

WORKING WITH METALS

PART ONE

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This mobile revision pdf is based on detailed work found in the 'EQUIPMENT AND PROCESSES' section. Tap on the green link button below to go to the website.



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WORKING WITH METALS

PART ONE

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1. STOCK FORMS AND SECTIONS

2. METALS AND STANDARD FITTINGS / COMPONENTS

3. METALS AND GENERAL WORKSHOP TOOLS AND EQUIPMENT

4. USING JIGS AND FORMERS

5. SPECIALIST ENGINEERING MACHINERY

6. CASTING AND SINTERING OF METALS

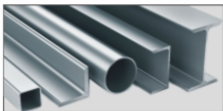
7. IMPORTANT FREE MOBILE APPS ON METALS YOU NEED TO DOWNLOAD, FOR A FULL UNDERSTANDING

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PROFILES AND HOLLOW SECTIONS



profile (size) x length



I-SECTION



T-SECTION



L-SECTION



CIRCULAR
SECTION



SQUARE
SECTION



U-SECTION

Tap the blue button for the next page.



Tap the red button to return to the
Contents page



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SOLID / BAR SECTIONS AND RODS



length x width x thickness



SQUARE



ROUND



FLATS



HEXAGONAL



OCTAGONAL

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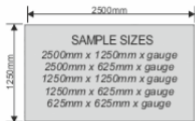
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METAL SHEETS A VARIETY OF SIZES AVAILABLE



SAMPLE THICKNESSES

GAUGE: 16 19 20 22 26 30



SIZE IN mm: 1.30 0.92 0.82 0.64 0.40 0.25

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Tap the red button to return to the Contents page



STOCK FORMS AND SECTIONS

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When ordering metals:

Sheets are ordered by length x width x thickness (gauge)

Solid Rounds are ordered by diameter x length.

Hollow round sections are ordered by diameter x wall thickness x length

Solid square sections are ordered by height x width x length

Square sections are ordered by height x width x wall thickness

AND SO ON.....

Tap the link button for a POSTER on stock forms.



Tap the red button to return to the Contents page



METALS AND STANDARD FITTINGS / COMPONENTS

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Standard fittings and components used with materials such as wood and metal, can generally be used with polymers.

The following slides will take through a range of standard fittings and components

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Tap the red button to return to the Contents page

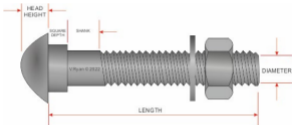


COACH BOLTS

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The coach bolt has a square collar under the domed head and this locks into a square slot / hole when the nut is tightened. A washer is normally placed before the nut.

Tap the image for more information



COLLAR SINKS INTO WOOD AS THE NUT IS TIGHTENED

HEXAGONAL NUT IS USED TO TURN ON THE THREAD OF THE BOLT. Note the washer to protect the wood surface.



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Tap the red button to return to the Contents page

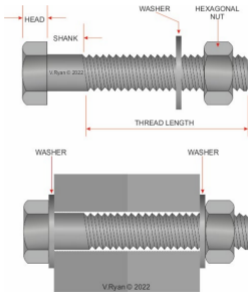


MACHINE BOLTS

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Two spanners are needed to tighten this nut and bolt. The first spanner fits round the hexagonal head of the bolt and a second spanner is used to tighten the hexagonal nut.

Tap the image for more information



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Tap the red button to return to the Contents page



EXERCISE

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Tap the image for more information
and an exercise on coach / machine bolts



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slide / page.



Tap the red button to return to the
Contents page

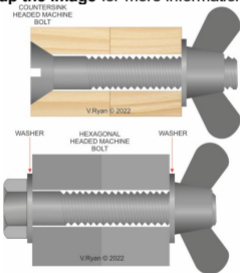


COUNTERSUNK BOLT AND WING NUT

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The countersunk machine screw fits level with the surface of the wood/metal/plastic. A screwdriver is used to keep the bolt still whilst the wing nut is tightened by hand. The 'wings' of the wing nut, are designed to be comfortable when tightening the nut and bolt.

Tap the image for more information



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JOINTS page.



Tap the red button to return to the
Contents page



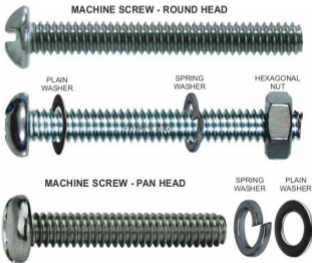
OTHER COMMON BOLTS

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Tap the images for more information and an exercise

A plain washer prevents damage to the surface of the metal, as the nut is tightened.

If there is a need to prevent A nut and bolt loosening a spring washer is used.



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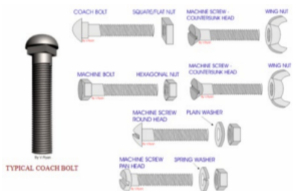
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BOXED LEARNING EXERCISE

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Tap the image for a revision exercise



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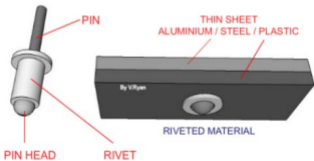


POP RIVETING

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Pop riveting is a technique that is used to join thin pieces of metal and it can also be used to join plastic sheet. The rivet has two parts; the pin and the rivet. The pop rivet pliers are used to pull the pin through the rivet and as this happens the rivet is deformed slightly so that it joins the metal or plastic pieces. This technique is used where the metal or plastic is thin and where the joint does not have to be very strong.

Tap the image for more information



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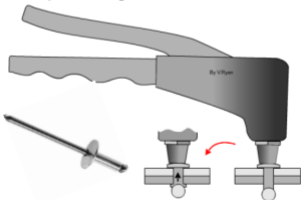


POP RIVETING

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The two pieces of steel or aluminium or other metal, are drilled slightly larger than the rivet. The pop rivet is passed through both holes in the sheet plastic / aluminium. Rivet pliers are pushed on to the pin of the rivet and the handles are pulled together. The pin head is pulled into the rivet and the end of the rivet expands. Eventually the pin breaks off, leaving the rivet permanently fixed in position, holding the two pieces of plastic / aluminium together.

Tap the image for more information



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Tap the red button to return to the Contents page



POP RIVETING - EXERCISES

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Tap the link buttons for exercises



Tap the blue button for the next page.



Tap the red button to return to the
Contents page



COLD RIVETS - TYPES AND USES

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Rivets are used to join plates together and they have been used for hundreds of years. Before the widespread use of welding, rivets were used in heavy industries such as ship building. The steel plates used to build ships such as the Titanic and the naval Dreadnaughts of World War One were held together by steel rivets.

Joining plates together with rivets, is still a useful technique especially if the plates to be joined are quite small.

Tap the images for more information



By V.Ryan
SNAP HEAD



PAN HEAD



MUSHROOM



COUNTERSUNK

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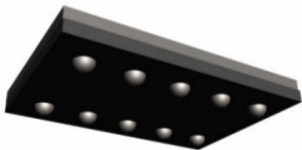


COLD RIVETS - CONTINUED

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Below are two steel plates that have been joined permanently using steel 'snap head' rivets. The plates cannot move a part because the rivets hold them firmly together. The rivets shown above are the main types and the heads of each vary in shape. Snap head rivets have been selected for the work shown below because it does not matter that the heads show above the surface of the metal.

Tap the image for more information and exercises



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Tap the red button to return to the Contents page

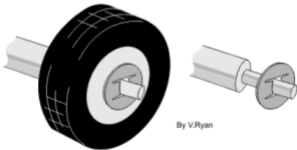


PUSH FITTINGS

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Push on fittings are very popular as they are simply pushed onto the steel / plastic shaft. They are made from hardened spring steel which makes them tough and flexible. They can only be pushed in one direction only (forwards). To remove them they must be forced backwards, this will damage them so that they cannot be used again. As they are very cheap and disposable, they can be replaced. They are suitable for light wheeled vehicles such as light trolleys.

Tap the image for more information and an exercise



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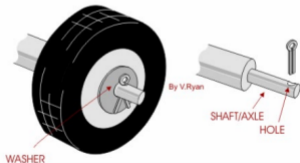


SPLIT PINS

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Split pins are very common as they are easy to use and effective. Often they are found on self-assembly trolleys, light wheel barrows, lawn mowers and similar items. They are usually made from 'soft' steel or aluminium and they come in a range of sizes.

Tap the image for more information and an exercise



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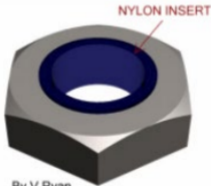
LOCK NUTS

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A close look at the lock nut shows that it has a nylon sleeve. As the nut is tightened, the thread on the shaft / axle cuts into the nylon, holding it firmly in position.

As the wheel rotates a normal nut will loosen because of friction and vibration of the wheel. However, the nylon holds the nut firmly in position.

Tap the image for more information and an exercise



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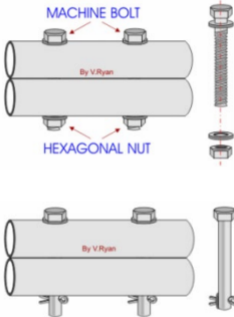
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USING NUTS AND BOLTS TO JOIN TUBE

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Tap the two images for information and exercise on joining tubes using nuts and bolts



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Tap the red button to return to the
Contents page



SELF-TAPPING SCREWS

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These are normally used to cut a thread in metal. A hole is drilled in the metal, a fraction smaller than the width of the screw. The self-tapping screw is then turned into the hole cutting a thread. This type of screw works well with plastics.

Tap the images for more information and an exercise



Tap the red button to return to the Contents page



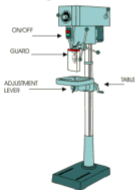
THE DRILLING MACHINE

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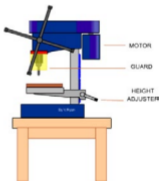
There are two types of machine drill, the bench drill and the pillar drill. Both are used for drilling holes through materials including a range of woods, plastics and metals. The material should be clamped, placed in a machine vice or bolted down, for safety. Plastics such as acrylic, should have a layer of masking tape on the surface, before drilling, just in case the material shatters.

Tap the images for information / an exercise

MACHINE DRILL



BENCH DRILL



Tap the blue button for the next slide / page.



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SUITABLE DRILL BITS

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Tap the images for information / an exercise

Twist Drill

Used for drilling holes.

A normal drill set will include sizes from 1mm to 14mm.



Hole Saw

For large diameters a 'hole saw' can be used.

Interchangeable sizes



Countersunk Bit

Creates a hole that allows countersunk screws to be level with the surface



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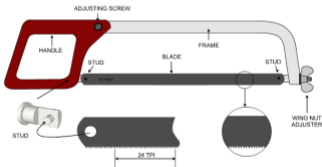


SAWS SUITABLE FOR PLASTICS

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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.

Tap the image for information / an exercise



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Tap the red button to return to the Contents page



MACHINE HACKSAW

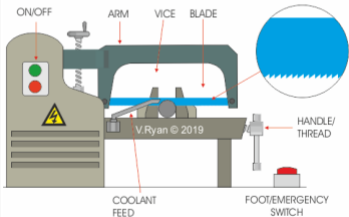
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Power hacksaws are used to cut large sizes (sections) of metals such as steel. Cutting diameters of more than 10/15mm is very hard work with a normal hand held hacksaw.

Therefore power hacksaws have been developed to carry out the difficult and time consuming work.

The heavy 'arm' moves backwards and forwards, cutting on the backwards stroke.

Tap the image for information / an exercise



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Tap the red button to return to the Contents page

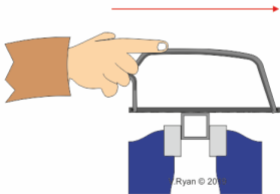


SAWS SUITABLE FOR PLASTICS

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The Junior Hacksaw. This is a small version of the full sized hacksaw. It has a smaller blade which has 'fine' teeth, making it a little easier to use when cutting plastics. Other smaller saws suitable for plastic include the 'abrafile', ideal for cutting in any direction and the piercing saw for very fine and accurate work.

Tap the image for information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page



PUNCHES

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Both the centre and dot punches are used in the same way. A ball pein hammer is used to tap the head of the punch and this delivers enough force to the point of the punch to put a small indentation into the surface of the material. This is important when drilling plastic accurately and safely.

Tap the image
for information /
an exercise



**CENTRE
PUNCH**



**DOT
PUNCH**

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slide / page.



Tap the red button to return to the
Contents page

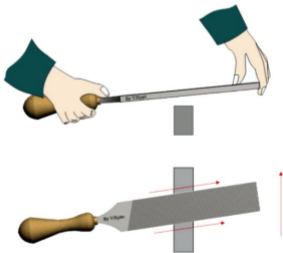


HAND FILES

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Hand files are used in the workshop to smooth rough edges. They can be used to smooth a range of materials including metals such as brass and steel to plastic based materials. They are made from high carbon steel and they are heat treated so that they are tough and durable.

Tap the image for information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page



NEEDLE FILES

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Below is a **high carbon steel** needle file set. The set includes, Round, Half Round, Barrette, Pillar (Flat), Warding, Knife, Crossing, Square, Oval, Slitting, Crochet and Three Square (Triangle). Needle files are very useful for accurate and intricate work, and finishing surfaces. They are often used for working in tight spaces / angles, such as internal corners.

Tap the image for information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page



DIAMOND COATED NEEDLE FILES

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Diamond coated needle files, are more expensive than traditional carbon steel files. They are graded from fine to coarse. These files are used by specialists, such as toolmakers, gunsmiths, jewellers and engineers. Diamond coating produces an extremely hard and wear resistant file surface and is superior to the surface of traditional needle files. They can cut / file in all directions, due to the nature of the diamond coating, unlike high carbon steel files, which cut on the forward stroke only.

Tap the image for information / an exercise



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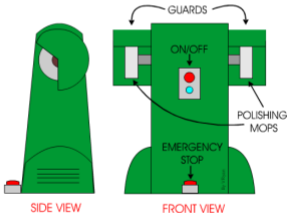


THE POLISHING MACHINE

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The edge of a piece of plastic is smoothed using hand files, sanding disks, wet and dry paper and finally the **buffing / polishing machine**. It is used to polish the plastic 'edge'. The two 'mops' spin at high speed when the 'on' switch is pressed. If the material is carefully pressed against the mop and moved backwards and forwards it will be polished.

Tap the image for information / an exercise



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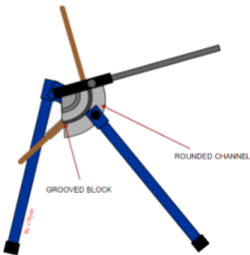


PIPE BENDER

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A pipe bender is the piece of equipment used to bend tube to a precise radius. The rounded channel can be replaced with one that has a larger or smaller radius. The tube is first positioned in a straight grooved block - this holds it firmly. The lever arm is then rotated, bending the pipe slowly to the shape of the rounded channel.

Tap the image for detailed information / an exercise



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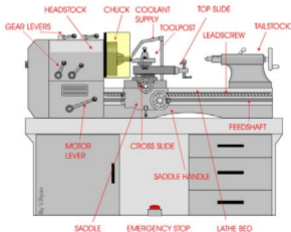


THE CENTRE LATHE

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The Centre Lathe is used to manufacture cylindrical shapes from a range of materials including; steels and plastics. Many of the components that go together to make an engine work have been manufactured using lathes. These may be lathes operated directly by people (manual lathes) or computer controlled lathes (CNC machines) that have been programmed to carry out a particular task

Tap the images for information / an exercise



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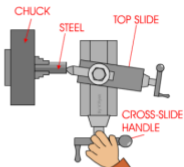


LATHE PROCESSES

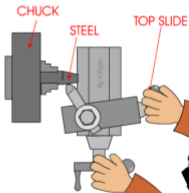
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Tap the images for information / an exercise

“FACING OFF”
Levelling materials



“TAPER TURNING”
Levelling materials



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slide / page.



Tap the red button to return to the
Contents page

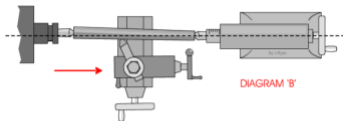


LATHE PROCESSES

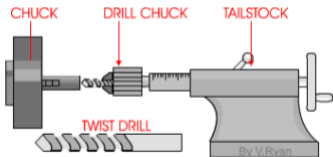
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Tap the images for information / an exercise

TURNING A LONG TAPER



DRILLING WITH THE CENTRE LATHE



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Tap the red button to return to the Contents page



LATHE PROCESSES

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THE KNURLING TOOL

A knurling tool is used to press a pattern onto a round section. The pattern is normally used as a grip for a handle. Apprentice engineers often manufacture screwdrivers. These have patterned handles, to provide a grip and this is achieved through the technique called knurling. The pattern produced is called a 'knurled pattern'.

Tap the images for information / an exercise



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Tap the red button to return to the Contents page



LATHE CUTTING TOOLS

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Tap the images for information / an exercise



RECESSING
TOOL



PARTING
TOOL



RIGHT



LEFT

KNIFE TOOLS



ROUGHING
TOOL



RIGHT



LEFT

TURNING TOOLS

Tap the blue button for the next
slide / page.



Tap the red button to return to the
Contents page



THE CENTRE LATHE

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Tap the Link Buttons for detailed information / an exercises



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Tap the red button to return to the Contents page

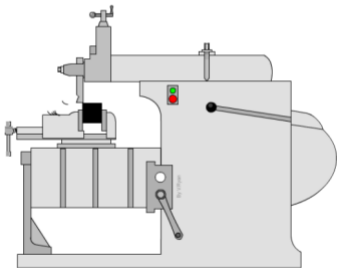


THE SHAPING MACHINE

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A shaping machine is used to machine surfaces. It can cut curves, angles and many other shapes. It is a popular machine in a workshop because its movement is very simple although it can produce a variety of work.

Tap the images for information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page



THE SHAPING MACHINE

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Tap the images for information / an exercise

The tool post has been turned at an angle so that side of the material can be machined



By V.Ryan

The tool post is not angled so that the tool can be used to level a surface.



By V.Ryan

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Tap the red button to return to the Contents page



THE SHAPING MACHINE

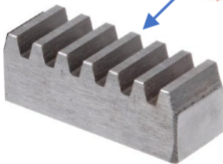
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Tap the images for information / an exercise

The top slide is slowly feed into the material so that a 'rack' can be machined for a rack and pinion gear system.



By V.Ryan



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Tap the red button to return to the Contents page

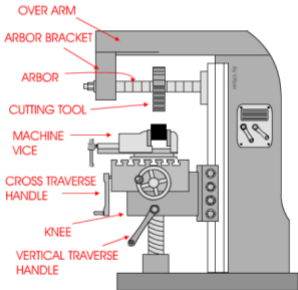


THE HORIZONTAL MILLING MACHINE

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This type of milling machine is used when larger amounts of metal has to be machined away and less accuracy is needed, compared to a Vertical Miller.

Tap the images for information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page



THE HORIZONTAL MILLING MACHINE CUTTERS AND UP-MILLING

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Tap the images for information / an exercise



CYLINDRICAL
CUTTER



CONVEX
CUTTER



SIDE AND FACE
CUTTER



EQUAL ANGLE
CUTTER

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slide / page.



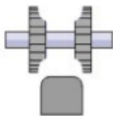
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Contents page



THE HORIZONTAL MILLING MACHINE CUTTERS AND UP-MILLING

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Tap the images for information / an exercise



CONCAVE
CUTTER



SINGLE CORNER
ROUNDING CUTTER

By V.Ryan



SINGLE ANGLE
CUTTERS

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slide / page.



Tap the red button to return to the
Contents page

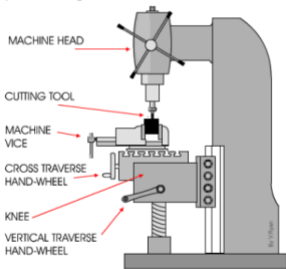


THE VERTICAL MILLER

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A vertical miller is used to accurately shape metals, such as mild steel and aluminium. The cutting tools are very expensive. When using a vertical miller, the machine should be set up to cut away only a small amount of metal each time the cutter passes over the surface of the metal.

Tap the images for information / an exercise



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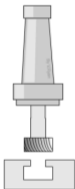


THE VERTICAL MILLER - CUTTERS

V.Ryan © www.technologystudent.com 2019

A wide selection of cutting tools are available. They are made from high speed steel and are strong enough to cut through mild steel, cast steel and aluminium. Three examples are shown below with an example of the profile they cut into the metal.

Tap the images for information / an exercise



TEE SLOT CUTTER



SLOT DRILL



DOVETAIL CUTTER

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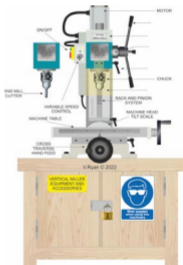


MODEL ENGINEER – PRECISION VERTICAL MILLING MACHINE

V.Ryan © www.technologystudent.com 2022

This vertical milling machine, is every bit as functional, as a full sized version, except it is smaller and fits on a bench top. It is an ideal miller for precision model makers and for those learning to use a vertical miller. The cost of one of these millers, is normally much less than a full sized version.

Tap the image
for information /
an exercise



Tap the blue button for the next
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Contents page



THE VERTICAL MILLER

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Tap the **LINK BUTTONS** for detailed information and exercises on Vertical Millers



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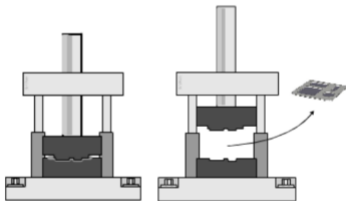


MOULDING THROUGH COMPRESSION

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Moulding through the force of compression is another very common industrial process. Sheet metals can be formed into different shapes through applying both heat and pressure.

Tap the images for detailed information / an exercise



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WHAT IS METAL SPINNING

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Metal spinning (manual spinning), is a useful 'cold forming' process, carried out by a machine operator, on a lathe. CNC machinery is used for the spinning process (power spinning), when high volumes of production are required. Metal Spinning is a process whereby a sheet metal circle is rotated on a lathe, pressure is then applied, forming it into a symmetrical form, such as a cone, bell or dish shape (see example below)

Tap the images for information / an exercise

EXAMPLE OF
METAL SPINNING



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Tap the red button to return to the
Contents page

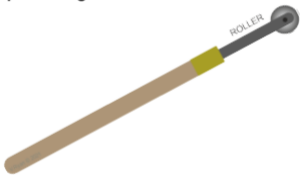


METAL SPINNING TOOLS

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The spinning tool shown below, is one of the most common. The 'roller' spins as it is pressed against the rotating metal on the lathe. The heat created by contact between the 'roller' and the metal, is minimised by the rotation of the roller. Wide rollers are used to smooth the surface of the spinning metal, whereas, thinner rollers are used in the initial shaping.

Tap the images for information / an exercise



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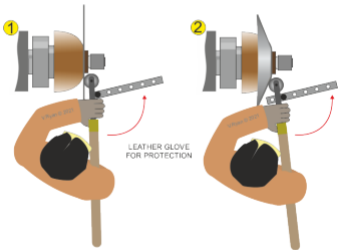


THE METAL SPINNING TECHNIQUE

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The highly skilled machine operator uses a smooth, sweeping motion towards the headstock, to form / press the metal disc against the mandrel. The careful sweeping motion is repeated, until the metal takes the shape of the mandrel.

Tap the images for information / an exercise



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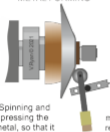
THE MAIN STAGES OF METAL SPINNING

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As the blank is formed through the spinning process, it experiences tensile and compressive forces. The final thickness of the metal is reduced.

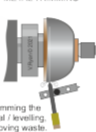
Tap the images for information / an exercise

METAL FORMING



Spinning and pressing the metal, so that it takes the form of the mandril.

METAL TRIMMING



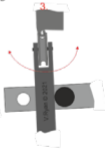
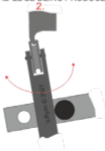
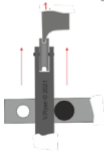
Trimming the metal / levelling, removing waste.

METAL FINISHING



Finishing with a 'duckbill' spinning tool. Light pressure applied.

BEAD EDGE BEING PRODUCED



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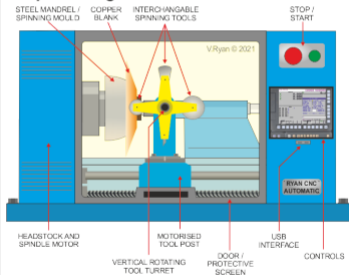


CNC METAL SPINNING

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CNC metal spinning is an automated process, requiring little handling by the machine operator. The operator acts as a supervisor and makes adjustment to the machine tools, when required. The spinning tools are set up on a rotary head. This rotates the various tools, as and when they are required.

Tap the images for information / an exercise



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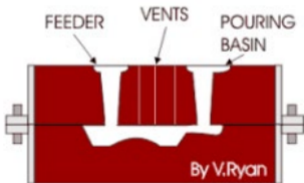


CASTING

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In schools and colleges, casting (foundry work) usually involves casting molten aluminium. First, a wooden pattern is made precisely. The pattern is placed in a casting box, packed with sand, with a top box added to aid the pouring of the molten metal. The pattern is eventually removed from the casting box, leaving a 'cavity' that will be filled by molten metal.

Tap the images for information / an exercise



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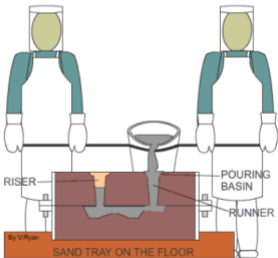
CASTING

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Molten aluminium is poured down a hole called the 'runner'. As it runs down the runner it flows into the cavity left by the pattern and up the riser (see diagram).

The casting should be left for at least an hour before removal from the sand.

Tap the images for information / an exercise



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Tap the red button to return to the Contents page



CASTING

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Tap the Link Buttons for the **FULL, DETAILED** casting process



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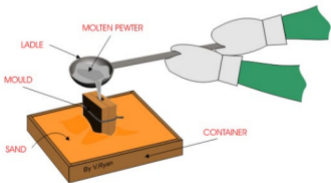


PEWTER CASTING

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Pewter is an ALLOY which means it is composed of more than one metal. Most modern pewter is composed of 96 percent tin and 4 percent copper although there are many variations. It is a soft metal and can be shaped easily by hand tools and machine tools. Due to its low melting point (approximately 230 degrees centigrade) it is suitable for casting. It is a bright material, which makes it popular for the manufacture of 'silverware' such as tankards, candlesticks and even jewellery.

Tap the images for information / an exercise



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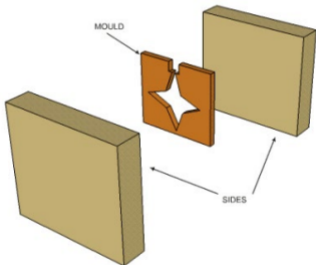


MOULDS AND PEWTER CASTING

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MDF is ideal for use as a mould when casting pewter. The melting point of pewter is low and does not burn or damage the MDF so that it can be reused time and time again.

Tap the images for information / an exercise



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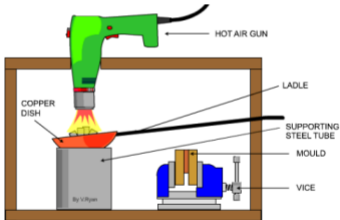


PEWTER CASTING

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When the mould is finished it is placed between the two supporting pieces of MDF and secured in a vice. A hot air gun is normally used to strip old paint from wood. However, it is ideal for heating up pewter and usually takes about two to three minutes before it is ready for pouring.

Tap the images for information / an exercise



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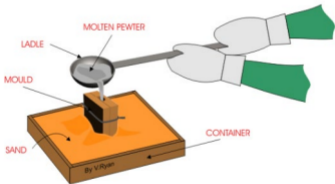


PEWTER CASTING

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When the pewter is molten it is ready to pour into the mould. Safety equipment should be worn when carrying out this procedure. Leather gloves, a safety visor and leather apron are usually worn.

Tap the images for information / an exercise



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Tap the red button to return to the Contents page



PEWTER CASTING

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Tap the Link Buttons for the **FULL, DETAILED PEWTER CASTING** process



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LOST WAX CASTING INVESTMENT METHOD

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Lost wax casting is a process whereby, a wax model of the final product is used to manufacture a mould. A mould composed of a mixture called 'investment' is formed around the wax model. Once the mould has solidified, the wax is melted by heating in a kiln / oven. The molten metal is poured into the mould, cooling to form the final product.

Tap the images for information / an exercise regarding mixing / preparing the 'investment'



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Tap the red button to return to the Contents page

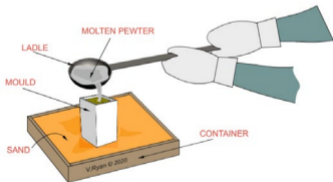


LOST WAX CASTING

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The molten pewter is carefully poured into the 'investment' mould. It is important that the flask is stood in sand, in case any of the molten metal runs down the sides. If this happens, the molten metal will simply stay on the surface of the sand and cool down. The flask should never be placed on a cold surface. If molten metal comes in contact with a cold surface, it will 'splatter' violently. Anyone close to the area will be in serious danger.

Tap the images for information / an exercise



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Tap the red button to return to the Contents page



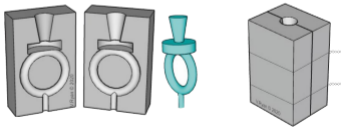
LOST WAX CASTING – USING A SILICON RUBBER MOULD

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An alternative casting technique, is to use 'silicone rubber' in the place of 'investment'. This surrounds the wax model, producing the mould.

The RTV is a two part mix, which cures at room temperature, over a couple of days. Great care must now be taken, to cut the mould accurately in two, using a craft knife. The wax model can then be removed, leaving the cavity. The two halves are wired or carefully clamped together, ready for accepting molten metal. Casting of the molten metal can then take place.

Tap the images for information / an exercise



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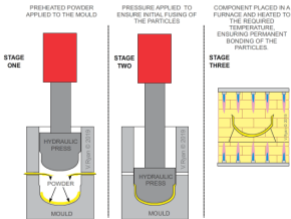
PRESSING AND SINTERING OF METALS

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A process involving the use of metal powder, whereby parts / components are manufactured, through the application of pressure and heat.

The powder is preheated and placed in a mould. Pressure is applied by a hydraulic press, helping to start the process of fusing the powder particles together. The component being made is then placed in a furnace, which ensures the permanent fusing of the metal particles.

Tap the image for information / an exercise



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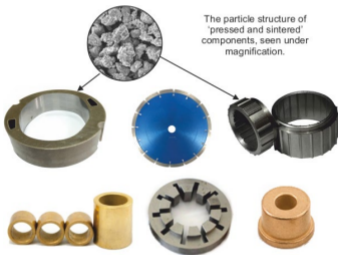
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METAL PRESSED AND SINTERED COMPONENTS

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Tap the images for information / an exercise



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LINKS TO INFORMATION AND EXERCISES ON PRESSING AND SINTERING

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Tap the link buttons for information / exercises



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USING JIGS AND FORMERS TO SHAPE METALS

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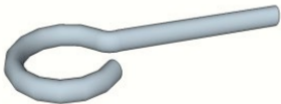
Sometimes it is necessary to manufacture a 'Jig' first, to help the manufacture of a product or component.

The component shown below is part of a mechanism for a foot operated rubbish bin.

The shape is called an 'eye' and is manufactured from round section mild steel.

Making this entirely by hand is time consuming and requires good skill levels. Making a 'Jig' first, saves time, and allows less skilled people to manufacture the part.

Tap the images for information / an exercise



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Tap the red button to return to the
Contents page



USING JIGS AND FORMERS TO SHAPE METALS

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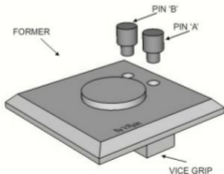
The jig is manufactured from mild steel. The circular part is called the former. Two pins are also needed.

Pin 'A' holds the mild steel rod in place whilst it is forced round the circular former.

Pin 'B' holds the rod in the second position whilst the rod is forced form its final shape.

JIGS VARY IN SHAPE, SIZE AND COMPLEXITY, DEPENDING IN THE METAL BEING FORMED.

Tap the images for information / an exercise



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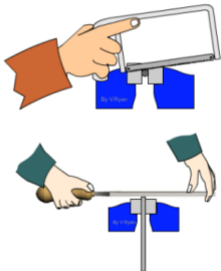


USING JIGS AND FORMERS TO SHAPE METALS

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The round section steel rod is cut to length. A hand file is used to smooth the ends, ready for use in the jig.

Tap the images for information / an exercise



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Tap the red button to return to the
Contents page

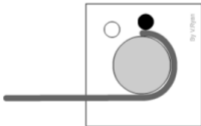
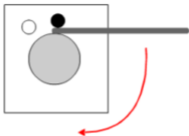


USING JIGS AND FORMERS TO SHAPE METALS

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Pin 'A' is used to hold the steel rod in position in preparation for applying pressure to it. Pin 'B' is not positioned in the block at this stage.

Tap the images for information / an exercise



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Contents page

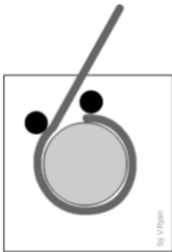


USING JIGS AND FORMERS TO SHAPE METALS

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The steel rod is forced round the former until it reaches the position of pin 'B'. Pin 'B' is then inserted in the jig.

Tap the images for information / an exercise



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Contents page

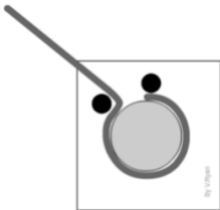


USING JIGS AND FORMERS TO SHAPE METALS

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The rod is then forced into its final position, forming an accurate eye.

Tap the images for information / an exercise



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Contents page



IMPORTANT FREE MOBILE APPS ON METALS YOU NEED TO DOWNLOAD, FOR A FULL UNDERSTANDING

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Tap the red button to return to the
Contents page

