

**MALLA REDDY  
COLLEGE OF ENGINEERING & TECHNOLOGY  
(AUTONOMOUS)**

**DEPARTMENT OF MECHANICAL ENGINEERING**

**LABORATORY MANUAL**

**CAD/ CAM LAB**

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## **CONTENTS**

- 1. Introduction to CAD**
- 2. ACAD – BASICS**
  - 2.1 Starting with ACAD
  - 2.2 Layout and sketching
  - 2.3 Drawing environment
  - 2.4 Elements of drawing
    - 2.4.1 Draw commands
  - 2.5 3D functions
  - 2.6 Starting the drawing
    - 2.6.1 Drawing sheet layout -1
    - 2.6.2 Drawing sheet layout - 2
- 3. 2D – FIGURES USING ACAD**
- 4. ISOMETRIC DRAWINGS USING ACAD**
- 5. Computer Aided Manufacturing**

## 1. INTRODUCTION

Computer Aided Drafting is a process of preparing a drawing of an object on the screen of a computer. There are various types of drawings in different fields of engineering and sciences. In the fields of mechanical or aeronautical engineering, the drawings of machine components and the layouts of them are prepared. In the field of civil engineering, plans and layouts of the buildings are prepared. In the field of electrical engineering, the layouts of power distribution system are prepared. In all fields of engineering use of computer is made for drawing and drafting.

The use of CAD process provides enhanced graphics capabilities which allows any designer to

- Conceptualize his ideas
- Modify the design very easily
- Perform animation
- Make design calculations
- Use colors, fonts and other aesthetic features.

### ***REASONS FOR IMPLEMENTING A CAD SYSTEM***

1. **Increases the productivity of the designer:** CAD improves the productivity of the designer to visualize the product and its component, parts and reduces the time required in synthesizing, analyzing and documenting the design
2. **Improves the quality of the design:** CAD system improves the quality of the design. A CAD system permits a more detailed engineering analysis and a larger number of design alternatives can be investigated. The design errors are also reduced because of the greater accuracy provided by the system
3. **Improves communication:** It improves the communication in design. The use of a CAD system provides better engineering drawings, more standardization in the drawing, and better documentation of the design, few drawing errors and legibility.
4. **Create data base for manufacturing:** In the process of creating the documentation for these products, much of the required data base to manufacture the products is also created.
5. **Improves the efficiency of the design:** It improves the efficiency of the design process and the wastage at the design stage can be reduced.

### ***APPLICATION OF CAD:***

There are various processes which can be performed by use of computer in the drafting process.

1. **Automated drafting:** This involves the creation of hard copy engineering drawings directly from CAD data base. Drafting also includes features like automatic dimensioning, generation of cross – hatched areas, scaling of the drawing and the capability to develop sectional views and enlarged views in detail. It has ability to perform transformations of images and prepare 3D drawings like isometric views, perspective views etc.,
2. **Geometric modeling:** concerned with the computer compatible mathematical description of the geometry of an object. The mathematical description allows the image of an object to be displayed and manipulated on a graphics terminal through signals from the CPU of the CAD system. The software that provides geometric modeling capabilities must be designed for efficient use both by computer and the human designer.

### ***BENEFITS OF CAD:***

The implementation of the CAD system provides variety of benefits to the industries in design and production as given below:

1. Improved productivity in drafting
2. Shorter preparation time for drawing
3. Reduced man power requirement
4. Customer modifications in drawing are easier
5. More efficient operation in drafting
6. Low wastage in drafting
7. Minimized transcription errors in drawing
8. Improved accuracy of drawing
9. Assistance in preparation of documentation
10. Better designs can be evolved
11. Revisions are possible
12. Colours can be used to customize the product
13. Production of orthographic projections with dimensions and tolerances
14. Hatching of all sections with different filling patterns
15. Preparation of assembly or sub assembly drawings
16. Preparation of part list
17. Machining and tolerance symbols at the required surfaces
18. Hydraulic and pneumatic circuit diagrams with symbols
19. Printing can be done to any scale

### ***LIMITATIONS OF CAD***

1. 32 – bit word computer is necessary because of large amount of computer memory and time
2. The size of the software package is large
3. Skill and judgment are required to prepare the drawing
4. Huge investment

## ***CAD SOFTWARES***

The software is an interpreter or translator which allows the user to perform specific type of application or job related to CAD. The following softwares are available for drafting

1. AUTOCAD
2. Pro – E
3. CATIA
4. MS OFFICE
5. PAINT
6. ANSYS
7. MSc.NASTRAN
8. IDEAS
9. SOLID WORKS
10. HYPERMESH
11. FLUENT – GAMBIT

The above software's are used depending upon their application.

## ***AUTO CAD***

Auto CAD package is suitable for accurate and perfect drawings of engineering designs. The drawing of machine parts, isometric views and assembly drawings are possible in AutoCAD. The package is suitable for 2D and 3D drawings.

## **2. AutoCAD – BASICS**

### **2.1 STARTING WITH ACAD**

CAD uses four basic elements for preparation of any drawing:

1. Line
2. Curves
3. Text
4. Filling point.

Computer Aided Drafting is done by the operator by placing the mouse pointer by placing the mouse pointer at the desired location and then executing the command to draw the graphic elements using different methods.

Advanced computer aided drafting packages utilize four areas on the screen.

1. Drawing Area
2. Command Area
3. Menu Area

4. Tool boxes.

## 2.2 LAYOUT AND SKETCHING

The package provides various facilities for layout, sketching and borders for preparing a drawing. It provides facilities for display co-ordinates and measurement units.

a. **Units:** The format for display co – ordinates and measurement can be selected according to the requirement.

Several measurement styles are available in ACAD. The main methods are engineering and architectural, having specific base unit assigned to them.

- i. Decimal: select to enter and display measurements in decimal notation
- ii. Engineering: Display measurements in feet and decimal inches.
- iii. Architectural: Display measurements in feet, inches and fractional inches
- iv. Fractional: Display measurements in mixed numbers notation
- v. Scientific: Display measurements in scientific notation.

The precision that is specified controls the number of decimal places or fractional size to which we want linear measurements displayed.

b. **Angles:** Select the format in which we want to enter and display angles.

- i. Decimal Degrees: Display partial degrees as decimals
- ii. Deg/Min/Sec: Display partial degrees as minutes and seconds.
- iii. Grades: Display Angles as grades
- iv. Radians: Display angles as radians.
- v. Surveyor: Displays angles in surveyor units.

c. **Angle measure:** Select the direction of the zero angle for the entry of angles:

- i. East: Select to specify the compass direction east as the zero angle.
- ii. North: Select to specify the compass direction north as the zero angle.
- iii. West: Select to specify the compass direction west as the zero angle.
- iv. South: Select to specify the compass direction south as the zero angle.
- v. Other: Select to specify a direction different from the points of the compass as the zero angle.

d. **Area:** Enter the approximate width and length which is planned to draw in full scale units. This limits the area of the drawing covered by grid dots when the grid is turned on. It also adjusts several default settings, such as text height, line type scaling and snap distance to convenient values. It is possible to adjust these settings.

e. **Title block:** Select the description of an ACAD drawing file of a title block to insert as a symbol in the new drawing. It can add or remove drawing files of title blocks from the list with the Add or Remove buttons

f. **Layout:** Paper space is often used to create complex multiple view drawings. There are three types of paper spaces:

1. Work on the drawing while viewing the layout.
2. Work on the drawing without the layout visible

3. Work on the layout of the drawing.

The following procedure is used for this purpose

1. From the File menu or from the standard tool bar, choose New
2. In the startup dialog box, choose Use a wizard, and select Advanced wizard
3. Choose OK
4. In the Advanced Setup Dialog box, select Title Block.
5. Select Title Block Description and Title Block file Name from the lists and then choose Add.
6. In the Select Title Block File dialog box, Select a title block, then choose open
7. In the Advanced Setup dialog box, a sample of that title is displayed.
8. Choose Done.

### 2.3 DRAWING ENVIRONMENT

ACAD provides two drawing environments for creating and laying out the drawing.

- i. Model Space
- ii. Paper Space.

ACAD allows creating drawing, called a model, in full scale in an area known as model space without regard to the final layout or size when the drawing is plotted on the paper.

In the space opened for the first time, it is possible to create floating viewports to contain different views of the model. In the paper space, floating viewports are treated as objects which can be moved and resized in order to create a suitable layout.

#### LIMITS

This sets and controls the drawing boundaries.

At the command prompt, enter **limits**

**ON/OFF/<LOWER LEFT CORNER> <current>: Specify a point, enter on or off, or press Enter.**

#### LTSCALE

This sets the line type scale factor. Use LTSCALE to change the relative length of the dash – dot line types per drawing unit

At the Command prompt, enter **ltscale**

**New scale factor <current> : Enter a positive real value or press enter**

**Changing the line type scale factor causes the drawing to regenerate.**

## MEASURE

This places point objects or blocks at measured intervals on an object. At the command Prompt, enter **measure**

**Select object to measure: Use an object selection method <segment length> / Block: Specify a distance.**

## PAN

This moves the drawing display in the current viewport. At the command prompt, enter **Pan**

**Displacement: Specify a point (1)**

The point which specify indicates the amount to move the drawing or the location of the drawing to be moved.

**Second point: Press or specify a point (2)**

If pressed, ACAD moves the drawing by the amount which is specified in the Displacement

Prompt. If we specify a point, ACAD moves the location of the drawing to that point.

## 2.4 ELEMENTS OF DRAWING

### 2.4.1 DRAW COMMANDS

#### LINE:

A line is specified by giving its two end points or first point and the distance of line along with its angle of inclination. A line can be drawn by using two commands.

Command: **line**

Specify first point: Specify a point (1)

Specify next point or [Undo]: Specify a point (2)

The second point can be indicated by **@d<a**

Where **d** is the distance of line and **a** is the angle of inclination in degrees.

#### PLINE:

This is a poly line which allows continuous segment of the line and it is drawn similar to the line command. The polyline allows to change the thickness of the line according to the requirement.

From the Draw tool bar choose the Polyline flyout.

Draw pull down menu: **Polyline**

At the command prompt, enter **pline**

### Syntax

Specify start point: Specify a point (1) Current line-width is <current>

Specify next point or [Arc/Close/Halfwidth/Length/Undo/Width]: Specify a point (2)  
or enter an option

### LINETYPE

Creates, loads, and sets linetypes. The LINETYPE command defines line characteristics consisting of dashes, dots, and spaces.

Format menu: Linetype or Command line: linetype

### 1. CURVES

Following are the various types of curves used in the drawings:

- i. Circle
- ii. Ellipse
- iii. Arc
- iv. Regular or any other type.

#### i. **Circle:** The circle can be drawn by using two types of commands

##### a. **Circle**

##### b. **Donut**

##### a. **CIRCLE:** This command draws the circle by using four methods:

Center point and radius

Two point circle

Three point circle

Tangent circle

At the command prompt, enter **circle**

**Specify center point for circle or [3P (Three Points)/2P (Two Points)/Ttr]: Specify a point or enter an option**

##### b. **DONUT:** This draws filled circles and rings.

Donuts are constructed of a closed polyline composed of wide arc segments.

At the command prompt, enter **donut**

Specify inside diameter of donut <current>: Specify a distance or press ENTER

**If you specify an inside diameter of 0, the donut is a filled circle.**

Specify outside diameter of donut <current>: Specify a distance or press ENTER

Specify center of donut or <exit>: Specify a point (1) or press ENTER to end the command

**ii. ELLIPSE:** It is a curve having major and minor axis with a center.

The ellipse can be prepared by four methods.

Axis endpoint

Arc

Centre

Iso circle

### **ELLIPSE**

Creates an ellipse or an elliptic arc.

**Axis end point:** Defines the first axis by two specified endpoints. The angle of the first axis determines the angle of the ellipse. The first axis can define either the major or the minor axis of the ellipse.

**Arc:** Creates an elliptical arc. The angle of the first axis determines the angle of the elliptical arc. The first axis can define either the major or the minor axis of the elliptical arc.

**Center:** Creates the ellipse by a specified center point.

**Isocircle:** Creates an isometric circle in the current isometric drawing plane.

At the command prompt, enter **ellipse**.

**iii. Arc:** The arc is a curve specified by center and radius as well as the start angle and end angle. There are seven method used for drawing an arc.

1. Three point method
2. Start point-center point –end point
3. Start point-center point-length of chord
4. Start point-end point –angle of inclusion
5. Start point-end point-direction
6. Start point-center point-angle of inclusion
7. Start point-end point-radius

These methods can be used by executing the arc command

- **ARC:** creates an arc.

At the command prompt, enter arc

Center/<start point>: specify a point, enter c, or press enter

- **Polyarc:** the second method of the drawing the arc is poly arc by use of pline command. This command allows drawing of filled arc of any width .it also allows for drawing of a regular or irregular curve.

**2. Drawing of Rectangle:** A rectangle can be drawn by LINE command or by Rectangle command. The **PLINE** command also allows for drawing of hollow or filled rectangle .A **SOLID** command is also used for drawing of filled rectangles.

1. **RECTANGLES:** draws a rectangular polyline

At the command prompt, enter **rectangle**

First corner: specify point (1)

Other corner: specify point (2)

2. **SOLID:** creates solid –filled polygons .solids are filled only when fill system Variable is set to on view is set to plan.

At the command prompt, enter **solid**

First corner: specify point (1)

Other corner: specify point (2)

The first two points define one edge of the polygon.

Third point: specify a point (3) diagonally opposite the second

Forth point: specify a point (4) or press enter

**3. DRAWING OF POLYGON**

Creates an equilateral closed polyline .A polygon is a polyline object. AUTOCAD draws polyline with zero width and no tangent information.

At the command prompt enter **polygon**

Number of sides <current>: enter a value between **3 and 1024** or press enter

Edge/<center of polygon>: **specify a point (1) or enter.**

**4. POINT**

Creates a point object .points can act as nodes to which you can snap objects .you can specify a full 3D location for a point.

At the command prompt, enter **point**

Point: specify a point

**5. ERASING OF OBJECT:**

The object can be removed or erased by use of erase command

**ERASE**

This removes object from drawing

At the command prompt, enter **erase**

**Select objects: use an object selection method.**

## 6. COLOURING OF OBJECT:

The object can be drawn with any variety of colour which ranges from 0 to 256.

The setting of colour can be done by color command

### COLOR

Sets the colour for new objects.

At the command prompt, enter color <current> :enter a value (1-255),color name ,by block, or by layer

## 7. FILLING OF OBJECT:

the object can be filled with different colors and patterns by use of

## 8. hatch command

This command allows selection of various patterns, scale of pattern and angle of pattern.

### HATCH

This fills an area with a pattern.

HATCH fills the specified hatch boundary with non-associative hatch

A non –associative hatch is not updated when its boundaries are modified. a hatch boundary

consists of an object or objects that completely enclose an area

At the command prompt, enter hatch

Pattern (? Or name/ U, style) <current>: enter a predefined pattern name, enter u, enter? Or press enter.

## 9. SCALING OF DRAWING:

zoom command displays the object at a specified scale factor. the value entered is relative to the limits of the drawing .for example ,entering 2 doubles the apparent display size of any objects from what it would be if it were zoomed to the limits of the drawing

If you enter a value followed by xp, auto CAD specifies the scale relative to paper scale unit's .for example, entering 0.5xp displays model space at half the scale of paper space unit's .the following illustration shows a number of viewports arranged in paper space. the view in each view port is scaled relative to paper space .the first view is scaled 1=1 relative to paper space (1xp) ,the second is scaled 0.5=1 relative to paper space (0.5xp),and so on.

## ZOOM

This increases or decreases the apparent size of objects in the current view port

At the command prompt, enter zoom

All/center/dynamic/ extents/left/previous/vmax/window/<scale(x/xp)>: enter an option or value ,specify a point ,or press enter

- 10. TEXT:** The text in software is indicated by font's .the fonts define the shapes of the text characters that make up each character set. In AUTOCAD, you can use true type fonts in addition to AUTOCAD's own compiled shape (SHX) fonts.

A font is indicated by various parameters like

- i. Style :these are four types: normal, bold, italic, underline
- ii. Size: this is the size of characters
- iii. Colour: there are facilities to colour the characters selecting layer.
- iv. Type: different types of fonts may be used:

Mono text: COMPUTER AIDED DESIGN

Romans: COMPUTER AIDED DESIGN

Romand: **COMPUTER AIDED DESIGN**

**Dtext:** This displays text on the screen as it is entered .AutoCAD can create text with a variety of character patterns, or fonts. These fonts can be stretched, compressed, oblique, mirrored, or aligned in a vertical column by applying a style to the font .text can be rotated, justified, and made any size.

At the command prompt, enter text

Justify/style/<start point>: specify a point or enter an option

**TEXT:** This creates a single line of text .AutoCAD can create text with a variety of character patterns, or fonts. These fonts can be stretched, compressed, oblique, mirrored, or aligned in a vertical column by applying a style to the font.

At the command prompt, enter **text**

Justify/style/<start point>: specify a point or enter an option

**QTEXT:** This controls the display and plotting of text and attribute of objects.

At the command prompt, enter **text**

ON/OFF <current>: enter on or off, or press enter

- 11. TRANSFORMATIONS:** These are the modifications in the drawn objects.

There are different types of transformations used

1. **MOVE:** This allows to move or displace objects a specified distance in a specified direction

At the command prompt, enter **move**

Select objects: use an object selection method

Base point or displacement: specify a base point (1)

Second point of displacement: specify a point (2) or press enter

2. **COPY:** This is used for producing a duplicate copy of the drawing.

At the command prompt, enter **copy**

Select objects: use an object selection method

<Base point or displacement >/multiple: specify a base point (1)

For a single copy or enter m for multiple copies

3. **ROTATE:** It moves objects about a base point

At the command prompt, enter **rotate**

Select objects: use an object selection method

<Rotate angle >/reference: specify an angle or enter r

4. **STRETCH:** This moves or stretches objects .AutoCAD stretches lines, arcs, elliptical arcs, splines, rays and polyline segments that cross the selection window.

At the command prompt, enter **stretch**

Select objects: use the CPOLYGON or cross object selection method(1,2)

Base point or displacement: specify a point (3) or press

Second point of displacement: specify a point (\$) or press

5. **EXTEND:** This extends an object to meet another object. Objects that can be extended include arcs, elliptical arcs, lines, open 2D, and 3Dpolylines and rays.

At command prompt, enter **extend**

Select boundary edges

(projmode=UCS, edge mode=no extend)

Select objects: use an object selection method

**6. SCALE:** This enlarges or reduces selected objects equally in X and Y directions

At the command prompt, enter **scale**

Select objects: use an object selection method

Base point: specify a point (1)

<Scale factor>/reference: specify a scale or enter r

**7. TRACE:** This creates solid lines.

From the miscellaneous tool bar choose

At the command prompt, enter **trace**

Trace width<current>: specify a distance, enter a value ,or press enter

From point: specify point (1)

To point: specify a point (2)

To point: specify a point (3) or press to end the command

**8. EXTRUDE:** This creates unique solid primitives by extruding existing two-dimensional objects extrudes also creates solids by extruding two-dimensional objects along a specified path .we can extrude multiple objects with extrude

At the command prompt enter, **extrude**

Select objects: use an object selection method

Path/<height of extrusion>: specify a distance or enter p

**9. MIRROR:** This is used to producing mirror image of the object

At the command prompt enter, **mirror**

Select objects: use an object selection method

First point of the mirror line: specify a point (1)

Second point: specify a point (2)

**10. OFFSET:** This creates concentric circles, parallel lines and parallel curves, offset creates a creates a new object at a specified distance from an existing object or through a specified point

At the command prompt enter, **offset**

Offset distance: specify a distance, enter t or press enter

**11. ARRAY:** This creates multiple copies of objects in pattern.

Each object in an array can be manipulated independently

At the command prompt enter, **array**

Rectangular or polar array<current>: enter an option or press enter specify a point

## 12. CUTTING OF OBJECTS

The drawn objects can be cut or trimmed by using following commands

1. **TRIM:** Trims objects at a cutting object defined by other objects. Objects that can be trimmed include arcs ,circles, elliptical arcs, lines, open 2D and 3Dpolylines,rays and splines

At the command prompt, enter **trim**

Select cutting edges:

Select objects: use object selection method

<Select object to trim>/project/edge/undo: select an object, enter an option, or press enter

2. **BREAK:** This erases an object or splits the object in to two parts

From the modify toolbar select break flyout

At the command prompt, enter **break**

Select objects: use an object selection method

First point of the mirror line: specify a point (1) on an object

Enter second point: specify the second break point (2) or enter F

## 13. DIMENSIONING IN DRAWINGS:

The dimensions are inserted in the drawing by use of DIM command. There are various types of dimensions used in AutoCAD.

1. Linear dimensions:

Horizontal- this allows horizontal dimensions

Vertical- this allows vertical dimensions

Aligned- this allows inclined dimensions

Rotated- this allows inclined dimensions

2. Angular dimensions:

This allows angular dimensioning of objects

### 3. Radial dimensions:

This allows radial dimensioning of arc or circle

### 4. Diametric dimensions:

This allows diametral dimensions of the circle

For dimensioning of objects, the first point and second point has to be specified. The dimension text

must be written and then the position of dimension must be specified

at the command prompt, enter **dim**

**Dim:** Enter a dimensioning mode command

### 14. AREA:

This allows calculation of the area and perimeter of objects or of defined areas

From the object properties toolbar, choose the inquiry flyout, then

At the command prompt, enter **area**

**<First point>/object/add/subtract: specify a point or enter option**

### 15. FILLET

Rounds and fillets the edges of the object

At the command prompt enter **fillet**

Polyline / Radius / Trim / <Select first object>: use an object selection method or enter an

option

Select first object

Select second object: use an object selection method

Enter radius <current>: specify a distance or press

Chain / Radius <Select edge>: Select edges or enter **c** or **r** their intersection

### 16. CO-ORDINATE SYSTEM

The co- ordinate system can be modified in the AutoCAD. There are two types of co-

Ordinate systems used. The WCS (World co- ordinate system) is a universal system in which

Its origin is at the fixed position. The UCS (User co- ordinate system) is a system in which

User can fix his origin at any point.

1. UCS : This manages user co- ordinate systems

At the command prompt enter **ucs**

Origin / z axis/ 3 point/ object/ view/ X/Y/Z / Prev/ Restore/Save/ Del/?/< world>:  
enter

An option or press enter

2. WCS: This manages world co- ordinate system

### 17. EXPLODE:

This breaks a compound object into its component objects

At the command prompt enter **explode**

Select objects: use an object selection method.

### 18. UNION:

This measures the distance and angle between two points.

At the command prompt, enter **union**

Select object: Use an object selection method

### 19. DIST: This measures the distance and the angle between two points.

At the command prompt area enter **dist**

First point: Specify a point (1)

Second point: Specify a point (2)

Distance = calculated distance

Angle in XY plane = angle from XY plane = angle

**Delta X = change in X**

**Delta Y = change in Y**

**Delta Z = change in Z.**

### 20. REGENERATION OF DRAWING:

ACAD provides a facility of regenerating a drawing to clear the cross points or marks on the screen.

- REDRAW
- REGEN
- REGENALL
- REGENAUTO

### 21. TOLERANCE

This creates geometric tolerances. Geometric tolerances define the maximum allowable variations of form or profile, orientation, location and run out from the exact geometry in a drawing. They specify the required accuracy for proper function and fit the objects drawn in AutoCAD

## 22. SKETCH

This creates a series of free hand line segments.

From the miscellaneous toolbar, choose

At the command prompt enter **sketch**

Follow the prompting

## 2.5 3D FUNCTIONS

### 1. BOX

This creates a three dimensional solid box.

At the command prompt enter **box**

Center/<corner of the box><0,0,0> :

Specify a point (1), enter c, or press enter

Corner of a box

Specifying a point or pressing defines the first corner of the box.

Cube/length /<other corner>: specify a point (2) or enter an option **center**

Creates the box by a specified center point

### 2. CONE

This creates a 3D solid cone. A cone is solid primitive with a circular or elliptical based tapering symmetrically to a point perpendicular to its base.

At the command prompt enter **cone**

Elliptical /<center point> <0,0,0> : specify a point , enter e or press enter

### 3. CYLINDER

This creates a 3D solid cylinder. A cylinder is solid primitive with a circular or elliptical based to a point perpendicular to its base without a taper.

At the command prompt enter **cylinder**

Elliptical /<center point> <0,0,0> : specify a point , enter e or press enter

### 4. SPHERE

This creates a 3D solid sphere. A sphere is positioned so that its central axis is parallel to the Z-axis of the current UCS. Latitudinal lines are parallel to the XY plane.

At the command prompt enter **sphere**

Center of the sphere <0,0,0> : specify a point , enter e or press enter

## 5. WEDGE

This creates a three dimensional solid with a sloped face tapering along X axis.

At the command prompt enter **wedge**

Center <corner of the wedge> <0,0,0> : specify a point , enter e or press enter

Follow the prompting

## 6. ELEV

This sets an elevation and extrusion thickness of new objects. The current elevation is the Z value that is used whenever a 3D point is expected but only X and y values are supplied.

At the command prompt enter **elev** Follow the prompting

## 7. SHADE

This displays a flat shaded image of the drawing in the current view port. SHADE removes hidden lines and displays a shaded picture of the drawing.

From the render toolbar, choose

At the command prompt, enter **shade**

## 8. REGION

This creates a region object from a selection set of existing objects. Regions are 2Dimensional areas you create from closed shapes.

## 9. REINIT

This reinitializes the input/output ports, digitizer, display and program parameters file.

## 10. REPLAY

This displays a GIF, TGA or TIFF image.

From the tools menu, choose image, then view.

## 11. REVOLVE

This creates a solid by revolving a two – dimensional object about an axis. From the solids toolbar, choose

At the command prompt, enter **revolve**

**12. SHAPE**

This inserts a shape. Before inserting a shape, you must load the file containing the desired shape.

**13. ROTATE 3D**

This moves objects about a three dimensional axis

From the modify toolbar, choose the rotate flyout then

Follow the prompting

**14. SECTION**

This uses the intersection of a plane and solids to create a region.

AutoCAD creates regions on the current layer and inserts them at the location of the cross – section. Selecting several solids creates separate regions for each solid.

**15. SLICE**

This slices a set of solids with a plane.

**16. SHELL**

This accesses operating system commands.

**17. REVOLVE**

This creates a solid by revolving a two dimensional object about an axis.

**18. RENDER**

This creates a realistically shaded image of a three dimensional wireframe or solid model. RENDER produces an image using information from a scene, the current selection set, or the current view.

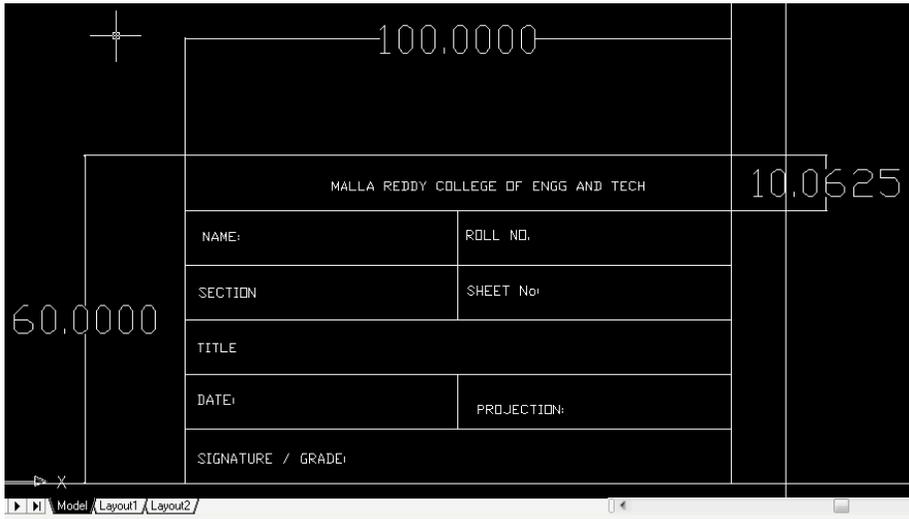
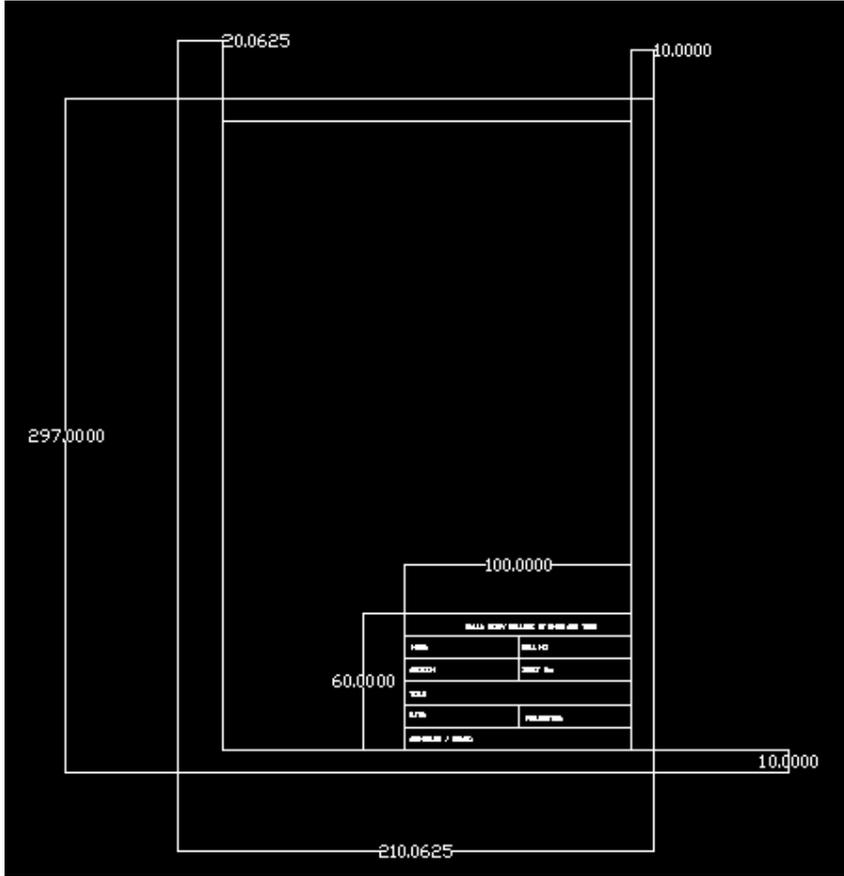
**2.6 Starting the drawing**

The figures we do in engineering are fitted into a template. In ACAD we manually draw a template known as *Drawing sheet* in two different formats.

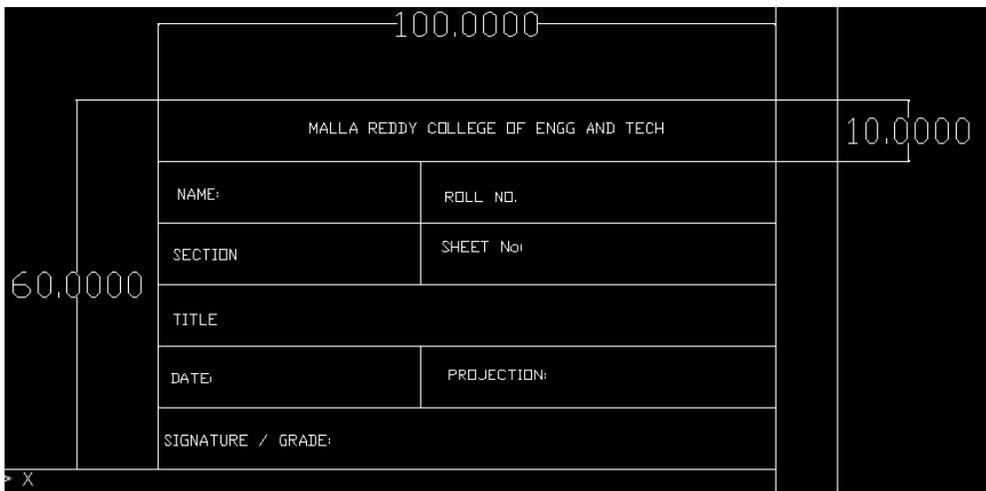
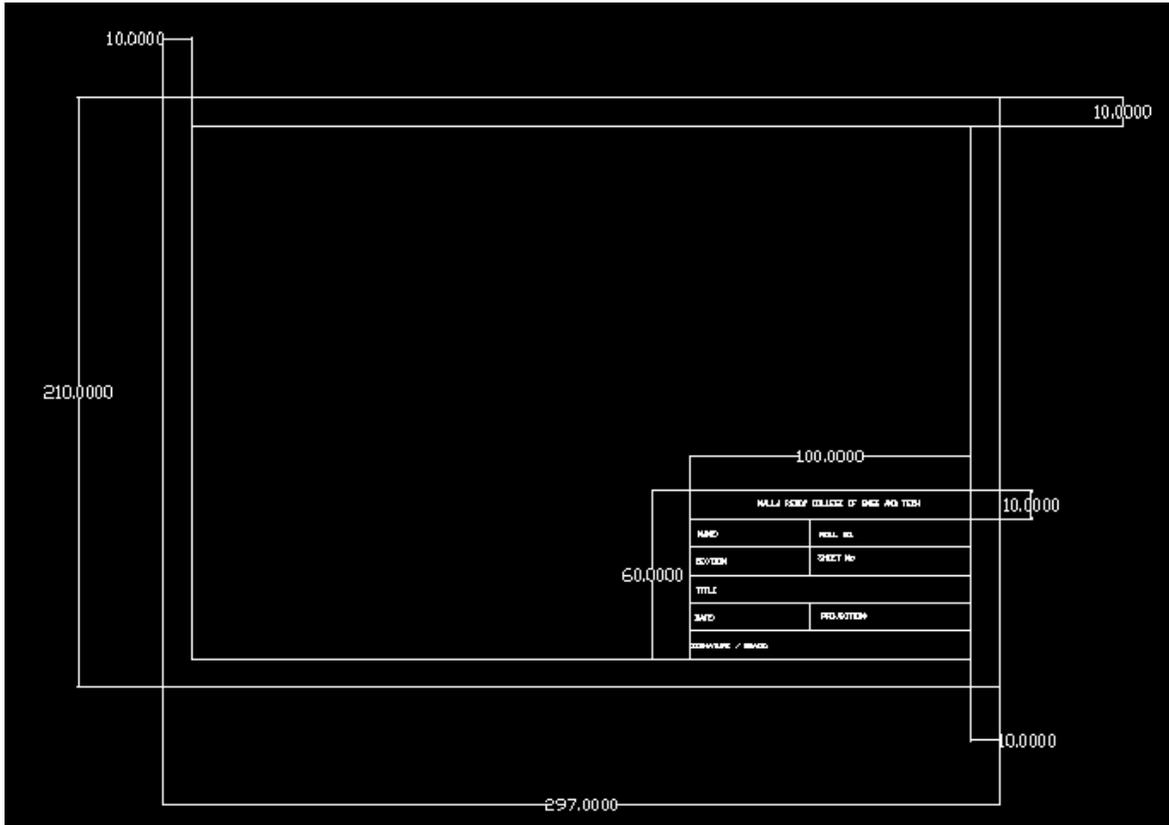
The size of the drawing sheet is ISO A4 210 X 297.

The format is as given in the following figures

# DRAWING SHEET LAYOUT -1



## DRAWING SHEET LAYOUT -2



### 3. 2D DRAWINGS

#### FIGURE 1

##### EXERCISE 1 ON 2D DRAFTING USING AUTOCAD

**Aim:** - Draw the plan and elevation of the given drawing using autocad-2008.

**Hardware specification:-**

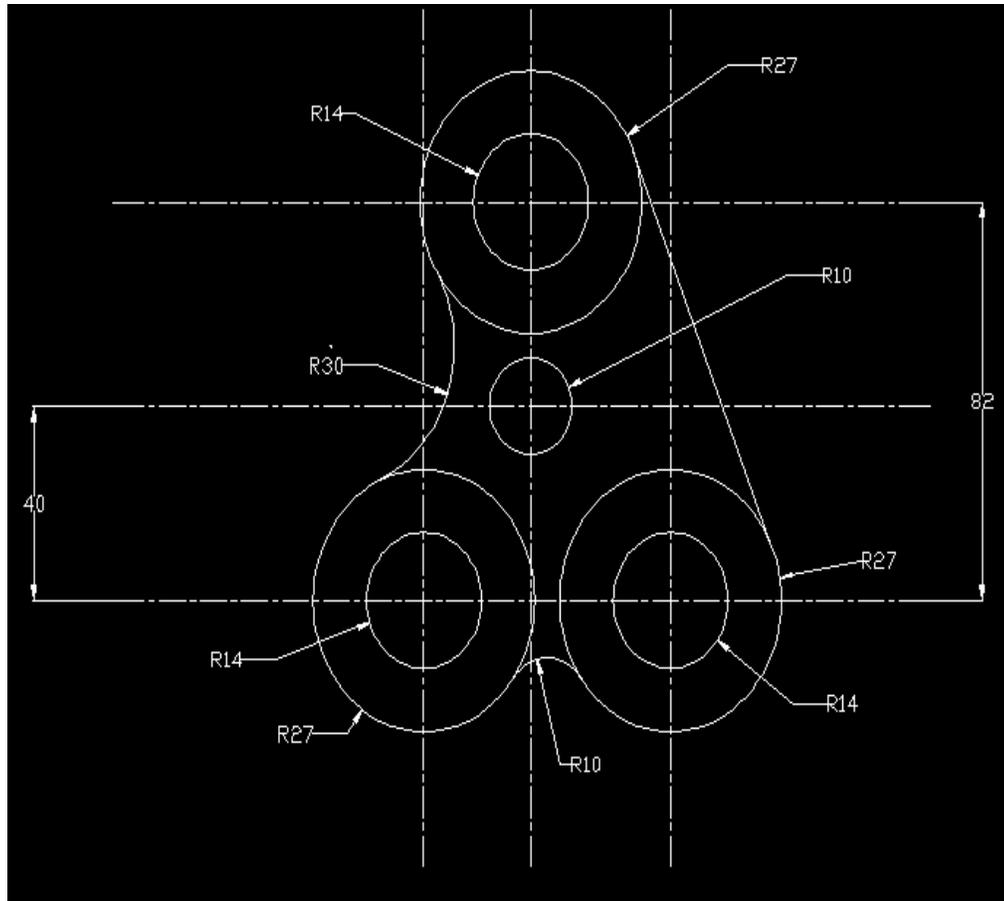
Zenith premium PC with Intel Pentium 4 Processor 3.06GHZ, 533 MHZ FSB 1MB cache, Intel 615 chip set mother board, 8GB SATA hard disk.1GB DDR RAM.

Maximum 3d/2d resolution of 2048×1536, 16 million colors (shared memory using dynamic video memory technology) On board 10/100 LAN chip. PS2, 107keys keyboard, Optical Mouse, 17” pure flat CRT monitor.

**Commands used:** - Construction line, circle, fillet, Tangent trim offset.

**Procedure:-**

- 1) Invoke auto cad -2008 from the menu or from shortcut icon on the desktop.
- 2) Set limits for the working window  
limits <enter> (0,0)<enter>(150, 150) <enter>  
xl <enter> select horizontal line and again.  
yl <enter> select vertical line. The origin is considered as O1.
- 3) Draw a circle of diameter 28 mm from the origin (O1)
- 4) Now take an offset command with a distance of 60mm and draw a vertical line on right side. The origin is considered as O2. From origin O2 draw a circle of diameter 28mm.
- 5) Draw the circle of radius 27mm from the origins O1 and O2.
- 6) With an offset command, draw a horizontal line with a distance of 40mm in the upward direction from the origins O1 and O2 lines. Draw a vertical line on the right side with an offset distance of 26mm from the origin O1 line. This gives us an origin O from the origin O3; draw a circle of dia 20mm.
- 7) With an offset command, draw a horizontal line with a distance of 82mm in the upward direction from the origin O1 and O2 line. We get origin O4 from origin O4 draw a circle of 28mm dia and 27mm radius
- 8) Use the fillet command to get an arc on the large circle of origin O1 and O4 with a 30mm radius and on the large circle of origin O1 and O2 with a radius 10mm.
- 10) Using OSNAP function, →settings→ tangent draw a line on O4 and O2.



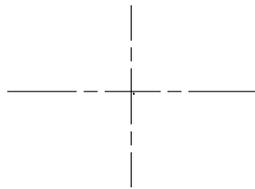
## FIGURE 2

Aim: to draw the following figure using ACAD

### PROCEDURE

**STEP 1:** Draw axis lines in the respective format with their intersection point at **(0,0)**

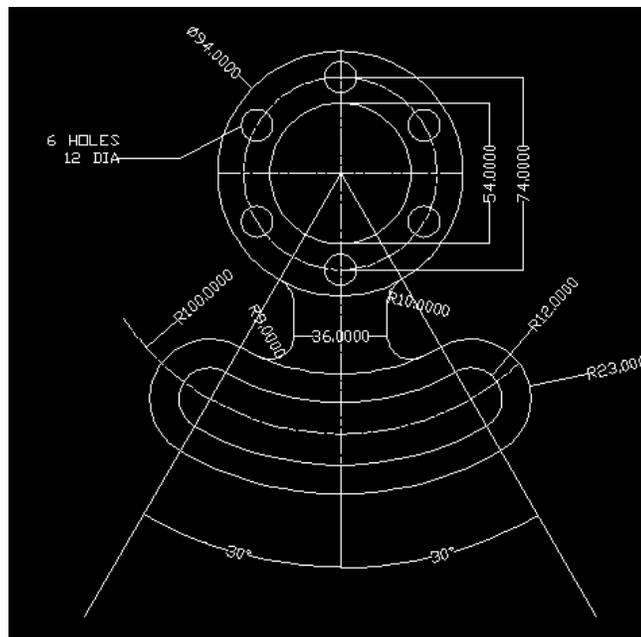
- Go to **PROPERTIES** tool bar
- Load line type as **ISO LONG DASH SHORT DASH** in the line type area.
- Select line type ISO LONG DASH SHORT DASH in the line type area.

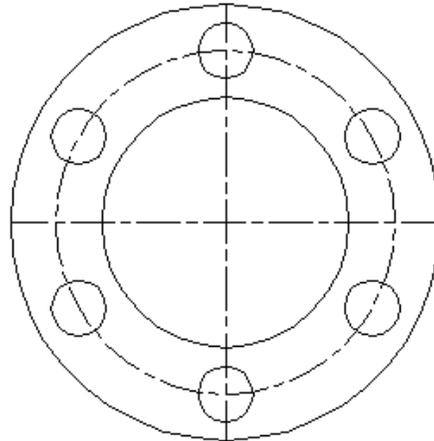
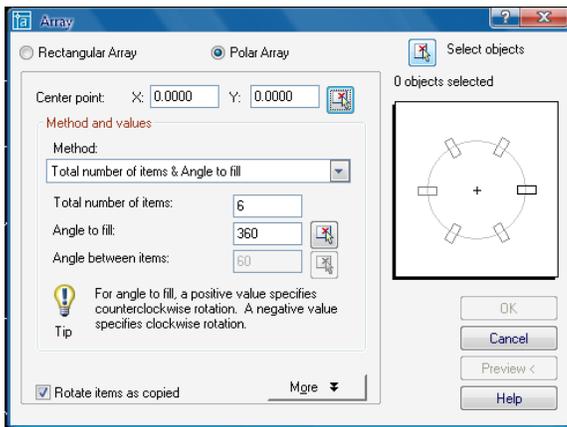


**STEP 2 a:** Draw circles of given dimensions using circle command with their centre as the intersection of the axis lines.

- 3 circles of diameters 94, 74 and 54 are to be drawn
- The circle with 74 diameter is of **ISO LONG DASH SHORT DASH** format

**STEP 2 b:** Using **POLAR ARRAY** draw the 6 holes on the circle of diameter 74 each of 12 dia as shown in the figure below





**STEP 3:** Draw two construction lines at an angle of  $30^\circ$  to the vertical axis line

**STEP 4:** With A as center an radius 100 draw an arc between the above lines

**STEP 5:** Offset the arc on the either side by the distances as mentioned in the figure.

**STEP 6:** Complete the figure by using fillet command.

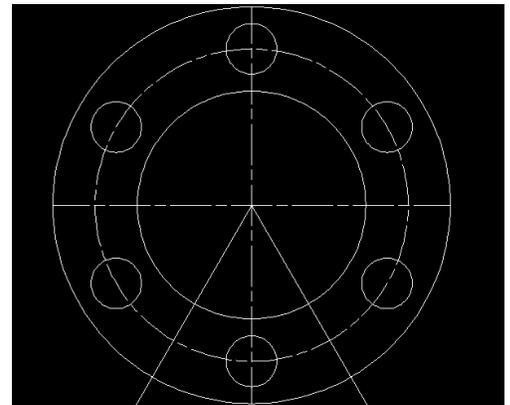
**STEP 7:** Give dimensions to the completed figure.

**Command:** `_qsave`

### **PRECAUTIONS:**

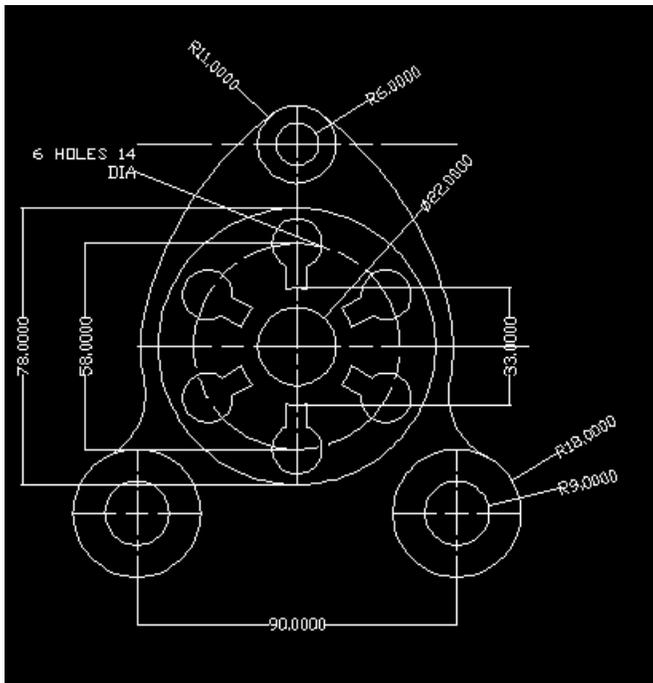
Put **ORTHO ON** where ever necessary.

Use the required modify tool bar commands like **TRIM**, **ERASE**, **COPY**, **MIRROR** ETC.,



## FIGURE 3

Aim: to draw the following figure using ACAD



### PROCEDURE

**Set the limits of the drawing screen**

**STEP 1:** Draw axis lines in the respective format with their intersection point at **(0,0)**

**STEP 2:** Draw circles of given dimensions using circle command with their centre as the intersection of the axis lines.

**STEP 3:** Using **POLAR ARRAY** draw the 6 key holes on the circle of diameter 58 of given dimensions

**STEP 4:** For the outer cover use **CIRCLE** command and the in command prompt area type **TAN TAN RADIUS**. This gives the idea of drawing the outer cover

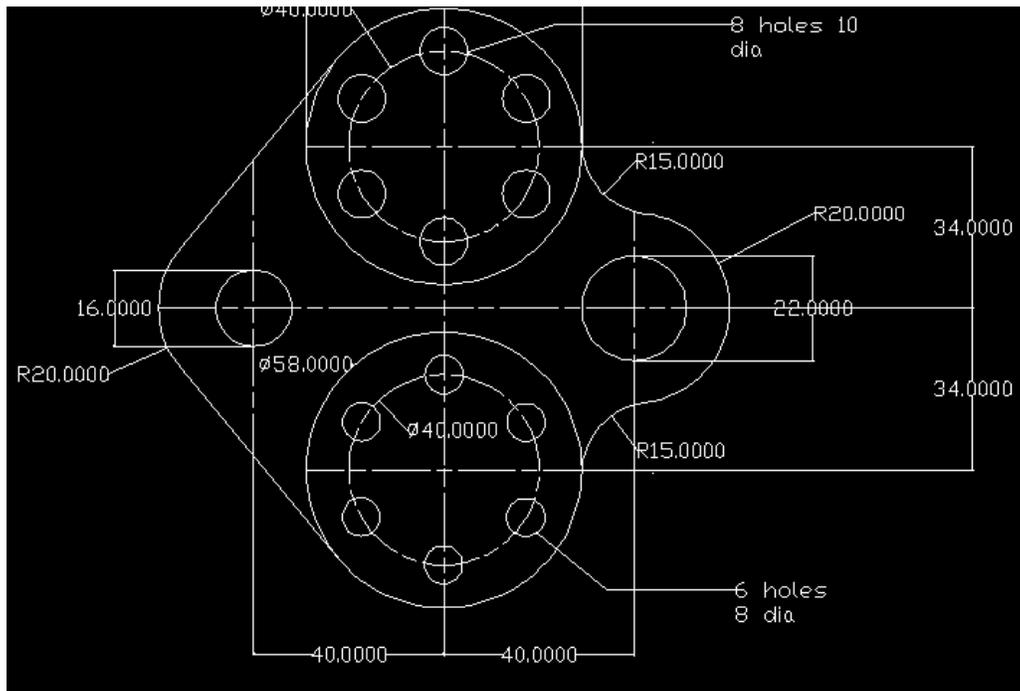
**STEP 7:** Give dimensions to the completed figure.

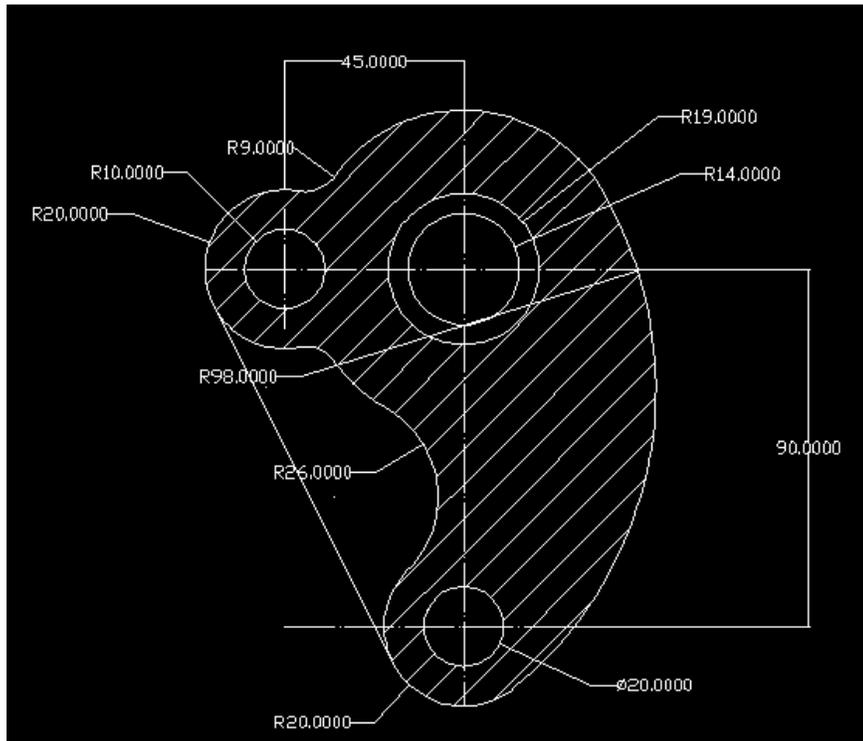
**Command:** `_qsave`

### PRECAUTIONS:

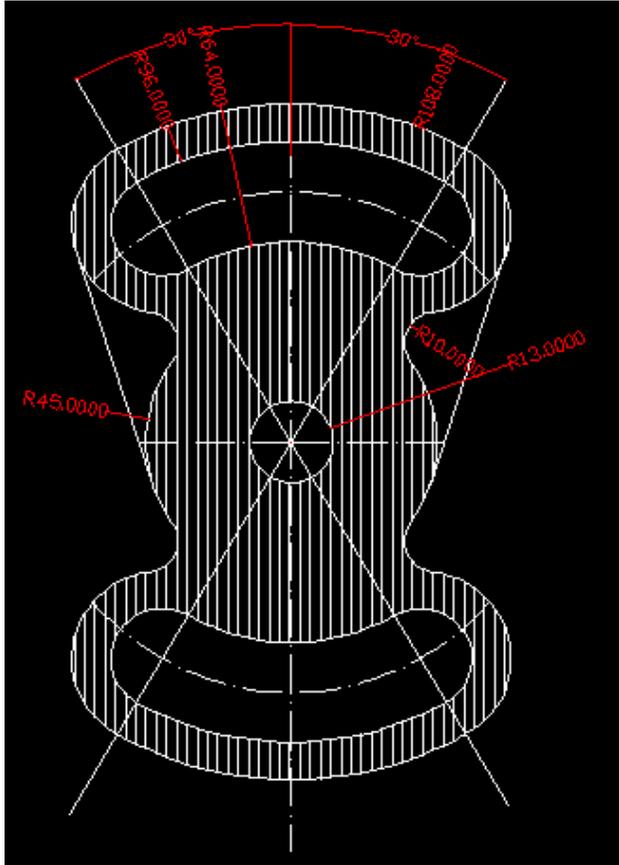
Put **ORTHO ON** where ever necessary.

Use the required modify tool bar commands like **TRIM, ERASE, COPY, MIRROR** ETC.,

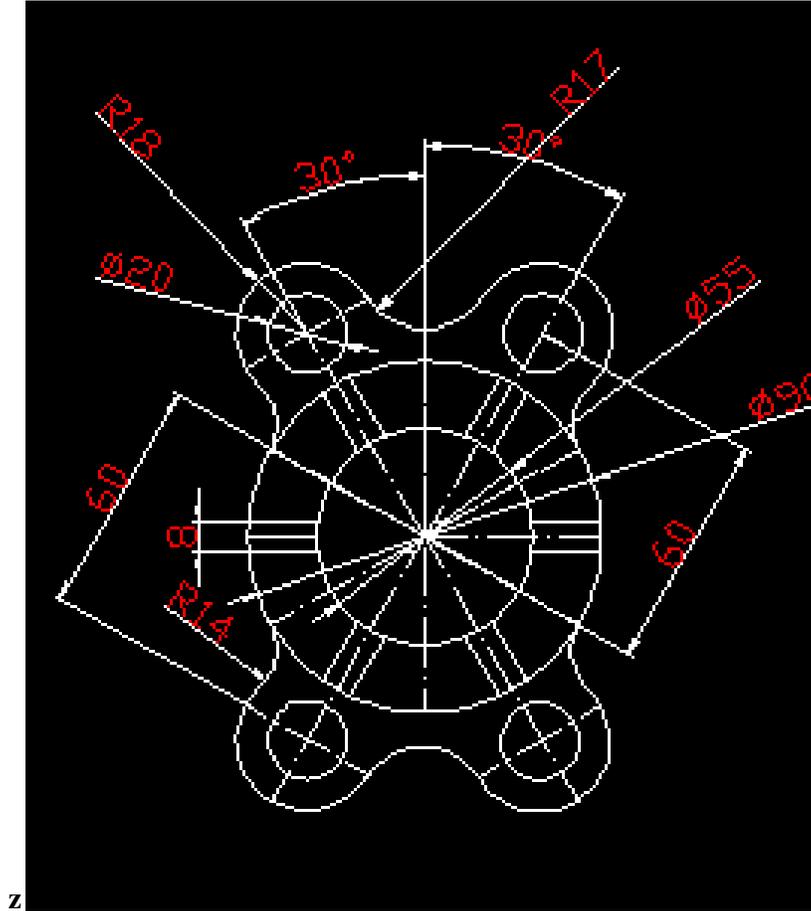
**PRACTICE FIGURE 1**

**PRACTICE FIGURE 2**

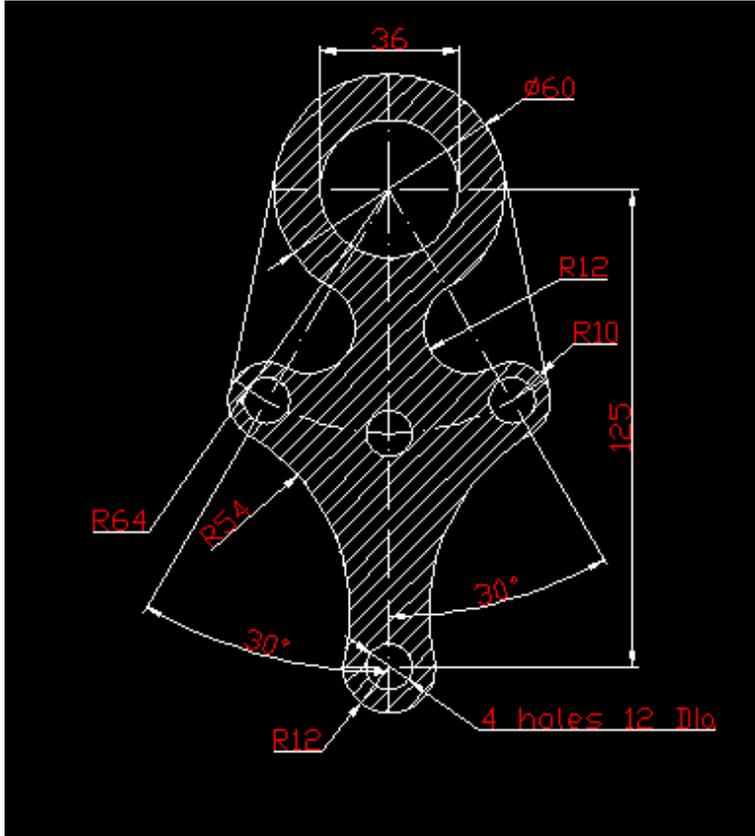
**DO THE HATCHING USING *HATCH* COMMAND IN THE DRAW TOOL BAR.**

**PRACTICE FIGURE 3**



**PRACTICE FIGURE 5**



**PRACTICE FIGURE 7**

## 4. ISOMETRIC DRAWINGS

For all isometric figures right click **GRID** in drafting tool bar <setting> change grid snap to **ISOMETRIC SNAP**. And check **ORTHO ON**

**F5 – TOGGLE KEY BETWEEN ISOPLANE TOP, ISOPLANE LEFT AND ISOPLANE RIGHT**

### FIGURE 1

Aim: to draw the following figure using ACAD

#### COMMANDS USED

Line, Dimensions, Drafting commands

#### PROCEDURE

<Ortho on> <Isoplane Top> <Osnap on>

**Command: \_line Specify first point:**

Specify next point or [Undo]: **104**

Specify next point or [Undo]:

**Command: \_qsave**

**Command: \_dimaligned**

Specify first extension line origin or <select object>:

Specify second extension line origin:

**Command: \_dimlinear**

Specify first extension line origin or <select object>:

Specify second extension line origin:

Specify dimension line location or [Mtext/Text/Angle/Horizontal/Vertical/Rotated]:

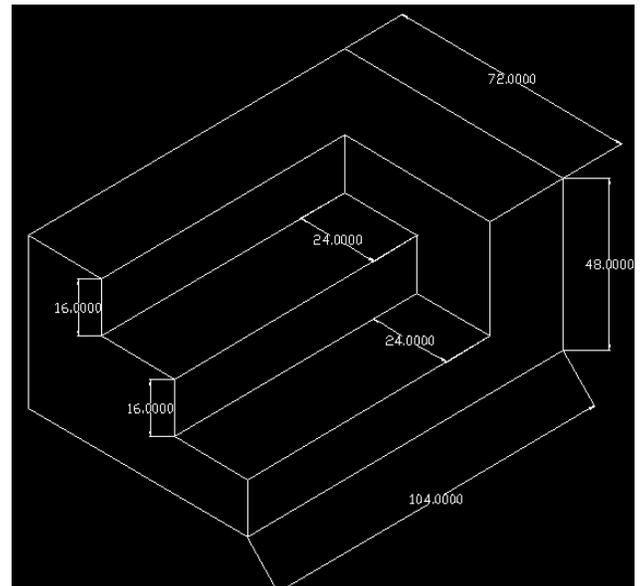
Dimension text = 48.0000

**Command: \_dimedit**

Enter type of dimension editing [Home/New/Rotate/Oblique] <Home>: **\_o**

Select objects: 1 found

Enter obliquing angle (press ENTER for none): **30**      **Command: \_qsave**



**FIGURE 2**

Aim: to draw the following figure using ACAD

**COMMANDS USED**

Line, Drafting commands, Dimension aligned, Dimension linear, Dimension oblique, Layers

**Command: \_line**

Specify first point: <Isoplane Left>

Specify next point or [Undo]: 12

Specify next point or [Undo]: <Isoplane Top> 25

**Command: \_qsave****Command: \_dimlinear**

Specify first extension line origin or <select object>:

Specify second extension line origin:

Specify dimension line location or [Mtext/Text/Angle/Horizontal/Vertical/Rotated]:

Dimension text = 12.0000

**Command: \_dimaligned**

Specify first extension line origin or <select object>:

Specify second extension line origin:

Specify dimension line location or [Mtext/Text/Angle]:

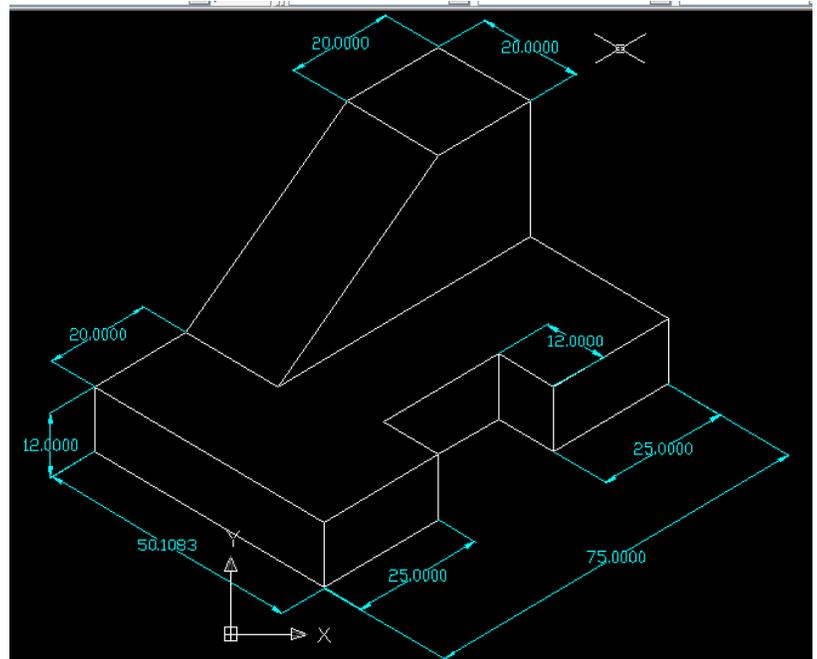
Dimension text = 25.0000

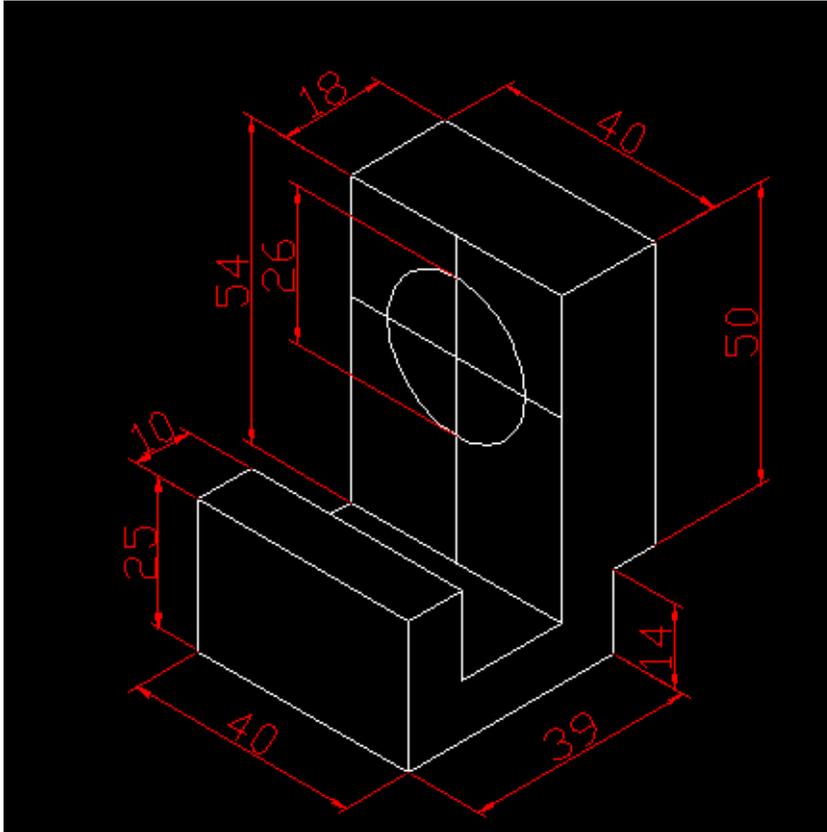
**Command: \_dimedit**

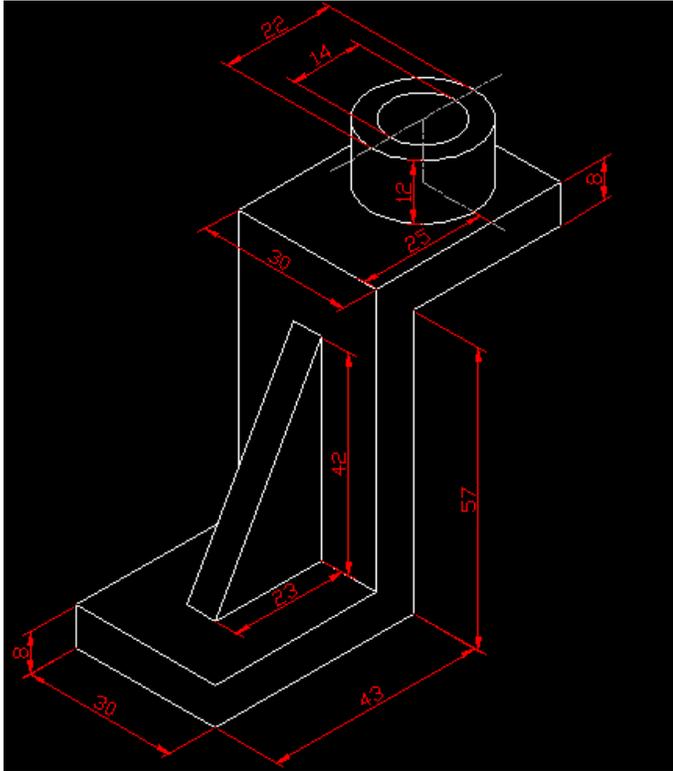
Enter type of dimension editing [Home/New/Rotate/Oblique] <Home>: **\_o**

Select objects: 1 found

Enter obliquing angle (press ENTER for none): **30 or -30** **Command: \_qsave**



**PRACTICE FIGURE 1**

**PRACTICE FIGURE 2**

***\*\*\*APART FROM THESE PRACTICE OTHER FIGURES GIVEN IN THE TEXT BOOK. THIS IMPROVES YOUR SKILL OF DRAWING***

# CAM

## Computer-aided manufacturing

**Computer-aided manufacturing (CAM)** is the use of computer-based software tools that assist engineers and machinists in manufacturing or prototyping product components. Its primary purpose is to create a faster production process and components with more precise dimensions and material consistency, which in some cases, uses only the required amount of raw material (thus minimizing waste), while simultaneously reducing energy consumption. CAM is a programming tool that makes it possible to manufacture physical models using computer-aided design (CAD) programs. CAM creates real life versions of components designed within a software package

## CNC Technology

Numerical Control (NC) is a software-based machine tool control technique developed at Massachusetts Institute of Technology (MIT) in early 1960s. It has now evolved into a mature technology known as Computer Numerical Control (CNC). Although major applications of CNC even today continue to be in machining, it finds applications in other processes such as sheet metal working, non-traditional machining and inspection. Robots and Rapid Prototyping machines are also CNC controlled. In fact, any process that can be visualized as a sequence of motions and switching functions can be controlled by CNC. These motions and switching functions are input in the form of alphanumeric instructions. CNC is the basis of flexible automation which helps industries cut down time-to-market and enables launch of even low volume products. Unlimited muscle power, unmanned operation, independent axes coordinated through software, simplified generic tooling even for the most complex jobs and accurate construction are some of the salient features of CNC.

## CNC Machining

Automats and Special Purpose Machines (SPMs) require special cams/ templates and clutch settings for each part. Manufacture of these cams/ templates is costly and slow.

Furthermore, changing over from one part to the other on these machines also consumes considerable time. The high cost and long time of these hard automated machines to produce parts can be justified only in mass production. With the advent of fast, rigid and accurate CNC machines and sophisticated CAM packages, generation of NC programs and change over from one product to the other are easy and fast as it does not require any mechanical change. These in conjunction with advanced cutting tools have made High Speed Cutting (HSC) of hard materials a reality. Therefore, CNC machining has become a standard means to produce dies and molds; tool makers today require EDM only for producing inaccessible regions, sharp corners, tiny features and desired surface quality. Intricate aerospace parts are realized through 5 axis CNC machining. Internet technology in a global village enables designing in one place, NC programming and verification in another place and actual machining in yet another place.

### Advantages of CNC

- Flexibility
- Accuracy
- Speed
- Simplified fixturing and generic cutting tools
- Storage of machining skill in NC programs
- Less skilled operators will do
- Less fatigue to the operators

## **G-codes**

**G-Code**, or preparatory code or function, are functions in the Numerical control programming language. The G-codes are the codes that position the tool and do the actual work, as opposed to M-codes, that manages the machine; T for tool-related codes. S and F are tool-Speed and tool-Feed, and finally D-codes for tool compensation. The programming language of Numerical Control (NC) is sometimes informally called **G-code**. But in actuality, G-codes are only a part of the NC-programming language that controls NC and CNC machine tools.

A basic list of 'G' operation codes is given below. These direct motion of the tool.

1. G00 - Rapid move (not cutting)
2. G01 - Linear move
3. G02 - Clockwise circular motion
4. G03 - Counterclockwise circular motion
5. G04 - Dwell
6. G05 - Pause (for operator intervention)
7. G08 - Acceleration
8. G09 - Deceleration
9. G17 - x-y plane for circular interpolation
10. G18 - z-x plane for circular interpolation
11. G19 - y-z plane for circular interpolation
12. G20 - turning cycle or inch data specification
13. G21 - thread cutting cycle or metric data specification
14. G24 - face turning cycle
15. G25 - wait for input #1 to go low (Prolight Mill)
16. G26 - wait for input #1 to go high (Prolight Mill)
17. G28 - return to reference point
18. G29 - return from reference point
19. G31 - Stop on input (INROB1 is high) (Prolight Mill)
20. G33-35 - thread cutting functions (Emco Lathe)
21. G35 - wait for input #2 to go low (Prolight Mill)
22. G36 - wait for input #2 to go high (Prolight Mill)
23. G40 - cutter compensation cancel
24. G41 - cutter compensation to the left
25. G42 - cutter compensation to the right
26. G43 - tool length compensation, positive
27. G44 - tool length compensation, negative
28. G50 - Preset position
29. G70 - set inch based units or finishing cycle
30. G71 - set metric units or stock removal
31. G72 - indicate finishing cycle (EMCO Lathe)
32. G72 - 3D circular interpolation clockwise (Prolight Mill)
33. G73 - turning cycle contour (EMCO Lathe)
34. G73 - 3D circular interpolation counter clockwise (Prolight Mill)
35. G74 - facing cycle contour (Emco Lathe)
36. G74.1 - disable 360 deg arcs (Prolight Mill)
37. G75 - pattern repeating (Emco Lathe)
38. G75.1 - enable 360 degree arcs (Prolight Mill)
39. G76 - deep hole drilling, cut cycle in z-axis
40. G77 - cut-in cycle in x-axis
41. G78 - multiple threading cycle
42. G80 - fixed cycle cancel
43. G81-89 - fixed cycles specified by machine tool manufacturers
44. G81 - drilling cycle (Prolight Mill)

45. G82 - straight drilling cycle with dwell (Prolight Mill)
46. G83 - drilling cycle (EMCO Lathe)
47. G83 - peck drilling cycle (Prolight Mill)
48. G84 - tapping cycle (EMCO Lathe)
49. G85 - reaming cycle (EMCO Lathe)
50. G85 - boring cycle (Prolight mill)
51. G86 - boring with spindle off and dwell cycle (Prolight Mill)
52. G89 - boring cycle with dwell (Prolight Mill)
53. G90 - absolute dimension program
54. G91 - incremental dimensions
55. G92 - Spindle speed limit
56. G93 - Coordinate system setting
57. G94 - Feed rate in ipm (EMCO Lathe)
58. G95 - Feed rate in ipr (EMCO Lathe)
59. G96 - Surface cutting speed (EMCO Lathe)
60. G97 - Rotational speed rpm (EMCO Lathe)
61. G98 - withdraw the tool to the starting point or feed per minute
62. G99 - withdraw the tool to a safe plane or feed per revolution
63. G101 - Spline interpolation (Prolight Mill)

## M-Codes

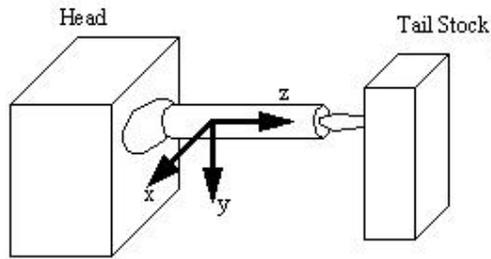
M-Codes control machine functions and these include,

1. M00 - program stop
2. M01 - optional stop using stop button
3. M02 - end of program
4. M03 - spindle on CW
5. M04 - spindle on CCW
6. M05 - spindle off
7. M06 - tool change
8. M07 - flood with coolant
9. M08 - mist with coolant
10. M08 - turn on accessory #1 (120VAC outlet) (Prolight Mill)
11. M09 - coolant off
12. M09 - turn off accessory #1 (120VAC outlet) (Prolight Mill)
13. M10 - turn on accessory #2 (120VAC outlet) (Prolight Mill)
14. M11 - turn off accessory #2 (120VAC outlet) (Prolight Mill) or tool change
15. M17 - subroutine end
16. M20 - tailstock back (EMCO Lathe)
17. M20 - Chain to next program (Prolight Mill)
18. M21 - tailstock forward (EMCO Lathe)
19. M22 - Write current position to data file (Prolight Mill)
20. M25 - open chuck (EMCO Lathe)
21. M25 - set output #1 off (Prolight Mill)
22. M26 - close chuck (EMCO Lathe)

23. M26 - set output #1 on (Prolight Mill)
24. M30 - end of tape (rewind)
25. M35 - set output #2 off (Prolight Mill)
26. M36 - set output #2 on (Prolight Mill)
27. M38 - put stepper motors on low power standby (Prolight Mill)
28. M47 - restart a program continuously, or a fixed number of times (Prolight Mill)
29. M71 - puff blowing on (EMCO Lathe)
30. M72 - puff blowing off (EMCO Lathe)
31. M96 - compensate for rounded external curves
32. M97 - compensate for sharp external curves
33. M98 - subprogram call
34. M99 - return from subprogram, jump instruction
35. M101 - move x-axis home (Prolight Mill)
36. M102 - move y-axis home (Prolight Mill)
37. M103 - move z-axis home (Prolight Mill)

## CNC PROGRAMMING

- The coordinates are almost exclusively cartesian and the origin is on the workpiece.
- For a lathe, the infeed/radial axis is the x-axis, the carriage/length axis is the z-axis. There is no need for a y-axis because the tool moves in a plane through the rotational center of the work. Coordinates on the work piece shown below are relative to the work.



WARNING: Be cautious, the x axis is intuitively the radius of the workpiece. But, many systems use the dimension as a diameter. Make sure you know what the coordinate values are for.

### CNC lathe / CNC turning center



CNC lathes are rapidly replacing the older production lathes (multispindle, etc) due to their ease of setting and operation. They are designed to use modern carbide tooling and fully utilize modern processes. The part may be designed and the tool paths programmed by the CAD/CAM process, and the resulting file uploaded to the machine, and once set and trailed the machine will continue to turn out parts under the occasional supervision of an operator. The machine is controlled electronically via a computer menu style interface; the program may be modified and displayed at the machine, along with a simulated view of the process. The setter/operator needs a high level of skill to perform the process, however the knowledge base is broader compared to the older production machines where intimate knowledge of each machine was considered essential. These machines are often set and operated by the same person, where the operator will supervise a small number of machines (cell).

## PLAIN TURNING AND FACING OPERATION

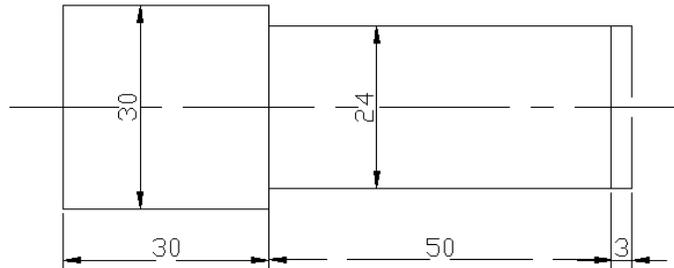
### AIM:

To write the part program for component shown in **Fig. 01**. Assuming the work piece is Aluminum and the speed is 1200 rpm, feed 20 mm/min and maximum depth of cut is 1 mm.

- a. With Canned cycle
- b. Without Canned cycle.

**MATERIAL REQUIRED:** Aluminum Rod of 30 mm diameter and 80 mm length.

### PART DRAWING:



**FIGURE: 01**

### PART PROGRAM:

#### **(A) WITH CANNED CYCLE**

```

N 00      G 21  G 90                      <EOB>
N 01      M 03  S 1200                    <EOB>
N 02      G 00  X 30  Z 0                  <EOB>
N 03      G 71  Z -3  X 0  I 1  F 20      <EOB>
N 04      G 00  X 30  Z 0                  <EOB>
N 05      G 72  X 24  Z -50  I 1  F 20    <EOB>
N 06      G 00  X 50  Z 10                 <EOB>
N 07      M 30                             <EOB>

```

**(B) WITHOUT CANNED CYCLE**

```
N 00      G 21  G 90                      <EOB>
N 01      M 03  S 1200                    <EOB>
N 02      G 00  X 30  Z 1                  <EOB>
N 03      G 01  Z -1      F 20            <EOB>
N 04      G 01  X 00      F 20            <EOB>
N 05      G 00  X 30  Z 00                  <EOB>
N 06      G 01  Z -2      F 20            <EOB>
N 07      G 01  X 00      F 20            <EOB>
N 08      G 00  X 30  Z 00                  <EOB>
N 09      G 01  Z -3      F 20            <EOB>
N 10      G 01  X 00      F 20            <EOB>
N 11      G 00  X 30  Z 00                  <EOB>
N 12      G 01  Z -50     F 20            <EOB>
N 13      G 01  X 28     F 20            <EOB>
N 14      G 00  X 30  Z 00                  <EOB>
N 15      G 01  Z -50     F 20            <EOB>
N 16      G 01  X 26     F 20            <EOB>
N 17      G 00  X 30  Z 00                  <EOB>
N 18      G 01  Z -50     F 20            <EOB>
N 19      G 01  X 24     F 20            <EOB>
N 20      G 00  X 50  Z 10                  <EOB>
N 21      M 30                      <EOB>
```

**RESULT:**

The program is written and simulated and stored in System No...and file name as...

## STEP TURNING OPERATION

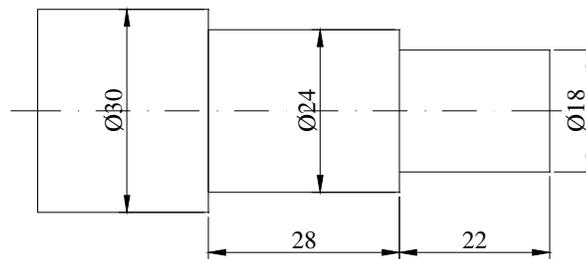
### AIM:

To write the part program for the component shown in fig 2. assuming work piece as AL the speed is 1200rpm, feed given is 20mm/min.

- (a) Without canned cycle
- (b) With canned cycle.

**MATERIAL REQUIRED:** Aluminum Rod of 30 mm diameter and 80 mm length.

### PART DRAWING:



### PART PROGRAM: (A) WITHOUT CANNED CYCLE

```

N 00    G 21  G 90          <EOB>
N 01    M 03  S 1200       <EOB>
N 02    G 04  X 02        <EOB>
N 03    G 00  X 30  Z 00   <EOB>
N 04    G 01  Z -50  F 20  <EOB>
N 05    G 00  X 30  Z 00   <EOB>
N 06    G 01  X 26  F 20  <EOB>
N 07    G 01  Z -50  F 20  <EOB>
N 08    G 00  X 30  Z 00   <EOB>
N 09    G 01  X 24  F 20  <EOB>
N 10    G 01  Z -50  F 20  <EOB>
N 11    G 00  X 30  Z 00   <EOB>
N 12    G 01  X 22  F 20  <EOB>

```

```
N 13      G 01  Z -22  F 20  <EOB>
N 14      G 00  X 30  Z 00  <EOB>
N 15      G 01  X 20  F 20  <EOB>
N 16      G 01  Z -22  F 20  <EOB>
N 17      G 00  X 30  Z 00  <EOB>
N 19      G 00  X 50  Z 10  <EOB>
N 20      M 30                      <EOB>
```

**( B ) WITH CANNED CYCLE:**

```
N 00      G 21  G 90                      <EOB>
N 01      M 03  S 1200                    <EOB>
N 02      G 04  X 03                      <EOB>
N 03      G 00  X 30  Z 00                <EOB>
N 04      G 72  X 24  Z -50  I 01  F 20  <EOB>
N 05      G 72  X 20  Z -22  I 01  F20  <EOB>
N 06      G 00  X 30  Z 00                <EOB>
N 08      X 50  Z 10                      <EOB>
N 09      M 30                          <EOB>
```

**RESULT:**

The program is written and simulated and stored in System No...and file name as...

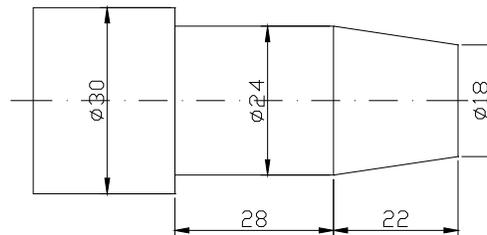
## PATTERN REPEATED CYCLE

### AIM:

To write the part program for the component shown in **Fig. 3**. Assuming work piece is Aluminum and the speed is 1200 rpm, feed given is 20 mm/min, using pattern repeated cycle.

**MATERIAL REQUIRED:** Aluminum Rod of 30 mm diameter and 80 mm length.

### PART DRAWING:



**FIGURE. 3.**

### PART PROGRAM:

```

N 00      G 21  G 90                <EOB>
N 01      M 03  S 1200              <EOB>
N 02      G 04  X 04                <EOB>
N 03      G 00  X 30  Z 00          <EOB>
N 04      G 73  P 05  Q 09  I 01   <EOB>
N 05      G 01  X 18  F 20          <EOB>
N 06      G 01  X 24  Z -22  F 20   <EOB>
N 07      G 01  Z -50  F 20        <EOB>
N 08      G 00  X 30                <EOB>
N 09      G 00  Z 00                <EOB>
N 10      G 00  X 50  Z 05          <EOB>
N 11      M 30                      <EOB>

```

**RESULT:** The program is written and simulated and stored in System No...and file name as...

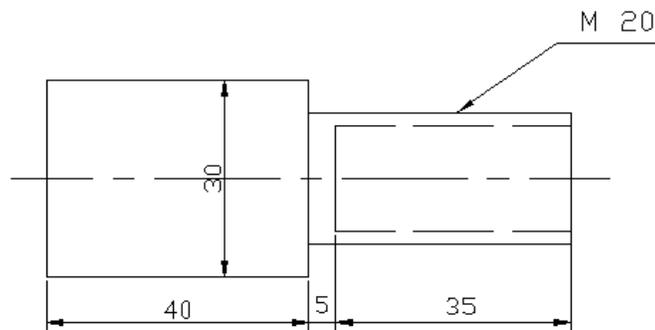
## THREAD CUTTING

### AIM:

To write the part programming for the component shown in **Fig 4**. Assuming work piece as Aluminum and the turning speed is 1200 rpm and feed is 20 mm / min and the depth of cut is 1 mm. For thread cutting reduce the speed to half of the turning speed and pitch is 0.1mm.

**MATERIAL REQUIRED:** Aluminum Rod of 30 mm diameter and 80 mm length.

### PART DRAWING:



**FIGURE.4.**

### PART PROGRAMME:

```

N 00      G 21  G 90                <EOB>
N 01      M 03  S 1200              <EOB>
N 02      G 00  X 30  Z 00          <EOB>
N 03      G 01  Z -01  F 20         <EOB>
N 04      G 01  X 00  F 20         <EOB>
N 05      G 00  X 30  Z 00          <EOB>
N 06      G 72  X 20  Z -40  I 01  F 20  <EOB>
N 07      G 00  X 30  Z 05          <EOB>
N 08      M 05                      <EOB>
N 09      T 0202                    <EOB>
N 09      M 03  S 600              <EOB>

```

```
N 10      G 04 X 02                <EOB>
N 11      G 01 X 20 Z 00 F 20      <EOB>
N 12      G 93 (or) 92 X 20 Z -35 I 0.1 F 01 <EOB>
N 13      G 00 X 30 Z 01          <EOB>
N 14      M 30                    <EOB>
```

**RESULT:**

The program is written and simulated and stored in System No...and file name as...

## CIRCULAR INTER POLATION

### AIM:

To write the part programming for the figure shown in **Fig.5**. speed is 1200 rpm, feed is 20 mm / min. Assuming work piece as Aluminium.

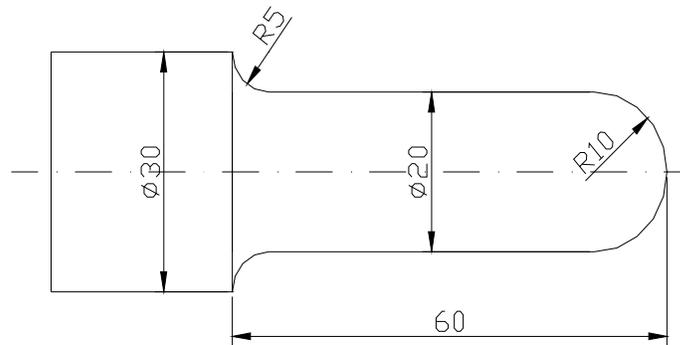
**MATERIAL REQUIRED:** Aluminum Rod of 30 mm diameter and 80 mm length.

### THEORY:

Circular interpolation is used to simplify the programming of arcs and circles. It required of four bits of information those are.

- The direction of cutter travel (G02 for cw and G03 is for CCW)
- Start point for arc ( $x_s, z_s$ ) for lathe and ( $x_s, y_s$ ) for milling
- Center of arc ( $x_1, z_1$ ) for lathe and ( $x_1, y_1$ ) for milling machine
- The final point of the arc except for ( $x_f, z_f$ ) for lathe and ( $x_f, y_f$ ) for milling.

### PART DRAWING:



**FIGURE.5.**

### PART PROGRAM:

```

N 00 G 21 G 90 <EOB>
N 01 M 03 S 1200 <EOB>
N 02 G 04 X 04 <EOB>
N 03 G 00 X 30 Z 00 <EOB>
N 04 G 72 X 20 Z -55 I 01 F 20 <EOB>
N 05 G 00 X 30 Z 00 <EOB>
N 06 G 00 X 20 Z 00 <EOB>
N 07 G 01 X 18 F 20 <EOB>

```

N 08 G 02 X 20 Z -01 K -1 I 0 F 20 <EOB>  
N 09 G 00 Z 00 <EOB>  
N 10 G 01 X 16 F 20 <EOB>  
N 11 G 02 X 20 Z -02 K -2 I 0 F 20 <EOB>  
N 12 G 00 Z 00 <EOB>  
N 13 G 01 X 14 F 20 <EOB>  
N 14 G 02 X 20 Z -03 K -3 I 0 F 20 <EOB>  
N 15 G 00 Z 00 <EOB>  
N 16 G 01 X 12 F 20 <EOB>  
N 17 G 02 X 20 Z -04 K -4 I 0 F 20 <EOB>  
N 18 G 00 Z 00 <EOB>  
N 19 G 01 X 10 F 20 <EOB>  
N 20 G 02 X 20 Z -5 K -5 I 0 F 20 <EOB>  
N 21 G 00 Z 00 <EOB>  
N 22 G 01 X 8 F 20 <EOB>  
N 23 G02 X20 Z-6 K-6 I0 F20 <EOB>  
N 24 G00 Z 00 <EOB>  
N 25 G 01 X 6 F 20 <EOB>  
N 26 G 02 X 20 Z -7 K -7 I 0 F 20 <EOB>  
N 27 G 00 Z 00 <EOB>  
N 28 G 01 X 4 F 20 <EOB>  
N 29 G 02 X 30 Z -8 K-8 I 0 F 20 <EOB>  
N 30 G 00 Z 00 <EOB>  
N 31 G 01 X 2 F 20 <EOB>  
N 32 G 02 X 20 Z -9 K -9 I 0 F 20 <EOB>  
N 33 G 00 Z 00 <EOB>  
N 34 G 01 X 0 F 20 <EOB>  
N 35 G 02 X 20 Z -10 K -10 I 0 F 20 <EOB>  
N 36 G 01 Z -31 F 20 <EOB>  
N 37 G 01 X 28 F 20 <EOB>

```
N 38 G 03 X 30 Z -32 K 0 I 2 F 20 <EOB>
N 39 G 00 Z -31 <EOB>
N 40 G 01 X 26 F 20 <EOB>
N 41 G 03 X 30 Z-33 K 0 I 4 F 20 >EOB>
N 42 G 00 Z -31 <EOB>
N 43 G 01 X 24 F 20 <EOB>
N 44 G 03 X 30 Z -34 K 0 I 6 F 20 <EOB>
N 45 G 00 Z -31 <EOB>
N 46 G 01 X 22 F 20 <EOB>
N 47 G 03 X 30 Z -35 K 0 I 8 F 20 <EOB>
N 48 G 00 Z -31 <EOB>
N 49 G 01 X 20 F 20 <EOB>
N 50 G 03 X 30 Z -36 K 0 I 10 F 20 <EOB>
N 51 G 00 X 35 Z 10 <EOB>
N 52 M 30 <EOB>
```

**RESULT:**

The program is written and simulated and stored in System No...and file name as...

**MALLA REDDY  
COLLEGE OF ENGINEERING & TECHNOLOGY  
(AUTONOMOUS)**

**DEPARTMENT OF MECHANICAL ENGINEERING**

**LABORATORY MANUAL**

***INSTRUMENTATION & CONTROL SYSTEMS LAB***

**B.TECH IV YEAR - I SEMESTER  
(2016-2017)**

CONTENTS

<b>SI No.</b>	<b>EQUIPMENT</b>	<b>Page No.</b>
<b>1</b>	<b>CALIBRATION OF PRESSURE CELL</b>	<b>3 – 5</b>
<b>2</b>	<b>CALIBRATION OF LVDT</b>	<b>6 – 8</b>
<b>3</b>	<b>CALIBRATION OF STRAIN GAUGE</b>	<b>9 – 13</b>
<b>4</b>	<b>ANGULAR DISPLACEMENT BY CAPACITIVE TRANSDUCER</b>	<b>14 – 16</b>
<b>5</b>	<b>SPEED MEASUREMENT</b>	<b>17 – 19</b>
<b>6</b>	<b>CALIBRATION OF McLEOD GAUGE</b>	<b>20 – 22</b>
<b>7</b>	<b>CALIBRATION OF TEMPERATURE TRANSDUCER</b>	<b>23 – 26</b>

## CALIBRATION OF PRESSURE CELL.

### AIM:

Calibrate the given Pressure Cell with Pressure Guage for its performance

### APPARATUS REQUIRED :

Pressure cell

Hydraulic dead weight Pressure gauge Tester to develop the pressure

Digital pressure indicator

Dial type pressure indicator

### THEORY BEHIND:

Pressure is defined as force per unit area and is measured in Newton per square meter (Pascal) or in terms of an equivalent head of some standard liquid.

Thus a pressure gauge is connected to the hydraulic line and the gauge itself stands in atmospheric pressure.

Pressure transducer is basically an electro mechanical devices, especially manufactured and designed or wide range application in pressure measurement.

The pressure transducer comprises of diaphragm and an inputs to facilitate pressure measurement. The strain gauges are bonded directly to the sensing member to provide excellent linearity, low hysteresis and repeatability.

Fluid medium whose parameter has to be measured is allowed to deflect the diaphragm(sensing member), which is a single block material and forms an integral part of the pressure transducer.

Usually the Pressure Transducers are made up non-magnetic stainless steel and thus has the advantage of avoids the yielding effects and leakage problems. The slight deflection of the diaphragms due to the pressure provides an electrical output.

The material most commonly used for manufacture of diaphragms are steel, phosphor bronze, nickel silver and beryllium copper. The deflection generally follows a linear variation with the diaphragm thickness.

**PANEL DETIALS:**

**MAINS ON INDICATOR :** To indicate the Power given to the system.

**CONSOLE ON SWITCH :** Provided to activate the system.

**PRESSURE INDICATOR :** To indicate the Pressure in digital format with Zero knob facility.

**SOFTWARE :** FACILITATES TO DO THINGS IN COMPUTER FORMAT.

**PREPARATION OF EQUIPMENT:**

1. Connect the pressure cell to the pressure indicator given cable.
2. Connect the instrument to 1ph, 230V AC supply which is having proper earthing.
3. Adjust the zero pot of the indicator to indicate zero.
4. Close the release valve of pressure gauge tester and apply the 10kg dead weight on flange.

**LIMITATIONS**

1. Range of Pressure Cell ---- Max.  $10\text{kg}/\text{cm}^2$

**PROCEDURE:**

1. Slowly rotate the screw rod in clockwise direction with the help of handle until flange lift up (so that pressure is developed up to applied load). Now observed the digital reading. If it is not showing zero then make it zero by rotating ZERO knob. Now instrument is calibrated.
2. Apply the load up to 10Kgs ONE by ONE on the flange and give pressure by rotating the screw rod SUCH THAT THE DIAL GAUGE READS 1 to 10 with respect to load applied.
3. Note down the readings of dial gauge and pressure indicator, simultaneously in every step.
4. Calculate the error if any and % error.

**TABULATIONS:**

Sl. No	Pressure in Dial gauge, $P_c$ kg / cm <sup>2</sup>	Pressure in Digital indicator, $P_g$ kg / cm <sup>2</sup>	Correction $P_c - P_g$	Error $P_g - P_c$	% Error $(P_g - P_c) / P_g$ *100

**CONCLUSIONS OF THE RESULTS TABULATED:**

Summarizing the entire operation

Describing the possible error factors

Techniques which can be adopted to minimize the errors in all aspects i.e, from startup to end.

## CALIBRATION OF LVDT.

### AIM:

Calibrate **Linear Variable Differential Transformer (LVDT)** for the performance using Micrometer.

### APPARATUS REQUIRED :

LVDT

Digital LVDT indicator

MICROMETER

### THEORY BEHIND:

LVDT is an inductive transducer used to translate the linear motion into electrical signal LVDT consists of a single primary winding 'P' and two secondary windings (S1 & S2) winds on a cylindrical armature. An AC source is connected to the primary winding. A movable soft iron core attached with an arm placed inside the armature.

The primary winding produces an alternating magnetic field which induces alternating voltage in the secondary windings. Single voltage is obtained by connecting the two secondary windings in series. Thus the output voltage of the transducer is the difference of the two voltages.

When the core is at null position, the flux linking with both the secondary windings is equal. Since both the secondary winding have equal number of turns, M the induced emf is same in them. The output voltage is the difference of the two emf say  $e_1$  &  $E_2$ . When they are equal, the voltage is zero at null position.

When the core is moved to the left side from null position more flux links with S1. The output voltage is  $V=E_2-E_1$ , is greater, the V value is -ve. Means the voltage is read in terms of mm length on the display board indicates the negative value. When the core is moved to the right side of the null position, more flux links with S2 induces voltages which is +ve. The display board indicates the +ve value in mm of length.

The voltage output is linear and is depending on the position of the core. Hence LVDT can be conveniently used to measure the thickness ranging from fraction of a mm to a few cm's. normally LVDT can give better result up to 5mm.

**PANEL DETAILS:**

**MAINS ON INDICATOR :** To indicate the Power given to the system.

**CONSOLE ON SWITCH :** Provided to activate the system.

**LVDT INDICATOR :** To indicate the Distance moved.

**SOFTWARE :** FACILITATES TO DO THINGS IN COMPUTER FORMAT.

**PREPARATION OF EQUIPMENT:**

1. Make the Micrometer to Read 10mm on the scale.(ZERO POSITION of LVDT)
2. Connect the instrument to 1ph, 230V AC supply which is having proper earthing.

**LIMITATIONS**

Range of Pressure LVDT : -10mm to +10mm

**PROCEDURE:**

1. Slowly rotate the screw head of the Micrometer Either Clockwise or Anticlockwise to measure 1mm on it.
2. Note the Reading on the LVDT indicator
3. Repeat step 1 and step 2 until 10mm on either side.
4. Note down the readings of Micrometer, simultaneously in every step.
5. Calculate the error if any and % error.

Note: Clockwise will give readings in -ve direction and Anticlockwise will give in +ve direction.

**TABULATIONS:**

Sl. no	Actual Reading, 'R <sub>a</sub> ' mm	Measured Reading, 'R <sub>m</sub> ' mm	Error 'E'	% Error

**CONCLUSIONS OF THE RESULTS TABULATED:**

Summarizing the entire operation

Describing the possible error factors

Graph Plotting

Techniques which can be adopted to minimize the errors in all aspects i.e, from startup to end.

## CALIBRATION OF STRAIN GAUGE.

### AIM:

To determine the elastic constant (modulus of elasticity) of a **Cantilever beam** subjected to concentrated end load by using **STRAIN GAUGES**.

### APPARATUS REQUIRED :

LOAD CELL with Strain Guage

Digital Strain indicator

Weights

### THEORY BEHIND:

A body subjected to external forces is in a condition of both stress and strain. Stress can be directly measured but its effect. i.e. change of shape of the body can be measured. If there is a relationship between stress and strain, stresses occurring in a body can be computed if sufficient strain information is available. The constant connecting the stress and strain in elastic material under the direct stresses is the modulus of elasticity,

$$\text{i.e. } E = \sigma / \epsilon$$

the principle of the electrical resistance strain gauge was discovered by Lord Kelvin, when he observed that a stress applied to a metal wire, besides changing resistance strain gauges are made into two basic forms, bonded wire and bonded foil. Wire gauges are sandwiched between two sheets thin paper and foil gauges are sandwiched between two thin sheets of epoxy.

The resistance factor 'R' of a metal depends on its electrical resistivity,  $\rho$ , its area,  $a$  and the length  $l$ , according to the equation  $R = \rho l / a$ .

Thus to obtain a high resistance gauge occupying a small area, the metal chosen has a high resistivity, a large number of grid loops and a very small cross sectional area. The most common material for strain gauge is a copper - nickel alloy known as Advance.

The strain gauge is connected to the material in which it is required to measure the strain, with a thin coat of adhesive. Most common adhesive used is Eastman, Deco Cement, etc. as the test specimens extends or contracts under stress in the direction of windings, the length and cross sectional area of the conductor alter, resulting in a corresponding increase or decrease in electrical resistance.

### GAUGE FACTOR:

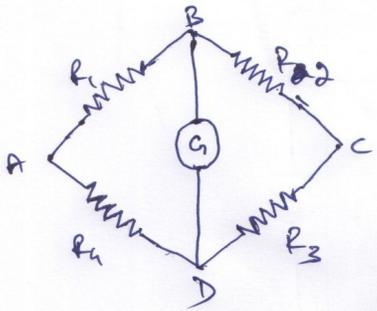
The dimension less relationship between the change in gauge resistance and change in length is called Gauge factor of the strain, which is expressed mathematically,

$$\text{Gauge Factor, } \delta g = (\Delta R/R) / (\Delta l/l)$$

In this relationship R and l represent, respectively the initial resistance and initial length of the strain gauge filament, while  $\Delta R$  &  $\Delta l$  represents the small change in resistance and length, which occurs as the gauge is strained along with the surface to which it is bonded. This gauge factor of a gauge is a measure of the amount of resistance change for a given strain. The higher the gauge factor greater the electrical output for indication or recording purpose. The gauge factor is supplied by the manufacturer and may range from 1.7 to 4.

The usual method of measuring the change of resistance in a gauge element is by means of Wheatstone bridge as shown in figure. It consists of Galvanometer, 4 resistor & a battery. Resistance  $R_1$  is the strain gauge is used for strain measurement, which is mounted on the specimen. The three resistors  $R_2$ ,  $R_3$  and  $R_4$  are internal to the device.

Let us assume that the resistance have been adjusted so that the bridge is balanced.



i.e. Voltage  $E_{bd} = 0$ .

The most common bridge arrangements are single arm, two arm and four arm mode.

### **Single Arm Mode (Quarter bridge).**

This bridge arrangement consists of a single active gauge in position, say  $R_1$  and three resistor are internal to the device. Temperature compensation is possible only if a self temperature compensating strain gauge is used.

### **Two Arm Mode ( Half bridge).**

In this mode, two resistor are internal to the device and the remaining two are strain gauges. One arm of this bridge is commonly labeled as active arm and the other as compensating arm. The bridge is temperature compensated.

### **Four Arm Mode (Full Bridge).**

In this bridge arrangement, four active gauges are placed in the bridge with one gauge in each of the four arms. If the gauges are placed on a beam in bending as shown in fig of the elastic constant by bending test experiment, the single from each of the four gauges will add. This bridge arrangement is temperature compensated.

**PANEL DETAILS:**

**MAINS ON INDICATOR :** To indicate the Power given to the system.

**CONSOLE ON SWITCH :** Provided to activate the system.

**STRAIN INDICATOR :** To indicate the Distance moved.

**SOFTWARE :** FACILITATES TO DO THINGS IN COMPUTER FORMAT.

**PREPARATION OF EQUIPMENT:**

1. Connect the instrument to 1ph, 230V AC supply which is having proper earthing.
2. Switch on the Console
3. Select the BRIDGE Mode
4. Connect the Strain wires accordingly in the table below

Sl. No	Bridge Mode	Color	No of Wires	Connect To
1	Quarter	ORANGE	2	A & B
2	Half	ORANGE	2	A & B
		GREEN	2	B & C
3	FULL	WHITE	2	A & D
		ORANGE	2	A & B
		GREEN	2	B & C
		BLACK	2	C & D

6. Make the Indicator to Read Zero.(ZERO POSITION )
7. Prepare the Loads to be added

**LIMITATIONS**

Range of Load cell : 10kg

**PROCEDURE:**

1. For the Bridge selected and connected wires, slowly add the Weights in steps of 1kg.
2. Note the Reading on the Strain indicator
3. Repeat step 1 and step 2 until 10kg is loaded.
4. Note down the weights added , simultaneously in every step.
5. Calculate the error if any and % error
6. Modulus of Elasticity of the given load cell.

**TABULATIONS:**

Sl. No	Load Applied W (N)		Strain Indicator Reading ε – micro strain	Measured Strain $\epsilon_m = \epsilon * 10^{-6} /$ No. of Bridge	Bending stress. $\sigma = 6wl / bh^2$	Modulus of elasticity. $E = \sigma / \epsilon_m$ (N/nm <sup>2</sup> )
	W	N				

**CONCLUSIONS OF THE RESULTS TABULATED:**

Summarizing the entire operation

Describing the possible error factors

Graph Plotting

Techniques which can be adopted to minimize the errors in all aspects i.e, from startup to end.

**MEASUREMENT OF ANGULAR DISPLACEMENT.**

**AIM:** Measurement of angular displacement using capacitive transducer.

**APPARATUS REQUIRED :**

CAPACITIVE ANGULAR DISPLACEMENT CELL

Digital ANGULAR indicator

STEPPER MOTOR ASSEMBLY with Controller

**THEORY BEHIND:**

Capacitance is well known to be a function of effective area of the conductors, separation between them, the dielectric strength of the material in the separation. Capacitive transducers convert the physical quantity to be measured into a change of capacitance which is processed by the measuring circuit of the transducer. The capacitance of a parallel plate capacitor may be changed by varying the separation between the plates, varying the effective area of the plates or varying the dielectric.

Capacitive type transducers are used essentially for displacement or positioning measurements. But they are more susceptible to environmental factors such as dust or moisture in the atmosphere than inductive type transducers.

The meshing area between two stator and rotor plates of the capacitor goes on changing as the shaft capacitor is rotated. The arrangement is used to demonstrate the measurement of angular displacement.

The transducer is mounted on to the face of a protractor which indicates the angle of displacement and the readout display the amount of displacement.

**PANEL DETIALS:**

**MAINS ON INDICATOR :** To indicate the Power given to the system.

**CONSOLE ON SWITCH :** Provided to activate the system.

**ANGULAR INDICATOR :** To indicate the Distance moved.

**STARTER :** To Start the Motor and to Select the Mode of Operation

**INCREMENTAL :** To Give Step input to the Motor according to mode selected.

**SOFTWARE :** FACILITATES TO DO THINGS IN COMPUTER FORMAT.

**PREPARATION OF EQUIPMENT:**

1. Connect the instrument to 1ph, 230V AC supply which is having proper earthing
2. Press the STARTER switch and select MANUAL MODE.
3. Set ZERO position on the Manual Indicator by pressing the INCREMENTAL Button.

**LIMITATIONS**

1. Range of ANGULAR DISPLACEMENT : Upto 360deg
2. In AUTO Mode the Incremental will be in steps of 22.5deg.

**PROCEDURE:**

1. After the Preparation of equipment, Now press the INCREMENTAL button so the stepper motor sets accordingly with the selected mode of previously.
2. Note the Reading on the Angular Displacement indicator
3. Repeat step 1 and step 2 until required.
4. Note down the readings of Manual Angular, simultaneously in every step.
5. Calculate the error if any and % error.

Note: Rotation will be in Clockwise direction only.

**TABULATIONS:**

Sl. no	The displacement protractor reading	Measured displacement meter reading	Deviation

**CONCLUSIONS OF THE RESULTS TABULATED:**

Summarizing the entire operation

Describing the possible error factors

Graph Plotting

Techniques which can be adopted to minimize the errors in all aspects i.e, from startup to end.

**CALIBRATION OF PHOTO SPEED SENSOR.****AIM:**

Calibrate **PHOTO SPEED SENSOR** for the performance using **MAGNETIC Speed Sensor**.

**APPARATUS REQUIRED :**

PHOTO & MAGNETIC SPEED SENSORS

Digital SPEED indicators

MOTOR with Controller.

**THEORY BEHIND:**

The measurement of rotational velocity is more common. For velocity (speed) measurement the most convenient calibrator scheme uses a combination of toothed wheel, a simple magnetic proximity pickup a photo couple sensor and an electronic indicator to measure the speed. The angular rotation is provided by some adjustable speed drive of adequate stability. The toothed wheel mounted with iron rods while passing under magnetic and photo pickup produces an electric pulse. These pulses are fed to signal conditioner unit and displays reading visually. The stability of the rotational drive is easily checked by observing the variation of display reading.

**PANEL DETIALS:**

**MAINS ON INDICATOR :** To indicate the Power given to the system.

**CONSOLE ON SWITCH :** Provided to activate the system.

**SPEED INDICATORS :** To indicate the SPEED.

**MOTOR CONTROLLER :** To run the motor at various speeds.

**SOFTWARE :** FACILITATES TO DO THINGS IN COMPUTER FORMAT.

**PREPARATION OF EQUIPMENT:**

1. Keep the Speed controller knob in minimum position.
2. Connect the instrument to 1ph, 230V AC supply which is having proper earthing.
3. Switch on the Console to activate the panel.

**LIMITATIONS**

Maximum RPM : 2500rpm

**PROCEDURE:**

1. Once the equipment is prepared, slowly rotate the Speed controller to set the speed desired in range.
2. Note the Reading on the PHOTO SENSOR PICKUP Indicator
3. Repeat step 1 and step 2 until required within the range.
5. Note down the readings of MAGNETIC PICKUP, simultaneously in every step.
6. Calculate the error if any and % error.

Note: Clockwise to increase the speed and Anticlockwise to reduce the speed.

**TABULATIONS:**

Sl. no	Actual Reading, 'R <sub>a</sub> ' mm	Measured Reading, 'R <sub>m</sub> ' mm	Error $E = (R_a - R_m)$	% Error $\{(R_a - R_m)/R_a\} * 100$

**CONCLUSIONS OF THE RESULTS TABULATED:**

Summarizing the entire operation

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Graph Plotting

Techniques which can be adopted to minimize the errors in all aspects i.e, from startup to end.

**CALIBRATION OF McLEOD GAUGE.****AIM:**

Calibrate the Vacuum Cell (McLeod Gauge) in comparison with Vacuum Dial Gauge.

**APPARATUS REQUIRED :**

CYLINDRICAL CELL

Digital Vacuum Gauge

Analog Vacuum Gauge

High Capacity Vacuum Pump.

**THEORY BEHIND:**

In everyday usage, vacuum is a volume of space that is essentially empty of matter, such that its gaseous pressure is much less than atmospheric pressure. The word comes from the Latin for “empty”. A perfect vacuum would be one with no particles in it at all, which is impossible to achieve in practice. Physicists often discuss ideal test results that would occur in a perfect vacuum, which they simply call “vacuum” or “free space”, and use the term partial vacuum to refer to real vacuum. The Latin term in vacuum is also used to describe an object as being in what would otherwise be a vacuum.

Vacuum is useful in a variety of processes and devices. Its first widespread use was in the incandescent light bulb to protect the filament from chemical degradation. The chemical inertness produced by a vacuum is also useful for electron beam welding, cold welding, vacuum packing and vacuum frying. Ultra-high vacuum is used in the study of atomically clean substrates, as only a very good vacuum preserves atomic-scale clean surfaces for a reasonably long time (on the order of minutes to days). High to ultra-high vacuum removes the obstruction of air, allowing particle beams to deposit or remove materials without

contamination. This is the principle behind chemical vapor deposition, physical vapor deposition, and dry etching which are essential to the fabrication of semi conductors and optical coatings, and to surface science. The reduction of convection provides the thermal insulation of thermos bottles. Deep vacuum lowers the boiling point of liquids and promotes low temperature out gassing which is used in freeze drying, adhesive preparation, distillation, metallurgy, and process purging. The electrical properties of vacuum make electron microscopes and vacuum tubes possible, including cathode ray tubes. The elimination of air friction is useful for flywheel energy storage and ultracentrifuges.

### **PANEL DETIALS:**

**MAINS ON INDICATOR :** To indicate the Power given to the system.

**CONSOLE ON SWITCH :** Provided to activate the system.

**VACUUM ON SWITCH :** Provided to activate the system.

**VACUUM INDICATORS :** To indicate the Vacuum inside the cylinder.

### **PREPARATION OF EQUIPMENT:**

1. Make sure the Vacuum On switch is in off condition.
2. Connect the instrument to 1ph, 230V AC supply which is having proper earthing.

### **LIMITATIONS**

Maximum Vacuum Range : 600mm of Hg or 800mbar

**PROCEDURE:**

1. Switch on the Console to activate the Panel.
2. Close the Valve on the Cylinder.
3. Start the Vacuum pump and allow to attain maximum vacuum.
4. Note down the Readings on Digital and Analog gauges.
5. Now Slowly open the Valve on the cylinder and set to the required Vacuum.
6. Once again note down the Digital and Analog readings.
7. Repeat Steps 5 and 6 until zero.
8. Calculate the error if any and % error.

**TABULATIONS:**

Sl. no	Actual Reading, 'R <sub>a</sub> ' mm	Measured Reading, 'R <sub>m</sub> ' mm	Error $E = (R_a - R_m)$	% Error $\{(R_a - R_m)/R_a\} * 100$

**CONCLUSIONS OF THE RESULTS TABULATED:**

Summarizing the entire operation

Describing the possible error factors

Graph Plotting

Techniques which can be adopted to minimize the errors in all aspects i.e, from startup to end.

## CALIBRATION OF TEMPERATURE SENSOR.

### AIM:

Calibrate **TEMPERATURE SENSORS** for the performance using **STANDARD** water bath.

### APPARATUS REQUIRED :

STANDARD WATER BATH with Temperature Controller

Temperature Sensors like RTD, J – Type, K – Type & T – type

Individual Digital Temperature Indicators

### THEORY BEHIND:

#### **RESISTANCE TEMPERATURE DETECTOR (RTD)**

Resistance thermometers, also called **resistance temperature detectors or resistive thermal devices (RTD)**, are temperature sensors that exploit the predictable change in electrical resistance of some materials with changing temperature. As they are almost invariably made of platinum, they are often called **platinum resistance thermometers (PTR)**. They are slowly replacing the use of thermocouples in many industrial application below 600°C, due to higher accuracy and repeatability.

There are many categories like carbon resistors, film and wire wound types are the most widely used.

- **Carbon resistor** are widely available and are very inexpensive. They have very reproducible results at low temperatures. They are the most reliable from at extremely low temperatures. They generally do not suffer from significant hysteresis or strain gauge effects.
- **Film thermometer** have a layer of platinum on a substrate, the layer may be extremely thin, perhaps one micrometer. Advantage of this type are relatively low cost and fast response. Such devices have improved performance although the different expansion rates of the substrate and platinum give “strain gauge” effects and stability problems.

- *Wire – wound thermometers* can have greater accuracy, especially for wide temperature ranges.
- *Coil element* have largely replaced wire wound elements in industry. This design has a wire coil which can expand freely over temperature, held in place by some mechanical support which lets the coil keep its shape.

### THERMOCOUPLES

The common electrical method of temperature measurement uses the thermocouple, when two dissimilar metal wires are joined at both ends, an emf will exist between the two junctions, if the two junctions are at different temperatures. This phenomenon is called Seebeck effect. If the temperature of one junction is known then the temperature of the other junction may be easily calculated using the thermoelectric properties of the materials. The known temperature is called reference temperature and is usually the temperature of ice. Potential (emf) is also obtained if a temperature gradient along the metal wires. This is called Thomson effect and is generally neglected in the temperature measuring process. If two materials are connected to an external circuit in such a way that current is drawn, an emf will be produced. This is called as Peltier effect. In temperature measurement, Seebeck emf is of prime concern since it is dependent on junction temperature.

The thermocouple material must be homogeneous. A list of common Thermocouple materials in decreasing order of emf chrome, iron and copper platinum – 10% rhodium, platinum, alumel and constantan (60% copper and 40% nickel). Each material is thermoelectrically positive with respect to the below it and negatives with respect those above.

The material used in the Thermocouple probe is:

1. Iron – Constantan (Type J)
2. Copper – Constantan (Type T)
3. Chromel – Alumel (Type K)

**PANEL DETAILS:**

**MAINS ON INDICATOR :** To indicate the Power given to the system.

**CONSOLE ON SWITCH :** Provided to activate the system.

**TEMPERATURE INDICATORS :** To indicate the Temperatures of various sensors.

**WATER BATH SETTINGS :** To Set the Temperature of Water bath.

**SOFTWARE :** FACILITATES TO DO THINGS IN COMPUTER FORMAT.

**PREPARATION OF EQUIPMENT:**

1. Fill the water into the Water Bath to the required level.
2. Make sure the water bath is in off condition.
3. Connect the instrument to 1ph, 230V AC supply which is having proper earthing.

**LIMITATIONS**

Maximum Temperature : up to 100deg

**PROCEDURE:**

1. Switch on the Console to activate the Panel and then switch on the waterbath.
2. Set the required Temperature of the bath
3. Select the Sensor under study {however other sensors will also be working condition, this is only done to concentrate on particular sensor type}and Note the readings of the selected Sensor indicator for every two degree rise of water bath temperature .
4. Repeat step 2 and step 3 until required within the range.
5. Repeat the above for different sensors.
6. Calculate the error if any and % error.

**TABULATIONS:**

Sl. no	Actual Reading, 'R <sub>a</sub> ' mm	Measured Reading, 'R <sub>m</sub> ' mm	Error $E = (R_a - R_m)$	% Error $\{(R_a - R_m)/R_a\} * 100$

**CONCLUSIONS OF THE RESULTS TABULATED:**

Summarizing the entire operation

Describing the possible error factors

Graph Plotting

Techniques which can be adopted to minimize the errors in all aspects i.e, from startup to end.