Basic Metal Works

Level-I

Learning Guide-32

Unit of Competence: Perform Bench Work

Module Title: Performing Bench Work

LG Code: IND BMW1 M10 LO1-LG-32

TTLM Code: IND BMW1 M10 TTLM1019v1

LO1: Plan task and prepare work piece

Instruction Sheet	Learning Guide #32

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Applying safety regulations
- Planning work activities sequentially
- Selecting materials
- Marking dimensions/features on work pieces

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, **upon completion of this Learning Guide, you will be able to**:

- Plan work activities sequentially based on the required tasks and the applied safety regulations.
- Select materials according to specifications of the drawing.
- Mark dimensions/features on work piece in accordance with drawing specifications.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information "Sheet 1, Sheet 2, Sheet 3 and Sheet 4".
4. Accomplish the "Self-check 1, Self-check t 2, Self-check 3 and Self-check 4" **in page -5, 9, 12 and 27** respectively.
5. If you earned a satisfactory evaluation from the "Self-check" proceed to "Operation Sheet 4 " **in page -28.**
6. Do the "LAP test" **in page – 29 and 30** (if you are ready).

Information Sheet-1	Applying safety regulations

1. Introduction

The term '**bench work**' refers to the production of components by hand on the **bench**, where as fitting deals which the assembly of mating **parts**, through removal of **metal**, to obtain the required fit. Both the **bench work** and fitting requires the use of number of simple hand tools and considerable manual efforts.

Bench work and fitting have important roles to play to complete the production of our articles by hand on the bench. Fitting if the assembling to gather of parts and remove metal to secure the necessary fits and may or may not be carry out at the bench .The working of metals is made possible by the manipulation of tools and machines. Hand tools are the basic tools normally used in the school and college workshop to realize designed artifacts. The first part of this chapter covers bench work tools such as files, saws and chisels; the second part deals with tools for marking out, measurement and inspection.

1.1. Metal work shop Safety

1.1.1. Definition of Safety

General safety

Safety means the right way of doing things.

The safety in Workshops has been written not only to provide appropriate safety procedures but also to assist trained workshop personnel with the provision of a reference document outlining the general principles of safe working practices relevant to the mechanical engineering aspects. It relates to specific areas where definite safety measures are required for workshop operations.

Refer:- http://ecoursesonline.iasri.res.in/mod/page/view.php?id=3783

General safety rules are established for three good reasons:-

- ✓ To protect you and your colleagues from badly harm.
- ✓ To minimize damage to facilities, machinery and tools with which you work.
- ✓ To enable you experience a positive safety attitude not only in the work shop but also in your entire professional career.

Safety is not only the responsibility of a single fellow. It is the responsibility of every one.

1.1.2. **Classification of Safety**

1. Personal safety:

- Wear approved safety glasses or goggles at all times.
- Wear approved foot wears at all times.

- Remove all rings, Watches, or bracelets.
- Long hair must be protected by a hair net or an approved protective shop cap.
- Avoid horse play at all times, since an accidental slip or fall can cause a serious cut or body injury.
- Never handle sharp tools or cutters by hand.
- Use proper lifting techniques whenever lifting tools or machines.
- Do not carry sharp tools on pockets.
- Remove all rings, Watches, or bracelets.
- Don't wear loose clothes.
- Do not use a file without handle.

2. Bench work and fitting shop safety:

- Keep hands and tools wiped clean and free of dirt, oil and grease.
- Always keep the work shop clean.
- Do no keep working tools at the edge of the table.
- Keep the floor free of oil and grease
- While sawing, keep the blade straight; otherwise it will break
- Clean the vice after use.
- Keep the floor around a machine or bench free of tools or stock.
- Sweep up the metal chips on the floor frequently.

3. **Machine and tool safety**

- Do no keep working tools at the edge of the table.
- Never place tools or materials on machine tools.
- Always keep the machine clean.
- Always stop a machine before attempting to clean it.
- Do not use vice as an anvil.

Cause of accidents

1. improper dressing
2. poor house keeping
3. insensible behavior
4. incorrect procedure

Preventing accidents

1. proper dressing
2. good house keeping
3. sensible behavior
4. correct procedure

Refer:-https://www.youtube.com/watch?v=VW6a1TIqjxA

Self-Check -1	Multiple choice

Directions: Choose the best answer for the following questions. (**2 point each**)

1. Which one of the following is not a bench work and fitting shop safety?
   a. Do not carry sharp tools in your pockets
   b. Clean the vice after use
   c. keep your-self from car accident
   d. do not use a file without handle

2. What is the reason that general safety rules are established for?
   a. To protect you and your colleagues from badly harm
   b. To decrease accidents in the work shop
   c. To minimize damage of facilities, machinery and tools
   d. All

3. Which one of the following is the cause of accident?
   a. Improper dressing
   b. Good housekeeping
   c. Sensible behavior
   d. Correct procedure

4. Safety is only the responsibility of a single fellow.
   a. True
   b. False

5 Which one of the following is a personal safety?
   a. Remove all rings, watches, bracelets
   b. Wear approved foot wears at all times
   c. Wear approved safety glasses or goggles
   d. All

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

You can ask your teacher for the copy of the correct answers.

Score = ___________	
Rating: ____________	

Name: _________________________ Date: _______________

Information Sheet- 2	Planning work activities sequentially

2.1. Definition of Planning

What is planning?

Planning:- is the process of deciding in detail how to do something before you actually start to do it. It is the process of setting goals, developing strategies, and outlining tasks and schedules to accomplish the goals.

Planning :- is the systematic process of establishing a need and then working out the best way to meet the need, within a strategic framework that enables you to identify priorities and determines your operational principles. Planning means thinking about the future so that you can do something about it now. This doesn't necessarily mean that everything will go according to plan. It probably won't. But if you have planned properly, your ability to adjust, without compromising your overall purpose, will be that much greater.

2.2. **Why do Plan?**

Four reasons for planning:-

- Provides direction
- Reduces uncertainty
- Minimizes waste and redundancy
- Sets the standards for controlling

Refer:- https://www.youtube.com/watch?v=J5_AYavfIUM

2.3. Engineering:-

- Engineering is a professional art of applying science and technology to optimize the conversion of natural resources to the benefit of mankind. (Natural resources available in the universe are Iron ore, Air, Sun, Water, Space, Human etc.)
- Human resource is a supreme strength to develop Engineering to contribute the welfare and progress of the society or to this nation.

2.4. Engineer:-

- Engineer is a person having creative thoughts and ideas to develop technology for the noble cause of the society or to nation.
- All objects begins an idea, Conceived and visualized by the Engineer. He makes an internal representation of the object in his mind and communicates it to others through media of expression.

2.4.1. Professional activities of an engineer:

1. Planning: (Proposal of doing something)

- It means a set of preparation is to do in order to achieve something or any kind of task/work. (Preparation means programmes, drawings, Materials requirement and their sources, time schedule, cost estimate, scheme and design and method of preparation etc.)
- It is a management function of defining goal of an individual / organizations.
- It determines the task/work and resources necessary to achieve set goals.
- It helps to save materials, labor, time, money efforts and process etc. so that any kind of work/task can be performed successfully without having any difficulty with full confidence.

2. Visualization (related to vision / creating picture in mind)

- It is a behavioral technique of improving performance of his individual.
- It encourage for creating metal picture for successful execution of any work.

3. Hard work and practice (doing something repeatedly)

There is no substitute for hard work. A spiritual person says that “Work is Worship”, “Practice makes the man perfect”. Practice makes a person to acquire skill to use their knowledge for gaining self-assurance and confidence to handle any kind of work without any difficulty.

4. Punctuality (being in time):

Punctuality is a moral goodness, which is to be practiced very well punctuality is nothing but courtesy to others. By being punctual you respect the value of time of others. This is more than anything else. It helps you to plan your activities and schedule with precision and efficiency.

5. Work place Environment:

Workplace environment is to be maintained neat and clean, and spread happiness, cheerful, love & affection around your work place, at home and also to the community.

6. Efficiency: It is the ability to do whatever we expected of us as promptly accurately and economically as possible.

These activities are to be performed by an engineer to maintain quality and integrity for successful execution of any task & to face the challenge of globalization.

2.5. Workshop:-

It is a place of work for preparing variety of jobs/products by using different kinds of Instruments, hand tools and Machines.

In order to prepare the products in W/s, the w/s is divided in to many branches according to nature of work.

Ex: 1.Fitting shop

2. Welding shop
3. Sheet metal shop
4. Machine shop
5. Foundry & Forging shop etc.

Required information to prepare the product

It is a common experience that when we want to prepare any product, the following information's are required:-

1. Actual Shape
2. Accurate Size
3. Manufacturing Method

Before taking up the construction of a product, the person who prepares it must have a clear picture of the shape and size of the object in his mind and to know the method of manufacturing process for successful execution of the work.

Self-Check -2	Multiple Choice

Directions: Choose the best answer for the following questions. (**2 point each**)

1. The ability to do whatever we expected of us as promptly accurately and economically as possible is: __________.
   a. Skill b. Knowledge c. Attitude d. Efficiency
2. Why planning is necessary?
   a. To provides direction b. To reduces uncertainty
   c. To minimize waste and redundancy d. All

3. The production of components by hand on the bench is _______________ .

   a. Turning b. Bench work c. Milling d. Boring

4. The process of deciding in detail how to do something before actually start to do is __.

   a. Planning b. Managing c. Manufacturing d. None

5. Which one of the following information is required when we want to prepare any product?

   a. Actual shape b. manufacturing method c. accurate size d. All

Note: **Satisfactory rating - 5 points Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet-3	Selecting materials

3.1. Concepts of engineering materials

The knowledge of materials and their properties is significant for a design engineer. The machine elements should be made of such a material which has properties suitable for the conditions of operation.

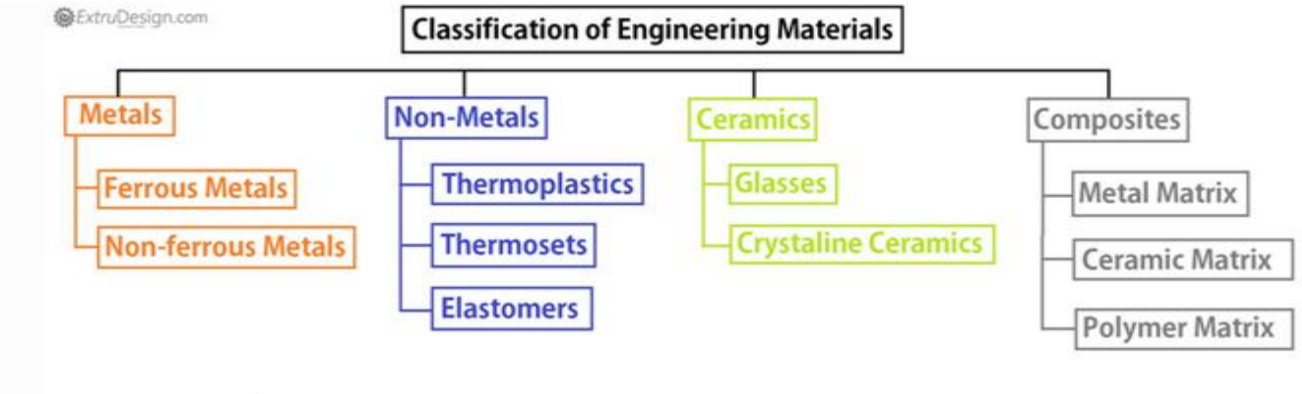


Fig 3.1. Classification of Engineering Materials.

3.1.1. Identifying properties of ferrous and nonferrous metals

Metals are an element that can conducts heat & electricity. Metals have the following properties:

- Solid at room temperature
- Reflective when polished
- Expand up on heating &contract on cooling
- Good conductor of heat & electricity

3.1.2. **Metals can be classified in to two groups:-**

1. **Ferrous metals**: - are those which contain iron as the main content.
   E.g. Pig iron, wrought iron, cast iron, steel, alloy steel etc.
2. **Nonferrous metals**: - are those which don't contain an iron.
   E.g. Copper, zinc, tin, lead, brass, bronze, etc.

The basic source of iron is iron ore. The separation of iron from iron ore is by smelting in blast furnace.

- **Pig iron**: all iron and steel products are derived from pig iron. The principal raw materials of used to produce pig iron are iron ore, coke; lime stone, coal, fluxes etc. Pig iron produce in a blast furnace is the first product in the process of converting by melting iron ore in to useful metals.
- **Steel**:-is an alloy of iron and carbon. It has high compressive strength & corrosion resistance compare to other elements. It is used for cutting tools, hand tools, building frame structure etc.

The main difference b/n pig iron & steel is the carbon content. Pig iron contains 3%-4%carbon. To make steel the carbon has to be reduced & other additional impurity to be burnt out , the carbon content varies from 0.1%- 1.5% .

3.1.3. **Classification of Steels on their carbon content is:-**

- Low carbon steel:-have less than 0.25% carbon content.
  It is used for making wires, rivets, nails etc.
- Medium carbon steel:-have b/n 0.15%-0.25% c- content.
  It is used for garden hoes, cranes, bolts, dies etc.
- High carbon steel: - have b/n 0.5% & 1.5% c- content. It is used for making hammers, springs, chisels, punches, hand files, reamers, screw drivers etc.

Section of steels: - steel ingots are worked in to their final shapes by rolling to produce various shapes. For example Sheet, plate, rod, square, hexagonal angle, channel

- **Cast iron**: - is an easily broken iron which contains some carbon & other impurities. It contains small amount of silicon, phosphorous, sulfur, manganese, etc. it has carbon content between 2%-4%

Self-Check -3	Multiple choice

Directions: Choose the best answer for the following questions (**2 point each**):

1. Which one of the following is ferrous metal?
   a. Zinc b. Wrought iron c. Lead d. Bronze
2. What is the basic source of iron?
   a. Pig iron b. Steel c. Iron ore d. Furnace
3. Which one of the following steel is used for making wires, rivets and nails?
   a. Low carbon steel c. High carbon steel
   b. Medium carbon steel d. all

***Note:* Satisfactory rating - 3 points Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Score = ___________
Rating: ____________

Name: _________________________ Date: _______________

Information Sheet-4	**Marking dimensions/features on work pieces**

4.1. Concepts of Marking and Measuring Tools

Marking out and measuring is a critical part of manufacturing and is usually subject to a number of quality control checks. If components are marked out and measured wrongly before being cut out, there is no chance of them fitting together when they are assembled. Always take marking out measurements from a datum as indicated in Figure 4.1. A datum edge is a flat face or straight edge from which all measurements are taken. This prevents cumulative errors being made. If you are using timber, choose the face side carefully, before marking it with a small symbol for identification purposes, as shown in Figure 4.2. Then select a face edge that is at right angles to the face side. Take all your measurements from this side and/or edge.

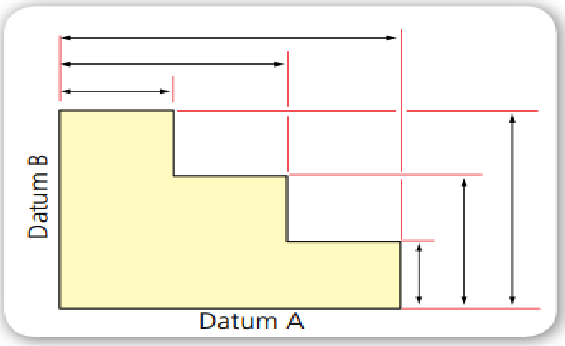


Fig.4.1: Datum edges

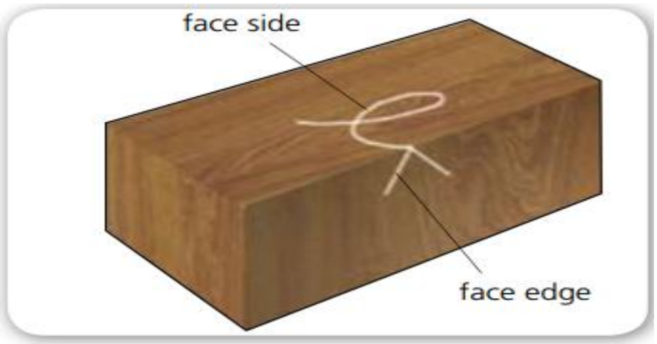


Fig.4.2: Face edges

These are tools used for marking out and measuring that you need to know about:

- rules
- punches
- squares
- templates
- gauges
- micrometers
- Scribers.

4.1.1. Measuring Tools

- **Rules:**

There are two basic types of rule: steel rule and steel tape. Both start at zero and have millimeter graduations.

Item	Name	Use	Advantages	Disadvantages
	steel rule	for measuring up to 300 mm in length	rigid form which means it will not bend and flex	ends can get worn, so the measurements are not accurate
	measuring tape	for making longer measurements up to 5 m	longer, so more versatile	can become twisted and break ends can break off, making them useless

Table 4.1: The uses of rules

✓ **Steel rule**

These are made up of stainless steel and are available in many sizes ranging from 1/2 ft. to 2 ft. These are marked in inches or millimeters. All the faces are machined true. The edges of steel rule should be protected from rough handling**.**

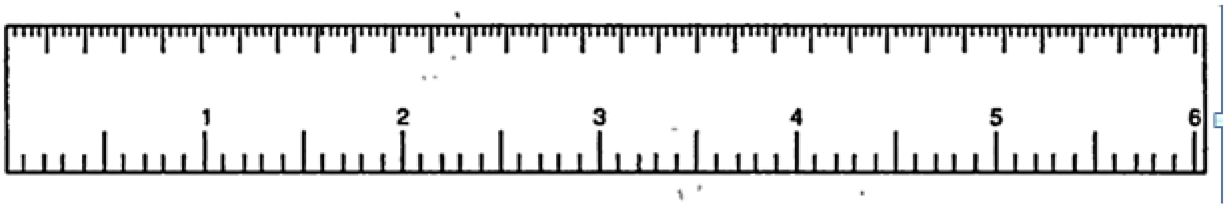


Fig.4.3. Steel rule

- **Micrometers:**

A micrometer is a specialized instrument used to take very accurate measurements. The thimble, which rotates as the micrometer is tightened, has 50 equal divisions around its diameter, giving an accuracy of 0.01mm.A reading is taken by adding all the visible whole numbers to the nearest 0.5 mm. The reading from the thimble, which will be between 0 and 0.49 mm, is added to the main reading to get the exact measurement. Although the micrometer provides a very accurate measurement, it can be difficult to learn how to read it. A micrometer is a very useful instrument. It enables you to take measurements to within one hundredth of a millimeter (0.01mm).The metric micrometer is able to measure ranges of 25 mm (that is, for 0-25 mm, 25-50 mm, and so on).A common type is shown in Figure. The micrometer has a thread with pitch 0.5 mm.

This means that the spindle advances by 0.5 mm for each turn. However, there are 50 graduations on the thimble. So the movement advanced for each graduation of the thimble is 0.5/50 = 0.01 mm. Micrometers are one of the precision measuring tools, used to measure to one-hundredth of a mm (0.01mm). On micrometers, the pitch of a screw thread is used to determine lengths or diameters. Each complete turn of the measuring screw changes the distance between the measuring surfaces by the pitch of its thread (e.g. 0.5mm).

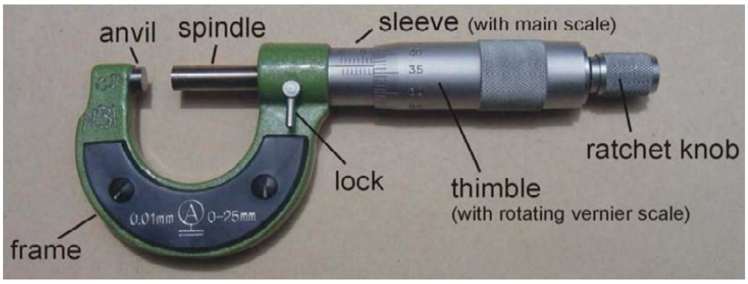


Fig.4. 4. outside micrometer

Types of Micrometers:

✓ **Outside Micrometer:**

An outside micrometer is used for measuring outside diameter of cylindrical objects, parallel surfaces or other outside dimension. The work to be measured is placed between the anvil and the tip of the spindle.

Reading the micrometer:

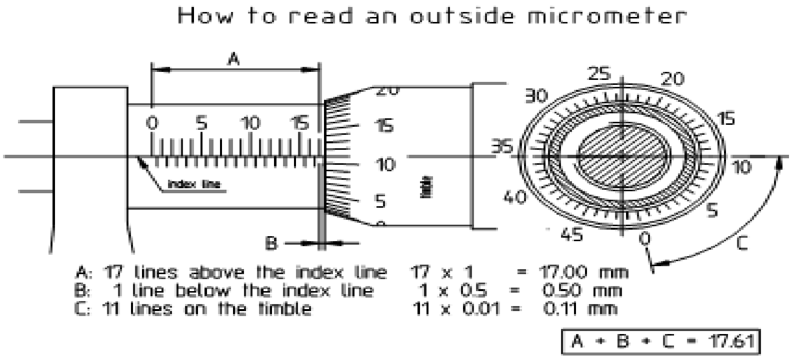


Fig.4.5. Outside micrometer reading

For example

1. Upper main scale (sleeve) 12.00 mm
2. Lower main scale (no half mm) 0.00 mm
3. Circular thimble scale 0.13 mm
4. 13 X 0.01 mm = 0.13mm
5. Total reading <u>12.13 mm</u>

✓**Inside Micrometer:**

The structure of this micrometer is as similar as that of an outside micrometer. It is used for measuring internal dimensions.

Fig.4.6. Inside Micrometer

✓ **Depth Micrometer:**

Depth micrometers are used for measuring the depth of holes, slots, grooves, Keyway and shoulders etc. Note that the scales are graduated in reverse as compared with external or internal micrometers.

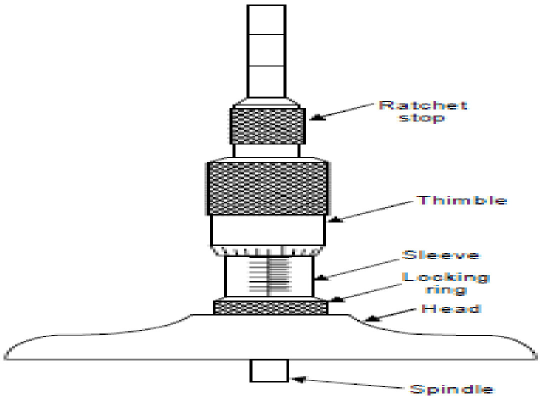


Fig.4.7. Depth micrometer

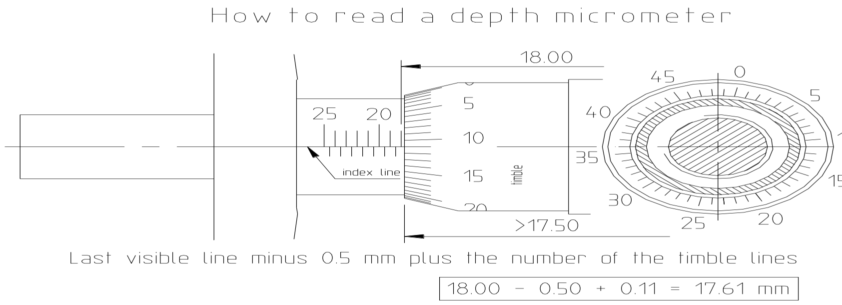


Fig.4.8.Depth micrometer reading

- **Vernier Calipers:**

These are used for measuring outside as well as inside dimensions accurately. It may also be used as a depth gauge. It has two jaws. One jaw is formed at one end of its main scale and the other jaw is made part of a Vernier scale.

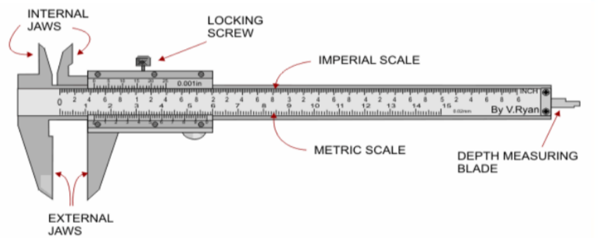


Fig.4.9. Vernier caliper

Fig.4.10.Digital caliper capable of recording inside, Outside, diagonal, hole edge and hole dimensional measurements

Reading a 1/50th Vernier Caliper

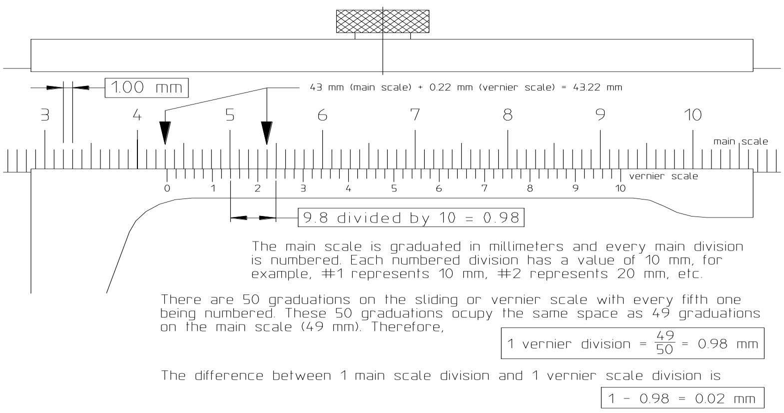


Fig.4.11.Vernier caliper reading

- **Calipers:**

They are indirect measuring tools used to measure or transfer linear dimensions. These are used with the help of a steel Rule to check inside and outside measurements. These are made of Case hardened mild steel or hardened and tempered low carbon steel. While using, but the legs of the calipers are set against the surface of the work, whether inside or outside and the distance between the legs is measured with the help of a scale and the same can be transferred to another desired place. These are specified by the length of the leg. In the case of outside caliper, the legs are bent inwards. Calipers are used for transferring measurements.

The three common types are:

- ✓Outside
- ✓inside and
- ✓odd-leg Hermaphrodite

You can use inside calipers as outside calipers by merely turning the legs about the hinge. and in the case of inside caliper, the legs bent outwards.

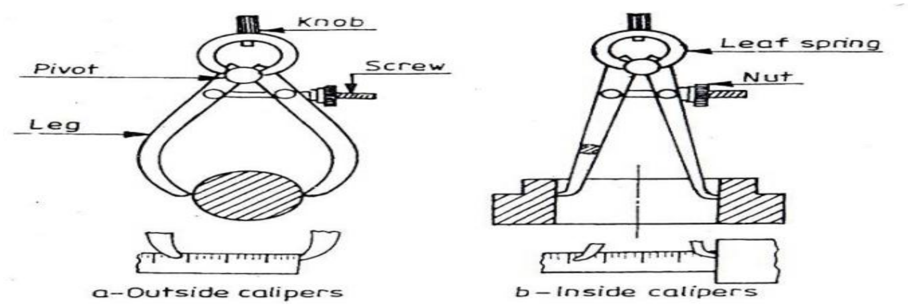


Fig.4.12.Outside caliper and inside caliper.

Fig.4.13. A-firm joint outside caliper. B-Bow spring outside caliper. C-Firm joint inside caliper. D- Bow spring in side caliper. E-Hermaphrodite caliper

- **Protractor:**

Engineer's Protractor

An engineer's protractor, as shown in Fig. 4.13, is a general purpose tool used for the measuring / checking angles, e.g. the angle of drill head, angle of cutting tool, and even for the marking out of angles on a component part.

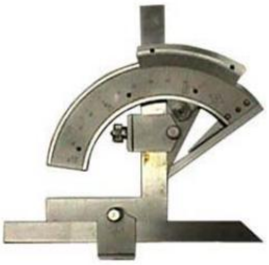
 

Fig.4.14.Engineer's Protractor *Fig.4.15.Vernier Protractor*

- **Vernier Protractor**:

This is a precision measuring tool that the accuracy of measurement can reach ±5 minutes of an angle through the vernier scale as shown in Fig.4.14.

- **Dial Indicator:**

A dial indicator (dial gauge) can measure dimensions up to an accuracy of 0.01mm or even less. The principle of it is that the linear mechanical movement of the stylus is magnified and transferred to the rotation of pointer as shown in Fig. 12. It is usually used as a comparator for calibration or alignment of machine.

Fig 4.16.Dial Indicator

4.1.1.1. Laying out and laying out tools

I. **Laying out**

Layout is the process of making lines, circles, and other marks with a variety of hand tools to represent the features on the blueprint. These marks act as a reference for the operator during machining. They indicate features such as hole locations, dimensions, and other specific areas to be machined. The work piece is coated with a special layout dye, which helps the lines appear more clearly. Layout lines guide the operator to ensure the part fits within the acceptable tolerances. By preventing errors, layout reduces costs.

II. **Laying out tools**

- **Squares:**

  There are a number of squares:

  - ✓ Try square
  - ✓ Miter square
  - ✓ Engineer's square.

Both the try square and engineers square are used to mark lines at 90° to an edge. A try square is used on timber and an engineer's square is used on metals. Both can be used for marking out plastics. You can also use try squares and engineer's squares to check that a cut or an edge has been made at right angles to another. Hold the stock part of the square tightly against the edge that you have just cut. If you can see light between the two edges then the cut is not square. A miter square is used for marking out 45° or 135° angles on wood and plastic. Take great care when using any form of square for marking out or checking, and ensure that it is being held firmly and tightly against the surfaces or edges of the material.

In practice, try is used for checking the squareness of many types of small works when extreme accuracy is not required .The blade of the try square is made of hardened steel and the stock of cast Iron or steel. The size of the try square is specified by the length of the blade.

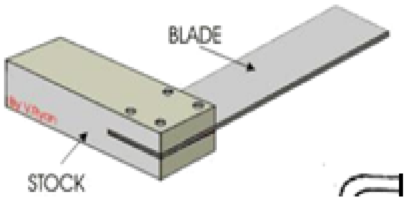


Fig4.17. Try square

Item	Name and use
	try square marking out or checking right angles on wood or plastic
	engineer's square marking out or checking right angles on metal or plastic
	mitre square marking out or checking angles of 45° or 135°

Table 4.18:The uses of squares.

- **Gauges:**

There are three basic types of gauge:

- ✓ marking gauge,
- ✓ mortise gauge
- ✓ cutting gauge.

A marking gauge is used for marking lines parallel to the face edge and side on wood. It consists of a stock that slides up and down the stem, allowing various measurements to be set. The gauge should be set using a steel rule that has a zero end. The spur (sharp point) is pushed into the wood as the gauge is pushed or pulled along the length of the timber. It is important to hold the stock tightly against the edge of the timber to ensure that you mark a parallel line.

A vernier height gauge is used for measuring height of an object or marking lines onto an object of given distance from a datum base.

A cutting gauge is used for cutting across the grain. It is used in the same way as a marking gauge, but has a blade instead of a spur. The blade cuts the fibers across the grain, making it easier and neater to cut with a saw.

A mortise gauge has two pins; one pin is fixed and the other is adjustable. It is used for marking two parallel lines where a mortise and tenon joint is to be cut. The process of marking out is exactly the same tise gauge as with the two other gauges.

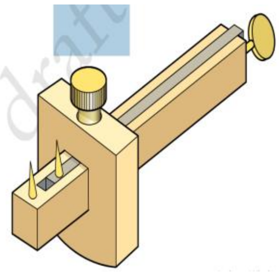


Fig.4.19. Mortise gauge

Fig.4.20. Vernier Height Gauge

- **Scribers:**

A scriber is used to scratch on the surface of metal and plastic lightly. If you are using a scriber on metal, it is a good idea to apply a coat of engineer's blue. This is a spirit-based liquid that is applied to a metal surface. When the scriber is dragged across the engineer‘s blue it leaves a clean line, which can be easily seen.

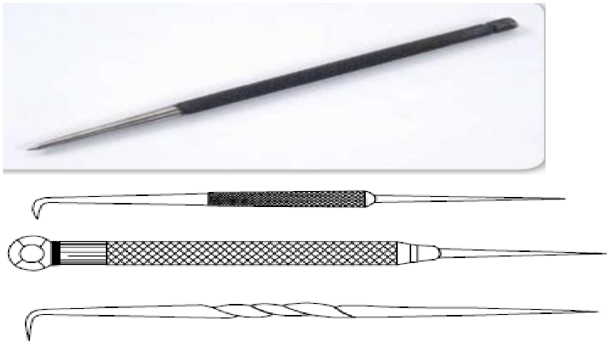


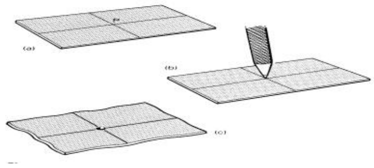
Fig.4.21: Scribers

- **Punches:**

Centre punches are used to make an indent in the surface where holes are to be drilled in metal, as shown in Figure 4.19. They provide a starting point for the drill and stop it skidding over the surface. Dot punches are used for marking the centers where dividers are to be used. They are similar to a center punch, except that the tips are ground to a 60° rather than a 90° point.

Center Punch Procedure

1. Make sure that the point of the punch is sharp before starting.
2. Hold the punch at a 45 degree angle and place the point carefully on the layout line.
3. Tilt the punch to a vertical position and strike it gently with a light hammer.
4. If the punch mark is not in the proper position, correct it as necessary.



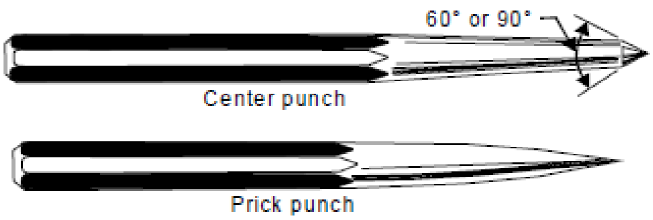


Fig.4.22. A Center punch, and the punch in use.

- **Hammer:**

Hammer is a common work shop hand tools used for striking purpose. There are different types of hammers based on their function.

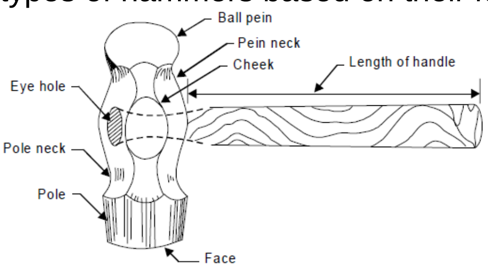
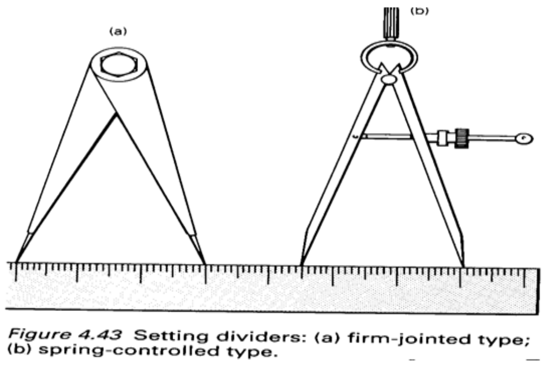


Fig4.23.Common types of ball peen hammer and its parts.

- **Divider:**

It is basically similar to the calipers except that its legs are kept straight and pointed at the measuring edge. This is used for marking circles, arcs laying out perpendicular lines, by setting
lines. It is made of case hardened mild steel or hardened and tempered low carbon steel. Its size is specified by the length of the leg**.**



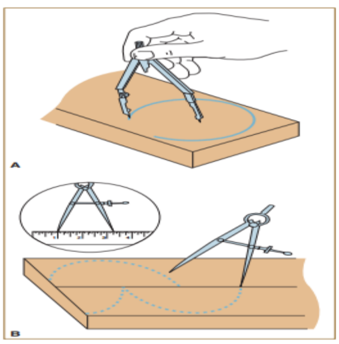
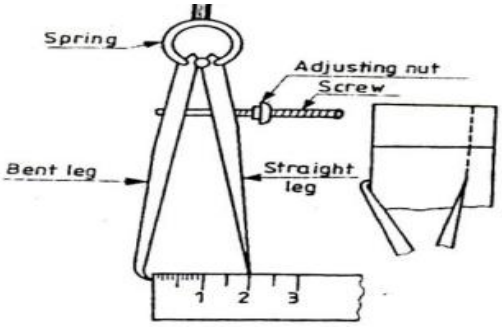


Fig.4.24.A-place and swing the compass on the center point of the circle or arc.



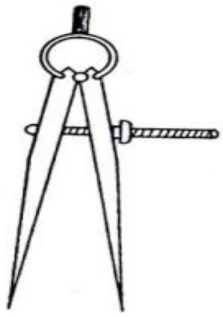
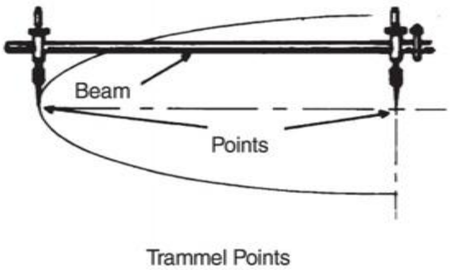


Fig.4.25. Odd leg caliper and divider.

- Trammel Points:

Trammel points are used to mark large circles or make arcs that have large radii. They are used similarly to dividers. The beam is usually made of metal.



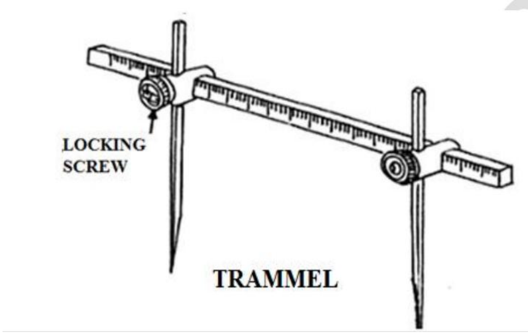


Fig.4.25. Trammel Points

- **Surface plate**

The surface plate provides a 'plane of reference' for checking other surfaces. The plate is made from an iron casting. Its top surface is perfectly flat, and the underside is ribbed to prevent distortion of the plate (Figure 4.22). It is used generally for setting up work for marking out and testing. The surface table allows larger work to be checked for flatness.

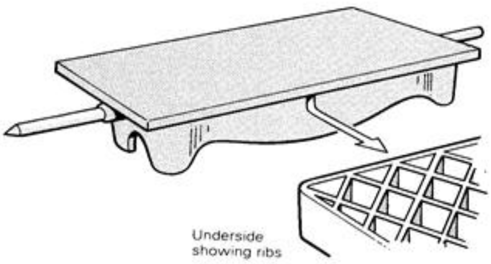


Fig.4.26. Surface plate

- **Surface gauge:**

You use the surface gauge for marking parallel lines and finding centers. Figure 4.24 shows the procedure:

1. Set the scriber at the height you want, using the rule
2. Hold the work against an angle plate or on a vee block.
3. Move the block until the scriber touches the work.

- **Angle Plate:**

The angle plate is made from a good-quality casting.

It consists of two faces machined at 90° to each other (Figure 4.25). You can fix work to the plate using bolts, which can pass through the slots provided. You can also use the angle plate to support work when you are using the surface gauge for marking out.

- **Vee Blocks:**

You use vee blocks to support cylindrical work when you are testing it or marking it out. The blocks, which are supplied in pairs, are made from cast iron. There are grooves along the sides, which allow the clamp to be used (Figure 4.27). If the work is long, you will need a 'matching pair'.

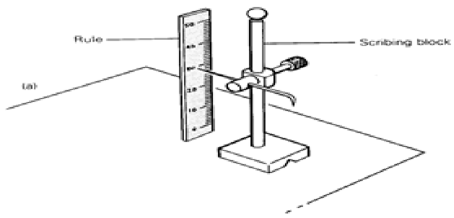


Fig.4.27. Surface gauge

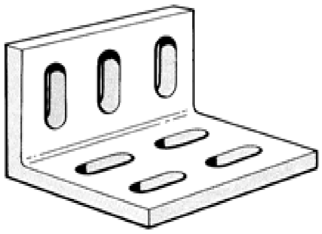


Fig.4.28. Angle plate

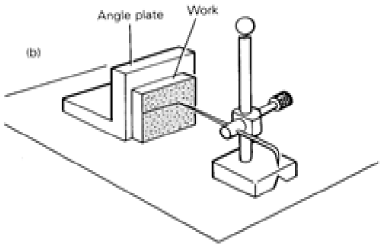


Fig.4.29. Using the surface gauge.
(a) Set the scriber; (b) Hold the work against the angle plate and move the block against the work.

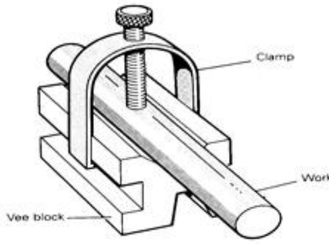


Fig.4.30. Using the Vee block.

- **Combination Set:**

The combination set (Figure 4.28) is an important tool in the workshop, because you can use it as a center square, a try square, a protractor for marking out, measuring and testing. There are three heads (protractor, square and center), which slide onto a rule, which can be fixed at any position using the nut provided.

The main parts of the combination set are used as follows.

1. The try square has angles of 45° and 90°, which you can use to mark out, or to check that a surface is vertical. You can also use it as a square (Figure 4.30(a)).
2. You can use the center square to find the center of circular pieces (Figure 4.30 (b)).
3. You use the protractor with the rule to mark out or measure angular surfaces (Fig 4.30 (c)).

Measuring and inspection tools

You can obtain detailed dimensions of work pieces using measuring tools such as the rule, or the combination set. You can also test existing features (such as holes) for accuracy using inspection tools such as plugs and gauges.

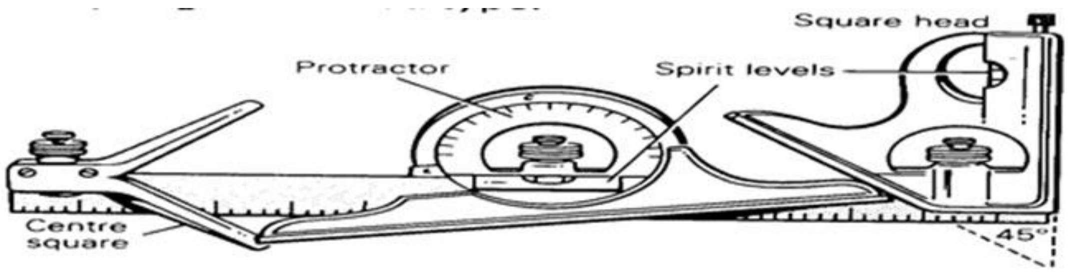


Fig.4.31. Combination set.

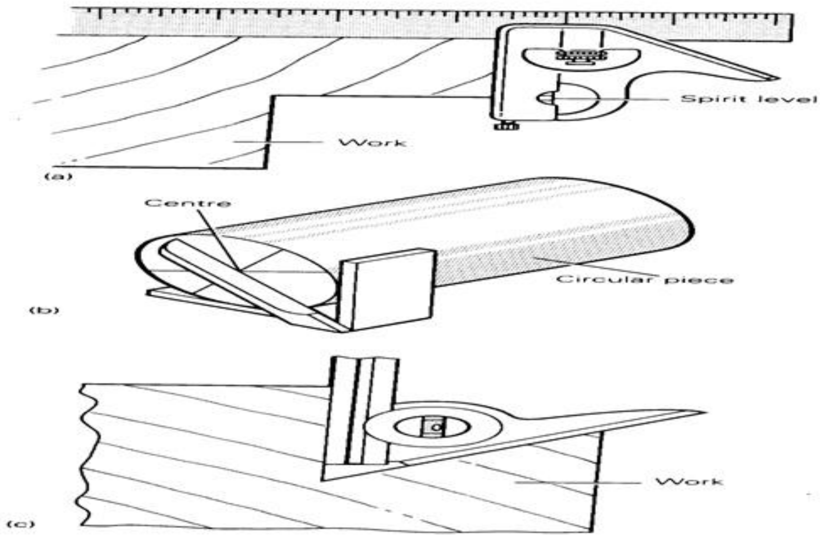


Fig.4.32. Using the combination set: (a) try square;
(b) Center square; (c) protractor

4.1.2. Shop Mathematics

Basic arithmetic operations

- **Fractions and decimals**
  - ✓ **Converting ratios from fractions to decimals**

Although ratios are often given as fractions, they can also be expressed as decimals. You need to deal with a mixture of fractions and decimals, and to compare ratios given in either form, so you need to be able to convert between the two forms.

The ratio of the circumference of a circle to its diameter is a constant denoted by π(the Greek letter *p*) pronounced pi, it has been approximated by a number of different fractions. One such fraction is $\frac{22}{7}$, another is 355/113. How do these compare with the decimal value from a calculator of 3.141592 654?

Answer

If you have a calculator handy then you could key in 22 ÷ 7 to convert to a decimal. However, if not, you might use long division or an informal method of division. Either way you should get 3.1428 …. So $\frac{22}{7}$ agrees to 3 significant figures.

You will probably find it easier to use a calculator for dividing 355 by 113. The result is 3.14159292, which agrees to 7 significant figures.

Refer: OpenLearn – www.open.edu/openlearn/free-courses

- **Percentages and ratios**
  - ✓ **Ratios**

A ratio is used to make comparisons between two similar terms. The items within a ratio are typically of the same units and the resulting comparison is dimensionless (i.e., no units). Ratios are typically expressed in one of three ways, the first being the most common:

- A fraction (division): $\frac{5}{6}$
- In words, using "to": 5 to 6
- With a colon: 5:6

For instance, RU has 409 biology majors and 76 math majors. As a ratio the number of biology majors to math majors is

$$\frac{\#\ \text{biology majors}}{\#\ \text{math majors}} = \frac{409\ \text{students}}{76\ \text{students}} = 5.38.$$

The number of biology majors : math majors is approximately 5:1.

- ✓ **Percentage Calculations**

A percentage is a ratio expressed as part of 100 or per hundred. "Percent" means "per 100."

To calculate a percentage use

$$Percentage = \frac{subgroup}{total} \times 100$$

Ex.) A class has 52 female and 38 male students. What is percentage of female students? What is ratio of female to male students?

The total number of students is 52+38 =90 students. The subgroup being examined is the number of female students (52).

The percentage of female students is then

$$\frac{52}{90} \times 100 \approx 57.78$$

Therefore, approximately 57.78% of the students are female.

The ratio of female to male students is 52:38, or $\frac{52}{38} = \frac{26}{19}$

Ordinarily,100 percent of any quantity is represented by the number 1.00,mean-ing the total quantity. Thus, if we take 50 percent of any quantity, or any multiple of 100 percent, it must be expressed as a decimal:

1% = 0.01

10% = 0.10

65.5% = 0.655

145% = 1.45

- **Conversion of units (English to metric)**
  - ✓ **English to Metric Conversions**

There are two different conversions to relate the foot and the meter. In 1893, the United States officially defined a meter as 39.37 inches. Under this standard, the foot was equal to 12/39.37 m (approximately 0.3048 m). In 1959, a new standard was adopted that defined an inch equal to 2.54 cm. Under this standard, the foot was equal to exactly 0.3048 m. The older standard is now referred to as the U.S. survey foot, while the new standard is referred to as the international foot.

$$1\ meter = 39.37\ inches$$

$$1\ meter * \frac{39.37}{12} \cong 3.2808\ feet$$

$$1\ foot * \frac{12}{39.37} \cong 0.3048\ meters$$

$$1\ mile \cong 1609.4\ meters \cong 1.6094\ kilometers$$

http://www.dot.state.wy.us/files/live/sites/wydot/files/shared/Highway_Development/Surveys/Survey%20Manual/Appendix%20G%20-%20Units%20of%20Measure.pdf

- **Trigonometric functions**

Definition of Trigonometric functions

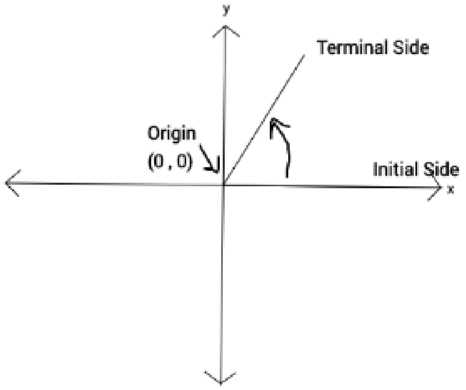
Trigonometry is a branch of mathematics that focuses on relationships between the sides and angles of triangles. The word trigonometry comes from the Latin derivative of Greek words for triangle (trigonon) and measure (metron).

Trigonometry (Trig) is an intricate piece of other branches of mathematics such as, Geometry, Algebra, and Calculus.

✓ UNDERSTAND HOW ANGLES ARE MEASURED

Since Trigonometry focuses on relationships of sides and anglesof a triangle, let's go over how angles are measured...

Angles are formed by an initial side and a terminal side. An initial side is said to be in standard position when it's vertex is located at the origin and the ray goes along the positive x axis.



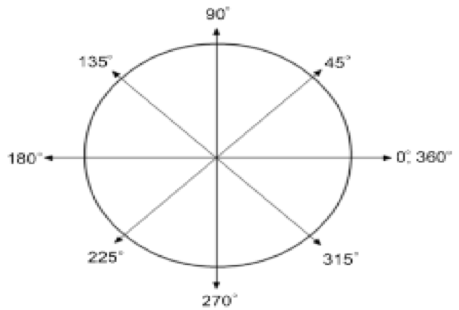
An angle is measured by the amount of rotation from the initial side to the terminal side. A positive angle is made by a rotation in the counterclockwise direction and a negative angle is made by a rotation in the clockwise direction.

Angles can be measured two ways:

1.Degrees
2.Radians

Degrees

A circle is comprised of 360°, which is called one revolution

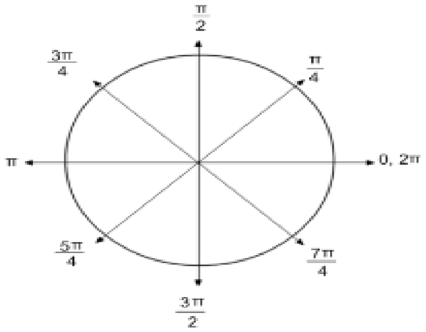


Degrees are used primarily to describe the size of an angle.

The real mathematician is the radian, since most computations are done in radians.

Radians

1 revolution measured in radians is 2π, where π is the constant approximately 3.14



How can we convert between the two you ask?
Easy, since 360° = 2π radians(1 revolution)
Then, 180° = π radians

So that means that $1° = \frac{\pi}{180}$ radians

And $\frac{180}{\pi}$ degrees = 1 radian

Example1

Convert 60° into radians

$$60 \cdot (1\ \text{degree})\ \frac{\pi}{180} = 60 \cdot \frac{\pi}{180} = \frac{60\pi}{180} = \frac{\pi}{3}\ \text{radian}$$

Example 2

Convert (-45°) into radians

$$-45 \cdot \frac{\pi}{180} = \frac{-45\pi}{180} = -\frac{\pi}{4}\ \text{radian}$$

Example 3

Convert $\frac{3\pi}{2}$ radian into degrees

$$\frac{3\pi}{2} \cdot (1\ \text{radian})\ \frac{180}{\pi} = \frac{3\pi}{2} \cdot \frac{180}{\pi} = \frac{540\pi}{2\pi} = 270°$$

Example 4

Convert $-\frac{7\pi}{3}$ radian into degrees

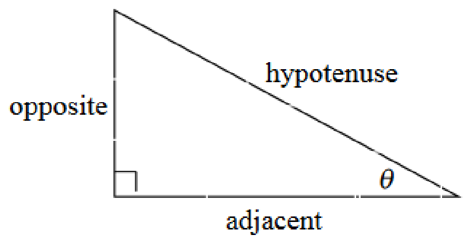
$$-\frac{7\pi}{3} \cdot \frac{180}{\pi} = \frac{1260}{3} = 420°$$

The sine, cosine and tangent of an angle are all defined in terms of trigonometry.

Right triangle definition

For this definition we assume that

$0 < \theta < \frac{\pi}{2}$ or $0° < \theta < 90°$.



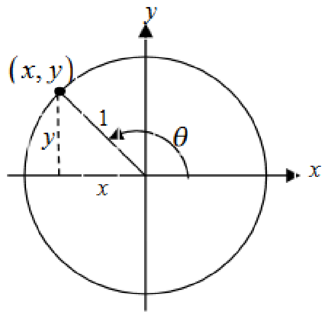
$$\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}} \qquad \csc\theta = \frac{\text{hypotenuse}}{\text{opposite}}$$

$$\cos\theta = \frac{\text{adjacent}}{\text{hypotenuse}} \qquad \sec\theta = \frac{\text{hypotenuse}}{\text{adjacent}}$$

$$\tan\theta = \frac{\text{opposite}}{\text{adjacent}} \qquad \cot\theta = \frac{\text{adjacent}}{\text{opposite}}$$

Unit circle definition

For this definition θ is any angle.



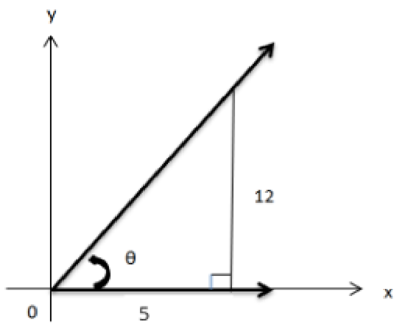
$$\sin\theta = \frac{y}{1} = y \qquad \csc\theta = \frac{1}{y}$$

$$\cos\theta = \frac{x}{1} = x \qquad \sec\theta = \frac{1}{x}$$

$$\tan\theta = \frac{y}{x} \qquad \cot\theta = \frac{x}{y}$$

Fig4.33. Trigonometric formula.

Exact values for Trigonometric functions of most commonly used angles



Before we can find the values of the six trig ratios, we need to find the length of the missing side. Any ideas? Good call, we can use r = $\sqrt{x^2 + y^2}$ (from the Pythagorean Theorem)

r = $\sqrt{5^2 + 12^2}$ = $\sqrt{25 + 144}$ = $\sqrt{169}$ = 13

Now we can find the values of the six trig functions

$\sin\theta = \frac{opposite}{hyptoenuse} = \frac{12}{13}$ $\qquad$ $\csc\theta = \frac{hyptoenuse}{opposite} = \frac{13}{12}$

$\cos\theta = \frac{adjacent}{hypotenuse} = \frac{5}{13}$ $\qquad$ $\sec\theta = \frac{hypotenuse}{adjacent} = \frac{13}{5}$

$\tan\theta = \frac{opposite}{adjacent} = \frac{12}{5}$ $\qquad$ $\cot\theta = \frac{adjacent}{opposite} = \frac{5}{12}$

Refer:https://www.govst.edu/uploadedFiles/Academics/Colleges_and_Programs/CAS/Trigonometry_Short_Course_Tutorial_Lauren_Johnson.pdf

Self-Check -4	Written Test

Directions: Choose the best answer for the questions (**2 point each**):

1. A marking out tool used for checking the squareness of many types of small works when extreme accuracy is not required is _______ .
   a. Scriber b. Try square c. Caliper d. Punch
2. ___ Is a marking out tool used to scratch on the surface of metals and plastics lightly.
   a. punch b. Steel rule c. Try square d. Scriber
3. Which one of the following steel is a more precise measuring instrument than the others?
   a. Micrometer c. Steel rule
   b. Vernier caliper d. Divider
4. A marking (laying) out tool used for marking (making) circles and arcs on metal surface is;
   a. Center punch b. Divider c. prick punch d. chisel
5. Which one of the following is used to make an indent in the surface where holes are to be drilled in metal?
   a. Chisel c. Center punch
   b. Drilling machine d. Hack saw

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Score = ____________

Rating: _____________

Name: ___________________________ Date: ________________

Operation Sheet 4	Measuring work pieces

4.1. To Measuring work pieces using different measuring instruments;

Steps 1- Use bench work tools and equipment.
Step 2- Use measuring instruments.
Step 3- Prepare work piece to be measured.

Step 4- Select the appropriate measuring instruments.

Step 5- Measure the work piece.

Step 6- Record the results.

4.2. To Marking out the hack sawing and filling lines:

Steps 1- Locate the reference plane.

Step 2- Use the surface plate, surface gauge and steel ruler to set the required height as shown in Fig.2.1.
Step 3- Use the angle plate, surface gauge to scribe the first line and repeat the same procedure to scribe the other three lines.
Step 4- Punch the scribed lines by using the prick punch.

LAP Test	Practical Demonstration

Name: ______________________________ Date: ________________

Time started: _________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within **3-4** hours.

Task 1: You will be given a V- Block similar to the one shown in Fig.1.1, use the steel rule to measure the dimensions shown in Fig. 1.2. Record your measurements in the table below.

Fig.1.1: V-Block

NOTE:

The accuracy of your readings should be in a range of 0.5 mm.

Table of measurements:

Dimension	A	B	C	D	E	F
Dimension in (mm)						

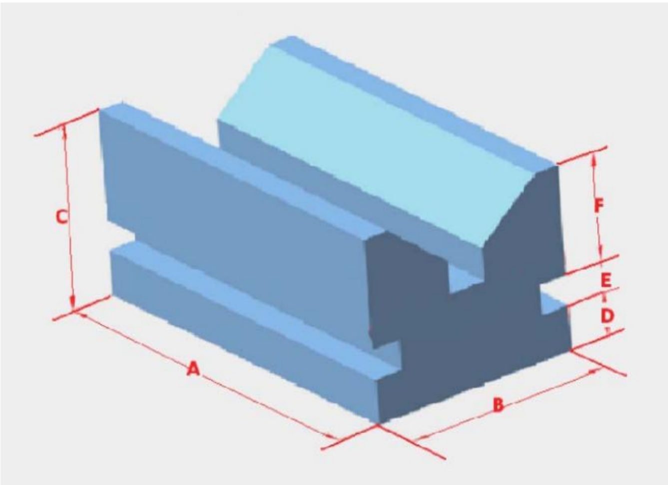


Fig.1.2: dimensions A to F to be measured on a V-Block.

Task 2: Marking out the hack sawing and filling lines.

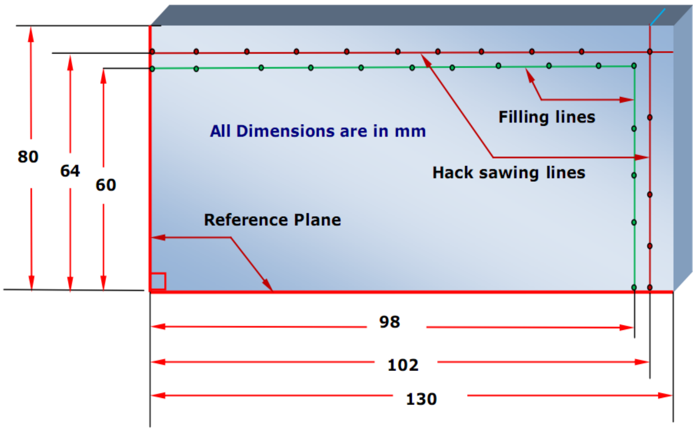


Fig.2.1. The filling and hack sawing lines.

NOTE:

Use a Vernier caliper with 0.02 mm accuracy

Task 3: You will be given a work piece similar to the one shown in Fig.3.1. Use the micrometer to measure the dimensions shown in Fig. 3.2. Record your measurements in the table below.

Fig.3.1 a copper work piece

NOTE:

The accuracy of the micrometer is 0.01 mm

Table of measurements

Dimension	R1	R2	A	B
Dimension in (mm)				

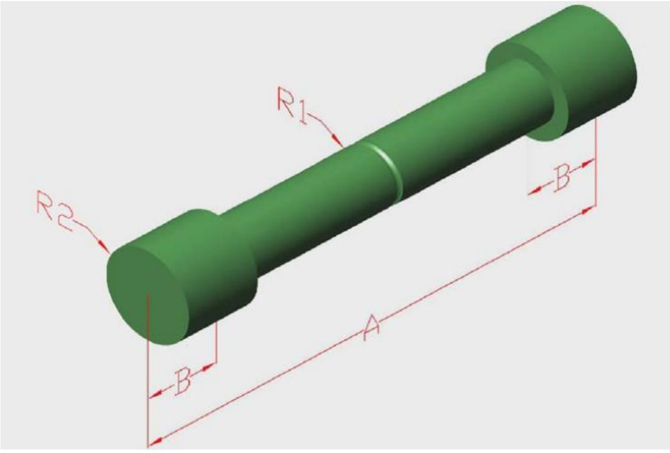


Fig.3.2 a copper work piece

List of Reference Materials

1. Workshop Technology Parts 1, 2 and 3, Author : WAJ Chapman Publisher : London: Edward Arnold, 1972.
2. Manufacturing Technology Author: G Bram & C Downs Publisher: London: MacMillan, 1975.
3. General safety:http://ecoursesonline.iasri.res.in/mod/page/view.php?id=3783
4. Machinery and tool safety: https://www.youtube.com/watch?v=VW6a1TIqjxA
5. Planning: **https://www.youtube.com/watch?v=J5_AYavfIUM**
6. Converting ratios from fractions to decimals: OpenLearn www.open.edu/openlearn/free-courses
7. English to Metric Conversions: http://www.dot.state.wy.us/files/live/sites/wydot/files/shared/Highway_Development/Surveys/Survey%20Manual/Appendix%20G%20-%20Units%20of%20Measure.pdf
8. Trigonometric functions: **https://www.govst.edu/uploadedFiles/Academics/Colleges_and_Programs/CAS/Trigonometry_Short_Course_Tutorial_Lauren_Johnson.pdf**

Basic Metal Works

Level-I

Learning Guide-33

Unit of Competence: Perform Bench Work

Module Title: Performing Bench Work

LG Code: IND BMW1 M10 LO2-LG-33

TTLM Code: IND BMW1 M10 TTLM 1019v1

LO 2: Perform hand tool operations

Instruction Sheet	Learning Guide # 33

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Clamping work pieces
- Selecting and using hand tools
- Cutting, chipping, filing and scraping work pieces with in tolerances
- Cutting Threads
- Performing bench work operations

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Clamp work pieces based on instructions and applied standards.
- Select and use hand tools according to task and safety regulations.
- Cut, chip, file or scrape work pieces within tolerances specified in the drawing.
- Cut threads according to standard procedures.
- Perform bench work operations applying safety procedures and using personal protective devices.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information "Sheet 1, Sheet 2, Sheet 3, Sheet 4 and Sheet 5".
4. Accomplish the "Self-check 1, Self-check t 2, Self-check 3, Self-check 4 and Self-check 5" **in page -38, 43, 51, 57 and 59** respectively.
5. If you earned a satisfactory evaluation from the "Self-check" proceed to "Operation Sheet 3 and Operation Sheet 4" **in page -60.**
6. Do the "LAP test" **in page 61– 62** (if you are ready).

Information Sheet-1	Clamping work pieces

1.1. Concepts of clamping

Once work piece is located, it is necessary to press it against locating surfaces and hold it there against the force acting upon it. The tool designer refers to this action as clamping and the mechanisms used for this action are known as clamps. It is necessary that the work should be properly and securely held on for machining operations, a VISE is an effective work holding device.

Vises: Vises are the most common appliances for holding work on table due to its quick loading and unloading arrangement.

1.2. Types of work holding devices

- **Bench vice**

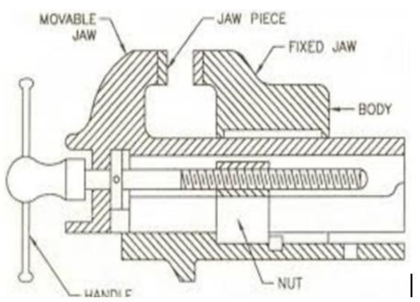
A **bench vise** is like an extra hand and is a common tool found in any shop or garage. It is attached to a **workbench** and its purpose is to hold material steady, allowing you to use both hands to work on the material with other tools. They are ideal for sawing, sanding, planing, drilling, screwing, soldering and more.

Bench Vises with Swivel Base

There are mainly three types of vises commonly used:

- Plain vise
- Swivel vise
- Tool makers universal vise

2. Removable hardened alloy steel jaw inserts.
3. Completely enclosed center screw.
4. Attractive hammered enamel finish



ttps://www.google.com/search?q=Bench+vice+for+bench+work+operation+pdf&tbm=isch&source=univ&sa=X&ved=2ahUKEwj

Fig.1.1. Bench vice

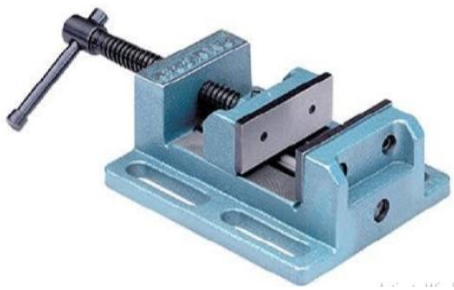


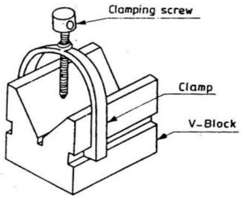
Fig.1.2. Machine vice

- **V-block**

V-block is rectangular or square block with a V-groove on one or both sides opposite to each other. The angle of the 'V' is usually 90^0. V-block with a clamp is used to hold cylindrical work securely, during layout of measurement, for measuring operations or for drilling for this the bar is faced longitudinally in the V-Groove and the screw of V-clamp is tightened. This grip the rod is firm with its axis parallel to the axis of the v-groove

- **C-Clamp**

This is used to hold work against an angle plate or v-block or any other surface, when gripping is required. Its fixed jaw is shaped like English alphabet 'C' and the movable jaw is round in shape and directly fitted to the threaded screw at the end .The working principle of this clamp is the same as that of the bench vice.



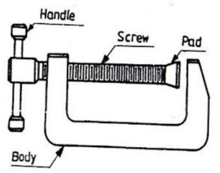


Fig.1.3 V-Block *Fig.1.4. C- Clamp*

- **Pliers**

There is a vast range of pliers used in the vehicle body building industry, with the most common being combination pliers, slip joint pliers, side cutters, circlip pliers, long-nosed pliers and multi grips. The correct pliers to use depend on the type of vehicles being built. For example, long-nosed pliers are used to hold and grip small work in awkward places so these may be used extensively with hydraulic or electrical work. However, they may not be much use when building a semitrailer. Name these pliers:

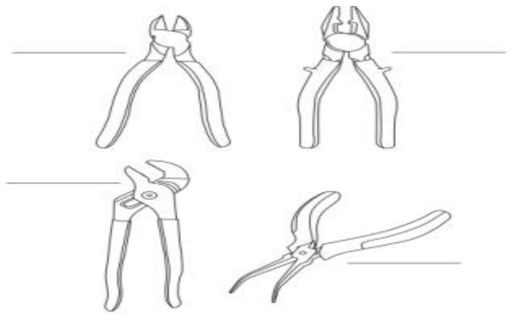


Fig.1.5. Pliers

- **Parallel Clamps**

Jaws are made of hardened and tempered steel. Clamps are equipped with spring clips

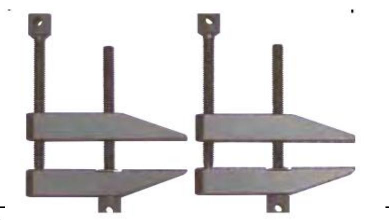


Fig1.6. Parallel Clamps

Self-Check -1	Written Test

Directions: choose the correct answer for the following questions (**2 points each**):

1. Which one of the following is not clamping tools?
   a. Vice
   b. V- block
   c. hacksaw
   d. C- clamp
2. One of the following is not the parts of bench vice.
   a. Jaw face
   b. Thimble
   c. Fixed jaw
   d. Movable jaw
3. ______is used for clamping work piece.
   a. Bench vice
   b. C-clamp
   c. V-block
   d. All

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet-2	Selecting and using hand tools

2.1. Introduction to selecting and using hand tools

Vehicle body building is a very diverse trade and therefore requires the tradesperson possess many and varied skills. This person must be able to use and operate a wide range of tools and equipment, possibly a wider range than in any other trade. This learning resource covers a selection of hand tools and equipment used in the vehicle body building trade.

1.2 Tools

Tools can be divided into two main groups: hand tools and power tools. Hand tools are operated by the physical strength of the user. Power tools require an external source of power such as electricity or compressed air to operate. Each of these groups can also be divided into sub groups.

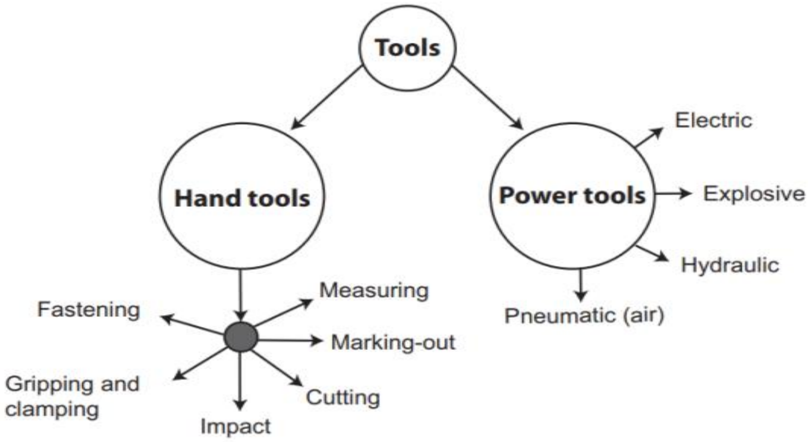


Fig.2.1. Division of tools

2.3. Hand tools

Hand tools have been devised to enable trades people to carry out a job more efficiently, quickly and safely than would otherwise be possible. Some tools are quite simple, such as a screwdriver, which is almost indispensable for undoing a countersunk screw located in a recess. Others are more complicated, such as a micrometer; these are indispensable are when measuring fine tolerances.

2.3.1. Hand tools can be classified into several groups:

- fastening tools
- gripping and clamping tools
- impact tools
- cutting tools
- marking-out tools

- Measuring tools.

Fastening tools

2.3.1.1. Spanners

There are several types of spanners, each suitable for a specific job. The most commonly used spanners in a vehicle body building workshop are:

- ✓ open-ended spanners
- ✓ ring spanners
- ✓ combination spanners
- ✓ sockets and their accessories
- ✓ hook spanners
- ✓ pin spanners
- ✓ adjustable spanners
- ✓ ratchet spanners
- ✓ Flare nut spanners.

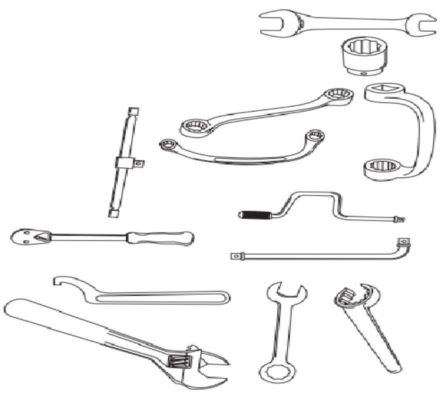


Fig.2.2. Types of spanners

2.3.1.2. Wrenches

Wrenches are tools used for holding and turning. A variety of wrenches are used in the vehicle body building industry. Adjustable pipe wrenches are sometime called still son wrenches. Typically, they are used on cylindrical objects such as pipes and rails where there are no flats on which to use a spanner. Another type of wrench is the hexagon wrench, which would typically be used for undoing hexagonal recessed drain plugs. Smaller hexagon wrenches are called Allen keys. Torque wrenches are used to tighten nuts or bolts to a specific tension and are sometimes called tension wrenches. They are used to correctly tension down the bolts holding engineering components such as power take-off units or bolts on kingpins. Never use a torque wrench to undo nuts or bolts, as this may damage or alter the accuracy of the wrench.

Fig.2.3. Torque wrench

2.3.1.3. Screwdrivers

Screwdrivers are accurate precision tools and are not designed to be used as punches or cold chisels. The most common types of screwdrivers are the standard (straight blade or flat) type and the Phillips screwdriver, and they are available in many different sizes and lengths. There are also special screwdrivers designed for hard-to-get screws, for example right-angle screwdrivers.

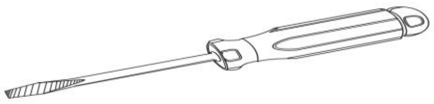


Fig.2.4. Flat screw driver

2.3.1.4. Keys

Keys used in the trade include drill chuck keys, lathe chuck keys and hexagon keys. Hexagon keys are also called Allen keys and include ball driver keys which can be used at an angle, unlike straight hexagon keys, which must be inserted squarely into the hexagonal recess.

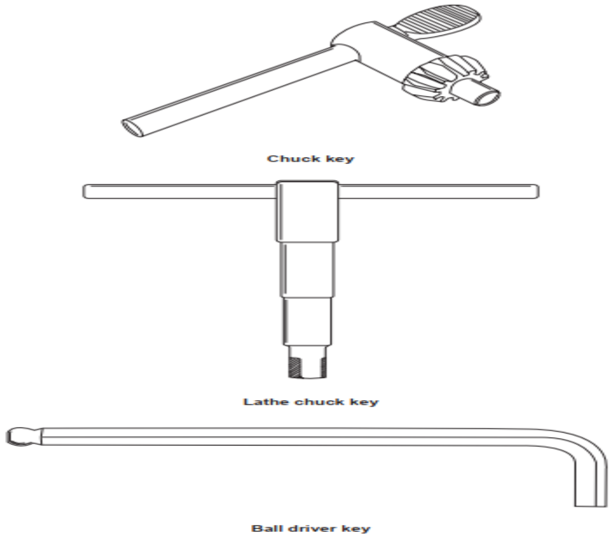


Fig.2.5. Keys, (a) Chuck key, (b) Lathe Chuck key,(c)Ball driver key

2.3..1.5 Hand snips

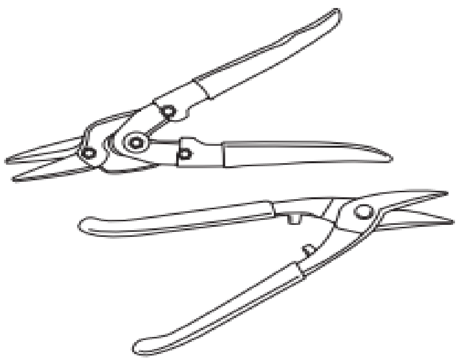


Fig.2.5. Hand snips

2.3.1.6. Taps and wrenches

Taps are used to cut internal threads in holes which are usually drilled for the purpose of attaching an item with bolts or metal threads. Taps come in all sizes and threads to match the wide variety of bolts and metal threads available in the trade.

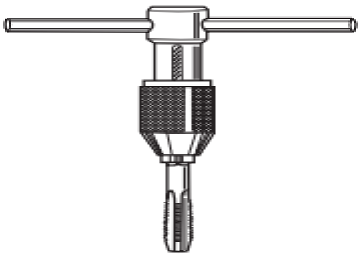


Fig.2.6. Hand snips

2.3.1.7. **Stock and dies**

Dies are used to cut external threads on rods, studs, shafts or bolts. They can also be used to clean up or repair damaged external threads.

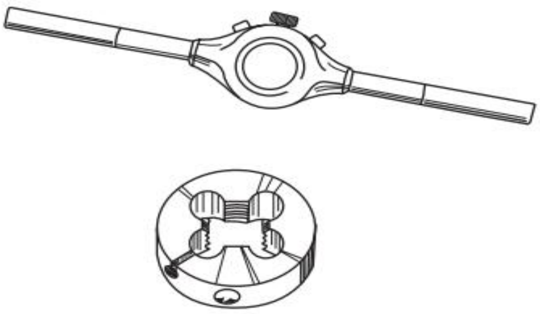


Fig.2.5. Die and die- stock

Self-Check -2	Written Test

Directions: choose the best answer for the following questions (**2points each**):

1. _______is used to cut internal threads in holes which are usually drilled for the purpose of attaching an item with bolts or metal threads.
   a. Tap c. snips
   b. Die d. all
2. _______is hand tools used for holding and turning materials.
   a. Snip c. trammel
   b. Wrench d. Screwdrivers
3. Which one of the following is not include under hand tools?
   a. Wrench c. Taps
   b. Power hacksaw d. all

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet-3	Cutting, chipping, filing and scraping work pieces within tolerances

3.1. Concepts of Cutting metals

Sawing is the process of cutting metal stock that is impractical to use a file, a chisel or a machine with a multi-point cutting tool called a hand hack saw. A hand hack saw can also be used for cutting off a jammed bolt, pipes, tubing and rods for special or custom fittings on the job (on the field work).

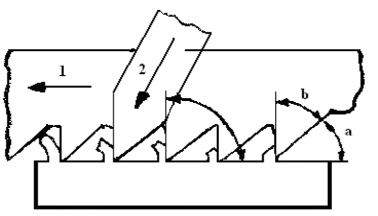
Some of the most common tools used to cut metals are **hacksaws**, **band saws**, **cold chisels**, **bolt cutters, tin snips, and abrasive saws**. Large stock is sawed, while bar stock is either sawed or cut with a cold chisel. Sheet metal is usually cut with metal snips. In fabrication facilities, large amounts of metal are cut with horizontal band saws or metal shears, commonly called “ironworkers. Layout tools are used to measure and mark metal stock before cutting, shaping, and doing other types of work with cold metal.

3.1.1. Saws

Saws are used to cut material that is not needed away from material which is. Saw blades have alternate teeth bent out or ‘set’ in opposite directions. This is so that when they cut, they make a gap, called the kerfs. The kerfs must be wider than the saw blade so that the blade cannot get stuck. When using a saw, you should always cut to the waste side of the marked line so that you leave a small amount for finishing by either sanding or filing. Whatever you are cutting, it is important to keep as many teeth in contact with the piece being cut as possible. You should choose the correct saw for the type of material you are using. Table 2.3 on the next page shows the most common types of saws used in school workshops.

- **Cutting process**

The saw is moved from the right to left and shows how the chip is formed. The cutting process is the result of the horizontal cutting direction and the pressure on the work piece. The angle of the teeth enables the saw to cut the material effectively. The teeth are set (bent out) that they do not get jammed in the cut.



a = clearance **b = cutting angle**

Fig.3.1. Teeth setting

Forces on a saw blade:

1 = indicates the cutting direction

2 = indicates the pressure on the work piece

- **Steps to Follow in Making the Cut with a Hacksaw**

Place the metal to be cut in a vise and mark it. The mark should be placed near the jaws, especially if the metal is thin. It may be necessary to use boards between the vise jaws to prevent scarring the work. Mark over the original mark with a file.

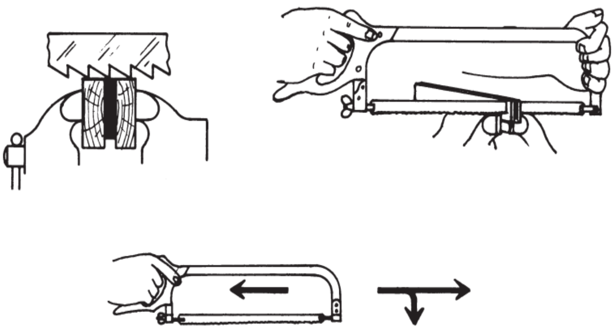


Fig.3.2. Using a hack saw

Depending upon the direction of cut, blades are classified as:

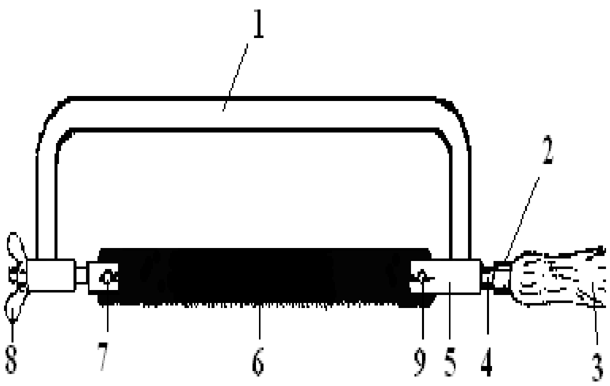
- ✓ Forward cut
- ✓ Backward cut.

Depending upon the pitch of the teeth (Distance between the two consecutive teeth) blades is classified as:

- ✓ Coarse (8-14 teeth per Inch)
- ✓ Medium (16-20 teeth per inch)
- ✓ Fine (24-32 teeth per inch)

- **Parts of a hacksaw**

1. Saw frame
2. Handle protector
3. Handle
4. Tang
5. Blade holder
6. Blade



7. Pins

8. Wing-Nut

9. Pins

Fig.3.3. Parts of hack saw

- **Types of blades for hacksaws**

One side toothed **Both sides toothed**

Fig.3.4. Types of hack saw blades.

How to handle a hacksaw?

1 and 3 Indicate the forward stroke with pressure

2 and 4 The backward stroke without pressure the circle shows the direction of teeth (facing the front of the hacksaw) all strokes should be in a straight line and along the whole length of the blade.

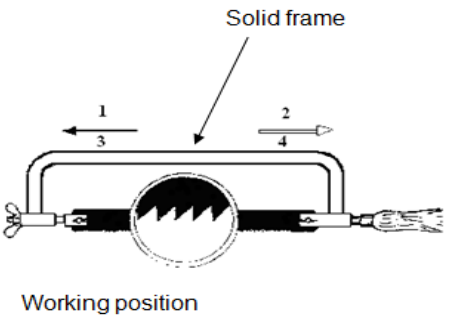


Fig.3.5. Non- adjustable frame (fixed frame)

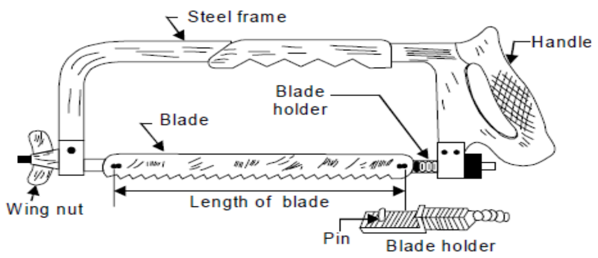
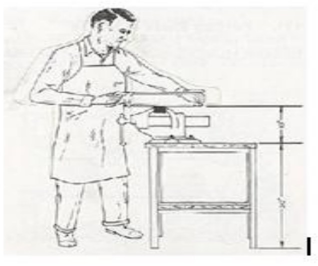


Fig.3.6. Aadjustable frame

The work piece must be clamped to allow free movement when sawing. Left-handed people clamp their work to the right of the vice and right-hander people to the left.



Working Position

Body position when sawing.

Fig.3.7. Working position

Saw teeth for different materials

No of teeth /inch	Functions
14	For solid sections of soft materials

18	Suitable for general use. Solid sections of soft materials and large sections of hard materials (e.g. alloy steel)
24	Small solid sections, between 3 and 6 mm(e.g. heavy tubing and sheets)
32	For sections less than 3 mm thick

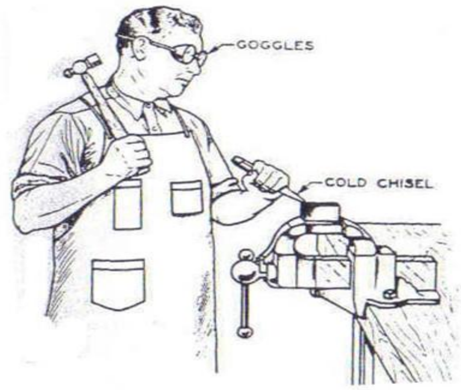
Note: At least three consecutive teeth should be in contact with the material. If the material is soft and has a large section, use a blade with few teeth per 25 mm (14 or 18 teeth per 25 mm) Use a fine-tooth blade when cutting a fairly thin section.

Hacksaw blades are made of high-speed steel.

There are two types: all-hard and flexible. The difference between the two is that the all-hard snaps easily, and it is therefore not recommended for school work. The blades come in the following lengths: 200, 250 and 300 mm. They are also available with 14, 18, 24 and 32 teeth per 25 mm for cutting different materials

3.2. Chipping

Removing the metal with a chisel is called chipping and is normally used where machining is not possible. While chipping, safety goggles must be put on to protect eyes from the flying chips. To ensure safety of others, a chip guard is placed in position. Care should be taken to see that the chisel is free from mushroom head.



Proper body position when chiseling and holding the hammer

Fig.3.8. Proper body position when chipping

- **Chisels**
  - ✓ **Types of chisls:**

These are sometimes referred to as cold chisels because they are used to cut cold metals. They are made of cast steel or alloy steel, with a hardened and tempered cutting edge.

The common types of chisel (Figure 3.8) include:

1. **The flat chisel**: used for general-purpose chiseling;

2. **The cross-cut chisel**: used for cutting grooves such as keyways, and for chipping;

3. **The half-round-nosed chisel**: used for cutting grooves (which are either curved or half-round);

4. **The diamond-pointed chisel**: used for working into corners and cutting small grooves.

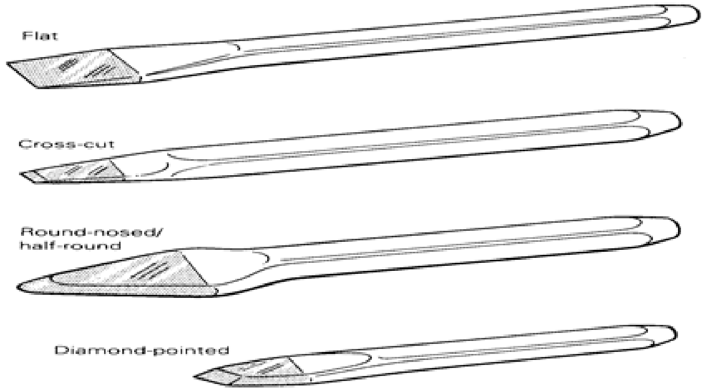


Fig.3.8. Common types of chisel

3.3. Filing

Filing is a method of removing metal, and the file (Figure 3.9), which is the most widely used hand tool in the school workshop, is used for this cutting operation. It is made of carbon tool steel containing about 1.3 per cent carbon.

- The Main Parts

A file is a hand cutting tool made of high-carbon steel, having a series of teeth cut on the body by parallel chisel cuts. The parts of a file are shown in figure. 3.9. Files are used to remove surplus metal and to produce finished surfaces.

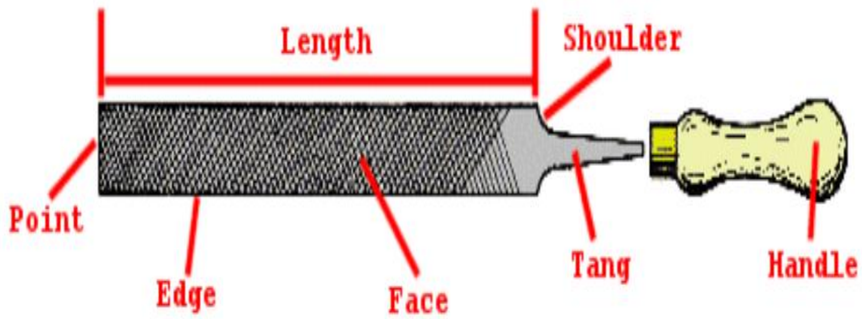


Fig.3.9. Flat file and its parts.

- **Methods of filing:**

There are several methods of filing, each with a specific purpose. With reference to the figure, the following may be noted:

1. **Holding the file:** For heavy work and to remove more metal, a high pressure is used. For light and fine work, a light pressure is applied.
2. **Filing internal curves:** A part of half round file only makes contact as shown during filing operation. Movement of the file is indicated by arrows.

3. **Cross filing:** It is the most common method of filing. Cross filing is carried out across two diagonals, to produce medium surface finish. It is used when large an amount of metal is to be removed. By cross filing 'rounding' the surface is reduced.
4. **Straight filing:** When a short length of work piece is required to have a flat surface, straight filing is used. File marks made during cross filing may be removed, to produce a relatively smooth surface.
5. **Draw filing:** It is done to get a finely finished surface. It produces a smoother surface finish than straight filing. A smooth or dead smooth flat file is used for this.

Use the single cut on softer materials (such as brass and aluminum) and the double cut for general filing, especially on iron and steel.

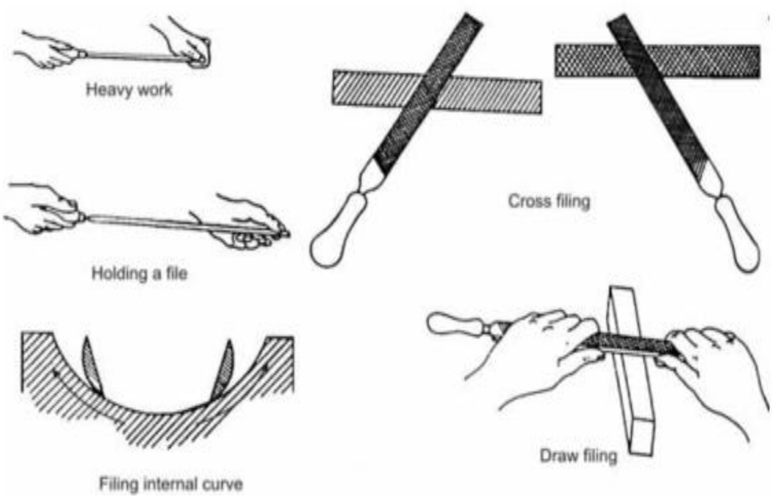


Fig.3.10. Methods of filing

The coarseness of file cuts is described by the terms listed in Table 4.1.

Table 4.1 Grades of file cut

Cut	Typical use
Rough	Filing soft metals, plastics
Bastard	Shaping steel and fettling iron castings
Second cut	Generally used for harder metals and for good finish
Smooth cut	Draw filing and finishing hard metals
Dead smooth	Accurate filing with a high finish

- **Types of file based on their shapes:**

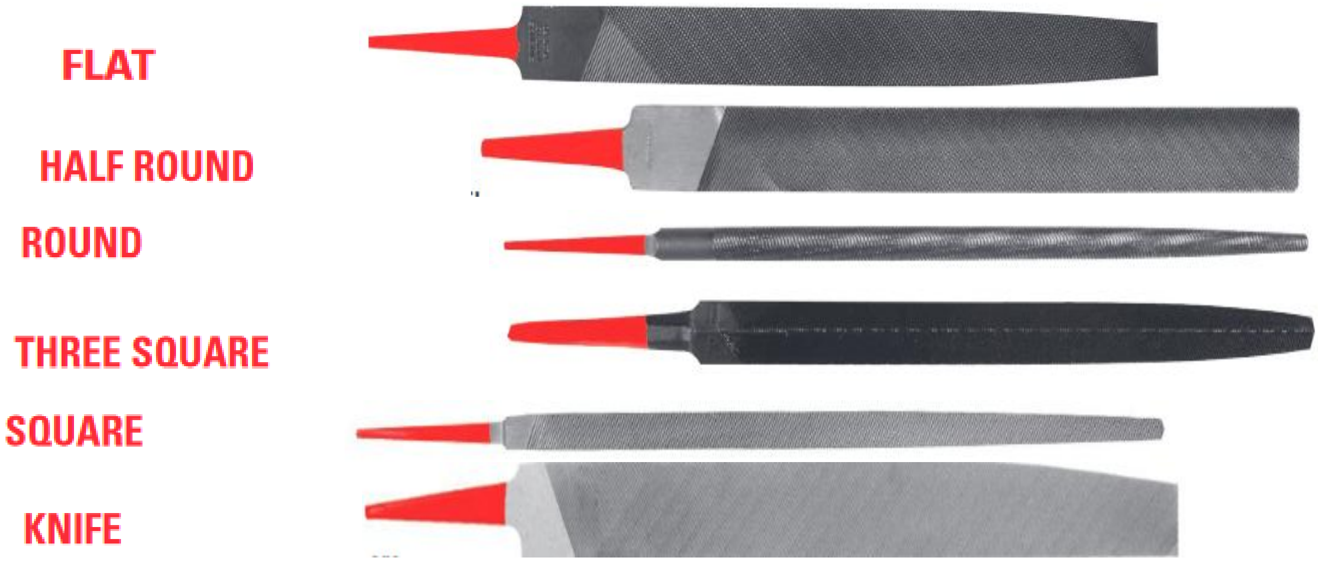


Fig.3.11. Types of file based on shapes.

http://www.simondssaw.com/handfiles/hand%20files%20publications/simonds-file%20catalog.pdf

3.4. Scraping

Scraping is the process of removing high spots on the surface of a piece of work. It is a difficult operation, and is not often performed in the school workshop.

- **Types of scrappers:**

These sharp edged tools are used to remove uneven spots on the surfaces. They are of different shapes.

3.4.1. **Flat scraper**

It is used for removing metal from flat surfaces. The blade must have a slight curvature at the cutting edge. The corners are rounded to help the user, scrape at the exact spots.

3.4.2. Half round bearing scraper

This is used for scraping curved and cylindrical surface split bearings, big bush bearings etc.

3.4.2. Triangular scraper

This is used for scraping curved surfaces, holes and bores. Specification is by length. Example: 200 mm, 300 mm etc.

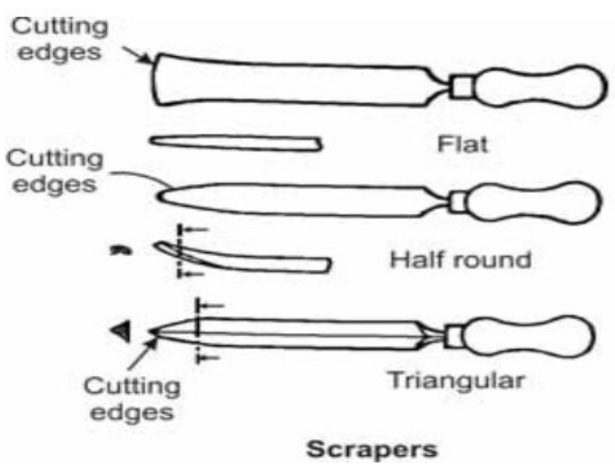


Fig.3.12. Common types of scraper

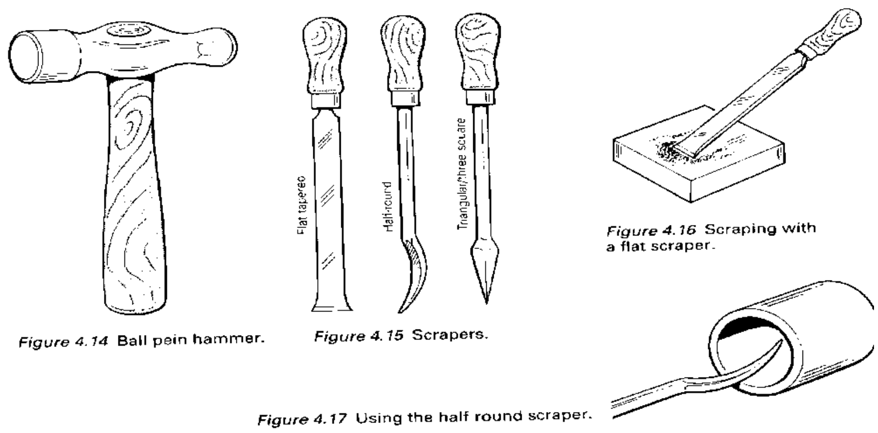


Fig.3.13. Using half round scraper

Self-Check -3	Written Test

Directions: choose the best answer for the following question (**2 point each**):

1. Removing the metal with a chisel is called________
   a. Scrapping
   b. Filling
   c. Chipping
   d. All
2. Some of the most common tools used to cut metals are_______
   a. hacksaws
   b. tin snips
   c. cold chisels,
   d. all
3. ______a file is used when large an amount of metal is to be removed.

a. Cross filing
b. Straight filing
c. Draw filing
d. All

4. _____ is used to mark the center of a hole and make an indentation for a twist drill.
   a. Scriber
   b. Center punch
   c. Trammel point
   d. None
5. _____is used for scraping curved and cylindrical surface split bearings, big bush etc.
   a. Flat scraper
   b. Half round bearing scraper
   c. Triangular scraper
   d. All

***Note:* Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Score = ___________
Rating: ____________

Name: _________________________ Date: _______________

Information Sheet-4	Cutting Threads

4.1. Cut threads using tap and stock and die

Introduction

Threads may be cut internally using a tap externally using a die. The proper selection and use of these threading tools is an important phase of machine shop work.

- **Dies**

Dies are made either of high-carbon steel or of high-speed steel. Unlike taps, dies are used for cutting external (male) threads. There are three types (Figure blow). The circular split die is a circular piece with a split across one of the flutes. The split is provided to enable small adjustments to be made, using three set screws in the stock. The half die comprises two loose pieces, which are held in the stock. There is a small screw on the stock for adjustment.

The die nut has a hexagonal body. This type, strictly speaking, does not cut new threads but is used to 'clean up' threads that are damaged.

- **Taps and dies**

Screwing is a temporary method of fastening parts together. Methods for cutting screw threads include the use of the centre lathe. For bench work, however, taps and dies are used.

✓ **Taps**

These are the tools used for cutting internal (female) threads. They are made of high-carbon steel or high-speed steel. The tap has a shank with a square end to take the tap wrench or holder. The shank is smaller than the threaded portion. The tap has four rows of threads, cutting edges or teeth, which suit a particular thread form. They perform the cutting action. The grooves between the cutting edges are called flutes. They allow waste material (chippings) to escape. They also allow cutting oil into the work.

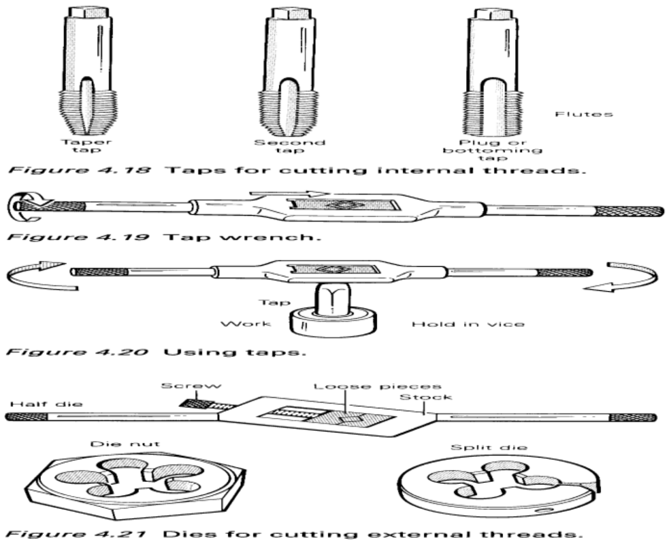


Fig.4.1. Taps and dies

The procedure for cutting external threads is as follows:

1. Square the end of the work and chamfer it (using a file, grinding machine or centre lathe) for an easy start.
2. Grip the die, held in the stock, firmly and squarely on the work.
3. Turn clockwise, about a quarter-turn, and ease back to remove chippings.
4. Apply a good supply of oil (lubricant).
5. Make adjustments of the screws after making a full cut until the depth required is achieved.

Care and maintenance is important:

1. Do not use either the stock or the die as a hammer; the threads may be broken.
2. Remove the die from the stock after every thread cutting, clean them and pack them into their boxes.

3. Use plenty of oil during cutting to reduce friction.

Tap Drill Size

Before a tap is used, the hole must be drilled to the correct tap drill size. This is the drill size that would leave the proper amount of material in the hole for a tap to cut a thread. When a chart is not available, the tap drill size for the ISO (International Standards Organization) thread can be found easily by applying this simple formula:

$$TDS = M - P$$

TDS = tap drill size

M = metric diameter of the tap

P = pitch of the thread in millimeters

Hand Tap

A tap is a cutting tool used to cut internal threads. Normally it's made of high-speed steel (HSS). Hand taps are usually made in sets of three, because it is better to distribute all the cutting work during the thread−process to three taps.

No. 1 (taper) tap: 1 ring on shank

No. 2 (plug) tap: 2 rings on shank

No. 3 (bottoming) tap: without ring

The most common taps have two or three flutes in order to form the cutting edges, transport the chips out of the hole and give way for the lubricant. The end of the tap is square so that a tap wrench can be used to turn it into a hole.

Tapping a Hole

Before a tap is used, a hole must be **drilled** in the work piece to the correct tap drill size. The tap drill size (T.D.S.) is the size of the drill that should be used to leave the proper amount of material in the hole for a tap to cut threads. Then **countersink** both sides of the hole.

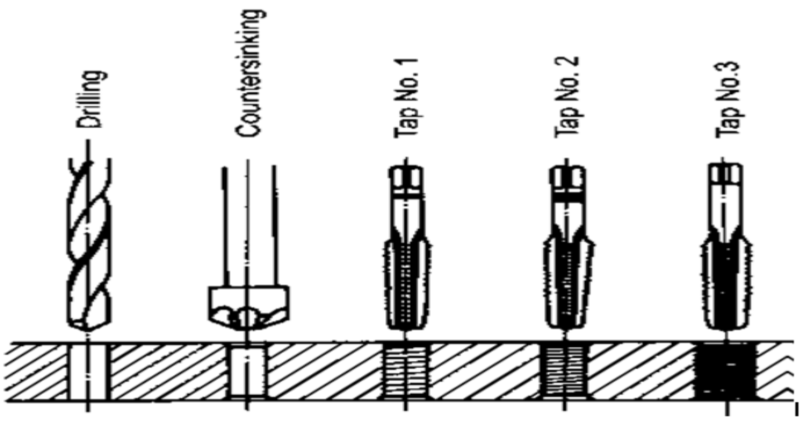


Fig.4.2. Drill, Countersink and tapping a hole

Working Steps for Hand Tapping

1. Select the correct size and type of tap for the job (blind hole or through hole).
2. Select the correct tap wrench for the size being used.

3. Use a suitable cutting fluid (No cutting fluid for brass or cast iron).
4. Place the tap in the hole as near to **vertical** as possible.
5. Apply equal down pressure on both handles, and turn the tap clockwise (for right-hand thread) for about two turns.
6. Remove the tap wrench and check the tap for squareness. Check at two positions 90 degree to each other.
7. If the tap has not entered squarely, remove it from the hole and restart it by applying slight pressure in the direction from which the tap leans. Be careful not to exert too much pressure in the straightening process, otherwise the tap may be broken.
8. Turn the tap clockwise one−half turn and then turn it backward about one−quarter of a turn to break the chip. This must be done with a steady motion to avoid breaking the tap.

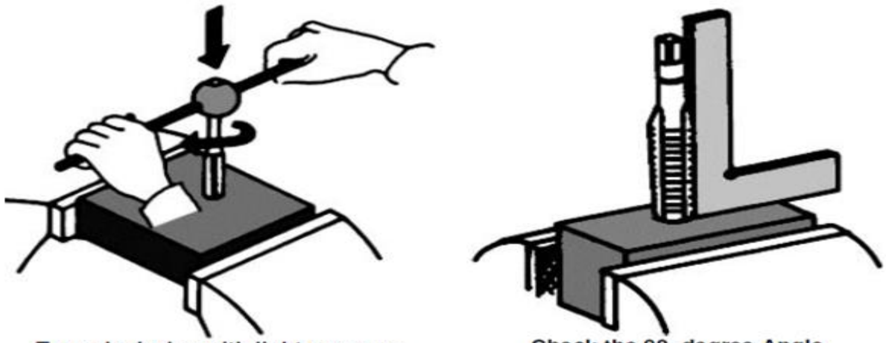


Fig.4.3. Tapping operation

Table1.1.Drill size

Metric	Pitch mm	Drill Ø mm		UNC	TPI	Drill Ø mm		UNF	TPI	Drill Ø mm
M 3	0.50	2.5		1/4"	20	5.1		1/4"	28	5.5
M 4	0.70	3.3		5/16"	18	6.6		5/16"	24	6.9
M 5	0.80	4.2		3/8"	16	8.0		3/8"	24	8.5
M 6	1.00	5.0		7/16"	14	9.4		7/16"	20	9.9
M 8	1.25	6.8		1/2"	13	10.8		1/2"	20	11.5
M 10	1.50	8.5		9/16"	12	12.2		9/16"	18	12.9
M 12	1.75	10.2		5/8"	11	13.5		5/8"	18	14.5
M 16	2.00	14.0		3/4"	10	16.5		3/4"	16	17.5
M 20	2.50	17.5		7/8"	9	19.5		7/8"	14	20.4
M 24	3.00	21.0		1"	8	22.25		1"	12	23.25

Threading Dies

A threading die is used to cut external threads on round work pieces. The most common threading dies are the adjustable and solid types. The round adjustable die is split on one side and can be adjusted to cut slightly over or undersized threads. It is mounted in a die stock, which has two handles for turning the dies onto the work. The solid die, cannot be adjusted and generally used for recutting damaged or oversized threads. Solid dies are turned onto the thread with a **special** diestock, or adjustable wrench.

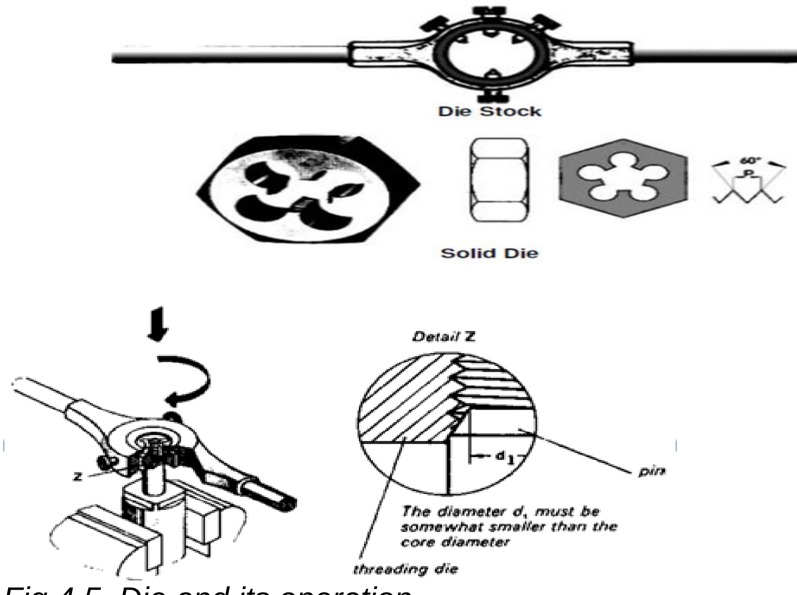


Fig.4.5. Die and its operation

Thread with a Hand Die Working Steps

The threading process requires the machinist to work carefully to produce usable parts and avoid damage. The following describes the procedure to be used.

1. Chamfer the end of the work piece with a file or on the grinder. Consider that a 3/4" thread requires a bolt with an outside diameter of 3/4".
2. Fasten the work piece securely in a vise. Hold small diameter work short to prevent it from bending.
3. Select the proper die and die stock.
4. Lubricate the tapered end of the die with a suitable cutting lubricant.
5. Place the tapered end of the die squarely on the work piece.
6. Apply down pressure on both die stock handles and turn clockwise several turns.
7. Check the die to see if it has started squarely with the work.
8. If it is not square, remove the die from the work piece and restart it squarely, applying slight pressure while the die is being turned.
9. Turn the die forward one turn, and then reverse it approximately one half of a turn to break the chip.
10. Apply cutting fluid frequently during the threading process.

Metric Threads

These threads are identified by the letter „M", the nominal diameter, and the pitch. For example, a metric thread with an outside diameter of 5mm and a pitch of 0.8mm would be identified as follows: M5x0.80

Table1.2. Pitch of metric thread

nom. dia.	pitch	nom. dia.	pitch
M3	0.50	M9	1.50
M4	0.70	M10	1.75
M5	0.80	M11	2.00
M6	1.00	M12	2.50
M8	1.25	M13	3.00

Self-Check -4	Written Test

Directions: Answer the following questions. **(2 points)**

1. Which one of the following is used for cutting external threads?

   a. Tap   b. drill bit   c. Die   d. saw

2. Write procedures for cutting external threads. **(4 points)**

Note: Satisfactory rating – 3 points   **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________   Date: _______________

Information Sheet-5	Performing bench work operations

5. Concepts of bench work operations

5.1. Bench work operations

Bench work operations for the manual mill often occur before and after the machining of the part. These operations are commonly performed on a standard workbench with the part secured in a **vise**, or secured to the worktable depending on the operation. Bench work operations involve processes that allow the work piece to achieve the accuracies specified by the blueprint. These operations require operator skill and attention to detail.

- ✓ Follow safety and correct working procedures to perform bench work operations.

Bench work operations performed prior to machining include the following:

- Layout
- Cutting: in the metal work shop materials (especially metals) are cut to shape before filing. There are numerous types of cutting operations.
  - ✓ Points to watch when using the hack saw:
    1. Hold the work securely in the vice.
    2. Grip the hack saw firmly, using both hands.
    3. Use the same stance as filing.
    4. Use the full length of the blade.

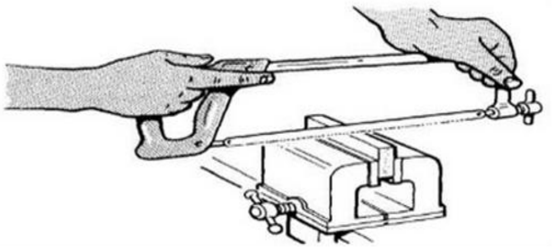


Fig.5.1. *Sawing operation*

- Chipping:
  - ✓ chipping metal (chiseling)

Chiseling is one of the methods of cutting materials.

-you can chip the metal to produce grooves or to reduce the width or thickness.

Procedures to chip metal:

1. hold the metal in the vice
2. Hold the chisel at an angle of about 45^0 to the work.
3. Hammer to remove the chip.

- Filing: is a method of removing metal.
- Filing: is a skill that is difficult to learn. It is not easy to explain how to use afile.

https://www.google.com/search?q=perform+bench+work+operations+ppt&tbm=isch&source=iu&ictx=1&fir=VtGeDnQPXpvjSM%253A%252CEwta3Cj6TxlvPM%252C_&vet=1&usg=AI4_-kQu0DC7ui6liCHNNe5LtaJwGUdumw&sa=X&ved=2ahUKEwixyKXSm4LlAhWMJFAKHWwEBN4Q9QEwDXoECAUQBg#imgrc=VtGeDnQPXpvjSM:&vet=1

https://www.slideshare.net/Lemmalove/performing-bench-work-ppt

Self-Check -5	**Written Test**

Directions: Answer all the questions listed below:

1. ______is the operation of marking lines, circles and arcs on metal surfaces. (**2 points**)
   A. Drilling
   B. Laying out
   C. cutting
   D. Boring
2. List the Methods of filing. (**6 points**)
3. List the points to watch when using the hack saw: (**4 points**)

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 10 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Operation Sheet 1	Cut the work piece to produce a drill and file to make a T-fitting

1. **To cut the work piece to produce a drill:**

Procedures:

1. Wear the safety clothes required.
2. Measure the stock to the required dimension.
3. Mount the work piece firmly on the vice.
4. Choose the correct blade according to the type of material and thickness being cut.
5. Install the hacksaw blade.
6. Use the blade check list to ensure proper installation.
7. Use the hacksaw to cut the work piece. Use the marked sawing lines to guide the cutting process.

2. **To make a T-fitting from the given two M.S pieces.:**

Procedures:

1. Filing
2. Checking flatness and square ness
3. Marking and measuring
4. Punching
5. Sawing
6. Chipping
7. Finishing

Operation Sheet 2	Perform tapping and threading.

3. **To perform the required tapping and threading:**

Procedures:

1. Select the correct taps and tap wrench
2. Apply suitable cutting fluid to the tap
3. Place tap in hole as vertically as possible
4. Press downward on wrench, applying equal pressure on both handles
5. If tap is not entered squarely, remove from hole and restart it by applying pressure in direction from which tap leans
6. Turn tap clockwise one-quarter turn, and turn it backward about ½ turn to break the

chip (must turn with steady motion)

7. Care must be taken not to tap too deep for a blind hole
8. When finished, clean hole and check with thread gage or appropriate bolt

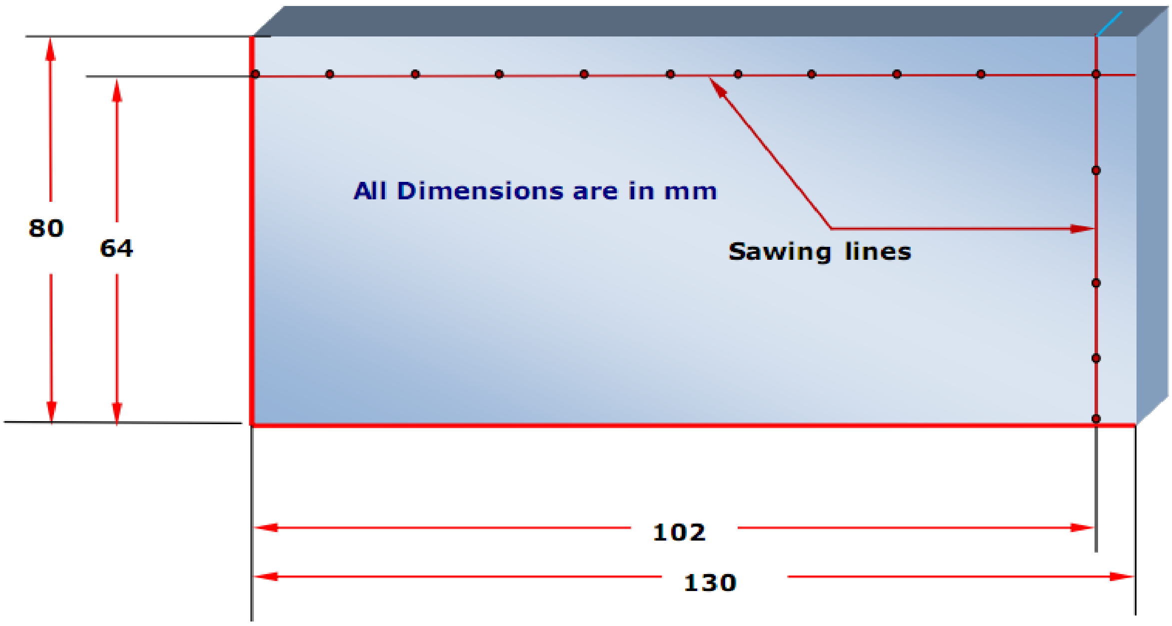
LAP Test	Practical Demonstration

Name: ______________________________ Date: ________________

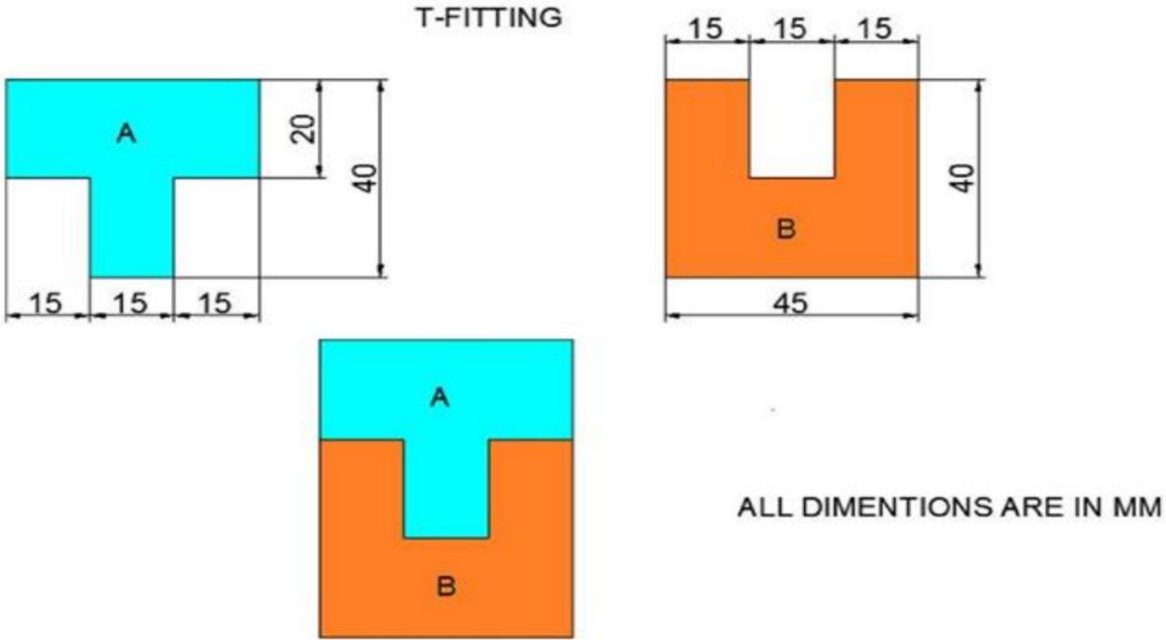
Time started: _________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within **2-5** hours.

Task 1: Cut the work piece to produce a drill gauge according to the dimensions given.

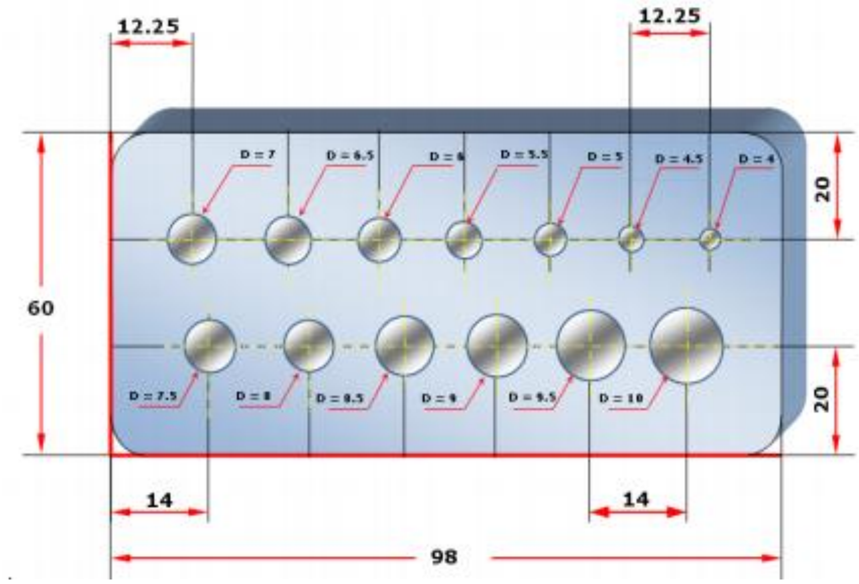


Task 2: To make a T-fitting from the given two M.S pieces.



SQUARE (T) – FITTING

Task 3: Perform the required tapping and threading.



The drill gauge project

*All dimensions are in mm

List of Reference Materials

1. Workshop Technology Parts 1, 2 and 3, Author : WAJ Chapman Publisher : London: Edward Arnold, 1972
2. Types of file based on their shapes: Thttp://www.simondssaw.com/handfiles/hand%20files%20publications/simonds-file%20catalog.pdf
3. Bench work operations: https://www.slideshare.net/Lemmalove/performing-bench-work-ppt
4. Chipping metal (chiseling): https://www.google.com/search?q=perform+bench+work+operations+ppt&tbm=isch&source=iu&ictx=1&fir=VtGeDnQPXpvjSM%253A%252CEwta3Cj6TxIvPM%252C_&vet=1&usg=AI4_-kQu0DC7ui6IiCHNNe5LtaJwGUdumw&sa=X&ved=2ahUKEwixyKXSm4LlAhWMJFAKHWwEBN4Q9QEwDXoECAUQBg#imgrc=VtGeDnQPXpvjSM:&vet=1

Basic Metal Works

Level-I

Learning Guide-34

Unit of Competence: Perform Bench Work

Module Title: Performing Bench Work

LG Code: IND BMW1 M10 LO3-LG-34

TTLM Code: IND BMW1 M10 TTLM 1019v1

LO3: Perform basic drill, ream and hone operations.

Instruction Sheet	Learning Guide # 3

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Drilling, boring, reaming and honing Bore holes
- Performing all operations

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Drill, ream and hone bore holes to drawing specification and according to guidance.
- Perform all operations applying safety procedures and using personal protective devices.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information "Sheet 1and Sheet".
4. Accomplish the "Self-check 1and Self-check t 2" **in page -77, and 80,** respectively.
5. If you earned a satisfactory evaluation from the "Self-check" proceed to "Operation Sheet 1" **in page -81.**

6. Do the "LAP test" **in page – 82** (if you are ready).

Information Sheet-1	**Drilling, boring, reaming and honing holes.**

1. Introduction to drilling

Drilling: is a process of producing round holes in a solid material or enlarging existing holes with the use of multi tooth cutting tools called drills or drill bits. In other words it is the process of making holes of cylindrical shape on metals and other materials using drill bits and drilling machines.

Drilling machine: are driven either manual or by electrical power.

1.1. Classification of drilling machines

Drilling machines: are classified into hand and breast drill, portable electrical drill, bench drill, pillar dills and others.

1. **The hand and breast drill:** are driven by hand and are commonly used where electricity is unavailable and are used for light work
2. **Portable electrical drill:** are most suitable to work which cannot be done with bench drill.
3. **Bench drill:** is one of the most common used machines in the work shop. This machine has the following parts. The base, the column, the head, the spindle, the pulleys, the motor, the belt, the safety swatch, the feed handle, the depth gauge, the head locking handle, the gear lever, the collar, the chuck and the main switch.
4. **Pillar dills:** is similar in design to the bench drill. But it is floor mounted and usually much large.

Various cutting tools are available for drilling, but the most common is the *twist drill*.

- **Standard Operations**

Drilling machines may be used for performing a variety of operations besides drilling a round hole. A few of the more standard operations, cutting tools and work set-ups will be briefly discussed.

A. Drilling – may be defined as the operation of producing a hole by removing a metal from a solid mass using a cutting tool called a twist drill.

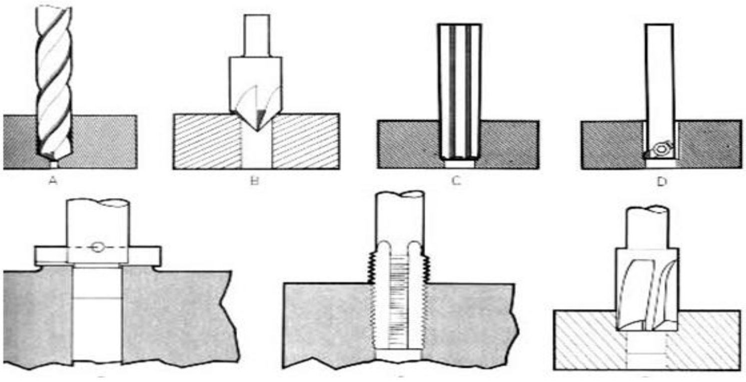


Fig1.1. Variety of operations of drilling machine.

B. Countersinking – is the operation of producing a tapered or cone shaped enlargement to the end of the hole.

C. Reaming – is the operation of sizing and producing a smooth round hole from a previously drilled or bored hole with the use of a cutting tool having several cutting edges.

D. Boring – is the operation of enlarging and truing a hole by means of a single-point cutting tool which is usually held in a boring bar.

E. Spot-facing – is the operation of smoothing and squaring the surface around a hole to provide a seat for the head of a cap screw or a nut. For the spot facing operation, the work being machined should be securely clamped and the machine set approximately ¼ of the drilling speed.

Spot facing is a process of machining a flat surface around the mouth of a hole in order to provide a flat seat for the head of a bolt or a nut.

F. Tapping – is the operation of cutting internal threads in a hole with a cutting tool called a tap. Special machine or gun taps are used with a tapping attachment when this operation is performed by power in a machine.

G. Counter boring – is the operation of enlarging the top of a previously drilled hole to a given depth to provide a square shoulder for the head of a bolt or a cap screw. Counter boring is used to form a flat, recessed seating for a cheese head bolt or cap screw.

Sensitive Drill Presses

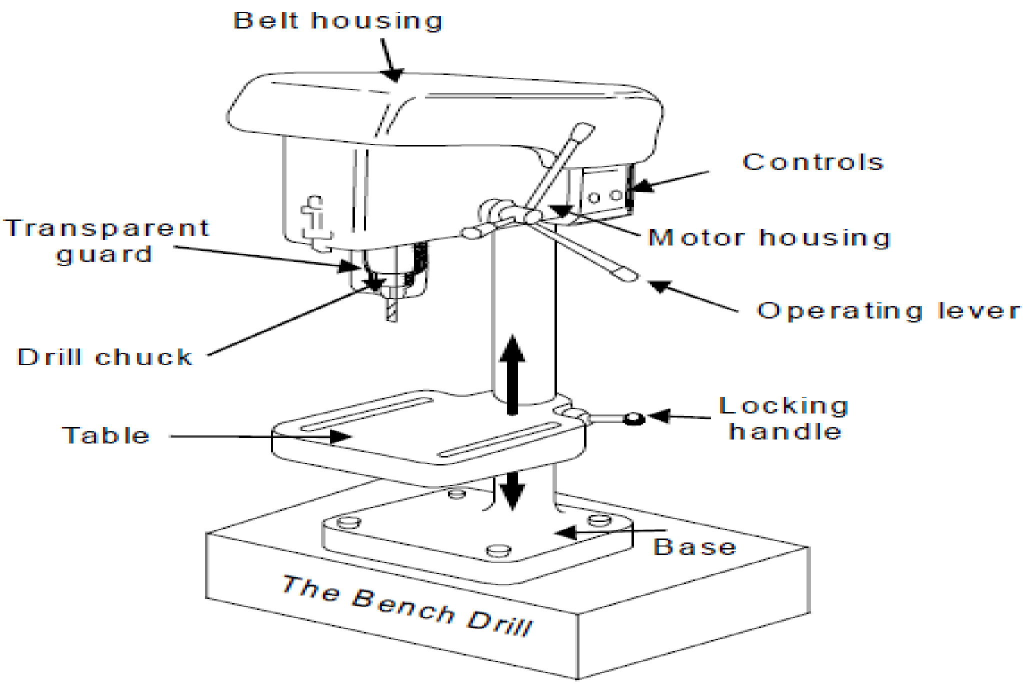


Fig1.2. Parts of drill Presses.

1.2. Drill Bits

Introduction

Twist drills are end-cutting tools used to produce holes in most types of material. On standard drills, two helical grooves, or flutes, are cut lengthwise around the body of the drill. They provide cutting edges and space for the cuttings to escape in the drilling process. Since drills are one of the most efficient tools, it is necessary to know the main parts, how to sharpen the cutting edges, and the correct speeds and feeds for drilling various metals in order to use them most efficiently and prolong their life.

1.2.1 Parts of Twist drills

Shank

Most twist drills used in machine shop work today are made of high-speed steel. High-speed drills have replaced carbon-steel drills since they can be operated at double the cutting speed and the cutting edge lasts longer. A drill may be divided into three main parts: the shank, the body and the point.

- Generally drills up to 13mm in diameter have straight drill shanks, while those over this diameter usually have tapered shanks. Straight-shank drills (fig. 08/02) are held in a drill chuck; tapered-shank drills (fig. 08/01) fit into the internal taper of the drill press spindle.

➢ A tang (fig. 08/01) is provided on the end of tapered-shank drills to prevent the drill from slipping while it is cutting and to allow the drill to be removed from the spindle or socket without the shank being damaged by using a drill drift.

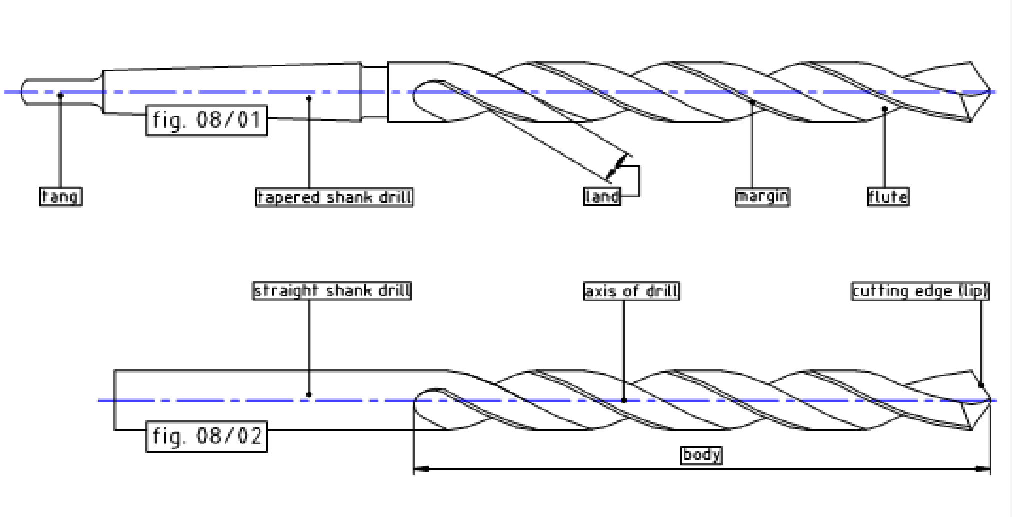


Fig1.3. Twist drills bit.

Body

The body is the portion of the drill between the shank and the point. It consists of a number of parts important to the efficiency of the cutting action.

The flutes are two or more helical grooves cut around the body the body of the drill. They form the cutting edges, admit cutting fluid, and allow the chips to escape from the hole.

➢ The margin is the narrow, raised section on the body of the drill. It is immediately next to the flutes and extends along the entire length of the flutes. Its purpose is to provide a full size to the drill body and cutting edges.

➢ The lip clearance is the undercut portion of the body between the margins and the flutes. It is made smaller to reduce friction between the drill and the hole during the drilling operation.

➢ The web is the thin partition in the center of the drill which extends the full length of the flutes. This part forms the chisel edge at the cutting end of the drill. The web gradually increases in thickness toward the shank to give the drill strength.

➢ Point The point of a twist drill consists of the chisel edge, the lips, the lip clearance angle and the heel.

➢ The chisel edge (web) is the chisel-shaped portion of the drill point.

➢ The lip (cutting edge) a formed by the intersection of the flutes. The lips must be equal length and have the same angle so that the drill will run true and will not cut a hole larger than the size of the drill.

➢ The lip clearance angle is the relief which is ground on the point of the drill extending from the cutting lops back to the heel. The average lip clearance is from 8° to 12°, depending upon the hardness or softness of the material to be drilled.

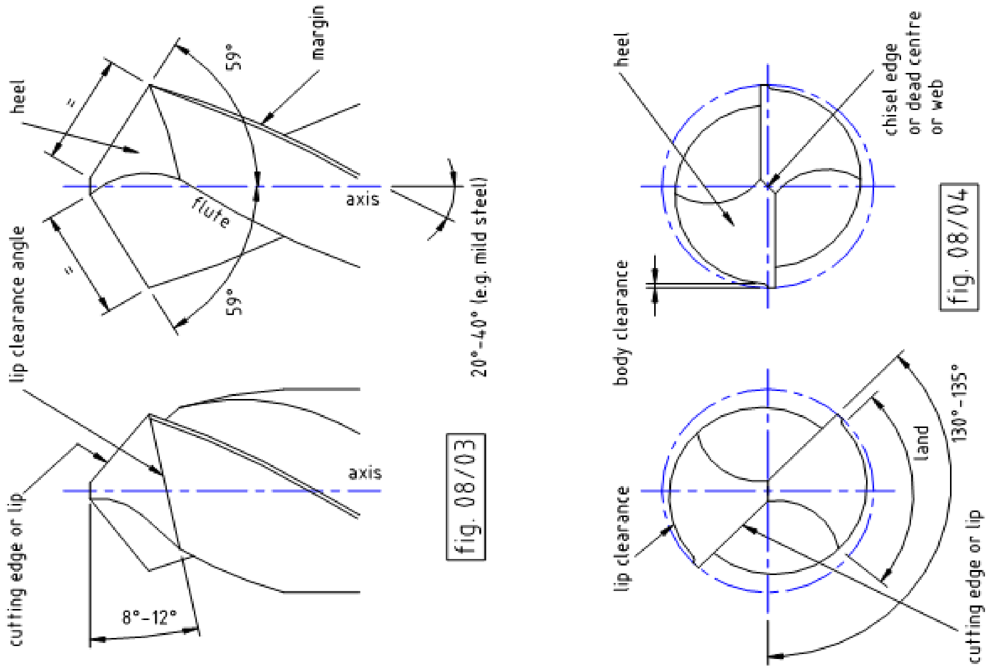


Fig1.4. Body of Twist drills.

1.2.2 Speed

A wide range of drills and drill sizes is used to cut various metals; an equally wide range of speeds is required for the drill to cut efficiently. For every job, there is the problem of choosing the drill speed which will result in the best production rates and the least amount of downtime for regrinding the drill. The recommended cutting speeds for drilling various types of materials may be found in the table shown below. The most economical drilling speed depends upon many variables such as:

- the type and hardness of the material
- the diameter and material of the drill
- the type and condition of the drill press
- the efficiency of the cutting fluid employed

To determine the correct number of r/min (revolution per minute) of a drill press spindle for a given size drill, the following should be known:

✓ the type of material to be drilled
✓ the recommended cutting speed of the material
✓ the type of material from which the drill is made

Table 1.1.Drill size and types of materials.

Drill size	stainless steel	tool steel	cast iron	machine steel	aluminum
2	1910	2865	3820	4775	9550
3	1275	1910	2545	3185	6365
4	955	1430	1910	2385	4775
5	765	1145	1530	1910	3820
6	635	955	1275	1590	3180
7	545	820	1090	1365	2730
8	475	715	955	1195	2390
9	425	635	850	1060	2120
10	350	520	695	870	1735
15	255	380	510	635	1275
20	190	285	380	475	955
25	150	230	305	380	765
	CS = 12	CS = 18	CS = 24	CS = 30	CS = 60

- ✓ CS in m/min   CS x 1000   CS x 320
- ✓ Formula   r/min = --------- ⇒ ------- ⇒ -------------
- ✓ π x D in mm   3.14 x D
- ✓ D For metric calculations, the formula is used:

$$rpm = \frac{CS(m)}{\Pi D(mm)}$$

It is necessary to convert the meters in numerator to millimeters so that both parts of the equation are in the same unit. To accomplish this, multiply the CS in meters per minute by 1000 to bring it to millimeters per minute.

$$rpm = \frac{CS \times 1000}{\Pi D}$$ This can be simplified to $$rpm = \frac{CS \times 320}{D}$$

This is done for the reason that not all machines have variable speed drives and therefore cannot be set to the exact calculated speed. Dividing 1000 by π (3.14) we arrive at the formula above. This formula is accurate enough for most drilling operations.

Example:

Calculate the rpm required to drill a 15mm hole in tool steel using a high speed steel drill.

Solution:

$$rpm = \frac{CS \times 320}{D} = \frac{18 \times 320}{15} = \frac{5760}{15} = 384$$

1.1.1. Feed

Feed is the distance that a drill advances into the work for each revolution.

In other words the feed of a drill is the distance the drill moves into the job at each revolution of the spindle. It is expressed in millimeter. The feed may also be expressed as feed per minute. The feed per minute may be defined as the axial distance moved by the drill into the work per minute. The feed per minute may be calculated as:

$$F = Fr \times N$$

The rate of feed is generally governed by:

- the diameter of the drill
- the material of the work piece
- the condition of the machine

Table1.2. Drill size and feed per revolution.

Drill size	feed per revolution	
1 to 3		0.02 to 0.05
3 to 6		0.05 to 0.10
6 to 13		0.10 o 0.18
13 to 25		0.18 o 0.38

2. Boring holes

2.1 Introduction to Boring

In machining, **boring** is the process of enlarging a hole that has already been drilled (or cast) by means of a single-point cutting tool (or of a **boring** head containing several such tools), such as in **boring** a gun barrel or an engine cylinder

The enlargement of holes is achieved via boring operations. The hole diameter is either enlarged with a single insert attached to a long boring bar, or with a boring head which has a diameter equal to the diameter of the hole to be enlarged. Long boring bars statically and dynamically deform under the cutting forces during boring operations. Excessive static defections may violate the dimensional tolerance of the hole, and vibrations may lead to poor surface, short tool life and chipping of the tool. Predictions of the force, torque and power are required in order to identify suitable machine tool and fixture set up for a boring operation. A comprehensive engineering model, which allows prediction of cutting forces, torque, power, dimensional surface finish and vibration free cutting conditions, is required in order to plan boring operations in the production floor.Boring is performed on the inside diameter of an existing hole.

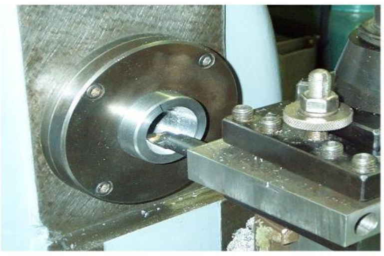


Fig 2.1.Boring operation.

Boring Tools

- Metal boring tools are used in metalwork and in the art. Metal-working applications include drilling holes during car manufacture, precision cutting and roof installation. Some artists, searching for more ways to express themselves, make excellent sculptures and other works using different metals. They produce high-quality using metal-boring machines, including hand drills, drill presses and lathes. Almost all of these tools require external power sources.

3. Reaming holes

3.1 Introduction

Reaming: is similar to drilling operation. It is basically used for finishing of holes and enlarging of small holes. Reaming is carried out by the reamer, which has large number of flutes. Each component in a product must be made to exact standards in order for that product to function properly. Since it is impossible to produce holes which are round, smooth and accurate to size by drilling, the reaming operation is very important. Reamers are used to enlarge, and finish a hole previously formed by drilling or boring. Speed, feed, and reaming allowances are the three main factors which will affect the accuracy and finish of the hole and the life of the reamer.

a. Reamers

A reamer is a rotary cutting tool with several straight or helical cutting edges along its body. It is used to accurately size and smooth a hole which has been previously drilled or bored. Some reamers are operated by hand (hand reamers), while others may be used under power in any type of machine tool (machine reamers).

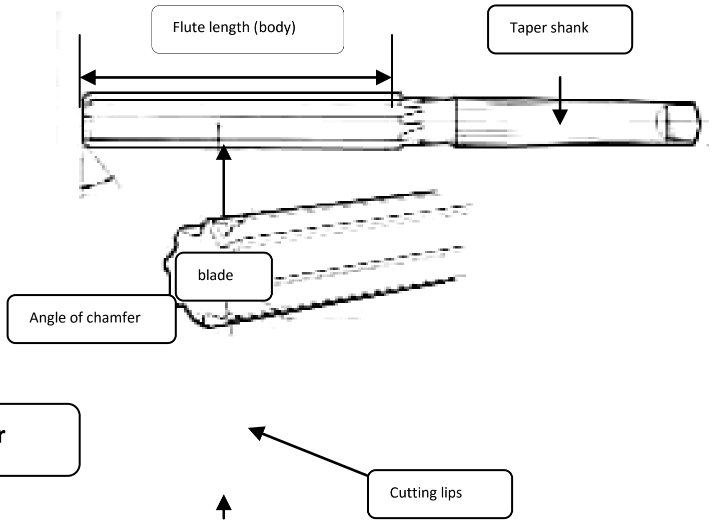
3.3 Parts of the Reamer

Reamers generally consist of three main parts: shank, body and angle of chamfer.

The ***shank***, which may be straight or tapered, is used to drive the reamer. The shank of machine reamers may be straight or tapered, while hand reamers have a square end on the end to accommodate a tap wrench.

The ***body*** of a reamer contains several straight or helical grooves or *flutes*, and *lands* (the portion between the flutes). A *margin* (the top of each tooth) runs from the angle of chamfer to the end of the flute. The *body clearance angle* is the relief or clearance behind the margin which reduces the friction while the reamer is cutting. The *rake angle* is the angle formed by the face of the tooth when a line is drawn from a point on the front marginal edge through the center of the reamer. If there is no angle on the face of the tooth, the reamer is said to have radial land.

The ***angle of chamfer*** is the part of the reamer which actually does the cutting. It is ground on the end of each tooth and there is clearance behind each chamfered cutting edge. On rose reamers, the angle of chamfer is ground ion the end only and the cutting action occurs at this point. On fluted reamers, each tooth is relieved and most of the cutting is done by the reamer teeth.



Parts of the reamer

Fig1.5.Reamer and its parts.

3.4 Types of Reamers

Reamers are available in a variety of design and sizes; however, they fall into two general classifications: ***machine*** and ***hand*** reamers.

- **Hand Reamers**

Hand reamers are finishing tools used when a hole must be finished to a high degree of accuracy and finish. Holes to be hand reamed should be bored to within 0.07 to 0.12mm of the finish size. Never attempt to ream more than 0.12mm with a hand reamer.

A square on the shank end allows a wrench to be used for turning the reamer into the hole. The teeth on the end of the reamer are tapered slightly for a distance equal to the reamer diameter so that it can enter the hole to be reamed.

A hand reamer should never be used under mechanical power and should never be turned backwards. When using a hand reamer, keep it true and straight with the hole. The dead center in a lathe or a stub center in a drill press will help keep the reamer aligned during the hand reamer operation.

Straight and helical fluted hand reamers

Fig1.6. Hand reamers

Reaming cannot correct a badly positioned hole; it can only smooth it.

Points to remember in hand reaming include the following:-

1. Drill the hole to be reamed with care.
2. Hold the work securely in the vice.
3. Use a good supply of cutting lubricant to help remove chips and reduce friction to obtain a smooth finish.

4. Honing holes

- **Purpose of Honing**

Honing is the abrading process done mostly for finishing round holed Produced by drilling, reaming or boringly means of bonded abrasive stones Called ‘hones’. Honing is a machining process and is used to remove metal up to 0.25 mm. The surface roughness value can be maintained between 0.025and 0.4 microns. So honing is used to correct some out of roundness, tapers, tool marks and axial distortion.

Honing is a finishing process performed by a honing tool, which contains a set of three to a dozen and more bonded abrasive sticks. The sticks are equally spaced about the periphery of the honing tool. They are held against the work surface with controlled light pressure, usually exercised by small springs. The honing tool is given a complex rotational and oscillatory axial motion, which combine to produce a crosshatched lay pattern of very low surface roughness:

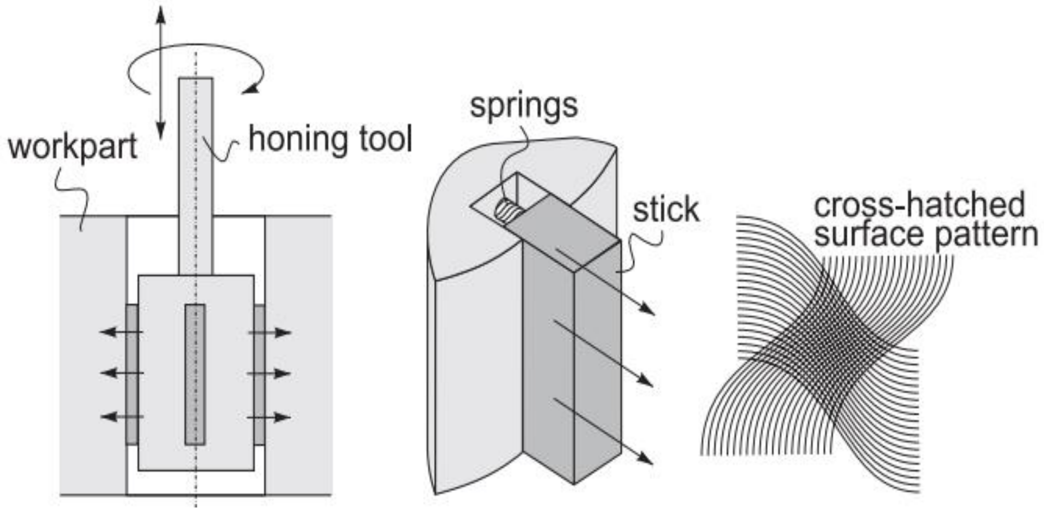


Fig1.6. Honing operation

Schematics of honing process showing the honing tool, how the abrasive sticks are pressed against the work surface by springs, and the resulting surface pattern.

In addition to the surface finish of about 0.1 µm, honing produces a characteristic crosshatched surface that tends to retain lubrication during operation of the component, thus contributing to its function and service life. A cutting fluid must be used in honing to cool and lubricate the tool and to help remove the chips. A common application of honing is to finish the holes. Typical examples include bores of internal combustion engines, bearings, hydraulic cylinders, and gun barrels.

5. **Lapping**

In lapping, instead of a bonded abrasive tool, oil-based fluid suspension of very small free abrasive grains (aluminum oxide and silicon carbide, with typical grit sizes between 300 and 600) called a lapping compound is applied between the work piece and the lapping tool. The lapping tool is called a lap, which is made of soft materials like copper, lead or wood. The lap has the reverse of the desired shape of the work part. To accomplish the process, the lap is pressed against the work and moved back and forth over the surface in a figure-eight or other motion pattern, subjecting all portions of the surface to the same action. Lapping is sometimes performed by hand, but lapping machines accomplish the process with greater consistency and efficiency.

The cutting mechanism in lapping is that the abrasives become embedded in the lap surface, and the cutting action is very similar to grinding, but a concurrent cutting action of the free abrasive particles in the fluid cannot be excluded. Lapping is used lo produce optical lenses, metallic bearing surfaces, gages, and other parts requiring very good finishes and extreme accuracy.

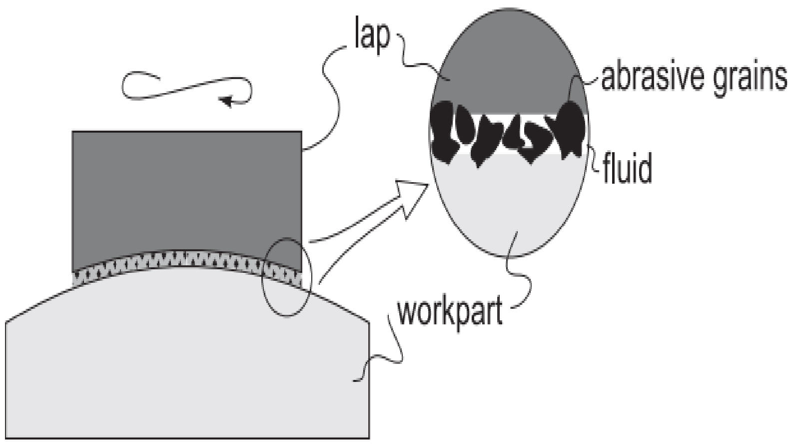


Fig 1.7. Schematics of lapping process showing the lap and the cutting action of suspended abrasive particles.

Self-Check -1	**Multiple choices**

Directions: choose the best answer for the following questions (2 points each)

1. _____is the process of producing round hole in a solid material or enlarging existing holes.
   a. Reaming b. Drilling c. Honing d. Filling
2. Which one of the following is a finishing process of drilled holes?

a. Honing b. filling c. Sawing d. Drilling

3. ____is the process of enlarging a hole that has already been drilled.

   a. Drilling b. Honing c. Boring d. None

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet-2	Perform drilling, reaming and honing operations

1.1. Perform basic drilling, reaming and honing operations applying safety procedures and using personal protective devices.

When performing drilling, reaming and honing operation safety precaution and personal protective equipment (PPE) is necessary to protect ourselves, machines,tools and equipment. Following the right safety procedures and personal protective device perform the operations listed below:

- **Drilling**

✓ Drilling operations

To practice drilling, counter boring, counter sinking, reaming.

PROCEDURE

- ✓ Prior to drilling a hole, locate the hole position and put a punch mark to aid the drill in starting the hole.
- ✓ Select the proper drill bit according to the size need.
- ✓ Select cutting fluid.
- ✓ Select the correct rpm.
- ✓ Use an interrupted feed, called peck drilling, to break up the chips being produced.
- ✓ Counter sinking and counter boring operations are performed with the same procedure by changing the tools.
- ✓ Select the reamer.
- ✓ Drill a pilot hole that is a bit smaller to a reamer.
- ✓ Drive the reamer at a slow, constant speed. The cutting speed for reaming should be 1/3 of drilling.

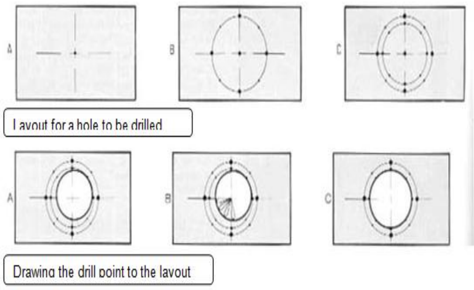


Fig1.1. Layout for a hole to be drilled.

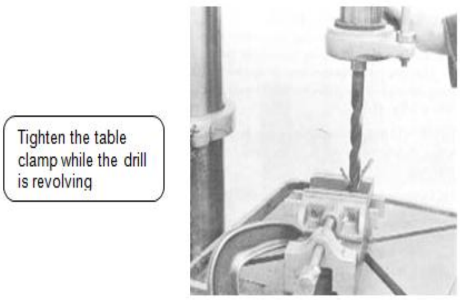


Fig1.2. Tighten the table clamp.

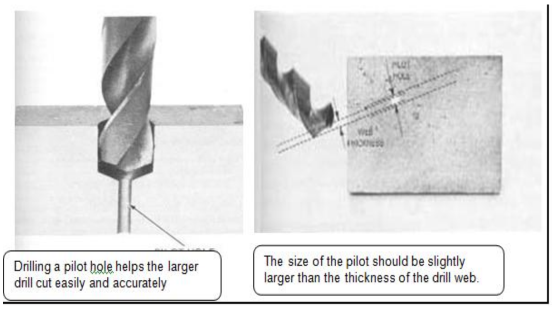


Fig1.3. Drilling a pilot hole.

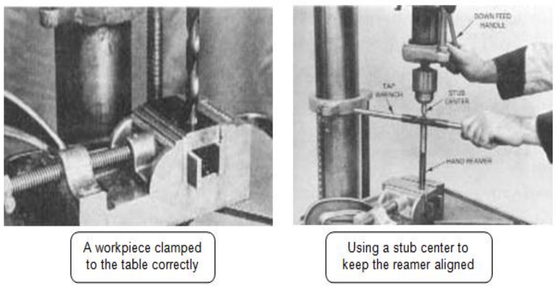


Fig1.4.Clamping a work piece to the table and drilling.

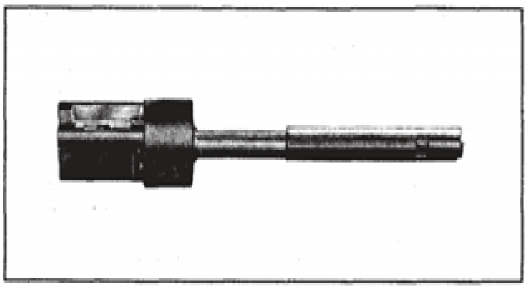


Fig1.5. Single- stone Honing Tool.

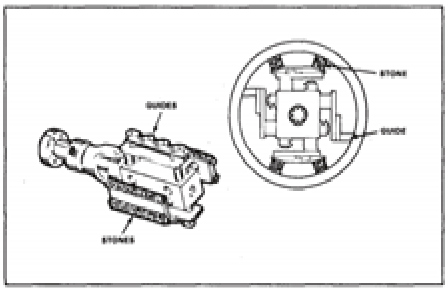


Fig1.7.Multiple –point Honing Tool.

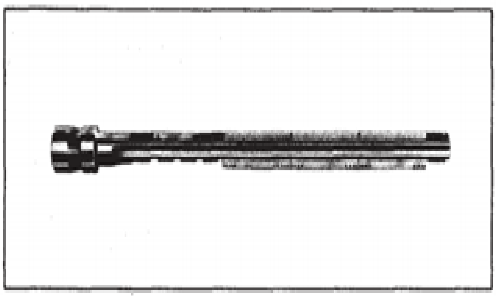


Fig1.6. Multiple-Stone Honing Tool.

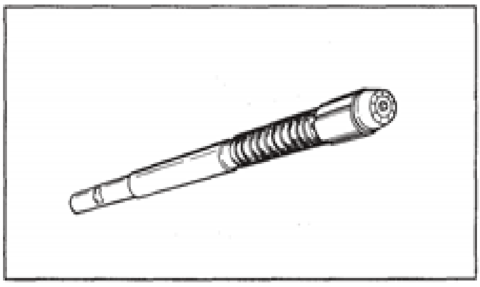


Fig1.8. Single-Stroke Honing Tool.

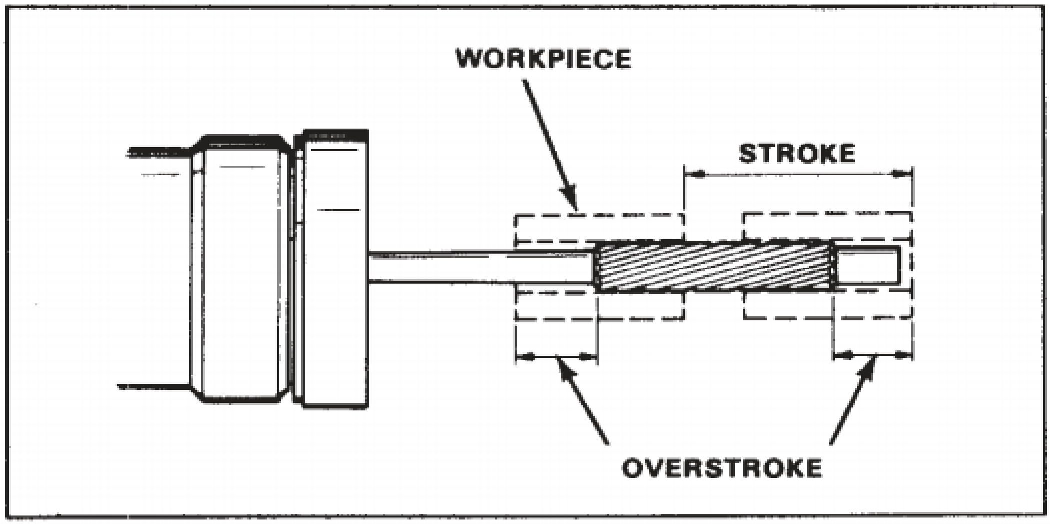


Fig1.9. Over stroke.

Refer: https://www.youtube.com/watch?v=ZGU1zP7KPbY

Self-Check -2	Written Test

Directions: Answer all the questions listed below:

1. What mean by PPE? (**2 points**)
2. Write the steps to provide drilling operation. (**2 points**)

3. Write the importance of PPE in the work shop. (**2 points**)
4. List out the types honing tools. (**2 points**)
5. Write the function of honing operation. (**2 points**)

Note: **Satisfactory rating - 25 points** **Unsatisfactory - below 25 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

Operation Sheet 1	Drilling, Tapping and Reaming Practice

3. To practice drilling, tapping and reaming:

Operations to be carried out: filing, checking, marking, punching, cutting, drilling, tapping, reaming, and finishing

Procedure:

1. Hold the mild steel flat piece of 50 x 50 x 6mm between the jaws of the bench vice.
2. Start filing on first flat surface after removing the rust with the tip of flat file.
3. Straight filing is continued till the surface is formed perfectly flat.
4. Check the straightness by using straight edge.
5. Turn to the adjacent side which is narrow and make it straight, flat and 90° with flat surface prepared.
6. File the next adjacent side and make it flat and perpendicular to both flat surface and first narrow side which is already prepared.
7. Apply chalk on the finished flat surface and mark dimensions
8. Use surface plate V-block and vernier height gauge for marking.
9. Marked lines are punched by using dot punch and ball peen hammer.
10. File to correct dimensions in length and width and check the dimensions using an outside caliper and steel rule.
11. Mark two curve on the edge of M.S flat using divider.
12. Make curve using round file.

Operations: to make a Square cutting.

Procedure:

1. The given mild steel flat piece is checked for given dimensions.
2. One edge of given is filled to straightness with rough and smooth files and checked with try square.
3. An adjacent is also filled such that is square to first edge and checked with try square.
4. Wet chalk is applied on one side of the flat and dried for making.
5. Lines are marked according to given figure, using odd leg caliper and steel rule.
6. using the dot punch are made along the marked lines.
7. The excess materials removed from the remaining two edges with try square level up to half of the marked dots.
8. Finally buts are removed by the filling on the surface of the fitted job.

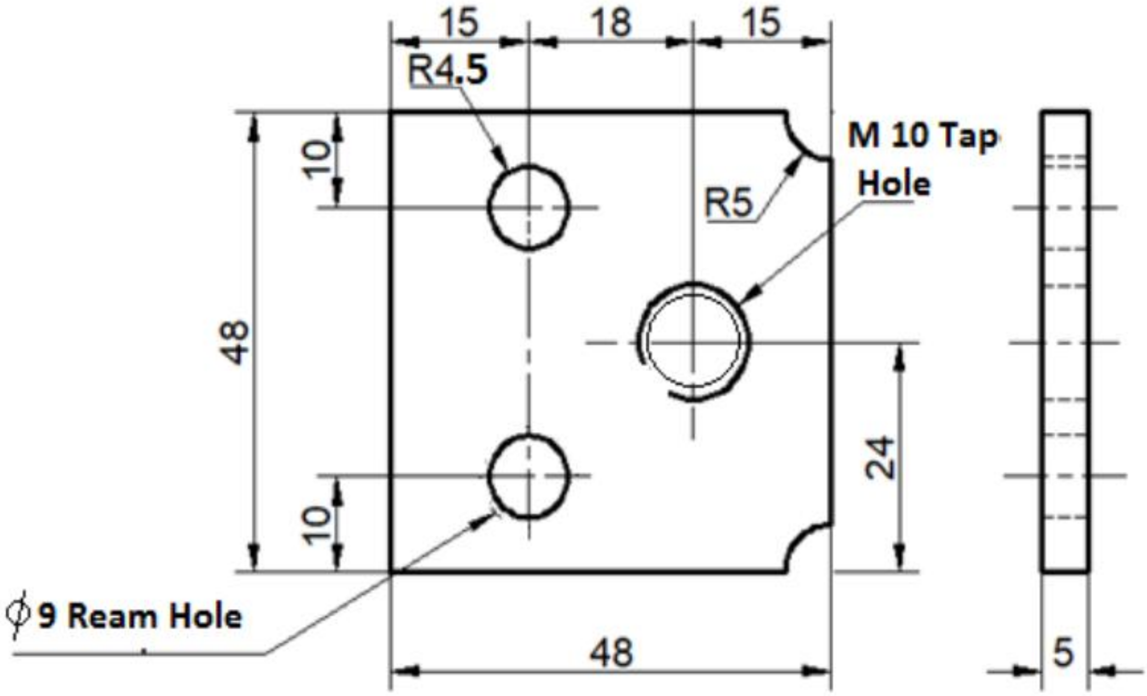
LAP Test	Practical Demonstration

Name: ______________________________ Date: ________________

Time started: _________________________ Time finished: ________________

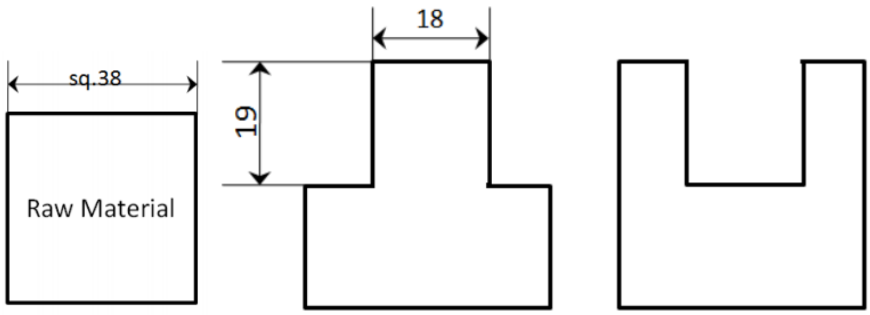
Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within **2-5** hours.

Task 1: Cut the work piece to produce a drill gauge according to the dimensions given.



All dimensions are in mm.

Task 2: Make a Square fit from the given mid steel pieces.



* All dimensions are in mm.

Materials required: mild steel flat (40*40*3mm).

List of Reference Materials

1. Workshop Technology Parts 1, 2 and 3, Author : WAJ Chapman Publisher : London: Edward Arnold, 1972
2. Work shop practice: http://gptcperumbavoor.ac.in/gptcpbvr/Materials/Lab/3027.pdf
3. Filing : http://www.simondssaw.com/handfiles/hand%20files%20publications/simonds-file%20catalog.pdf
4. Bench work operations: https://www.slideshare.net/Lemmalove/performing-bench-work-ppt

Basic Metal Works

Level-I

Learning Guide-35

Unit of Competence: Perform Bench Work

Module Title: Performing Bench Work

LG Code: IND BMW1 M10 LO4-LG-35

TTLM Code: IND BMW1 M10 TTLM 1019v1

LO 4: Perform off-hand grind cutting tools

Instruction Sheet	Learning Guide # 4

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Honing cut edges
- Performing cutting tool grinding
- Grind Cutters using appropriate cooling agents
- Sharpening Cutters

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Hone cut edges and free of burrs.
- Sharpen cutter to conform to specifications.
- Grind cutters using appropriate cooling agents.
- Perform cutting tool grinding applying safety procedures and using personal protective device

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information “Sheet 1, Sheet 2, Sheet 3 and Sheet 4”.
4. Accomplish the “Self-check 1,Self-check 2, Self-check 3 and Self-check 4” **in page -88, 95, 99 and 103** respectively.
5. If you earned a satisfactory evaluation from the “Self-check” proceed to “Operation Sheet 1” **in page -104.**
6. Do the “LAP test” **in page105 – 107** (if you are ready).

Information Sheet-1	Honing cut edges

1.1. Concepts of off-hand grinding

Off – hand grinding is the term used in engineering to describe the process where the work is held by hand material is removed using an abrasive wheel.

This type of grinding is carried out in the workshop for such work as:

a. Removing excess materials

b. Smoothening surfaces

c. Preparing plates for welding

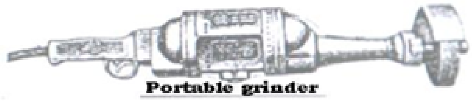
d. Sharpening cutting tools (drills, chisels, punches, shaper and lathe tools)

Off – hand grinding must be performed with great regard of safety. The principle of operation requires an exposed portion of the abrasive wheel to be in close proximity to the operator.

Hazard may be created by having relatively heavy abrasive wheels rotating a high speed. The wheels on all types of machines must be heavily guarded.

The guard exposes enough of the wheel surface to enable the operator to perform the work required.

NOTE: Wear safety goggles when performing any grinding operation.



Bench grinder

Pedestal grinder

Fig.1.1.Girding machines.

https://www.google.com/search?q=Bench+grinder&sa=X&stick=H4sIAAAAAAAAAOOQUeLUz9U3MEkptyw2EiupLEgtVshPU0gvysxLSS1SKMnPzymO0ihILUrLL8oFyqQpZCTmpUDkFZJLS0oy89IhqhQKUtJOMXKBTDNNM8kwsoRyjAotipNSTjGC7TEzMDCtgLKBdlokI9iWxb8YxUKwOmARK69Tal5yBkwUAE4BQFm2AAAA&biw=1366&bih=654&tbm=isch&source=iu&ictx=1&fir=Jx_vFe5gKAMPaM%253A%252CeNBPSNeMKubL8M%252C%252Fm%252F04dw9s&vet=1&usg=AI4_-kQcrE1IkrmOKmrHBKwq6r6bOJlC8A&ved=2ahUKEwilsq6UvITlAhUDPFAKHZ2HAewQ_B0wGnoECAgQAw#imgrc=Jx_vFe5gKAMPaM:

- Parts and Functions (features of machines)

a. Work Rests

b. Wheel Guards

c. Wheel Speed

d. Wheel Rotation

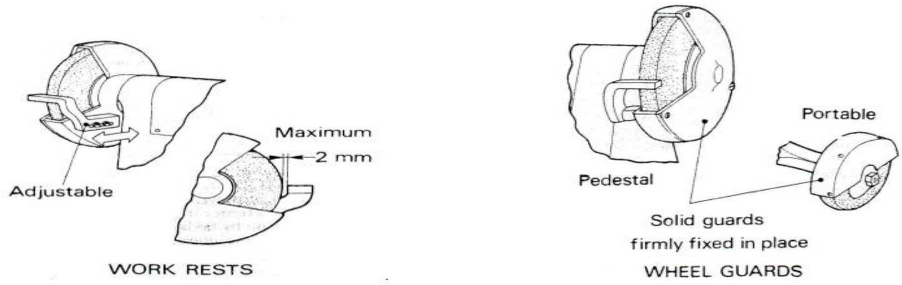


Fig1.2.Parts of Bench Girding machine.

1.2. Honing cut edges

Importance of honing:

Honing is an abrasive machining process that produces a precision surface on a metal work piece by scrubbing an abrasive stone against it along a controlled path. Honing is primarily used to improve the geometric form of a surface, but may also improve the surface texture.

Typical applications are the finishing of cylinders for internal combustion engines, air bearing spindles and gears. There are many types of hones, but all consist of one or more abrasive stones that are held under pressure against the surface they are working on.

In terms of sharpening knives, a honing steel does not actually hone knives, but simply realigns the metal along the edge.

Other similar processes are lapping and super finishing.

Honing uses a special tool, called a *honing stone* or a *hone*, to achieve a precision surface. The hone is composed of abrasive grains that are bound together with an adhesive. Generally, honing grains are irregularly shaped and about 10 to 50 micrometers in diameter (300 to 1,500 mesh grit). Smaller grain sizes produce a smoother surface on the work piece.

A honing stone is similar to a grinding wheel in many ways, but honing stones are usually more friable so that they conform to the shape of the work piece as they wear in. To counteract their friability, honing stones may be treated with wax or sulfur to improve life; wax is usually preferred for environmental reasons.

Any abrasive material may be used to create a honing stone, but the most commonly used are corundum, silicon carbide, cubic boron nitride, or diamond. The choice of abrasive material is usually driven by the characteristics of the work piece material. In most cases, corundum or silicon carbide are acceptable, but extremely hard work piece materials must be honed using super abrasives.

The hone is usually turned in the bore while being moved in and out. Special cutting fluids are used to give a smooth cutting action and to remove the material that has been abraded. Modern advances in abrasives have made it possible to remove much larger amount of material than was previously possible. This has displaced grinding in many applications where "through machining" is possible. External hones perform the same function on shafts.

Refer:https://www.youtube.com/watch?v=KjRyy5IhHZo

Refer:https://www.youtube.com/watch?v=-jLcA5z99r8

Refer: https://www.youtube.com/watch?v=T5hIXPBGBgw

Self-Check -1	Multiple choose

Directions: choose the best answer for the questions (2 points each)

1. Honing tool is used for _____________ .
   a. cutting
   b. finishing
   c. drilling
   d. none
2. Honing operation is___________.
   a. abrasive machining process
   b. drilling
   c. grinding
   d. cutting

***Note:* Satisfactory rating - 2points Unsatisfactory - below 2 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet-2	Sharpening Cutters

2.1. Concepts of Sharpening Cutters

The word sharpening is usually used for the final finishing of edge tools. Like all edge tools, a drill bit needs to have the right shape before you can start to sharpen it. Creating the initial shape often means that quite a lot of steel needs to be re-moved when for example, you change the point angle of a drill or you shape a broken or heavily worn drill. Once the geometry of the point is established, you maintain the sharpness by sharpening. With the Tormek system you can exactly replicate an existing shape and therefore you just need to touch up the edges. Shaping and Sharpening

Edge tools need to be sharp to work efficiently. The bevels of a sharp edge tool end in a uniform tip. After a period of use the tip becomes rounded and the edge is no longer sharp. You can sharpen tools with a bench stone or, in the case of knives, with a sharpening steel. This means that you work on the very tip of the bevel and the tool is sharp again.

When sharpening with a steel or a bench stone, a very limited amount of steel is removed. After several sharpenings or honings, the edge angle becomes too wide and the tool must be re-shaped. Sooner or later all edge tools need to be re-shaped and this is done by grind-ing on a grindstone or a grinding wheel. When only a limited amount of steel is removed this operation is also called sharpening.

Grinding means that so much steel is removed from the tool that the edge is restored to the original angle or altered on purpose to a new angle. The shape of the tool can also be changed according to your requirements.

2.2. Tool Sharpening

For some tools it is very important to keep them sharp at all times. Common tools, such as scribers, center punch, chisels, drill bits, tool bits for lathe machine needs to be sharpened every time you feel that they do not cut well.

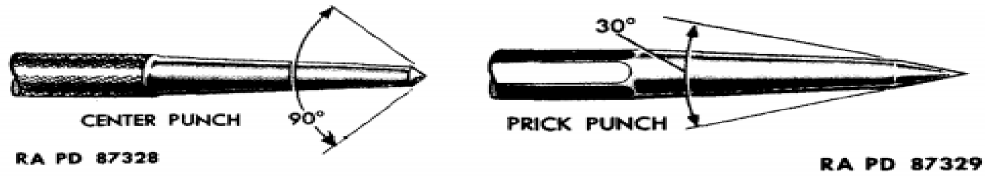
- **Sharpening Scriber and Center Punch**

1. Scriber and center punch should be ground in the position as shown beside.
2. Use the tool rest to rest your hands while bringing the tool in the right position.
3. Rotate the tool while grinding.

4. Cool the tool down from time to time.
5. Do not overheat the metal.

Cone-pointed Punches

Center punches and prick punches are ground to cone points. Correct point angle for center punches is about 90 degrees. Right point angle for prick punch is approximately 30 degrees. These angles may be altered for special work.



Correct Punch Point Angles

Adjust rest so punch meets face of wheel at desired angle (see illustration). Rotate punch during grinding to make point symmetrical. Dip punch in water at frequent intervals to avoid "burning." Do not grind away more material than necessary to secure satisfactory point.

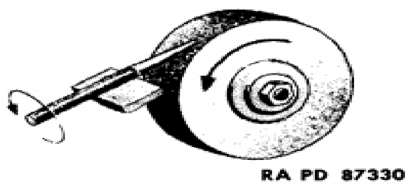


Fig 2.1. Punches and their grinding angles.

Refer: https://www.youtube.com/watch?v=zxvbKlur96A

- **Sharpening Chisel**
  - ✓ Use the tool rest to rest your hands while bringing the tool in the right position.
  - ✓ Use the whole grinding wheel while grinding. Move with the tool regularly from the left to the right side and back.
  - ✓ Cool the tool down from time to time.
  - ✓ Do not overheat the metal.
  - ✓ Grind the chisel−point parallel and straight. See also the pictures below.

2.3. Grinding twist drills

Twist drills may be ground in a drill holder fixture or free hand. Use fixture if available. Grind drill lips or cutting edges at an angle of 59 degrees, as illustrated below (50 to 60degrees for drilling brass or bronze, 68 degrees for extremely hard material). Both cutting edges must make same angle with drill angle with angle drill axis, and both cutting edges must be same length.

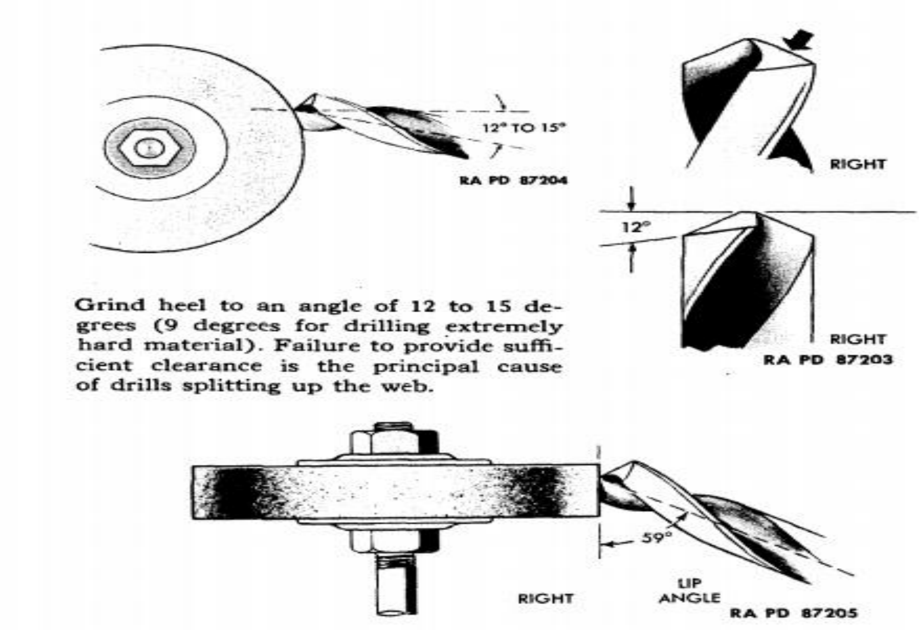


Figure2.2. Grinding angles of Twist drill points

Refer: https://www.youtube.com/watch?v=y0SQkzScQk0

- **Using Drill Holder Fixture**

Exact procedure for grinding will vary with make of drill grinding machine used. General procedure, which applies to conventional type machine, is given in the following steps:

- ✓ **Adjust** machine to desired cutting edge and heel angles.
- ✓ **Place** drill in V- block of holder. Turn so cutting edge will contact abrasive wheel as drill is feed in to wheel.
- ✓ Start motor and advance tailstock until drill makes contact with wheel.
- ✓ **Hold** drill in place in V- blocks and swing holder spindle slowly through its arc. Without changing tailstock adjustment , revolve drill one- half turn in V- blocks and sharpen other lip of dill in same manner.

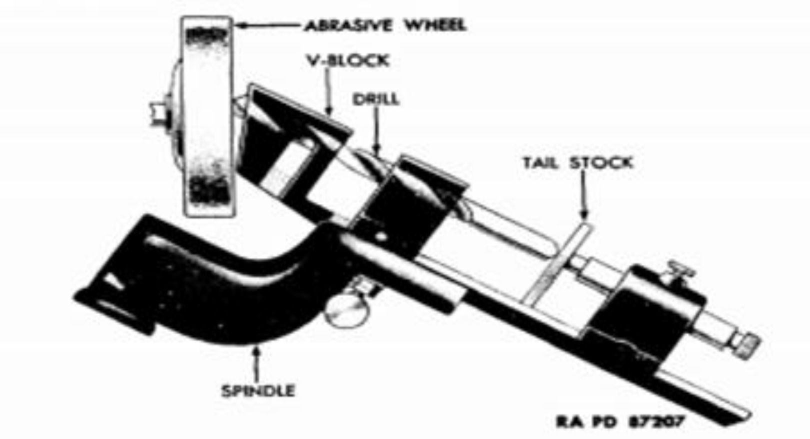


Fig2.3. Grinding with Drill Holder Fixture.

- ✓ **Inspect** drill point to see if it has been ground block far enough to eliminate all nicks. Repeat grinding and inspections operations until perfect appearing points are obtained.

- **Free Hand Grinding**

1. **Adjust** tool rest to convenient height for resting back of forehead on it while grinding.
2. **Hold** drill between thumb and index finger of right or left hand grasp body of drill near shank with other hand.
3. **Place** forehand on drill rest with centerline of drill making desired angle with cutting face of wheel and slightly lower shank end of drill as illustrated.
4. **Slowly** place heel of drill against grinding wheel.
5. **Check** results of grinding with a gage to determine if cutting edge Are same length and at desired angle and if heel is ground to angle of 12 to 15 degree.

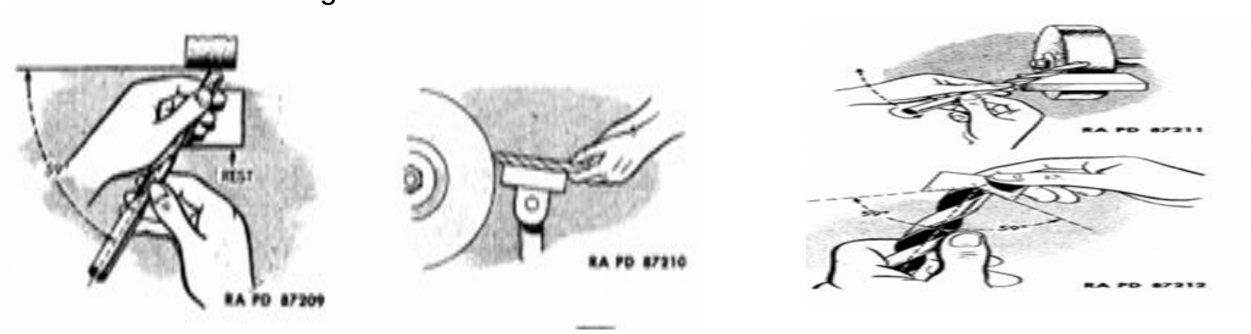


Fig2.4. Free Hand Grinding.

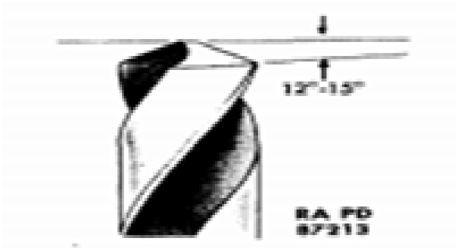


Fig2.5. Heel Angle.

Web thinning

On a conventional twist drill bit there is what is known as a web. The web is the center part of the body that joins the lands (Figure)

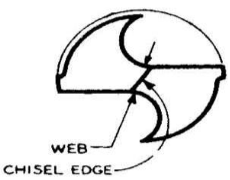


Fig2.6. Twist drill point

The extreme ends of the web form the chisel edge. The thickness of the web is not uniform; it increases from the point to the shank (Figure).

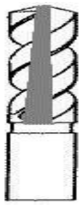


Fig2.7.Twist drill bit

The web thickness gets larger toward the shank of the drill.

The cutting action of the chisel edge requires a relatively large amount of thrust be used to cause the drill to penetrate into the work piece. The increased amount of thrust needed to drive the chisel edge becomes more apparent as the drill is sharpened, since the web of the drill is made thicker toward the shank. We can reduce the amount of force it takes to cause the drill to penetrate by thinning the web of the drill (Figure).

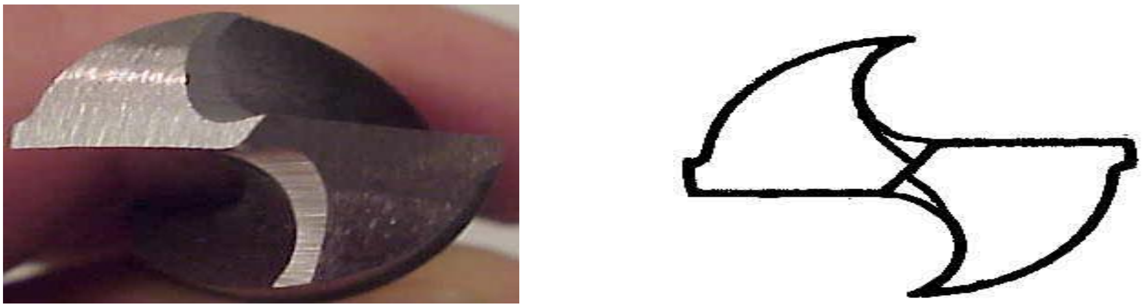


Fig2.8. Web thinning

The best way to thin the web of a drill is by using a machine equipped with a drill point thinner. It is possible, however, to thin the web of a drill by hand using a pedestal grinder.

Web Thinning on a pedestal Grinder

- When thinning the web be careful not to make the web any thinner than it was when original and **do not** disturb the cutting lips of the drill. Start with a clean, sharp grinding wheel. Hold the drill at approximately 35 degrees of the axial centerline of the drill.

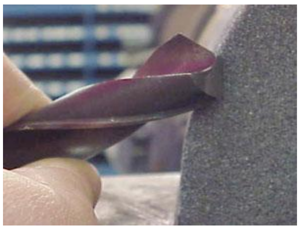


Fig2.9. Holding the drill at a 30- degree angle

Line up the corner of the wheel with the tip of the web (Figure).

Turn the cutting lip out approximately 10 degrees. Lightly grind away the web of the drill. You have to grind the same amount off of each web to assure that the drill point will remain on center. Try to stay away from the cutting edge as much as possible.

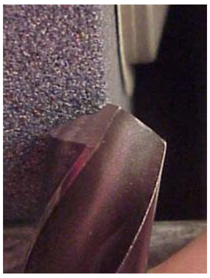


Fig2.10. Line up the end of the web with the corner of the wheel.

Modified split point done on a pedestal grinder

It is sometimes easier for a beginning student to grind a modified split point by hand than it is to do off-hand web thinning. The split point drill (Figure) accomplishes the same end result, a thinned web, but you are actually grinding away the heel or non-cutting side of the drill point.
https://www.ibiblio.org/hyperwar/USA/ref/TM/pdfs/TM9-867.pdf

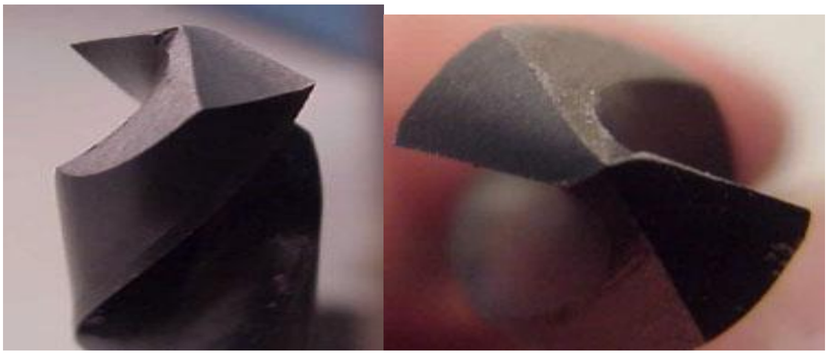


Fig2.11. Split point

Procedures:

1. Start with a clean sharp grinding wheel. Hold the drill at approximately 55 degrees off of the axial centerline of the drill (Figure).

Figure 2.12. The approach angle is steeper when web splitting than it is when web thinning.

2. Line up the corner of the wheel with the tip of the web (Figure). Turn the cutting lip out approximately 10 degrees away from the wheel edge.

3. Lightly grind away the heel of the drill until you have ground away the appropriate amount of the web of the drill.

Self-Check -2	Written Test

Directions: Answer all the questions listed below.

1. _____ is usually used for the final finishing of edge tools. (**2 points**)
   a) Sharpening b)cutting c)drilling d)boring
2. Twist drills may be ground in . (**2 points**)
   a) Drill holder fixture b) drill chuck c) free hand d) a & c
3. ______ Is the center part of the body of twist drill bit that joins the land . (**2 points**)
   a) Shank b) web c) body d) chisel edge
4. The web thickness gets larger toward the shank of the drill. . (**2 points**)
   a) True b) false
5. Which one of the following is correct point angle for center punches? . (**2 points**)
   a) 30 degrees b) 45 degrees c) 90 degrees d) 75 degrees

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Score = ____________
Rating: _____________

Name: ___________________________ Date: ________________

Information Sheet-3	Grind Cutters using appropriate cooling agents

3. Concepts of cooling agents

3.1. Properties of Cutting Fluids

- **Functions of cutting fluids**

Cutting fluids are used in metal machining for a variety of reasons such as improving tool life, reducing work piece thermal deformation, improving surface finish and flushing away chips from the cutting zone.

Cutting fluids consist of those liquids and gases that are applied to the tool and the material being machined to facilitate the cutting operation. Vast quantities are used annually to accomplish a number of objectives. (Boston, 1952)

1) To prevent the tool from overheating, i.e. so that no temperature is reached where the tool's hardness and resistance to abrasion are reduced, thus decreasing the tool life.
2) To keep the work cool, preventing machining those results in inaccurate final dimensions.
3) To reduce power consumption, wear on the tool, and the generation of heat, by affecting the cutting process. This investigation wishes to establish a relationship between the surface chemistry of the lubricants involved and how they can accomplish reducing the contact length on the rake face of the tool where most of the heat during cutting is produced.

4) To provide a good surface finish on the work.

5) To aid in providing a satisfactory chip formation (related to contact length)

6) To wash away the chips/clear the swarf from the cutting area.

7) To prevent corrosion of the work, the tool and the machine.

- The desirable properties of cutting fluids in general are (Boston, 1952)

1) High thermal conductivity for cooling
2) Good lubricating qualities
3) High flash point, should not entail a fire hazard
4) Must not produce a gummy or solid precipitate at ordinary working temperatures
5) Be stable against oxidation.
6) Must not promote corrosion or discoloration of the work material.
7) Must afford some corrosion protection to newly formed surfaces.
8) The components of the lubricant must not become rancid easily
9) No unpleasant odour must develop from continued use
10) Must not cause skin irritation or contamination
11) A viscosity that will permit free flow from the work and dripping from the chips.

3.2 Types of cutting fluids

Cutting fluids may be divided into four main categories (FVTC, 2000):

i- straight or neat cutting oils

ii- water miscible or water-based fluids

iii- gases

IV- paste or solid lubricants

i. Straight Cutting Oils

Straight cutting oils are not mixed with water. Cutting oils are generally mixtures of mineral oil and animal, vegetable or marine oils to improve the wetting and lubricating properties. Sulphur, chlorine, and phosphorous compounds are sometimes added to improve the lubrication qualities of the fluid for extreme pressure applications. There are two main types of straight oils: active and inactive.

ii. Water miscible or water-based fluids

The water-based fluids act mainly as coolants and the neat cutting oils act mainly as lubricants. There are many variants of both types. Fatty acids are often incorporated in the neat oils. Until recently both the emulsions or soluble oils as they are also called and the neat oils, contained chlorine and sulphur additives that improved lubrication under extremely difficult conditions. Chlorine affects the skin detrimentally and its degradation products are often carcinogenic and sulphur is environmentally unacceptable. Consequently other lubrication improvers under difficult conditions are searched for.

Ester technology is used successfully for softer materials where high rates of metal working are needed, and where heat generation is not a major problem. (du Plessis, 2001) These can operate at higher temperatures as they have better resistance to thermal degradation than mineral oils. (Mortier & Orszulik, 1993) They arebiodegradable and do not cause dermatitis and are therefore more environmentally acceptable. In many cases phosphor and sulphur do however still form part of the cutting fluid. (FYTC, 2000)

For the water miscible fluids water quality has a large effect on the coolant. Hard water (high mineral content) can cause stains and corrosion of machines and work pieces. Water can be deionized to remove the impurities and minerals. Water is the best fluid for cooling. It has the best ability to carry heat away. Water, however, is a very poor lubricant and causes corrosion.

Oil is excellent for lubrication but very poor for cooling, and it is also flammable. It is clear that, from a lubrication point of view water and oil have strengths but also some weaknesses. If water and oil are combined and an attempt is made to minimise the weaknesses the best properties of both may be balanced to obtain desirable end properties for the cutting fluid. Water-soluble fluids have been developed which have good lubrication, cooling ability, low-flammability and corrosion resistance. These fluids are usually mixed on site. It is crucial that the mixing directions and concentrations are followed very closely to get the maximum benefit from the coolant. (FYTC, 2000)

Emulsions

An emulsion is a dispersion of oil droplets in water. Soluble oils are mineral oils that contain emulsifiers. Emulsifiers are soaps or soap-like agents that allow the oil to mix with water and stay in suspension. Emulsions (soluble oils) when mixed with water produce a milky white product. Lean concentrations (more water, less oil) provide better cooling but less lubrication. Rich concentrations (less water, more oil) have better lubrication qualities but poorer cooling properties.

There are different types of soluble cutting fluids available including extreme pressure soluble oils. These are used for extreme machining conditions like broaching and gear hobbing for example. (FYTC, 2000)

Chemical Fluids

Chemical coolants are also miscible cutting fluids. Chemical cutting fluids are pre-concentrated emulsions that contain very little oil. Chemical fluids mix very easily with water to form an emulsion. The chemical components in the fluid are used to enhance the lubrication, bacterial control, and rust and corrosion characteristics. There are several types of chemical coolants available including coolants for extreme cutting conditions.

Inactive chemical cutting fluids are usually clear fluids with high corrosion inhibition, high cooling, and low lubrication qualities. Active chemical fluids include wetting agents. They have excellent rust inhibition and moderate lubrication and cooling properties.

Sulphur-, chlorine- and phosphorous- containing compounds are sometimes added to improve the extreme pressure characteristics. These are usually in an organic form, i.e. the sulphur, chlorine or phosphorus IS grafted onto a hydro-carbon backbone. (FVTC, 2000).

iii.Gases and vapours

Cutting oils and water miscible types of cutting fluids are the most widely used. Compressed air, ineli gases like carbon dioxide, Freon, and Nitrogen are sometimes used. A vortex tube may be used to apply gaseous lubricants or coolants (ARTX, 2002). Using this tube, it is possible to apply the gases at a very low temperature and under medium pressure thereby facilitating a higher gas density and cooling and lubrication capability. Cutting using sub-zero cold gas is known as cryogenic cutting. The gas stream also helps to blow away chips from the cutting area. (FVTC, 2000)

iv. Paste and Solid Lubricants

Waxes, pastes, soaps, graphite and molybdenum disulphide are examples falling into this category. These are generally applied directly to the work piece or tool or in some cases impregnated directly into the tool, for example the grinding wheel of a grinder. One example of a paste lubricant is lard. Many experienced journeymen recommend lard for tapping.

Self-Check -3	**Written Test**

Directions: Answer all the questions listed below.

1. Which one of the following is not the reason that cutting fluid is used in metal machining? (**2 points**)
   a) reducing work piece thermal deformation c) reducing surface finish
   b) improving tool life d) flushing away chips from the cutting zone
2. Which one of the following oils are not mixed with water? (**2 points**)
   a) straight cutting oils c) Gases and vapours
   b) paste and Solid Lubricants d) Water miscible or water-based fluids

3. Which one of the following is paste and solid lubricants? (**4 points**)
   a) be stable against oxidation c) must not cause skins contamination
   b) good lubricating qualities d) all of the above

4. A dispersion of oil droplets in water is ______ .

a) chemical fluids c) vapours

b) an emulsion d) Solid Lubricants

5. Which one of the following is the desirable property of cutting fluids?

a) be stable against oxidation c) must not cause skins contamination

b) good lubricating qualities d) all of the above

***Note:* Satisfactory rating – 5 points** **Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Information Sheet-4	**Performing cutting tool grinding**

4.1. Introduction

Grinding is a metal cutting operation like any other process of machining removing metal in comparatively smaller volume. The cutting tool used is an abrasive wheel having many numbers of cutting edges. The machine on which grinding the operation is performed is called a grinding machine.

Grinding is done to obtain very high dimensional accuracy and better appearance. The accuracy of grinding process is 0.000025mm. The amount of material removed from the work is very less.

Grinding machines are made in a variety of types and sizes, depending upon the class of work for which they are to be used.

Pedestal grinders are used to sharpen high-speed steel cutting tools used on the lathes and milling machines, debur, or used to remove surface imperfections and to work extremely hard materials.

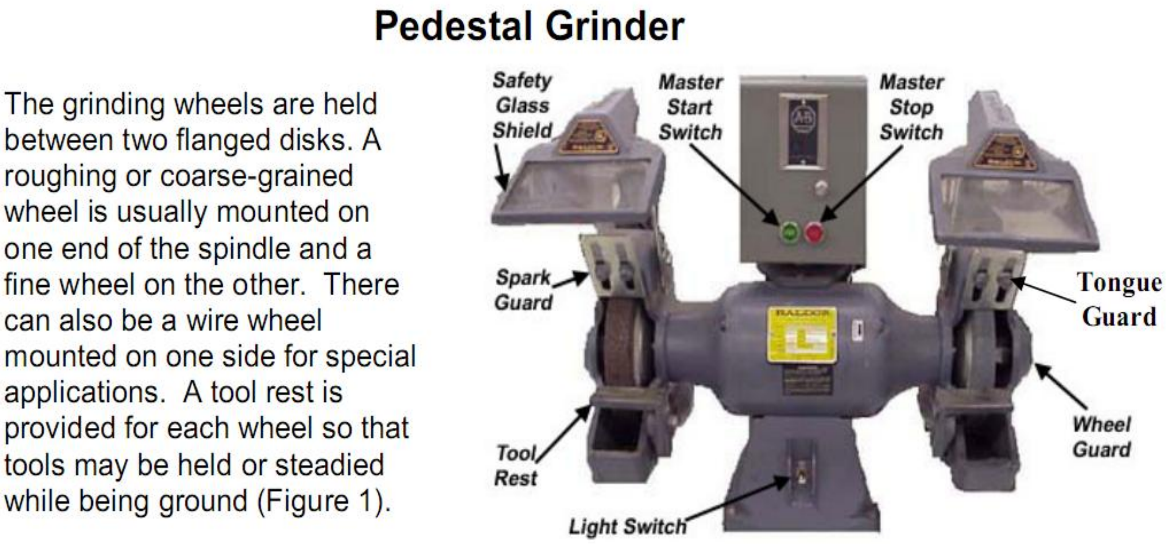


Fig4.1. Main Parts of a Pedestal Grinder

The operator is protected against flying abrasive particles and ground material by the wheel guards, which are an integral part of a machine. Safety glass shields are also provided for additional protection.

These grinders are used for all kinds of general off-hand grinding and for the sharpening of drills, chisels, tool bits, and other small tools.

Procedure for Grinding:

1. Examine the grinder to see that the tool rest is set at the required height, is within 1/8 if an inch to the face of the wheel, and is securely fastened in this position (Figure 2).
   Tongue guard is to be set at ¼” from the wheel (figure 1).
2. Adjust safety glass shields on the grinder to permit clear vision of the part to be ground and still protect the oprator from flying particles.
   CAUTION: Always wear safety glasses and/or face shield when using

Fig.4.2. Position of the tool rest

3. Start the grinder.

CAUTION: Stand to one side of the wheel when operating the grinder.

4. Hold the work in one hand, and steady it with the other. Place the work on the tool rest; then guide it against the face of the revolving wheel and apply enough pressure togrind, depending upon the hardness of the material and the wheel itself.

Note: Support the work on the tool rest to steady it when grinding, except in the case of the small tool bits which can be guided better by supporting them with the fingers or with a hand resting on the tool rest.

5. Cool work in a water pot as it becomes heated from grinding, especially the small hardened tools that would lose their temper if overheated. **Twist drills should not** be cooled by dipping in water, as it may cause cracking.

Grind the job to the required shape or size by moving the work back and forth across the face of the wheel. This will prevent wearing a groove into the wheel and will result in a flatter surface on the work.

CAUTION: Keep fingers away from the revolving wheel, especially when grinding small pieces. Also make sure that the tool rest is close enough to the wheel to prevent the work from slipping into the space between the two.

Note: Remove as much metal by rough grinding as is possible; then use the finer wheel for finishing.

Do not grind on the side of the wheel except when absolutely necessary, and then with only light pressure.

6. Check work with a gage or other measuring tool.
7. Stop grinder.

4.2. SHARPENING THE TWIST DRILL BIT

To get a good performance from a drill bit the sharpening must be done correctly, this means that all the angles and the lengths of the edges must be exactly as established and will not occur during the grinding edge of the material structural modifications.

Drill bits are cutting tools used to create cylindrical holes, almost always of circular cross-section. Bits are held in a tool called a drill, which rotates them and provides torque and axial force to create the hole. There are several types of drill bits are used currently such as Spade, lip and spur (brad point), masonry bit and twist drill bits. Our focused will be on standard size Twist Drill Bits. Twist drills become dull and must be sharpened. The preferred method of sharpening a twist drill is with the drill grinding machine which is done manually by holding and feeding the blunt drill bit on to the rotating grindstone, but this machine is not always available in field and maintenance units, so the offhand method of drill sharpening must be used (Fig4.3). The offhand method requires that the operator have knowledge of the drilling geometry (Fig4.4)

To execute the correct sharpening are therefore required special equipment and dedicated grinding machines.

The geometric elements to consider are:

- Point angle
- Lip relief angle
- Length of cutting edges

The control of the angle φ and of the length of the cutting edges is done with a small and simple gauge or with precision optical equipment.

- **Operational procedures:**

1. Dress grinding wheel with dressing tool.
2. Hold drill bit against face of wheel at 59^0 angle on cutting lip.

3. Carry drill bit up the wheel face by dropping end and rotating very slightly in a clockwise direction.
4. Make slow deliberate strokes, the full width of the cutting lip.
5. Do not lower cutting lip below the horizontal position as this will round the cutting edge.
6. When one lip is ground, rotate the drill one half turn and grind the other lip.
7. Use tool gauge to check equal lengths of lips, 590 angle cutting lip and 12-150 lip clearance.
8. Test bit by boring hole in mild steel plate.
9. Stop while drilling, turn drill press in reverse direction to release drill bit from hole.
10. Make grinding corrections on drill bit as indicated by hole.
11. Submit drill bit and metal for evaluation.

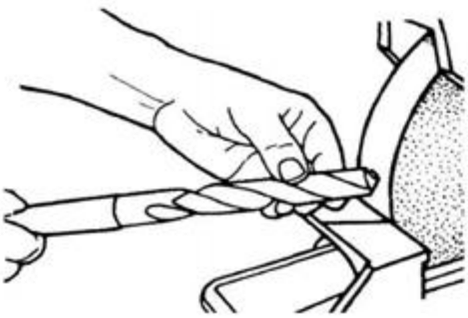


Figure 4.3: Offhand method of drill Sharpening

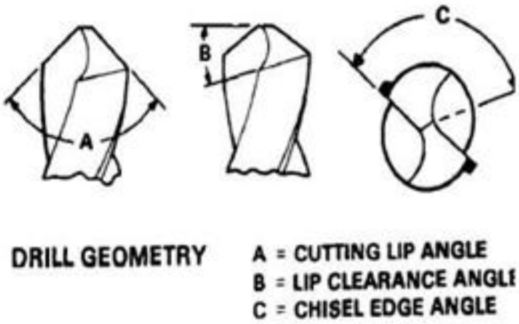


Figure 4.4. Drilling geometry point

Self-Check -4	Written Test

Directions: Answer all the questions listed below. (**2 points**):

1. Which one of the following is the geometric element to consider for twist drill bit?
   A) Shape B) lip relief angle C) point angle D) B & C
2. _____are cutting tools used to create cylindrical holes of circular cross-section.
   A) Drill bits B) chisels C) center punches D) scribers
3. Always keep hands at a safe distance from moving machine parts.
   A. False B. True
4. A utility grinder mounted on its own freestanding base is called?

A. freestanding grinder B. An upright grinder

C. A post grinder D. A pedestal grinder

5. The clearance between the tool rest and the wheel should never exceed _________.

A. 3/16” B. 1/16” C. 1/4” D. 1/8”

6. The main purpose of a grinding wheel guard is to?

A. Limit grinding to a small part of the wheel

B. Protect the operator from flying sparks

C. Prevent pieces from being thrown from a broken grinding wheel

D. Prevent the work piece from being pulled into the grinding wheel

E. All of the above

***Note:* Satisfactory rating – 6 points** **Unsatisfactory - below 6 points**

You can ask you teacher for the copy of the correct answers.

Score = ____________
Rating: _____________

Name: ____________________________ Date: _________________

Operation Sheet-4	Performing cutting tool grinding

Procedures to Perform cutting tool grinding operation:

Step1- Adjust safety glass shields on the grinder to permit clear vision of the part to be ground and still protect the operator from flying particles.

Step 2- Dress grinding wheel with dressing tool.

Step 3- Hold drill bit against face of wheel at 59^0 angle on cutting lip.

Step 4- Carry drill bit up the wheel face by dropping end and rotating very slightly in a clockwise direction.

Step5- Make slow deliberate strokes, the full width of the cutting lip.

Step 6- Do not lower cutting lip below the horizontal position as this will round the cutting edge.

Step 7- When one lip is ground, rotate the drill one half turn and grind the other lip.

Step 8- Use tool gauge to check equal lengths of lips, 590 angle cutting lip and $12\text{-}15^0$ lip clearance.

Step 9- Test bit by boring hole in mild steel plate.

Step 10- Stop while drilling, turn drill press in reverse direction to release drill bit from hole.

Step 11- Make grinding corrections on drill bit as indicated by hole.

Step 12- Submit drill bit and metal for evaluation.

LAP Test	Practical Demonstration

Name: _______________________________ Date: _________________

Time started: __________________________ Time finished: _________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 20 hours.

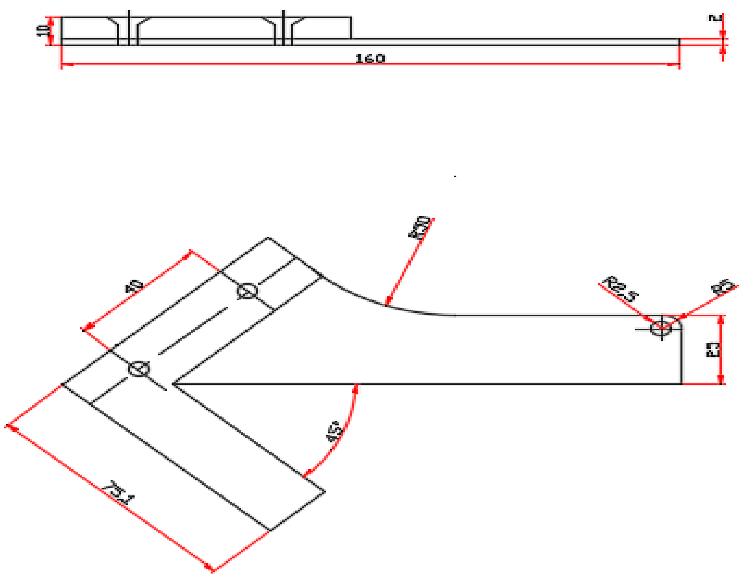
Task 1- Perform center punch grinding operation with its correct point angle following safety regulation.

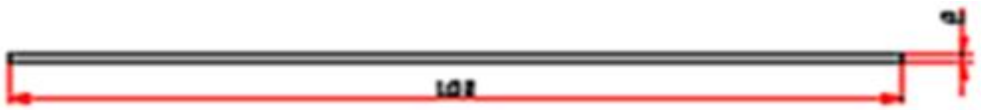
Task 2- Sharpen 12mm diameter twist drill bit by using bench type grinder with its appropriate angle.

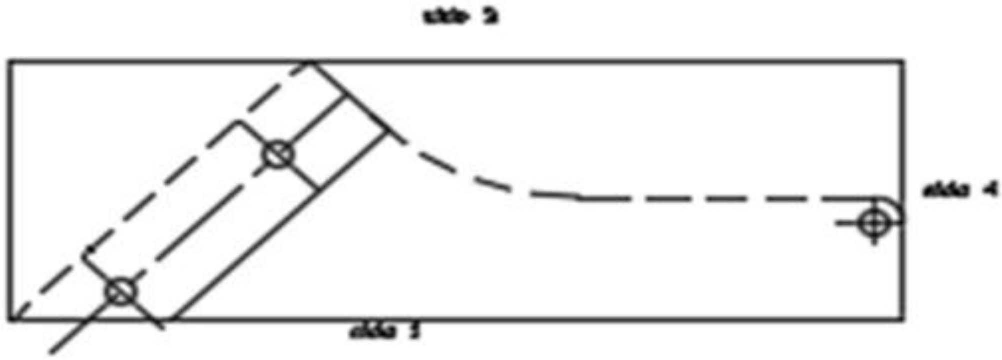
Task 3- Perform the following tasks using necessary bench work operations.

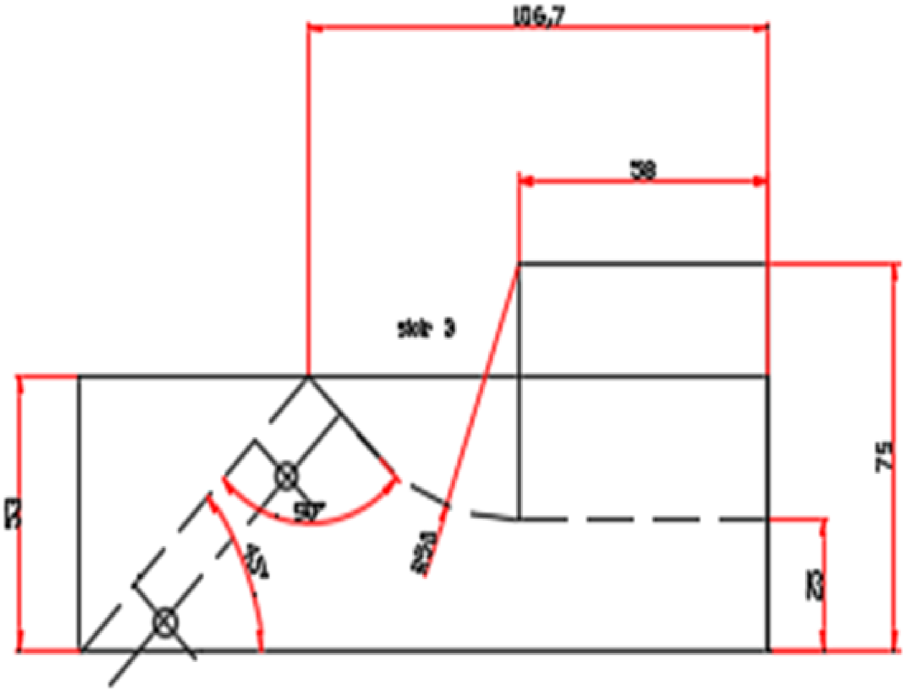
1. Measure the stock using proper tools.
2. Lay out according to the drawing.
3. Cut within the given dimension.
4. File and make it smooth.
5. Drill according to given dimension.

Project – Centre finder





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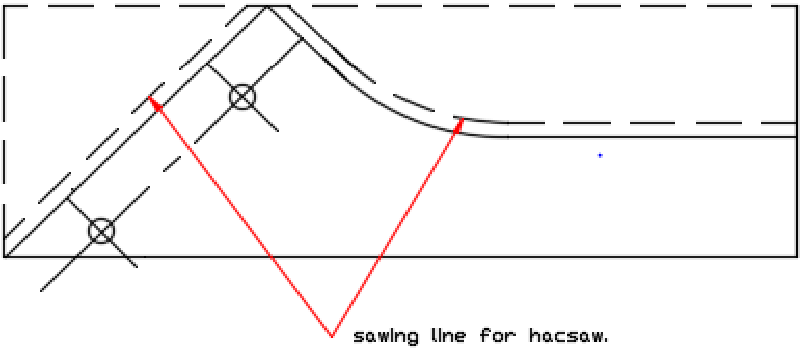
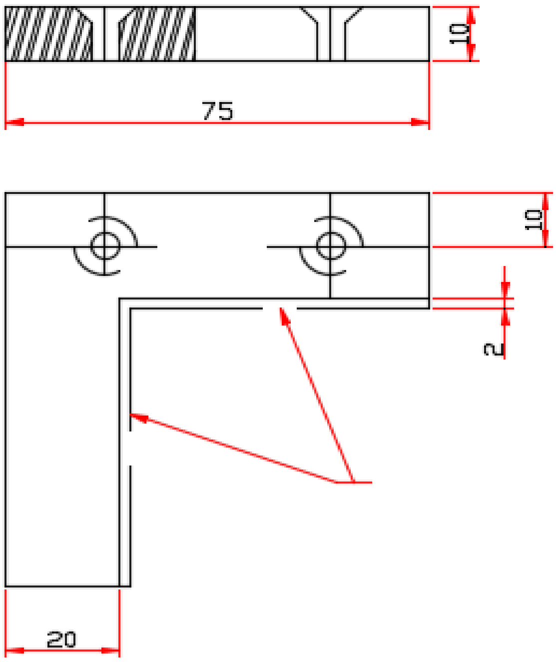


tools
1.Hacsaw
2. scriber.
3. double cut file.
4. smooth file.
5.half round file.
6. radius gauge.
7. radius gauge.
8. combination set.
9. 5mm diameter drill bit.

Fifth step



1. marking out the holes and the sawing line.
2. Drill of the diameterb5.5mm diameter and the countersnuk.
3. sawing alng sawing line .
4. Filing of the straight border line.

Tools.
1. Hand hacksaw.
2. Double cut file.
3. Try square.
4. Vernier caliper.
5. 5mm drill Bit
6. countersnuk drill bit
7. center punch
8. 5.5mm drill bit

List of Reference Materials

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2. Manufacturing Technology Author: G Bram & C Downs Publisher:London: MacMillan, 1975.
3. Concepts of off-hand grinding: https://www.google.com/search?q=Bench+grinder&sa=X&stick=H4sIAAAAAAAAAOOQUeLUz9U3MEkptyw2EiupLEgtVshPU0gvysxLSS1SKMnPzymO0ihILUrLL8oFyqQpZCTmpUDkFZJLS0oy89IhqhQKUtJOMXKBTDNNM8kwsoRyjAotipNSTjGC7TEzMDCtgLKBdlokI9iWxb8YxUKwOmARK69Tal5yBkwUAE4BQFm2AAAA&biw=1366&bih=654&tbm=isch&source=iu&ictx=1&fir=Jx_vFe5gKAMPaM%253A%252CeNBPSNeMKubL8M%252C%252Fm%252F04dw9s&vet=1&usg=AI4_-kQcrE1IkrmOKmrHBKwq6r6bOJlC8A&ved=2ahUKEwilsq6UvITlAhUDPFAKHZ2HAewQ_B0wGnoECAgQAw#imgrc=Jx_vFe5gKAMPaM
4. Honing cut edges: https://www.youtube.com/watch?v=KjRyy5IhHZo
   - https://www.youtube.com/watch?v=-jLcA5z99r8
   - https://www.youtube.com/watch?v=T5hIXPBGBgw
5. Punch grinding: *https://www.youtube.com/watch?v=zxvbKlur96A*
6. Grinding twist drill: https://www.youtube.com/watch?v=y0SQkzScQk0

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