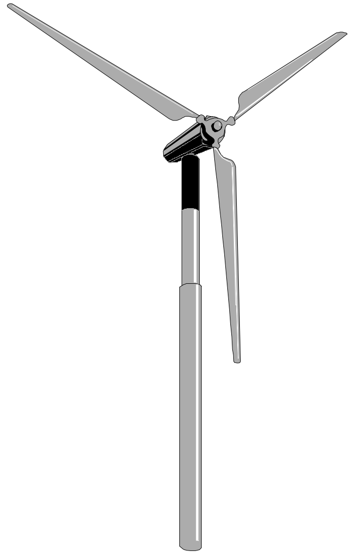
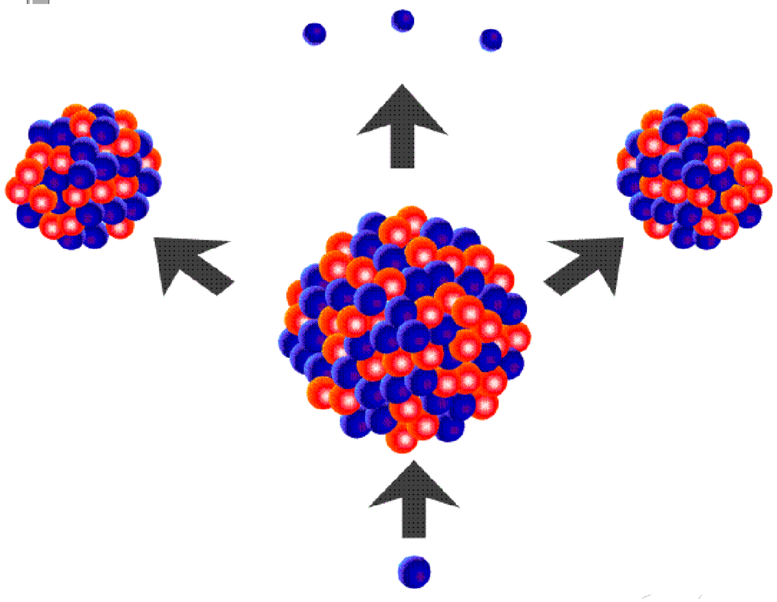
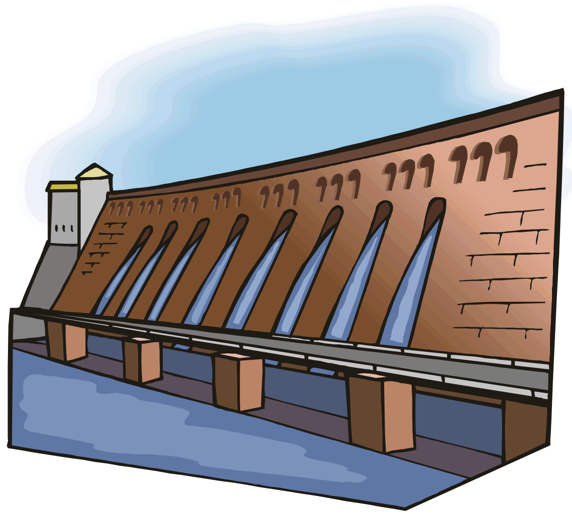
Standard Grade Physics



Power Stations





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

Power Stations **Learning Outcomes** **Blue = general** **Red = credit**

	Section 1 - Supply and Demand				
1	state that fossil fuels are at present the main sources of energy				
2	state that the reserves of fossil fuels are finite				
3	explain one means of conserving energy related to the use of energy in industry, in the home and in transport				
4	carry out calculations relating to energy supply and demand				
5	classify renewable and non-renewable sources of energy				
6	explain the advantages and disadvantages associated with at least three renewable energy sources.				

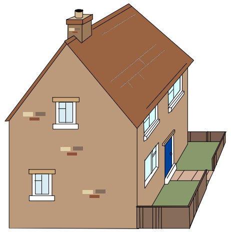
	Section 2 - Generation of Electricity				
1	identify from a diagram the energy transformation at each stage of: thermal power station / hydro-electric power station / nuclear power station				
2	state that radio-active waste is produced by nuclear reactors				
3	carry out calculations on energy transformation to include gravitational potential energy				
4	describe the principle and give the advantages of a pumped hydro-electric scheme				
5	compare energy output from equal masses of coal and nuclear fuel				
6	carry out calculations involving efficiency of energy transformation				
7	state that energy is degraded in energy transformation				
8	explain in simple terms a chain reaction.				

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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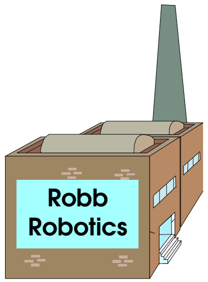

How we can conserve (save) energy **in industry**:

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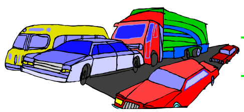

How we can conserve (save) energy **in transport**:

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• Non-Renewable Sources of Energy

Finite means ______________________________

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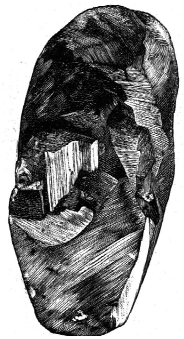
Fossil Fuels



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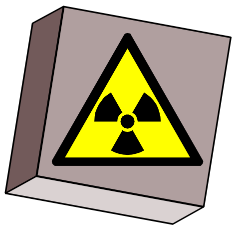
At present, **fossil fuels** are our **main source of energy**.

Nuclear Fuels



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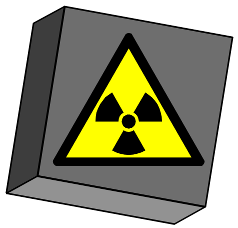

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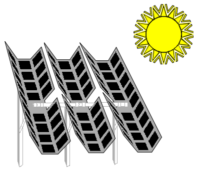
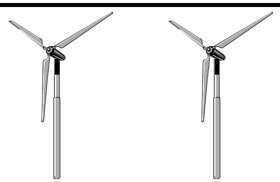
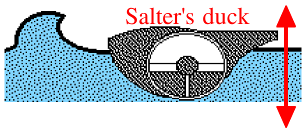
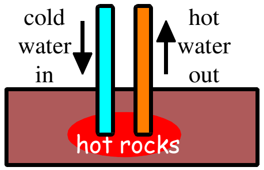
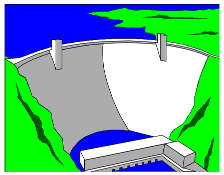
• Renewable Sources of Energy

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

For example:

Renewable Energy Source	Advantages	Disadvantages
		
		
		
		
		
		

• 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*** :

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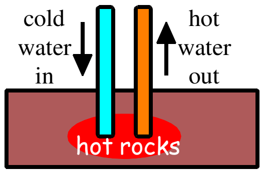

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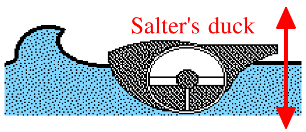
renewable energy sources

non-renewable energy sources



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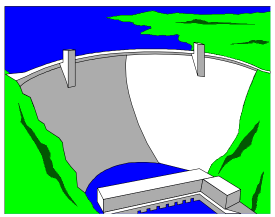

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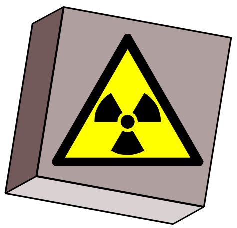

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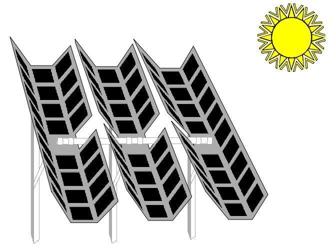

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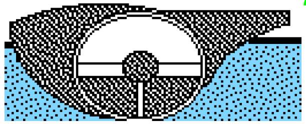
• Typical Energy Supply and Demand Calculations

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?

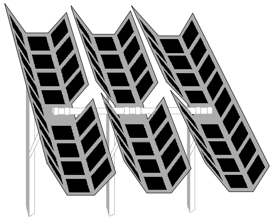


2) A 1 kilometre length of Salter's ducks (wave energy converters) is spread along a coastline. Every second, the ducks generate a total of 4 000 000 joules of electrical energy.

(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.

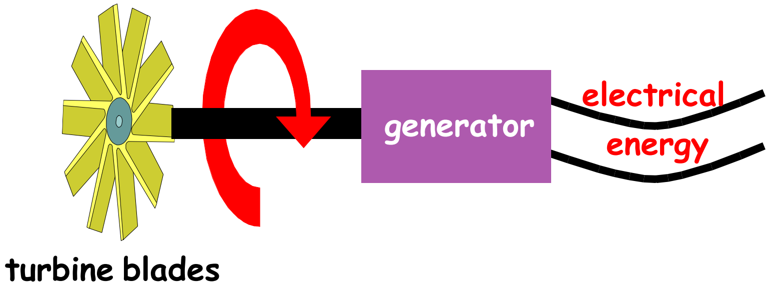
(a) If 1 acre of land can produce 5 000 kilograms of sugar cane, how many acres are required to produce 100 000 kilograms of sugar cane?

(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:

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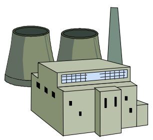
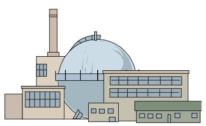
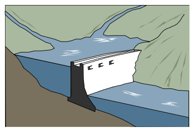
Thermal Power Stations	Nuclear Power Stations	Hydro-Electric Power Stations
		

Thermal Power Station

boiler → turbine → generator

Nuclear Power Station

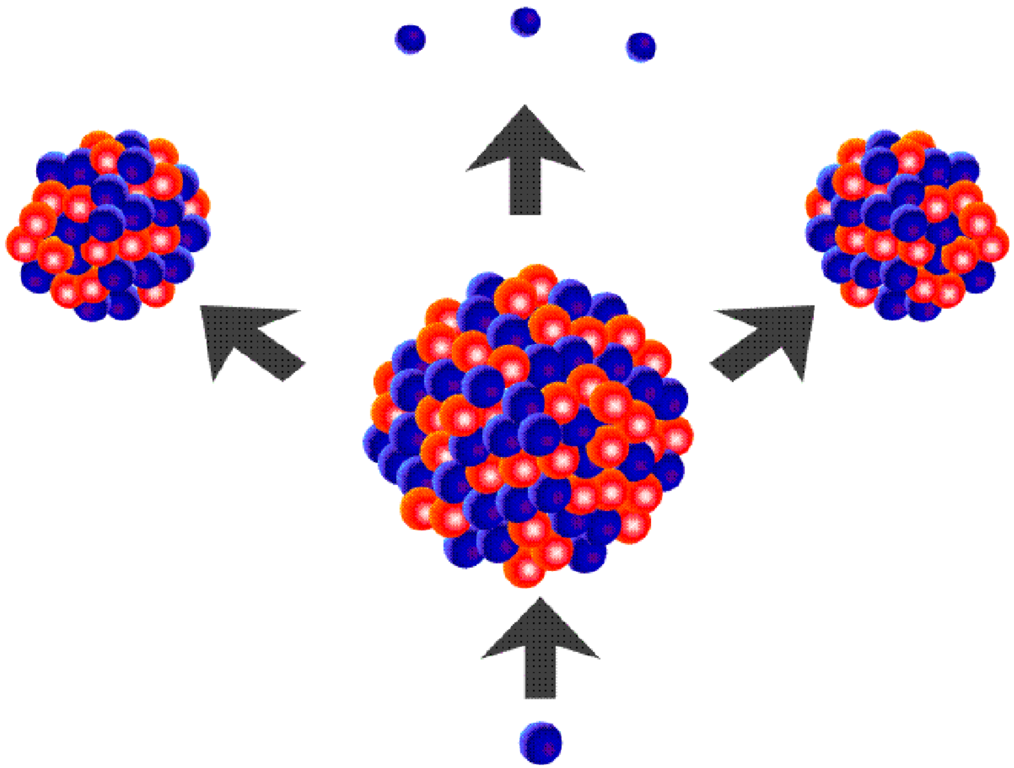
nuclear reactor → turbine → generator

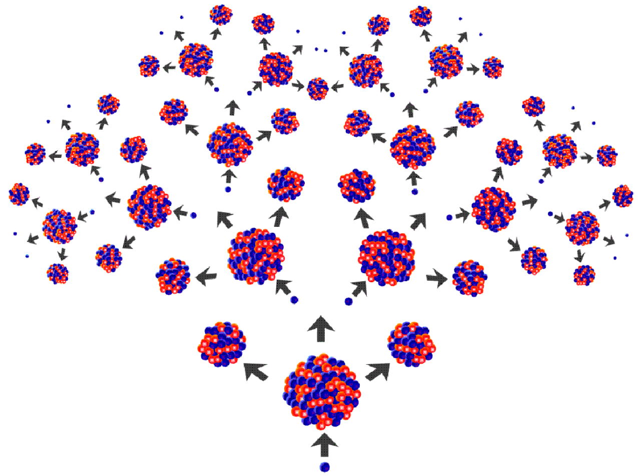
Hydro-Electric Power Station

dam → turbine → generator

• Nuclear Power Stations

Label the diagram:



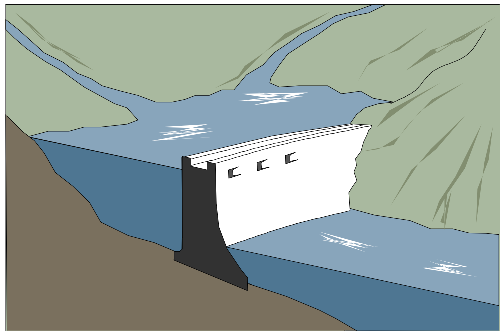


- 1 kg of coal releases 2 800 000 J of energy.
- 1 kg of uranium releases 5 000 000 000 000 J of energy.

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

Pumped Storage Hydro-Electric Power Stations



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

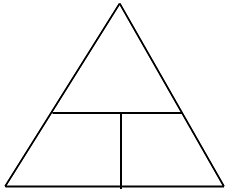
We cannot make or destroy energy - but we can transform (change) it from one type to another.

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)

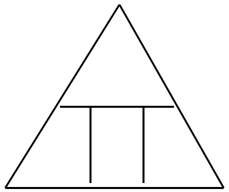
joules (J) | watts (W) | seconds (s)



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)

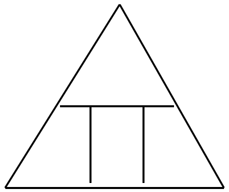


Any object which is above ground level has gravitational potential energy - As the object falls to the ground, its gravitational potential energy is transformed (changed) to mainly kinetic energy.

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.

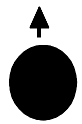
(b) Assuming that all the gravitational potential energy has been transformed to kinetic energy at the instant just before the handbag reaches the bottom of the cliff, calculate the speed of the handbag at this instant.

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.

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.

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**.

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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:

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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

(b) electric fan

Energy input = 5 000 joules

Useful energy output = 4 000 joules

(c) colour television

Energy input = 1 600 joules

Useful energy output = 1 400 joules

(d) electric drill

Power input = 10 000 watts

Useful power output = 6 000 watts

(e) electric light bulb

Power input = 525 watts

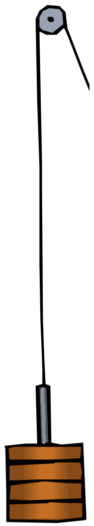
Useful power output = 25 watts

(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.

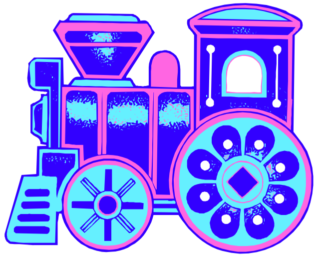


(a) Calculate the energy input - The electrical energy supplied to the motor during the 5 seconds.

(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.

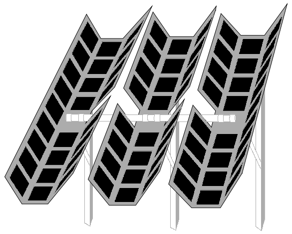
17) A conveyor belt at a supermarket check out counter is powered by a 20 watt electric motor. Every 3 seconds, the motor can move groceries with a mass of 15 kilograms at a constant speed of 1.2 metres per second.

(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.

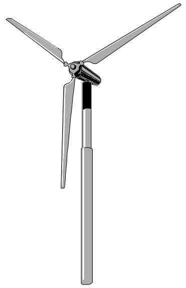
18) A 1 $metre^2$ area of solar cells provide 1 500 watts of solar energy.



(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.

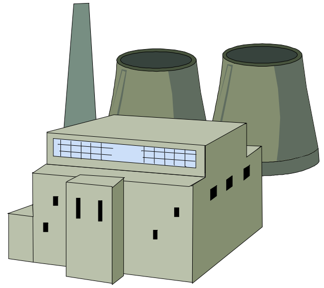
19) A wind turbine receives 9×10^6 joules of energy every second.



(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.