SCIENCE AT WORK

Science of the Motor Car

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Project Director
John Taylor

Editorial Team
Jackie Hardie
Peter Llewellyn
Colum Quinn
Keith Roberts

Language Consultant
Grahame Mitchell

Author of this book
Ken Swinswood

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1 Oil and its uses

Distilling crude oil

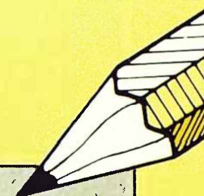
Apparatus

★ crude oil ★ tin tray ★ splints ★ mineral wool ★ pipette
★ side-arm test tube ★ one holed stopper with thermometer fitted ★ clamp stand
★ heatproof mat ★ delivery tube ★ rubber tube ★ 4 test tubes ★ Bunsen burner
★ safety goggles

You are going to split up crude oil by **distilling** it.

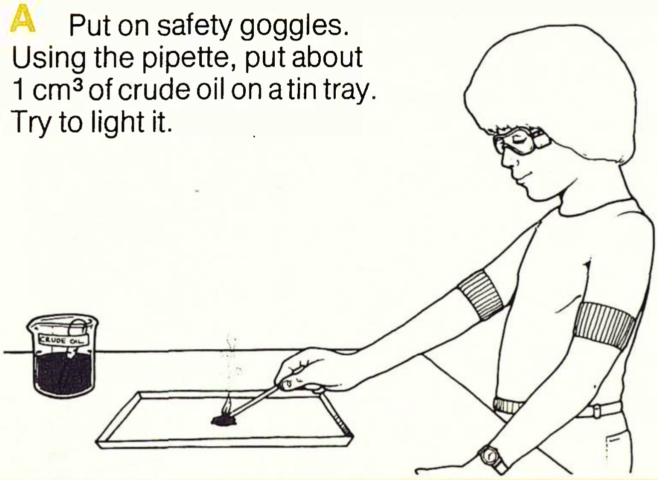
Wear safety goggles. This experiment should be performed in a fume cupboard.

Q1 Copy this table.

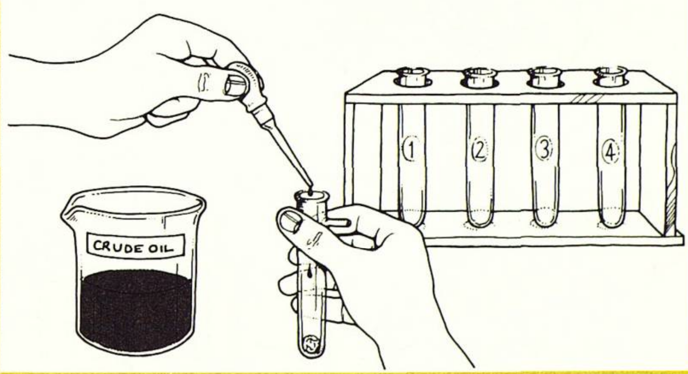


Number of test tube	Temperature range	Colour of liquid	How easily does liquid light?
1	up to 100°C		
2	100°C to 150°C		
3	150°C to 200°C		
4	200°C to 250°C		

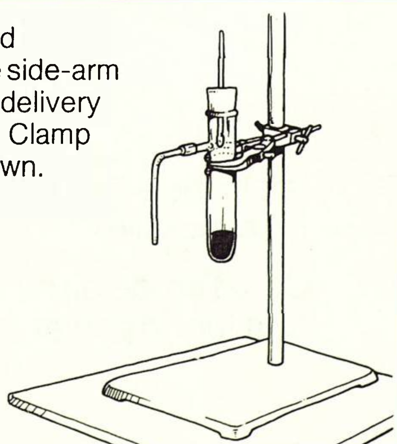
A Put on safety goggles. Using the pipette, put about 1 cm^3 of crude oil on a tin tray. Try to light it.



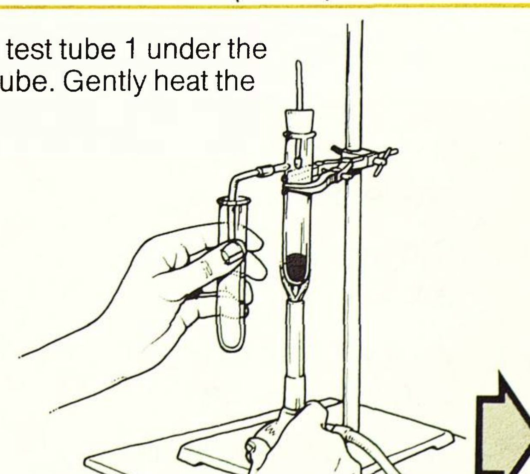
B Put a piece of mineral wool in a side-arm test tube. Add about 3 cm^3 of crude oil.



C Put a stopper and thermometer into the side-arm test tube. Connect a delivery tube to the side-arm. Clamp the apparatus as shown.

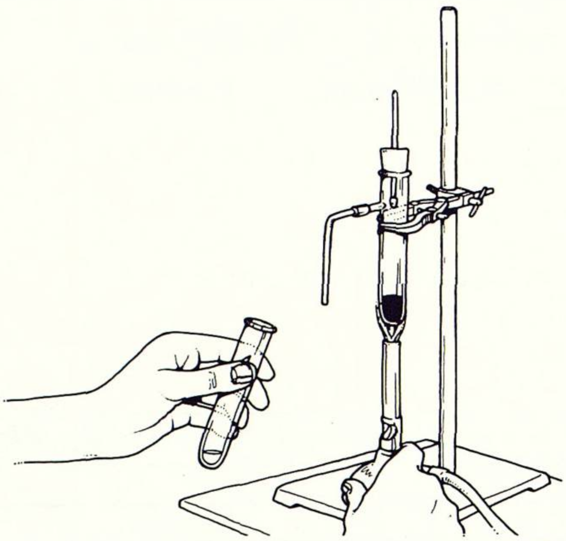


D Hold test tube 1 under the delivery tube. Gently heat the crude oil.

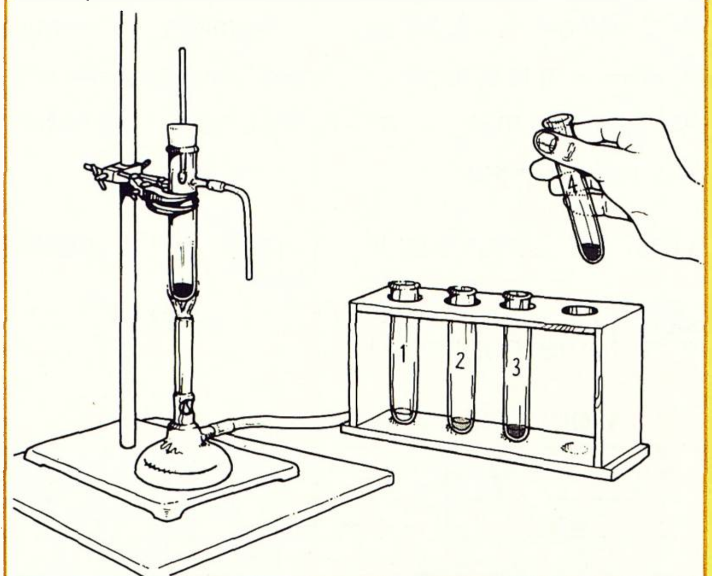


Oil and its uses

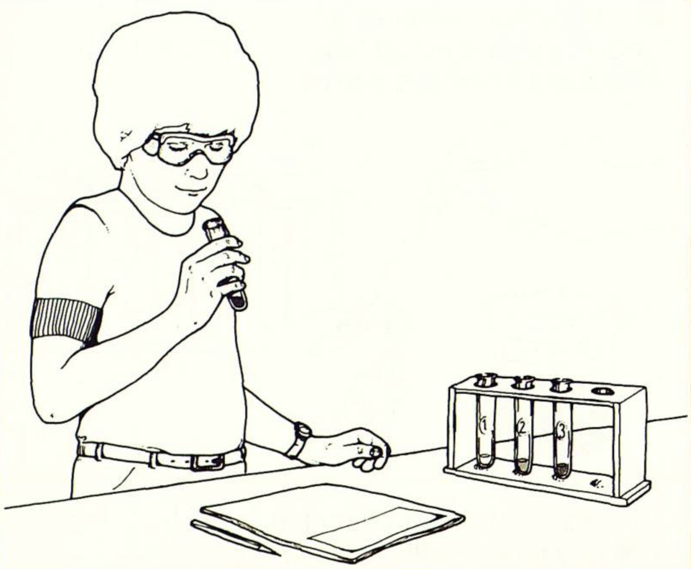
E When the temperature reaches 100 °C stop collecting the liquid in test tube 1.



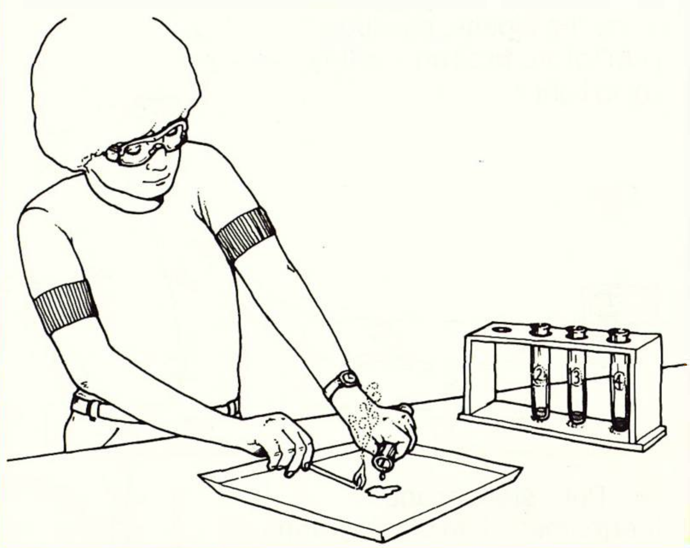
F Collect liquids in test tubes 2, 3 and 4 at the temperatures shown in your table.



G Look at the liquid in each test tube. Record its colour in your table. Carefully smell each liquid.



H Pour the liquid in test tube 1 onto the tin tray and try to light it. Record the results in your table. Repeat for liquids 2, 3 and 4.



Q2 What colour was the crude oil?

Q3 Did the crude oil burn easily?

Q4 Which distilled liquid burned most easily?

Q5 Which distilled liquid smelled like petrol?

Q6 What did the substance left in the side-arm test tube look like?

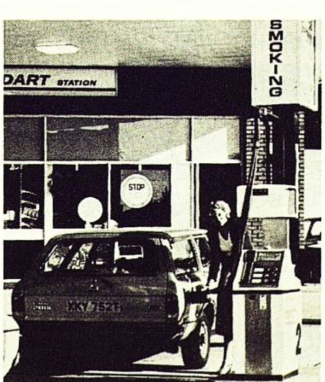
Q7 Could crude oil be used as a fuel to power a car?

Information: Distilling crude oil

Crude oil is found underground. It contains stored energy. Unfortunately crude oil does not burn well. The best way to release its stored energy is to **distill** the crude oil, which splits it up into useful products that can themselves be burned.

One of the most important products is **petrol**. It burns easily and contains the energy to power motor vehicles.

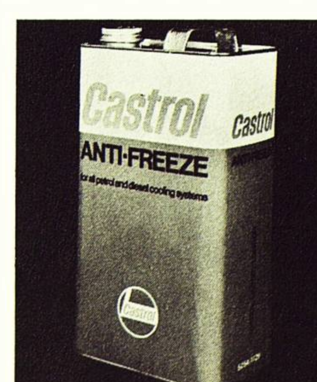
Distilled crude oil from the **oil refinery** gives these products:



Petrol

Diesel oil

Motor oil



Anti-freeze

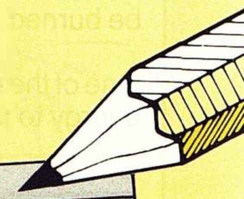
Q8 List some of the products made by distilling crude oil, and their uses.

The viscosity of oil

Apparatus

★ 4 thistle funnels ★ clip ★ 4 capillary tubes ★ rubber tube ★ clampstand
★ labelled samples of oil ★ stop clock ★ ruler ★ tape ★ beakers

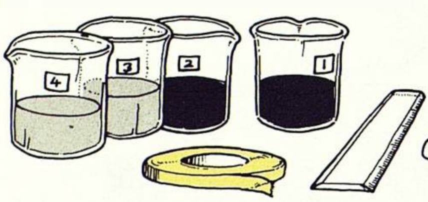
You are going to compare the **viscosity** (thickness) of different kinds of oil.

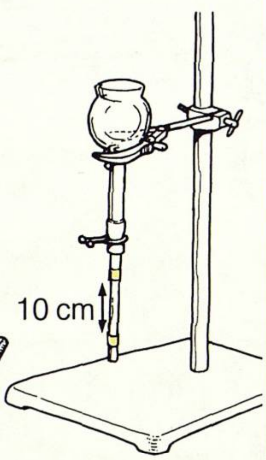


Q9 Copy this table.

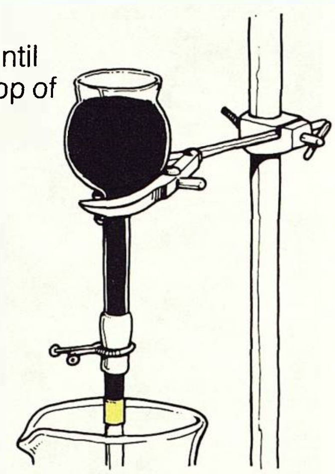
Oil sample	Type of oil	Time taken(s)
1		
2		

A Fix a rubber tube, a clip and a capillary tube onto a thistle funnel. Fix 2 pieces of tape 10 cm apart on the capillary tube.

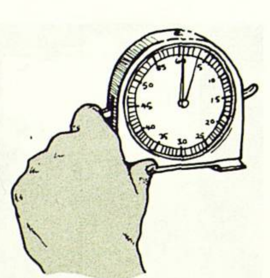


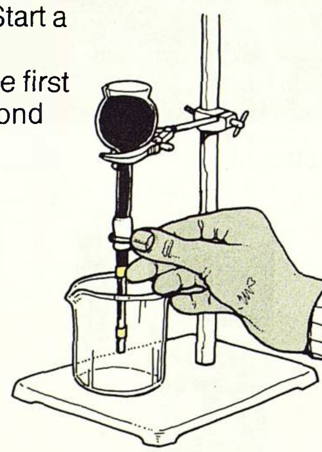


B Fill the funnel with oil sample 1. Open the clip until the oil level reaches the top of the first piece of tape.

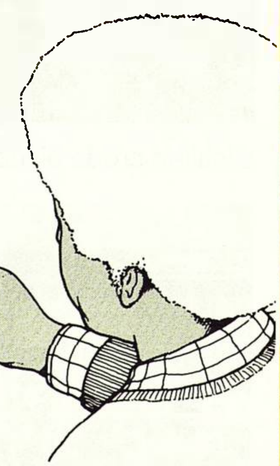


C Fully open the clip. Start a stop-clock. Time the oil moving from the top of the first tape to the top of the second tape.





D Record your results in your table. Repeat steps A, B and C for oil samples 2, 3 and 4 using clean equipment each time.



Q10 Which oil took the shortest time to run between the tape marks?

Q11 What does this tell you about the oil?

Q12 The oil in an engine gets hot when the car is running. What do you think happens to the viscosity?

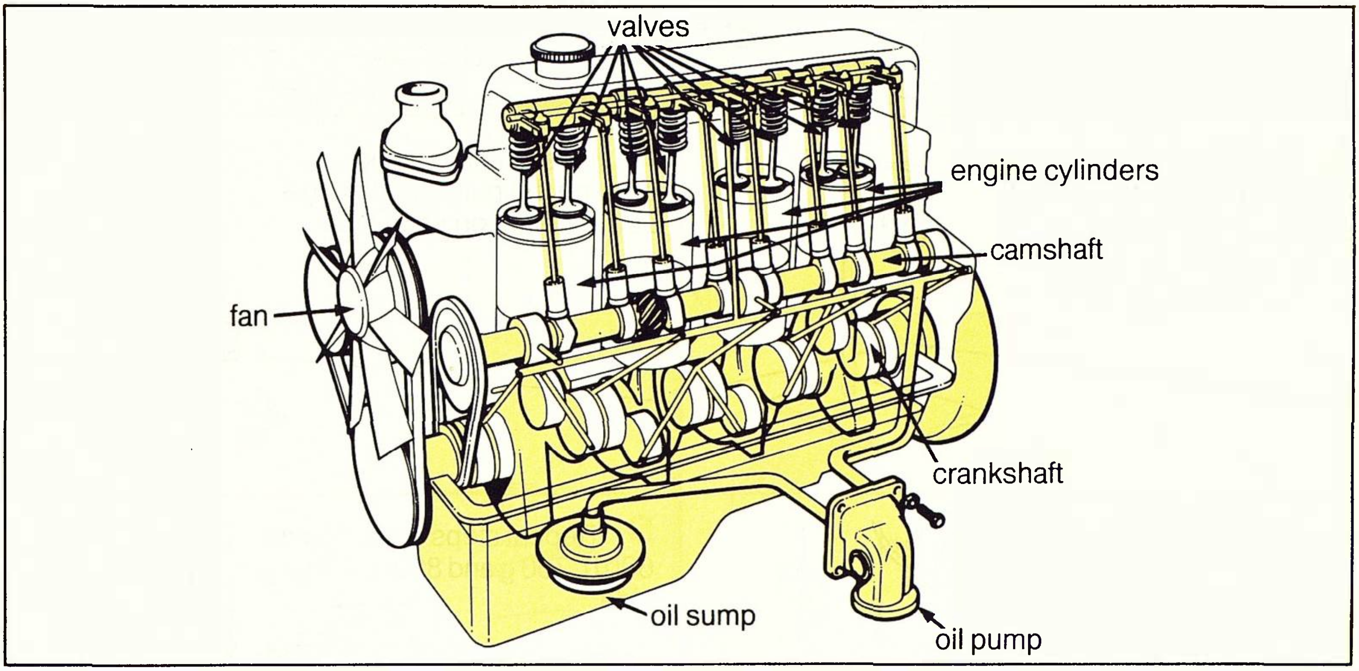
Q13 How could you test your answer to Q12 in the laboratory?

Information: Types of oil

Friction between the moving parts of a car causes wear and wastes energy. Oil, as a lubricant, helps reduce friction. The place where the friction occurs determines the type of oil used.

Inside the engine the lubricant is usually a **multi-grade** oil which is circulated around the moving parts by an **oil pump.**

The circulation of oil in the engine.



Lubricating oils are often rated with an **S.A.E.** number. A low number means the oil is thin or runny. A high number means that the oil is thick.

The viscosity of engine oil becomes less as the engine warms up. Thin hot oil is ineffective in preventing friction and wear. If a thicker oil is used the engine is difficult to start when cold, because the thick cold oil does not flow easily.

Multi-grade oils have solved these problems. They contain an additive which reduces the thinning effect at high temperatures. For example, S.A.E. 20-50 oil has the viscosity of S.A.E. 20 when cold and the viscosity of S.A.E. 50 when hot.

Other types of oil are used in the rear axle. Semi-solid lubricants, like grease, are also used to reduce friction.

Q14 Which is the thicker oil: S.A.E. 20 or S.A.E. 50?

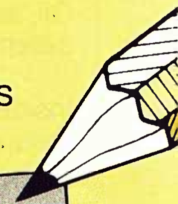
Q15 What properties must an oil have if it is used inside an engine?

Lubrication – cutting down friction

Apparatus

★ clampstand ★ pulley ★ string ★ weights ★ oil

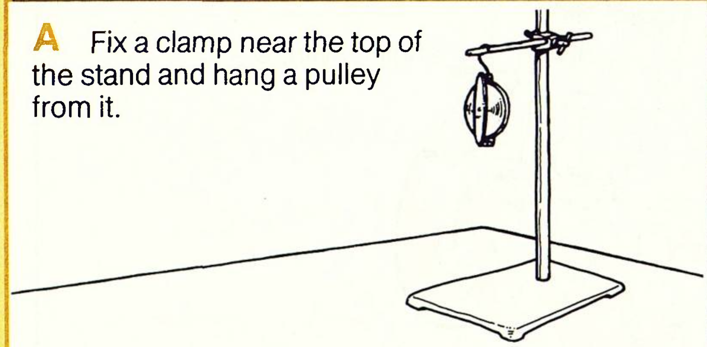
You are going to measure the friction of a pulley and find out the effect of oil on this friction.



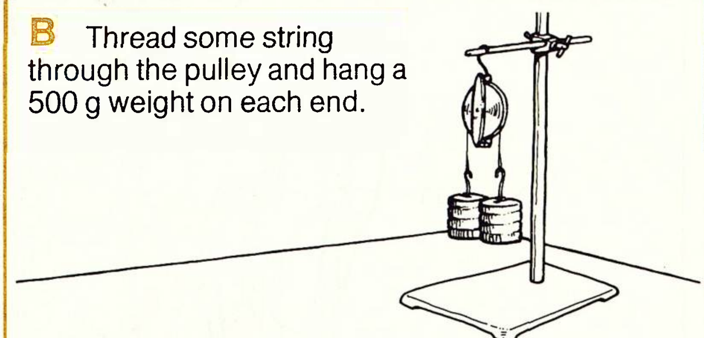
Q16 Copy this table.

Weight on each side	"Extra weight" needed to turn pulley	
	Before oiling	After oiling
500g		

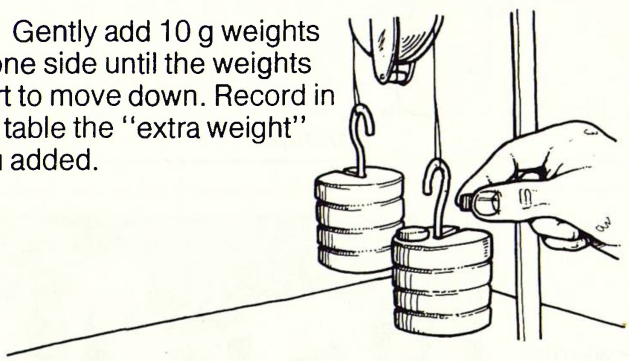
A Fix a clamp near the top of the stand and hang a pulley from it.



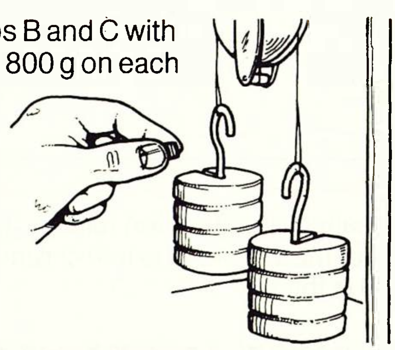
B Thread some string through the pulley and hang a 500 g weight on each end.



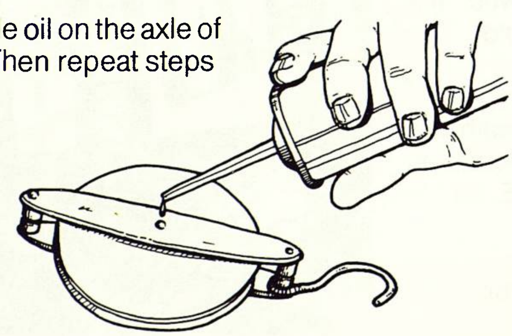
C Gently add 10 g weights to one side until the weights start to move down. Record in the table the "extra weight" you added.



D Repeat steps B and C with 600 g, 700 g and 800 g on each side.



E Put a little oil on the axle of the pulley. Then repeat steps B, C and D.



Q17 How much "extra weight" was needed to overcome friction in step C?

Q18 From your table, is more "extra weight" needed to turn the pulley when there are bigger weights hanging on it? Why is this?

Q19 Is the same "extra weight" needed after the pulley has been oiled?

Q20 What has the oiling done to the friction of the pulley?

2 The four-stroke cycle

Making a model cylinder, piston and crank mechanism

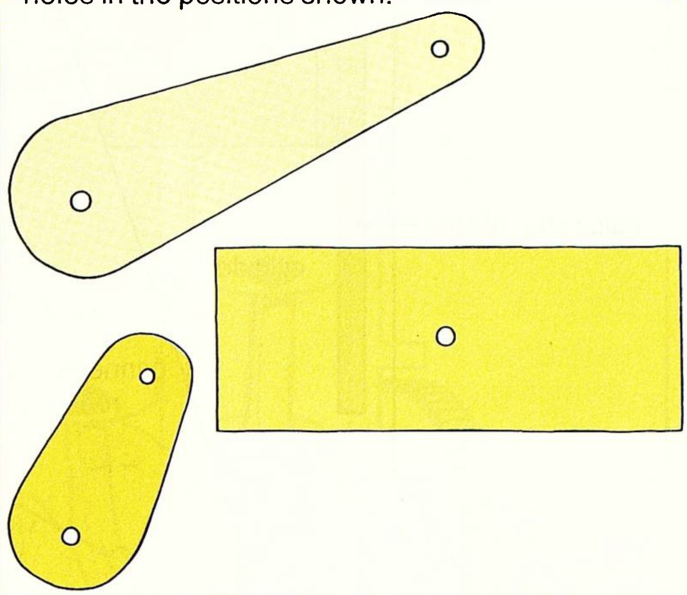
Apparatus

★ cardboard ★ scissors ★ glue ★ paper fasteners ★ balsa strips
★ tracing paper

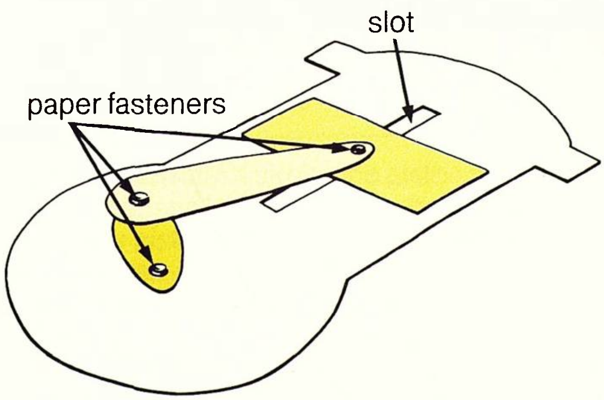
You are going to make a model of a piston and see how it moves inside a cylinder.

A Look at the template on page 8. Trace the overall shape and the slot. Stick your tracing to the cardboard and cut out the shape.

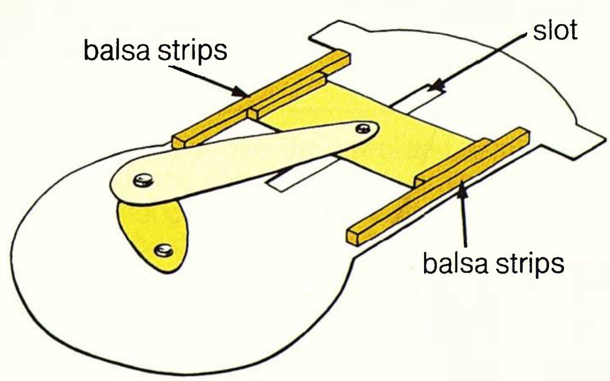
B Trace the piston, connecting rod and crank arm. Stick these to card, and cut them out. Make holes in the positions shown.



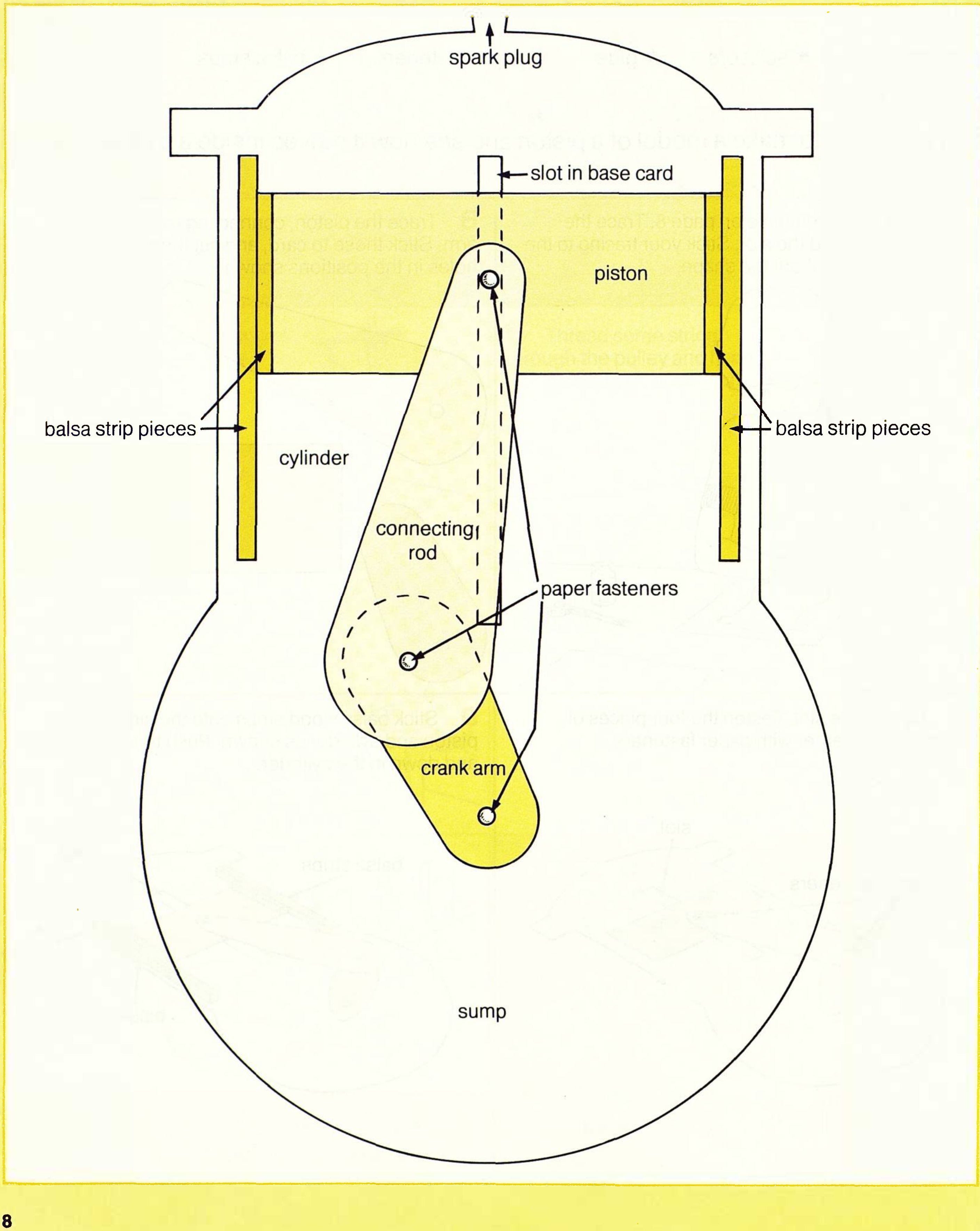
C Cut out the slot. Fasten the four pieces of cardboard together with paper fasteners.



D Stick balsa wood strips onto the sides of the piston and cylinder as shown. Push the piston up and down in the cylinder.

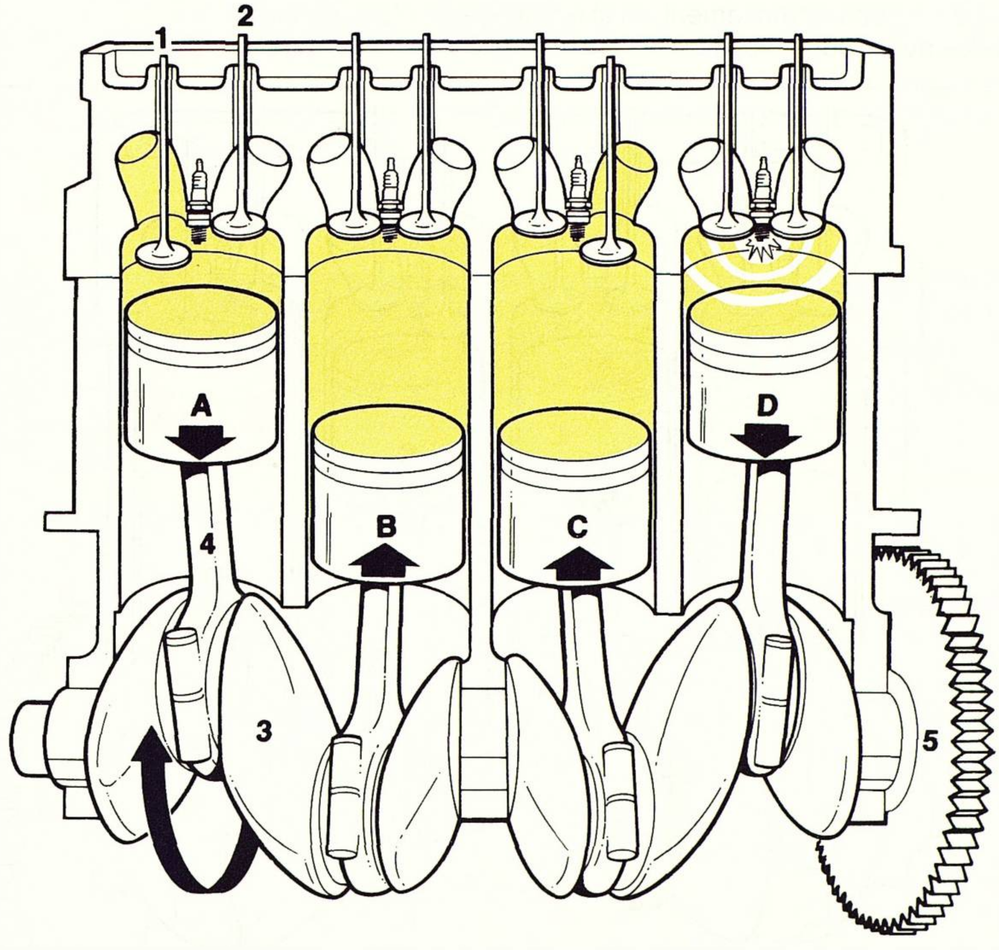


Template for model cylinder, piston and crank mechanism



Information: The four-stroke cycle

This car engine has four cylinders, each with its own **piston, valves** and **spark plug.** Each piston makes four different strokes during each cycle. The cycle is then repeated. The four strokes are shown below.



1 On the **induction** stroke the piston moves down and causes low pressure in the cylinder. In the diagram piston **A** is in its induction stroke. Inlet valve **1** is open and a mixture of air and petrol vapour is drawn in. Exhaust valve **2** is closed.

2 On the **compression** stroke, the piston moves up and compresses (squeezes) the mixture into the top of the cylinder. In the diagram piston **B** is in its compression stroke. Both inlet and exhaust valves are closed.

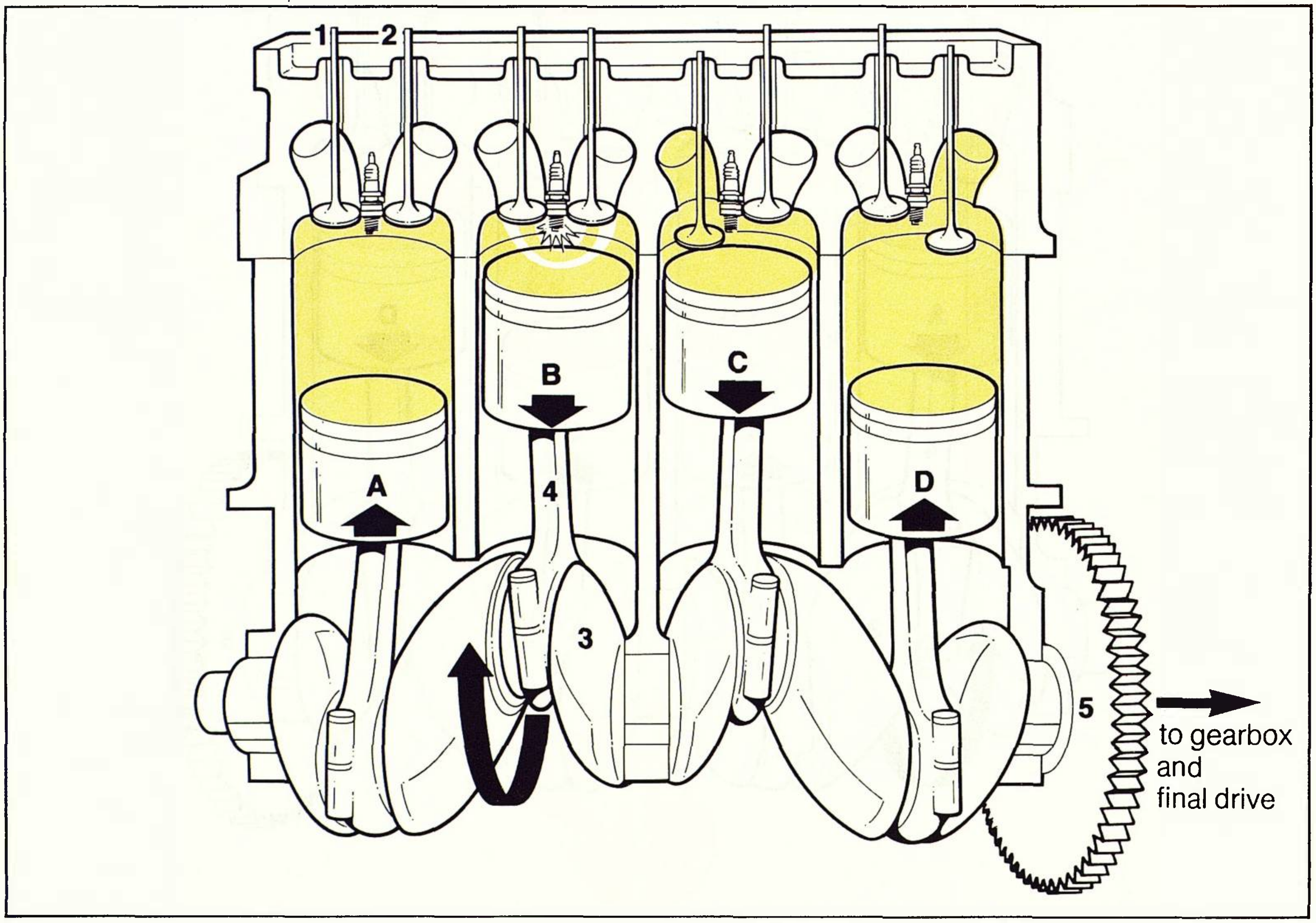
3 In the **power** stroke, the petrol and air mixture is **ignited** (lit) by the spark plug and burns. The expanding hot gases force the piston down the cylinder. In the diagram piston **D** is in its power stroke. The power stroke turns the **crankshaft (3)** and the **flywheel (5).**

4 On the **exhaust** stroke the piston moves up the cylinder. The exhaust valve opens to let out waste gases. The inlet valve is closed. In the diagram, piston **C** is in its exhaust stroke.

The four-stroke cycle

Each movement of a piston up or down the cylinder turns the crankshaft through **half a turn.** In the illustration below piston **A** is rising on its compression stroke. Piston **B** is descending on its power stroke. Piston **C** is descending on its induction stroke. Piston **D** is rising on its exhaust stroke.

The four pistons are timed to be on different strokes at any one time. This gives the engine a smoother movement, as at a road speed of 30 mph the crankshaft makes over 2000 revolutions every minute.



The pistons are connected by **connecting rods (4)** to the **crankshaft (3).** The crankshaft turns the **flywheel(5).** The flywheel is connected to the **gearbox** through the **clutch**. The drive passes from the gearbox to the wheels and so the movement of the engine is used to drive the car.

Q1 What produces the spark for the ignition?

Q2 During which stroke is the chemical energy of the petrol changed to useful movement energy?

Q3 How many times does the crankshaft turn for each piston to complete its cycle?

3 The Battery

Making a simple lead-acid battery

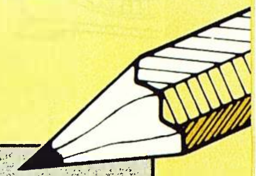
Apparatus

★ glass beaker ★ lead plates ★ connecting wires with crocodile clips
★ low voltage D.C. supply ★ stop clock ★ sulphuric acid ★ funnel ★ gloves
★ safety goggles

You are going to make a simple battery, charge it and use it to light a bulb.

☠ Wear safety goggles and gloves. If any acid splashes on your skin wash it off immediately.

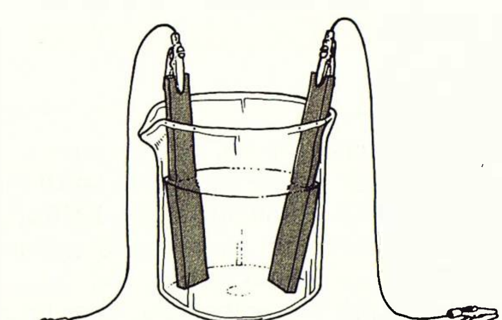
Q1 Copy this table.



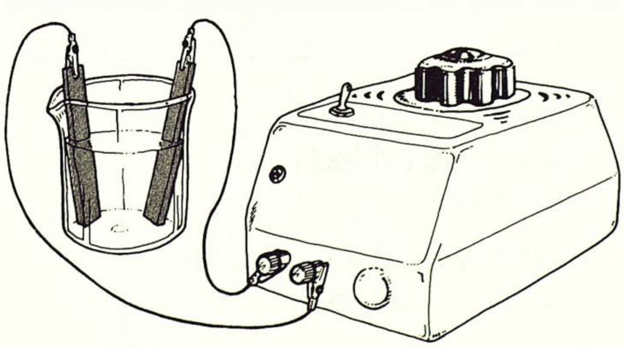
Minutes connected to electricity supply	Time bulb stays alight
1	
2	
3	
1 (half quantity of acid)	

A Pour the acid into a beaker.

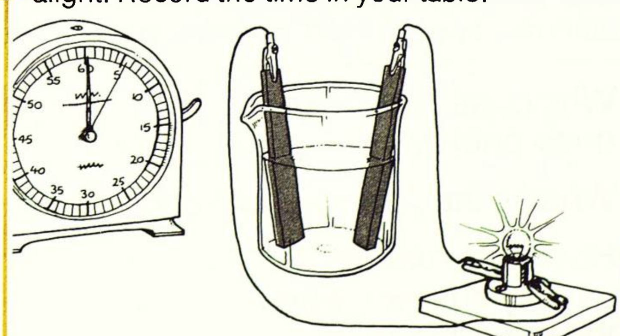
B Put 2 lead plates in the acid and clip one wire to each. Make sure the lead plates do not touch.



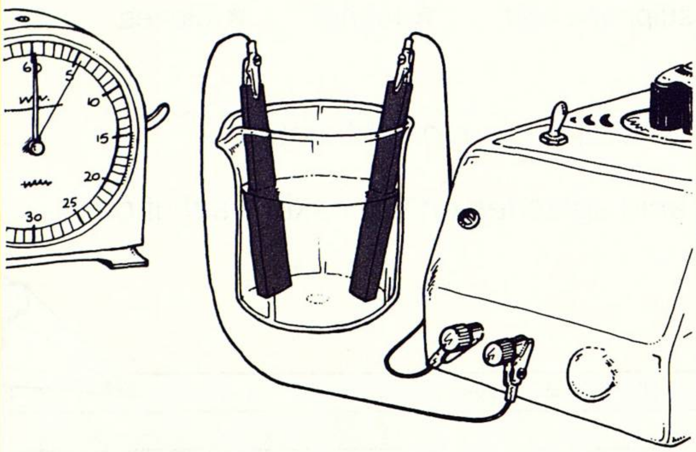
C Connect the wires to the low voltage D.C. supply and switch on for 1 minute. You are **charging** the battery.



D Disconnect the wires from the electricity supply and connect them to the bulb. The battery is now **discharging**. Time how long the bulb stays alight. Record the time in your table.



E Repeat steps C and D with the electricity switched on for 2 minutes. Then repeat with it switched on for 3 minutes.



F Using a funnel pour half the liquid into the bottle and repeat steps C and D.

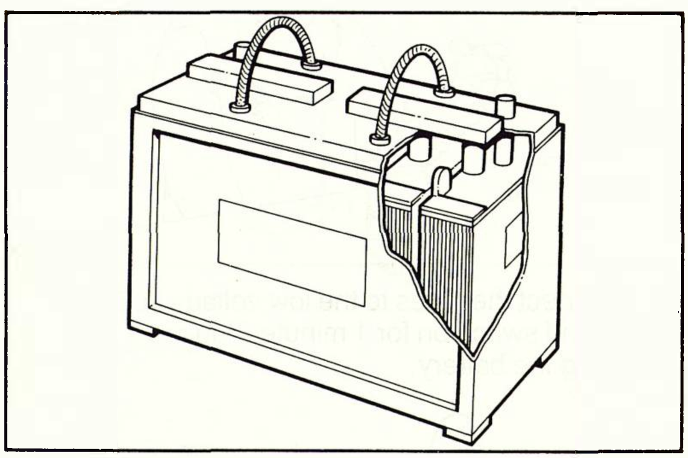
Q2 Does the bulb stay alight longer the more you charge the battery?

Q3 What effect did low acid level have?

Information: Car batteries

The car battery stores energy for important purposes. It is used to turn the **starter motor** to **start** the car and to operate the **radio, lights,** etc., when the engine is not running. The car battery is usually a **12 volt lead-acid** battery. The drawing on the right shows the lead plates inside the battery.

The battery is usually charged by the car **dynamo** or **alternator** when the car is moving. A car battery will last a very long time if treated with care. If the acid level drops below the top of the lead plates it should be topped up with **distilled** water, otherwise the battery may become **"flat"** more quickly.



Q4 Why does the battery need energy?

Q5 What is the battery used for?

Q6 How is the battery usually charged when the car is moving?

Q7 When should distilled water be added to a battery?

Q8 What would you do with a "flat" battery?

4 The electrical system

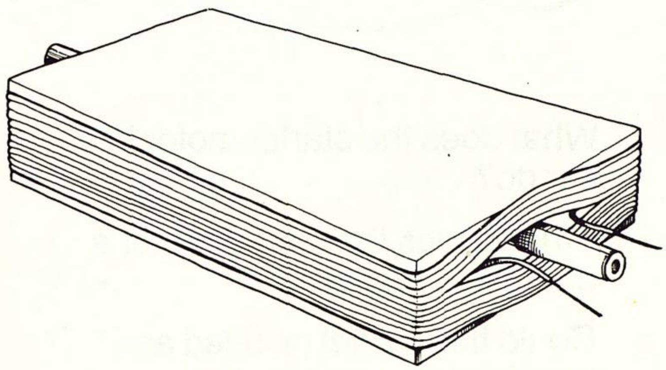
An electric motor

Apparatus

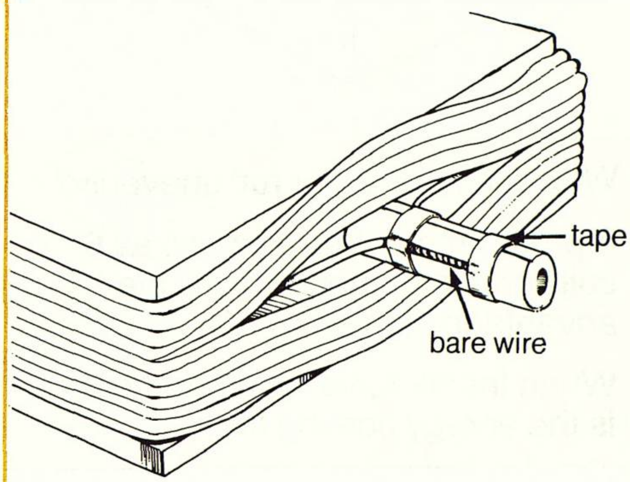
★ Motor kit ★ low voltage D.C. electrical supply

You are going to make a working model of an electric motor.

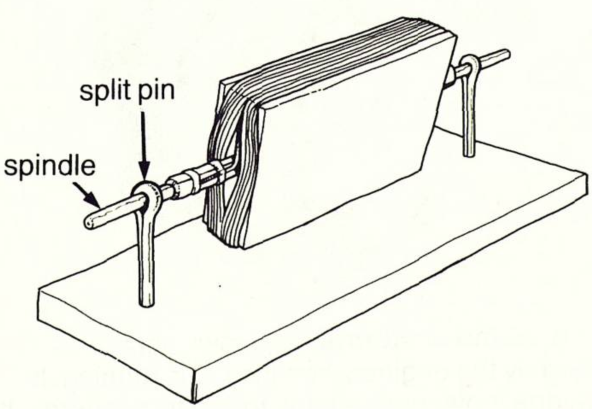
A Wind about 10 turns of insulated wire tightly round the wooden former.



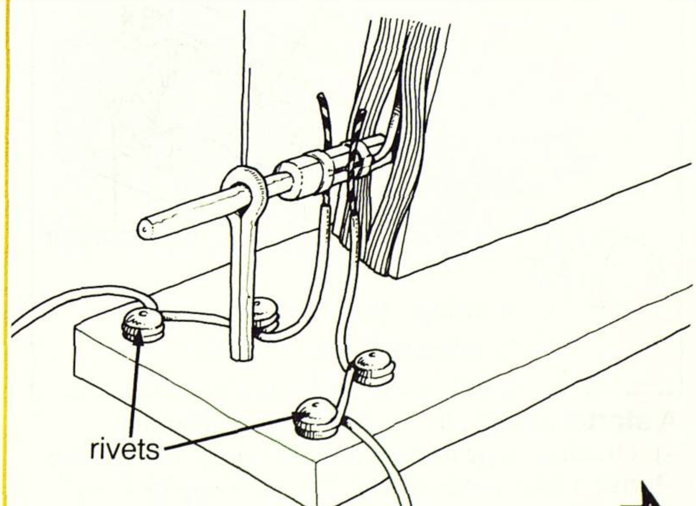
B Bare the 2 ends of the wire and tape them to the end of the tube as shown.



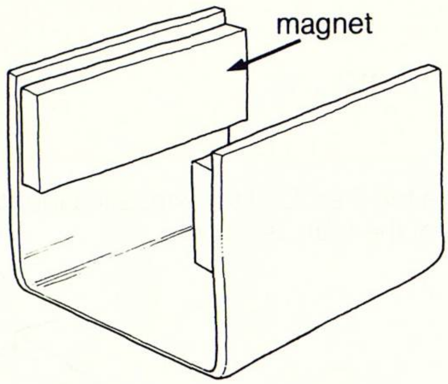
C Push 2 split pins into the base plate. Push a spindle through the tubes and through the split pins.



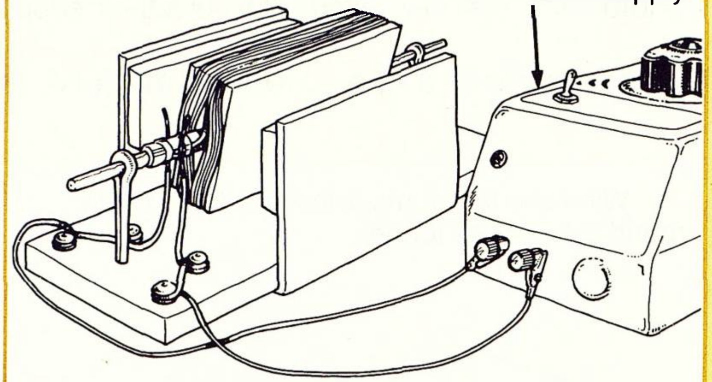
D Make 2 "brushes" of bare wire, held to the base by rivets as shown.



E Fix 2 magnets to a yoke with opposite poles facing each other. Put the motor between the poles.



F Connect the brushes to a 1 volt D.C. supply and flick the coil. Adjust the motor until it runs continuously.



Q1 Why does the motor run unevenly?

Q2 A proper motor has as many as 6 coils on the former. What is the advantage of this?

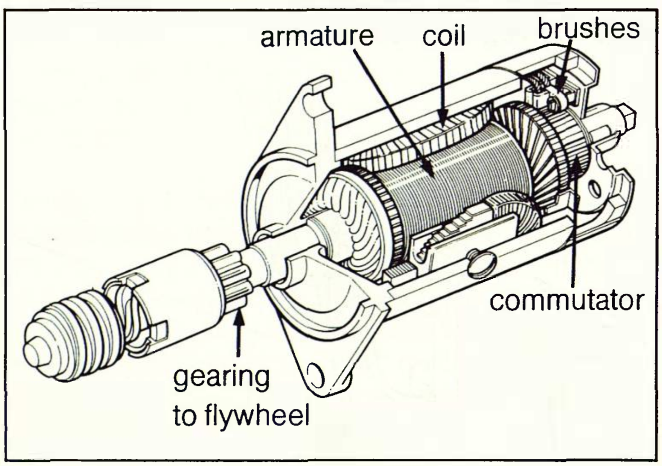
Q3 When the motor is running where is the energy coming from?

Q4 What does the starter motor in a car do?

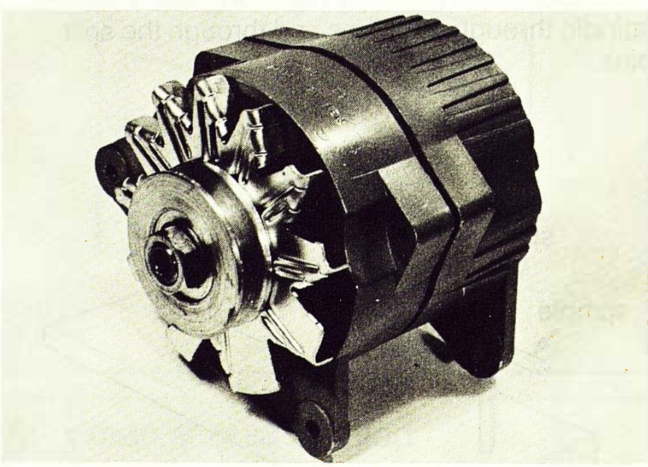
Q5 Where does the starter motor's energy come from?

Q6 Could this model be used as a simple dynamo? How?

Information: Motors and dynamos



A **starter motor,** as shown above, converts electrical energy to movement energy. In a car the starter motor is needed to "turn the engine over" so that it will start to "fire".



The **dynamo** or **alternator** (shown above), is turned by the engine when the car is running. It converts movement energy to electrical energy. It powers the lights, ignition system, and other electrical components. It also recharges the car battery.

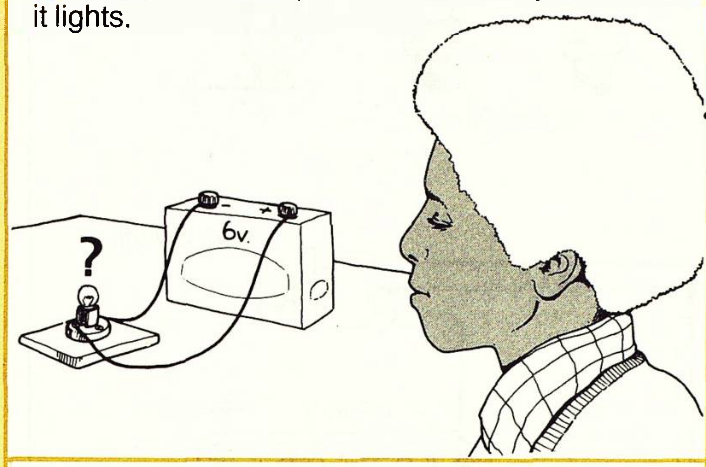
The induction coil

Apparatus

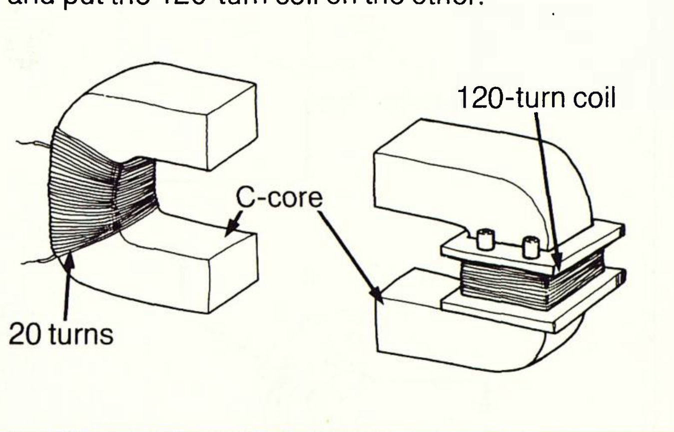
★ 2 C-cores ★ insulated wire ★ 120-turn coil ★ neon lamp on stand
★ 6 volt battery ★ leads

You are going to make a model induction coil which produces a high voltage from a low voltage.

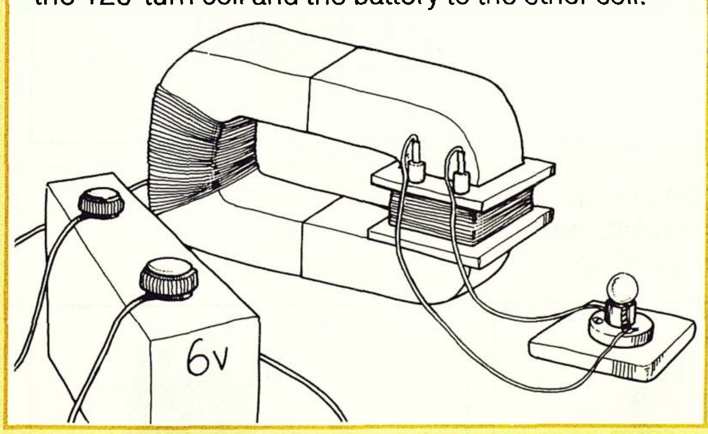
A Connect the lamp to the 6 volt battery and see if it lights.



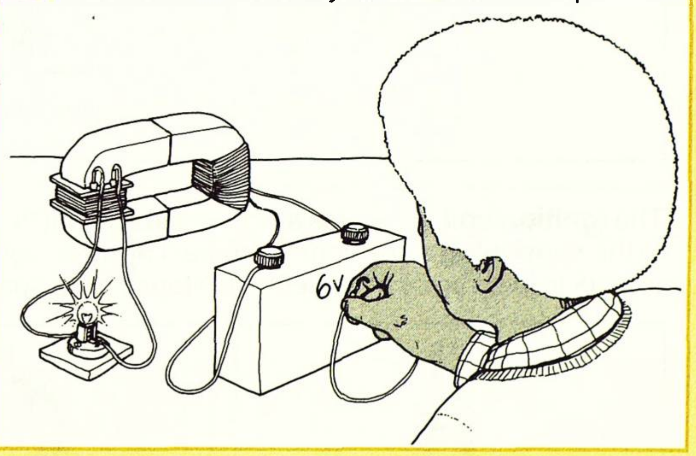
B Wind 20 turns of insulated wire on one C-core and put the 120-turn coil on the other.



C Put the C-cores together. Connect the lamp to the 120-turn coil and the battery to the other coil.



D Switch off the battery and watch the lamp.



Q7 Does the neon lamp light when connected to the 6 V battery?

Q8 Is 6 V enough to light the lamp?

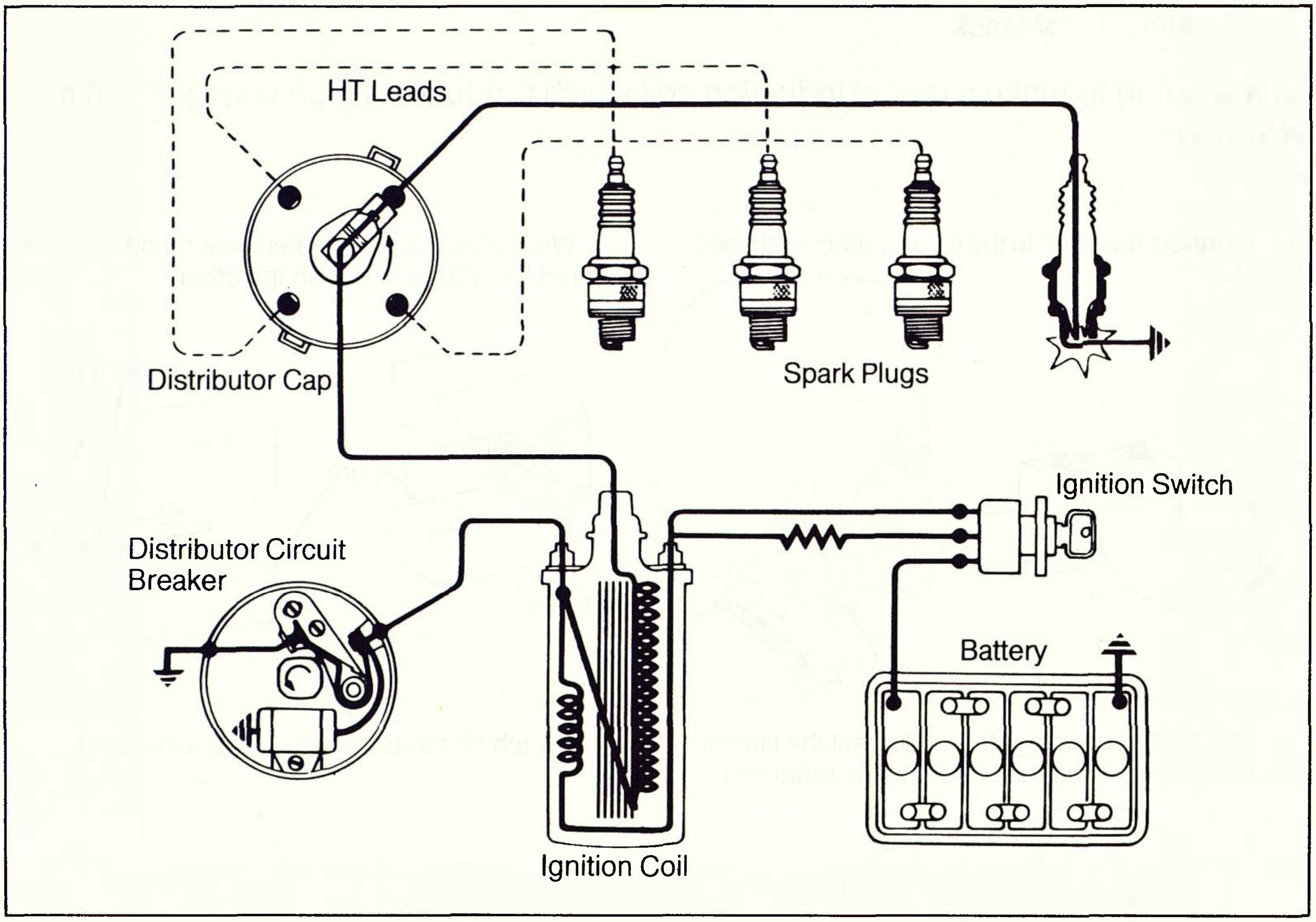
Q9 What happens to the lamp as the battery is switched off?

Q10 What can you say about the voltage across the 120-turn coil compared with the voltage of the battery?

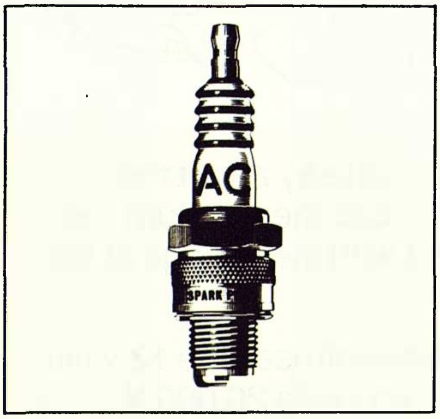
Q11 The ignition coil uses the 12 V car battery to produce 20 000 V. What can you say about the number of turns on this coil?

Information: The ignition system

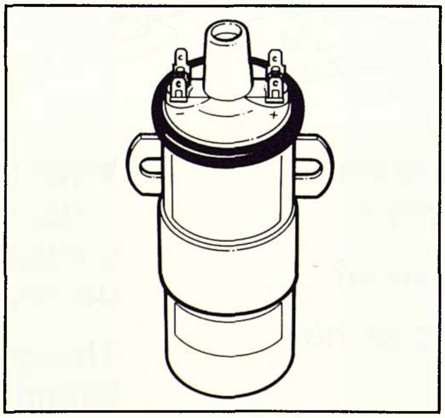
The petrol and air mixture in the engine cylinders is **ignited** (lit) by means of a spark. This spark is produced electrically in an **ignition circuit** (see photo below).



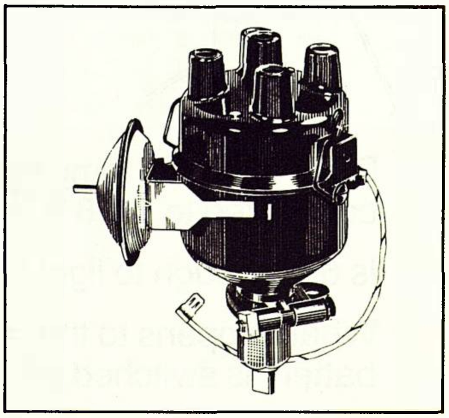
The **ignition coil** generates a high voltage (about 20 000 V) which is connected to the **spark plug** at the correct moment by means of a **distributor.** This causes a spark to jump across the electrodes forming the spark plug gap.



Spark plug



Ignition coil



Distributor

5 Hydraulic systems

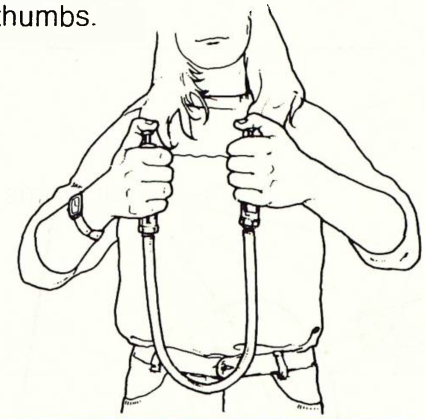
Transmission of force

Apparatus

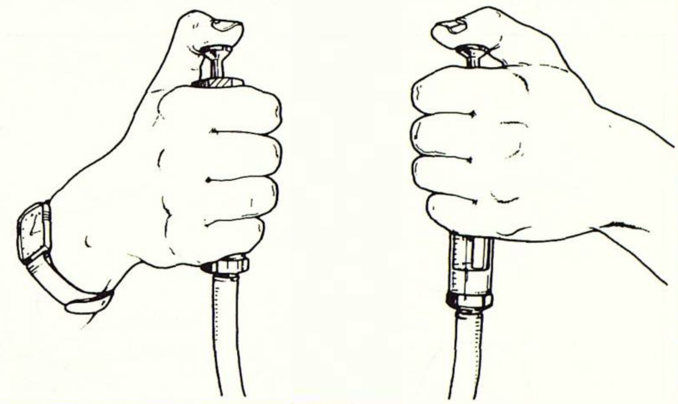
★ 3 syringes ★ rubber tubing

You are going to find out about methods of transmitting forces without solid contact.

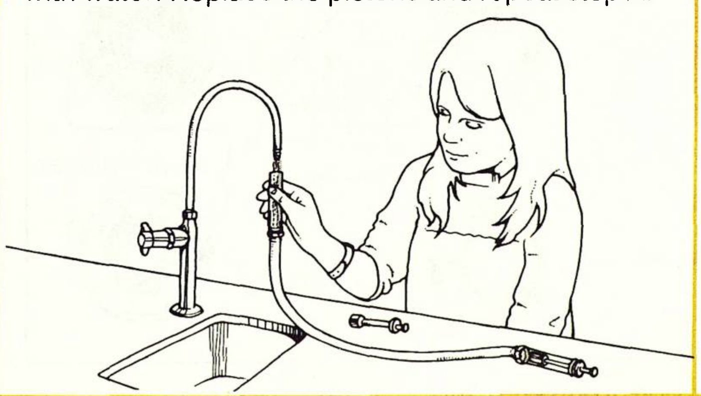
A Connect 2 syringes by means of a rubber tube. Hold one in each hand and press the pistons with your thumbs.



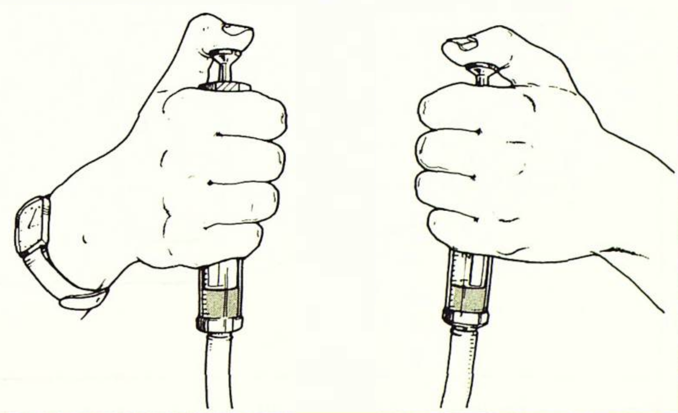
B Change one of the syringes for one of a different size and repeat step A.



C Connect the 2 syringes of the same size. Remove the pistons and fill the syringes and tube with water. Replace the pistons and repeat step A.



D Change one of the syringes for one of a different size and repeat step C.



Q1 When you press one piston in step A can you feel a force on the other piston?

Q2 What carries the force from one syringe to the other?

Q3 What difference does it make if the syringes and tube are filled with water?

Q4 Does it make any difference to the force if the syringes are of different sizes?

Q5 Which is the easiest syringe to push?

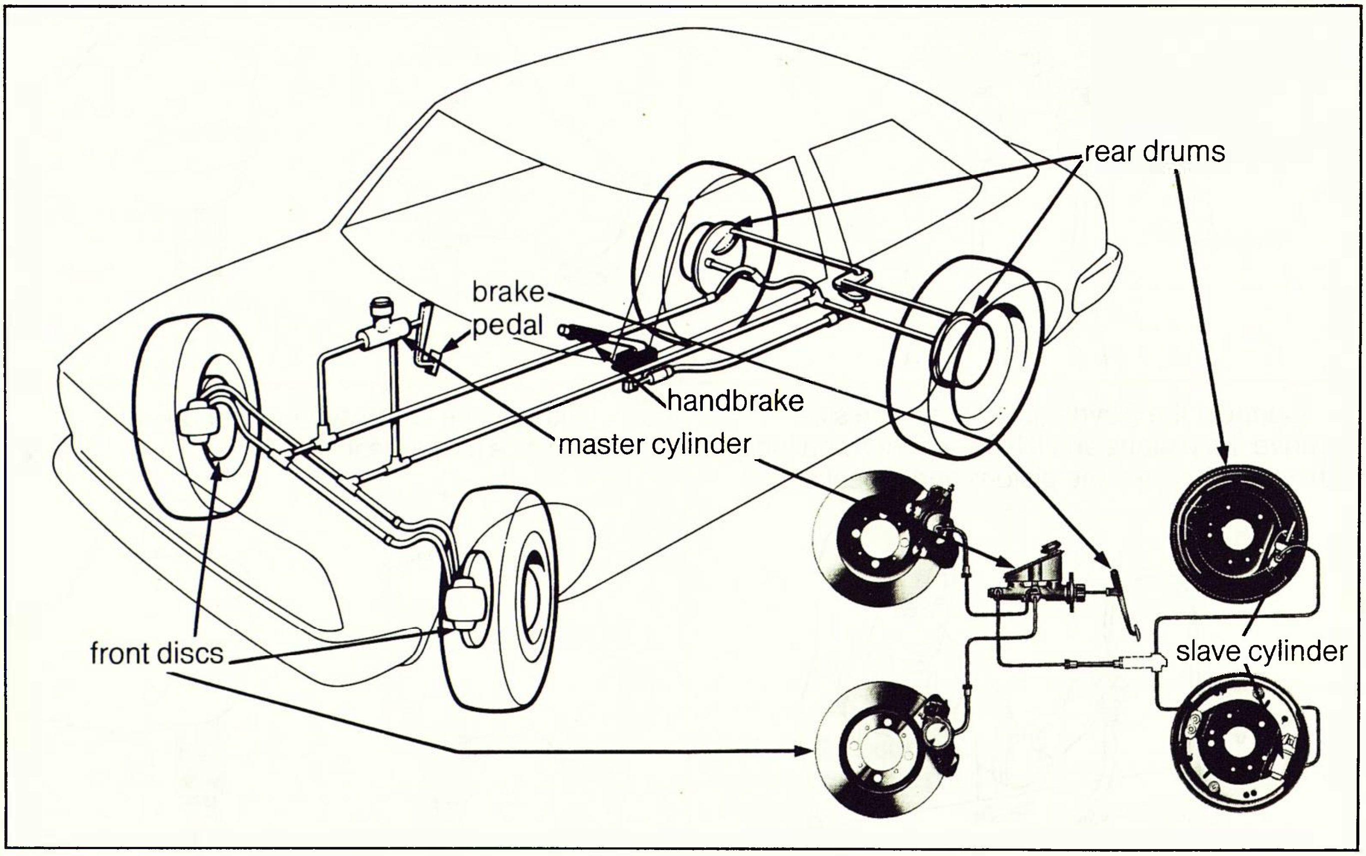
Q6 Why is water not used in a car hydraulic system?

Information: Hydraulic systems

Hydraulic systems in the motor car are used to transmit pressure or force. The main system operated in this way is the **brake** system.

A hydraulic brake system (as shown below) has a **master** cylinder and **slave** cylinders connected by pipes. The system is filled through the master cylinder with **hydraulic fluid**.

When the **brake pedal** is pushed a piston inside the master cylinder forces the hydraulic fluid to the slave cylinders. The pistons inside the slave cylinders push brake pads onto the brake **drums** or **discs.**



If air gets into the system this will make for poor transmission of pressure. Air is **compressible** (can be squeezed into a smaller size) and therefore takes up some of the essential movement in the system.

Q7 What type of fluid is used in hydraulic systems?

Q8 What would be the effect of air inside a hydraulic system?

Q9 In a hydraulic braking system one piston is operated by the brake pedal and the other piston pushes the brakes on. Which one is the bigger piston?

Q10 Why is this?

6 Cooling systems

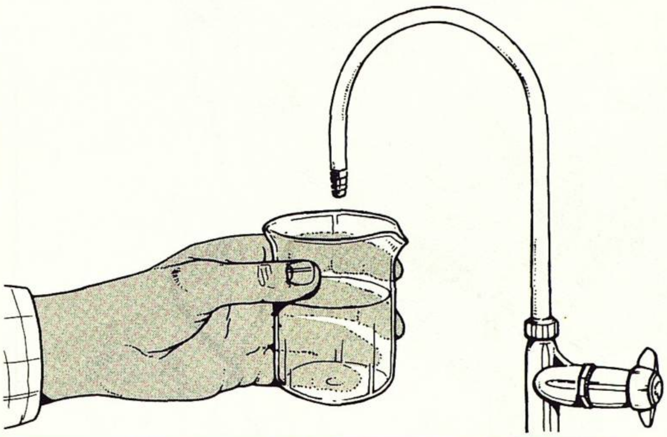
Convection currents

Apparatus

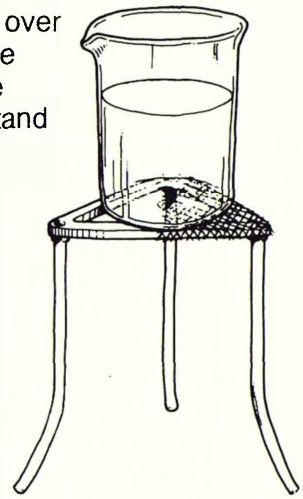
★ 500 cm³ beaker ★ Bunsen burner ★ heatproof mat ★ gauze ★ tripod
★ teaspoon ★ sawdust ★ water

You are going to look for a convection current in heated water.

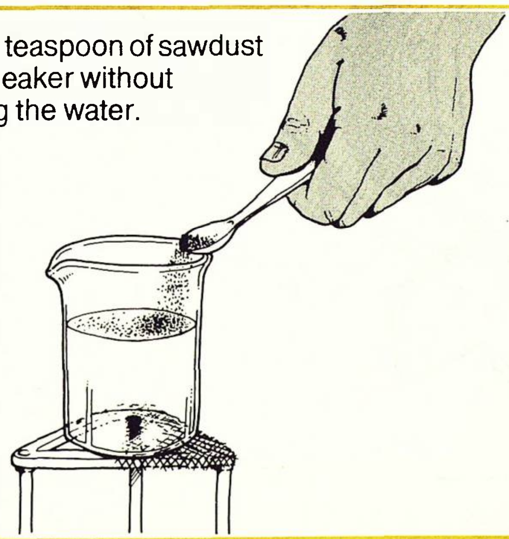
A Pour water into a beaker until it is ¾ full.



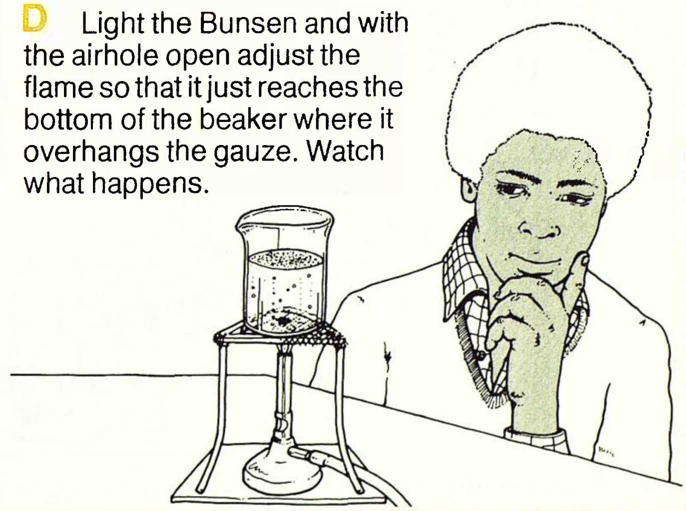
B Put a gauze halfway over the top of a tripod. Put the beaker carefully over the gauze as shown. Let it stand for 5 minutes.



C Put a teaspoon of sawdust into the beaker without disturbing the water.



D Light the Bunsen and with the airhole open adjust the flame so that it just reaches the bottom of the beaker where it overhangs the gauze. Watch what happens.



Q1 What happened to the water in step B when you let it stand for 5 minutes?

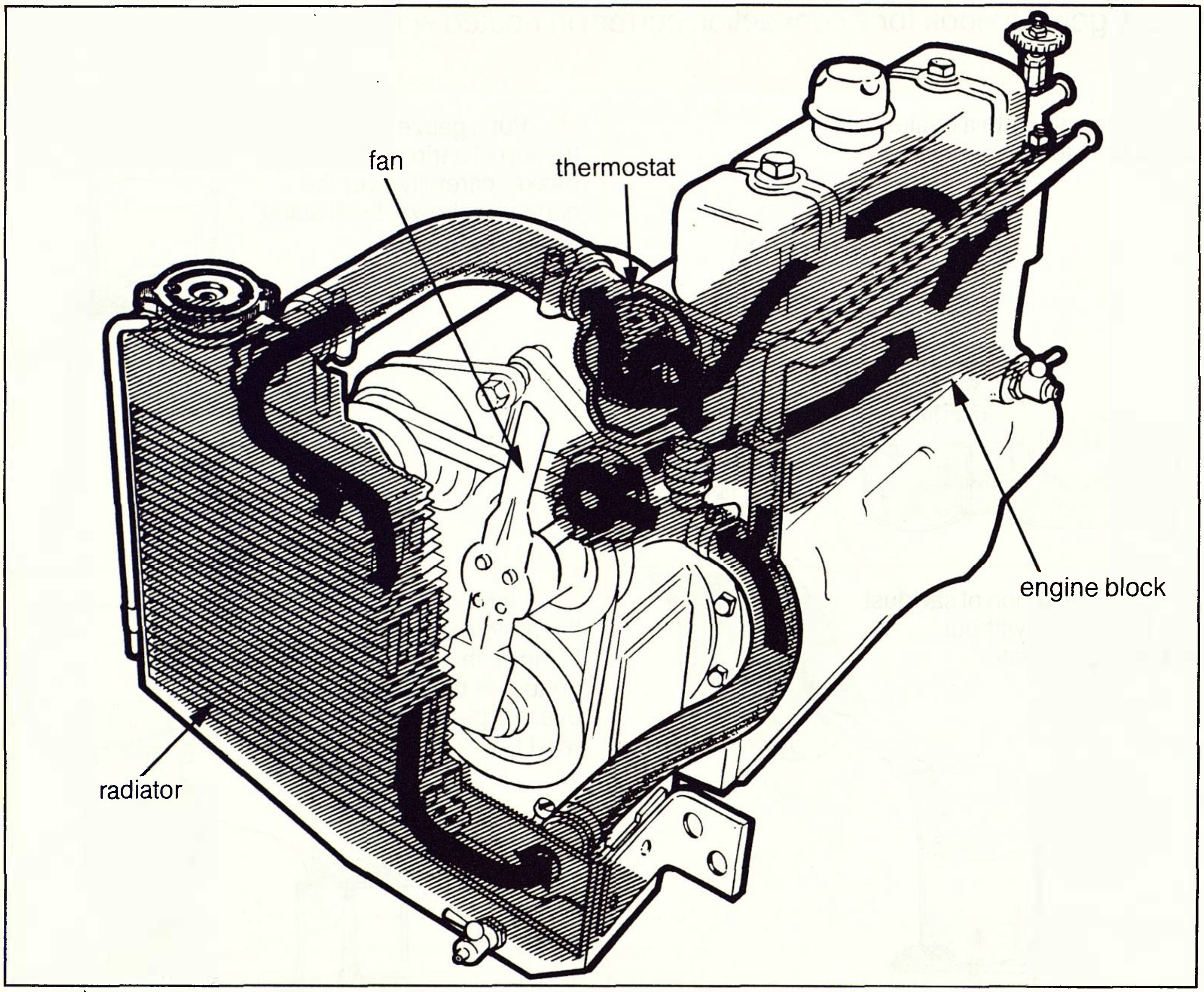
Q2 Draw a diagram to show the movement of the sawdust when the water was nearly boiling.

Q3 Why would iron filings not be suitable instead of sawdust?

Q4 The movement is called a convection current. What is being carried round by the current, as well as the sawdust?

Information: Water cooling

Without some means of cooling, the heat produced within the engine would soon cause it to **overheat** and **sieze**. By far the most common method of cooling is to use water which moves constantly around the engine, absorbing its heat. The diagram below shows a **water-cooling** circuit.



Heat from the engine's cylinders passes to the water in a jacket around the engine block. When the water is hot enough the **thermostat** opens and the hot water rises to the top of the radiator. This hot water is then cooled by air drawn through the **radiator** by the **fan.** The cooled water returns to the bottom of the engine, and the cycle begins again.

Q5 Why does the engine need to be water cooled?

Q6 The water is not circulated when the engine first starts from cold. What is the reason for this?

Wax

Apparatus

★ Bunsen burner ★ heatproof mat ★ gauze ★ clampstand
★ boiling tube ★ wax ★ beaker ★ water ★ thermometer ★ felt-tip pen
★ stop clock ★ safety goggles

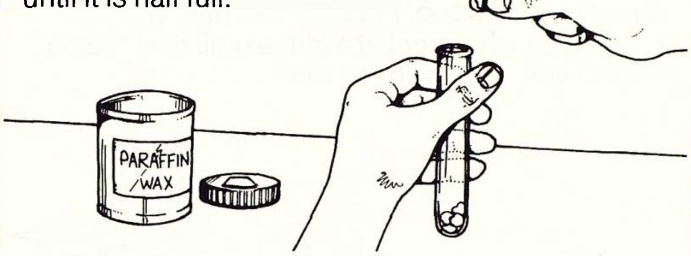
You are going to plot a cooling graph for molten wax.

Wear safety goggles.

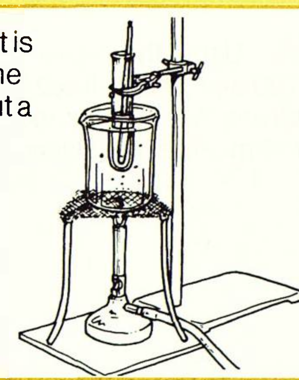
Q7 Copy this table.

Time (minutes)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Temperature (°C)																				

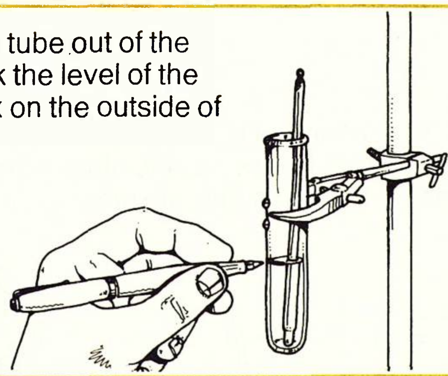
A Put small pieces of paraffin wax into a boiling tube until it is half full.



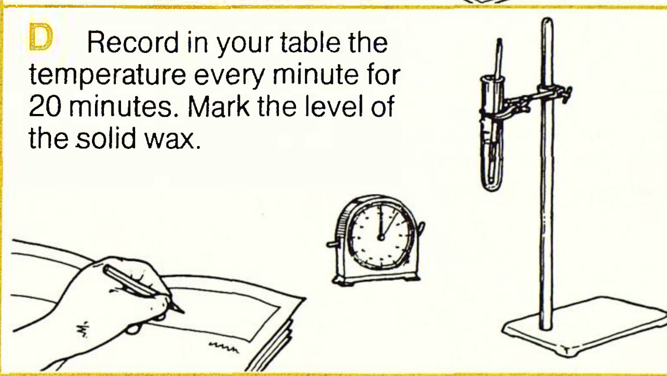
B Clamp the tube so that it is in a beaker of water. Heat the water until the wax melts. Put a thermometer into the wax.



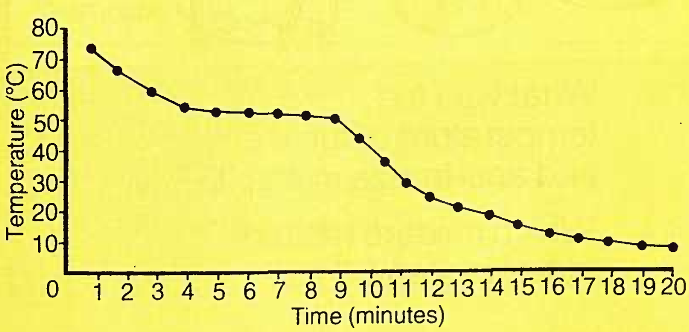
C Lift the tube out of the water. Mark the level of the melted wax on the outside of the tube.



D Record in your table the temperature every minute for 20 minutes. Mark the level of the solid wax.



Q8 Draw a graph like this of your results.



Q9 At what temperature is the flat part of the graph?

Q10 What was happening to the wax at this time?

Q11 Was there a difference between the levels of liquid and solid wax?

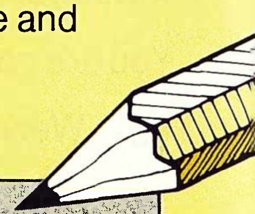
Q12 What happens to the size of wax when it **melts?**

Anti-freeze

Apparatus

★ 4 plastic cups ★ water ★ anti-freeze ★ measuring cylinder ★ 2 thermometers
★ 2 beakers

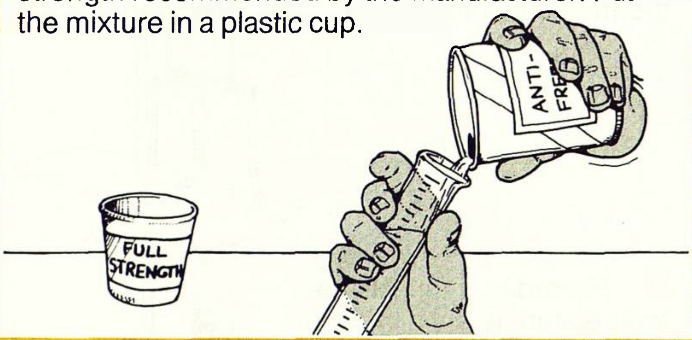
You are going to find out what happens when you cool mixtures of anti-freeze and water.



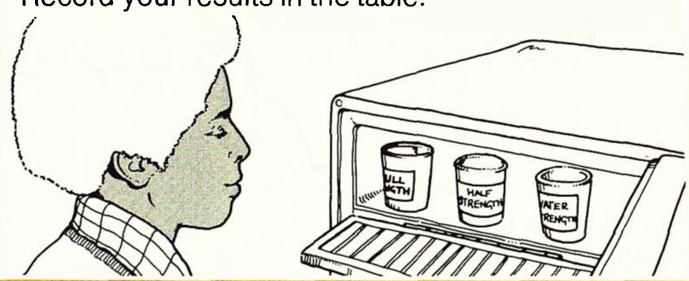
Q13 Copy this table.

Mixture strength	Condition after cooling
Full strength	
Half strength	
Quarter strength	

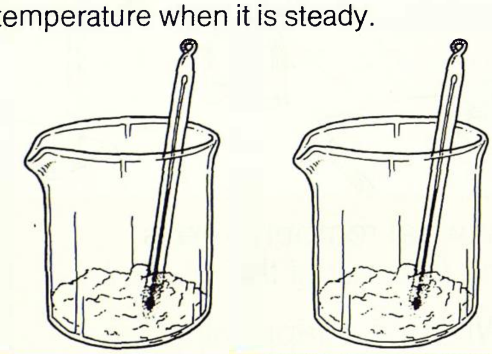
A Using the measuring cylinder make up 100 cm³ of anti-freeze and water mixture to the strength recommended by the manufacturer. Put the mixture in a plastic cup.



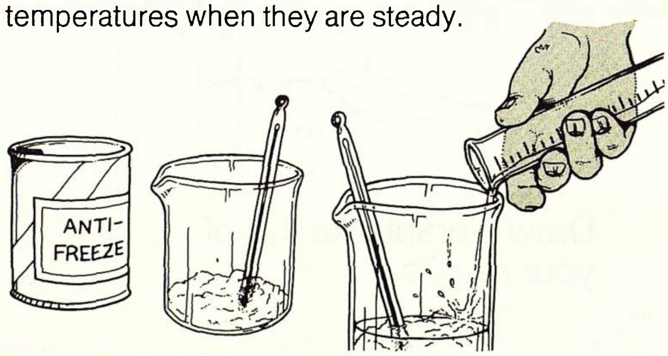
B Now make up 100 cm³ at half strength and 100 cm³ quarter strength. Put each sample in a separate plastic cup. Put the 3 samples in the freezing compartment of a fridge until next lesson. Record your results in the table.



C Put equal amounts of crushed ice in 2 beakers. Put a thermometer in each and measure the temperature when it is steady.



D Pour 10 cm³ of tap water into one beaker and 10 cm³ of anti-freeze into the other. Note the temperatures when they are steady.



Q14 In step B which mixture was the hardest to freeze?

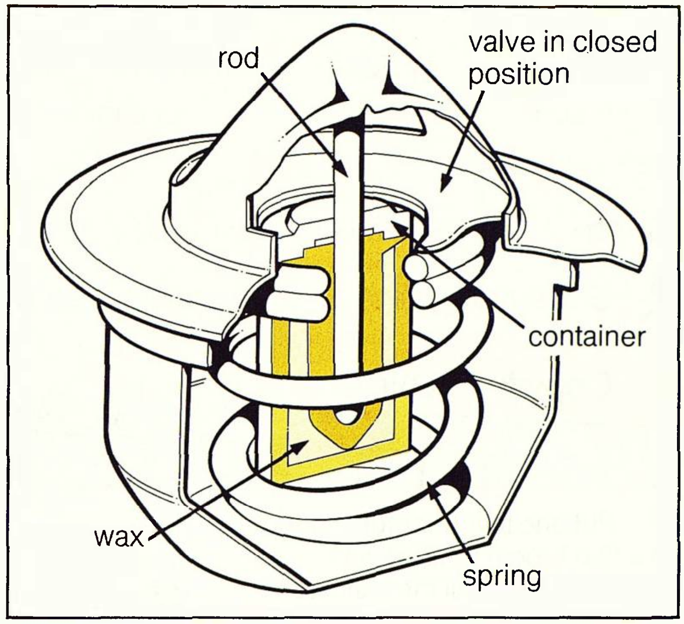
Q15 What was the temperature of the ice and water in step D?

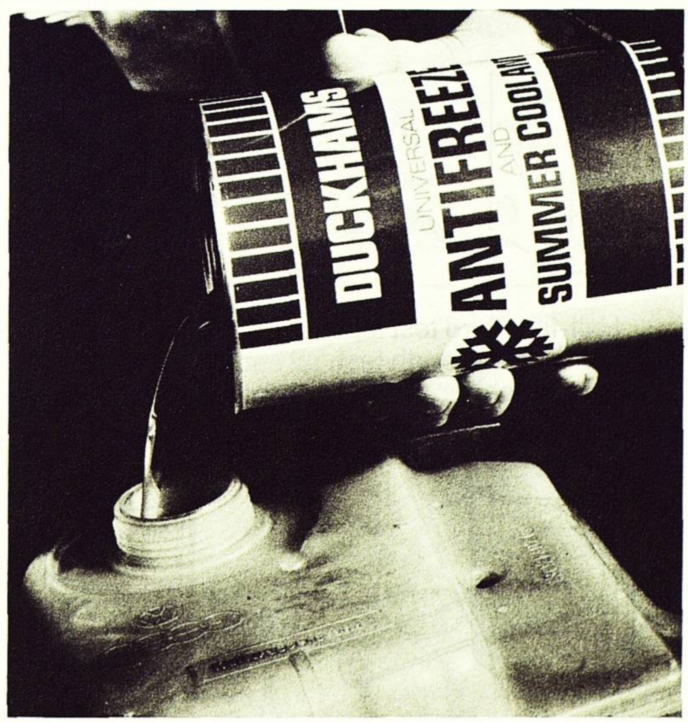
Q16 What was the temperature of the ice and anti-freeze in step D?

Q17 Which mixture melted faster in step D?

Information: Thermostats and anti-freeze

The **thermostat** shuts off the flow of water from the radiator when the engine is cold. Most cars have a **wax-filled** thermostat fitted to the engine. When the wax is cold, the **valve** is closed and water cannot flow between the engine and the radiator. When the wax is hot, it melts and expands, forcing the **container** downwards and so opening the valve. A **spring** pushes the container and valve back when the wax cools.





If the water in the cooling system freezes it can ruin the engine. To prevent this happening **anti-freeze** is mixed with the radiator water. This must be done carefully according to the manufacturer's instructions.

Q18 What does the thermostat do?

Q19 What happens to the wax when it gets hot?

Q20 What is the spring for?

Q21 How could you find out the opening temperature of the thermostat?

Q22 Why is anti-freeze used in the cooling system?

7 Corrosion

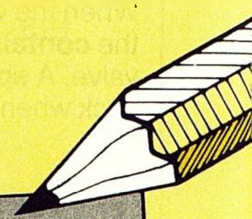
The corrosion of iron

Apparatus

★ 4 test tubes ★ nails ★ stoppers ★ sulphuric acid ★ anti-freeze ★ salt
★ teaspoon ★ labels ★ test tube rack ★ 10 cm^3 measuring cylinder
★ safety goggles

You are going to find out how quickly different liquids cause iron to rust.

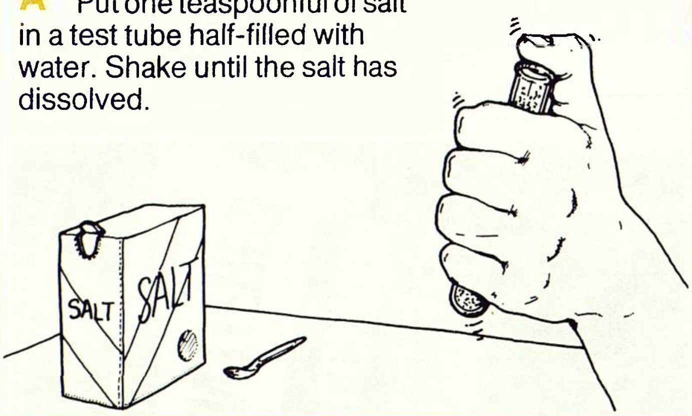
Safety goggles must be worn when working with acid.



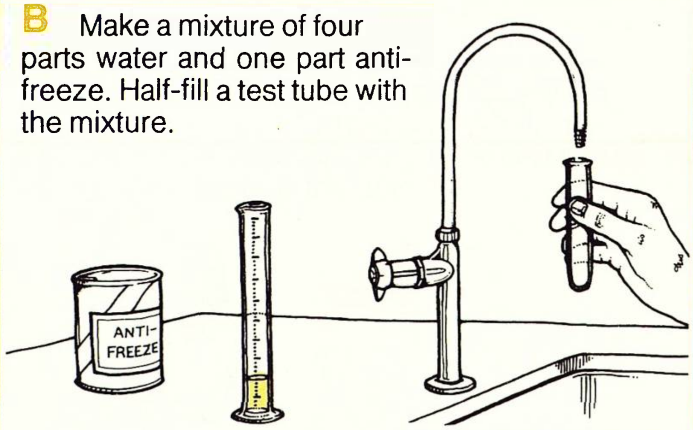
Q1 Copy this table.

Liquid	Appearance of nail after:			
	1 day	2 days	3 days	7 days

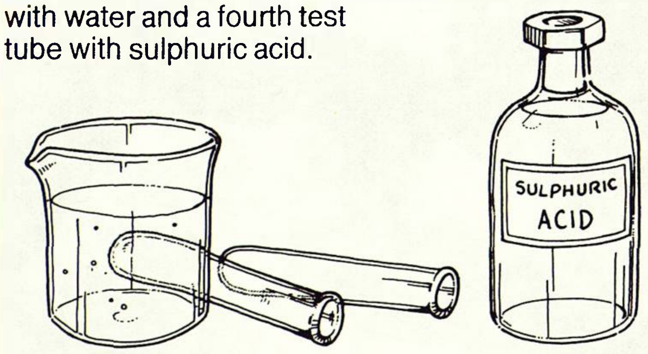
A Put one teaspoonful of salt in a test tube half-filled with water. Shake until the salt has dissolved.



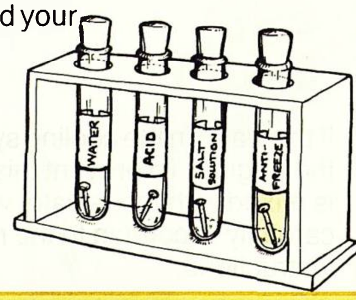
B Make a mixture of four parts water and one part anti-freeze. Half-fill a test tube with the mixture.



C Half-fill a third test tube with water and a fourth test tube with sulphuric acid.



D Label your test tubes and put a shiny nail into each. Put in stoppers and leave the tubes in the rack. Look at them after 1, 2, 3 and 7 days. Record your results in your table.



Q2 Which nail rusted most quickly?

Q3 Which nail was the last to rust?

Q4 When is salt water likely to splash on the car?

Q5 What should a motorist do to prevent corrosion due to salt water?

Q6 Where could acid come from in the car?

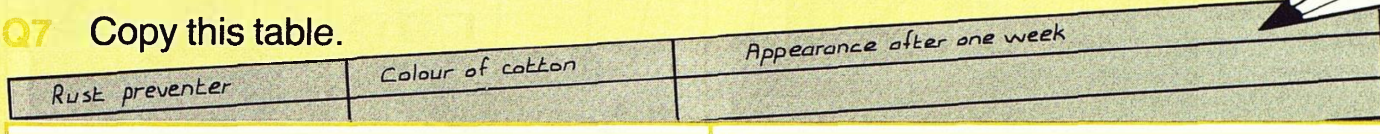
Preventing corrosion

Apparatus

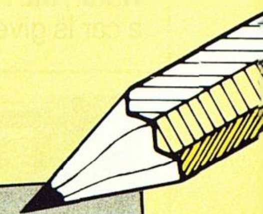
★ 4 test tubes ★ nails ★ stoppers ★ water ★ salt solution
★ 4 rust preventers ★ coloured cottons ★ test tube rack

You are going to test four rust preventers.

Q7 Copy this table.

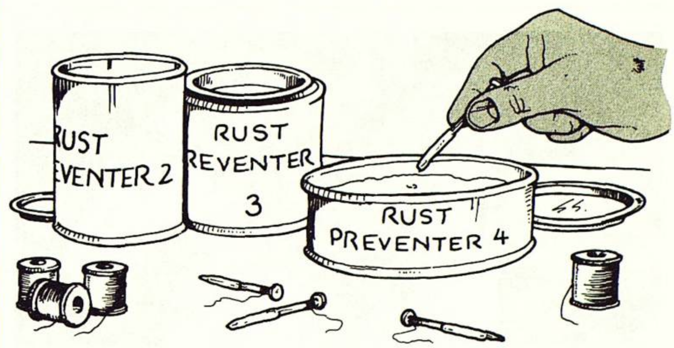


Rust preventer	Colour of cotton	Appearance after one week

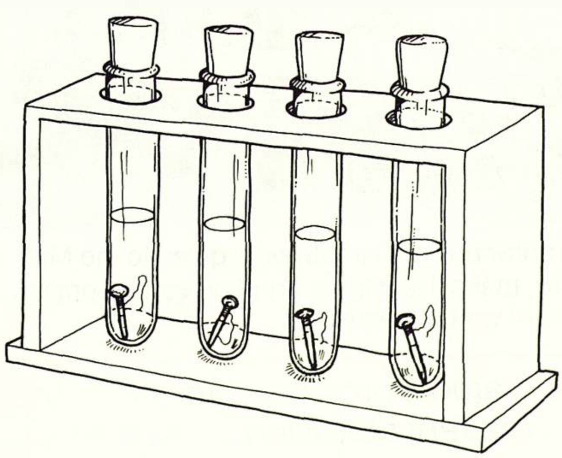


A Dip a nail into rust preventer 1 until it is half covered.

B Using a new nail each time, dip into rust preventers 2, 3 and 4 until each nail is half covered. Leave them to dry and then tie cotton of a different colour to each nail.



C Put each nail into a test tube of salt solution. Put a stopper into each tube.



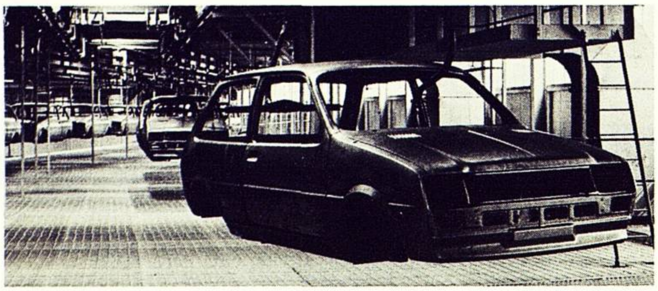
D Leave the tubes for one week and then examine them. Record your results in your table.

Q8 Which rust preventer worked best?

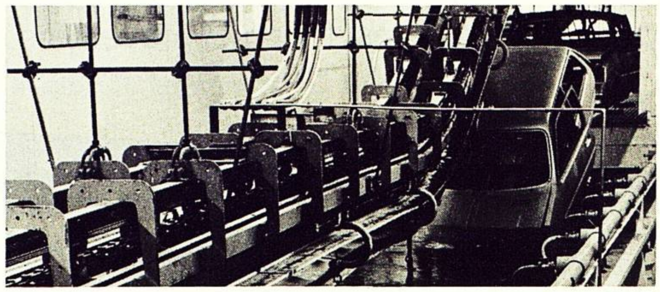
Q9 Which was the least effective?

Information: Bodywork

Most cars are made from steel which is a **metal.** Metals are **corroded** by rain water, the atmosphere and some chemicals. For this reason the bodywork of a car is given special treatment during manufacture.

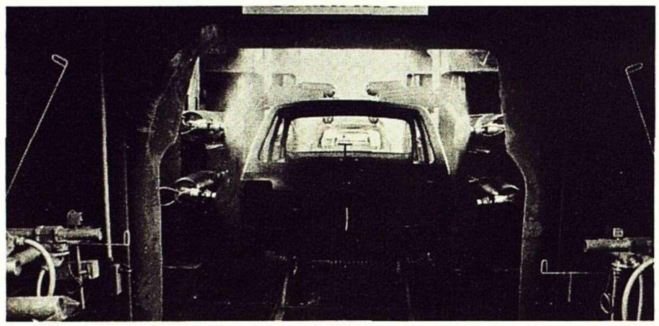


Once the "body shell" is put together it needs to be cleaned to remove all the grease and oil. This is called the **body in white** state.

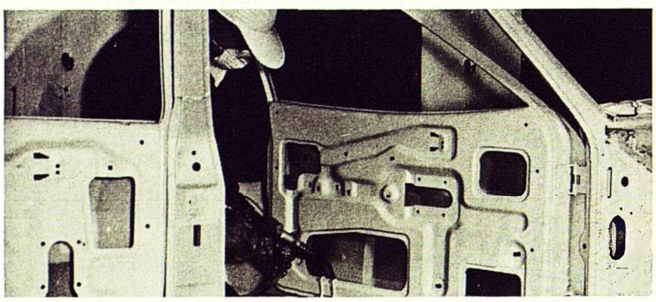


From the "body in white" the car is **dipped** in anti-corrosive paint, so that all the metal is covered.

The underneath of the bodywork is sealed with a chip resistant coating or **underbody sealer.**



Coats of sealer and primer paint are then applied in a spraying booth. The colour coat is then put on.



The car is then **baked** to harden the colour coat. **Wax** is put in areas like the doors, to help prevent corrosion.

The anti-corrosion treatments given to the Mini Metro, make it last longer and protect it from the worst of winter weather.

Q10 How is metal corroded?

Q11 What is the "body shell" called after the grease and oil has been removed?

Q12 Name 4 processes to prevent corrosion.

8 Safety

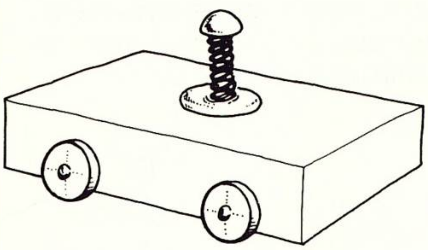
Crumple zones

Apparatus

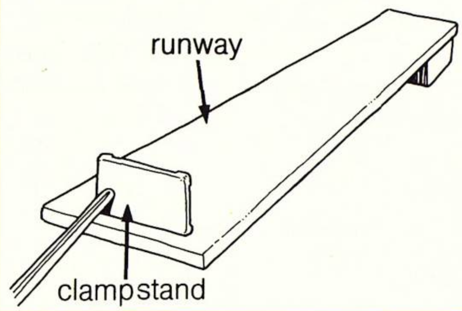
★ dynamics trolley ★ runway ★ clampstand ★ spring ★ plasticine
★ balance ★ paper ★ tape ★ scissors ★ ruler

You are going to find out what happens to a model passenger in a head-on collision. You will then make a "crumple zone" for the model car, and test it.

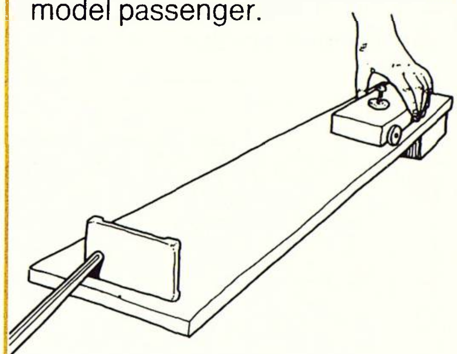
A Weigh out 15 g of plasticine to fix the spring to the car. Weigh out 10 g of plasticine for the "head". Set up your model as shown.



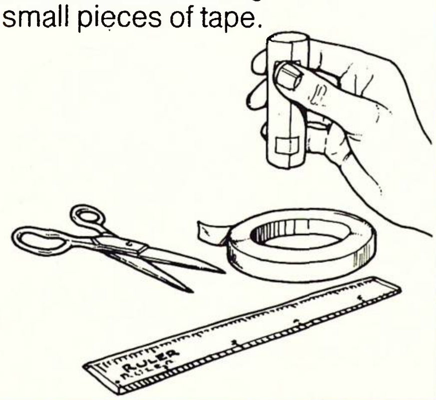
B Put one end of the runway on a solid support about 10 cm high. Put a clampstand at the bottom of the runway as shown.



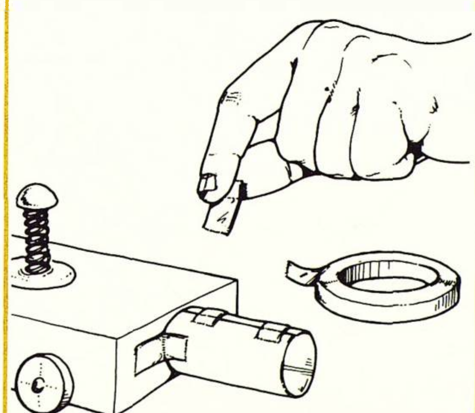
C Let the trolley run about 1·5 metres down the slope and hit the clampstand base. Watch what happens to the model passenger.



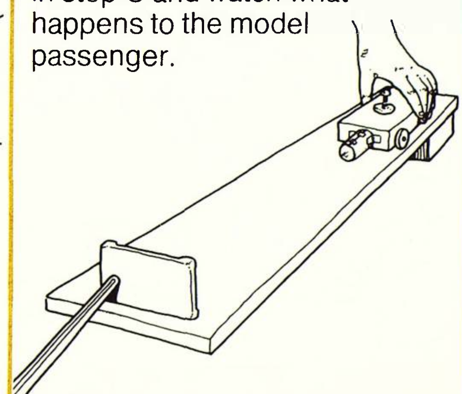
D Cut out a square of paper 10 cm x 10 cm and roll it into a tube. Fix the tube together with small pieces of tape.



E Fix the tube onto the front of the trolley with tape.



F Let the trolley roll down the slope the same distance as in step C and watch what happens to the model passenger.



Q1 What happens to the model passenger in the head-on collision (step C)?

Q2 Does the paper cylinder make any difference to what happens to the model passenger?

Q3 Why is this?

Q4 Where is the best place for a crumple-zone in an ordinary car?

Q5 Car bumpers are not very good as crumple-zones. Why is this?

Q6 What else might help prevent a passenger moving forwards in a head-on collision?

Testing reaction times

Apparatus

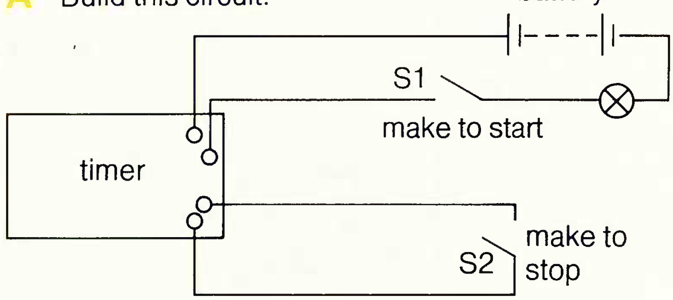
★ electric timer ★ switches ★ lamp ★ bell ★ battery ★ radio ★ screen

You are going to connect up a reaction-timer and test a person's reaction time under different conditions.

Q7 Copy this table.

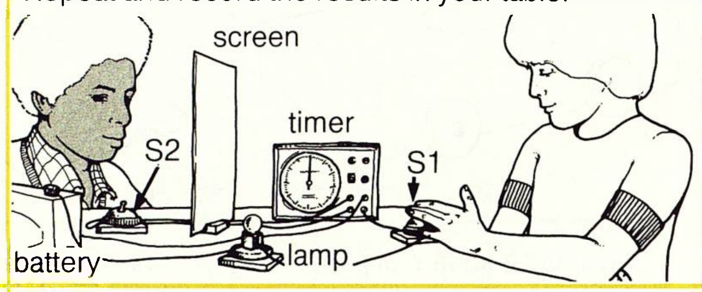
Reaction time in milliseconds					
Normal		Listening to radio		In conversation	
Lamp	Bell	Lamp	Bell	Lamp	Bell

A Build this circuit.

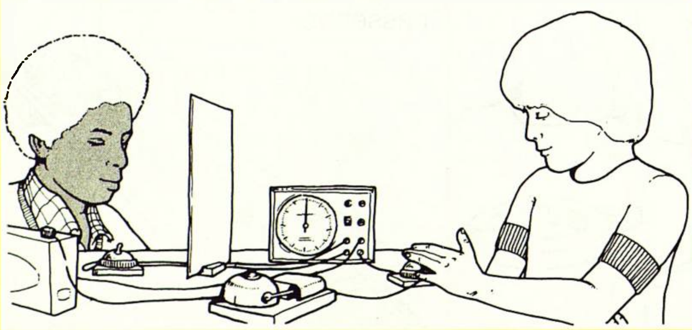


Place a screen so that the person being tested can see the lamp but not the switch S1.

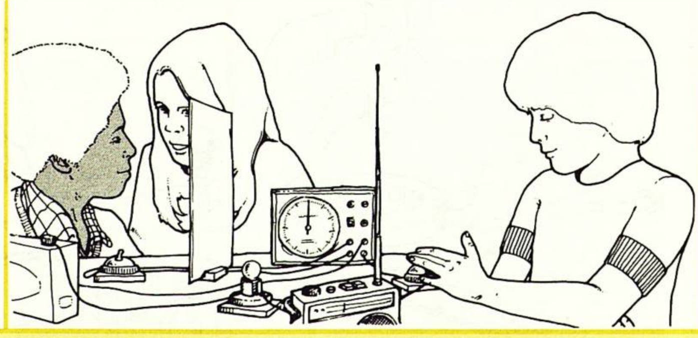
B Press switch S1. Ask the person being tested to watch the lamp and when it comes on to press switch S2. The timer shows the reaction time. Repeat and record the results in your table.



C Replace the lamp with a bell. Repeat step B. Record the result in your table.



D Repeat steps B and C with a radio on and then with someone talking to the person being tested.



Q8 What is the fastest reaction time?

Q9 At 60 mph (which is about 27 metres per second), how far would the car travel before the driver could press the brake pedal?

Q10 How is the reaction time affected by listening to the radio?

Q11 How does the reaction time change when someone is talking to the driver?

Q12 What other distractions are likely to slow down a driver's reactions?

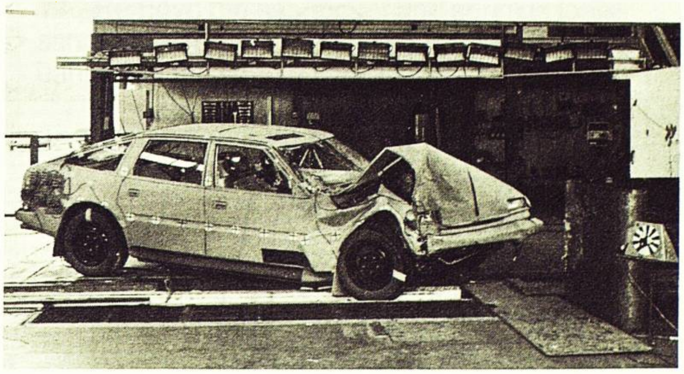
Information: Accidents and driver safety

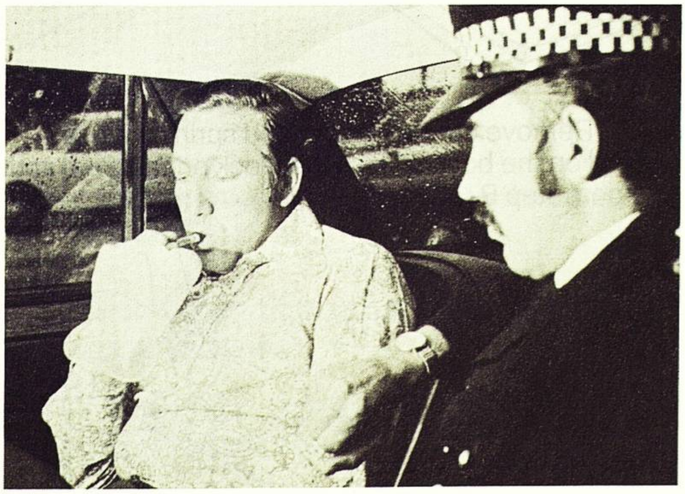
There are many thousands of people killed or seriously injured each year in road accidents. Many deaths and serious injuries can be avoided if seat belts are worn.

A car travelling at 30 mph at moment of impact.
Driver **with** seat belt on.

A car travelling at 30 mph at moment of impact.
Driver **without** seat belt on.

There are other safety features used in car design. The photo (right) shows the effect of a crumple zone. The crumple zone at the front of the car has taken all the impact energy. The body structure around the driver and passenger compartment is still intact.





Accidents are often caused when the driver loses concentration. This may be due to tiredness, distractions or drinking alcohol.

The driver needs to react quickly when danger occurs. Drinking alcohol slows down these reactions. Many accidents are caused each year as a result of drinking and driving.

Heavy fines or even imprisonment may result if a driver fails the breathalyser test given by the Police.

Q13 Do you think the breathalyser is effective in reducing accidents?

Q14 Why does it have this effect?

9 Friction

Road friction

Apparatus

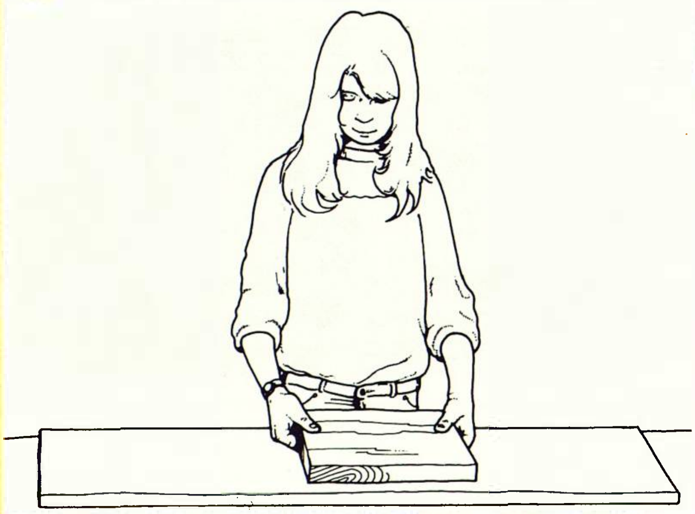
★ friction board ★ wooden block ★ sandpaper ★ sand ★ rubber bands
★ ruler ★ tape

You are going to find out how friction between solid surfaces can be increased and decreased.

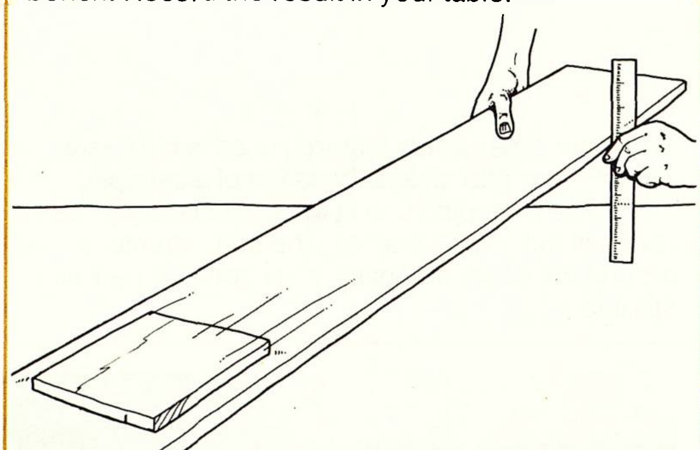
Q1 Copy this table.

Block	Height of end of friction board (cm)		
	board on its own	sandpaper on board	loose sand on board
on its own			
with rubber bands			

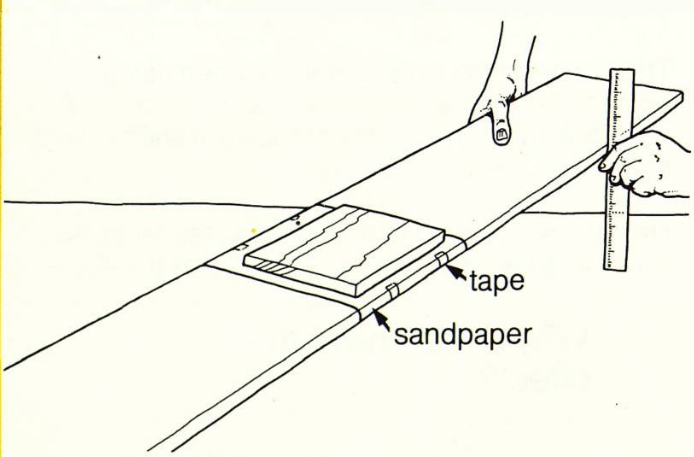
A Place a wooden block on a friction board.



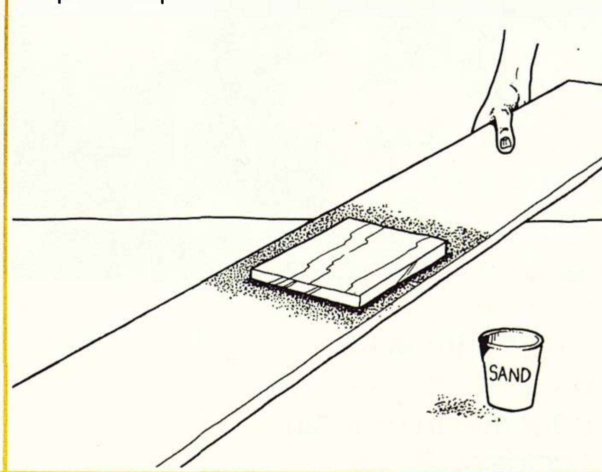
B Lift the board slowly at one end until the block slips. Measure the height of the end from the bench. Record the result in your table.



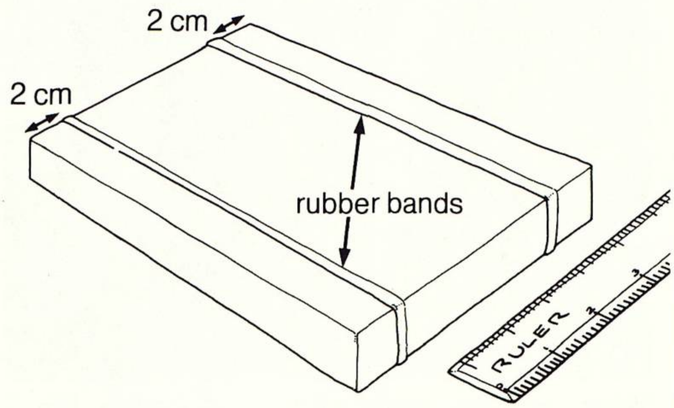
C Tape a sheet of sandpaper on the surface of the friction board and repeat step B with the block on the sandpaper.



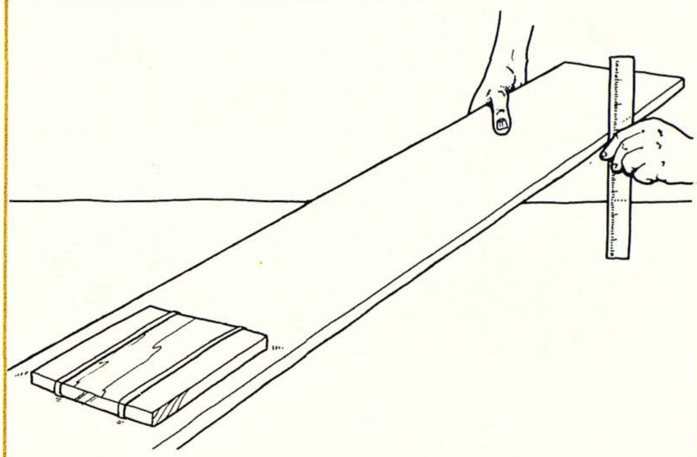
D Remove the sandpaper and sprinkle loose sand on the board. Place the block on the sand and repeat step B.



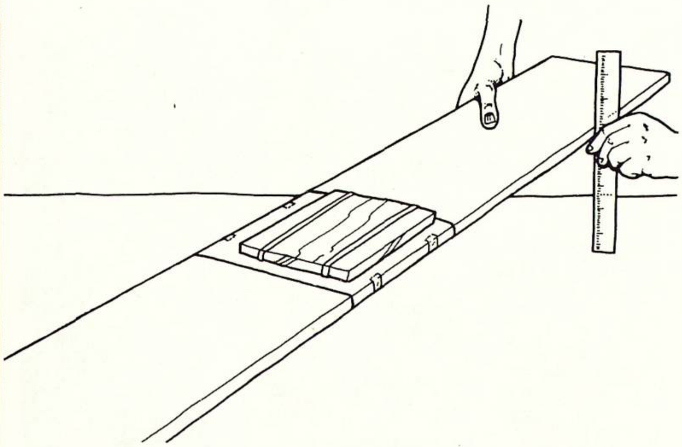
E Fix 2 rubber bands lengthways round the block about 2 cm from each edge.



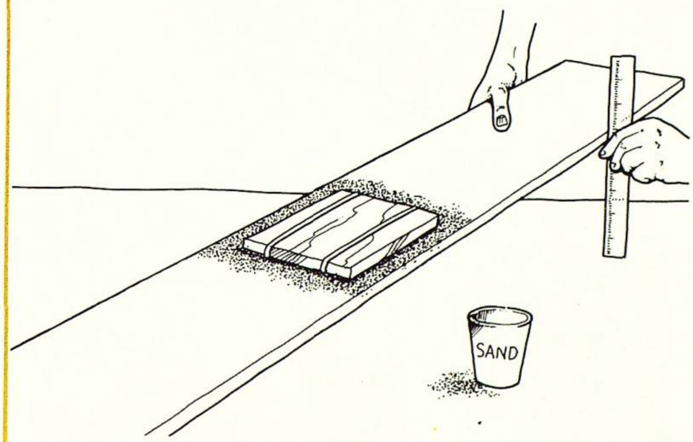
F Put the block on the friction board and repeat step B.



G Tape a sheet of sandpaper to the board. Put the block (with rubber bands) on the sandpaper and repeat step B.



H Remove the sandpaper and sprinkle loose sand on the board. Put the block (with rubber bands) on the sand and repeat step B.



When the block starts to slip the height of the end of the board is a measure of the friction between the block and the board.

Q2 Which conditions produce the least friction?

Q3 What is the purpose of setting gravel in the road surface?

Q4 What happens when the rubber bands (tyres) are put on the block?

Q5 It is illegal to have smooth tyres on a car. Why is this?

Read page 32 before answering Q6 and Q7.

Q6 What is the top layer of the road surface called?

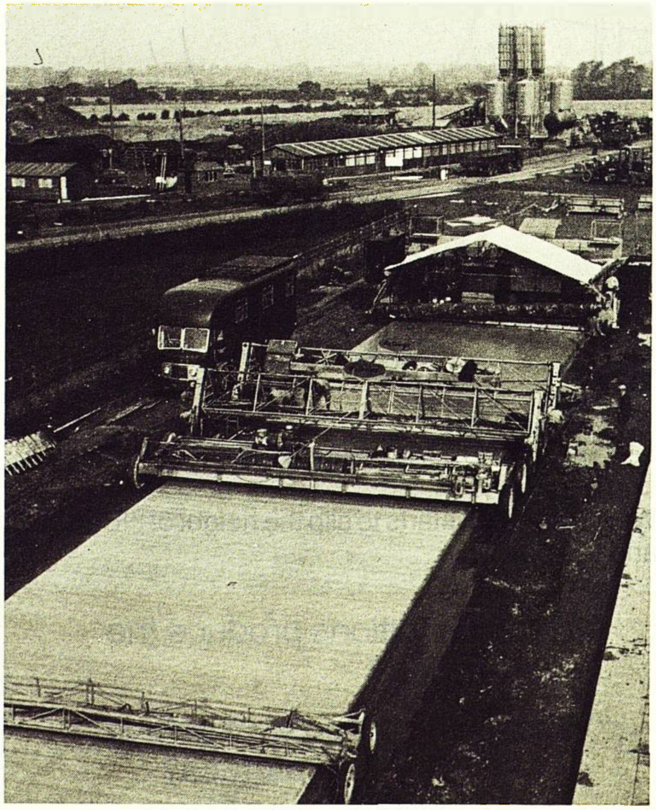
Q7 Name 3 materials that a pavement can be made from.

Information: Road friction

Friction between the tyres and the road is very important. Without this friction the car could not move or turn corners. Tyre treads, like the ones shown above, are designed to give a good safe grip on wet or dry roads.

When the tyre is worn its friction is a lot less. The tyre shown above would not be able to grip the road surface properly and could lead to a serious accident.

Worn tyres are dangerous. It is illegal to drive a car when the tread depth is below 1 mm. The depth of tyre tread can be checked regularly using a tyre measuring gauge.



Road surfaces are normally treated to increase friction. The top layer of the road surface is called the **pavement**. This can be made from materials such as **concrete, gravel** and **asphalt.** The photo above shows a concrete road being laid down.

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