Linear measurement

Objectives: At the end of this lesson you shall be able to
- **name the base unit of linear measurement as per the International System of units of measurement (SI)**
- **state the multiples of a metre and their values**
- **state the purpose of steel rule**
- **name the types of steel rule**
- **state the precautions to be followed while using a steel rule.**

Scan the QR Code to view the video for this exercise

When we measure an object, we are actually comparing it with a known standard of measurement.

The base unit of length as per SI is METRE.

Length - SI UNITS and MULTIPLES

Base unit

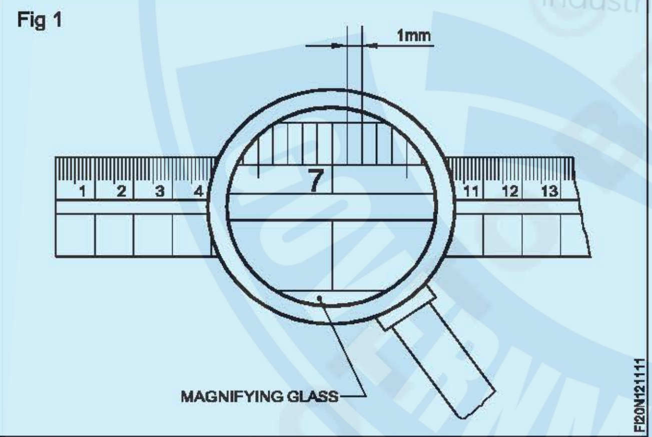
The base unit of length as per the Systems International is metre. The table given below lists some multiples of a meter.

METRE(m)	= 1000 mm
CENTIMETRE (cm)	= 10 mm
MILLIMETRE (mm)	= 1000µ
MICROMETRE (µm)	= 0.001 mm

Measurement in engineering practice

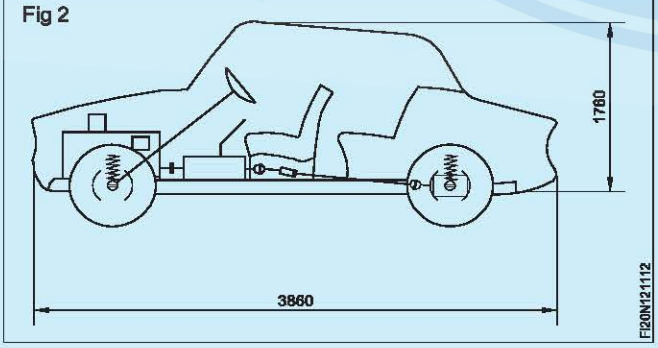
Usually, in engineering practice, the preferred unit of length measurement is millimetre. (Fig 1)

Fig 1



Both large and small dimensions are stated in millimetres. (Fig 2)

Fig 2

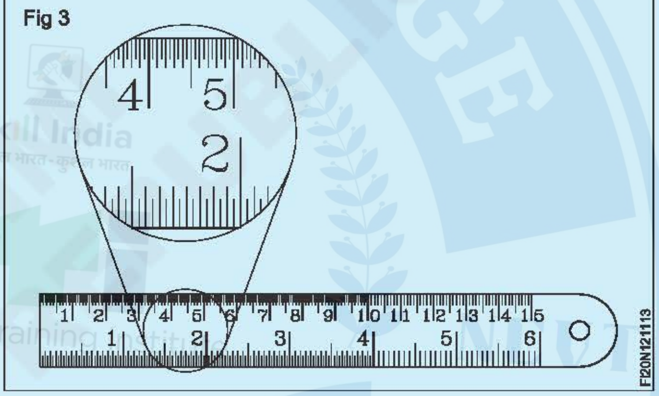


The British system of length measurement

An alternative system of length measurement is the British system. In this system, the base unit is the Imperial Standard Yard. Most countries, including Great Britain itself, have however in the last few years, switched over to SI units.

Engineer's steel rule (Fig 3) are used to measure the dimensions of work pieces.

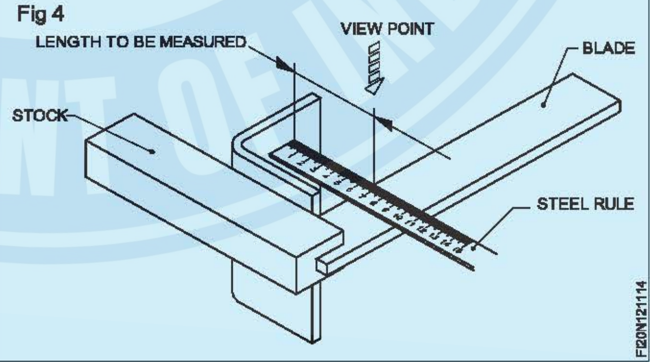
Fig 3



Steel rules are made of spring steel or stainless steel. These rules are available in length 150mm, 300mm and 600mm. The reading accuracy of steel rule is 0.5 mm and 1/64 inch.

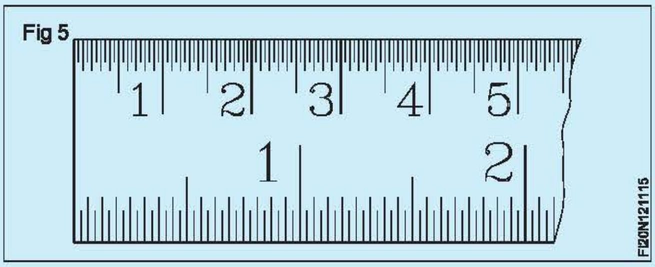
For accurate reading it is necessary to read directly to avoid errors arising out of parallax. (Fig 4)

Fig 4



Steel rule in English measure, they can also be available with metric and English graduation in a complete range of sizes 150, 300, 500 and 1000 mm. (Fig 5)

Fig 5



Other types of rule

– narrow steel rules

– short steel rules

– full flexible steel rule with tapered end.

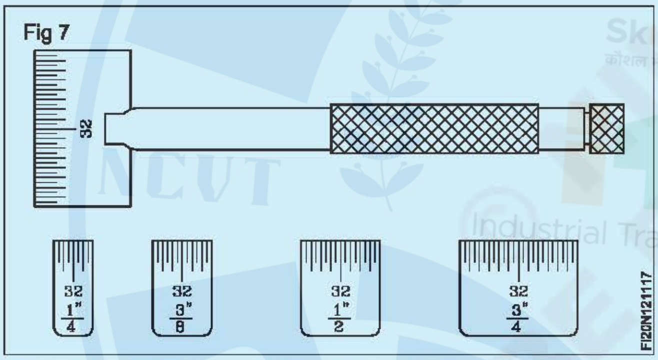
Narrow steel rule

Narrow steel rule is used to measure the depth of key-ways and depth of smaller dia, blind holes of jobs, where the ordinary steel rule can not reach. Its width is approximately 5 mm and thickness 2 mm. (Fig 6)

Fig 6

Short steel rule (Fig 7)

Fig 7



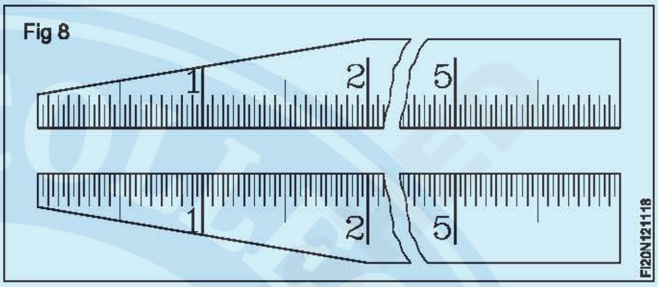
This set of five small rules together with a holder is extremely useful for measurements in confined or hard to reach locations which prevent the use of ordinary steel rules. It is used suitably for measuring grooves, short shoulder, recesses, key ways etc. in machining operation on shapers, millers and tool and die work.

The rules are easily inserted in the slotted end of the holder and are rigidly clamped in place by a slight turn of the knurled nut at the end of the handle. Five rule lengths are provided 1/4", 3/8", 1/2", 3/4" and 1" and each rule is graduated in 32nds on one side and 64ths on the reverse side.

Steel rule with tapered end

This rule is a favorite with all mechanics since its tapered

Fig 8



end permits measuring of inside size of small holes, narrow slots, grooves, recesses etc. This rule has a taper from 1/2 inch width at the 2 inch graduation to 1/8 inch width at the end. (Fig 8)

For maintaining the accuracy of a steel rule, it is important to see that its edges and surfaces are protected from damage and rust.

Do not place a steel rule with other cutting tools. Apply a thin layer of oil when not in use.

Angular measurement

Angular measurement of angles of an object is usually expressed in degrees, minutes and seconds. One degree is divided into 60 minutes and one minute is to 60 seconds.

Measurements of fundamental, derived units

Measurement of length				
Metric			**British**	
Micron	1µ	= 0.001 mm	Thousand^th of an inch	= 0.001"
Millimetre	1 mm	= 1000µ	Inch	= 1"
Centimetre	1 cm	= 10 mm	Foot 1 ft	= 12"
Decimeter	1 dm	= 10 cm	Yard 1yd	= 3 ft
Metre	1 m	= 10 dm	1 furlong 1 fur	= 220 yds
Decametre	1 dam	= 10 metre	1 mile	= 8 fur

Scan the QR Code to view the video for this exercise

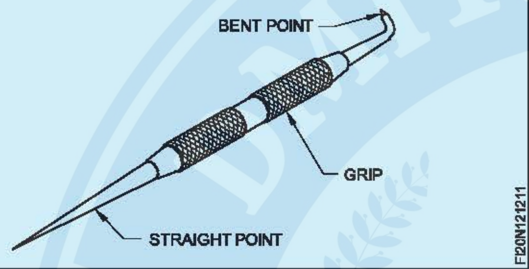
Scribers

Objectives: At the end of this lesson you shall be able to
- **state the features of scribers**
- **state the uses of scribers.**

Scribers: In lay out work it is necessary to scribe lines to indicate the dimensions of the workpiece to be filed or machined. The scriber is a tool used for this purpose. It is made of high carbon steel and hardened. For drawing clear and sharp lines, the point should be ground and honed frequently for maintaining its sharpness.

Scribers are available in different shapes and sizes. The most commonly used one is the plain scriber. (Fig 1)

Fig 1

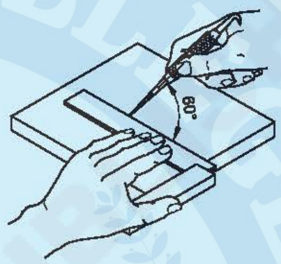


While scribing lines, the scriber is used like a pencil so that the lines drawn are close to the straight edge. (Fig 2)

Scriber points are very sharp; therefore, do not put the plain scriber in your pocket.

Place a cork on the point when not in use to prevent accidents.

Fig 2

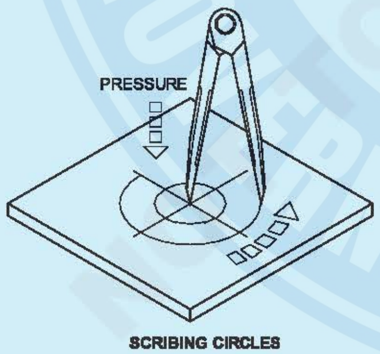


Dividers

Objectives: At the end of this lesson you shall be able to
- **name the parts of a divider**
- **state the uses of dividers**
- **state the specifications of dividers**
- **state the important hints on divider points.**

Dividers are used for scribing circles, arcs and for transferring and stepping off distances. (Fig 1,2 and 3)

Fig 1



Dividers are available with firm joints and spring joints. (Figs 1 & 4). The measurements are set on the dividers with a steel rule. (Fig 2)

The sizes of dividers range between 50 mm to 200 mm.

Fig 2

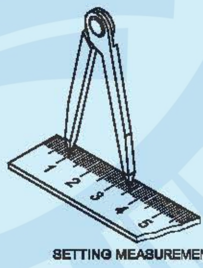
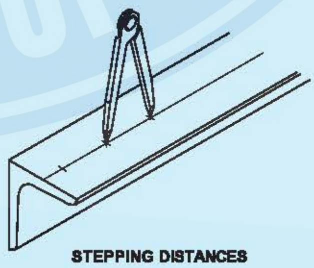
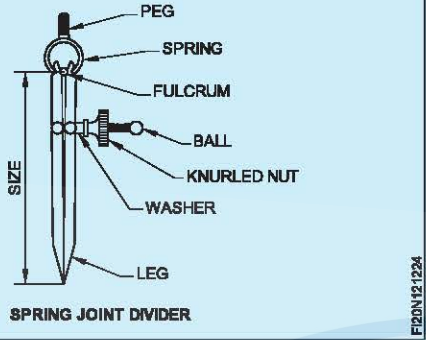


Fig 3



The distance from the point to the centre of the fulcrum roller (pivot) is the size of the divider. (Fig 4)

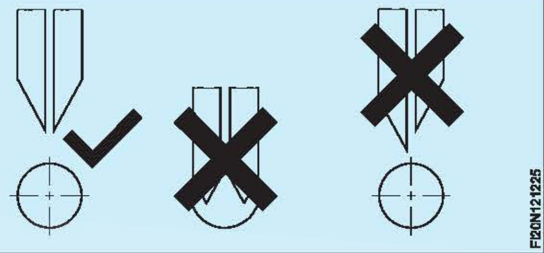
Fig 4



For the correct location and seating of the divider point prick punch marks of 30° are used.

The two legs of the divider should always be of equal length. (Fig 5) Dividers are specified by the type of their joints and length.

Fig 5



The divider point should be kept sharp in order to produce fine lines. Frequent sharpening with an oilstone is better than sharpening by grinding. Sharpening by grinding will make the points soft.

Scan the QR Code to view the video for this exercise

Calipers

Objectives: At the end of this lesson you shall be able to
- **name the commonly used calipers**
- **state the advantages of spring joint calipers.**

Calipers are indirect measuring instruments used for transferring measurements from a steel rule to a job, and vice versa.

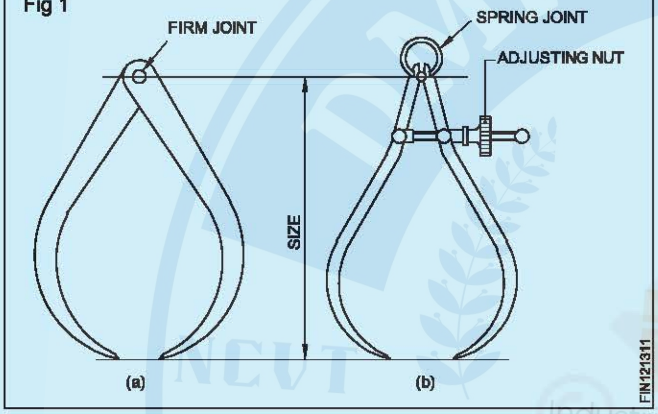
Calipers are classified according to their joints and their legs.

Joint

– Firm joint calipers (Fig 1a)

– Spring joint calipers (Fig 1b)

Fig 1



Legs

– Inside caliper for internal measurement. (Fig 2)

– Outside caliper for external measurement. (Fig 3)

Fig 2

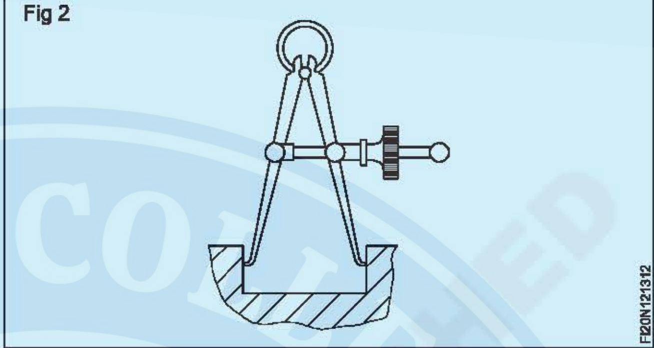


Fig 3

Calipers are used along with steel rules, and the accuracy is limited to 0.5 mm; parallelism of jobs etc. can be checked with higher accuracy by using calipers with sensitive feel.

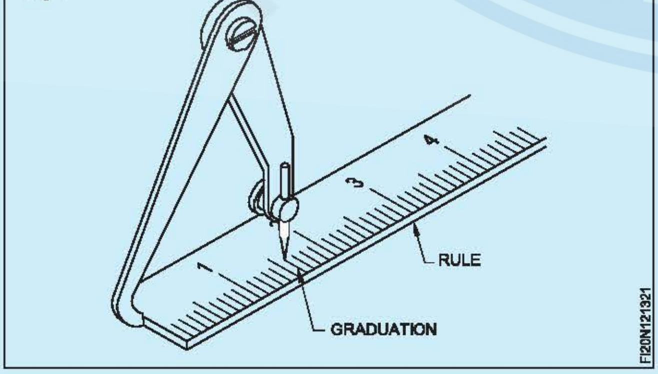
Spring joint calipers have the advantage of quick setting with the help of an adjusting nut. For setting a firm joint caliper, tap the leg lightly on a wooden surface.

Jenny calipers

Objectives: At the end of this lesson you shall be able to
- **state the uses of a jenny caliper**
- **state the two types of legs of a jenny caliper.**

Jenny calipers have one leg with an adjustable divider point, while the other is a bent leg. (Fig 1) These are available in sizes of 150 mm, 200 mm, 250 mm and 300 mm.

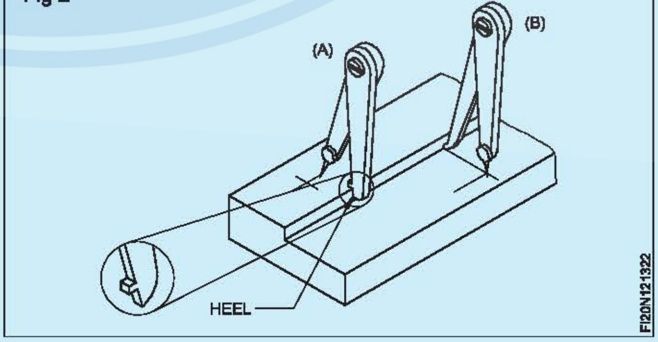
Fig 1



Jenny calipers are used

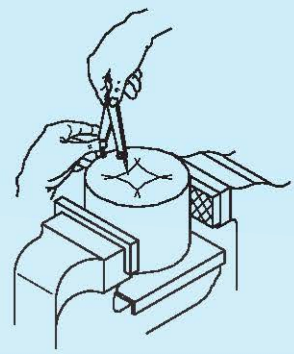
– for marking lines parallel to the inside and outside edges (Fig 2)

Fig 2



- for finding the centre of round bars. (Fig 3)

Fig 3



These calipers are available with the usual bent leg or with heel.

Calipers with bent leg (Fig 2B) are used for drawing lines parallel along an inside edge, and the heel type (Fig 2A) is used for drawing parallel lines along the outer edges.

The other names for this caliper are:

- hermaphrodite calipers
- leg and point calipers
- odd leg caliper

Scan the QR Code to view the video for this exercise

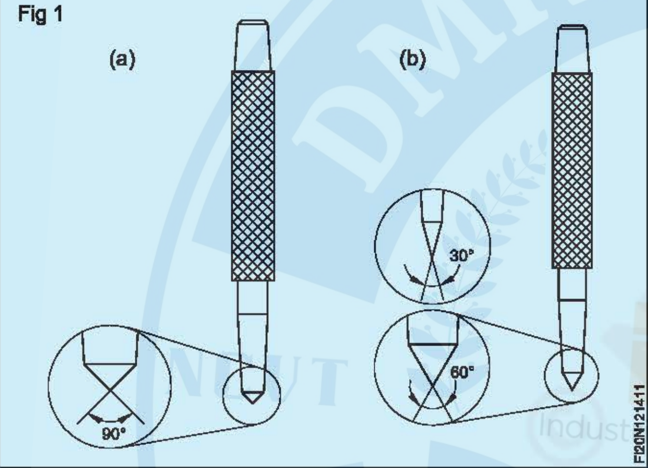
Types of marking punches

Objectives: At the end of this lesson you shall be able to
- **name the different punches in marking**
- **state the features of each punch and its uses.**

Punches are used in order to make certain dimensional features of the layout permanent. There are two types of punches. They are centre punch and prick punch made of high carbon steel, hardened and ground.

Centre Punch: The angle of the point is 90° in a centre punch. The punch mark made by this is wide and not very deep. This punch is used for locating centre of the holes. The wide punch mark gives a good seating for starting the drill. (Fig 1a)

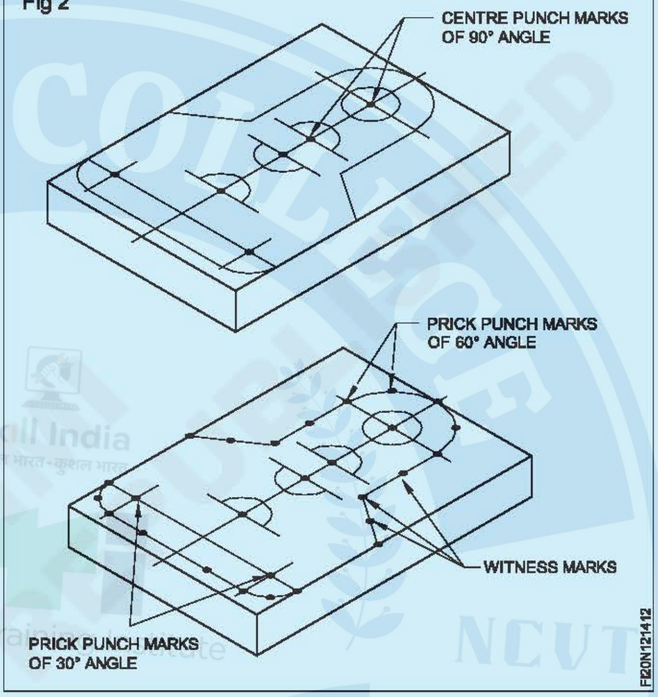
Fig 1



Prick Punch/Dot punch: The angle of the prick punch is 30° or 60°. (Fig 1b) The 30° point punch is used for making light punch marks needed to position dividers. The divider point will get a proper seating in the punch mark. The 60° punch is used for marking witness marks and called as dot punch. (Fig 2)

The witness marks should not be too close to one another.

Fig 2



Hammers

Objectives: At the end of this lesson you shall be able to
- **state the uses of an engineer's hammer**
- **identify the parts of an engineer's hammer**
- **name the types of engineer's hammer**
- **specify the engineer's hammer.**

An engineer's hammer is a hand tool used for striking purposes while punching, bending, straightening, chipping, forging or riveting.

Major parts of a hammer: The major parts of a hammer are the head and the handle.

Hammer is made of drop-forged carbon steel, while the wooden handle must be capable of absorbing shock.

The parts of a hammer-head are the face (1), pein (2), cheek (3) and the eyehole (4).

Face: The face is the striking portion. A slight convexity is given to it to avoid digging of the edge. It is used for striking while chipping, bending, punching, etc.

Pein: The pein is the other end of the head. It is used for shaping and forming work like riveting and bending. The pein is of different shapes such as:

- ball pein (Fig.2a)
- cross-pein (Fig.2b)
- straight pein. (Fig 2c)

Fig 1

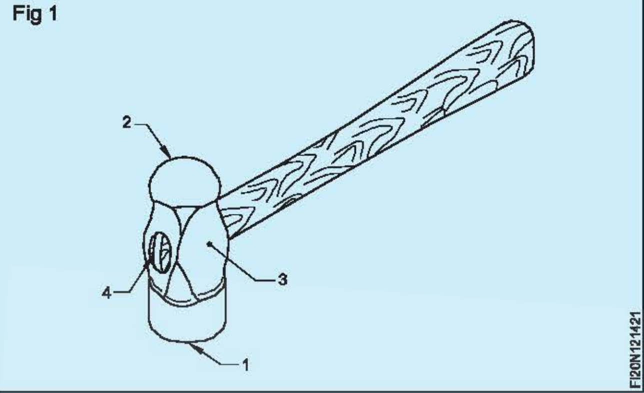
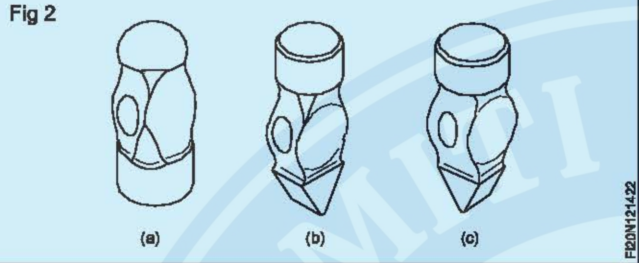


Fig 2



The face and the pein are case hardened.

Cheek: The cheek is the middle portion of the hammer-head. The weight of the hammer is stamped here.

This portion of the hammer-head is left soft.

Eyehole: The eyehole is meant for fixing the handle. It is shaped to fit the handle rigidly. The wedges fix the handle in the eyehole. (Figs 3 and 4)

Fig 3

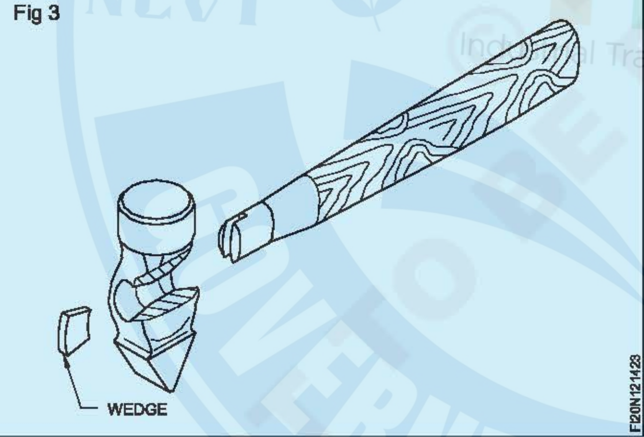
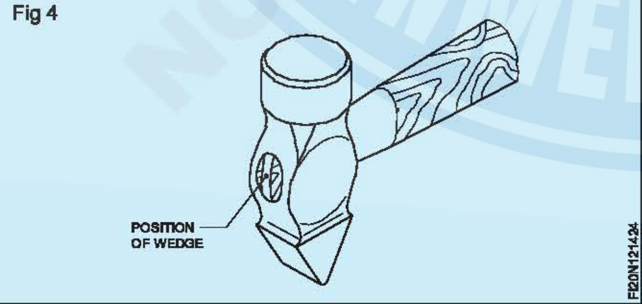


Fig 4



Application of hammer pein: The ball pein is used for riveting. (Fig 5)

The cross-pein is used for spreading the metal in one direction. (Fig 6)

Fig 5

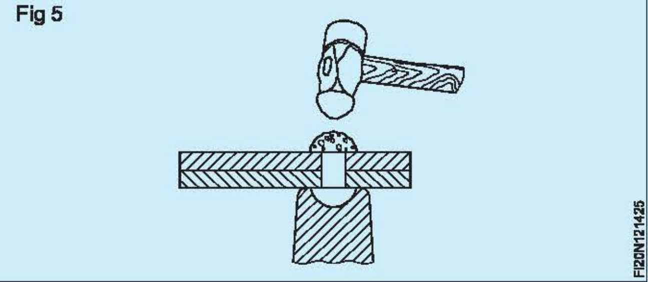
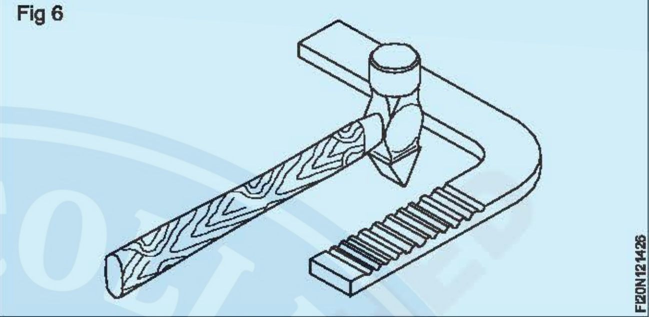
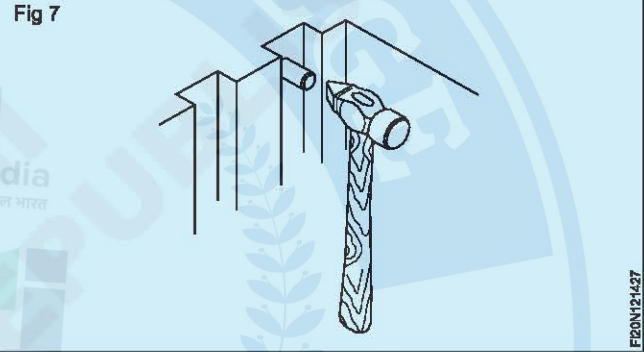


Fig 6



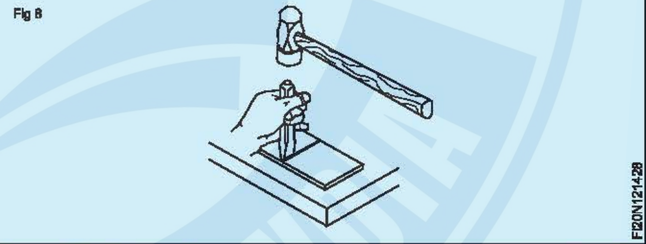
The straight pein is used at the corners. (Fig 7)

Fig 7



The ball pein hammer is used for driving a chisel in parting metal. (Fig 8)

Fig 8



Specification: An engineer's hammers are specified by their weight and the shape of the pein. Their weight varies from 125 gms to 750 gms.

The weight of an engineer's hammer, used for marking purposes, is 250 gms.

The ball pein hammers are used for general work in a machine/ fitting shop.

Before using a hammer

- make sure the handle is properly fitted
- select a hammer with the correct weight suitable for the job
- check the hammer head and handle whether any crack is there
- ensure that the face of the hammer is free from oil or grease.

'V' Blocks

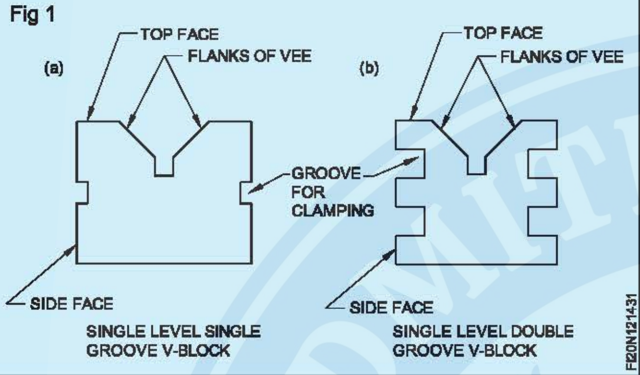
Objectives: At the end of this lesson you shall be able to
- **state the constructional features of 'v' blocks**
- **name the types of 'v' blocks and state their uses**
- **specify 'v' blocks as per B.I.S standard.**

Scan the QR Code to view the video for this exercise

Constructional features

'V' Blocks are devices used for marking and setting up work on machines. The features of the common type of 'V' Blocks are as given in Figs 1 and 2.

Fig 1



The included angle of the VEE is 90° in all cases. 'V' Blocks are finished to a high accuracy in respect of dimension, flatness and squareness.

Types

Different types of 'V' blocks are available. As per BIS, there are four types, as listed below.

Single level single groove 'V' Block (Fig 1)

This type has only one 'V' groove, and has single groove (slots) on either side. These grooves are for accommodating the holding clamps.

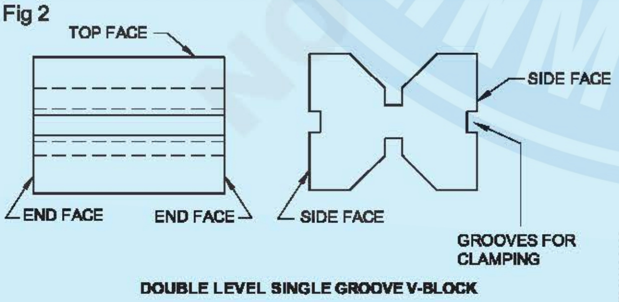
Single level double groove 'V' Block (Fig 2)

This type will have one 'V' groove, and two grooves (slots) on either side for clamping in two positions.

Double level single groove 'V' Block (Fig 3)

In this case, the 'V' Block will have two 'V' grooves on the top and bottom, and a single groove for clamping on either side.

Fig 2



Matched pair 'V' Block (Figs 4 and 5)

These blocks are available in pairs which have the same size and the same grade of accuracy. They are identified by the number or letter given by the manufacturer. These sets of blocks are used for supporting long shafts parallel on machine tables or marking off tables.

Fig 3

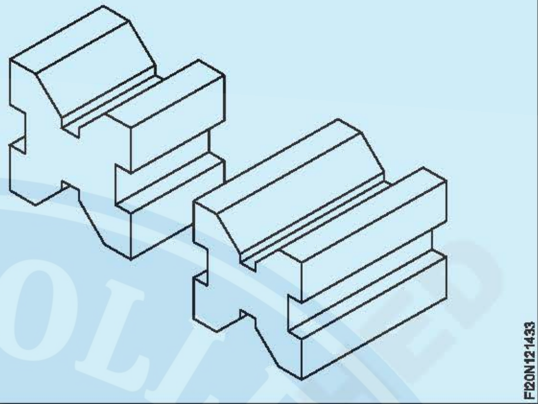
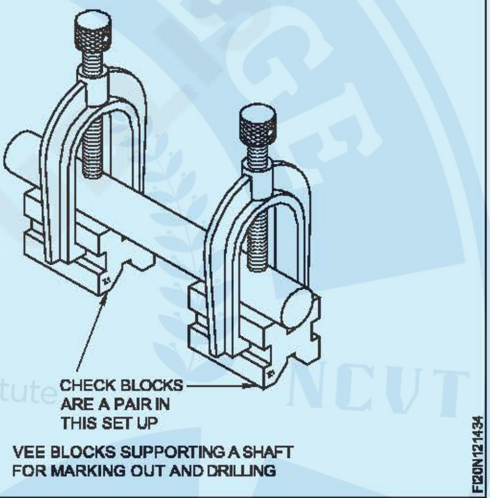


Fig 4



Grades and materials

'V' Blocks are available in Grade A and Grade B.

Grade A 'V' Blocks

These are more accurate, and are available only up to 100 mm length. They are made of high quality steel.

Grade B 'V' Blocks

These blocks are not as accurate as the ones in Grade A. These blocks are used for general machine shop work. These blocks are available up to 300 mm length. These 'V' Blocks are made of closely grained cast iron.

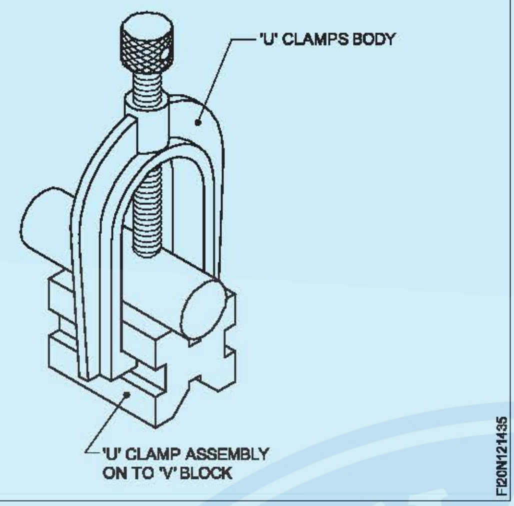
Clamping devices for `V'-Blocks

'U' clamps are provided for holding cylindrical jobs firmly on 'V' Blocks. (Fig 6)

Designation

'V' Blocks are designated by the nominal size (length) and the minimum and maximum diameter of the workpiece capable of being clamped, and the grade and the number of the corresponding B.I.S. standard.

Fig 5



In the case of matched pairs, it should be indicated by the letter M.

For 'V' Blocks with clamps it should be indicated as, 'WITH CLAMPS'.

Example

A 50 mm long (nominal size) 'V' Block capable of clamping workpieces between 5 to 40 mm in diameter and of Grade A will be designated as

'V' Block 50/5 - 40 A - I.S.2949.

In the case of a matched pair, it will be designated as

'V' Block M 50/5 - 40 A I.S.2949.

For 'V' Block supplied with clamps, the designation will be

'V' Block with clamp 50/5 - 40 A I.S. 2949.

Care and maintenance

- Clean before and after use.
- Choose the correct size of 'V' block according to the job requirement.
- Apply oil after the use.

Marking off and marking off table

Objectives : At the end of this lesson you shall be able to
- **state why marking off is necessary**
- **state the function of witness marks**
- **state the features of marking tables**
- **write the uses of marking tables**
- **state the maintenance aspects concerning marking tables.**

Marking off

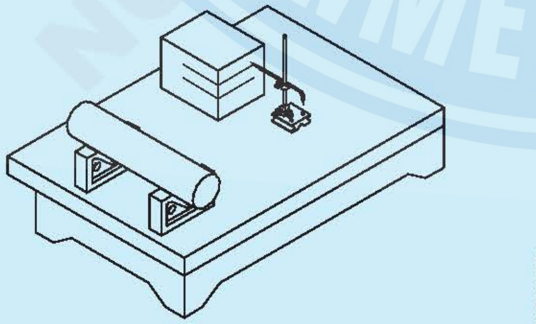
Marking off or layout is carried out to indicate the locations of operation to be done, and provide guidance during rough machining or filing.

Witness marks

The line marked on metal surfaces is likely to be erased due to handling. To avoid this, permanent marks are made by placing punch marks at convenient mark intervals along the marked line. Punch marks act as a witness against inaccuracies in machining and hence, they are known as witness marks.

Marking off table (Figs 1 and 2)

Fig 1



A marking table (marking-off table) is used as a reference surface for marking on workpieces.

Marking tables are of rigid construction with accurately finished top surfaces. The edges are also finished at right angles to the top surface.

Marking tables are made of cast iron or granite, and are available in various sizes. These tables are also used for setting measuring instruments, and for checking sizes, parallelism and angles.

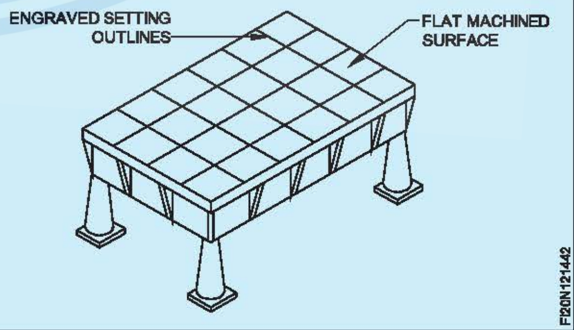
Care and maintenance

A marking table is very precise equipment, and should be protected from damage and rust.

After use, the marking table should be cleaned with a soft cloth.

The Surface of the marking table, made of cast iron, should be protected by applying a thin layer of oil.

Fig 2



Bench vice

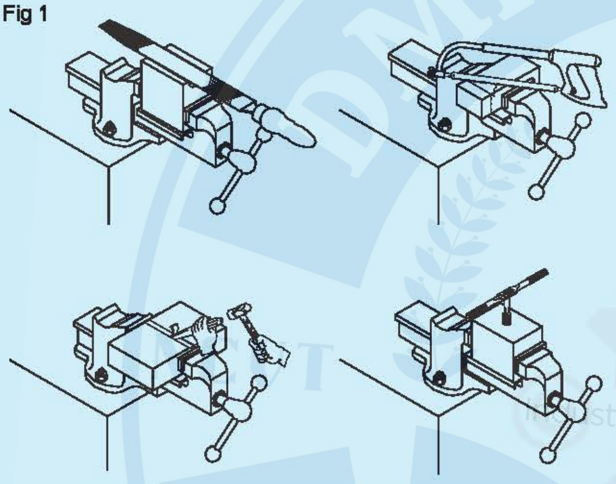
Objectives: At the end of this lesson you shall be able to
- **state the uses of bench vice**
- **specify the size of the bench vice**
- **name the parts of the bench vice**
- **state the uses of vice clamps.**
- **mention the care and maintenance of vices**

Scan the QR Code to view the video for this exercise

Vices are used for holding the workpieces. They are available in different types. The vice used for bench work is the bench vice or called Engineer's vice.

A bench vice is made of cast iron or cast steel and it is used to hold work for filing, sawing, threading and other hand operations. (Fig 1)

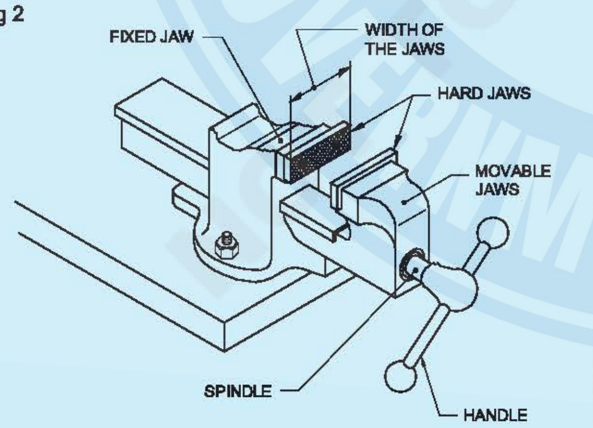
Fig 1



The size of the vice is stated by the width of the jaws.eg. 150mm parallel jaw bench vice

Parts of a bench vice (Fig 2)

Fig 2



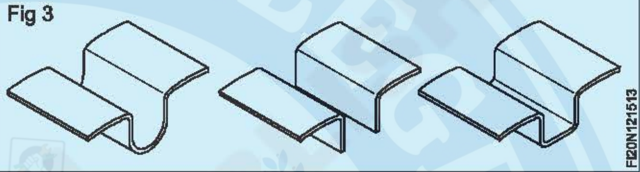
The following are the parts of a vice.

Fixed jaw, movable jaw, hard jaws, spindle, handle, box-nut and spring are the parts of a vice.

The box-nut and the spring are the internal parts.

Vice clamps or soft jaws (Fig 3)

Fig 3



To hold a finished work use soft jaws (vice clamps) made of aluminium over the regular jaws. This will protect the work surface from damage.

Do not over-tighten the vice as, the spindle may be damaged.

Care and maintenance of vices

- Always keep all threaded and moving parts clean by wiping the vice with a cloth after each use.
- Make sure to oil and lubricate the joints and sliding parts.
- To oil the sliding section, open the jaws completely and apply a layer of grease to the screen.
- Remove the rust if appears on the vice using rust remover chemical.
- When the vice is not in use bring the jaws lightly gap together and place the handle in a vertical position.
- Avoid striking the handle of the vice by a hammer for tightening fully, otherwise the handle will become bend or damaged.

Hacksaw frames and blades

Objectives: At the end of this lesson you shall be able to
- **name the different types of hacksaw frames**
- **specify hacksaw blades**
- **name the different type of hacksaw blades**
- **describe the method of sawing**

Scan the QR Code to view the video for this exercise

Hacksaw frame: A hacksaw frame is used along with a blade to cut metals of different sections, and is specified by the type and maximum length of the blade that can be fixed.

Example

Adjustable hacksaw frame - tubular - 250 - 300mm or 8'' - 12''

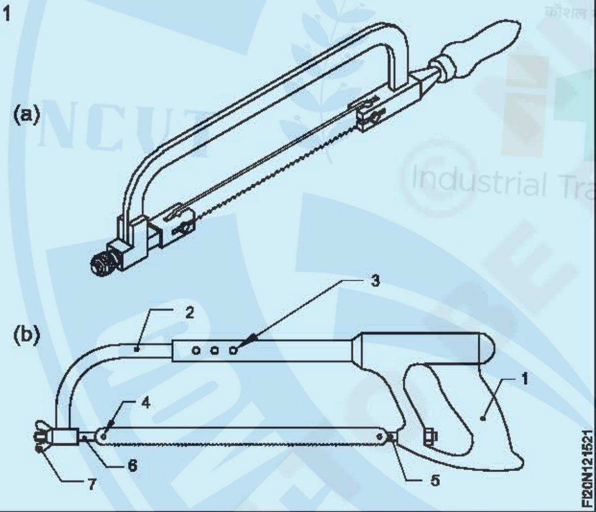
Types of hacksaw frames

Solid frame (Fig 1a)**:** Only a blade of a particular standard length can be fitted to this frame. e.g 300 mm or 250 mm.

Adjustable frame (flat type)**:** Different standard lengths of blades can be fitted to this frame i.e. 250 mm and 300 mm.

Adjustable frame (tubular type) (Fig 1b)**:** This is the most commonly used type. It gives a better grip and control, while sawing.

Fig 1



Parts of a hacksaw frame

1 Handle

2 Frame

3 Tubular frame with holes for length adjustment

4 Retaining pins

5 Fixed blade-holder

6 Adjustable blade-holder

7 Wing-nut

A hacksaw blade is made of either low alloy steel (LA) or high speed steel (HSS), and is available in standard lengths of 250 mm and 300mm. (Fig 2)

Parts of a hacksaw blade (Fig 2)

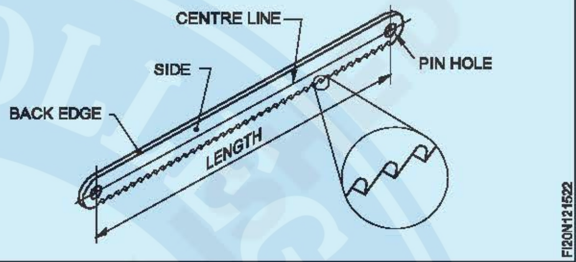
1 Back edge

2 Side

3 Centre line

4 Pin holes

Fig 2



Type of hacksaw blades

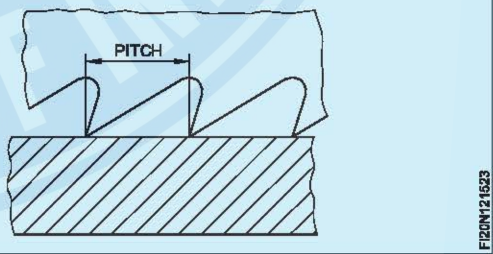
All-hard blade: The full length of the blade between the pins is hardened and it is used for harder metals such as tool steel, die steel and HCS.

Flexible blade: Only the teeth are hardened. Because of their flexibility these blades are useful for cutting along curved lines. Flexible blades should be thinner than all-hard blades.

Pitch of the blade (Fig 3)**:** The distance between adjacent teeth is known as the 'pitch' of the blade.

Classification	Pitch
Coarse	1.8 mm
Medium	1.4 mm & 1.0 mm
Fine	0.8 mm

Fig 3



Specification: Hacksaw blades are specified by the length, pitch and type of material. (The width and thickness of blade is standardised)

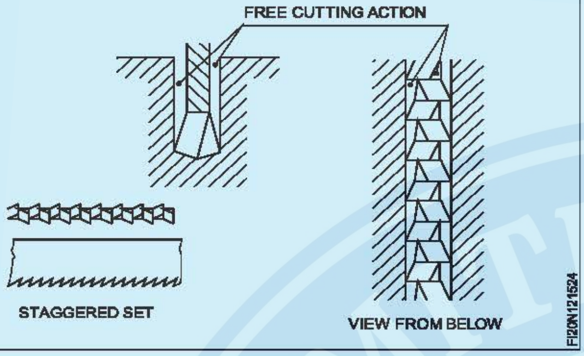
Example

300 x 1.8 mm pitch LA all-hard blade.

To prevent the hacksaw blade binding when penetrating into the material, and to allow free movement of the blade, the cut is to be broader than the thickness of the hacksaw blade. This is achieved by the setting of the hacksaw teeth. There are two types of hacksaw teeth settings.

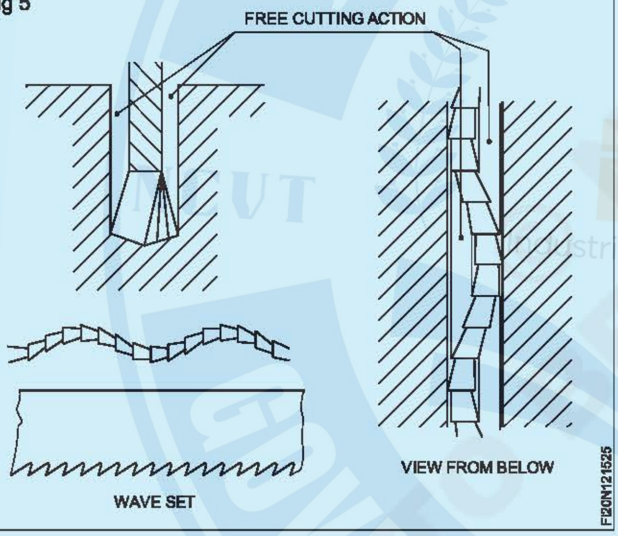
Staggered set (Fig 4)**:** Alternate teeth or groups of teeth are staggered. This arrangement helps for free cutting, and provides for good chip clearance.

Fig 4



Wave set (Fig 5)**:** In this, the teeth of the blade are arranged in a wave-form. The types of sets for different pictures are as follows:

Fig 5



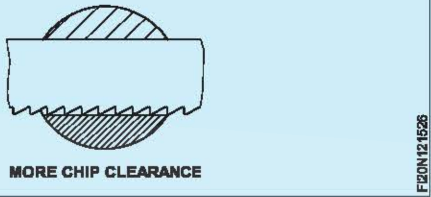
Pitch	Type of set
0.8 mm	Wave-set
1.0 mm	Wave-set or staggered
Over 1.0 mm	Staggered

For the best results, the blade with the right pitch should be selected and fitted correctly.

Selection of blade: The selection of the blade depends on the shape and hardness of the material to be cut.

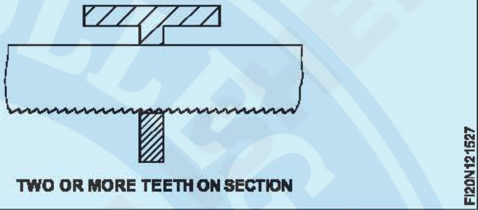
Pitch selection (Fig 6)**:** For soft materials such as bronze, brass, soft steel, cast iron, heavy angles etc. use a 1.8 mm pitch blade.

Fig 6



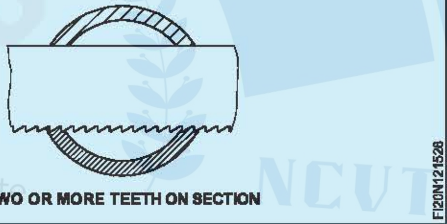
For tool steel, high carbon, high speed steel etc. use a 1.4 mm pitch. For angle iron, brass tubing, copper, iron pipe etc. use a 1 mm pitch blade. (Fig 7)

Fig 7



For conduit and other thin tubing, sheet metal work etc. use a 0.8 mm pitch. (Fig 8)

Fig 8



Method of sawing

Select the correct blade for the material to be cut.

HSS - Blades are used for tough resistant materials

High Carbon Steel - General cutting

Select the correct number of teeth / inch the general rule is that atleast 3 teeth should extend across the surface of the material to be cut.

The hand holds the hacksaw handle, and the index finger is support the handle and also points in the direction of cutting.

The other hand holds the frame, near the wing nut. Cutting/ sewing should be carried out close to the jaws of the vice. This ensures that the metal does not flex or bend under the force of the hacksaw and the sawing motion.

Scan the QR Code to view the video for this exercise

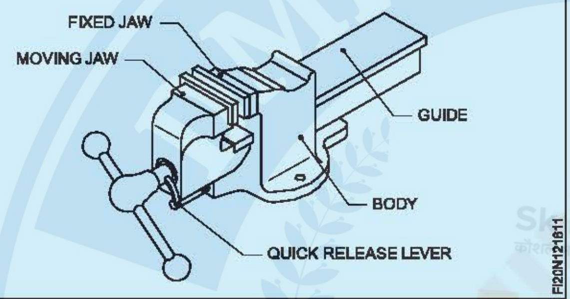
Types of vices

Objectives: At the end of this lesson you shall be able to
- **state the different types of vices**
- **state the uses of quick releasing vice, pipe vice, hand vice, pin vice and leg vice.**

There are different types of vices used for holding work-pieces. They are quick releasing vice, pipe vice, hand vice, pin vice and toolmaker's vice.

Quick releasing vice (Fig 1)**:** A quick releasing vice is similar to an ordinary bench vice but the opening of the movable jaw is done by using a trigger (lever). If the trigger at the front of the movable jaw is pressed, the nut disengages the screw and the movable jaw can be set in any desired place quickly.

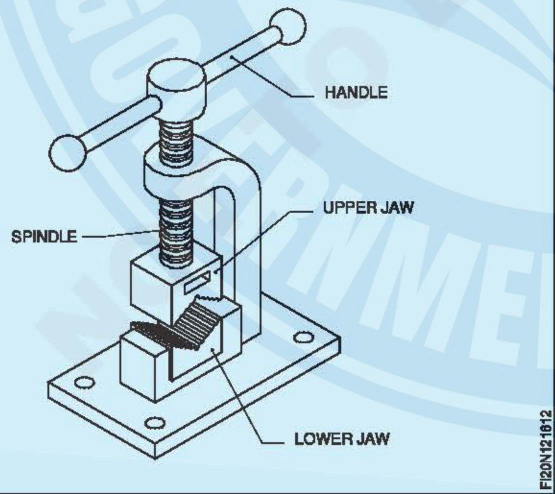
Fig 1



Pipe vice (Fig 2)**:** A pipe vice is used for holding round sections of metal, tubes and pipes. In the vice, the screw is vertical and movable. The jaw works vertically.

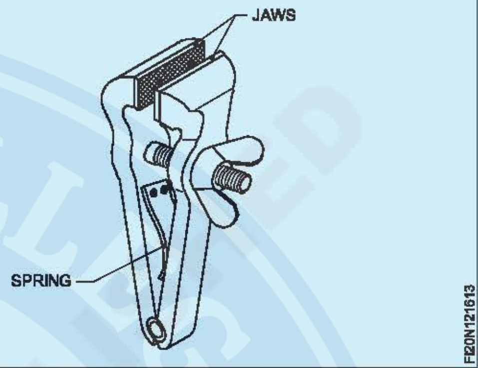
The pipe vice grips the work at four points on its surface. The parts of a pipe vice are shown in Fig 2.

Fig 2



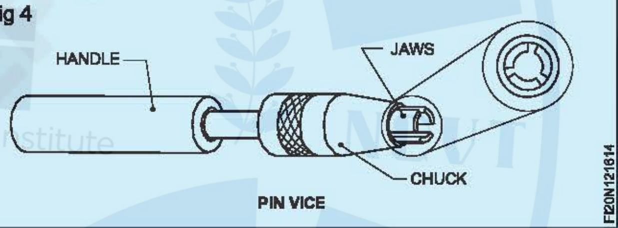
Hand vice (Fig 3)**:** Hand vices are used for gripping screws, rivets, keys, small drills and other similar objects which are too small to be conveniently held in the bench vice. A hand vice is made in various shapes and sizes. The length varies from 125 to 150 mm and the jaw width from 40 to 44 mm. The jaws can be opened and closed using the wing nut on the screw that is fastened to one leg, and passes through the other.

Fig 3



Pin vice (Fig 4)**:** The pin vice is used for holding small diameter jobs. It consists of a handle and a small collet chuck at one end. The chuck carries a set of jaws which are operated by turning the handle.

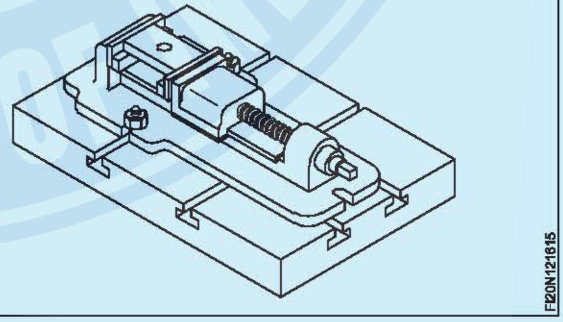
Fig 4



Toolmaker's vice (Fig 5)**:** The toolmaker's vice is used for holding small work which requires filing or drilling and for marking of small jobs on the surface plate. This vice is made of mild steel.

Toolmaker's vice is accurately machined.

Fig 5



Leg vice

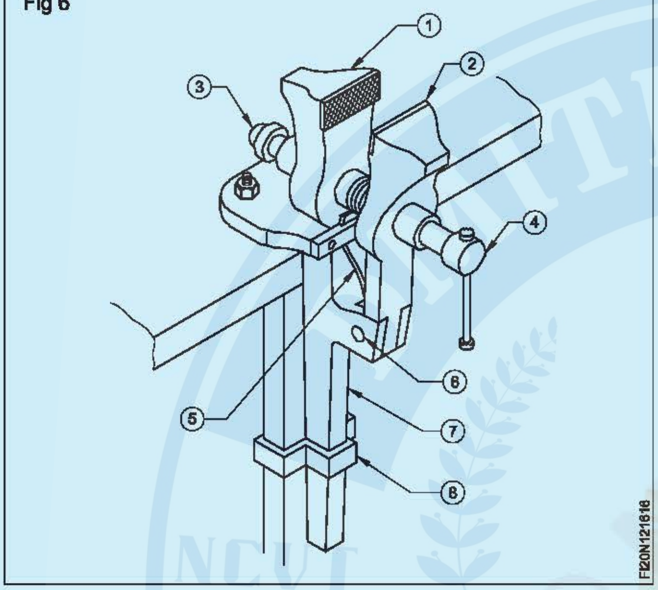
A leg vice is a holding device generally used in a forge shop for bending and forging work. It is made fo mild steel to avoid breakage while hammering.

Main pats of a leg vice (Fig 6**)**

The following are the main parts of a leg vice.

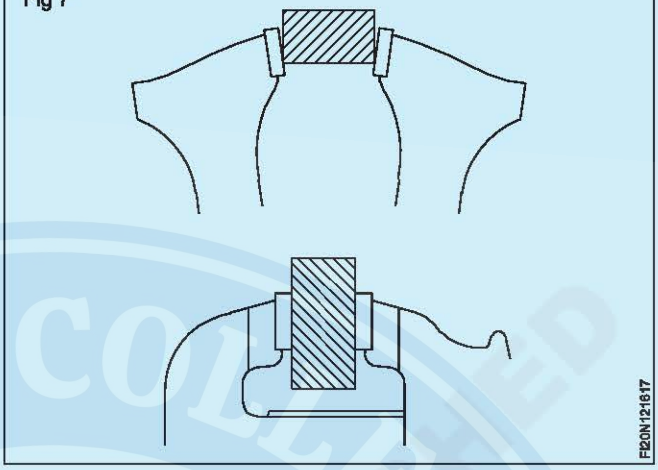
1 Solid jaw
2 Movable jaw
3 Threaded jaw
4 Spindle
5 Spring
6 Pivot
7 Leg
8 Clamp

Fig 6



Since the hinged jaw moves in a radial path, the job held in this vice in not gripped properly because of the line contact. (Fig 7) Hence a work which can be carried out on a bench vice is not held on a leg vice. Jobs which require hammering only are held on a leg vice.

Fig 7



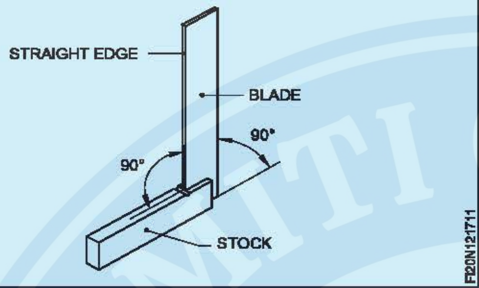
Try square

Objectives: At the end of this lesson you shall be able to
- **name the parts of a try square**
- **state the uses of a try square.**

Scan the QR Code to view the video for this exercise

The try square (Fig 1) is an instrument which is used to check squareness (angles of 90°) of a surface.

Fig 1



The accuracy of measurement by a try square is about 0.002 mm per 10 mm length, which is accurate enough for most workshop purposes. The try square has a blade with parallel surfaces. The blade is fixed to the stock at 90°.

Try squares are made of hardened steel.

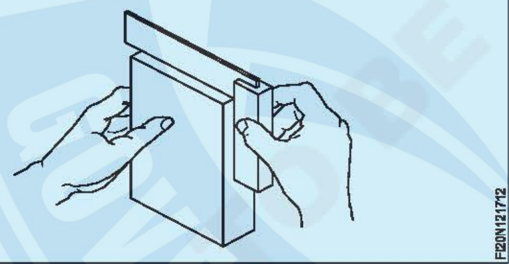
Try squares are specified according to the length of the blade i.e. 100 mm, 150 mm, 200 mm.

Uses:

The try-square is used to:

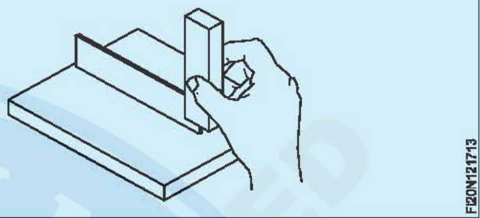
– check the squareness (Fig 2)

Fig 2



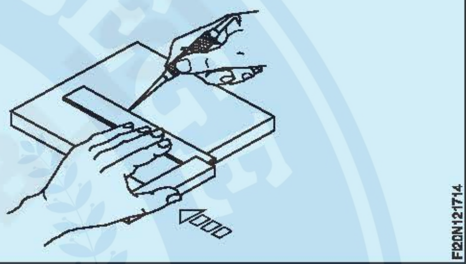
– check the flatness (Fig 3)

Fig 3



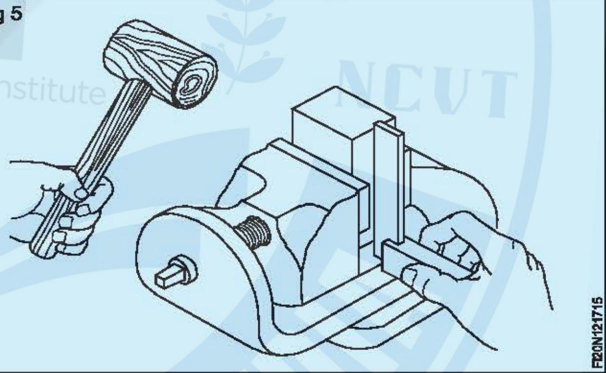
– mark lines at 90° to the edges of workpieces (Fig 4)

Fig 4



– set workpieces at right angles. (Fig 5)

Fig 5



Elements of a file

Objectives: At the end of this lesson you shall be able to
- **name the parts of a file**
- **state the material of a file.**

Methods of material cutting: The three methods of metal cutting are abrasion (Fig.1), fusion (Fig 2) and incision (Fig 3)

Filling is a method for removing excess material from a workpiece by using a file which acts as a cutting tool. Figure 4 shows how to hold a file. Files are available in many shapes and sizes.

Fig 1

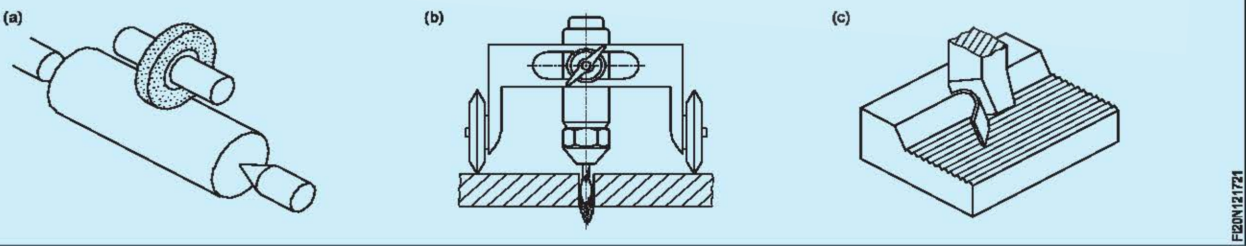
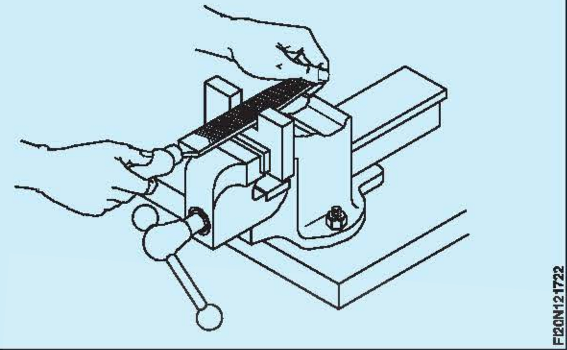


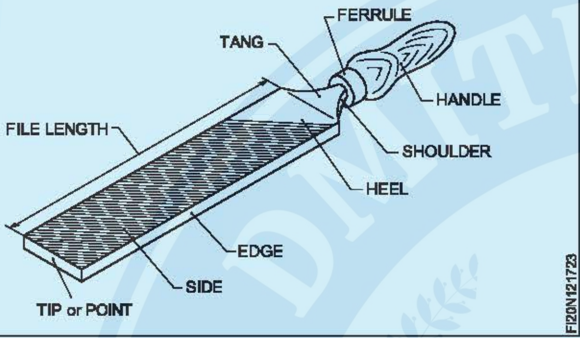
Fig 2



Parts of a file (Fig 5)

The parts of a file can be seen in figure 5, are

Fig 3



Tip or Point
the end opposite to tang

Face or side
The broad part of the file with teeth cut on its surface

Edge
The thin part of the file with a single row of parallel teeth

Heel
The portion of the broad part without teeth

Shoulder
the curved part of the file separating tang from the body

Tang
The narrow and thin part of a file which fits into the handle

Handle
The part fitted to the tang for holding the file

Ferrule
A protective metal ring to prevent cracking of the handle.

Materials

Generally files are made of high carbon or high grade cast steel. The body portion is hardened and tempered. The tang is however not hardened.

Cut of files

Objectives: At the end of this lesson you shall be able to
- **name the different cuts of files**
- **state the uses of each type of cut.**

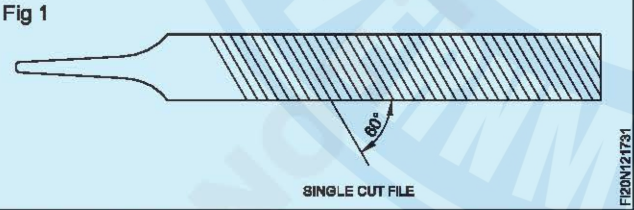
The teeth of all file are formed by cuts made on its face. Files have cuts of different types. Files with different cuts have different uses.

Types of cuts

Basically there are four types.
Single cut, Double cut, Rasp cut and Curved cut.

Single cut file (Fig 1)

Fig 1



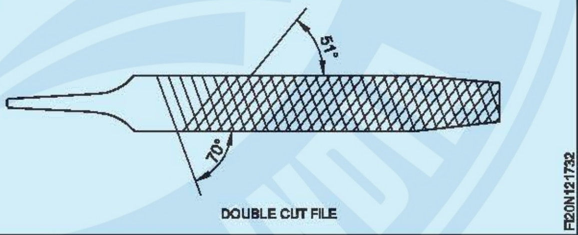
A single cut file has rows of teeth cut in one direction across its face. The teeth are at an angle of 60^0 to the centre line. It can cut chips as wide as the cut of the file. Files with this cut are useful for filing soft metals like brass, aluminium, bronze and copper.

Single cut files do not remove stock as fast double cut files, but the surface finish obtained is much smoother.

Double cut file (Fig 2)

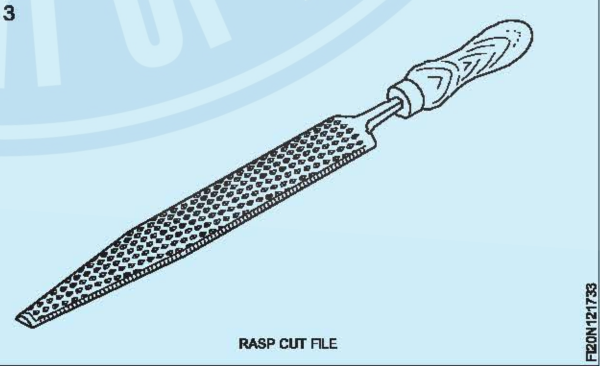
A double cut file has two rows of teeth cut diagonal to each other. The first row of teeth is known as OVERCUT and they are cut at an angle of 70^0. The other cut, made diagonal to this, is known as UPCUT, and is at an angle of 51^0. This removes stock faster than the single cut file.

Fig 2



Rasp cut file (Fig 3)

Fig 3

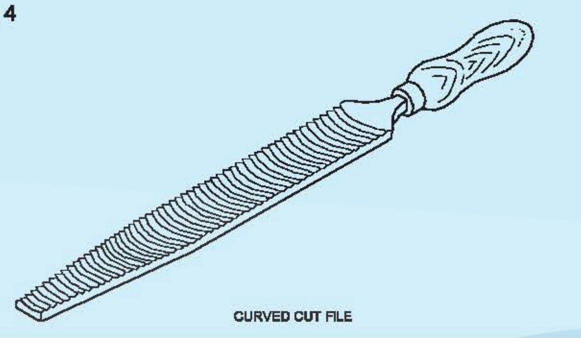


The rasp cut has individual, sharp, pointed teeth in a line, and is useful for filing wood, leather and other soft materials.

These files are available only in half round shape.

Curved cut file (Fig 4)

Fig 4



These files have deeper cutting action and are useful for filing soft materials like - aluminium, tin, copper, and plastic.

The curved cut files are available only in a flat shape.

> **The selection of a file with a particular type of cut is based on the material to be filed. Single cut files are used for filing soft materials. But certain special files, for example, those used for sharpening saws, are also of single cut.**

File specifications and grades

Objectives: At the end of this lesson you shall be able to
- **state how files are specified**
- **name the different grades of files**
- **state the application of each grade of file.**

Files are manufactured in different types and grades to meet the various needs.

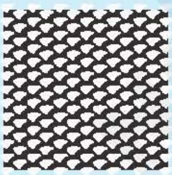
Files are specified according to their length, grade, cut and shape.

Length is the distance from the tip of a file to the heel.

File grades are determined by the spacing of the teeth.

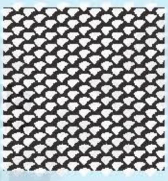
A **rough file** is used for removing rapidly a larger quantity of metal. It is mostly used for trimming the rough edges of soft metal castings.

A **bastard file** is used in cases where there is a heavy reduction of material



A **second cut file** is used to give a good finish on metals. It is excellent to file hard metals. It is useful for bringing the jobs close to the finishing size.

It may also be observed that the number of cutting edges in rows of a file changes according to the Length of a file.



A **smooth file** is used to remove small quantity of material and to give a good finish.

A **dead smooth** file is used to bring the material to accurate size with a high degree of finish.

The most used grades of files are bastard, second cut, smooth and dead smooth. These are the the grades recommended by the bureau of indian standards (BIS)

Different sizes of files with the same grade will have varying sizes of teeth. In longer files, the teeth will be coarser.

The number of cutting edge in rows in each of the above grades over a Length of 10mm as shown in Table (1).

TABLE (1)

	Grade of files (Number of cuts over the length of 10mm)				
Length of file	**Rough**	**Bastard**	**Second cut**	**Smooth**	**Dead smooth**
150mm	8	13	17	24	33
200mm	7	11	16	22	31
250mm	6	10	15	20	30
300mm	5	9	14	19	28

Types of files

Objectives: At the end of this lesson you shall be able to
- **identify the different shape of files(types)**
- **state the uses of flat files, Hand files square, round, half round, triangular and knife-edge files**
- **state the correct shape of files for filing different profiles.**

Scan the QR Code to view the video for this exercise

For filing and finishing different profiles, files of different shapes are used

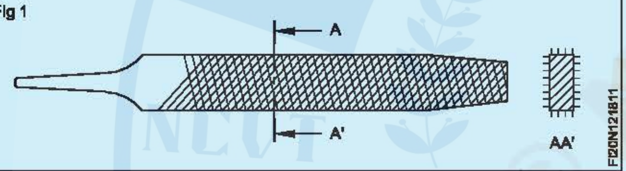
The shape of files is stated by its cross section.

Common files of different shapes: Flat file, Hand file, Square file, Round file, Half round file, Triangular file and Knife-edge file.

Flat file (Fig 1)

These files are of a rectangular cross section. The edges along the width of these files are parallel up to two-thirds of the length, and then they taper towards the point. The faces are double cut, and the edges single cut. These files are used for general purpose work. They are useful for filing and finishing external and internal surfaces.

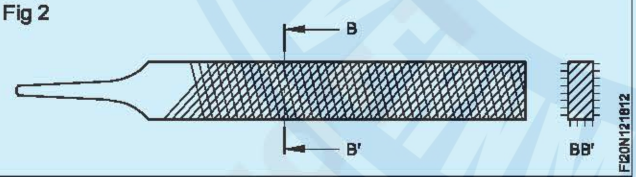
Fig 1



Hand file (Fig 2)

These files are similar to the flat files in their cross section. The edges along the width are parallel throughout the length. The faces are double cut. One edge is single cut whereas the other is safe edge. Because of the safe edge, they are useful for filing surfaces which are at right angles to surfaces already finished.

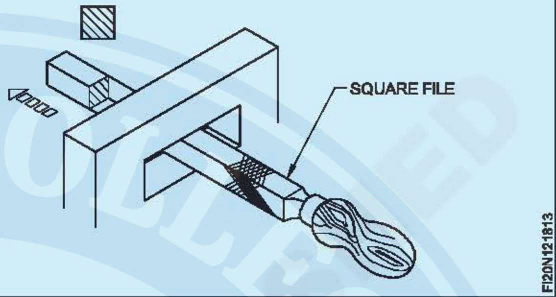
Fig 2



> **Flat files are general purpose files. They are available in all grades. Hand files are particularly useful for filling at right angles to a finished surface.**

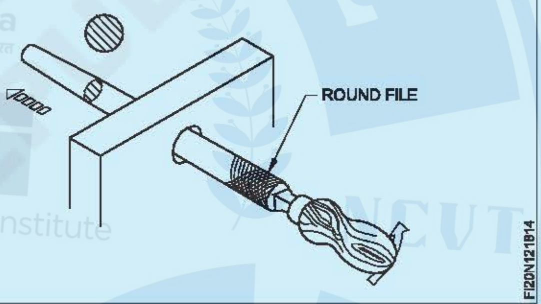
Square File: The square file is square in its cross section. It is used for filing square holes, internal square corners, rectangular openings, keyways and splines. (Fig 3)

Fig 3



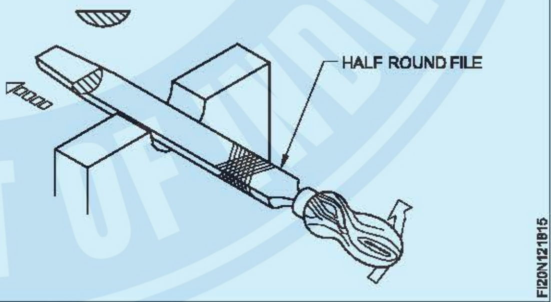
Round file: A round file is circular in its cross section. It is used for enlarging the circular holes and filing profiles with fillets. (Fig.4)

Fig 4



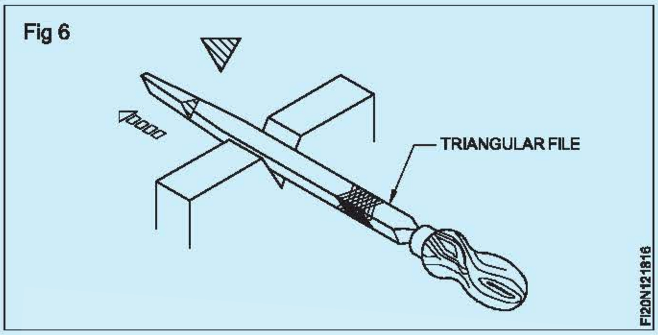
Half round file: A half round file is in the shape of a segment of a circle. It is used for filing internal curved surfaces. (Fig.5)

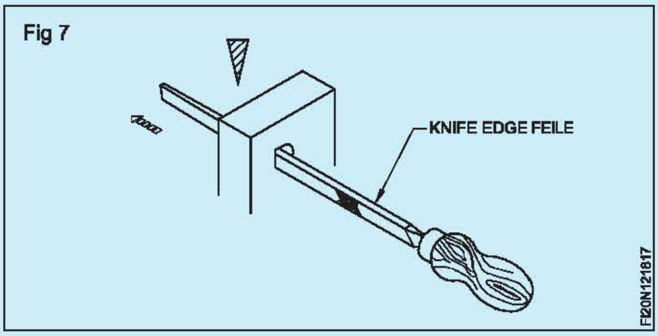
Fig 5



Knife edge file: A knife edge file has the cross section of a sharp triangles. It is used for filing narrow grooves and angles above 10° (Fig.7)

The above files have one third of their lengths tapered. They are available both single and double cuts.





Triangular file: A triangular file is of a triangular cross section. It is used for filing corners and angles which are more than 60°. (Fig.6)

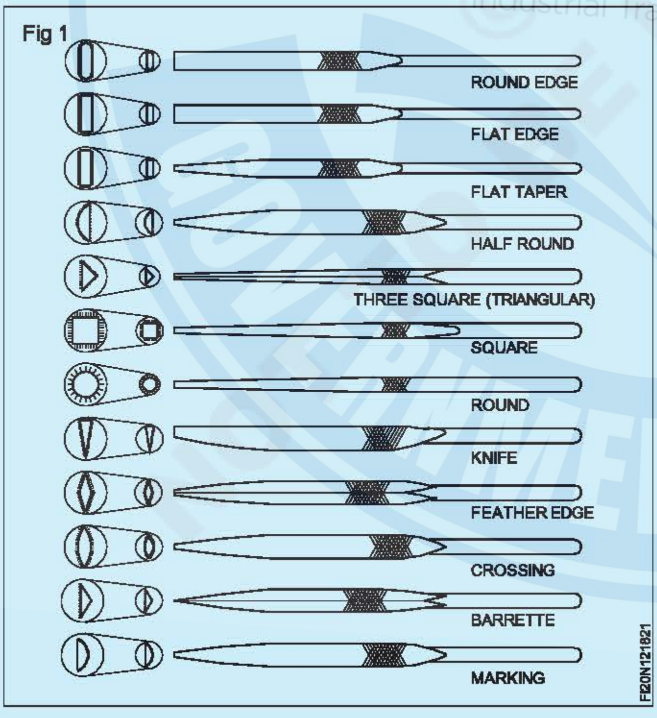
Square, round, half-round and triangular files are available in lengths of 100, 150, 200, 250, 300 and 400mm. These files are made in bastard, second cut and smooth grades.

Needle files

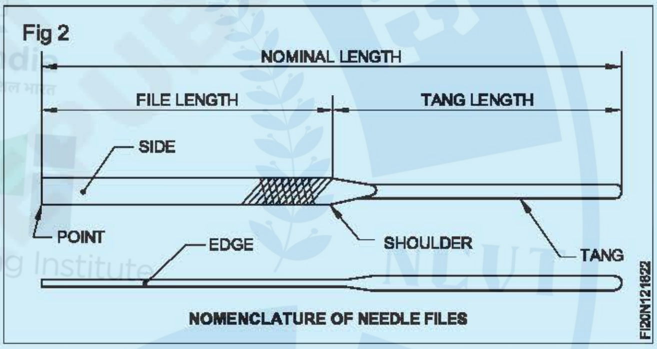
Objectives: At the end of this lesson you shall be able to
- **name the different shapes of needle files**
- **designate needle files as per BIS.**

Needle files are usually available in sets with assorted shapes. These types of files are used for delicate, light kinds of work. These files are available in bastard and smooth grade.

Shapes: The common shapes of needle files are shown in figure 1. The shapes are round edge, flat edge, flat taper, half round, triangular, square, round, knife, feather edge, crossing, barred and marking. (Fig 1)



Nomenclature of needle files. (Fig.2)



Length: These files are available in a nominal length of 120mm to 180mm.

Grades: The grades of cut may be identified by the cut number as follows

- bastard - Cut 0.

- smooth - Cut 2.

Designation of needle files: The needle files are designated by their names

- grade of cut

- nominal length

- BIS number

Example

A flat edge needle file with grade of cut bastard, having a nominal length of 160mm shall be designated as flat edge needle file bastard, 160 IS 3152

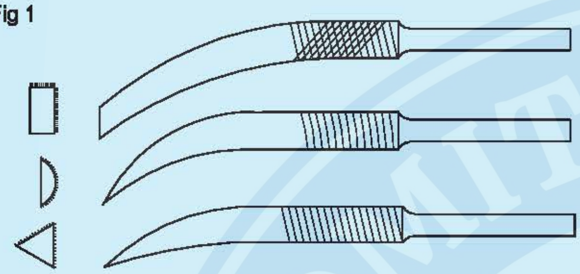
Special files

Objectives: At the end of this lesson you shall be able to
- **name the different types of special files**
- **state the uses of each type of special files.**

In addition to the common type of files, files are also available in a variety of shapes for 'special' applications. These are as follows.

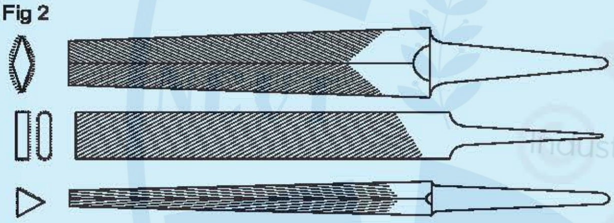
Riffle files (Fig 1)**:** These files are used for die-sinking, engraving and in silversmith's work. They are made in different shapes and sizes and are made with standard cuts of teeth.

Fig 1



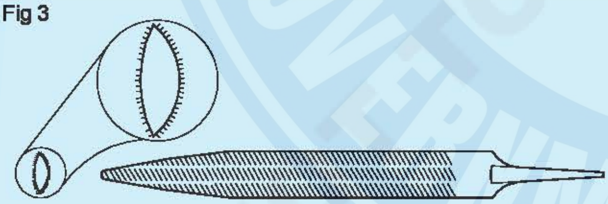
Mill saw files (Fig 2)**:** Mill saw files are usually flat and have square or rounded edges. These are used for sharpening teeth of wood-working saws, and are available in single cut.

Fig 2



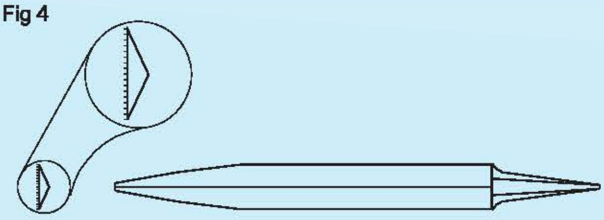
Crossing file (Fig 3)**:** This file is used in the place of a half round file. Each side of the file has different curves. It is also known as 'fish back' file.

Fig 3



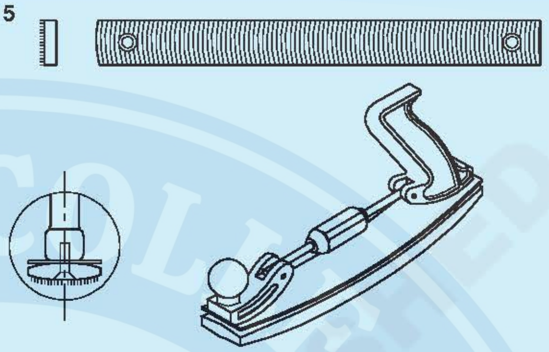
Barrette file (Fig 4)**:** This file has a flat, triangular face with teeth on the wide face only. It is used for finishing sharp corners.

Fig 4



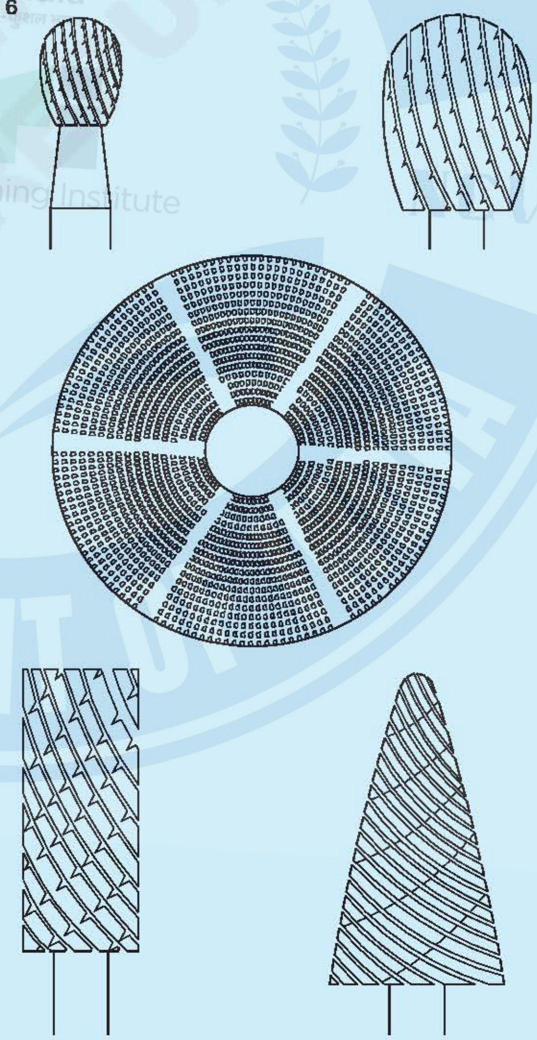
Tinker's file (Fig 5)**:** This file has a rectangular shape with teeth only at the bottom face. A handle is provided on the top. This file is used for finishing automobile bodies after tinkering.

Fig 5



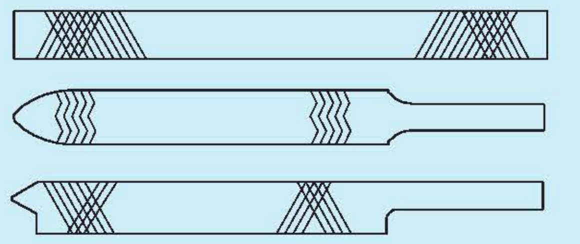
Rotary files (Fig 6)**:** These files are available with a round shank. They are driven by a special machine with a portable motor and flexible shaft. These are used in diesinking and mould-making work.

Fig 6



Machine files for hand filing machine (Fig 7)**:** Machine files are of double cut, having holes or projections to fix to the holder of the filing machine. The length and shape will vary according to the machine capacity. These files are suitable for filing the inner and outer surfaces, and are ideal for die sinking and other tool-room work.

Fig 7



Pinning of files

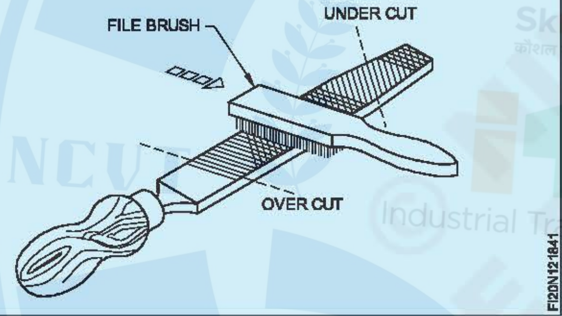
Objective: At the end of this lesson you shall be able to
- **clean the files.**

During filing, sometimes the metal chips (filings) will clog between the teeth of files. This is known as 'pinning' of files.

Files which are pinned will produce scratches on the surface being filed, and also will not bite well.

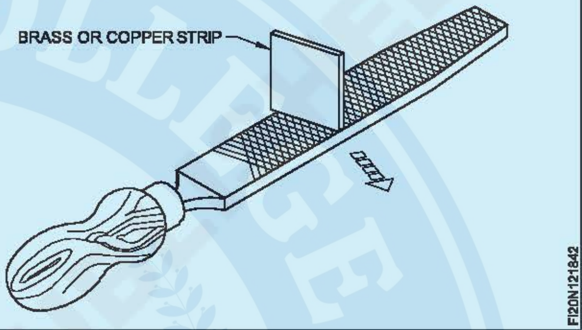
Pinning of the files is removed by using a file brush also called a file card, (Fig 1) with either forward or backward stroke.

Fig 1



Filings which do not come out easily by the file card should be taken out with a brass or copper strip. (Fig 2)

Fig 2



For new files, use only soft metal strips (brass or copper) for cleaning. The sharp cutting edges of the files will wear out quickly if a steel file card is used. When filing a workpiece to a smooth finish more 'pinning' will take place because the pitch and depth of the teeth are less.

Application of chalk on the face of the file will help reduce the penetration of the teeth and 'pinning'.

Clean the file frequently in order to remove the filings embedded in the chalk powder.

Care and maintenance

Objective: At the end of this lesson you shall be able to
- **write the care and maintenance of file.**

- Do not use files having the blunt cutting edge
- Remember that files cut on the push stroke. Never apply the pressure on the pull stroke, or you could crush the file teeth, blunt them or cause them to break off.
- Prevent from pinning.
- Giving your files teeth a light brush with oil during long storage.
- Normally do not apply any oil while filing.
- Files should be stored separately so that their faces cannot rub against each other or against other tools.

Convexity of files

Objective: At the end of this lesson you shall be able to
- **list the reasons for convexity on files.**

Most files have the faces slightly bellied lengthwise. This is known as convexity of a file. This should not be confused with the taper of a file. A flat file has faces which are convex and it also tapers slightly in width and thickness.

Purpose: If the file is parallel in thickness, all the teeth on the surface of the work will cut. This would require more downward pressure to make the file 'bite' and also more forward pressure to make the file to cut.

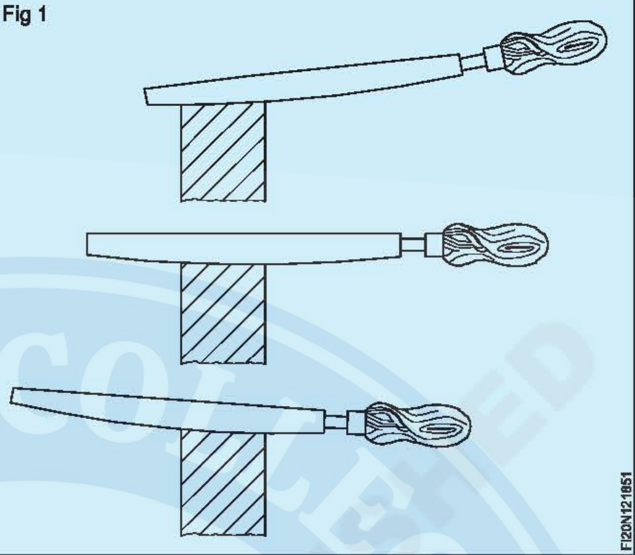
It is more difficult to control a file of uniform thickness.

To produce a flat surface with a file of parallel thickness, every stroke should be straight. But it is not possible due to the see-saw action of the hand.

If the file is made with parallel faces, while giving heat treatment, one face may warp and become concave, and the file will be useless for flat filing.

Excessive chip removal at the front or rear workpiece edge is prevented and filing of the flat surface is made easier because of the convexity on the cutting faces. (Fig 1)

Fig 1



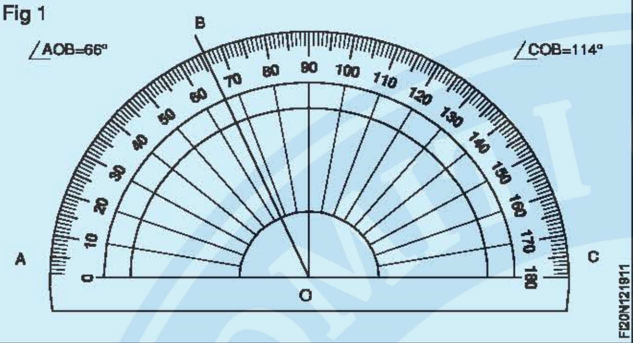
Scan the QR Code to view the video for this exercise

Measurement of angles

Objectives: At the end of this lesson you shall be able to
- **state the units and fractional units of angles**
- **express degrees, minutes and seconds using symbols.**

The unit of an angle: For angular measurements a complete circle is divided into 360 equal parts. Each division is called a degree. (A half circle will have 180°) (Fig 1)

Fig 1



Subdivisions of an angle: For more precise angular measurements, one degree is further divided into 60 equal parts. This division is one MINUTE ('). The minute is used to represent a fractional part of a degree and is written as 30° 15'.

One minute is further divided into smaller units known as seconds ("). There are 60 seconds in a minute.

An angular measurement written in degrees, minutes and seconds would read as 30° 15' 20".

Examples for angular divisions

1	complete circle	360°
1/2	circle	180°
1/4	of a circle (right angle)	90°

Sub divisions 1 degree or 1° = 60 mts or 60'

1 min or 1' = 60 secs or 60"

Angular measuring instruments (Semi-precision)

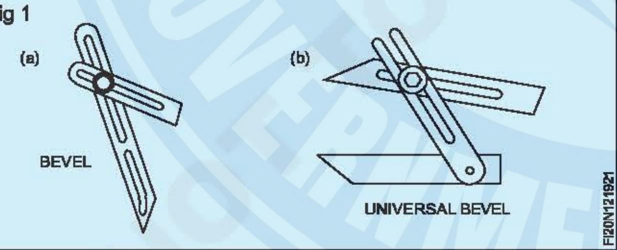
Objectives: At the end of this lesson you shall be able to
- **state the names of semi-precision angular measuring instruments**
- **differentiate between bevel and universal bevel gauges**
- **state the features of bevel protractors.**

The most common instruments used to check angles are the:

bevel or bevel gauge (Fig 1)

universal bevel gauge (Fig 2)

Fig 1



bevel protractor. (Fig 3)

Bevel gauges : The bevel gauges cannot measure angles directly. They are, therefore, indirect angular measuring instruments. The angles can be set and measured with bevel protractors.

Universal bevel gauges : The universal bevel gauge has an additional blade. This helps in measuring angles which cannot be checked with an ordinary bevel gauge. (Fig 4)

Bevel protractor (Fig 3)**:** The bevel protractor is a direct angular measuring instrument, and has graduation marked from 0° to 180°. Angles can be measured within an accuracy of 1° using this instrument. (Fig 3)

Fig 2

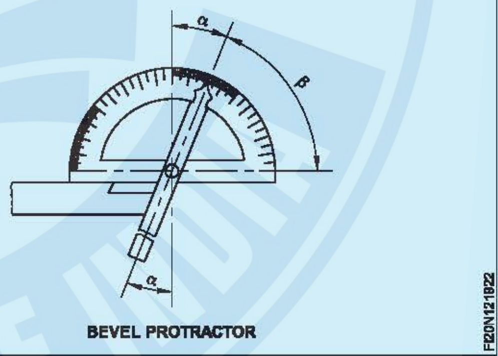
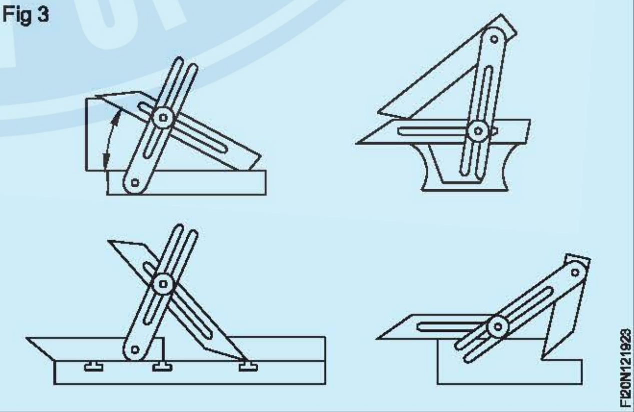


Fig 3



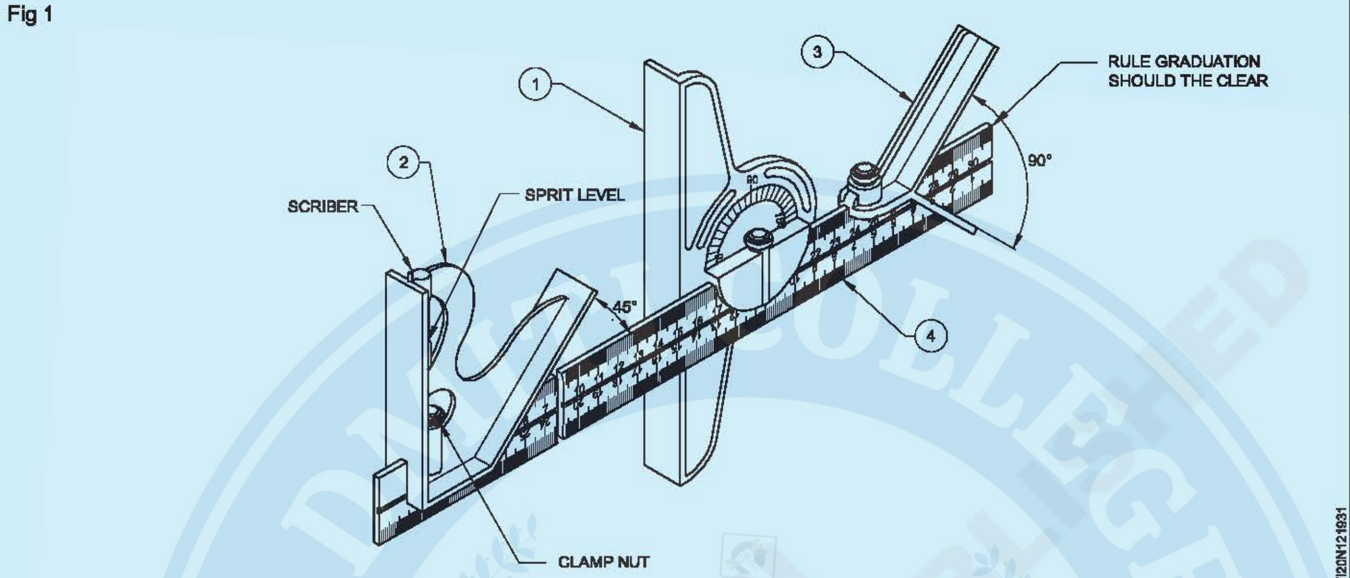
Combination set

Objectives: At the end of this lesson you shall be able to
- **name the parts of a combination set**
- **state the uses of each attachment in a combination set**

Combination sets can be used for different types of work, like layout work, measurement and checking of angles.

The combination set (Fig 1) has a

Fig 1



Protractor head	(1)
Square Head	(2)
Centre head, and a	(3)
Rule	(4)

Protractor Head

The protractor head can be rotated and set to any required angle.

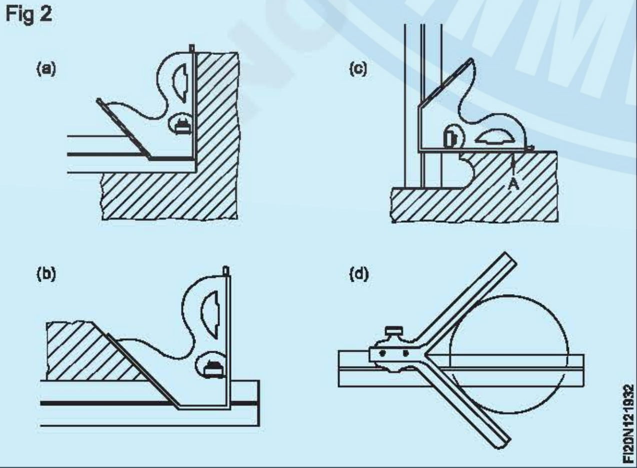
The protractor head is used for marking and measuring angles within an accuracy of 1^0. The spirit level attached to this is useful for setting jobs in a horizontal plane. (Fig.6)

Square Head

The square head has one measuring face at 90^0 and another at 45^0 to the rule.

It is used to mark and check 90^0 and 45^0 angles. It can also be used to set workpieces on the machines and measure the depth of slots. (Fig 2,3 and 4)

Fig 2

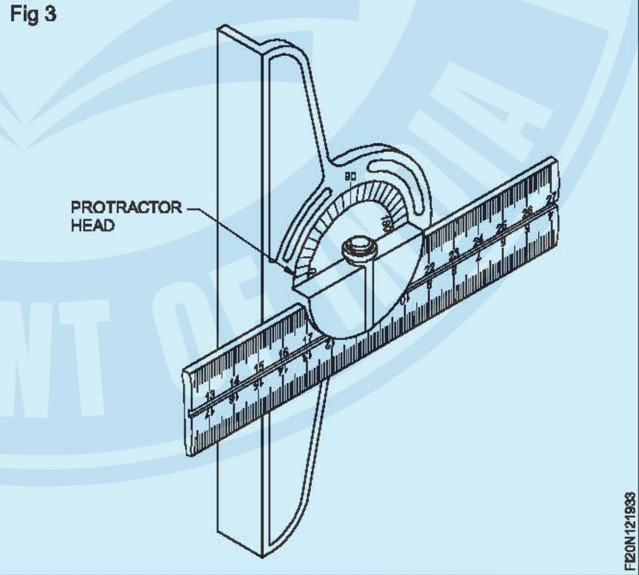


Centre Head

This along with the rule is used for locating the centre of cylindrical jobs. (Fig 5)

> **For ensuring accurate results, the combination set should be cleaned well after use and should not be mixed with cutting tools, either while using or storing.**

Fig 3



Measuring standards (English & metric)

Objective: At the end of this lesson you shall be able to
- **describe the measuring standards of english and metric units.**

Necessity

All physical quantities are to be measured in terms of standard quantities.

Unit

A unit is defined as a standard or fixed quantity of one kind used to measure other quantities of the same kind.

Classification

Fundamental units and derived units are the two classifications.

Fundamental units

Units of basic quantities of length, mass and time.

Derived units

Units which are derived from basic units and bear a constant relationship with the fundamental units.

Ex : Area, Volume, Pressure, Force, etc.

System of units

F.P.S. system is the British system in which the basic units of length, mass and time are foot, pound and second respectively.

C.G.S. system is the metric system in which the basic units of length, mass and time are centimetre, gram and second respectively.

M.K.S system is another metric system in which the basic units of length, mass and time are metre, kilogram and second respectively.

S.I. units is referred to as Systems International units which is again of metric and the basic units, their names and symbols are Listed in table - 1

Table 1

Basic Quantity	Metric Unit		British unit	
	Name	Symbol	Name	Symbol
Length	Metre	m	Foot	F
Mass	Kilogram	kg	Pound	P
Time	Second	S	Second	S
Current	Ampere	A	Ampere	A
Temperature	Kelvin	K	Farenheit	F^o
Light intensity	Candela	Cd	Candela	Cd

Fundamental units and derived units are the two classification of units.

Length, mass and time are the fundamental units in all the systems (ie) F.P.S, C.G.S, M.K.S and S.I systems.

Surface gauges

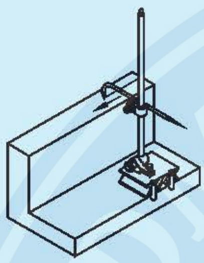
Scan the QR Code to view the video for this exercise

Objectives: At the end of this lesson you shall be able to
- **state the uses of surface gauges**
- **name the types of surface gauges**
- **state the advantages of universal surface gauges.**
- **state care and maintenance of surface gauges**

The surface gauge is one of the most common marking tools used for:

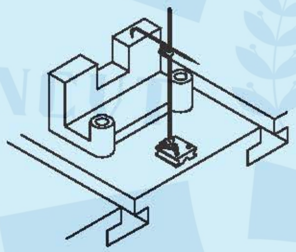
scribing lines parallel to a datum surface (Fig.1)

Fig 1



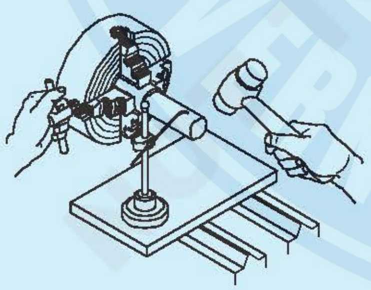
Setting jobs on machines parallel to a datum surface (Fig.2)

Fig 2



Checking the height and parallelism of jobs, setting jobs concentric to the machine spindle. (Fig 3)

Fig 3



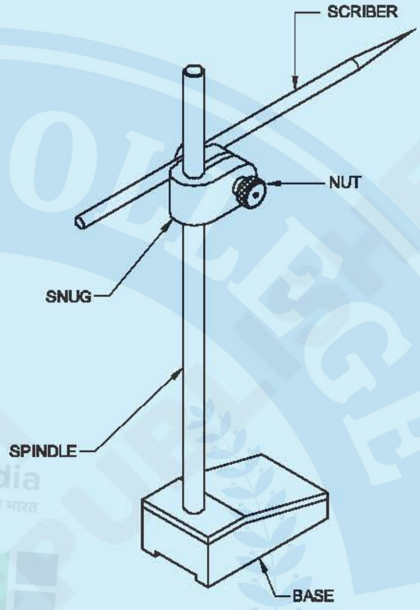
Types of surface gauges

Surface gauges/scribing blocks are of two types, fixed and universal.

Suface gauge - fixed type (Fig 4)

The fixed Type of surface gauge consists of a heavy flat base and a spindle, fixed upright, to which a scriber is attached with a snug and a clamp nut.

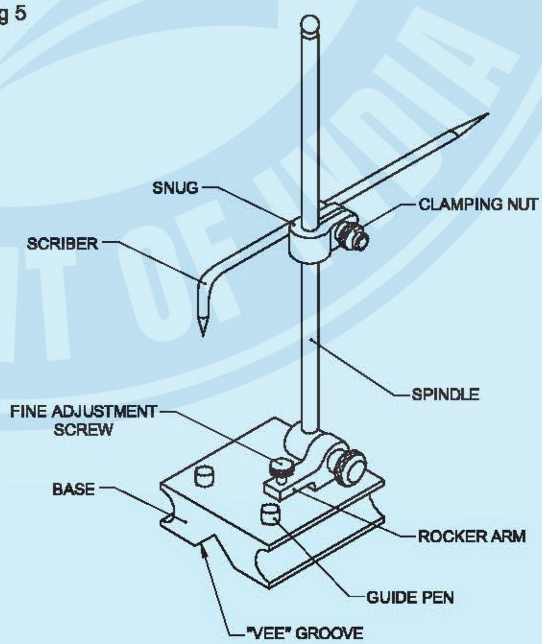
Fig 4



Universal surface gauge (Fig 5)

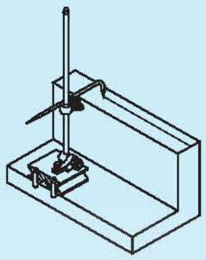
This has the following additional features: The spindle can be set to any position. Fine adjustment can be made quickly. Can also be used on cylindrical surfaces.

Fig 5



Parallel lines can be scribed from any datum edge with the help of guide pins. (Fig 6)

Fig 6



FI20N122018

Parts and functions of a Universal Surface Gauge

Base

The base is made of steel or cast iron with a 'V groove at the bottom. The 'V' groove helps to seat on circular work. The guide-pins, fitted in the base, are helpful for scribing lines from any datum edge.

Rocker arm

The rocker arm is attached to the base along with a spring and a fine adjustment screw. This is used for fine adjustments.

Spindle

The spindle is attached to the rocker arm.

Scriber

The scriber can be clamped in any position on the spindle with the help of a snug and a clamping nut.

Care and maintenance

- Clean before and after the use
- Apply thin layer of oil to the bottom of the surface base before using for marking.
- Sharpen the Scriber if necessary.
- Do not exert more pressure while marking

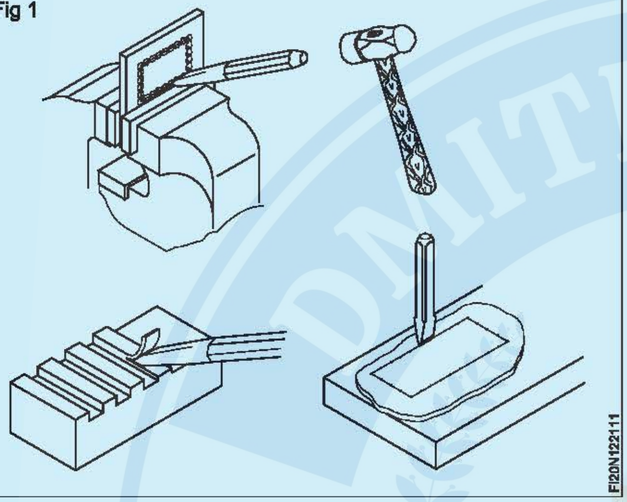
Cold Chisel

Scan the QR Code to view the video for this exercise

Objectives: At the end of this lesson you shall be able to
- **list the uses of a cold chisel**
- **name the parts of a cold chisel**
- **state the different types of chisels**
- **specify the chisel**

The cold chisel is a hand cutting tool used by fitters for chipping and cutting off operations. (Fig 1)

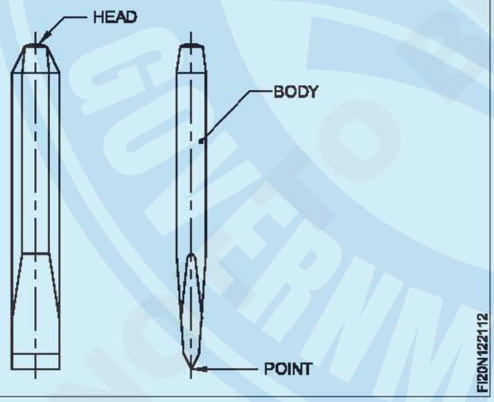
Fig 1



Chipping is an operation of removing excess metal with the help of a chisel and hammer. Chipped surfaces being rough, they should be finished by filing.

Parts of a Chisel (Fig 2)**:** A chisel has the following parts.

Fig 2



Head, body, point or cutting edge.

Chisels are made from high carbon steel or chrome vanadium steel. The cross-section of chisels is usually hexagonal or octagonal. The cutting edge is hardened and tempered.

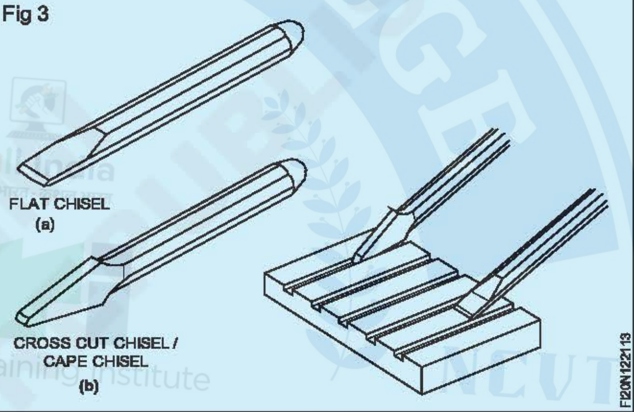
Common types of chisels: There are five common types of chisels.

- Flat chisel
- Cross-cut chisel
- Half-round nose chisel
- Diamond point chisel
- Web chisel

Flat chisels (Fig.3a)**:** They are used to remove metal from large flat surfaces and chip-off excess metal of welded joints and castings.

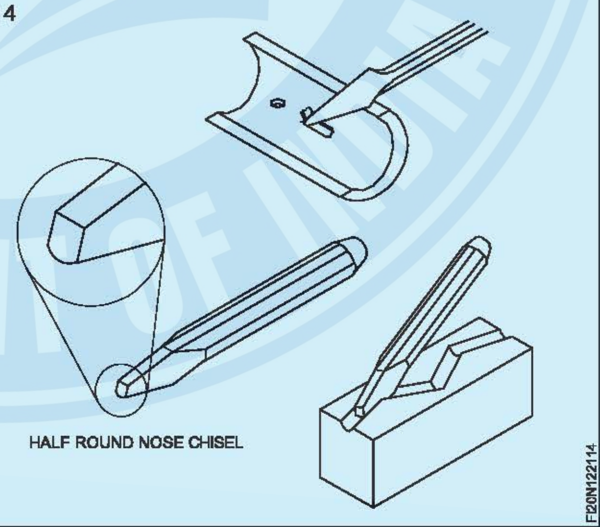
Cross-cut or cape chisels (Fig.3b)**:** These are used for cutting key ways, grooves and slots.

Fig 3



Half-round nose chisels (Fig 4)**:** They are used for cutting curved grooves (oil grooves).

Fig 4



Diamond point chisels (Fig 5)**:** These are used for squaring materials at the corners, joints.

Fig 5

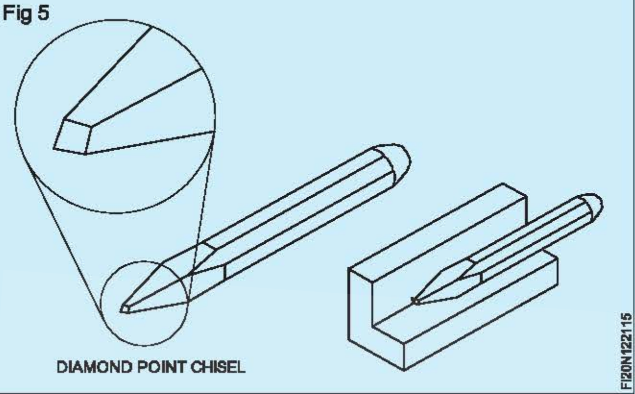
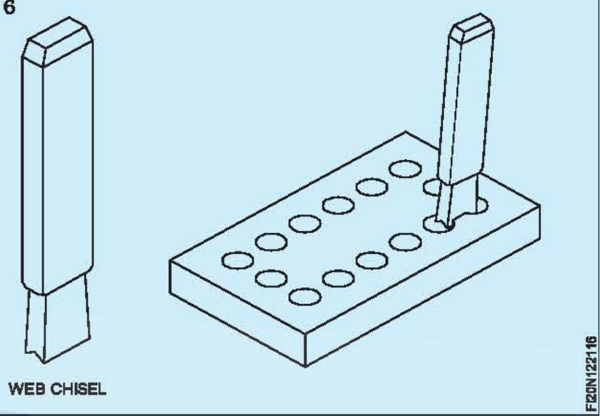


Fig 6



Web chisels/ punching chisels (Fig 6)**:** These chisels are used for separating metals after chain drilling.

Chisels are specified according to their

– length

– width of the cutting edge

– type

– cross-section of the body.

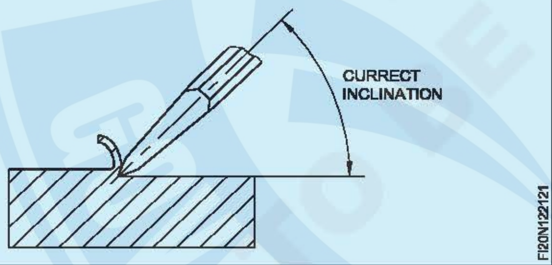
Angles of chisels

Objectives: At the end of this lesson you shall be able to
- **select the point angles of chisels for different materials**
- **state the effect of rake and clearance angles**
- **brief the care and maintenance of chisels.**

Point angles and materials: The correct point/cutting angle of the chisel depends on the material to be chipped. Sharp angles are given for soft materials, and wide angles for hard materials.

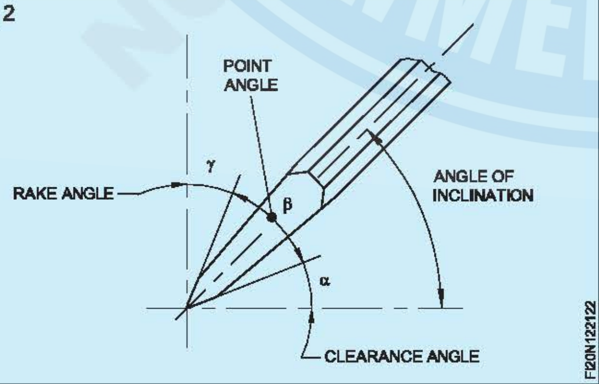
The correct point and angle of inclination generate the correct rake and clearance angles. (Fig 1)

Fig 1



Rake angle: Rake angle is the angle between the top face of the cutting point, and normal (90°) to the work surface at the cutting edge. (Fig 2)

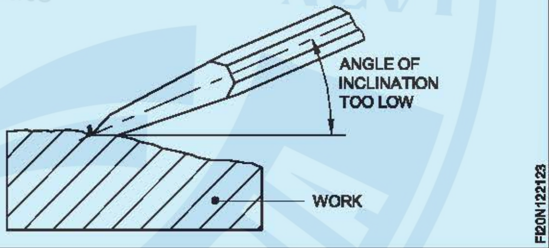
Fig 2



Clearance angle: Clearance angle is the angle between the bottom face of the point and the tangent to the work surface originating at the cutting edge. (Fig 2)

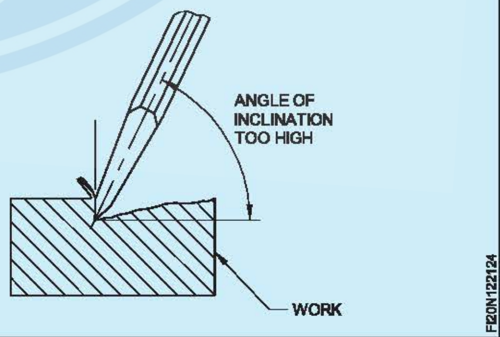
If the clearance angle is too low or zero, the rake angle increases. The cutting edge cannot penetrate into the work. The chisel will slip. (Fig 3)

Fig 3



If the clearance angle is too great, the rake angle reduces. The cutting edge digs in and the cut will become deeper and deeper. (Fig 4) The correct point angle and angle of inclination for different materials for chipping is given in Table 1.

Fig 4



Crowning: A slight curvature is ground called "Crowning" to the cutting edge of the chisel, to prevent digging of corners, which leads to breakage of chisel point. "Crowning" allows the chisel to move freely along a straight line while chipping.

Table 1

Material to be cut	Point angle	Angle inclination
High Carbon Steel	65°	39.5°
Cast iron	60°	37°
Mild steel	55°	34.5°
Brass	50°	32°
Copper	45°	29.5°
Aluminium	30°	22°

Care & maintenance

- Sharpen the chisel before use.
- Apply oil to avoid rust.
- Don't use the mushroom head chisel.
- Use safety goggles while chipping.
- While chipping.
- No greasy subject on the head of the chisel.

Ordinary depth gauge

Objectives: At the end of this lesson you shall be able to
- **state the uses of ordinary depth gauge**
- **name the parts of depth gauge.**

Scan the QR Code to view the video for this exercise

Ordinary depth gauge

Ordinary depth gauge is semi precision instrument used for measuring of depth of recesses, slots and steps.

Parts of ordinary depth gauge

1 Graduated beam

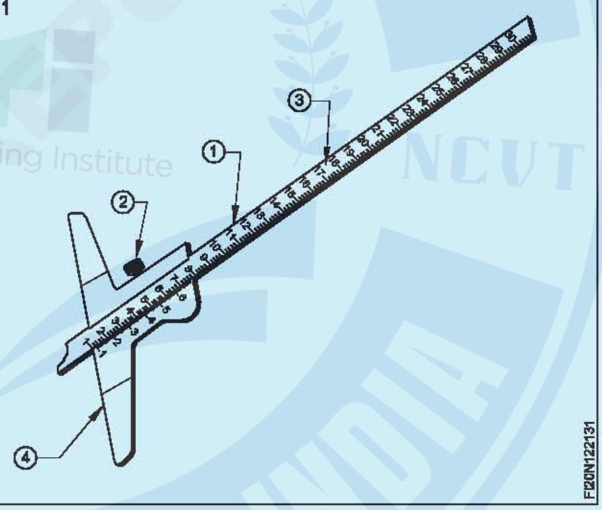
2 Clamping screw

3 Scale

4 Base

Available in the ranges of 0-200 mm. Ordinary depth gauge is used to measure an accuracy of 0.5 mm.

Fig 1



Marking media

Objectives: At the end of this lesson you shall be able to
- **state the purpose of marking media**
- **name the common types of marking media**
- **select the correct marking medium for different applications.**

Scan the QR Code to view the video for this exercise

Purpose of marking media

In marking off/Layout, the surface of the job/workpiece is coated with a medium to show the marked lines clear and visible. To get clear and thin lines, the best layout medium is to be selected.

Different marking media

The different marking media are Whitewash, Marking blue, Prussian Blue, Copper Sulphate and Cellulose Lacquer.

Whitewash

Whitewash is prepared in many ways.

Chalk powder mixed with water

Chalk mixed with methylated spirit

White lead powder mixed with turpentine

Whitewash is applied to rough forgings andcastings with oxidised surface. (Fig 1)

Whitewash is not recommended for workpieces of high accuracy.

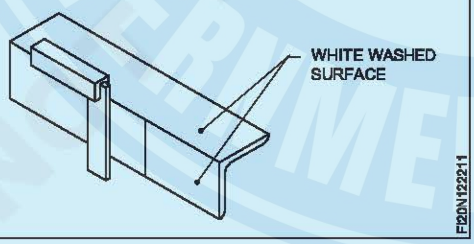
Marking blue

A Chemical dye, blue based colour mixed with methylated spirit used for marking on workpieces which are reasonably machined surface.

Prussian blue

This is used on filed or machine-finished surfaces. This will give very clear lines but takes more time for drying than the other marking media. (Fig 2)

Fig 1

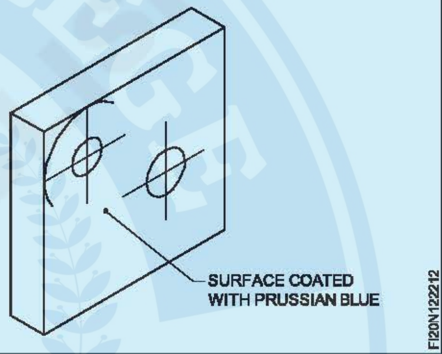


Copper sulphated

The solution is prepared by mixing copper sulphate water and a few drops of nitric acid. The copper sulphate is used on filed or machine-finished surfaces. Copper sulphate sticks to the finished surfaces well.

Copper sulphate needs to be handled carfully as it is poisonous. Copper sulphate coating should be dried before commencing marking, as otherwise, the solution may stick on the instruments used for marking.

Fig 2



Cellulose lacquer: This is a commercially available marking medium. It is made in different colours and dries very quickly.

> **The selection of marking medium for a particular job depends on the surface finish and the accuracy of the workpiece.**
>
> **In present days, marking media used are readily available in aerosol container, which can be applied by spraying on to any surface, which needs marking.**
>
> **Readymade solutions of marking dye/ink which are quick drying and thin layer to mark precise dimensions and clear visible lines. Also permanent marker pens are available in different. colours, which are quick drying and used for smaller workpieces of metal, wood and plastics.**

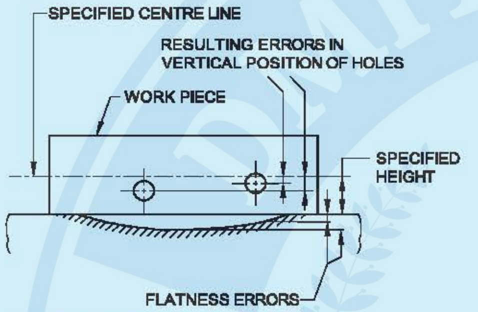
Surface plates

Objectives: At the end of this lesson you shall be able to
- **state the necessity of surface plate**
- **state the material of surface plate**
- **state the specification of surface plate.**

Surface plates - their necessity

When accurate dimensional features are to be marked, it is essential to have a datum plane with a perfectly flat surface. Marking using datum surfaces which are not perfectly flat will result in dimensional inaccuracies. (Fig.1) The most widely used datum surfaces in machine shop work are the surface plates and marking tables.

Fig 1



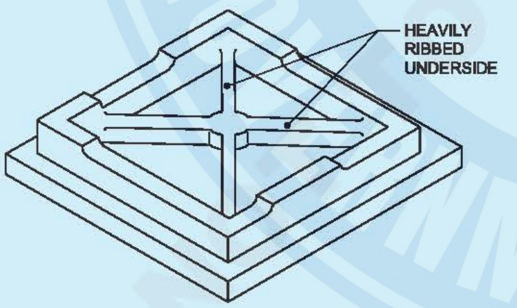
EFFECT OF MARKING-OUT FROM NON-FLAT SURFACE. NOTE THAT THE ERRORS IN THE HOLE POSITIONS ARE EQUAL TO THE FLATNESS ERRORS

Materials and construction

Surface plates are generally made of good quality cast iron which are stress-relieved to prevent distortion.

The work-surface is machined and scraped. The underside is heavily ribbed to provide rigidity. (Fig 2)

Fig 2

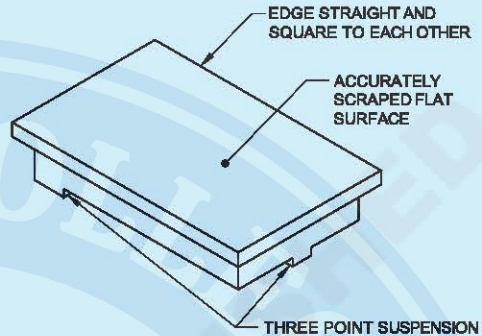


CAST IRON SURFACE PLATE

For the purpose of steadiness and convenience in levelling, a three point suspension is given. (Fig 3)

Smaller surface plates are placed on benches while the larger surface plates are placed on stands.

Fig 3



Other materials used

Granite is also used for manufacturing surface plates. Granite is a dense and stable material. Surface plates made of granite retain their accuracy, even if the surface is scratched. Burrs are not formed on these surfaces.

Classification and uses

Surface plates used for machine shop work are available in three grades - Grades 1, 2 and 3. The grade 1 surface plate is more acceptable than the other two grades.

Specifications

Cast iron surface plates are designated by their length, breadth, grade and the Indian Standard number.

Example

Cast iron surface plate 2000 x 1000 Gr1. I.S. 2285.

Care & maintenance

- Clean before and after use.
- Do not keep job on the surface plate.
- Don't keep any cutting tool on the table.

Angle plates

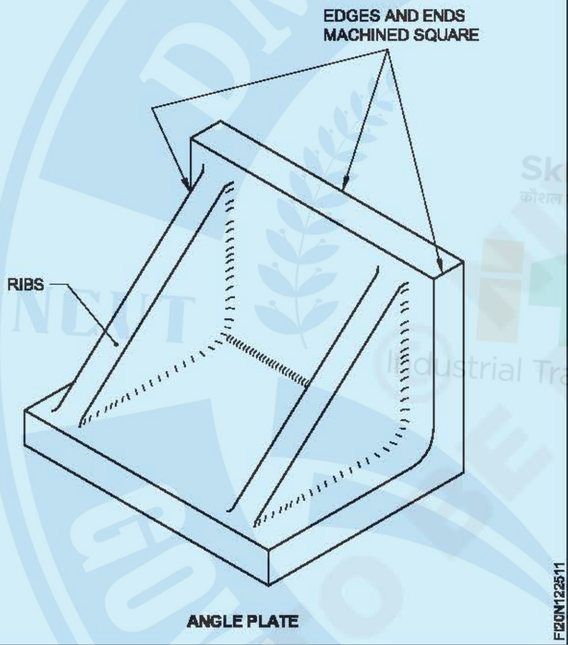
Objectives: At the end of the lesson you shall be able to
- **state the constructional features of different types of angle plates**
- **name the types of angle plates**
- **state the uses of different types of angle plates**
- **state the grades of angle plates.**
- **specify angle plates. Constructional features**

Angle plates have two plane surfaces, machined perfectly flat and at right angles. Generally these are made of closely grained cast iron or steel. The edges and ends are also machined square. They have ribs on the machined part for good rigidity and to prevent distortion.

Types of angle plates

Plain solid angle plate (Fig 1)

Fig 1



Among the three types of angle plates normally used, the plain solid angle plate is the most common. It has the two plane surfaces perfectly machined at 90° to each other. Such angle plates are suitable for supporting work-pieces during layout work. They are comparatively smaller in size.

Slotted type angle plate (Fig 2)

The two plane surfaces of this type of angle plate have slots milled. It is comparatively bigger in size than the plain solid angle plate.

The slots are machined on the top plane surfaces for accommodating clamping bolts. This type of angle plate can be tilted 90° along with the work for marking or machining. (Figs 3 and 4)

Fig 2

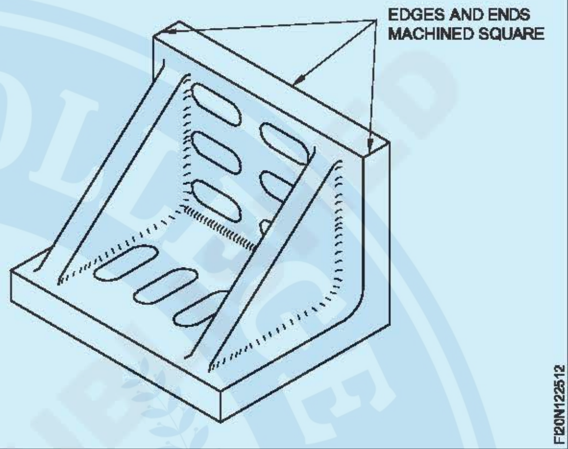
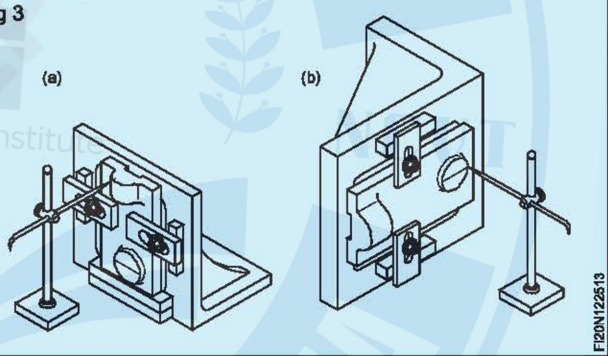
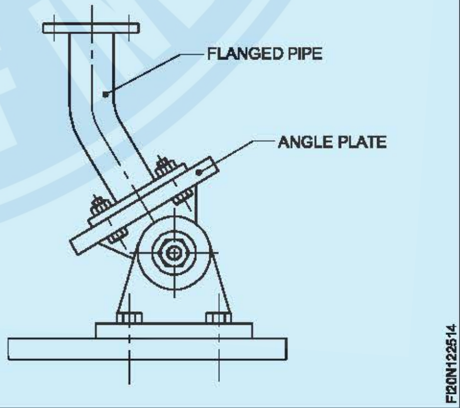


Fig 3



Swivel type angle plate (Fig 5)

Fig 4

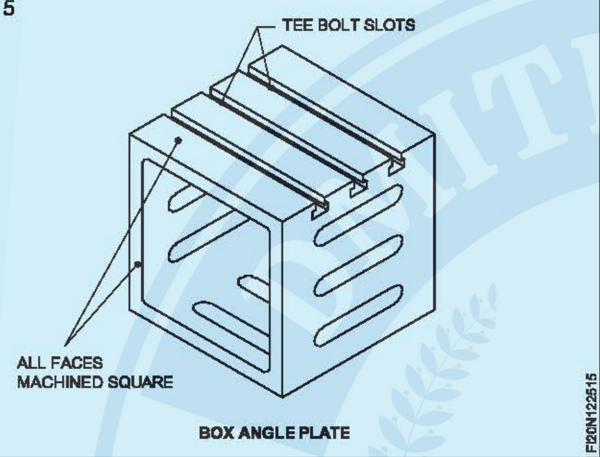


This is adjustable so that the two surfaces can be kept at an angle. The two machined surfaces are on two separate pieces which are assembled. Graduations are marked on one to indicate the angle of tilt with respect to the other. When both zeros coincide, the two plane surfaces are at 90° to each other. A bolt and nut are provided for locking in position.

Box angle plate (Fig 6)

They have applications similar to those of other angle plates. After setting, the work can be turned over with the box enabling further marking out or machining. This is a significant advantage. This has all the faces machined square to each other.

Fig 5



Grades

Angle plates are available in two grades - Grade 1 and Grade 2. The Grade 1 angle plates are more accurate and are used for very accurate tool room type of work. The Grade 2 angle plates are used for general machine shop work. In addition to the above two grades of angle plates, precision angle plates are also available for inspection work.

Sizes

Angle plates are available in different sizes. The sizes are indicated by numbers. Table 1 gives the number of the sizes and the corresponding size proportions of the angle plates.

Specification of angle plates

a) Size 6 Grade 1

Box plate will be designated as - box angle plate 6 Gr 1 IS 623.

b) Size 2 - Grade 2 angle plate will be designated as

Angle plate 2 Gr 2 I.S 623.

TABLE 1

Size No.	L	B	H
1	125	75	100
2	175	100	125
3	250	150	175
4	350	200	250
5	450	300	350
6	600	400	450
7	700	420	700
8	600	600	1000
9	1500	900	1500
10	2800	900	2200
Grade 2 only			

Care & Maintenance

– Clean before and after use.

– Apply oil after the use.

Parallel blocks

Objectives: At the end of this lesson you shall be able to
- **name the types of parallels**
- **state the constructional features of parallel blocks**
- **specify parallel blocks as per BIS recommended**
- **state the uses of parallel blocks.**

Parallel blocks of different types are used for setting workpieces for machining. The commonly used are of two types.

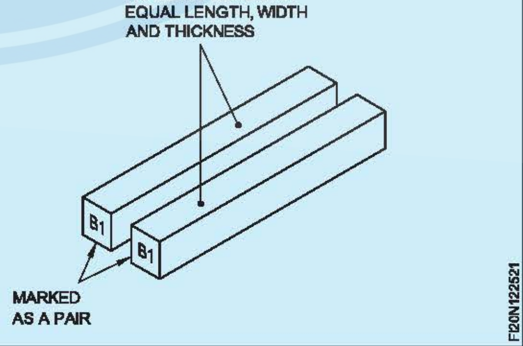
– Solid Parallels

– Adjustable Parallels

Solid parallels (Solid parallel blocks) (Fig 1)

This is the type of parallel which is very much used in machine shop work. They are made of steel pieces of rectangular cross section, and are available in different lengths and cross sectional sizes.

Fig 1



They are hardened and ground, and, sometimes, finished by lapping.

Parallels are machined to close limits, and are perfectly flat, square, and parallel throughout the length. These are made in pairs of identical dimensions.

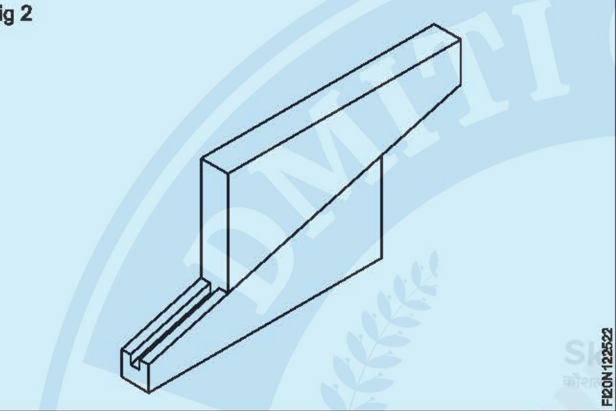
Grades

Parallels are made in two grades - Grade A and Grade B. Grade A is meant for fine toolroom type of work, and Grade B for general machine shop work.

Adjustable parallels (Fig 2)

These consist of two tapered blocks sliding one over the other in a tongue and groove assembly. These types of parallels can be adjusted and set to different heights.

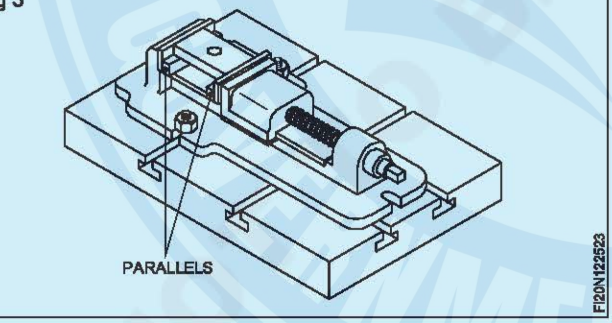
Fig 2



Uses

Solid and adjustable parallels are used for parallel setting of workpieces while machining. They are also useful for raising the workpieces held in vices or machine tables to provide better observation of the machining process. (Fig 3)

Fig 3



Parallels are made in pairs and should be used in matching pairs to ensure accuracy in set-up.

Care and maintenance

- Clean before and after the use.
- Apply oil after use
- Do not use as a hammer.

Sizes of parallels

These are given in TABLE 1 and TABLE 2.

Designation of parallels

Parallels are designated by the type, grade (for solid parallels only) size, and the number of the standard. Fig 4

Examples

Solid parallel A5 x 10 x 100 IS: 4241

Adjustable parallel 10 x 13 IS:4241

Fig 4

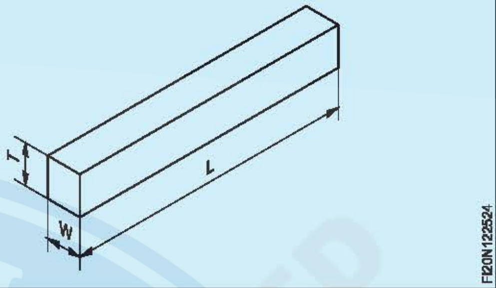


Table 1

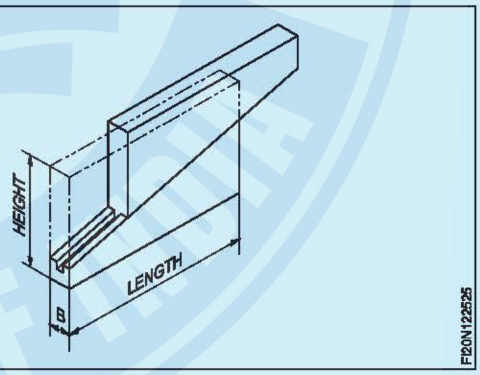
Sizes of solid parallels

Grade	Size T.W.L.
A & B	5 x 10 x 100
A & B	10 x 20 x 150
A & B	15 x 25 x 150
A & B	20 x 35 x 200
A & B	25 x 45 x 250
A & B	30 x 60 x 250
A & B	35 x 70 x 300
B	40 x 80 x 350
B	50 x 100 x 400

Table 2

Range and size of Adjustable Parallels

Fig 5



Height Range	Length
10 - 13	40
13 - 16	50
16 - 20	60
20 - 25	65
25 - 30	70
30 - 40	85
40 - 50	100

Physical and mechanical properties of metals

Objectives: At the end of this lesson you shall be able to
- **name the different physical and mechanical properties of materials**
- **state the characteristics of the mechanical properties of metals.**

Properties of metals: Metals have different properties. Depending on the type of application, different metals are selected.

Physical properties of metals

- Colour
- Weight/Specific gravity
- Structure
- Conductivity
- Magnetic property
- Fusibility

Colour

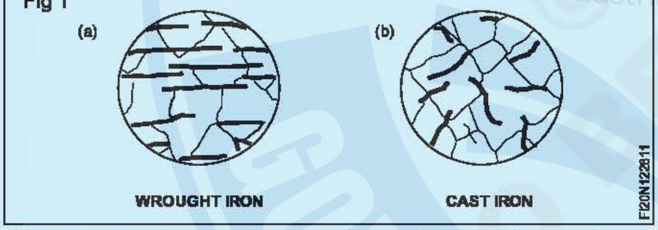
Different metals have different colours. For example, copper is of a distinctive red colour. Mild steel is of a blue/black sheen.

Weight

Metals differ based on their weight. A metal, like aluminium, weighs lighter (specific gravity 2.8) than many others, and a metal, like lead, is heavy (specific gravity 9).

Structure (Figs 1 and 2)

Fig 1



Generally metals can also be differentiated by their internal microstructure. Metals like wrought iron and aluminium will have a fibrous structure, and metals like cast iron and bronze will have a granular structure.

Conductivity: Thermal conductivity and electrical conductivity are the measure of the ability of a material to conduct heat and electricity. Conductivity will vary from metal to metal. Copper and aluminium are good conductors of heat and electricity.

Magnetic property: A metal is said to possess magnetic property, if it is attracted by a magnet.

Almost all ferrous metals, excepting some types of stainless steel, can be attracted by a magnet and all non-ferrous metals and their alloys will not be attracted by a magnet.

Fusibility (Fig 3)

It is the property possessed by a metal by virtue of which it melts when heat is applied. Many materials are subject to the transformation in shape (i.e.) from solid to liquid at different temperatures. Tin has a low melting temperature (232°C)and tungsten melts at a high temperature (3370ºC).

Fig 2

Specific gravity

It is the ratio between the weight of the metal and the weight of equal volume of water.

Mechanical properties

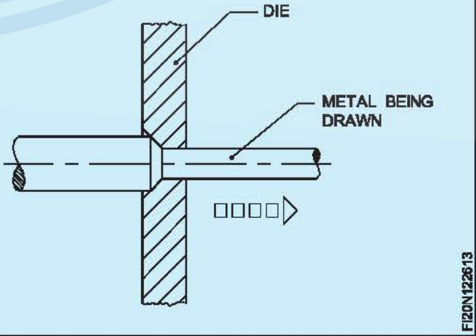
The mechanical properties of a metal are

- ductility
- malleability
- hardness
- brittleness
- toughness
- tenacity
- elasticity

Ductility (Fig 4)

A metal is said to be ductile when it may be drawn out in tension without rupture. Wire-drawing depends upon ductility for its successful operation. A ductile metal must be both strong and plastic. Copper and aluminium are good examples of ductile metals.

Fig 3



Malleability (Figs 5 and 6)

Fig 4

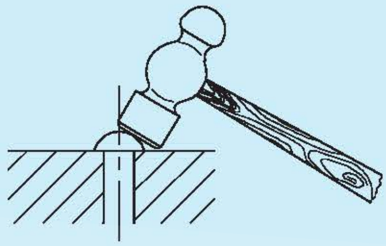
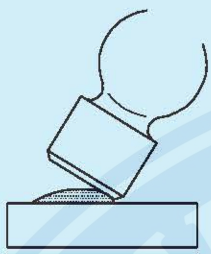


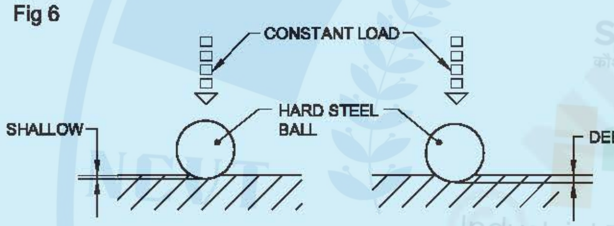
Fig 5



Malleability is the property of permanently extending in all directions without rupture by hammering, rolling etc. to change its size and shape. Lead is a very malleable metal.

Hardness (Fig 7)

Fig 6

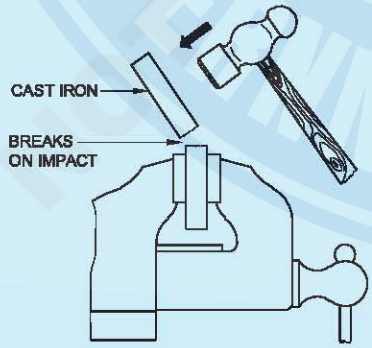


Hardness is a measure of a metal's ability to withstand scratching, wear, abrasion and penetration.

Brittleness (Fig 8)

Brittleness is the property of a metal which permits no permanent distortion before breaking. Cast iron is an example of a brittle metal, and it will break rather than bend under shock or impact.

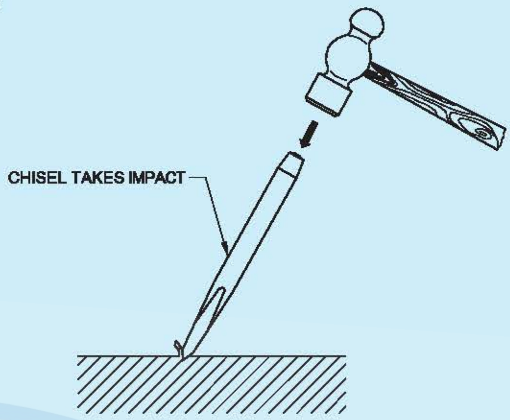
Fig 7



Toughness (Fig 9)

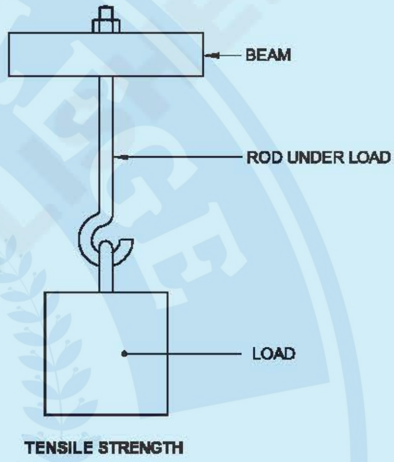
Toughness is the property of a metal to withstand shock or impact. Toughness is the property opposite to brittleness. Wrought iron is an example of a tough metal.

Fig 8



Tenacity (Fig 10)

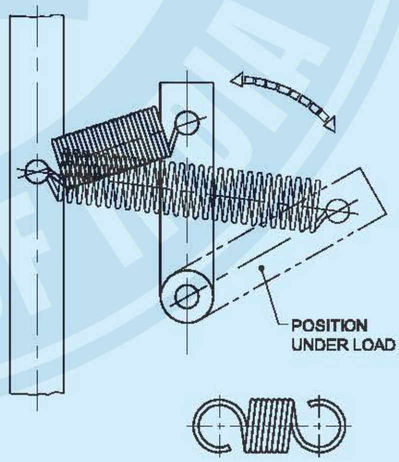
Fig 9



Tenacity of a metal is its ability to resist the effect of tensile forces without rupture. Mild steel, wrought iron and copper are examples of tenacious metals.

Elasticity (Fig 11)

Fig 10



Elasticity of a metal is its power of returning to its original shape after the applied force is released. Properly heat-treated spring is a good example of elasticity.

Specific gravity

It is the ratio between the weight of the metal and the weight of equal volume of water.

Metal-cutting saws

Objectives: At the end of this lesson you shall be able to
- **name the common types of metal-cutting saws**
- **state the advantages of a horizontal band-saw**
- **state the features of different types of cutting saws**
- **state the specific use of a contour-saw.**
- **state the precautions to be observed while machine sawing.**

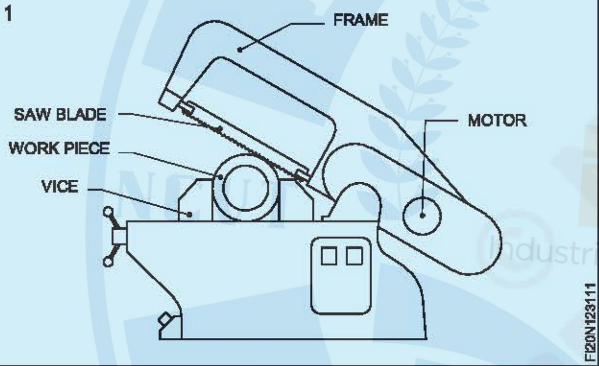
Metal-cutting saws of different types are used in industries. The most commonly used are the:

- power saw
- horizontal band-saw
- circular saw
- contour band-saw.

Power saw (Fig 1)

This is the most commonly used metal-cutting saw and discussed in related theory for Ex: 1.2.31.

Fig 1

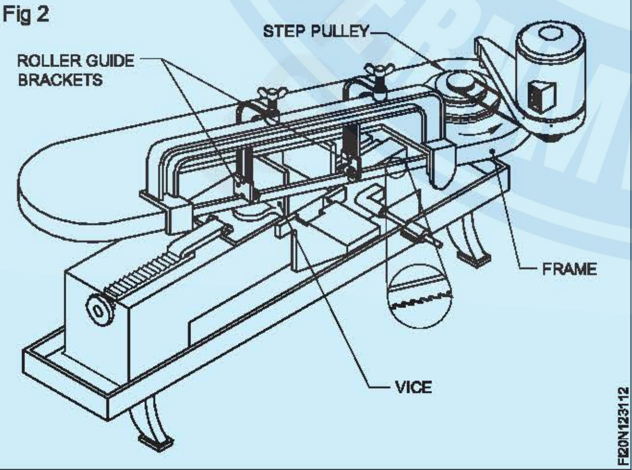


Horizontal band-saw (Fig 2)

This has a saw frame on which a motor is fitted.

There are two pulley wheels on which an endless bandsaw passes.

Fig 2



Speed variation is obtained through the stepped pulleys on the motor.

The roller-guide brackets provide the rigidity for the blade in the cutting area and also prevent wandering of the blade while cutting.

The blade tension is maintained by using the adjusting handle. provided for this purpose.

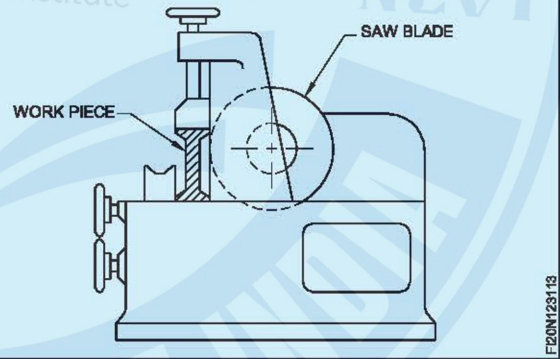
A vice is provided for holding the metal stocks. The vice is adjustable for angular cutting.

This machine has the advantage of continuous cutting ability, and is much faster than a power saw. It may be noted that a power saw cuts only in every alternate stroke.

Cirucular saw (Fig 3)

This type of cutting machine is used when cutting materials have a large cross-section. The circular saw has a continuous cutting action and is economical in production work where heavy section metals are used.

Fig 3



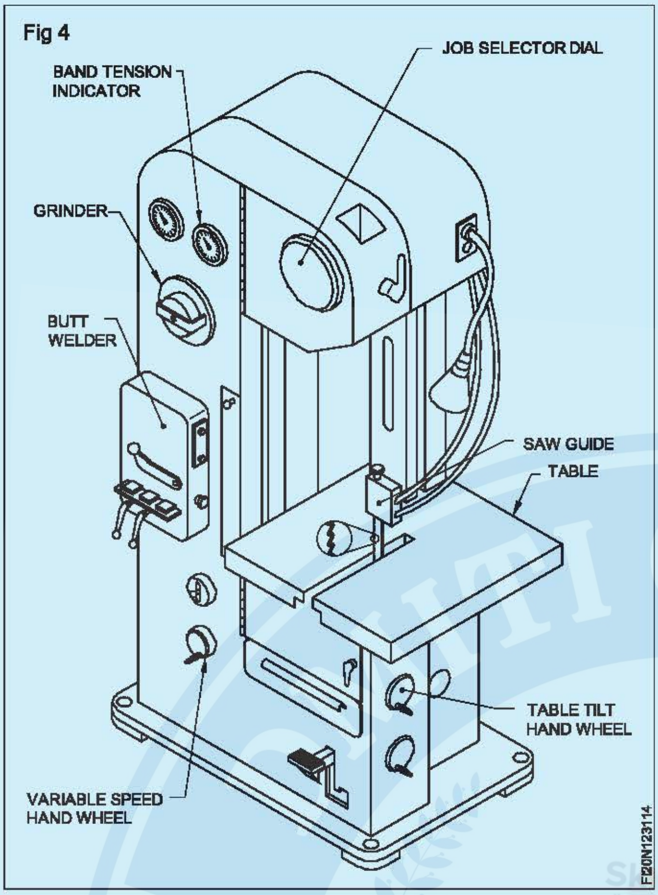
Contour saw (Fig 4)

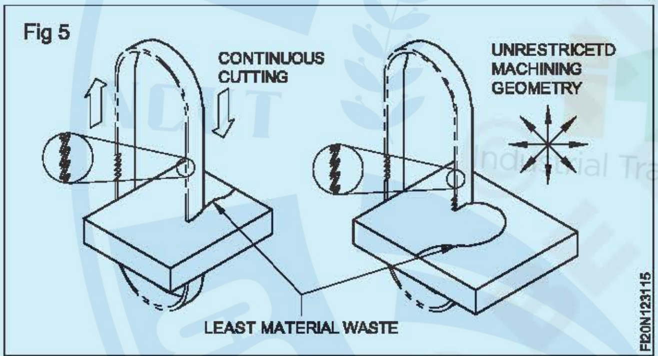
In this, a metal band saw blade is used, and the contour saw has a continuous cutting motion. (Fig 5)

These machines are very much used for cutting metals to different profiles. (Fig 6)

Different speeds can be obtained while cutting, with the help of variable speed pulleys.

For repairing broken countour saw blades, these machines are fitted with a shear for trimming the blade ends, a butt-welding machine for joining the ends and the small grinder to finish the welded joint.





The table can be tilted to any angle for angular cutting.

The blade passes through a guide which prevents the blades from wandering and keeps it rigidly.

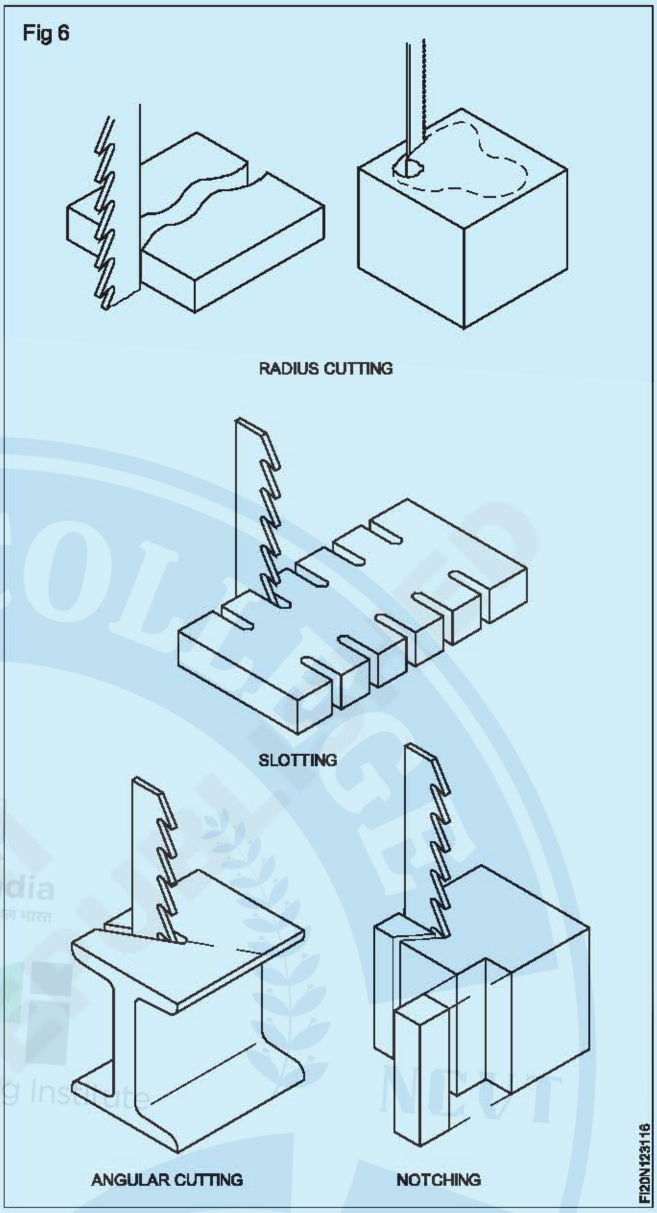
These machines are widely used for tool-room work, and not as a machine for cutting raw material stock.

Precautions to be observed while machine sawing

In order to work safely and efficiently, certain precautions are to be observed.

While taking measurements of the work for setting, always stop the machine.

Projecting ends of the work should be well guarded, so that safety may be provided to others.



Ensure that the work does not protrude into the gangways.

When sawing thin pieces, hold the material flat in the vice to prevent the saw teeth from breaking.

Ensure a cutting fluid is used always.

Avoid giving excessive cutting pressure, because this can cause breakage to the blade, and cut work out of square.

When several pieces of the same length are to be cut, use a stop gauge.

When holding short workpieces in a vice, be sure to place a short piece of the same thickness in the opposite end. This will prevent the vice from twisting when it is tightened.

Lubricate the machines on the indicated points using oil can, oil gun or grease gun as specified by the machine manufacturer.

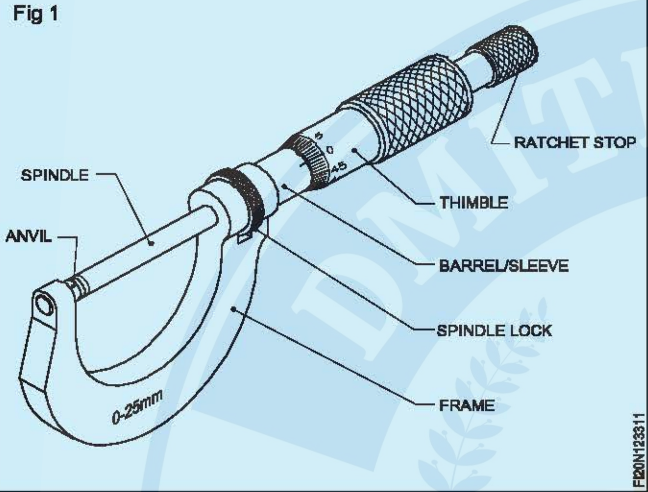
Outside micrometer

Objectives: At the end of this lesson you shall be able to
- **name the parts of an outside micrometer**
- **state the functions of the main parts of an outside micrometer.**

A micrometer is a precision instrument used to measure a job, generally within an accuracy of 0.01 mm.

Micrometers used to take the outside measurements are known as outside micrometers. (Fig 1)

Fig 1



The parts of a micrometer are listed here.

Frame

The frame is made of drop-forged steel or malleable cast iron. All other parts of the micrometer are attached to this.

Barrel/Sleeve

The barrel or sleeve is fixed to the frame. The datum line and graduations are marked on this.

Thimble

On the beveled surface of the thimble also, the graduation is marked. The spindle is attached to this.

Spindle

One end of the spindle is the measuring face. The other end is threaded and passes through a nut. The threaded mechanism allows for the forward and backward movement of the spindle.

Anvil

The anvil is one of the measuring faces which is fitted on the micrometer frame. It is made of alloy steel and finished to a perfectly flat surface.

Spindle lock nut

The spindle lock nut is used to lock the spindle at a desired position.

Ratchet stop

The ratchet stop ensures a uniform pressure between the measuring surfaces.

Graduations of metric outside micrometer

Objectives: At the end of this lesson you shall be able to
- **state the principle of a micrometer**
- **determine the least count of an outside micrometer.**

Working principle

The micrometer works on the principle of screw and nut. The longitudinal movement of the spindle during one rotation is equal to the pitch of the screw. The movement of the spindle to the distance of the pitch or its fractions can be accurately measured on the barrel and thimble.

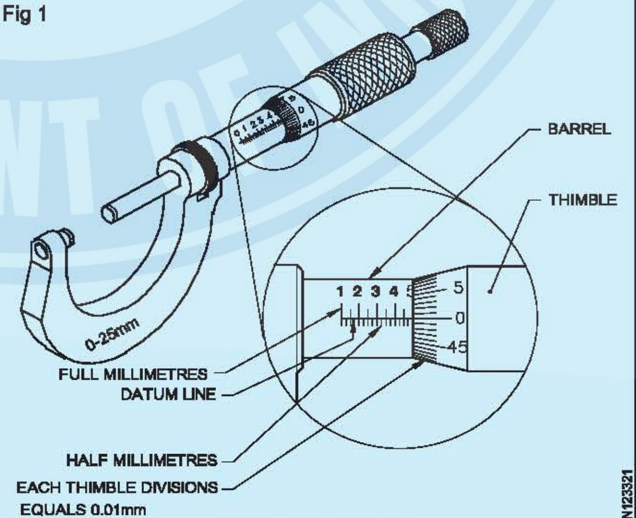
Graduations (Fig 1)

In metric micrometers the pitch of the spindle thread is 0.5 mm.

Thereby, in one rotation of the thimble, the spindle advances by 0.5 mm.

On the barrel a 25 mm long datum line is marked. This line is further graduated to millimetres and half millimetres

Fig 1



OUTSIDE MICROMETER

(i.e. 1 mm & 0.5 mm). The graduations are numbered as 0, 5, 10, 15, 20 & 25 mm.

The circumference of the bevel edge of the thimble is graduated into 50 divisions and marked 0-5-10-15 .... 45-50 in a clockwise direction.

The distance moved by the spindle during one rotation of the thimble is 0.5 mm.

Movement of one division of the thimble = 0.5 x 1/50

= 0.01 mm

Accuracy or least count of a metric outside micrometer is 0.01 mm.

Reading dimensions with outside micrometer

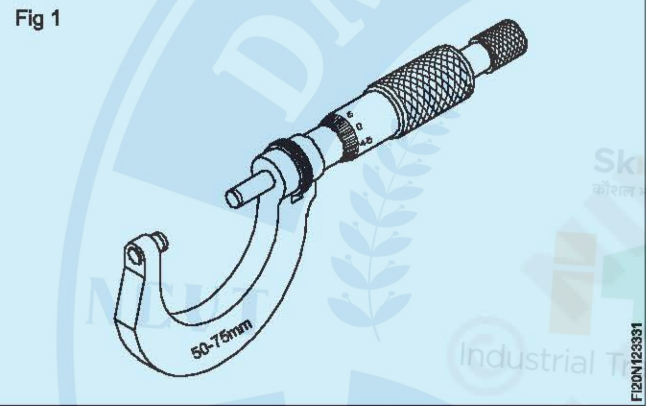
Objectives: At the end of this lesson you shall be able to
- **select the required range of a micrometer**
- **read micrometer measurements.**

Ranges of outside micrometer

Outside micrometers are available in ranges of 0 to 25 mm, 25 to 50 mm, 50 to 75 mm, 75 to 100 mm, 100 to 125 mm and 125 to 150 mm.

For all ranges of micrometers, the graduations marked on the barrel is only 0-25 mm. (Fig 1)

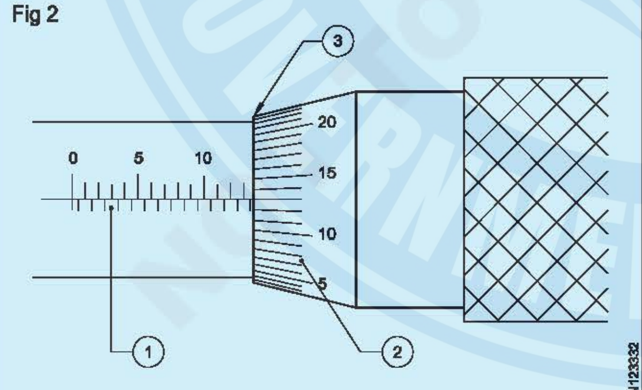
Fig 1



Reading micrometer measurements

How to read a measurement with an outside micrometer? (Fig 2)

Fig 2



First note the minimum range of the outside micrometer. While measuring with a 50 to 75 mm micrometer, note it as 50 mm.

Then read the barrel graduations. Read the value of the visible lines on the left of the thimble edge.

13.00 mm (Main division reading on barrel)

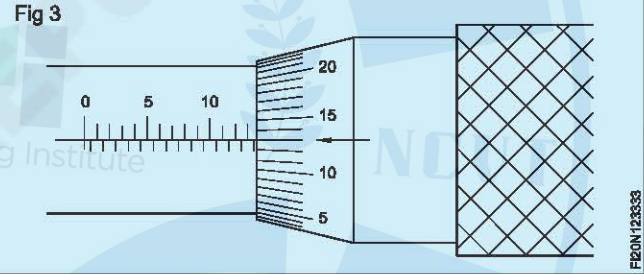
+ 00.50 mm (Sub division reading on barrel)

13.50 mm (Main division + sub - division value)

Next read the thimble graduations.

Read the thimble graduations in line with the barrel datum line, 13th div. (Fig 3)

Fig 3



Multiply this value with 0.01 mm (least count).

13 x 0.01 mm = 0.13 mm.

Add

Minimum range	50.00 mm
Barrel reading	13.50 mm
Thimble reading	00.13 mm
Total	63.63 mm

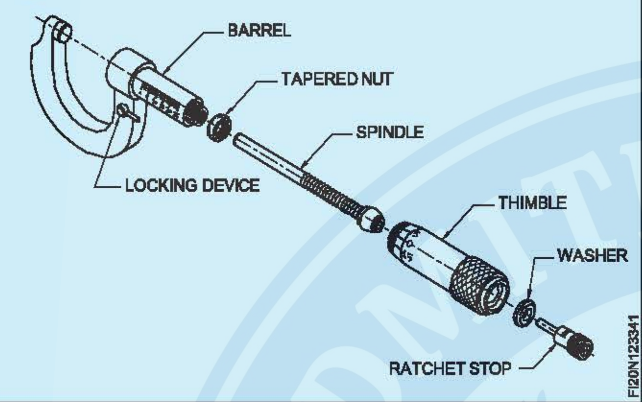
The micrometer reading is 63.63 mm.

Constructional features of outside micrometer

Objectives: At the end of this lesson you shall be able to
- **name the internal parts of a micrometer**
- **state the functions of the various parts of a micrometer**
- **state the precautions to be observed while dismantling and assembling micrometers.**

In order to dismantle and carry out cleaning or adjustment of a micrometer, it is essential to know the functions of its various parts. (Fig 1)

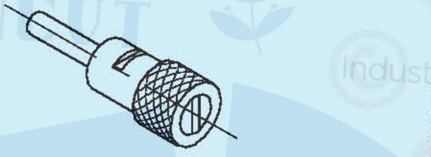
Fig 1



Ratchet stop (Fig 2)

This is a device fitted on micrometers to ensure uniform pressure between the measuring face of the micrometer while measuring.

Fig 2

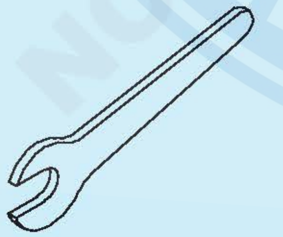


The ratchet stop will slip beyond certain pressure, thus preventing further advancement of the spindle when excessive pressure is used.

This is mounted on the thimble of the micrometer, and it connects with the spindle when assembled.

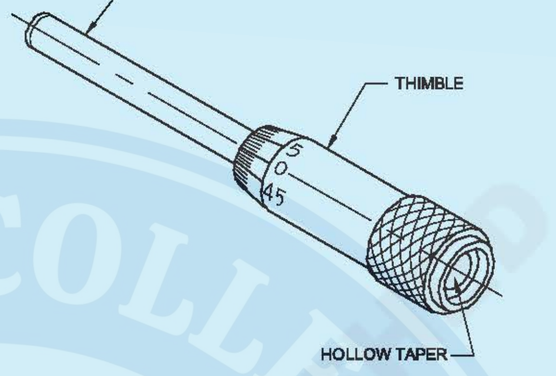
A special spanner is provided along with the micrometer for fixing and removing the ratchet stop. (Fig 3)

Fig 3



Thimble: The thimble has a hollow taper (Fig 4) to match with the taper nose fitted on the spindle.

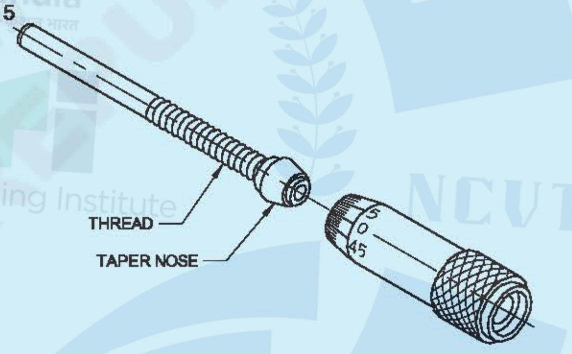
Fig 4



Spindle

One end of the spindle forms the measuring face. The other end of the spindle is threaded, the tapered nose is fitted on it. (Fig 5)

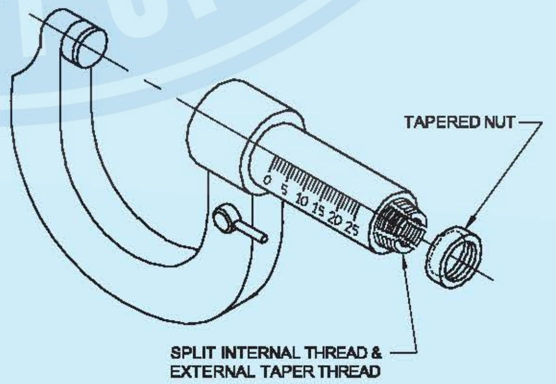
Fig 5



The taper nose is very accurately finished for axial alignment and it also permits positioning of the thimble in any required place during the adjustment of zero error.

The spindle passes through a split internal thread (Fig 6) which forms part of the barrel. The outer portion of this split internal thread has tapered external threads. A taper threaded nut is fitted on this.

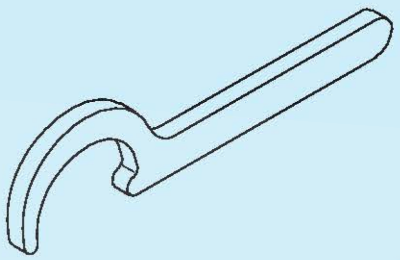
Fig 6



Tightening and loosening of this nut enables the spilt internal thread to close or open. This permits the wear adjustmet. in the mating threads.

A special spanner is provided for this purpose. (Fig 7)

Fig 7



The locking device provided on the spindle is to arrest the movement of the spindle after taking the measurement.

Precautions while dismantling micrometers

Avoid touching the measuring faces with bare fingers as it might cause rusting.

Protect the components of the micrometer free from dust while dismantling and assembling.

Use carbon tetrachloride for cleaning the parts after dismantling.

While assembling - apply a few drops of thin oil.

Do not use metallic surface for placing the parts after dismantling. An enameled tray is preferable.

Apply a thin coating of oil when placing the micrometer back after the adjustment.

Avoid frequent dismantling and assembling.

Inside micrometer

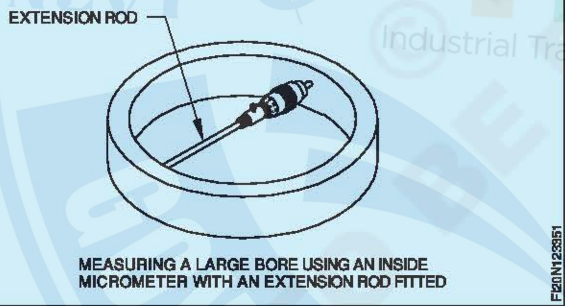
Objectives : At the end of this lesson you shall be able to
- **list the purposes of an inside micrometer**
- **identify the parts of an inside micrometer**
- **state the safety precautions to be followed while using an inside micrometer.**

An inside micrometer is a precision measuring instrument which measures with an accuracy of 0.01mm.

Purpose

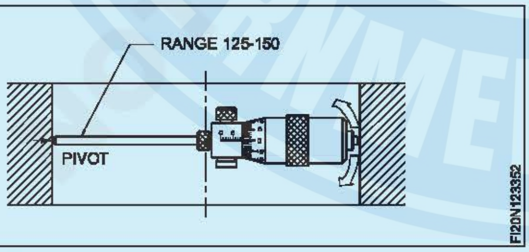
An inside micrometer is used to measure the diameter of holes. (Fig 1)

Fig 1



To measure the distance between internal parallel surfaces like slots (Fig 2)

Fig 2



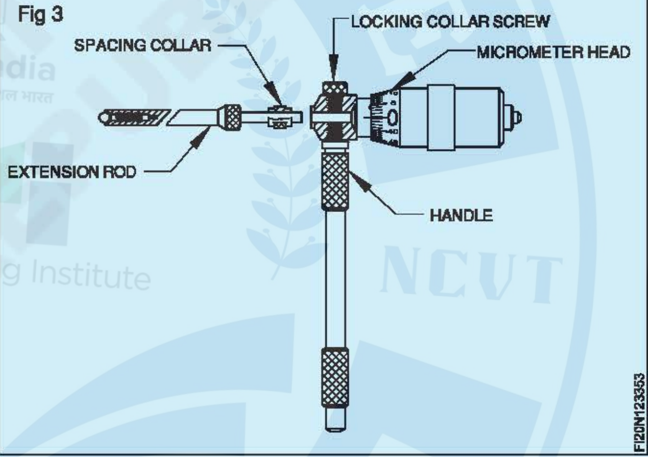
Parts (Fig 3)

The following are the parts of an inside micrometer

Micrometer head: It consists a sleeve, a thimble, an anvil and locking screw for extension rods.

Extension rod: This is fitted in the hole provided in the barrel of the micrometer head. It provides another measuring surface. It is available in different sizes.

Fig 3



Locking Screw It is used to lock the extension rods.

Handle It is fitted in the threaded hole provided in the micrometer head. It is used to hold the micrometer assembly while measuring deep bores.

Spacing collar It is added to the extension rod for additional length. It is available in different sizes.

The range of inside micrometer

Using the different sizes of extension rods and spacing collars the following ranges of measurement can be taken

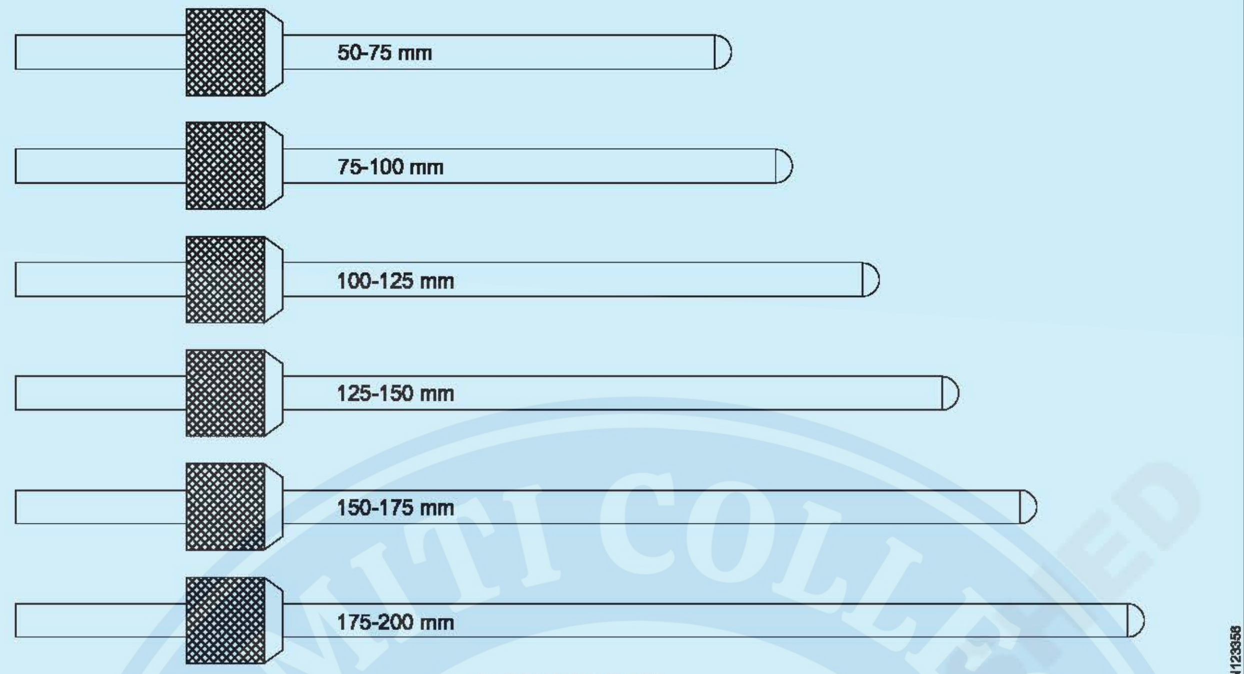
25-50mm, 50-200mm, 50-300mm, 200-500mm, 200-1000mm

Inside micrometer

Ranges of extension rod for (50 - 200mm) Inside micrometer

Checking parallelism of surfaces of deep bores

Fig 6

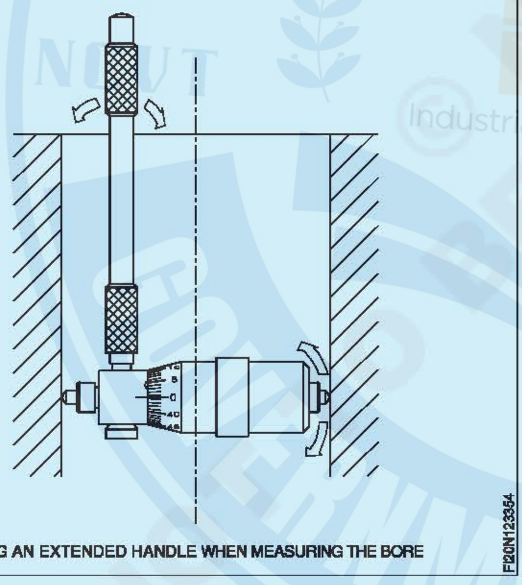


EXTENSION RODS

An extended handle can be used while measuring deep bores. (Fig 4) for checking the parallelism of surfaces of the bore.

Find out the readings at 2 or 3 places i.e. one reading at the top, another reading at the middle and the third reading at the bottom of the bore. If all the three readings are the same, then the surfaces of the bore are parallel. Any variation in the readings shows an error in the bore.

Fig 4



USING AN EXTENDED HANDLE WHEN MEASURING THE BORE

Precautions

Ensure that the extension rod/spacing collar are fitted correctly.

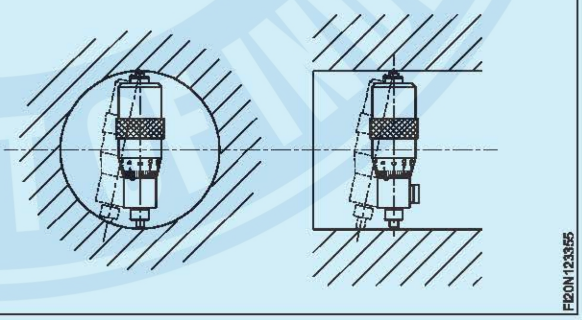
Check the 'O" setting of the inside micrometer with an outside micrometer.

Ensure that the measuring faces are perpendicular to the axis, and the handle parallel to the axis of the above.

When measuring bores the micrometer must be set for the largest value. While measuring between flat surfaces, the micrometer should be set for the smallest value. (Fig 5)

Ensure that the wall surfaces of the bore are free from burrs, oil etc. before using an inside micrometer. Set the inside micrometer in the bore to the correct FEEL. Do not drag or force the inside micrometer in the bore.

Fig 5



Depth micrometer

Scan the QR Code to view the video for this exercise

Objectives: At the end of this lesson you shall be able to
- **name the parts of a depth micrometer**
- **state the constructional features of a depth micrometer**
- **read depth micrometer measurements.**

Constructional features

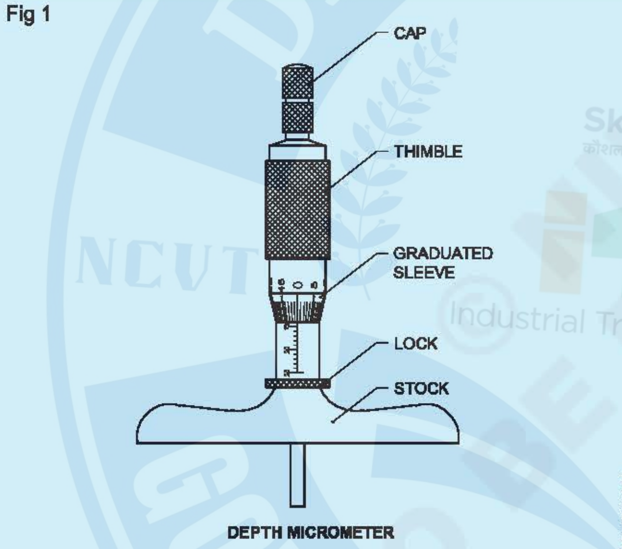
The depth micrometer consists of a stock on which a graduated sleeve is fitted.

The other end of the sleeve is threaded with a 0.5 mm pitch `V' thread.

A thimble which is internally threaded to the same pitch and form, mates with the threaded sleeve and slides over it.

The other end of the thimble has an external step machined and threaded to accommodate a thimble cap. (Fig 1)

Fig 1



A set of extension rods is generally supplied. On each of them the range of sizes that can be measured with that rod, is engraved as 0-25, 25-50, 50-75, 75-100, 100-125 and 125-150.

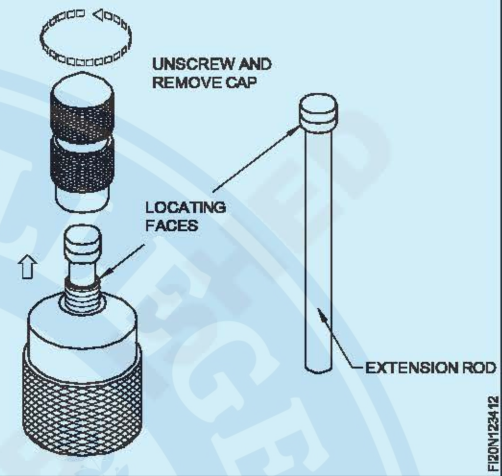
These extension rods can be inserted inside the thimble and the sleeve.

The extension rods have a collar-head which helps the rod to be held firmly. (Fig 2)

The measuring faces of the stock and the rods are hardened, tempered and ground. The measuring face of the stock is perfectly machined flat.

The extension rods may be removed and replaced according to the size of depth to be measured.

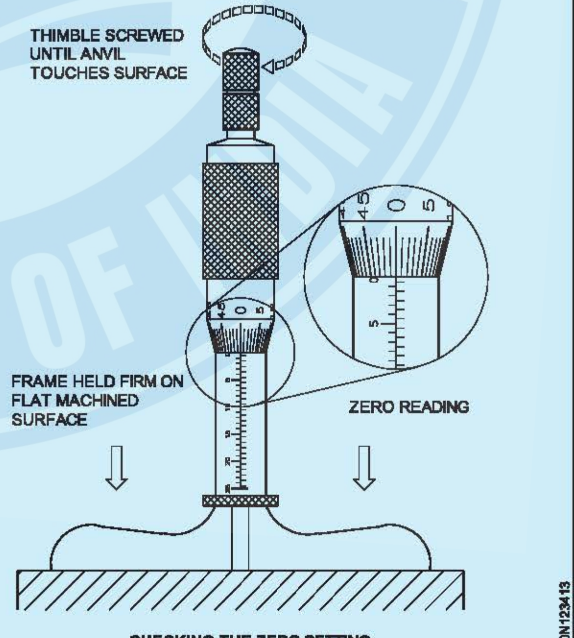
Fig 2



Graduation and least count

On the sleeve a datum line is marked for a length of 25 mm. This is divided into 25 equal parts and graduated, each line representing one millimetre. Each fifth line is drawn a little longer and numbered. Each line representing 1 mm is further subdivided into two equal parts. Hence each sub-division represents 0.5 mm. (Fig 3)

Fig 3

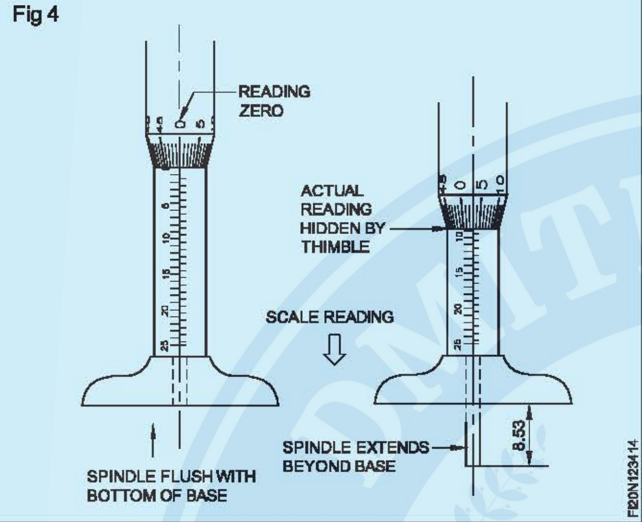


The graduations are numbered in the reverse direction, to that marked on an outside micrometer.

The zero graduation of the sleeve is on the top and the 25 mm graduation near the stock.

The bevel edge of the thimble is also graduated. The circumference is equally divided into 50 equal parts and every 5th division line is drawn a little longer and numbered. The numbering is in the reverse direction and increases from 0, 5,10,15, 25, 30, 35, 40,45 and 50 (0). (Fig 4)

Fig 4



The advancement of the extension rod for one full turn of the thimble is one pitch which is 0.5 mm.

Therefore, the advancement of the extension rod for one division movement of the thimble will be equal to 0.5 / 50 = 0.01 mm.

This will be the smallest measurement that can be taken with this instrument, and so, this is the accuracy of this instrument.

Reading of depth micrometer

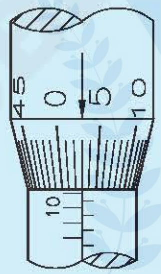
Barrel reading (1 mm division)	=	8 x 1 mm	= 8.00 mm
Sub division (0.5 mm division)	=	1 x 0.5 mm	= 0.50 mm
Thimble reading	=	3 x 0.01 mm	= 0.03 mm
(Thimble division x L.C) Total reading			= 8.53 mm

In barrel reading main division and sub division have been hidden covered by thimble

Uses of depth micrometer

- Depth micrometers are special micrometers used to measure
- the depth of holes.
- the depth of grooves and recesses
- the heights of shoulders or projections.

Fig 5



Digital micrometers

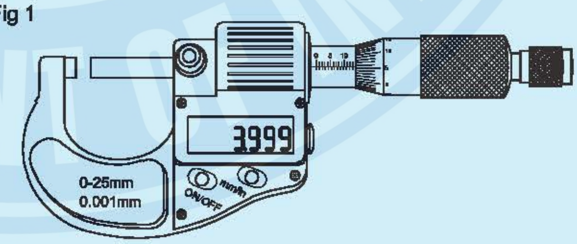
Objectives: At the end of this lesson you shall be able to
- **state the uses of digital micrometer**
- **list the parts of digital micrometer**
- **read the reading from LED display and thimble and barrel**
- **brief the maintenance, maintenance of digital micrometers.**

Digital micrometers is one of the simplest and most widely used measuring equipment in any manufacturing industry. Its simplicity and the versatile nature make Digital Micrometers so popular. Different kinds of Digital Micrometers available in the market.

Feature of digital micrometers (Fig 1)

- LCD displays measuring data and makes direct read out with resolution of 0.001mm.
- Origin setting mm/inch conversion, switch for absolute and incremental measurement.
- Carbide tipped measuring faces.
- Ratchet ensures invariable measurement and accurate repeatable reading

Fig 1



FEATURE OF DIGITAL MICROMETERS

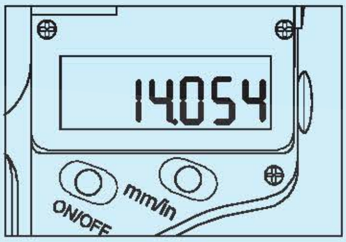
Accuracy of digital micrometers

Digital micrometers provide 10 times more precision and accuracy : 0.00005 inches or 0.001mm resolution, with 0.0001 inches or 0.001mm accuracy.

Reading of the digital micrometer

The digital micrometers are provided with high precision reading with LCD display. The reading is 14.054 mm as shown in Fig 2.

Fig 2



READING OF THE DIGITAL MICROMETERS

F120N123422

Reading also by reading the marks on the sleeve and the thimble. Usually, the reading from the large LCD display for the digital micrometer because the digital reading is more accurate. The reading on the sleeve and the thimble is just for reference. Read the markings on the sleeve and the thimble, firstly, read the point which the thimble stops at it on the right of the sleeve (It is 14mm here, because each line above the centre long line represents 1mm while each line below the centre long line represent 0.5mm) (Fig 3)

Secondly, read the markings on the thimble, It is between 5 and 6, So you need to estimate the reading. (It is 0.054mm for each line here represents 0.001mm). At last, add all the reading up : 14mm + 0.054 mm = 14.054mm. So the total reading is 14.054mm.

Maintenance of a digital micrometers

Never apply voltage (e.g. engraving with an electric pen) on any part of the Digital Micrometers for fear of damaging the circuit.

Press the ON/OFF button to shut the power when the Digital Micrometers stands idle; take out the battery if it stands idle for a long time.

As for the battery, abnormal display (digit flashing or even no display) shows a flat battery. Thus you should push the battery cover as the arrow directing and then replace with a new one. Please note that the positive side must face out If the battery bought from market dosen't work well (the power may wear down because of the long-term storage or the battery's automatic discharge and etc.) Please do not hesitate to contact the supplier.

Flashing display shows dead battery. If this is the case please replace the battery at once. No displace shows poor contact of a battery or short circuit of both poles of the battery. Please check and adjust pole flakes and battery insulator cover. In case water enters the battery cover, open the cover immediately and blow the inside of the battery cover at a temperature of not more than 40°C till it gets dry.

Fig 3

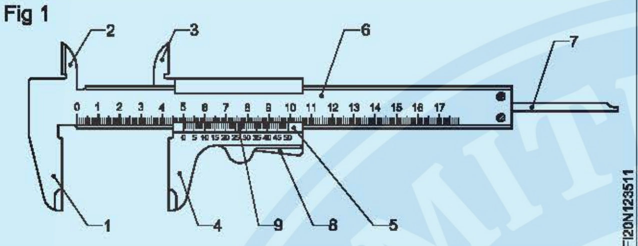
F120N123423

Vernier calipers

Objectives : At the end of this lesson you shall be able to
- **name the parts of a vernier caliper**
- **describe the parts of a vernier calipers**
- **state the uses of a vernier caliper.**

A vernier caliper is a precision measuring instrument. It is used to measure up to an accuracy of 0.02 mm. (Fig 1)

Fig 1



Parts of a vernier caliper

(Numbers as per Fig 1)

Fixed jaws (1 and 2): Fixed jaws are part of the beam scale. One jaw is used for taking external measurements, and the other for taking internal measurements.

Movable jaws (3 and 4): Movable jaws are part of the vernier slide. One jaw is used for external measurements, and the other for internal measurements. (Figs 2 and 3)

Fig 2

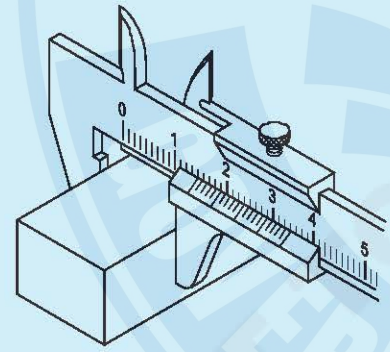
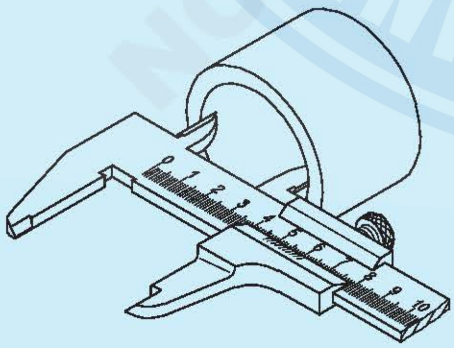


Fig 3

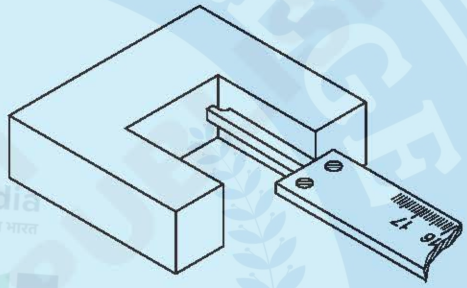


Vernier slide (5): A vernier slide moves over the beam and can be set in any position by means of a spring-loaded thumb lever.

Beam (6): The vernier slide and the depth bar attached to it, slide over the beam. The graduations on the beam are called the main scale divisions.

Depth bar (7) (Fig 4)**:**The depth bar is attached to the vernier slide and is used for measurement of depth.

Fig 4



Thumb lever (8): The thumb lever is spring-loaded which helps to set the vernier slide in any position on the beam scale.

Vernier scale (9): The vernier scale is the graduation marked on the vernier slide. The divisions of this scale are called vernier divisions.

Main scale: The main scale graduations or divisions are marked on the beam.

Sizes: Vernier calipers are available in sizes of 150 mm, 200, 250, 300 and 600 mm. The selection of the size depends on the measurements to be taken. Vernier calipers are precision instruments, and therefore, extreme care should be taken while handling them.

Never use a vernier caliper for any purpose other than measuring.

Vernier calipers should be used only to measure machined or filed surfaces.

They should never be mixed with any other tools.

Clean the instrument after use, and store it in a box.

Graduations and reading of vernier calipers

Objectives : At the end of this lesson you shall be able to

- **determine the least count of a vernier caliper**
- **state how graduations are made on a vernier caliper with 0.02 mm least count**
- **read vernier caliper measurements.**

Vernier calipers: Vernier calipers are available with different accuracies. The selection of the vernier caliper depends on the accuracy needed and the sizes of the job to be measured.

This accuracy/least count is determined by the graduations of the main scale and the vernier scale divisions.

Vernier Principle: The vernier principle states that two different scales are constructed on a single known length of line and the difference between them is taken for fine measurements.

Determining the least count of vernier calipers: In the vernier caliper shown in Fig 1 the main scale divisions (9 mm) are divided into 10 equal parts in the vernier scale.

i.e. One main scale division (MSD) = 1 mm

One vernier scale division (VSD) = 9/10 mm

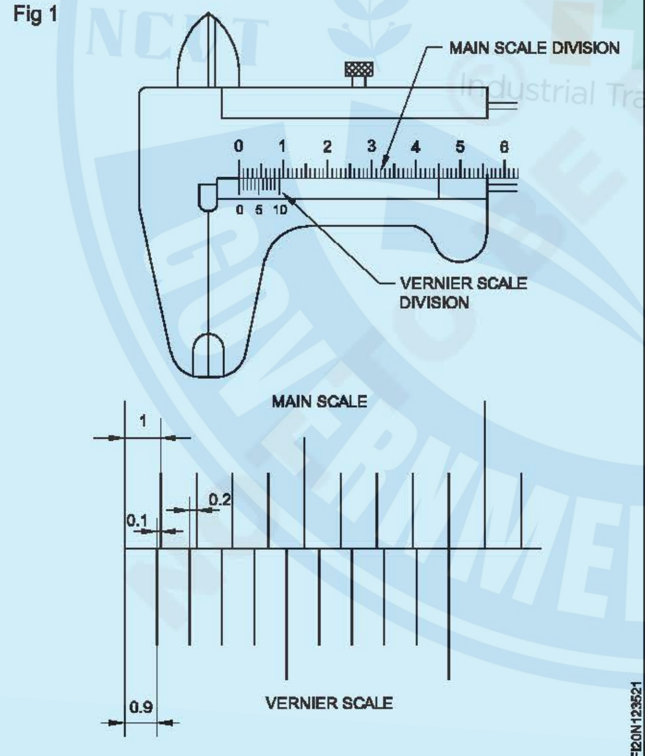
Least count = 1 MSD - 1 VSD

= 1 mm - 9/10 mm

= 0.1 mm

The difference between one MSD and one VSD = 0.1 mm

Fig 1



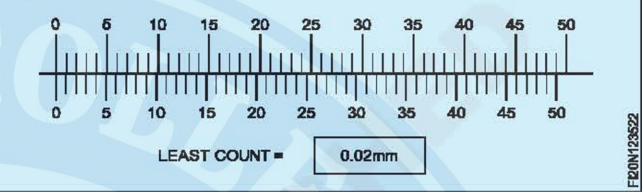
Reading vernier measurements: Vernier calipers are available with different graduations and least counts. For reading measurements with a vernier caliper, the least count should be determined first. (The least count of calipers is sometimes marked on the vernier slide)

Fig 2 shows the graduations of a common type of vernier caliper with a least count of 0.02 mm. In this, 50 divisions of the vernier scale occupy 49 divisions (49 mm) on the main scale.

Example

Calculate the least count of the vernier given in Fig 2.

Fig 2



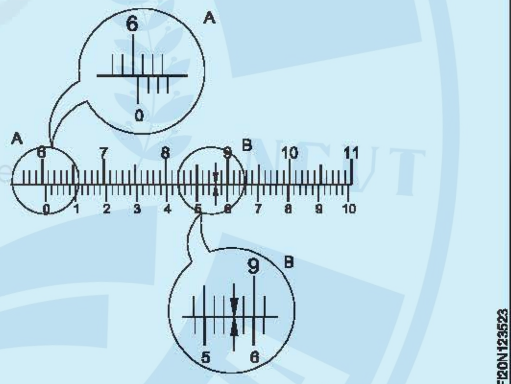
Least count = 1 mm - 49/50 mm

= 1/50 mm

= 0.02 mm.

Example for reading vernier caliper (Fig 3)

Fig 3



Main scale reading = 60 mm

The vernier division coinciding with the main scale is the 28th division, value = 28 x 0.02mm

= 0.56 mm

Reading = 60 + 0.56

Total Reading = 60.56 mm

The british system of measurement

Objectives : At the end of this lesson you shall be able to
- **name the different units and multiples of liner measurements in the Birtish System**
- **state the metric equivalent of the unit in the inch system**

The metric system for measurement is most widely used for industrial measurements. But in certain industries, the British system of measurement is still being used.

In this system of measurement, the inch, its multiples and sub-divisions are used to represent length measurements.

36 inches or 3 feet make 1 yard. 5280 feet or 1760 yards make 1 mile.

Coversions from inch to metric and vice versa		
CONVERSION FACTORS		
1"	=	25.4 mm or 2.54 cm
1 yard	=	36" or 0.9144 m
1 mm	=	0.03937"
1 metre	=	1000 mm or 39.37"

FRACTIONS/DECIMALS EQUIVALENT

1/64"	=	0.015625"
1/32"	=	0.03125"
1/16"	=	0.0625"
1/8"	=	0.125"
1/4"	=	0.25"
1/2"	=	0.5"

1.00 unit inch
0.1 one tenth
0.01 one hundredth
0.001 one thousandth
0.0001 one ten thousandth
0.00001 one hundred thousands
0.000001 one millionth (one micro inch)

Example of conversion (Metric to inch)

1) .05mm = .00196 inch (.05x03937 = 0.0019685 inch)
2) 1.25m = 49.215 inch (1.25x39.37 = 49.215 inches)

Example of conversion (Inch to Metric)

1) 3/4" = .75" = 19.05 mm (.75x 25.4 = 19.05 mm)
2) 1/1000" = 0.001 = 0.0254 mm (.001x25.4 = 0.0254mm)

(One thousandth of an inch = 25 micrometre approx)

ASSIGNMENT

Convert the following.

1) 38.1mm =________ inches
2) 300 mm =________ inches
3) 8" =________ mm
4) 40" =________ mm.

5) Express the tolerance ± .05" in metric terms to the nearest mm. ______________________________

6) Express the tolerance ± .02 mm in terms of inches to the nearest 1/10,000". ______________________________

Reading vernier caliper and micrometer with inch graduations

Objectives : At the end of this lesson you shall be able to
- **state the graduations of vernier calipers in the inch system**
- **state the graduations of micrometers in the inch system**
- **read the measurement of vernier calipers and micrometers with inch graduations.**

Reading vernier caliper and micrometer

The universal vernier calipers generally used in machine shop will have graduations in both metric units and inches.

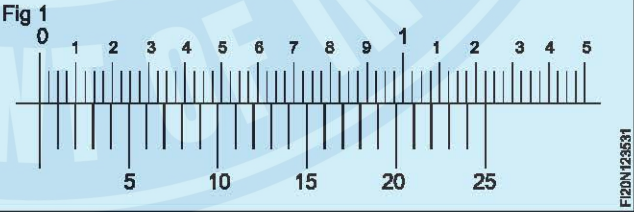
The vernier caliper with inch graduation will have a least count of 0.001".

The vernier scales for these calipers have graduation with 25 division or 50 divisions.

Vernier caliper with 25 divisions in vernier scale. (Fig.1)

One inch of the mainscale is divided into 10 major divisions, and each of these is further divided into 4 equal parts. The value of each sub-division is 0.025 inch. Such 49 divisions of the main scale are equal to 25 divisions of the vernier scale.

Fig 1



Least count

25 vernier scale divisions = 49 x 0.025 = 1.225"

Value of vernier scale division = 0.049"

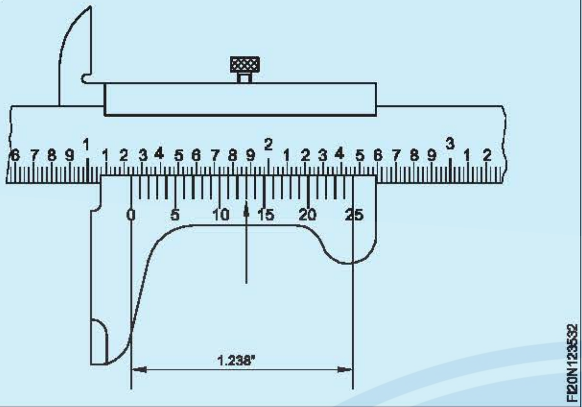
Value of 2 main scale divisions = 0.025 x 2 = 0.50"

Least count = Value of main scale division - value of 1 vernier scale division

= 0.05" - 0.049" = 0.001" or 1/1000"

Example of reading (Fig 2)

Fig 2

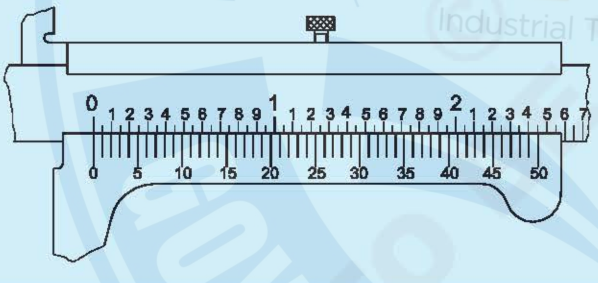


In Figure 2 the vernier '0' line is after 1" on the scale

Full inch		=	1.000"
2 main scale divisions		=	.200"
Value of 1 subdivision		=	.025"
coinciding	(13 x 001")	=	.013"
	Reading		1.238"

In the vernier caliper given in fig 3 (50 divisions vernier scale), each inch of the main scale is divided into 10 major divisions, and they are further sub - divided into two equal parts. The value of each subdivision is 0.05". 50 divisions of the vernier scale are equal to 49 subdivisions of the main scale.

Fig 3



Least count

Value of 50 V.S.D. = 49 x 0.05 = 2.45"

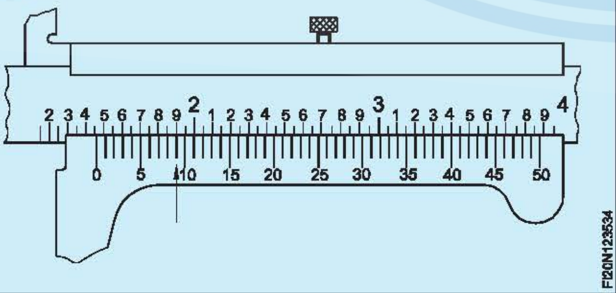
1.V.S.D. = 2.45"/50 = 0.049"

Least count = Value of 1 MSD - Value of 1 VSD

= 0.05" - 0.049 = 0.001"

Example of reading (Fig 4)

Fig 4



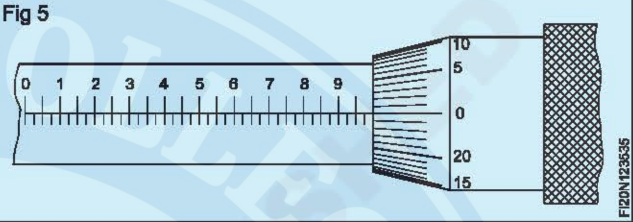
Vernier '0' line is after 1" on the main scale

Full inch		=	1.000"
The value of 4 major divisions	(4 x 0.1")	=	.400"
The value of 1 subdivision	(1 x 0.05")	=	.050"
The value of 9th vernier dividion coinciding	(9 x 0.001")	=	.009"
	Reading		1.459"

Micrometer with graduations in inches

On micrometers with graduations in the inch system, the datum line on the barrel of the micrometer is graduated to a distance of 1 inch. This one inch is divided into 10 equal parts, and each of this is further subdivided into 4 equal parts. (Fig 5)

Fig 5

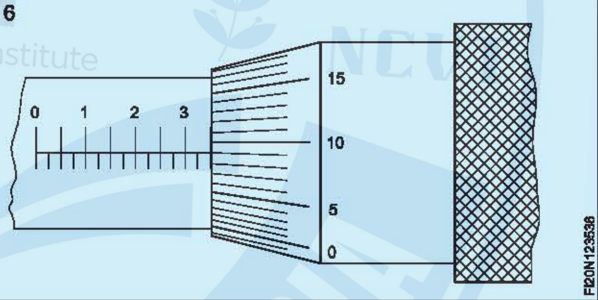


The value of each subdivision = 1/40" or 0.025". The thimble had 25 equal divisions marked on the circumference. The least count is = 1/40"x1/25 = 1/1000" = .001'.

When the spindle of the micrometer advances by one division on the thimble, the actual value of the linear movement is = .001".

Example of reading (Fig 6)

Fig 6



Main divisions	3 x .1	= .300"
Subdivisions	2 x .025	= .05"
Thimble divisions	9 x .001	= .009"
Reading		= .359"

The barrel is graduated into 10 equal divisions each of which is further subdivided into 4 smaller divisions. The length of the sleeve graduations is 1". It is the distance the thimble travels in 40 complete revolutions.

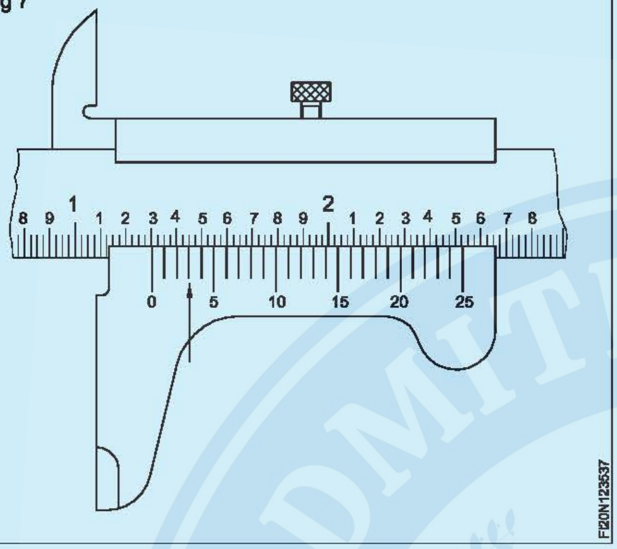
Barrel main divisions = 1/10 of an inch or 0.100" the distance the thimble moves in four complete revolutions. The thimble has 25 equal graduations on its circumference. Each graduation of the thimble is equal to 1/25 of 1/40 or 0.001".

Barrel subdivision 1/40 or 0.025 of an inch is equal to the distance the thimble moves in one complete revolution. The spindle screw has 40 TPI.

Assignment

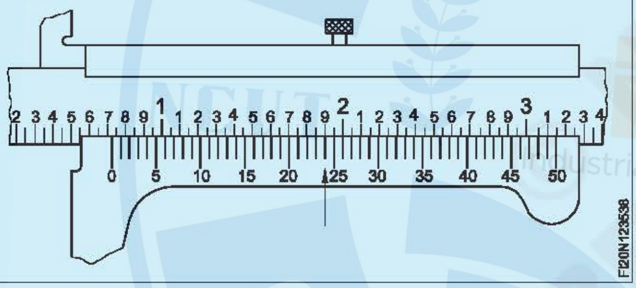
1 Read the vernier caliper measurement as shown in Figures 7 and 8.

Fig 7



Answer ....inch.

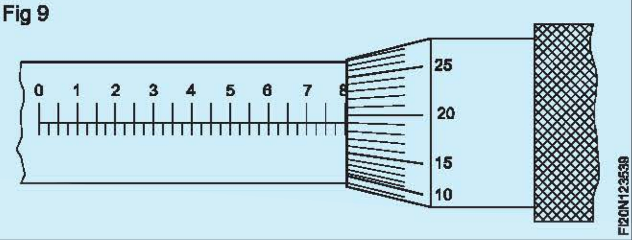
Fig 8



Answer ....inch.

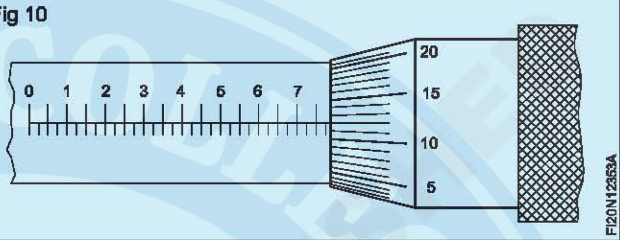
2 Read and record the measurements of an outside micrometer shown in the Figures 9 and 10.

Fig 9



Answer ....inch.

Fig 10



Answer ....inch.

Vernier height gauge

Objectives: At the end of this lesson you will be able to

- **name the parts of a vernier height gauge**
- **state the constructional features of a vernier height gauge**
- **state the functional features of a vernier height gauge**
- **state the various applications of the vernier height gauge in engineering.**

Parts of a vernier height gauge (Fig 1)

A Beam

B Base

C Main slide

D Jaw

E Jaw clamp

F Vernier scale

G Main scale

H Finer adjusting slide

I Finer adjusting nut

J&K Locking screws

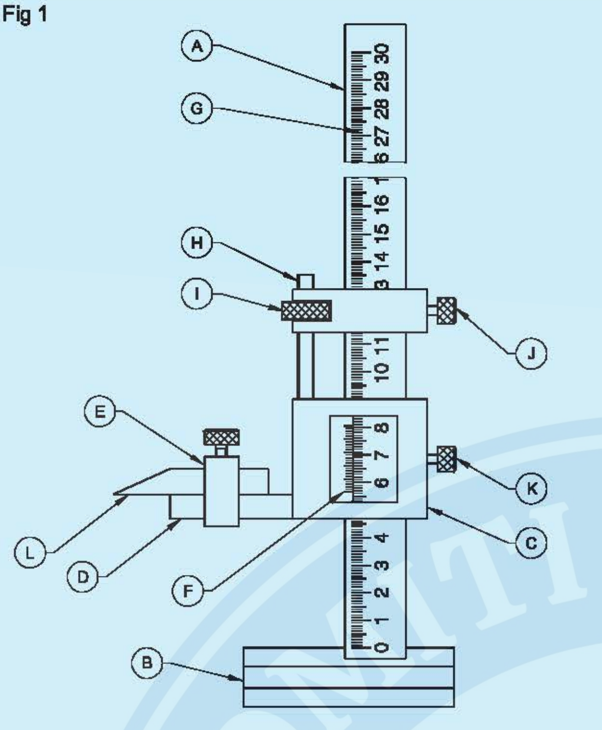
L Scriber blade

Constructional features of a vernier height gauge: The construction of a vernier height gauge is similar to that of the vernier caliper that it is vertical with a rigid base. It is graduated on the same vernier principle which is applied to the vernier caliper.

The beam is graduated with the main scale in mm as well as in inches. The main slide carries a jaw upon which various attachments may be clamped. The jaw is an integral part of the main slide.

The vernier scale is attached to the main slide which has been graduated, to read metric dimensions as well as the inch dimensions. The main slide is attached with the finer adjusting slide. The movable jaw is most widely used with

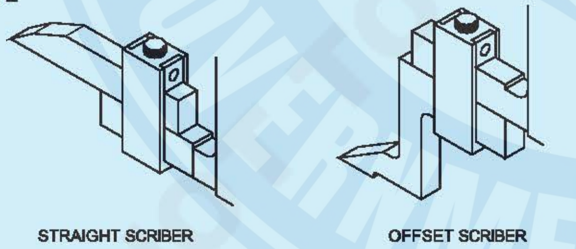
Fig 1



the chisel pointed scriber blade for accurate marking out as well as for checking the height, steps etc. Care should be taken to allow for the thickness of the jaw depending on whether the attachment is clamped on the top or under the jaw for this purpose.

The thickness of the jaw is marked on the instrument. As like in a vernier caliper, the least count of this instrument is also 0.02 mm. An offset scriber is also used on the movable jaw when it is required to take measurement from the lower planes. (Fig 2) The complete sliding attachment along with the jaw can be arrested on the beam to the desired height with the help of the locking screws. The vernier height gauges are available in ranges of capacities reading from zero to 1000 mm.

Fig 2



Functional features of the vernier height gauge: Vernier height gauges are used in conjunction with the surface plate. In order to move the main slide, both the locking screws of the slide and the finer adjusting slide have to be loosened. The main slide along with the chisel pointed scriber has to be set by hand, for an approximate height as required.

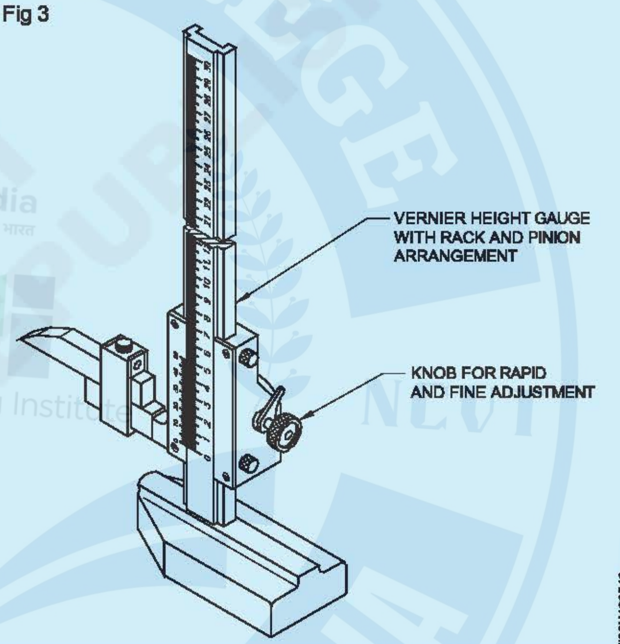
The finer adjusting slide has to be locked in position, for an approximate height as required. To get an exact markable height, the finer adjustments have to be carried on the slider with the help of the adjusting nut. After obtaining the exact markable dimension, the main slide is also to be locked in position.

Modern vernier height gauges are designed on the screw rod principle. In these height gauges, the screw rod may be operated with the help of the thumb screw at the base. In order to have a quick setting of the main slide, it is designed with a quick releasing manual mechanism. With the help of this, it is possible to bring the slide to a desired approximate height without wastage of time. For all other purposes, these height gauges work as ordinary height gauges. In order to set the 'zero' graduation of the main scale for the initial reading.

Some vernier height gauges are equipped with a sliding main scale which may be set immediately for the initial reading. This minimises the possible errors in reading the various sizes in the same setting.

Another kind of modern vernier height gauge has a rack and pinion set up for operating the sliding unit. This is shown in Fig 3.

Fig 3



Various applications of a vernier height gauge: The vernier height gauge is mainly used for layout work. (Fig 4)

It is used for measuring the width of the slot and external dimension.

The vernier height gauge is used with the dial indicator to check hole location, pitch dimensions, concentricity and eccentricity.

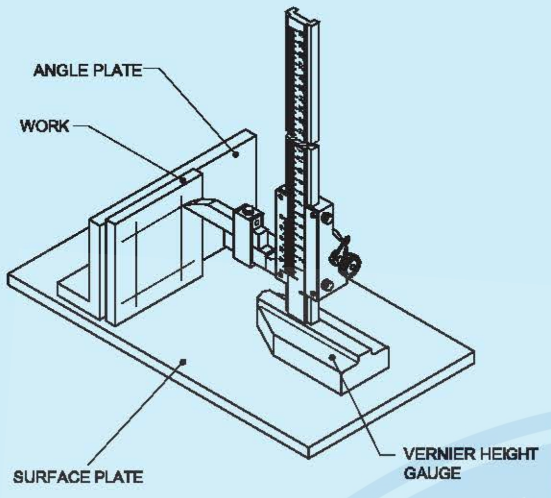
It is also used for measuring depth, with a depth attachment.

It is used to measure sizes from the lower plane with the help of an offset scriber.

Care and Maintenance

Store after use in room with controlled

Fig 4



Care and maintenance

- Store after use in room with controlled temperature
- Do not drop (or) knock it
- Clean tool before and after use
- Do not take measurement on rotating specimen.
- Do not keep with other working tools.

Vernier bevel protractor

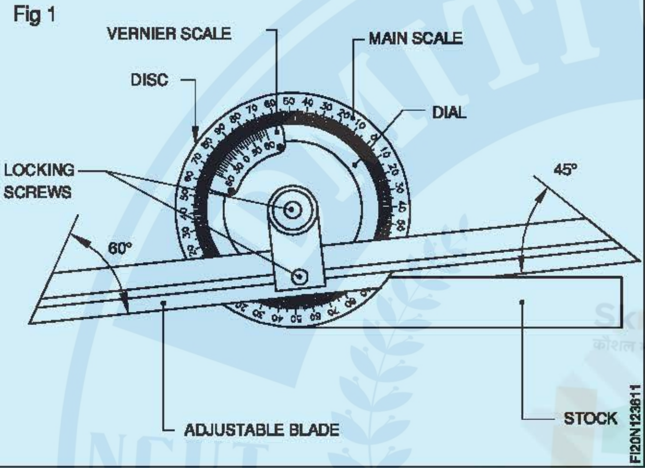
Objectives : At the end of this lesson you shall be able to
- **name the parts of a vernier bevel protractor**
- **state the functions of each part**
- **list out the uses of a vernier bevel protractor.**

The vernier bevel protractor is a precision instrument meant for measuring angles to an accuracy of 5 minutes. (5')

Parts of a vernier bevel protractor

The following are the parts of a vernier bevel protractor. (Fig 1)

Fig 1



Stock: This is one of the contacting surfaces during the measurement of an angle. Preferably it should be kept in contact with the datum surface from which the angle is measured.

Dial: The dial is an integrated part of the stock. It is circular in shape, and the edge is graduated in degrees.

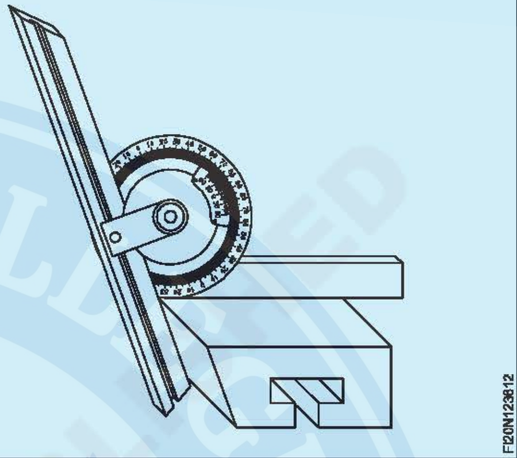
Blade: This is the other surface of the instrument that contacts the work during measurement. It is fixed to the dial with the help of the clamping lever. A parallel groove is provided in the centre of the blade to enable it to be longitudinally positioned whenever necessary.

Locking screws: Two knurled locking screws are provided, one to lock the dial to the disc, and the other to lock the blade to the dial..

All parts are made of good quality steel, properly heat-treated and highly finished. A magnifying glass is sometimes fitted for clear reading of the graduations.

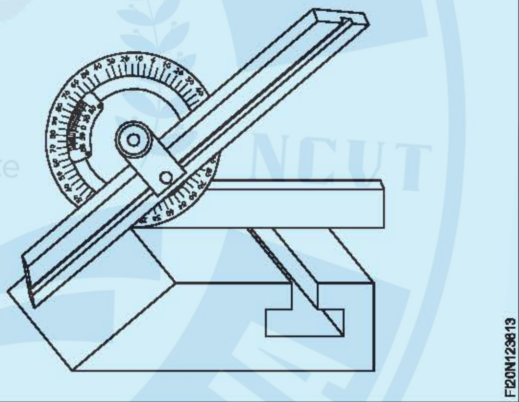
Uses of a vernier bevel protractor: Apart from being used for measuring angles a vernier bevel protractor is also used for setting work-holding devices on machine tools, work-tables etc.

Fig 2



The vernier bevel protractor is used to measure acute angles than 90° (Fig.2) obtuse angles more than 90° (Fig.3).

Fig 3



For setting work-holding devices to angles on machine tools, work tables etc., (Fig 4 & Fig 5)

Fig 4

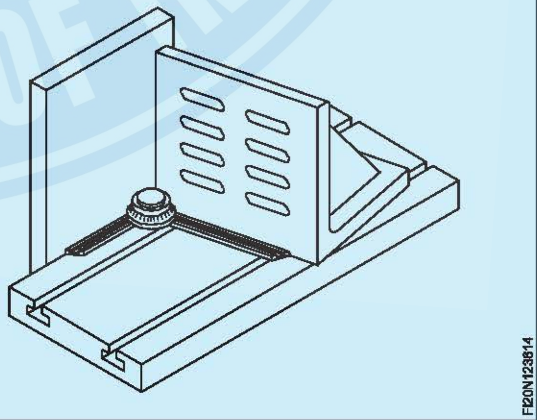
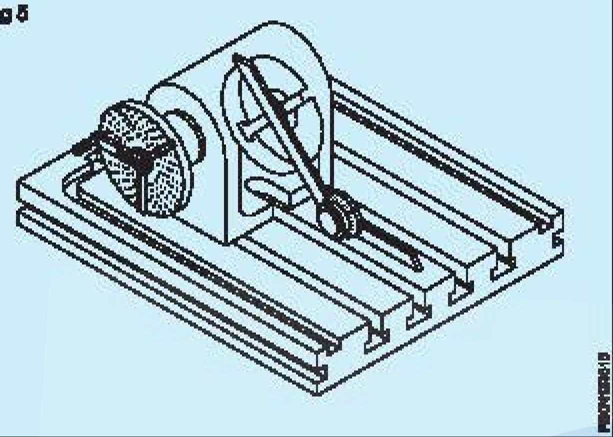


Fig 5

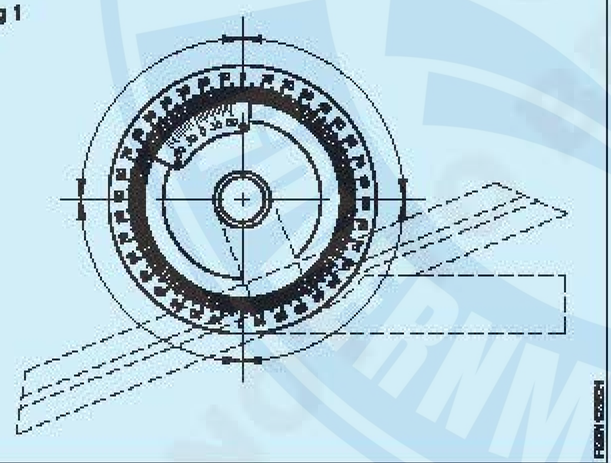


Graduations on universal bevel protractor

Objectives: At the end of this lesson you will be able to
- **state the main scale graduations on the disc**
- **state the vernier scale graduations on the dial**
- **determine the least count of the vernier bevel protractor.**

The main scale graduations (Fig 1 & 2): For purposes of taking angular measurements, the full circumference of the dial is graduated in degrees. The 360° are equally divided and marked in four quadrants, from '0' degree to 90 degrees, 90 degrees to '0' degree. Every tenth division is marked longer and numbered. Each division represents 1 degree. The graduations on the dial are known as the main scale divisions. On the disc, 23 divisions spacing of the main scale is equally divided into 12 equal parts on the vernier. Each 3rd line is marked longer and numbered as 0, 15, 30, 45, 60. This constitutes the vernier scale. Similar graduations are marked to the left of '0' also. (Fig 1)

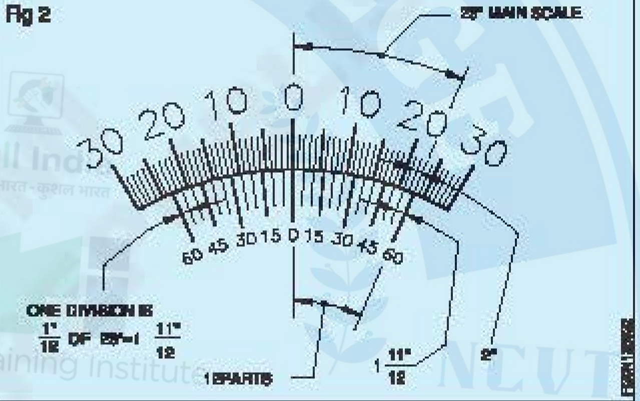
Fig 1



One vernier scale division VSD (Fig 2)

The least count of the vernier bevel protractor: When the zero of the vernier scale coincides with the zero of the main scale, the first division of the vernier scale will be very close to the 2nd main scale division. (Fig 2)

Fig 2



Hence the least count is

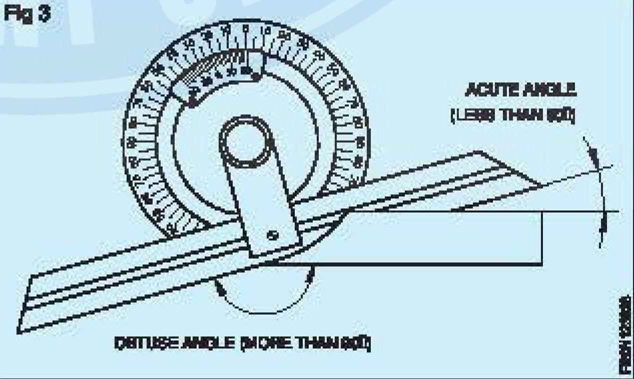
2 MSD - 1 VSD

i.e the least count = 2°

$$= \frac{24}{12} - \frac{23^0}{12} = \frac{1^0}{12} \text{ or } 5'$$

For any setting of the blade and stock, the reading of the acute angle and the supplementary obtuse angle is possible, and the two sets of the vernier scale graduations on the disc assist to achieve this. (Fig 3)

Fig 3

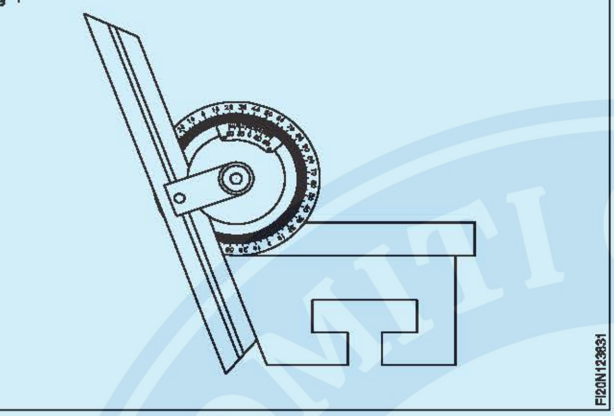


Reading of universal bevel protractor

Objectives: At the end of this lesson you will be able to
- **read a vernier bevel protractor for acute angle setting**
- **read a vernier bevel protractor for obtuse angle setting.**

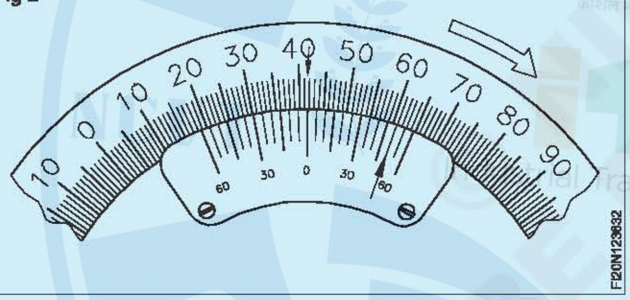
For reading acute angle set up (Fig 1)**:** First read the number of whole degrees between zero of the main scale and zero of the vernier scale.

Fig 1



Note the line on the vernier scale that exactly coincides with any one of the main scale divisions and determine its value in minutes. (Fig 2)

Fig 2



To take the vernier scale reading, multiply the coinciding divisions with the least count.

Example

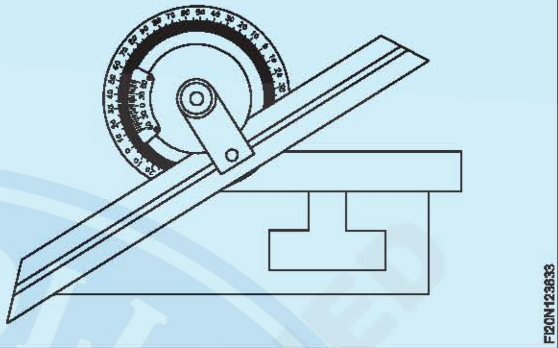
10 x 5' = 50'

Total up both the readings to get the measurements=41°50'.

If you read the main scale in an anticlockwise direction, read the vernier scale also in an anticlockwise direction from zero.

For obtuse angle set up (Fig 3**)**

Fig 3

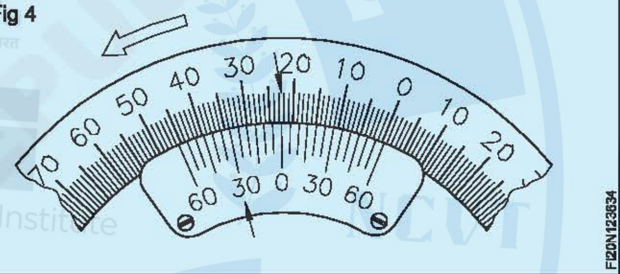


The vernier scale reading up is taken on the left side as indicated by the arrow (Fig 4). The reading value is subtracted from 180° to get the obtuse angle value.

Reading 22°30'

Measurement 180°-22°30'=157"30'

Fig 4



Care and maintenance of vernier bevel protractor

1 Clean the vernier bevel protractor before use.

2 Loosen the locking screw of dial to move the blade according to the angle measurement.

3 While taking a measurement apply light pressure on vernier bevel protractor

4 Heavy pressure will force the two scales out of parallel and show the false reading.

5 After using vernier bevel protractor wipe it clean and apply a thin coating of oil and keep it in safe place.

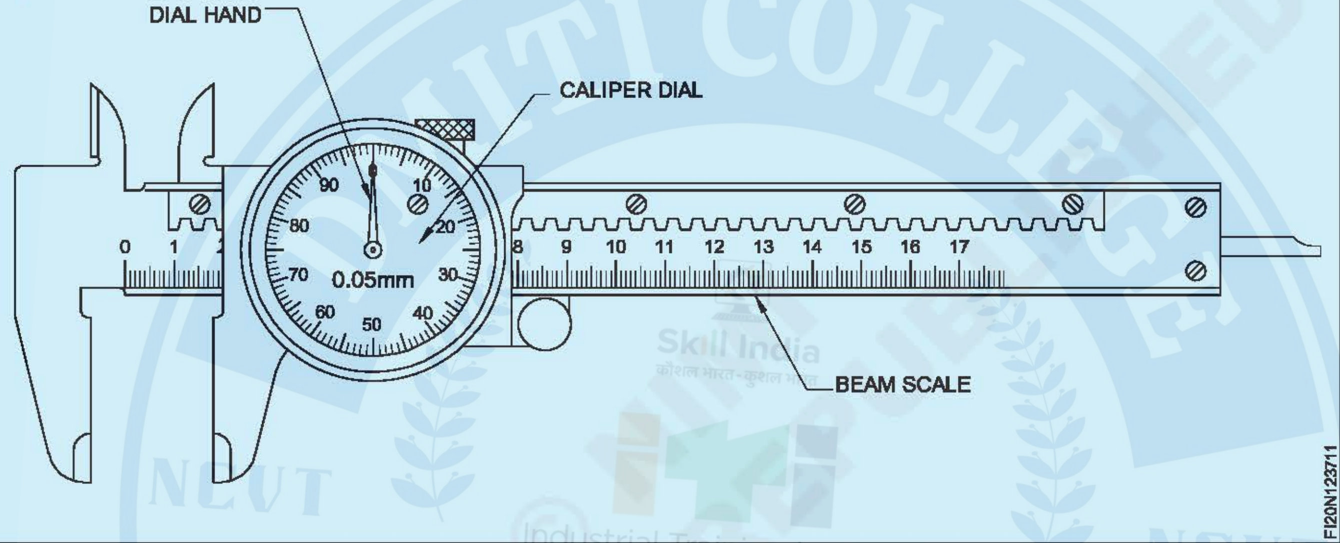
Dial Caliper

Objectives: At the end of this lesson you shall be able to
- **state the advantages of a dial caliper over a vernier caliper**
- **state the constructional features of a dial caliper**
- **read the dial caliper.**

A dial caliper is a direct reading instrument which resembles the vernier caliper. It is faster and easier to read a dial caliper than to read the traditional vernier caliper. (Fig 1)

The beam scale is graduated into 5mm increments on 0.05 mm accuracy caliper

Fig 1



Constructional features of dial caliper

The resemblance of a dial caliper is similar to normal Vernier caliper, but with additional construction of a rack mounted over the beam scale which is engaged to a pinion of the dial. The dial pointer is actuated by the movable action of vernier slide unit fixed with dial gauge.

The caliper dial on the movable jaw is graduated into 100 equal divisions. The hand of the dial makes one complete revolution for each 5 mm. Therefore, each dial grauduation represents 1/100th of 5mm or 0.05 mm.

The dial hand is operated by a pinion that engages a rack on the beam.

Dial calipers are available in various sizes like vernier calipers. A dial caliper with 0.02 mm accuracy is also available.

For reading a measurement (Fig 2)

Read the beam scale reading (25 mm) and add the reading shown by the hand of the dial. 24 x 0.05 = 1.2mm

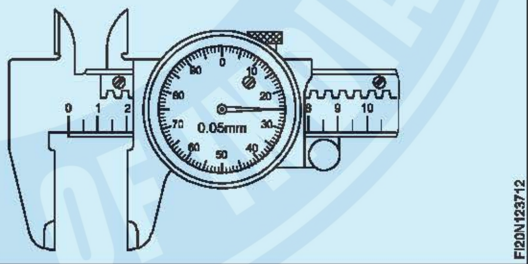
Reading = 25+1.2 mm = 26.2 mm.

Care and maintenance of dial caliper

1 Clean the dial caliper with a soft cloth before use.

2 Apply a small drop of oil to the beam, rack and pinion of the dial caliper to slide freely.

Fig 2



3 Check calibration of dial caliper, make sure that it is working correctly.

4 After using dial caliper, wipe it with a clean dry cloth, apply a thin coating of oil on sliding parts and keep it in safe place.

The digital caliper

Objectives : At the end of this lesson you shall be able to
- **state the uses of digital caliper**
- **name the parts of a digital caliper**
- **brief the zero setting of a digital caliper**

The digital Caliper (sometime incorrectly called the digital vernier caliper) is a precision instrument thant can be used to measure internal and external distance accurately to 0.01 mm, The digital vernier caliper is shown in fig 1, The distance or the measurements are read from LCD/LED display. The parts of digital calipers are similar to the ordinary vernier caliper except the digital display and few other parts.

Part of Digital Caliper (Fig 1)

1. Internal jaws
2. External jaws
3. Power On / Off button
4. Zero Setting button
5. Depth measuring blade
6. Beam scale
7. LED/ LCD Display
8. Locking screw
9. Metric/Inch button.

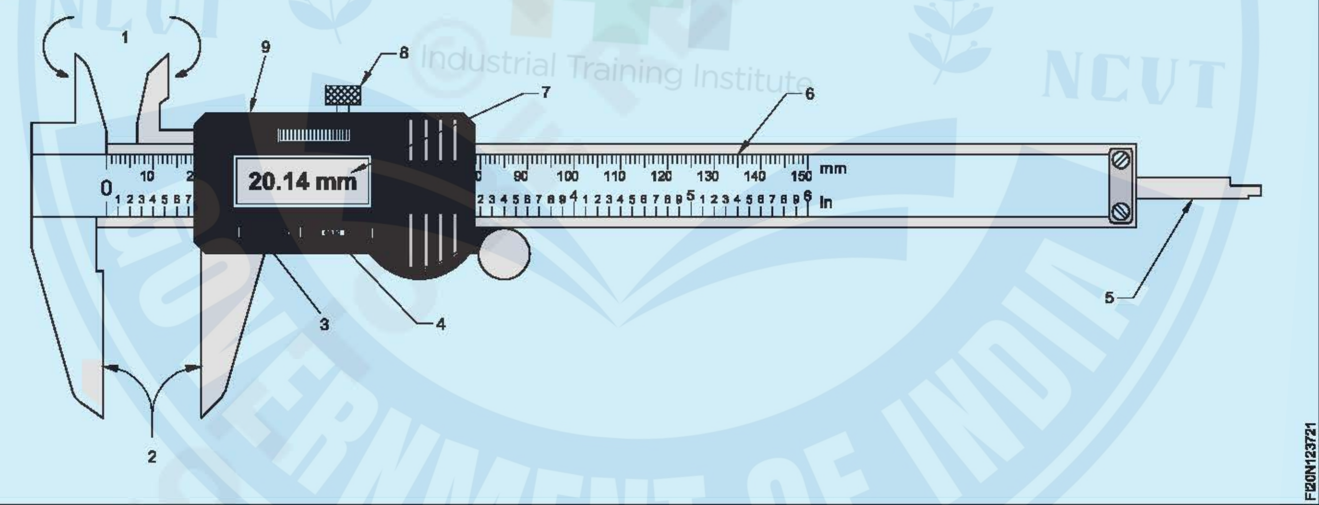
The digital caliper requires a small battery whereas the manual version does not need any power source. The digital calipers are easier to use as the measurement is clearly displayed and also, by pressing inch/mm button the distance can be read as metric or inch.

Zero setting of Digital Caliper

The display is turned on with the ON/OFF button. Before measuring, the zero setting to be done, by bringing the external jaws together untill they touch each other and then press the zero button. Now the digital caliper is ready to use.

> **Caution**
>
> **Always set zero position when turning on the display for the first time.**

Fig 1



Drilling processes - Drilling Machines, Types, Use and Care

Objectives: At the end of this lesson you shall be able to
- **name the various types of drilling machines**
- **name the parts of the bench and pillar type drilling machines**
- **compare the features of the bench and pillar type drilling machines.**

The principle types of drilling machines are

- the sensitive bench drilling machine
- the pillar drilling machine
- the column drilling machine
- the radial arm drilling machine (radial drilling machine).

(You are not likely to use the column and radial type of drilling machines now. Therefore, only the sensitive and pillar type machines are explained here)

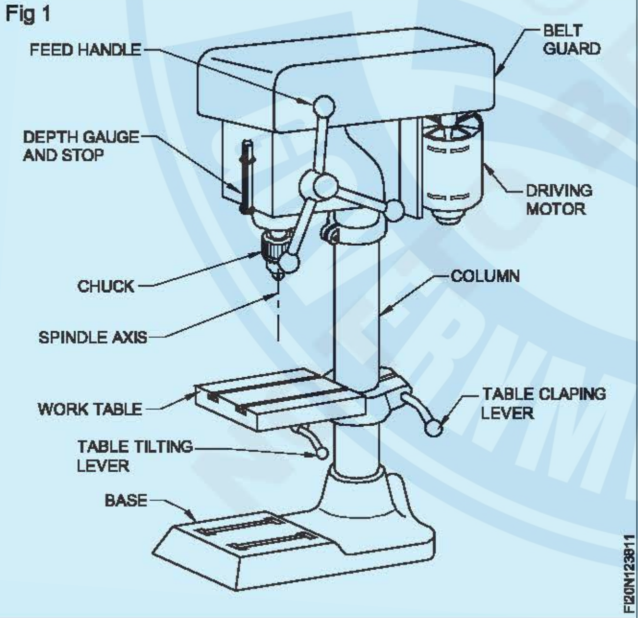
The sensitive bench drilling machine (Fig 1)

The simplest type of the sensitive drilling machine is shown in the figure with its various parts marked. This is used for light duty work.

This machine is capable of drilling holes up to 12.5 mm diameter. The drills are fitted in the chuck or directly in the tapered hole of the machine spindle.

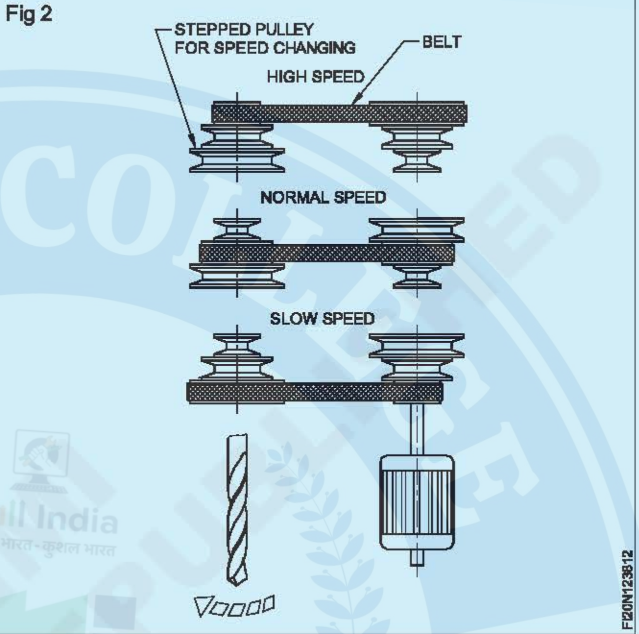
For normal drilling, the work-surface is kept horizontal. If the holes are to be drilled at an angle, the table can be tilted. (Tilting arrangement is shown in Fig.1)

Fig 1



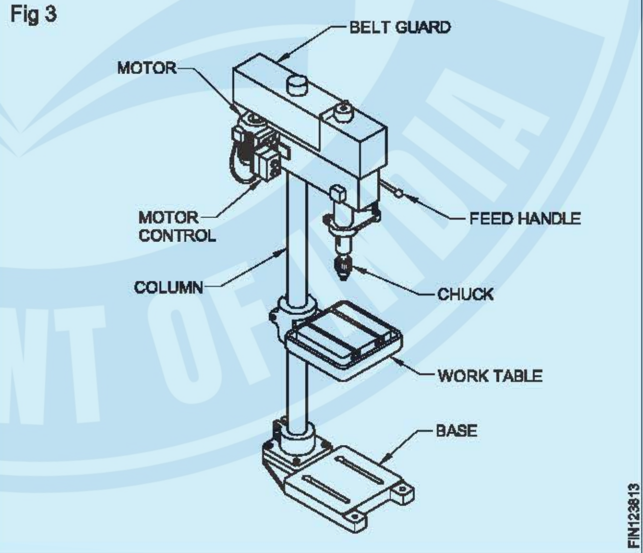
Different spindle speeds are achieved by changing the belt position in the stepped pulleys. (Fig 2)

Fig 2



The pillar drilling machine (Fig 3)**:** This is an enlarged version of the sensitive bench drilling machine. These drilling machines are mounted on the floor and driven by more powerful electric motors.

Fig 3



They are also used for light duty work. Pillar drilling machines are available in different sizes. The larger machines are provided with a rack and pinion mechanism to raise the table for setting the work.

Radial drilling machines

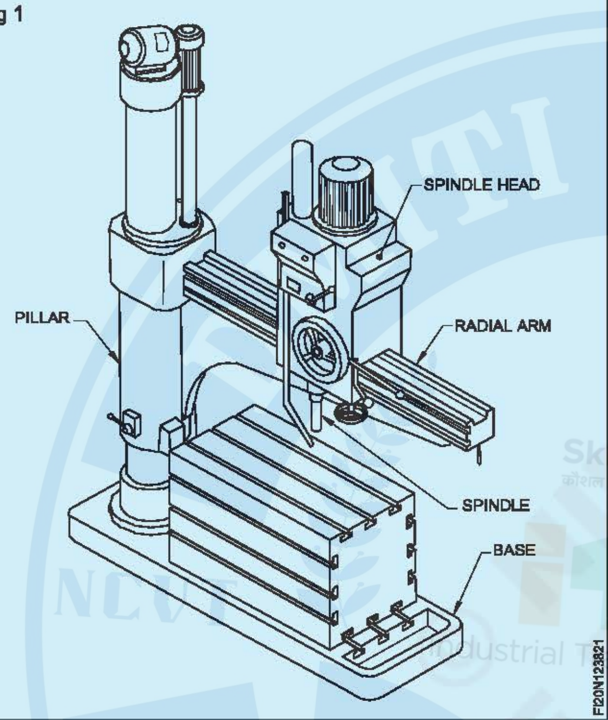
Objectives : At the end of this lesson you shall be able to
- **state the uses of a radial drilling machine**
- **state the features of radial drilling machine.**

Radial drilling machines are used to drill

- large diameter holes
- multiple holes in one setting of the work
- heavy and large workpieces.

Features (Fig 1)

Fig 1



The radial drilling machine has a radial arm on which the spindle head is mounted

The spindle head can be moved along the radial arm and can be locked in any position

The arm is supported by a pillar (column). It can be rotated about with the pillar as centre. Therefore, the drill spindle can cover the entire working surface of the table. The arm can be lifted or lowered.

The motor mounted on the spindle head rotates the spindle.

The variable-speed gear box provides a large range of R.P.M.

The spindle can be roated in both clockwise and anticlockwise directions.

Angular holes can be drilled on machines having tilting tables.

A coolant tank is mounted on the base.

Precautions

Ensure that the spindle-head and the arms are locked properly to avoid vibration.

The workpiece and the drill should be rigidly held.

Bring back the spindle head nearer to the pillar after use.

Switch off power when not in use.

Use the drill drift for removing the drills, chucks or sockets.

Use a minimum number of sockets and sleeves to make for the spindle bore size.

Clean and oil the machine after use.

Stop the machine to remove the swarf.

Use a brush to clean the chips and swarf.

Gang drilling machine and multiple spindle head drilling machine

Objectives: At the end of this lesson you shall be able to
- **state the uses of a gang drilling machine**
- **state the construction of a gang drilling machine**
- **state the uses and construction of a multiple spindle head drilling machine.**

Gang drilling machine (Fig 1)

It consists of a large base supporting a long table. The top of the table is designed in such a way that several units may be mounted on it. Each spindle is driven by its individual directly connected motor.

The table has a groove around the outside for the return of the cutting lubricant, and may have 'T'-slots on its surface for ease in clamping the work to the table.

This type of machine is generally preferred when the work is to be moved from spindle to spindle for successive operations.

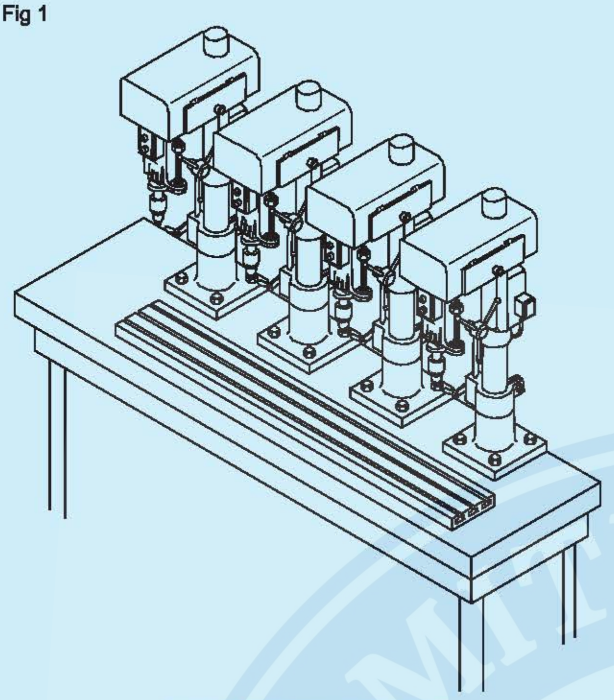
Multiple spindle head drilling machine (Fig 2)

The multiple spindle head drilling machine may have any number of spindles - from 4 to 48 or more, all driven from the one-spindle drive gear in one head.

The multiple spindle head drilling machine is specially designed for mass production operations such as drilling, reaming or tapping many holes at one time in a specific unit of work such as an automobile engine block.

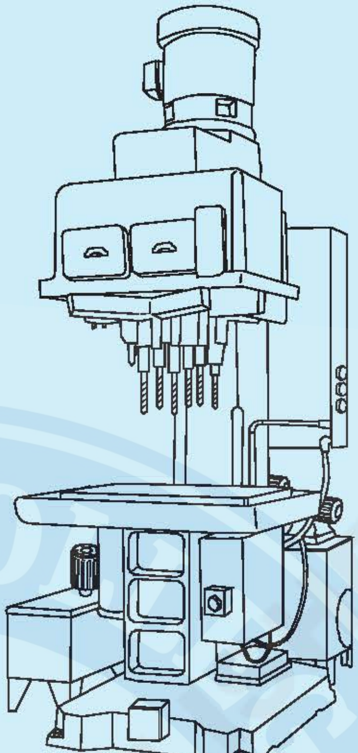
There may be two or more drill heads on one machine, each with many spindles. This is necessary when holes are drilled from more than one direction - for example, on the

Fig 1



top side, and the end of a piece of work. Production units of this type are seldom used in a tool room that usually does highly skilled work.

Fig 2



Work-holding devices

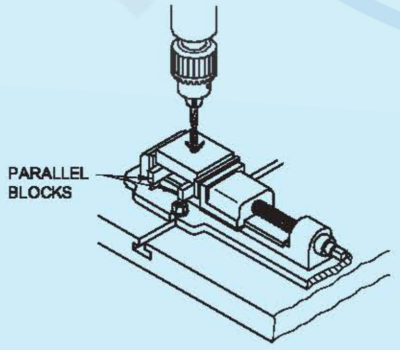
Objectives : At the end of this lesson you shall be able to
- **state the purpose of work-holding devices**
- **name the devices used for holding work**
- **state the precautions to be obsല്ലd while using work-holding devices.**

Workpieces to be drilled should be properly held or clamped to prevent from roating along with the drill. Improperly secured work is not only a danger to the operator but can also cause inaccurate work, and breakage to the drill. Various are used to ensure proper holding.

The machine vice

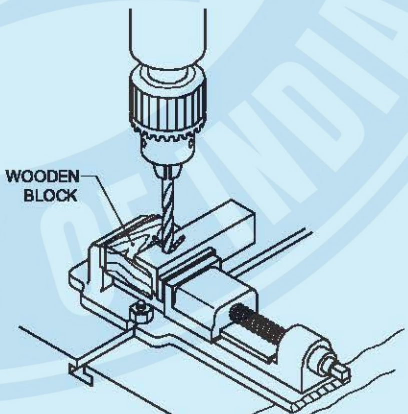
Most of the drilling work can be held in a machine vice. Ensure that the drill does not drill through the vice after it has passed through the work. For this purpose, the work can be lifted up and secured on parallel blocks providing a gap between the work and the bottom of the vice. (Fig 1)

Fig 1



Workpieces which are not accurate may be supported by wooden pieces. (Fig 2)

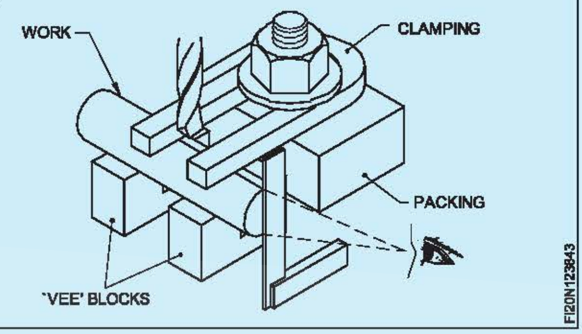
Fig 2



Clamps and bolts

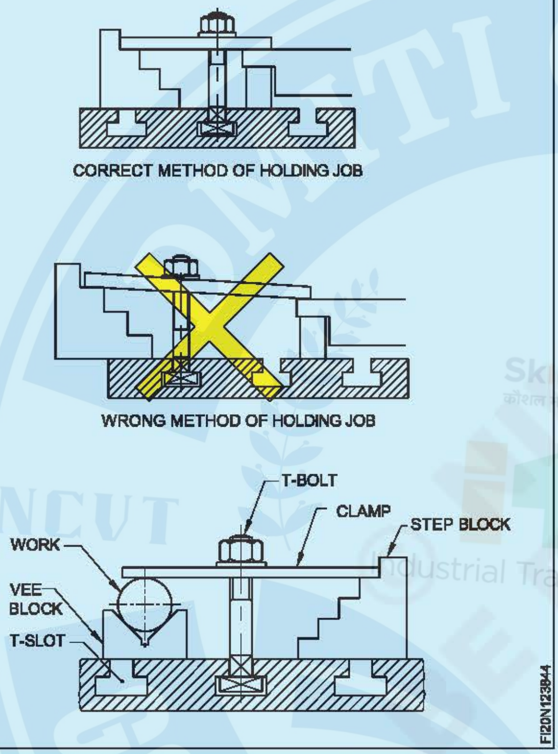
Driling machine tables are provided with T-slots for fitting bolt heads. Using clamps and bolts, the workpieces can be held very rigidly. (Fig 3) While using this method, the

Fig 3



packing should be, as far as possible, of the same height as the work, and the bolt nearer to the work. (Fig 4)

Fig 4



There are many types of clamps and it is necessary to determine the clamping method according to the work. (Fig 5& 6)

Fig 5

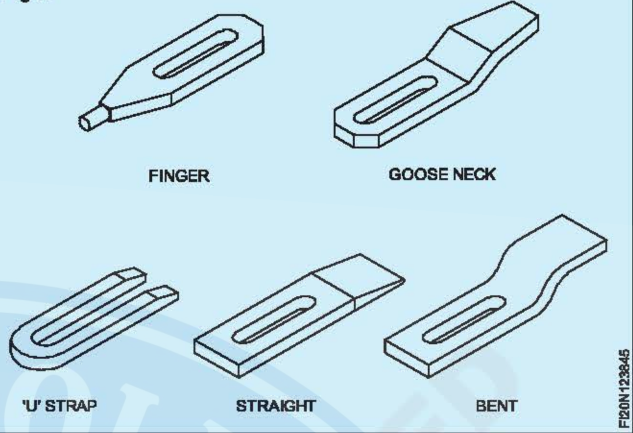
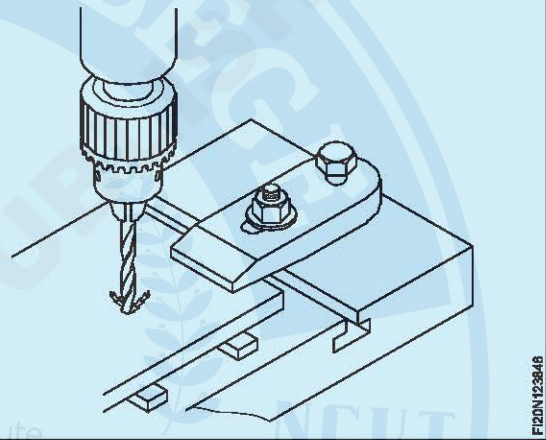


Fig 6



Hand taps and wrenches

Objectives: At the end of this lesson you shall be able to
- **state the uses of threading hand taps**
- **state the features of hand taps**
- **distinguish between different taps in a set**
- **name the different types of tap wrenches**
- **state the uses of different types of wrenches.**

Use of hand taps

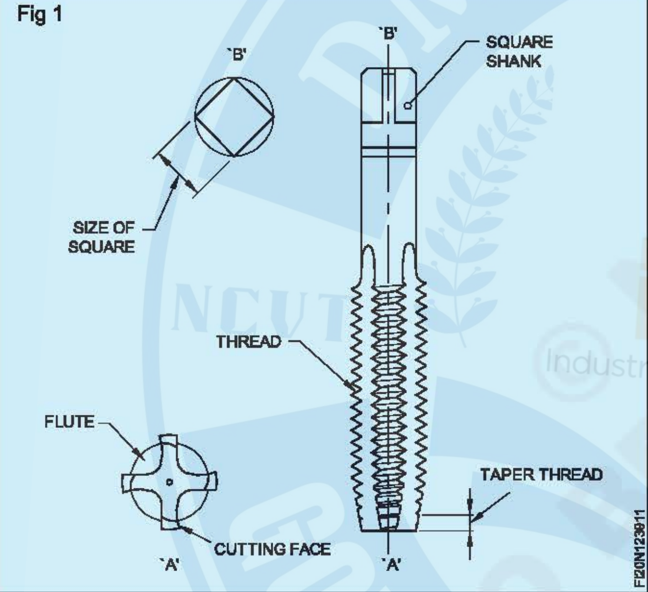
Hand taps are used for internal threading of components.

Features (Fig 1)

They are made from high carbon steel or high speed steel, hardened and ground.

Threads are cut on the surface, and are accurately finished.

Fig 1



To form the cutting edges, the flutes are cut across the thread.

For holding and turning the taps while cutting threads, the ends of the shanks are squared.

The ends of the taps are chamfered (taper lead) for assisting, aligning and starting of the thread.

The size of the taps and the type of the thread are usually marked on the shank.

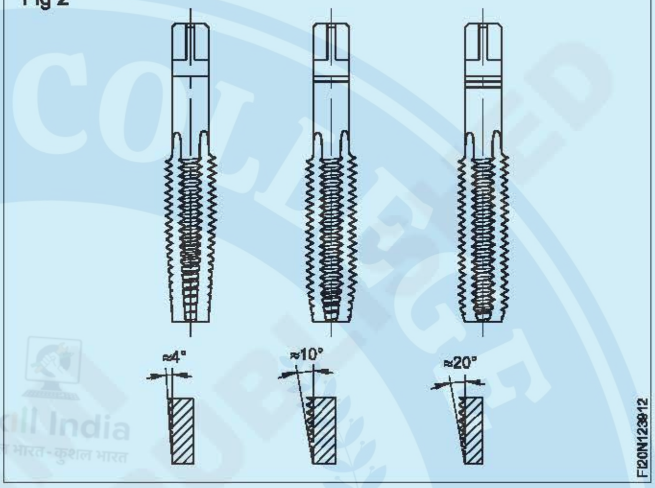
In certain cases, the pitch of the thread will also be marked.

Markings are also made to indicate the type of tap i.e. first, second or plug.

Types of Taps in a set

Hand taps for a particular thread are available as a set consisting of three pieces. (Fig 2)

Fig 2



These are

first tap or taper tap

second tap or intermediate tap

plug or bottoming tap.

These taps are identical in all features except in the taper lead.

The taper tap is to start the thread. It is possible to form full threads by the taper tap in through holes which are not deep.

The bottoming tap (plug) is used to finish the threads of a blind hole to the correct depth.

For identifying the type of taps quickly - the taps are either numbered as 1, 2 and 3 or rings are marked on the shank.

The taper tap has one ring, the intermediate tap has two rings and the bottoming tap has three rings. (Fig 2)

Tap Wrenches

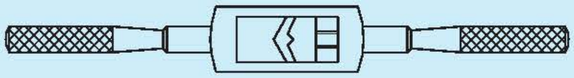
Tap wrenches are used to align and drive the hand taps correctly into the hole to be threaded.

Tap wrenches are of different types.

Double ended adjustable wrench, T-handle tap wrench, solid type tap wrench.

Double-ended Adjustable Tap Wrench or Bar Type Tap Wrench (Fig 3)

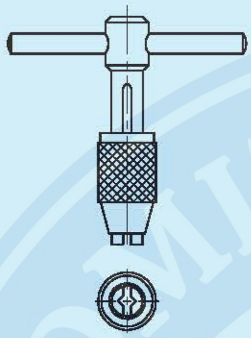
Fig 3



This is the most commonly used type of tap wrench. It is available in various sizes. These tap wrenches are more suitable for large diameter taps, and can be used in open places where there is no obstruction to turn the tap. It is important to select the correct size of wrench.

T-Handle tap wrench (Fig 4)

Fig 4



These are small adjustable chucks with two jaws and a handle to turn the wrench.

This tap wrench is useful to work in restricted places, and is turned with one hand only.

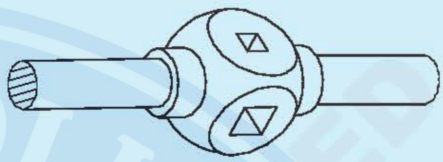
This wrench is not available for holding large diameter taps.

Solid type tap wrench (Fig 5)

These wrenches are not adjustable.

They can take only certain sizes of taps. This eliminates the use of wrong length of the tap wrenches, and thus prevents damage to the taps.

Fig 5



Tap drill size

Objectives: At the end of this lesson you shall be able to
- **state what is tap drill size**
- **choose the tap drill sizes of different threads from tables**
- **calculate the tap drill sizes for ISO metric and ISO inch.**

What is a tap drill size?

Before a tap is used for cutting internal threads, a hole is to be drilled. The diameter of the hole should be such that it should have sufficient material in the hole for the tap to cut the thread.

Tap drill sizes for different threads

ISO Metric Thread

Tapping drill size

for M10 x 1.5 thread

Minor diameter = Major diameter – 2 x depth

depth of thread = 0.6134 x pitch of a screw

2 depth of thread = 0.6134 x 2 x pitch

=1.226 x 1.5 mm = 1.839 mm

Minor dia (D1)=10 mm – 1.839 mm

=8.161mm or 8.2 mm

This tap drill will produce 100% thread because this is equal to the minor diameter of the thread. For most fastening purposes a 100% formed thread is not required.

A standard nut with 60% thread is strong enough to be tightened until the bolt breaks without stripping the thread.

Further it also requires a greater force for turning the tap if a higher percentage formation of thread is required.

Considering this aspect, a more practical approach for determining the tap drill sizes is

Tap drill size = Major diameter – pitch

= 10 mm - 1.5 mm

= 8.5 mm.

Compare this with the table of tap drill sizes for ISO metric threads.

ISO Inch (Unified) threads Formula

Tap Drill size =

$$\text{Major diameter} - \frac{1}{\text{number of thread sperinch}}$$

For calculating the tap drill size for 5/8" UNC thread

Tap drill size = 5/8" – 1/11"

= 0.625" – 0.091"

= 0.534"

The next drill size is 17/32" (0.531 inches)

Compare this with the table of drill sizes for unified inch threads.

What will be the tapping size for the following threads?

(a) M 20

(b) UNC 3/8

Refer to chart for determining the pitches of the thread.

COMMERCIAL DRILL SIZES ISO INCH (UNIFIED) THREAD

NC National Coarse				**NF National Fine**		
Tap size	**Tharads per inch**	**Tap dirll size per inch**		**Tap size**	**Therads**	**Tap drill size**
5	40	38		5	44	37
6	32	36		6	40	33
8	32	29		8	36	29
10	24	25		10	32	21
12	24	16		12	28	14
1/4 "	20	7		1/4 "	28	3
5/16 "	18	F		5/16 "	24	1
3/8 "	16	5/16 "		3/8 "	24	0
7/16 "	14	U		7/16 "	20	25/64 "
1/2 "	13	27/64 "		1/2 "	20	29/64 "
9/16 "	12	31/64 "		9/16 "	18	33/64 "
5/8 "	11	17/32 "		5/8 "	18	37/64 "
3/4 "	10	21/32 "		3/4 "	16	11/16 "
7/8 "	9	49/64 "		7/8 "	14	13/16 "
1"	8	7/8 "		1 "	14	15/16 "
1 1/8 "	7	63/64 "		1 1/8 "	12	1 3/6 "
1 1/4 "	7	17/64 "		1 1/4 "	12	1 11/6 "
1 3/8 " "	6	17/32 "		1 3/8 "	12	1 19/64
1 3/4 "	5	1 9/16 "				
2 "	4 1/2	1 25/32 "				
NPT National pipe thread						
1/8 "	27	11/32 "		1 "	11 1/2	1 5/32 "
1/4 '	18	7/16 "		1 1/4 "	11 1/4	1 1/2 "
3/8 "	18	19/32 "		1 1/2 "	11 1/2	1 23/32 "
1/2 "	14	23/32 "		2 "	11 1/2	2 23/16 "
3/4 "	14	15/16 "		2 1/2 "	8	2 5/8 "

TABLE FOR TAP DRILL SIZES- ISOMETRIC THREADS

PITCH / NOMINAL DIA.	0.25	0.3	0.35	0.4	0.45	0.5	0.6	0.7	0.75	0.8	1	1.25	1.5	1.75		2.5	3	3.5	4	4.5	5	5.55
1	0.75																					
1.1	0.85																					
1.2	0.95																					
1.4		1.10																				
1.6			1.25																			
1.8			1.45																			
2				1.60																		
2.2					1.75																	
2.5			2.15		2.05																	
3			2.65			2.50																
3.5							2.90															
4						3.50		3.30														
4.5						4.00			3.70													
5						4.50				4.20												
5.5						5.00																
6									5.20		5.00											
7									6.20		6.00											
8									7.20		7.00	6.80										
9									8.20		8.00	7.80										
10									9.20		9.00	8.80	8.50									
11									10.20		10.00		9.50									
12											11.00	10.80	10.50	10.20								
14											13.00	12.80	12.50		12.00							
15											14.00		13.50									
16											15.00		14.50		14.00							
17											16.00		15.50									
18											17.00		16.50		16.00	15.50						
20											19.00		18.50		18.00	17.50						
22											21.00		20.50		20.00	19.50						
24											23.00		22.50		22.00		21.00					
25											24.00		23.50		23.00							
26													24.50									
27											26.00		25.50		25.00		24.00					
28											27.00		26.50		26.00							
30											29.00		28.50		28.00		27.00	26.50				
32													30.50		30.00							
33													31.50		31.00		30.00	29.50				
35													33.50									
36													34.50		34.00		33.00		32.00			
38													36.50									
39													37.50		37.00		36.00		35.00			
40													38.50		38.00		37.00					
42													40.50		40.00		39.00		38.00	37.50		
45													43.50		43.00		42.00		41.00	40.50		
48													46.50		46.00		45.00		44.00		43.00	
50													48.50		48.00		47.00					
52													50.50		50.00		49.00		48.00		47.00	
56																						50.50