Technical and Vocational Stream
Learning Resource Material

Engineering Drawing

(Grade 9)

Electrical Engineering

Government of Nepal
Ministry of Education, Science and Technology
Curriculum Development Centre
Sanothimi, Bhaktapur

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Preface

The curriculum and curricular materials have been developed and revised on a regular basis with the aim of making education objective-oriented, practical, relevant and job oriented. It is necessary to instill the feelings of nationalism, national integrity and democratic spirit in students and equip them with morality, discipline, self-reliance, creativity and thoughtfulness. It is essential to develop linguistic and mathematical skills, knowledge of science, information and communication technology, environment, health and population and life skills in students. It is also necessary to bring the feeling of preserving and promoting arts and aesthetics, humanistic norms, values and ideals. It has become the need of the present time to make them aware of respect for ethnicity, gender, disabilities, languages, religions, cultures, regional diversity, human rights and social values to make them capable of playing the role of responsible citizens with applied technical and vocational knowledge and skills. This learning resource material for Electrical engineering has been developed in line with the Secondary Level Electrical engineering Curriculum with an aim to facilitate the students in their study and learning on the subject by incorporating the recommendations and feedback obtained from various schools, workshops, seminars and interaction programs attended by teachers, students, parents and concerned stakeholders.

In bringing out the learning resource material in this form, the contribution of the Director General of CDC Mr. Yubaraj Paudel and members of the subject committee Dr. Nandabikram Adhikari, Er. Chitra Bahadur Khadka, Mr. Damberdhwaj Angdembe, Er. Sanju Shrestha is highly acknowledged. This learning resource material is compiled and prepared by Er. Rupesh Maharjan, Er. Jaya Prakash Maharjan, Er. Uddav Giri. The subject matter of this material is edited by Mr. Badrinath Timsina and Mr. Khilanath Dhamala. Similarly, the language is edited by Mr. Bijay Kumar Ranabhat. CDC extends sincere thanks to all those who have contributed to developing this material in this form.

This learning resource material contains a wide coverage of subject matters and sample exercises which will help the learners to achieve the competencies and learning outcomes set in the curriculum. Each chapter in the material clearly and concisely deals with the subject matters required for the accomplishment of the learning outcomes. The Curriculum Development Centre always welcomes creative and constructive feedback for the further improvement of the material.

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Table of Content

Guidelines to Teachers

A. Facilitation Methods

The goal of this course is to combine the theoretical and practical aspects of the contents needed for the subject. The nature of contents included in this course demands the use of practical or learner focused facilitation processes. Therefore, the practical side of the facilitation process has been focused much. The instructor is expected to design and conduct a variety of practical methods, strategies or techniques which encourage students engage in the process of reflection, sharing, collaboration, exploration and innovation new ideas or learning. For this, the following teaching methods, strategies or techniques are suggested to adopt as per the course content nature and context.

Brainstorming

Brainstorming is a technique of teaching which is creative thinking process. In this technique, students freely speak or share their ideas on a given topic. The instructor does not judge students' ideas as being right or wrong, but rather encourages them to think and speak creatively and innovatively. In brainstorming time, the instructor expects students to generate their tentative and rough ideas on a given topic which are not judgmental. It is, therefore, brainstorming is free-wheeling, non-judgmental and unstructured in nature. Students or participants are encouraged to freely express their ideas throughout the brainstorming time. Whiteboard and other visual aids can be used to help organize the ideas as they are developed. Following the brainstorming session, concepts are examined and ranked in order of importance, opening the door for more development and execution. Brainstorming is an effective technique for problem-solving, invention, and decision-making because it taps into the group's combined knowledge and creative ideas.

Demonstration

Demonstration is a practical method of teaching in which the instructor shows or demonstrates the actions, materials, or processes. While demonstrating something the students in the class see, observe, discuss and share ideas on a given topic. Most importantly, abstract and complicated concepts can be presented into visible form through demonstration. Visualization bridges the gap between abstract ideas and concrete manifestations by utilizing the innate human ability to think visually. This enables students to make better decisions, develop their creative potential, and obtain deeper insights across a variety of subject areas.

Peer Discussion

Peer conversation is a cooperative process where students converse with their peers to exchange viewpoints, share ideas, and jointly investigate subjects that are relevant or of mutual interest. Peer discussion is an effective teaching strategy used in the classroom to encourage critical thinking, active learning, and knowledge development. Peer discussions encourage students to express their ideas clearly, listen to opposing points of view, and participate in debate or dialogue, all of which contribute to a deeper comprehension and memory of the course material. Peer discussions also help participants develop critical communication and teamwork skills by teaching them how to effectively articulate their views, persuasively defend their positions, and constructively respond to criticism.

Peer conversation is essential for professional growth and community building outside of the classroom because it allows practitioners to share best practices, work together, and solve problems as a group. In addition to expanding their knowledge horizon and deepening their understanding, peer discussions help students build lasting relationships and a feeling of community within their peer networks.

Group Work

Group work is a technique of teaching where more than two students or participants work together to complete a task, solve a problem or discuss on a given topic collaboratively. Group work is also a cooperative working process where students join and share their perspectives, abilities, and knowledge to take on challenging job or project. Group work in academic contexts promotes active learning, peer teaching, and the development of collaboration and communication skills. Group work helps individuals to do more together than they might individually do or achieve.

Gallery Walk

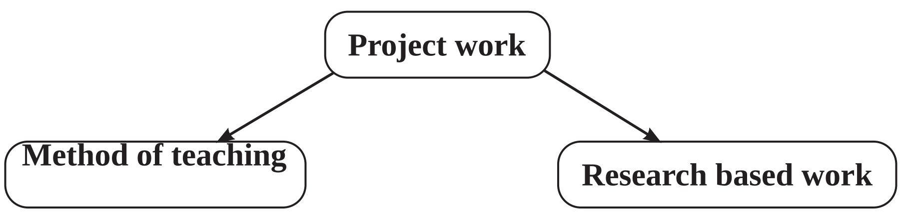
Gallery walk is a critical thinking strategy. It creates interactive learning environment in the classroom. It offers participants or students a structured way to observe exhibition or presentation and also provides opportunity to share ideas. It promotes peer-to-peer or group-to-group engagement by encouraging participants to observe, evaluate and comment on each other’s work or ideas. Students who engage in this process improve their communication and critical thinking abilities in addition to their comprehension of the subject matter, which leads to a deeper and more sophisticated investigation of the subjects at hand.

Interaction

The dynamic sharing of ideas, knowledge, and experiences between people or things is referred to as interaction, and it frequently takes place in social, academic, or professional settings. It includes a broad range of activities such as dialogue, collaboration or team work, negotiation, problem solving, etc. Mutual understanding, knowledge sharing, and interpersonal relationships are all facilitated by effective interaction. Interaction is essential for building relationships, encouraging learning, and stimulating creativity in both in-person and virtual contexts. Students can broaden their viewpoints, hone their abilities, and jointly achieve solutions to difficult problems by actively interacting with others.

Project Work

Project work is a special kind of work that consists of a problematic situation which requires systematic investigation to explore innovative ideas and solutions. Project work can be used in two senses. First, it is a method of teaching in regular class. The next is: it is a research work that requires planned investigation to explore something new. This concept can be presented in the following figure.



Project work entails individuals or teams working together to achieve particular educational objectives. It consists of a number of organized tasks, activities, and deliverables. The end product is important for project work. Generally, project work will be carried out in three stages. They are:

- Planning
- Investigation
- Reporting

B. Instructional Materials

Instructional materials are the tools and resources that teachers use to help students. These resources/materials engage students, strengthen learning, and improve conceptual comprehension while supporting the educational goals of a course or program. Different learning styles and preferences can be accommodated by the variety of instructional resources available. Here are a few examples of typical educational resource types:

- Daily used materials
- Related Pictures
- Reference books
- **Slides and presentation:** PowerPoint slides, keynote presentations, or other visual aids that help convey information in a visually appealing and organized manner.
- **Audiovisual materials:** Videos, animations, podcasts, and other multimedia resources that bring concepts to life and cater to auditory and visual learners.
- **Online Resources:** Websites, online articles, e-books, and other web-based materials that can be accessed for further reading and research.

Maps, charts, and graphs: Visual representations that help learners understand relationships, patterns, and trends in different subjects.

Real-life examples and Case Studies: Stories, examples, or case studies that illustrate the practical application of theoretical concepts and principles.

C. Assessment

Formative Test

Classroom discussions: Engage students in discussions to assess their understanding of concepts.

Quizzes and polls: Use short quizzes or polls to check comprehension during or after a lesson.

Homework exercises: Assign tasks that provide ongoing feedback on individual progress.

Peer review: Have students review and provide feedback on each other's work.

Summative Test

Exams: Conduct comprehensive exams at the end of a unit or semester.

Final Projects: Assign projects that demonstrate overall understanding of the subject.

Peer Assessment

Group projects: Evaluate individual contributions within a group project.

Peer feedback forms: Provide structured forms for students to assess their peers.

Classroom Presentations: Have students assess each other's presentations.

Objective Test

Multiple-choice tests: Use multiple-choice questions to assess knowledge.

True/False questions: Assess factual understanding with true/false questions.

Matching exercises: Evaluate associations between concepts or terms.

Portfolio Assessment

Compilation of work: Collect and assess a variety of student work samples.

Reflection statements: Ask students to write reflective statements about their work.

Showcase events: Organize events where students present their portfolios to peers or instructors.

Observational Assessment

Classroom observations: Observe students' behavior and engagement during class.

Performance observations: Assess practical skills through direct observation.

Field Trips: Evaluate students' ability to apply knowledge in real-world settings.

Introduction to Drawing

Unit 1

Introduction to Drawing

Drawing is a form of visual art in which a person uses various drawing instruments to mark paper or another two-dimensional medium. Instruments include graphite pencils, pen and ink, various kinds of paints, inked brushes, coloured pencils,crayons,charcoal,chalk,pastels, various kinds of erasers, markers, styluses, and various metals (like silverpoint).

"Digital drawing" is the act of using a computer to draw. Common methods of digital drawing include a stylus or finger on a touch -screen device, stylus-to-touchpad, finger-to-touchpad, or in some cases, a mouse.

A drawing instrument releases a small amount of material onto a surface, leaving a visible mark. The most common support for drawing is paper, although other materials,suchascardboard, plastic,leather, canvas, and board, may be used. Temporary drawings may be made on blackboard or whiteboard or indeed almost anything. The medium has been a popular and fundamental means of public expression throughout human history. It is one of the simplest and most efficient means of communicating visual ideas. The wide availability of drawing instruments makes drawing one of the most common artistic activities.

In addition to its more artistic forms, drawing is frequently used in commercial illustration, animation, architecture, engineering and technical drawing. A quick, freehand drawing, usually not intended as a finished work, is sometimes called a sketch. An artist who practices or works in technical drawing may be called a drafter, draftsman or a draughtsman.

Types of Drawing

Illustration Drawing

These are drawings that are created to represent the lay-out of a particular document. They include all the basic details of the project concerned clearly stating its purpose, style, size, colour, character, and effect.

Life Drawing

Drawings that result from direct or real observations are life drawings. Life drawing, also known as still-life drawing or figure drawing, portrays all the expressions that are viewed by the artist and captured in the picture. The human figure forms one of the most enduring themes in life drawing that is applied to portraiture, sculpture, medical illustration, cartooning and comic book illustration, and other fields.

Emotive Drawing

Similar to painting, emotive drawing emphasizes the exploration and expression of different emotions, feelings, and moods. These are generally depicted in the form of a personality.

Analytic Drawing

Sketches that are created for clear understanding and representation of observations made by an artist are called analytic drawings. In simple words, analytic drawing is undertaken to divide observations into small parts for a better perspective.

Perspective Drawing

Perspective drawing is used by artists to create three-dimensional images on a two-dimensional picture plane, such as paper. It represents space, distance, volume, light, surface planes, and scale, all viewed from a particular eye-level.

Diagrammatic Drawing

When concepts and ideas are explored and investigated, these are documented on paper through diagrammatic drawing. Diagrams are created to depict adjacencies and happenstance that are likely to take place in the immediate future. Thus, diagrammatic drawings serve as active design process for the instant ideas so conceived.

Geometric Drawing

Geometric drawing is used, particularly, in construction fields that demand specific dimensions. Measured scales, true sides, sections, and various other descriptive views are represented through geometric drawing.

Engineering Drawing

Engineering drawing is a two dimensional representation of three dimensional objects. In general, it provides necessary information about the shape, size, surface quality, material, manufacturing process, etc. of the object. It is the graphic language from which a trained person can visualize objects.

Drawings prepared in one country may be utilized in any other country irrespective of the language spoken. Hence, engineering drawing is called the universal language of engineers. any language to be communicative should follow certain rules so that it conveys the same meaning to everyone. Similarly, drawing practice must follow certain rules, if it is to serve as a means of communication. For this purpose, Bureau of Indian Standards (BIS) adapted the International Standards on code of practice for drawing. The other foreign standards are: DIN of Germany, BS of Britain and ANSI of America.

Role of Engineering Drawing

The ability to read drawing is the most important requirement of all technical people in any profession. As compared to verbal or written description, this method is brief and more clear. Some of the applications are: building drawing for civil engineers, machine drawing for mechanical engineers, circuit diagrams for electrical and electronics engineers, computer graphics for one and all.

The subject in general is designed to impart the following skills.

1. Ability to read and prepare engineering drawings.
2. Ability to make free - hand sketching of objects.
3. Power to imagine analyses and communicate, and 4.Capacity to understand other subjects.

Drawing Instrument and Aids

The Instruments and other aids used in drafting work are listed below:

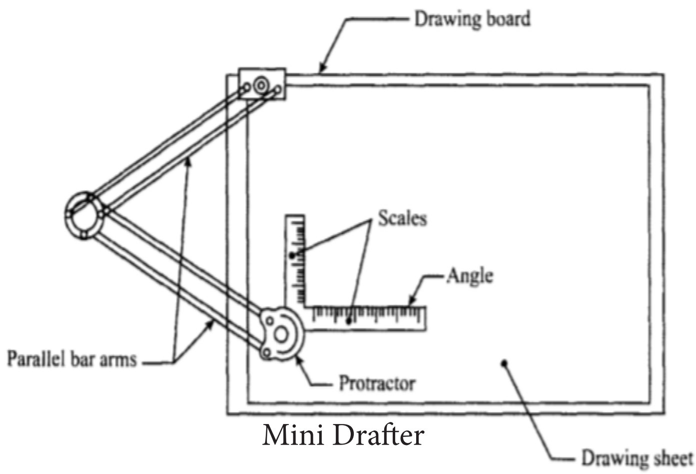
1. Drawing board
2. Mini drafting
3. Instrument box
4. Set squares
5. Protractor
6. Set of scales
7. French curves
8. Drawing sheets
9. Pencils
10. Templates

Drawing Boards

Recently drawing boards used are made of well-seasoned softwood of about 25 mm thick with a working edge for T-square. Nowadays mini-draftingis used instead of T-squares which can be fixed on any board. The standard size of board depends on the size of drawing sheet size required.

Mini-Drafting

Mini-drafting consists of an angle formed by two arms with scales marked and rigidly hinged to each other. It combines the functions off-square, set-squares, scales and protractor. It is used for drawing horizontal, vertical and inclined lines, parallel and perpendicular lines and for measuring lines and angles.

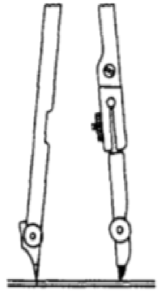


Mini Drafter

Instrument Box

Instrument box contains

1. Compass
2. Dividers and
3. Inking pens.



(a) Sharpening and position of compass lead

(b) Position of the lead leg to draw larger circles

What is important is the position of the pencil lead with respect to the tip of the compass. It should be at least I mm because the tip goes into the board for grip by 1 mm.

Set of Scales

Scales are used to make drawing of the objects to proportionate size desired. These are made of wood; steel or plastic .BIS recommends eight set-scales in plastic cardboard with designations MI, M2 and so on. set of scales

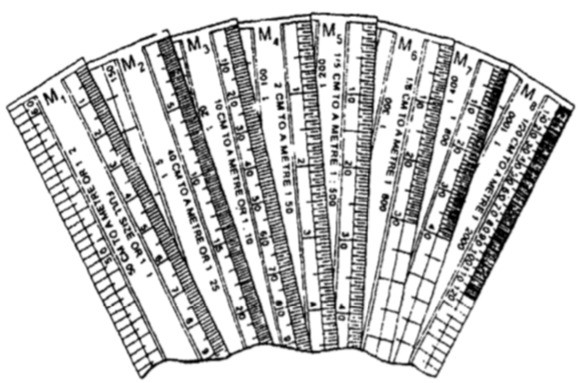


Table 1.1 Set of Scales

Table 1.1 Set of Scales

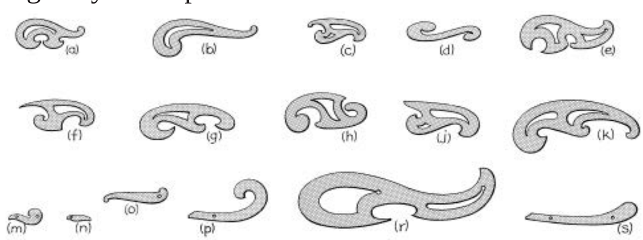
	M1	M2	M3	M4	M5	M6	M7	M8
Scale on one edge	1:1	1:2.5	1:10	1:50	1:200	1:300	1:400	1:1000
Scale on other edge	1:2	1:5	1:20	1:100	1:500	1.600	1:800	1:2000

Note: Do not use the scales as a straight edge for drawing straight lines. These are used for drawing irregular curved lines, other than circles or arcs of circles.

Scales for use on technical drawings (IS : 46-1988)			
Category	**Recommended scales**		
Enlargement scales	50 : 1	20 : 1	10 : 1
	5 : 1	2 : 1	
Full size	1 : 1		
Reduction scales	1 : 2	1 : 5	1 : 10
	1 : 20	1 : 50	1 : 100
	1 : 200	1 : 500	1 . 1000
	1 . 2000	1 · 5000	1 10000

French Curves

French curves are available in different shapes (Fig. 1.4). First a series of points are plotted along the desired path and then the most suitable curve is made along the edge of the curve. A flexible curve consists of a lead bar inside rubber which bends conveniently to draw a smooth curve through any set of points.



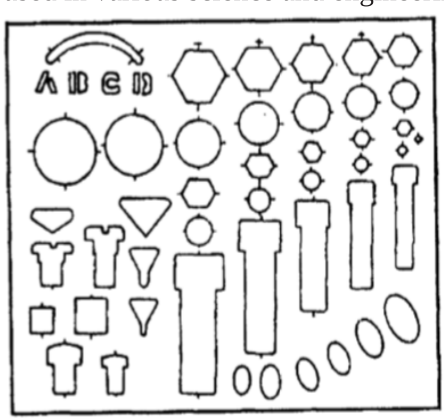
Irregular or French Curves.

(a) French curves

(b) Flexible curve

Templates

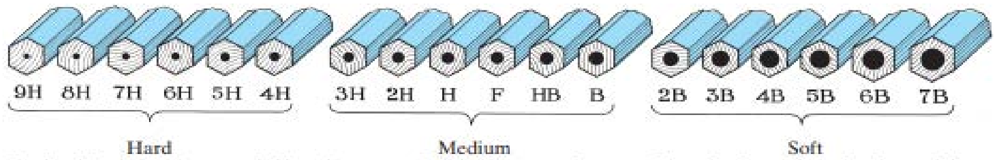
These are aids used for drawing small features such as circles, arcs, triangular, square and other shapes and symbols used in various science and engineering fields



Templates

Pencils

Pencils with leads of different degrees of hardness or grades are available in the market. The hardness or softness of the lead is indicated by 3H, 2H, H, HB, B, 2B, 3B, etc. The grade HB denotes medium hardness of lead used for general purpose. The lead becomes softer, as the value of the numeral before B increases



pencil leads

The selection of the grade depends on the line quality desired for the drawing. Pencils of grades H or 2H may be used for finishing a pencil drawing as these give a sharp black line. Softer grade pencils are used for sketching work. HB grade is recommended for lettering and dimensioning. Nowadays mechanical pencils are widely used in place of wooden pencils. When these are used, much of the sharpening time can be saved. The number 0.5,0.70 of the pen indicates the thickness of the line obtained with the lead and the size of the lead diameter. Micro-tip pencils with 0.5 mm thick leads with the following grades are recommended.

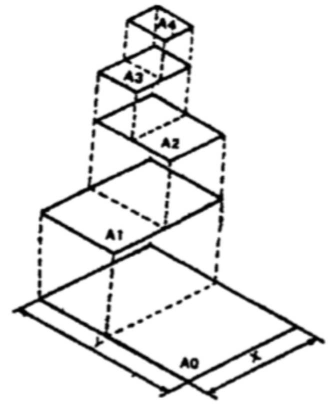
HB soft grade for border lines, lettering and free sketching H Medium grade for visible outlines, visible edges and boundary lines 2H grade for Construction lines, Dimension lines, Leader lines, Extension lines, Centre lines, Hatching lines and Hidden lines.

Drawing Sheet

The standard drawing sheet sizes are arrived at on the basic Principle of x: y = 1 : -..12 and xy = 1 where x and y are the sides of the sheet. For example AO, having a surface area of 1 Sq.m; x = 841 mm and y = 1189 mm. The successive sizes are obtained by either by halving along the length or. Doubling the width, the area being in the ratio 1: 2. Designation of sizes is given in Fig.2.l and their sizes are given in Table 2.1. For class work use of A2 size drawing sheet is preferred.

Table 2.1

Designation	Dimension, mm Trimmed size
A0	841 × 1189
A1	594 × 841
A2	420 × 594
A3	297 × 420
A4	210 × 297

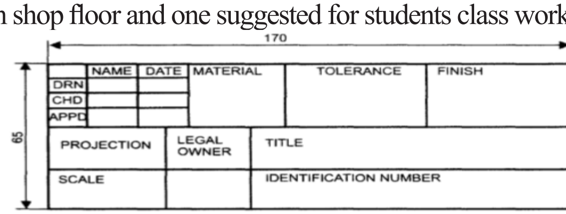


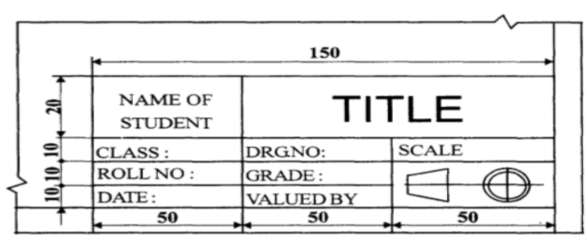
Title Block

The title block should lie within the drawing space at the bottom right hand corner of the sheet. The title block can have a maximum length of 170 mm providing the following information.

1. Title of the drawing
2. Drawing number
3. Scale
4. Symbol denoting the method of projection
5. Name of the firm, and
6. Initials of staff,which have designed, checked and approved

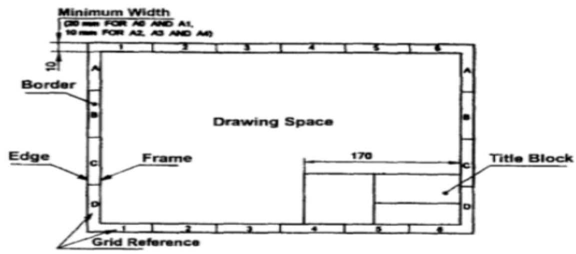
The title block used on shop floor and one suggested for students class works are shown in Fig.2.2.

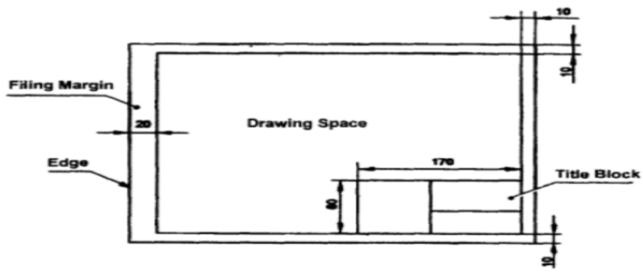




Drawing Sheet Layout

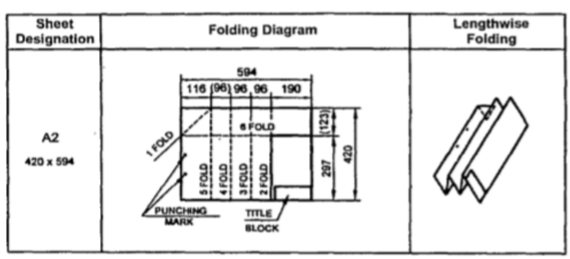
The layout of a drawing sheet used on the shop floor is shown in Fig.2.3a;the layout suggested to students is shown in figure.

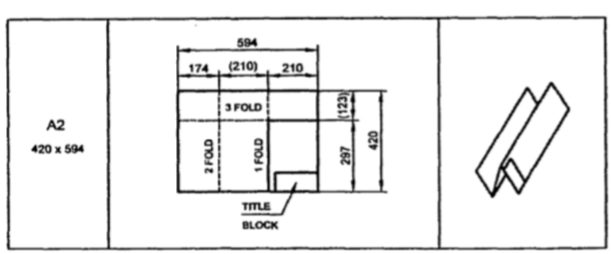




Folding of Drawing Sheets

IS: 11664 - 1999 specifies the method of folding drawing sheets. Two methods of folding of drawing sheets, one suitable for filing or binding and the other method for keeping in filing cabinets are specified by BIS. In both the methods of folding, the Title Block is always visible.





Geometric Nomenclature

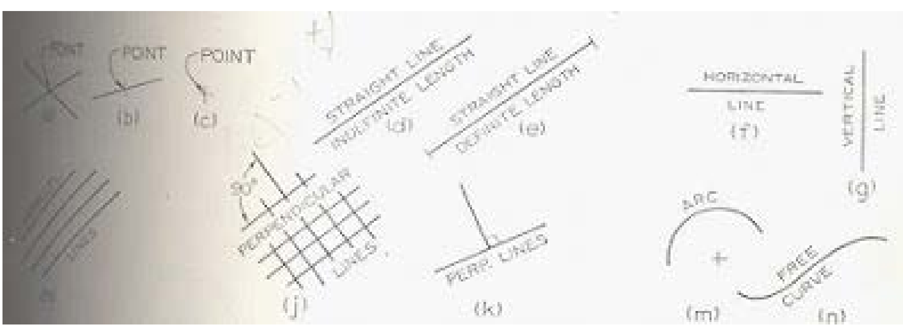
A. Points in Space

A point is an exact location in space or on a drawing surface. A point is actually represented on the drawing by a crisscross at its exact location. The exact point in space is where the two lines of the crisscross intersect. When a point is located on an existing line, a light, short dashed line or cross bar is placed on the line at the location of the exact point. Never represent a point on a drawing by a dot; except for sketching locations.

B. Line

Lines are straight elements that have no width, but are infinite in length (magnitude), and they can be located by two points which are not on the same spot but fall along the line. Lines may be straight lines or curved lines. A straight line is the shortest distance between two points. It can be drawn in any direction. If a line is indefinite, and the ends are not fixed in length, the actual length is a matter of convenience. If the end points of a line are important, they must be marked by means of small, mechanically drawn crossbars, as described by a point in space.

Straight lines and curved lines are considered parallel if the shortest distance between them remains constant. The symbol used for parallel line is //. Lines, which are tangent and at 90^0 are considered perpendicular. The symbol for perpendicular line is ⊥.



C. Angle

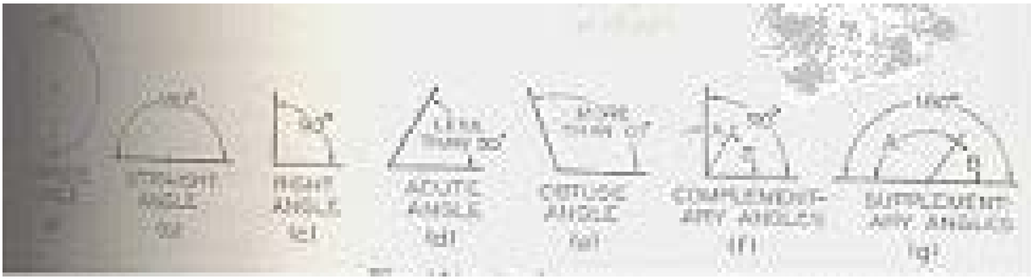
An angle is formed by the intersection of two lines. There are five major kinds of angles: acute angles, right angels, obtuse angles, straight angle and reflex angles.

1. **Acute angle:** Angle is an angle less than 90^0.
2. **Right angle:** The right angle is an angle of 90^o
3. **Obtuse angle:** An obtuse angle is an angle more than 90^o but less than 180^o.
4. **Straight angle:** A straight line is 180^o.

5. **Reflex angle:** A reflex angle is an angle more than 180° but less than 360°.

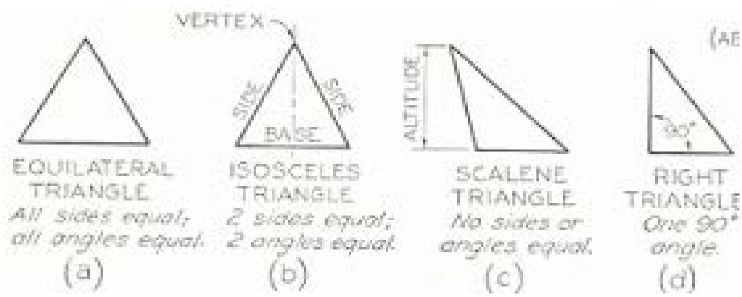
6. **Complete angle:** A complete angle measures exactly 360°.

To draw an angle, use the drafting machine, a triangle, or a protractor.



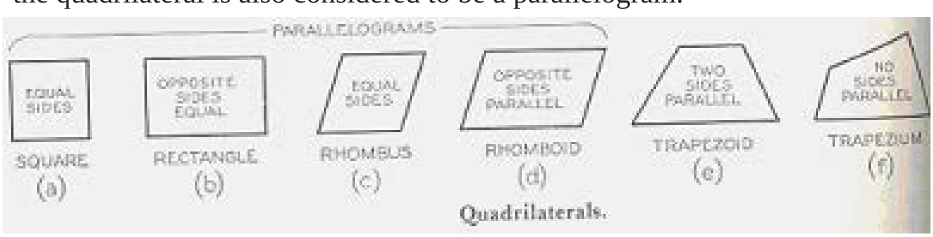
D. Triangles

A triangle is a closed plane figure with three straight sides and their interior angles sum up exactly 180^0. The various kinds of triangles: a right triangle, an equilateral triangle, an isosceles triangle, and an obtuse angled triangle.



E. Quadrialteral

It is a plane figure bounded by four straight sides. When opposite sides are parallel, the quadrilateral is also considered to be a parallelogram.



F. Polygon

A polygon is a closed plane figure with three or more straight sides. The most important of these polygons as they relate to drafting are probably the triangle with three sides, square with four sides, the hexagon with six sides, and the octagon with eight sides.

G. Circle

A circle is a closed curve with all points on the circle at the same distance from the center point. The major components of a circle are the diameter, the radius and circumference.

The diameter of the circle is the straight distance from one outside curved surface through the center point to the opposite outside curved surface.

The radius of a circle is the distance from the center point to the outside curved surface. The radius is half the diameter, and is used to set the compass when drawing a diameter.

A central angle: is an angle formed by two radial lines from the center of the circle.

A sector: is the area of a circle lying between two radial lines and the circumference.

A quadrant: is a sector with a central angle of 90^0 and usually with one of the radial lines oriented horizontally.

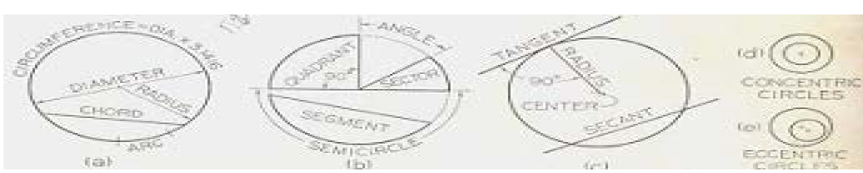
A chord: is any straight line whose opposite ends terminate on the circumference of the circle.

A segment: is the smaller portion of a circle separated by a chord.

Concentric circles are two or more circles with a common center point.

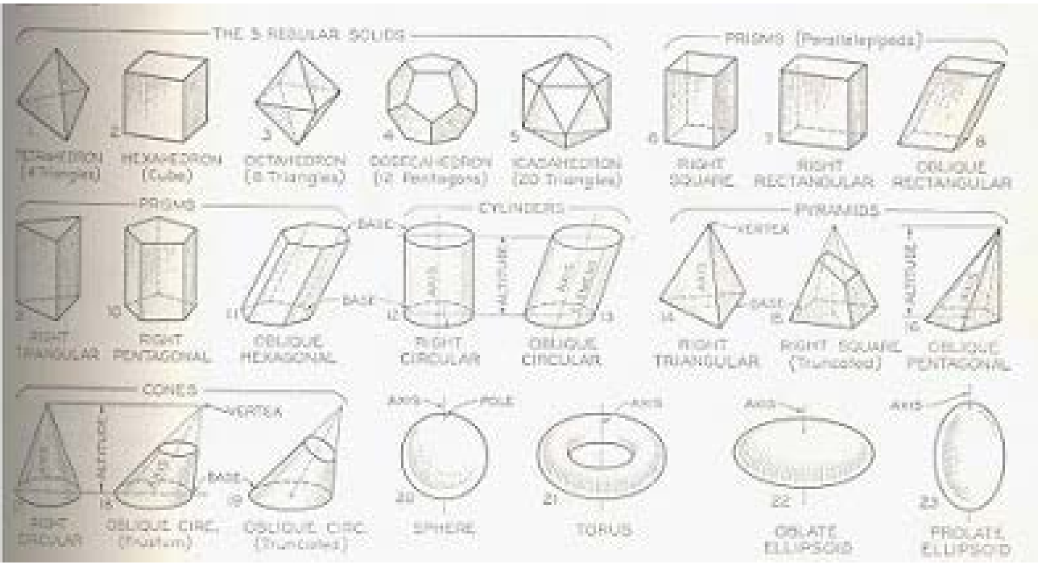
Eccentric circles are two or more circles without a common center point.

A semi circle is half of the circle.



H. Solids

They are geometric figures bounded by plane surfaces. The surfaces are called faces, and if these are equal regular polygons, the solids are regular polyhedra.

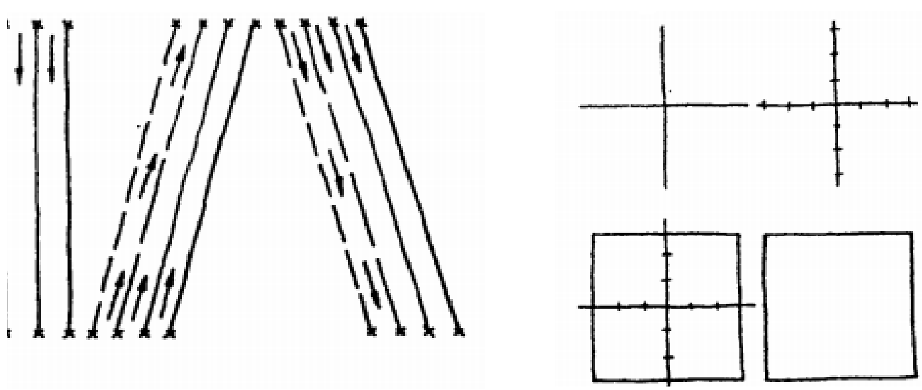


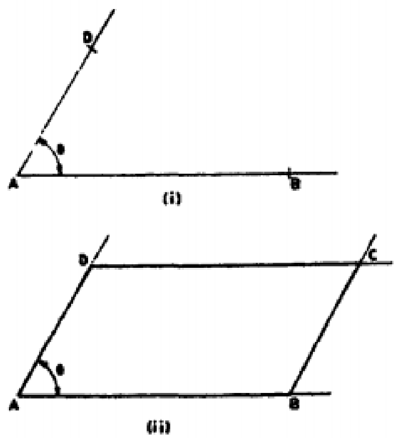
Freehand Practicing

Freehand drawing is a form, which is done only by means of hand and eye coordination. In simple terms, this type of drawing is done by a person without use of any tools like rulers, protractor, etc., or by using tracing or any other such techniques and without using any mechanical tools. Many people who enjoy drawing as a hobby use this method of drawing, just by carrying a sketchbook and pencils, and sketching any subjects they like.

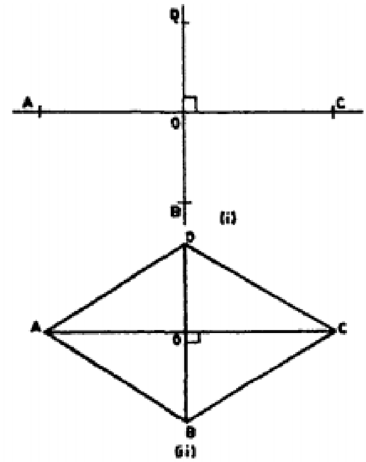
For freehand sketching, one needs to have good sense of proportions, a smooth motion of hand that allows to draw neat lines, and some shading skills to give more depth to the drawing. These skills take time, patience, and practice, and advice from a teacher or an artist will help a person to learn freehand drawing by the right way.

Sketching of different shapes

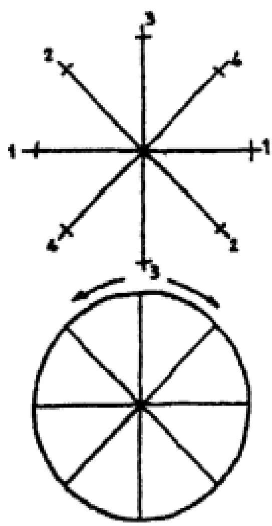




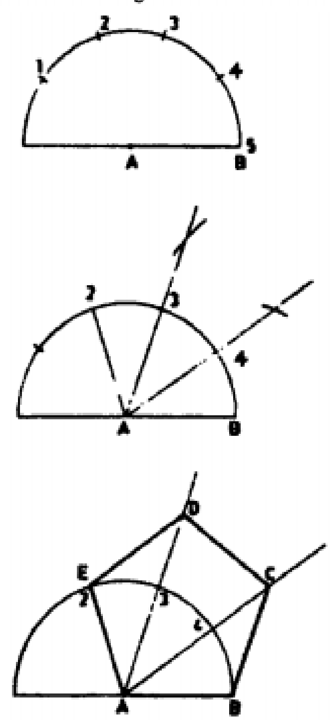
a - Sketching a Parallelogram



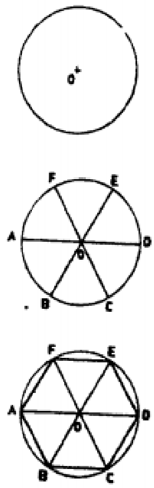
b - Sketching a Rhombus



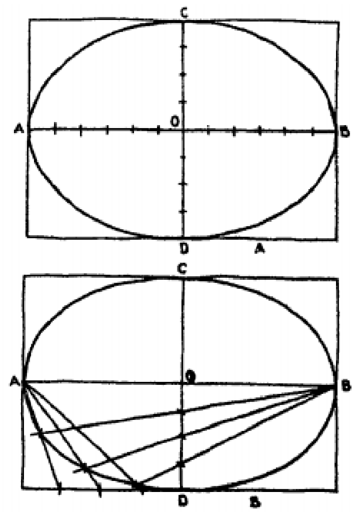
Sketching a Circle



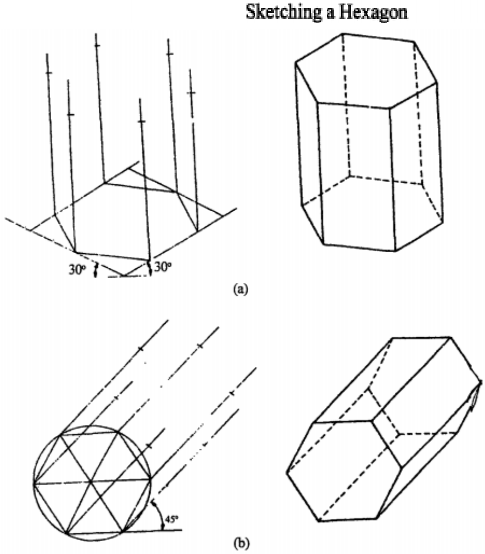
Sketching a Pentagon



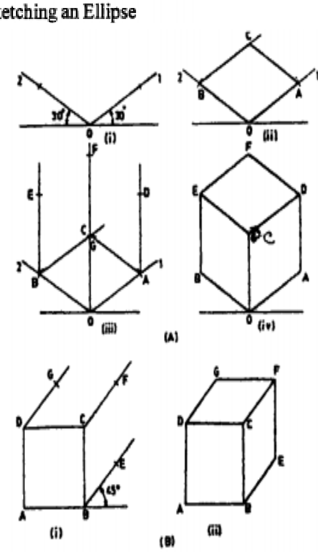
Sketching a Hexagon



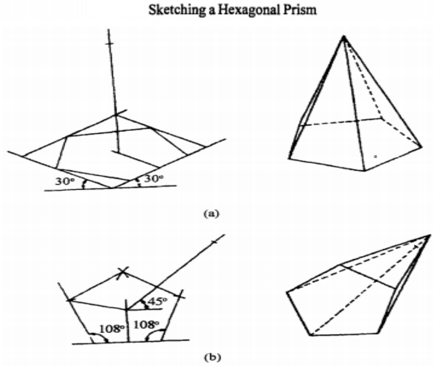
Sketching an Ellipse



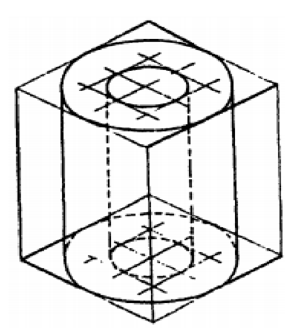
Sketching a Hexagonal Prism



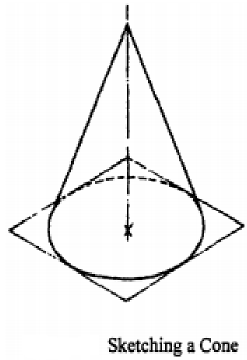
Sketching a Cube



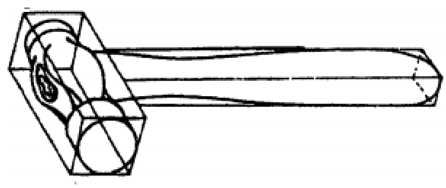
Sketching a Pentagonal Pyramid



Sketching a Hollow Cylinder



Sketching a Cone



Sketching a Ball Peen Hammer

Lettering

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

Importance of Lettering

To undertake production work of an engineering component as per the drawing, the size and other details are indicated on the drawing. This is done in the front of notes and dimensions.

Single Stroke Letters

The word single-stroke should not be taken to mean that the lettering should be made in one stroke without lifting the pencil. It means that the thickness of the letter should be uniform as if it is obtained in one stroke of the pencil.

Types of Single Stroke Letters

1. Lettering Type A: (i) Vertical and (ii) Sloped (at 75^0 to the horizontal)
2. Lettering Type B: (i) Vertical and (ii) Sloped (at 75^0 to the horizontal)

(Type B Preferred)

In Type A, height of the capital letter is divided into 14 equal parts, while in Type B, height of the capital letter is divided into 10 equal parts. Type B is preferred for easy and fast execution, because of the division of height into 10 equal parts.

(Vertical Letters Preferred : Vertical letters are preferred for easy and fast execution, instead of sloped letters.)

(Note: Lettering in drawing should be in CAPITALS (i.e., Upper-case letters).

Lower-case (small) letters are used for abbreviations like mm, cm, etc.

Size of Letters

- Size of letters is measured by the height h of the Capital letters as well as numerals.

- Standard heights for capital letters and numerals recommended by BIS are given below:

  1.8, 2.5, 3.5, 5, 6, 10, 14 and 20 mm

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

Guide Lines

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

Procedure for Lettering

1. Thin horizontal guide lines are drawn first at a distance 'h' apart.
2. Lettering Technique: Horizontal lines of the letters are drawn from left to right. Vertical, inclined and curved lines are drawn from top to bottom.
3. After lettering has been completed, the guidelines are not erased.

Dimensioning of Type B Letters

BIS denotes the characteristics of lettering as:

h (height of capita) letters), ci (height of lower-case letters), c 2 (tail of lower-case letters), c 3 (stem of lower-case letters), a (spacing between characters), bl& b2 (spacing between baselines), e (spacing between words) and d (line thickness).

Lettering Proportions

Recommended size (height h) of Letters I Numerals

Main title 5 mm, 7 mm, 10 mm

Sub-titles 3.5 mm, 5 mm

Dimensions, Notes, etc. 2.5 mm, 3.5 mm, 5 mm

Table 2.3 Lettering Proportions

Recommended Size (height h) of Letters / Numerals	
Main Title	5 mm, 7 mm, 10 mm
Sub-Titles	3.5 mm, 5 mm
Dimensions, Notes, etc.	2.5 mm, 3.5 mm, 5 mm

Lettering practice

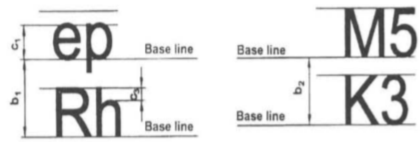


Fig. 2.7 Lettering

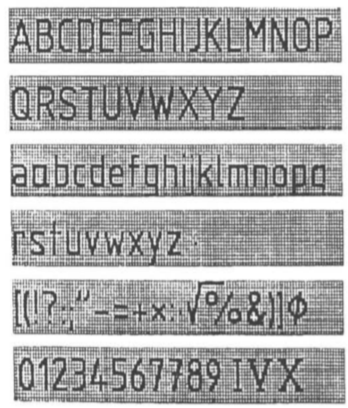
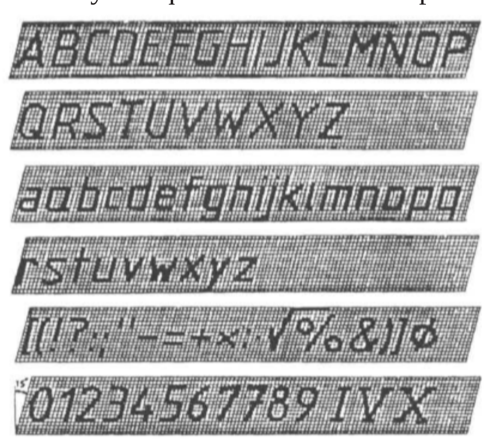


Fig. 2.8 Vertical Lettering

Practice of lettering capital and lower case letters and numerals of type B

The following are some of the guidelines for lettering:-

1. Drawing numbers, title block and letters denoting cutting planes, sections are written in 10 mm size
2. Drawing title is written in 7 mm size
3. Hatching, sub-titles, materials, dimensions, notes, etc., are written in 3.5 mm size
4. Space between lines = ~ h
5. Space between words may be equal to the width of alphabet M or 3/5 h



6. Space between letters should be approximately equal to 115 h. Poor spacing will affect the visual effect

7. The spacing between two characters may be reduced by half if it gives a better visual effect, as for example LA, TV; over lapped in case of say LT, TA etc., and the space is increased for letters with adjoining stems

Capital Letters

- Ratio of height to width for most of the capital letters is approximately = 10:6
- However, for M and W, the ratio = 10:8 for I the ratio = 10:2
- Lower-case Letters
- Height of lower-case letters with stem I tail (b, d, f, g, h, j, k, I, p, q, t, y) = Cz = c3 = h
- Ratio of height to width for lower-case letters with stem or tail = 10:5
- Height of lower-case letters without stems or tail c1 is approximately = (7/10) h
- Ratio of height to width for most lower-case letters without stem or tail = 7: 5
- However, for m and w, the ratio = 7: 7. For I and I, the ratio = 10:2 Numerals
- For numerals 0 to 9, the ratio of height to width = 10: 5. For I, ratio = 10: 2
- Spacing • Spacing between characters = a = (2/10) b • Spacing between words = e = (6/10) b

Fig:guide line for lettering

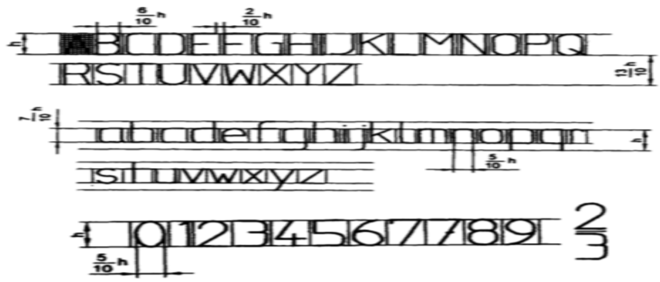


Fig. 2.11 Vertical capital & Lowercase letters and numerals of type B

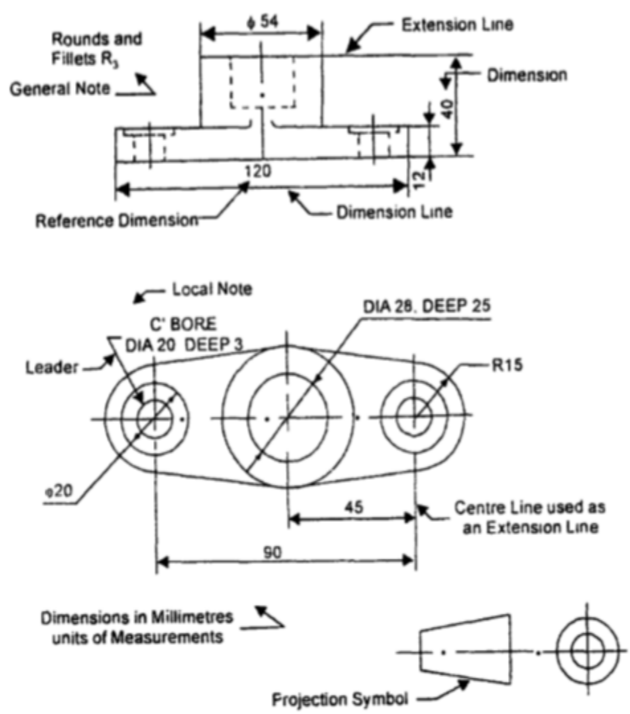
EXAMPLE IN LETTERING PRACTICE

Write freehand the following, using single stroke vertical CAPITAL letters of 5 mm (h) size

Fig. 2.12

Dimensioning

Drawing of a component, in addition to providing complete shape description, must also furnish information regarding the size description. These are provided through the distances between the surfaces, location of holes, nature of surface finish, type of material, etc. The expression of these features on a drawing, using lines, symbols, figures and notes is called dimensioning.



Elements of Dimensioning

Principles of Dimensioning

Some of the basic principles of dimensioning are given below.

I. All dimensional information necessary to describe a component clearly and completely shall be written directly on a drawing.

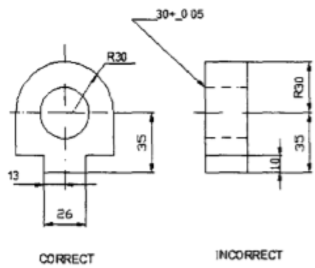
2. Each feature shall be dimensioned once only on a drawing, i.e., dimension marked in one view need not be repeated in another view.

3. Dimension should be placed on the view where the shape is best seen.

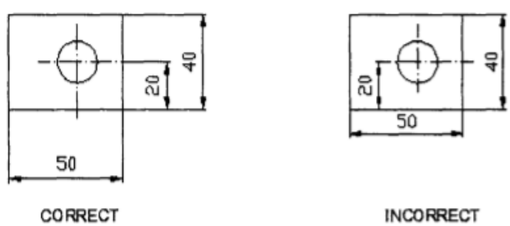
4. As far as possible, dimensions should be expressed in one unit only preferably in millimeters, without showing the unit symbol (mm).

5. As far as possible dimensions should be placed outside the view.

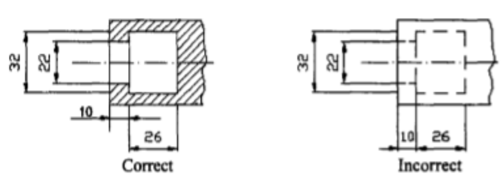
6. Dimensions should be taken from visible outlines rather than from hidden lines.



Placing the Dimensions where the Shape is Best Shown



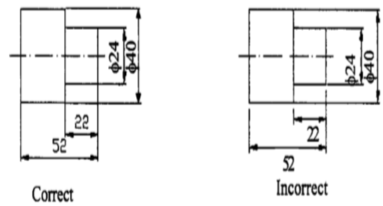
Placing Dimensions Outside the View



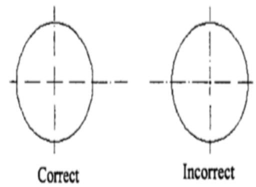
Marking the dimensions from the visible outlines

7. No gap should be left between the feature and the start of the extension line.

8. Crossing of center lines should be done by a long dash and not a short dash.



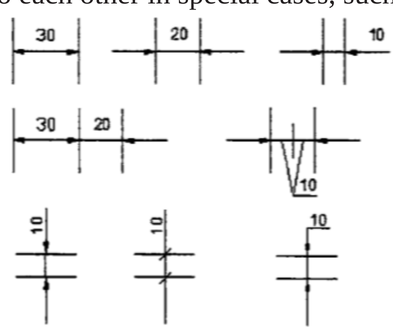
Marking of Extension Lines



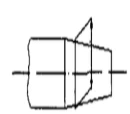
Crossing of Centre Lines

Execution of Dimensions

1. Projection and dimension lines should be drawn as thin continuous lines. Projection lines should extend slightly beyond the respective dimension line. Projection lines should be drawn perpendicular to the feature being dimensioned. If the space for dimensioning is insufficient, the arrow heads may be reversed and the adjacent arrow heads may be replaced by a dot figure. However, they may be drawn obliquely, but parallel to each other in special cases, such as on tapered feature figure.



Dimensioning in Narrow Spaces



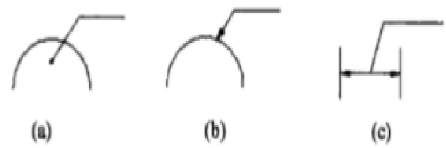
Dimensioning a Tapered Feature

2. A leader line is a line referring to a feature (object, outline, and dimension). Leader lines should be inclined to the horizontal at an angle greater than 30°. Leader line should terminate,

   (a) with a dot, if they end within the outline ofan object figue.

   (b) With an arrow head, if they end on outside of the object figure.

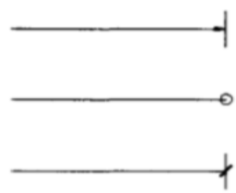
(c) Without a dot or arrow head, if they end on dimension line (Fig.2.21c).



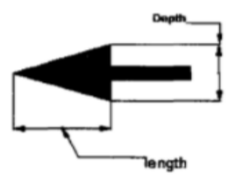
Termination of leader lines

Dimension Termination and Origin Indication

Dimension lines should show distinct termination in the front of arrow heads or oblique strokes or where applicable an origin indication figure. The arrow head included angle is 15°. The origin indication is drawn as a small open circle of approximately 3 mm in diameter. The proportion length to depth 3 : 1 of arrow head is shown in figure.

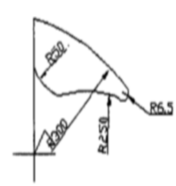


Termination of Dimension Line



Proportions of an Arrow Head

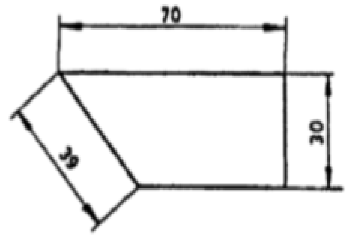
When a radius is dimensioned only one arrow head, with its point on the arc end of the dimension line should be used. The arrow head termination may be either on the inside or outside of the feature outline, depending on the size of the feature.



Dimensioning of Radii

Methods of Indicating Dimensions

The dimensions are indicated on the drawings according to one of the following two methods. Method -1 (Aligned method) Dimensions should be placed parallel to and above their dimension lines and preferably at the middle, and clear of the line figure.



Dimensions may be written so that they can be read from the bottom or from the right side of the drawing. Dimensions on oblique dimension lines should be oriented as shown in above figure and except where unavoidable, they shall not be placed in the 30° zone. Angular dimensions are oriented as shown in figure. Dimensions should be indicated so that they can be read from the bottom of the drawing only. Non-horizontal dimension lines are interrupted, preferably in the middle for insertion of the dimension. Angular dimensions may be oriented.

Note: Horizontal dimensional lines are not broken to place the dimension in both cases.

Lines

Just as in English textbook the correct words are used for making correct sentences; in Engineering Graphics, the details of various objects are drawn by different types of lines. Each line has a defined meaning and sense to convey.

IS 10714 (Pint 20): 2001 (General principles of presentation on technical drawings) and SP 46:2003 specify the following types of lines and their applications:

- **Visible Outlines, Visible .Edges:** Type 01.2 (Continuous wide lines) The lines drawn to represent the visible outlines/ visible edges / surface boundary lines of objects should be outstanding in appearance.
- **Dimension Lines:** Type 01.1 (Continuous narrow Lines) Dimension Lines are drawn to mark dimension.
- **Extension Lines:** Type 01.1 (Continuous narrow lines)
- There are extended slightly beyond the respective dimension lines.
- **Construction Lines:** Type 01.1 (Continuous narrow Lines) Construction lines are drawn for constructing drawings and should not be erased after completion of the drawing.
- **Hatching/Section Lines:** Type 01.1 (Continuous Narrow Lines) Hatching Lines are drawn for the sectioned portion of an object. These are drawn inclined at an angle of 45° to the axis or to the main outline of the section. • Guide Lines: Type 01.1

(Continuous Narrow Lines) Guide Lines are drawn for lettering and should not be erased after lettering.

- **Break Lines:** Type 01.1 (Continuous Narrow Freehand Lines) Wavy continuous narrow line drawn freehand is used to represent bre~ of an object.
- **Break Lines:** Type 01.1 (Continuous Narrow Lines With Zigzags) Straight continuous ~arrow line with zigzags is used to represent break of an object.
- **Dashed Narrow Lines:** Type 02.1 (Dashed Narrow Lines) Hidden edges / Hidden outlines of objects are shown by dashed lines of short dashes of equal lengths of about 3 mm, spaced at equal distances of about 1 mm. the points of intersection of these lines with the outlines / another hidden line should be clearly shown.
- **Center Lines:** Type 04.1 (Long-Dashed Dotted Narrow Lines) Center Lines are drawn at the center of the drawings symmetrical about an axis or both the axes. These are extended by a short distance beyond the outline of the drawing.
- **“Cutting Plane Lines:** Type 04.1 and Type 04.2 Cutting Plane Line is drawn to show the location of a cutting plane. It is long-dashed dotted narrow line, made wide at the ends, bends and change of direction. The direction of viewing is shown by means of arrows resting on the cutting plane line.
- **Border Lines:** Border Lines are continuous wide lines of minimum thickness 0.7 mm

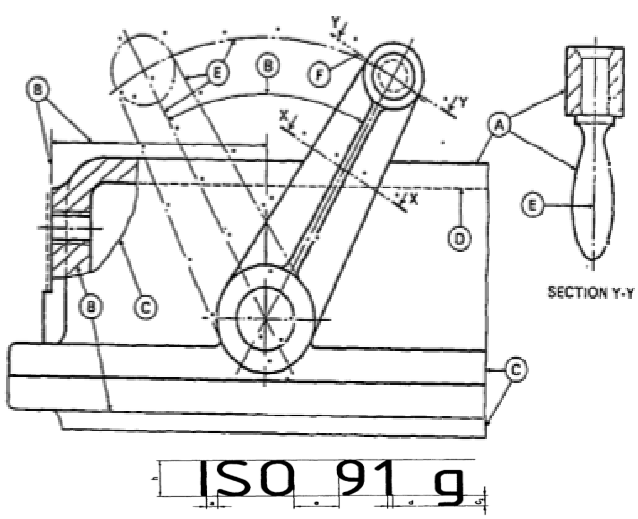
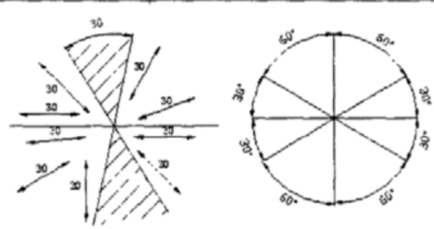


Fig. 2.6

Understanding the various types of lines used in drawing (i.e.,) their thickness, style of construction and appearance as per BIS and following them meticulously may be considered as the foundation of good drawing skills. Table 2.2 shows various types of lines with the recommended applications.

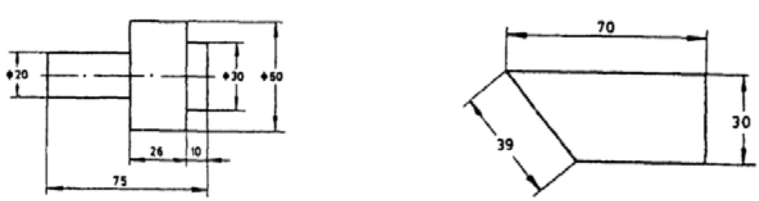
Table 2.2 Types of Lines and their applications (IS 10714 (Part 20) : 2001) and BIS: SP46 : 2003.

No.	Line description and Representation	Applications
01.1	Continuous narrow line B	Dimension lines, Extension lines
		Leader lines, Reference lines
		Short centre lines
		Projection lines
		Hatching
		Construction lines, Guide lines
		Outlines of revolved sections
		Imaginary lines of intersection
01.1	Continuous narrow freehand line C	Preferably manually represented termination of partial or interrupted views, cuts and sections, if the limit is not a line of symmetry or a center line [a].
01.1	Continuous narrow line with zigzags A	Preferably mechanically represented termination of partial or interrupted views, cuts and sections, if the limit is not a line of symmetry or a center line[a].
01.2	Continuous wide line	Visible edges, visible outlines
		Main representations in diagrams, maps, flow charts
02.1	Dashed narrow line D	Hidden edges
		Hidden outlines
04.1	Long-dashed dotted narrow line E	Center lines / Axes, Lines of symmetry
		Cutting planes (Line 04.2 at ends and changes of direction)
04.2	Long-dashed dotted wide line F	Cutting planes at the ends and changes of direction outlines of visible parts situated in front of cutting plane



(a) (b)

Angular Dimensioning

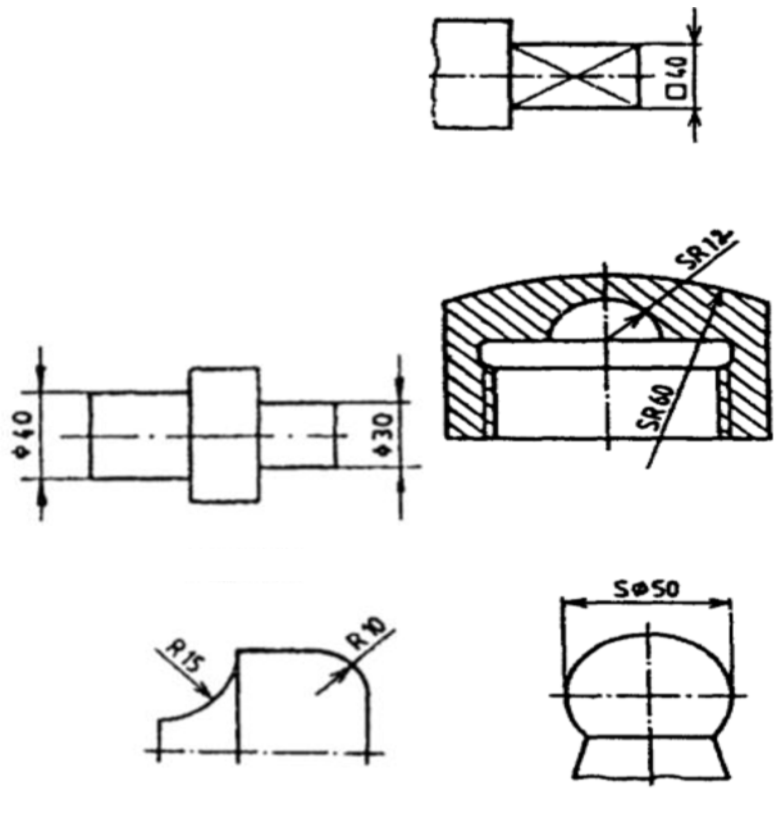


(a) (b)

Uni-directional Method

Identification of Shapes

The following indications are used with dimensions to show applicable shape identification and to improve drawing interpretation. The diameter and square symbols may be omitted where the shape is clearly indicated. The applicable indication (symbol) shall precede the value for dimension figures.



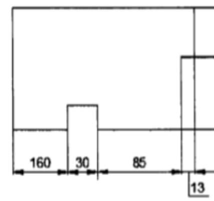
Arrangement of Dimensions

The arrangement of dimensions on a drawing must indicate clearly the purpose of the design of the object. They are arranged in three ways.

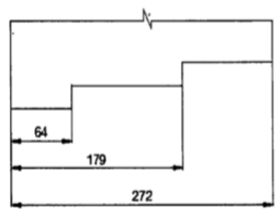
1. Chain Dimensioning
2. Parallel Dimensioning
3. Combined Dimensioning.

1. Chain Dimensioning : Chain of single dimensioning should be used only where the possible accumulation of tolerances does not endanger the fundamental requirement of the component.

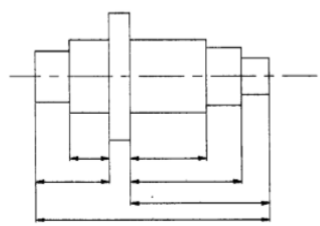
2. Parallel Dimensioning : In parallel dimensioning, a number of dimension lines parallel to one another and spaced out, are used. This method is used where a number of dimensions have a common datum feature figures.



Chain Dimensioning



Parallel Dimensioning



Combined Dimensioning

Exercise

Choose the correct answer from the given alternatives.

1. How many battens will be there for a Drawing board?

   a. 1 b. 2 c. 3 d. 4

2. Which part doesn't belong to T-square ?

   a. Working edge b. Blade c. Stock d. Ebony

3. The angle which we can't make using a single Set-square is _________

   a. 45^o b. 60^o c. 30^o d. 75^o

4. __________ is used to draw curves which are not circular.

   a. Compass b. Protractor

   c. French curves d. Pro circle

5. The areas of the two subsequent sizes of drawing sheet are in the ratio _____

   a. 1:5 b. 1:4 c. 1:2 d. 1:10

6. What is the next size of 210 mm x 297 mm in drawing papers?

   a. 148 mm x 210 mm b. 297 mm x 420 mm

   c. 420 mm x 594 mm d. 105 mm x 148 mm

7. The Grade becomes _______ according to the figure placed in front of the letter B, 2B, 3B, 4B etc.

   a. harder b. lighter c. darker d. softer

8. Which of the following instrument is made of thin strips of wood arranged in a line to form a rectangle and on which, the drawing is made?

   a. Mini–drafter b. Drawing Board c. Protractor d. Scale

9. Which of the following tools is used to draw horizontal lines?

   a. Mini – drafter b. Protractor

   c. T – square d. French curve

10. Which of the following instrument can be used to draw accurate perpendicular lines, parallel lines and angular lines?

a. Mini – drafter b. T – square

c. Protractor d. Set square

11. Which is the most common tool used for drawing circles?

    a. French curve b. Mini – drafter

    c. Divider d. Compass

12. Which of the following drawing tools is used by architects for making blueprints?

    a. Drawing Pencils b. Dusters

    c. Ink Pen d. Erasers

13. Which of the following drawing tool is not used to set the drawing sheet onto the drawing board?

    a. Drawing clips b. Drawing pins

    c. Divider d. Adhesive tape

14. Which of the following drawing tool is used to transfer dimensions when there is a repetition of the dimensions?

    a. Compass b. Protractor c. Divider d. Mini – Drafter

15. Which of the following grades of leads is the hardest?

    a. 6B b. 5H c. 4B d. 6H

16. For marking angles, which of the following drawing tool is used?

    a. Protractor b. Divider c. Compass d. French curve

17. Using $30^\circ - 60^\circ - 90^\circ$ and $45^\circ - 45^\circ - 90^\circ$ set squares, which of the following angle is not possible to draw?

    a. 45° b. 30° c. 10° d. 90°

18. With the use of _______________ the accuracy and the quality of the drawing comes as desired.

    a. Costly instruments b. Advanced instruments

    c. Quality instruments d. Complex instruments

19. Which part of the drawing board guides the T-square?

    a. Bottom the board b. Ebony

c. Working edge d. Above the board

20. The stock and the blade of the T-square are joined at _______ to each other.

a. 45^o b. 30^o c. 60^o d. 90^o

21. Small bow ink-pen is used to draw ________

a. Lines in ink b. Triangles in ink

c. Big-circles in ink d. Small circles and arcs in ink

22. French curves are most importantly used to draw _______

a. Long lines b. Triangles c. Curves d. Circles

23. The untrimmed size for ________ sheet is 240 mm x 330 mm.

a. A1 b. A3 c. A4 d. A5

24. The number of folding methods for folding of various sizes of drawing sheets is _____

a. 1 b. 2 c. 3 d. 4

25. ___________ is not an essential thing for free-hand sketching.

a. A soft-grade pencil

b. French curves

c. A soft rubber-eraser

d. A paper in form of a sketch-book or a pad

26. In a finished drawing drawn with pencil, what are the features of the lines except for construction lines?

a. Dense and thin b. Dense and clean

c. Faint and clean d. Faint and very thin

27. In a finished drawing drawn with pencil, what are the features of the construction lines?

a. Dense and thin b. Dense and clean

c. Faint and clean d. Faint and very thin

28. Which of the following pencil grades are used to draw construction lines?

a. H b. 2H c. 3H d. 4H

29. Which of the following pencil grades are used to draw outlines?

a. H b. 2H c. 3H d. 4H

30. Which of the following pencil grades are used to draw dotted lines?

a. H b. 2H c. 3H d. 4H

31. Which of the following pencil grades are used to draw center lines?

a. H b. 2H c. 3H d. 8H

32. Which of the following pencil grades are used to draw section lines?

a. H b. 2H c. 3H d. 8H

33. Which of the following pencil grades are used for arrowhead?

a. H b. 2H c. 3H d. 4H

34. Which of the following pencil grades are used to draw dimension lines?

a. H b. 2H c. 3H d. 4H

35. Which of the following increases proficiency in sketching?

a. Using proper instruments b. Using a better scale

c. Using appropriate dimensions d. Having constant practice

36. Which of the following pencil grade is suitable for sketching?

a. 9H b. 10H c. 6H d. H

37. What should be the minimum distance between the hand and the pencil tip while drawing a horizontal line?

a. 5mm b. 100mm c. 40mm d. 80mm

38. Which of the following is not used in free-hand sketching?

a. Cross-sectioned graph paper b. Soft rubber-eraser

c. Soft-grade pencil d. Hard-grade pencil

39. Initial work and construction lines are drawn using __ pencil.

a. 3H b. 4H c. H d. 2H

40. In engineering drawing, which type of line indicates that there is a change of plane?

a. Continuous thin wavy b. Long chain thin

c. Continuous thick d. Medium thick short dashes

41. Which of the following lines are used to show that the object is cut and then viewed?

a. Hidden lines b. Leader lines c. Centre lines d. Hatching Lines

42. What do hidden lines in orthographic projections denote?

a. Holes or slots
b. Change of Plane
c. Position of cut
d. Centre of a circle or cylinder

43. The axis of the cylinder or sphere? Which of the following line?

a. Section line
b. Centre line
c. Hidden line
d. Leader line

44. What is the standard length and width of the arrowhead of dimension lines do notes?

a. 2mm and 2mm
b. 3mm and 1mm
c. 4mm and 2mm
d. 3mm and 2mm

45. What is the length of the short dashes of the centre lines?

a. 5mm b. 2mm c. 1mm d. 3mm

46. Which type of line is used to join the dimension line and the curve that needs to be dimensioned?

a. Leader line
b. Outline
c. Dimension line
d. Section line

47. What is the difference between the section line and the centre line?

a. The length of the long dashes
b. The length of short dashes
c. The width of the gap
d. The two ends of the lines

48. In unidirectional system the dimensions are _______

a. Placed above the dimension lines
b. Placed below the dimension lines
c. Placed by breaking the dimension line in the middle
d. Placed left side of the dimension line

49. In aligned system the dimensions are ___________

a. Placed parallel to the dimension line
b. Placed perpendicular to the dimension line

c. Placed left side of the dimension line

d. Placed right side of the dimension line

50. In which system of dimensioning the figures can read from the bottom as well as right hand side of the drawing?

a. Aligned system | b. Unidirectional system

c. Nonaligned multidirectional system | d. Parallel system

Write short answer to the following questions.

1. What is engineering drawing?
2. List out the different types of drawing.
3. Classify the drawing paper according to the standard size.
4. What is free hand drawing?
5. Write the applications of free hand drawing.
6. Mention of importance of lettering in engineering drawing.
7. Define dimensioning.
8. What are the advantages of dimensioning?
9. Write the functions of a Tee-scale.
10. Write the full form of H and B written on pencils.

Write long answer to the following questions.

1. What is engineering drawing? How is it different from other drawings? List out the different types of drawing tools and equipments. Explain them in brief.
2. What are the scopes of engineering drawing? Explain them.
3. Mention the safety procedures and care to be taken while doing the drawings.
4. Define dimensioning. Explain its types in detail.
5. List out the rules to be followed while doing dimensioning.

Introduction of Geometrical Shapes

Unit 2

2.1 Line and Classification Lines

Introduction

Strict interpretation of geometric construction allows use of only the compass and an instrument for drawing straight lines and accomplishes his solutions. In technical drawing, the principles of geometry are employed constantly using the instruments like T-squares, triangles, scales, curves etc. to make constructions with speed and accuracy.

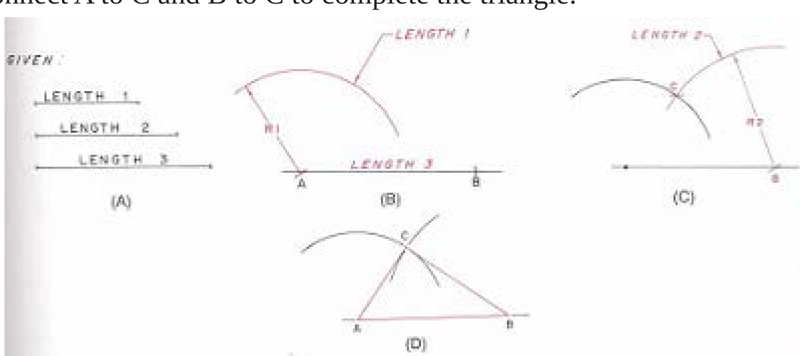
To Draw A Triangle with Known Lengths of Sides

Given: lengths 1, 2, and 3.

Step 1: Draw the longest length line, in this example length 3, with ends A and B. Swing an arc (R1) from point A whose radius is either length 1 or length 2; in this example length 1.

Step 2: Using the radius length not used in step 1, swing an arc (R2) from point B to intercept the arc swung from point A at point.

Step 3: Connect A to C and B to C to complete the triangle.



To Draw a Square

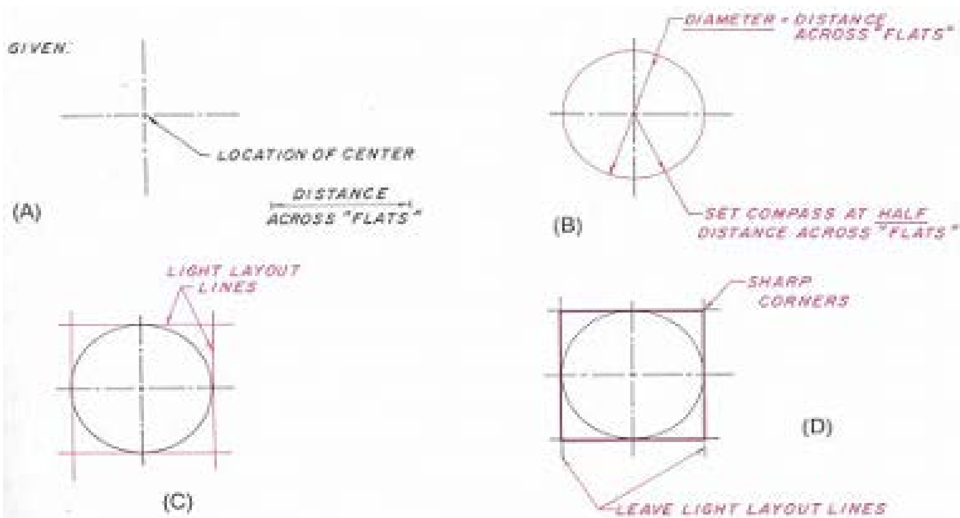
Method-1

Given: The locations of the center and the required distance across the sides of a square

Step 1: Lightly draw a circle with a diameter equal to the distance around the sides of the square. Set the compass at half the required diameter.

Step 2: Using triangles, lightly complete the square by constructing tangent lines to the circle. Allow the light construction lines to project from the square, with out erasing them.

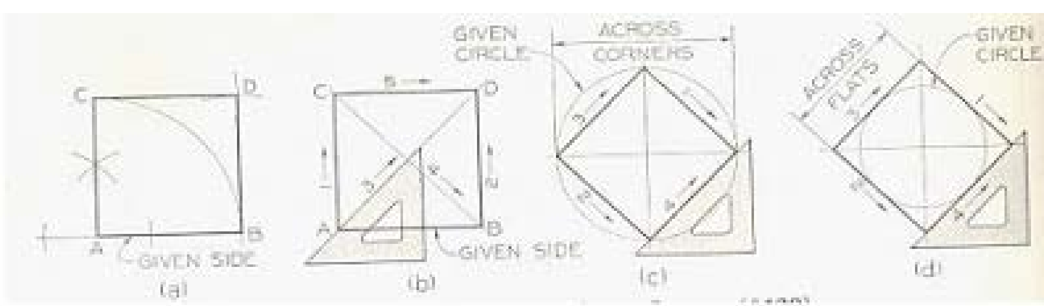
Step 3: Check to see that there are four equal sides and, if so, darken in the actual square using the correct line thickness.



Method-2

Given one side AB. Through point A, draw a perpendicular.

With A as a center, and AB as radius; draw the arc to intersect the perpendicular at C. With B and C as centers, and AB as radius, strike arcs to intersect at D. Draw line CD and BD.



To Draw a Pentagon (5 Sides)

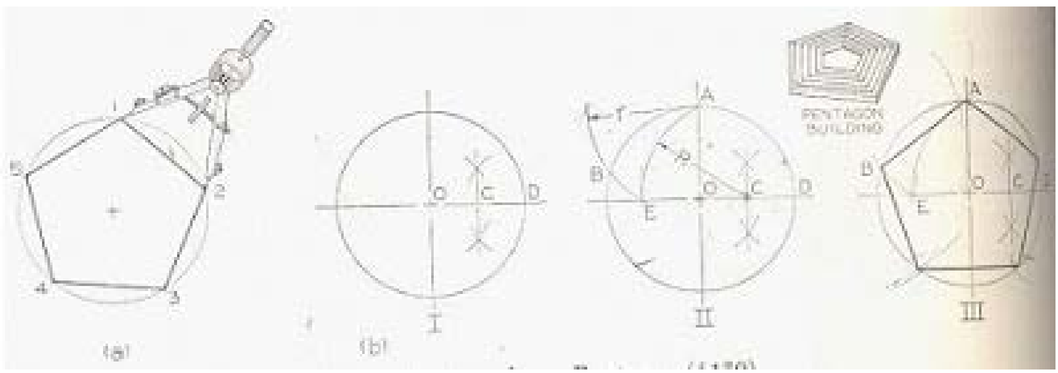
Given: The locations of the pentagon center and the diameter that will circumscribe the pentagon.

Step 1: Bisect radius OD at C.

Step 2: With C as center, and CA as radius, strike arc AE.

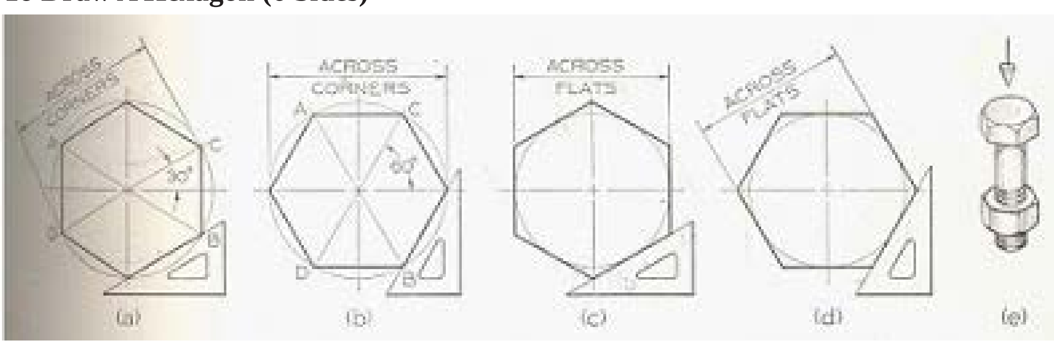
With A as center, and AE as radius, strike arc EB.

Step 3: Draw line AB, then set off distances AB around the circumference of the circle, and draw the sides through these points.



C

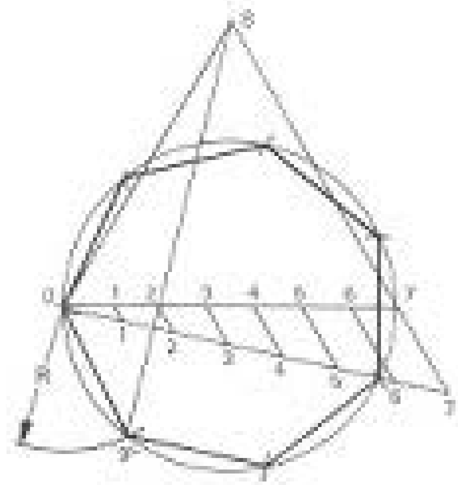
To Draw A Hexagon (6 Sides)



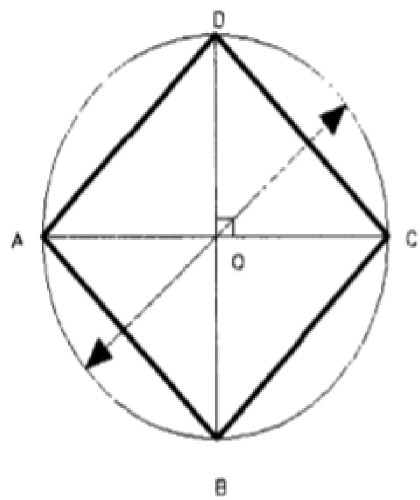
To Draw Any Sided Regular Polygon

To construct a regular polygon with a specific number of sides, divide the given diameter using the parallel line method as shown in figure below. In this example, let us assume seven sided regular polygon. Construct an equilateral triangle (0-7-8) with the diameter (0-7) as one of its sides. Draw a line from the apex (point 8) through the second point on the line (point 2). Extend line 8-2 until it intersects the circle at point 9.

Radius 0-9 will be the size of each side of the figure. Using radius 0-9 steps off the corners of the seven sides polygon and connect the points.



To inscribe a square in a given circle.



Construction

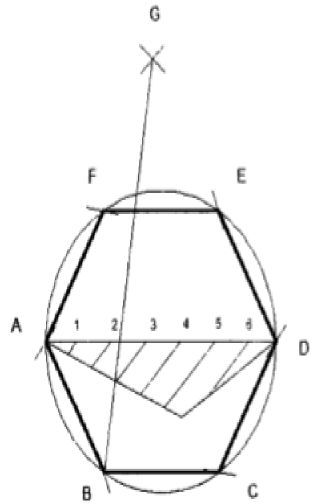
1. With Centre 0, draw a circle of diameter D.
2. Through the Centre 0, drawn two diameters, say AC and BD at right angle to each other.
3. Join A-B, B-C, and C- D, and D-A. ABCD is the required square.

To inscribe a regular polygon of any number of sides in a given circle.

Construction

1. Draw the given circle with AD as diameter.
2. Divide the diameter AD into N equal parts say 6.

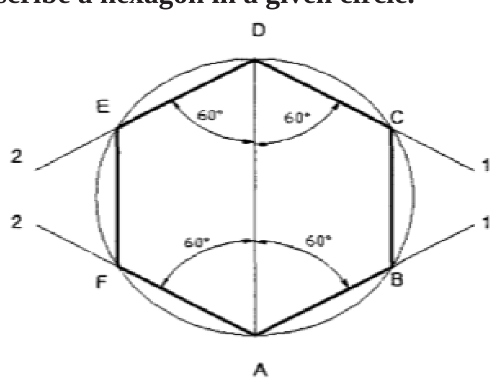
3. With AD as radius and A and D as centers, draw arcs intersecting each other at G

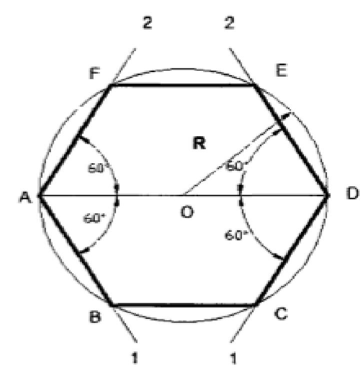


4. Join G-2 and extend to intersect the circle at B.
5. JoinA-B which is the length of the side of the required polygon.
6. Set the compass to the length AB and starting from B mark off on the circumference of the circles, obtaining the points C, D, etc.

   The figure obtained by joing the points A, B, C etc., is the required polygon.

To inscribe a hexagon in a given circle.





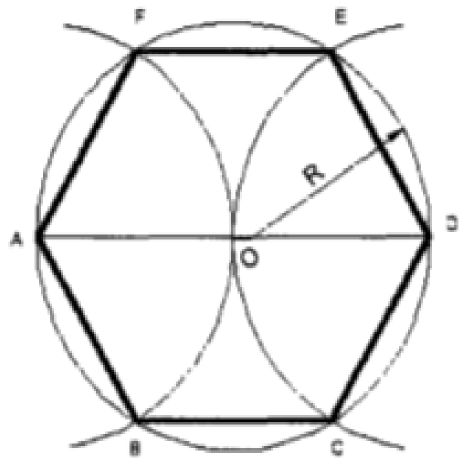
Construction by using a set-square or mini-drafter

1. With Centre 0 and radius R draw the given circle.
2. Draw any diameter AD to the circle.
3. Using 30° - 60° set-square and through the point A draw lines AI, A2 at an angle 60° with AD, intersecting the circle at B and F respectively.

4. Using 30° - 60° and through the point D draw lines Dl, D2 at an angle 60° with DA, intersecting the circle at C and E respectively.

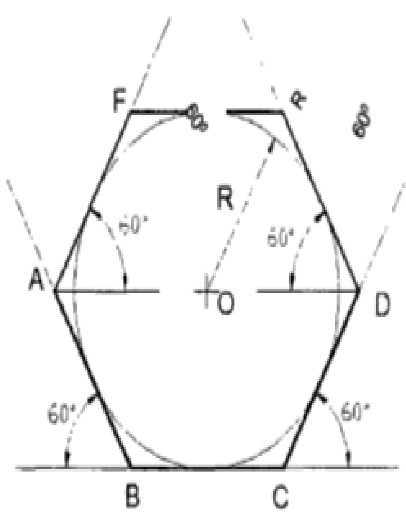
   By joining A,B,C,D,E,F, and A the required hexagon is obtained.

Construction by using compass



1. With Centre 0 and radius R draw the given circle.
2. Draw any diameter AD to the circle.
3. with centers A and D and radius equal to the radius of the circle draw arcs intersecting the circles at B, F, C and E respectively.
4. ABC D E F is the required hexagon.

To circumscribe a hexagon on a given circle of radius R

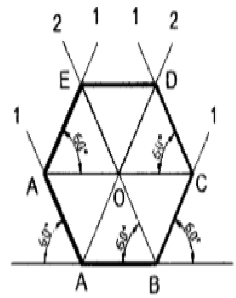


Construction

1. With centre 0 and radius R, draw the given circle.
2. Using 60° position of the mini drafter or 300-600set square, circumscribe the hexagon as shown.

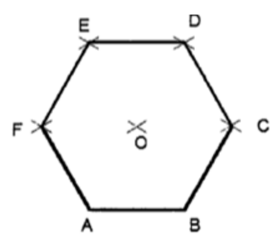
To construct a hexagon, given the length of the side.

(a) Construction Using set square



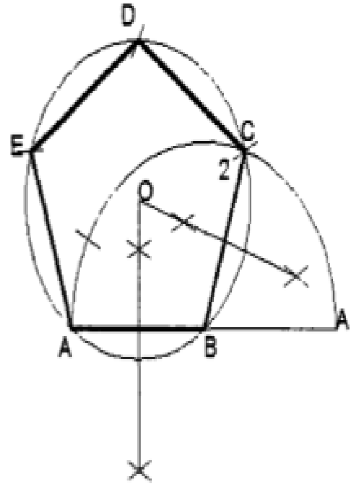
1. Draw a line AB equal to the side of the hexagon.
2. Using 30° - 60° set-square, draw lines AI, A2, and BI, B2.
3. Through 0, the point of intersection between the lines are A_2 at D and B_2 at E.
4. JoinD, E
5. ABCDEF is the required hexagon.

(b) By using compass



1. Draw a line AB equal to the side of the hexagon.
2. Withcenters A and B and radius AB, draw arcs intersecting at 0, the Centre of the hexagon.
3. With centers 0 and B and radius OB (=AB), draw arcs intersecting at C.
4. Obtain points D, E and F in a similar manner.

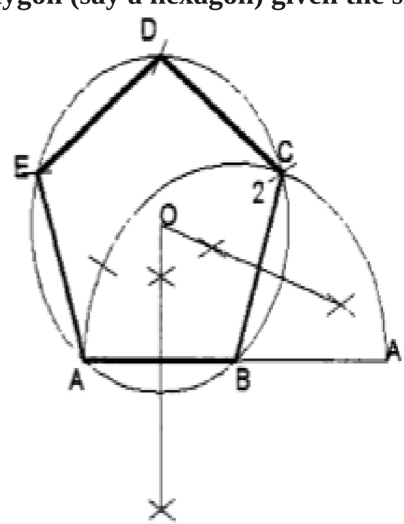
To construct a regular polygon (say a pentagon) given the length of the side.



Construction

1. Draw a line AB equal to the side and extend to P such that AB = BP
2. Draw a semicircle on AP and divide it into 5 equal parts by trial and error.
3. Join B to second division 2. Irrespective of the number of sides of the polygon B is always joined to the second division.
4. Draw the perpendicular bisectors of AB and B2 to intersect at O.
5. Draw a circle with 0 as Centre and OB as radius.
6. With AB as radius intersect the circle successively at D and E. Thenjoin CD. DE and EA.

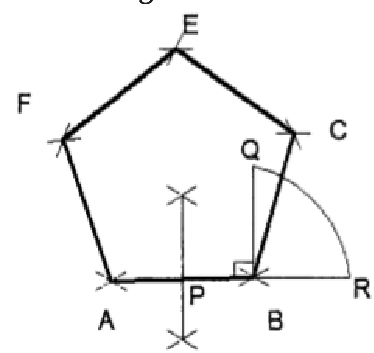
To construct a regular polygon (say a hexagon) given the side AB - alternate method.



Construction

1. Steps 1 to 3 are same as above
2. Join B- 3, B-4, B-5 and produce them.
3. With 2 as Centre and radius AB intersect the line B, 3 produced at D. Similarly get the point E and F.
4. Join 2- D, D-E, E-F and F-A to get the required hexagon.

To construct a pentagon, given the length of side

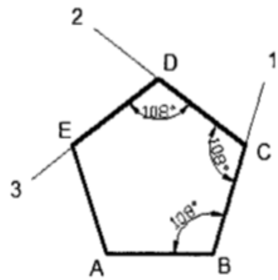


(a) Construction

1. Draw a line AB equal to the given length of side.
2. Bisect AB at P.
3. Draw a line BQ equal to AB in length and perpendicular to AB.
4. With Centre P and radius PQ, draw an arc intersecting AB produced at R. AR is equal to the diagonal length of the pentagon.
5. With centers A and B and radii AR and AB respectively, draw arcs intersecting at C.
6. with centers A and B and radius AR, draw arcs intersecting at D.
7. with centers A and B and radii AB and AR respectively, draw arcs intersecting at E. ABCDE is the required pentagon

(b) By included angle method

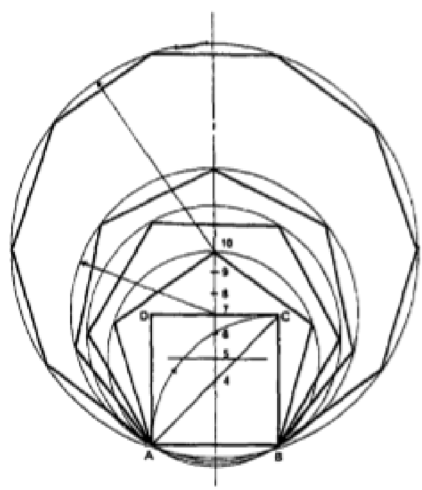
1. Draw a line AB equal to the length of the given side.
2. Draw a line B 1 such that <AB 1 = 108° (included angle) $Angle = \frac{180(n-2)}{n}$
3. Mark Con Bl such that BC = AB 4. Repeat steps 2 and 3 and complete the pentagon ABCDE



To construct a regular figure of given side length and of N sides on a straight line.

Construction

1. Draw the given straight line AB.
2. At B erect a perpendicular BC equal in length to AB.
3. Join AC and where it cuts the perpendicular bisector of AB, number the point 4.
4. Complete the square ABCD of which AC is the diagonal.
4. With radius AB and Centre B, describe arc AC as shown.



5. This is the Centre in which a regular pentagon of side AB can now be drawn.
6. Where this arc cuts the vertical centre line number the point 6.
7. This is the centre of a circle inside which a hexagon of side AB can now be drawn.
8. Bisect the distance 4-6 on the vertical centre line.
9. Mark this bisection
10. On the vertical centre line step off from point 6 a distance equal in length to the distance 5-6. This is the centre of a circle in which a regular heptagon of side AB can

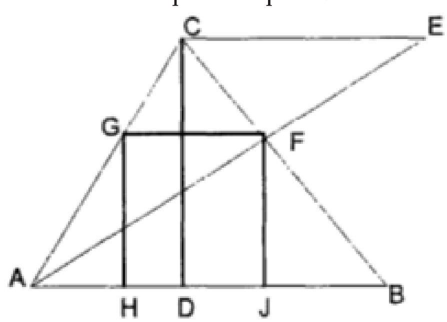
now be drawn.

11. If further distances 5-6 are now stepped off along the vertical centre line and are numbered consecutively, each will be the Centre of a circle in which a regular polygon can be inscribed with sine of length AB and with a number of sides denoted by the number against the Centre.

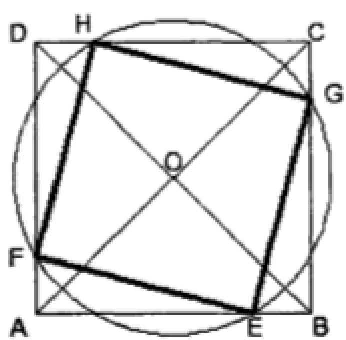
To Inscribe a Square in a Triangle

Construction

1. Draw the given triangle ABC.
2. From C drop a perpendicular to cut the base AB at D.
3. From C draw CE parallel toAB and equal in length to CD.
4. Draw AE and where it cuts the line CB mark F.
5. From F draw FG parallel to AB.
6. From F draw F J parallel to CD.
7. From G draw GH parallel to CD.
8. Join H to 1. Then HJFG is the required square.



To inscribe within a given square ABCD, another square, one angle of the required square to touch a side of the given square at a given point construction in figure.



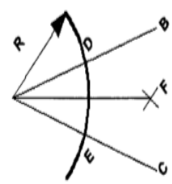
1. Draw the given square ABCD.
2. Draw the diagonals and where they intersect mark the point O.
3. Mark the given point E on the line AB.
4. With Centre 0 and radius OE, draw a circle.
5. Where the circle cuts the given square, mark the points G, H, and F.
6. Join the points GHFE. Then GHFE is the required square.

2.6 Divisions

Introduction

Engineering drawing consists of a number of geometrical constructions that includes the division of the lines into different segments. A few methods are illustrated here without mathematical proofs.

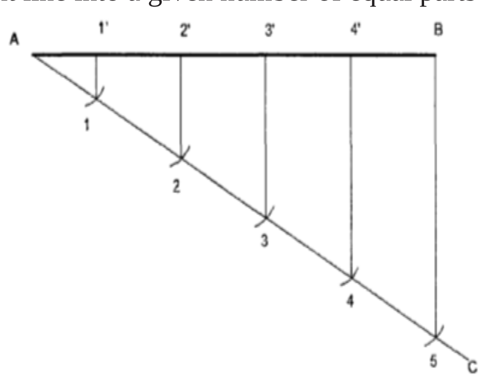
To bisect a given angle.



Construction

1. Draw a line AB and AC making the given angle.
2. With centerA and any convenient radius R, draw an arc intersecting the sides at D and E.
3. With centers D and E and radius larger than half the chord length DE, draw arcs intersecting at F 4. JoinAF, <BAF = <PAC.

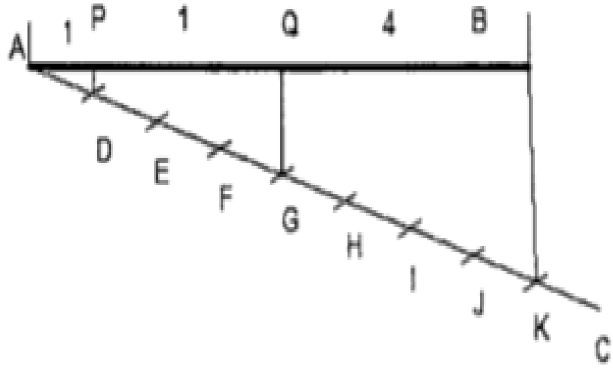
   To divide a straight line into a given number of equal parts say 5.



Construction

1. Draw AC at any angle e to AB.
2. Construct the required number of equal parts of convenient length on AC like 1, 2, and 3.
3. Join the last point 5 to B
4. Through 4, 3, 2, 1 draw lines parallel to 5B to intersect AB at 4',3',2' and 1'.

To divide a line in the ratio 1:3:4.



Construction

As the line is to be divided in the ratio 1:3:4 it has to be divided into 8 equal divisions. By following the previous example divide AC into 8 equal parts and obtain P and Q to divide the lineAB in the ratio 1:3:4.

To Divide a line in to number of equal parts

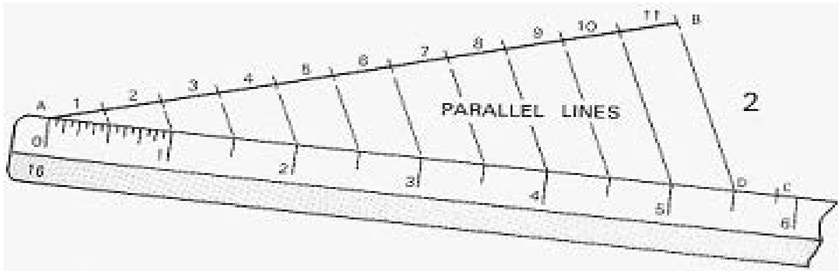
Given: Line A-B.

Step 1: Draw a construction line AC that starts at end A of given line AB. This new line is longer than the given line and makes an acute angle with it.

Step 2: Find a scale that will approximately divide the line AB in to the number of parts needed (11 in the example below), and mark these divisions on the line AC.

There are now ‘n’ equal divisions from A to D that lie on the line AC (11 in this example).

Step 3: Set the adjustable triangle to draw a construction line from point D to point B. Then draw construction lines through each of the remaining ‘n-1’ divisions parallel to the first line BD by sliding the triangle along the straight edge. The original line AB will now be accurately divided.



To divide the circle into any number of equal parts

1. Two equal parts

Construction

a. Draw the circle of given radius (diameter).

b. Draw the chord passing through the centre.

1. Four Equal parts.

Construction

a. Draw the circle of given radius (diameter).

b. Draw the chord passing through the centre, AB.

c. Draw a perpendicular line at the centre to the line AB.

Exercise

Choose the correct answer from the given alternatives.

1. Perpendiculars can't be drawn using ______________

   a. T- Square　　b. Set-squares　　c. Pro- circle　　d) Protractor

2. How many pairs of parallel lines are there in regular hexagon?

   a. 2　　b. 3　　c. 6　　d. 1

3. How many pairs of parallel lines are there in a regular pentagon?

   a. 0　　b. 1　　c. 2　　d. 5

4. What is the shape with 'n' no. of sides, in which all the sides are equal, called?

   a. Rectangle　　b. Circle　　c. Triangle　　d. Regular polygon

5. ________ is a curve with two same curves in which one curve is a reverse of the other curve.

   a. Ellipse　　b. Parabola　　c. Ogee　　d. Hyperbola

6. For drawing a polygon with a side of given length, first we draw a _______ with centre at one of the ends of the length and the radius as length.

   a. Circle　　b. Arc　　c. Semicircle　　d. Quarter circle

7. Using how many methods can you draw perpendicular lines through a point within the lines?

   a. 1　　b. 2　　c. 3　　d. 4

8. How many ways can we draw parallel lines to an existing line?

   a. 1　　b. 2　　c. 3　　d. 4

9. While drawing a perpendicular line through a point which is nearer to the middle of a given line, _______ is cut at two points on the line.

   a. A circle　　b. A square　　c. A rectangle　　d. An arc

10. For drawing parallel lines to a given line through a given point we make use of _____

    a. Arcs　　b. Triangles　　c. Lines　　d. Quadrilaterals

Write short answer to the following questions.

1. Define line segment. How does it differ from a line?
2. What is polygon?
3. Construct a triangle *ABC* in which a = 4 cm, b = 5 cm, c = 6 cm.
4. Construct a triangle *ABC* in which c = 7.5 cm, α = 45°, β = 60°.
5. Construct a triangle *ABC* in which b = 6 cm, c = 4.5 cm, α = 72°.
6. Construct a triangle *ABC* in which a = 6.5 cm, c = 8 cm, α = 38°.
7. Construct a triangle *ABC* in which a = 4 cm, c = 6.5 cm, β = 60°.
8. Construct a triangle *ABC* in which a = 4.5 cm, c = 7 cm, γ = 90°.
9. Construct a triangle *ABC* in which c = 8 cm, h_c = 4 cm, m_c = 7 cm.
10. Construct a triangle *ABC* in which a = 6 cm, b = 8.5 cm, h_a = 5 cm.
11. Draw a regular hexagon having a length of 6cm.
12. Draw a regular pentagon of length 5cm.
13. Draw a regular octagon of length 8cm.
14. Draw a square of length of side 4.5cm.
15. Draw a square of length of diagonal 6cm.
16. Construct a rhombus of length of diagonals 8cm and 10 cm resp.
17. Construct an equilateral triangle of length 4.2 cm.
18. Construct a regular pentagon of 25 mm side, by two different methods.

Write long answer to the following questions.

1. Construct an isosceles triangle *ABC* with base *AB* in which a = 5 cm, h_a = 4 cm.
2. Construct a right-angled triangle *ABC* with hypotenuse *AB*, $|AB| = c$ = 10 cm and height of the hypotenuse h_c = 4 cm.
3. Construct a square *ABCD* with diagonal $|AC| = e$ = 12 cm.
4. Construct a rhombus *ABCD* in which $|AB| = a$ = 6 cm, $|AC| = e$ = 7 cm.
5. Construct a convex quadrilateral *ABCD* in which a = 8 cm, b = 6 cm, c = 5 cm, $|AC| = e$ = 7 cm, α = 60°.
6. Construct a trapezium *ABCD* with bases *AB* and *CD* in which a = 10 cm, b = 4.8 cm, c = 4.2 cm, β = 65°.
7. Construct a parallelogram *ABCD* in which a = 7.5 cm, b = 4 cm and the size of an angle $|\angle DAB|$ = 100°.

Scale

Unit 3

3.1 Scales

Introduction

It is not always possible to make drawings of an object to its actual size. If the actual linear dimensions of an object are shown in its drawing, the scale used is said to be a full size scale. Wherever possible, it is desirable to make drawings to full size.

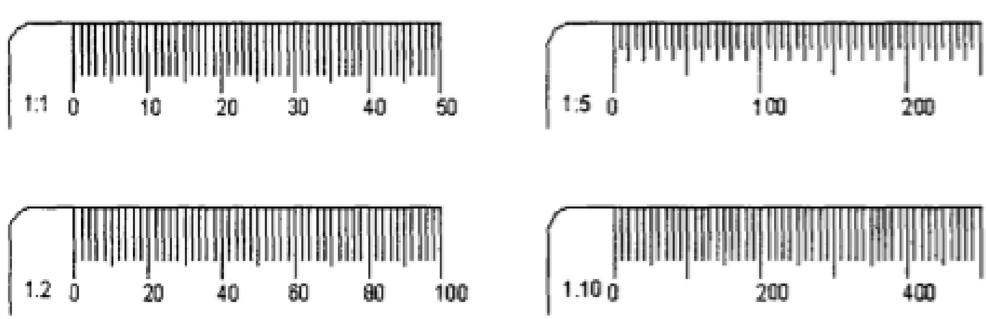
Reducing and Enlarging Scales

Objects which are very big in size cannot be represented in drawing to full size. In such cases the object is represented in reduced size by making use of reducing scales. Reducing scales are used to represent objects such as large machine parts, buildings, town plans etc. A reducing scale, say 1: 10 means that 10 units length on the object is represented by 1 unit length on the drawing.

Similarly, for drawing small objects such as watch parts, instrument components etc., and use scale may not be useful to represent the object clearly. In those cases enlarging scales are used. An enlarging scale, say 10: 1 means one unit length on the object is represented by 10 units on the drawing.

The designation of a scale consists of the word. SCALE, followed by the indication of its ratio as follows. Scale 1: 1 for full size scale 1: x for reducing scales (x = 10, 20 ...... etc.,) Scale x: 1 for enlarging scales.

Note: For all drawings the scale has to be mentioned without fail.



Scale

Representative Fraction (RF)

The ratio of the dimension of the object shown on the drawing to its actual size is called the Representative Fraction (RF).

$$RF = \frac{\text{Drawing size of an object}}{\text{Its actual size}} \text{ (in same units)}$$

For example, if an actual length of 3 metres of an object is represented by a line of 15mm length on the drawing

$$RF = \frac{15mm}{3m} = \frac{15mm}{(3 \times 1000)mm} = \frac{1}{200} \text{ or } 1:200$$

If the desired scale is not available in the set of scales it may be constructed and then used.

Metric Measurements

10 millimeters (mm) = 1 centimeter(cm)

10 centimeters (cm) = 1 decimeter (cm)

10 decimeter (cm) = 1 meter (m)

10 meters (m) = 1 decameter (dam)

10 decameter (dam) = 1 hectometer (cm)

10 hectometers (cm) = 1 kilometer (km)

1 hectare = 10,000 m^2

Types of Scales

The types of scales normally used are

1. Plain scales
2. Diagonal Scales
3. Vernier Scales

Plain Scales

A plain scale is simply a line which is divided into a suitable number of equal parts, the first of which is further sub-divided into small parts. It is used to represent either two units or a unit and its fraction such as km and cm, m etc.

Problem 1: On a survey map the distance between two places 1 km apart is 5 cm. Construct the scale to read 4.6 km.

Solution:

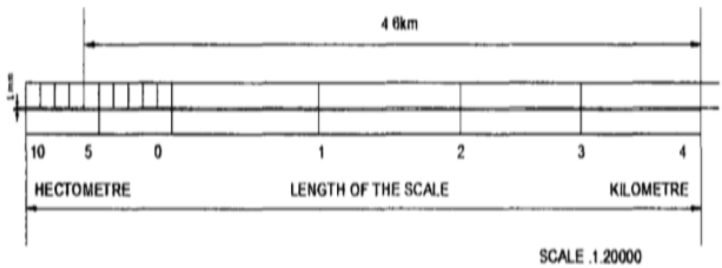
Scm 1 RF==-- 1 x 1000 x 100cm 20000

1 Ifx is the drawing size required x = 5(1000) (100) x 20000

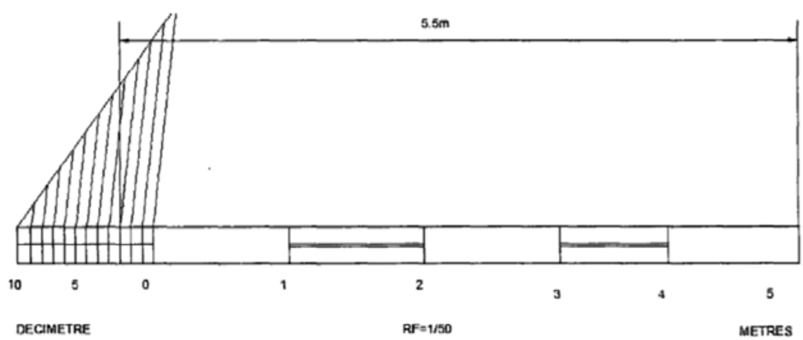
Therefore, x = 25 cm

Note: If 4.6 km itself were to be taken x = 23 cm. To get 1 km divisions this length has to be divided into 4.6 parts which is difficult. Therefore, the nearest round figure 5 km is considered. When this length is divided into 5 equal parts each part will be 1 km.

1. Draw a line of length 25 cm.
2. Divide this into 5 equal parts. Now each part is 1 km.
3. Divide the first part into 10 equal divisions. Each division is 0.1 km.
4. Mark on the scale the required distance 4.6 km.



Problem 2: Construct a scale of 1:50 to read meters and decimeters and long enough to measure 6 m. Mark on it a distance of 5.5 m.



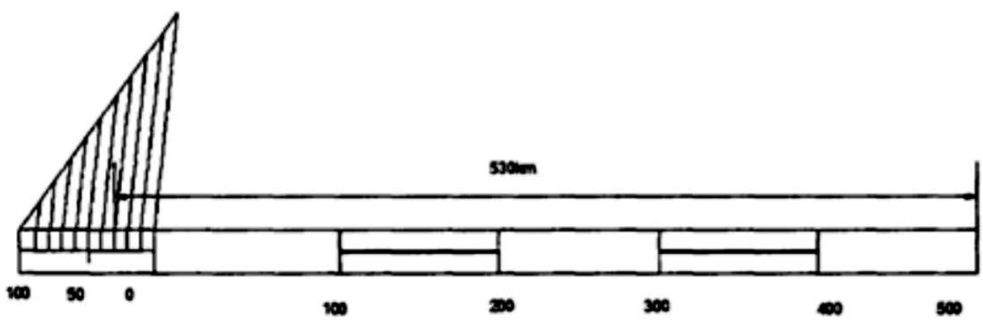
Construction

1. Obtain the length of the scale as: RF x 6m = 1/50 x 6 x 100 = 12 cm
2. Draw a rectangle strip of length 12 cm and width 0.5 cm.
3. Divide the length into 6 equal parts, by geometrical method each part representing 1m.
4. Mark O (zero) after the first division and continue 1, 2, 3 etc., to the right of the scale.

5. Divide the first division into 10 equal parts (secondary divisions), each representing 1 cm.
6. Mark the above division points from right to left.
7. Write the units at the bottom of the scale in their respective positions. 8. Indicate RF at the bottom of the figure.
9. Mark the distance 5.5 m as shown.

Problem 3: The distance between two towns is 250 km and is represented by a line of length 50mm on a map. Construct a scale to read 600 km and indicate a distance of 530 km on it.

1. Determine the RF value as = =
2. Obtain the length of the scale as : × 600 km = 120 mm.
3. Draw a rectangular strip of length 120 mm and width 5 mm.
4. Divide the length into 6 equal parts, each part representing 10 km.
5. Repeat the steps 4 to 8 of construction in Fig 3.2 suitably.
6. Mark the distance 530 km as shown.



Solution: (Fig 3.4)

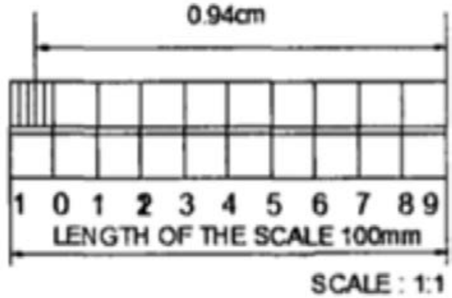
Problem 4: Construct a plain scale of convenient length to measure a distance of 1 cm and mark on it a distance of 0.94 cm.

This is a problem of enlarged scale.

Solution :

This is a problem of enlarged scale.

1. Take the length of the scale as 10 cm.
2. RF = 10/1, scale is 10:1
3. The construction is shown in figure.



Diagonal Scales

Plain scales are used to read lengths in two units such as meters and decimeters, centimeters and millimeters etc., or to read to the accuracy correct to first decimal.

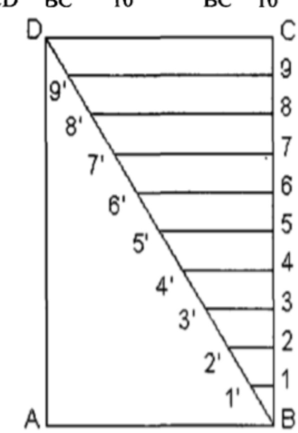
Diagonal scales are used to represent either three units of measurements such as meters, decimeters, centimeters or to read to the accuracy correct to two decimals.

Principle of Diagonal Scale

1. Draw a line AB and erect a perpendicular at B.
2. Mark 10 equi-distant points (1, 2, 3, etc.) of any suitable length along this perpendicular and mark C.
3. Complete the rectangle ABCD
4. Draw the diagonal BD.
5. Draw horizontals through the division points to meet BD at l' , 2' , 3' etc.

   Considering the similar triangles say BCD and B44'

$$\frac{B4'}{CD} = \frac{B4}{BC}; \ = \frac{4}{10} \times BC \times \frac{1}{BC} = \frac{4}{10}; \ 44' = 0.4CD$$



Principle of Diagonal Scale

Exercise

Choose the correct answer from the given alternatives.

1. Representative fraction is the ____________________

   a. ratio of the length in drawing to the actual length

   b. ratio of the actual length to the length in drawing

   c. reciprocal of actual length

   d. square of the length in drawing

2. The scale of a drawing is given as 1:20. What is the representative fraction?

   a. 20 b. 1/20 c. 0.5 d. 0.02

3. The scale of a drawing is given as 15:1. What is the representative fraction?

   a. 15 b. 0.15 c. 1.5 d. 1/15

4. The length of the drawing is 50 mm, the scale is given as 1:5. Find the actual length....

   a. 50 cm b. 10 cm c. 25 cm d. 10 mm

5. The ratio of a length of an actual object to the length of drawing is given as 5. Find the scale and R.F. (Representative factor).........

   a. 1:5, 1/5 b. 5:1, 1/5 c.1:5, 5 d. 5:1, 5

6. What is the representative factor of a line, whose length is 24cm on the drawing sheet, representing an actual length of 6m?

   a. 1:50 b. 1:25 c. 1:24 d. 1:60

7. A line of 10cm is drawn on a drawing sheet. It represents an actual length of 25mm. What is the representative factor?

   a. 1:4 b. 1:40 c. 4:1 d. 40:1

8. Which of the following representative factor will have an enlarging scale?

   a. 1:24 b. 1:5 c. 1:3 d. 1:0.5

9. Which of the following representative factors depict that the actual length of the object is greater than the length of the drawing?

   a. 2:5 b. 4:1 c. 3:2 d. 5:3

10. Which of the following scales is neither an enlarging nor a reducing scale?

a. 3:2 b. 1:4 c. 1:0.5 d. 1:1

Write short answer to the following questions.

1. Give two practical applications of an enlarged scale.
2. What is a representative fraction?
3. Enlist types of scales used in engineering practices.
4. What is a comparative scale?
5. What is the difference between a direct and a retrograde vernier?
6. What is the difference between a diagonal and a vernier scale?
7. What are the applications of the scale of chords?

Write long answer to the following questions.

1. Distinguish between a full size, a reduced size and an enlarged sized drawing.
2. What are the advantages of using graphical scale over an engineering scale?
3. What is the principle used for measuring lengths from diagonal scale?
4. What are the advantages of using a diagonal scale over a plain scale?

Numericals

1. Construct a plain scale of 1:50 to measure a distance of 7 meters. Mark a distance of 3.6 meters on it.
2. The length of a scale with a RF of2:3 are 20 cm. Construct this scale and mark a distance of 16.5 cm on it.
3. Construct a scale of 2 cm = 1 decimeter to read upto 1 meter and mark on it a length of 0.67 meter.
4. Construct a plain scale of RF = 1 :50,000 to show kilometers and hectometers and long enough to measure upto 7 km. Mark a distance of 5:3 kilometers on the scale.
5. On a map, the distance between two places 5 km apart is 10 cm. Construct the scale to read 8 km. What is the RF of the scale?
6. Construct a diagonal scale ofRF = 1150, to read meters, decimeters and centimeters. Mark a distance of 4.35 km on it.
7. Construct a diagonal scale of five times full size, to read accurately upto 0.2 mm and mark a distance of 3 .65 cm on it.

8. Construct a diagonal scale to read upto 0.1 mm and mark on it a 'distance of 1.63 cm and 6.77 cm. Take the scale as 3: 1.
9. Draw a diagonal scale of 1 cm = 2.5krn and mark on the scale a length of26.7 km.
10. Construct a diagonal scale to read 2krn when it's RF=I: 20,000. Mark on it a distance of 1:15 km.
11. Draw a vernier scale of meters when mm represents 25cm and mark on it a length of 24.4 cm and 23.1 mm. What is the RF?
12. The LC of a forward reading vernier scale is 1 cm. Its vernier scale division represents 9 cm. There are 40 m on the scale. It is drawn to 1: 25 scale. Construct the scale and mark on it a distance ofO.91m.
13. 15cm of a vernier scale represents 1 cm. construct a backward reading vernier scale of RF 1: 4.8 to show decimeters cm and mm. The scale should be capable of reading upto 12 decimeters. Mark on the scale 2.69 decimeters and 5.57 decimeters.

Tangent

Tangent

A tangent is a line that touches the curve exactly at a point. The point is called the point of tangency. The tangent to a circle is defined as the perpendicular to the radius at the point of tangency. In this article, we are going to discuss what is tangent to a circle, how to construct a tangent to a circle, and also we will learn how to draw a tangent from the point outside of the circle with a step by step procedure.

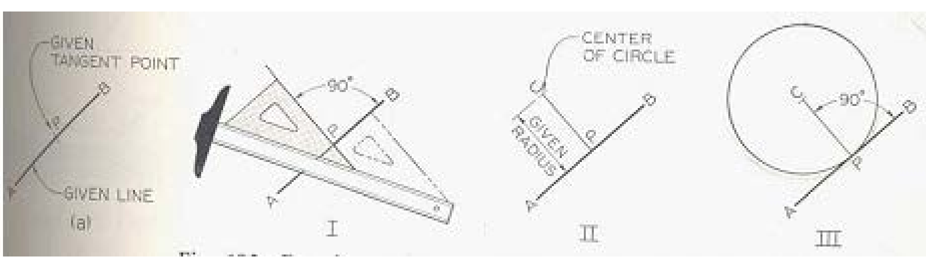
To Draw A Circle Tangent To A Line At A Given Point

Given: Given line AB and a point on the line.

Step 1: At P erect a perpendicular to the line.

Step 2: Set off the radius of the required circle on the perpendicular.

Step 3: Draw circle with radius CP.



To Draw A Tangent to A Circle Through A Point

Method-1

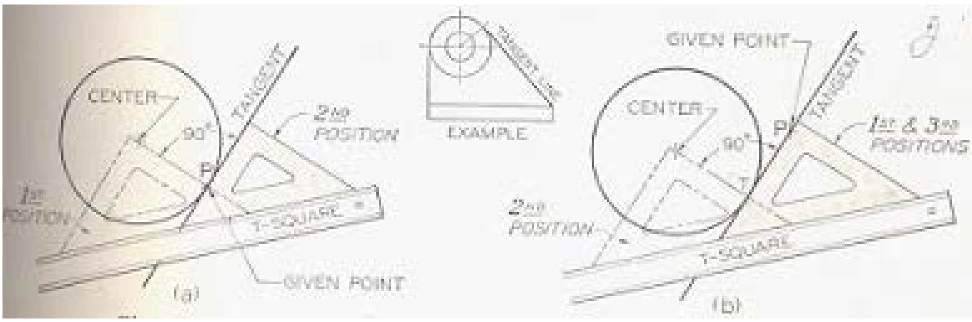
Given: Point P on the circle.

Move the T-square and triangle as a unit until one side of the triangle passes through the point P and the center of the circle; then slide the triangle until the other side passes through point P, and draw the required tangent.

Method-2

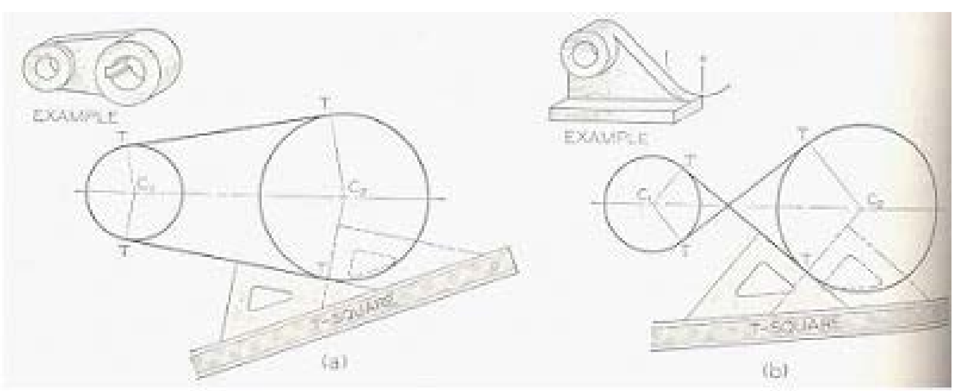
Given: Point P outside the circle.

Move the T-square and triangles as a unit until one side of the triangle passes through point P and, by inspection, is the tangent to the circle; and then slide the triangle until the other side passes through the center of the circle, and lightly mark the point of tangency T. Finally move the triangle back to its starting position and draw the required tangent.



To Draw Tangents To Two Circles

Move the T-square and triangles as a unit until one side of the triangle is tangent, by inspection, to the two circles; then slide the triangle until the other side passes through the center of one circle, and lightly mark the point of tangency. Then slide the triangle until the side passes through the center of the other circle, and mark the point of tangency. Finally slide the triangle back to the tangent position, and draw the tangent lines between the two points of tangency. Draw the second tangent line in similar manner.



To Construct an Arc Tangent to An Angle

Given: A right angle, lines A and B and a required radius

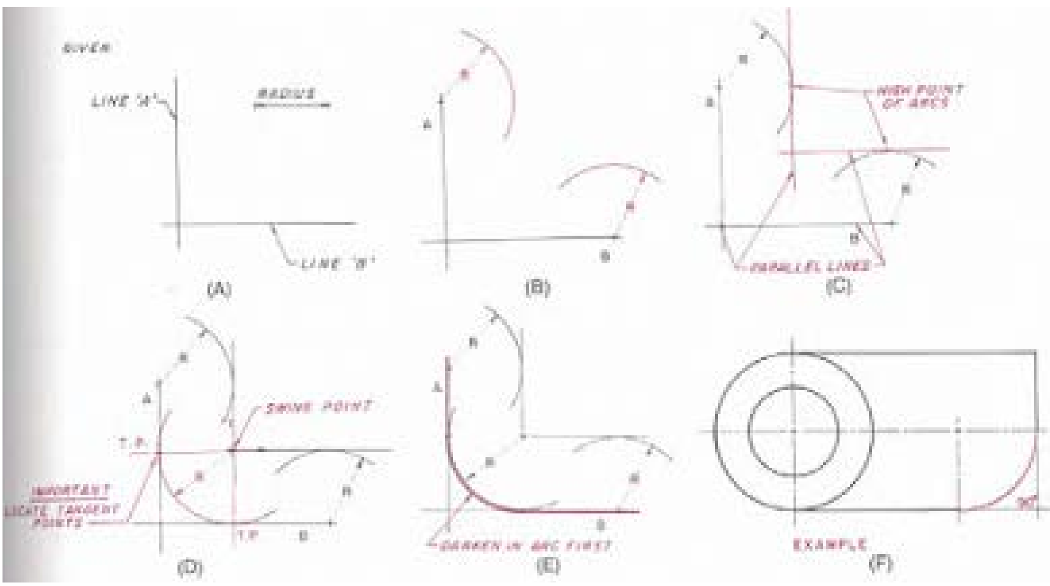
Step 1: Set the compass at the required radius and, out of the way, swing a radius from line A and one from line B.

Step 2: From the extreme high points of each radius, construct a light line parallel to line A and another line parallel to line B.

Step 3: Where these lines intersect is the exact location of the required swing point. Set the compass point on the swing point and lightly construct the required radius.

Allow the radius swing to extend past the required area. It is important to locate all tangent points (T.P) before darkening in.

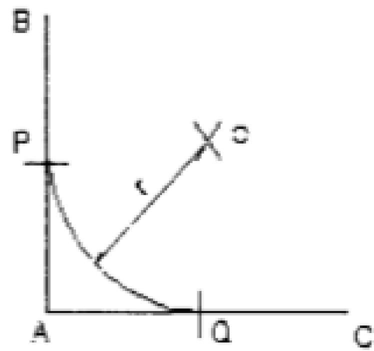
Step 4: Check all work and darken in the radius using the correct line thickness. Darken in connecting straight lines as required. Always construct compass work first, followed by straight lines. Leave all light construction lines.



To draw an arc of given radius touching two straight lines at right angles to each other

Construction

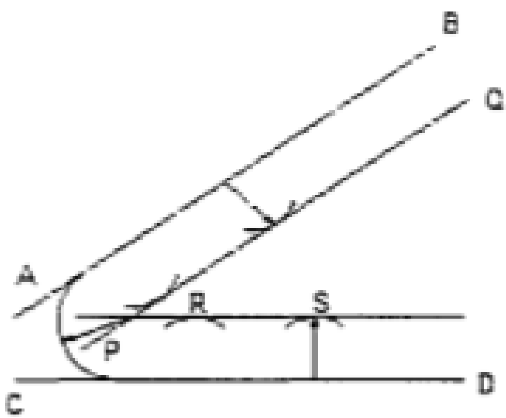
Let r be the given radius and AB and AC the given straight lines. With A as centre and radius equal to r draw arcs cutting AB at P and Q. With P and Q as centers draw arcs to meet at O. With 0 as Centre and radius equal to r draw the required arc.



To draw an arc of a given radius, touching two given straight lines making an angle between them.

Construction

Let AB and CD are the two straight lines and r, the radius. Draw a line PQ parallel to AB at a distance r from AB. Similarly, draw a line RS parallel to CD. Extend them to meet at O. With 0 as Centre and radius equal to r draw the arc to the two given lines.



To Construct An Arc Tangent To Two Radii Or Diameters

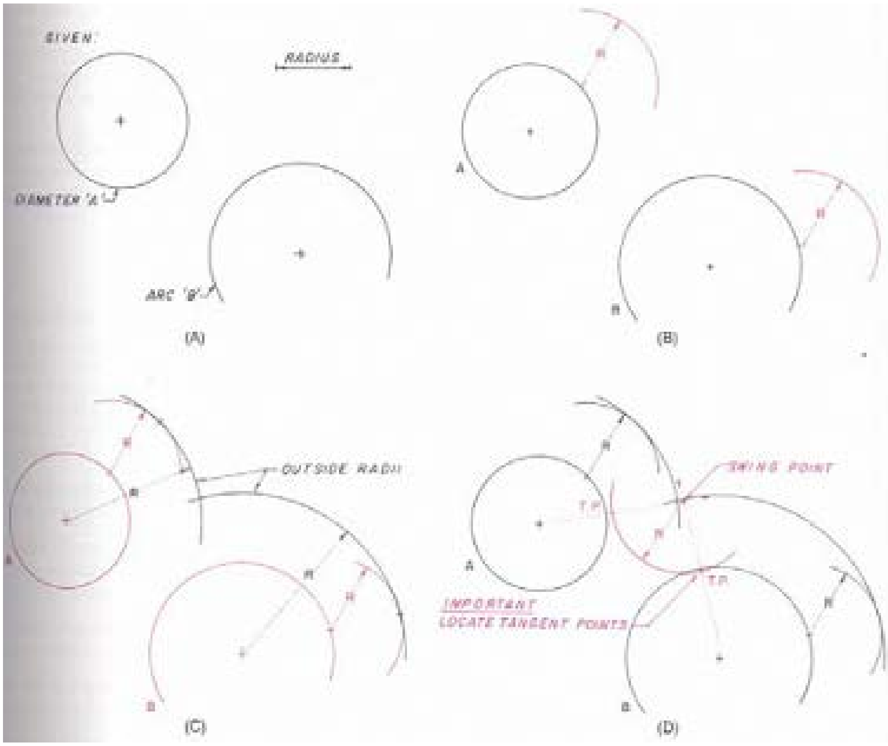
Given: Diameter A and arc B with center points located, and the required radius.

Step 1: Set the compass at the required radius and, out of the way, swing a radius of the required length from a point on the circumference of given diameter A. Out of the way, swing a required radius from a point on the circumference of a given arc B.

Step 2: From the extreme high points of each radius, construct a light radius outside of the given radii A and B.

Step 3: Where these arcs intersect is the exact location of the required swing point. Set the compass point on the swing point and lightly construct the required radius.

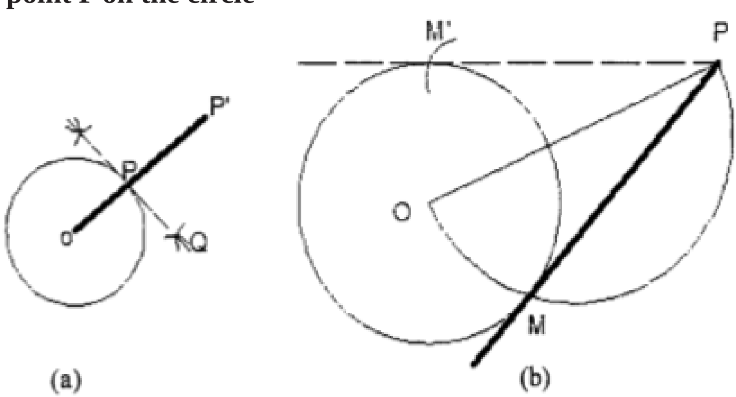
Allow the radius swing to extend past the required area.



Step 4: Check all work; darken in the radii using the correct line thickness. Darken in the arcs or radii in consecutive order from left to right or from right to left, thus constructing a smooth connecting line having no apparent change in direction.

To draw a tangent to a circle construction

(a) At any point P on the circle



1. With 0 as centre, draw the given circle. P is any point on the circle at which tangent to be drawn.

2. Join 0 with P and produce it to p’ so that OP = pp’
3. With 0 and p’ as centers and a length greater than OP as radius, draw arcs intersecting each other at Q.
4. Draw a line through P and Q. This line is the required tangent that will be perpendicular to OP at P.

(b) From any point outside the circle

1. With 0 as Centre, draw the given circle. P is the point outside the circle from which tangent is to be drawn to the circle.
2. Join 0 with P. With OP as diameter, draw a semi-circle intersecting the given circle at M. Then, the line drawn through P and M is the required tangent.
3. If the semi-circle is drawn on the other side, it will cut the given circle at MI. Then the line through P and MI will also be a tangent to the circle from P.

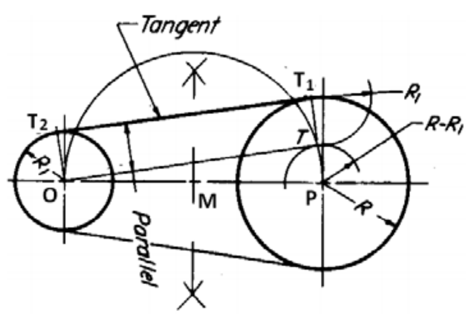
Uncrossed (Open Belt) Line Tangent

Construction of line tangents to two circles (Open belt)

Given: Circles of radii R1 and R with centers O and P, respectively.

Steps:

1. With P as center and a radius equal to (R-R_1) draw an arc.
2. Locate the midpoint of OP as perpendicular bisector of OP as “M”.



3. With M as centre and Mo as radius draw a semicircle.
4. Locate the intersection point T between the semicircle and the circle with radius (R-R_1).
5. Draw a line PT and extend it to locate T_1.
6. Draw OT_2 parallel to PT_1.

The line T_1 to T_2 is the required tangent

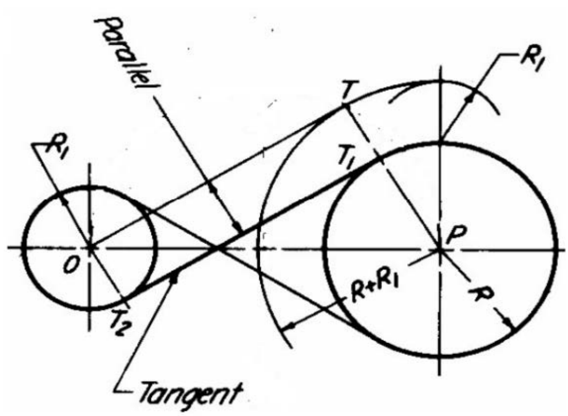
Crossed (Cross Belt) Line Tangent

Construction of line tangents to two circles (crossed belt)

Given: Two circles of radii R1 and R with centers O and P, respectively.

Steps

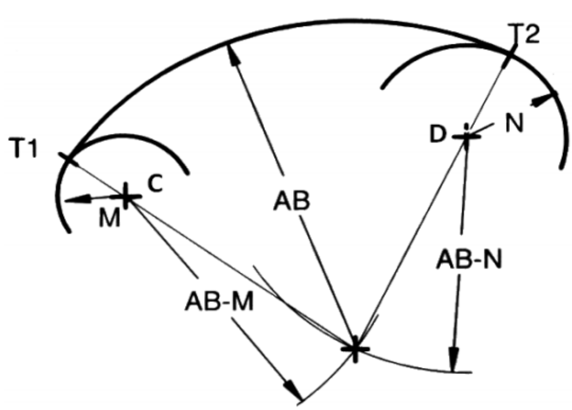
1. Using P as a center and a radius equal to ($R+ R_1$) draw an arc.
2. Through O draw a tangent to this arc.
3. Draw a line PT cutting the circle at T_1
4. Through O draw a line OT_2 parallel to PT_1.
5. The line T_1T_2 is the required tangent.



Arc Tangent

Construction of an arc tangent of given radius to two given arcs

Given - Arcs of radii M and N. Draw an arc of radius AB units which is tangent to both the given arcs. Centers of the given arcs are inside the required tangent arc.



Steps

1. From centers C and D of the given arcs, draw construction arcs of radii (AB – M) and (AB - N), respectively.
2. With the intersection point as the center, draw an arc of radius AB.
3. This arc will be tangent to the two given arcs.
4. Locate the tangent points T_1 and T_2.

Exercise

Choose the correct answer from the given alternatives.

1. Given are the steps to draw a tangent to any given circle at any point P on it. Arrange the steps.....

   i. Draw the given circle with center O and mark the point P anywhere on the circle.

   ii. With centers O and Q draw arcs with equal radius to cut each other at R.

   iii. Join R and P which is the required tangent.

   iv. Draw a line joining O and P. Extend the line to Q such that OP = PQ.

   a. i, iv, ii, iii   b. iv, i, iii, ii   c. iii, i, iv, ii   d. ii, iv, i, iii

2. Given are the steps to draw a tangent to given circle from any point outside the circle. Arrange the steps........

   i. With OP as diameter, draw arcs on circle at R and R1.

   ii. Draw the given circle with center O.

   iii. Join P and R which is one tangent and PR1 is another tangent.

   iv. Mark the point P outside the circle.

   a. ii, iv, iii, i   b. iv, i, iii, ii   c. iii, i, iv, ii   d. ii, iv, i, iii

3. Given are the steps to draw a tangent to given arc even if center is unknown and the point P lies on it. Arrange the steps. Let AB be the arc...

   i. Draw EF, the bisector of the arc CD. It will pass through P.

   ii. RS is the required tangent.

   iii. With P as center and any radius draw arcs cutting arc AB at C and D.

   iv. Draw a perpendicular RS to EF through P.

   a. ii, iv, iii, I   b. iv, i, iii, ii   c. iii, i, iv, ii   d. ii, iv, i, iii

4. Given are the steps to draw a tangent to given circle and parallel to given line. Arrange the steps.......

   i. Draw a perpendicular to given line and extend to cut the circle at two points P and Q.

   ii. At P or Q draw perpendicular to normal then we get the tangents.

   iii. PQ is the normal for required tangent.

iv. Draw a circle with center O and line AB as required.

a. ii, iv, iii, I b. iv, i, iii, ii c. iii, i, iv, ii d. ii, iv, i, iii

5. How many external tangents are there for two circles?

a. 1 b. 2 c. 3 d. 4

6. How many internal tangents are there for two circles?

a. 4 b. 3 c. 2 d. 1

7. Arrange the steps. These give procedure to draw internal tangent to two given circles of equal radii..........

i. Draw a line AB which is the required tangent.

ii. Draw the given circles with centers O and P.

iii. With center R and radius RA, draw an arc to intersect the other circle on

the other circle on the other side of OP at B.

iv. Bisect OP in R. Draw a semi circle with OR as diameter to cut the circle at A.

a. ii, iv, iii, i b. iv, i, iii, ii c. iii, i, iv, ii d. ii, iv, i, iii

8. How many tangents to a given circle, can we draw parallel to a given line?

a. 1 b. 2 c. 3 d. 4

9. In how many ways can there be a common tangent between two circles?

a. 3 b. 4 c. 1 d. 2

10. How many internally common tangents can two circles have?

a. 3 b. 1 c. 2 d. 4

11. To draw a tangent to an arc of unknown radius and centre through any point on the arc we use _________

a. Angle bisectors b. Semicircles

c. Arc d. Perpendicular bisector

12. How is a normal to a tangent drawn?

a. Angle bisector b. Perpendicular bisector

c. Rectangle d. Semicircle

Write short answer to the following questions.

1. Define a tangent.
2. What is a tangent in geometry and how is it used in engineering drawing?
3. What is the importance of tangents in engineering drawing?
4. Differentiate between tangent and normal.

Write long answer to the following questions.

1. Draw a tangent to a circle of radius 40mm from a point at the circumference of it.
2. Draw a tangent to a circle of radius 30mm from a point atdistance of 90mm from its centre.
3. Construct common tangents (internal and external) to two given circles of radius 50mm and 30mm.
   (a) Touching externally
   (b) Touching internally
   (c) Not touching
4. Draw a pair of tangents from a point to a circle of 30 mm radius with the point located 60 mm from the center.
5. Construct an arc of a given radius (e.g., 20 mm) tangential to two given straight lines at a given angle.
6. Draw a circle tangent to two lines inclined at 60°, and passing through a given point.
7. Draw a circle of radius 25 mm tangential to two circles of radii 20 mm and 30 mm.

Unit 5 Engineering curves and Conic Section

5.1 Engineering Curves

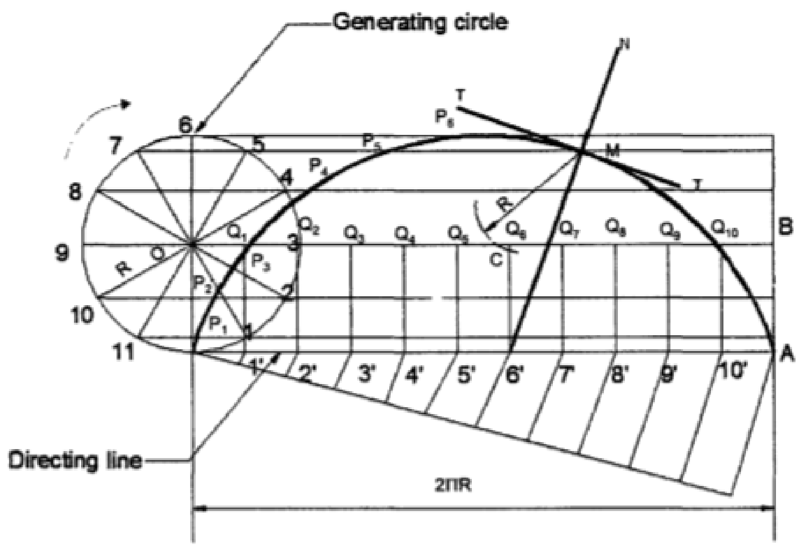
Special Curves

Cycloid curves are generated by a fixed point in the circumference of a circle when it rolls without slipping along a fixed straight line or circular path. The rolling circle is called the generating circle, the fixed straight line, the directing line and the fixed circle, the directing circle.

Cycloid

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

To draw a cycloid, given the radius R of the generating circle.



Construction of a Cycloid

1. With center ° and radius R, draw the given generating circle.
2. Assuming point P to be the initial position of the generating point, draw a line PA,

tangential and equal to the circumference of the circle.

3. Divide the line PA and the circle into the same number of equal parts and number the points.

4. Draw the line OB, parallel and equal to PA. OB is the locus of the center of the generating circle.

5. Erect perpendiculars at 1 I,2I,3I, etc., meeting OB at °1, 0z' 03' etc.

6. Through the points 1,2,3 etc., draw lines parallel to PA.

7. Withcenter 0, and radius R, draw an arc intersecting the line through 1 at PI' PI is the position of the generating point, when the center of the generating circle moves to °1, S. Similarly locate the points P2, P3 etc.

9. A smooth curve passing through the points P, P I' P z,P 3 etc., is the required cycloid.

   Note: T-T is the tangent and NM is the normal to the curve at point M.

Epi-Cycloid and Hypo-Cycloid

An epi-cycloid is a curve traced by a point on the circumference of a generating circle, when it rolls without slipping on another circle (directing circle) outside it. If the generating circle rolls inside the directing circle, the curve traced by the point in called hypo-cycloid.

Involutes

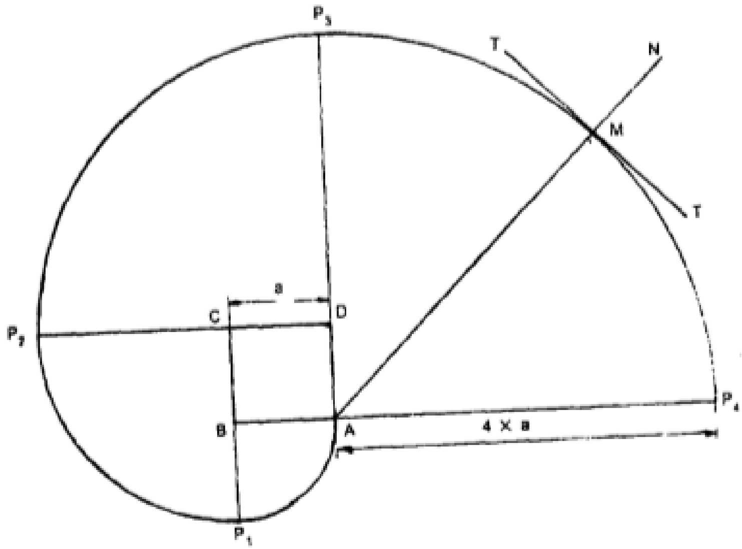
An involute is a curve traced by a point on a perfectly flexible string, while unwinding from around a circle or polygon the string being kept taut (tight). It is also a curve traced by a point on a straight line while the line is rolling around a circle or polygon without slipping.

To draw an involute of a given square.

1. Draw the given square ABCD of side a.

2. Taking A as the starting point, with center B and radius BA=a, draw an arc to intersect the line CB produced at P_1.

3. With Centre C and radius CP_1= 2a, draw on arc to intersect the line DC produced at P_2.

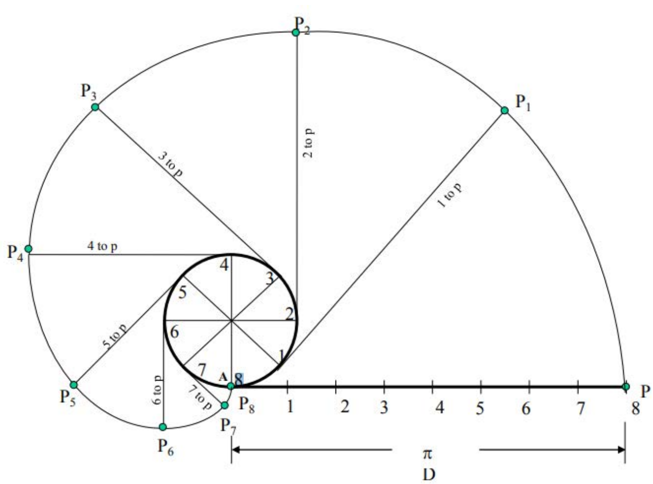


4. Similarly, locate the points P_3 and P_4.
   The curve through A, PI' P2 , P3 and P4 is the required involute.
   A P 4 is equal to the perimeter of the square.

Involute of a circle

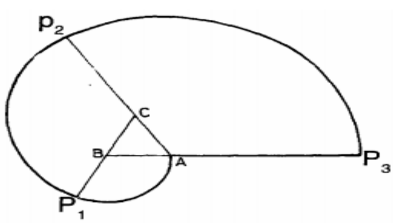
Solution Steps

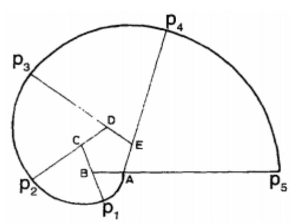
1. Point or end P of string AP is D distance away from A.πexactly means if this string is wound round the circle, it will completely cover given circle. B will meet A after winding. D (AP) distance into 8π.
2. Divide number of equal parts.
3. Divide circle also into 8 number of equal parts.

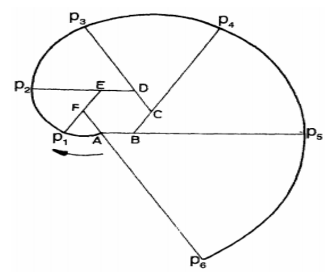


4. Name after A, 1, 2, 3, 4, etc. up D line AP as well as on$\pi$to 8 on circle (in anticlockwise direction).
5. To radius C-1, C-2, C-3 up to C-8 draw tangents (from 1,2,3,4,etc to circle).
6. Take distance 1 to P in compass and mark it on tangent from point 1 on circle (means one division less than distance AP).
7. Name this point P1
8. Take 2-B distance in compass and mark it on the tangent from point 2. Name it point P2.
9. Similarly take 3 to P, 4 to P, 5 to P up to 7 to P distance in compass and mark on respective tangents and locate P3, P4, P5 up to P8 (i.e. A) points and join them in smooth curve it is an INVOLUTE of a given circle.

   Similarly the involutes of a triangle, pentagon and hexagon are shown below.







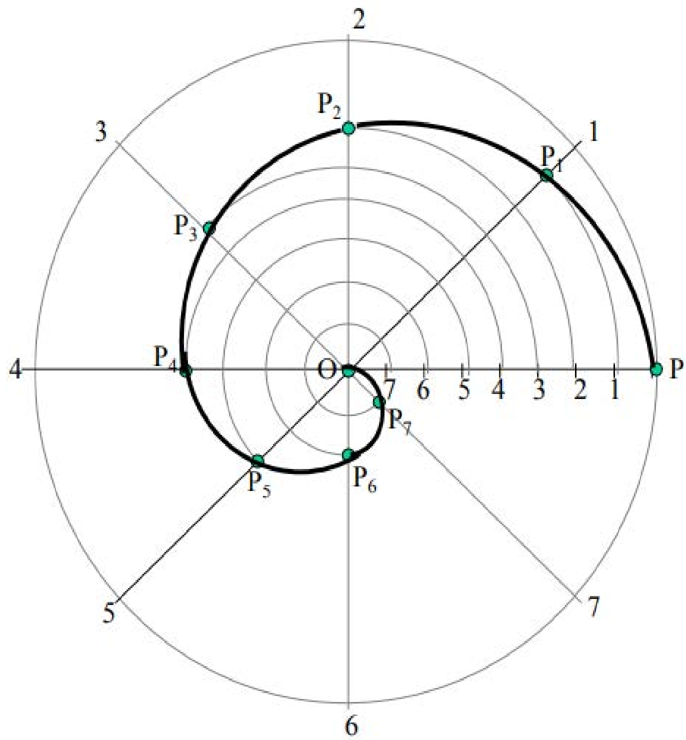
Archimedian Spiral

Solution (Radius of 40mm)

Steps

1. With PO radius draw a circle and divide it in EIGHT parts. Name those 1,2,3,4, etc. up to 8.
2. Similarly divided line PO also in EIGHT parts and name those 1,2,3,-- as shown.
3. Take o-1 distance from op line and draw an arc up to O1 radius vector. Name the point P_1.
4. Similarly mark points P_2 , P_3 , P_4 up to P_8.

   And join those in a smooth curve. It is a SPIRAL of one convolution.



Cylindrical Helix

Draw a helix of one convolution, upon a cylinder. Given 80 mm pitch and 50 mm diameter of a cylinder. (The axial advance during one complete revolution is called the pitch of the helix)

SOLUTION

Draw projections of a cylinder.

Divide circle and axis in to same no. of equal parts. (8)

Name those as shown. Mark initial position of point 'P'

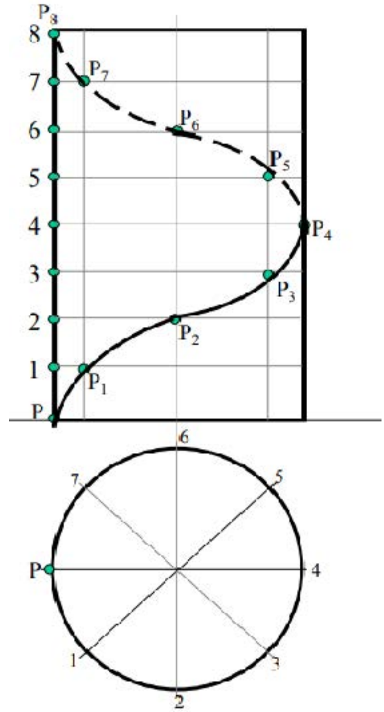
Mark various positions of P as shown in the figure.

Join all points by smooth possible curve.

Make upper half dotted, as it is going behind the solid and hence will not be seen from front side.

Conical Helix

Draw a helix of one convolution, upon a cone, diameter of base 70 mm, axis 90 mm and 90 mm pitch. (The axial advance during one complete revolution is called the pitch of the helix)



SOLUTION

Draw projections of a cone

Divide circle and axis in to same no. of equal parts.

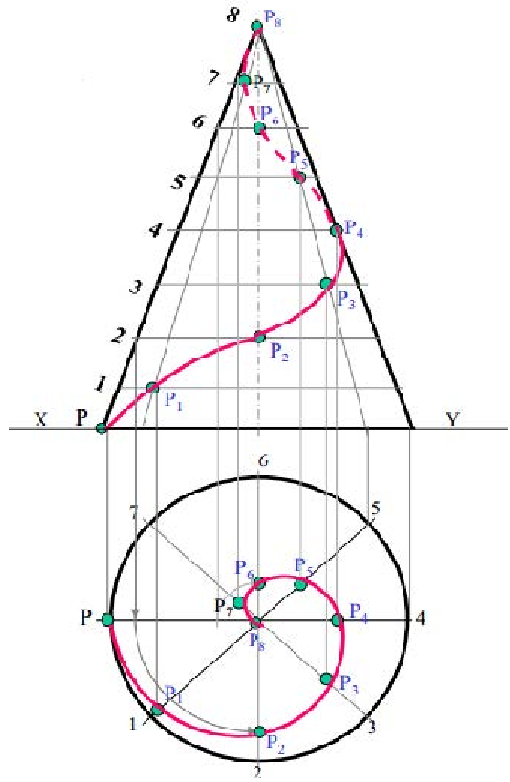
Name those as shown in the figure.

Mark initial position of point ‘P’

Mark various positions of P as shown in figure.

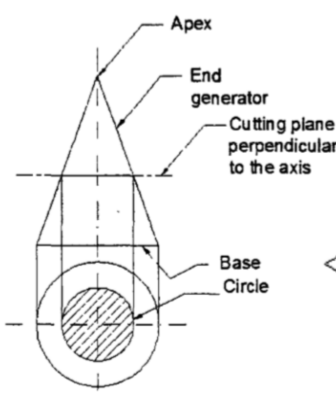
Join all points by smooth possible curve.

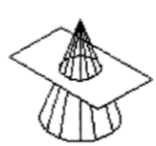
Make upper half dotted, as it is going behind the solid and hence will not be seen from front side.

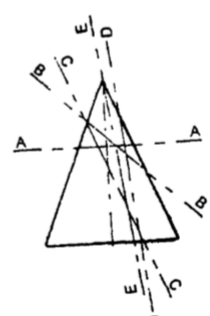


Conic Sections

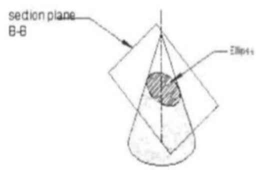
Cone is formed when a right angled triangle with an apex and angle e is rotated about its altitude as the axis. The length or height of the cone is equal to the altitude of the triangle and the radius of the base of the cone is equal to the base of the triangle. The apex angle of the cone is 2.



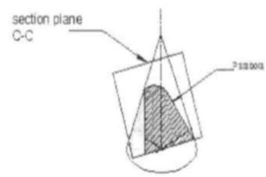




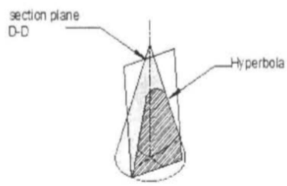
When a cone is cut by a plane, the curve formed along the section is known as a conic. For this purpose, the cone may be cut by different section planes and the conic sections obtained.



c- Ellipse



d- Parabola



e- Hyperbola

Circle

When a cone is cut by a section plane A-A making an angle $\alpha = 90°$ with the axis, the section obtained is a circle.

Ellipse

When a cone is cut by a section plane B-B at an angle, α more than half of the apex angle i.e., θ and less than 90°, the curve of the section is an ellipse. Its size depends on the angle α and the distance of the section plane from the apex of the cone.

Parabola

If the angle α is equal to θ i.e. when the section plane C-C is parallel to the slant side of the cone. The curve at the section is a parabola. This is not a closed figure like circle or ellipse. The size of the parabola depends upon the distance of the section plane from the slant side of the cone.

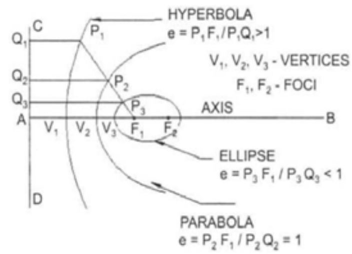
Hyperbola

If the angle α is less than θ (section plane D-D), the curve at the section is hyperbola. The curve of intersection is hyperbola, even if $\alpha = \theta$, provided the section plane is not passing through the apex of the cone. However if the section plane passes through the apex, the section produced is an isosceles triangle.

Conic Sections as Loci of a Moving Point

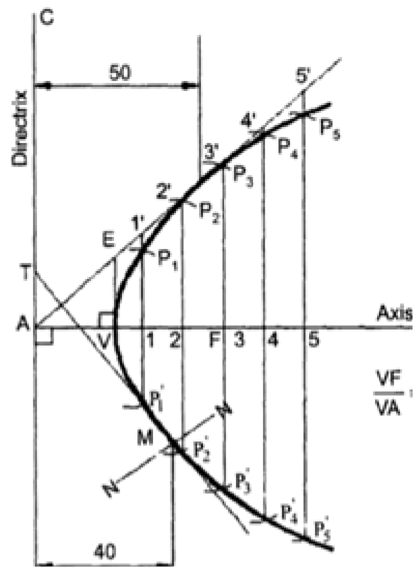
A conic section may be defined as the locus of a point moving in a plane such that the ratio of its distance from a fixed point (Focus) and fixed straight line (Directrix) is always a constant. The ratio is called eccentricity. The line passing through the focus and perpendicular to the directrix is the axis of the curve. The point at which the conic section intersects the axis is called the vertex or apex of the curve.

The eccentricity value is less than 1 for ellipse, equal to I for parabola and greater than 1 for hyperbola.



Eccentricity Method for Drawing Different Curves

To draw a parabola with the distance of the focus from the directrix at 50mm



1. Draw the axis AB and the directrix CD at right angles to it:
2. Mark the focus F on the axis at 50mm.
3. Locate the vertex V on AB such that AV = VF
4. Draw a line VE perpendicular to AB such that VE = VF
5. Join A, E and extend. Now, VENA = VFNA = 1, the eccentricity.
6. Locate number of points 1,2,3, etc., to the right of V on the axis, which need not be equidistant.
7. Through the points 1,2,3, etc., draw lines perpendicular to the axis and to meet the line AE extended at 1',2',3' etc.

8. With center F and radius 1-1, draw arcs intersecting the line through 1 at P_1 and P_1^1.

9. Similarly, locate the points P_2, P_2^1, P_3, P_3^1 etc., on either side of the axis. Join the points by smooth curve, forming the required parabola.

To Draw a Normal and Tangent through a Point 40mm from the Directrix

To draw a tangent and normal to the parabola. locate the point M which is at 40 mm from the directrix. Then join M to F and draw a line through F, perpendicular to MF to meet the directrix at T. The line joining T and M and extended is the tangent and a line NN, through M and perpendicular to TM is the normal to the curve.

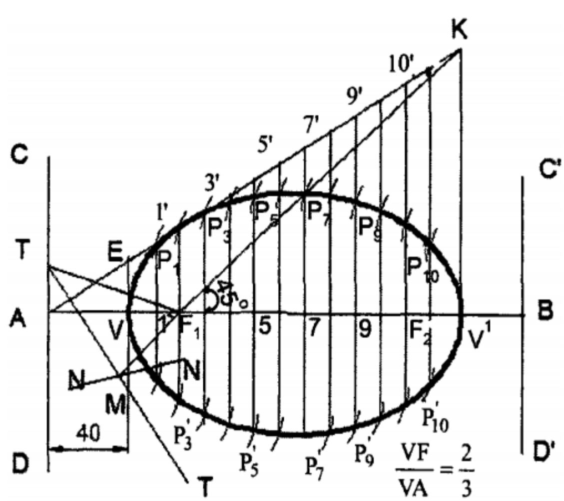
Ellipse with eccentricity equal to 2/3 for the above problem

Construction is similar to the construction of parabola. To draw an ellipse including the tangent and normal, only the eccentricity is taken as 2/3 instead of one.

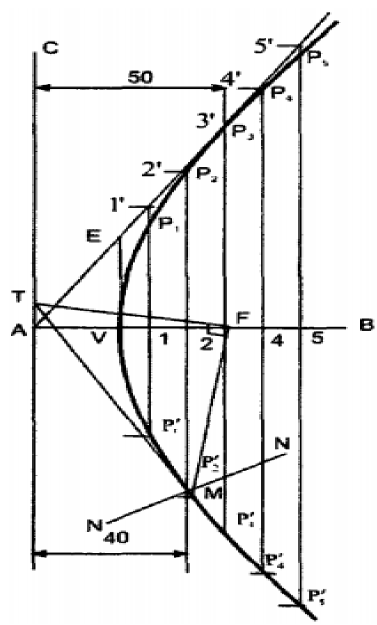
Hyperbola with eccentricity equal to 3/2 for the above problem

The construction of hyperobola is similar to the above problems except that the eccentricity ratio VF/VA = 3/2 in this case.

Note: The ellipse is a closed curve and has two foci and two directrices. A hyperbola is an open curve.



Ellipse



Hyperbola

Methods for Drawing an Ellipse

When the dimensions of major and minor axes are given, the ellipse can be drawn by :

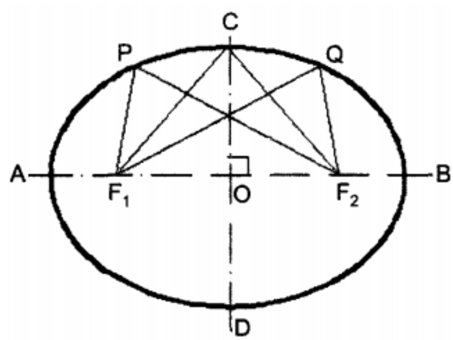
(i) Foci method

(ii) Oblong method

(iii) Concentric circle method and

(iv) Trammel method.

Definition of Ellipse

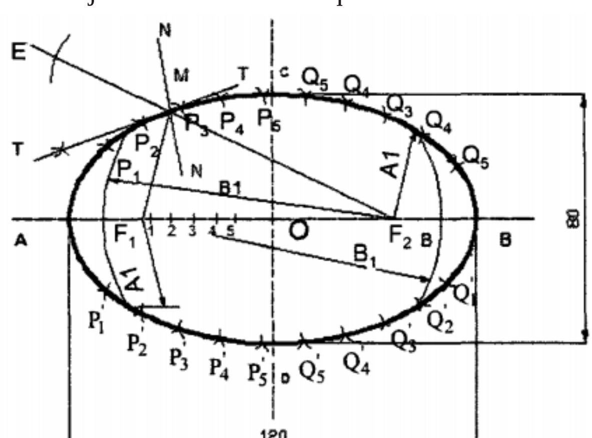


Ellipse is a curve traced by a point moving such that the sum of its distances from the two fixed points, foci, is constant and equal to the major axis.

Referring the given figure, F_1 and F_2 are the two foci, AB is the major axis and CD is the minor axis. As per the definition, $PF_1 + PF_2 = CF_1 + CF_2 = QF_1 + QF_2 = AB$. It may also be noted that $CF_1 = CF_2 = 1/2$ AB (Major axis)

Construction of Ellipse by Foci Method

To draw an ellipse with major and minor axes equal to 120 mm and 80 mm respectively.



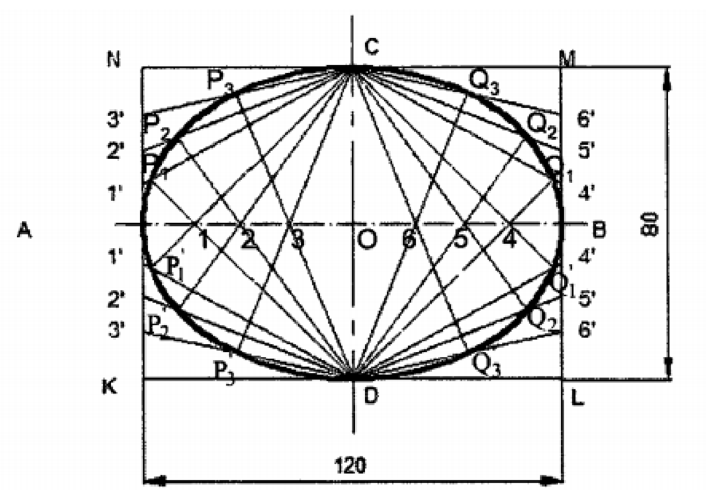
1. Draw the major (AB) and ninor (CD) axes and locate the centre O.
2. Locate the foci F_1 and F_2 by taking a radius equal to 60 mm (1/2 of AB) and cutting AB at F_1, P_1 and F_2 with C as the centre.
3. Mark a number of points 1,2,3 etc., between F_1 and 0, which need not be equidistance.
4. With centres F_1 and F_2 and radii A_1 and B_1 respectively, draw arcs intersecting at the points P_1 and P_1^1 .
5. Again with centres F_1 and F_2 and radii B_1 and A_1 respectively, draw arcs intersecting at the points Q_1 and Q_1^1 .
6. Repeat the steps 4 and 5 with the remaining points 2,3,4 etc., and obtain additional points on the curve.

   Join the points by a smooth curve, forming the required ellipse.

To mark a Tangent and Normal to the ellipse at any point, say M on it, join the foci F1 and F2 with M and extend F2M to E and bisect the angle <EMF1. The bisector TT represents the required tangent and a line NN drawn through M and perpendicular to TT is the normal to the ellipse.

Construction of ellipse by Oblong Method

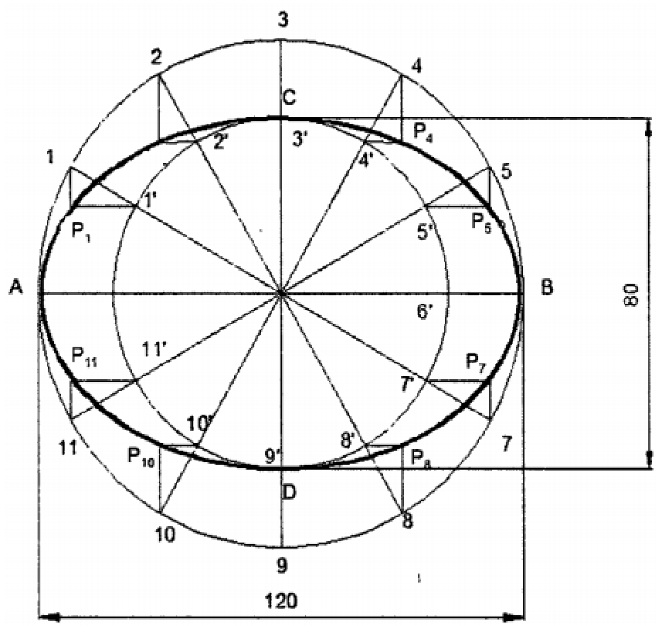
To draw an ellipse with major and minor axes equal to 120 mm and 80 mm respectively.



1. Draw the major and minor axes AB and CD and locate the centre O.
2. Draw the rectangle KLMN passing through A,D,B,C.
3. Divide AO and AN into same mumber of equal parts, say 4.

4. Join C with the points 1',2',3' .
5. Join D with the points 1,2,3 and extend till they meet the lines C_1^1, C_2^1, C_3^1 respectively at P_1, P_2 and P_3.
6. Repeat steps 3 to 5 to obtain the points in the remaining three quadrants.
7. Join the points by a smooth curve forming the required ellipse.

Construction of Ellipse by Concentric Circles Method

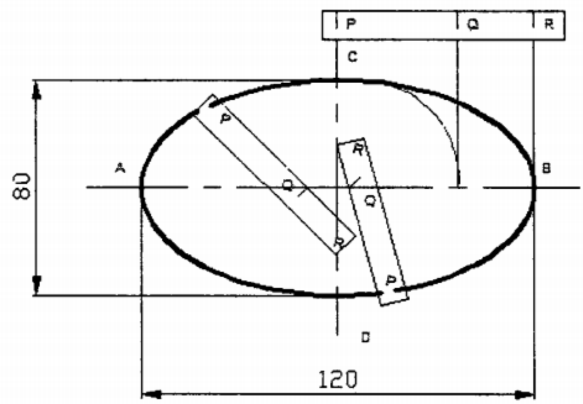


To draw an ellipse with major and minor axes equal to 120 mm and 80 mm respectively.

1. Draw the major and minor axes AB and CD and locate the centre O.
2. With centre 0 and major axis and minor axes as diameters, draw two concentric circles.
3. Divide both the circles into equal number of parts, say 12 and draw the radial lines.
4. Considering the radial line 0-1'-1, draw a horizontal line from 1' to meet the vertical line from 1 at P_1.
5. Repeat the steps 4 and obtain other points P_2, P_3 etc.
6. Join the points by a smooth curve forming the required ellipse.

Construction of ellipse by Trammel Method

To draw an ellipse with major and minor axes equal to 120 mm and 80 mm respectively.



Trammel Method

1. Draw the major and minor axes AB and CD and then locate the centre O.
2. Take a strip of stiff paper and prepare a trammel as shown. Mark the semi-major and semi-minor axes PR and PQ on the trammel.
3. Position the trammel so that the points R and Q lie respectively on the minor and major axes. As a rule, the third point P will always lie on the ellipse required.
4. Keeping R on the minor axis and Q on the major axis, move the trammel to other position and locate other points on the curve.
5. Join the points by a smooth curve forming the required ellipse.

Methods for Drawing a Parabola.

When the dimensions of base and axis are given, the parabola can be drawn by:

(i) Tangent method

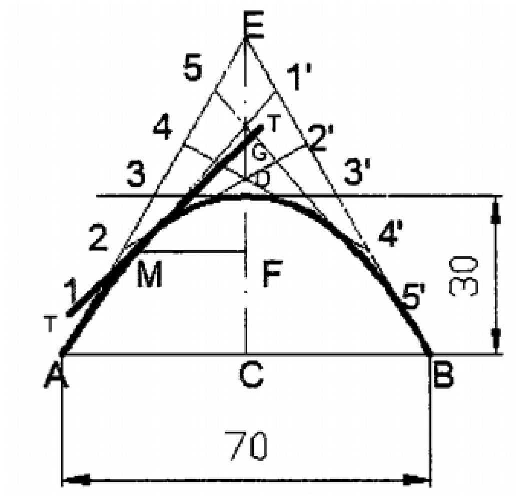
(ii) Rectangular method

(iii) Parallelogram method

Construction of Parabola by Tangent Method

To draw a parabola with 70 mm as base and 30 mm as the length of the axis.

1. Draw the base AB and locate its mid-point C.
2. Through C, draw CD perpendicular to AB forming the axis
3. Produce CD to E such that DE = CD



4. Join E-A and E-B. These are the tangents to the parabola at A and B.
5. Divide AE and BE into the same number of equal parts and number the points as shown.
6. Join 1-1' ,2-2' ,3-3' , etc., forming the tangents to the required parabola.
7. A smooth curve passing through A, D and B and tangential to the above lines is the required parabola.

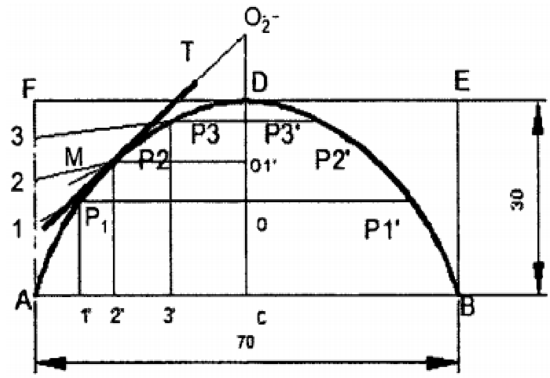
Note:

To draw a tangent to the curve at a point, say M on it, draw a horizontal through M, meeting the axis at F. mark G on the extension of the axis such that DG = FD. Join G, M and extend forming the tangent to the curve at M.

Construction of Parabola by Rectangle Method

To draw a parabola with 70 mm as base and 30 mm as the length of the axis.

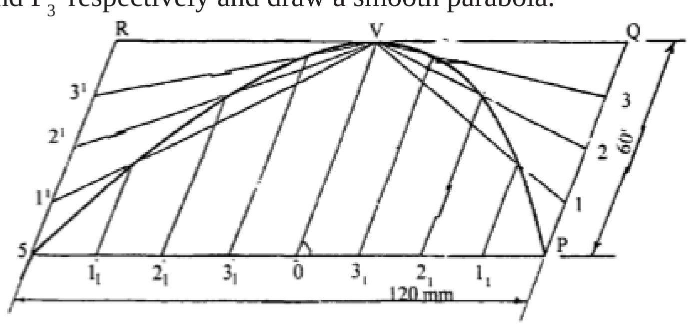
1. Draw the base AB and axis CD such that CD is perpendicular bisector to AB.
2. Construct a rectangle ABEF, passing through C.
3. Divide AC and AF into the same number of equal parts and number the points as shown.
4. Join 1,2 and 3 to D.
5. Through 1',2' and 3', draw lines parallel to the axis, intersecting the lines ID, 2D and 3D at P_1, P_2 and P_3 respectively.



6. Obtain the points P11, P21, and P31, which are symmetrically placed to P1, P2 and P3 with respect to the axis CD.
7. Join the points by a smooth curve forming the required parabola.

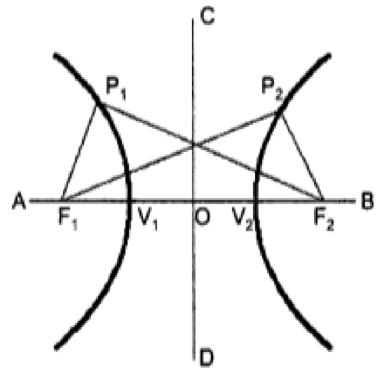
Construction of parabola by Parallelogram Method

1. Construct the parallelogram PQRS (PS = 120 mm PQ = 60 mm and angle QPS = 75°). Bisect PS at 0 and draw VO parallel to PQ.
2. Divide PO and SR into any number of (4) equal parts as 1, 2, 3 and 1^1,2^1 , 3^1 respectively starting from P on PQ and from S on SR. Join V1, V2 & V3. Also join V1', V2', and V3'
3. Divide PO and OS into 4 equal parts as 1_1,2_1,3_1 and 1_1' ,2_1' ,3_1' respectively starting from P on PO and from S on SO.
4. From 1_1 draw a line parallel to PQ to meet the line V1 at P_1 similarly obtain the points P_2 and P_3.
5. Also from 1_1' ,2_1' ,3_1' draw lines parallel to RS to meet the lines V1', V2', and V3' at P_1', P_2', and P_3' respectively and draw a smooth parabola.



Hyperbola

A hyperbola is a curve generated by a point moving such that the difference of its distances from two fixed points called foci is always constant and equal to the distance between the vertices of the two branches of hyperbola. This distance is also known as the major axis of the hyperbola.

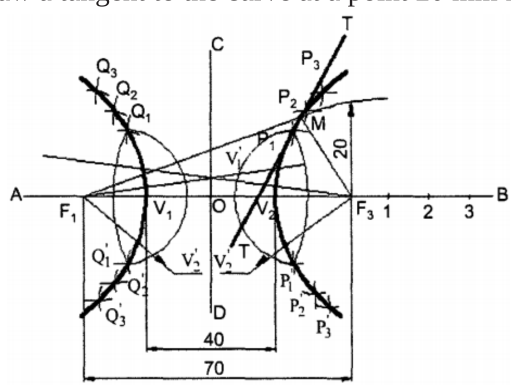


In figure, the difference between $P_1F_1 \sim P_1F_2 = P_2F_2 \sim P_2F_1 = V_1V_2$ (major axis)

The axes AB and CD are known as transverse and conjugate axes of the hyperbola. The curve has two branches which are symmetric about the conjugate axis.

Construction of Hyperbola

Construct a hyperbola with its foci 70 mm apart and the major axis (distance between the vertices) as 40 mm. Draw a tangent to the curve at a point 20 mm from the focus.



1. Draw the transverse and conjugate axes AB and CD of the hyperbola and locate F1 and F2 the foci and V1 and V2 the vertices.
2. Mark number of points 1,2,3 etc., on the transverse axis, which need not be equi-distant.
3. With center F1 and radius V11, draw arcs on either side of the transverse axis.
4. With center F2 and radius V21, draw arcs intersecting the above arcs at P1 and P11.
5. With center F2 and radius V11, draw arcs on either side of the transverse axis.

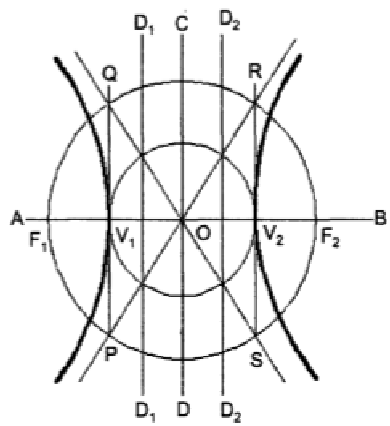
6. With center F1 and radius V21, draw arcs intersecting the above arcs at Q1, Q11.
7. Repeat the steps 3 to 6 and obtain other points P2, P2' etc. and Q2, Q2' etc.
8. Join the points P1,P2, P3, P1',P2',P3' and Q1,Q2,Q3 Q1',Q2',Q3' forming the two branches of hyperbola.

Note:

To draw a tangent to the hyperbola, locate the point M which is at 20mm from the focus say F2. Then, join M to the foci F_1 and F_2. Draw a line TT, bisecting the angle $<F_1 MF_2$ forming the required tangent at M.

To Draw the Asymptotes to the given Hyperbola

Lines passing through the center and tangential to the curve at infinity are known as asymptotes.



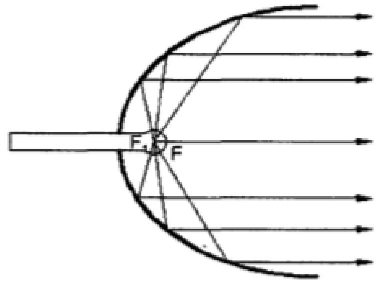
1. Through the vertices V_1 and V_2 draw perpendiculars to the transverse axis.
2. With center O and radius $OF_1 = (OF_2)$, draw a circle meeting the above lines at P, Q and R,S.
3. Join the points P, O, R and S, O, Q and extend, forming the asymptotes to the hyperbola.

Note: The circle drawn with O as center and V_1, V_2 as diameters is known as auxiliary circle. Asymptotes intersect the auxiliary circle on the directrix. Thus, D_1, D_1 and D2, D2 are the two directrices for the two branches of hyperbola.

Application of Conic Curves

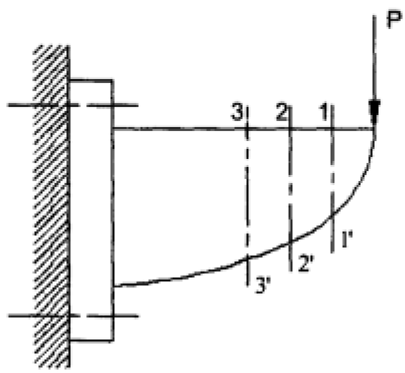
An ellipsoid is generated by rotating an ellipse about its major axis. An ellipsoidal surface is used as a head-lamp reflector. The light source (bulb) is placed at the first focus F I .

This works effectively, if the second focus F2 is at a sufficient distance from the first focus. Thus, the light rays reflecting from the surface are almost parallel to each other.



Parabolic Curve

The parabolic curve feds its application for reflecting surfaces oflight, Arch forms, cable forms in suspension bridges, wall of uniform strength, etc.



The parabolic reflector may be used as a solar heater. When it is properly adjusted, the sun rays emanating from infinite distance concentrate at the focus and thus produce more heat. The wall bracket of parabolic shape exhibits equal bending strength at all sections.

Exercis

Choose the correct answer from the given alternatives.

1. Which of the following is the eccentricity for an ellipse?

   a. 1 b. 3/2 c. 2/3 d. 5/2

2. Which of the following is not belonged to ellipse?

   a. Latus rectum b. Directrix c. Major axis d. Asymptotes

3. The two fixed points in the ellipse are called ________

   a. Focus b. Directrix c. Matrix d. Centre of focus

4. Which of the following passes through the two foci of an ellipse?

   a. Directrix b. Minor axis c. Major axis d. Conjugate axis

5. The normal at any point on the ellipse bisects the angle made by the point with the two foci of the ellipse. What is this property called?

   a. Normality property b. Eccentricity property

   c.Directrix property d. Focus-to-Focus property

6. In which of the following elliptical curves are not used?

   a. Arches b. Bridges c. Light reflectors d. Stuffing-box

7. In which of the following elliptical curves are used?

   a. Sound reflectors b. Light reflectors

   c. Cooling towers d. Bridges

8. Which of the following method is not used for construction elliptical curves?

   a. Rectangular method b. Arc of circle method

   c. Concentric circle method d. Oblong method

9. Which of the following is used for the construction of ellipse?

   a. Rectangular method b. Circular method

   c. Trammel method d. Cylindrical method

10. Which is appropriate input needed to draw the ellipse in arcs of circle method?

    a. Length of the major axis

b. Length of major axis and distance between the foci

c. Length of the minor axis

d. Length of the semi-major axis

11. Which is appropriate input needed to draw the ellipse in concentric circle method?

    a. Length of the major axis
    b. Length of the major axis and minor axis
    c. Length of the minor axis
    d. Length of the semi-major axis

12. Which of the following designs do not require the parabolic curve?

    a. Light reflectors
    b. Sound reflectors
    c. Cooling towers
    d. Arches

13. Which of the following design requires the parabolic curves?

    a. Cooling towers
    b. Water channels
    c. Stuffing box
    d. Light reflectors

14. Which of the following is the eccentricity of the parabola?

    a. 1
    b. ½
    c. 3/2
    d. 4

15. Which of the following method is used for construction parabolic curves?

    a. Rectangular method
    b. Arc of the circle method
    c. Concentric circle method
    d. Oblong method

16. The generating point is outside the generating circle for_____________

    a. Cycloid
    b. Superior Trochoid
    c. Inferior Trochoid
    d. Epicycloid

17. Which of the following represents an Archemedian spiral?

    a. Tornado
    b. Cyclone
    c. Mosquito coil
    d. Fibonacci series

18. Which of the following does not represents an Archemedian spiral?

    a. Coils in heater
    b. Tendrils
    c. Spring
    d. Cyclone

19. The mosquito coil we generally see in house hold purposes and heating coils in electrical heater etc are generally which spiral.

    a. Logarithmic spiral
    b. Equiangular spiral

c. Fibonacci spiral d. Archemedian spiral

20. In the first step, what do we do to find the center of an arc?
    a. Draw a straight line connecting the ends of arcs
    b. Bisect the curve
    c. Draw two chords
    d. Draw a triangle inside the curve

21. Which of the following instrument is not needed to construct a square?
    a. Set-square b. T-square
    c. French curves d. Compass

22. When all the adjacent ends of the perpendicular diameters of the circle are connected, which of the following is the outcome?
    a. Inscribed square b. Circumscribed square
    c. Inscribed triangle d. Circumscribed triangle

23. Which of the following curves are used for the design of gear tooth profile of a dial gauge?
    a. Spirals b. Helix c. Cycloidal curves d. Evaluates

24. What is the fixed point which is responsible for generating the conics?
    a. Vertex b. Directrix c. Focus d. Eccentricity

25. The eccentricity for the hyperbola is ____________
    a. $e<1$ b. $e>1$ c. $e=1$ d. $-1<e<1$

26. In a rectangular hyperbola, the angle between the 2 asymptotes is equal to ___
    a. 180^0 b. 60^0 c. 90^0 d. 45^0

27. When the eccentricity of a conic curve is smaller than 1, the curve known as ___
    a. Parabola b. Hyperbola c. Ellipse d. Circle

28. Conic sections are the sections created by the intersection of _____________ by different relative positions of the plane to the axis.
    a. Cylinder b. Pyramid
    c. Right circular cone d. Trapezoid

29. Which curve is generated when the surface of a cone is intersected by a closed curve on one side of the apex?

    a. Hyperbola   b. Parabola

    c. Ellipse   d. Rectangular hyperbola

30. Which curve is generated when the surface of a cone is intersected by a closed curve parallel to the generating circle of the cone on one side of the apex?

    a. Hyperbola   b. Parabola

    c. Circle   d. Rectangular hyperbola

Write short answer to the following questions.

1. Differentiate between epicycloid and hypocycloid.
2. Define a cycloid? How a tangent is drawn at a point on a cycloid?
3. What is an epicycloid? Give its practical applications.
4. What is a hypocycloid? Give its practical applications.
5. Define an involute of a polygon.
6. What is an Archimedean spiral? Define the term convolution.
7. Differentiate between an Archimedean and a logarithmic spiral.
8. What is the nature of hypocycloid when radius of the directing circle is (a) equal tothe diameter of the rolling circle, (b) twice the diameter of the rolling circle?
9. Explain the working of a four bar mechanism with the help of a neat sketch.
10. With the help of a neat sketch describe a slider crank mechanism.
11. What is a conic section? Enlist its various types.
12. What is the inclination of the cutting plane in order to obtain following sections from a cone

    a. parabola   b. ellipse

    c. hyperbola   d. rectangular hyperbola.

13. Give two practical applications for the following curves.

    a. parabola   b. ellipse   c. hyperbola.

14. Define eccentricity.
15. Enlist at least four common methods to draw the following curves.

    a. parabola,   b. ellipse,   c. hyperbola.

16. What principle is used for construction of ellipse using intersecting arcs method?

17. How is a tangent drawn from a point on the ellipse?
18. Give an equation for an ellipse showing relationship among, major axis, minor axisand distance between foci.
19. Explain conjugate diameters.
20. What principle is used for construction of parabola by offset method?
21. How is a tangent drawn from a point on the parabola.
22. Define ordinate, double ordinate, abscissa and latus rectum.
23. What principle is used for construction of hyperbola using intersecting arcs method.

Write long answer to the following questions.

1. Draw an ellipse when the distance of its vertex from its directrix is 24mm and distance of its focus from directrix is 42mm.
2. Draw the locus of a point which moves in such a manner that its distance from a fixed point its distance from a fixed straight line. Consider the distance between the fixed point and the fixed line as 60mm. Name the curve.
3. Construct a parabola if the distance between its focus and directrix is 60 mm. Also draw a tangent to the curve.
4. A vertex of a hyperbola is 50 mm from its focus. Draw two parts of the hyperbola; if the eccentricity is 3/2.
5. The focus of a hyperbola is 60mm from its directrix. Draw the curve when eccentricity is 5/3.Draw a tangent and a normal to the curve at appoint distant 45mm from the directrix
6. A coin of 40mm diameter rolls over a horizontal table without slipping. A point on the circumference of the coin in contact with the table surface in the beginning and after one complete revolution. Draw the path traced by the point. Draw a tangent and normal at a point 25 mm from the table.
7. Draw a parabola when the distance between focus and directrix is 50mm. Draw a tangent and normal at a point distant 70mm from the directrix.
8. The vertex of a hyperbola is 5cm from directrix. Draw the curve if the eccentricity is 3/2. Draw the normal and tangent at a point 50mm from axis.
9. A circle of 30mm diameter rolls on the concave side of generating circle of radius 30 mm. Draw the path traced by a point on the generating circle for one complete revolution.

Unit 6 Orthographic Projections

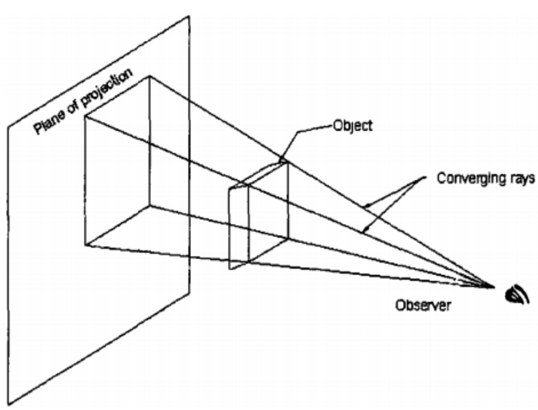
Introduction

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

Projection

As per the optical physics, an object is seen when the light rays called visual rays coming from the object strike the observer's eye. The size of the image formed in the retina depends on the distance of the observer from the object.

If an imaginary transparent plane is introduced such that the object is in between the observer and the plane, the image obtained on the screen is as shown in figure below. This is called perspective view of the object. Here, straight lines (rays) are drawn from various points on the contour of the object to meet the transparent plane, thus the object is said to be projected on that plane.



Perspective Projection

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

Types of Projections

1. Pictorial projections

(i) Perspective projection

(ii) Isometric projection

(iii) Oblique projection

2. Orthographic Projections

1. Pictorial Projections

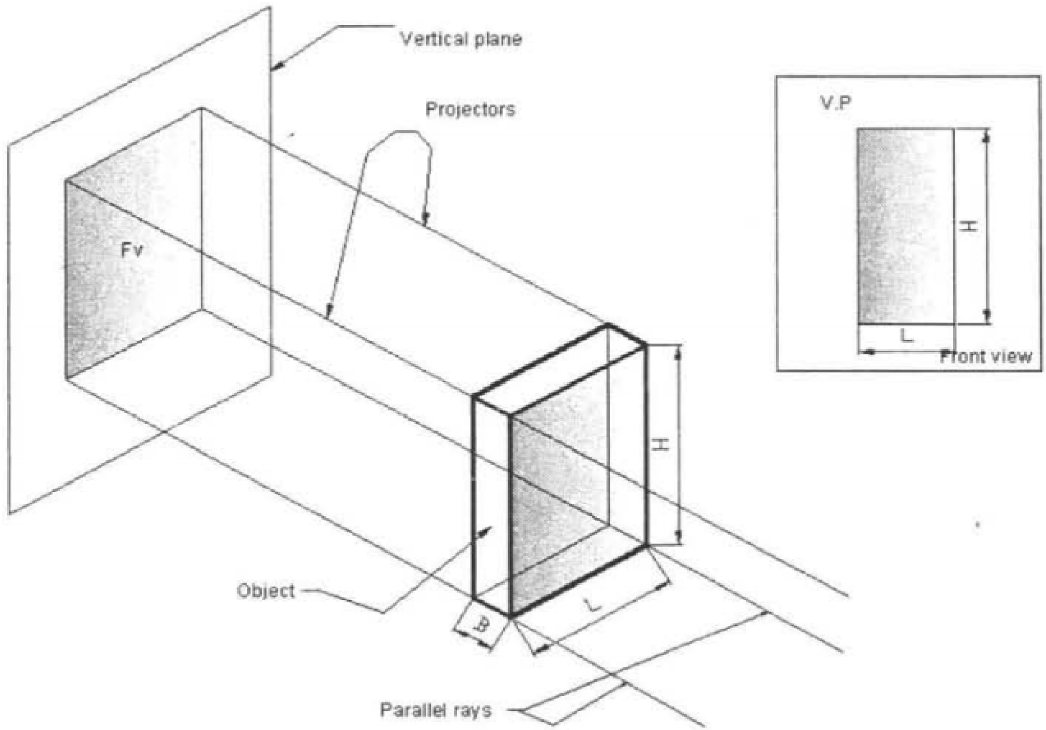
The Projections in which the description of the object is completely understood in one view is known as pictorial projection. They have the advantage of conveying an immediate impression of the general shape and details of the object, but not its true dimensions or sizes.

2. Orthographic Projection

'ORTHO' means right angle and orthographic means right angled drawing. When the projectors are perpendicular to the plane on which the projection is obtained, it is known as orthographic projection.

Method of Obtaining Front View

Imagine an observer looking at the object from an infinite distance. The rays are parallel to each other and perpendicular to both the front surface of the object and the plane. When the observer is at a finite distance from the object, the rays converge to the eye as in the case of perspective projection. When the observer looks from the front surface F or the block, its true shape and size is seen. When the rays or projectors are extended further they meet the vertical plane (V.P) located behind the object. By joining the projectors meeting the plane in correct sequence the front view is obtained.



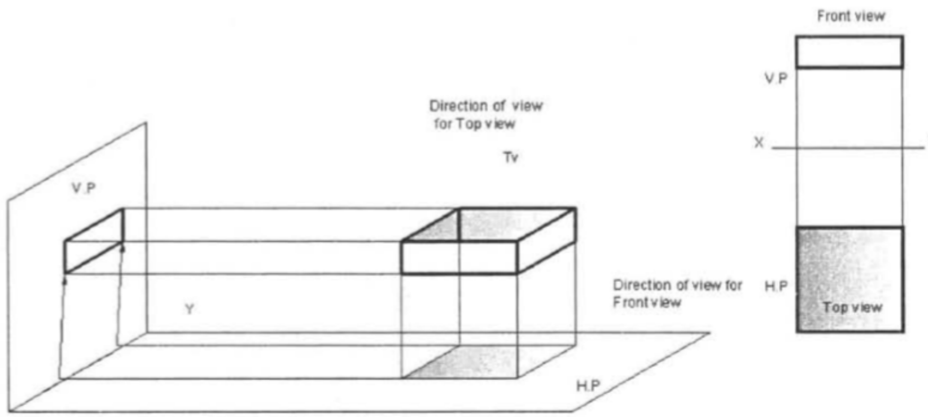
Method of Obtaining Front View

Front view shows only two dimensions of the object, Viz. length L and height H. It does not show the breadth B. Thus one view or projection is insufficient for the complete description of the object.

As Front view alone is insufficient for the complete description of the object, another plane called Horizontal plane (H.P) is assumed such that it is hinged and perpendicular to V.P and the object is in front of the V.P and above the H.P

Method of Obtaining Top View

Looking from the top, the projection of the top surface is the Top view (TV). Both top surface and top view are of exactly the same shape and size. Thus, top view gives the true length L and breadth B of the block but not the height H.



Method of Obtaining Orthographic Top View.

Note

(1) Each projection shows that surface of the object which is nearer to the observer and far away from the plane.

(2) Orthographic projection is the standard drawing form of the industrial world.

XY Line: The line of intersection of VP and H.P is called the reference line and is denoted as XY.

Obtaining the Projection on the Drawing Sheet

It is convention to rotate the H.P through 90^0 in the clockwise direction about xy line so that it lies in the extension of VP. The two projections front view and top view may be drawn on the two dimensional drawing sheet.

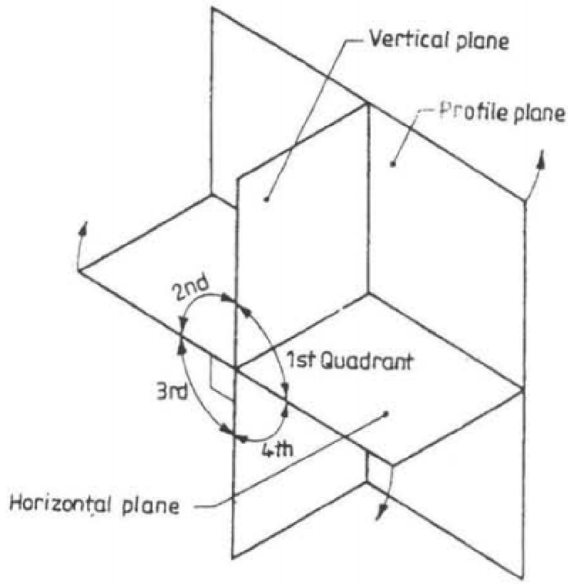
Thus, all details regarding the shape and size, Viz. Length (L), Height (H) and Breadth (B) of any object may be represented by means of orthographic projections i.e., Front view and Top view.

Terms Used

VP and H.P are called as Principal planes of projection or reference planes. They are always transparent and at right angles to each other. The projection on VP is designated as Front view and the projection on H.P as Top view.

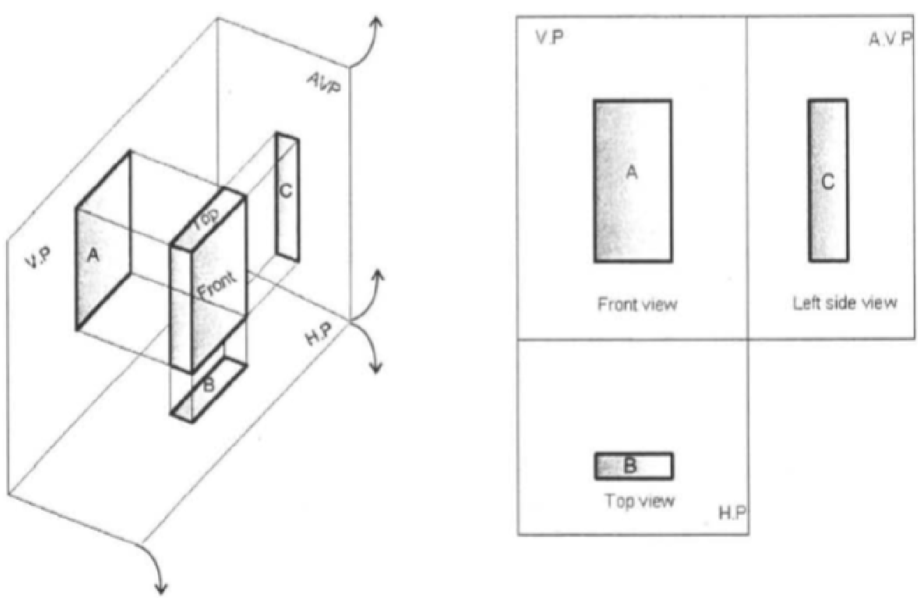
Four Quadrants

When the planes of projections are extended beyond their line of intersection, they form four quadrants. These quadrants are numbered as I, II, III and IV in clockwise direction when rotated about reference line xy as shown in figure 6.4.



Four Quadrants

In figure, the object is in the first quadrant and the projections obtained are "First angle projections" i.e., the object lies in between the observer and the planes of projection. Front view shows the length (L) and height (H) of the object, and top view shows the length (L) and the breadth (B) of it.



Orthographic Projection of Front, Top and Side views

The object may be situated in anyone of four quadrants, its position relative to the planes being described as in front of V.P and above H.P in the first quadrant and so on.

Figure 6.5 shows the two principle planes H.P and V.P and another Auxiliary vertical plane (AVP). AVP is perpendicular to both VP and H.P.

Front view is drawn by projecting the object on the V.P. Top view is drawn by projecting the object on the H.P. The projection on the AVP as seen from the left of the object and drawn on the right of the front view is called left side view.

First Angle Projection

When the object is situated in first quadrant, that is, in front of V.P and above H.P, the projections obtained on these planes is called First angle projection.

(i) The object lies in between the observer and the plane of projection.

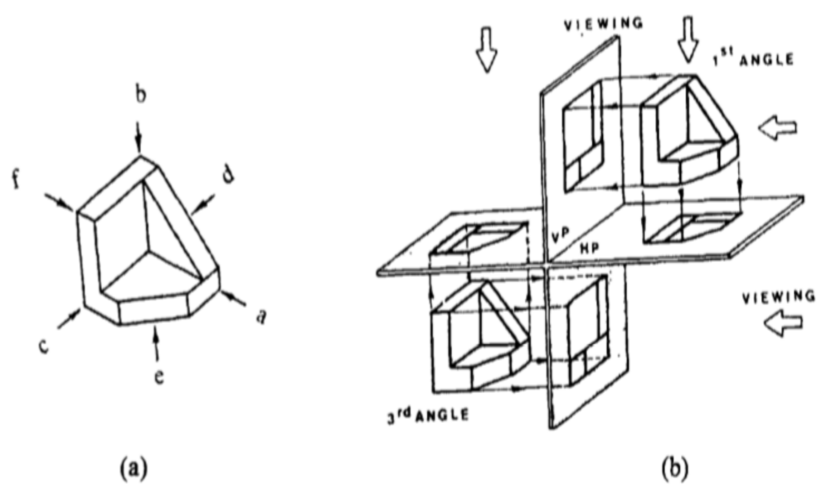
(li) The front view is drawn above the xy line and the top view below XY. (above XY line is V.P and below xy line is H.P).

(iii) In the front view, H.P coincides with xy line and in top view V.P coincides with XY line.

(iv) Front view shows the length (L) and height (H) of the object and Top view shows the length (L) and breadth (B) or width (W) or thickness (T) of it.

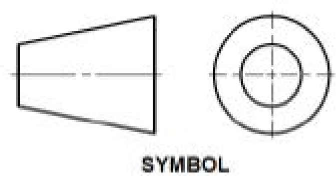
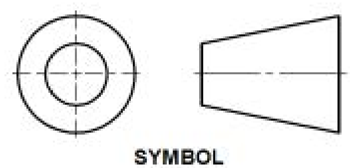
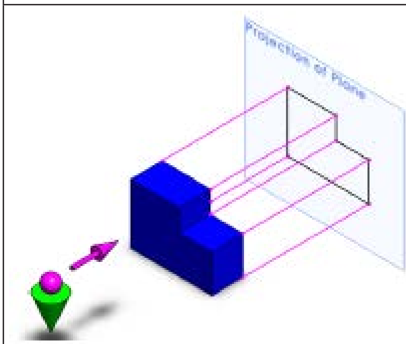
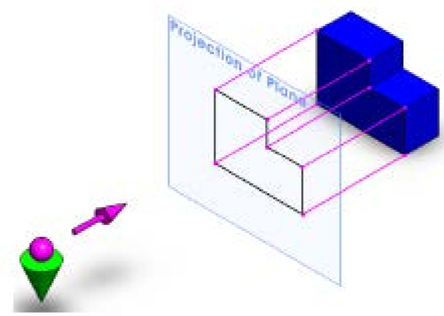
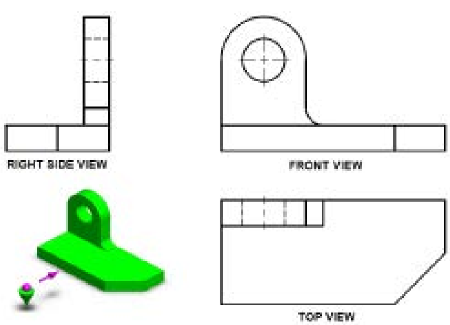
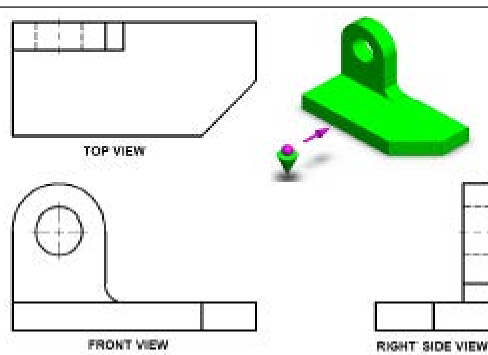
Third Angle Projection

In this, the object is situated in third quadrant. The Planes of projection lie between the object and the observer. The front view comes below the xy line and the top view about it.



Principles of orthographic projection.

Comparison between first angle and third angle projection

First Angle Projection	Third Angle Projection
1.The object is imagined to be in first quadrant.	1.The object is imagined to be in third quadrant.
2.The object lies between the observer and plane of projection.	2.The plane of projection lies between the observer and the object.
3.The plane of projection is assumed to be non transparent.	3.The plane of projection is assumed to be transparent.
4.When view are drawn in their relative position, top view comes below front view, right side view is drawn to the left side of elevation.	4.When views are drawn in their relative position, top view comes above front view, right side view is drawn to the right side of elevation.
	
	
	

Projection of Solids

Introduction

A solid has three dimensions, the length, breadth and thickness or height. A solid may be represented by orthographic views, the number of which depends on the type of solid and its orientation with respect to the planes of projection. Solids are classified into two major groups. (i) Polyhedral, and (ii) Solids of revolution

Polyhedra

A polyhedra is defined as a solid bounded by plane surfaces called faces.They are :

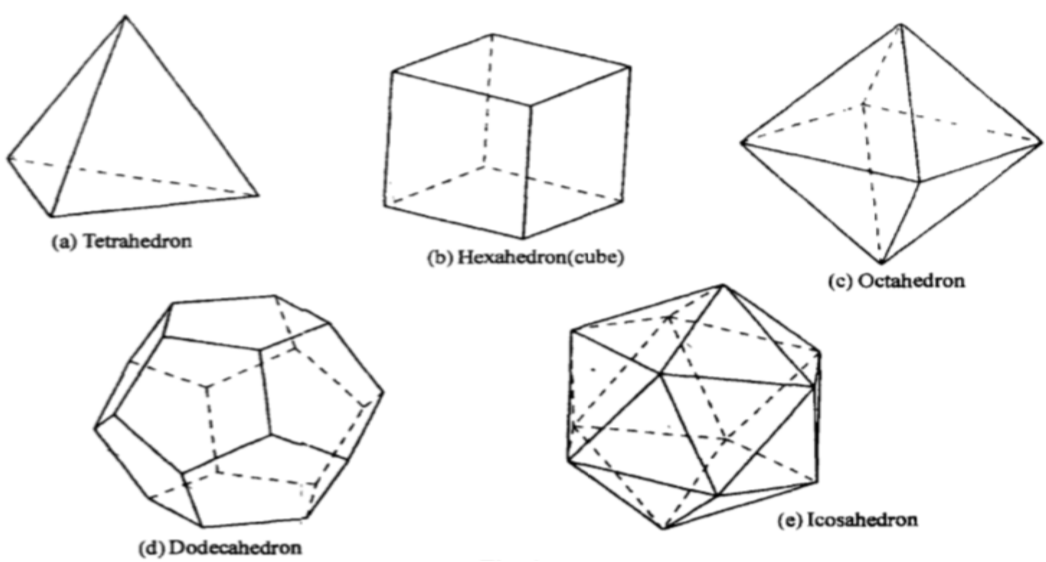
(i) Regular polyhedra

(ii) Prisms and

(iii) Pyramids.

Regular Polyhedra

A polyhedron is said to be regular if its surfaces are regular polygons. The following are some of the regular plolyhedra.



Types of polyhedra

(a) Tetrahedron: It consists of four equal faces, each one being a equilateral triangle.

(b) 'Hexahedron(cube): It consists of six equal faces, each a square.

(c) Octahedron: It has eight equal faces, each an equilateral triangle.

(d) Dodecahedron: It has twelve regular and equal pentagonal faces.

(e) Icosahedron: It has twenty equal, equilateral triangular faces.

Prisms

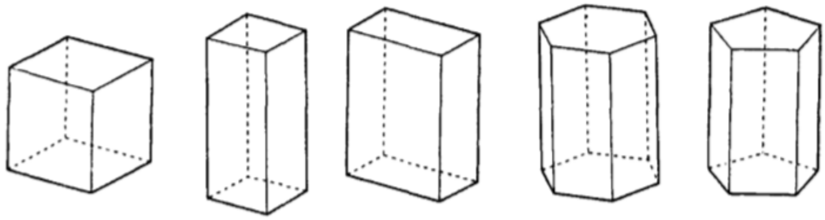
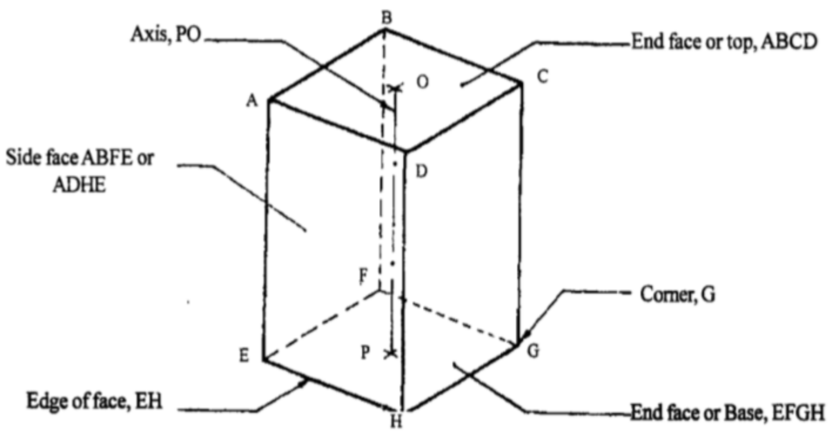


Fig. 6.2



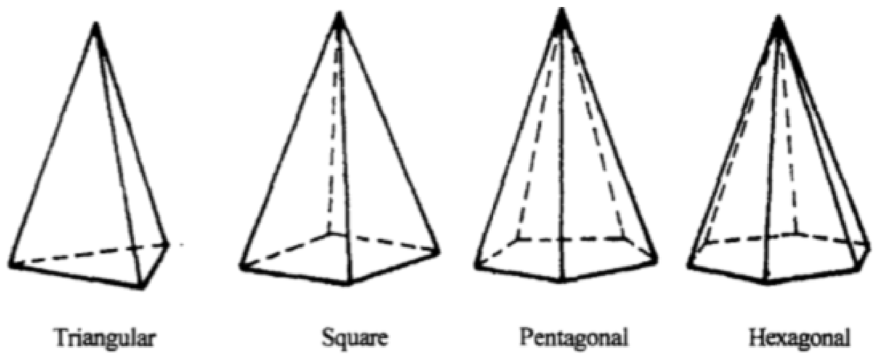
Nomenclature of a Square Prism

A prism is a polyhedron having two equal ends called the bases parallel I to each other. The two bases are joined by faces, which are rectangular in shape. The imaginary line passing through the centers of the bases is called the axis of the prism. A prism is named after the shape of its base. For example, a prism with square base is called a square prism, the one with a pentagonal base is called a pentagonal prism, and so on figure. The nomenclature of the square prism is given in figure.

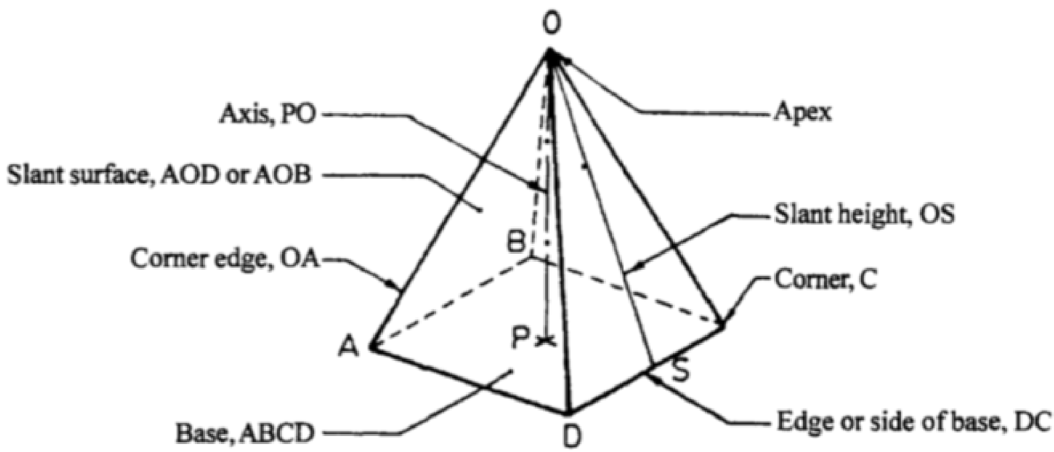
Pyramids

A pyramid is a polyhedron having one base, with a number of isosceles triangular faces, meeting at a point called the apex. The imaginary line passing through the center of the base and the apex is called the axis of the pyramid.

The pyramid is named after the shape of the base. Thus, a square pyramid has a square base and pentagonal pyramid has pentagonal base and so on figures. The nomenclature of a pyramid is shown in figure.



Pyramids



Nomenclature of a Square Pyramid

Solids of Revolution

If a plane surface is revolved about one of its edges, the solid generated is called a solid of revolution. The examples are:-

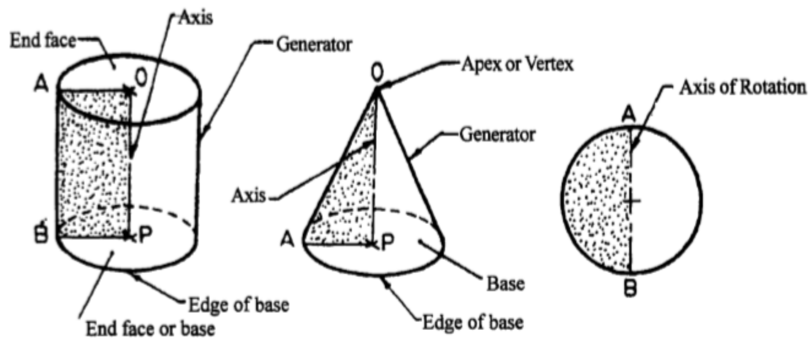
(i) Cylinder

(ii) Cone

(iii) Sphere.

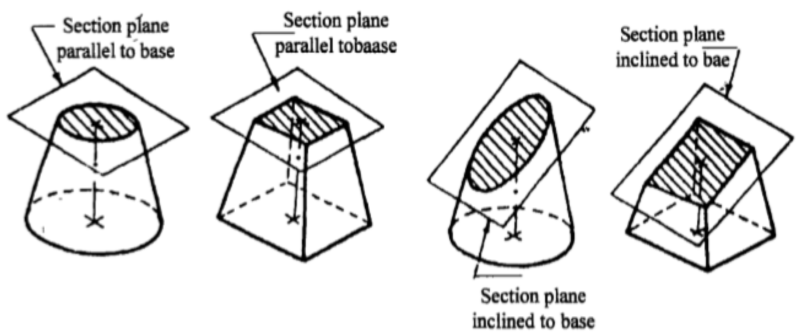
Frustums and Truncated Solids

If a cone or pyramid is cut by a section plane parallel to its base and the portion containing the apex or vertex IS removed, the remaining portion is called frustum of a cone or pyramid.



(a) Cylinder (b) Cone (c) Sphere

Solids of Revolution



Frustum of a Solid and Truncated Solids

Prisms (problem) Position of a Solid with Respect to the Reference Planes

The position of solid in space may be specified by the location of the axis, base, edge, diagonal or face with the principal planes of projection. The following are the positions of a solid considered.

1. Axis perpendicular to one of the principal planes
2. Axis parallel to both the principal planes
3. Axis inclined to one of the principal planes and parallel to the other
4. Axis inclined to both the principal planes

The position of solid with reference to the principal planes may also be grouped as follows:

1. Solid resting on its base

2. Solid resting on anyone of its faces, edges of faces, edges of base, generators, slant edges, etc.
3. Solid suspended freely from one of its comers, etc.

Section

Introduction

Sections of Solids

Sections and sectional views are used to show hidden detail more clearly. Theyare created by using a cutting plane to cut the object.

A section is a view of no thickness and shows the outline of the object at the cutting plane.

Visible outlines beyond the cutting plane are not drawn.

A sectional view, displays the outline of the cutting plane and all visible outlines which can be seen beyond the cutting plane.

Improve visualization of interior features. Section views are used when important hidden details are in the interior of an object. These details appear as hidden lines in one of the orthographic principal views; therefore, their shapes are not very well described by pure orthographic projection.

Types of Section Views

- Full sections
- Half sections
- Offset sections
- Revolved sections
- Removed sections
- Broken-out sections

Cutting Plane

Section views show how an object would look if a cutting plane (or saw) cut through the object and the material in front of the cutting plane was discarded

Representation of cutting Plane

According to drawing standards cutting plane is represented by chain line with alternate long dash and dot. The two ends of the line should be thick.

Full Section View

- In a full section view, the cutting plane cuts across the entire object
- Note that hidden lines become visible in a section view

Hatching

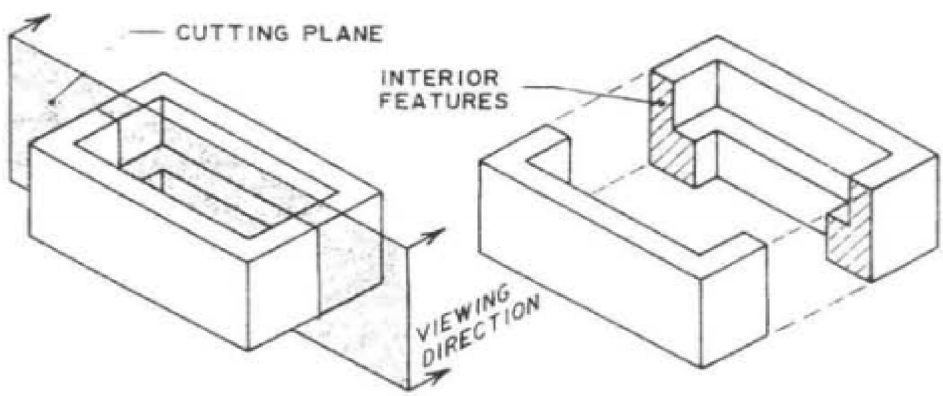
On sections and sectional views solid area should be hatched to indicate this fact. Hatching is drawn with a thin continuous line, equally spaced (preferably about 4mm apart, though never less than Imm) and preferably at an angle of 4S degrees.

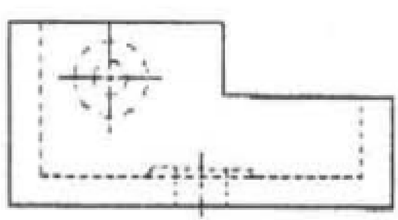
(i) Hatching a Single Object

When you are hatching an object, but the objects have areas that are separated. All areas of the object should be hatched in the same direction and with the same spacing.

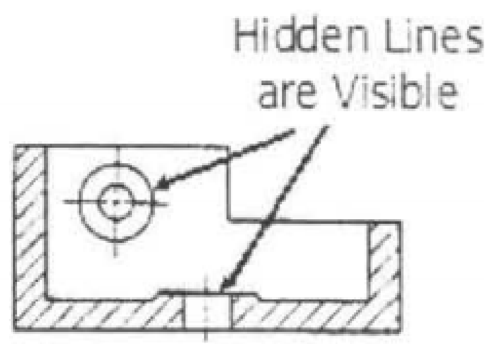
(ii) Hatching Adjacent Objects

When hatching assembled parts, the direction of the hatching should ideally be reversed on adjacent parts. If more than two parts are adjacent, then the hatching should be staggered to emphasize the fact that these parts are separate.

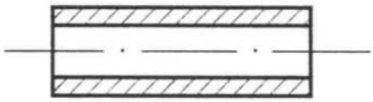




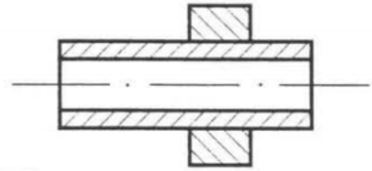
Normal multiview drawing



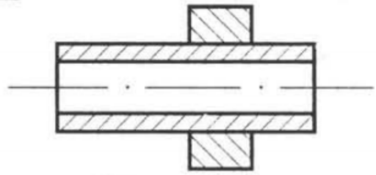
Section view drawing



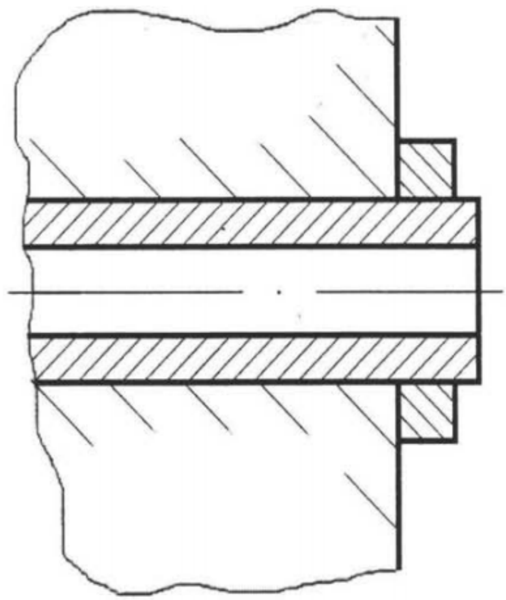
(a) Hatching a single object



(b) Reverse hatching



(c) Staggered Hatching



Hatching large areas

Examples

Problem 1 : A square prism of base side 30 mm and axis length 60 mm is resting on HP on one of its bases, with a base side inclined at 30° to V.P. It is cut by a plane .inclined at 40° to H.P. and perpendicular to V.P. and is bisecting the axis of the prism. Draw its front view, sectional top view and true shape of section.

Solution 7 : Draw the projections of the prism in the given position. The top view is drawn and the front view is projected.

To draw the cutting plane, front view and sectional top view

1. Draw the Vertical Trace (VT) of the cutting plane inclined at 40^0 to XY line and passing through the mid point of the axis.

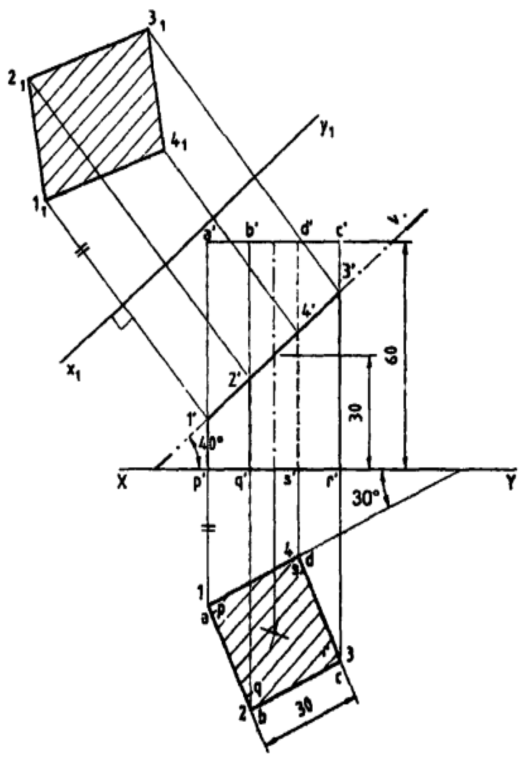
2 As a result of cutting, longer edge a' p' is cut, the end a' has been removed and the new corner 1' is obtained.

3. Similarly 2' is obtained on longer edge b' q', 3' on c' r' and 4' on d's',

4. Show the remaining portion in front view by drawing dark lines.

5. Project the new points 1',2',3' and 4' to. get 1,2,3 and 4 in the top view of the prism, which are coinciding with the bottom end of the longer edges p, q, r and s respectively.

6. Show the sectional top view or apparent section by joining 1, 2, 3 and 4 by drawing hatching lines.



To draw the true shape of a section

1. Consider an auxiliary inclined plane parallel to the cutting plane and draw the new reference line x1 y1 parallel to VT of the cutting plane at an arbitrary distance from it.

2. Draw projectors passing through 1',2',3' and 4' perpendicular to x1 y1 line.

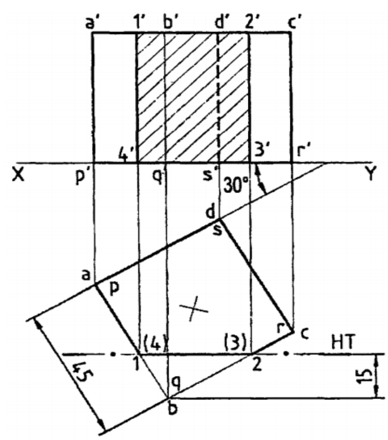
3. The distance of point 1 in top view from XY line is measured and marked from x1 y1 in the projector passing through 1' to get 11'. This is repeated to get the other points 21, 31 and 41,

4. Join these points to get the true shape of section as shown by drawing the hatching lines

Problems 2 : A cube of 4S mm side rests with a face on HP such that one of its vertical faces is inclined at 30° to VP. A section plane, parallel to VP cuts the cube at a distance of 15 mm from the vertical edge nearer to the observer. Draw its top and sectional front view.

Solution

1. Draw the projections of the cube and the Horizontal Trace (HT) of the cutting plane parallel to XY and 15 mm from the vertical edge nearer to the observer.
2. Mark the new points 1,2 in the top face edge as ab and be and similarly, 3, 4 in the bottom face edge as qr and pq which are invisible in top view.
3. Project these new points to the front view to get 1', 2 ' in top face and 3' , 4' in. bottom face.
4. Join them and draw hatching lines to show the sectional front view which also shows the true shape of section.



Problem 3 : A pentagonal pyramid of base side 40 mm and axis length 80 mm is resting on HP on its base with one of its base side parallel to VP. It is cut by a plane inclined at 30° to HP and perpendicular to VP and is bisecting the axis. Draw its front view, sectional top view, and the true shape of section.

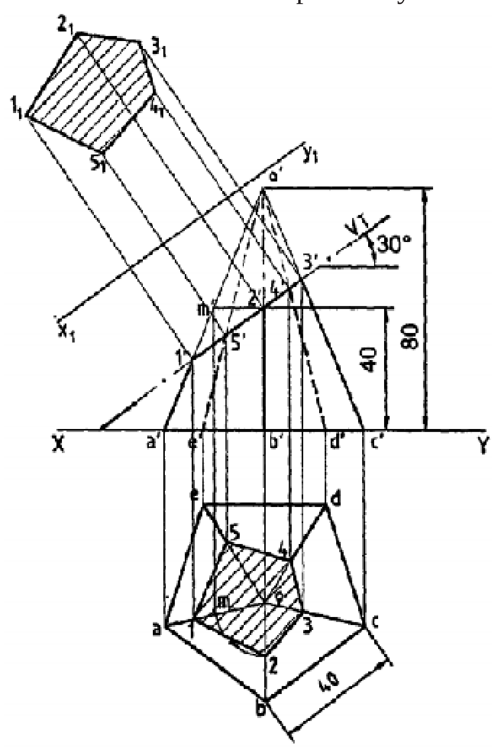
Solution: Draw the projection of the pyramid in the given position. The top view is drawn and the front view is projected.

To draw the cutting plane, front view and sectional top view

1. Draw the VT of the cutting plane inclined at 30° to XY line and passing through the

midpoint of the axis.

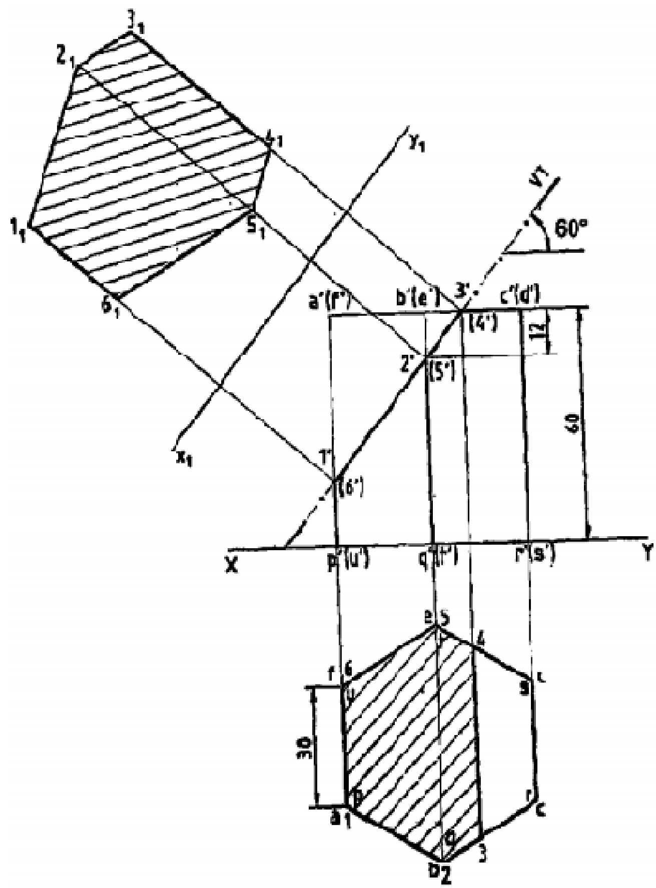
2. As a result of cutting, new comers 1', 2', 3', 4' and 5' are obtained on slant edges a '0', b '0',c '0', d'o' and e '0' respectively.
3. Show the remaining portion in front view by drawing dark lines.
4. Project the new points to get 1,2,3,4 and 5 in the top view on the respective slant edges.
5. Note that 2' is extended horizontally to meet the extreme slant edge a ' 0 ' at m', it is projected to meet ao in top view at m. Considering 0 as centre, om as radius, draw an arc to get 2 on bo.
6. Join these points and show the sectional top view by drawing hatching lines.



To Draw True Shape of Section

1. Draw the new reference.line x_1y_1 parallel to VT of the cutting plane.
2. Projectors from 1',2' etc. are drawn perpendicular to X_1Y_1 line.
3. The distance of point 1 in top view from XY line is measured and marked from X_1Y_1 in the projector passing through 1' to get 1_1' This is repeated to get 2_1,3_1 etc.
4. Join these points and draw hatching lines to show the true shape of section.

Problem 4: A hexagonal prism of base side 30 mm and axis length 60 mm is resting on HP on one of its bases with two of the vertical faces perpendicular to VP. It is cut by a plane inclined at 600 to HP and perpendicular to VP and passing through a point at a distance 12 mm from the top base. Draw its front view, sectional top view and true shape of section.



Solution: Draw the projections of the prism in the given position. The top view is drawn and the front view is projected.

To draw the cutting plane, front view and sectional top view

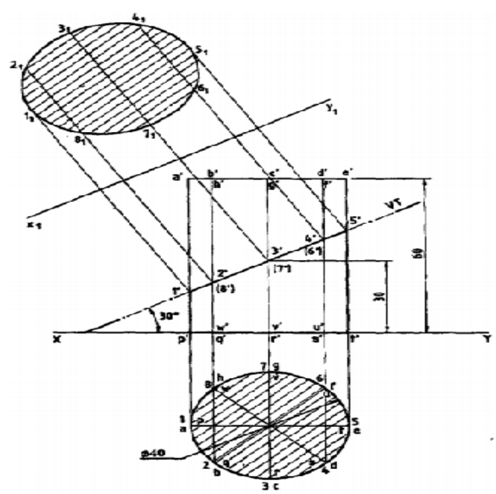
1. Draw the VT of the cutting plane inclined at 60° to XY and passing through a point in the axis, at a distance 12 mm from the top base.
2. New points 1',2', etc. are marked as mentioned earlier. Note that the cutting plane cuts the top base, the new point 3' is marked on base side b' c' and 4' marked on (d') (e') which is invisible.
3. Project the new points 1',2', etc. to get 1,2, etc. in the top view.

4. Join these points and draw the hatching lines to show the sectional top view.

To Draw True Shape of Section

1. Draw new reference line X_1Y_1 parallel to the VT of the cutting plane.
2. Draw the projectors passing through 1', 2', etc. perpendicular to X_1Y_1 line.
3. The distance of point 1 in top view from XY line is measured and marked from X_1Y_1 in the projector passing through 1' to get 1_1 This is repeated to get other points 2_1, 3_1 etc.
4. Join these points to get the true shape of section and this is shown by hatching lines.

Problem 5 : A cylinder of base diameter 40 mm and height 60 mm rests on its base on HP. It is cut by a plane perpendicular to VP and inclined at 30° to HP and meets the axis at a distance 30 mm from base. Draw the front view, sectional top view, and the true shape of section.



Solution : Draw the projections of the cylinder. The top view is drawn and the front view is projected. Consider generators by dividing the circle into equal number of parts and project them to the front view.

To draw the cutting plane, front view and sectional top view

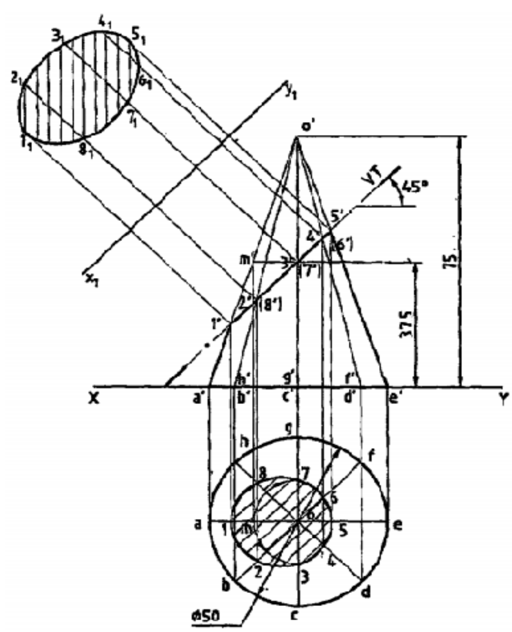
1. Draw the VT of the cutting plane inclined at 30° to XY line and passing through a point on the axis at a distance 30 mm from base.
2. The new point 1', 2' etc. are marked on the generators a' p', h' q' etc.
3. Project the new points to the top view to get 1, 2, etc. which are coinciding with p, q, etc. on the base circle.

4. Join these points and draw the hatching lines to show the sectional top view.

To Draw True Shape of Section.

1. Draw X_1Y_1 line parallel to VT of the cutting plane.
2. Draw the projectors through 1',2', etc. perpendicular to X_1Y_1 line.
3. The distance of point 1 in top view from XY line is measured and marked from X_1Y_1 in the projector passing through 1' to get 1_1' This is repeated to get other points 2_1,3_1 etc.
4. Join these points by drawing smooth curve to get the true shape of section and this is shown by hatching lines.

Problem 6 : A cone of base diameter 50 mm and axis length 75 mm, resting on HP on its base is cut by a plane in lined at 45° to HP and perpendicular to VP and is bisecting the axis. Draw the front view and sectional top view and true shape of this section.



Solution: Draw the projections of the cone. Consider generators by dividing the circle into equal number of parts and project them to the front view.

To draw the cutting plane, front view and sectional top view

1. Draw the VT of the cutting plane inclined at 45° to the XY line and passing through the mid point of the axis.
2. New points 1',2' etc; are marked on the generators a'0', h'0', etc.

3. Project the new points to the top view to get 1,2, etc. on the generators ao, bo etc.
4. Note that the new point 3' is produced to mark m' on a' 0' and is projected to get m on ao. Considering 0 as centre and om as radius, draw an arc to get 3 on co in the top view. The same method is repeated to get 7 on go.
5. Join these points by drawing smooth curve and draw the hatching lines to show the sectional top view.

To Draw True Shape of Section

1. Draw X_1Y_1 line parallel to VT of the cutting plane.
2. Draw the projectors through 1', 2' etc. perpendicular to X_1Y_1 line.
3. The distance of point 1 in top view from XY line is measured and marked from X_1Y_1 in the projector passing through 1' to get 1_1 and is repeated to get 2_1, 3_1 etc.
4. Join these points by drawing smooth curve to get the true shape of section and is shown by hatching lines.

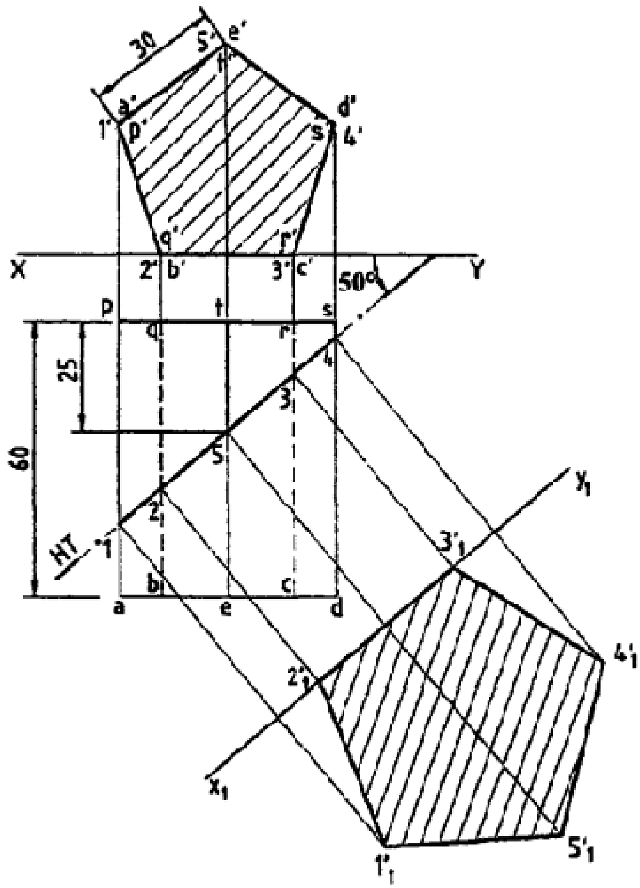
Problem 7: A pentagonal prism of base side 30 mm and axis length 60 mm is resting on HP on one of its rectangular faces, with its axis perpendicular to VP. It is cut by a plane inclined at 50° to VP and perpendicular to HP and passing through a point 25 mm from rear base of the prism. Draw its top view, sectional front view and true shape of section.

Solution: To draw the cutting plane, top view and sectional front view

1. Draw the projections of the prism. Draw the HI' of the cutting plane at 50° to XY and passing through the point on the axis at a distance of 25 mm from the rear base.
2. Mark the new points 1 on ap, 2 on bq etc.
3. Show the remaining portion in top view by drawing dark lines.
4. Project the new point 1, 2, etc. to the front view to get 1', 2' etc. which are coinciding with the rear end of the longer edges p', q' etc.
5. Show the sectional front view by joining 1', 2' etc. and draw hatching lines.

To Draw the True Shape of Section

1. Consider an AVP and draw X_1Y_1 line parallel to HT of the cutting plane.
2. Draw projectors through 1,2 etc. perpendicular to X_1Y_1 line.
3. The distance of I' in front view from XY line is measured and marked from X_1Y_1 in the projector passing through 1 to get 1_1', and this is repeated to get 2_1',3_1' etc.
4. Join them and show the true shape of section by drawing hatching lines.



C

Problem 8 : A cylinder of base diameter 45 and axis length 60 mm is resting on HP on one its generators with its axis perpendicular to VP. It is cut by a plane inclined 30° to VP and perpendicular to HP 'and is bisecting the axis of the cylinder. Draw its top view, sectional front view and true shape of section.

Solution: Draw the projections of the cylinder. Consider generators by dividing the circle into equal number of parts and project them to the top view.

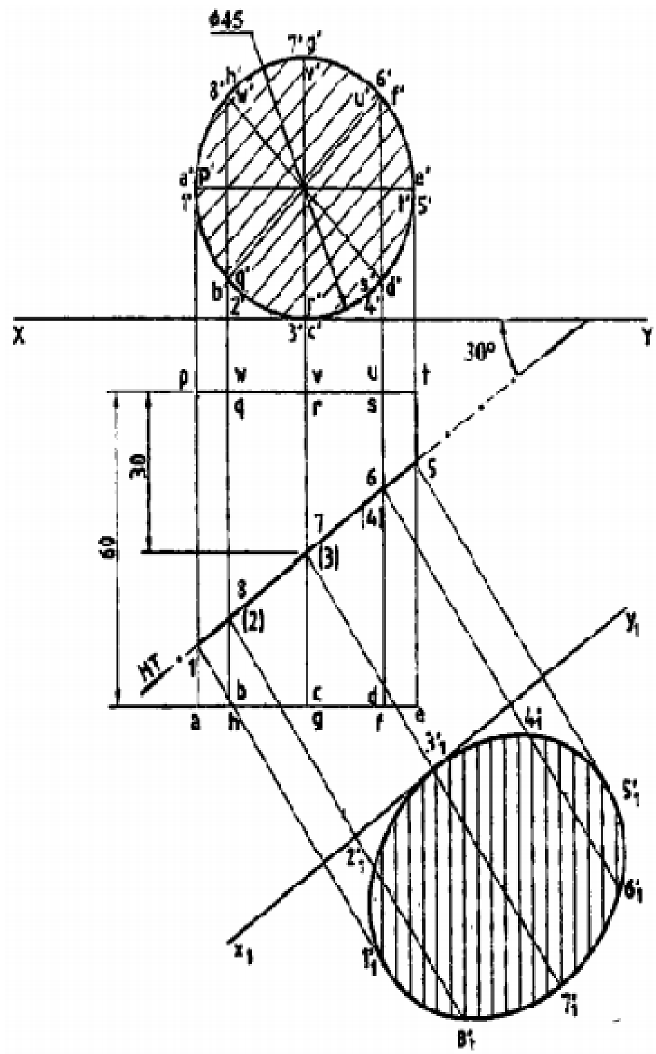
To draw the cutting plane, top view and sectional, front view

1. Draw the HT of the cutting plane inclined at 300 to XY and passing through the midpoint of the axis.
2. The new points 1,2, etc. are marked on generators ap, hq, etc.
3. Project the new points to the front view to get 1',2' etc. which are coinciding with p, q, etc. on the base circle.

4. Join them and draw hatching lines to show the sectional front view.

To Draw the True Shape of Section

1. Draw X_1Y_1 line parallel to HT of the cutting plane.
2. Draw projectors through 1, 2, etc. perpendicular to X_1Y_1 line.
3. The distance of I' in front view from XY line is measured and marked from X_1Y_1 in the projector passing through 1' to get $1_1'$ and is repeated to get $2_1'$,$3_1'$ etc.
4. Join them by drawing smooth curve and show the true shape of section by drawing hatching lines.



Exercise

Choose the correct answer from the given alternatives.

1. The straight lines which are drawn from various points on the contour of an object to meet a plane are.........

   a. Connecting lines   b. Projectors

   c. Perpendicular lines   d. Hidden lines.

2. When the projectors are parallel to each other and also perpendicular to the plane, the projection is

   a. Perspective projection   b. Oblique projection

   c. Isometric projection   d. Orthographic projection

3. In the Oblique projection, how many views typically used to represent an object?

   a. one view   b. two views   c. three views   d. four views

4. Which type of projection represents we usually see around us without using technical drawing? ?

   a. Perspective projection   b. Oblique projection

   c. Isometric projection   d. Orthographic projection

5. How many dimensions of an object does each projection view represent in orthographic projection?

   a. 1   b. 2   c. 3   d. 0

6. Which type of line is used to respect the hidden parts inside or onthe back side of on object orthographic projection?

   a. Continuous thick line   b. Continuous thin line

   c. Dashed thin line   d. Long-break line

7. What is additional 3rd view on orthographic projection in general for simple objects?

   a. Front view   b. Top view

   c. Side view   d. View at 45 degrees perpendicular to horizontal plane

8. In 3rd angle projection the object is kept in __________

a. 1st quadrant
b. 2nd quadrant
c. 3rd quadrant
d. 4th quadrant

9. In 3rd angle projection, the positions of front view and top views are?
   a. Top view lies above the front view
   b. Front view lies above the top view
   c. Front view lie left side to top view
   d. Top view lie left side to front view

10. Where is the position of bottom view in 3rd angle projection?
    a. Left side of right hand side view
    b. Right side of right hand side view
    c. Above the front view
    d. Below the top view

11. Where is the position of back view in 3rd angle projection?
    a. Left side of right hand side view
    b. Right side of right hand side view
    c. Above the front view
    d. Below the top view

12. To understand some of the hidden geometry of components an imaginary plane is used to cut the object which is called ______________
    a. Auxiliary plane
    b. Picture plane
    c. Section plane
    d. Additional plane

13. Which of the following is not the purpose of using cutting (section) plane?
    a. Interpretation of object
    b. Visualizing of object
    c. Cutting the objects
    d. Invisible features

14. A section plane is parallel to V.P the top view gives ____________ which is __________ to xy line.
    a. True shape, parallel
    b. Straight line, parallel
    c. Straight line, perpendicular
    d. True shape, perpendicular

15. The section plane is perpendicular to H.P and inclined to V.P the front view of section if section is a line. It _________________ xy line.

a. Is perpendicular to b. Is parallel to

c. Is inclined to V.P d. Crosses

16. The section plane is perpendicular to H.P and inclined to V.P the top view of section if section is a line. It ________________ xy line.

    a. Is perpendicular to b. Is parallel to

    c. Is inclined to V.P d. Crosses

17. A section is perpendicular to both the reference planes the true shape and size is obtained by taking projection of section on to _________ plane.

    a. Horizontal b. Vertical c. Profile d. Auxiliary

18. A section is parallel to horizontal plane the true shape and size is obtained by taking projection of section on to _________ plane.

    a. Horizontal b. Vertical c. Profile d. Auxiliary

19. A section is parallel to vertical plane the true shape and size is obtained by taking projection of section on to _________ plane.

    a. Horizontal b. Vertical c. Profile d. Auxiliary

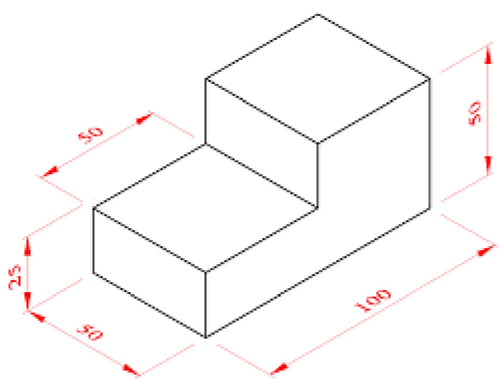
Write short answer to the following questions.

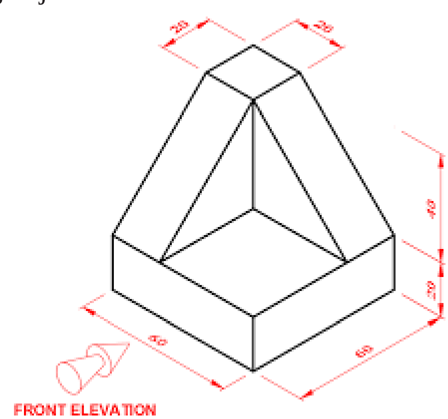
1. What do you mean by projection? Give its classification.
2. Differentiate between a pictorial view and multi-view.
3. What is an orthographic projection?
4. What is a multi-view projection? How does it differ from axonometric projection?
5. How should a solid or an object be placed on the planes to obtain multi-views. Explain it with the help of necessary sketches.
6. Define vertical, horizontal and profile plane.
7. Define elevation, plan and end view.
8. Differentiate between first angle and third angle projection.
9. Give the symbolic representation of first and third angle projection.
10. What is the criterion for selection of the face of an object suitable for front view, whiledrawing multi-views?
11. Explain reference arrows method for representation of multi-views as suggested byBIS. Where is this method beneficial?

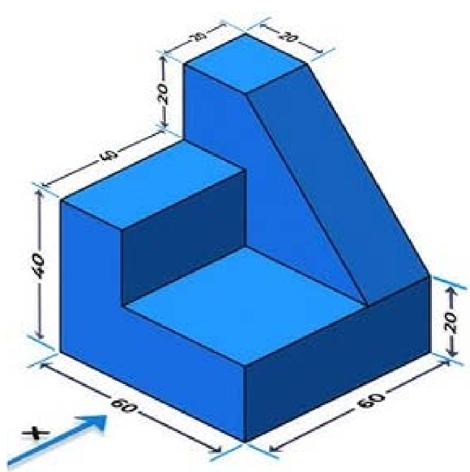
12. State the advantages of a sectional view.
13. State the advantages of a half sectional view.
14. To obtain a half sectional view, how much portion of the object is actually removed?
15. Can a cutting plane line ever be omitted in sectional drawings? If yes, when?
16. Name any five items that would not be cut in a sectional view though the cuttingplane line may cut them longitudinally.
17. With the help of a suitable example show the difference between a revolved and a removed section.
18. State the advantages of auxiliary views.
19. Describe a situation when a secondary auxiliary view would be necessary.

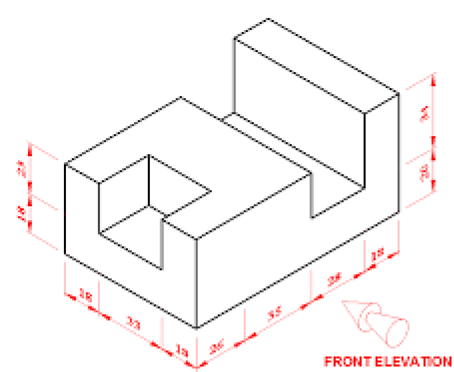
Write long answer to the following questions.

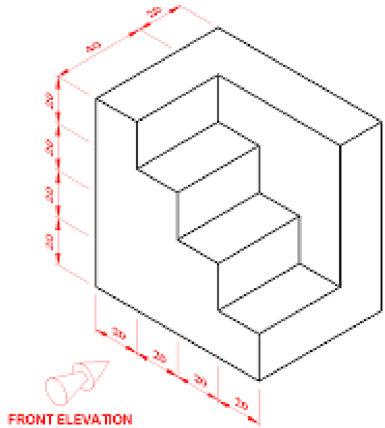
1. Draw orthographic projection of following objects.

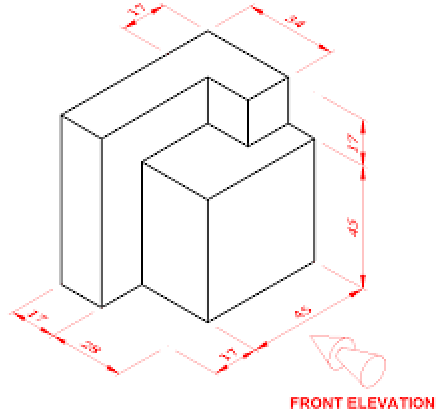









FRONT ELEVATION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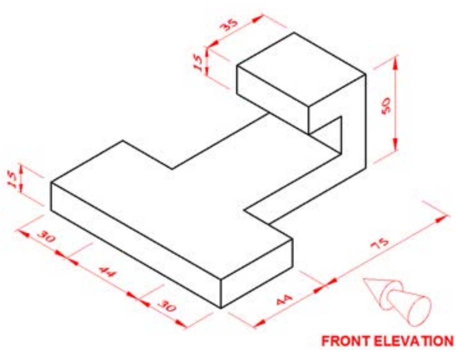
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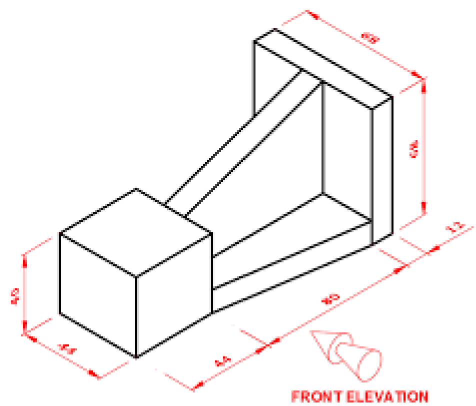
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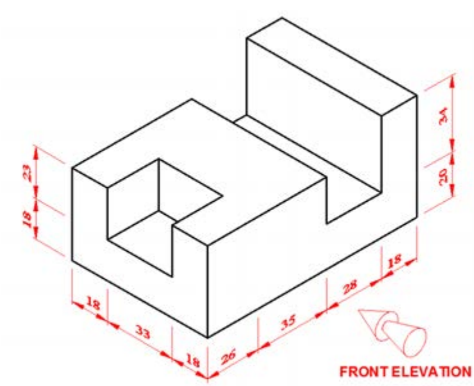
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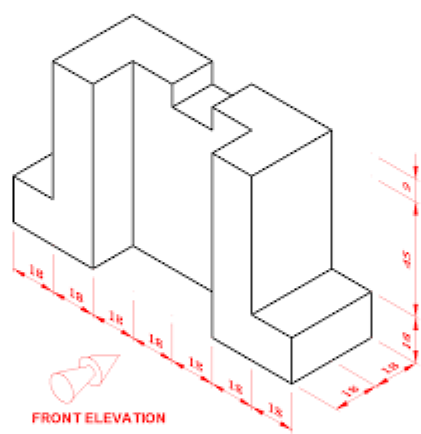
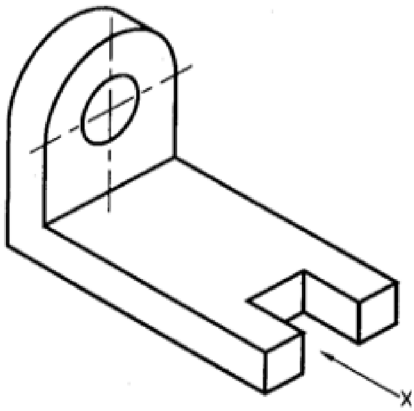
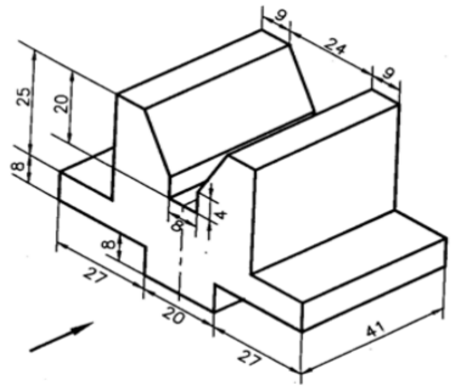

FRONT ELEVATION





Project works

1. A cube of side 35 mm rests on the ground with one of its vertical faces inclined at 30^0 to the V.P. A vertical section plane parallel to V.P. and perpendicular to H.P. and at a distance of 35 mm from V.P. cuts the solid. Draw the sectional front view and top view.

2. A regular hexagonal pyramid of side 30 mm and height 65 mm is resting on its base on H.P. one of its base sides is parallel to V.P. It is cut by a cutting plane which is parallel to H.P. and perpendicular to V.P. and passing through at a height of 45 mm from its bottom. Draw its sectional front view and top view.

3. A regular hexagonal prism of side 30 mm and height 70 mm is standing on V.P. with its axis perpendicular to V.P. being one of its rectangular faces parallel to H.P. It is cut by a section plane inclined at 60^0 to the H.P. perpendicular to V.P. and passing through the mid-point of the bottom side on the front face which is parallel to H.P. Draw its sectional front view and top view. Also draw the true shape.

4. A regular pentagonal prism of side 35 mm and height 75 mm has its base in H.P. and one of the rectangular faces makes an angle of 45^0 to V.P. It is cut by a section plane inclined at 60^0 to H.P. perpendicular to V.P. and passing through one of the vertical edges at a distance of 25 mm above the base Draw its

   a. Sectional front view b. Sectional top view and

   c. True shape.

5. A cone of diameter 60 mm and height 70 mm is resting on ground on its base. It is cut by a section plane perpendicular to V.P. inclined at 45^0 to H.P. and cutting the axis at a point 40 mm from the bottom. Draw the front view, sectional top view and true shape.

6. A right circular cylinder of diameter 60 mm and height 75 mm rests on its base such that its axis is inclined at 45^0 to H.P. and parallel to V.P. A cutting plane parallel to H.P. and perpendicular to V.P. cuts the axis at a distance of 50mm from the bottom face. Draw the front view and sectional top view.
7. A regular pentagonal pyramid of side 30 mm and height 60 mm is lying on the H.P. on one of its triangular faces in such a way that its base edge is at right angles to V.P. It is cut by a plane at 30^0 to the V.P. and at right angle to the H.P. bisecting its axis. Draw the sectional view from the front, the view from above and the true shape of the section.
8. A square pyramid base 50 mm side and axis 75 mm long is resting on the ground with its axis vertical and side of the base equally inclined to the vertical plane. It is cut by a section plane perpendicular to V.P. inclined at 45^0 to the H.P. and bisecting the axis. Draw its sectional top view and true shape of the section.
9. A hexagonal pyramid of base side 30 mm and height 75 mm is resting on the ground with its axis vertical. It is cut by plane inclined at $30^0$to the H.P. and passing through a point on the axis at 20 mm form the vertex. Draw the elevation and sectional plane.
10. A cut of 40 mm side rests on the H.P. on one of its faces with a vertical face inclined on 30^0 to V.P. A plane perpendicular to the H.P. and inclined at $60^0$to the V.P. cuts the cube 5mm away from the axis. Draw the top view and the sectional front view.
11. A cylinder 40 mm dia. and 60 mm long is lying in the H.P. with the axis parallel to both the planes. It is cut by a vertical section plane inclined at 30^0 to V.P. so that the axis is cut a point 20 mm from one of its ends. Draw top view, sectional front view and true shape of section.

Unit 7 Pictorial Projection

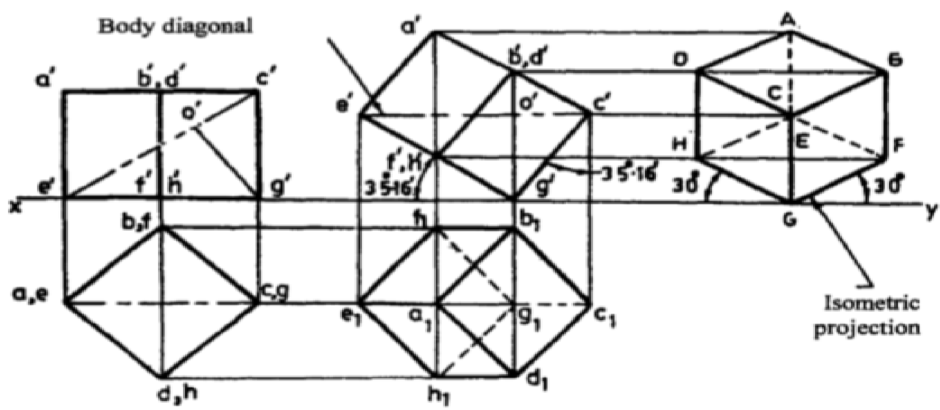
Introduction

Pictorial projections are used for presenting ideas which may be easily understood by persons even without technical training and knowledge of multi-view drawing. The Pictorial drawing shows several faces of an object in one view, approximately as it appears to the eye.

Principle of Isometric Projections

It is a pictorial orthographic projection of an object in which a transparent cube containing the object is tilted until one of the solid diagonals of the cube becomes perpendicular to the vertical plane and the three axes are equally inclined to this vertical plane.

Isometric projection of a cube in steps is shown in figure. Here ABCDEFGH is the isometric projection of the cube.



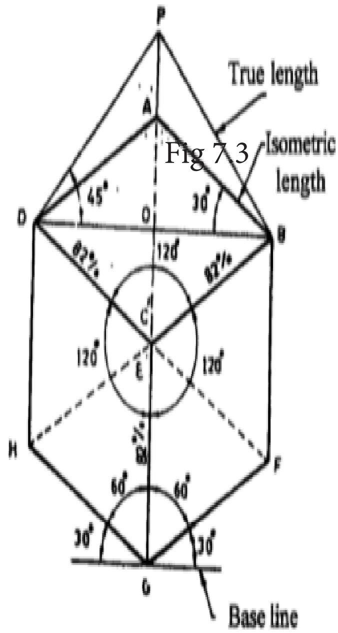
Principle of Isometric Projection

The front view of the cube, resting on one of its corners (G) is the isometric projection of the cube. The isometric projection of the cube is reproduced in figure.

Isometric Scale

In the isometric projection of a cube shown in figure, the top face ABED is sloping away from the observer and hence the edges of the top face will appear fore-shortened. The true shape of the triangle DAB is represented by the triangle DPB.

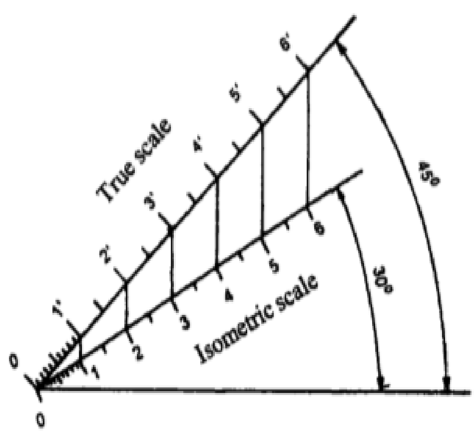
The extent of reduction of an isometric line can be easily found by construction of a diagram called isometric scale. For this, reproduce the triangle DPA as shown in figure. Mark the divisions of true length on DP. Through these divisions draw vertical lines to get the corresponding points on DA. The divisions of the line DA give dimensions to isometric scale.



An Isometric Cube

From the triangle ADO and PDO in figure, the ratio of the isometric length to the true length i.e. DAIDP = cos 45°/cos30^0 = 0.816

The isometric axes are reduced in the ratio 1 :0.816 ie. 82% approximately.



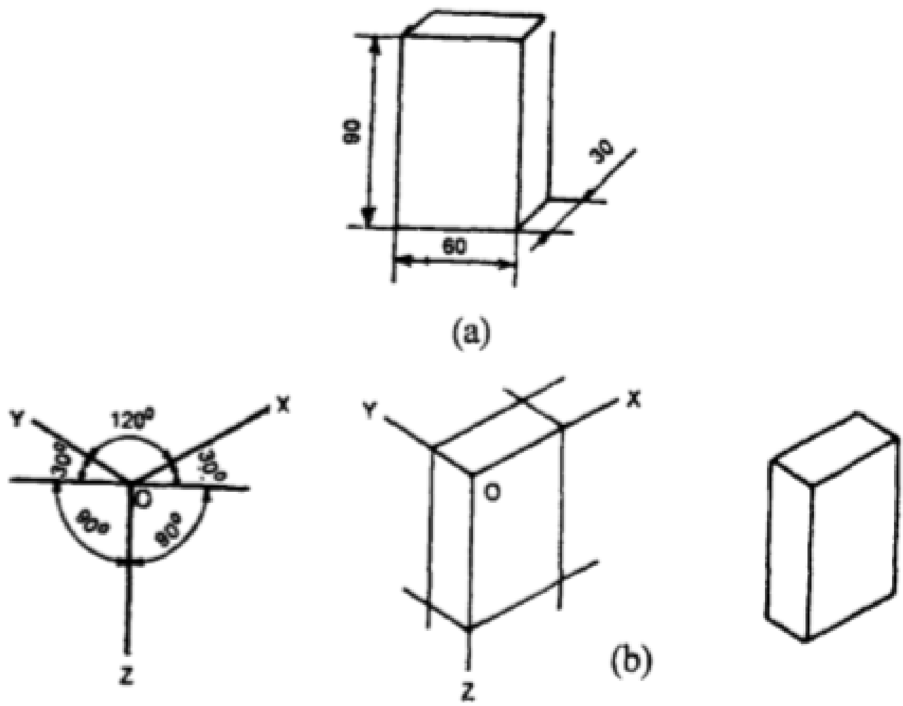
Isometric Scale

Lines in Isometric Projection

The following are the relations between the lines in isometric projection which are evident from figure.

1. The lines that are parallel on the object are parallel in the isometric porjection.
2. Vertical lines on the object appear vertical in the isometric projection.
3. Horizontal lines on the object are drawn at an angle of 30° with the horizontal in the isometric projection.
4. A line parallel to an isometric axis is called an isometric line and it is fore shortened to 82%.
5. A line which is not parallel to any isometric axis is called non-isometric line and the extent of fore-shortening of non-isometric lines are different if their inclinations with the vertical planes are different.

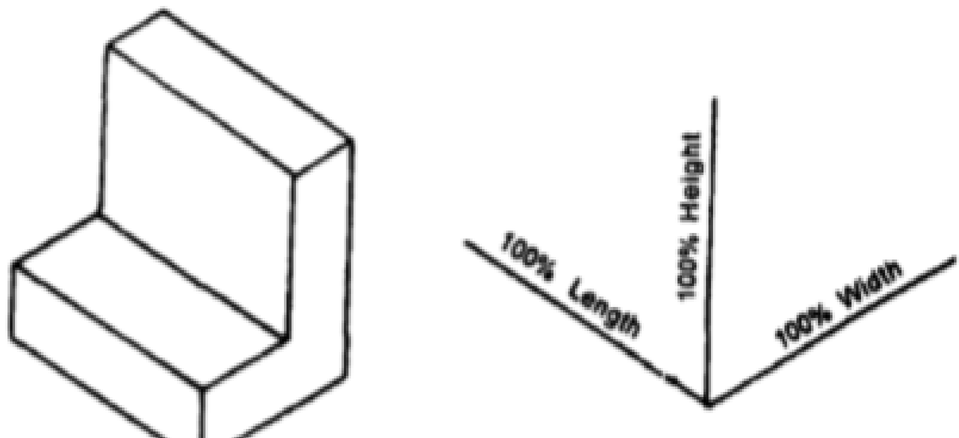
   Figure shows a rectangular block in pictorial form and figure, the steps for drawing an isometric projection using the isometric scale.



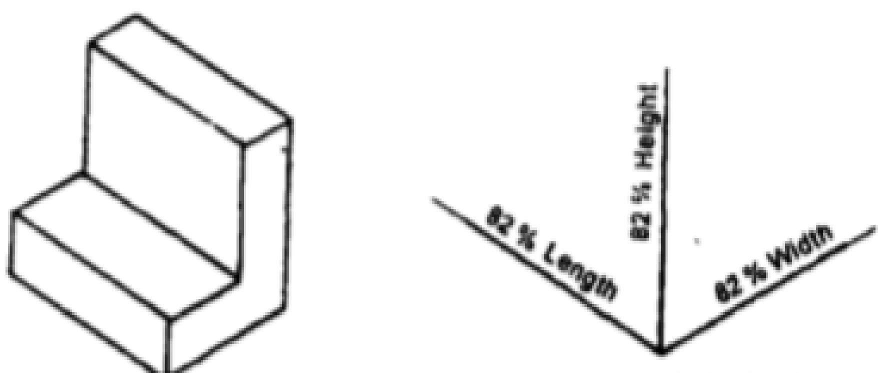
Developing Isometric Projection

Isometric Drawing

Drawing of objects is seldom drawn in true isometric projections, as the use of an isometric scale is inconvenient. Instead, a convenient method in which the fore shortening of lengths is ignored and actual or true lengths are used to obtain the projections, called isometric drawing or isometric view is normally used. This is advantageous because the measurement may be made directly from a drawing.



(a) Isometric Drawing



(b) Isometric Projection

The isometric drawing of figure is slightly larger (approximately 22%) than the isometric projection. As the proportions are the same, the increased size does not affect the pictorial value of the representation and at the same time, it may be done quickly. Above figure shows the difference between the isometric drawing and isometric projection.

Steps to be followed to make isometric drawing from orthographic views are given below :

1. Study the given views and note the principal dimensions and other features of the

object.

2. Draw the isometric axes (a).
3. Mark the principal dimensions to-their true values along the isometric axes(b).

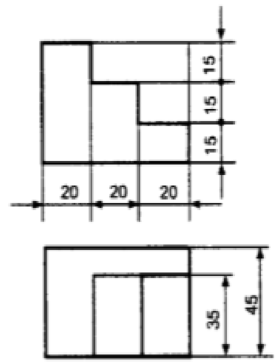
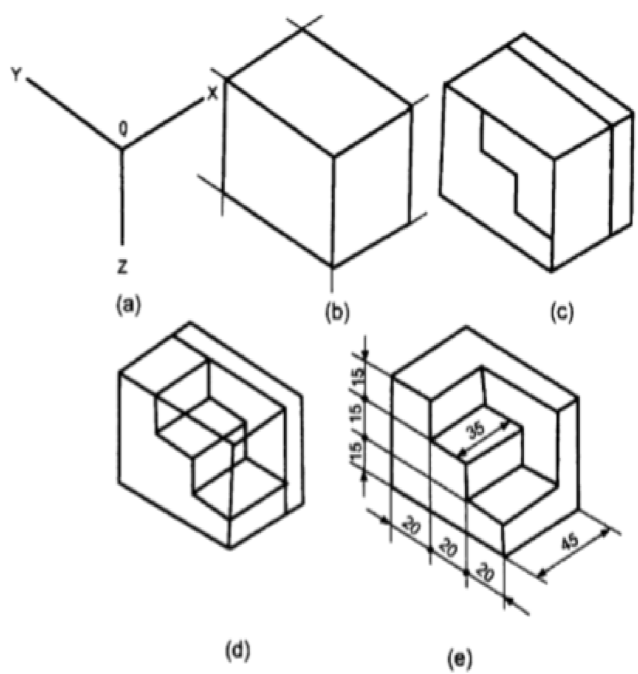


Fig. 9.6(a) Otrhographic view



Isometric View

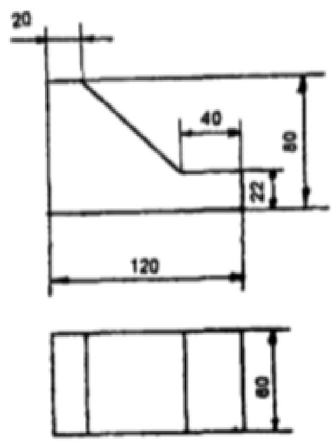
4. Complete the housing block by drawing lines parallel to the isometric axes and passing through the above markings (e).

5. Locate the principal corners of all the features of the object on the three faces of the housing block (d).
6. Draw lines parallel to the axes and passing through the above points and obtain the isometric drawing of the object by darkening the visible edges (e).

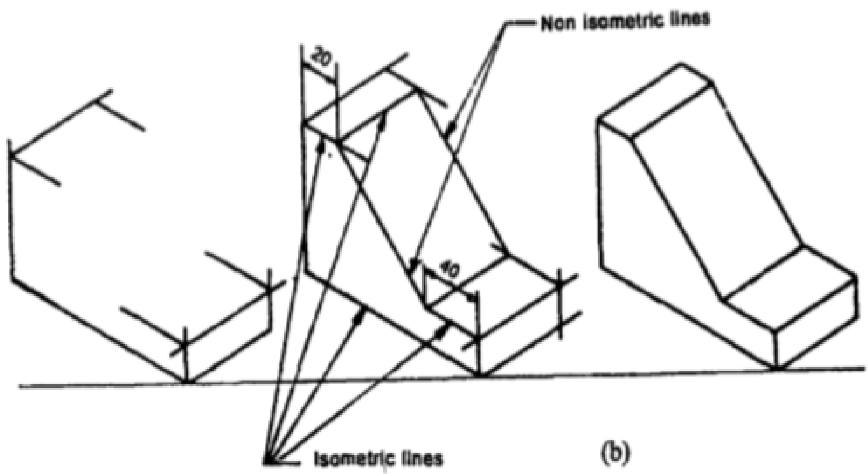
Non-Isometric Lines

In an isometric projection or drawing, the lines that are not parallel to the isometric axes are called non-isometric lines. These lines obviously do not appear in their true length on the drawing and cannot be measured directly. These lines are drawn in an isometric projection or drawing by locating their end points.

Figure shows the steps in constructing an isometric drawing of an object containing non-isometric lines from the given orthographic views.



(a)



(b)

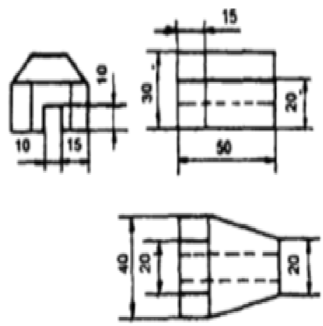
Methods of Constructing Isometric Drawing

The methods used are

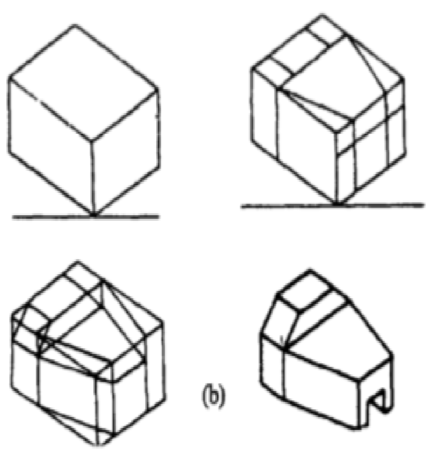
1. Box method.
2. Off-set method.

Box Method

When an object contains a number of non-isometric lines, the isometric drawing may be conveniently constructed by using the box method. In this method, the object is imagined to be enclosed in a rectangular box and both isometric and non-isometric lines are located by their respective points of contact with the surfaces and edges of the box.



(a)



(b)

Off-set Method

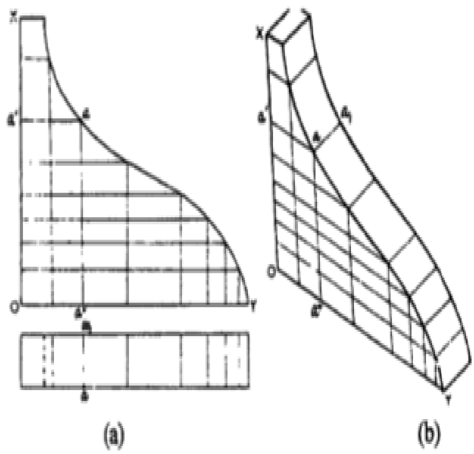
Off-set method of making an isometric drawing is preferred when the object contains irregular curved surfaces. In the off-set method, the curved feature may be obtained by plotting the points on the curve, located by the measurements along isometric lines.

Figure illustrates the application of this method.

Isometric Projection of Planes Problem

Draw the isometric projection of a rectangle of 100mm and 70mm sides if its plane is (a) Vertical and (b) Horizontal.

Construction

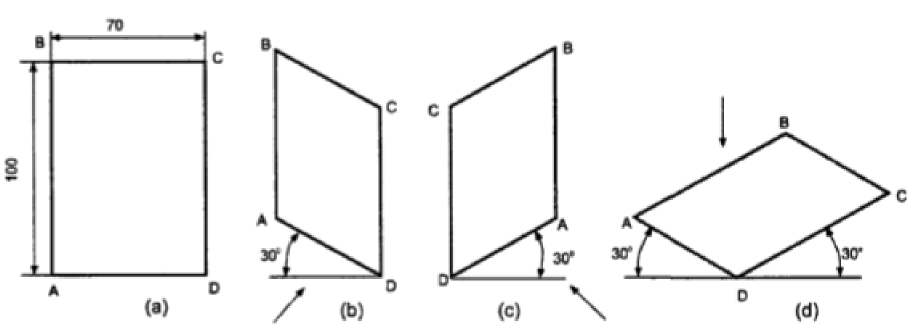


1. **Draw the given rectangle ABCD as shown in figure (a).**

   Note: (i) In the isometric projection, vertical lines are drawn vertical and the are drawn inclined 30° to the base line.

Horizontal Lines

(It) As the sides of the rectangle are parallel to the isometric axes they are fore-shortened to approximately 82% in the isometric projections. Hence AB = CD = 1000 x 0.82mm = 82mm. Similar, B C = A D = S7.4mm. (a) When the plane is vertical: 2. Draw the side A D inclined at 30° to the base line as shown in Fig.9.10b and mark A D = S7.4mm. 3. Draw the verticals at A and D and mark off A B = D C = 82mm on these verticals. 4. Join B C which is parallel to A D.



AB C D is the required isometric projection. This can also be drawn as shown in figure. Arrows show the direction of viewing.

(b) When the plane is horizontal.

Draw the sides AD and DC inclined at 30° to be base line and complete the isometric projectionAB C D as shown in figure. Arrow at the top shows the direction of viewing.

To draw the isometric projection of a square plane

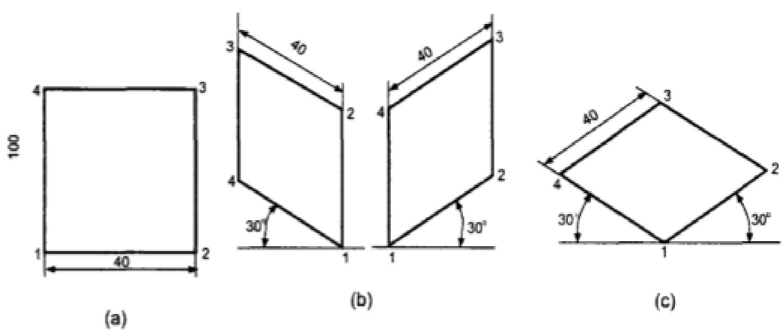
Construction

Case 1 Vertical plane figure. 1. Draw a line at 30° to the horizontal and mark the isometric length on it. 2. Draw verticals at the ends of the line and mark the isometric length on these parallel lines. 3. Join the ends by a straight line which is also inclined at 30° to the horizontal.

There are two possible positions for the plane

Case IT Horizontal plane figure. Draw two lines at 30° to the horizontal and mark the isometric length along the line. 2. Complete the figure by drawing 30° inclined lines at the ends till the lines intersect.

Note (i) the shape of the isometric projection or drawing of a square is a Rhombus. (ii) While dimensioning an isometric projection or isometric drawing true dimensional values only must be used.



Problem

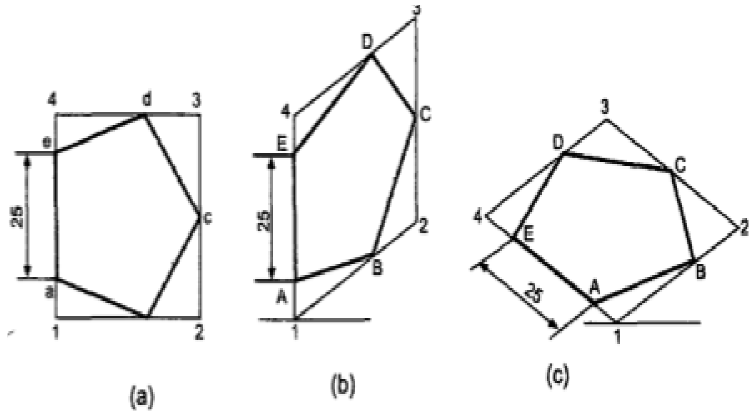
Figure shows the projection of a pentagonal plane. Draw the isometric drawing of the plane (i) when the surface is parallel to v.p and (ii) parallel to H.P.

Construction

1. Enclose the given pentagon in a rectangle 1234.
2. Make the isometric drawing of the rectangle 1234 by using true lengths.

Fig 7.12

3. Locate the points A and B such that Ia = lA and 1b = IB.
4. Similarly locate point C, D and E such that 2c = 2C, 3d = 3D and e4 = E4.
5. ABCDE is the isometric drawing of the pentagon.
6. Following the above principle of construction 7.12c can be

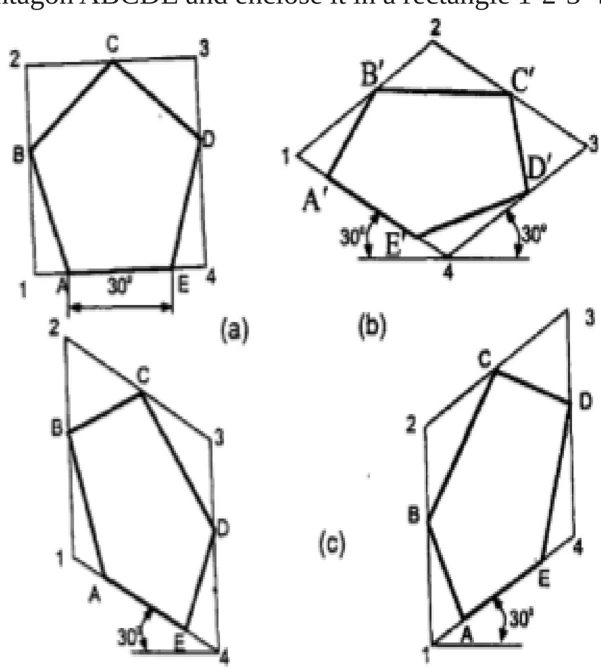


Problem

Draw the isometric view of a pentagonal plane of 30mm side when one of its sides is parallel to H.p, (a) When it is horizontal and (b) vertical.

Construction

1. Draw the pentagon ABCDE and enclose it in a rectangle 1-2-3-4 as shown in figure.



(a) When it is horizontal the isometric view of the pentagon can be represented by ABCDE as shown in figure.

(b) When the plane is vertical it can be represented by ABCDE as shown in figures.

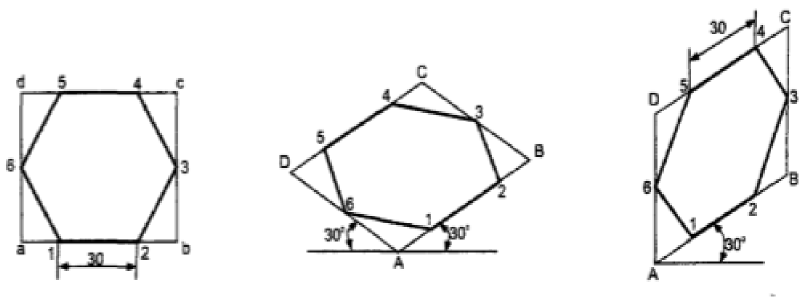
Note: It may be noted that the point A on the isometric view can be marked after drawing the isometric view of the rectangle 1-2-3-4 for this, mark 1AI = IA and so on.

Problem

Figure given below shows the orthographic view of a hexagonal plane of side 30mm. Draw the isometric drawing (view) of the plane keeping it (a) horizontal and (b) vertical.

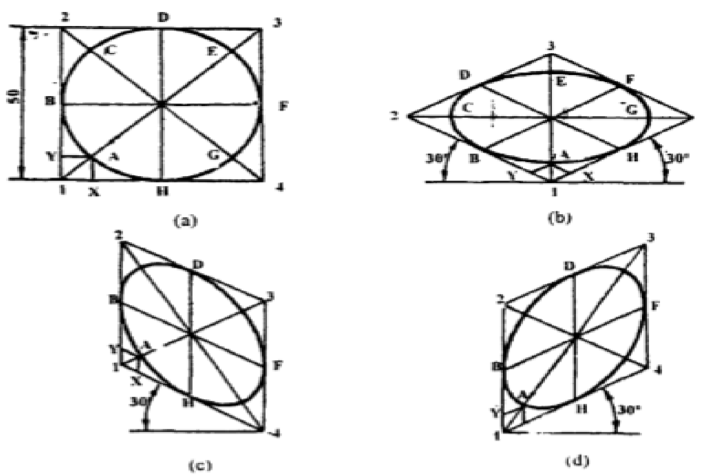
Construction

Following the principle of construction of figure obtain the figures respectively for horizontal and vertical position of the plane.



(a) (b) (c)

Problem



Draw the isometric view of a circular plane of diameter 60mm whose surface is (a) Horizontal, (b) Vertical.

Construction of method using points

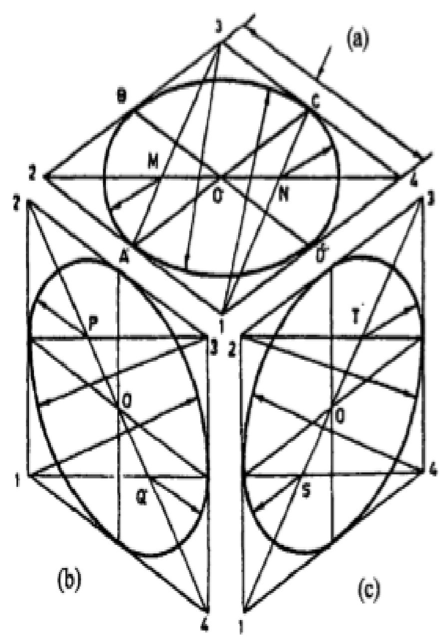
1. Enclose the circle in a square 1-2-3-4 and draw diagonals, as shown in figure. Also draw lines YA horizontally and XA vertically.

   To draw the isometric view of the square 1-2-3-4 as shown in b.

2. Mark the mid points of the sides of the square as B 0 F and H.
3. Locate the points X and Y on lines 1-4 and 1-2 respectively.
4. Through the point X, draw A X parallel to line 1-2 to get point A on the diagonal 1-3. The point A can be obtained also by drawing Y A through the point Y and parallel to the line 1-4.
5. Similarly obtain other points C, E and G
6. Draw a smooth curve passing through all the points to obtain the required isometric view of the horizontal circular plane.
7. Similarly obtain isometric view of the vertical circular plane as shown in figures..

Problem: Draw the isometric projection oj a circular plane oj diameter 60mm whose surface is (aJ Horizontal and (b) Vertical-use Jour-centre method

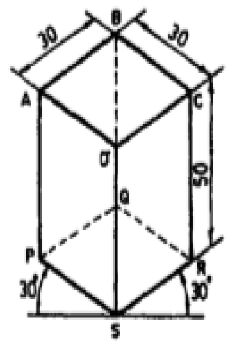
Construction

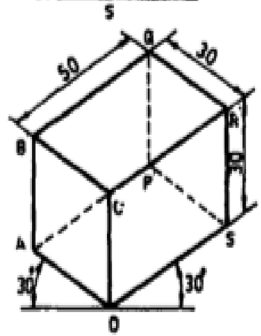


1. Draw the isometric projection of the square 1-2-3-4 (rhombus) whose length of side is equal to the isometric length of the diameter of the circle = 0.82 x 60.

2. Mark the mid points AI, BI, CI and 01 of the four sides of the rhombus. Join the points 3 and AI. This line intersects the line 2-4 joining the point 2 and 4 at MI. Similarly obtain the intersecting point N.
3. With centre M and radius = MA draw an arc A B. Also draw an arc C D with centre N.
4. With centre 1 and radius = 1C, draw an ace B C. Also draw the arc A D.
5. The ellipse ABC D is the required isometric projection of the horizontal circular plane.
6. Similarly obtain the isometric projection in the vertical plane as shown in Fig.7.16b & c.

Problem: Draw the isometric view of square prism with a side of base 30mm and axis 50mm long when the axis is (a) vertical and (b)horizontal.





Isometric drawing of a square prism

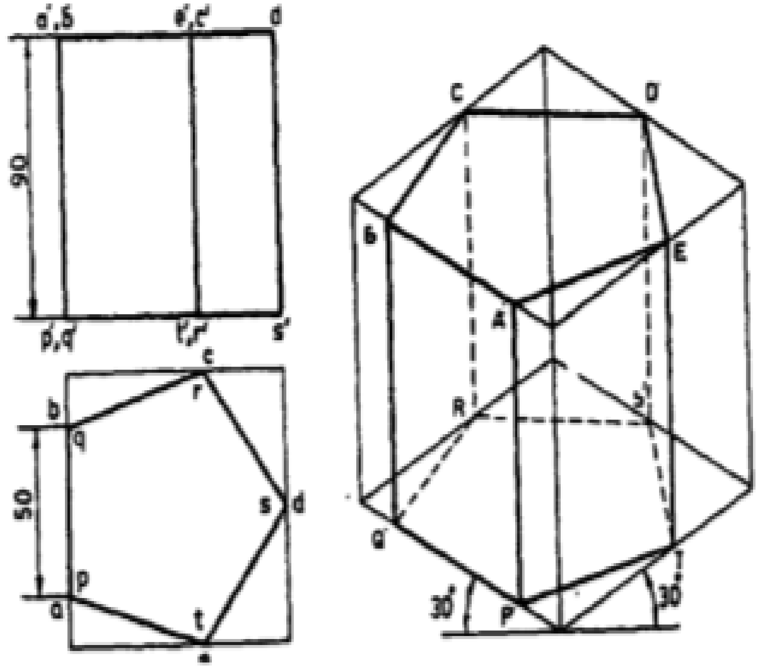
Construction

(a) Case 1 when the Axis is Aertical

1. When the axis of the prism is vertical, the ends of the prism which is square will be horizontal.
2. In an isometric view, the horizontal top end of the prism is represented by a rhombus

ABCD as shown in figure.

The vertical edges of the prism are vertical but its horizontal edges will be inclined at 30° to the base.



Isometric Drawing of a Pentogonal Prism

(b) Case 2 when the Axis is Horizontal

When the axis of the prism is horizontal, the end faces of the prism which are square, will be vertical. In the isometric view, the vertical end face of prism is represented by a rhombus ABCD. The isometric view of the prism is shown in figure.

Isometric Projection of Prisms

Problem: Draw the isometric view of a pentagonal prism of base 60mm side, axis lOOmm long and resting on its base with a vertical face perpendicular to V.P.

Construction

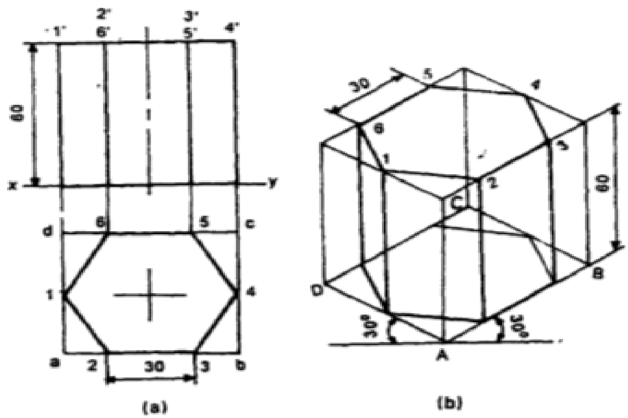
1. The front and top views of the prism are shown in figure.
2. 2, Enclose the prism in a rectangular box and draw the isometric view as shown in figure using the box method.

Problem

A hexagonal prism of base of side 30mm and height 60mm is resting on its base on H.P.

Draw the isometric drawing of the prism.

Construction



Isometric Drawing of a Hexagonal Prism

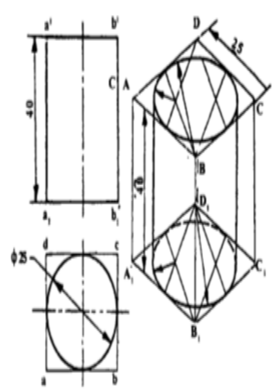
1. Draw the orthographic views of the prism as shown in figure.
2. Enclose the views in a rectangle (ie the top view -base- and front views).
3. Determine the distances (off-sets) of the corners of the base from the edges of the box.
4. Join the points and darken the visible edges to get the isometric view.

Isometric Projection of Cylinder

Problem:

Make the isometric drawing of a cylinder of base diameter 20mm and axis 35mm long.

Construction



Isometric drawing of a cylinder

1. Enclose the cylinder in a box and draw its isometric drawing.

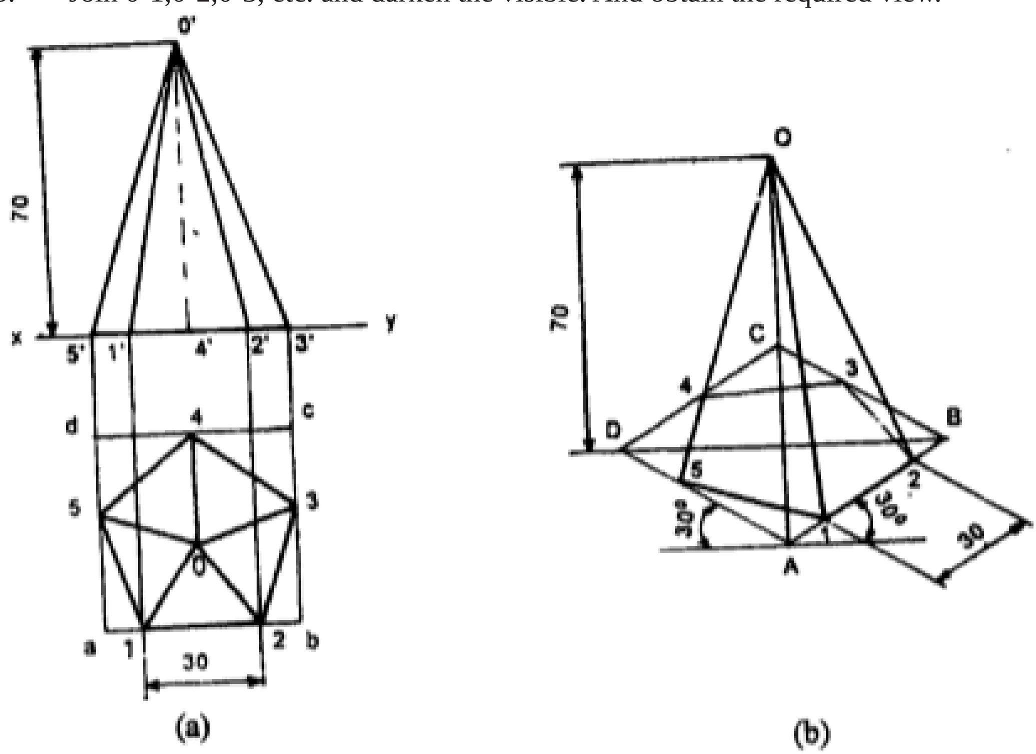
2. Draw ellipses corresponding to the bottom and top bases by four centre method.
3. Join the bases by two common tangents.

Isometric Projection of Pyramid

Problem: A pentagonal pyramid of side of base 30mm and height 70mm is resting with its base on H.P. Draw the isometric drawing of the pyramid.

Construction

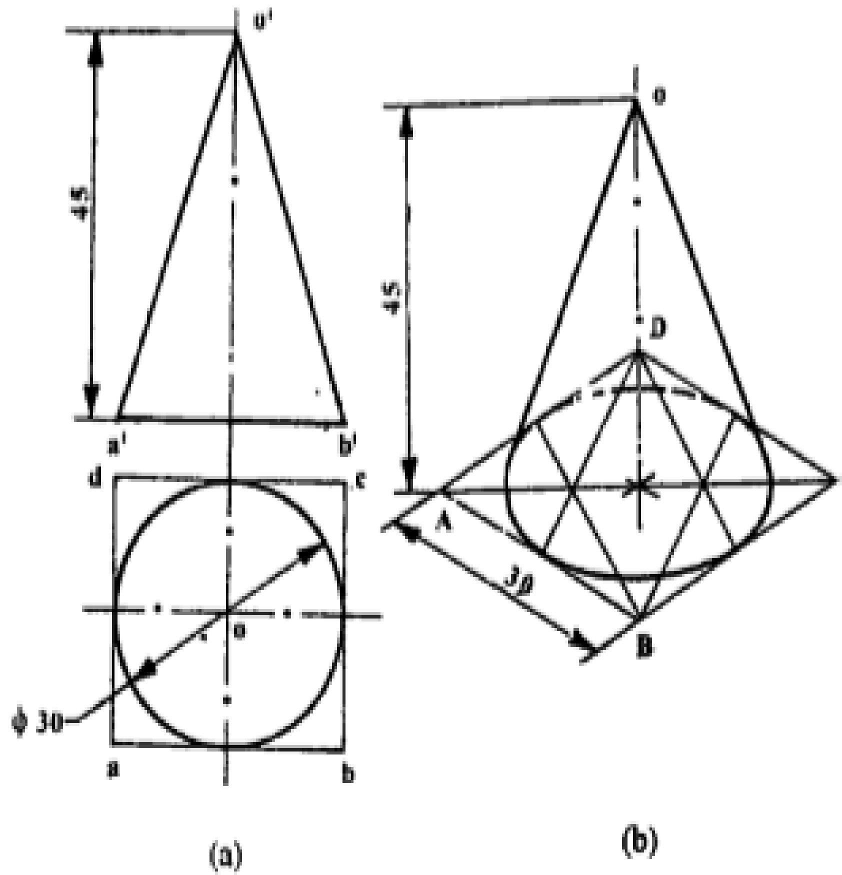
1. Draw the projections of the pyramid.
2. Enclose the top view in a rectangle arced and measure the off-sets of all the corners of the base and the vertex.
3. Draw the isometric view of the rectangle ABCD.
4. Using the off-sets locate the corners of the base 1, 2, etc. and the vertex o.
5. Join 0-1,0-2,0-3, etc. and darken the visible. And obtain the required view.



Isometric Projection of Cone

Problem: Draw the isometric drawing of a cone of base diameter 30mm and axis 50mm long.

Construction off-set method.



Isometric Drawing of a Cone

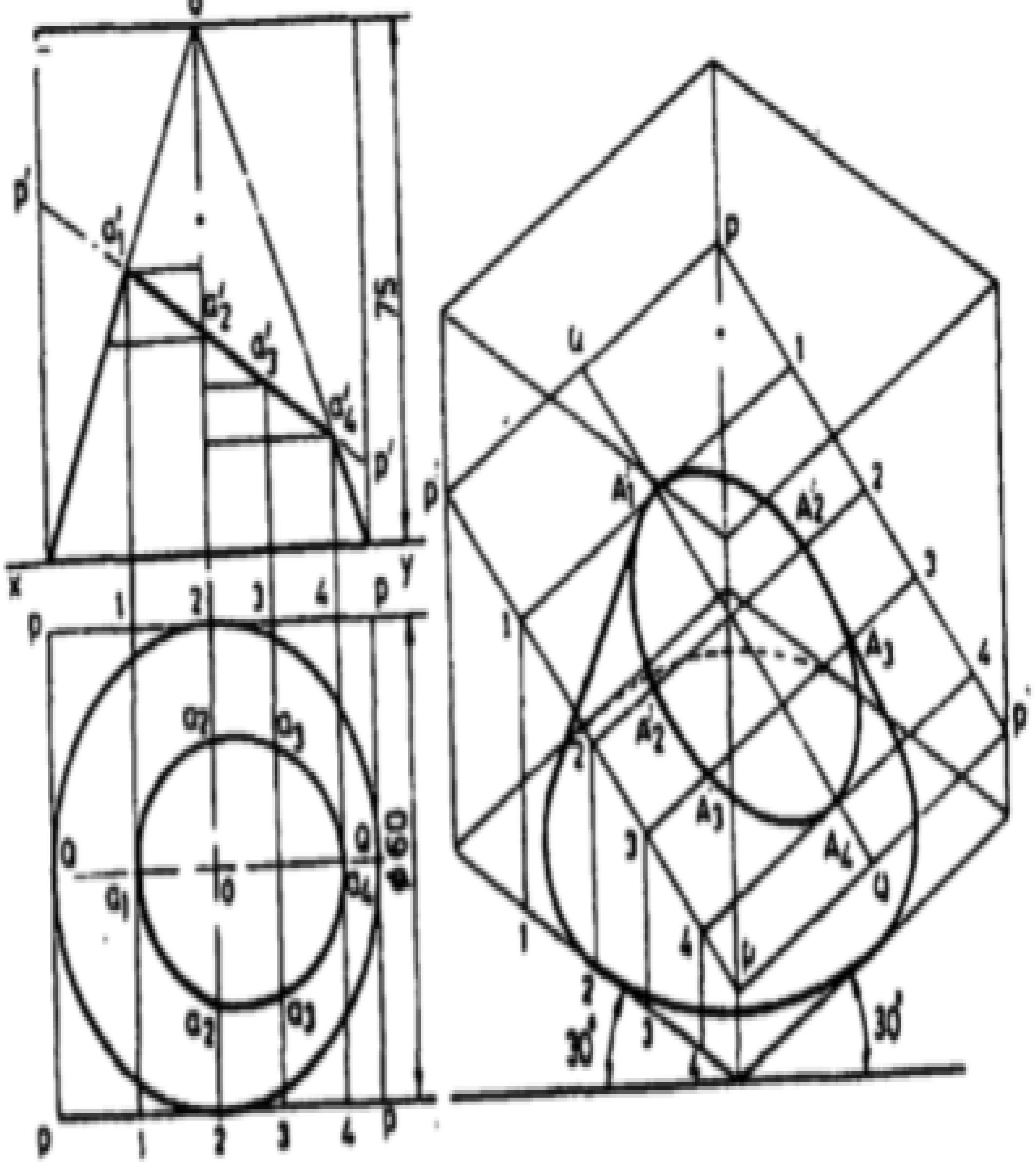
1. Enclose the base of the cone in a square.
2. Draw the ellipse corresponding to the circular base of the cone.
3. From the centre of the ellipse draw a vertical centre line and locate the apex at a height of 50mm.
4. Draw the two outer most generators from the apex to the ellipse and complete the drawing.

Isometric Projection Truncated Cone

Problem

A right circular cone of base diameter 60mm and height 75mm is cut by a plane making an angle of 300 with the horizontal. The plane passes through the midpoint of the axis. Draw the isometric view of the truncated solid.

Construction



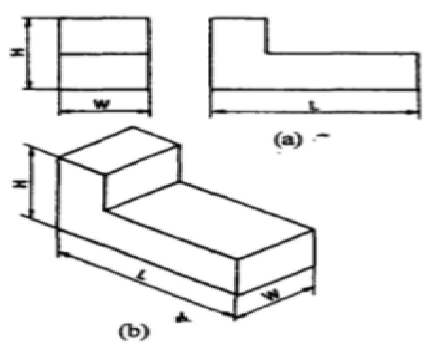
Isometric view of a trauncated cone

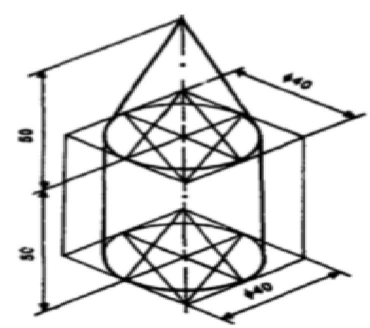
1. Draw the front and top views of the cone and name the points.
2. Draw a rectangular prism enclosing the complete pyramid.
3. Mark the plane containing the truncated surface of the pyramid. This plane intersects the box at PP in the front view and PPPP in the top view.

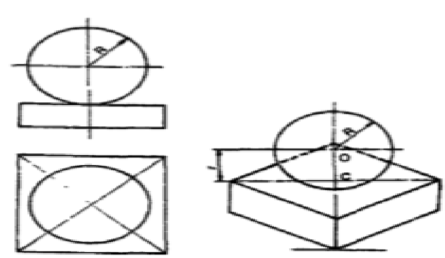
4. Draw the isometric view of the cone and mark the plane P PPP, containing the truncated surface of the pyramid as shown in Fig.7.23b.
5. Draw the isometric view of the base of the cone which is an ellipse.
6. It is evident from the top view that the truncated surface is symmetrical about the line qq. Hence mark the corresponding line Q Q in the isometric view.
7. Draw the line 1-1,2-2,3-3 and 4-4 passing through the points a1 a2 a3 and a4 in the top view. Mark the points 1,2,3,4 on the corresponding edge of the base of the cone and transfer these points to the plane P PPP by drawing verticals as shown.
8. Point al is the point of intersection of the lines qq and 1-1 in the top view. The point AI corresponding to the point al is the point of intersection of the lines Q Q and 1-1 in the isometric view. Hence mark the point AI Point Qo lies on the line 2- 2 in top view and its corresponding point in the isometric view is represented by A2 on the line 2-2 such that $2a^2 = 2$. Similarly obtain the remaining points and AA.loin these points by a smooth curve to get the truncated surface which is an ellipse.
9. Draw the common tangents to the ellipse to get the completed truncated cone.

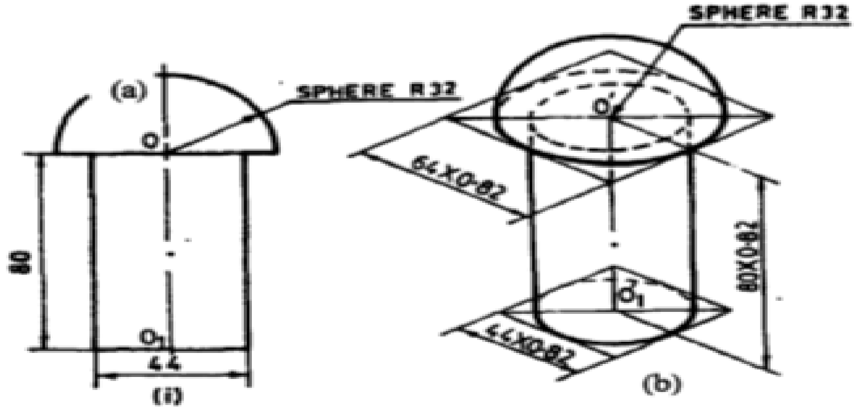
Examples

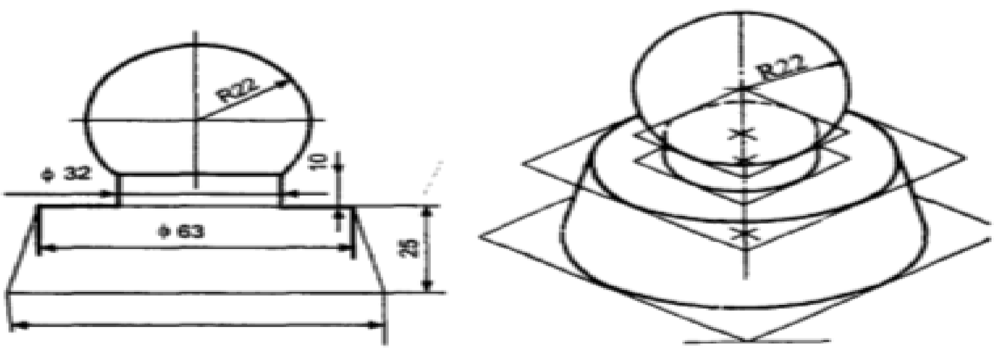
The orthographic projections and the isometric projections of some solids and machine components are shown from figures..

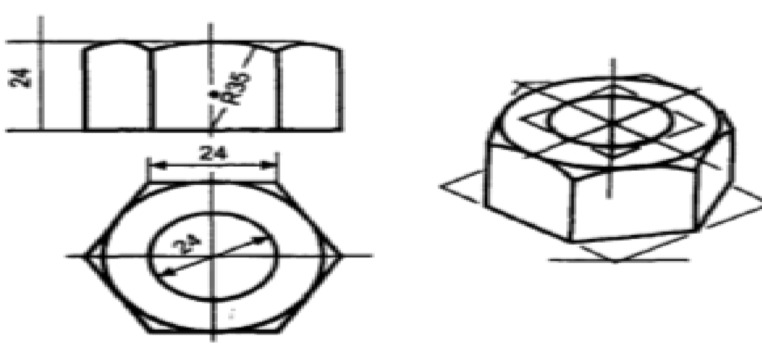


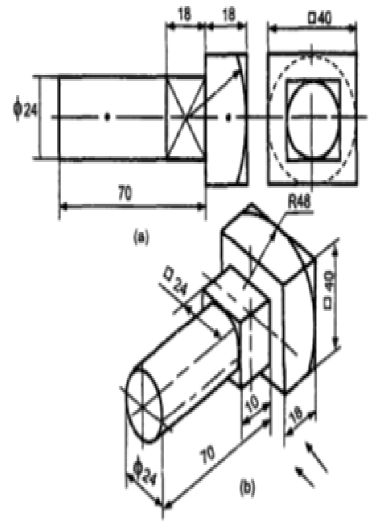





(a)
SPHERE R32
O
80
O1
44
(i)
SPHERE R32
O
64X0·82
80X0·82
O1
44X0·82
(b)


R22
ϕ 32
10
ϕ 63
25
R22


24
R35
24
24


18
18
□40
ϕ24
70
(a)
R48
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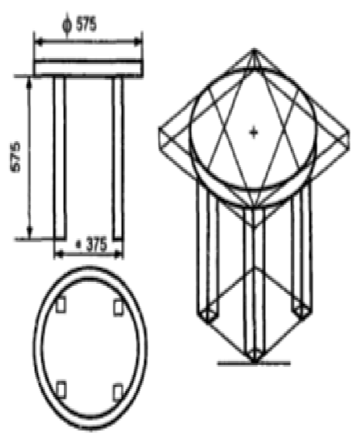
18
70
ϕ24
(b)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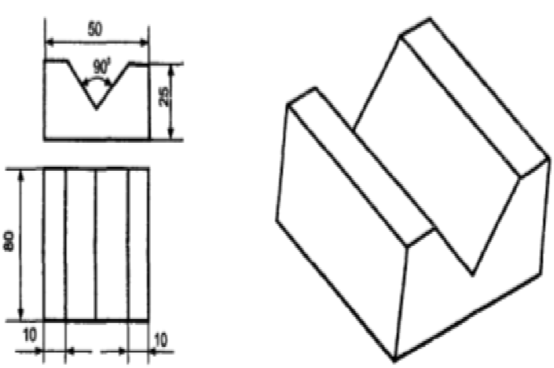
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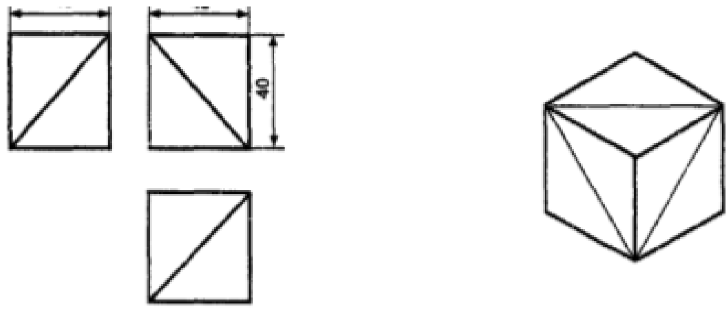
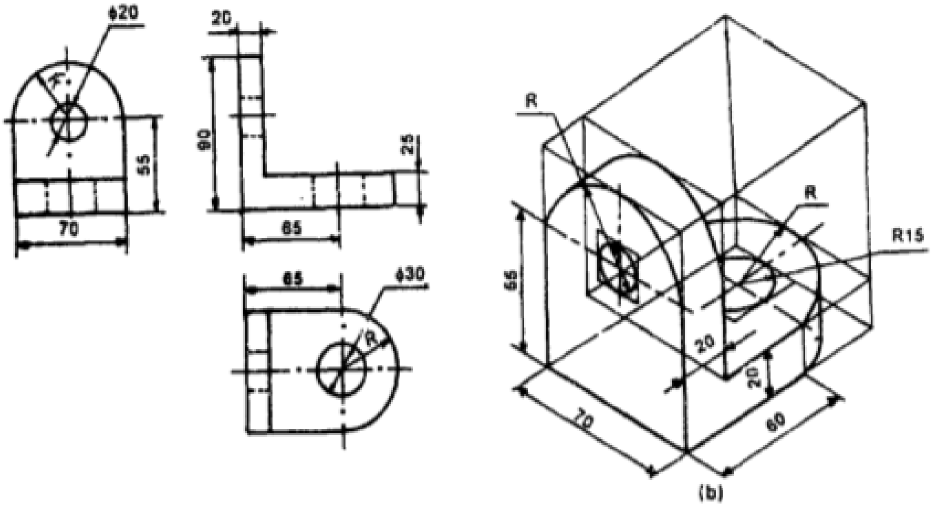
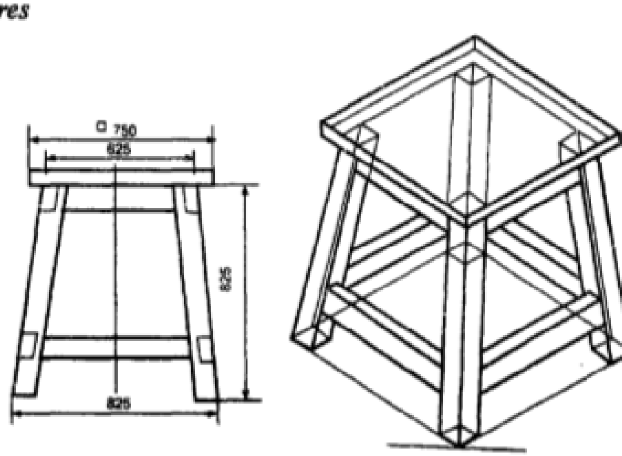


Wedge Piece

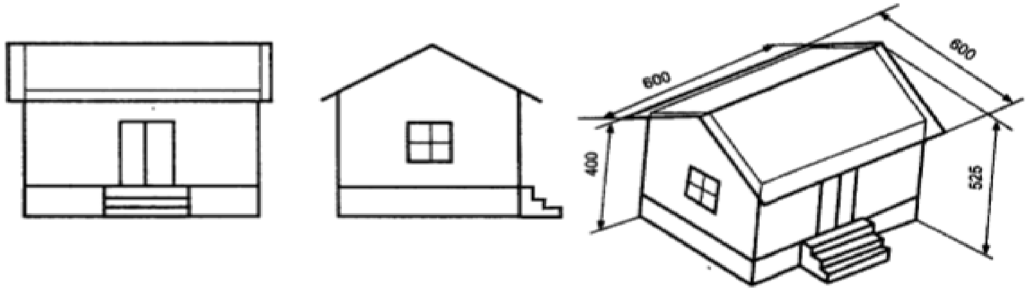


Angle Plate

Problem : *The orthographic projections and their isometric drawings of a stool and a house are shown in figures*



Stool



House

Projection of Points

A solid consists of a number of planes, a plane consists of a number of lines and a line in turn consists of number of points. From this, it is obvious that a solid may be generated by a plane.

A point may be situated in space or in any of the four quadrants formed by the two principle planes of projection or may lie in any one or both of them. Its projections are obtained by extending projectors perpendicular to the planes.

One of the planes is then rotated so that the first and third quadrants are opened out. The projections are shown on a flat surface in their respective positions either above or below or in XY.

Points in Space

A point may lie in space in anyone of the four quadrants. The positions of a point are:

1. First quadrant, when it lies above H.P and in front of V.P.
2. Second quadrant, when it lies above H.P. and behind V.P.
3. Third quadrant, when it lies below H.P and behind V.P.
4. Fourth quadrant, when it lies below H.P and in front of V.P.

Knowing the distance of a point from H.P and V.P, projections on H.P and V.P are found by extending the projections perpendicular to both the planes. Projection on H.P is called top view and projection on V.P is called front view

Notation followed

1. Actual points in space are denoted by capital letters A, B, C.
2. Their front views are denoted by their corresponding lower case letters with dashes a', b', c' etc. and their top views by the lower case letters a, b, c etc.

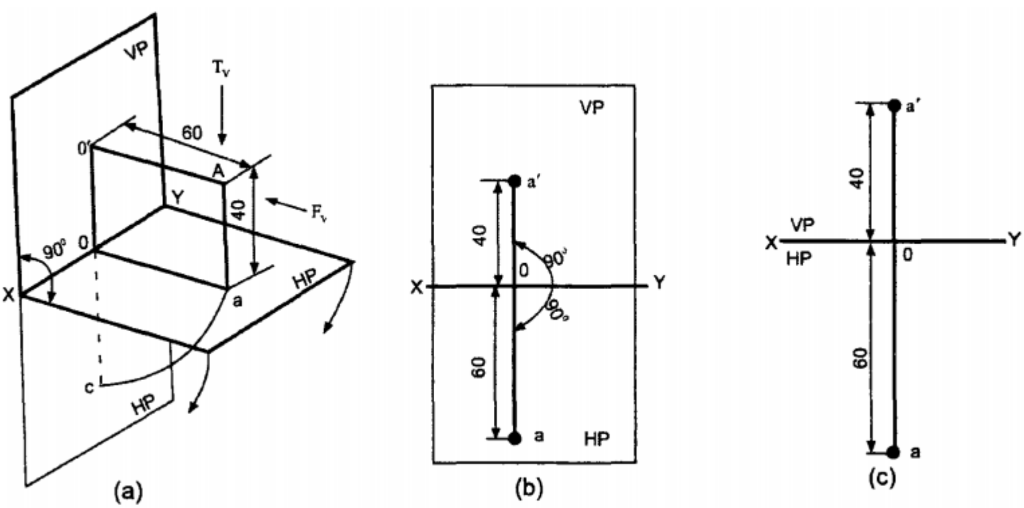
3. Projectors are always drawn as continuous thin lines.

Note

1. Students are advised to make their own paper/card board/perplex model of H.P and V.P. The model will facilitate developing a good concept of the relative position of the points lying in any of the four quadrants.
2. Since the projections of points, lines and planes are the basic chapters for the subsequent topics on solids viz, projection of solids, development, pictorial drawings and conversion of pictorial to orthographic and vice versa, the students should follow these basic chapters carefully to draw the projections.

Problem: Point A is 40 mm above HP and 60 mm in front of V.P. Draw its front and top view.

1. The point A lies in the I Quadrant



Orthographic projection of a point in First Quadrant

2. Looking from the front, the point lies 40 mm above H.P. A-a' is the projector perpendicular to V.P. Hence a' is the front view of the point A and it is 40 mm above the XY line.
3. To obtain the top view of A, look from the top. Point A is 60mm in front of V.P. Aa is the projector perpendicular to H.P. Hence, a is the top view of the point A and it is 60 mm in front of XY.
4. To convert the projections a' and a obtained in the pictorial view into orthographic projections, the following steps are needed.

(a) Rotate the H.P about the XY line through 90° in the clock wise direction as shown.

(b) After rotation, the fIrst quadrant is opened out and the H.P occupies the position vertically below the V.P. line. Also, the point a on H.P will trace a quadrant of a circle with o as centre and o-a as radius. Now a occupy the position just below o. The line joining a' and a, called the projector, is perpendicular to XY.

5. To draw the orthographic projections.

(a) Front view : Draw the XY line and draw a projector at any point on it. Mark a' 40mm above xy on the projector.

(b) Top view: on the same projector, mark a 60 mm below XY.

Note

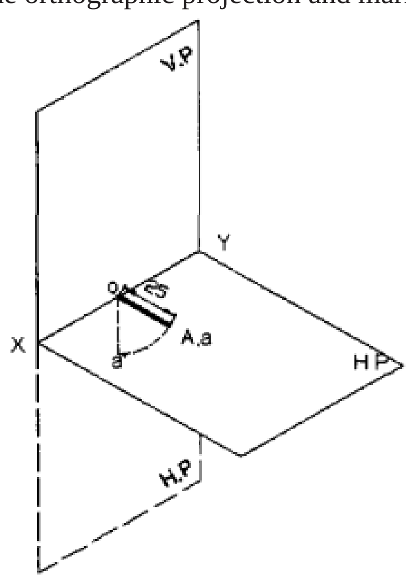
1. XY line represents H.P in the front view and V.P in the top view. Therefore while drawing the front view on the drawing sheet, the squares or rectangles for individual planes are not necessary.

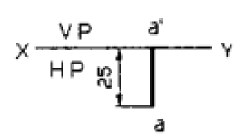
2. Only the orthographic projections is drawn as the solution and not the other two figures.

Problem : Draw the projections of a point A lying on HP and 25mm in front of V.P.

Solution

1. Point A is lying on H.P and so its front view a' lies on xy line. Therefore, mark a line XY in the orthographic projection and mark on it a'



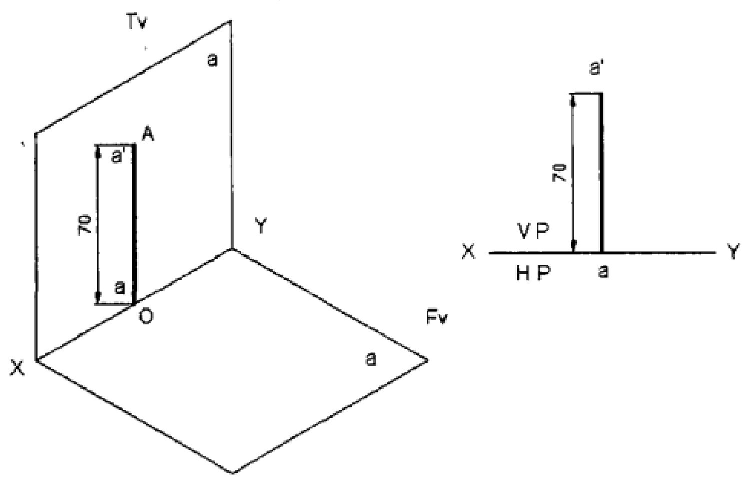


2. Point A is 25mm in front of V.P and its top view a lies on H.P itself and in front of XY.
3. Rotate the H.P through 90° in clock wise direction, the top view of the point a now comes vertically below a'.
4. In the orthographic projection a is 25 mm below xy on the projector drawn from a'.

Problem: Draw the projections of a point A lying on V.P and 70 mm above HP.

Solution

1. Looking at the pictorial view from the front the point A is 70 mm above H.P and so a' is 70 mm above xy. Hence, mark a' the orthographic projection 70 mm above xy
2. Looking at the pictorial view from the top, point a is on V.P and its view lies on xy itself. The top view a does not lie on the H.P. So in this case the H.P need not be rotated. Therefore mark a on xy on the projector drawn from a'.

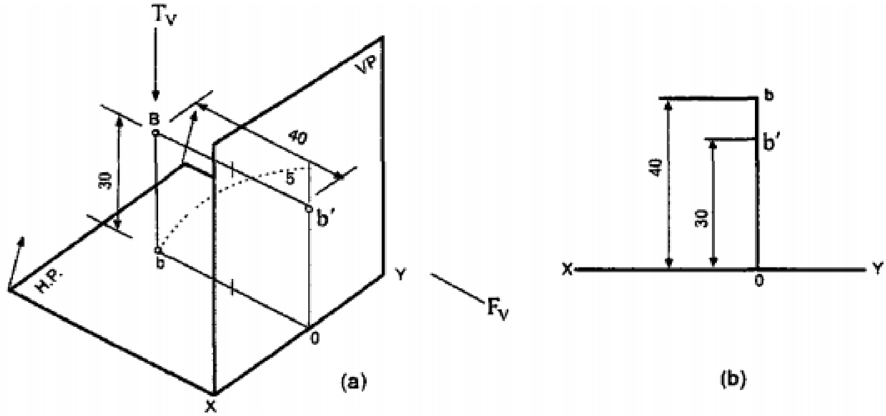


Problem : A Point B is 30 mm above HP and 40 mm behind V.P. Draw its projection.

Solution: The point B lies in the II Quadrant

1. It is 30 mm above H.P and b' is the front view ofB and is 30 mm above xy.
2. Point B is 40 mm behind V.P. and b is the top view of B which is 40 mm behind XY.
3. To obtain the orthographic projections from the pictorial view rotate H.P by 90° about xy. Now the H.P coincides with v.p and both the front view and top view are now seen above xy. b on the H.P will trace a quadrant of a circle with 0 as centre and ob as radius. Now b occupies the position above o.
4. To draw the orthographic projections, draw xy line on which a projection is drawn at any point. Mark on it b' 30mm above xy on this projector.

5. Mark b 40mm above xy on the same projector.

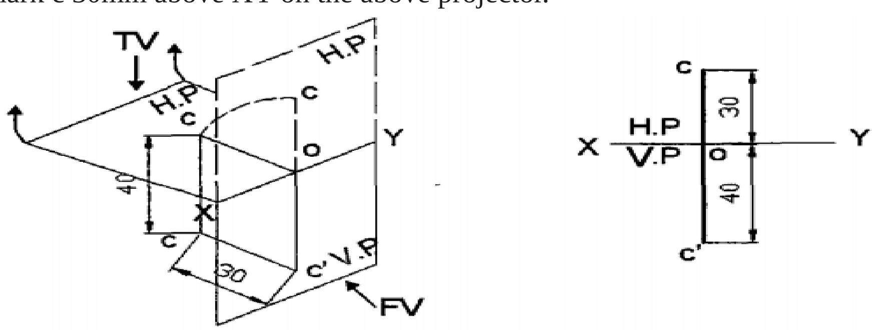


Point in II Quadrant

Problem : A point C is 40 mm below HP and 30 mm behind V.P. Draw its projection.

Solution : The point C is in the III Quadrant

1. C is 40 mm below H.P Hence c' is 40mm below XY.
2. Draw XY and draw projector at any point on it. Mark c' 40mm below xy on the projector.
3. C is 30mm behind V.P. So c' is 30mm behind xy. Hence in the orthographic projections mark c 30mm above XY on the above projector.

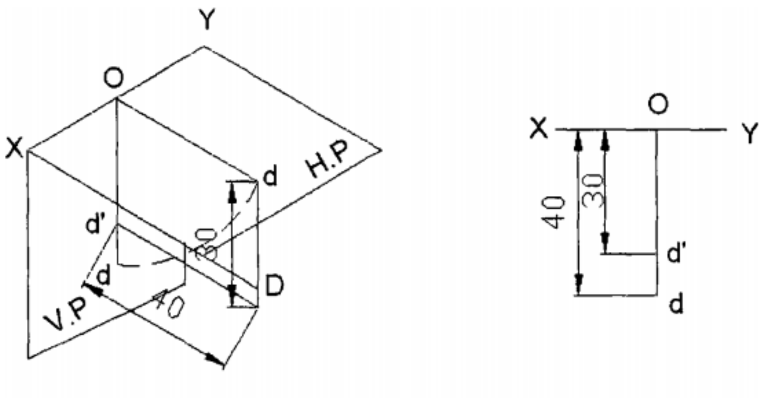


Point in III Quadrant

Problem: A point D is 30 mm below HP and 40 mm in front of V.P. Draw its projection.

Solution: The point D is in the IV Quadrant.

1. D is 30mm below H.P. Hence, d' is 30mm below XY. Draw XY line and draw a projector perpendicular to it. Mark d' 30mm below xy on the projector.
2. D is 40mm in front of V.P; so d is 40mm in front of XY. Therefore, mark d 40 mm below XY.



Point in IV Quadrant

Problem: Draw the orthographic projections of the following points.

(a) Point P is 30 mm. above H.P and 40 mm. in front of VP.

(b) Point Q is 25 mm. above H.P and 35 mm. behind VP.

(c) Point R is 32 mm. below H.P and 45 mm behind VP.

(d) Point S is 35 mm. below H.P and 42 mm in front of VP.

(e) Point T is in H.P and 30 mm. is behind VP.

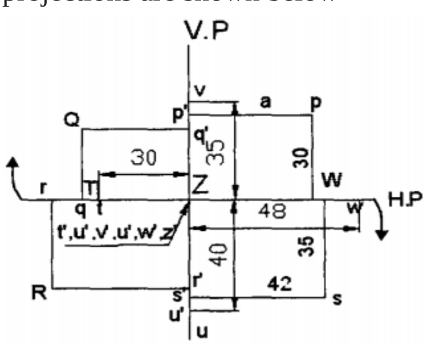
(f) Point U is in V.P and 40 mm. below HP.

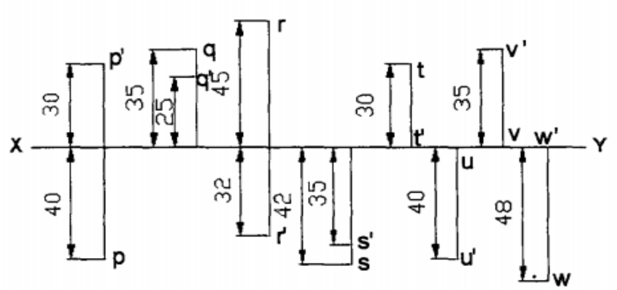
(g) Point V is in V.P and 35 mm. above H.P.

(h) Point W is in H.P and 48 mm. in front of VP.

Solution

The location of the given points is the appropriate quadrants and their orthographic projections are shown below





Exercise

Choose the correct answer from the given alternatives.

1. The angle between the isometric axes is __________

   a. 180 degrees b. 60 degrees c. 90 degrees d. 120 degrees

2. The lines parallel to isometric axes are called ________ lines.

   a. Parallel b. Auxiliary c. Isometric d. Oblique

3. The planes parallel to any of the two isometric lines are called ________ planes.

   a. Parallel b. Auxiliary c. Isometric d. Oblique

4. Isometric view of cube is drawn the angle between the edge of cube and horizontal will be______

   a. 15 degrees b. 120 degrees c. 45 degrees d. 30 degrees

5. Isometric view of cube is drawn the angle between the edge of cube and vertical will be______

   a. 15 degrees b. 120 degrees c. 60 degrees d. 30 degrees

6. Two points are placed in 1st quadrant of projection planes such that the line joining the points is perpendicular to profile plane the side view and top view will be __________

   a. Single point, two points b. Two points, single point

   c. Single point, single point d. Two points, two points

7. A point is 5 units away from the vertical plane and 4 units away from profile plane and 3 units away from horizontal plane in 1st quadrant then the projections are drawn on paper the distance between the front view and top view of point is ______________

   a. 7 units b. 8 units c. 9 units d. 5 units

8. A point is 20 units away from the vertical plane and 12 units away from profile plane and 9 units away from horizontal plane in 1st quadrant then the projections are drawn on paper the distance between the side view and front view of point is _______________

   a. 29 units b. 21 units c. 32 units d. 11 units

9. A point is 15 units away from the vertical plane and 12 units away from profile plane and horizontal plane in 1st quadrant then the projections are drawn on paper the distance between the front view and top view of point is _______________

a. 27 b. 15 c. 12 d. 24

10. A point is in 2nd quadrant 20 units away from the horizontal plane and 10 units away from the vertical plane. Orthographic projection is drawn. What is the distance from point of front view to reference line, top view point to reference line?

a. 20, 10 b. 10, 20 c. 0, 20 d. 10, 0

11. A point is in 2nd quadrant 15 units away from the vertical plane and 10 units away from the horizontal plane. Orthographic projection is drawn. What is the distance from point of front view to reference line, top view point to reference line?

a. 15, 10 b. 10, 15 c. 0, 15 d. 10, 0

12. A point is in 2nd quadrant, 15 units away from the vertical plane, 10 units away from the horizontal plane and 8 units away from the profile plane. Orthographic projection is drawn. What is the distance from point of front view to point of side view?

a. 25 b. 23 c. 18 d. 5

13. A point in 2nd quadrant is 15 cm away from both the horizontal plane and vertical plane and orthographic projections are drawn. The distance between the points formed by front view and top view is __________

a. 0 b. 30 c. 15

d. 15+ distance from a profile

14. A point in 2nd quadrant is 10 units away from the horizontal plane and 13 units away from both the vertical plane and profile plane. Orthographic projections are drawn find the distance from side view and front view.

a. 10 b. 13 c. 20 d. 26

15. A point is 9 units away from the vertical plane and 5 units away from profile plane and 4 units away from horizontal plane in 3rd quadrant then the projections are drawn on paper the distance between the side view and front view of point is _____________

a. 12 units b. 14 units c. 10 units d. 8 units

16. A point is 20 cm away from the vertical plane and 8 units away from profile plane and

17 cm away from horizontal plane in 3rd quadrant then the projections are drawn on paper the shortest distance from top view and side view of point is _______________

a. 37 b. 44.65 c. 46.40 d. 37.53

17. A point is 15 cm away from the vertical plane and 10 cm away from profile plane and horizontal plane in 3rd quadrant then the projections are drawn on paper the distance between the front view and top view of point is _____________

a. 27 cm b. 15 cm c. 12 cm d. 25 cm

18. A point is 3 m away from the vertical plane and horizontal planes in 3rd quadrant then the projections are drawn on paper the distance between the side view and vertical reference line?

a. 3 b. 0 c. Can't found d. 6

19. A point is 3 m away from the vertical plane and 7 m away from profile plane in 3rd quadrant then the projections are drawn on paper the distance between the side view and vertical reference line?

a. 6 b. 3 c. 14 d. 7

20. A point in 4th quadrant is 13 inches away from the horizontal plane and 10 inches away from both the vertical plane and profile plane. Orthographic projections are drawn find the distance from side view and front view.

a. 10 b. 13 c. 20 d. 26

21. A point in 4th quadrant is 15 cm away from the vertical plane and 10 cm away from the horizontal plane, orthographic projections are drawn. What is the distance from side view of point to line of vertical reference?

a. 10 b. 15 c. 25 d. Can't be found

22. A point is in 4th quadrant which is 15 inches away from horizontal and 30 inches away from profile plane. Orthographic projections are drawn. What is the distance from the top view to xy reference line?

a. 5 b. 3 c. 8 d. Can't be found

Write short answer to the following questions.

Isometric Projections

1. What is the relation among projectors in isometric projections?

2. What is the relation between true length and isometric length?
3. Differentiate between isometric projection and isometric view.
4. State two similarities between isometric projections and oblique projections.
5. State the similarities and dissimilarities between dimetric and trimetric projections.
6. Name the methods preferred for drawing ellipse in isometric projections.
7. Define isometric axes and isometric planes.
8. What are the principles of dimensioning in isometric projections?
9. What are the advantages of drawing isometric views?

Oblique Projection Review Quqestions

1. State the similarities and dissimilarities between isometric projections and obliqueprojections.
2. Differentiate between the orthographic projection and oblique projection.
3. Explain the terms receding axes, receding angles and receding planes.
4. Differentiate between cavalier projection and cabinet projection.
5. With the help of suitable examples, explain the rules for selecting the position of anobject in oblique projection.
6. What are the principles of dimensioning in oblique drawing?
7. What are the advantages of drawing oblique projection?
8. Name the method that is preferred for drawing ellipse in oblique projections.

Perspective Projection Review Questions

1. What are the characteristics of Perspective projections?
2. Name different types of perspectives and their fields of application.
3. State the limitations of perspective drawing.
4. State the alternative names of one-point, two-point, three-point and aerialperspectives.
5. Compare visual ray and vanishing point methods of drawing perspective views.
6. Compare the merits and demerits of perspective projections with isometric andoblique projections.
7. Define the following terms with reference to perspective projections:(a) Ground plane (b) Picture plane (c) Horizon plane (d) Central plane
8. Define the following terms with reference to perspective projections:(a) Ground line

(b) Horizon line (c) Central line (d) Axis of vision

9. What is a station point? What is its relation with the visual rays?

10. Make a line diagram and indicate the following:(a) Ground plane (b) Picture plane (c) Horizon plane (d) Central plane(e) Ground line (f) Horizon line (g) Central line (h) Axis of vision

Projection of points

1. If both the views of a point coincide with each other and lie below the reference line,state the angle in which the point lies.

2. State the similarities and dissimilarities in the projections of points which lie in thesecond angle and the fourth angle.

3. State the position of the point, the front view of which lies 50 mm below the referenceline and the top view 30 mm above the front view.

4. State the position of the point, the top view of which lies 50 mm above the referenceline and the front view 30 mm below the top view.

5. If the front view of a point lies above the reference line, state the possible angles in which the point may lie.

6. If the top view of a point lies above the reference line, state the possible angles inwhich the point may lie.

7. If the front view of a point lies below the reference line, state the possible angles in which the point may lie.

8. If the top view of a point lies below the reference line, state the possible angles in which the point may lie.

9. State the relationship between front view and top view of a point.

10. State the position of the point if its both views lie on the reference line.

11. State the position of the point, the top view of which lies on the reference line and thefront view 50 mm below it.

12. State the position of the point, the front view of which lies on the reference line andthe top view 50 mm below it.

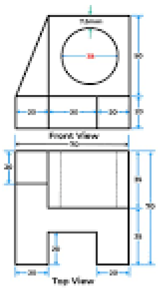
13. State the position of the point, the top view of which lies on the reference line and thefront view 45 mm above it.

14. State the position of the point, the front view of which lies on the reference line and the top view 35 mm above it.

Write long answer to the following questions.

1. Draw the objects using the following views.

a.



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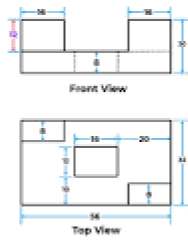
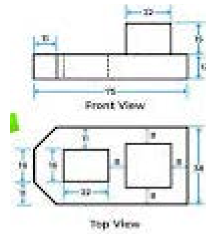


c.



Unit 8 Surface Development

8.1 Introduction

A layout of the complete surface of a three dimensional object on a plane is called the development of the surface or flat pattern of the object. The development of surfaces is very important in the fabrication of articles made of sheet metal.

The objects such as containers, boxes, boilers, hoppers, vessels, funnels, trays etc., are made of sheet metal by using the principle of development of surfaces.

In making the development of a surface, an opening of the surface should be determined first. Every line used in making the development must represent the true length of the line (edge) on the object.

The steps to be followed for making objects, using sheet metal are given below:

1. Draw the orthographic views of the object to full size.
2. Draw the development on a sheet of paper.
3. Transfer the development to the sheet metal.
4. Cut the development from the sheet.
5. Form the shape of the object by bending.
6. Join the closing edges.

Note: In actual practice, allowances have to be given for extra material required for joints and bends. These allowances are not considered in the topics presented in this chapter.

Methods of Development

The method to be followed for making the development of a solid depends upon the nature of its lateral surfaces. Based on the classification of solids, the following are the methods of development.

Parallel-line Development

It is used for developing prisms and single curved surfaces like cylinders in which all the edges/generators of lateral surfaces are parallel to each other.

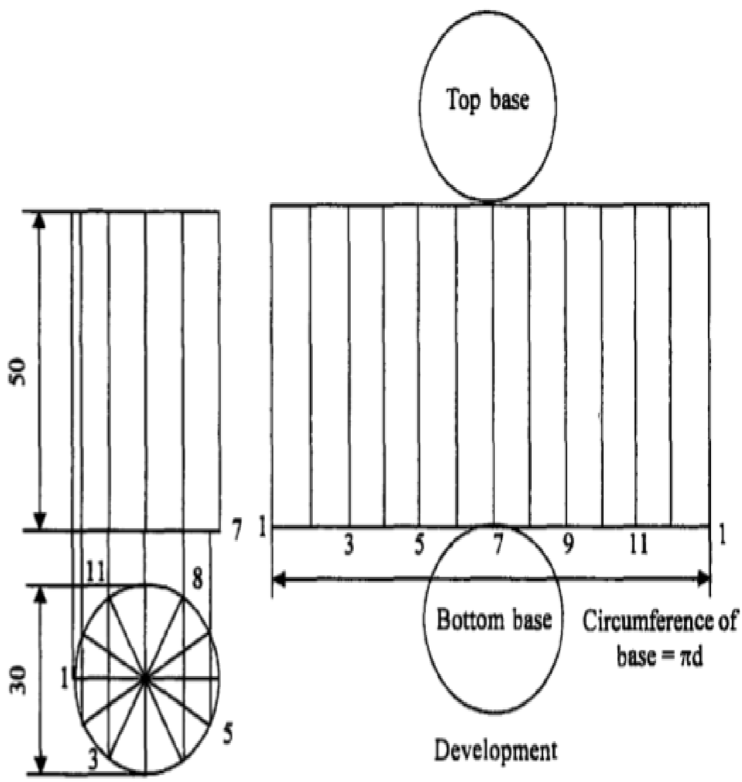
Radial-line Development

It is employed for pyramids and single curved surfaces like cones in which the apex is taken as centre and the slant edge or generator (which are the true lengths) as radius for its development.

Development of Prism

To draw the development of a square prism of side of base 30mm and height 5Omm.

Construction



Development of Cylinder

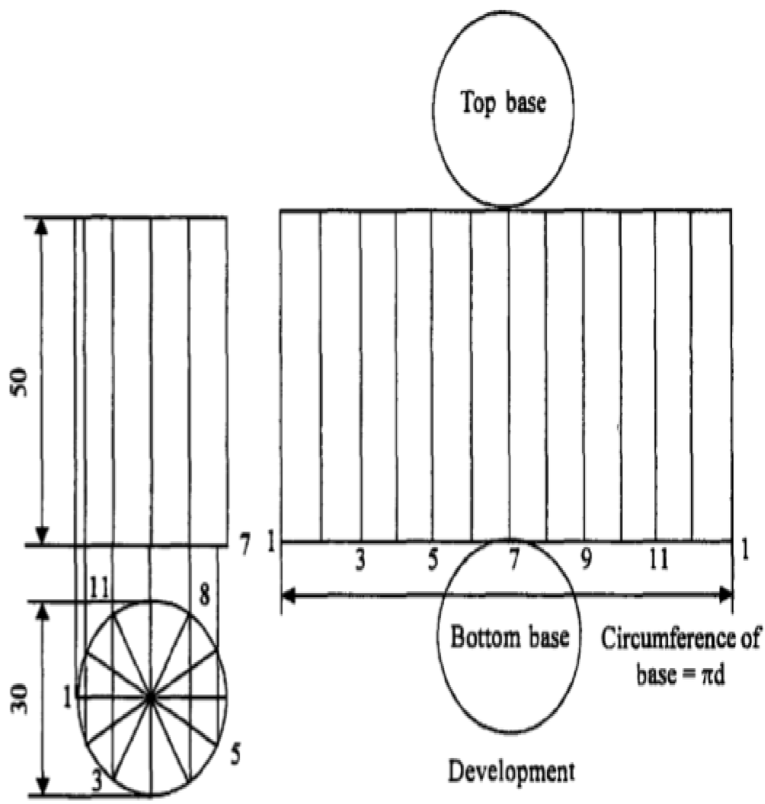
1. Assume the prism is resting on its base on H.P. with an edge of the base parallel to V.P and draw the orthographic views of the square prism.
2. Draw the stretch-out line 1-1 (equal in length to the circumference of the square prism) and mark off the sides of the base along this line in success on i.e 1-2,2-3,3-4 and 4-1.

3. Erect perpendiculars through 1,2,3 etc., and mark the edges (folding lines) I-A, 2-B, etc., equal to the height of the prism 50 mm.
4. Add the bottom and top bases 1234 and ABCD by the side of the base edges.

Development of a Cylinder

Construction

Figure shows the development of a cylinder. In this the length of the rectangle representing the development of the lateral surface of the cylinder is equal to the circumference πd here d is the diameter of the cylinder) of the circular base.



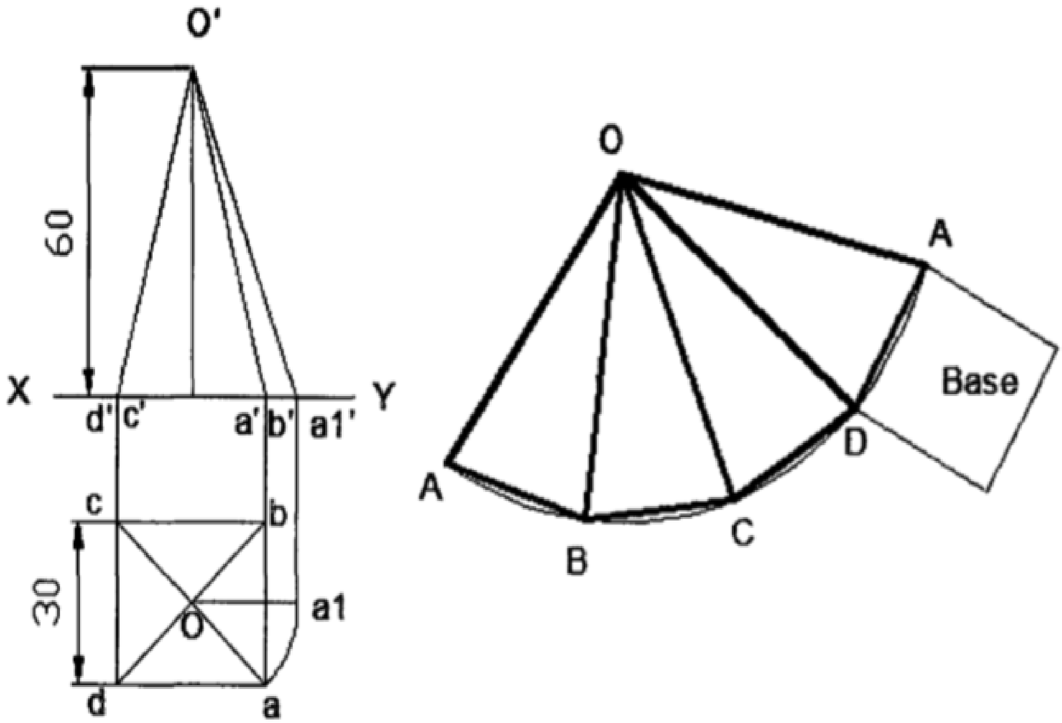
Development of Cylinder

Development of a square pyramid with side of base 30 mm and height 60 mm.

Construction

1. Draw the views of the pyramid assuming that it is resting on H.P and with an edge of the base parallel to V.P.

2. Determine the true length o-a of the slant edge.



Development of Square Pyramid

Note

In the orientation given for the solid, all the slant edges are inclined to both H.P and V.P. Hence, neither the front view nor the top view provides the true length of the slant edge. To determine the true lehiter of the slant edge, say OA, rotate oa till it is parallel to xy to the position.

l. Through al ' draw a projector to meet the line xy at all'

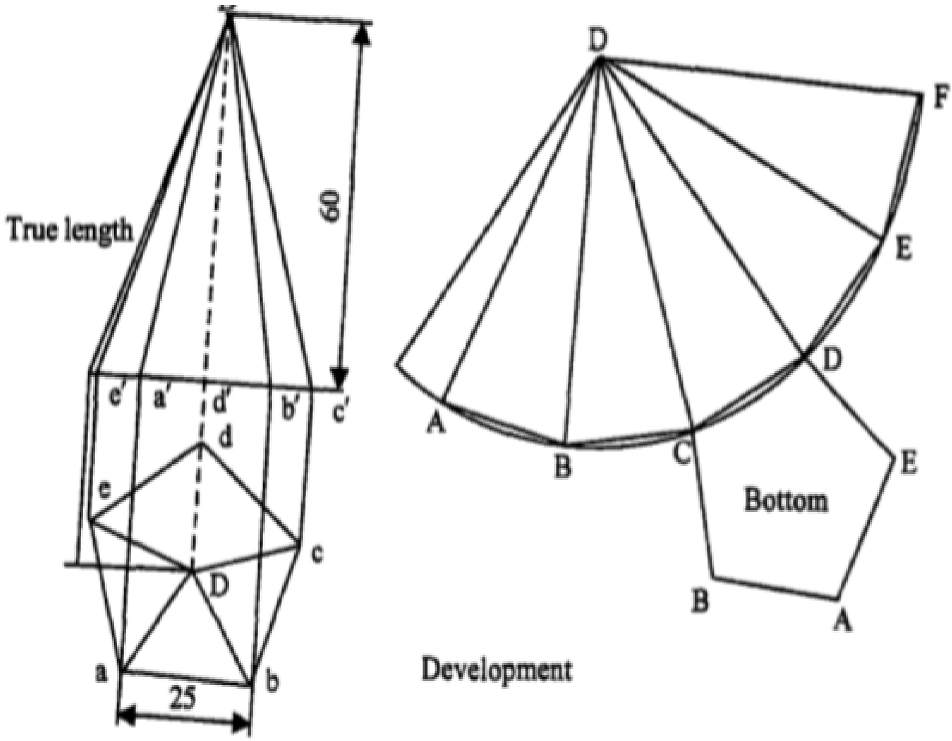
2. Then oil all represents the true length of the slant edge OA. This method of determining the true length is also known as rotation method.

3. withcentre 0 and radius o’a’draw an arc.

4. Starting from A along the arc, mark the edges of the base i.e. AB, BC, CD and DA. 5. Join 0 to A,B,C, etc., representing the lines of folding and thus completing the development.

Development of Pentagonal Pyramid

Construction



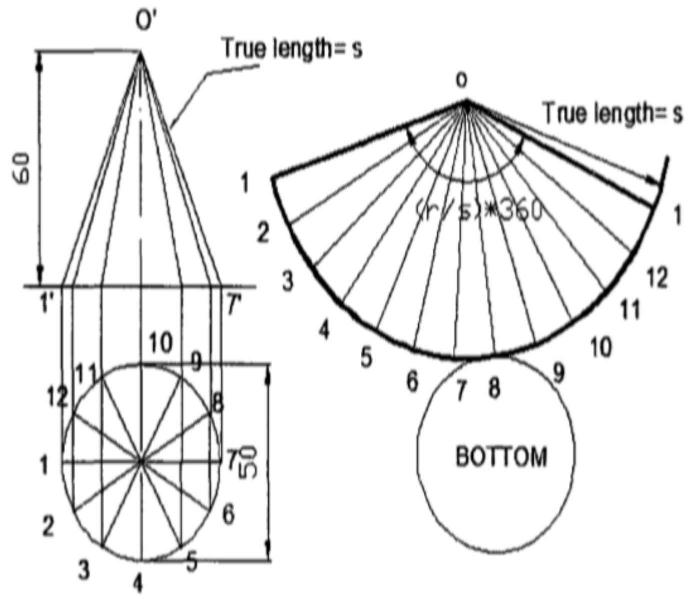
Development of pentagonal pyramid

1. Draw the orthographic views of the pyramid ABCDE with its base on H.P and axis parallel to V.P.
2. With center 0 of the pyramid and radius equal to the true length of the slant edge draw an arc
3. Mark off the edges starting from A along the arc and join them to 0 representing the lines of folding.
4. Add the base at a suitable location.

Development of a Cone

Construction

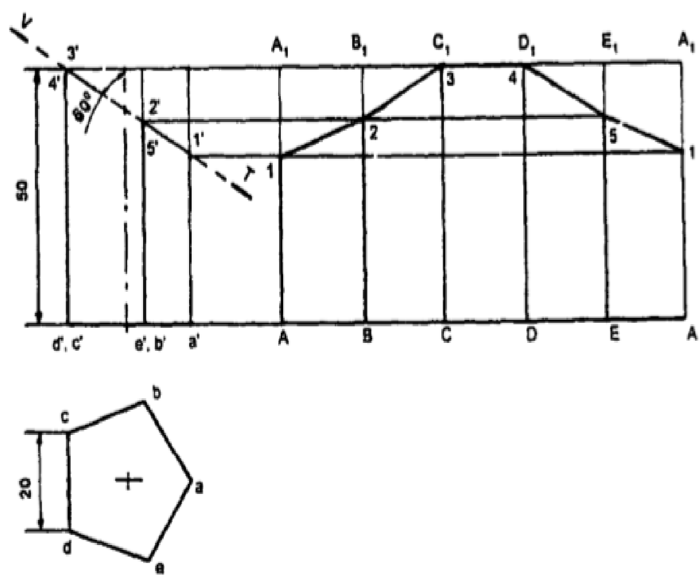
The development of the lateral surface of a cone is a sector of a circle. The radius and length of the arc are equal to the slant height and circumference of the base of the cone respectively. The included angle of the sector is given by (r / s) x 360°, where r is the radius of the base of the cone and s is the true length.



Development of cone

Problem: A pentagonal prism of side of base 20 mm and height 50 mm stands vertically on its base with a rectangular face perpendicular to V.P. A cutting plane perpendicular to V.P and inclined at 600 to the axis passes through the edges of the top base of the prism. Develop the lower portion of the lateral surface of the prism.

Construction



Development of pentagonal pyramid

1. Draw the projections of the prism.
2. Draw the trace (V.T.) of the cutting plane intersecting the edges at points 1,2,3, etc.
3. Draw the stretch-out AA and mark-off the sides of the base along this in succession i.e., AB, BC, CD, DE and EA.
4. Erect perpendiculars through A,B,C etc., and mark the edges AA 1 , BB I' equal to the height of the prism.
5. Project the points 11,21,31 etc., and obtain 1,2,3 etc., respectively on the corresponding edges in the development.
6. Join the points 1,2,3 etc., by straight lines and darken the sides corresponding to the truncated portion of the solid.

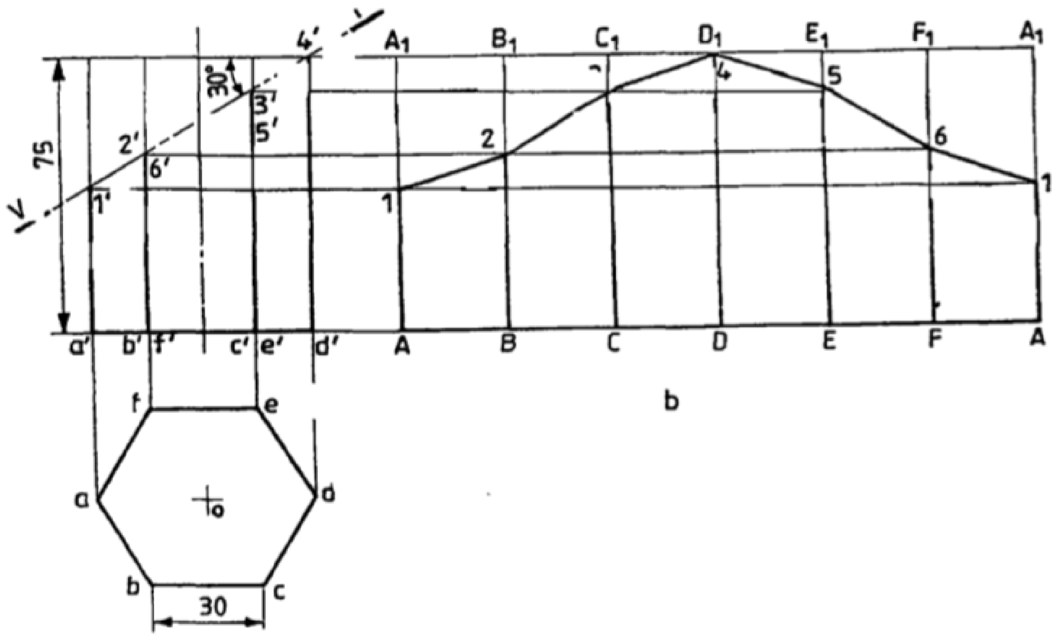
Note

1. Generally, the opening is made along the shortest edge to save time and soldering.
2. Stretch-out line is drawn in-line with bottom base of the front view to save time in drawing the development.
3. AAI-AIA is the development of the complete prism.
4. Locate the points of intersection 11, 21, etc., between VT and the edges of the prism and draw horizontal lines through them and obtain 1,2, etc., on the corresponding edges in the development
5. Usually, the lateral surfaces of solids are developed and the ends or bases are omitted in the developments. They can be added whenever required easily.

Problem

A hexagonal prism of side of base 30 mm and axis 70 mm long is resting on its base on HP. such that a rectangular face is parallel to V.P. It is cut by a section plane perpendicular to v.p and inclined at 300 to HP. The section plane is passing through the top end of an extreme lateral edge of the prism. Draw the development of the lateral surface of the cut prism.

Construction

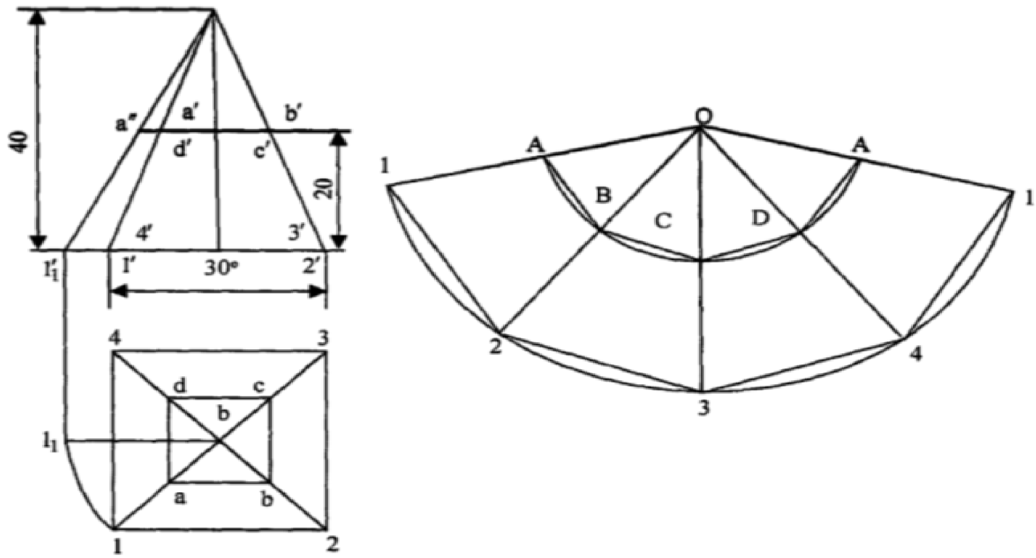


Development of hexagonal prism

1. Draw the projections of the prism.
2. Draw the section plane VT. 3. Draw the development AAI-AIA of the complete prism following the stretch out line principle.
4. Locate the point of intersection 11,21 etc., between VT and the edges of the prism.
5. Draw horizontal lines through 11,21 etc., and obtain 1,2, etc., on the corresponding edges in the development.
6. Join the points 1,2, etc., by straight lines and darken the sides corresponding to the retained portion of the solid.

Problem: Draw the development of the lateral surface other frustum of the square pyramid of side of base 30 mm and axis 40 mm, resting on HP with one of the base edges parallel to VP. It is cut by a horizontal cutting plane at a height of 20 mm.

Construction



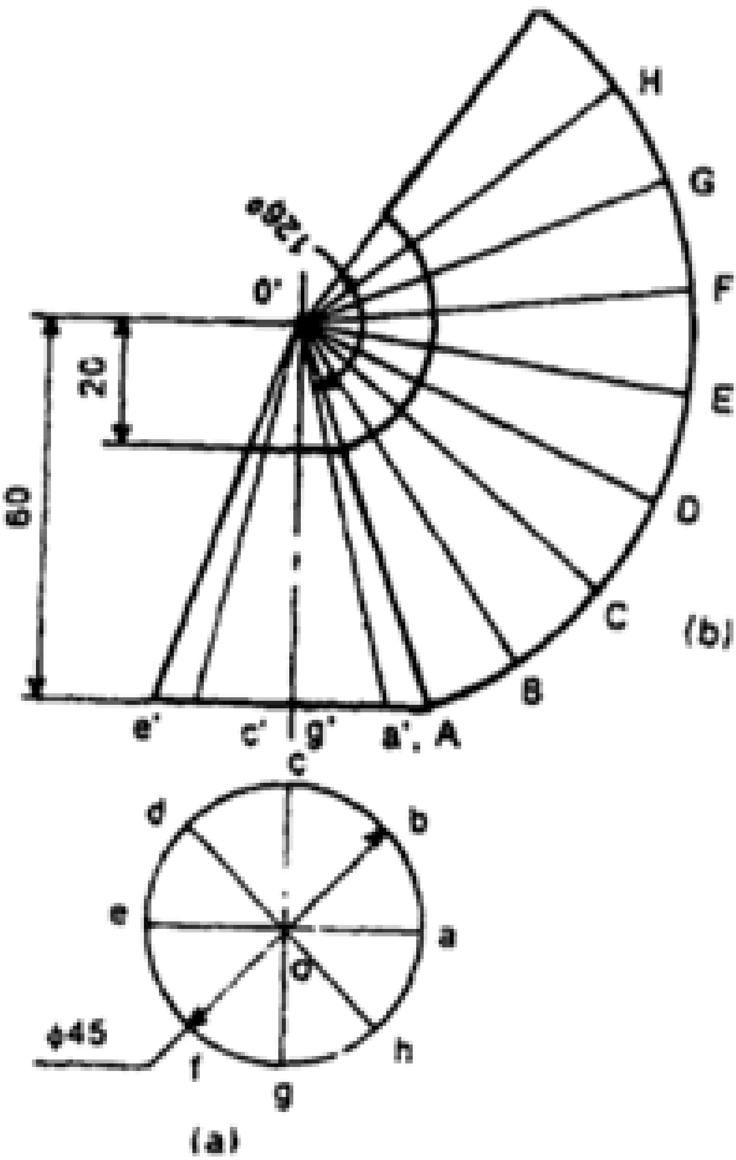
Development of Frustum of Square pyramid

1. Draw the projections of the square pyramid.
2. Determine the true length. o-a of the slant edge.
3. Draw the trace of the cutting plane VT.
4. Locate the points of intersection of the cutting plane on the slant edges a1b1c1dl of the pyramid.
5. With any point 0 as centre and radius equal to the true length of the slant edge draw an arc of the circle.
6. With radius equal to the side of the base 30 mm, step-off divisions on the above arc.
7. Join the above division points 1,2,3 etc in the order with the centre of the arc o. The full development of the pyramid is given by 0 12341.
8. With center 0 and radius equal to on mark-off these projections at A, B, C, D, A. Join A-B, B-C etc. ABCDA-12341 is the development of the frustum of the square pyramid.

Problem

A cone of diameter of base ./5 mm and height 60 mm is cut by horizontal cutting plane at 20 mm from the apex. Draw the development of the truncated cone.

Construction



1. Draw the two views of the given cone and indicate the cutting plane.
2. Draw the lateral surface of the complete cone by a sector of a circle with radius and arc length equal to the slant height and circumference of the base respectively. The included angle of the sector is given by (360 x rls), where r is the radius of the base and s is the slant height.
3. Divide the base (top view) into an equal number of parts, say 8.
4. Draw the generators in the front view corresponding to the above division points

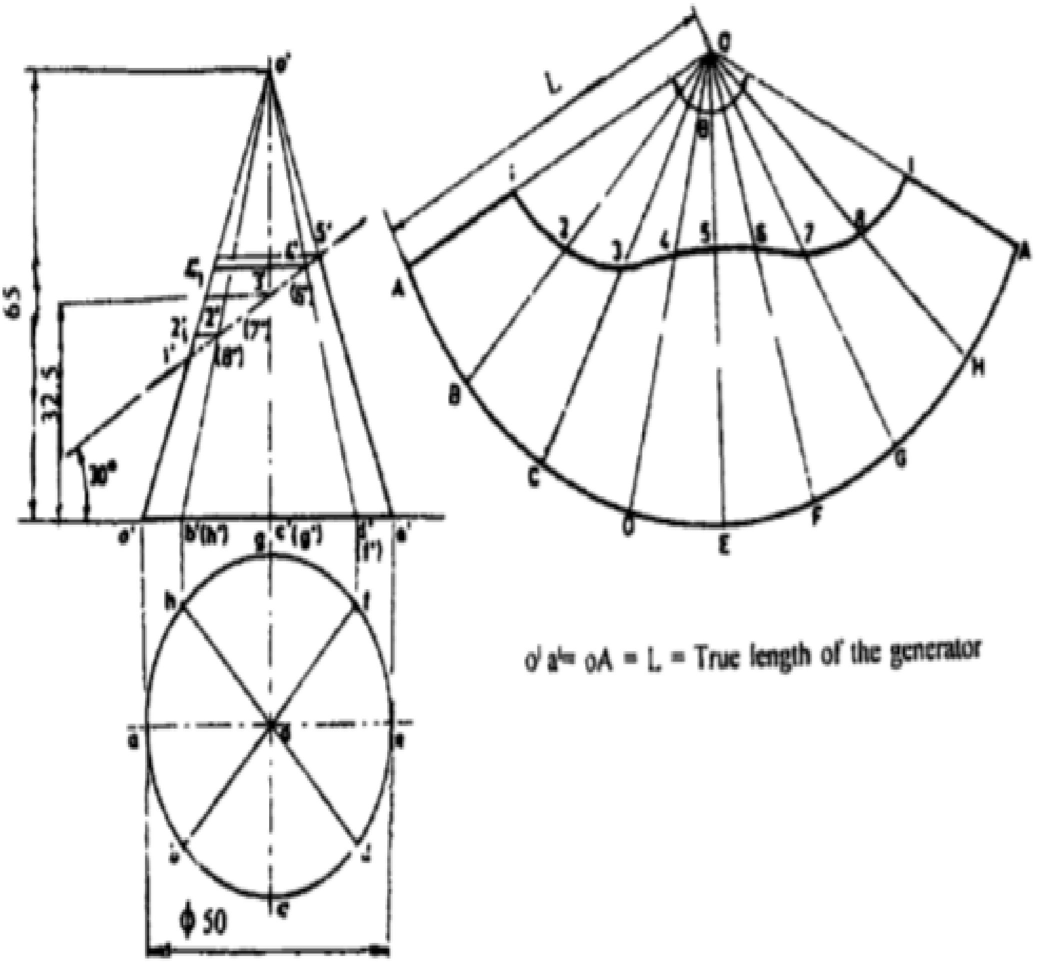
a,b,c etc.

5. With d 11 as radius draw an arc cutting the generators at 1, 2,3 etc.
6. The truncated sector AJ-IIA gives the development of the truncated cone.

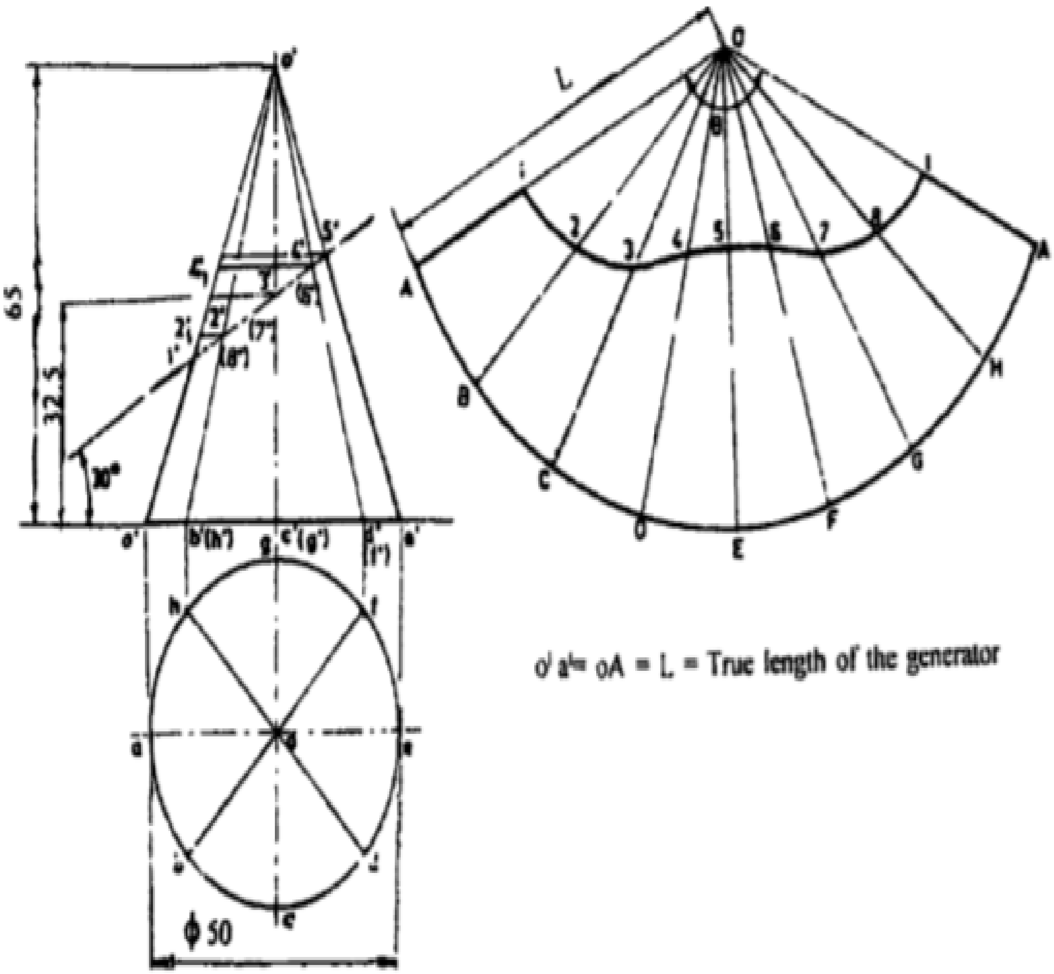
Problem

A cone of base 50mm diameter and height 60mm rests with its base on H.P. and bisects the axis of the cone. Draw the development of the lateral surface of the truncated cone.

Construction



1. Draw the two views of the given cone and indicate the cutting plane.
2. Draw the lateral surface of the complete cone.



3. Divide the base into 8 equal parts.
4. Draw the generators in the front view corresponding to the above divisions.
5. Mark the points of intersection 1, 2,3 etc. between the cutting plane and the generators.
6. Transfer the points 1, 2,3 etc. to the development after finding the true distances of 1,2,3 etc from the apex 0 of the cone in the front view.

Note: To transfer a point says 4 on od to the development.

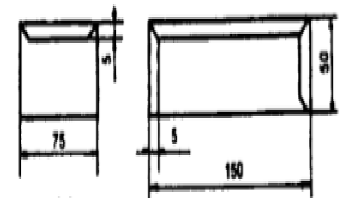
(i) Determine the true length of 0-4 by drawing a horizontal through 4 meeting at 4.

(ii) On the generator 00, mark the distance 0-4 equal to 0-4.

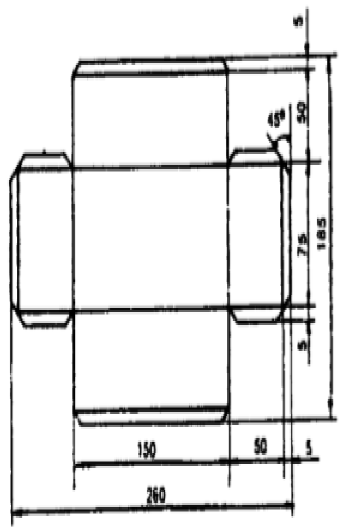
Problem

Figure shows a tools tray with an allowance for simple hem and lap-seam.

Another figure represents its development with dimensions.

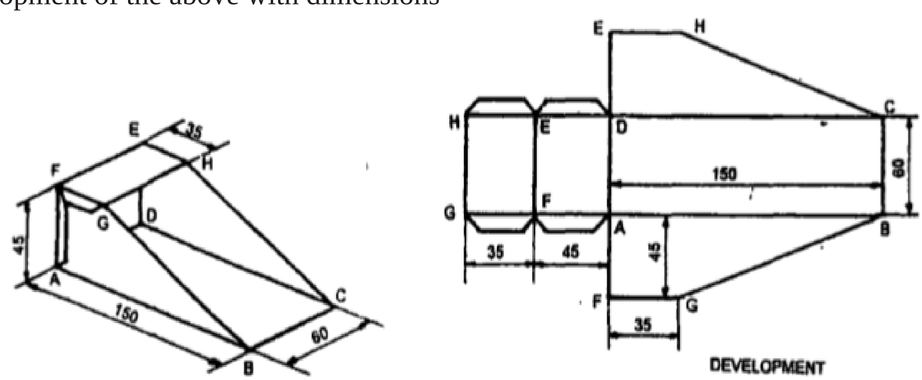


(a)



Problem

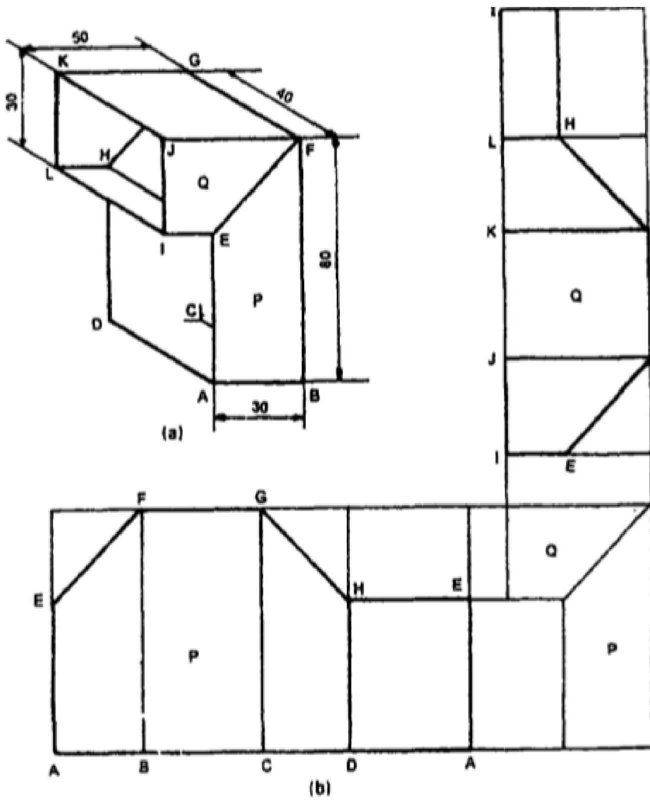
Figure shows a rectangular scoop with allowance for lap-seam and figure shows the development of the above with dimensions



Rectangular Scoop

Problem

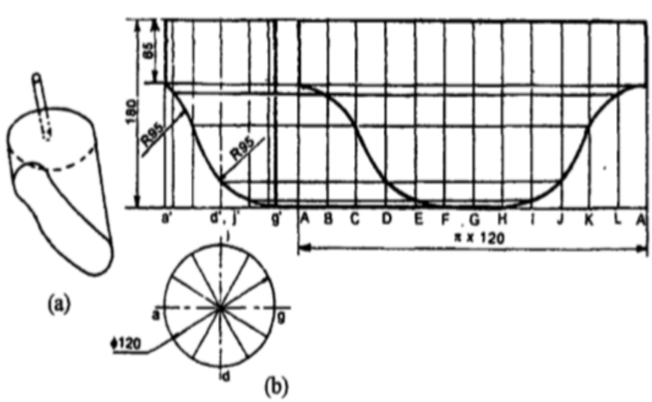
Figure shows the pictorial view of a rectangular 90° elbow and its development in two parts.



Development of 90^0 Elbow (Rectangular)

Problem

Figure represents the projection of a round scoop and its development.



Development of Round Scoop

Problem

Figure shows the orthographic projection of a chute and the development of the parts.

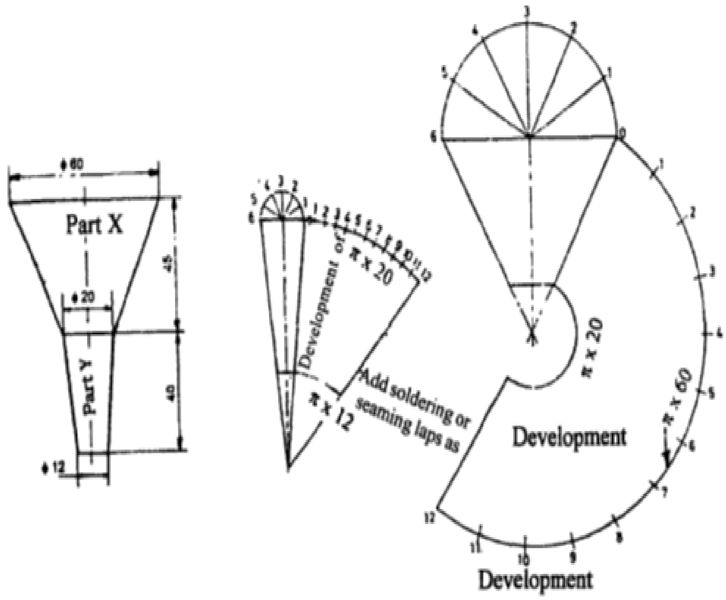
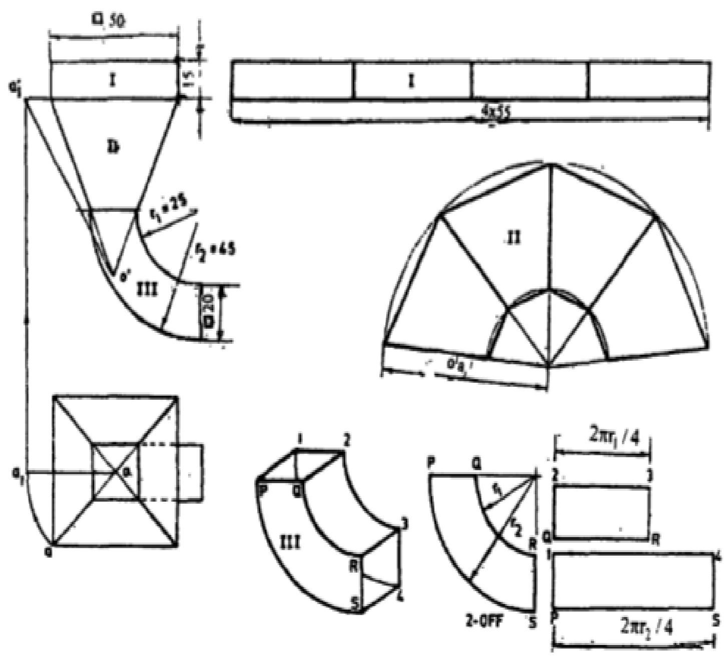
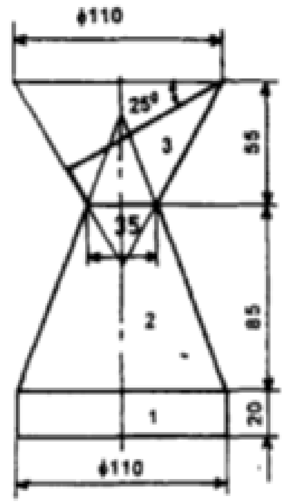


Fig. 7.19 Development of Funnel

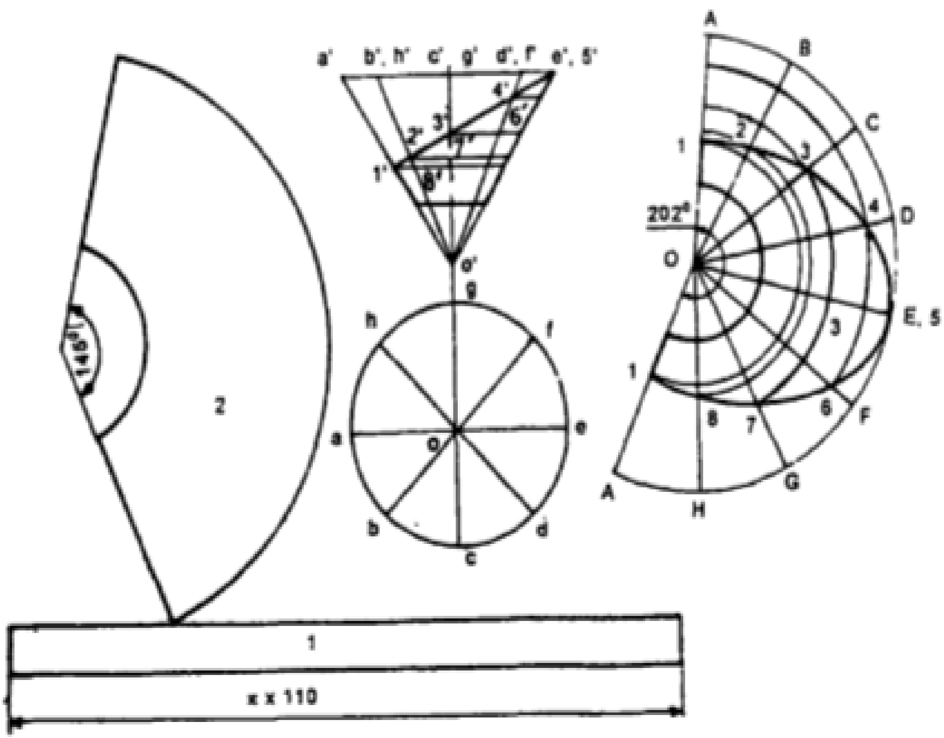


Development of Chutre

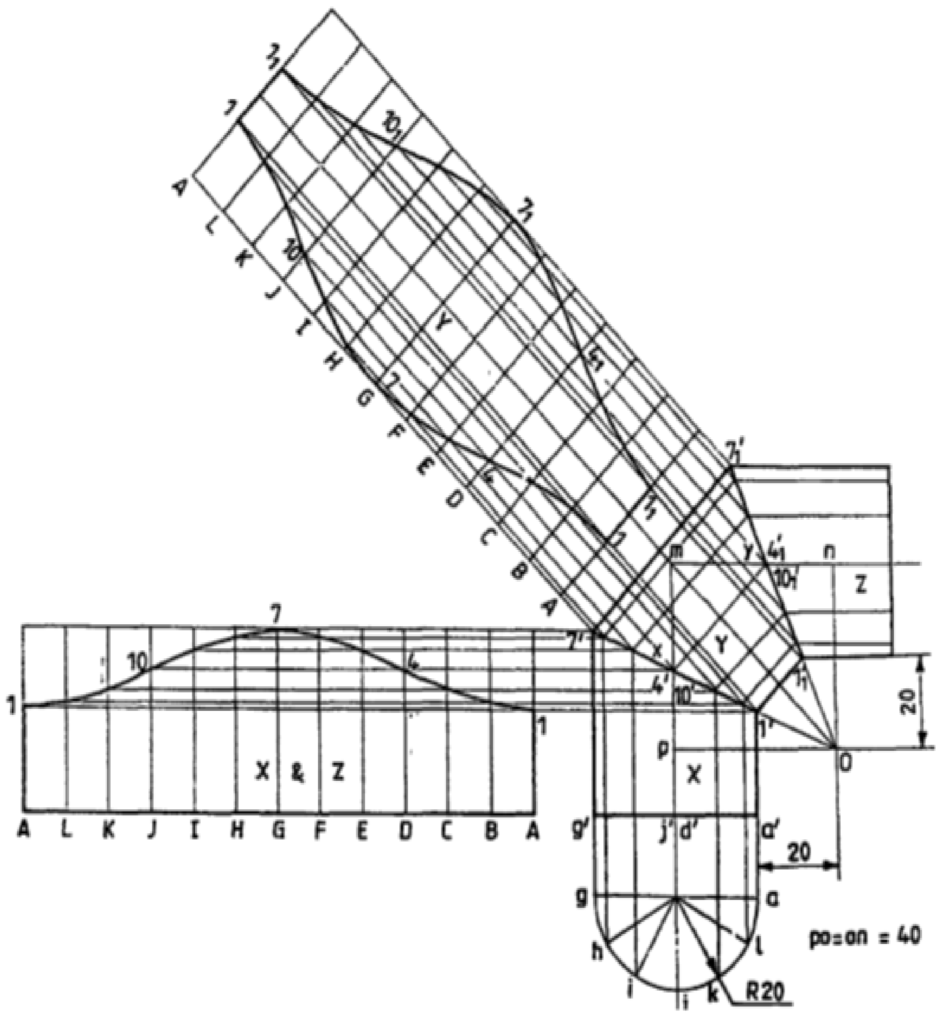
Problem : Figure shows the development of measuring oil can and three piece pipe elbow respectively.



(a)



Development of Measuring Oil Can



Development of Three Piece Pipe Elbow

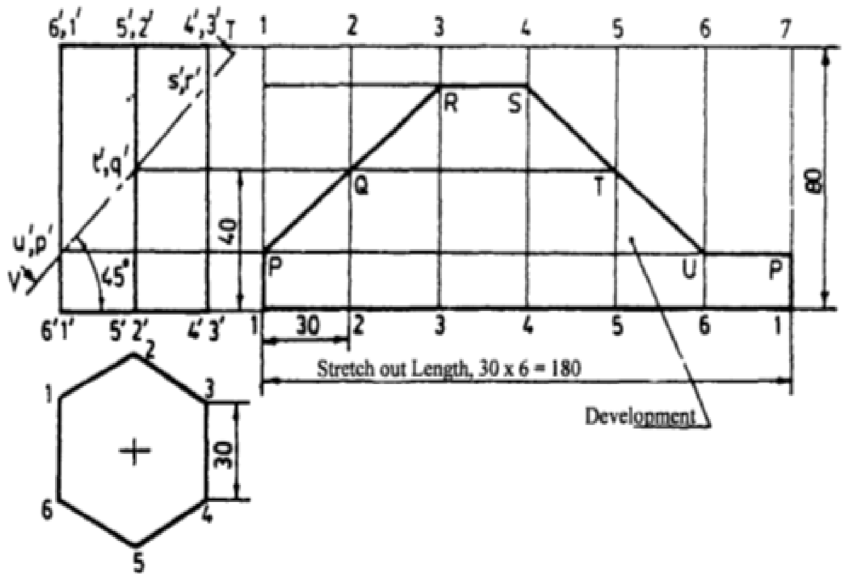
Examples

Problem: A hexagonal prism with edge of base 30 mm and height 80 mm rests on its base with one of its base edges perpendicular to V.P. An inclined plane at 45° to H.P. cuts its axis at its middle. Draw the development of the truncated prism.

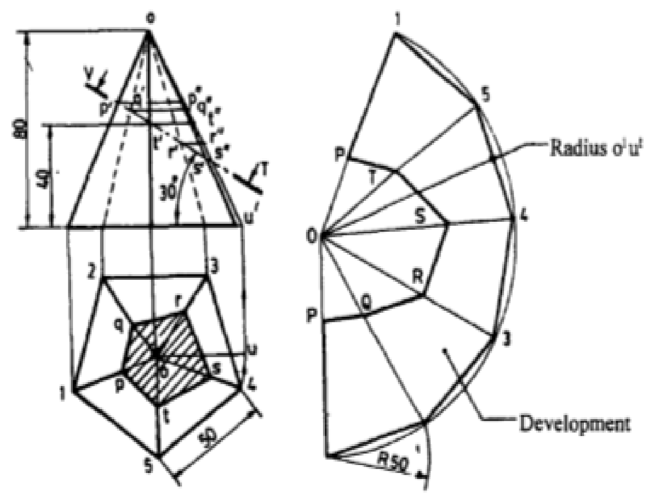
Solution:

Problem: A pentagonal pyramid, side of base 50 mm and height 80 mm rests on its base on the ground with one of its base sides parallel to V.P. A section plane perpendicular to VP and inclined at 30° to H.P c uts the pyramid, bisecting its axis. Draw the development of the truncated pyramid.

Solution:



Development of a Right Regular truncated Hexagonal Prism



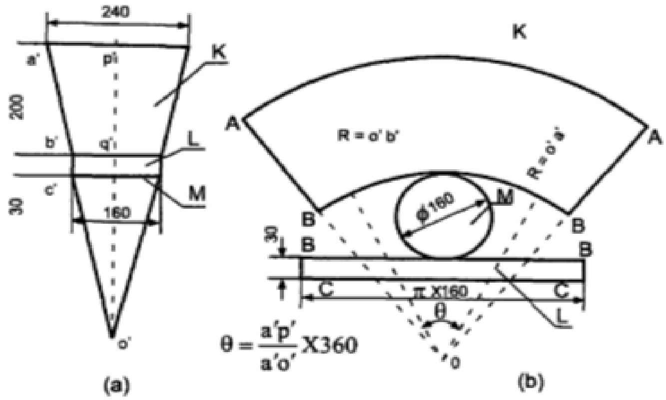
Development of a Right Regular Truncated Pentagonal Pyramid

Problem: Draw the development of a bucket shown in figure.

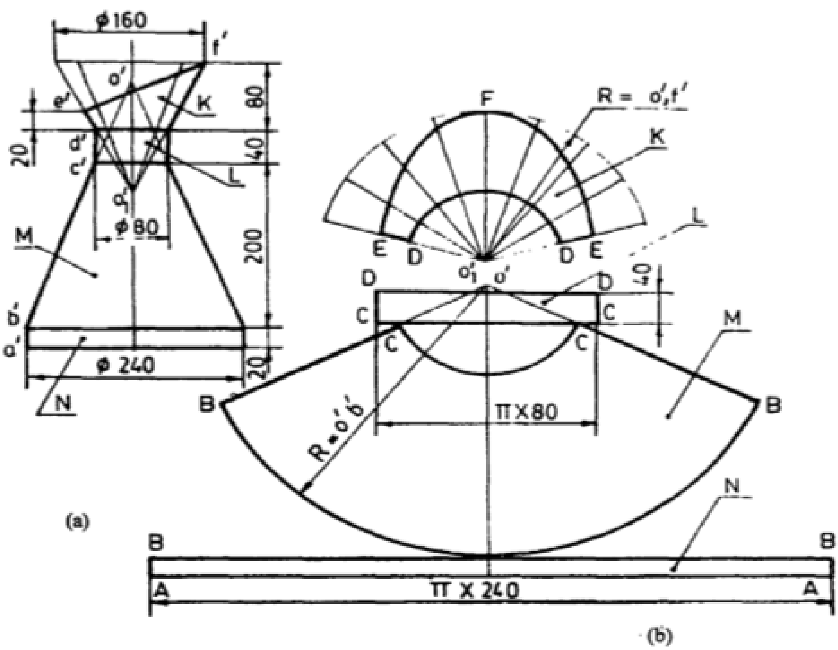
Solution:

Problem: Draw the development of the measuring jar shown in figure.

Solution:



Development of a Bucket



Development of Surfaces

1. A frustum of a square pyramid has its base 50 mm side, top 25 mm side and height 60 mm. It is resting with its base on HP, with two of its sides parallel to VP. Draw the projections of the frustum and show the development of its lateral surface.
2. A cone of diameter 60 mm and height 80 mm is cut by a section plane such that the plane passes through the mid-point of the axis and tangential to the base circle. Draw

the development of the lateral surface of the bottom portion of the cone.

3. A cone of base 50 mm diameter and axis 75 mm long, has a through hole of25 mm diameter. The center of the hole is 25 mm above the base. The axes of the cone and hole intersect each other. Draw the development of the cone with the hole in it.

4. A transition piece connects a square pipe of side 25 mm at the top and circular pipe of 50 mm diameter at the bottom, the axes of both the pipes being collinear. The height of the transition piece is 60 mm. Draw its development.

Exercise

Choose the correct answer from the given alternatives.

1. Which method of development is employed in case of prisms?

   a. Parallel-line development   b. Approximation method

   c. Triangulation development   d. Radial-line development

2. Which method of development is employed in case of cones?

   a. Parallel-line development   b. Approximation method

   c. Triangulation development   d. Radial-line development

3. Which method of development is employed in case of double curved objects?

   a. Parallel-line development   b. Approximation method

   c. Triangulation development   d. Radial-line development

4. Which method is used to develop transition pieces?

   a. Parallel-line development   b. Approximation method

   c. Triangulation development   d. Radial-line development

5. Developments of the lateral surface of a prism consist of the same number of ___________ in contact as the number of the sides of base of the prism.

   a. squares   b. rectangles   c. triangles   d. parallelograms

6. The development of the lateral surface of a cylinder is a rectangle having one side equal to the ___________ of its base-circle and the other equal to its length.

   a. circumference   b. area   c. diameter   d. radius

7. The development of lateral surface of a pyramid consists of a number of equal __________triangle in contact.

   a. equilateral   b. isosceles   c. scalene   d. right angled

8. The development of the curved surface of a cone is a ___________ of a ___________

   a. sector, circle   b. segment, circle   c. segment, ellipse   d. arc, parabola

9. The development of the surface of a cube consists of ____ equal squares, the length of the side of the squares being equal to the length of the edge of the cube.

   a. 4   b. 6   c. 12   d. 8

10. Which method of development is employed in case of pyramids?

a. Parallel-line development
b. Approximation method
c. Triangulation development
d. Radial-line development

11. In ____________________ method, the true length of slant edges of the cones is used as radius in development of surfaces.

a. Approximate development
b. Parallel line development
c. Triangulation development
d. Radial line development

12. Theoretically undeveloped surfaces are ______

a. Cube surface
b. Cone surface
c. Pyramid surface
d. Double curved surfaces

13. In _____________ method, theoretically undeveloped surfaces such as sphere, double-curved surfaces are developed approximately.

a. Triangulation development
b. Parallel line development
c. Approximate development
d. Radial line development

14. Approximate development is the method of developing of non-developable surfaces, by divided the surface of the object into _____________

a. Parallel parts
b. Triangular parts
c. Circular parts
d. Zone and lune

15. Which of the following is suitable for the development of spheres?

a. Triangulation development
b. Parallel line development
c. Approximate development
d. Radial line development

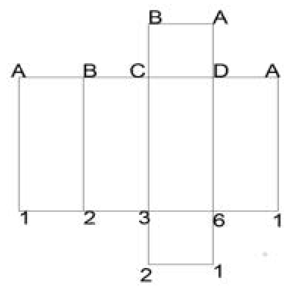
16. Which method the most suitable for the development of the special shape which is the combination of two different shapes and sizes?

a. Triangulation development
b. Parallel line development
c. Approximate development
d. Radial line development

17. The most suitable method for the development of cones is ______

a. Triangulation development
b. Parallel line development
c. Approximate development
d. Radial line development

18. What is the method used for the following development of a square prism?



a. Triangulation development b. Parallel line development

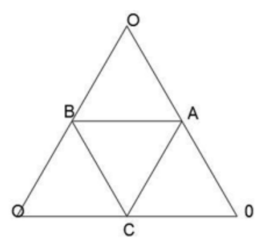
c. Approximate development d. Radial line development

19. In ____________ method, stretching and distortion of the true length are allowed in the process of development.

a. Triangulation development b. Parallel line development

c. Approximate development d. Radial line development

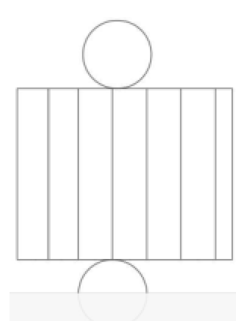
20. What is the development method employed for the following development of a triangular pyramid?



a. Triangulation development b. Parallel line development

c. Approximate development d. Radial line development

21. What is the development method employed for the following development of a cylinder?



a. Triangulation development

b. Parallel line development

c. Approximate development

d. Radial line development

Write short answer to the following questions.

1. Differentiate between singly curved surface and doubly curved surface.
2. Name the method used for obtaining the developments of prisms and cylinders.
3. Name the method used for obtaining the developments of pyramids and cones.
4. Name two common methods of getting the development of spheres.
5. What precaution should be taken while obtaining the development of pyramids?
6. What are the dimensions of the cone whose development is a semicircle of 120 mmdiameter?
7. State a few practical applications of development of surfaces.

Write long answer to the following questions.

a. Develop the surfaces of a cube of length 4cm.

b. Develop the surfaces of a cuboid of length 6cm, breadth 5cm and height 4cm.

c. Develop the surfaces of a cylinder with radius of base 3.5 cm and height 6 cm.

5. Develop the surfaces of a right circular cone of radius 2.1 cm and height 6.3cm.

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Highway Engineering Khanna S. K & Justo CEG, Nem Chand and Bros. Roorkee. *Principles and practice of Highway Engineering*, Dr.L.R. Kayali and Dr. N.B.Lal, Khanna publishers,

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