Trilogy Higher– Energy (page 1)

START

Energy Store	Examples
Thermal	Any hot object
Magnetic	Two magnets held close together
Electrostatic	Charge build-up on a balloon
Kinetic	Any moving object
Gravitational potential	Objects that are raised up
Elastic potential	Stored in Springs, bungee chord
Chemical	Stored in fuels & batteries
Nuclear	Stored in the nuclei of atoms

The law for the conservation of energy states that energy cannot be created or destroyed, only transferred from one type into another.

E.g. A lightbulb:

60J electrical energy →  → 40J thermal energy; → 20J light energy

Joules (J) are the units of energy

Energy is transferred **mechanically** (by a force doing work), **electrically** (work done by moving charges), by **heating,** or by **radiation** (light or sound)

Elastic Potential energy is energy stored in a stretched spring – it depends on the spring constant (stiffness of the spring) & how much the spring is stretched (the extension)

Elastic potential energy = 0.5 x spring constant x (extension in m)^2

E.g. A spring has a spring constant of 500N/m. How much energy is stored when it is stretched 10cm.

$E_K = ½ke^2 = ½ \times 500 \times 0.1^2$
$= 250 \times 0.01 = \underline{2.5J}$

Rollercoaster Energy Transfers

Dropping down: Gravitational potential energy is transferred into kinetic energy

Going back up: Kinetic energy is transferred back into gravitational potential energy

Gravitational Potential Energy is energy stored in an object because of its height above the ground.

To work out how much GPE an object gains when it is lifted up we would use the simple equation…

GPE = mass (kg) × gravitational field strength × height (m)

E.g. How much GPE does a 50kg person have when lifted up 0.5m by a friend. On Earth g=10N/kg

$E_P = mgh = 50 \times 10 \times 0.5 = \underline{250J}$

Key words:

1. **System** – an object or group of objects
2. **Potential Energy** – Energy stored in a system
3. **Conservation of Energy** – the rule that states the total amount of energy stays the same in a closed system
4. **Efficiency** – the proportion of the energy supplied that is transferred usefully
5. **Dissipated** – when energy is wasted & 'lost', usually as heat
6. **Work** – the transfer of energy
7. **Power** – the rate of doing work/transferring energy
8. **Energy Resource** – a way of getting energy for generating electricity
9. **Renewable** – a resource that can be replaced (eg. Wind)
10. **Non-renewable** – a resource that cannot be replaced (eg. Coal)
11. **Fuel** – a concentrated store of energy
12. **Fossil fuel** – a fuel made from the remains of living things

When a system changes, energy is transferred.

- When energy is used it is transferred from one type to another we say that **Work** is done.
- The amount of Work (in Joules) is equal to the amount of energy transferred (in Joules)
- Whenever a force is applied to move an object (eg. Lifting a box), work has to be done.

Kinetic energy is energy an object has because it is moving – it depends on the object's speed & mass.

Kinetic energy= 0.5 x mass x(speed)^2
in J, in kg, in m/s

E.g. A bike at a speed of 10m/s. If the mass of the bike & rider is 80kg what is their kinetic energy?

$E_K = ½mv^2 = ½ \times 80 \times 10^2$
$= 40 \times 100 = \underline{400J}$

Power is the rate of doing work/transferring energy – measured in **Watts (W)**.

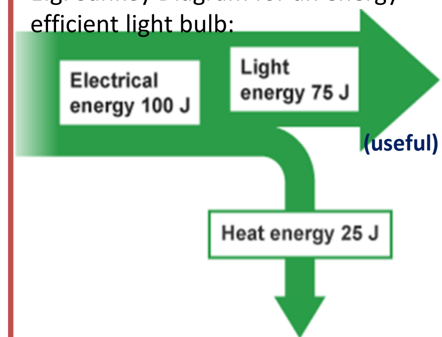
$$Power = \frac{Energy\ (or\ Work)}{Time}$$

E.g. What is the power of an electric fire that transfers 10,000J of energy in 5 seconds?

P = E/t = 10,000/5 = <u>2000W</u>

The efficiency of a system can be increased by reducing the amount of wasted energy (usually heat) by lubricating moving parts with oil to reduce friction or by insulating the device to stop heat being lost to the surroundings.

E.g. Sankey Diagram for an energy efficient light bulb:



Efficiency is a measure of how much of the energy supplied to a device is transferred into useful energy.

An energy efficient light bulb transfers 10J of electrical energy into 8J of light energy every second. Calculate its efficiency.

$$efficiency = \frac{useful\ energy\ out}{total\ energy\ in} \times 100\%$$

= 8/10 x100%
= 0.8 x100 = 80%

Also

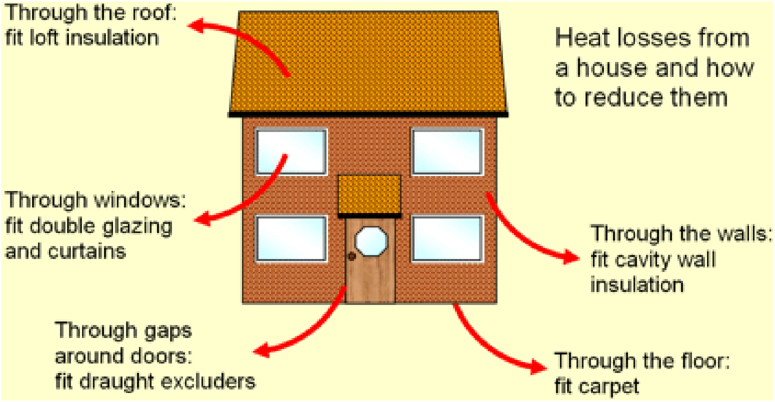
$$efficiency = \frac{useful\ power\ out}{total\ power\ in} \times 100\%$$

Insulation reduces the rate of energy transfer by heating

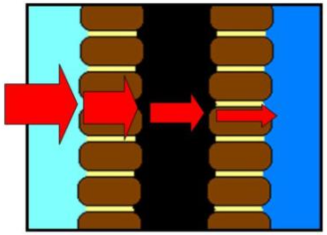
Thermal conductivity describes how well a material conducts heat. To insulate a house, it is a good idea to build it from materials that have a low thermal conductivity.
The thicker the walls or the layers of insulation the lower the thermal conductivity

The higher the **thermal conductivity** of a material, the higher the rate of energy transfer through it. Still air has a low thermal conductivity so the rate of heat transfer through it is low. This means it is a good **insulator**

Where is heat lost from the home & how do we stop it?



1. Cavity Walls



Most outside walls have an empty space between the 2 layers of bricks called a *cavity*.

This reduces heat loss by *conduction* through the bricks.

How does a cavity wall prevent heat loss from a home?

Heat energy reaches the interior wall

The heat energy is conducted through the wall

The air cavity between the two walls in a cavity wall acts as an insulator and reduces heat loss by conduction

What is specific heat capacity ?

Energy = specific heat capacity x mass x change in temperature
(J) (J/kg/ ^{0}C) (kg) (^{0}C)

If you calculate how much energy 1kg of water needs to become 1^{0}C hotter, you will find it needs 4200J. This number is called the specific heat capacity of water.

The specific heat capacity of a substance is the amount of energy that is needed to raise the temperature of 1kg of the substance by 1^{0}C.

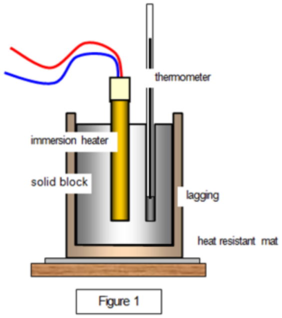
Copper is used for pans has it has a very low specific heat capacity, and hence warms up very fast.

Water has a high specific heat capacity, and hence it takes a lot of energy to heat up the water for a bath. And also very expensive – take a shower!!!

E.g. How much energy is needed to heat 2kg of water from 10 ^{0}C to 30 ^{0}C?

Energy needed = mcΔθ
= 4200 x 2 x 20
= <u>168000 J</u>

Using Specific Heat Capacity to Calculate the Energy Gained by a Block



1. Use a top-pan balance to measure the mass of the block.
2. Set up the apparatus as shown in the diagram.
3. Use the thermometer to measure the initial temperature of the block.
4. Attach the Immersion heater to the power pack set at 12V and switch on.
5. After 5 minutes switch the power pack off and measure the final temperature of the block.

CAUTION – THE HEATER & BLOCK WILL GET HOT!

Material	S.H.C (J/kg/°C)	Mass (kg)	Initial Temp. (°C)	Final Temp. (°C)	Temp. change (°C)	Energy gained (J)

Trilogy Higher Energy (page 2)

Energy Resources

Type Of Power	Advantages	Disadvantages
Coal	Cheap to use High power output Can be used easily Large reserves still available	Lowest energy density of fossil fuels Non-renewable High CO_2 and SO_2 emissions Contribute to the enhanced greenhouse effect
Oil	Convenient in some oil producing countries Can be used in engines	Medium energy density Non-renewable High CO_2 and SO_2 emissions Contribute to the enhanced greenhouse effect
Natural gas	High energy density Cleaner and more efficient than other fossil fuels Can be used in engines	Medium CO_2 emissions Non-renewable Contribute to the enhanced greenhouse effect
Nuclear	High power output Reserves available	Expensive to build and run Radioactive materials have to be disposed of Possible nuclear accident
Passive solar	No fuel costs Renewable Non-polluting	Only works in daylight Not efficient when clouds present Power output is low
Photovoltaic solar	No fuel costs Renewable Non-polluting	Only works in daylight Not efficient when clouds present Power output is low Initial costs high Energy needs to be stored
Hydro-electric Tidal	No fuel costs Renewable Non-polluting	Need correct location Changes in the environment destroys ecosystems and can displace people Expensive to construct
Wind	No fuel costs Renewable Non-polluting	Need a windy location Power output is low Environmentally noisy High maintenance costs due to metal stress and strain
Wave	No fuel costs Renewable Non-polluting	High maintenance due to the power of waves High establishment costs.

Non-renewable energy resources are reliable . Some renewable energy resources, eg. wind, are not reliable because they don’t give a controllable or predictable energy output.

The three main uses of energy resources are for generating electricity, heating and transport

1. Write down five energy stores.
2. What energy store is energy transferred into when you compress a spring?
3. Describe the energy transfers when an electric kettle heats water.
4. Describe how energy is transferred as an apple falls to the ground.
5. Describe how energy is transferred when a firework flies into the air and explodes.
6. Describe the energy transfers when an object is accelerated by a constant force.
7. Describe the energy transfers when a vehicle slows down by using its brakes.
8. What is the equation for calculating the amount of energy in an objects kinetic energy store
9. What is the definition of specific heat capacity?
10. Describe an experiment to find the specific heat capacity of a material.
11. What is the Principle of Conservation of Energy?
12. What is the equation for calculating power?
13. True or false: A high thermal conductivity means there is a high rate of energy transfer
14. List the 4 non-renewable energy resources and four renewable resources.
15. What sort of energy resources are more reliable?
16. What is the equation for efficiency?