Practical Metalwork
National 4/5
Course Notes

Introduction & the exam.

N4 Practical Metalworking.

The National 4 Practical Metalworking course consists of:

- 3 Unit assessment tasks
  - Machine Proccesses
  - Fabrication and thermal Joining
  - Bench Skills

- Added Value Unit - Garden Lantern **100%**

The following information contained within this booklet contains all the information required to fulfil certain outcomes for the units of the course. It is therefore imperative that candidates are fully conversant with the information contained within this booklet.

N5 Practical Metalworking.

The National 5 course consists of:

- External assessment by examination paper **30%**
- Internal assessment by Course Assessment Task - Garden Lantern **70%**

The examination paper is 1 hour long and consists of one part:-
Metalwork knowledge *(Content of this booklet)*

The graphics knowledge consists of a total of **60** marks.
The Course Assessment Task consists of **70** marks

The following information contained within this booklet contains all the information required to fulfil this aspect of the examination paper. It is therefore imperative that candidates are fully conversant with the information contained within this booklet.

National 5 Exam Question Topics.
The following topics will be assessed in the exam paper:

Measuring and marking out:
A knowledge and understanding of the use of the tools and equipment listed below:
Scriber; scribing block; steel rule; combination set; engineer's square; centre finder; spring dividers; calipers: oddleg, inside, outside; micrometer: analogue and digital; Vernier calipers: analogue and digital; centre punch; witness marks; surface table; angle block; vblock; engineer's blue; units of measurement; datum lines; functional dimensions; the need to make allowances for expansion, bending, stretching, forming, trimming, welding, brazing and soldering.

Reading and interpreting drawings and documents:
working drawings, pictorial drawings, diagrams, cutting lists
orthographic projection
Scale
basic drawing conventions: line types — outlines, centre lines, fold lines, hidden detail and dimension lines
reading and extracting information from working drawings: linear, radial, angular and diametric dimensions

Materials:
Properties of the metalworking materials listed below:
ferrous metals: steel, high carbon steel, iron
non-ferrous metals: aluminium, copper, nickel
alloys: bronze, brass, stainless steel
common sections: square bar, round bar, hexagonal bar, angle iron, tube
sheet materials: tin plate, copper, brass, steel, aluminium

Bench work:
the safe use of the following bench tools and their component parts:
engineer's vice, ball-pein hammer cold chisels, file types: flat, square, round, needle and 3 square, file parts: tang, safe-edge, handle, ferrule, file cut: smooth, 2nd cut and rough, filing methods: cross filing and draw filing, saws: hacksaw and junior hacksaw, taps: taper, intermediate and plug, tap wrench, drill sizes for tapping, dies: adjustment of split die, die stock, rivet set and snap.

Sheet metal tools and machines:
The safe use of tools, machines and equipment used in sheet metalwork listed below:
folding bars, folding machine, notchers, guillotine, hide and rubber mallets, tin snips (straight, curved, right and left hand), pop riveter, spot welder.

Machine Processes:
The actions carried out on the machines/processes listed below:
pedestal/pillar drill: drilling and countersinking, bench grinders, centre lathe processes: facing off, parallel turning, taper turning, chamfering, drilling and use of compound slide, milling machines: vertical, horizontal and CNC, industrial cutting processes: laser and plasma cutters.

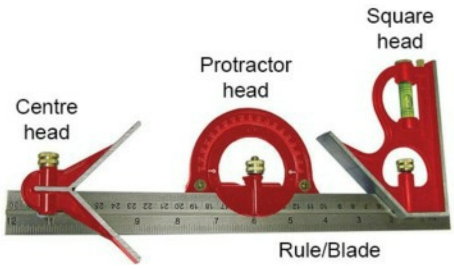
Machine tools:
The safe use of the equipment and machinery parts listed below:
parts of centre lathe: headstock, tailstock, tool post, compound slide, cross slide and saddle, lathe cutting tools: left-hand knife tool, right-hand knife tool, knurling tool, parting tool, 3-jaw chuck, 4-jaw chuck, Jacob's chuck, chuck keys, revolving centre, machine vice.

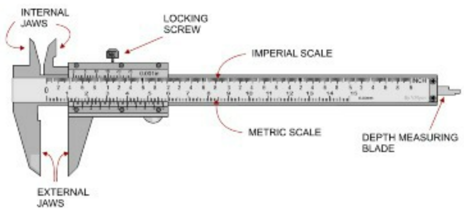
Finishing:
The•finishing•processes•listed•below:
Planishing,•polishing,•bluing,•machine•finishing•(ground,•milled),•preparation•and application•of•paint•and•powder-dip•coating.

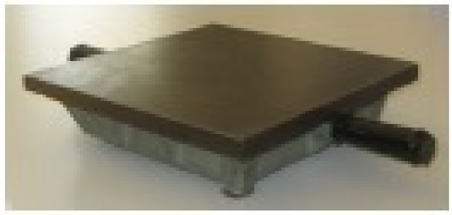
Safe•working•practices:
Good•practices•and•safe•systems•for•general•workshop•and•individual•activities•as appropriate.
Personal•protective•equipment:•apron,•gloves,•safety•goggles,•safety•specs,•visors, welding•masks.

Fabrication•and•thermal•joining:
The•processes•and•techniques•listed•below:
thermal joining: welding (mig, spot and electric arc), soldering, brazing; mechanical fixing: riveting (snaphead, countersink and pop), screwfixing; metalwork adhesives; heat treatment•methods:•annealing,•hardening•and•tempering.

Measuring and marking out.
Tools and equipment

Tool	Description	Image
Scriber	The scriber is a tool which is used to ”SCRIBE” or mark lines on metal.	
Scribing Block	A scriber block is used to lay out lines at a set height from the base, thus its second name surface height gauge or just surface gauge.	
Combination Set	A combination square is a tool used for multiple purposes in metalworking. It is composed of a ruled blade and one or more interchangeable heads that may be affixed to it. The most common head is the standard or square head which is used to lay out or check right and 45° angles.	
Engineer’s Square	An Engineers Square is similar to the Try Square except it is smaller and made of metal. It is used to check that the edges of the plastic or metal are square or to scribe lines at Right Angles to an edge.	
Centre Finder	The centre square is probably one of the simplest tools ever designed as it is composed of only two pieces of material. When placed up against a round piece of material such as a round section of steel it can be used to find the centre accurately.	
Spring Dividers	These are used to mark out circles and arcs and to step out equal lengths along a line.	

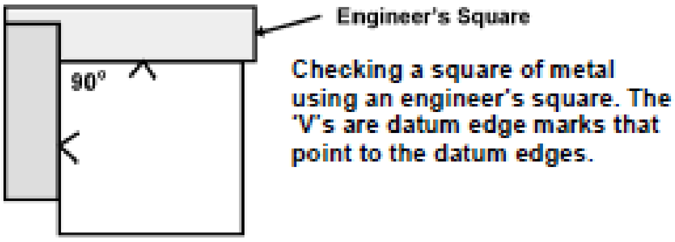
Tool	Description	Image
Oddleg Callipers	These are used to mark out lines on metal Parallel to an edge.	
Inside Callipers	Inside callipers are used to test the diameters of holes or the distances between two surfaces where it would be difficult to use a steel rule.	
Outside Calipers	Outside callipers are used for testing the outside diameters of round bars and thickness of sheet metal where it is difficult to use a steel rule.	
Micrometer	This tool is used to measure sizes with great accuracy. The most commonly used micrometers can measure to one hundredth of a mm. The micrometer is generally used for measuring external sizes.	
Digital micrometer	Same as a micrometer but offers a digital reading.	
Vernier calipers	The vernier callipers are also used for measuring very accurate sizes. The vernier calliper can measure internal sizes, depths and external sizes.	
Digital calipers	Same as a Vernier calipers but offers a digital reading.	

Tool	Description	Image
Centre•punch	Before•metal•can•be•drilled•with•a twist•drill•the•surface•must•be firstly•punched•using•the•Centre Punch.•The•reason•for•this•is•to ensure•the•drill•does•not•slip•on the•surface.	
Surface•table	A surface•table is•a solid, flat plate used•as•the•main horizontal reference•plane for precision•inspection, marking out (layout),•and•tooling setup. The•surface•plate•is•often used•as•the•baseline•for•all measurements•to•the•workpiece.	
Angle•block	Slotted•holes•or•"T"•bolt•slots•are machined•into•the•surfaces•to enable•the•secure•attachment•or clamping•of•workpieces•to•the plate,•and•also•of•the•plate•to•the worktable.•Angle•plates•also•may be•used•to•hold•the•workpiece square•to•the•table•during marking-out•operations.	
V-block	V-Blocks are•precision metalworking•jigs•typically•used•to hold•round•metal•rods•or•pipes•for performing•drilling•or•milling operations.	
Steel•Rule	The steel•rule is•a•basic measuring•tool.•When•used correctly,•a•good steel•rule is•a surprisingly•accurate•measuring device.	

Marking•out•Tips•and•hints

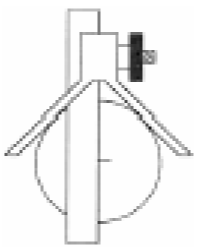
Pens•and•pencils•do•not•work•well•on•metal,•they•rub•off•easily•and•don't•show•up•well. Marking•out•is•shown•by•scratched•lines.•To•help•the•scratches•to•show•up,•before•marking out,•the•surface•of•the•metal•can•be covered•with•a•thin•layer•of•a•quick•drying ink•called **Engineer's•Blue**.•Marking•out tools•scratch•away•the•blue•layer•to•show the•contrasting•metal•colour•underneath.

Before•marking•out,•the•metal•should•be prepared•by•filing•two **datum•edges**,•from which•all•measurements•are•made. These•edges•should•be•perfectly•straight and•be•at•90°•to•each•other.



Combination•Square

The•photo•shows•all•three•heads•on•the•rule.•In•use,•only•one head•at•a•time•would•be•on•the•rule.

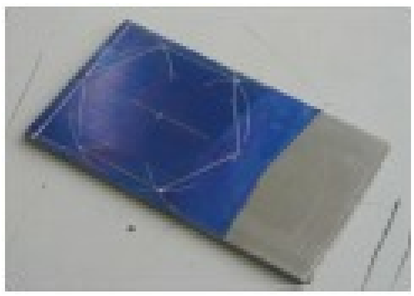


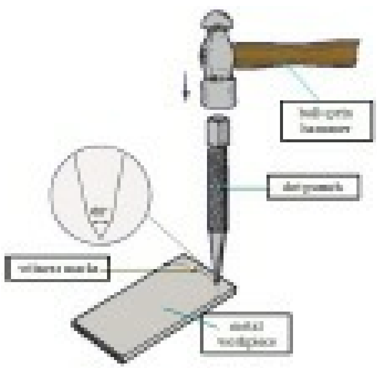
Centre•square•being•used•to•find•the•centre•of•a disc.•With•the•disc•edges•touching•the•arms,•draw•two•lines•at•different angles,•where•they•cross•is•the•centre.

The•angle•head•being•used•to•draw•a•line•at•a•set angle.

Engineer's•Blue

Engineer's•blue is•a dye used•in metalworking to•aid in marking•out rough•parts•for•further•machining.•It•is•used•to stain•or•paint•a•metal•object•with•a•very•thin•layer•of•dye•that can•be•scratched•off•using•a scriber reveal•a•bright,•yet•very narrow•line•in•the•metal•underneath.•The•advantages•are•that any•existing•scratches•are•covered•with•the•dye•and•the•new lines•have•a•contrasting•background.



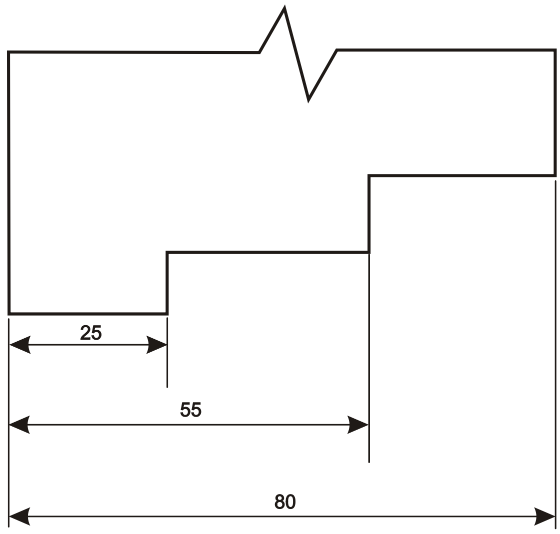


Witness•marks

In•order•that•lines•can•be•seen•more•clearly•feint•dots,•called witness•marks.•can•be•lightly•punched•around•the•entire•shape (that•will•be•cut-out).•A•centre•punch•is•used,•along•with•a hammer:•to•create•witness•marks.•Rest•the•work•on•a•block•of metal•to•do•this,•not•in•a•vice.

Datum lines

Using the same point every time when marking out your component will reduces the chance of accumulating a tolerance error.



Using datum lines

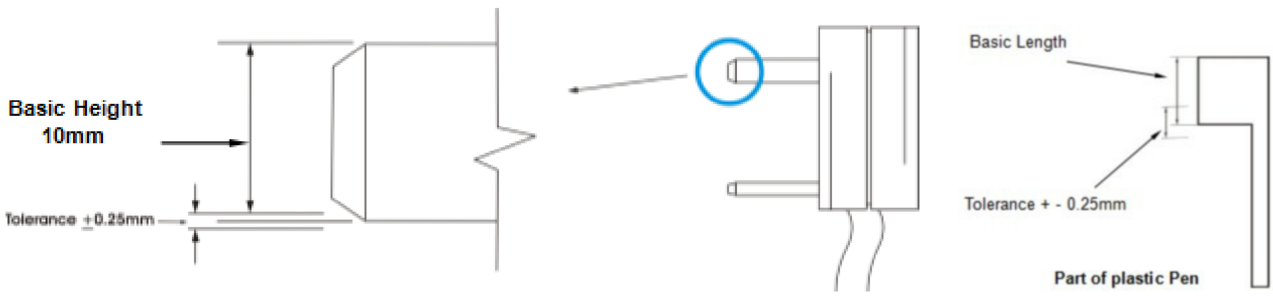
Dimensional Tolerances

When products are manufactured, they, in many cases have to be able to be assembled to other components which make up the complete product. It is very difficult to ensure that the components are the exact size every time, therefore to allow for slight mistakes in manufacturing we use a system called Tolerance. This allows the components to be made within certain sizes which in turn allows for slight mistakes allowing the components to still fit.

In the first example given overleaf the component has a tolerance of 0.25mm either way. This means the component can be made within the sizes 19.75mm to 20.25mm. The tolerances vary depending what is being made.

In the example shown opposite (*button for TV remote)* the button has been made with a tolerance of 0.5mm. This means that in the manufacturing process it will have a full 1mm allowance. This does not seem a lot but in manufacturing terms is a substantial allowance.

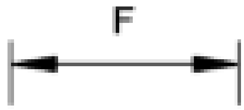
For example, the height of a pin of an electrical plug, as shown on the next page, is 10mm. The company has determined that the size could vary between 9.75mm and 10.25mm and still be able to fit in the slots in the socket. In this case a tolerance of 0.5mm could be applied to this dimension without affecting the function of the part. This size is normally stated as 0.25mm.



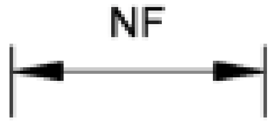
When manufacturing or constructing an item it is virtually impossible to achieve precisely the required size of the item. The error permissible in manufacture is called tolerance - this is normally given on the drawing of the item. Tolerances which affect the size of an object or feature on it are referred to as dimensional tolerances. They are also used to tolerance the size of locating features on an item in relation to another. For example, the required length (or basic length) of part of a plastic pen clip shown below is 10mm. This size could vary, between 9.5mm and 10.5mm and still fit in the slot provided for it on the pen. tolerance of 1mm, normally stated as +- 0.5mm could therefore be applied to the dimension without affecting the function of the part. The length of the part of the clip could then be manufactured to any size between 9.5mm and 10.5mm and still be acceptable.

Types of Tolerance

Functional & non-functional dimensions



The remote button and the electrical pin of the plug shown on the previous page are examples of a ***functional dimension*** as they are directly affected by the size of both components. If either was out with the tolerance allowed they would not fit.



Whereas a ***non-functional dimension*** would be the height of the inside button or the length of the pin would not affect the fit of the two components.
Due to a number of different processes involved in the manufacture of products in metalwork we need to make allowances for expansion, bending, stretching, forming, trimming, welding, brazing and soldering etc.
The tolerances that you need to work to in your Course Assessment Task are:

Operation	Tolerance
Individual Components	
Marking out	±0.5mm
Fitting work	±0.5mm
Sheet metal work (cutting)	±1mm
Bending work — sheet metal	±2mm
Bending work — metal strip/ bar	±5mm
Forge processes (twisting, drawing down and flattening)	±3mm
Assembly, joining and fitting	
Functional sizes	±0.5mm linear
Thermal joining	Minimum length of 20mm consistent in width
Drilling and countersinking	±0.5mm
Parallel turning, facing and chamfering	±0.5mm linear ±0.2mm diameter

Units of Measurement

Most countries use the **Metric** System, which uses the measuring units such as meters and grams and adds prefixes like kilo, milli and centi to count orders of magnitude. The United States uses the older **Imperial** system, where things are measured in feet, inches and pounds.

1meter = 100 centimetres = 1000 millimetres

Reading and interpreting drawings and documents.

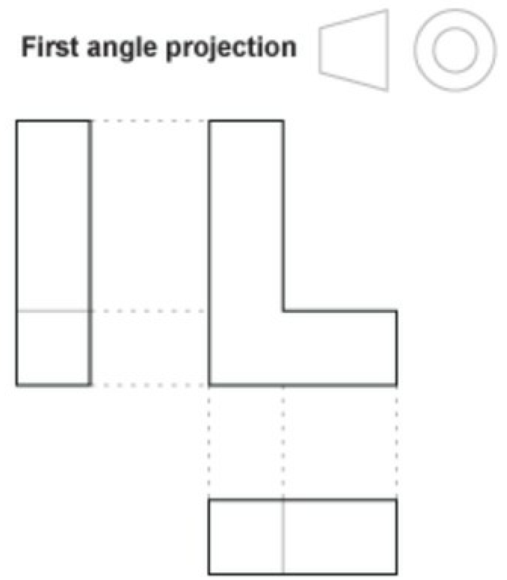
Development of ideas: working drawings
Working drawings contain all the information needed to make the design, including:

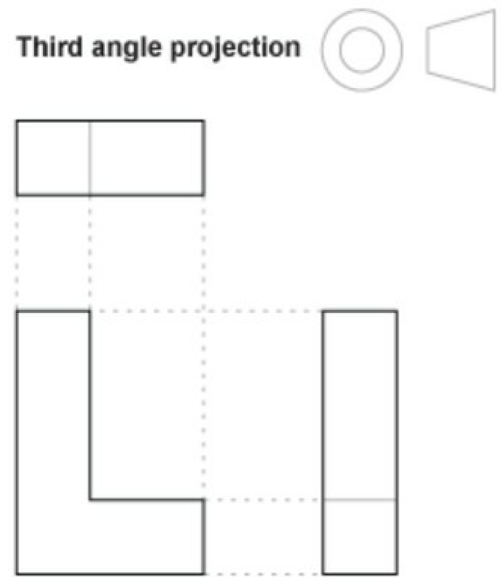
- dimensions
- details of components
- materials
- assembly instructions

Working drawings are normally done as orthographic projections.

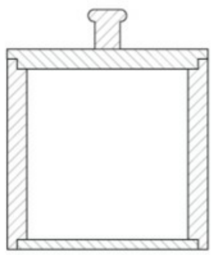
Orthographic projection
Orthographic drawings usually consist of a front view, a side view and a plan, but more views may be shown for complex objects with lots of detail. A drawing board and parallel motion or T-square is used to project one view from another. Orthographic drawings can be produced from Computer Aided Design software for example Autodesk Inventor.

Orthographic drawing may be done using first angle projection or third angle projection. We use the third angle projection method in the UK.





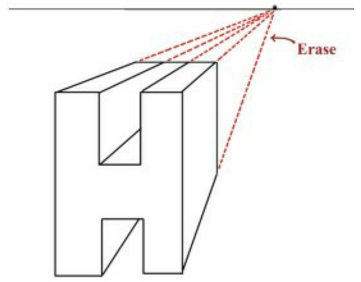
Sectional and assembly drawings
Some products may need a section drawing to give extra structural information, or an assembly drawing to show how parts fit together.



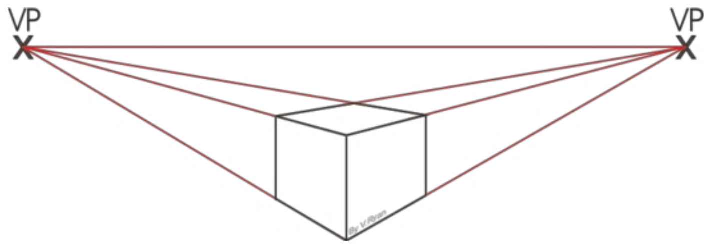
Pictorial Drawings

Perspective:

There are two types of perspective views. They give a 'realistic view of an object or building. Often used to promote or advertise an item.



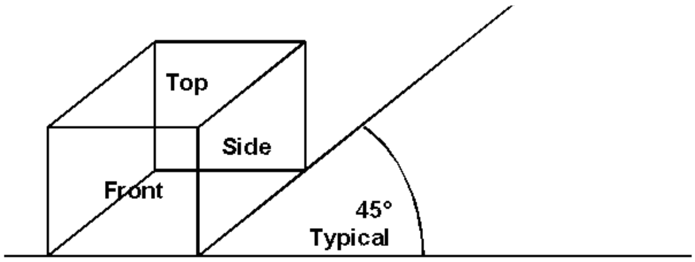
One point perspective



Two point perspective

Oblique:

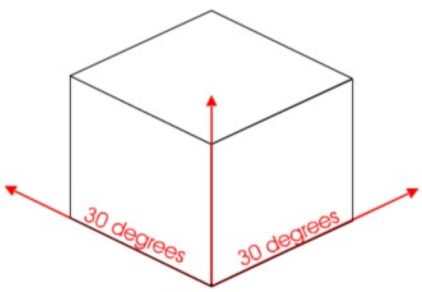
The main advantage of an oblique view is that the initial drawing is 2D. This allows us to easily draw circles before extending the shape back to give a depth. All depth sizes are drawn half size to ensure the drawing looks more realistic.



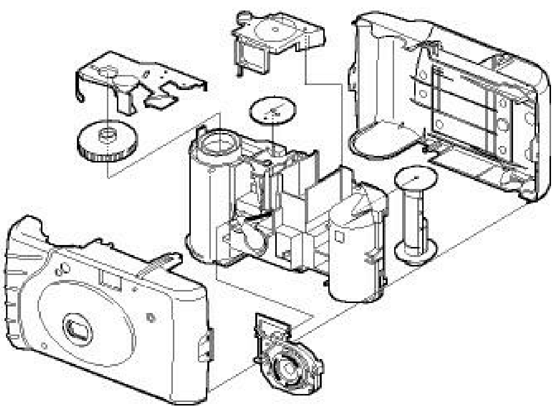
Oblique

Isometric:

Isometric views are often used in engineering as they can give a very clear view of how a component or object will look. This is especially so with exploded views which help show how several components are assembled together.



Isometric View



Exploded Isometric View

Scales
Scaling drawings allow us to draw exceptionally large objects such as houses on any size of paper available to us. To enable this to happen we have to scale every size (dimension) by the same factor. i.e. taking the example of the house, every dimension would have to be di vided by say 100. By doing this we are scaling **DOWN** the size of the house. We can also draw exceptionally small objects larger, examples of which are, the minute electronic chips which are now part of our every day life. They are so small we could not draw them as they are we have to **SCALE UP** the drawing to be able to draw them.

When we carryout a drawing using the actual dimensions, this is called '**full size**', or the drawing has been drawn to a scale of **1:1.** For every 1mm drawn, 1mm is represented. When we carryout a drawing and reduce all the sizes by a factor of 2, i.e. all dimensions are divided by 2, this is scaling down the drawing. This makes the drawing half its original size. What the 1 & 2 represent are, for every 1mm drawn on paper the actual size of the real ob ject is 2mm.

We can also increase the size of an object by any factor. In the example shown opposite the sizes have been increased by a factor of 2. This will make the drawing twice its original size. The 2 is stating that for every 1mm actual size of the object, 2mm have been drawn. If we increased the object by **10** the scale would be **10:1.** If we reduced the objects dimensions by twenty the scale would be **1:20.**

We can also increase the size of an object by any factor. In the example shown opposite the sizes have been increased by a factor of 2. This will make the drawing twice its original size. The 2 is stating that for every 1mm actual size of the object, 2mm have been drawn. If we increased the object by **10** the scale would be **10:1.** If we reduced the objects dimensions by twenty the scale would be **1:20.**

With respect to Engineering drawings, there are recommended scales for reduction and en largement. These are as follows:-

Reduction:- 1:2, 1:5, 1:10, 1:20, 1:50, 1:100, 1:500, and 1:1000
Enlargement:- 2:1, 5:1, 10:1, 20:1, and 50:1.

The size of scale used is mainly dependant on two factors. These
factors are the;

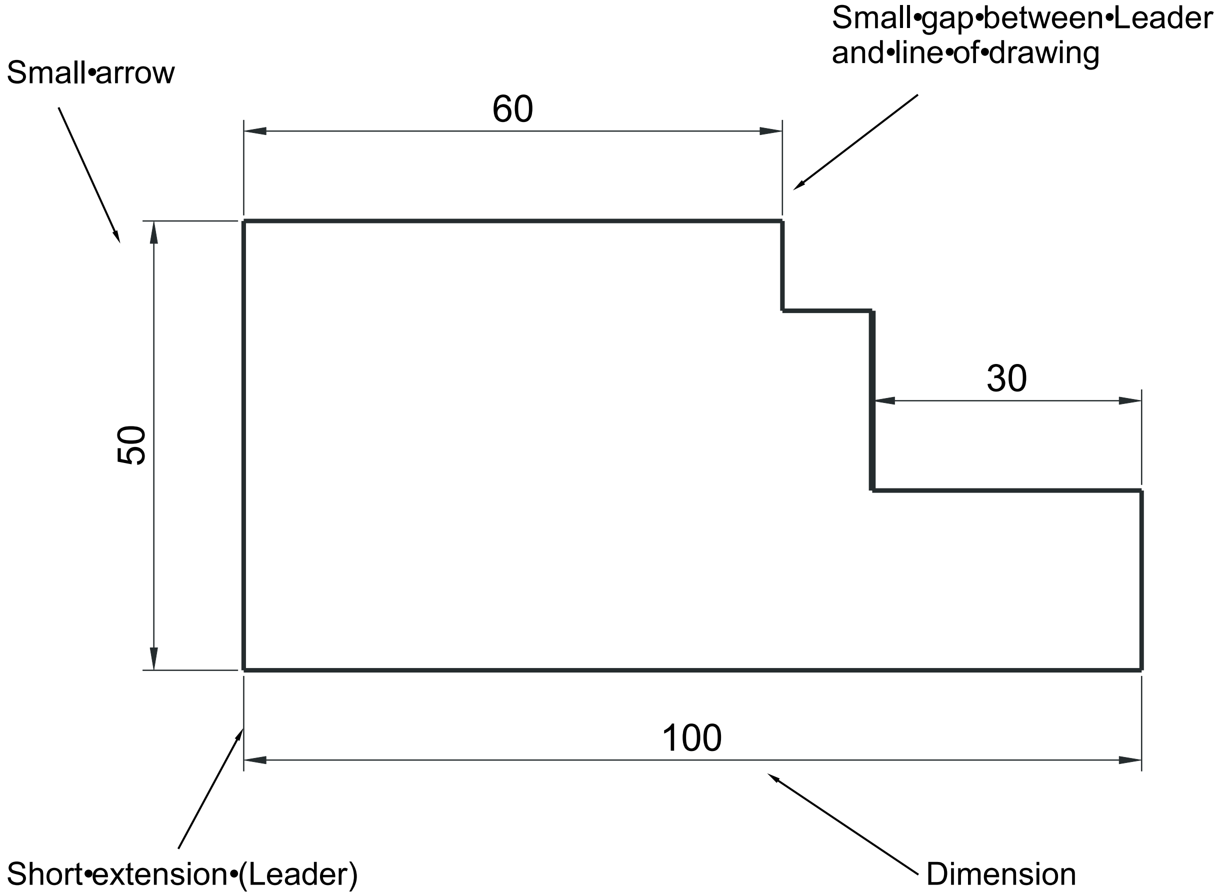
Size of paper available; And the size of the object being drawn;
The amount of detail required

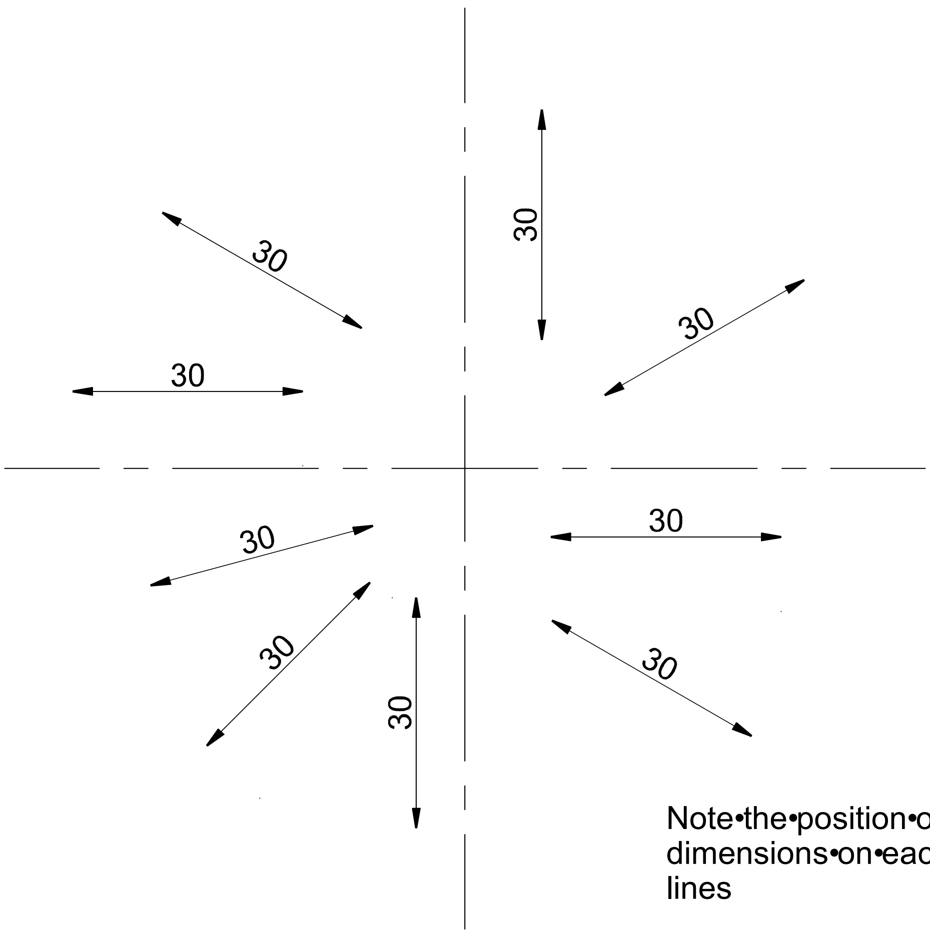
E.g. If house was being drawn on a piece of A4 paper opposed to a sheet of A2 paper, the scale used will obviously have to be different or it won't fit onto the page.

Line Types

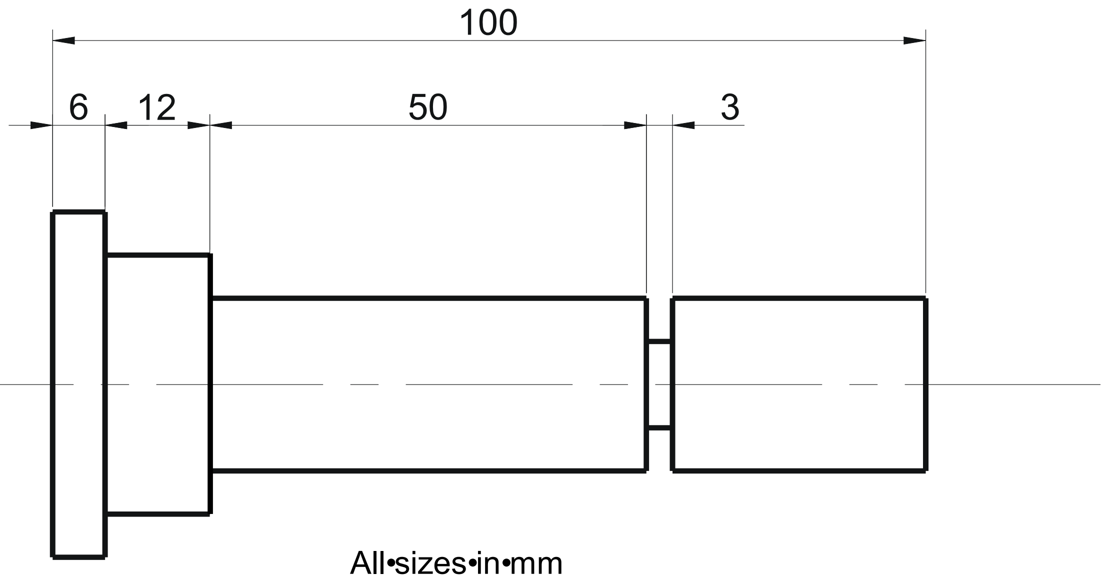
Line Type	Image	Description	Use
Outline Solid		Continuous thick	Used for visible outlines and edges.
Projection Line		Continuous thin	Used for projection, dimensioning, leader lines, hatching and short centre lines.
Hidden Detail Line		Dashed thin line.	Used for hidden outlines and edges.
Centre Line		Chain Long dash, dot, Or Chain thin.	Used for centre lines, lines of symmetry.
Fold Line		Chain thin double dash	Used for ghost outlines and bend lines.

Dimensioning



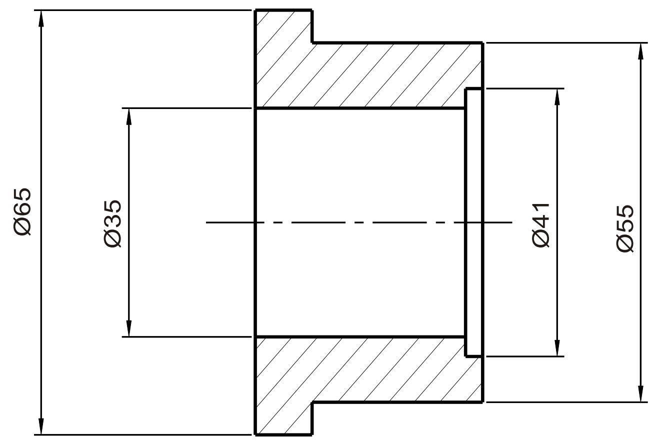


Note the position of the dimensions on each of the lines



All sizes in mm

Notice on the above drawing that the largest dimension is placed on the outside of the smaller dimensions. Where there is a limited space for dimensioning, the dimension can be placed above, or in line with, the extension of one of the dimension lines. E.g. the 3mm dimension uses the 50mm dimension leader. It is also important when dimensioning not to include the units of measurement. As can be seen from the drawing above, state on the drawing the unit of measurement. i.e. (**All sizes in mm**).



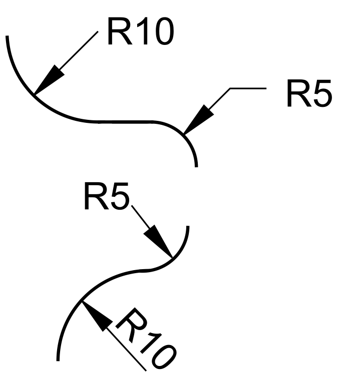
The sectioned drawing opposite shows some possibilities for putting a diameter on a drawing. This is by no means the only method.

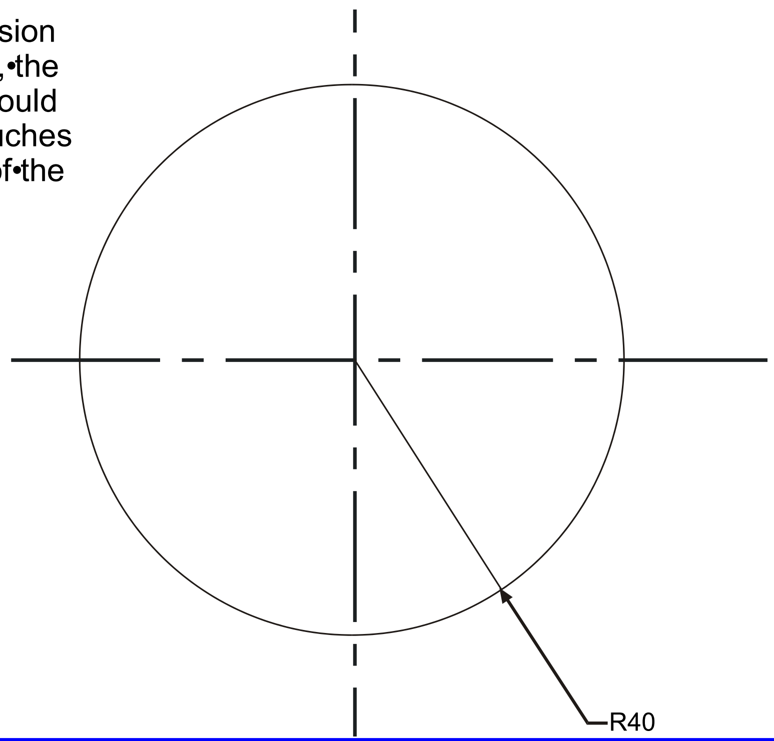
If the section shown was **Square**, then the following symbol would be used.

□45

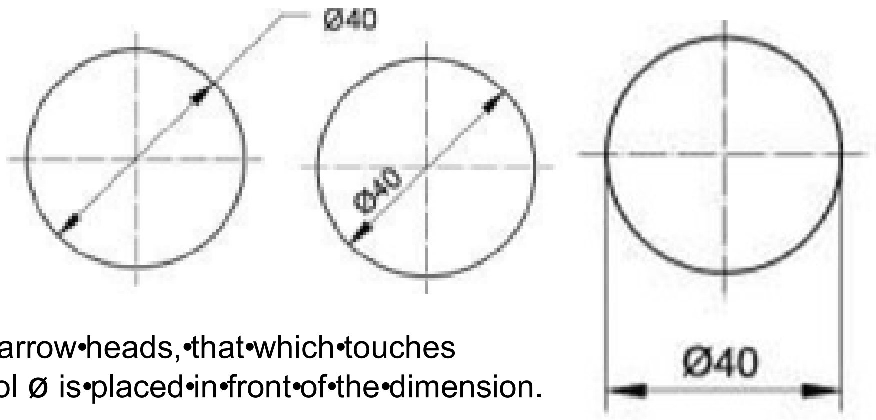
Dimensioning the Radius

Radii should be dimensioned by a dimension line that passes through, or is in line with, the centre of the arc. The dimension lines should have one arrow head only, that which touches the arc. The symbol R is placed in front of the dimension.



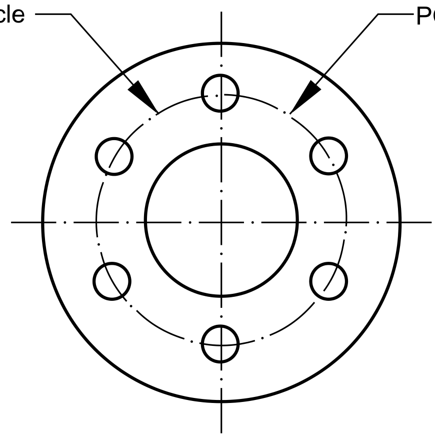


Dimensioning•the Diameter

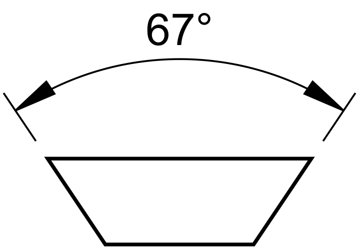


Diameter•should•be dimensioned•by•a dimension•line•that•passes through,•or•is•in•line•with the•edges•of•the•circle.•The dimension•lines•should•have•two•arrow•heads,•that•which•touches perimeter•of•the•circle.•The•symbol ø is•placed•in•front•of•the•dimension.

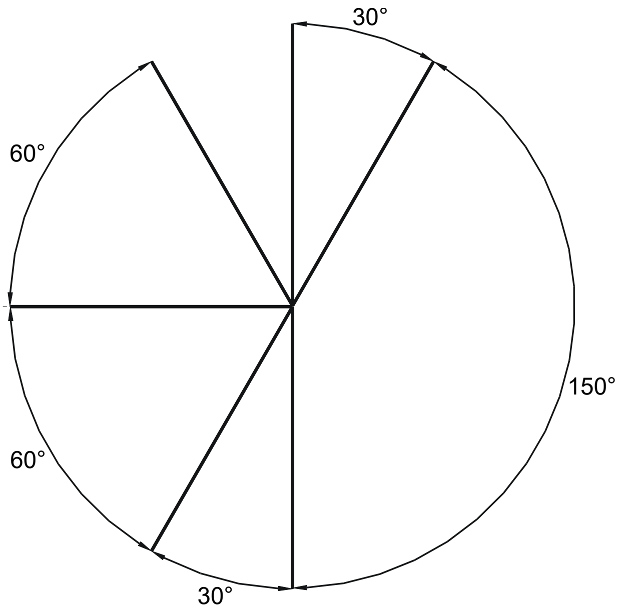
The•pitch•circle•diameter•is•the•diameter of•a•circular•component•that•is•to•be manufactured.•This•circular•component often•has•holes•drilled•into•it.•It•can•also be•modified•in•other•ways.



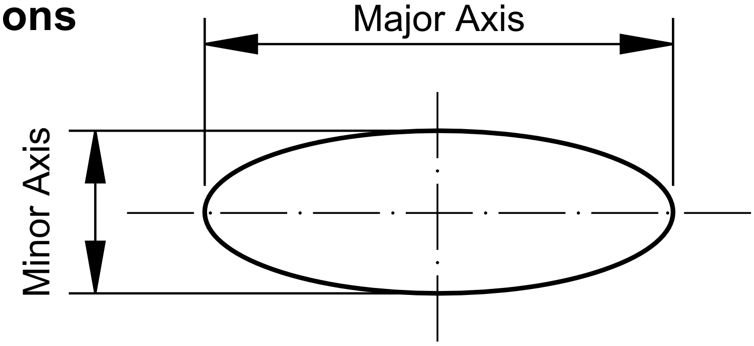
Angular•Dimensions



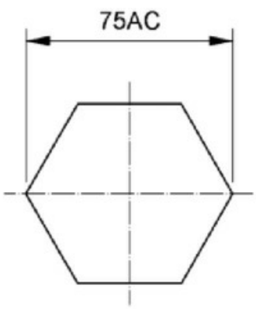
Note•the•position•of•the dimensions•on•each•of the•lines.

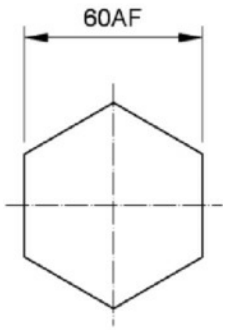


Axis Dimensions



Dimensioning Across Corners/Flats





Cutting List

A cutting list, which can also be known as a material list, bill of materials, or schedule of materials is simply a listing of all the parts that will be required to construct a project. This information can be derived from multiple sources: a measured or scaled drawing, a mocked-up project or an existing piece of furniture. Most cutting lists follow the convention of listing the:-
Part Name, Quantity, Length, Width, thickness and material to be used.

NAME:	NUMBER:	LENGTH:	WIDTH:	THICKNESS:	MATERIALS:
Top	1	1000mm	540mm	20mm	pine
Bread boards	2	540mm	96mm	20mm	" "
Legs	4	470mm	96mm	75mm	" "
Front and back rails	4	1050mm	60mm	20mm	" "
Side rails	4	450mm	60mm	20mm	" "
Slats	20	525mm	40mm	20mm	" "

Materials

Metals are usually classified into two main groups; FERROUS metals and NONFERROUS metals.

Ferrous•Metals
These metals contain iron and are affected by magnetism (apart from stainless steel); examples•of•such•are•Cast•Iron,•Mild•Steel,•High•Carbon•Steel,•etc.

Non-Ferrous•Metals
As•the•name•implies•(NON),•this•category•of•metal•does•not•contain•iron•and•is•usually•non-magnetic; examples are, Aluminium, Copper, Brass, Duralumin, Lead, Gold, Silver, etc.

Metals•can•also•be•grouped•into•two•categories:

Pure•Metals
Pure•metals•are•made•up•from•only•one•chemical•element.•Copper,•iron,•tin,•lead,•gold•and silver•are•all•examples•of•pure•metals•which•have•been•mined•from•the•Earth•and•extracted from•the•ore•using•a•process•called•smelting.

Alloys
An ALLOY is a mixture of pure metals or a metal with a substance such as carbon added; examples•of•alloys•are:- **Steel** (Iron•&•Carbon), **Duralumin** (Aluminium•&•Copper), **Brass** (Copper•&•Zinc)•& **Bronze** (Copper•&•Tin).

Alloying
Metals•are•alloyed•to•improve•the•qualities•of•the•individual•pure•metals•e.g.•both•copper•and tin•as•pure•metals•are•both•soft•metals•that•are•easily•bent•and•scratched.•When•alloyed together•(90%•copper•plus•10%•tin)•they•produce•bronze•which•is•hard,•rigid•and•resists scratching.•Bronze•is•used•for•our 'copper' coins.

Corrosion
When•choosing•metals,•resistance•to•corrosion•mat•be•an•important•factor.

Corrosion•is•caused•by•oxygen•in•the•air•combining•with•the•atoms•of•metal,•at•the•surface•of the•metal,•to•create•a•new•chemical•called•oxide,•e.g.•iron•oxide•is•called•rust.

In steel the rust layer is loose and can fall away; this exposes new atoms that will combine with•oxygen•to•form•new•rust.

In nonferrous metals the oxide layer is dense and does not fall away; this creates a barrier to•the•oxygen•in•the•air•and•new•corrosion•occurs•very•slowly.•The•layer•is•called•tarnish.

Properties
Both•physical•and•mechanical•properties•vary•greatly•between•different•metals•and•alloys and•are•an•important•part•of•the•selection•process.

Ferrous Metals

Name	Composition	Properties	Uses
Cast Iron	Iron + 3.5% carbon	Smooth skin with soft core, strong when compressed, self lubricating, cannot be bent or forged.	Vices, lathe beds, garden bench ends, car brake drums, etc.
Mild steel	Iron + 0.15 - 0.35 % carbon	Ductile, malleable & tough, high tensile strength , poor resistance to corrosion, easily welded.	Car Bodies, washing machine bodies, nuts & bolts, screws, nails, girders, etc.
High carbon steel (tool steel)	Iron + 0.8 - 1.5% carbon	Very hard, rather brittle, difficult to cut, poor resistance to corrosion.	Tool blades e.g. saws, chisels, screwdrivers, punches, knives, files etc.
High Speed Steel	Iron Tungsten Chromium Vanadium	Very hard, heat resistant, remains hard when red.	Drills, lathe cutting tools, milling cutters, power hacksaw blades etc.
Stainless steel	Iron Chromium Nickel Magnesium	Tough and hard, corrosion resistant, wears well, difficult to cut, bend and file.	Cutlery, sinks, teapots, dishes, saucepans, etc.

Non Ferrous Metals

Name	Composition	Properties	Uses
Aluminium	Pure metal	Good strength / weight ratio, malleable and ductile, difficult to weld, non-toxic, resists corrosion, conducts heat and electricity well. Polishes well.	Kitchen foil, saucepans, drinks cans, etc.
Copper	Pure metal	Tough, ductile and malleable. Conducts heat and electricity well. Corrosion resistant, solders well. Polishes well	Electrical wire, central heating pipes, circuit boards, saucepan bases.
Brass	Copper Zinc	Quite hard, rigid, solders easily. Good conductor of heat and electricity. Polishes well	Water taps, lamps, boat fittings, ornaments, door knockers.
Bronze	Copper Tin	Tough, strong, wears very well, good corrosion resistance.	Coins, wheel bearings, statues and boat fittings.
Tin	Pure metal	Weak and soft, malleable and ductile, excellent corrosion resistance, low melting point.	Solder (with lead), coating over mild steel (tin can).
Zinc	Pure metal	Poos strength/weight ratio, weak, ductile, and malleable, low melting point. Casts well.	Coating over mild steel (galvanising) die casings used in cars e.g. Carburettor.
Nickel	Pure metal	Corrosion Resistant, ductile and malleable, high melting point	Making alloys like stainless steel, machinery for large scale chemicals, batteries

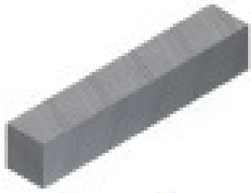
Form of Supply

Most metals are available in a wide variety of shapes and sizes and are usually described by their cross-section. i.e. what they look like when they have been sawn through.

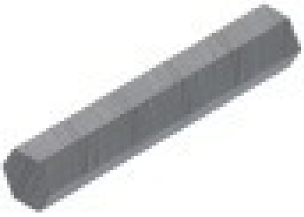
The following cross sections are typical examples of how metals are supplied to the school workshop.

Flat Bar

Round Bar



Square Bar



Hexagonal Bar

Octagonal Bar

Round Tube

Square Tube

Rectangular Tube

Angle Iron

Sheet

Tin plate, copper, brass, steel and aluminium are available in sheet form.

Metal Properties

Density:
The amount of matter (mass) in a material.

Density	Material
High	Gold, Lead
Medium	Copper, Steel
Low	Woods, Plastics

Thermal Conductivity:
how fast heat can travel through a material. If a material is known as an insulating material, heat travels very slowly through it.

Thermal Conductivity	Material
High	Copper, Aluminium
Medium	Mild Steel, Tin
Low	Woods, Polystyrene

Electrical Conductivity:
how fast electricity can travel through a material. A poor conductor is an insulator.

Electrical Conductivity	Material
High	Copper, Aluminium
Medium	Mild Steel, Tin
Low	Woods, Polystyrene

Fusibility:
The measure of how easy it is to melt the material. A highly fusible material has a low melting point.

Fusibility	Material
High	Tungsten, Chromium
Medium	Copper, Steel
Low	Zinc, Lead

Thermal Expansion:

The amount of expansion that occurs when the material is heated. A high expansion material will become noticeably larger when heated.

Thermal Expansion	Material
High	Polythene, Nylon
Medium	Aluminium, Tin
Low	Woods, Titanium

Mechanical Properties

Strength:

The measure of how well a material can withstand force without permanently breaking. There are different types of strength measurements.

Tensile Strength

Resists stretching by the pull of forces and is an essential strength for cables, chains and ropes.

Compressive Strength

Withstands pushing forces which try to crush or shorten.

Bending Strength

Has the ability to withstand forces attempting to bend.

Shear Strength

Resists strong sliding forces in opposite directions.

Torsional Strength

Withstands twisting forces under torsion (torque).

Malleability:

The measure of how easily a material can be permanently deformed by compressive forces e.g. hammering without cracking.

Malleability	Material
High	Copper, Aluminium
Medium	Mild Steel, Bronze
Low	Woods, Thermoset Plastics

Ductility:
The measure of how easily a material can be permanently deformed, without breaking, by bending, stretching or twisting.

Ductility	Material
High	Polypropylene, Copper
Medium	Mild Steel, Bronze
Low	Woods, Thermoset Plastics

Hardness:
The measure of how well a material resists scratching and being worn away by other materials.

Hardness	Material
High	Diamond, Chromium
Medium	Mild Steel, Bronze
Low	Woods, Thermoplastics

Toughness:
The measure of how well a material can stand up to sudden forces e.g. a hammer blow, without cracking.

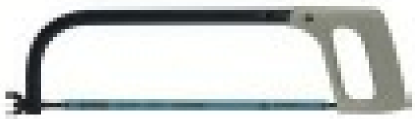
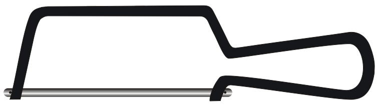
Toughness	Material
High	Polycarbonate, Copper
Medium	Mild Steel, Brass
Low	Glass, Polyester Resin

Brittleness:
The opposite of tough. Brittle materials cannot withstand sudden impact.

Durability:
The measure of how well a material stands up to weathering (the sun, cold, wind, rain, corrosion and rotting).

Durability	Material
High	Gold, Tin
Medium	Ceramics, Bronze
Low	Mild Steel, Softwoods

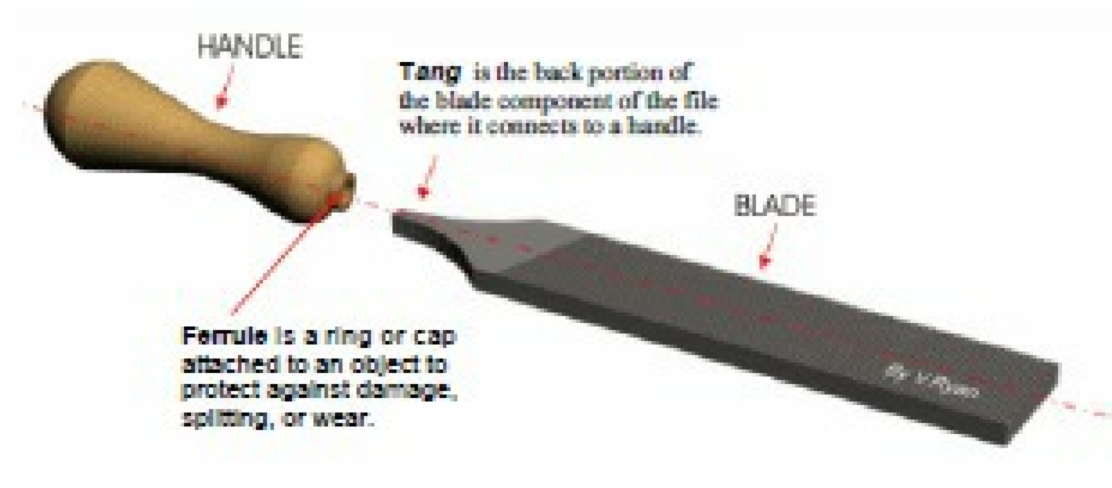
Bench Work
Tools and equipment

Tool	Description	Image
Engineer's Vice	The vice is bolted to the bench top so as to ensure the vice does not move while working on it. The vice is used primarily to hold metal while cutting, sawing, filing, etc. are carried out. As with the machine vice the body has also been CAST in two separate pieces.	
Ball Pein Hammer	This is a general use hammer although the ball pein end of the hammer is used specifically to round the heads of the snap head rivet.	
Hacksaw	The hacksaw is used for general cutting of metal bar, tubes, etc. The blade is easily removed by slackening or tightening of the front wing nut.	
Junior Hacksaw	This type of saw is also used for cutting metal but is used for light work or where a hacksaw is too clumsy.	
Cold Chisel	Cold chisels are chisels from metal and are made from high carbon steel.	
File	A **file** is a **tool** used to remove fine amounts of material from a workpiece	
Tap	A Tap is used for creating internal screw threads.	

Tool	Description	Image
Tap wrench	A **tap wrench** is a hand tool used to turn **taps** or other small tools, such as hand reamers and screw extractors	
Die	A die is used to cut an external screw thread	
Die stock	A double-handled **wrench** for turning the **dies** used in threading operations (cutting the male threads such as on a bolt).	
Rivet set and snap	This comes as a pair allowing you to set the rivet up and then from the rivet head.	

Files

Files are used to remove small amounts of metal and for smooting a surface after it has been sawn. They are made from high carbon steel and come in many shapes, sizes and grades of cut..



The most common files are named after their cross section.

Flat file

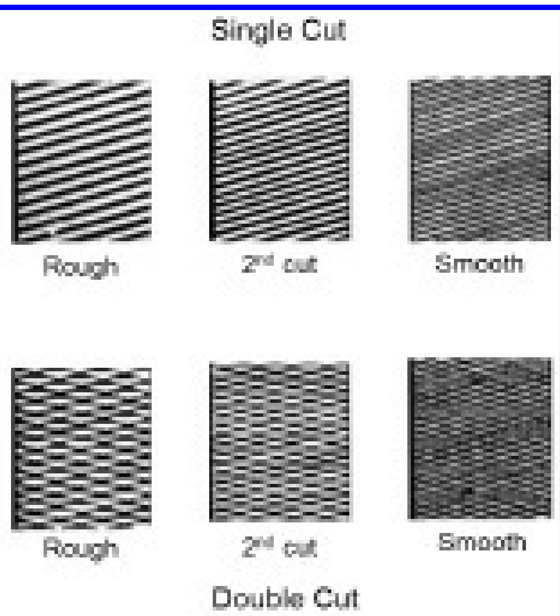
Round file

3 square file

Square file

Half round file

The roughness of a file is known by its cut.

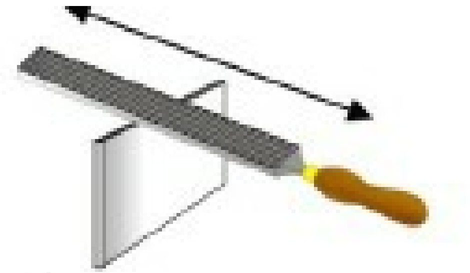


Rough cut
Used first to get rid of most of the waste quickly.
Leaves a rough finish.

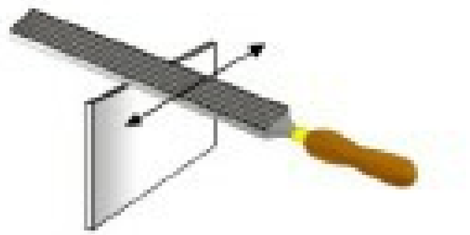
Second cut
Used to file closer to the line and for general work.
Leaves a reasonably smooth finish.

Smooth cut
Used to file to the line and to provide a smooth finish.

Cross filing
In this type of filing the file is moved across the work piece using the full length of the blade. This method of filing is used for removal of a lot of material with every stroke applied.

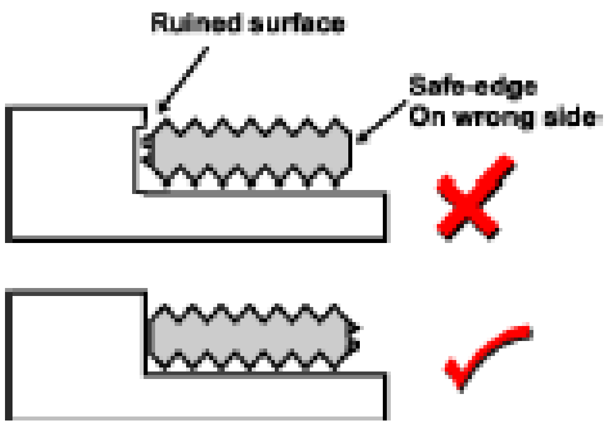


Draw filing
In this method of filing, the file is moved sideways along the work piece and is used to obtain a smooth finish after cross filing. This method does not remove much material.



Cleaning the file
Small pieces of aluminium or plastic can be trapped in between the teeth of the file. This is called pinning. A file card can be used to clear the file of the excess material. The file card looks very similar to a wire brush except the teeth are very short.

Safe edge
Some flat files have a safe edge. The safe edge is useful to use when filing into a corner. It stops the file from filing into the other surface.



Standard Screw Threads

The screw thread is a very important detail in engineering. It is used to hold parts together. (e.g. bolt & nut) and to transmit power (e.g. vice screw).

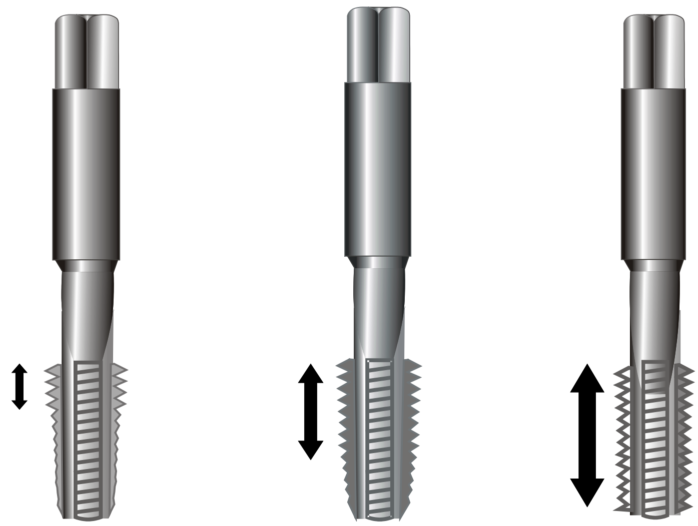
Screw Cutting

To achieve an internal screw thread, a hole has to be drilled first and then a tool called a tap is used to cut a thread within the hole. Taps are made from high speed steel (HSS). The top of the tap is square which enables the tap to be held securely in a tap wrench, which can be seen opposite.

Taps are generally available in sets of three and are used in the following order:-

1. **Taper Tap**
2. **Intermediate Tap**
3. **Plug Tap**

As can be seen in the taps above, the Taper tap has much smaller teeth at the bottom than the Intermediate or the Plug taps. This allows the taper tap to get started by making a shallower thread cut. The taper cut is followed by the second tap which has slightly more teeth. Finally, the Plug tap is used which will make the full thread cut. **Remember to use the correct cutting lubricant**.



Taper **Intermediate** **Plug**

Internal Threading

When tapping a thread in an internal hole the actual diameter of the hole to be drilled must be smaller than the actual overall size of the thread to be cut. An explanation of this is shown in the sketch opposite.

The drawing shows that if a hole was drilled which was the same size as the threaded bar, the bar would just fall through. The hole which must be drilled must therefore be smaller in diameter so as to allow the tap to cut the threads.

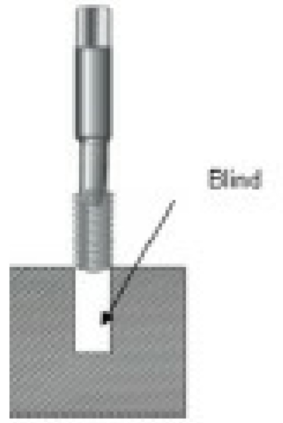
Drilling Data

The table below shows the diameter of hole which would be required to be drilled prior to tapping. E.g. if an M5 (Metric 5mm) thread has to be cut, the size of hole to be drilled will be 4.2mm.

ISO Metric Coarse Pitch Threads		
Diameter	**Tapping**	**Clearance**
M2	**1.6mm**	**2.5mm**
M2.5	**2.1mm**	**3.0mm**
M3	**2.5mm**	**3.5mm**
M4	**3.3mm**	**4.5mm**
M5	**4.2mm**	**5.5mm**
M6	**5.0mm**	**6.5mm**
M8	**6.8mm**	**8.5mm**
M10	**8.5mm**	**10.5mm**
M12	**10.2mm**	**13.0mm**

Blind Hole

A blind hole is a hole which has a bottom to it. If a blind hole is to be threaded it is very important to ensure that the depth of the hole is established before commencing to thread the hole. If this is not established it would be very easy to break the taps. A piece of tape attached to the tap indicating the depth is an ideal way of avoiding the tap from being broken by being forced into the bottom of the hole.



External Screw Cutting

In the previous few pages internal screw cutting was explored. External screw cutting will now be investigated. To cut an external thread on a metal rod a tool called a **DIE** will be used.

Circular Split Die

The picture opposite shows a split die, this is the most common type of die used in the school workshop. These are used for cutting external threads. The die is made from high speed steel (HSS). To assist in starting the thread cut, the split die has a split which enables the die to be opened slightly thus cutting a shallower cut.

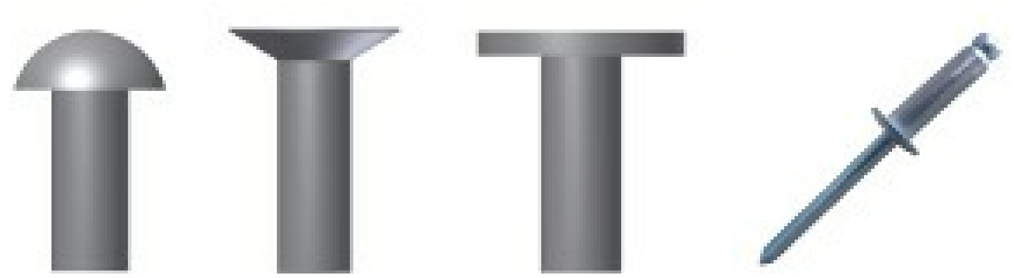
Die Holder or Stock

The circular split die fits into the die stock with the tapered side of the thread (shown by the writing on the die). The split in the die fits opposite the centre screw to allow the opening and closing of the die. The two screws at the side hold the die in the stock. To ensure the die can start to create a thread on the rod the rod must firstly be tapered at the end.

Riveting

Riveting is the process of joining two or more pieces of metal together permanently. The process uses metal plugs, more commonly known as rivets. To form the joint, the shank of the rivet is passed through a previously drilled hole in the components to be joined, it is then cut to size and spread or shaped, thus preventing the parts from separating. Sketches of the process are shown overleaf.

Rivets are classified by the shape of the head, their diameter and length. Common rivet head shapes are round (or snap), countersunk, pan and flat. Other types of rivet found in the workshop are bifurcated and pop rivets. In general the type of work at hand will determine the type of rivet to use.

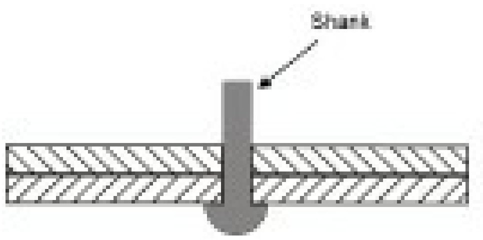


Snap Head **Countersink Rivet** **Flat Head** **Pop Rivet**

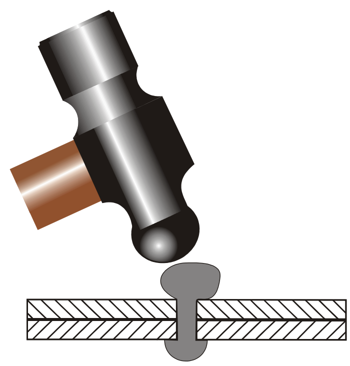
Rivets are made in most types of metal; e.g. mild steel, copper, stainless steel, brass, aluminium. When using a rivet always ensure that the rivet being used is the same material as the metals being joined or it will result in aggravated corrosion at the rivet site.

Snap Head Riveting Process

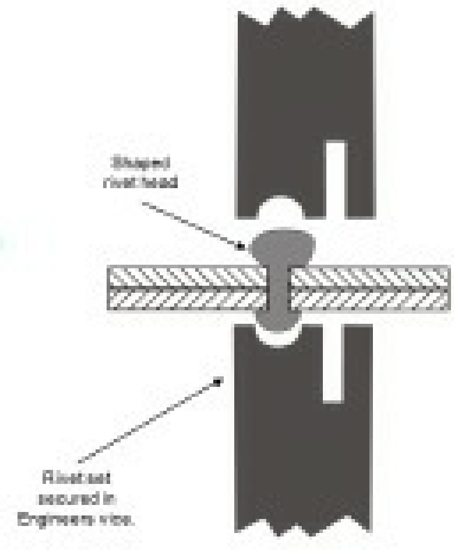
In the sketch shown opposite the rivet is placed through the two sheets of metal. The shank of the rivet is then cut to the desired length. This length is generally 1.5 times the diameter of the rivet. E.g. if the diameter of the rivet is 5mm then the length to be measured above the sheet metal on the shank will be **5mm x 1.5 = 7.5mm.**



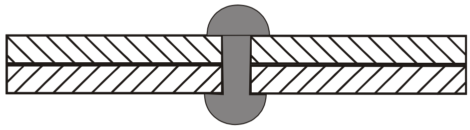
The next stage of the operation is to shape the shank of the rivet to the approximate shape of the final head using the Ball Pien hammer.



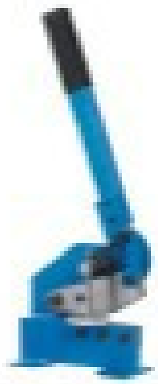
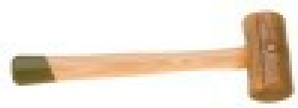
The•final•stage•is•to•place•one•rivet•set•into•an•Engineers vice,•place•the•rounded•head•of•the•rivet•into•the•indent•in•the rivet•set•as•shown.•Next•place•the•other•half•of•the•rivet•set•on top•of•the•shaped•head•and•hit•it•with•a•hammer•until•desired shaped•has•been•achieved.



The•sketch•opposite•shows•the•completed•riveting•of•two sheets•of•metal•using•a•snap•head•rivet.



Sheet metal tools and machines

Tool	Description	Image
Folding Bars	The folding bar is used when folding sheet metal in order to obtain a straight, neat bend. They are usually held in a vice for small scale work.	
Folding machine	A folding machine is a metalworking machine that allows the bending of sheet metal. Some models only allows for simple bends and creases, while others can have interchangeable blocks which also allows one to form box and pan shapes.	
Notcher	Notching is a metal-cutting process used on sheet metal or thin barstock, sometimes on angle sections or tube. A shearing or punching process is used in a press, so as to cut vertically down and perpendicular to the surface, working from the edge of a workpiece.	
Guillotine	A Guillotine, also known as a bench shear, is bench mounted blade with a long leaver making it easy to cut sheet metal. It is usually used for cutting rough shapes out of medium-sized pieces of sheet metal, but cannot do delicate work.	
Raw Hide Mallet	Is used to protect the surface from dents when bending meta.	
Rubber mallet	Is used to protect the surface from dents when bending meta.	

Tool	Description	Image
Tin•snips	Tin•snips•work•like•scissors•and use•a•shearing•action•to•cut•thin sheet•metal.•Straight•snips•are used•for•cutting•along•straight lines.	
Pop•rivet•gun	A•pop•rivet•gun•is•used•to•secure pop•rivets•in•the•piece•of•work.	

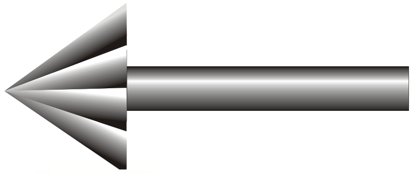
Spot•welding
Also•known•as•resistance•welding.•This•is•suitable•for•thin•sheet steel.•It•relies•upon•passing•a•current•through•the•sheets•of•metal and•heating•them•up•where•they•touch•each•other,•because•this•is where•there•is•most•resistance.•(Electrical•resistance•produces heat).
Two•electrodes•squeeze•the•sheets•together•and•then•pass•an electric•current•through•for•approximately•2•seconds,•then•hold•until the•weld•sets•(2•or•3•seconds)
Resistance•welding•does•not•produce•a•continuous•weld.•The result•is•like•a•line•of•tack•welds•30•to•40•mm•apart.

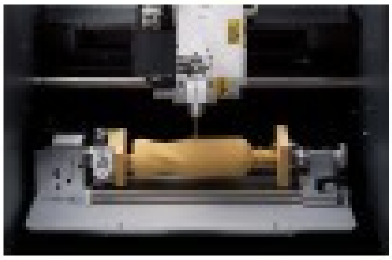
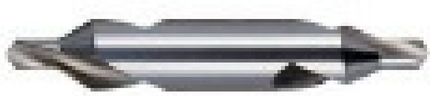
Tin•snips:
Curved•tin•snips
Curved•tin•snips•have•rounded•blades•designed•for•tasks•requiring cutting•curves•or•circles. They•are•often•similar•in•appearance•and design•to•straight•cut•tin•snips,•with•long•handles•for control.

Universal•tin•snips
Universal•tin•snips•can•be•used•for•straight•cuts•or long,•wide•curves. They•are•available•in•either•straight handled,•left•hand•cranked•or•right•hand•cranked versions. A•fail•safe•method•for•remembering•the•cut orientation•of•snips•is•as•follows, “the•snips•will•always cut•a•curve•in•the•direction•of•the•lower•cutting•blade”.

Machine processes

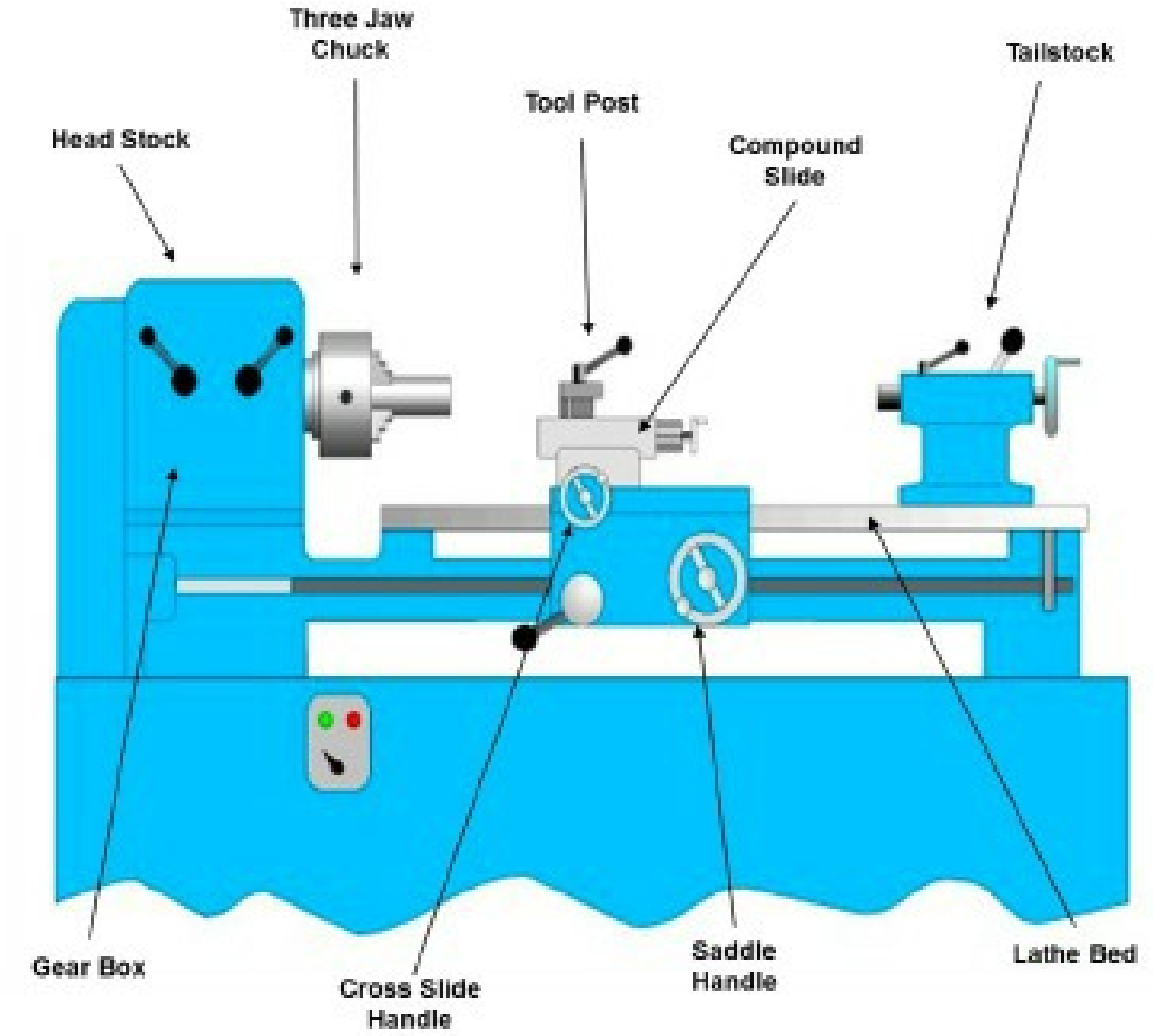
Tool	Description	Image
Hand Drill	The hand drill or wheel brace is used to hold and turn twist drills up to 8mm in diameter. The chuck has three self centring jaws which securely grip the shank of the drill.	
Portable Electric Drill	These drills are usually available in schools with a maximum chuck capacity of 13mm (i.e. can hold a drill diam. of 13mm maximum).	
Pedestal drill	Very similar to a pillar drill but mounted on a worktop or bench	
Pillar Drill	The adjustable table which holds the work piece can slide up or down and can be locked at a desirable height. Mounted on the floor.	
Drill Bit	Drills are manufactured from high speed steel (H.S.S.) or carbon steel and are used for drilling circular holes in metal, plastic or wood. • The most common type of drills used are the twist drills. These drills have three basic parts, a point, a parallel body and a shank which can be either parallel or tapered.	

Tool	Description	Image
Countersink Drill/Rose•bit	A•countersunk•drill•is•used•to•countersink holes•in•wood,•metal•and•plastics•to allow•the•accommodation•of•a countersunk•screw•head.•This•allows•the screw•will•head•sit•below•the•surface•of the•material.	
Bench•Grinder	A bench•grinder is•a benchtop type of grinding•machine used•to drive abrasive•wheels•used•for sharpening•cutting•tools•such•as tool bits, drill•bits, chisels,•and gouges. Alternatively,•it•may•be•used•to•roughly shape•metal•prior•to welding or•fitting.	
Centre•Lathe	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.or computer•controlled•lathes•(CNC machines)•that•have•been•programmed to•carry•out•a•particular•task.	
CNC•Lathe	Computer•controlled•lathes•(CNC machines)•that•have•been•programmed to•carry•out•a•particular•task.	
Milling•machine (vertical)	Milling•machines•are•very•versatile.•They are•usually•used•to•machine•flat surfaces,•but•can•also•produce•irregular surfaces.•They•can•also•be•used•to drill, bore,•cut•gears,•and•produce•slots. Milling•machines•are•very•versatile.•They are•usually•used•to•machine•flat surfaces,•but•can•also•produce•irregular surfaces.•They•can•also•be•used•to drill, bore,•cut•gears,•and•produce•slots.•In the vertical•mill the•spindle•axis•is vertically•oriented•.	
Milling•machine (horizontal)	This horizontal miller•is•used•when a vertical miller•is•less•suitable.	

Tool	Description	Image
Milling machine (CNC)	CNC milling is a specific form of computer numerical controlled (CNC) machining. Milling itself is a machining process similar to both drilling and cutting, and able to achieve many of the operations performed by cutting and drilling machines. Like drilling, milling uses a rotating cylindrical cutting tool.	
Laser cutter	*Laser cutting* is a precise method of *cutting* a design from a given material using a CAD file to guide it. There are three main types of *lasers* used in the industry: CO_2 *lasers,* Nd and Nd-YAG. his involves firing a *laser* which cuts by melting, burning or vaporizing your material.	
Plasma Cutter	Plasma cutting (plasma arc cutting) is a melting process in which a jet of ionised gas at temperatures above 20,000°C is used to melt and expel material from the cut. During the process, an electric arc is struck between an electrode (cathode) and the workpiece (anode).	
Centre Drill	This is a drill and countersink combined. It is used to drill a hole in one end of a piece of bar so as to accommodate the revolving centre as shown below. As it is not possible to punch holes prior to drilling the centre drill is used first.	

Centre Lathe

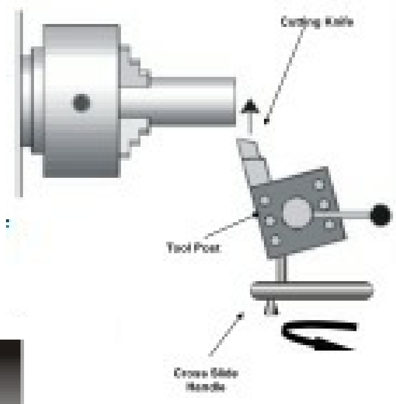
The purpose of a centre lathe is to shape metal bar into various desired shapes. A typical example is the nut & bolt assembly seen earlier in this booklet. The work piece (metal bar) is secured to a rotating three jaw chuck. The tools which are made from High Speed Steel (HSS) are secured in the tool post. An electric motor spins the work piece to which the cutting tools are then brought into contact with the metal bar.



The work, normally rotating towards the operator, can be set up between two centres which engage in countersunk holes at either end, or it can be gripped in a chuck or bolted to a face-plate. The cutting tool, mounted on top of the carriage, can be moved along the machine or square across it and these two motions perform the basic functions in the generation of a true cylinder. The lengthwise traverse of the tool is commonly referred to as 'sliding' which produces a round face and the cross-traverse as 'surfacing' (or `facing') which produces a flat surface. In addition to sliding and surfacing, the lathe can be used to produce tapered work, to cut screw threads, for boring and recessing, for profiling (shaping to contours), whilst the chucks and face-plates can be used in machining a variety of flat, cylindrical or irregular forms. A further range of operations can be undertaken by reversing the locations of tool and work, the tool rotating whilst the work is held on the carriage and brought up to the tool.

Facing Off

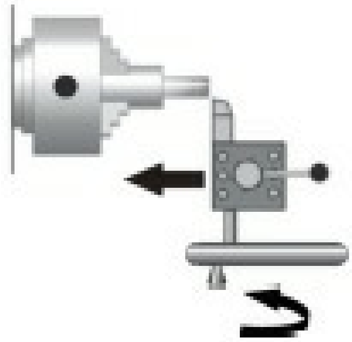
Before starting to shape the metal bar it is essential to face off the end of the bar. This basically means to make the end of the bar perfectly square to the sides of the bar.



When facing off a piece of round bar it is essential to ensure the cutting knife is lined up centrally to the piece of bar. If it is not a “**pip**” will develop which means the face of the bar will not be truly flat.

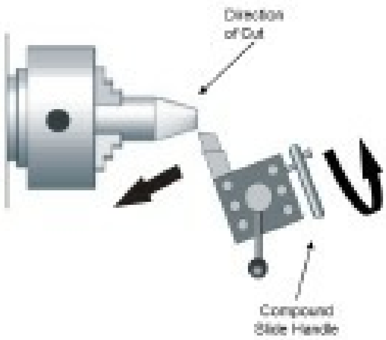
Parallel Turning

This technique moves the tool parallel to the centre axis of the bar as can be seen from the drawing.



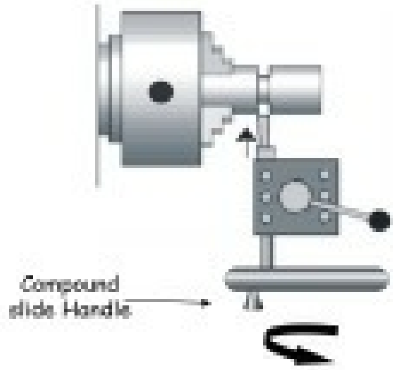
Taper Turning

This is where the tool moves along the bar at an angle moving further away from the centre axis of the bar.



Parting Off

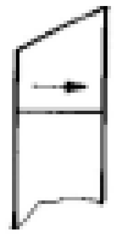
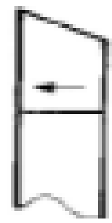
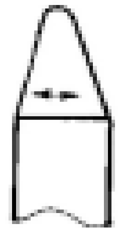
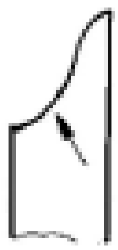
When all turning work has been completed the final task is to “Part Off” (remove the turned piece from the bar secured in the three jaw chuck).

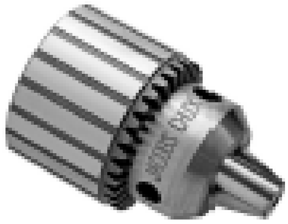
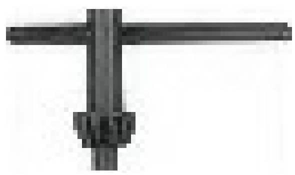


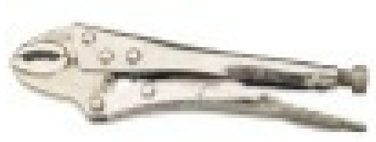
Chamfering
A•small•taper,•called•a•chamfer•can•be•put•onto•a•piece•of metal•by•sharpening•a•tool•up•to•the•required•angle.•This is•quite•useful•for•finishing•the•end•of•a•bar•off.•Instead•of a•chamfer•a•small•radius•could•be•put•onto•the•bar•by sharpening•up•a•suitable•tool.

Drilling•on•Centre•Lathe

When•drilling•on•the•lathe•the•drill•is stationary•and•the•work•revolves.•This•is the•opposite•of•a•pillar•drill.
The•drill•is•held•in•a•chuck•in•the tailstock•of•the•lathe.•The•work•rotates and•the•drill•is•moved•up•to•the•work•by turning•the•wheel•on•the•end•of•the tailstock.
Before•using•a•twist•drill•a•centre•drill should•always•be•used•on•a•slow•speed to•locate•the•centre•of•the•bar•being•drilled.•A•normal•twist•drill•does•not•go•to•a•point•and will•not•find•the•centre.

Tool	Description	Image
Left Hand Knife Tool	Left-hand knife tools can be used to cut to a left-handed shoulder or cut along the work from left to right.	
Right Hand Knife tool	Right-hand knife tools can be used to face off the right-hand end of a bar, to cut to a right-handed shoulder, or to cut along the work from right to left.	
Round Nose Tool	Round nosed tools can be used to cut in either direction and to cut to left- or right-handed shoulders where a radiused corner is wanted.	
Parting Tool	Parting uses a blade-like cutting tool plunged directly into the workpiece to cut off the workpiece at a specific length.	
Form Tool	Form tools can be specially ground to produce any required shape, such as the curved top of a turned screwdriver handle.	
Knurling Tool	Knurling is a manufacturing process, typically conducted on a lathe, whereby a pattern of straight, angled or crossed lines is cut or rolled into the material.	

Tool	Description	Image
3 Jaw Chuck	a device that holds a workpiece in a lathe or tool in a drill, having a number of adjustable jaws geared to move in unison to centralize the workpiece or tool.	
4 Jaw Chuck	Whilst the 4-jaw independent chuck is indispensable for holding work of irregular shape and for off-centre turning, it can also be used for holding squares or rounds. Centring takes a little longer but it can be done very accurately using each individual jaw adjustment.	
Jacobs chuck	This tool is placed in the tailstock of the centre lathe and is used to hold twist drills.	
Revolving Centre	The revolving centre is secured in the tailstock. The bar to be turned is secured at one end by the chuck and held in place at the other end using the revolving centre. The revolving centre allows the bar to rotate freely allowing turning between centres.	
Chuck Key - lathe	The tool used to tighten most drill and lathe chucks. A device used to loosen or tighten the bolts or cam locks on the chuck.	
Chuck Key - drill		

Tool	Description	Image
Machine Vice	This type of vice is used to hold heavier pieces of metal while drilling. The main body of the vice has been cast in a mould. The handle of the vice has been knurled.	
Hand Vice	This is used for holding small and especially irregular shaped parts while drilling, riveting etc.	
Toolmaker's clamps	These are used to hold parts together while marking out, shaping and drilling.	
Mole Grips	Mole grips, also known as 'locking pliers', are a hand tool with adjustable jaws which can be locked into place around an object to hold it firmly.	

Heat Treatment
When a metal is cold worked, i.e. when it is cut, beaten, hammered, bent, twisted or shaped, etc. at normal room temperature, tremendous internal forces are set up within its grain structure and the metal becomes extremely hard and liable to split. The term 'heat treatment' is applied to metals that undergo some form of heating process in order to change their properties.
Generally, any heating process carried out on a solid metal is referred to as heat treatment. Heat treatments involve processes such as annealing, normalising, forging, hardening, tempering, etc.

Work Hardened
If a material has been bent, hammered or twisted consistently over a period of time the metal will be **Work Hardened.** What is meant by this, is, the tiny molecules which make up the metal have been pushed and twisted out of their original positions thus making the metal very liable to breaking. This can be fixed by **Annealing** the metal.

Annealing
This process makes the metal as soft as possible to relieve the internal stresses, and make it easier to shape. The annealing process generally involves heating up to a certain temperature and allowing to cool, either in the air or in water depending on the material being annealed. If soap is applied to Aluminium prior to heating it will turn **Black** when the correct temperature has been reached.

Tempering
This process involves heating the metal to various temperatures and then immediately quenching it in water. As the metal is being heated it changes colour starting with a pale straw to dark straw to reddish brown to purple then dark blue. Dependant on what properties are required of the steel being tempered will determines what heat it will be heated to. E.g. when it reaches a dark blue colour it is at 300° C. These colours are known as TEMPERING COLOURS.

Case Hardening
Mild steel cannot be hardened and tempered as its carbon content is too low. What can be done is to provide it with a hard outer case. In this process the metal is heated to a bright red heat and then rolled in a carbon rich powder. The carbon is absorbed into the skin of the metal thus making it very hard on the outer skin. This type of metal is ideal for components such as gear wheels which require to be hard wearing.

Hardening
To enable carbon steel (i.e. tool steel) to be used for the wide variety of tools and articles that are necessary in the school workshop and in industry it must first be hardened, then tempered.
Taking a high carbon screwdriver blade for example, this is HARDENED by heating it slowly to a dull cherry colour and then quenching it in oil or tepid water. When this part of the process has been carried out, it is unusable. Although it is very hard it is also very brittle (i.e. it can break very easily). To make the hardened steel usable it must now be TEMPERED, i.e. given properties such as toughness, elasticity, strength.

Malleability
This is the ability of a material to withstand being hammered, rolled or bent without the material breaking.

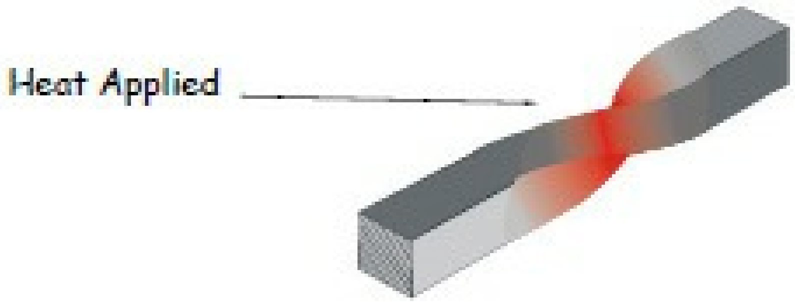
Ductility
This is the ability of a material to withstand being stretched without the material breaking.

Toughness
This•property•of•the•material•is•the•amount•of•energy•it•can•absorb•without•breaking•and measures•its•ability•to•withstand•shocks.• It•is•the•opposite•of•brittleness.

Flattening
This•involves•the•heating•and•re-heating•of•the•metal•bar•and•hammering•it•until•the•desired flatness•is•achieved.

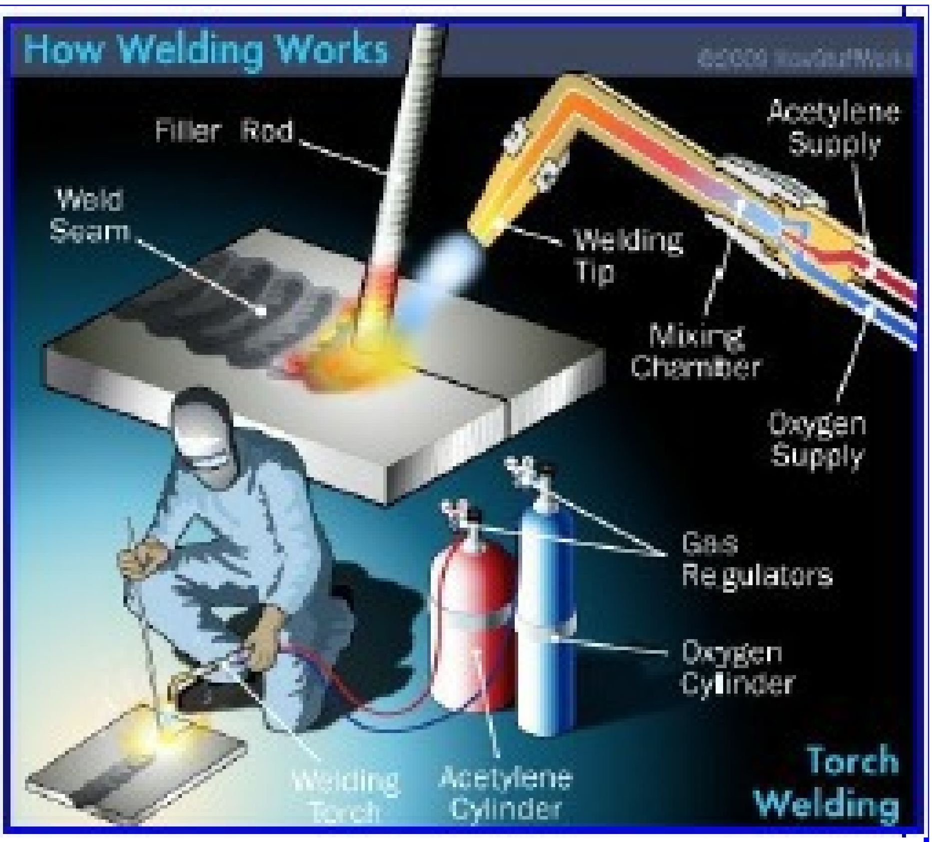
Drawing•Down
This•involves•the•heating•and•re-heating•of•the•metal•bar•and•hammering•it•until•a•desired point•is•achieved.

Twisting
As•can•be•seen•from•the•sketch•opposite,•the•metal•bar•is•heated•until•red•hot,•it•is•then twisted•to•the•desired•shape.



Welding

Welding is the process of joining two pieces of metal together using very high heat and an additional filler metal. The filler metal used must be the same type of metal being permanently joined.



Soldering

Soldering is the process of permanently joining two pieces of metal together using a mixture of tin and lead. Mixing these two metals reduces the overall melting temperature enough to melt the solder using a soldering iron (a heated piece of metal attached to a handle) .

Brazing

This process is very similar to soldering in that it uses an alloy heated to it's melting temperature to join two pieces of metal together. When Brazing, the filler metal used is called BRAZING SPELTER, which is an alloy of copper and zinc (BRASS). The heat is generated by the use of a blow torch.

Finishing

Types of finishes
The purpose of applying a finish to a piece of metal is to protect it from tarnishing or corrosion (rusting). Think of a metal artefact (say a bike) was to be constructed and left outside without any protective coating (paint), how long do you think it would take before it rusted? Not very long! Therefore metals have to be protected from rain, snow, etc. There is a number of ways of doing this depending on the type of metal being protected. The following examples are just some methods of protecting metals.

Painting
Paints are applied to bikes, garden gates, bridges, washing machines, etc because these artefacts are generally made from steel. Paints are usually applied this type of metal because they come in various forms and many colours.

Lacquering
This is very similar to varnishing, it can be applied with a brush or can be sprayed on. The purpose of using this type of finish, is, if the base metal has a nice colour to it e.g. copper or brass, it allows this colour to be seen but at the same time protecting it.

Bluing
This process involves heating the metal up and dipping it in a bath of oil, leaving it to cool and wiping dry with a cloth.

Oil Blacking
This traditional and simple process is normally applied to forged steel products. The steel is heated to a dull red and then quenched in a high flash point oil. The oil burns black onto the surface providing a thin protective skin that can be lacquered to provide additional protection.

Enamelling
This process uses powdered glass which is melted to flow over the metal to give a hard, colourful and protective finish.
Vitreous (stove) enamelling is used on steel for equipment such as cookers and provides a finish which is heat, chemical, wear and corrosion resistant. Enamelled jewellery is made using a base metal such as copper or gilding metal. Small enamelling kilns are used for this purpose.

Electroplating
Electroplating is used to give metals such as copper and brass a decorative, protective finish. The product to be coated is immersed in a metallic salt solution called and **electrolyte**. A current is passed between the metal to be used for the coating and the product causing deposits of the coating to be formed on the product. Electroplating us used for chrome-plating taps and silver-plating jewellery.

Anodising
Anodising is a process that is used on aluminium to thicken the oxide layer of the surface. It is an electro process similar to electroplating except that no other metal is introduced. Coloured dyes are added to the process to provide a colourful ‘metallic’ surface finish.

Plastic•Dip•Coating

If•a•ferrous•metal•is•left•in•the•atmosphere for•a•length•of•time•it•will•rust.• In•order•to prevent•this•from•occurring•a•barrier•has to•be•placed•between•the•metal•and•the atmosphere.• One•method•of•doing•this•is protecting•the•metal•with•a•plastic•coating. This can be applied to most metals and is used on wire metal baskets, racks and handles for tools such as scissors and pliers.

The coating process, **fluidisation**, takes place in a tank called the **fluidiser.** The tank contains powdered plastic with air passing through it, which makes the powder behave like a liquid. When the hot metal is dipped into the powder, it melts onto the surface and bonds to the metal.

Fluidiser

A•plastic•coating•is•applied•in•the•following•way:-

1. Thoroughly•clean•and•degrease•the•metal.
2. Heat•the•metal•to•180^{o} degree•C•in•an•oven.
3. Dip•the•metal•into•the•fluidised•plastics•powder for•a•few•seconds.
4. Return•it•to•the•oven•to•fuse•the•coating•to•a smooth•glass•finish.•Leave•to•cool.

If the surface finish appears gritty, the metal has not been heated to a hot enough temperature before dipping into the plastic.

Glossary