NOIDA INSTITUTE OF ENGINEERING AND TECHNOLOGY GREATER NOIDA

(An autonomous institute)

NIET
Greater Noida
Estd.2001
Get Future Ready
Autonomous Institute

CAD&DM LAB MANUAL

Computer Aided Design and Digital Manufacturing (BME0151N/0251N)
2024-25

COURSE: B.TECH (1 Yr) **SEMESTER : I**

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Lab O/C

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VISION OF INSTITUTE

To be an Institute of academic excellence in the field of education, with future plan of becoming a deemed university, earn name and hence win faith of the society.

MISSION OF INSTITUTE

To impart to its students a high-quality education, develop their skills, broaden their mental horizon and nurture them into competent and talented professionals to meet the challenges of the new millennium.

PROGRAM OUTCOMES (POs)

PO1 Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2 Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3 Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4 Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5 Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6 The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the subsequent responsibilities relevant to the professional engineering practice.

PO7 Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8 Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9 Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10 Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11 Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12 Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

COURSE OUTCOMES

Course Name	CAD&DM (BME0151N/0251N) 1st/2nd Semester
On the completion of all lab experiments, the students will be able to-	
BME-0151N/0251N - 1	Understand engineering drawings, projections, and CAD software for accurate technical design and visualization
BME-0151N/0251N - 2	Gain proficiency in sketching, dimensioning, editing, and detailing drawings in CAD, including advanced layout and plotting techniques.
BME-0151N/0251N - 3	Apply skills in 3D modeling, visualization, and assembly, mastering techniques for creating and editing complex digital prototypes and blueprints.
BME-0151N/0251N - 4	Understand workshop practices, machining tools, and materials, with insights into digital manufacturing, automation, and Industry 5.0 innovations.
BME-0151N/0251N - 5	Demonstrate and apply 3D printing, understand various production types, and explore smart factories and industry technologies for advanced manufacturing.

MAPPING OF CO's WITH PO'S

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BME-0151N/0251N - 1	3	1	-	-	2	1	1	1	1	1	1	3
BME-0151N/0251N - 2	3	1	-	1	3	2	1	1	1	1	1	3
BME-0151N/0251N - 3	3	2	2	1	3	3	1	1	2	1	2	3
BME-0151N/0251N - 4	3	1	-	-	2	3	2	1	2	1	2	3
BME-0151N/0251N - 5	3	2	2	1	3	3	2	1	2	1	3	3
Average	3	1.4	0.8	0.6	2.6	2.4	1.4	1	1.6	1	1.8	3

Experiment-1

Aim: To study the Engineering Drawing Format and Elements.

Theory: An engineering drawing is a graphical representation of a part, assembly, system, or structure and it can be produced using freehand, mechanical tools, or computer methods. Working drawings are the set of technical drawings used during the manufacturing phase of a product. They contain all the information needed to manufacture and assemble a product.

- **A Code** is a set of specifications for the analysis, design, manufacturing, and construction of something.
- **A Standard** is a set of specifications for parts, materials, or processes intended to achieve uniformity, efficiency, and specific quality.

Examples of the organizations that establish standards and design codes: ISO, AISI, SAE, ASTM, ASME, ANSI, DIN.

Drawing Format and Elements:

1.1. Sheet Size:

Engineering drawings are to be prepared on standard size drawing sheets. The drawings must be prepared with a certain standard practice, as recommended by **Bureau of Indian Standards (BIS).**

Table 1. A: Standard Sizes:

Series Designation	Trimmed Size, mm		Inside Border, mm	
	Y	X	H	W
A0	841	1189	821	1159
A1	594	841	574	811
A2	420	594	400	564
A3	297	420	277	390
A4	210	297	190	267
A4 Vertical	297	210	277	180
B1	707	1000	687	970

1.2. Engineering Drawing Sheet Layout:

Every drawing sheet is to follow a particular layout. As a standard practice sufficient margins are to be provided on all sides of the drawing sheet. The drawing sheet should have drawing space and title block.

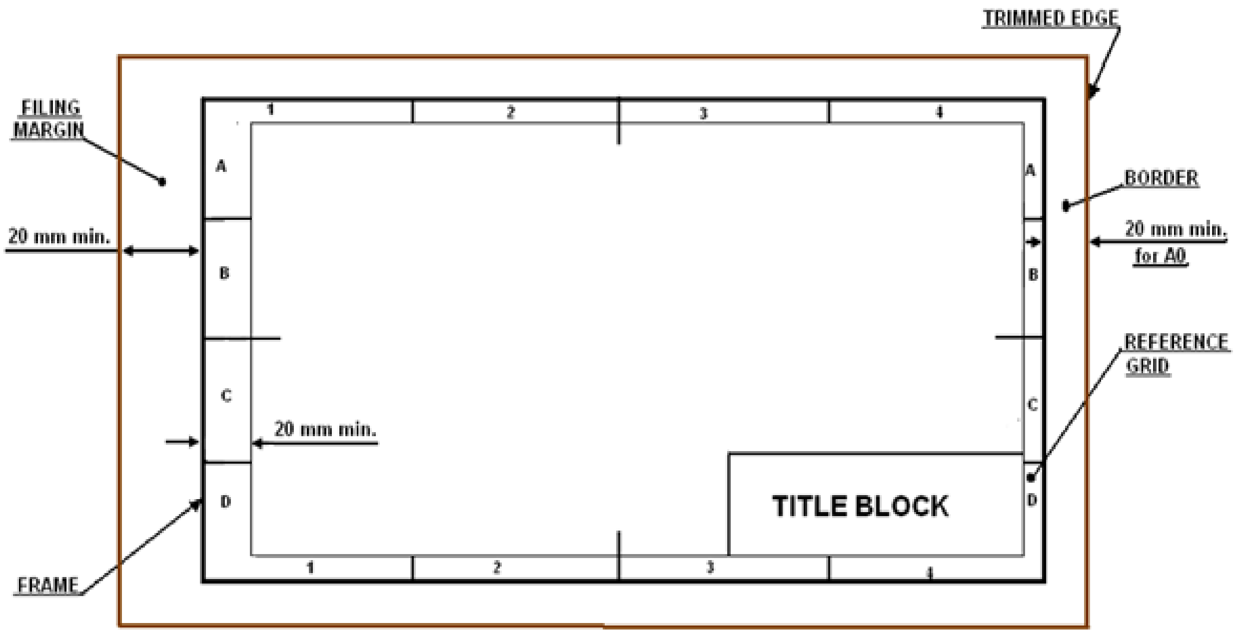


Fig 1.a: Engineering Drawing Sheet Layout

1.3. Main Components of Sheet Layout:

a. **Border**: A frame around the drawing area to contain the drawing elements and title block. A minimum of 10 mm space left all around in between the trimmed edges of the sheet.

b. **Margin**: Space between the border and the drawing to prevent content from being cut off.

c. **Filing Margin:** A minimum of 20 mm space left on the left-hand side with border included. This provided for taking perforations.

d. **Drawing Area**: The area where the actual drawing (or design) is depicted, using appropriate scale and proportions.

e. **Views**: Various projections (top, front, side, isometric) showing different aspects of the object.

f. **Dimensioning:**

- **Linear Dimensions**: Indicate lengths, widths, and heights.
- **Angular Dimensions**: Show angles between features.
- **Tolerances**: Specify allowable variations in dimensions.
- **Datum References**: Establish reference points for measurements.

g. **Notes and Annotations:**

- **General Notes**: Provide additional information about the drawing that may not be clear from the visuals alone.
- **Part Numbers**: Identify specific components in assemblies.
- **Material Specifications**: Indicate the materials to be used.

h. **Scale Indicator:** A graphical representation or numerical scale to indicate how the drawing relates to the actual size of the object.

i. **Grid or Layout Lines**: Lightly drawn lines that assist in positioning elements on the sheet, ensuring everything is aligned properly.

j. **Grid Reference System:** This is provided on all sizes of industrial drawing sheets for easy location of drawing within the frame. The length and the width of the frames are divided into even number of divisions.

1.4. Visual Representation in Graphics:

When creating an engineering drawing in graphics software (AutoCAD, PTC CREO). Different layers are used for different visual representations.

- **Layer for Borders**: Separate layer to control visibility and editing of the border.
- **Layer for Title Block**: Different layer for title block elements, making it easy to modify.
- **Layer for Main Drawing**: A dedicated layer for the actual drawing elements.
- **Layer for Dimensions and Annotations**: Keeps dimensions and notes organized and easily editable.

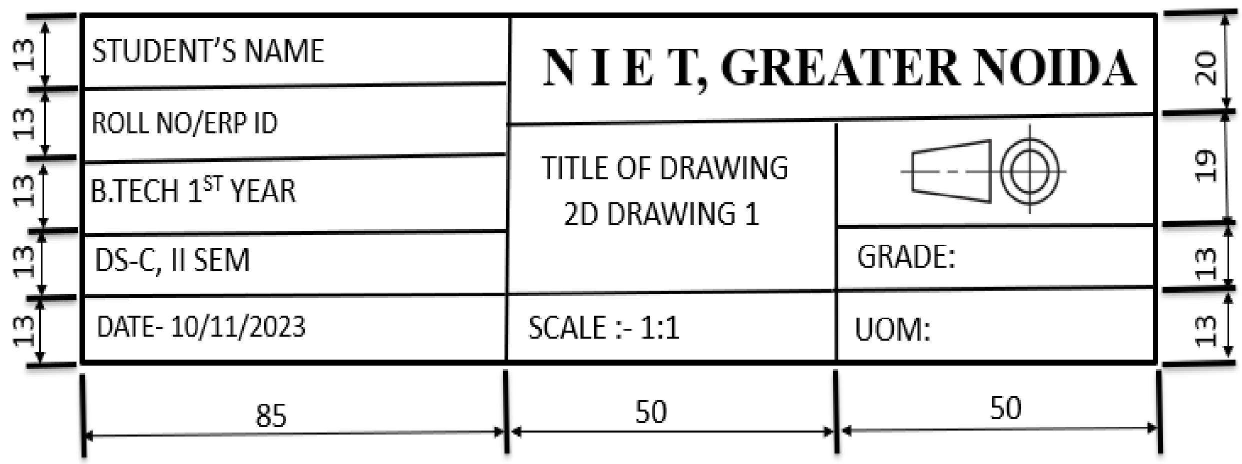
1.5. **Title block**:

A title block is the form on which the actual drawing is a section. The title block includes the border and the various sections for providing quality, administrative and technical information. This is located at the bottom right-hand corner of every sheet and provides the technical and administrative details of the drawing.

The title box is divided into two zones

a. Identification zone: In this zone the details like the identification number or part number, Title of the drawing, legal owner of the drawing, etc. are to be mentioned.

b. Additional information zone: Here indicative items lime symbols indicting the system of projection, scale used, etc., the technical items lime method of surface texture, tolerances, etc., and other administrative items are to be mentioned.



*****Size of the Title Block** = 185X65

Fig 1.b: Title Block

1.6. Sheet Layout with Title Block: Designed in AutoCAD Software.

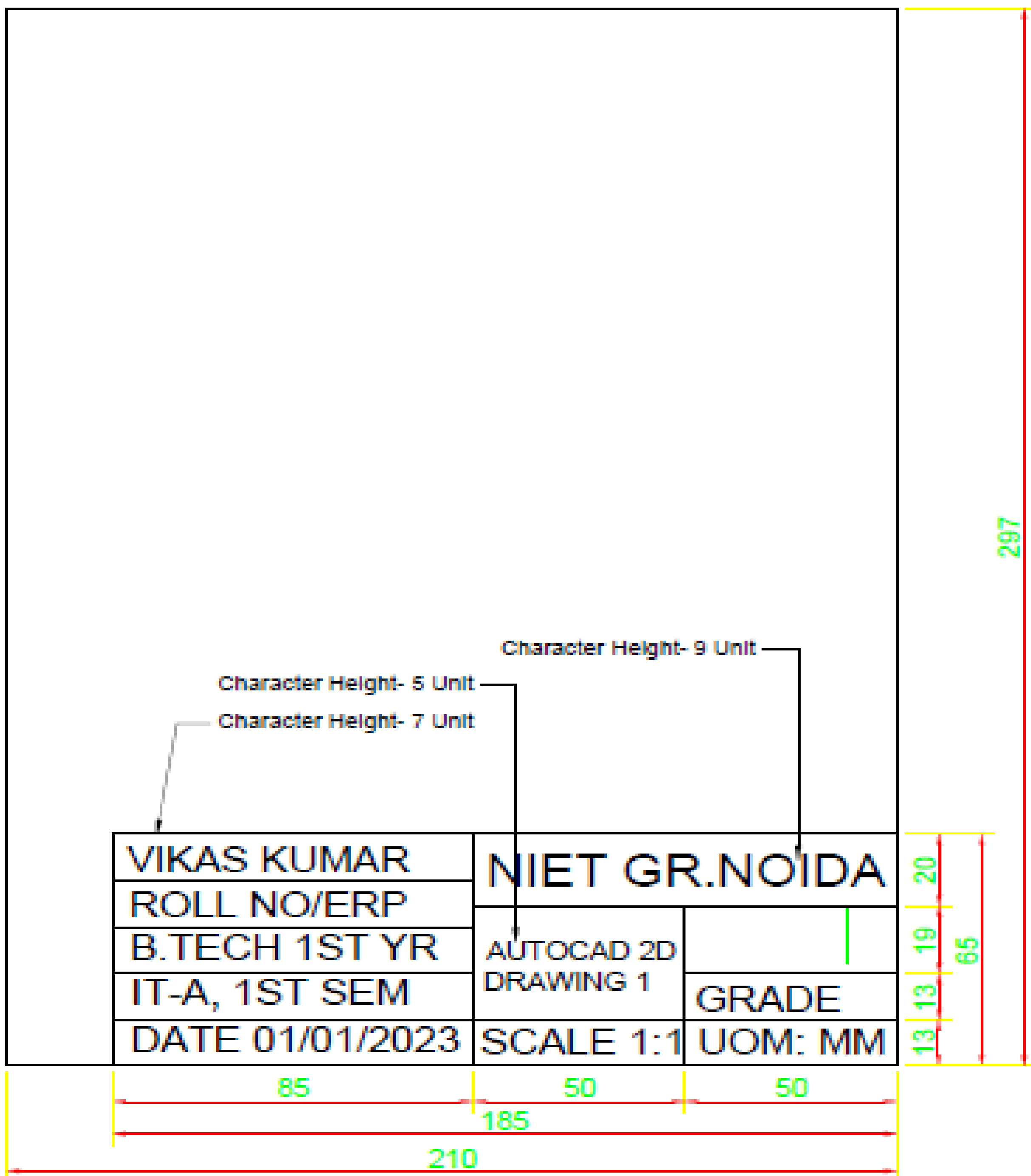


Fig 1.c: Sheet Layout with Title Block

Experiment No- 2

Aim: To accurately create and represent the given 2D drawings in AutoCAD, utilizing the Aligned System of dimensioning.

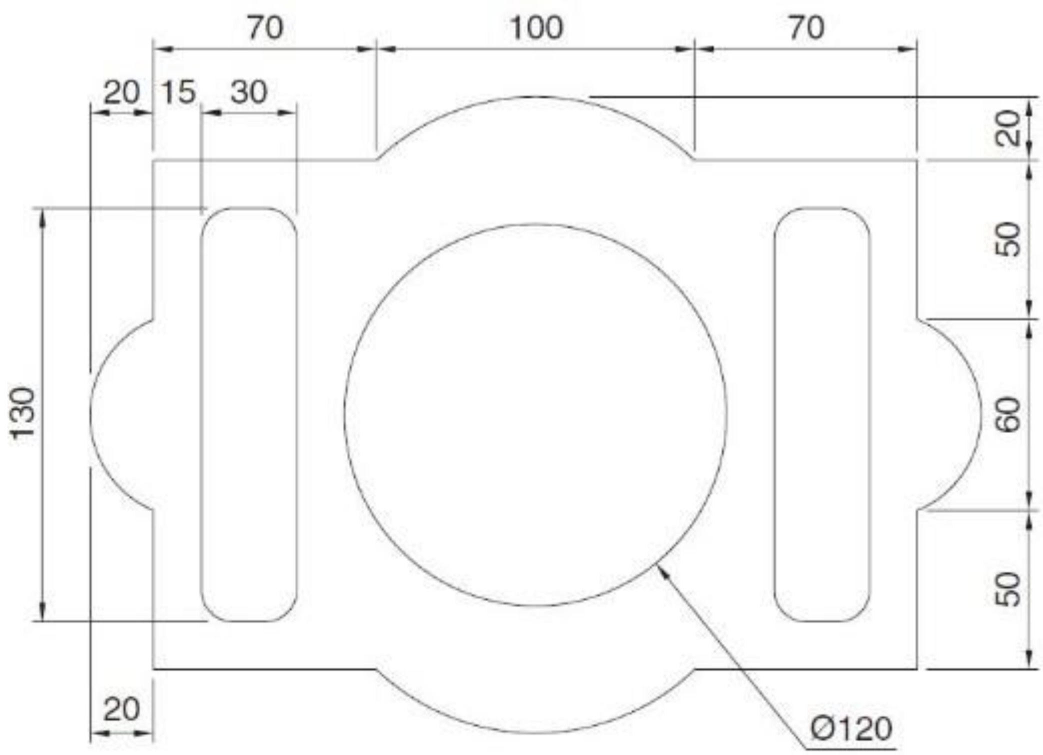


Figure 2.1: 2D drawing 1

Drawing Methodologies and steps:

Step 1: In the AutoCAD start window, go to the **Templates** tab and select acadiso.dwt. This template uses ISO standard settings.

Step 2: Select the Model Layout

- At the bottom of the workspace, select the **Model** tab. This ensures you are working in the model space for 2D drawing.

Step 3: Specify the Units of Measurement

- Type UNITS in the command line and press **Enter**.
- In the **Drawing Units** dialog box, set:
  - **Type**: Decimal
  - **Precision**: 0 (if only whole numbers are required)
  - **Units**: Millimeters (as per the standard industrial unit)
  - **OK** to apply the changes.

Step 4: Set the Limits of the Designing Area

- Type LIMITS in the command line and press **Enter**.
- Specify the lower-left corner as 0,0 and press **Enter**.
- Specify the upper-right corner as 300,200 (or larger to give some working space) and press **Enter**.
- Type Z and then **Enter**, followed by **A** (to zoom to the full drawing area).

Step 5: Draw a Rectangle of Given Dimensions (240 x 160)

- Type RECTANGLE and press **Enter**.
- Click anywhere in the drawing area to set the first corner (for example, at 0,0).
- Type @240,160 and press **Enter** to draw the rectangle of 240 units in length and 160 units in width.

Step 6: Draw the Diagonal of the Rectangle and Use It to Draw the Circle

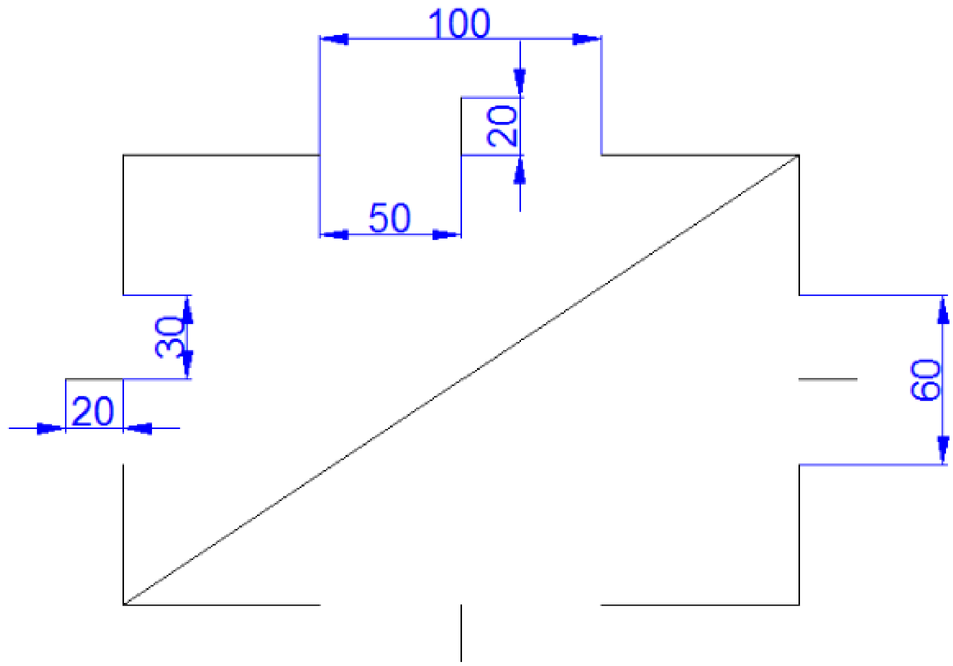


Figure 2.1: A

Step 7: Draw a Circle Using the Diagonal of the Rectangle
Step 8: Use the ARC Command to Draw Arcs at the Corner Points of the Rectangle
Step 9: Mirror the Arcs to Create the Remaining Two Arcs

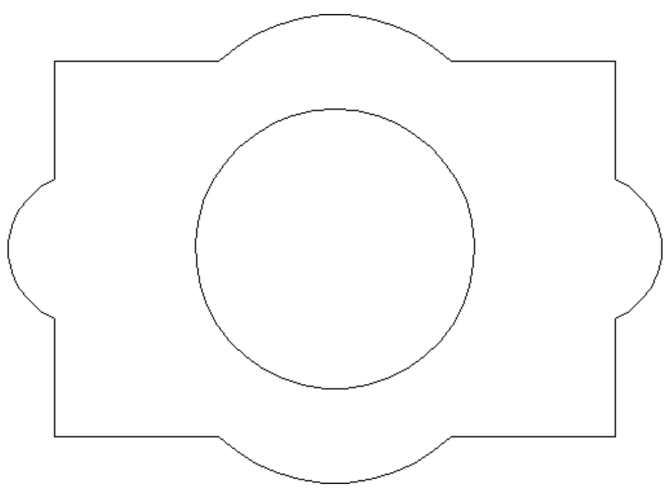


Figure 2.1: B

Step 10: To draw the rectangles with rounded corners. Enter the LINE command, come near the end of a line, now move slowly horizontally or vertically. Through the green dotted line, leave the mouse in that position, and typethe dimension value.

Step 11: To get the rounded shapes of radius 10 on each edge of the rectangle, use the FILLET command.

a. Click on the icon shown on the figure above
b. Type “R” on your keyboard and press ENTER
c. Type “10” and press ENTER
d. Select the first side of the corner to round
e. Select the second side of the corner to round

Repeat this for the other 3 corners.

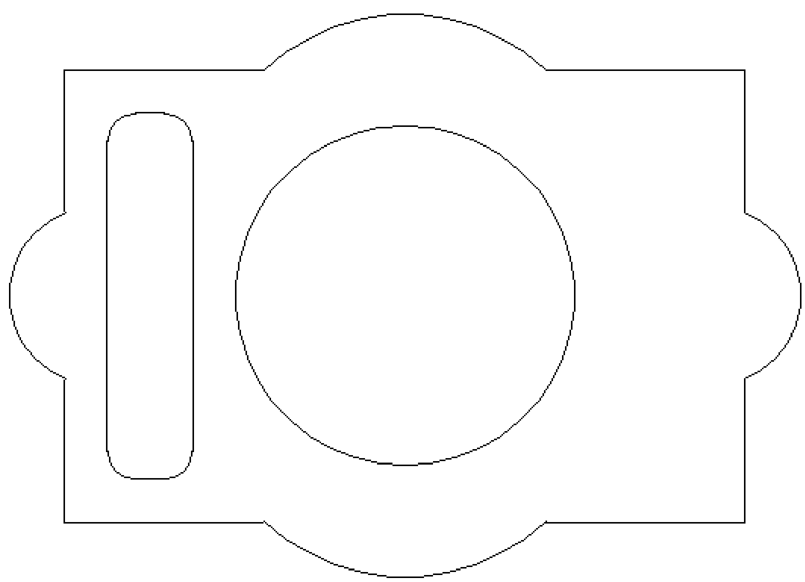


Figure 2.1: C

Step 12: Now use the MIRROR command to obtain the rectangle on the right, sinceit is a symmetry of the figure. Use the center of the circle as center of the symmetry.

Step 13: Specify the dimensions of various features of the drawing.

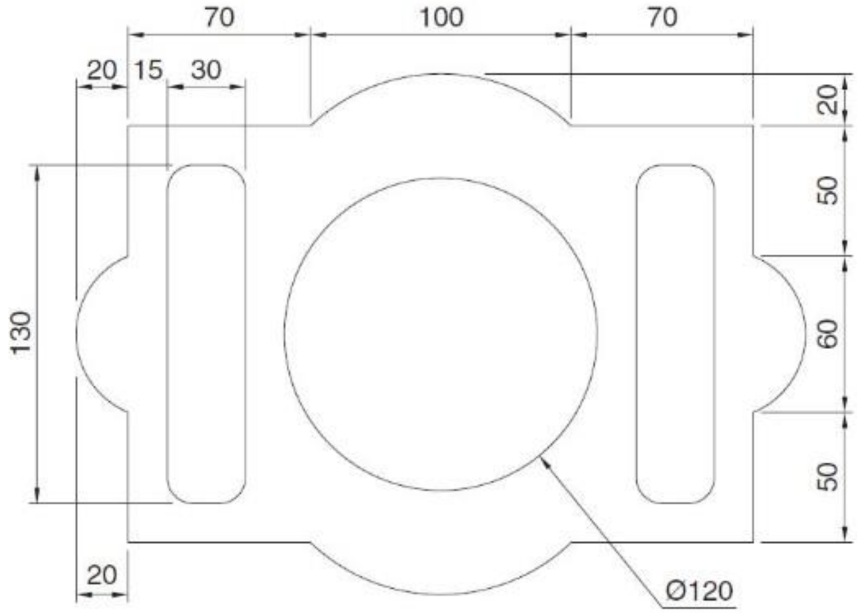


Figure 2.1: D

Experiment No.3

Aim: To accurately create and represent the given 2D drawing in AutoCAD, utilizing the Aligned System of dimensioning.

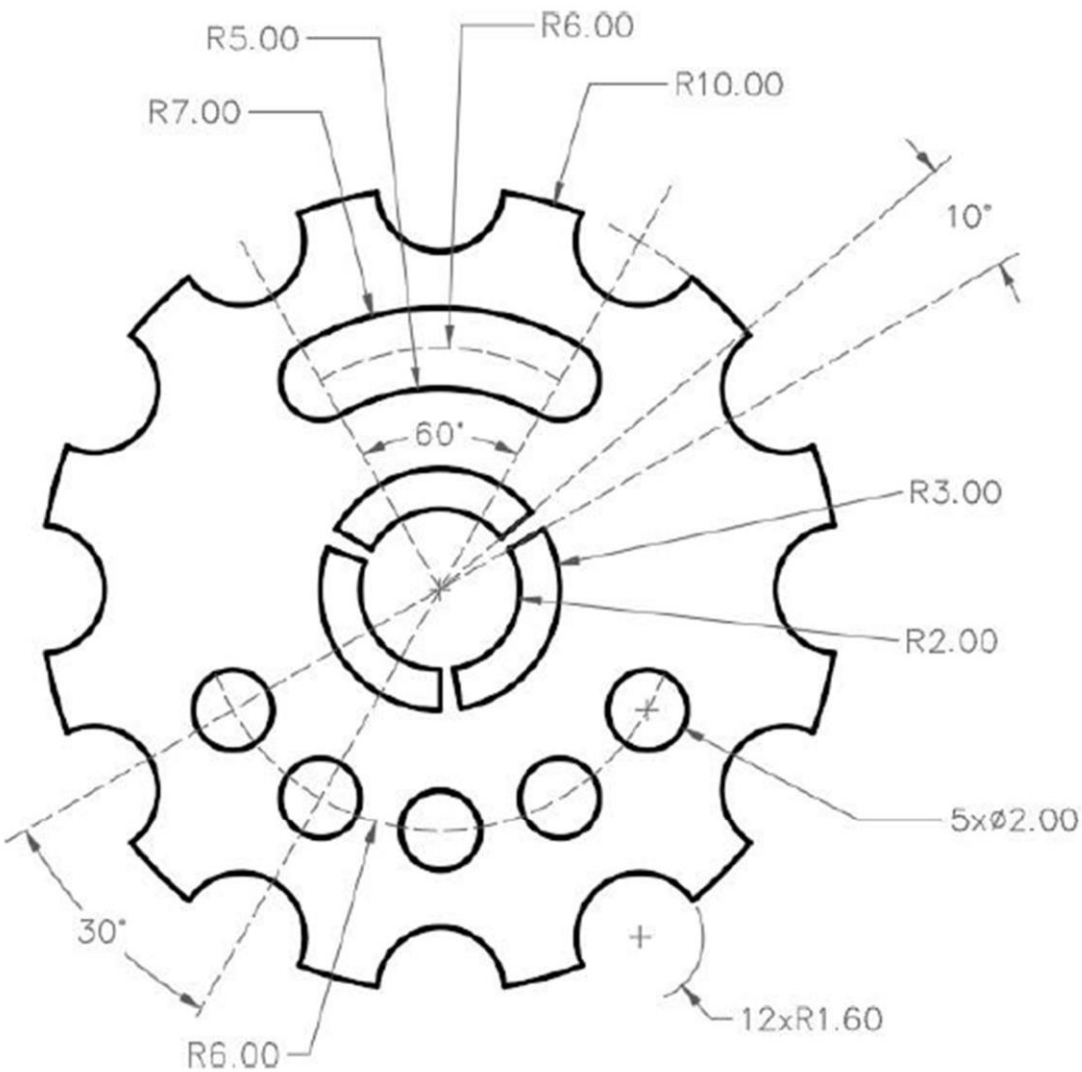


Figure 3.1: 2D Drawing 2

Drawing Methodologies and steps:

Step 1: In the AutoCAD start window, go to the **Templates** tab and select acadiso.dwt. This template uses ISO standard settings.

Step 2: Select the Model Layout

- At the bottom of the workspace, select the **Model** tab. This ensures you are working in the model space for 2D drawing.

Step 3: Specify the Units of Measurement

- Type UNITS in the command line and press **Enter**.
- In the **Drawing Units** dialog box, set:
    - **Type**: Decimal
    - **Precision**: 0 (if only whole numbers are required)
    - **Units**: Millimeters (as per the standard industrial unit)

Step 4: Set the Limits of the Designing Area

- Type LIMITS in the command line and press **Enter**.
- Specify the lower-left corner as 0,0 and press **Enter**.

Step 5: Making the outer circle: Create the circle of 100mm radius using centre-radius circle command form draw tool barof the home tab.

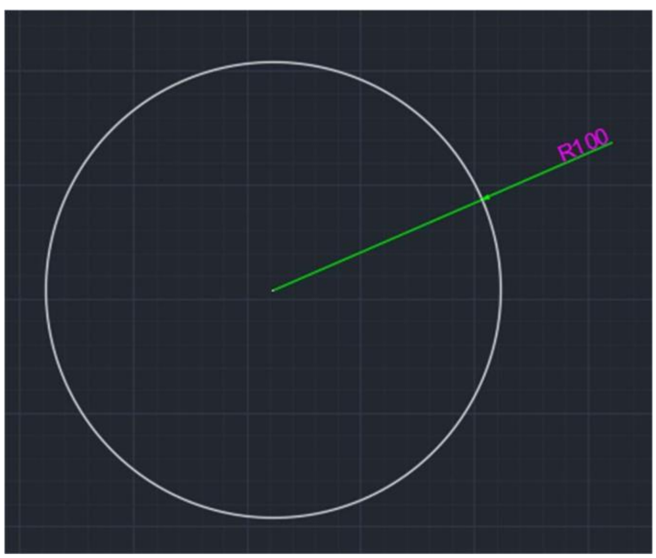


Figure 3.1: A

Step 6: Draw the small circle of 16 mm radius on the top quadrant point of the bigger circle usingcircle command and then trim it outer part as shown in figure below.

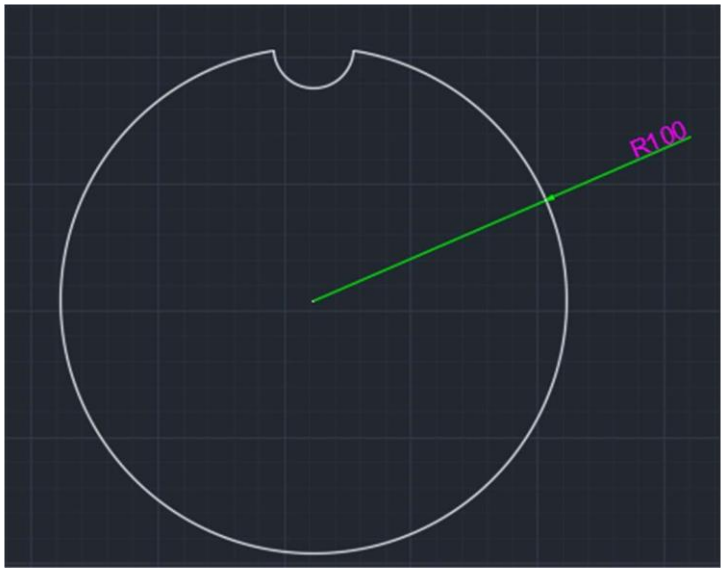


Figure 3.1: B

Step 7: Select the Polar Array command and select the semicircle as the object and then enter after this select as the center of thearray command at centre of the bigger circle and then write down the 12 no. in items of the polar array and then close it.

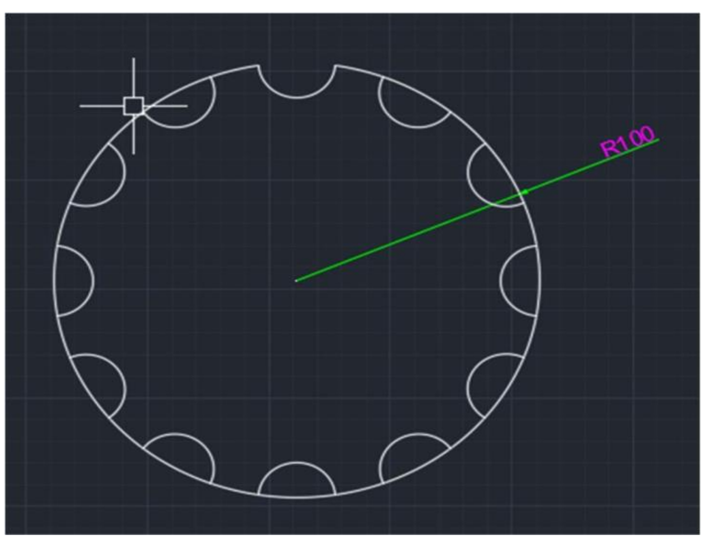


Figure 3.1: C

Step 8: Making 5 small circles on the dash circle periphery

- Draw the circle of radius of 60mm as Centre same as the bigger circle.
- Now draw two lines using line command, one line passing through centre of big circle and making angle of 150 deg with horizontal and second line making angle of 120 deg with horizontal in clock wise direction.

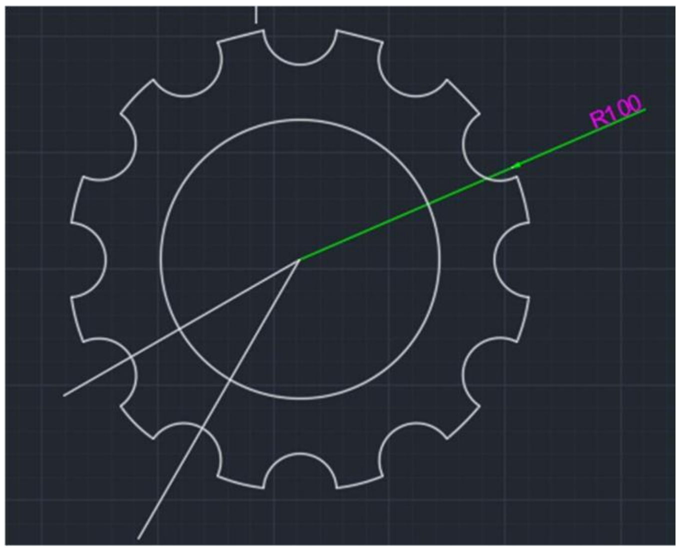


Figure 3.1: D

- Now draw the small circle of 20mm diameter at intersection of the line making 150 degwith horizontal and inside circle.

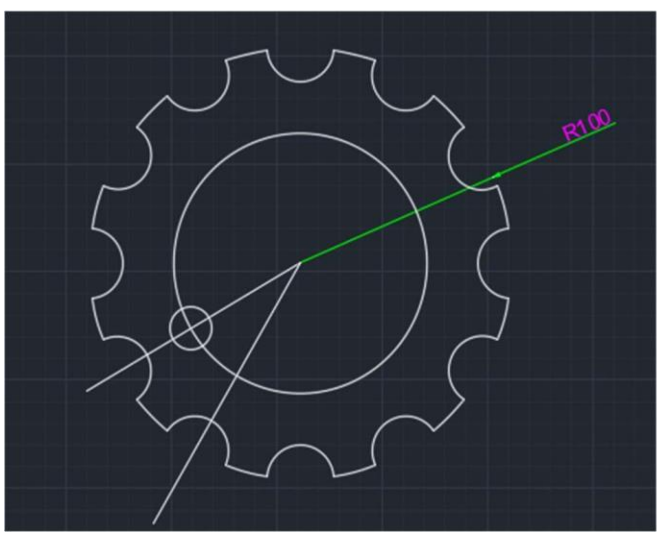


Figure 3.1: E

Step 7: Then take the polar array command and select object this small circle as object and then assign centre point of the array and assign 5 items in the array tab opened.

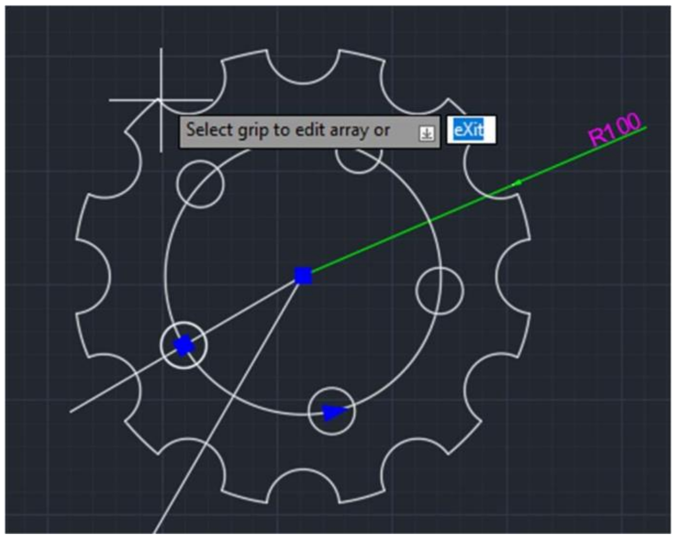


Figure 3.1: F

- Then capture the centre point of the second small circle created and drag it to theintersection of the second line and inside circle and the click it and then close.

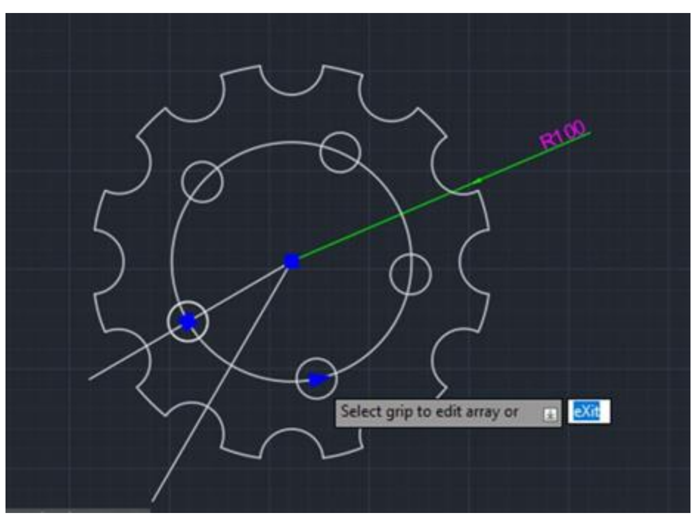


Figure 3.1: G

Step 8: Making groove in arc form

- Draw two lines first passing through the center and 120 deg with horizontal and 2nd linepassing through center and 60 deg with horizontal in anticlockwise.
- Trim the extra circle.
- Make offset the arc remained after trimming with offset distance of 10mm in above andblew direction.
- Draw two circles on the both ends of this arc-based groove using two-point circle. And trim the undesired part.

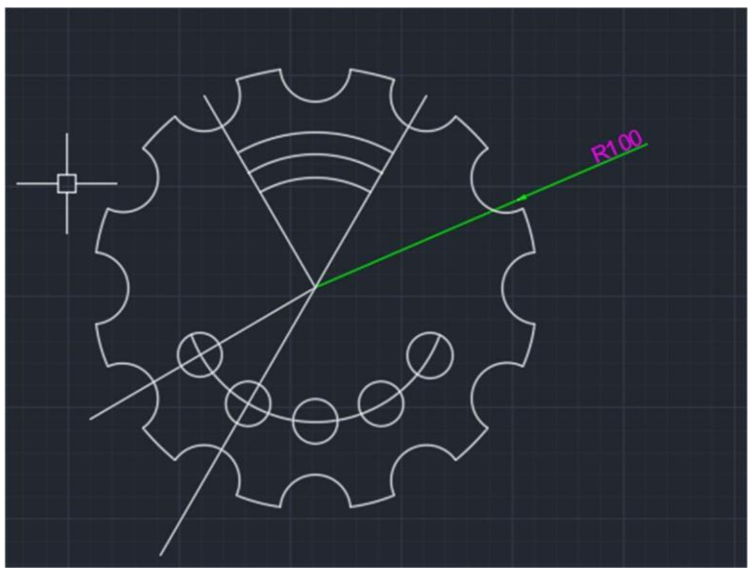


Figure 3.1: H

Step 5: Making the inner cut section

- Draw two circles of radius 20mm and 30mm as center same that of the bigger circle.
- Then draw two lines making angles of 25 and 35 deg with horizontal as shown below.

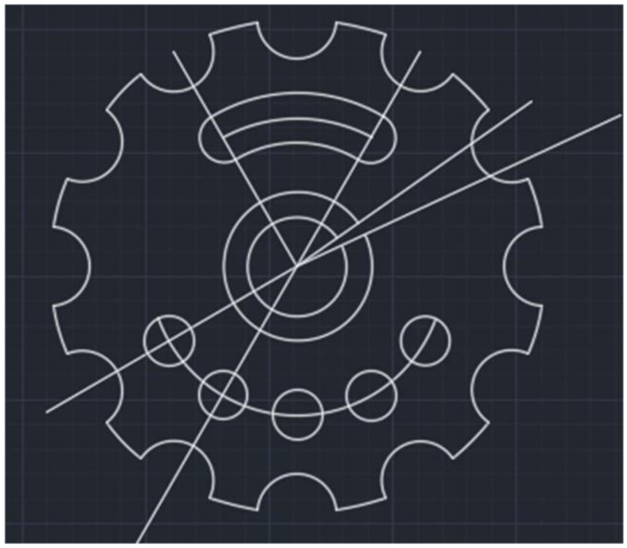


Figure 3.1: I

- Trim the unwanted part.
- Then use polar array command selecting the two groove lines as object and center ofarray same with bigger circle.
- Trim the unwanted parts.

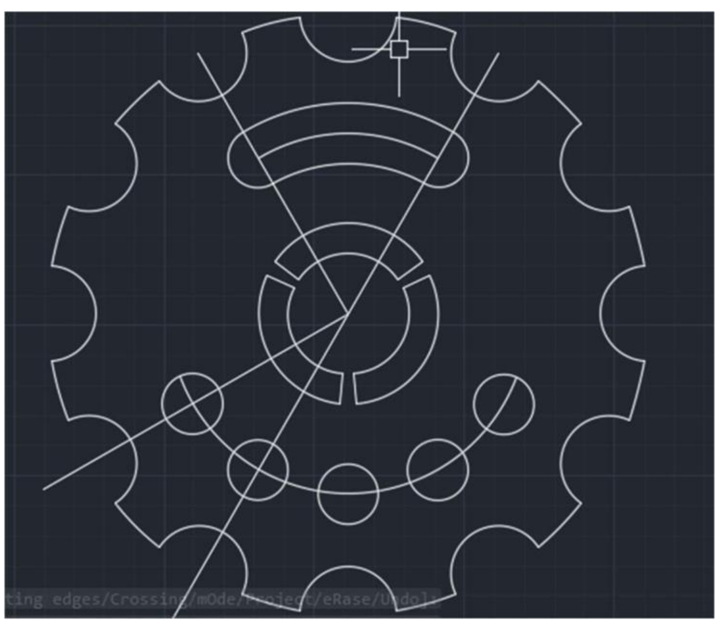


Figure 3.1: J

Step 6: Dimensioning

- Do the dimensioning
- Then modify on typing dimsty in command line

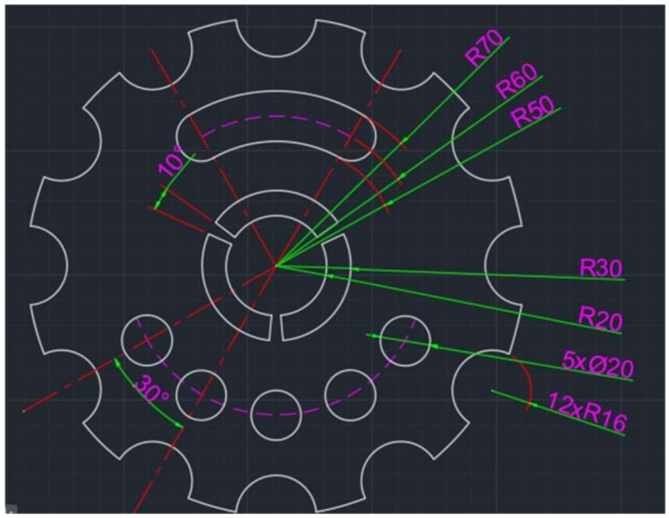


Figure 3.1: K

Experiment-4

Aim: To design the given 3D Component in AutoCAD, utilizing the Aligned System of dimensioning.

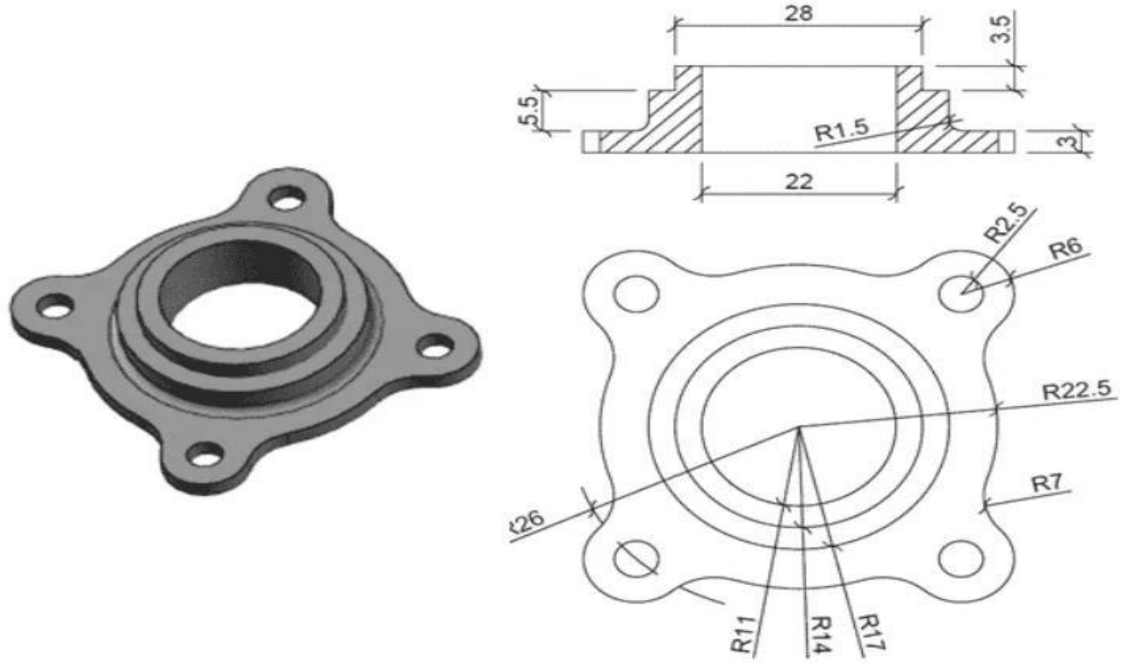
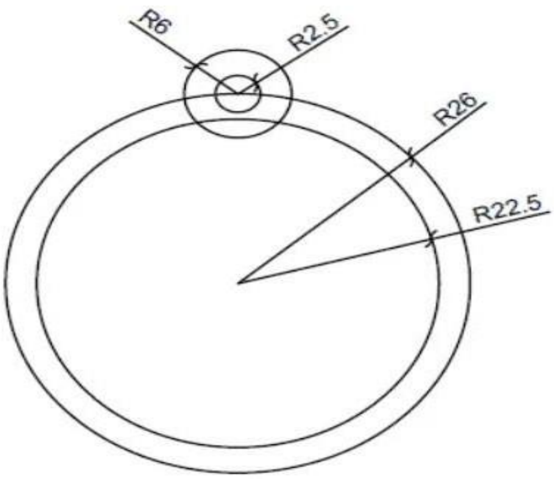


Figure 4.1: A. 3D Component 1

Procedure:

Step 1: Making Circles

- Create the following circles using CIRCLE command from draw panel of home tab.
- Make sure circle with radius 2.5 units has its center on the circumference of the circlewith radius 26 units.



igure 4.1: B

Step 2: Polar array

- Select Polar Array from the Modify panel of Home tab and select two small circles onthe top of geometry.
- Now specify the center of the largest circle as the center of the array and enter 4 in theNumber of Items field.
- You will get an array like the one shown in the image below.

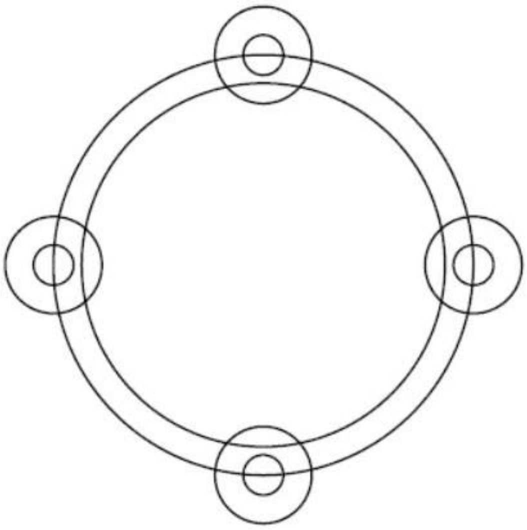


Figure 4.1: C

Step 3: Clean geometry

- Delete the biggest circle and select FILLET command now enter R on the commandline and type 7 as the fillet radius.
- Now apply this fillet at the intersections of the circle with R2.5 and R22.5 as shown inthe image below

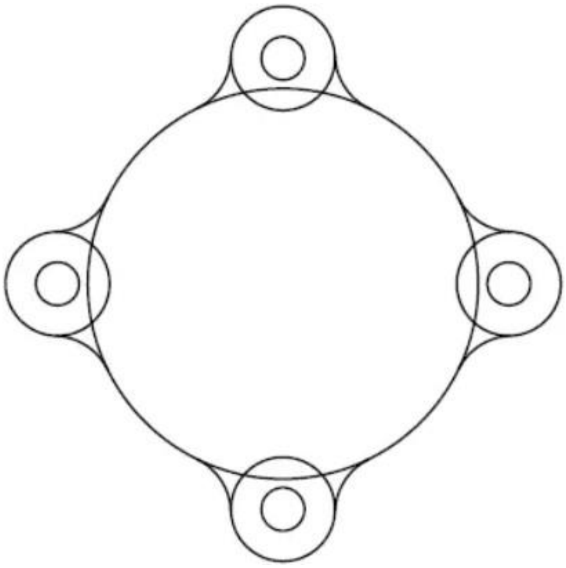


Figure 4.1: D

Step 4: Making outline

- Trim all the geometries to make it look like the image below.

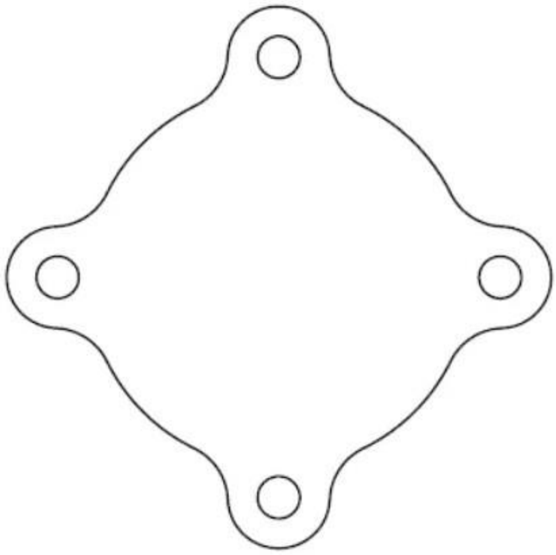


Figure 4.1: E

Step 5: Joining sketch

- Type J on the command line and press enter then select complete geometry and pressenter again.
- This will join all external 2D segments into a single unit.
- You may need to repeat the JOIN command couple of times to join the geometrycompletely.

Step 6: Changing visual style

- Change view to southwest isometric and visual style to Shaded from Views and Visualstyles panel of Visualize tab.

Step 7: Converting into 3D

- Type PRESSPULL on the command line and click at a location inside the geometry.
- Make sure you are clicking inside the geometry and not on the geometry. Enter theheight of 3 units on the command line and press Enter again.

Figure 4.1: F

NOTE: This command will add the thickness of 3 units to the 2D geometry which we havemade so far and your drawing will look like the image shown above.

Step 8: Making sketch on 3D plane

- Create a circle of R17 on the top of the object made in previous step.
- For making a circle on top plane you need to make sure that dynamic UCS is turned onfrom the status bar toggle.
- Press F6 to turn on dynamic UCS then select circle command and move your cursor tothe top plane.
- Now click at the center of geometry for circle’s center and enter a radius of 17 unitsand press Enter again.

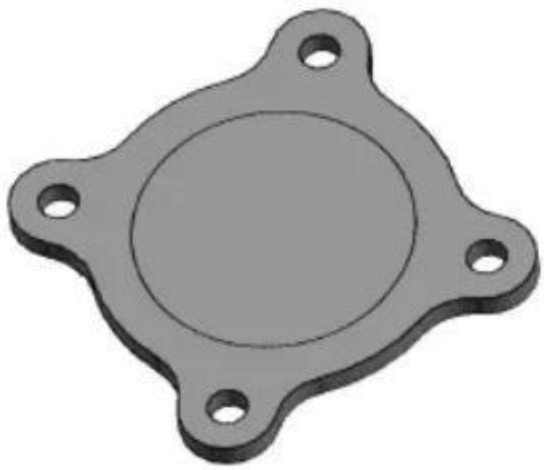


Figure 4.1: G

Step 9: Extruding sketch

- Type EXT on the command line and press enter then select the circle we have drawn inprevious step and press enter again.
- Enter a height of 5.5 units and press enter again to exit the extrude command.

Figure 4.1: H

Step 10: Making more extrusions

- Now create another circle of radius 14 units with the same center on top of geometrywhich we have drawn in the previous step.
- Then extrude it by 3.5 units the same way we did previously.

Figure 4.1: I

Step 11: Combining 3D parts

- Now type UNION and Press ENTER then select complete geometry and press enteragain.
- This will ensure that all geometries get combined as a single unit.

Step 12: Creating hole

- Create a circle of R11 on the top most surface of the geometry.
- Now type PRESSPULL on the command line and press Enter then click inside the circleof radius 11 units and enter -12 as depth of geometry.
- This will make a hole in existing geometry.

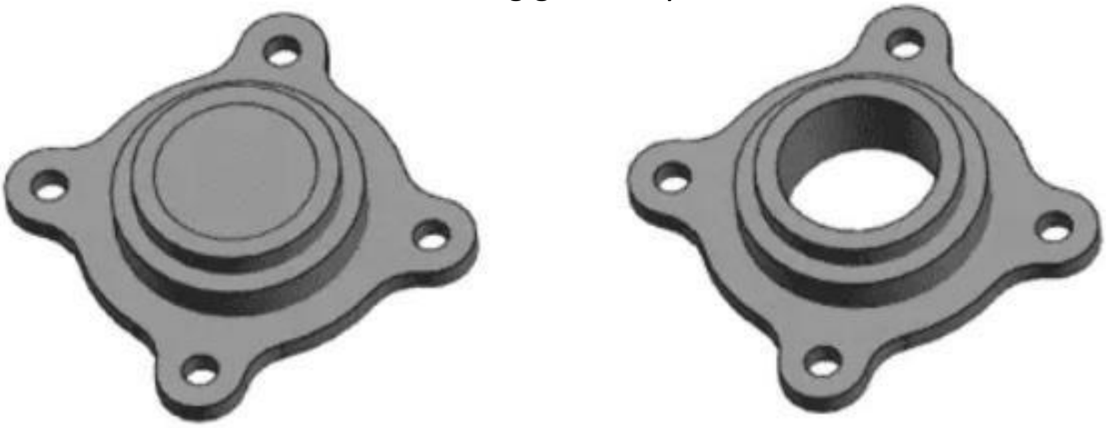


Figure 4.1: J

Step 13: Making fillets

- Type F on the command line and press enter to start fillet command, type R on thecommand line and enter a radius of 1.5 units for the fillet.
- Now select the edge between the flat piece and the biggest cylinder as shown in theimage below and press enter twice to exit the command.

Figure 4.1: K

Aim: To design the given 3D Component in AutoCAD, utilizing the Unidirectional System of dimensioning and Layer Properties.

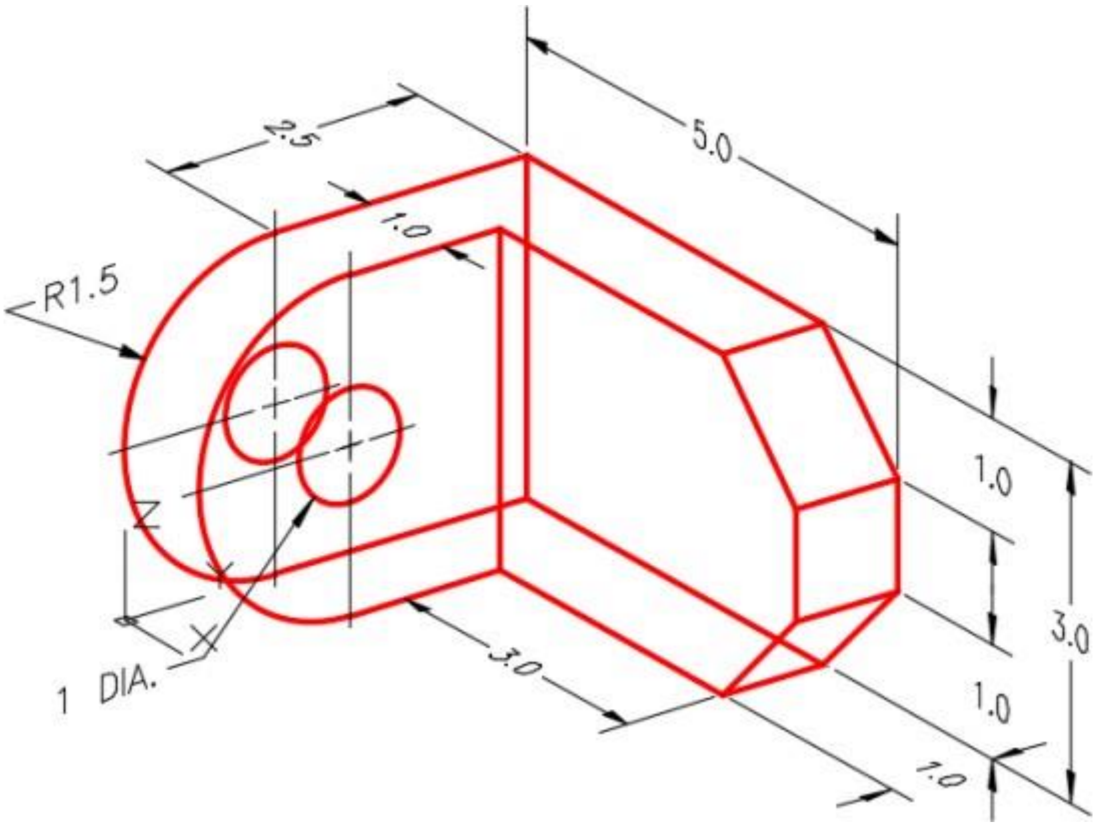


Figure 5.1: A. 3D Component 2

Steps of Drawing:

1. Start a new drawing using the template: 3D Layout English.
2. Save and name the drawing: AutoCAD 3D Project.
3. Ensure that the current UCS is set to World and the current view is set to SEIsometric. Then set layer: Model as the current layer.

4. Using the LINE command, draw the lines to outline the Top view.

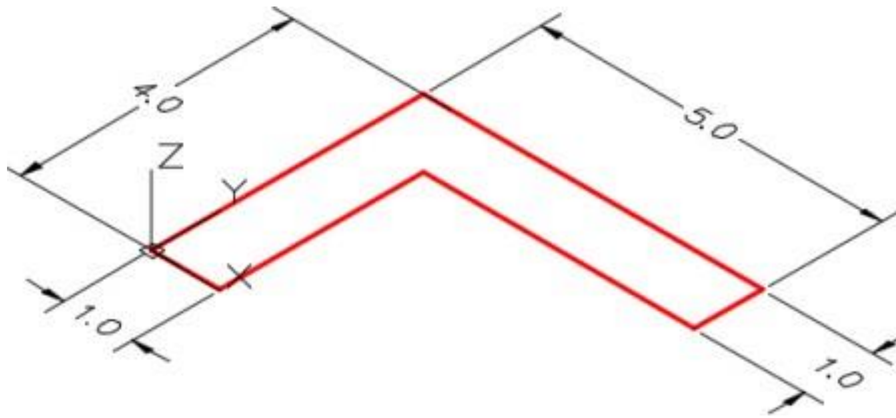


Figure 5.1: B

5. Now copy all of the lines 3 units in the positive Z direction.

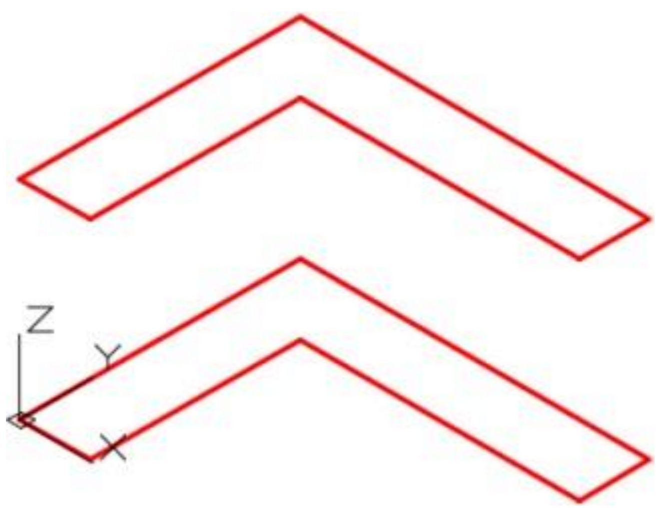


Figure 5.1: C

6. Using the 3DFORBIT command, orbit the model slightly. The model is orbited so that the corner does not line up and the lines in the front do notcover the lines in the back.

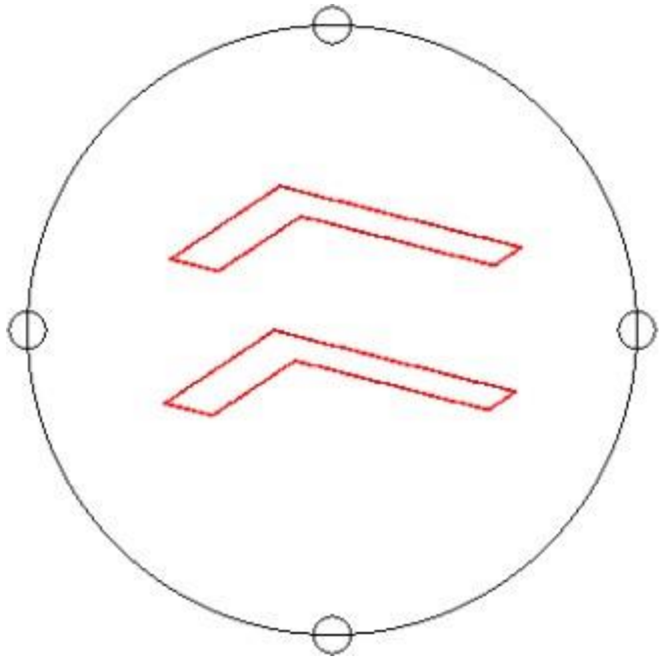


Figure 5.1: D

7. Using the LINE command, draw the 6 vertical lines. Ensure that you enable object snap and snap to endpoints of the existing lines.

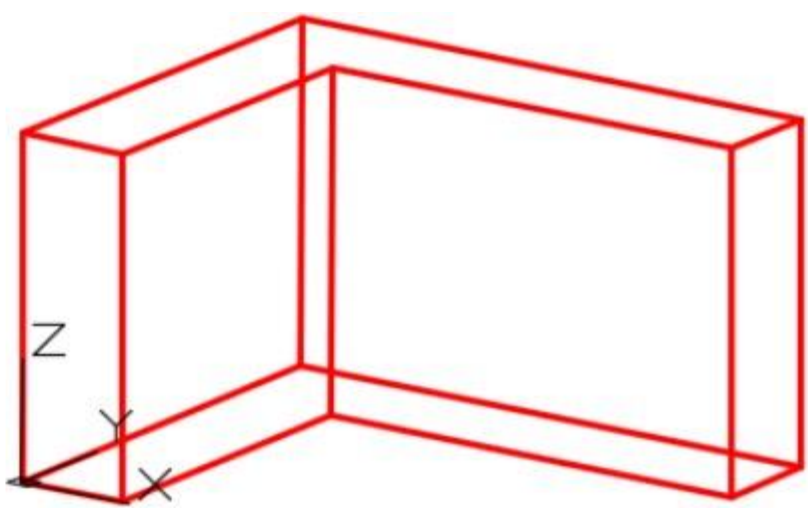


Figure-5.1: E

8. Set the current UCS to Right and then locate the icon by snapping to thecorner of the model as shown in the figure.

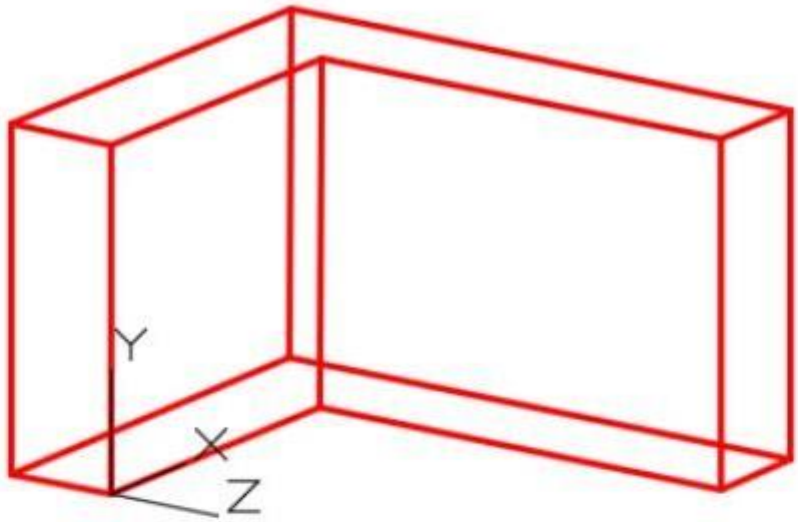


Figure 5.1: F

9. Draw the necessary construction lines using the OFFSET command. Change their layer to layer: Construction. Draw the arc and the circle.

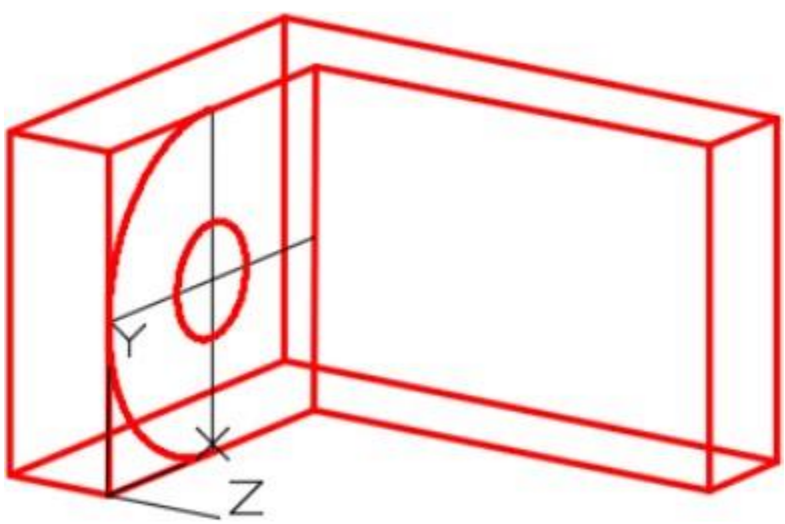


Figure 5.1: G

10. Copy the arc and the circle in the negative Z direction.

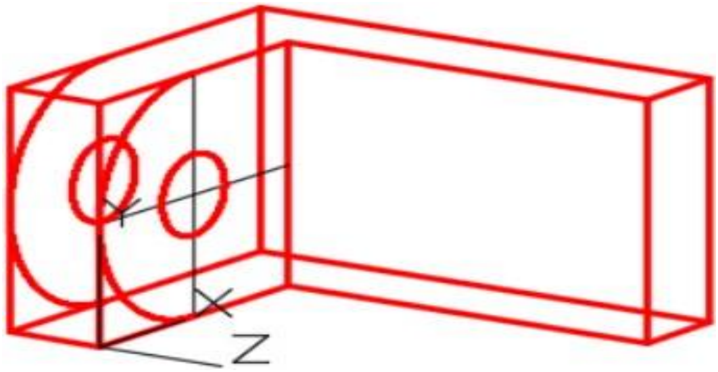


Figure 5.1: H

11. Trim or delete necessary lines.

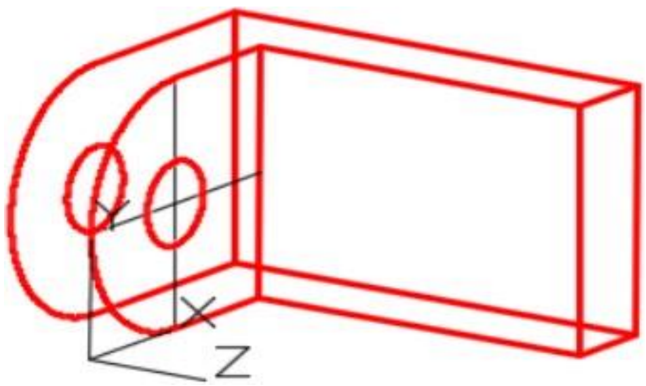


Figure 5.1: I

12.Set the current UCS to Front and then locate it to the corner as shown in thefigure.

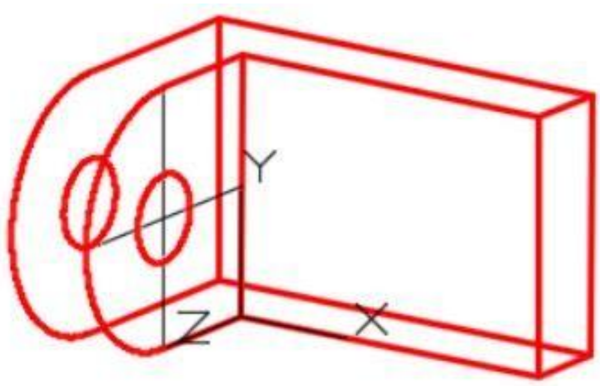


Figure 5.1: J

13. Draw the necessary construction lines using the OFFSET command. Change their layer to layer: Construction. Draw the object lines as shown inthe figure.

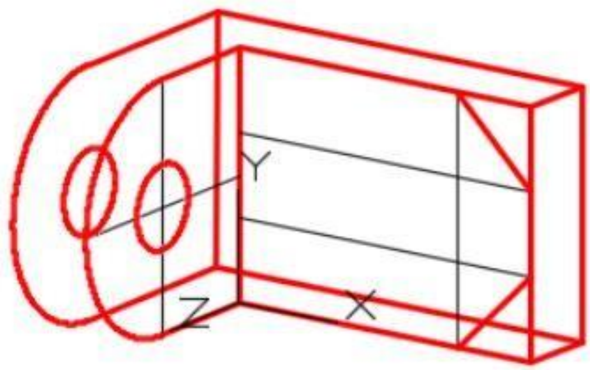


Figure 5.1: K

14. Copy the lines in the negative Z direction and add the necessary object lines.

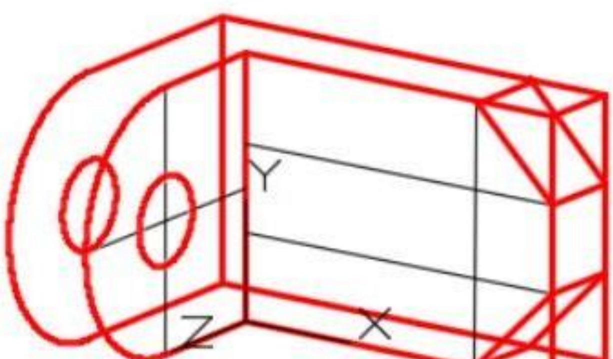


Figure 5.1: L

15. Trim or delete the necessary lines and freeze layer: Construction to completethe wireframe model.

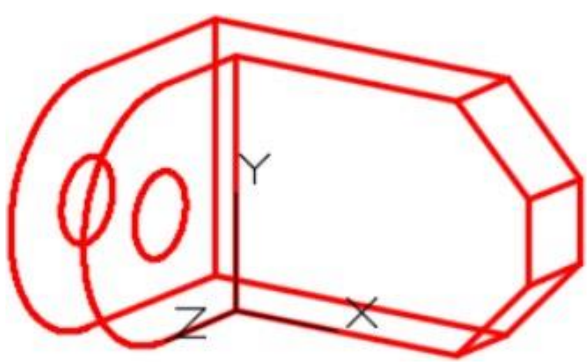


Figure 5.1: M

16. Change the current view to SE Isometric.

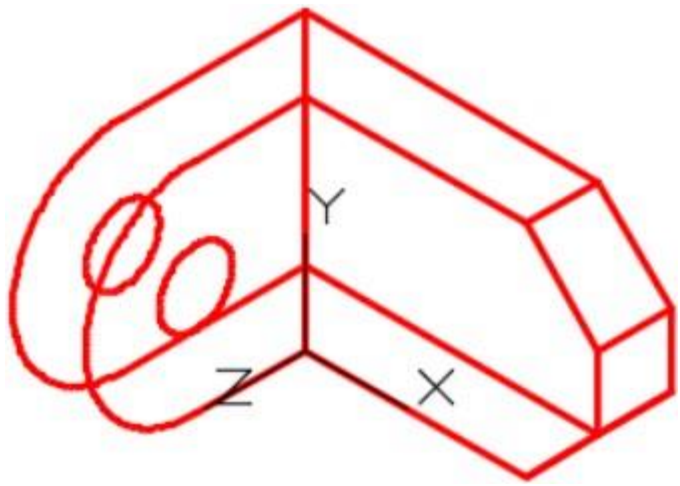


Figure 5.1: N

17.Set the current UCS to World. And hence the final diagram is obtained.

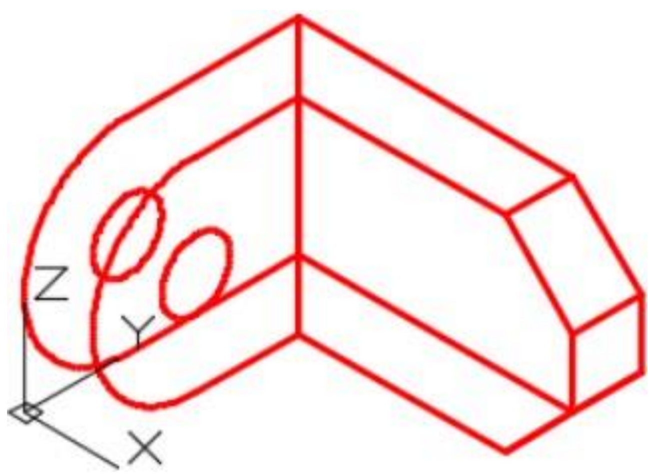


Figure 5.1: O

Experiment No.6

Aim: To design the given 3D Component in AutoCAD, utilizing the Aligned System of dimensioning and Layer Properties.

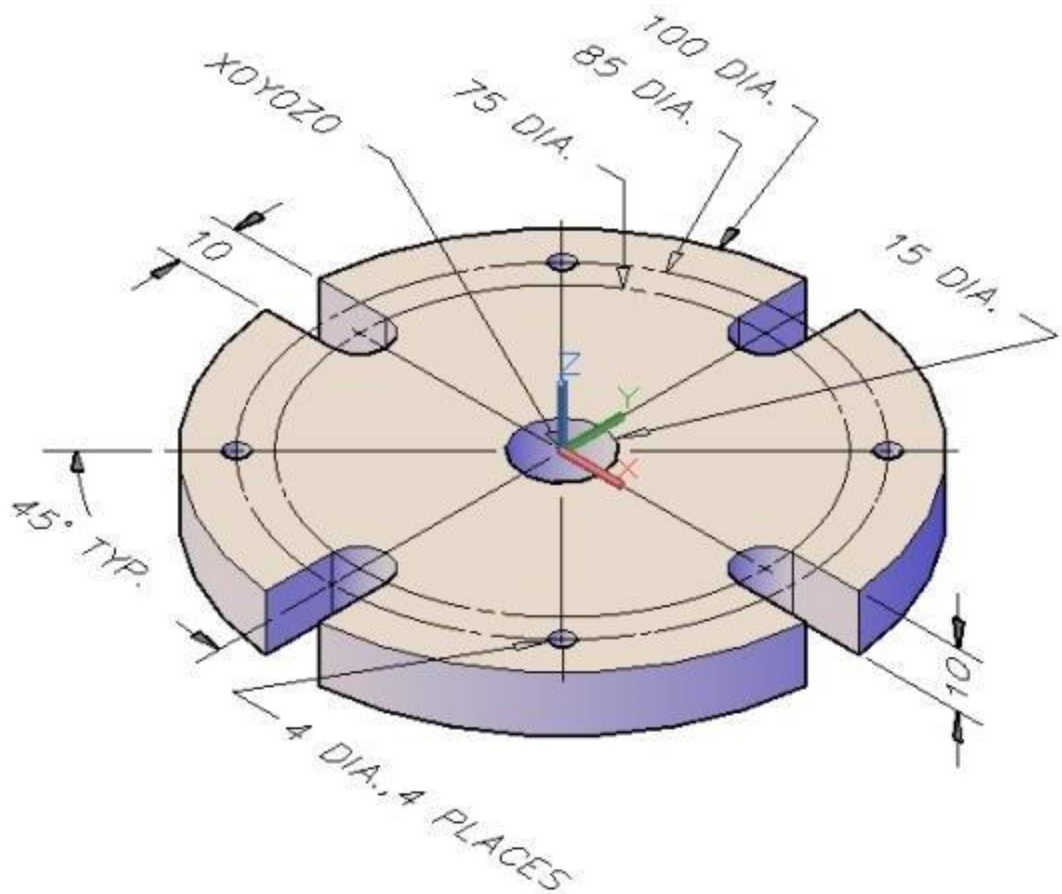


Figure 6.1: A. 3D Component 3

Steps of Drawing:

1. Start a new drawing using the template: 3D Layout English.
2. Save and name the drawing: AutoCAD 3D Project.
3. Ensure that the current UCS is enabled and the current view is set to SEIsometric. Then set layer: Model as the current layer.

4. Draw the shape of the top of the object. Use the ARRAY command to speed up the construction.

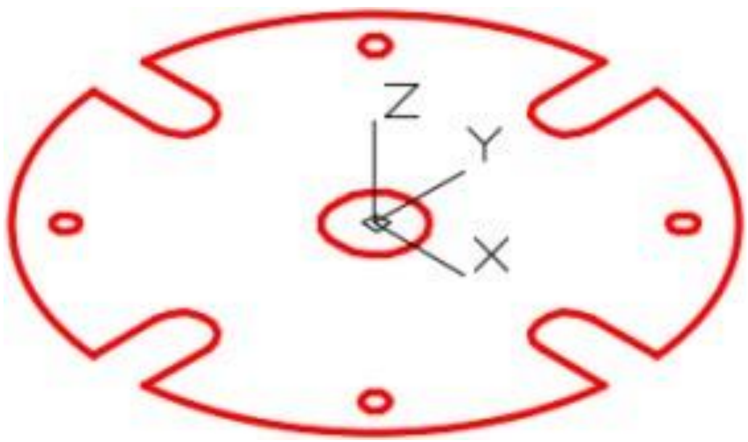


Figure 6.1: B

5. Using the COPY command, as shown below, copy all of the objects 10 units in the negative Z direction. (Figure Step 6) Command: COPY Select objects: (Select all objects.) Select objects: Specify base point or displacement, or [Multiple]: 0,0,0 Specify second point of displacement or : @0,0,-10

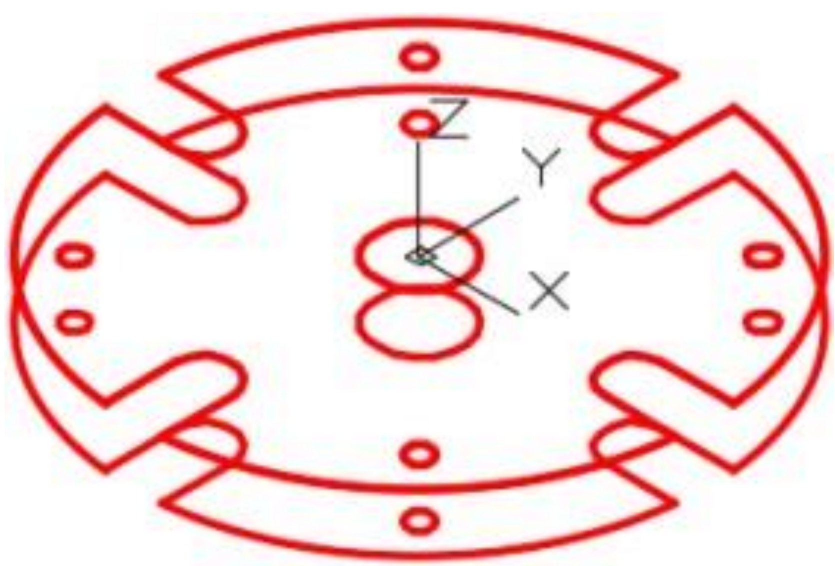


Figure 6.1: C

6. Using the 3DFORBIT command, orbit the model slightly. The model is orbited so that the corner does not line up and the lines in the front do notcover the lines in the back.

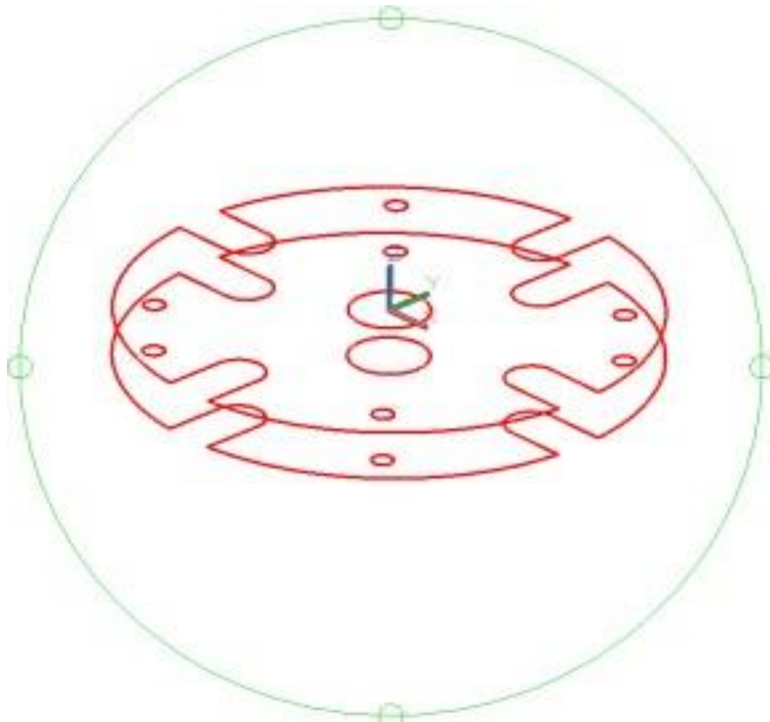


Figure 6.1: D

7. Draw the vertical lines by snapping to the endpoints to complete the wireframe model and change the view to SE Isometric. And hence thewireframe model of the given figure is obtained.

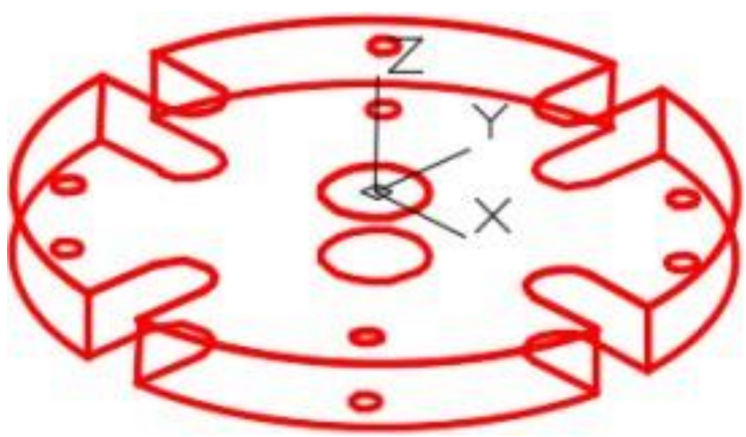


Figure 6.1: E

EXPERIMENT-7

Aim: To study the CNC Simulator and perform simulation of the drilling operation in a CNC simulator for evaluating and optimizing the drilling process by virtually testing and validating CNC programs under controlled conditions.

Apparatus Required: CNC Simulator, Twist Drill, Centre Drills, CNC Drilling Machine, Work holding Device, and Coolant system.

Theory: A Computer Numerical Control (CNC) simulator is a software tool used to virtually replicate the operations of a CNC machine. It allows users to program, test, and visualize machining processes like milling, drilling, turning, and more, without the need for actual machinery or materials. CNC simulators mimic the behavior of real CNC machines, enabling users to verify their G-code programs, optimize tool paths, and detect potential errors or collisions before running the program on a physical machine.

Key components of a CNC simulator:

- User Interface (UI)
- G-Code Editor
- Machine Model
- Tool Path Visualizer
- Workpiece Simulation
- Tool Library
- Collision Detection
- Machine Controller Emulator
- Material Removal Simulation
- Parameter and Performance Settings
- Error Checking and Debugging Tools
- Post-Processing

CNC Machine Codes:

In CNC programming, machine codes are a set of instructions that direct the CNC machine to perform specific tasks. Here are some categories of machine codes, including G-codes (motion and control) and M-codes (miscellaneous functions):

G-Codes (Geometric Codes)

- **G00** - Rapid positioning.
- **G01** - Linear interpolation at a specified feed rate.
- **G02** - Circular interpolation clockwise.
- **G03** - Circular interpolation counterclockwise.
- **G04** - Dwell for a specified time.
- **G20** - Programming in inches.
- **G21** - Programming in millimeters.
- **G28** - Return to home position.
- **G90** - Absolute positioning.
- **G91** - Incremental positioning.
- **G92** - Position register (sets current position as a specified coordinate).
- **G94** - Feed per minute.
- **G95** - Feed per revolution.
- **G96** - Constant surface speed.
- **G97** - Cancel constant surface speed.

M-Codes (Miscellaneous Codes)

1. **M00** - Program stop.
2. **M01** - Optional stop.
3. **M02** - End of program.
4. **M03** - Spindle on (clockwise rotation).
5. **M04** - Spindle on (counterclockwise rotation).
6. **M05** - Spindle stop.

7. **M06** - Tool change.
8. **M08** - Coolant on.
9. **M09** - Coolant off.
10. **M30** - End of program and rewind.
11. **M98** - Call subprogram.
12. **M99** - Return from subprogram.

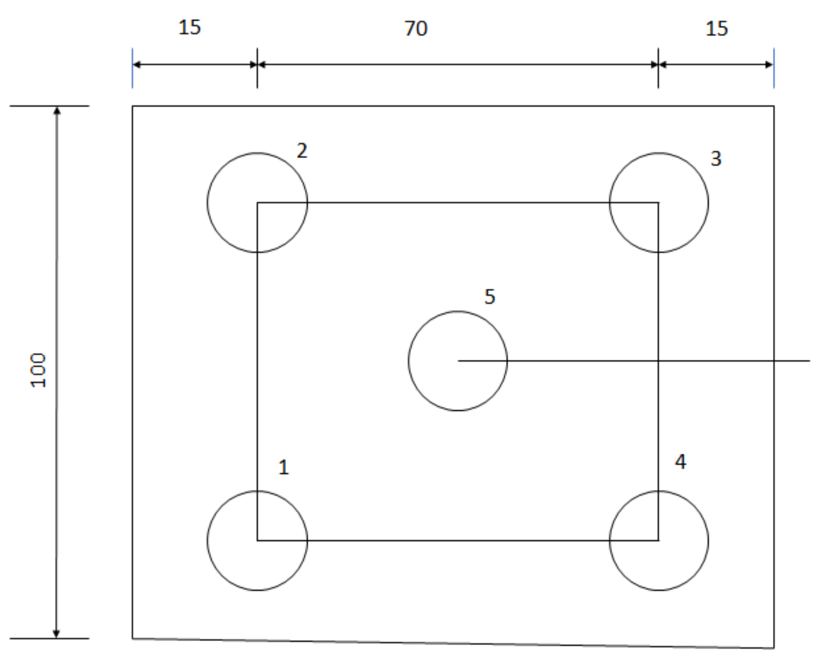
Other Codes

- **T Codes**: Tool selection (e.g., T01 for tool 1).
- **S Codes**: Spindle speed (e.g., S1000 for 1000 RPM).
- **F Codes**: Feed rate specification (e.g., F150 for a feed rate of 150 units/min).

MATERIAL (with Dimensions): Aluminum Plate 100*100*10(mm)

Drilling Positions:

1. 15,15
2. 15,85
3. 85,85
4. 85,15
5. 50,50



Part Program for a CNC Drill Operation:

```
N001 G28 X0 Y0 Z0;
N002 G90 G17 G21;
N003 M06 T01;
N004 M03 S1500;
N005 G00 X15 Y15 Z20;
N006 Z5;
N007 G01 Z-10;
N008 G00 Z5;
N009 X15 Y85;
N0010 G01 Z-10;
N0011 G00 Z5;
N0012 X85 Y85;
N0013 G01 Z-10;
N0014 G00 Z5;
N0015 X85 Y15;
N0016 G01 Z-10;
N0017 G00 Z5;
N0018 G00 X50 Y50;
N0019 G01 Z-10;
N0020 G00 Z20;
N0021 G28 X0 Y0 Z0;
N0022 M05;
N0023 M30;
```

G00: Rapid Transverse

G01: Linear Interpolation

Procedure for CNC Simulator Drilling Operation:

- Download & Install CNC Simulator.
- Open the CNC Simulator
- Set Up the Workpiece
- Select or Create G-Code Program
- Choose the Drilling Tool
- Configure Machining Parameters
- Simulate Tool Path
- Check for Collisions
- Run Material Removal Simulation
- Optimize Parameters (Optional)
- Post-Process the Simulation
- Save and Document
- Prepare for Machining

Applications of CNC Drilling Machine:

- Aerospace Industry
- Automotive Industry
- Electronics Industry (PCBs)
- Metal Fabrication
- Medical Devices
- Furniture and Woodworking
- Oil and Gas Industry
- Construction Industry
- Shipbuilding
- Jewellery and Watchmaking

Examples of CNC Simulators:

- **Fusion 360:** Offers a comprehensive CNC simulation tool integrated with CAD features.
- **Mastercam:** Provides robust simulation capabilities tailored for milling operations.
- **SolidWorks CAM:** Integrates simulation with SolidWorks for seamless design and machining.
- **G-Simple:** A simple and user-friendly CNC simulator for basic G-code visualization.

Experiment No - 8

Aim: To design and execute a CNC program to accurately cut a slot in a material using a CNC simulator, ensuring precision in dimensions and adherence to safety protocols.

Apparatus Required: CNC Simulator, End Mills, Drill Bits, CNC Milling Machine, and Tool Charger.

Theory: A CNC milling is a machining process that utilizes computerized controls to manage the movement and operation of multi-point rotary cutting tools. As the tools rotate and move across the surface of the work piece, they slowly remove excess material to achieve the desired shape and size.

A CNC simulator for milling operations is a software tool that allows users to design, test, and visualize CNC programs in a virtual environment before executing them on actual machines.

Key Features of CNC Simulator:

- **G-Code Simulation:** Users can input G-code programs and simulate the machining process to visualize how the machine will operate.
- **3D Visualization:** Provides a 3D representation of the workpiece, tools, and cutting paths, helping users understand the milling operation's dynamics.
- **Tool Path Verification:** Allows for checking the tool paths for potential collisions or errors before actual machining.
- **Material Removal Simulation:** Visualizes the material being removed during the milling process, showing the final shape of the workpiece.
- **Post-Processing:** Some simulators can generate G-code from CAD models, facilitating the transition from design to machining.

Material (with Dimension): Aluminum plate 100*100*10(mm)

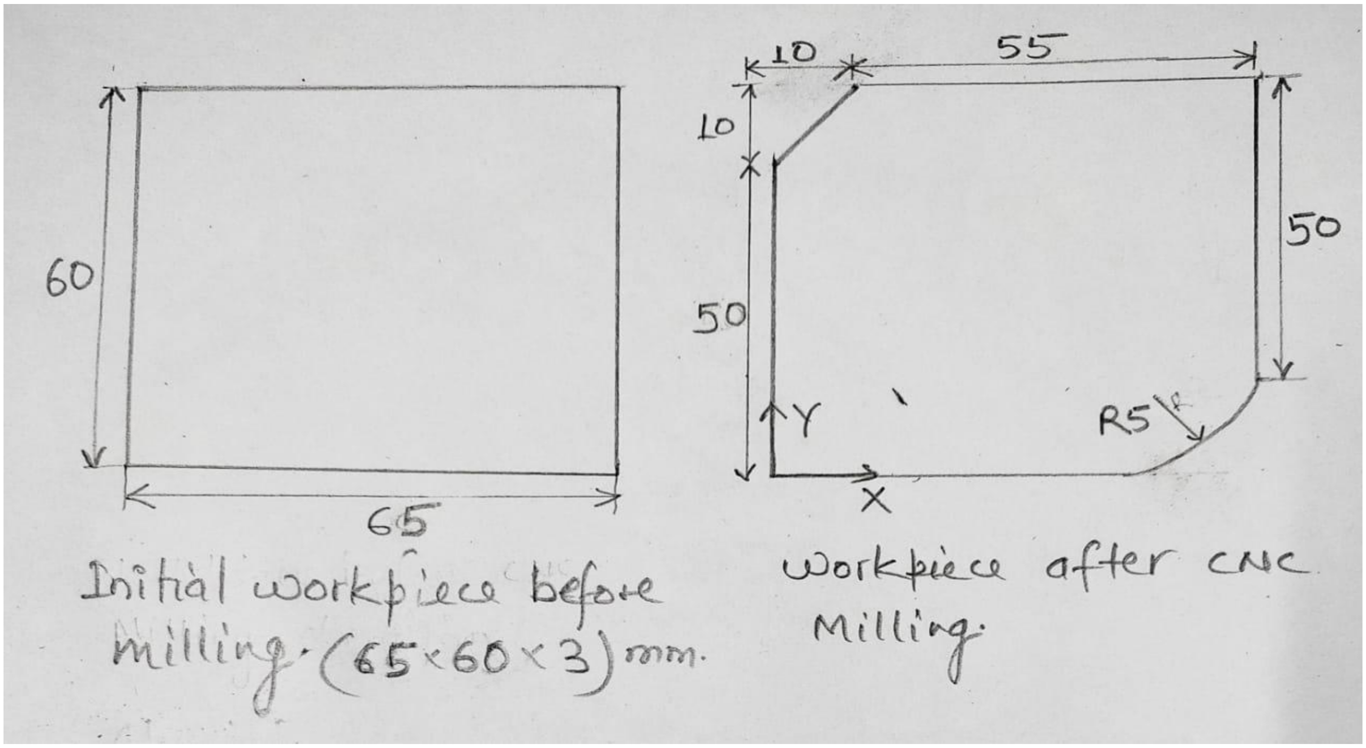


Figure 8.1: Milling Object

Part Program for Milling Operation:

N01 G21 G94 G90;
N02 G28 X0.0 Y0.0 Z0.0;
N03 M03 S1200 M08 G41;
N04 G00 X0.0 Y0.0 Z5;
N05 G01 X0.0 Y0.0 Z-5 F100;
N06 G01 X0.0 Y50 F100;
N07 G01 X10.0 Y60.0 F100;
N07 G01 X65.0 Y60.0 F100;
N08 G01 X65.0 Y5.0 F100;
N09 G02 X60.0 Y0.0 R5 F100;
N10 G01 X0 Y0 Z5;
N11 M09 M05;
N12 G28 X0 Y0 Z0;
M30;
G00: Rapid transverse
G01: Linear interpolation

Procedure for CNC Milling Operation in a CNC Simulator:

- Download & Install CNC Simulator.

- Open the CNC Simulator
- Set Up the Workpiece
- Select or Create G-Code Program
- Setup the simulator.
- Select the material/workpiece with dimension.
- Select cutting tool.
- Develop the program (write G-code).
- Load and run the simulation.
- Verify and adjust as needed.
- Document findings and analysis.
- Prepare for actual machining (if applicable).

Applications of CNC Drilling Machine:

- Aerospace Industry
- Automotive Industry
- Electronics Industry (PCBs)
- Metal Fabrication
- Medical Devices
- Furniture and Woodworking
- Oil and Gas Industry
- Construction Industry
- Shipbuilding
- Jewellery and Watchmaking

Examples of CNC Simulators:

- Fusion 360
- Mastercam
- G-Simple
- NC Viewer
- SolidWorks CAM
- CNC Simulator Pro
- EMCO Machining Simulator
- HSMWorks

Experiment No- 9

Aim: To Study FDM 3D Printer and fabricate a 3D printed part using Fused Deposition Modeling (FDM) technology, focusing on understanding the printing process, material properties, and post-processing techniques.

Apparatus Required: FDM 3D Printer, CAD Software, Slicing Software, 3D Printing Filament, Print Bed Adhesive, Digital Caliper, Post-Processing Tools (Sandpaper, Craft knife or scalpel, Paintbrush), Safety Equipment, Power Supply, and Cleaning Tools.

Theory: 3D printing is the process of making a physical object from a three-dimensional digital model, typically by laying down many thin layers of a material in succession. It is also called the additive manufacturing.

Additive Manufacturing (AM) is an appropriate name to describe the technologies that build 3D objects by adding layer-upon-layer of material as opposed to the subtractive manufacturing such as machining.

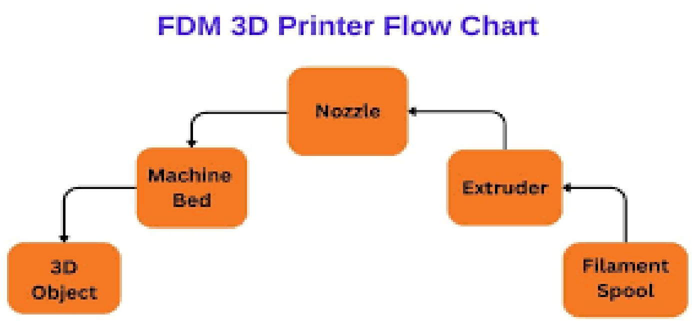


Figure 9.1: FDM Process Flow

Fused Deposition Modeling (FDM): It is an additive manufacturing process that belongs to the material extrusion family. In FDM, an object is built by selectively depositing melted material in a pre-determined path layer-by-layer. The materials used are thermoplastic polymers and come in a filament form.

Main Components of an FDM-Based 3D Printer:

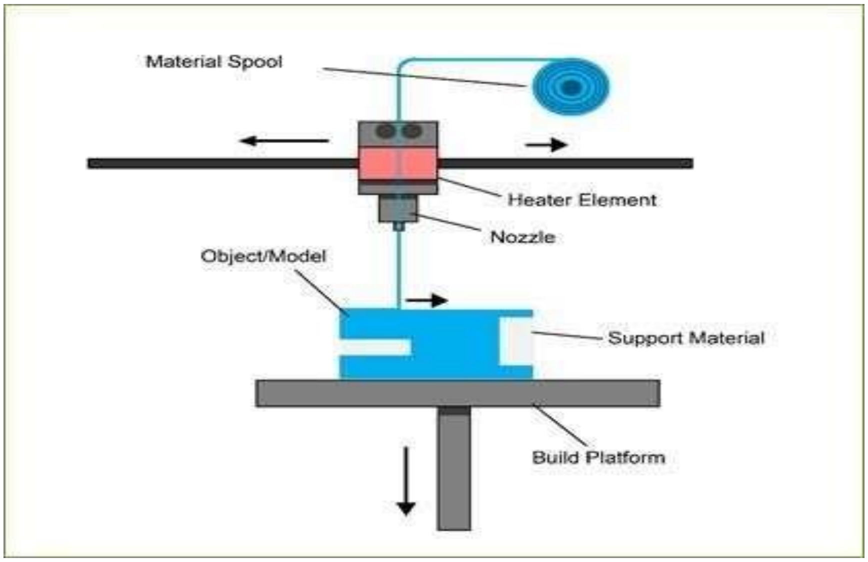


Figure 9.2: Components of FDM Printer

- **Frame:** The structural support that holds all components in place.
- **Print Bed:** The surface where the 3D print is built; can be heated to improve adhesion.
- **Extruder:** The mechanism that feeds filament into the hotend and melts it for printing.
- **Hotend:** The part that melts the filament and deposits it onto the print bed.
- **Stepper Motors:** Drive the movement of the print head and the print bed along the X, Y, and Z axes.
- **Control Board:** The electronic component that processes commands and controls the printer’s functions.
- **Power Supply Unit:** Provides the necessary electrical power to all components.
- **Cooling Fans:** Help cool the printed material as it is deposited, preventing warping and improving detail.
- **Filament Spool Holder:** Supports the filament spool and allows for smooth feeding of filament into the extruder.
- **Endstops:** Sensors that detect the position of the print head and the print bed to define limits for movement.
- **Display Interface:** A screen and controls (like a knob or buttons) for user interaction and monitoring printer status.
- **Firmware:** The software that runs on the control board, dictating the printer's operations.
- **Filament:** Filaments are available in spools. These are heated to certain temperature and are liquified to be deposited on the print bed. The objects created by 3D printers

are made of these filaments. There are many types of filaments used for 3D printing including PLA, ABS and many others.

- **Nozzle:** The filament is melted and it comes out of the nozzle for deposition. There are different sizes of nozzles that the printers use. 0.4 mm is the most common one. By keeping the smaller diameter of nozzle, one can achieve finer details with greater accuracy. And, larger nozzle helps in printing at a higher speed.

- **Feeder system:** There are two most common feeder system used in 3D printers: Bowden feeder system and Direct feeder system. In a Bowden setup, there are different locations for cold and hot ends. While a filament tube is used to direct the filament towards the hot end.

Design and Fabrication of Spur Gear using 3D Printer:

Figure 9.3: Spur Gear

Step 1. Design the Spur Gear:
- Use CAD software to create a 3D model of the spur gear.
- Define parameters such as gear diameter, number of teeth, pitch, and thickness.

Step 2. Export the Design: Save the CAD model in a compatible format (e.g., STL or OBJ) for slicing.

Step 3. Slice the Model:
- Open slicing software (e.g., Cura, PrusaSlicer).
- Import the STL file of the spur gear.
- Adjust print settings: Layer height, Infill density, Print speed, Support structures, and Generate the G-code.

Step 4. Prepare the 3D Printer:
- Ensure the printer is clean and well-maintained.

- Load the appropriate filament (e.g., PLA, ABS) into the extruder.
- Level the print bed to ensure proper adhesion.

Step 5. Set Up the Print:

- Transfer the G-code to the printer (via SD card or direct connection).
- Preheat the print bed and hotend to the recommended temperatures for the selected filament.

Step **6. Start the Printing Process:**

- Begin the print job.
- Monitor the first few layers to ensure proper adhesion and layer formation.

Step 7. Post-Processing:

- Once printing is complete, remove the spur gear from the print bed.
- Trim any support structures if used.
- Sand or smooth the gear surfaces if necessary.

Step 8. Testing:

- Verify the gear fits with other components (e.g., axles, other gears) as needed for your project.

Applications of FDM 3D Printers

- Prototyping
- Manufacturing Aids
- Customized Parts
- Education
- Medical Applications
- Hobby and Crafts
- Architecture and Construction
- Automotive Industry
- Aerospace
- Consumer Products
- Art and Design
- Research and Development

Safety Instructions for Working with FDM 3D Printers:

- Wear safety glasses and use heat-resistant gloves.
- Ensure proper airflow in the workspace.
- Place the printer on a stable, non-flammable surface.
- Keep the area clear of flammable materials.

- Inspect power cords regularly.
- Allow hotend and bed to cool before touching.
- Use tools to handle hot parts.
- Minimize direct contact with heated filament.
- Keep a fire extinguisher nearby.
- Perform routine inspections.
- Do not leave the printer unattended.
- Double-check print settings before starting.

Experiment No.10

Aim: To investigate the operational principles, advantages, and applications of Stereolithography (SLA) printers, enhancing understanding of their role in additive manufacturing and their impact on industries such as prototyping, medical devices, and jewelry design.

Apparatus Required: SLA 3D Printer, CAD Software, Slicing Software, SLA Resins, Cleaning Tools, UV Curing Light, Isopropyl Alcohol, Personal Protective Equipment (gloves, safety goggles), Digital Caliper, and Reliable power source for the printer.

THEORY: Stereolithography (SLA) is an additive manufacturing process that belongs to theVat Photopolymerization family. In SLA, an object is created by selectively curing a polymer resin layer-by-layer using an ultraviolet (UV) laser beam. The materials used in SLA are photosensitive thermoset polymers that come in a liquid form.

Figure 10.1: SLA Printer

Main Components of SLA Printers:

- **Resin Tank:** Holds the photopolymer resin used for printing.
- **Build Platform:** The surface where the printed part is formed, often adjustable to different heights.
- **Laser or UV Light Source:** Cures the resin layer by layer, solidifying it based on the design.

- **Optical System:** Focuses the laser or light onto the resin, often including mirrors or lenses for precision.

- **Control System:** The electronic components that manage printer operations, including motion and light exposure.
- **Step Motors and Motion System:** Drive the movement of the build platform and the light source across the resin tank.
- **Cooling System:** Maintains optimal temperature during the printing process to ensure resin properties.
- **Power Supply:** Provides electrical power to all components of the printer.
- **User Interface:** Allows users to control and monitor the printer, often through a touchscreen or software interface.
- **Cleaning and Maintenance Features:** Built-in systems or accessories for post-print cleaning and maintenance of the printer.

Working Procedure of SLA 3D Printers

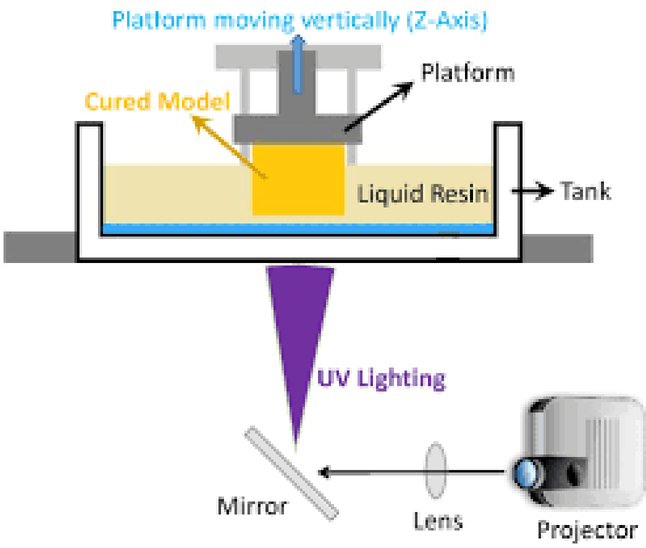


Figure 10.2: Working Model of SLA Printer

1. **Design the 3D Model:**
    - Create or modify a 3D design using CAD software
    - Ensure the model is suitable for SLA printing.
2. **Export the Model:**
    - Save the design in a compatible format (e.g., STL or OBJ).
3. **Prepare the Model for Printing:**
    - Import the 3D model into slicing software
    - Configure print settings, including layer height, exposure time, and support structures.

4. **Load the Resin:**
    - Fill the resin tank with the appropriate photopolymer resin, ensuring no bubbles are present.
5. **Set Up the Printer:**
    - Level the build platform to ensure proper adhesion during printing.
    - Power on the printer and connect it to the computer or control interface.
6. **Start the Printing Process:**
    - Send the sliced model to the printer.
    - The printer uses a laser or UV light source to cure the resin layer by layer, gradually building the object from the bottom up.
7. **Monitor the Print:**
    - Observe the printing process to ensure proper operation and detect any issues, such as misalignment or material shortages.
8. **Post-Processing:**
    - Once printing is complete, remove the printed part from the build platform.
    - Clean the part using isopropyl alcohol to remove uncured resin.
    - Cure the part further using a UV light source to enhance its strength and durability.
9. **Finish the Part:**
    - If necessary, perform additional post-processing, such as sanding or painting, to achieve the desired finish.
10. **Maintenance:**
    - Regularly clean and maintain the printer, including the resin tank and optical components, to ensure optimal performance for future prints.

Common Parameters of SLA 3D Printer:

Materials–	Photopolymer resins (thermosets)
Dimensional Accuracy	± 0.5% (lower limit: ±0.10 mm) – desktop ± 0.15% (lower limit ± 0.01 mm) industrial
Typical Build Size	- Up to 145 x 145 x 175 mm -desktop - Up to 1500 x 750 x 500 mm - industrial
Common layer thickness	25 - 100 microns
Support	Always required (essential to producing an accurate part)

Applications of SLA 3D Printers

- Prototyping
- Medical Applications
- Jewelry Design
- Aerospace and Automotive
- Consumer Products
- Architecture and Construction
- Art and Design
- Education
- Research and Development
- Electronics

Safety Instructions for Working with FDM 3D Printers:

- Wear safety glasses and use heat-resistant gloves.
- Ensure proper airflow in the workspace.
- Place the printer on a stable, non-flammable surface.
- Keep the area clear of flammable materials.
- Inspect power cords regularly.
- Keep a fire extinguisher nearby.
- Perform routine inspections.
- Do not leave the printer unattended.
- Double-check print settings before starting.
- Avoid skin contact with uncured resin; wash any spills immediately with soap and water.

Experiment No. 11

Aim: To study and understand the working of MV Laser and perform laser engraving operation.

Apparatus:

1. MV Laser setup
2. Safety goggles
3. Engraving material (wood, acrylic, etc.)
4. Computer with design software
5. Compatible engraving control software

Theory:

A MV Laser is typically a high-precision laser device used for engraving and cutting a variety of materials, such as metals, plastics, wood, and sometimes even glass. MV lasers work based on light amplification by stimulated emission of radiation. A laser engraving machine works by using a focused laser beam to mark, cut, or engrave materials. The basic principle behind laser engraving is the high-energy interaction between the laser beam and the material's surface.

The application scope of laser cutting machine is very wide. Different designs have been used in machines to meet the needs of all use. It can be used for:

1. Printing and packaging: rubber plate laser engraving, laser cutting of paper product, etc.
2. Artwork and gift: bamboo slip laser engraving, wooden book laser carving, redwood laser engraving, double-coloured plate laser engraving, box-shaped artwork laser engraving, chessboard laser carving, etc.
3. Advertising: organic glass laser engraving (cutting), laser carving of all kinds of boards, double-coloured plate laser carving, etc.
4. Leather clothing: genuine and synthetic leather cutting and surface pattern engraving of different kinds of leather clothing, pattern engraving of all kinds of clothing and textile, etc.
5. Trade of model producing: building model laser engraving (cutting), laser engraving (cutting) of aviation and navigation models, laser engraving (cutting) of cartoon figures, industrial model laser engraving (cutting), etc.

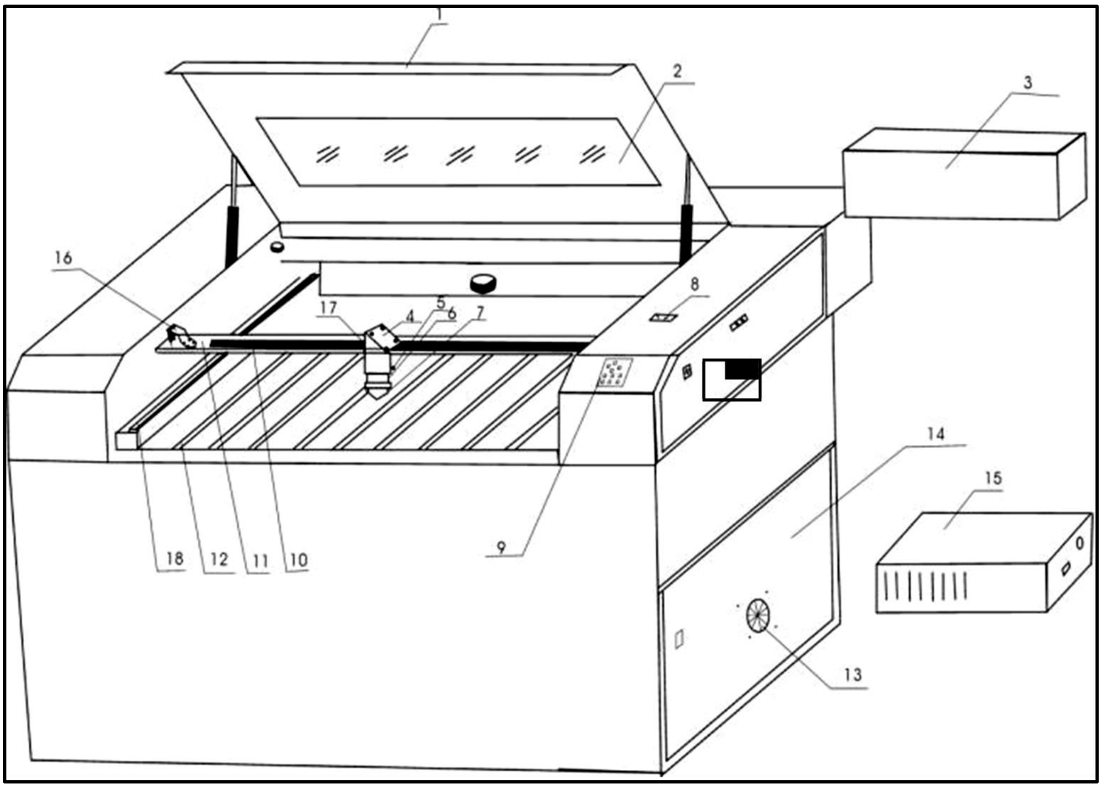


Figure 1. Schematic representation of MV Laser engraving machine.

1. Upper cover
2. Observation window
3. Length-extended cage of the laser tube
4. The third reflecting mirror
5. Focus head adjusting screw
6. Focus head
7. Air nozzle
8. Ammeter
9. Operation panel
10. X straight line guide rail
11. X crossbeam
12. Cutting platform
13. Heat abstraction blower
14. Control cabinet door
15. Laser power supply
16. The second reflecting mirror
17. Ray inlet hole of the third reflecting mirror
18. Y axes guide rail

Key Components:

1. Laser Source: This is the actual laser diode that produces the coherent light. For MV lasers, the beam is of violet color (405 nm wavelength).
2. Focusing Lens: The lens focuses the beam into a small point, making the laser precise enough for engraving operations.
3. Engraving Bed/Table: The platform where the material to be engraved is placed.
4. Stepper Motors: These control the movement of the laser in the X, Y, and sometimes Z axes for 3D engraving.
5. Cooling System: To prevent overheating, cooling systems (air or water-cooled) are used to maintain the laser at optimal temperature.
6. Control Software: Software interfaces are required to input the design and manage laser intensity, speed, and other parameters.

Operation Panel

Figure 2. Operation panel of MV Laser engraving machine

Function of keys and buttons:

← Move left

→ Move Right

↑ Move Forward

↓ Move Backward

Frame: Outer frame of object is carved

Laser: Laser start

Origin: when the carving machine is working, the machine will stop working and return back to the original point.

Reset: The laser head will return back to the upper right corner of the machine.

Pause: Make a pause of the working machine. Press the start button, it will start working again.

Start: The laser tube begins to work.

Procedure:

1. Prepare the engraving material and place it securely on the engraving bed (Select a material compatible with the laser (e.g., wood, acrylic, or metal)).

2. Load the design file into the laser control software: Use design software to create or import the graphic or text you want to engrave. Export the design in a compatible file format.

3. Set appropriate laser power, speed, and resolution settings.

4. Focus the laser and perform a test fire.

5. Begin the engraving operation and monitor the process, especially the first few runs, to ensure that the laser is operating correctly.

6. Once completed, allow the material to cool before handling.

7\. Clean the engraved material.

7\. Inspect the engraved area to check if adjustments are needed for depth or clarity, and document observations.

Observation Table:

Document the laser settings (power, speed, DPI).

Power	Speed	DPI	Feed

Safety Precautions:

1. Wear laser safety glasses.
2. Ensure proper ventilation and fume extraction.
3. Avoid using unsafe materials (e.g., PVC).
4. Keep a fire extinguisher nearby.
5. Never leave the machine unattended during operation.
6. Regularly inspect and maintain electrical components.
7. Clean the laser lens and mirrors frequently.
8. Use correct power, speed, and focus settings.
9. Keep the work area free of flammable objects.
10. Familiarize yourself with the emergency stop button.

Experiment No. 12

Aim: Understanding the Working of a CNC Router Machine and to perform operation using the CNC router machine.

Apparatus:

1. CNC Router machine
2. Safety goggles and hearing protection
3. Material for engraving (wood, plastic, metal, etc.)
4. Clamps or vacuum table
5. Computer with design software and CNC control software

Theory:

A CNC router machine is a computer-controlled cutting device used for precisely shaping and cutting materials like wood, metal, plastics, and foam. It operates by following programmed paths (G-code) to move a rotating cutting tool along multiple axes (usually X, Y, and Z) to carve or cut material into specific shapes or patterns. CNC routers are widely used in industries such as woodworking, sign-making, furniture production, and manufacturing due to their ability to produce accurate and intricate designs with high repeatability. They are efficient for both 2D cutting and 3D carving applications.

Key components of a CNC router include:

1. Frame: The structural base that supports all other components and provides stability.
2. Worktable: The surface where the material is placed for cutting or engraving.
3. Spindle/Router: The motorized unit that holds and rotates the cutting tool.
4. Cutting Tool/Router Bit: The tool used to cut or engrave the material.
5. Linear Rails and Guides: Components that facilitate smooth movement of the cutting tool along the X, Y, and Z axes.
6. Stepper/Servo Motors: Motors that drive the movement of the cutting tool along the designated axes.
7. Control System: The electronics that process the G-code and control the motors and spindle.
8. Power Supply: Provides electrical power to the machine and its components.
9. Computer Interface: The software or computer used to send commands and manage the CNC operation.
10. Cooling System: Optional system to cool the cutting tool during operation.
11. Dust Collection System: A system to collect dust and debris generated during cutting.

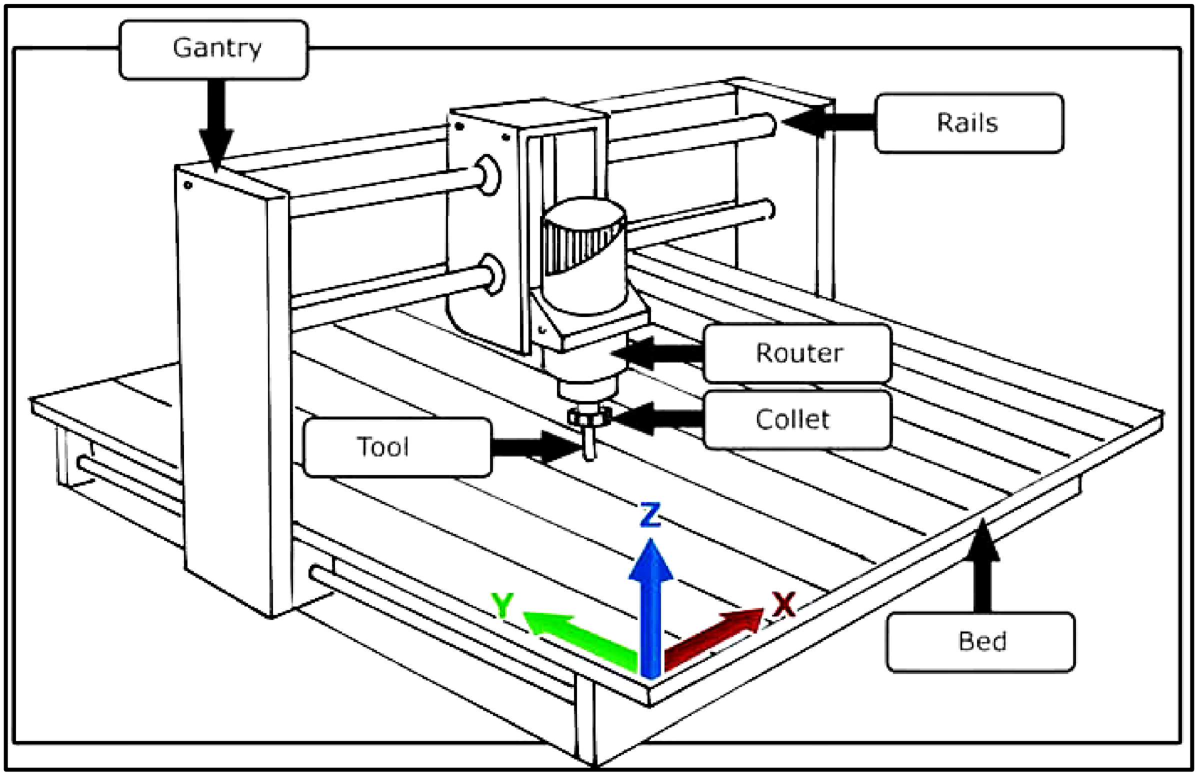


Figure 3. Schematic diagram of a CNC Router.

Setting the Router Parameter:

1. The CNC router requires specific parameters to be set based on the material and the design:
2. Spindle Speed: Determines the rotation speed of the router bit. Softer materials may require lower speeds, while harder materials need higher speeds.
3. Feed Rate: Controls how fast the cutting tool moves through the material. Slower feed rates provide more precision but take longer.
4. Depth of Cut: Defines how deep the cutting tool should go into the material for each pass. Multiple shallow passes are often better than a single deep cut to avoid damaging the tool or material.

Procedure:

1. Prepare the Material: Select the material appropriate for engraving.
2. Clean and flatten the material to ensure a smooth surface.
3. Secure the material firmly to the CNC router's work table using clamps or a vacuum table
4. Using CAD software, create the design, then export it as G-Code.
5. Load the prepared G-Code file into the CNC router's control software.
6. Configure spindle speed, feed rate, and depth of cut based on the material.
7. Zero the X, Y, and Z axes.

8. Run a test pass without cutting to ensure the alignment and settings are correct.
9. Start the engraving operation. Monitor the process to ensure everything is running smoothly, and adjust speed or depth settings if necessary.
10. After engraving, clean and inspect the material for any needed adjustments.

Observation:

Document the settings used (spindle speed, feed rate, depth of cut)

Specimen No.	Spindle speed	Feed rate	Depth of cut

Safety Precautions:

1. Wear protective eyewear to shield against debris.
2. Wear hearing protection if the machine generates loud noise.
3. Secure the material on the worktable to prevent movement during operation.
4. Ensure proper ventilation or use a dust collection system to manage dust and fumes.
5. Avoid loose clothing or jewellery that could get caught in the machine.
6. Keep hands away from moving parts and the cutting tool.
7. Use the correct router bit for the material being processed.
8. Check the machine setup and power connections before starting.
9. Do not leave the machine unattended while it's running.
10. Familiarize yourself with the emergency stop button in case of malfunction.
11. Regularly maintain and inspect the machine for wear and tear.
12. Unplug the machine before performing any maintenance or tool changes.

Experiment No. 13

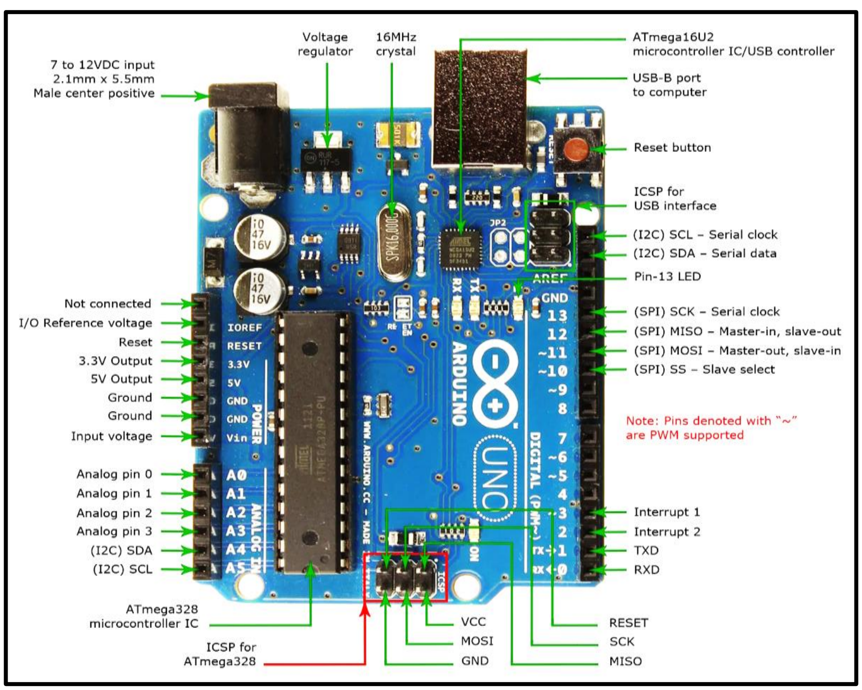
Aim: Introduction to Arduino Boards and Hands-On Session with Arduino IDE for Basic Automation

Tools used:

(i) Arduino Uno (or similar)
(ii) Breadboard
(iii) LED
(iv) 220-ohm resistor
(v) Jumper wires
(vi) USB cable (to connect the Arduino to your computer)

Theory:

Arduino boards are open-source electronics platforms based on simple hardware and software, designed to make microcontroller-based projects accessible to a wide audience. The most common board is the Arduino Uno, which features an ATmega328 microcontroller, 14 digital I/O pins, and 6 analog inputs. Other popular variants include the Arduino Nano, a compact version for breadboards, and the Arduino Mega, which offers more pins for larger projects. Some boards, like the Arduino Leonardo, can emulate USB devices such as keyboards or mice, while others, like the Arduino Uno WiFi or Arduino 101, feature built-in wireless capabilities like Wi-Fi or Bluetooth. Arduino boards are powered via USB or an external power supply, such as a battery, making them versatile for different applications.



Hardware:

Arduino Uno R3:

The Arduino Uno is a microcontroller board based on the ATmega328. It has 20 digital input/output pins (of which 6 can be used as PWM outputs and 6 can be used as analog inputs), a 16 MHz resonator, a USB connection, a power jack, an in-circuit system programming (ICSP) header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with AC-to-DC adapter or battery to get started.

Arduino Uno Pin Description:

Power USB: Arduino board can be powered by using the USB cable from your computer. All you need to do is connect the USB cable to the USB connection.

Power (Barrel Jack): Arduino boards can be powered directly from the AC mains power supply by connecting it to the Barrel Jack.

Voltage Regulator: The function of the voltage regulator is to control the voltage given to the Arduino board and stabilize the DC voltages used by the processor and other elements.

Crystal Oscillator: The crystal oscillator helps Arduino in dealing with time issues. How does Arduino calculate time? The answer is, by using the crystal oscillator. The number printed on top of the Arduino crystal is 16.000H9H. It tells us that the frequency is 16,000,000 Hertz or 16 MHz.

Arduino Reset: You can reset your Arduino board, i.e. start your program from the beginning. You can reset the UNO board in two ways. First, by using the reset button on the board. Second, you can connect an external reset button to the Arduino pin labeled RESET

Analog pins: The Arduino UNO board has six analog input pins A0 through A5. These pins can read the signal from an analog sensor like the humidity sensor or temperature sensor and convert it into a digital value that can be read by the microprocessor.

Pins (3.3, 5, GND, Vin) 3.3V − Supply 3.3 output volt 5V − Supply 5 output volt

Most of the components used with Arduino board works fine with 3.3 volt and 5 volt.

GND (Ground): There are several GND pins on the Arduino, any of which can be used to ground your circuit.

Vin: This pin also can be used to power the Arduino board from an external power source, like AC mains power supply.

Main microcontroller: Each Arduino board has its own microcontroller. You can assume it as the brain of your board. The main IC (integrated circuit) on the Arduino is slightly different from board to board. The microcontrollers are usually of the ATMEL Company.

ICSP pin: Mostly, ICSP is an AVR, a tiny programming header for the Arduino consisting of MOSI, MISO, SCK, RESET, VCC, and GND. It is often referred to as an SPI (Serial Peripheral Interface), which could be considered as an "expansion" of the output. Actually, you are slaving the output device to the master of the SPI bus.

Power LED indicator: This LED should light up when you plug your Arduino into a power source to indicate that your board is powered up correctly. If this light does not turn on, then there is something wrong with the connection.

TX and RX LEDs: On your board, you will find two labels: TX (transmit) and RX (receive). They appear in two places on the Arduino UNO board. First, at the digital pins 0 and 1, to indicate the pins responsible for serial communication. Second, the TX and RX led. The TX led flashes with different speed while sending the serial data. The speed of flashing depends on the baud rate used by the board. RX flashes during the receiving process.

Digital I/O: The Arduino UNO board has 14 digital I/O pins (of which 6 provide PWM (Pulse Width Modulation) output. These pins can be configured to work as input digital pins to read logic values (0 or 1) or as digital output pins to drive different modules like LEDs, relays, etc. The pins labeled "~" can be used to generate PWM.

AREF: AREF stands for Analog Reference. It is sometimes, used to set an external reference voltage (between 0 and 5 Volts) as the upper limit for the analog input pins.

Arduino Uno Technical Specifications:

Microcontroller	ATmega328P – 8bit AVR family microcontroller
Operating Voltage	5V
Recommended Input Voltage	7-12V
Input Voltage Limits	6-20V
Analog Input Pins	6 (A0 – A5)
Digital I/O Pins	14 (Out of which 6 provide PWM output)
DC Current on I/O Pins	40 mA
DC Current on 3.3V Pin	50 mA
Flash Memory	32 KB (0.5 KB is used for Bootloader)
SRAM	2 KB
EEPROM	1 KB
Frequency (Clock Speed)	16 MHz

Software:

Arduino IDE:

The Arduino IDE is open-source software, which is used to write and upload code to the Arduino boards. The IDE application is suitable for different operating systems such as Windows, Mac OS X, and Linux. It supports the programming languages C and C++. Here, IDE stands for Integrated Development Environment.

The program or code written in the Arduino IDE is often called as sketch. The Arduino IDE will appear as:

Steps for Software installation:

Step 1: Visit http://www.arduino.cc/en/main/software to download the latest Arduino IDE version for your computer's operating system. There are versions for Windows, Mac, and Linux systems. At the download page, click on the "Windows Installer" option for the easiest installation.

Step 2: Save the .exe file to your hard drive. Step 3: Open the .exe file.

Step 4: Click the button to agree to the licensing agreement

Step 5: Decide which components to install, then click "Next"

Step 6: Select which folder to install the program to, then click "Install"

Step 7: Wait for the program to finish installing, then click "Close"

Step 8: Now find the Arduino shortcut on your Desktop and click on it. The IDE will open up and you'll see the code editor.

Experiment No 14

Aim: To study various power tools used in industry

Theory:

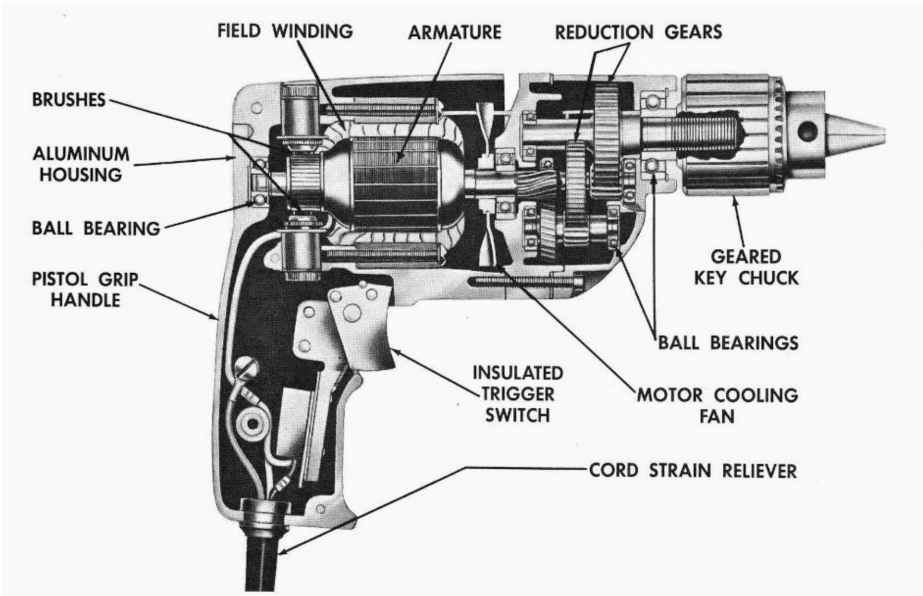
Power tools are electrically, battery, or air-powered devices designed to perform tasks more efficiently than hand tools. They are commonly used in construction, manufacturing, and DIY projects for drilling, cutting, sanding, and grinding. Popular types include drills, saws, grinders, sanders, and nail guns. Power tools can be corded for continuous power or cordless for portability, with pneumatic tools using compressed air. While they offer speed and precision, safety is crucial, requiring protective gear like gloves and goggles, proper handling, and regular maintenance to prevent accidents. Power tools significantly improve productivity and accuracy across a wide range of applications.

Tools:

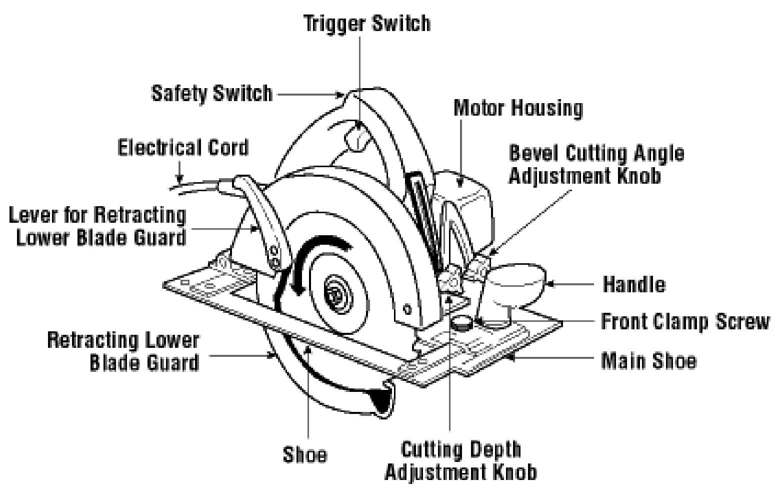
1. **Power Hacksaw:** A mechanized version of the traditional hacksaw, the power hacksaw is used to cut through metal or other tough materials. It features a motorized reciprocating blade, which moves back and forth to perform the cutting action, reducing manual effort and increasing precision. Power hacksaws are typically used in industrial settings or workshops where quick and accurate cutting of large metal sections is required, providing efficiency and consistency in repetitive tasks.

2. **Cordless Drill**: A versatile power tool, the cordless drill operates on rechargeable batteries and is used for drilling holes or driving screws in wood, metal, and other

materials. It offers mobility without the constraint of a power cord, making it ideal for both indoor and outdoor projects. Various drill bits and torque settings provide flexibility for different tasks, from light home repairs to professional construction work.

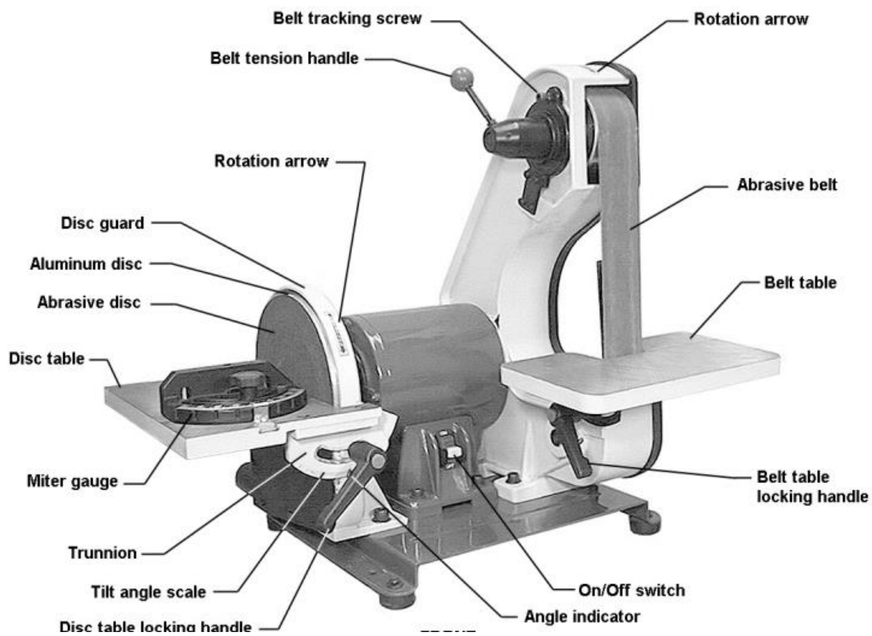


3. **Power Circular Saw**: A powerful cutting tool with a rotating blade, the circular saw is used for making straight cuts in wood, metal, and plastic. Available in corded or cordless versions, it's designed for precision cutting at various angles. Circular saws are commonly used in construction, carpentry, and DIY projects, offering fast, efficient cutting for tasks like framing, panel cutting, or cabinetry.



4. **Disc Sanding Machine**: This machine uses a rotating abrasive disc to smooth surfaces, remove material, or shape edges. It's commonly used in woodworking, metalworking, and finishing applications. Disc sanders come in various sizes and can handle coarse or fine sanding jobs depending on the grit of the sanding disc. They

offer consistent, even results and are ideal for sanding larger surfaces quickly and efficiently.



5. **Scroll Saw**: A scroll saw is a stationary power tool used for intricate cutting, allowing for precise, delicate work on wood, metal, or plastic. It features a fine, thin blade that moves up and down to make detailed curves or patterns. Commonly used by woodworkers, artists, and craftsmen, it excels in creating intricate designs or patterns that require detailed, smooth cuts.

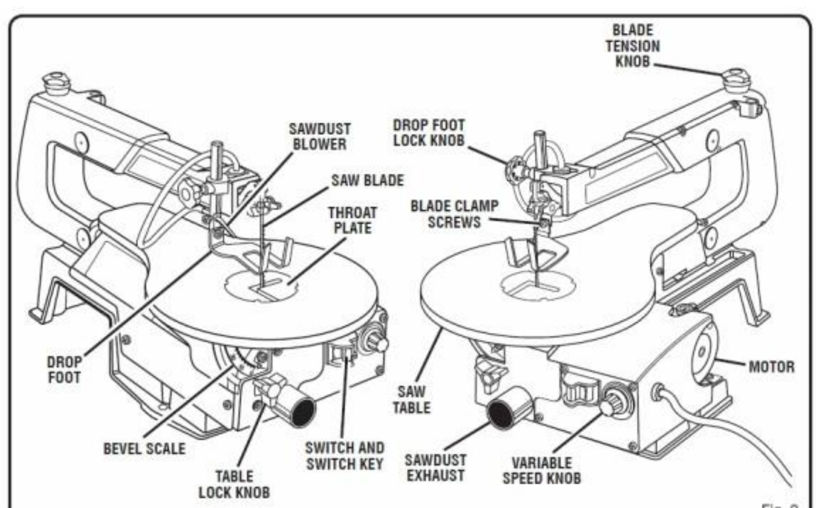
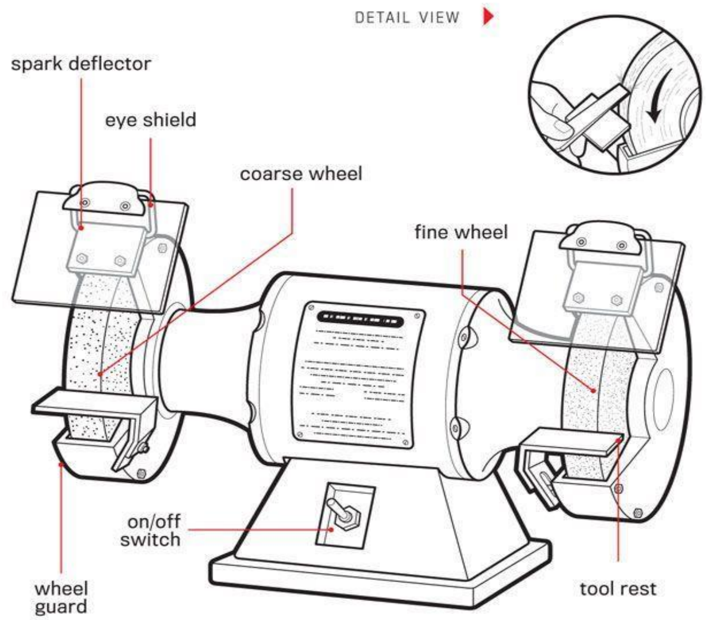
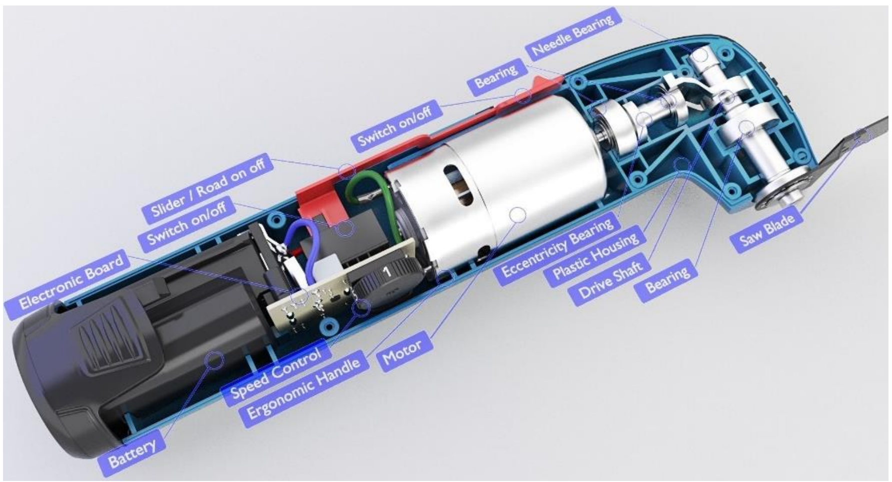


Fig. 2

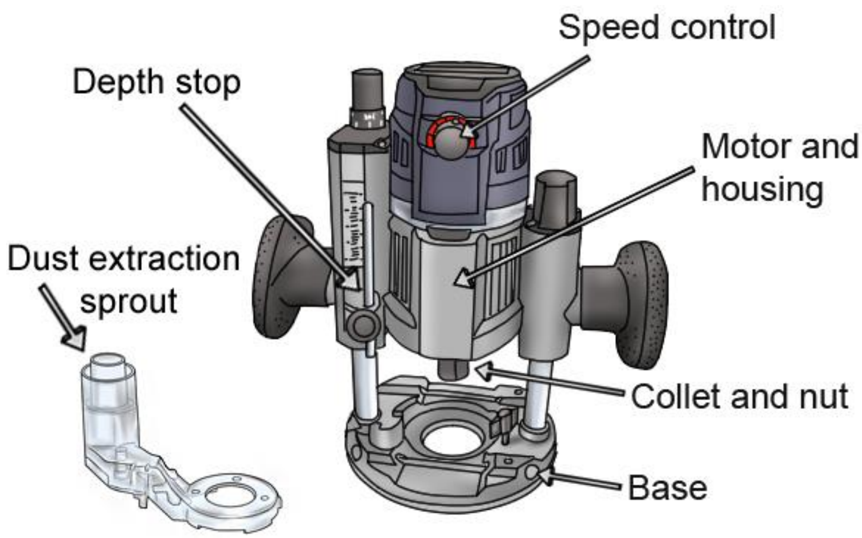
6. **Bench Grinder**: A stationary tool with two rotating abrasive wheels, a bench grinder is used for sharpening, shaping, or polishing metal objects. It's commonly found in workshops and used for tasks like sharpening tools, removing rust, or shaping metal components. Bench grinders come with different grit wheels for varying levels of coarseness, providing versatility for both rough and fine work.



7. **Cordless Rotary Tool**: A compact, battery-powered tool with multiple attachments, the cordless rotary tool is used for various tasks like cutting, sanding, engraving, polishing, or grinding. It's highly versatile and ideal for intricate work on wood, metal, plastic, and more. Cordless designs offer greater portability and flexibility, making them popular among hobbyists, craftsmen, and DIY enthusiasts for detailed, small-scale projects.



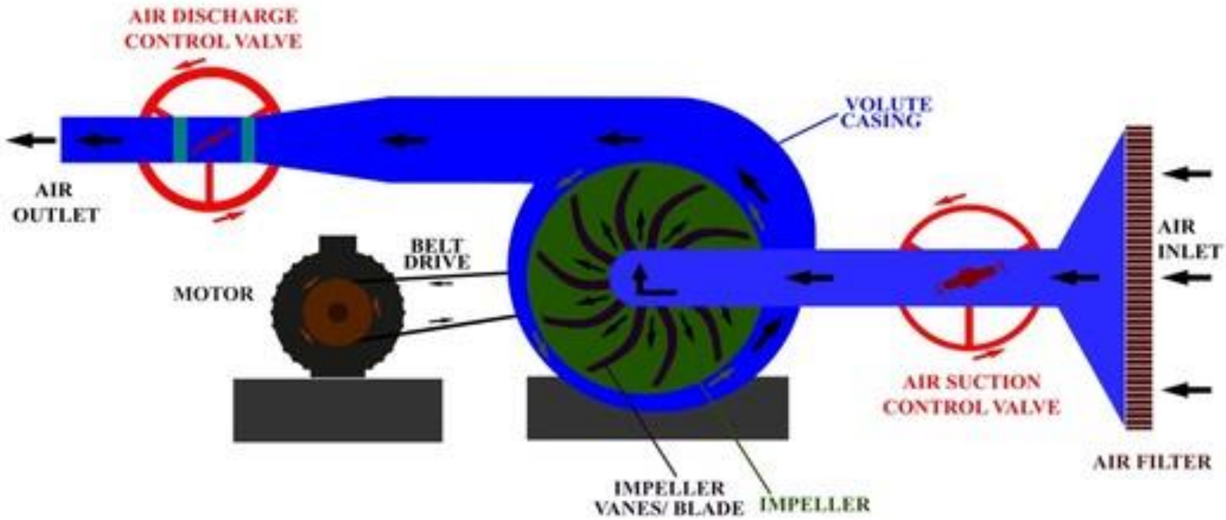
8. **Power Router**: A power router is a woodworking tool used for hollowing out an area in wood, plastic, or metal. It's commonly employed to shape edges, create decorative patterns, or cut grooves. Power routers come with various bit attachments for different tasks. They are essential in cabinetry, furniture making, and decorative woodwork, providing precision and speed for detailed craftsmanship.



9. **Impact Drill Machine**: This drill combines rotation with hammering action to drive screws or drill holes into tough materials like masonry or concrete. It delivers high torque and force, making it ideal for heavy-duty applications. Impact drills are commonly used in construction, renovation, and DIY projects where regular drills may lack the necessary power. They can be corded or cordless, depending on the task.

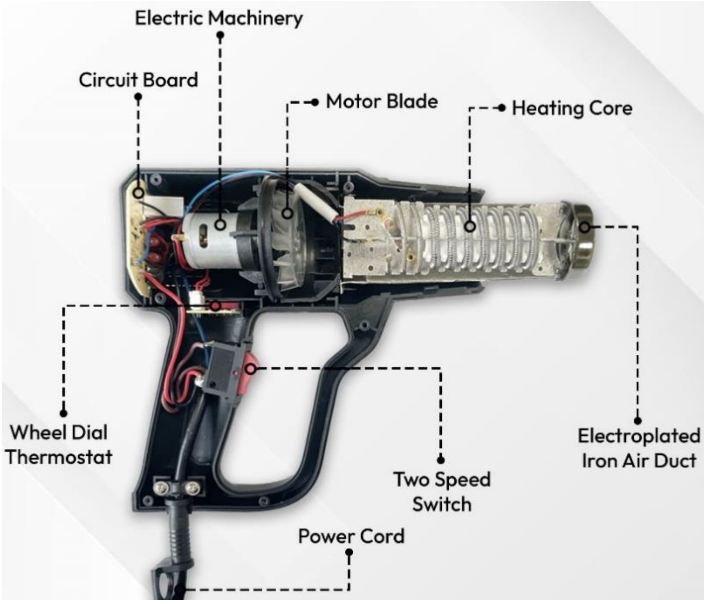
10. **Tin Cutter with Spring**: A handheld tool used for cutting thin sheets of metal, particularly tin, this cutter features a spring mechanism that returns the blades to their open position after each cut. The spring assists in reducing fatigue during prolonged use, making it ideal for metalworkers, roofers, or sheet metal fabricators who need to make precise, repeated cuts in thin metal sheets.

11.**Centrifugal Blower**: A device that uses a rotating impeller to move air or gases at high speed, creating airflow for ventilation, heating, or cooling. Centrifugal blowers are commonly used in HVAC systems, industrial processes, and dust control. They offer high-pressure airflow and are efficient in moving air over longer distances, making them ideal for environments where strong, continuous air circulation is needed.



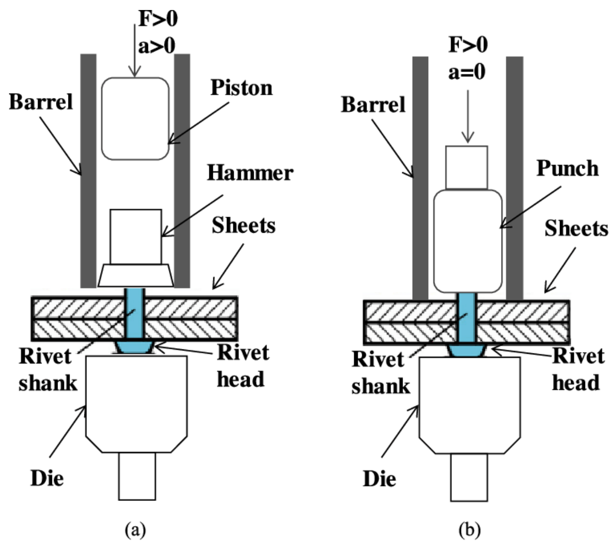
CENTRIFUGAL AIR BLOWER

12.**Hot Air Gun**: A hot air gun emits a stream of heated air and is used for tasks such as paint stripping, plastic welding, or drying surfaces. It resembles a hairdryer but reaches much higher temperatures. Adjustable heat settings allow control over the intensity. Hot air guns are commonly used in DIY projects, electronics repair, and automotive work for tasks requiring controlled heat application.

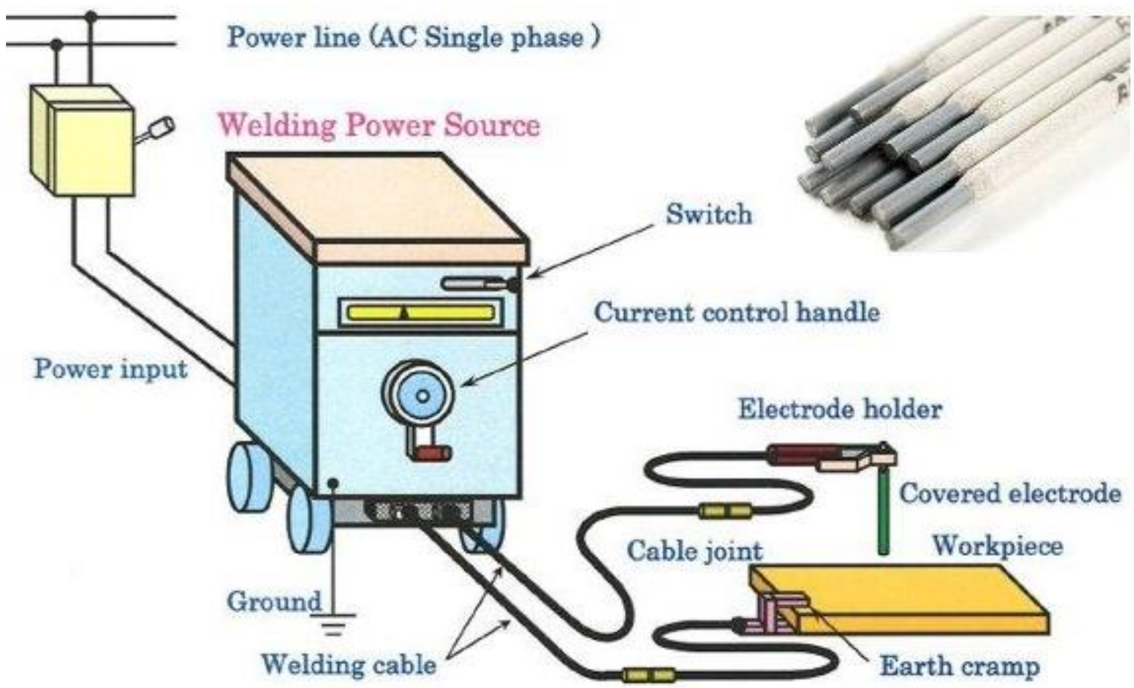


13. **Cordless Screwdriver Set**: A cordless screwdriver is a battery-powered tool designed for driving screws quickly and efficiently. It comes with interchangeable bits to accommodate different screw types and sizes. The cordless feature allows for ease of use in various locations without the hassle of a cord. Ideal for assembling furniture, installing fixtures, or small home repairs, it is portable and convenient for light-duty work.

14. **Riveting Machine**: A riveting machine is used to join materials by driving rivets into them, creating a strong, permanent bond. It applies pressure or uses a hammering action to deform the rivet's end, securing it in place. Commonly used in metal fabrication, construction, and automotive industries, it offers high strength for fastening components. Riveting machines can be manual, pneumatic, or hydraulic, depending on the application.



15. **Portable Welding Machine**: This machine allows for welding tasks to be performed anywhere due to its compact, portable design. Portable welders are used for fusing metal parts together using electricity, gas, or a combination of both. They are ideal for repair work, field construction, or DIY projects. Portable welders offer versatility and convenience, coming in various types like MIG, TIG, and arc welding, depending on the material and task.



Safety Precautions:

1. Wear Personal Protective Equipment (PPE): Always use safety goggles, gloves, ear protection, and appropriate clothing (like lab coats) to protect from debris and noise.
2. Inspect Tools Before Use: Check power tools for damage, loose parts, or frayed cords. Ensure all safety guards are in place and functioning.
3. Use Tools for Their Intended Purpose: Avoid using tools in ways they weren't designed for. This reduces the risk of accidents and damage.

4. Maintain a Clean Work Area: Keep the workspace free of clutter and flammable materials. A clean area reduces hazards like tripping or fire risks.
5. Disconnect When Not in Use: Unplug power tools when not in use, during servicing, or while changing accessories like blades or bits.
6. Ensure Proper Ventilation: If using power tools that generate dust, fumes, or sparks, work in a well-ventilated area to avoid inhaling harmful particles.
7. Use the Correct Tool for the Job: Avoid using makeshift tools or accessories, and always match the tool's power and speed to the task at hand.
8. Secure the Workpiece: Use clamps or a vice to hold the material in place. This prevents it from moving while working, reducing the chance of accidents.
9. Avoid Distractions: Focus fully on the task when operating power tools. Stay alert and avoid using tools when fatigued or under the influence of alcohol or drugs.
10. Follow Instructions: Always read and follow the operating manual and safety guidelines provided by the tool manufacturer.