GOVERNMENT COLLEGE OF ENGINEERING, KALAHANDI, BHAWANIPATNA

WORKSHOP AND DIGITAL MANUFACTURING LAB MANUAL

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&

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Workshop and Digital Manufacturing Laboratory

1. Preparation of job in carpentry section/milling operation on CNC milling machine.
2. Preparation of job in fitting section/Study of lathe and turning operation
3. Preparation of job in black smith section/ Study of milling machine and milling operation.
4. Study of CNC lathe machine and turning on CNC lathe.
5. Study of Robot (Pick and place and palletizing operation).
6. Study of additive manufacturing using 3D printer and product development.

1. **Carpentry Section**: Study of different Hand tools, measuring instruments and equipments used in Carpentry work. Safety precautions.

   Preparation of Job: Carpentry job involving different types of joints.

   Includes the operations: Measuring, Marking, Sawing, Planing, Chiseling, Mortesing, Tenoning, making Half-lap joint, Mortese & Tenon joint and Nail joint.

2. **Fitting Section**: Study of different Hand tools, measuring instruments and equipments used in Fitting work. Safety precautions. Study of Drilling Machine and Grinding Machine.

   Preparation of Job: Paper Wt. / Square or Rectangular joint (male-female joint) (any one)

   Includes the operations: Measuring, Marking, Filing, Sawing, Drilling, Tapping, Dieing and Punching.

3. **Black Smith Section**: Study of different Hand tools, equipments and Open-hearth furnace used in Blacksmith work. Different types of heat treatment processes. Safety precautions.

   Preparation of Job: Weeding hook/ Chisel (any one)

   Includes the operations: Measuring, Marking, Cutting, Upsetting, Drawing down, Bending, Fullering and Quenching.

4. **Turning/ Milling Section (Conventional & CNC)**

   A. Study of Lathe Machine, different parts of Lathe and different applications of Lathe. Study of different measuring & marking instruments.

   B. Study of Milling Machine, different parts and applications of Milling Machine. Study of different measuring & marking instruments.

   C. (i) Study of CNC Lathe Machine, different parts of CNC Lathe and its operation.

   (ii) Part programming for turning operations.

   D. (i) Study of CNC Milling Machine, different parts of CNC Milling Machine and its operation.

   (ii) Part programming for milling operations.

5. **Robotics Lab:**

   A. Study of Robot.

   B. Pick and place operation, demonstration and explanation of code.

   C. Palletizing operation, demonstration and explanation of code.

6. **Additive Lab**

   Study of 3D Printer and demonstration of its operation.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Acquire knowledge of conventional & CNC (Lathe and Milling Machine). CNC code and part programming for Milling and Turning operations. Different types of hand tool, measuring instruments and machine tools used in Fitting, Carpentry & Smithy work.
CO2	Know about different types of operations and joints performed in different shops i.e. in Fitting and Carpentry.
CO3	Explore learning about forging temperature of different types of ferrous metals and different types of operation (e.g. upsetting, edging, flattening and bending etc.) carried out on hot metals to prepare jobs.
CO4	Acquire knowledge for the preparation of different types of jobs by using conventional/ CNC Lathe and Milling Machines (e.g. facing, step turning, knurling, drilling, boring, taper turning, thread cutting and different methods of indexing for machining gears.
CO5	Acquire skills in using different precision measuring and marking instruments. Understand the importance of safety precaution in different shops.

Course Articulation Matrix

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	2	2	1	1	3	1	2	1
CO2	-	-	1	-	2	2	1	1	3	1	2	1
CO3					1	2	1	2	3	1	2	1
CO4					3	2	1	1	3	1	2	1
CO5	-	-	-	-	-	-	-	1	2	1	1	1

	CONTENTS	
Sl. No	**EXPEIMENT DETAILS**	**Page No.**

CARPENTRY SECTION

Experiment Number-01

Aim of The Experiment: Preparation of job in carpentry section/milling operation on CNC milling machine.

A. Study of different Hand tools, measuring instruments and equipments used in Carpentry work. Safety precautions. Includes the operations: Measuring, Marking, Sawing, Planing, Chiseling, Mortesing, Tenoning, making Half-lap joint, Mortese & Tenon joint and Nail joint.

Carpentry is the process of shaping Timber using hand tools. The products produce is used in building construction, such as doors, windows, furniture manufacturing, patterns for moulding in foundries.

Timber:

- Timber is the name given to wood obtained from exogenous (outward growing) trees. In these the growth is outward from the centre by adding almost concentric layers of fresh wood every year known as annual ring.
- After the full growth, these trees are cut and sawed to convert in to rectangular section of various sizes for engineering propose.
- Timber is available in market in various shapes and sizes. The common shapes and sizes are

i. Log: this is the trunk of die tree which is free from branches.
ii. Balk: this is the log after sawing roughly to square section.
iii. Deal: this is the log after sawing into rectangular cross section of width about 225 mm and thickness up to 100 mm.
iv. Plank: this is the timber piece having width more than 275 mm and thickness 50 to 150 mm.
v. Board: This is the timber piece below 50 mm in thickness and above 125 mm in width.
vi. Batten: this is timber below 175 mm width and thickness between 30 to 50 mm.
vii. Scantlings: These are timber of various assorted and nonstandard size other than the given above.

Seasoning of wood:

Seasoning of wood is the process of drying wood to reduce moisture content.

- The advantage of seasoning is that it makes timber lighter in weight, more resilient, and less liable to twist, wrap, and spilt.
- It is also in a better condition to retain its size and shape after being made into pieces of joinery. Also increases in strength, hardness, and stiffness as it dries.

Natural seasoning:

This is also known as air drying.

- In this method the balk is stacked under cover with spacers in between, so that a free air circulation is provided all around them. This method is slow, but gives the best results.

Artificial seasoning:

In this method, the period of seasoning is very much reduced, a matter of two- or three-weeks beings sufficient, according to size or species of timber to be seasoned.

- The timber is stacked on a special truck and wheeled into a chamber which is then sealed. Hot air is circulated by fans and a certain amount of steam is added in order to retain the humidity. And samples are checked in regular interval of time for how much moisture left in the timber.

- For out-of-doors work moisture should contain in timber is 16 to 22 percent.
- For interior work or in heated atmosphere moisture contain is 8 to 12 percent

Measuring tools:

Measuring tools in carpentry are used to precisely determine dimensions, angles and levels in wood working project.

1.Steel ruler:

A steel ruler also known as a machinist's rule or engineer's rule, is a precision measuring tool used to measure lengths, widths, or depth.

- Its typically made of hardened steel, featuring a flat, rectangular shape with a calibrated scale or ruler marked along its length.

2.Measuring tape:

A tape measure, or measuring tape is a type of hand tool typically used to measure distance or size.

- It is like a much longer flexible ruler consisting of a case, thumb lock, blade/tape, hook, and sometimes a belt clip.
- A tape measure will have imperial reading, metric reading or both.

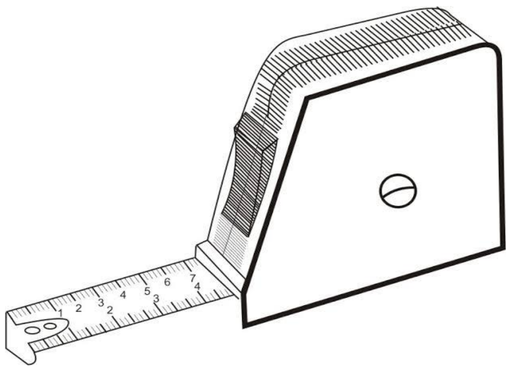


Fig: Measuring tape.

3.Try square:

A try square is a wood working tool used for marking and checking 90-degree angles on pieces of wood.

- It consists of a steel blade, riveted into a hard wood stock which has a protective brass plate on the working surface.
- Another type is the all-metal square, with steel blade and cast-iron stock. Sizes vary from 150 to 300 mm, according to the length of the blade.

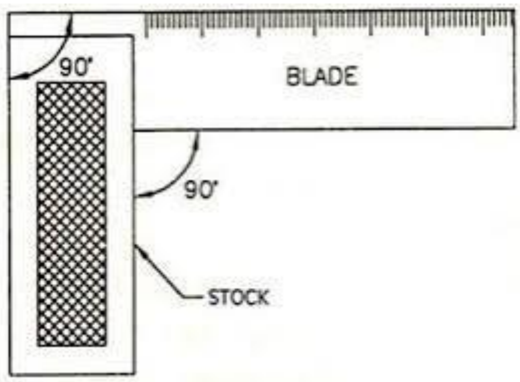


Fig: Try square.

4.Bevel square:

- The bevel square is similar to the try square but has a blade that may be swiveled to any angle from 0 to 180.
- This tool is adjusted by releasing with a turn screw of suitable in a machine screw running in a slot in the table.

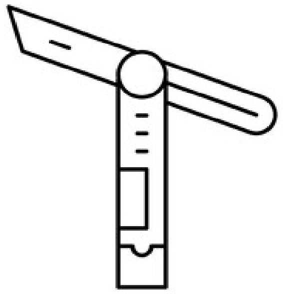


Fig: Bevel square.

5.Straight edge:

In carpentry, a straight edge is a tool used to draw straight lines or check the straightness of a line or surface.

Fig: Straight edge.

Marking Tools:

Marking tools in carpentry are used to accurately transfer measurements and design onto wood, creating guidelines for cutting, joining, and other wood working tasks.

1.Marking Gauge:

The marking gauge has one marking point. It gives an accurate cut line parallel to a true edge, usually with the grain.

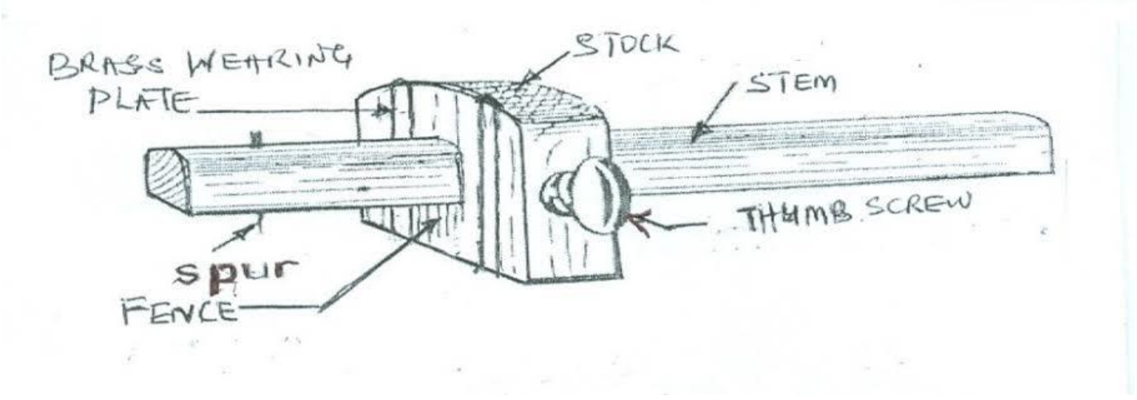


Fig: Marking Gauge.

2.Mortise Gauge:

- The mortise gauge has two marking points- one fixed near to the end of the stem and the other attached to a brass sliding bar.
- These two teeth cut two parallel, called mortise lines.

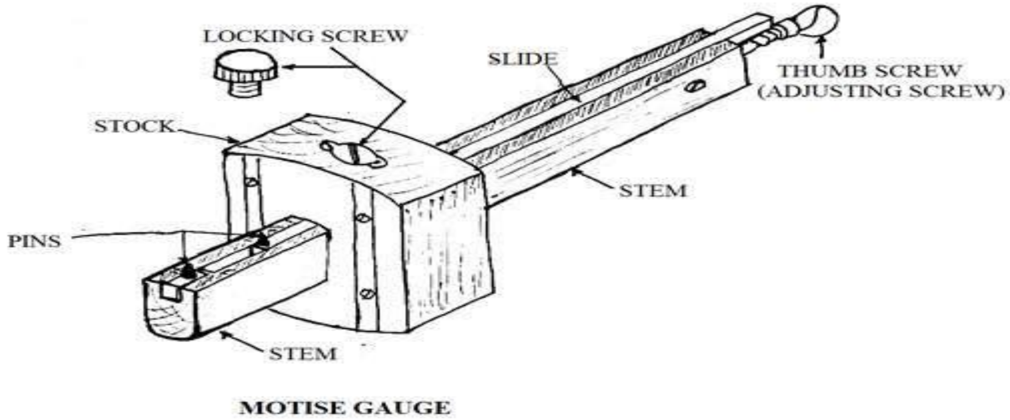


Fig: Mortise Gauge.

Sawing Tools:

Sawing is a cutting method that uses a saw, which is a tool with a blade featuring small, sharp teeth or abrasive particles, to make a narrow cut in material to remove a specific amount of material or separate a piece or cut off a section.

1.Rip Saw:

It is use for cutting along the grain in thick wood.

- The blade is made of high-grade tool steel.
- Rip saws are about 700 mm long with 3 to 5 points or teeth per 25 mm.

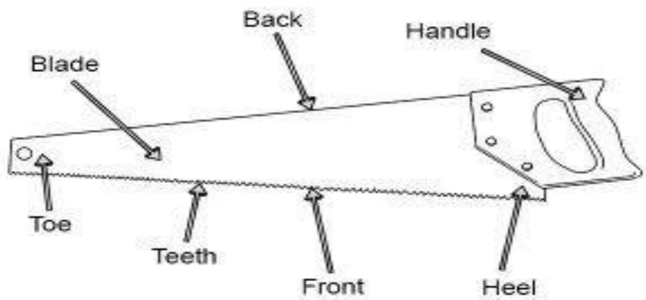


Fig: Rip Saw.

2.Cross cut saw or hand saw:

It is use for cutting across the grain in thick wood.

- 600 to 650 mm long with 8 to 10 teeth per 25 mm.

3.Panel Saw:

Panel Saw is about 500 mm long with 10 to 12 teeth per 25 mm similar to cross cut saw.

- It has a finer blade and is used for fine work mostly on bench.

4.Tenon or back saw:

It is use for cross cutting when a fine and more accurate finish cut is required.

- The blade is very thin & re-in forced with a rigid steel back.
- Blades are from 250 to 400 mm 13 teeth per 25 mm.

- Teeth are shaped in the form of equilateral triangle and are sometimes peg teeth.

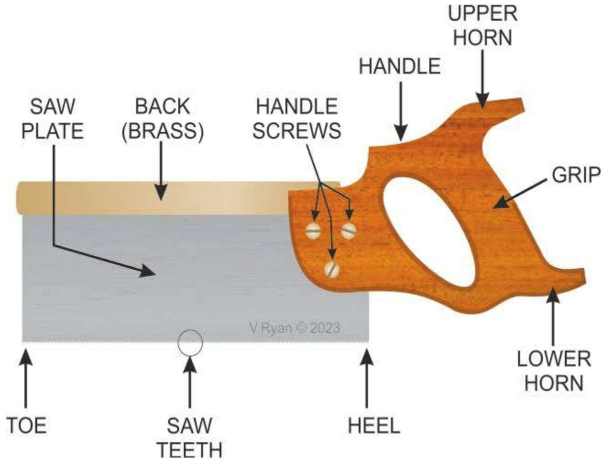


Fig: Rip Saw.

5.Dovtail saw:
It is the smaller version of tenon saw.

- It is use when greatest accuracy and shallow cuts are required.
- 12 to 18 teeth per 25 mm and length vary from 200 to 350 mm.

6.Compass saw:
It is use for cutting small curve in confined spaces and has narrow tapering blade 250 to 400 mm.

7.Pad & keyhole saw:
It is smallest saw; blade is above 25 mm long.

- The blade of the pad saw is screwed to the handle, through which it passes by two screws.
- This arrangement allows the blade to be adjusted to the best length required according to the work.
- This saw is used for cutting key holes or the starting of any interior cuts.

Chiseling:
Chiseling is a wood working technique that involves using a chisel to cut, shape or sculpt wood.

1.Firmer chisel:
The most useful chisel for general purpose may be used by hand pressure or mallet.

- It has a flat blade about 125 mm long.
- The width of blade varies from 1.5mm to 50 mm.

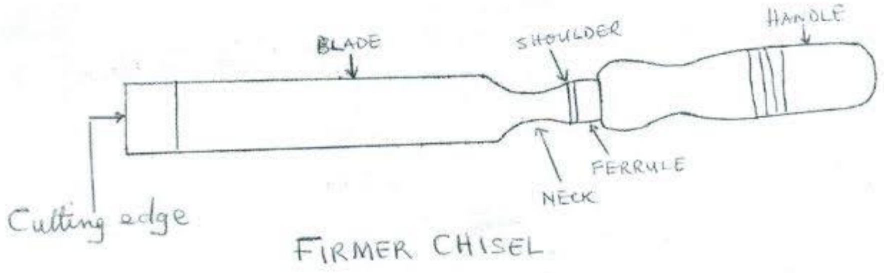


Fig: Firmer chisel.

2.Beveled edge firmer chisel:

It is use for more delicate and fine work.

- They are useful for getting into corners where ordinary firmer chisel would be clumsy.

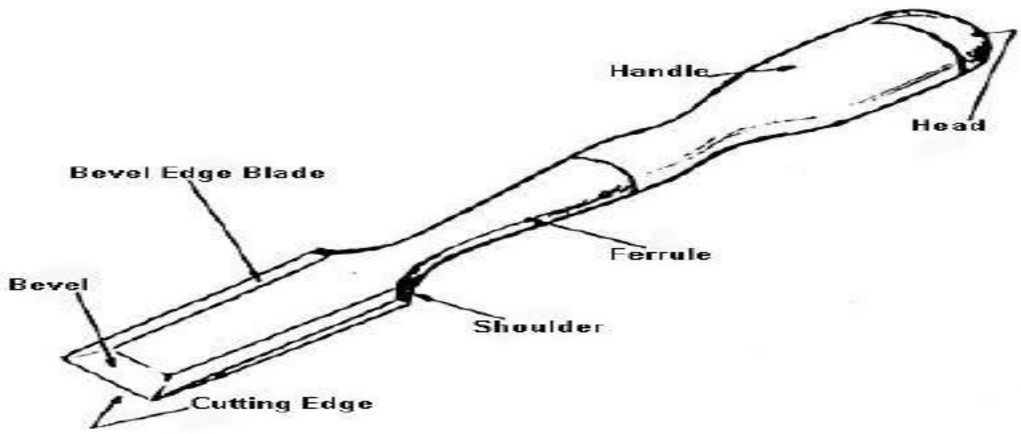


Fig: Beveled edge firmer chisel.

3.Paring chisel:

Both firmer and bevel edge chisel when they are made with long thin blades are known as paring chisel.

- This is used for shaping and preparing the surface of the wood and is manipulated by the hands.
- Length varies from 225 to 500 mm and with 5-50 mm.

4.Mortise chisel:

The mortise chisel as its name indicate is used for chopping out mortise.

- These chisels are designed to withstand heavy work.
- They are made with a heavy deep blade with a generous shoulder or collar to withstand the force of mallet blows on the oval section handled, many chisel are fitted with a leather washer at the shoulder to absorb the shock of the mallet blows.
- Blades vary in width in 3-16 mm.

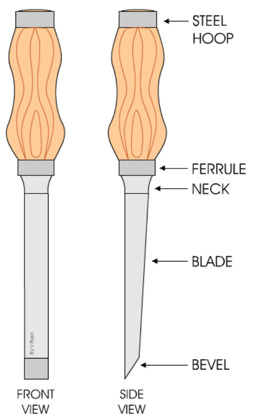


Fig: Mortise chisel.

Gouges:

Gouges are chisels with curved section and may be either inside or outside ground.

- In side ground gouges are used in exactly the same way for inside curved edges as a chisel would be for straight on.
- Outside ground gouges are used for curving hollows.

- Outside gouges are known as firmer gouge.
- Inside gouges are called scribing gouges.

Planing:

To make the surface of a piece of wood flat and smooth using a plane.

1.Metal jack plane:

The body of a metal plane is made of grey cast iron (casting) with the side and sole machined and ground to a bright finish.

- The thickness of the shaving removed governed by a fine screw adjustment and a lever is used for adjusting the blade at right angles.

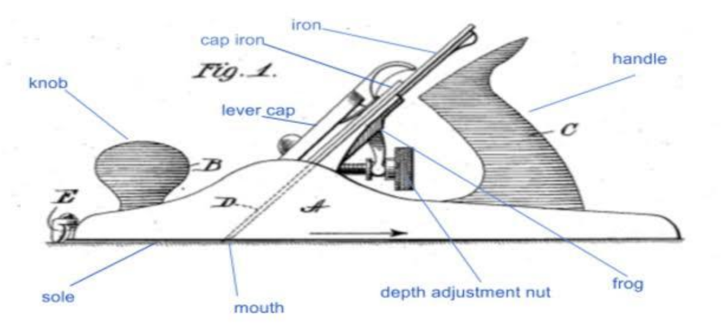


Fig: Metal jack plane.

2.Thickness planer:

A Thickness planer is a woodworking machine to trim boards to a consistent thickness throughout their length and flat on both surfaces.

3.Electric planer:

An electric planer machine or simply electric planer is a powered tool used for smoothing and shaping wood surfaces.

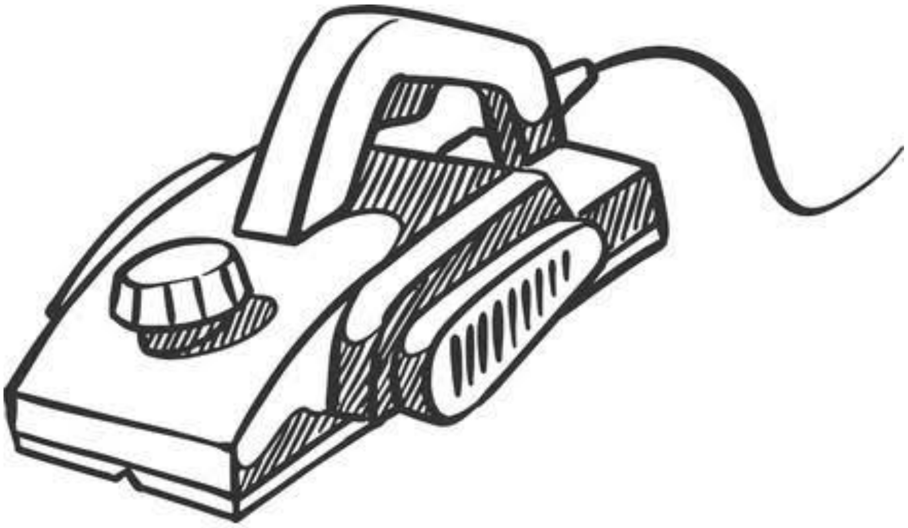


Fig: Electric planer.

Boring tools:

Boring tools in carpentry are used to create holes in wood, primarily for inserting screws, nails, or dowels, and for creating features like mortise and tenons. Common tools include brace and bits, gimlets, bradawls and auger bits.

1.Auger bits:

An Auger tool bit used with a carpenter's brace for drilling holes in wood.

- It looks like a corkscrew and has parts: screw, spurs, cutting edges, twist, shank, and tank.

2.Ratchet brace:

A rachet brace, also known as a brace and bit, is a hand tool used for drilling holes or driving screws into wood.

- The ratchet mechanism allows for short, reciprocal movements, making it use full in tight space or when a full 360- degree rotation is restricted.
- It's particularly helpful when drilling large holes or working with hars wood, as the ratchet action helps to apply pressure with the handle.

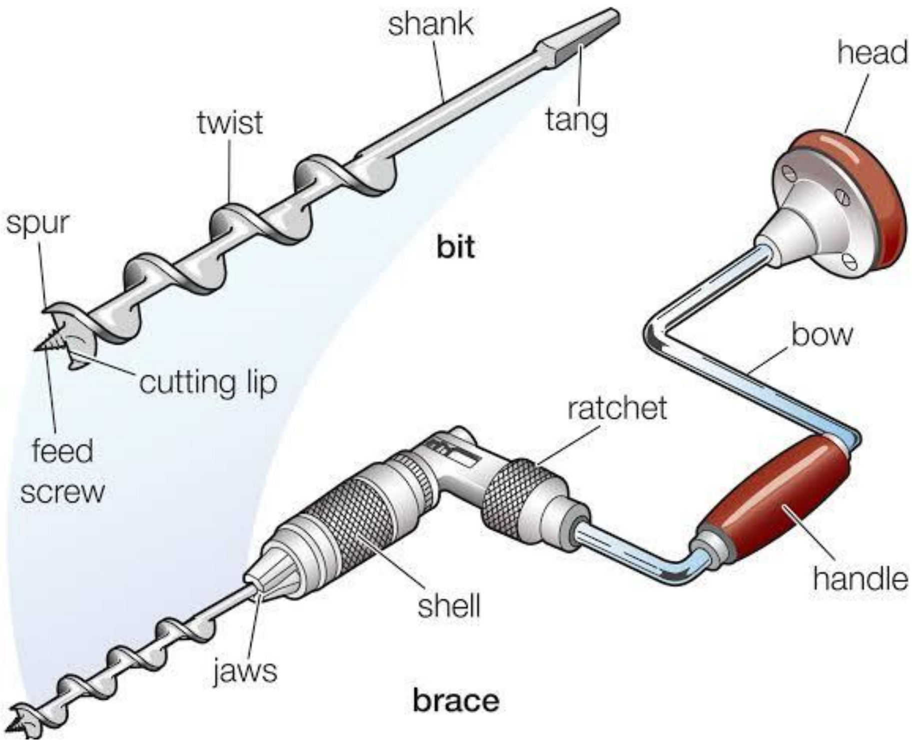


Fig: Ratchet brace.

Striking tools:

Striking tools are hand tools used to apply force through impact to an object like hammering nails and others.

1.Mallet:

A mallet is a tool, often made of wood or rubber, with a large head and a handle, used for striking or hammering objects.

- It is designed to deliver controlled force without causing damage to the object being stuck.
- Mallets are used in various applications, including woodworking, carpentry, and even sports like coroquet and polo.

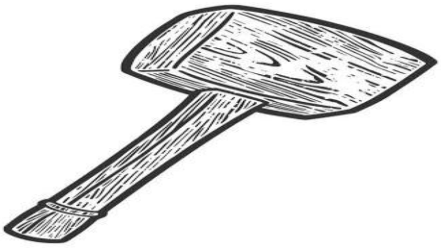


Fig: Mallet.

2.Ball peen hammer:

A ball peen hammer is a metal working tool primarily used for shaping, peening, and reverting metal.

- Its flat face is used for striking, while the rounded peen is used for rounded peen is used for rounding of edges, shaping, and applying compressive forces to the metal.

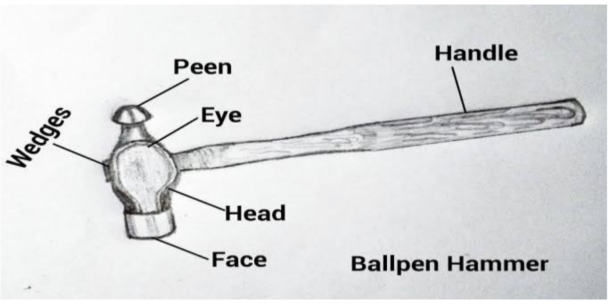


Fig: Ball peen hammer.

3.Claw hammer:

A claw hammer is a hammer primarily used in carpentry for driving nails into or pulling them from wood.

- It is not suitable for heavy hammering on metal surfaces.

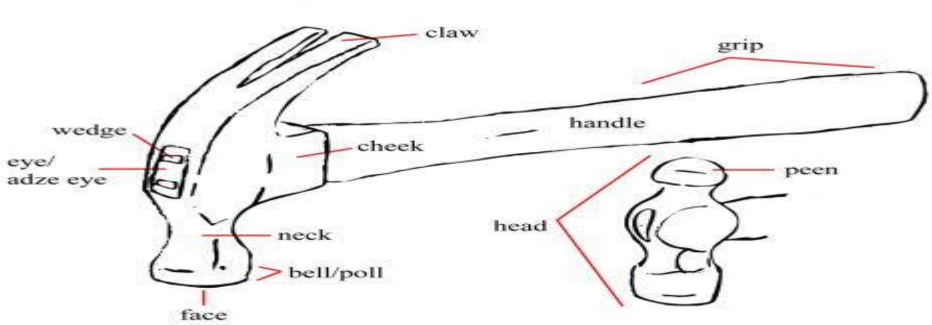


Fig: Claw hammer.

Holding tools:

To enable the woodworker to cut his wood accurately, it must be held steady. There are number of tools and devices to hold wood having its own purpose according to the kind of cut to be done.

1.Bench vice:

The vice is most commonly used. It's one jaw is fixed to the side of the table while the other is kept moveable by means of a screw and handle.

- The whole vice is made of iron and steel; the jaws being lined with hardwood face which do not mark and which can be renewed as required.

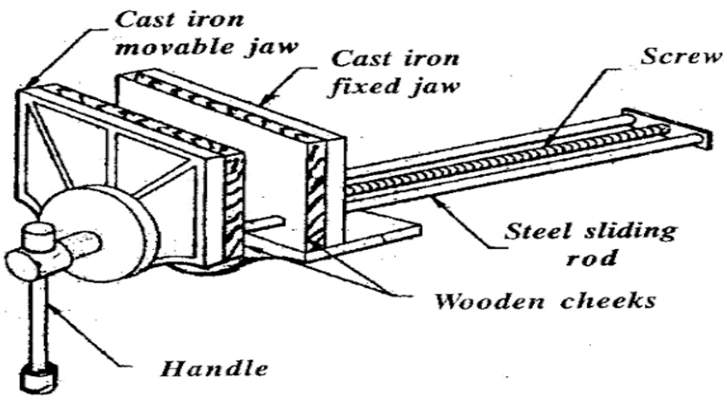


Fig: Bench vice.

2.Sash cramp:

The sash cramp or bar cramp is made up of a steel bar of rectangular section, with malleable iron fitting and a steel screw.

- This is used for holding wide work such as frames or tops.

3.G-Cramp:

The G-cramp is used for smaller work. It consists of a malleable iron frame that can be swiveled and a steel screw to which is fitted a thumb screw.

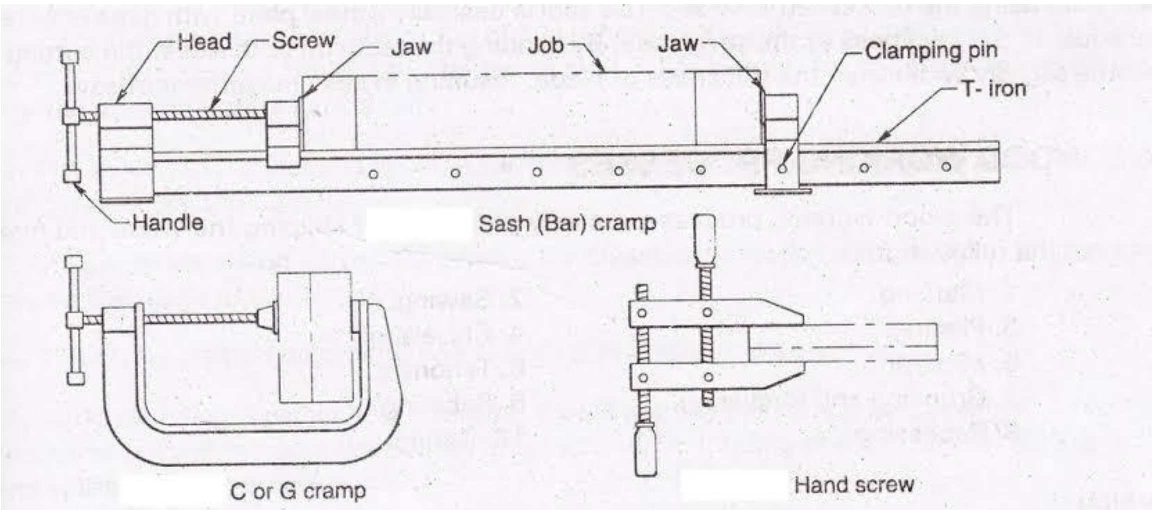


Fig: G-Cramp.

Miscellaneous tools:

1.Rasp & Files:

The file is used to shape, refine and to smooth out surfaces. The rasp is used to take larger shavings of material off. The rasp is often used to chamfer corners or remove sharp points, as well as for rounding and shaping.

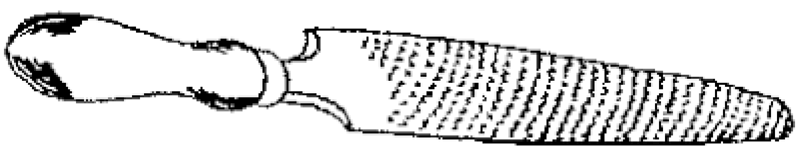


Fig: Rasp & Files.

2.Pincer:

A tool made of two pieces of metal with blunt concave jaws that are arranged like the blades of scissors, used for gripping and pulling things.

- They are used to pinch, cut or pull an object. Pincers are first-class levers. Pincers differ from pliers in that the concentration of force is either to a point, or to an edge at a right angle to the handle of the tool.

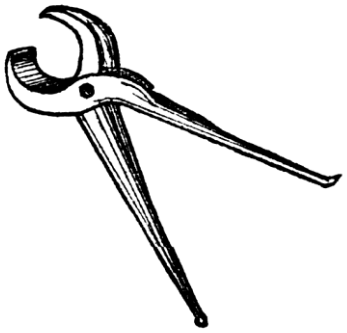


Fig: Pincer.

Preparation of Job: Carpentry job involving different types of joint.

Aim of The Experiment: To make a wooden stool / bench / rack.

Raw Materials Required:

Sal wood and dimension will be as per diagram and instructed by concerned person.

Tools Required:

i. Steel rule
ii. Try square
iii. Bevel square
iv. Straight edge
v. Marking gauge
vi. Mortise gauge
vii. Metal jack plane
viii. Thickness planer
ix. Mortise chisel
x. Firmer chisel
xi. Bench vice
xii. Sash cramp
xiii. Mallet
xiv. Ball peen hammer
xv. Rasp file

Operation to be performed:

1. Sawing
2. Planning
3. Marking
4. Chiseling
5. Boring
6. Assembling
7. finishing

Procedure:

1. At first, check measurements of all the unfinished work pieces provided. Then perform sawing operation on these unfinished work pieces taking a little bit more measurement say 10 mm than that indicated in the diagram.
2. Choosing the best surface, do planning operation a little on this surface. Check trueness is perfect mark it as No. 1 surface which will be treated as reference plane for other three planes.
3. Then plane another good surface adjacent to No. 1 face and mark No. 2 on it.
4. Next do marking operation using marking gauge only as per the measurement indicated in the diagram.

5. Plane these faces and mark No. 3 & No. 4 face.

6. Then draw mortising and tenoning mark line on No. 2 & No. 4 faces as per the measurement provided in the diagram by using mortise gauge.

(Gauge: - pronounced as gej not gej)

7. Then do sawing operations by using tenon saw to generate the tenons on the job.

8. Carry out chiseling operation on the job with the help of mortise chisel and firmer chisel. Depth of mortise hole is 34mm.

9. Assemble the individual work pieces by involving mortise and tenon joints and other suitable joints.

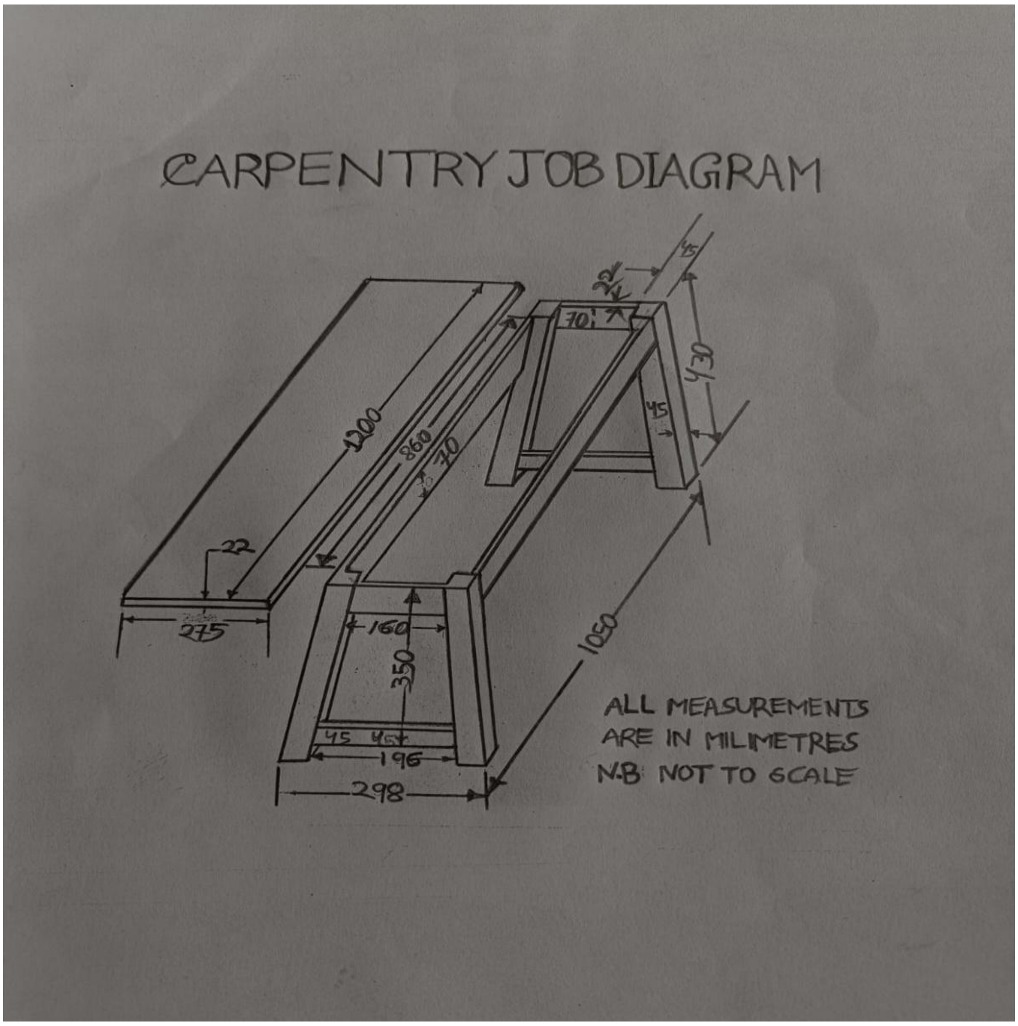
10. Use sand paper in order to provide finishing to the job. Punch your Roll number on the job and submit it for evaluation.

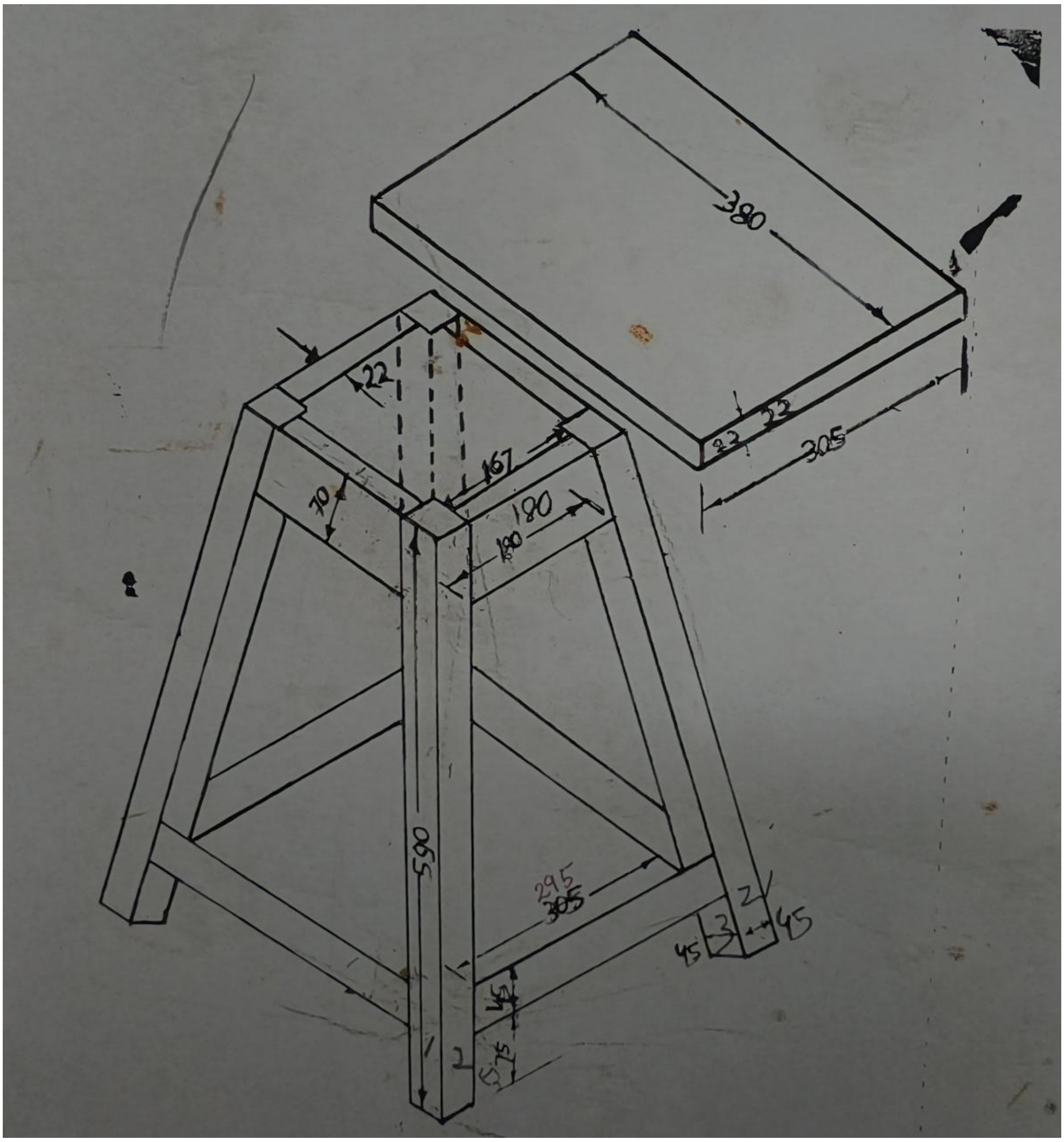
Precautions:

1. Wood must be free from moisture.
2. Marking should be done without parallel error.
3. Care should be taken while chiseling and tenoning.
4. Proper joining of two matting parts tightly.

Conclusion:

The wooden stool/bench/rack is made success fully.

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FITTING SECTION

Experiment Number-02

Aim of The Experiment: Preparation of job in fitting section/Study of lathe and turning operation.

A. Study of different Hand tools, measuring instruments and equipments used in Fitting work. Safety precautions. Study of Drilling Machine and Grinding Machine. Includes the operations: Measuring, Marking, Filing, Sawing, Drilling, Tapping, Dieing and Punching.

The term *fitting*, is related to assembly of parts, after bringing the dimension or shape to the required size or form, in order to secure the necessary fit. The operations required for the same are usually carried out on a work bench, hence the term *bench work* is also added with the name *fitting.*

The bench work and fitting play an important role in engineering. Although in today's industries most of the work is done by automatic machines which produces the jobs with good accuracy but still it (job) requires some hand operations called fitting operations. The person working in the fitting shop is called fitter.

Fitting tools:

Fitting shop tools are classified as below:

- Work Holding Devices/ Clamping Tools.
- Measuring and Marking Tools.
- Cutting Tools.
- Striking Tools.
- Drilling Tools.
- Threading Tools.

Work holding devices /clamping tools:

1. **Work Bench:**

- A fitting process can be done at various places, but most of the important operations of fitting are generally carried out on a table called *work bench*.
- The work bench is a strong, heavy and rigid table made up of hard wood.
- The size of the work bench required is about 150 to 180 cm length, nearly 90 cm width and approximately 76 to 84 cm height.

2. **Bench vice:**

It is firmly fixed to the bench with the help of nuts and bolts. It consists of a cast Iron body and cast-iron jaws. Two jaw plates are fitted on both the jaws. The holding surface of the jaw plates is knurled in order to increase the gipping. Jaw plates are made up of carbon steel and are wear resistant. One jaw is fixed to the body and the second slides on a square threaded screw with the help of a handle.

The jaws are opened up to required length; job is placed in the two jaws and is fully tightened with the help of handle. Handle is used to move the movable jaw.

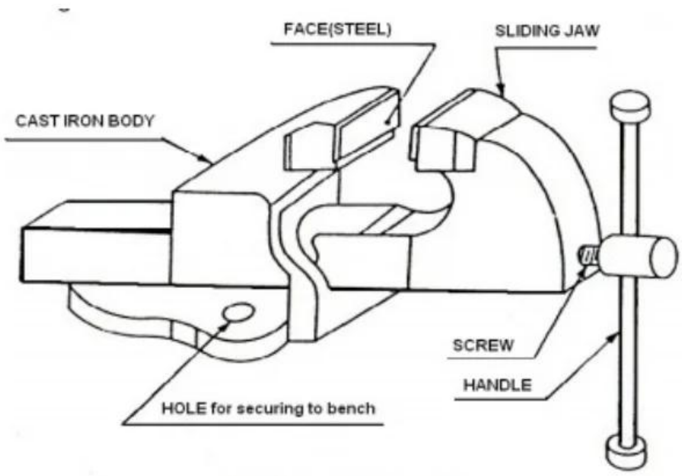


Fig: Bench Vice.

3. V Block:

In V Block, V grooves are provided to hold the round objects longitudinally. The screw of the clamp applies the holding pressure. When the handle is rotated there is movement in the screw.

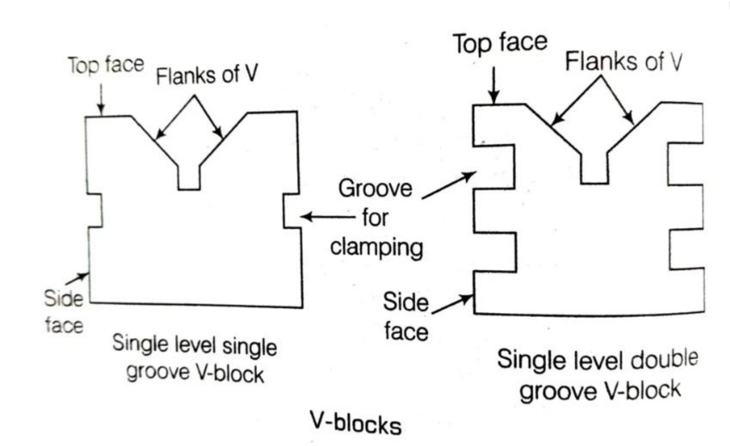


Fig: V Blocks.

I. Measuring tools:

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**.**

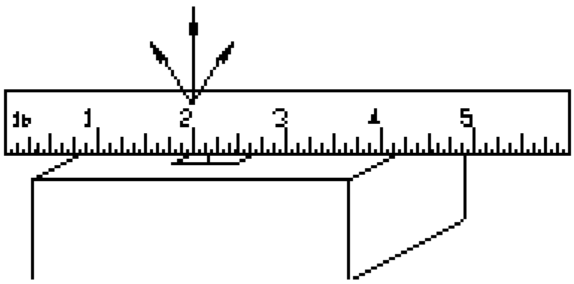


Fig: Steel Rule.

Calipers:

These are generally used to measure the inside or outside diameters. Different types are:

- Outside Caliper: It is used to measure the outside dimensions.
- Inside Caliper: It is used to measure the inside dimensions.
- Spring Caliper: Spring is provided to apply the pressure and lock nut is provided to lock any desired position.
- Hermaphrodite, Jenny or Odd leg Caliper: One leg is bent at the tip inwardly and the other has a straight pointed end. It is used to scribe lines parallel to the straight edges.

Vernier Caliper:

It is used for measuring the outer dimensions of round, flat, square components and also the inner size of the holes and bore. A narrow blade is used to measure the depth of bar slots etc. The reading accuracy in metric system is 0.02 mm and British system it is 0.001”. It is made of stainless steel.

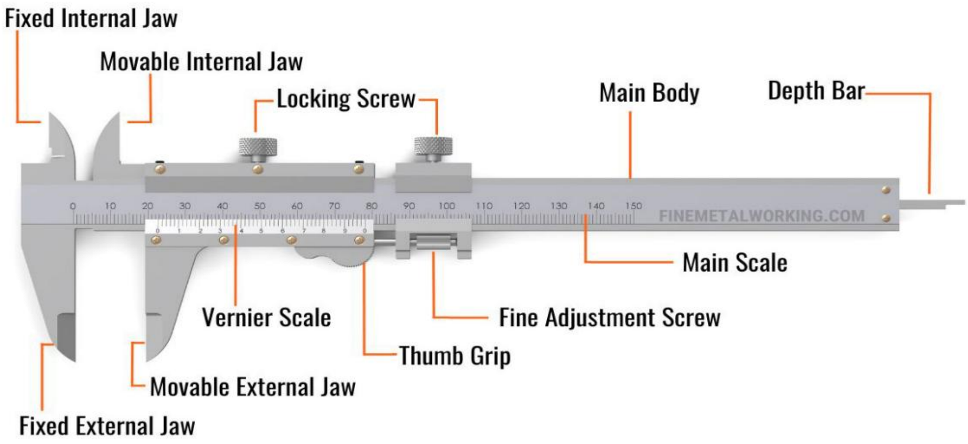


Fig: Vernier Caliper.

II. Marking Tools:

1. Surface Plate:

- It is used for testing the flatness, trueness of the surfaces. It is made up of cast iron or graphite. Its upper face is planned to form a very smooth surface. It is also used in scribing work.
- While not in use, it should be covered with a wooden cover.

2. Angle Plate:

- It is made up of cast iron in different sizes; it has two planed surfaces at right angles to each other and has various slots in each surface to hold the work by means of bolts and clamps.
- Never do hammering on the angle plate to fasten (lighten) the nuts and bolts.

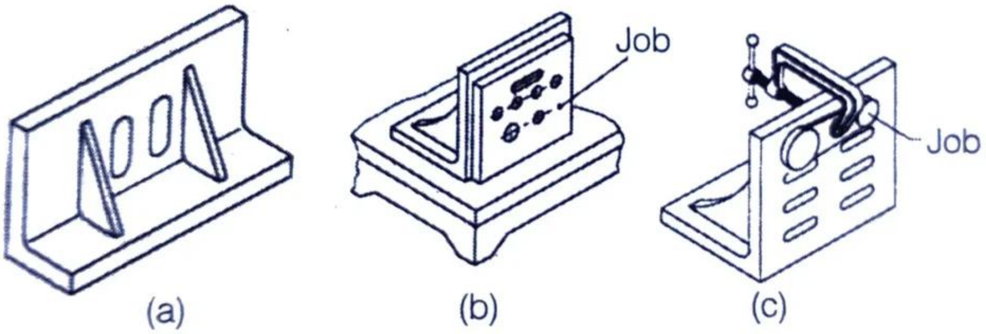


Fig: Angle Plates.

3. **Scriber and Surface Gauge:**

- It consists of a cast iron bass on the center of which a steel rod is fixed vertically. Scriber is made up of high carbon steel and is hardened from the front edge.
- It is used for locating the centres of round bars or for marking of the lines.

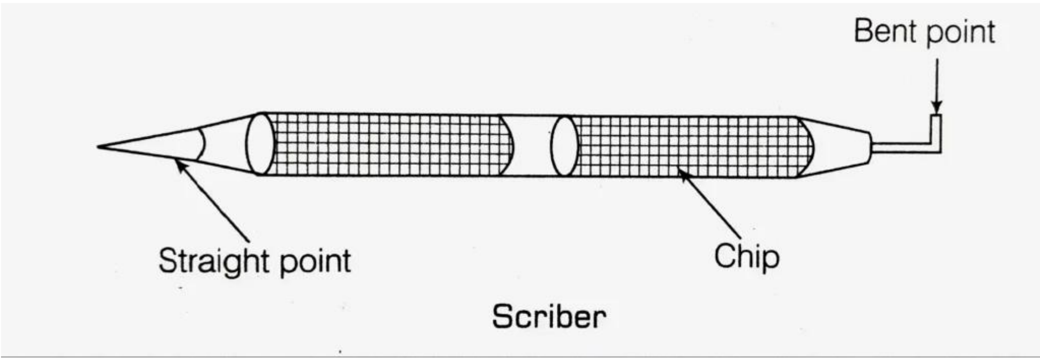


Fig: Scriber.

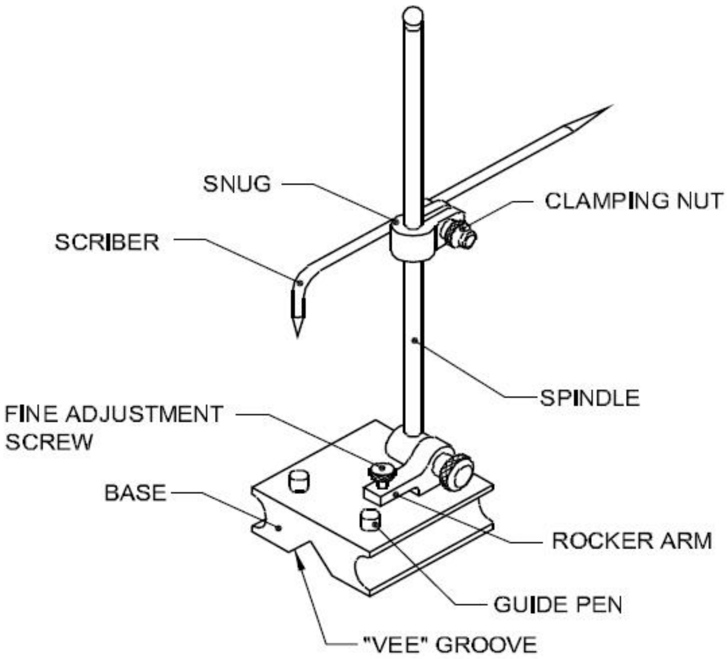


Fig: Surface Gauge.

4. Punches:

- Punches are used for marking purposes. Dot punches are used for marking dotted line and centre punch is used to mark the centre of hole before drilling.
- Punches are made up of high carbon steel or high-speed steels. One end is sharpened. Hammering is done on the second end while working.
- For dot punch, angle of the punching end is 60 degrees while in centre punch; angle of punching end is 90 degrees.

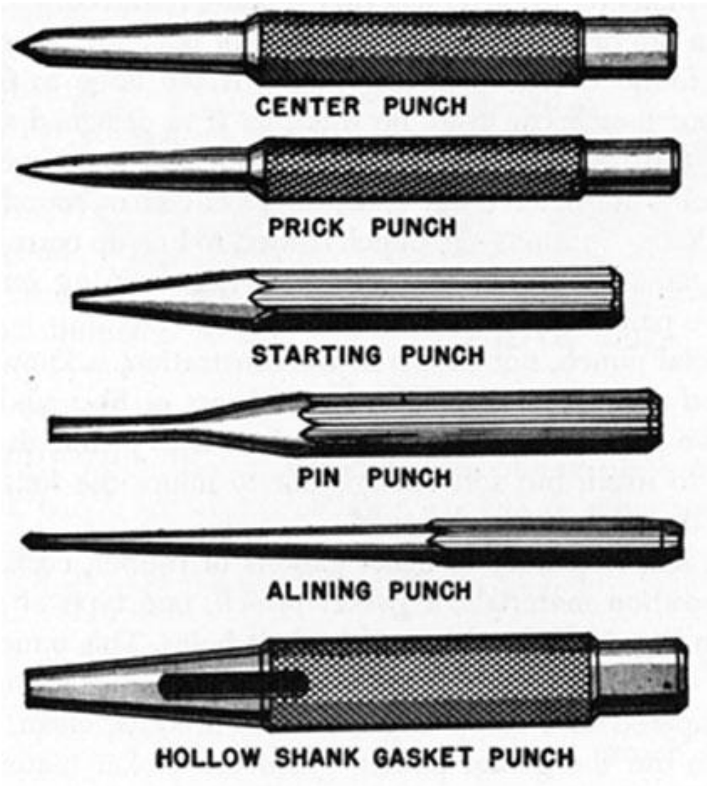


Fig: Punches.

5. Try Square:

- It is used for checking squareness of two surfaces. It consists of a blade made up of steel, which is attached to a base at 90 degrees.
- The base is made up of cast iron or steel. It is also used to mark the right angles and measuring straightness of surfaces. Never use try square as a hammer.

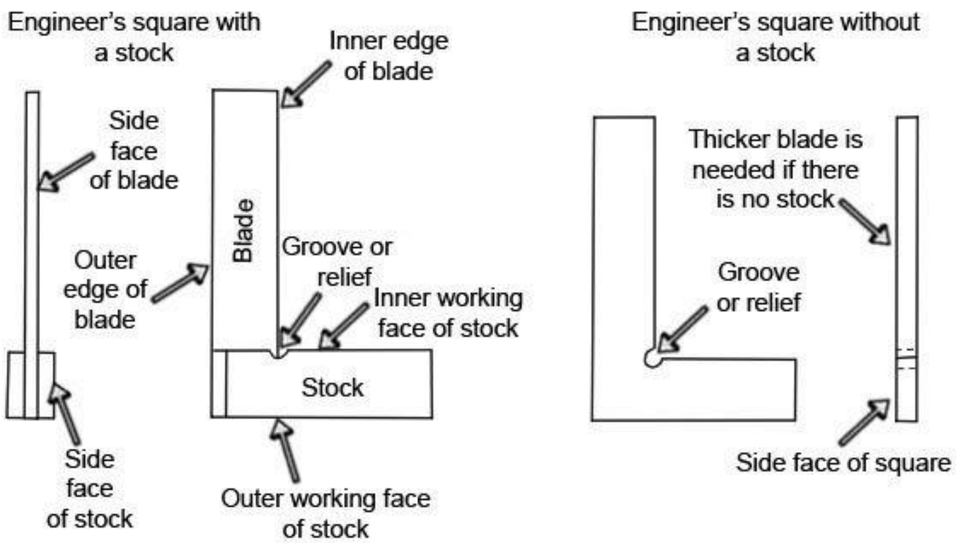


Fig: Try Square.

6. **Vernier Height gauge:**

- A Vernier height gauge consists of a heavy base, a graduated beam, a sliding head with Vernier sliding jaws holding the scriber and a fine adjustment clamp.
- It is similar to large Vernier calipers in construction, except that it consists of a heavy base which allows the gauge to stand upright instead of a fixed jaw in a Vernier.
- The movable jaw of Vernier height gauge consists of a projection or extension which is levelled to sharp edge for scribing lines at any required height.

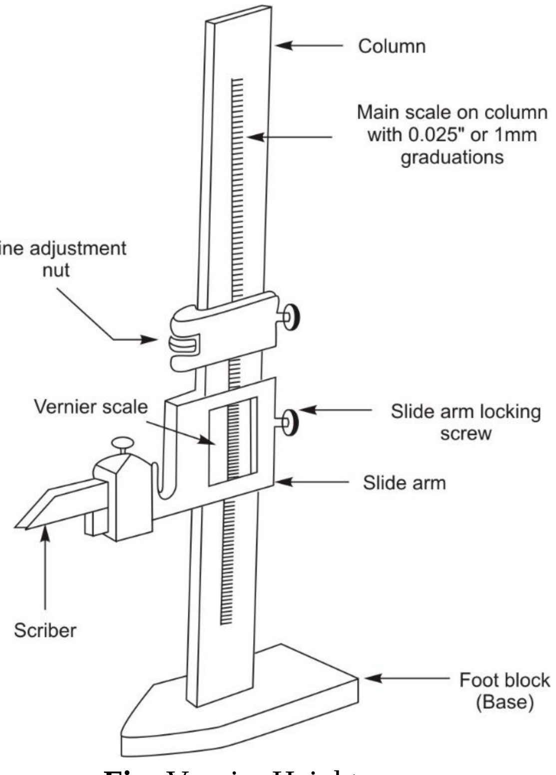


Fig: Vernier Height gauge.

Method Of Marking:

Marking means setting out dimensions with the help of a working drawing or directly transferring them from a similar part. The procedure of marking is as follows:

1. The surface to be marked is coated with the paste of chalk or red lead and allowed to dry.
2. Then the work is held in a holding device depending upon shape
and size. If it is flat, use surface plate, if it is round use V block and clamp, else use angle plate etc.
3. Lines in horizontal direction are scribed by means of a surface gauge. Lines at right angles can be drawn by turning the work through 90 degree and then using the scriber. If true surface is available, try square can also be used.
4. The centre on the end of a round bar can be located by using an odd leg caliper, surface gauge etc.
5. The circles and arcs on a flat surface are marked by means of a divider.
6. After the scribing work is over, indentations on the surface are made using dot punch and hammer.

III. Cutting Tools:

1. Hacksaw:

- Hacksaw is used for cutting of rods, bars, pipes, flats etc. It consists of a frame, which is made from mild steel. The blade is placed inside the frame and is tightened with the help of a flange nut. The blade is made up of high carbon steel or high-speed steel.
- The points of the teeth are bent in a zig-zag fashion, to cut a wide groove and prevent the body of the blade from rubbing or jamming in the saw cut. The teeth of the blades are generally forward cut so in the case; pressure is applied in the forward direction only.
- Depending upon the direction of cut, blades are classified as:

o Forward cut

o 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)

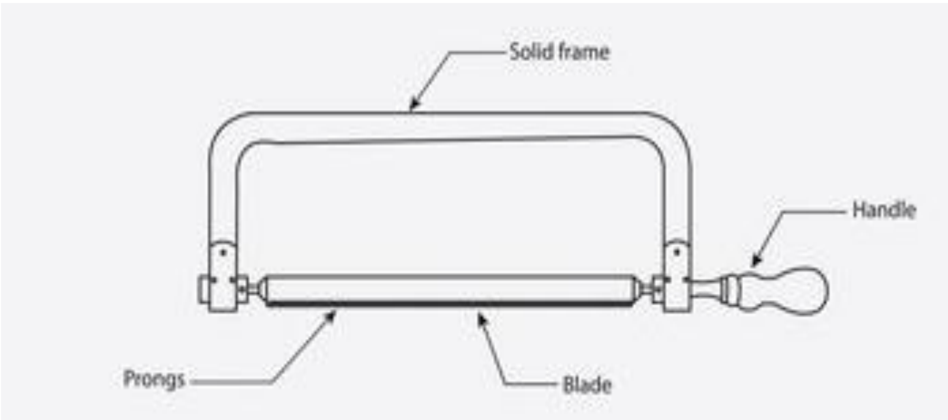


Fig: Hacksaw.

Files are multi points cutting tools. It is used to remove the material by rubbing it on the metals. Files are available in a number of sizes, shapes and degree of coarseness.

Classification of files:

i. On the basis of length
4”,6”,8”,12”

ii. On the basis of grade:

- Rough (R) (20 teeth per inch)
- Bastard (B) (30 teeth per inch)
- Second cut (Sc) (40 teeth per inch)
- Smooth file (S) (50 teeth per inch)
- Dead smooth (DS) (100 teeth per inch)
  - Rough and bastard files are the big cut files. When the material removal is more, these files are used. These files have bigger cut but the surface produced Is rough.
  - Dead smooth and smooth files have smaller teeth and used for finishing work. Second cut file has degree of finish in between bastard and smooth file.

iii. On the basis of number of cuts:

- Single cut files.
- Double cut files.
- Rasp files.
  - In single cut files the teeth are cut in parallel rows at an angle of 60 degree to the face.
  - Another row of teeth is added in opposite direction in case of double cut files. Material removal is more in case of double cut files.

iv. On the basis of shape and size:

The length of the files varies from 4' to 14*. The various shapes of cross-section available are hand file, flat file, triangular, round; square, half round, knife-edge, pillar, needle and mill file.

a. Flat file: This file has parallel edges for about two-thirds of the length and then it tapers in width and thickness. The faces are double cut while the edges are single cut.

b. Hand file: for a hand file the width is constant throughout, but the thickness tapers as given in flat file. Both faces are double cut and one edge is single cut. The remaining edge is kept uncut in order to use for filing a right-angled corner on one side only.

c. Square file: It has a square cross-section. It is parallel for two-thirds of its length and then tapers towards the tip. It is double cut on all sides. It is used for filing square corners and slots.

d. Triangular file: It has width either parallel throughout or up to middle and then tapered towards the tip. Its section is triangular (equilateral) and the three faces are double cut and the edges single cut. It is used for filing square shoulders or comers and for sharpening wood working saws.

e. Round file: It has round cross-section. It carries single cut teeth all round its surface. It is normally made tapered towards the tip and is frequently known as rat-tail file. Parallel round files having same diameter throughout the length are also available. The round files are used for opening out holes, producing round comers, round-ended slots etc.

f. Half-round file: Its cross-section is not a true half circle but is only about one-third of a circle. The width of the file is either parallel throughout or up to middle and then tapered towards the tip. The flat side of this file is always a double cut and curved side has single cut. It is used for filing curved surfaces.

g. Knife edge file: It has a width tapered like a knife blade and it is also tapered towards the tip and thickness. It carries double cut teeth on the two broad faces and single cut teeth on the edge. It is used for finishing sharp corners of grooves and slots

h. Diamond file: Its cross-section is like a diamond. It is used for special work.

i. Needle file: These are thin small files having a parallel tang and a thin, narrow and pointed blade made in different shapes of its cross-section to suit the particular need of the work. These are available in sizes from 100 mm to 200 mm of various shapes and cuts. These files are used for filing very thin and delicate work.

Fig: Files.

Methods of filing:

The following are the two commonly used methods of filing:

1. Cross-filing 2. Draw filing.

Cross – filing:

This method is used for efficient removal of maximum amount of metal in the shortest possible time. It may be noted that the file must remain horizontal throughout the stroke (long, slow and steady) with pressure only applied on the forward motion.

Draw filing:

This method is used to remove file marks and for finishing operations. Here, the file is gripped as close to the work as possible between two hands. In this filing method, a fine cut file with a flat face should be used.

File Card:

It is a device fashioned like a wire brush used to clean dirt and chips from the teeth of a file. When particles of metal clog the teeth the file is said to the pinned, a condition that causes scratching of the surface of the work. Files, therefore, require cleaning by means of a file card or by dislodging the material between the teeth by means of a piece of soft iron, copper, brass, tin plate and so on, sharpened at the end. Hardened steel should never be used

B. Paper Wt. / Square or Rectangular joint (male-female joint) (any one).

<u>Aim of The Experiment:</u> To prepare a square paper weight by using hand tools.

<u>Raw Materials Required:</u>

i. M.S (Mild Steel) Flat of – (50×50×10) mm.
ii. M.S Rod of – (50×6) mm.

<u>Tools Required:</u>

i. Steel Rule
ii. Hack Saw
iii. Flat File
iv. Scriber
v. Vernier Height Gauge
vi. Try-Square
vii. Center Punch
viii. Bench Vice
ix. Centre Punch
x. Power Hack Saw
xi. Drilling Machine

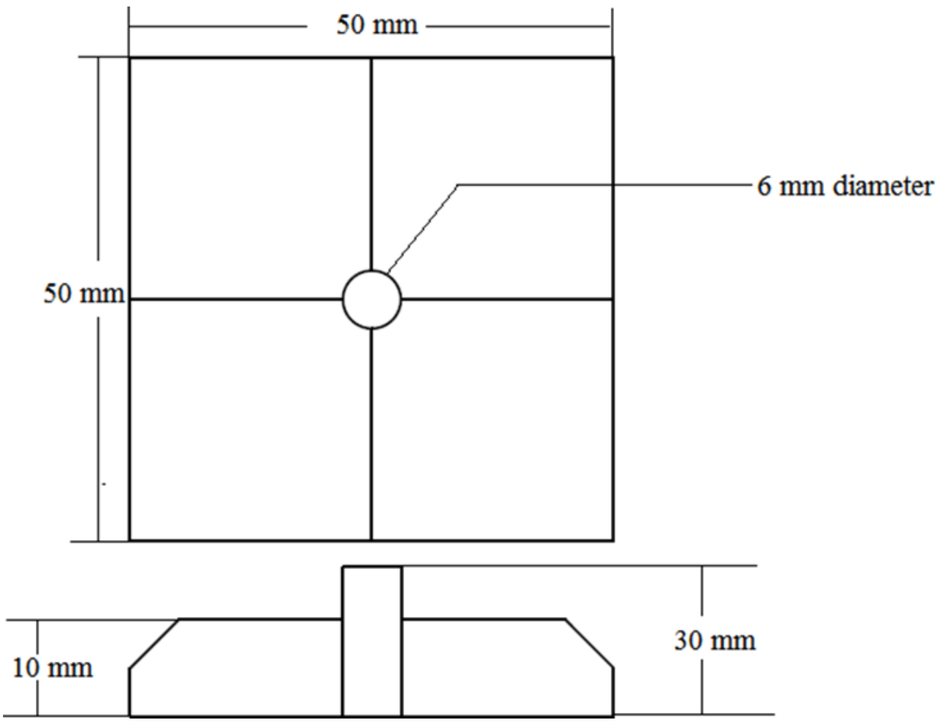


Fig: Square Paper Weight.

Procedure:

- Cut M.S square of (50×50×5) cross-section from a M.S flat by using power hacksaw.
- Fix the workpiece in the bench vice tightly.
- Filed the workpiece and after filing check the edges and surface of the workpiece with a Try-square to achieve perfect right angles.
- Draw lines on the front surface and side surfaces of the square block, which is 5mm away from the edges by using vernier height gauge.
- Create dotted marks on these lines by using a center punch, for clear visibility of these lines.
- Then use the square file to make chamfers (inclined surface at an angle of 45^0).
- Drill a hole of 6mm diameter at the center position of the square by using a parallel drilling machine.
- Cut a rod of 6mm diameter and 50mm by using hack saw.
- Pressed that rod on the hole produced at the center of the square block.
- Lastly apply a layer of paint on it, to avoid rusting.

Precautions:

- Tighten the job properly in the bench vice.
- The perpendicularity of face end edges is checked perfectly by using try square.
- Finishing is given by using only with smooth files.
- Marking is done without parallax error.

Conclusion:

The paper weight was prepared successfully and safely.

BLACK SMITH SECTION

Experiment Number-03

Aim of The Experiment: Preparation of job in black smith section/ Study of milling machine and milling operation.

A. Study of different Hand tools, equipments and Open-hearth furnace used in Blacksmith work. Different types of heat treatment processes. Safety precautions. Includes the operations: Measuring, Marking, Cutting, Upsetting, Drawing down, Bending, Fullering and Quenching.

Theory:

Blacksmith or Forging is an oldest shaping process used for the producing small articles for which accuracy in size is not so important. The parts are shaped by heating them in an open fire or hearth by the blacksmith and shaping them through applying compressive forces using hammer.

Thus forging is defined as the plastic deformation ofmetals at elevated temperatures into a predetermined size or shape using compressive forces exerted through some means of hand hammers, small power hammers, die, press or upsetting machine. It consists essentially of changing or altering the shape and section of metal by hammering at a temperature of about 980°C, at which the metal is entirely plastic and can be easily deformed or shaped under pressure. The shop in which the various forging operations are carried out is known as the smithy or smith's shop.

Hand forging process is also known as black-smithy work which is commonly employed for production of small articles using hammers on heated jobs. It is a manual controlled process even though some machinery such as power hammers can also be sometimes used. Black-smithy is, therefore, a process by which metal may be heated and shaped to its requirements by the use of blacksmith tools either by hand or power hammer.

Forging by machine involves the use of forging dies and is generally employed for mass-production of accurate articles. In drop forging, closed impression dies are used and there is drastic flow of metal in the dies due to repeated blow or impact which compels the plastic metal to conform to the shape of the dies.

Applications of forging:

Almost all metals and alloys can be forged. The low and medium carbon steels are readily hot forged without difficulty, but the high-carbon and alloy steels are more difficult to forge and require greater care. Forging is generally carried out on carbon alloy steels, wrought iron, copper-base alloys, aluminum alloys, and magnesium alloys. Stainless steels, nickel-based super alloys, and titanium are forged especially for aerospace uses.

Forgeability:

The ease with which forging is done is called forgeability. The forgeability of a material can also be defined as the capacity of a material to undergo deformation under compression without rupture. Forgeability increases with temperature up to a point at which a second phase, e.g., from ferrite to austenite in steel, appears or if grain growth becomes excessive.

Common hand forging tools:

For carrying out forging operations manually, certain common hand forging tools are employed. These are also called blacksmith's tools, for a blacksmith is one who works on the forging of metals in their hot state. The main hand forging tools are as under.

Tongs:

The tongs are generally used for holding work while doing a forging operation.

a) Straight-lip fluted tongs are commonly used for holding square, circular and hexagonal bar stock.

b) Rivet or ring tongs are widely used for holding bolts, rivets and other work of circular section.

c) Flat tongs are used for mainly for holding work of rectangular section.

d) Gad tongs are used for holding general pick-up work, either straight or tapered.

Flatter:

Flatter is commonly used in forging shop to give smoothness and accuracy to articles which have already been shaped by fullers and swages.

Swage:

Swage is used for forging work which has to be reduced or finished to round, square or hexagonal form. It is made with half grooves of dimensions to suit the work being reduced. It consists of two parts, the top part having a handle and the bottom part having a square shank which fits in the hardie hole on the anvil face.

Fuller:

Fuller is used in forging shop for necking down a forgeable job. It is made in top and bottom tools as in the case of swages. Fuller is made in various shapes and sizes according to needs, the size denoting the width of the fuller edge.

Punch:

Punch is used in forging shop for making holes in metal part when it is at forging heat.

Rivet header:

Rivet header is used in forging shop for producing rivets heads on parts.

Chisels:

Chisels are used for cutting metals and for nicking prior to breaking. They may be hot or cold depending on whether the metal to be cut is hot or cold. A hot chisel generally used in forging shop. The main difference between the two is in the edge. The edge of a cold chisel is hardened and tempered with an angle of about 60°, whilst the edge of a hot chisel is 30° and the hardening is not necessary. The edge is made slightly rounded for better cutting action.

Hand hammers:

There are two major kinds of hammers are used in hand forging:

a. The hand hammer used by the smith himself and

b. The sledge hammer used by the striker.

Hand hammers may further be classified as (a) ball peen hammer, (b) straight peen hammer, and (c) cross peen hammer.

Sledge hammers may further be classified as (a) Double face hammer, (b) straight peen hammer, and (c) cross peen hammer.

Hammer heads are made of cast steel and, their ends are hardened and tempered. The striking face is made slightly convex. The weight of a hand hammer varies from about 0.5 to 2 kg whereas the weight of a sledge hammer varies from 4 to 10 kg.

Set hammer:

A set hammer generally used in forging shop is shown in Fig. 14.9. It is used for finishing corners in shouldered work where the flatter would be inconvenient. It is also used for drawing out the gorging job.

Anvil:

An anvil is a most commonly tool used in forging shop which is shown in. It acts as a support for blacksmith's work during hammering. The body of the anvil is made of mild steel with a tool steel face welded on the body, but the beak or horn used for bending curves is not steel faced. The round hole in the anvil called pritchel hole is generally used for bending rods of small diameter, and as a die for hot punching operations. The square or hardie hole is used for holding square shanks of various fittings. Anvils in forging shop may vary up to about 100 to 150 kg and they should always stand with the top face about 0.75 mt. from the floor. This height may be attained by resting the anvil on a wooden or cast-iron base in the forging shop.

Swage block:

Swage block generally used in forging shop is shown in figure. It is mainly used for heading, bending, squaring, sizing, and forming operations on forging jobs. It is 0.25 mt. or even more wide. It may be used either flat or edgewise in its stand.

Forging operations:

The following are the basic operations that may be performed by hand forging:

1. Drawing-down:

Drawing is the process of stretching the stock while reducing its cross-section locally. Forging the tapered end of a cold is an example of drawing operation.

2. Upsetting:

It is a process of increasing the area of cross-section of a metal piece locally, with a corresponding reduction in length. In this, only the portion to be upset is heated to forging temperature and the work is then struck at the end with a hammer. Hammering is done by the smith (student) himself, if the job is small, or by his helper, in case of big jobs, when heavy blows are required with a sledge hammer.

3. Fullering:

Fullers are used for necking down a piece of work, the reduction often serving as the starting point for drawing. Fullers are made of high carbon steel in two parts, called the top and bottom fullers. The bottom tool fits in the hardie hole of the anvil. Fuller size denotes the width of the fuller edge.

4. Flattering:

Flatters are the tools that are made with a perfectly flat face of about 7.5 cm square. These are used for finishing flat surfaces. A flatter of small size is known as set-hammer and is used for finishing near corners and in confined spaces.

5. Swaging:

Swages like fullers are also made of high carbon steel and are made in two parts called the top and swages. These are used to reduce and finish to round, square or hexagonal forms. For this, the swages are made with half grooves of dimensions to suit the work.

6. Bending:

Bending of bars, flats, etc., is done to produce different types of bent shapes such as angles, ovals, circles etc. Sharp bends as well as round bends may be made on the anvil, by choosing the appropriate place on it for the purpose.

7. Twisting:

It is also one form of bending. Sometimes, it is done to increase the rigidity of the work piece. Small piece may be twisted by heating and clamping a pair of tongs on each end of the section to be twisted and applying a turning moment.

Larger pieces may be clamped in a leg vice and twisted with a pair of tongs or a monkey wrench. However, for uniform twist, it must be noted that the complete twisting operation must be performed in one heating.

8. Cutting (Hot and Cold Chisels):

Chisels are used to cut metals, either in hot or cold state. The cold chisel is similar to fitter’s chisel, except that it is longer and has a handle. A hot chisel is used for cutting hot metal and its cutting edge is long and slender when compared to cold chisel. These chisels are made of tool steel, hardened and tempered.

9. Iron-Carbon Alloy:

If the carbon is less than 2% in the iron-carbon alloy, it is known as steel. Again, based on the carbon content, it is called mild steel, medium carbon steel and high carbon steel. The heat treatment to be given to these steels and their applications are shown in table below.

NOTE: The forging produced either by hand forging or machine forging should be heat treated.

The following are the purposes of heat treatment:

i. To remove internal stresses set-up during forging and cooling.
ii. To normalize the internal structure of the metal.
iii. To improve machinability.
iv. To improve mechanical properties, strength and hardness.

	Carbon %	Hardening temp. 0C	Tempering temp. 0C	Applications.
Mild Steel	0.1	800-840	250-300	Chains, rivets, soft wire, sheet
	0.25	800-840	250-300	Tube, rod, strip
	0.5	800-840	250-300	Girders
	0.6	800-840	250-300	Saws, hammers, smith's and general purpose tools
Medium Carbon steel	0.75	760-800	250-300	Cold chisels, smith's tools shear blades, table cutlery
	0.9	760-800	250-300	Taps, dies, punches, hot shearing blades Drills, reamers, cutters, blanking and slotting tools, large turning tool
	1.0	760-800	250-300	
High Carbon	1.2	720-760	250-300	Small cutters, lathe and engraving tools, files drills
	1.35	720-760	250-300	Extra hard, planning, turning and slotting tools, dies and mandrels
	1.5	720-760	250-300	Razor blades

Safety precautions:

1. Hold the hot work downwards close to the ground, while transferring from the hearth to anvil, to minimize danger of burns; resulting from accidental collisions with others.
2. Use correct size and type of tongs to fit the work. These should hold the work securely to prevent its bouncing out of control from repeated hammer blows.
3. Care should be exercised in the use of the hammer. The minimum force only should be used and the flat face should strike squarely on the work; as the edge of the hammer will produce heavy bruising on hot metal.
4. Water face shield when hammering hot metal.
5. Wear gloves when handling hot metal.
6. Wear steel-toed shoes.
7. Ensure that hammers are fitted with tight and wedged handles.

B. Preparation of Job: S- hook/ Chisel (any one)

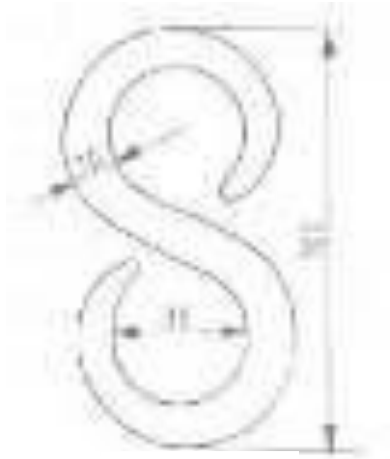
Aim of the experiment: To make an S-hook from a given round rod, by following hand forging operation.

Tools required:

Smith's forge**,** Anvil**,** 500gm and I kg ball-peen hammers, Flatters, Swage block, Half round tongs, Pick- up tongs, Cold chisel.

Sequence of operations:

1. One end of the bar is heated to red hot condition in the smith's forge for the required length.
2. Using the pick-up tongs; the rod is taken from the forge, and holding it with the half round tongs, the heated end is forged into a tapered pointed end.
3. The length of the rod requires for S-hook is estimated and the excess portion is cut-off, using a cold chisel.
4. One half of the rod towards the pointed end is heated in the forge to red hot condition and then bent into circular shape as shown.
5. The other end of the rod is then heated and forged into a tapered pointed end.
6. The straight portion of the rod is finally heated and bent into circular shape as required.
7. Using the flatter, the S-hook made as above, is kept on the anvil and flattened so that, the shape of the hook is proper.



S- HOOK

NOTE: In-between the above stage, the bar is heated in the smith's forge, to facilitate forging operations.

Result:

The S-hook is thus made from the given round rod; by following the stages mentioned above.

Precautions:

1. Hold the job carefully while heating and hammering
2. Job must be held parallel to the face of the anvil.
3. Wear steel-toed shoes.
4. Wear face shield when hammering the hot metal
5. Use correct size and type of tongs to fit the work.

TURNING/ MILLING SECTION (CONVENTIONAL & CNC)

Experiment Number-04

Aim of the experiment: Study of CNC lathe machine and turning on CNC lathe.

A. Study of Lathe Machine, different parts of Lathe and different applications of Lathe. Study of different measuring & marking instruments.

Apparatus Required:

- Centre lathe machine (engine lathe)

Theory:

A lathe is one of the most important and commonly used machine tools in any workshop. In a lathe, the workpiece is held and rotated about its own axis while a cutting tool is fed against it to remove material. Because many basic machine-tool principles are demonstrated on it, the lathe is often called the "mother of machine tools." A standard centre lathe consists of a rigid bed on which all other units are mounted, a headstock fixed at one end of the bed that houses the spindle and speed-change mechanism, a tailstock at the other end to support the free end of long workpieces or to hold tools, and a carriage assembly that carries and feeds the cutting tool. The carriage includes the saddle, cross-slide, compound rest, tool post, and apron, and it can be moved both longitudinally along the bed and transversely across it. The spindle in the headstock drives the workpiece, usually through a chuck or faceplate, while the lead screw and/or feed rod provide accurate motion for turning and thread cutting operations.

Using different tool geometries and feed arrangements, a wide variety of operations can be performed on a lathe. These include turning to reduce diameter and produce cylindrical surfaces, facing to obtain flat surfaces at the ends of the work, taper turning to generate conical profiles, parting (cutting off) to separate components, grooving and undercutting to produce relief features, and thread cutting using the lead screw and a single-point tool. The lathe can also be used for drilling, boring, reaming, and counterboring by holding the cutting tools in the tailstock and rotating the work in the chuck. Knurling operations are carried out with a knurling tool to produce a textured pattern on the surface for better grip. Proper understanding of the construction and functions of each lathe part is essential for safe and accurate machining.

Accurate machining also depends heavily on correct measurement and marking. Measuring instruments like the steel rule, vernier caliper, micrometer, height gauge, depth gauge, and bevel protractor are used to measure length, diameter, thickness, depth, and angles of components. The vernier caliper can measure external, internal and depth dimensions with better accuracy than a steel rule, while the micrometer is used when very fine accuracy is required in external or internal measurements. Height gauges used with a surface plate help in setting and marking heights from a reference plane. Bevel protractors enable precise angular measurement. Before machining, marking or layout instruments are used to transfer dimensions from the drawing onto the raw workpiece. For this purpose, a surface plate provides a flat reference surface, over which tools like scribers, surface gauges, try squares, dividers and punches are used. Marking blue is often applied on the surface so that the scribed lines are clearly visible. Try squares help check and mark 90° angles, dividers are used for arcs and circle divisions, and centre or prick punches make small indents at important points to guide drills and avoid tool slip. Thus, the combined study of the lathe machine with its parts and applications, along with the study of measuring and marking instruments, forms the basic foundation for all further machining and fitting operations in the workshop.

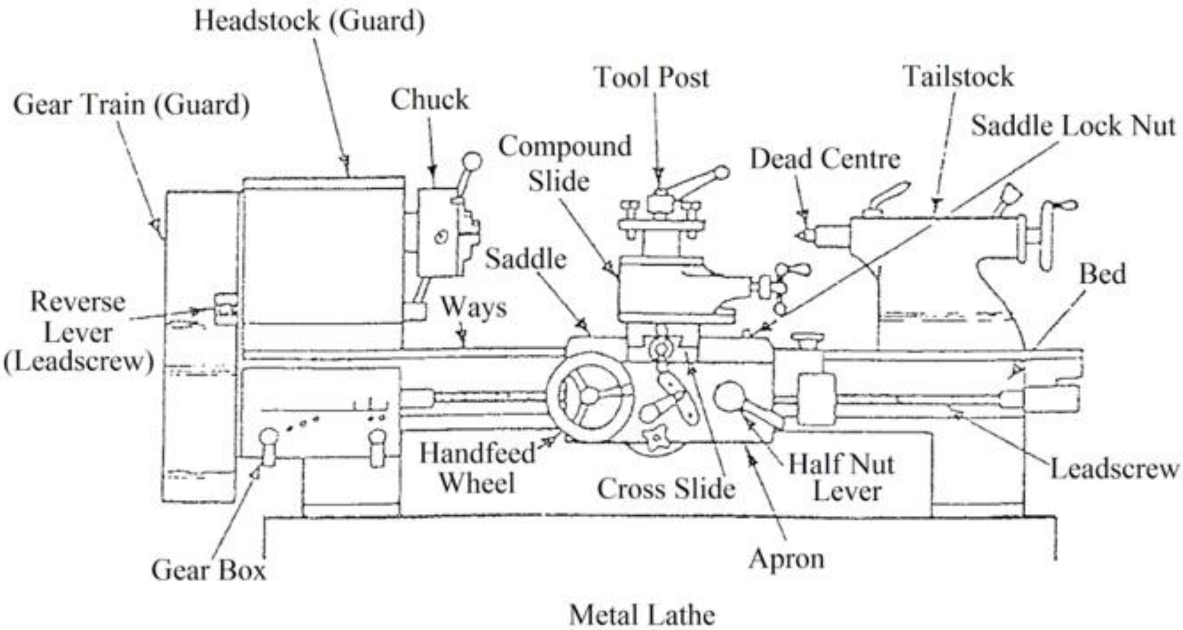


Fig: Schematic representation of a lathe machine.

Conclusion:

In this experiment, the construction and main parts of a centre lathe, such as the bed, headstock, tailstock, carriage, lead screw, feed mechanisms and tool post, were identified and their functions understood. The various applications of the lathe, including turning, facing, taper turning, threading, drilling, boring, parting, knurling and grooving, were conceptually studied. Different measuring instruments like the steel rule, vernier caliper, micrometer, height gauge, depth gauge and bevel protractor, as well as marking instruments such as the surface plate, scriber, surface gauge, try square, dividers and punches, were also observed and their uses understood. Hence, the aim of studying the lathe machine, its parts and applications, and the different measuring and marking instruments has been successfully achieved.

B. Study of Milling Machine, different parts and applications of Milling Machine. Study of different measuring & marking instruments.

Raw Materials Required:

Cast iron block of (50×50×50 mm)

Tools and Equipments Required:

i. Base pan hammer.
ii. Brush
iii. Vernier height gauge
iv. Vernier caliper
v. Spirit level
vi. Double ended spanner
vii. Milling Machine

Theory:

Milling machine is a machine tool that removes materials as the work is feed against the rotating multipoint cutter. The cutter rotated at a high speed and because of multiple cutting edges it removes material at very faster rate. The machine can hold one or more number of cutters at a time. This is why the milling machine finds its application in the production work. The mechanism of milling machine is composed of spindle drive mechanism and power feed mechanism. The spindle drive mechanism is incorporated in the column. The power is transmitted from the feed gear box. Telescopic shaft and universal joints are necessary to allow vertical movements. The main limitation of the milling machine is, it can't produce sharp corners.

Parts of Milling Machine:

1. **Base:** It is the foundation part of a milling machine. All other parts are jointed on it. It carries the entire load so it should have high compressive strength so it is made by cast iron. It also works as reservoir of cutting fluid.
2. **Column:** Column is another foundation part of milling machine. It is mountain vertically on the base. It supports the knee, table etc. Work as housing for the all the other driving member. It is a hollow member which contains driving gears and sometimes motor for spindle and the table.
3. **Knee:** Knee is the first moving part of milling machine. If is mounted on the column and moves along the slide ways situated over the column. It is made by cast iron and moves vertically on slide ways. It moves up and down on sideways which change the distance between tool and workpiece It is driven by mechanically or hydraulically.
4. **Saddle:** It is placed between table and the knee and work as intermediate part between them. It can move transversally to the column face. It slides over the guide ways provided situated on the knee which is perpendicular to the column face. The main function of it is to provide motion in horizontal direction to work piece. It is also made by cast iron.

5. **Table:** Table is situated over the knee. It is the part of machine which holds the work piece while machining. It is made by cast iron and have T slot cut over it. The work piece clamp over it by using clamping bolts. The one end of clamping bolt fix into this slot and other is fix to work piece which hold the work piece. It can provide three degrees of freedom to work piece.
6. **Spindle:** Spindle is the main part of the machine which hold tool at right place in vertical milling machine and hold arbor in horizontal milling machine. It is a moving part which is in rotary motion. It is motor driven and drives the tool. It has a slot on the front end of it. The cutting tool fix in that slot.
7. **Ram:** Ram is work as overhanging arm in vertical milling machine. One end of the arm is attached to the column and other end to the milling head.

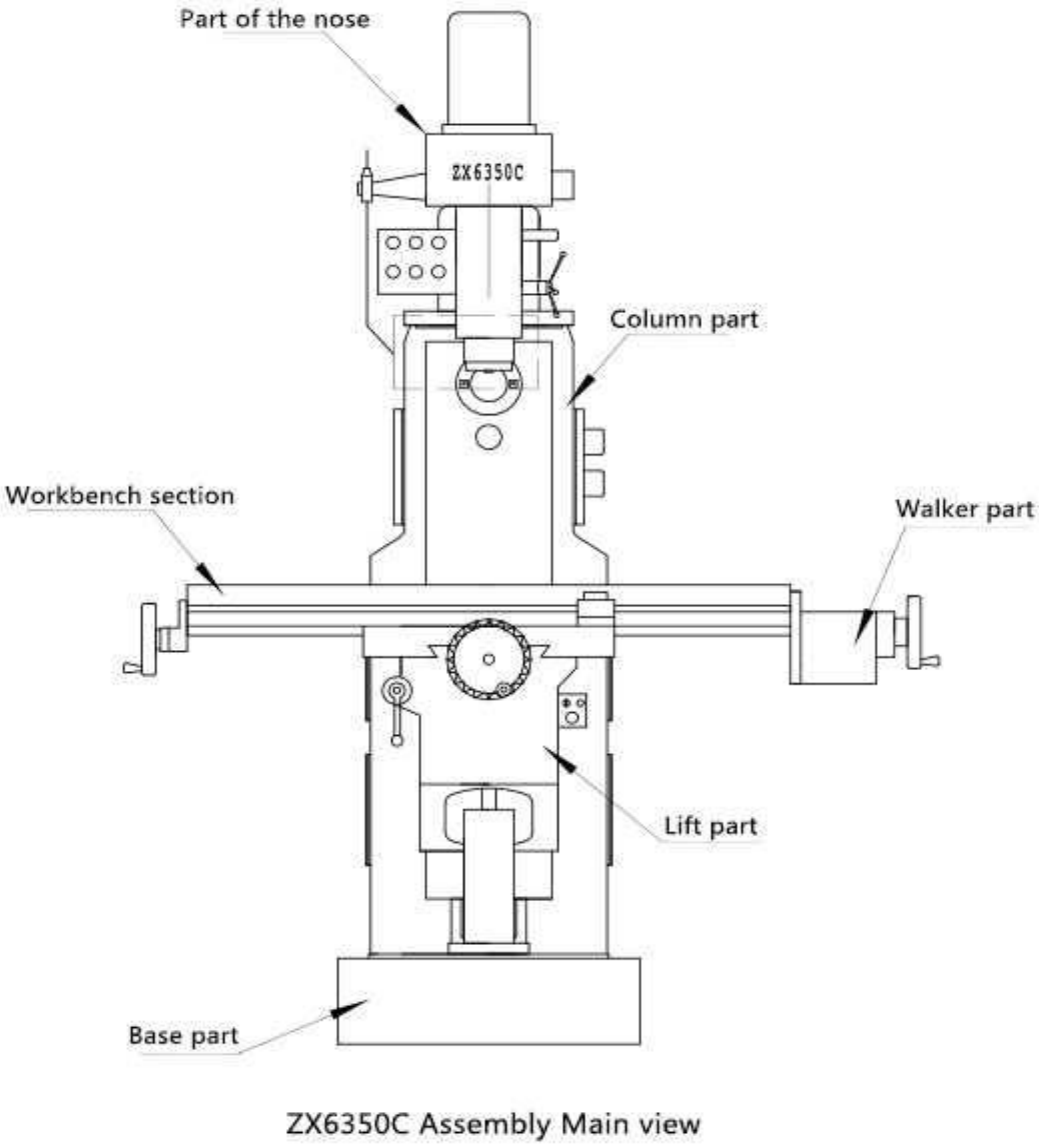


Fig: Schematic representation of a Milling Machine.

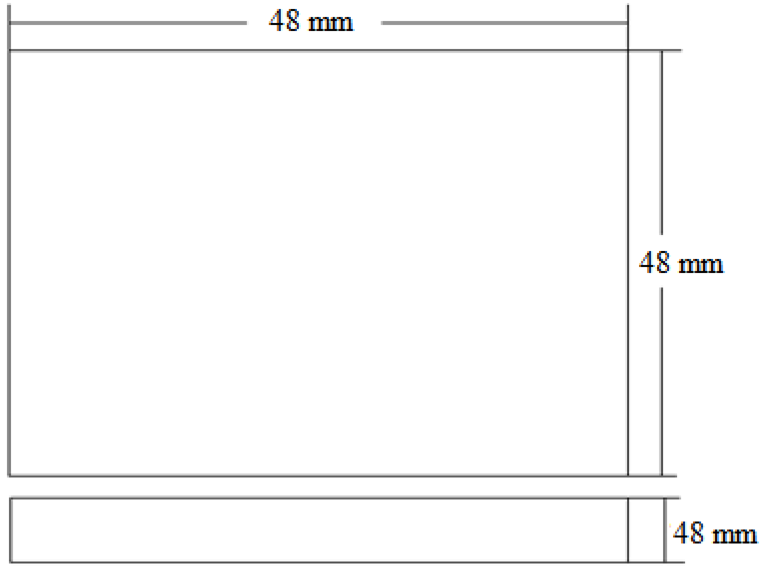


Fig: Layout of the job

Procedure:

- Use vernier height gauge to draw lines on the job surface to make it square.
- Fix the block in the milling machine.
- Set the feed, spindle speed and depth of cut.
- Mill the surface of the block until the height of the job reduced to 48 mm.
- After getting required dimensional product, clean the surface of the block by using brush.

Precautions:

- The job should be properly cleaned.
- Tool should be properly fixed in the tool head.
- Do not touch the block, tool head, and any other component of the machine, when the machine is working.
- Proper attention should be given to the machine.

Conclusion:

The job was prepared successfully and safely.

C. (i) Study of CNC Lathe Machine, different parts of CNC Lathe and its operation.

(ii) Part programming for turning operations.

Apparatus Required:

• CNC lathe machine

Theory:

A CNC (Computer Numerical Control) lathe is a modern version of the conventional lathe in which all major movements and operations are controlled automatically by a computer-based control unit. In a CNC lathe, the workpiece is held and rotated in a spindle just like in an ordinary lathe, but the tool motions, spindle speeds, feeds and cutting sequences are executed according to a pre-written program rather than manual handwheels and levers. The main parts of a CNC lathe include the machine bed and guideways, the headstock with spindle and chuck for holding and rotating the workpiece, the tool turret which carries several tools and indexes them automatically, the tailstock or sub-spindle (if provided), the ball-screw driven slides for longitudinal (Z-axis) and cross (X-axis) movements, and the CNC control panel containing screen, keyboard, mode selector and other switches. The control system reads the program, interprets the instructions, and sends signals to servo motors, which precisely position the slides and rotate the spindle. This leads to higher accuracy, repeatability and productivity compared to conventional lathes.

In CNC operation, the turning process is defined by a part program, which is a set of instructions written in a standard code (usually ISO G-code). Each instruction line is called a block and typically contains a block number (N…), a preparatory function (G-code), coordinates and other commands. Common G-codes in turning include G00 for rapid positioning, G01 for linear interpolation (straight-line cutting), G02 and G03 for circular interpolation, as well as specific codes for turning cycles depending on the control system. The cutting path is defined in terms of X and Z coordinates, where Z is along the spindle axis (length of the job) and X is radial or diameter direction. M-codes (miscellaneous functions) are used to control spindle ON/OFF and direction (e.g., M03 for spindle clockwise), coolant (M08/M09), and other auxiliary functions. A simple CNC turning program usually begins with safety and initialization commands (e.g., specifying units and reference plane), followed by tool selection and spindle start, then rapid approach to a safe point, followed by cutting moves using G01, G02, or G03 to perform facing and turning, and finally retract, spindle stop and program end.

For example, to perform basic turning on a cylindrical bar, the program will first define the work coordinate system and call the appropriate tool. Then the tool will rapidly move to a position near the workpiece, face the job to create a flat reference surface, and then move along Z while reducing X to gradually reduce the diameter to the required size. For safety and consistency, CNC lathes use reference points like machine zero, program zero and tool reference points; tool offsets are stored in the control so that different tools can be automatically compensated for their length and nose position. Once a correct program is written and verified (often by simulation or dry run), the same part can be produced repeatedly with minimal variation, which is a major advantage of CNC machining. Thus, the study of CNC lathe parts and their functions, together with the basics of part programming for turning, provides the foundation for understanding modern automated machining.

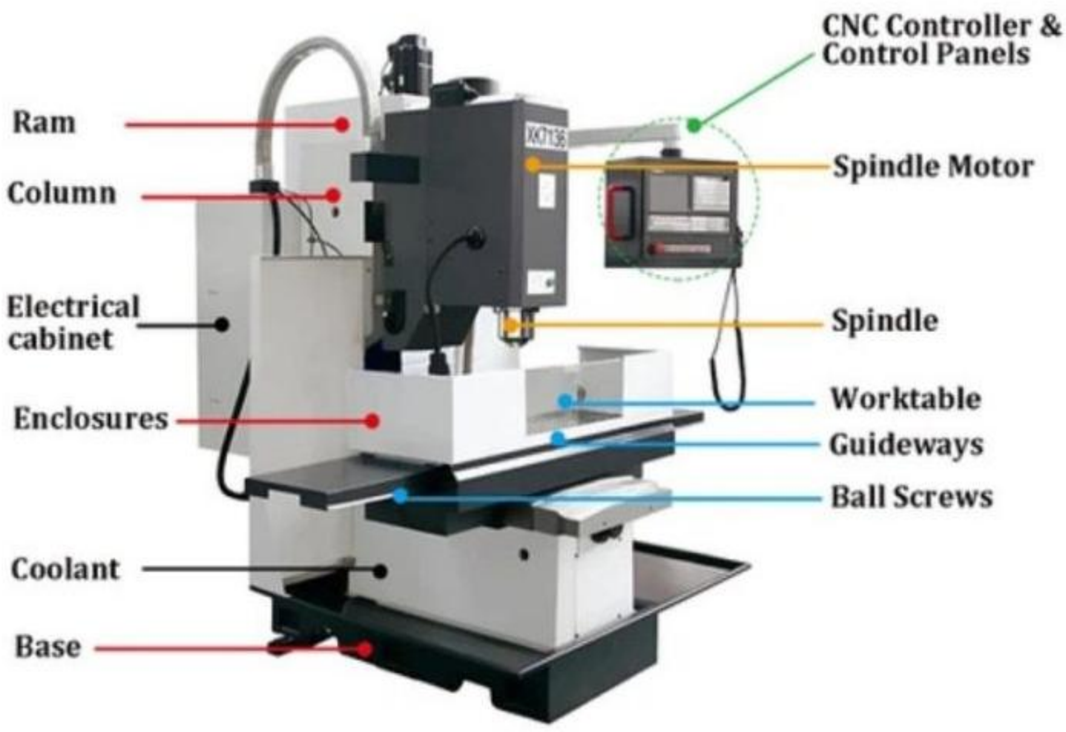


Fig: Schematic diagram of a CNC Lathe Machine.

Conclusion:

In this experiment, the construction and main parts of a CNC lathe—such as the bed, headstock with spindle and chuck, tool turret, slides (X and Z axes), tailstock or sub-spindle, and the CNC control panel—were identified and their functions understood. The principle of CNC operation, in which tool and spindle motions are controlled by a numerical program rather than manual operation, was studied. The basics of part programming for turning operations using G-codes and M-codes were introduced, including the concept of blocks, coordinates, tool selection, rapid positioning and cutting moves for facing and turning. Thus, the aim of studying the CNC lathe machine, its different parts and operations, along with the fundamentals of part programming for turning operations, has been successfully achieved.

D. (i) Study of CNC Milling Machine, different parts of CNC Milling Machine and its operation.

(ii) Part programming for milling operations.

Apparatus Required:

- CNC milling machine (vertical / machining centre, as available)

Theory:

A CNC (Computer Numerical Control) milling machine is an advanced form of conventional milling machine in which all major movements and functions are controlled automatically by a computer-based control unit. In milling, a rotating multi-point cutting tool removes material from the workpiece to generate flat, curved, slotted or contoured surfaces. In a CNC milling machine, the spindle holds the milling cutter and rotates it at high speed, while the workpiece is fixed on the machine table. Unlike a manual machine, the motions of the table and spindle are governed by servo motors driven according to a pre-written numerical program. Typical CNC milling machines have three basic linear axes: X (usually table longitudinal movement), Y (cross movement), and Z (vertical movement of spindle or table). Machining centres may also have rotary axes and automatic tool changers to increase productivity and flexibility.

The main parts of a CNC milling machine include the base and column, which support the entire structure and house the spindle drive and guideways; the knee, saddle and table, which provide vertical, cross and longitudinal movements; and the spindle head, which holds and drives the tool. In vertical machining centres, the spindle is vertically oriented, while horizontal machining centres have a horizontal spindle and often a rotary table. The tool magazine and automatic tool changer (ATC), when present, allow multiple tools to be stored and automatically swapped into the spindle as required by the program. The CNC control panel consists of a display screen, soft keys, mode selector, manual pulse generator (MPG) handwheel, emergency stop, and alphanumeric keypad, through which the operator inputs and edits programs, sets offsets, and monitors machine status. The axes are typically driven by precision ball screws and servo motors to achieve accurate and repeatable positioning.

Operation of a CNC milling machine is based on a part program written in standard G-code. The program consists of a sequence of blocks, each containing instructions such as tool calls, spindle speed and direction, coolant commands, and motion commands. Preparatory functions (G-codes) define the type of movement or machining mode: for example, G00 for rapid positioning, G01 for linear interpolation (straight-line cutting), and G02/G03 for circular interpolation (clockwise or counter-clockwise arcs). The cutter path is described in terms of X, Y and Z coordinates within a defined work coordinate system (such as G54). Miscellaneous functions (M-codes) control auxiliary operations such as spindle ON/OFF (e.g., M03, M05), coolant ON/OFF (M08, M09), and tool change (M06). A simple CNC milling program for a rectangular pocket or a slot will start with initialization commands, selection of the work offset and tool, spindle start and rapid approach to a safe height. Then, using G01 with appropriate feed rates and coordinates, the cutter is fed into the workpiece to perform facing, slot cutting, or contour milling. After machining, the tool is retracted to a safe position, the spindle and coolant are stopped, and the program is ended with M30 or similar.

To machine accurately, the control uses reference points such as machine home position, work zero, and tool length and radius offsets. Before running the program, the operator sets the workpiece zero point (using a probe or edge finder), enters tool offset values, and may perform a simulation or dry run to ensure there are no collisions or programming errors. Once a verified program is available, the same component can be produced repeatedly with high accuracy and consistency. CNC milling allows complex shapes and patterns to be produced which would be difficult or time-consuming on a conventional machine. Therefore, understanding the construction and functions of a CNC milling machine, along with the basics of part programming for milling operations, is essential for modern manufacturing practice.

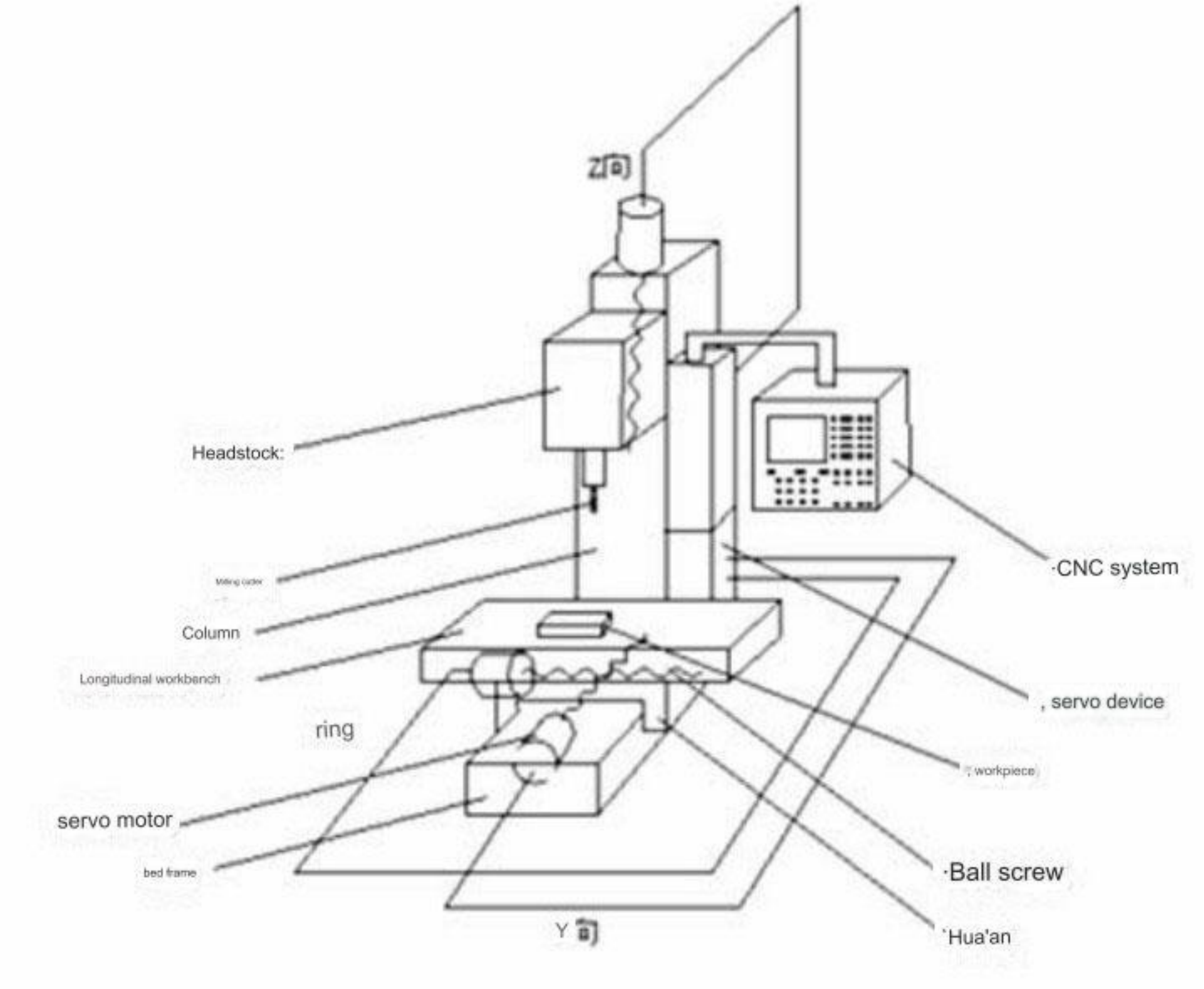


Fig: Schematic diagram of a CNC Milling Machine.

Conclusion:

In this experiment, the main parts of a CNC milling machine—such as the base, column, knee, saddle, table, spindle head, tool holding system, tool magazine/ATC and CNC control panel—were identified and their functions understood. The principle of CNC milling, where tool motions along the X, Y and Z axes and spindle operation are controlled by a numerical program rather than manual operation, was studied. The fundamentals of part programming for milling operations were introduced, including the structure of G-code programs, the use of G-codes and M-codes, the definition of coordinate systems, and the basic motion commands required for facing, slotting, contouring and other milling tasks. Thus, the aim of studying the CNC milling machine, its different parts and operations, together with the basics of part programming for milling operations, has been successfully achieved.

ROBOTICS LAB

Experiment Number-05

Aim of The Experiment: Study of Robot (Pick and place and palletizing operation).

A. Study of Robot.

- A robot is a type of automated machine that can execute specific tasks with little or no human intervention and with speed and precision. The field of robotics, which deals with robot design, engineering and operation.
- Robots can perform some tasks better than humans, but others are best left to people and not machines.
- **Robot:** It is a machine capable of carrying out a complex series of actions automatically, especially one programmable by computer.
- **According to ISO**: It is an automatically controlled, reprogrammable, multipurpose manipulator (robot with fixed base) programmable in three or more axes, which can either be fixed in place or mobile for use in industrial automation applications.
- **According to RIA (Root Institute of America)**: It is reprogrammable multi-Functional manipulator designed to move materials, parts, tools or specialized devices through variable programmed motions for the performance of a variety of tasks.
- **Manipulator:** Mechanical Hand. We model, design and develop the human hand in the form of an artificial Hand. It is reprogrammable and multifunctional.
- **CNC:** Computerized Numerical Control Machine-We can perform a variety of tasks by changing the program. Similarly, the same Robot can be used to perform variety of tasks by reprogramming it. But the level of reprogrammability differs in CNC machine and Robot(more).

Robotics: It is the science which deals with the issues related to design, manufacturing and usage of robots.

- 3H's of Human beings are copied into Robotics such as

i. Hand-with Manipulator
ii. Head-with Intelligence
iii. Heart-with emotions

Machines that can replace human beings as regards to physical work and decision making are categorized as Robots and their study as robotics.

- Czech writer, Karel Capek in his drama introduced the word robot to the world in1921.It is derived from the Czech word robota meaning "forced labourer".
- Isaac Asimov the well-known Russian science fiction writer coined the word Robotics in his story "Runaround", published in 1942 to denote the science devoted to the study of Robotics.
- The robot technology is advancing rapidly. Robots and robot-like manipulators are now commonly employed in hostile environment such as at various places in an atomic plant for handling radioactive materials.
- Robots are being employed to construct and repair space stations and satellites.

- There are now increasing number of applications of robots such as in nursing and aiding a patient. Microrobots are being designed to do damage control inside human veins.
- One type of robot commonly used in the industry is a robotic manipulator or simply a robotic arm.
- It is an open or closed kinematic chain of rigid links interconnected by movable joints.
- In some configurations, links can be considered to correspond to human anatomy as waist, upper arm, and forearm with joints at shoulder and elbow.
- At the end of the arm, a wrist joint connects an end effector to the forearm.
- The end effector may be a tool and it's a fixture or a gripper or any other device to do work. The end effector is similar to the human hand with or without fingers.

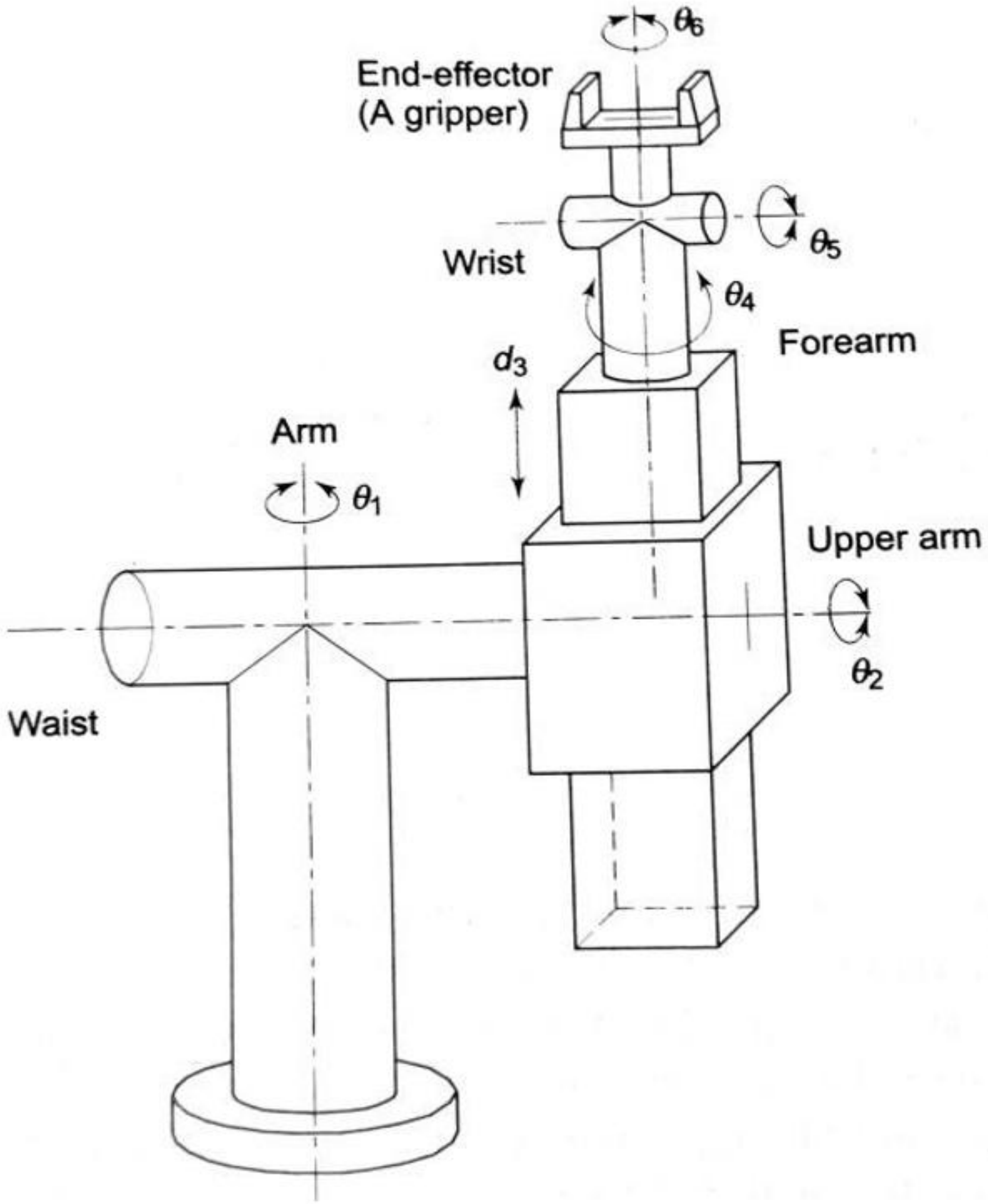


Fig: Kinematic Model of a Robot Manipulator showing Joint Axes.

Motivation behind Robotics: To cope up with increasing demands of a dynamic and competitive market, modern manufacturing methods should satisfy the following requirements:

- Reduced Production Cost
- Increased Productivity
- Improved Product Quality

Laws of Robotics:

1) A robot should not injure a human being or through inaction allow a human to be harmed.
2) A robot must obey orders given by humans except when that conflicts with the first law.
3) A robot must protect its own existence unless that conflicts with the first or second law.

The following are things robots do better than humans:

- Automate manual or repetitive activities in corporate or industrial settings.
- Work in unpredictable or hazardous environments to spot hazards like gas leaks.
- Process and deliver reports for enterprise security.
- Fill out pharmaceutical prescriptions and prep IVs.
- Deliver online orders, room service and even food packets during emergencies.
- Assist during surgeries.
- Robots can also make music, monitor shorelines for dangerous predators, help with search and rescue and even assist with food preparation.

Different Types of robots:

There are as many different types of robots as there are tasks.

1. **Androids**

Androids are robots that resemble humans. They are often mobile, moving around on wheels or a track drive. According to the American Society of Mechanical Engineers, these humanoid robots are used in areas such as caregiving and personal assistance, search and rescue, space exploration and research, entertainment and education, public relations and healthcare, and manufacturing.

2. **Telechir**

A telechir is a complex robot that is remotely controlled by a human operator for a telepresence system. It gives that individual the sense of being on location in a remote, dangerous or alien environment, and enables them to interact with it since the telechir continuously provides sensory feedback.

3. **Telepresence robot**

A telepresence robot simulates the experience and some capabilities of being physically present at a location. It combines remote monitoring and control via telemetry sent over radio, wires or optical fibers, and enables remote business consultations, healthcare, home monitoring, childcare and more.

4. **Industrial robot**

The IFR (International Federation of Robotics) defines an industrial robot as an "automatically controlled, reprogrammable multipurpose manipulator programmable in three or more axes." Users can adapt these robots to different applications as well. Combining these robots with AI has helped businesses move them beyond simple automation to higher-level and more complex tasks.

• In 2019, there were over 390,000 industrial robots installed worldwide, according to the IFR -- with China, Japan and the U.S. leading the way.

In industrial settings, such robots can do the following:

• optimize process performance;
• automate production to increase productivity and efficiency;
• speed up product development;
• enhance safety; and lower costs.

5. **Swarm robot**

Swarm robots (aka insect robots) work in fleets ranging from a few to thousands, all under the supervision of a single controller. These robots are analogous to insect colonies, in that they exhibit simple behaviors individually, but demonstrate behaviors that are more sophisticated with an ability to carry out complex tasks in total.

6. **Smart robot**

This is the most advanced kind of robot. The smart robot has a built-in AI system that learns from its environment and experiences to build knowledge and enhance capabilities to continuously improve. A smart robot can collaborate with humans and help solve problems in areas like the following:

• agricultural labor shortages;
• food waste;
• study of marine ecosystems;
• product organization in warehouses; and
• clearing of debris from disaster zones.

B. Pick and place operation, demonstration and explanation of code.

Aim: Robot Programming and simulation for pick and place.

Materials Required:

- Arduino UNO or equivalent
- Servo motors (2 or more)
- Ultrasonic sensor
- Breadboard and jumper wires
- USB cable
- Computer with Arduino IDE software installed

Procedure:

Step 1: Build the robot arm

- Build the robot arm using servo motors and other materials.
- Connect the servo motors to the Arduino UNO board and make sure they are properly mounted.

Step 2: Connect the ultrasonic sensor

- Connect the ultrasonic sensor to the breadboard and Arduino board.
- Connect the power, ground, and signal pins of the sensor to the appropriate pins on the board.

Step 3: Program the Arduino

- Open the Arduino IDE software on your computer.
- Write a code to control the robot arm and ultrasonic sensor.
- The code should instruct the robot arm to move in a certain direction when the ultrasonic sensor detects an object at a certain distance.
- Use the Servo library to control the servo motors and the NewPing library to read the ultrasonic sensor.
- Verify and upload the code to the Arduino board.

Step 4: Test the robot arm

- Power up the Arduino board and run the program.
- Test the robot arm by placing objects within the range of the ultrasonic sensor and observing how it responds.

- You can adjust the code to make the robot arm move in a certain way depending on the position of the object.

Step 5: Simulate the robot arm

- To simulate the robot arm, you can use a software tool like Tinker cad or SolidWorks.
- Create a virtual model of the robot arm and connect it to a virtual Arduino board.
- Write a code to control the virtual robot arm and simulate its movement based on the inputs from the virtual ultrasonic sensor.
- Test and refine the code until the virtual robot arm is able to perform the desired tasks.

Code using Arduino:

```
#include <Servo.h>
Servo servoX;
Servo servoY;
const int buttonPin = 2;
const int servoXPin = 9;
const int servoYPin = 10;
const int motorPin = 3;
int buttonState = 0;
void setup() {
 pinMode(buttonPin, INPUT);
 pinMode(motorPin, OUTPUT);
 servoX.attach(servoXPin);
servoY.attach(servoYPin);
}
void loop() {
 buttonState = digitalRead(buttonPin);
 if (buttonState == HIGH) {
// move to pick up position
servoX.write(90);
servoY.write(45);
delay(1000);
// activate motor to pick up object
digitalWrite(motorPin, HIGH);
delay(500);
digitalWrite(motorPin, LOW);
delay(500);
// move to drop off position
servoX.write(0);
servoY.write(90);
delay(1000);
// activate motor to drop off object
digitalWrite(motorPin, HIGH);
delay(500);
digitalWrite(motorPin, LOW);
delay(500);
}
}
```

Result:

Thus, we completed the Robot Programming and simulation for pick and place.

C. Palletizing operation, demonstration and explanation of code.

Apparatus Required:

Industrial robot (articulated / SCARA, as available)

Theory:

In a robotic palletizing operation, a robot automatically stacks objects in a desired pattern on a pallet. The robot replaces manual lifting and stacking and can work faster, more accurately and for longer periods without fatigue. A typical palletizing cell contains the robot arm with a gripper, a source of parts (table or conveyor), the pallet, sensors (part-present or pallet-present), and the controller. The robot is a multi–degree-of-freedom manipulator whose joints are driven by servo motors. A gripper mounted at the wrist holds the workpieces while moving between the pick and place positions. During operation, the controller executes a stored program that coordinates all joint motions and input/output (I/O) signals to perform the pick-and-place cycle repeatedly.

To make the programming simple and flexible, coordinate frames are defined in the controller. A base or world frame defines the global reference, and user frames are created at the workpiece source and at the pallet corner. Once a user frame is attached to the pallet, all pallet locations can be described as X, Y and Z offsets from this reference. Important points such as the robot home position, an approach point above the pick location, the actual pick point, an approach point above the pallet, and the first place point are taught using the teach pendant and stored as positions. The basic motion sequence is: move from home to a safe approach, go down to the pick point, close the gripper to grasp the part, lift to a safe height, move above the pallet, go down to the place point, open the gripper to release the part, and return to start the next cycle. By repeating this sequence with suitable changes in the X, Y and Z coordinates, the robot can fill the pallet row by row, column by column, and layer by layer.

The pallet pattern is usually generated through logic in the program instead of teaching each position separately. The program uses variables to represent the current row, column and layer number, and uses constant offset distances between two columns, two rows and two layers. After each placement, the program adds an X-offset or Y-offset to move to the next position on the pallet. After finishing one row, the column counter is reset and the row counter is incremented; after finishing one layer, the layer counter is incremented and a Z-offset is added so that the next layer is stacked above the previous one. While running the program, the robot controller also handles I/O commands to open and close the gripper, delays to allow the gripper to actuate, and safety interlocks. In the lab, the program is usually executed at low speed or in step mode so that students can clearly see how each line of code corresponds to a specific motion or gripper action, and how the repetitive logic builds up the complete pallet.

Code Explanation for Palletizing Operation:

Below is a generic structure of a palletizing program and an explanation of each part. The exact syntax (names of commands) may change depending on the robot brand, but the logic is the same.

1. **Initialization / Header**

- Set the active tool and work frame (for example, select the pallet user frame).
- Set motion speed and acceleration.
- Clear counters and initialize variables, e.g. ROW = 1, COL = 1, LAYER = 1.
- Move the robot to a safe HOME position.
- Example (pseudo-code):
    - SETTOOL 1
    - SETFRAME PALLET_FRAME
    - SPEED 50%
    - ROW=1, COL=1, LAYER=1
    - MOVEJ HOME

2. **Definition of Base Positions and Offsets**

- A reference PICK_POS is taught at the source location where the robot grips the part.
- A reference PLACE_POS is taught at the first pallet position (row 1, column 1, layer 1).
- Constant offset values are defined:
    - DX = distance between two columns,
    - DY = distance between two rows,
    - DZ = distance between two layers.
- These offsets are used to calculate the current pallet cell position from the reference.

3. **Main Program Loop**

- An outer loop may control the number of layers.
- Inside it, nested loops control rows and columns.
- The main loop calls the PICK_PART and PLACE_PART sections each time.
- Example structure:
    - FOR LAYER = 1 TO MAX_LAYER
    - FOR ROW = 1 TO MAX_ROW
    - FOR COL = 1 TO MAX_COL
        - Call PICK_PART
        - Call PLACE_PART with current ROW, COL, LAYER
        - NEXT COL
        - NEXT ROW
        - NEXT LAYER

4. **PICK_PART Section**

- Robot moves quickly above the pick position, then slowly down to the exact pick height.
- The gripper closes to hold the part, then the robot moves back to a safe height.
- Signals and delays ensure reliable gripping.
- Typical steps:
    - MOVEJ PICK_APPROACH (approach point above source)
    - MOVEL PICK_POS (down to pick point at slow speed)
    - DO[GRIPPER_CLOSE] = ON (close gripper)
    - WAIT 0.5 s (allow time to grip)
    - MOVEL PICK_APPROACH (lift part safely)

5. **PLACE_PART Section**

- The current place position is calculated from the base PLACE_POS using offsets:
    - X = PLACE_POS.X + (COL-1)*DX
    - Y = PLACE_POS.Y + (ROW-1)*DY
    - Z = PLACE_POS.Z + (LAYER-1)*DZ

- A temporary target position (e.g. TARGET_PLACE) is created with these coordinates.
- The robot moves to an approach point above this target, then down to place height, opens the gripper and retracts.
- Typical steps:
    - Compute TARGET_PLACE with current offsets.
    - MOVEJ PLACE_APPROACH(TARGET_PLACE)
    - MOVEL TARGET_PLACE (down to place point)
    - DO[GRIPPER_OPEN] = ON (release part)
    - WAIT 0.5 s
    - MOVEL PLACE_APPROACH(TARGET_PLACE) (move up to safe height)

6. **End of Program**

- After all layers, rows and columns are completed, the robot returns to HOME, stops the gripper and ends the program.
- Example:
- MOVEJ HOME
- DO[GRIPPER_OPEN] = OFF
- END

7. **Demonstration and Observation in the Lab**

- The instructor first runs the program in step mode or at reduced speed. Students can watch each motion and match it with the corresponding part of the code (for example, the line that closes the gripper or the line that moves to the next column).
- Students note how changing MAX_ROW, MAX_COL or the offset values DX, DY, DZ changes the pallet pattern without re-teaching all positions, and how loops reduce the length of the program.

Conclusion:

In this experiment, the robotic palletizing operation was studied in detail. The major elements of a palletizing cell—robot arm, controller, teach pendant, gripper, part supply and pallet—were identified and their functions understood. The principles of using coordinate frames and offsets to generate pallet positions were learned. A typical palletizing program was examined section by section, showing how initialization, definition of base positions, looping logic, and the PICK_PART and PLACE_PART routines work together to stack parts in rows, columns and layers. By observing the robot executing the program, the link between written code and actual robot motions and gripper actions became clear. Thus, the aim of studying the palletizing operation along with a separate, detailed explanation of the corresponding code has been successfully achieved.

ADDITIVE LAB

Experiment Number-06
Aim of The Experiment: Study of 3D Printer and demonstration of its operation.

Introduction to Prototyping

Prototyping is defined as the process of iteratively producing a custom model. A prototype is a work in progress, something that is still being improved. 3D printers are perfect for prototyping because they make it incredibly easy to make custom objects using a wide range of materials. From simple, rigid fixtures to flexible, organic geometries, the array of things 3D printers can make is constantly expanding.
Additive manufacturing is a formal name of 3D printing, a previously used technology for rapid prototyping Additive manufacturing also facilitates the evaluation and testing of designs before producing the finished product. In addition, this technique is a breakthrough in the world of technology, namely the ability to make a prototype at a low cost and a simple process. The application of 3D printing products has also been widely used in the automotive and medical industries The existence of 3D printing technology in manufacturing has brought major changes to the world. The rapid prototyping technology was first invented by Chuck Hall using a stereo lithographic (SLA) 3D printer. He used UV light to form plastic into layers. Scott Crump introduced another technique of 3D printing called fused deposition modeling (FDM) in 1988 by melting and pouring the plastic into a thin layer. Further, he applied the CNC to automate the process. With this technology, his machine melted and layered the plastic filament on a flat surface.

Types of 3D Printing:

Varieties of 3D printing technologies have been developed with the different function. According to ASTM Standard F2792. ASTM catalogued 3D printing technologies into seven groups, including the binding jetting, directed energy deposition, material extrusion, material jetting, powder bed fusion, sheet lamination and vat photo polymerization. There are no debates about which machine or technology function better because each of them has its targeted applications. Nowadays, 3D printing technologies are no longer limited to prototyping usage but are increasingly also being used for making variety of products.
Binder jetting: Binder jetting is a rapid prototyping and 3D printing process in which a liquid binding agent is selectively deposited to join powder particles. The binder jetting technology uses jet chemical binder onto the spread powder to form the layer. The application of the binder jetting is would be producing the casting patterns, raw sintered products or similar large-volume products from sand. Binder jetting can print a variety of materials including metals, sands, polymers, hybrid and ceramics. Some materials like sand not required additional processing. Moreover, the process of binder jetting is simple, fast and cheap as powder particles are glued together. Lastly, binder jetting also has the ability to print very large products.
Directed energy deposition: Directed energy deposition is a more complex printing process commonly used to repair or add additional material to existing components. Directed energy deposition has the high degree control of grain structure and can produce the good quality of the object. The process of directed energy deposition is similar in principle to material extrusion, but the nozzle not fixed to a specific axis and can move in multiple directions. Furthermore, the process can be used with ceramics, polymers but is typically used with metals and metal-based hybrids, in the form of either wire or powder. The example of this technology is laser deposition and laser engineered net shaping (LENS). Laser deposition is the emerging technology and can be used to produce or repair parts measured in millimeter to meters. Laser deposition technology

is gaining attraction in the tooling, transportation, aerospace, and oil and gas sectors because it can provide scalability and the diverse capabilities in the single system. Meanwhile, laser LENS can exploit thermal energy for melting during the casting and parts are accomplished subsequently.

Materials extrusion: Material extrusion-based 3D printing technology can be used to print multi- materials and multi-color printing of plastics, food or living cells. This process has been widely used and the costs are very low. Moreover, this process can build fully functional parts of product. Fused deposition modelling (FDM) is the first example of a material extrusion system. FDM was developed in early 1990 and this method uses polymer as the main material. FDM builds parts layer- by-layer from the bottom to the top by heating and extruding thermoplastic filament. The operations of FDM are as follows: I. Thermoplastic heated to a semi-liquid state and deposits it in ultra-fine beads along the extrusion path. II. Where support or buffering needed, the 3D printer deposits a removable material that acts as scaffolding. For example, FDM uses hard plastic material during the process to produce 3D bone model.

Materials jetting: According to ASTM Standards, material jetting is a 3D printing process in which drop by drop of build material is selectively deposited. In material jetting, a printhead dispenses droplets of a photosensitive material that solidifies, building a part layer-by-layer under ultraviolet (UV) light. At the same time, material jetting creates parts with a very smooth surface finish and high dimensional accuracy. Multi-material printing and a wide range of materials such as polymers, ceramics, composite, biological and hybrid are available in material jetting.

Powder bed fusion: The powder bed fusion process includes the electron beam melting (EBM), selective laser sintering (SLS) and selective heat sintering (SHS) printing technique. This method uses either an electron beam or laser to melt or fuse the material powder together. The example of the materials used in this process is metals, ceramics, polymers, composite and hybrid. Selective laser sintering (SLS) is the main example of powder-based 3D printing technology. Carl Deckard developed SLS technology in 1987. SLS is 3D printing technology that's functionally in fast speed, has high accuracy, and varies surface finish. Selective laser sintering can used to create metal, plastic, and ceramic objects. SLS used a high-power laser to sinter polymer powders to generate a 3D product. Meanwhile, SHS technology is another part of 3D Printing technology uses a head thermal print in the process to melt the thermoplastic powder to create 3D printed object. Lastly electron beam melting enhances an energy source to heat up the material.

Sheet lamination: According to ASTM definition, sheet lamination is the 3D printing process in which sheet of materials are bond together to produce a part of object. The example of 3D printing technology that uses this process are laminated object manufacturing (LOM) and ultrasound additive manufacturing (UAM). The advantages of this process are sheet lamination can do full-color prints, it relatively inexpensive, easy of material handling and excess material can be recycled. Laminated object manufacturing (LOM) is capable to manufacture complicated geometrical parts with lower cost of fabrication and less operational time. Ultrasound additive manufacturing (UAM) is an innovative process technology that uses sound to merge layers of metal drawn from featureless foil stock.

Vat Photo polymerization: The main 3D printing technique that frequently used is photo polymerization, which in general refers to the curing of photo-reactive polymers by using a laser, light or ultraviolet (UV). The example of 3D printing technologies by using photo polymerization is stereo lithography (SLA) and digital light processing (DLP). In the SLA, it was influenced by the photo initiator and the irradiate exposure particular conditions as well as any dyes, pigments, or other added UV absorbers. Meanwhile, digital light processing is a similar process to Stereo lithography that works with photopolymers. Light source is the major difference. Digital Light Process uses a more conventional light source, such as an arc lamp with a liquid crystal display panel. It can apply to the whole surface of the vat of photopolymer resin in a single pass, generally making it faster than Stereo lithography. The important parameters of Vat Photo polymerization are the time of exposure, wavelength, and the amount of power supply. The materials used initially are liquid and it will harden when the liquid exposed to ultraviolet light. Photo polymerization is suitable for making a premium product with the good details and a high quality of surface.

To Study of 3D Printing

Introduction: - 3D printing allows for rapid prototyping and onsite manufacturing of products. Initially done with plastic, 3D printing now uses new techniques with new materials, such as aluminum, bronze, and glass. Biomaterials are also being incorporated, such as 3D printing ear cartilage and liver tissue. As the 3D printing industry grows, 3D printing will become a big part of many engineering fields.

Flow layout of Pre 3D Printing Components of 3D Printer: -

1. axes

Fixed Rods: The three axes that the 3D printer utilizes are on the Cartesian coordinate system. The linear fixed rods are maintained at right angles to each other and each represents a coordinate axis.

Movement: The timing belts and pulleys allow the movement of the hot end (or the print bed, depending on the type of 3D printer) along each axes according to the g-code (generated by slicing software). The stepper motors power this movement.

2. Extruder

Extrusion is the feeding of filament into the hot end of the 3D printer. This movement is also powered by a stepper motor.

Retraction: This mechanism is the pulling of the melted filament from the hot end. This movement is primarily programmed through the g-code to prevent the formation of unwanted filament creating a bridge between two areas. The bridging of unwanted filament is referred to as stringing or the formation of cobwebs.

Dual Extrusion: Some models of 3D printers are equipped with dual extrusion capabilities. This allows for mixed material objects to be printed. Dual extrusion can be used to print out complex objects with a different color material as the support, making it easy to differentiate between the object and the support.

3. Hot End

The hot end is heated to temperatures ranging from 160 C to 250 C, depending on the type of filament to be used. The hot end melts the filament and pushes the melted filament through the nozzle. The hot end needs to be thermally insulated from the other components of the 3D printer to prevent any damage.

4. Print Bed

Heated Print beds that are heated improve print quality of 3D printed objects. The heated bed is heated to the glass transition temperature of the filament being used. This allows the model layers to slightly melt and stick to the heated bed.

Non-Heated Print beds that are not heated require adhesion in the form of glue, tape, hairspray, etc. In the innovation lab, painters tape is frequently used for adhesion.

5. Filament

Filament is a consumable used by the 3D printer to print layers. Filament comes in a variety of materials and colors. Filament can be composed of metal, wood, clay, biomaterials, carbon fiber, etc.

i). ABS: - ABS is a thermoplastic that needs to be heated to temperatures from 210C to 250C. ABS can only be printed on a 3D printer with a heated bed, which prevents the cracking of the object. When ABS is heated, it emits a strong unpleasant odor. ABS requires a complete enclosure while printing.

ii). PLA: - PLA is a thermoplastic that needs to be heated to temperatures from 160C to 220C. PLA is also biodegradable and emits slight odors. PLA is most frequently used in the Innovation Lab on all 3D printers.

Preparing your 3D Model in CAD Software: -

CAD software is used to create 3D models and designs. This software is available on our computers and the level of difficulty varies. With the exception of Sketch up Pro and the industry standard software mentioned, all of these programs are available on the innovation lab computers.

Solid works main idea is user to create drawing directly in 3D or solid form. From this solid user can assemble it directly on their workstation checking clashes and functionality of it. Creating drawing is pretty easy just drag and drop the solid to drawing block.

Preparing your 3D Model for print in Idea maker software: -

These are following step for 3D printing of model

1. Install the 3D print software idea maker
2. Check repair option in this software
3. Set the nozzle parameter and build tack temperature according to the printer guide.

Step: -1 Prepare the design Model using Designing Software (Solids Work, AutoCAD etc.)

Step: -2 Convert the designed Model file in Stl, obj format.

Step: -3 Prepare the design model for printing Using Software Idea Maker and Ultimaker. Then set all parameter (nozzle temp., buildtak temp and support) and also repair your design using software option. Then after generate the file in gcode format.

Step: -4 ON the 3D Printer and load the filament in nozzle and give the command print by using 3D Printing Machine.

Precaution of 3D Printer machine: -

These are some following precautions when you print the design in 3D Printer

1. Mechanical: Do not place limbs inside the build area while the nozzle is in motion. The printer nozzle moves in order to create the object.
2. High Temperature: Do not touch the printer nozzle – it is heated to a high temperature in order to melt the build material.
3. Always buy replacement parts from the manufacturer for safety related equipment
4. Choose an area that has adequate ventilation and exhaust capability Safety Equipment: -

- Safety Glasses
- Gloves (recommended for postprocessing)

Application of 3D Printer: -

- Automotive
- Marine
- Aerospace
- Medical
- Engineering
- Architecture
- Complex shapes
- Freedom for design
- Customize parts
- Less waste
- Fewer unsold products

Less transport Limitations: -

- Time
- Cost
- Skill
- Materials