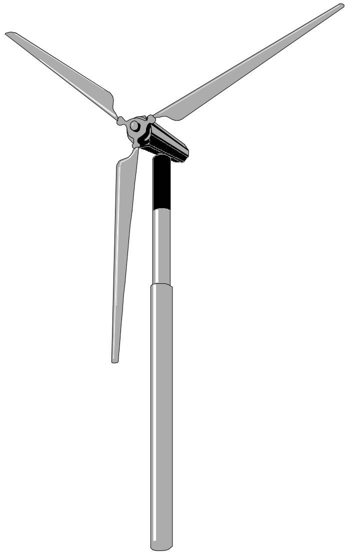
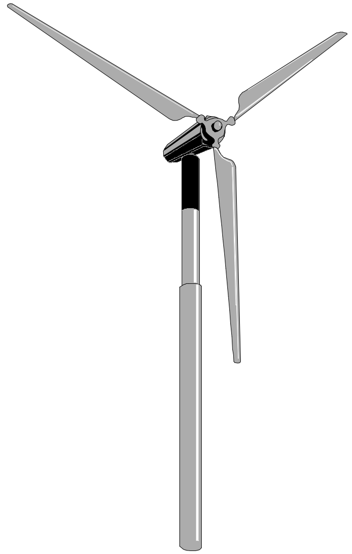
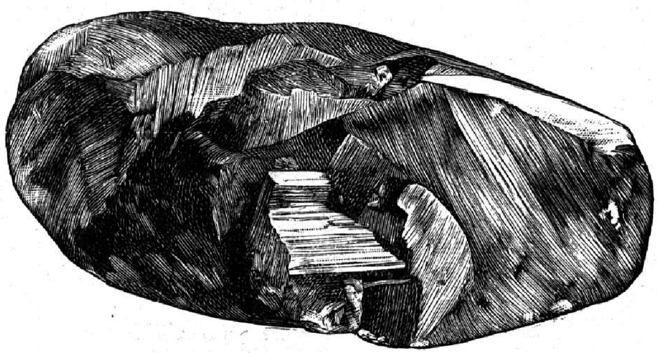
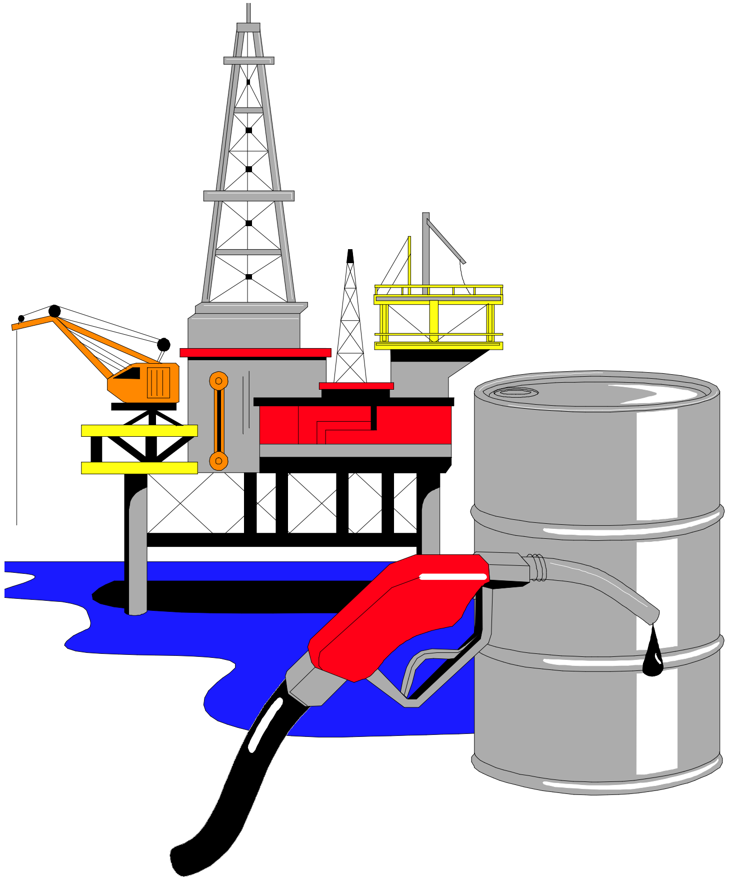
Standard Grade Physics

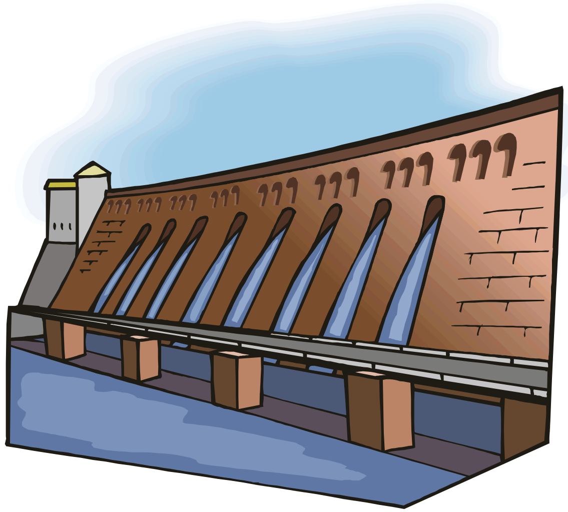


"ENERGY"









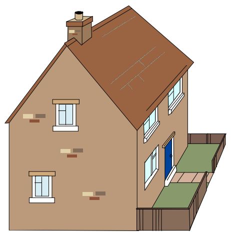
Name: ______________________________ **Class:** ______ **Teacher:** ______________________

Section 1: SUPPLY and DEMAND

• Conserving (Saving) Energy

- The more **energy** we use, the more **money** it costs us.
- Where we will get **energy** from in the future is very uncertain.

For these reasons, it is important that we **conserve** (**save**) **energy** - We should use as little as possible and try not to waste it.



How we can conserve (save) energy **at home**:

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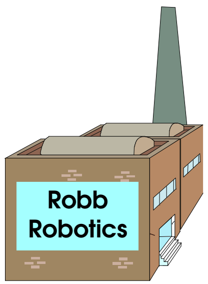

How we can conserve (save) energy **in industry**:

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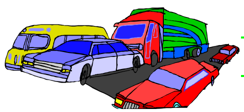

How we can conserve (save) energy **in transport**:

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• Non-Renewable Sources of Energy

Fossil fuels and **nuclear fuels** (used in **nuclear power stations**) are **non-renewable** sources of energy - Their reserves are **finite**.

Finite means ______________________________

____

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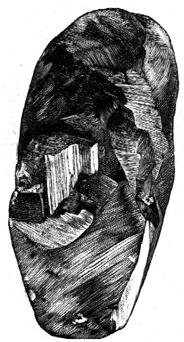
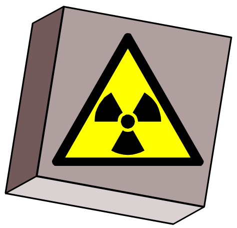
Fossil Fuels

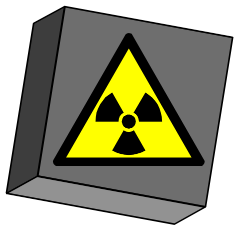


- c _ _ _
- o _ _
- n _ _ _ _ _ _ g _ _
- p _ _ _

At present, **fossil fuels** are our **main source of energy**.

Nuclear Fuels



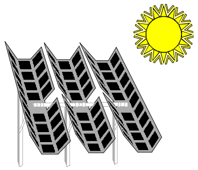
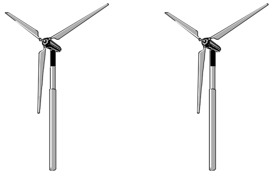
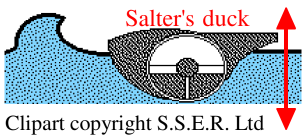
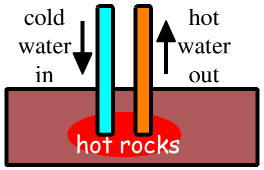
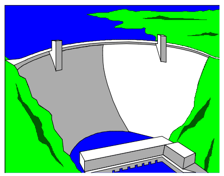


- u _ _ _ _ _ _
- p _ _ _ _ _ _ _ _

• Renewable Sources of Energy

Renewable sources of energy **will not run out** - They are being **constantly replaced** by **nature**.

For example:

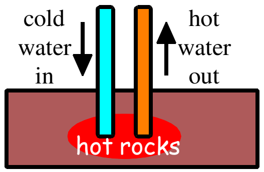
Renewable Energy Source	Advantages	Disadvantages
 **solar energy** 1) **Light energy** from the **sun** is converted to **electrical energy** by **solar cells**. 2) **Heat energy** from the **sun** heats **cold water** running through **solar panels**.		
 **wind energy** The wind pushes the blades of **wind turbines** round, giving them **kinetic (movement)** energy. The **wind turbines** change the **kinetic energy** to **electrical energy**.		
 Clipart copyright S.S.E.R. Ltd **wave energy** Waves on the sea cause devices called **Salter's ducks** to rock continuously up and down, giving them **kinetic (movement) energy**. The **Salter's ducks** change the **kinetic energy** to **electrical energy**.		
 **geothermal energy** In countries like Iceland where there are many **hot underground rocks**, **cold water** is pumped down into the **hot rocks**. The **cold water** is heated by the **hot rocks**. The **hot water** produced is pumped up to the surface.		
 **hydro-electric** In **mountain areas** where there is a **high rainfall**, **dams** are built to store water. Running some **stored water** down the dam over **turbine blades** gives them **kinetic (movement) energy**. They **turbine blades** turn a **generator** which changes the **kinetic energy** to **electrical energy**.		
 **biomass** **Plants** are grown then harvested. The **plant material** can be **burned** or **turned into alcohol** which can also be **burned**.		

• Classifying Renewable and Non-Renewable Energy Sources

A number of **energy sources** are shown below.

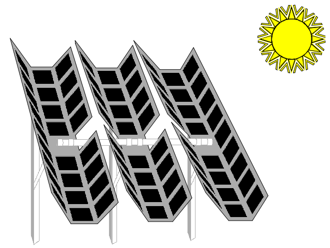
Name each **energy source** and classify it as **renewable** or **non-renewable** by joining it with a ***line*** to the correct ***star*** :

• p _ _ _

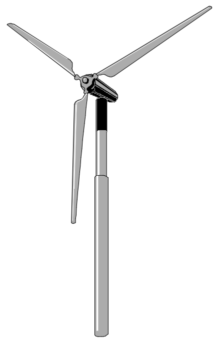


• g _ _ _ _ _ _ _ _ _ _
_ _ _ _ _ _ _

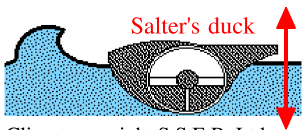
renewable energy sources



• s _ _ _ _
_ _ _ _ _ _ _



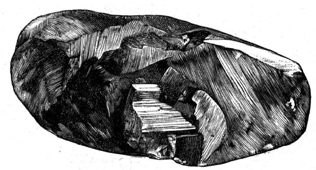
• w _ _ _
_ _ _ _ _ _ _



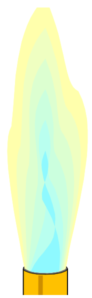
• w _ _ _
_ _ _ _ _ _ _

non-renewable energy sources

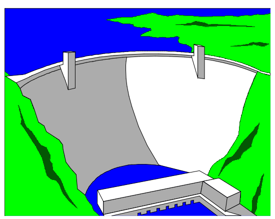
• o _ _



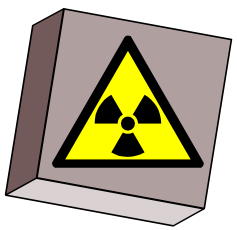
• c _ _ _



• n _ _ _ _ _ _ _
g _ _



• h _ _ _ _ - _ _ _ _ _ _ _ _ _



• n _ _ _ _ _ _ _
_ _ _ _

• b _ _ _ _ _ _ _

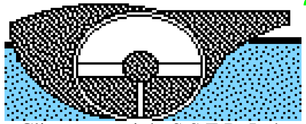
• Typical Energy Supply and Demand Calculations

1) One wind turbine generates 300 000 joules of electrical energy every second.

(a) How much electrical energy would be generated every second by 5 identical wind turbines?

(b) How much electrical energy would these 5 identical wind turbines generate in 1 minute?

(c) How many identical wind turbines would be needed to generate 9 000 000 joules of electrical energy every second?



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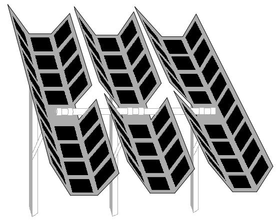
2) A 1 kilometre length of Salter's ducks (wave energy converters) is spread along a coastline. Every second, the ducks generate a total of 4 000 000 joules of electrical energy.

(a) Assuming identical sea conditions, how much electrical energy would be generated every second by a 3 kilometre length of Salter's ducks?

(b) How much electrical energy would be generated by the 3 kilometre length of Salter's ducks in 5 minutes?

(c) If 1 000 000 joules of electrical energy can be sold for 2.5 pence, how much money could the 3 kilometre length of Salter's ducks earn in 5 minutes?



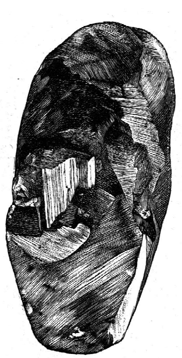
3) During daylight hours, Mrs. Smith's home requires an average of 10 000 joules of electrical energy every second. She considers fitting solar cells in her large garden to provide this energy. A 1 metre^2 area of solar cells will produce an average of 500 joules of electrical energy every second. The cost of solar cells is £750 per metre^2.

(a) What area of solar cells would Mrs. Smith need to fit in her garden in order to supply all her electrical energy needs during the day?

(b) How much would this cost?

(c) Mrs. Smith's daytime electrical energy costs are £500 per year. How many years of "free" daytime electrical energy from the solar cells would it take to cover their cost?

4) When burned, 1 kilogram of coal releases 2 800 000 joules of heat energy.



(a) In a small furnace, 1.5 kilograms of coal is burned every second. How much heat energy is released in the furnace during this second?

(b) What mass of coal would be burned in the furnace in 1 hour?

(c) If coal costs £0.05 per kilogram, how much does it cost to run the furnace for 1 hour?

5) Burning peat releases 2 000 000 joules of heat energy per kilogram.

(a) 5 000 000 joules of heat energy was given out by a peat fire. What mass of peat was burned?

(b) If 1 kilogram of peat costs £1.50, how much did the peat for the fire in part (a) cost?

(c) On average, it takes a peat fire 15 minutes to burn 1 kilogram of peat. For what time was the peat fire in part (a) lit?

6) In Brazil, sugar cane is harvested then turned into alcohol.

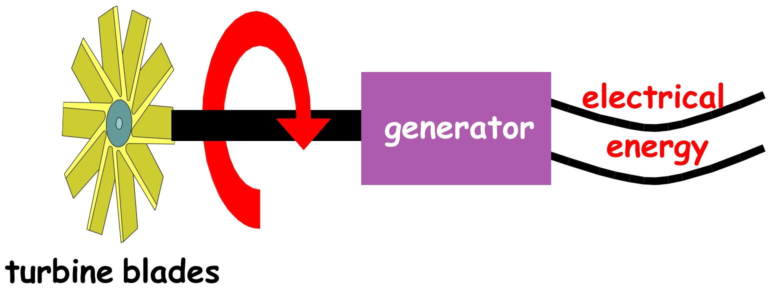
(a) If 1 acre of land can produce 5 000 kilograms of sugar cane, how many acres are required to produce 100 000 kilograms of sugar cane?

(b) If 100 acres of sugar cane can yield 25 litres of alcohol, how many acres of land are required to produce enough alcohol to fill the 100 litre fuel tank of a truck?

(c) If 1 litre of alcohol releases 500 000 joules of heat energy when burned, how much heat energy will be released by burning the 100 litres of alcohol in the truck's fuel tank?

Section 2: Generation of Electricity

In a power station, **electrical energy** (**electricity**) is generated when large metal turbine blades are turned by something hitting them. The turning turbine blades turn a generator which changes the **kinetic** (**movement**) energy to **electrical energy**.

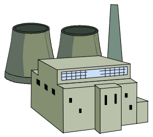


The turbine blades and generator are the size of a large room.

The **energy change** in the generator is:

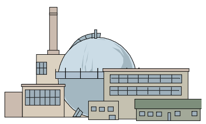
__________ → __________

Thermal Power Stations



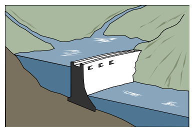
These burn **f _ _ _ _ _ fuels**. The **h _ _ _ energy** released boils water in a **boiler**. **S _ _ _ _** is produced and this hits the **t _ _ _ _ _ _ blades**, making them **t _ _ _**.

Nuclear Power Stations



In a **n _ _ _ _ _ _ r _ _ _ _ _ _ _**, **nuclear reactions** produce **h _ _ _ energy** which boils water in a **boiler**. **S _ _ _ _** is produced and this hits the **t _ _ _ _ _ _ blades**, making them **t _ _ _**.

Hydro-Electric Power Stations



These **do not** boil water to produce **s _ _ _ _**. **Water** falls from a great height down a **dam** and hits **t _ _ _ _ _ _ blades** at the bottom of the **dam**, making them **t _ _ _**.

Thermal Power Station

boiler → **turbine** → **generator**

C _ _ _ _ _ _ _ energy in a fossil fuel is changed to **h _ _ _ energy** as the fuel burns.

Moving steam (**k _ _ _ _ _ _ energy**) hits **turbine blades**, giving them **k _ _ _ _ _ _ energy**.

As **generator** is turned, **k _ _ _ _ _ _ energy** is changed to **e _ _ _ _ _ _ _ _ _ energy**.

Nuclear Power Station

nuclear reactor → **turbine** → **generator**

N _ _ _ _ _ _ energy in **nuclear fuel** is changed to **h _ _ _ energy** as a result of **nuclear reactions**.

Moving steam (**k _ _ _ _ _ _ energy**) hits **turbine blades**, giving them **k _ _ _ _ _ _ energy**.

As **generator** is turned, **k _ _ _ _ _ _ energy** is changed to **e _ _ _ _ _ _ _ _ _ energy**.

Hydro-Electric Power Station

dam → **turbine** → **generator**

G _ _ _ _ _ _ _ _ _ _ _ _ p _ _ _ _ _ _ _ _ energy in **water** stored high in **dam** is changed to **k _ _ _ _ _ _ energy** as **water** falls down **dam**.

Moving water (**k _ _ _ _ _ _ energy**) hits **turbine blades**, giving them **k _ _ _ _ _ _ energy**.

As **generator** is turned, **k _ _ _ _ _ _ energy** is changed to **e _ _ _ _ _ _ _ _ _ energy**.

• Nuclear Power Stations

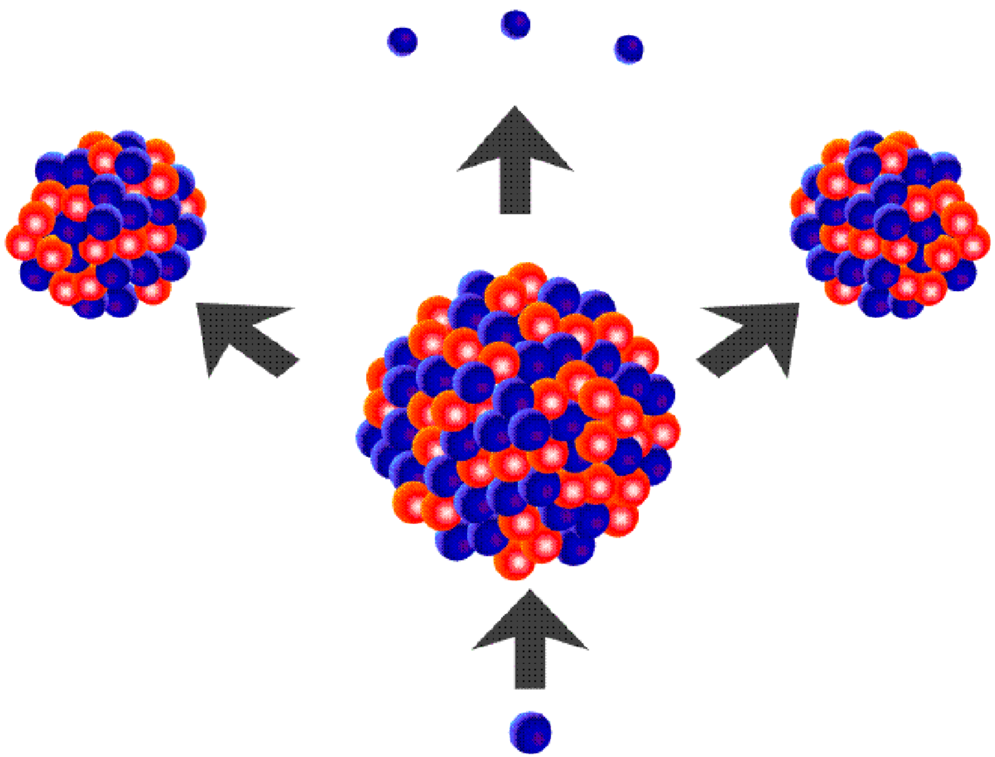
In a **nuclear power station**, **n** _ _ _ _ _ _ **f** _ _ _ _ _ _ **reactions** take place in a **n** _ _ _ _ _ _ **r** _ _ _ _ _ _.

A particle called a **n** _ _ _ _ _ _ hits the **nucleus** (**centre**) of a **uranium** or **plutonium atom**, causing the atom to **break up** into **2 smaller parts** (**fission fragments**).

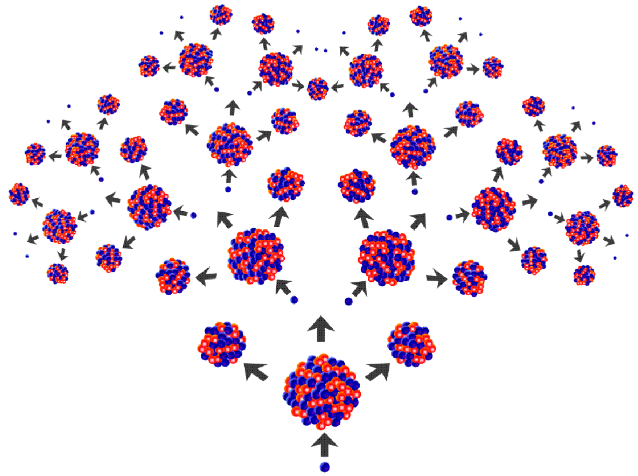
Every time this happens, **h** _ _ _ **energy** is released.

Two or **three** more **n** _ _ _ _ _ _ _ are also released from the split atom.

Label the diagram:



The **n** _ _ _ _ _ _ _ which are released hit other **uranium** or **plutonium atoms**, causing them to break up and release more **n** _ _ _ _ _ _ _ which go on to hit other **uranium** or **plutonium** atoms.



This is known as a **c** _ _ _ _ **r** _ _ _ _ _ _ _.

To stop the **c** _ _ _ _ **r** _ _ _ _ _ _ _ getting out of control, some of the **n** _ _ _ _ _ _ _ produced are removed.

The main problem with **nuclear reactors** is that they produce **r** _ _ _ _ _ _ _ _ _ _ **w** _ _ _ _ - This can seriously damage your health or even kill you. It has to be stored for thousands of years in thick-walled containers, deep underground.

- 1 kg of coal releases 2 800 000 J of energy.
- 1 kg of uranium releases 5 000 000 000 000 J of energy.

7) How many kilograms of **coal** would be needed to produce the same amount of energy as 1 kg of **uranium**?

- **Hydro-Electric Power Stations**

Water stored behind a dam has
g _ _ _ _ _ _ _ _ _ _ _ _ _ **p** _ _ _ _ _ _ _ _ _ **e** _ _ _ _ _ _.
When the water runs down the dam, its
g _ _ _ _ _ _ _ _ _ _ _ _ _ **p** _ _ _ _ _ _ _ _ _ **e** _ _ _ _ _ _ **is**
converted to **k** _ _ _ _ _ _ _ **e** _ _ _ _ _ _.

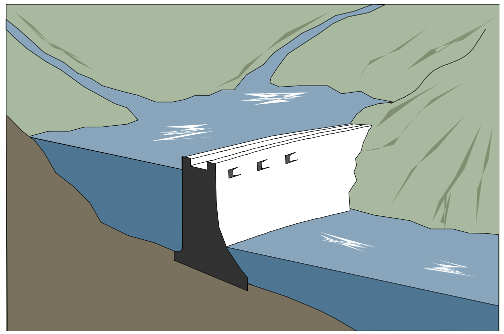
When the water hits **t** _ _ _ _ _ _ _ **b** _ _ _ _ _ _ at the bottom of the dam, it gives the **t** _ _ _ _ _ _ _ **k** _ _ _ _ _ _ _ **e** _ _ _ _ _ _ , making it **t** _ _ _.

As the **t** _ _ _ _ _ _ _ turns, it turns a **g** _ _ _ _ _ _ _ _ _ which changes the **k** _ _ _ _ _ _ _ **e** _ _ _ _ _ _ to **e** _ _ _ _ _ _ _ _ _ _ _ **e** _ _ _ _ _ _.

Pumped Storage Hydro-Electric Power Stations

In a **p** _ _ _ _ _ _ **s** _ _ _ _ _ _ _ **hydro-electric power station**, the water which runs down the dam is **p** _ _ _ _ _ _ back up to the top, so it can be used again. This is usually done at **n** _ _ _ _ _ when the demand for **e** _ _ _ _ _ _ _ _ _ _ _ _ is **l** _ _ and **n** _ _ _ _ _ _ _ **power stations** (which can't be switched off) are producing **e** _ _ _ _ _ _ _ _ _ _ _ _ which nobody will use. The **e** _ _ _ _ _ _ _ _ _ _ _ _ from the **n** _ _ _ _ _ _ _ **power stations** is used to **p** _ _ _ the water back up the dam, so the **e** _ _ _ _ _ _ _ _ _ _ _ _ is not **w** _ _ _ _ _ _.

Hydro-electric power stations are often used to supply **e** _ _ _ _ _ _ _ _ _ _ _ _ for a **s** _ _ _ _ _ time, when there is a sudden **i** _ _ _ _ _ _ _ _ in demand (such as the advert break during Coronation Street when many people switch on their kettle to make a cup of tea). The **w** _ _ _ _ _ **f** _ _ _ _ down the dam can be started very **q** _ _ _ _ _ _ _, so **e** _ _ _ _ _ _ _ _ _ _ _ can be produced almost straight away.



Degradation of Energy

In all power stations, when energy is changed from one form to another, some energy is always changed to **h** _ _ _ **e** _ _ _ _ _ _ which is **l** _ _ _ to the surroundings, so can't be used
- Energy is **d** _ _ _ _ _ _ _ _.

• Typical Energy Transformation Calculations

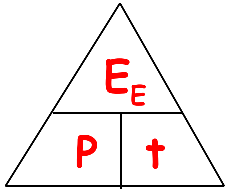
We cannot make or destroy energy - but we can transform (change) it from one type to another.

You will need these **formulae** to solve the following problems. The problems involve the **transformation** (**change**) of energy from one type to another:

An electric motor transforms (changes) electrical energy to mainly kinetic energy.

Electrical Energy (E_E) = Power (P) x time (t)

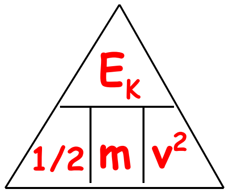
joules (J) | watts (W) | seconds (s)



Kinetic energy is movement energy - It depends on the mass and speed of the moving object.

Kinetic Energy (E_K) = 1/2 x mass (m) x speed (v)^2

joules (J) | kilograms (kg) | metres per second (m/s)

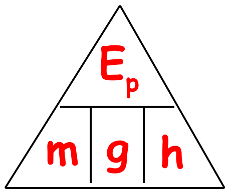


Any object which is above ground level has gravitational potential energy - As the object falls to the ground, its gravitational potential energy is transformed (changed) to mainly kinetic energy.

Gravitational potential energy (E_P) = mass (m) x gravitational field strength (g) x height (h)

joules (J) | kilograms (kg) | newtons/kilogram (N/kg) | metres (m)

g = 10 N/kg near Earth's surface



8) An electric motor has a power of 40 watts. It takes 5 seconds for the motor to pull a mass of 16 kilograms across a frictionless floor at constant speed.

(a) Calculate the electrical energy transformed by the motor during the 5 seconds.

(b) Assuming that all the electrical energy is transformed to kinetic energy, calculate the speed at which the motor pulls the mass across the floor.

9) A radio-controlled toy car is powered by an electric motor. The car has a mass of 0.8 kilograms and travels across the floor for 6 seconds.

(a) If the car travels across the floor at a constant speed of 3 meters per second, calculate its kinetic energy.

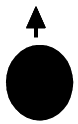
(b) All of the electrical energy supplied to the electric motor is transformed to kinetic energy. Calculate the power rating of the motor.

10) Kelly drops her handbag, which has a mass of 0.5 kilograms, 200 metres down a cliff.

(a) Calculate the gravitational potential energy of the handbag before it is dropped.

(b) Assuming that all the gravitational potential energy has been transformed to kinetic energy at the instant just before the handbag reaches the bottom of the cliff, calculate the speed of the handbag at this instant.

11) A 1.5 kilogram cannonball is fired straight up in the air from ground level with a speed of 30 metres per second.



(a) Calculate the kinetic energy of the cannonball at the instant it leaves the ground.

(b) When the cannonball reaches its maximum height, all of the kinetic energy has been transformed to gravitational potential energy. Calculate the maximum height the cannonball reaches.

12) A teacher sets up a model pumped storage hydro-electric power station in her lab. The model uses a small electric motor (power rating 20 watts) to raise 5 kilograms of water through a small height. This takes 8 seconds.

(a) Calculate the electrical energy transformed by the electric motor while lifting the water.

(b) If all the electrical energy is transformed to gravitational potential energy, calculate the height the water is raised to.

13) During the night, surplus electrical energy produced by nuclear power stations is used to pump 50 000 kilograms of water every minute a height of 300 metres up a dam.

(a) Calculate the gravitational potential energy gained by the 50 000 kilograms of water.

(b) Assuming all the electrical energy supplied to the electric motor of the pump is transferred to gravitational potential energy of the water, calculate the power rating of the motor.

• Typical Efficiency of Energy Transformation Calculations

In the previous energy transformation calculations, it was assumed that no energy was transformed into unwanted types - The transformations were **100 % efficient**.

In reality, during any energy transformation, as well as the useful type of energy given out, some energy is also transformed into unwanted types, usually heat - The transformations are **not 100 % efficient**.

We say that, during the energy transformation, energy is **degraded**.

● Describe why **kinetic energy** is transformed into usually unwanted **heat energy** by any working machine:

____

____

____

The **efficiency** of any machine/device indicates how good it is at transforming the energy supplied to it into another useful type of energy.

Efficiency is expressed as a percentage.

$$\text{Efficiency} = \frac{\text{Useful Energy Output}}{\text{Energy Input}} \times 100\ \%$$

OR

$$\text{Efficiency} = \frac{\text{Useful Power Output}}{\text{Power Input}} \times 100\ \%$$

14) In each case, calculate the efficiency of the machine/device:

(a) food mixer

Energy input = 200 joules

Useful energy output = 140 joules

(d) electric drill

Power input = 10 000 watts

Useful power output = 6 000 watts

(b) electric fan

Energy input = 5 000 joules

Useful energy output = 4 000 joules

(e) electric light bulb

Power input = 525 watts

Useful power output = 25 watts

(c) colour television

Energy input = 1 600 joules

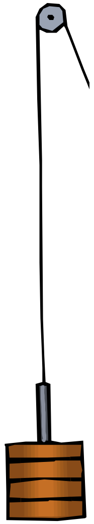
Useful energy output = 1 400 joules

(f) computer

Power input = 900 watts

Useful power output = 300 watts

15) A 100 watt electric motor lifts a mass of 2.5 kilograms through a height of 3.5 metres. This takes 5 seconds.

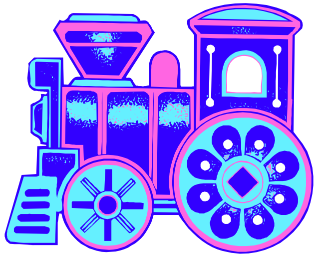


(a) Calculate the energy input - The electrical energy supplied to the motor during the 5 seconds.

(b) Calculate the energy output - The gravitational potential energy gained by the mass.

(c) Calculate the efficiency of the electric motor during the lifting process.

16) A 2 watt electric motor moves a 0.5 kilogram toy train 15 metres across a floor with a constant speed of 6 metres per second. This takes 10 seconds.



(a) Calculate the electrical energy supplied to the motor during the 10 seconds - The energy input.

(b) Calculate the kinetic energy the motor supplies to the toy train - The energy output.

(c) Calculate the efficiency of the electric motor.

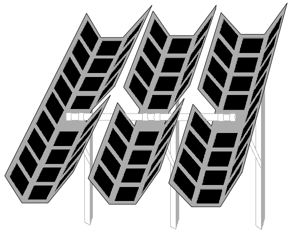
17) A conveyor belt at a supermarket check out counter is powered by a 20 watt electric motor. Every 3 seconds, the motor can move groceries with a mass of 15 kilograms at a constant speed of 1.2 metres per second.

(a) Calculate the electrical energy supplied to the electric motor during the 3 seconds.

(b) Calculate the kinetic energy the motor supplies to the food on the conveyor belt.

(c) Calculate the efficiency of the electric motor.

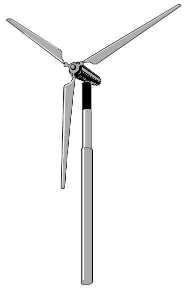
18) A 1 $metre^2$ area of solar cells provide 1 500 watts of solar energy.



(a) Calculate the solar power which would be provided to solar cells with an area of 3 $metre^2$.

(b) If the output power from this 3 $metre^2$ area of solar cells is 1 500 watts, calculate the efficiency of the solar cells.

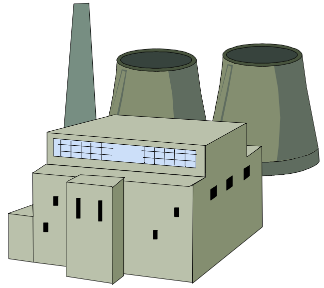
19) A wind turbine receives 9×10^6 joules of energy every second.



(a) Calculate the power input to the wind turbine.

(b) If the power output from the wind turbine is 6×10^6 watts, calculate the efficiency of the turbine.

20) Every second, 2.5×10^8 joules of heat energy is input to a thermal power station.



(a) Calculate the power input to the power station.

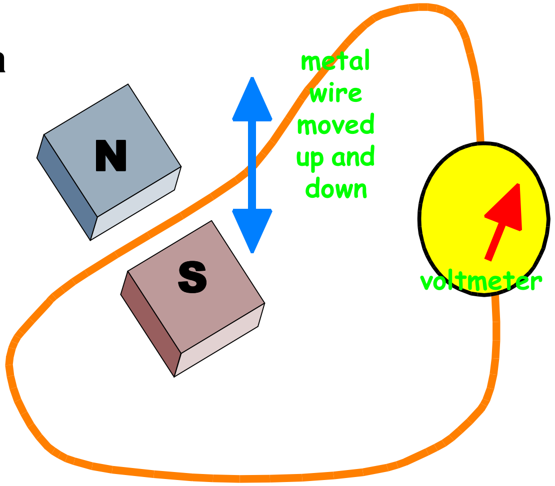
(b) If the power station outputs 1.1×10^8 watts of power, calculate its efficiency.

Section 3: SOURCE to CONSUMER

• Inducing a Voltage in a Conductor

We can induce (make) a voltage in a metal wire conductor by:

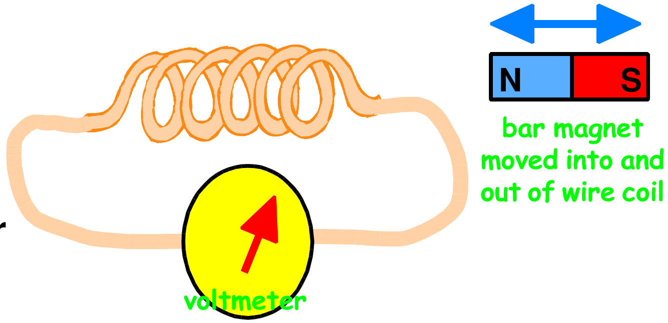
(a) Moving a metal wire ___ or _____ between the _________ poles of a bar magnet.



When the metal wire moves up, the voltmeter kicks in one direction.

When the metal wire moves down, the voltmeter kicks in the ___________ direction.

(b) Winding the metal wire into a _______ then moving a bar magnet ____ or _____ ___ the coil.



When the bar magnet moves into the wire coil, the voltmeter kicks in one direction.

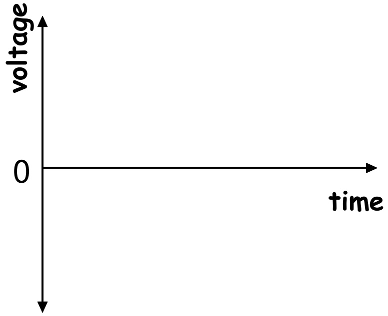
When the bar magnet moves out of the wire coil, the voltmeter kicks in the ___________ direction.

To make the induced voltage larger, we can:

- **use a s _ _ _ _ _ _ _ magnet;**
- **move the wire or magnet f _ _ _ _ _;**
- **wind m _ _ _ turns of wire on the coil.**

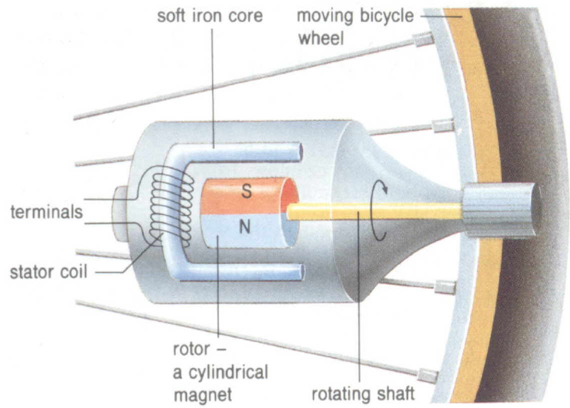
The voltage produced by <u>continuous</u> up and down or in and out movement is <u>alternating</u> - It produces alternating current (a.c.)

Draw the shape of an a.c. voltage.



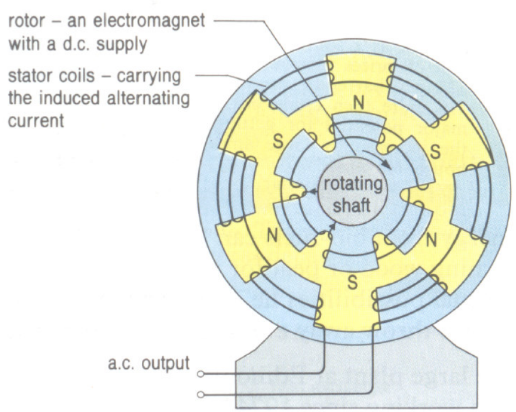
In a simple a.c. generator, like the dynamo on a bicycle, a bar m _ _ _ _ _ is turned next to a metal wire c _ _ _ (called a s _ _ _ _ _ c _ _ _) which is wound round a soft iron c _ _ _.

This i _ _ _ _ _ _ (makes) a v _ _ _ _ _ _ in the s _ _ _ _ _ c _ _ _.



In full size generators, like those in a power station:

- the bar magnet is replaced by several e _ _ _ _ _ _ _ _ _ _ _ _ _.
- There is more than one s _ _ _ _ _ c _ _ _, so the a.c. produced is s _ _ _ _ _ _ _.



Both diagrams taken from page 170 of "PHYSICS THROUGH APPLICATIONS", edited by Jim Jardine, publisher: Oxford University Press, ISBN 0 19 914280 7.

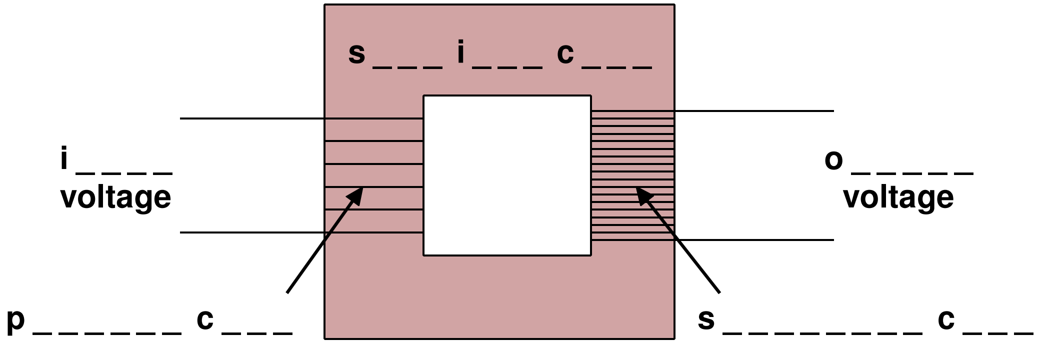
• Transformers

Transformers are used to change the size of an
_._. v_ _ _ _ _ _ _.
They do not work with d_ _ _ _ _ c_ _ _ _ _ _ _ (_._.).
These devices contain transformers:

____

____

Label the parts of this transformer:

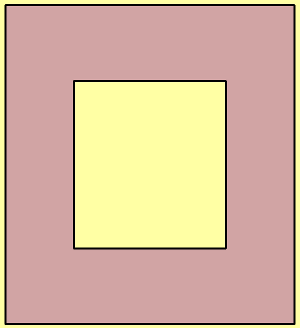


• Step-Up Transformers

These have more turns of wire in their s_ _ _ _ _ _ _ _ _ c_ _ _ than they have in their p_ _ _ _ _ _ c_ _ _.

They i_ _ _ _ _ _ _ the size of the a.c. v_ _ _ _ _ _ applied across the p_ _ _ _ _ _ c_ _ _.
(The output voltage is l_ _ _ _ _ than the input voltage).

Draw the primary and secondary coils on this transformer to show which has more turns:

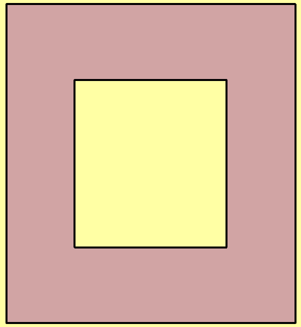


• Step-Down Transformers

These have less turns of wire in their s_ _ _ _ _ _ _ _ _ c_ _ _ than they have in their p_ _ _ _ _ _ c_ _ _.

They d_ _ _ _ _ _ _ the size of the a.c. v_ _ _ _ _ _ applied across the p_ _ _ _ _ _ c_ _ _.
(The output voltage is s_ _ _ _ _ _ than the input voltage).

Draw the primary and secondary coils on this transformer to show which has more turns:



This formula applies to transformers. It relates the primary and secondary voltages to the number of turns of wire in the primary and secondary coils:

$$\frac{N_p}{N_s} = \frac{V_p}{V_s}$$

- N_p: number of turns of wire in p_ _ _ _ _ _ c_ _ _
- N_s: number of turns of wire in s_ _ _ _ _ _ _ _ _ c_ _ _
- V_p: voltage across p_ _ _ _ _ _ c_ _ _
- V_s: voltage across s_ _ _ _ _ _ _ _ _ c_ _ _

$\frac{N_p}{N_s}$ is known as the turns ratio of the transformer.

21) Use the transformer formula to calculate the missing quantity in each case.
Say whether the transformer is a step-up or step-down transformer:

N_p = 100 turns, N_s = 200 turns V_p = 2 V a.c., V_s = ?	N_p = 1 000 turns, N_s = 250 turns V_p = 20 V a.c., V_s = ?	N_p = 100 turns, N_s = 500 turns V_p = ?, V_s = 10 V a.c.	N_p = 10 000 turns, N_s = 500 turns V_p = ?, V_s = 6 V a.c.
N_p = ?, N_s = 2 000 turns V_p = 2.5 V a.c., V_s = 50 V a.c.	N_p = ?, N_s = 3 000 turns V_p = 2.4 V a.c., V_s = 0.6 V a.c.	N_p = 1 500 turns?, N_s = ? V_p = 1.2 V a.c., V_s = 24 V a.c.	N_p = 10 000 turns?, N_s = ? V_p = 23 V a.c., V_s = 2.3 V a.c.

This formula also applies to transformers. It relates the voltage and current for the primary coil to the voltage and current for the secondary coil.

Input power = Output power

voltage across p _ _ _ _ _ _ c _ _ _ (v)

voltage across s _ _ _ _ _ _ _ _ c _ _ _ (v)

$$V_p I_p = V_s I_s$$

current in p _ _ _ _ _ _ c _ _ _ (A)

current in s _ _ _ _ _ _ _ _ c _ _ _ (A)

22) Use the above formula to calculate the missing quantity in each case.
Say whether the transformer is a step-up or step-down transformer:

V_p = 5 V a.c., V_s = 15 V a.c.
I_p = ?, I_s = 4 A a.c.

V_p = 24 V a.c., V_s = 2 V a.c.
I_p = ?, I_s = 30 A a.c.

V_p = 1.2 V a.c., V_s = ?
I_p = 9 A a.c., I_s = 1.5 A a.c.

V_p = 125 V a.c., V_s = ?
I_p = 1.6 A a.c., I_s = 5 A a.c.

V_p = 3 V a.c., V_s = 15 V a.c.
I_p = 10 A a.c., I_s = ?

V_p = 12 V a.c., V_s = 3 V a.c.
I_p = 1.5 A a.c., I_s = ?

V_p = ?, V_s = 230 V a.c.
I_p = 7.5 A a.c., I_s = 1.5 A a.c.

V_p = ?, V_s = 24 V a.c.
I_p = 4.5 A a.c., I_s = 1.5 A a.c.

No transformer is 100% efficient - Some of the electrical energy supplied to the primary coil is always lost to the surroundings. This is due to:

- H _ _ _ loss in the coils - When current passes through the primary and secondary coils, some electrical energy is changed to h _ _ _ energy which escapes into the air.
- H _ _ _ _ _ _ _ _ _ loss - The transformer core is constantly being magnetised and demagnetised. This converts some of the electrical energy to heat.
- E _ _ _ c _ _ _ _ _ _ _ are created in the transformer core.

This formula is used to calculate the efficiency of a transformer (or any other machine/device):

$$\text{Efficiency} = \frac{\text{Power Output}}{\text{Power Input}} \times 100\ \%$$

23) Use the above formula to calculate the efficiency of these transformers:

Power output = 30 W
Power input = 40 W

Power output = 200 W
Power input = 250 W

Power output = 720 W
Power input = 1 000 W

Power output = 1 300 W
Power input = 2 000 W

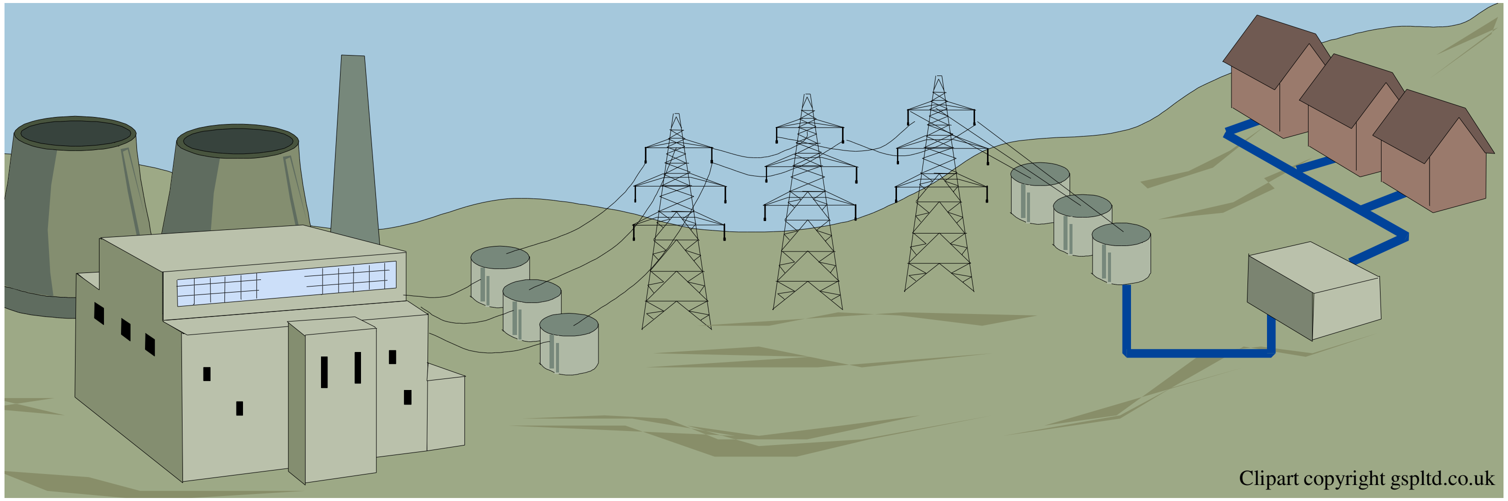
V_p = 100 V a.c., I_p = 2 A a.c., V_s = 60 V a.c., I_s = 3 A a.c.

V_p = 25 V a.c., I_p = 5 A a.c., V_s = 150 V a.c., I_s = 0.5 A a.c.

• The National Grid - Sending Electricity Around The Country

Use the words in the box to label the diagram which shows how electricity is sent from a power station to your home:

homes
overhead power lines
power station
pylons
step-down transformers
step-up transformers
substation
underground power lines



1) Electricity from a power station is sent to a _ _ _ _ - _ _ transformer which makes the v _ _ _ _ _ _ larger (typically _________ V) but makes the c _ _ _ _ _ _ smaller.

2) The electricity is sent around the country through o _ _ _ _ _ _ _ p _ _ _ _ l _ _ _ _ which are held up by p _ _ _ _ _ - The connection of pylons across the country is called the N _ _ _ _ _ _ _ G _ _ _.

3) The electricity arrives at a _ _ _ _ - _ _ _ _ transformer which makes the v _ _ _ _ _ _ smaller (___ V for our homes, but ________V for factories). This makes the c _ _ _ _ _ _ larger.

4) The electricity is passed to our homes via a s _ _ _ _ _ _ _ _ _ through u _ _ _ _ _ _ _ _ _ _ p _ _ _ _ l _ _ _ _.

Power is lost when electricity passes through overhead power lines.

$$P = I^2 R$$

- P: power lost in overhead power lines (w)
- I: size of current passing through overhead power lines (A)
- R: resistance of overhead power lines (Ω)

By using a step-up transformer to make the voltage higher but the current smaller before it is passed through the overhead power lines, less power is lost in the overhead lines.

24) Use the "power formula" to calculate the power lost in each of these overhead power lines:

Current = 100 A Resistance of power line = 20 Ω	Current = 10 A Resistance of power line = 20 Ω
Current = 50 A Resistance of power line = 5 Ω	Current = 10 A Resistance of power line = 5 Ω
Current = 250 A Resistance of power line = 10 Ω	Current = 25 A Resistance of power line = 10 Ω
Current = 20 A Resistance of power line = 30 Ω	Current = 5 A Resistance of power line = 30 Ω

Section 4: HEAT in the HOME

• Heat and Temperature

Temperature tells us how h _ _ or c _ _ _ an object is.

Temperature is measured in units of
d _ _ _ _ _ _ C _ _ _ _ _ _ _ (°_).

Heat is a form of energy which flows from places at h _ _ _ _ _ temperature to places at l _ _ _ _ temperature.

• Heat Loss From a House

The heat energy lost from a house in a given time depends on the temperature difference between the inside and outside of the house.
(The inside is usually warmer than the outside).

The h _ _ _ _ _ the temperature difference, the m _ _ _ heat energy is lost.

Explain which house (A or B) loses most heat energy to the air outside in a given time:

____

____

____

____

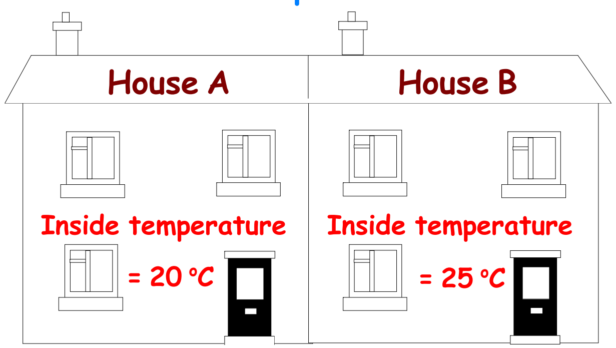
____

____

____

____

Outside air temperature = 10 °C.



Heat energy can be lost from a house by:

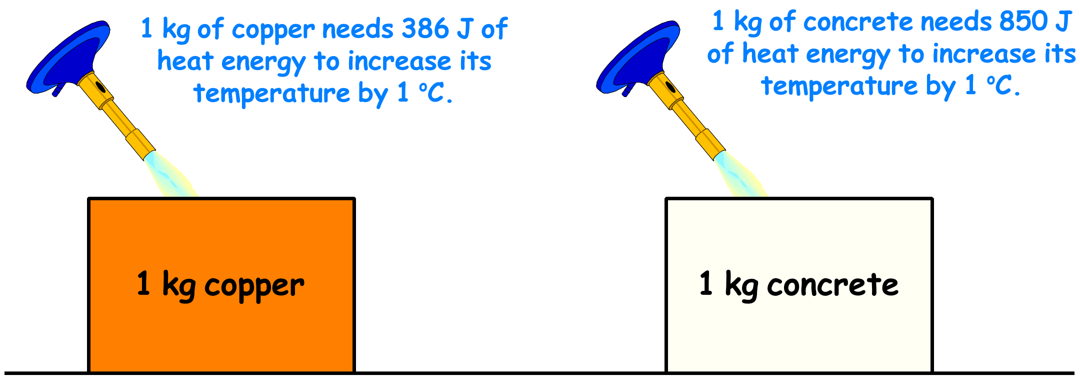
- **Conduction** - Happens mainly in solids. Particles vibrate against each another, passing heat energy from one particle to the next.
- **Convection** - Happens in liquids and Gases. Hot particles move up while cold particles move down. This creates a convection current.
- **Radiation** - Does not involve particles. Infra-red heat energy travels through gases and liquids as waves.

To reduce the amount of heat energy escaping from a house by conduction, convection and radiation we can:

conduction	
convection	
radiation	

Specific Heat Capacity

Different substances need different amounts of heat energy to increase the temperature of 1 kg of them by 1 °C.



The s _ _ _ _ _ _ _ _ h _ _ _ c _ _ _ _ _ _ _ _ of a substance is the amount of h _ _ _ energy needed to change the temperature of 1 kg of the substance by 1 °C
- Each substance has a different value of s _ _ _ _ _ _ _ _ h _ _ _ c _ _ _ _ _ _ _ _.

This formula applies to any substance, so long as it does not melt, freeze, evaporate or condense while heat energy is being added to it or taken away from it:

$$E_h = m c \Delta T$$

- E_h – heat energy added to or taken away from substance (J)
- m – mass of substance (kg)
- c – specific heat capacity of substance (J/ kg °C)
- ΔT – change in temperature of substance (°C)

The table shows the specific heat capacity of different substances:

substance	specific heat capacity
alcohol	2 350 J/ kg °C
aluminium	902 J/ kg °C
concrete	850 J/ kg °C
copper	386 J/ kg °C
glass	500 J/ kg °C
water	4 180 J/ kg °C

Use the values given in the table to solve these problems:

25) How much heat energy would you need to add to 3 kg of copper to increase its temperature by 2 °C?

26) How much heat energy would you need to add to 5 kg of concrete to increase its temperature by 3 °C?

27) How much heat energy does 1.5 kg of alcohol need to take in to increase its temperature by 5 °C?

31) Amy puts 0.8 kg of water with a temperature of 20 °C in an electric kettle. How much heat energy must the kettle supply in order to increase the temperature of the water to boiling point (100 °C)?

28) How much heat energy is given out by a 4 kg sheet of glass when its temperature falls by 4 °C?

32) During a chemistry lesson, Jack was asked to heat 0.05 kg of alcohol up to its boiling point of 79 °C. If the temperature of the alcohol just before heating was 19°C, how much heat energy was needed?

29) How much heat energy is given out by a 2.5 kg aluminium sheet when its temperature falls by 12 °C?

33) Melissa measured the temperature of water in an electric kettle and found it to be 25 °C. When the kettle was switched on, it increased the water temperature to 95 °C by supplying 175 560 J of heat energy. Calculate the mass of water in the kettle.

30) How much heat energy does 0.75 kg of alcohol need to give out to decrease its temperature by 1.8 °C?

34) Kevin put 0.25 kg of hot water in a beaker. As the water cooled, it gave out 36 575 J of heat energy to the surroundings. Calculate the decrease in water temperature.

• Change of State

When a substance melts, freezes, evaporates or condenses, we say it is changing s _ _ _ _.

For a substance to melt or evaporate, it must g _ _ _ h _ _ _ energy.

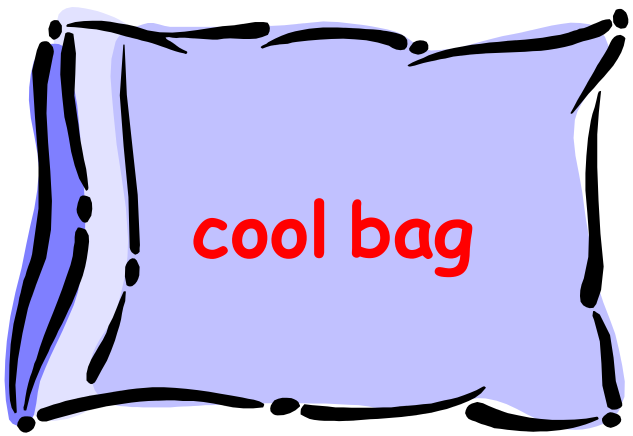
For a substance to freeze or condense, it must l _ _ _ h _ _ _ energy.

When melting, freezing, evaporating or condensing takes place, the t _ _ _ _ _ _ _ _ _ _ of the substance does not change.

This is very useful. For example:

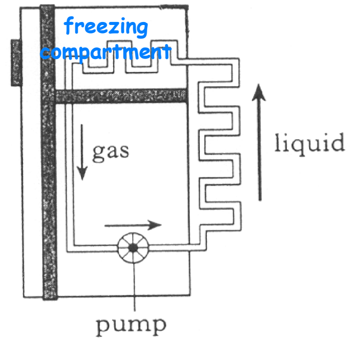
1) A cool bag/box for food - This contains a special block containing ice or other frozen material. The frozen material takes h _ _ _ energy away from the food in the bag/box and m _ _ _ _, turning into a liquid.

As a result, the t _ _ _ _ _ _ _ _ _ _ of the material and the food does not increase.



2) A fridge - A special liquid is pumped through the walls of the freezing compartment. The liquid takes h _ _ _ energy away from the food in the compartment and e _ _ _ _ _ _ _ _ _, turning into a gas - As a result, the t _ _ _ _ _ _ _ _ _ _ of the food d _ _ _ _ _ _ _ _.

The gas is pumped to the back of the fridge where it gives out the heat energy into the room. The gas c _ _ _ _ _ _ _ _, turning back to liquid, which is pumped into the freezing compartment again.



fridge

• Specific Latent Heat

- The specific latent heat of fusion is the amount of heat energy taken in to change 1kg of a solid at its melting point temperature to a liquid (or the amount of heat energy given out when 1 kg of a liquid at its freezing point temperature changes to a solid).
- The specific latent heat of vaporisation is the amount of heat energy taken in to change 1 kg of a liquid at its boiling point temperature to a gas (or the amount of heat energy given out when 1 kg of a gas at its condensing point temperature changes to a liquid).

$$E_h = m\,l$$

E_h – heat energy added to or taken away from substance (J)

m – mass of substance (kg)

l – specific latent heat of fusion or vaporisation of substance (J/kg)

35) Calculate how much heat energy 2 kg of ice (frozen water) at its melting point temperature must take in so that it all changes to liquid water. (Specific latent heat of fusion for water = 3.34×10^5 J/kg).

36) 0.5 kg of liquid alcohol at its freezing point temperature freezes, thereby turning into a solid. How much heat energy does the alcohol give out to the surroundings? (Specific latent heat of fusion for alcohol = 0.99×10^5 J/kg).

37) Calculate how much heat energy 1.5 kg of liquid water at its boiling point temperature must take in so that it all changes to steam. (Specific latent heat of vaporisation for water = 22.6×10^5 J/kg).

38) 0.4 kg of gaseous alcohol at its condensing point temperature changes into liquid alcohol. How much heat energy does the alcohol give out to the surroundings? (Specific latent heat of vaporisation for alcohol = 11.2×10^5 J/kg).

39) How much heat energy is needed to completely melt a 5 kg block of solid copper which is at its melting point temperature? (Specific latent heat of fusion for copper = 2.05×10^5 J/kg).

40) When a mass of liquid water at its freezing point temperature freezes, it gives out 5.01×10^6 J of heat energy to the surroundings. Calculate the mass of water. (Specific latent heat of fusion for water = 3.34×10^5 J/kg).

41) How much heat energy is needed to completely turn 0.6 kg of liquid turpentine at its boiling point temperature into turpentine gas? (Specific latent heat of vaporisation for turpentine = 2.90×10^5 J/kg).

42) When a mass of gaseous glycerol at its condensing point temperature condensess, it gives out 1.245×10^6 J of heat energy to the surroundings. Calculate the mass of glycerol. (Specific latent heat of vaporisation for glycerol = 8.30×10^5 J/kg).

• Temperature-Heat Energy Graph

This is a typical graph showing how the **temperature** of a **solid substance** changes as **heat energy** is supplied to it:

Label the graph to explain the various changes in its slope: