

Design and Manufacture

NATIONAL 4/5

COURSE NOTES

DO NOT REMOVE FROM CLASSROOM



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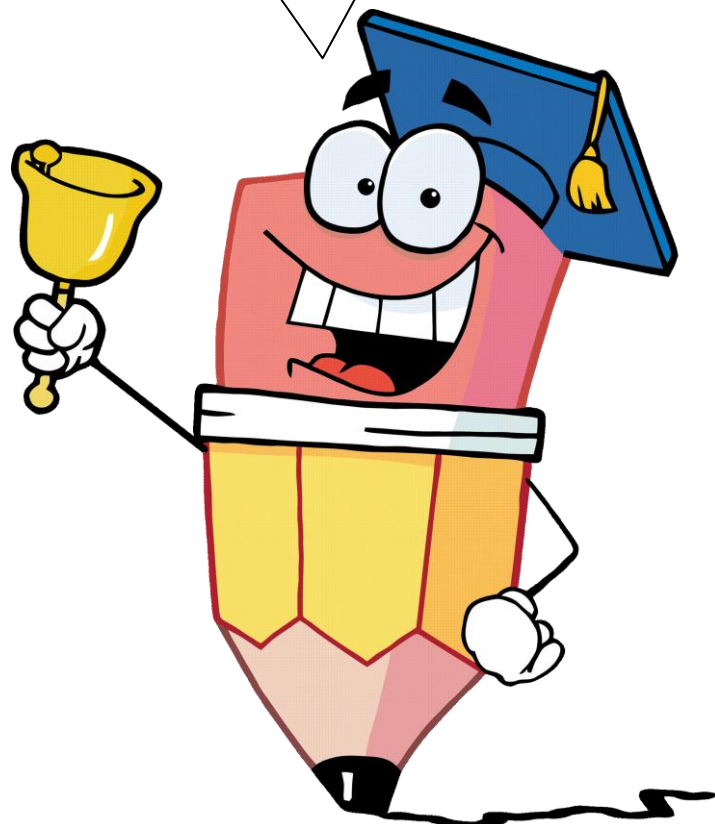
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- Materials.
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Remember these booklets
are a shared resource and
should be well looked after.

NO WRITING ON PAGES!



Section 1

DESIGN FACTORS

(FEEDSCAMMP)



Introduction

Although there are no rules for developing ideas, it is useful to be aware of the main factors, how they are intertwined and how a designer's thinking is influenced by them. The main factors that you must understand are:

- Function.
- Ergonomics.
- Environment.
- Durability.
- Safety.
- Cost/Economics.
- Aesthetics.
- Materials.
- Manufacture.
- Performance.

Function

Function is the word used to describe what a product does. Every product has a **primary function** and can have infinite **secondary functions**.

- The primary function refers to the products main job.
- Secondary functions refer to the unlimited things the product can do in addition to it's primary function.

Product	Primary function	Secondary Function
Kettle	Boil water.	Light up. Make noise. Indicator lights.
Clock	Display time.	Alarm. Light up. Play music.
Tin Opener	Open tins.	Electronic. Open bottles.

Questions

There are 6 products shown , in your jotter write down each products' primary function and any additional secondary functions it has.



Product 1: Office Chair
Primary Function:

Secondary Functions:



Product 2: iPod Nano
Primary Function:

Secondary Functions:

Questions cont'd



Product 3: Radio Alarm
Primary Function:

Secondary Functions:



Product 4: Juicer
Primary Function:

Secondary Functions:



Product 5: Tin Opener
Primary Function:

Secondary Functions:



Product 6: Gas BBQ
Primary Function:

Secondary Functions:

Ergonomics

Ergonomics refers to design in relation to the human body and human interaction. It can be split into 3 subsections: Anthropometrics, Psychology and Physiology.

Anthropometrics: Refers to the dimensions of the human body. Products are designed for anthropometric ranges/percentiles. These percentile ranges depend on age, sex and race.

In a group of 100 people, the smallest 5 would be our 5th percentile (0-5%) and the biggest 5 would be our 95th percentile (95-100%). The 50th percentile is our average Joe, this percentile accounts for the largest fraction of our 100 people. The %ile range we design for will depend on the product, it should be chosen to ensure the maximum fraction of the general population can use the product comfortably.

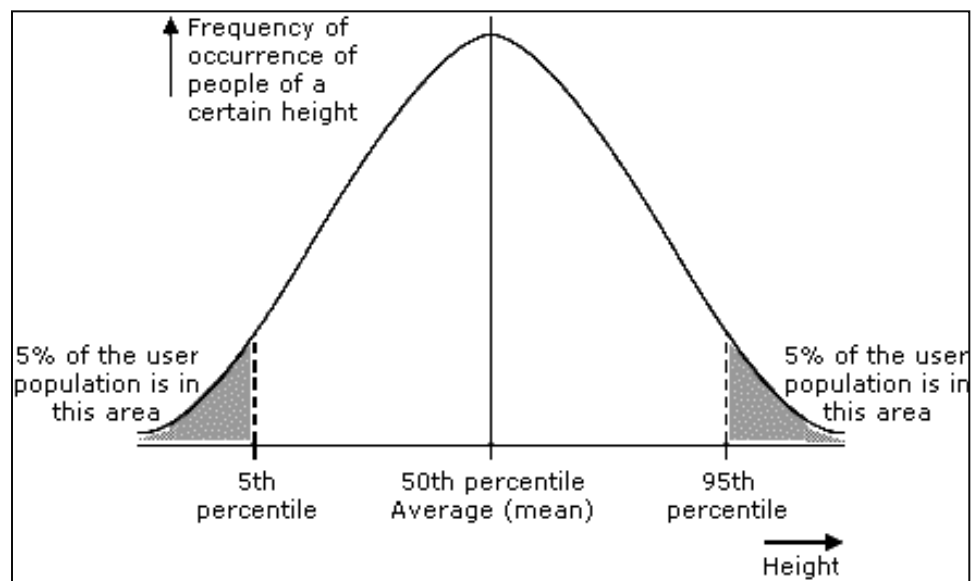
Example

Door Frame Height:

95th percentile

Door Handle: 5th percentile

Chair: 50th percentile



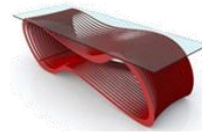
Psychology: Refers to how a product makes the user feel when looking at or using the product.

Example

Colour Red- warm, angry, danger.
White- clean, simple, innocent.
Brown- earthy, organic.



Shape Organic Curves- modern, comfortable, fast.
Geometric Angles- old, cheap, uncomfortable.



Even aspects of a design can influence the way you feel.

Example:

- If a chair has a belt, you assume you will be safer sitting in it.
- If a handle has a rubber cover, you assume you will be able to grip it better.

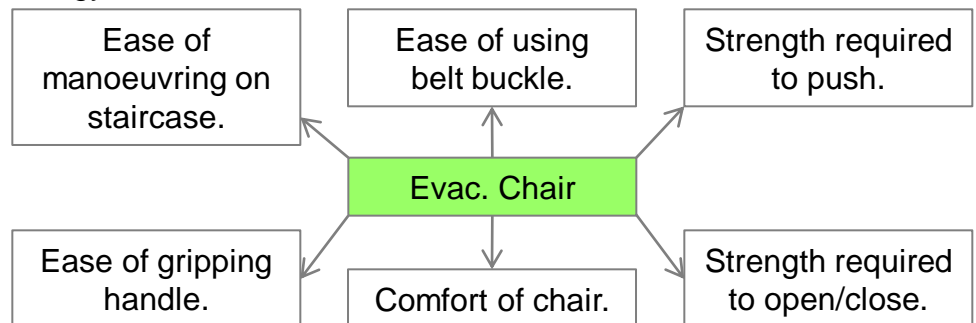
These assumptions may not be right but it will affect how the user feels towards the product.

Physiology: Refers to how people have physical interaction with a product. This could be:

- Lifting or holding a product.
- Using a product's mechanisms i.e. opening or closing, switching, twisting, etc.

All interaction between humans and products should be easy and smooth. Products are designed based on the average strengths of people.

Here is an example of physiology considerations in relation to an evacuation chair.



Questions

There are 3 products shown below, answer the questions, in sentences for each of the products.



Porcupine Chair



Torch



Tool Box

Questions cont'd

Anthropometrics: What sizes of the human body would the designer need to design this product?

Physiology: In what ways would a human physically interact with this product?

Psychology: What emotions are felt when looking at this product's shape, colour and texture?

Environment

Product Designers have to be aware of the effect their work will have on the environment. They have an important role to play in helping find solutions to the global problems faced by our planet today.

These problems are often referred to as 'green issues' and can be summarised as follows:

- Energy consumption: during the manufacture, storing or transportation of a product.
- Pollution: generated during the manufacture and transportation of a product.
- Conservation of natural resources: use readily available materials, i.e. softwoods instead of hardwoods.
- Waste disposal: use of recyclable materials for manufacture or renewable energy sources to power machines.

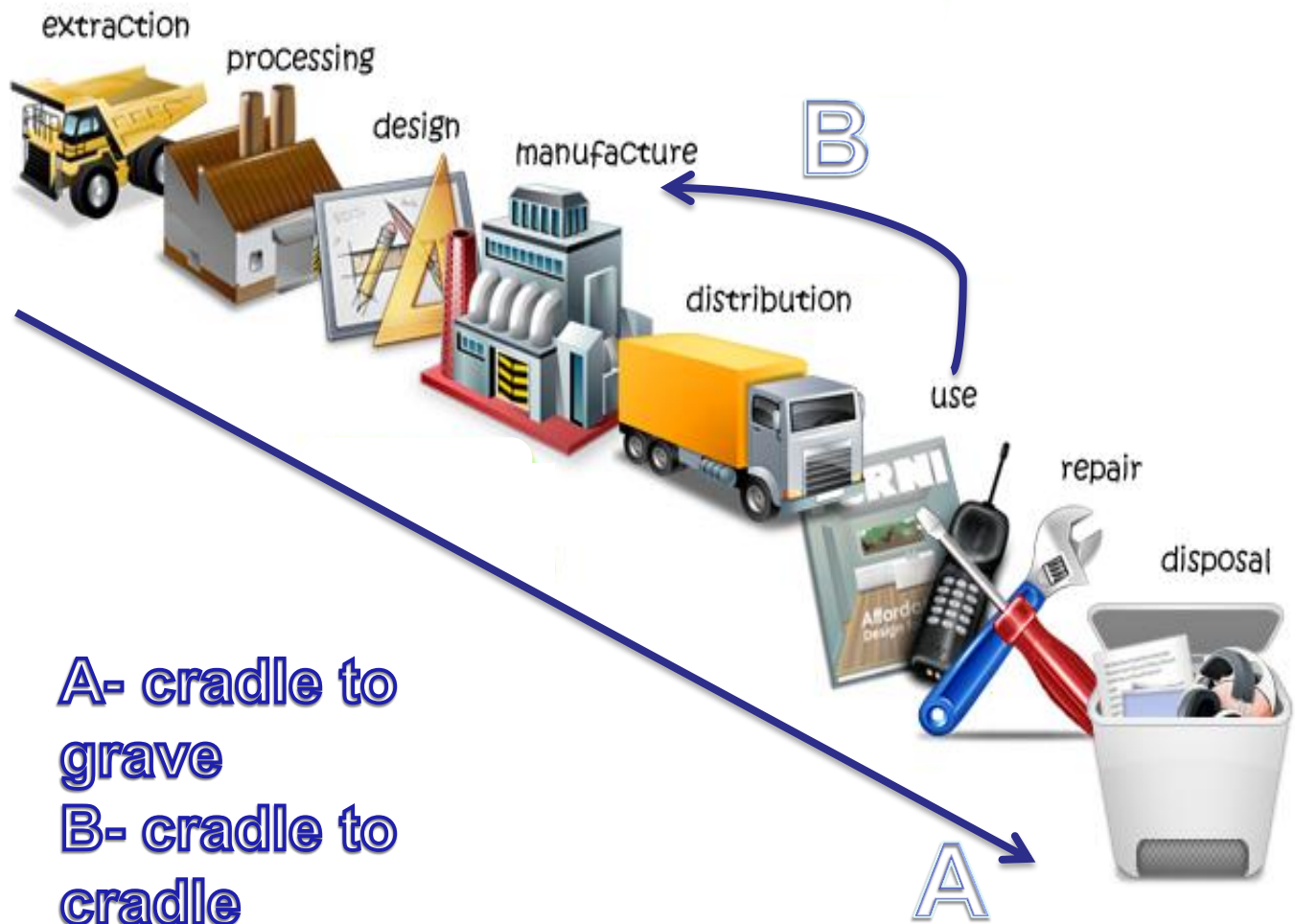
Designers must consider the effect a product will have from the extraction of the raw materials up until its ultimate disposal. This time frame used to be known as the 'cradle-to-grave' approach, nowadays it can often be called the 'cradle-to-cradle' approach because many products can be recycled in some form.



Questions

The diagram below shows the different stages in a product's life cycle, describe what happens in each stage of the lifecycle.

Life Cycle Analysis



Durability

The durability of a product or material refers to the strength, stability and ability to withstand wear and tear. The materials chosen will be an influencing factor in it's durability.

Durable products may be:

- Corrosion resistant.
- Weather-proof.
- Resistant to fatigue.
- Able to withstand large force being applied.
- Scratch resistant.



Questions cont'd

Copy out the paragraph shown below into your jotter. Using the word bank at the bottom of the page fill in the blanks.

A durable product is a product that does not ____ out quickly. It is one that lasts over time. Items like bricks could be considered durable goods because they should theoretically never wear out. _____ durable products such as refrigerators, cars or _____ phones usually continue to be useful for three or more years, durable products are typically characterized by ____ periods between purchases.

Examples of durable goods include cars, household goods (home appliances, _____, furniture, etc.), sports equipment and toys.

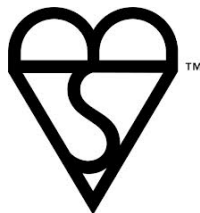
Non durable goods (consumables) are the _____ of durable goods. They may be defined either as goods that are immediately consumed in one use or ones that have a lifespan of ____ than 3 years.

Examples of non _____ goods include fast moving consumer goods such as cosmetics, cleaning products, office _____, packaging, containers, paper products, textiles, _____ and footwear.

long	supplies	mobile	less	highly
clothing	wear	opposite	electronics	durable

Safety

Safety is vital to the success of any product. New products go through vast amounts of safety checks and quality control to ensure that no-one will be harmed when using the product. Products today are designed to meet the regulations set by BSI (British Standards Institute) and the ISO(International Standards Organisation).



Risks that are considered and tested relate to:

- Health and safety of humans.
- Impact on the environment.
- Possible malfunctions of the product, causing it to fail (stop working).

Every product will be dangerous in the wrong hands, a designer has no control over how it will be used or what it will be used for once purchased, all he or she can do is provide clear instructions for use and build in any possible safety features.

Questions

When designing any product for any target market group, designers have the responsibility of making sure their product is safe for the user to use.

With such a variety of products on the modern market, there is always a massive and varying range of safety considerations that designers must take in to account when finalising their products.

Example

When designing and manufacturing hair straighteners, the designer had to take the following safety concerns into consideration:

1. The hot plates must not over heat and burn the users hair.
2. The body of the straighteners must not conduct heat from the hot plates as the user could burn their hand while they use the product.
3. The user must be able to hold and use the straighteners in such a way that they will not burn or injure themselves.



There are 4 products shown below that while being designed had very important safety considerations. In your jotter, write down **4 safety considerations for each.**



Kettle



Swing Sofa



High Chair



Bunk Beds

Cost (Economics)

When people talk about economics they begin to think about the retail cost. This retail cost is the end result in a long process, it has many contributing factors, these include:

Cost incurred during the initial design

Paying designers, market researchers, model makers, field experts, etc.

Cost incurred in manufacture

Paying for engineers, raw materials, standard components, machines/equipment, labour, sub-contractors, energy, storage, etc.

Cost incurred after manufacture

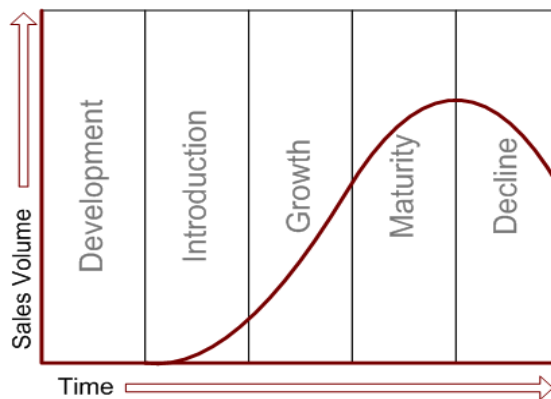
Paying to transport the product, marketing/advertising the product, packaging, etc.

Good economic awareness and planning are important to the success of any new product.

Questions

When a product is designed, manufactured and sold it goes through a process called 'the product lifecycle'. This simple process explains when money is lost and made, from it's initial development through to removal from market.

Copy the graph and paragraphs below into your jotter. Match the section headings to the appropriate paragraph, the first one has been done for you.



DEVELOPMENT



In this stage the product is being developed from an initial idea through to the point of manufacture. No profit is made, often the manufacturer is making a loss on outgoings such as salaries, materials and marketing.

INTRODUCTION

Finally product sales begin to decrease, it is time to release a new product to the market.

GROWTH

The maturity phase is characterized by sales volumes levelling off. Competition will begin to stiffen, it may be time to tweak the products by adding new features.

DECLINE

It takes time of a new product to begin selling. The marketplace may be unfamiliar with the product and creating awareness takes time. Consequently sales show a slow growth during the introduction phase.

MATURITY

The growth space is characterized by a rapid increase in sales volume. This is created by increased demand.

Aesthetics

Aesthetics is a word that describes the appearance of a product. Every product has numerous aesthetic qualities that can be examined in depth. They are all linked in some way. Common words associated with the aesthetics are:

Shape: Organic shapes come from looking at forms seen in nature. Geometric shapes come from looking at man-made forms, i.e. architecture, engineering.

Colour: Contrasting colours come from opposite sides on a colour wheel, they are said to compliment each other. Harmonising colours are close together on the colour wheel.

Other words associated with aesthetics are:

Line Form Proportion Texture Balance Pattern

Questions

Below there are 4 products and a large word bank full of words that could be used to describe the aesthetics of the products. Write down the name of the product and then in sentences, describe the aesthetics using the words from the word bank. Now choose a further 3 products you are familiar with and repeat the process.

Example

Chair One by Konstanian Grcic



This chair is geometric in shape. It is plain in colour but bold because it is black. The pattern at the back is uniformed and modern. The angles are harsh.

iPhone 5 by apple



My Squeeze by Alessi



Lomsk Chair by IKEA



Red and Blue Armchair by Gerrit Rietveld



BOLD

MODERN

ABSTRACT

COLOURFUL

PLAIN

UNIFORMED

HARMONISING

PROPORTIONED

CONTRASTING

ORGANIC

GEOMETRIC

SUBTLE

BRIGHT

CALM

SHINY

ROUGH

FLOWING

HARSH

Materials

There thousands of materials that could be used in the production of a product. The material selected will be the one most appropriate based on colour, physical properties and working characteristics. Other considerations may include; functional requirements, availability of materials, manufacturing restrictions and costs of materials.

The materials that you must know about are:

Woods: Hardwoods, Softwoods, Manufactured Boards and Composites.

Plastics: Thermoplastics, Thermosetting Plastics and Plastic Composites.

Metals: Ferrous, Non-Ferrous and Alloys.

Questions

There are different justifications for choosing materials to make products. Usually they are chosen because of their physical and aesthetics properties. At a National 4 or 5 level we will be focussing on woods, metals and plastics. It is important that you are able to identify and discuss these different materials.

Task

Copy out the statements below. Research the materials either in your course booklets or online and complete the statements.

Woods

Woods come from ...

They can be split into ... groups, they are ...

Metals

Metals come from ...

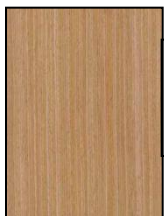
They can be split into ... groups, they are ...

Plastics

Plastics come from ...

They can be split into ... groups, they are ...

The pictures below show 3 woods and 3 metals, identify them, explain how you knew and list 2 products that could be manufactured from the material. An example has been done for you.



The material shown is oak. I knew this because oak does not have many knots, it has a close grain and is golden brown in colour. Oak is a hardwood.

Woods

Metals



1



2



3



1



2



3

Manufacture

The word manufacture means to make. Every product will be manufactured using a process. These processes may be traditional manual processes, like we carry out in our school workshops or automated processes, these will be carried out by robots and machines.

The process used to manufacture an item will depend on a number of things:

- The material being used.
- The manufacturing budget.
- The scale of production.

Performance

To compete in today's competitive market, manufacturers must compete with an increasing number of product performance requirements, such as cost, reliability and environmental impact.

How well a product performs can be measured in sales and customer satisfaction.

Sales

Short term: Success is measured by first year sales, market share and profit.

Long-Term: Success is measured by marketing growth.



Customer Satisfaction

Customer satisfaction is measured by the number or percentage of customers, whose experience with a product exceeds specified satisfaction goals.



Section 2

PLASTICS



Plastics

Plastics were initially used as a substitute for more expensive materials like ivory. It is now widely used in commercial products. There are 2 groups of plastic:

- Thermosetting Plastics
- Thermoplastics

The basic chemicals used in the manufacture of plastics are extracted from coal and crude oil. These are obtained by using heat and chemical catalysts. There are 4 main stages in this process:

1. Extraction of basic chemicals.
2. Refining and processing into monomers.
3. Converting these into polymers, in the form of plastic granules.
4. Processing the plastic granules into products.

Thermosetting plastics are formed by chemical reactions which leave them in a relatively fixed state. They are formed and set in a single operation. They cannot be softened or reformed then heated again. Thermosets can withstand high temperatures, excess heat will simply cause the material to decompose. The ability to withstand heat means these plastics are often used when a product needs to resist temperature, electric current or chemicals.

Name	Common Name	Properties and working characteristics	Uses
Epoxy Resin	Araldite	Excellent adhesive qualities, low shrinkage, strong when reinforced.	Bonding, encapsulation, laminating, surface coating.
Melamine Formaldehyde	Formica or Melaware	Waterproof, tasteless, odourless, mark and scratch resistant.	Worktops, tableware, buttons, electrical insulation.
Urea Formaldehyde	Areolyte or Cascamite	Good adhesive qualities, stiff, hard, brittle, good electrical insulator.	Electrical fittings, paper and textile coating, wood adhesive.
Polyester Resin	Orel or Beetle	Stiff, hard, brittle, formed without heat or pressure.	Panels for car bodies and boat hulls, casting, embedding.

Thermoplastics soften when heated and harden when cooled. The softening and hardening can be repeated indefinitely. When thermoplastics are soft, they are easily formed under pressure. When gently heated they will return to their original state, this is called plastic memory. Thermoplastics are used in products which do not have to withstand high temperatures.

Name	Common Name	Properties and working characteristics	Uses
Poly-methacrylate	Acrylic or perspex	Stiff, hard, durable, scratches easily, easily machined and polished.	Signs, lighting, lenses, cases, jewellery.
Polyvinyl chloride	uPVC	Rigid, abrasive resistance, water/weather resistant.	pipes, gutters, bottles, roofing, window frames.
Acrylonitrile butadiene styrene	ABS	Strong, light, durable, scratch/chemical resistant, high surface finish.	Kitchenware, toys, cases, crash helmets, telephones.
Polyamide	Nylon	Tough, durable, machines well, self-lubricating.	Bearings, gears, bristles, textiles, clothing, upholstery.

Questions

Answer in sentences.

1. Why was plastic originally created?
2. Where does plastic come from?
3. What are the 2 groups of plastics?
4. Explain the difference between the 2 groups.
5. Name 2 Thermoplastics, list their properties and uses.
6. Name 2 Thermosetting plastics, list their properties and uses.

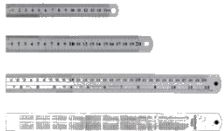
Marking Out

Different materials require different tools, you should be familiar with most of these tools from S1 and S2. These tools are used when measuring and marking out on plastic:

- Permanent Marker Pen
- Steel Rule
- Template

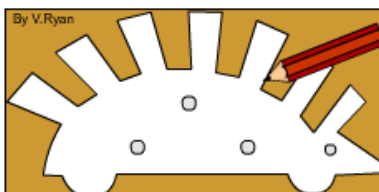
The majority of plastic sheets come with a clear or white protective cover on them. It is a very thin cover made from polythene. This cover protects the plastic underneath from becoming scratched.

When marking out dimensions or shapes on plastic sheet a pencil is no good as it will be hard to see and will easily rub off. Lines drawn with a **marker pen** are clear and will not smudge or be removed by accident.



The simplest and most common measuring tool. The flat **steel rule** is usually 6 or 12 inches long, but longer sizes are available. Steel rules can be flexible or nonflexible, thin or wide. The thinner the rule, the more accurately it measures, because the division marks are closer to the work.

Templates are used when you are making more than one of the same object. Using an accurate template to draw around ensures all shapes are identical without having to waste time measuring and marking out again and again. Templates can be made from a range of materials, such as card, hardboard or aluminium.



Questions

Answer in sentences.

1. Why does plastic sheet have a thin polythene cover on it?
2. Why would you not use pencil to mark out on plastic?
3. What would you use to mark out dimensions and shapes?
4. What tool is used measure accurately?
5. When would you use a template? Why?

Cutting and Shaping

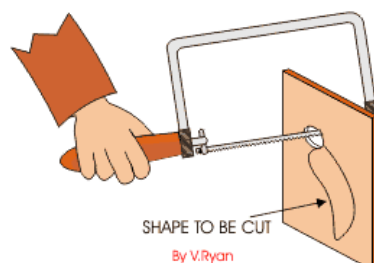
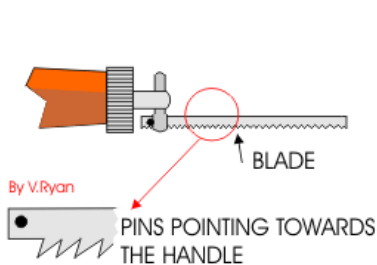
Different materials require different tools, you should be familiar with most of these tools from S1 and S2. These tools are used when cutting on plastic:

- Coping Saw
- Band Saw
- Fret Saw

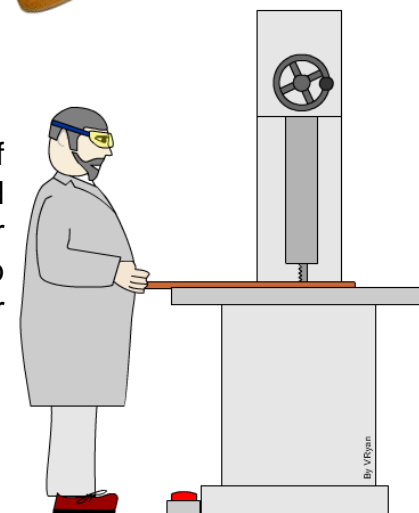
As previously covered in the Woods notes, **Coping saws** are used for cutting a range of woods or plastics and are very useful for cutting unusual shapes or curves. Using a coping saw is a test of skill as it can be difficult to control and requires practice.

Care must be taken when fitting the blade so that the teeth point towards the handle. If the blade is fitted the opposite way the coping saw will be very difficult, if not impossible, to use.

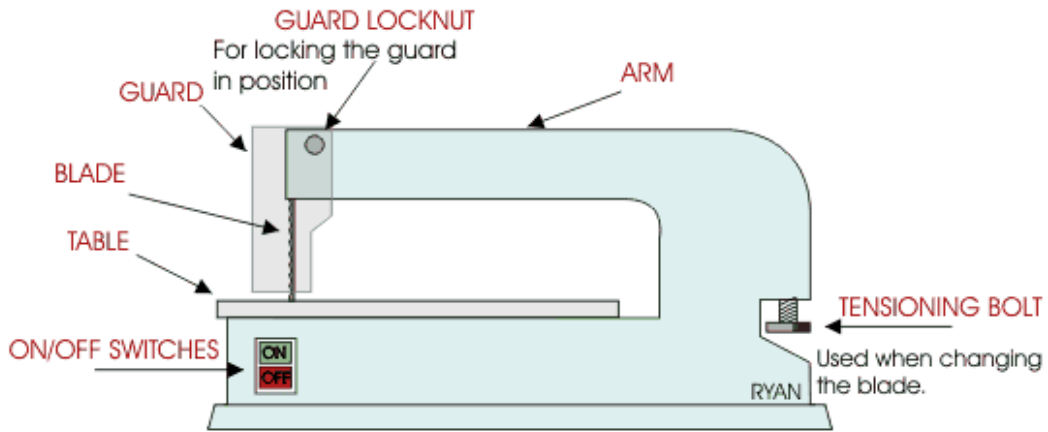
A coping saw can be used to cut shapes in the middle of a piece of material. First, the blade is removed from the coping saw and then passed through a hole that has been drilled. The blade is then fitted to the coping saw frame.



A **band saw** is a power tool which uses a continuous band of metal with teeth along one edge to cut various shapes. Band saws are used for woodworking and are particularly useful for cutting irregular or curved shapes, but can also be used to produce straight cuts. Band saws are generally used to cut larger boards. Pupils are not allowed to use the band saw.



The **fretsaw** is a general workshop machine. It is used to cut and shape light materials such as acrylic, MDF and plywood. They can be used to cut very detailed shapes and they are supplied with different types of blade according to the material that is to be cut. The general rule is that the thicker the material, the slower the machine operator pushes the work against the blade.



Questions

Answer in sentences.

1. Which hand tool is used to cut unusual shapes or curves in woods or plastics?
2. What direction should the teeth on the blade be going?
3. Explain how the coping saw can be used to cut out a shape in the middle of a piece of acrylic.
4. Which 2 machine saws can be used to cut out irregular shapes in plastic?
5. Which one of these can pupils use?
6. Should the fret saw be slowed down or speeded up for thicker material?

Finishing

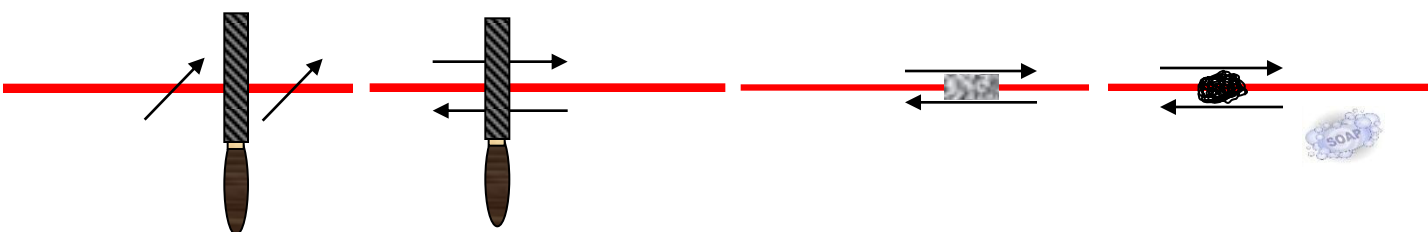
Different materials require different finishing methods, you should be familiar with most of these methods from S1 and S2. These methods are used when finishing the edges of plastic:

- File (refer to Woods Cutting and Shaping presentation)
- Wet and Dry Paper
- Polish

Wet and dry paper is an abrasive paper that, like the name suggests can be used when wet or dry. Unlike like normal sand/glass paper the backing is waterproof and so holds together. When wet the paper allows the user to get a very smooth finish.



There are 4 steps to be followed when finishing the edges of plastic. These steps are:



1. Cross File.

2. Draw File.

3. Rub with wet and dry paper.

4. Polish with steel wool and soap.

Questions

Answer in sentences.

1. What is wet and dry paper?
2. List four steps in finishing the edges of plastic.

Joining

Different materials require different joining methods, you may be familiar with some of them from S1 and S2. These adhesives are used when joining plastic:

- Tensol Cement
- Contact Adhesive
- Epoxy Resin
- Super Glue

Tensol Cement is the best glue for joining plastics such as perspex permanently. The glue is applied to the surfaces to be glued and they are pressed together. They should be clamped for 24 hours and this gives a permanent joint.



Contact adhesive can be used to join plastics. The adhesive is applied to both surfaces and when the surfaces appear to be dry they are pushed together. If the two pieces of material are left for a number of hours, they are virtually impossible to take apart.



Many adhesives are plastics themselves. A good example is 'Araldite' which is an **epoxy resin** that hardens when a second chemical is added (called a catalyst). It can bond most materials including some plastics. The two tubes can be seen in the diagram. An equal amount of each tube are mixed together and then applied to the material to be glued.



Super glue is another adhesive that joins plastics together, very quickly. Great care must be taken when using this type of glue as it will just as easily glue fingers together.



Questions

Answer in sentences.

1. Name 4 adhesives that can be used to join plastics.
2. How long should tensol cement be clamped to give a permanent joint?
3. How is contact adhesive applied?
4. Name an epoxy resin.
5. How does epoxy resin work?
6. Why must care be taken when using super glue?

Processes

Different materials have different manufacturing processes, you may be familiar with some of them from S1 and S2. These processes are used when manufacturing plastic:

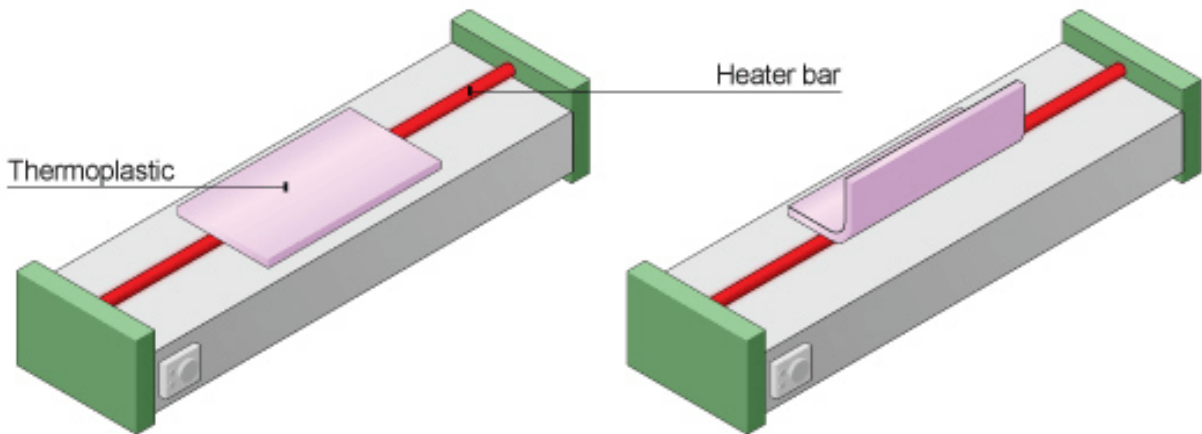
- Strip Heater
- Drilling
- Vacuum Forming
- Press Forming
- Injection Moulding
- Rotational Moulding
- Blow Moulding
- Extrusion

The **strip heater** is used to heat a thermoplastic before **bending**. A long heating element runs the length of the strip heater and produces the heat needed.

Steps:

1. Smooth edges of plastic.
2. Mark fold positions with china-graph pencil.
3. Place plastic across rests, above the heating element.
4. Turn plastic over every 30 seconds.
5. Once soft remove plastic and place into former until cool and hardened.

Note: Heat protective gloves must be worn.



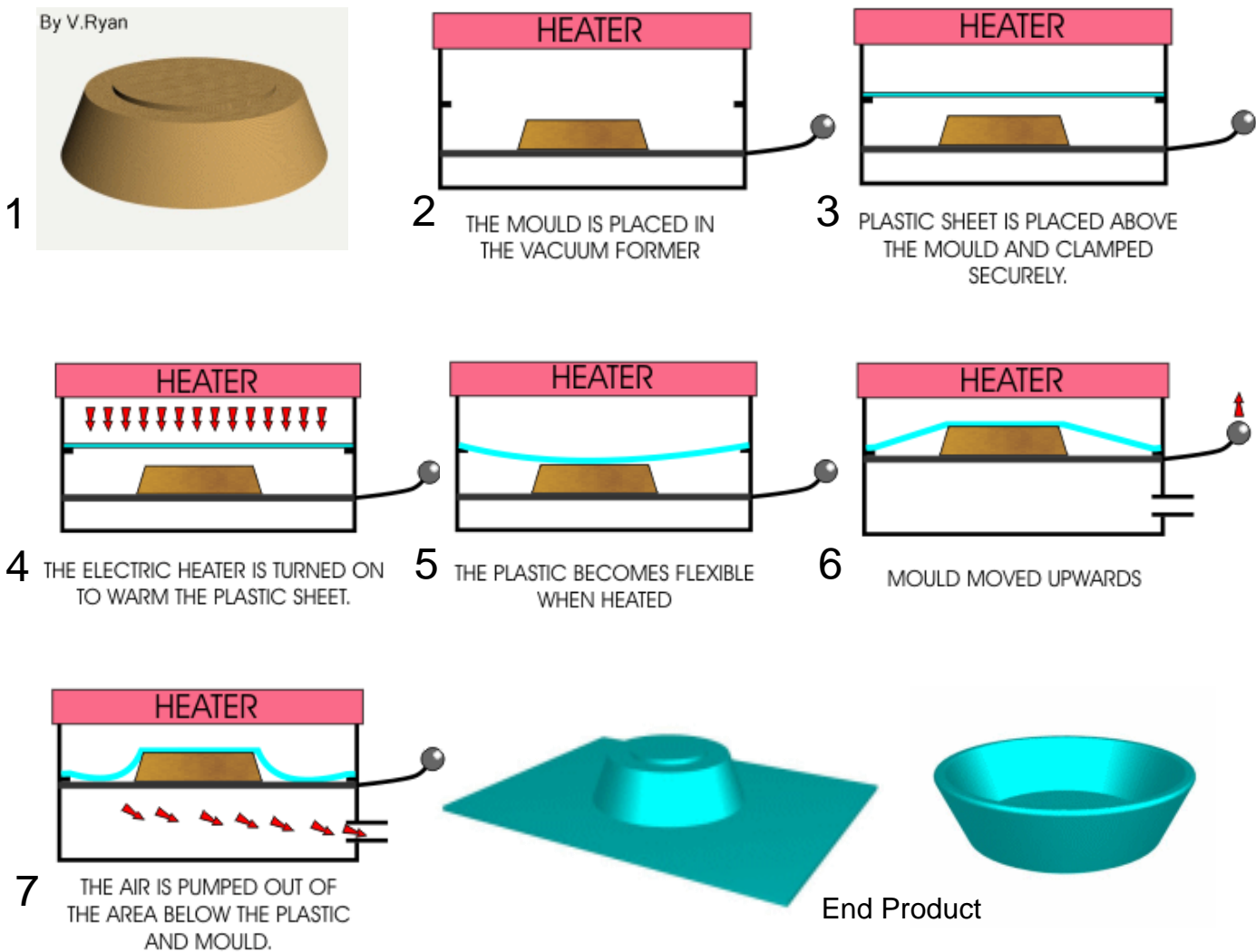
Plastic can be very brittle, this means it often cracks or breaks when being **drilled**. There are a number of methods to stop this happening:

- Place a piece of scrap wood underneath the plastic. This will support any movement in the plastic.
- Use a small pilot hole. This will make it easier for a bigger hole to be drilled without cracking.
- Use lubricant, water will be fine. This will allow the drill bit to run smoother and stop it catching on the plastic.
- Use a stepped drill bit. This will drill the hole in stages to reach the final diameter.



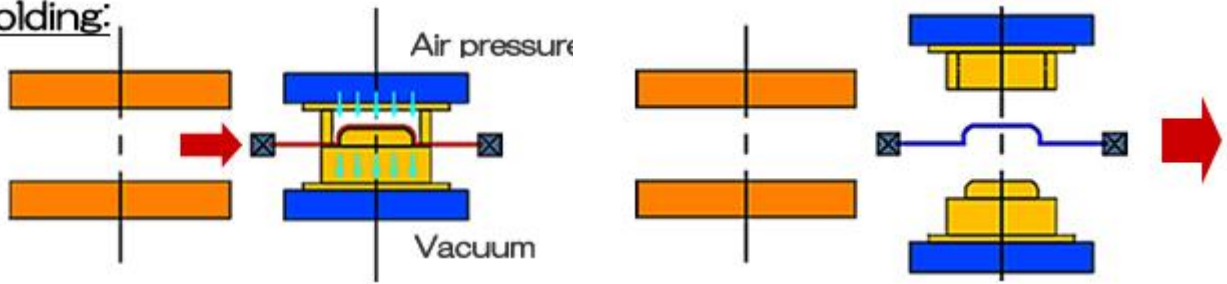
Vacuum forming is a technique that is used to shape a variety of thin plastic sheets. It is used when an unusual shape like a 'dish' or a box-like shape is needed. Below you can see the stages involved in vacuum forming.

1. First, a former is made from a material such as a soft wood. The edges or sides are shaped at an angle so that when the plastic is formed over it, the former can be removed easily.
2. The former is placed in a vacuum former.
3. A sheet of plastic (for example, compressed polystyrene) is clamped in position above the mould.
4. The heater is then turned on and the plastic slowly becomes soft and pliable as it heats up. The plastic can be seen to 'warp' and 'distort' as the surface expands.
5. After a few minutes the plastic is ready for 'forming' as it becomes very flexible.
6. The heater is turned off and the mould is moved upwards by lifting the lever until it locks in position.
7. The 'vacuum' is turned on and this pumps out all the air beneath the plastic sheet. When the plastic has cooled sufficiently the vacuum pump is switched off.



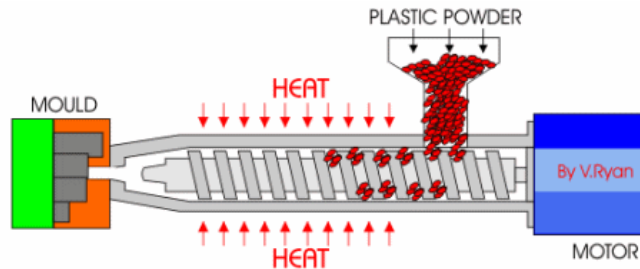
Press forming requires the whole sheet of plastic to be heated in an oven. The plastic is heated to 160 degrees. Once soft the plastic is removed from the oven and is shaped by squashing it in a former.

Molding:



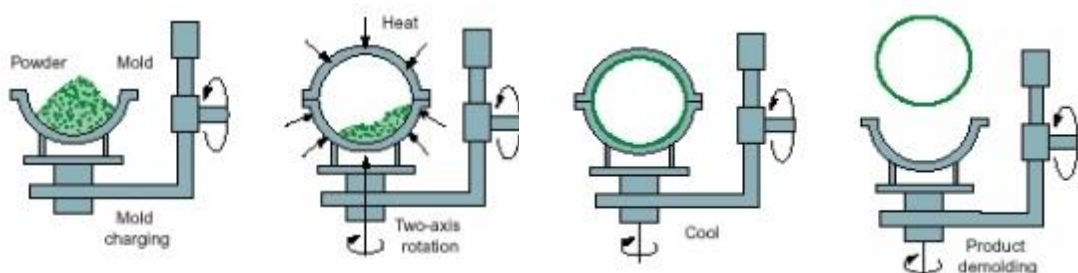
Injection moulding is a process that allows large quantities of detailed plastic products to be made quickly and accurately.

1. Granules of plastic powder are poured or fed into a hopper which stores it until it is needed.
2. A heater heats up the tube and when it reaches a high temperature a screw thread starts turning.
3. A motor turns a thread which pushes the granules along the heater section which melts then into a liquid. The liquid is forced into a mould where it cools into the shape.
4. The mould then opens and the unit is removed.



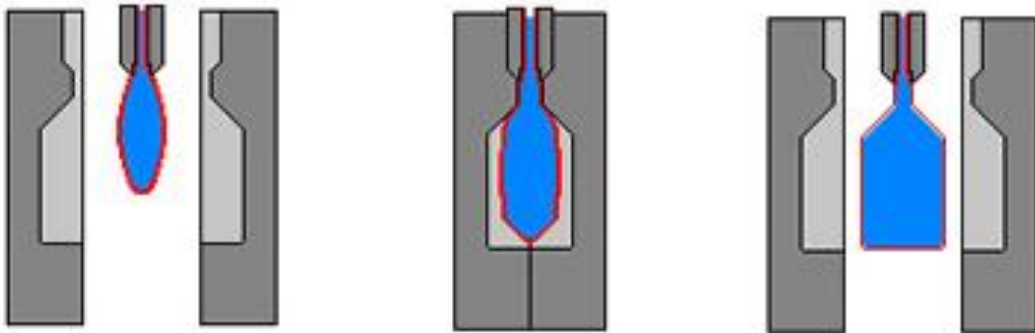
Rotational moulding is used to produce 'closed and seam free' products.

1. A measured amount of plastic powder is added to the mould.
2. The mould is closed and rotated slowly around two or three axes. This allows the plastic to be spread around the hot mould surface.
3. The plastic melts on contact and builds up even layers inside the surface of the mould.
4. When the mould cools the plastic hardens into shape.
5. The mould is opened to release the hollow product.



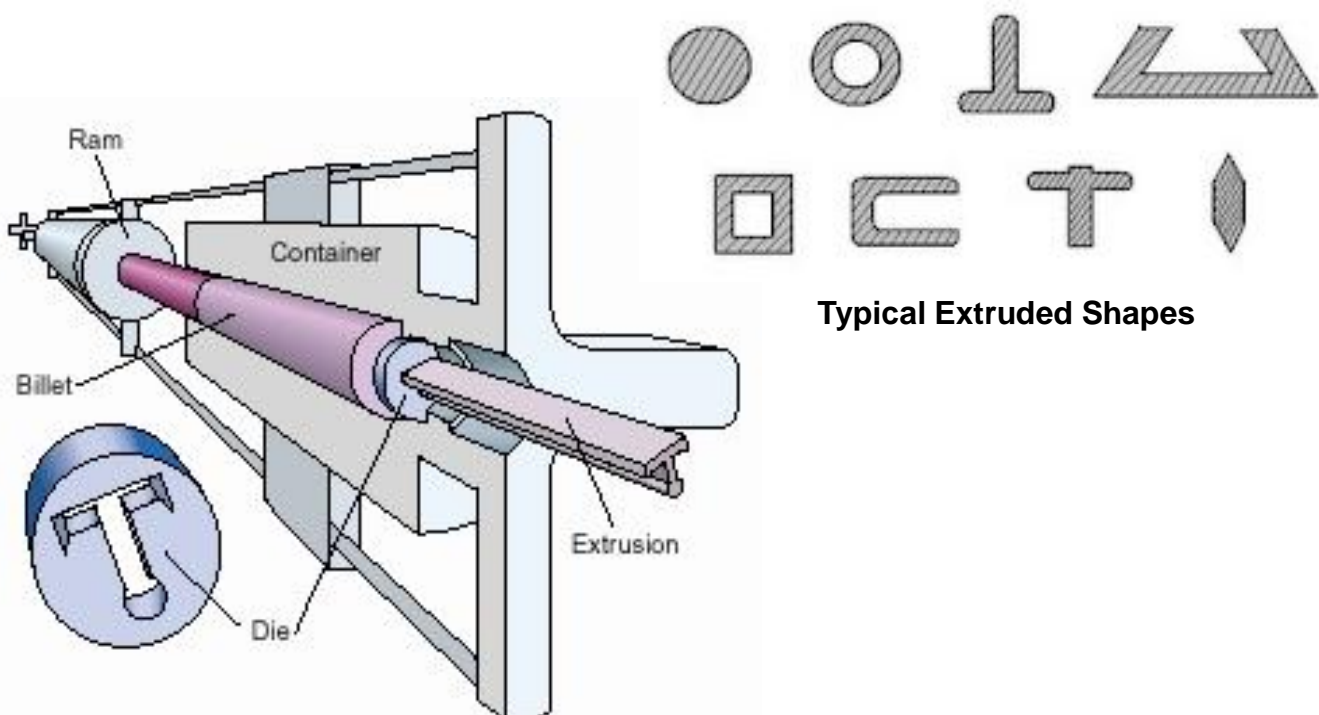
Blow moulding a shape is a common industrial process. The example shown below is of the production of a plastic bottle.

1. A balloon of material is injected between the two halves of the mould.
2. The mould closes and air is forced in, causing the balloon to fill the mould cavity.
3. The mould is then open and the bottle released



The process of **extrusion** is used for products with long uniform cross sections.

1. Granules of plastic powder are poured or fed into a hopper which stores it until it is needed.
2. A heater heats up the tube and when it reaches a high temperature a screw thread starts turning.
3. A motor turns a thread which pushes the granules along the heater section which melts then into a liquid. The liquid is forced into a mould where it cools into the shape.
4. The molten plastic is forced through a die to get its shape.
5. The extruded product passes through a cooling chamber to reharden the plastic.



Questions

Answer in sentences.

1. What process is used when you want to bend plastic?
2. Which safety rule should be followed when using the strip Heater?
3. List 2 possible methods of preventing plastic from cracking when being drilled?
4. How does a stepped drill bit work?
5. With the aid of diagrams, explain the process of vacuum forming.
6. What temperature should plastic be heated to in the oven before being press formed?
7. Which process enables large quantities of detailed plastic products to be made quickly and accurately?
8. With the aid of diagrams, explain the process of rotational moulding.
9. With the aid of diagrams, explain the process of blow moulding.
10. With the aid of diagrams, explain the process of extrusion.
11. Name one product that could be made using the following processes:
 - Injection moulding
 - Rotational moulding
 - Blow moulding
 - Extrusion

Section 3

WOODS



Wood

Wood is an extremely useful natural material. There are 3 groups of wood to be considered:

- Softwood
- Hardwood
- Manufactured Board

Trees are converted to useable timber by logging, sawing and seasoning. Unseasoned timber twists and splits. When first cut, wood has excess sap and moisture. It is dried out before being sold as rough or planed planks and boards.

Softwoods are mostly produced from evergreen conifers with thin needle-like leaves. These trees are grown in regions in the Northern Hemisphere, in countries with colder climates. Softwood trees grow quickly, with most trees reaching maturity at around 30 years. Numbers are easier to sustain by replanting and therefore are cheaper. Softwoods can be easily identified by their open grain patterns and light colour.

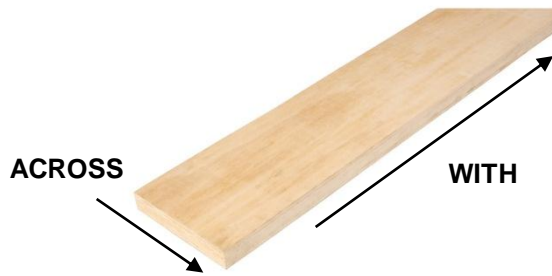
Name	Colour	Properties and working characteristics	Uses
Scots Pine	Cream, pale brown.	Straight grained but knotty, fairly strong, easy to work.	Furniture, joinery, construction work.
Red Cedar	Dark, reddish brown.	Light, soft, weak, natural oils make it weather durable.	Exterior shingles, cladding, sheds.
Parana Pine	Pale yellow with red-brown streaks.	Hard, straight, knot free, strong, durable, smooth finish, tends to warp, expensive.	Quality interior joinery i.e. staircases, built in furniture, lathe work.
Spruce	Creamy white.	Fairly strong, small hard knots, resistant to splitting, not durable.	Construction, general indoor work, furniture.

Hardwoods are produced from deciduous trees (trees that shed their leaves annually) and evergreen broad-leaved trees. These trees are grown in countries with warmer climates. Hardwood trees grow slowly, with most trees reaching maturity at around 100 years. This slow growth makes hardwood more expensive. Hardwoods can be identified by their attractive grain structures, textures and colours. They are more durable than softwoods.

Name	Colour	Properties and working characteristics	Uses
Beech	Whitish pink, pale brown.	Straight grained, even texture, strong.	Furniture, steam bending, turnery.
Oak	Light brown or pinkish brown.	Strong, durable, hard, tough, contains tannic acid which corrodes steel.	Furniture, flooring, boat building, veneers.
Mahogany	Reddish brown.	Fairly strong, medium weight, easy to work, durable, some difficult interlocking grain, prone to warping.	Furniture, shop fittings, panelling, veneers.
Teak	Golden brown.	Hard, strong, durable, natural oils make it resistant to water, acids and alkalis, works well but blunts tools quickly.	Interior/exterior furniture, boat building, laboratory equipment.

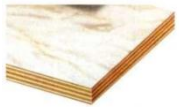
To use timber successfully there are a number of things you need to know about the properties of wood.

Grain is the lines that run along the length of the timber. The way the grain runs effects the strength of the timber. Wood is strong across the grain but will split easily with the grain.

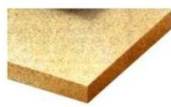


All timber expands as it soaks up moisture from the air and shrinks when it dries out. This change takes place along the width and thickness. The length does not alter.

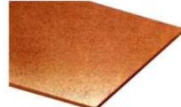
Manufactured boards are now extensively used in industry and in the home. These materials are known as composites. They are generally manufactured using natural timber in thin sheets or particles, which are bonded with resin, compressed and heated. These boards are environmentally friendly because they are often produced from waste products such as sawdust, bark and off-cuts. Manufactured boards can be identified by the colour, texture and end grain.



Plywood



MDF



Hardboard



Chipboard



Blockboard

Name	Colour	Properties and working characteristics	Uses
Plywood	Varies depending on veneers.	Stable, strong, easy to machine.	Furniture, joinery, construction work.
MDF	Brown, compressed wood fibres.	Easily machined, moulded and painted.	General carcass construction/painted work.
Hardboard	Brown, highly compressed wood fibres.	Cardboard-like, weak, brittle.	Cabinet backs, drawer bottoms.
Chipboard	Varies, compressed wood chips.	Strong, stiff.	General carcass construction.
Block board	Wood strips glued, faced with ply.	Stiff, heavy, good load bearing qualities.	Furniture, worktops.

Questions

Answer in sentences.

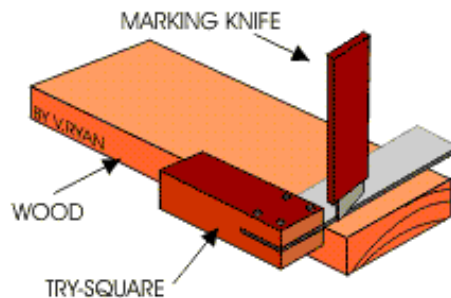
1. What happens to unseasoned timber?
2. Timber can be categorised into 3 groups, what are they?
3. Why are softwoods generally cheaper than hardwoods?
4. Why is red cedar a suitable wood for a garden shed?
5. Name 2 softwoods, describe their properties/working characteristics and uses.
6. How long does a hardwood tree take to reach full maturity?
7. Name 2 hardwoods, describe their properties/working characteristics and uses.
8. What type of wood is more durable, hardwood or softwood?
9. Why are wide boards of naturally grown timber rare?
10. What makes manufactured boards environmentally friendly?
11. Draw 2 rectangles the same as the ones shown below, sketch the end grain of plywood and blockboard in the rectangles.
12. Name 2 manufactured boards, describe their properties/working characteristics and uses.

Marking Out

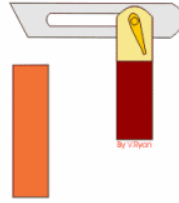
Different materials require different tools, you should be familiar with most of these tools from S1 and S2. These tools are used when measuring and marking out on wood:

- Try Square
- Sliding Bevel
- Marking Gauge
- Mortise Gauge

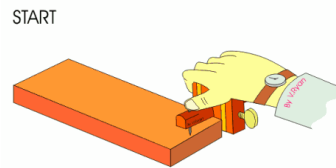
The **woodworkers try-square** is used to measure right angles in wood, either across the breadth or checking something is 'squared up' before gluing. It composes of two main parts the stock and the blade. The blade is made from hardened and tempered steel which makes it resistant to damage. The stock is usually made from rosewood although cheaper versions can be made from plastic or cheap woods. A brass face is added to the stock to ensure a straight edge.



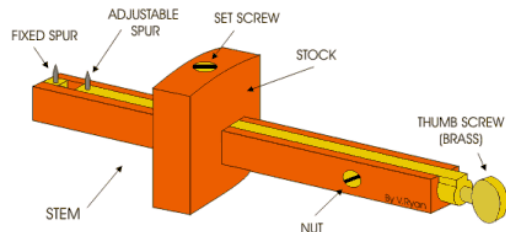
The **sliding bevel** is composed of two parts, the stock and the blade. The stock is usually made from rosewood which is a high quality material. The blade is made from hardened and tempered steel. The blade can be adjusted to a variety of angles and locked in position. This is useful when a line has to be marked at an angle on wood.



A **marking gauge** is used to mark a line parallel to a straight edge. The stem and stock are made from beech and the thumbscrew from clear yellow plastic. The better quality gauges have brass inserts at the front of the stock. These help reduce the wear on the stock as it is pushed against the surface of the wood to be marked. The marking gauge is an extremely important tool for marking parallel lines and preparing for cutting joints.



The **mortise gauge** is a special type of marking gauge and it is used to mark wood so that a mortise can be cut into it. The mortise is marked out using the mortise gauge although it must be set to the correct size of mortise chisel very carefully. A mortise chisel is then used to remove the waste wood. The mortise gauge is normally made from a hardwood such as rose wood with brass being used for the parts that slide along the stem.



Questions

Answer in sentences.

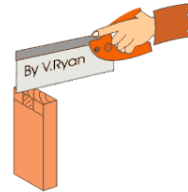
1. What unit of measurement is used in Design and Manufacture?
2. Name the tool used to measure dimensions.
3. What is the function of a try square?
4. What is a try squares blade made from?
5. When would a sliding bevel be used?
6. Name the tool used to mark parallel lines to an edge.
7. Name the 3 parts of a marking gauge.
8. What type of frame joint would you be manufacturing if you needed a mortise gauge?

Cutting and Shaping

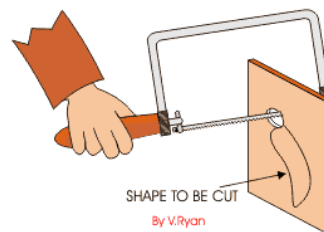
Different materials require different tools, you should be familiar with most of these tools from S1 and S2. These tools are used when cutting and shaping wood:

- Tenon saw
- Coping saw
- Mallet
- Chisels
- Files
- Plane

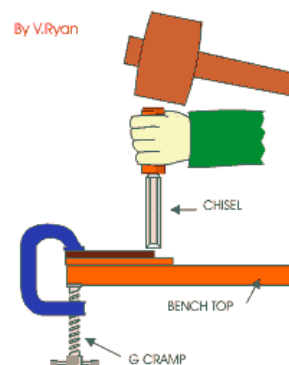
The **tenon saw** is used for general sawing and cutting mortise and tenon joints. The heavy back gives the saw its weight which is useful when sawing wood. The weight of the saw along with the forward sawing motion allows the saw to cut through woods relatively easily and accurately.



Coping saws are used for cutting a range of woods and plastics and are very useful for cutting unusual shapes or curves. In a modern workshop these shapes are normally cut using machine fretsaws. However, there are times when these machines are not available. Using a coping saw is a test of skill as it can be difficult to control and requires practice.



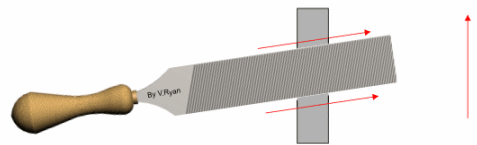
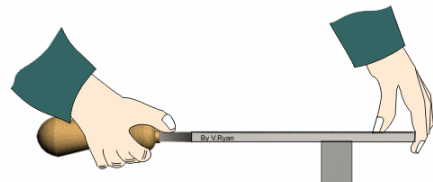
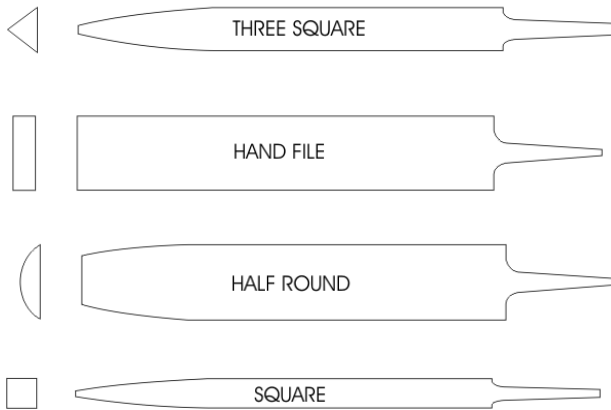
There are many different types of chisels and each has a particular use. **Bevel edged chisels** are slightly undercut making them easy to push into corners. They are normally used for finishing dovetail joints. The handles of most chisels are made from ash, beech, box wood or plastic and a mallet (not a hammer) is normally used to apply force.



Mortise chisels are used for 'chopping out' joints. They are particularly useful for cutting mortise joints as they are strong enough to withstand heavy blows with a mallet. The handle is normally made of ash or beech with a steel hoop at the top to stop it splitting. It also has a strengthening piece called a ferrule which prevents the handle from splitting at the bottom when it is hit repeatedly by a mallet.



Hand files are used in the workshop to smooth rough edges. They can be used to smooth a range of materials including metals, wood and plastics. They are made from high carbon steel and they are heat treated so that they are tougher than the steel or other materials that they are to be applied to.



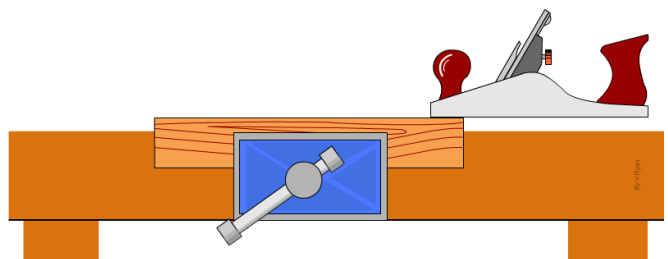
A large range of planes are available and they are used for different purposes. The body of a plane is made from high grade cast iron with the cutters being tungsten made from vanadium steel. **Smoothing planes and Jack planes** are used to smooth rough surfaces or plane down the thickness of a piece of wood to the required size.



JACK



SMOOTHING



Questions

Answer in sentences.

1. What direction does a tenon saw cut?
2. Name the type of saw used to cut curved shapes from wood.
3. Why do bevel-edged chisels have tapered edges?
4. Where should your hands be when using a chisel?
5. What tool is used to hit a chisel when additional force is needed?
6. Name the wood joint cut with a mortise chisel.
7. What stops the wooden handle on a mortise chisel from splitting?
8. Name 4 types of file.
9. Name the 3 cuts of file.
10. What are the 2 functions of a smoothing plane.

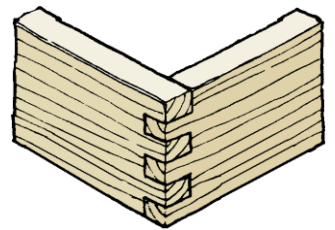
Assembly

Different materials require different tools. These tools and joints are used when joining wood:

- Finger
- Dovetail
- Housing
- Dowel
- Cross halving
- Corner Lap
- Mortise and Tenon
- Knock down fittings
- Screws
- Nails/Pins
- Glue
- Cramps

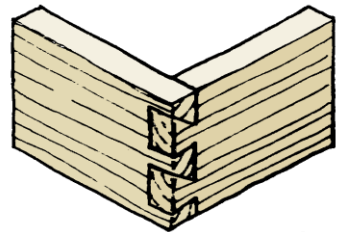
Finger Joint

This is an interlocking corner joint. It must be made accurately or the strength and appearance of the joint will be severely limited.



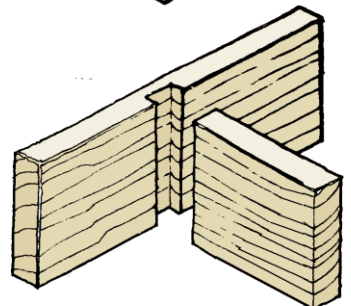
Dovetail

This is a very strong joint but is also a very difficult joint to cut. It has very good mechanical strength which is increased if it is glued.



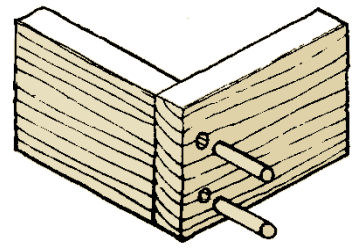
Housing

Is stronger than as simple butt joint. It is usually used for shelves or partitions but it is difficult to cut accurately. It is usually glued but can also be nailed.



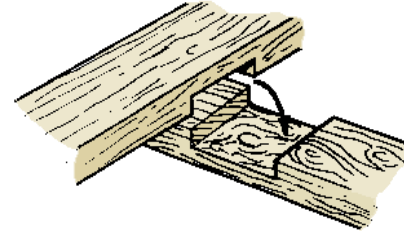
Dowel

This corner joint is essentially a butt joint which is strengthened by wooden pegs called dowels which are pushed into both pieces of wood as they are glued. Dowel joints can also be used to make partitions. If the dowel holes are 'blind' (they do not go all the way through) the dowels are completely hidden.



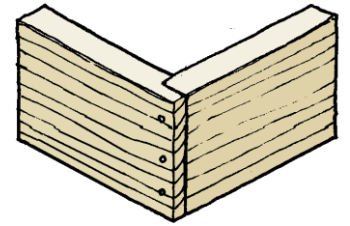
Cross Halving Joint

This type of wood joint is used where two pieces of a framework cross. It is similar to the corner and tee halving joints, and can also be strengthened with dowels or screws if necessary.



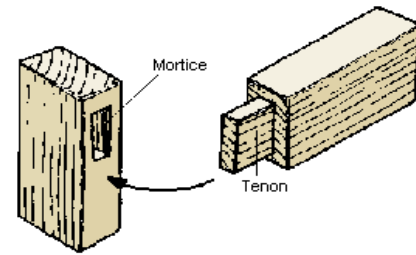
Corner Lap

This corner joint is stronger and more rigid than a butt joint, but some end grain shows. You will need a saw, chisel and mallet to cut this joint by hand.

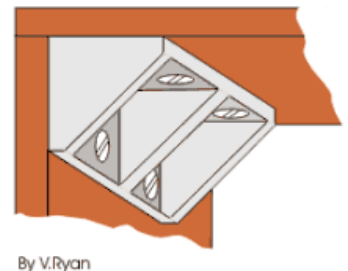
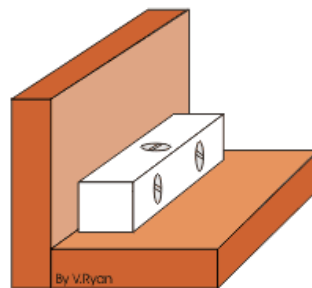


Mortise and Tenon

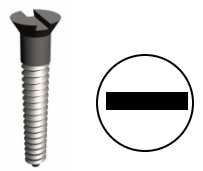
The Plain Mortise and Tenon joint is very common and is widely used for the joints of tables. Although it is quite strong, if enough force is placed on the joint it will eventually break or come loose.



Knock-down fittings are those that can be put together easily, normally using only a screw driver, a drill, a mallet/hammer and other basic tools. They are temporary joints although many are used to permanently join together items such as cabinets and other pieces of furniture that are purchased in a flat pack. Flat packed furniture benefits the customer in many ways, they are able to transport it home themselves and build it with the aid of instructions, this saves money because they don't need to pay for delivery.



Countersunk/slot-head: This can be used for general woodworking for example fitting hinges to doors. Because the screw is countersunk it can be tightened 'flush' to the surface of the material.



Pozidrive head: Used with special screw drivers which will not slip when pressure is applied. This is ideal when using screws in corners or confined spaces.



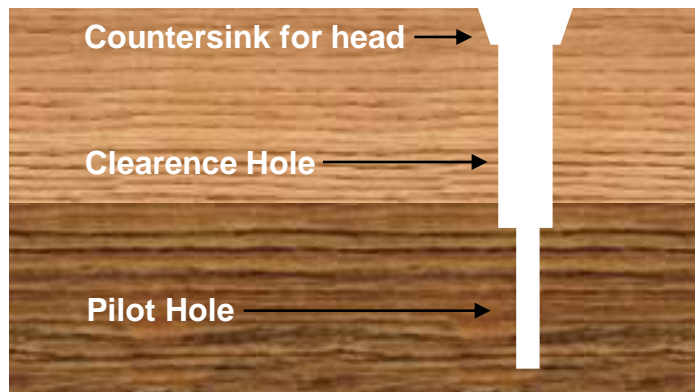
Round head: These are used for fixing pieces of material together where countersunk holes are not being used. Round head screws can look quite decorative especially if they are made of brass.



By V. Ryan

Steps to carry out when fixing woodscrews:

1. Make a pilot hole using a bradawl.
2. Drill a clearance hole.
3. Countersink the hole.
4. Fix screw with screwdriver.



BRADAWL

Using **nails** is an effective way of fixing or joining pieces of softwood together. Hardwoods can be difficult to join with nails as they tend to bend under the impact of the hammer.

Round wire nail: This is used for general work. It is not attractive in shape and it can split wood when hammered in position.



Lost head nail: This is ideal if it is necessary to hide the head of the nail as a punch can be used to hammer the head beneath the surface level.



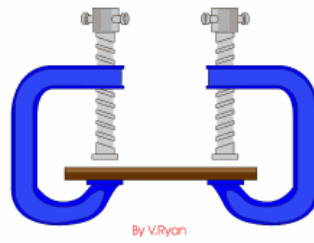
Panel pin: A very popular way of joining woods although glue is usually included as part of the join.



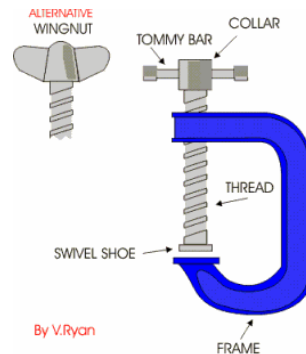
A nail punch can be used to drive the nail heads below the surface.



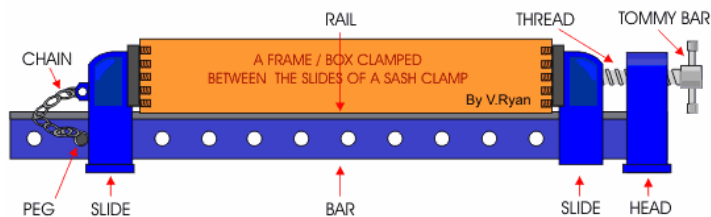
When you manufacture a product using woods it will soon be necessary to join parts together. P.V.A. (Polyvinyl Acetate) **Glues** are very popular as they do not need preparation. These glues are supplied in a plastic container and can be used straight away. A good example of this is 'Evo-stik Woodworkers Resin'.



G Cramps are an essential tool in the workshop and they come in a range of sizes and are generally used for clamping work securely to a surface/workbench top. They can also be used to hold parts together whilst glue is drying.



Sash clamps are used to clamp work together when it is glued. They vary in size and are normally used in pairs. The bar is made from cold drawn mild steel and the head and slides made from malleable iron.



Questions

Answer in sentences.

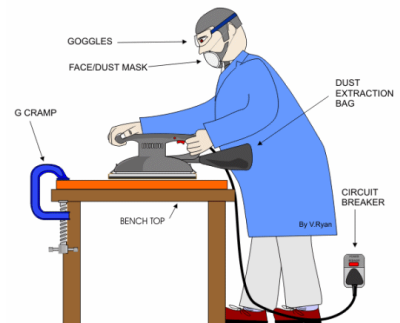
1. Name a suitable wood joint to build a box.
2. Name a suitable wood joint to support a shelf in a cabinet.
3. Name a suitable wood joint for joining table legs and rails.
4. Sketch and label a finger joint.
5. Why is most modern furniture flat packed?
6. What benefits does flat packed furniture give to the customer?
7. Why would you use a countersunk screw?
8. List the steps to fix a countersunk screw.
9. When would you use a nail punch?
10. Name the glue used to join wood.
11. Explain the difference between a G-cramp and a sash clamp. When they would be used?

Finishing

Different materials require different tools, you should be familiar with most of these tools from S1 and S2. These tools and processes are used when finishing wood:

- Sanding
- Varnish
- Stain
- Wax
- Paint

Glass/sand paper is used to smooth wood surfaces. When sanding wood, glass paper can be used with a cork block or is 'clipped' into the sheet sander. If the surface requires a lot of sanding then start with 'coarse' glass paper rather than fine - as this will reduce the amount of time required.



Varnish

- **Appearance:** Creates a very shiny, transparent surface on the finished wood.
- **Protection:** Gives good protection against marking and scratching.
- **Durability:** Good durability.
- **Application:** Can be applied using brush or spray. Brushing it on needs good technique or you will get bubbles and streaks.
- **Extra information:** Can be removed using paint removers. Brushes can be washed using hot soapy water.



Stain

- **Appearance:** Matt finish, similar to original surface of wood. Available in a large variety of colours. Stain soaks into the wood and so the wood grain is still visible.
- **Protection:** Gives minimum protection, wood will still mark easily.
- **Durability:** Poor durability.
- **Application:** Can be applied using a rag, brush or spray gun, then rubbed into the grain in circular motions.
- **Extra information:** Gloves should be worn when using wood stain. Cannot be removed from wood.



Wax

- **Appearance:** Creates a very shiny, transparent surface on the finished wood.
- **Protection:** Gives great protection against marking and scratching.
- **Durability:** Can last forever when applied correctly.
- **Application:** Wax is very easy to apply. Applied using steel wool, rubbed down, with a soft cloth, then repeat process until you get a perfect finish.
- **Extra information:** Can be removed using solvents. Buffing the surface will bring back a dulling shine.



Paint

- **Appearance:** Matt or gloss finish, put layer over surface of wood, grain of wood is no longer visible. Paint comes in a large variety of colours.
- **Protection:** Gives some protection to woods surface.
- **Durability:** Medium durability. Can be scratched or chipped easily.
- **Application:** Applied using a brush. Thin layers brushed on to avoid running and drips
- **Extra information:** Can be removed by sanding down surfaces. Brushes can be washed with hot soapy water.



Questions

Answer in sentences.

1. What is the function of glasspaper?
2. How is varnish applied?
3. How is wood stain applied?
4. How is wax applied?
5. How is paint applied?
6. Name a suitable finish for a child's chair, it must be:
 - Coloured.
 - Shiny.
7. Name a suitable finish for an oak coffee table, it must be:
 - Shiny.
 - Clear.
8. Name a suitable finish for a pine picture frame, it must:
 - Be coloured.
 - Allow the wood grain to be seen.

Processes

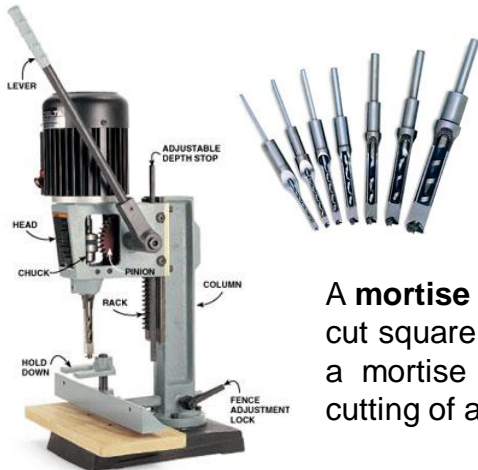
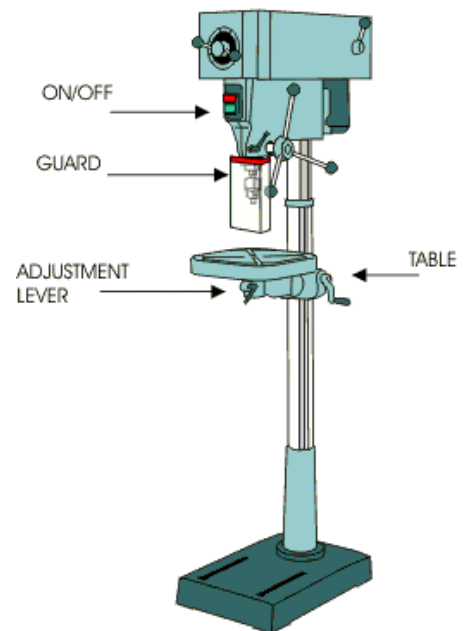
Different materials require different processes and machines. These machines are used when working with wood:

- Drill Press
- Mortise Machine
- Belt/disk Sander
- Sheet sander
- Jigsaw
- Lathe

The **drill press (pillar drill)** has a long column which stands on the floor. It is used for drilling holes through materials including a range of woods, plastics and metals. Its larger size means it is capable of being used to drill larger/longer pieces of material and produce larger holes.

SAFETY

1. Always use the guard.
2. Wear goggles when drilling materials.
3. Clamp the materials down or use a machine vice.
4. Never hold materials by hand while drilling.
5. Always allow the 'chippings' to clear the drill by drilling a small amount at a time.
6. Follow all teacher instructions carefully.

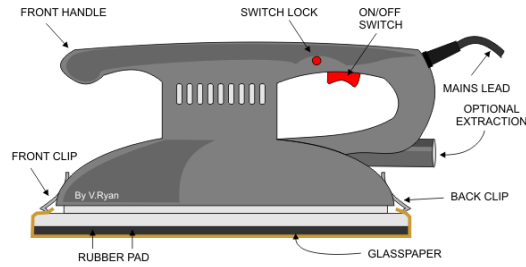


A **mortise drill/machine** is a specialised woodworking machine used to cut square or rectangular holes in a piece of wood, such as a mortise in a mortise and tenon joint. The hollow chisel mortiser combines the cutting of a four-sided chisel with the action of a drill bit in the centre.

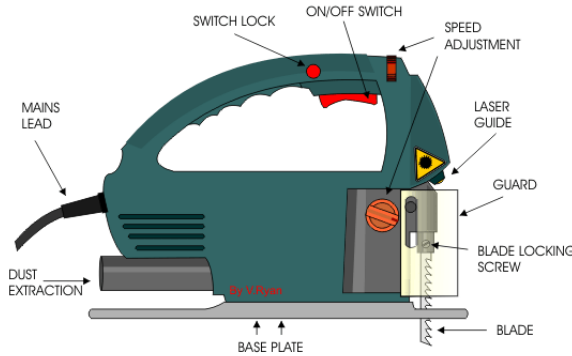
The **Sander** is used to smooth materials such as woods and plastics. It is also used to remove small amounts of waste material. The disc sander is the round piece of sand paper on the front of the machine that spins around at high speed. The belt sander is the length of sand paper that rotates around like a very fast conveyer belt. Hand held and fixed belt sanders are available.



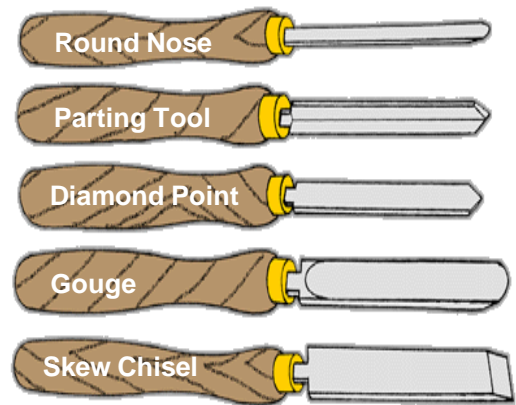
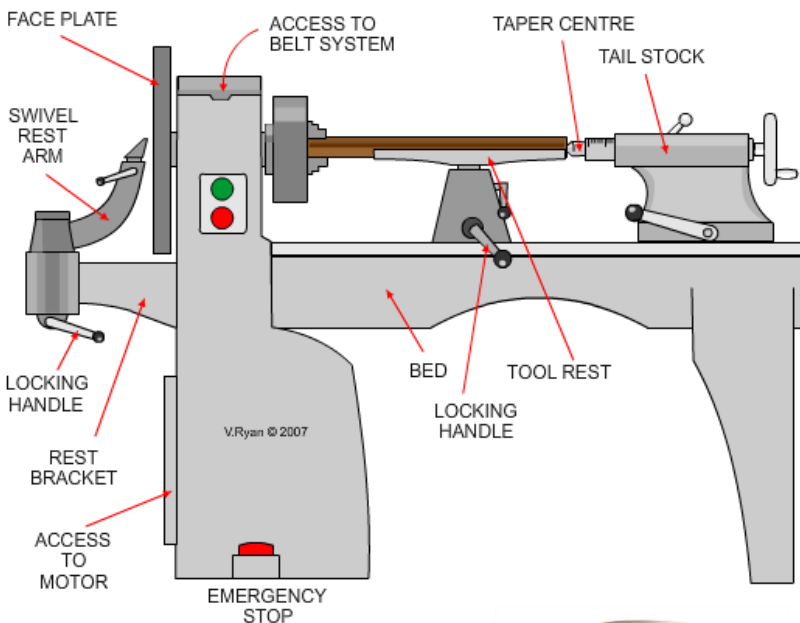
Sheet sanders are used to smooth wood surfaces. When sanding wood, glass paper is 'clipped' into the sheet sander.



Jigsaws are general cutting and shaping tools. They are provided with a selection of blades suitable for cutting and shaping a range of materials. They are ideal for cutting thin manmade boards such as plywood and MDF and they are capable of cutting detailed curves.



Woodturning is a form of woodworking that is used to create round wooden objects on a lathe. Woodturning differs from most other forms of woodworking in that the wood is moving while a stationary tool is used to cut and shape it. Many intricate shapes and designs can be made by turning wood.



The Live Centre is in the shape of a fork (butterfly) and is used to drive the timber round.

The dead centre fits in the tailstock and supports the end of the wood. It does not rotate the cone and so it is greased to stop the wood from burning.



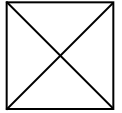
FORK



CENTRE

Preparing wood for turning:

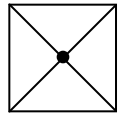
1. Find the centre on the ends of the timber by joining the diagonals.



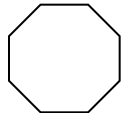
2. Saw along the diagonals on one end to take the fork centre.



3. Nail punch a hole on the opposite end to take the cone centre. Remember to grease the hole.



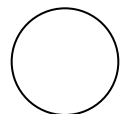
4. Use a jack plane to remove the four corners of the wood, making it octagonal in shape.



5. Place the wood into the fork centre and cone centre, tighten.

6. Adjust the tool rest to the correct position and height. Spin the wood to ensure adequate clearance.

7. Form a cylindrical shape using the gouge, smooth with glass paper.



Questions

Answer in sentences.

1. What is the function of a press drill?
2. State 3 safety precautions when using the press drill.
3. Explain the function of a mortise drill.
4. What joint would you be cutting if you used the mortise drill?
5. Name 2 types of sander.
6. State 3 safety precautions when using the belt sander.
7. What is the function of a sheet sander?
8. Which hand machine will allow the user to cut curved shapes from manufactured boards?
9. Name a product that could be turned on a wood lathe.

Section 4

METALS



Metals

Metals form the major portion of the Earth's elements. They are combined with other minerals and are mined in various ways. These metal ores are processed to produce usable materials. There are two groups of metals to be considered:

- Ferrous
- Non-Ferrous

Alloys are mixtures of metals and/or other elements combined together. Ferrous alloys, particularly steels, form 90% of the world's total metal usage. This is because of their low cost and versatility.

Ferrous

These are metals which contain iron. They may have small amounts of other metals or other elements added, to give the required properties. All ferrous metals are magnetic and give little resistance to corrosion.

Name	Colour	Properties and working characteristics	Uses
Cast Iron	Black/Grey	Brittle/hard skin.	Machine tools, vices.
Mild Steel	Black/Grey	Malleable/ductile, uniform texture.	Nuts, bolts, screws, tubes, girders, car bodies.
High carbon Steel	Black/Grey	Malleable/ductile, can be hardened and tempered.	Cutting tools, files, drills, saws, knives, hammers, taps and dies.

Non Ferrous

These are metals which do not contain any iron. They are not magnetic and are usually more resistant to corrosion than ferrous metals.

Name	Colour	Properties and working characteristics	Uses
Aluminium	Silver	Good strength to weight ratio, casts easily.	Window frames, pots and pans.
Copper	Orange/Gold	Ductile/malleable, low melting point, expensive.	Central heating pipes, electric wiring/cable, jewellery.
Tin	Silver/White	Heavy/soft, low melting point.	Bearings, solder, coating sheet steel.

Questions

Answer in sentences.

1. Where do metals come from?
2. How many groups of common metals are there?
3. What are the different groups of metals known as?
4. Explain the difference between the 2 groups.
5. What type of metal would normally be used to make car bodies?
6. What are two common uses for copper?

Marking Out

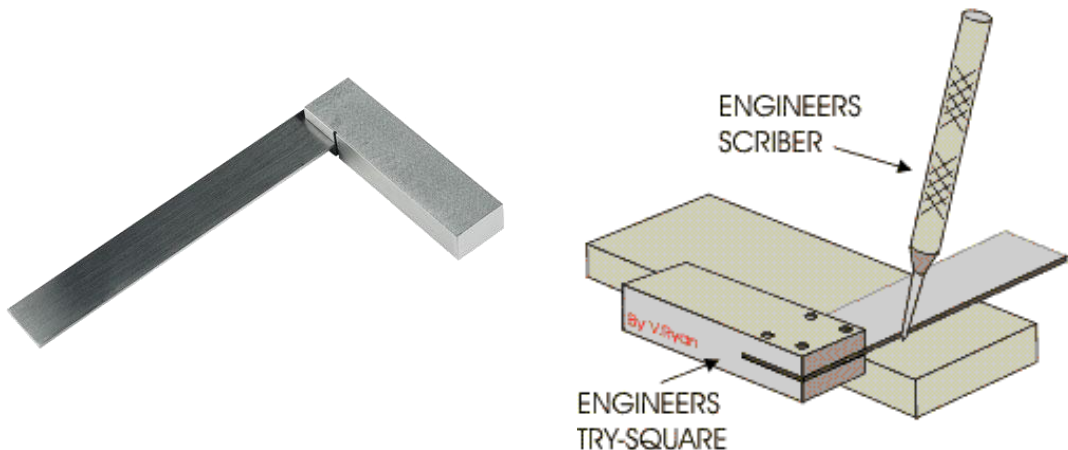
Different materials require different tools, you should be familiar with most of these tools from S1 and S2. These tools are used when measuring and marking out on metal:

- Scriber
- Engineers Square
- Calipers
- Micrometer
- Centre Punch

A **scriber** is a hand tool used in metalworking to mark lines on work pieces, prior to machining. The process of using a scriber is called scribing and is just part of the process of marking out. It is used instead of pencils or ink lines, because the marks are hard to see, easily erased, and inaccurate due to their wide mark; scribe lines are thin and semi-permanent.



The **engineers try-square** is used to measure right angles from an edge. It is composed of two parts, the stock and the blade. They are usually made from bright mild steel with the blade being hardened and tempered so that it resists damage.

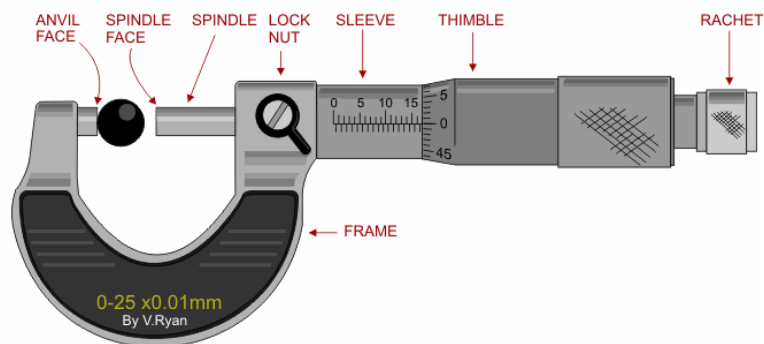


A **caliper** is a device used to measure the distance between two opposing sides of an object. There are various types, some are listed below:

- Outside calipers are used to measure the external size of an object.
- The inside calipers are used to measure the internal size of an object.
- Odd leg callipers (Jennys) are used to mark lines parallel to an edge.
- Divider calipers are used for drawing arcs or circles on a metal surface.
- Vernier calipers are used to give a direct reading of a distance measured to high accuracy.



The **micrometer** is a precision measuring instrument, used by engineers. Each revolution of the ratchet moves the spindle face 0.5mm towards the anvil face. The object to be measured is placed between the anvil face and the spindle face. The ratchet is turned clockwise until the object is 'trapped' between these two surfaces and the ratchet makes a 'clicking' noise. This means that the ratchet cannot be tightened any more and the measurement can be read.



A **center punch** is used to mark the center of a point. It is usually used to mark the center of a hole when drilling holes. A drill bit has the tendency to "wander" if it does not start in a recess. A center punch forms a large enough dimple to "guide" the tip of the drill bit.



Questions

Answer in sentences.

1. Why are scribes preferred over pen marks and lines, when working with metal?
2. What is an engineer's square used for?
3. What process is usually carried out on engineer's squares to make them last longer through use?
4. How can a center punch help improve health and safety when drilling?

Cutting Out

Different materials require different tools, you should be familiar with most of these tools from S1 and S2. These tools are used when cutting and shaping metal:

- Hacksaw
- Guillotine
- Tin Snips

The **hacksaw** is used to cut steel and other metals. It can also be used to cut plastics, although it is not normally used to cut woods. It is sometimes called an adjustable hacksaw because the length of the frame can be altered to hold blades of different sizes. Blades are supplied in two lengths, 250mm and 300mm. If the adjusting screw is unscrewed, the frame can be pushed into the handle so that the smaller blades fit the hacksaw.



Junior hacksaws have the same function but are used on small pieces of material.

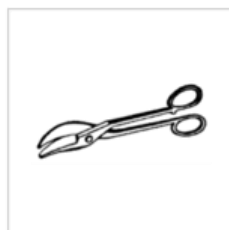
The **guillotine** consists of a shear table, work-holding device, upper and lower blades, and a gauging device. The shear table is the part of the machinery that the work piece rests on while being sheared. The work-holding device is used to hold the work piece in place and keep it from moving or buckling while under stress. Used for cutting sheet metal usually.



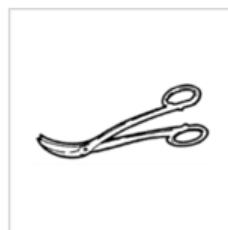
Tin snips are used to cut sheet metal and other tough webs. Tin snips are one of the most popular type of snips. They are defined by their long handles and short blades. They usually have extra wide jaws and are made of drop forged carbon steel.



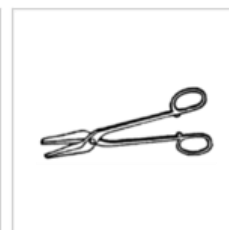
Bulldog tinner's snips



Circle snips



Hawk's bill snips



Duckbill- or trojan-pattern snips

Questions

Answer in sentences.

1. What type of material would not be cut with a hacksaw?
2. Why is a hacksaw sometimes known as an **adjustable** hacksaw?
3. Would a hacksaw be a good choice to use for cutting curves in material? Justify your answer.
4. What type of metal is a guillotine usually used to cut?

Joining Metals

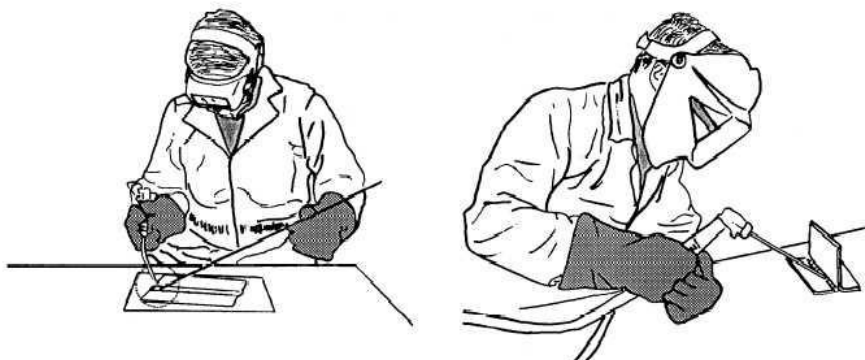
Different materials require different tools, you should be familiar with most of these tools from S1 and S2. These tools and processes are used when joining metals:

- Spot Welding
- Electric Arc Welding
- Brazing
- Nuts and Bolts
- Riveting

Spot welding is a quick and easy way of joining sheet steel. The sheet metal is gripped between the copper electrodes. When the trigger is pressed the current flows and melts to form the round spot.

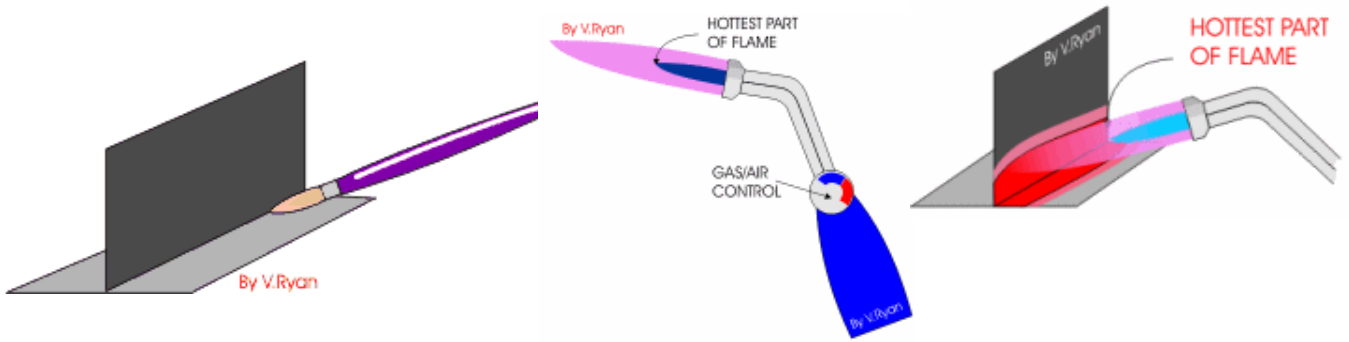


Electric arc welding is used to join thick sections of steel together. The welding rod has a steel centre and a flux coated outside. The welding rod is struck like a match across the metal then lifted off. The current jumps across the gap, like lightning, and carries the molten steel from the rod to make the weld. The flux forms a protective skin over the weld while it cools.

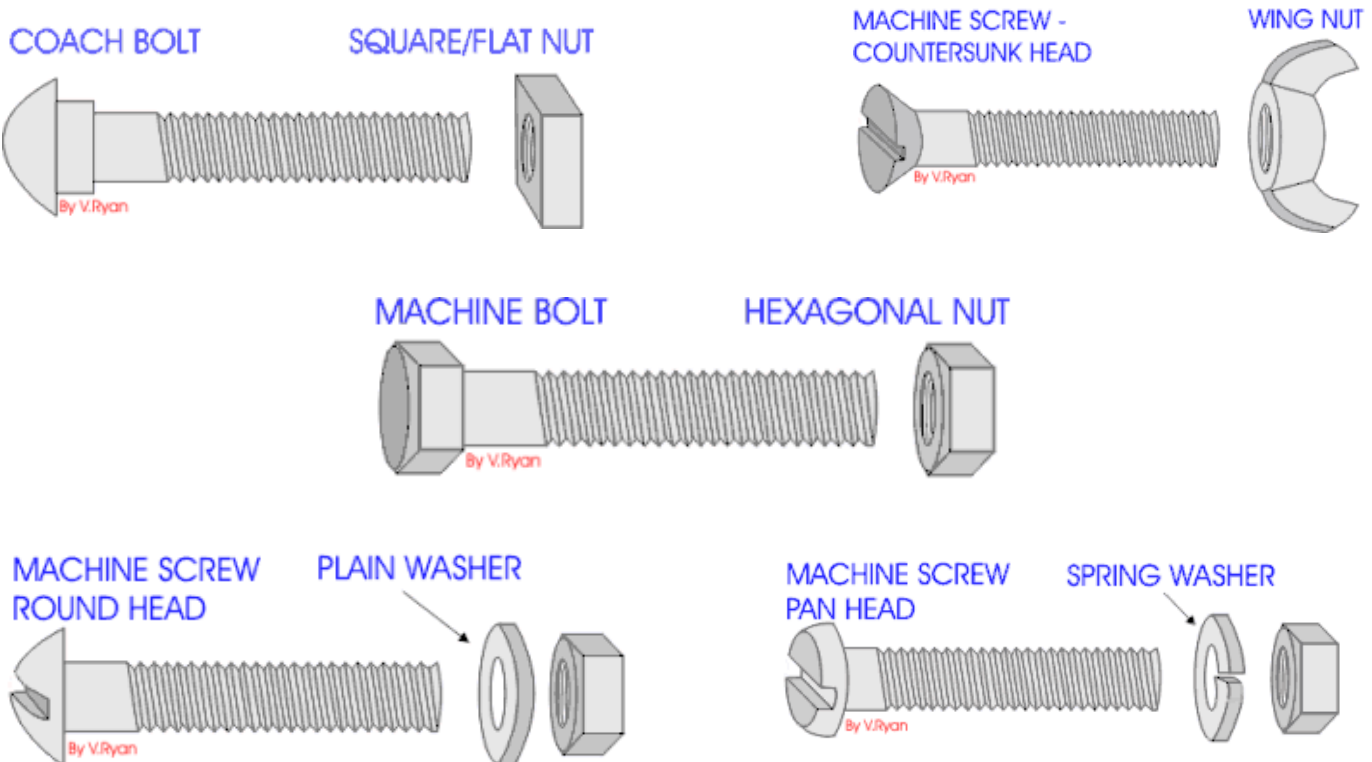


Brazing is a very strong method of joining steel. The brazing rod, called spelter (an alloy of copper and zinc).

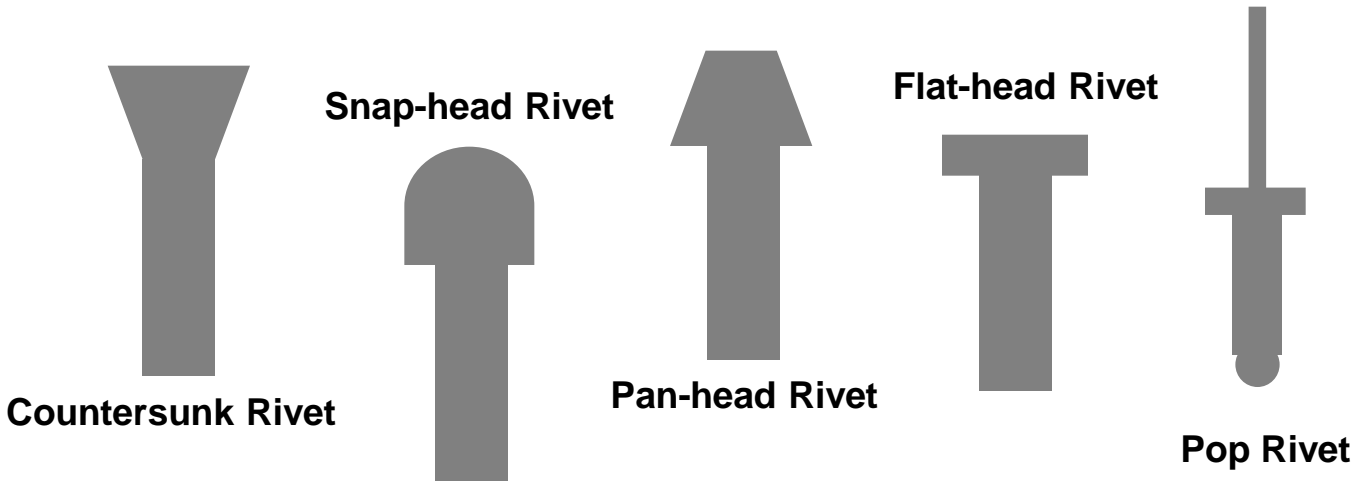
1. The metal is thoroughly cleaned with emery cloth.
2. The borax flux powder is mixed with water and spread along the joint. This keeps the surface clean while heating.
3. The metal is placed in the brazing hearth and fire bricks are arranged to keep the heat in.
4. As the metal is heated, more flux is added using the tip of the brazing rod. Once the metal is red, the brazing rod is held over the joint until it melts and flows along the surface.



Nuts and Bolts are used to join pieces of metal together either permanently or temporarily. Many steel structures, including buildings, are simply bolted together. Nuts and bolts come in many different types and sizes. Some are shown below.



Rivets are used to permanently join metals together. There are a variety of rivets to suit different situations.



Questions

Answer in sentences.

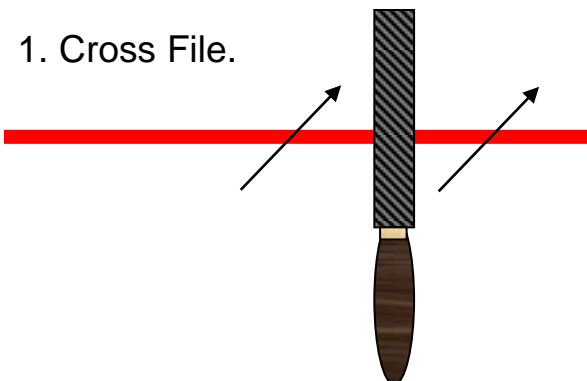
1. What would be the quickest and most effective method of joining sheet steel together?
2. State an advantage of using nuts and bolts as a joining method instead of a different permanent join?
3. What is the purpose of Borax Flux powder, during Brazing?
4. What is an aesthetical advantage of using snap-head rivets?
5. What is the difference between a permanent and semi-permanent join in metals?

Finishing Metals

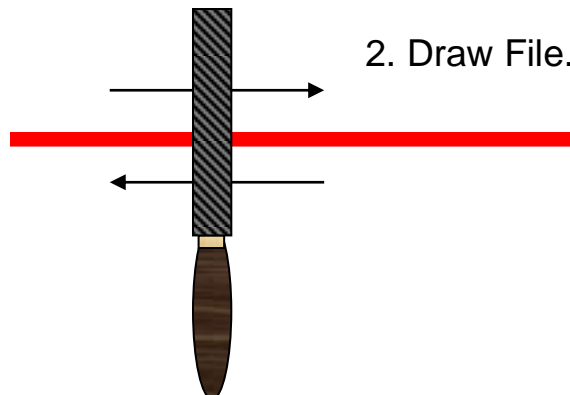
Filing is the process of using a file to work the edges, surface and corners of metal. There are many different sized files to choose from to help smooth and shape edges of metal.



1. Cross File.



2. Draw File.



Emery tape or cloth is used to smooth the surfaces of metal. You have to be careful when using the cloth as it is abrasive. The cloth may scratch the surface of your work if not used correctly.



Steel wool, also known as **wire wool**, is a bundle of strands of very fine soft steel filaments.

Uses

- Polishing Wood with wax
- Polishing Metal with soap
- Cleaning household cookware.



Paint is used to protect the surface from damage or corrosion or to alter the aesthetics of the item. It comes in a variety of surface finishes, i.e. gloss, matte, etc. When using paint you must:

- Ensure surface is clean before painting
- Surface may be primed using a primer.
- Decide on what kind of finish you want.
- Paint can be applied using 2 or 3 coats using a brush or spray.



Matt



Gloss

Lacquer; Various clear or colored synthetic coatings. To give a sleek, glossy finish to your metal item.

How to use lacquer

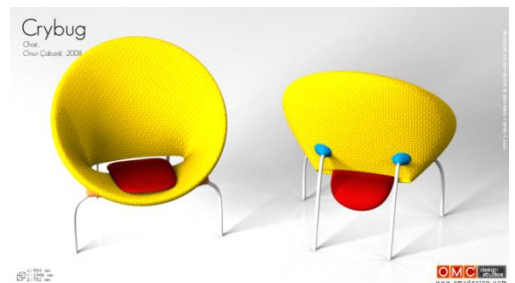
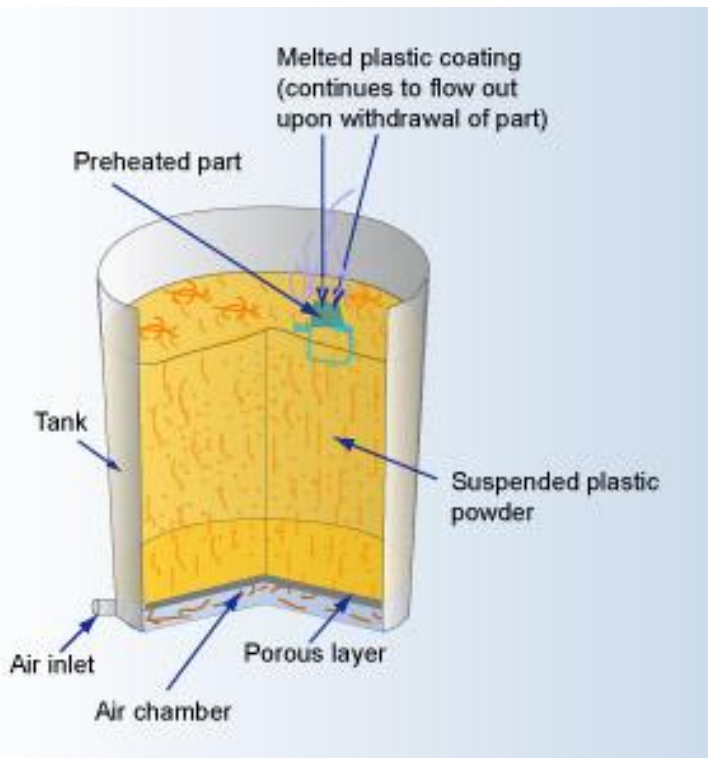
1. Make sure that your metal is clean and that there is no dust, dirt or rust on it.
2. Tape any parts of the metal that you do not want covered in lacquer.
3. Spray a single coat of lacquer onto the metal. Provide enough time for the first coat to dry before spraying on the second. Unlike paint, which may have just two or three coats, lacquer often requires 10 or more. spray on the next coat of lacquer until you are satisfied that there are enough layers on the metal.



Dip Coating

The dipping of heated metal into thermoplastic powder.

- Thermoplastic coating material is ground into a fine powder and kept in a steel box known as the fluidiser.
- The metal is heated up to between 250 and 400 degrees in an oven.
- Air is then introduced up through the inside of the fluidiser which makes the powder particles rise and act like a box of fluid, hence 'Fluidiser'.
- The heated metal is then dipped into the fluidiser.
- The Powder particles melt onto the metalwork forming a smooth continuous coating.



Chair Legs



Handles of Tools

Questions

Answer in sentences.

1. What must you be careful of when using emery cloth?
2. What is normally used with steel wool when polishing metal?
3. State an aesthetic advantage of using paint as a finish.
4. Why must you clean your metal before applying lacquer?
5. What advantage would you gain by using dip coating as a finish?
6. What machine is the plastic powder kept in during dip coating?

Metalwork Processes

Die casting is a process used to produce engineered metal parts by forcing molten metal under high pressure into steel moulds. These moulds, called dies, can be designed to produce complex shapes which are very accurate and can also be used many times over. The parts can be made with a variety of smooth or textured surfaces and are suitable to receive different finishes.

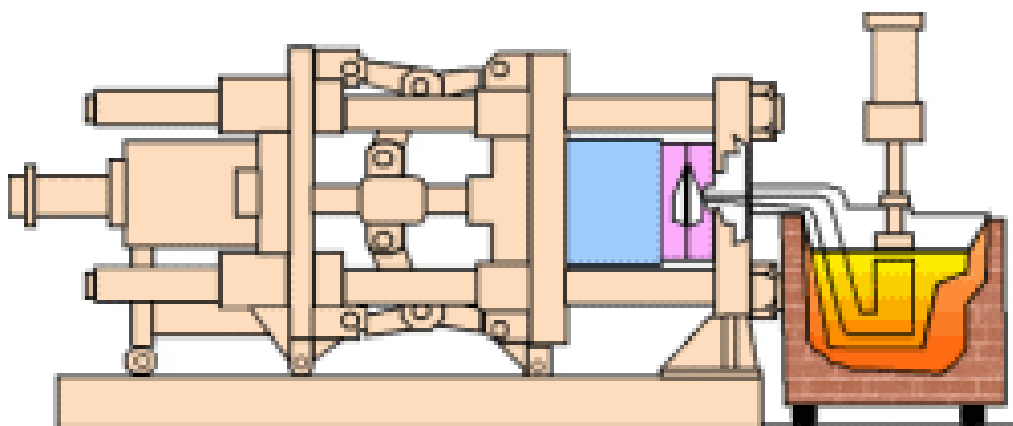
Advantages of Die Casting

- Very accurate to low tolerances.
- The mould can be used over and over again.
- The process can be fully automated.

Disadvantages of Die Casting

- The initial cost is usually very high.
- This process is limited to high fluidity metals.
- The parts that can be made must be quite small compared to other processes that can manufacture much larger items.
- The moulds are expensive to make and can only be used to make one part.

Items made by die casting are amongst the most commonly mass produced items in the world. They can be found in thousands of products and components. These components can be found in anything from toys to car parts. This is a good choice for large scale mass production.



See “Metal Processes” Powerpoint for description of components.

Sand casting is another casting process that is used to form molten metal into a shape which will be used as a product or a component. Unlike die casting where a mould is made from solid metal, sand casting used dense sand called *casting sand* to shape out moulds with.

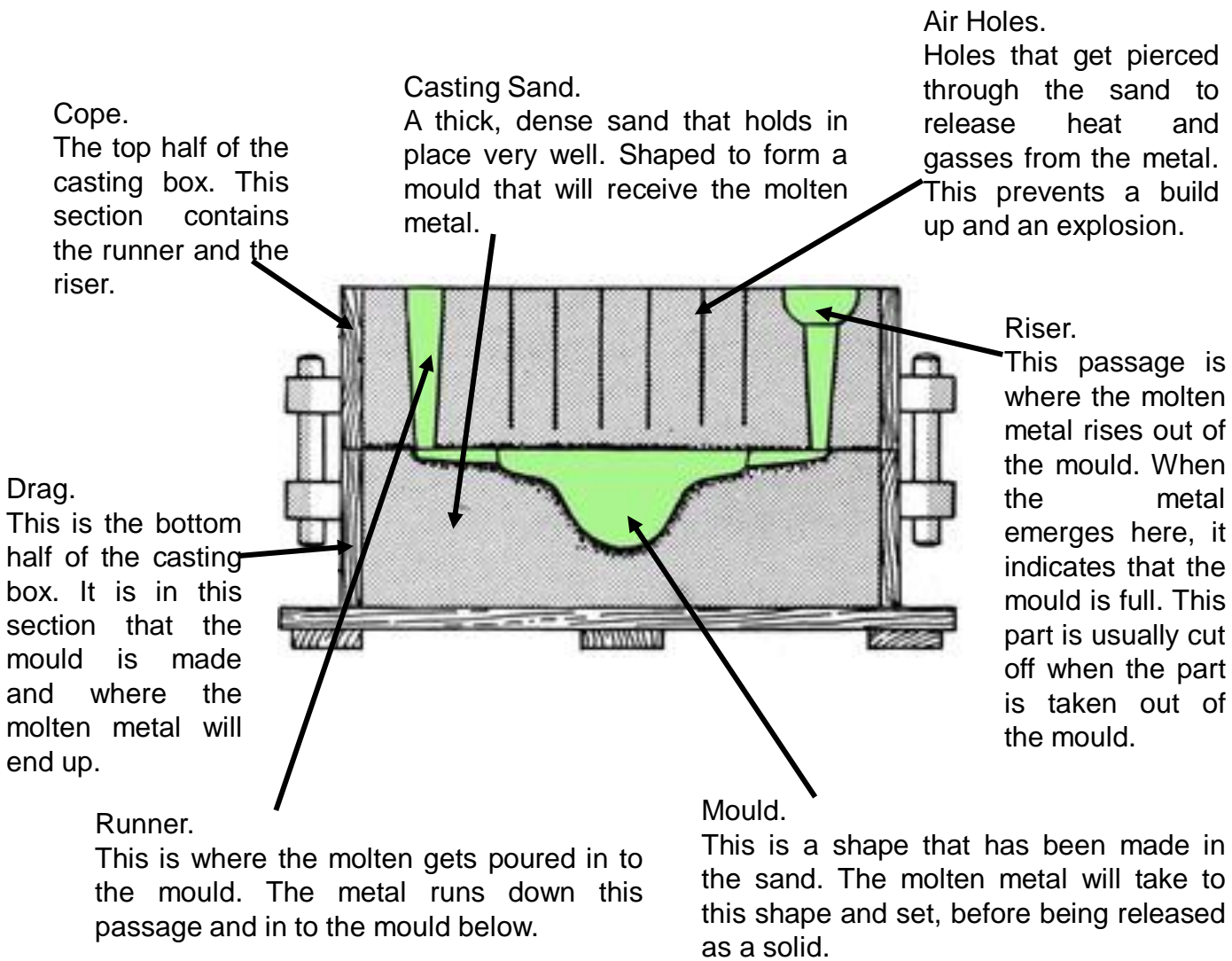
Advantages of Sand Casting

- The initial cost is quite cheap.
- It is a fairly easy process – no skilled operators needed.
- Can produce much larger components and items than other casting methods.
- Limited waste of materials – casting sand can be used repeatedly to make different moulds.

Disadvantages of Sand Casting

- Almost always requires human involvement.
- Not really suitable for large mass production numbers, as the moulds do not last as well as others.
- Produces a poor surface finish compared to other methods.
- A more dangerous process, as human involvement is needed.

Due to the rough, poorer finish and slower production time, sand casting is normally used for prototypes and small number productions. Other processes are usually better options for large scale, top quality mass production lines.



Metal turning is a similar process to wood turning. The centre lathe is used to turn metal bar into cylindrical shapes.

Shown below is a diagram of a simple **metal lathe** with each part labelled and their functions explained.

3 Jaw Chuck.

A chuck is a vice which is designed to hold the material that is being machined. When the machine is switched on, this chuck rotates very quickly, which is where the name “turning” comes from. On a metal lathe the chuck usually has 3 jaws which clamp round the material – hence the name. This chuck is tightened and loosened with a chuck key.

Headstock.

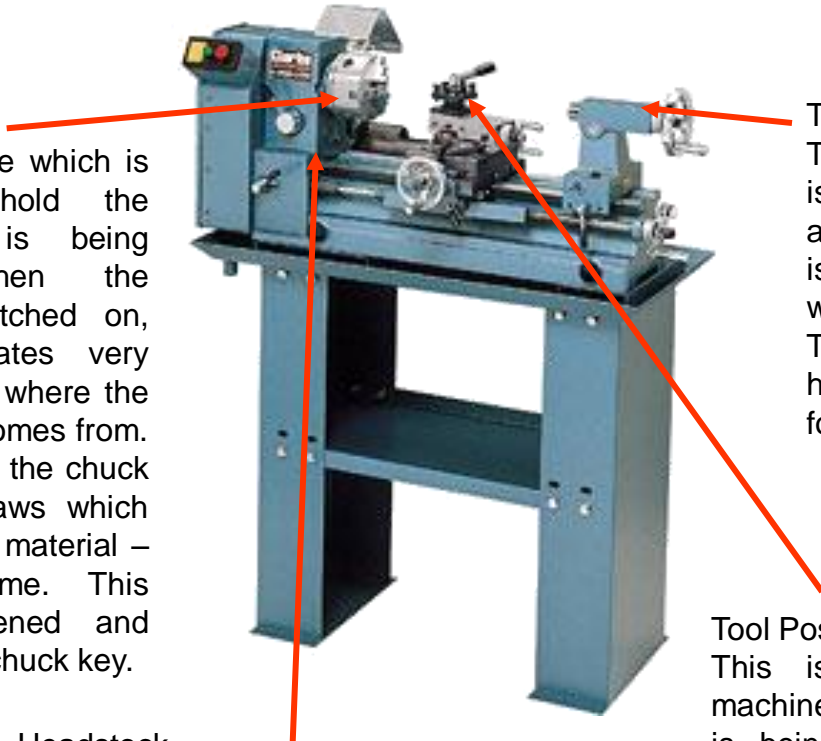
The headstock on a lathe is where the motor that operates the turning of the chuck and also the gears are housed. The 3 jaw chuck is attached on to the headstock. Usually the on and off buttons are here also.

Tailstock.

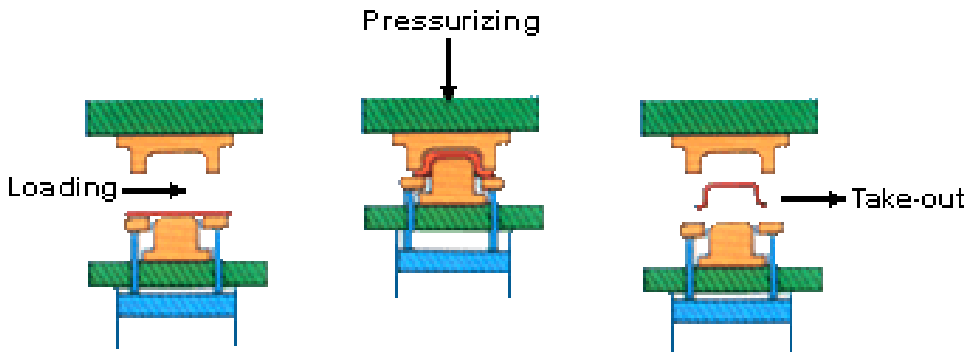
This part of the lathe is mostly used to hold a drill bit. If any drilling is required this part will come in to use. This can be moved horizontally back and forth on the lathe.

Tool Post.

This is the part of the machine to which the tool that is being used is attached. There are different tools for cutting, shaping and adding textures to the metal being turned. The tools are changed by loosening a lever or a bolt which releases them from the tool rest.



Press Forming is a process that uses a large pressing machine. Press forming is usually used to form sheet metal into a required shape.



Stage 1.

The sheet metal is cut to size and entered in to the machine. It is laid flat on top of a pre set pattern which it will be formed in to.

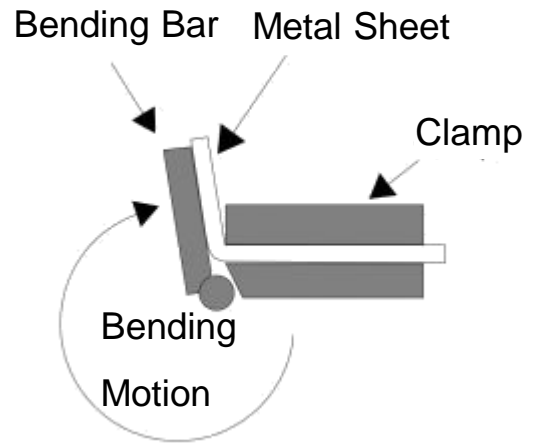
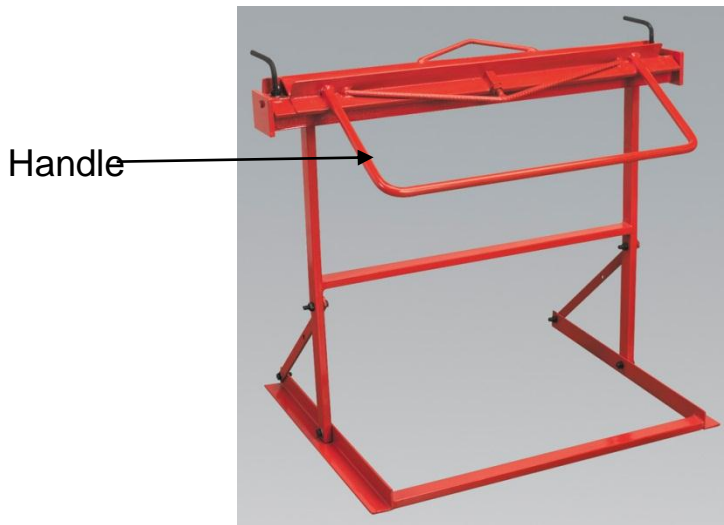
Stage 2.

The machine is then activated. The machine presses down on the sheet metal with a huge amount of force, bending the metal into the pattern as shown above.

Stage 3.

Once the sheet metal has been formed in to the pattern that is required, the machine removes the pattern from the metal and releases it. The metal is now formed into the required shape.

Folding Sheet Metal – Once the metal has been marked out, showing where the fold will be applied, it is clamped into the bending machine as show. This clamp is tightened to make sure the metal does not move, improving the quality of the fold. Then the user simply has to raise the handle of the machine, which will also raise the bending bar as shown. When the user has folded the metal and is happy with the angle that it has been folded to, they simply remove it from the machine and the process is completed.



Questions

Answer in sentences.

1. State two advantages and two disadvantages of Die Casting, with regards to cost.
2. Why is Die Casting a good choice for mass producing items?
3. What safety concerns are there with regards to Sand Casting?
4. Describe the functions on the Runner and Rise in Sand Casting.
5. What is the purpose of the Three Jaw Chuck on a metal lathe?
6. What production process should I use if I want my components to be made to very specific tolerances?