Bench-fitting Principles

The Sheffield College

Motor Vehicle

Introduction

The purpose of bench-fitting is to introduce you to the skills, techniques and knowledge that are all essential to help you become a more confident and competent mechanic.

As with every single course in College and every single trade or profession in the world, there will be certain tools or techniques that are used to perform that trade or skill.

For example, imagine a bricklayer or a hairdresser; what would it be like if they didn't know the correct way to use their tools such as a spirit level or scissors. Walls wouldn't be straight, or people would never go back there for a haircut again.

Imagine also what it would be like if they didn't know the correct names for their tools, how unprofessional it would sound in front of customers and how they wouldn't give the customer a very good impression.

People have a strong connection and reliance on their cars. For some people they are essential to get to work, pick their children up, go to the shops, even to make a living. So just think how the customer would feel if they saw you unable to use your tools properly while fixing their car?

Think to yourself how that customer would feel and what they would think if they overheard you talking and you didn't know the correct names for the tools or techniques you were using. You will also have to discuss repairs, costs and procedures with customers when they bring their vehicle to you for repair.

It is all about creating the right impression and creating a professional appearance for the customer to make them feel happy to bring their vehicle to you for repair and for them to feel confident that you have done the correct repairs to their car.

The happier and more confident a customer is, the more money you will be able to make. They will keep coming back to your garage, they will tell their friends and family and even post reviews for you.

You probably have a Facebook account or other social media, think how people leave reviews and how at times they can close a business because of how quickly that information or review is shared.

It is also essential to gain these skills as they are an essential part of employment in the first place. You will need to be confident in the technical terms and information, to be able to show your skills and impress those people who may interview you for that job that you really want.

Content

Many of the technical trades within the motor industry and mechanical engineering must learn bench-fitting skills. In the course and during the workshop practical sessions you will be able to:

Learn how to identify the different tools:

This is essential for you to be able to ask for, buy or even search for the right tools for the tasks that you are doing. Knowing the correct tool for the job.

Learn how to use the tools correctly:

You will need to be able to use all kinds of different hand tools safely, effectively and to ensure that you do the repair or maintenance task to the highest standards. This also helps to keep you safe and prevents you from causing any damage that may be expensive to repair or cause any further danger.

Learn the correct names and parts of the tools:

You will learn the correct names for the tools and the parts of them to help your professional development and to help your understanding of working as a motor vehicle mechanic.

Learn how to care for the tools:

A mechanics tools can be very expensive to buy, if you are able to care for your tools and use them properly they should last a very long time. They will always be there when you need them, you know that if you have looked after your tools, they will be safe for you to use. It will save you money and time in the long term.

Sometimes in repair and maintenance procedures there may be a requirement for you to make a tool yourself because you cannot buy one to do the job safely or because you have identified a need for a special tool to do a job. All the tools that a mechanic uses will have been invented by someone else, spanners, sockets, ratchets, files, hammers; these have been invented, designed and made to do a job. You may invent a tool to do a job and to be able to make that tool, you need to have skills in bench-fitting.

What would you make the tool from? What kind of material would you use? Does it need to be hard or soft, rigid or flexible? Is it straight or curved? Has someone made the tool before and created an engineering drawing?

It is important that you can read, interpret and follow engineering drawings as part of your skills as a mechanic. Engineering drawings are not only used in bench-fitting but also repair and maintenance procedures.

Engineering drawings are used in many ways:

For making specialist tools.

For modifying vehicle parts to improve performance, reliability or safety.

For adapting or changing vehicles to suit a role, such a converting a small van into an ambulance or a rescue vehicle.

For fitting extra parts to a vehicle following a manufacturer recall or safety programme.

There are many different materials used in the manufacture of a motor vehicle, can you think of some of the materials that are used and where you would find them?

Material	Where it would be used

If you understand the materials that are used in making tools and vehicle parts you will have a better understanding of how to make a tool, how to perform an effective repair and how to ensure the material can be protected from damage to ensure it works properly when you have finished.

During the bench-fitting practical sessions, you will learn how to make two different tools that you will be able to keep in your own toolbox and give you the opportunity to develop, practice and learn new skills as a trainee mechanic.

Tools

Many people think that as a mechanic, you will need to have a huge toolbox filled with many different and expensive tools. Something like the pictures below:

Many of the tools in the pictures above are expensive and contain many different tools, many of which may be specialised tools and test equipment that may not be required for the day-to-day mechanical repair and maintenance tasks. The following picture and tables show the contents of a typical mechanics toolbox for general repair and maintenance procedures. Look in the workshops at the tool lockers, are they filled with large amounts of tools or do they contain only the essential hand tools?

The Basic Toolbox

The basic toolbox required looks similar in size to the one in the picture below:

It is sturdy, small enough not to take up too much space, it has a lock and a handle to allow it to be easily carried. It is metal and will withstand knocks and drops and if required can be used as a seat or a step.

Contents

Essential	Desirable
Combination spanner Metric, 8 – 19mm.	Combination spanner imperial, 1/4" - 15/16" AF.
Socket 3/8" square drive, 6-point Metric, 11 – 17mm.	Socket 3/8" square drive, 6-point Imperial, 7/16" – 3/4" AF.
Extension bar 3/8" square drive, 75mm / 3 Inch, 150mm / 6 Inch, 300mm / 12 Inch.	
Ratchet 3/8" square drive.	
Knuckle bar / swivel handle 3/8" square drive.	
Universal Joint 3/8" square drive.	
Drive adapter 1/4" Female to 3/8" Male.	
Drive adapter 3/8" Female to 1/2" Male.	
Extra deep socket 3/8" square drive, 11mm.	Extra deep socket 3/8" square drive, 7/16" AF.
1/4" Square drive socket set, with Metric sockets 5 – 10mm.	1/4" Square drive socket set, with Imperial sockets 3/16" – 3/8" AF.
1/4" Square drive Hex bit and adaptor, Metric bits 3 – 6mm.	1/4" Square drive Hex bit and adaptor, Imperial bits 3/32" – 1/4" AF.

Contents

Essential	Desirable
1/4" Square drive ratchet.	
1/4" Square drive extension 150mm / 6".	
1/4" Square drive Screwdriver bit standard blade 3, 4, 5mm.	
1/4" Square drive Screwdriver bit Pozidrive 1, 2, 3.	
1/4" Square Drive universal joint.	
Ball pein hammer 680gr / 1 ½ lb.	
Electrical Multimeter.	
Hand torch.	
Trimming (Stanley) knife with spare blades.	
Junior hacksaw with spare blades.	
Hacksaw frame and 12" blades, 18 t.p.i.	
Metric feeler gauges.	Imperial feeler gauges.
Engineer's 12" / 30cm steel rule.	Engineer's 6" / 15cm steel rule.
Nippers diagonal.	
Snipe Nose pliers.	
Combination pliers.	
Mole grips.	
10" Stilson wrench.	
8" Bastard file and handle, half round.	
8" Bastard file and handle, round.	
Brass drift 3/8" & 1/2" diameter 6 ½" long.	
Centre punch.	
Pin punches 150mm / 6" long, 3, 4, 6mm & 5/16" diameter faces.	
Cold chisel 150mm / 6" long, 10mm wide.	
Cold chisel 200mm / 8" long, 19mm wide.	
Adjustable spanner 4" & 12" long.	
Stubby screwdriver Phillips drive, standard drive 6.3mm tip.	
Electricians insulated screwdriver 3.15 & 5.5mm blade.	
Phillips screwdriver N° 1 & 2.	
Screwdriver standard blade 6mm X 100mm long. 8mm X 150mm long.	
Spanner double open end 10 / 11mm & 13 / 17mm.	
Spanner double open end 7/16" / 1/2" AF & 9/16" / 5/8" AF.	

Engineering Hygiene / Housekeeping

As with every practical session in the workshop, engineering hygiene and housekeeping is an essential skill to ensure that best practices and health & safety procedures are followed. List below some of the examples of engineering hygiene or housekeeping that you would undertake in bench-fitting:

1.
2.
3.
4.
5.
6.
7.
8.

PPE

What items of PPE do you think would be required or used during a bench-fitting practical lesson?

1.
2.
3.
4.
5.
6.

Hammers

Safety Information:

Hammers are striking tools and as such can be dangerous. Before use you must:

1. Ensure that the hammer is not damaged, the head is secure and is free from any defects or chips.

2. Ensure that you are wearing safety goggles and that any tool you are striking is correct for the job (screwdrivers are not to be used as a chisel)!

3. That you have a firm grip on the hammer and that it is safe to use the tools in the areas that you are working (sparks can be made from striking tools and can cause an explosion)!

4. Hammers have hardened steel faces and as such should not be struck against another hammer or hardened material.

5. When using a soft faced hammer, ensure that the soft face is secure and is not excessively damaged.

6. Avoid using a hammer at an angle, the face or surface to be struck should be square to the hammer face.

7. If the tool is damaged or is unsafe either report it or replace it.

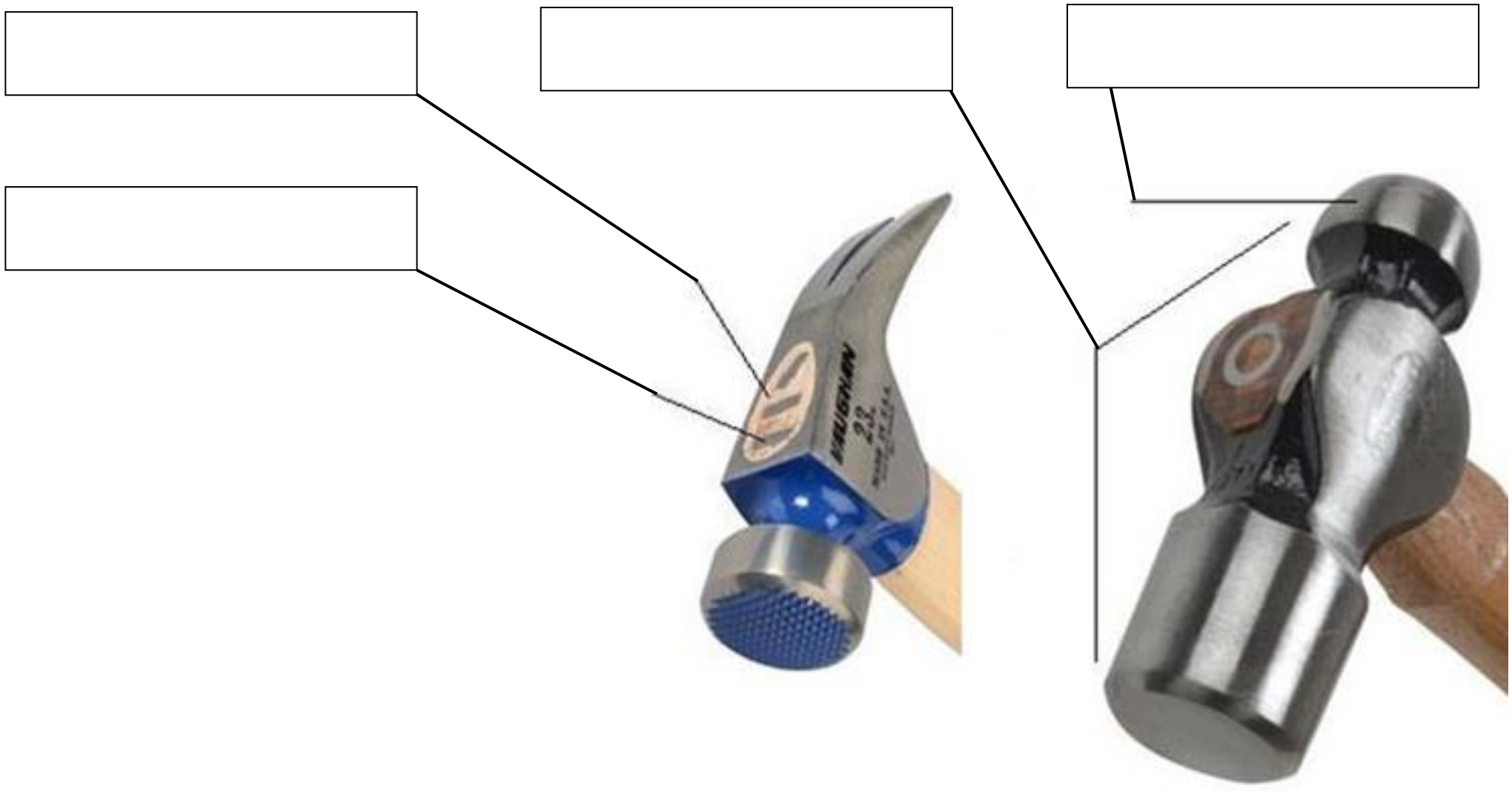
Types of hammer:

In the following pictures you will be shown a couple of different types of hammers, there are a few parts that are called the same on all hammers.

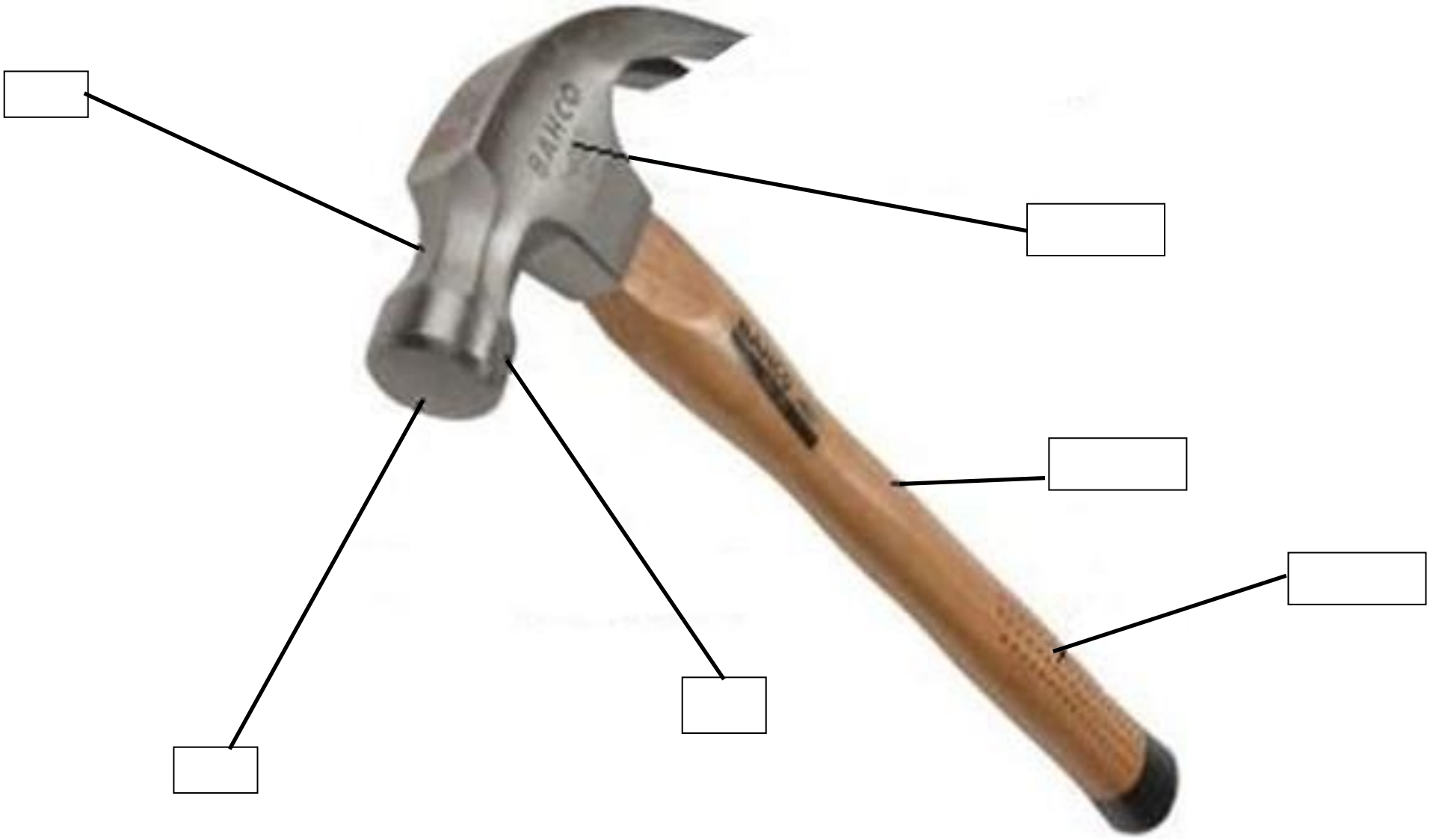
In the table below can you name the different hammers that would be used in the workshop and what they would be used for?

Name of hammer	Where or how it would be used

Naming the parts:



Naming the parts:



Chisels and Punches

Safety Information:

Chisels are struck tools and as such can be dangerous. Before use you must:

1. Ensure that the head of the chisel has been dressed and is not mushroomed.

2. Ensure that you are wearing safety goggles and that any tool you are striking is correct for the job (screwdrivers are not to be used as a chisel)! Heavy duty gloves should also be worn, to protect your hands and fingers.

3. The chisel cutting edge is sound, free from chips and has been sharpened correctly.

4. You maintain a firm grip and use only reasonable force when striking the head of the chisel.

5. To maintain an accurate strike and avoid hitting your hand, fingers or any other surface, keep your eyes on the tip of the chisel.

6. Remember to keep checking on the work to see if the chisel is performing correctly and to check the head and cutting edge periodically while using the tool.

7. Be aware the punches and chisels when being struck can cause sparks, do not use in an explosive atmosphere.

8. Always try to ensure that the chisel is at the right angle and is square to the work, do not use at an acute or steep angle, this may cause the tools to slip resulting in injury to you or damage to the work.

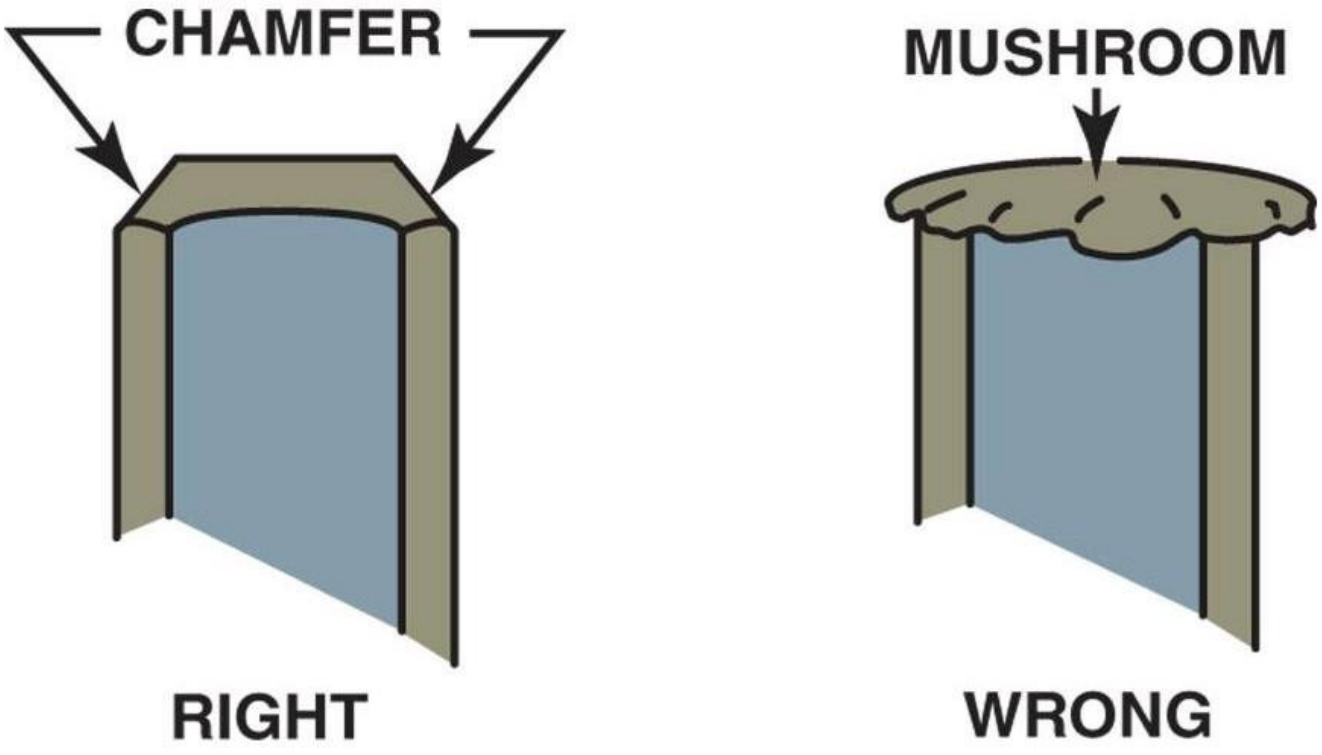
9. Always strike the head of the chisel squarely and at 90 degrees to the head.

10. When using a chisel, hold the tool at an angle of approximately 45 degrees to the work, if the angle is too steep it will not cut, if it is too shallow it will slip.

Mushroom head:

As the head of the chisel or punch is being struck, it will cause a mushroom effect of the metal being peeled over. This can be seen in the following pictures. Give a brief explanation of the dangers with mushroom heads on chisels and punches and how they are repaired:

Mushroom head:



Dressing a damaged head

If a chisel or punch has a damaged head, it must be repaired so that it is safe to be used in the workshop. This is done by using the bench grinder to remove the damaged area and make the tools safe to use.

If you find a damaged tool in the workshop, please report it to either the tutor or the workshop technician for it to be repaired. You will be given a demonstration and guidance on the safe use of abrasive wheels on the Level 1 Motor Vehicle Course.

The following image shows a damaged chisel in the process of being dressed:

The damage to the head has been removed by using the bench grinder, this has safely removed the mushroom effect.

Bench grinder in use

The image below shows a bench grinder being used to remove a mushroom head:

The chisel is being held against the tool rest, with both hands to ensure a safe grip and is standing at right angles to the grinder.

The safety screen and safety goggles are worn to prevent any injury to the eyes. Gloves can be worn to protect the hands, but only if it does not affect your ability to grip the tool safely.

Types of chisel

Just as there are many different types of hammers used in the various trades that use hand tools, there are also many different types of chisels used by different people for different purposes.

The type of chisel used by a mechanic is called a 'Cold Chisel'. It is called a cold chisel because it is used with cold metals, meaning that it hasn't been heated in a forge or other method. It is used when a hacksaw or file is not suitable for the task.

The images below, show the different types of cold chisel used by mechanics:

Flat Cold Chisel

This chisel has a flat cutting edge, these are used for removing excess metal in metal bar or rods, like removing excess wood with a wood chisel. They can also be used for removing sharp burrs or cutting sheet metal that is too thick to cut with tin snips. Another use is to remove difficult rivets or seized nuts and bolts.

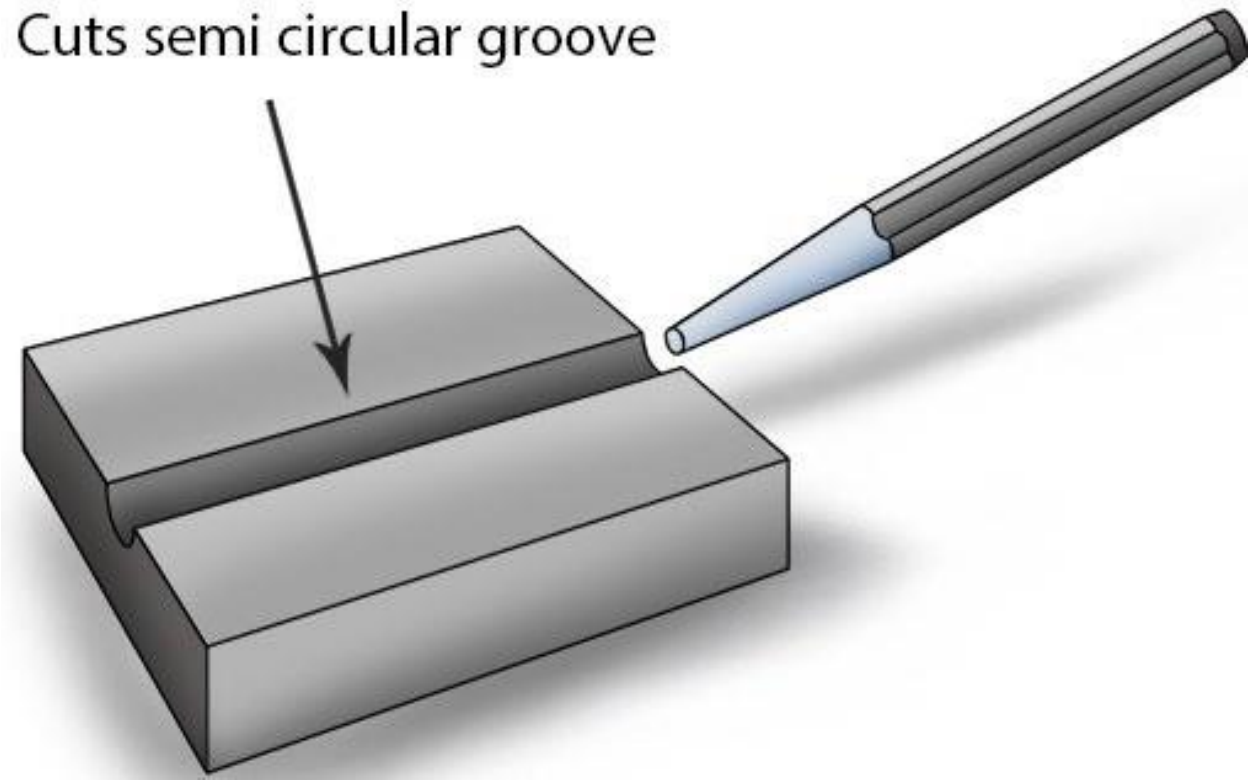
They can come in a different variety of length and width of the cutting edge. Typical lengths are 4, 6, 8 and 10 inches long with a width between a ½ and 1 ½ inches.

A cross-cut chisel

This chisel has a very narrow cutting blade in a diamond shape. This is used to cut a groove or a channel in a piece of metal. The cut would have square edges like a trench.

Another type of chisel used to cut a groove or a slot in metal is the round nose chisel. This would be used for cutting oil galleries in bearing journals, the shape of the cut is shown in the image below.

A round nose chisel

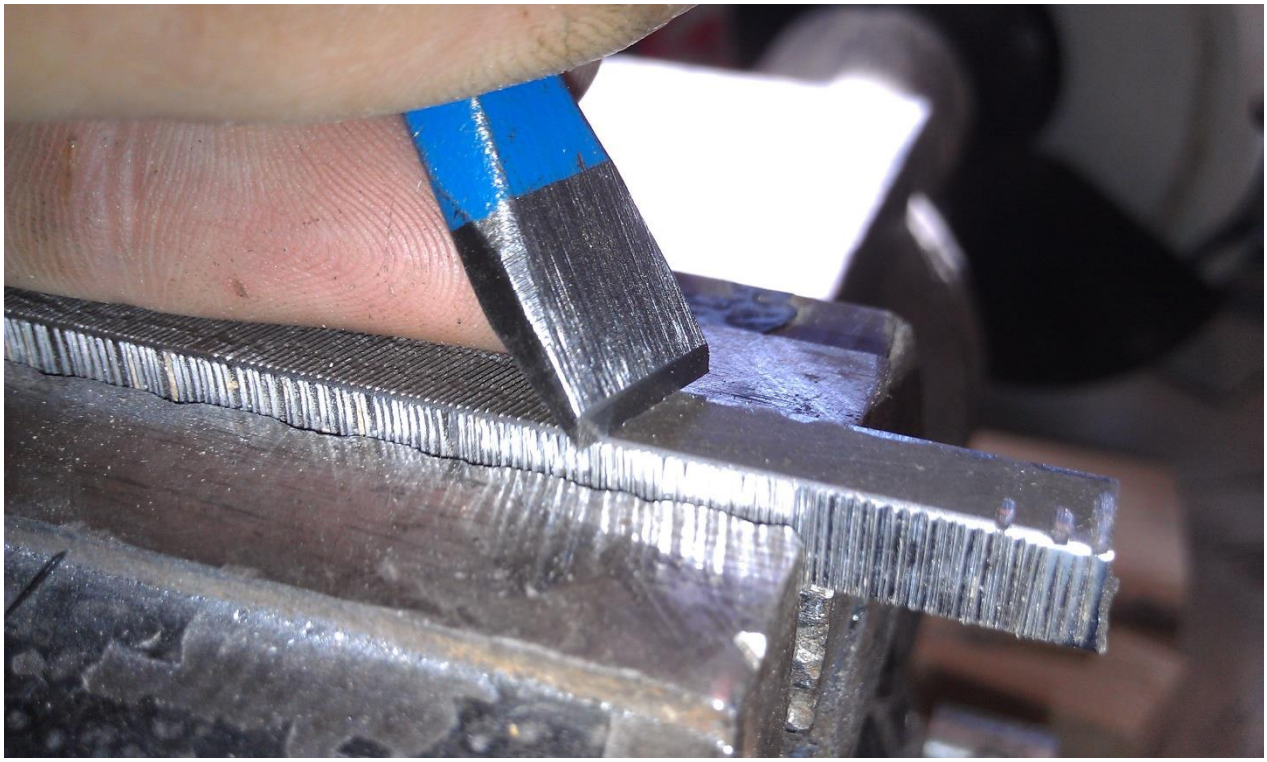


Diamond cut chisel

As you can see in the image above, this cold chisel has a specially shaped tip for getting onto sharp corners and areas where other chisels cannot reach. It can be used for removing excess weld or splatter in right angle corners for example.

Cutting a piece of bar

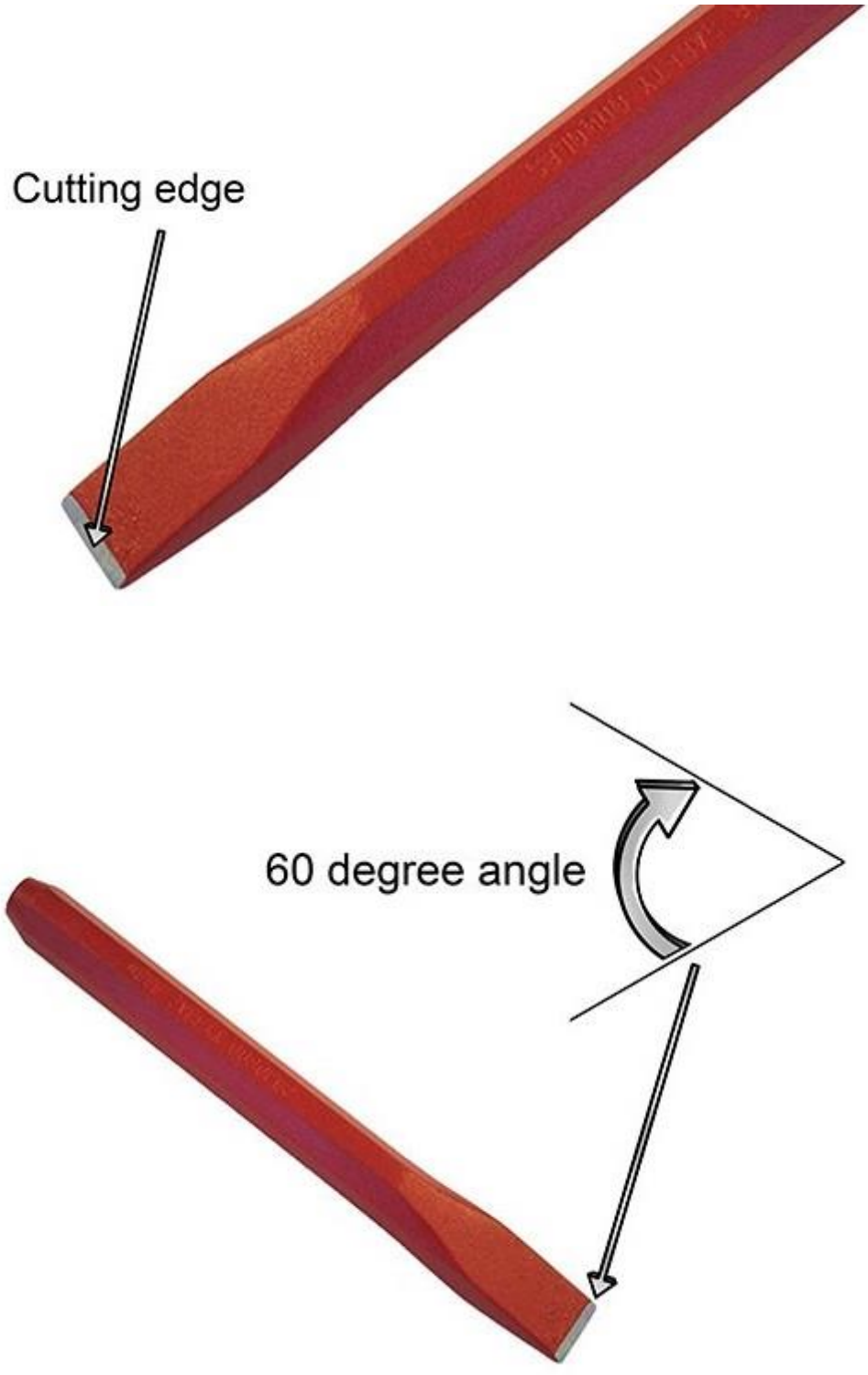
The image below shows a piece of metal being cut with a flat cold chisel to remove excess material.



Cutting angle

A cold chisel is a cutting tool, as it is used for cutting the edge may require sharpening or where it has been damaged by a harder material, re-dressing and re-cutting. This is done using the bench grinder and will be demonstrated on the Level 1 course.

Because the cutting edge is required to remove metal there needs to be an optimum cutting angle. For a flat or crosscut cold chisel this is ideally 60 degrees. The picture below shows the correct cutting angle of the flat chisel cutting edge.



Damage to the cutting edge

Damage to the cutting edge can happen when the chisel is struck against a material that is harder or with excessive force and this may blunt or damage the cutting edge. The picture below shows typical damage.

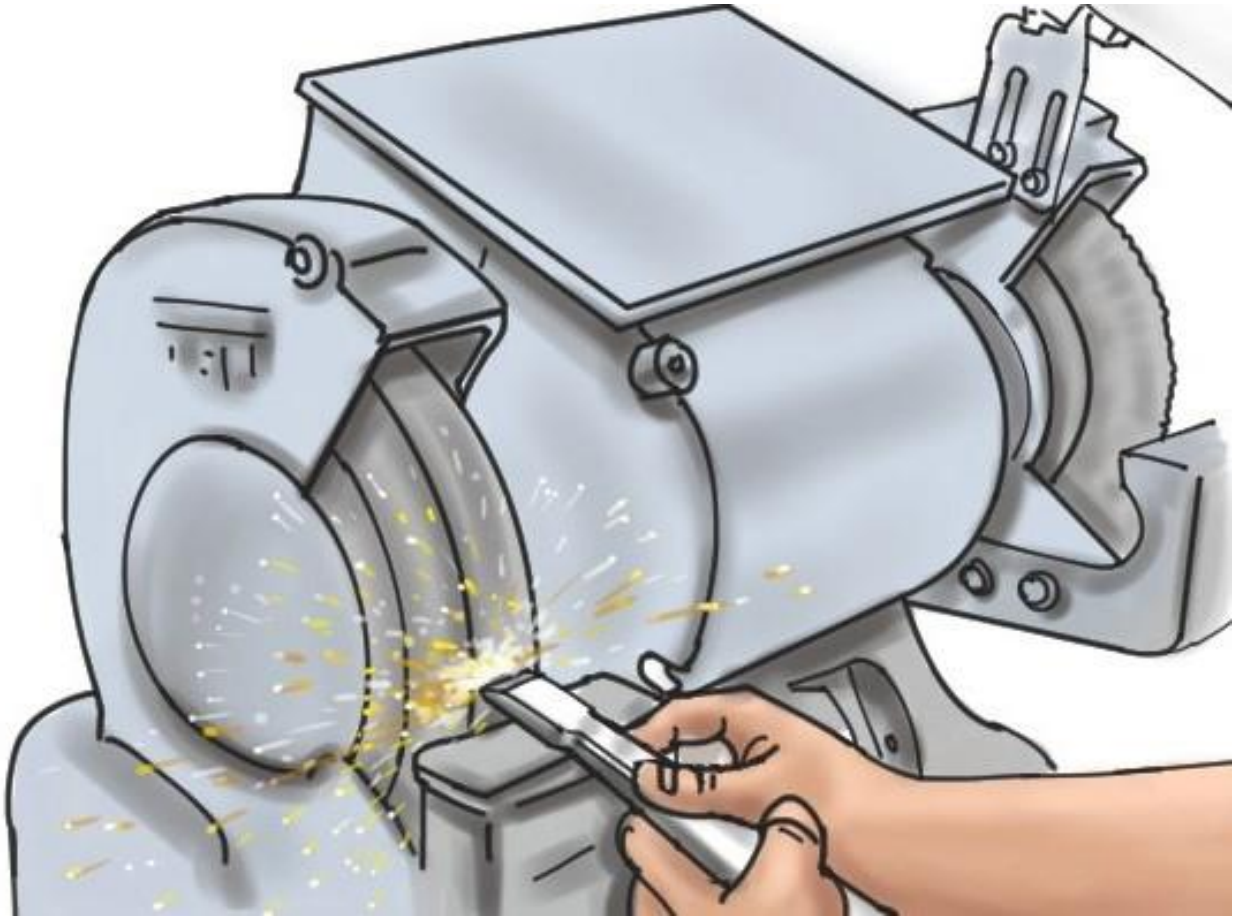
The cutting edge of the chisel is not straight and has been damaged in use. This will need to be ground and sharpened using either the bench grinder or files and whetstone. Using the bench grinder is quicker and easier.

Dressing the cutting edge

When the cutting edge is no longer straight it will need to be dressed. The chisel is held at right angles to the grinding wheel to remove any uneven wear and to present a square edge for sharpening. The picture below shows the cutting edge being dressed.

The chisel should not be pressed against the grinding wheel using anything more than a gentle pressure with a firm grip. Pressing on the wheel will damage the hardness of the metal and can cause damage to the grinding wheel.

Dressing the cutting edge



Once the cutting edge has been squared off, the correct cutting angle of 60 degrees will need to be ground into the chisel. As before, only a light pressure with a firm grip should be used to offer the tool to the grinding wheel.

The tool should be placed against the tool rest and inspected regularly to ensure an even and accurate ground surface is produced. Remember that both sides of the chisel will have to be ground equally to produce an accurate cutting edge.

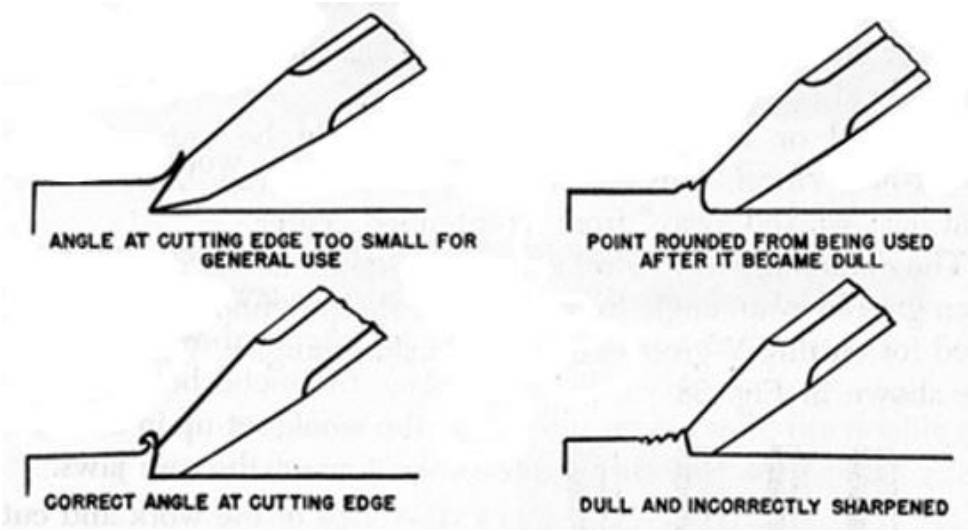
The image below, shows the cutting edge of the chisel being ground. Eye and hand protection should be worn whilst performing this procedure. The tool should be inspected and if required dipped in cold water between grinding applications to prevent the cutting edge from overheating.

Grinding the cutting edge angle

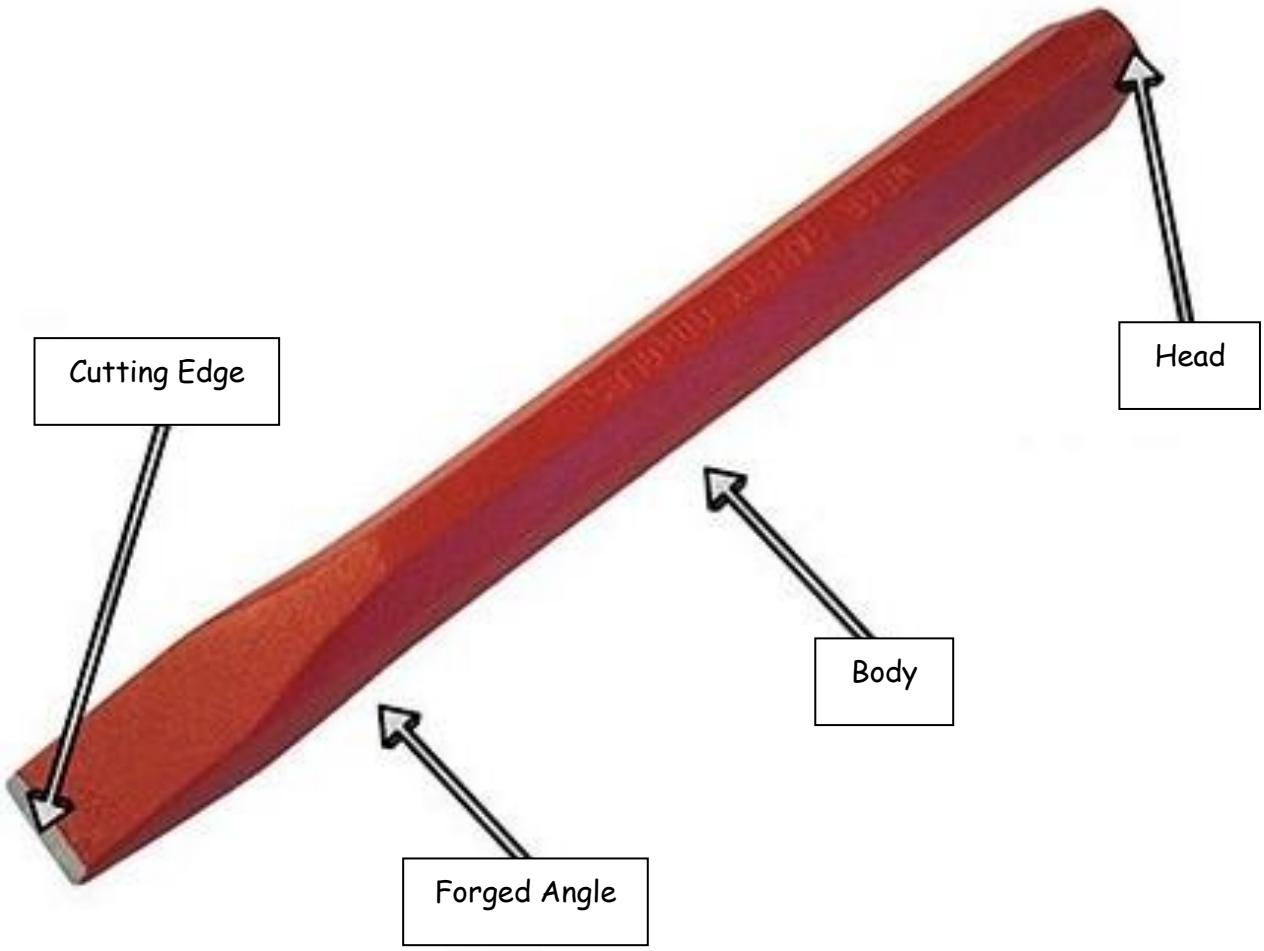
The chisel needs to be offered to the wheel at the correct angle to create the 60 degree cutting angle.

Application

The diagram below shows the correct angles and why the cold chisel cutting edge needs to be sharp.



Naming the parts



Punches

Punches come in a variety of different diameters and lengths and for different purposes. The main job of a punch is to remove pins or other mechanical fasteners or can be used to drive a mechanical fastener such as a roll pin into a hole.

These tools are struck with a hammer and as with a chisel, as the head or even the tip starts to deform or mushroom, they must be dressed.

They are made from hardened steel and the same safety precautions must be followed:

Safety Information:

Punches are tools which are struck and as such can be dangerous. Before use you must:

1. Ensure that the head of the punch has been dressed and is not mushroomed.

2. Ensure that you are wearing safety goggles and that any tool you are striking is correct for the job (screwdrivers are not to be used as a punch)!

3. The faces of the punch are square, free from chips or cracks and are not bent.

4. You maintain a firm grip and use only reasonable force when striking the head of the punch.

5. To maintain an accurate strike and avoid hitting your hand, fingers or any other surface, keep your eyes on the tip of the punch.

6. Remember to keep checking on the work to see if the punch is performing correctly and to check the tip and striking head while using the tool.

7. Be aware the punches when being struck can cause sparks, do not use in an explosive atmosphere.

8. Always try to ensure that the punch and strike is square to the work, do not use a punch at angle, this may cause the tools to slip resulting in injury to you or damage to the work. The diameter of the punch should be either equal to or greater than the piece that you are removing.

9. Always strike the head of the punch squarely and at 90 degrees to the head.

Types of punch

A mechanic will typically use two types of punch. The first is a parallel punch, it is made from hardened steel and come in a variety of different lengths and diameters depending on the work requirements. The other type of punch that a mechanic would use is a centre punch.

They can either have a hexagonal or knurled body to assist in the grip or holding the tool. The following images show the different types of parallel punch that may be used:

Hexagonal body parallel punches

Knurled body parallel punches

Centre punch

This is used for marking a piece of material prior to drilling. The purpose of this is to mark where the hole needs to be and allows the drill bit to be centralised on the work.

It provides a reference point and shows the mechanic where the hole needs to be drilled as well as ensuring that the work does not slip under the drill bit when using a pillar drill and helps to stop the drill bit from slipping when using a hand drill.

The following diagram shows a typical centre punch:

The punch is made from hardened steel, it has a knurled body for grip and a square head to allow it to be stuck firmly with a hammer. The tip is pointed to ensure accuracy when placing onto the work and to allow a small indentation to be made.

How to use

The centre punch is placed onto the work where the hole is to be drilled, the fine point allows the mechanic to ensure that the punch is in the correct place left to right and front to rear, a gentle tap is then made using a hammer to make a small punch mark.

Moving the punch away, the mechanic will look at the mark and make sure that it is central to the measurements and markings that they have made. Placing the centre punch back onto the punch mark, the centre punch is hit with a hammer again to make a more prominent or bigger mark. This requires only a gentle or reasonable tap, it is to make a mark. It is a centre punch and not a tent peg.

If the tip becomes blunt, it can be sharpened again with either a bench grinder or a hand file. The head can also be dressed if it has become mushroomed over time.

There is one other tool that is like the parallel punches that is used by mechanics. These are known as a brass drift. It is made from brass and as it is a softer metal than steel it is used where a parallel punch may damage a surface or component.

Similar in principle to using a soft faced or rubber / nylon mallet to remove or install a component, the brass drift is used where a parallel punch would be impractical. For example, fitting a bearing onto a shaft or removing a woodruff key.

Should a small piece of the drift break off while being used, as it is soft metal it would not cause damage to the components such as the bearing race. A small piece of steel could be harder than the bearings and this may cause premature damage.

The following image shows a typical brass drift:

They are available in different diameters and lengths as required for the task, they can have a knurled section to improve grip while they are used. When the head and face become mushroomed, they are not to be removed with either a file or bench grinder.

Brass is a soft metal and would clog an abrasive wheel or the cutting teeth of a file, therefore the mushroom head or face is removed by cutting the end off the brass drift using a standard hacksaw.

Hacksaws

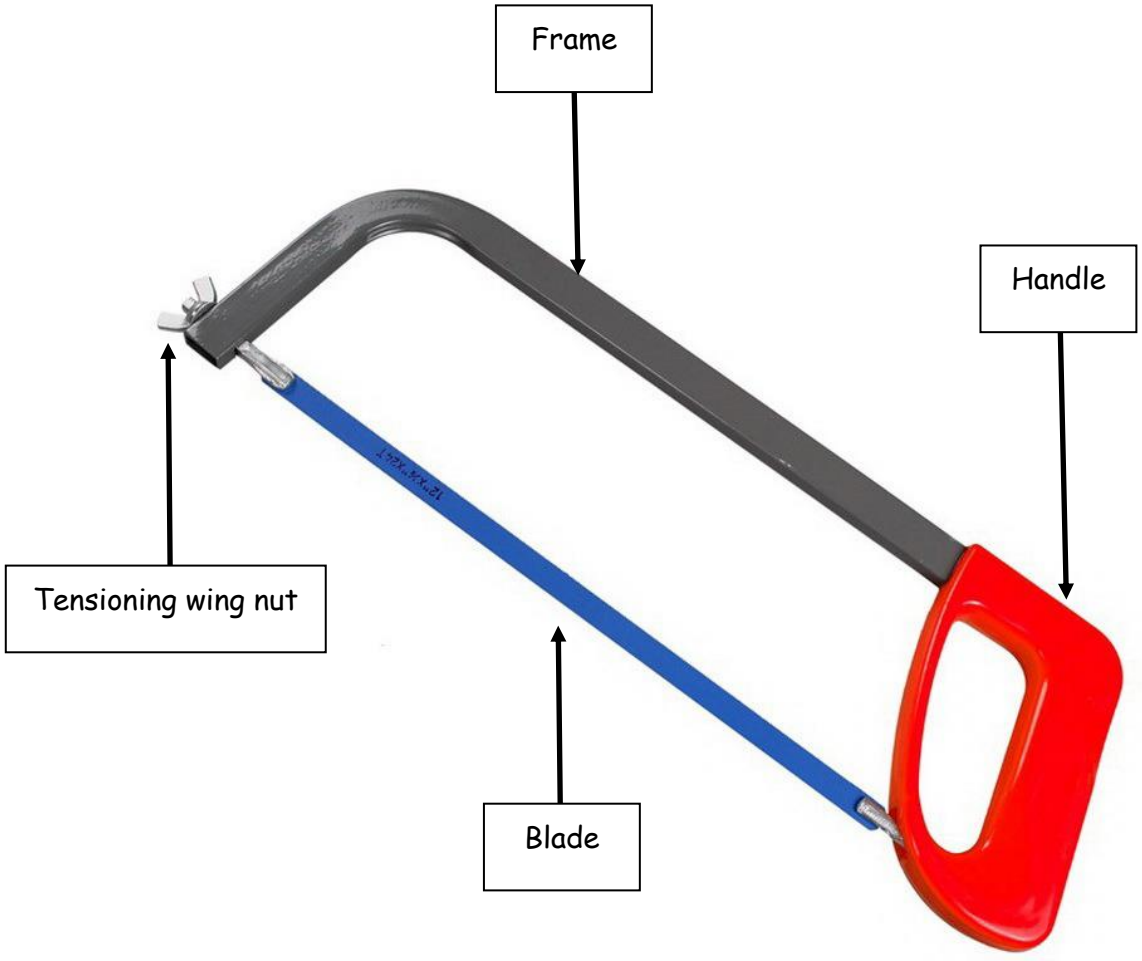
Hacksaws are hand cutting tools used by mechanics for cutting a variety of metals and materials in the repair and maintenance of motor vehicles and equipment. They are an extremely useful tool for removing excess material and cutting it to the right length or shape.

They are available in two sizes depending on the work that is being done. The first is the 12" framed hacksaw, the second is the junior hacksaw with a 6" blade. There is one other handsaw that a mechanic may use, this is known as a pad saw.

A pad saw is used for removing or cutting through mechanical fastenings and material in hard to reach or difficult places where a fully framed hacksaw cannot be used.

The following images show the different types of hacksaw:

12" Framed hacksaw



The following image shows a more sophisticated design of the 12" framed hacksaw, the two saws will work equally the same.

This hacksaw has rubber handgrips on each end of the saw, an adjustable frame and a more sophisticated tensioning system for the blade. This would be more expensive than the first hacksaw but is still designed to do the same task. This is more refined in the design and construction.

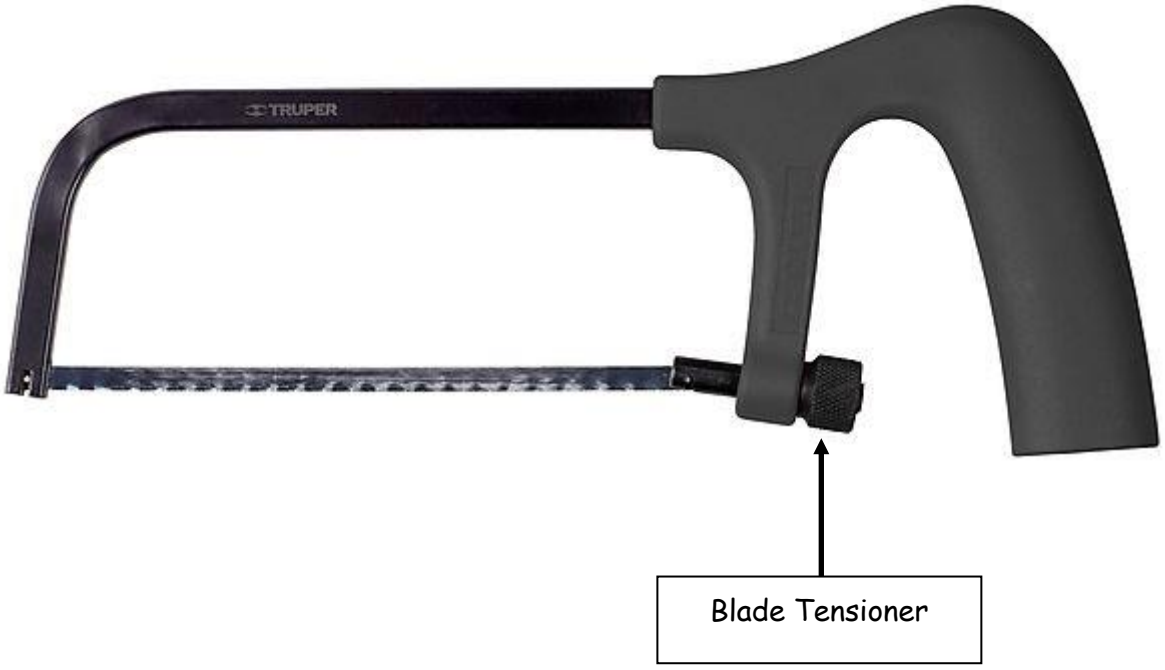
Junior hacksaw

The junior hacksaw as the name suggests is a smaller version of the framed 12" hacksaw. The blades are smaller in length and have finer teeth for smaller work or more refined work where it would be impractical to use a full framed hacksaw.

The images below show a simple frame and more refined frame junior hacksaw. The blade tension in the simple frame hacksaw is provided by the frame shape. More specialist or sophisticated frames have a tensioning nut.

Simple frame junior hacksaw

Adjustable frame hacksaw



The pad saw is a simple tool designed to hold a 12" hacksaw blade for use in confined or small spaces where a framed hacksaw cannot be used. The diagram below shows a pad saw and blade.

Pad saw

The blade is held inside the hand grip and is secured to the frame with a locking tab shown by the silver screw. The blade extends from the frame and can be used in difficult to reach areas or where a full framed hacksaw cannot be used. This saw uses the 12" hacksaw blades.

Hacksaw blades

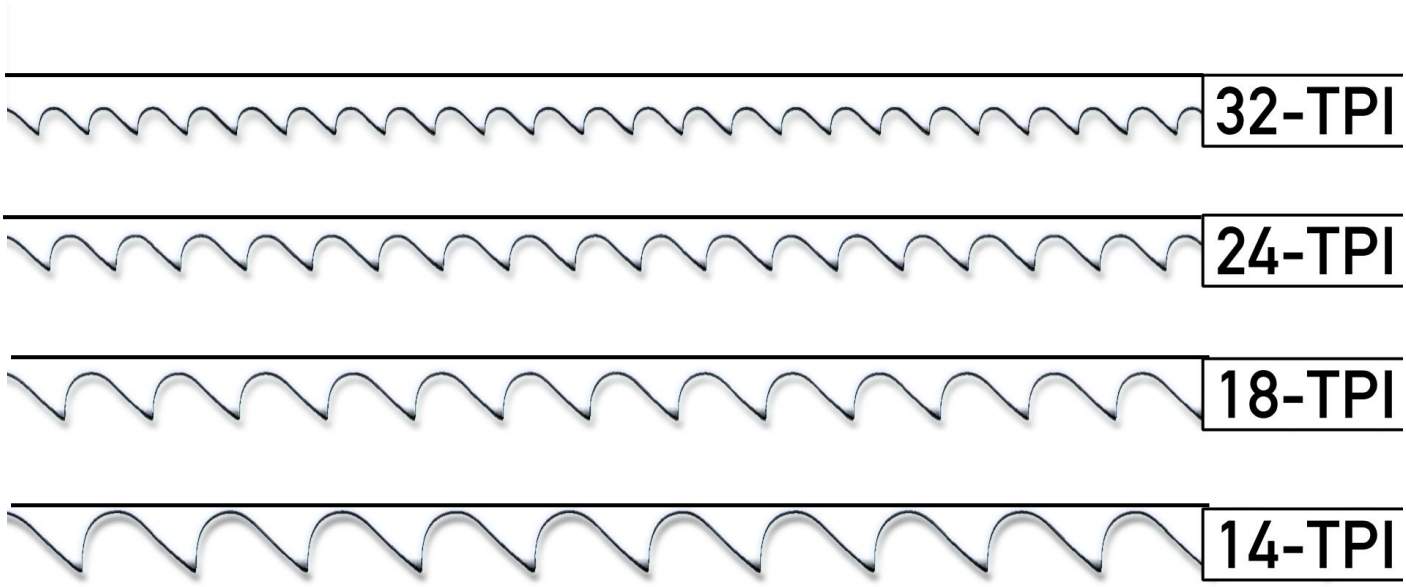
The hacksaw blade is made from two metals, high carbon and high-speed steel creating a bi-metal blade. This gives flexibility and strength to cut through a variety of materials. The blades although flexible are not indestructible and can still break or snap if placed under too much pressure or stress. High speed steel is used to make the teeth and the high carbon steel is used to make the spine of the blade.

The teeth of the blade are prone to wear if the material being cut is too hard or harder than the blade material and if excessive heat build up is generated whilst cutting. In normal use, the saw blade should provide a reasonable life. As this is fitted to a hand saw patience is required when using, remember that it takes time and effort to cut through a material. The more patience used the better the cut and the greater the accuracy of the cut.

TPI – Teeth Per Inch

The 12" hacksaw blade is designated by the number of teeth per inch. For every inch of the blade there will be so many teeth. This can range from 14 – 32 teeth per inch. The diagram below shows the difference between the different tpi.

Teeth Per Inch



The reason behind the requirement for the different number of teeth per inch is as follows:

When cutting soft metals such as aluminium, a blade with a higher number of teeth per inch should be used, this is because a finer blade, or one with more teeth per inch will produce a neater cut.

When cutting thin materials such as a piece of sheet steel or thin walled pipe only a few millimetres thick, a blade with a higher number of teeth per inch should be used to prevent the blade from catching or sticking.

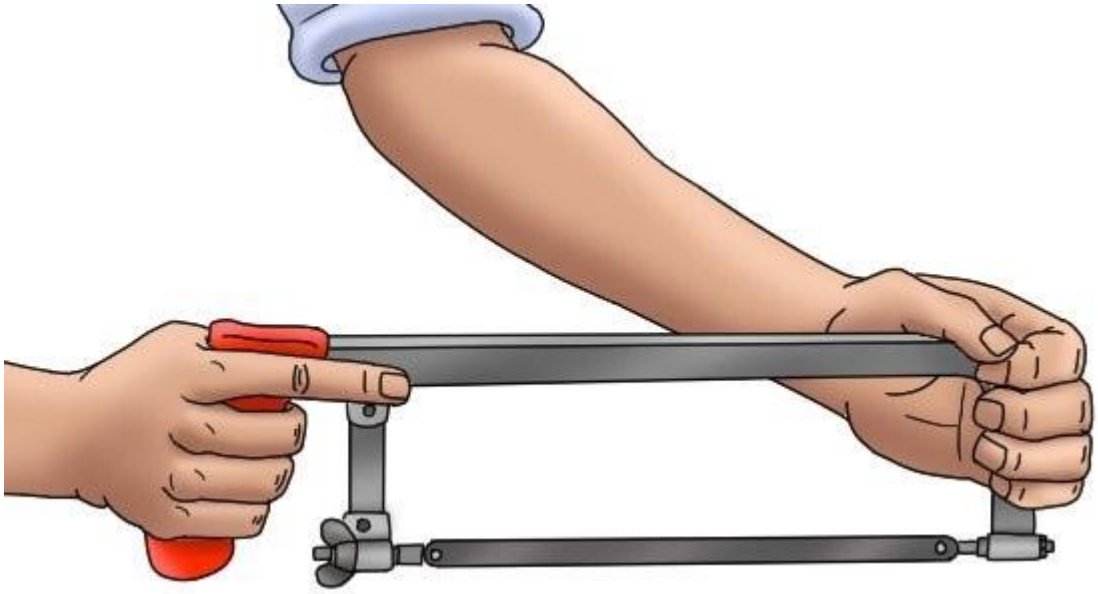
For steel bar or thicker materials, fewer teeth per inch should be used. If the teeth are too fine or small, the hardness and thickness of the material being cut will damage the teeth of the blade and wear it out quickly.

How to fit a blade correctly

A hacksaw blade is designed to cut on the forward or push stroke and clear the cut of metal swarf on the pull or backwards stroke. When pushing the blade, you have more control of the stability of the blade and the cut as well as being able to apply a precise effort. For this reason, when fitting a hacksaw blade either in the 12" hacksaw or the junior hacksaw, the teeth should always point forward or away from the handle. Looking at the diagram above, if you imagine the handle is on the left and the tensioning screw is on the right for a 12" hacksaw frame. This will give you the correct fitting direction.

How to use a hacksaw

When using a 12" hacksaw, it is designed to be held with both hands. The dominant hand, the one you use to write with, should be the hand that holds the handle. If you are left handed, your left hand holds the handle and vice versa if you are right handed.



Your feet should be shoulder width apart and you should be stood behind the piece of material that is being cut. You will push the hacksaw with the dominant hand and steady the frame and guide the blade with the other hand. The dominant hand pushes and pulls the hacksaw, the other hand is there to guide and steady the frame to help make a straight and even cut.

The full length of the blade should be used to make the cut, the stroke should be precise, full and steady, this will ensure that a precise, accurate and straight cut can be achieved. Remember that it is not a race to the finish line, the more that you rush the cutting process the worse it will be. Short strokes when cutting will result in wearing the blade out, make you tired and give a poor cut.

The same principles should be applied when using a junior hacksaw, the dominant hand is pushing the blade and the other hand is guiding the frame and the cut. Slow, steady and full cuts should be made to avoid damage to the blade, give a more precise cut and to save your energy.

Cutting to the correct side

When you have marked your piece of work, you should cut to the correct side of the marking. The hacksaw blade, just like any other saw blade has a thickness and when you are making precision cuts, you need to make sure that the piece you have cut is the correct length afterwards.

A simple rule to remember is to always cut to the waste side of the line or marking.

A piece of flat steel bar has been marked for cutting. The darker piece is the one that is to be kept. The light grey piece is the waste side. Where on the marked line should I place the blade to cut?

Remember that the saw blade has a thickness, when you are making a cut you are removing material. What would happen if I cut on the left-hand side of the mark? What would happen if I cut right on the mark? What would happen if cut on the right-hand side of the mark?

Remember you can always take more off but its very hard to put it back on once you have made a cut.

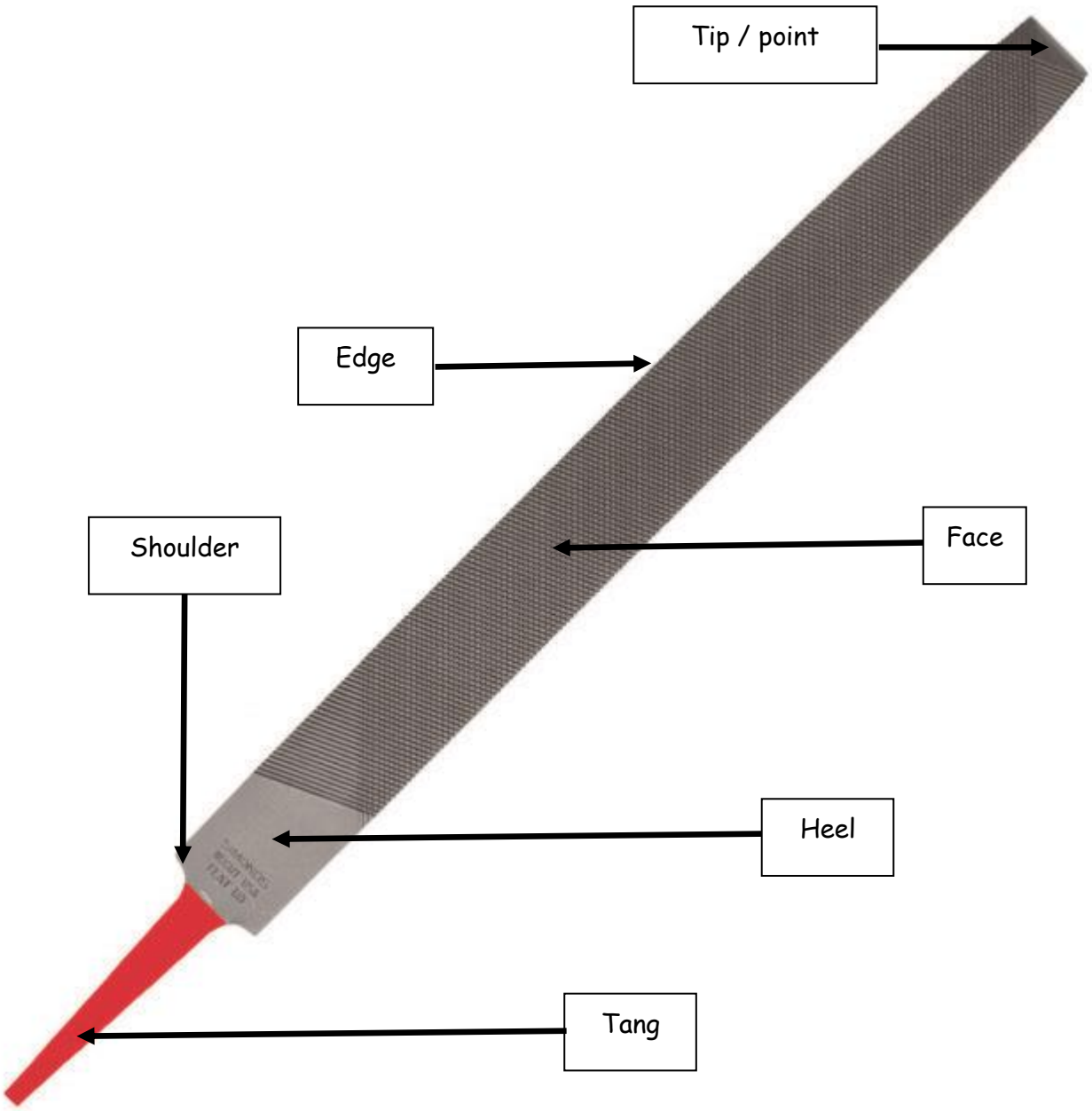
Blade tension

A hacksaw blade is flexible and so to give a straight and precise cut it is placed inside a frame that allows the blade to be stretched or placed under tension. Before using either a 12" hacksaw or a junior hacksaw, ensure the blade is facing the correct direction of travel and that blade is correctly tensioned. If the blade is not under tension, it will flex and give an inaccurate cut or may even slip out of the frame or break.

Hand Files

Hand files are used to shape, smooth, reduce or finish a piece of metal to the final desired specifications. They are a hand tool that is extremely versatile and with practice can be easily mastered to produce satisfactory results. As with all hand tools, they require patience and practice.

Naming the parts



Classification

Hand files are classified and described by their four main characteristics, these are:

Length The length of the file is measured from the end of the file to the tip of the tang and is measured in inches. These are typically 6, 8, 10 or 12 inches long.

Shape The shape of the file is classified by its cross-sectional shape. These are:

Flat, the diagram shows a flat file.

Round, this is used for enlarging or smoothing holes or radii.

Half round, these are used for filing internal curves.

Triangular, these are used for creating internal angles and corners.

Square, these are used for creating internal angles and corners.

Grade This is a measure of the coarseness of the blade, the typical file used by a mechanic will be American pattern and these have three levels of coarseness:

Bastard – This is the coarsest and will remove a large amount of material.

Second cut – This is the middle coarseness.

Smooth cut – This removes only a small amount of material and is typically used for finer work or finishing.

Cut The following diagram shows the different kinds of cut. As a mechanic you would more commonly use a single of double cut file. Rasps are for soft materials and curved tooth are commonly used in bodywork repairs.

Hand safe edge

When you look at the files used by a mechanic they will have one edge that has teeth and one that does not. The one that is smooth is called the hand safe edge. This is used to protect the piece of material that is being filed. If filing a right-angle piece of work, the hand safe edge is placed against the part that you want to protect.

Before use

Files are now normally fitted with a fixed handle for safety reasons. If the file does not have a fixed handle a wooden handle is fitted. To fit the handle, place the handle over the tang of the file and wile holding the face of the file, turn it upside down and tap the file into the handle on the workbench. This will comfortably seat the tang of the file into the handle.

Do not use a file without a handle. The tang of the file will cause serious damage to the palm of the hand and can be very sharp.

Care of files

Although the files may look robust and rather strong they are in fact very delicate. Great care should be taken when handling files. They should not be dropped as they can break easily.

Do not bang files together or on the workbench to try and clean the file. This should be done with a wire file card to remove any metal or material.

They should not be used for filing soft metals and should be kept clean, free from oil and grease and dry to avoid corrosion.

If soft metals are to be filed, the file teeth should be coated with chalk, a process called pinning. This will assist in the cleaning and removal of soft metal material from the teeth of the file after use.

When using a file on hardened material or sharp corners, apply only light pressure to remove the material as using excessive force will blunt the teeth or create grooves in the file surface known as shelling.

If files are to be carried in a toolbox, they should be wrapped in a cloth to protect the teeth from damage and from rubbing against each other or other tools. This will also help to keep the teeth clean and free from contamination.

Measuring & Marking

To be able to produce a working and functional tool or piece of equipment requires precision and practiced skills. The most important part of competent bench-fitting is the ability to accurately mark out the material from which the tool or part is going to be made.

Accurate measurement and marking will:

Save time.

Save money.

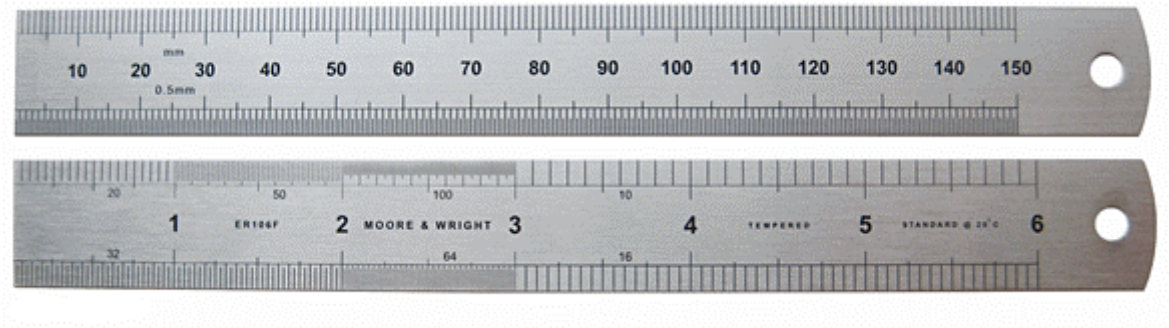
Save material.

Show professionalism.

There are a few different tools that can be used for marking and measuring used by a mechanic. They all require the individual to be as accurate as the tool itself. Precision is only provided by your level of commitment. Remember to always measure twice and that way you only need to cut once.

Engineer's steel rule.

These are available in different sizes, most commonly they are 12" and 6" and have metric and imperial measurements or may only have metric measurements. As most work is done in metric measurements it is advisable to use a metric rule.



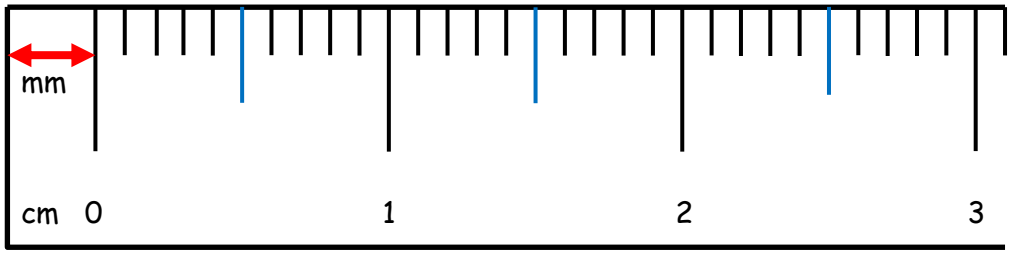
This 6" rule has markings on both sides, one side is Imperial and the other is metric. You will notice that there is a difference between this rule and one that you may have used in the classrooms at school. Can you spot the difference in the markings?

In the workshop, there may be many times when you may be required to measure the length, width or height of an object. To gain an accurate measurement we can use a rule.

This will be done with an Engineer's steel rule, this has accurate graduations marked on the edge to show the measured length, these increments will be marked clearly and numbered to show the graduations.

Looking at the image of the Engineer's steel rule, where do the markings start? Do they start at the same part as a normal school rule?

Diagram of a school rule:



This gap is there to allow the rule to be used should the edge or end be chipped, damaged or worn away. However, as an Engineer's rule is made from steel, the end should not be damaged, so the end of the rule is the point where you will take all measurements from.

In engineering and mechanics, the dimensions are usually mm or cm.

10mm = 1cm

100 cm = 1m

Marking

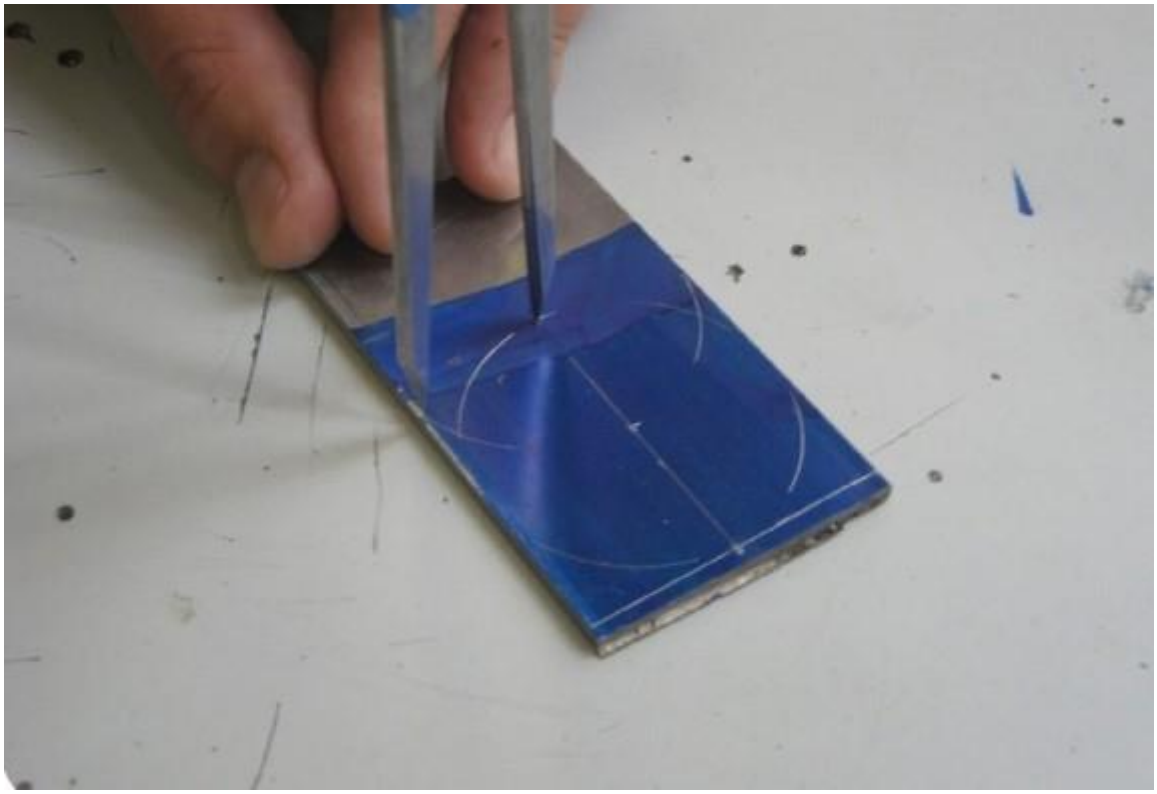
Depending on the task and the material being used, measurement marks will have to be applied onto the surface of the material to know where to make cuts and holes.

Pencil can be used but this will rub off and can be difficult to see. Biro or other inks may not stick, a permanent pen can be used, but this may not work if the metal or material surface is oily or may be exposed to alcohol or other chemicals that may wash the ink off.

So to overcome this problem, allow for a semi-permanent mark to be applied and one that can be easily seen, Engineer's blue is used. This is a chemical colouring that will produce a purple / blue coating on the surface of the metal and allow a scribed line to be drawn into the surface.

An advantage of using Engineer's blue is that if you make a mistake in the marking process, you can simply apply a second coat and start again.

Engineer's blue



In the diagram the student is using a set of dividers to mark a radius into the Engineer's blue to show where the material will need to be cut. This provides a very fine line and helps to ensure accuracy. The thicker you make the marking the less accurate the cuts will be. Bench-fitting requires precision.

In addition to using dividers to mark out a radius or scribe a parallel line, the other tool that is used is known as an Engineers scribe. This is a pointed tool with a fine point used for marking the material.

Engineer's scribe

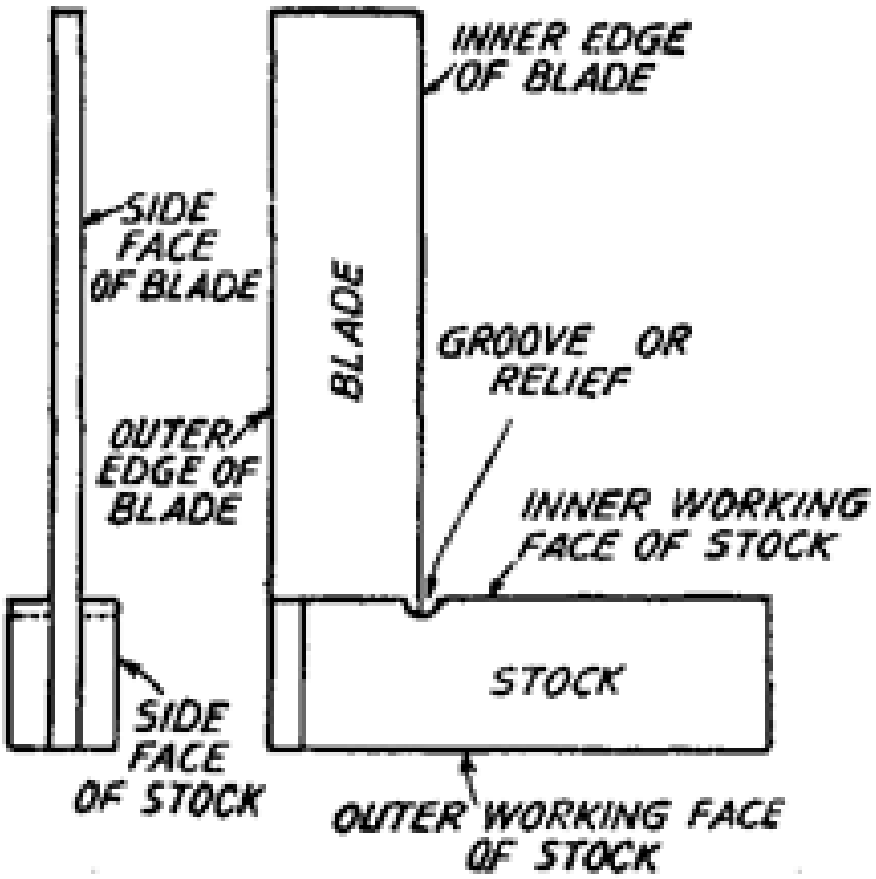
To ensure that markings are made at true right angles and that lines are as straight as possible when marking, another tool is required. This is a precision tool and as such should be treated with the same care and respect as all the other hand tools. It should not be dropped or misused.

This tool is called an Engineer's square. It is used for measuring and marking cutting lines at right angles to the straight edge of the material.

Engineer's square

This tool, like many of the other hand tools used in bench-fitting will come in different sizes and will be chosen for its applicable size to the task required.

Naming the parts



Checking for accuracy

To check that the engineer's square has not ben damaged and is still true a simple test can be carried out.

Laying the square onto a piece of scrap material, holding the square at right angles, make a scribe mark along the top edge of the blade.

Turn the square over and again holding the square at right angles to the straight edge of the material make another scribe mark along the top edge of the blade.

Remove the square and the two lines that have been scribed should run exactly parallel to each other and the distance between the lines be equal. This shows that the square is still true and has not been damaged.

Conclusion

As you can see from this handbook, there are a few different tools and skills that you will be required to understand and master within your bench-fitting skills.

These are in no way impossible and the two most important things that are required to master bench-fitting is your time and patience.

If you take your time and have the patience to practice and keep using these skills, they will no doubt get better over time. It is not a race and accuracy does not come with speed.

Practice makes perfect and the most skilled bench-fitters, engineers. mechanics and craftsmen have all spent time practicing and perfecting their skills. Even the most skilled tradesman has had to start off at the bottom of the skills tree.

Only practice and time will improve your skills, there is no shortcut and taking your time will always give the better result rather than rushing the task and making mistakes.