COMPUTER AIDED ENGINEERING DRAWING

18EGDL15/18EGDL25

ATME COLLEGE OF ENGINEERING

VISION

Development of academically excellent, culturally vibrant, socially responsible and globally competent human resources.

MISSION

- To keep pace with advancements in knowledge and make the students competitive and capable at the global level.
- To create an environment for the students to acquire the right physical, intellectual, emotional and moral foundations and shine as torch bearers of tomorrow's society.
- To strive to attain ever-higher benchmarks of educational excellence.

DEPARTMENT OFMECHANICAL ENGINEERING

VISION

To impart excellent technical education in mechanical engineering to develop technically competent, morally upright and socially responsible mechanical engineering professionals.

MISSION:

- To provide an ambience to impart excellent technical education in mechanical engineering.

- To ensure state of-the- art facility for learning, skill development and research in mechanical engineering.

- To engage students in co-curricular and extra-curricular activities to impart social & ethical values and imbibe leadership quality.

PROGRAM EDUCATIONAL OBJECTIVES (PEO'S)

After successful completion of program, the graduates will be

PEO 1: Graduates will be able to have successful professional career in the allied areas and be proficient to perceive higher education.

PEO 2: Graduates will attain the technical ability to understand the need analysis, design, manufacturing, quality changing and analysis of the product.

PEO 3: Work effectively, ethically and socially responsible in allied fields of mechanical engineering.

PEO 4: Work in a team to meet personal and organizational objectives and to contribute to the development of the society in large.

PROGRAM OUTCOMES (PO'S)

The Mechanical engineering program students will attain:

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

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

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

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

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

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

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

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

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

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

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

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

PROGRAM SPECIFIC OUTCOMES (PSO'S)

After successful completion of program, the graduates will be

PSO 1: To comprehend the knowledge of mechanical engineering and apply them to identify, formulate and address the mechanical engineering problems using latest technology in a effective manner.

PSO 2: To work successfully as a mechanical engineer in team, exhibit leadership quality and provide viable solution to industrial and societal problems.

PSO 3: To apply modern management techniques and manufacturing techniques to produce products of high quality at optimal cost.

PSO 4: To exhibit honesty, integrity, and conduct oneself responsibly, ethically and legally, holding the safety and welfare of the society paramount.

COURSE MODULE

Faculty Name:				Academic Year: **2019-20**			
Department: **Mechanical Engineering**							
Course Code	Course Title	Credits	Prerequisite	Contact Hours			Total Hrs/ Sessions
				L	T	P	
18EGDL15/25	**Engineering Graphics**	**03**	**Basic Knowledge about Geometry**	**2**	**-**	**2**	**52**

Course Learning Objectives (CLO's)

This Course will enable students to

CLO1: To expose the students to standards and convections followed in preparation of engineering drawing.

CLO2: To make them understand the concepts of orthographic and isometric projections.

CLO3: Develop the ability of conveying the engineering information through drawings.

CLO4: To make them understand the relevance of engineering drawing to different engineering domains.

CLO5: To develop the ability of producing engineering drawings using drawing instruments.

CLO6: To enable them to use computer aided drafting packages for the generation of drawings.

Topics Covered as per Syllabus

MODULE - 1

Introduction to Computer Aided Sketching

Introduction, Drawing Instruments and their uses, BIS conventions, Lettering, Dimensioning and free hand practicing. Computer screen, layout of the software, standard tool bar/menus and description of most commonly used tool bars, navigational tools. Co-ordinate system and reference planes. Of HP, VP, RPP & LPP. of 2D/3D environment. Selection of drawing size and scale. Commands and creation of Lines, Co-ordinate points, axes, poly-lines, square, rectangle, polygons, splines, circles, ellipse, text, move, copy, off-set, mirror, rotate, trim, extend, break, chamfer, fillet, curves, constraints viz. tangency, parallelism, inclination and perpendicularity. Dimensioning, line conventions, material conventions and lettering.

2 Hrs

MODULE -2

Orthographic projections of Points, Straight Lines and Planes

Introduction, Definitions **-** Planes of projection, reference line and conventions employed, Projections of points in all the four quadrants, Projections of straight lines (located in First quadrant/first angle only), True and apparent lengths, True and apparent inclinations to reference planes (No application problems). Orthographic Projections of Plane Surfaces (First Angle Projection Only) Introduction, Definitions–projections of plane surfaces–triangle, square, rectangle, rhombus, pentagon, hexagon and circle, planes in different positions by change of position method only (No problems on punched plates and composite plates).

12 Hrs

MODULE – 3

Projections of Solids (First angle Projection only) Introduction, Definitions – Projections of right regular tetrahedron, hexahedron (cube), prisms, pyramids, cylinders and cones in different positions (No problems on octahedrons and combination solid).

16 Hrs

MODULE – 4

Development of Lateral Surfaces of Solids - Sections and Development of Lateral Surfaces of Solids Introduction, Section planes, Sections, Section views, Sectional views, Apparent shapes and True shapes of Sections of right regular prisms, pyramids, cylinders and cones resting with base on HP. (No problems on sections of solids) Development of lateral surfaces of above solids, their frustums and truncations. (No problems on lateral surfaces of trays, tetrahedrons, spheres and transition pieces).

10 Hrs

MODULE – 5

Isometric Projection (Using Isometric Scale Only) Introduction, Isometric scale, Isometric projection of simple plane figures, Isometric projection of tetrahedron, hexahedron(cube), right regular prisms, pyramids, cylinders, cones, spheres, cut spheres and combination of solids (Maximum of three solids). **12 Hrs**

List of Text Books:

1) **Engineering Drawing -** N.D. Bhatt & V.M. Panchal, 48th edition, 2005- Charotar Publishing House, Gujarat.
2) **Engineering Graphics** – K R Gopalakrishna, 32nd edition, 2005 – Subash Publishers Bangalore.
3) **Computer Aided Engineering Drawing** by Dr. M H Annaiah, Dr C N Chandrappa and Dr B Sudheer Premkumar Fifth edition, New Age International Publishers.

Reference Books:

1) **Computer Aided Engineering Drawing -** S. Trymbaka Murthy, **-** I.K. International Publishing House Pvt. Ltd., New Delhi, 3rd revised edition- 2006.
2) **Engineering Drawing** – by N S Parthasarathy and Vela Murali, Oxford University Press, 2015
3) **Fundamentals of Engineering Drawing with an Introduction to Interactive Computer Graphics for Design and Production-** Luzadder Warren J., Duff John M., Eastern Economy Edition, 2005- Prentice-Hall of India Pvt. Ltd., New Delhi.
4) **A Primer on Computer Aided Engineering Drawing-**2006, Published by VTU, Belgaum

List of URLs, Text Books, Notes, Multimedia Content, etc

1. **Projection of Solids demo:** https://www.youtube.com/watch?v=Lx1Rurl8nVw&list=PLqivUu0_booTlAXUSRSdizoSGv9BhXZFs.
2. https://www.youtube.com/watch?v=_M5eYB6056M

Course Outcomes (CO's): After studying this course,	**RBT Levels**
CO1: Prepare Engineering Drawings as per BIS conventions mentioned in the relevant codes and produce computer generated drawings.	**L2, L3**
CO2: Use the knowledge of Orthographic Projection to represent Engineering information/concepts and present the same in the form of drawings.	**L2, L3**
CO3: Develop isometric drawings of simple objects reading the orthographic projection and also converting the isometric projection to orthographic views.	**L2, L3**

Scheme Off Examination:

From Chapters	**Marks Allotted**
Module 2 [Choice between Lines & Planes)	**25**
Module 3	**45**
Module 4 or Module 5	**30**
Total	**100**

The Correlation of Course Outcomes (CO's) and Program Outcomes (PO's)

Subject Code:	18EGDL15/25		TITLE: Engineering Graphics					Faculty Name:					
Course Outcomes	Program Outcomes												Total
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	
CO-1	2	-	2	-	3	-	-	-	-	2	-	2	**11**
CO-2	2	2	-	-	-	-	-	-	-	2	-	-	**06**
CO-3	2	2	-	-	-	-	-	-	-	2	-	-	**06**
Total	**6**	**4**	**2**	-	**3**	-	-	-	-	**6**	-	**2**	**23**

Note: 3 = Strong Contribution 2 = Average Contribution 1 = Weak Contribution **-** = No Contribution

MODULE-1

INTRODUCTION TO COMPUTER AIDED SKETCHING

OBJECTIVES:

1) To understand the basic concept of Engineering Drawing
2) To demonstrate the usage of CAD software

LESSON CONTENT:

Introduction, Drawing Instruments and their uses, BIS conventions, Lettering, Dimensioning and free hand practicing. Computer screen, layout of the software, standard tool bar/menus and description of most commonly used tool bars, navigational tools. Co-ordinate system and reference planes. Of HP, VP, RPP & LPP. of 2D/3D environment. Selection of drawing size and scale. Commands and creation of Lines, Co-ordinate points, axes, poly-lines, square, rectangle, polygons, splines, circles, ellipse, text, move, copy, off-set, mirror, rotate, trim, extend, break, chamfer, fillet, curves, constraints viz. tangency, parallelism, inclination and perpendicularity. Dimensioning, line conventions, material conventions and lettering.

1.1 Layout of a drawing sheet

Every drawing sheet is to follow a particular layout. As a standard practice sufficient margins are to be provided on all sides of the drawing sheet. The drawing sheet should have drawing space and title page. A typical layout of a drawing sheet is shown in the figure below:

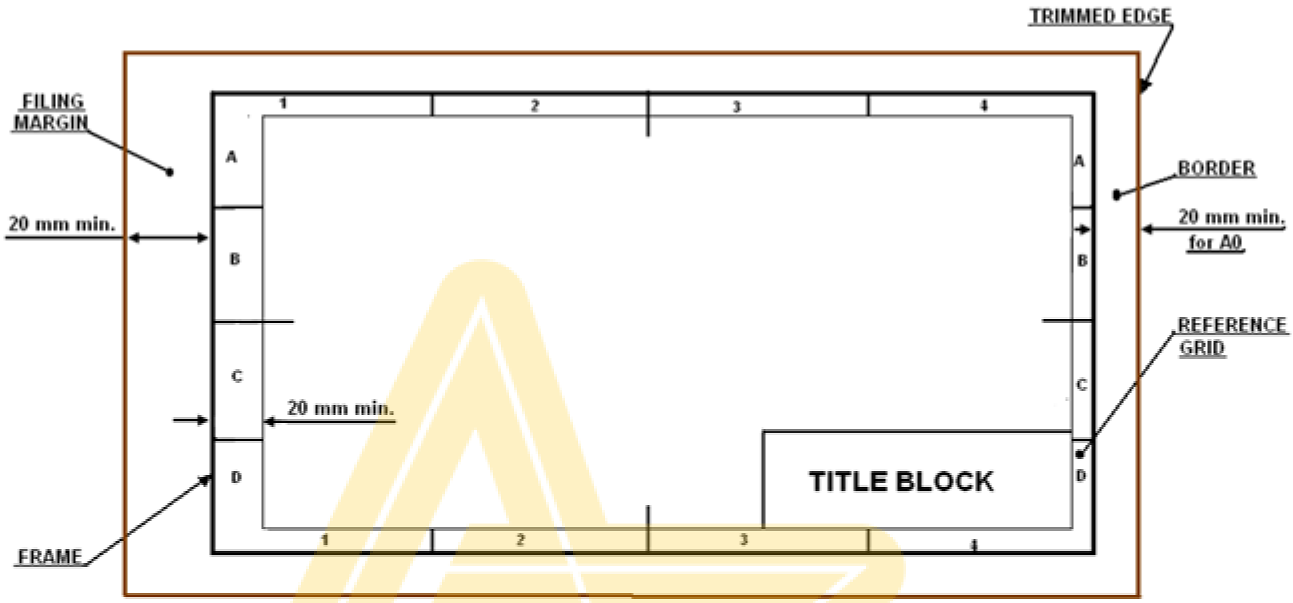


Figure 1. A typical layout of a drawing sheet.

- Borders – A minimum of 10 mm space left all around in between the trimmed edges of the sheet.
- Filing margin – Minimum 20 mm space left on the left hand side with border included. This provided for taking perforations .
- Grid reference system – This is provided on all sizes of industrial drawing sheets for easy location of drawing within the frame. The length and the width of the frames are divided into even number of divisions and labeled using numerals or capital letters. Number of divisions for a particular sheet depends on complexity of the drawing. The grids along the horizontal edges are labeled in numerals where as grids along vertical edges are labeled using capital letters. The length of each grids can be between 25 mm and 75 mm. Numbering and lettering start from the corner of the sheet opposite to the title box and are repeated on the opposite sides. they are written upright. Repetition of letters or numbers like AA, BB, etc., if they exceed that of the alphabets. For first year engineering students grid references need not be followed.
- Title box – An important feature on every drawing sheet. This is located at the bottom right hand corner of every sheet and provides the technical and administrative details of the drawing. The title box is divided into two zones

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

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

1

Layout of the title box recommended for Engineering Drawing Course
The title box shown in figure 2 can be used for the engineering Drawing Course.

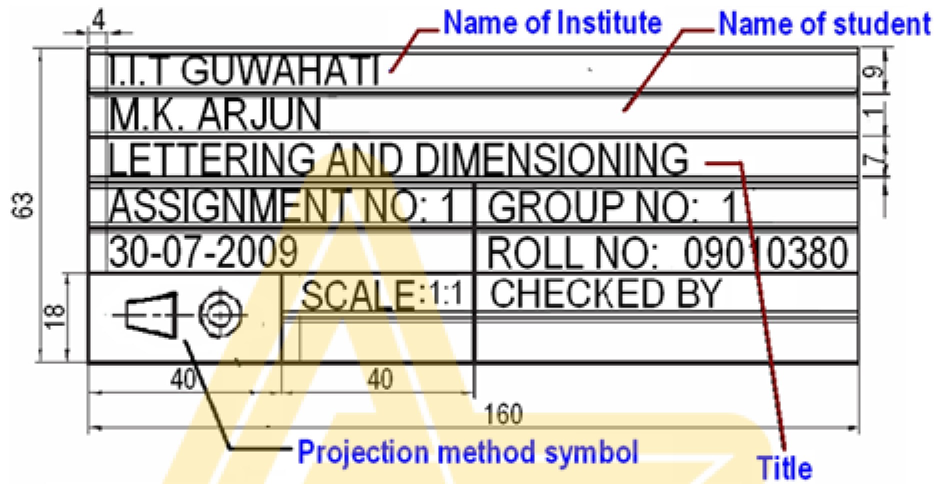


Figure 2. A typical title box recommended for Engineering students.

1.2 Lettering

Lettering is used for writing of titles, sub-titles, dimensions, scales and other details on a drawing. Typical lettering features used for engineering drawing is shown in figure 3. The following rules are to be followed in lettering. The letter sizes generally recommended for various items are shown in Table 1.

- Essential features of lettering – legibility, uniformity, ease, rapidity, and suitability for microfilming/photocopying/any other photographic processes
- No ornamental and embellishing style of letter
- Plain letters and numerals which are clearly distinguishable from each other in order to avoid any confusion even in case of slight mutilations

The Indian standard followed for lettering is BIS: 9609

- Single stroke lettering for use in engineering drawing – width of the stem of the letters and numerals will be uniformly thick equal to thickness of lines produced by the tip of the pencil.
- Single stroke does not mean – entire letter written without lifting the pencil/pen

Lettering types generally used for creating a drawing are

- Lettering A – Height of the capital letter is divided into 14 equal parts
- Lettering B – Height of the capital letter is divided into 10 equal parts

Table 2 and Table 3 indicates the specifications for Type A and Type B letters.

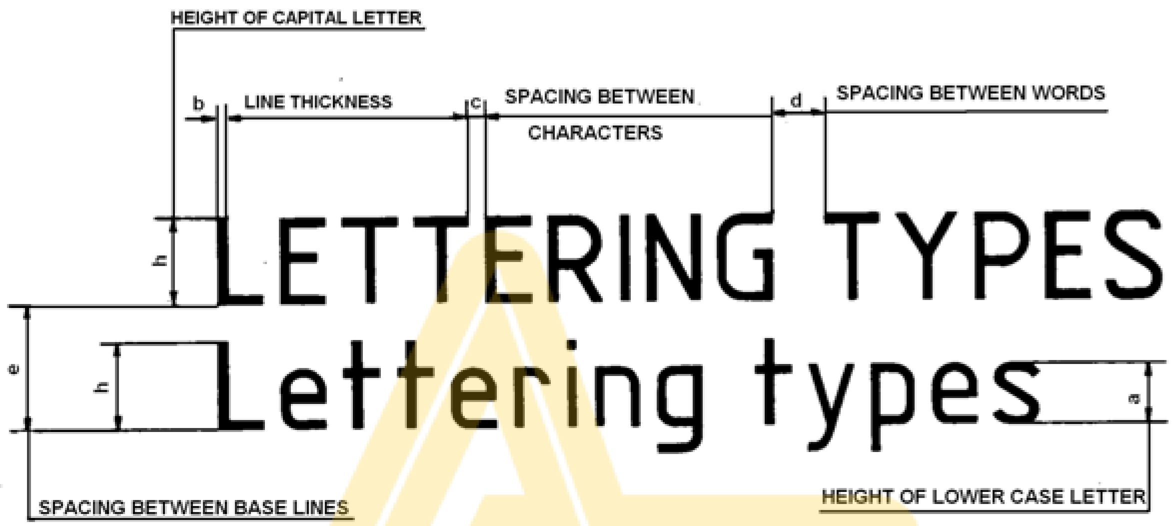


Figure 3. Typical lettering features.

Heights of Letters and Numerals

1. Height of the capital letters is equal to the height of the numerals used in dimensioning
2. Height of letters and numerals – different for different purposes

Table 1 The letter sizes recommended for various items

Sr. No.	Item	Size (mm)
1	Name of the company	10, 14,20
2	Drawing numbers, letters denoting section planes	10, 14
3	Title of the Drawing	7, 10
4	Sub-titles and heading	5, 7
5	Dimensioning, Notes, Schedules, Material list	3.5, 7
6	Alteration entries and tolerances	3.5

Table 2. Specifications of A -Type Lettering

Specifications	Value	Size (mm)						
Capital letter height	h	2.5	3.5	5	7	10	14	20
Lowercase letter height	a = (5/7)h	-	2.5	3.5	5	7	10	14
Thickness of lines	b = (1/14)h	0.18	0.25	0.35	0.5	0.7	1	1.4
Spacing between characters	c = (1/7)h	0.35	0.5	0.7	1	1.4	2	2.8
Min. spacing b/n words	d = (3/7)h	1.05	1.5	2.1	3	4.2	6	8.4
Min. spacing b/n baselines	e = (10/7)h	3.5	5	7	10	14	20	28

Table 3. Specifications of B -Type Lettering

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

How to begin your drawing?
To start with the preparation of a drawing the procedure mentioned below may be followed:

- Clean the drawing board and all the drawing instruments using duster.
- Fix the drawing sheet on the drawing board.
- Fix the mini-drafter in a convenient position.
- Draw border lines using HB pencil..
- Complete the title box using HB pencil .
- Plan spacing of drawings b/n two problems/views beforehand.
- Print the problem number on the left top and then commence the drawing work.

Keeping the drawing clean is a must

- Never sharpen pencils over drawing.
- Clean pencil point with a soft cloth after sharpening.
- Keep drawing instruments clean.
- Rest hands on drawing instruments as much as possible – to avoid smearing the graphite on the drawing.
- When darkening lines – try to work from the top of the drawing to the bottom, and from left to the right across the drawing.
- Use brush to remove eraser particles. Never use hands.
- Always use appropriate drawing pencils.

Lines

Lines is one important aspect of technical drawing. Lines are always used to construct meaningful drawings. Various types of lines are used to construct drawing, each line used in some specific sense. Lines are drawn following standard conventions mentioned in BIS (SP46:2003). A line may be curved, straight, continuous, segmented. It may be drawn as thin or thick. A few basic types of lines widely used in drawings are shown in Table 1.

Table 1. Types of letters used in engineering drawing.

Illustration	Application
Thick	Outlines, visible edges, surface boundaries of objects, margin lines
Continuous thin	Dimension lines, extension lines, section lines leader or pointer lines, construction lines, boarder lines
Continuous thin wavy	Short break lines or irregular boundary lines – drawn freehand
Continuous thin with zig-zag	Long break lines
Short dashes, gap 1, length 3 mm	Invisible or interior surfaces
Short dashes	Center lines, locus lines Alternate long and short dashes in a proportion of 6:1,
Long chain thick at end and thin elsewhere	Cutting plane lines

Line Strokes

Line strokes refer to the directions of drawing straight and curved lines. The standards for lines is given in BIS : SP-46, 2003

Vertical and inclined lines are drawn from top to bottom, horizontal lines are drawn from left to right. Curved lines are drawn from left to right or top to bottom. The direction of strokes are illustrated in figure 1.

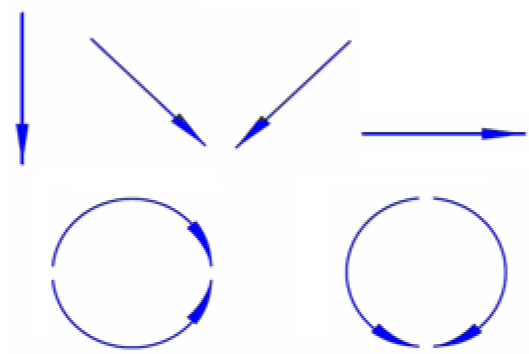


Figure 1. The line strokes for drawing straight and curved lines.

Conventions used in lines

- International systems of units (SI) – which is based on the meter.
- Millimeter (mm) - The common SI unit of measure on engineering drawing.
- Individual identification of linear units is not required if all dimensions on a drawing are in the same unit (mm).
- The drawing should contain a note: ALL DIMENSIONS ARE IN MM. (Bottom left corner outside the title box)

Typical figures showing various lines used in the construction of engineering drawing is shown in figure 2.

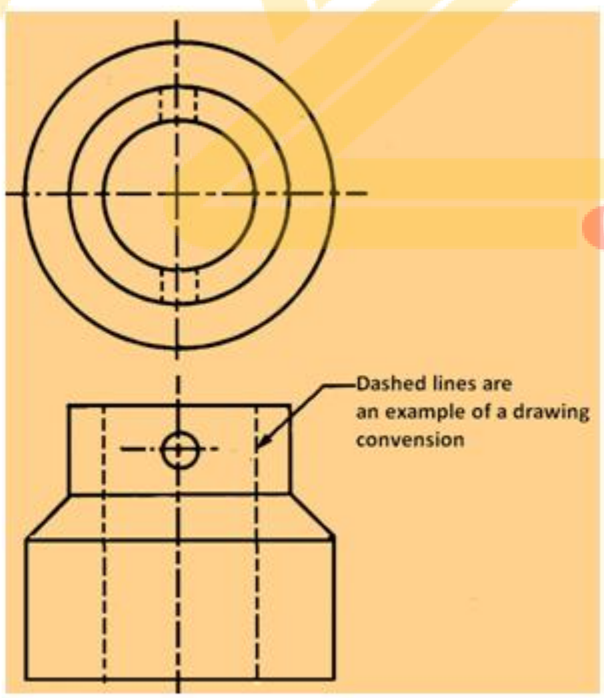
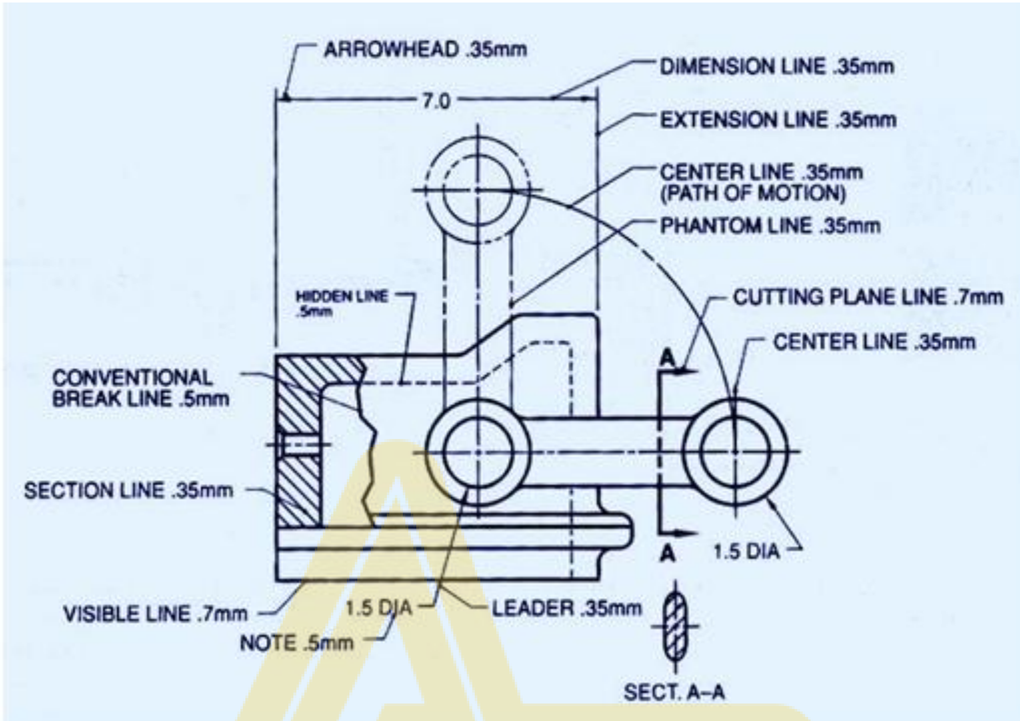


Figure 2 Typical figure showing various lines used engineering drawing

A typical use of various lines in an engineering drawing is shown in figure below:



1.3 Dimensioning

The size and other details of the object essential for its construction and function, using lines, numerals, symbols, notes, etc are required to be indicated in a drawing by proper dimensioning. These dimensions indicated should be those that are essential for the production, inspection and functioning of the object and should be mistaken as those that are required to make the drawing of an object. The dimensions are written either above the dimension lines or inserted at the middle by breaking the dimension lines.

Normally two types of dimensioning system exist. i.e. Aligned system and the unidirectional system.These are shown in figure 3.

In the aligned system the dimensions are placed perpendicular to the dimension line in such a way that it may be read from bottom edge or right hand edge of the drawing sheet. The horizontal and inclined dimension can be read from the bottom where as all the vertical dimensions can be read from the right hand side of the drawing sheet. In the unidirectional system, the dimensions are so oriented such that they can be read from the bottom of the drawing.

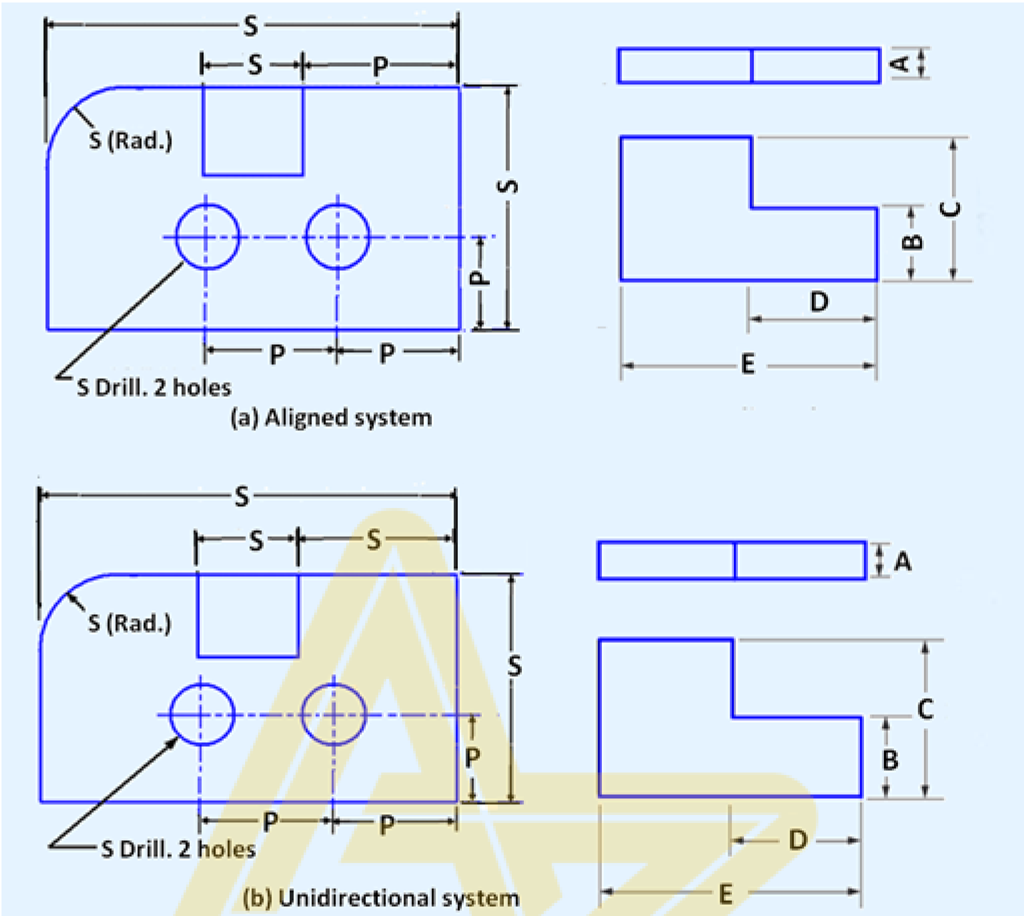


Figure 3. The aligned system and unidirectional system of dimensioning.

Rules to be followed for dimensioning. Refer figure 4.

- Each feature is dimensioned and positioned only once.
- Each feature is dimensioned and positioned where its shape shows.
- Size dimensions – give the size of the component.
- Every solid has three dimensions, each of the geometric shapes making up the object must have its height, width, and depth indicated in the dimensioning.

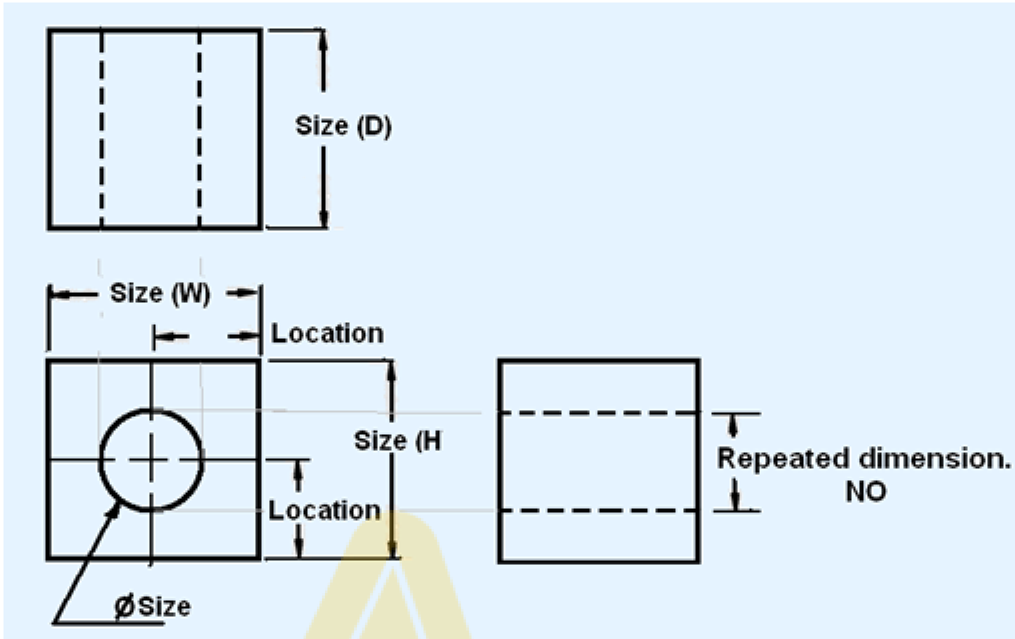


Figure 4. typical dimension lines

1.4 Scales

There is a wide variation in sizes for engineering objects. Some are very large (eg. Aero planes, rockets, etc) Some are vey small (wrist watch, MEMs components) There is a need to reduce or enlarge while drawing the objects on paper. Some objects can be drawn to their actual size. The proportion by which the drawing of aan object is enlarged or reduced is called the scale of the drawing.

Definition
A scale is defined as the ratio of the linear dimensions of the object as represented in a drawing to the actual dimensions of the same.

- Drawings drawn with the same size as the objects are called full sized drawing.
- It is not convenient, always, to draw drawings of the object to its actual size. e.g. Buildings,
- Heavy machines, Bridges, Watches, Electronic devices etc.
- Hence scales are used to prepare drawing at

  - Full size
  - Reduced size
  - Enlarged size

BIS Recommended Scales are shown in table 1.

Table 1. The common scales recommended.

Reducing scales 1:Y (Y>1)	1:2 1:20 1:200 1:2000	1:5 1:50 1:500 1:5000	1:10 1:100 1:1000 1:10000
Enlarging scales X:1 (X>1)	50:1 5:1	20:1 2:1	10:1
Full size scales			1:1

Intermediate scales can be used in exceptional cases where recommended scales can not be applied for functional reasons.

Types of Scale :-
Engineers Scale : The relation between the dimension on the drawing and the actual dimension of the object is mentioned numerically (like 10 mm = 15 m).

Graphical Scale:_ Scale is drawn on the drawing itself. This takes care of the shrinkage of the engineer's scale when the drawing becomes old.

Types of Graphical Scale :-

- Plain Scale
- Diagonal Scale
- Vernier Scale
- Comparative scale
- Scale of chords

Representative fraction (R.F.) :-

$$\text{R.F.} = \frac{\text{Length of an object on the drawing}}{\text{Actual Length of the object}}$$

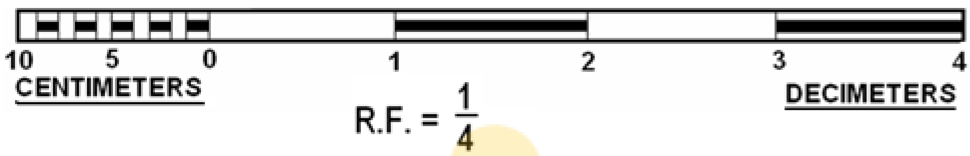
When a 1 cm long line in a drawing represents 1 meter length of the object

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

Length of scale = RF x Maximum distance to be represented

Plain scale :-

- A plain scale is used to indicate the distance in a unit and its nest subdivision.
- A plain scale consists of a line divided into suitable number of equal units. The first unit is subdivided into smaller parts.
- The zero should be placed at the end of the 1st main unit.
- From the zero mark, the units should be numbered to the right and the sub-divisions to the left.
- The units and the subdivisions should be labeled clearly.
- The R.F. should be mentioned below the scale.



OUTCOMES:

1) Students will be able to representation of Engineering Drawing
2) Student will be able to understand the concept of scaling
3) Students will be able to the usage of CAD software

Questionnaires

1. Define drawing.
2. What is the importance of lettering in drawing?
3. What is scaling? Explain the types of scaling.
4. Explain the concept of dimensioning.

FURTHER READING:

1) Computer Aided Engineering Drawing - S. Trymbaka Murthy, - I.K. International Publishing House Pvt. Ltd., New Delhi, 3rd revised edition- 2006.
2) Engineering Graphics - K.R. Gopalakrishna, 32nd edition, 2005- Subash Publishers Bangalore.
3) 1. Dhananjay A Jolhe, Engineering Drawing, Tata McGraw Hill, 2007.
4) 2. M.B. Shah and B.C. Rana, Engineering Drawing, pearson Education, Eds. 2, 2009.
5) 3. K. Venugopal, Engineering Drawing and Graphics, New Age International (P) Ltd., publishers, 2000.
6) 4. N.D. Bhatt and V.M. Panchal, Engineering Drawing, Charotar Publishing house, 2005

MODULE-3

PROJECTIONS OF SOLIDS (FIRST ANGLE PROJECTION ONLY)

OBJECTIVES:

1) To understand the projection of solids in 1^{st} quadrant when the solid inclined to HP and VP.
2) To understand the projection of solids when it is suspended.

LESSON CONTENT:

Introduction, Definitions – Projections of right regular tetrahedron, hexahedron (cube), prisms, pyramids, cylinders and cones in different positions (No problems on octahedrons and combination solid).

3.1 Projections of Planes

Solid

A solid is a 3-D object having length, breadth and thickness and bounded by surfaces which may be either plane or curved, or combination of the two.
Solids are classified under two main headings

- Polyhedron
- Solids of revolution

A regular polyhedron is solid bounded only by plane surfaces (faces). Its faces are formed by regular polygons of same size and all dihedral angles are equal to one another. when faces of a polyhedron are not formed by equal identical faces, they may be classified into prisms and pyramids.

Five regular polyhedral are shown in figure 1

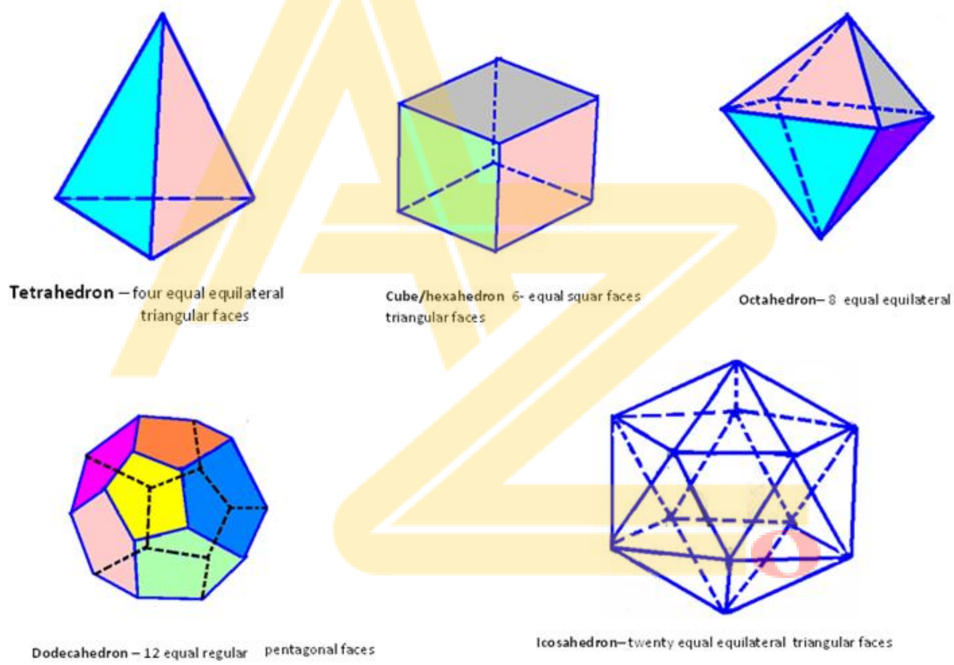


Figure 1: Five regular polyhedra

Prism

Prisms are polyhedron formed by two equal parallel regular polygon, end faces connected by side faces which are either rectangles or parallelograms.
Different types of prisms are shown in figure 2

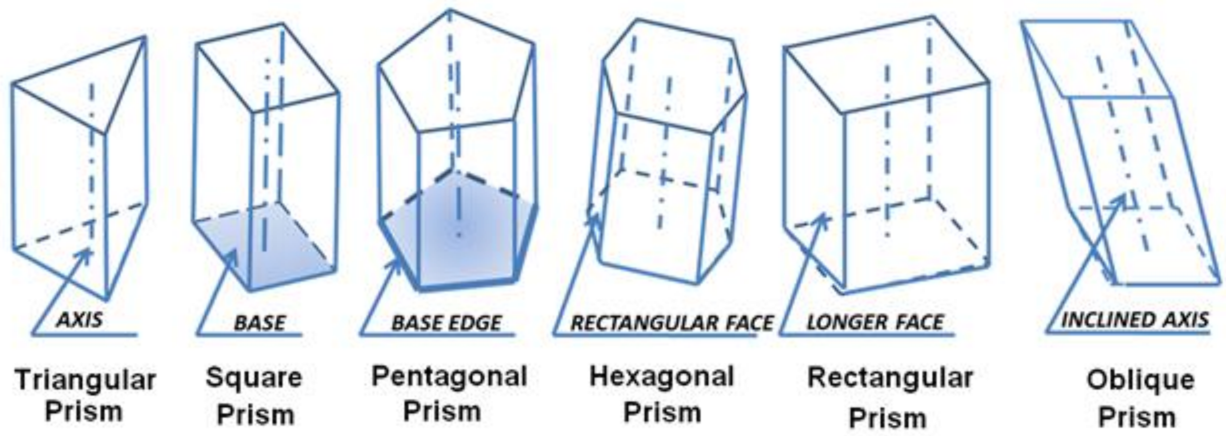


Figure 2. Various types of prisms generally encountered in engineering applications

Some definitions regarding prisms

Base and lateral faces. When the prism is placed vertically on one of its end faces, the end face on which the prism rests is called the base. The vertical side faces are the lateral faces, as shown in Figure 3.

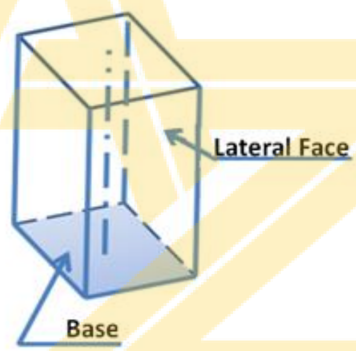


Figure 3. Shows the base and lateral face of a prism.

Base edge/Shorter edge: These are the sides of the end faces, as shown in figure 4.

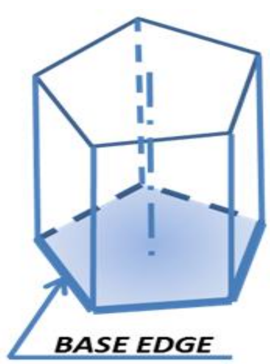


Figure 4. showing the base edge or shorter edge of a pentagonal prism.

Axis – it is the imaginary line connecting the end faces is called axis and is shown in figure 5.

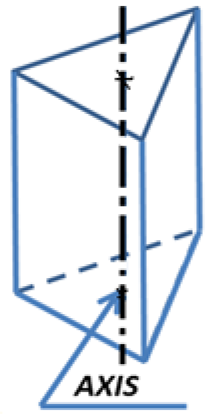


Figure 5 showing the Axis of a triangular prism.

Longer edge/lateral edges: These are the edges connecting the respective corners of the two end faces. The longer edge of a square prism is illustrated in figure 6.

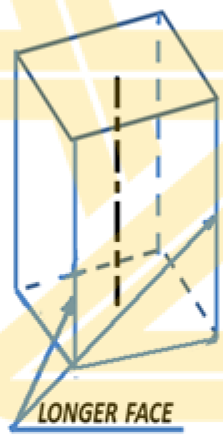


Figure 6. illustrating the longer edge of a square prism.

Right prism – A prism whose axis is perpendicular to its end face is called as a right prism .Prisms are named according to the shape of their end faces, i.e, if end faces are triangular, prism is called a triangular prism.

Oblique prism: It is the prism in which the axis is inclined to its base.

Pyramids

Pyramid is a polyhedron formed by a plane surface as its base and a number of triangles as its side faces, all meeting at a point, called vertex or apex.

Axis – the imaginary line connecting the apex and the center of the base.

Inclined/slant faces – inclined triangular side faces.

Inclined/slant/longer edges – the edges which connect the apex and the base corners.

Right pyramid – when the axis of the pyramid is perpendicular to its base.

Oblique pyramid – when the axis of the pyramid is inclined to its base.

Solids of revolution

when some of the plane figures are revolved about one of their sides – solids of revolution is generated some of the solids of revolution are:

1. Cylinder: when a rectangle is revolved about one of its sides, the other parallel side generates a cylinder.
2. Cone: when a right triangle is revolved about one of its sides, the hypotenuse of the right triangle generates a cone.
3. Oblique cylinder: when a parallelogram is revolved about one of its sides, the other parallel side generates a cylinder.
4. Sphere: when a semi-circle is revolved about one of its diameter, a sphere is generated..
5. Truncated and frustums of solids – when prisms, pyramids, cylinders are cut by cutting planes, the lower portion of the solids (without their top portions) are called, either truncated or frustum of these solids. Some examples are shown in figure 7.

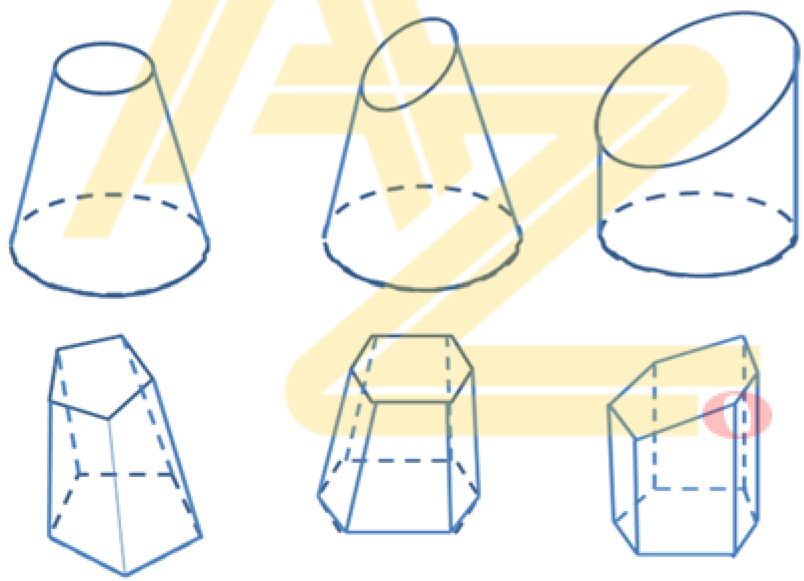


Figure 7. Illustrates some examples of truncated / frustrum of solids.

Visibility
When drawing the orthographic views of an object, it will be required to show some of the hidden details as invisible. To distinguish the invisible portions from the visible ones, the invisible edges of the object are shown on the orthographic views by dashed lines. However, in practice, these lines of dashes conveniently and colloquially, but wrongly called as dotted lines. To identify the invisible portions of the object, a careful imaginative thinking is essential.

Rules of visibility
When viewing an object, the outline of the object is visible. Hence the outlines of all the views are shown by

full lines. All the visible edges will be shown as solid lines as shown in figure 8. Figure shows the frustum of a pentagonal pyramid.

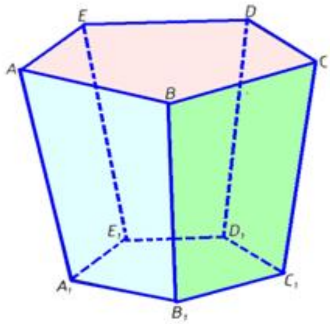


Figure 8. Front view of the object. The visible edges are shown as solid lines and the hidden edges are shown as dashed lines.

Figure 9 shows the projections of the object. In the top view, the highest portions of the object are visible. The top face ABCDE is at the top and is completely visible in the top view. In the top view, edges ab, bc, cd, de and ea are shown as full lines. The bottom pentagonal faces A1B1C1D1E1 is smaller than the top face, hence invisible. The slant edges AA_1, BB_1, CC_1, DD_1 and EE_1 are invisible in the top view, hence they are shown as lines of dashes. The line connecting a visible point and an invisible point is shown as an invisible line of dashes unless they are out lines.

In the front view, the front faces of the object are shown as visible. The faces ABB1A1 and BCC1B1 are the front faces. Hence in the front view, the corners a, b, c and a_1, b_1, c_1 are visible to the observer. Hence in the front view, the lines $a'a'_1$, $b'b'_1$ and $c'c'_1$ are shown as full lines. However the corners d, e, d_1 and e_1 are invisible in the front view. The lines, $e'e'_1$, $d'd'_1$ are invisible, hence shown as dashed lines. The top rear edges a'e', e'd' and d'c' coincide with the top front visible edges a'b' and b'c'.

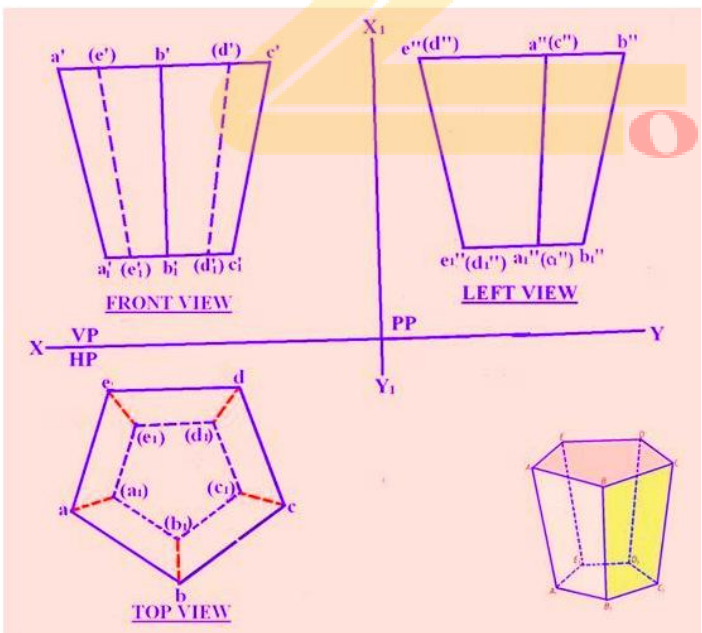


Figure 9. Projections of the frustrum of a pentagonal pyramid.

In the side view - the face lying on that side are visible. As seen in the left side view, the corners e, a, b and e_1, a_1, b_1 lie on left side and are visible in the left view. Hence the lines, e"e_1", a"a_1" and b"b_1" are shown as full lines. The edges d"d_1", c"c_1" coincide with the visible edges e"e_1" and a"a_1" respectively.

3.2 Projections of solids placed in different positions

The solids may be placed on HP in various positions

1. The way the axis of the solid is held with respect to HP or VP or both -
   - Perpendicular to HP or VP
   - Parallel to either HP or VP and inclined to the other
   - Inclined to both HP and VP
2. The portion of the solid on which it lies on HP, except when it is freely suspended position. It can lie on HP on its base edge or a corner, or a lateral face, or apex.

Axis of the solid perpendicular to HP

A solid when placed on HP with its axis perpendicular to it, then it will have its base on HP. This is the simplest position in which a solid can be placed. When the solid is placed with the base on HP position, in the top view, the base will be projected in its true shape. Hence, when the base of the solid is on HP, the top view is drawn first and then the front view and the side views are projected from it. Figure 10 shows a cylinder with its axis perpendicular to HP. There is only one position in which a cylinder or a cone may be placed with its base on HP.

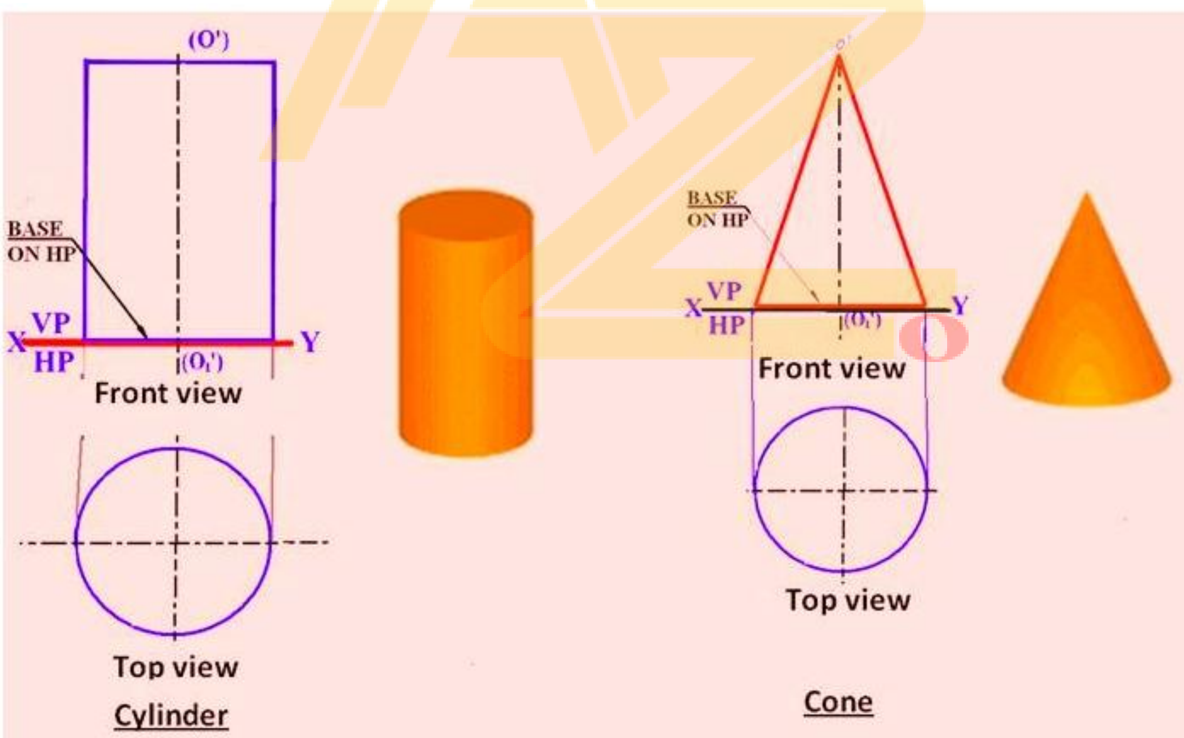


Figure 10. Front view and top view of a cylinder and cone

For prisms, there are 4 positions it may be placed with its base on HP.These positions are illustrated in figure 11.

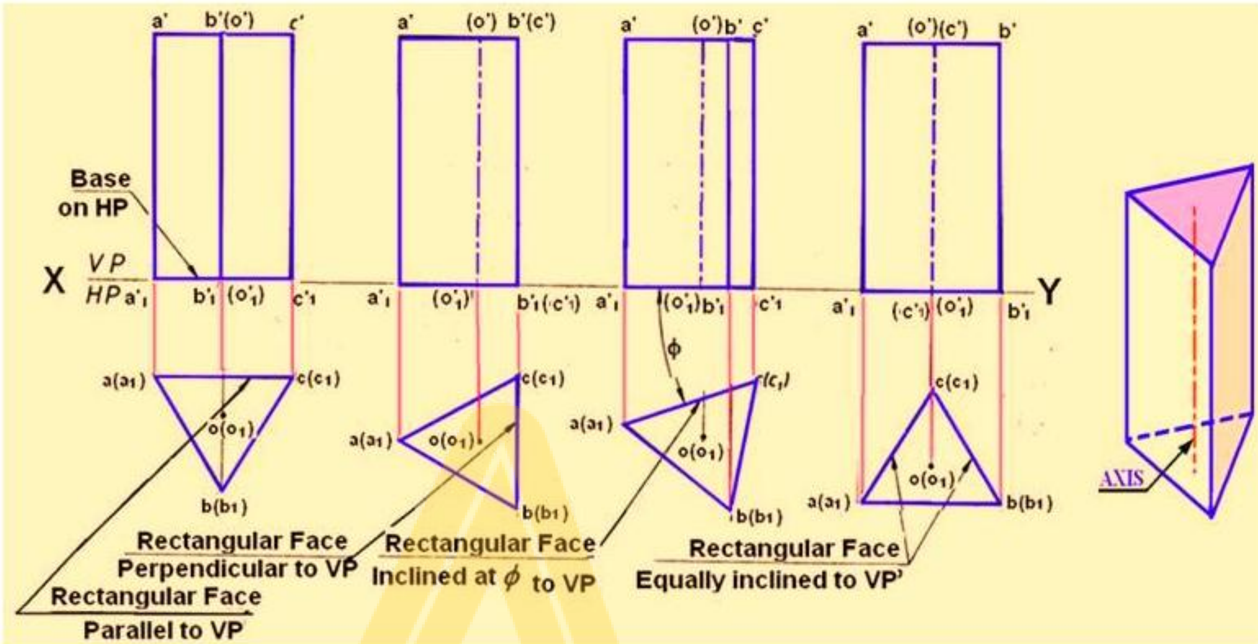


Figure 11. Projections of a triangular prism resting on its base on HP with different positions.

There are 4 positions in which pyramids may be placed with its base on HP. These positions are shown in figure 12.

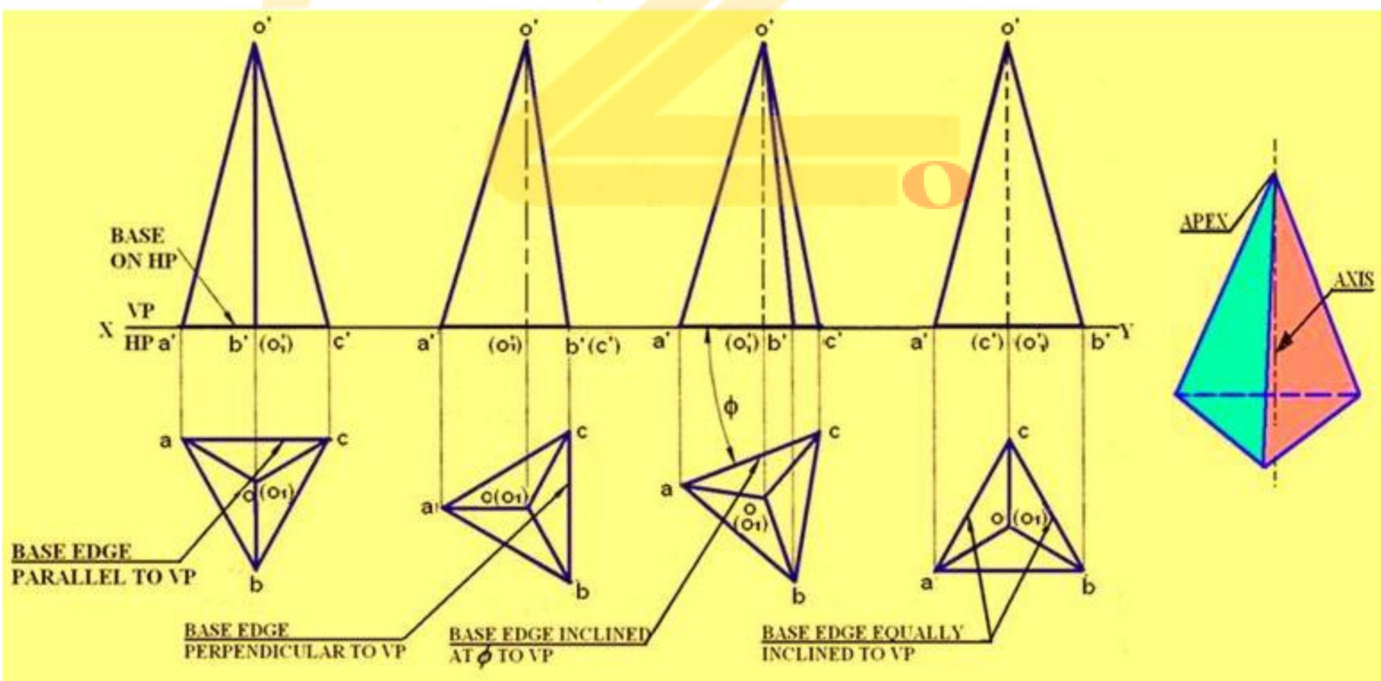


Figure 12. Projections of a triangular Pyramid resting on its base on HP with different positions.

Projections of a solid with the axis perpendicular to VP

When a solid is placed with its axis perpendicular to VP, the base of the solid will always be perpendicular to HP and parallel to VP. Hence in the front view, base will be projected in true shape. Therefore, when the axis of the solid is perpendicular to VP, the front view is drawn first and then the top and side views are drawn from it. When a cylinder rests on HP with its axis perpendicular to VP, one of its generators will be on HP. Figure 13 shows the Front view and Top view of a cylinder and cone resting on HP with their axes perpendicular to VP. In this case one of the points on the circumference of the base will be on XY.

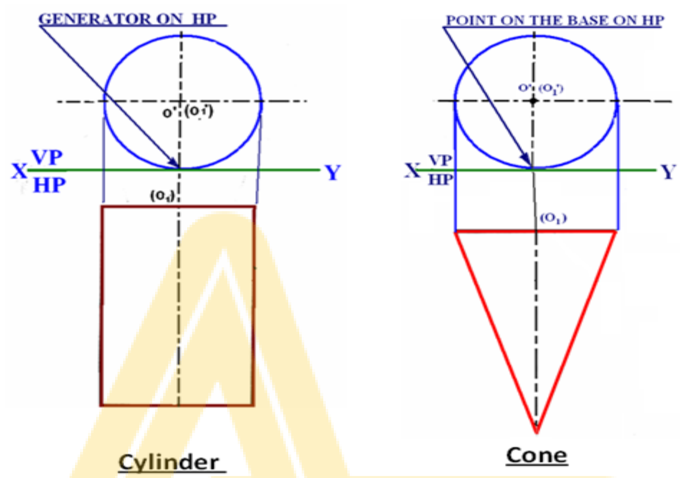


Figure 13 shows the Front view and Top view of a cylinder and cone

Prism may be placed with their axis perpendicular to VP in three different positions. The different positions are shown in figure 14.

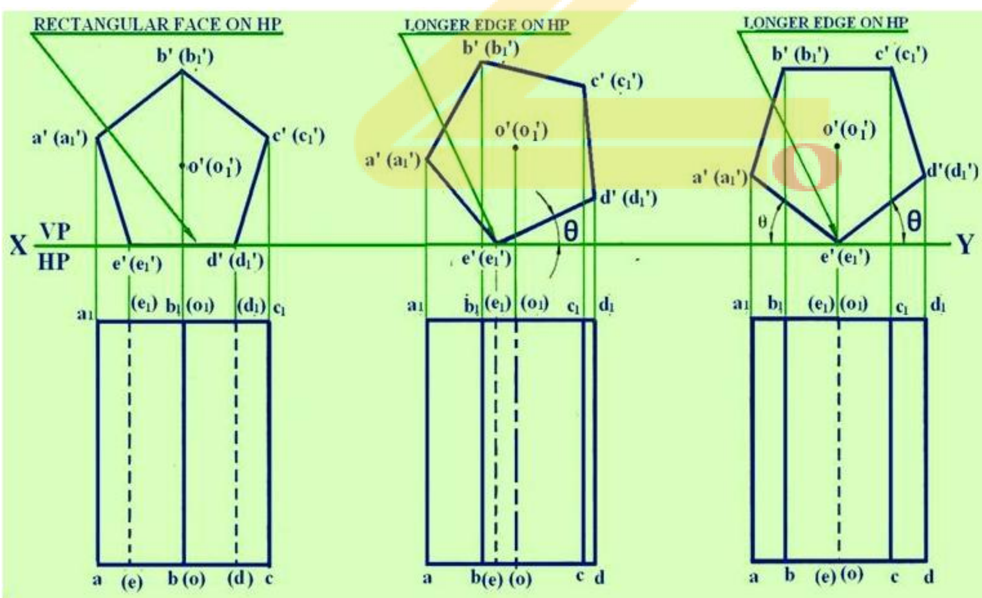


Figure 14. Projections of a pentagonal prism resting on HP and axis perpendicular to VPwith different positions.

As shown in Figure 15, pyramid may be placed with their axis perpendicular to VP in three different positions.

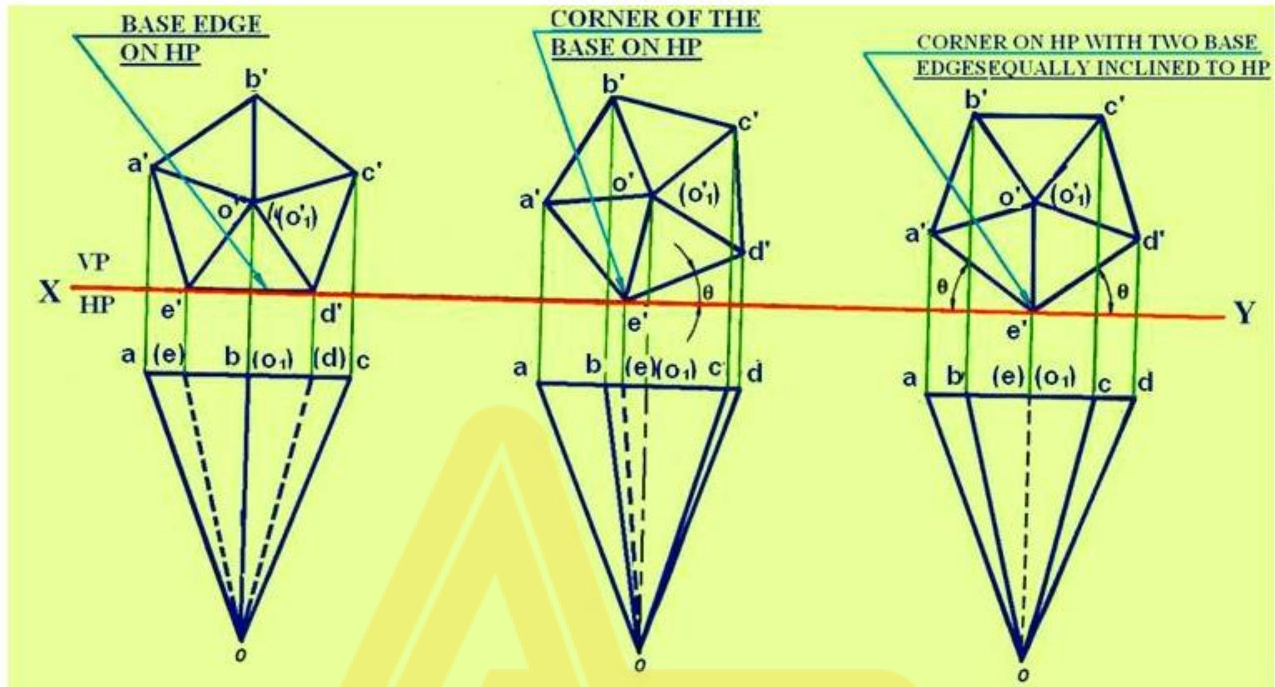


Figure 15. Projections of a pentagonal pyramid resting on HP and axis perpendicular to VP with different positions.

Axis of the solid inclined to HP and parallel to VP

When a solid is placed on HP with its axis inclined to HP, the elemental portion of the solid that lies on HP depends upon the type of the solid.
When a prism is placed on HP with its axis inclined to it, then it will lie either on one of its base edges or on one of its corners on HP.
When a pyramid is placed on HP with its axis inclined to HP, then we will have one of its base edges on HP or one of its base corners on HP or one of its slant edges on HP or one of its triangular faces on HP or an apex on HP.

3.3Methods of drawing the projections of solids

These are two methods for drawing the projections of solids:

1. Change of position method.
2. Auxiliary plane method (Change of reference-line method)

Change of position method
In this method**,** the solids are placed first in the simple position and then tilted successively in two or three stages to obtain the final position. The following are some of the examples.

a. Method of obtaining the top and the front views of the pyramid when it lies on HP on one of its base edges with its axis or the base inclined to HP.

If the solid is required to be placed with an edge of the base on HP, then initially the solid has to be placed with its base on HP such that an edge of the base is perpendicular to VP, i.e., to XY line in top view preferably to lie on sthe right side.

When a pentagonal prism has to be placed with an edge of base on HP such that the base or axis is inclined to HP, then initially, the prism is placed with its base on HP with an edge of the base perpendicular to VP and the lying on the right side. In this position, the first set of top and front views are drawn with the base edges $(c_1)(d_1)$ perpendicular to XY line in the top view. In the front view, this edge $c_1'(d_1')$ appears as a point. Since the prism has to lie with an edge of the base on HP, the front view of the prism is tilted on the edge $c_1'(d_1')$ such that the axis is inclined at q to HP.

Redraw the first front view in the tilted position. Whenever the inclination of axis q with HP is given, first the base is drawn at (90- θ) in the front view, otherwise improper selection of the position of the axis may result in the base edge $c_1'(d_1')$ lying above or below the XY line. The second top view is projected by drawing the vertical projectors from the corners of the second front view and the horizontal projectors from the first top view. Figure 1 shows the sequence in obtaining the projection of the solid for the above case.

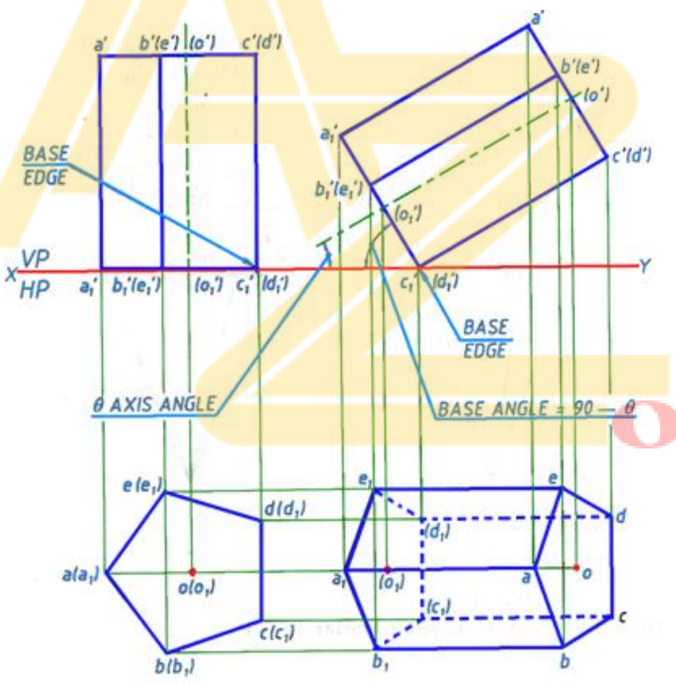


Figure 1. Illustrating the sequence for obtaining the projections of a pentagonal prism placed with an edge of base on HP such that the base or axis is inclined to HP

b.Corner of the base on HP with two base edges containing the corner on which it rests make equal inclinations with HP

When a solid lies on one of its corners of the base on HP, then the two edges of the base containing the corner on which it lies make either equal inclinations or different inclination with HP. Initially the solid should be placed with its base on HP such that an imaginary line connecting the center of the base and one of its corners is parallel to VP, i.e. to XY line in the top view, and preferably to lie on the right side. For example, when a hexagonal prism has to be placed with a corner of the base on HP such that the base or the axis is inclined to HP, then initially the prism is placed with its base on HP such that an imaginary line connecting the center of the base and a corner is parallel to VP and it lies on the right side. In this position, the first set of top and front views are drawn , as shown in step-1 of figure 2 . The line (o1)(d1) is parallel to the XY line in the top view.

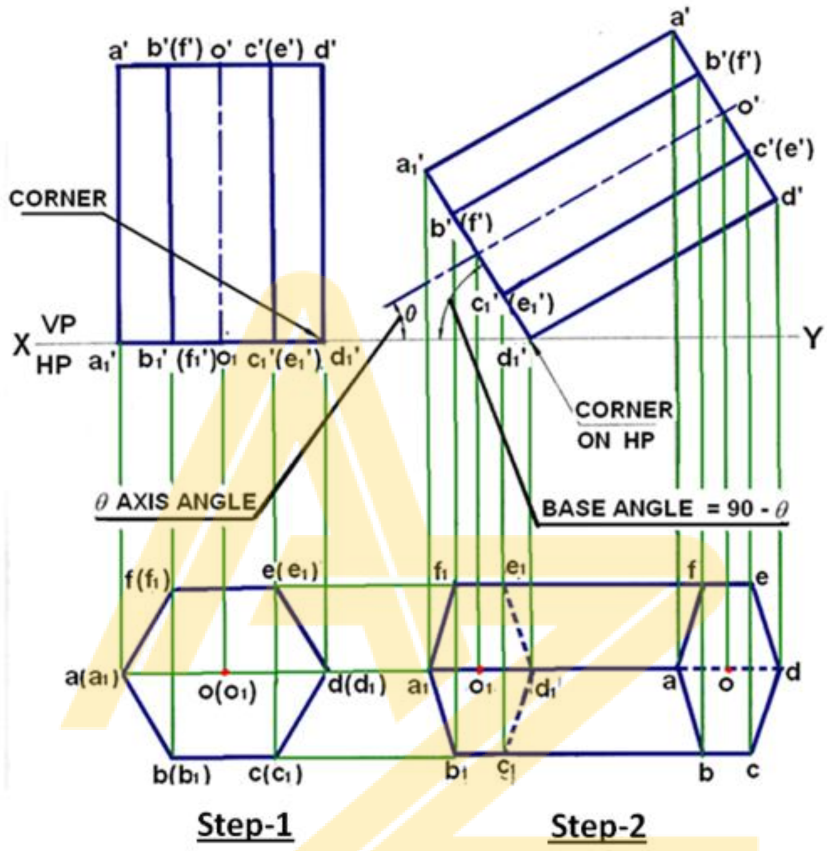


Figure 2: Projections of a prism with a corner of the base on HP and the axis is inclined to HP.

Since the prism has to lie on one of its corners of the base on HP, the front view of the prism is tilted on the corner d_1' such that the axis is inclined at q to HP. Redraw the front view in the tilted position as shown in Step-2 of figure-2. The base edge is drawn at (90- θ) in the front view. The second top view is projected by drawing the vertical projectors from the corners of the second front view and horizontal projectors from the first top view.

Following the above procedure, the top and front views of the pyramid when it rests on HP on one of its base corners such that the two base edges containing the corner on which it rests make equal inclinations with HP is shown in figure 3.

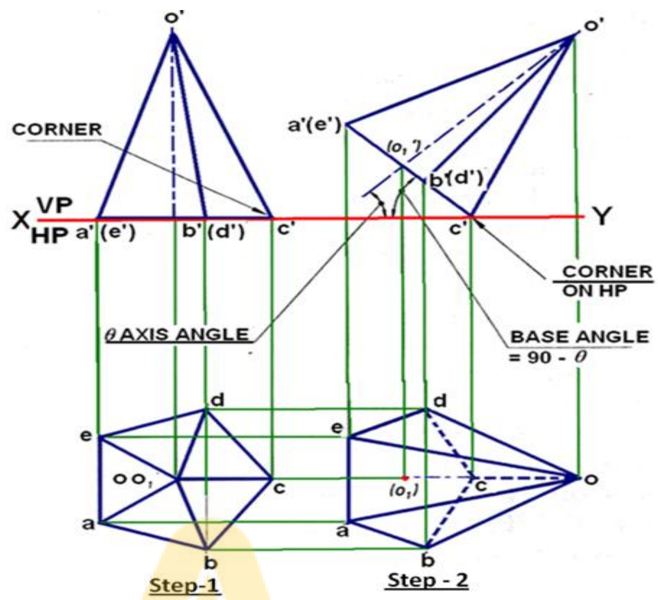


Figure 3 showing the projection of a pyramid resting on HP on one of its base corners with two base edges containing the corner on which it rests make equal inclinations with HP

c. Projections of a pyramid lying on one of its triangular faces on HP

If a pyramid has to be placed on one of its triangular faces on HP, then initially let the pyramid be placed with its base on HP such that the base edge containing that face is perpendicular to VP. (i.e. perpendicular to XY line). Figure 4 illustrates the sequence in obtaining the projections of the pyramid. In the first front view, the inclined line, **o'c'(d')** represents a triangular face. Redraw the front view such that the line representing the triangular face **o'c'(d')** lies on HP. Project the top view in this position.

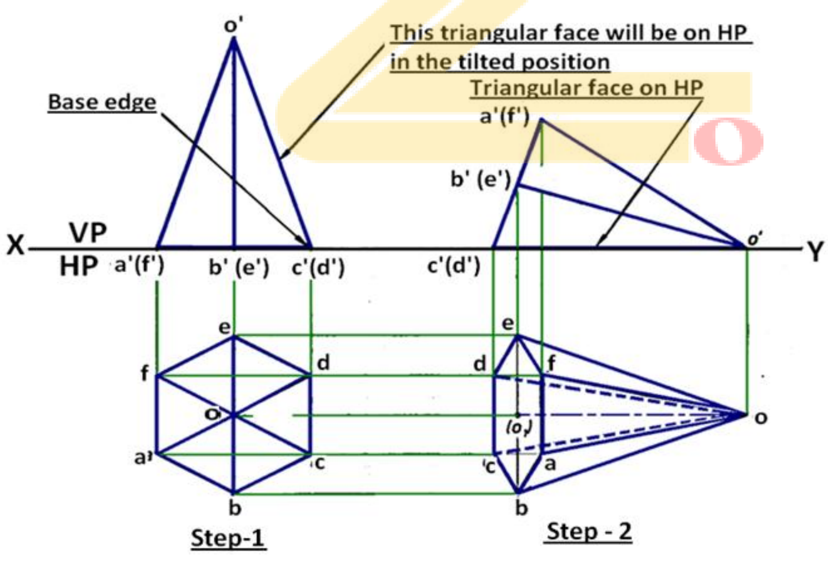


Figure 4 Illustrates the sequence in obtaining the projections a pyramid lying on one of its triangular faces on HP

d. Projections of a pyramid lying on one of its slant edge HP

The sequence of obtaining the projections of a pyramid lying on one of its slant edge on HP is shown in figure 5. In step-1, The FV and TV of the pyramid in the simple projection is drawn such that in the, top view the slant edge (line cd) on which it will rest on ground is drawn parallel to HP (parallel to XY line) in the. In the front view this edge will be line c’ o’. In step-2, the object is then rotated such that the pyramid lies with its edge o’c’ on HP. i.e. in the front view, o’c’ lies on XY line. Project the Top view from this Front view.

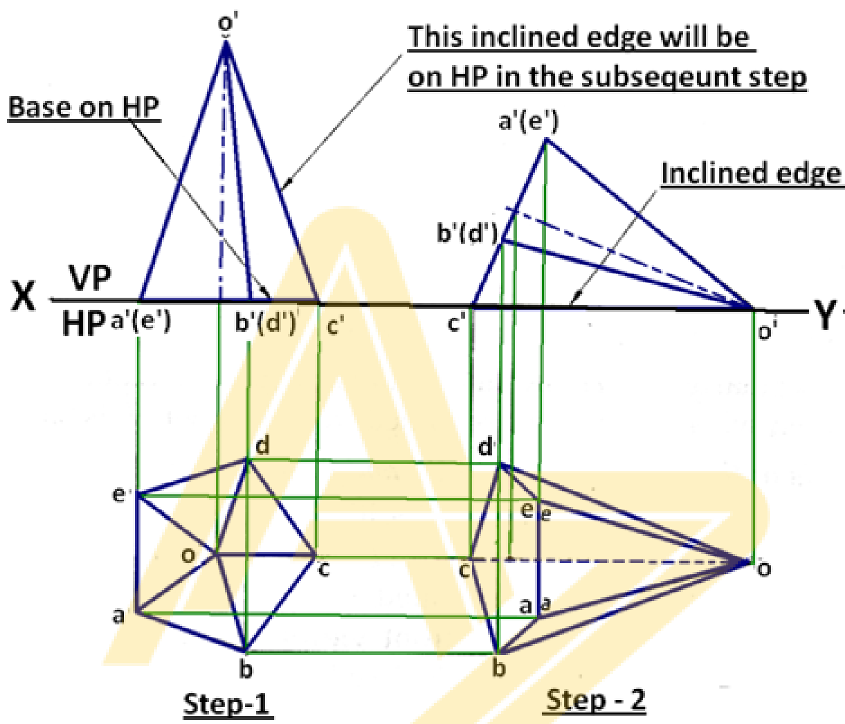


Figure 5. Projections of a pyramid lying on one of its slant edges on HP

Problem 1.
A cube of 30 mm sides is held on one of its corners on HP such that the bottom square face containing that corner is inclined at 30^0 to HP. Two of its adjacent base edges containing the corner on which it rests are equally inclined to VP. Draw the top and front views of the cube.

Solution:
The procedure of obtaining the projections is shown in figure 6. InStep-1, the projections of the cube is drawn in the simple position. The cube is assumed to lie with one of its faces completely on HP such that two vertical faces make equal inclinations with VP. Draw a square abcd to represent the top view of the cube such that two of its sides make equal inclinations with the XY line, i.e., with VP. Let (a_1), (b_1), (c_1) and (d_1) be the four corners of the bottom face of the cube which coincide in the top view with the corners a, b, c and d of the top face. Project the front view of the cube. The bottom face a_1’b_1’c_1’(d_1’) in the front view coincide with the XY line. Now the cube is tilted on the bottom right corner c_1’ (step-2) such that the bottom face a_1’b_1’c_1’(d_1’) is inclined at 30^0 to HP. Reproduce the front view with face a_1’b_1’c_1’(d_1’) inclined at 30^0 to the XY line. Draw the vertical projectors through all the corners in the reproduced front view and horizontal projectors through the corners of the first top view. These projectors intersect each other to give the corresponding corners in the top view

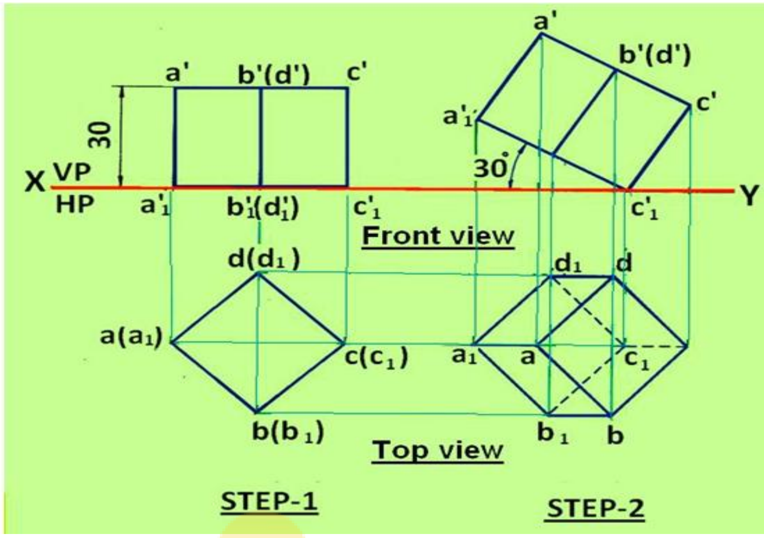


Figure 1. The projections of the cube of problem 1.

Problem-2.

A cube of 30 mm side rests with one of its edges on HP such that one of the square faces containing that edge is inclined at 30^0 to HP and the edge on which it rests being inclined to 60^0 to VP. Draw its projections.

Solution.

The procedure of obtaining the projections is shown in figure 7. First the TV and FV of the cube is drawn with the cube in the simple position. The edge bc is drawn perpendicular to the XY line. In step2, the cube is tilted such that the base of the cube is inclined at 30^0 to HP. The front view is reproduced with b1' c1'a1'd1' inclined at 30^0 to XY. The top view of the cube in step-2 is obtained by drawing projectors mentioned in problem 1. In step-3, the top view in step-2 is rotated such that line c1 b1 is inclined at 60^0 to XY line. The front view in step-2 is obtained by drawing projectors from the top view in step-3 and Front view in Step-2.

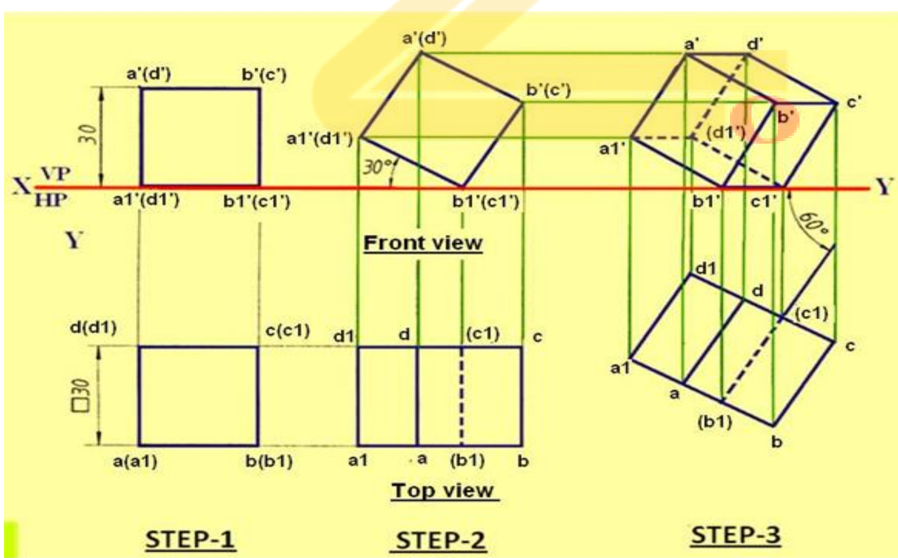


Figure 2. The projections of the cube of problem 2.

Problem 3

An equilateral triangular prism 20 mm side of base and 50 mm long rests with one of its shorter edges on HP such that the rectangular face containing the edge on which the prism rests is inclined at 30^0 to HP. The edge on which prism rests is inclined at 60^0 to VP. Draw its projections.

Solution: The procedure of obtaining the projections is shown in figure 8. The prism rests with one of its shorter edges, i.e., triangular or base edge on HP such that the rectangular face containing that edge is inclined at 30^0 to HP.

Draw the simple views of the prism when it rests with one of its triangular faces, i.e., base completely lying on HP and also with one of its shorter edges perpendicular to VP, i.e., to XY line. The shorter edge $(b_1)(c_1)$ is perpendicular to the XY line. The rectangular face containing the edge $b_1'(c_1')$ is $b_1'b'(c')(c_1')$.

Now tilt the prism on the edge $b_1'(c_1')$ such that the rectangular face $b_1'b'(c')(c_1')$ is inclined at 30^0 to the XY line. In this tilted position, project the top view.

It is seen that the edge b_1c_1 in the top view shown is perpendicular to VP, i.e, to XY line. But the edge b_1c_1 has to be inclined at 60^0 to VP, i.e, to XY line.

Therefore, reproduce the top view with the edge b_1c_1 inclined at 60^0 to the XY line as shown in the top view. Project the reproduced top view to get the front view.

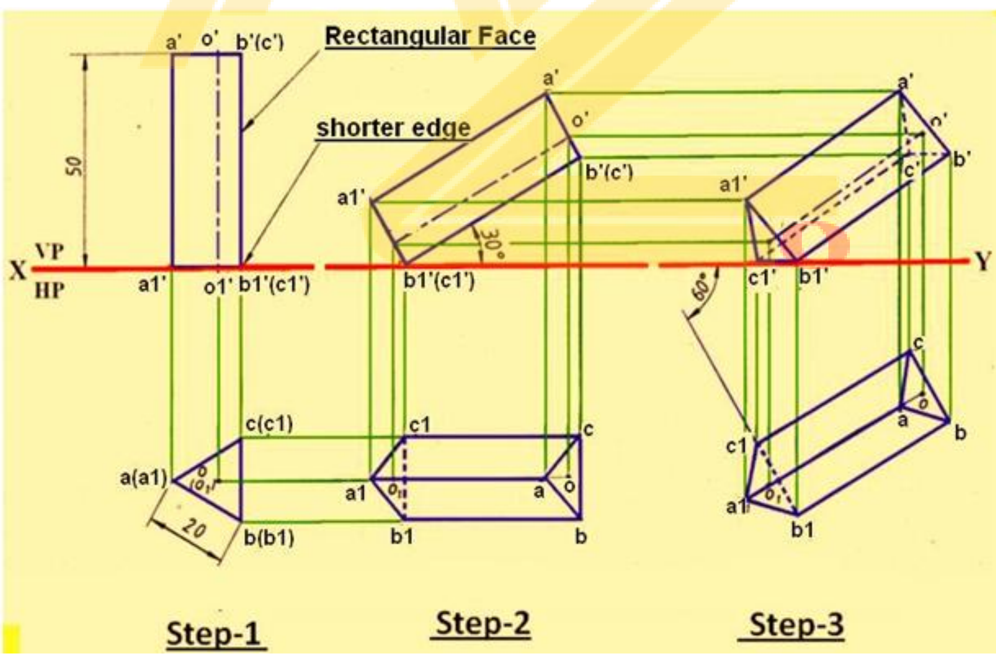


Figure 3. The projections of the triangular prism of problem-3

Problem-4

A hexagonal pyramid has an altitude of 60 mm and side base 30mm. The pyramid rests on one of its side of the base on HP such that the triangular face containing that side is perpendicular to HP. Draw the front and top views.

Solution: The solution the problem is shown in figure 9. In step-1, the pyramid is drawn in the simple position with base edge cd perpendicular to XY line. In Step-2, the Front view is tilted about cd such that line o'c'd' is made perpendicular to XY line. The top view is obtained by drawing projectors from the top view of step 1 and front view in step-2.

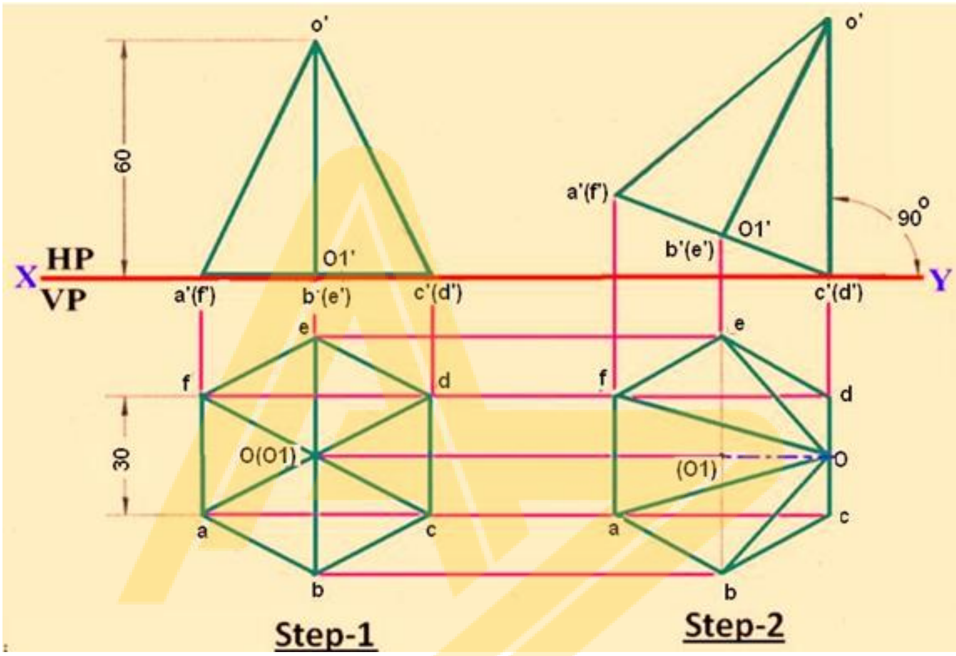


Figure 4. The projections of the hexagonal pyramid of problem-4.

Problem-5

Problem Draw the top and front views of a rectangular pyramid of sides of base 40x 50 mm and height 70 mm when it lies on one of its larger triangular faces on HP. The longer edge of the base of the triangular face lying on HP is inclined at 60^0 to VP in the top view with the apex of the pyramid being nearer to VP.

Solution :

The solution the problem is shown in figure 5. The projectors are obtained in 3-steps as illustrated in the figure. In the first step, the solid is projected in the simple position with base BC perpendicular to VP. In the second step, the solid is tilted about the edge BC such that the face BCO is made to lie on the ground. The front view is rotated and the top view is projected from the front view and the top view in the first step. In step-3, the top view is rotated such that edge BC is inclined at 60° to XY line . The Front view is projected using this top view and Front view of Step-2.

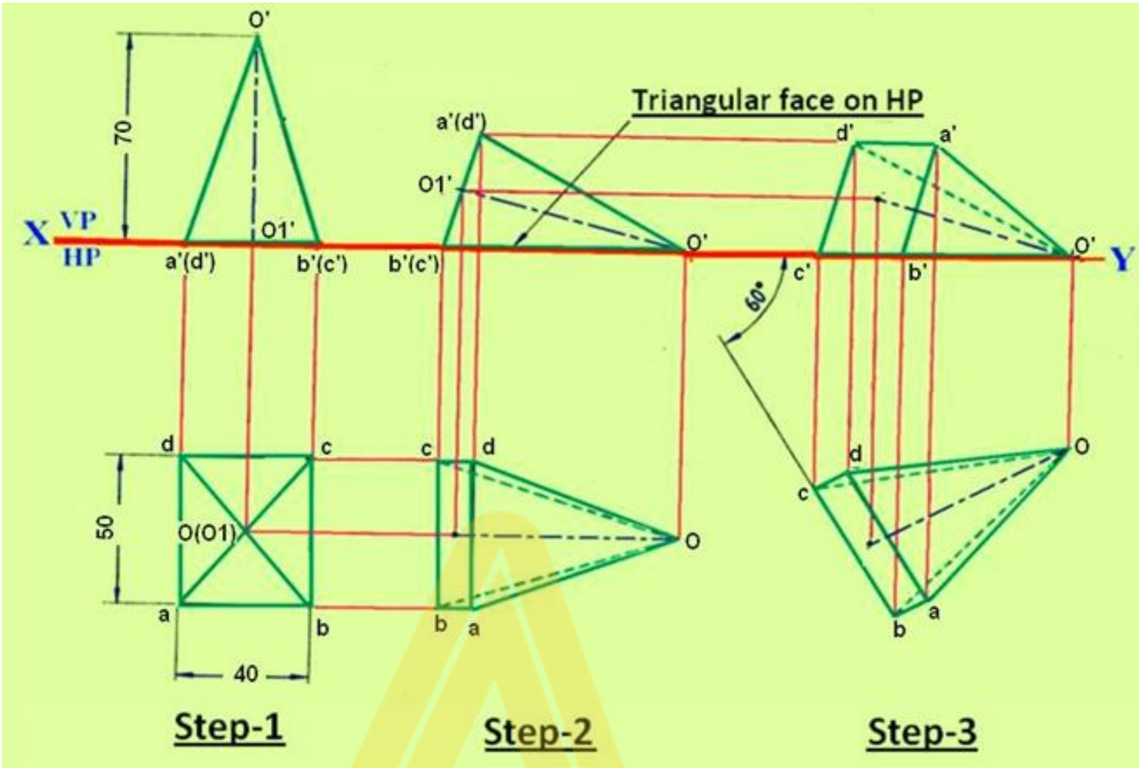


Figure 5. The projections of the rectangular pyramid of problem-5.

Problem-6
A cone of base 80 mm diameter and height 100 mm lies with one of its generators on HP and the axis appears to be inclined to VP at an angle of 40^0 in the top view. Draw its top and front views.

Solution:
Figure 6 illustrates the procedure for obtaining the projections of the cone. Three steps are involved. In step-1, the Top view and Front View of the cone is drawn in the simple position. The base circle is divided in to 12 equal parts. These points ate joined with the apex to obtain the respective generators. Instep 2, the cone is tilted such that the cone lies on one of its generator in the HP. i.e. the generator g'o' is made to coincide with the XY line. The top view of the object in this condition is drawn by drawing projectors. In step-3, the cone is titled such that in the top view the axis is inclined at 400 to the XY line. The front view of the object is obtained by projection technique.

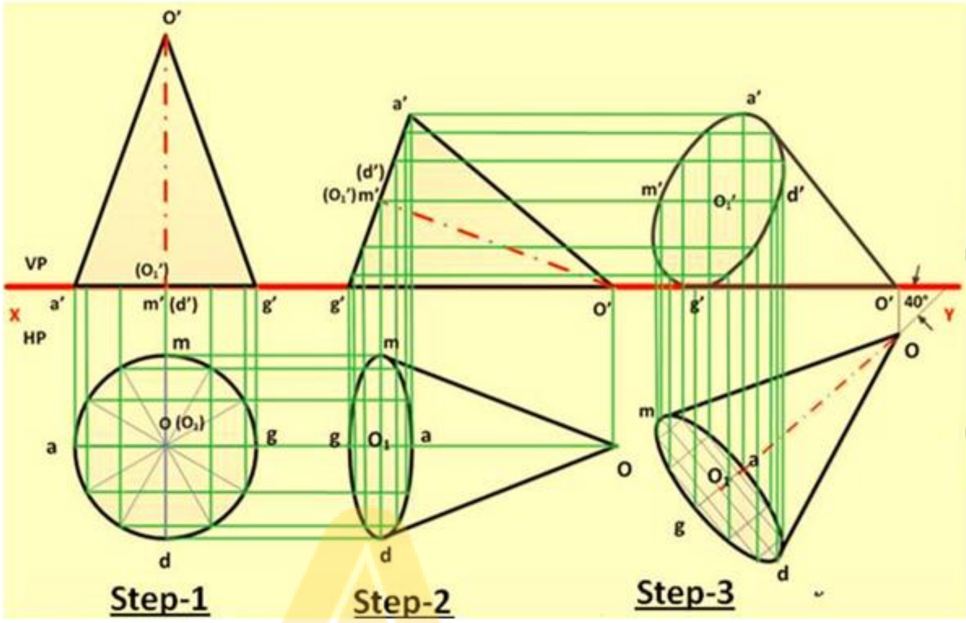


Figure 6. The projections of the cone of problem-6.

Problem-7

Draw the top and the front views of a right circular cylinder of base 45 mm diameter and 60 mm long when it lies on HP such that its axis is inclined at 35^0 to HP and the axis appears to be perpendicular to VP in the top view.

Solution:

The solution to the problem is illustrated in figure-7 . Three steps are involved as shown in the figure. In Step-1, the cylinder is drawn in the simple position (resting on the base on HP). The circle in the top view is dived in to 12 equal parts and then projected in to the front view. In step-2, The Front view is rotated about g1 such that the axis is inclined at 35° to HP (or XYline). The top view is projected from this front view with thehelp of Top view in step-1. . In step 3, the top view is rotated such that axis is perpendicular to XY line. The front view is then projected from the top view.

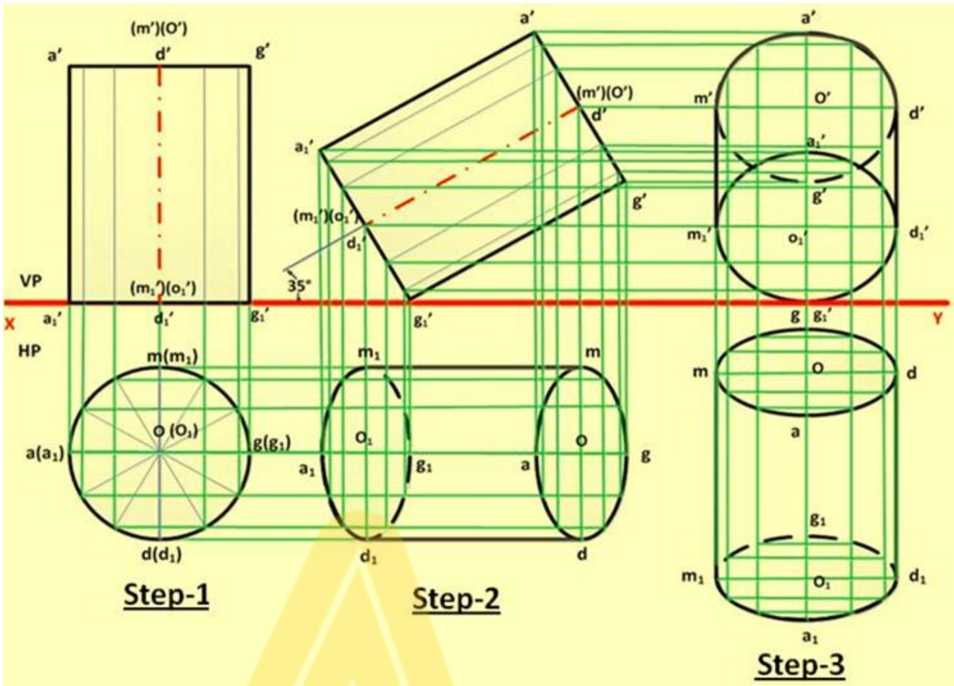
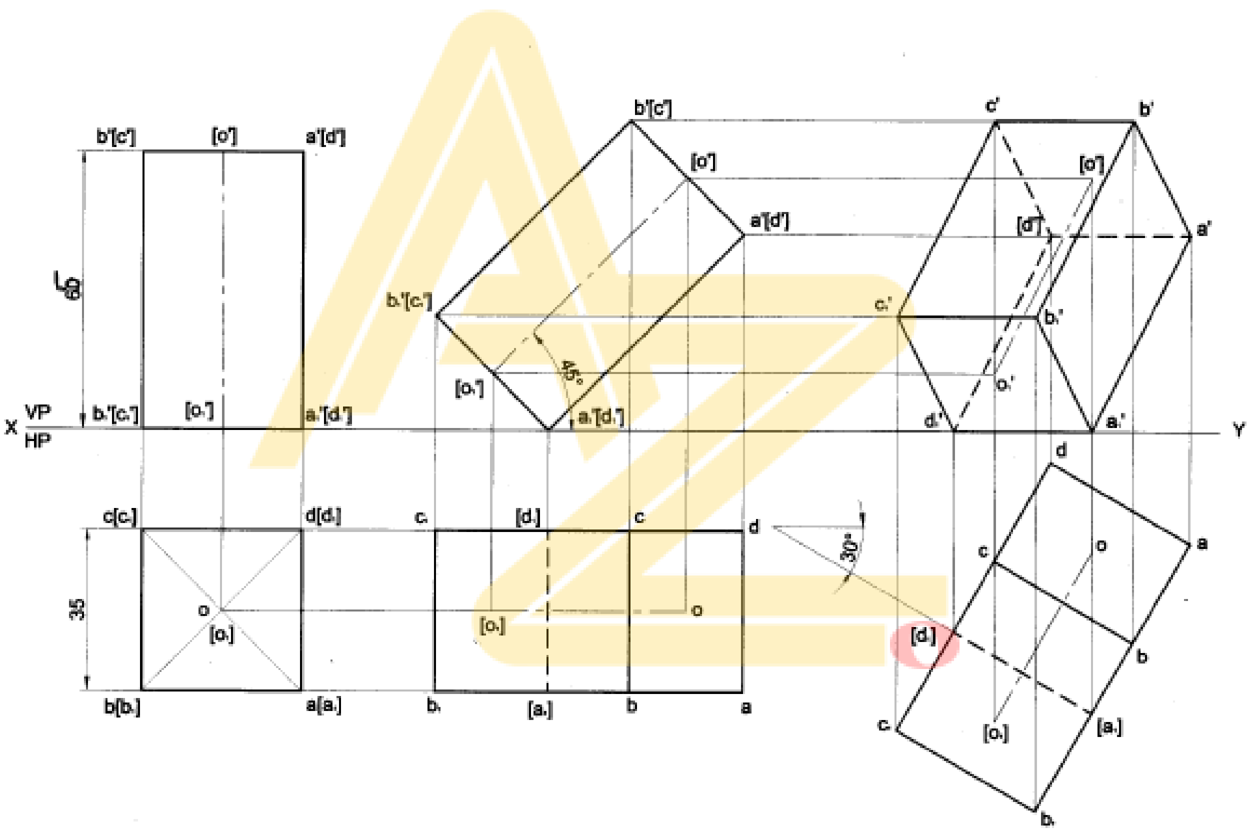


Figure 7. The projections of the cylinder as per problem-7.

Worked Examples- Projection of Solids

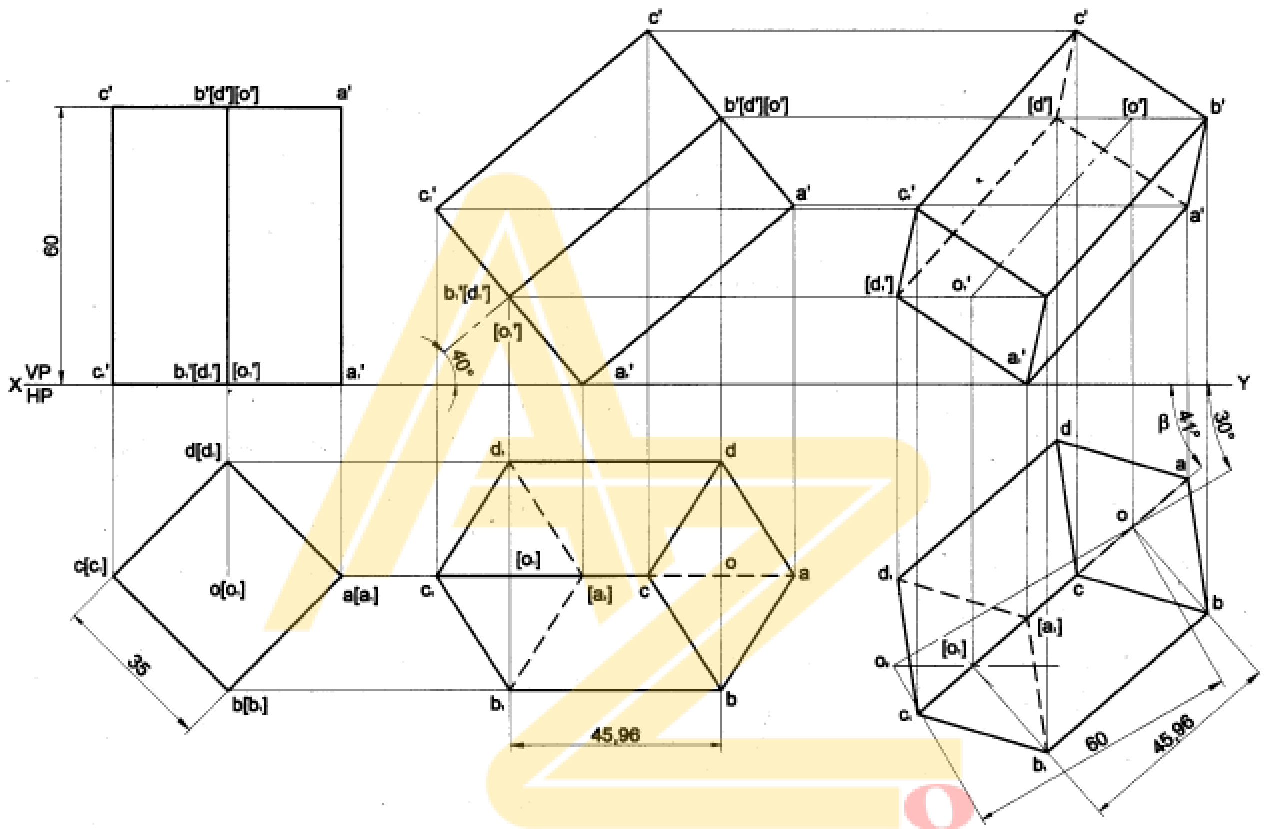
Problem 1 A square prism 35 mm sides of base and 65 mm axis length rests on HP on one of its edges of the base which is inclined to VP at 30º. Draw the projections of the prism when the axis is inclined to HP at 45º.

Solution



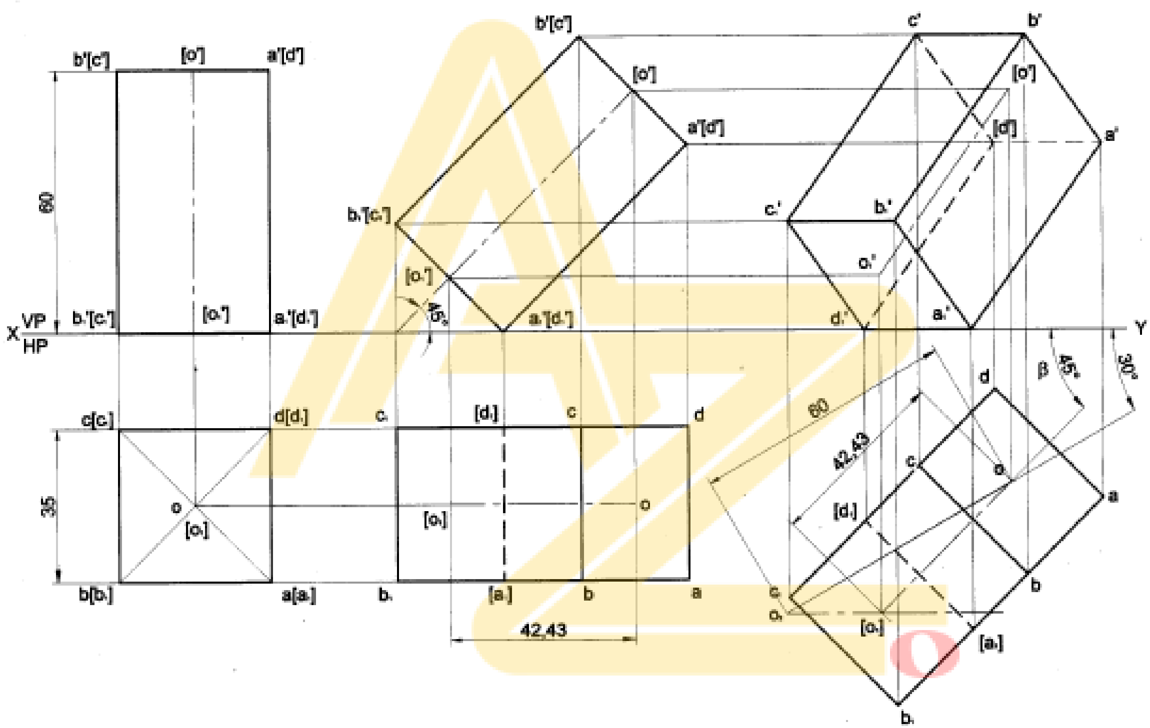
Problem 3 A square prism 35 mm sides of base and 60 mm axis length rests on HP on one of its corners of the base such that the two base edges containing the corner on which it rests make equal inclinations with HP. Draw the projections of the prism when the axis of the prism is inclined to HP at 40º and to VP at 30º.

Solution



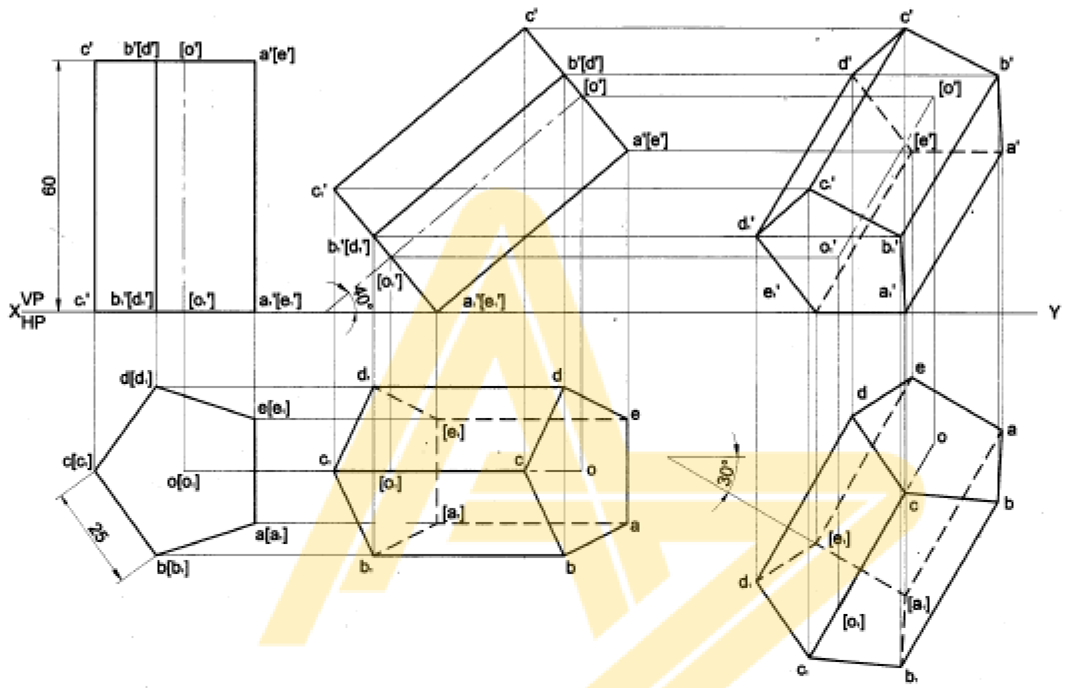
Problem 4 A square prism 35 mm sides of base and 60 mm axis length rests on HP on one of its edges of the base. Draw the projections of the prism when the axis is inclined to HP at 45º and VP at 30º.

Solution



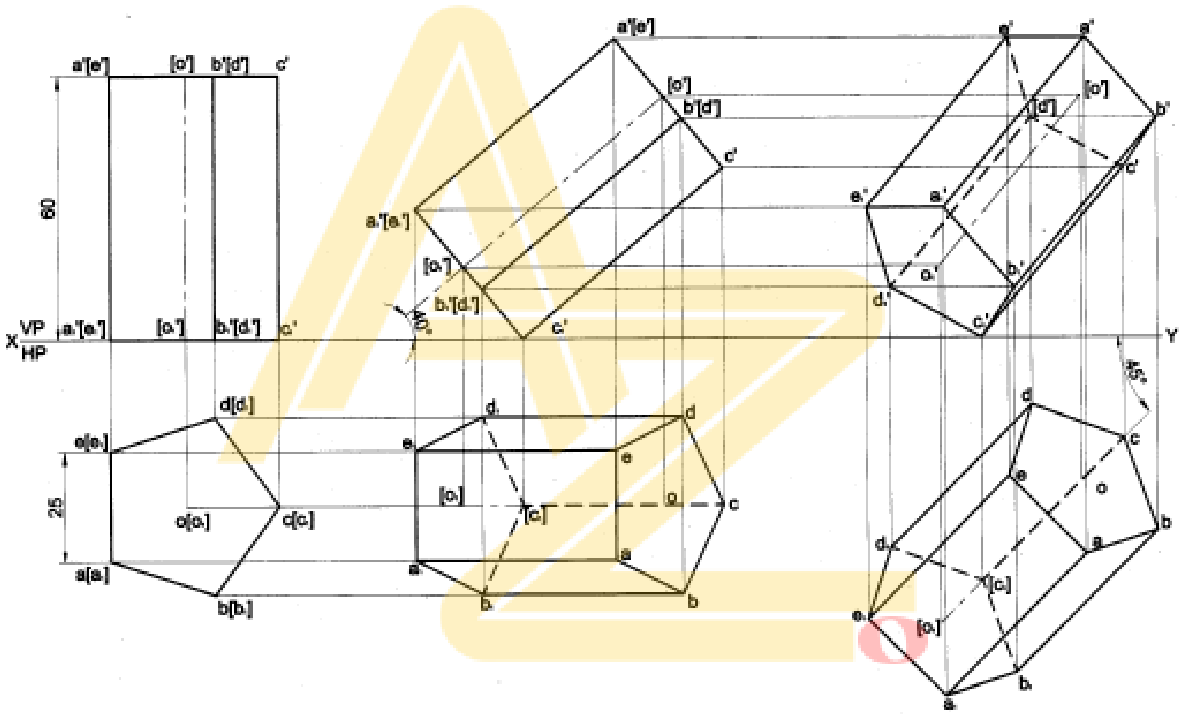
Problem 5 A pentagonal prism 25 mm sides of base and 60 mm axis length rests on HP on one of its edges of the base which is inclined to VP at 30º. Draw the projections of the prism when the axis is inclined to HP at 40º.

Solution



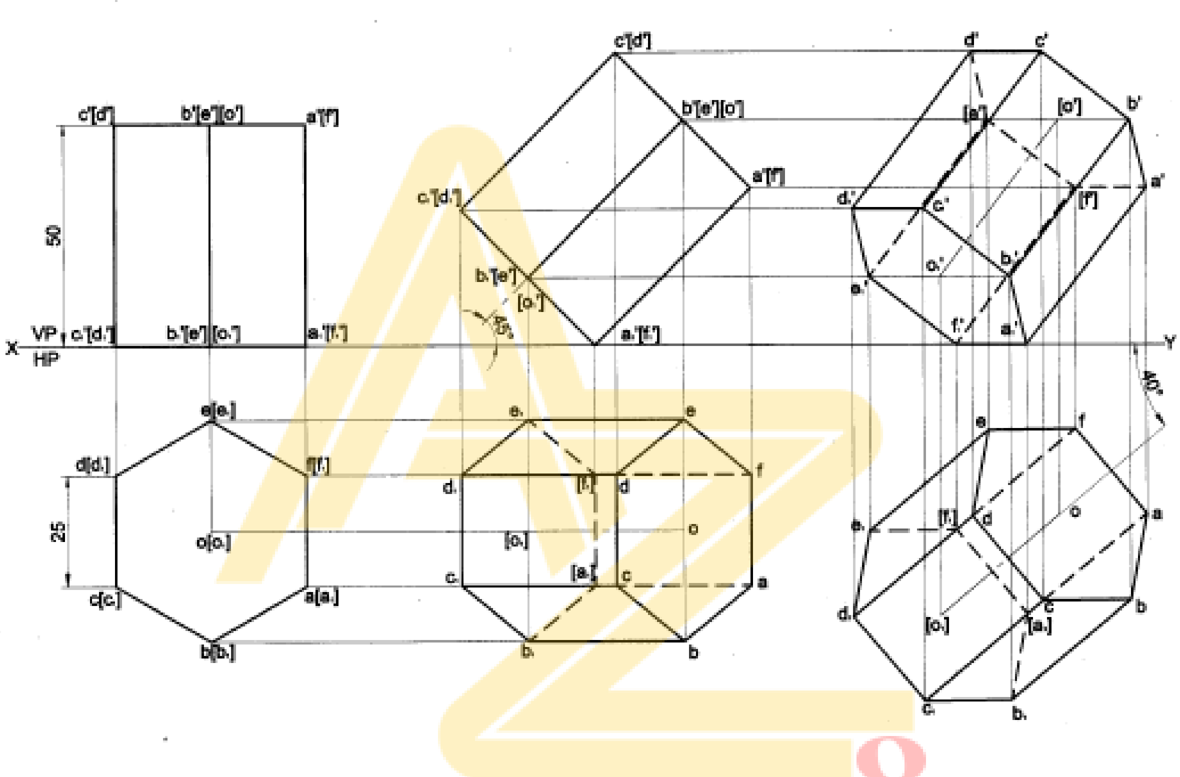
Problem 7 A pentagonal prism 25 mm sides of base and 50 mm axis length rests on HP on one of its corners of the base such that the two base edges containing the corner on which it rests make equal inclinations with HP. Draw the projections of the prism when the axis of the prism is inclined to HP at 40º and appears to be inclined to VP at 45º.

Solution



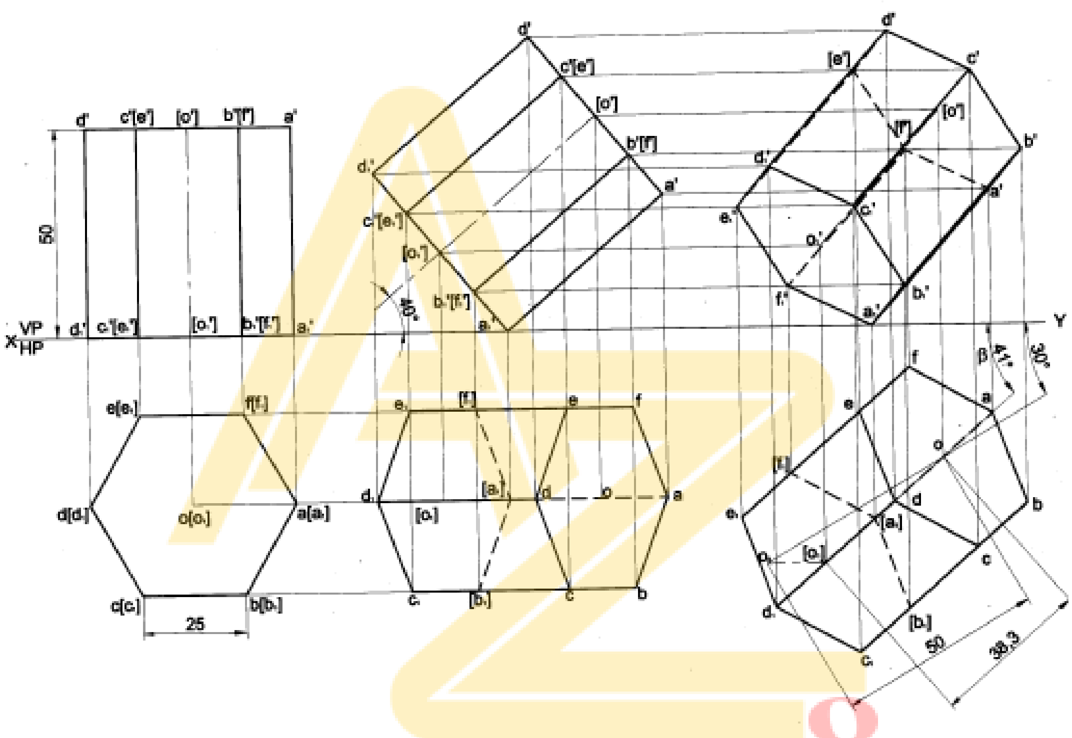
Problem 9 A hexagonal prism 25 mm sides of base and 50 mm axis length rests on HP on one of its edges. Draw the projections of the prism when the axis is inclined to HP at 45º and appears to be inclined to VP 40⁰.

Solution



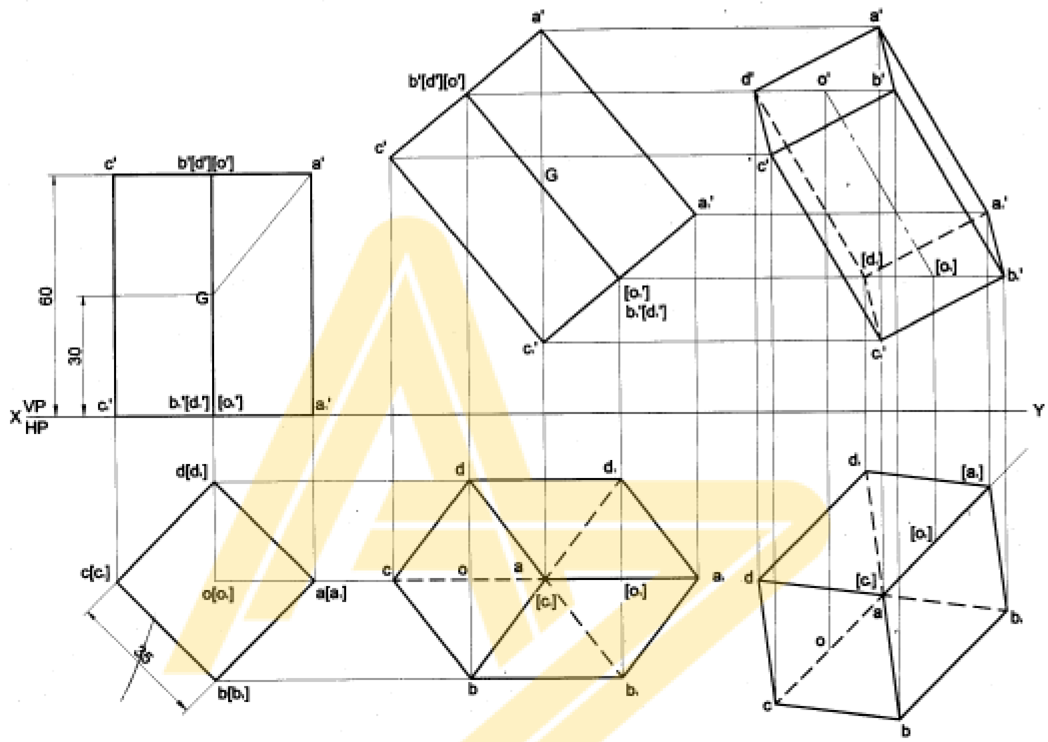
Problem 12 A hexagonal prism 25 mm sides of base and 50 mm axis length rests on HP on one of its corners of the base such that the two base edges containing the corner on which it rests make equal inclinations with HP. Draw the projections of the prism when the axis of the prism is inclined to HP at 40º and to VP at 30º.

Solution



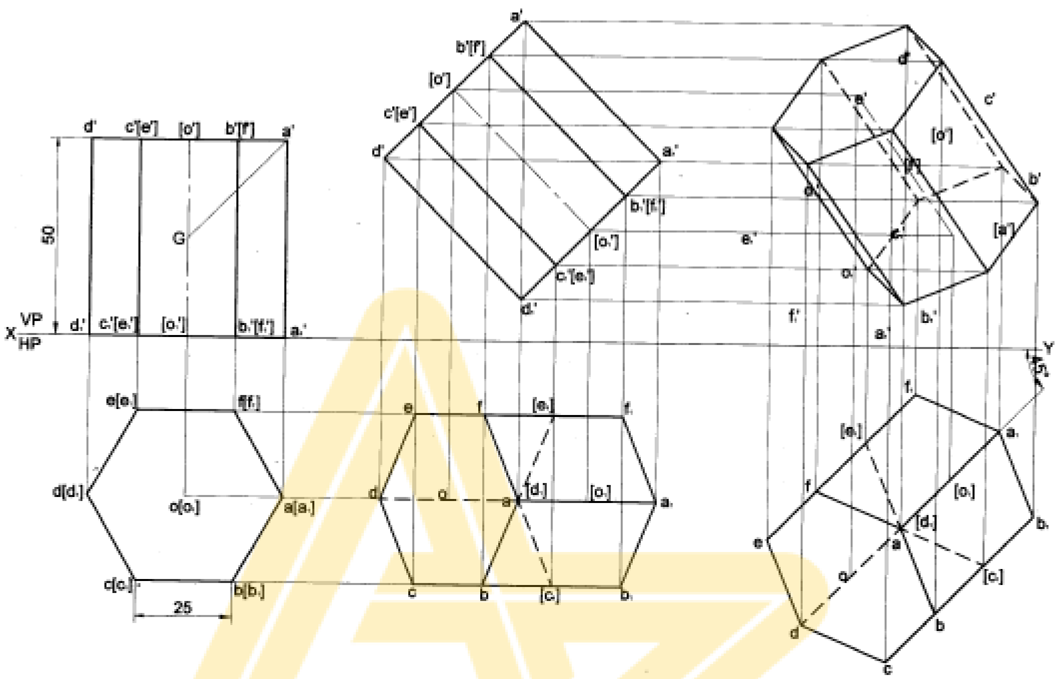
Problem 13 A square prism 35 mm sides of base and 60 mm axis length is suspended freely from a corner of its base. Draw the projections of the prism when the axis appears to be inclined to VP at 45º.

Solution



Problem 15 A hexagonal prism 25 mm sides of base and 50 mm axis length is suspended freely from a corner of its base. Draw the projections of the prism when the axis appears to be inclined to VP at 45º.

Solution



d'
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b'[f']
a'
50
G
X
VP
HP
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e[e.]
f[f.]
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o[o.]
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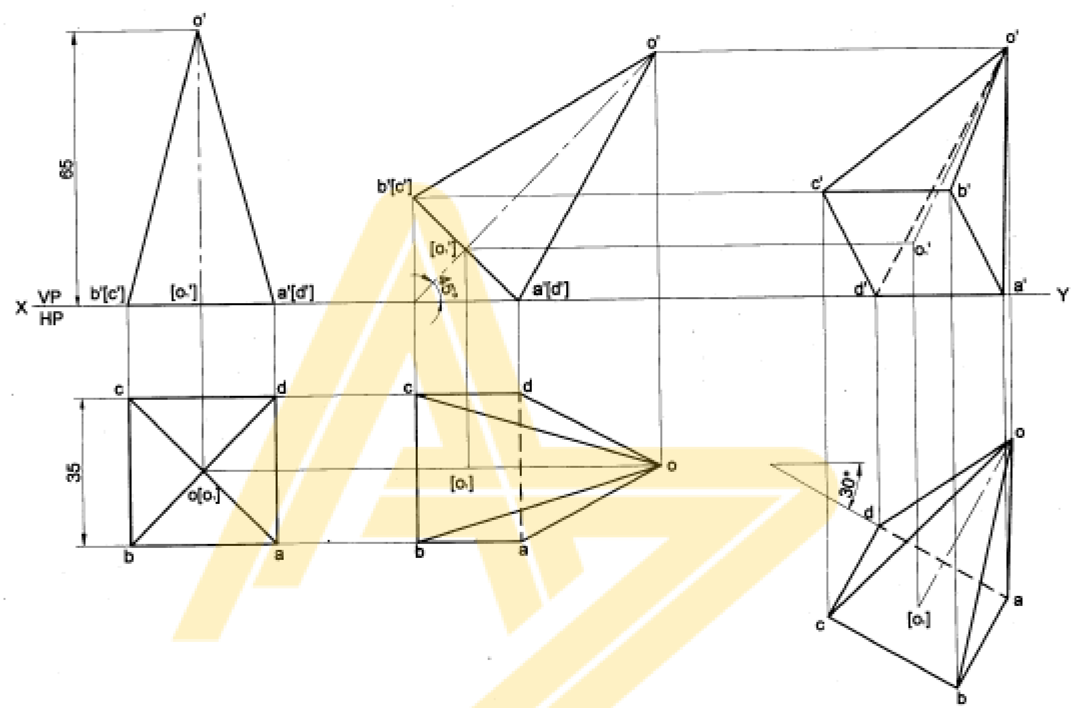
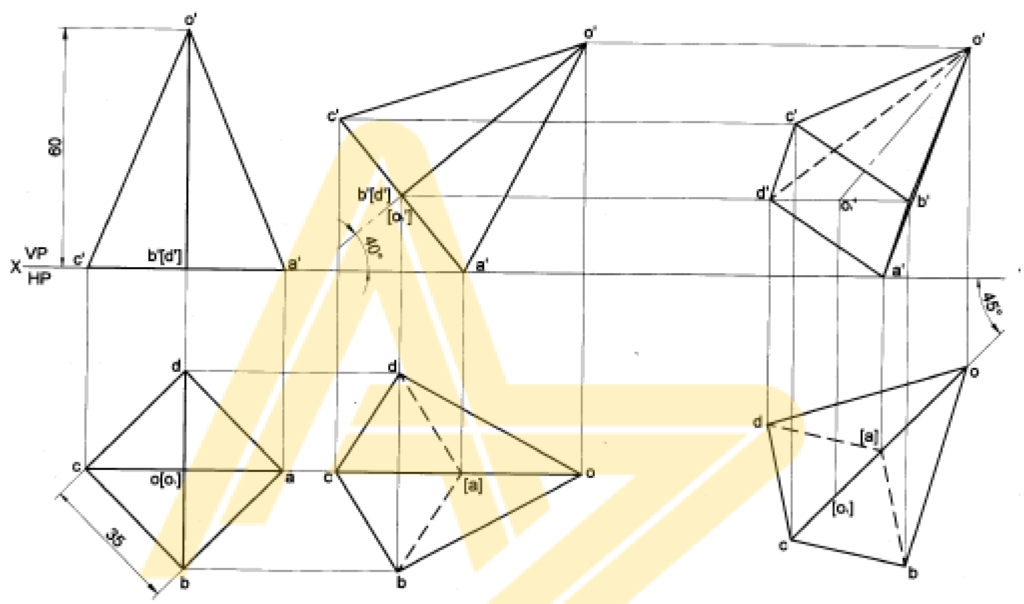
Problem 16 A square pyramid 35 mm sides of base and 65 mm axis length rests on HP on one of its edges of the base which is inclined to VP at 30º. Draw the projections of the pyramid when the axis is inclined to HP at 45º.

Solution



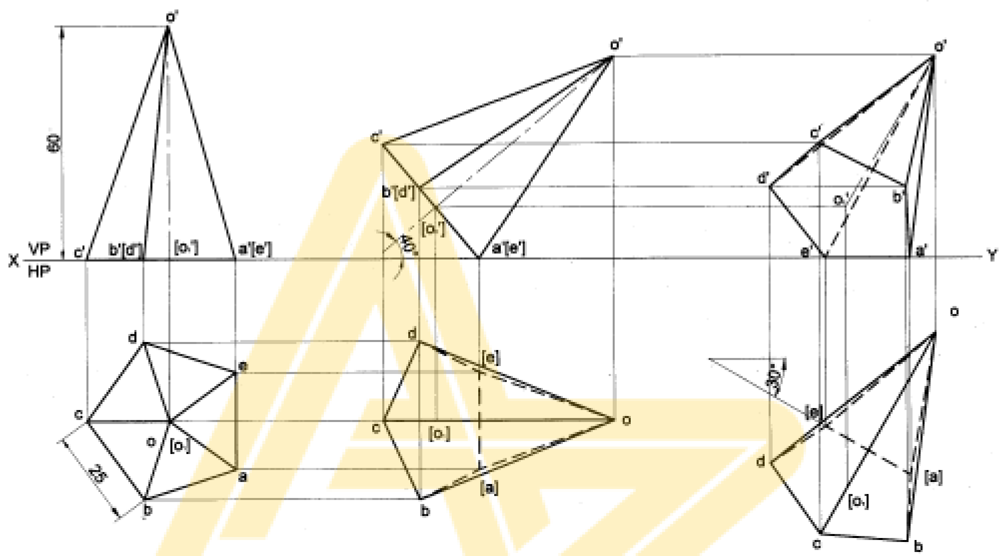
Problem 17 A square pyramid 35 mm sides of base and 60 mm axis length rests on HP on one of its corners of the base such that the two base edges containing the corner on which it rests make equal inclinations with HP. Draw the projections of the pyramid when the axis of the pyramid is inclined to HP at 40º and appears to be inclined to VP at 45º.

Solution



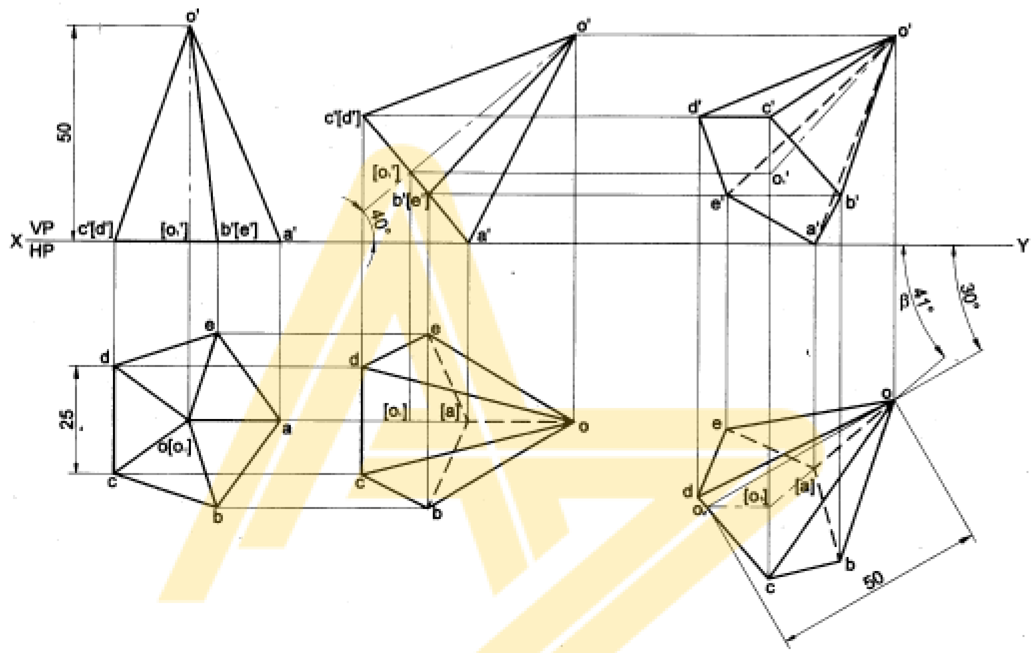
Problem 20 A pentagonal pyramid 25 mm sides of base and 60 mm axis length rests on HP on one of its edges of the base which is inclined to VP at 30º. Draw the projections of the pyramid when the axis is inclined to HP at 40º.

Solution



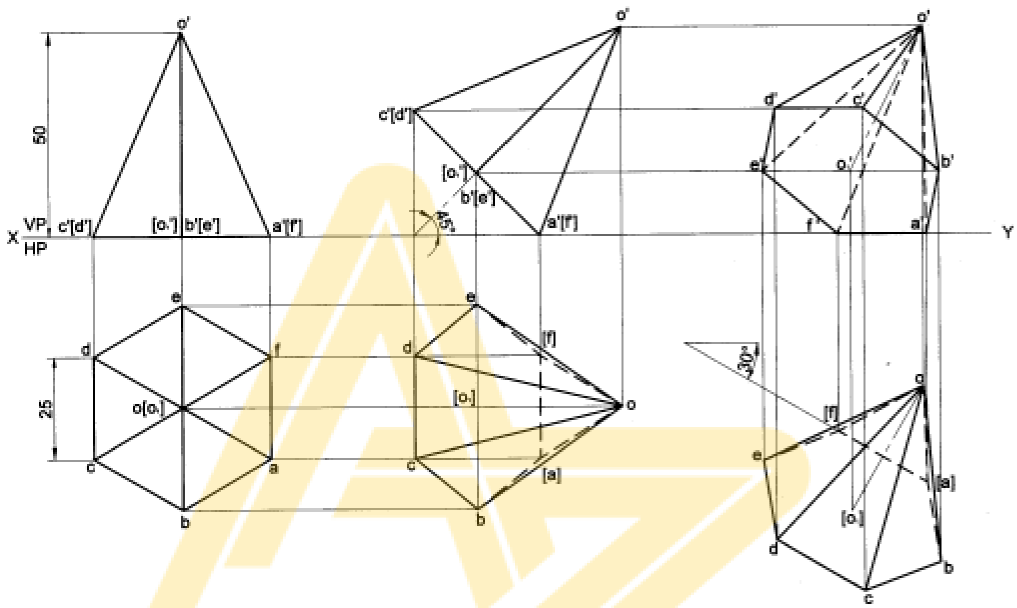
Problem 23 A pentagonal pyramid 25 mm sides of base and 50 mm axis length rests on HP on one of its corners of the base such that the two base edges containing the corner on which it rests make equal inclinations with HP. Draw the projections of the pyramid when the axis of the pyramid is inclined to HP at 40º and to VP at 30º.

Solution



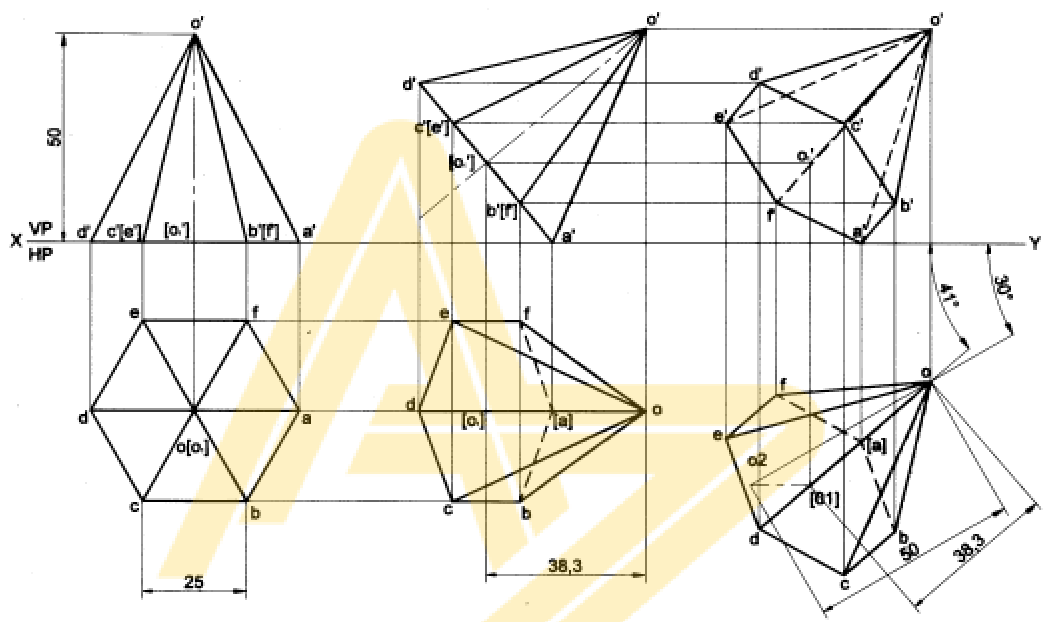
Problem 24 A hexagonal pyramid 25 mm sides of base and 50 mm axis length rests on HP on one of its edges of the base which is inclined to VP at 30º. Draw the projections of the pyramid when the axis is inclined to HP at 45º.

Solution



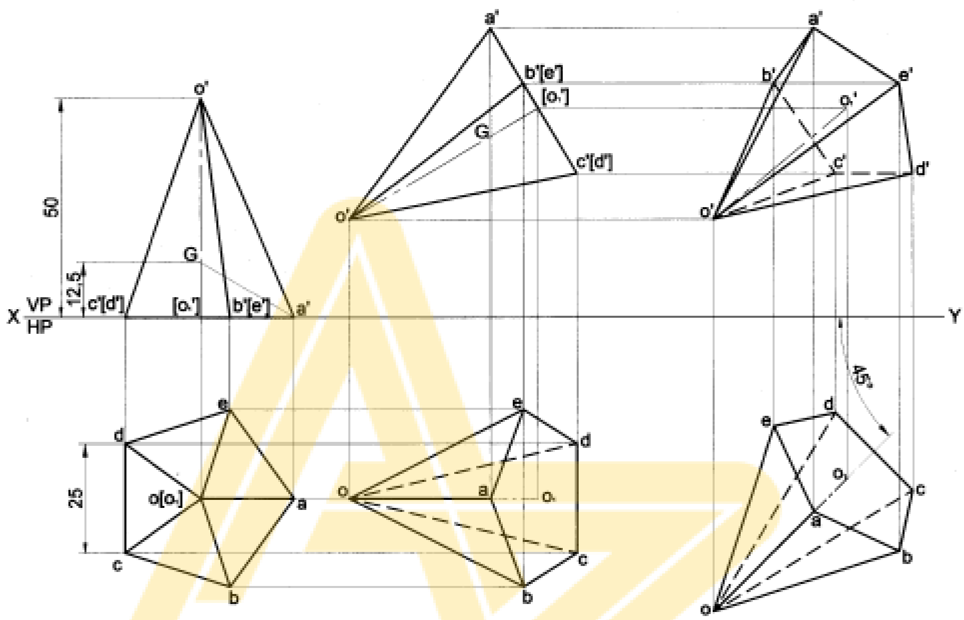
Problem 27 A hexagonal pyramid 25 mm sides of base and 50 mm axis length rests on HP on one of its corners of the base such that the two base edges containing the corner on which it rests make equal inclinations with HP. Draw the projections of the pyramid when the axis of the pyramid is inclined to HP at 40º and to VP at 30º.

Solution



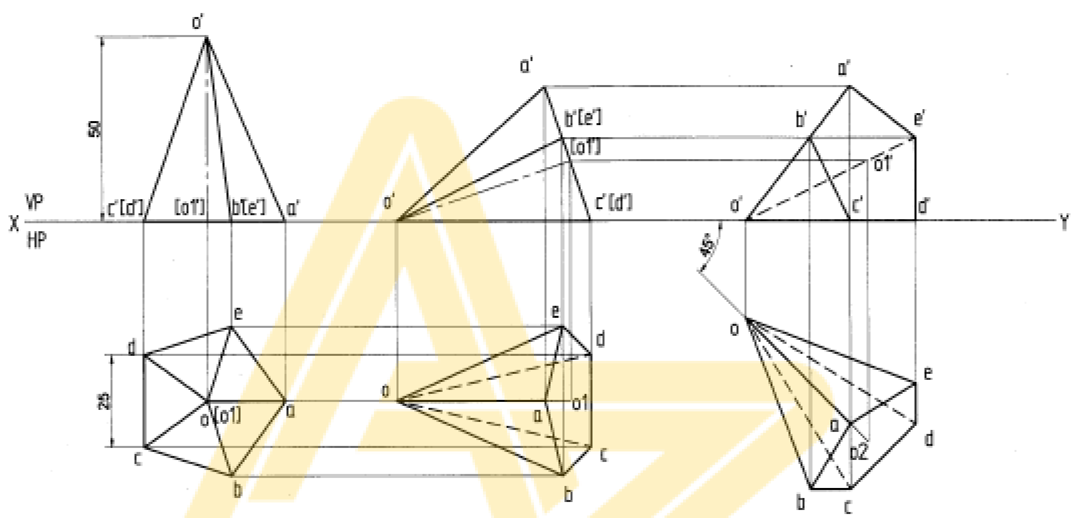
Problem 29 A pentagonal pyramid 25 mm sides of base and 50 mm axis length is suspended freely from a corner c its base. Draw the projections of the pyramid when the axis appears to be inclined to VP at 45º.

Solution



Problem 37 A pentagonal pyramid 25 mm sides of base and 50 mm axis length rests on HP on one of its slant triangular faces. Draw the projections of the pyramid when the axis appears to be inclined to VP at 45º.

Solution



Problems on Solids

1. A pentagonal pyramid 25 mm sides of base and 60 mm axis length rests on HP on one of its edges of the base which is inclined to VP at 30°. Draw the projections of the pyramid rests HP on one of its edges of the base which is inclined to VP at 30°. Draw the projections of the pyramid when the axis is inclined to HP at 40°.
2. A pentagonal pyramid 25 mm sides of base and 50 mm sides of base and 50 mm axis length rests on HP on one of its edges of the base. Draw the projections of the pyramid when the is inclined to HP at 45° and VP at 30°.
3. A pentagonal pyramid 25 mm sides of base and 50 mm axis length rests on HP on one of its corners of the base such that the two base edges containing the corner on which it rests make equal inclinations with HP. Draw the projections of the pyramid when the axis of the pyramid inclined to HP at 40° and appears to be inclined to VP at 45°.

4. A pentagonal pyramid 25 mm sides of base and 50 mm axis length rests on HP on one of its corners of the vase such that the two base edges containing the corner on which it rests make equal inclined with HP. Draw the projections of the pyramid when the axis of the pyramid is inclined to HP at 40° and to VP at 30°.
5. A hexagonal pyramid 25 mm sides of base and 50 mm axis length rests on HP on one of its edges of the base which is inclined to VP at 30°. Draw the projections of the pyramid when the axis is inclined to HP at 45°.
6. A hexagonal pyramid 25 mm sides of base and 50 mm axis length rests on HP on one of its edges of the base. Draw the projection of the pyramid when the axis is inclined to HP at 45° and VP at 30°.
7. A hexagonal pyramid 25 mm sides of base and 50 mm axis length rests on one of its corners of the base such that the two base containing the corner on which it rests make equal inclinations with HP. Draw the projections of the pyramid on when the axis of the pyramid is inclined to HP at 40° and appears to be inclined to VP at 45°.
8. A hexagonal pyramid 25 mm sides of base and 50 mm axis length rests on HP on one of its corners of the base such that the two base edges containing the corner on which it rests make equal inclinations with HP. Draw the projections of the pyramid when the axis of the pyramid is inclined to HP at 40° and to VP at 30°.
9. A square pyramid 35 mm sides of base and 60 mm axis length is suspended freely from a corner of its base. Draw the projections of the pyramid when the axis appears to be inclined to VP at 45°.
10. A pentagonal pyramid 25 mm sides of base and 50 mm axis length is suspended freely from a corner of its base. Draw the projections of the pyramid when the appears to be inclined to VP at 45°.
11. A hexagonal pyramid 25 mm sides of base and 50 mm axis length is suspended freely from a corner of its base. Draw the projections of the pyramid when the axis appears to be inclined to VP at 45°.
12. A square pyramid 35 mm sides of base and 60 mm axis length rests on HP on one of its slant edges. Draw the projections of the pyramid when the axis appears to be inclined to VP at 45°.
13. A square pyramid 35 mm sides of base and 60 mm axis length rests on HP on one of its slant5 edges. Draw the projections of the pyramid when the axis is inclined to VP at 45°.
14. A square pyramid 35 mm sides of base and 60 mm axis length rests on HP on one of its slant triangular faces. Draw the projections of the pyramid when the axis appears to be inclined to VP at 45°.

FURTHER READING:

1) Computer Aided Engineering Drawing - S. Trymbaka Murthy, - I.K. International Publishing House Pvt. Ltd., New Delhi, 3rd revised edition- 2006.
2) Engineering Graphics - K.R. Gopalakrishna, 32nd edition, 2005- Subash Publishers Bangalore.
3) Dhananjay A Jolhe, Engineering Drawing, Tata McGraw Hill, 2007.
4) M.B. Shah and B.C. Rana, Engineering Drawing, pearson Education, Eds. 2, 2009.
5) K. Venugopal, Engineering Drawing and Graphics, New Age International (P) Ltd., publishers, 2000.
6) N.D. Bhatt and V.M. Panchal, Engineering Drawing, Charotar Publishing house, 2005.

MODULE-4

SECTIONS AND DEVELOPMENT OF LATERAL SURFACES OF SOLIDS

OBJECTIVES:

1) To understand the basic concept of development
2) Development of lateral surface of prisms and cylinders when it is cut by section plane.
3) Development of lateral surface of pyramids and cone when it is cut by section plane.

LESSON CONTENT:

Introduction, Section planes, Sections, Section views, Sectional views, Apparent shapes and True shapes of Sections of right regular prisms, pyramids, cylinders and cones resting with base on HP. (No problems on sections of solids) Development of lateral surfaces of above solids, their frustums and truncations. (No problems on lateral surfaces of trays, tetrahedrons, spheres and transition pieces).

4.1 Development of surfaces

A development is the unfold / unrolled flat / plane figure of a 3-D object. It is also called a pattern where the plane may show the true size of each area of the object. When the pattern is cut, it can be rolled or folded back into the original object as shown in figure 1.

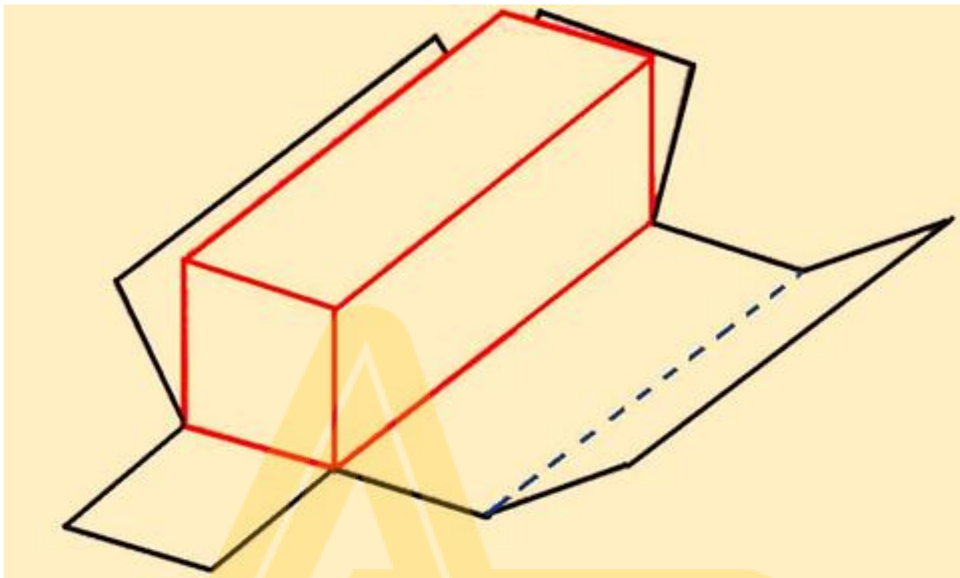


Figure 1. Typical development of the surface of a cuboid.

Types of development
There are three major types of development followed by industries. Examples are shown in figure 2.

1. **Parallel line development**: In this parallel lines are used to construct the expanded pattern of each three-dimensional shape. The method divides the surface into a series of parallel lines to determine the shape of a pattern.
2. **Radial line development**: In this, lines radiating from a central point to construct the expanded pattern of each three-dimensional shape is used. These shapes each form part of a cone and lines radiating from the vertex of the cone generate the expanded pattern of the curved surface as shown in the following explorations.
3. **Triangulation method**: This is generally used for polyhedron, single curved surfaces, and warped surfaces.
4. **Approximate development**: In this, the shapes obtained are only approximate. After joining, the part is stretched or distorted to obtain the final shape

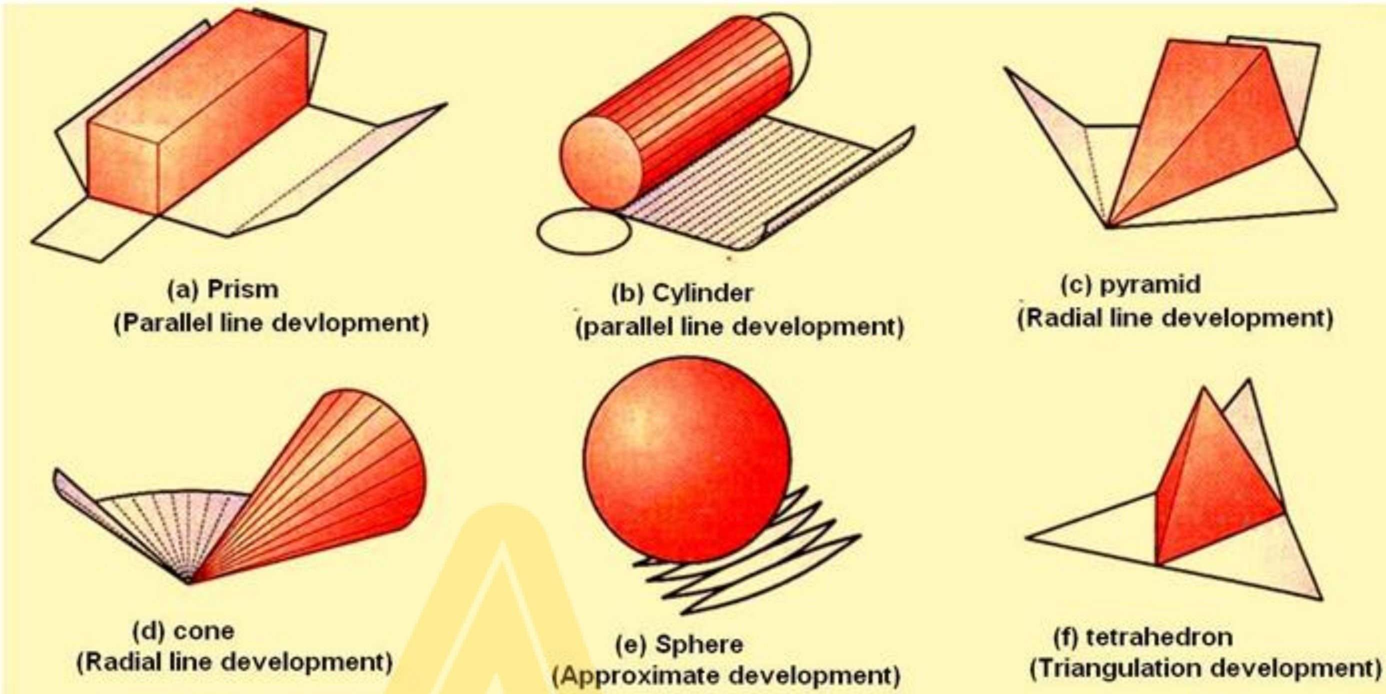


Figure 2. Typical examples of the various types of development.

A true development is one in which no stretching or distortion of the surfaces occurs and every surface of the development is the same size and shape as the corresponding surface on the 3-D object. e.g. polyhedrons and single curved surfaces.
As illustrated in figure 3, polyhedrons are composed entirely of plane surfaces that can be flattened true size onto a plane in a connected sequence, where as single curved surfaces are composed of consecutive pairs of straight-line elements in the same plane which is obtained for a cone.

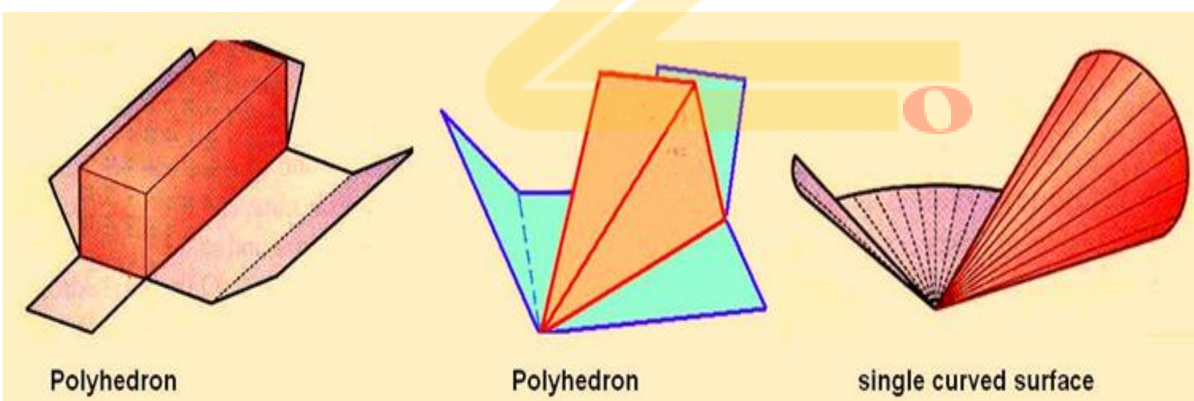


Figure 3. shows the true development obtained for polyhedrons and single curved surface

An approximate development is one in which stretching or distortion occurs in the process of creating the development. The resulting flat surfaces are not the same size and shape as the corresponding surfaces on the 3-D object. Wrapped surfaces do not produce true developments, because pairs of consecutive straight-line elements do not form a plane. Also double-curved surfaces, such as a sphere do not produce true developments, because they do not contain any straight lines. An example of the approximate development of a sphere is shown in figure 4 .

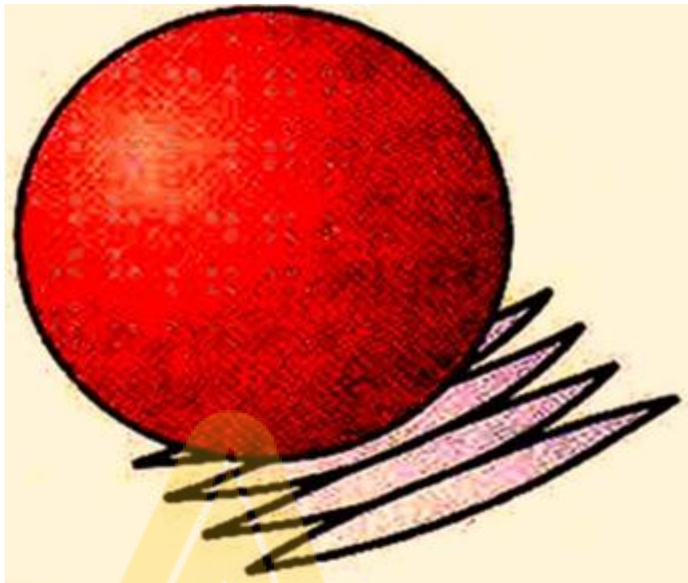


Figure 4 showing an approximate development of a sphere.

4.2 Classifications of developments

1. Parallel-line development: They are made from common solids that are composed of parallel lateral edges or elements. e.g. Prisms and cylinders as shown in figure 5. The cylinder is positioned such that one element lies on the development plane. The cylinder is then unrolled until it is flat on the development plane. The base and top of the cylinder are circles, with a circumference equal to the length of the development. All elements of the cylinder are parallel and are perpendicular to the base and the top. When cylinders are developed, all elements are parallel and any perpendicular section appears as a stretch-out line that is perpendicular to the elements.

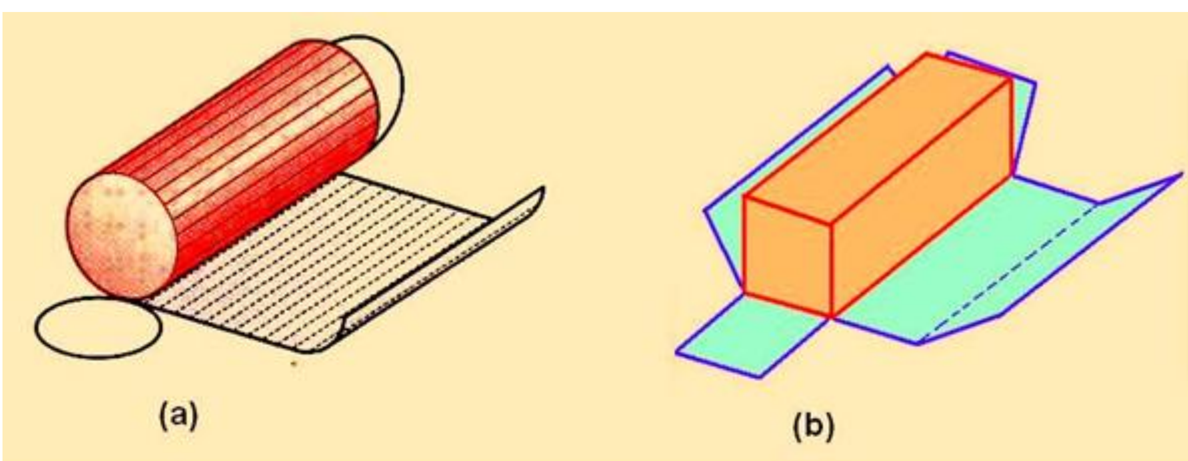


Figure 5 shows the parallel line development technique for (a) cylinder and (b) rectangular block.

2. Radial-line development

Radial-line developments are made from figures such as cones and pyramids. In the development, all the elements of the figure become radial lines that have the vertex as their origin. Figure 6 shows the radial development for a cone. The cone is positioned such that one element lies on the development plane. The cone is then unrolled until it is flat on the development plane. One end of all the elements is at the vertex of the cone. The other ends describe a curved line. The base of the cone is a circle, with a circumference equal to the length of the curved line.

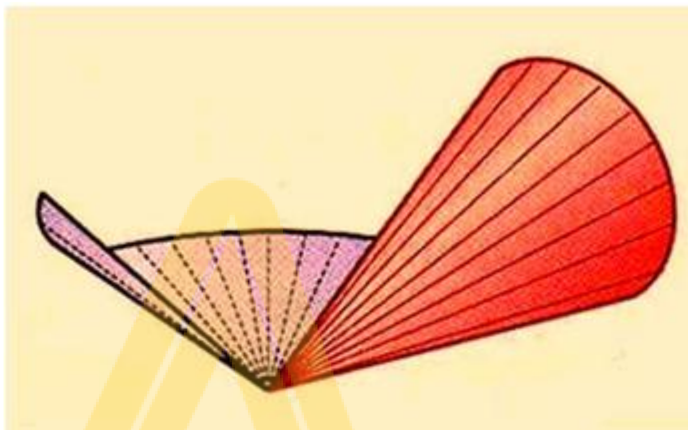


Figure 6 shows the radial development method for a cone.

3. Triangulation developments:

Made from polyhedrons, single-curved surfaces, and wrapped surfaces. The development involve subdividing any ruled surface into a series of triangular areas. If each side of every triangle is true length, any number of triangles can be connected into a flat plane to form a development. This is illustrated in figure 7 for a triangular pyramid. Triangulation for single curved surfaces increases in accuracy through the use of smaller and more numerous triangles. Triangulation developments of wrapped surfaces produces only approximate of those surfaces.

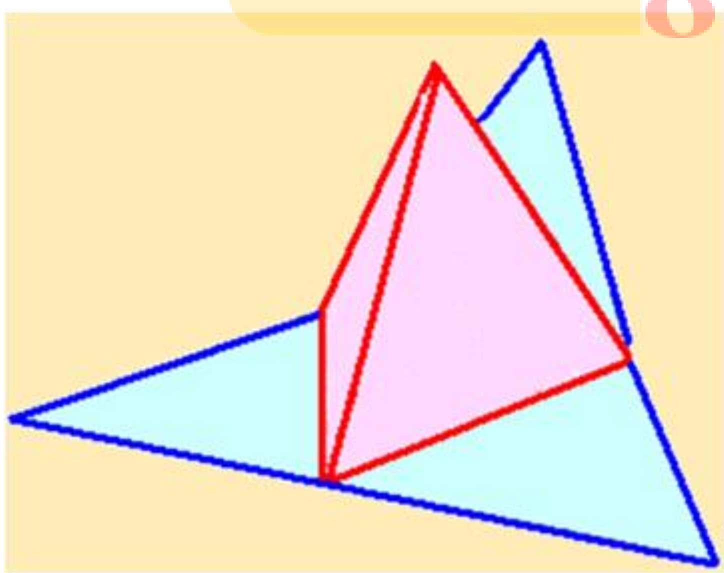


Figure 7 shows the triangulation method for obtaining the development of a triangular pyramid.

4.Approximate developments
Approximate developments are used for double curved surfaces, such as spheres. Approximate developments are constructed through the use of conical sections of the object. The material of the object is then stretched through various machine applications to produce the development of the object. This is illustrated in figure 4.

4.3 Parallel-line developments

Developments of objects with parallel elements or parallel lateral edges begins by constructing a stretch-out line that is parallel to a right section of the object and is therefore, perpendicular to the elements or lateral edges. Figure 8 illustrates the steps followed for obtaining the development of a rectangular prism by parallel line development. In the front view, all lateral edges of the prism appear parallel to each other and are true length. The lateral edges are also true length in the development. The length, or the stretch-out, of the development is equal to the true distance around a right section of the object.

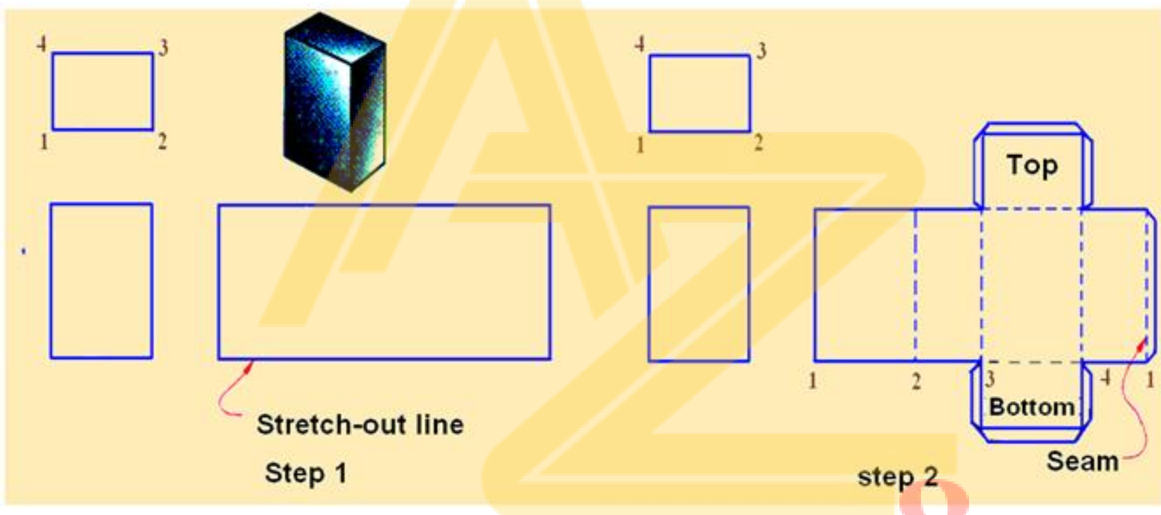


Figure 8. Stepwise procedure for obtaining the development of a rectangular prism.

***Step* 1.** To start the development, draw the stretch-out line in the front view, along the base of the prism and equal in length to the perimeter of the prism. Draw another line in the front view along the top of the prism and equal in length to the stretch-out line. Draw vertical lines between the ends of the two lines, to create the rectangular pattern of the prism.
***Step* 2.** Locate the fold line on the pattern by transferring distances along the stretch-out line in length to the sides of the prism, 1-2, 2-3, 3-4, 4-1. Draw thin, dashed vertical lines from points 2, 3, and 4 to represent the fold lines. Add the bottom and top surfaces of the prism to the development, taking measurements from the top view. Add the seam to one end of the development and the bottom and top.

1. **Development of a truncated prism**

The methoid of obtaining the development of a truncated prism is shown in figure 1.

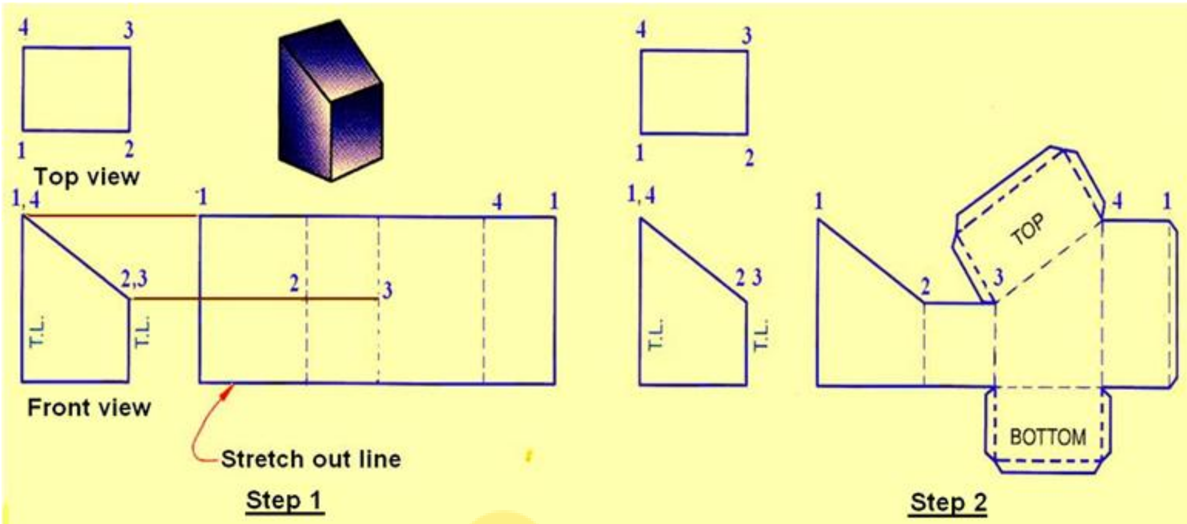


Figure1. shows the development of a truncated rectangular prism.

***Step* 1:** Draw the stretch-out line in the front view, along the base of the prism and equal in length to the perimeter of the prism.

Locate the fold lines on the pattern along the stretch-out line equal in length to the sides of the prism, 1-2, 2-3, 3-4, and 4-1.
Draw perpendicular construction lines at each of these points.
Project the points 1, 2, 3, and 4 from the front view **Step 2:** Darken lines 1-2-3 and 4-1. Construct the bottom and top, as shown and add the seam to one end of the development and the top and bottom

2. **Development of a right circular cylinder**

The Procedure for obtaining the development of a cylinder is illustrated in figure 2.

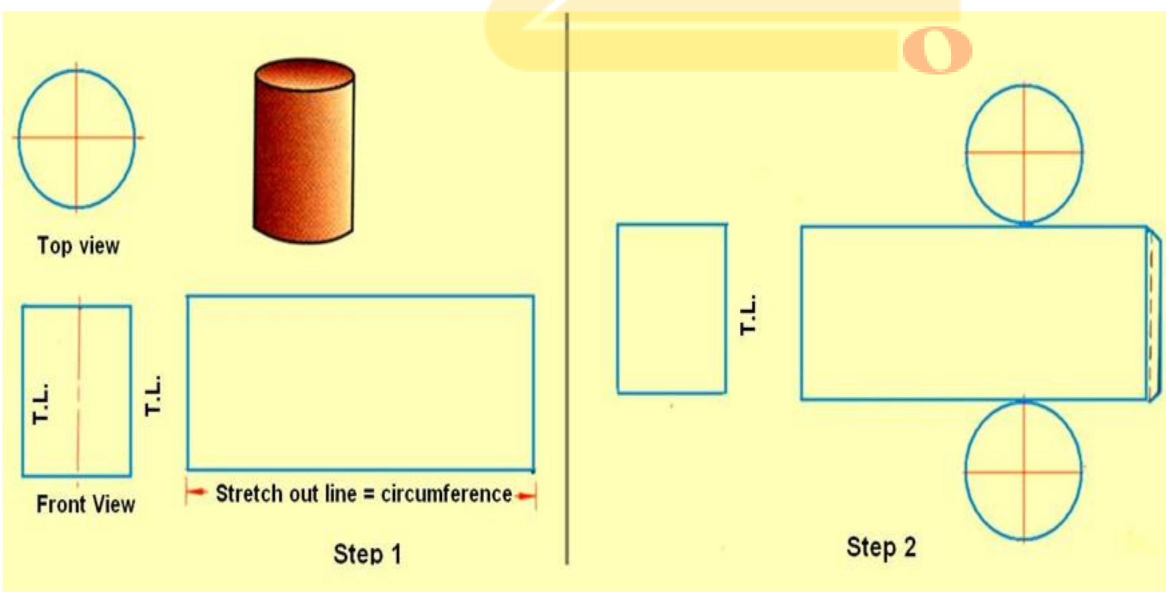


Figure 2. Shows the step wise procedure for obtaining the development of a cylinder.

***Step* 1.** In the front view, draw the stretch-out line aligned with the base of the cylinder and equal in length to the circumference of the base circle.
At each end of this line, construct vertical lines equal in length to the height of the cylinder.
***Step* 2.** Add the seam to the right end of the development, and add the bottom and top circles.

3.Development of a truncated right circular cylinder

The development of a truncated cylinder is shown in figure 3.

Step1. The top view and front view of the cylinder is drawn. The stretch out line, is aligned with the base in the F.V., is drawn with length equal to the circumference of the cylinder. Construct the rectangle with the stretch out line as one length and height of the cylinder as the width.

Step2. The top circular view of the cylinder then divided into a number of equal parts . The stretch-out line is also divided into 12 equal parts from which vertical lines 1, 2, 3, 4, …. 12 are constructed. The intersection points in the T.V. are projected into the F.V. . Draw horizontal projectors from points 1, 2, 3, …., 12 to intersect the vertical lines 1,2, 3, 4, …. 12 in the stretch out line. , where the projected lines intersect the angled edge view of the truncated surface of the cylinder. The intersections between these projections and the vertical lines constructed from the stretch-out line are points along the curve representing the top line of the truncated cylinder. Join the intersection points with a smooth curve to obtain the developmentof the lateral surface of the cylinder.

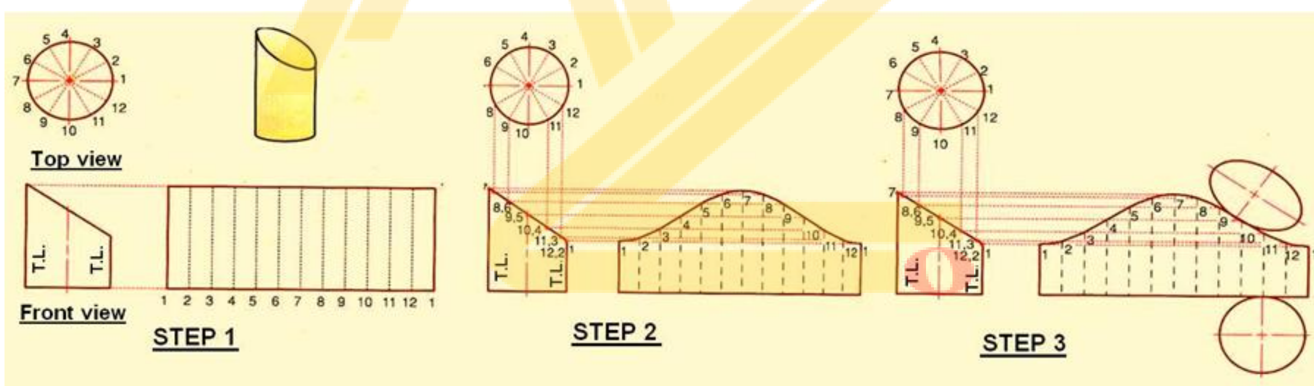


Figure 3. shows the development of a truncated cylinder.

Step 3. Draw the circle with diameter equal to the diameter of the cylinder at any point on the base of the development to obtain the development of the base surface of the cylinder. Draw an ellipse with the truncated length (length 1-7 in the step 2) as major diameter and diameter of the cylinder as the minor diameter on the top part of the development to obtain the final development of the surfaces of the truncated cylinder.

4.Development of a right circular cone

The development of a cone is shown in figure 4. For a cone, the front view will be a triangle with the slant edge showing the true length of the generator of the cone. To begin this development, use a true-length element of the cone as the radius for an arc and as one side of the development. Draw an arc whose length is equal to the circumference of the base of the cone. This can also be determined by angle θ = (r/l) * 360°, where, r is the radius of the base of the cone and l is the true length of the slant edge. Draw another line from the end of the arc to the apex and draw the circular base to complete the development.

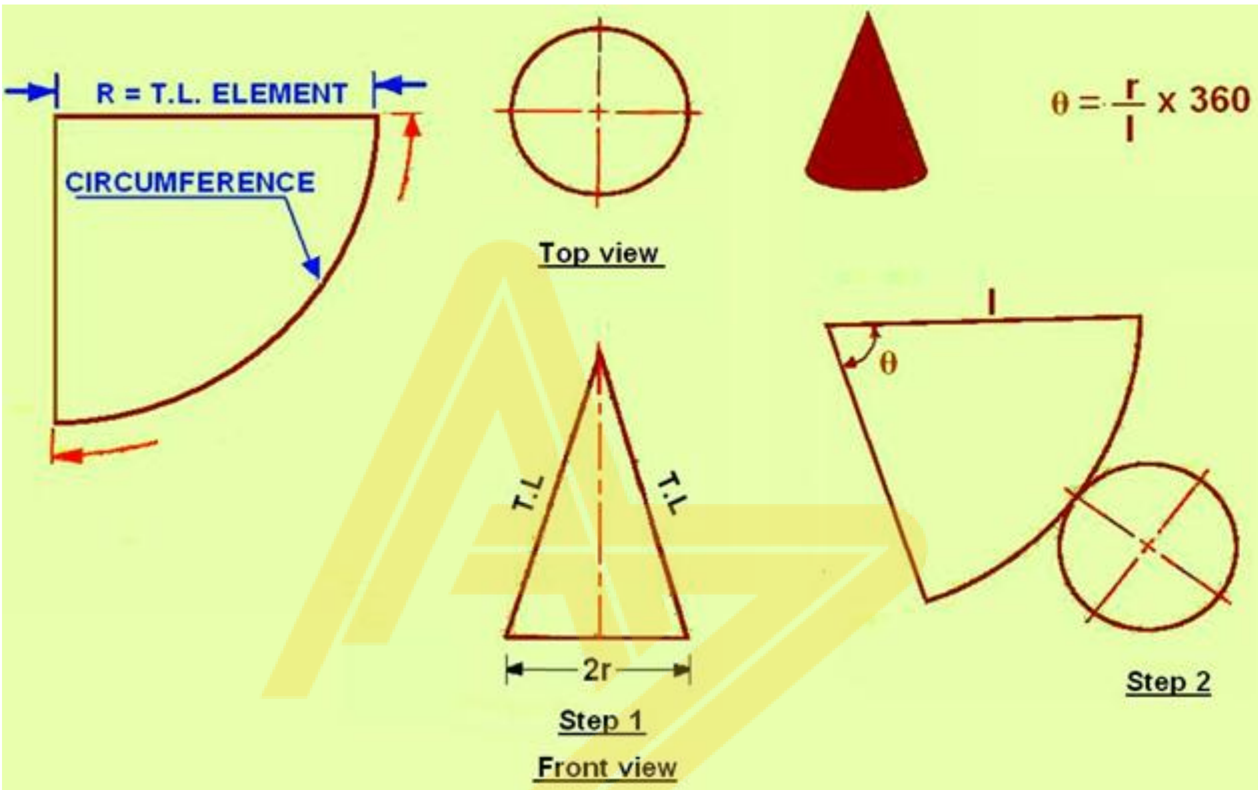


Figure 4. Development of a right cone.

5.Development of a truncated cone:

A cone of base diameter 40 mm and slant height 60 mm is kept on the ground on its base. An AIP inclined at 45° to the HP cuts the cone through the midpoint of the axis. Draw the development.

Solution:
The development of the truncated cone is shown in figure 5.

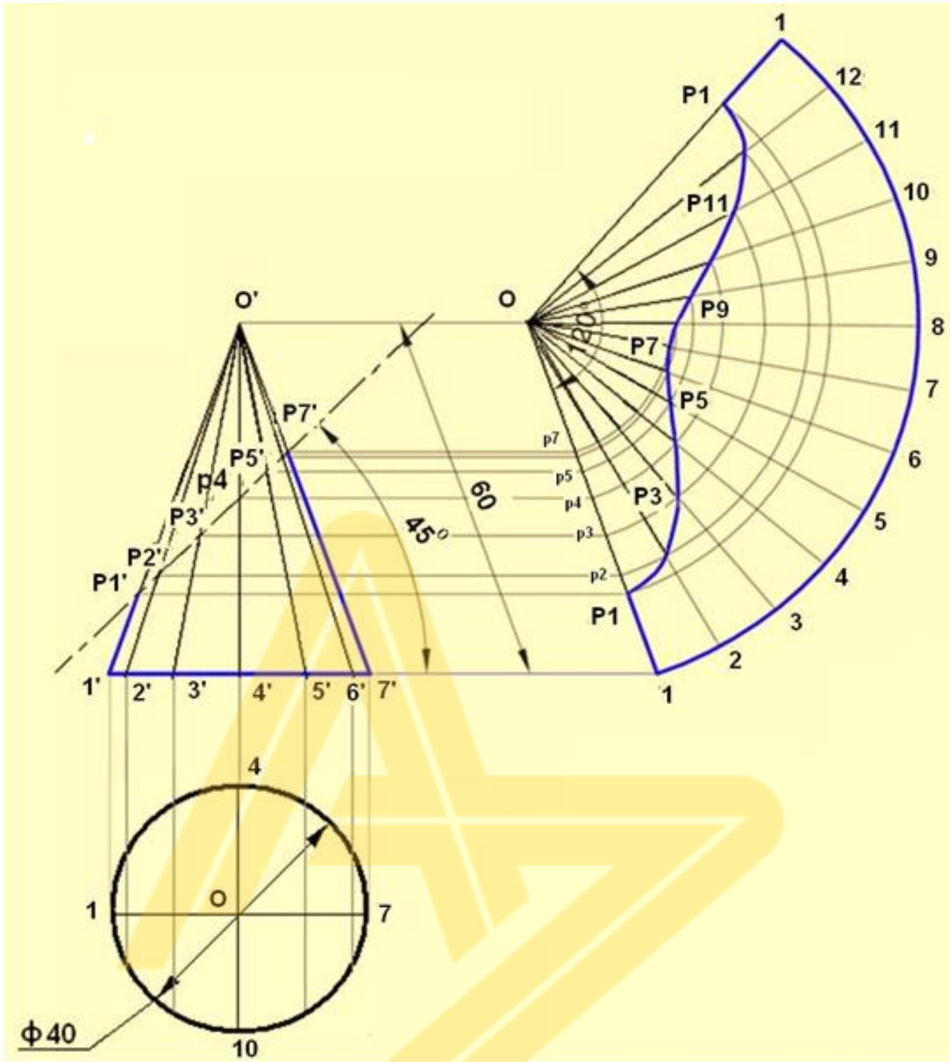


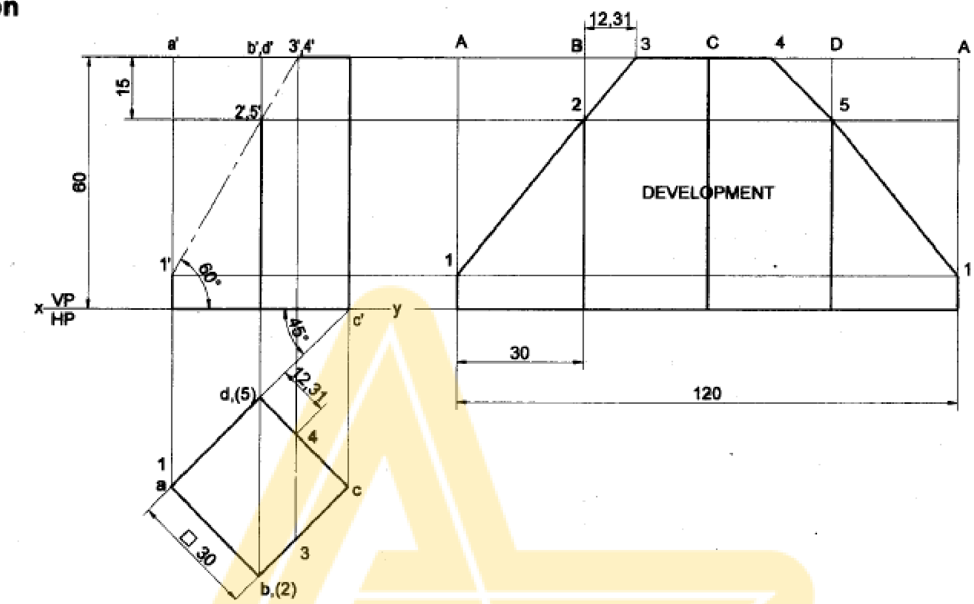
Figure 5. Development of the truncated cone (problem 5).

Draw the Front view and top view of the cone. Dive the circumference of the circle (Top View) in to 12 equal parts 1, 2, 3, 4, …., 12. Project these points on the Front view to obtain the points 1’, 2’, 3’, …., 12’. Draw a line inclined at 45 ° to the horizontal and passing through the mid pint of the axis of the cone to represent the AIP. The locate the intersection points of the AIP with the generators O’-1’, O’-2’, …. O’-12’ as P1’, p2’, p3’, …. P12’. Draw the projection (figure shown on the right of the Front view) by drawing the line O1 parallel to O’ 7’. Obtain the included angle of the sector. θ = (20/60)* 360 = 120° (following the procedure shown in problem 4). Then draw sector O–1–1– O with O as a centre and included angle 120°. Divide the sector into 12 equal parts (i.e., 10° each). Draw lines O–2, O–3, O–4, …, O–12. Draw horizontal projectors from P1’, P2’, …., P12’ such that it meets the line O1 at p1, p2, p3, …, p12. With O as centre and radius O’P1’, mark point P1 on line O1. With O as centre and radius equal to Op2, draw an arc to intersect the radial line O2 at point P2. Similarly obtain points P3, P4, …, P12, and P1. Join points P1, P2, P3, …., P12 and P1 to obtain the development of the truncated cone.

Worked Examples- Sections and Development of Lateral Surfaces of Solids

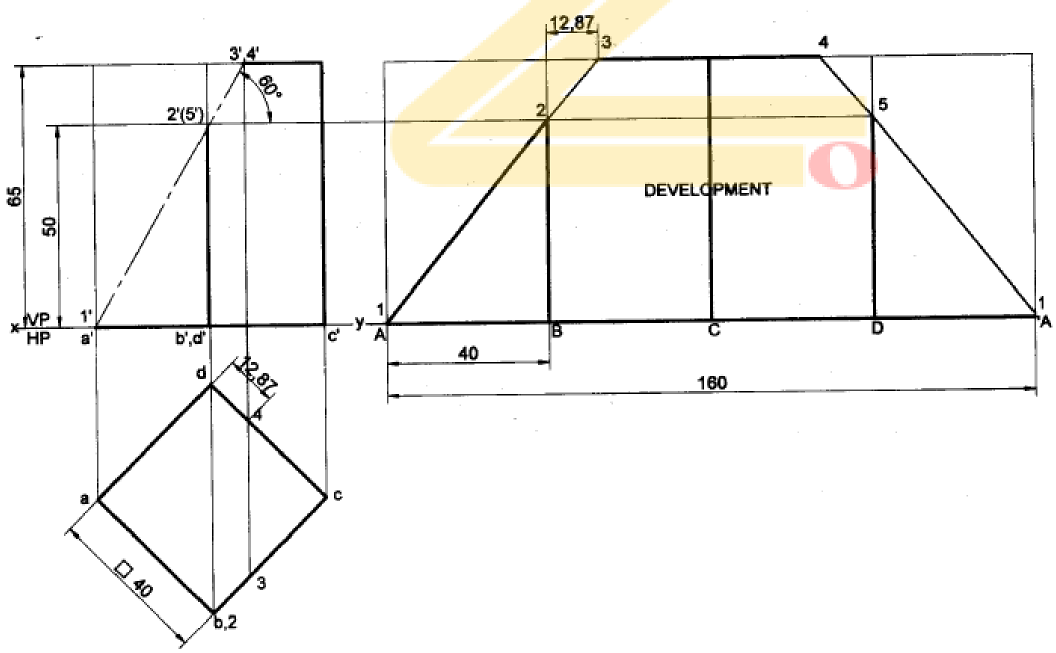
Problem 2 A square prism of base side 30 mm and axis length 60 mm is resting on HP on its base with all the vertical faces being equally inclined to VP. It is cut by an inclined plane 60° to HP and perpendicular to VP and is passing through a point on the axis at a distance 50 mm from the base. Draw the development of the lower portion of the prism.

Solution



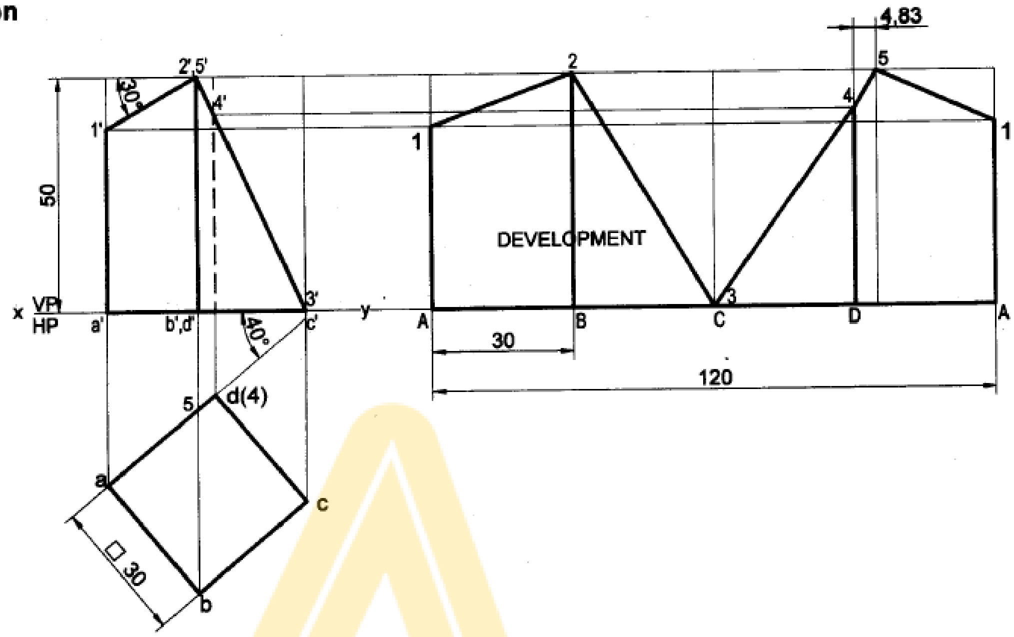
Problem 3 A square prism of base side 40mm and axis length 65mm is resting on HP on its base with all the vertical faces being equally inclined to VP. It is cut by an inclined plane 60° to HP and perpendicular to VP and is passing through a point on the axis at a distance 15mm from the top face. Draw the development of the lower portion of the prism.

Solution



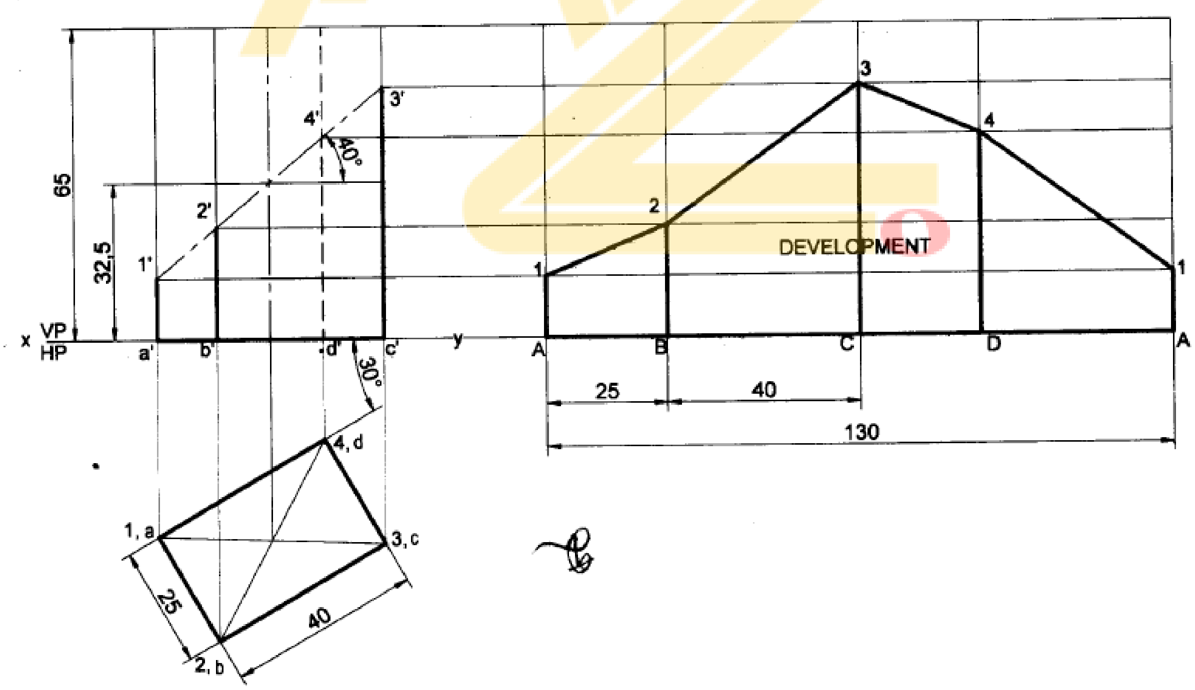
Problem 4 A square prism of 30mm side of the base and height 50mm is resting with its base on HP such that one of its vertical faces is inclined at 40° to VP. It is cut as shown in the following front view figure. Draw the development of the lateral surface of the prism.

Solution



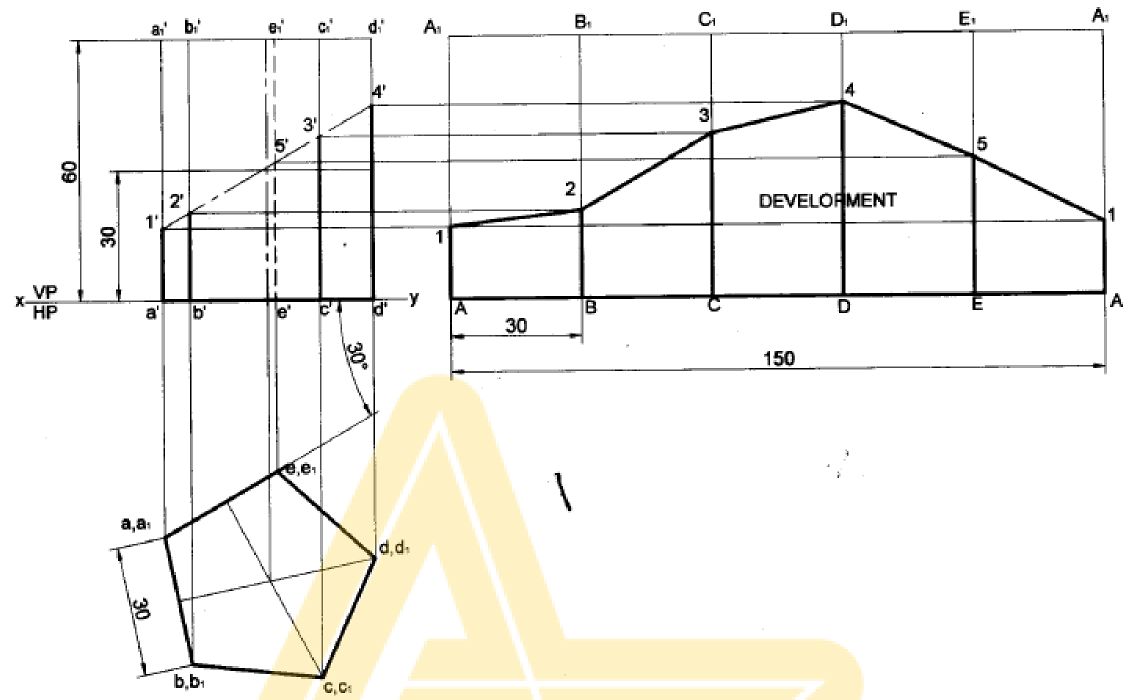
Problem 7 A rectangular prism of base 40mm x 25mm and height 65mm rests on HP on its base with the longer base side inclined at 30° to VP. It is cut by a plane inclined at 40° to HP, perpendicular to VP cuts the axis at its mid height. Draw the development of the remaining portion of the prism.

Solution



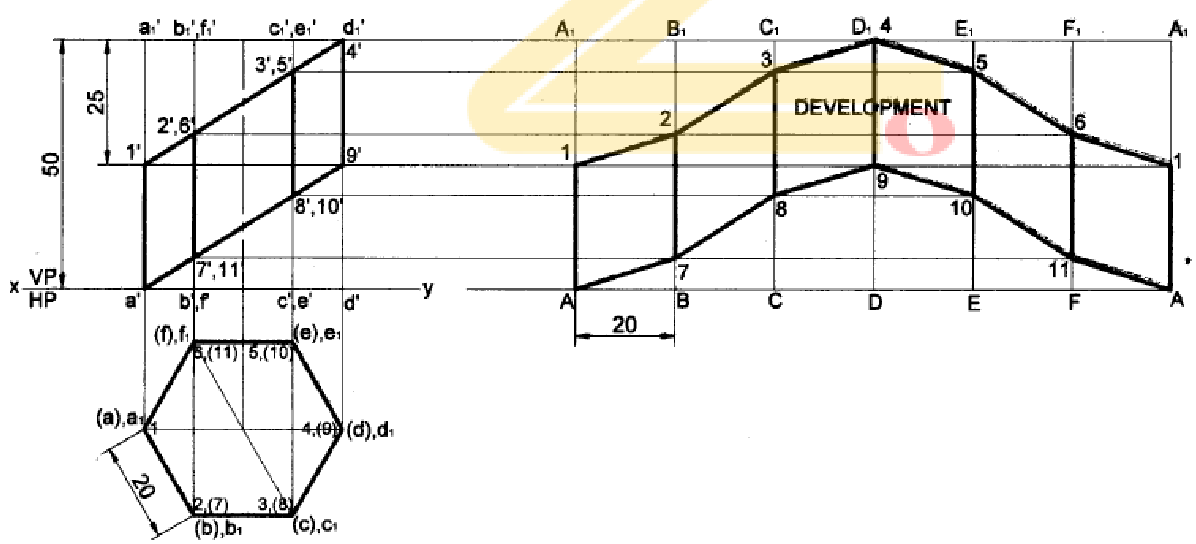
Problem 11 A regular pentagonal prism of height 60mm and base edge 30mm rests with its base on HP. The vertical face closest to VP is 30° to it. Draw the development of the truncated prism with its truncated surface inclined at 60° to its axis and bisecting it.

Solution



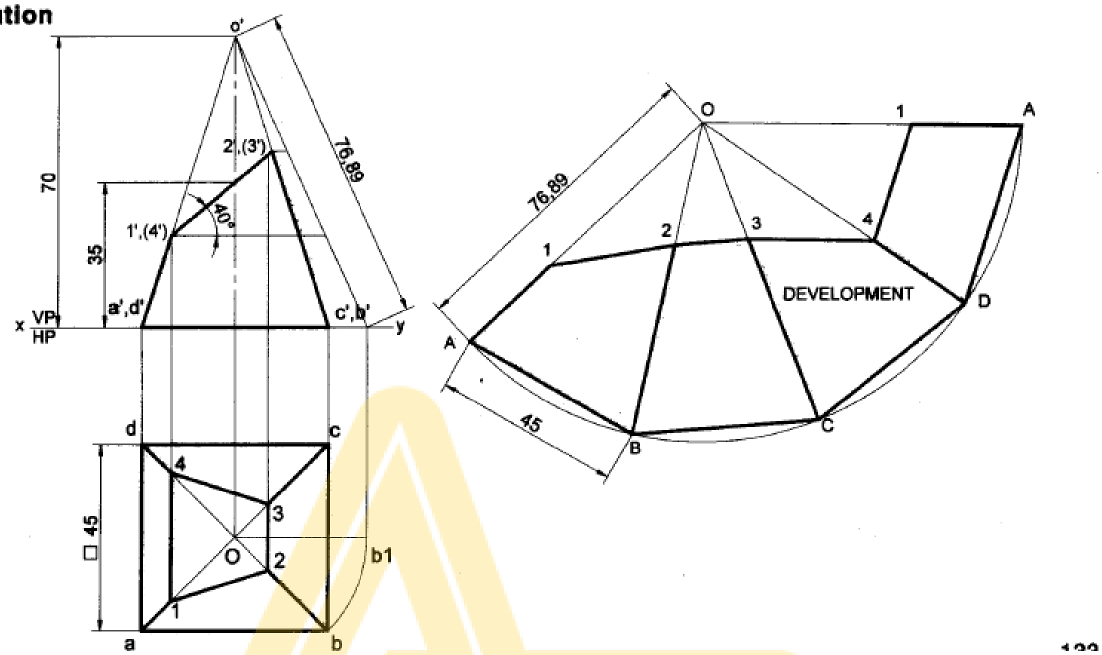
Problem 15 A hexagonal prism of base side 20mm and height 50mm is resting on HP on its base, such that one of its base edge is parallel to VP. The prism is cut in this position as shown in the following front view. Draw the development of the lateral surface of the prism.

Solution



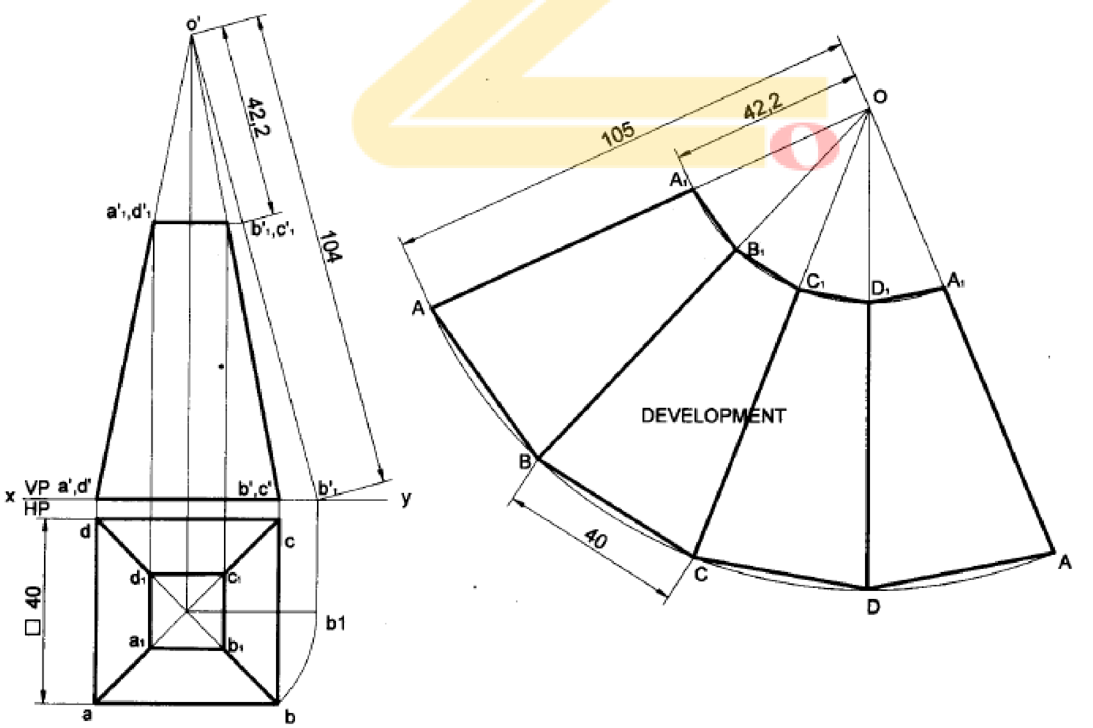
Problem 18 A square pyramid of side of base 45mm, altitude 70mm is resting with its base on HP with two sides of the base parallel to VP. The pyramid is cut by a section plane which is perpendicular to the VP and inclined at 40° to the HP. The cutting plane bisects the axis of the pyramid. Obtain the development of the lateral surfaces the truncated pyramid.

Solution



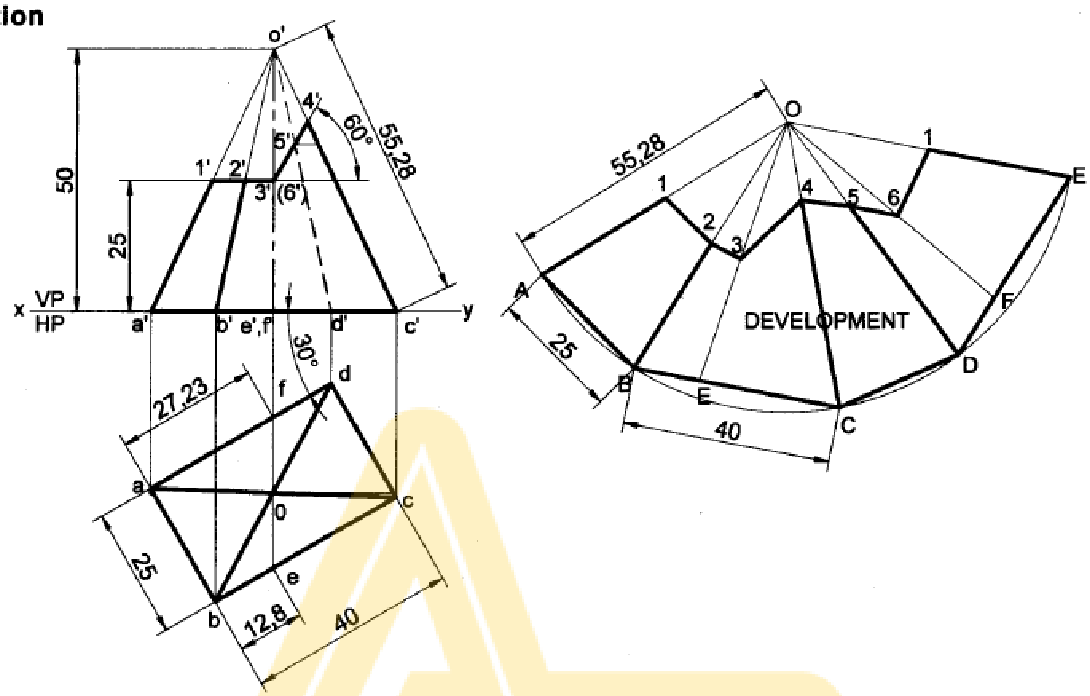
Problem 20 A frustum of a square pyramid has its base 40 mm sides, top 16 mm sides and height 60mm, its axis is vertical and a side of its base is parallel to VP. Draw the projections of the frustum and show the development of the lateral surfaces of it.

Solution



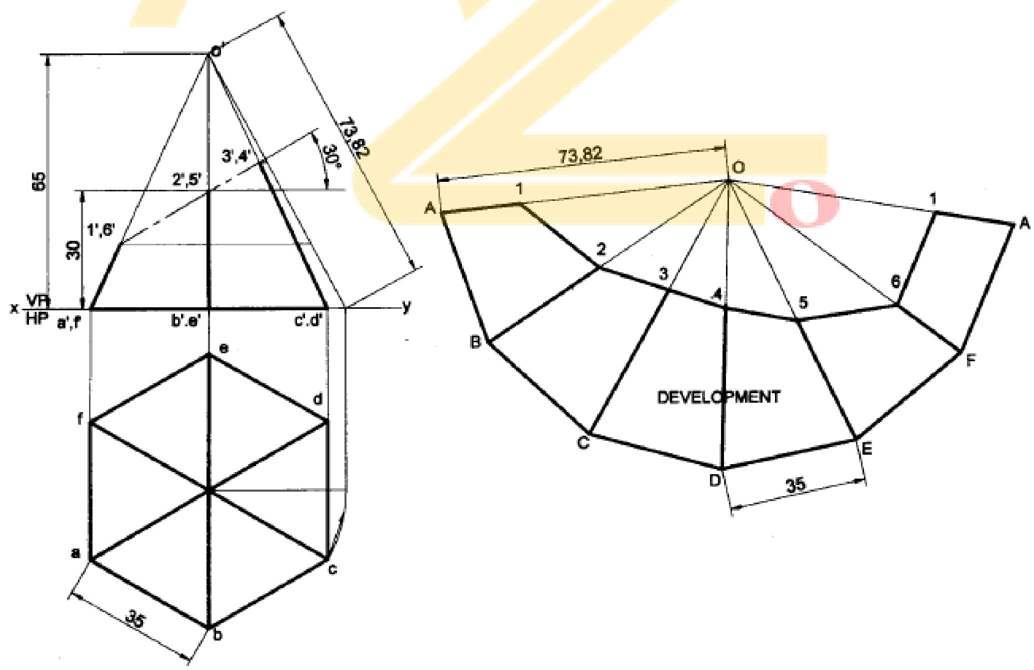
Problem 22 A rectangular pyramid, side of base 25mm x 40mm and height 50mm has one of the sides of the base is inclined at 30º to the VP. Draw the development of the lateral surface of the cut pyramid, whose front view is shown below.

Solution



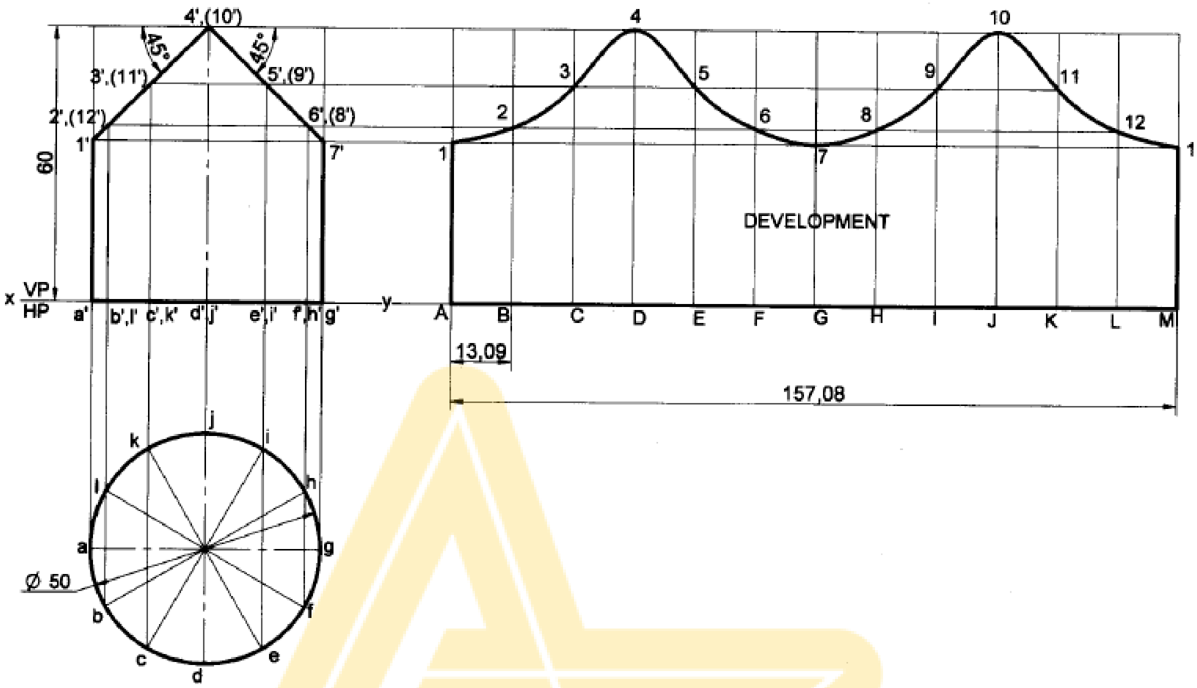
Problem 28 A hexagonal pyramid of sides 35mm and altitude 65mm is resting on HP on its base with two of the base sides perpendicular to VP. The pyramid is cut by a plane inclined at 30° to HP and perpendicular to VP and is intersecting the axis at 30mm above the base. Draw the development of the remaining portion of the pyramid.

Solution



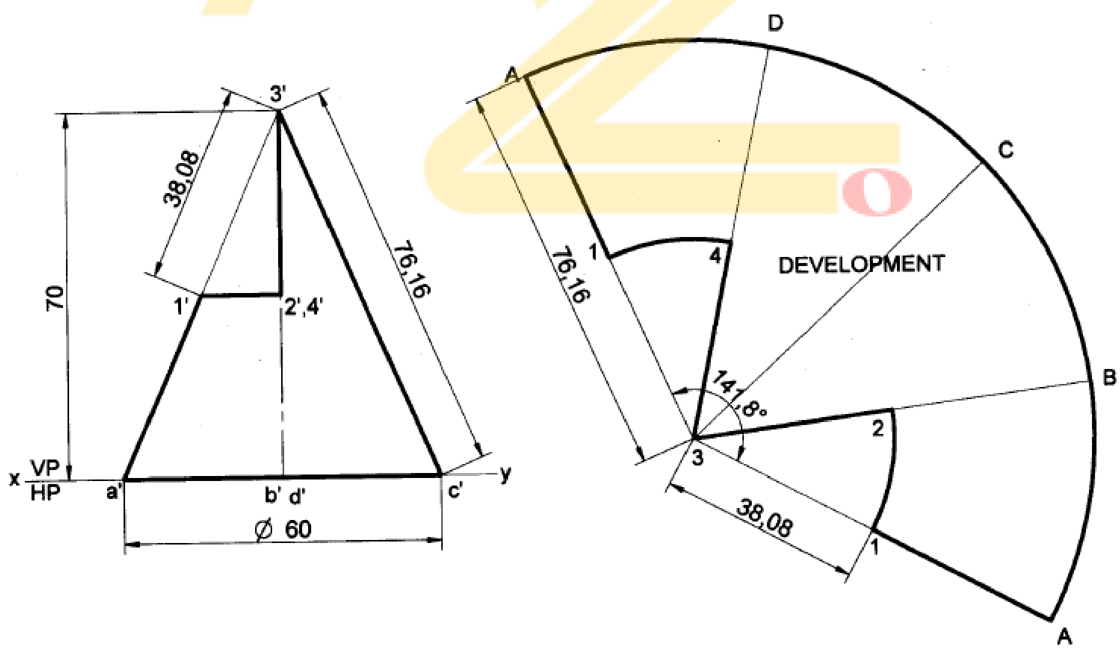
Problem 33 A vertical cylinder of base diameter 50mm and axis length 60mm is cut by a two planes which are perpendicular to VP and inclined at 45° to HP and passing through either side the centre point of the top face. Draw the development of the lateral surface of the cylinder.

Solution



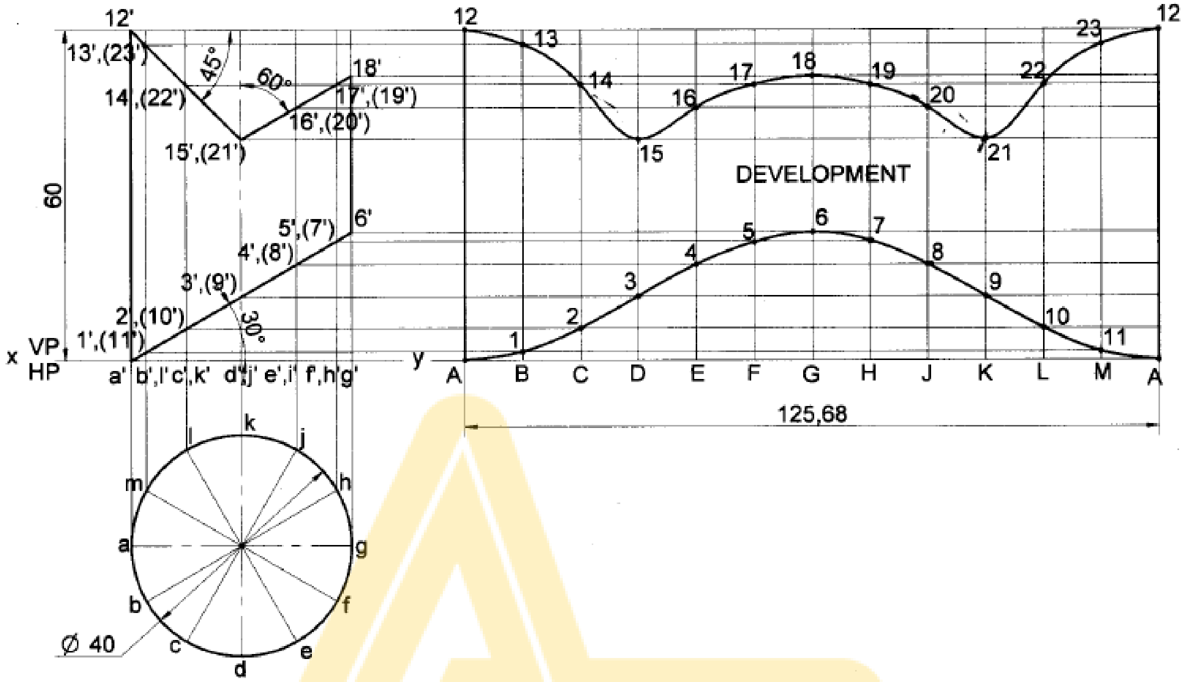
Problem 36 A cone of base diameter 60mm and height 70mm is resting on its base on HP. It is cut as shown in the following figure. Draw the development of the lateral surface of the remaining portion of the cone.

Solution



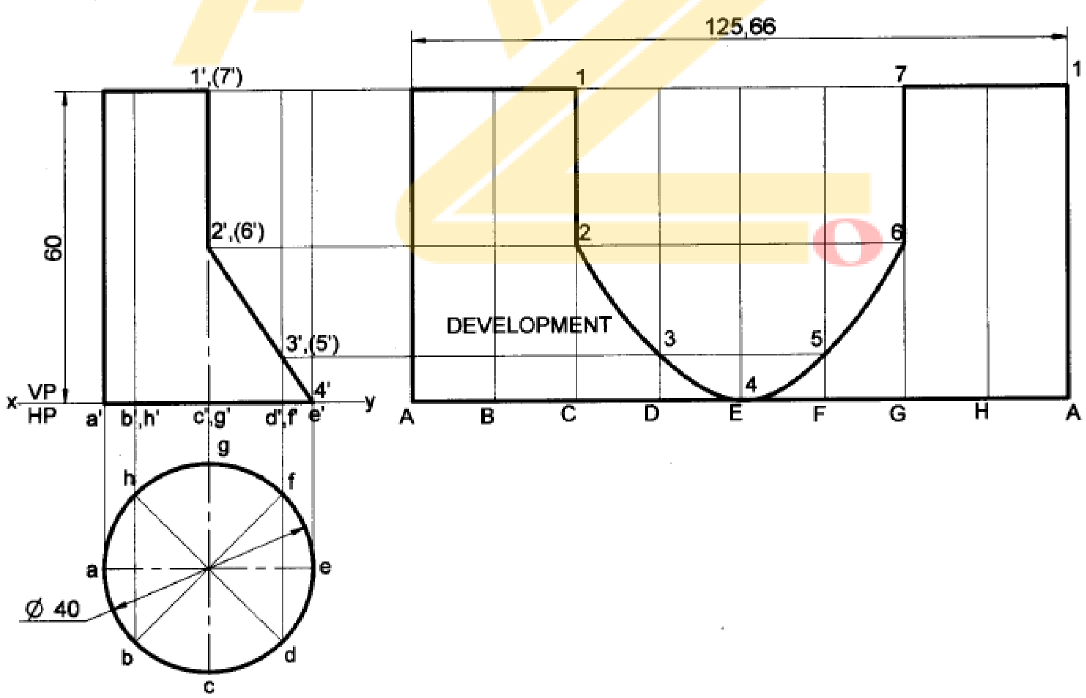
Problem 37 Develop the lateral surface of the cylinder of 40mm diameter and height 60mm which is cut in the following way.

Solution



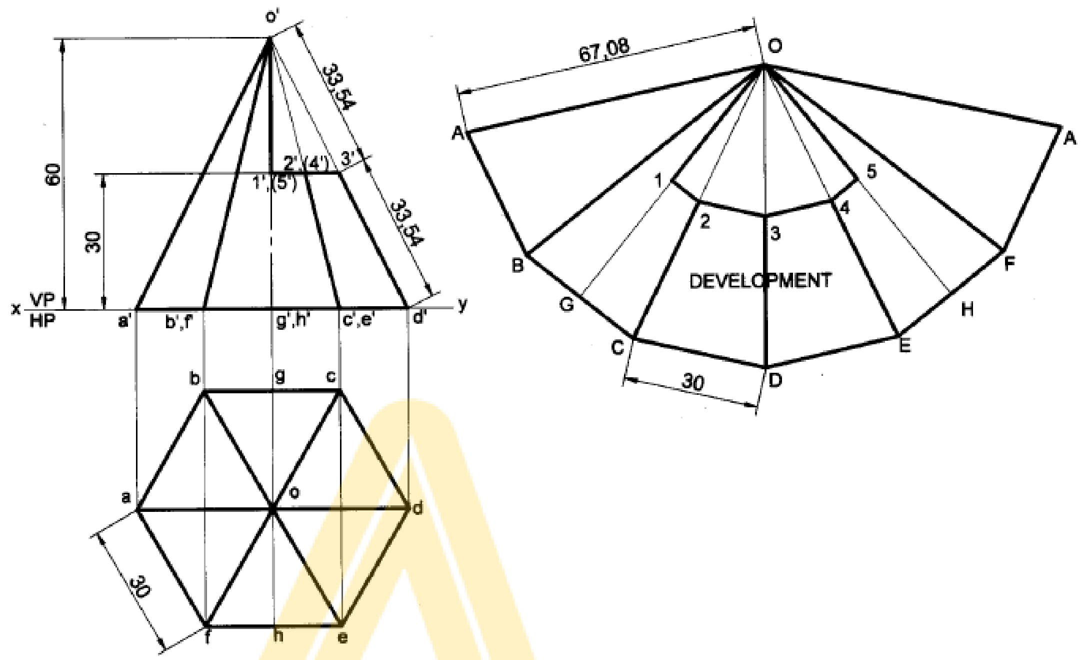
Problem 44 Develop the lateral surface of the cylinder of 40mm diameter and height 60mm which is cut in the following way.

Solution



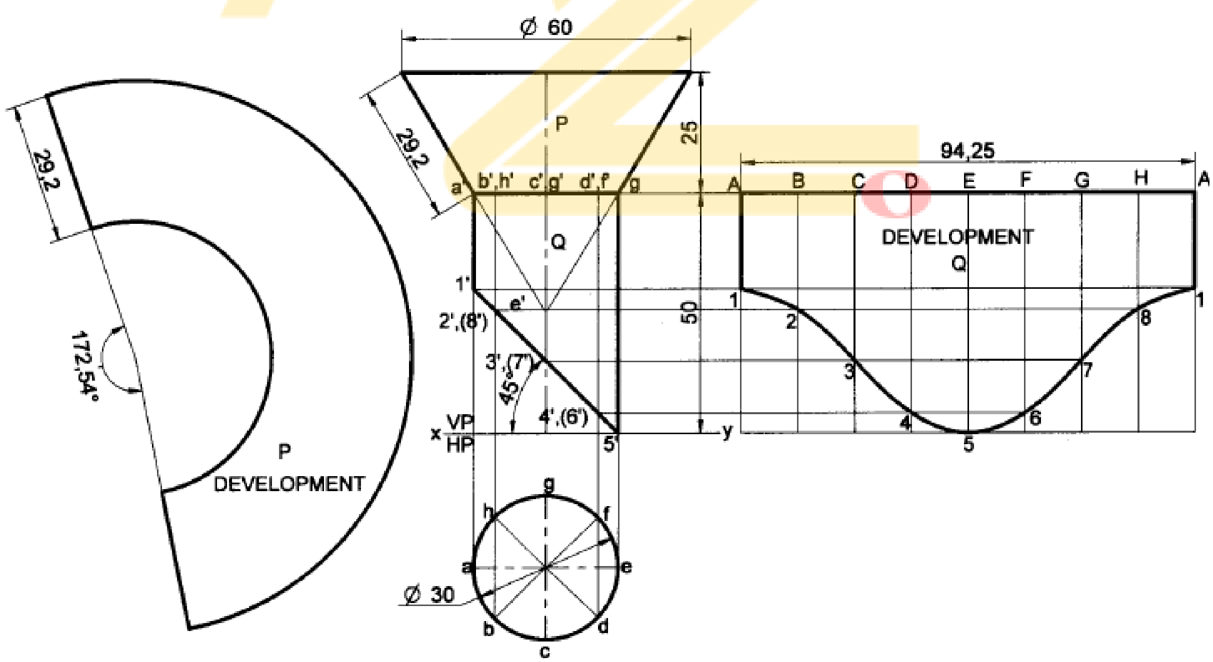
Problem 43 A hexagonal pyramid of 30mm sides of base with a side of base parallel to VP. Draw the development o the lateral surfaces of the retained portion of the pyramid which is shown by dark lines in the following figure.

Solution



Problem 50 A funnel is made of sheet metal. The funnel tapers from 60 mm. to 30 mm. diameters to a heigh mm. and then forms to a cylinder with a height of 50 mm. Bottom of funnel is beveled off completely at an angle to axis Draw the development of funnel.

Solution



Problems on Development

1. A regular pentagonal prism of height 60 mm and base edge 30 mm rests with its base on HP. The vertical face closest to VP is 30 deg to it. Draw the development of the truncated prism with its truncated surface inclined at 60 deg to its axis and bisecting it.
2. A pentagonal prism of 30 mm side of base and height 50 mm lies with its base on HP such that one of the rectangular faces is inclined at 40 deg to VP. It is cut to the shape of a truncated pyramid with the truncated surface inclined at 30 deg to the axis so as pass through a point on it 30 mm above the base. Develop the truncated portion of the prism so as to produce a one piece development.
3. A pentagonal prism of base sides 30 mm and axis length 60 mm rests with its base on HP and an edge of the base inclined at 45 deg to VP. It is cut by a plane perpendicular to VP, inclined at 40 deg to HP and passing through a point on the axis, at a distance of 30 mm from the base. Develop the remaining surface of the truncated prism.
4. A pentagonal prism of base sides 20 mm and height 40 mm is resting with its base on HP and base edge parallel to the VP. The prism is cut as shown in the following front view. Draw the development of the lateral surface of the prism.
5. A hexagonal prism of base side 20 mm and height 50 mm is resting on HP on its base, such that one of its base edge is parallel to VP. The prism is cut in this position as shown in the following front view. Draw the development of the lateral surface of the prism.
6. A hexagonal prism of base side 25 mm and height 55 mm is resting on HP on its base, such that one of its base edge is parallel to VP. The prism is cut in this position as shown in the following front view. Draw the development of the lateral surface of the prism.
7. The inside of a hopper of a flour mill is to be lined with thin sheet. The top and bottom of the hopper are regular pentagons with each side equal to 30 mm and 22.5 mm respectively. The height of the hopper is 30 mm. Draw the shape of the sheet to which it is to be cut so as to fit into the hopper.
8. A square pyramid of side of base 45 mm, altitude 70 mm is resting with its base on Hp with two sides of the base parallel to VP. The pyramid is cut by a section plane which is perpendicular to the VP and inclined at 40 deg to the HP. The cutting plane bisects the axis of the pyramid. Obtain the development of the lateral surfaces the truncated pyramid.
9. A square pyramid base 40 mm side and axis 65 mm long has its base on HP and all the edges of the base are equally inclined to VP. It is cut to with an inclined section plane so as the truncated surface at 45 deg to its axis, bisecting it. Draw the development of the truncated pyramid.
10. A frustum of a square pyramid has its base 40 mm sides, top 16 mm sides and height 60 mm, its axis is vertical and a side of its base is parallel to VP. Draw the projections of the frustum and show the development of the lateral surface of it.
11. A square pyramid of 25 mm base edge and 50 mm height rests with its base on HP with all of its base edges equally inclined to VP. It is cut by a plane perpendicular to VP and inclined to HP at 60 deg, passing through the extreme right corner of base. Draw the development of the lateral surface of the pyramid.

12. A rectangular pyramid, side of base 25 mm $\times$ 40 mm and height 50 mm has one of the base is inclined at 30 deg to the VP. Draw the development of the lateral surface of the cut pyramid, whose front view is shown below.
13. A frustum of a pentagonal pyramid, smaller base sides 16 mm and bigger top face sides 32 mm and height 40 mm, is resting on the HP on its smaller base. With one of its base sides parallel to the VP. Draw the projections of the frustum and develop the lateral surface it.

FURTHER READING:

1) Computer Aided Engineering Drawing - S. Trymbaka Murthy, - I.K. International Publishing House Pvt. Ltd., New Delhi, 3rd revised edition- 2006.
2) Engineering Graphics - K.R. Gopalakrishna, 32nd edition, 2005- Subash Publishers Bangalore.
3) Dhananjay A Jolhe, Engineering Drawing, Tata McGraw Hill, 2007.
4) M.B. Shah and B.C. Rana, Engineering Drawing, pearson Education, Eds. 2, 2009.
5) K. Venugopal, Engineering Drawing and Graphics, New Age International (P) Ltd., publishers, 2000.
6) N.D. Bhatt and V.M. Panchal, Engineering Drawing, Charotar Publishing house, 2005.

MODULE-5

ISOMETRIC PROJECTION (USING ISOMETRIC SCALE ONLY)

OBJECTIVES:

1) To understand the basic concept of isometric projection.
2) To understand the concepts of isometric scale.
3) Construction of isometric projections of simple solids and combination of solids.

LESSON CONTENT:

Introduction, Isometric scale, Isometric projection of simple plane figures, Isometric projection of tetrahedron, hexahedron(cube), right regular prisms, pyramids, cylinders, cones, spheres, cut spheres and combination of solids (Maximum of three solids).

5.1 Axonometric projection-

Axonometric projection is a parallel projection technique used to create a pictorial drawing of an object by rotating the object along one or more of its axes relative to the plane of projection (or the picture plane). Axonometric projection is one of the four principal projection techniques: multiview, axonometric, oblique and perspective projection (Figure-1). In multi view, axonometric, and oblique projections, the observer is theoretically infinitely far away from the projection plane. In addition, the lines of sight are parallel to each other and perpendicular to the plane of projection. The main difference between a multiview drawing and an axonometric drawing are that, in a multiview, only two dimensions of an object are visible in each view and hence more than one view is required to define the object. In an axonometric drawing, the object is rotated about an axis to show all three dimensions, and only one view is required.

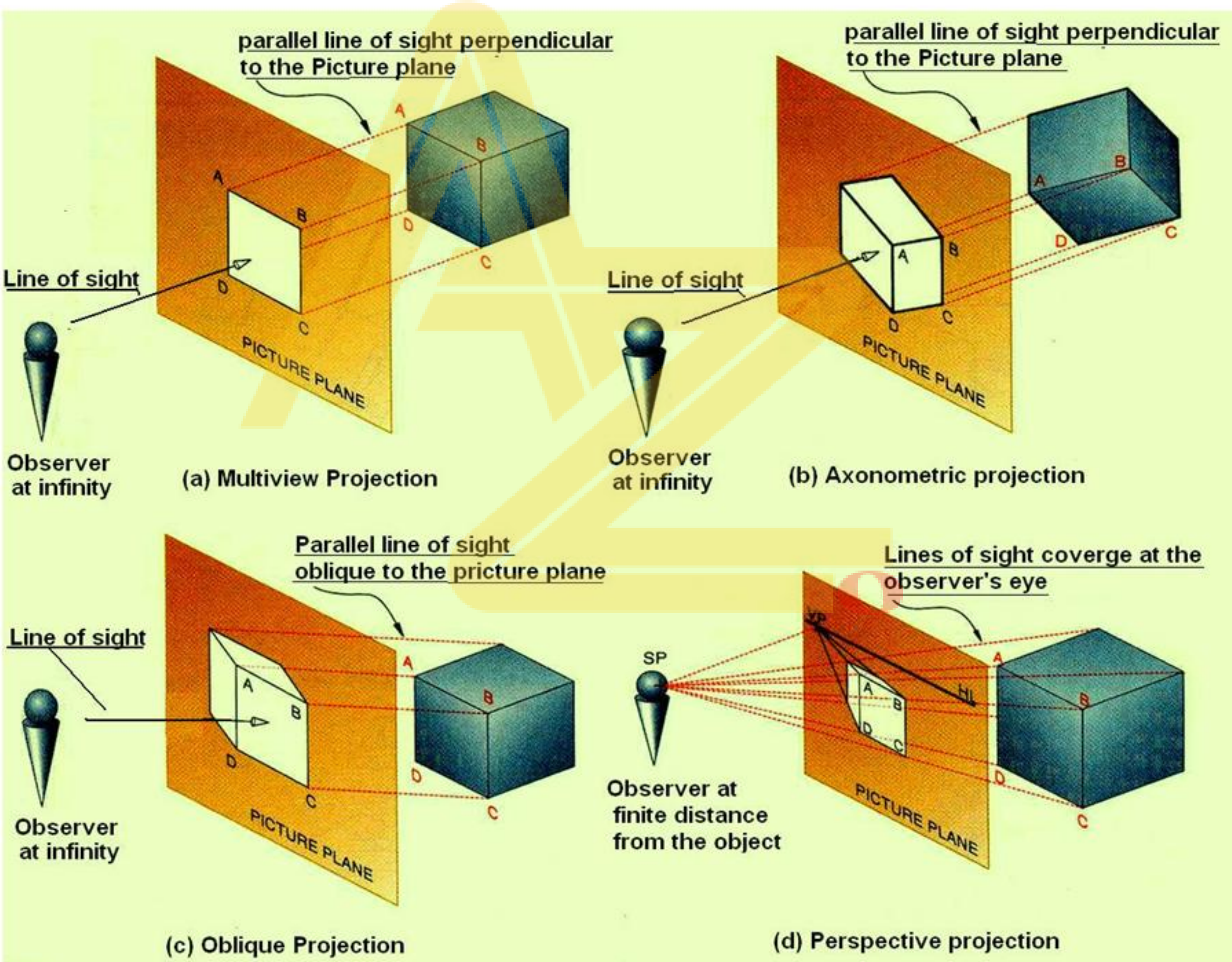


Figure 1. illustrates the four principle projection techniques.

Isometric projection is a type of pictorial projection in which the dimensions along the three axes of the solid are shown in one view. It is one of the three types of axonometric projection In axonometric drawing, one axis of space is shown vertical and depending on the exact angle at which the view deviates from the orthogonal, axonometric projections are generally three types: (a) trimetric projection, (b) dimetric projection, and (c) isometric projection.. This is illustrated in figure 2.

1. In trimetric projection, the direction of viewing is such that all of the three axes of space appear unequally foreshortened. The scale along each of the three axes and the angles among them are determined separately as dictated by the angle of viewing. Trimetric perspective is seldom used
2. In dimetric projection, the direction of viewing is such that two of the three axes of space appear equally shortened, of which the attendant scale and angles of presentation are determined according to the angle of viewing; the scale of the third direction (vertical) is determined separately. When two of the three angles are equal, the drawing is classified as a dimetric projection. Dimetric drawings are less pleasing to the eye, but are easier to produce than trimetric drawings
3. In isometric projection, the most commonly used form of axonometric projection in engineering drawing. Here all three angles are equal. The isometric is the least pleasing to the eye, but is the easiest to draw and dimension.

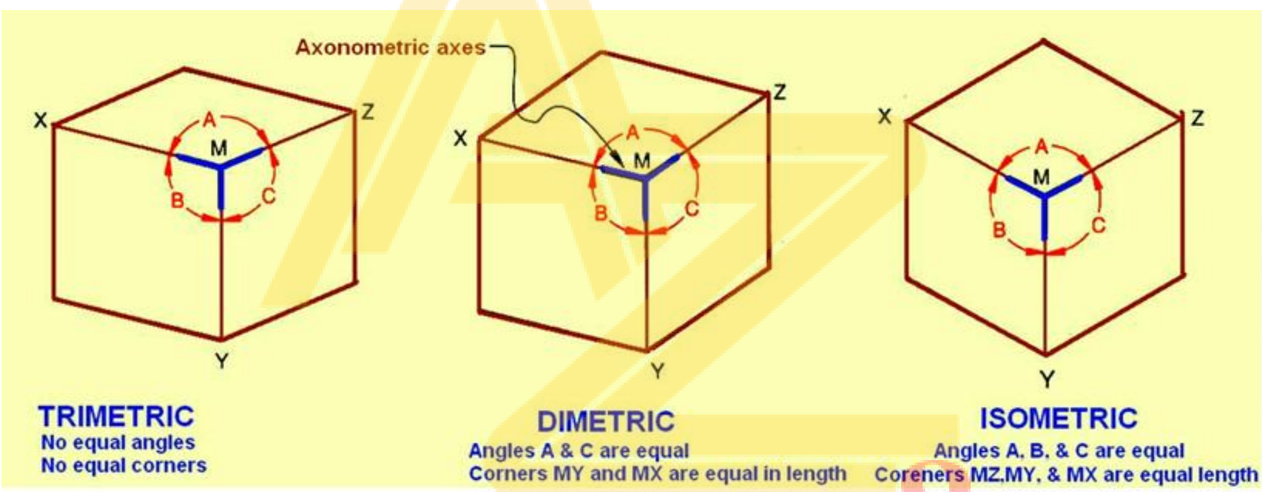


Figure 2. Shows the three types of axinometric drawing. The angles determine the type of axinometric drawing.

5.2 Isometric Axonometric Projections

An isometric projection is a true representation of the isometric view of an object. An isometric view of an object is created by rotating the object 45° about a vertical axis, then tilting the object (see figure 3, in this case, a cube) forward until the body diagonal (AB) appears as a point in the front view. The angle the cube is tilted forward is 35° 16'. The 3 axes that meet at A, B form equal angles of 120° and are called the isometric axes. Each edge of the cube is parallel to one of the isometric axes. Line parallel to one of the legs of the isometric axis is an isometric line. Planes of the cube faces & all planes parallel to them are isometric planes

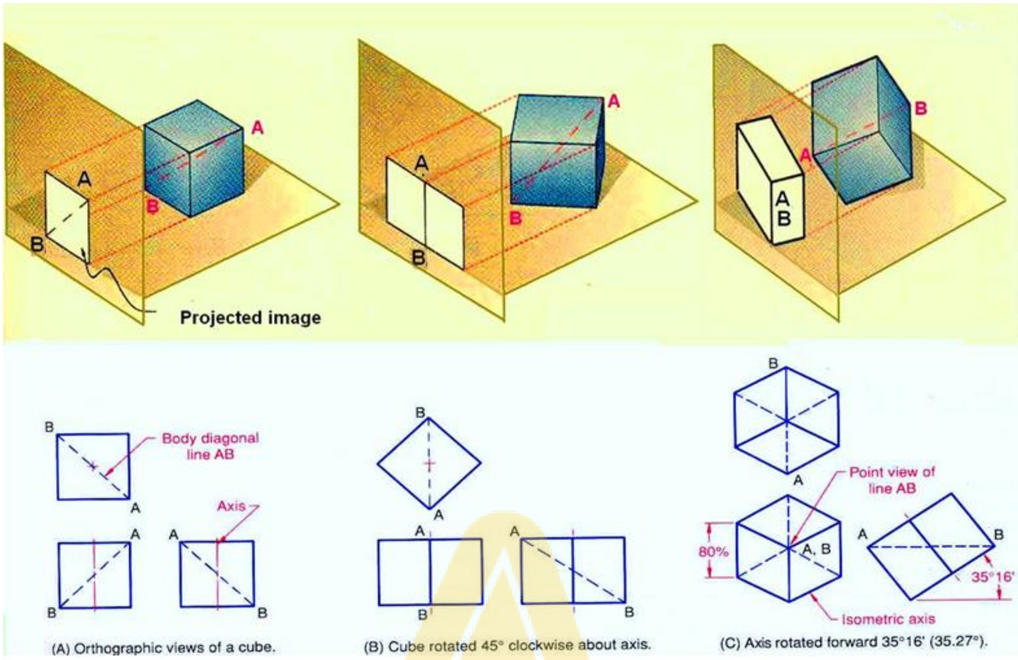


Figure 3. Rotation of the object with respect to the projection plane result in isometric projection.

The forward tilt of the cube causes the edges and planes of the cube to become shortened as it is projected onto the picture plane. The lengths of the projected lines are equal to the cosine of 35° 16', or 0.81647 times the true length. In other words, the projected lengths are approximately 80% of the true lengths. A drawing produced using a scale of 0.816 is called an *isometric projection* and is a true representation of the object. However, if the drawing is produced using full scale, it is called an isometric drawing, which is the same proportion as an isometric projection, but is larger by a factor of 1.23 to 1. Figure 4. Illustrates the isometric projection and isometric drawing. Isometric drawings are almost always preferred over isometric projection for engineering drawings, because they are easier to produce. An isometric drawing is an axonometric pictorial drawing for which the angle between each axis equals 120° and the scale used is full scale.

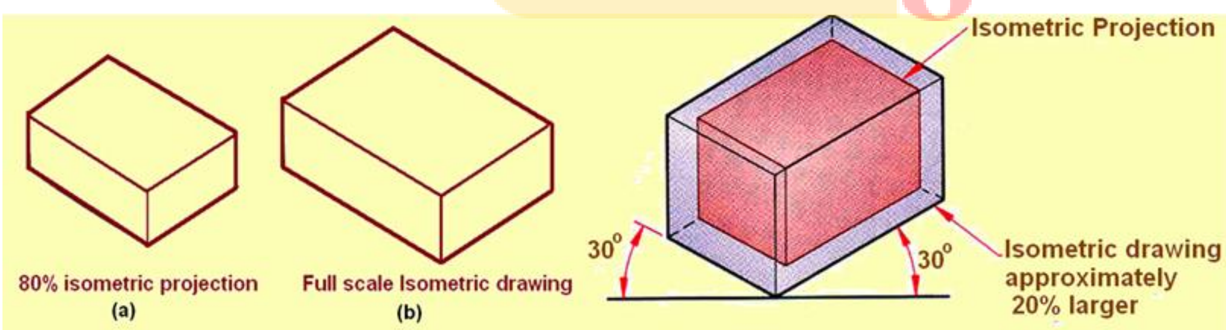


Figure 4 Shows the (a) isometric projection and (b) isometric drawing (or view) of a cuboid.

While drawing isometric projection, an Isometric scale is to be constructed for convenience and all the measurements are to be taken from this scale. As shown in figure 5, isometric scale is produced by positioning a regular scale at 45 ° to the horizontal and projecting lines vertically to a 30° line.

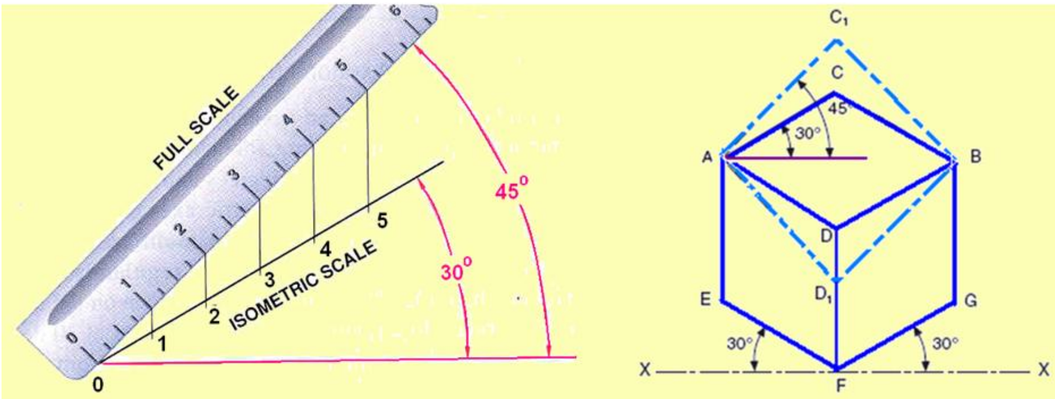


Figure 5. illustrates the construction of an isometric scale.

$$\text{Isometric scale} = \left(\frac{\text{Isometric length}}{\text{True length}}\right) = \frac{\cos 45^{o}}{\cos 30^{o}} = \frac{1}{\sqrt{2}} + \frac{\sqrt{3}}{2} = 0.8165$$

i.e. isometric length = 82% (approximately)

Isometric axes can be positioned in a number of ways to create different views of the same object. Figure 6(a) is a regular isometric, in which the viewpoint is looking down on the top of the object. In a regular isometric, the axes at 30° to the horizontal are drawn upward from the horizontal. In the reversed axis isometric, as shown in figure 6(b), the viewpoint is looking up on the bottom of the object, and the 30° axes are drawn downward from the horizontal. Figure 6(c)&(d) show the long axis isometric, where the viewpoint is looking from the right or from the left of the object, and one axis is drawn at 60 ° to the horizontal. While drawing the Isometric view, first the view point will have to be decided for obtaining the maximum technical information.

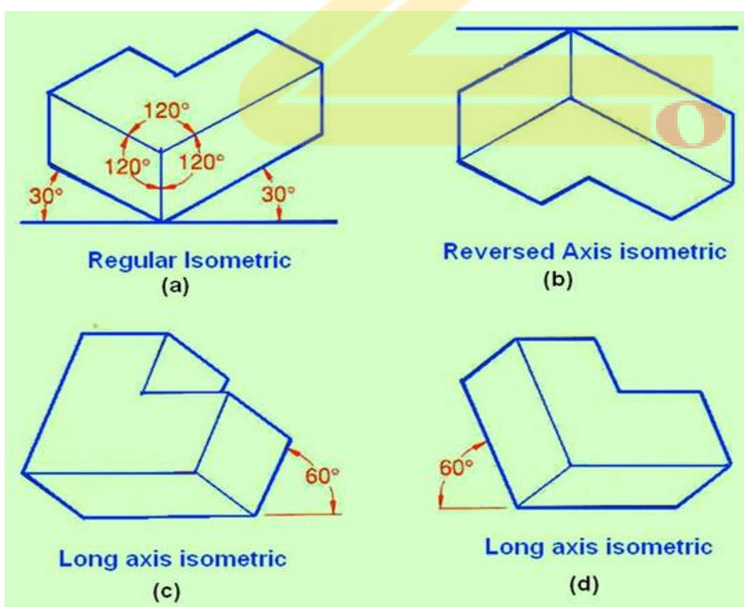


Figure 6. shows different isometric axis depending on the direction of view point.

Isometric axes and non-isometric axes

Figure 7(a) illustrates the isometric axes, non-isometric axes and isometric planes. In an isometric drawing, true length distances can only be measured along isometric lines. i.e. lines that run parallel to any of the isometric axes. Any line that does not run parallel to an isometric axis is called a non-isometric line. Non-isometric lines include inclined and oblique lines and cannot be measured directly. Instead they must be created by locating two end points. Figure 7(b) is an isometric drawing of a cube. The three faces of the isometric cube are isometric planes, because they are parallel to the isometric surfaces formed by any two adjacent isometric axes. Planes that are not parallel to any isometric plane are called non-isometric planes sa shown in figure 7(a).

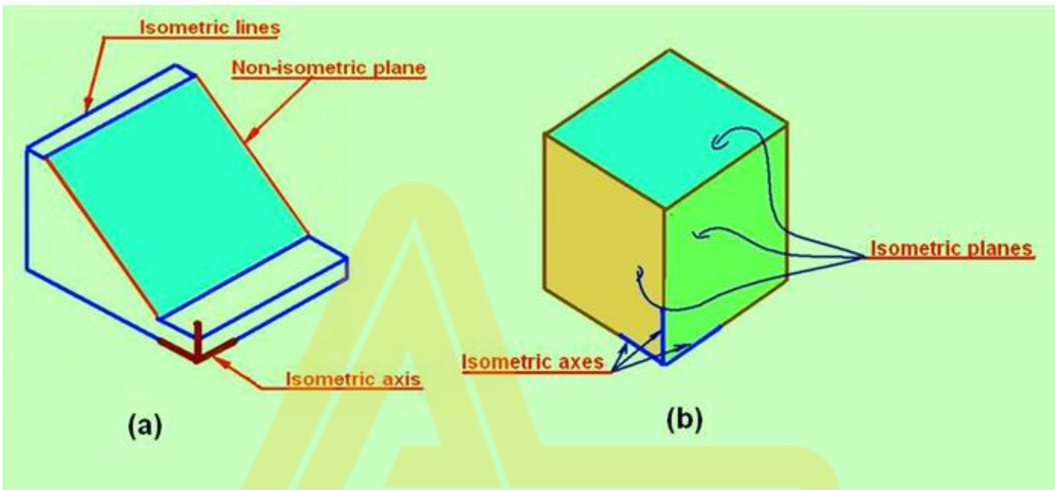


Figure 7. showing isometric axes, non-isometric axes and isometric planes.

Hidden Lines, Center Lines and Dimensions

In isometric drawings, hidden lines are omitted unless they are absolutely necessary to completely describe the object. Most isometric drawings will not have hidden lines. To avoid using hidden lines, choose the most descriptive viewpoint. However, if an isometric viewpoint cannot be found which clearly depicts all the major features, hidden lines may be used. eg. Figure 8(a). Centerlines are drawn only for showing symmetry or for dimensioning. Normally, centerlines are not shown, because many isometric drawings are used to communicate to non-technical people and not for engineering purposes.

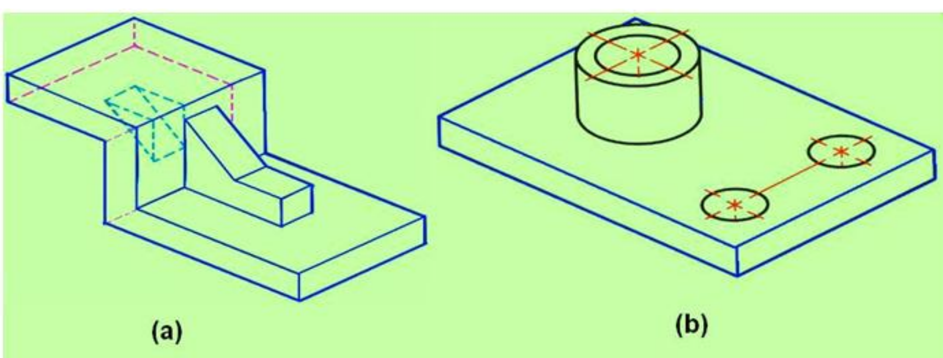


Figure 8 showing hidden lines and centre lines.

Dimension lines, extension lines, and lines being dimensioned shall lie in the same plane. All dimensions and notes should be unidirectional, reading from the bottom of the drawing upward and should be located outside the view whenever possible. The texts are read from the bottom, using horizontal guidelines as shown in Figure 9.

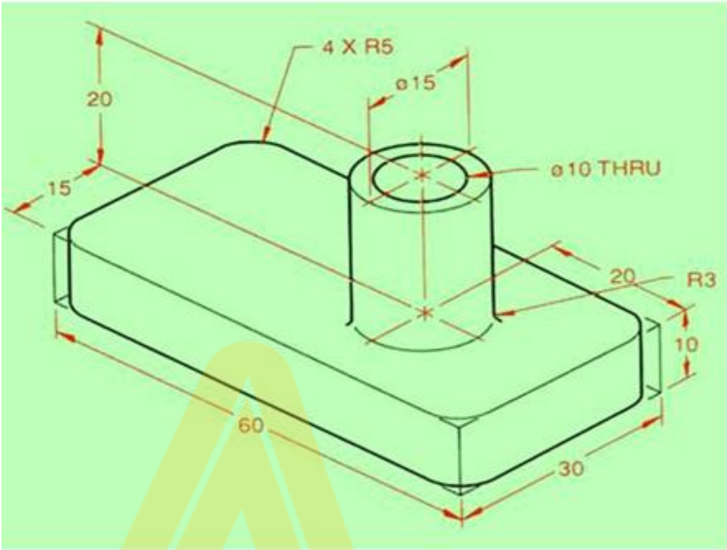


Figure 9 showing the procedure of using dimension lines, extension lines and text.

5.3 Isometric view of some standard shapes

1.Square

Consider a square ABCD with a 30 mm side shown in Fig. If the square lies in the vertical plane, it will appear as a rhombus with a 30 mm side in isometric view as shown in Fig. (a) or (b), depending on its orientation, i.e., right-hand vertical face or left-hand vertical face. If the square lies in the horizontal plane (like the top face of a cube), it will appear as in Fig.(c). The sides AB and AD, both, are inclined to the horizontal reference line at 30°.

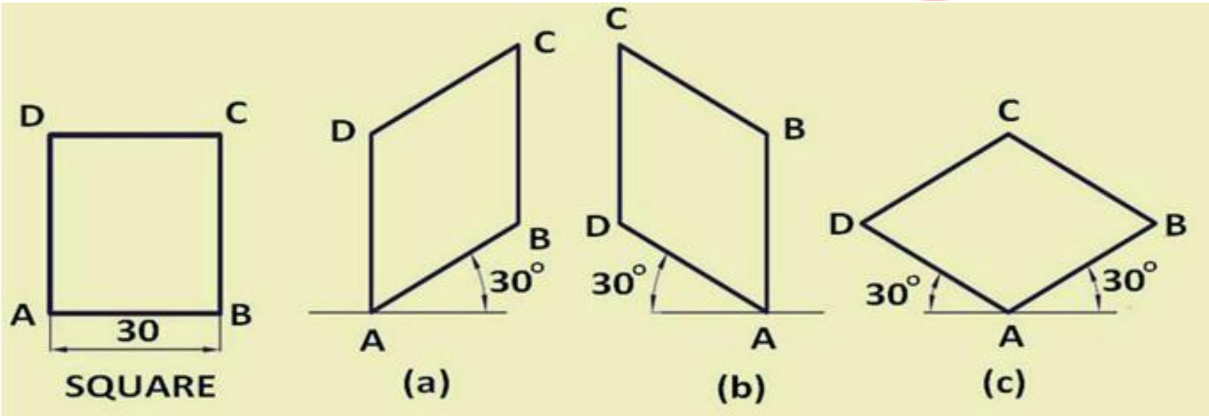


Figure 10. Isometric views of a square.

2.Rectangl*e*

A rectangle appears as a parallelogram in isometric view as shown in figure 11.. Three versions are possible depending on the orientation of the rectangle, i.e., right-hand vertical face, left-hand vertical face or horizontal face.

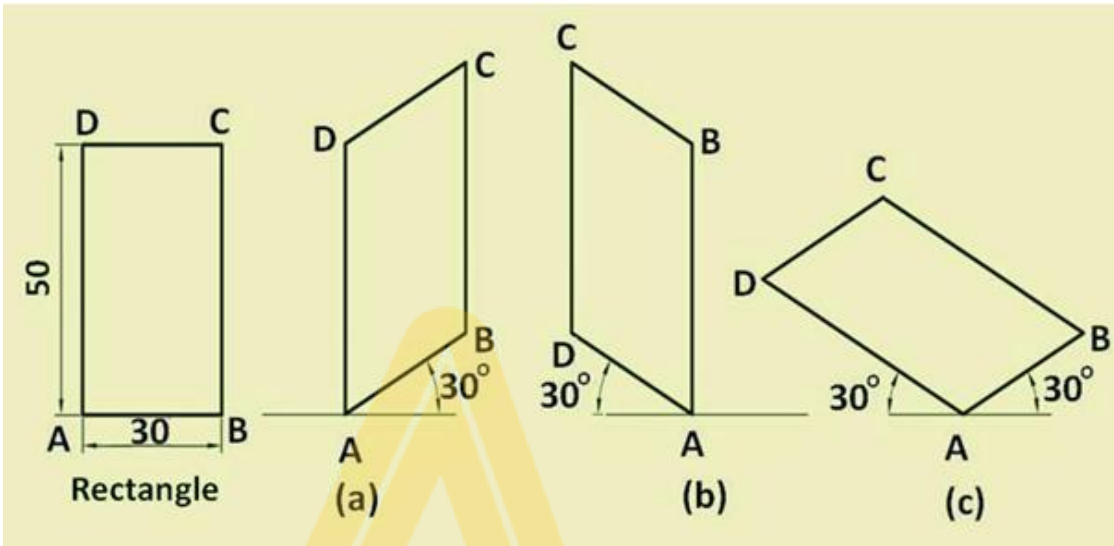


Figure 11. Isometric views of a rectangle.

3.Triangle

A triangle of any type can be easily obtained in isometric view as explained below. First enclose the triangle in rectangle *ABCD*. Obtain parallelogram *ABCD* of the rectangle as shown in Fig. 12(a) or (b) or (c). Then locate point 1 in the parallelogram such that *C*–1 in the parallelogram is equal to *C*–1 in the rectangle. *A*–*B*–1 represents the isometric view of the triangle.

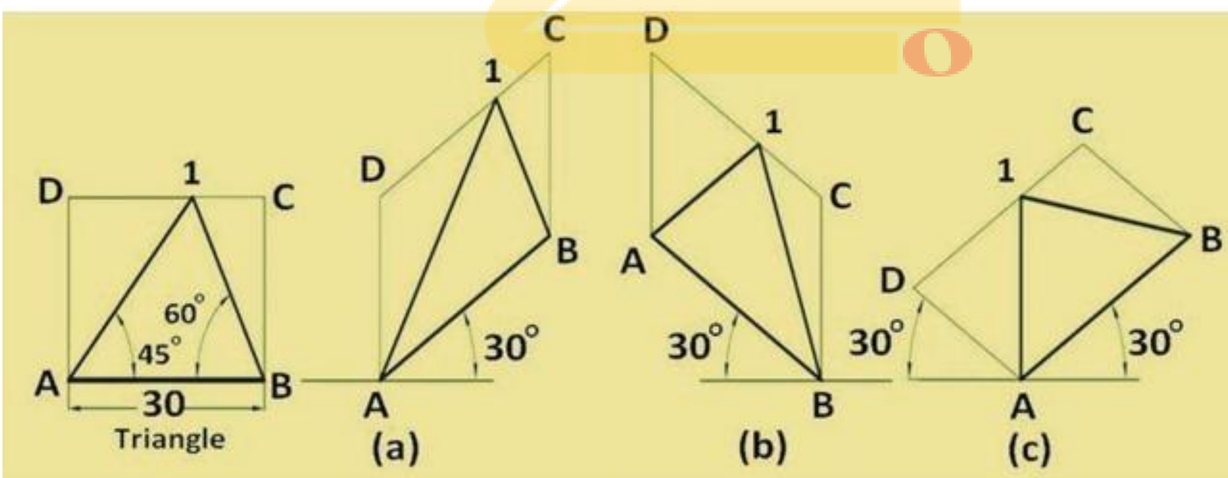


Figure 12. Method of obtaining the isometric views of a triangle.

4.Pentagon

Enclose the given pentagon in a rectangle and obtain the parallelogram as in Fig. 13 (a) or (b) or (c). Locate points 1, 2, 3, 4 and 5 on the rectangle and mark them on the parallelogram. The distances *A*–1, *B*–2, *C*–3, *C*–4 and *D*–5 in isometric drawing are same as the corresponding distances on the pentagon enclosed in the rectangle since the edges of the rectangle are isometric axes.

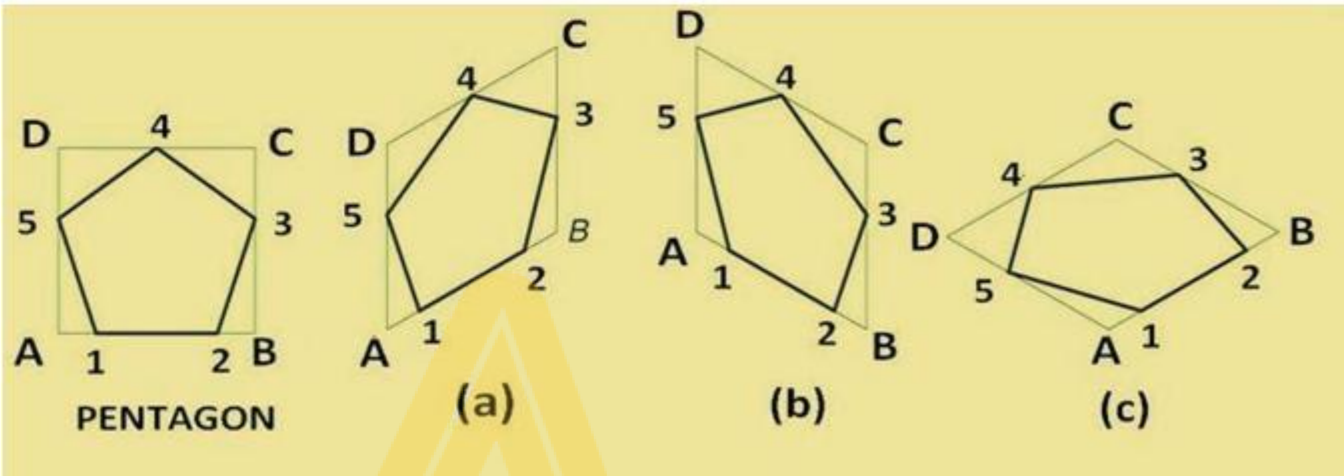


Figure 13. Method of obtaining the isometric views of a pentagon.

5.Circle

The isometric view or isometric projection of a circle is an ellipse. It is obtained by using four-centre method explained below and illustrated in Figure 14.
***Four-Centre Method*:** First, enclose the given circle into a square *ABCD*. Draw rhombus *ABCD* as an isometric view of the square. Join the farthest corners of the rhombus, i.e., *A* and *C*. Obtain midpoints 3 and 4 of sides *CD* and *AD* respectively. Locate points 1 and 2 at the intersection of *AC* with *B*–3 and *B*–4 respectively. Now with 1 as a centre and radius 1–3, draw a small arc 3–5. Draw another arc 4–6 with same radius but 2 as a centre. With *B* as a centre and radius *B*–3, draw an arc 3–4. Draw another arc 5–6 with same radius but with *D* as a centre.

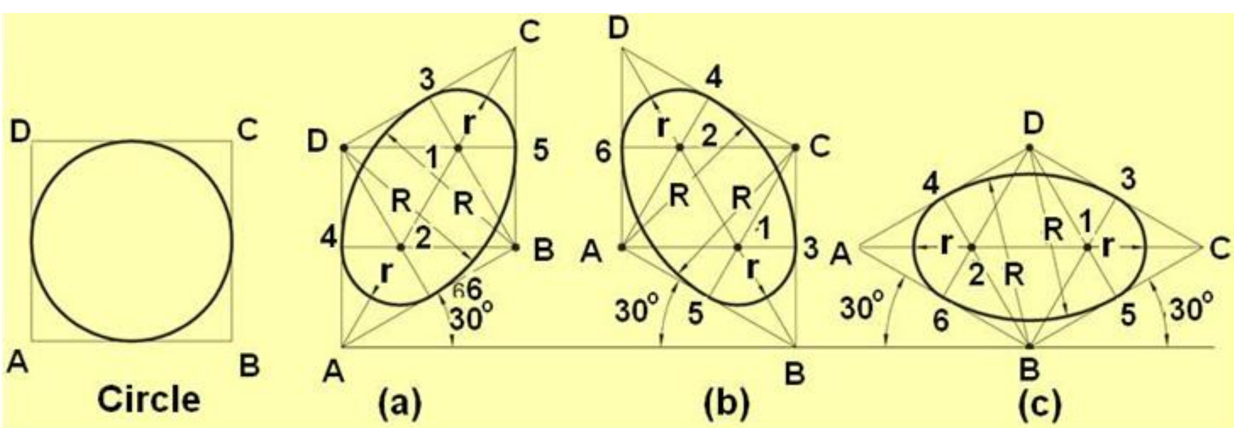


Figure 14. Method of obtaining the isometric views of a circle by four-centre method.

6.Isometric view of irregular Shape

The method of drawing the isometric view of an irregular shape 1–2–3–4–5–6–7 is illustrated in Figure 15. First the figure is enclosed in a rectangle. The parallelogram is obtained in isometric for the rectangle as shown. The distances B–2, D–2, C–3, E–3, G–4, F–4, H–5, H–6 and A–7 has the same length as in original shape since they are along the isometric axis. The points 1 to 7 are located by travelling along the isometric lines. After locating the points, the points are joined for lines which lie along non-isometric lines viz. 1-2, 2-3, 3-G, 6-5, 7-6.

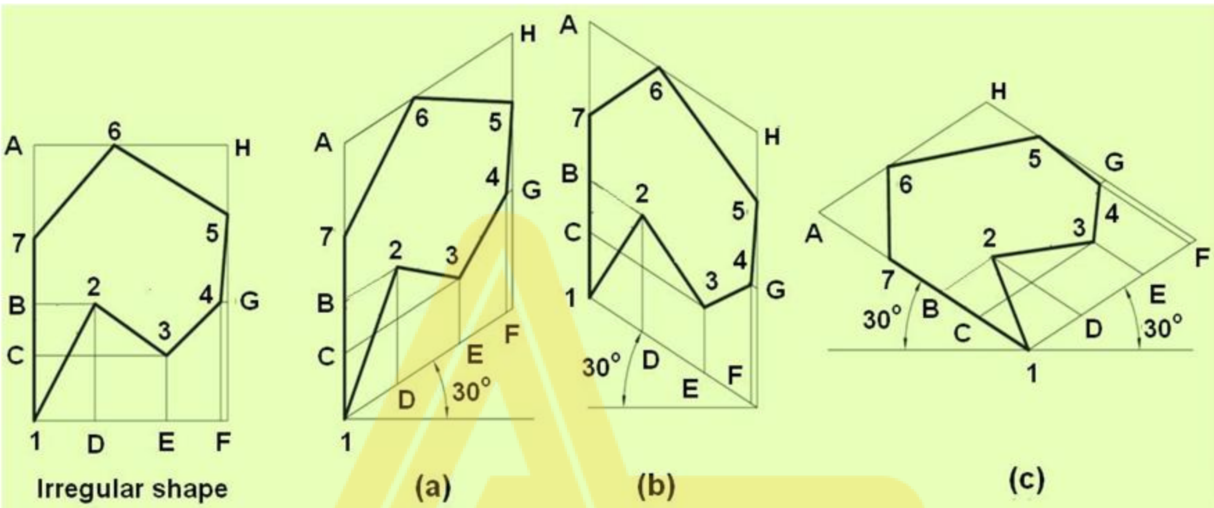
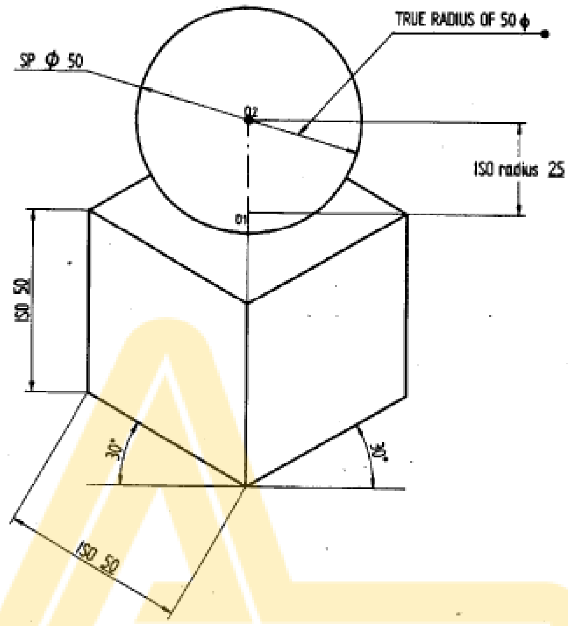


Figure 15. Method of obtaining the isometric views of an irregular shape.

Worked Examples- Isometric Projection

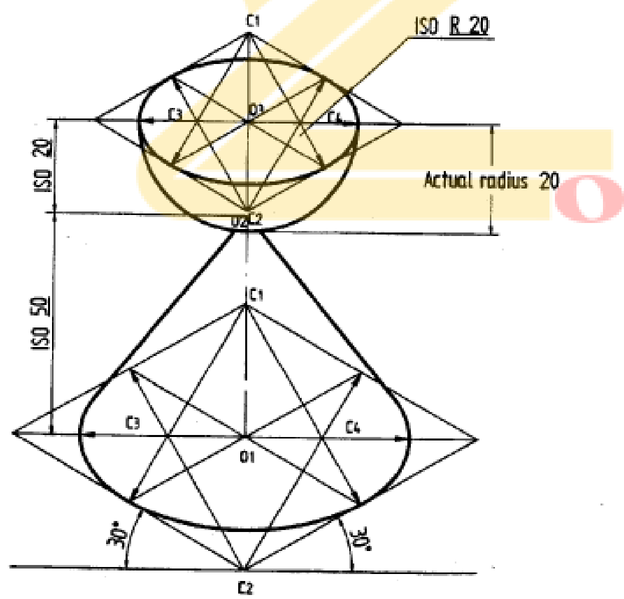
Problem 1 A sphere of diameter 50 mm rests centrally on top of a cube of sides 50 mm. Draw the Isometric projections of the combination of solids.

Solution



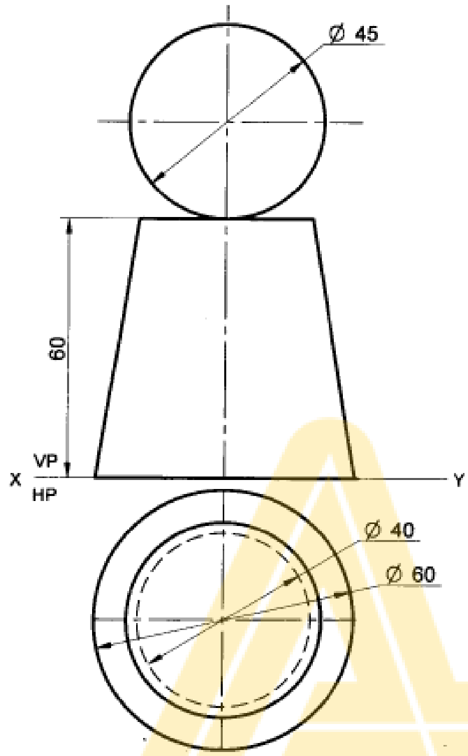
Problem 2 A hemisphere of 40 mm diameter is supported co-axially on the vertex of a cone of base dia. 60 mm and axis length 50 mm. The flat circular face of the hemisphere is facing upside. Draw the isometric projection of the combination of solids.

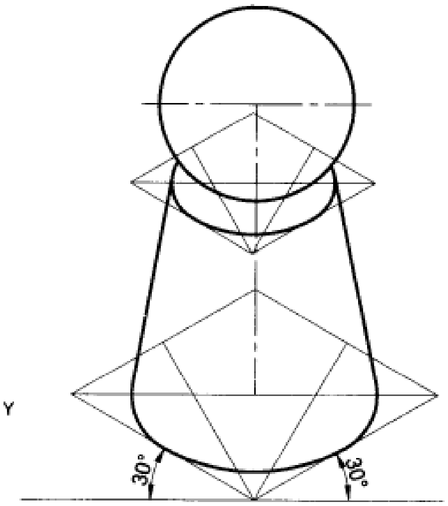
Solution



Problem 14 A sphere of diameter 45mm rests centrally over a frustum of cone of base diameter 60mm, top diameter 40mm and height 60mm. Draw its isometric projections.

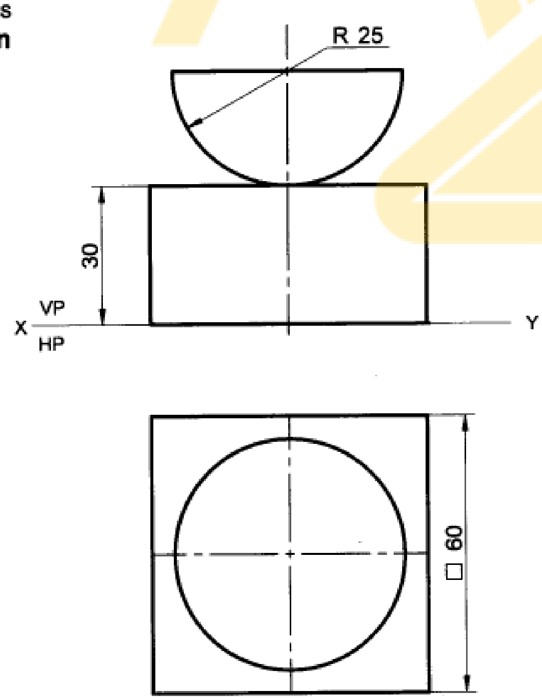
Solution

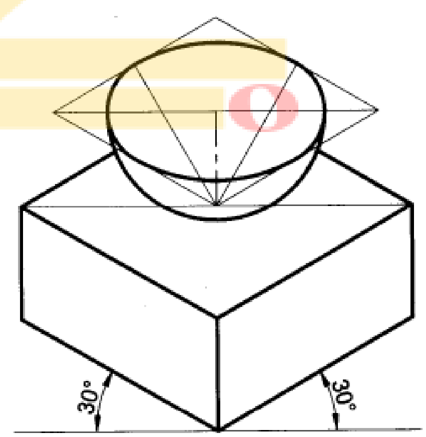




Problem 15 A hemisphere of diameter 50mm is centrally resting on top of a square prism of base side 60mm and height 30mm such that the curved surface of hemisphere is touching the top face of the prism. Draw its isometric projections

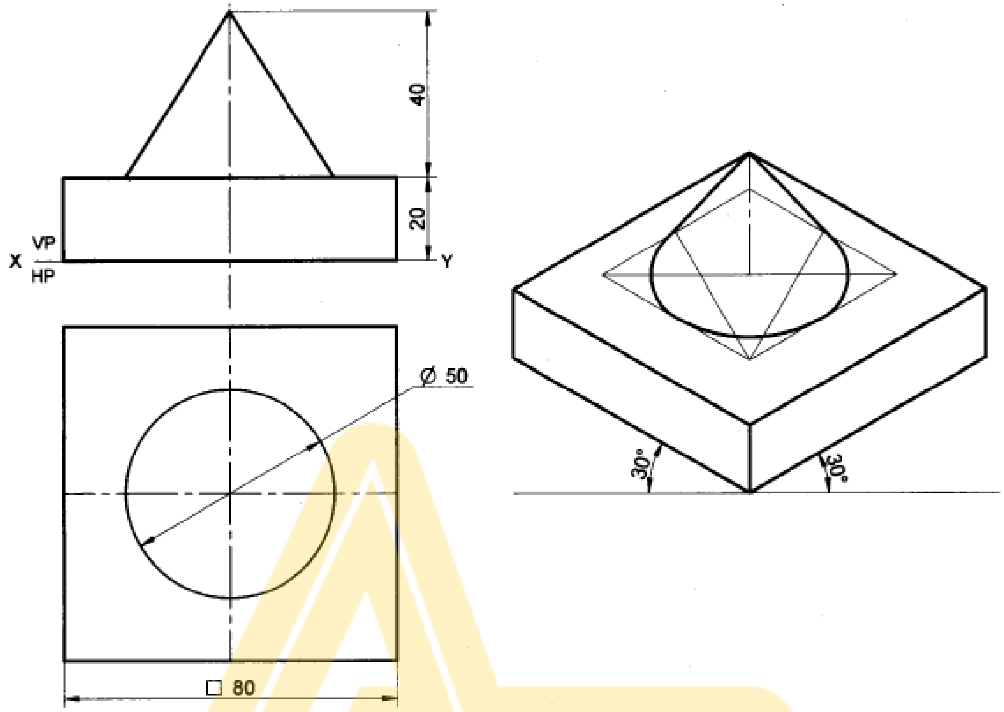
Solution





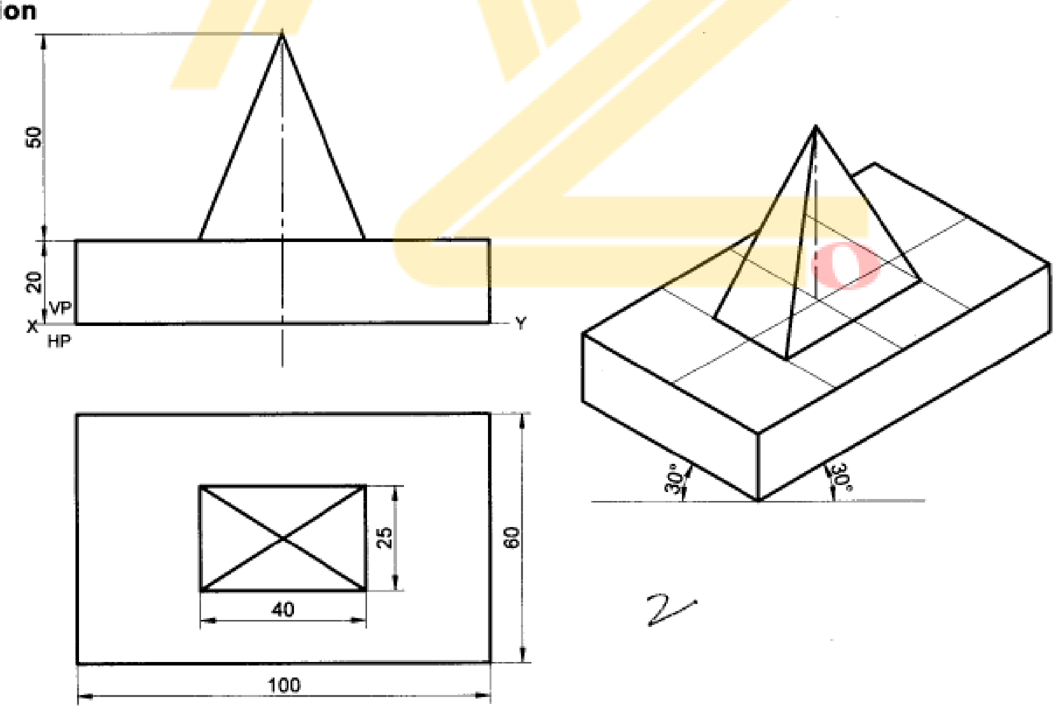
Problem 17 A cone of base diameter 50mm and height 40mm is placed centrally on the top face of a square slab side-80mm and height20mm. Draw the isometric projection of the combination

Solution



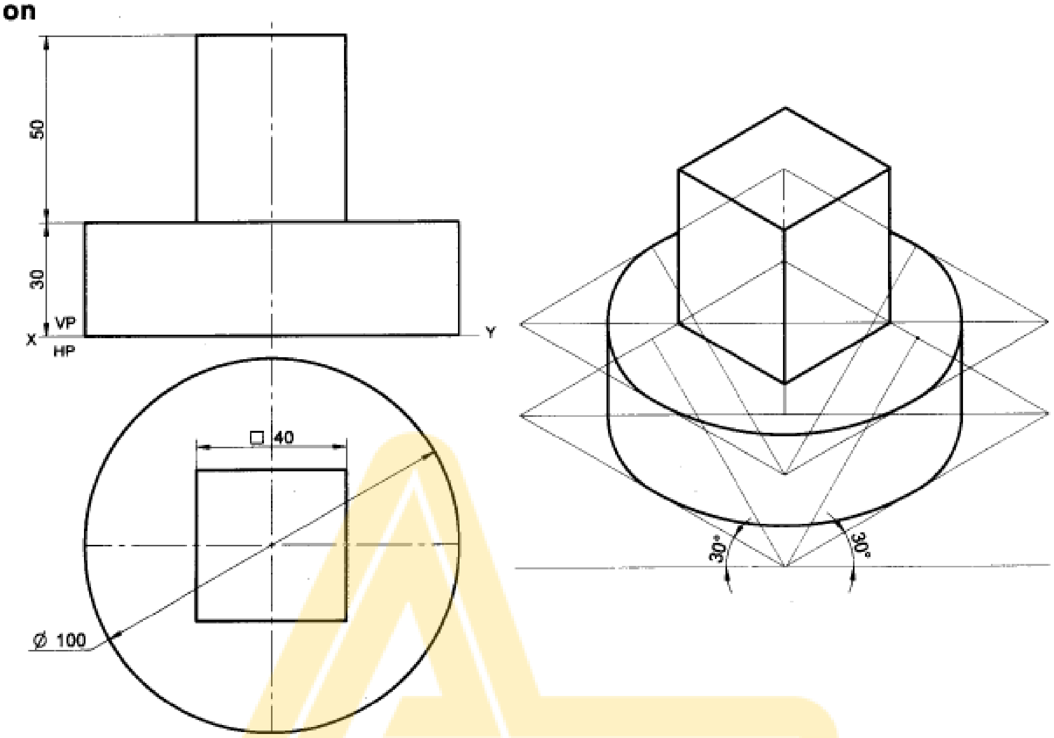
Problem 19 A rectangular pyramid of base-40mmx25mm and height50mm is placed centrally on a rectangular slab sides-100mmx60mm and thickness-20mm. Draw the isometric projection of the combination

Solution



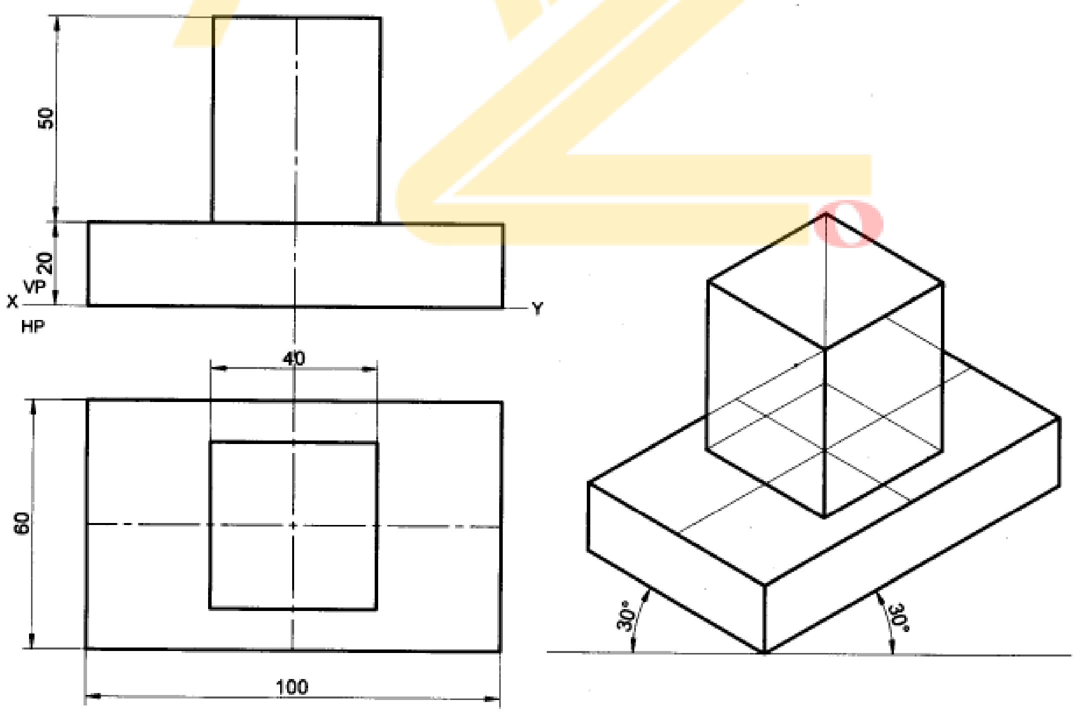
Problem 20 A square prism base side-40mm, height50mm is placed centrally on a cylindrical slab of diameter 100mm and thickness-30mm. Draw the isometric projection of the combination

Solution



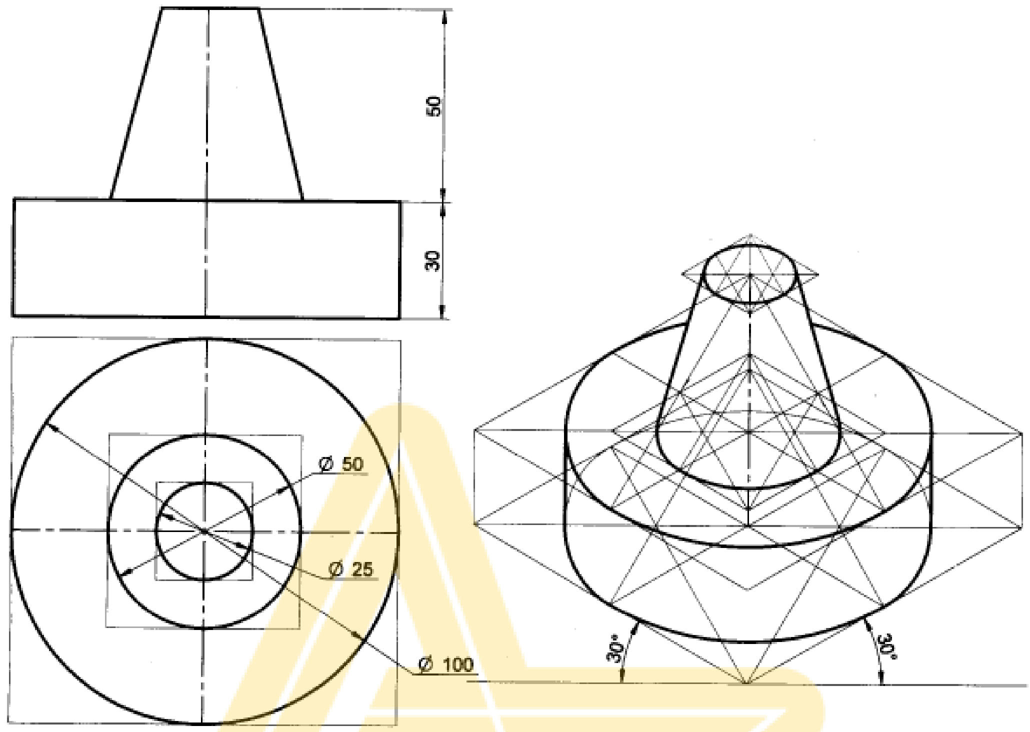
Problem 21 A square prism base side-40mm, height50mm is placed centrally on a rectangular slab sides-100mmx60mm and thickness-20mm. Draw the isometric projection of the combination

Solution



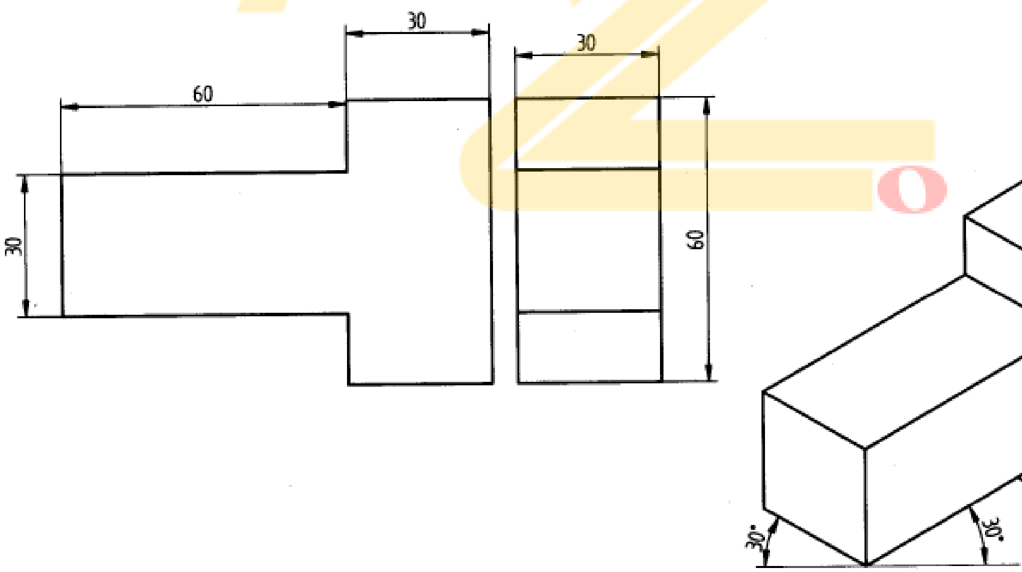
Problem 22 A frustum of cone base diameter 50mm, top diameter 25mm and height50mm is placed centrally on a cylindrical slab of diameter 100mm and thickness-30mm. Draw the isometric projection of the combination

Solution



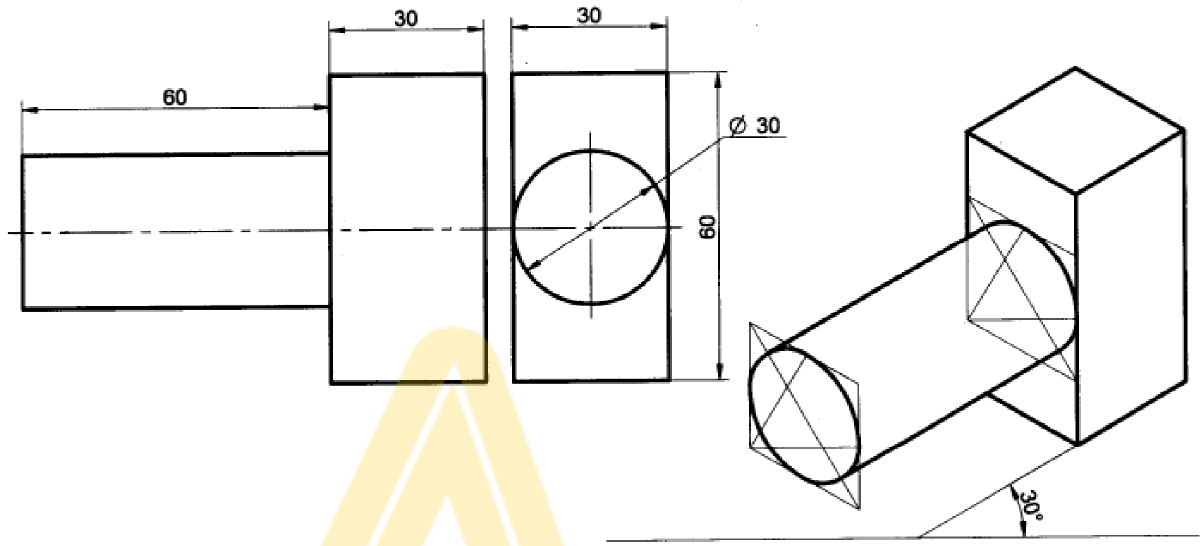
Problem 27 Following figure shows the front and side views of solid. Draw the Isometric projection of the solid.

Solution



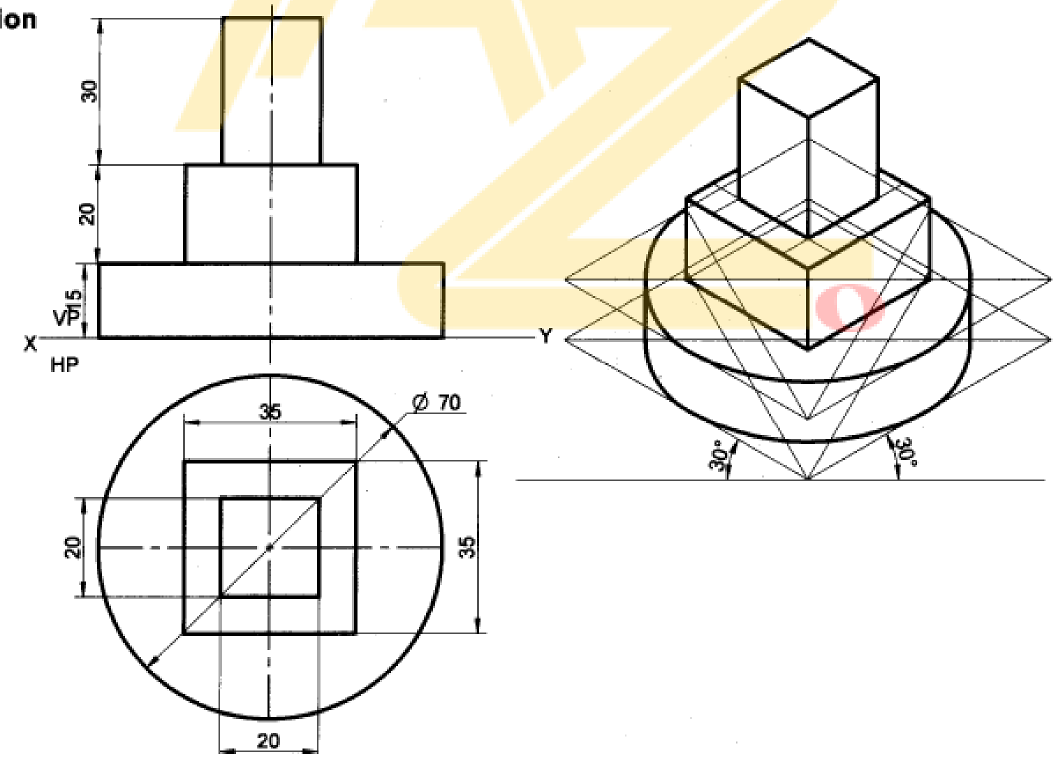
Problem 28 Following figure shows the front and side views of solid. Draw the Isometric projection of the solid.

Solution



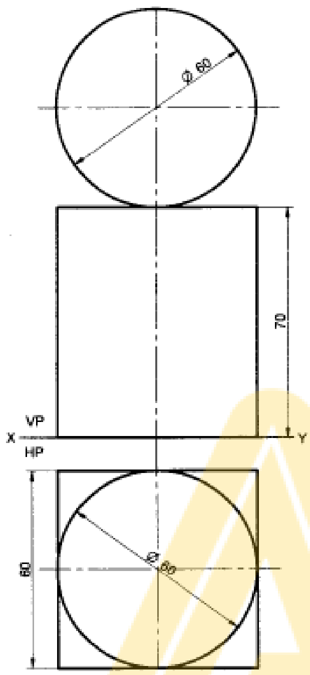
Problem 30 Following figure shows the front and top views of solid. Draw the Isometric projection of the solid.

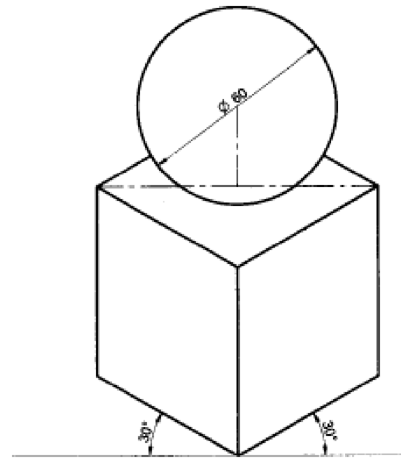
Solution



Problem 33 A sphere diameter 60mm is placed centrally on the top face of a square prism side-60mm and height 70mm. Draw the isometric projection of the combination

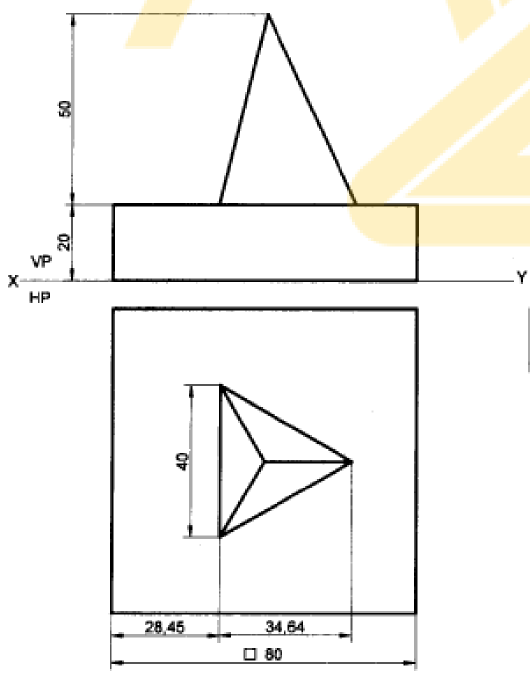
Solution

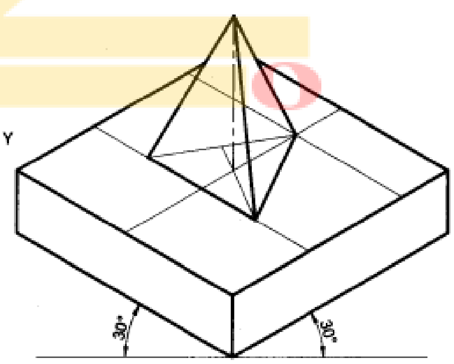




Problem 40 A triangular pyramid base side-40mm and height 50mm is placed centrally on a square slab side-80mm and 20mm-thick. Draw the isometric projection of the combination

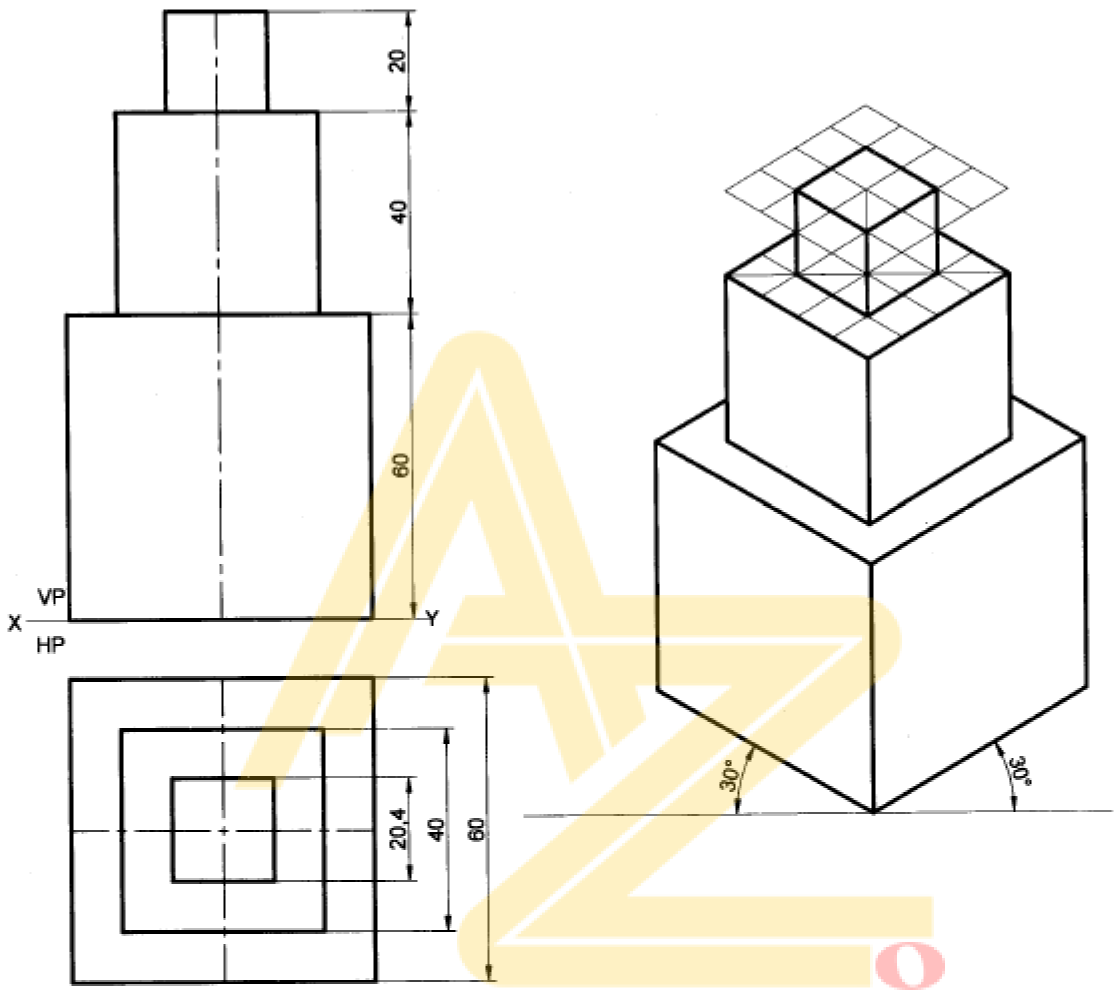
Solution





Problem 47 Three cubes of sides 60mm, 40mm and 20mm are placed centrally one above the other in the ascending order of their side. Draw the isometric projection of the combination

Solution



Problems on Isometrics

1. A rectangular pyramid of base-$40mm \times 25mm$ and height 50mm is placed centrally on a cylindrical slab of diameter 100mm and thuckness-30mm. Draw the isometric projection of the combination.
2. A rectangular pyramid of base-$40mm \times 25mm$ and height 50mm is placed centrally on a rectangular slab sides-$100mm \times 60mm$ and thickness-20mm. Draw the isometric projection of the combination.
3. A square prism base side-40mm, height 50mm is placed centrally on a cylindrical slab of diameter 100mm and thickness-30mm. Draw the isometric projection of the combination
4. A square prism base side-40mm, height50mm is placed centrally on a rectangular slab sides-$100mm \times 60mm$ and thickness-20mm. Draw the isometric projection of the combination
5. A frustum of cone base diameter 50mm, top diameter 25mm and height50mm is placed centrally on a cylindrical slab of diameter 10mm and thickness-30mm. Draw the isometric projection of the combination.
6. A frustum of cone base diameter 50mm, top diameter 25mm and height 50mm is placed centrally on a square slab side-80mm and thickness-30mm. Draw the isometric projection of the combination
7. A frustum of cone base diameter 50mm, top diameter 25mm and height 50mm is placed centrally on the top face of a cylinder diameter 60mm and height 60mm. Draw the isometric projection of the combination
8. A hemisphere diameter 50mm is resting on its curved surface centrally on the top face of a rectangular pyramid base-$80mm \times 60mm$ and top-$60mm \times 40mm$, height 55mm. Draw the isometric projection of the combination
9. A hemisphere diameter 70mm is placed on the ground on its curved surface. A cone base diameter 70mm and height 70mm is placed centrally on it. Draw the isometric projection of the combination
10. Following figure shows the front and side. Draw the Isometric projection of the solid.
11. Following figure shows the front and side views of solid. Draw the Isometric of the solid.
12. Following figure shows the front and side views of solid. Draw the Isometric projection of the solid.

FURTHER READING:

1) Computer Aided Engineering Drawing - S. Trymbaka Murthy, - I.K. International Publishing House Pvt. Ltd., New Delhi, 3rd revised edition- 2006.
2) Engineering Graphics - K.R. Gopalakrishna, 32nd edition, 2005- Subash Publishers Bangalore.
3) Dhananjay A Jolhe, Engineering Drawing, Tata McGraw Hill, 2007.
4) M.B. Shah and B.C. Rana, Engineering Drawing, pearson Education, Eds. 2, 2009.
5) K. Venugopal, Engineering Drawing and Graphics, New Age International (P) Ltd., publishers, 2000.

6) N.D. Bhatt and V.M. Panchal, Engineering Drawing, Charotar Publishing house, 2005.