

# **COMPUTER AIDED DESIGN(CAD )**

## **LABORATORY MANUAL**

**B.TECH  
(II YEAR – I SEM)  
(2016-17)**

**Prepared by:**

**Mr. S. Shailesh Babu, Assistant Professor**

**Department of Aeronautical Engineering**



## **MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY**

**(Autonomous Institution – UGC, Govt. of India)**

Recognized under 2(f) and 12 (B) of UGC ACT 1956

Affiliated to JNTUH, Hyderabad, Approved by AICTE - Accredited by NBA & NAAC – 'A' Grade - ISO 9001:2015  
Certified)

Maisammaguda, Dhulapally (Post Via. Hakimpet), Secunderabad – 500100, Telangana State, India.

# **MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY**

**(Autonomous Institution – UGC, Govt. of India)**

Recognized under 2(f) and 12 (B) of UGC ACT 1956

Affiliated to JNTUH, Hyderabad, Approved by AICTE - Accredited by NBA & NAAC – 'A' Grade - ISO 9001:2015  
Certified)

Maisammaguda, Dhulapally (Post Via. Hakimpet), Secunderabad – 500100, Telangana State, India.

## **MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY**

### **VISION**

❖ To establish a pedestal for the integral innovation, team spirit, originality and competence in the students, expose them to face the global challenges and become technology leaders of Indian vision of modern society.

### **MISSION**

- ❖ To become a model institution in the fields of Engineering, Technology and Management.
- ❖ To impart holistic education to the students to render them as industry ready engineers.
- ❖ To ensure synchronization of MRCET ideologies with challenging demands of International Pioneering Organizations.

### **QUALITY POLICY**

- ❖ To implement best practices in Teaching and Learning process for both UG and PG courses meticulously.
- ❖ To provide state of art infrastructure and expertise to impart the quality education.
- ❖ To groom the students to become intellectually creative and professionally competitive.
- ❖ To channelize the activities and tune them in heights of commitment and sincerity, the requisites to claim the never ending ladder of SUCCESS year after year.

**For more information: [www.mrcet.ac.in](http://www.mrcet.ac.in)**

# DEPARTMENT OF AERONAUTICAL ENGINEERING

## VISION

Department of Aeronautical Engineering aims to be indispensable source in Aeronautical Engineering which has a zeal to provide the value driven platform for the students to acquire knowledge and empower themselves to shoulder higher responsibility in building a strong nation.

## MISSION

- a) The primary mission of the department is to promote engineering education and research.
- (b) To strive consistently to provide quality education, keeping in pace with time and technology.
- (c) Department passions to integrate the intellectual, spiritual, ethical and social development of the students for shaping them into dynamic engineers.



## PROGRAM OBJECTIVES (PO'S)

### Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **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.
3. **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.
4. **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.
5. **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.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **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.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **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.
11. **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 multi disciplinary environments.
12. **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.



## **PROGRAMME EDUCATIONAL OBJECTIVES (PEO'S)**

### **PEO1: PROFESSIONALISM & CITIZENSHIP**

To create and sustain a community of learning in which students acquire knowledge and learn to apply it professionally with due consideration for ethical, ecological and economic issues.

### **PEO2: TECHNICAL ACCOMPLISHMENTS**

To provide knowledge based services to satisfy the needs of society and the industry by providing hands on experience in various technologies in core field.

### **PEO3: INVENTION, INNOVATION AND CREATIVITY**

To make the students to design, experiment, analyze, interpret in the core field with the help of other multi disciplinary concepts wherever applicable.

### **PEO4: PROFESSIONAL DEVELOPMENT**

To educate the students to disseminate research findings with good soft skills and become a successful entrepreneur.

### **PEO5: HUMAN RESOURCE DEVELOPMENT**

To graduate the students in building national capabilities in technology, education and research.

## **PROGRAM SPECIFIC OBJECTIVES (PSO's)**

1. To mould students to become a professional with all necessary skills, personality and sound knowledge in basic and advance technological areas.
2. To promote understanding of concepts and develop ability in design manufacture and maintenance of aircraft, aerospace vehicles and associated equipment and develop application capability of the concepts sciences to engineering design and processes.
3. Understanding the current scenario in the field of aeronautics and acquire ability to apply knowledge of engineering, science and mathematics to design and conduct experiments in the field of Aeronautical Engineering.
4. To develop leadership skills in our students necessary to shape the social, intellectual, business and technical worlds.

## **(R15A0389) CAD LAB**

### **Objectives:**

- To develop skill to use software to create 2D and 3D models.

### **LIST OF EXPERIMENT:**

1. INTRODUCTION to CAD
  2. AutoCAD – BASICS
    - 2.1 Starting with AutoCAD
    - 2.2 Layout and sketching
    - 2.3 Drawing environment
    - 2.4 Elements of drawing
      - 2.4.1 Draw commands
    - 2.5 3D functions
      3. 2D – FIGURES for practice USING AutoCAD 2013
      4. ISOMETRIC DRAWING for practice USING AutoCAD2013
      5. 3-D SOLID FIGURES USING ACAD 2013
  6. INTRODUCTION TO CREO 3.0
    - 6.1 Learning Different Operations like Threading, Sweep, Sweptblend.
    - 6.2 Modeling
    - 6.3 Assembling

**Equipment needed: Computers and Software: Autocad 2013 and CREO – 3.0**

### **Reference Books:**

1. Engineering graphics with Auto CAD- R.B. Choudary/Anuradha Publishes

### **Outcomes:**

- Ability to use the software packers for drafting and modeling
- Ability to create 2D and 3D models of Engineering Components

## CONTENTS

S.No	NAME OF THE EXPERIMENT	PAGE NO
1.	Introduction to CAD	9
2.	ACAD – Basics	11
3	2 - D Figures Using ACAD	36
4	Isometric Drawings Using ACAD	46
5	3-D Figures Using ACAD	50
6	Introduction to CREO 3.0	53
7	Exercises on CREO 3.0	61

## 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, 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 is 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

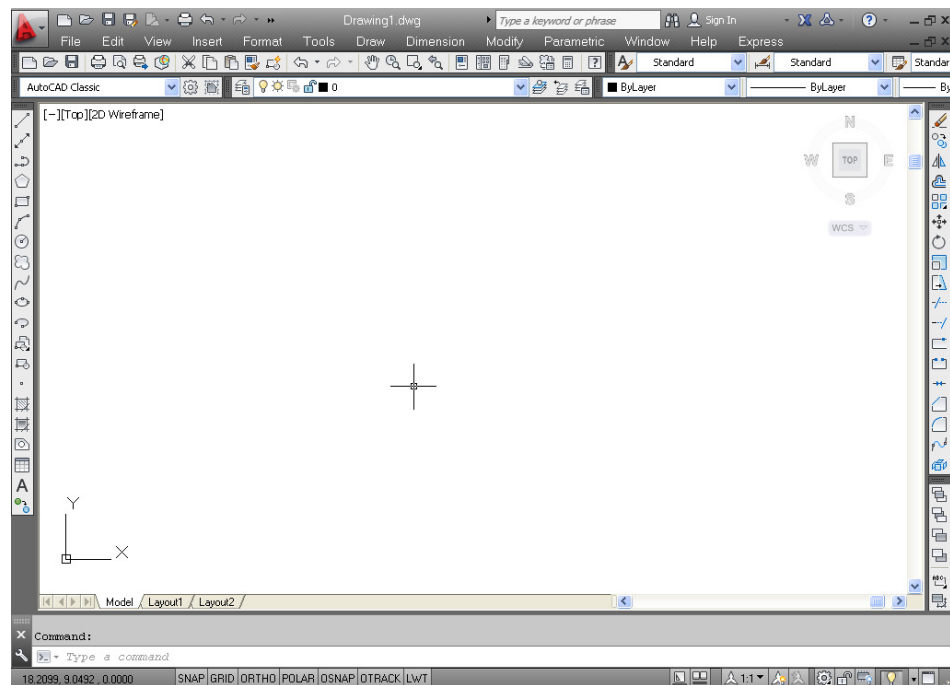
CAD uses four basic elements for preparation of any drawing:

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 angles.

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 start up 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. Layout 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 changing 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)

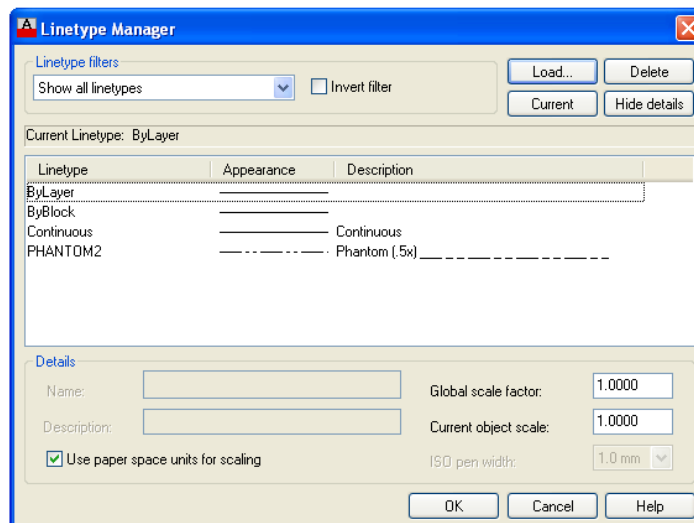
Current line-width is <current>

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:

- i. Center point and radius
- ii. Two point circle
- iii. Three point circle
- iv. 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 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.

**8. 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 units for example; entering 0.5xp displays model space at half the scale of paper space units. 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

**9. 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

**10. 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 new object at a specified distance from an existing object or through a specified point

At the command prompt enter, **offset**

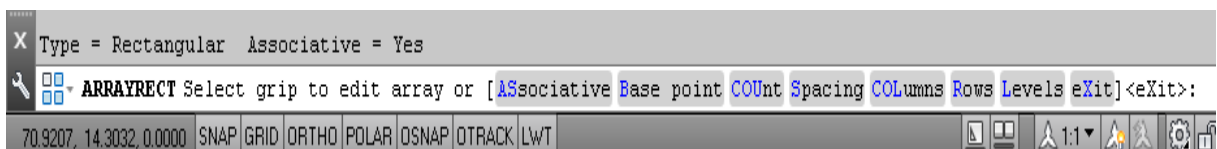
Offset distance: specify a distance, enter t or press enter

**11. ARRAY:** This creates multiple copies of objects in pattern. Arrays are three types.

- a) Rectangular Array
- b) Path Array
- c) Polar Array

**Rectangular Array:** In this, the object is arranged in an array of rows and columns.

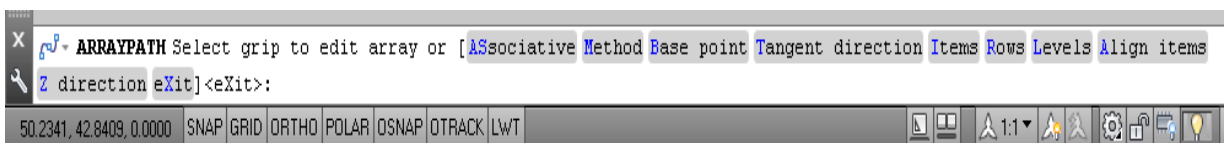
At the command prompt: type **ARRAYRECT** or select the option from **MODIFY** toolbar. It asks you to select objects. Select the object and press enter. By default it shows an array of 3 rows and 4 columns. The no. of rows and columns can be changed by selecting the **COUNT**



option (OR) by selecting **COLUMNS** and **ROWS** options separately

**Path Array:** In this, an object is arranged in a specified path.

At the command prompt: type **ARRAYPATH** or select the option from **MODIFY** toolbar. Then select object to be arrayed. Then select the path through which the object is made to be arrayed.



## 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

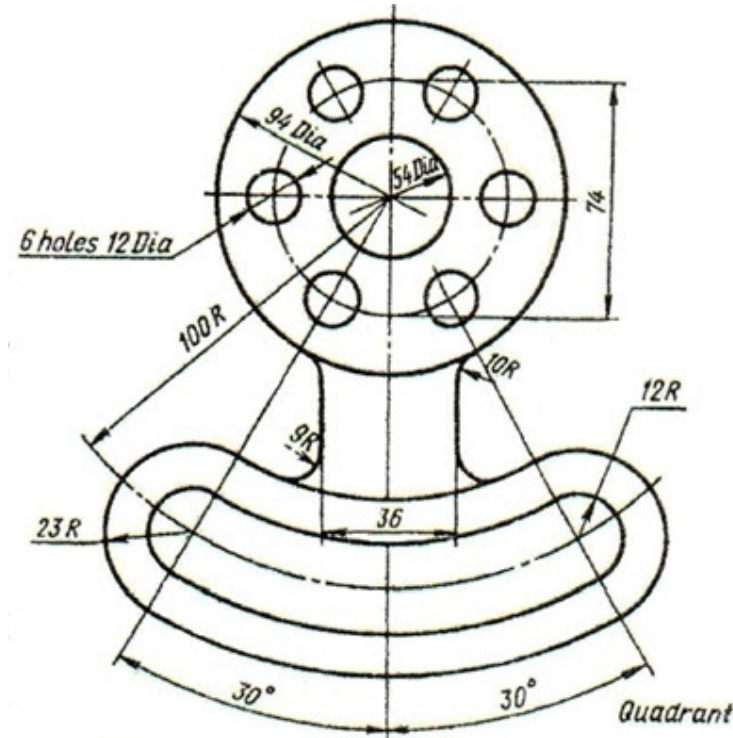
**Polar Array:** In this, an object is arranged in a circular shape.

At the command prompt: type **ARRAYPOLAR** or select the option from **MODIFY** toolbar. Then select object to be arrayed. Then select the center point of array. By default, a six items array is created. The No. of items can be changed by selecting the **Items** option. Angle between the two items can also be changed.

### 3. 2D DRAWINGS

**FIGURE 1**

Aim: to draw the following figure using ACAD

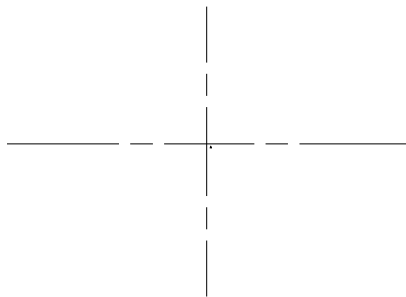


#### PROCEDURE

**Set the limits of the drawing screen**

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

- 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.

**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:**

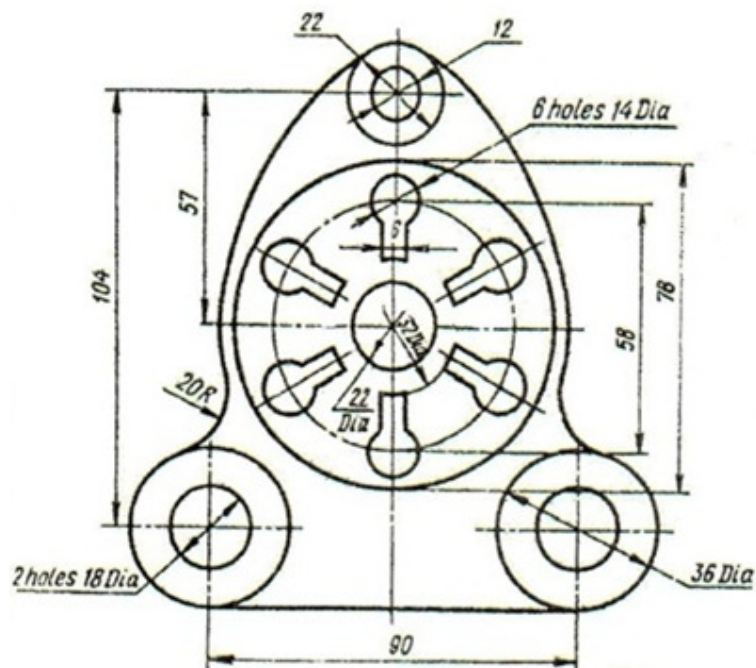
Put **ORTHO ON** where ever necessary.

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



## FIGURE 2

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 5:** Give dimensions to the completed figure.

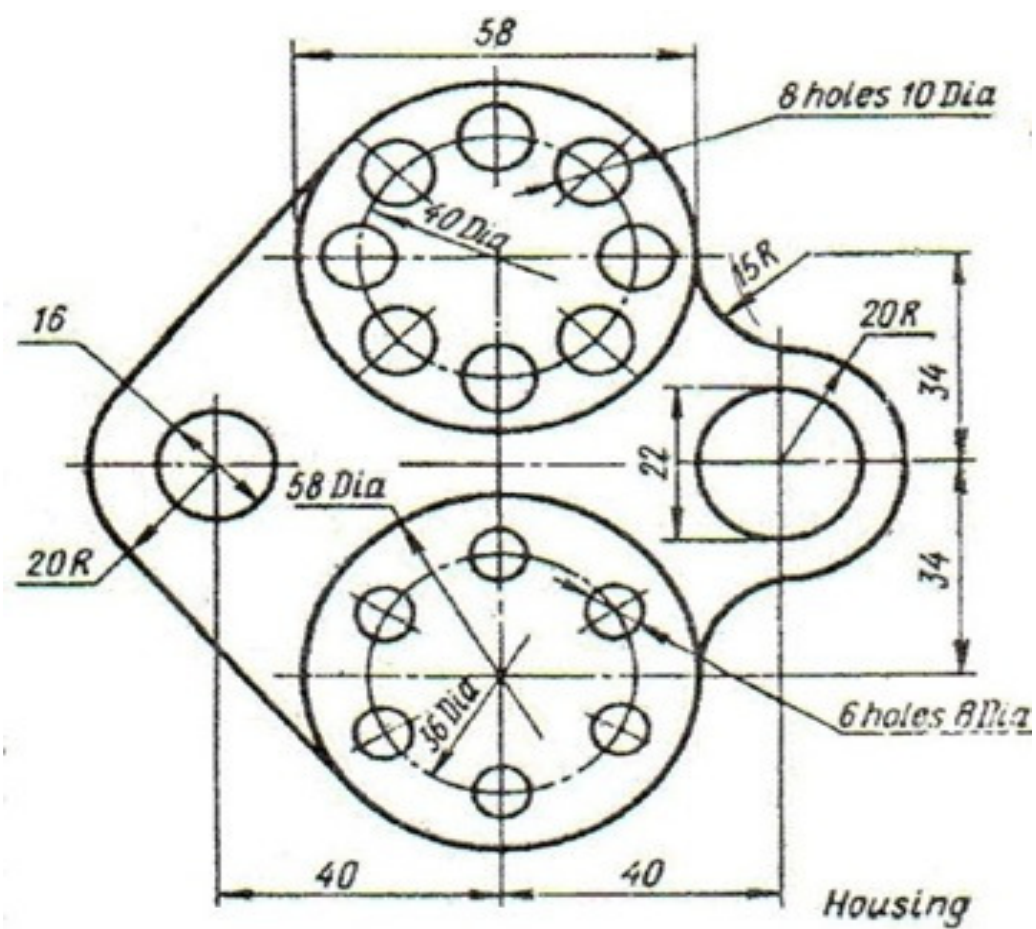
**Command:** `_qsave`

### PRECAUTIONS:

Put **ORTHO ON** where ever necessary.

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

# PRACTICE FIGURE 3



The diagram shows the orthographic projection of a mechanical part, consisting of a front view (top) and a top view (bottom).

**Front View (Top):**

- Overall width: 62
- Overall height: 90
- Top edge: Semi-circular with a radius of 40R.
- Bottom edge: Semi-circular with a radius of 25R.
- Left and right edges: Vertical lines with rounded corners, each with a radius of 17R.
- Central feature: A semi-circular cutout with a radius of 105R.
- Internal features: Two circular holes, each with a diameter of 20.
- Shading: The central semi-circular cutout is shaded with diagonal lines.

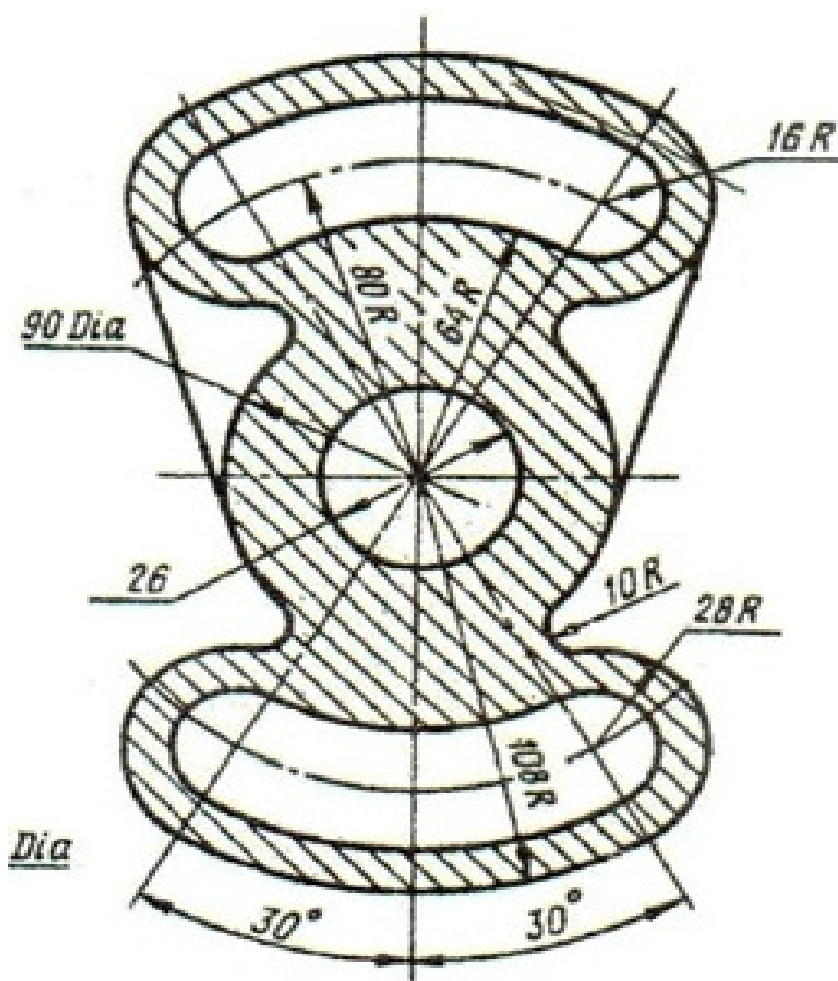
**Top View (Bottom):**

- Overall width: 84
- Overall height: 48
- Top edge: Semi-circular with a radius of 40R.
- Bottom edge: Semi-circular with a radius of 25R.
- Left and right edges: Vertical lines with rounded corners, each with a radius of 17R.
- Central feature: A semi-circular cutout with a radius of 105R.
- Internal features: Two circular holes, each with a diameter of 20.
- Shading: The central semi-circular cutout is shaded with diagonal lines.

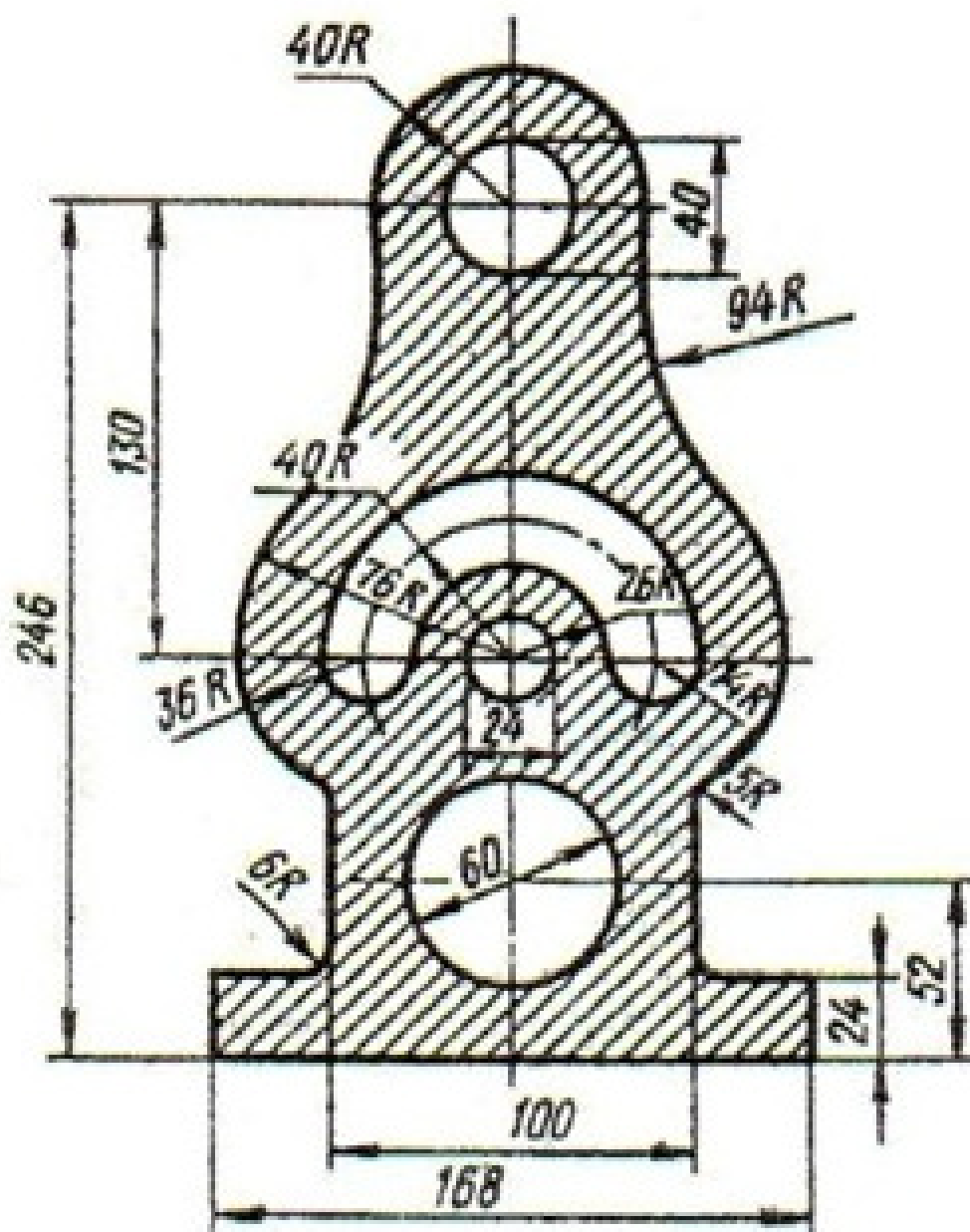
**Labels:**

- 2 holes 10 Dia
- 2 holes 20 Dia
- Frame

## PRACTICE FIGURE 5



PRACTICE FIGURE 6



The diagram shows the orthographic projection of a mechanical part, consisting of a front view (top) and a top view (bottom).

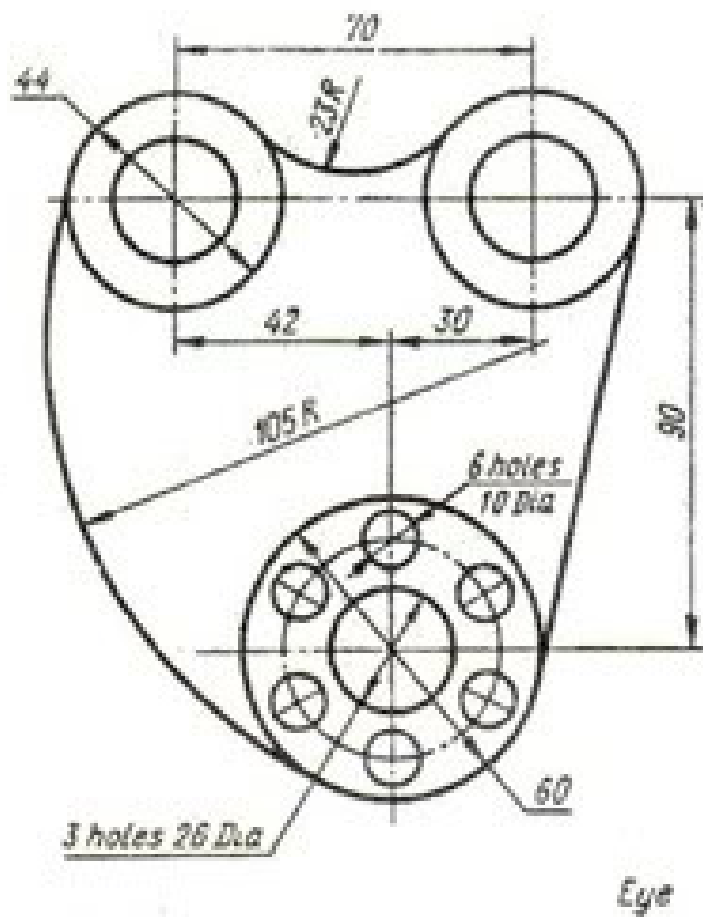
**Front View (Top):**

- Overall width: 60
- Overall height: 60
- Top corners are rounded with a radius of  $18R$ .
- Four circular holes are located in the corners, each with a diameter of 20.
- The distance between the centers of the top two holes is 30.
- The distance between the centers of the bottom two holes is 30.
- The distance between the center of a hole and the nearest vertical centerline is 17.
- The distance between the center of a hole and the nearest horizontal centerline is 14.
- The central circular feature has an outer diameter of 55 and an inner diameter of 90.
- The thickness of the part is 8.

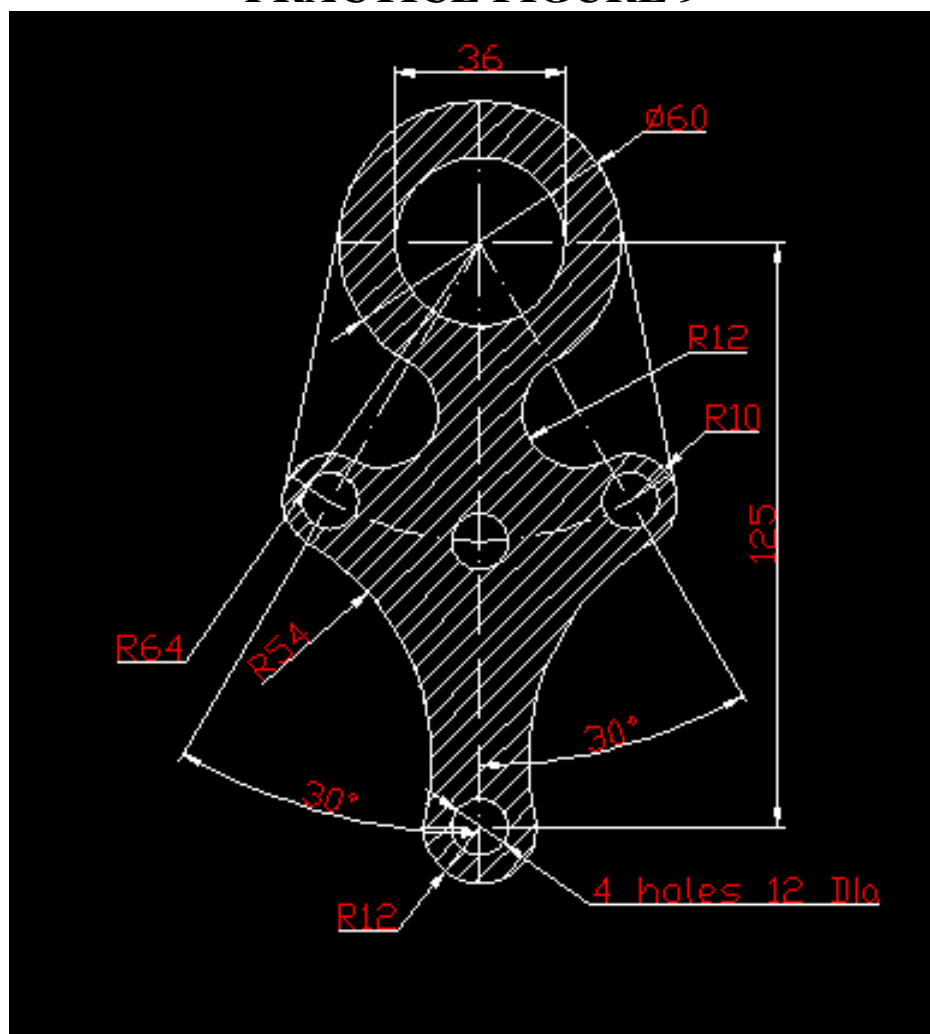
**Top View (Bottom):**

- Shows the circular end view of the part.
- Four holes are located around the perimeter, each with a diameter of 20.
- The distance between the centers of the top two holes is 30.
- The distance between the centers of the bottom two holes is 30.
- The distance between the center of a hole and the nearest vertical centerline is 17.
- The distance between the center of a hole and the nearest horizontal centerline is 14.
- The central circular feature has an outer diameter of 55 and an inner diameter of 90.
- The thickness of the part is 8.

## PRACTICE FIGURE 8



**PRACTICE FIGURE 9**





## 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

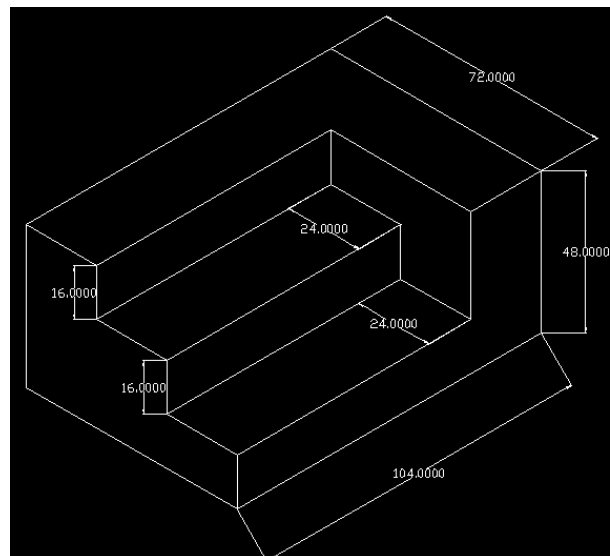
**Command: \_dimedit**

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

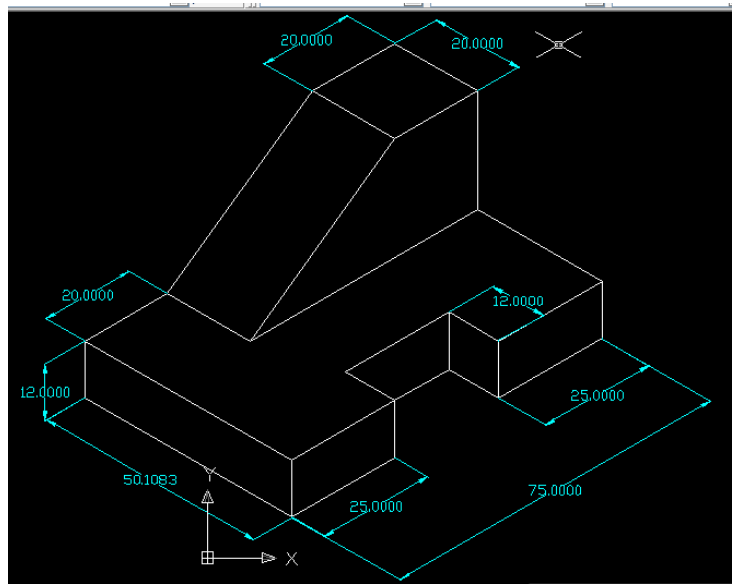
**Command: \_qsave**

**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**

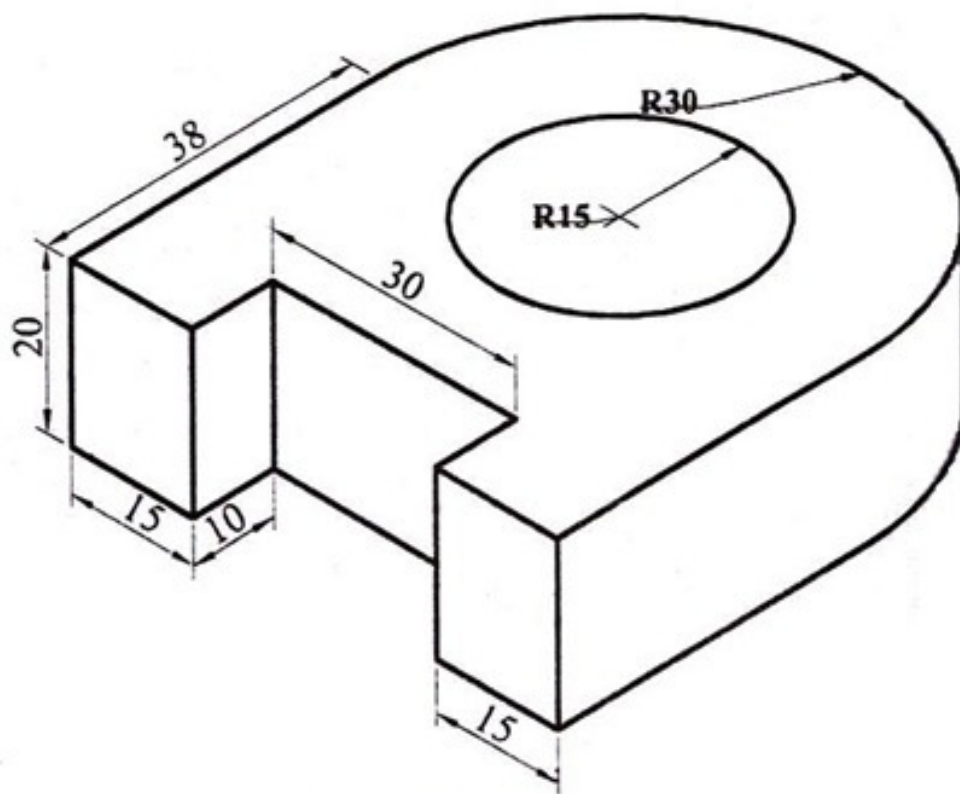
Enter type of dimension editing [Home/New/Rotate/Oblique] <Home>: \_o

Select objects: 1 found

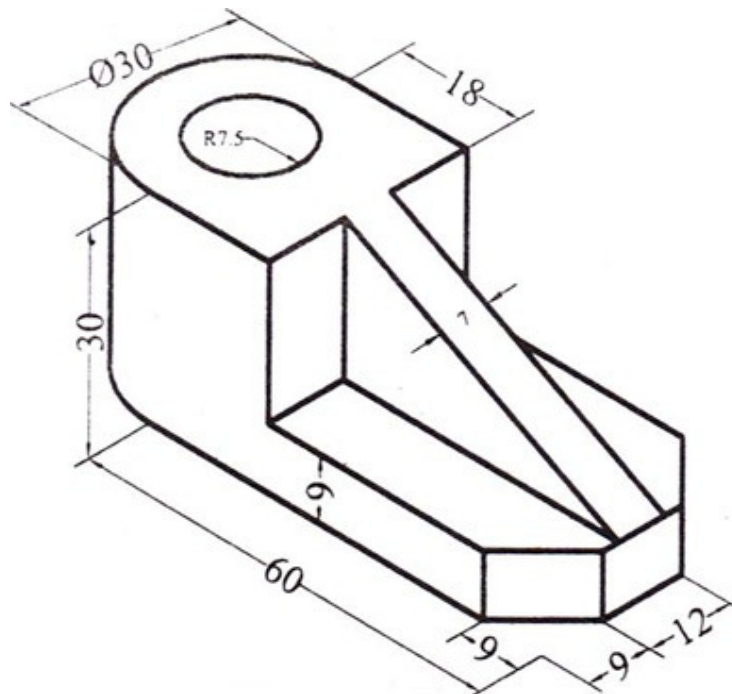
Enter obliquing angle (press ENTER for none): 30 or -30

**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***

## 5. 3- D DRAWINGS

The commands used while draing 3D solids are briefly discussed in the beginning.

The major commands used are:

- **Pedit** – To join the individual poly line segments
- **Explode** - To break the joined part into individual entities
- **Extrude** – To add thickness to the object and create a solid
- **Union** – To unite two solids and form an union
- **Intersect** – To form an intersection of two solids
- **Shade** – This displays a flat – shaded image of the drawing in the current viewport.

**SHADE** removes hidden lines and displays a shaded picture of the drawing

- **Rotate 3D** – This moves objects about a three dimensional space
- **Revolve** – This creates a solid by revolving a two – dimensional object about an axis
- **Region** – This creates a region object from a selection set of existing objects. Regions are two dimensional areas.

- **View ports** – Splits the screen into a number of ports. Enables us to have a multi viewing of the object at the same time.

**VIEW** pull down menu → **View ports**

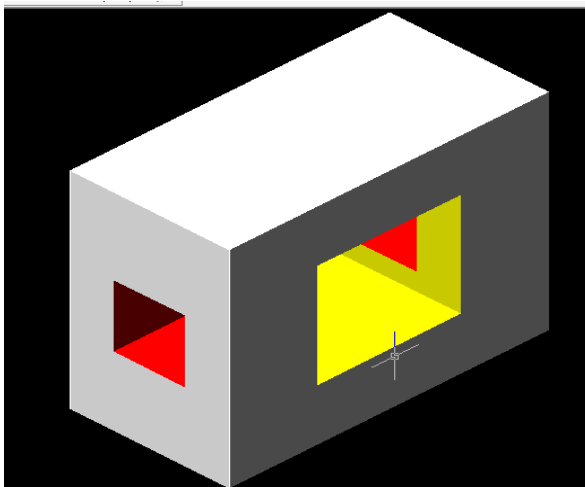
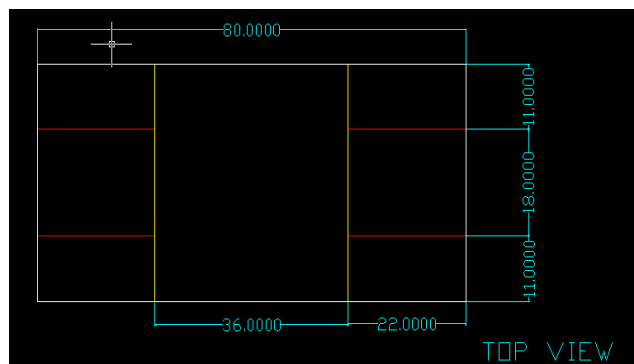
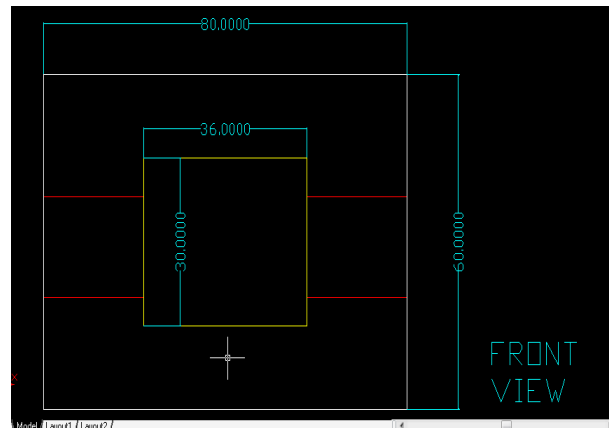
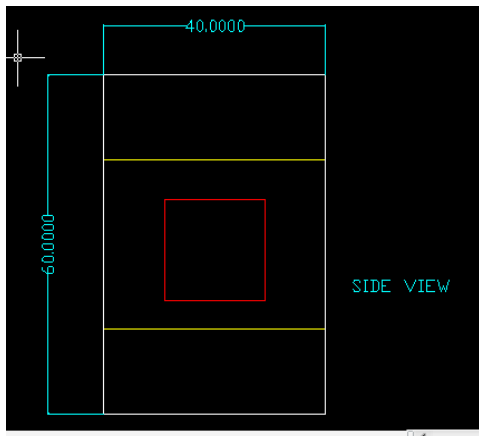
- **3D ORBIT** - Allows us to rotate the object on a 3 dimensional axis.

**VIEW** pull down menu → **3D orbit**

- **3D VIEWS** - Allows us to visualize the views of object object

**VIEW** pull down menu → **3D view**

## PRACTICE FIGURE – 1



### PROCEDURE:

**STEP 1:** Set your screen to **SW ISOMETRIC VIEW**.

Go to **VIEW** pull down menu.

Select **3D VIEWS** and from the **sub menu select SW ISOMETRIC VIEW**.

**STEP 2:** Using **RECTANGLE** command draw the bottom rectangle of dimensions 80 X 60 and **EXTRUDE** it to a height of 40. We get the outside solid

To put the holes required on the front and the side of the solid,

**STEP 3:** Draw the inner rectangles and extrude them as per give dimensions

**STEP 4:** Substract the inner solids from the outer one

We can use different colours to distinguish between the solids, so that it is easier to substract.

**STEP 5:** Shading can be done to the wire frame model using **commands in the SHADE tool bar**.

**The** front, top and the side views of the figure can be obtained from the

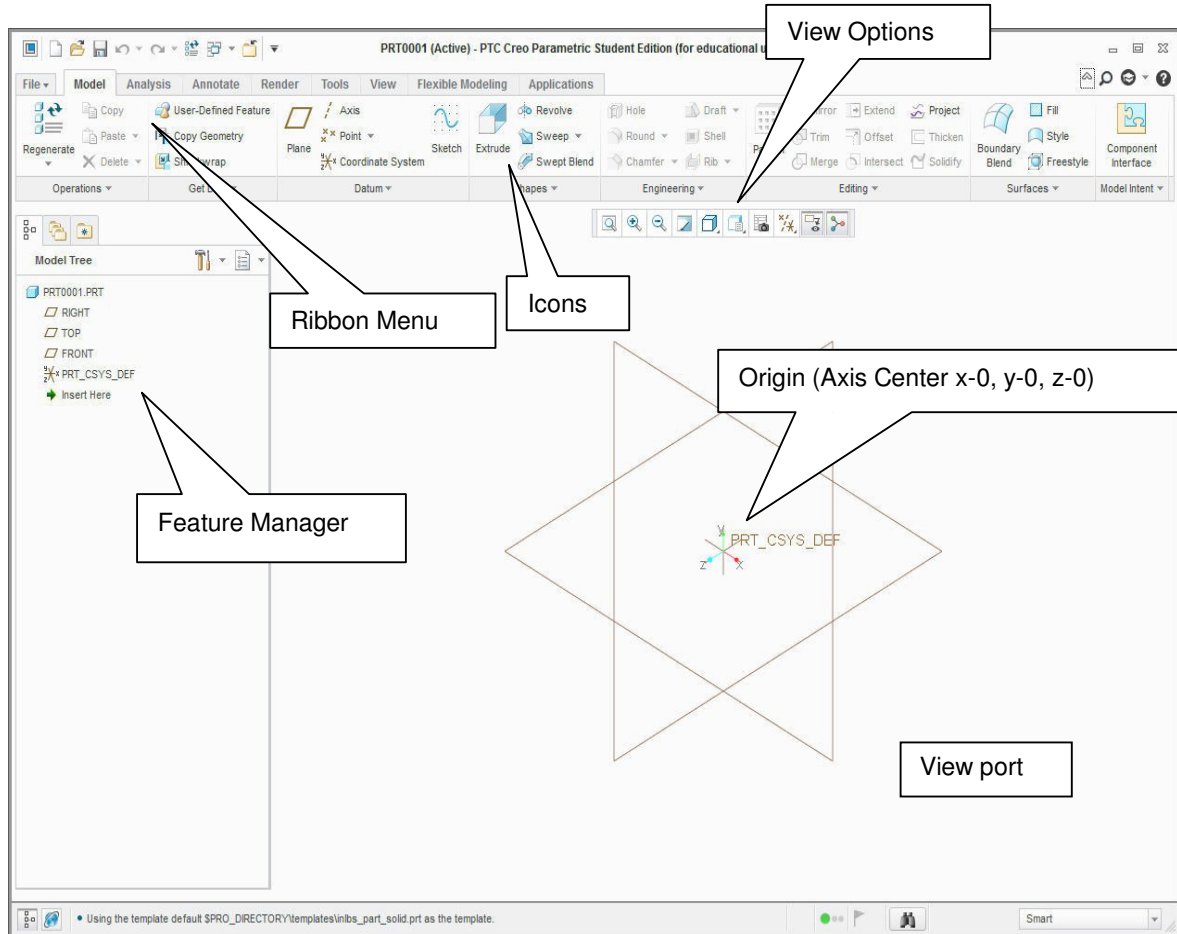
**View** pull down menu → **3D views** → **Front view** etc.,

The model can be made to orbit using

**View** pull down menu → **3D ORBIT**

## 6. Introduction to Pro/E - creo

### CreoParametric 3.0 Interface



## Mouse Buttons

**Left Button** - Most commonly used for **selecting** objects on the screen or sketching.

**Right Button** – Used for activating pop-up **menu** items, typically used when editing. (Note: you must hold the down button for 2 seconds)

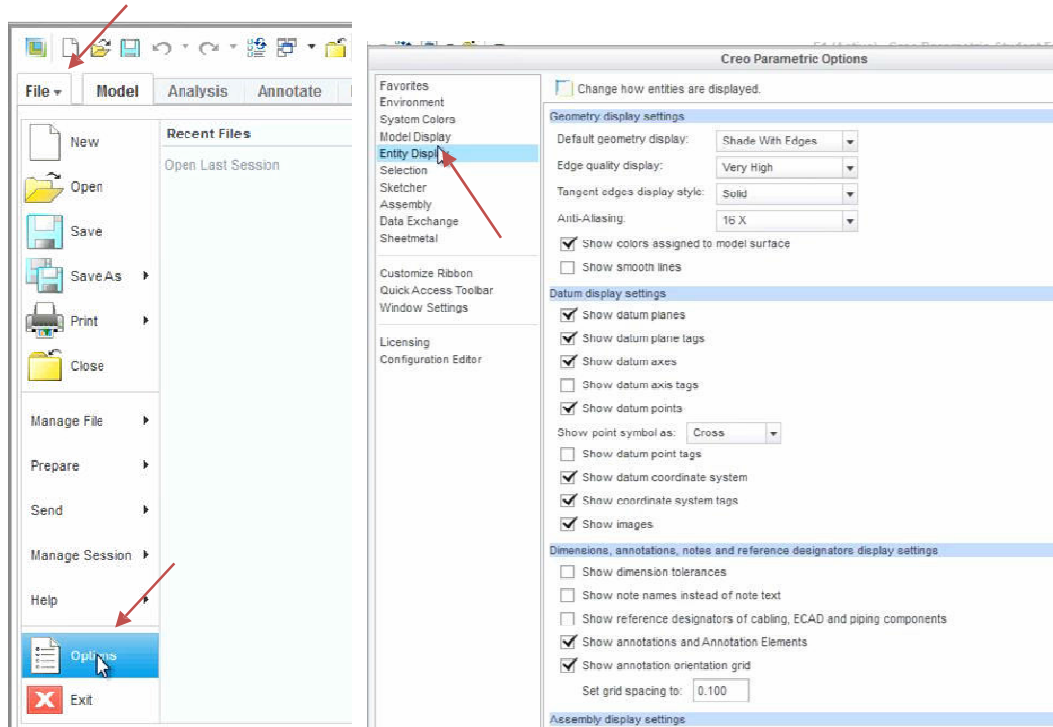
**Center Button** – (option) Used for model **rotation**, **dimensioning**, **zoom** when holding Ctrl key, and **pan** when holding Shift key. It also **cancels** commands and line chains.

**Center Scroll Wheel** – (option) same as Center Button when depressed, only it activates **Zoom** feature when scrolling wheel

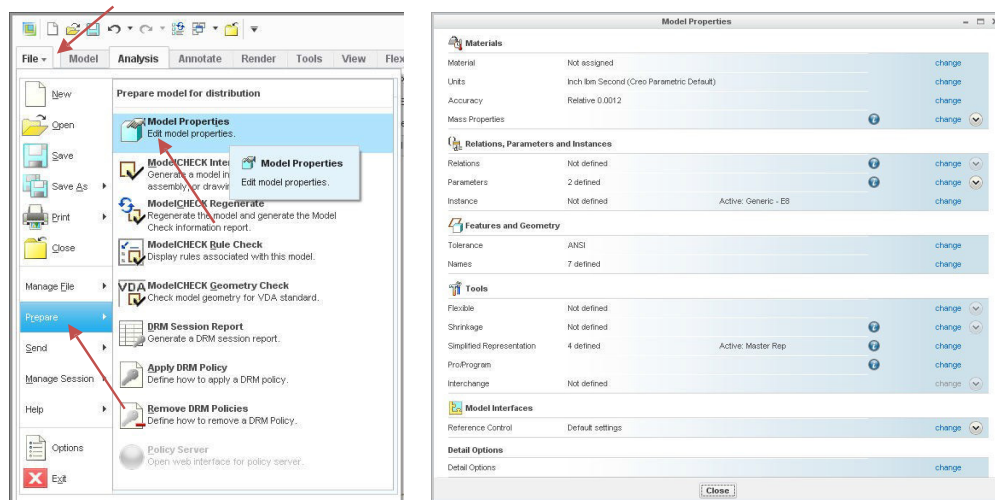


## Options & Properties, menus, *The heart of CREO*

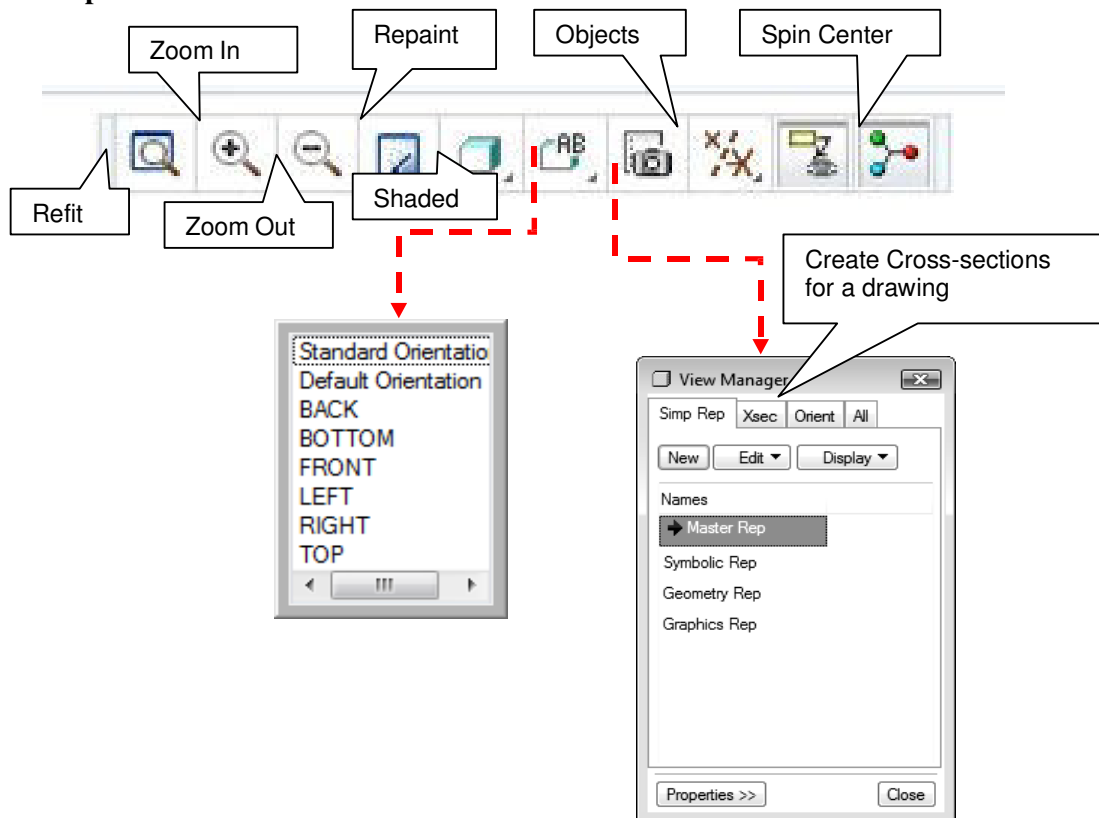
Selecting the **File—Options --pull down-** (located at the top left side of the screen) opens the active documents **Options**.



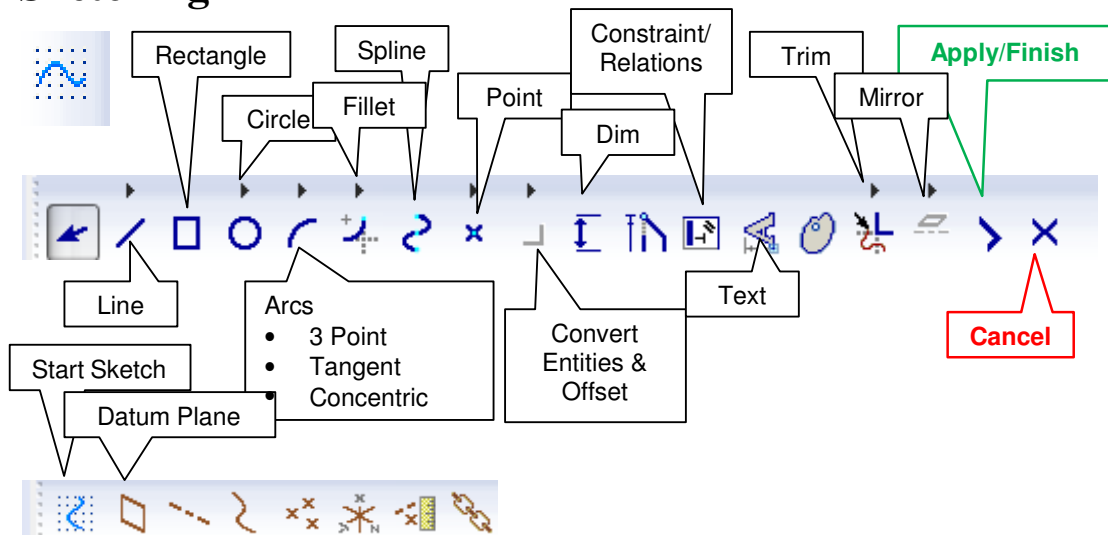
## Model Properties



## View options



## Sketching

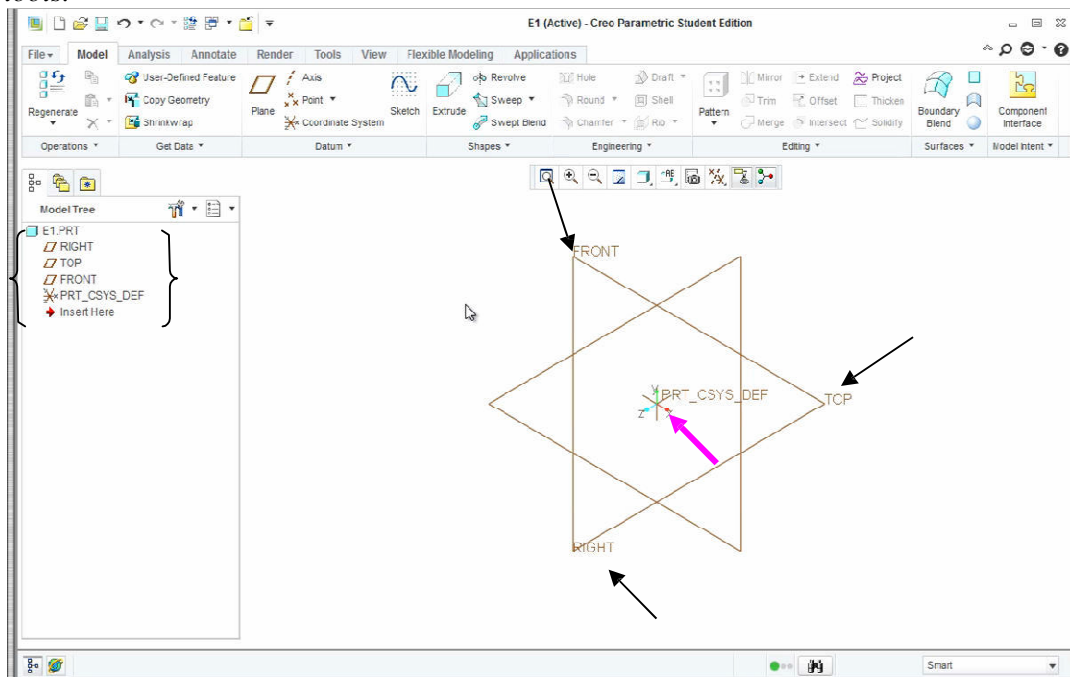


**NOTE:** If you do not see all of these icons on your interface you can customize the toolbars to bring them up.

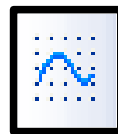
### Where do you start a sketch?

Sketches can be created on any Datum Plane or Planar Face or Surface. Pro/E provides you with three datum planes centralized at the Origin (your zero mark in space)

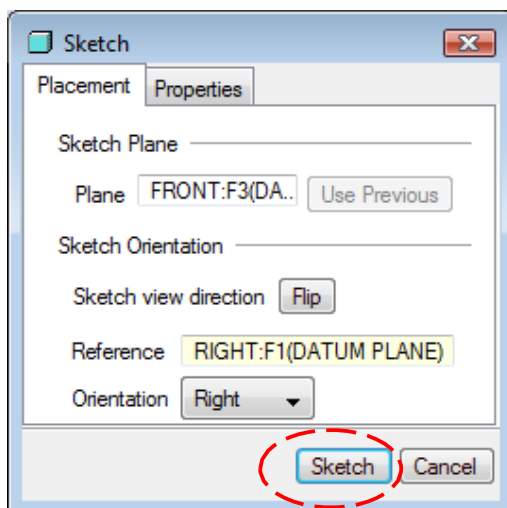
*NOTE: Planes can also be created and will be discussed in more detail in the future. Also after completing a sketch always select the Apply/Finish check mark on the sketch toolbar, this will activate the extrude or revolve feature tools.*



To start a sketch Pre-select the plane or face you desire to sketch on and then select the Sketch Icon.



## Sketch Options

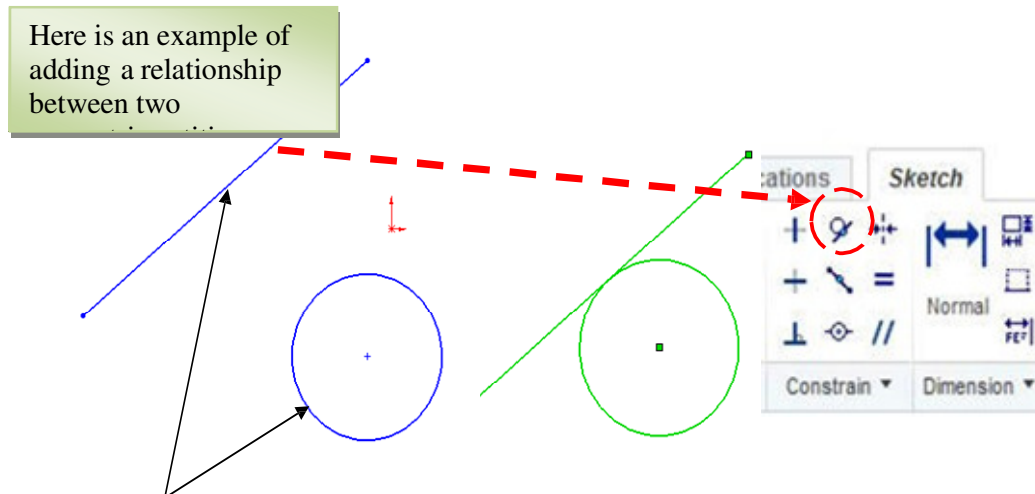


## Controlling your geometry

Pro/E uses two methods for constraining geometric entities.

### Constraints and Dimensions

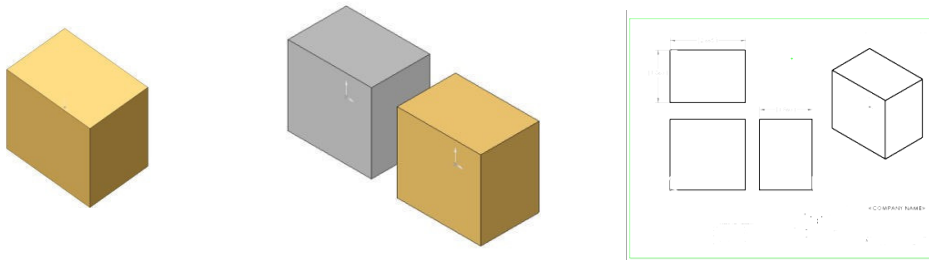
**Constraints** can be referred to as common elements of geometry such as Tangency, Parallelism, and Concentricity. These elements can be added to geometric entities automatically or manually during the design process.



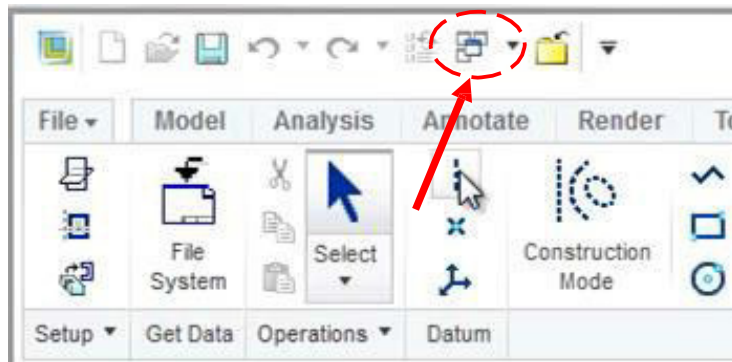
### *Cautious sketching can save time*

There are 3 primary file types in Creo, which include...

1. **Part** (.prt)  
Single part or volume.
2. **Assembly** (.asm)  
Multiple parts in one file assembled.
3. **Drawing** (.drw)  
The 2D layout containing views, dimensions, and annotations.

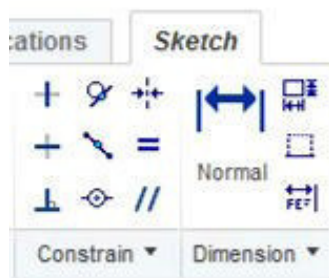


## Switching between documents (Activating a document)



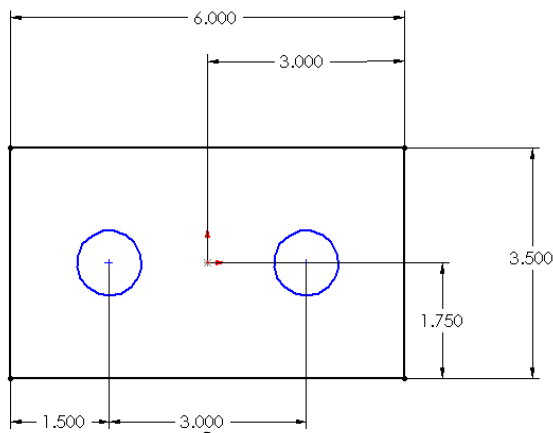
Select the Window pull-down menu and you will see the available documents. Click on the document you wish to work on from the list to update it.

## Sketch Constraints (Relations)



Constraint	Geometric entities to select	Resulting Constraint
<b>Horizontal or Vertical</b>	One or more lines or two or more points.	The lines become horizontal or vertical (as defined by the current sketch space). Points are aligned horizontally or vertically.
<b>Collinear</b>	Two or more lines.	The items lie on the same infinite line.
<b>Perpendicular</b>	Two lines.	The two items are perpendicular to each other.
<b>Parallel</b>	Two or more lines. A line and a plane (or a planar face) in a 3D sketch.	The items are parallel to each other. The line is parallel to the selected plane.
<b>Tangent</b>	An arc, ellipse, or spline, and a line or arc.	The two items remain tangent.
<b>Concentric</b>	Two or more arcs, or a point and an arc.	The arcs share the same centerpoint.
<b>Midpoint</b>	Two lines or a point and a line.	The point remains at the midpoint of the line.
<b>Coincident</b>	A point and a line, arc, or ellipse.	The point lies on the line, arc, or ellipse.
<b>Equal</b>	Two or more lines or two or more arcs.	The line lengths or radii remain equal.
<b>Symmetric</b>	A centerline and two points, lines, arcs, or ellipses.	The items remain equidistant from the centerline, on a line perpendicular to the centerline.

## Controlling your geometry with dimensions...

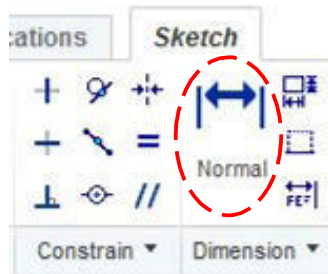
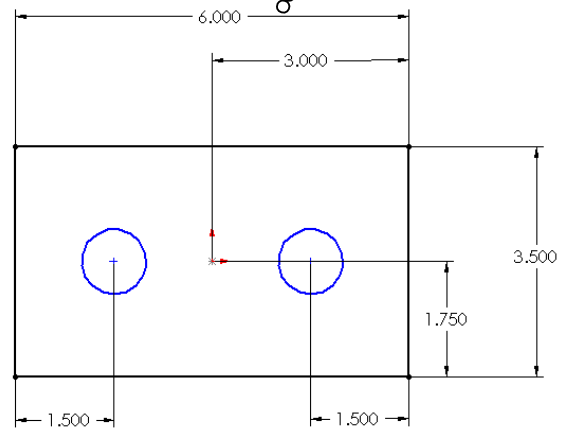


Dimensioning this way will enable the length of the bracket to change but the holes will always remain positioned to the left side.



**Strong** versus **Weak**  
Dimensions -  
Double click and  
change to make  
them Strong!

Dimensioning this way will  
enable the length of the  
bracket to change but the  
holes will always remain  
positioned to 1.5" off each



# Solid Modeling Basics

## 1. Layer Cake method



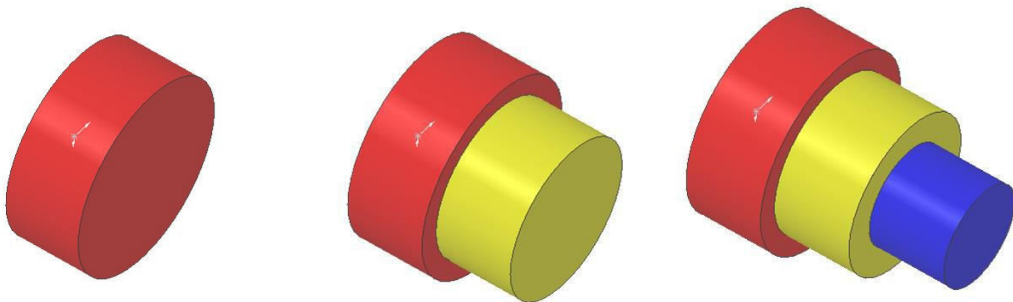
Extruded Boss/Base (Creates/Adds material)



Extruded Cut (Removes material)

*Ingredients:*

- Profile



## 2. Revolve method



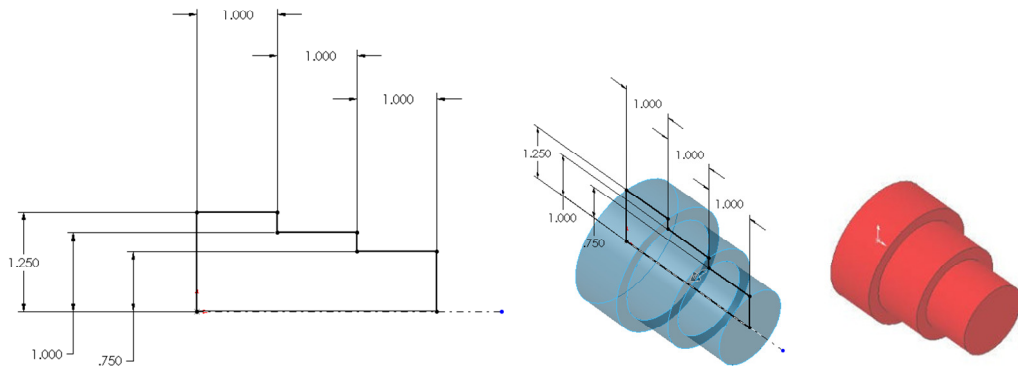
Revolve Boss/Base (Creates/Adds material)



Revolve Cut (Removes material)

*Ingredients:*

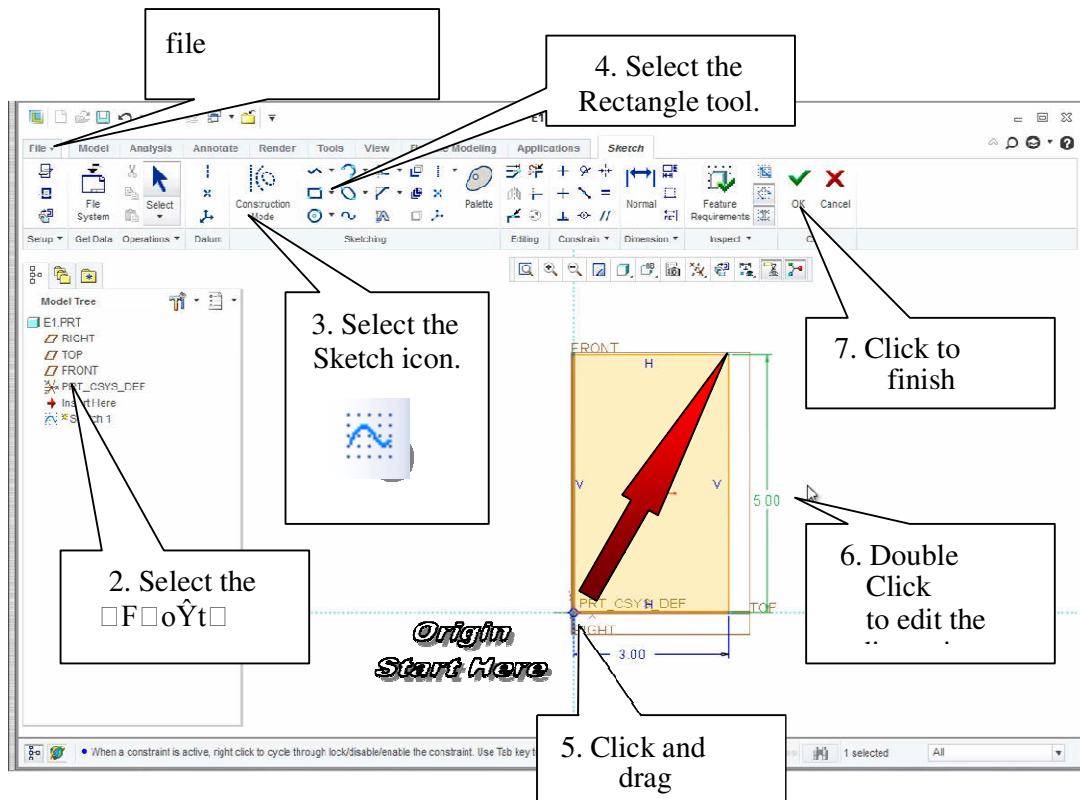
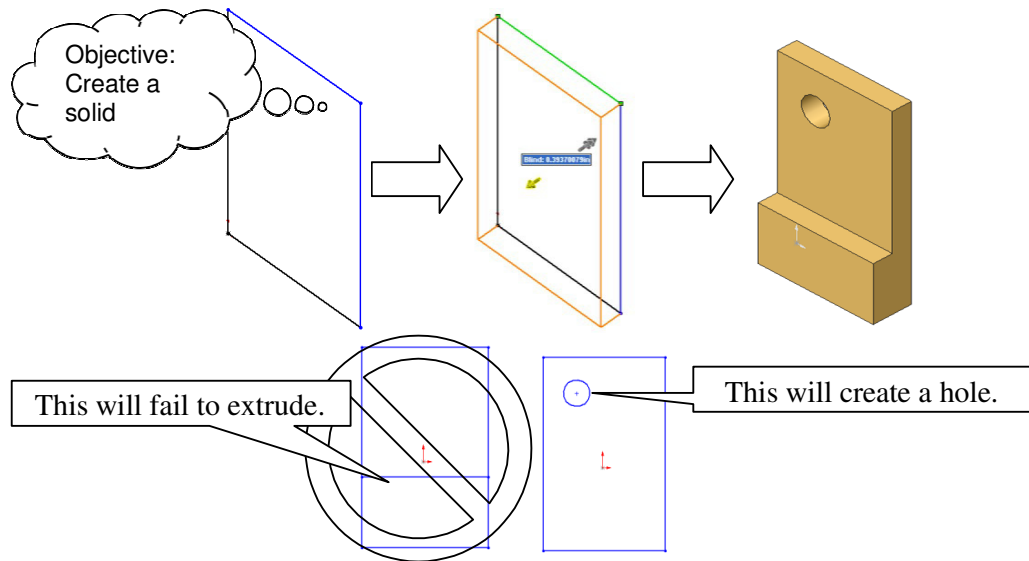
- Profile
- Center Line (*Note: The profile cannot cross over the center line!*)



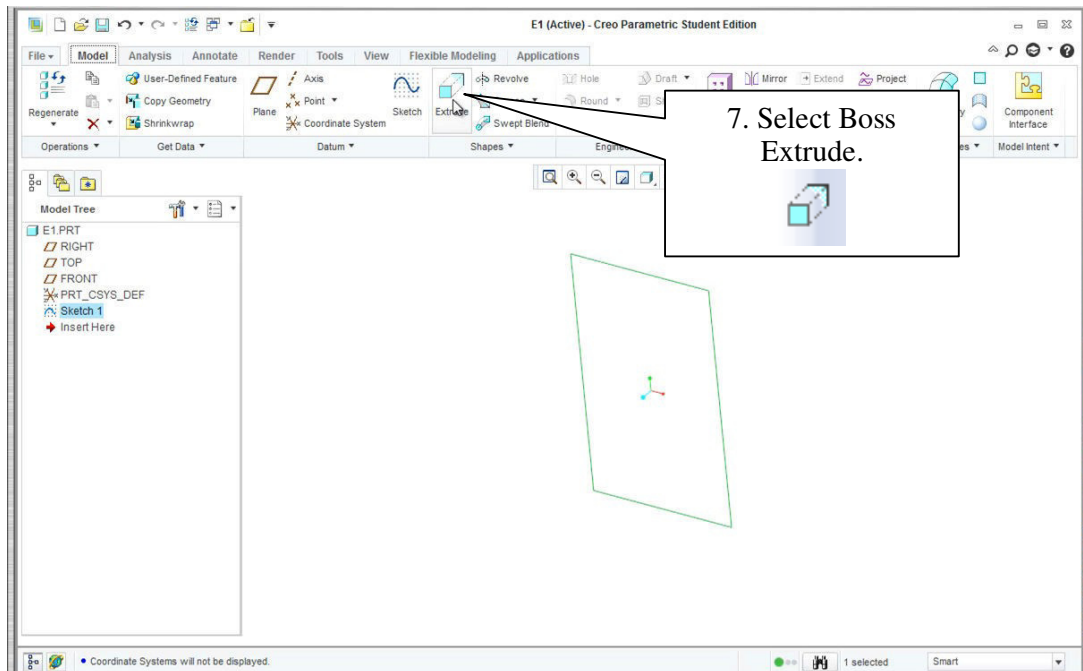
# EXERCISE 1

## Introduction to basic part modeling

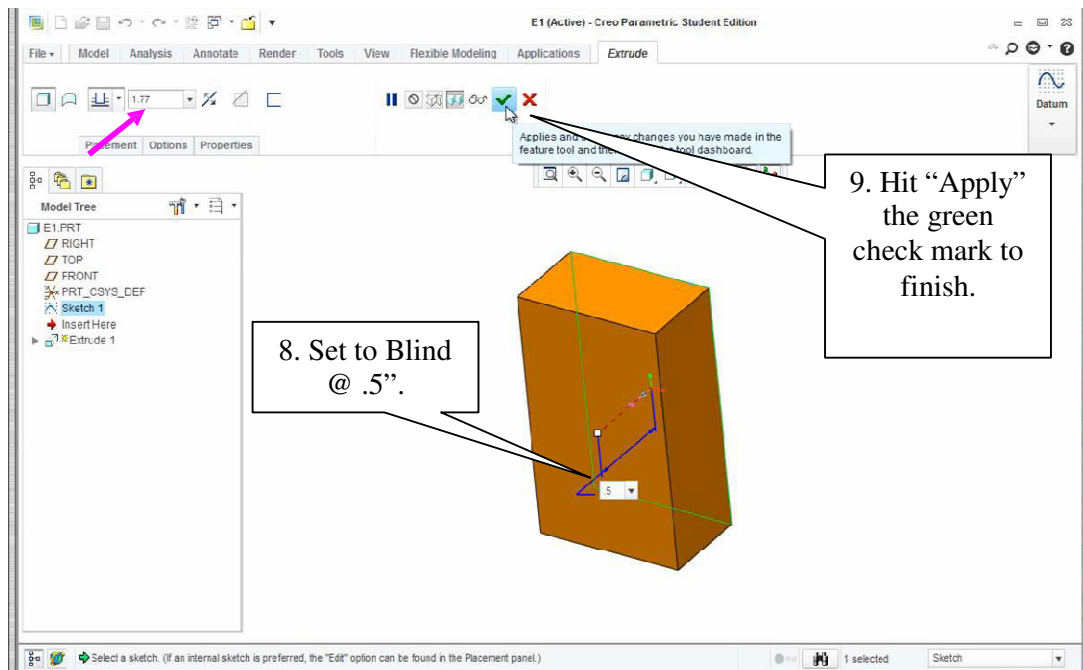
**Base Extrude Features** create a 3D solid representation by extruding a 2 dimensional profile of the entity.

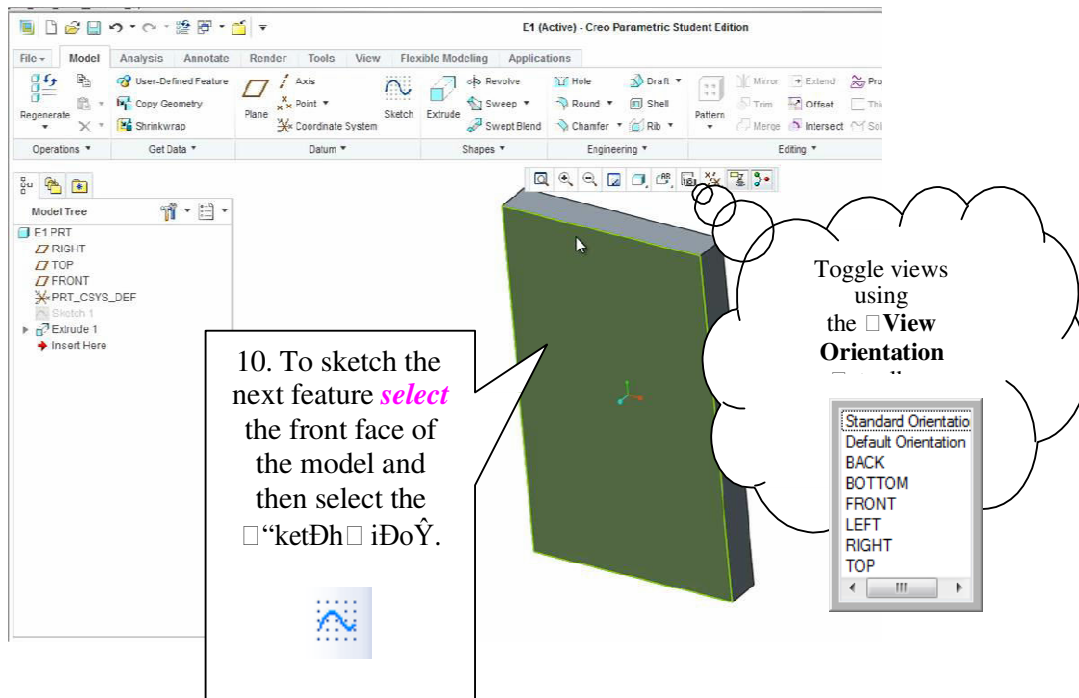




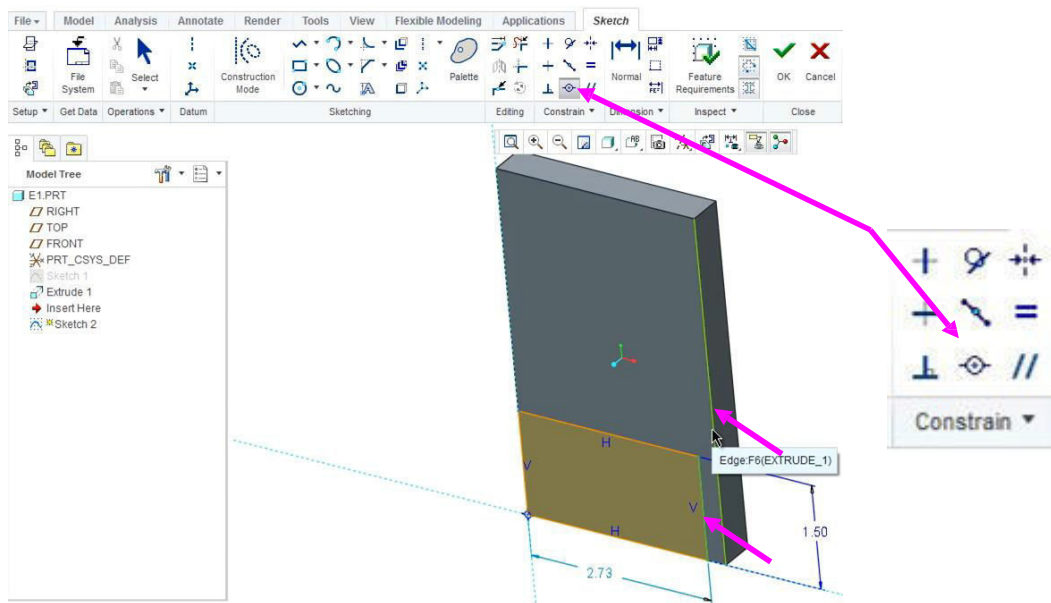


NOTE: When dimensioning use the dimension tool and make edge selections, mouse center button click to apply dimension.

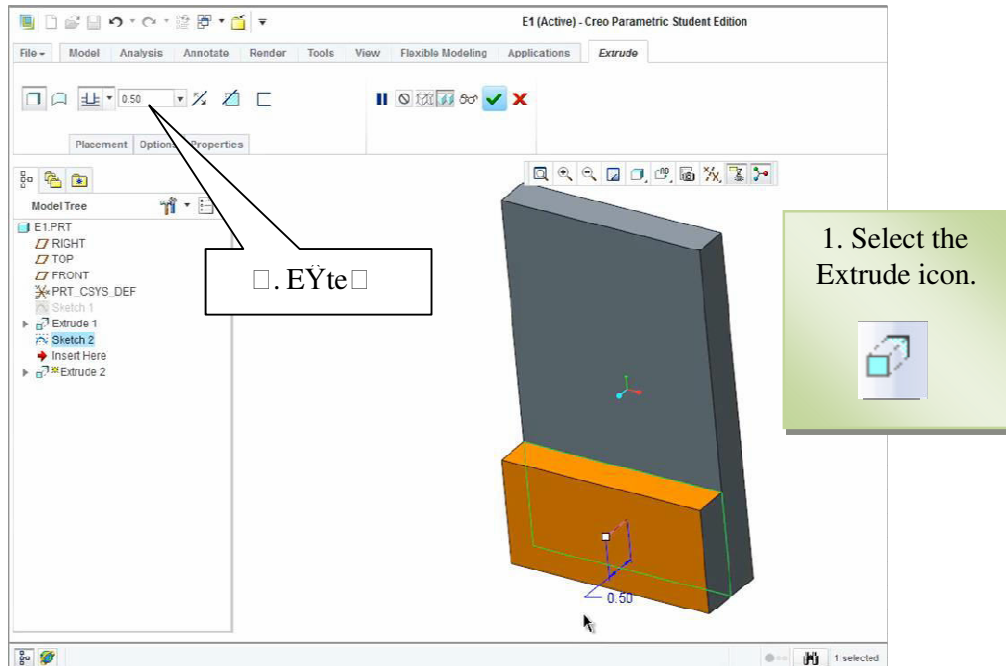




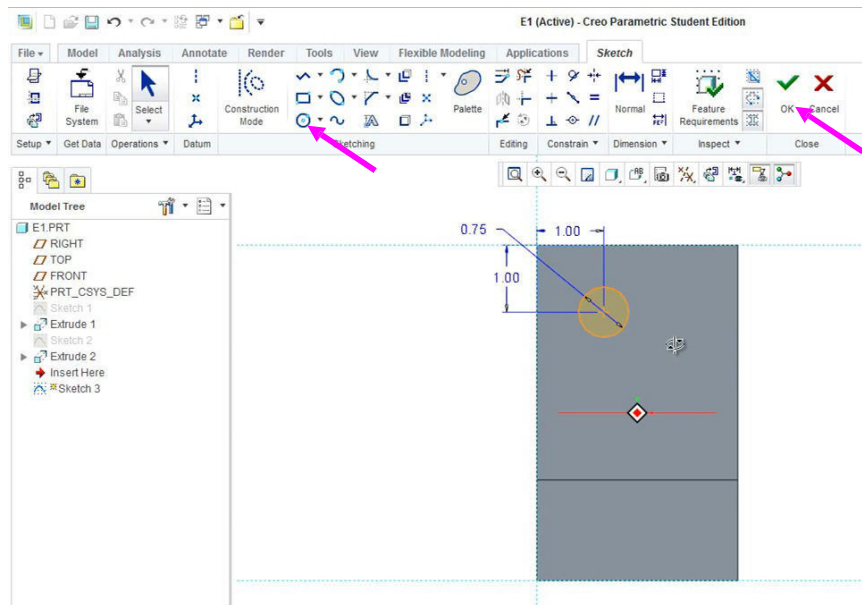
**Adding a constraint** – Ctrl Select both left edges of sketch and solid. Select Coincident



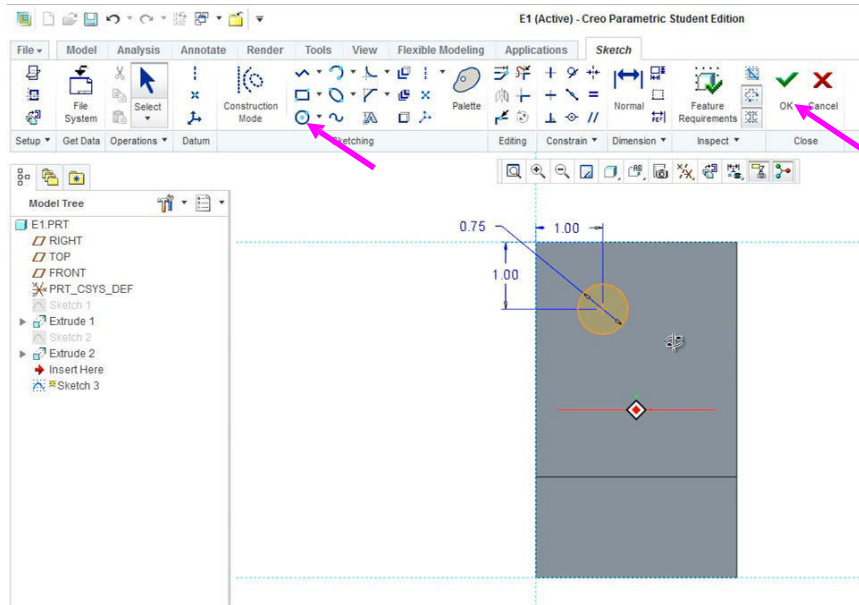
**Extrude**



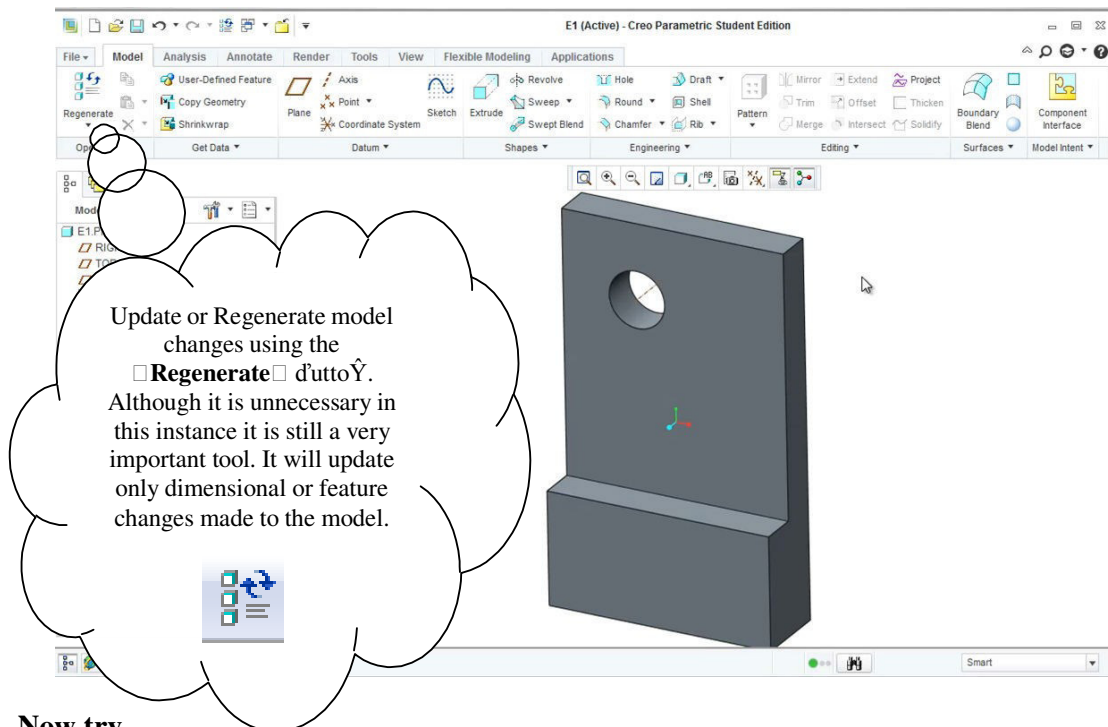
Select the face, select sketch icon and draw a circle on the face. Dimension, Hit ☐ Ok ☐



Select the face, select sketch icon and draw a circle on the face. Dimension, Hit ☐ Ok ☐

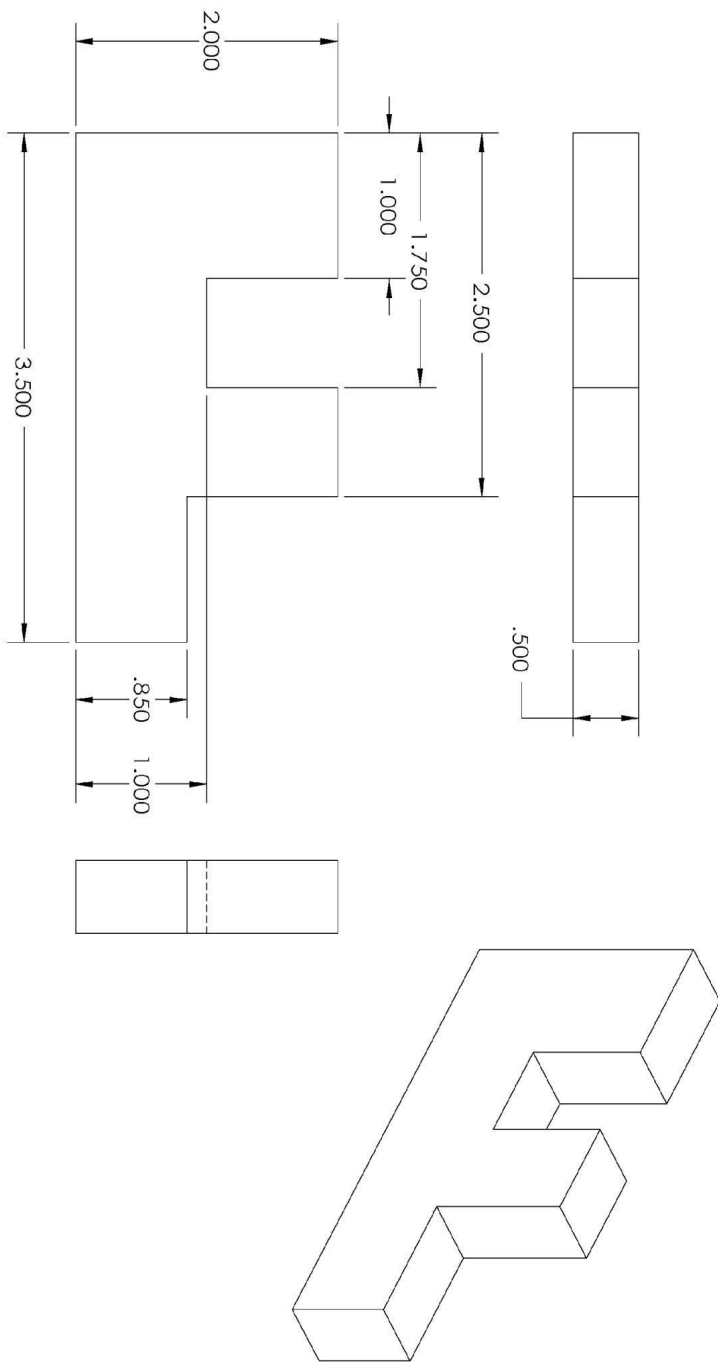


Go to file save



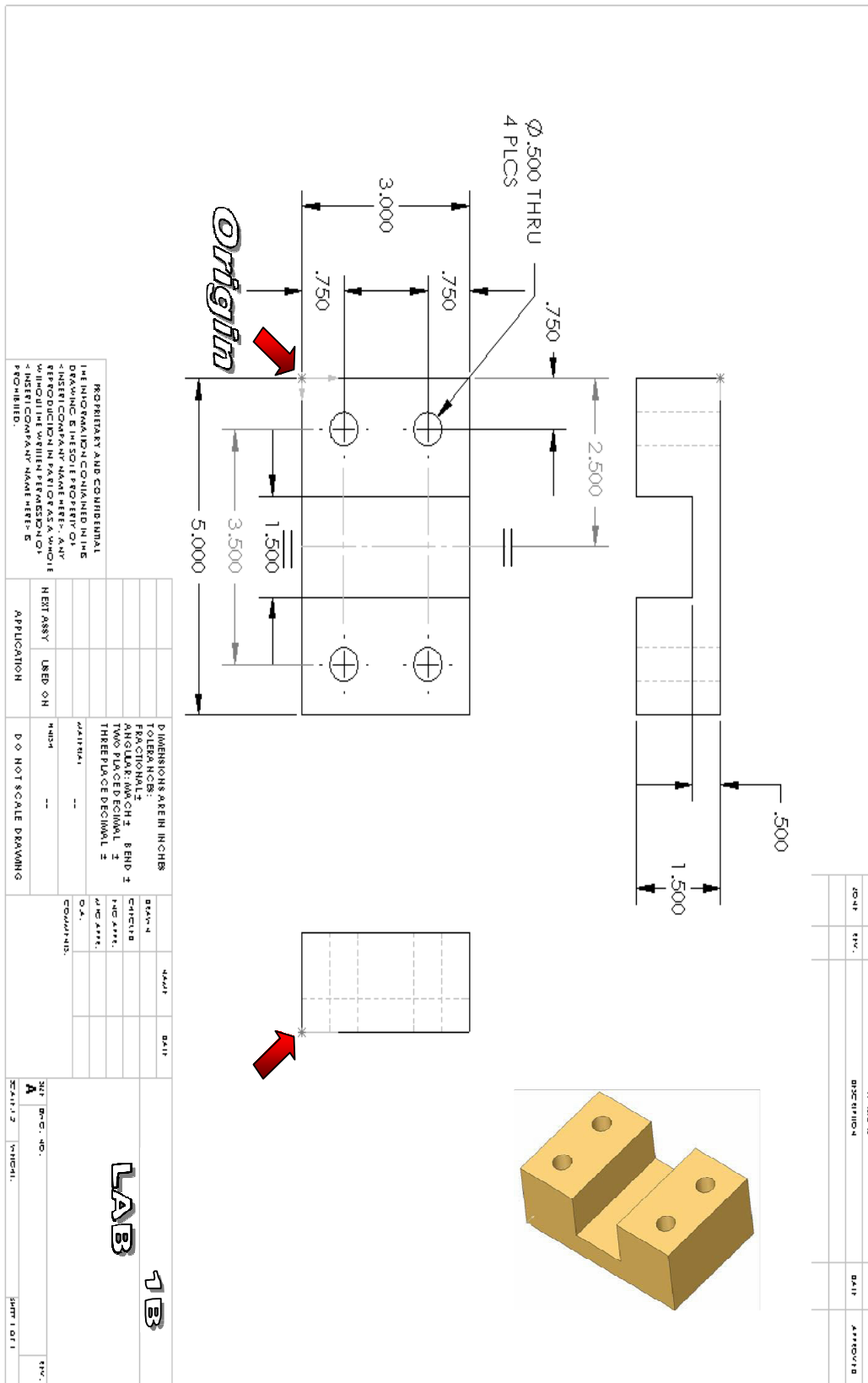
**Now try**

*NOTE: Patterns/Arrays and Mirroring will be covered in the next three chapters. Please try to model LAB 1 without using them. It's good practice to just dimension and sketch all geometry when first starting out learning this software.*



UNLESS OTHERWISE SPECIFIED:			
DIMENSIONS ARE IN INCHES		DRAWN	NAME
TOLERANCES:		CHECKED	DATE
FRACTIONAL ±		ENG APPR.	
DECIMAL ±		MFG APPR.	
HOLE POSITION ±			
TWO PLACE DECIMAL ±			
THREE PLACE DECIMAL ±			
INTERPRET GEOMETRIC TOLERANCING PER:		COMMENTS:	
MATERIAL		Q.A.	
FINISH			
NEXT ASSY			
USED ON			
APPLICATION			
DO NOT SCALE DRAWING			
5		2	
4		1	
3		1	
2		1	
1		1	
TITLE:		SIZE DWG. NO. REV	
L1		A Part1	
SCALE: 1:1		WEIGHT: 1	
SHEET 1 OF 1			

PROPRIETARY AND CONFIDENTIAL  
THE INFORMATION CONTAINED IN THIS  
DRAWING IS THE SOLE PROPERTY OF  
MILITARY AERONAUTICAL  
REPRODUCTION IN PART OR AS A WHOLE  
WITHOUT THE WRITTEN PERMISSION OF  
MILITARY AERONAUTICAL  
<INSERT COMPANY NAME HERE> IS  
PROHIBITED.

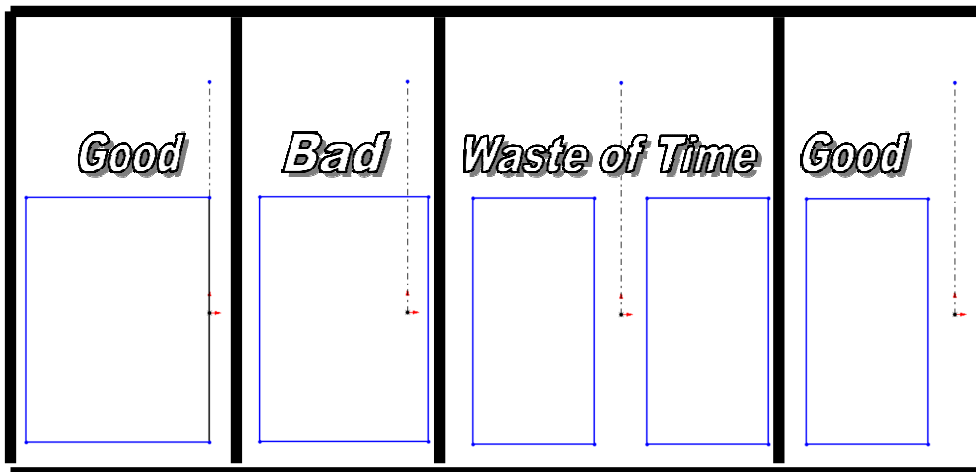
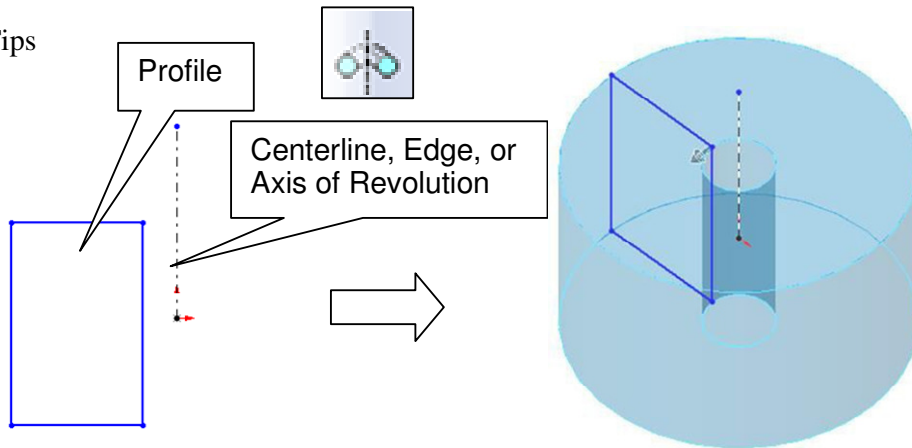


## EXERCISE 2

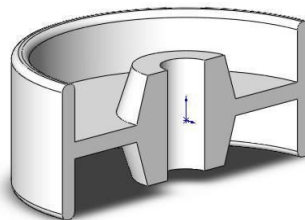
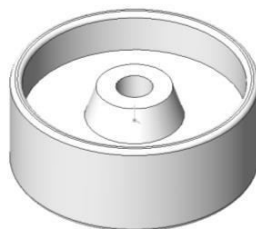
### Revolved Features

**Revolved Feature** - creates features that add or remove material by revolving one or more profiles around a centerline. The feature can be a solid, a thin feature, or a surface.

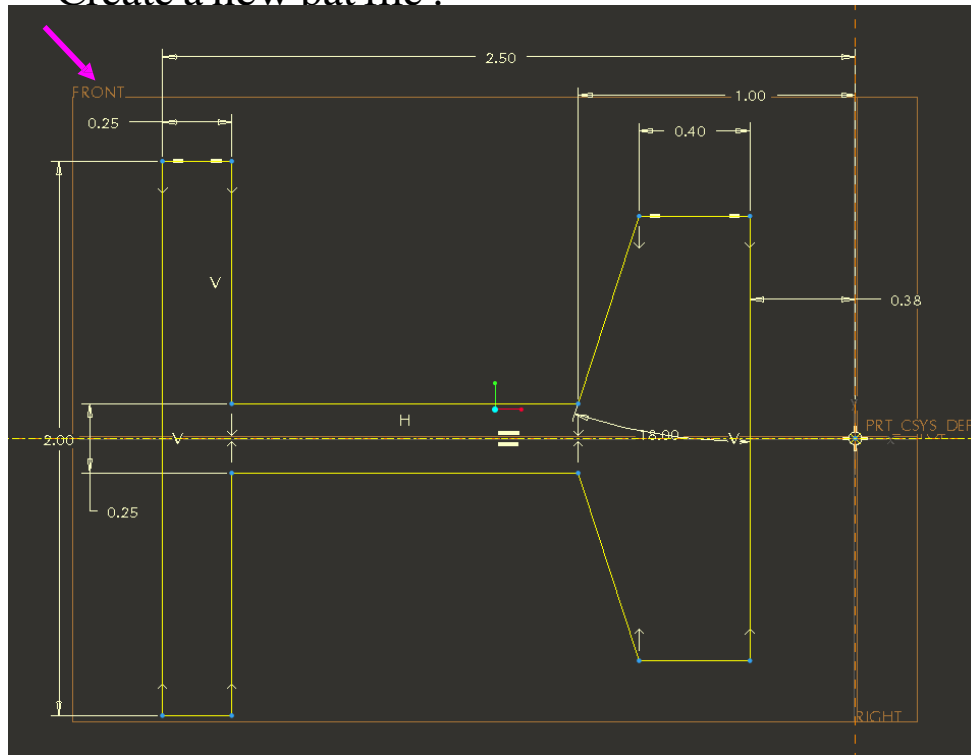
Tips



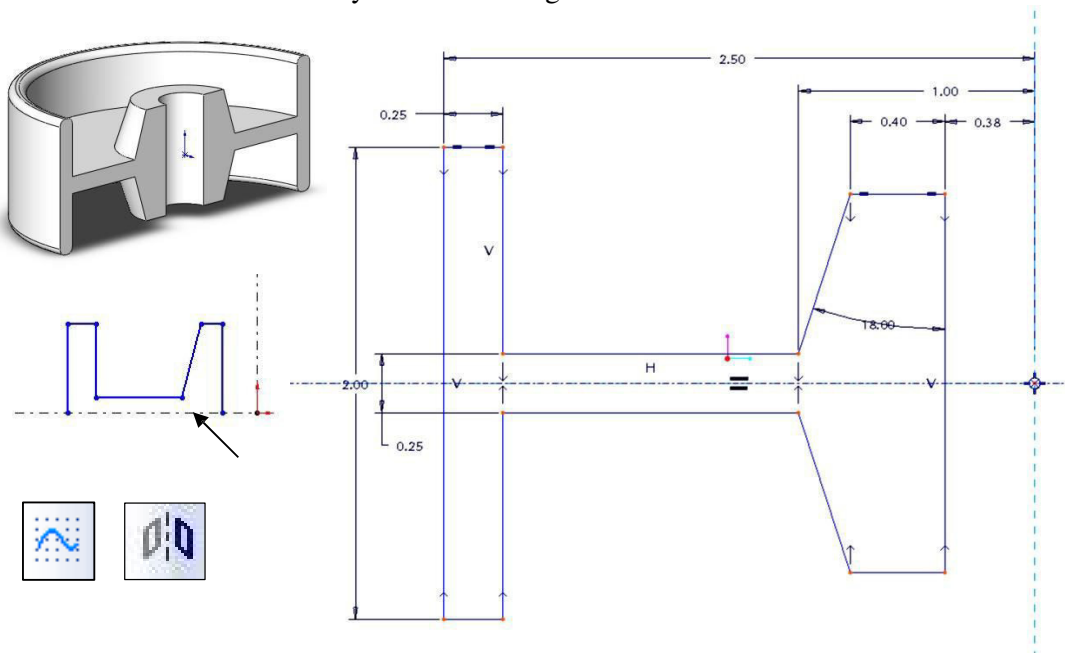
The profile should never cross over the centerline, nor should there be profiles on both sides of the centerline.



1. Create a new pat file .



2. using the dimension tool to create a ¼ of the geometry and then sweep it to the other side. Make sure you finish adding the dimensions.

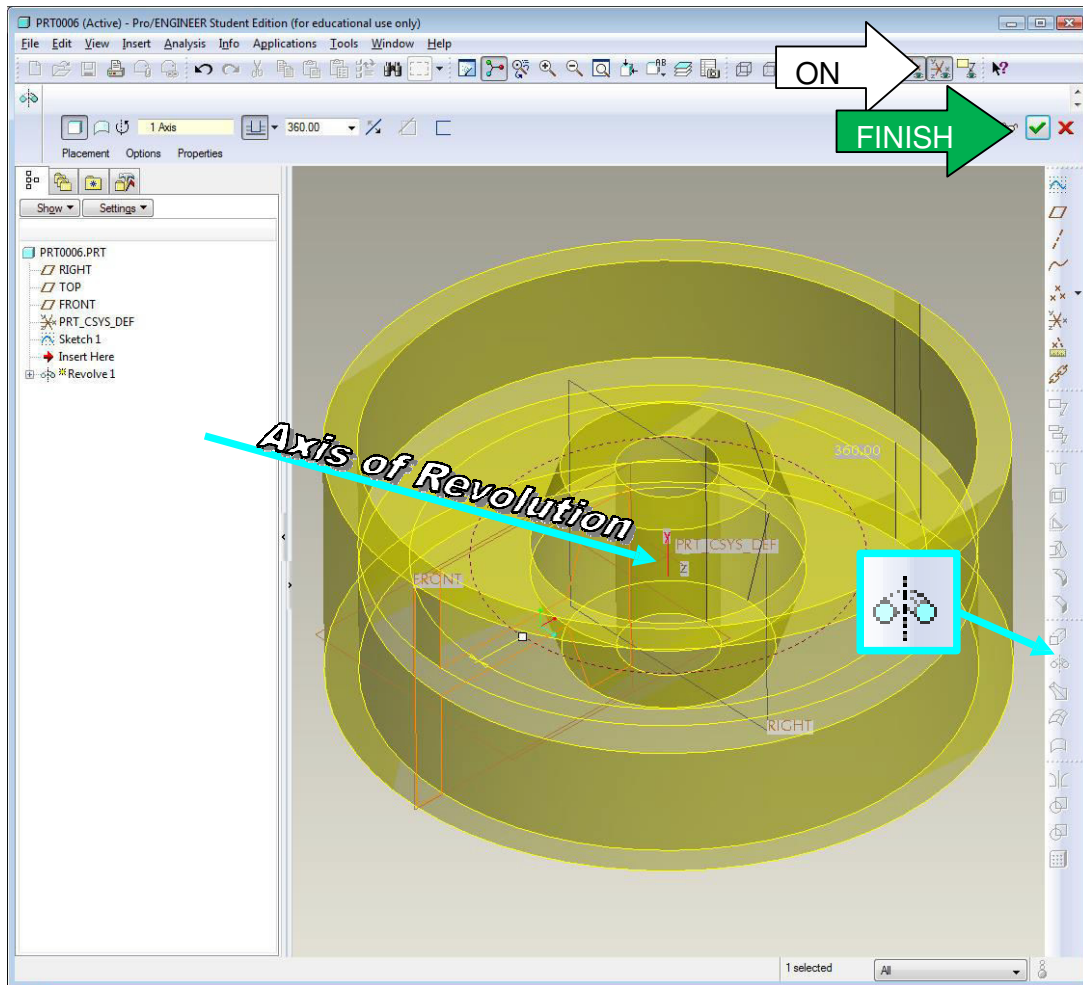


1. Select the **Revolve** feature icon.



Then select the axis/centerline.



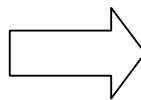
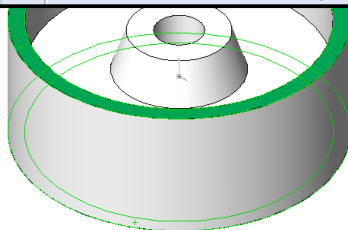
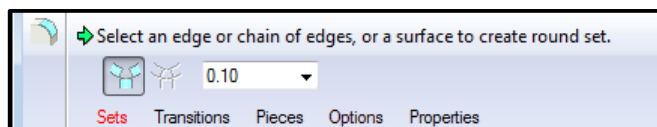


## Rounds

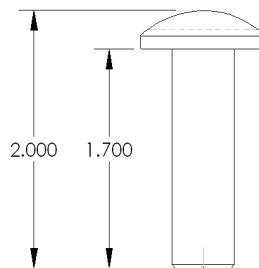
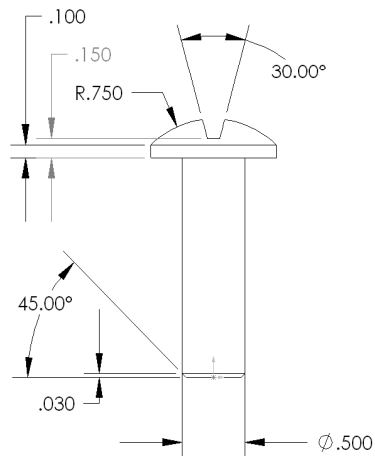
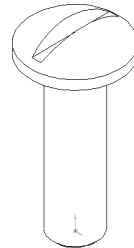
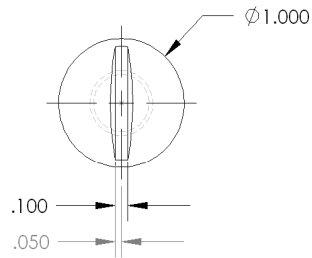
4. Select the top and bottom edges and add a



ds/fillets.



REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED



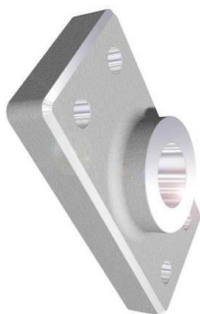
**Origin**

<b>PROPRIETARY AND CONFIDENTIAL</b> THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF <INSERT COMPANY NAME HERE>. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF <INSERT COMPANY NAME HERE> IS PROHIBITED.		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±		NAME	DATE	<b>LAB 2</b>
		MATERIAL —		DRAWN		
		FINISH —		CHECKED		
		NEXT ASSY USED ON		ENG APPR.		
APPLICATION		DO NOT SCALE DRAWING	COMMENTS: Q.A. MFG APPR.		SIZE DWG. NO. <b>A</b>	REV.
			SCALE: 1:1 WEIGHTS:		SHEET 1 OF 1	

Technical drawing of a mechanical part, likely a bracket or base plate, showing dimensions and features. The part is a rectangular plate with a central circular feature and four smaller circular features. The dimensions are as follows:

- Overall width: 6.000
- Overall height: 3.000
- Central circular feature:  $\Phi 1.250$  THRU
- Four smaller circular features:  $\Phi .500$  THRU, 4 PLCS
- Top edge: 1.000
- Bottom edge: .750
- Left edge: .750
- Right edge: .750
- Top-left corner: R.250
- Bottom-right corner: R.250
- Top-right corner: R.250
- Bottom-left corner: R.250 TYP.
- Chamfer: .125 x 45° CHAMFER

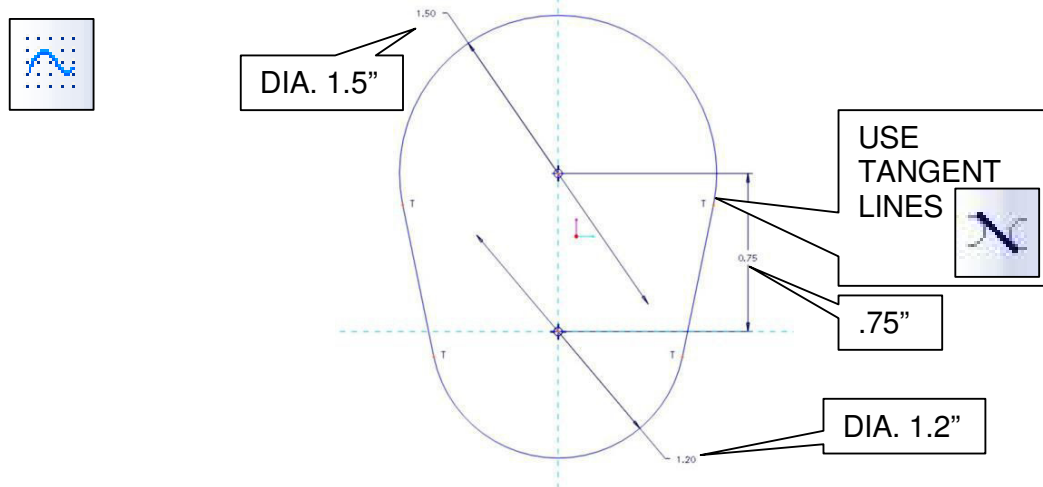
A 3D model of the part is shown in the top right corner, illustrating its isometric view.



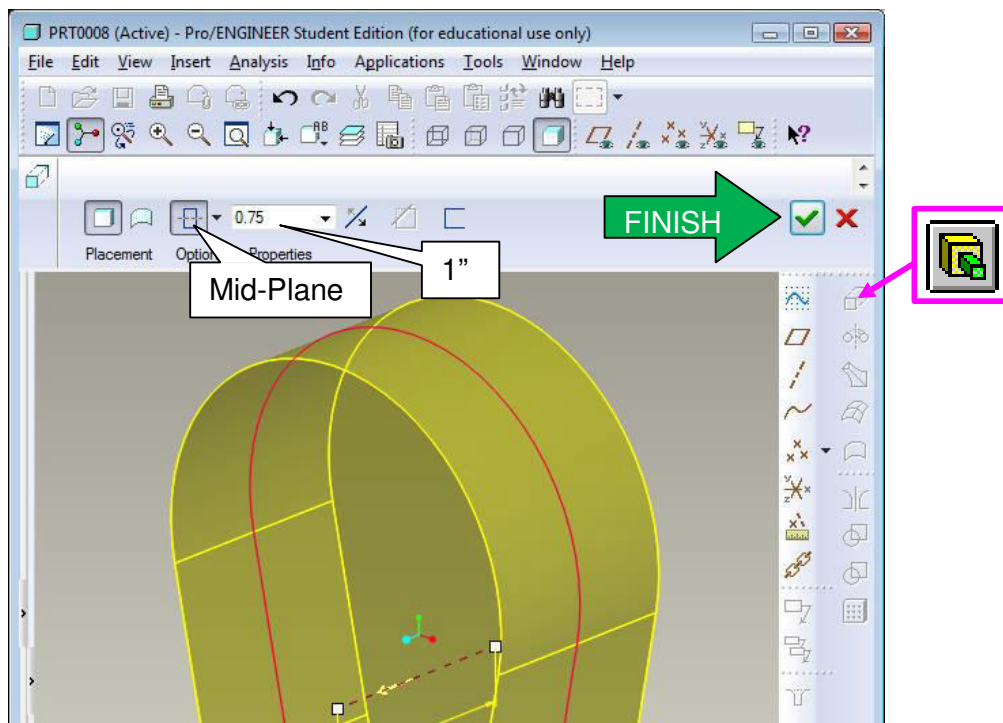
## EXERCISE 3

### Secondary Feature Modeling

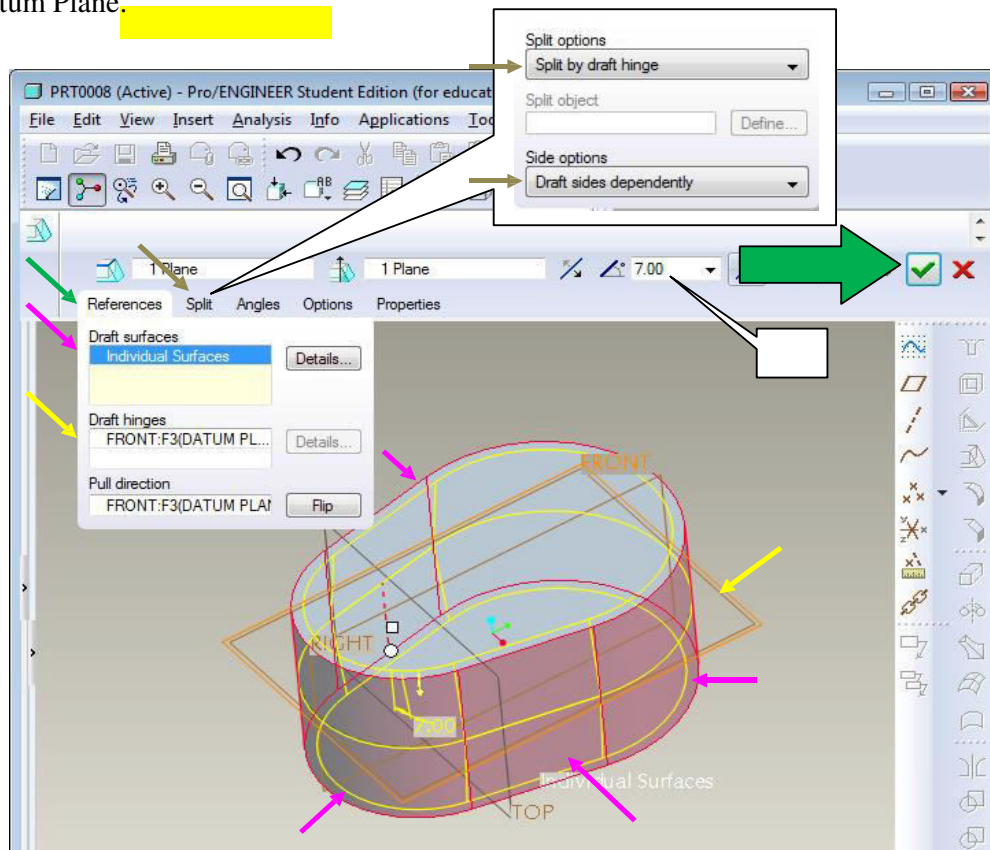
1. Sketch the geometry as shown below on the front plane.



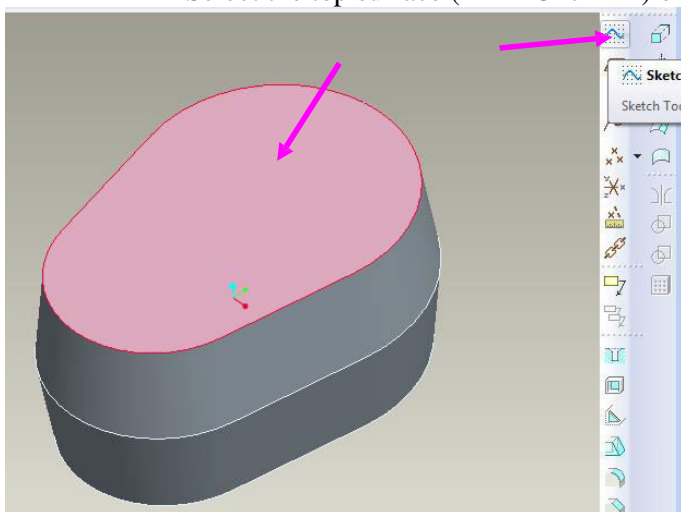
2. **Extrude.** Select Mid-Plane,



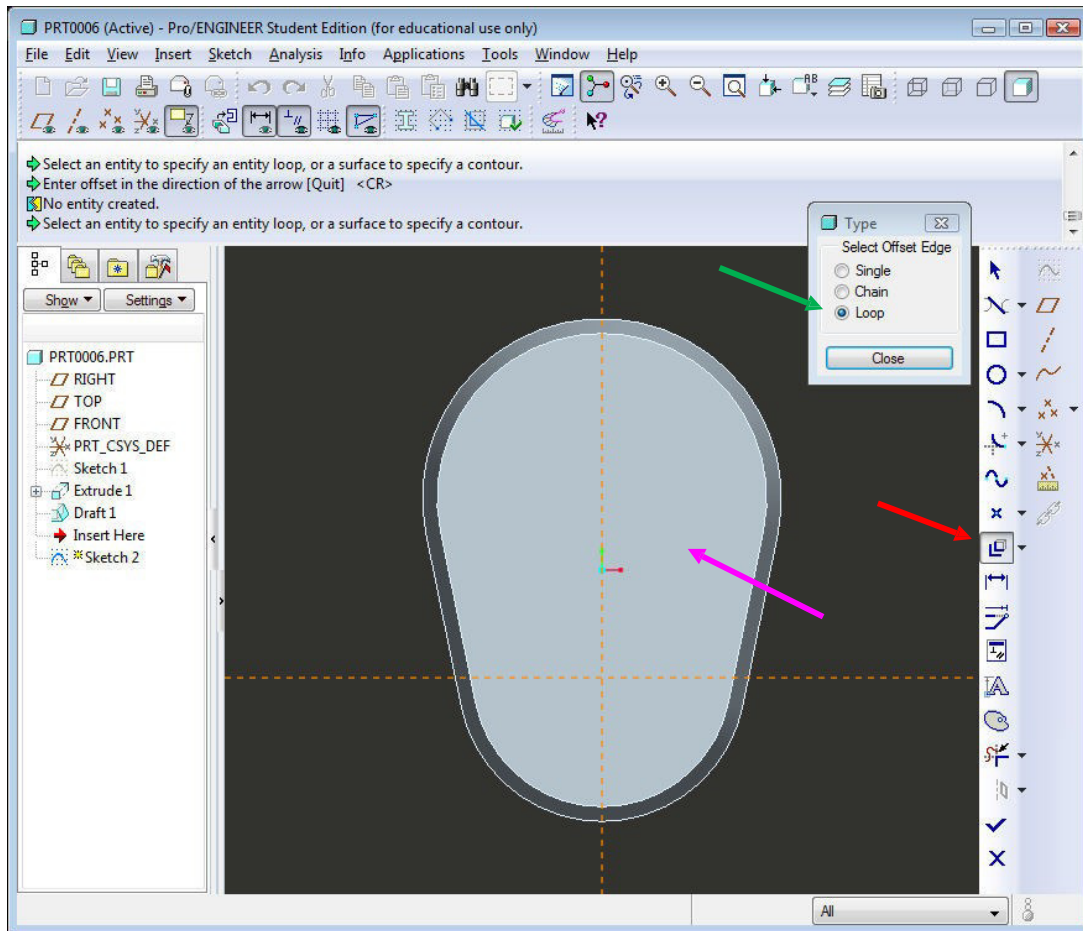
1. **DRAFT:** Select the Draft tool, and then References, Ctrl select all side faces of the model. Then Click on the draft hinges dialog box, and select the Front Datum Plane.



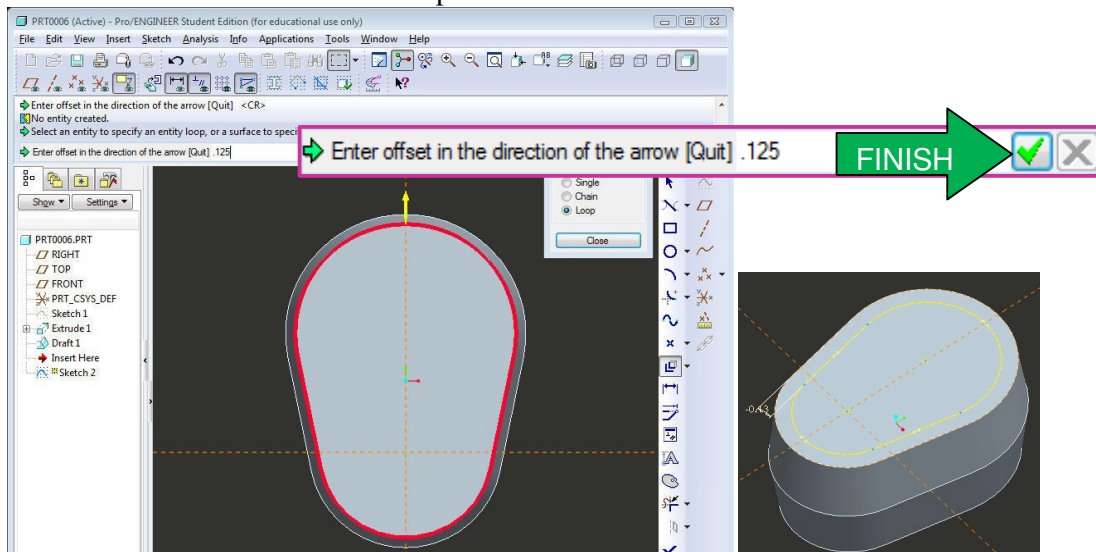
2. Select the top surface (LMB Click 2 x) on the model and start a sketch on it.



3. **OFFSET:** Select the **Offset** tool. Then select **Loop**. Then select the **face**.

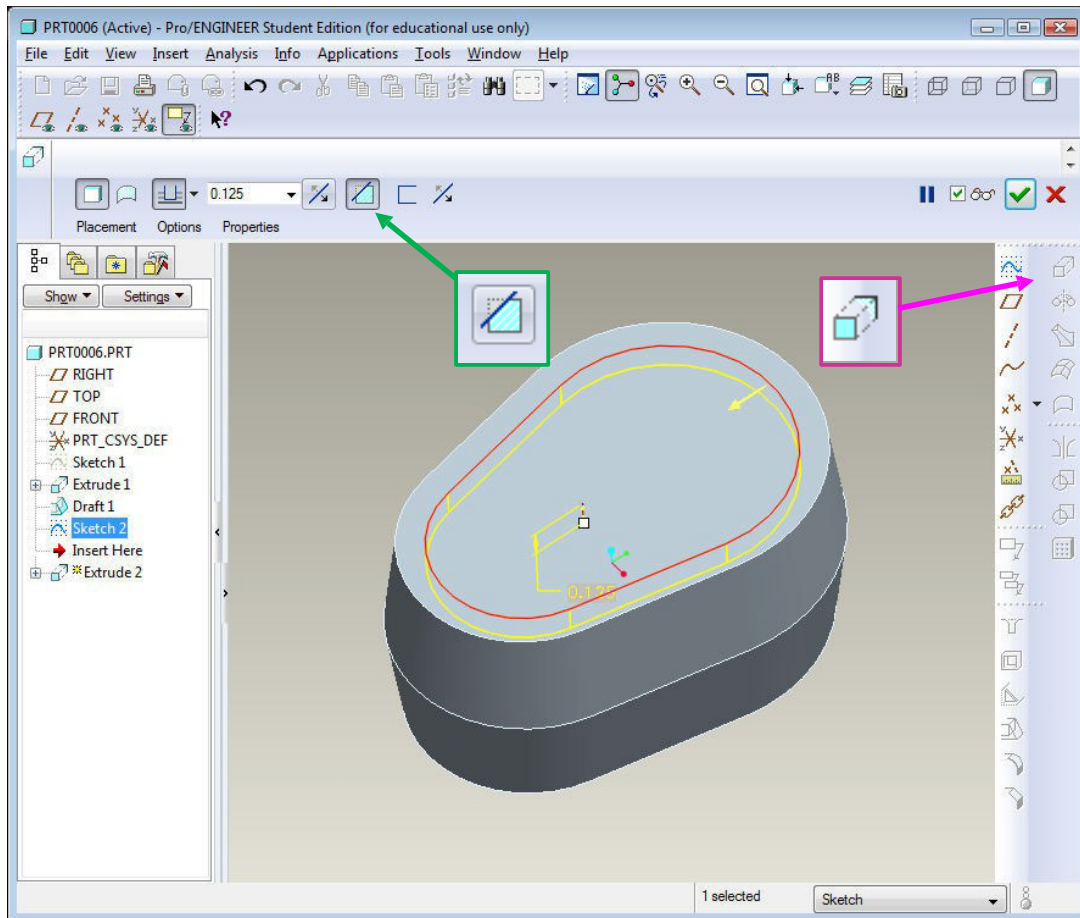


1. Enter **-.125** and to flip the offset direction.

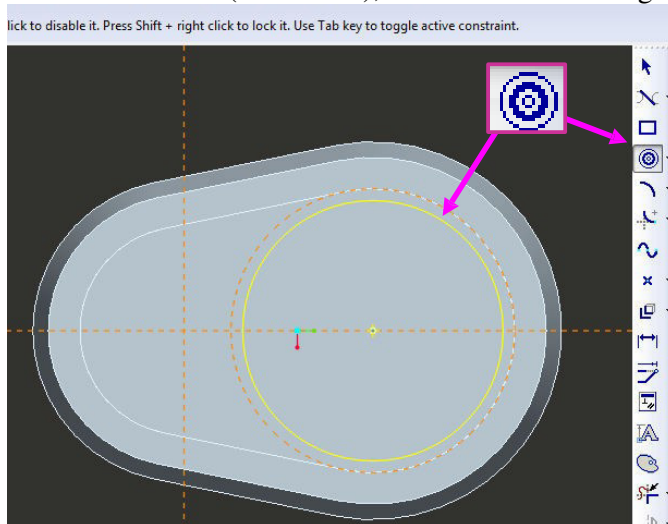


1. Select the **extrude** icon, and then set to **cut** and **.125** depth.

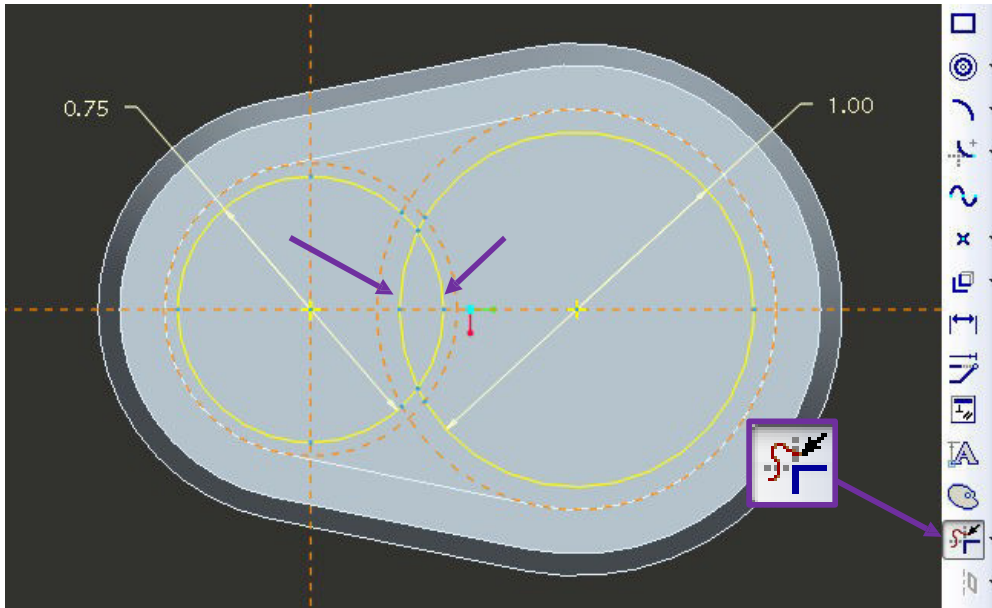




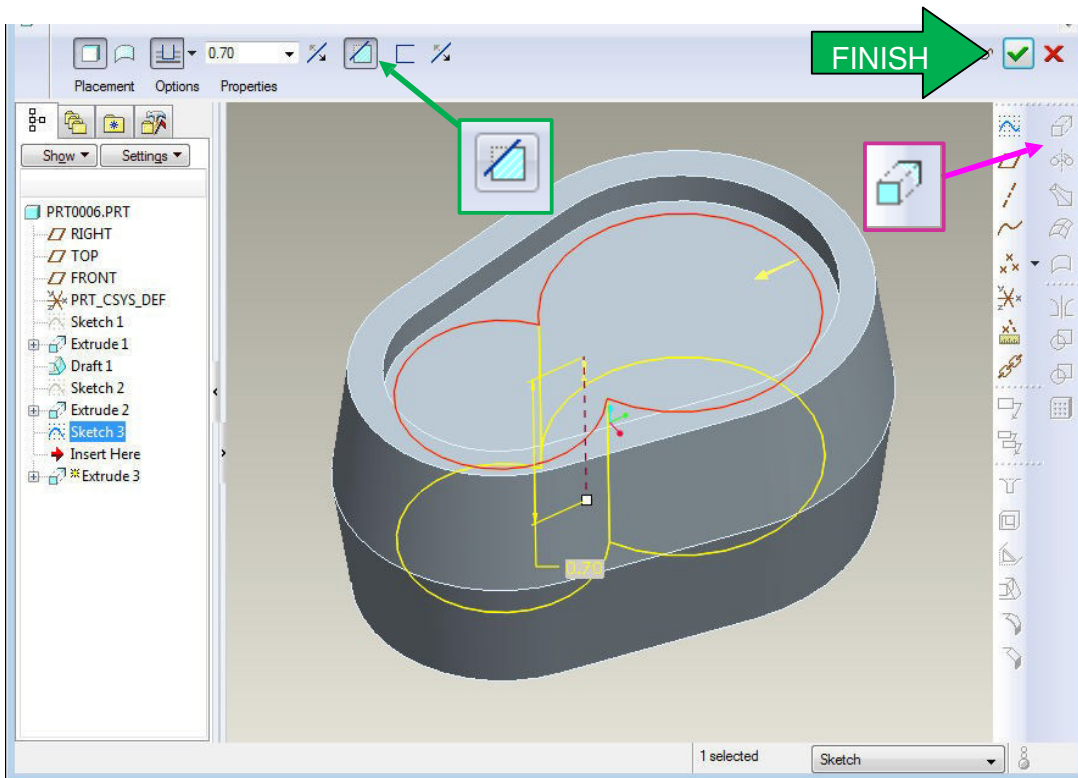
Select Concentric (Circle tool), then select the arc edge of the part.



9. **Trim** the intersection.

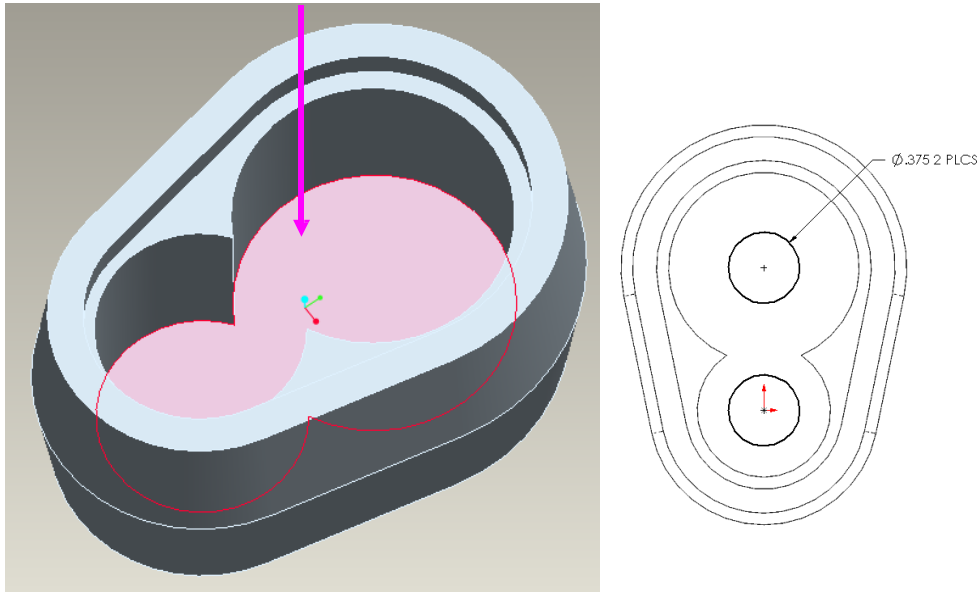


9. Select the extrude icon, and cut depth.

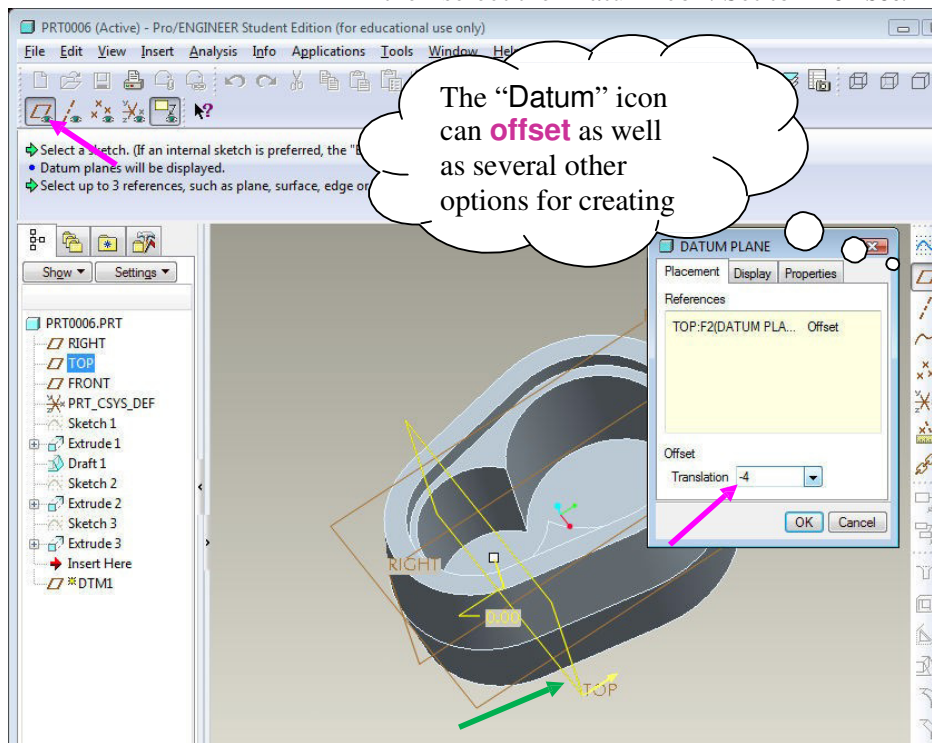


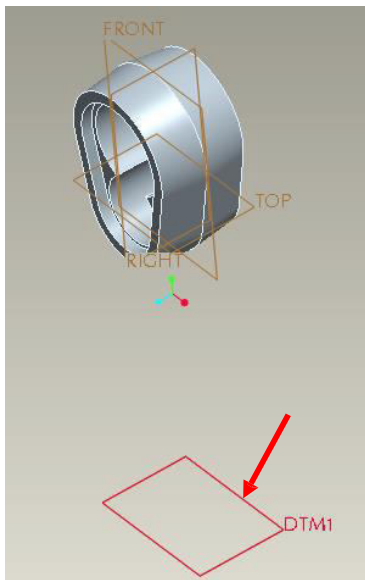
10. Select the base of the pocket and start a sketch. Draw the following two .375 DIA. circles, and extrude.



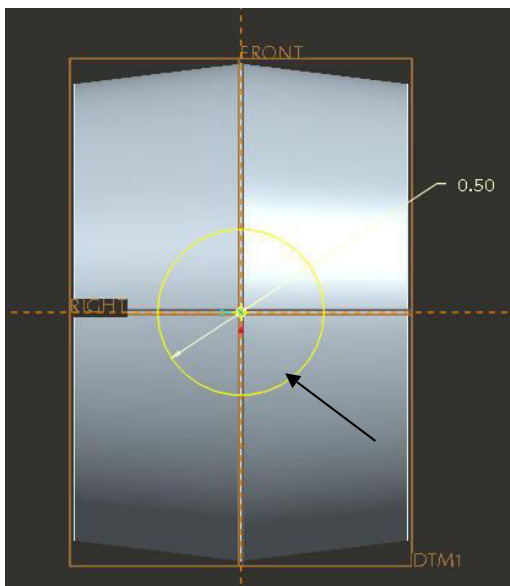


11. **DATUM PLANE OFFSET:** Select the Top datum plane, then select the Datum icon. Set to **-4 offset**.

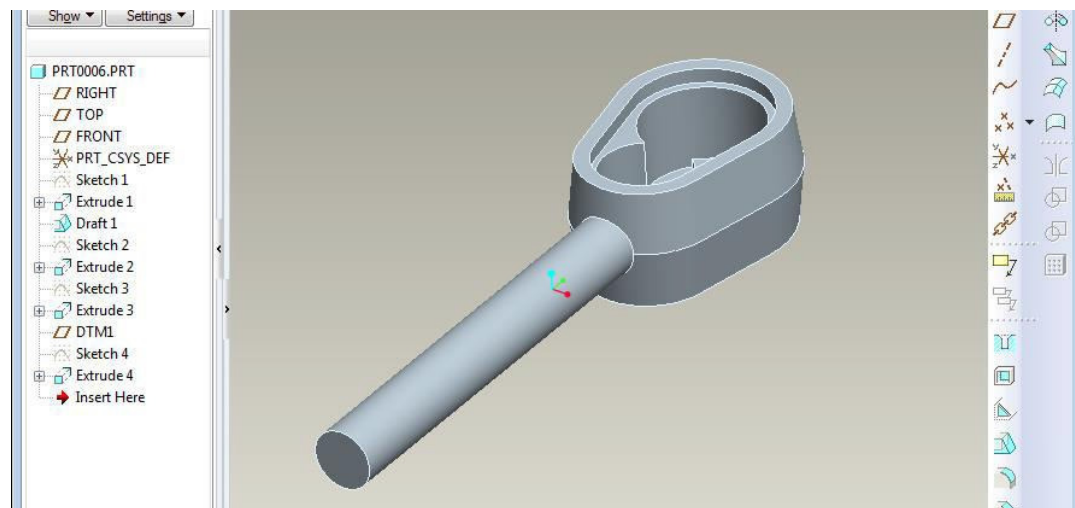
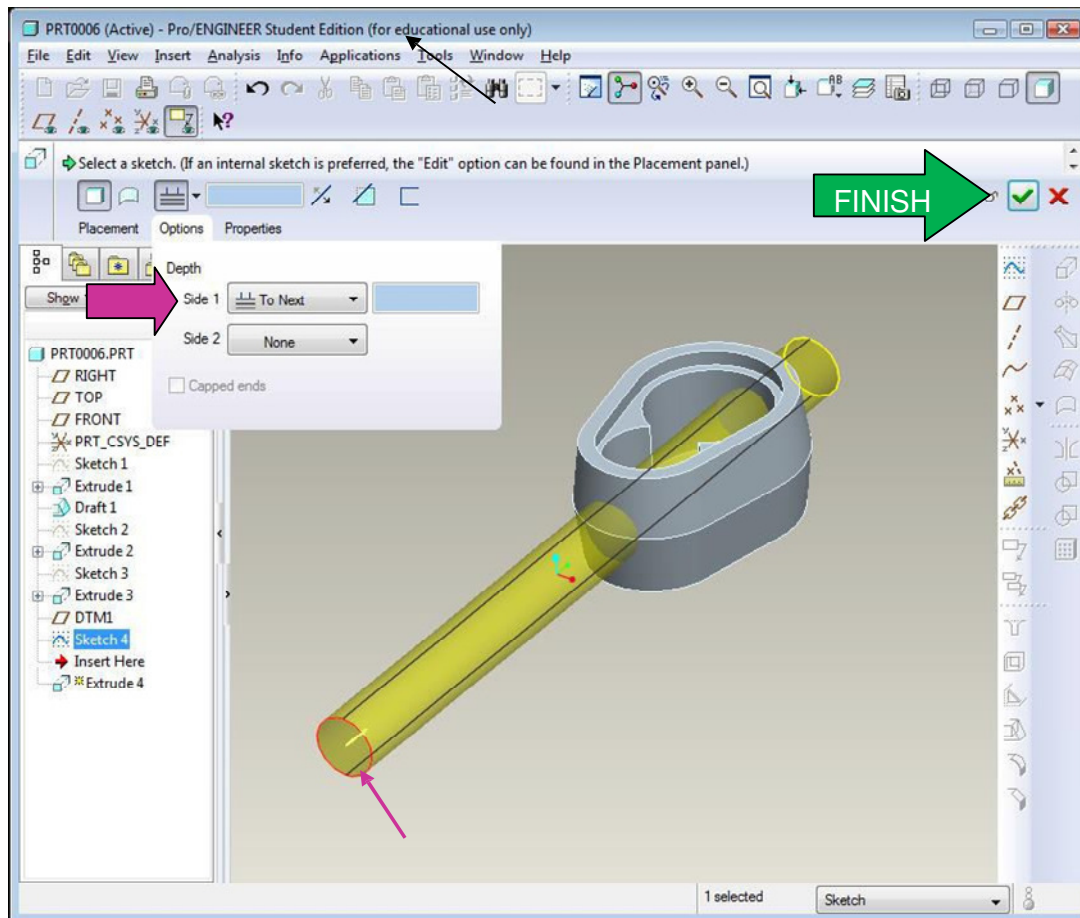




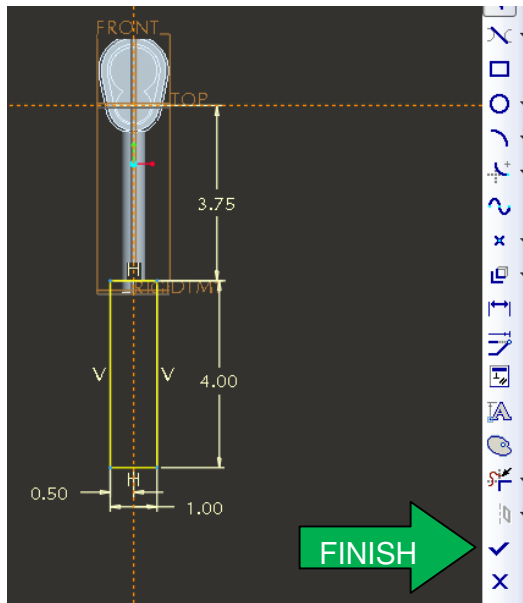
## 12. Extrude



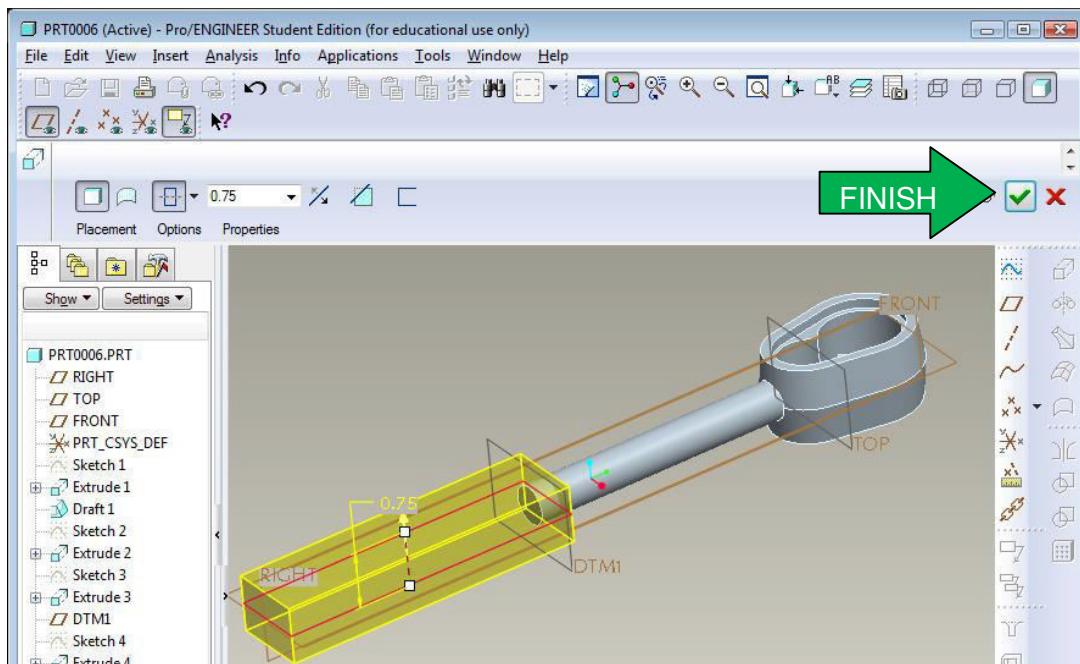
15. Select the circle and use the setting as shown in the illustration below.



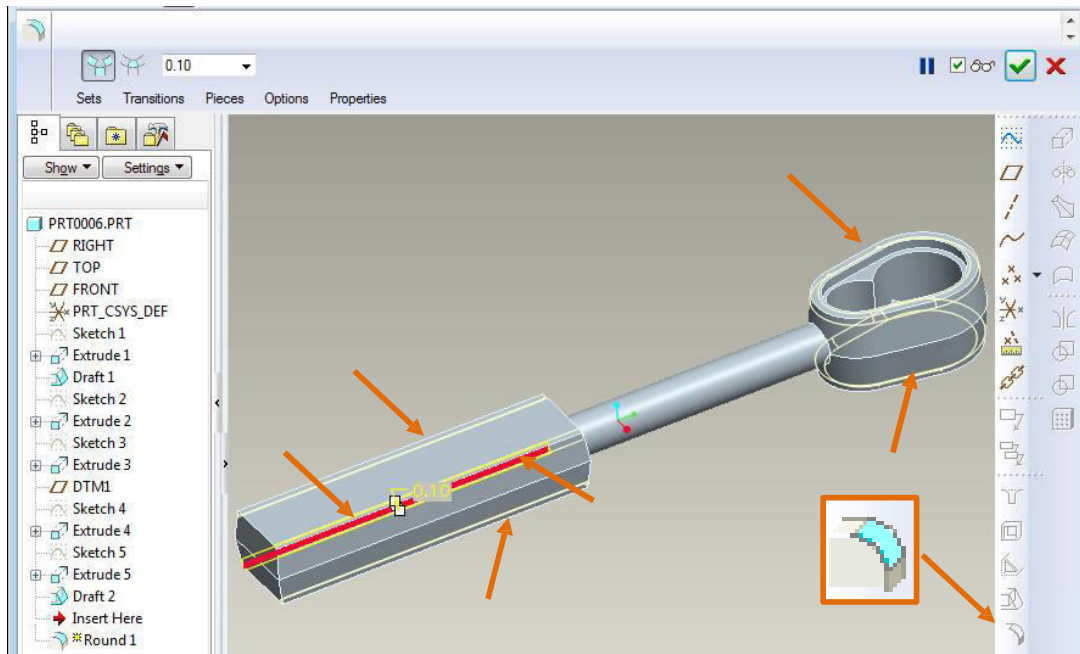
17. Start a sketch on the front datum plane and draw a rectangle with the following dimensions.



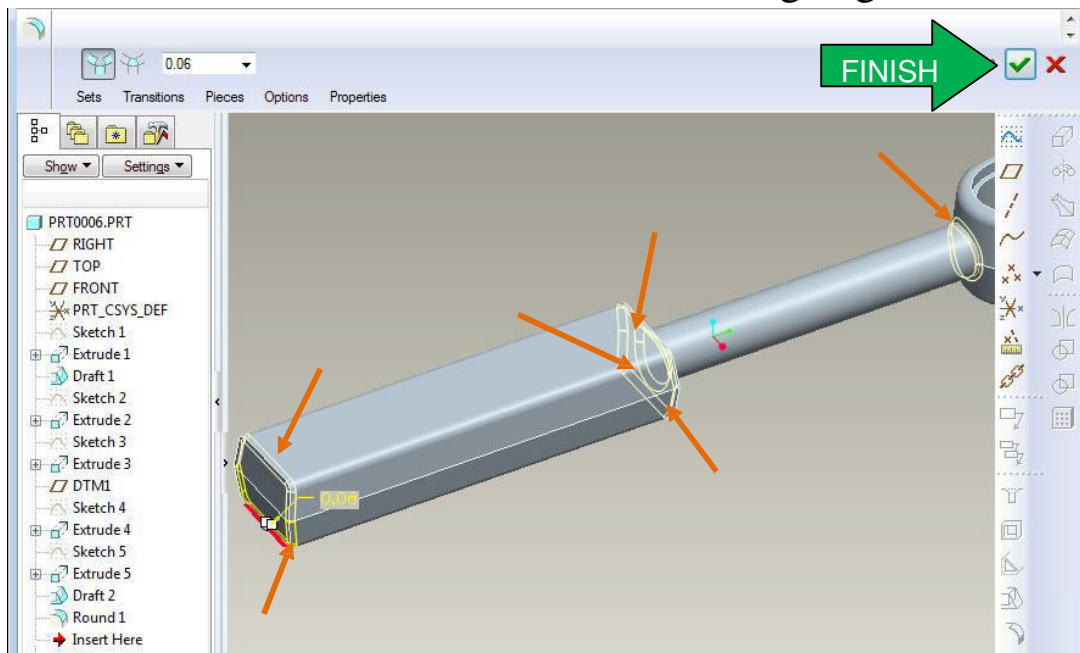
18. Extrude boss using the mid-plane option and .750 thick.

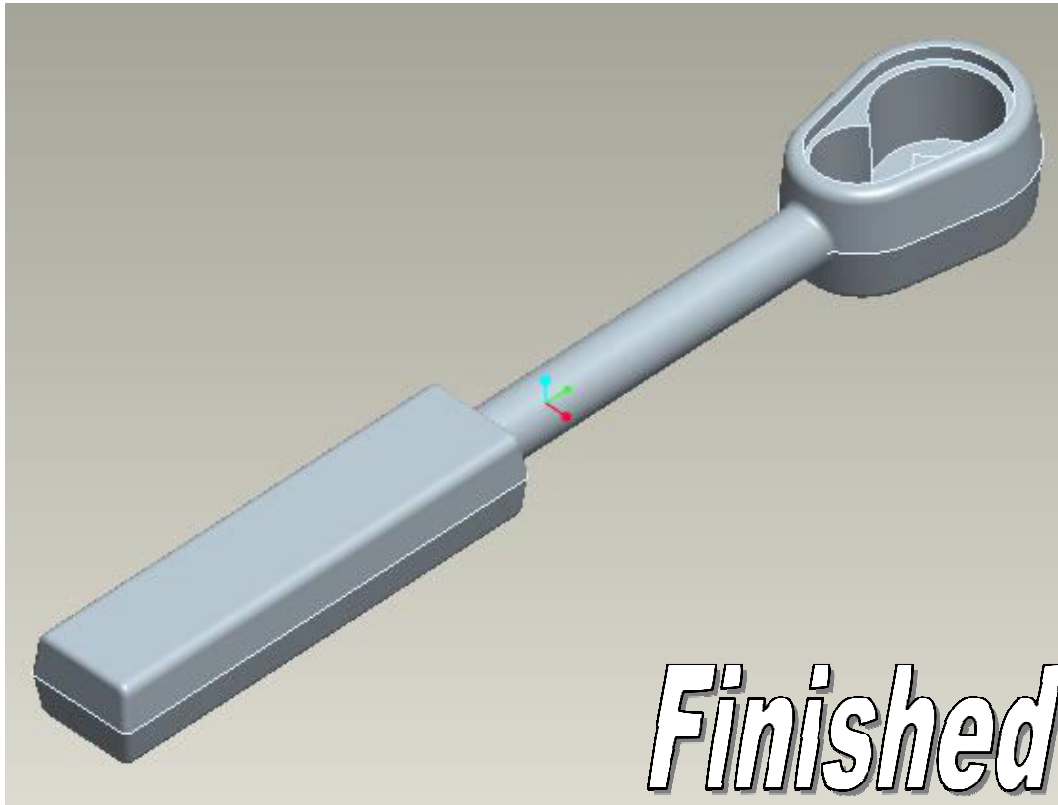


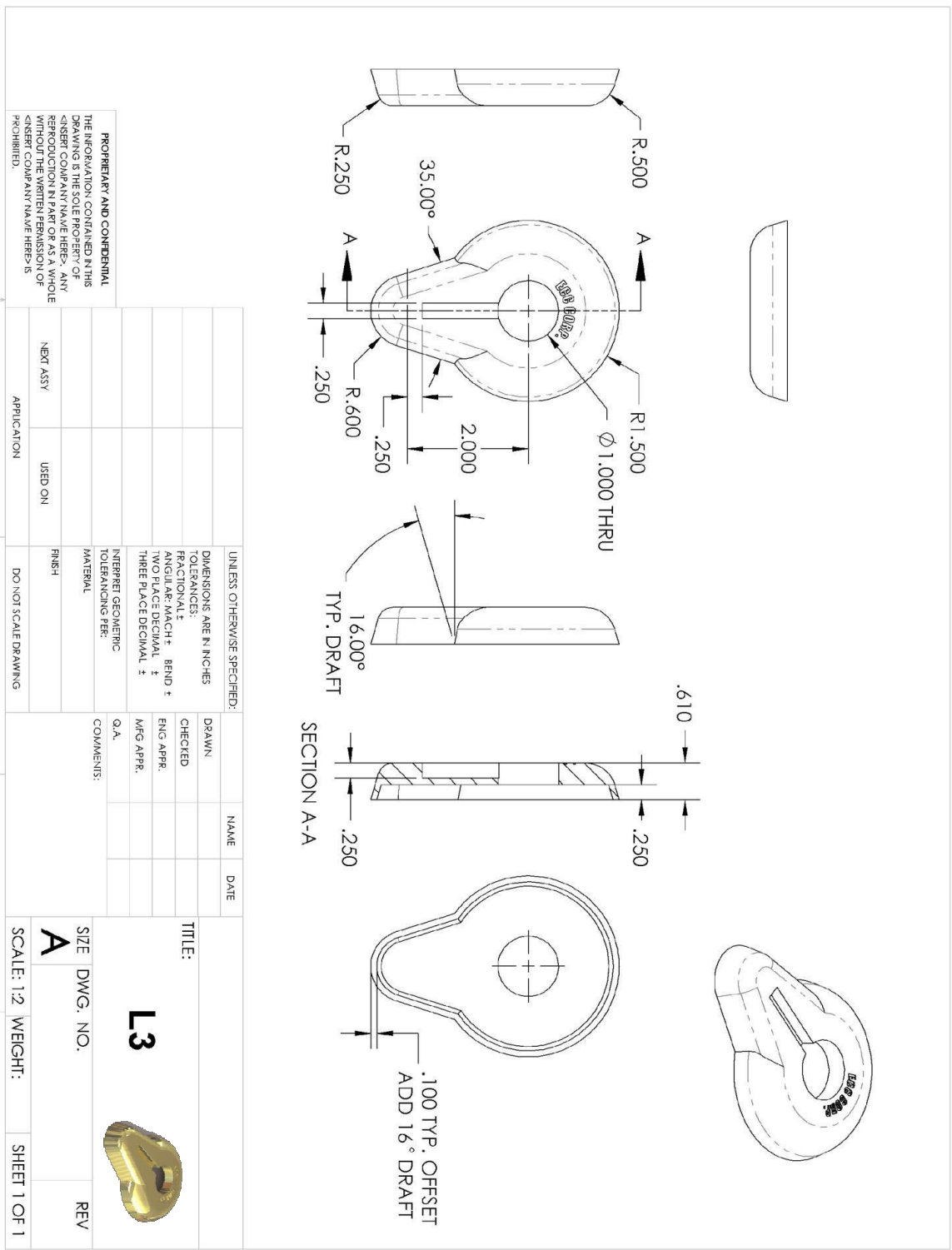
19. **Rounds:** Select the rounds/fillet icon, then select the edges as shown in the illustration below. Add..

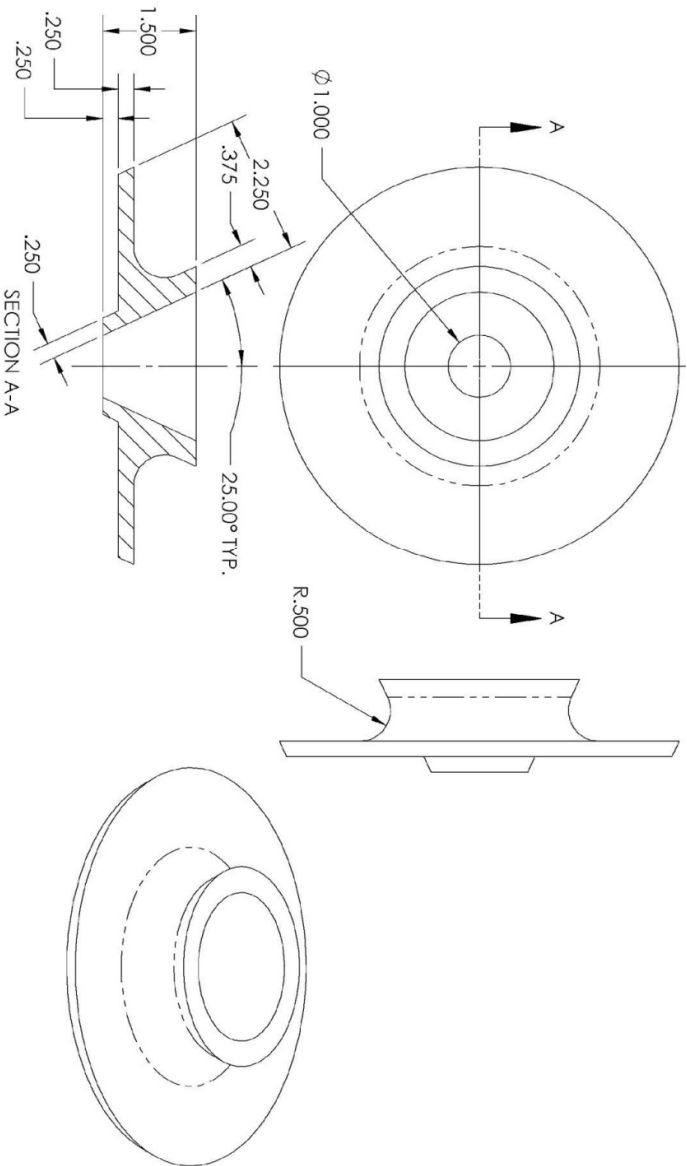


20. Add . ☐ ☐ ☐ ☐ Rounds to the following edges.









PROPRIETARY AND CONFIDENTIAL  
THE INFORMATION CONTAINED IN THIS  
DRAWING IS THE SOLE PROPERTY OF  
SASER COMPANY MAKE HERE. ANY  
REPRODUCTION OR TRANSMISSION  
WITHOUT THE WRITTEN PERMISSION OF  
SASER COMPANY NAME HERE IS  
PROHIBITED.

UNLESS OTHERWISE SPECIFIED:		DRAWN		NAME		DATE	
DIMENSIONS ARE IN INCHES		CHECKED					
TOLERANCES:		FRACTIONAL ±		ENG APPR.			
ANGULAR: MACH ±		BEND ±		MFG APPR.			
TWO PLACE DECIMAL ±							
THREE PLACE DECIMAL ±							
INTERPRET GEOMETRIC		Q.A.					
TOLERANCING FEE:							
MATERIAL							
FINISH							
NEXT ASSY							
USED ON							
APPLICATION							
DO NOT SCALE DRAWING							

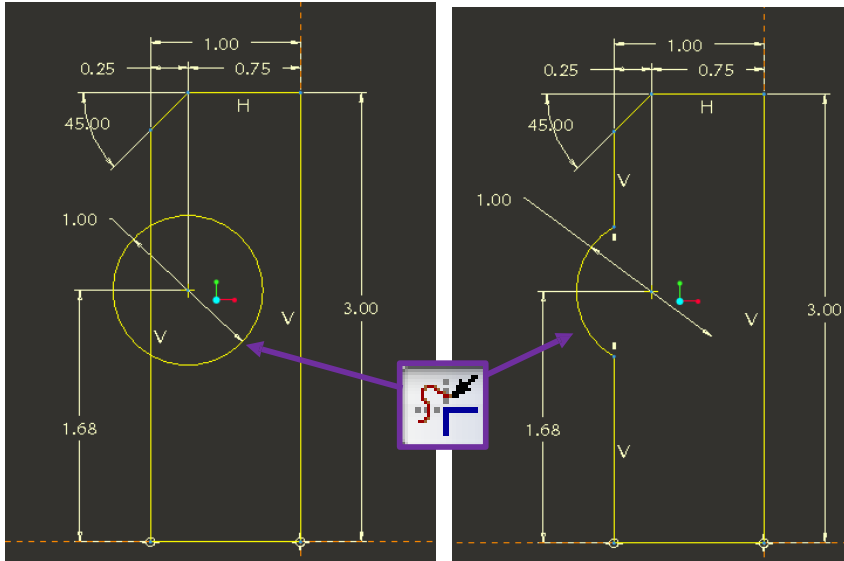
SIZE DWG. NO. REV  
**A** **L3b**  
SCALE: 1:2 WEIGHT: SHEET 1 OF 1



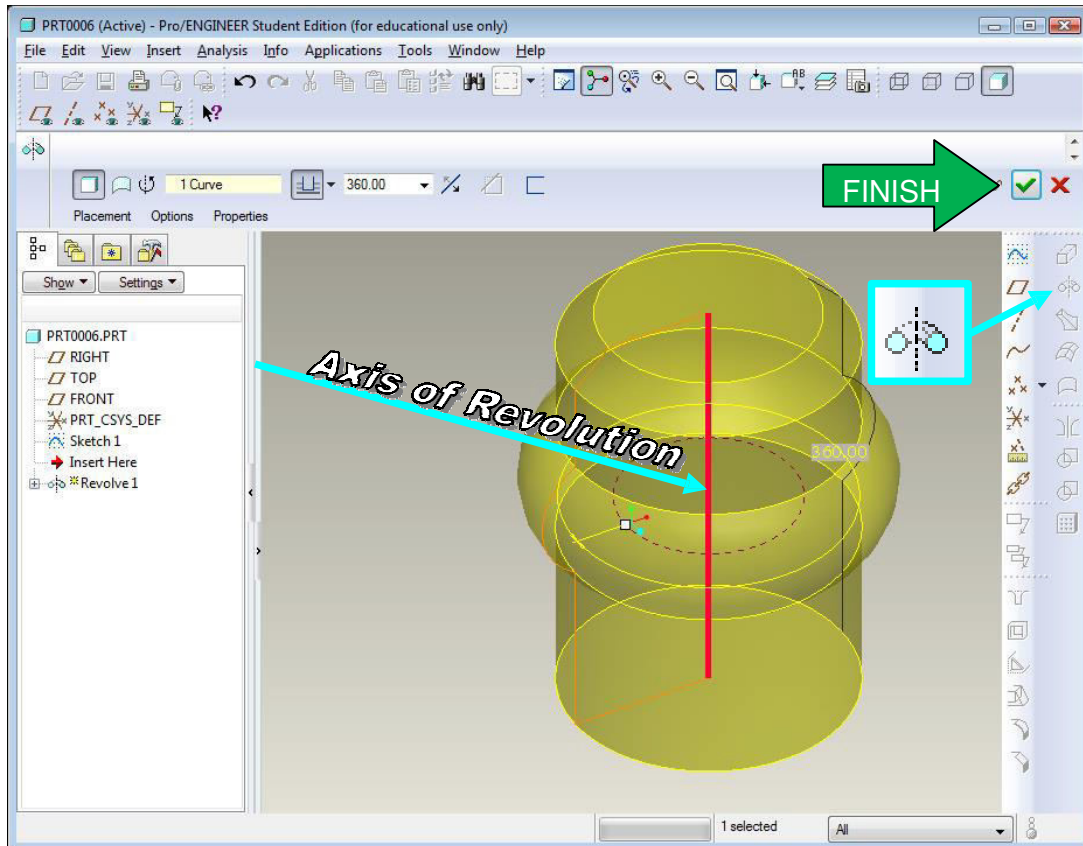
## EXERCISE 4

### Secondary Feature Modeling

1. sketch the geometry as shown below  
Then **Trim**.

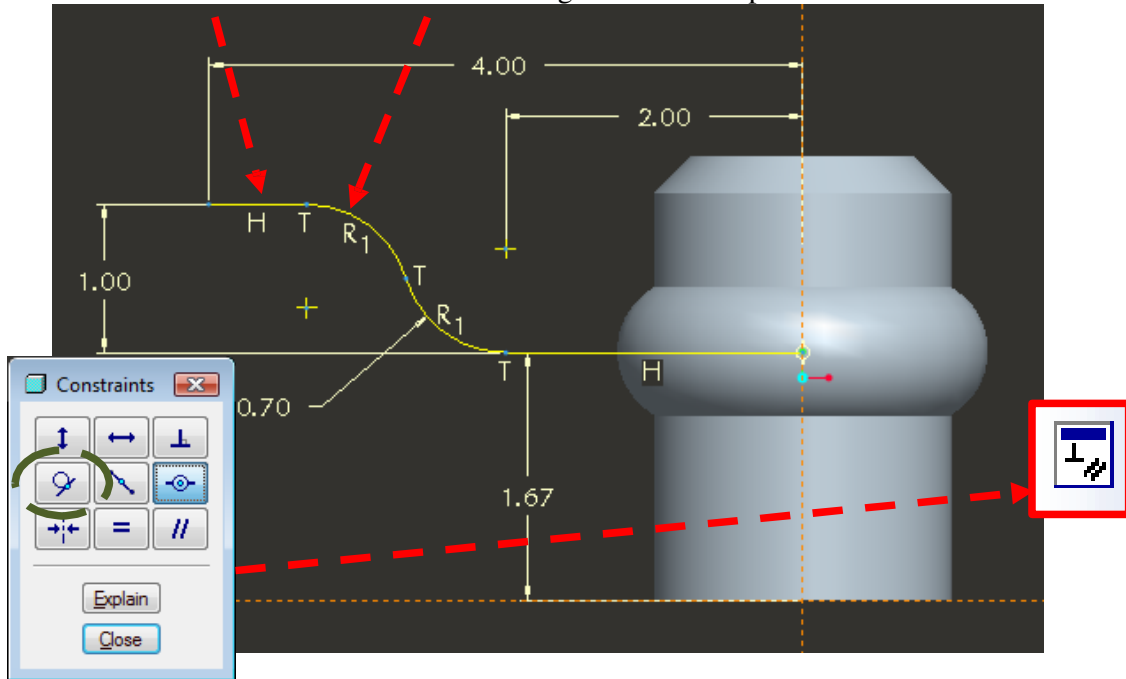


8. **Revolve.**



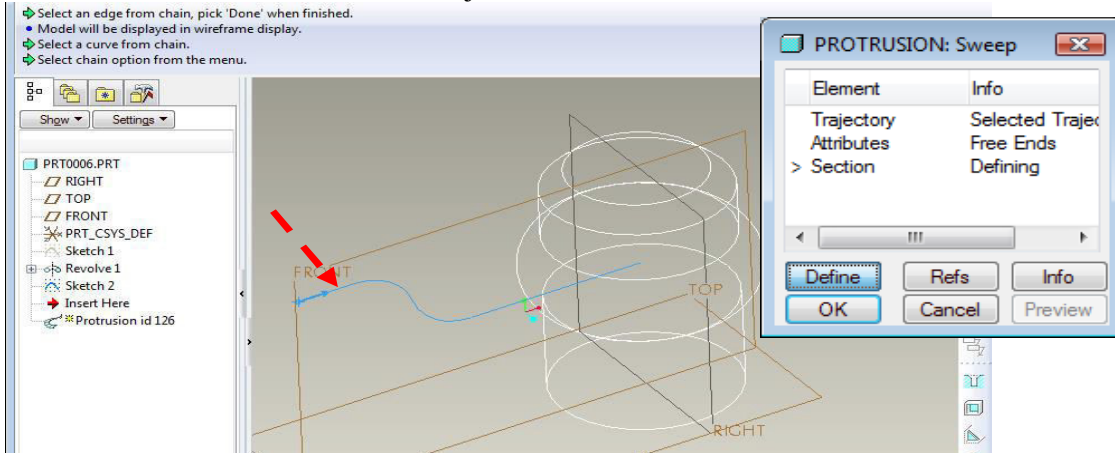
8. **Constraints:** Select the Front datum plane and sketch the following. Use the Constraint tool and select the **Tangent** option. Then select the left most horizontal

line and the arc attached to it to establish a tangent relationship.

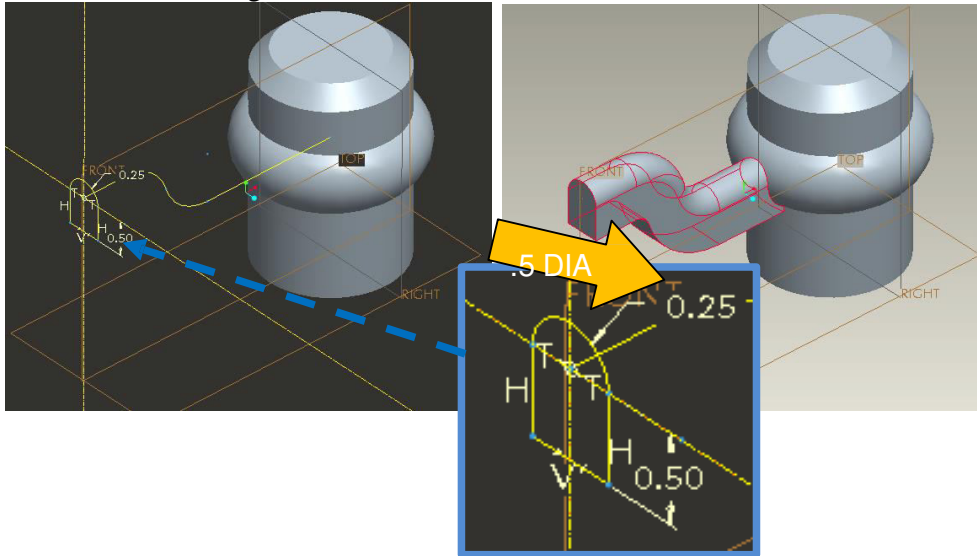


9. **Sweeps:** left side of the curve we just created to create a new sketch datum at the end.

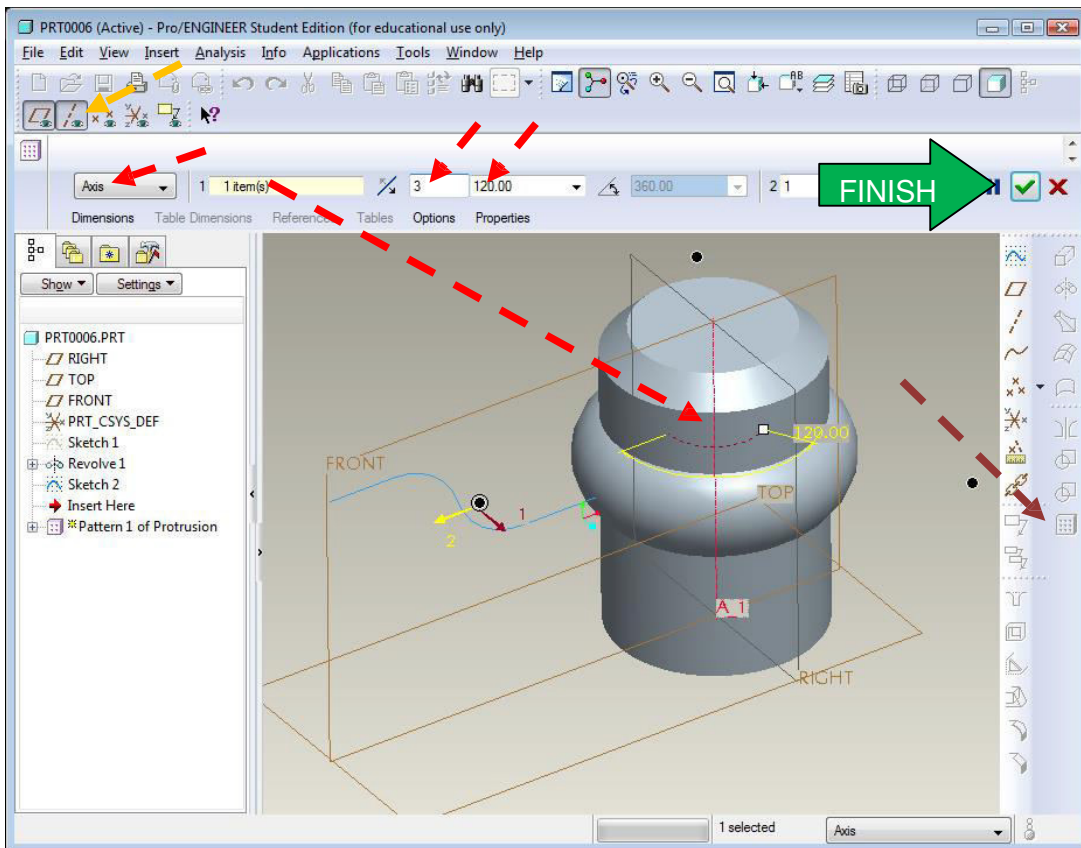
10. Also select: ☐ SelectTraj/Curve Chain/Select All/Done/Done ☐



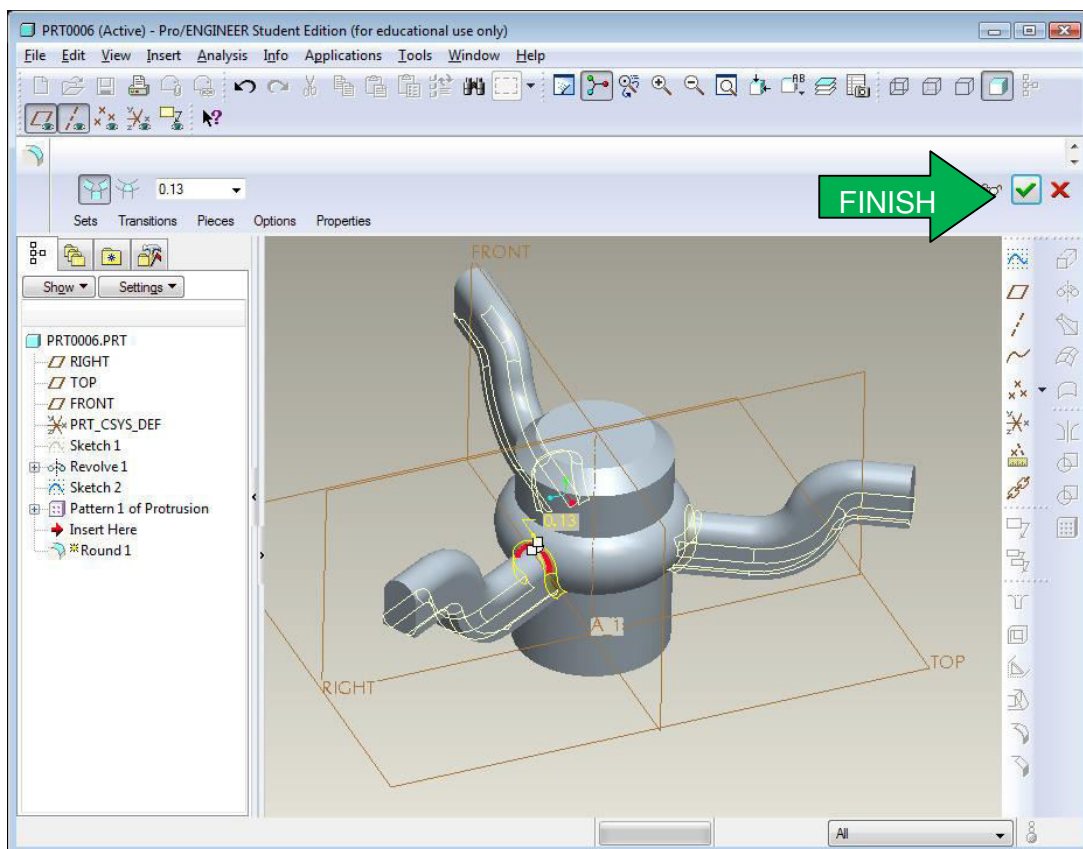
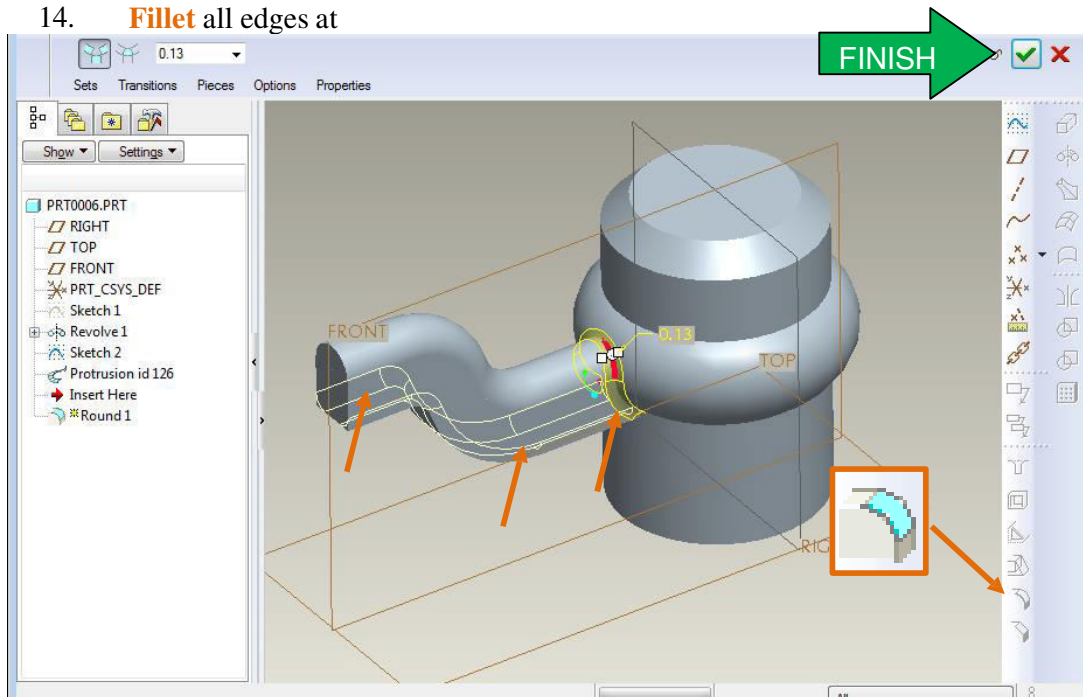
8. Draw the following sketch



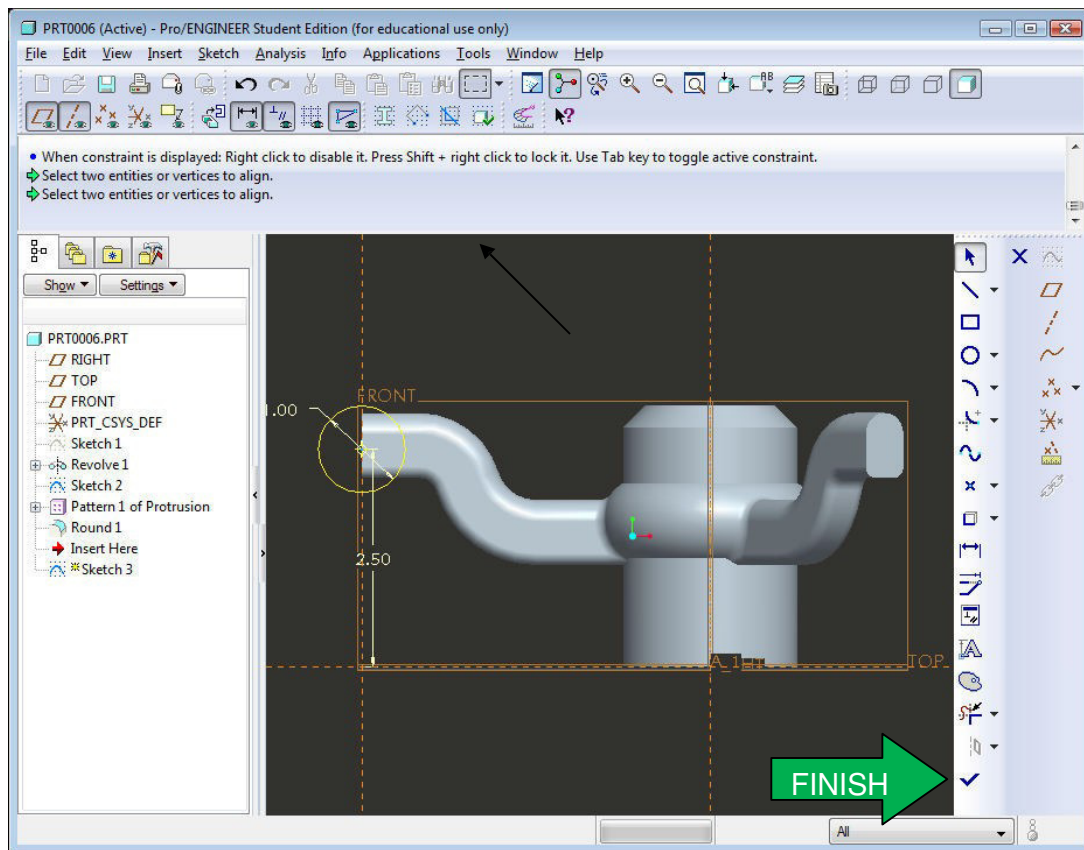
8. **Pattern Circular Pattern:**  $360^\circ/3 = 120^\circ$  (NOTE: First select the spoke to activate the icon.) “SelectAxis ☐ also select the ☐ view axis ☐



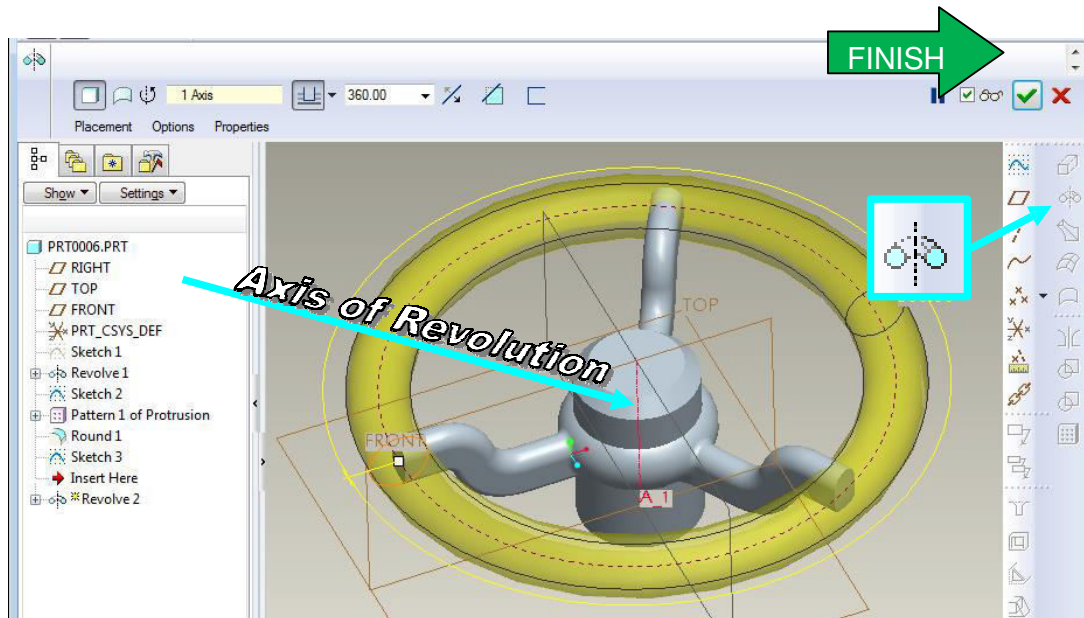
14. **Fillet** all edges at



15. Rebuild after completion.

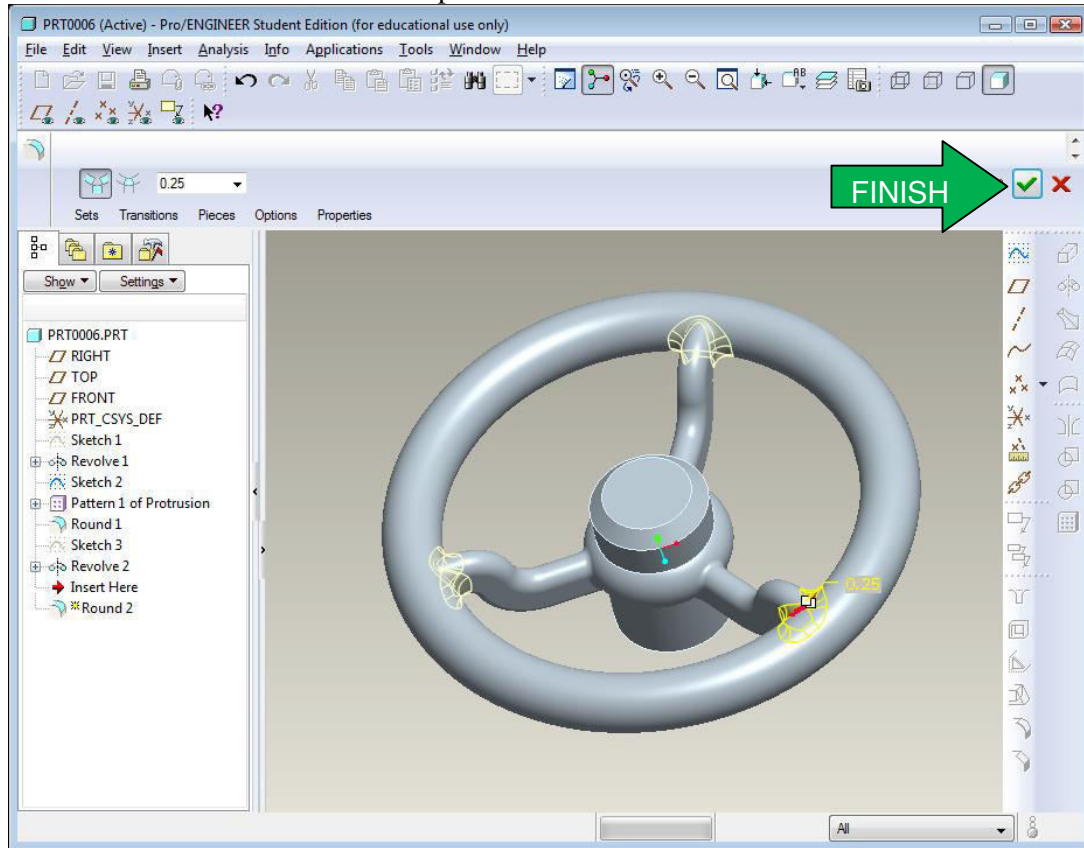


16. REVOLVE

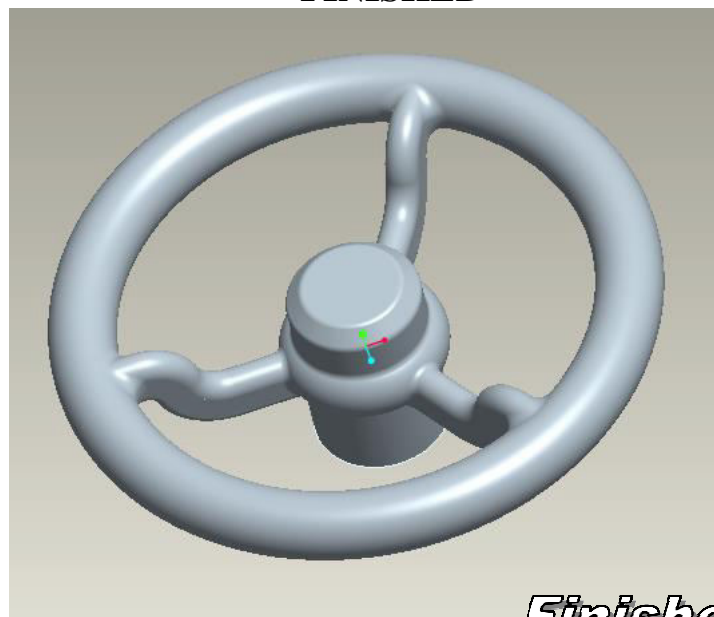




15. Add **Rounds** to the spoke – handle sections.



**FINISHED**



*Finished*

# **MECHANICS OF SOLIDS AND MECHANICS OF FLUIDS**

## **LABORATORY MANUAL**

**B.TECH  
(II YEAR – I SEM)  
(2016-17)**

**Prepared by:**

**Mr. K. Durga Rao, Associate Professor  
Mr. I. Ramakrishnudu, Associate Professor**

**Department of Aeronautical Engineering**



## **MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY**

**(Autonomous Institution – UGC, Govt. of India)**

Recognized under 2(f) and 12 (B) of UGC ACT 1956

Affiliated to JNTUH, Hyderabad, Approved by AICTE - Accredited by NBA & NAAC – 'A' Grade - ISO 9001:2015 Certified)  
Maisammaguda, Dhulapally (Post Via. Hakimpet), Secunderabad – 500100, Telangana State, India.

# **MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY**

**(Autonomous Institution – UGC, Govt. of India)**

Recognized under 2(f) and 12 (B) of UGC ACT 1956

Affiliated to JNTUH, Hyderabad, Approved by AICTE - Accredited by NBA & NAAC – 'A' Grade - ISO 9001:2015 Certified)

Maisammaguda, Dhulapally (Post Via. Hakimpet), Secunderabad – 500100, Telangana State, India.

## **MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY**

### **VISION**

- ❖ To establish a pedestal for the integral innovation, team spirit, originality and competence in the students, expose them to face the global challenges and become technology leaders of Indian vision of modern society.

### **MISSION**

- ❖ To become a model institution in the fields of Engineering, Technology and Management.
- ❖ To impart holistic education to the students to render them as industry ready engineers.
- ❖ To ensure synchronization of MRCET ideologies with challenging demands of International Pioneering Organizations.

### **QUALITY POLICY**

- ❖ To implement best practices in Teaching and Learning process for both UG and PG courses meticulously.
- ❖ To provide state of art infrastructure and expertise to impart the quality education.
- ❖ To groom the students to become intellectually creative and professionally competitive.
- ❖ To channelize the activities and tune them in heights of commitment and sincerity, the requisites to claim the never ending ladder of SUCCESS year after year.

**For more information: [www.mrcet.ac.in](http://www.mrcet.ac.in)**



# DEPARTMENT OF AERONAUTICAL ENGINEERING

## VISION

Department of Aeronautical Engineering aims to be indispensable source in Aeronautical Engineering which has a zeal to provide the value driven platform for the students to acquire knowledge and empower themselves to shoulder higher responsibility in building a strong nation.

## MISSION

- a) The primary mission of the department is to promote engineering education and research.
- (b) To strive consistently to provide quality education, keeping in pace with time and technology.
- (c) Department passions to integrate the intellectual, spiritual, ethical and social development of the students for shaping them into dynamic engineers.

## PROGRAM OBJECTIVES (PO'S)

### Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **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.
3. **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.
4. **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.
5. **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.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **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.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **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.
11. **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 multi disciplinary environments.
12. **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.

## **PROGRAMME EDUCATIONAL OBJECTIVES (PEO'S)**

### **PEO1: PROFESSIONALISM & CITIZENSHIP**

To create and sustain a community of learning in which students acquire knowledge and learn to apply it professionally with due consideration for ethical, ecological and economic issues.

### **PEO2: TECHNICAL ACCOMPLISHMENTS**

To provide knowledge based services to satisfy the needs of society and the industry by providing hands on experience in various technologies in core field.

### **PEO3: INVENTION, INNOVATION AND CREATIVITY**

To make the students to design, experiment, analyze, interpret in the core field with the help of other multi disciplinary concepts wherever applicable.

### **PEO4: PROFESSIONAL DEVELOPMENT**

To educate the students to disseminate research findings with good soft skills and become a successful entrepreneur.

### **PEO5: HUMAN RESOURCE DEVELOPMENT**

To graduate the students in building national capabilities in technology, education and research.

## **PROGRAM SPECIFIC OBJECTIVES (PSO's)**

1. To mould students to become a professional with all necessary skills, personality and sound knowledge in basic and advance technological areas.
2. To promote understanding of concepts and develop ability in design manufacture and maintenance of aircraft, aerospace vehicles and associated equipment and develop application capability of the concepts sciences to engineering design and processes.
3. Understanding the current scenario in the field of aeronautics and acquire ability to apply knowledge of engineering, science and mathematics to design and conduct experiments in the field of Aeronautical Engineering.
4. To develop leadership skills in our students necessary to shape the social, intellectual, business and technical worlds.

## **(R15A0384) MECHANICS OF SOLIDS AND MECHANICS OF FLUIDS LAB**

### **Objectives:**

- To supplement the theoretical knowledge gained in Mechanics of Solids with practical testing for determining the strength of materials under externally applied loads.
- This would enable the student to have a clear understanding of the design for strength and stiffness.
- Upon Completion of this subject, the students can able to have hands on experience in flow measurements using different devices

### **(A) MECHANICS OF SOLIDS LAB:**

1. Direct tension test
2. Torsion test
3. Hardness test
  - a) Brinells hardness test
  - b) Rockwell hardness test
4. Test on springs
5. Compression test on cube
6. Impact test
7. Punch shear test

### **(B) MECHANICS OF FLUIDS LAB**

8. Calibration of Venturimeter
9. Calibration of orifice meter
10. Calibration of Triangular notch
11. Verification of Bernoulli's apparatus.
12. Pipe friction.
13. Determination of co-efficient of loss of head in a sudden retraction.

### **Equipment needed**

#### **MOS – lab**

1. UTM – 20 / 40 Tons with load Vs Elongation graphical attachment and provision for Bending and sheering along with accessories and end grips
2. Deflection test rig (Fabricated hardware + precession dial gauge)
3. Torsion testing Machine
4. Hardness testing Machine ( Brinnel and Rockwell)
5. Impact Testing Machine
6. Spring testing Machine.

#### **MOF – lab**

- 1 Venturimeter test rig
2. Test rig for Flow over notch
3. Pipe friction apparatus
4. Bernoulli's apparatus
5. test rig for Orifice meter

**Outcomes:**

- Ability to characteristic materials
- Ability to use the measurement equipments for flow measurement

## CONTENTS

### MECHANICS OF SOLIDS LABORATORY

S.No	NAME OF THE EXPERIMENT	PAGE No	EQUIPMENT USED
1	Impact Izod Test	10	Izod impact testing machine
2	Rockwell Hardness Test	13	Rockwell hardness testing machine
3	Brinells Hardness Test	16	Brinell's hardness testing machine
4	Spring Test	19	Spring testing machine
5	Torsion test	22	Torsion testing machine
6	Tensile Test	25	Universal testing machine
7	Punch Shear Test	53	Punch Shear Setup

### MECHANICS OF FLUIDS LABORATORY

S.No	NAME OF THE EXPERIMENT	PAGE No	EQUIPMENT USED
1	Calibration of Venturi meter	31	Venturi meter test rig
2	Calibration of Orifice meter	35	Orifice meter test rig
3	Pipe friction factor	40	Pipe friction apparatus
4	Verification of Bernoullis Theorem	45	Bernoullis apparatus
5	Calibration of Triangular notch	48	Triangular notch test rig
6	Calibration of Coefficient of Discharge meter	50	Mouth piece setup

## MECHANICS OF SOLIDS

### EXPERIMENT -1

#### IZOD IMPACT TEST

**AIM:** To perform the izod impact test on materials.

**APPARATUS:** Izod impact test machine, test specimen, vernier calipers, steel rule.

**IMPACT STRENGTH:** The resistance of a material to fracture under sudden load application

**MATERIALS:** Two types of test pieces are used for this test as given.

- 1) Square cross-section
- 2) Round cross-section.

**THEORY:** The type of test specimen used for this test is a Square Cross-section

The specimen may have single, two or three notches. The testing machine should have the following specifications.

The angle between top face of grips and face holding the specimen

vertical= $90^{\circ}$  The angle of tip of hammer =  $75^{\circ} \pm 1^{\circ}$

The angle between normal to the specimen and underside face of the hammer at striking point =  $10^{\circ} \pm 1^{\circ}$

Speed of hammer at impact = 3.99m/sec Striking energy = 168N-m or Joules Angle of drop of pendulum =  $90^{\circ}$  Effective weight of pendulum = 21.79kg

Minimum value of scale graduation = 2 Joules.

Permissible total friction loss of corresponding energy = 0.50%

Distance from the axis of rotation of distance between the base of specimen notch and the point of specimen hit by the hammer =  $22\text{mm} \pm 0.5\text{mm}$

The longitudinal axes of the test piece shall lie in the plane of swing of the center of gravity of the hammer. The notch shall be positioned so that it is in the plane of the hammer .the notch shall be positioned its plane of symmetry coincides with the top face of the grips .for setting the specimen the notch impact strength I is calculated according to the following relation.

where I= impact strength in joules/m<sup>2</sup>



### PROCEDURE:

1. For conducting Izod test, a proper striker is to be fitted firmly to the bottom of the hammer with the help of the clamping piece.
2. The latching take for izod test is to be firmly fitted to the bearing housing at the side of the columns.
3. The frictional loss of the machine can be determined by free fall test, raise the hammer by hands and latch in release the hammer by operating lever the pointer will then indicate the energy loss due to friction. From this reading confirm that the friction loss is not exceeding 0.5% of the initial potential energy. Otherwise frictional loss has to be added to the final reading.
4. The specimen for izod test is firmly fitted in the specimen support with the help of clamping screw and élan key. Care should be taken that the notch on the specimen should face to pendulum striker.
5. After ascertaining that there is no person in the range of swinging pendulum, release the pendulum to smash the specimen.
6. Carefully operate the pendulum brake when returning after one swing to stop the oscillations.
7. Read-off position of reading pointer on dial and note indicated value.
8. Remove the broken specimen by loosening the clamping screw.

The notch impact strength depends largely on the shape of the specimen and the notch. The values determined with other specimens therefore may not be compared with each other.

### OBSERVATION TABLE:

S.No	A(Area of cross section of specimen)	K Impact energy observed	I Impact Strength

**RESULT:**

**Calculation Part:**

## **EXPERIMENT -2**

### **ROCKWELL HARDNESS TEST**

**AIM:** To determine the Rockwell hardness of the given test specimen.

**APPARATUS:** Rockwell hardness testing machine, test specimen.

**THEORY:** Hardness-the resistance of a metal to plastic deformation against indentation scratching, abrasion or cutting.

The depth of penetration of the indenter measures the hardness of a material by this Rockwell's hardness test method. The depth of penetration is inversely proportional to the hardness. Both ball or diamond cone types of indenters are used in this test. There are three scales on the machine for taking hardness readings.

Scale „A- with load 60kgf or 588.8N and diamond indenter is used for performing tests on steel and shallow case hardened steel.

Scale „B- with load 100kgf or 980.7 N and 1.588mm dia ball indenter is used for performing tests on soft steel, malleable iron, copper and aluminum alloys.

Scale „C- with load 150kgf or 1471 N and diamond indenter is used for performing tests on steel, hard cost steel, deep case hardened steel , other metals which harder.

First minor load is applied to overcome the film thickness on the metal surface. Minor load also eliminates errors in the depth of measurement due to spring of the machine frame or setting down of the specimen and table attachments.

The Rockwell hardness is derived from the measurement of the depth of the impression. This method of test is suitable for finished or machined parts of simple shapes.

#### **PROCEDURE:**

1. Select the load by rotating the nob and fix the suitable indenter.
2. Clean the test piece and place on the special anvil or worktable of the machine.
3. Turn the capstan wheel to evaluate the test specimen into contact with the indenter point.
4. Further turn the wheel for three rotations forcing the test specimen against the indenter. This will ensure the minor load has been applied.
5. As soon as the pointer comes to rest pull the handle in the reverse direction slowly. This releases the major but not the minor load. The pointer will now rotate in the reverse direction.

6. The Rockwell hardness can read off the scale dial, on the appropriate scale, after the pointer comes to rest.

### OBSERVATIONS:

Material of the specimen =  
 Thickness of test specimen =  
 Hardness scale used =

Test no	Material	Rockwell Scale of weights			Rockwell number			Average Rockwell no.
		Scale	weight	indent	1	2	3	

### PRECAUTIONS:

1. For testing cylindrical test specimens use V-type platform.
2. Calibrate the machine occasionally by using standard test blocks.
3. For thin metal pieces place another sufficiently thick metal piece between the test specimen and the platform to avoid any damage, which may likely occur to the platform.
4. After applying major load wait for some time to allow the needle to come to rest. The waiting time may vary from 2 to 8 seconds.
5. The surface of the test piece should be smooth and even and free from oxide scale and foreign matter.
6. Test specimen should not be subjected to any heating or cold working.
7. The distance between the centers of two adjacent indentations should be at least 4 times the diameter of the indentation and the distance from the center of any indentation to the edge of the test piece should be at least 2.5 times the diameter of the indentation.

**RESULT:**

**Calculation Part:**

## **EXPERIMENT -3**

### **BRINELLS HARDNESS TEST**

**AIM:** To determine the Brinells hardness of the given test specimen.

**APPARATUS:** Brinells hardness machine, test specimen, Brinells Microscope.

**THEORY:**

**Indentation Hardness**-A number related to the area or to the depth of the impression made by an indenter or fixed geometry under a known fixed load.

This method consists of indenting the surface of the metal by a hardened steel ball of specified diameter D mm under a given load F kgf and measuring the average diameter d mm of the impression with the help of Brinell microscope fitted with a scale. The Brinell hardness HB is defined, as the quotient of the applied force F divided by the spherical area of the impression.

HB= Test load in kgf/surface area of indentation

$$=2F/ \{ \pi D (D- \sqrt{D^2 - d^2}) \} \text{ kg/mm}^2$$

**PROCEDURE:**

1. Select the proper size of the ball and load to suit the material under test.
2. Clean the test specimen to be free from any dirt and defects or blemishes.
3. Mount the test piece surface at right angles to the axis of the ball indenter plunger.
4. Turn the platform so that the ball is lifted up.
5. By shifting the lever applies the load and waits for some time.
6. Release the load by shifting the lever.
7. Take out the specimen and measure the diameter of indentation by means of the Brinell microscope.
8. Repeat the experiments at other positions of the test piece.
9. Calculate the value of HB.

**OBSERVATIONS:**

Test piece material =  
Diameter of the ball” D “ =  
Load section  $F/D^2$  =  
Test load =  
Load application time =  
Least count of Brinell Microscope =

S. No	Diameter			F in kg	D in mm	Average
	Impression					HB
	(d <sub>1</sub> )	(d <sub>2</sub> )	(d <sub>1</sub> +d <sub>2</sub> )/2			Kg/mm <sup>2</sup>

**PRECAUTIONS:**

1. The surface of the test piece should be clean
2. The testing machine should be protected throughout the test from shock or vibration.
3. The test should be carried out at room temperature.
4. The distance of the center of indentation from the edge of test piece should be at least 2.5 times the diameter of the indentation and the distance between the center of the two adjacent indentations should be at least 4 times the diameter of the indentation.
5. The diameter of each indentation should be measured in two directions at right angles and the mean value readings used the purpose of determining the hardness number.

**RESULT:**

**Calculation Part:**



## **EXPERIMENT -4**

### **SPRING TEST**

**AIM:** To determine the rigidity modulus of the spring

**APPARATUS:** Spring testing machine, vernier calipers, spring specimen.

#### **THEORY:**

Closed coiled helical springs are the springs in which helix angle is very small or in other words the pitch between two adjacent turns is small, a closed coiled helical spring carrying an axial load. As helix angle in case of close coiled helical springs are small, hence the bending effect on the spring is ignored and we assume that the coils of close coiled helical springs are to stand purely tensional stresses.

Let  $d$  = diameter of the spring wire

$P$  = pitch of the helical spring  $N$  = number of coils

$R$  = mean radius of the spring coil

$W$  = axial load on spring  $C$  = modulus of rigidity

$\tau$  = maximum shear stress induced in the wire  $\theta$  = angle of twist in the spring wire and

$x$  = deflection of spring due to axial load  $l$  = length of wire

Net twisting moment on the wire  $T = WR$

But twisting moment is also given by  $T = (\pi/16) \tau d^3$

From (1) and (2)

above equation which gives the maximum shear stress induced in the wire

(1)

Length of one coil =  $2\pi R$

(2)

Total length of the wire =  $2\pi Rn$

Strain energy stored by the spring due to torsion

$$U = (\tau / 4C) [(\pi/4)d^2 2\pi Rn] \quad (3)$$

Work done on the spring = average load x deflection

$$= (1/2) Wx \quad (4)$$

Equating (3) and(4)

$$(1/2) Wx = (32W^2R^3n)/Cd^4$$

$$x=64WR^3n/Cd^4$$

Rigidity modulus of the spring  **$C=64WR^3n/d^4$**

#### **PROCEDURE:**

- 1) Consider the spring and find out its mean coil radius R with the help of vernier calipers.
- 2) Find the diameter of the spring and number of turns.
- 3) Fix the spring between two hooks.
- 4) Now load is gradually applied.
- 5) Note the deflection from the deflection scale for different loads applied.
- 6) Calculate the rigidity modulus using above formula.

#### **PRECAUTIONS:**

- 1) Dimensions should be measure accurately with the help of vernier calipers.
- 2) Deflection from the scale should be noted carefully and accurately

#### **OBSERVATION TABLE:**

S.no	Load applied	deflection	Rigidity modulus C

Average rigidity modulus C =

**RESULT:**

**Calculation Part:**

## **EXPERIMENT -5**

### **TORSION TEST**

**AIM:** To conduct torsion test on mild steel or cast iron specimen to find modulus of rigidity or to find angle of twist of the materials which are subjected to torsion.

#### **APPARATUS:**

1. A torsion test machine along with angle of twist measuring attachment.
2. Standard specimen of mild steel or cast iron.
3. Steel rule.
4. Vernnier caliper or a micrometer.

#### **THEORY:**

For transmitting power through a rotating shaft it is necessary to apply a turning force. The force is applied tangentially and in the plane of transverse cross section. The torque or twisting moment may be calculated by multiplying two opposite turning moments. It is said to be in pure torsion and it will exhibit the tendency of shearing off at every cross section which is perpendicular to the longitudinal axis.

#### **Torsion equation:**

Torsion equation is given by below

$$T / I_P = C\theta/L = \tau/R$$

T= maximum twisting torque

(Nmm)  $I_P$  = polar moment of inertia ( $\text{mm}^4$ )

$\tau$  =shear stress ( $\text{N/mm}^2$ )

C=modulus of rigidity ( $\text{N/mm}^2$ )

$\theta$ =angle of twist in radians

L=length of shaft under torsion (mm)

#### **Assumptions made for getting torsion equation**

1. The material of the shaft is uniform throughout.
2. The shaft, circular in section remain circular after loading.

- Plane sections of shaft normal to its axis before loading remain plane after the torque have been applied.
- The twist along the length of the shaft is uniform throughout.
- The distance between any two normal-sections remains the same after the application of torque.
- Maximum shear stress induced in the shaft due to application of torque does not exceed its elastic limit.

**PROCEDURE:**

- Select the suitable grips to suit the size of the specimen and clamp it in the machine by adjusting sliding jaw.
- Measure the diameter at about the three places and take average value.
- Choose the appropriate loading range depending upon specimen.
- Set the maximum load pointer to zero
- Carry out straining by rotating the hand wheel or by switching on the motor.
- Load the members in suitable increments, observe and record strain reading.
- Continue till failure of the specimen.
- Calculate the modulus of rigidity  $C$  by using the torsion equation.
- Plot the torque –twist graph ( $T$  Vs  $\theta$ )

**OBSERVATIONS:**

Gauge length  $L$  =

Polar moment of inertia  $I_P$  =

Modulus of rigidity  $C = TL / I_P \theta$  =

S.No	Twisting Kgf	Moment Nm	Angle of Twist Degrees	Radians	Modulus of rigidity $C$	Average $C$ N/mm

**RESULT:**

**Calculation Part:**

## **EXPERIMENT -6**

### **TENSILE TEST**

#### **AIM:**

To conduct tensile test on a mild steel specimen and determine the following

- |                                 |                               |
|---------------------------------|-------------------------------|
| 1. Limit of proportionality     | 2. Elastic Limit              |
| 3. Upper yield point            | 4. Lower yield point          |
| 5. Ultimate strength            | 6. Fracture strength          |
| 7. Young`s Modulus              | 8. Percentage elongation      |
| 9. Percentage reduction in area | 10. Ductility                 |
| 11. Toughness                   | 12. True stress & true strain |
| 13. Malleability                |                               |

**APPARATUS:** Universal testing machine, specimen, steel rule, vernier caliper, micrometer

#### **THEORY:**

The tensile test is most applied one of all mechanical tests. In this test, a test specimen is fixed into grips connected to a straining device and to a load-measuring device. (One end in stationary grips and the others are in movable grips). If the applied load is small enough, the deformation of any solid body is entirely elastic. An elastically deformed solid will return to its original form as soon as load is removed. However if the load is too large, the material can be deformed permanently. The initial part of the tension curve, which represents the manner in which solid undergoes plastic deformation is termed as plastic. The stress below which the deformation is essentially entirely elastic is known as the elastic limit of the material. In some materials like mild steel a sudden drop in load indicating both an upper and lower yield point denotes the onset of plastic deformation. However some materials do not exhibit a sharp yield point. During plastic deformation at larger extensions, strain hardening cannot compensate for the decrease in section and thus the load passes through a maximum and then begins to decrease. At this stage the ultimate strength, which is defined as the ratio of the load on the specimen to the original cross-section area, reaches a maximum value. Until this point the deformation is uniform at all the sections of the specimen. Further loading will eventually cause „neck□ formation and rupture follows. Usually a tension test is conducted at room temperature; the tensile load is applied

slowly. During this test either round or flat specimens may be used. The load on the specimen

is applied mechanically or hydraulically depending on the type of testing machine.

**1. Nominal/Engg stress and Nominal/Engg strain:**

Original C/S area =  $A_0$  ( $\text{mm}^2$ )

Original gauge length =  $L_0$  (mm)

Increase in gauge length =  $\delta L_0$

Nominal stress =  $P/A_0$  ( $\text{N/mm}^2$ )

Nominal strain =  $\delta L_0/L_0$

**2. Limit of Proportionality:**

Stress is proportional to strain up to this point.

Normal Stress =  $P_A/P_0$

Normal Strain =  $(\delta L_0)/L_0$

**3. Elastic limit:**

When the load is removed at “B”, the specimen will go back to original

Dimensions i.e  $L_0$  and  $\delta$

$A_0$  Nominal stress =

$P_B/A_0$

Normal Strain =  $(\delta L_0)_B/L_0$

If the specimen is loaded beyond elastic limit it will undergo permanent strain  
ie. Plastic deformation.

**4. Upper yield point:**

Nominal stress =  $P_C/A_0$

Nominal strain =  $(\delta L_0)_D/L_0$

**5. Lower yield point:**

Nominal stress =  $P_D/A_0$

Nominal strain =  $(\delta L_0)_D/L_0$

**6. Ultimate load or maximum load point:**

Nominal ultimate stress =  $P_E/A_0$

Nominal strain =  $(\delta L_0)_E/L_0$

**7. Fracture Load point F:**

Nominal fracture stress =  $P_F/A_0$



Nominal strain at fracture =  $(\delta L_o)_F / L_o$

**8. Young`s modulus (E):**

Young`s modulus (E) = Stress/Strain

(In elastic region, limit of proportionality=Nominal stress at A/Nominal strain at A

**9. Modulus of resilience** =  $(\text{Nominal stress at elastic limit})^2 / 2E$

Area under Engg. Stress - Strain diagram up to elastic limit

**10. Resilience** = Modulus of Resilience x Volume of specimen undergoing Tensile stress.

**11. Yield point Elongation:** Elongation taking place in the specimen from C to D. this is taking place without increase in stress.

**12. Modulus of toughness:**

Area under engineering stress – strain diagram up to fracture **13. Toughness** = Modulus of toughness x Volume of specimen. This indicates the amount of energy absorbed by the specimen before fracture take place.

**14. Ductility**=  $(\text{Final length at fracture} - \text{original length}) / \text{original length} \times 100$

**15. Malleability:**

It is the ability of the material to undergo plastic deformation prior fracture under compressive loading conditions. In a tensile test it is approximated as percentage reduction in cross sectional area of the specimen. Malleability =

$$\{(A_o - A_f) / A_o\} \times 100$$

True stress – true strain diagram

Engineering stress is calculated based on original cross sectional area ( $A_o$ )

But not on the actual cross sectional area at load „P□

$$\text{True stress} = P/A = P/A_o \times A_o/A$$

Since volume remains constant during plastic deformation we have  $A_o L_o = A_L$

$$\text{True stress} = P/A_o \times L / L_o$$

$$= P/A_o \times ((L_o + \delta L_o) / L_o)$$

$$= P (1+e)$$

$$= \text{Nominal stress} (1+ \text{nominal strain})$$

$$\text{True strain} = \epsilon = \ln (1+e)$$

These relations are valid up to ultimate load i.e., up to which the strain is uniform all along the gauge length.

1. True Stress at upper yield point = Nominal stress at upper yield point ( $1+e_0$ ) True strain at C =  $\ln(1+e_0)$

2. True stress at ultimate load ( $E_1$ ) = Nominal ultimate stress ( $1+e_E$ ) True strain at ultimate load =  $\ln(1+e_E)$

3. True stress at fracture ( $E_1$ ) =  $P_f / A_f$

Where  $A_f$  is the area of cross section at fracture can be measured. True strain at fracture =  $\ln(A_0/A_f)$

Area relation is taken instead of lengths because the strains are localized in the region between ultimate load point and fracture point.

4. Strain Hardening :

From lower yield point onwards increase in load is required for increase in strain. Thus the stress required for further deformation is more. This phenomenon is called strain hardening.

5. True – stress – true strain curve in log – log co – ordinates.

When the true – stress and true – strain are plotted on log – log co – ordinates the curve is a straight line.

6. Ductile and Brittle Materials

If a material fails without much plastic deformation it can be called brittle.

If the percentage elongation at fracture is less than 2.5 the material is classified as brittle.

Usually the metals with F.C.C and CPH structures are highly ductile.

### PROCEDURE:

1. Measure the original gauge length and diameter of the specimen.
2. Insert the specimen into grips of the test machine.
3. Begin the load application and record load vs elongation data.
4. Take the readings more frequently as yield point is approached.
5. Measure elongation values.
6. Continue the test till fracture occurs.
7. By joining the two broken halves of the specimen together measure the final length and diameter of specimen at fracture.

## RESULTS AND DISCUSSIONS:

1. Plot the Engg. Stress strain curve and determine the following

Limit of proportionality = (N/mm<sup>2</sup>)

Yield strength = (N/mm<sup>2</sup>)

Ultimate strength = (N/mm<sup>2</sup>)

Young's modulus = (N/mm<sup>2</sup>)

Percentage elongation = %

Percentage reduction in area = %

Fracture strength = (Nominal /Engg)

Toughness = Area under stress – strain curve up to fracture

Malleability

2. Plot True Stress, True strain curve after calculating true – stress and true strain values at various points.

Estimate

- 1) Strength coefficient
- 2) Strain hardening coefficient
- 3) Determine whether the material is ductile or brittle
- 4) Comment on the results.

S.No	Load	Deformation	Stress	Strain	E

**Calculation part:**

## MECHANICS OF FLUIDS

### EXPERIMENT 1

#### VENTURIMETER TEST RIG

##### Introduction

A VENTURI METER is a device that is used for measuring the rate of flow of fluid through a pipeline. The basic principle on which a Venturi Meter works is that by reducing the cross-sectional area of the flow passage, a pressure difference is created between the inlet and throat & the measurement of the pressure difference enables the determination of the discharge through the pipe.

A Venturi Meter consists of,

- An inlet section followed by a convergent cone,
- A cylindrical throat,
- A gradually divergent cone.

The inlet section of the Venturi Meter is of the same diameter as that of the pipe, which is followed by a convergent one. The convergent cone is a short pipe, which tapers from the original size of the pipe to that of the throat of the Venturi Meter. The throat of the Venturi Meter is a short parallel side tube having its cross-sectional area smaller than that of the pipe. The divergent cone of the Venturi Meter is a gradually diverging pipe with its cross-sectional area increasing from that of the throat to the original size of the pipe. At the inlet and the throat, of the Venturi Meter, pressure taps are provided through pressure rings.

##### General Description:

The apparatus consists of (1) Venturimeter (2) Piping system (3) supply pump set (4) Measuring tank (5) Differential manometer (6) Sump

##### Constructional Specification:

- **Flow Meters:** Consists of Venturimeter of size 25 mm provided for experiments. The meter has the adequate cocks also with them
- **Piping System:** Consists of a set of G.I. piping of size 25 mm with sufficient upstream and down stream lengths provided with separate control valves and mounted on a suitable stand. Separate upstream and down stream pressure feed pipes are provided for the measurement of pressure heads with control valves situated on a common Pipe for easy operation.
- **Supply Pump Set:** Is rigidly fixed on sump. The mono block pump with motor, operating on single phase 220/240 volts 50 Hz AC supply.
- **Measuring Tank:** Measuring tank with gauge glass and scale arrangement for quick and easy measurement.
- **Differential Manometer:** Differential manometer with 1 mm scale graduations to measure the differential head produced by the flow meter.
- **Sump:** Sump to store sufficient water for independent circulation through the unit for

experimentation and arranged within the floor space of the main unit.

**Before commissioning:**

- Check whether all the joints are leak proof and water tight.
- Fill the manometer to about half the height with mercury
- Close all the cocks, pressure feed pipes and manometer to prevent damage and over loading of the manometer.
- Check the gauge glass and meter scale assembly of the measuring tank and see that it is fixed water height and vertically.
- Check proper electrical connections to the switch, which is internally connected to the motor.

**Experiments:**

- The apparatus is primarily designed for conducting experiments on the coefficient of discharge of flow meters. Each flow meter can be connected to the manometer through the pressure feed opening and the corresponding cocks.
- While taking readings, close all the cocks in the pressure feed pipes except the two (Down-stream and upstream) cocks which directly connect the manometer to the required flow meter, for which the differential head is to be measured. (Make sure while taking reading that the manometer is properly primed. Priming is the operation of filling the manometer upper part and the connecting pipes with water and venting the air from the pipes).
- First open the inlet gate valve of the apparatus. Adjust the control valve kept at the exit end of the apparatus to a desired flow rate and maintain the flow steadily.
- The actual discharge is measured with the help of the measuring tank. The differential head produced by the flow meter can be found from the manometer for any flow rate.

## CALIBRATION OF VENTURIMETER

**Aim:** - To calibrate a given venture meter and to study the variation of coefficient of discharge of it with discharge.

**Apparatus:** - Venturimeter, manometer, stop watch, experimental set-up.

**Procedure:-**

1. Start the motor keeping the delivery valve close.
2. The water is allowed to flow through the selected pipe by selecting the appropriate ball valve.
3. By regulating the valve control the flow rate and select the corresponding pressure tapings (i.e. of orifice meter).
4. Make sure while taking readings, that the manometer is properly primed. Priming is the operation of filling the manometer's upper part and the connecting pipes with water by venting the air from the pipes. Note down the difference of head "h" from the manometer scale.
5. Note down the time required for the rise of 10cm (i.e. 0.01m) water in the collecting tank by using stop watch. Calculate actual discharge using below formula.

**Discharge:** - The time taken to collect some 'R' cm of water in the collecting tank in m<sup>3</sup>/sec.

$$Q_{\text{act}} = \frac{A \times R}{t}$$

Where: A = area of the collecting tank in m<sup>2</sup> (0.3m X 0.3m)

t = time taken for rise of water level to rise 'R' in 't' seconds.

6. Using difference in mercury level "h" calculate the theoretical discharge of venturimeter by using following expression.

$$Q_{\text{th}} = \frac{a_1 a_2 \sqrt{2gH}}{\sqrt{a_1^2 - a_2^2}}$$

Where

$$H = \text{difference of head in meters} = (h_1 - h_2) \times \left( \frac{S_m}{S_w} - 1 \right) = (h_1 - h_2) \times 12.6 \text{ m}$$

$$a_1 = \text{area of venturi at inlet} = \frac{\pi d_1^2}{4}$$

$$a_2 = \text{area of venturi at throat} = \frac{\pi d_2^2}{4}$$

g = Acceleration due to gravity

d1 = Inlet diameter in meters.

d2 = Throat diameter in meters.

7. Calculate the coefficient of discharge of orifice meter (Cd):

$$C_d = \frac{Q_{act}}{Q_{theo}}$$

8. Repeat the steps 3 to 7 for different sets of readings by regulating the discharge valve.

S. No.	Venturi inlet diameter $d_1$	Throat Diameter $d_2$
1.	25mm	13.5 mm

S. No.	Time for (10 cm) raise of water level in sec.	Actual discharge = $Q_a$	Differential head in mm of mercury			Theoretical discharge = $Q_t$	$C_d = Q_a/Q_t$	
			$h_1$	$h_2$	H			
1								
2								
3								
4								
5								
6					+			
7								
8								
9								
10								

**Precautions:**

- Do not run the pump dry.
- Clean the tanks regularly, say for every 15days.
- Do not run the equipment if the voltage is below 180V.
- Check all the electrical connections before running.
- Before starting and after finishing the experiment the main Control valve should be in close position.
- Do not attempt to alter the equipment as this may cause Damage to the whole system.

**Results and Conclusions:**



## **EXPERIMENT 2**

### **ORIFICE METER TEST RIG**

#### **Introduction**

An ORIFICE METER is a simple device used for measuring the discharge through pipes. The basic principle on which an Orifice meter works is that by reducing the cross – sectional area of the flow passage, a pressure difference between the two sections before and after Orifice is developed and the measure of the pressure difference enables the determination of the discharge through the pipe. However an Orifice meter is a cheaper arrangement for discharge measurement through pipes and its installation requires a smaller length as compared with Venturi Meter. As such where the space is limited, the Orifice meter may be used for the measurement of discharge through pipes.

#### **General Description**

The apparatus consists of (1) Orifice meter (2) Piping system (3) supply pump set (4) Measuring tank (5) Differential manometer (6) Sump

#### **Constructional Specification**

- **Flow Meters:** Consists of Orifice meter of size 25 mm provided for experiments. The meter has the adequate cocks also with them.
- **Piping System:** Consists of a set of G.I. piping of size 25 mm with sufficient upstream and downstream lengths provided with separate control valves and mounted on a suitable stand. Separate upstream and downstream pressure feed pipes are provided for the measurement of pressure heads with control valves situated on a common plate for easy operation.
- **Supply Pump Set:** Is rigidly fixed on sump. The mono block pump with motor. Operating on single phase 220/240 volts 50 Hz AC supply.
- **Measuring Tank:** Measuring tank with gauge glass and scale arrangement for quick and easy measurement.
- **Differential Manometer:** Differential manometer with 1 mm scale graduations to measure the differential head produced by the flow meter.
- **Sump:** Sump to store sufficient water for independent circulation through the unit for experimentation and arranged within the floor space of the main unit.

#### **Before Commissioning**

- Check whether all the joints are leak proof and water tight.
- Fill the manometer to about half the height with mercury
- Close all the cocks, pressure feed pipes and manometer to prevent damage and over loading of the manometer.
- Check the gauge glass and meter scale assembly of the measuring tank and see that it is fixed water tight and vertically.
- Check proper electrical connections to the switch, which is internally connected to the motor.

### **Experiments**

- The apparatus is primarily designed for conducting experiments on the coefficient of discharge of flow meters. Each flow meter can be connected to the manometer through the pressure feed opening and the corresponding cocks.
- While taking readings, close all the cocks in the pressure feed pipes except the two (Down-stream and upstream) cocks which directly connect the manometer to the required flow meter, for which the differential head is to be measured. (Make sure while taking reading that the manometer is properly primed. Priming is the operation of filling the manometer upper part and the connecting pipes with water and venting the air from the pipes).
- First open the inlet gate valve of the apparatus. Adjust the control valve kept at the exit end of the apparatus to a desired flow rate and maintain the flow steadily.
- The actual discharge is measured with the help of the measuring tank. The differential head produced by the flow meter can be found from the manometer for any flow rate.

## **CALIBRATION OF ORIFICE METER**

**Aim:** - To calibrate a given Orifice meter and to study the variation of coefficient of discharge of it with discharge.

**Apparatus:** -Orifice meter, manometer, stop watch, experimental set-up.

**Procedure:-**

1. Start the motor keeping the delivery valve close.
2. The water is allowed to flow through the selected pipe by selecting the appropriate ball valve.
3. By regulating the valve control the flow rate and select the corresponding pressure tapings (i.e. of orifice meter).
4. Make sure while taking readings, that the manometer is properly primed. Priming is the operation of filling the manometer's upper part and the connecting pipes with water by venting the air from the pipes. Note down the difference of head "h" from the manometer scale.
5. Note down the time required for the rise of 10cm (i.e. 0.01m) water in the collecting tank by using stop watch. Calculate actual discharge using below formula.

**Discharge:** - The time taken to collect some 'R' cm of water in the collecting tank in m<sup>3</sup>/sec.

$$Q_{\text{act}} = \frac{A \times R}{t}$$

Where: A = area of the collecting tank in m<sup>2</sup> (0.3m X 0.3m)

R = rise of water level taken in meters (say 0.1m or 10cm)

t = time taken for rise of water level to rise 'R' in 't' seconds.

6. Using difference in mercury level "h" calculate the theoretical discharge of venturimeter by using following expression.

$$Q_{\text{th}} = \frac{a_1 a_2 \sqrt{2gH}}{\sqrt{a_1^2 - a_2^2}}$$

Where,

$$H = \text{difference of head in meters} = (h_1 - h_2) \times \left( \frac{S_m}{S_w} - 1 \right) = (h_1 - h_2) \times 12.6 \text{ m}$$

$$a_1 = \text{area of orifice at inlet} = \frac{\pi d_1^2}{4}$$

$$a_2 = \text{area of orifice at inlet} = \frac{\pi d_2^2}{4}$$

g = Acceleration due to gravity

d1 = Inlet diameter in meters.

d2 = Throat diameter in meters.

7. Calculate the coefficient of discharge of orifice meter (Cd):

$$C_d = \frac{Q_{\text{act}}}{Q_{\text{theo}}}$$

8. Repeat the steps 3 to 7 for different sets of readings by regulating the discharge valve.

S. No.	Orifice inlet diameter d1	Orifice diameter d2
1.	25mm	13.0

S. No.	Time for (10 cm) raise of water level in sec.	Actual discharge = $Q_a$	Differential head in mm of mercury			Theoretical discharge = $Q_t$	$C_d = Q_a/Q_t$
			$h_1$	$h_2$	H		
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

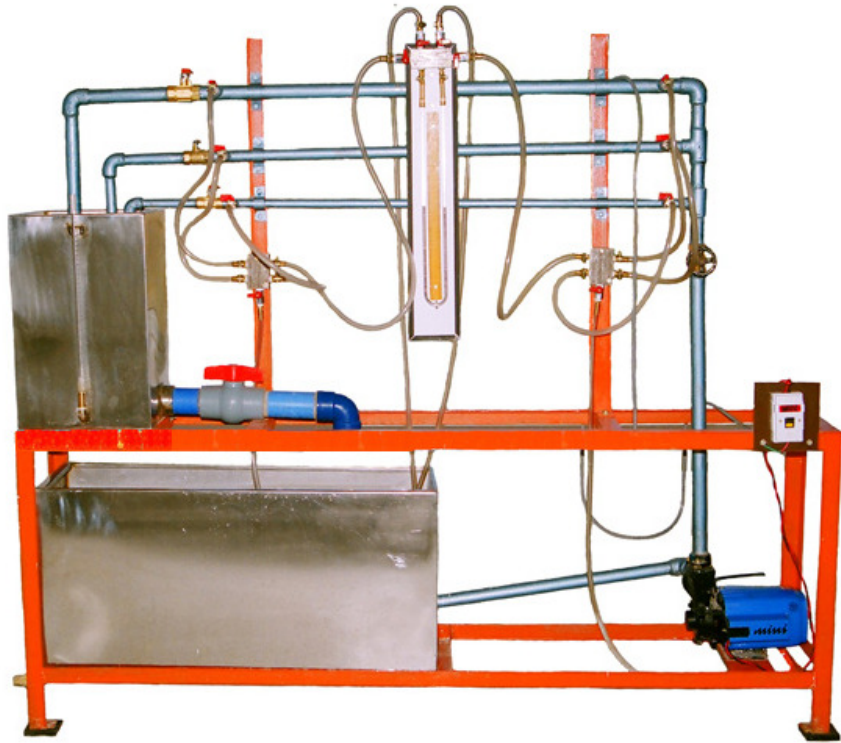
**Calculation:-**

**Precautions:-**

- Do not run the pump dry.
- Clean the tanks regularly, say for every 15days.
- Do not run the equipment if the voltage is below 180V.
- Check all the electrical connections before running.
- Before starting and after finishing the experiment the main
- Control valve should be in close position.
- Do not attempt to alter the equipment as this may cause
- Damage to the whole system.

**Results and Conclusions:-**

## PIPE FRICTION APPARATUS



### Introduction

A pipe may be of various diameters and may have bends, valves, etc. When a liquid is flowing through such pipes, the velocity of the liquid layer adjacent to the pipe wall is zero. The velocity of the liquid goes on increasing from the wall and hence shear stresses are produced in the liquid due to viscosity. This viscous action causes loss of energy, which is usually known as Frictional loss.

Here, we are going to consider two important losses that occur during flow,

- Major Losses.
- Minor Losses.
- Major losses occur due to friction. This friction may be due to viscosity or roughness in the pipe.
- Minor losses can be due to various reasons such as Inlet and Outlet of the pipe, bends, gates, sudden expansions and contractions. The apparatus is designed to study the friction losses that appear in long pipes and the obstructions that are encountered in the way of flow by various types of fittings.

### General Description

The unit consists mainly of 1) Piping System 2) Measuring Tank 3) Differential Manometer 4) Supply pump set 5) Sump.

- **Constructional Specification**
- **Piping System:** Piping System of size 12.7 mm, 20 mm and 20 mm (S.S.) dia. With tapings at 1 meter distance and a flow control valve.

- **Measuring Tank:** Measuring tank is provided to measure the discharge of water from the unit.
- **Differential Manometer:** Differential manometer with 1 mm scale graduations to measure the loss of head in the pipe line.
- **Supply Pump Set:** Supply pump set is rigidly fixed on the sump. The pump set is mono block pump with 0.5 HP motor operating on single phase 220 volts 50 Hz AC supply.
- **Sump:** Sump is provided to store sufficient waters for independent circulation through the unit for experimentation and arranged within the floor space of the main unit.

#### **Before Commissioning**

- Check whether all the joints are leak proof and watertight.
- Close all the cocks on the pressure feed pipes and Manometer to prevent damage and overloading of the manometer.
- Check the gauge glass and meter scale assembly of the measuring tank and see that it is fixed water tight and vertical.
- Check proper electrical connections to the switch, which is internally connected to the motor.

#### **Experiments**

- The apparatus is primarily designed for conducting experiments on the frictional losses in pipes of different sizes. Three different sizes of pipes are provided for wide range of experiments. Each individual pipe can be connected to the Manometer through the pressure feed pipes having individual quick operating cocks.
- While taking reading close all the cocks in the pressure feed pipe except the two (upstream and downstream) cocks, which directly connect the manometer to the required pipe for which the loss in head has to be determined. (Make sure while taking readings, that the manometer is properly primed. Priming is the operating of filling the Manometer upper part and the connecting pipes with water venting the air from the pipes).
- First open the inlet gate valve of the apparatus. Adjust the control valve kept at the exit end of the apparatus to a desired flow rate and maintain the flow steadily.
- The actual discharge is measured with the help of the measuring tank. For each size of the pipe the area of cross section of flow can be calculated from the known diameter of the pipes. From these two values and the average velocity of stream through the pipe can be calculated.
- The actual loss of head is determined from the Manometer readings. The frictional loss of head in pipes is given by the Darcy's formula. The friction coefficient indicates 'f'.

## EXPERIMENT 3

### FRICTION FACTOR FOR A GIVEN PIPE LINE

**Aim:** - To calculate the friction factor for a given pipe line.

**Apparatus:** - experimental set-up, stop watch.

**Procedure:-**

1. Start the motor keeping the delivery valve close.
2. The water is allowed to flow through the selected pipe by selecting the appropriate ball valve.
3. By regulating the valve control the flow rate and select the corresponding pressure tapings.
4. Make sure while taking readings, that the manometer is properly primed. Priming is the operating of filling the Manometer upper part and the connecting pipes with water venting the air from the pipes. Note down the loss of head “hf” from the manometer scale.
5. Note down the time required for the rise of 10cm (i.e. 0.1m) water in the collecting tank by using stop watch. Calculate discharge using below formula.

**Discharge:** - The time taken to collect some ‘x’ cm of water in the collecting tank in m<sup>3</sup>/sec.

$$Q = \frac{A \times R}{t}$$

A = area of the collecting tank in m<sup>2</sup> (0.3m X 0.3m)

R = rise of water level taken in meters (say 0.1m or 10cm)

t = time taken for rise of water level to rise ‘r’ in ‘t’ seconds.

6. Calculate the velocity of the jet by following formula

$$V = \frac{\text{Discharge}}{\text{Area of the pipe}} = Q/A \quad \text{m/sec}$$

A = cross sectional area of the pipe =  $\pi d^2 / 4$

d = pipe diameter [Type equation here.](#)

7. Calculate the coefficient of friction for the given pipe by

$$h_f = \frac{fLv^2}{\rho gd}$$

Where,

$h_f$  - Loss of head of water =  $(h_1 - h_2)(S_n / S_o - 1) = (h_1 - h_2) 12.6/1000 \text{ m}$

f - Co-efficient of friction for the pipe

L - Discharge between sections for which loss of head is measured (1 meter)

v - Average velocity of flow in m/sec

g - Acceleration due to gravity 9.81m/sec

d - Pipe diameter in meters

8. Repeat the steps 2 to 7 for different sets of readings by regulating the discharge valve.



**Tabular Form:**

S. No.	Ø of pipe (mm)	Area (a)	Time for rise of 10 cm water	Discharge	Velocity	Loss of Head $h_f$	Co-efficient of friction $f$

**Calculation:-**

- Total Head, H

$$H = (h_1 + h_2) \times 12.6 \text{ m of water}$$

Where,

12.6 = conversion factor from mercury to water head

- Discharge, Q

$$Q = \frac{A \times R}{t \times 100} \text{ m}^3/\text{s}$$

Where,

A = Area of collecting tank = 0.125 m<sup>2</sup>.

R = Rise in water level of the collecting tank, cm.

t = time for 'R' cm rise of water, sec

100 = Conversion from cm to m.

- Velocity, V

$$V = \frac{Q}{A'} \text{ m/s}$$

Where, A' = area of the pipe/fitting in use

$$A' = \frac{\pi \times D^2}{4} \text{ m}^2$$

- Friction Factor, (Major Losses) F:

$$f = \frac{\rho g H}{L V^2}$$

Where, H = total head, m of water

V = velocity, m

g = acceleration due to gravity, 9.81m/s<sup>2</sup>

L = Distance b/w tapping = 1.5m

- Head Loss Due To Fittings, (Minor Losses) K:

$$K = \frac{2gH}{V^2}$$

Where, H = total head, m of water

V = velocity, m

g = acceleration due to gravity, 9.81m/s<sup>2</sup>

#### **Precautions:**

- 1) Do not run the pump dry.
- 2) Clean the tanks regularly, say for every 15days.
- 3) Do not run the equipment if the voltage is below 180V.
- 4) Check all the electrical connections before running.
- 5) Before starting and after finishing the experiment the main control valve should be in close position.
- 6) Do not attempt to alter the equipment as this may cause damage to the whole system.

#### **Results and Conclusions:**

## **EXPERIMENT 4**

### **VERIFICATION OF BERNOULLIS THEOREM**

#### **Introduction**

Bernoulli's Theorem gives the relationship between pressure head, velocity head and the datum. Here the attempt has been made to study the relationship of the above said parameters using venturimeter.

#### **General Description**

- The apparatus consists of a specially fabricated clear **ACRYLIC Venturimeter** with necessary tappings connected to a **Multibank Piezometer** also made of clear **ACRYLIC**.
- The apparatus consists of two overhead tanks interconnected with the venturimeter, which is placed in between the tanks.
- The overhead tanks are provided with the Head variation mechanism for conducting the experiments at various heads.
- Water in the sump tank is pumped using a **Monobloc Centrifugal pump** (Kirloskar make) which passes through the control valve to the overhead tank.
- The height of the water in the **collecting tank** is measured using the **acrylic Piezometer** to find the flowrate.
- The whole arrangement is mounted on an **aesthetically designed sturdy frame** made of MS tubes and **NOVAPAN Board** with all the provisions for holding the tanks and accessories.

#### **Aim:**

- The experiment is conducted to
- Study of Pressure Gradient at different zones.
- Verification of Bernoulli's Equation.
- Comparative analysis under different flow rates

#### **Apparatus:**

1) Venturimeter, 2) Piezometer, 3) Overhead Tank, 4) Sump Tank, 5) Centrifugal Pump

#### **Procedure:**

- 1) Fill in the sump tank with clean water.
- 2) Keep the delivery valve closed.
- 3) Check and give necessary electrical connections to the system.
- 4) Switch on the pump & Slowly open the delivery valve.
- 5) Adjust the flow through the control valve of the pump.
- 6) Allow the system to attain the steady state. i.e., let the water pass from the second overhead tank to the collecting tank.
- 7) Note down the Pressure head at different points of the venture meter on the multi-tube piezometer. (Expel if any air is the by inserting the thin pin into the piezometer openings)
- 8) Close the ball valve of the collecting tank and measure the time for the known rise of water.
- 9) Change the flow rate and repeat the experiment.

#### **Observation:**

Sl. No	Static Head Loss, h										Time for 'R' cm rise in water 'T' sec
	1	2	3	4	5	6	7	8	9	10	
1											
2											
3											
4											
5											

### Calculations:

1. Discharge, QA

2.

Where,

$$Q = \frac{A \times R}{t \times 100} m^3/s$$

A = Area of collecting tank = 0.045 m<sup>2</sup>.

R = Rise in water level of the collecting tank, cm.

t = time for 'R' cm rise of water, sec

100 = Conversion from cm to m.

3. Pressure Head,

Where,

$$Pressure\ Head = \frac{P}{\rho \times g} = h \quad m\ of\ water$$

$\rho$  = density of water.

g = gravitational constant

h = head measured, m of water column

3. Velocity Head,

$$Velocity\ Head = \frac{V^2}{2g} \quad m\ of\ water$$

Where,

$V = Q / a$ , a = Area at the particular section\* of the venturimeter m<sup>2</sup>.

4. Verification of BERNOULLI'S EQUATION

Bernoulli's Equation is given as:

After finding,

$$\frac{p}{\rho g} + \frac{V^2}{2g} + z = 0$$

a. Pressure Head, h

b. Velocity head,

at different cross-section of the Venturimeter.

Put the same in the above equation for different points and verify whether all the values obtained are same.

**Note:** Consider the datum, z to be constant.

### Precautions:

- Do not run the pump dry.
- Clean the tanks regularly, say for every 15days.
- Do not run the equipment if the voltage is below 180V.

- Check all the electrical connections before running.
- Before starting and after finishing the experiment the main
- Control valve should be in close position.
- Do not attempt to alter the equipment as this may cause
- Damage to the whole system.

**Result and Conclusion:**

## **EXPERIMENT 5**

### **CALIBRATION OF A TRIANGULAR NOTCH**

**AIM:** -To find the coefficient of discharge of given triangular notch

**THEORY:-**A notch is a device used for measuring the rate of flow of liquid through a small channel or a tank .It may be defined as an opening in the side of a tank or small channel in such that a way that the liquid surfaces in the tank or channel is below the top edge of the opening.

#### **NOTCHES ARE CLASSIFIED AS:-**

1. Rectangular notch
2. Triangular notch
3. Trapezoidal notch
4. Stepped notch

A triangular notch is preferred to a rectangular notch due to the following reasons. The expression for discharge of triangular notch is compared to rectangular notch is simple. For measuring low discharge a triangular notch gives more accurate results than a rectangular notch. In the case of triangular notch only H is required for the computation of discharge. A trapezoidal notch is a combination of rectangular and triangular notch and thus the discharge through trapezoidal notch is the sum of above notches. A stepped notch is a combination of rectangular notch and triangular notch. The discharge through the stepped notch is equal to sum of discharges through the different rectangular notches.

**DESCRIPTION:-** The apparatus consists of

- 1) Measuring tank
- 2) Sump tank
- 3) Supply pump
- 4) Inlet and out let valve

**Measuring tank:** Stainless steel tank of size 0.3\*0.3\*0.5mm height with the gage glass, a scale arrangement for quick and easy measurements. A ball valve is provided to empty the tank and a drain is provided at the bottom of the tank to drain the waste water when the unit is not in use. Water for independent circulation through the unit for experimentation and arranged within the floor space of the main unit.

**Sump tank:** The sump tank is a size of 0.2\*0.3\*0.3m stainless steel tank to store sufficient water for independent circulation through the unit for experimentation and arranged within the floor space of the main unit about 0.6\*0.3\*0.5m with a gauge glass and scale arrangement. A ball valve is provided to empty the tank.

**Supply Pump set:** The pump is 25\*25mm size mono block with ½ HP, 2880 RPM, single phase, 220volts AC supply. **Inlet and out let valve:-** These valves are used to control the flow of water at inlet and out let .

#### **PROCEDURE:**

1. Allow the water to drain up to triangular notch.
2. Note down the depth of the water when the water is coinciding with the v notch point.
3. Collect water in collecting tank and close the drain valve and find the time taken for the rise of water up to 20cm.
4. Calculate the discharge by using the above results.

5. Now substituting the values in the formula for calculation of discharge for v- notch gives the required result.

#### CALCULATIONS:-

The theoretical discharge through a v- notch of an angel  $\theta_H$  is given by

$$\theta_H = (8/15)1.414 g \tan (\theta/2)H^{5/2}$$

The theoretical discharge through a v-notch where H=height of water above inlet of the notch.

**Coefficient of discharge**

$$C_d = Q_a/Q_H$$

#### OBSERVATION TABLE

S.No	Depth Of water			Theoretical Discharge $Q_H$	Time t sec	Actual Discharge	Coefficient of Discharge $C_d = Q_a/Q_H$
	$h_1$	$h_2$	$h$				
1							
2							

#### Precautions:

- Do not run the pump dry.
- Clean the tanks regularly, say for every 15days.
- Do not run the equipment if the voltage is below 180V.
- Check all the electrical connections before running.
- Before starting and after finishing the experiment the main
- Control valve should be in close position.
- Do not attempt to alter the equipment as this may cause
- Damage to the whole system.

#### Result and Conclusion:

## EXPERIMENT 6

### CALIBRATION OF COEFFICIENT OF DISCHARGE METER

#### **1. INTRODUCTION:**

All openings cannot be considered as an orifice unless the water level on the upstream side is above the opening. The purpose of the orifice is to measure the discharge. When the water comes out through the orifice, the water particles contract to the minimum area called as the vena contracta. The diameter of this vena contracta is approximately considered as the half the diameter of the orifice. However, to view the vena contracta the head should be very high and due limitations an attempt has been made to study the process.

It should be borne in mind that the results are analyzed qualitatively and not quantitatively.

#### **2. DESCRIPTION OF THE APPARATUS:**

1. Water from the sump tank is sucked by the pump and is delivered through the delivery pipe to the collecting tank.
2. Overflow arrangement is provided to the collecting and overhead tanks.
3. Butterfly valve is provided in the measuring tank for instant close and release.
4. The suction and delivery can be controlled by means of control valves.
5. Piezometer with Vinyl sticker scale ( For better readability) is provided to measure the height of the water collected in the measuring tank.
6. The equipment has been designed for 0.6m of ma heads and works on closed circuit method.
7. The equipment comes with accessories viz orifices & mouthpieces each 4nos. of different varieties.
8. The X & Y co-ordinates are measured using the moving scale fixed by the side of the tank.
9. The whole arrangement is mounted on an aesthetically designed sturdy frame made of MS angle with all the provisions for holding the tanks and Accessories.

#### **3. EXPERIMENTATION:**

##### **i. AIM:**

The experiment is used to determine

- a) Co-efficient of discharge (CD) of mouthpieces.
- b) Co—efficient of Velocity (CV)and

##### **ii. PROCEDURE:**

1. Fill the sump tank with water to the specified level.
2. Place the Orifice of study in the overhead tank.
3. Set the head by opening the required valve in the overhead tank.
4. Close the main control valve and give necessary electrical connections.
5. Switch on the supply pump starter after confirming the mains on indicator is glowing.
6. Open the main control valve slowly and steadily such that the required constant head is maintained.



7. Measure the X & Y co-ordinates using the traveling scale.
8. Measure the discharge in the collecting tank by closing the butterfly valve and taking the time for R cm rise.
9. Open the butterfly valve after taking the readings.
10. Repeat the above steps for different orifices and heads.
11. Calculate the discharge, velocity and contraction co-efficients using the given formulae.
12. After finishing the experiment the close the main control valve and switch off the supply pump starter and disconnect the electrical connections.
13. Repeat the above steps for mouthpieces also.

NOTE: Only discharge is measured for mouthpieces.

#### iv. CALCULATIONS

##### 1. CROSS-SECTIONAL AREA OF THE JET:

$$a = \frac{\pi d^2}{4} \quad m^2$$

Where,

d = diameter of the orifice in study.

$\pi$  = constant

##### 2. ACTUAL DISCHARGE, QA

$$Qa = \frac{A \times R}{t \times 100} \quad m^3 / \text{sec.}$$

Where,

A = Cross-sectional area of the tank, m<sup>2</sup>.

R = Rise in water level of the collecting tank in cm.

t = time for 'R' cm rise in water

##### 3. THEORITICAL DISCHARGE, QTH

$$QTH = \sqrt{2gH} \times a \quad m^3 / \text{sec.}$$

G= acceleration due to gravity, 9.81m/s<sup>2</sup>

H=head above the orifice in m of water.

a= Cross-sectional area of the jet.

#### RESULTS:

#### **4. PRECAUTIONS:**

1. Do not run the pump dry
2. Clean the tanks regularly, say for every 15days.
3. Do not run the equipment if the voltage is below 180V.
4. Check all the electrical connections before running.
5. Before starting and after finishing the experiment the main control valve should be in close position.
6. Do not attempt to alter the equipment as this may cause damage to the whole system.

## EXPERIMENT 7

### PUNCH SHEAR SETUP

#### DESCRIPTION OF APPARATUS

The Apparatus consists of:

1. A RIGID Punch and Die Attachment in the Wagner beam setup.
2. A Heavy Die can be attached to the panel.
3. Loading is applied by means of Gear Box Assembly and the applied load indicator which is attached with Load Cell.
4. Pins of particular dimension is provided for the test.
5. Sturdy Frame for attachment of different types of Cantilever beams is provided.

#### EXPERIMENTATION

##### AIM:

The experiment is conducted to determine the **SHEAR STRENGTH OF THE GIVEN SPECIMEN.**

##### PROCEDURE:

1. Fix the PUNCH AND DIE at the position.
2. Adjust the load unit at the required distance
3. Connect the pin under test in between the punch and the die.
4. Holes are provided to align the pin.
5. Connect the Load Cell cable to the Load Indicator respectively.
6. Provide necessary electrical connection (230V 1ph 5Amps with neutral and earthing) to the indicator provided.
7. Tare the load if any on the indicator.
8. Press the peak button on the indicator so the maximum load to shear the specimen can be noted at the end of shear.
9. Now, using the Hand wheel provided load the punch until shear of the material.
10. Note down the maximum load required to shear the specimen.
11. Now, calculate the shear stress required using the below formulas.

#### OBSERVATIONS:

SI NO.	Maximum Load Applied		Diameter of the rod, d mm
	Kg	N	

**CALCULATIONS:****1. Area of the Pin used, A**

$$A = \frac{\pi d^2}{4} \text{ mm}^2$$

Where,

d = diameter of the pin, mm

**2. SHEAR STRESS,  $\tau$** 

$$\tau = \frac{P}{2A} \text{ N/mm}^2$$

**PRECAUTIONS:**

1. Clean the equipment regularly and grease all visual rotational parts periodically say for every 15days.
2. Do not run the equipment if the voltage is below 180V.
3. Do not leave the load to the maximum.
4. Check all the electrical connections before running.
5. Before starting and after finishing the experiment the main control valve should be in close position.
6. Do not attempt to alter the equipment as this may cause damage to the whole system.