A Laboratory Manual for

Engineering Graphics and Design (BE01000061)

B.E. Semester 1/2 (All Branches)

Directorate of Technical Education, Gandhinagar, Gujarat

Certificate

This is to certify that Mr./Ms. _____

Enrollment No. _____ of B.E. Semester _____

_____ Engineering of this Institute (GTU Code: <u>015</u>) has satisfactorily

completed the Practical / Tutorial work for the subject **Engineering Graphics**

and Design (BE01000061) for the academic year <u>2025-26</u>.

Place: _____

Date: _____

Name and Sign of Faculty member   **Head of the Department**

Preface

The aim of any laboratory/practical/field work is to enhance required skills and create ability amongst students to solve real time problems. GTU has designed a competency focused outcome-based curriculum for engineering degree programs, giving sufficient weightage to practical work. It emphasizes the importance of enhancement of skills amongst the students and pays attention to utilize every second of time allotted for practical amongst students, instructors and faculty members to achieve relevant outcomes. This lab manual is designed to focus on the industry defined relevant outcomes, rather than traditional chalk and board content delivery method in the classroom.

By using this lab manual students can go through the relevant theory and procedure in advance before the actual performance which creates an interest and students can have basic idea prior to performance. This in turn enhances pre-determined outcomes amongst students. Each experiment in this manual begins with competency, industry relevant skills, course outcomes as well as practical outcomes (objectives). The students will also achieve safety and necessary precautions to be taken while performing practical.

This manual also provides guidelines to faculty members to facilitate student centric lab activities through each experiment by arranging and managing necessary resources in order that the students follow the procedures with required safety and necessary precautions to achieve the outcomes. It also gives an idea that how students will be assessed by providing rubrics.

Engineering Drawing is an effective language of engineers. It is the foundation block which strengthens the engineering & technological structure. Moreover, it is the transmitting link between ideas and realization. In general, engineering drawings gives the essential details regarding the object's form, size, surface quality, composition, manufacturing method, etc. Students can visualize objects from this graphic language.

Utmost care has been taken while preparing this lab manual however always there is chances of improvement. Therefore, we welcome constructive suggestions for improvement and removal of errors if any.

Practical – Course Outcome matrix

Course Outcomes (COs):
CO1 Apply the conventions and the methods of engineering drawing also interpret engineering drawings
CO2 Construct basic and intermediate geometry and comprehend the theory of projection
CO3 Dissect the objects in three dimensions with different orientation.
CO4 Make use of computer software for engineering drawings.

Sr. No.	Objective(s) of Experiment	CO1	CO2	CO3	CO4
1.	Practice sheet (Dimensioning methods, different types of line, construction of different polygon, divide the line and angle in parts, use of stencil)	√			
2.	Plain scale and diagonal scale	√			
3.	Engineering curves	√			
4.	Projections of Points and Lines		√		
5.	Projections of plane		√		
6.	Projection of solid, section of solid		√		
7.	Orthographic projection			√	
8.	Orthographic drawing (three views) using AutoCAD commands				√

Industry Relevant Skills

The following industry relevant competencies are expected to be developed in the student by undertaking the practical work of this laboratory.
1. Able to read, comprehend and create technical drawings using conventional drafting methods or CAD software
2. Capacity to comprehend the industry standards for engineering drawings
3. Visualize and represent 3D objects in 2D drawings or 3D models
4. Effective communication for engineering projects using engineering graphics to communicate concepts, designs and requirements
5. Paying close attention to essential details
6. Time management in order to fulfill project deadlines and deliverables

Guidelines for Faculty members
1. Teacher should provide the guideline with demonstration of practical to the students with all features.
2. Teacher shall explain basic concepts/theory related to the experiment to the students before starting of each practical
3. Involve all the students in performance of each experiment.
4. Teacher is expected to share the skills and competencies to be developed in the students and ensure that the respective skills and competencies are developed in the students after the completion of the experimentation.
5. Teachers should give opportunity to students for hands-on experience after the demonstration.
6. Teacher may provide additional knowledge and skills to the students even though not covered in the manual but are expected from the students by concerned industry.
7. Give practical assignment and assess the performance of students based on task assigned to check whether it is as per the instructions or not.
8. Teacher is expected to refer complete curriculum of the course and follow the guidelines for implementation.

Instructions for Students
1. Students are expected to carefully listen to all the theory classes delivered by the faculty members and understand the COs, content of the course, teaching and examination scheme, skill set to be developed etc.
2. Students shall organize the work in the group and make record of all observations.
3. Students shall develop maintenance skill as expected by industries.
4. Student shall attempt to develop related hand-on skills and build confidence.
5. Student shall develop the habits of evolving more ideas, innovations, skills etc. apart from those included in scope of manual.
6. Student shall refer technical magazines and data books.
7. Student should develop a habit of submitting the experimentation work as per the schedule and s/he should be well prepared for the same.

Common Safety Instructions
1. Students are expected to carefully use the instruments with sharp edges.

Index
(Progressive Assessment Sheet)

Sr. No.	Objective(s) of Experiment	Page No.	Date of performance	Date of submission	Assessment Marks	Sign. of Teacher with date	Remarks
1.	1. Practice sheet (Dimensioning methods, different types of line, construction of different polygon, divide the line and angle in parts, use of stencil)						
2.	Plain scale and diagonal scale						
3.	Engineering curves						
4.	Projections of Points and Lines						
5.	Projections of plane						
6.	Projection of solid, section of solid						
7.	Orthographic projection						
8.	Orthographic drawing (three views) using AutoCAD commands						
Total							

Suggested Project:
Students must prepare at least one model using cardboard/paper to understand the fundamentals of topic no. 1 to 6. This project work will be considered for practical evaluation.

Experiment – 1
Sheet No. 1: PRACTICE SHEET

Date:

Competency and Practical Skills: Comprehend the industry standards for engineering drawings

Relevant CO: CO1
Objectives:
- To know and understand the conventions and the methods of engineering drawing.
- Construct basic and intermediate geometry.
- To know about various line types and dimensioning systems.

DRAFTING EQUIPMENTS REQUIRED
1. Mechanical pencil (clutch pencil) -**0.5mm size**. (Lead box – **0.5mm size**, H grade, 2H Grade), Eraser
2. Sketch book – A3 size (27.5 cm*34.7 cm)
3. Set squares – 30°-60° & 45°
4. Rounder (which can accommodate Mechanical pencil).
5. Mini drafter.
6. Drawing sheets - A2 size (Half Imperial Size).
7. Drawing board – B2 size (optional).
8. Drawing clips
9. Sheet box (Sheet container)
10. Circle master, Protractor & Scales

Important guidelines for students:
- Before starting each sheet, signature of concerned batch teacher should be taken on the sheet without fail; else no credit would be given to that practical sheet.
- Students should bring the drawing sheet ready for the practical i.e. the borderlines and Title block should be drawn on the drawing sheet before coming for the practical.
- Before starting each sheet in the college, **each student will have to ensure that the work in the sketch Book pertaining to that sheet is completed in all respect; else the student will not be allowed to start his work in the sheet.**
- Any data written on the sheets should be in the block (CAPITAL) letters only.
- All problems of all sheets should be drawn by first angle projection method if not specified.
- **Name and Enrollment No. Should be written on sheet in the title block with the ball pen.**
- Student must come with all Drawing Equipment & Materials for laboratory work without fail; otherwise, individual will not be permitted to enter in drawing hall.

Instructions for drawing sheet preparation:
- Student should draw the boundary in the pages of the sketchbook/sheet and then solve problems. Boundary margin for sketch-book is 10 mm from all sides. Boundary margin for sheet is 40 mm from left hand side and 10 mm from remaining three sides.
- Student should write the full problem in the sketchbook and draw the problem with proper dimensioning.
- Student will have to draw title block in the sheet and have to draw all the problems within the boundary with proper dimensioning.
- Student will have to write drawing scale, if different for a particular problem.

- Student will have to specify the projection system that they have used.
- Standard dimensioning pattern must be considered.

LETTERING [IS 9609 (PART 0) : 2001 AND SP 46 : 2003]

Lettering is defined as writing of titles, sub-titles, dimensions, etc., on a drawing.
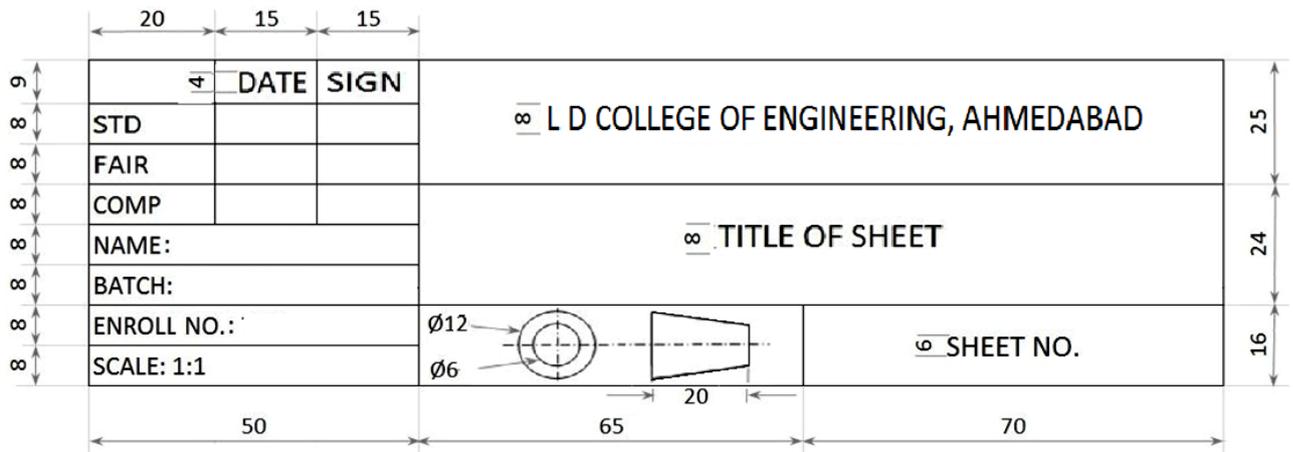
Size of Letters:

• Size of Letters is measured by the height h of the CAPITAL letters as well as numerals.
• Standard heights for CAPITAL letters and numerals recommended by BIS are given below:
1.8, 2.5, 3.5, 5, 6, 10, 14 and 20 mm
Note: Size of the letters may be selected based upon the size of drawing.
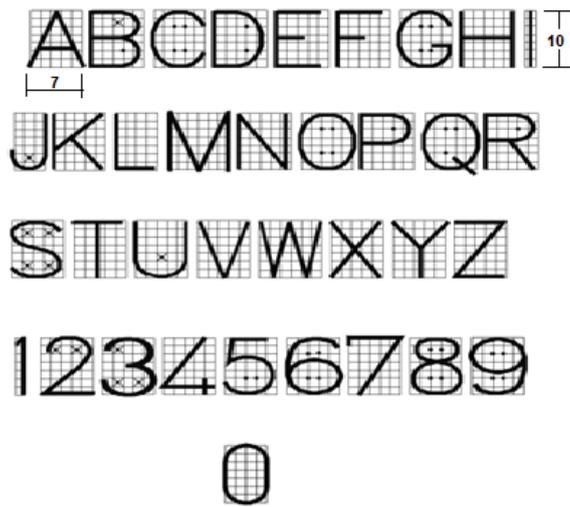
**ALL DIMENSIONS ARE IN MM**

TITLE BLOCK FOR SHEET

ALL DIMENSIONS ARE IN MM

TYPES OF LINES

SR	LINE TYPE	ILLUSTRATION	APPLICATION
1	CONTINUOUS THICK	————————	VISIBLE OUTLINES
2	CONTINUOUS THIN	————————	DIMENSION, LEADER, EXTENSION, CONSTRUCTION LINES, OUTLINES OF ADJACENT PARTS, HATCHING,REVOLVED SECTIONS
3	DASHED THICK	– – – – – – – –	HIDDEN LINES
4	CHAIN THIN	—— – —— – ——	CENTRE LINES, LINES OF SYMMETRY, LOCUS LINES, PITCH CIRCLES
5	CHAIN THIN WITH THICK ENDS	▬— · — · — ▬	CUTTING PLANES
6	CONTINOUS THIN – FREE HAND	∿∿∿	IRREGULAR BOUNDARY LINES, SHORT BREAK LINE
7	CONTINUOUS THIN WITH ZIGZAGS	⸺⅄⸺⅄⸺	LONG BREAK LINES
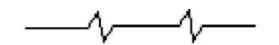
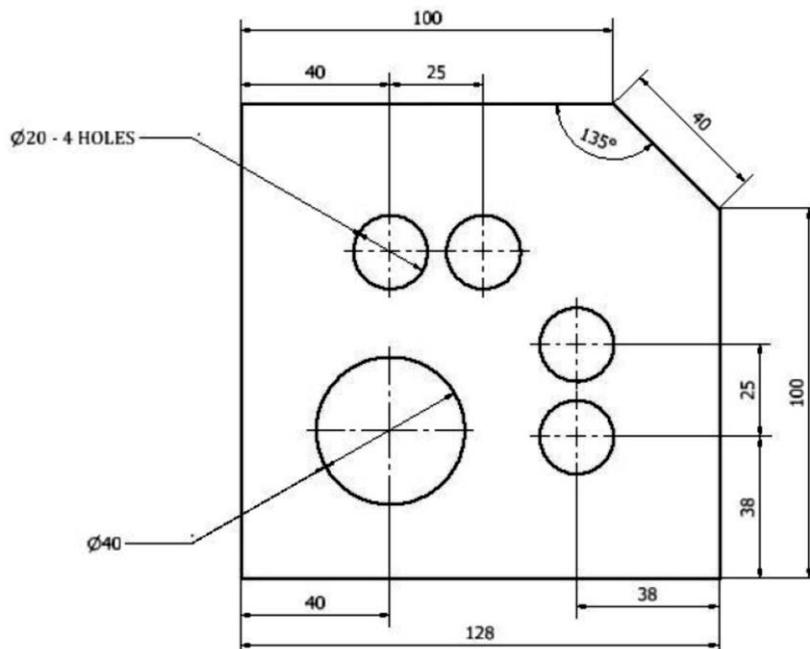## APPLICATION OF DIFFERENT LINES
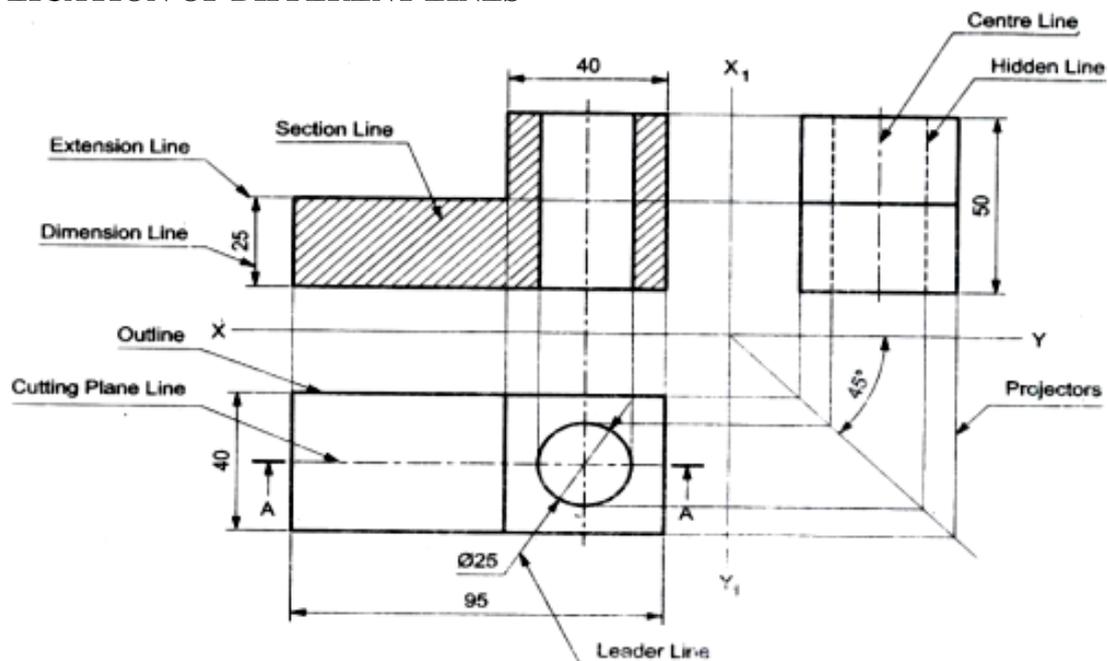
DIMENSIONING SYSTEM

General Rules for dimensioning:
1. Dimensioning should be done so completely that further calculation or assumption of any dimension, or direct measurement from the drawing is not necessary.
2. Every dimension must be given, but none should be given more than once.
3. Dimensions should be placed outside the views, unless they are clearer and more easily read inside.
4. Dimension lines should be drawn at least 8 mm away from the outlines and from each other.
5. Smaller dimensions should be placed nearer the view and the larger further away so that extension lines do not cross dimension lines. Extension lines may cross each other or other outlines.
6. Mutual crossing of dimension lines and dimensioning between hidden lines should be avoided. Dimension lines should not cross any other line of the drawing.
7. An outline or a centre line should never be used as a dimension line. A centre line may be extended to serve as an extension line.

ELEMENTS OF DIMENSIONING

- Students should identify and know the correct drawing of the following dimensioning elements: Dimension lines, Extension lines, Leader lines and Arrowheads.
- Dimensions in a series may be placed in two ways:
  (i) Continuous or chain dimensioning (ii) Progressive or parallel dimensioning.
- Draw the following figure in both, Aligned system & unidirectional system.

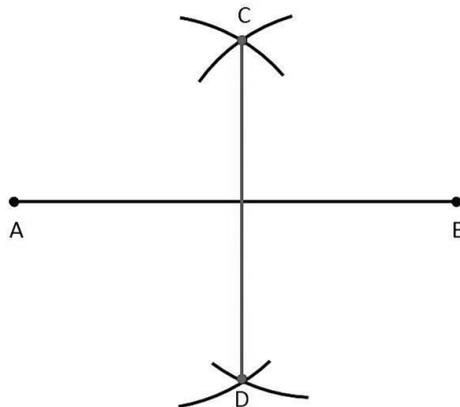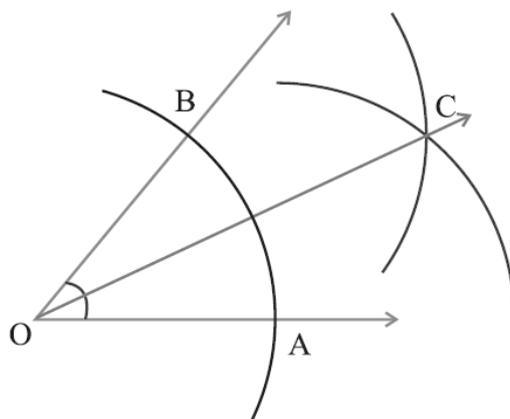ALIGNED METHOD OF DIMENSIONING
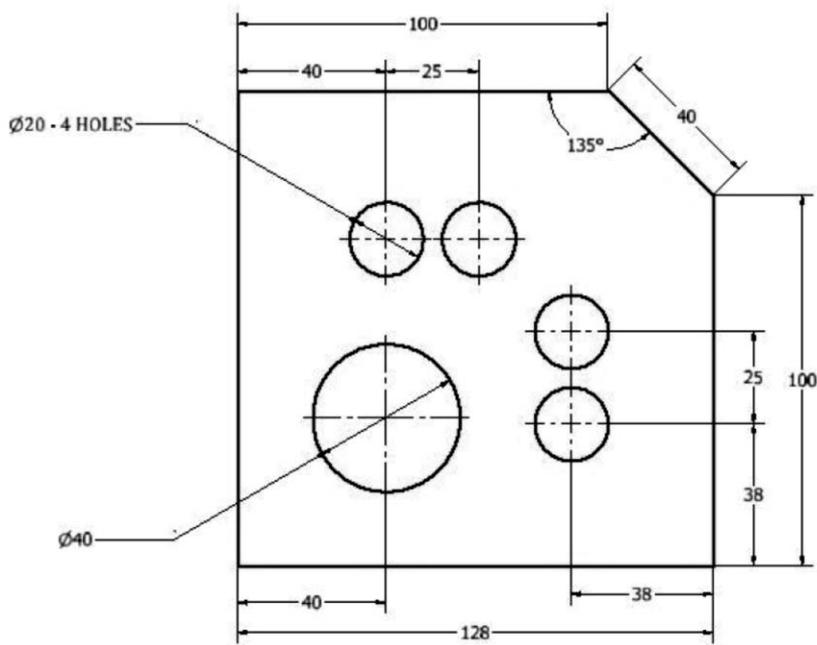
LINE BISECOTR

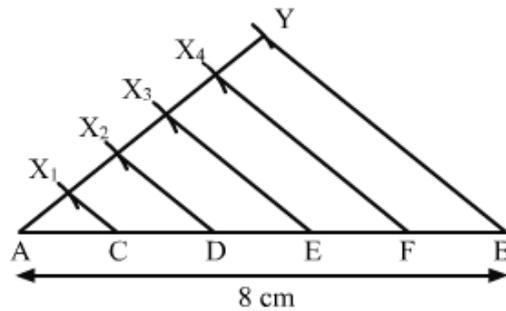Draw a line segment of length 8.5 cm and construct its perpendicular bisector


ANGLE BISECTOR

EQUAL DIVISIONS OF A LINE :

Draw a line, 8 cm long and divide it into five equal parts.

UNIVERSAL METHOD FOR DRAWING PLOYGON

1. Draw the given straight line AB of 50 mm.
2. At B erect a perpendicular BC equal in length to AB.
3. Join AC and where it cuts the perpendicular bisector of AB, number the point 4.
4. Complete the square ABCD of which AC is the diagonal.
5. With radius AB and centre B describe arc AC as shown.
6. Where this arc cuts the vertical centre line numbers the point 6.
7. This is the centre of a circle inside which a hexagon of side AB can now be drawn.
8. Bisect the distance 4-6 on the vertical centre line.
9. Mark this bisection 5. Using this as centre, regular pentagon of side AB can be drawn.
10. On the vertical centre line step off from point 6 a distance equal in length to the distance 5-6. Using this as centre, a regular heptagon of side AB can be drawn.
11. If further distances 5-6 are now stepped off along the vertical centre line and are numbered consecutively, each will be the centre of a circle in which a regular polygon can be inscribed with side of length AB and with a number of sides denoted by the number against the centre.
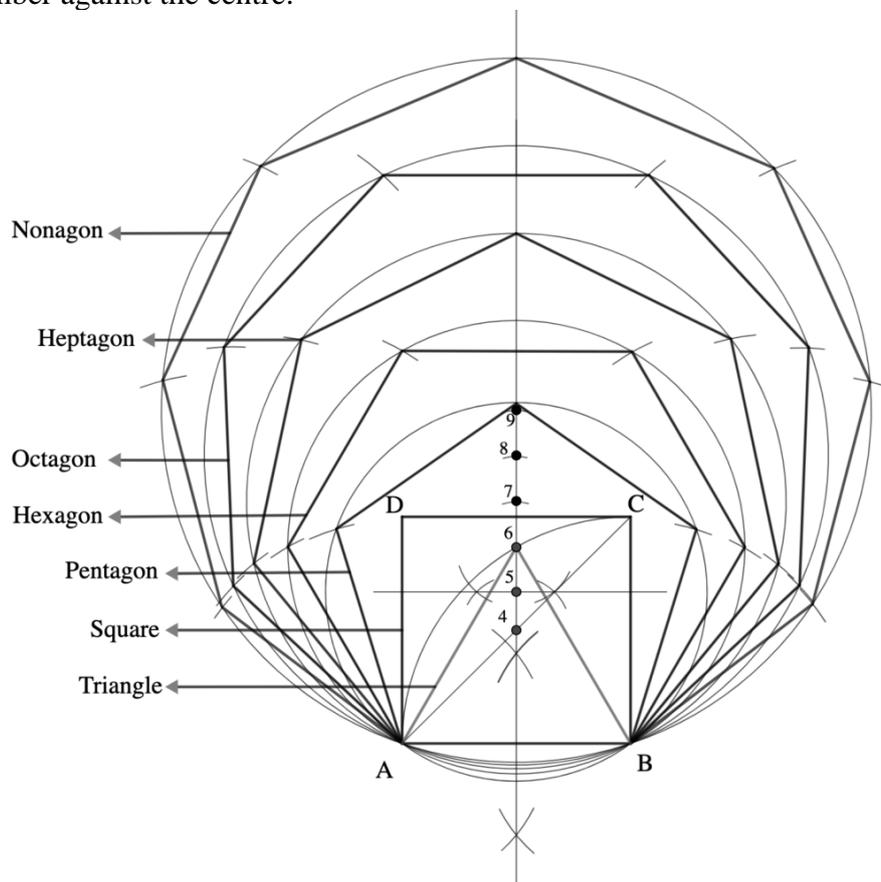
Rubrics of Sheet No-1

Sr. No.	Assessment criteria	Maximum-Mark	Level		
		/10	High	Medium	Low
1	Understanding of Problem/ Drawing	/4	4	3	2
2	Line Quality (dark/ thin)	/2	2	1	0
3	Accuracy and Precision	/2	2	1	0
4	Dimension and lettering	/2	2	1	0

Reference books:

1. A Text Book of Engineering Graphics by P.J. Shah S. Chand & Company Ltd., New Delhi.
2. Elementary Engineering Drawing by N.D. Bhatt Charotar Publishing House, Anand.
3. A text book of Engineering Drawing by P S Gill, S.K. Kataria & sons, Delhi.

Experiment – 2
Sheet No. 2 - PLAIN AND DIAGONAL SCALES

Date:

Competency and Practical Skills: Paying close attention to essential details

Relevant CO: CO1

Objectives:
- To prepare different types of scales used in engineering practice.
- To recognize the use of various engineering scales in different applications

THEORY:
  Scale is defined as the ratio of linear dimensions of elements of the objects as represented in a drawing to the actual dimensions of the same elements of the objects itself.
  Representative Fraction is ratio of the length of the object represented on the drawing to the actual length of the object represented.

TYPES OF SCALES:

• Full size	• Plain Scale
• Reduced size	• Diagonal Scale
• Enlarged size	• Isometric Scale
	• Vernier Scale

Q-1
  Construct a scale of 1:4, to show centimetres and long enough to measure up to 5 decimetres and show 3.7 decimetres on it.

- **Length of the scale = R.F. × max. length = ¼ × 5 dm = 12.5 cm.**
- **Draw a line 12.5 cm long and divide it in to 5 equal divisions, each representing 1 dm.**
- **Mark 0 at the end of the first division and 1, 2, 3 and 4 at the end of each subsequent division to its right.**
- **Divide the first division into 10 equal sub-divisions, each representing 1 cm.**
- **Mark cm to the left of 0 as shown.**
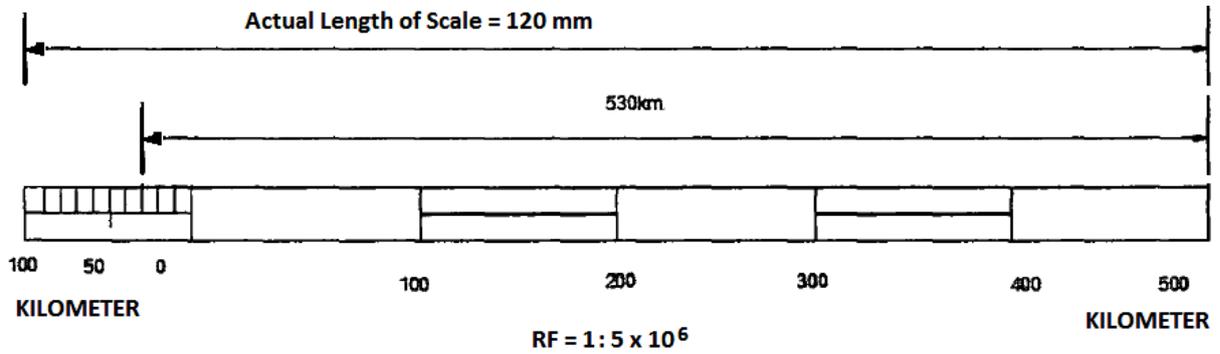

$$R.F. = \frac{1}{4}$$
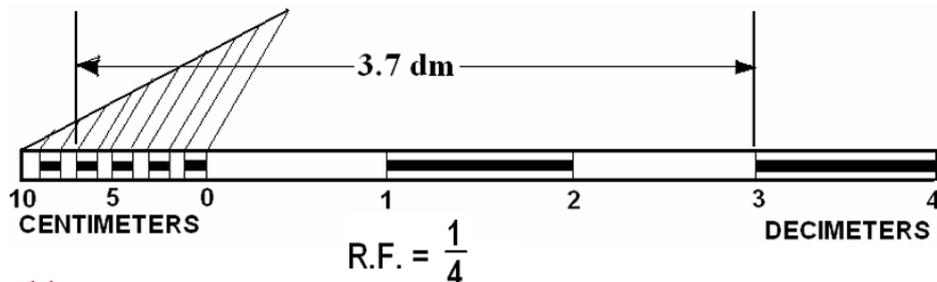
Q-2
  The distance between two towns is 250 km and is represented by a line of length 50mm on a map. Construct a scale to read 600 km and indicate a distance of 530 km on it.

1. Determine the RF value as $\dfrac{50mm}{250km} = \dfrac{50}{250 \times 1000 \times 1000} = \dfrac{1}{5 \times 10^6}$

2. Obtain the length of the scale as: $\dfrac{1}{5 \times 10^6} \times 600km = 120mm$.

Actual Length of Scale = 120 mm

530km

100 50 0
KILOMETER

100   200   300   400   500
KILOMETER

RF = 1:5 x 10^6

Q-3

A length of 4.5 meters is represented by a 3 cm long line. Extend this line to measure upto 30 meters. Show the length of 22 meters on this line.

22m

5 4 3 2 1 0   5   10   15   20   25

METRES

R.F = $\dfrac{1}{150}$
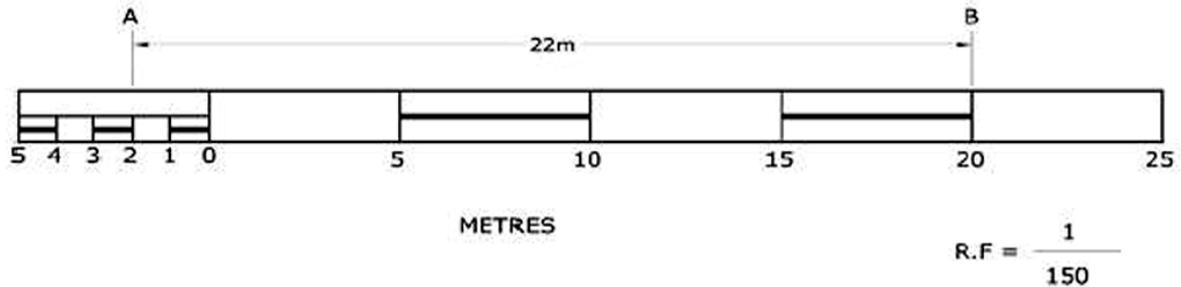
Q-4

On a map, the distance between two points is 14 cm. The real distance between them is 20 km. Draw a diagonal scale of this map to read kilometers and hectometers, & to measure up to 25 km. Show a distance of 17.6 km on this scale.

RF = 14 cm/ (20 x 1000 x 100) cm = 7/1000000.

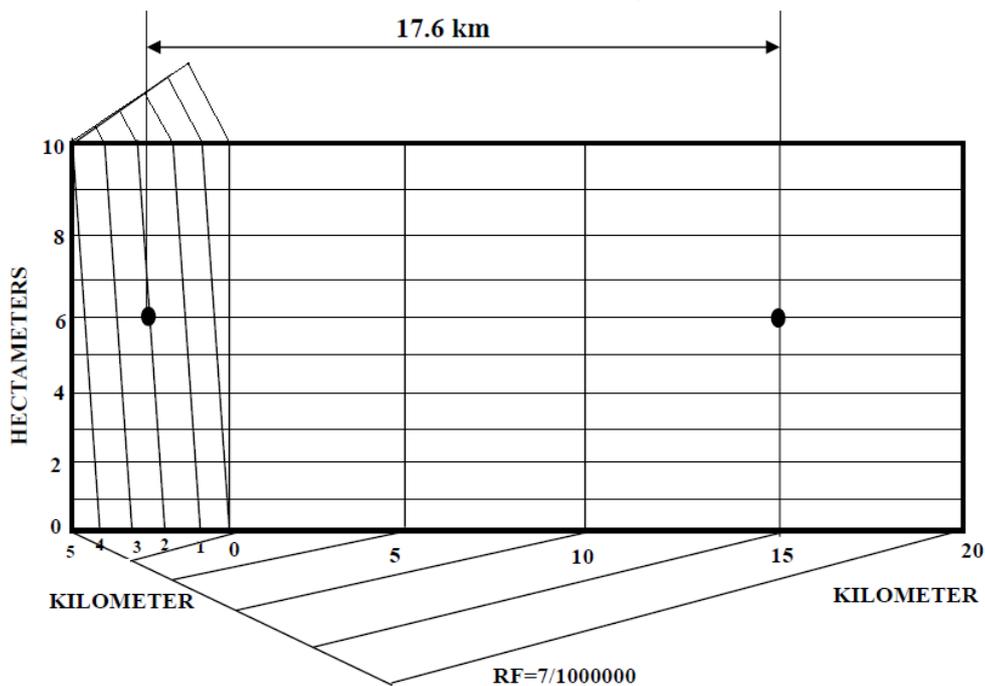Max Length (ML) = 25 km; (no. of parts of scale =5 parts, each of 5 km)

Length of scale (LOS) = RF X ML

= (7/1000000) x 25 x 1000 x 100 cm (1 km=1000 x 100 cm)

= 17.5 cm.

The sub unit is divided into 5 parts so that each division represents 1 km. The vertical sub-sub unit is hectometer and it is divided into 10 parts as 1 km = 10 hm.

17.6 km

HECTAMETERS

10
8
6
4
2
0

5 4 3 2 1 0   5   10   15   20
KILOMETER   **KILOMETER**

RF=7/1000000

Q-5 : An area of 144 sq. cm on a map represents an area of 9 sq. km on the field. Find the of

R.F. the scale and draw a diagonal scale to show kilometers, hectometers and decameters and to measure up to 10 kilometers. Indicate on a distance of 7 kilometers, 5 hectometers and 6 decameters on the scale.

$$RF = \sqrt{144 / (36 \times (1000 \times 100)^2)} = 1/50,000.$$

Max Length (ML) = 10 km.

No. of parts of scale (n) = 10 parts (each of 1 km)

Length of scale (LOS) = $(1/50000) \times 10 \times 1000 \times 100$ cm (1 m=100 cm)

= 20 cm.

7km 5 hm 6 dm

HECTOMETERS   KILOMETERS

RF=1/50000
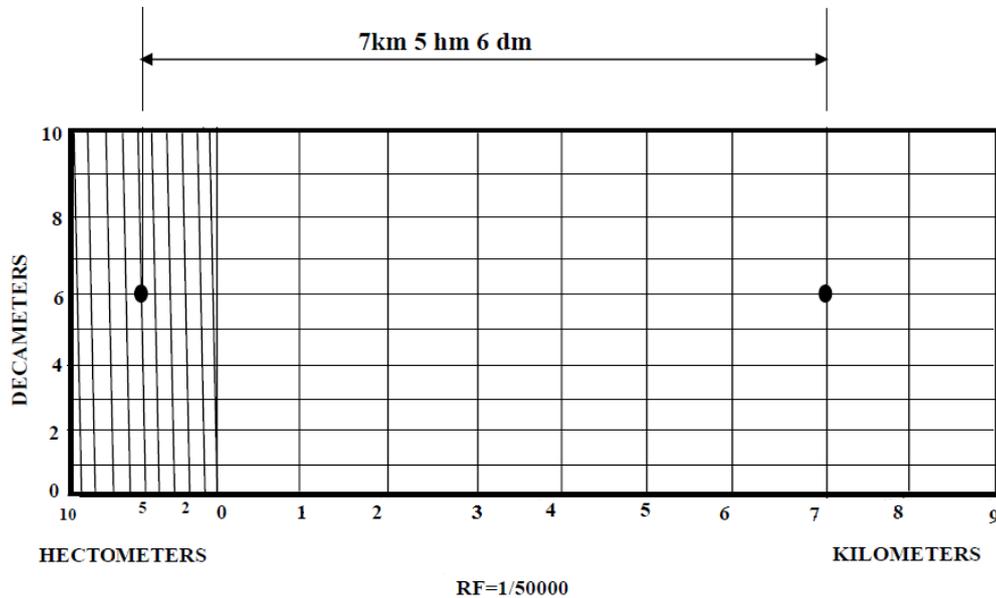
Q-6 : The distance between two cities is 200 km and it is represented by a 5 cm long line on a map. Find the R.F. and construct a diagonal scale showing a single kilometer and long enough to measure upto 600 km. Show a distance of 467 km on this scale.

467k m

KILOMETRE   R.F = 1:4000000
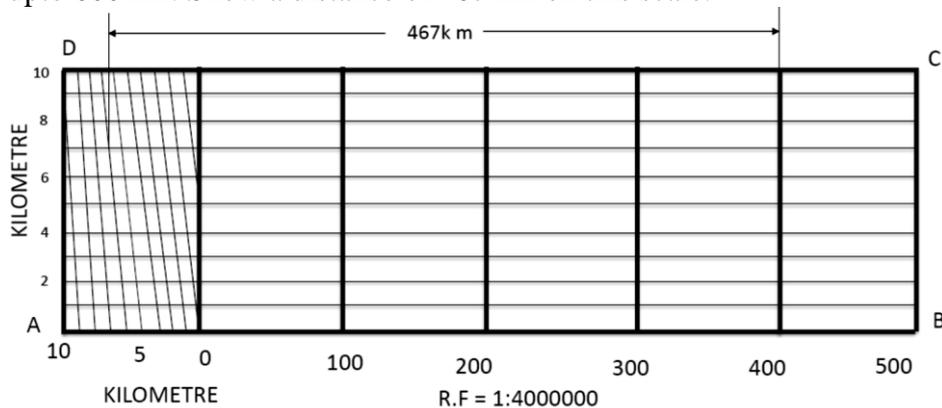
Rubrics of Sheet No-2

Sr. No.	Assessment criteria	Maximum-Mark /10	Level		
			High	Medium	Low
1	Understanding of Problem/ Drawing	/4	4	3	2
2	Line Quality (dark/ thin)	/2	2	1	0
3	Accuracy and Precision	/2	2	1	0
4	Dimension and lettering	/2	2	1	0

Reference books:

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3. A text book of Engineering Drawing by P S Gill, S.K. Kataria & sons, Delhi.

Experiment – 3
Sheet No. 3 - ENGINEERING CURVES

Date:

Competency and Practical Skills: Able to read, comprehend and create technical drawings using conventional drafting

Relevant CO: CO1
Objectives:
- To draw conic curves using different methods.
- To draw Cycloidal curves, Spiral, Involute using different methods.

CONIC SECTIONS

Cone is formed when a right-angled triangle is rotated about its altitude as the axis. The length or height of the cone is equal to the altitude of the triangle and the radius of the base of the cone is equal to the base of the triangle. The apex angle of the cone is 2θ. When a cone is cut by a plane, the curve formed along the section is known as a conic.

- An ellipse is obtained when a section plane A–A, inclined to the axis cuts all the generators of the cone.
- A parabola is obtained when a section plane B–B, parallel to one of the generators cuts the cone. Obviously, the section plane will cut the base of the cone.
- A hyperbola is obtained when a section plane C–C, inclined to the axis cuts the cone on one side of the axis.
- A rectangular hyperbola is obtained when a section plane D–D, parallel to the axis cuts the cone.
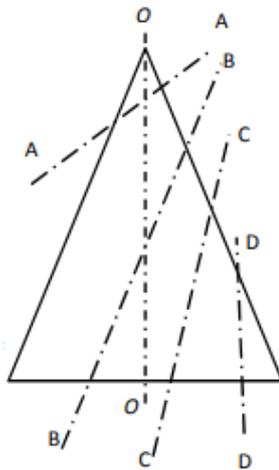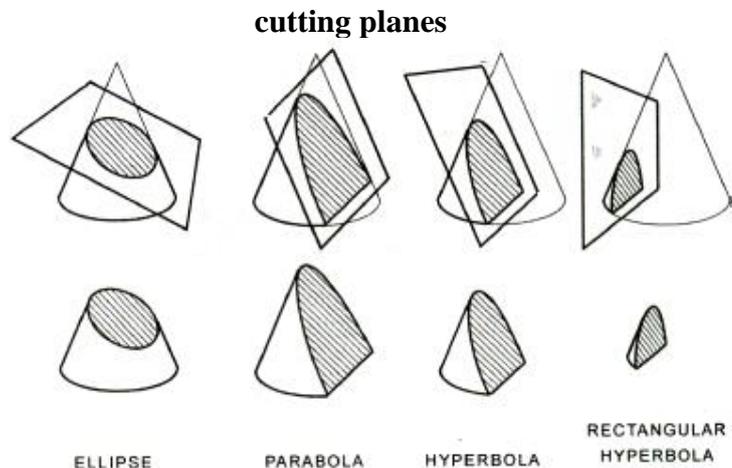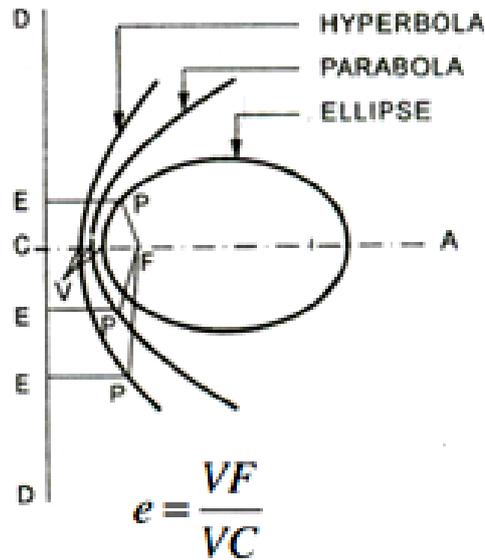
Fig : A cone cut by different

Fig : Conic Sections

Conic is defined as locus of a point moving in a plane such that the ratio of its distance from a fixed point (F) to the fixed straight line is always a constant. This ratio is called as eccentricity.

$$e = \frac{VF}{VC}$$

CA=AXIS, V=VERTEX, F=FOCUS, DD=DIRECTRIX

Fig: Different Terminology for Conic Curves

Ellipse: eccentricity is always <1

Parabola: eccentricity is always=1

Hyperbola: eccentricity is >1

The fixed point is called the Focus

The fixed line is called the Directrix

Axis is the line passing though the focus and perpendicular to the directrix

Vertex is a point at which the conic cuts its axis

Special Curves

Cycloid: A cycloid is a curve generated by a fixed point on the circumference of a circle, when it rolls without slipping along a straight line.

Epi-cycloid: if the circle is rolling on another circle from outside

Hypo-cycloid: if the circle is rolling from inside the other circle,

Involute: An involute is a curve traced by a point on a perfectly flexible string, while unwinding from around a circle or polygon the string being kept taut (tight). It is also a curve traced by a point on a straight line while the line is rolling around a circle or polygon without slipping.

Spiral: it is a curve generated by a point which revolves around a fixed point and at the same moves towards it.

Ellipse : The ellipse can be drawn by any one of the following methods: (i) Rectangle or oblong method (ii) Concentric circles method (iii) Arcs of circles method (iv) Focus-directrix method
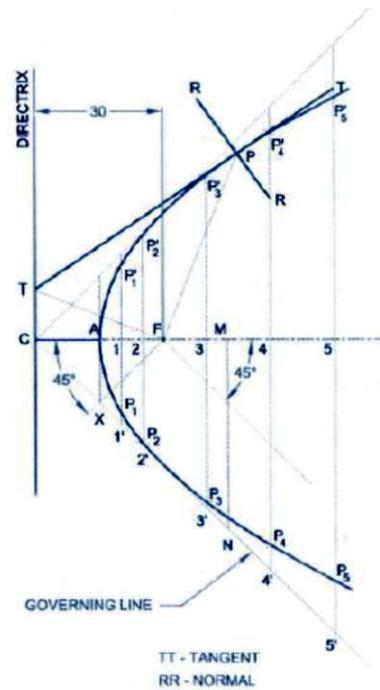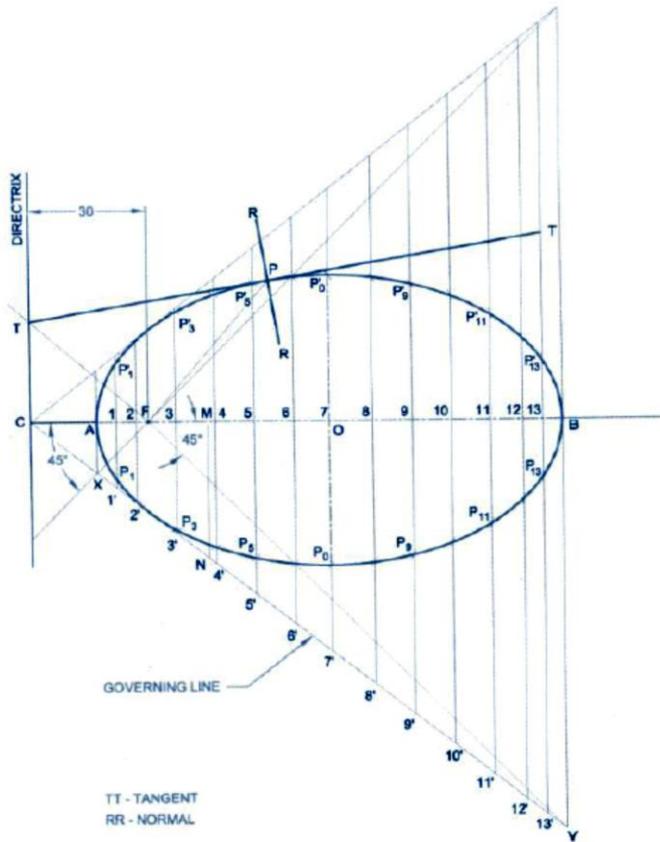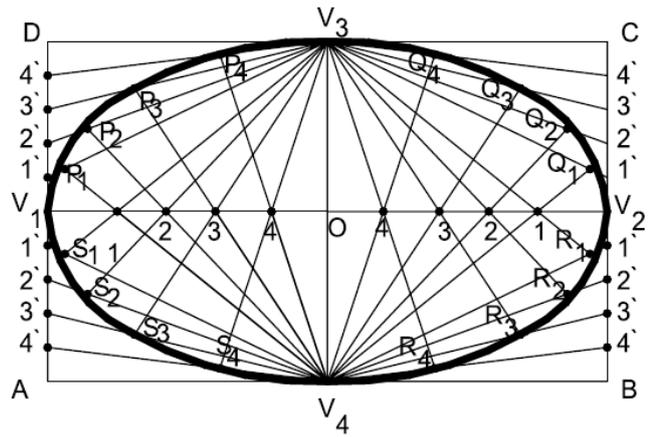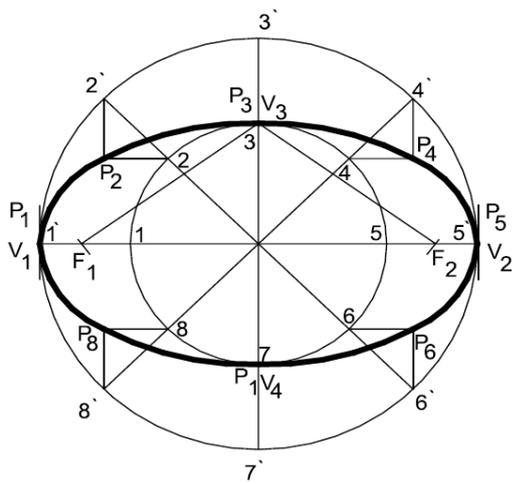
Parabola : The parabola can be drawn by any one of the following methods: (i) Rectangle method (ii) Tangent method (iii) Focus-directrix method
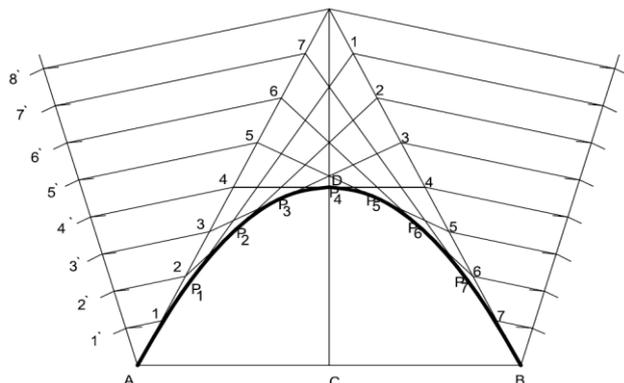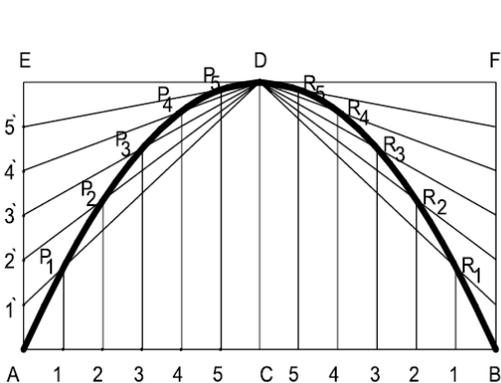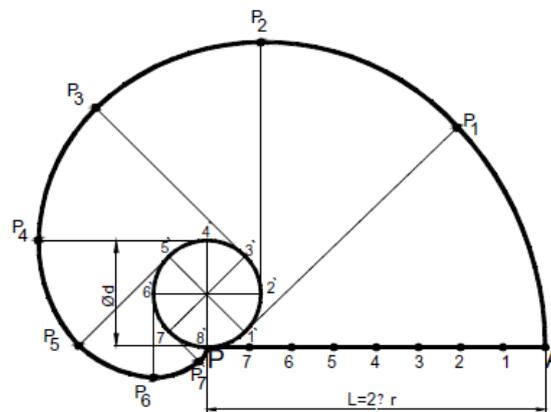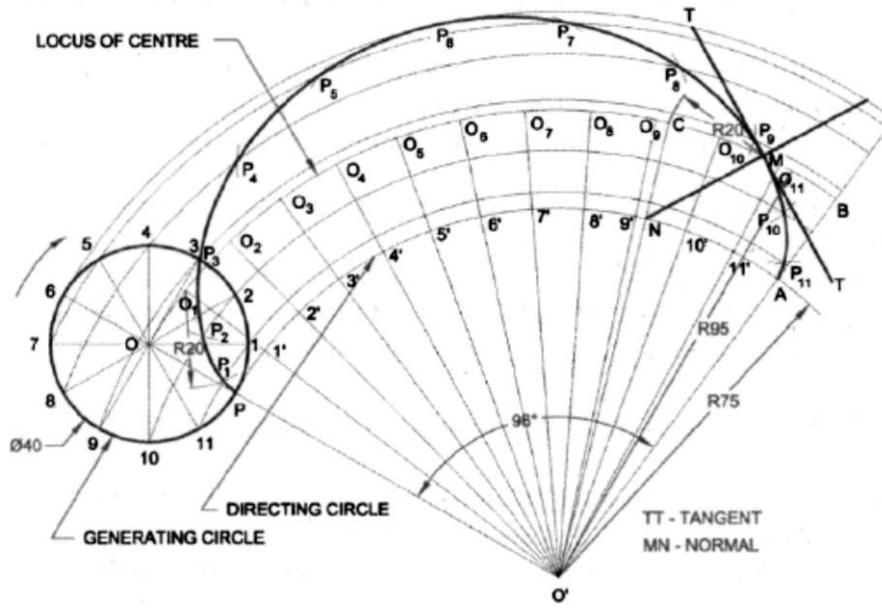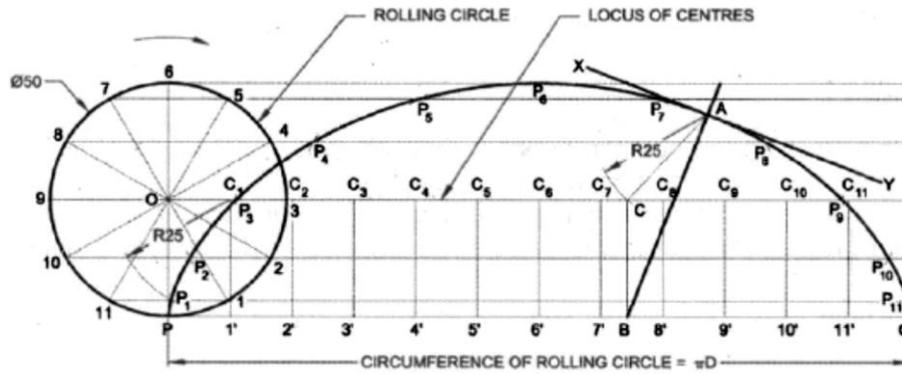
Following Exercise problems for Sketch Book as well as Drawing Sheet:

1. The foci of an ellipse are 110mm apart. The minor axis 70 mm long. Determine the length of the major axis and draw half ellipse by rectangle method and other half by concentric circle method.

2. Draw ellipse, parabola and hyperbola on the same axis and same directrix. Take distance of focus from the directrix equal to 50 mm and eccentricity for the ellipse, parabola and hyperbola as 2/3, 1 and 3/2 respectively. Plot at least 8 points. Take suitable point on each curve and draw tangent and normal to the curve at that point.

3. Draw a parabola by tangent method, given its base as 90 mm and the height of axis is 75 mm.

4. Draw an Archemedian spiral of 1.5 convolutions, the largest & the smallest radius being 55 mm & 10 mm respectively. Draw tangent & normal to the spiral at a point 40 mm from the pole.
5. Construct the involute of circle of 30mm diameter for one turn. Draw tangent and normal to the involute at any point of it.
6. Draw a cycloid for a rolling circle of 60 mm diameter rolling along a straight line without slipping. Take initial position of the tracing point at the bottom of the vertical Centre line of the rolling circle. Draw tangent and normal to the curve at a point 35mm above the directing line.
7. Draw the epicycloid generated by the moving point P which is initially at the point of the contact between the rolling circle and the directing circle. Take the rolling circle radius as 30 mm and the directing circle radius as 90 mm. The rolling circle rolls for one rotation. Draw tangent and normal to the curve at any point of the curve.

Rubrics of Sheet No-3

Sr. No.	Assessment criteria	Maximum-Mark	Level		
		/15	High	Medium	Low
1	Understanding of Problem/ Drawing	/4	4	3	2
2	Line Quality (dark/ thin)	/2	2	1	0
3	Accuracy and Precision	/2	2	1	0
4	Dimension and lettering	/2	2	1	0

Reference books:

1. A Text Book of Engineering Graphics by P.J. Shah S. Chand & Company Ltd., New Delhi.

2. Elementary Engineering Drawing by N.D. Bhatt Charotar Publishing House, Anand.

3. A text book of Engineering Drawing by P S Gill, S.K. Kataria & sons, Delhi.

Experiment – 4
Sheet No. 4 - PROJECTIONS OF POINTS AND LINES

Date:

Competency and Practical Skills: Able to read, comprehend and create technical drawings using conventional drafting

Relevant CO: CO2
Objectives:
- To get the projection of a straight line inclined with both the reference planes.
- To imagine the position of a line in space and find the true length and inclinations

Orientation of Straight Lines
- Line perpendicular to H.P and parallel to V.P
- Line perpendicular to V.P and parallel to H.P
- Line parallel to both H.P and V.P
- Line inclined to H.P and parallel to V.P
- Line inclined to V.P and parallel to H.P
- Line inclined to both the reference planes.
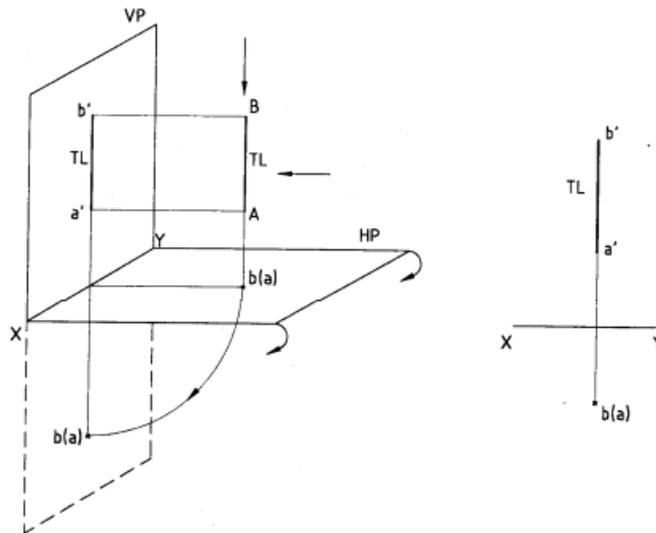
Line perpendicular to H.P and parallel to V.P
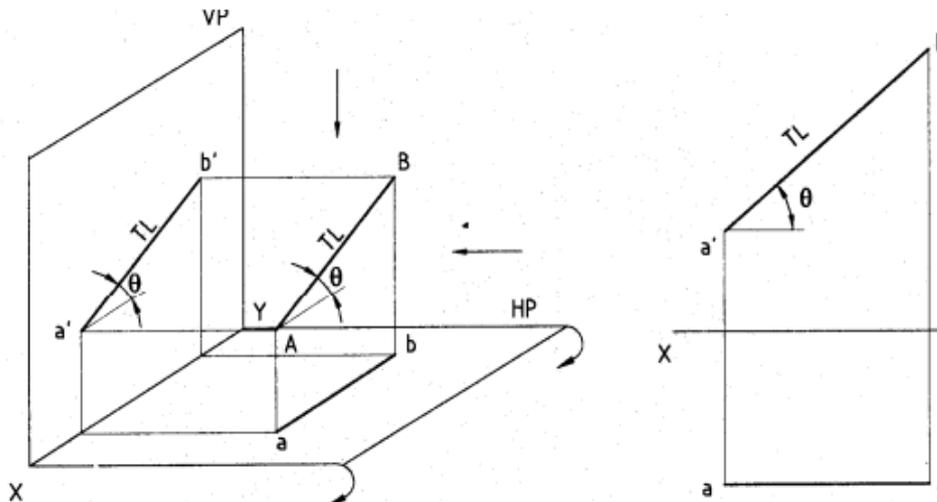
Line inclined to H.P and parallel to V.P
Line inclined to both the reference planes.

A line AB 80 mm long has its end A 20 mm above HP and 25 mm in front of VP. The line is inclined at **45⁰ to HP and 35⁰ to VP**. Draw its projections.
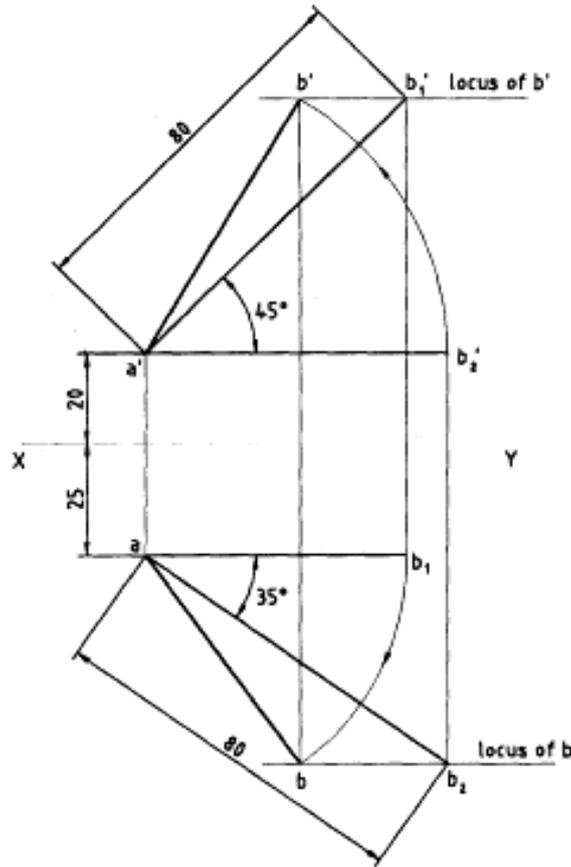
1. Mark the projections of end A by considering it as a point. Its front view a' is **20 mm above XY and top view a is 25 mm below the XY line**.
2. Assume that the line is kept inclined to HP and parallel to VP. Draw the front view a 'b '$_1$, a line inclined at 45^0 to XY line and having a length of 80 mm. Project and get the top view ab$_1$ length which is parallel to XY line.
3. Assume that the line kept inclined to VP and parallel to HP. Draw the top view ab$_2$, a line inclined at 35^0 to XY line and having a length of 80 mm. Project and get the front view a'b'$_2$ length which is also parallel to XY line.
4. Draw the locus of the other end B of the line in top and front views. Draw the locus of b' which is a line passing through b'1 and parallel to XY line. Also draw the locus of b which is a line passing through b$_2$ and parallel to XY line.
5. Rotate the top view ab$_1$ and front view a 'b'$_2$ to the required position. Take a as Centre, top view length ab$_1$ as radius, draw an arc to intersect the locus of b at b. Join and b to get the top view ab of the line. Take a' as Centre, front view length a 'b'$_2$ as radius, draw an arc to intersect the locus of b' at b'. Join a' and b' to get the front view a'b' of the line.
6. **Check the result obtained by drawing the projector joining b' and b which should be a vertical line.**

Following Exercise problems for Sketch Book as well as Drawing Sheet:

1.) A line PQ ,50 mm long, is in V.P. It makes an angle of 30° with the H. P. Point P is 20 mm above H.P Draw the projections of line PQ. (Only for Sketchbook)

2.) A Line AB 80 mm long. It is inclined at angle 45^0 to H.P and 30^0 to V.P. The end A is

15 mm above H.P and 20 mm Infront of V.P. Draw the projections of straight line while B is in first quadrant. State the name and symbols of 7 elements of projection of straight line. (Only for Sketchbook)

3.) A line AB, 75mm long, is parallel to VP and inclined to the HP, by an angle 45^0. Point A is 30mm below HP and 20mm in front of VP. Point B is in the first quadrant. Draw the projections of the straight-line AB. (Only for Sketchbook)

4.) A line PQ 65 mm long has its end P in VP and end Q in H.P. Line is inclined to H.P by 60^0 and V.P by 30^0 .Draw the Projections. (Only for Sketchbook)

5.) The distance between the end projectors of a straight-line PQ is 130mm. The end P is 40mm below HP and 25mm in front of the VP. Q is 75 mm above HP and 30 mm behind VP. Draw its projections. Find TL of the line.

6.) A line AB has its end point A 15 mm above H.P. and 25 mm infront of V.P. Line AB is making an angle of 20^0 to the H.P. Length of the line in the T.V. is 90mm. End B of the line is equidistant from both the principal planes. Find the true length of the line and the angle made by the line with V.P.

7.) A straight-line AB 80 mm long is inclined at 30° to the HP and at 45° to the VP. Its mid-point C is in the VP and 18 mm above the HP, while its end A is in the third quadrant, and the end B is in the first quadrant. Draw its projections.

8.) Plan and elevation of a line AB, 80 mm long, measure 60 mm and 72 mm respectively. End A of the line is in HP and end B is in VP. Draw its projections, assuming the line to lie in first quadrant.

Rubrics of Sheet No-4

Sr. No.	Assessment criteria	Maximum-Mark	Level		
		/10	High	Medium	Low
1	Understanding of Problem/ Drawing	/4	4	3	2
2	Line Quality (dark/ thin)	/2	2	1	0
3	Accuracy and Precision	/2	2	1	0
4	Dimension and lettering	/2	2	1	0

Reference books:
1. A Text Book of Engineering Graphics by P.J. Shah S. Chand & Company Ltd., New Delhi.
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Experiment – 5
Sheet No. 5 - PROJECTIONS OF PLANE

Date:

Competency and Practical Skills: Able to read, comprehend and create technical drawings using conventional drafting

Relevant CO: CO2
Objectives:
- To get the projection of planes inclined with both the reference planes

Introduction:

A plane is a two-dimensional object having length and breadth only. Its thickness is always neglected; various shapes of plane figures are considered such as square, rectangle, circle, pentagon, hexagon, etc

| (i) Square | (ii) Pentagon | (iii) Hexagon | (iv) Circle |

| (v) Equilateral triangle | (vi) Rightangle triangle | (vii) Rectangle |
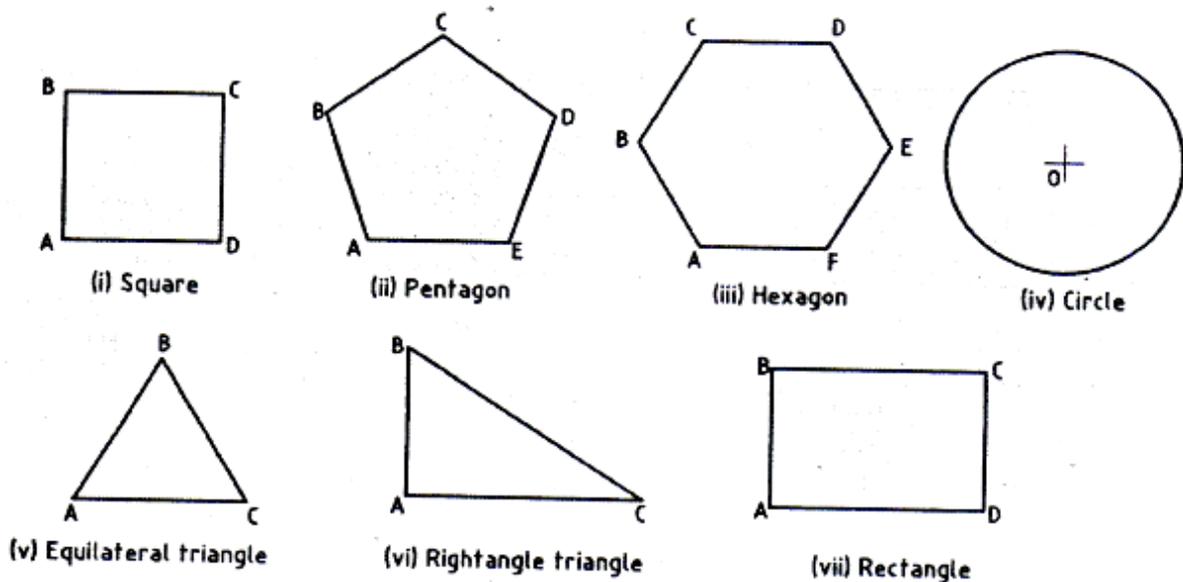
Figure.: Various types of planes.

Types of Planes
1. Perpendicular planes which have their surface perpendicular to any one of the reference planes parallel or inclined to the other reference plane.
2. Oblique planes which have their surface inclined to both the reference planes.

Positions of Planes
A plane figure is positioned with reference to the reference planes by referring its surface in the following possible positions.
1. Surface of the plane kept perpendicular to HP and parallel to VP.
2. Surface of the plane kept perpendicular to VP and parallel to HP.
3. Surface of the plane kept perpendicular to both HP and VP.
4. Surface of the plane kept inclined to HP and perpendicular to VP.
5. Surface of the plane kept inclined to VP and perpendicular to HP.
6. Surface of the plane kept inclined to both HP and VP.

Sample problems:

1. A circular plate of diameter 50 mm is resting on HP on a point on the circumference with its surface inclined at 45° to HP and perpendicular to VP. Draw its projections.
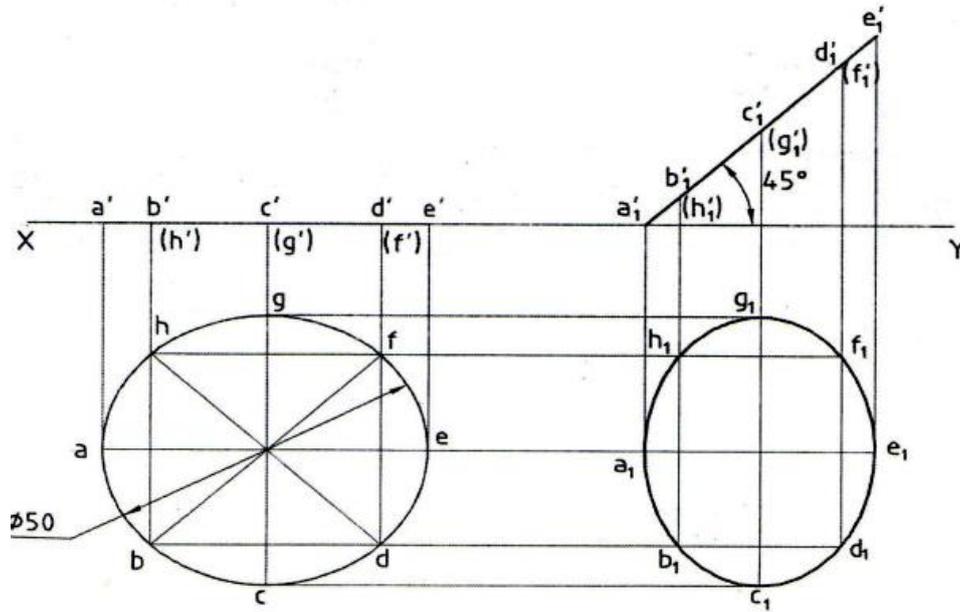
Figure: Projection of planes.

Steps to draw the projections:
1. Assume that the plate has its surface parallel to HP perpendicular to VP. Draw its top view. It is a circle of radius 25 mm.
2. Project and get the front view which is a line on XY.
3. As the circle does not have any corners, divide the circle into equal parts, say 8, in such a way that 8 points are marked on its circumference and project them to the front view.
4. Tilt and reproduce the front view to the given angle 45° with XY line, in such a way that the end a' is on XY line.
5. Draw horizontal lines from a, b, c, etc., and vertical lines from a1', b1', c1', etc., to get the required top view a1, b1, c1, etc.,
6. Join a1, b1, c1, etc., by drawing a smooth curve to get the top view of the circle as an ellipse.

2. A rectangular plate of side 50 × 25 mm is resting on its shorter side on HP and inclined at 30° to VP. Its surfaces is inclined at 60° to HP. Draw its projections.

Figure: Projection of planes.

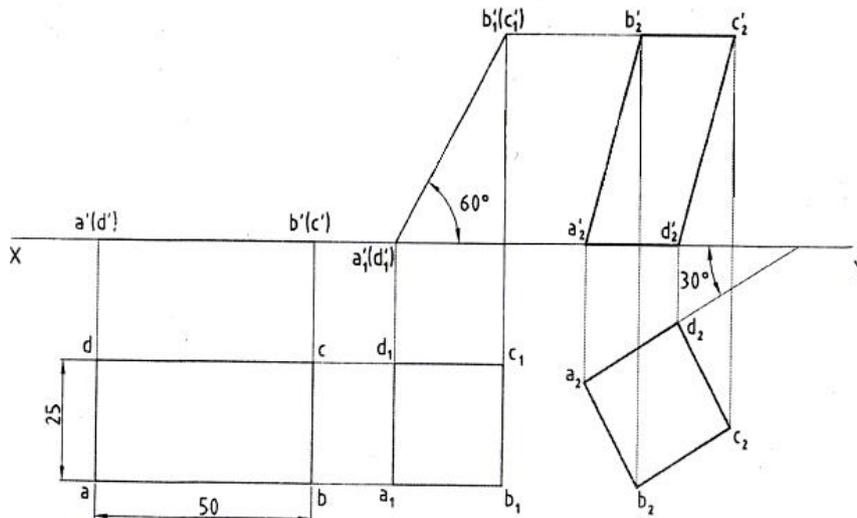Solution In this position, the surface of the plate is inclined to both HP and VP; its projections are obtained in three steps.

Step – 1: Assume that the plate has its surface parallel to HP and perpendicular to VP. Draw the top view which will have the true shape and size. Project the front view which will be a line parallel to XY.

Step – 2: Reproduce the front view tilted to the given angle θ to HP and project the top view of the plate which will be smaller that the true shape and size.

Step – 3: Reproduce the top view by considering the side of the plate that makes the given angle with VP. Project the front view of the plate which is also smaller than the true shape and size.

Steps to draw the projections
1. Draw the top view of the rectangle considering that one of the shorter sides is perpendicular to XY. Then only while tilting the surface to the required angle with HP, this side of the plate will rest on HP.
2. The front view of the plate is projected and obtained on XY as a line a'(d')b'(c').
3. Tilt and reproduce the front view a'(d')b'(c') to the given angle 60° with XY in such a way that the end a'(d') is on XY line.
4. Draw horizontal lines from top view a, b, c and d and vertical lines from front view a1', b1', c1' and d1' to get the top view a1, b1, c1 and d1 smaller than the true shape and size.
5. Reproduce the top view a1, b1, c1 and d1 in such a way that the side a1d1 is inclined to the given angle 30° to VP.
6. Draw horizontal lines from a1', b1', c1' and d1' and vertical lines from top view a2, b2, c2 and d2 to get the required front view a2', b2' c2', d2' of the plate smaller than the true shape and size.

Following Exercise problems for Sketch Book as well as Drawing Sheet:
1) A square plate PQRS, edge 25mm, is in space with one of its corners in VP. Surface of the plate makes 50^0 with VP and it is perpendicular to HP. Draw its projections. (Only for Sketchbook)
2) A rectangle ABCD 60 mm x 40 mm, is parallel to HP with one of its sides inclined at 30º to VP and the end of the side near to VP is 15 mm in front of the VP and 30 mm above HP. Draw its projections. (Only for Sketchbook)
3) A square lamina of side 35 mm is resting on HP on one of its sides such that the surface of the lamina is inclined at 40º to HP. Draw its top view and front view when the side on which it rests is parallel to VP. (Only for Sketchbook)
4) A thin 30º-60º set square has its longest edge is 80 mm in the VP and inclined at 45º to the HP. Its surface makes an angle of 60º with the VP. Draw its projections. (Only for Sketchbook)
5) A regular pentagon of 30mm side has one side parallel to the V.P. and making an angle of 40° with the H.P. the plane surface of the pentagon makes 35° the V.P. Draw its projections.
6) A rhombus of negligible thickness is having its diagonals 100 mm and 50 mm long. Draw the projections of the rhombus when the longer diagonal is inclined at 300 to the Horizontal Plane and 300 to Vertical Plane.
7) A circular plane having the diameter 50 mm is resting with point A of its periphery on H.P. The surface of the plane is inclined to H.P. such that the plan of the plane becomes an ellipse with minor axis 30mm.Draw the projection of the plane when the plan of the diameter through point A is inclined at 30º to V.P.and the centre of the plane is 40mm from V.P.Find the inclination of the plane with H.P.
8) An isosceles triangular plate ABC has its base 45 mm and altitude 60 mm. It is so placed that the front view is seen as an equilateral triangle of 45 mm side and (i) base is inclined

at 45º to HP, (ii) side is inclined at 45º to HP. Draw its plan when its corner A is on HP.

Rubrics of Sheet No-5

Sr. No.	Assessment criteria	Maximum-Mark	Level		
		/10	High	Medium	Low
1	Understanding of Problem/ Drawing	/4	4	3	2
2	Line Quality (dark/ thin)	/2	2	1	0
3	Accuracy and Precision	/2	2	1	0
4	Dimension and lettering	/2	2	1	0

Reference books:
1. A Text Book of Engineering Graphics by P.J. Shah S. Chand & Company Ltd., New Delhi.
2. Elementary Engineering Drawing by N.D. Bhatt Charotar Publishing House, Anand.
3. A text book of Engineering Drawing by P S Gill, S.K. Kataria & sons, Delhi.

Experiment – 6
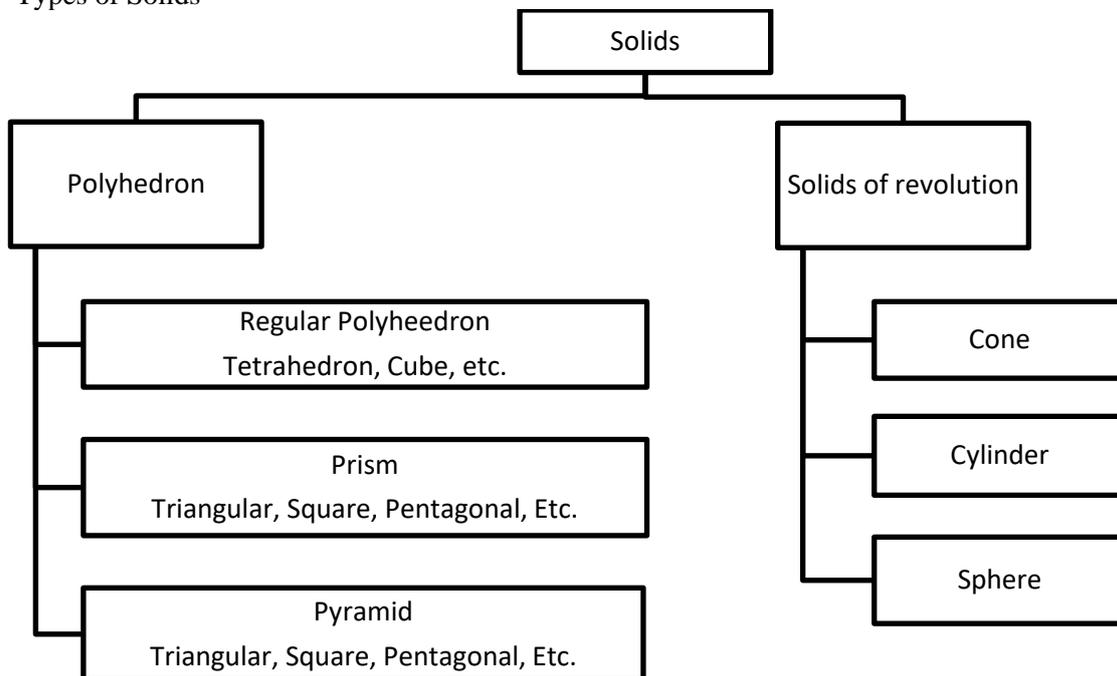## Sheet No. 6 -PROJECTION OF SOLID AND SECTION OF SOLID

Date:

Competency and Practical Skills: develop visualization skills that helps in developing new products

Relevant CO: CO3

Objectives:
- To draw projections of solids regular.
- To draw sectional views of solids and true shape of sections.
- To develop surface of solids in given conditions.

Types of Solids

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                          ┌─────────┐
                          │ Solids  │
                          └────┬────┘
             ┌─────────────────┴─────────────────┐
      ┌──────┴──────┐                    ┌────────┴──────────┐
      │ Polyhedron  │                    │ Solids of revolution │
      └──────┬──────┘                    └────────┬──────────┘
             │   ┌──────────────────────────┐     │   ┌──────────┐
             ├───┤ Regular Polyheedron      │     ├───┤   Cone   │
             │   │ Tetrahedron, Cube, etc.  │     │   └──────────┘
             │   └──────────────────────────┘     │   ┌──────────┐
             │   ┌──────────────────────────┐     ├───┤ Cylinder │
             ├───┤ Prism                    │     │   └──────────┘
             │   │ Triangular, Square,      │     │   ┌──────────┐
             │   │ Pentagonal, Etc.         │     └───┤  Sphere  │
             │   └──────────────────────────┘         └──────────┘
             │   ┌──────────────────────────┐
             └───┤ Pyramid                  │
                 │ Triangular, Square,      │
                 │ Pentagonal, Etc.         │
                 └──────────────────────────┘
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Polyhedron: A polyhedron is defined as a solid bounded by planes called faces. When all the faces are equal and regular, the polyhedron is said to be regular.

Prism: This is a polyhedron having two equal and similar faces called its ends or bases, parallel to each other and joined by other faces, which are parallelograms. The imaginary line joining the centers of the bases is called the axis. A right and regular prism has its axis perpendicular to the bases. All its faces are equal rectangles.

Pyramid: This is a polyhedron having a plane figure as a base and a number of triangular faces meeting at a point called the vertex or apex. The imaginary line joining the apex with the centre of the base is its axis. A right and regular pyramid has its axis perpendicular to the base, which is a regular plane figure. Its faces are all equal isosceles triangles.

Frustum: When a pyramid or a cone is cut by a plane parallel to its base, thus removing the top portion, the remaining portion is called its frustum.

Truncated solid: When a solid is cut by a plane inclined to base it is said to be truncated solid.

Illustrative Examples:

1. A cone 40 mm diameter and 50 mm axis is resting on one generator on HP which makes 30° inclination with VP. Draw it's projections.
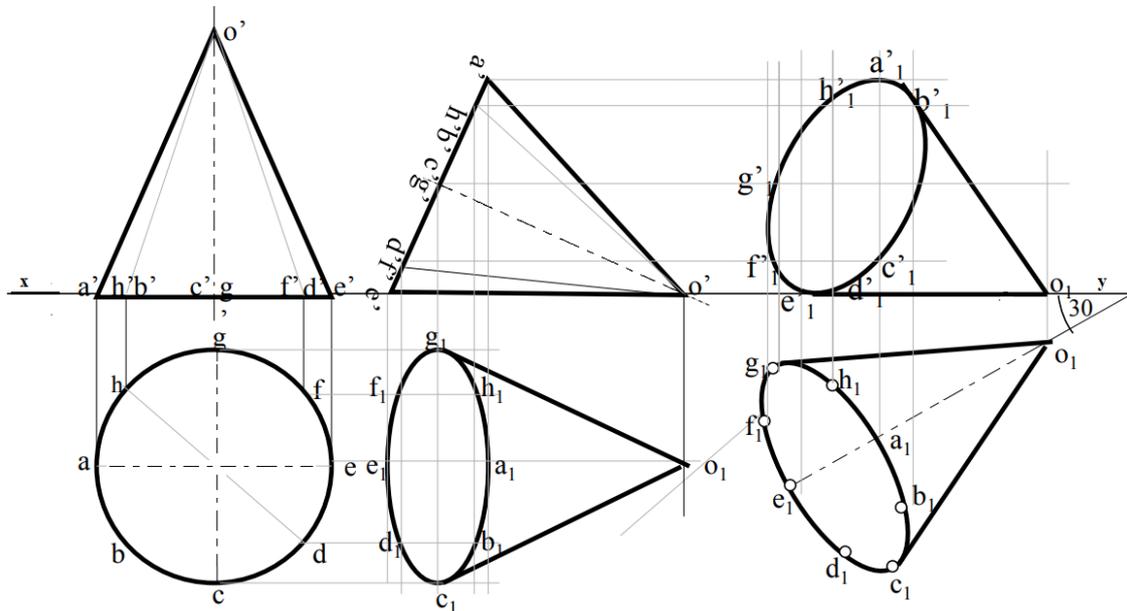
2. A cube having 70 mm sides is kept on HP such that its vertical faces are equally inclined to the VP. The cube is cut by an AIP in two parts. The true shape of the section is a regular hexagon. Find inclination of the AIP with the HP. Draw FV, sectional TV and true shape of the section.

True shape of section
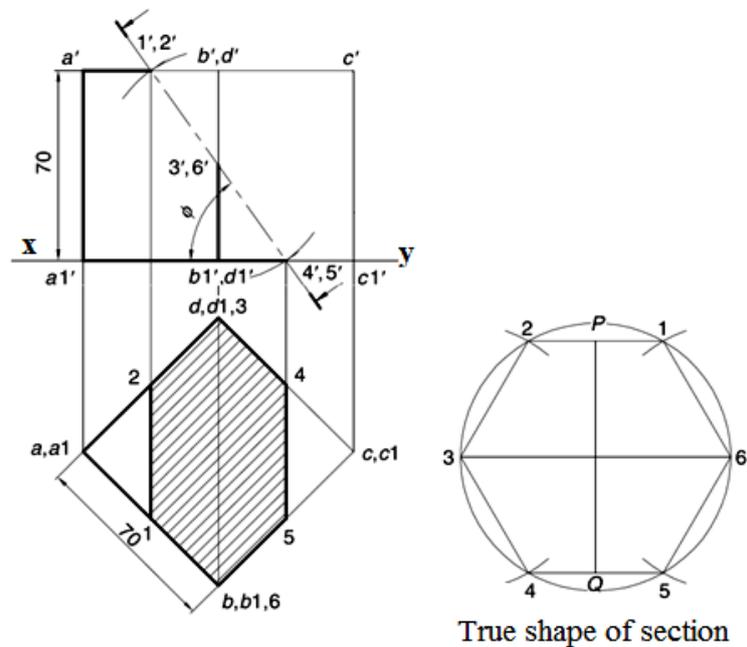
3. A square pyramid, base 40 mm side and axis 65 mm long, has its base on the HP and all the edges of the base equally inclined to the VP. It is cut by a section plane, perpendicular to the VP, inclined at 45° to the HP and bisecting the axis. Draw its sectional top view, sectional side view and true shape of the section. Also draw its development.
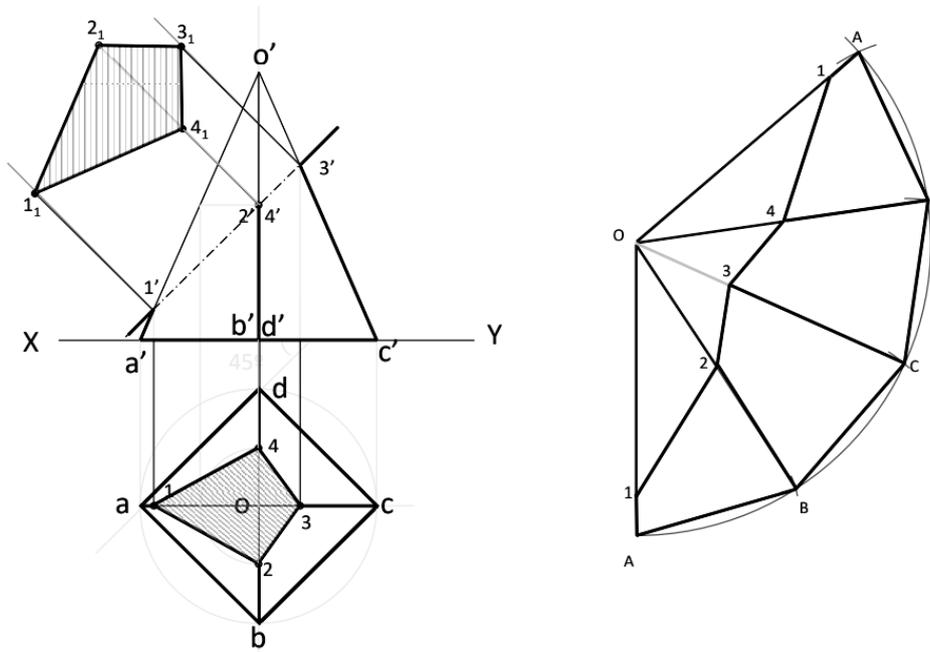
Following Exercise problems for Sketch Book as well as Drawing Sheet:

1. A cylinder of 40 mm diameter and 60 mm axis is resting on one point of a base circle on VP while its axis makes 45° with VP and FV of the axis 35° with HP. Draw its projections. (for sketchbook only)

2. A pentagonal pyramid, side of base 25 mm and axis 70 mm long, is standing on the H.P. on its base with one of the side of the base perpendicular to V.P. It is cut by a section plane inclined at 45° to the H.P. through midpoint of the axis. Draw its projections. Also draw true shape of the section. (for sketchbook only)

3. A cylinder of diameter of base 40 mm and axis 55 mm long is resting on its base on H.P. It is cut by a section plane, perpendicular to V.P. and inclined at 45^0 to H.P. The section plane is passing through the top end of an extreme generator of the cylinder. Draw its projections of the cylinder. (for sketchbook only)

4. A hexagonal prism side of base 30 mm & axis length 60 mm is resting on one of its base edge on HP such that its axis inclined at 45° to HP and the side on which it is resting is inclined at 30° to VP. Draw the projections.

5. A tetrahedron of 50 mm long edges is resting on one edge on HP while one triangular face containing this edge is vertical and 45° inclined to VP. Draw projections.

6. A hexagonal prism, edge of base 20 mm and axis 50 mm long, rests with its base on HP such that one of its rectangular faces is parallel to VP. It is cut by a plane perpendicular to VP, inclined at 45° to HP and passing through the right corner of the top face of the prism. Draw the sectional top view.

7. A Cone base 75 mm diameter and axis 80 mm long is resting on its base on H.P. It is cut by a section plane perpendicular to the V.P., inclined at 45° to the H.P. and cutting the axis at a point 35 mm from the apex. Draw the front view, sectional top view, sectional side view and true shape of the section.

Rubrics of Sheet No-6

Sr. No.	Assessment criteria	Maximum-Mark	Level		
		/10	High	Medium	Low
1	Understanding of Problem/ Drawing	/4	4	3	2
2	Line Quality (dark/ thin)	/2	2	1	0
3	Accuracy and Precision	/2	2	1	0
4	Dimension and lettering	/2	2	1	0

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Sheet No. 7 - ORTHOGRAPHIC PROJECTION

Date:

Competency and Practical Skills: draw communicative drawings using conventional methods.

Relevant CO: CO3

Objectives:
- To learn conversion of the pictorial views into the pictorial views.
- To draw different views of an object looking from different directions.
- To draw different full sectional views of objects.

Introduction

Engineering drawing, particularly solid geometry is the graphic language used in the industry to record the ideas and information necessary in the form of blue prints to make machines, buildings, structures etc., by engineers and technicians who design, develop, manufacture and market the products.

Projection

Projection is defined as an Image or drawing of the object made on a plane. The lines form the object to the Plane are called projectors.

Methods of Projections: In Engineering drawing the following four methods of Projection are commonly used:

(1) Orthographic Projection	(2) Isometric projection
(3) Oblique projection	(4) Perspective Projection

In orthographic projection an object is represented by two are three views on the mutual perpendicular projection planes each projection view represents two dimensions of an object. In iso, oblique and perspective projections represent the object by a pictorial view as eyes see it. In these methods of projects in three-dimensional object is represented on a projection plane by one view only.

Orthographic Projection: When the Projectors are parallel to each other and also perpendicular to the plane the projection is called orthographic Projection.

Plane of projection: The two planes employed for the purpose of orthographic projections are called reference planes or principal planes of projection. They intersect each other at right angles. The vertical plane of projection (in front of the observer) is usually denoted by the letters V.P. It is often called the frontal plane and denoted by the letters F.P. The other plane is the horizontal plane of projection known as the H.P. The line in which they intersect is termed the reference line and is denoted by the letters xy. The projection on the V.P. is called the front view or the elevation of the object. The projection on the H.P. is called the top view or the plan.
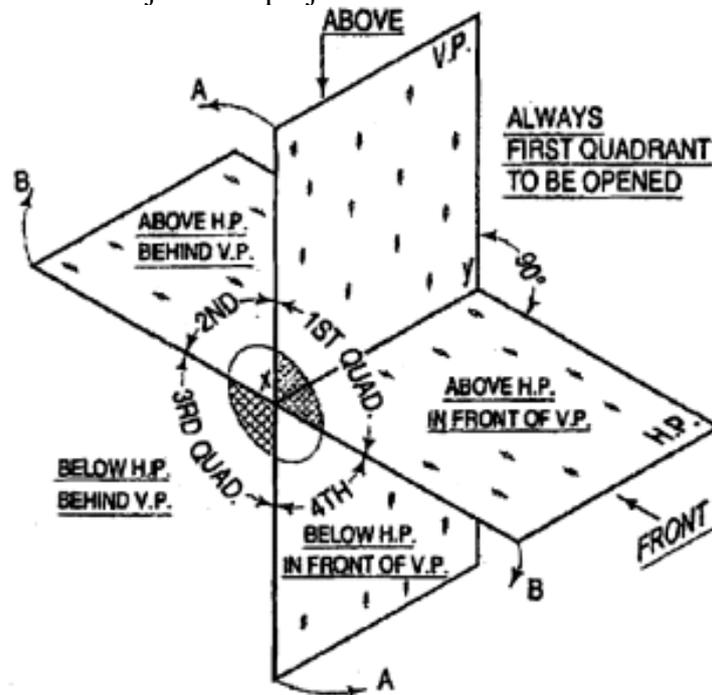
Four quadrants

First-Angle Projection:

We have assumed the object to be situated in front of the V.P. and above the H.P. i.e. in the first quadrant and then projected it on these planes. This method of projection is known as first-angle projection method. The object lies between the observer and the plane of projection. In this method, when the views are drawn in their relative positions, the top view comes below the front view. In other words, the view seen from above is placed on the other side of (i.e. below) the front view. Each projection shows the view of that surface (of the object) which is remote from the plane on which, it is projected and which is nearest to the observer.
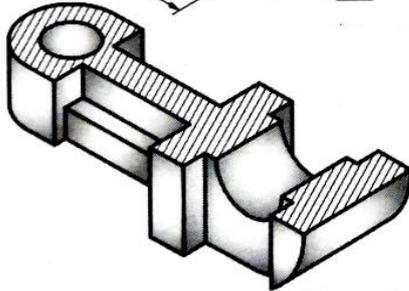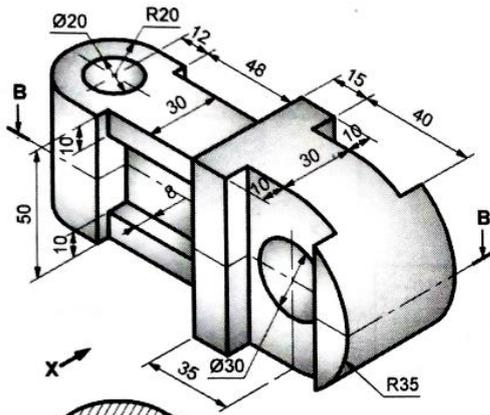
Third-Angle Projection:

In this method of projection, the object is assumed to be situated in the third quadrant The planes of projection are assumed to be transparent. They lie between the object and the observer. When the observer views the object from the front, the rays of sight intersect the V.P. The figure formed by joining the points of intersection in correct sequence is the front view of the object. The top view is obtained in a similar manner by looking from above. When the two planes are brought in line with each other, the views will be seen as shown in fig. The top view in this case comes above the front view.

FIRST ANGLE PROJECTION

THIRD ANGLE PROJECTION
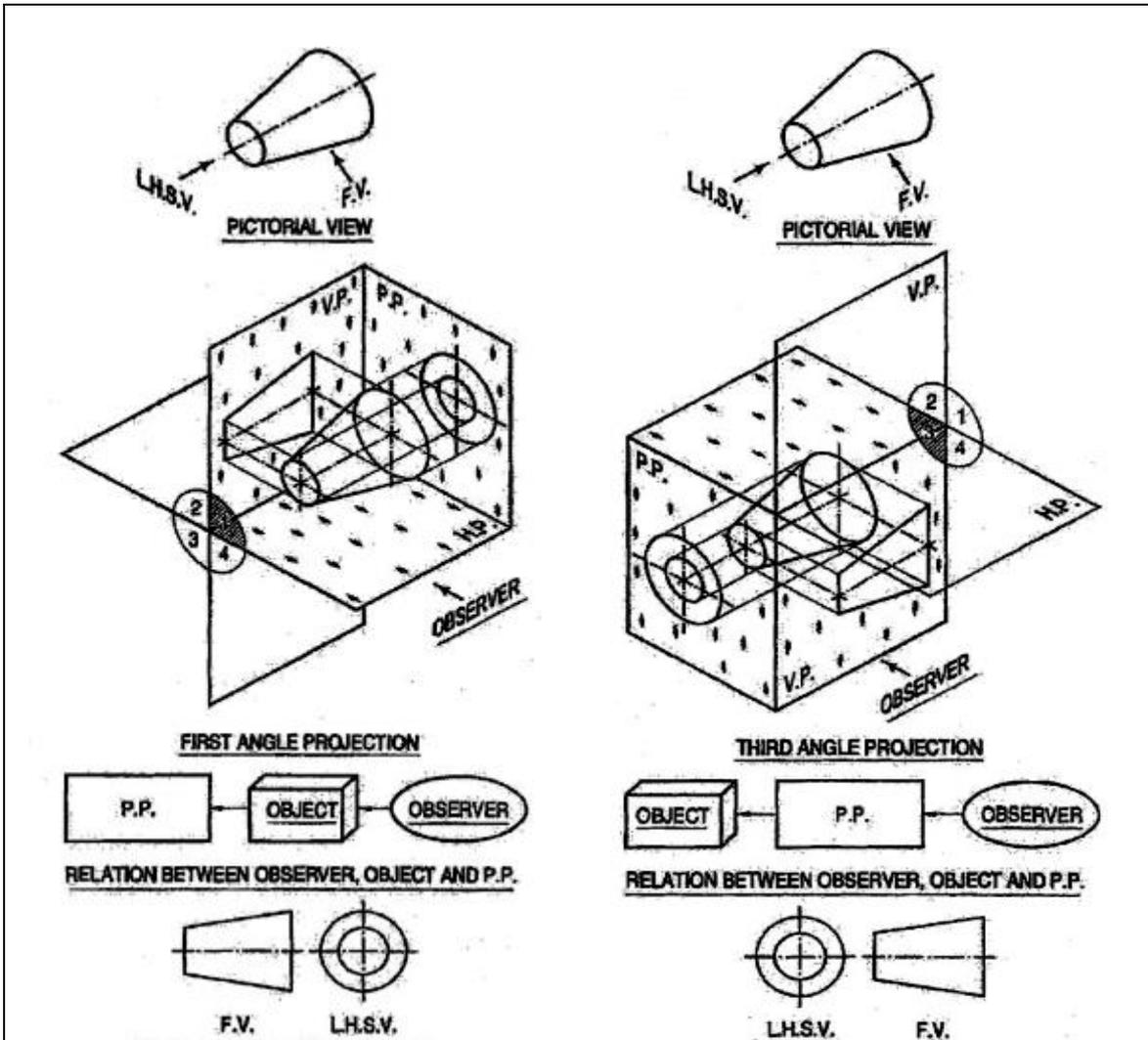
Sample reference problem:


A - principal view
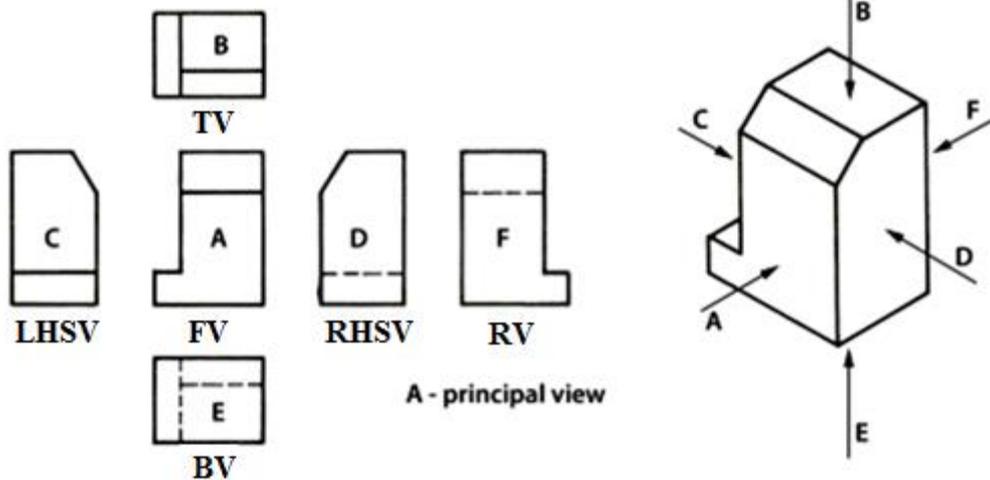
Sectional Orthographic Projection: There are objects with complicated internal details and when represented by hidden lines, may not effectively reveal the true interior details. This may be eliminated by representing one or more of the views 'in the section'. Generally, A sectional view is obtained by imagining the object, as if cut by a cutting plane and the portion between the observer and the section plane being removed.
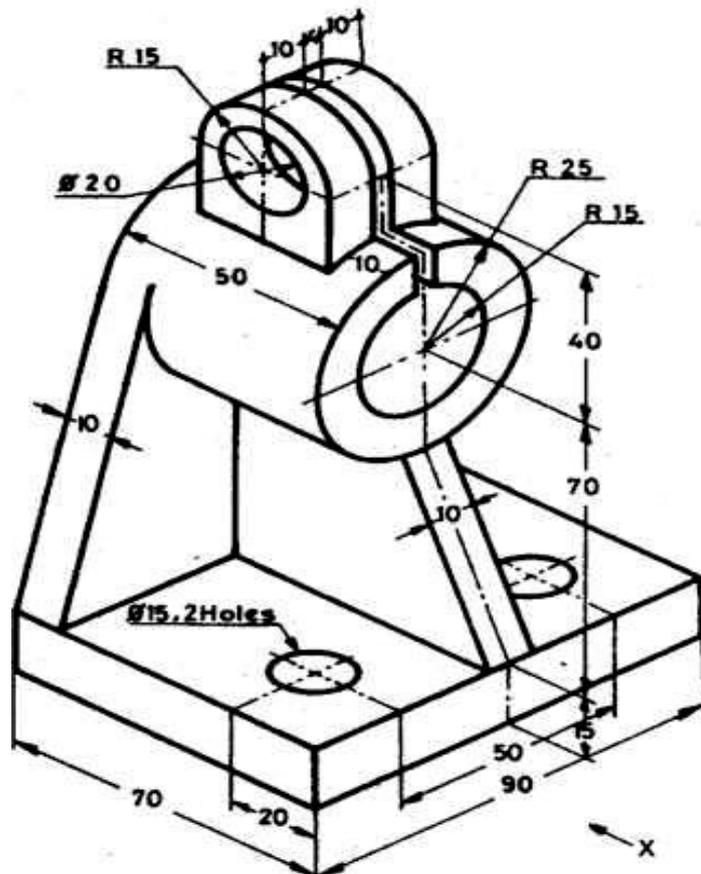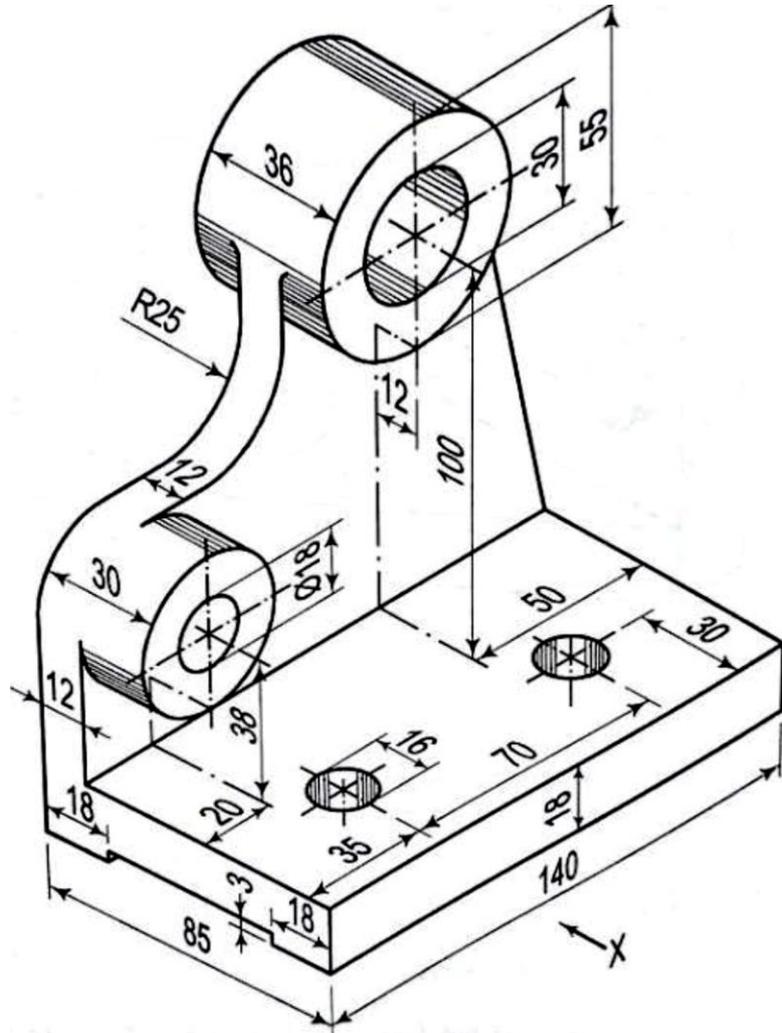
Soln :

F. V.

SECTIONAL ISOMETRIC VIEW
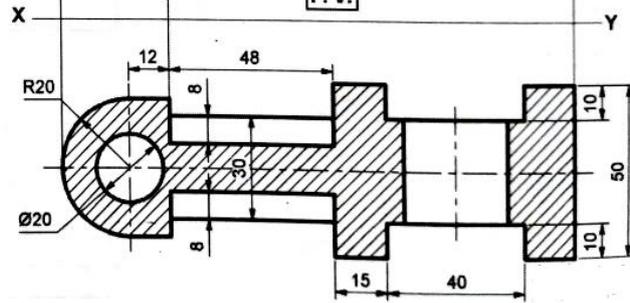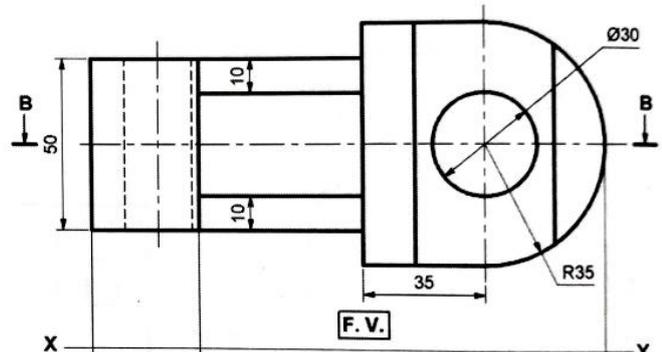
SECTIONAL T. V.

1. Draw the, front view looking from X -direction, plan and LH side view of a below given object using first angle projection method.

2. Draw the, front view looking from X - direction, plan and LH side view of a below given object using first angle projection method. **(Batch-2 Only)**

3. Draw the, front view looking from X - direction, plan and LH side view of a below given object using first angle projection method.
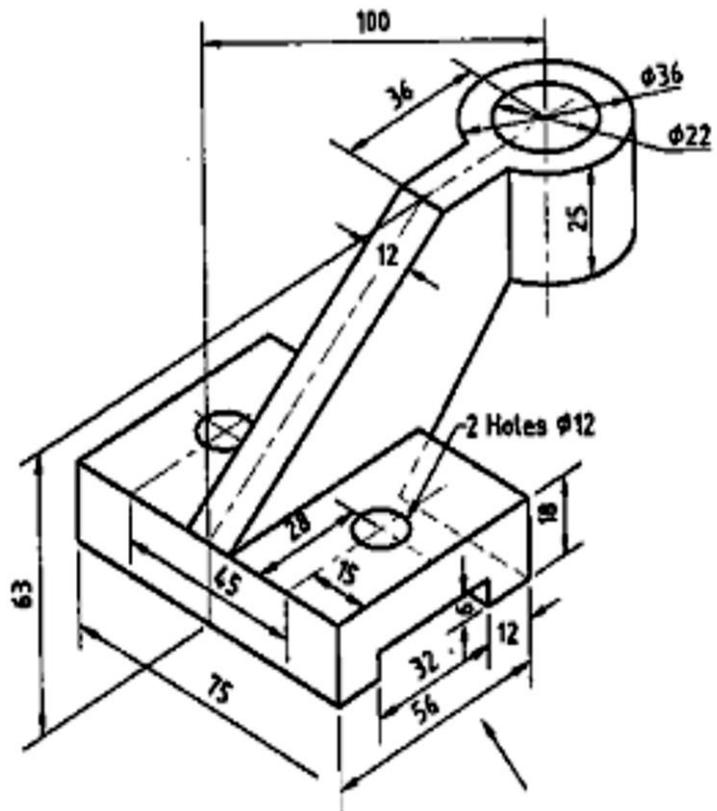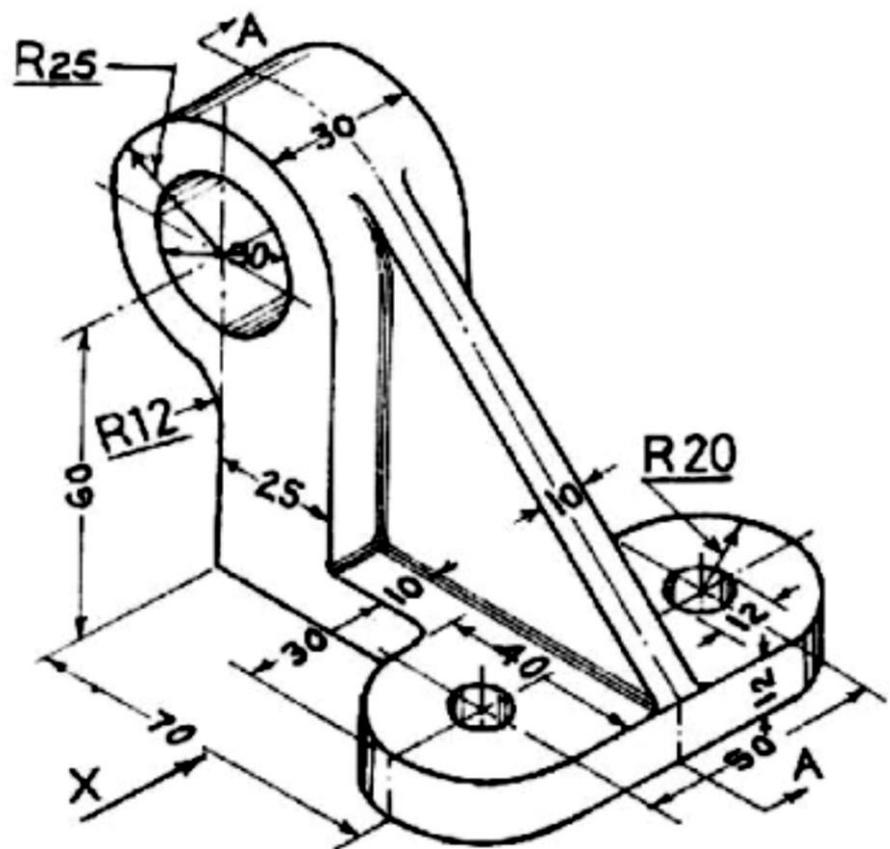
4. Fig. shows pictorial view of objects. Draw the following views using third angle projection method.
(i) Sectional Front View shown by X-direction
(ii) Top View &
(iii) Right Hand Side View
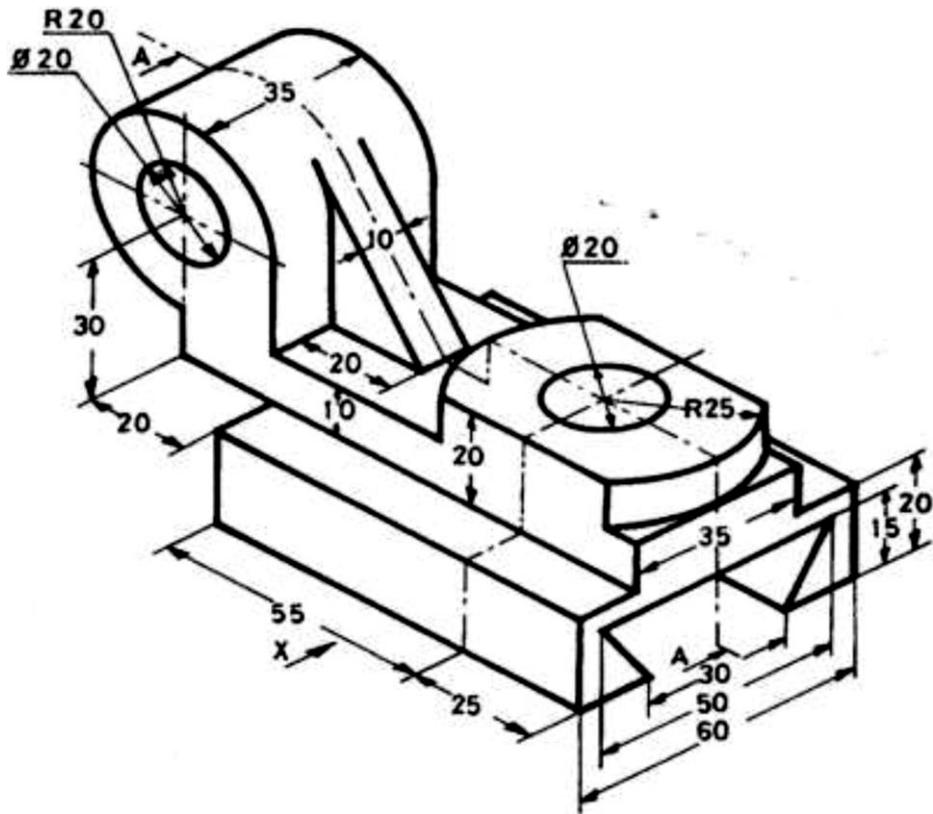
5. Fig. shows pictorial view of an object. Draw following views
(a) Sectional Elevation from – X
(b) Plan and
(c) Right hand side view

Rubrics of Sheet No-7

Sr. No.	Assessment criteria	Maximum-Mark /10	Level High	Medium	Low
1	Understanding of Problem/ Drawing	/4	4	3	2
2	Line Quality (dark/ thin)	/2	2	1	0
3	Accuracy and Precision	/2	2	1	0
4	Dimension and lettering	/2	2	1	0

Reference books:
1. A Text Book of Engineering Graphics by P.J. Shah S. Chand & Company Ltd., New Delhi.
2. Elementary Engineering Drawing by N.D. Bhatt Charotar Publishing House, Anand.
3. A text book of Engineering Drawing by P S Gill, S.K. Kataria & sons, Delhi.

Experiment - 8
ORTHOGRAPHIC DRAWING (THREE VIEWS) USING AUTOCAD COMMANDS

Date:

Competency and Practical Skills: Draw engineering drawings using AutoCAD software

Relevant CO: CO4

Objectives:
- To get the Basic knowledge of computer aided drawing
- To use AutoCAD commands to draw orthographic views.

Introduction

- Computer Aided Drafting can be done by using the graphic commands available in High Level languages (HLL) like BASIC, FORTRAN, PASCAL, C and C++.

- CAD is an important industrial art extensively used in many applications, including automotive, ship building, and aerospace industries, industrial and architectural design, prosthetics, jewelry designing and many more. CAD is also widely used to produce computer animation for special effects in movies, advertising and technical manuals, often called Digital content creation (DCC)
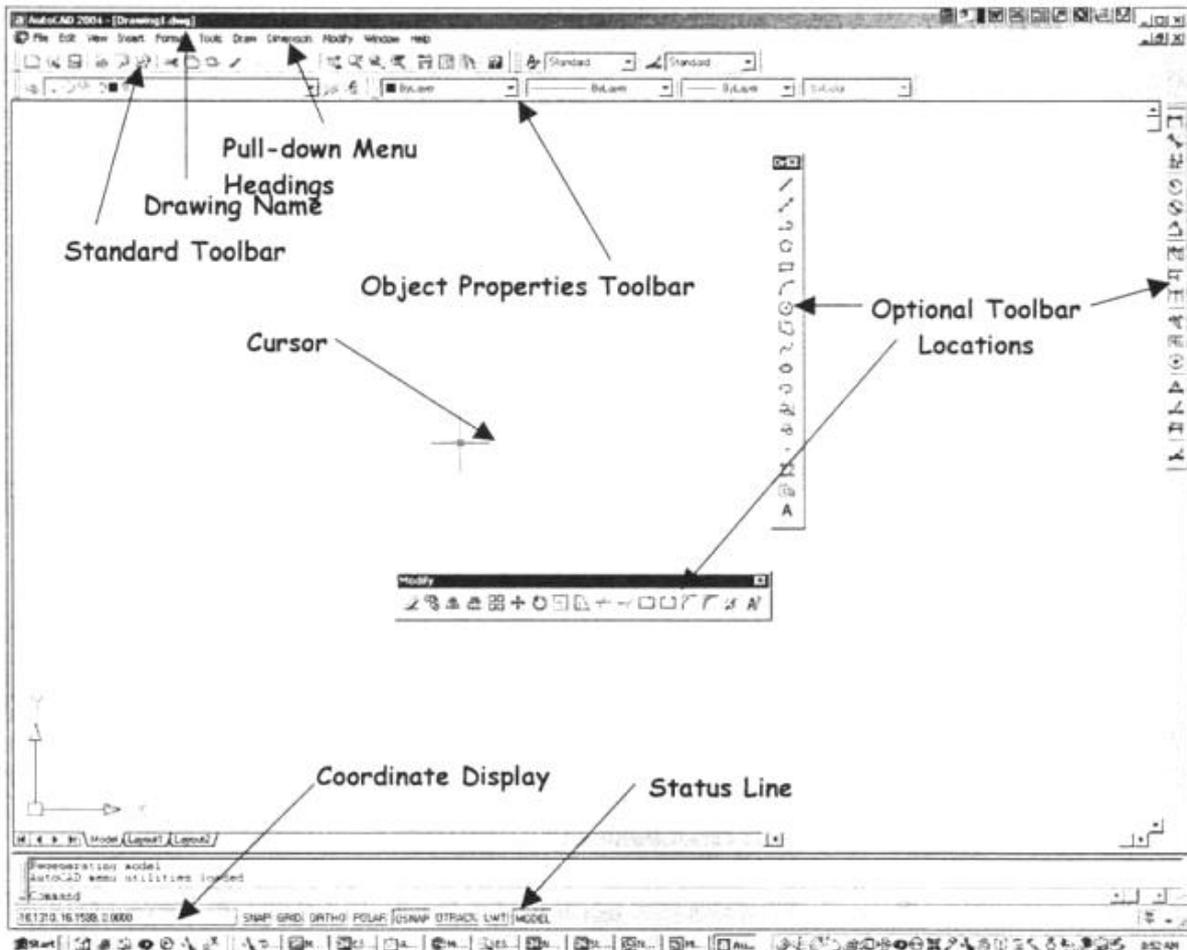
Advantages of using CAD:

- Increases efficiency of your drawings
- Time saving
- Accurate, precise, & immediately alterable
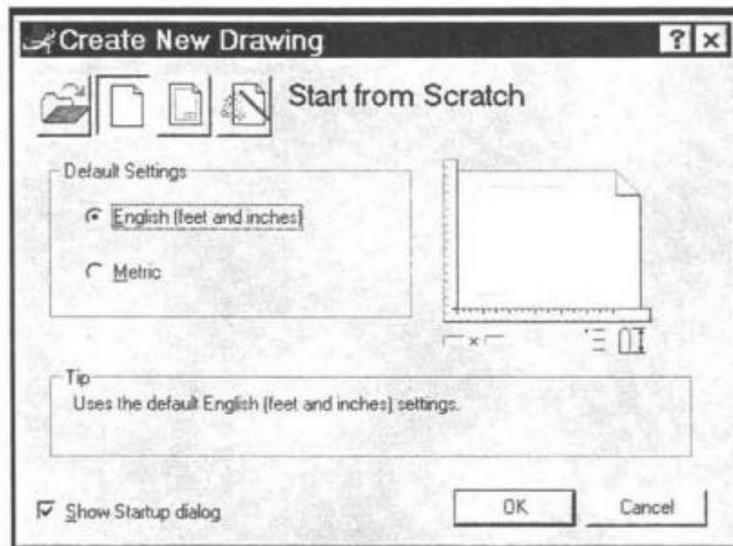
Disadvantages of using CAD:

- Financially costs more per license
- Must and should have computer basic knowledge irrespective of concept

CAD is divided in many types
- 2D
- 3D
- Orthographic
- Isometric
- Perspective

Layout of AutoCAD Screen

Creating new drawing in AutoCAD

Important AutoCAD Commands

- Measuring Commands

    GRID: Displays a grid of dots at a desired spacing on the screen.

    Command: GRID (enter)

    On/Off/Tick spacing(x)/Aspect: (enter value) (enter)

    SNAP: Specifies a "round off" interval so that points entered with the mouse can be locked into alignment with the grid spacing.

- Basic Draw Commands

Command: SNAP (enter)
On/Off/Value/Aspect/Rotate/Style: (enter value) (enter)

CIRCLE: Draws circles of any size.
Command: Circle (enter)
3P/2P/TTR/<center point>: (pick a center point)
Diameter or <Radius>: (Pick a point on the circle)

LINE: Draws straight lines between two points
Command: LINE (enter)
From Point: (pick a point using the mouse)
To Point: (Pick a point using the mouse)
To Point: (Press return to end the command)

ARC: Draws an arc (any part of a circle or curve) through three known points.
Command: ARC (enter)
Center/ < Start point > : (pick the first point on the arc)
Center/End/ < Second point > : C
Center: (pick the arc's center point)
Angle/Length of chord/ <End point > : (pick the arc endpoint)

- Display Commands

LIMITS: Sets the size of the drawing paper. For size "A" drawing paper the limits should be set for 10.5 x 8.
Command: LIMITS (enter)
On/Off/Lower left corner <0.0000> (enter)
Upper right corner: 10.5,8 (enter)

ZOOM: Enlarges or reduces the display of a drawing.
Command: ZOOM (enter)
All/Center/Dynamic/Extents/Left/Previous/Vmax/Window/<Scale(x/XP)>:
(pick a point to define one corner of a rectangular viewing window then pick a point to define the second point to define the opposite diagonal corner of the viewing window)

PAN: Allows you to move your view point around the drawing without changing the magnification factor.
Command: PAN (enter)
Editing Commands

CHANGE: Alters properties of selected objects
Command: CHANGE (enter)
Select objects or window or Last (select objects to be changed)
Properties/<Change point>: (type P)
Change what property (Color/Elev/LAyer/LType/Thickness)? (type Layer)
New Layer: (enter new layer name and press enter)

ERASE: Erases entities from the drawing.
Command: ERASE (enter)
Select objects or Window or Last: (Select objects to be erased and press enter when finished)

EXTEND: Lengthens a line to end precisely at a boundary edge.
Command: Extend (enter)
Select boundary edge(s)...
Select Objects (pick the line which represents the boundary edge which lines will be extended to) (press enter when finished selecting cutting edges)
<Select object to extend>/Undo: (pick the line(s) that need to be extended

TRIM: Trims a line to end precisely at a cutting edge.
Command: Trim (enter)
Select cutting edge(s)...
Select Objects (pick the line which represents the cutting edge of line in which objects will be trimmed to) (press enter when finished selecting cutting edges)
<Select object to trim>/Undo: (pick the line(s) that need to be trimmed)

- Construction Commands
    - ARRAY: Makes multiple copies of selected objects in a rectangular or circular pattern
        Command: ARRAY (enter)
        Select objects or Window or Last: (select object to array)
        Rectangular or Polar array (R/P) <current>: (P)
        Center point of array: (pick the point around which to form the array)
        Angle to fill (+=CCW, -=Cw) <360>: (enter)
    - COPY: Draws a copy of selected objects.
        Command: COPY (enter)
        Select objects or Window or Last: (select objects to be copied)
        Base point or displacement: (pick a point on the object to be use as a reference point)
        Second point of displacement: (pick a point which represents the new location of the copied object)
    - MIRROR: Makes mirror images of existing objects.
        Command: MIRROR (enter)
        Select objects or Window or Last: (select objects to be mirrored)
        First point of mirror line: (pick a point on top of the mirror line)
        Second point: (pick a point on the bottom of the mirror line)
        Delete old objects? <N> y or n (enter)
    - MOVE: Moves designated entities to another location.
        Command: MOVE (enter)
        Select objects or Window or Last: (select objects to move)
        Base point or displacement: (pick a point on the object to be use as a reference point)
        Second point of displacement: (pick a point which represents the new location of the object)
    - OFFSET: Constructs an entity parallel to another entity at a specified distance. Offset can be used with lines, circles, arcs, and polylines.
        Command: OFFSET (enter)
        Offset distance or Through <last>: (enter a distance value)
        Select object to offset: (select object to offset)
        Side to offset: (Pick any point on the side of the object you wish to offset)
    - FILLET: Changes any corner to a rounded corner.
        Command: FILLET
        Polyline/Radius/Angle/Trim/Method/ <Select first line > : (pick the first line)
        Select second line: (pick the second line)
   - CHAMFER: Changes any corner to an angled corner.
        Command: CHAMFER
   Polyline/Distance/Angle/Trim/Method/ < Select first line > : (pick the first line)
        Select second line: (pick the second line)

ASSIGNMENT
1. Explain the following draw commands.
   Line, arc, circle, rectangle, polygon, spline, hatch

2. Explain the following modify commands.
   Move, copy, scale, rotate, mirror, offset, array, extend, trim, fillet, chamfer

3. Draw below figure by use of AutoCAD commands and submit printout to batch mentor. Also write step by step procedure for making this figure by use of AutoCAD commands.
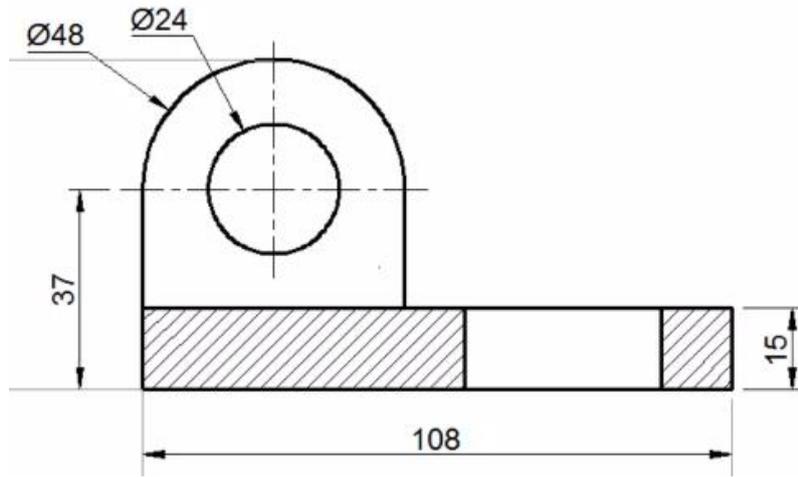
4. Draw three views of following figure by using of AutoCAD commands and submit printout. Also write various AutoCAD commands used for it.
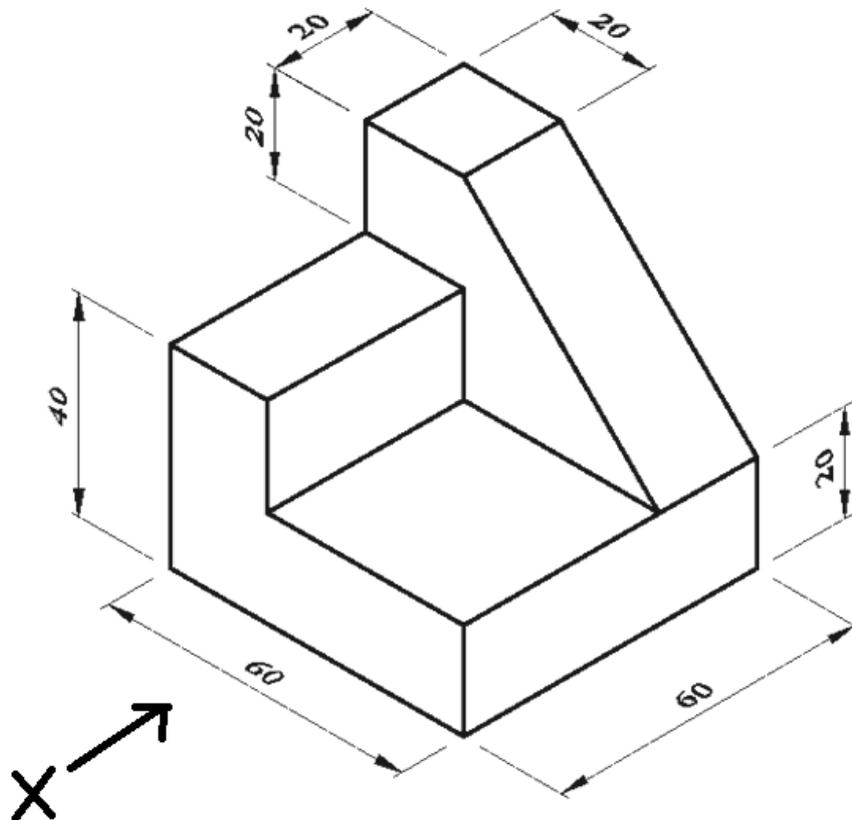
Rubrics for Experiment-8

Sr. No.	Assessment criteria	Maximum-Mark	Level		
		/10	High	Medium	Low
1	Understanding of Autocad commands	/4	4	3	2
2	Use of proper command	/2	2	1	0
3	Dimension and lettering	/2	2	1	0
4	**Viva voce** (Questions-Answer)	/2	2	1	0