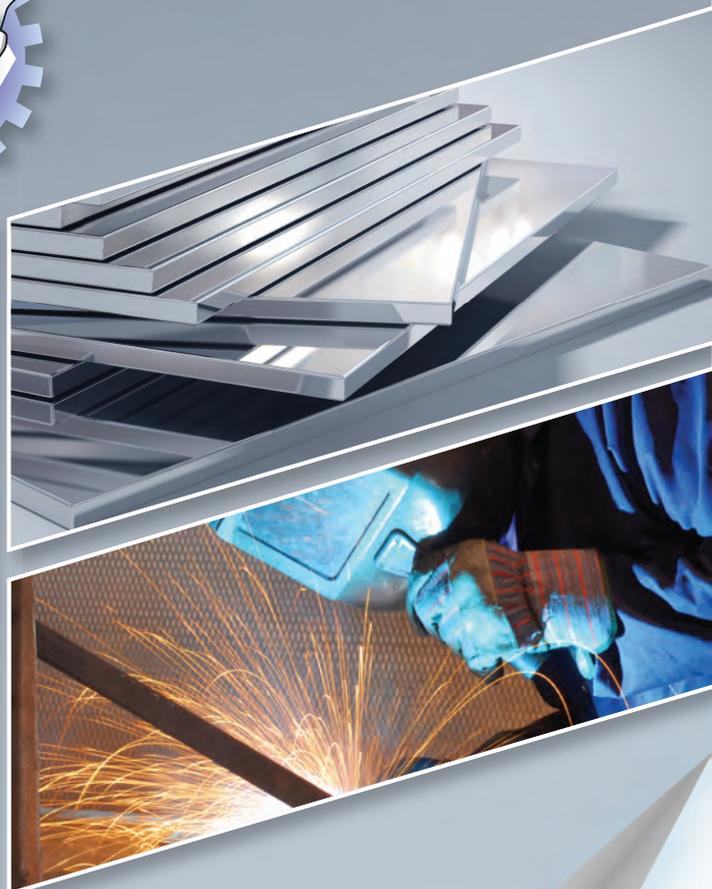


Metalwork at a Glance

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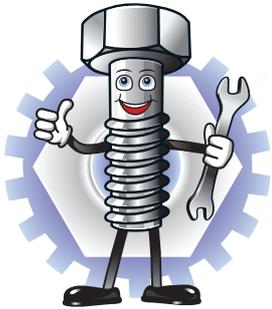
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HEALTH & SAFETY



In the metalwork room there are a number of dangers you have to watch out for. Here are some rules you should follow to stay safe.

1) No loose clothing

Loose clothing can get caught in the moving parts of machines like the lathe and drills. Make sure you tie back your sleeves and tuck in your tie when working on any of these machines. Where possible, a work apron should be worn.

2) Tie back long hair

Like loose clothing, long hair could easily get wrapped up in the moving parts of the machines. Make sure that it is tied back at all times when working on a machine.

3) Tools

All tools should be used correctly. If you are not sure how to use any tool you must ask your teacher to show you. **Never** hold a piece in the palm of your hand when using a tool like a screw driver.

4) Work area

Be in charge of your work area. Make sure to keep the walkway clear of bags and stools/chairs during a practical class as they can cause somebody to trip over. Keep your work bench clean when working and always tidy your area at the end of every class.

5) Eye Protection

Eye protection such as safety goggles, safety glasses or face shield should be

worn whenever you are working on a machine. If a piece of material big or small goes into your eye, it can damage your vision.

6) Fumes

If you are spray-painting, soldering or brazing, make sure to turn on the extraction fan so that the area is well ventilated. It is dangerous to breathe in fumes.

7) Hot objects.

Be very careful when handling hot objects. Always wear gloves and tongs to carry the object. Never leave a hot object down on a work area and walk away. Make sure it is cool before you leave it just in case somebody accidentally picks it up.

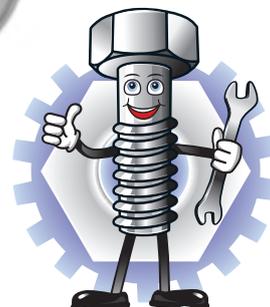
8) Electricity

In the metalwork room there is a lot of electrical equipment. If you notice any damaged cables or equipment you should notify the teacher straight away. **Do not** attempt to fix anything yourself.

9) Hygiene

Always wash your hands after a practical class.

Here are some health and safety signs you might see around the room



HEALTH AND SAFETY SIGNS

No loose clothing



Eye protection



Clear walkways



Electrical danger



First Aid



No running in the room



Wash your hands



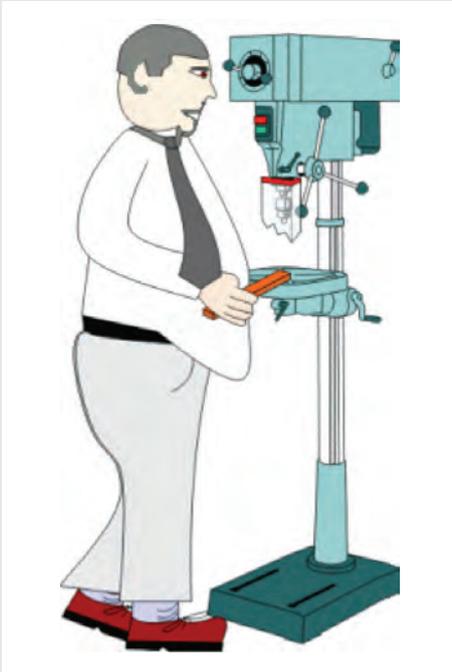
Fire Exit



Emergency stop



ACTIVITY TIME



This person is drilling a piece for his metalwork project.

Can you spot any health and safety issues?

What would you advise him to do to work in a safer way?

QUESTION TIME

- 1) Why is it important to wash your hands after a metalwork class?
- 2) Why should you not leave a hot piece of metal on a desk?
- 3) How can you help stop people tripping in the metalwork room?
- 4) Why is it important to spray-paint in a well-ventilated area?
- 5) What safety precautions should you take when working on the drill?
- 6) If you see a cable on the ground and notice sparks coming from it, what do you do?

7) What do these signs mean? A)



B)



C)



- 8) On an A3 sheet, design a health and safety poster for the Metalwork room. You should include relevant rules and health and safety signs.

WHERE IRON COMES FROM

Words you might not know

Excavated - To dig something up

Extracted - To take something out

Metals are found in rocks in the ground.
These rocks are called **Iron Ore**.

Iron ore is mined or excavated from the ground.
Once it is excavated it must be sent off to have
the metal removed.



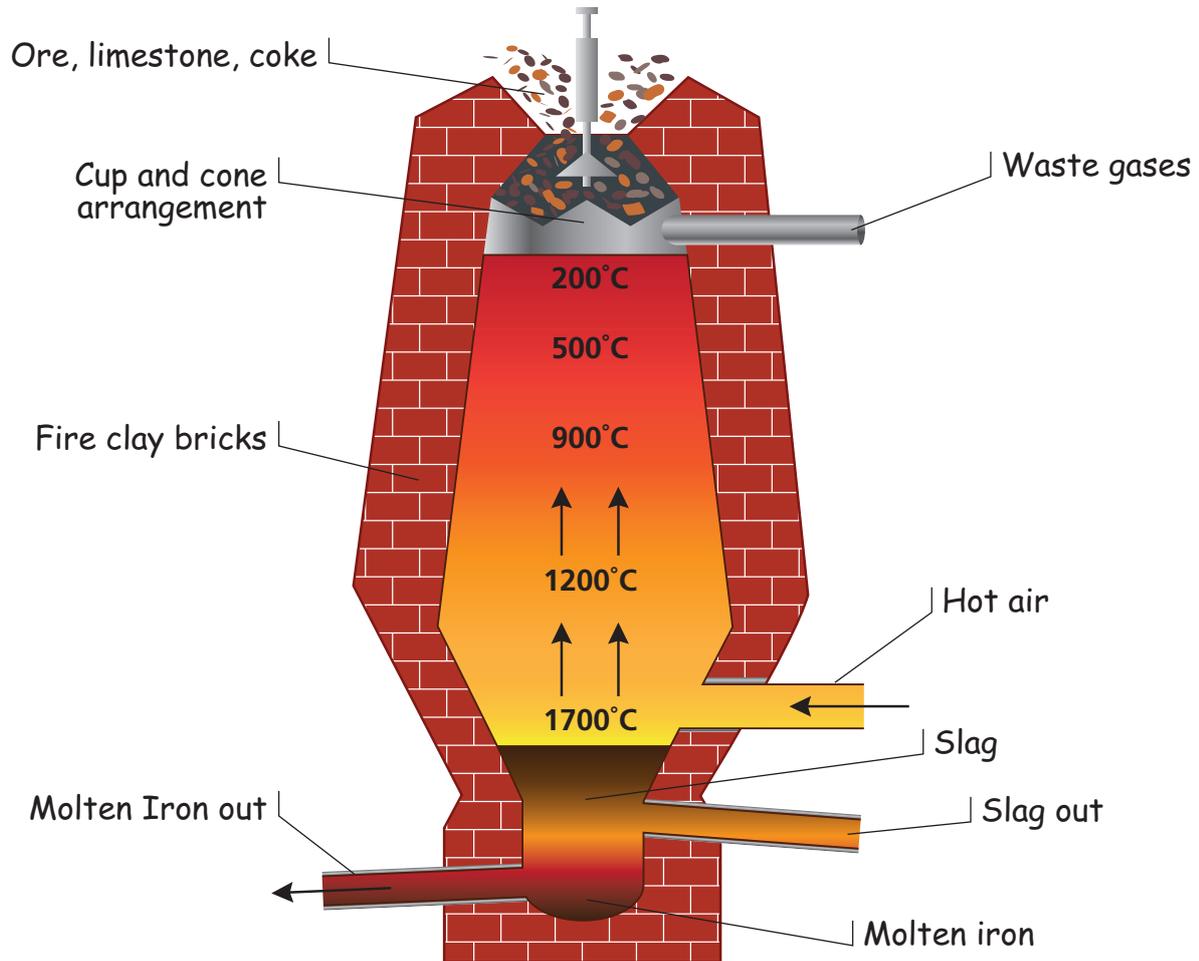
Sample of Iron Ore

The ore is put into a furnace to be melted down and
the metal will then be extracted.



Iron ore is a mixture of clay,
rocks, sand and silt.

THE BLAST FURNACE



- Iron comes from the blast furnace.
- A charge made up of iron ore, limestone and coke is put in the furnace.
- Hot air is blown into the furnace by **Tuyeres** to increase the heat.
- The fire bricks also known as the **Refractory Lining** help keep the heat in the furnace.
- As the mixture melts, the molten iron sinks to the bottom of the furnace.
- The limestone makes the waste or **Slag** float on top of the molten iron.
- The slag is taken out of the furnace from time to time. This can be used as a fertilizer for farming.
- The molten iron, now known as **Pig Iron**, is removed from the furnace.

Each part of the charge has an important part to play in making iron:

Coke = Fuel

Limestone = To float the waste to the top of the molten iron

Iron Ore = the rocks containing the iron



How do you keep the heat in furnace when loading the charge?

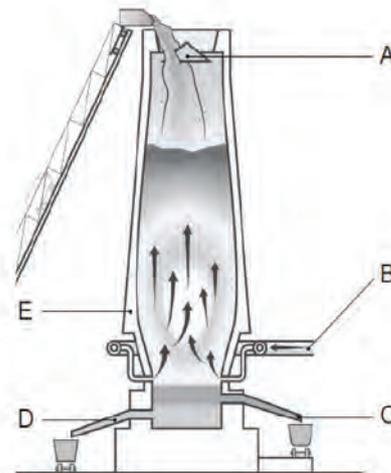
- The same as if you were baking a cake, if you open the oven door during the baking you will leave all the heat out.
- On the diagram you see the furnace has a cup and cone (double bells) arrangement. This is made up of two cones that can be raised and lowered.
- When the furnace is on, both cones are pulled up and the furnace is air-tight.
- When you want to add more charge only the top cone drops down.
- Since the bottom cone is still pulled up the heat has not escaped.
- Once all the charge is loaded in, the top cone is then pulled back up.
- Now the bottom cone is dropped down and all the charge falls into the furnace.
- Once all the charge is in the furnace the bottom cone is pulled back up.

QUESTION TIME

- 1) What is the difference between excavated and extracted?
- 2) What has to be removed from iron ore before it can be made into steel?
- 3) In your own words, state the function of the refractory lining and the tuyeres
- 4) In your own words, state the function of the coke, limestone and iron ore in the charge
- 5) How is heat stopped from escaping from the blast furnace?
- 6) In your own words, write the story of how iron gets from the ground to the way it comes out of the furnace.
- 7) Have a look below at an example of how a question on the blast furnace can be asked in an exam. See how you would do:

The diagram shows a Blast Furnace.
Name **any three** of the parts labelled.

Part	Name
A	
B	
C	
D	
E	



Ordinary Level

- (a) (i) Name the type of furnace shown.
 (ii) List the materials in the charge.
 (iii) Describe how heat loss is prevented from this furnace.
 (iv) Name **any two** steel producing furnaces.

(9 marks)

- (b) Define **any two** of the following material properties:

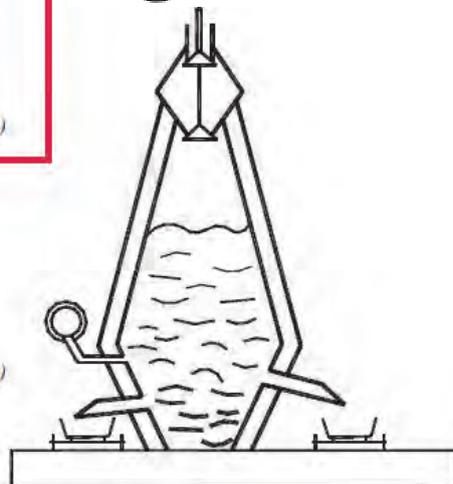
- (i) Hardness;
- (ii) Conductivity;
- (iii) Ductility;
- (iv) Elasticity.

(6 marks)

- (c) (i) Name **any two** heat treatments which may be carried out on steel.
 (ii) Describe **one** of the heat treatment processes named.

(5 marks)

Higher Level

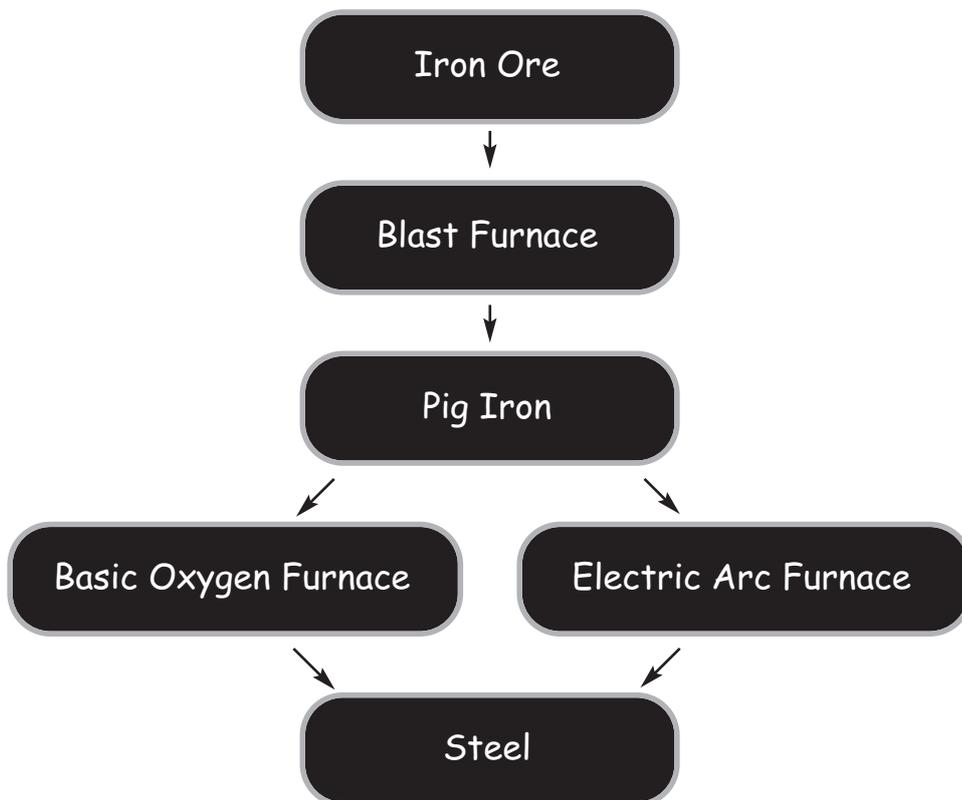


IRON TO STEEL

Words you might not know

Refined - To make something pure

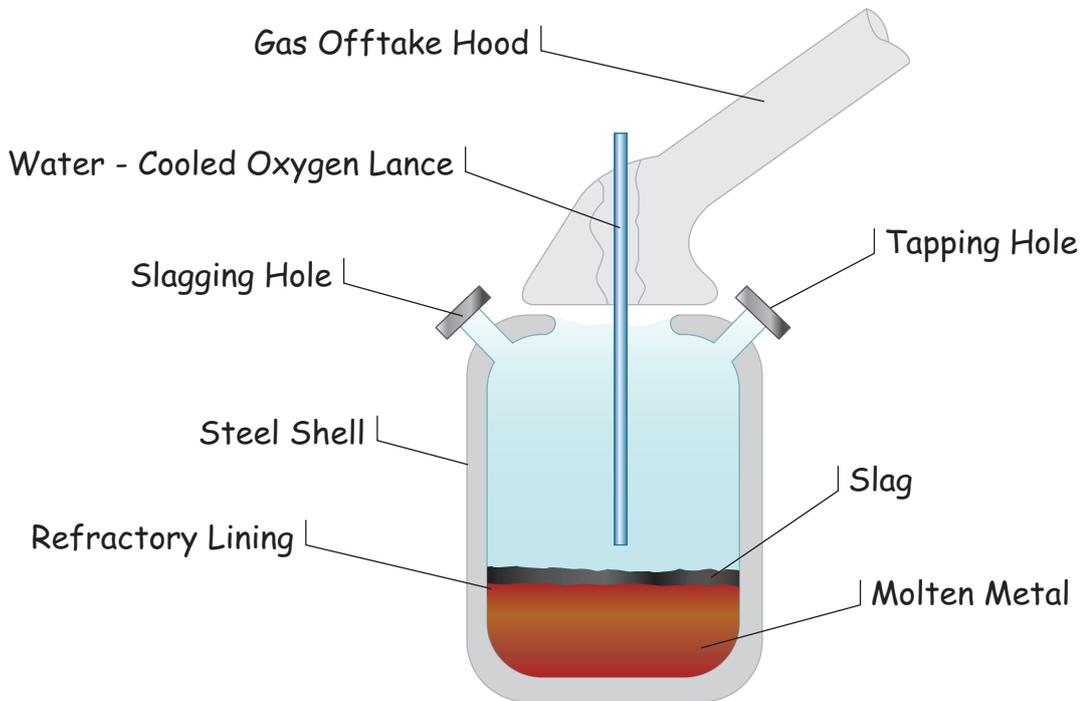
Brittle - Shatters easily



When pig iron comes out of the blast furnace, it is very brittle and has no use in industry. The pig iron must be refined in another furnace to turn it into steel.

Above is the map of the steps needed to turn iron ore into steel.

BASIC OXYGEN FURNACE



- The basic oxygen furnace is the most common way in which steel is produced in the world.
- There are six main steps in how steel is produced in this furnace:

1) First scrap iron and steel are fed into the furnace



2) Molten pig iron is then poured into the furnace



- 3) The **oxygen lance** is then lowered into the furnace for oxygen to be blown in to the furnace to increase the heat. The oxygen also makes slag in the furnace.



Water runs through the lance to stop it from melting in the furnace.

- 4) Samples are taken from time to time to check the quality of the steel.

- 5) The lance is removed and rolled on its side to allow the molten iron to be poured through the **tapping hole**.



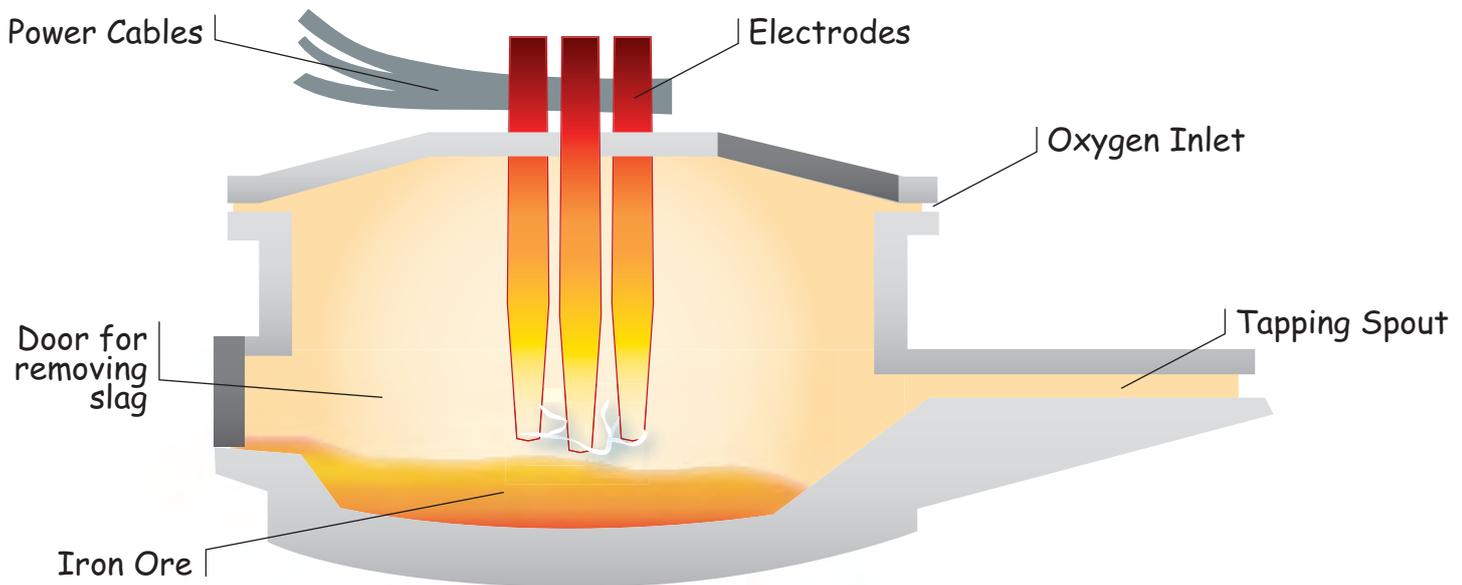
- 6) Then it is rolled over to allow the slag to be poured out of the **slagging hole**.



In the past, a blacksmith used a hand bellows to help make the forge hotter. This is the same principle as the water cooled oxygen lance in the basic oxygen furnace.



ELECTRIC ARC FURNACE



- A charge of iron and scrap steel is fed into the furnace.
- The carbon electrodes are then lowered into the furnace and current is supplied through the power cables.
- The current jumps or arcs from the tips of the electrodes onto the iron and steel. This produces heat and causes the metals to melt.
- Like the basic oxygen furnace, samples are taken from time to time to check the quality of the steel.
- When it is time to remove the slag, the back door is opened and the furnace is tilted allowing the slag to flow out.
- Once the slag is gone, the furnace is tilted forward allowing the molten steel to flow out the **Tapping Spout**.

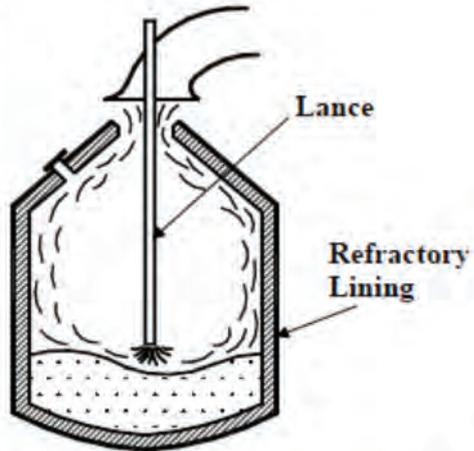


The electric arc furnace works along the same lines as the stick welder. Both need the current jump or arc to produce enough heat to melt the metal

QUESTION TIME

Higher Level

- (a) Name the type of furnace shown. (1 mark)
- (b) List the materials in the charge. (3 marks)
- (c) Briefly outline the operation of the furnace. (2 marks)
- (d) Explain what prevents the Lance from melting. (1 mark)
- (e) Outline the purpose of the Refractory Lining. (2 marks)
- (f) Describe, using diagrams, how each of the following is removed from the furnace:
 - (i) Steel;
 - (ii) Slag. (4 marks)

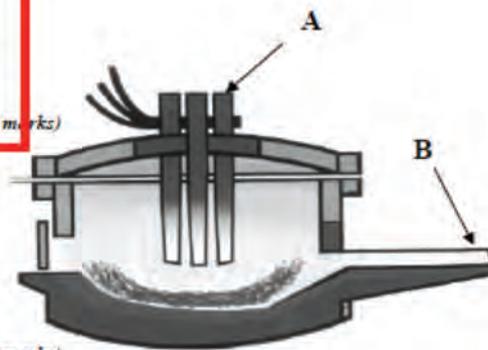


Composition	Alloy	Property
Copper + Zinc		
Iron + Carbon		
Lead + Tin		

- (g) Redraw the given table into your answer book. Complete the table by naming the alloys and listing one important property of each. (7 marks)

Higher Level

- (a) (i) Name the type of furnace shown.
- (ii) List the materials in the charge.
- (iii) Describe how the furnace is charged.
- (iv) Explain, making reference to part 'A', how the charge is heated or melted.
- (v) Outline the function of part 'B'. (10 marks)



- (b) Define any two of the following material properties:
 - (i) Toughness;
 - (ii) Strength;
 - (iii) Malleability;
 - (iv) Brittleness. (4 marks)

- (c) (i) List the elements used to make each of the following alloys:
 - > Brass;
 - > Bronze.
- (ii) Identify one alloy used to manufacture the piston shown opposite. (6 marks)



Piston

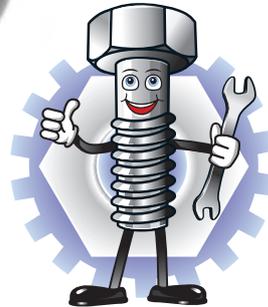
METAL FAMILIES

Words you might not know

Resistance - To withstand

Properties - Characteristics of something

Before we start looking at the different types of metals, let's look at the different properties of metals.



- Strength** → A material that cannot be stretched or squashed easily
- Hardness** → A material that will not be marked or scratched easily
- Ductile** → A material that can stretch without breaking
- Malleable** → A material that can be shaped easily
- Toughness** → A material that can withstand hammering without cracking or breaking
- Brittleness** → A material that breaks or shatters easily
- Elasticity** → A material that if stretched, will go back into its original form
- Conductivity** → A material that allows heat or electricity to flow through it
- Insulator** → A material that will not allow heat or electricity to flow through it

ACTIVITY TIME

List an example of a material that you would find at home for each of the above properties.

Metals can be broken into three different families:

1. Ferrous
2. Non-Ferrous
3. Alloys



Ferrous Metals

Below are some examples of ferrous metals and what can be made from them

"Ferrous metals contain iron"

Mild steel	The most common type of steel used in the metalwork room	Used to make boats, bridges, etc.
High Carbon Steel	Very hard and has good resistance to wear	Used to make chisels, hammers, screwdrivers
High Speed Steel	Very hard and can withstand heat from friction	Used to make drill bits, hacksaw blades
Stainless Steel	High resistance to rusting	Used to make sinks, cutlery, etc.

Can you think of any other examples to add to our list?



Non-Ferrous Metals

Below are some examples of non-ferrous metals and what can be made from them

"Non - Ferrous metals do not contain iron"

Aluminium	A soft metal which is a good conductor and has a high resistance to corrosion	Used to make cooking foil, bodies of cars, window frames, etc.
Copper	A very good conductor of heat and electricity	Used to make water cylinders, electric wires, etc.
Lead	A very soft metal that is rust resistant	Used in car batteries
Zinc	This metal is rust resistant	Used to galvanise metals
Gold	An expensive metal	Used to make jewellery

Alloy Metals

Below are some examples of alloys and what can be made from them

"Mixing two or more metals to give a better metal"

Brass	Copper (60%) + Zinc (40%)	Used to make water fittings, screws, musical instruments, etc.
Bronze	Copper (80%) + Tin (20%)	Used to make statues, boat propellers
Solder	Lead (70%) + Tin (30%)	Used to join metals together and for joining electrical wires

If we leave iron or steel outside in the rain they will **corrode** or **rust**. Let's have a look how we can protect them



Ways to protect metals

- 1) Paint the metal
- 2) Dip it in powder plastic
- 3) Galvanise it

Can you think of objects at home that are designed to protect the metal?

QUESTION TIME

- 1) A metal that can be stretched easily is said to be _____ -

- 2) A metal that can withstand hammering is said to be

- 3) In your own words, what is the difference between toughness and hardness in metals?
- 4) In your own words, what is the difference between ferrous and non-ferrous metals?
- 5) What metal would you use for the following: electric cables, boat propellers, ships, screws, a sink, musical instruments and kitchen foil?
- 6) In your own words, describe galvanising
- 7) What is the difference between a conductor and an insulator?
- 8) On an A3 sheet, design a poster that summaries the chapter of "metal families".

PLASTICS

Words you might not know

Organic - Natural

Molecule - A group of atoms bound together

A plastic is a man-made material made from a wide range of organic polymers such as polyethylene, PVC, nylon, etc., that can be moulded into shape

A polymer is a long chain of molecules bound together



Uses for plastics



Like metals, plastics are broken into two families:

1. Thermosetting Plastics
2. Thermoplastics



Thermosetting Plastics



"These plastics cannot be melted down or recycled"

Below are some examples of thermosetting plastics and what they are used for

<p>Bakelite</p>	<p>Used as Electrical insulators</p>	
<p>Urea Formaldehyde</p>	<p>Used in Plugs and sockets</p>	
<p>Melamine resin</p>	<p>Used in Plastic cutlery</p>	

Thermosetting Plastics



"These plastics can be melted down or recycled"

Below are some examples of thermoplastics and what they are used for

<p>PVC</p>	<p>Used in Toys</p>	
<p>Nylon</p>	<p>Used in Gears</p>	
<p>Acrylic</p>	<p>Used in Perspex sheets</p>	
<p>Polystyrene</p>	<p>Used in Disposable cups</p>	
<p>Polypropylene</p>	<p>Used in Hard hats</p>	

QUESTION TIME



- 1) In your own words, what is the difference between thermosetting and thermoplastics?
- 2) Why do you think disposable cups are made from polystyrene?
- 3) What is the common property in Bakelite and Urea Formaldehyde?
- 4) On an A3 sheet, design a poster that compares thermosetting plastics to thermoplastics.

MEASURING & MARKING OUT

Words you might not know

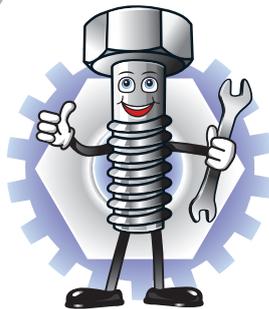
Accurately - As exact as possible

Perpendicular - To be 90° to something

Parallel - To be the same distance apart and never touching

Marking out

Drawing out the shape of the piece to show us where to cut out and file



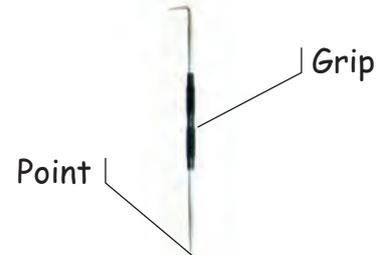
Marking out is one of the most important skills in metalwork. It is very important to mark out as accurately as possible.

Below are some of the tools you might use to mark out a piece for one of your projects.



Scriber

- The metalwork version of a pencil
- The point on the scriber is 30°
- The scriber scratches lines into the metal to show you where to cut/file

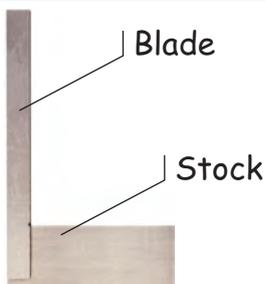
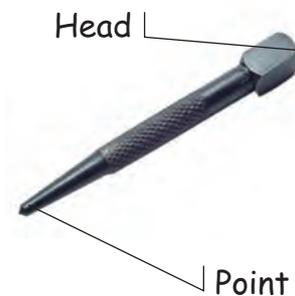


The Rule

- The rule is used to measure or mark out a piece
- It can be used to draw straight lines
- You need to look directly over the rule for accuracy

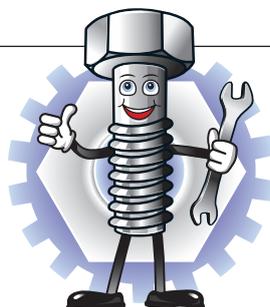
Punches

- There are two types: a centre punch and a dot punch
- The angle of the point on the centre punch = 90°
- The angle of the point on the dot punch = 60°
- A Centre punch marks the point for the dividers or where to drill a hole
- A dot punch also marks the point to drill and to mark dots along a line for cutting.



Engineer's Try Square

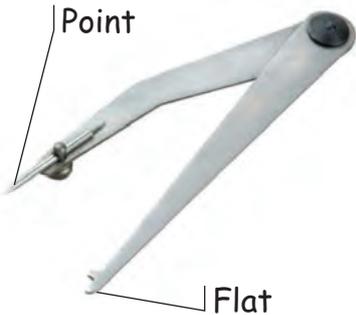
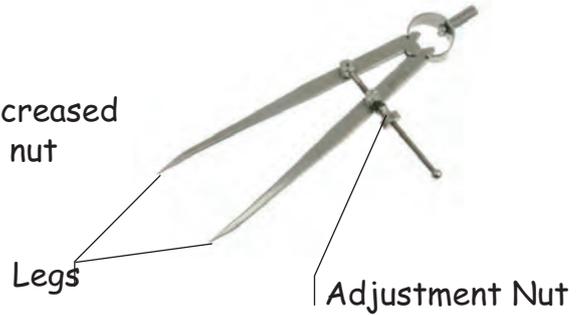
- Made up of a blade and stock
- Used to square a piece or to draw perpendicular lines
- If there is a burr, it will cause it to be inaccurate



A burr is a raised edge on a piece after cutting or drilling

Dividers

- Used for drawing circles and arcs
- The distance between the legs can be increased or decreased by turning the adjustment nut



Odd leg or "jenny" Callipers

- Used to draw a parallel line to the edge of a piece
- The flat leg runs along the edge while the point marks the piece
- Very useful for finding centre lines

From the tools you have studied in this chapter, have a look at the next page and apply what you now know to solving both activities.

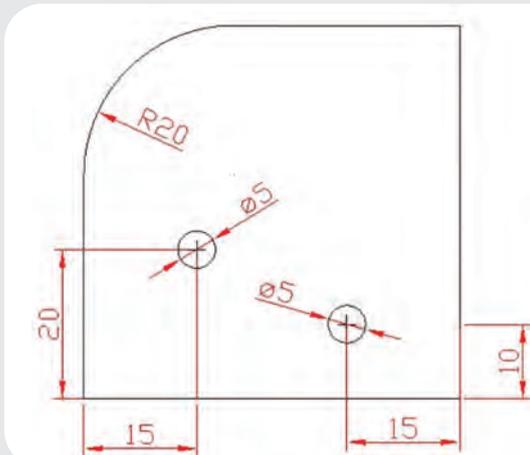
Best of luck!



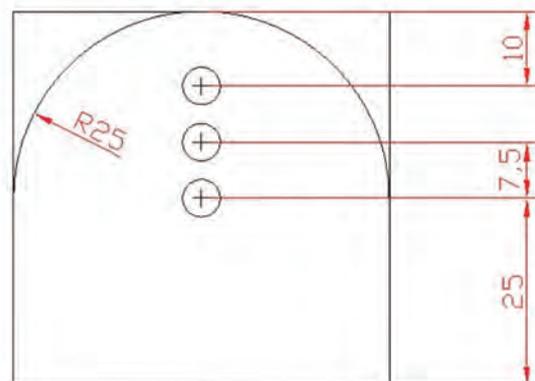
ACTIVITY TIME

Can you list the tools you would need and how you would mark out each of the following pieces

Piece A



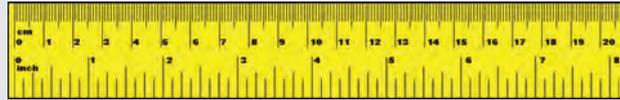
Piece B



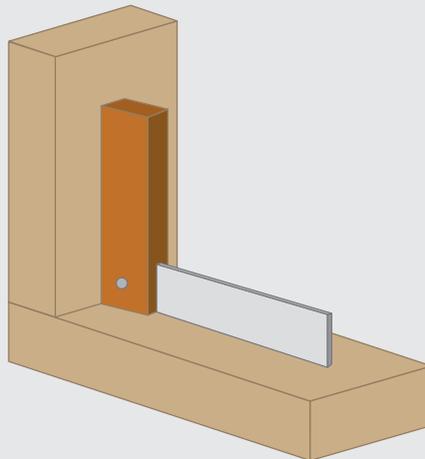
QUESTION TIME



- 1) How does a scriber mark out a piece of metal?
- 2) In your copy, redraw the ruler below and on it mark:
 - a. 15mm
 - b. 20mm
 - c. 35mm
 - d. 115mm



- 3) What is a useful tool if you have to draw circles on a piece of steel?
- 4) Why do you think you would dot punch before you drill a hole?
- 5) Why is it important to smooth off all the edges before using an engineer's try square?
- 6) In your own words, describe what is being done in the picture below:



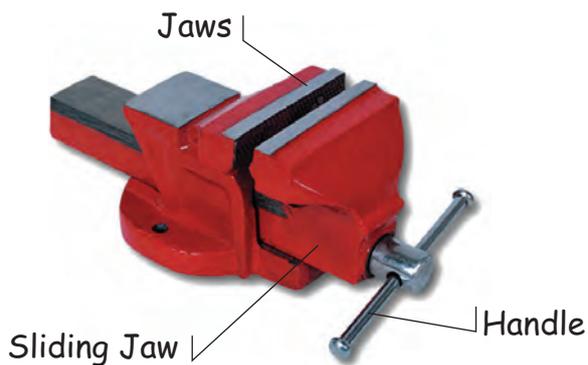
- 7) In your own words, what is the difference between a dividers and an odd leg callipers?
- 8) On an A3 sheet, design a poster that summarises all the marking out tools.

BENCH WORK

Any work you do at your bench in metalwork is known as **bench work**.

It is important to keep your bench clean at all times.

Let's have a look at some of the tools you might find at your bench.



Vice

- Usually made of cast iron
- Used for holding pieces while working
- The vice opens and closes by turning the handle and moving the sliding jaw in and out
- It is important to keep the piece low in the vice when working

Vice Clamps

- Fits onto the jaws of the vice
- Used to stop metal getting scratched from the jaws of the vice
- Useful when working with soft metals



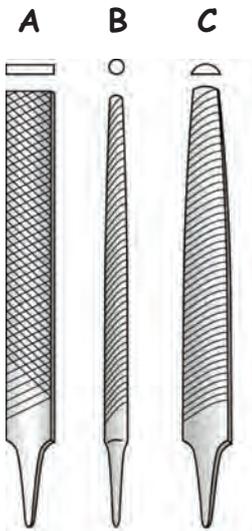
Can you think back to any examples of soft metals?

File

- Files are used to remove waste material
- The handle slides onto the **tang** of the file



- Files are made from high carbon steel
- There is two types of finishes on a file:
1) smooth 2) rough



Different types of files

On the left, are some of the most common files used in the metalwork room:

A = Flat File

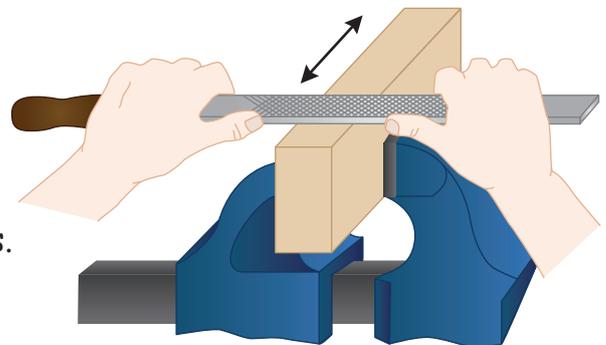
B = Round File or "Rat Tail File"

C = Half Round File

Draw Filing

If we want to produce a smooth finish on the edges of a piece, you must draw file all the edges.

This involves using a flat file and moving it forward and backwards as shown in the diagram.



File Card

- When filing soft metals a file can get clogged with metal
- To remove the clogged metal, you use a file card
- A file card has a number of pins in it so that when you brush the file it removes the clogged metal

Junior Hacksaw



Blade

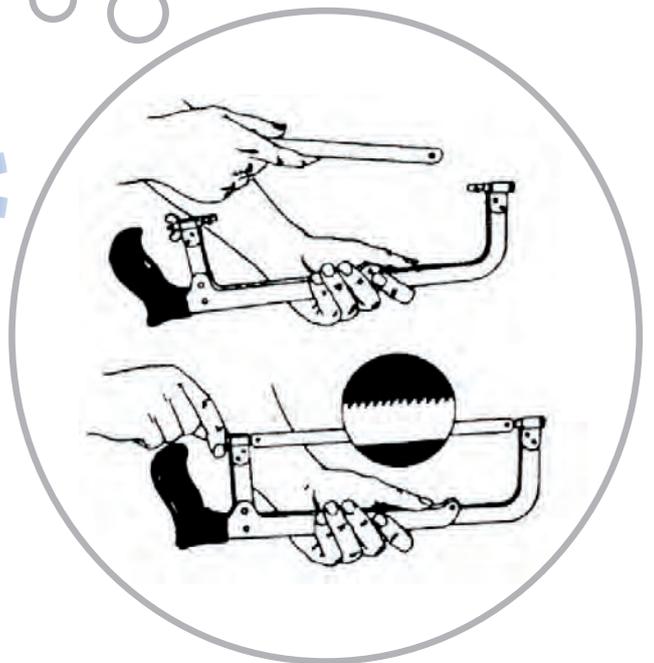
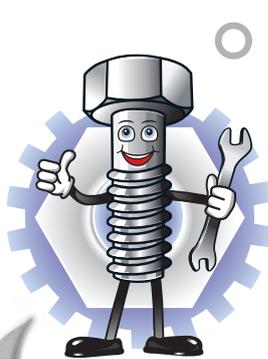
Senior Hacksaw



Blade

Hacksaw

- A hacksaw is used for cutting material
- There is two types:
 - 1) Senior Hacksaw
 - 2) Junior Hacksaw
- A senior hacksaw is usually used but the junior one can be used for light work
- The blade of the hacksaw is made from high speed steel



When changing the blade on a hack saw it is very important that you have the teeth of the blade pointing in the correct direction

Hammer

- The most common hammer used in the metalwork room is the **ball pein** hammer
- Ball pein hammers are made from high carbon steel

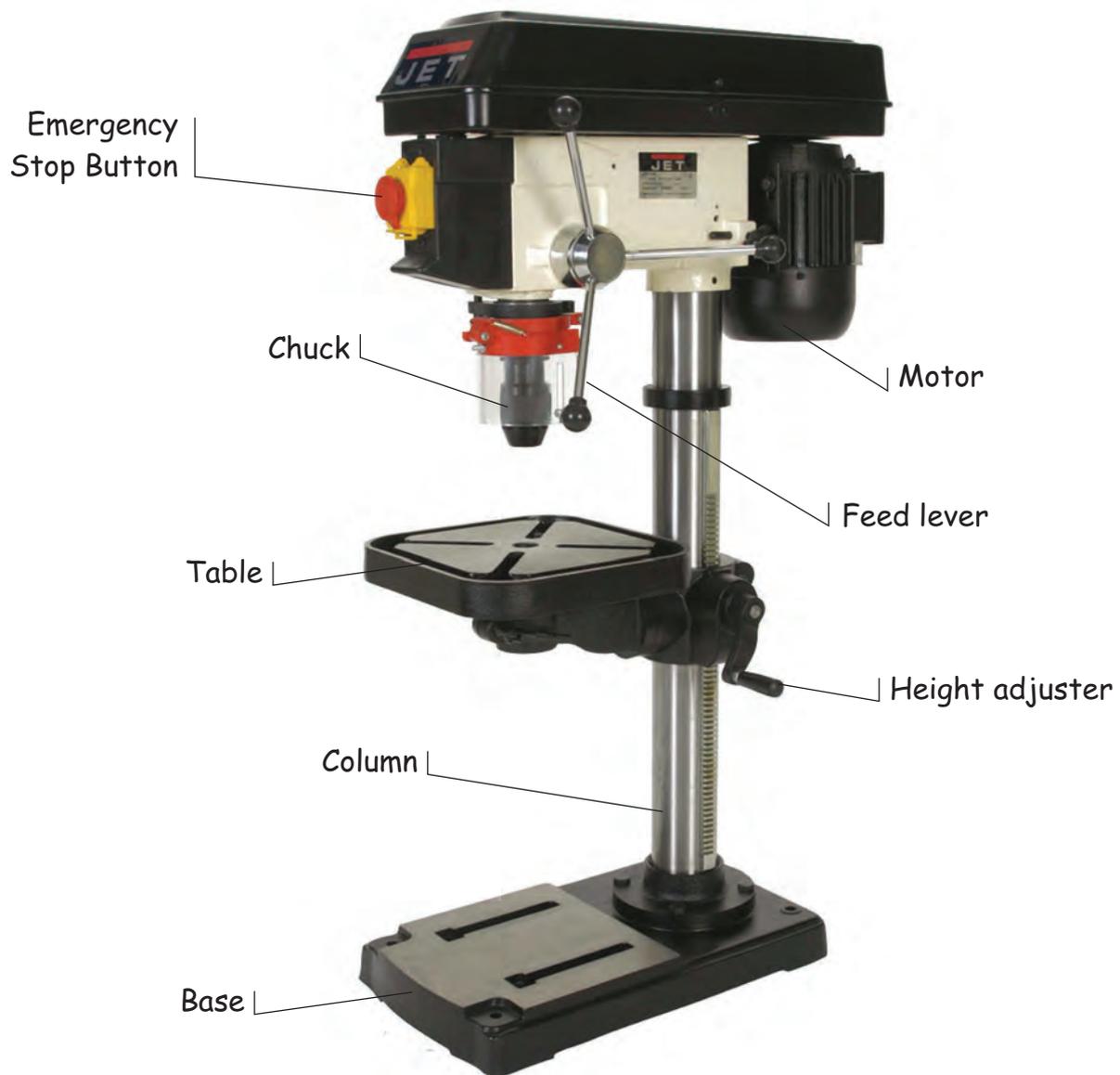


QUESTION TIME



- 1) In your own words, how does the vice open and close
- 2) Why do you think it is important to use vice clamps?
- 3) Can you think of a use for the three types of files mentioned in this chapter?
- 4) In your copy, draw and label the flat file.
- 5) How do we clean the files if they become clogged?
- 6) In your own words, describe draw filing
- 7) In your copy, draw the hacksaw and show the direction of the teeth.
- 8) Name the metals that make:
 - a. Files
 - b. Hacksaw blades
 - c. Vice

THE DRILL



This is a high risk machine. Great care must be taken when using it. Safety gear must be worn at all times.



Words you might not know

Secure - Held tight and safe**Enlarge** - Make bigger

Emergency Stop Button	→	If there is any problem with the drill, this button cuts off the power
Chuck	→	This holds the drill bit. To tighten the chuck, use the chuck key
Table	→	A vice can be attached to the table to hold a piece for drilling
Column	→	Supports the drill
Base	→	Keeps the entire drill balanced when in use
Height Adjuster	→	This handle can move the table up or down via a rack and pinion
Feed lever	→	By turning this, the chuck is moved up and down for drilling
Motor	→	Turns the pulleys which causes the chuck to spin for drilling

For drilling we use twist drill bits.

The **shank** is held in the **chuck** and the **body** does the drilling.

**HEALTH AND SAFETY PRECAUTIONS**

- No loose clothing
- Hair tied back
- Always wear safety goggles
- Have the piece to be drilled secure in the vice or clamp
- Make sure the drill bit is secure in the chuck
- Use cutting fluid if needed
- If anything goes wrong, hit the emergency stop button straight away and tell the teacher
- If the piece comes out of the vice and is spinning with the chuck, **DO NOT ATTEMPT TO STOP IT WITH YOUR HAND**, hit the emergency stop button and wait for the chuck to stop spinning



ACTIVITY TIME

Try to come up with a list of steps that you would follow if you had to drill a hole in a piece of a project. [Hint list the tools you would use and how you would drill it]

INSTRUCTIONS FOR DRILLING

- Centre punch where the hole is to be drilled
- Secure the piece into the drill's vice
- Place a piece of wood under it if needed
- Select the correct size drill bit
- Make sure the drill bit is secure in the chuck
- Select the correct drilling speed
- Use cutting fluid if needed
- Drill through the piece
- Turn off the drill
- Wait for the chuck to stop spinning and removed the piece
- De-burr the hole

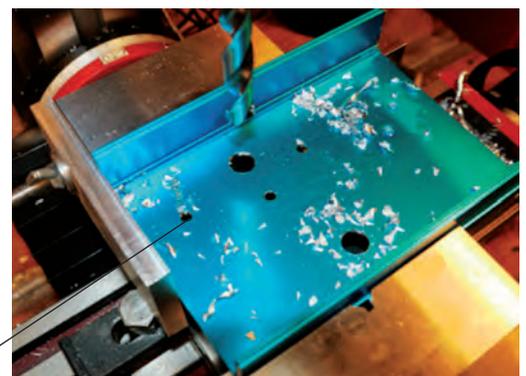


De-burring is removing the burr from hole with a large drill bit or de-burring tool

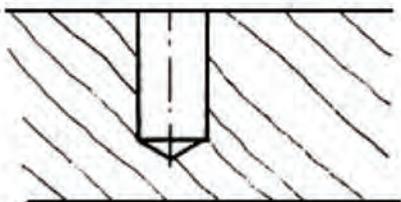
DIFFERENT TYPES OF HOLES**Pilot Hole**

Pilot holes are smaller holes drilled first before a large hole is drilled.

In the picture we see the pilot holes that are drilled in the body of a computer before they are drilled with a larger bit.



Pilot Hole

**Blind Hole**

A blind hole is a hole that is not drilled the whole way through like in the in the sketch shown.

Tapping Hole

A tapping hole is similar to a pilot hole. For a thread to be cut or "tapped" the hole must be smaller than the size of the thread.

The chart on the right is a guide to the size hole that should be drilled when drilling a tapping hole.

Tapping/Drilling Chart	
Tap Size	Drill Size
M3	2.5 mm
M4	3.3 mm
M5	4.2 mm
M6	5.0 mm
M7	6.0 mm
M8	6.8 - 7.0 mm
M10	8.5 - 9.0 mm
M12	10.2 - 10.5 mm
M14	12.0 - 12.5 mm
M16	14.0 - 14.5 mm



Countersinking

Countersinking is where the mouth of the drill hole is enlarged (like in the picture).

This is done so that a countersunk screw will sit flush with the surface.

Counterboring

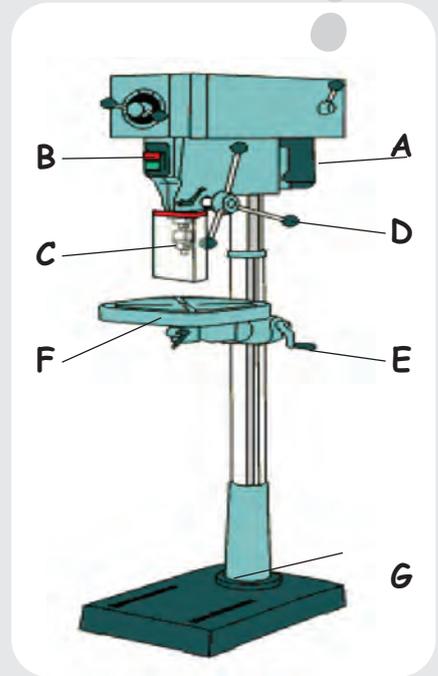
Counter boring is drilling down to make the hole wider to a certain depth (like in the picture).

This is done so that a cheese-head screw will sit flush with the surface.



QUESTION TIME

- 1) Below is the pillar drill, name each labelled part in your copy.
- 2) In your own words, describe how the pillar drill works
- 3) In your own words, list what safety precautions you should take when drilling
- 4) Why is it important to have the piece secured in the vice when drilling?
- 5) What part of the drill
 - a. goes into the chuck?
 - b. does the cutting?
- 6) In your own words, what is a pilot hole?
- 7) In your own words what is a blind hole?
- 8) What is the difference between a countersunk hole and a counterbore hole?
- 9) On an A3 sheet, design a pillar drill poster for the room. [Hint: include diagram, health and safety tips, etc.]
- 10) Have a look below at an example of how a higher level question on the drill can be asked in an exam. See how you would do:



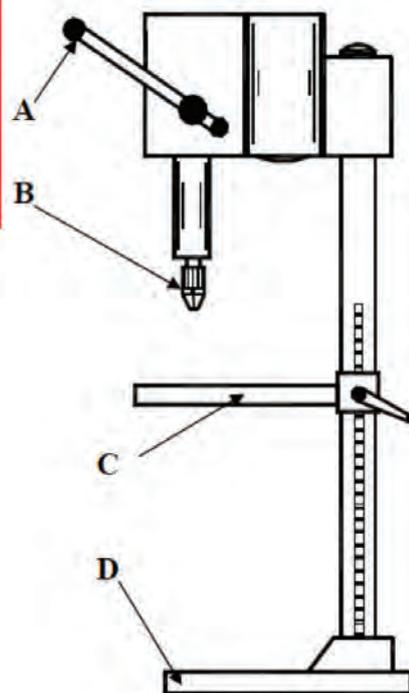
- (a) (i) Name parts 'A', 'B', 'C' and 'D' of the pillar drilling machine shown.
 (ii) Describe the mechanism used to raise and lower part 'C'.
 (iii) List **two** safety precautions to be observed when working on this drill. (8 marks)

- (b) An 8 mm hole is to be drilled in a material which has a surface cutting speed of 36 m/min. Using the given formula calculate the speed in RPM. (Take π as 3)

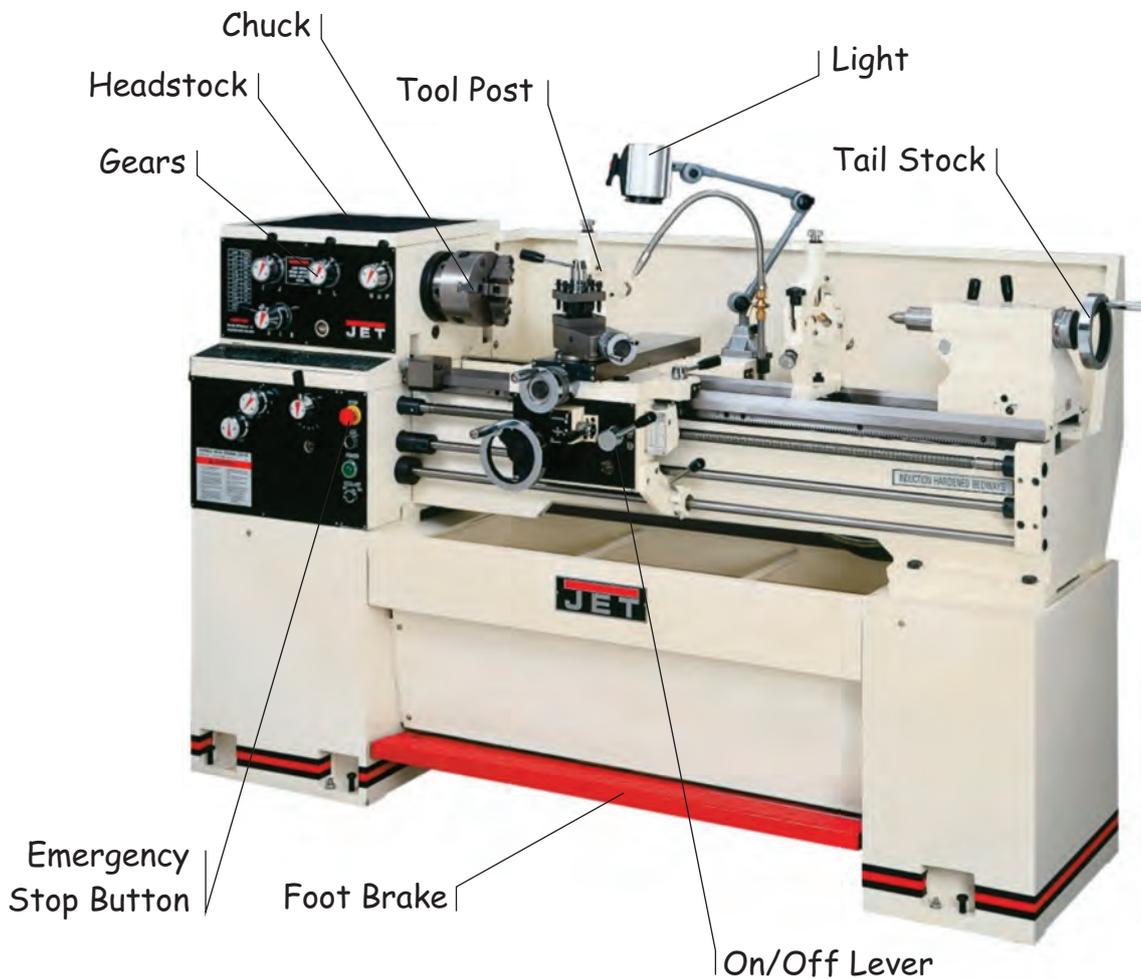
$$N = \frac{S \times 1000}{\pi \times D}$$

(4 marks)

- (c) Select **any two** of the following and explain the difference between the terms:
 (i) Countersinking and Counterboring;
 (ii) Clearance hole and Tapping hole;
 (iii) Taper tap and Plug tap. (8 marks)



THE LATHE



This is a high risk machine. Great care must be taken when using it. Safety gear must be worn at all times



Gears	→	The gears on the lathe are used to change the speed of the chuck
Headstock	→	The headstock is where the gears are housed
Chuck	→	The work piece is held in the chuck while the chuck spins around
Tool Post	→	This holds the various tools used on the lathe
Tailstock	→	The tailstock moves along the bed and can be clamped into position. It can be used for drilling or supporting long bars
On/Off Lever	→	This lever either turns on the lathe in forward or reverse and also turns it off
Foot Break	→	If something happens, the foot brake can be used to stop the chuck from spinning
Emergency Stop Button	→	This button can be used in an emergency to turn off the power to the lathe

HEALTH AND SAFETY PRECAUTIONS

- No loose clothing
- Hair tied back
- Always wear safety goggles
- Have the piece being worked on secured in the chuck
- Mark sure the correct tool is used and that it is secure in the tool post
- Mark sure all tools around the lathe are put away and cannot fall into the lathe
- Select the correct speed for the material being used
- Use cutting fluid if needed
- Be careful not to hit the tool post off the chuck
- If anything goes wrong, hit the emergency stop button straight away and tell the teacher
- When taking out the piece do not leave the chuck key in the chuck

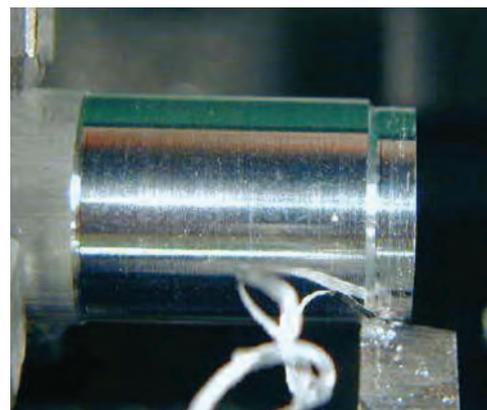


LATHE PROCESSES

Parallel Turning

The tool moves "parallel" to the piece.

This process reduces the diameter of the bar by making it thinner as shown in the picture





Facing Off

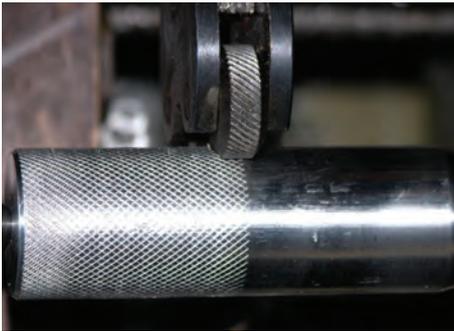
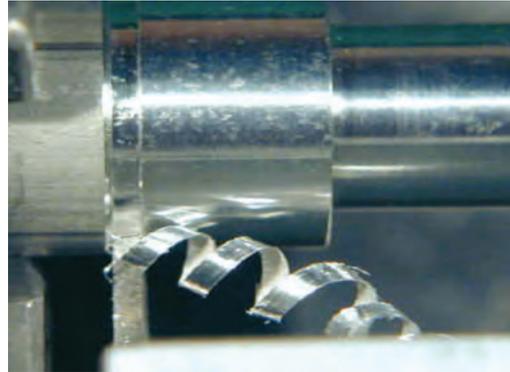
This process is done to make the face of the bar flat and level.

The tool takes small cuts off the face making it shorter as shown in the picture

Parting Off

Parting off is how we cut on the lathe.

As you can see in the picture, the parting off tool cuts into the bar until it cuts through the piece.



Knurling

Knurling is done when putting a grip on a bar. To do this the lathe is turned down to a slow speed and the knurling tool is pressed in against the bar.



Drilling

For drilling there are two steps.

First the chuck is put into the tailstock and a centre drill is placed in it. The tail stock is pushed up to the bar and clamped. The centre drill is then pressed against the bar to find the centre.

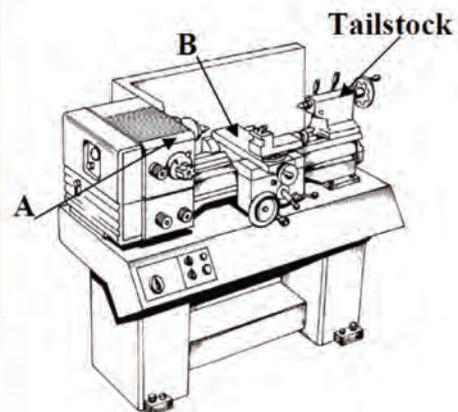
Then the centre bit is removed and the drill bit is put into the chuck. The drill bit is then turned until the piece is drilled.



QUESTION TIME

- 1) In your own words, state the function of each of the following parts on the lathe:
 - a. The gears
 - b. The headstock
 - c. The tailstock
 - d. The foot brake
 - e. The tool post
 - f. The chuck
- 2) List 5 health and safety precautions that should be followed when working on the lathe
- 3) Why do you think it is important to have no loose clothing while working on the lathe?
- 4) Give 2 uses of the tailstock
- 5) In your own words, what is the difference between parallel turning and facing off?
- 6) In your own words, describe how to drill on the lathe
- 7) What is knurling and how is it done?
- 8) What is parting off and how is it done?
- 9) Why might the speed of the chuck need to be changed?
- 10) On an A3 sheet, design a lathe poster for the room. [Hint: include diagram, health and safety tips, etc.]
- 11) Have a look below at an example of how a higher level question on the lathe can be asked in an exam. See how you would do:

- (a) (i) Name parts 'A' and 'B' of the lathe shown.
- (ii) Outline **any two** functions of the tailstock.
- (iii) State **any two** reasons why lathes are designed to run at different speeds (RPM).
- (iv) List **any two** safety precautions to be observed when working on the lathe.
- (10 marks)*



- (b) A 10 mm diameter bar is to be turned on the lathe. The material has a surface cutting speed of 78 m/min. Using the given formula calculate the speed in RPM (Take π as 3).

THREAD CUTTING



They are two different types of threads, an **INTERNAL** thread and an **EXTERNAL** thread.

On a working drawing a hole to be drilled will be shown as $\varnothing 4$ or $\varnothing 5$ but a thread will read as M4 or M5

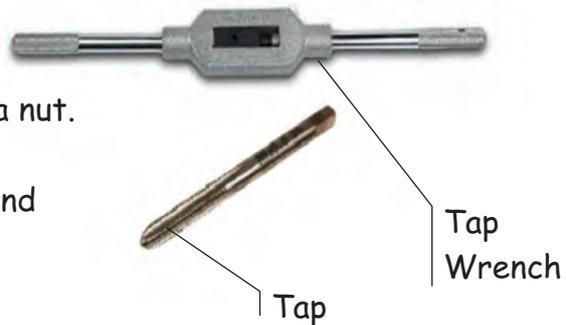
INTERNAL THREADS

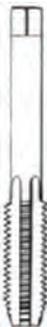
Internal threads are found on the inside of a nut.

For cutting an internal thread we use a tap and tap wrench.

There are three different types of taps we use:

- 1) Taper Tap
- 2) Second Tap
- 3) Plug Tap



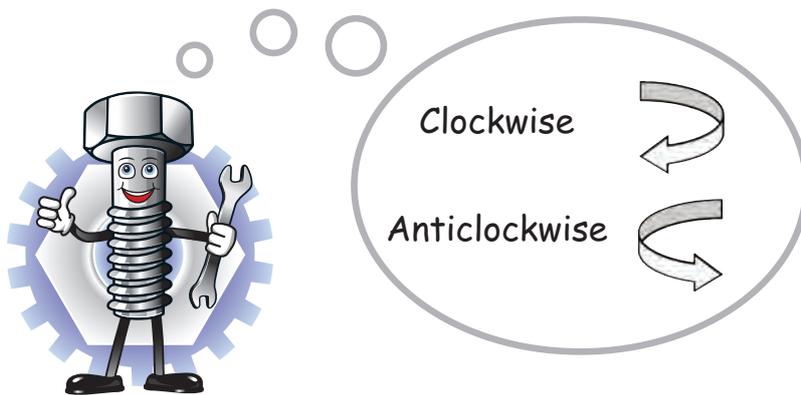
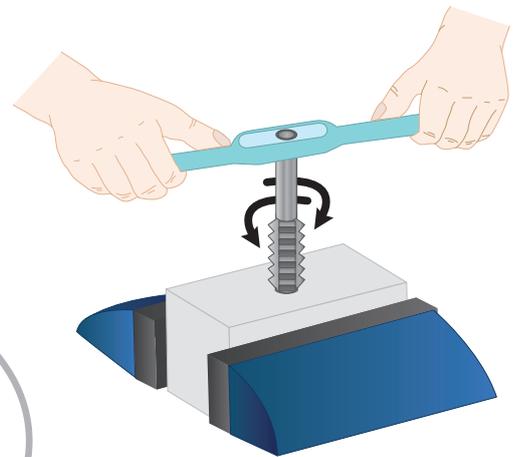
Taper Tap	Second Tap	Plug Tap
		
<p>Since it is tapered at the top it allows us to start cutting the thread gradually</p>	<p>Less of a taper at the end so it cuts more of a thread</p>	<p>Used for finishing the cutting of a thread or for threading blind holes</p>

Can you remember the chart for drilling sizes for tapping holes in the drilling chapter?



Steps for tapping a hole

- Drill the hole needed for the thread to be cut (remember holes are drilled smaller than the size needed to be threaded)
- Start with the taper tap and place it into the tap wrench
- Put the tap into the hole and make sure it is perpendicular to the piece
- Start turning the wrench until you feel it cutting into the piece
- Once this happens turn the wrench half a turn (180°) clockwise
- Then turn it back quarter of a turn (90°) anticlockwise
- By doing this, the waste is removed and the tap is prevented from breaking
- Continue this until the tap has gone down through the hole
- Repeat this with the second tap and plug tap



EXTERNAL THREADS

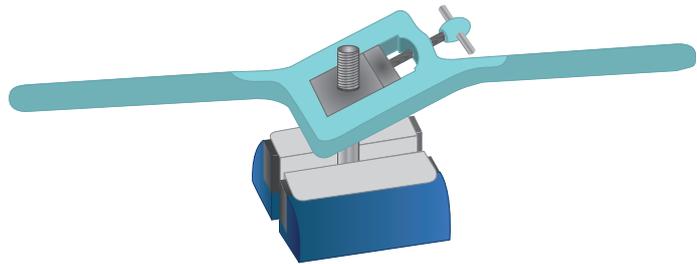
External threads are found on screws and bolts.

For cutting an external thread we use a **stock** and **die**.



Steps for threading a bar

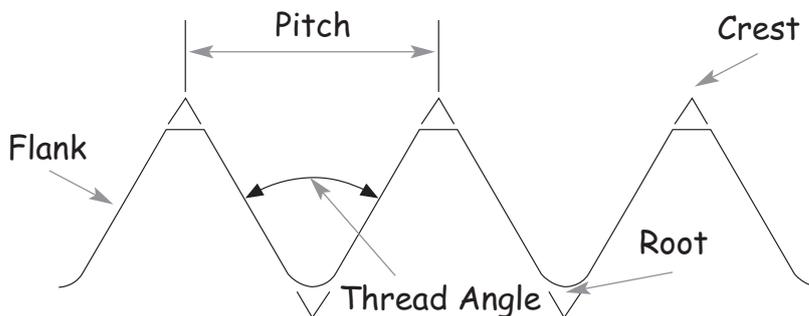
- Unlike internal threading, if we need to cut an M5 thread on a bar then we use a $\varnothing 5$ mm bar
- Put the die into the stock
- File a small chamfer on the bar to help the die to grab the bar
- After that, the process is the exact same as cutting an internal thread
- Make sure the stock and die is perpendicular to the bar
- Start turning the stock until it cuts into the piece
- Once this happens turn the stock half a turn (180°) clockwise
- Then turn it back quarter of a turn (90°) anticlockwise
- By doing this, the waste is removed and the die is prevented from breaking
- Repeat this until is cut the amount of thread needed



There are a number of different types of threads used worldwide. The most commonly used thread is the **ISO METRIC** thread. The angle of this thread is 60°



THREAD TERMINOLOGY



- **Flank** - Straight part of the thread between the root and crest
- **Pitch** - The distance between two equal point
- **Crest** - the highest point on the tread
- **Root** - the lowest point of a thread
- **Thread Angle** - the angle the thread makes

TYPES OF THREADS

Thread Type	Thread Angle	Use	Diagram
Isometric	60°	Most common thread used internationally	
Buttress	45°	Used in woodwork bench vices	
Square	90°	Used in screw jacks	
Acme	29°	Leadscrew on a lathe	

QUESTION TIME

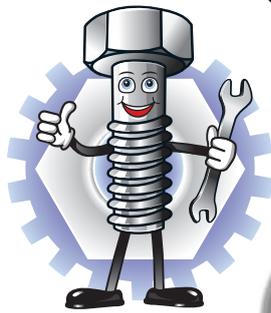


- 1) From a working drawing drawing, how is it decided whether to drill a hole or to cut a thread?
- 2) What is a plug tap used for?
- 3) In your own words, describe how to cut an internal thread
- 4) Why is it important to turn the tap or die back a quarter turn when threading?
- 5) In your copy:
 - a. draw the shape of the thread and label each part
 - b. Explain what each part is
- 6) For each of the following, name the size of the thread angle and a use for the thread:
 - a. Acme thread
 - b. Square thread
 - c. Buttress thread
- 7) On an A3 sheet, design a poster that shows the different types of threads.
- 8) On an A3 sheet, design a poster to compare internal and external threads.

JOINING MATERIALS

Words you might not know

Expands - Makes bigger



When joining material we can temporarily join them with nuts and bolts or screws, or else permanently join them by welding, riveting, brazing, or gluing them.

Screws

Screws are used for joining parts together. They do not need a nut to hold the pieces together but a nut can be used if needed. Below are some examples:

Hex Head Screw	Grub Screw	Cheese Head Screw	Round Head Screw
			

Nuts and Bolts

Unlike a screw, a bolt needs a nut if it is being used to join two pieces together



Nuts

Nuts are used with screws and bolts to hold pieces together. Below are some examples:

Wing Nut	Lock Nut	Castle Nut and Pin	Plain Hex Nut
			

Washers

Washers are put on before a nut to stop the piece getting scratched when tightening the nut.



We have looked at the most common ways of temporarily joining parts together.

Now let us have a look at some ways we can permanently join parts together.

**RIVETING**

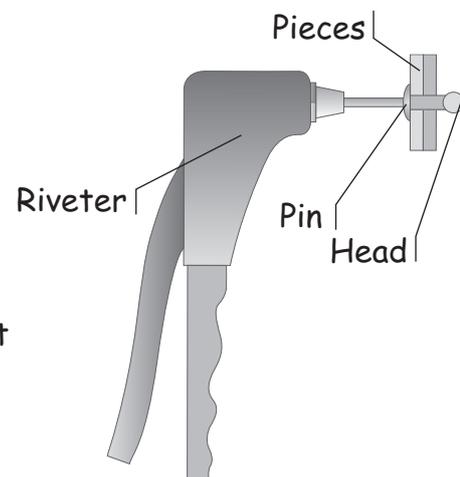
Riveting is a permanent way to join parts together.

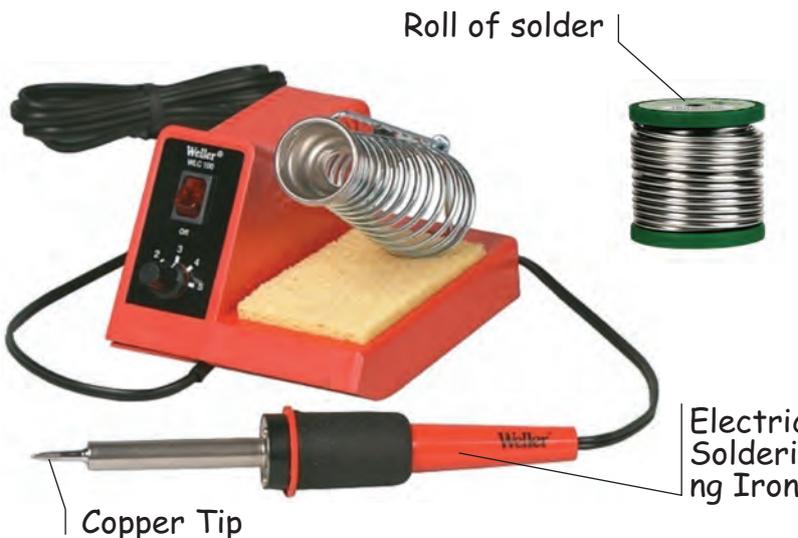
The most common form of riveting is pop riveting.

Pop rivets are useful for joining light materials.

The pop rivet fits in to the riveter and when the handles are squeezed together the head of the rivet expands.

After one or two squeezes the head snaps off the pin and the pieces are then held together.





Roll of solder

Copper Tip

Electric Soldering Iron

SOLDERING

Soldering is joining two pieces of metal together with an alloy called solder.

Both joining pieces are heated up with the electric solder iron or gas torch. Once hot enough, solder is fed onto the hot pieces.

The solder melts and when it cools it turns hard again which joins the metals together.

Solder can also be used to join wires together, for this a light soldering iron can be used.



Great care must be taken when using the soldering iron as it gets very hot and you could burn yourself or others with it.





Can you remember what metals make up the alloy solder?
Why do you think copper is used for the tip

How to solder two pieces together

- Make sure both pieces are clean
- Place the two pieces together with no gaps
- Dip the tip into flux to stop the solder from oxidising
- Place the tip of the hot soldering iron onto the joint of the two pieces and leave it there for them to heat up
- Once hot, feed in the solder into the joint
- Wait for the solder to melt and spread onto the joint
- Take away the iron and allow the solder to cool and turn solid again
- The pieces are now soldered together

In rugby, did you ever hear the referee shout "crouch, touch, pause, engage" before a scrum?

This can be used when you are soldering.



Crouch = lean in over the pieces

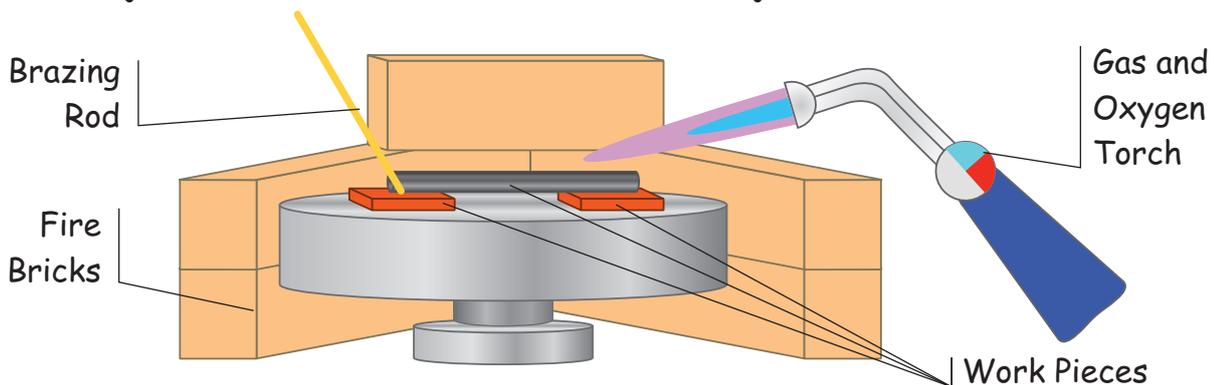
Touch = touch the hot iron off the pieces

Pause = leave the metal heat

Engage = feed in the solder

BRAZING

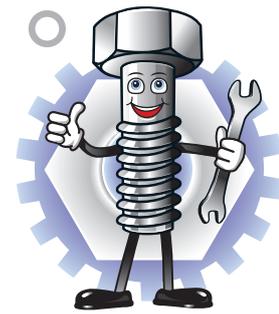
Brazing is where two pieces of metal are joined with brass. The work pieces are heated with an oxygen and gas flame. Once hot enough, a brass rod is touched off the joint, it melts and then cools to make the joint.



Great care must be taken when brazing as it gets very hot and you could burn yourself or others with it.



Can you remember what metals make up the alloy Brass?



How to braze two pieces together

- Make sure both pieces are clean
- Build up fire bricks (as shown in the above picture) in the hearth as they will reflect the heat
- Place the pieces to be brazed in the middle of the firebricks
- Heat up the metals with the torch
- Heat the rod and dip it into the flux
- Feed the rod into the joint where the metals are to be joined
- Once the brass spreads over the joint let it cool down
- When the brass has turned solid again the pieces will be joined

You might need to dip the metals in water to help cool them down. Be careful not to burn yourself on the metal and the steam that will come from dipping the metals in water.



QUESTION TIME

- 1) Why would somebody want to temporarily join something together?
- 2) What is the difference between a screw and a bolt?
- 3) What is the function of a washer?
- 4) In your own words, describe how riveting works
- 5) Describe how to solder two pieces together in your own words
- 6) Describe how to braze two pieces together in your own words
- 7) What is the purpose of the fire bricks?
- 8) Why is care needed when dipping the hot metal in water to cool it down after brazing?
- 9) Make a list of health and safety rules that could be used when soldering or brazing
- 10) How can "crouch, touch, pause, engage" be applied to soldering?



HOT & COLD FORMING

Words you might not know

Quench - To cool down fast in water



Cold forming is where metal is cut, twisted or bent without having to heat it up.

Below are some tools that can be used when cold forming.

Snips

- Used for cutting light sheet metal
- Works similar to a scissors

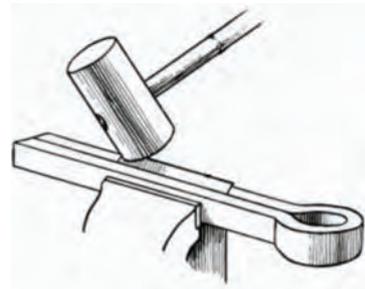


Guillotine/Shears

- Used for cutting heavier sheet metal
- By pulling the long arm, it shears the metal apart

Folding Bars and Mallet

- Used to bend sheet metal
- The folding bars are clamped in the vice while a mallet is used to bend or fold the sheet metal





Hot forming is where metal must be heated up before it can be shaped
Below is a picture of a student heating up steel and bending it on an anvil to make a handle



HEAT TREATMENT OF METALS

1) Hardening

Heating up a piece of metal cherry red and quenching it in water. This causes the metal to become brittle and hard.

2) Tempering

Heating the metal up and just before it turns cherry red, quench it in water. This removes some of the hardness and brittleness.

3) Annealing

Heating up a piece of metal cherry red and allowing it to cool slowly. This softens the metal.

4) Normalising

After a piece has been cold formed, it is heated up cherry red and allowed to cool slowly. This removes the stresses caused by cold forming.

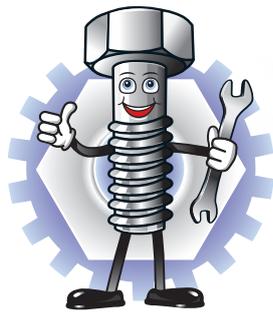
QUESTION TIME

- 1) In your own words, describe cold forming
- 2) Describe some ways of cold forming
- 3) From what you have learnt in this chapter, list some other examples of cold forming
- 4) In your own words, describe hot forming
- 5) In your own words, explain what tempering does to metal
- 6) Explain what happens to metal after hardening
- 7) Why do we use normalising?

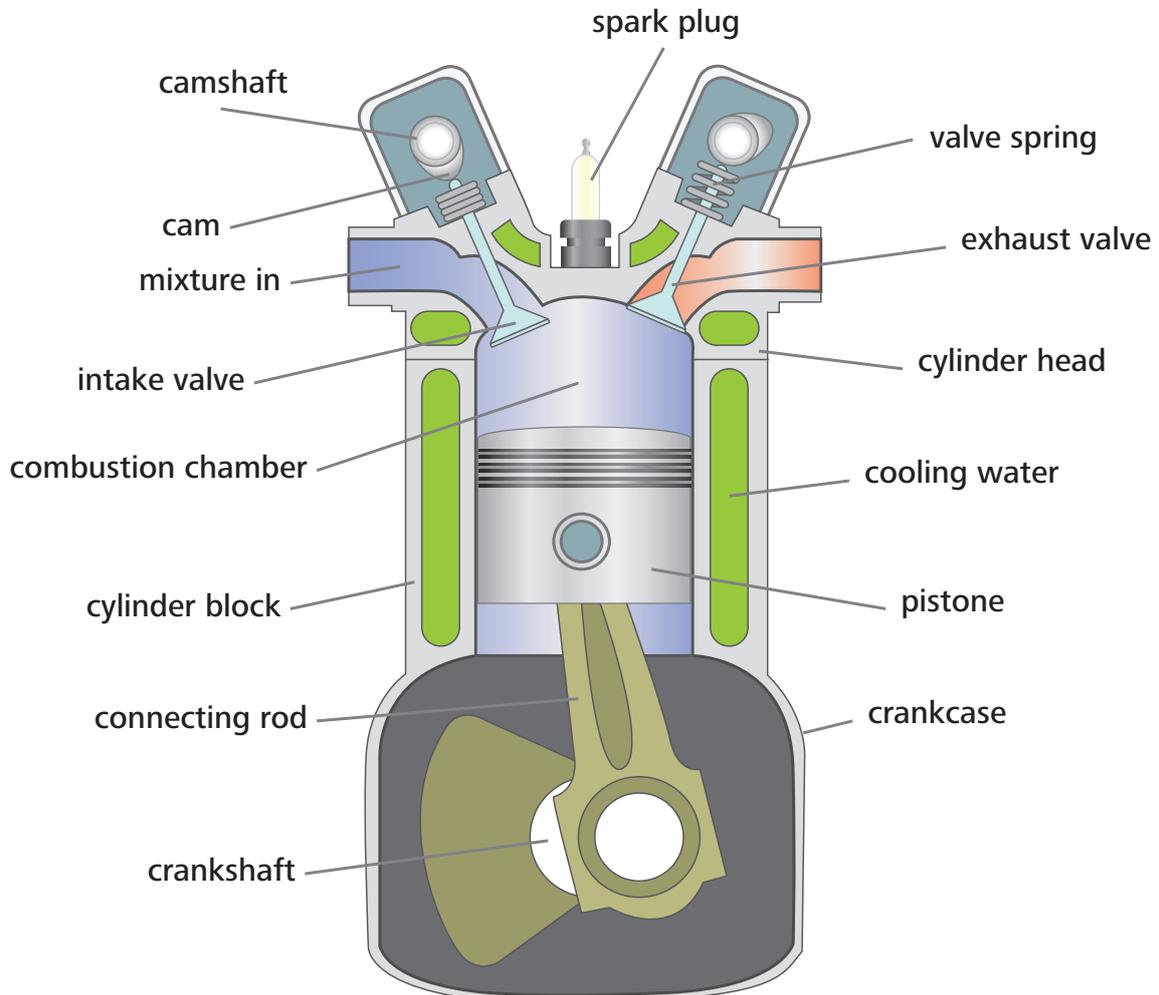


ENGINES

They are two different types of engines:
1) Four-stroke engine - used in most cars
2) Two-stroke engine - used in motorbikes



THE FOUR-STROKE ENGINE



1) Camshaft

This turns around, opening the intake and exhaust valves.



2) Intake Valve

When opened, it lets in the petrol and air mixture

3) Combustion cylinder

The cylinder guides the piston up and down. Inside the cylinder is where the combustion happens. The fuel explodes and pushes down the piston.

4) Connecting Rod

Connects the piston to the crankshaft

5) Crankshaft

When the piston goes up and down, the crankshaft turns around turning the wheels



6) Piston

The piston travels up and down in the cylinder. The piston compresses the petrol and air mixture

7) Cooling Water

Keeps the engine cool when it is running

8) Exhaust Valve

Lets out the exhaust fumes after the ignition of the petrol and air mixture

9) Valve spring

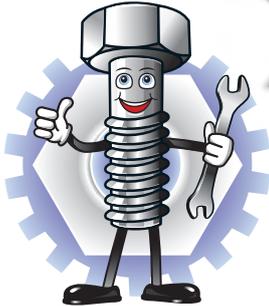
Closes the valve after the camshaft opens it.

10) Spark Plug

This gives the spark to ignite the petrol and air mixture

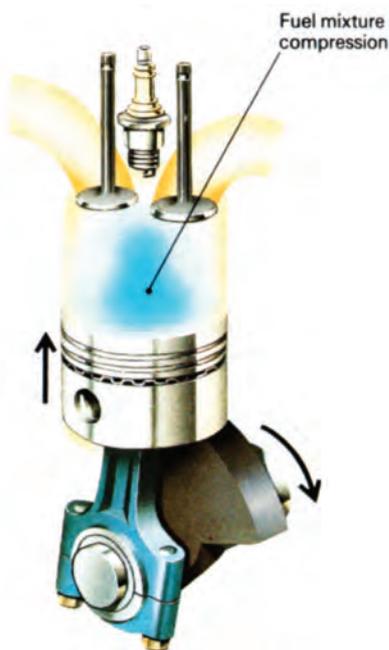
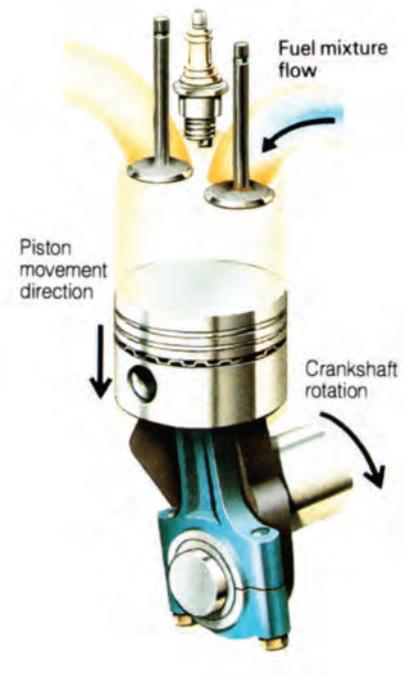
HOW THE FOUR-STROKE ENGINE WORKS

The reason it is called a four-stroke engine is because there are four strokes in the cycle. During each cycle the crankshaft turns twice.



Stroke One - Induction or "Suck"

- The intake valve opens and lets in the petrol and air mixture
- The piston goes down and draws in the mixture

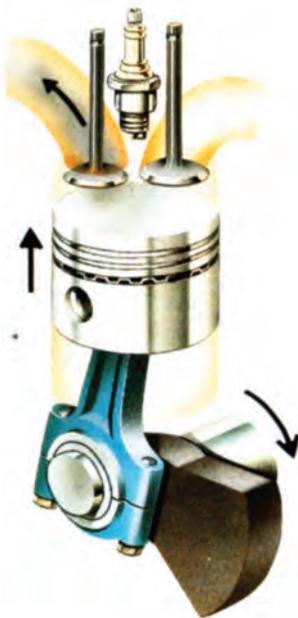
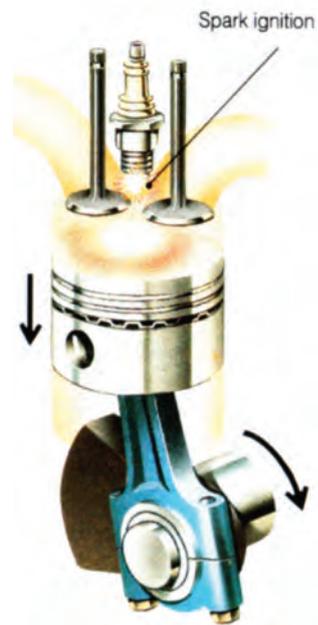


Stroke Two - Compression or "Squeeze"

- Both valves are closed
- The piston comes back up and compresses the petrol and air mixture

Stroke Three - Ignition or "Bang"

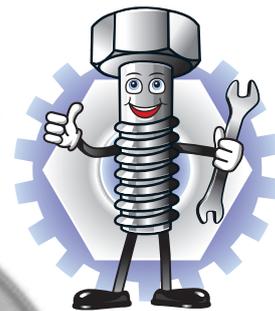
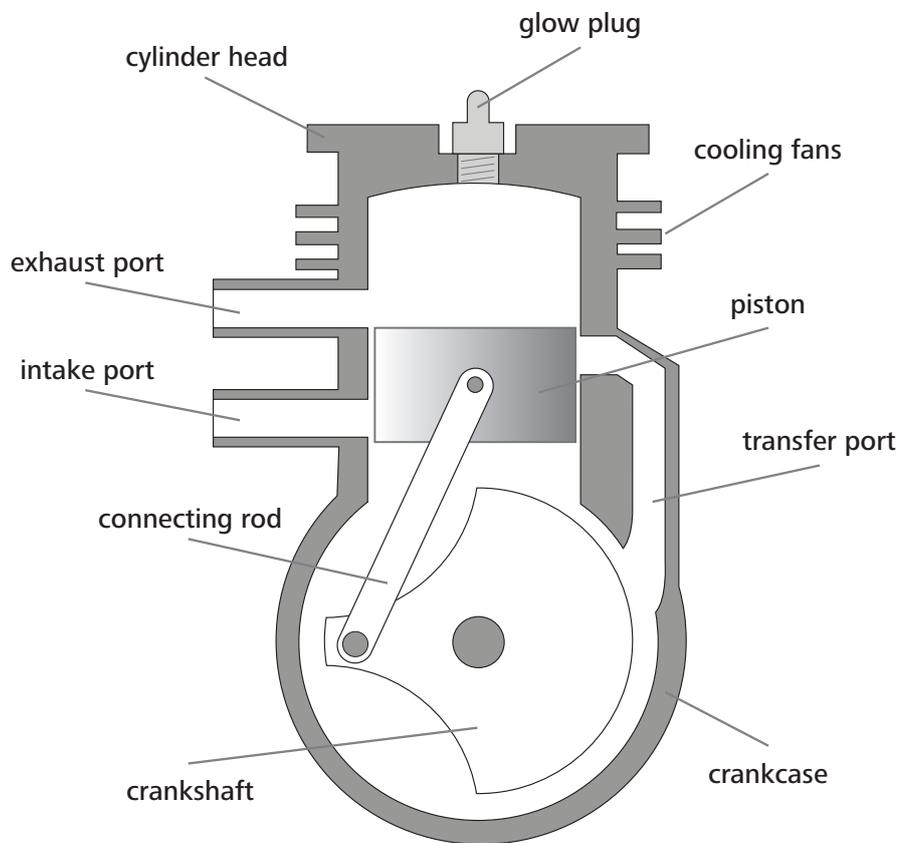
- Both valves are closed
- The spark plug ignites the petrol and air mixture and forces down the piston



Stroke Four - Exhaust or "Blow"

- Exhaust valve is open
- The piston pushes back up and forces the exhaust fumes out the valve

THE TWO-STROKE ENGINE



The reason it is called a two stroke engine is because there are two strokes in the cycle. After each cycle the crankshaft only turns once.

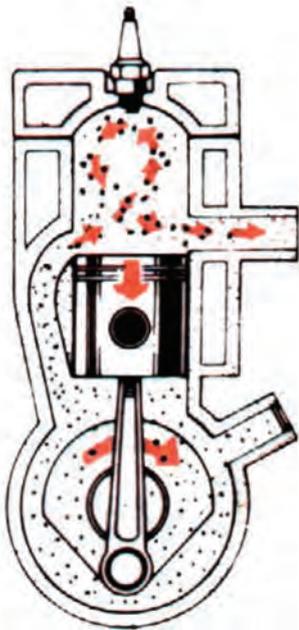
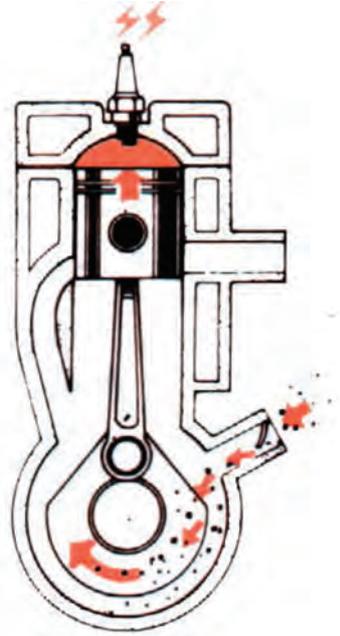
The parts are the same as in the four stroke engine only instead of valves there are ports. Instead of water cooling the engine there are cooling fins.

HOW THE TWO-STROKE ENGINE WORKS

Stroke One - Upward Stroke (Induction & Compression)

"Suck" & "Squeeze"

- The piston moves up
- The only port open is the intake to leave the fuel mixture in to the crankcase
- While this is happening, the mixture from the previous stroke is being compressed



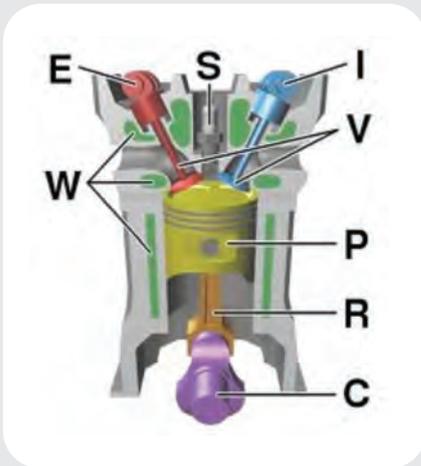
Stroke Two - Downward Stroke (Ignition & Exhaust)

"Bang" & "Blow"

- The mixture is ignited by the spark plug
- The piston is forced down
- The exhaust port is open and when the piston comes down, the exhausts leave the chamber through it

QUESTION TIME

- 1) Why are the engines called "a four-stroke engine" and a "two-stroke engine"?



- 2) Below is a picture of a four stroke engine. In your own words, name and describe what each part does

- 3) In your own words, describe how a four stroke engine works

- 4) In your own words, describe how the two stroke engine works

- 5) Below are examples of how engines can be asked in a higher level exam. Have a go and see how you would do:

Answer any five questions.

The diagram, Fig. 1, shows some of the main parts of a basic four-stroke engine.

Questions (b) to (e) relate to this diagram.

- (a) Briefly describe the contribution made to technology by one of the following people:
- John B. Dunlop, or
 - John L. Baird, or
 - James Watt.
- (4 marks)
- (b) (i) Identify each of the valves shown.
 (ii) Name the engine stroke for which Valve A opens.
 (iii) Name the engine stroke for which Valve B opens.
- (4 marks)
- (c) Describe the mechanisms used to open and close the valves.
- (4 marks)
- (d) (i) Identify part 'D'.
 (ii) State the purpose of part 'D'.
- (4 marks)
- (e) (i) Name one other type of engine.
 (ii) Suggest a suitable application for the engine named.
- (4 marks)

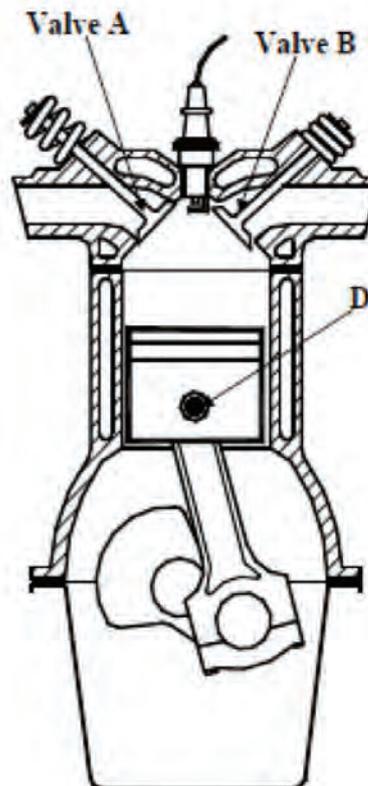
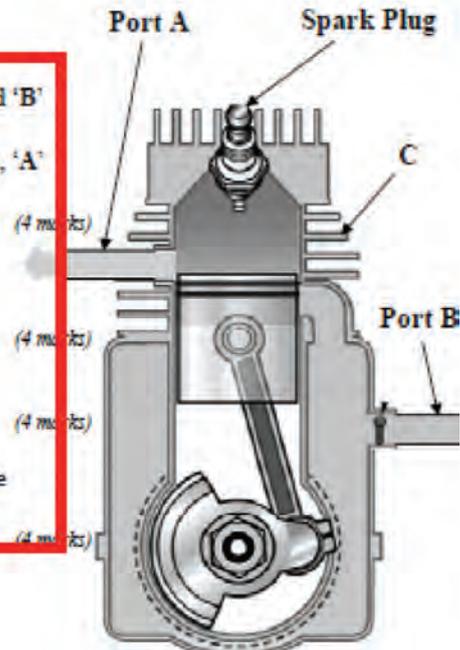


Fig.1

The diagram, Fig. 1, shows some of the main parts of a basic two-stroke engine.

Questions (a) to (d) relate to this diagram.

- (a) (i) Name both of the engine Ports 'A' and 'B' shown.
- (ii) Explain the purpose of one of the ports, 'A' or 'B'.
- (b) (i) Identify part 'C' of the engine.
- (ii) Explain the purpose of part 'C'.
- (c) Describe the function of the Spark Plug.
- (d) Outline the operation of the engine during the downward stroke.



Answer any five questions.

The diagram, Fig. 1a, shows some of the main parts of a basic four-stroke engine.

Questions (b) to (e) relate to this diagram.

- (a) Briefly describe, the contribution made to technology by one of the following people:
 - (i) Fr. Nicholas Callan, or
 - (ii) Michael Faraday, or
 - (iii) The Wright brothers.

(4 marks)
- (b) (i) Name Part 'A'.
- (ii) Explain the purpose of Part 'A'.

(4 marks)

- (c) (i) Name Part 'B'.
- (ii) Suggest a suitable material for Part 'B'.

(4 marks)

- (d) Briefly describe the function of Part 'C'.

(4 marks)

- (e) Part 'D' shows a valve. What is the purpose of this valve?

(4 marks)

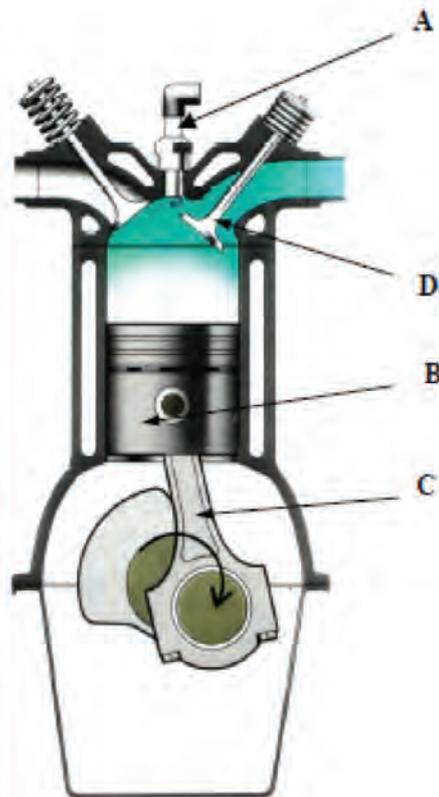


Fig. 1a

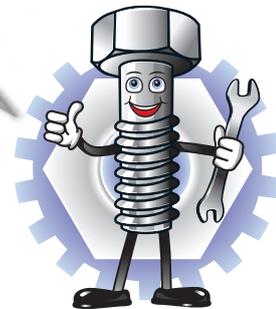
ELECTRICITY AT HOME



Be very careful when dealing with anything to do with electricity. Electric shocks can result in death.



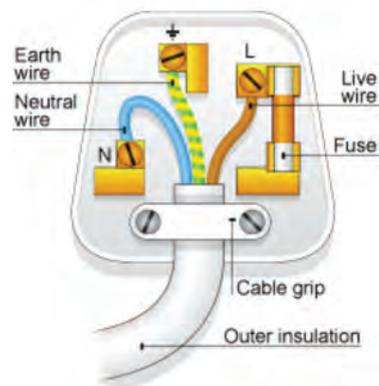
There are two types of current:
AC - Alternating Current (this type is the current in the mains in a house)
DC - Direct Current (This type is the current in batteries)



THE PLUG

The wiring of a three pin plug is shown in the diagram on right

- The **Earth** wire works with the fuse so that if there is a surge, the earth takes a large amount of the current and sends it into the ground. The fuse will blow when the electricity surges.
- The **Live** wire carries the current to the device.



FUSES

- A fuse is connected to the live wire in a plug (see plug diagram).
- Fuses are for safety.
- If too much current flows through the fuse, it will blow and stop current going to the appliance.
- It is very important to use the fuse recommended by the appliance manufacturer.

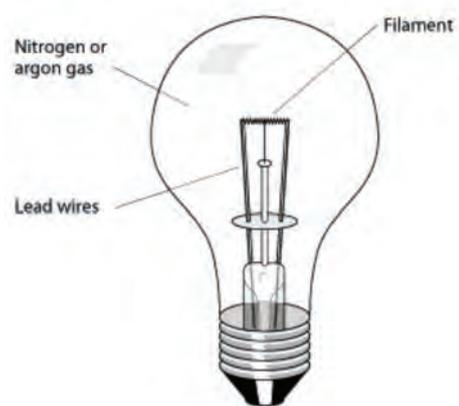


CIRCUIT BREAKERS

- A circuit breaker is the modern fuse.
- They are mostly used in household circuits.
- If too much current flows through the circuit breaker, instead of it blowing like a fuse the switch flicks or "trips".
- To reset, flick the switch back up.

FILAMENT LIGHT BULB

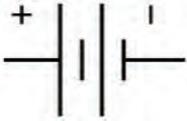
- The bulb makes light by the current heating the tungsten filament and causes it to glow.
- If too much current flows through the filament it will break or "blow" and this stops the current flowing through it.



ELECTRONICS

When reading a circuit diagram, you will see all the components as symbols. In this chapter you will learn all about the electronic symbols and what they do

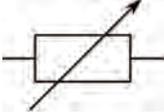


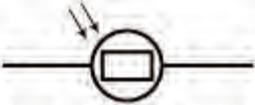
Battery	
Real life	
Symbol	
What does it do	To drive motors, light bulbs, give power to something

Switch	
Real life	
Symbol	
What does it do	To complete a circuit to allow current to flow

Lamp/Bulb	
Real life	
Symbol	
What does it do	To give light

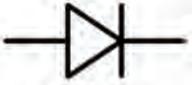
Resistor	
Real life	
Symbol	
What does it do	To restrict the flow of the current

Variable Resistor	
Real life	
Symbol	
What does it do	Varies the current by turning the dial

Light Dependant Resistor (L.D.R)	
Real life	
Symbol	
What does it do	The resistance depends on how much light there is. It controls the amount of current flowing

Motor	
Real life	
Symbol	
What does it do	Used to drive things like cars

Buzzer	
Real life	
Symbol	
What does it do	When current passes through it buzzes

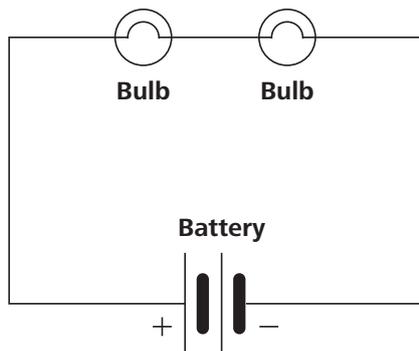
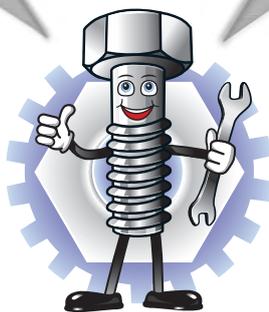
Diode	
Real life	
Symbol	
What does it do	Will only allow current to flow in the direction the triangle is pointing

Light Emitting Diode (L.E.D.)	
Real life	
Symbol	
What does it do	Needs a resistor wired in front of it to stop it from blowing. LED gives out a light

HOW A CIRCUIT WORKS

A circuit is made up of a number of electronic components to make something

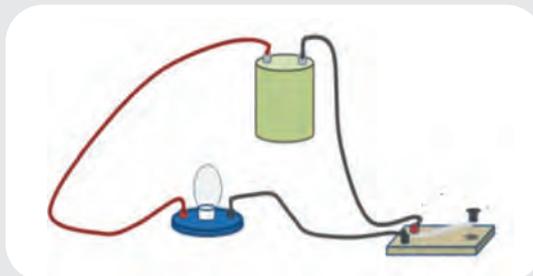
When wiring, remember the positive is usually a red wire and the negative is a black wire. With components like an LED, one leg will be longer. This leg will be positive and the current must flow in through this.



- In this circuit we have a battery and two bulbs
- On the left is what the circuit diagram would look like
- The current flows from the longer leg of the battery (+) and flows through the two bulbs and turns both of them on

ACTIVITY TIME

On the right is a battery, bulb and a switch. Work together and show what the circuit diagram will look like.

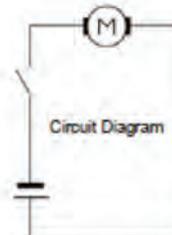
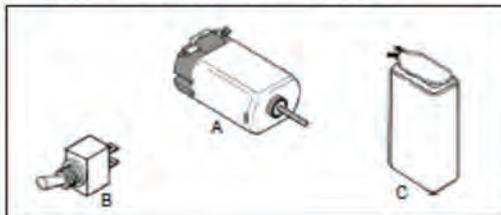


QUESTION TIME



- 1) In your copy, draw and label the three pin plug.
- 2) What is the purpose of fuses and circuit breakers?
- 3) What is the difference between the fuse and the circuit breaker?
- 4) Draw the symbols for the following:
 - a. L.E.D
 - b. L.D.R
 - c. Battery
 - d. Diode
 - e. Switch
 - f. Motor
 - g. Buzzer
- 5) In your own words, what does a light dependent resistor do
- 6) On an A3 sheet, design a poster that shows all the electronic symbols mentioned in the chapter.
- 7) Have a look at these exam questions and see how you would do [note redraw the questions into your copy]

(i) Using the circuit diagram as a reference, draw the connecting wires between the components in the box below.

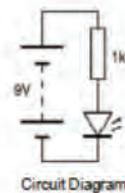
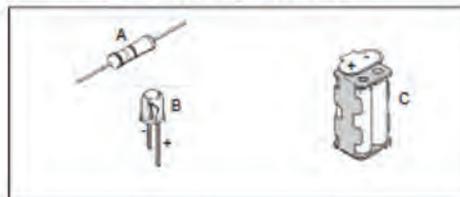


(ii) Match the number to the component in the table opposite.



Component	No.
Resistor	
LED	
Push Switch	
Buzzer	

(a) (i) Using the circuit diagram as a reference, draw the connecting wires between the components in the box below.



(ii) Name the components shown above.

A	
B	
C	

(iii) State a use for component 'C'.

