LORDS

Institute of Engineering & Technology

(An UGC Autonomous Institution)

Approved by AICTE / Affiliated to Osmania University / Estd.2002.

Accredited with ‘A’ grade by NAAC, Accredited by NBA

B.E I/II SEMESTER

ENGINEERING GRAPHICS & DESIGN PRACTICE

LAB MANUAL

(Common to all branches)

Name:______________________________

Roll No.:____________________________

Branch & Section:__________________

Vision

To impart high standards of quality education which enhance students' career efficaciously, to become a holistic well-qualified engineer who are competent, innovative, entrepreneurial and research oriented to meet the standards of new millennium.

Mission

- **DM1:** An integrated educational approach that blends knowledge of engineering fundamentals, technical skills, practical knowledge and research.
- **DM2:** To enrich undergraduate experience of distinctive academic curriculum through interaction with major stake holders, hands-on learning, team work, management and multi-disciplinary skill set.
- **DM3:** To make students aware of professional responsibilities, ethics, global demands, sustainable solutions, environmental, technological challenges and the needs of lifelong learning.
- **DM4:** To prepare students in developing solutions of global standards through research and innovation, design and development of demand-based projects, entrepreneurial skills and employability capabilities.

Note: DM: Department Mission

LORDS INSTITUTE OF ENGINEERING & TECHNOLOGY [A]
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DEPARTMENT OF MECHCANICAL ENGINEERING

LABORATORY MANUAL

ENGINEERING GRAPHICS & DESIGN PRACTICE

Prepared by
Mr. A. SWAMY
Mr. S.RAGHAVENDRA, Mr. KHALID AHMED,
Assistant Professors

S. No.	Program Outcomes (POs):
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 modelling 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 multidisciplinary 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.

B.E I/II SEMESTER
(Common to ALL Branches)

ENGINEERING PHYSICS LABORATORY

Int. Marks: 50 **Ext. Marks: 50** **Total Marks: 100**

L	T	P	C
-	-	4	3

List of Experiments:

S. No.	Topic / Exercises	Contact Hours L	Contact Hours P
1	**Introduction to Engineering Graphics** Engineering Graphics, Significance, Drawing instrument used in engineering drawing and types of sheet layout and their folding. Types of lines used in engineering drawing, various lettering and dimensioning formats.	**1**	
2	**Scales** Scales, Representation, Units, Representative fraction [RF] Types: a) Reducing, Enlarging & True. b) Plain & Diagonal.	**1**	**4**
3	**Conic Sections-I** Conic section, Types, Construction of Ellipse, Parabola & Hyperbola given focus and eccentricity	**1**	**2**
4	**Conic Sections-II** Construction of ellipse [given major and minor axis], parabola [given base and height] & rectangular hyperbola		**2**
5	**Engineering Curves** Introduction and Construction of Cycloid, Epicycloid along with tangent and normal, Involutes (involute of triangle, square & circle)	**1**	**4**
6	**Introduction to AutoCAD** Basic commands and simple drawings. Demonstrating knowledge of the theory of CAD software [such as : The Menu System, Toolbars (standard, object properties, Draw, Modify and Dimension), Drawing Area (Background, Crosshairs, Coordinate System), Dialog boxes and windows, Short menus (Button Bars), The Command Line (Where applicable), The Status Bar, Different methods of zoom as used in CAD, Select and erase objects]	**1**	
7	**Orthographic Projection** Principles of Orthogonal projections-Conventions – Projections of points situated in different quadrants.	**1**	**2**
8	**Projections of straight lines - I** Line parallel to both the reference planes, line perpendicular or inclined to one reference plane.	**1**	**2**
9	**Projections of straight lines - II** Line inclined to both the reference planes.	**1**	**2**
10	**Projection of Planes - I** Perpendicular Planes.	**1**	**2**
11	**Projection of Planes - II** Oblique Planes.		**2**
12	**Projection of Solid - I** Axis parallel to HP or VP, Projection of regular solids in simple position.	**1**	**2**
13	**Projection of Solid - II** Projections of solids axis Inclined to one or both the reference planes.	**1**	**4**
14	**Section of Solids-I** When the sectional plane is parallel or perpendicular to one Reference Plane.	**1**	**2**

15	**Section of Solids - II** Sectional plane is inclined to one reference plane.		**2**
16	**Development of surfaces** Development of surfaces of Right Regular Solids - Prism, Pyramid, Cylinder and Cone.	**1**	**4**
17	**Intersection of surfaces – I** Intersection of cylinder and cylinder	**1**	**2**
18	**Isometric projection-I** Planes and Principle of isometric projection, Isometric scale, Isometric Views – Conventions lines & Planes.	**1**	**2**
19	**Isometric projection-II** Compound solids, isometric Projections of simple solids & compound solids		**2**
20	**Conversion of Isometric to Orthographic views.**	**1**	**2**
21	**Conversion of Orthographic to Isometric views.**		**2**
22	**Optional [Any one must be done]** Floor plan windows, doors, and fixtures such as WC, bath, sink, shower, etc. Simple Machine Element Basic Electrical Drawing Basic Networking Drawing	**1**	**2**

NOTE:

1. At least 20 sheets must be covered.
2. Sheet number 1 to 5 (Graph sheets / drawing sheets)
3. Sheet number 6 to 22 (AutoCAD drawings)

Lab course outcomes mapping with Blooms Toxonomy

Course Name: Engineering Graphics& Design Practice Lab

Course Code: U21ME2L1

CO. No.	Description	Bloom's Taxonomy Level
C18.1	Learn basics of Dimensioning, Detail Drawings and Engineering Design.	BTL1
C18.2	Demonstrate the projection of point's lines, planes to create virtual drawing by using CAD software.	BTL2
C18.3	Construct the projection of Solids & Sectional view of the solids.	BTL3
C18.4	Develop isometric drawing of simple objects and Visualizing the multi views of the objects.	BTL6
C18.5	Understand and visualize. 3D to 2D & 2D to 3D Vice- Versa.	BTL2
C18.6	Use the knowledge of Engineering Graphics to draw floor drawing, Simple Machine Element, Basic Electrical Drawing, Basic Networking Drawing.	BTL6

Note: Bloom's Taxonomy Levels

BTL1-Remember	BTL2 - Understand	BTL3 –Apply
BTL4-Analyze	BTL5 –Evaluate	BTL6–Create

Faculty Incharge

CO-PO and PSO mapping

Course Name: Engineering Graphics & Design Practice Lab

Course Outcomes (CO)	Program Outcomes (PO)												Program Specific Outcomes (PSO's)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO9	PO 10	P O1 1	P O1 2	PSO 1	PSO 2
C18.1	3	3	3	3	3	-	-	-	-	1	3	3	3	3
C18.2	2	2	3	3	3	-	-	-	-	2	2	3	3	3
C18.3	3	2	3	3	3	-	-	-	-	3	3	3	3	3
C18.4	3	3	3	3	3	-	-	-	-	2	2	3	3	2
C18.5	2	2	3	3	2	-	-	-	-	3	3	2	3	2
C18.6	3	3	3	**3**	3	-	-	-	-	3	3	3	3	3

Level: 1- Low correlation (Low), 2- Medium correlation (Medium), 3-High correlation (High)

PO1: Engineering knowledge, **PO2:** Problem analysis, **PO3:** Design/Development of solutions,

PO4: Conduct investigations of complex problems, **PO5:** Modern tool usage, **PO6:** The engineer and society, **PO7:** Environment and sustainability, **PO8:** Ethics, **PO9:** Individual and team work,

PO10: Communication, **PO11:** Project management and finance, **PO12:** Life-long learning

PSO1: Professional Skills, **PSO2:** Problem-Solving Skills

Faculty Incharge

Do's

1. Keep your bags inside the rags available outside the lab. q
2. Remove your footwear outside the lab.
3. Teachers expect students to be calm and discipline. Your behavior and attitude in the lab should be excellent. The safety of you and other persons depend on it.
4. There is always plenty to do in the lab, so teachers expect you to arrive on times and to use your time well.
5. Listen to all instructions given by your teacher and follow them carefully.
6. Read your lab assignments before coming to lab. Prepare your pre-lab write-up prior to entering the lab.
7. Familiarize yourself with all lab procedures before doing the lab exercise.
8. Get signature in your observation book from your teacher before leaving the lab.
9. Perform only those experiments which you have been instructed.
10. It is your responsibility to take care of lab equipment, use it only as instructed, and report any damages to your teacher.
11. Pleases take care your personal stuff with you (Backpacks, purses, Mobiles, keys, etc.). Do not leave them in the laboratory.
12. Before leaving the lab switch off the systems and arrange the chairs properly.

Don'ts

1. Don't eat or drink in the lab room at any time
2. Don't chew gum or eat candy during lab exercises.
3. Don't be mischievous in the lab
4. Never remove any pages from the observation notebook & record.
5. Never use electrical equipment around water.

INDEX

SHEET NO: 1

INTRODUCTION TO ENGINEERING GRAPHICS

Introduction

- It is the graphical representation of physical objects and their relationships.
- It is prepared based on certain basic principles, symbolic representations, standard conventions, notations etc.
- It is a graphical language that communicates ideas and information from one mind to another and can be kept as a record of the planning process.
- It is called as the Universal language of engineers.
- It is a graphics language from which a trained person can visualize the object.
- It is a powerful tool to convey the ideas of an engineer.

The Purpose or the requirement of Studying Engineering Drawing:

- To develop the ability to produce simple engineering drawing and sketches based on current practice.
- To develop the skills to read manufacturing and construction drawings used in industry.
- To develop a working knowledge of the layout of plant and equipment.
- To develop skills in abstracting information from calculation sheets and schematic diagrams to produce working drawings for manufacturers, installers and fabricators.
- Technical drawing is the language of engineers, without which the drawings of various magnificent structures or intricate machines could not have been constructed.
- By means of a drawing, the shape, size, finish, color of any object can be described accurately and clearly.
- Drawings help and give a clear cut idea for the further revisions of the structure or a machine.

Drawing Instruments and aids:

Drawing Instruments are used to prepare drawings easily and accurately. A neat and clean drawing is prepared by the help of good quality drawing instruments and other aids. The following are the drawing aids commonly used in industries:

1. Drawing board
2. French curves
3. Templates
4. Mini drafter
5. Instrument box
6. Set squares
7. Protractor
8. Set of scales
9. Drawing sheets
10. Pencils

Drawing Sheet:

Engineering drawings are prepared on standard size drawing sheet. The correct shape and size of the object can be visualized from the understanding of not only its views but also from the various types of lines used, dimensions, notes, scales etc., The standard drawingsheet sizes are arrived at on the basic Principal of X:Y =1: √2 and XY=1 where x and y are the sides of the sheet. For example, AO, having a surface area of 1Sq.m; X=841mm and Y=1189mm.The successive sizesare obtained by either by halving along the length or doubling the width, the area being in the ratio1:2. Designation of sizes is given in the fig. For class work use of A2 size drawing sheet is preferred.

Table.1Standard size drawing sheets

Designation	Trimmed Sizes in mm (width x length)
A0	841 x 1189
A1	594 x 841
A2	420 x 594
A3	297 x 420
A4	210 x 297

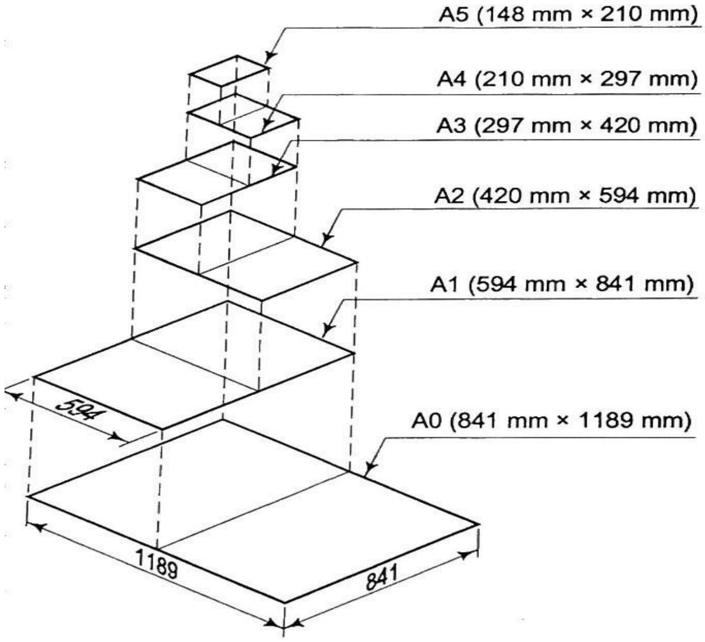


Fig. 1 Trimmed sizes

Drawing Sheet Layout

It is an important function of engineering drawing. Also, it is very important to understand the standard for the selection of suitable scale, margin space, title block and part list etc., on the sheet. The below mentioned details in the drawing sheet is according to IS46:2003

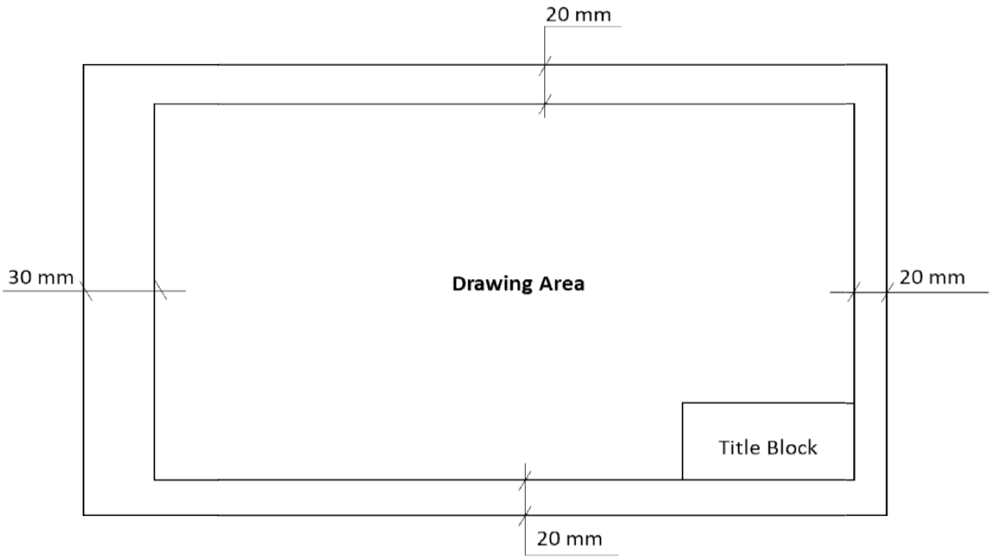


Fig. 2 Sheet lay out

Title Block

Title block is to be placed within the drawing space at the bottom right hand corner of the drawing sheet and it should be visible when prints are folded. It should consist of one or more adjoining rectangles. These rectangles may be divided further into boxes for inserting specific information. The size of the title block as recommended by the B.I.S. is 185 mm x 65 mm fro all designations of the drawing sheets. All the title blocks should contain at least the particulars mentioned below.

Table.2

S.No.	Particulars
1	Name of the firm
2	Title of the Drawing
3	Scale
4	Symbol denoting the method of projection
5	Drawing number
6	Initials with dates of persons who have designed, drawn, checked, standards, and approved
7	No. of sheet and total number of sheets of the drawing of the object

The Title blocks used in industries and for class work purpose are shown below.

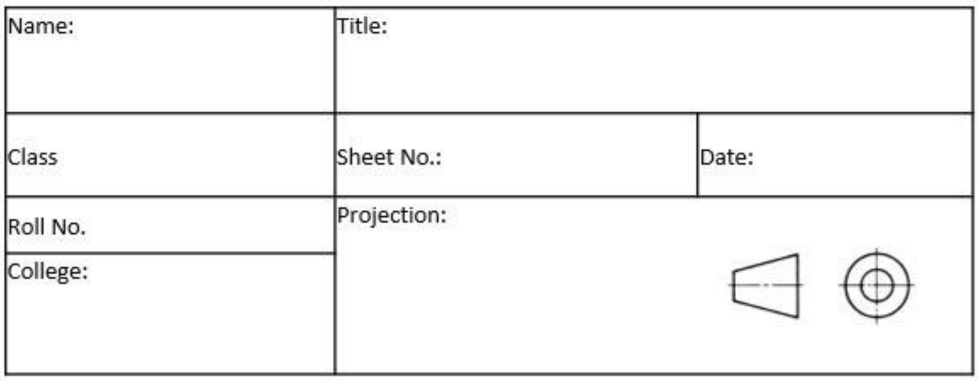


Fig. 3 Title Box

Types of Lines:

1. **Outlines (A):** Continuous thick or wide lines drawn to represent the visible edges and surface boundaries of the objects are called Outlines or Principal Lines.

2. **Margin Lines (A):** They are continuous thick or wide lines along which the prints are trimmed

3. **Dimension lines (B):** these lines are continuous thin lines that are terminated at the outer ends by pointed arrowheads touching the outlines, extension lines or centre lines.

4. **Extension or Projection Lines (B):** These are also continuous thin lines that extend by about 3 mm beyond the dimension lines.

5. **Construction Lines (B):** These continuous thin light lines used for constructing figures.

6. **Hatching or Section Lines (B):** These are the continuous thin lines generally drawn at an angle of 45^0 to the main outline of the section and are uniformly spaced about 1mm to 2 mm apart. These are used to make the section evident.

7. **Leader or pointer lines (B):** It is a continuous thin line drawn to connect a note with the feature to which it applies.

8. **Border Lines (B):** Perfectly rectangular working space is determined by drawing the border lines.

9. **Short- break lines (C):** These are continuous, thin and wavy lines drawn freehand and are used to show a short break or irregular boundaries.

10. **Long-break lines (D):** These are thin ruled lines with short zigzags within them and are drawn to show the long breaks.

11. **Hidden or dotted lines (E/F):** Interior or hidden edges and surfaces are shown by hidden lines. They are also called as dotted lines.
12. **Centre lines (G):** These are thin, long, chain lines composed of alternately long and dot lines drawn to indicate the axes of cylindrical, conical or spherical objects or details and also to show the centres of circles and arcs.
13. **Cutting-plane lines (H):** The location of cutting plane is shown by this line. It is a long, thin, chain line, thick at ends only.

Table.3 Types of Lines

Line Type		Descri ption	General Applications
A.		Continuous thick or Continuous wide	Visible outlines, Visible edges, Main representations in diagrams, flow charts etc.,
B.		Continuous thin(narrow)	Imaginary lines of intersection, Dimensions ,Extension, Projection, Leader lines, Reference lines, Hatching, Construction lines, Outlines of revolved sections
C.		Continuous thin(narrow)freehand	Limits of partial or interrupted views And sections, if the limit is not a chain thin line
D.		Continuous thin(narrow)with zigzags	Long-break line
E.		Dashed thick(wide)	Lines how in permissible of surface treatment
F.		Dashed thin(narrow)	Hidden out lines, hidden edges
G.		Chain thin Long–dashed dotted	Centre lines, lines of symmetry, trajectories, Pitch circle of holes, Axes
H.		Chain thin (narrow) with thick(wide)at the ends and at changing of the position	Cutting planes

Lettering

Lettering is defined as writing of titles, sub-titles, dimensions, and other important particulars on a drawing. To undertake production work of an engineering component as per the drawing, the size and there details are indicated on the drawing. This is done in the form of notes and dimensions. Main features of lettering consume more time. Lettering should be done freehand with speed. Practice accompanied by continuous efforts would improve the lettering skill and style.

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, 20mm

Note: Size of the letters may be selected based upon the size of the drawing.

Guidelines:

In order to obtain correct and uniform height of letters and numerals, guide lines are drawn using 2H pencil with light pressure. HB grade conical end pencil is used for lettering.

The following are some of the guide lines for lettering

- Drawing numbers, title block and letters denoting cutting planes, sections are written in 10mm size.
- Drawing title is written in 7mm size.
- Hatching, subtitles, materials, dimensions, notes, etc., are written in 3.5mm size.

Table.4 Characteristics of lettering as per BIS

Specifications	Value	Size (mm)						
Capital letter height	h	2.5	3.5	5	7	10	14	20
Lowercase letter height	a = (7/10)h	-	2.5	3.5	5	7	10	14
Thickness of lines	b = (1/10)h	0.25	0.35	0.5	0.7	1	1.4	2
Spacing between characters	c = (1/5)h	0.5	0.7	1	1.4	2	2.8	4
Min. spacing b/n words	d = (3/5)h	1.5	2.1	3	4.2	6	8.4	12
Min. spacing b/n baselines	e = (7/5)h	3.5	5	7	10	14	20	28

Dimensioning

A drawing describes the shape of an object. For complete details of an object, its size description is also required. The information like distance between surfaces and edges with tolerance, location of holes, machining symbols, surface finish, type of material, quantity, etc., is indicated on the drawing by means of lines symbols, and holes. The process of furnishing this information on a technical drawing as per a code of practice is called dimensioning.

Principles of 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. A dimension should be placed on the view where its use is shown more clearly.

4. Dimensions should be placed outside the views, unless they are clearer and more easily read inside.

5. Mutual crossing of dimension lines and dimensioning between hidden lines should be avoided. Dimension lines should not cross any other line of the drawing.

6. An outline or a center line should never be used as a dimension line. A center line may extend to serve as an extension line

7. Aligned system of dimensioning is recommended.

Elements of dimensioning

1. Projection or extension Line

It is a thin continuous line drawn in extension of an outline. It extends by 3mm beyond the dimension line.

2. Dimension Line

It is a thin continuous line terminated by arrowheads touching the outlines, extension lines or center lines.

3. Leader line

A leader line is a thin continuous line connecting a note or a dimension figure with the feature to which it applies. One end of the leader line terminated either in an arrowhead or a dot. The other end of the leader line is terminated in a horizontal line at a bottom level of the first or the last letter of the note. It is always drawn at a convenient angle of not less than 300 to the line which it touches.

4. Arrow head or Termination of dimension line

An arrow head is placed at each end of a dimensional line. Its pointed end touches an outline, an extension line or a center line. The size of an arrow head should be proportional to the thickness of the outlines. The length of the arrowhead should be three times its maximum. width. Different types of arrow heads can be observed, but closed and filled type of arrow head is widely used in engineering drawing.

Methods of indicating Dimensions:

The two methods of indicating dimensions are:

1. Aligned
2. Unidirectional.

1. **Aligned method**

In this method, the dimension is placed perpendicular to the dimension line such away that it may be read from the bottom edge of the right-hand edge of the drawing sheet. The dimensions must be placed in the middle and above the dimension line.

Fig. 4 Aligned method

2. **Uni directional method**

In unidirectional method, all the dimensions are placed in such a Way that they can be read from the bottom edge of the drawing sheet. The dimension lines are broken near the middle for inserting the dimensions. This is method is generally used on large drawings.

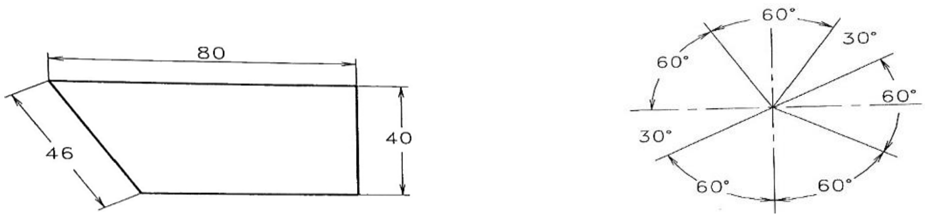


Fig. 5 Unidirectional method

Arrangement of Dimension lines

The dimensions of an object can be placed according to either Aligned or Uni directional methods, but they are arranged in the followings ways and this lection depends on the design and the construction requirements.

1. **Chain dimensioning**

This type of dimensioning is used only where the possible accumulation of tolerances does not endanger the functional requirements of the part.(fig.)

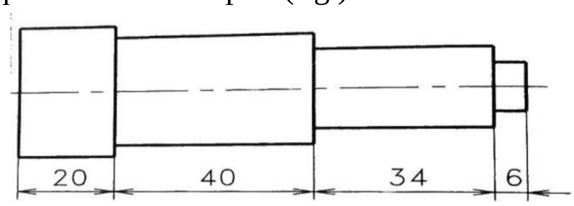


Fig. 6 Chain dimensioning

2. **Parallel dimensioning.**

This type of dimensioning is used only where a number of dimensioning of part have common datum feature

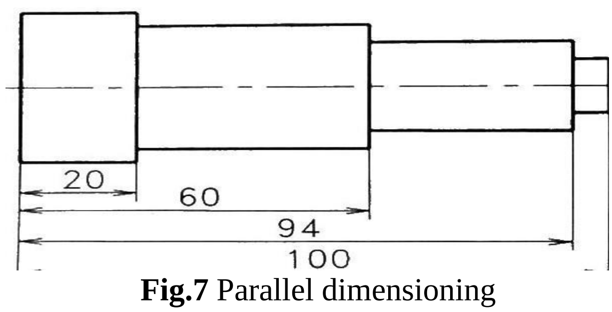


Fig.7 Parallel dimensioning

3. Combined dimensioning

In this a combination of both chain and parallel dimensioning are applied. But ,the distance of dimension line from the object boundary or nearby dimensions line should be at least 5mmto 6mm.

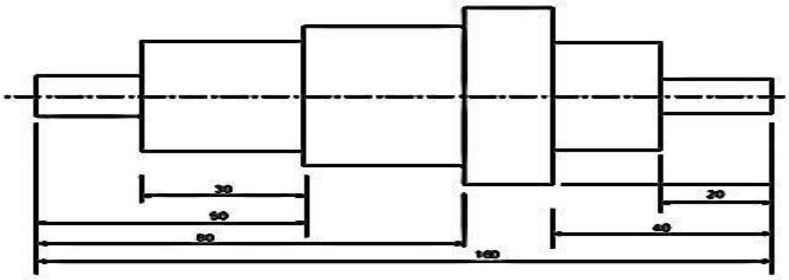


Fig. 8 Combined dimensioning

1. Super imposed running dimensioning

This type of dimensioning is a simple parallel dimensioning and may be used where there are space limitations and where no legibility problems will arise. In this, origin is to be indicated appropriately and the opposite end of each dimension line should be terminated only with arrowhead.

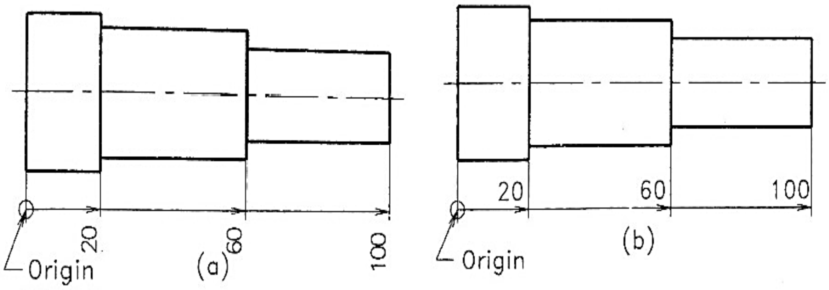
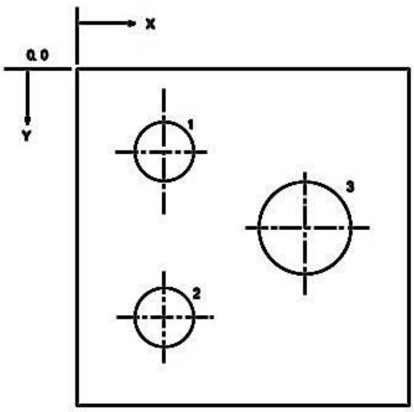


Fig. 9 Super imposed running dimensioning

2. Dimensioning by coordinates

This type of dimensioning follows the principle of coordinate system of identifying the points. This type of dimensioning follows the principle of coordinate system of identifying the points. There are three of indicating this type of dimensioning.



	1	2	3
X	20	20	40
Y	20	45	30
ϕ	15	15	20

Fig. 10 dimensioning by coordinates

Q1) Divide aline11cm long into 9 equal parts.

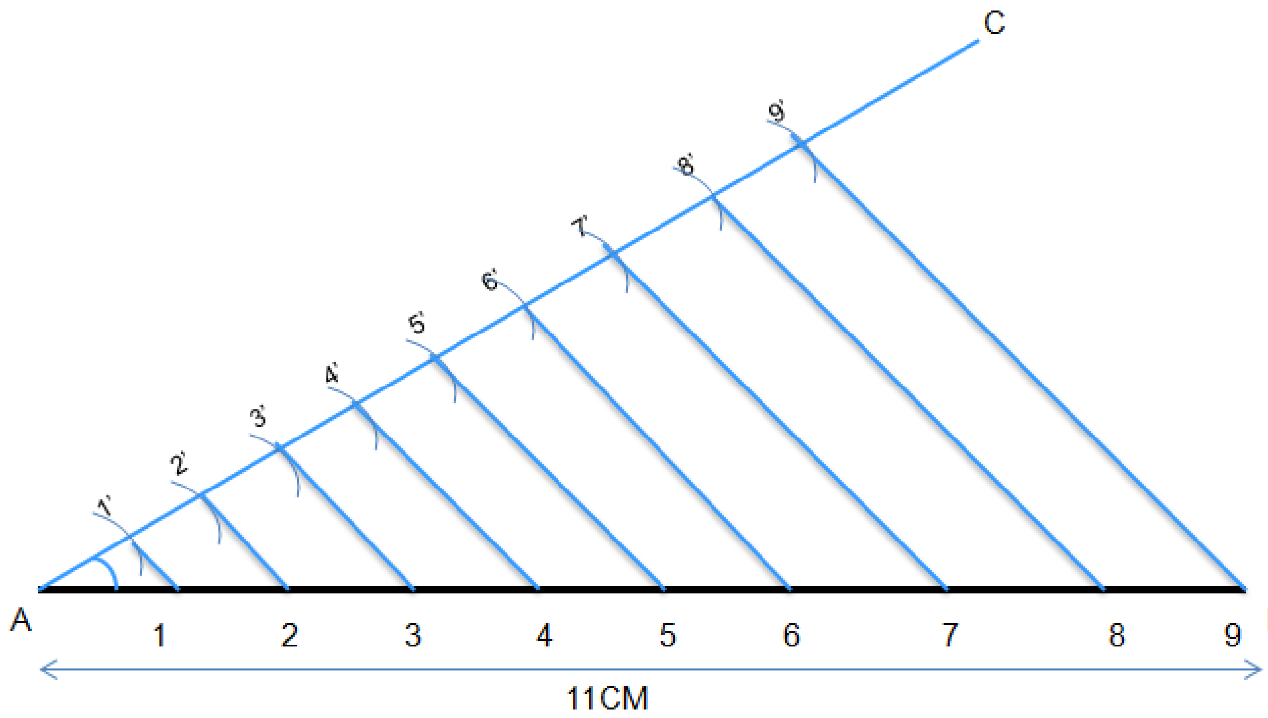


Fig. 11 Line division method

Construction steps

1. Draw the AB of given length (11cm).
2. Draw a line Ac taking an angle less than 45^0.
3. From A, along AC cut off with a divider, nine equal divisions of any convenient length (say1cm).
4. Draw a line joining B and 9^1.
5. Draw parallel lines B-9^1through the division's points on the line AC.
6. These parallel lines cut the line AB and divide it in to 9 equal parts.

POLYGONS

Q1) Construct a pentagon, hexagon, heptagon and octagon of side 3cms.

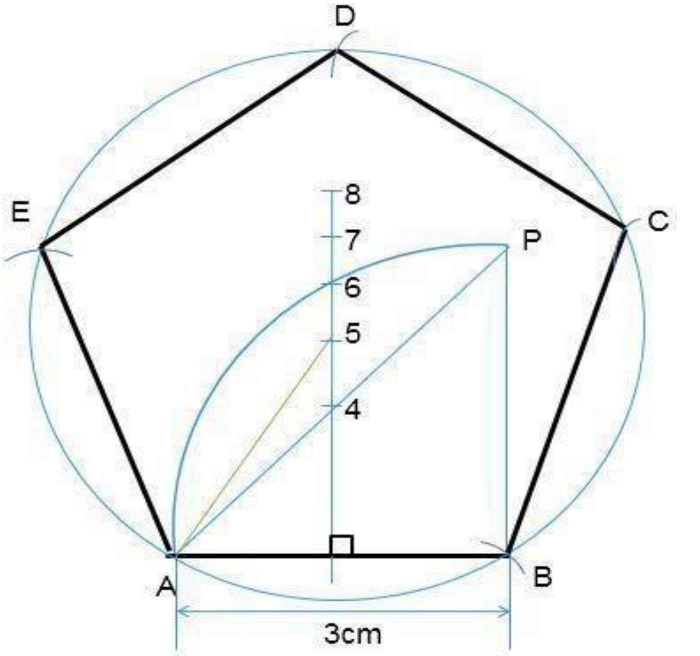


Fig. 12 Inscribe a pentagon in a circle

Pentagon Construction steps

1. Draw a line AB=3cms.
2. At B draw a line BP, perpendicular and equal to AB.
3. Draw a line joining A with P.
4. With centre B and radius AB, draw the quadrant AP.
5. Draw the perpendicular bisector to line AB to intersect the line AP at point 4 and to intersect the arc AP at point6.
6. Them id point 5 of the line 4-6 is the centre of the circle of radius A-5 in which a regular pentagon of a side equal to AB can be inscribed.
7. With B as centre and AB as radius, cut the circle at point C starting from B continue to cut the circle in 5 equal divisions with radius equal to AB.
8. Draw the line BC, CD, DE & EA, the figure ABCDE is the required pentagon.

Viva Questions

Sheet no 1: Introduction to Engineering Graphics

Lettering, dimensioning and Construction of polygons

1. What is lettering?

A. Writing of titles, dimensions, notes and other important particulars on a drawing is called as Lettering. There are different types of lettering like single stroke letters (thickness of the letter should be obtained in one stroke of the pencil), Gothic letters (like Bold in MS word), etc. In single stroke lettering, there are two types, namely vertical letters and inclined letters (like Italicized in MS word)

2. Write the letter M and W in at least two types of letterings.

A. M and W can be written in vertical, inclined and gothic lettering as follows:

M W (vertical); *M W (inclined at 75^0);* **M, W (Gothic)**

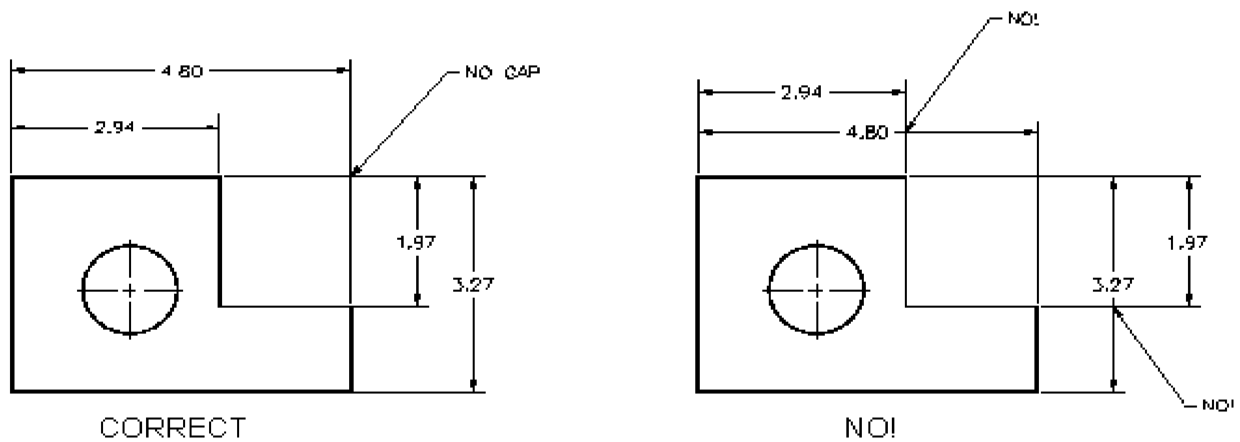
3. What is meant by aspect ratio?

A. It is the proportional relationship between the width and height ratio used for lettering. Usually 6:5, 7:4, etc are some examples of aspect ratios used for lettering.

4. The size of a letter is given by its________________.(Ans: Aspect ratio)
5. Write double stroke vertical alphabets, G and M of height 35 mm, taking ratio of 7:4. (Refer text book for correct representations)
6. What are the 2 systems of placing dimensions on a drawing? Illustrate your answer with sketches.

A. There are two systems of placing dimensions. They are the unidirectional system and the aligned system.

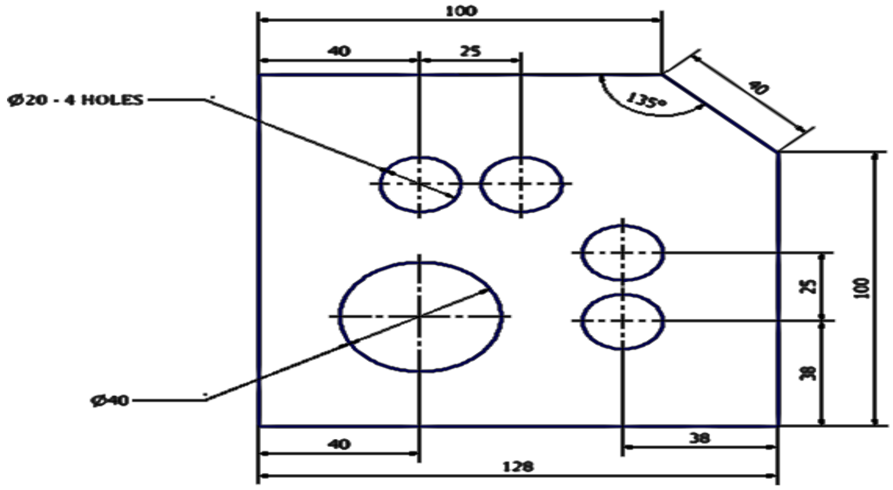
(i) Unidirectional system: In this system all the dimensions are so placed that they can be read from the bottom edge of the drawing sheet. The dimension lines are broken near the middle for inserting the dimensions. This system is mainly used on large drawings.



Always place shorter dimensions nearest to the object lines. Dimension lines should never cross. However, extension lines may cross each other.

(ii) Aligned system: In this system the dimensions are placed perpendicular to the dimension line in such a way that it may be read from the bottom edge or the right hand edge of the drawing sheet. The dimensions should be placed near the middle and above the dimension lines when seen from bottom or right edge of sheets.

ALIGNED METHOD OF DIMENSIONING



7. Explain with sketches the various types of lines used in drawing.

A. The following is the list of lines and their uses in drawing:

Line		Description	General Application	
A		Continuous thick	A1 A2	Visible outlines. Visible edges.
B		Continuous thin (straight or curved)	B1 B2 B3 B4 B5 B6 B7	Imaginary lines of intersection. Dimension lines. Projection lines. Leader lines. Hatching lines. Outlines of revolved sections in place. Short centre lines
C		Continuous thin free hand	C1	Limits of partial or interrupted views and sections, If the limit is not a chain thin.
D		Continuous thin (straight) with zigzags	D1	Long break line
E		Dashed thick	E1 E2	Hidden outlines. Hidden edges.
F		Dashed thin	F1 F2	Hidden outlines. Hidden edges.
G		Chain thin	G1 G2 G3	Center lines. Lines of symmetry. Trajectories
H		Chain thin, thick at ends and changes of direction	H1	Cutting planes.
J		Chain thick	J1	Indication of lines or surfaces to which a special requirement applies
K		Chain thin double dashed	K1 K1 K3 K4 K5	Outlines of adjacent parts. Alternative or extreme position of movable parts. Centroidal lines. Initial outlines prior to forming Parts situated in front of the cutting plane

8. What are the different sizes of sheets used in drawing?

A. The drawing sheets are designated as A series with the size decreasing as the number increases. The commonly used sheets are A0, A1, A2, A3, A4.

S.No	Designation of sheet	Dimensions of the sheet (mm)
1	A0	841 X 1189
2	A1	594 X 841
3	A2	420 X 594
4	A3	297 X 420
5	A4	210 X 297
6	A5	147X210

9. Write where the following lines are used in graphics:

a) Continuous thick line; b) Continuous thin with zig zag line; c) dash dot lines; d) thin dash lines.

A (a)-Visible parts of objects and main drawings; (b)- irregular boundaries or long breaks;

(c) - used for axis lines, center lines, lines of symmetry, etc; (d) -Hidden outlines & hidden edges

10. Match the following sizes of drawing paper as per BIS recommendation

Designation of sheet	Trimmed size in mm, width x length
1. A4	a. 420 x 594
2. A2	b. 210 x 297
3. A1	c. 297 x 420
4. A3	d. 594 x 841

(Ans: 1-b; 2-a; 3-d; 4-c)

SHEET NO: 2
SCALES

SCALES

SCALE:- Scale is defined as the ratio of the linear dimensions of element of the object as represented in drawing to the actual dimensions of the same element of the object itself.

WHY DO WE NEED SCALES?

Drawing of all the size objects cannot be drawn on the paper. Drawing of very large and very small size objects have to be accommodated on the paper.

Depending upon the size of the objects, the scales generally used for engineering drawing are:-

1.) Full size scale. 2.) Reducing Scale. 3.) Enlarged scale.

- Full size scale: -When the drawings are made equal to the actual size then the scale is said to be a full size scale. (1 : 1). Ex:-of a pencil size.
- Reducing Scale: -When the drawings are made smaller than their actual size then the scale is said to be a reduced scale. (1 : x where x>1). Ex: - Very big objects like buildings, large machine parts, town plans etc.
- Enlarged scale: When the drawings are made larger than their actual size then the scale is said to be an enlarged scale. (x: 1 where x>1). Ex: - Very small objects like parts of precision instruments such as watches, electronic devices etc.

The scales can be expressed in the following three ways:

i. Engineer's scale: In this case the relation between the dimension on the drawing and the actual dimension of the object is mentioned numerically in the style as 10mm= 5metc.

ii. Graphical Scale: The scale is drawn on the drawing itself. As the drawing becomes old, the engineer's scale may shrink and may not give accurate results.

However, such is not the case with graphical scale because if the drawing shrinks, the scale will also shrink. Hence in general we are using graphical scales in survey maps.

iii. Representative Fraction: The ratio of the length of the object represented on drawing to the actual length of the object represented is called the Representative Fraction (R.F) or Scale Factor(S.F).

Construction of any scale requires the following data:

1. Length of the scale.
2. The representative Fraction (R.F) of the scale.
3. The Units which it must represent. (Ex: mm, cm, feet etc.)
4. The maximum length which the scale must show.

*The Length of the scale is determined by the formula:

Length of the scale(L.O.S)=R.FX Maximum length required to be measured.

Representative Fraction: The ratio of the length of the drawing to the actual length of the object represented is called the Representative Fraction (R.F) or Scale Factor (S.F)

$$\textbf{R.F/S.F} = \frac{\text{Length of the Drawing}}{\text{Actual Length of the Object}}$$

Example: When 1cm line represents 1m length on the object,

$$\textbf{R.F} = \frac{1cm}{1m} = \frac{1cm}{1\text{x}100cm} = \frac{1}{100}$$

Then the scale of drawing will be1 : 100

NOTE: The scale or R.F of a drawing is given usually below the drawing. If the scale adopted is common for all drawings on that particular sheet, then it is given commonly for all figures under the title of sheet.

Be Friendly with these Units:

10milimetres(mm)	=	1centimetre(cm)
10centimetres	=	1decimetre (dm)
10decimetres	=	1 metre (m)
10 metres	=	1decametre(dam)
10decametres	=	1hectametre(hm)
10hectametres	=	1kilometre(km)
1hectametres	=	10,000squaremeters
1feet(1’)	=	12 inches(12”)
1Inch	=	2.54cm(or)25.4mm
1knot	=	1.85 km,
1 mile	=	1.609km,
1yard	=	3Feet
1verst	=	1.067 km

Plain Scales:

Plain Scale consists of a line divided in to suitable number of equal parts or units ,the first part of which is divided into smaller parts.

- Plain scales represents or (read or measure) up to two units or a unit and its sub-division, for example centimeters (cm) and millimeters (mm).When measurements are required up to first decimal, for example 2.3 more 4.6cm etc.

Diagonal Scales:

- Diagonal scales are used to read or measure up to three units. For example : decimeters (dm), centimeters (cm) and millimeters(mm).
- This scale is used when very small distancessuchas0.1 mm are to be accurately measured.
- Small divisions of short lines are obtained by the principle of diagonal division, as explained below.

Exercise Problem-1: Draw a scale of 1:50 showing meters and decimeters and to measure up to 8 meters, mark a distance of 6.4 meters on it.

Solution:

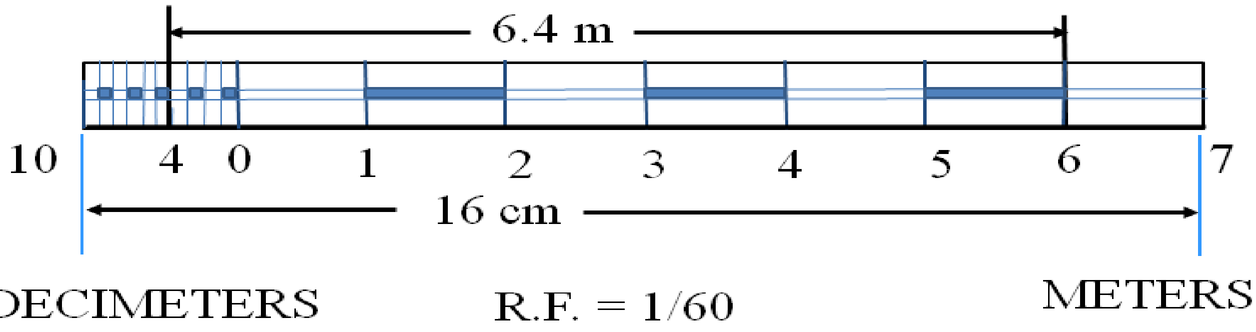


Fig. 13 Plain scales

Construction Steps:-

1. Calculation:

   Determine R For scale , here RF=1/50

   Determine Length of scale

   Length of scale= R.F. X Maximum Distance

   =1/50 X 800 cm = 16 cm

2. Draw a line 16cm long and divide it in8 equal parts, each part will represent Primary units (i.e1Meterforthisproblem).
3. Mark 0 at the end of first division and 1, 2, 3,..at the end of each subsequent division to the right(primary units).
4. Divide the first division to10equal parts, each part represents secondary division (1decimeter).
5. Show the distance 6.4 m on it with a dimension line, by placing one extension line on 6m mark on primary scale and the other extension line on 4dm mark on secondary scale.

Note (Common in every scale):

* The zero should be placed at the end of the first main division, i.e. between the unit and its sub-divisions. From the zero mark, the units should be numbered to the right and its sub-divisions to the left.

* To distinguish the divisions clearly, show the scale as a rectangle of small width about 5mm instead of only a line.

* Draw the division-lines showing primary units throughout the width of the scale and draw the lines for the sub-divisions as shown in fig.

* Draw thick and dark horizontal lines in the middle of all alternate divisions and subdivisions, this helps in taking measurements.

* Below the scale, mention names of primary units on the right-hand side, secondary units on left-hand side, and R.F in the middle.

Exercise Problem-2: A 3.2cm long line represents a length of 4m. Extend the line to measure length upto 25m and show on it unit of1 m and 5meter. Show the length of 17meterson this line.

Solution:

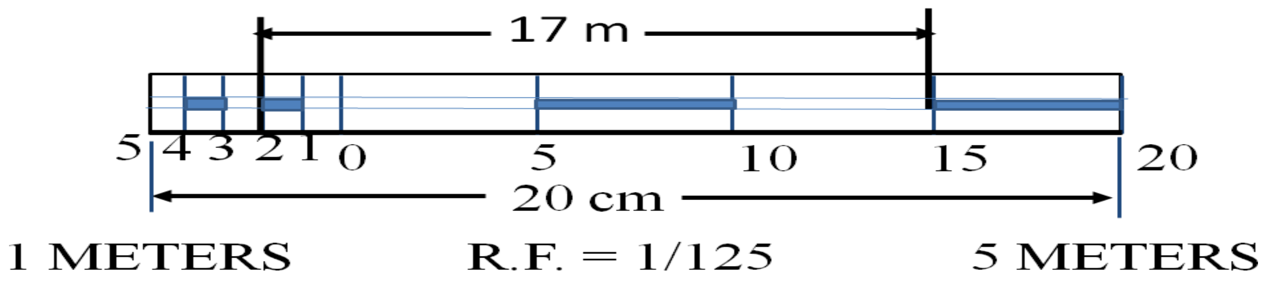


Fig. 14 Plain scales

Construction Steps:-

1. **Calculation:**

Determine RF of scale,

R.F.=3.2cm/ 4m = 32/400 =1/125

Determine Length of scale,

L.O.S= R.F. X Max. Distance

=1/125 X 25m= 20 cm

2. Draw a line 20cmlong and divide it in 5 equal parts each part will represent 5 meter distance.

3. Mark 0 at the end of first division and 1, 2, 3.. at the end of each subsequent division to the right(primary units).

4. Divide the first division in to5 equal parts, each part representing1 meter (Secondary Units).

5. Show the distance17 m on it bytaking15 m on main scale and2 meters on secondary scale.

Exercise Problem-3: Draw a diagonal scale of R.F=3/100, showing meters, decimeters, and centimeter and to measure 5 meters. Show the length of 3.69meters on it.

Solution:

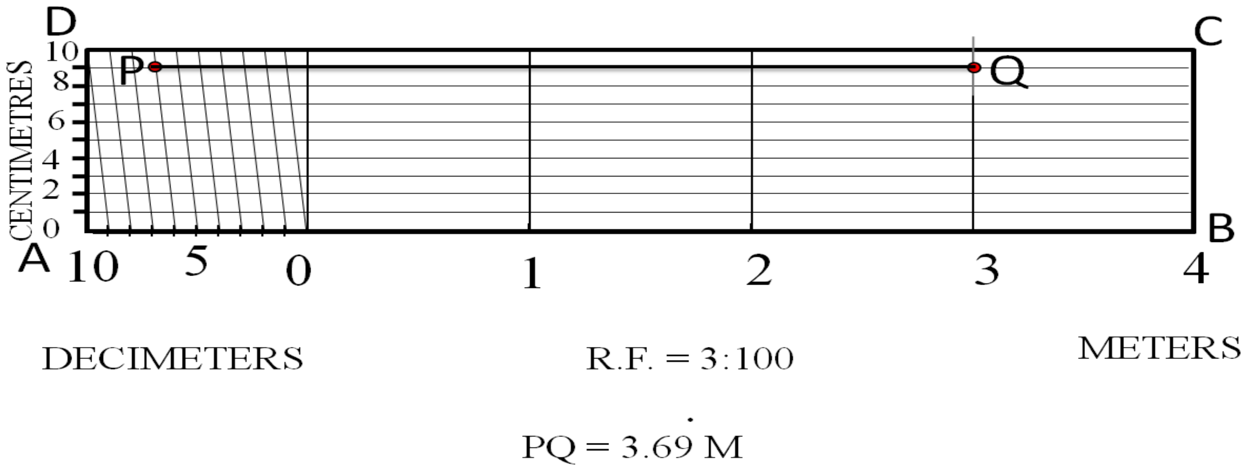


Fig. 15 Diagonal Scales

Construction Steps:-

1. Calculation:

   Determine RF of scale, R.F.=3/100

   Determine Length of scale=R.F. X Max. Distance

   =3/100 X 5 X100 cm =15cm

2. Draw a line AB=15 cm long and divide it into 5 equal parts. Each division will show 1m (primary units).

3. Divide the first part A0 into ten equal divisions, each division shows 1decimeteror 0.1m.

4. At A perpendicular of suitable length and step off along it,10 equal divisions, ending at D. Complete the rectangle ABCD

5. Erect perpendiculars at meter divisions 0,1,2,3 and 4.

6. Draw horizontal lines through division points on AD.

7. Join D with the end of first division along A0 that is point 9.

8. Throughremainingpointsi.e.,8, 7,6… draw parallel line toD9.

9. Mark the distance PQ = 3.69 m (using principle of diagonal scales), 3m on primary (meters) scale, 6cm on secondary (decimeters)scale & 9cm on tertiary(centimeters)scale.

Exercise Problem-4: On a map, the distance between two points in 14cm. The real distance between them is 20Km. Draw a diagonal scale of this map to read kilometers and hectometers and to measure up to 25Kms. Show a distance of 17.6Kms on this scale.

Solution:

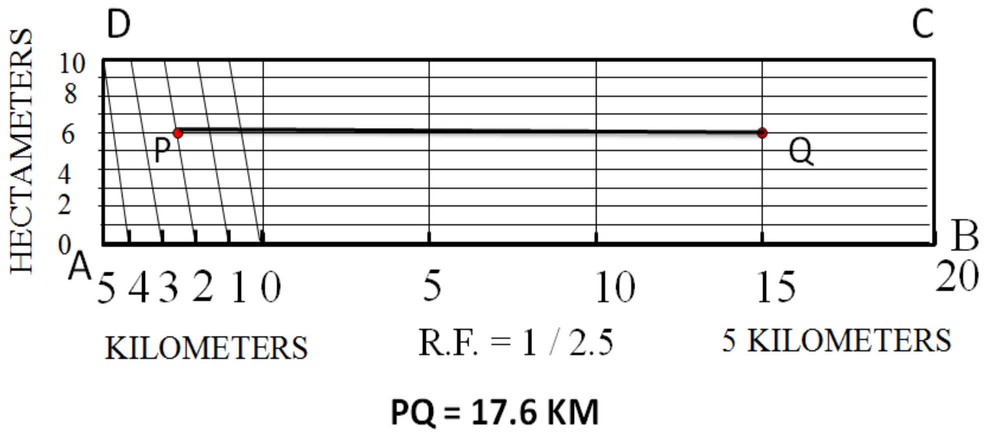


Fig. 16 Diagonal Scales

Construction Steps:-

Calculation:

RF of scale=14cm / 20km= $7/10^6$

Length of scale=.FX max length=$7/10^6$X25X10^5cm=17.5cm

1. Draw a line AB=17.5cmlonganddivideit into 5equal parts. Each part will show a 5km.
2. Divide the first part A0 in to five equal divisions, each showing a one kilometer.
3. At A erect a perpendicular of suitable length and step off along it, 10 equal divisions, ending at D. Complete the rectangle ABCD
4. Erect perpendicular at 5 kilometer divisions0,5, 10,15and 20.
5. Draw horizontal lines through division points on AD.
6. Join D with the end of first division alongA0 that is point9.
7. Through remaining points i.e.,8, 7,6… draw parallel line toD9.
8. Mark the distance PQ = 17.6 km (using principle of diagonal scales), 15km on primary scale, 5km on secondary scale & 2km on tertiary scale.

Viva Questions

Sheet no: 2 Scales (Plain scales, Diagonal scales)

1. What is meant by Representative Fraction (RF) for a scale?

A: It is the ratio of the length of the drawing on the chart to the actual length of the object.

For lengths, RF = Length of drawing / actual length.

For areas, RF = $\sqrt{\frac{Area\ of\ the\ drawing}{Actual\ Area}}$

For volumes, RF = $\sqrt[3]{\frac{Volume\ of\ the\ drawing}{Actual\ Volume}}$

2. In a scale, if RF < 1, it is______________scale (reducing scale)
3. In a scale, if RF = 1, it is called as_______________scale (full scale)
4. In a scale, if RF > 1, it is called as____________scale (Enlarging scale).
5. Match the following :

1) Reduction scale	a) 1 : 1	
2) Full scale	b) 100 : 1	
3) Enlargement scale	c) 1 : 100	(Ans: 1-c;2-a;3-b)

6. When dimensions are to be measured in 3 units,__________scale is used. (Vernier and diagonal scales may be used)
7. Explain the principle of diagonal scale. (refer to text book, use similar triangles concept)

   8. What are the differences between

   (i) plain scales and diagonal scale.

8. A room of 1728 m^3 volume is shown by a cube of 216 cm^3 volume. Find its RF

A: RF = $\sqrt[3]{\frac{Volume\ of\ the\ drawing}{Actual\ Volume}} = \sqrt[3]{\frac{216\ cm^3}{1728 m^3}} = \frac{1\ cm}{2\ m} = \frac{1}{200}$

9. An area of 144 sq.cm on a map represents an area of 36 sq.km on the field. Find the RF.

A. For areas, RF = $\sqrt{\frac{Area\ of\ the\ drawing}{Actual\ Area}} = \sqrt{\frac{144\ cm^2}{36 km^2}} = \frac{4\ cm}{1\ km} = \frac{1}{50000}$

10. A 3.2 cm long line represents a length of 4 meters. What is its RF? (ans: 3.2/400= 1/125)
11. Construct a plain scale to show meters & decimeters, when 3 cms are equal to 2 meters & long enough to measure up to 5 meters.

A: RF = 3cm/2 m = 3/200; ML = 5 m; Length of Scale = (3/200)* 5*100 = 7.5 cm.

(As it is asked under short answers, in the OU exam, this may be drawn with free hand to save time.)

SHEET NO: 3

CONIC SECTIONS -I

Q1) Construct an ellipse whose distance of the focus from directrix is equal to 50 mm and eccentricity =2/3. Draw tangent and normal at any point 70mm away from directrix on the curve?

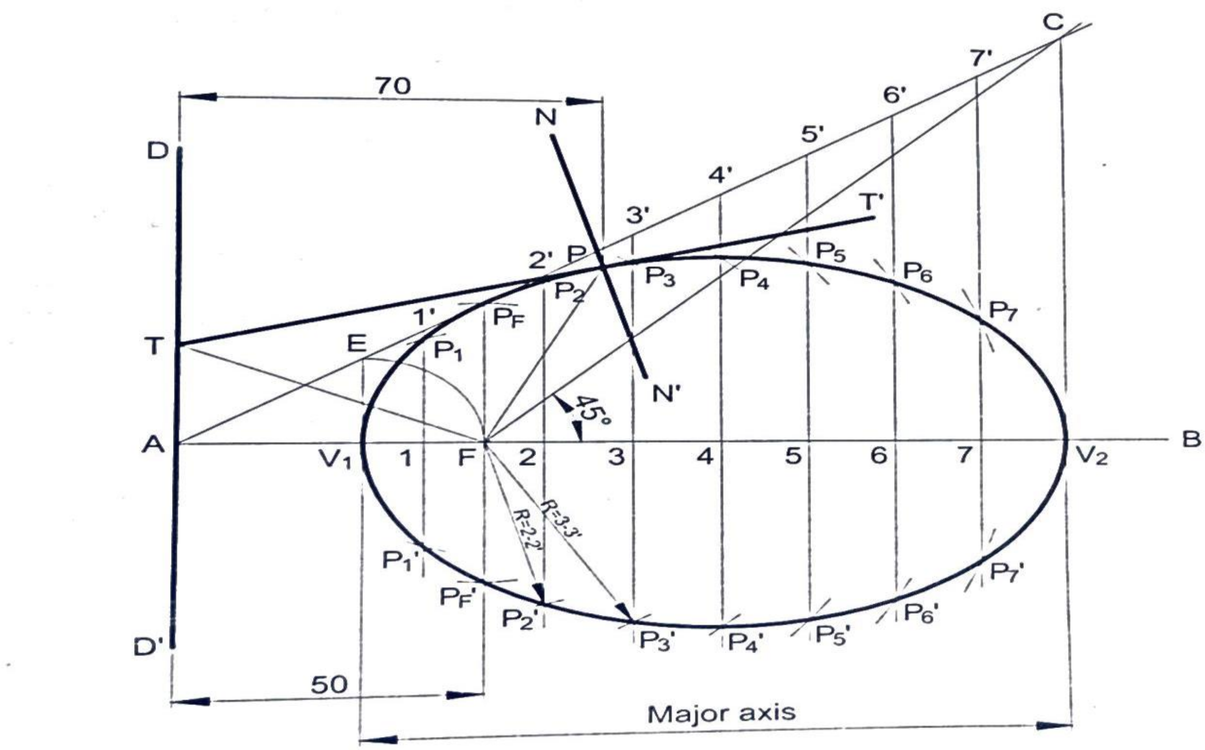


Fig. 17 Ellipse General method

1. Draw Axis and Directrix
2. Mark a point(F)at 50mm from directrix
3. Divide(OF)line in five equal parts mark the vertex at 3point
4. Draw a Perpendicular bisector from (V) and semi-circle of radius (VF) taking V as center mark the point(E).
5. Draw a ray from(A)passing through(E)
6. Draw perpendiculars to axis from (V) to right side with so me intervals and label as 1,2,3,…….n
7. At intersection if (AE-ray) and perpendiculars mark the points as1',2',3',………n'
8. Taking11' as radius (F) as center cut 11' line and soon
9. Mark the points as p1, p2, p3,…..pn
10. Jointhep1, p2,p3, …..pn with smooth curve to required ellipse.

Tangent and Normal

1. Mark the given point Q and join PF .
2. At F draw a line perpendicular to QF to cut AB at P.
3. Join QP and extend it. QP is the tangent at P
4. Through Q, draw a line NM perpendicular to QP. NM is the normal at P

Q2) Construct a parabola whose distance of the focus from directrix is equal to50mm. Draw tangent and normal at any point on the curve.

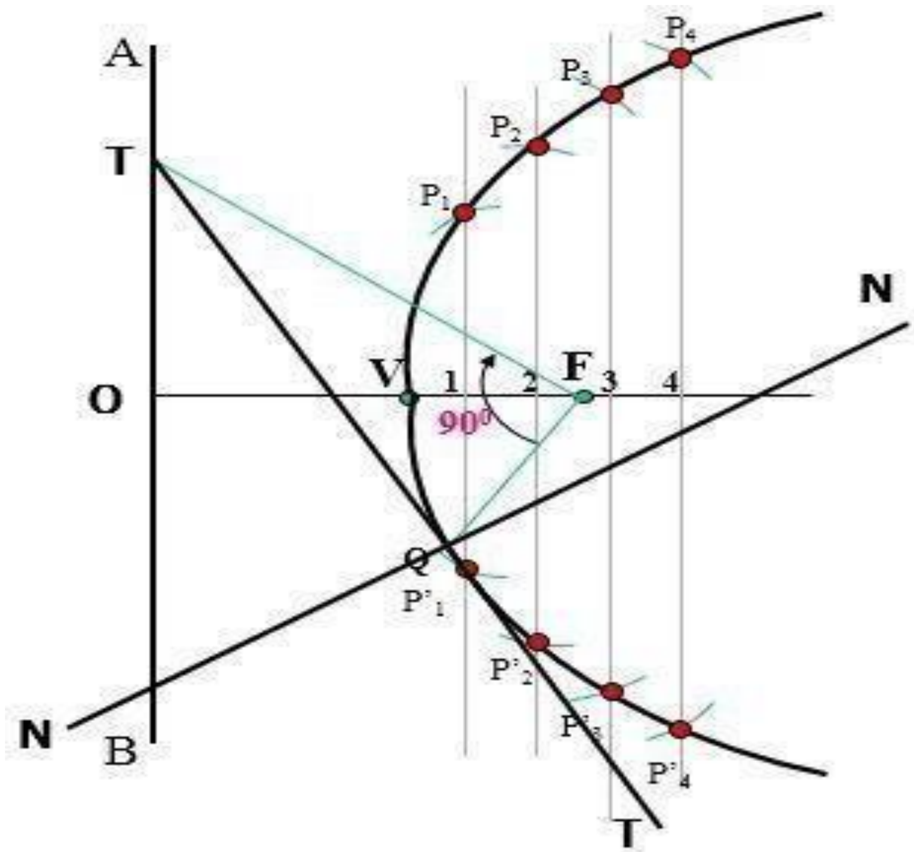


Fig. 18 Parabola General Method

1. Draw Axis and Directrix
2. Mark a point(F)at50mm from directrix
3. Mark them id point as vertex(V)
4. Draw a Perpendicular bisector from (V) and semi-circle of radius (VF) taking V as center mark the point(E).
5. Draw a ray from(O)passing through(E)
6. Draw perpendiculars to axis from (V) to right side with so me intervals and label as 1, 2,3,…….n
7. At intersection if (OE-ray)and perpendiculars mark the points as1',2',3',
8. ………n'
9. Taking11' as radius (F) as center cut 11'lineand soon
10. Mark the points as p1, p2, p3,…..pn
11. Jointhep1,p2, p3,…..pn with smooth curve to required Parabola.

Tangent and Normal

1. Mark the given point Q and join PF .
2. At F draw a line perpendicular to QF to cut AB at P.
3. Join QP and extend it. QP is the tangent at P
4. Through Q, draw a line NM perpendicular to QP. NM is the normal at P

Q3) Construct a Hyperbola whose distance of the focus from directrix is equalto50mm. Draw tangent and normal at any point 25mm away from directrix on the curve.

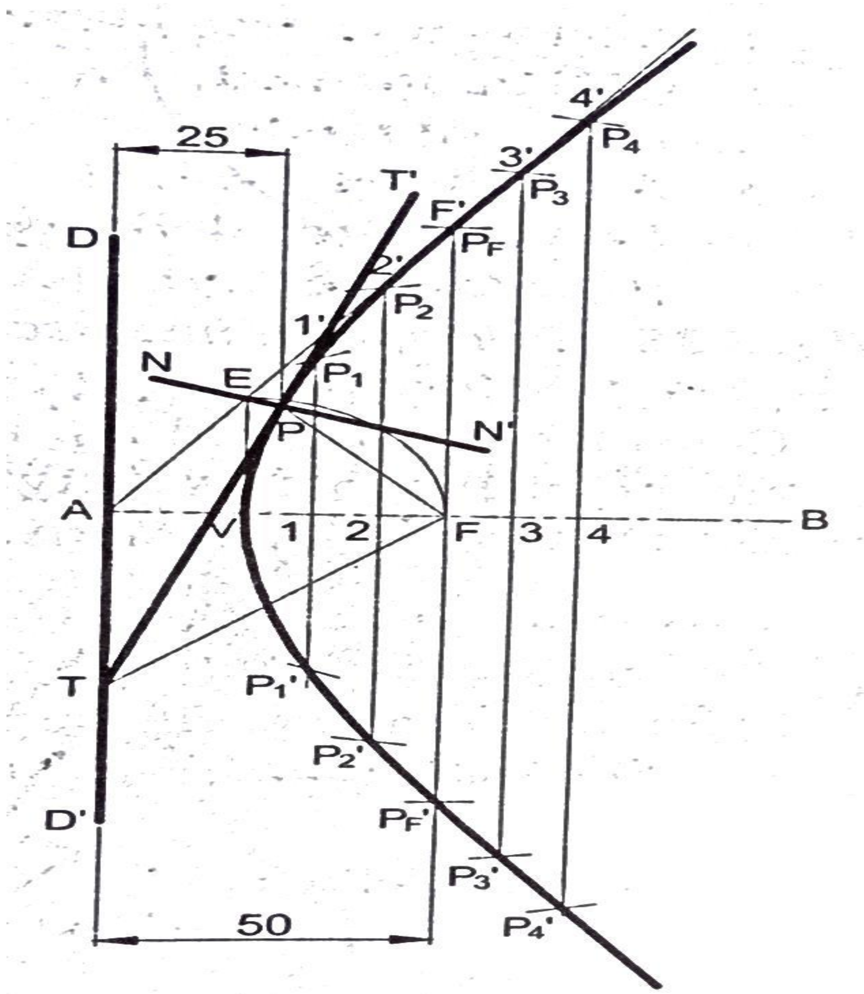


Fig. 19 Hyperbola General Method.

1. Draw Axis and Directrix
2. Mark a point(F)at 50mm from directrix
3. Divide(OF)line in five equal parts mark the vertex(V)at2point
4. Draw a Perpendicular bisector from (V) and semi-circle of radius (VF) taking V as center mark the point(E).
5. Draw a ray from(O) passing through(E)
6. Draw perpendiculars to axis from (V) to right side with some intervals and label as 1,2,3, 7.n.
8. At intersection if(AE-ray)and perpendiculars mark the points as 1',2',3',

………n'

9. Taking11' as radius (F) as center cut 11'lineand soon
10. Mark the points as p1,p2,p3,................................pn
11. Join the p1, p2,p3,................................pn with smooth curve to required Hyperbola

Tangent and Normal

1. Mark the given point Q and join PF .
2. At F draw a line perpendicular to QF to cut AB at P.
3. Join QP and extend it. QP is the tangent at P
4. Through Q, draw a line NM perpendicular to QP. NM is the normal at P

SHEET NO: 4
CONIC SECTION - II

Q1) Major axis AB & minor axis CD are 110 and 70mm long respectively. Draw ellipse by Concentric Circle method?

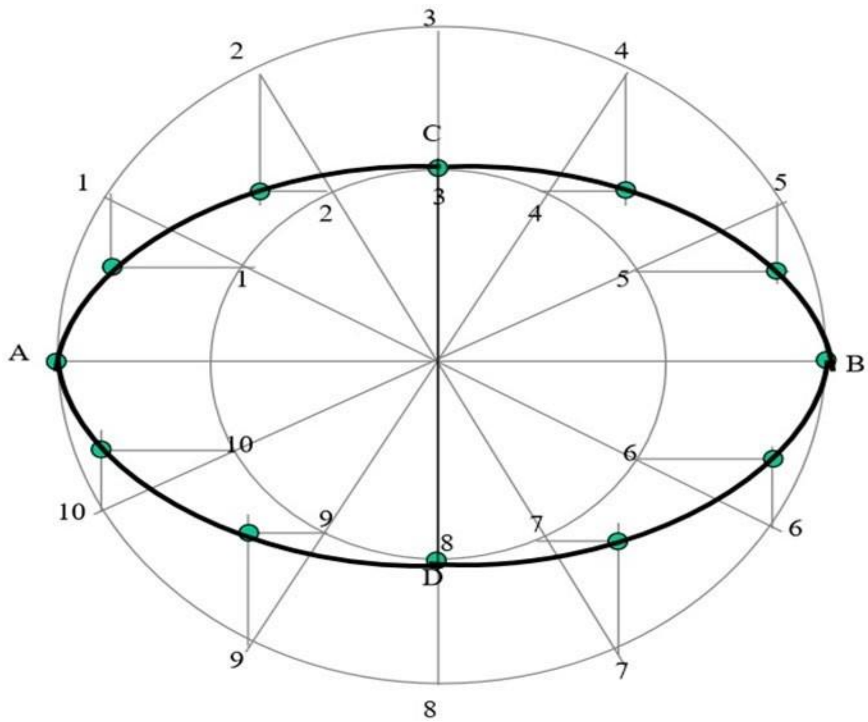


Fig. 20 Ellipse by Concentric Circle Method

1. Draw both axes as perpendicular bisectors of each other & name their ends as shown.

2. Taking their intersecting point as a center, draw two concentric circles considering both as respective diameters.

3. Divide both circles in 12 equal parts & name as shown.

4. From all points of outer circle draw vertical lines downwards and upwards respectively.

5. From all points of inner circle draw horizontal lines to intersect those vertical lines.

6. Mark all intersecting points properly as those are the points on ellipse.

7. Join all these points along with the ends of both axes in smooth possible curve. It is required ellipse.

Q2) Draw ellipse by Rectangle method. Take major axis 160 mm and minor axis 100 mm long

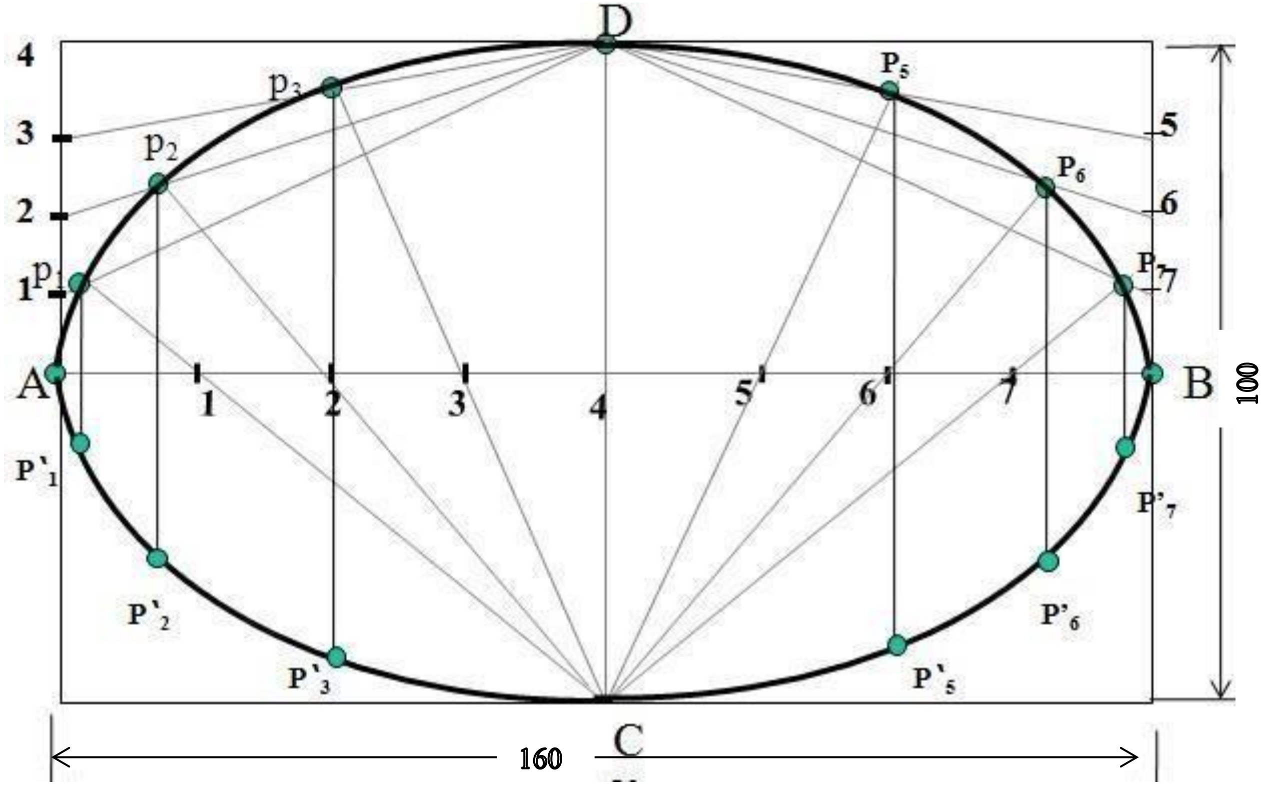


Fig. 21 Ellipse Rectangle Method

1. Draw a rectangle taking major and minor axes as sides.
2. In this rectangle draw both axes as perpendicular bisectors of each other..
3. For construction, select upper left part of rectangle. Divide vertical small side Horizontal long side into same number of equal parts.(here divided in four parts)
4. Name those as shown..
5. Now join all vertical points 1,2,3,4, to the upper end of minor axis. And all horizontal points i.e.1,2,3,4 to the lower end of minor axis.
6. Then extend C-1 line up to D-1 and mark that point. Similarly extend C-2, C-3, C-4linesup to D-2, D-3, & D-4lines.
7. Mark all these points properly and join all along with ends A and D in smooth possible curve. Do similar construction in right side part along with lower half of the rectangle. Join all points in smooth curve. It is required ellipse.

Q3) A ball thrown in air attains 120 m height and covers horizontal distance 80m on the ground. Drawthe path of the ball (projectile)

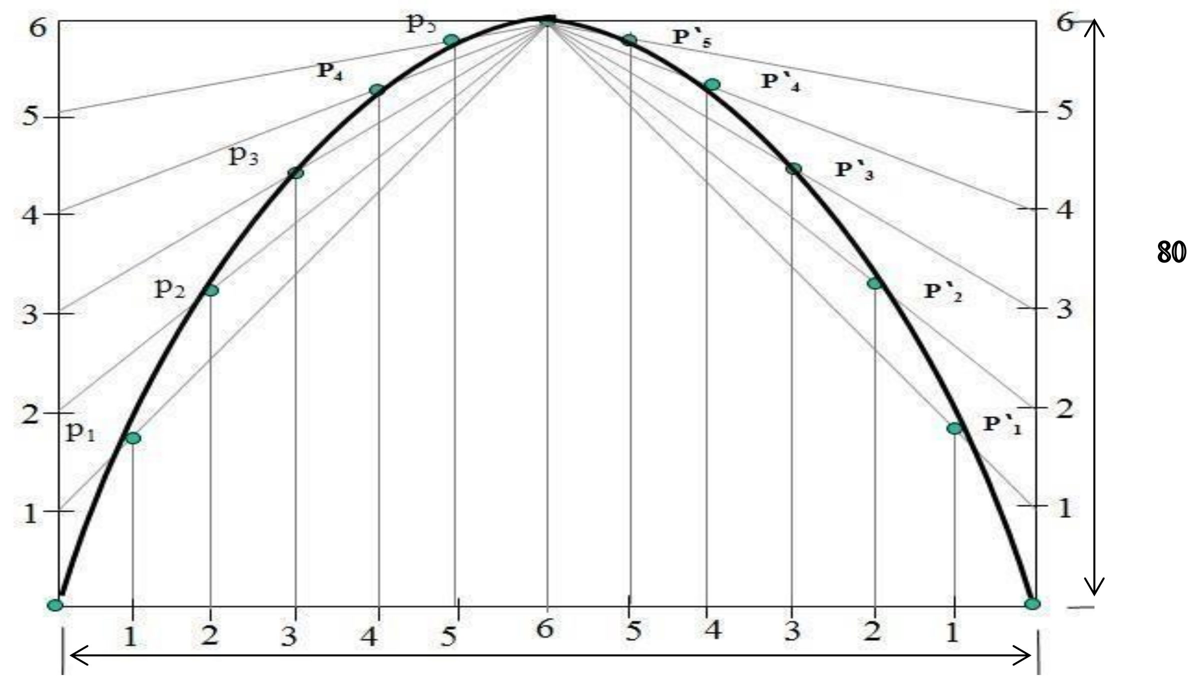


Fig. 22 Parabola Rectangle Method

1 Draw rectangle of above size and divide it in two equal vertical parts

2 Consider left part for construction. Divide height and length in equal number of parts and name those1,2,3,4,5&6

3 Join vertical 1,2,3,4,5&6 to the to p center of rectangle

4 Similarly draw upward vertical lines from horizontal 1,2,3,4,5 And wherever these lines intersect previously drawn inclined lines in sequence Mark those points and further join in smooth possible curve.

5 Repeat the construction on right side rectangle also .Join all in sequence. This locus is a Parabola**.**

Q4) . Draw a rectangular hyperbola using the orthogonal asymptotes method when the position of a point P on the curve is at a distance of 35 mm and 50mm from two asymptotes.

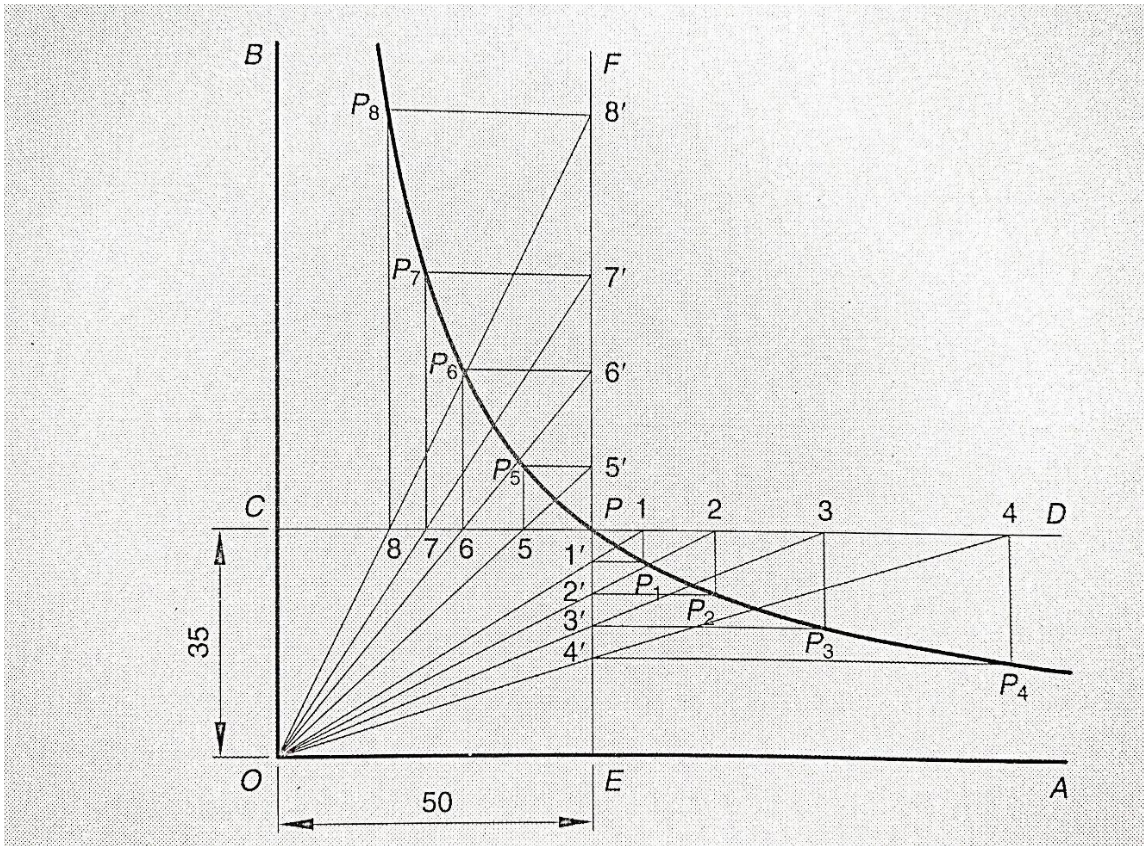


Fig. 23 Rectangular Hyperbola using asymptotes method

1. Extend horizontal line from P to right side.
2. Extend vertical line from P upward.
3. On horizontal line from P, mark some points taking any distance and name them after P-1, 2, 3, 4. etc.
4. Join 1-2-3-4 points to pole O. Let them cut part [P-B] also at 1,2,3,4 points.
5. From horizontal 1,2,3,4 draw vertical lines downwards and
6. From vertical 1,2,3,4 points [from P-B] draw horizontal lines.
7. Line from 1 horizontal and line from 1 vertical will meet at P1 .Similarly mark P2 , P3 , P4 points.
8. Repeat the procedure by marking four points on upward vertical line from P and joining all those to pole O. Name this points P6 , P7 , P8 etc. and join them by smooth curve.

<u>Viva Questions</u>

<u>Sheet no: 3&4 Conic sections *(*Ellipse, parabola, hyperbola and rectangular hyperbola*)*</u>

1. What is a conic?

A: It is a locus of point moving in a plane in such a way that the ratio of its distances from a fixed point (focus) and a fixed line (directrix) is always constant.

The fixed point is called as focus and the fixed line is called as directrix.

2. In a conic, the line passing through the fixed point & perpendicular to the fixed line is called the __________ (Ans: Axis).
3. The point at which the conic cuts its axis is called as________(Ans: Vertex)
4. Define eccentricity.

A: Eccentricity is the ratio of distance of the point from the focus to the distance of the point from directrix. ($e = PF/PD$)

5. State the values of eccentricity for different conics.

A: Ellipse: $e<1$; Parabola: $e = 1$; Hyperbola: $e>1$; rectangular hyperbola: $e = \sqrt{2}$.

6. Explain how a cone is to be cut to get various conic sections with simple sketches.

A: When the section plane is inclined to the axis and cuts all the generators on one side of apex, the section (true shape of cut portion) is an ellipse.

When the section plane is inclined to the axis and is parallel to one of the generators, the section is a parabola.

When the section plane cuts both the parts of the double cone on one side of the axis, the section is a hyperbola. (refer to the figure from text book in introduction of conic sections)

7. Explain the oblong method of drawing an ellipse. (Refer to the construction procedure).

8. The locus of a point P moving in such a way that the sum of its distance from two fixed points is always constant is called as_________. (ellipse; as $PF_1+PF_2 = c = 2a$)

9. The locus of a point P moving in such a way that the difference between its distances from two fixed points is always constant is called as_______. (Hyperbola; $PF_1-PF_2 = c$)

SHEET NO: 5

CYCLOIDS

Cycloidal Curves

Cycloid: It is the locus of a point on the periphery of a circle which rolls on a straight line path. The rolling circle is called the **generating circle** and the fixed straight line is called the **directing line** .The cycloidal curves are used in to ortho profile of gears.

1Q. Draw locus of a point on the periphery of a circle which rolls on straight line path, take circle diameter as 50 mm. Or a circle of 50 mm dia rolls along a straight line without slipping. Draw the curve traced out by a point p on the circumference, for one complete revolution of the circle. Draw a tangent to the curve at a point 40mm from the line.

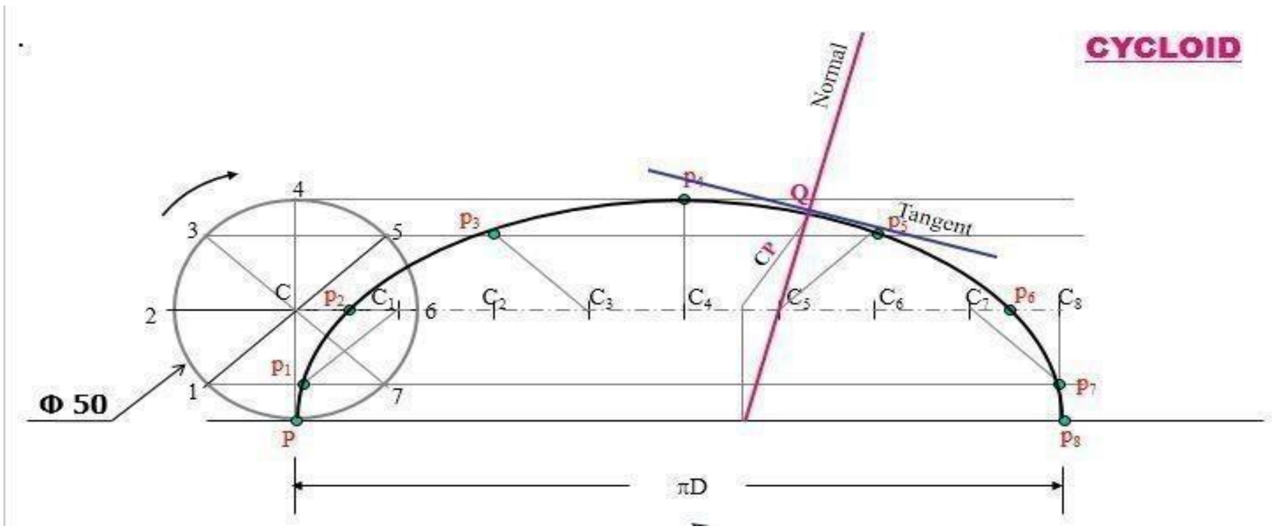


Fig. 24 Cycloid

1. From center C draw a horizontal line equal to D distance
2. Divide πD distance in to 8 number of equal parts and name them C1, C2, C3…etc.
3. Dividethecirclealsointo8numberofequalpartsandinclockwisedirection, afterP name1, 2, 3 up to8.
4. From all these points on circle draw horizontal lines. (parallel to locus of C)
5. With a fixed distance C-Pin compass,C1 as center, mark a point on horizontal line from 1. Name it P_1.
6. Repeat this procedure from C2, C3, C4 uptoC8 as centers. Mark points P_2,P_3,P_4,P_5up to P_8on the horizontal lines drawn from 2,3, 4,5, 6,7respectively.
7. Join all these points by a smooth curve. It is a Cycloid.

Tangent and Normal

1. Mark Point Q on curve at a distance 40mm above base line.
2. With CP Distance, from Q. cut the point on Locus of C and Join it to Q. from this point drop a perpendicular on ground line and name it N
3. Join N with Q. This will be normal to Cycloid.
4. Draw a line at right angle to this line from Q. It will be Tangent to Cycloid.

Epicycloid: The curve generated by a point on the circumference of a circle, which rolls with out slipping along another circle outside it, is called an epicycloid.

1Q. A circle of 40 mm dia rolls on the circumference of another circle of 150 mm dia and outside it. Trace the locus of a point on the circumference of the rolling circle for one complete revolution. Name the curve and draw a tangent & normal to the curve at a point 125mm from the centre of the directing circle

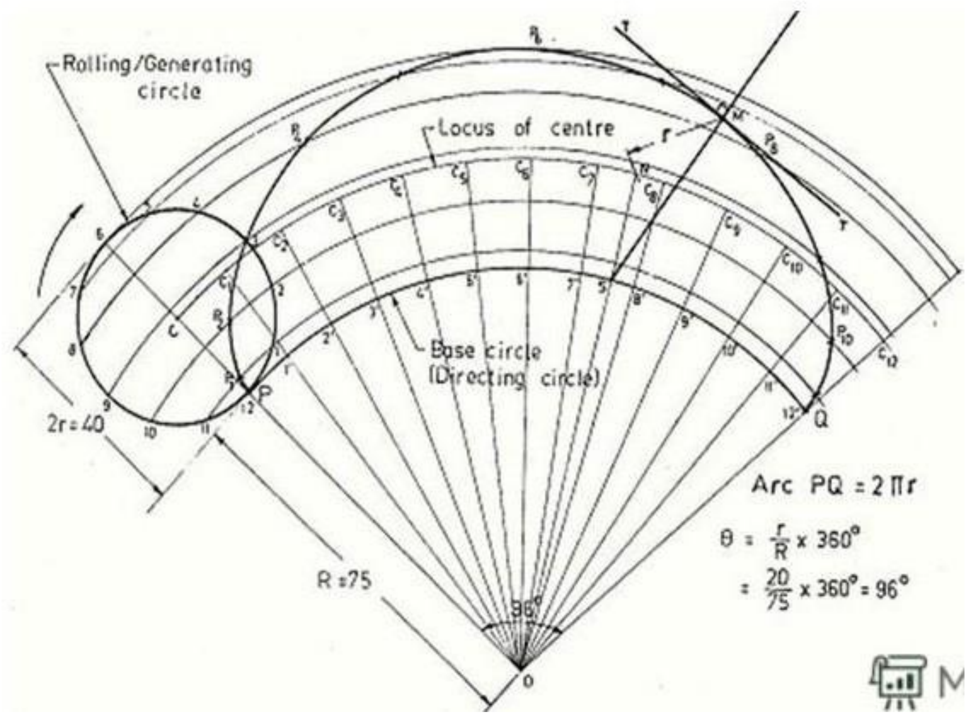


Fig. 25 Epicycloid.

1. When smaller circle will roll on larger circle for one revolution it will cover Π D distance on arc and it will be decided by included arc angle θ.
2. Calculate θ by formula θ = (r/R) x 360.
3. With O as centre and OC as radius, draw an arc to represent locus of centre.
4. Divide arc PQ in to 12 equal parts and name them as 1', 2', …., 12'
5. Join O1', O2', … and produce them to cut the locus of centres at C1, C2, …
6. Taking C1 as centre, and radius equal to 20 mm, draws an arc cutting the arc through 1 at P1. Similarly obtain points P2, P3,…., P12.

Tangent and Normal

1. Mark Point Q on curve at a distance of 125mm from Origin O.
2. With CP Distance, From Q. Cut the point on locus of C and join it to Q. from this point drop a perpendicular on ground line and name it N Join N with Q.
3. This will be Normal to Epicycloid now draw a line perpendicular to the normal that will be Tangent.

Viva Questions

Sheet no: 5 Cycloid, Epicycloid

1. What is a cycloid?

A: The curve generated by a point on the circumference of a circle rolling along a straight line without slipping is called as Cycloid. It can be described by an equation $y = a(1-\cos\theta)$

2. Define base line, rolling circle and generating point in a cycloid.

A: The fixed line on which the circle rolls is called the base line. The circle which rolls along the straight line is called as rolling circle or generating circle. The intersecting point of the circle and the line in the initial contact position is called generating point.

3. What is the length of the base line for one complete revolution of a circle in a cycloid? (ans: πD or $2\pi R$; where R is the radius of the circle and D is the diameter)
4. Define epicycloid.

A. It is the curve generated by a point on the circumference of a circle rolling along another circle & outside it.

5. When the rolling circle (generating circle) diameter is half of the base circle (or directing circle), the hypocycloid is a________(ans: straight line).

INVOLUTES

INVOLUTE

It is a curve traced out by an end of a piece of thread unwound from a circle or a polygon, the thread being tight. It may also be defined as a curve trace doubt by a point in a straight line which rolls without slipping a long a circle or a polygon. It is used as teeth profile of a gear wheel.

1. Draw Involute of a triangle, Square and pentagon of side25mm.

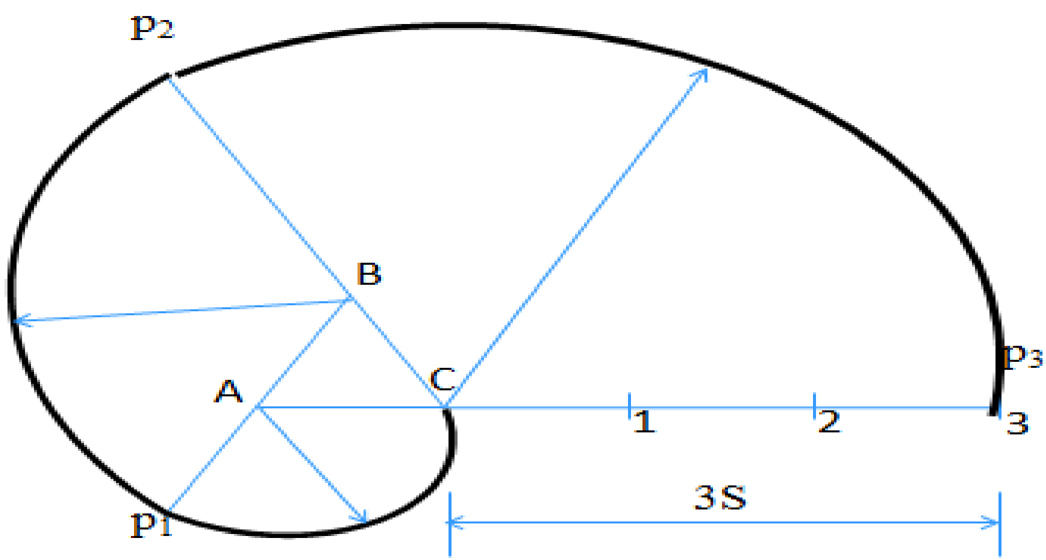


Fig. 26 Triangle

1. Let ABC be the given triangle.
2. With centre A & radius AC, draw an arc to cut the line BA-produce data pointP**1**.
3. With centre B & radius BP**1,** draw an arc to cut the line CB-produce data pointP**2**.
4. Similarly with center C and radius CP**2**, draw arc to cut AC-produced at a point P**3.**The curve thus obtained is the Involute of the triangle.

SQUARE

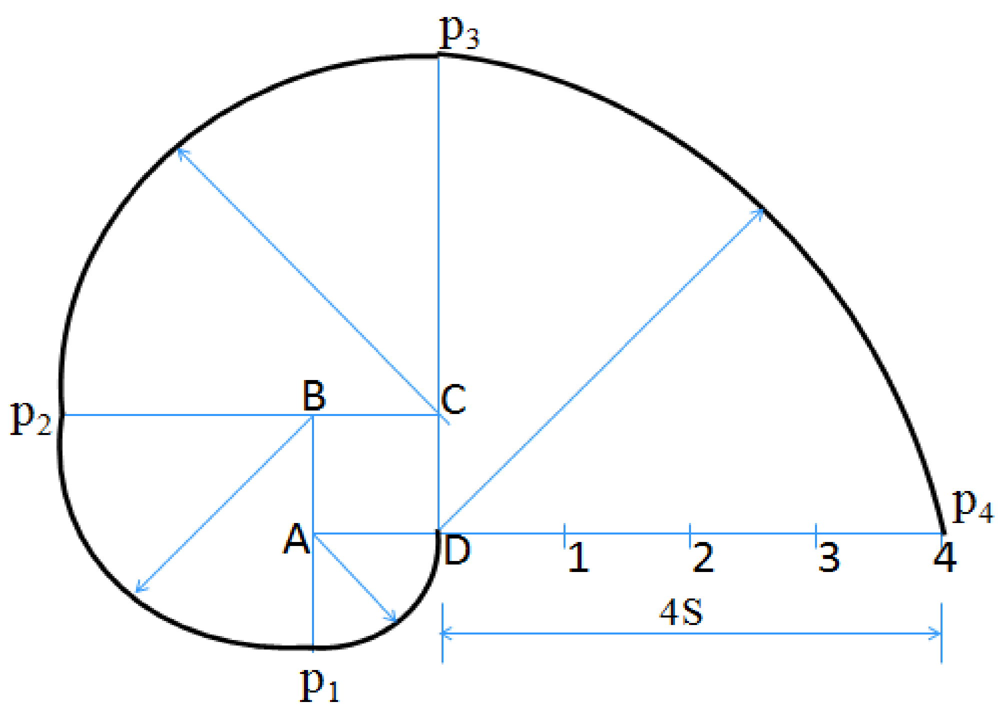


Fig. 27 Involutes of Square

1. Let ABCD be the given square.
2. With centre A & radius AD, draw an arc to cut the line BA-produced at a point P**1**.
3. With centre B & radius BP_1 (i.e.BA+AD) draw an arc to cut the line CB-produced at a pointP**2**.
4. Similarly with centers C & D and radii CP**2** & DP**3**, draw arcs to cut DC-produced at a point P**3** and AD produced at a point P**4**.
5. The curve thus obtained is the Involute of the square.

PENTAGON

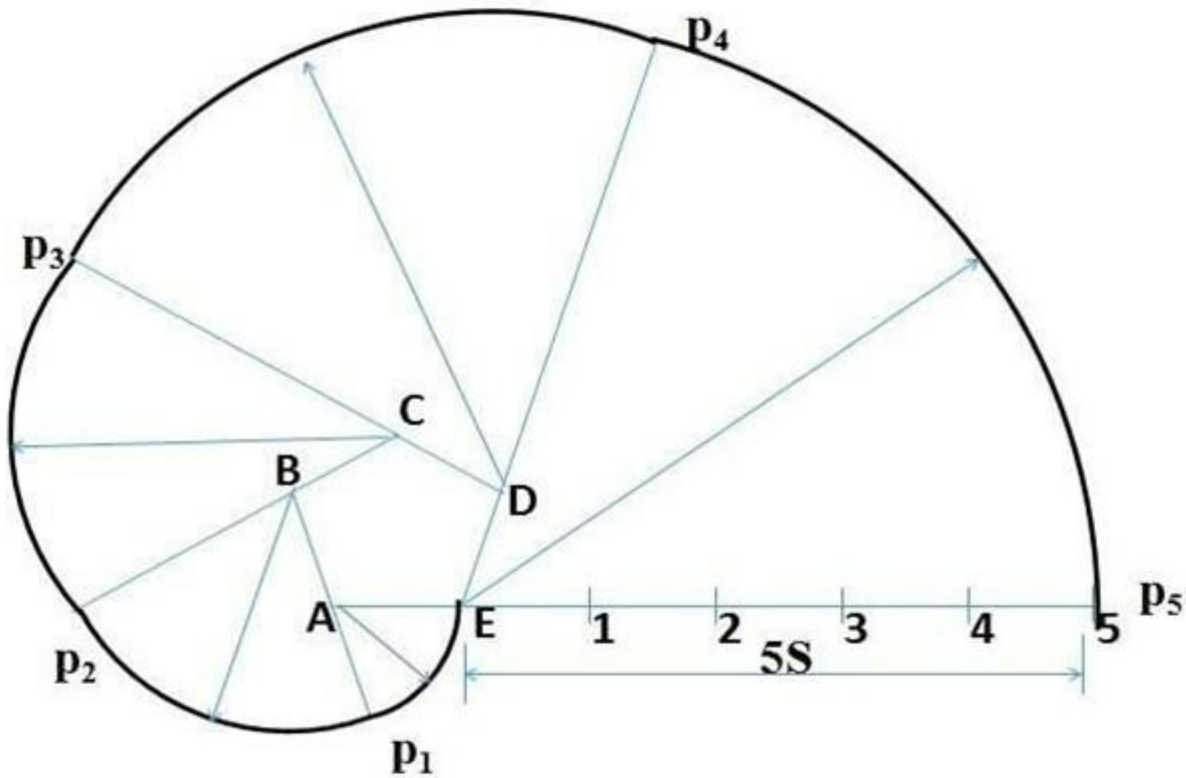


Fig. 28 Involutes of Pentagon

1. Let ABCDE be the given Pentagon.
2. With centre A & radius AE, draw an arc to cut the line BA- produced at a point P**1**.
3. With centre B & radius BP_1 (i.e. BA+AE) draw an arc to cut the line CB-produced at a point P**2**.
4. Similarly with centers C, D & E and radii CP**2,** DP**3** & EP**4**, draw arcs to cut DC-produced at a point P**3**, ED produced at a point P**4**& AE produced at a point P**5**.
5. The curve thus obtained is the Involute of the Pentagon.

CIRCLE

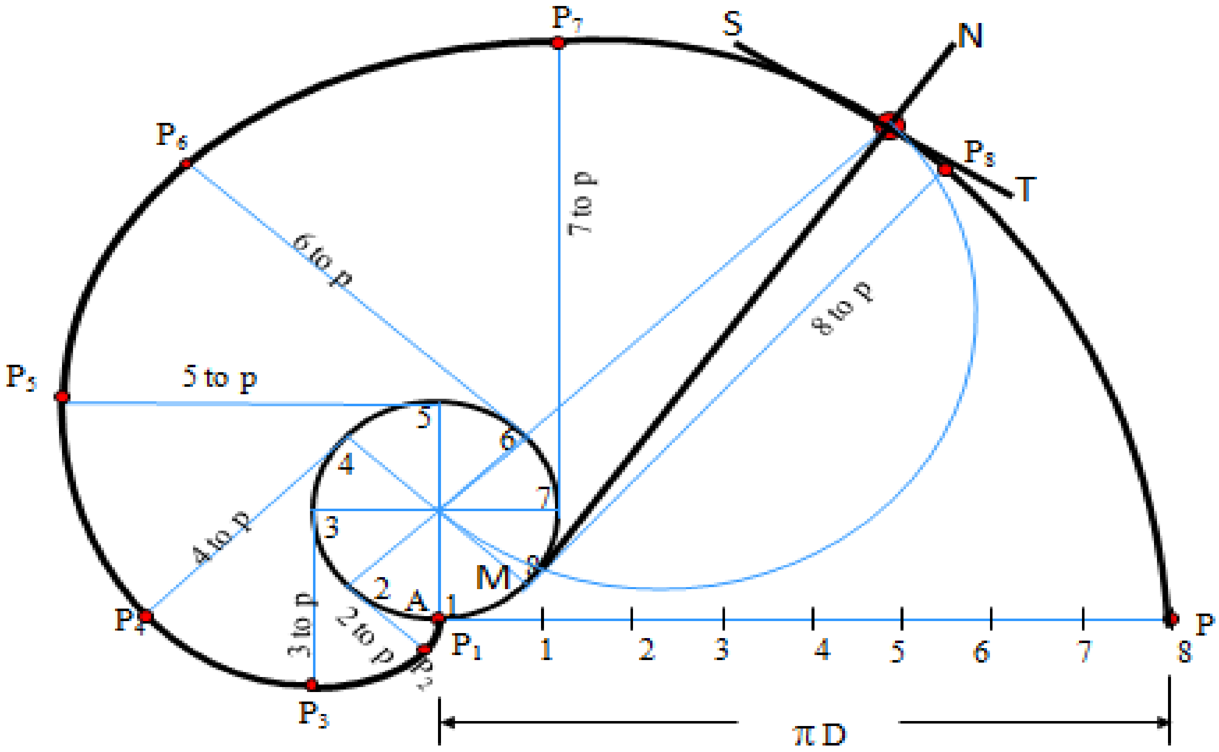


Fig. 29 Involutes of Circle

1. Draw a circle having a 50mm diameter with center ‘c’.
2. Draw a line PQ, tangent to the circle and equal to the circumference of the circle ($\pi D=\pi x50=15.7cm$).
3. Divide the circle and the line PQ into12equal parts.
4. Draw the tangents at points 1,2, 3,_ _,12 (on the circle).
5. Mark the points P**1**,P**2**,P**3**,_ __,P**12**on these tangents such that 1P**1**=P**1**’;2P**2**=P**2**’;3P**3**=P**3**’;_ _ _12P**12**=P**12**’.
6. Draw the curve through the points P**1**,P**2**,P**3**___P**12**.The curve thus obtained is the Involute of the circle.

Normal &tangent to the Involute

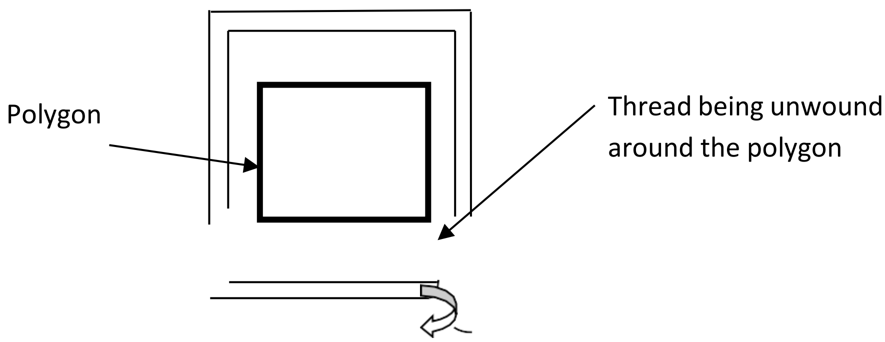
1. Mark a point N on the Involute at 100mm from center ‘C’.
2. Join CN. Mark ‘O’ as its mid point.
3. With ‘O’ as center and ‘ON’ as radius draw a semicircle cutting the circle at point M.
4. Join the points M&N. This line MN is the required normal.
5. Draw a line ST perpendicular to NM & passing through N. The line ST is the required tangent.

Viva Questions

Sheet no: 5 Involutes

6. Define an involute.

A: Involute is defined as the curve traced by the end of a thread as it is unwound around a line, polygon or a circle, the thread being kept tight. Involute is also defined as the curve traced out by a point on a straight line when the line rolls along a circle or a polygon without slipping.



7. Differentiate between a cycloid and an involute

A: A cycloid is a curve in which the circle rolls along a straight line where as an involute is a curve in which the line rolls along the circle or a polygon.

8. What are the applications of involutes and cycloids?

A: Involutes shapes are used as teeth profiles in gears as they give less noise, vibrations, wear and tear. The involute of a circle is also an important shape in gas compressing, as a scroll compressor can be built based on this shape. Scroll compressors make less sound than conventional compressors, and have proven to be quite efficient.

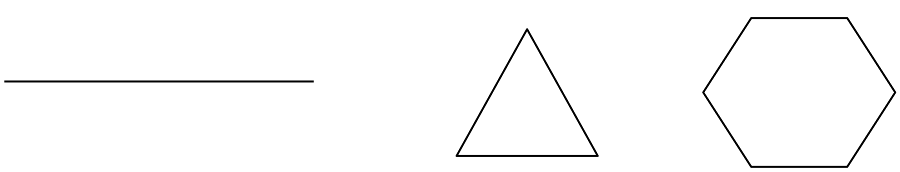
9. What are the applications of cycloidal curves?

A: Cycloidal curves are used in the design of tooth profiles of gears. It is also used in the design of conveyor of mould boxes in foundry shops. Cycloidal curves are also commonly used in kinematics (motion studies) and in mechanisms that work with rolling contact.

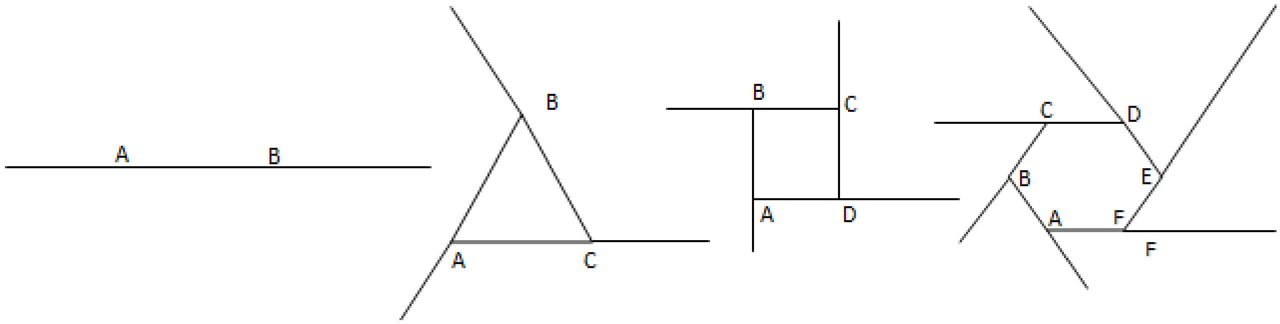
Problems

Common procedure for involutes of lines and polygons:

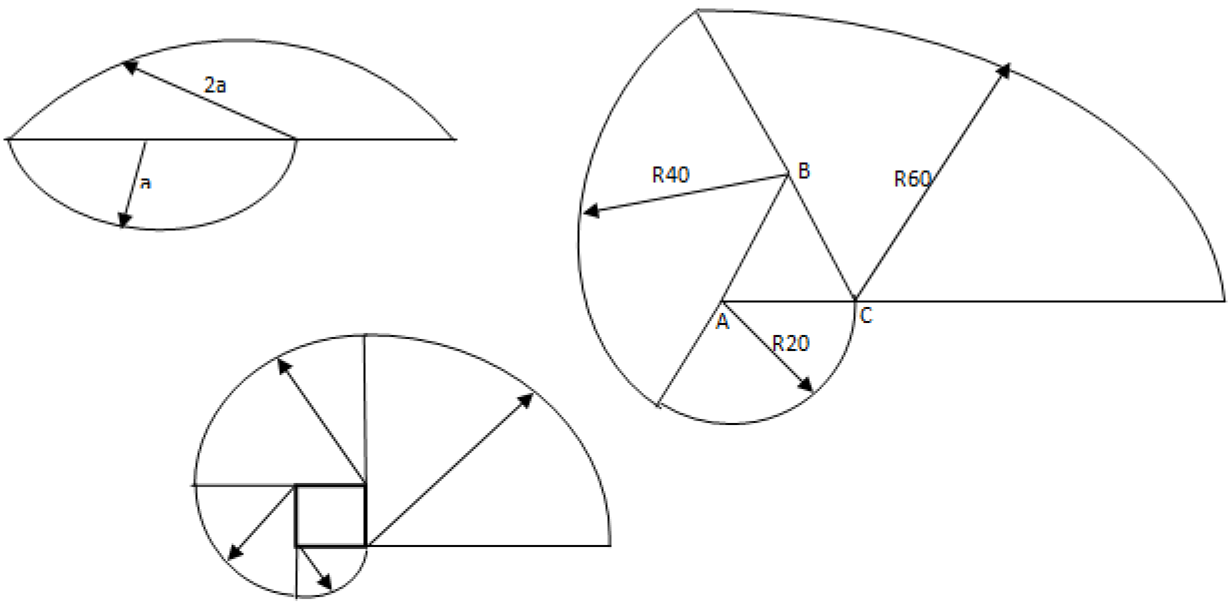
Step1. Draw the required line or polygon of given dimensions and give labelling as A, B, etc starting from the left bottom corner for standard is ation.



Step 2: Draw extension lines on each labelled point in the opposite direction of the next labelling sequence. E.g. On AB, draw extension line in direction of BA, on BC, draw extension line in direction of CB; for CD, draw along DC, etc. This sequence should be followed to have uniformity and avoid confusion.



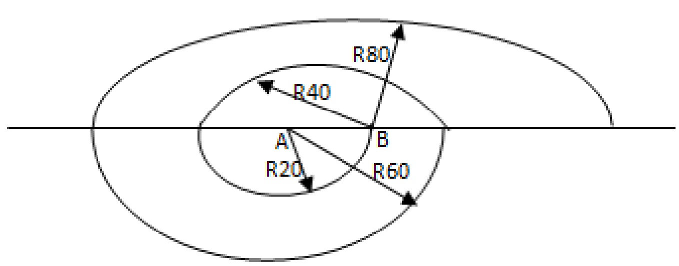
Step 3. Starting from point A, draw arcs of radius = a, 2a, 3a, 4a, etc where a is the length of the line or side of the polygon such that the arcs end on each extensions. Using the steps mentioned above, solve the following problems.



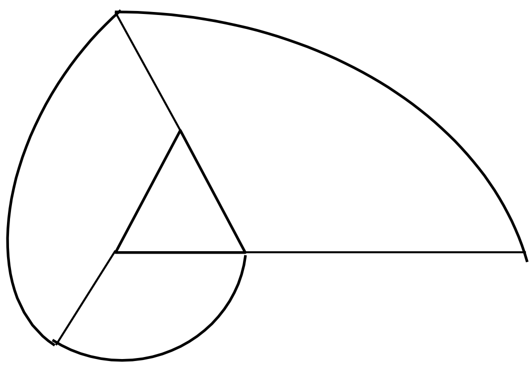
10. Draw an involute of a line of 20 mm for (i) 1 convolution; (ii) 2 convolutions.

A. One convolution for a line means 2 arcs as there are two ends, A and B. R20 and R40 will the radii for completer one convolution. Two convolutions means the involute has to be repeated again from A and B. Length of arcs will be R60 and R 80.

4 convolutions means 4 times involutes have to be drawn. (A,B; A,B; A,B; A,B)



11. Draw an involute of a triangle, square, pentagon and hexagon taking side as 30 mm.

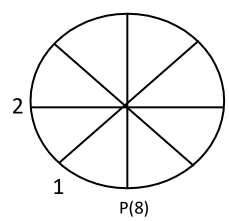


The above figure is the involute of a triangle of sides 30 mm. Similarly, involutes for square, pentagon and hexagon may also be drawn.

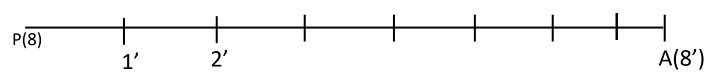
12. Draw an involute of a circle of 40 mm diameter. Also draw a tangent and normal to the involute at 100 mm from the centre of the circle.

A. Steps: (a) To draw the involute of the circle:

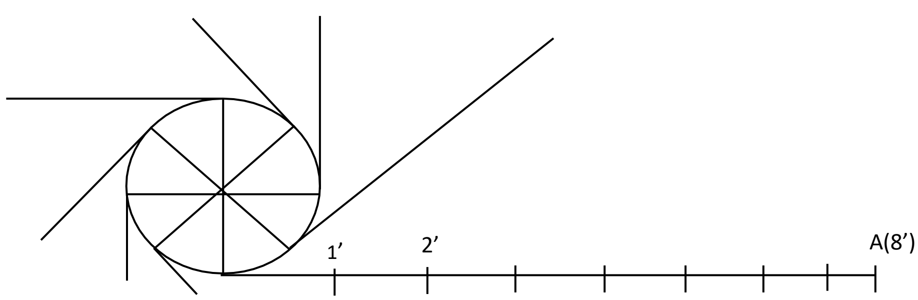
(i) Draw a circle of radius 20 mm, divide it into 8 equal parts (45^0) and label them 1, 2, 3, etc.
Take the bottom most point as P and ensure that labelling is in the anticlockwise direction. P will coincide with



(ii) On P, draw a horizontal line PA (tangent) of length $=2\pi R$ or πD (circumference) and divide this line also into 8 equal parts. Here $L = \pi*40 = 125.6$ mm; Use line division. Label the parts of line as 1’, 2’, 3’, etc.

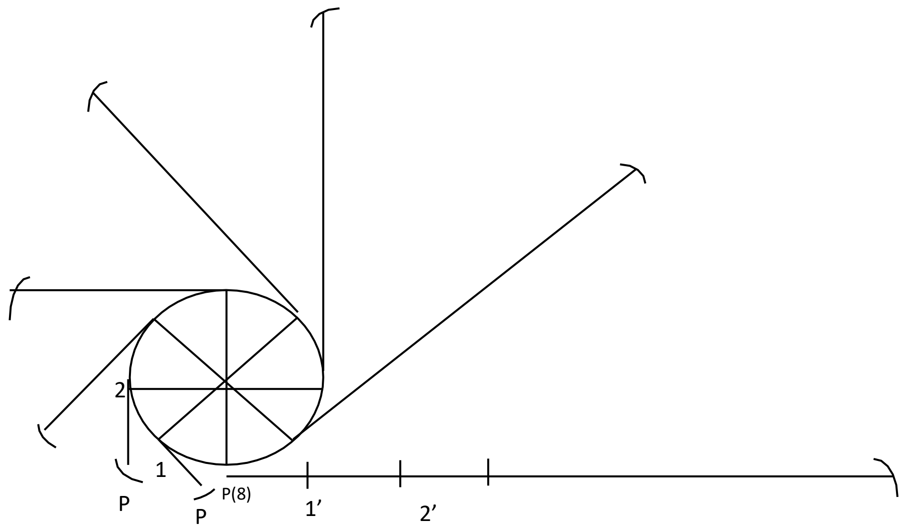


(iii) At points 1, 2, 3, 4, etc on the circle, draw tangents by keeping the drafter perpendicular to C1, C2, C3, etc.

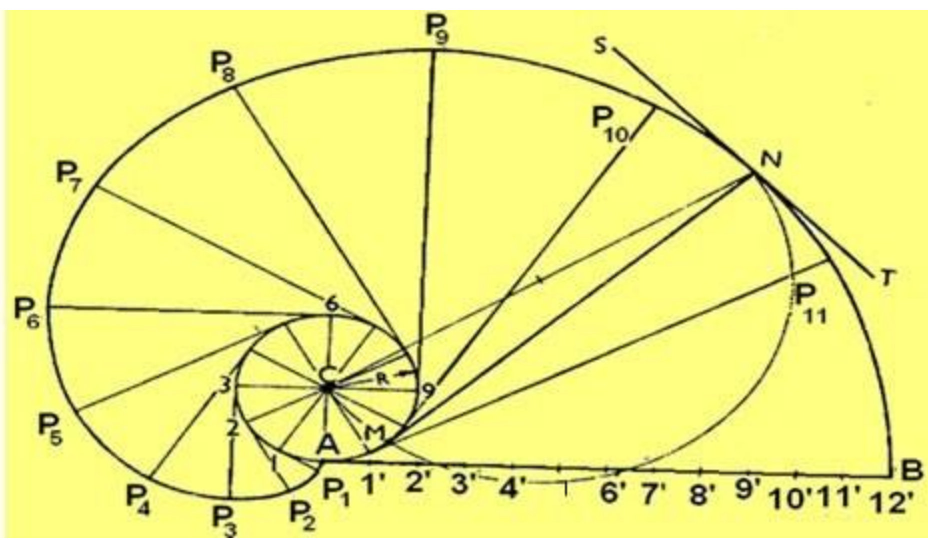


(iv) To get the points of the involute, use the principle, P-1’ = 1-P_1 ; P-2’ = 2-P_2,etc.
Keep 1 as center, radius = P-1’, cut arc on line 1 to get P_1.
Similarly with 2 as center, radius = P-2’, cut arc on line 2 to get P_2. Thus using this principle, cut the other arcs on the tangents to get points P_3, P_4, etc. Last point is PA and need not mark.

(v) Join all the points P_1, P_2, P_3,...A to get the required involute.



(b) To draw tangent and normal to the involute at 100 mm from the centre of the circle:
Steps:
(i) With C as center and radius 100 mm, mark point N on the involute.
(ii) On CN, locate midpoint O and draw a semicircle on CN with OC or ON as radius.
(iii) The point where the semicircle cuts the circle is the point M (starting point of normal) and draw the normal by joining NM.
(iv) Draw the tangent TT' (or ST) perpendicular to NM.



The above figure is for 12 points but 8 parts are sufficient if time is a constraint.

SHEET NO:6

COMPUTER AIDED DRAFTING

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.

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. Colors 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

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 software's are available for drafting

1. AUTOCAD
2. CRO
3. CATIA
4. SOLID WORKS
5. NX Unigraphics
6. FUSION 360
7. INVENTOR
8. SOLID EDGE

The above software's are used depending upon their application

AutoCAD Installation Process

1. Go to the following website: https://www.autodesk.com/education/free-software/all
2. Click AutoCAD
3. Create your login account using the MRU mail id. xyz@mru.ac.in (you can access thesoftware for 3 Years).
4. After you create your account, sign in and choose
   a. Version: AutoCAD 2020
   b. Operating System: 32 or 64 bit
      (To find the information, Right click on My Computer or My PC and select properties.)
   c. Language: English (so you can have more effective technical support)
5. Serial number and Product key will be displayed. This information is required at the time ofactivation after installing the software.
6. Download can be carried in two ways:
   a. Download Now (Recommended)
   b. Browser Download
7. After downloading the file, double click on the installation file, and then click Yes to complete the installation.
8. Now click on Install
9. Check the box I accept the click next
10. For the standalone License type default option, enter the serial key & product key detailsfound on the software database for this software version.
11. Click Install and the Click Finish to complete the installation.

System Requirements

- Operating System : 32 or 64-bit Microsoft Windows/ XP-professional/vista or more
- Processor : Pentium 4 or later
- RAM : 4GB or more
- Graphics Card : 1GB or more/ integrated graphics
- Hard Disk : 20GB free hard disk space available including installation
- Pointing devices : Mouse, digitizer with win tab drive, Keyboard
- DVD ROM : Any Speed (not mandatory)

Function Keys

The keyboard function keys F1-F12 control settings that are commonly turned on and off as we work in the product.

Key	Feature Description
F1	Help Displays Help for the active tooltip, command, Palette or dialog box.
F2	Expanded History Displays an expanded command history in the Command window
F3	Object Snap Turns object snap ON and OFF
F4	3D Object Snap Turns additional object snaps for 3D ON and OFF
F5	Isoplane Cycles through 2D isoplane settings (Top, Right and Left)
F6	Dynamic UCS Turns automatic UCS alignment with planar surfaces ON and OFF
F7	Grid display Turns the grid display ON and OFF
F8	Ortho Locks cursor movement to horizontal or vertical
F9	Grid Snap Restricts cursor movement to specified grid intervals
F10	Polar Tracking Guides cursor movement to specified angles
F11	Object Snap Tracking Tracks the cursor horizontally and vertically from object snap locations
F12	Dynamic input Displays distances and angles near the cursor and accepts input as we use Tab between fields

Note: F8 and F10 are mutually exclusive -turning one On will turn the other OFF

User Interface

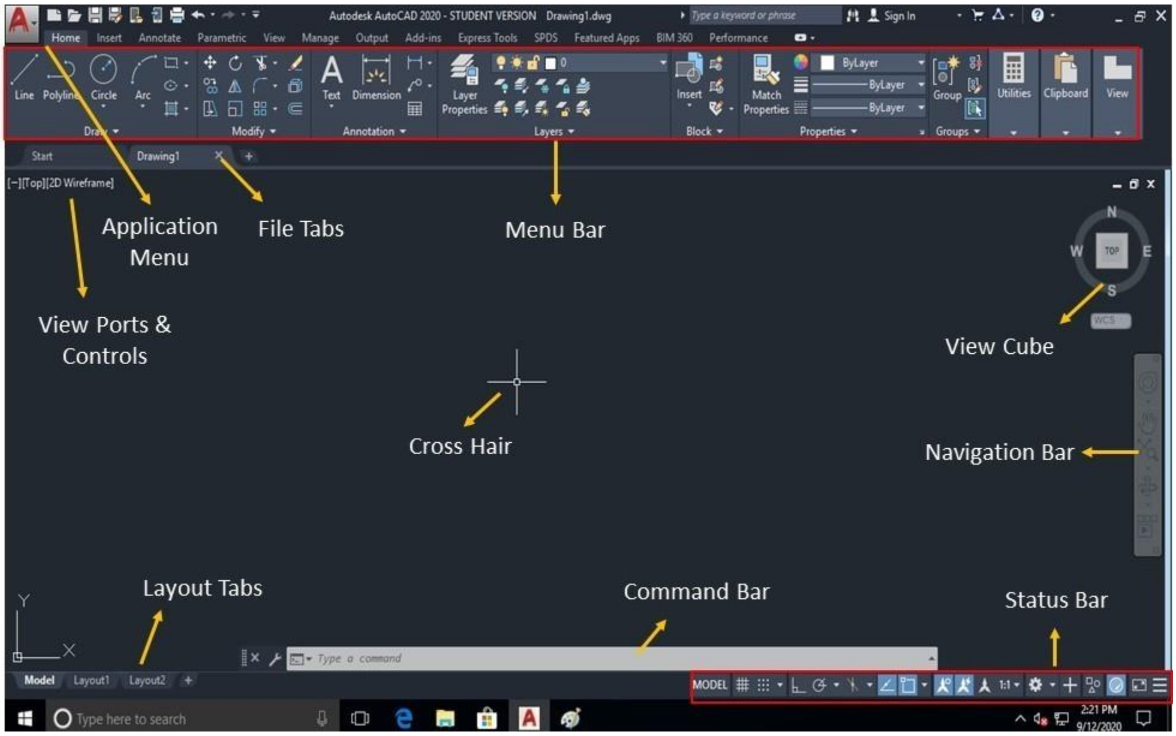


Fig. 30 User Interface

Application Menu 

Menus are available through the application button in the upper left corner of the drawing window. This menu contains the commands used to create, save, print, and manage your drawing

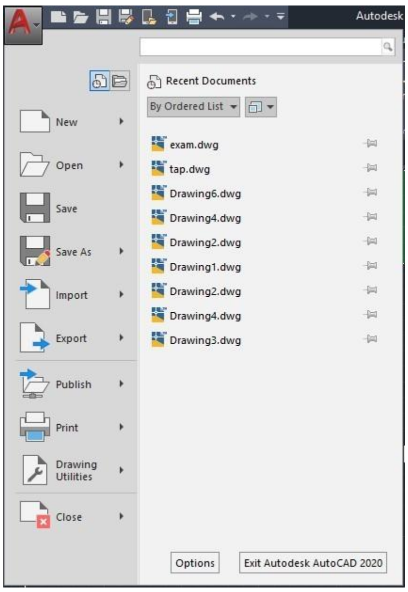


Fig. 31 Application Menu

Command prompt

The rectangular horizontal window at lower side of the screen is called the command area. The instructions given to the computer through keyboard is shown in this area. It important to read the command prompt when working with an unfamiliar command.

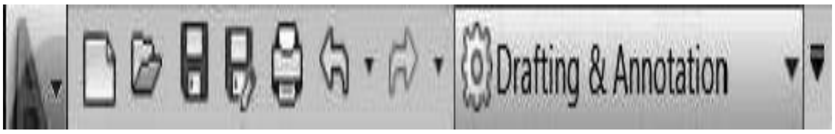
To enter a command using the keyboard, type the command name on the command line and press Enter or the Spacebar.

Navigation Bar

The navigation bar is a user interface element where you can access both unified and product-Specific navigation tools. Unified navigation tools are those that can be found across many Autodesk products. Product-specific navigation tools are unique to a product.

Quick access toolbar

The Quick Access toolbar, displayed in the Drafting & Annotation workspace, is located at the very top of the drawing window next to the Application button. The Quick Access toolbar may be customized by adding or removing commands. This is done by right clicking on the toolbar and selecting Customize Quick Access toolbar or selecting the arrow at the end of the toolbar.



The Quick Access toolbar contains the following commands:

- QNew: Opens a new drawing.
- Open: Opens an existing drawing. (Ctrl+O)
- Save: Saves the current drawing. (Ctrl+S)
- Save as: Allows you to save the current drawing under a different name. (Ctrl+Shift+S)
- Plot: Plots or prints the current drawing. (Ctrl+P)
- Undo: Used to undo previous command or actions.
- Redo: Used to redo commands that have been undone.

Drawing area & Cross Hair

The rectangular large space between the pull-down menu bar and the command window is the drawing area. The cursor moves in this area in the form of a cross hair as mouse is moved by the user. The cross hair position is indicated by coordinate values shown at the left end of the status bar.

View Cube

The View Cube is a navigation tool that allows you to switch between viewing directions. While this is very useful in 3D space, it is not very useful in 2D space. It is located in the upper right corner of the drawing area.

Status bar

The status bar displays the cursor location, drawing tools, and the tools that affect the drawing environment. It also provides quick access to some of the most commonly used drawing tools, Coordinates of the cross hair (Cursor) and we can toggle the settings such ads grid, snap, polar tracking and object snap.

Fig. 32 Status bar

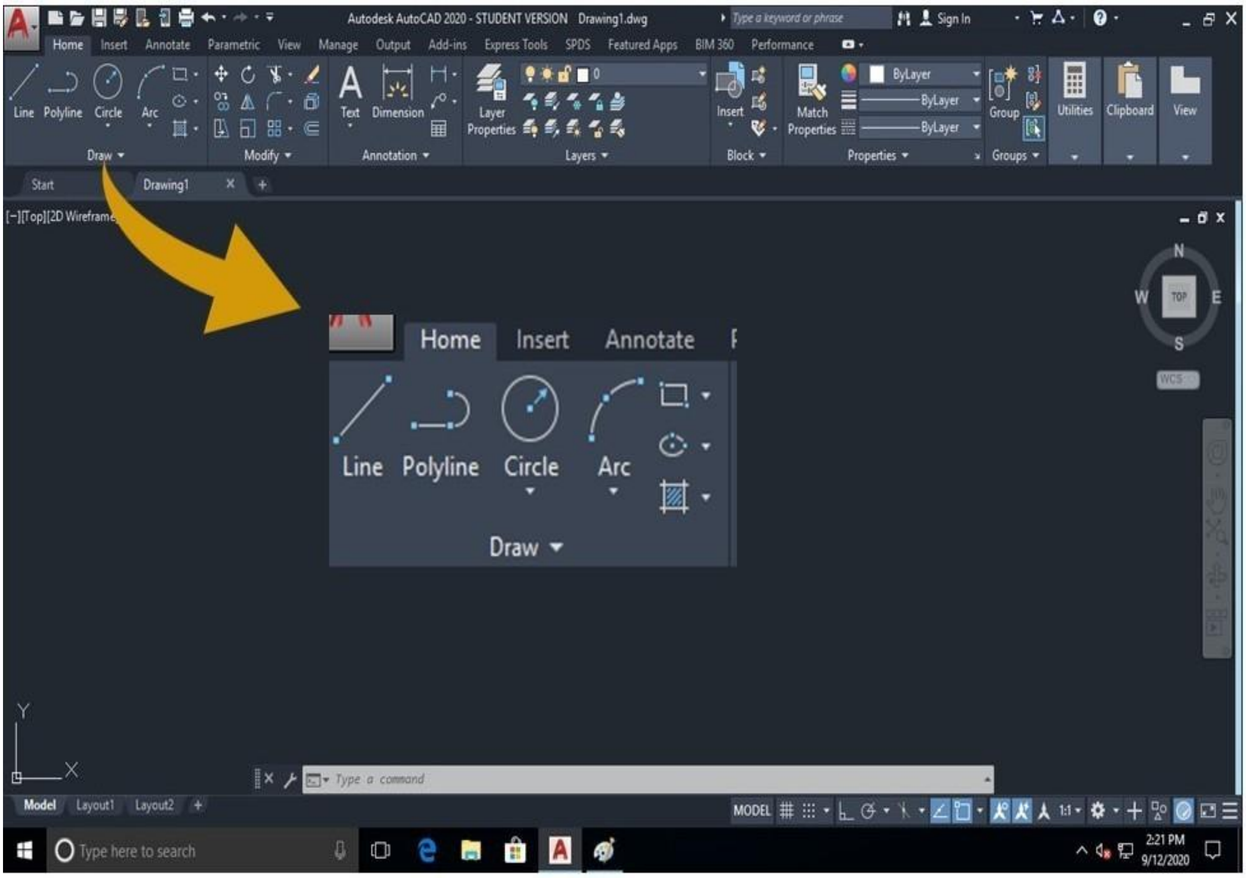


Fig. 33 Draw Commands

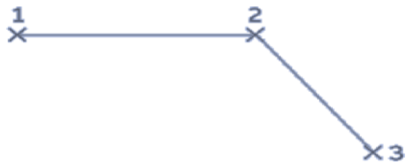
1. Point:

The Point command will insert a point marker in your drawing at a position which you pickor at any coordinate location which you enter in the Command window. Other ways of defining a point can be accessed through the fly-out menu. The default point style is a simple dot, which is often difficult to see but you can change the point style to something moreeasily visible or elaborate using the point style dialogue box.

Tool Bar: Menu → Draw → Point	**Command**: Point(PO)

2. **Line:**

Creates a straight line segment. It is used to draw lines continuously. Each segment is a line object that can be edited separately.



Continue: Continues a line from the endpoint of the most recently drawn line.
Close: End the line segment at the beginning of the first line segment, which forms a closed loop of line segment.
Undo: Erases the most recent segment of a line sequence.

Tool Bar: Menu → Draw → Line	**Command**: Line (L)

3. **Construction Line (XL):**

The construction line (XLINE) command creates a line of infinite through two picked points. Construction lines are very useful for length which passes creating construction Frame works or grids. Construction lines are not normally used as objects in finished drawings. Therefore, it is usual to draw all your construction lines on a separate layer which will be turned off or frozen prior to printing.

Construction line options

- **Hor:** Creates a horizontal construction line.
- **Ver:** Creates a vertical construction line.
- **Ang:** Creates a construction line at a specified angle.
- **Bisect:** Create a construction line that bisects an angle defined by 3 points.
- **Offset:** Creates a construction line that is offset from an existing line by a specified distance.

Tool Bar: Menu → Draw → Xline	**Command**: Xline (xl)

4. **Polyline (Pline):**

The PLINE command differs from the LINE command in that the segments of the PLINE are connected. When using the LINE command, each segment is its own object. When using PLINE, all line segments are one object.

Tool Bar**: Menu → Draw → Polyline**	Command**: Pline (PL)**

5. **Polygon**

A polygon of sides ranging from 3 to any number can be drawn using Polygon command. Itcreates an equilateral closed polyline.

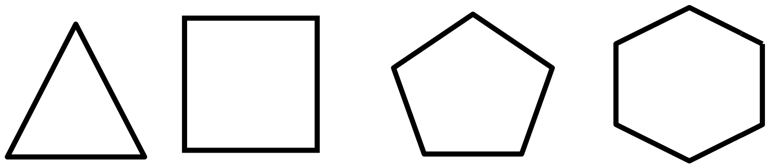


Fig. 34 Polygon Shapes

Centre of Polygon: Defines the center of the polygon.

Inscribed in Circle: Specifies the radius of a circle on which all vertices of the polygon line.
Circumscribe about circle: Specifies the distance from the centre of the polygon to the midpoints of the edges of the polygons.

Edge: Defines a polygon by specifying the endpoints of the first edge.

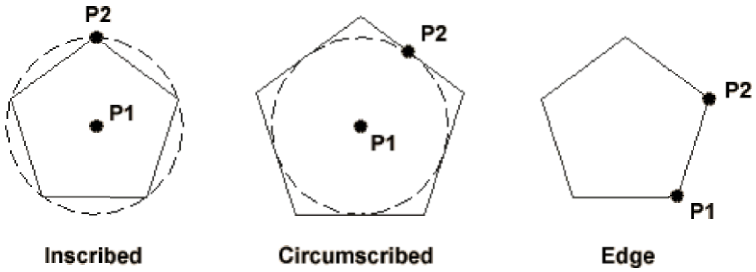


Fig. 35 Centre of Polygon

Specifying the radius with your pointing device determines the rotation and size of the polygon. Specifying the radius with a value draws the bottom edge of the polygon at the current snap rotation angle.

Tool Bar: **Menu → Draw → Polygon**	Command: **Polygon**

6. Arc

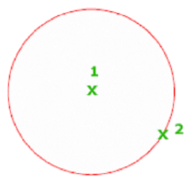
This command is used to draw an arc accurately. To create an arc, a combination of centre, endpoint, start point, radius, angle, chord length, and direction values can be specified. Arcs are drawn in a counter clockwise direction by default.
Start Point: Draws an arc

Tool Bar: **Menu → Draw → Arc**	Command: **Arc**

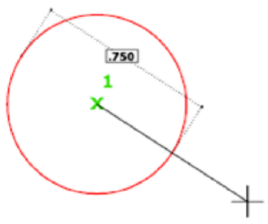
7. Circle

There are many ways to draw a circle, the default being the centre point of circle and radius.Below are the possible ways of drawing the circle.

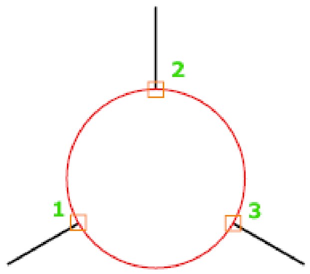
i. **Centre point and Radius:** Defines the radius of the circle.



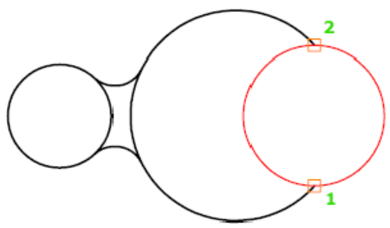
ii. **Centre point and Diameter:** Defines the diameter of the circle.



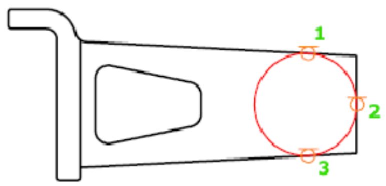
iii. **3P (Three Points):** Draws a circle based on three points on circumference.



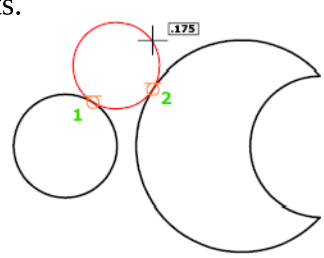
iv. **2P (Two Points):** Draws a circle based on two endpoints of the diameter.



v. **Tan, Tan, Tan**: Creates a circle tangent to three objects.



vi. **Tan, Tan, Radius:** Creates a circle with a specified radius and tangent to two objects. Sometimes more than one circle matches the specified criteria. The program draws the circle of the specified radius whose tangent points are closest to the selected points.



1. Ellipse

Tool Bar: **Menu → Draw →Circle**	Command: **Circle (C)**

The Ellipse command gives you a number of different creation options. The default option is to pick the two end points of an axis and then a third point to define the eccentricity of the ellipse.

Tool Bar: **Menu → Draw →Ellipse**	Command**: Ellipse (E)**

2. Donut

The DONUT is a special type of polyline which is made up of arc segments. A DONUT has two properties: it has width, and it is closed. The width of DONUT is set by specifying inside and outside diameters. The inside diameter may be zero thereby making it a filled circle.

3. Hatch patterns

The HATCH command is used to fill up the area using a suitable pattern. The type of pattern and pattern variables can be chosen from a library of patterns available. The hatching will be carried out inside a closed defined area.

Tool Bar: **Menu → Draw →Hatch**	Command**: Hatch (H)**

4. Text

Words, messages and numbers can be inserted as required on an engineering drawing. The alphanumeric keyboard is used extensively for non-graphical input such as text. The text style, height, text angle, aspect ratio, color, etc. are some of the attributes associated with text. These attributes can be changed as per requirements.

5. Rectangle

Creates a rectangular polyline. With this command, the parameters (length, width, rotation)can be specified control the type of corners (fillet, chamfer, and square).

Tool Bar: **Menu → Draw → Rectangle**	Command**: Rectang (R)**

Drafting Aids

1. Limits

Drawing limits are used to set the boundaries of the drawing. The drawing boundaries are usually set to match the size of a sheet of drawing paper. This means that when the drawingis plotted and a hard copy is made, it will fit on the drawing paper.

Fig : Page 67 : Engineering Graphics with AutoCAD 2020

Command: Limits
  Specify lower left corner or [ON/OFF] <0,0>: Specify a point
  Specify upper right corner or <12,9>: Specify a point
Note: Limits has no limit, it can be infinity with respect to paper size.

2. Layers

A layer is like a clear piece of paper that can be laid directly over the drawing. We can draw on the layer and see through it to the original drawing. Layers can be made invisible, and information can be transferred between layers. Layers are used to control the visibility of objects and to assign properties such as color and line type. Objects on a layer normally assume the properties of that layer.

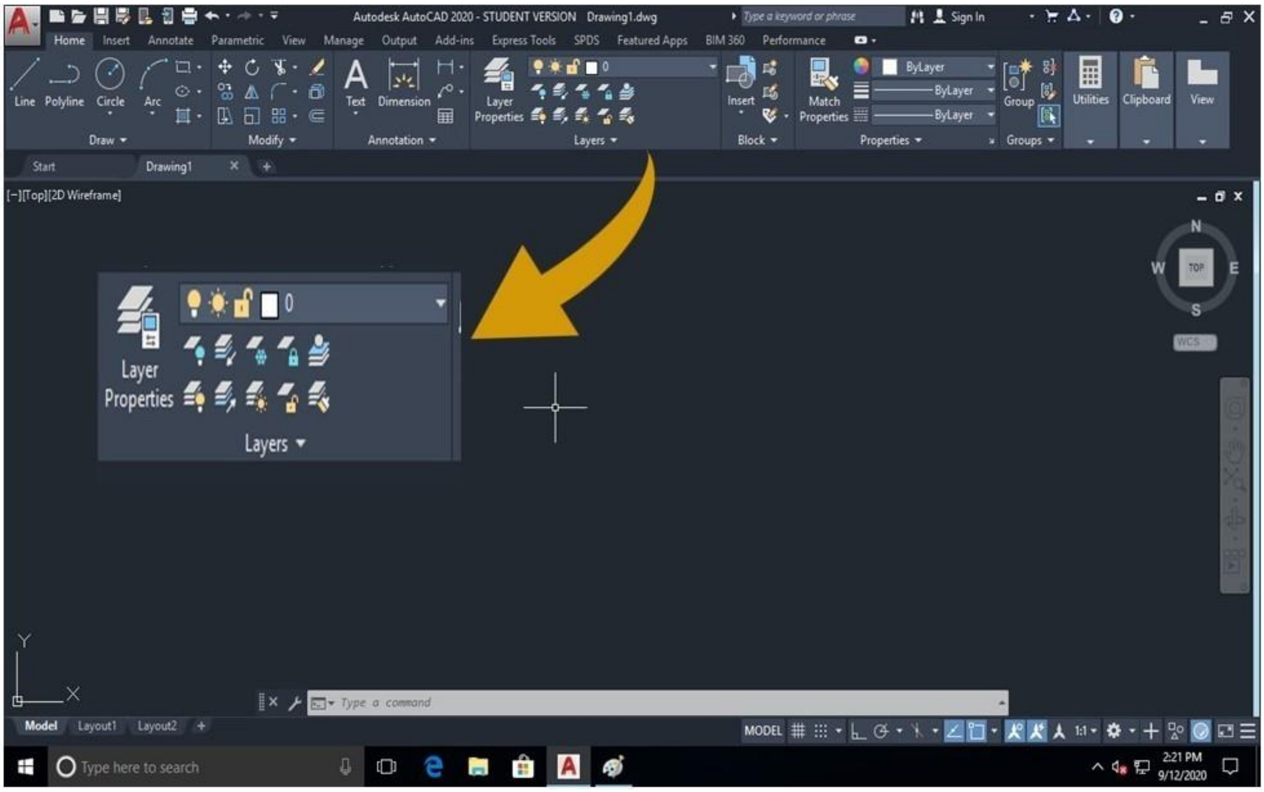
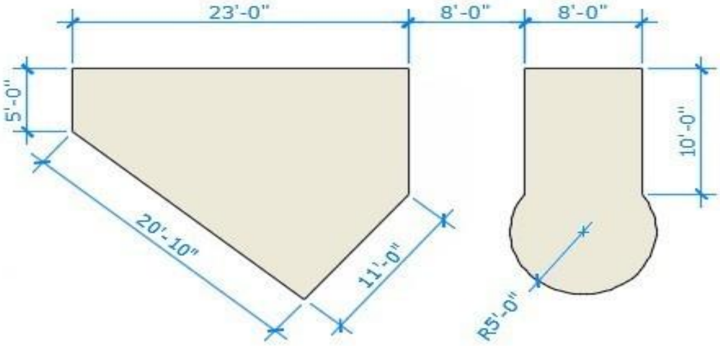


Fig. 36 Layers

3. **Dimensioning**

   Create several types of dimensions and save dimension settings by name.



Linear Dimensions

Horizontal, vertical, aligned, and radial dimensions can be created with the DIM command. The type of dimension depends on the object that is selected and the direction of dimension line.

Dimension Styles

Dimension styles help establish and enforce drafting standards. There are many dimension variables that can be set with the DIMSTYLE command to control virtually every nuance of the default dimension style is named either Standard (imperial) or ISO-25 (metric). It is assigned to all dimensions until you set another style as the current dimension style. The current dimension style name, Hitchhiker in this case, is displayed in the drop-down list ofthe Annotation panel.

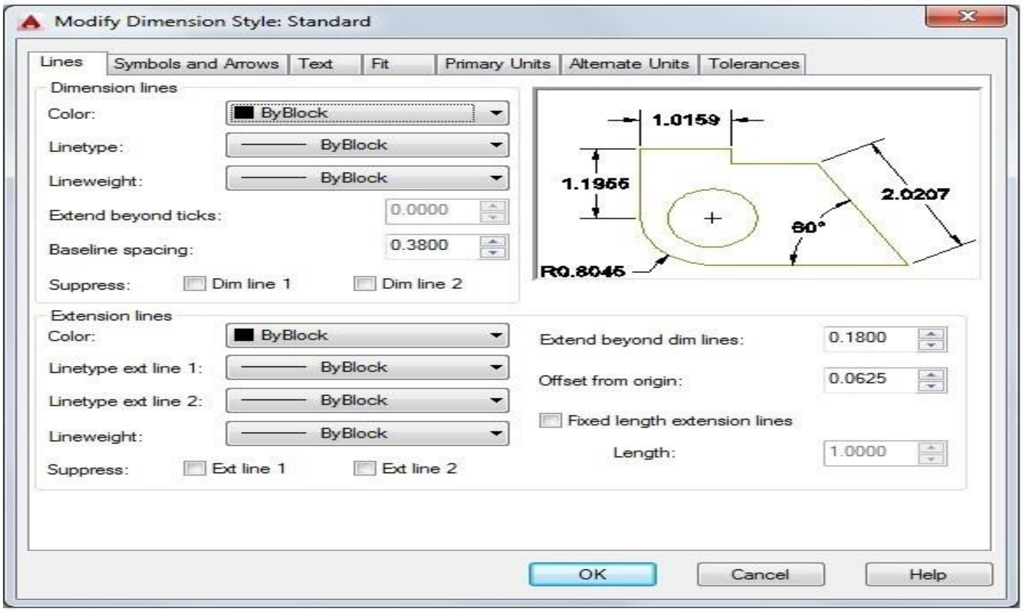


Fig. 37 Dimension Style

4. **Object snap**

Object snap provide a way to specify precise locations on objects whenever you are prompted for a point within a command. With running object snap(Osnap) settings, a snap point at an exact location on an object can be specified. When more than one option is selected, the selected snap modes are applied to return a point closest to the center of the aperture box.

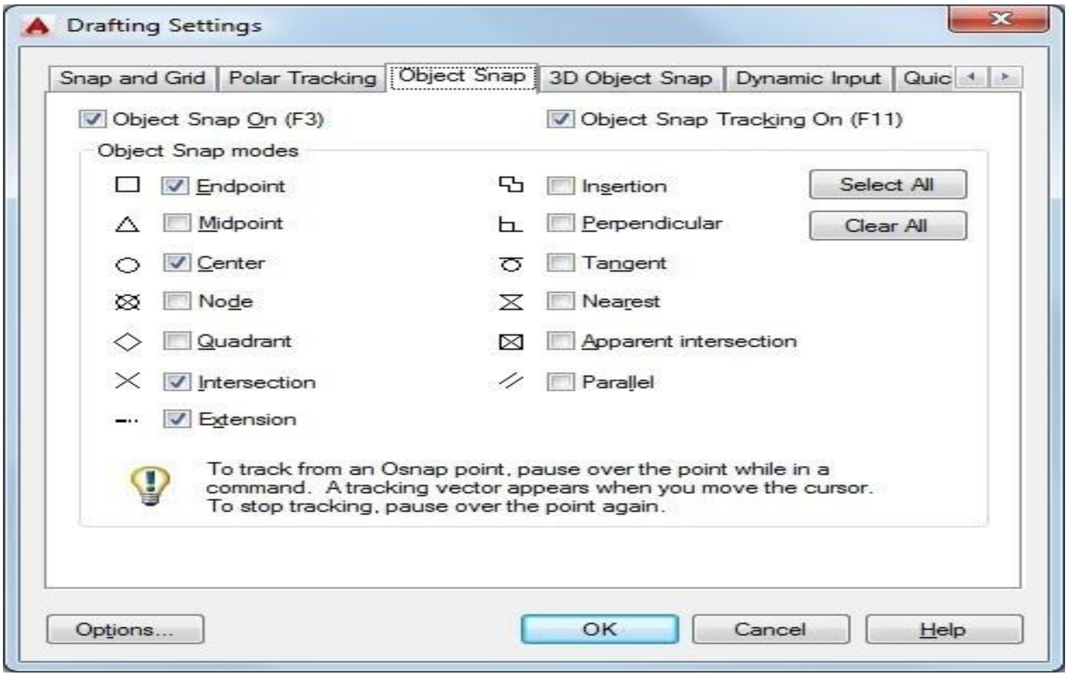


Fig. 38 Object snap Setting

Object Snap ON (F3)

Turns running object snaps ON and OFF. The object snaps selected under Object SnapModes are active while the Snap mode in ON.

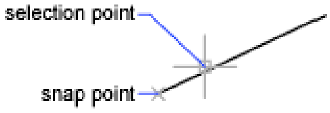
Object Snap Tracking On (F11)

Turns object snap tracking ON and OFF. With object snap tracking, the cursor can track along alignment paths based on other object snap points when specifying points in a command.

Object Snap Modes:

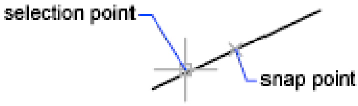
End Point

Snaps to the closest endpoint of an arc, elliptical arc, line, multiline, polyline segment, spline,region or to the closest corner of a trace. Solid or 3D face.



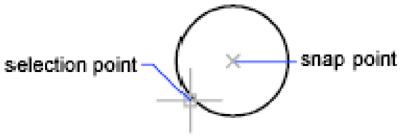
Midpoint

Snaps to the midpoint of an arc, ellipse, elliptical arc, line, multiline, polyline segment,region, solid, spline or xline.



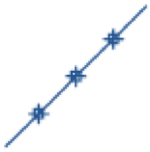
Center

Snaps to the center of an arc, circle, ellipse, or elliptical arc.

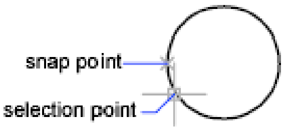


Node

Snaps to a point object, dimension definition point, or dimension text origin.



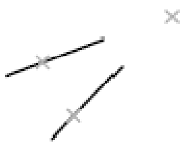
Quadrant



Snaps to a quadrant point of an arc, circle, ellipse, or elliptical arc.

Intersection

Snaps to the intersection of an arc, circle, ellipse, line, multiline, polyline, spline, or xline and other geometrical objects. Extended intersections are not available as a running object snap.



Extension

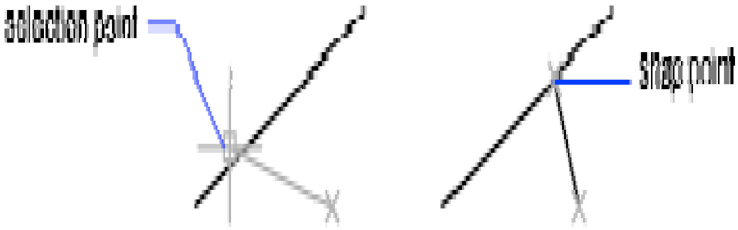
It causes a temporary extension line or arc to be displayed when the cursor is passed over the endpoint of objects, so that points can be specified on the extension

Insertion

Snaps to the insertion point of an attribute, a block, a shape, or text.

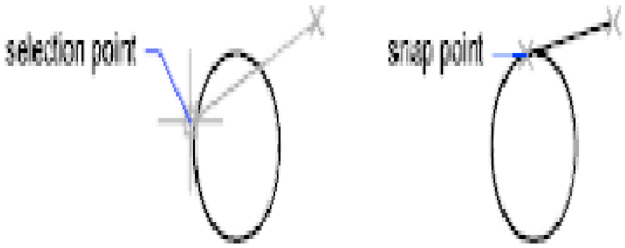
Perpendicular

Snaps to a point perpendicular to the selected geometric object. Deferred Perpendicular snap mode is automatically turned on when the object you are drawing requires that more than one perpendicular snap can be completed. An object such asa line, arc, circle, polyline, ray, xline, multiline, or 3D solid edge as an object from which to draw a perpendicular line can be used



Tangent

Snaps to the tangent of an arc, circle, ellipse, elliptical arc, polyline arc, or spline. DeferredTangent snap mode is automatically turned on when the object that is being drawn requires and complete more than one tangent snap. It can be used to draw a line or xline that is tangent to arcs, polyline arcs, or circles. When the cursor passes over a Deferred Tangent snap point, a marker and an Auto Snap tooltip are displayed.



Apparent Intersection

Snaps to the visual inter s ection of two objects that do not intersect in 3D space but may appear to intersect in the current view.

Nearest

Snaps to the nearest point on an arc, circle, ellipse, elliptical arc, line, multiline, point,polyline, ray, spline or xline.

Parallel

Constraints a line segment, polyline segment, ray or xline to be parallel to another linear object. The parallel object snap is to be specified, after specifying the first point of a linear object. Unlike other object snap modes, the cursor must be moved and hover over another linear object until the angle is acquired. Then, move the cursor back toward the object that is to be created. When the path of the object is parallel to the previous linear object, an alignment path is displayed, which you can use to create the parallel object.

Select All

Turns on all running object snap modes.

Clear All

Turns off all running object snap modes.

Zoom

The objects viewed in the drawing area can be zoomed in or out, and moved to see different portions of the sheet in detail by using the following commands:

The zoom fly out of standard tool bars has nine icons to opt.

a) Zoom window: This command enlarges a rectangular area of a drawing based on adefined window using the cross hair
b) Zoom all: This command displays the are of the drawing limits or extent whichever are greater.
c) Zoom dynamic: Pans and zooms using a rectangular view box.
d) Zoom scale: Zooms to change the magnification of a view using a scale factor.
e) Zoom center: Zooms to display a view defined by a center point and a magnification value or a height.
f) Zoom Object: Zooms to display one or more selected objects as large as possible and in the center of the view.
g) Real Time: Zooms interactively to change the magnification of the view.
h) Zoom extends: Zooms to display the maximum extents of all objects.
i) Zoom Previous: Zooms to display the previous view. You can restore up to 10 previous views.

Out of these "Zoom window" and "Zoom all" command are more useful. Similarly, "Zoom real time", "Pan real time" and "Zoom previous" commands are also frequently applied for drafting.

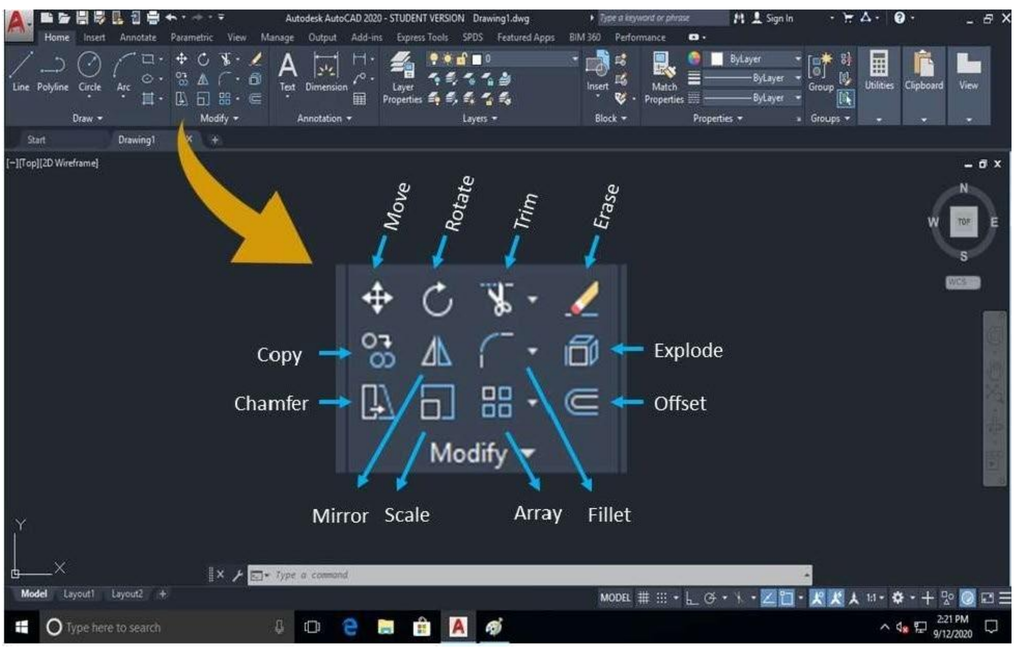


Fig. 39 Editing Commands (Modify Commands)

Editing Commands (Modify Commands):

1. **Move**

The Move command works in a similar way to the COPY command except that no copy is made; the selected object(s) is simply moved from one location to another

Tool Bar: **Menu Modify→**	Command**: explode**

2. Rotate

The Rotate command allows an object or objects to be rotated about a base point selected and the angle can be typed in the command prompt by the user.

Tool Bar: **Menu** **Modify→**	Command: **explode**

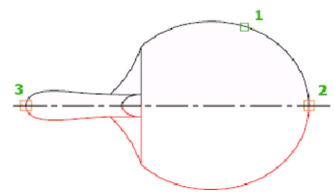
3. Copy

The Copy command can be used to create one or more duplicates of any object(s) which have been previously created.

Tool Bar: **Menu** **Modify→**	Command: **explode**

4. Mirror

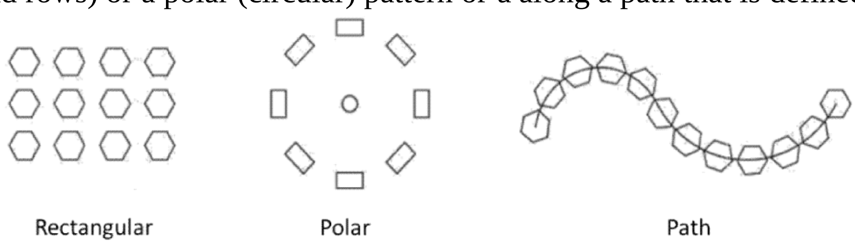
The Mirror command allows you to mirror selected objects in your drawing by picking them and then defining the position of an imaginary mirror line using two points. To create perfectly horizontal or vertical mirror lines turn the ORTHO command on.



Tool Bar: **Menu** **Modify→**	Command: **explode**

5. Array

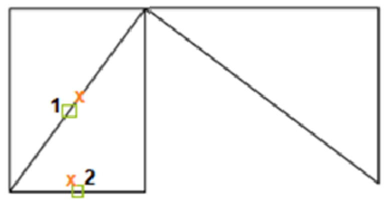
The Array command makes multiple copies of a selected objects in a rectangular pattern (columns and rows) or a polar (circular) pattern or a along a path that is defined.



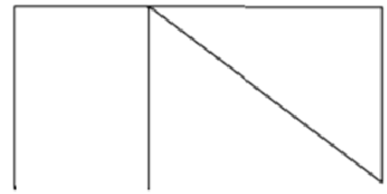
Tool Bar: **Menu** **Modify→**	Command: **explode**

6. Erase

The Erase command is one of the simplest AutoCAD commands and is one of the most used. The command erases or deletes any selected object(s) from the drawing.



Selected lines before erasing

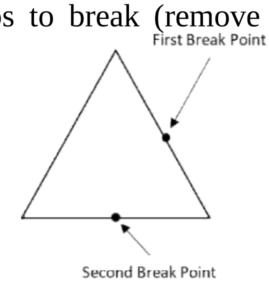


Removed lines after erasing

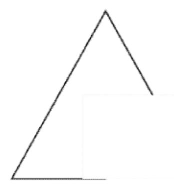
Tool Bar: **Menu** **Modify→**	Command: **explode**

7. Break

The Break command helps to break (remove a part of) an objectpoints by defining two break



Before Break

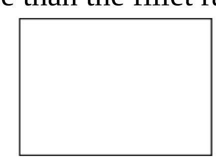


After Break

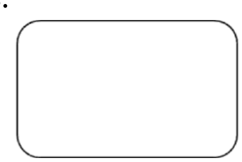
Tool Bar: **Menu** **Modify→**	Command: **explode**

8. Fillet

The Fillet command is a very useful tool which allows to draw a tangent arc between two objects. The objects are usually intersecting. The objects do not have to intersect, but their separation cannot be more than the fillet radius.



Without Fillet



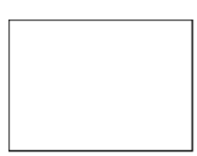
Filleted Object

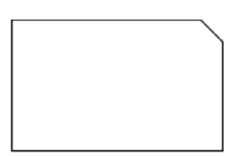
Tool Bar: **Menu** → **Modify→**	Command: **explode**

9. Chamfer

The Chamfer command creates an angled corner (Chamfer) between any two non-parallel lines or any two adjacent polyline segments. A chamfer is usually applied to intersecting lines.

10. Extend.

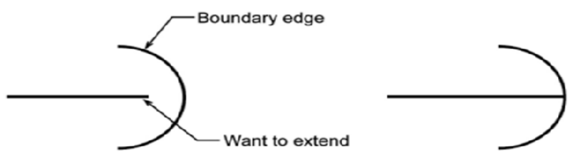




Chamfered Object

Tool Bar: **Menu → Modify→ Fillet →**	Command: **explode**

The Extend command is used to extend a line, polyline or arc to meet an already existing object

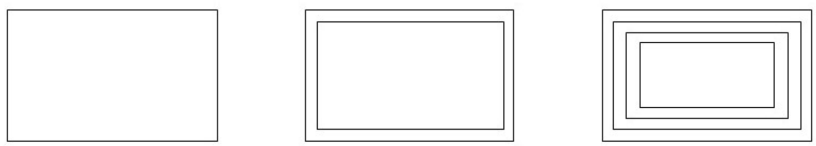


Before Extending After Extending

Tool Bar: **Menu → Modify→**	Command**: explode**

11. Offset

The OFFSET command creates a new object parallel to or concentric with a selected object. The new object is drawn at a user defined distance (the offset) from the original and in a direction chosen. The OFFSET command may only be used on one object or entity at a time.

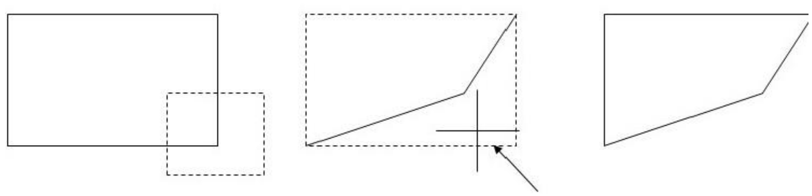


Original Object Single Offset Multiple offset

Tool Bar: **Menu → Modify→**	Command**: explode**

12. Stretch

The STRETCH command can be used to move one or more vertices of an object while leaving the rest of the object unchanged

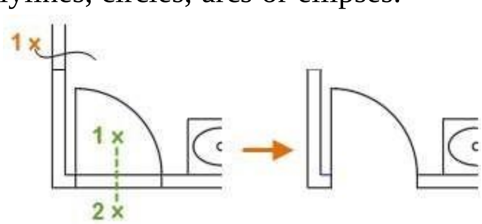


Select Vertex Move the Vertex Final Shape

Tool Bar: **Menu → Modify→**	Command**: explode**

13. Trim

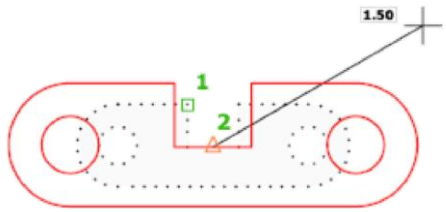
The Trim command is used to trim off the part of an object that is not necessary. In order to trim an object, a second object which forms the cutting edge must be drawn. Cutting edges can be lines, xlines, rays, polylines, circles, arcs or ellipses.

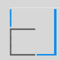


Tool Bar: **Menu → Modify→**	Command**: explode**

14. Scale

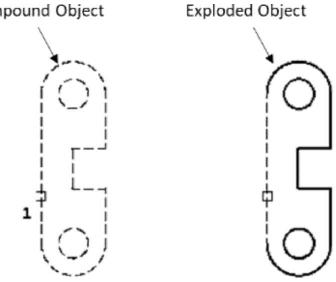
The Scale command can be used to change the size of an object or group of objects. It allows to shrink or enlarge the already existing drawing objects about a base point on specifying the scale factor.

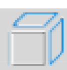


Tool Bar: **Menu → Modify→** 	Command**: explode**

15. Explode

This command is used to break a single compound object into their constituent parts. In other words, s compound object explodes when the components to be modified separately. the command is used to return blocks, polylines, rectangles, etc.,



Tool Bar: **Menu → Modify→** 	Command**: explode**

Quick access toolbar

The Quick Access toolbar, displayed in the Drafting & Annotation workspace, is located at the very top of the drawing window next to the Application button. The Quick Access toolbar may be customized by adding or removing commands. This is done by right clicking on the toolbar and selecting Customize Quick Access toolbar or selecting the arrow at the end of the toolbar.

The Quick Access toolbar contains the following commands (reading left to right):

- QNew: Opens a new drawing.
- Open…: Opens an existing drawing. (Ctrl+O)
- Save: Saves the current drawing. (Ctrl+S)
- Save as: Allows you to save the current drawing under a different name. (Ctrl+Shift+S)
- Plot…: Plots or prints the current drawing. (Ctrl+P)
- Undo: Used to undo previous command or actions.
- Redo: Used to redo commands that have been undone

Starting a new Drawing

When starting a new drawing (QNEW), you have a choice of either starting from the Create New Drawing window or the Select Template window. The Create New Drawing window allows you to set up a drawing to your preferences. You may set parameters such as the units (Imperial or Metric), the size of the drawing, and the degree of precision. The Select Template window allows you to choose from predefined templates. Figure 2.5-1 shows both startup windows. The **STARTUP** variable is used to choose what is displayed when the application is started, or which window will appear when you start a new drawing. It has 4 values that may be set (i.e., 0, 1, 2, and 3). However, for starting a new drawing, only 0 and 1 are of interest. If STARTUP = 0, then the Select Template window will appear. If STARTUP = 1, then Create New Drawing window will appear.

Template drawings store all the settings for a drawing and may also include predefined layers, dimension styles, and views. Template drawings are distinguished from other drawing files by the .dwt file extension. Seve al template drawings are included in AutoCAD®. You can make additional template drawings by changing the extensions of drawing file names to .dwt.

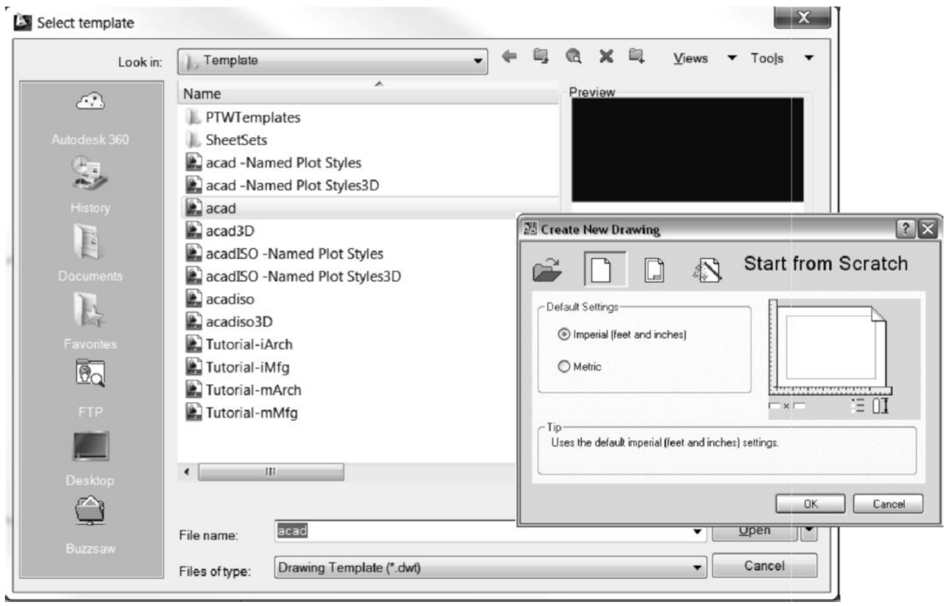


Fig. 40 Starting a new Drawing

Starting a new drawing using the Create New Drawing window

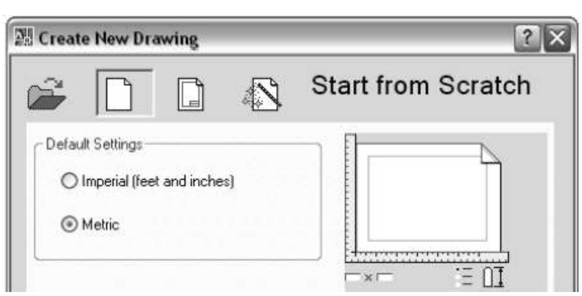
Command: **startup**

Enter new value for STARTUP <0>: **1**

Quick Access toolbar or Application button: **File – New…** (**Ctrl+N**). This window will appear.

4) Create New Drawing window: Activate the **Start from Scratch** Imperial or Metric toggle, and then select OK

Create New Drawingbutton, activate either



5) Quick Access toolbar:

6) Create New Drawing window:

a. Activate the **Use a Wizard** button.
b. Select a Wizard field: Select **Advanced Setup** and then **OK**.

7) The wizard will take you through a setup which will allow you to choose your drawings nits, angle, angle measure, angle direction and drawing area.

Saving and opening a drawing

When saving (or open) a drawing (**Application** button - **Save** or **Save as** or **Open**), you have the option of saving (or opening) the following file types.

- **DWG** (Drawing) is a binary file format used for storing two and three dimensional design data and metadata. Most of what you draw will be saved in this format.
- **DWT** is a template file. These files are used as a starting point when starting a new drawing. They may contain drawing preferences, settings, and title blocks that you do not want to create over and over again for every new drawing.
- **DXF** (Drawing Interchange Format, or Drawing Exchange Format) is a CAD data file format developed by Autodesk® for enabling data interoperability between AutoCAD® and other programs.
- **DWS** is a standards file. To set standards, you create a file that defines properties for layers, dimension styles, line types, and text styles, and you save it as a standards file with the . dws file name extension.

Plotting of Drawings

- To print a drawing, click on the icon ‘Plot’. This opens a dialogue box having two pages, namely ‘Plot device and Plot Settings’.
- The plotter configuration or its equivalent has to be selected in the Plot Device page. And the following options to be set in the Plot setting page
- Page Size : A4 (210x297 mm) or A3 or etc.,
- Units : Mm
- Drawing Orientation: Portrait / LandscapePlot Area: Limits
- Plot Scale : 1:1

- By clicking on the Full preview button, the area of the figure to printed will be projected. Click OK if it has a suitable orientation to start printing.

Geometrical Constructions

Introduction:

Engineering drawing consists of a number of geometrical Constructions. A few methods areillustrated here without mathematical proofs**.**

1. To divide a straight line 65 mm into a given number of equal parts say 5.

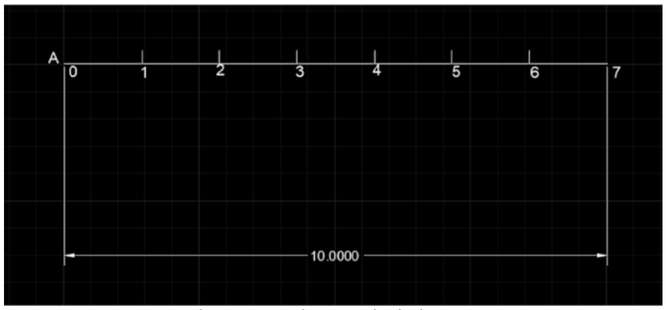


Fig. 41 Line Division

Solution

1. Draw a line of 65 mm with Command **L**
2. Name the Line With Text Command A,B
3. To Divide line Type Command **DIV** Enter
4. Select Object To Divide Select Line
5. Enter the Number Of Segment of 5 Enter
6. Select Point Style from utilities to show divisions.

2. To bisect a given angle 90^0

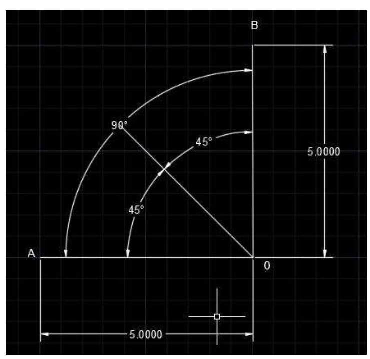


Fig. 42 Bisecting

Solution

1. Draw a line of 50 mm with Command L Name the Lane With Text Command A,B.
2. Draw another Line 50 mm From the End of Previous Line with **90⁰** Angle with Command L name the Line With Text Command B,C
3. To Bisect Line Type Command **XL** press enter
4. Select Bisect Option or Enter **B** and specify angle vertex point at End Point.
5. Specify Angle Starting Point
6. Specify angle end point enter and Mention Angle After Bisection

Polygons

1. To construct a regular polygon (say a pentagon) given the length of the side 5(EDGE METHOD)

Solution

1. To construct any polygon Enter Command **POL**
2. Enter No Of Sides **5**
3. Specify Center pf Polygon Or Edge enter Command **E**
4. Specify First End Point Of Edge & Specify second End Point Of Edge by entering specific Distance **5**
5. Name the Edges With text Command **TEXT**

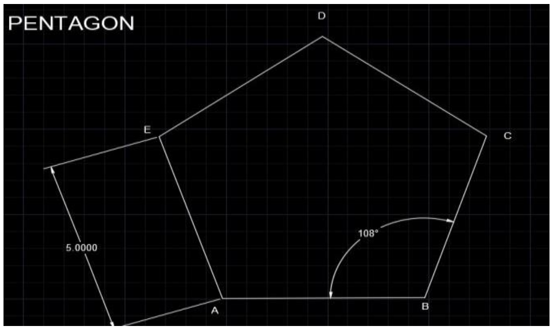


Fig. 43 Pentagon

Inscribe a hexagon in a given circle of 50 mm Diameter (Inscribe Circle Method)

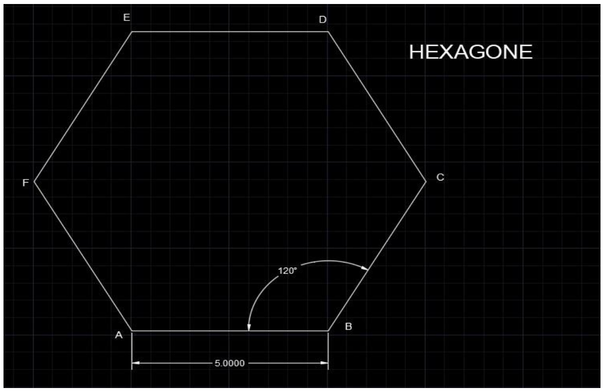


Fig. 44 Hexagon

Solution

1. To construct any polygon Enter Command **POL**
2. Enter No Of Sides **6**
3. Specify Center pf Polygon Or Edge enter select Center
4. Enter an option with Inscribed In Circle with command **I**
5. Specify radius Of Circle with 50
6. Name the Edges With text Command **TEXT**

SHEET NO:7
ORTHOGRAPHIC PROJECTIONS

Projections of points situated in different quadrants.

A **projection** is defined as the representation of an object on a two dimension plane.

Principal of Projection: If straight lines are drawn from various points on the contour of an object to meet aplane, the object is said to be projected on that plane.

The figure formed by joining in correct sequence, the points at which these lines meet the plane, is called the **projection** of the object. The lines or the rays drawn from the object to the plane are called projectors.

METHODS OF PROJECTION

1. **Orthographic Projections (2D - view)**

a) 1st Angle Projections

b) 3rd Angle Projections

2. **Pictorial Projections (3D - view)**

a) Isometric Projections

b) Oblique Projections

c) Prospective Projections

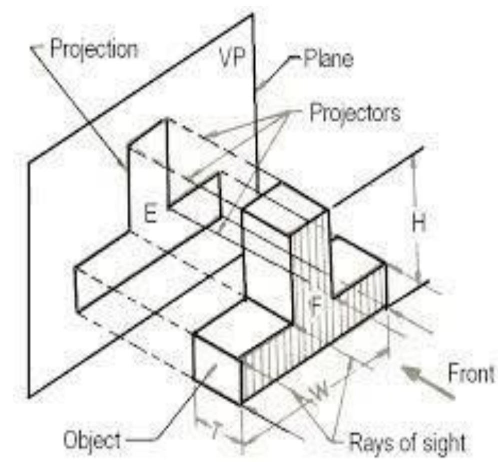
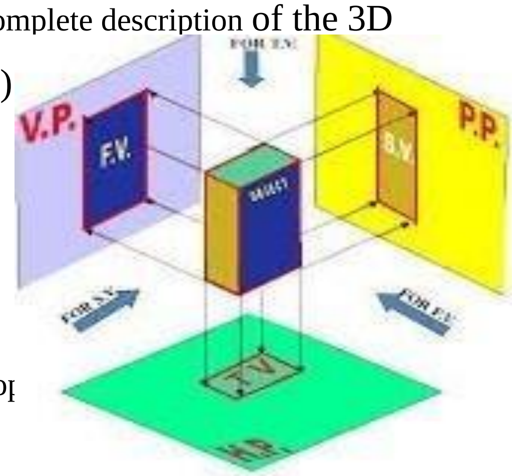


Fig. 45 Orthographic Projections

Orthographic Projection:

When the projectors are parallel to each other and also perpendicular to the plane the projection iscalled Orthographic Projection.

This projection views represents two dimensions of an object. For the complete description of the 3D object, more than one view is required (like FV, T.V, and S.V)



Method of Obtaining Orthographic Projections:

Front View: the front view is obtained by looking the object normal to its front surface and projecting it on the vertical plane (V.P)

Top View: the top view is obtained by looking the object normal toits top surface and projecting it on the horizontal surface.

Side View: the side view is obtained by looking the object normal toits side surface and projecting it on the profile plane.

Planes of Projection:

The planes used for the purpose of projection are called as the planesof projection or reference plane (or) Principal planes of projection.

1. Horizontal plane (H.P) (Top View)
2. Vertical Plane (V.P) (Front View)
3. Profile Plane (P.P) (Side View

Reference line: The line of intersection of H.P and V.P is called as reference line(X-Y)

Projection Planes and Four Quadrants: This quadrant pattern, if observed along x-y line (in red arrow direction) will exactly appear as shown on right side.

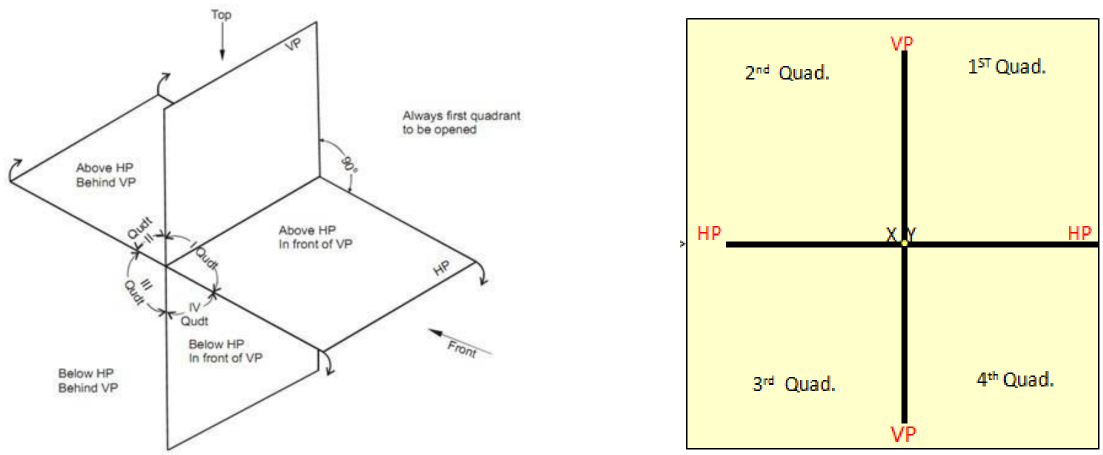
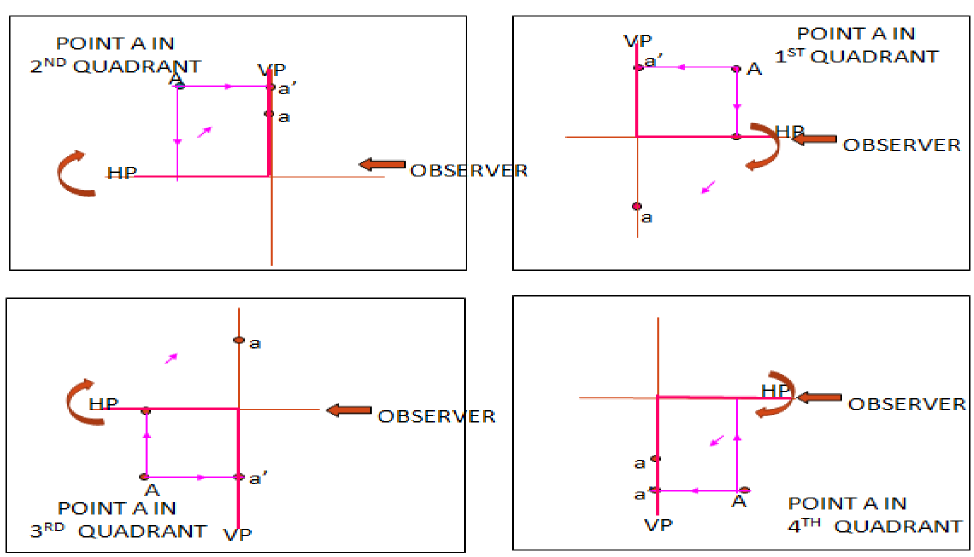


Fig. 46 Projection Planes and Four Quadrants

Rotation of Planes: Once the object is assumed to be in one of the quadrant, H.P is rotated at an angle of 90^0 in clock wise direction, such that the H.P and V.P lies in the same plane. The Planes of projections are assumed to be transparent.

Four Quadrants: When the planes of projection are extended beyond the line of intersection, they form four quadrants (or) dihedral angles which may be numbered I, II, III, IV. The object may be situated in any one of the quadrant its position relating to their plane is described as above H.P and in front of V.P Above H.P and behind V.P.

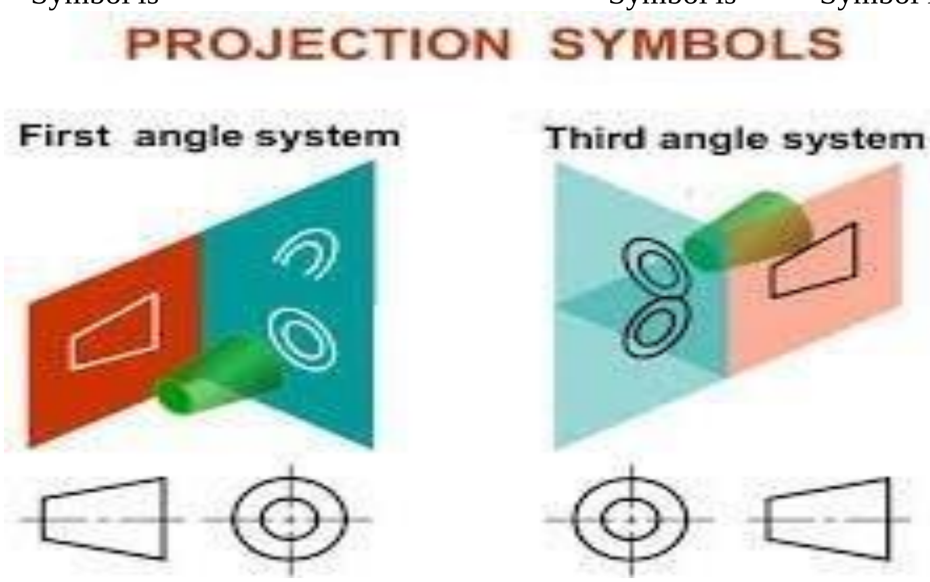


First Angle Projection: It is assumed that the object is placed in first quadrant.

Third Angle Projection: The object is assumed to be situated in the third quadrant.

DIFFERENCE BETWEEN FIRST ANGLE PROJECTION AND THIRD ANGLE PROJECTION

S.NO	**FIRST ANGLE PROJECTION**	**THIRD ANGLE PROJECTION**
1.	Object-first quadrant	Object-third quadrant
2.	Object b/w observer and plane of on	Plane of projection b/w observer and object
3.	Front View-above the Top view	Top View-above the Front View
4.	Now recommended by the "Bureau of Indian standards" from 1991	Used in U.S.A and other countries
5.	Symbol is	Symbol is Symbol is



Projection of Points

Point

A Point usually represented by a dot is a dimension less geometrical entity that has a position but no magnitude. Where as in computer aided engineering drawing the point has dimension but it is not considered or A point is obtained whenever two straight or curved lines interest neglected each other.

Projection of Points

Projection of points in various quadrants is the basis for projection of lines, projection of planes and projection of solids. In a conventional coordinate system, the position of a point in space is denoted by its three coordinates i.e. , x, y and z.

In projections, two principal planes are used to get the projection of an object that is **vertical plane** and **horizontal plane**, the vertical plane denoted by **(V.P.)** and horizontal plane denoted by **(H.P.)** as shown in Fig. They intersect each other at right angles and the line of intersection is known as axis of the plane. The vertical plane of projection is always infront of the observer and the projection on this plane is known as front view or elevation. The other plane is the horizontal plane of projection and the projection on this plane is called the top view or plan.

The view obtained by viewing object form right side is called **right side view** or right end view. A plane perpendicular to both H.P. and V.P. is called **profile plane (P.P).** The right side view is always on the right to the front view. If the object is viewed from left on profile plane then the view is known as **left side view or left end view**.

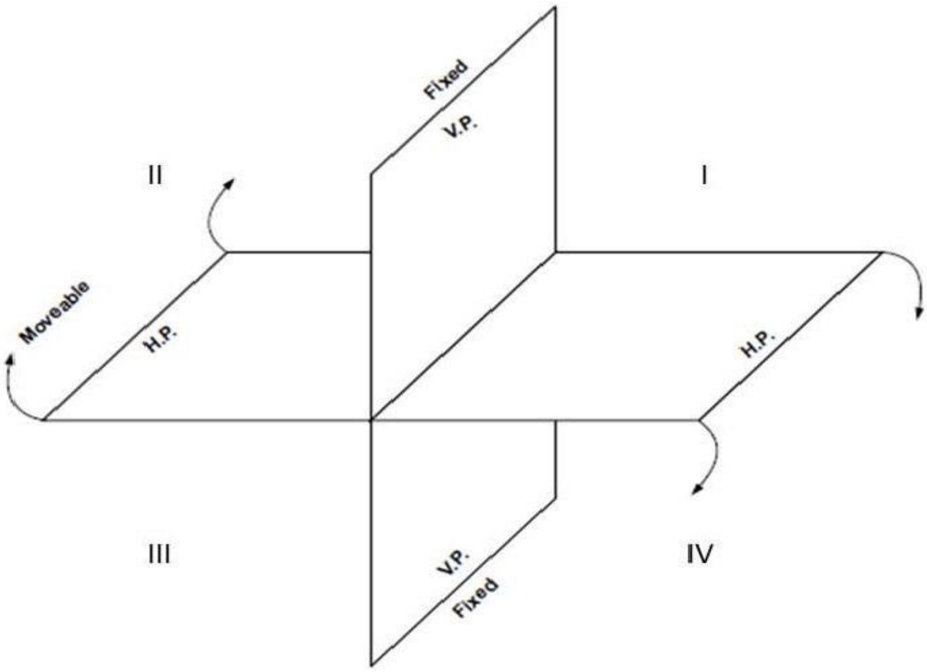
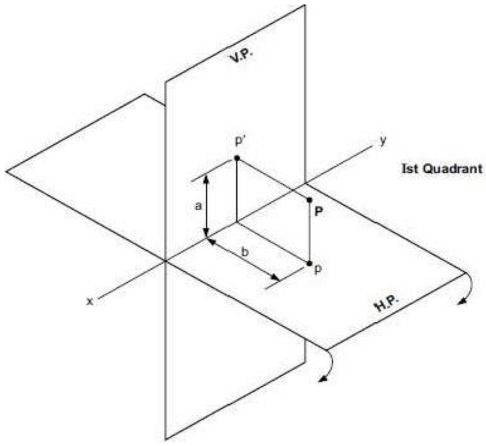
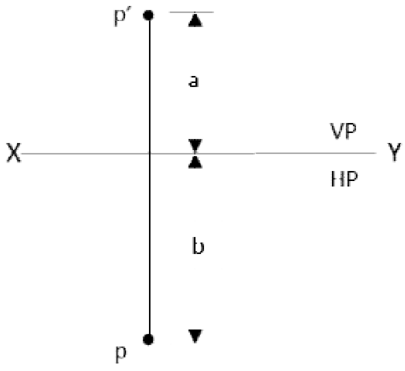


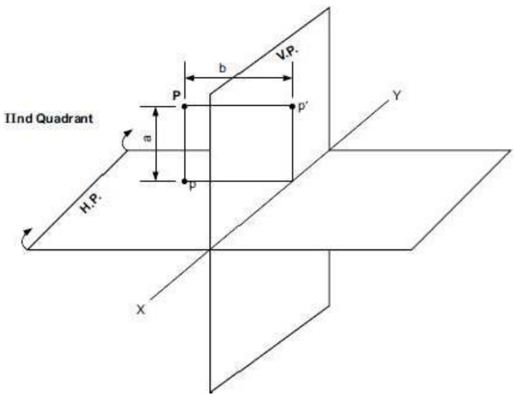
Fig . 47 Pictorial view of Principal Planes

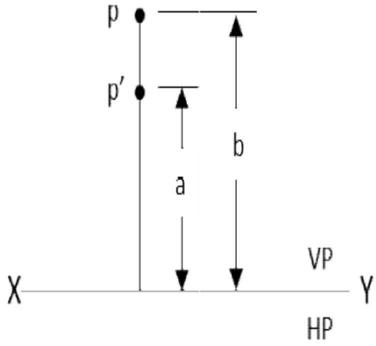
1. **When point is in First Quadrant**
   When a Point P is situated in I quadrant i.e., above H.P. and infront of V.P., Its front view (p') will be above XY line and its top view (p) will be below the XY line.



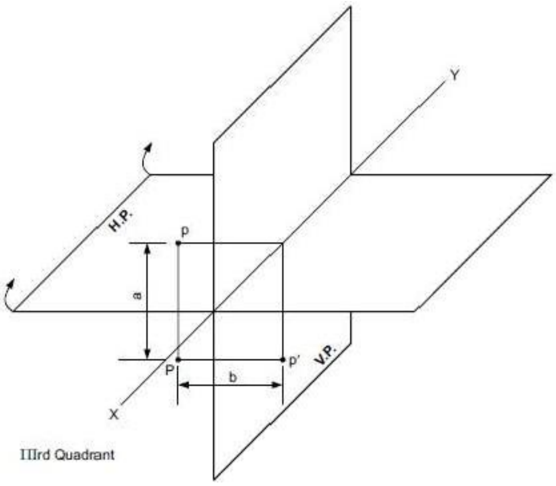


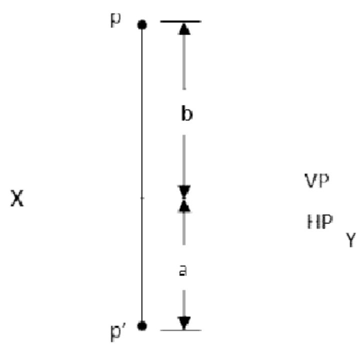
2. **When point is in Second Quadrant**
   When a Point P is situated in II quadrant i.e., above H.P. and behind V.P., Its front view (p') will be above XY line and its top view (p) will also be above the XY line.



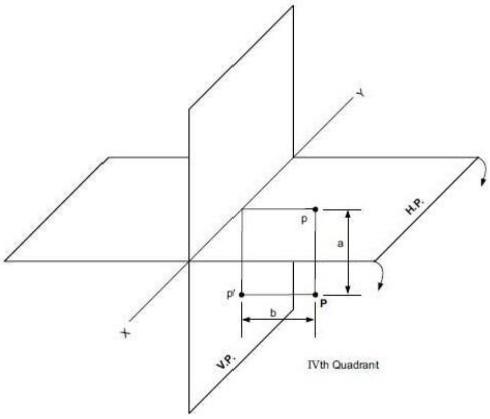


3. **When point is in Third Quadrant**
   When a Point P is situated in III quadrant i.e. , below H.P. and behind of V.P. ,Its front view (p') will be below XY line and its top view (p) will be above the XY line.





4. **When point is in Fourth Quadrant**
When a Point P is situated in IV quadrant i.e., below H.P. and infront V.P., Its front view (p’) will be below XY line and also its top view (p).



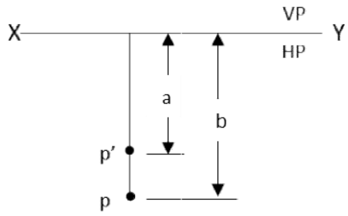


Table no . 5 Positions of geometrical entities in various quadrants of the projections

When	Position		Quadrant	FrontView	TopView
	VP	HP			
Point is	Infront	Above	I	Above XY	Below XY
Point is	Behind	Above	II	Above XY	Above XY
Point is	Behind	Below	III	Below XY	Above XY
Point is	Infront	Below	IV	Below XY	Below XY
Point is	Infront	Infront	I or IV	On XY	Below XY
Point is	Infront	Above	I or II	Above XY	On XY
Point is	Behind	Infront	II or III	On XY	Above XY
Point is	Infront	Below	III or IV	Below XY	On XY
Point is	Infront	Infront	I, II, III, or IV	On XY	On XY

System of Notation

1. The actual points in space are denoted by capital letters A, B, C etc.
2. The front view (FV) of the points are denoted by their corresponding lower-case letters with dashes as a', b', c', etc.
3. The top view (TV) of the points are denoted by their corresponding lower-case letters without dashes as a ,b, c etc.
4. The side view (SV)of the points are denoted by their corresponding lower-case letters with double dashes as a'', b'', c'' etc.
5. Projectors are always drawn as continuous thin lines and Points with Dot.

In Computer Aided Engineering Graphics for projection of points following commands are used other than evoking software, opening file, saving file and giving print command. Using these minimum nine commands any type of projection of point problem can be solved they are as follows:

1. Select tool Command.
2. Point command.
3. Poly-line command.
4. Two point line command.
5. Parallel line command.
6. Bisector command.
7. Smart dimension command.
8. Line width command.
9. Insert text command.

PROJECTIONS OF POINTS EXERCISE QUESTIONS:

Exercise Problem-1: Draw the projection of the following points on the same ground line, keeping the projectors 25mm apart.

1. A point in HP and 20mm behind VP.
2. 40mm above HP and 25mm in front of VP.
3. In the VP and 40mm above HP.
4. 25mm below HP and 25mm behind the VP.
5. 15mm above HP and 50mm behind VP.
6. 40mm below HP and 25mm in front of VP.
7. In both HP and VP.

Solution:

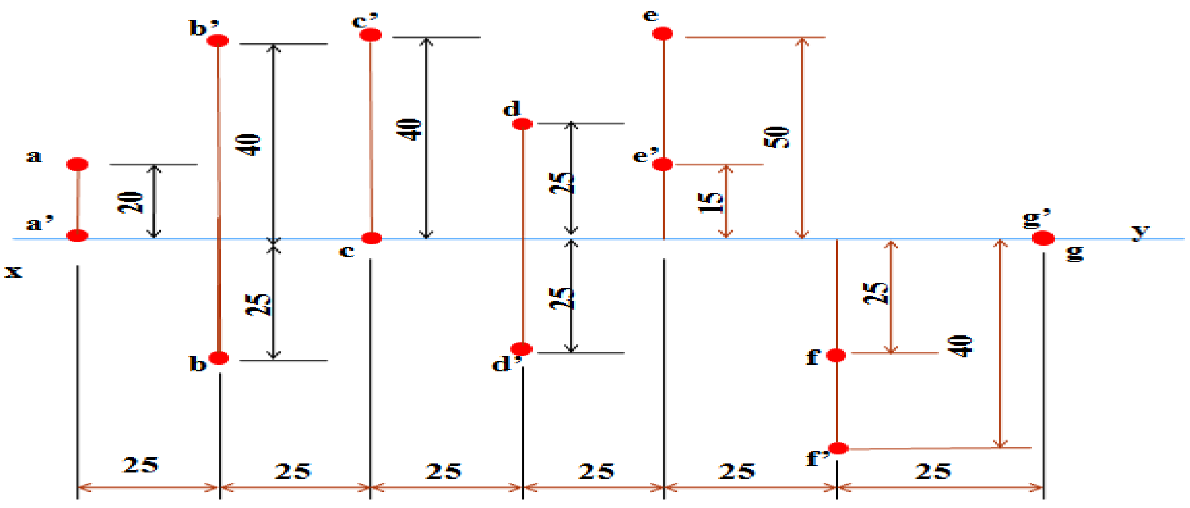


Fig . 48 Projections of points

Exercise Problem-2:- A point is 50mm from both the reference planes draw its projections in all possible directions.

Solution:

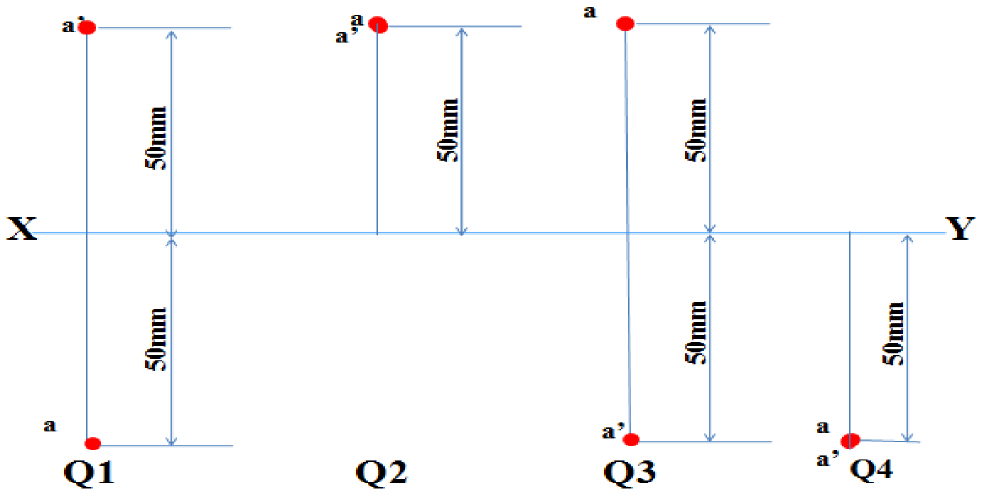


Fig . 50 Projections of all possible directions

Practice Problems

Practice Problem-1: Projections of various points are given below. State the positions of eachpoint with respect to planes of projections. Mention distances in centimetres.

1. Point A is 20mm above H.P and in a V.P.
2. Point B is 40mm below H.P and in V.P.
3. Point C is 30mm below H.P and 20mm behind V.P
4. Point D is 30mm behind V.P and in H.P.
5. Point E is 30mm above H.P and 15mm behind V.P

Solution:

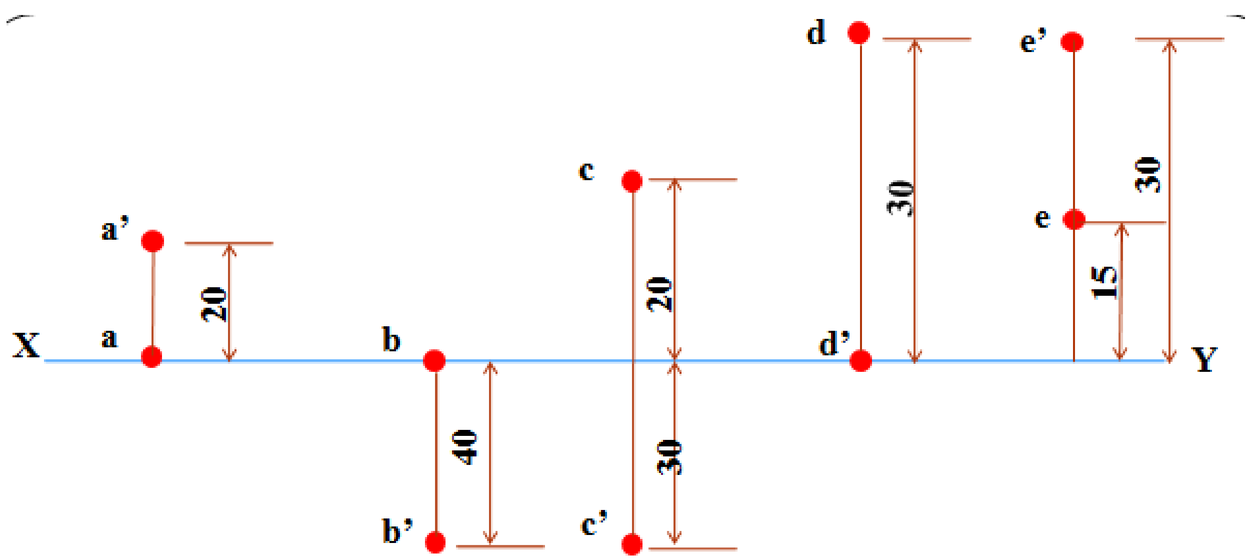


Fig . 52 Projections of various points

Practice Problem-2: A point P is 15mm above HP and 20mm in front of VP. Another point Q is 25mm behind the VP and 40mm below HP. Draw the projections of P and Q keeping the distances between projections equal to 90mm. Also draw straight lines joining their top views and front views.

Solution:

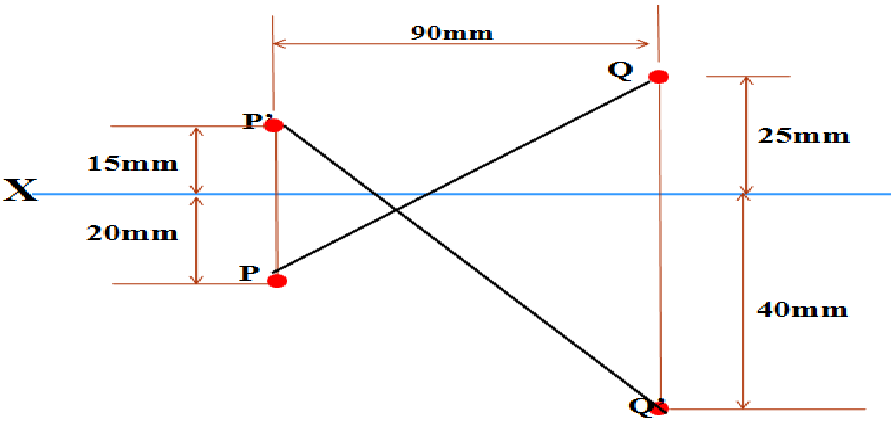


Fig . 51 Projections of straight lines joining their top views and front views

Practice Problem-3: Projections of various points are given below. State the positions of each point with respect to planes of projections. Mention distances in centimeters.

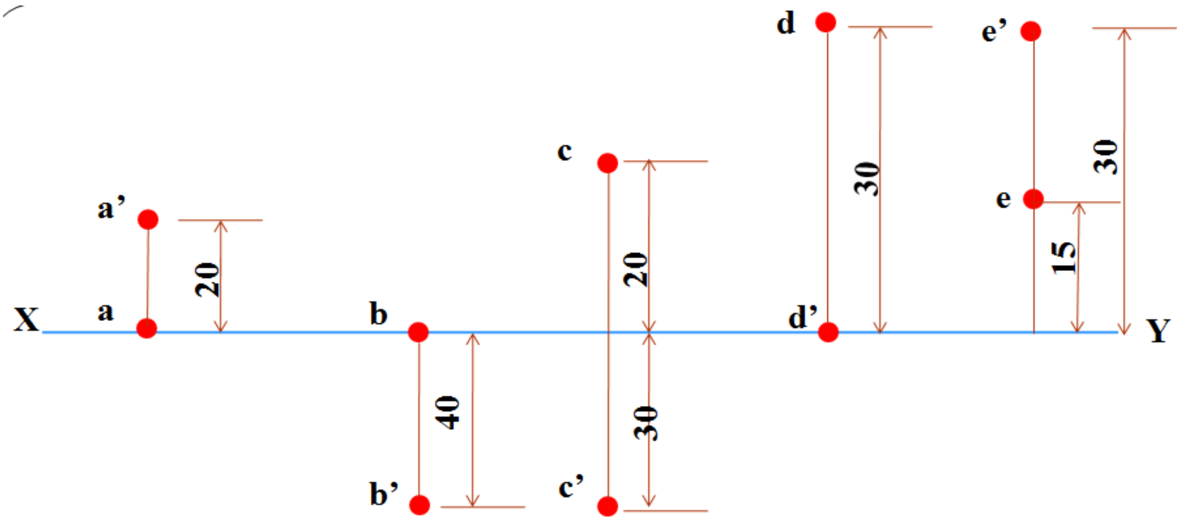


Fig . 49 Projections of various points

Viva Questions

Sheet no:7 Projections of Points

Terms: FV-front view; TV- top view; SV- side view; HP- horizontal plane; VP- vertical plane

1. What is meant by orthographic projections?

Ans: When the projectors (straight lines) drawn from the object are parallel to each other and perpendicular to the plane of projection, it is called as orthographic projection.

2. What are the three reference planes used for projections? Which views are drawn on them?

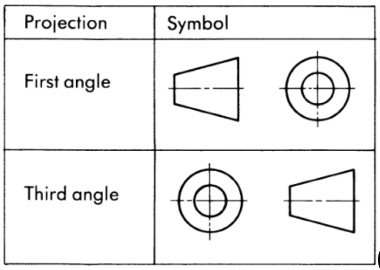
A: The 3 planes of projection are HP, VP and PP (profile plane). FV →VP; TV→HP; SV→PP

3. What is the difference between 1st angle and 3rd angle projections?

A:

	1st angle projection	3rd angle projection
1.	Object is placed in the 1st quadrant	Object is placed in the 3rd quadrant
2.	Object lies in between the observer and the plane of projection	The plane of projection lies in between the observer and the object
3.	The plane of projection is assumed to be transparent	The plane of projection is assumed to be non transparent.
4.	The FV is above xy and TV is below xy.	The FV is below xy and TV is above xy.
5.	The left side view is drawn on the right side of front view.	The left side view is drawn on the left side of front view.
6.	Usually followed in India	Usually followed in USA.

4. Draw the standard notation for 1st angle and 3rd angle projection.



(The above symbol is for frustum of a cone; FV and SV are shown; In 1st angle-Left side view on right of FV; in 3rd angle, Left SV on left of FV)

5. Why 2nd angle and 4th angle projections are not used in drawing?

A: In 2nd angle and 4th angle projections, the object is in 2nd and 4th quadrant, where the FV and TV both coincide in the same plane w.r.t xy. Hence it creates confusions in identifying the FV and TV of objects separately. So they are not used in drawing conventions.

6. What is the standard representation for point in front view, top view and side view?

A: FV-a',b',c',...etc. TV- a,b,c,..etc. SV-a'', b'', c'',...etc.

7. What is meant by plan, elevation and side elevation?

A: Plan→ Top view; Elevation→ Front view; Side elevation→ Side view.

8. The plane which is perpendicular to both reference planes is (c) Profile plane

(a) Perpendicular (b) Oblique (c) Profile plane (d) Parallel

PROJECTION OF STRAGHT LINES

Introduction

A line may be defined as the locus of a point moving along a fixed path. A line consists of a number of points; its projections are drawn by joining the projection of its extreme (end) points. Hence, the projections of a straight line may be drawn by joining the respective projections of it sends, which are points. In a conventional drawing, a line has only length but no thickness. Whereas in computer aided engineering graphics the line has length and thickness. The position of a straight line may have different orientations in space. A sper first angle projection, it may be parallel, perpendicular or inclined to either or both the Reference planes (horizontal or vertical planes) as mentioned in the below classification.

Classification of Line Positions

A line may be placed in infinite number of positions with respect to the reference planes. These positions may be classified according to the inclination of the line to reference planes and the quadrants in which it is placed.

1. Line parallel to both the reference planes (HP&VP)
   a) Line away from both HP and VP.
   b) Line in HP and away from VP.
   c) Line in VP and above HP.
   d) Line on both HP and VP.

2. Line perpendicular to either of reference planes (HP or VP)
   a) Line perpendicular to HP and away from VP.
   b) Line perpendicular to HP and on VP.
   c) Line perpendicular to VP and above HP.
   d) Line perpendicular to VP and on HP.

3. Line inclined to HP and parallel to VP
   a) Line inclined to HP, parallel to VP and away from VP.
   b) Line inclined to HP, parallel to VP and in VP.
4. Line inclined to VP and parallel to HP
   a) Line inclined to VP, parallel to HP and away from HP.
   b) Line inclined to VP, parallel to HP and in HP.

5. Line inclined to both HP and VP
   a) One end of line in HP and the other end away from VP.
   b) One end of line in VP and the other end away from HP.
   c) One end above HP and the other end away from VP.
   d) One end away from VP and the other end above HP.
   e) One end in HP and VP and other end away from HP and VP.
   f) Both ends on HP and VP.

System of Notation

1. The actual line in space Is denoted by capital letters A and B, or C and D etc.
2. The front view (FV) of a line is denoted by their corresponding lower letters with dashes as a 'and b', c' and d' etc.
3. The top view (TV) of a line is denoted by their corresponding lower case letters without dashes as a and b , c and d etc.
4. The side view (SV) of a line are denoted by their corresponding lower case letters with
5. Double dashes as a" and b", c" and d" etc.
6. Projectors are always drawn as continuous thin lines.
7. Line with specific thickness for a particular type of line.

SHEET NO: 8

Projections of straight lines–I Line parallel to both the reference planes, line perpendicular or inclinedto one reference plane.

1. A 60 mm long line AB has its end A 20 mm above the HP. The line is perpendicular to HP and 40 mm in front of the V.P. Draw its projections.

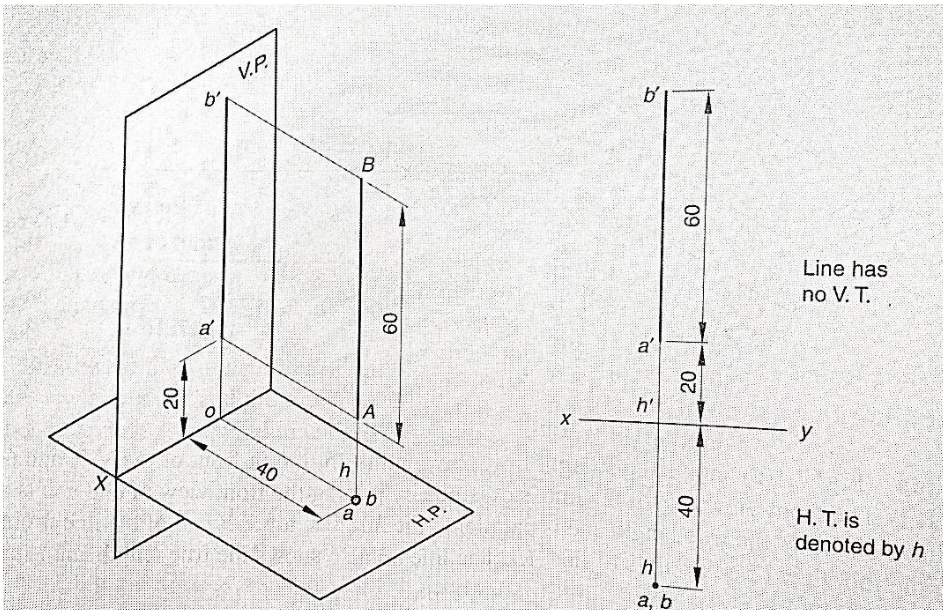


Fig . 53 Projections of line is perpendicular to HP

2. A 60 mm long line AB has its end A at a distance of 20 mm in front of the V.P the lineis perpendicular to the VP and 40 mm above the HP. Draw its projections.

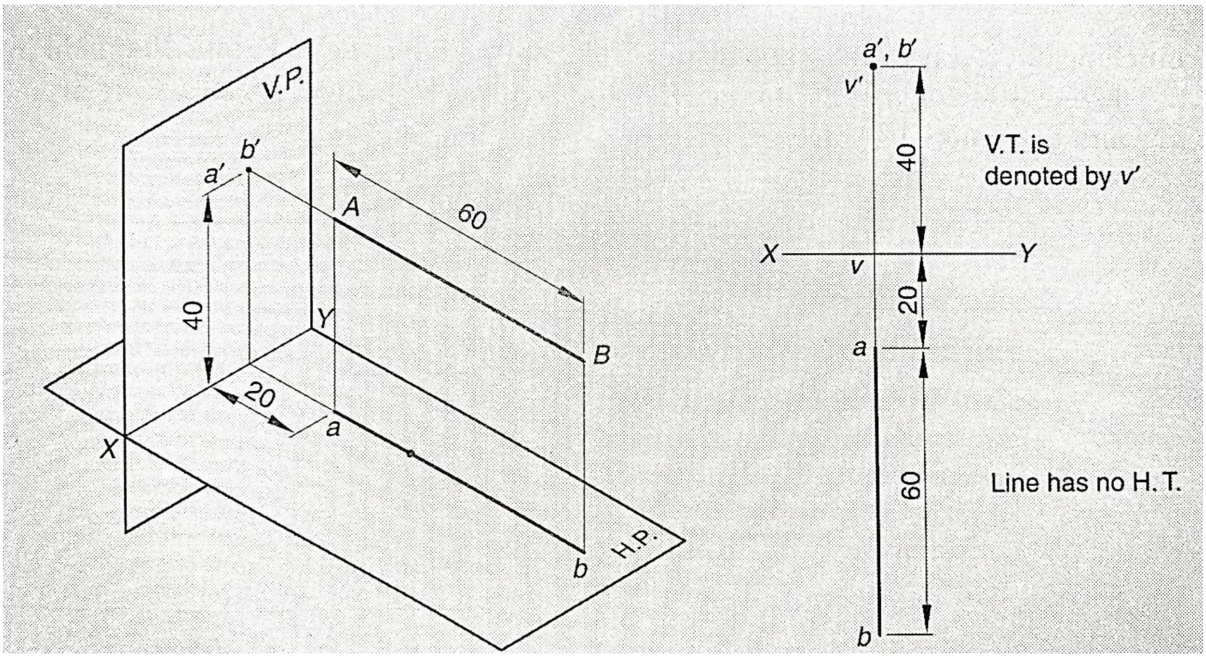


Fig . 54 Projections of the lineis perpendicular to the VP

3. An 80 mm long line AB has end A at a distance of 20 mm above the HP and 40 mm infront of the VP. The line is inclined at 30 degrees to the HP. And is parallel to the VP.Draw its projections.

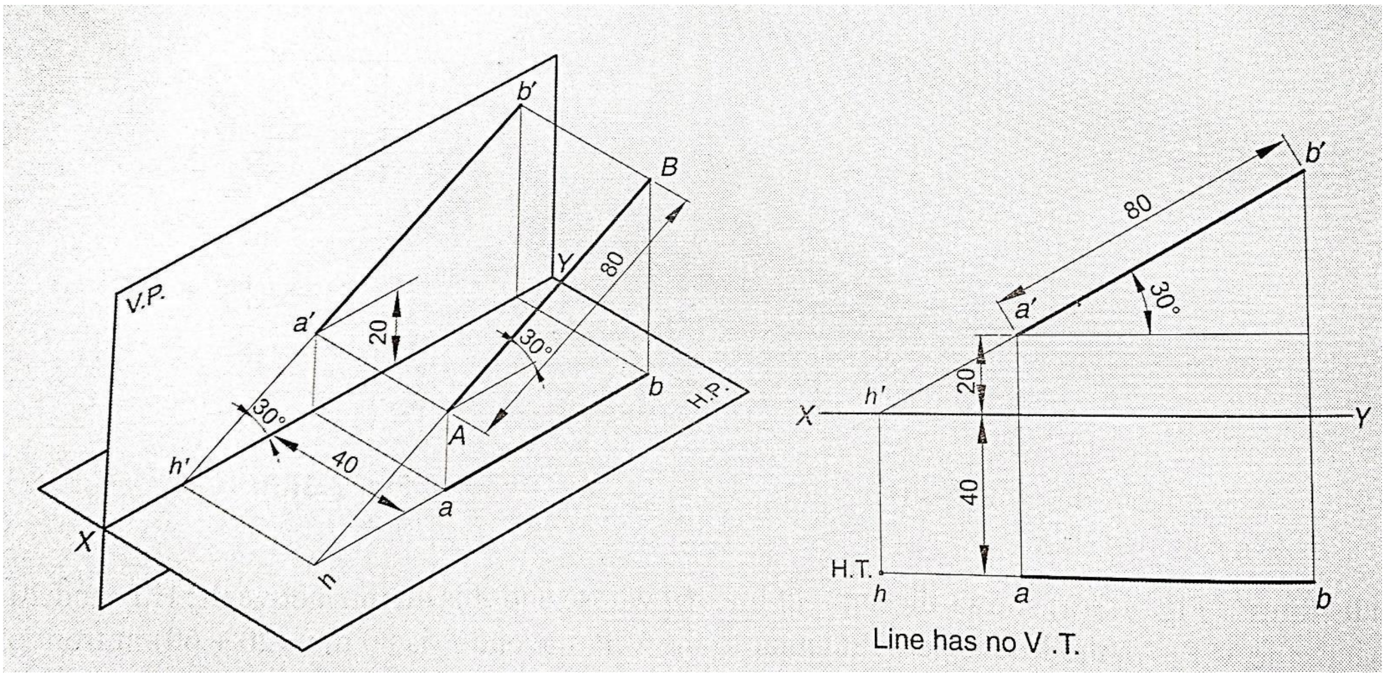


Fig . 55 Projections of the line is is parallel to the VP

SHEET NO: 9

Projections of Straight lines –II

Line inclined to both the reference planes.

1. A 70 mm long line PQ has its end P 20mm above the HP and 30 mm in front of the VP. The line is inclined at 45 degree to the HP and 30 degree to the VP. Draw its Projection.

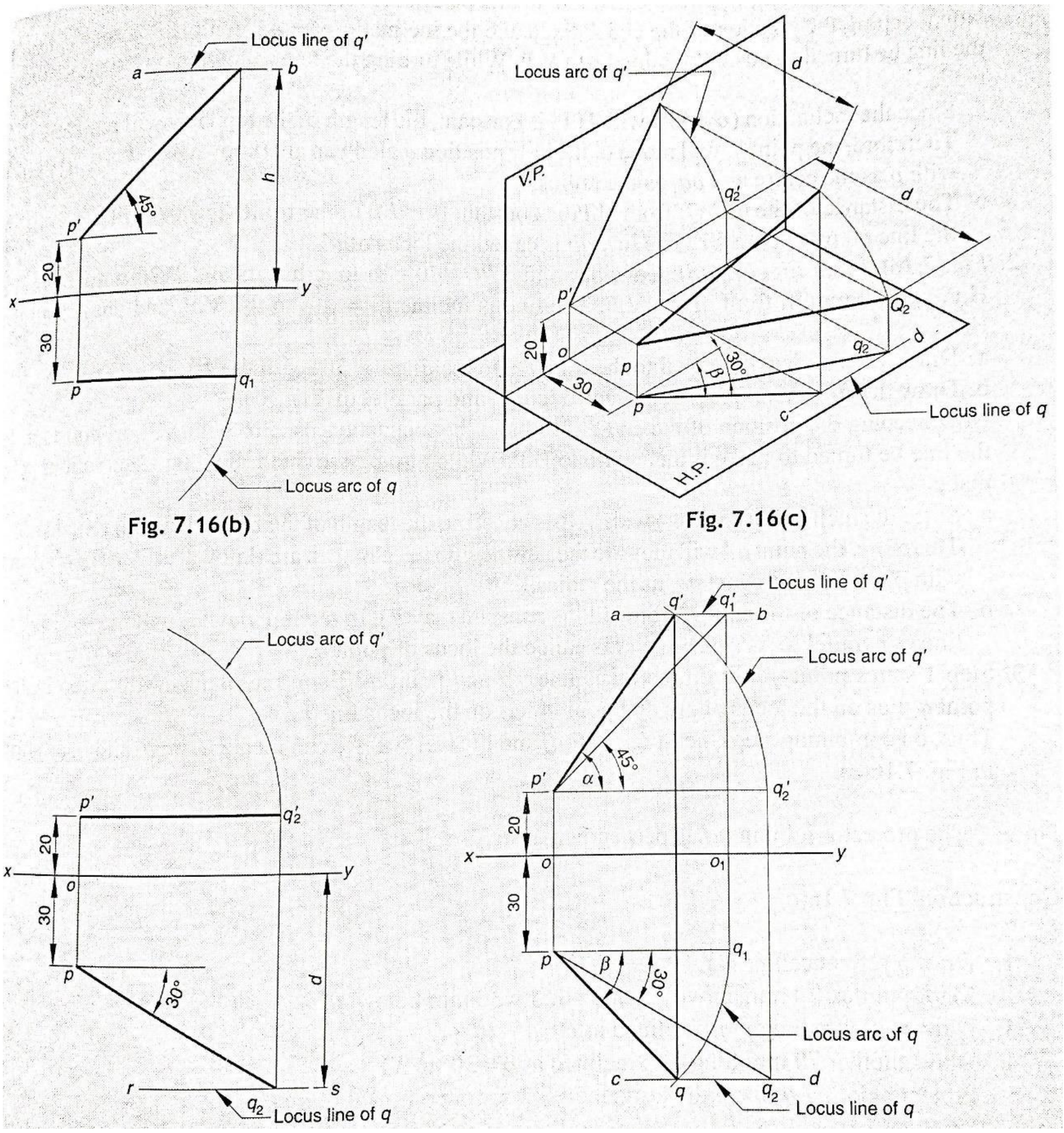


Fig . 56 Projections of Line inclined to both the reference planes

2. A straight line PQ has its end P 20 mm above the HP and 30 mm in front of the VPand the end Q is 80 mm above the HP and 70mm in front of the VP. If the end projectors are 60 mm apart draw the projections of the line. Determine its true length and True inclinations with the reference planes.

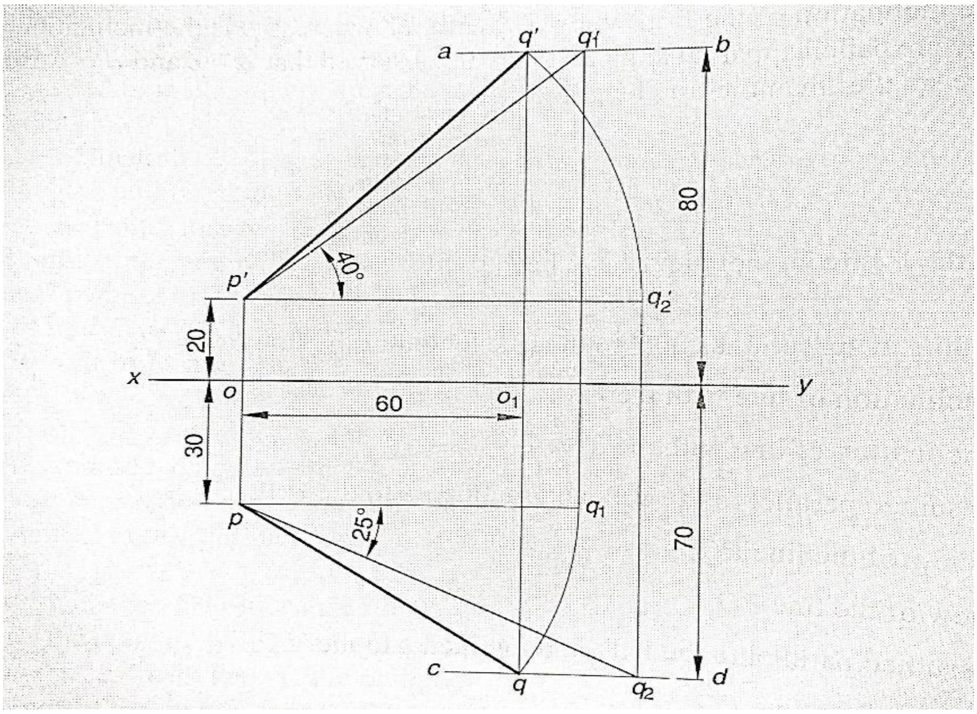


Fig . 57 Projections of line, true length and True inclinations with the reference planes

3. A line CD 80 mm long is inclined at 45 degree to HP and 30 degree to the VP its endC is in the HP and 40mm in front of VP. Draw its Projections.

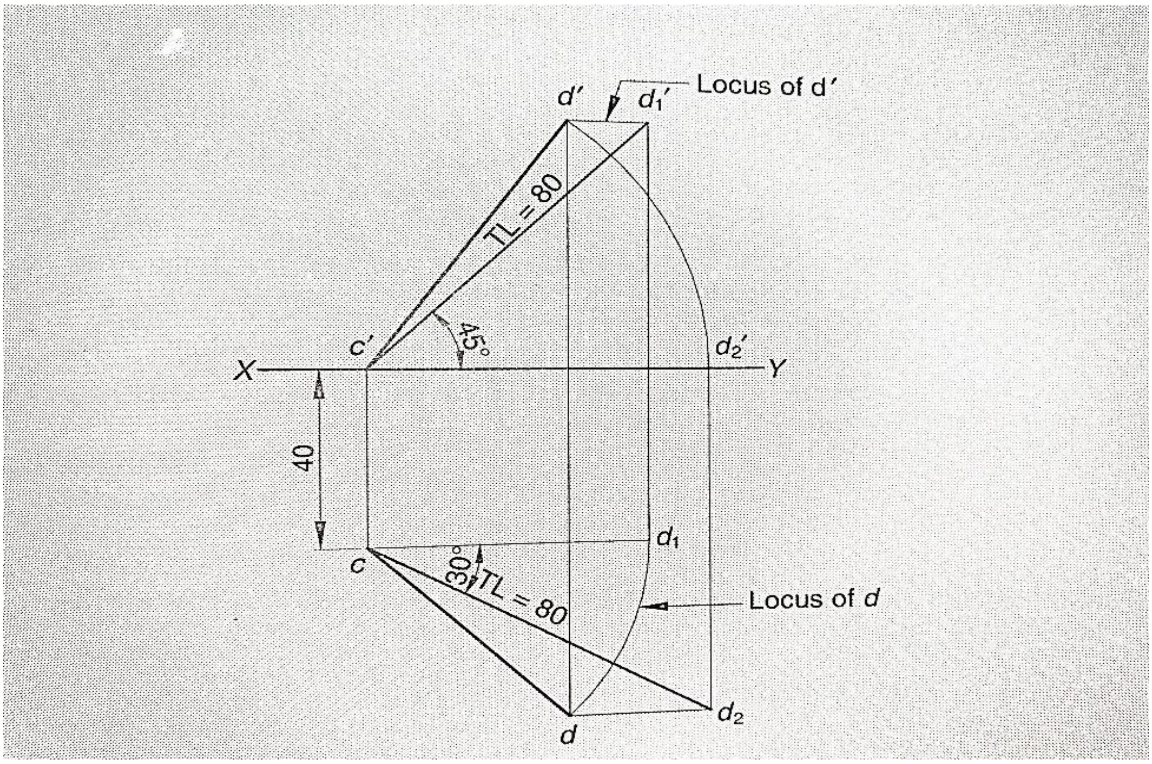


Fig . 58 Projections of line, true length and True inclinations with the reference planes

Viva Questions

Sheet no: 8&9 Projections of Lines- I,II

1. What is meant by trace of a line?

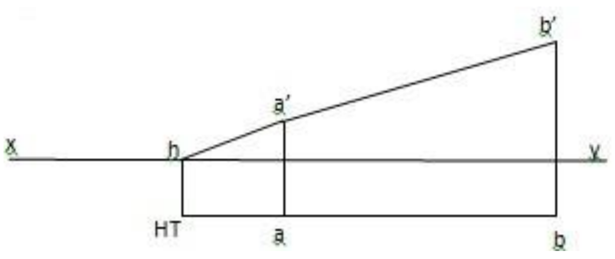
A. It is defined as the extension of a given line to the reference plane (HP or VP) to which it is perpendicular or inclined. The line meets the HP or VP as a point. This point is called trace of a line.

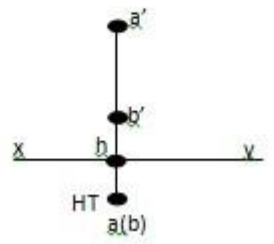
2. Explain the terms horizontal trace (HT) and vertical trace (VT) for a line.

A. The point in which the line meets the HP when extended is called HT and the point in which the line meets the VP when extended is called as VT. HT and VT need not lie on HP and VP always. In case of lines inclined to both HP and VP, the HT and VT do not lie always on HP and VP.

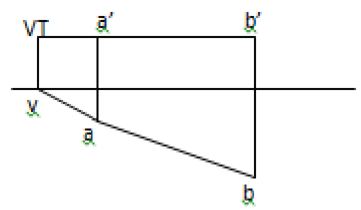
3. Explain the method of determining a trace with simple sketches.

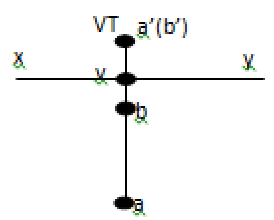
A. HT: Consider a line inclined to HP. Extend it to xy to get h. From h, drop a perpendicular on to TV to get HT.





VT: Consider a line inclined to VP. Extend it to xy to get v. From v, drop a perpendicular on to FV to get VT.





4. When does a line have no traces?

A. (i): When a line is parallel to HP and VP, it has no traces.
(ii) When a line is parallel to HP and inclined to VP, it has only VT and no HT.
(iii) When a line is parallel to VP and inclined to HP, it has only HT and no VT.
(iv) When a line is perpendicular to HP, its HT is its top view and it has no VT.
(v) When a line is perpendicular to VP, its VT is its Front view and it has no HT.

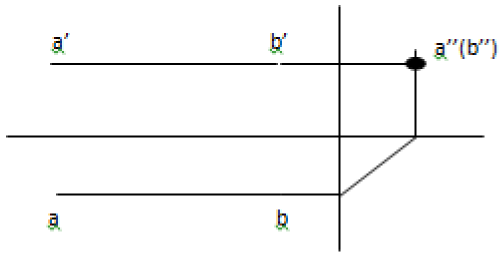
5. When a line is parallel to a plane, its projection on that plane is equal to its________________. (straight line)
6. When a line is perpendicular to a plane, its projection on that plane is a__________(Point).
7. (i) If a straight line is inclined to the VP & is in the HP, what is its front view & in which projection is the inclination of the line seen?
(ii) If a straight line is inclined to the HP and is in the VP, what is its top view and in which view will the inclination of the line be seen?

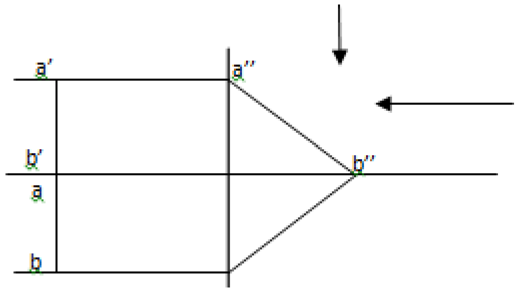
A. (i) The front view is a reduced line ∥ to xy and the inclination of the line is seen in top view.
(ii) The top view is a reduced line ∥ to xy and the inclination of the line is seen in Front view. The

8. projections of a straight line on to HP & VP are identical. Describe the position of the straight line & its projection on to a plane perpendicular to both HP & VP.

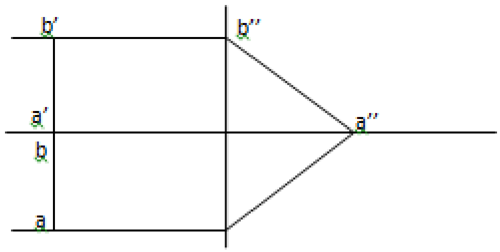
A. (i) The line is parallel to both HP and VP. The projection on the profile plane is a point.

(ii) The line is inclined at complimentary angles to HP and VP (sum of angles = 90^0). The projection on the profile plane will be the line at true angle to HP and VP.





9. A straight line AB of 40 mm long is contained by a profile plane, end A in HP, end B in VP. Draw its projections.



10. When a line is perpendicular to H.P. its_____trace will coincide with_______view. (HT, TV)

11. When a line is perpendicular to VP, its____trace will coincide with_________view. (VT, FV)

PROJECTION OF PLANES

Introduction

A plane is a two-dimensional geometrical entity. It has length and width but no thickness. For practical purposes, a flat face of an object may be treated as a plane. A plane which has limited extent is termed as a lamina.

A plane can be located by:

(i) Three non-collinear points,

(ii) A straight line and a point outside it,

(iii) Two parallel or intersecting straight lines, or

(iv) Traces of the lines.

This chapter deals with the projections of laminas of pre-defined shapes, e.g., triangular plane, square plane, rectangular plane, pentagonal plane, hexagonal plane, circular plane, semicircular plane, etc. Sometimes, a given plane is composed of two or more planes mentioned above. Such planes are called composite planes, e.g., plane composed of a half hexagon and a semicircle, circular plane with hexagonal hole, etc.

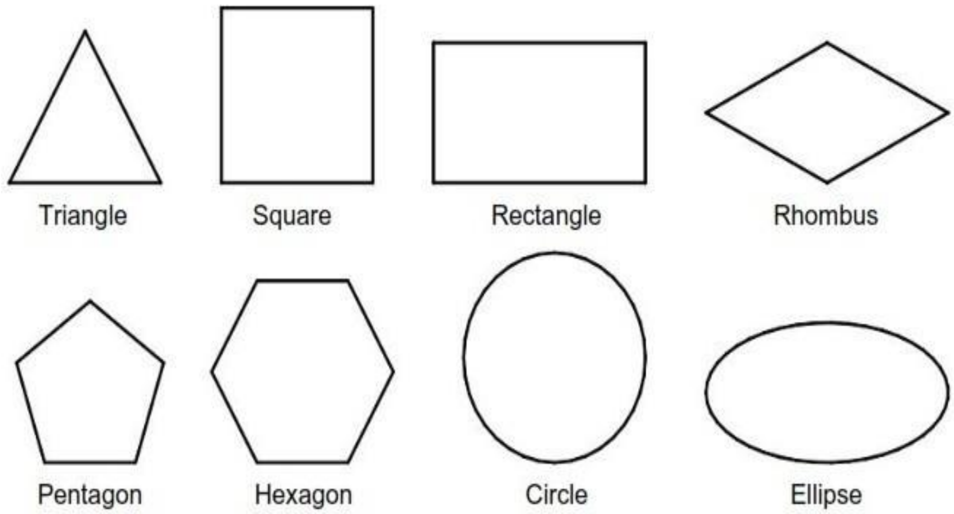


Fig. 59 Planes

Positions of Planes

1. Plane parallel and perpendicular to reference planes(HP&VP)
    A. Plane parallel to HP and perpendicular to VP.
    B. Plane parallel to VP and perpendicular to HP.
2. Plane perpendicular and inclined to reference planes(HP&VP)
    A. Plane perpendicular to HP and inclined to VP.
    B. Plane perpendicular to VP and inclined to HP.
3. Plane perpendicular to both HP&VP.

4. Plane inclined to both HP&VP
    A. Inclination to HP and VP is not equal to 90°.
    B. Inclination to HP and VP is equal to 90°.

Terms Used in Projections of Planes

The following terms must be understood before we proceed for the step-by-step procedure of obtaining the projections of a plane.

True Shape: The actual shape of a plane is called its true shape.

Inclination with the RPs: The inclination of a plane with an RP is the acute angle the plane makes with that RP. It is always measured in a plane perpendicular to the given plane and the RP.

Inclination with the HP (θ_P) It is the a cute angle the plane makes with the HP.

Inclination with the VP (ϕ_P) It is the a cute angle the plane makes with the VP.

Traces of the Plane:

Just like a line, a plane also has traces. The traces of a plane are the lines of intersections of the plane with the RPs. A plane may have a horizontal trace or vertical trace or both. Horizontal Trace (HT**)** The real or imaginary line of intersection of a plane with the HP is called horizontal trace of the plane. HT is always located in the TV. Vertical Trace (VT) The real or imaginary line of intersection of a plane with the VP is called vertical trace of the plane. VT is always located in the FV. It should be noted that the plane has no trace on the RP to which it is parallel. For example, a plane parallel to the HP will have no HT. Similarly, a plane parallel to the VP will have no VT. HT and VT of a plane (produced if necessary) meet at a point on the XY.

Perpendicular Planes: The planes perpendicular to one or both the RPs are called perpendicular planes. The first three positions of the planes mentioned in the previous section represent perpendicular planes.

Oblique Planes: The planes inclined to both the RPs are called oblique planes. The fourth position of the planes mentioned in the previous section represents oblique planes.

Line View or Edge View: The view of a plane seen as a line is called line view or edge view of the plane. One view of a perpendicular plane is always an edge view. The edge view always represents the trace of the plane. For example, if a plane is perpendicular to the VP, then its FV will be an edge view representing VT of the plane. Similarly, TV of a plane perpendicular to the HP Will be an edge view representing HT.

System of Notation

1. The actual plane in space is denoted by capital letters A, B, C and D etc.
2. The front view (FV)of a plane is denoted by their corresponding lower-case letters with dashes as a',b',c' and d' etc.
3. The top view (TV)of a plane is denoted by their corresponding lower-case letters without dashes as a, b, c and d etc.
4. The side view (SV)of a plane are denoted by their corresponding lower-case letters with

double dashes as a”, b", c" and d" etc.

5. Projectors are always drawn as continuous thin lines.
6. Line with specific thickness for a particular type of line.

In Computer Aided Engineering Graphics for projection of plane following commands are used other than evoking software, opening file, saving file and giving print command. Using these minimum12 commands any type of projection of line problem can be solved they are as follows:

1. Select tool Command.
2. Point command.
3. Poly-Line command.
4. Two Point Line command.
5. Parallel line command.
6. Center Circle command
7. Bisector command.
8. Smart Dimension command.
9. Line Width command.
10. Insert Text command.
11. Move Copy command.
12. Rectangle command.

Plane parallel and perpendicular to reference planes (HP&VP)

If the given plane is parallel to an RP, it remains perpendicular to the other RP. In such a case, the view of the plane on the RP to which it is parallel gives the true shape. Another view is always an edge view parallel to XY.

Plane parallel to HP and perpendicular to VP.

If a plane is parallel to the HP, its TV gives the true shape. Therefore, TV should be drawn first. FV will be an edge view parallel to XY. SV will be perpendicular to XY.

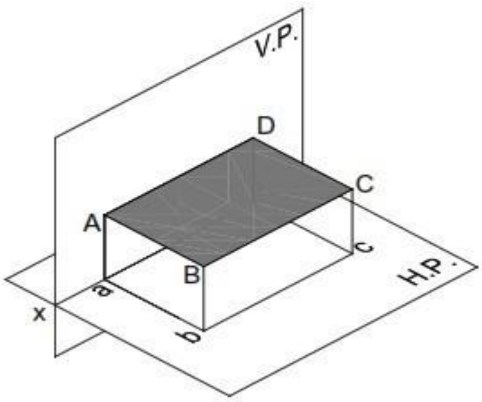


Fig. 60 Plane parallel to HP and perpendicular to VP.

Plane parallel to VP and perpendicular to HP.

If a plane is parallel to the VP, its FV gives the true shape. Therefore, FV should be drawn first. TV will be an edge view parallel to XY. SV will be perpendicular to X Y.

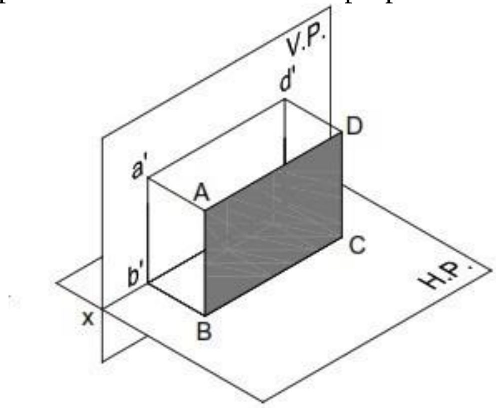


Fig. 61 Plane parallel to VP and perpendicular to HP.

Plane Inclined to one RP and Perpendicular to the other RP

If a plane is inclined to one RP and perpendicular to the other RP, none of its views will give the true shape. The view on the RP to which the plane is inclined will be smaller than the actual size of the plane. The view on the RP to which the plane is perpendicular will be a line view. Such problems can be solved in two stages. In the first stage, the given plane is assumed to be parallelto the RP to which it is finally inclined. The true shape can thus be obtained in one view. In the second stage, another view (which is an edge view parallel to XY) is tilted so as to make desired inclination with the first RP.

Plane Inclined to the HP and Perpendicular to the VP

When the surface of the plane is inclined at θ to the H.P. and perpendicular to the V.P., the projections are obtained in two stages. In the first stage, the plane is assumed to lie on the H.P.The true shape of the plane is viewed in the top view and a straight line lying on xy in the front view. In the second stage, the plane is tilted at θ to the H.P. The front view is redrawn inclined atθ to the xy. The final top view is obtained by joining the Points of intersection of the vertical projectors of the corners from the front view with the horizontal projectors of the corners from the top view of the preceding stage.

Note 1 If the plane has a side on the H.P. (or parallel to the H.P. or on the ground), then keep an edge of the plane perpendicular to xy in the top view of the first stage.
Note 2 If the plane has a corner in the H.P. (or on the ground), then keep the line joining a corner and the centre of the plane parallel to xy.

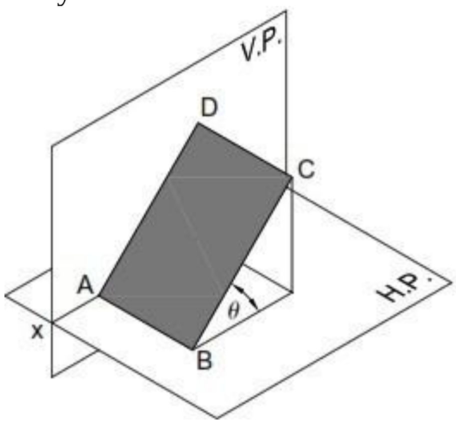


Fig. 62 Plane Inclined to the HP and Perpendicular to the VP

Plane Inclined to the VP and Perpendicular to the HP

When the surface of the plane is inclined at ϕ to the V.P. and perpendicular to the H.P., the projections are obtained in two stages. In the first stage, the plane is assumed to lie on the V.P. The true shape of the plane is viewed in the front view and a straight line lying on xy in the top view. In the second stage, the plane is tilted at ϕ to the V.P. The top view is redrawn inclined at ϕ to the xy. The final front view is obtained by joining the points of intersection of the vertical projectors of the corners from the top view with the horizontal projectors of the corners from the front view of the preceding stage.

Note 1 If the plane has a side on the V.P. (or parallel to the V.P. or on the ground), then keep an edge of the plane perpendicular to xy in the front view of the first stage.

Note 2 If the plane has a corner in the V.P. (or on the ground), then keep the line joining a corner and the centre of the plane parallel to xy in the front view of the first stage.

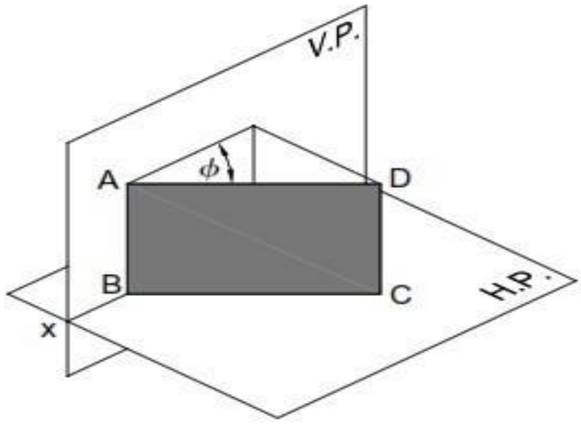


Fig. 63 Plane Inclined to the VP and Perpendicular to the HP

Plane perpendicular to both HP & VP.

If a plane is perpendicular to both the RPs, then its FV and TV both will be seen as edge views perpendicular to XY. Such a plane is parallel to the PP and hence its true shape is seen in SV. Therefore, for such problems, it is advisable to draw SV first.

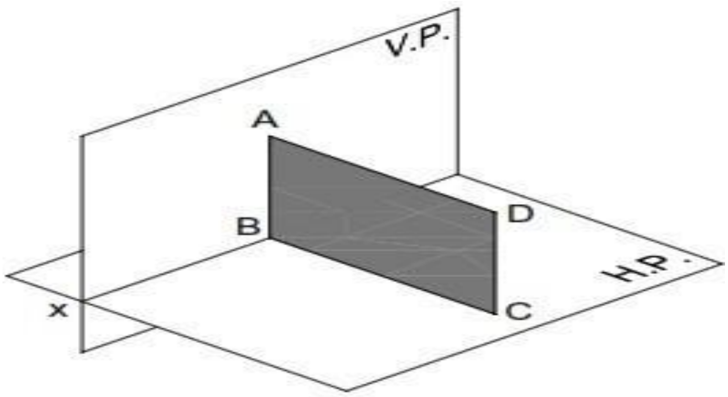


Fig. 64 Plane Perpendicular to both HP & VP

Plane inclined to both HP & VP.

A plane inclined to both the RPs is called an *oblique plane*. None of the views of the obliqueplane gives the true shape. It should be noted that the angles made by the oblique plane with the RPs (i.e., θ and ϕ) might not be directly given in the problem. Often, either of the inclinations, θ or ϕ, is given along with some other condition(s) that automatically pose the restriction on the other inclination. The problems on oblique planes are solved in three stages. In the first stage, the plane is often assumed to be parallel to one of the RPs so that the true shape can be obtained in one view. In the second stage, the given angle between the plane and the RP (i.e., either the HP or the VP) or some other condition mentioned in the problem is established. In the third stage, all other remaining conditions are satisfied.

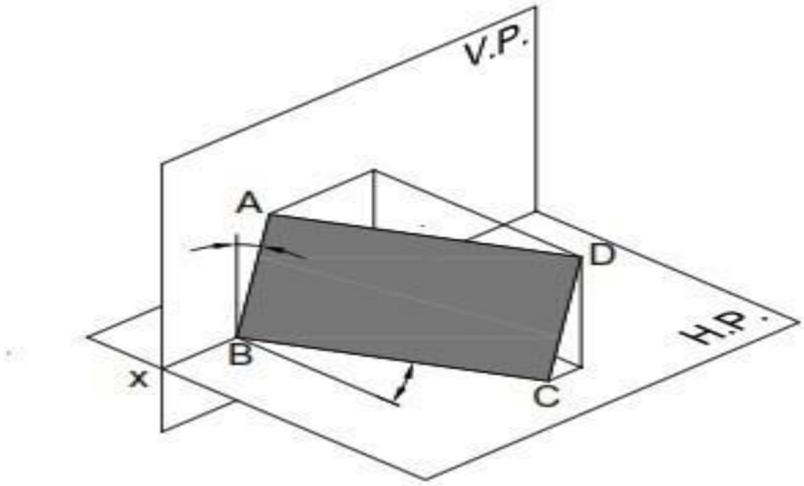


Fig. 65 Plane Inclined to both HP & VP

SHEET NO: 10
PROJECTIONS OF PLANES–I
PERPENDICULAR PLANES

1. Draw the projections of a regular hexagon of 25mm side having one its sides in the H.P. and inclined at 60 degree to the V.P. and it's surface making an angel of 45 degree with the H.P

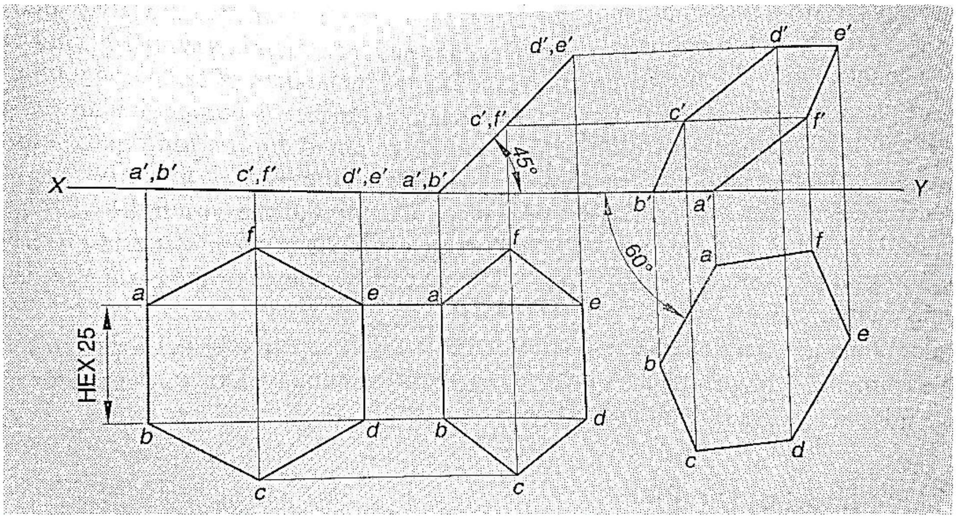


Fig . 66 Projections of a regular hexagon

2. A semicircular plate of 80mm diameter has its edge on the V.P and inclined at 30 degree to the H.P, while the surface of the plate is inclined at 45degree to the V.P. Draw the projection to the plate.

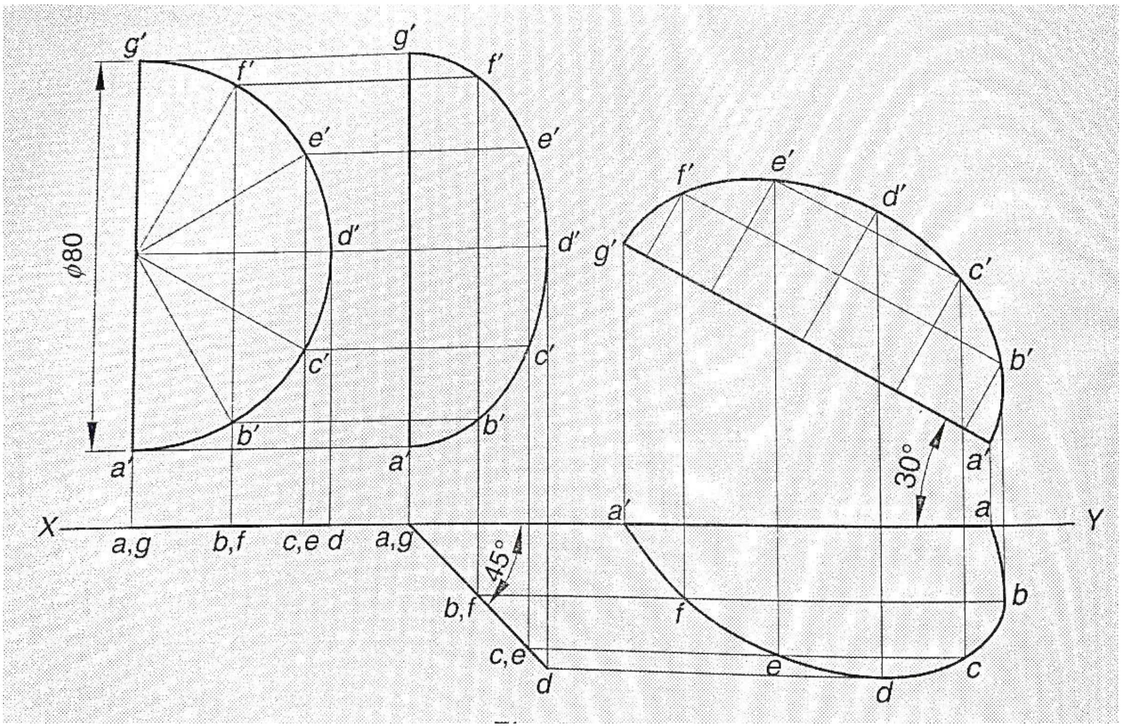


Fig . 67 Projections of a semicircular

SHEET NO: 11
PROJECTIONS OF PLANES–II
OBLIQUE PLANES

1. Draw the projections of a rhombus having 100mm and 40mm long diagonals. The bigger diagonal is inclined at 30 degree to H.P. With one of the end point H.P. and the smaller diagonal parallel to both the planes

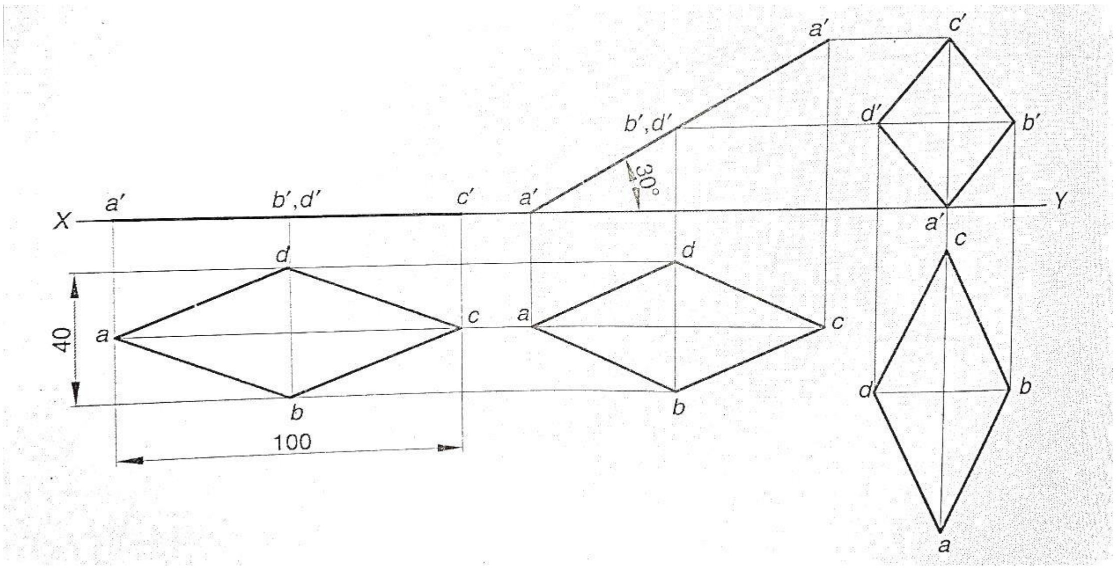


Fig . 68 Projections of a rhombus

2. A circular plate of negligible thickness and 50mm diameter appears as an ellipse in the front view, having major axis 50mm and minor axis 30mm long. Draw its top view when the major axis of the ellipse is horizontal.

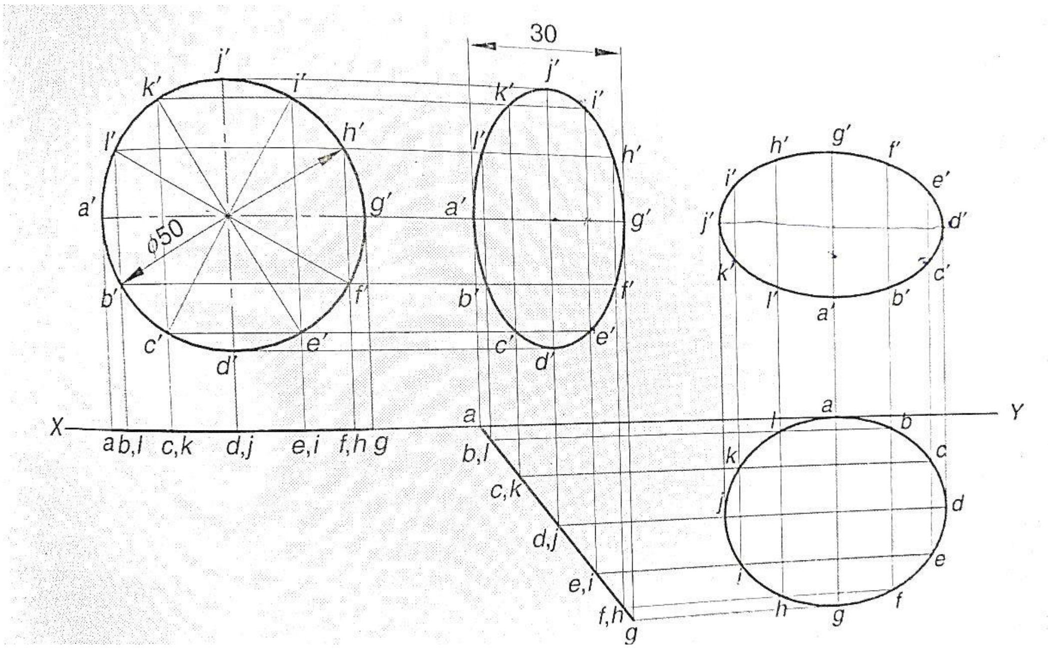


Fig . 69 Projections of a circular

3. A Pentagon ABCDE of 30 mm wide has its side AB in the V.P and inclined at 30 degree to the H.P, and the corner B is 15mm above the H.P. and the corner D is 30 mm in front of the V.P. Draw the projections of the plane and find it's inclination with the V.P

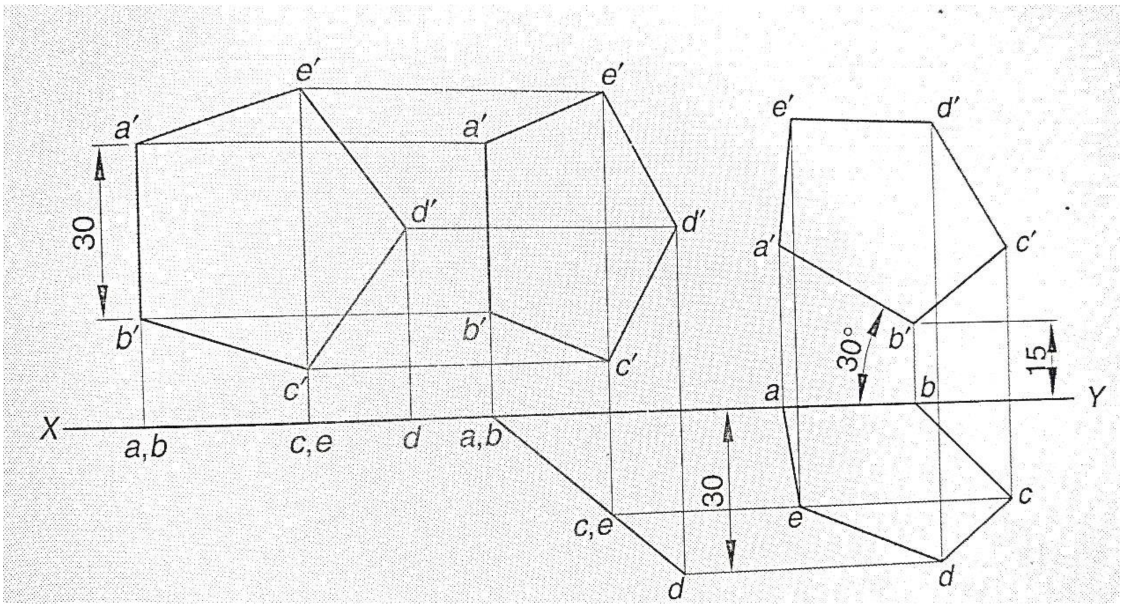


Fig . 70 Projections of a Pentagon

4. A Pentagonal lamina of 30mm side rests on the H.P on one its concerns with its surface inclined 30 degree to the HP. Draw its projections when the side opposite to the corner in the H.P is parallel to the V.P

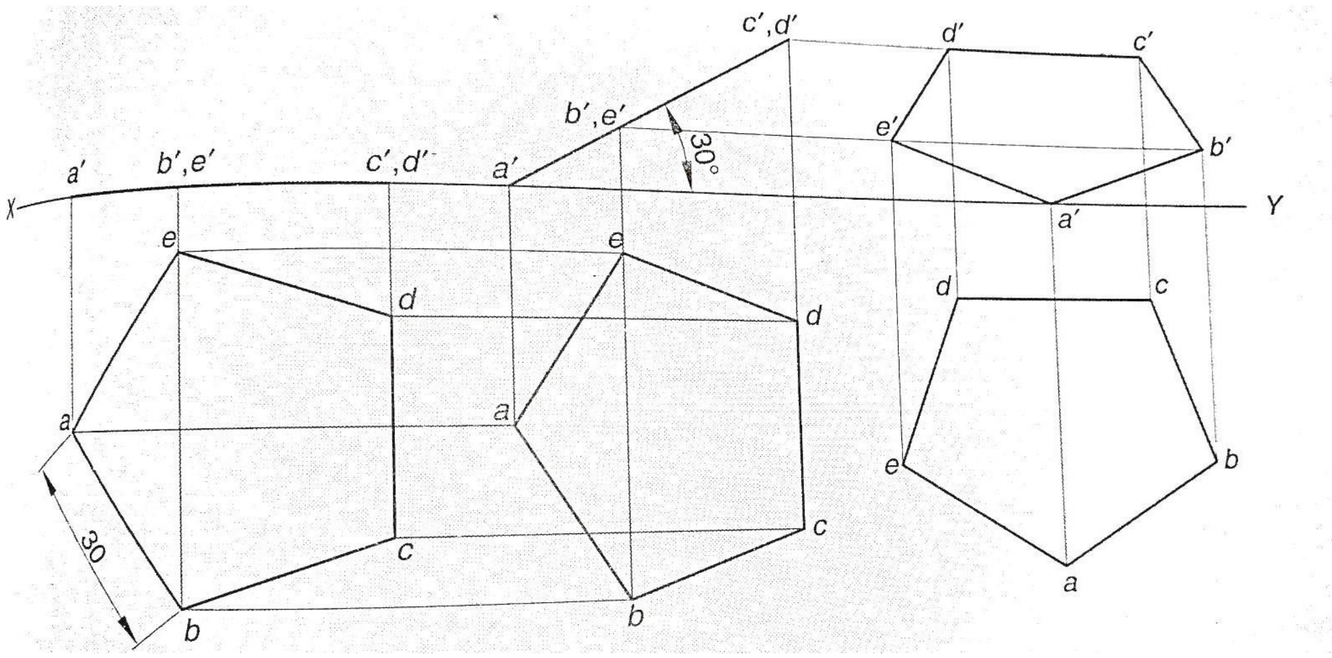


Fig . 71 Projections of a Pentagonal lamina

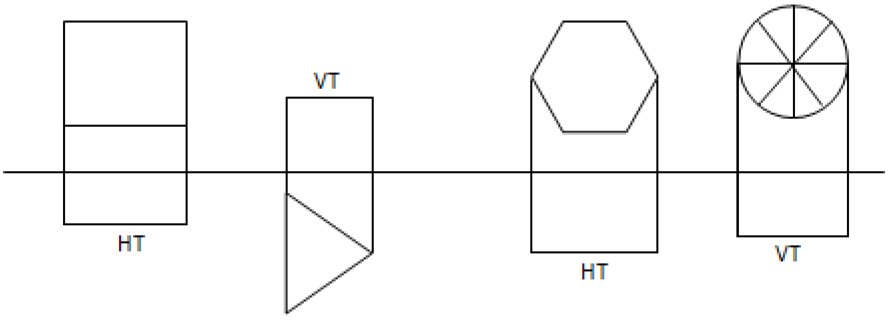
Viva Questions

Sheet no 10&11 : Projections of Planes- I,II

1. What is meant by trace of a plane?

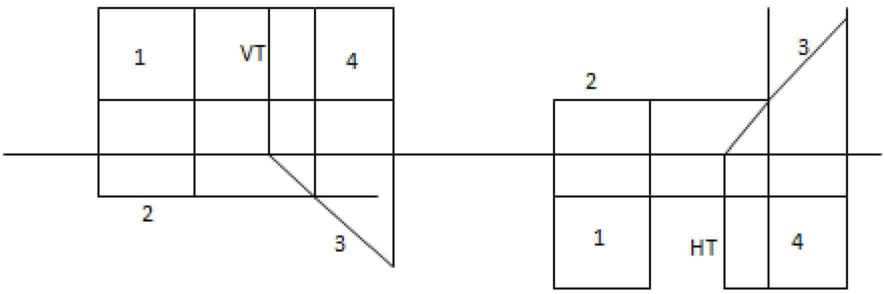
A. It is defined as the extension of a given plane shape to the reference plane (HP or VP) to which it is perpendicular or inclined. The plane meets the HP or VP as a line. This line is called trace of a plane.

2. Explain the terms horizontal trace (HT) and vertical trace (VT) for a plane.
A. The line in which the plane shape meets the HP is called HT and the line in which the plane shape meets the VP is called as VT.



(Refer to article 12.1 to 12.3 from ND Bhat on projections of planes – traces and general conclusions for further details)

3. Explain the method of determining a trace of a plane with simple sketches.
A. The traces for planes inclined to one reference plane (HP/VP) are given below.

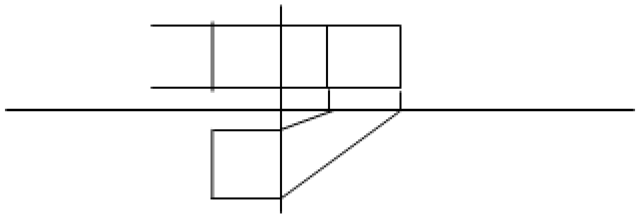


(Refer article 12.1 to 12.3 in projection of planes for more examples)
4. When does a plane have no traces?
A. When a plane is parallel to a plane, it has no trace on that plane.

5. Define oblique plane & auxiliary plane.
A. Oblique planes are planes which are inclined to both HP and VP. Auxiliary planes are planes parallel to section plane or cutting plane onto which the true shape of the cut section can be seen.

6. Explain oblique planes & their uses.
A. Oblique planes are the planes which are inclined to both HP and VP. With the help of these planes, we can find the orientation of a plane in its final position and also its approximate shape.

7. Describe the conditions necessary for a plane whose projections on to HP, VP & its traces are identical.
A. The plane is perpendicular to both HP and VP.



8. When a plane is perpendicular to a reference plane, what is the projection on that plane?
A. When a plane is perpendicular to a reference plane, its projection on that plane is a straight line.

9. When a plane is parallel to a reference plane, what is the projection on that plane?
A. When a plane is parallel to a reference plane, its projection on that plane will be its true shape and size.

PROJECTIONS OF SOLIDS

Any object having definite length, width and height is called a solid. In engineering drawing, solids are often represented by two or more orthographic views, i.e., FV, TV or SV. The study of the projections of a solid is very important in mechanical-design problems. The knowledge of projections of solids is essential in 3D modeling and animation. Projections of solids find wide applications in the construction industry.

Basic Solids

Basic solids are those which have predefined shapes. The basic solids are the constituent parts of any complex solid. Objects in the real world are made up of combinations of basic solids. In 3D modeling, the basic solids are called solid primitives. Solid primitives are combined in logicalways to obtain the desired 3D shape.

System of Notation

1. The actual plane in space is denoted by capital letters A, B, C and D etc.
2. The front view (FV) of a plane is denoted by their corresponding lower-case letters withdashes as a', b', c' and d' etc.
3. The top view (TV) of a plane is denoted by their corresponding lower-case letters without dashes as a, b, c and d etc.
4. The side view (SV) of a plane are denoted by their corresponding lower-case letters with double dashes as a”, b", c" and d" etc.
5. Projectors are always drawn as continuous thin lines.
6. Line with specific thickness for a particular type of line.

In Computer Aided Engineering Graphics for projection of solids following commands are used other than evoking software, opening file, saving file and giving print command. Using these minimum 13 commands any type of projection of line problem can be solved they are as follows:

1. Select tool Command.
2. Point command.
3. Poly-Line command.
4. Two Point Line command.
5. Parallel line command.
6. Center Circle command
7. Bisector command.
8. Smart Dimension command.
9. Line Width command.
10. Insert Text command.
11. Move Copy command.
12. Rectangle command.
13. Smart Delete Command

Classification of solids

Polyhedron

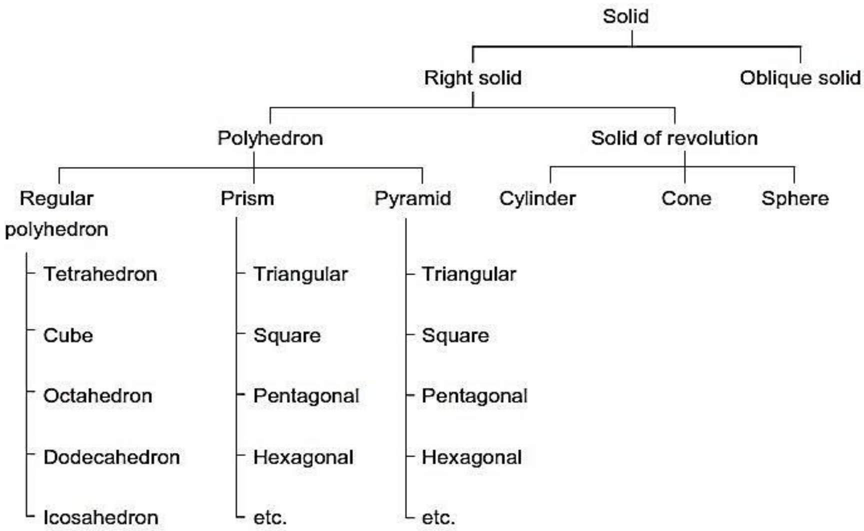


Fig . 72 Classifications of Regular Solids

A polyhedron is a solid bounded by planes called faces, which meet in straight lines called edges. A regular polyhedron has all the faces equal and regular as shown in Fig. 61

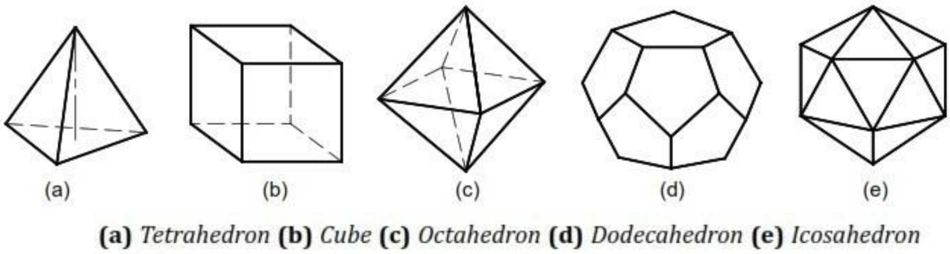


Fig . 73 Regular Polyhedron

Prism

A prism is a polyhedron with two n-sided polygonal bases which are parallel and congruent, and lateral faces are rectangles. All cross-sections parallel to the bases are congruent with the bases. An imaginary line that joins the centre of the bases is called an axis. A right and regular prism has regular polygonal bases, axis perpendicular to the bases and all the faces are equal rectangles, as shown in Fig. Prisms are named according to the shape of their base, so a prism with a triangular base is called a triangular prism; a square base is called a square prism and so on.

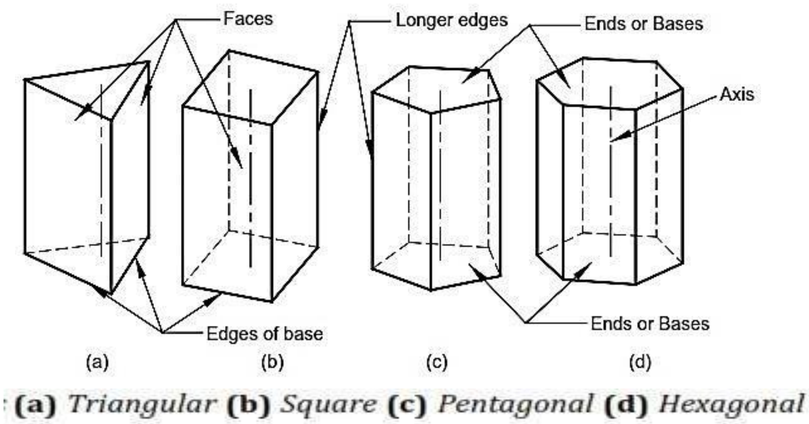
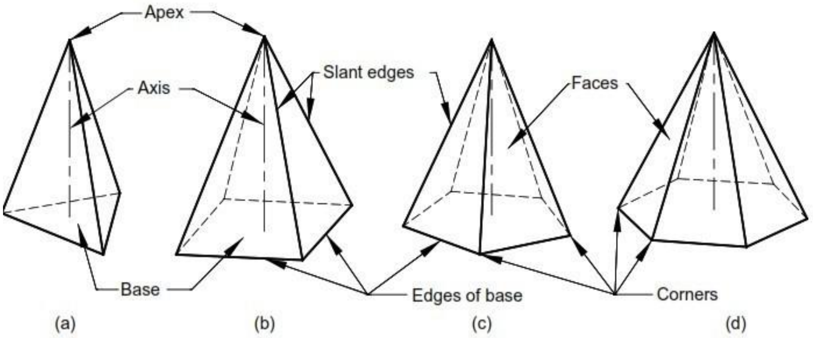


Fig. 74 Prism

Pyramid

A pyramid is a polyhedron with n-sided polygonal base and lateral faces are triangles meetingat a point called the vertex or apex. An imaginary line that joins the apex with the centre of the base is known as the axis. A right and regular pyramid has a regular polygon base, axis perpendicular to the base and all the faces are equal isosceles triangles, as shown in Fig. 3.4. Pyramids are named according to the shape of their base, so a pyramid with a triangular base is called a triangular pyramid; a square base is called a square pyramid and so on. The centre of gravity of pyramids lies on the axis at one-fourth of its height from the base.



: **(a)** *Triangular* **(b)** *Square* **(c)** *Pentagonal* **(d)** *Hexagonal*

Fig. 75 Pyramid

Solid of Revolution

These solids are obtained by revolving a plane figure like rectangle, triangle or a semi-circle about a fixed line.

Cylinder: A cylinder is a solid of revolution obtained by revolving a rectangle about one of its fixed side called an axis. It can be imagined as a prism of infinite number of lateral faces. Any line on the surface of a cylinder is called its generator. Thus, a cylinder has an infinite number of generators. A right cylinder has all the generators and the axis perpendicular to the base, as shown in Fig.

Cone: A cone is obtained by revolving a triangle about its fixed side called an axis. A cone can be imagined as a pyramid with infinite number of lateral faces. Any line on the surface of a cone is called its generator. Thus, a cone has an infinite number of generators. A right cone has all generators of equal length and the axis perpendicular to the base, as shown in Fig.

Sphere: A sphere is obtained by revolving a semi-circle around its diameter, as shown in Fig

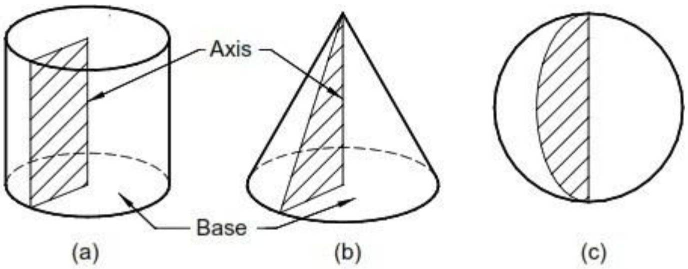
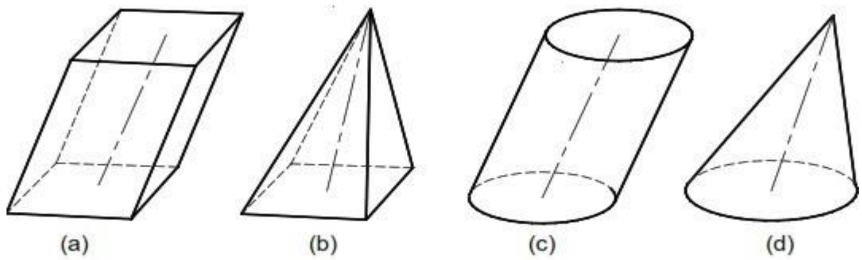


Fig . 76 Sphere

Oblique Solid

An oblique solid such as oblique prism, pyramid, cylinder or cone has its axis inclined to its base as shown in Fig.3.6. The faces of an oblique prism are parallelograms of different sizes.

The faces of an oblique pyramid are triangles of different sizes. The generators in an oblique cylinder have equal lengths whereas those in an oblique cone have unequal length

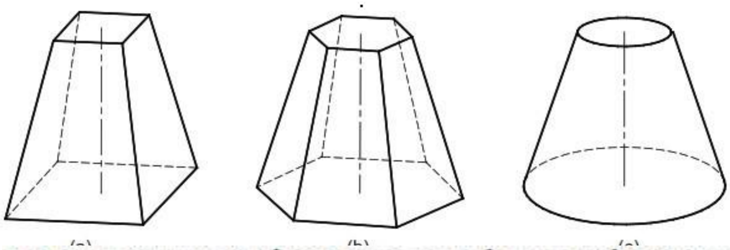


(a) *Square prism* **(b)** *Square pyramid* **(c)** *Cylinder* **(d)** *Cone*

Fig . 77 Oblique Solid

Frustum of Pyramid and Cone:

When a regular pyramid or a cone is cut by a plane parallel to its base and the portion of the solid containing apex is removed, the remaining portion of the solid is called the frustum of that pyramid or cone, as shown in Fig. 78



(a) *Square pyramid* **(b)** *Hexagonal pyramid* **(c)** *Cone*

Fig . 78 Frustum of Pyramid and Cone

Recommended Method of Labelling

It is recommended to label the corners of the solids in a manner as shown in Fig.

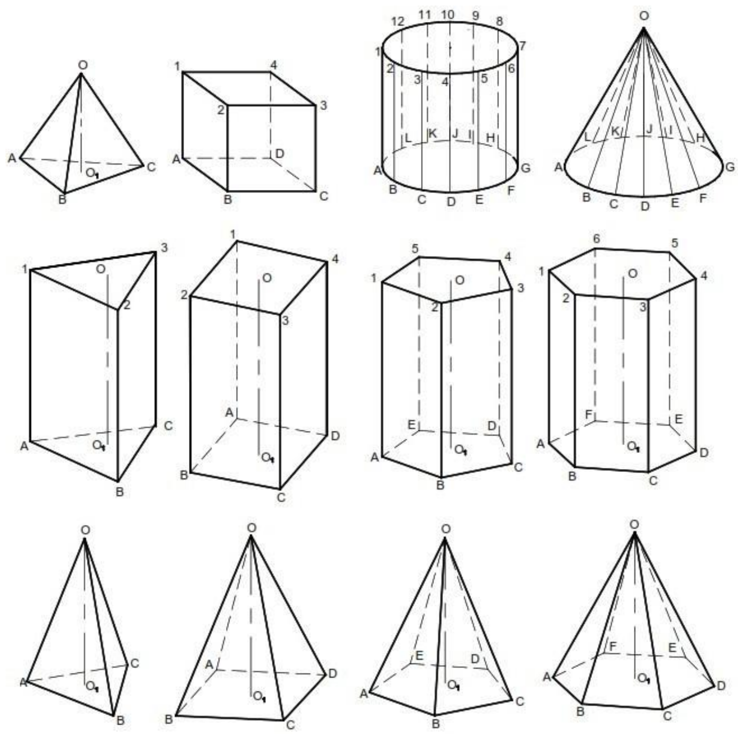


Fig . 79 Method of Labelling

Positions of Solids

The position of a solid in space is specified by the inclinations of its axis with the RPs. Therefore, a solid will have positions with respect to RPs same as that of a line. Depending onthe orientation of its axis in space, a solid may have the following positions

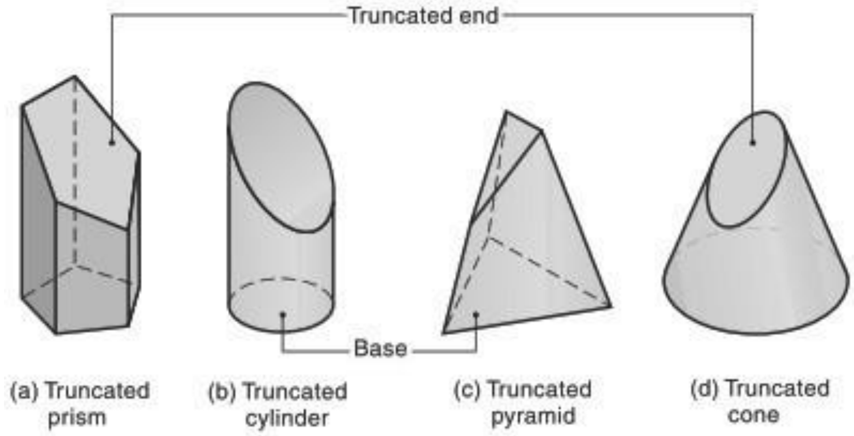


Fig . 80 Truncated Solids

The solid may be in one of the following positions:

1. Axis perpendicular to the H.P.
2. Axis perpendicular to the V.P.
3. Axis parallel to both the H.P. and the V.P. (i.e., perpendicular to the profile plane)
4. Axis inclined to the H.P. and parallel to the V.P.
5. Axis inclined to the V.P. and parallel to the H.P.
6. Axis inclined to both the H.P. and the V.P.
7.

Axis Perpendicular to H.P.

This is one of the basic positions of the solid. It is evident that if the axis of a right solid is perpendicular to the H.P., its base will be parallel to the H.P. The true shape and size of the base can be viewed in the top view. Therefore, first obtain the top view of the solid and then project it to obtain the front view.

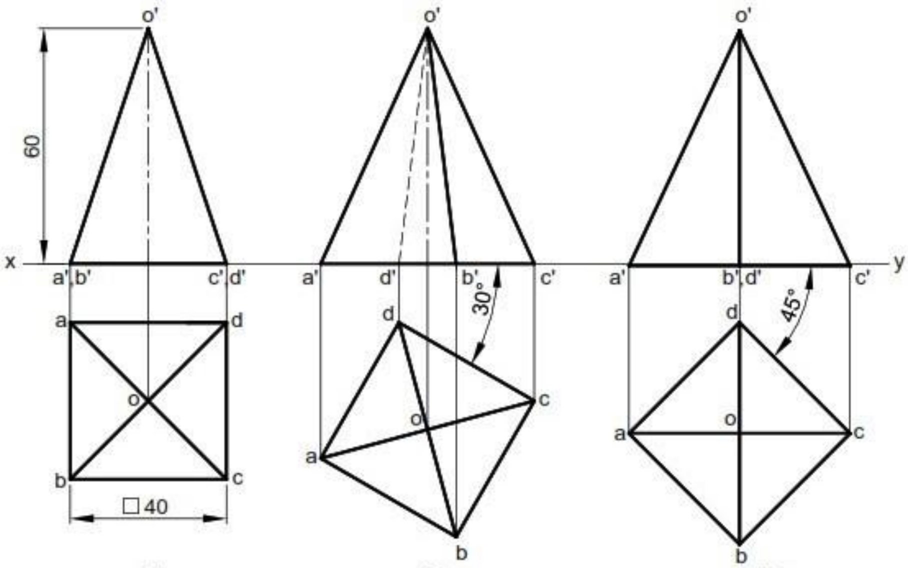


Fig . 81 Axis Perpendicular to H.P

Axis Perpendicular to V.P.

This is one of the basic positions of the solid. It is evident that if the axis of a right solid is perpendicular to the V.P., its base will be parallel to the V.P. The true shape and size of the base can be viewed in the front view. Therefore, first obtain the front view of the solid and then project it to obtain the top view.

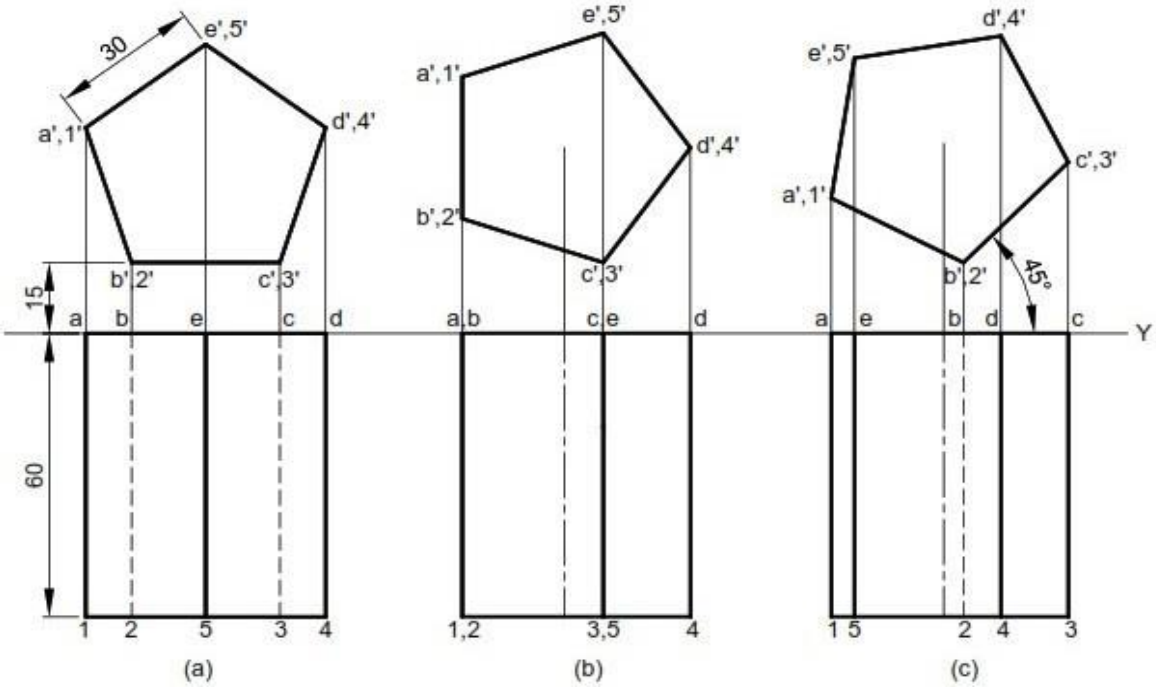


Fig . 82 Axis Perpendicular to V.P

Axis Parallel to both H.P. and V.P.

It is evident that if the axis of right solids is parallel to both H.P. and V.P., the base of thesolid will be perpendicular to the reference planes and parallel to the profile plane. The true shape and size of the base can be viewed in the side view. Therefore, first obtain the sideview of the solid and then project it to obtain the front and the top views.

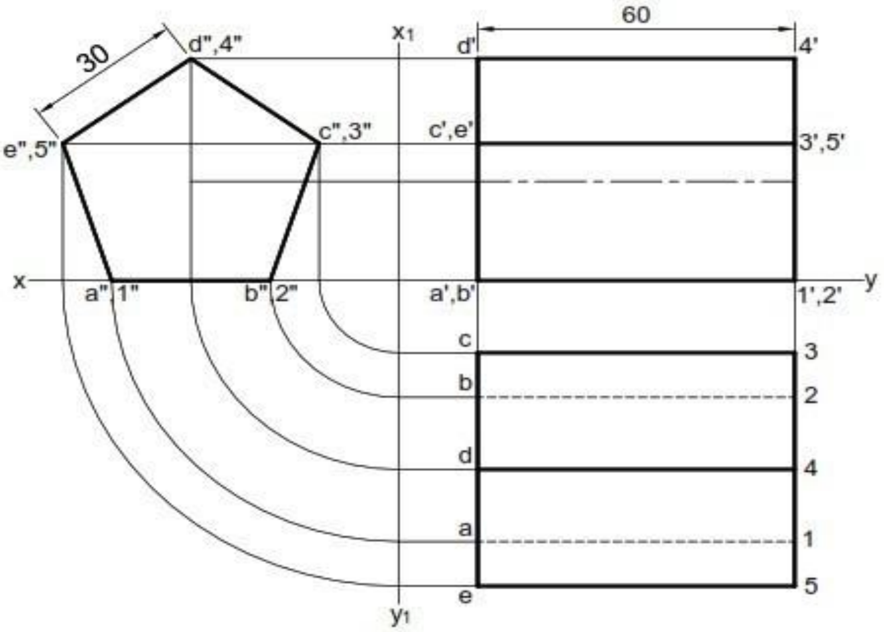


Fig . 83 Axis Parallel to both H.P and V.P.

Axis inclined to the R.P. and parallel to the R.P.

If the axis of a solid is inclined to one RP and parallel to the other RP then the problem is solved in two stages. In the first stage, the axis is assumed to be perpendicular to the RP to which it is finally inclined. The view obtained on that RP will give the true shape of the base. The corresponding other view will give the TL of the axis. In the second stage, the other view is redrawn in such a way that the axis will make the required angle with the given RP. Here, it should be noted that the inclination of the axis with a particular RP might not be given directly. Instead, it may be expressed in terms of other parameters, as mentioned earlier.

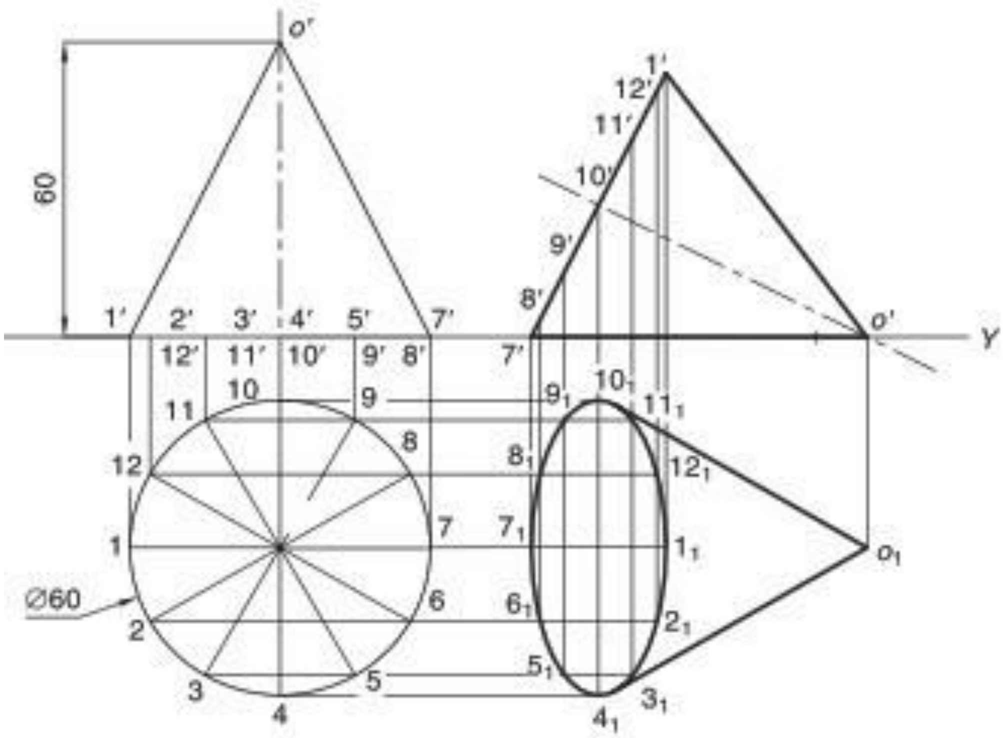


Fig . 84 Axis inclined to the H.P. and parallel to the V.P.

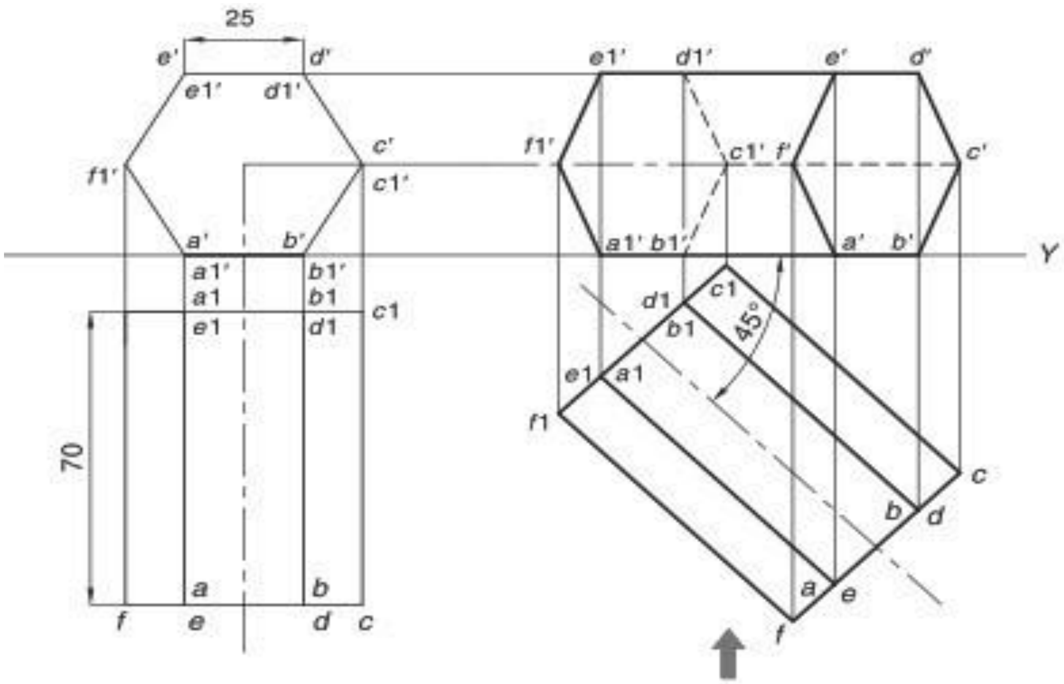


Fig . 85 Axis inclined to the V.P. and parallel to the H.P.

Axis inclined to the both R.P 'S.

If the axis of a solid is inclined to both the RPs then the problem is solved in three stages. As already mentioned, the inclinations of the axes may not be given directly. Instead, it may be indirectly mentioned by means some other parameters. If the inclinations are given directly then, in the first stage, the axis is assumed to be perpendicular to any one RP. The view obtained on that RP will give the true shape of the base. The corresponding other view will give the TL of the axis. In the second stage, the other view is redrawn so that the axis will make the required angle with the RP to which it was initially perpendicular. The corresponding next view is obtained in the second stage. In the third stage, the next view is redrawn so as to make the 'desired inclination' of the axis with the other RP. Here, the 'desired inclination' is the apparent inclination of the axis which is obtained by using the theory of projections of the lines. The view thus obtained satisfies all the conditions, i.e., inclinations with both the RPs, and hence represents the final view. This view is thenprojected to obtain the other corresponding final view.

If the inclinations are not given directly then the first stage must be decided carefully. Often an inclination of the axis with one RP is given and the inclination with the other RP is givenin terms of the inclination of an edge or face of the solid. In such a case, the first stage is to keep the axis perpendicular to that RP with which its inclination is known. In the second stage, the required inclination with that RP is obtained. In the third stage, the other condition, viz., inclination of the face or inclination of an edge, is established. It must be remembered that, in the first stage, the solid is always kept in such a way that the true shape of the baseand TL of the axis are visible. This helps to satisfy the condition on the axis (mentioned Directly or indirectly) easily in the second stage. Note that one view in the second stage always gives TL of the axis (since it is simply redrawn from the first stage).Other possibilities are explained with the help of examples.

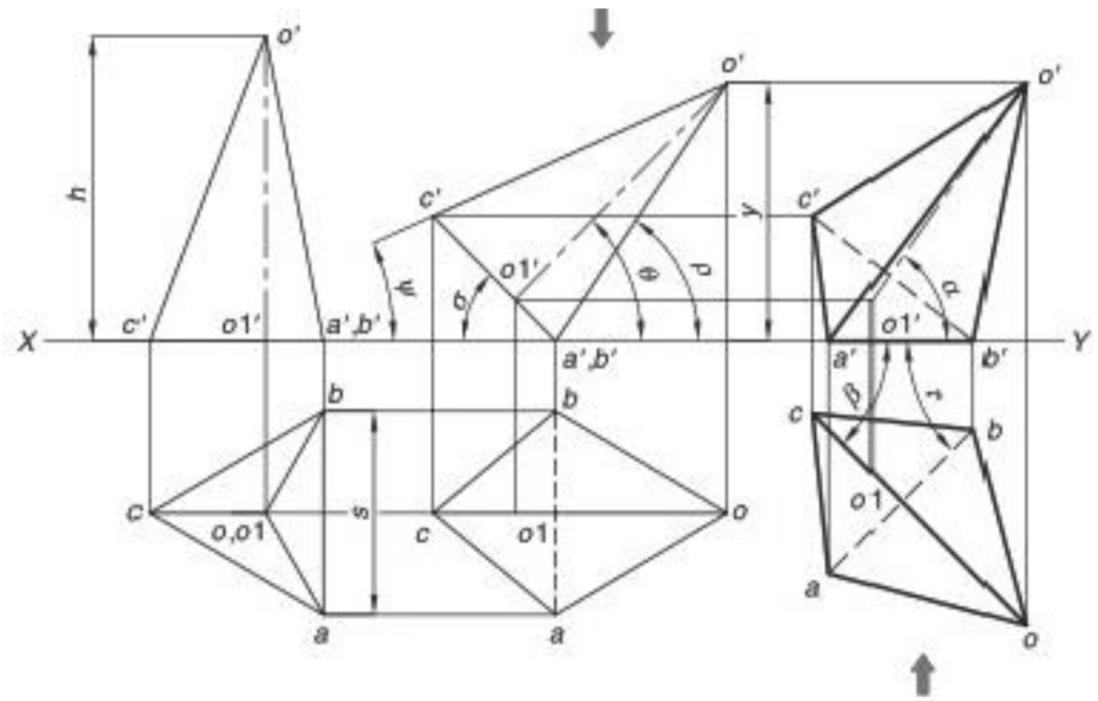


Fig . 86 Axis inclined to the both R.P

SHEET NO: 12
PROJECTIONS OF SOLIDS–I

Axis parallel to HP or VP, projection of regular solids in simple position.

1. A right regular pentagonal prism, 25mm edge of base and 55mm height rests on edge of is base in H.P. such that axis is parallel to V.P. and inclined to H.P at 45 degree. Draw the projections of the solid

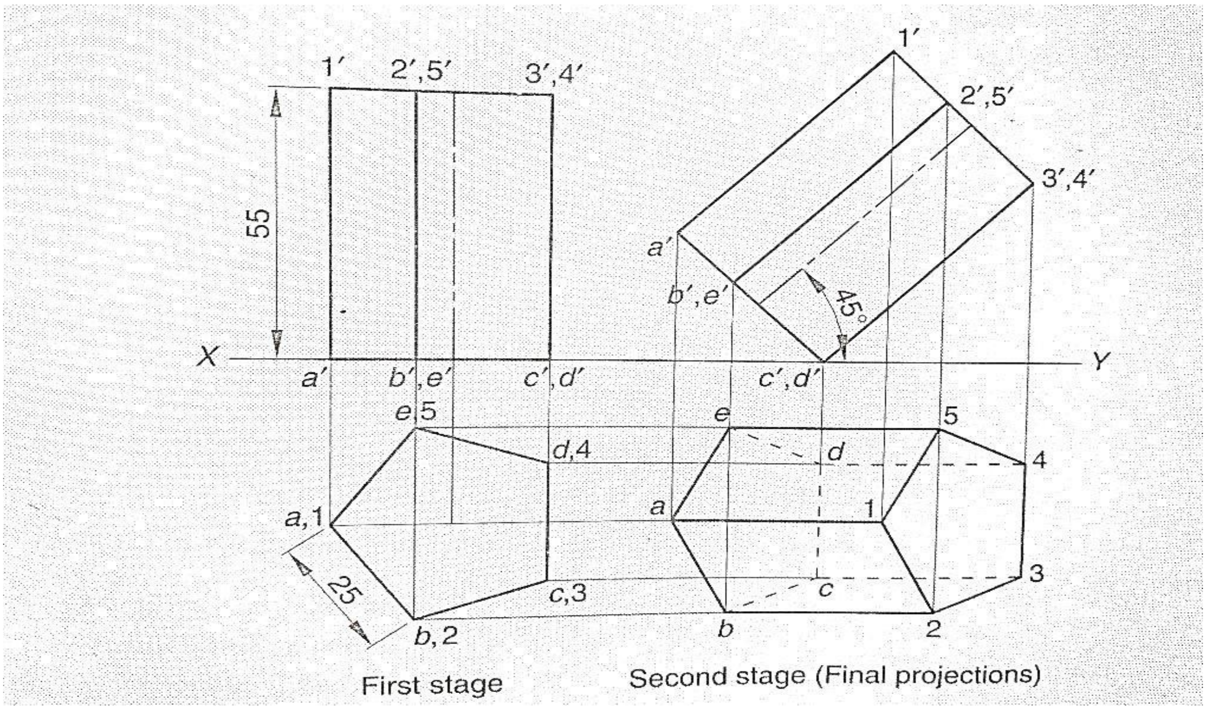


Fig . 87 Projections of a regular pentagonal prism

2. A hexagonal pyramid, base 25mm side and axis 50mm long an edge of its base on the ground. Its axis is inclined at 40 degree to the ground and parallel to the V.P. Draw it's projections.

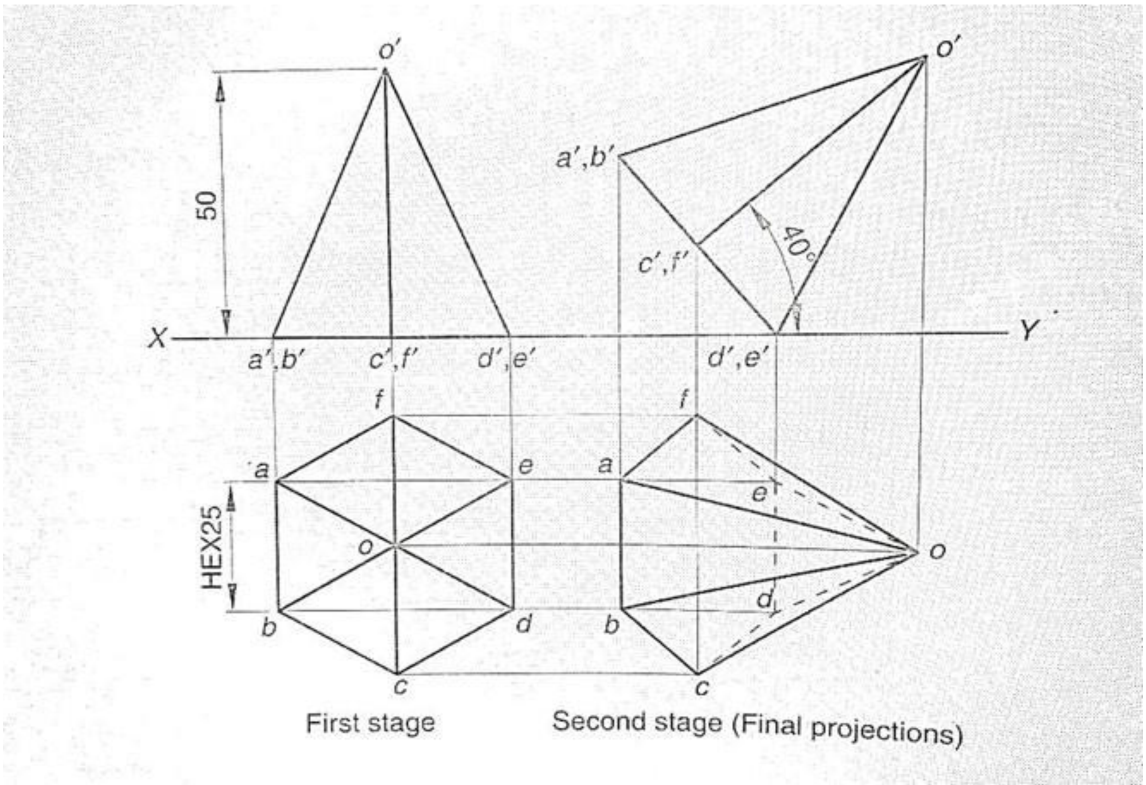


Fig . 88 Projections of a hexagonal pyramid

SHEET NO: 13

PROJECTION OF SOLIDS–II

Projections of solids axis Inclined to one or both the reference planes.

1. A right pentagonal prism, 60mm high with each side of the base 30mm is resting on one of edges on the horizontal plane and inclined at 30 to V.P. and face containing that you she is inclined at 45degree to H.P. Draw the projections of the pentagonal prism

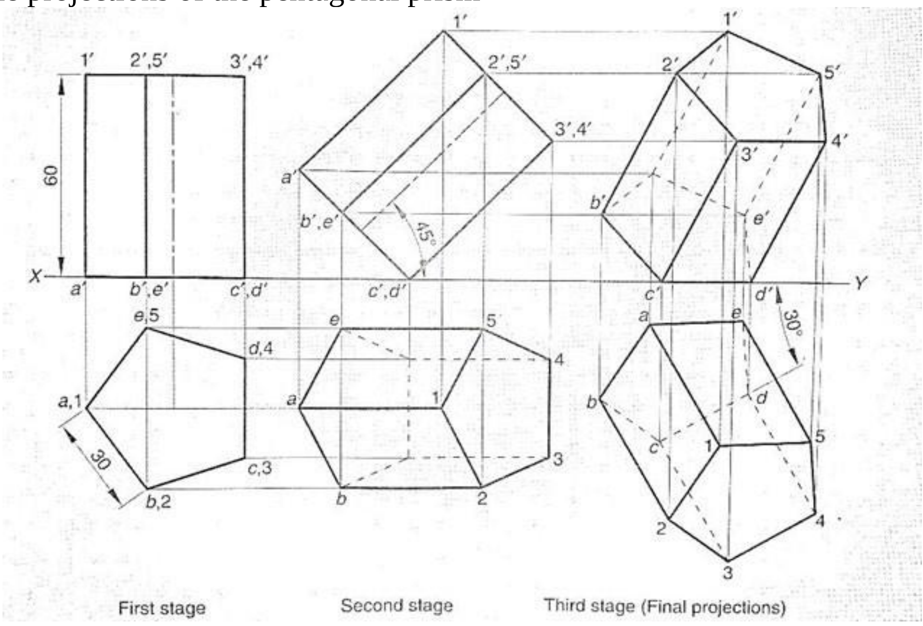


Fig . 89 Projections of a pentagonal prism

2. A hexagonal pyramid of 25mm base side and 55mm long axis, has one its slant edges on the ground. A plane containing that edge and the axis is perpendicular to H.P. and inclined at 45degree to V.P. Draw it's projections, when the apex is nearer to V.P then the base.

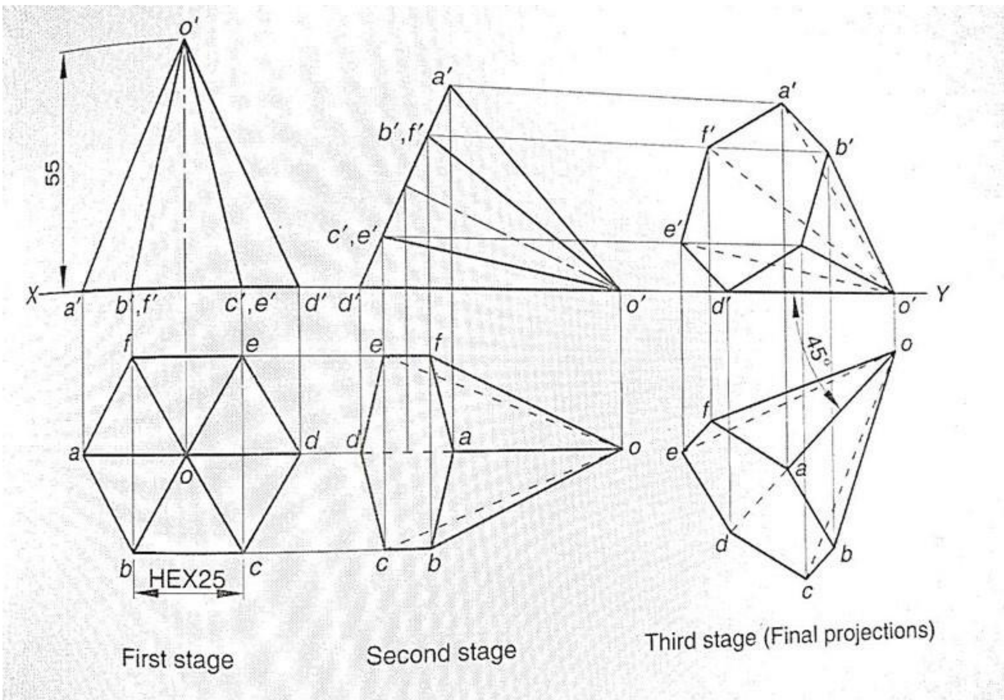


Fig . 90 Projections of a hexagonal pyramid

Viva Questions

Sheet no:12&13 Projections of Solids- I,II

1. Give a detailed classification of solids.

A. Solids are 3 dimensional objects defined by length, breadth and height. Solids may be divided into two main groups: Polyhedra and Solids of revolutions. In polyhedra, the solids are bounded by planes called faces. E.g. Prisms, pyramids, frustums, truncated solids, etc. In solids of revolution, a polygonal shape (rectangle, triangle, semicircle, etc) is revolved about a fixed side to generate the required solid. Eg. Cylinders, cones and spheres.

2. What is meant by polyhedron? Give examples.

A. A polyhedron is a solid bounded by planes, which are called as faces. A prism has rectangular faces and a pyramid has triangular faces. Eg. Polyhedra are prisms, pyramids.

3. What is meant by regular polyhedra? Give examples.

A. When all faces of the polyhedra are equal and regular, it is called as regular polyhedra. E.g. Cube (hexahedron), tetrahedron, icosahedrons, etc.

4. State the number of faces and shape of the face for (i) tetrahedron; (ii) Hexahedron; (iii) octahedron; (v) dodecahedron; (vi) Icosahedron

A: tetra-4 equilateral triangles; hexa- 6 squares(cube); octa-8 equilateral triangles; dodeca- 12 pentagons; icosa-20 equilateral triangles

5. What are solids of revolution? Give three examples and their formation

A. Solids of revolutions are solids obtained by revolving a polygon about a fixed side. There are 3 solids of revolutions, namely, cylinder, cone and sphere. A cylinder is obtained by revolving a rectangle about one of its sides which remains fixed. A cone is obtained by revolving a right angle triangle about one of its perpendicular sides which is fixed. A sphere is obtained by revolving a semicircle about its diameter as its axis.

6. Define frustum and truncated solid.

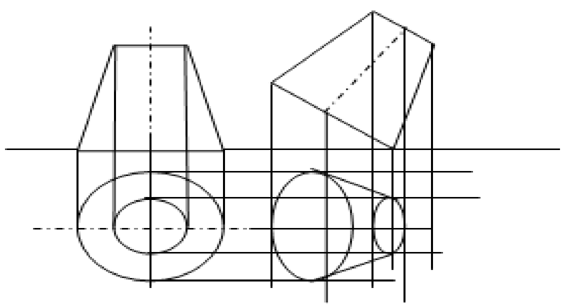
A. When a pyramid or cone is cut by a section plane parallel to its base, removing the top portion, the remaining portion is called its frustum. When a solid is cut by a plane inclined to its base, removing the top portion, the remaining portion is called as its truncated part.

7. A_________is a solid bounded by planes called______which meet in straight lines called_______. (Ans: Prism; faces; edges)

8. What are the ways to determine the visibility of an edge while drawing the projection of solids?

A. To determine the visibility of an edge while drawing, first give labelling to the base sides of the polygon. Then the edges along the labelled corners which are farther away from the HP/VP will be visible and the edges along the labelled corners nearer to the HP/VP will be invisible.

9. Name the solid whose projection in any position on to a plane is identical. Also name the shape of the projection. (Ans: Sphere; circle). The top view of a frustum of a right circular cone resting on HP is concentric circles of 50 mm 20 mm diameter. Sketch the front view when the generators are inclined at 45^0.



SECTIONS OF SOLIDS

The orthographic views of a solid may contain a number of dotted lines. These lines indicate the presence of hidden details which may lie behind or somewhere in the middle of the object. The interpretation of the object's shape becomes difficult with increasing number of such lines. As a remedy, it becomes obligatory to draw sectional views for a better and easier interpretation of the internal features. The present chapter describes the methods of obtaining sectional views and other related drawing.

The object is considered to be cut by a plane called a section plane or a cutting plane. The portion of the object, which falls between the section plane and the observer, is assumed to be removed. Thus, the internal details become visible. The projections of the remaining objectare termed as sectional views. It is always convenient to start by drawing the orthographic views of the uncut object. Then these are modified into sectional views. The cut surfacewhich is common to the object and the section plane is shaded with parallel lines called hatching to differentiate it from other surfaces. If the section plane is inclined to the plane of projection, the cut surface does not show its true shape. In such cases, it is generally required to determine the true shape of the cut surface popularly called the true shape of section.

Terminology

The following terms are frequently used in this chapter:

1. **Section plane:** It is an imaginary plane which cuts the given object to show the internal details. This plane is represented by its trace.
2. **Cut surface:** It is the surface created due to cutting the object by section plane. It is shown by hatching lines.
3. **Hatching lines:** These are used to indicate the cut surface. These are represented by continuous lines drawn at 45º to the reference line, parallel to each other at a uniform spacing of 2 to 3 mm.
4. **Apparent section:** It is the projection of cut surface when the section plane is not parallel to the plane of projection.
5. **True shape of section:** The projection of the cut surface on a plane parallel to the sectionplane is known as true shape of section. It shows actual shape and size of the cut surface.

Types of Section Planes

Section planes are of the following types:

1. Section plane perpendicular to V.P.
   (a) Horizontal section plane
   (b) Auxiliary inclined plane (A.I.P.)
2. Section plane perpendicular to H.P.
   (a) Plane parallel to V.P.
   (b) Auxiliary vertical plane (A.V.P.)
3. Profile section plane, i.e., a plane perpendicular to both the H.P. and the V.P.
4. Oblique section plane, i.e., inclined to both H.P. and V.P. (not considered in current study)

Section Plane Perpendicular to V.P.

A section plane that is perpendicular to the V.P. may either be parallel or inclined to the H.P.

1. **Horizontal section plane**

It is a plane parallel to the H.P. as shown in Fig. 3.16 (a). Its front view is a straight line parallel to xy. This line also represents the vertical trace (V.T.) of the section plane as shown in Fig. 3.16 (b). This plane has no horizontal trace. When an object is cut by a horizontal section plane, the sectional top view of the object gives the true shape of the section.

2. **Auxiliary inclined plane (A.I.P.)**

It is a plane perpendicular to the V.P. and inclined to the H.P. as shown in Fig. 3.17(a). Its front view is a straight line inclined at θ to xy. This line also represents the vertical trace (V.T.) of the section plane as shown in Fig.3.17(b). The horizontal trace (H.T.) of this plane isa line perpendicular to xy. When an object is cut by an auxiliary inclined plane, the true shapeof section is obtained by projecting the apparent section of the object on another plane parallel to the plane

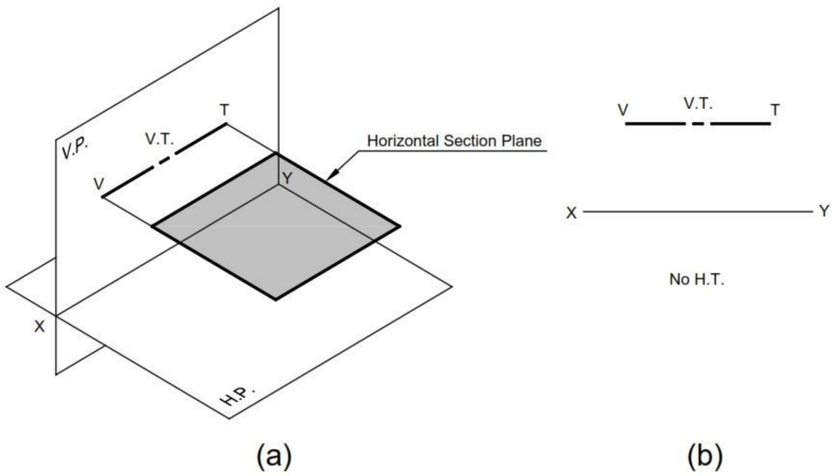


Fig . 91 Horizontal section plane (a) Pictorial view (b) Orthographic view

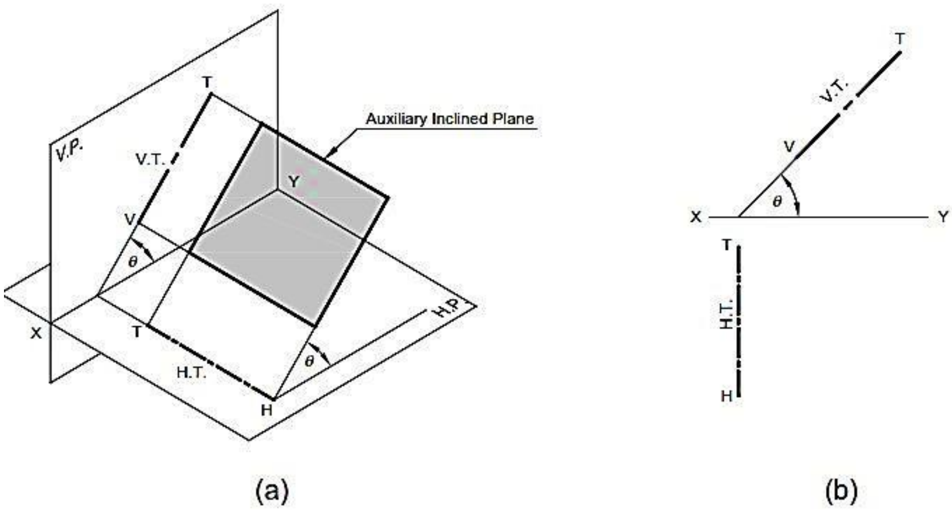


Fig . 92 Auxiliary inclined plane (a) Pictorial view (b) Orthographic view

Section Plane Perpendicular to H.P.

A section plane that is perpendicular to the H.P. may either be parallel or inclined to the V.P.

1. **Section plane parallel to V.P.**

It is a plane perpendicular to the H.P and parallel to the V.P. as shown in Fig.3.18 (a). Its top view is a straight line parallel to xy. This line also represents the horizontal trace (H.T.) of the section plane as shown in Fig. 3.18 (b). This plane has no vertical trace. When an objectis cut by a section plane parallel to the V.P., the sectional front view of the object gives the true shape of section.

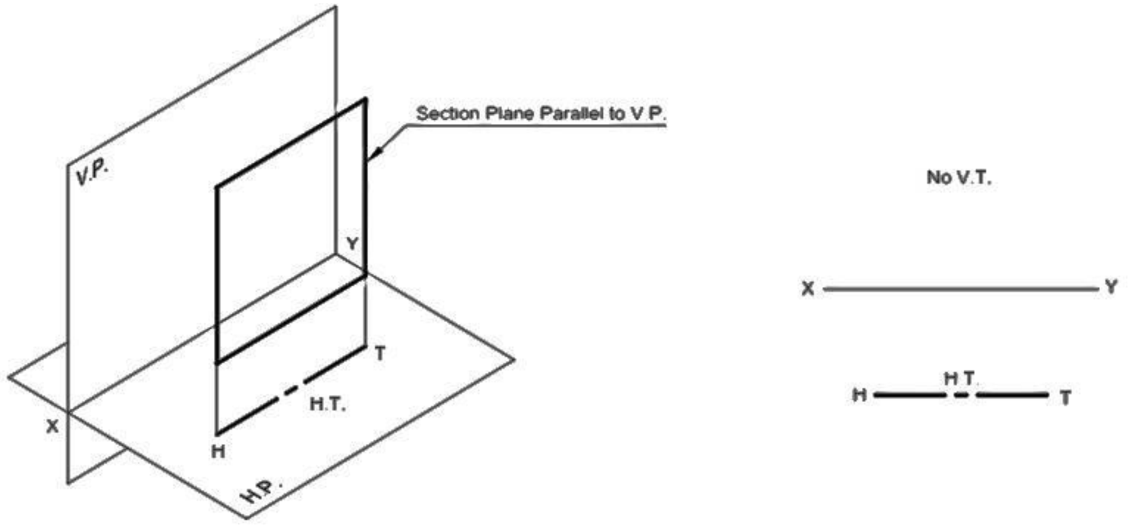


Fig . 93 Section Plane Parallel to VP (a) Pictorial view (b) Orthographic view

2. **Auxiliary vertical plane (A.V.P.)**

It is a plane perpendicular to the H.P. and inclined to the V.P. as shown in Fig. 3.19 (a). Its top view is a straight line inclined at ϕ to xy. This line also represents the horizontal trace (H.T.) of the section plane as shown in Fig. 3.19 (b). The vertical trace (V.T.) of the section plane is a line perpendicular to xy. When an object is cut by an auxiliary vertical plane, the true shape of section is obtained by projecting the apparent section of the object on anotherplane parallel to the section plane.

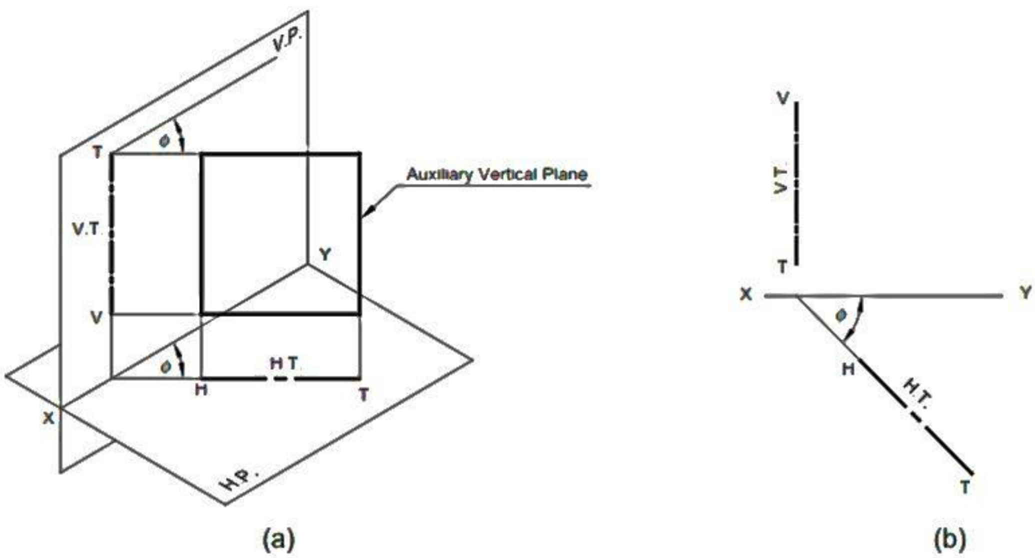


Fig . 94 Auxiliary vertical plane (a) Pictorial view (b) Orthographic view

Profile Section Plane

It is a plane perpendicular to both the H.P. and the V.P. as shown in Fig. 3.20 (a). Both of itstop and front views are straight lines perpendicular to xy. These lines also represent H.T. and V.T. respectively as shown in Fig. 3.20 (b). The sectional side view gives the true shape ofsection.

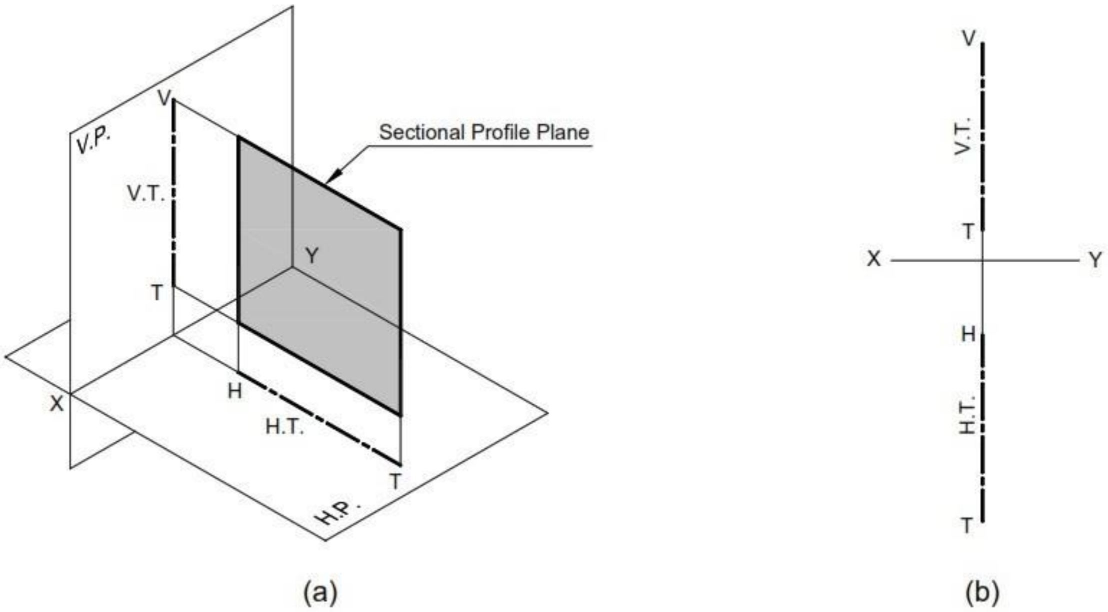


Fig . 95 Profile Section Plane (a) Pictorial view (b) Orthographic view

Note

(a) In case where two or more positions of section planes are possible to draw which satisfiesthe given conditions then as far as possible, the section plane through which minimum portion of the solid is cut away is selected.

(b) The portion of the solid lying between the observer and the section plane is assumed to be removed. The retained part of the solid is drawn with dark continuous lines and removed part of the solid with thin continuous lines.

(c) The hatching lines (section lines) are used to indicate cut surface in the sectional view. Usually, the hatching lines are inclined at 45º to the principal planes. If the boundary of the object itself is inclined at 45º to the reference line, hatching lines may draw at 45º to the boundary or at 30º or 60º to the reference line.

SHEET NO: 14

SECTION OF SOLIDS – I

When the sectional plane is parallel or perpendicular to one reference plane.

1. A regular circular cone of the 45mm base diameter and 55 mm axis long is lying on one its generators on the H.P. It's is cut by a horizontal section plane passing through the midpoint of the axis. Draw the projections of the cone and it's true section.

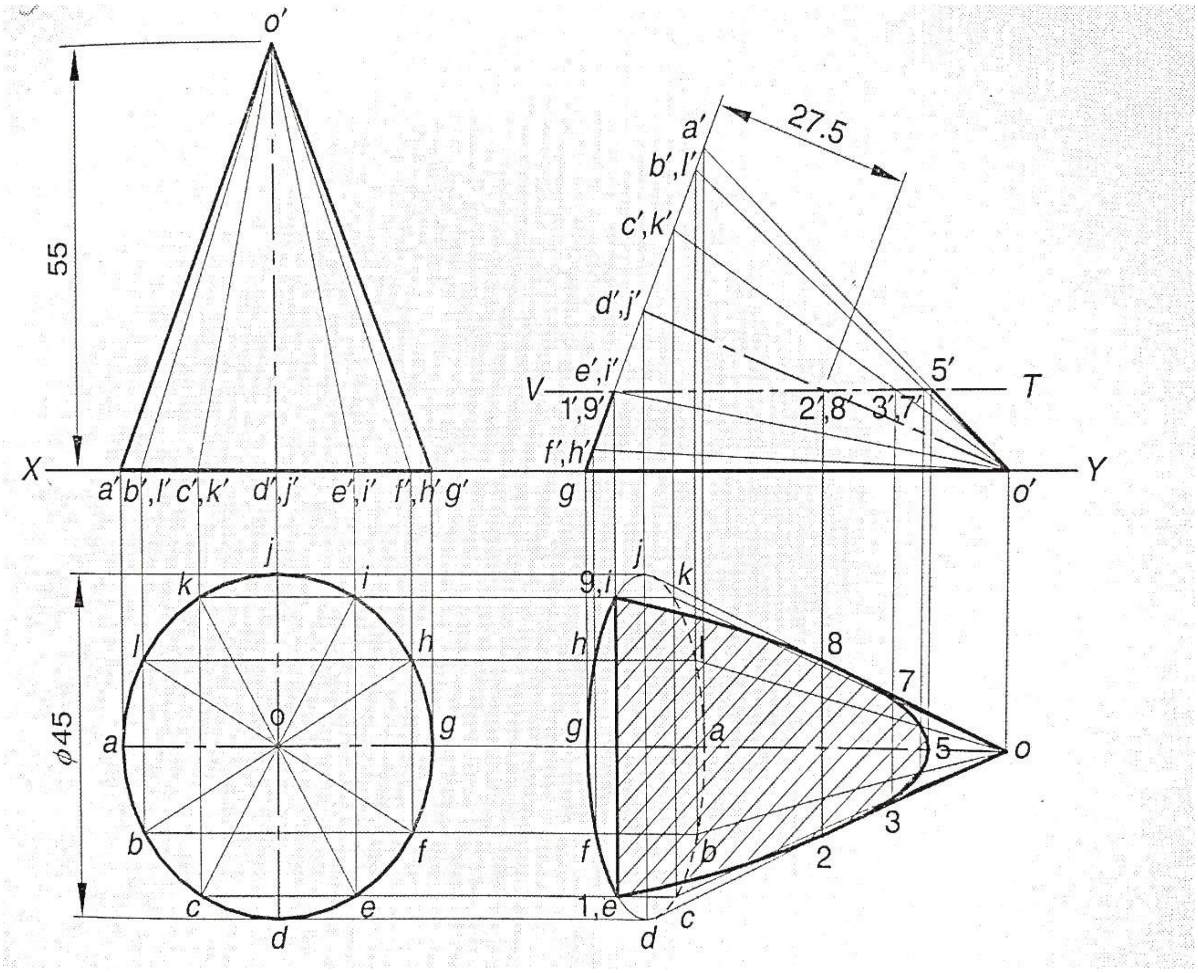


Fig . 96 Projections of a regular circular cone

SHEET NO: 15

SECTION OF SOLIDS–II

Sectional plane is inclined to one reference plane.

1. A cylinder of 45mm diameter and 70mm long is resting on one of its bases on H.P. It is cut by a section plane inclined at 60degree with H.P. and passing through a point on the axis at 15mm from one end. Draw the two views of the solid. Also obtain the true shape of the section.

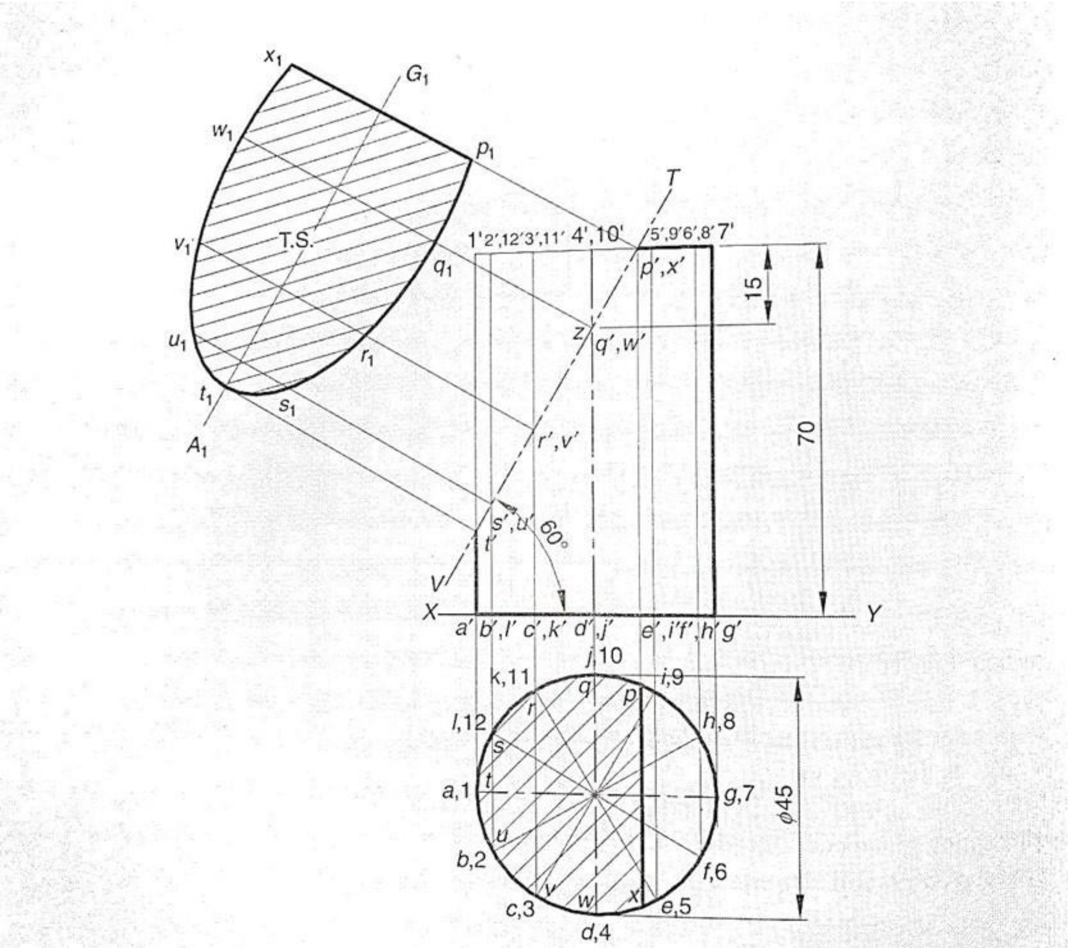


Fig . 97 Projections of a cylinder

Viva Questions

Sheet no : 14&15 Sections of solids – I,II

1. Define sectional plane, section and sectional view (sectional top view, sectional front view and sectional side view).

A. Section plane: It is the cutting plane that cuts the solid at different orientations to generate a section of the solid. The section plane can be oriented w.r.t HP and VP like parallel to, perpendicular to, inclined to, etc. Section planes are referred to by their traces.

If a section plane is inclined to HP, it is referred to as the VT makes angle with xy.

If a section plane is inclined to VP, it is referred to as the HT makes angle with xy.

Section: It is the cut portion of the solid obtained after cutting the solid by the sectional plane.

Sectional View: It is the portion of the solid shown along with the section part in one of the views.

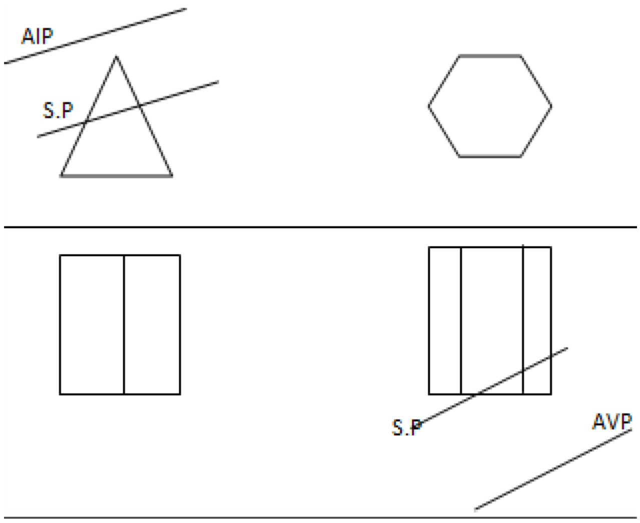
If the section is shown along with the top view, it is called as sectional top view.

If the section is shown along with the front view, it is called sectional front view.

If the section is shown along with the side view, it is called sectional side view.

2. What is meant by auxiliary plane? What is its use in sections of solids?

A. An auxiliary plane is a reference plane drawn parallel to the section plane. Its use in sections of solids is that whenever the section plane is inclined to HP or VP, the true shape of the section is shown on these auxiliary planes



3. What is meant by AVP and AIP? What is drawn on AVP and AIP? (Auxiliary Vertical Plane and Auxiliary Inclined plane)

A. AVP: It is auxiliary vertical plane. It is the auxiliary plane drawn parallel to the section plane which is inclined to VP. The true shape is drawn on AVP when the section plane is inclined to VP.

AIP: It is the auxiliary plane drawn parallel to the section plane which is inclined to HP. The true shape is drawn on AHP (or AIP) when the section plane is inclined to the HP.

4. When will the sectional front view (SFV) show the true shape of the section?

A. When the section plane is parallel to VP, the SFV will show the true shape of the section.

5. When does the sectional top view (STV) provide the true shape of a section?

A. When the section plane is parallel to HP, the STV will show the true shape of the section.

6. When does the sectional side view (SSV) provide the true shape of a section?

A. When the section plane is parallel to the profile plane (perpendicular to both HP and VP), the SSV will show the true shape of the section.

7. Discuss the importance of sectional views.

A. Sectional views are the views in which the cut portion of the solid is shown along with the solid's view. It helps in analysing the shape of the solid when cut by the planes. These concepts find applications in analysis of machine components when they are cut in different positions.

8. Explain the formation of different conic sections with reference to sectional planes cutting a cone (i.e., Explain how different conic sections are formed by cutting a cone)

A. The following are the various sections obtained by cutting a cone in different positions:

Circle: It is obtained when a cone is cut by a section plane parallel to the base.

Ellipse: It is obtained when a cone is cut by a section plane cutting both the extreme generators.

Parabola: It is obtained when a cone is cut by a section plane which is parallel to one of the generators and the section plane cuts the base of the cone too.

Hyperbola: It is obtained when a cone is cut by a section plane at an angle greater than the angle between the base and the generator.

9. Explain the method of obtaining the true shape of a section.

A. If the section plane is parallel to the HP or VP, the sectional view itself is sufficient to get the true shape. When the section plane is inclined to HP or VP, an AIP or AVP is to be drawn and the cutting points of the section plane (intersection points between section plane and the solid) is to be projected on to this AVP or AIP. Then the distances of the cutting points in the sectional views w.r.t. xy are to be measured and these distances are to be marked from the AIP or AVP line to get the true shape.

10. Define frustum and truncated solid with reference to pyramids and cones.

A. When a solid is cut by a section plane parallel to the base, the left over portion is called as frustum of the solids. When a solid is cut by a section plane inclined to the base, the left over portion is called as truncated solid.

11. A section plane is cutting all the generators of the cone. What is the shape of the section obtained? (A: if parallel to base-- circle; if inclined to the base- ellipse)
12. A cone is cut by a plane whose VT is parallel to the extreme generator. What is the true shape of the section? (A: VT ➔ w.r.t. HP; parallel to generator→ inclined to HP and parallel to generator→ parabola)
13. Distinguish between generator method & circle method in drawing the sections of cones.

A. In the generator method, the cutting points are selected based on the distance on the generators. In circle method, circles are drawn in the top view (usually) based on the section plane cutting the cone at different positions and then the circles are used to obtain the points of section. Refer article 14.4 in sections of cones.

14. If VT of section plane makes an angle α (e.g 30^0) with xy, the section plane is inclined to___. (Ans: HP)
15. If HT of a section plane makes an angle α (e.g. 30^0) with xy, the section plane is inclined to __. (Ans: VP)

SHEET NO: 16

DEVELOPMENT OF SURFACES

Development of surfaces of Right Regular Solids - Prism, Pyramid, Cylinder and Cone.

1. Develop the lateral surface of a right regular hexagonal prism of 35mm base side and 75mm height, kept vertically with a base side perpendicular to V.P and having a cylindrical hole of 40mm diameter drilled centrally with the axis of hole being perpendicular to V.P

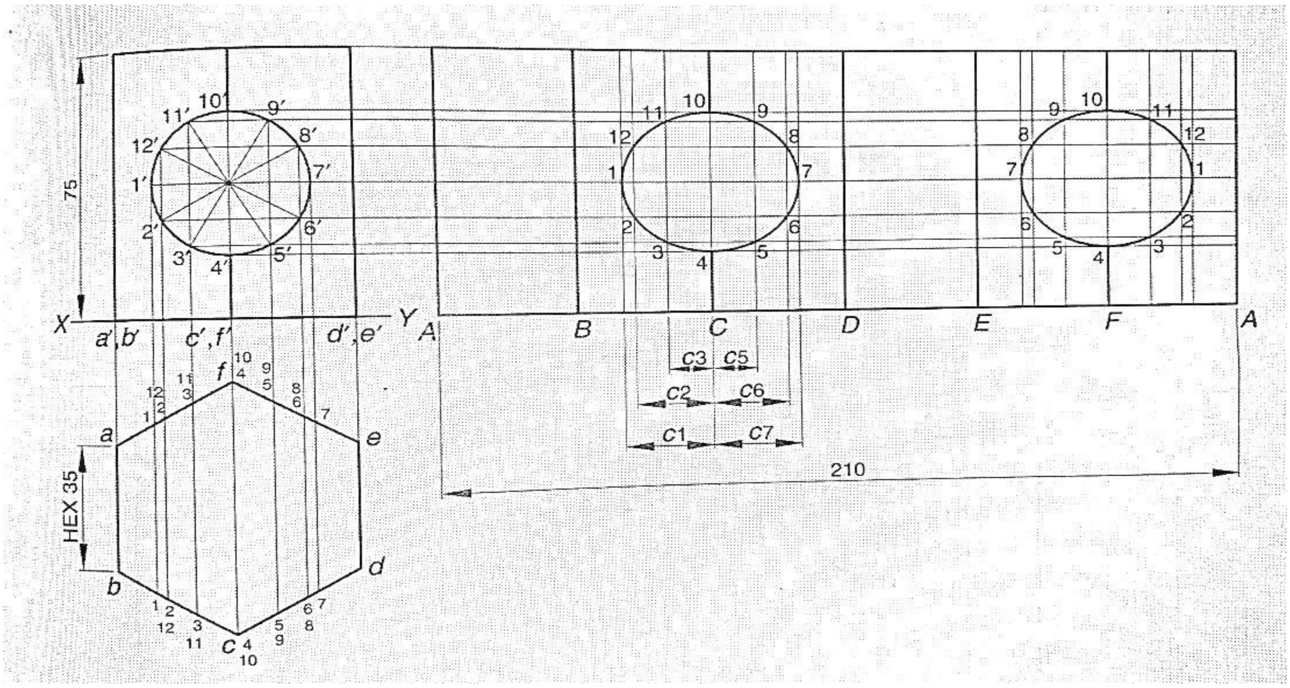


Fig . 98 Develop the lateral surface of a right regular hexagonal prism

2. A cylinder of 40mm diameter of base and 55mm long axis is resting on its base on H.P. It is cut by a section plane perpendicular to V.P. and inclined at 45 degree to H.P. The section passing through the top end of an extreme generator of the cylinder. Draw the development of the lateral surface of the cut cylinder.

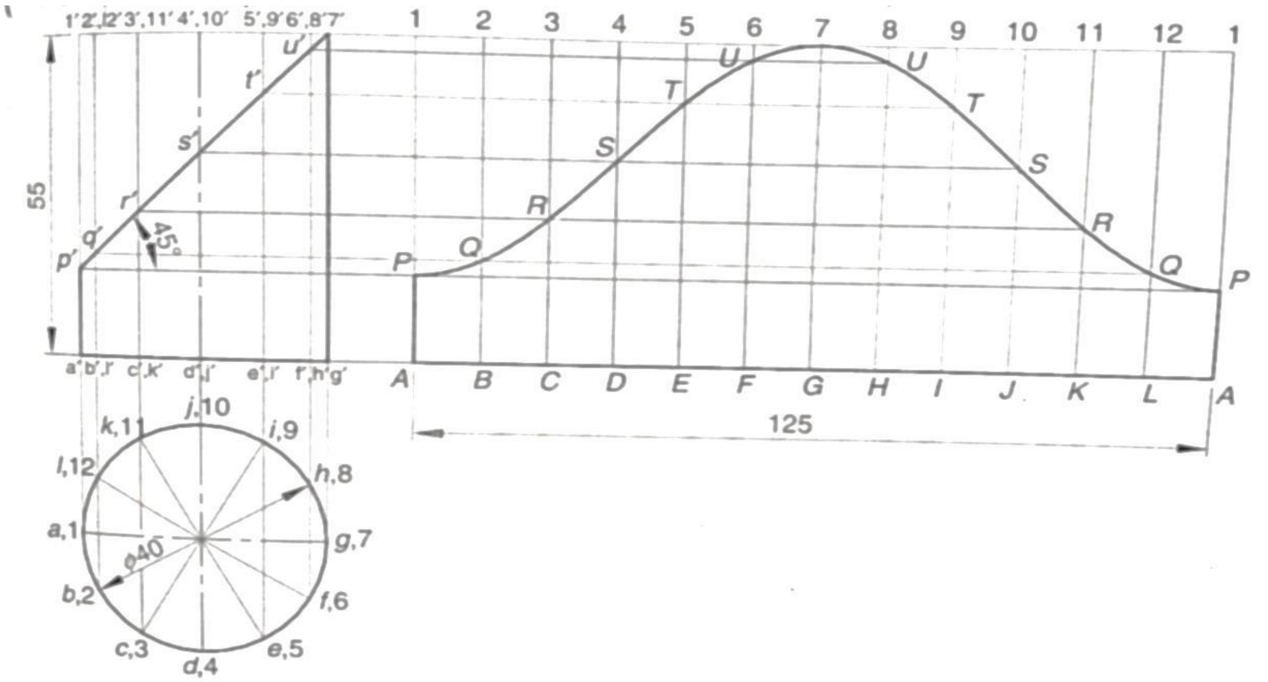


Fig . 99 development of the lateral surface of the cut cylinder

3.A pentagonal pyramid of 30mm base side and 60mm axis, rest on its base in the H.P. It is cut by two section plane which meet at a height of 20mm from the base. One of the section planes is horizontal; while the other is an auxiliary inclined plane whose V.T makes 45 degree with H.P. Draw the development of the lateral surface of the solid when apex is removed.

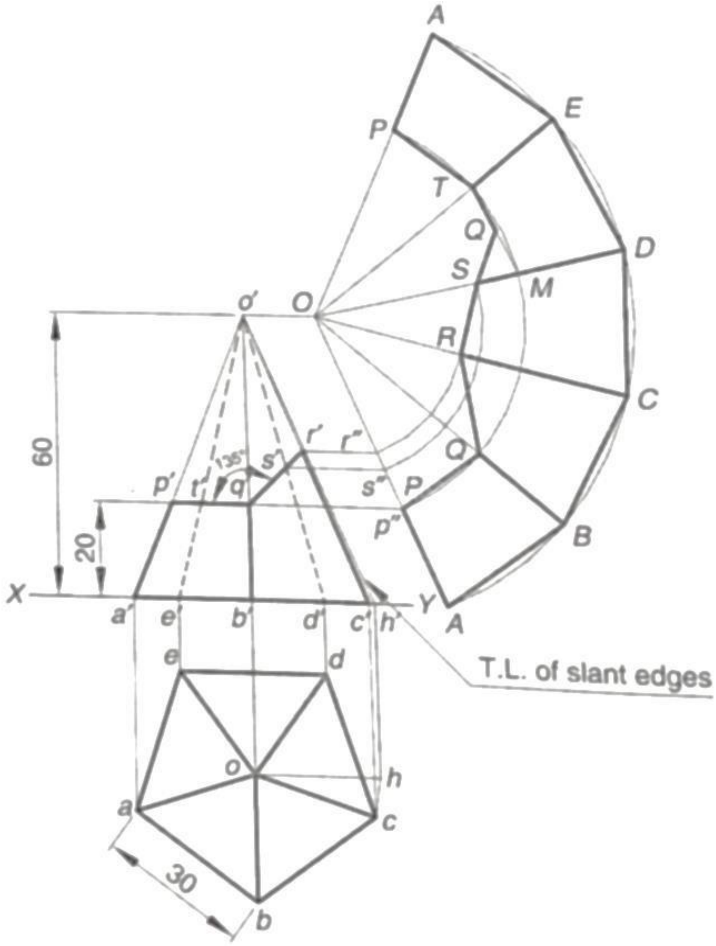


Fig . 100 development of the lateral surface of the pentagonal pyramid solid

SHEET NO: 17

INTERSECTION OF SURFACES–I

Intersection of cylinder and cylinder

1. A cylinder of base diameter 70mm is resting on its base on the H.P. It is penetrated by another cylinder of base diameter 60mm, such that their axes intersect each other at right angles. Draw the projections of the combination and show the curves of intersection.

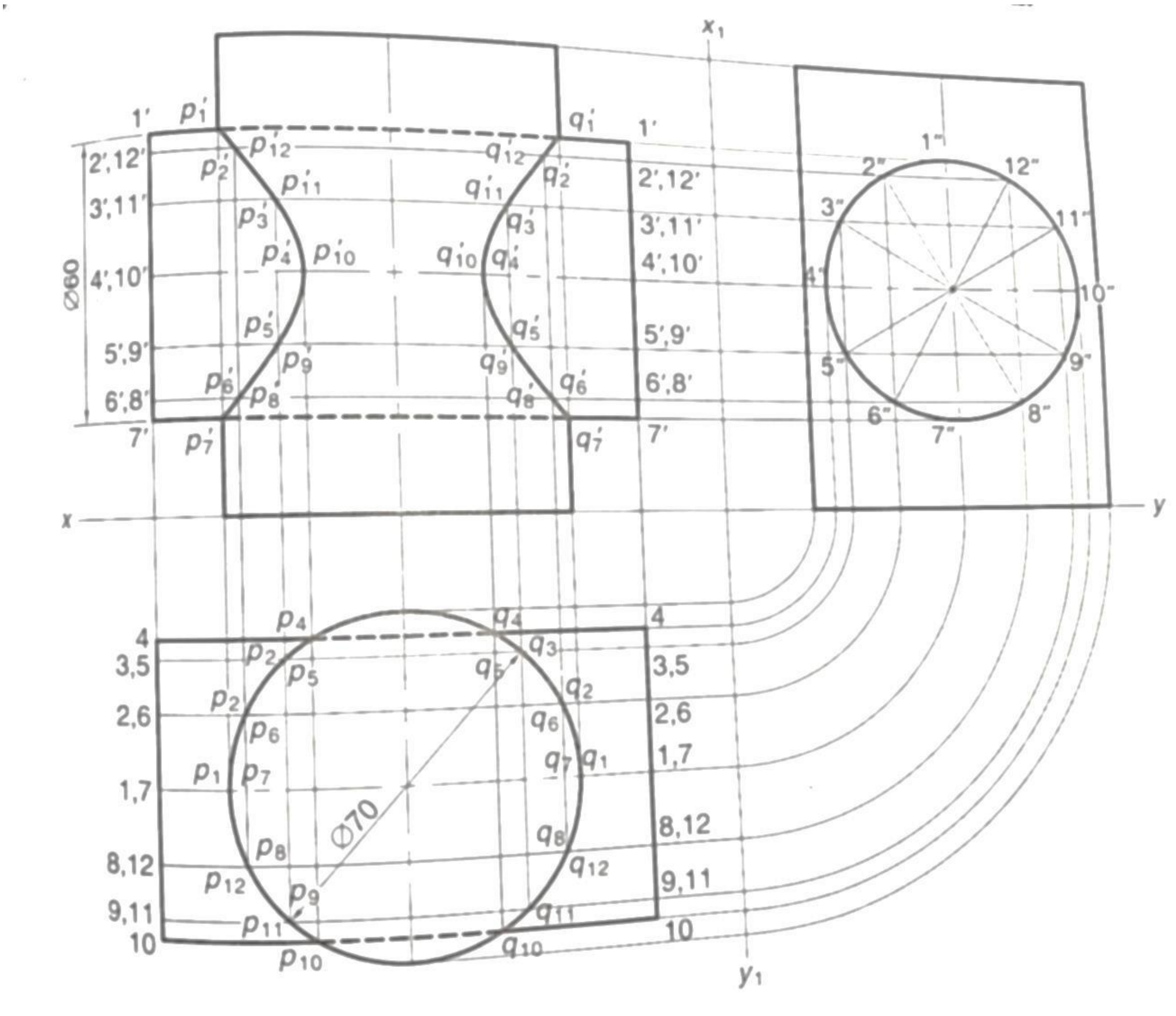


Fig . 101 the projections of the combination and show the curves of intersection of cylinder

2. A square prism, of base side 50mm, is resting on its base on the H.P. It is completely penetrated by another square prism of base side 40mm, such that the axes of both the prism intersect each other at right angles and faces of both the prisms equally inclined to the V.P. Draw the projections of the combination and show the lines of the intersection.

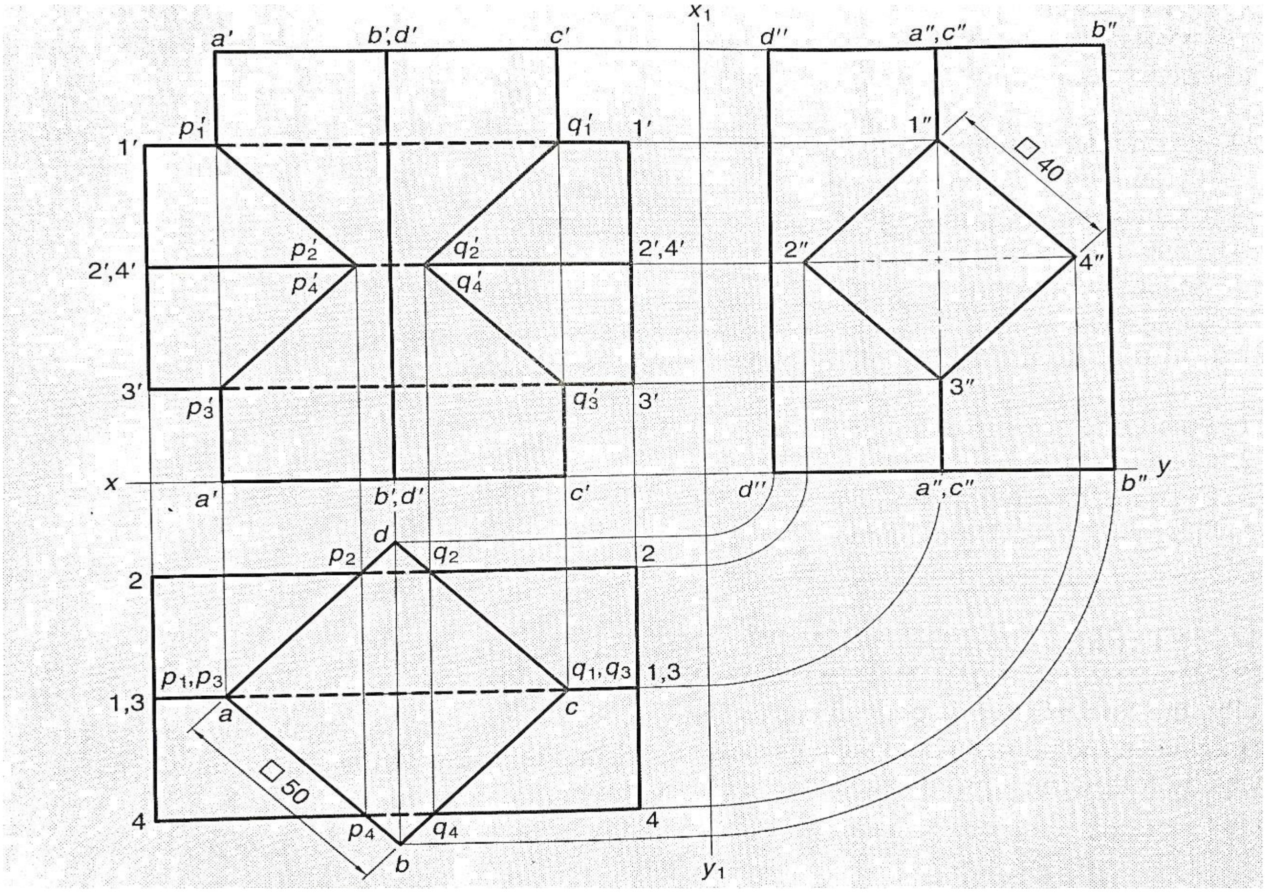


Fig . 102 the projections of the combination and show the lines of the intersection square prism

Viva Questions

Sheet no: 16&17 Development of surfaces

1. What is meant by development of a surface of a solid?

A. When a solid is opened and laid out on a plane, the opened surface obtained is usually called as the development of the solid. Usually, solids are cut by some section plane in different orientations and then the left over portion is opened out. This leftover opened portion is called as the development of the lateral surface of the remaining portion.

2. What are the applications of development of surfaces?

A. The development of surfaces concept is useful in making of sheets, trays, tins, etc in packaging industry. Also the automobile body works are developed using the concepts of development of surfaces. Hence developments of surfaces find wide application in sheet metal industry, packaging industry, automobile industry, etc.

3. Explain the parallel line method in development of prisms and cylinders.

A. Prisms and Cylinders are developed by using parallel line method. In this method, the solid is first opened out (laid out) as a surface and then a no. of parallel lines are drawn from the points of intersection of the section plane on the solid (from the front view) to intersect the respective edges or sides on the opened surface.

4. Explain the radial line method used in development of pyramids and cones.

A. This method is usually used for development of pyramids and cones. In this method, the true slant height of the cone or pyramid is first found out and this is used as the radius of development. After this, the true slant height is drawn in the development portion such that all the lines in the developed portion represent the true slant height.

Also in the front view of the solid, when it is cut by the section plane, the points have to be projected onto the true slant height only to translate the points into the developed portion. Every line on the development must correspond to the true length of the corresponding edge on the surface.

5. What is the angle of a sector in development of a cone?

A. The angle of sector in the development of a cone is given by $\theta = 360^0 * (R/L)$ where R is the base radius of the cone and L is the true slant height or generator of the cone.

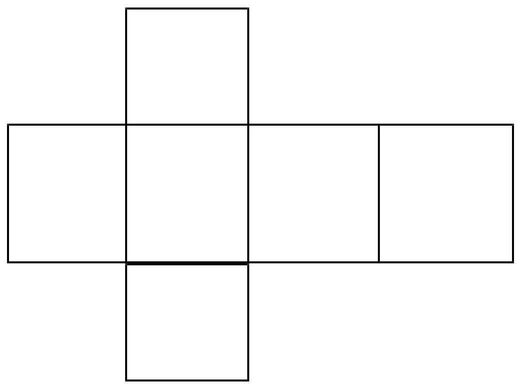
6. In the development of surfaces of a hexagonal pyramid, give the number of squares, rectangles, triangles and hexagons marked.

A. If the opening of the top and bottom portion is neglected, then only 6 rectangles are marked in the development of a hexagon. If the top and bottom portion of the hexagon is also considered, then we see also two hexagons in addition to the 6 rectangles.

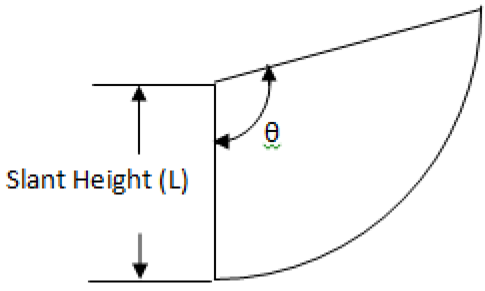
7. Show the development of a cube of 40 mm edges.

A. Cube development:

8.



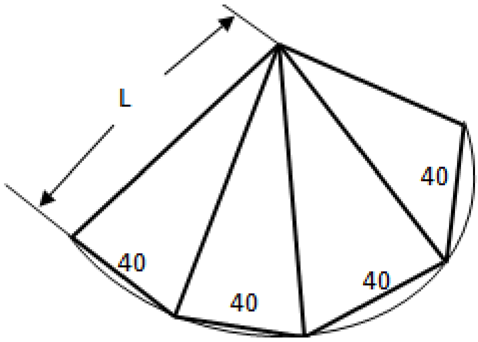
8. Draw the development of a right circular cone of base 40 mm diameter and axis 60 mm.



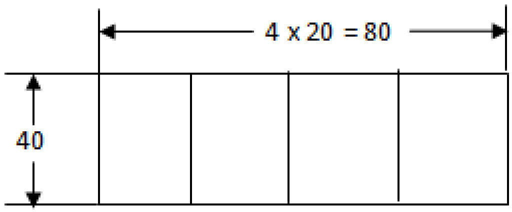
A.

L is the slant height to be measured from the front view of the cone and θ is the angle of sector of cone already mentioned earlier.

9. Sketch the development of surface of a square pyramid of base 40 mm and axis 60 mm.
A. L is the true slant height.



10. Develop the lateral surface of a square-base prism of base edge 20 mm and axis 40 mm.
A.



11. A cone of base radius 40 mm and height 60 mm has its development of its lateral surface as a sector of circle. What are the radius of the sector and the angle of the sector?
A. Draw the front view, top view and geometrically find the length of generator and take that as the radius of the sector. Angle of sector is obtained by $\theta = 360^0 \times (R/L)$

12. A right regular pentagonal prism edge of base 25 mm and height 70 mm resting on its base on HP is cut by a section plane 40^0 to the HP and meeting the axis at 20 mm from its top end. Develop the lateral surface of the cut prism. (Assignment).

13. How do you find the distance between any two points A & B situated on the surfaces of a cylinder?
A. The shortest distance between any two points on a cylinder shown in the front view can be found by developing the cylinder and mapping the points of front view on to the development.
Note: Length of cylinder for opening in development is $L = 2\pi R$ or πD

SHEET NO: 18
ISOMETRIC PROJECTION-I
Planes and Principle of isometric projection, Isometric scale, Isometric Views – Conventions lines & Planes.

In engineering drawing, orthographic projection of a solid is best way of projecting the details of an object when a solid is resting in its simple position. As the front view or top view taken separately, gives an incomplete idea of the object, a pictorial projection is the best method to show the object in one view only. Basically, pictorial projection represents three dimensional shape of an object and represents real things in one view only, which indicates length, breadth and height of the object. Therefore, the object is easily visualized from a pictorial projection than from its orthographic projection.

The pictorial projection may be divided as:

1. Oblique projection

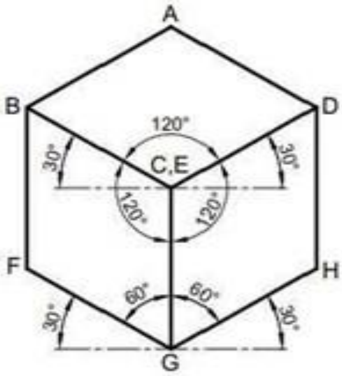
2. Perspective projection

3. Axonometric projection.

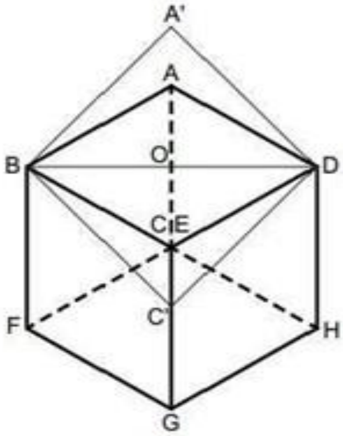
Principle of Isometric Projection

The isometric projection can be visualized is by considering a view of a cube with one of the solid diagonals perpendicular to the vertical plane and the three axes equally inclined to the vertical plane. The final front view is the isometric projection of the cube. Figure 15.3(a) shows the front view when hidden lines are removed. It gives the realistic view of the cube. The corners are renamed in capital letters. A keen study of this view reveals the following information.

1. The outer boundary ABFGHDA is a regular hexagon.
2. All the faces of the cube which are actually square in shape appear as rhombus
3. The three lines CB, CD and CG meeting at C, represent the three mutually perpendicular edges of the cube.
a. They make equal angles of 120° with each other.
b. They are equal in length but smaller than the true length of the edge of the cube.
The line CG is vertical, and the other lines CB and CD make 30° with the horizontal.
4. All other lines representing the edges of the cube are parallel to one or the other of the above three lines, i.e., CB, CD and CG, and are equally foreshortened.
5. The diagonal BD of the top face ABCD is parallel to V.P., and hence shows its true length.
6. A comparison of the rhombus ABCD of the front view with the square face of the cube is shown in below figure.



(a)



(b)

Isometric Axes, Lines and Planes

1. The three lines CB, CD, CG meeting at a point C and making an angle of 1200 with each other are called Isometric axes.

2. The lines (AB, BF, FG, GH, DH and AD) parallel to the Isometric axis are termed as

Isometric lines.

3. The lines (BD, AC, CF, BG, etc.,) which are not parallel to the isometric axes are known as Non-Isometric lines

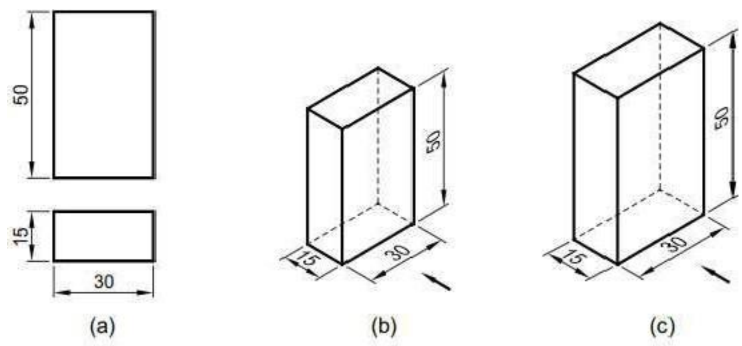
4. The plane (ABCD, BCGF, CGHD, etc.,) representing any face of the cube as well as other plane parallel to it is called an Isometric Plane.

5. The plane (ABGH, CDEF, AFH, CFH, etc.,) which is not parallel to isometric planes are known as Non-Isometric Planes.

6. The scale which is used Isometric Scale**.**

Isometric Projection and View

Isometric projection of an object is the front view of the object placed in isometric position. Isometric projection is the actual projection of the object on V.P. Here as the edges of the transparent cube are inclined 35016' to V.P., their projection on VP will have a length of about 82% of the true length, when measured in the isometric position. Isometric projection can be drawn directly, using the true length of the edges of the cube along the isometric axes. As a result, the projection obtained is larger in size than the actual. This projection is called isometric View or Isometric Drawing



(a) Multiview projection (b) Isometric projection (c) isometric view

Dimensioning

The general rules for the dimensioning of multi view projection are applicable for isometric projection, except the following:

1. All the extension lines and dimension lines should be parallel to the isometric axes and they should be on any of the isometric planes.

2. The text should be placed at the middle of the dimension line, after breaking it to a short length.

3. The dimensional values in X direction should be readable from the right side. While the Y direction from left side and Z direction from the right side respectively.

4. The numerals placed along the three axes should be aligned with the direction of the axes.

System of Notation

1. The actual solid in space is denoted by capital letters A1 , B1, C1 and D1 etc. for Base of solid and A, B, C and D etc. for top face of the solid and axis as o1 and o.

2. The front view (FV) of a solid is denoted by their corresponding lower case letters with dashes as a1', b1', c1' and d1' etc. for base of solid and a', b' c' and d' etc. for top face of the solid and for axis as o1' and o'.

3.The top view (TV) of a solid is denoted by their corresponding lower case letters with dashes as a1, b1, c1 and d1 etc. for bottom of solid and a, b c and d etc. for top face of the solid and for axis as o1 and o.

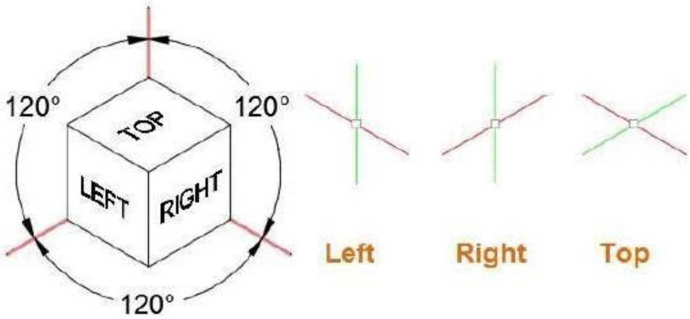
4. Projectors are always drawn as continuous thin lines.

5. Isometric projection annotations are made with the corresponding letters of the solid.

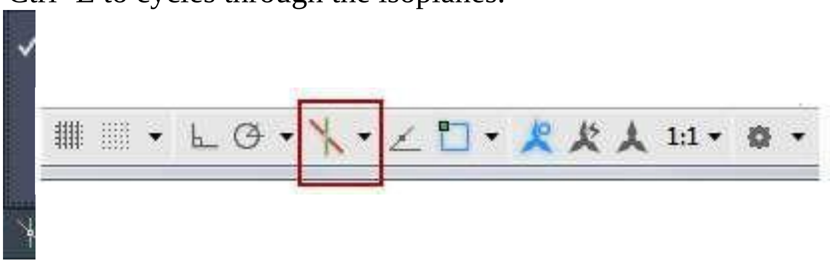
6. Line with specific thickness for a particular type of line.

Isometric Drawing using AutoCAD

In Computer Aided Engineering Graphics for isometric projections following commands are used other than evoking software, opening file, saving file and giving print command. A 2D isometric drawing is a flat representation of a 3D isometric projection. This method of drawing provides a fast way to create an isometric view of a simple design. Distances measured along an isometric axis are correct to scale, but the 3D distances and areas cannot be extracted since the drawings will be in 2D, display objects from different viewpoints, or remove hidden lines automatically. By using the ISODRAFT command, several system variables and settings are automatically changed to values that facilitate isometric angles. Isoplane specifies the current isometric plane. The standard isometric planes, called **isoplanes** , are as follows:



- Right.: Selects the right-hand plane, defined by the 30-and90-degreeaxespair
- Left: Selects the left-hand plane, defined by the 90- and 150-degree axes pair.
- Top: Selects the top face, called the top plane, defined by the 30-and150-degree axis pair.
- You can use the Isometric Drafting tool on the status bar to select the desired isoplane. Alternatively, you can pressF5 or Ctrl+E to cycles through the isoplanes.



Using these following commands and features are the most commonly used ones to maintain precision in isometric drawings:

- Polar tracking and direct distance entry
- Object snaps and grid snaps
- Object snap tracking
- Move and Copy

Extrude

The EXTRUDE command creates a solid or surface that extends the shape of a curve. Open curves create surfaces and closed curves create solids or surfaces

When you extrude objects, you can specify any of the following options:

Mode. Sets whether the extrude creates a surface or a solid.

Specify a path for extrusion. With the Path option, create a solid or surface by specifying an object to be the path for the profile, or shape, of the extrusion. The extruded object starts from the plane of the profile and ends on a plane perpendicular to the path at the endpoint of the path. For best results, use object snaps to make sure that the path is on or within the boundary of the object being extruded.

Taper angle. Tapering the extrusion is useful for defining part that require a specific taper angle, such as a mold used to create metal products in a foundry.

Direction. With the Direction option, you can specify two points to set the length and direction of the extrusion.

Expression. Enter a mathematical expression to constrain the height of the extrusion.

Revolve

Open profiles create surfaces and closed profiles can create either a solid or a surface. The Mode option controls is a solid of surface is created. When creating a surface, SURFACE MODELING MODE system variable controls if a procedural or NURBS surface is created.

Revolve path and profile curves can be:

- Open or closed
- Planar or non-planar
- Solid and surface edges
- A single object (to extrude multiple lines, convert them to a single object with the JOIN command)
- A single region (to extrude multiple regions, first convert them to a single object with the UNION command)

The following are the options for revolving

Objects to Revolve

Specifies the objects to be revolved about an axis.

Mode

Controls whether the revolve action creates a solid or a surface. Surfaces are extended as either NURBS surfaces or procedural surfaces, depending on the SURFACE MODELING MODE system variable.

Axis Start Point

Specifies the first point of the axis of revolution. The positive axis direction is from the first to the second point.

Axis Endpoint

Sets the end point for the axis of revolution.

Start Angle

Specifies an offset for the revolution from the plane of the object being revolved.

Angle of Revolution

Specifies how far the selected object revolves about the axis

Loft

Creates a 3D solid or surface by specifying a series of cross sections. The cross sections define the shape of the resulting solid or surface. Loft cross sections can be open or closed, planar and non-planar, and can also be edge sub objects. Open cross sections create surfaces and closed cross sections create solids or surfaces, depending on the specified mode.

The following prompts are used under loft:

Cross Sections in Lofting Order

Specifies open or closed curves in the order in which the surface or solid will pass through them.

Point

Specifies first or last point of the lofting operation. If you start with the Point option, you must next select a closed curve.

Join Multiple Edges

Handles multiple, end-to-end edges as one cross section.

Mode

Controls whether the lofted object is a solid or a surface.

Continuity

This option only displays if the LOFT NORMALS system variable is set to 1(smooth fit).Specifies whether the continuity is G0, G1, orG2 where the surfaces meet.

Bulge Magnitude

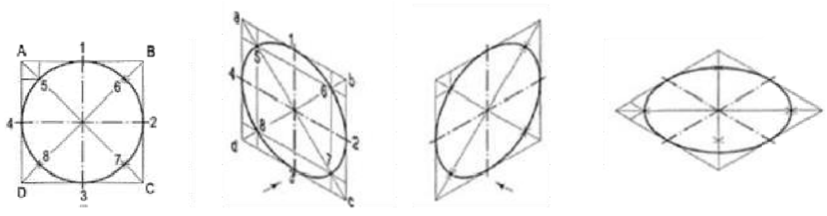
This option only displays if the LOFT NORMALS system variable is set to 1(smooth fit). Specifies a bulg magnitude value for objects that have a continuity of G1or G2.

Guides

Specifies guide curves that control the shape of the lofted solid or surface. Guide curves can be used to control how points are matched up on Corresponding cross sections to prevent undesired results, such as wrinkles in the resulting solid or surface.

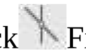
Problem:

1. Draw the isometric view of a Circle (Isocircle) with a 60mm Diameter on a ll three Principle Planes using Co-ordinate methods?

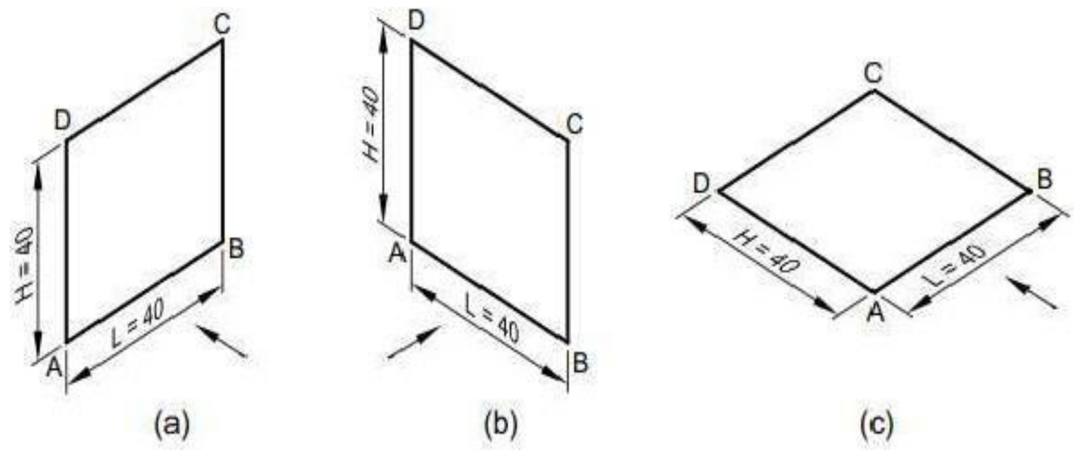


(a) (b) (c) (d)

Solution:

1. Do one of the following:
   - On the status bar, click  Find.
   - At the Command prompt, enter ISODRAFT.
2. Choose which iso plane orientation that you want to use :Left, Right, or Top.
   - PressF5orCtrl+Etocyclethroughthedifferentisoplanes
   - On the status bar, Iso draft button, click the dropdown arrow and choose an option
   - At the Iso draft prompt in the Command window, enter an option
3. At the Command prompt, enter ELLIPSE.
4. At prompt, enter (Isocircle).
5. The Iso circle option is available only when anisometric drawing plane is active.
6. Specify the center of the iso circle.
7. Specify the radius or diameter of the iso circle.

2. Draw the isometric view of a square of side 40mm kept in (a) vertical Position and (b) horizontal position?



Solution:

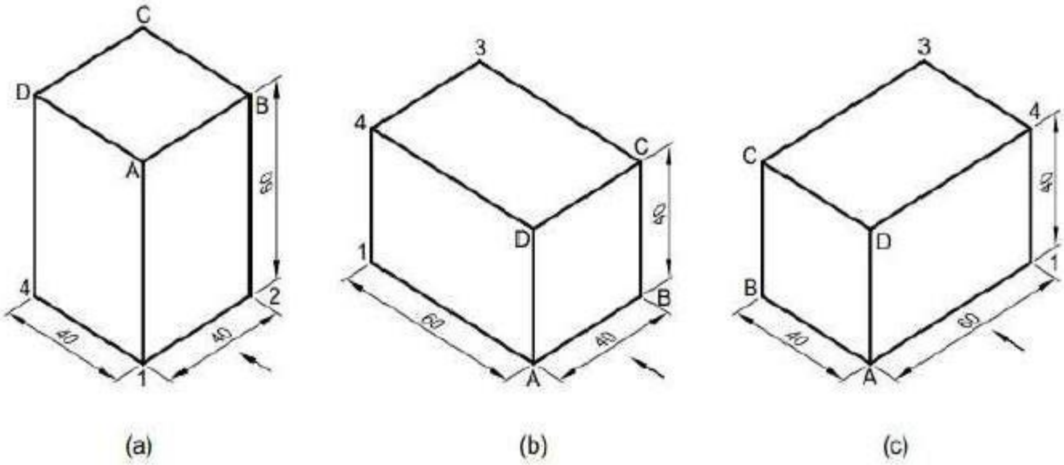
1. Do one of the following:
   - On the status bar, click Find.
   - At the Command prompt enter ISODRAFT.
2. Choose which isoplane orientation that you want to use: Left, Right, or Top.
   - PressF5orCtrl+Etocyclethroughthedifferentisoplanes
   - On the status bar, Isodraft button, click the dropdown arrow and choose an option
   - At the Isodraft prompt in the Command window, enter an option
3. At the Command prompt, enter Line.
4. The Polylineoptionisavailableonlywhenanisometricdrawingplaneisactive.
5. Specify the coordinates of the square to draw the square.

SHEETNO: 19

ISOMETRIC PROJECTION-II

Compound solids, isometric Projections of simple solids & compound solids

1. Draw the isometric view of a square prism of base side 40 mm and axis 60 mm resting on the H.P. on the (a) base with axis perpendicular to the H.P., (b) rectangular face with axis perpendicular to the V.P., and (c) rectangular face with axis parallel to the V.P.

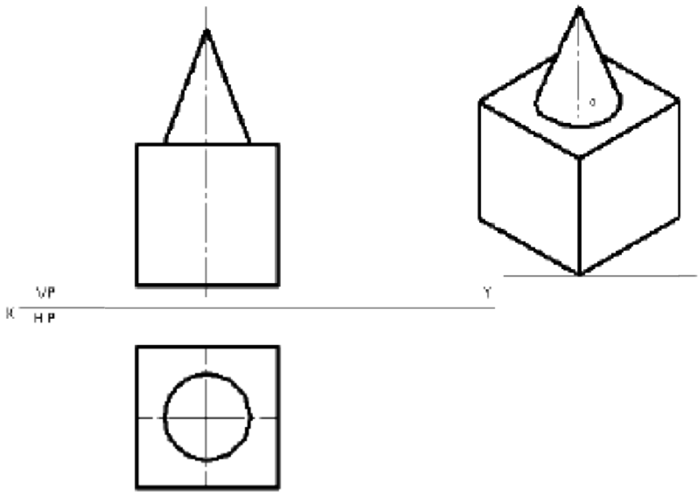


Solution:

1. At first, you need to change your snap settings to isometric. Type DS on the command line and press enter.
2. Drafting settings window will pop up from this window select snap and grid tab and make sure isometric snap radio button is checked. Click OK to exit drafting settings window.
3. Now make sure ortho mode is turned on from the status bar, if it is not turned on thenpressF8 to turn it on.
4. You can now select isometric plane for your drawing by pressing the F5 key. The three Isoplanes available for selection are Isoplane top, right and left.

5. Press F5 key to activate Isoplane top and then select line command and click any where in the drawing are at start your line. Specify a direction and type 5 on the command line then press enter, repeat this process by changing directions of line to make a closed square

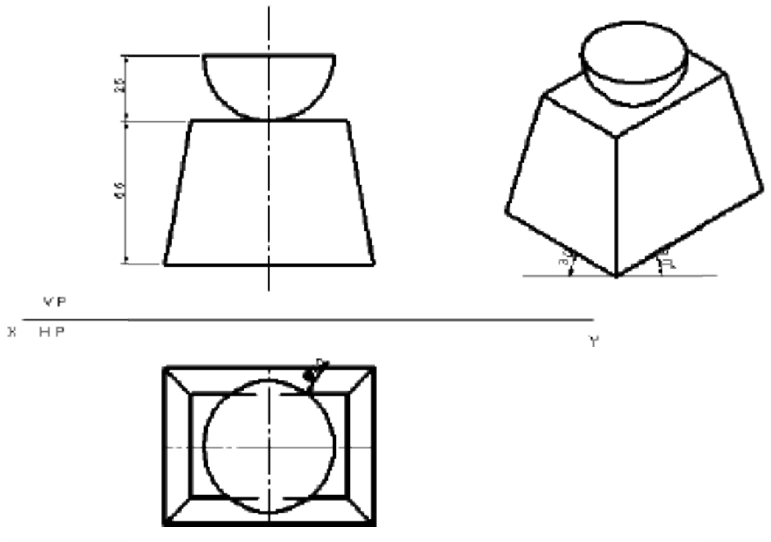
2. A of cone base diameter 30mm and height 40mm rests centrally over a cube of side 50mm. Draw the isometric projection of combination of solids.



Solution:

1. Open the SOFTWARE. Click on the DRAWING in the open dialog box and say OK.
2. To set up the sheet of required size (Ex: A4) by selecting TOOLS from Main Menu Bar and click on OPTIONS/PROPERTIES.
3. Select document properties in dialog box appeared and then select drawing in selection panel. Select the required size say A4, and click OK.
4. As per the problem commands draw top and front view of combined solids using suitable
5. Draw the isometric scale, as per the dimensions of the problem using **POLYLINE** command and inform at select PL for construction lines draw two lines of iso length of 50 mm along 30° line as shown. Draw another two lines, using **PARALLEL LINE COMMAND** and using **TRIM/EXTENDCURVES,** so that they are connected systematically**.**
6. Draw the vertical lines at corners of parallelogram equal to isometric height of square prism of 50mm using POLYLINE command and in format select VL.
7. Join all the top end points using 2 POINT LINE Command and in format select PL to get top face as shown below.
8. Since the axis of solids is collinear (square prism and cone), identify the center of rectangle represent it as o. With o as center construct a box of iso length of side 30mm similar to base drawn earlier as shown using POLYLINE command and in format select PL.
9. Using 3 POINT CIRCLE command in drafting tool bar. In mode option select arc, and use three center method draw an ellipse to get the bottom of cone.
10. Using POLYLINE command and in format select AL draw vertical line upwards at the center of rectangle, equal to the height of cone 40 mm (given) to get apex of the cone.
11. Using POLYLINE command and inform at select VL draw tangential line from bottom of cone to apex as shown. Trim all the unwanted construction lines by using SMARTDELETE COMMAND.
12. Using SMARTDIMENSION Command in drawing tool bar dimension the drawing as shown. To get a Hard Copy of the standard drawing select print from file menu bar. Print dialog window will appear select page and change width to Entities and select the activated button now substitute width 1 as 0.15 mm, width 2 as 0.05 mm, width 3as 0.5 mm, width 4 as 0.35 mm and say OK. Select print to get a hard copy and finally save the file. The required standard drawing is as shown below.

3. A hemisphere diameter 50mm is resting on its curved surface centrally on the top face of frustum of a rectangular pyramid base 80mm x 60mm and top 60mm x 40m m, height 55mm. Draw the isometric projection of combined solids.



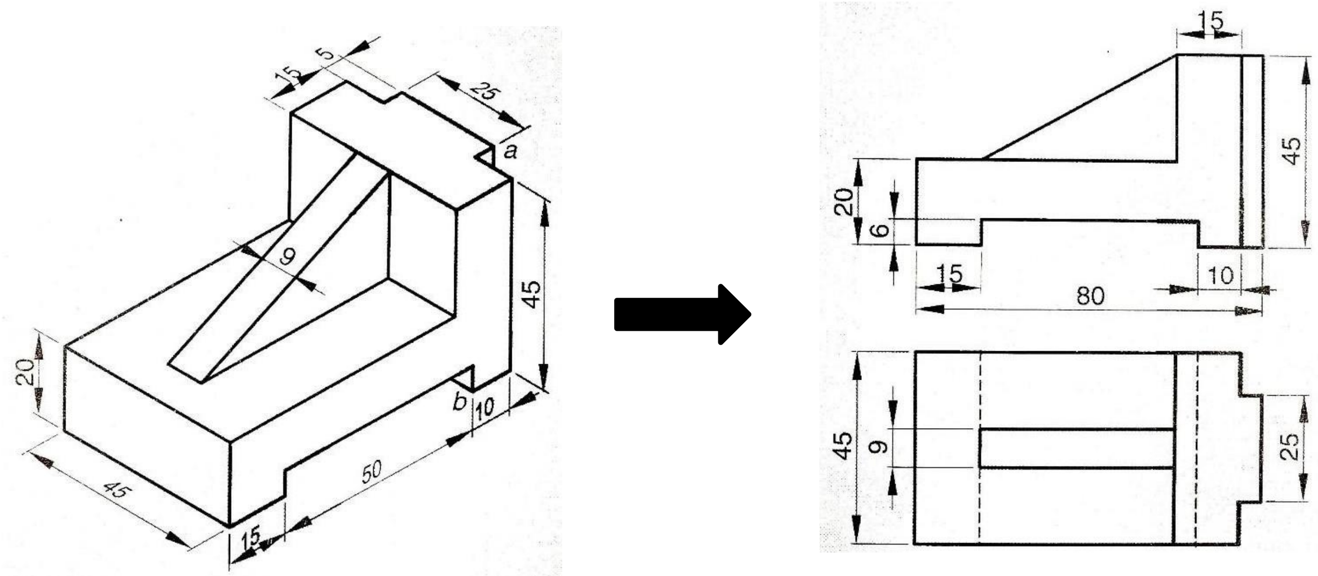
Solution:

1. Open the **SOFTWARE**. Click on the **DRAWING** in the open dialog box and say **OK**.
2. To set up the sheet of required size (Ex: A4) by selecting **TOOLS** from Main Menu Bar and click on **OPTIONS/PROPERTIES**. Select document properties India log box appeared and then select drawing in selection panel. Select the required size sayA4,and click **OK**.
3. As per the problem draw top and front view of combined solids using suitable commands.
4. Draw the isometric scale, as per the dimensions of the problem.
5. Using **POLYLINE** command and inform at select VL for visible edges draw two lines of iso length of 80 mm and 60 mm along 30° line as shown. Draw another two lines, using **PARALLEL LINE COMMAND** and using **TRIM/EXTEND CURVES** so that, they are connected systematically.
6. Using POLYLINE command and in format select AL draw vertical line upwards at the center of rectangle, equal to the height of rectangular frustum 55mm (given).
7. At top end of vertical line drawn, using POLYLINE command and inform at select VL for visible edges draw two lines of iso length of 60 mm and 40 mm along 30° line as shown. Draw another two lines, using PARALLEL LINE COMMAND and using TRIM/EXTENDCURVES so that, they are connected systematically.
8. Join all the relevant corners of top to base frustum using 2 POINTLINE command and in format select VL to get frustum as shown below.
9. Since the axis of solids is collinear (hemisphere and rectangular pyramid), identify the center of rectangle represent it as o. With o as center using POLYLINE command and in format select AL draw vertical line upwards at the center o of height equal to height of hemisphere 25 mm (given). Construct a box of iso length of side 50 mm to fit top face of hemisphere using POLYLINE command and inform at select PL.
10. Using 3 POINT CIRCLE command in drafting tool bar. In mode option select arc, and select3 points on rectangle draw a top face of hemisphere.
11. Using CENTER CIRCLE command in drafting tool bar. In mode option select arc, with center as center of top face of hemisphere and radius as actual radius of hemisphere draw an arc, so that it touches the top face of hemisphere and passes through the center of top face of the rectangle frustum.
12. Trim all the unwanted construction lines by using SMART DELETE COMMAND. Using SMART DIMENSION command in drawing tool bar dimensions the drawing as shown. To get a Hard Copy of the standard drawing select print from file menu bar. Print dialog window will appear select page and change width to Entities and select the activated button now substitute width 1 as 0.15 mm, width 2 as 0.05 mm, width 3 as 0.5 mm, width 4 as 0.35 mm and say OK. Select print to get a hard copy and finally save the file. The required standard drawing is as shown below. Top face ABCD is parallel to V.P.,

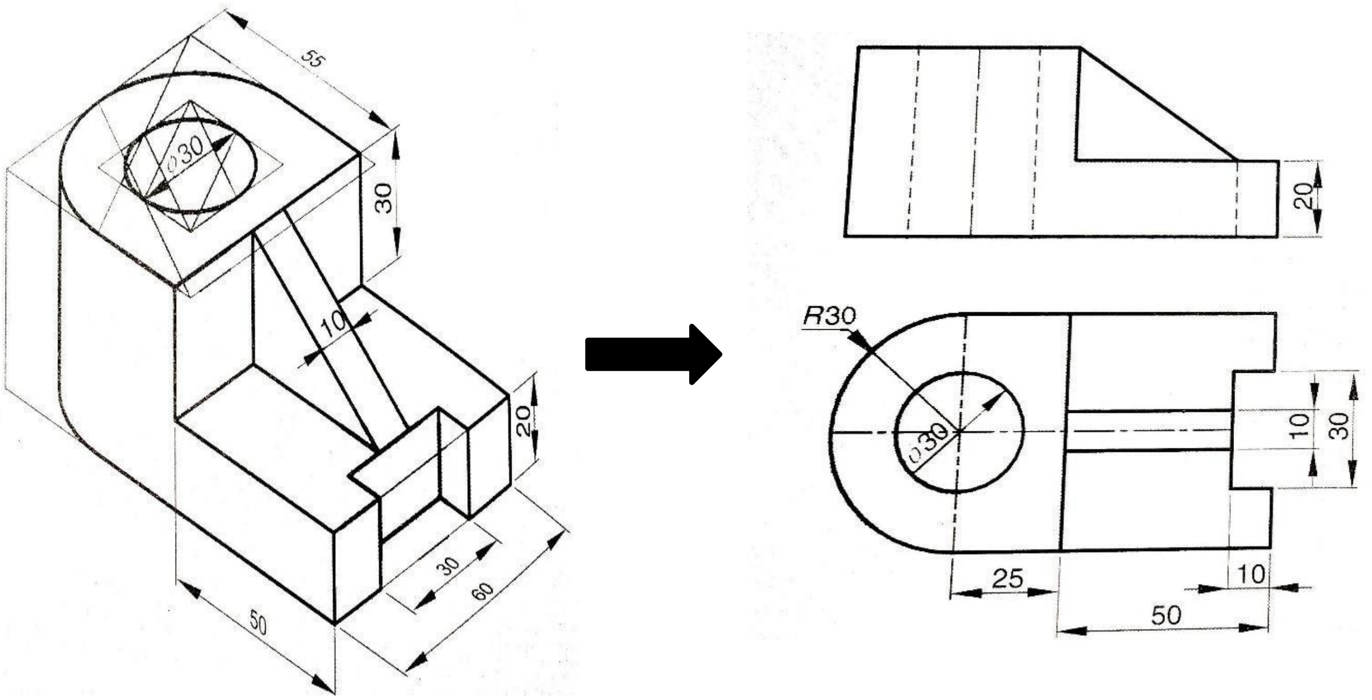
SHEET NO: 20

CONVERSION OF ISOMETRIC TO ORTHOGRAPHIC VIEWS.

1. Draw the orthographic projections from given isometric view

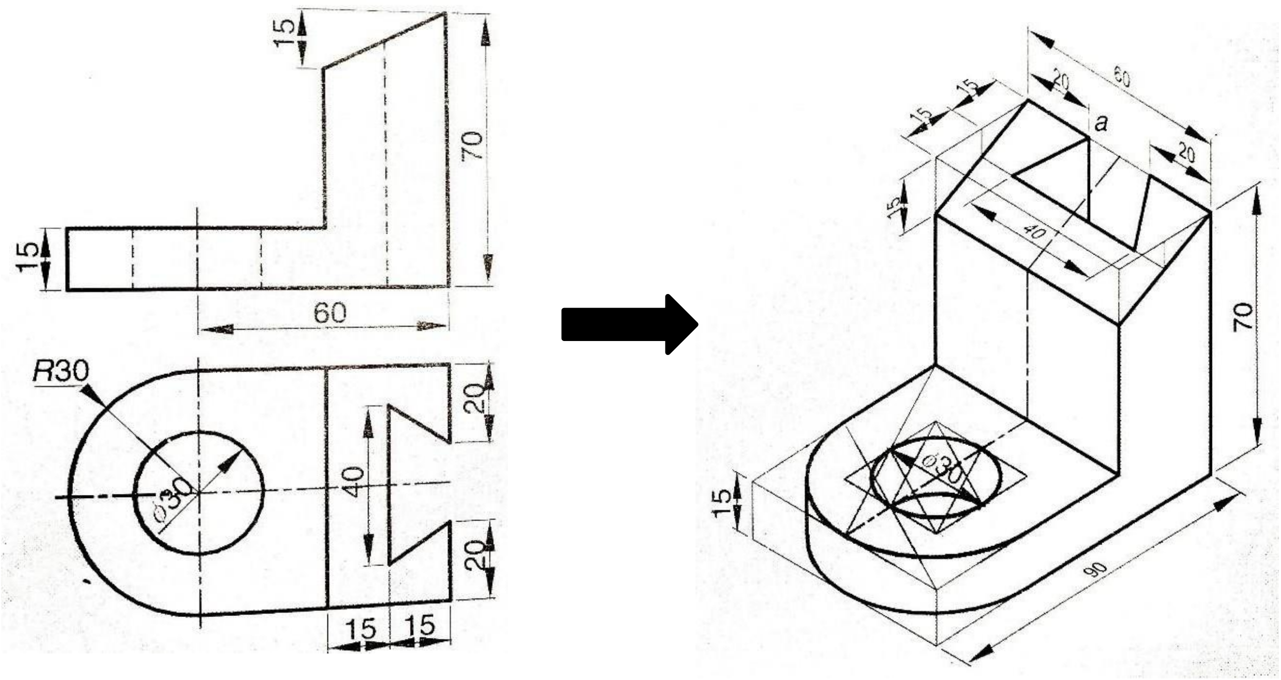


10. Draw the orthographic projections from given isometric view

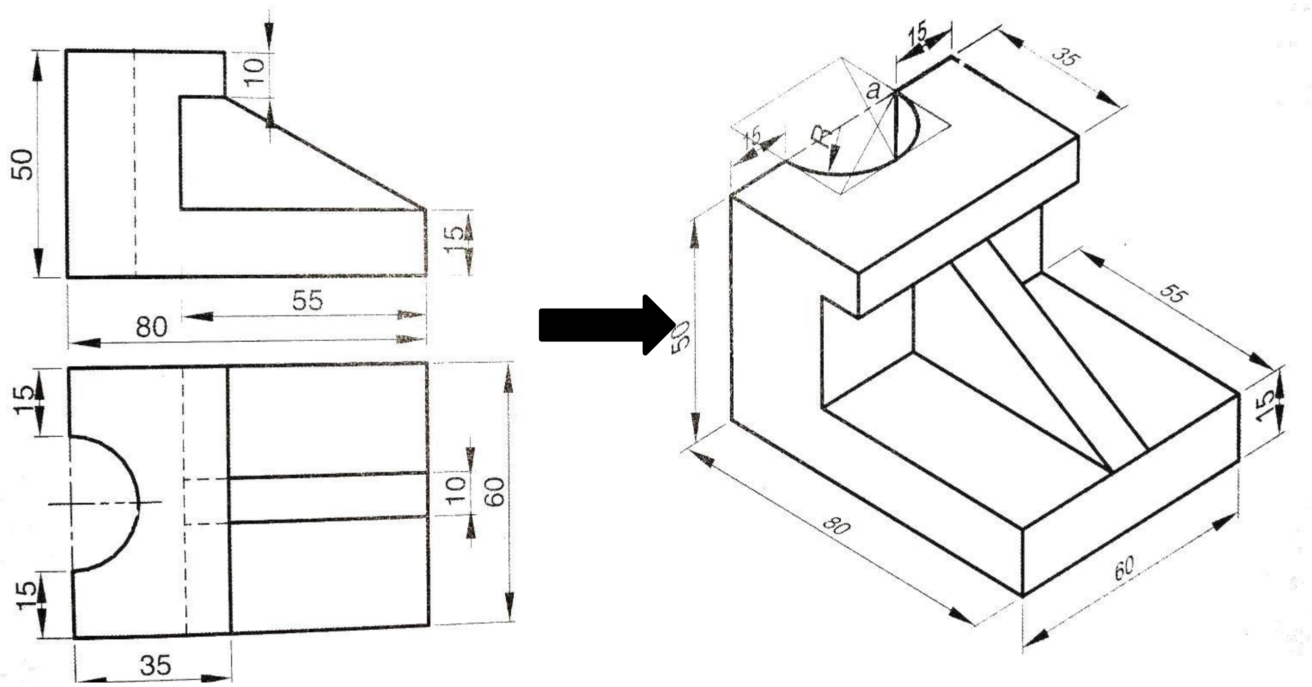


SHEET NO: 21
CONVERSION OF ORTHOGRAPHIC TO ISOMETRIC VIEWS

1. Draw the isometric view from given orthographic projections.



2. Draw the isometric view from given orthographic projections.



Viva Questions

Sheet no : 20&21 Orthographic Conversions

Concept of Orthographic Conversions:

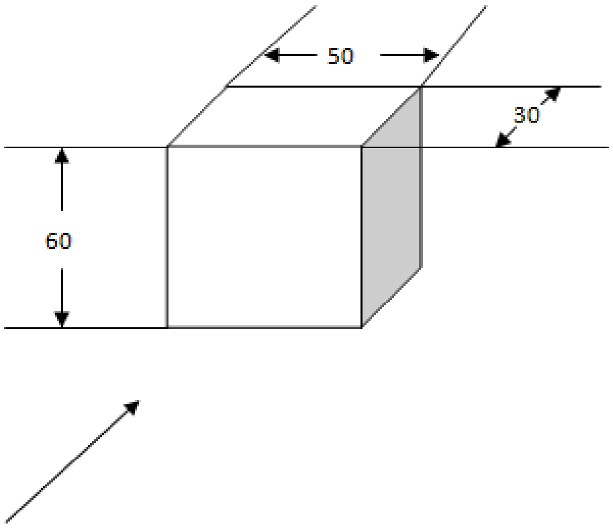
In orthographic conversions, an object will be given in its isometric view along with its dimensions. It is required to draw the three views for this solid.

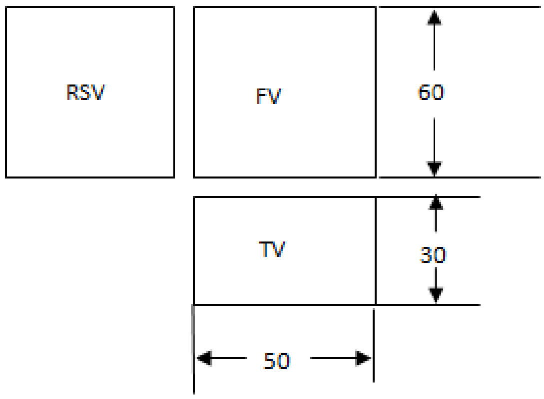
The three views are Front View (FV), Top View (TV) and Side View (SV).

In side view, two side views are possible. They are the left side view (LSV) and the right side view (RSV).

The conventions to be followed while drawing these views are as follows:

1. Identify the FV from the given arrow mark. ($\nearrow$).
2. Below the FV, draw the TV.
3. From the arrow given, identify if the left side view is visible or right side view.
4. Left side view is to be drawn on the right side of the front view and the right side view is to be drawn on the left side of the front view.
5. Give dimensions to FV, TV and SV.





Note: All the three views have to be drawn in the above shown order only. The views shouldn't be shown separately on a horizontal plane one beside the other.

If LSV is to be drawn, it is to be shown on the right of the front view.

SHEET NO: 22

Optional [Any one must be done]

Floor plan windows, doors, and fixtures such as WC, bath, sink, shower, etc.

Simple Machine Element

Basic Electrical Drawing

Basic Networking Drawing