DEPARTMENT OF MECHANICAL ENGINEERING

MACHINE SHOP LAB (10MEL48B)

IV SEMESTER (MECHANICAL)

LABORATORY MANUAL

ACADEMIC YEAR 2016-17
PART – A:
Preparation of three models on lathe involving Plain turning, Taper turning, Step turning, Thread cutting, Facing, Knurling, Drilling, Boring, Internal Thread cutting and Eccentric turning.

PART – B:

Scheme of Examination:

<table>
<thead>
<tr>
<th>Category</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>One question from part – A</td>
<td>40</td>
</tr>
<tr>
<td>One question from part – B</td>
<td>20</td>
</tr>
<tr>
<td>Viva – Voce</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>80</strong></td>
</tr>
</tbody>
</table>

IA MARKS: 20  
EXAM HRS: 03  
EXAM MARKS: 80
## CONTENTS

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>NAME OF THE EXPERIMENT</th>
<th>PAGE NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>PART – A</strong></td>
<td></td>
</tr>
<tr>
<td>01</td>
<td>A Tutorial on Machines &amp; Tools used in this shop</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. Cutting Tool Materials</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>b. Lathe Parts &amp; Their Functions</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>c. Lathe Operations</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Lathe Models</strong></td>
<td></td>
</tr>
<tr>
<td>02</td>
<td>a. Model No – I</td>
<td>15 16</td>
</tr>
<tr>
<td></td>
<td>b. Model No – II</td>
<td>17 18</td>
</tr>
<tr>
<td></td>
<td>c. Model No – III</td>
<td>19 20</td>
</tr>
<tr>
<td></td>
<td>d. Model No – IV</td>
<td>21 22</td>
</tr>
<tr>
<td></td>
<td><strong>PART – B</strong></td>
<td></td>
</tr>
<tr>
<td>03</td>
<td>A Tutorial on machines &amp; tools used in the machine shop</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. Detailed study of milling</td>
<td>23 38</td>
</tr>
<tr>
<td></td>
<td>b. Shaping</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c. Grinding machines</td>
<td></td>
</tr>
<tr>
<td>04</td>
<td><strong>Milling</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. First Model: Flat Surface Machining</td>
<td>39 39</td>
</tr>
<tr>
<td></td>
<td>b. Second Model: Key Way Machining</td>
<td>40 40</td>
</tr>
<tr>
<td></td>
<td>c. Third Model: Spur Gear</td>
<td>41 43</td>
</tr>
<tr>
<td></td>
<td>d. Fourth Model: Bevel Gear</td>
<td>44 46</td>
</tr>
<tr>
<td></td>
<td>e. Fifth Model: Helical Gear</td>
<td>45 46</td>
</tr>
<tr>
<td>05</td>
<td><strong>Shaping</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. First Model: Flat Surface Machining</td>
<td>50 50</td>
</tr>
<tr>
<td></td>
<td>b. Second Model: V groove - Block</td>
<td>51 51</td>
</tr>
<tr>
<td></td>
<td>c. Third Model: Square groove - Block</td>
<td>52 52</td>
</tr>
<tr>
<td></td>
<td>d. Fourth Model: Dove tail Block</td>
<td>53 53</td>
</tr>
<tr>
<td></td>
<td><strong>PART – C (DEMONSTRATION ONLY)</strong></td>
<td></td>
</tr>
<tr>
<td>06</td>
<td><strong>Grinding</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. Surface grinding model</td>
<td>54 56</td>
</tr>
<tr>
<td>05</td>
<td>VIVA - VOCE QUESTIONS</td>
<td>55 55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>56</td>
</tr>
</tbody>
</table>
MACHINE SHOP LAB

INTRODUCTION

In metal forming industry work pieces of different shapes, dimensions and of different materials is machined to obtain the finished work piece.

Classification of working processes is mainly of two types:

i. Non cutting shaping
ii. Cutting shaping

And in this lab we are going to deal with the cutting operations. In the cutting operations the finished piece is obtained by separating a layer from the parent work piece in the form of chips.

The important types of cutting operations are Turning, taper turning, thread cutting, forming, knurling, facing, drilling etc., are mainly using lathe.

Cutting tool is used for cutting apart or for removing chips.

Cutting tools are divided into two types:

i. Single point tools
ii. Multi point tools

Characteristics of the ideal cutting tool material:

a. Hot hardness- material must remain harder than work material at elevated operating temperatures.
b. Wear resistance-material must withstand excessive wear even though the relative hardness of the tool work material changes.
c. Toughness-it actually implies a combination of strength and ductility. It is the resistance of the material to the shock and vibrations.
d. Frictional coefficient at chip interface must remain low for minimum wear and reasonable surface finish.
e. Cost and ease ness in fabrication- the cost and ease ness of fabrication should be within reasonable limits.

Cutting tool materials are classified as follows:

a. Carbon steels
b. Medium alloy steels
c. High speed steels
d. Satellites
e. Cemented carbides
f. Ceramics
g. Diamonds
h. Abrasives
Properties of cutting tool materials: Cutting tool materials should have the following properties form the point of view of efficient cutting.

a. Hot (red) hardness, the ability of a tool material to maintain its hardness at elevated temperature. Hardness enables it to hold a cutting edge.

b. Strength and resistance to shock – toughness

c. Low coefficient of friction – to reduce the chip-tool friction.

d. Capable of being given a good surface finish

e. Toughness – enables it to withstand shock and heavy pressure

f. The ability to provide a good surface finish.

Carbon Tool Steels: Carbon tool steels have 1 to 1.4 % carbon + chromium + tungsten. Chromium is added to improve harden ability. Tungsten is added to improve wear resistance. Carbon tool steels lose their hardness at a temperature of about 250°C. Cutting speeds with high carbon steel tools are about one third of those with HSS. Carbon tool steels are limited in use, limited to hand tools and other cutting tools operating at low cutting speeds.

High Speed Steels: High-speed steels are still a very important cutting tool material. High-speed steels retain a cutting edge for much longer periods and under much more rigorous conditions. It is possible to take heavy cuts at elevated temperatures without losing their hardness. HSS can be used up to 600°C. It has a high hot hardness. It possesses good strength and shock resistant properties. 18-4-1 is common one.

a. 18 % Tungsten: The ability to remain hard at high temperature is due to inclusion of tungsten

b. 4% Chromium: With carbon forms very hard carbides

c. 1% Vanadium: Refines the grain structure and improves the shock resistance

da. 0.7 % carbon

HSS steel is used for the manufacture of the following:

a. Single point tools
b. Drills
c. Reamers
d. Milling cutters

Typical Cutting speeds

<table>
<thead>
<tr>
<th>Work piece material</th>
<th>Cutting speed m/min</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High carbon steel</td>
</tr>
<tr>
<td>Low carbon steel</td>
<td>24</td>
</tr>
<tr>
<td>Medium carbon steel</td>
<td>20</td>
</tr>
<tr>
<td>High carbon steel</td>
<td>14</td>
</tr>
<tr>
<td>Cast iron</td>
<td>16</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>8</td>
</tr>
<tr>
<td>Brass</td>
<td>45</td>
</tr>
<tr>
<td>Bronze</td>
<td>22</td>
</tr>
<tr>
<td>Aluminum alloy</td>
<td>55</td>
</tr>
</tbody>
</table>
Cemented Carbides: Cutting tools made of cemented carbides are the most widely used on account of their extreme hardness.

Titanium carbide is frequently used either on its own with a binder, or as a coating on a tungsten carbide tool. This coating of titanium carbide gives greater wear resistance and hence extended tool life.

Diamond Tools:

a. Diamond tools are finishing tools. The maximum depth of cut being 0.15 mm and the feed rate an absolute maximum of 0.05 mm/rev

b. The diamond is clamped in a special tool holder

c. The cutting edge profile is ground to an arc of a circle or as a number of very small facets

d. Diamond tools have very long life. Diamond tools tool life is measured in months rather than in minutes

e. Diamonds are extremely brittle. Easily damaged if subjected to shock

Ceramics:

Sintered oxides are the most recent major development in the ceramic cutting tool materials.

Why is it called cemented carbides?

Carbides of certain metals, notably tungsten and boron are extremely hard but are not in themselves tough enough to stand up the triggers of the metal cutting process. They are therefore bonded together by another material just as bricks are cemented together by mortar—hence the term cemented carbides

Stellite:

Stellite is a non-ferrous cast alloy of Cobalt, Chromium and tungsten. It is hard in the as cast condition. It cannot be further hardened or softened by heat treatment. It is tough enough to be used as a tool bit or drill without having to be brazed as a tip on a tough steel shank.

Coated Steel Tools:

a. Chemical vapour deposition (CVD) has resulted in commercial availability of high speed cutting tools coated with thin layers of refractory metal carbide or nitride

b. CVD layers on steel tools are usually less than 10 micron in thickness

c. Titanium carbide and nitride have been proposed as coatings.

d. Commercial development of chemical vapour deposition (CVD) coatings on cemented carbide tools began in 1970. A very thin layer of titanium carbide was bonded to the surface of the tool tips.

e. The deposition process is carried out by heating the tools in a sealed chamber in a current of hydrogen gas. The temperature is in the region of 800°-1050° c. The heating lasts several hours.

f. Many commercial coatings now consist of several layers of nitride, carbide and alumina. The thickness is one or two micrometer
Lathe Parts & Their Functions

Lathe is a machine for generating cylindrical forms. Lathe can be used to perform numerous other machining operations.

Lathe can be used:
- To cut screw threads
- For boring
- For profiling (shape contours)
- For recessing
- For machining a variety of flat, cylindrical or irregular forms

Types of Lathes:
- Centre lathe
- Capstan lathe
- Turret lathe
- Automated lathe
- CNC Lathe

The main parts of the centred lathe and their functions:

a. **Bed**: The bed is the foundation of the lathe. It is made of cast iron.

b. **Gap Bed**: Some lathes have a gap in the bed just in front of the headstock to allow larger work to be turned.

c. **The Head Stock**: The end of the lathe at which the main chuck and work is held and where the rotating mandrel is. Headstock carries the spindle in precision bearings. The driving mechanism is inside the headstock.

d. **Tail Stock**: The tailstock supports the ‘free’ end of the work. The tailstock is also used in the drilling and reaming of work held in chuck or on faceplate.

e. **Carriage or Saddle**: Carriage forms the base of the unit, which supports the cutting tool. Carriage can be traversed along the whole length of the bed by hand control or by power feed.

f. **Cross Slide**: A cross slide is provided for cross traversing. Compound slide (top slide) is mounted on the cross slide. It is so called because it is swiveling and allows compound angles to be set up.

g. **Apron**: Apron houses the control for hand or power feeding.

h. **Lead – Screw**: Lead –screw transmits feed motion for screw cutting.

i. **Feed Shaft**: Feed shaft is employed in operating the carriage or the cross slide in automatic turning.

j. **Chucks**:
   - Self centring –3 jaw chuck
   - 4-jaw- independent chuck
   Both types are used in many different machining operations.
   - **Self Centring Chuck**: The three-jaw chuck is a self-centring chuck. Self-centring means that all three jaws move in or out depending on the direction.
of rotation of the key. Three-jaw chuck will not directly hold square material. The 3-jaw self-centring chuck will automatically centre rounds of hexagons. As the scroll is turned with the key all jaws open or close together.

- **4 – Jaw Independent Chuck:** 4 – jaw independent chuck is used
  - For holding work of irregular shape
  - For off centre turning.
  - It can also be used for holding squares or rounds. Centering takes a little longer but it can be done very accurately using each individual jaw adjustment. The extra jaw gives a much firmer hold on the work. All jaws are controlled independently of each other. This helps or allows odd shapes to be set in the chuck. The jaws are reversible. This allows the holding of larger work.

k. **Face – Plate:** Faceplate is used for mounting work of awkward shapes, which cannot be chucked.

l. **Lathe Centers**
   - Live center
   - Half center
   - Dead center

   Centers have an included angle of 60°. Centers are accurately ground to standard tapers.
   - **Live Centre:** The live centre is so called because it is the centre, which always rotates with the work. This centre is associated with the driving.

m. **Steadies**
   - Fixed steady
   - Travelling steady

   Steadies are used for supporting long work against the pressure of the tool. The fixed steady is secured to the lathe bed. The travelling steady is mounted on the carriage. This steady move along the work behind the tool, as each cut is taken.

n. **Mandrels:** Mandrels are slightly tapered spindle. Previously bored components or part machined work can be mounted for further turning operations.

**Tool Post**

Tool posts are classified as follows

**Clamp Type Tool Post:** This is a simple tool post. It is robust, this has many disadvantages.

**Pillar Type Tool Post:**
   - This is used for light duty lathes
   - The tool height is easily adjusted by rocking the boat piece in its spherical seating.
   - This tool post lacks rigidity due to the overhang of the tool
   - Adjustment of the boat piece alters the effective cutting angles.

**Turret (4-Way) Tool Post:**
   - This saves tool changing.
   - Each tool is being swung into position as required
   - The number of tools is restricted to four
   - The vertical adjustment is by inserting packing under the tool. The shank size of the tool is restricted.

**Quick – Release Type Tool Post:**
   - The quick release tool post is increasingly used.
   - Number of tools may be pre-set in the tool holders ready for use
   - Tool height is easily adjusted by means of a screw.
Lathe Operations

The most common operations performed on a lathe are turning, facing, parting, grooving, knurling, drilling, boring, taper turning and threading.

Plain Turning: It is to remove excess material from the work-piece and to produce a cylindrical surface. Using a cross-slide the cutting tool is adjusted for the desired depth of cut. As the work-piece revolves the tool is fed against work-piece in a direction parallel to the axis of the spindle. A right-hand tool travels towards the headstock and a left-hand tool towards the tailstock.

Facing: It is to produce a flat surface normal to the rotational axis of the spindle. During facing the carriage is locked to the lathe bed to prevent its movement. Using the cross-slide the tool is fed at right angles to the axis of the work-piece.

Parting: Parting or cutting–off is the operation of separating a piece of initial work from the bar-stock.

Grooving or necking: Grooving is the operation of reducing the diameter of work-piece to a narrow surface.

Knurling: It is the process of embossing a diamond shaped pattern on the surface work piece by the use of revolving hardened steel wheels pressed against the work.

Drilling: It is an operation of producing cylindrical hole by means of a cutting tool i.e., drill.

Boring: It is operation of enlarging a hole previously made by a drilling

Thread Cutting

The point of the tool brought into contact with the work by moving the cross feed handle. The micrometer collar is set on the zero mark. All lathes have some interlock mechanism to prevent interface when the half nut lever is used. The half nut lever causes two halves of a nut to clamp over the lead screw.

Cutting Internal Threads

a. Many of the rules used for cutting external threads hold true for cutting internal threads
b. The tool may be shaped to the exact form of the thread
c. The tool must be set on the centre of the work piece
d. When cutting an internal thread, the inside diameter (hole size) of the work piece should be the minor diameter of the internal thread.
e. The advantages of making internal threads with a single point tool are that large threads of various forms can be made.
f. The threads are concentric to the axis of the work
g. Internal threads cut with a single point tool need to be checked. A precision thread plug gauge is generally sufficient for this purpose. The gauge is available in various sizes.

Threading in the lathe: Screw threading with taps and dies can be done quite easily and accurately in the lathe.

Screw cutting in the lathe: To cut a thread of any particular pitch, it is necessary to relate the carriage traverse precisely to the rotation of the work. Relating the sizes of the change wheels in the gear train does this. In all cases the pitch of the lead screw must be taken into account. Screw cutting is carried out with a single point cutting tool. Pitch is number of threads over a given distance. Pitch of 0.5mm means that each complete circumference of the thread travels a distance of 0.5mm along its length.
Exercise: 2a

MODEL – I

Aim: To perform machine cutting operations on a given metal rod to obtain the model shown below.

Tools Required: Right Hand Single Point Cutting Tool, Knurling Tools, Parting Tool, Chuck Key, Tool Post Key, Outside Caliper

Procedure:
1. Facing is done on both sides of the work piece.
2. The work piece is held between the live center and the dead center.
3. The plain turning operations are done and the work piece is marked as per the given dimensions.
4. The step turning is done.
5. Taper turning, knurling and chamfering are done respectively using the corresponding tools.
6. Hence the model is completed.

Pre viva questions:
   a. What are the difference metal and non metal?
   b. What is the difference between ferrous and non ferrous metal?
   c. What do you mean by cutting tool?
   d. What do you mean by coolant and what is the necessity of using coolant?
   e. What is the difference between iron and steel?

SKETCH OF THE FINISHED MODEL

Note: All dimensions are in mm
**Result:** The model is prepared as per the drawing given.

**Verification:** The measurement of the model reveals that there is a deviation of X mm in L1, Y mm in L2 and Z mm in L3 & L4.

**Conclusion:** The model prepared is within / beyond the tolerance.

**Post Viva Questions:**

1) What is truing?
2) What is turning?
3) What is knurling?
4) What is taper turning?
5) What is the nature of chip in cast iron and mild steel?
AIM: To perform machine cutting operations on a given metal rod to obtain the model shown below.

Tools Required: Right Hand Single Point Cutting Tool, Parting Tool, Chuck Key, Tool Post Key, Outside Caliper

Procedure:
   a. Facing is done on both sides of the work piece.
   b. The work piece is held between the live center and the dead center.
   c. The plain turning operations are done and the work piece is marked as per the given dimensions.
   d. The step turning is done.
   e. Taper turning and chamfering are done respectively using the corresponding tools.
   f. Hence the model is completed

Pre viva questions:
1. Explain the different types of taper turning method?
2. What is forming, define forming operations?
3. What are the different forms of threads?
4. What is the speed used for thread cutting and knurling?

Sketch of the Finished Model

Note: All dimensions are in mm
Result: The model is prepared as per the drawing given.

Verification: The measurement of the model reveals that there is a deviation of $X$ mm in $L_1$, $Y$ mm in $L_2$ and $Z$ mm in $L_3$ & $L_4$.

Conclusion: The model prepared is within / beyond the tolerance.

Post Viva Questions:

1) What is threading?
2) What is steep taper turning?
3) What is pitch?
4) What is the difference between pitch and lead?
Experiment No: 2c

Aim: To perform machine cutting operations on a given metal rod to obtain the model shown below

INTERNAL THREADING
(V) 4mm PITCH

CHAMFER 1.5mm

Tools Required: Right Hand Single Point Cutting Tool, Chuck Key, Tool Post Key, Outside Caliper

Procedure:
   a. Facing is done on both sides of the work piece.
   b. The work piece is held between the live centre and the dead centre.
   c. The internal threads are cut as per the given dimensions.
   d. Chamfering is done.
   e. Hence the model is completed.

Pre viva questions:
   a. What is chamfering? What is the standard angle and length of chamfering?
   b. What is the necessity of doing chamfering?
   c. What are the stages of drilling for this job?
   d. What are the parts in the centre drill?
   e. What is the difference between drilling and reaming?

SKETCH OF THE FINISHED MODEL

Note: All dimensions are in mm
**RESULT:** The model is prepared as per the drawing given.

**Verification:** The measurement of the model reveals that there is a deviation of $X$ mm in L1, $Y$ mm in L2, and $Z$ mm in L3 & L4.

**Conclusion:** The model prepared is within / beyond the tolerance.

**Post Viva Questions:**

1) What is drilling?
2) What is the difference between drilling and boaring?
3) What is orthogonal and oblique tool?
4) What is mean by chamfering?
Aim: To perform machine cutting operations on a given metal rod to obtain the model shown below

Tools required: Single Point Right Hand Cutting Tool, Centre Punch, Revolving Centre, Divider, Outside Caliper, and Scale.

Procedure:

a. Facing is done on both sides of the work piece.
b. Find out the centre at the two ends of the work piece by divider.
c. Mark off centre from the main centreline.
d. Draw the circle of given diameter and mark by punch.
e. Keep the work piece in four jaw chuck and adjust the off centre and do the plane turning operation by single point cutting tool.
f. Do the turning on the other side and hence the model is completed.

Pre viva questions:

a. What is meant by concentring turning and eccentric turning?
b. What type of chuck is used for eccentric turning?

Note: All dimensions are in mm
Result: The model is prepared as per the drawing given.

Verification: The measurement of the model reveals that there is a deviation of $X$ mm in $L_1$, $Y$ mm in $L_2$, and $Z$ mm in $L_3$ & $L_4$.

Conclusion: The model prepared is within / beyond the tolerance.

Post Viva Questions:

1) What is offset turning?
2) What is angle of cold centre punch?
3) What is least count of vernier caliper?
4) What is difference between least count and tolerance?
1. **A TUTORIAL ON MACHINES AND TOOLS USED IN THE MACHINE SHOP**

   a) **DETAILED STUDY OF MILLING**

   A milling machine is a machine tool, which machines a material when the work piece material is directed against a multipoint cutter. This machine can also hold more cutters at once and hence it is widely used for production work, which requires accuracy and better surface finish. There are various types of milling machines that can be classified based on the nature of the work and operations that is to be carried out. The types are as follows:

   **1. Column & Knee Type:** This type of milling machine is commonly used nowadays in the workshops. It may be further subdivided into different types such as Hand milling machine in which the table feeding movement is provided by hand control, Plain milling machine which is heavier than the Hand milling machine for accommodating heavier work pieces and the table feed may be given by hand or power. Universal milling machine so called owing to its capacity to perform wide range of milling operations. It has a circular swivel base table which can be swiveled up to 45 degrees and it can also be swiveled in a vertical axis other than 90 degrees to the spindle. Omniversal milling machine similar to a universal milling machine except the table can be tilted in a vertical plane with the help of a swivel arrangement at the knee, Vertical milling machine in which the spindle is perpendicular to the worktable.

   **2. Manufacturing or Fixed Bed Type:** It is very heavy and rigid compared to column and knee type milling machine. The table movement is restricted to reciprocation at right angles to the spindle axis with no facility for cross or vertical adjustment. It is again subdivided into simplex, duplex and triplex types, which mean the machine, may be provided with single, double or triple spindle heads respectively.

   **3. Planer Type:** It is a heavy machine made for heavy duty work which has spindle heads adjustable in vertical and traverse directions. It resembles a planer and hence the name Plano-miller.

   **4. Special Type:** These are non conventional types built to suit special purposes. The types are Rotary table machine, Drum milling machine, Planetary milling machine, Pantograph milling machine etc all of which have in common are the spindle for rotating the cutter and facility for moving the tool or work piece in different directions. The constructional features of a column and knee type-milling machine are shown in figure below.
It consists of a Base, Column, Knee, Saddle, Table, Overhanging Arm, Front Brace, Spindle & Arbor, which are explained below.

**Base:** - It is a iron casting machined on it’s top and bottom surface which provides the foundation for all the other parts that rest over it. It has a column on one end and in some cases its base is hollow to act as a reservoir for the cutting fluid.

**Column:** - It is the main supporting frame mounted vertically on the base. It is box shaped and encloses the driving mechanisms for the spindle and table feed. The front vertical face of the column is machined and consists of dovetail guide ways for supporting the knee. From the top of the column an overhanging arm extends outward.

**Knee:** - It slides up and down on the guide ways situated on the column face. The height can be adjusted with the help of an elevating screw mounted on the base and connected to the knee. The knee also houses the feed mechanism for the table and controls to operate it.

**Saddle:** - It is placed over the knee, which slides on the guide ways provided for it. A cross feed screw at the top of the knee engages a nut at the bottom of the saddle in order to move it horizontally to provide cross feed. The saddle is provided with guide ways on it’s top for mounting the table.

**Table:** - The table is mounted on the guide ways of the saddle, which travels longitudinally. The table is also machined with T-slots to facilitate the clamping of work pieces or fixtures. A lead screw below the table engages a nut on the saddle in order to move the table horizontally.

**Overhanging Arm:** - It extends from the top of the column face and provides a bearing support for the other end of the arbor.

**Front Brace:** - It is an additional support fitted between the knee and the over arm in order to provide rigidity to the arbor and the knee.

**Spindle:** - It is situated at the top of the column and obtains power from the motor through the belts or gears and transmits it to the arbor.

**Arbor:** - It is the extension of the machine spindle on which the milling cutters are mounted and rotated in order to properly align with the machine spindle the arbors are made with taper shanks.

Note the direction of rotation of the milling cutter
   a. The cutting edge of the tooth can be seen cutting in an upward direction
   b. As the cutter is rotating in an anti – clockwise direction, the work is fed from the right against the cut
   c. The direction of rotation will determine which side of the cutter the work should be fed into
   d. Conventional milling tends to lift the work away that the work is secure
   e. Rigidity is of great importance for efficient machining

**Climb Milling:**
   a. Should never be attempted except under skilled supervision. The machine should specially be equipped for this technique. The cutter tends to climb over the work.
   b. The advantage of this method is that when taking heavy cuts the work is forced down on to the machine table the feed force is also reduced.
Milling Cutters: Milling cutters are grouped under the following headings
   a. **Plain or Cylindrical Cutters**: Used in machining flat surfaces, Cutting only with their sides.
   b. **Face Cutters**: Face cutters cut with teeth formed on the ends.
   c. **Side & Face Cutters**: These cutters cut on both periphery and on face.
   d. **Saws & Slotting Cutters**: These cutters produce plain, the lee and dovetail slots.
   e. **Form Cutters**: Form cutters are used to produce rounded corners, hollows, and gear – teeth.
   f. **Inserted – Tooth Cutters**: These cutters are usually made in larger sizes of face and cylindrical mills.

**Cylindrical Cutter:**

**Slab or Rolling Milling Cutter**: This is a cylindrical cutter. This is made in a variety of diameters and widths. This has 16 teeth on the circumference only. This is used to produce flat surfaces. Usually it is mounted on a horizontal arbore. To prevent vibration helical teeth are preferred.

**Side & Face Cutter**: This cutter is used for light facing operations and for cutting slots. This is a narrow cylindrical cutter. It has teeth on both faces and on the periphery. This cutter can be used for side cutting as well as for edge cutting.
**Metal Slitting Saws:** This has teeth on the periphery only. It is a thin cylindrical cutter. The width is 0.25 to 6 mm wide. This is used for cutting-off operations. This is also used for producing deep narrow slots, or as a slitting saw. It is mounted on a shaft of arbor in a horizontal milling machine.

**Single Angle Cutter:** This cutter is used for cutting angular surfaces e.g. chamfers, dovetail slots, vee-notches, serrations and for cutting reamer teeth. It is a cylindrical cutter with teeth on the conical surface.

**Double Angle Cutter:** This is a cylindrical cutter. The teeth are on the two-conical surfaces forming vee-shaped teeth. Some cutters have equal angles between the conical faces. Other cutters have unequal angles. The included angles are 45°, 60° or 90°. This cutter is used for milling angular grooves and for milling helical flutes in cutter blanks.

**Shell End Mill Cutters:** This cutter has teeth on the periphery and end face. The length of teeth on periphery is greater than diameter. The teeth are of helical form. These cutters are not reversible. This cutter is used for face milling and for generating surface. It provides one of the most accurate methods of producing a flat surface on a milling machine.
Face Mill: This cutter is of larger diameter than the shell end mill. Diameter is greater than the tooth length.

Gear Cutters: Involute gear cutters are made in a range of eight cutter numbered 1 – 8 for each different module and pressure angle. The range, number, pressure angle, and module is clearly stamped on each cutter.

Straddle Milling: It is a common form of production milling. In this more than one face is called milled.

Gang Milling: In this a number of cutters of different diameters, lengths and shapes are mounted on the arbor at the same time. Several cutters may be ‘ganged’ together to produce complicated profiles.

Contour Milling Cutter: Contour Milling Cutters have special profiles such as concave or convex, circular arcs. These cutters are used for producing internal and external radii etc.

Form Cutting: Formed Milling Cutters are used in milling contours of various shapes. They are made in many shapes and sizes and play important part in milling.
Woodruff Cutters: Woodruff Cutters are used for producing woodruff key-seats. The cutters are made in the form of a slot cutter. It has no side cutting teeth. To produce the key-seat, the cutter is positioned over the work and sunk directly to the required depth.

Face Milling Cutter: This cutter can be fed along its own axis in the same way as drill. It is used to produce keyways and blind slots with the cutter sunk into the material like a drill and fed longitudinally.

Dovetail Cutter: A special type of cutter produces a dovetail. Machines the base surface with its end teeth and the angled surfaces with its inclined cutting face. These cutters are designed for milling dovetail slides of machines. The cutters are available in a variety of size up to 38mm diameter with 45° and 60° angles.

Vertical Milling Operations: Vertical milling operation is quicker, and smoother, uses less power and produces a superior finish. Vertical milling operation is preferred to horizontal milling on most production line.

End Milling Cutter: End milling cutter has helical teeth on the circumference and teeth on one end. These cutters are used for light operations such as milling.
Summary:

a. Milling cutters are multi-point cutting tools. Each individual tooth has a cutting action. Each tooth is geometrically similar to single point tools.
b. Milling cutters have number of teeth.
c. The majority of cutters are made in high-speed steel. Larger sizes are sometimes made from high-carbon steel with tungsten-carbide tooth inserts.
d. Milling cutters have positive, negative or zero rake angles, with both primary and secondary clearance angles.
e. The teeth are sometimes produced with a helix to reduce shock load and chatter.
f. Horizontal cutters can be used for either up-cut or down, cut milling, each producing a particular chip shape.
g. Vertical cutters combine both of those cutting actions and can be fed in any horizontal direction.
h. Cutting tools having number of teeth involve rotational movement of the cutting tool. This is essential in order to present each tooth to the work piece in the correct attitude for cutting.
i. Milling cutters are classified by the method of mounting the cutter on the machine.
j. Milling cutters are also classified according to the way they cut or the shape they produce in the work.
k. Helical mill or slab mill is known as the plain milling cutter.
l. Slab milling cutter with fewer teeth is used for heavy-duty work.
m. Side and face cutters are available in diameters up to 200 mm and widths up to 32 mm. On the diameters above 200 mm. The cutters are made with separate inserted teeth. Separate inserted teeth reduce the cost of the cutter and extend the life.

Dividing Head or Index Head: Dividing head is a piece of equipment used on machines such as milling, grinding and on drilling machines. The main function of a dividing head is to hold work and to rotate the work a part of a turn for machining operation. This device is used for milling slots, grooves, splines and teeth etc.

Parts of Dividing Head

Index Centers - work is mounted on index centers. When the index centres rotate the work also rotates.
Worm Wheel - worm wheel will have 40 teeth cut on it.
Worm Gear - single start worm, Worm and worm wheel help to get finer divisions.
Index Plate - Index plate is a circular disc. Index plate has a greater number of circular holes. Holes are equally spaced around the circumference. Plunger lock helps in fixing the pin into any one of the holes of the index plate.

Simple Indexing: When crank handle is rotated, the single start worm shaft rotates. The worm shaft is meshed to a 40 teeth worm wheel. Worm wheel is fixed to main spindle. Main spindle carries the work. A milling cutter remains fixed perpendicular to the work piece. When single start worm shaft rotates one rotation, it turns worm wheel by 1 teeth

\[ \begin{align*}
\text{i.e.} & \quad 40 \text{ teeth on worm wheel} = 360^\circ, \\
& \quad 1 \text{ teeth on worm wheel} = 360/40 = 9^\circ \\
& \quad \text{For 2 rotation of worm shaft, rotation of worm wheel} = 180^\circ \\
& \quad \text{For 3 rotation of worm shaft, rotation of worm wheel} = 27^\circ \\
& \quad \text{For 6 rotation on worm shaft rotation of worm wheel} = 54^\circ \\
& \quad \text{For 40 rotation of worm shaft rotation of worm wheel} = 360^\circ
\end{align*} \]
Ex. 1: Cut 18 teeth on the given blank. Use an index plate having 18 holes.

The no of teeth required are 18 i.e. to be cut.
The no of holes in the index plate = 18 holes.

No of rotations the crank has to be turned = \( \frac{40}{n} \)

\[ \begin{align*}
\text{No of teeth to be cut on blank} & = 40 \\
\text{No. of cranks} & = \frac{40}{18} = 2 \frac{4}{18} \\
\text{Full turn of crank} & = 2 \frac{4}{18} \text{ holes refers to holes in index plate}
\end{align*} \]

This means

\[ 2 \text{ complete turns} \\
4 \text{ holes in an 18-hole circle} \]

\[ \frac{40}{18} \] This division is obtained from index plate containing 18 holes
This refers to 4 holes in a circle containing 18 holes

Ex. 2: Cut 6 splines on a blank shaft

No. of teeth to be cut = 6

No. of turns the crank has to be rotated = \( \frac{40}{n} \)

\[ \begin{align*}
\text{If index plate with 6 holes is not available, then change to suitable one.}
\end{align*} \]
This means 6 full & 14 holes in a 21-circle index plate

Ex. 3: Cut 15 teeth on a gear blank

No. of teeth to be cut = 15
No. of turns the crank has to be rotated = \( \frac{40}{n} \)

\[
\text{no of teeth to be cut} = \frac{40}{15}
\]

This means 2 full turn & 10 holes in a 15-hole circle

Ex. 4: Mark 48 graduations on a collar

No. of graduations to be marked = 48
No. of turns the crank has to be rotated = \( \frac{40}{n} \)

\[
\text{no of teeth to be cut} = \frac{40}{48}
\]

If index plate having 48 holes is not available, then simplify as shown below

\[
\frac{40}{48} = \frac{20}{24} = \frac{10}{12} = \frac{5}{6}
\]

Select index plate containing 18 holes

Note: if the number of divisions does not match one of the hole circles, then factorize the fraction. Select a suitable hole circle maintaining the ratio.
It is required to index an angle of 29 degrees 25 minutes and 16 seconds. Make necessary calculations and suggest the necessary gearing between the worm gear spindle & the index plate. Assume reasonably the availability of gears in the shops.

360° - 40 teeth

For turning 1 rotation i.e. 360° of the work, the number of teeth on worm wheel in = 40 teeth

Turn of 1 teeth on worm wheel = 9°
Turn of 2 teeth on worm wheel = 18°
Turn of 3 teeth on worm wheel = 27°

For turning through 27° the number of teeth to be turned is 3.
For turning through 29°, 25 Mins & 16 Secs to be turned 3.26 teeth.
3.26 teeth of worm wheel is turned the work turns through an angle 29°, 25 Mins & 16 Secs.

To turn 3.26 teeth or \( \frac{326}{100} \) teeth of the worm wheel

\[
\frac{3}{100} \quad \text{3 full turn of the crank} \quad \frac{26}{100} \quad \text{13 holes} \\
\frac{50}{100} \quad \text{50 holed Plate}
\]

3 full turn and 26 holes in 100 holed plate. Select 100 holed plate and turn 3 times and 26 holes. Select 50 holed plate and turn 3 times and 13 holes

**Differential Indexing:** Differential Indexing is slightly different from simple indexing.

a. Simple indexing consists of index plate; single start worm, worm wheel & main spindle. In differential indexing an additional set of gears is added to the simple indexing setup.

b. Differential indexing is made possible by connecting the index plate to the head stock spindle by means of a gear train. In this the index plate can be made to move either in the same
direction (positive) or in the opposite direction (negative) to the index crank. This causes the movement of the index plate to be either faster or slower. Traveling either more or less than the movement of the index crank.

Ex. 05: index 77 divisions of a blank

No of turns the crank to be rotated = \( \frac{40}{77} \) - select an index plate having 77 holes.

The index plate will not have 77 hole circle. Therefore we must go for differential indexing. This system is to take an approximate indexing as near as possible to the one required.

This will be \( \frac{40}{77} \) - this is approximate to \( \frac{40}{75} \)

\[ \frac{40}{77} \cdot \frac{8}{15} \] Select 15 hole circle

1. Fix 15 hole index plate
2. In 15 hole circle index plate turn to 8 holes for 1 division to cut
3. In 15 hole circle index plate turn to 8 + 8 holes for 2 divisions to cut
4. In 15 hole circle turn to 8 \times 77 holes for 77 divisions to cut
5. To cut 77 division on the blank number of turns the crank has to be turned on a 15 hole circle index plate is \( \frac{77 \times 8}{15} = \frac{616}{15} = 41 \frac{1}{15} \)

Note: In simple indexing one rotation of crank turns worm wheel by 1 tooth. This in turn turns blank attached to main spindle by \( \frac{1}{40} \) as the worm wheel has 40 teeth only. Two rotation of crank turn worm wheel by 2 teeth. This turns blank attached to main spindle by \( \frac{2}{40} \)

In this way it is necessary to turn the crank in the index plate by 40 turns only. Because if you turn the crank 40 turns then the worm wheel would have rotated 1 complete rotation and the blank also would have turned one complete rotation.

In this problem the crank is rotated by \( 41 \frac{1}{15} \) turns by 15 calculations. But in practice the crank has to be turned through 40 turns only.

To make the crank turn only 40 turns, then the index plate is made to rotate back, slightly so that the extra \( \frac{1}{15} \) turn is avoided.

To help facilitate the index plate turn backward or forward, a set of change wheels (gear wheels) is introduced.

These Wheels if selected properly with no of idlers can change the direction of rotation of the index plate.

To know how the index plate should be rotated backward each rotation. \( \frac{1}{15} \) is
Spindle to plate = \[
\begin{align*}
\text{driver} & = 16 = 2 \times 8 \\
\text{driven} & = 15 = 3 \times 5 \\
\end{align*}
\]

\[= 48 \times 40
\]

Fit the gears in the same way as a compound gear train is fitted in a lathe. The arrangement of gears, change wheels, is shown in fig.
Experiment No: 4a

Aim: - To fabricate the given model as per the dimensions given in the figure.

Apparatus: - Milling cutter, indexing head, vernier caliper etc.

Procedure: -

a. Fix the work piece on the worktable and then fit the milling cutter on the tool holder
b. Select a suitable cutting speed and feed.
c. Work piece is fed to the cutter automatically or manually.
d. The work piece is fed against the direction of the milling cutter.
e. The surface is cleaned with the help of brush to remove the chips.
f. This procedure is followed until the required dimension is obtained.

Pre viva questions:

a. What is milling? How the size of milling machine specified?
b. What are the different types of milling machines?
c. Which type of measuring tool is used for marking of dimensions?
d. What is the least count of vernier height gauge?
e. Which type of punch is used for marking purpose?

Result: The model is prepared as per the drawing given.

Verification: The measurement of the model reveals that there is a deviation of X mm in L1, Y mm in L2 and Z mm in L3 & L4.

Conclusion: The model prepared is within / beyond the tolerance.

Post Viva Questions:

1) What is difference between shaper and planer?
2) What do you mean by indexing?
3) Explain the method of simply and compound indexing?
Aim: - To fabricate the given model as per the dimensions given in the figure.

Apparatus: - Milling cutter, indexing head, vernier caliper etc.

Procedure: -

1. Fix the workpiece on the worktable and then fit the milling cutter on the tool holder
2. Select a suitable cutting speed and feed.
3. Mark the dimensions of the groove as per the drawing on the model and punch along the outline with the help of a center punch.
4. Workpiece is fed to the cutter automatically or manually.
5. The workpiece is fed against the direction of the milling cutter.
6. The surface is cleaned with the help of brush to remove the chips.
7. This procedure is followed until the required dimension is obtained.

Pre viva questions:
  a. What is up milling and down milling?
  b. Which type of tool used in milling machine?
  c. Name the different milling cutter and their material?
  d. Why spacing collar is used in milling machine?

Result: The model is prepared as per the drawing given.

Verification: The measurement of the model reveals that there is a deviation of X mm in L1, Y mm in L2 and Z mm in L3 & L4.

Conclusion: The model prepared is within / beyond the tolerance.

Post Viva Questions:
  a. What is single point and multi point cutting tools?
  b. What is up and down milling?
Experiment No: 4c  

Aim: To fabricate the spur gear model according to the figure given below.

Tools required: Milling cutter, Indexing head, vernier caliper etc.

Procedure:

a. Fix the gear blank in milling mandrel between supporting center and Indexing head centre.
b. Fix the milling cutter in Arbor.
c. Calculate indexing for given blank diameter and find out the number of teeth i.e. Z.
d. Bring the cutter near the blank and it should touch the work piece.
e. Give depth of cut by knee elevating handle according to the calculations.
f. Continue this indexing procedure for the required number of teeth and complete the model.

Pre viva questions:

a. What is addendum?
b. What are the methods of power transmission?
c. Which drive is called as positive drive?
d. In order to transmit power for longer distances which type of drive is used?
e. What do you mean by pitch?

1. Outside Diameter  
   2. Pitch Diameter  
   3. Addendum  
   4. Dedendum  
   5. Tooth Depth  
   6. Working Depth  
   7. Tooth Thickness  

Note: All dimensions are in mm
SPUR GEAR PROPOSTIONS

SPUR GEAR TEETH PROPOSTIONS IN INDIAN STANDARD SYSTEM IN TERMS OF MODULE (m) AND NUMBER OF TEETH (Z)

Consider m =
Outside diameter =

<table>
<thead>
<tr>
<th>Name of the tooth element</th>
<th>Symbol</th>
<th>Gear tooth proportions (Pressure angle 20°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitch Dia</td>
<td>d'</td>
<td>Zm</td>
</tr>
<tr>
<td>Outside dia</td>
<td>d'+2ha</td>
<td>m(Z+2)</td>
</tr>
<tr>
<td>Addendum</td>
<td>ha</td>
<td>m</td>
</tr>
<tr>
<td>dedendum</td>
<td>hf</td>
<td>1.25m</td>
</tr>
<tr>
<td>Working depth</td>
<td>2ha</td>
<td>2m</td>
</tr>
<tr>
<td>Tooth depth</td>
<td>H</td>
<td>2.25m</td>
</tr>
<tr>
<td>Tooth thickness</td>
<td>S</td>
<td>1.5708m</td>
</tr>
<tr>
<td>Clearance</td>
<td>hf - ha</td>
<td>0.25m</td>
</tr>
<tr>
<td>Radius of Fillet</td>
<td>R</td>
<td>0.4m to 0.45m</td>
</tr>
</tbody>
</table>

INDEX CRANK MOVEMENT = 40/N

CUTTER SELECTION TABLE

<table>
<thead>
<tr>
<th>In volute gear</th>
<th>Cycloidal gear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutter No.</td>
<td>No. of teeth cut</td>
</tr>
<tr>
<td>No. 1</td>
<td>135 to a rack</td>
</tr>
<tr>
<td>No. 2</td>
<td>55 to 134 teeth</td>
</tr>
<tr>
<td>No. 3</td>
<td>35 to 54</td>
</tr>
<tr>
<td>No. 4</td>
<td>26 to 34</td>
</tr>
<tr>
<td>No. 5</td>
<td>21 to 25</td>
</tr>
<tr>
<td>No. 6</td>
<td>17 to 20</td>
</tr>
<tr>
<td>No. 7</td>
<td>14 to 16</td>
</tr>
<tr>
<td>No. 8</td>
<td>12 to 13</td>
</tr>
<tr>
<td>No. 9</td>
<td>10 to 16</td>
</tr>
<tr>
<td>No. 10</td>
<td>8 to 14</td>
</tr>
<tr>
<td>No. 11</td>
<td>6 to 12</td>
</tr>
<tr>
<td>No. 12</td>
<td>5 to 10</td>
</tr>
</tbody>
</table>

Result: The model is prepared as per the drawing given.

Verification: The measurement of the model reveals that there is a deviation of X mm in L1, Y mm in L2 and Z mm in L3 & L4.

Conclusion: The model prepared is within / beyond the tolerance.

Post Viva Questions:
- a. What is pitch circle?
- b. What do you mean by face and flank?
- c. What is Norton gearbox?
- d. What do you mean by circular pitch?
- e. What is clearance?
Aim: To fabricate the bevel gear model according to the figure given below.

Apparatus: - Milling cutter, Indexing head, Vernier caliper etc.

Procedure: -
1. The gear blank is fixed to the milling table.
2. The driving head spindle is next swivelled to the required cutting angle and the proper index plate is screwed to the sleeve.
3. The amount of offset required and the cutter size are determined after calculations.
4. Then the cutter is mounted on the arbor and is set radially with the gear blank.
5. The table is brought to the starting position and the first offset is applied.
6. The gear blank is next rotated by the given amount in the opposite direction by rotating the index crank.
7. The second cut is taken in this position of the blank. After the second cut the procedure is repeated for applying the second offset and the third cut is done to machine the other side of the tooth flank which finishes the first tooth space.
8. Similar procedure is followed to complete all the teeth’s of the gear.

Pre viva questions:

a. What do you meant by gear?
b. Why indexing is used in gear cutting?
c. Which type of indexing is used in cutting of gears?
d. What is the formula used for simple indexing method?
e. What is the formula used for compound indexing method?

Note: All dimensions are in mm

Bevel Gear Tooth Proportions

<table>
<thead>
<tr>
<th>Name of Teeth Elements</th>
<th>Symbol</th>
<th>Proportions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Addendum (large end)</td>
<td>ha</td>
<td>m</td>
</tr>
<tr>
<td>Dedendum (large end)</td>
<td>hf</td>
<td>1.25m</td>
</tr>
</tbody>
</table>
Tooth depth $h = 2.25\text{m}$
Tooth thickness $s = 1.5708\text{m}$
Circular pitch $p = \Pi\text{m}$
Pitch diameter $d' = Z\text{m}$
Number of teeth $Z$ $d'/m$

Bevel Gear Angular Dimensions

<table>
<thead>
<tr>
<th>Name of Tooth Element</th>
<th>Symbol</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Face width</td>
<td>$b$</td>
<td>$b=0.15$ to $0.33R$</td>
</tr>
<tr>
<td>Addendum (small end)</td>
<td></td>
<td>$-(R-b)/R \times ha$</td>
</tr>
<tr>
<td>Tooth thickness (small end)</td>
<td></td>
<td>$-(R-b)/R \times s$</td>
</tr>
<tr>
<td>Cone distance</td>
<td>$R$</td>
<td>$R=0.5d'\cosec\delta'$</td>
</tr>
<tr>
<td>Addendum angle</td>
<td>$\theta_a$</td>
<td>$\tan \theta_a = ha/R$</td>
</tr>
<tr>
<td>Dedendum angle</td>
<td>$\theta_f$</td>
<td>$\tan \theta_f = hf/R$</td>
</tr>
<tr>
<td>Tip angle (face angle)</td>
<td>$\delta_a$</td>
<td>$\delta_a = \delta' + \theta_a$</td>
</tr>
<tr>
<td>Pitch angle</td>
<td>$\delta'$</td>
<td>$\sin \delta' = 0.5d'/R$</td>
</tr>
<tr>
<td>Root angle (cutting angle)</td>
<td>$\delta_f$</td>
<td>$\delta_f = \delta' - \theta_f$</td>
</tr>
</tbody>
</table>

Calculations:

1) Blank diameter = $m(Z=2\cos\delta') = ------\text{mm}$
   $Z$-no. of teeth, $\delta' =$ pitch angle
2) Tooth depth = $2.25\text{m} = --------\text{mm}$
3) Cutter pitch = --------
4) Face angle = Pitch angle + Addendum angle
   Where Addendum angle = $\tan \theta_a = ha/R$
   $ha = m \& R = b/0.25$ (see table)
5) Inclination of large end = $900 - \delta' = --------$
6) Depth of cut = tooth depth $\times \cos \theta_f$
   From $\tan \theta_f = hf/R = 1.25\text{m/R}$ find $\theta_f$.
7) Index crank movement = $40/N$
8) Gear blank setting:
   Root angle = $\delta_f = \delta' - \theta_f = --------$
9) Offset calculation:
   Offset for first flank = $(R-b)/R \times \sin(90/Z)0 = --------\text{mm}$
   First angular movement = $(90/Z)0 = --------$
   Second offset movement measured from the first = $(R-b)/R \times \sin(180/Z)0 = ----\text{mm}$
   Second angular movement = $(180/Z)0 = --------$
10) Selection of cutter $Z' = Z/\cos\delta' = --------$. From this value obtained select the cutter number from the cutter selection table.

Result: The model is prepared as per the drawing given.

Verification: The measurement of the model reveals that there is a deviation of $X$ mm in $L1$, $Y$ mm in $L2$ and $Z$ mm in $L3$ & $L4$.

Conclusion: The model prepared is within / beyond the tolerance.

Post Viva Questions:

1) What is bevel gear?
2) What is the included angle of the bevel gear?
3) What is method used for manufacturing of bevel gear?
4) Which method is suitable for manufacturing of gear?
5) Which type of gauge is used to check the shape of the gear tooth?
1. The shaper is a small machine. The main function of the shaping machine is to produce flat surfaces. The primary motion is linear.

2. A shaping machine is used to produce flat surfaces by means of a single point reciprocating tool.

3. The surfaces may be vertical, horizontal (or) angled.

4. In shaping the cutting tool is given a reciprocating motion. Cutting is not continuous.

5. The cutting stroke is the forward stroke.

6. The single – point tool is gripped in a tool head, mounted on the end of a ram.

7. Ram provides tool movement. The ram is made to move backward & forward by a mechanical driver system (or) a hydraulic piston & cylinder.

8. The ram is driven by a variable – speed quick return mechanism.

9. The table movement provides feed. The depth of cut is controlled by the tool side on the ram.

10. The table: A workpiece is held in a vice situated on top of the table. The table is usually a box like casting. The vertical slide ways on the body of the shaper permit the raising (or) lowering of the table, whilst maintaining the necessary geometrical accuracy. On the upper surface & down one side T – slots are provided in the casting itself. On heavy – duty shapers a support is provided for the table. This gives rigidity & prevents deflection of the workpiece when the cut is heavy.

11. Shapers are used to machine flat surfaces on small components.

12. Shapers are suitable for low – batch quantities.

13. Skilled machinist can manipulate shaper to cut curved, irregular shapes, slots, grooves & keyways.
9. Forward ram speed is slower than the speed on the return stroke.

10. A quick-return mechanism is often used in mechanical shapers to increase the efficiency. The return stroke is carried out at a higher rate.

11. In all shapers, the length of the stroke can be adjusted to suit the particular workpiece being machined.

17. Shaper is unsuitable for generating flat surfaces on very large parts because of limitations on the stroke & overhang of the ram.

18. Operating the machine is easy, but setting the work to obtain accurate results is difficult.


20. When the job is long, shaping cannot be used. So planning is used.

21. The chief difference between a shaper & a slotter is the direction of the cutting action.
Prepare any of the models shown using shaping machine. Shapes are suggestive.
SHAPING  
Model – I

Experiment No: 5a  
Date:

Aim: To fabricate the model using shaping machine according to the figure given below.

Tools Required: Shaping cutting tool, Machine vise etc.

Procedure:

1. Initially, the work piece is clamped on the machine vise of the shaping table.
2. Then the shaping machine is operated to perform the necessary cutting action and ultimately complete the model as per the required dimensions.

Pre viva questions:

a. What do you meant by shaping?
b. Which type of tool is used in shaper?
c. What is the main difference between shaper and planer?
d. Name the parts of the shaper?
e. How the shaper are classified?

Result: The model is prepared as per the drawing given.

Verification: The measurement of the model reveals that there is a deviation of X mm in L1, Y mm in L2 and Z mm in L3 & L4.

Conclusion: The model prepared is within / beyond the tolerance.

Post Viva Questions:

1) In what stroke material is cutting?
2) How is the stroke length and ram position adjusted?
3) Name the various shaper operations?
4) What is quick return mechanism?
Experiment No: 5b

Aim: To fabricate the model using shaping machine according to the figure given below.

Tools Required: V-tool, Shaping cutting tool, Machine vise etc.

Procedure:

1. Initially, the square block is prepared to the required dimension on the shaping machine.
2. The marking is carried out on the work piece for cutting V-groove.
3. The shaping cutting tool is set to the required angle to form V-groove.
4. Then the shaping machine is operated to perform the necessary cutting action and ultimately complete the model as per the required dimensions.

Pre viva questions:

a. Which type of tool is used for v groove?
b. What is slotting?
c. specify slotter?
d. how to tilt the tool head doing slot cutting?

Result: The model is prepared as per the drawing given.

Verification: The measurement of the model reveals that there is a deviation of X mm in L1, Y mm in L2 and Z mm in L3 & L4.

Conclusion: The model prepared is within / beyond the tolerance.

Post Viva Questions:

1) Define shaping?
2) Name the parts of the shaper?
3) How the shapers are classified?
4) What is quick return mechanism?
Aim: To fabricate the model according to the figure given below.

**Tools Required:** Shaping tool, Square tool, Machine vise etc.

**Procedure:**

1. Initially, the square block is prepared to the required dimension on the shaping machine.
2. The marking is carried out on the work piece for cutting square groove.
3. The shaping tool is set to the required angle to form square groove.
4. Then the shaping machine is operated to perform the necessary cutting action & ultimately complete the model as per the required dimensions.

**Pre viva questions:**

a. What do you meant by shaping?
b. Which type of tool is used in shaper?
c. What is the main difference between shaper and planer?
d. Name the parts of the shaper?
e. How the shaper is classified?

**Result:** The model is prepared as per the drawing given.

**Verification:** The measurement of the model reveals that there is a deviation of X mm in L1, Y mm in L2 and Z mm in L3 & L4.

**Conclusion:** The model prepared is within / beyond the tolerance.

**Post Viva Questions:**

1) Define shaping?
2) Name the parts of the shaper?
3) How the shapers are classified
Aim: To fabricate the model according to the figure given below.

Tools Required: V-tool, Parting tool, Dovetail cutting tool etc.

Procedure:

1. Initially, the square block is prepared to the required dimension on shaping machine.
2. The marking is carried out on the work piece for cutting Dovetail groove.
3. The shaping tool is set to the required angle to form Dovetail groove.
4. Then the shaping machine is operated to perform the necessary cutting action and ultimately complete the model as per the required dimensions.

Pre viva questions:

a. Which type of tool is used for v groove?
b. What is slotting?
c. specify slotter?
d. how to tilt the tool head doing slot cutting

Result: The model is prepared as per the drawing given.

Verification: The measurement of the model reveals that there is a deviation of X mm in L1, Y mm in L2 and Z mm in L3 & L4.

Conclusion: The model prepared is within / beyond the tolerance.

Post Viva Questions:

1) Define shaping?
2) Name the parts of the shaper?
3) How the shapers are classified?
The horizontal spindle surface grinder has a horizontal spindle. The horizontal spindle provides primary motion to the wheel.

The worktable reciprocates. This is the principal feed motion. The work is mounted on the worktable. This motion is known as ‘Traverse’ motion. This is brought hydraulically. The wheel head can be moved up & down. This feed motion of the wheel head is known as ‘Cross – Feed”. This feed motion also is operated hydraulically. This feed motion is applied after each stroke (or) pass of the table.

**CYLINDRICAL GRINDING:**

Cylindrical Grinding is similar to Cylindrical Turning.

1. In this cylindrical surface is being generated using the traverse motion
2. In this single point a grinding wheel replaces cutting tool
3. In this the work piece is supported & rotated between centers. The headstock provides the low – speed rotational derives to the work piece. The headstock & the tailstock are mounted on a worktable. The worktable is reciprocated horizontally using a hydraulic drive
Answer the Questions.

a. What is grinding?

b. Grinding is the process for what operation.

c. What a grinding wheel is made of?

d. What are the general shapes of a grinding wheel?

e. To grind tungsten carbide tip which grinding wheel is required

f. How many types of abrasive grains are there

g. How is Aluminium Oxide manufactured?

h. How is Silicon Carbide manufactured?

i. Name the same material that can be ground using Silicon Carbide grinding Wheel?

j. Explain the terms: Grain Size, Hardness, Grade Structure

k. What is a Bond?

l. How many types if bonds are there?

m. Name the types of bonds
Viva Voice Questions

1. What is the difference between Machine tool & Cutting tool?
2. Name the different types of cutting tools used in machine shop?
3. Name the different types of Lathes? 
4. What are the different types of Operations that can be performed on Lathe?
5. Name the different types of Taper turning methods?
6. What is the difference between Mild steel & Cast Iron?
7. Name the different parts of Lathe and by which material, which it is made of?
8. What is the difference between 3-jaw chuck and 4-jaw chuck?
9. What are the different types of cutting fluids used?
10. What is the formula for calculating Taper angle?
11. What is the formula for cutting speed?
12. What is difference between Feed & Depth of cut?
13. What is the Unit of feed?
14. Name the different parts of Milling machine and their usage?
15. Name the different parts of Shaping machine & usage?
16. By which mechanism, shaping and Milling machine works?
17. What is the difference between Left-hand thread cutting & Right-hand thread cutting?
18. What is the importance of Lock nut in Lathe?
19. What is the importance of Gear box in Lathe?
20. What is the procedure for producing gear teeth’s in Milling machine?
21. What do you mean by Slotting machine?
22. Name the different parts of Slotting machine and their usage?
23. What do you mean by Eccentric turning?
24. What do you mean by Live-center and Dead-center?
25. How do you specify a lathe?
26. What do you mean Cutting tool nomenclature?
27. Name the different types of Cutting tool materials?
28. What do you mean by internal thread cutting, Boring, Reaming?
29. Name the different types of Chips produced in Lathe?
30. What are the factors caused to get different types of Chips?
31. What are different types of Gears?