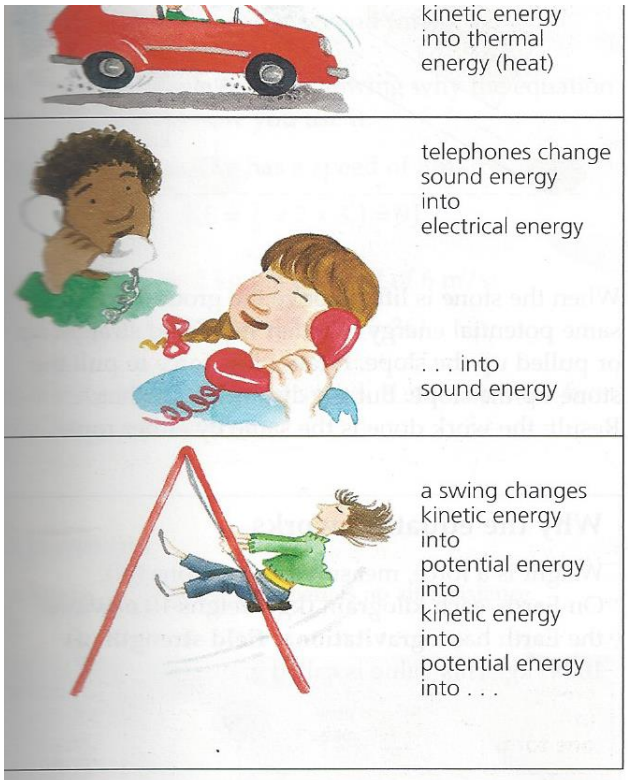
ENERGY CONSERVATION

- Turn off lights when they are not being used.
- Unplug appliances that are not in use.
- Do not leave the fridge door open unnecessarily.
- Use fluorescent lights instead of filament lights.
- If you are going to leave your computer for a short time, do not turn it off. More energy is required to boot up your computer than if you leave it on. Use the stand by or sleep mode instead.
- Energy efficient houses are being built which reduces the amount of fuel needed to be burnt to keep them warm.
- Cars are being fitted with catalytic converters which remove most of the sulphur dioxide and nitrogen oxides from exhaust gases.
- Energy efficient engines burn less fuel.
- Unleaded gasoline eliminates the release of lead compounds into the atmosphere.
- In some Latin American countries cars are being powered by a mixture of gasoline and ethanol.

Questions

1. What energy changes occur in the following devices?
   a TV set, a light bulb, an electric kettle, an electric motor, and atomic bomb, a candle.

2. Photosynthesis is a special type of energy converting process. What is the energy of photosynthesis? What type of energy is produced from photosynthesis? Why is photosynthesis one of the most important energy changing processes on earth?

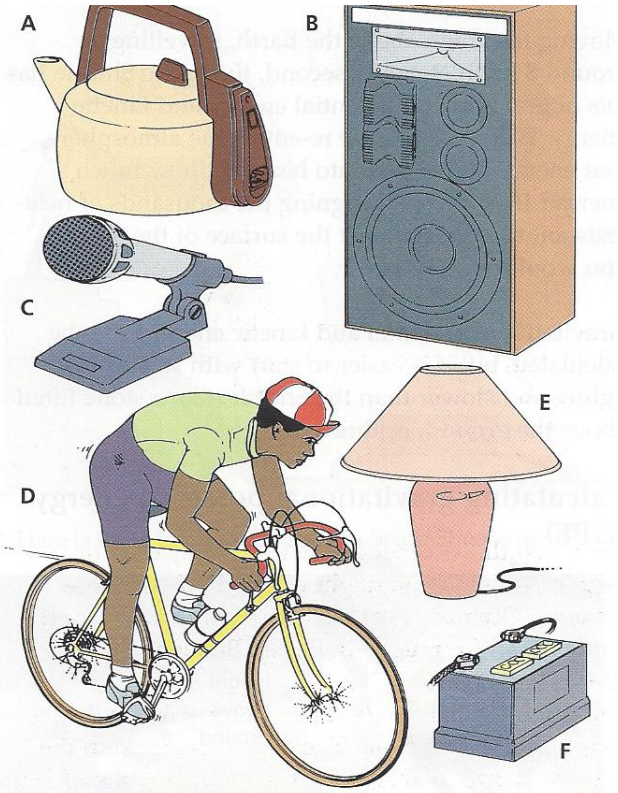


kinetic energy into thermal energy (heat)

telephones change sound energy into electrical energy

. . . into sound energy

a swing changes kinetic energy into potential energy into kinetic energy into potential energy into . . .



Questions

1 Which of the energy converters above right:
- a changes CHEMICAL energy into KINETIC energy?
- b changes ELECTRICAL energy into THERMAL energy?
- c changes CHEMICAL energy into ELECTRICAL energy?
- d changes ELECTRICAL energy into RADIATED energy?
- e changes ELECTRICAL energy into SOUND energy?

2 A pole-vaulter has 3500J of energy when he crosses a bar 7 metres high. How much kinetic energy will he have just before he reaches the ground (assuming no friction)?

3 This is an unusual way of describing the first half hour of someone's day:

gets up at 7:00 a.m.
gains chemical energy
gains thermal energy
leaves house
kinetic energy rises
jumps on vehicle
gravitational potential energy rises
kinetic energy rises
kinetic energy fall to zero
gravitational potential energy falls to zero

Rewrite, to show what could actually be happening to the person.

Definition

Potential Energy (P_E)

The potential energy of the body is the energy it possesses because of its position or state. We can calculate potential energy by using the formula:

P_E = mass × gravity (gravitational field strength) × vertical height
P_E = mgh

Where m = kg
g = N/kg
h = m

Units of P_E = Joules (J)

Example:

A stone of mass of 200g is lifted 5m above the ground. Calculate its potential energy given that g is equal to 10 N/kg

m = 200g h = 5m g =10 N/kg

$m = \frac{200}{1000} = 0.2kg$

$P_E = mgh$
$= 0.2 \times 5 \times 10$
$= 10J$

Kinetic Energy (K_E)

Kinetic Energy is the energy a body possesses because of its motion.

K_E = ½ mass x velocity squared OR ½ mass x velocity x velocity
$= ½ mv^2$

Where m is in kg and v is m/s or ms^{-1}

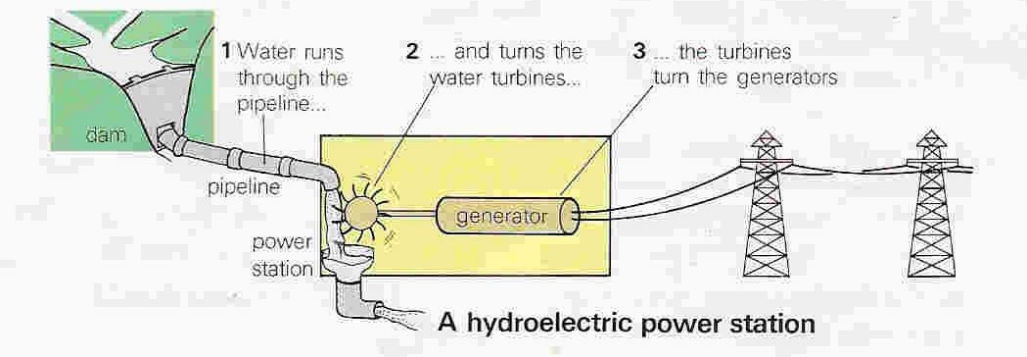
Example:

A rock of mass 3kg has a speed of $6ms^{-1}$. Calculate its K_E (m = 3kg).

K_E = ½ mass × velocity squared
$= ½ \times 3 \times 6^2$
$= ½ \times 3 \times 36$
$= 54J$

There are many examples of machines which convert potential energy into kinetic energy.
The stretched string of a bow possesses potential energy which is converted into kinetic energy of the moving arrow.

The water at the top of a waterfall possesses both potential energy and kinetic energy when it reaches the bottom all of this energy is converted to kinetic energy and it can be used to drive turbines to create electricity.



If these machines are frictionless than the P_E and the K_E are in a constant ratio. We can use the formula below to do calculations.

P_E last = K_E gained

$mgh = \frac{1}{2}\ mv^2$

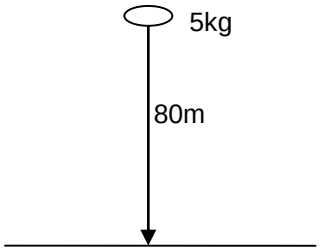
Example:

A stone has a mass of 5kg is dropped 80m given that gravity is equal to 10N/kg. Calculate:

a) PE of the stone
b) The velocity at which the stone will hit the ground

P_E lost = K_E gained

$mgh = 1/2\ mv^2$



a) PE = mgh
= 5 × 80 × 10
= 4000J

b) When the ball strikes the ground the potential energy was converted to KE

$4000 = 1/2\ mv^2$

$4000 = 1/2 \times 5 \times v^2$

$4000 = 2.5 \times v^2$

$v^2 = 4000/2.5$

$v^2 = 1600$

$v = \sqrt{1600}$

v = 40m/s

Fluid Friction

Liquid and gases are called fluids and they can also cause friction.
Example: When a car is travelling down the highway it experiences a resistance which increases with a speed (more speed, more air resistance).

Forces In-Balance

Most objects have several forces acting on them. Sometimes all the forces cancel out each other and the object behaves as if no force was acting on it at all.

Action and Reaction

No force exists by itself, forces always occur in pairs. One force acts on the object while the other is equal but is opposite to its partner.

This leads us into ***Newton's third law of motion***;

For every action there is an equal but opposite reaction.

OR

When Body A pushes on Body B then Body B pushes back on Body A, with an equal but opposite force.

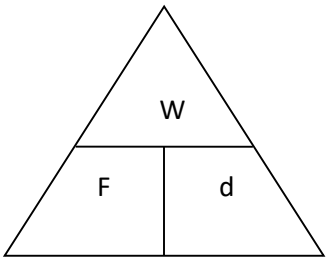
Examples: of pairs of forces.

As a skydiver freefalls the air resistance increases as the speed increases. Eventually the air resistance is going to stop accelerating and falls at a maximum speed. This speed is called Terminal Speed which is approximately two metres per second.

WORK AND POWER

WORK

Work is done whenever an object is moved by a force. We can measure the amount of work done by using the formula.



Work done = force × distance moved in the direction of the force

W = F × d
(where F is force measured in Newtons and d is the distance measured in one metre in a directions parallel to the force.)

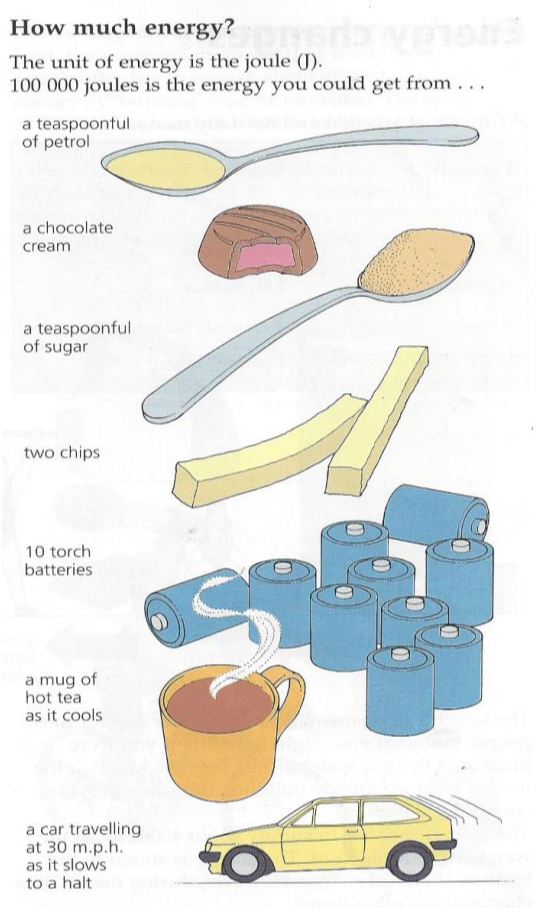
The unit of work is Joule (J).

Therefore 1J of work done when a force of 1N makes an object a distance of 1m. (in the same direction of the force) NB: 1J = 1Nm

Examples of doing work

a) If you lift an object vertically through a distance you have done work However if you stand still while holding the same object even though there are forces acting there is no movement. You will get tired after a while but you have done no work.
b) If you slide a box across the floor you are moving it against friction, hence you are doing work, however if you push against a wall, the wall would exert a resistance but there will be no movement hence no work is done.

1) Calculate the work done when a mass of 5kg is lifted 50cm.
2) Calculate the work done when a mass of 300g is lifted 150cm.
3) A lift of mass 250kg carries a man of mass 76kg, how much work is done by the wind rope which draws the lift through a height of 15m
4) A wind pump raises 2500N of water to the surface from 6m below the ground level. Find the work done by the pump.



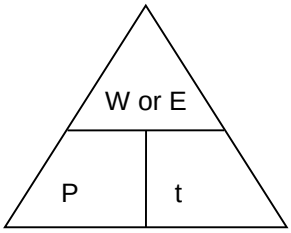
Questions

1 How much work is done when:
  a a 6N force moves 3m?
  b a 12N force moves 0.5m?
  c a 10N force moves 10mm?
2 In the 'How much energy?' chart above, which of the items have (or has):
  a CHEMICAL energy?
  b THERMAL energy?
  c KINETIC energy?
3 Which is likely to release most energy:
  a burning a canful of petrol, or dropping it?
  b catching a falling apple, or eating it?

POWER

Power is the rate of doing work. When we speak about power we mean how quickly work is done. Since work done is equal to energy transferred. We can also define power as the rate energy is transferred.

We can calculate power by using the formula:



Power = Work done or Energy /time

$P = W/t$

Where work done or Energy in Joules (J)
time (t) in seconds

Units of power = Watts (W)

1 watt is the power generated when 1 joule of work is done in 1 second.

Example

A forklift truck can lift a load 315kg to a height of 2m in 20 seconds.
Calculate (a) the work done
(b) the power of the forklift

Mass = 315kg Distance = 2m Time = 20s

a) Work done = force × distance
Weight of load = mass × gravity
= 315 × 10
= 3150N
Work done = 3150 x 2 =6300 J

b) Power = $\frac{\text{Energy}}{\text{time}} = \frac{6300}{20} =$ 315 W

QUESTIONS

1. I can raise a bucket of cement mix of mass 12 kg through a vertical height of 8 m in 10 seconds. Calculate the power used in raising the bucket against the gravitational force.
2. Student A pedaled an exercise bicycle against a force of 100 N for 2 min. During this time the pedals turned 100 times. The pedals were 20 cm long. Student B ran upstairs. She weighed 60 kg. She climbed 5 m in 10 s.
   (a) Who was the more powerful?
   (b) Who would be able to keep up this rate of energy transfer the longest?
3. A builder carries 24 bricks to the top of a 3m wall. Each brick weighs 25 N.
   (a) How much energy is transferred to the bricks?
   (b) In what form is this energy after transfer?
   (c) If the builder weighs 800 N and takes 15 s, calculate the power that he delivers.
   A motor driven conveyor is an alternative way of carrying the bricks to the top of the wall. The conveyor produces 1000 W or useful output.
   (d) How long would it take the conveyor to lift the bricks?
   (e) Which is the better way of lifting the bricks? Why?