ENGINEERING GRAPHICS & DESIGN

Lab Manual

ENGINEERING GRAPHICS & DESIGN LABORATORY

DEPARTMENT OF MECHANICAL ENGINEERING

INSTITUTE OF ENGINEERING & MANAGEMENT, KOLKATA

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CHAPTER - 1

Engineering Drawing

Engineering drawing, most commonly referred to as engineering graphics, is the art of manipulation of designs of a variety of components, especially those related to engineering. It primarily consists of sketching the actual component, for example a machine, with its exact dimensions. The scale of dimensions is suitably adjusted so as to properly fit within the contours of the drawing sheet.

Engineering drawing, is one of the most important aspect of mechanical engineering ,as it is a fundamental requirement for the development of the design /assembly of a machine or a product. While, the interpretation of a component in terms of sketching can be done in various methods, the three most necessary techniques of drawing/projection are namely Orthographic projection, Isometric projection & Section of solids.

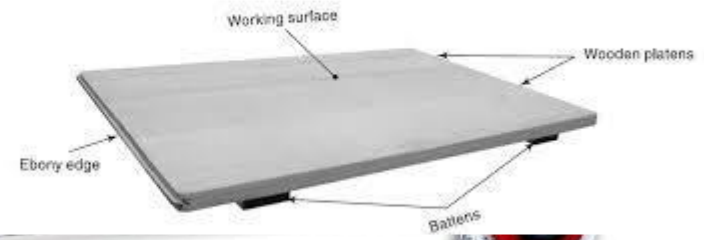
Hence, engineering drawing plays a vital role both in manufacture and design, as it not only explains the string of arrangements in a machine or structure, but also tells us about the method to be employed, for manufacture of individual blocks.

List of Instrument

Following is the list of drawing instruments that are required for creating proper engineering drawing on paper.

1. Drawing Board
2. Mini drafter / T-square
3. Set-squares (45° – 45° & 60° – 30°)
4. Protractor (180°, 360°)
5. 12” Stainless Scale (preferable)
6. Compass (drafting)
7. Circle Master
8. A set of French Curves

9. Drawing sheets (A4 size)
10. Drawing pencil (Lead pencil [Mechanical Pencil], wooden pencil)
11. Sharpener
12. Eraser
13. Drawing pins & board clips
14. Duster or handkerchief

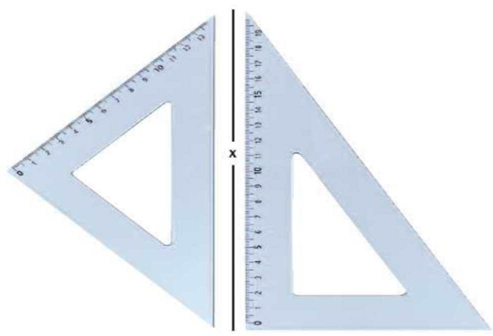


Drawing Board : Drawing board is a rectangular desk or flat surface of proper dimensions, fitted with an ebony edge and used for supporting the drawing sheet and make it ready for technical drawing. **Mini Drafter:** It is an instrument used to draw geometrical shapes and figures with great precision. It does not require support of any other instrument like scale or set squares.

The mini-drafter is a versatile tool and can be used to draw almost everything. It can be used to draw parallel lines, perpendiculars, inclined lines of any degree with unmatched speed. It consists of one long scale and one small scale and the scales are 'L' shaped which can be fitted on any drawing board easily.

Set-squares (45° – 45° & 60° – 30°)

A set square is an object used in engineering and technical drawing, with the aim of providing a straightedge at a right angle or other particular planar angle to a baseline.



These set squares come in two usual forms, both right triangles: one with 90-45-45 degree angles, the other with 30-60-90 degree angles.

T-square

A T-square is a technical drawing instrument used by draftsmen primarily as a guide for drawing horizontal lines on a drafting table.

It may also guide a set square to draw vertical or inclined lines. Its name comes from its resemblance to the letter T. The top of the T-square hangs off of the drafting table and is called the head; the blade is the part that stays on the drafting table. The T-square usually has a transparent edge made of plastic which should be free of nicks and cracks in order to provide smooth, straight lines.

Protractor (180°, 360°)

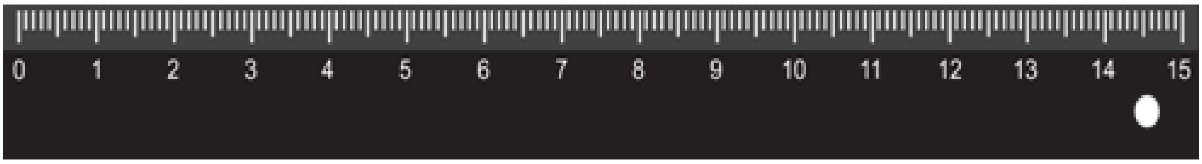
A protractor is a square, circular or semicircular tool, typically made of transparent plastic, for measuring angles.

Most protractors measure angles in degrees (°). Radian-scale protractors measure angles in radians.

Semi-circular protractor is of 180° and full circle protractor is of 360°. More advanced protractors, such as the bevel protractor, have one or two swinging arms, which can be used to help measure the angle.

Scales (Ruler)

A ruler, sometimes called a rule or line gauge, is an instrument used in geometry,

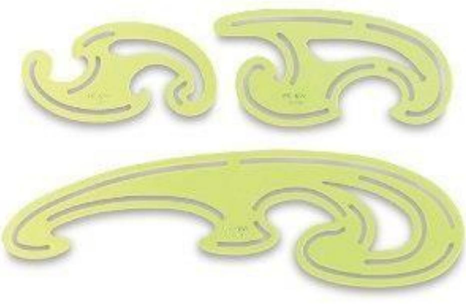


technical drawing, printing and engineering/building to measure distances and/or to rule straight lines. You'll need to use this instrument frequently for making technical drawing. The scales are available in plastic, wooden and steel material. Generally steel rule is used to draw engineering drawings.

Compass (Drafting)

A compass is a technical drawing instrument that can be used for inscribing circles or arcs. A typical compass is consists of two legs. One pencil lead is added to a leg and a tip point to pivot on paper is provided to another leg. Circles can be drawn by fastening one leg of the compasses into the paper with the spike, putting the pencil on the paper, and moving the pencil around while keeping the hinge on the same angle. Drafting compass is available in different variants that can be selected as per drawing requirement.

French Curves



A French curve is a template made out of metal, wood or plastic composed of many different curves. It is used in manual drafting to draw smooth curves of varying radii. The curve is placed on the drawing material, and a pencil or other implement is traced around its curves to produce the desired result.

Drawing Paper & Drawing Sheet

Generally a clean white paper or Sheet of size varying from A0, A1(most common), A2, A3, A4(as per ISO-A) is to be used to make technical drawings on it.

Layout of a drawing sheet

The drawing sheet laid and fixed on the board for drawing should contain **Border** & **Title Block** .For A1 size sheet, the border on all sides should have a minimum width of 20mm . Title Block of size 180 x 65 mm is generally provided at the bottom right corner of the sheet just inside the border and should contain title of the drawing, name of the project, scale, drawing number, revision number, name of the firm, symbol denoting method of projection, initial of persons drawn, checked and approved with date and any other relevant information as may be necessary.

A typical layout of a drawing sheet is shown in the figure below:

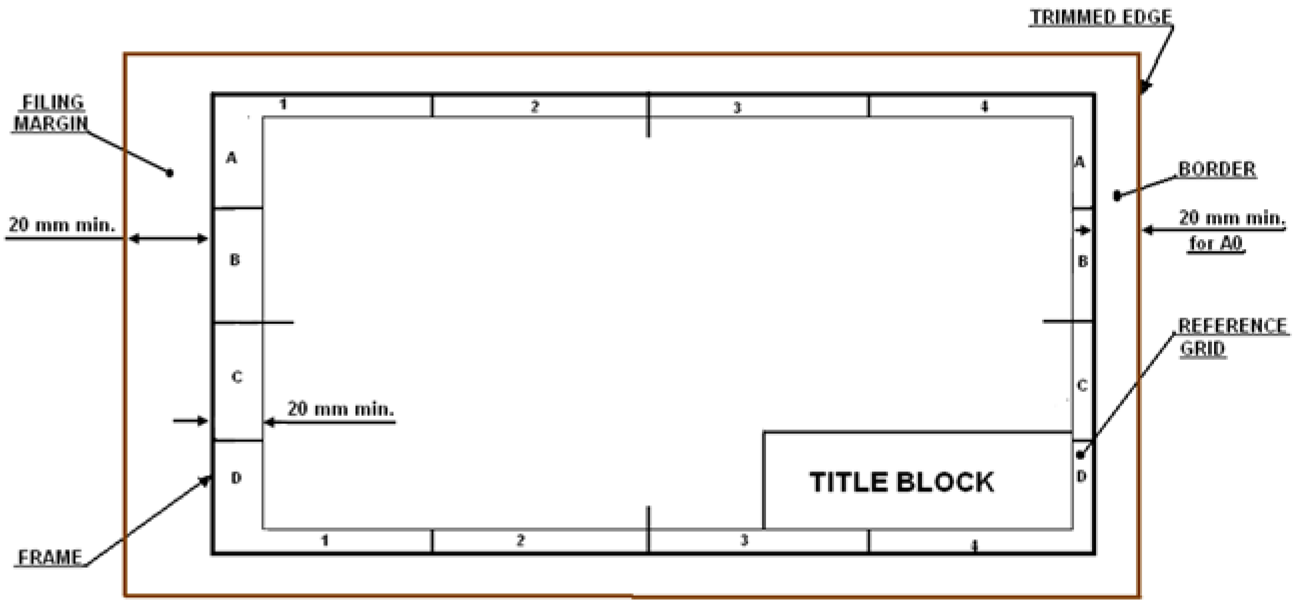


Figure 1. A typical layout of a drawing sheet.

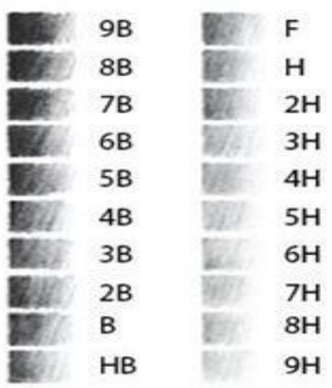
- Borders – A minimum of 10 mm space left all around in between the trimmed edges of the sheet.
- Filing margin – Minimum 20 mm space left on the left hand side with border included. This provided for taking perforations .

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

a. Identification zone : In this zone the details like the identification number or part number, Title of the drawing, legal owner of the drawing, etc. are to be mentioned.
b. Additional information zone : Here indicative items lime symbols indicting the system of projection, scale used, etc., the technical items lime method of surface texture, tolerances, etc., and other administrative items are to be mentioned.

Drawing Pencil (Lead pencil or mechanical pencil, wooden pencil)

A mechanical pencil is a pencil with a replaceable and mechanically extendable solid



pigment core called a lead. It is designed such that the lead can be extended as its point is worn away. The lead is usually graphite based and can easily be removed and placed by pushing tip at the top of mechanical pencil. Drawing pencil comes in wooden material too that are useful to draw sketches in shades. Different shades or grades of mechanical pencil are shown in figure at left.

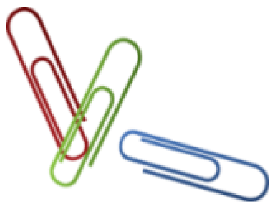
Sharpener

A pencil sharpener is a device for sharpening a pencil's writing point by shaving away its worn surface. It is mostly used when wooden pencil is selected to draw sketches and the writing point of wooden pencil becomes blunted and the drawing gets untidy.

Eraser

An eraser (specially no dust) is used for removing pencil markings on paper or sheet. It is very helpful in removing unnecessary line of drawing by rubbing it on unwanted lines and points.

Drawing pins & clips



Drawing clips are used to hold drawings on drawing boards which prevent movement of the sheet while working. Drawing pins are used to attach two or more sheets together. They are inserted and removed by hand, hence the terms "thumbtack" and "push pin" is also used. The term drawing pin comes from their being used to hold drawings on drawing boards.

Duster or handkerchief

Duster or handkerchief is often used to clean the paper on which drawing is being made. They are available in different variants. Maximum dust is produced when you use the eraser to erase something on paper. The duster is very helpful at that time as removal of dust from hand leads to more black spots on the drawing paper. Above are the basic but mostly used drawing instruments. All are easily available in stationary shops at your local store. You should use them to make precise drawings exactly as per data available.

Different types of lines

Various types of lines used in general engineering drawing. Not a single engineering drawing is possible without use of line types. Some of them with illustrations and applications are discussed here.

Line	*Description*	*General Applications*
A	Continuous thick	A1 Visible outlines
B	Continuous thin (straight or curved)	B1 Imaginary lines of intersection B2 Dimension lines B3 Projection lines B4 Leader lines B5 Hatching lines B6 Outlines of revolved sections in place B7 Short centre lines
C	Continuous thin, free-hand	C1 Limits of partial or interrupted views and sections, if the limit is not a chain thin
D	Continuous thin (straight) with zigzags	D1 Line (see Fig. 2.5)
E	Dashed thick	E1 Hidden outlines
G	Chain thin	G1 Centre lines G2 Lines of symmetry G3 Trajectories
H	Chain thin, thick at ends and changes of direction	H1 Cutting planes
J	Chain thick	J1 Indication of lines or surfaces to which a special requirement applies
K	Chain thin, double-dashed	K1 Outlines of adjacent parts K2 Alternative and extreme positions of movable parts K3 Centroidal lines

Dimensioning

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

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

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

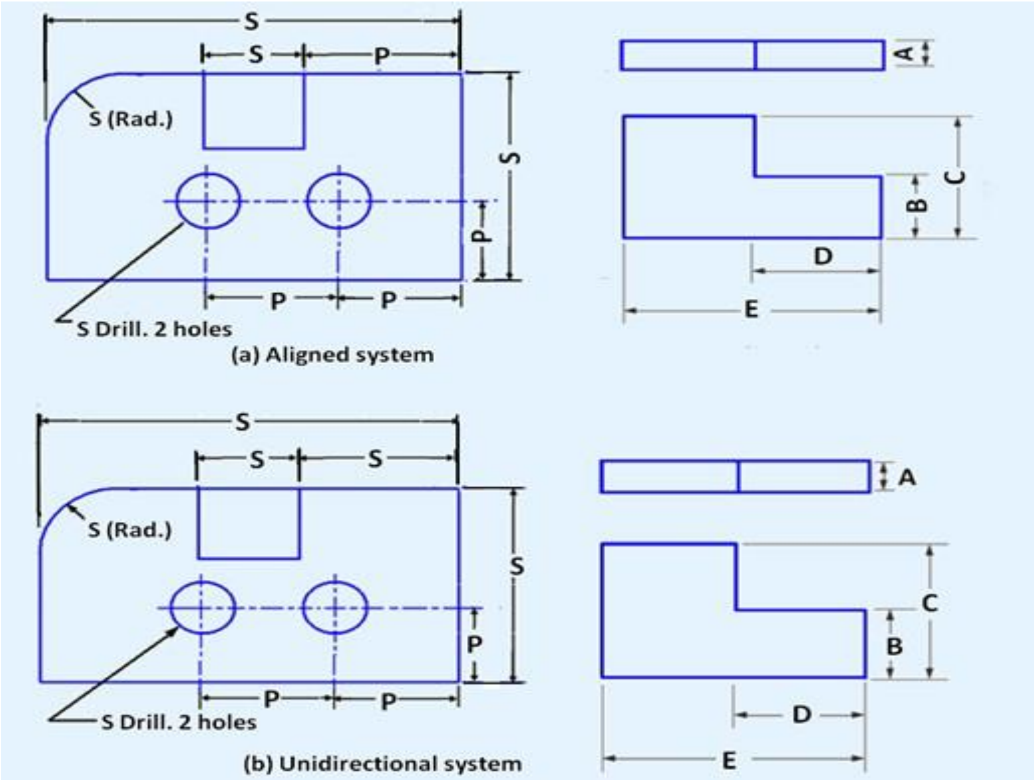


Figure 3. The aligned system and unidirectional system of dimensioning.

Rules to be followed for dimensioning. Refer figure 4.

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

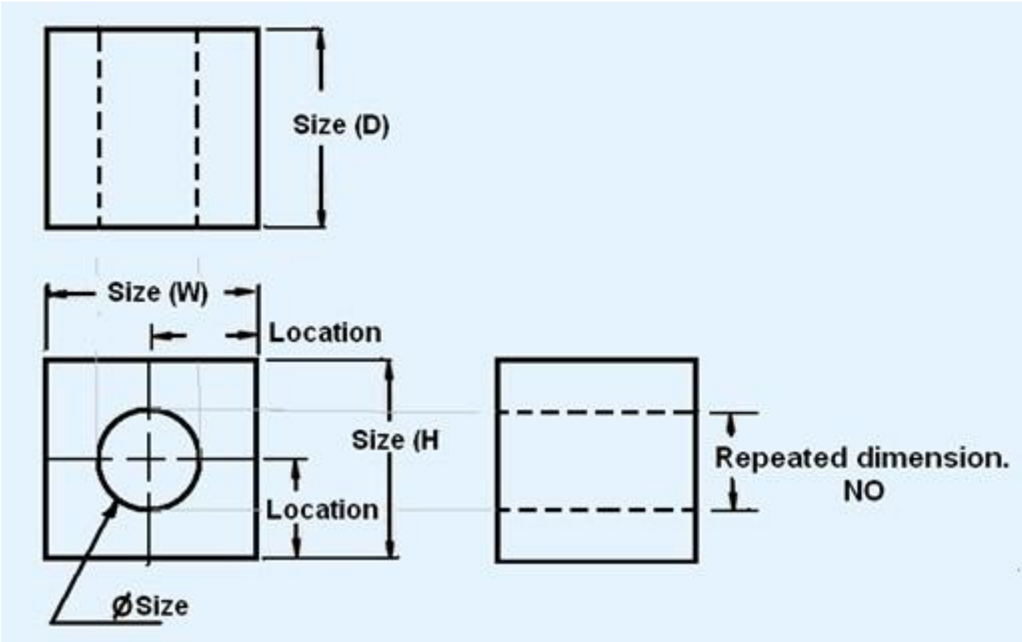


Figure 4.Typical dimension lines

Dimensioning consists of the following:

- A thin, solid line that shows the extent and direction of a dimension. Dimension lines are broken for insertion of the dimension numbers
- Should be placed at least 10 mm away from the outline and all
- other parallel dimensions should be at least 6 mm apart, or more, if space permits

The important elements of dimensioning consists of extension lines, leader line, arrows and dimensions.

Extension line – a thin, solid line perpendicular to a dimension line, indicating which feature is associated with the dimension. There should be a visible gap of 1.5 mm between the feature's corners and the end of the extension line.Figure 5 shows extensionlines.

Leaderline

A thin, solid line used to indicate the feature with which a dimension, note, or symbol is associated. Generally this is a straight line drawn at an angle that is neither horizontal nor vertical. Leader line is terminated with an arrow touching the part or detail. On the end opposite the arrow, the leader line will have a short, horizontal shoulder. Text is extended from this shoulder such that the text height is centered with the shoulder line

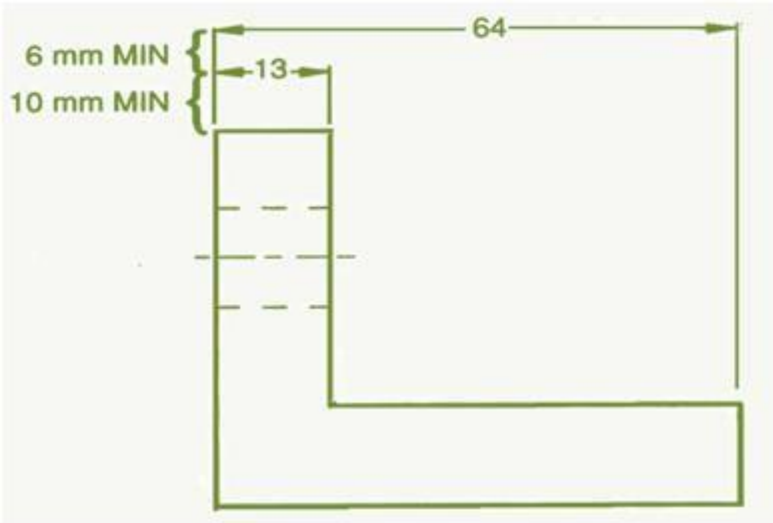


Figure 5. showing extension lines

- Arrows – 3 mm wide and should be 1/3rd as wide as they are long - symbols placed at the end of dimension lines to show the limits of the dimension. Arrows are uniform in size and style, regardless of the size of the drawing.Various types of arrows used for dimensioning is shown in figure 6.

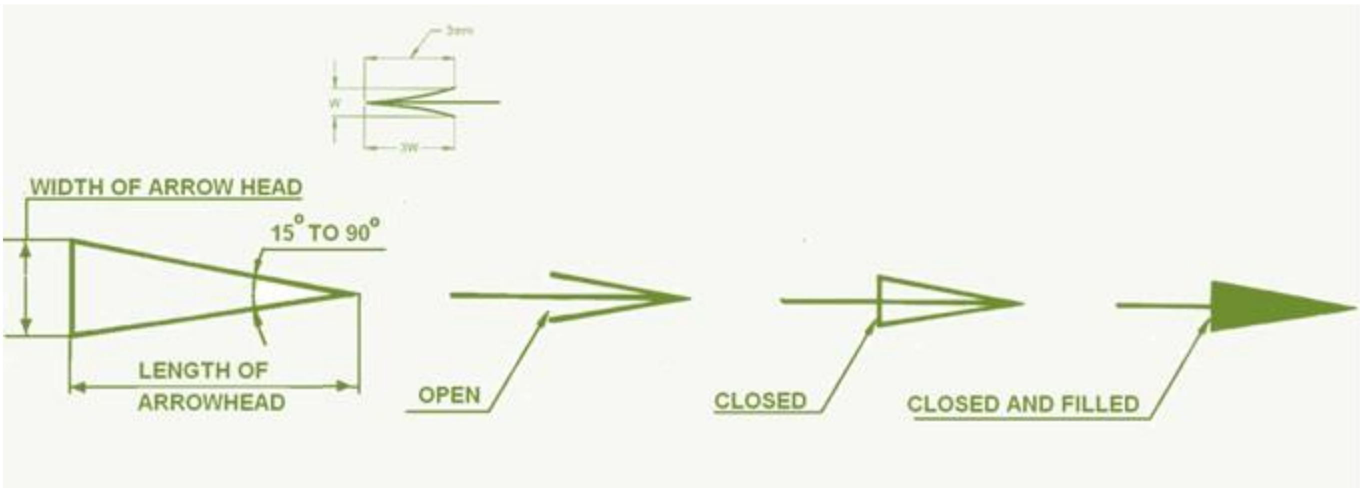


Figure 6.Various types of arrows used for dimensioning

The specification of dimension lines are shown in figure 7.

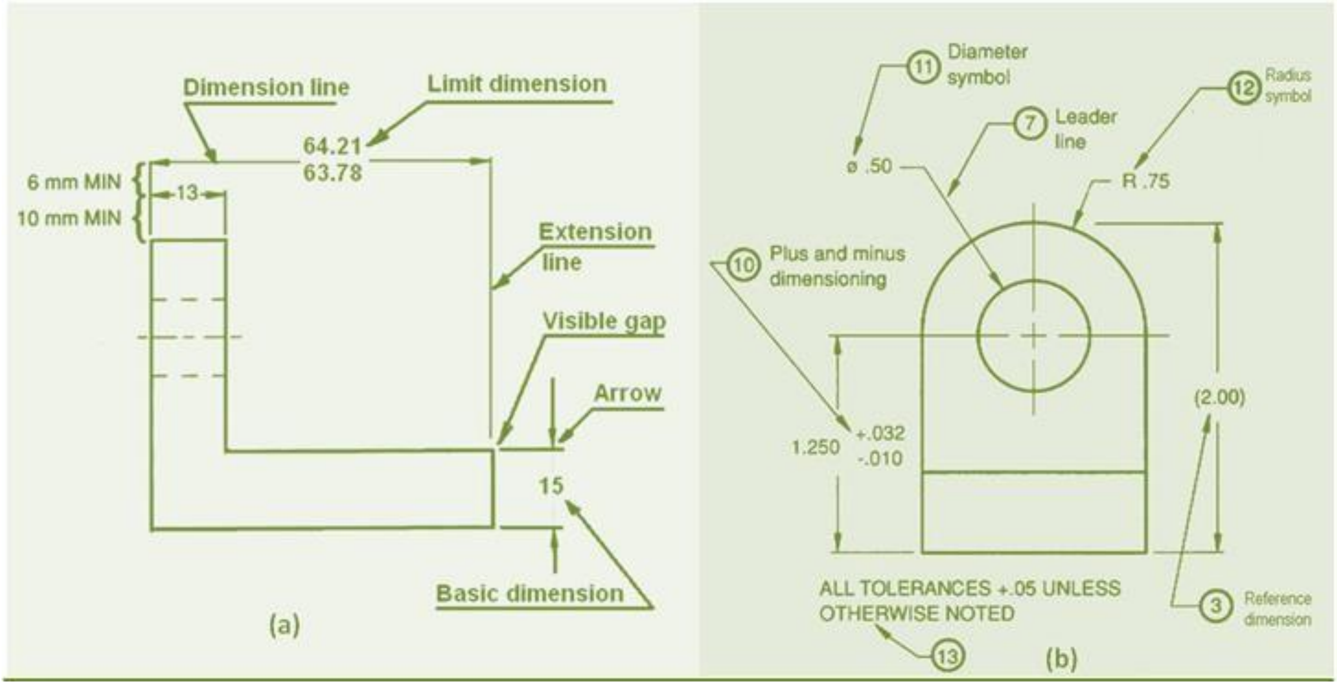


Figure 7 showing the specification of dimension lines.

Dimensioning of angles: The normal convention for dimensioning of angles are illustrated in figure 8.

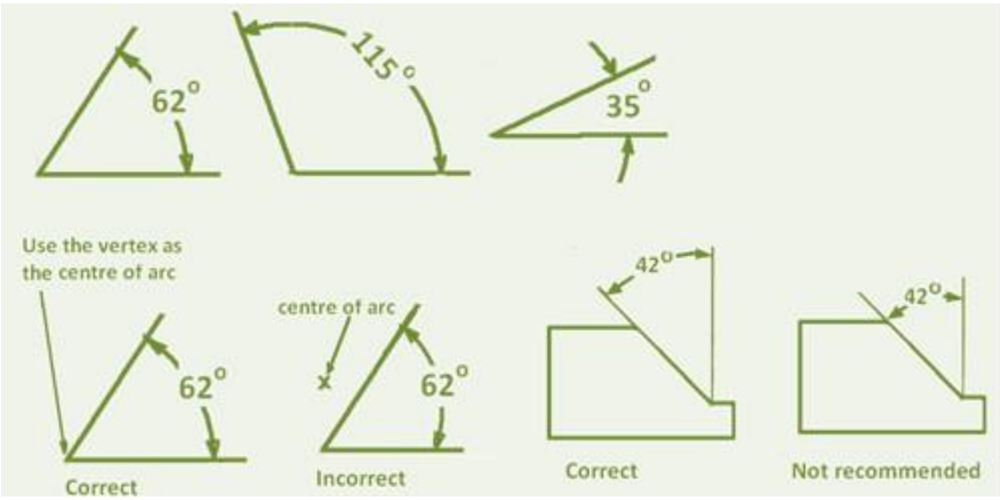


Figure 8 conventions used for dimensioning angles.

<u>Problems</u>

Problem 1 Divide a straight line in seven equal parts by (n-1) method.

<u>Solution:</u>

Step1. Take a line of length 5 cm (50 mm). Here it is AB(FIG-1).

Step2. From point A, draw any line AP with acute angle θ

Step3. From point B also draw BQ with same angle θ

Step 4. Now using divider & taking any length, cut on AP six times and name the division points like 1,2,3 etc.

Step5. Taking same length cut on BQ line six times and name the division points like 1',2',3' etc.

Step6. Now join point 1 with point 1', point 2 with 2' and so on.

Step7. Finally we will get seven equal divisions of AB line.

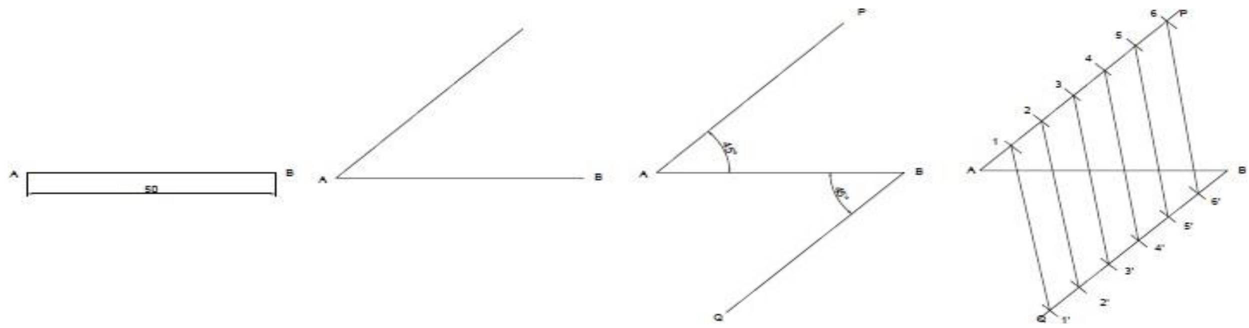


FIG-1

Problem 2 Divide a straight line in 10 equal parts by using two set square method.

Solution:

Step 1. Take a line AB of length 8cm (80mm).

Step 2. Draw <BAC = 30º (or any acute angle).

Step 3. Divide AC in ten equal division using the divider.

Step 4. Join last division point C with B.

Step 5. Draw lines parallel to BC from each division points with the help of the set squares to get 10 equal parts of AB.

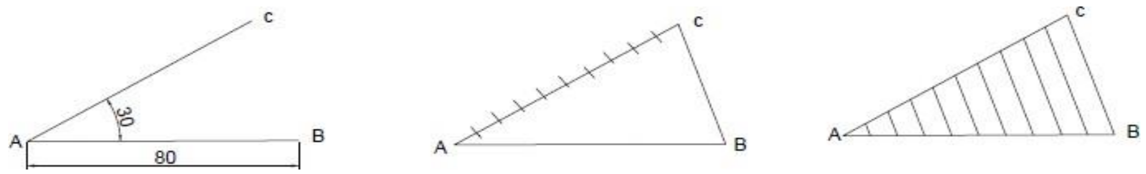


FIG-2

Problem 3 **Draw a regular heptagon of side 50 mm each (general method).**

Solution:

This method is used to draw a regular polygon. Here it is a regular heptagon and side is given as 50 mm.

Step 1. Draw a line AB equal to given length 50 mm.

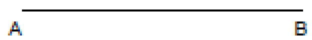


FIG-3A

Step 2. Draw 45^o and 60^0 inclined lines at point A.here <BAP $=45^o$. & <BAQ$=60^0$

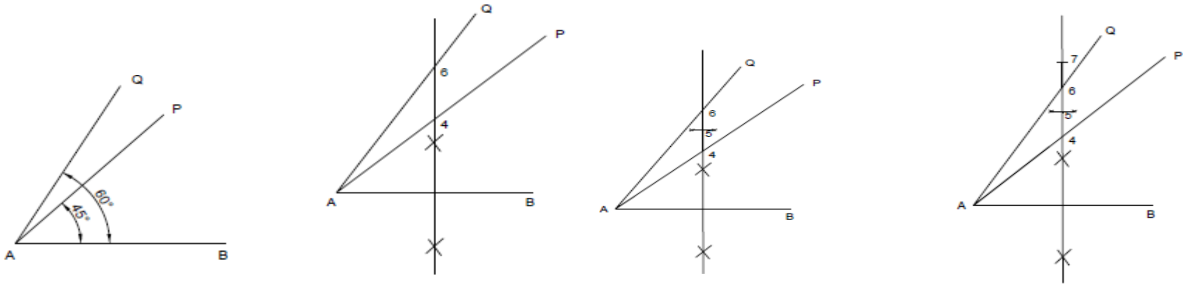


FIG-3B

Step 3. Bisect the line AB and this bisector line of AB will intersect AP and AQ at '4' and '6' points respectively.

Step 5. Now bisect 4-6 distance to get midpoint of its as '5'(Fig-3B).

Step 6. Now take 4-5 or 5-6 length by the divider and mark point as '7' on the bisector above point '6'.

Step 7. Join A with point '7'.

Step 8. Taking A-7 as radius and '7' as centre,

draw a circle which will touch A and B.

Step 9. Starting from B divide this circle in seven

equal division with radius equal to AB.

Step10. Join all the points sequentially on the

circle to get the regular heptagon(Fig-3C).

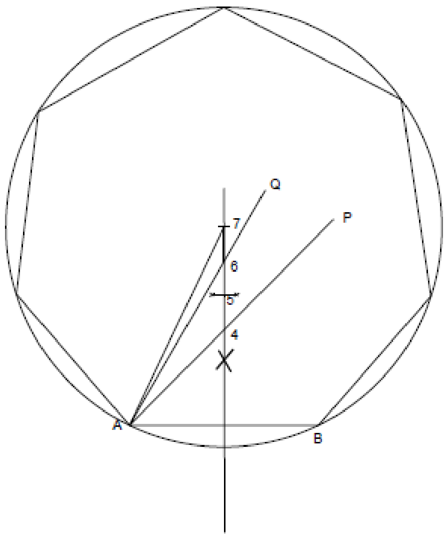


Fig-3C

Scales

There is a wide variation in sizes for engineering objects. Some are very large (eg. Aero planes, rockets, sky scrapers, bridges etc); Some are very small (wrist watch, MEMs-components) .

There is a need to reduce or enlarge while drawing the objects on paper. Some objects can be drawn to their actual size. The proportion by which the drawing of an object is enlarged or reduced is referred to as the scale of the drawing.

Definition

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

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

Types of Graphical Scale :-

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

Representative fraction (R.F.)

$$\boldsymbol{R.F.=\frac{Length\ of\ the\ drawing}{Length\ of\ actual\ size\ of\ the\ object}}$$

Under the present syllabus we have to deal with two types of scales :

1. Plain Scale

2. Diagonal Scale

PLAIN SCALE

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

Problem 4 Construct a plain scale where $R.F.=\frac{1}{4}$ to show centimetres and long enough to measure up to 5 decimetre.

<u>Solution</u>

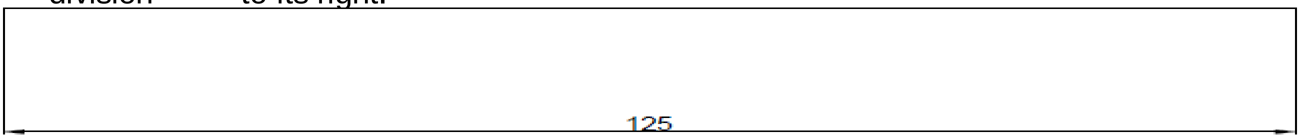
Here $R.F.=\frac{1}{4}$

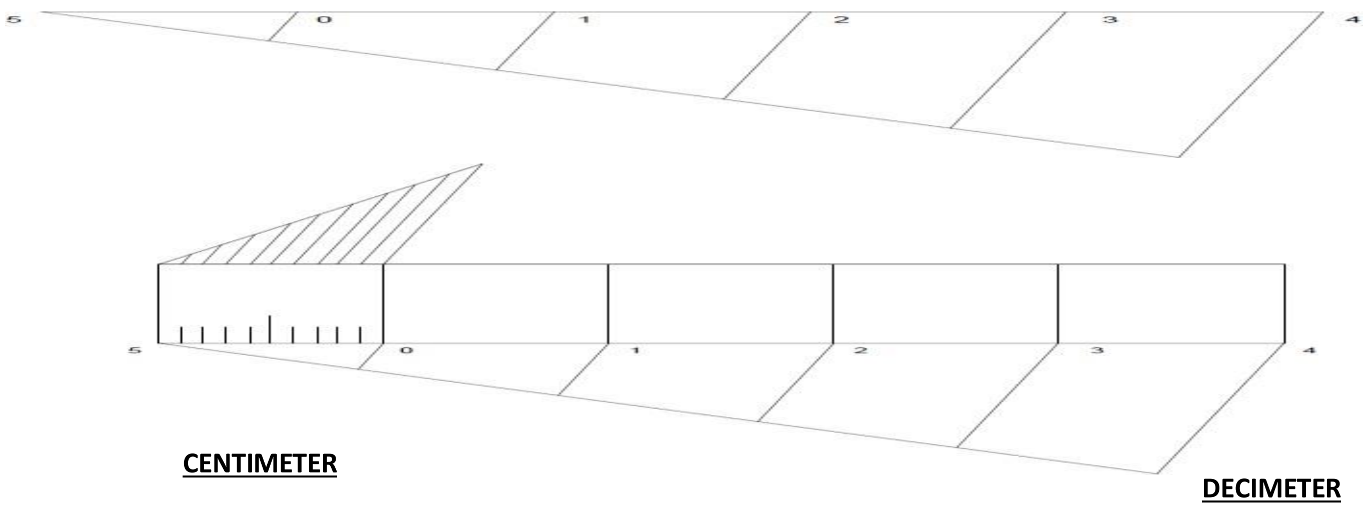
Now Calculate length of scale= R.F.X Maximum length= $\frac{1}{4}X\ 5\ dcm=12.5cm$

I) First take a line 12.5 cm long.

II) Divide it in 5 equal parts.

III) Mark 0 at the end of first division and 1,2,3,4 at the end of each subsequent division to its right.





DIAGONAL SCALE

A diagonal scale is used when very minute distances are to be accurately measured i.e., when measurements are required in three units for example dm, cm, mm or yard, foot, inch.

Problem 5 Construct a diagonal scale of R.F. =1/4000 to show meters and long enough to measure up to 500 meters. Mark distance 374 meters and 186 meters on it.

<u>**Solution**</u>

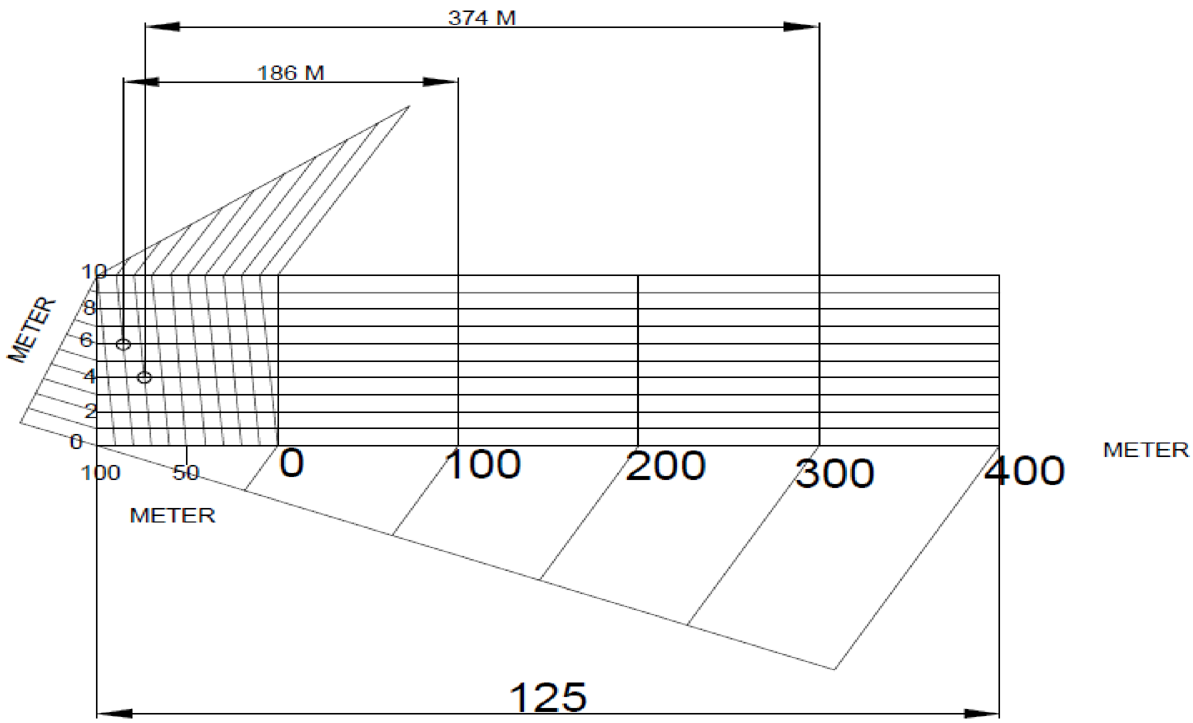
Length of Scale= $\frac{1}{4000} \times 500 \times 100 = 12.5\ cm = 125mm$

1. Draw a line of 12.5 cm or 125 mm and divide it into 5 equal parts. Each part will show 100 meters.

2. Divide 1st part into ten equal divisions. Each division will show 10 M.

3. At the left-hand end erect a perpendicular on it and step off 10 equal division of any length.

4. After completion, mark it properly as shown in the drawing below.


374 M
186 M
10
8
6
4
2
0
METER
100
50
METER
0
100
200
300
400
METER
125

CHAPTER -2

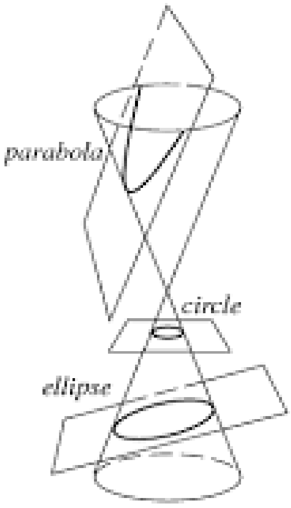
CURVES USED IN ENGINEERING PRACTICE

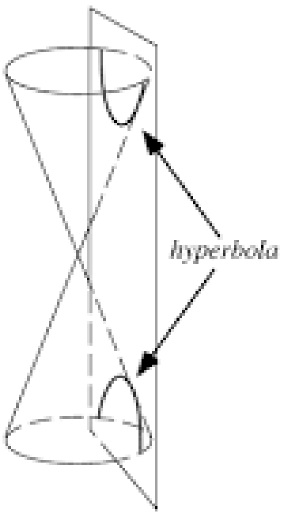
The profile of number of objects consists of various types of curves. Following curves are commonly used in engineering practice.

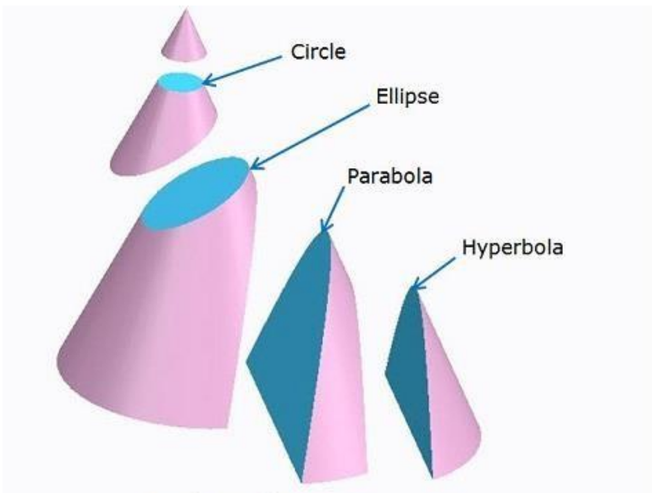
1. Conic Sections 2.Cycloidal Curves 3. Involute 4. Evolutes 5. Spirals 6. Helix

Curves which are developed from the conic sections are discussed below.

Conic Sections :







Conic Sections

The sections obtained by the intersection of a right circular cone with a plane in different positions relative to the axis of the cone are called **Conic Sections**.

Ellipse is generated when the section plane is inclined to the axis and cuts all the generators on one side of the apex.

Parabola is generated when the section plane is inclined to the axis and is parallel to one of the generators.

Hyperbola is a plane curve having two separate parts or branches, formed when two cones that point towards one another are intersected by a plane that is parallel to the axis of the cones.

The conic may be defined as the locus of a point moving in a plane in such a way that the ratio of its distances from a fixed point and a fixed straight line is always constant. The fixed point is the Focus and the fixed line is the Directrix.

The ratio (e) $= \frac{distance\ of\ the\ point\ from\ the\ focus}{distance\ of\ the\ point\ from\ the\ directrix}$

Ellipse : e < 1

Parabola : e $= 1$

Hyperbola: e > 1

The line passing through the focus and perpendicular to the directrix is called the Axis. The point at which the conic cuts its axis is called the Vertex.

Application :

Ellipse : Arches, bridges, dams, monuments, manholes, glands stuffing box etc.

Parabola : Arches, bridges, sound reflectors, light reflectors etc

Hyperbola : Cooling towers, water channels etc.

Ellipse is also defined as a curve traced out by a point, moving in the same plane as and in such a way that the sum of its distances from two fixed points is always same.

i. Each of the two fixed points is called the focus

ii. The line passing through the two foci and terminated by the curve, is called major axis.

iii. The line bisecting the major axis at right angles and terminated by the curve, is called minor axis.

<u>Problems</u>

Problem 1 Draw an ellipse by Concentric Circle method using Major Axis =170 M and Minor Axis=140M.

<u>Solution:</u>

In this problem major axis and minor axis are given and the lengths are 170M and 140M respectively. For drawing these two lines on the drawing sheet reducing scale needs to be used. Fix the scale factor; then as per the scale, follow the following steps to complete the ellipse(FIG-1).

Step1: Draw major axis AB 170 M and minor axis CD 140 M where the two axes bisect one other at O.

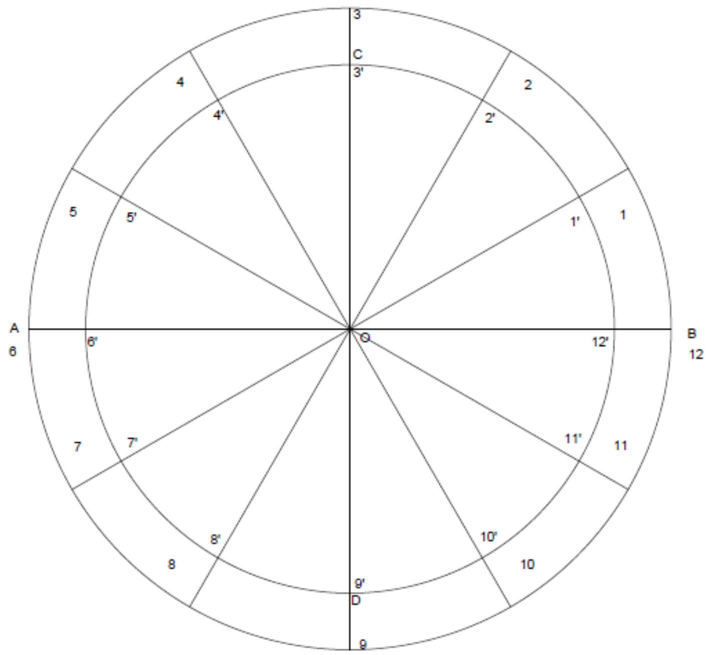


FIG-1

Step2: Taking O as centre and OA as radius, draw a circle and OC as radius draw another circle.

Step3: Divide the bigger circle in twelve equal parts starting at B anticlockwise and mark the corresponding points as 12,1,2,3 etc. starting at 12.

Step4: Draw the lines joining these points with centre O and cutting the minor axis circle at 1',2',3' etc.

Step5: Through point 1 and 2 on major axis circle, draw lines parallel to CD, the minor axis(FIG-2).

Step 6: Through point 1' and 2' on minor axis circle, draw lines parallel to AB, the major axis.

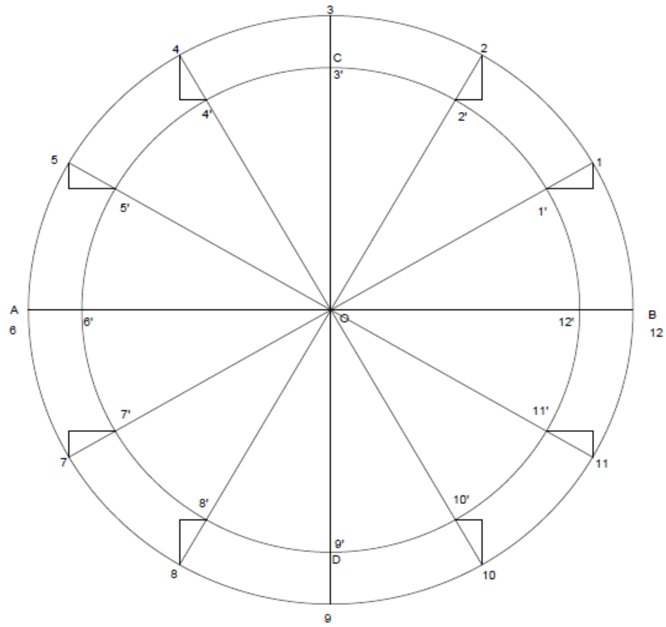


FIG-2

Step7: Wherever the two lines parallel to AB and CD intersect each other, that is a point on the required ellipse(FIG-3).

Step8: Repeat the procedure through the points 1-2, 4-5, 7-8 ,10-11 to minor axis, and 1'-2', 4'-5', 7'-8', 10'-11' parallel to major axis. Finally by drawing a smooth curve through all these intersected points and point no. 3,6,9 &12 we get the required ellipse.

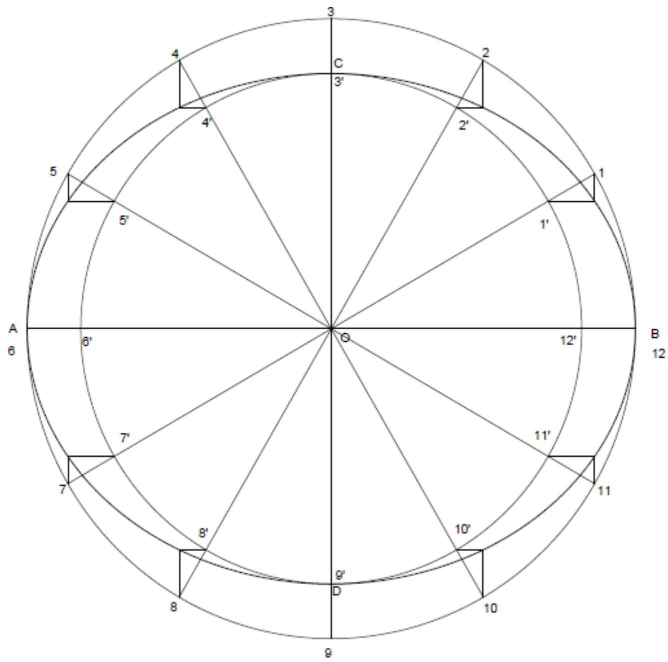


FIG-3

Problem 2 Construct a parabola using base and the axis method.

<u>Solution:</u>

Step1: Draw the base AB and bisect it to get its midpoint E.

Step2: At its midpoint E draw the axis EF at right angles to AB.

Step3: Construct a rectangle ABCD making side BC=AD(FIG-2A).

Step4. Divide AD and AE into same no. of equal parts and name them as shown in figure (FIG-2B).

Step4: Draw lines joining F with points 1, 2,3. Through 1", 2'.3' draw perpendicular to AB intersecting F-1, F- 2, F-3 Lines at points P, .. , .. etc.

Step5: Draw a curve through A, P, .. , .. etc. It will generate one half of a parabola. Other half of the parabola is generated using mirror image method, thus getting the parabola A P F P1 B.

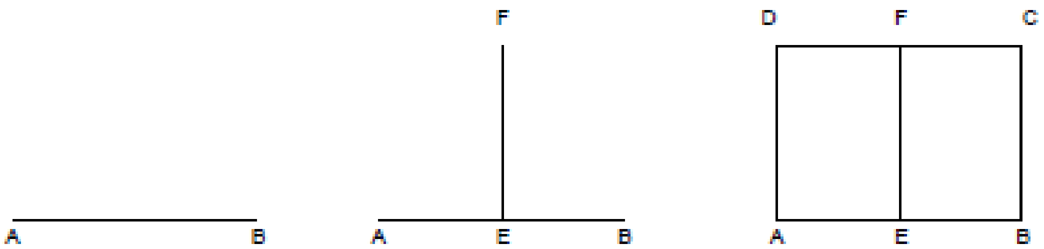


FIG-2A

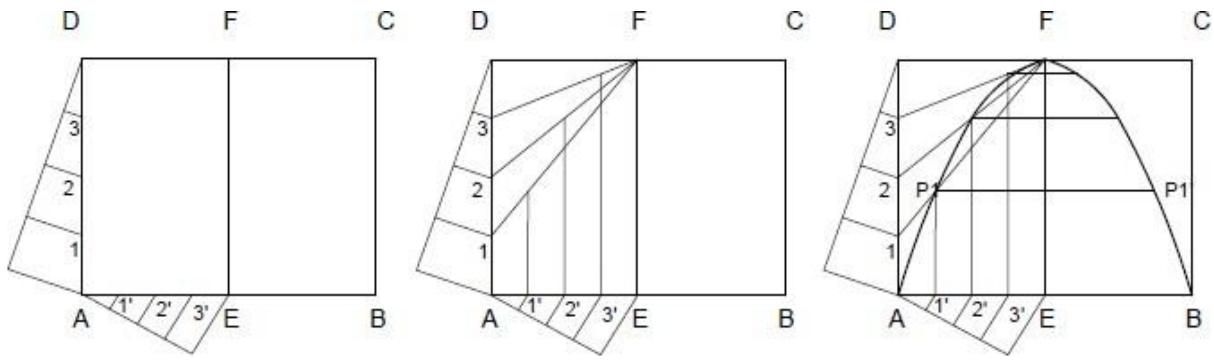


FIG-2B

PROBLEM 3 The distance between directrix and focus of a hyperbola is 7cm. Draw the hyperbola (e=3/2).

Solution:

Step1: Draw the directrix AB and axis CD and mark focus F on CD and 70mm from C(FIG-3).

Step2. Divide CF in equal five divisions and mark vertex V on the second division from C (as e=3/2).

Step3. Now to construct the scale for the ratio 3/2, draw a line VE perpendicular to CD such that VE=VF.

Now join C with E and extend it. Thus in ΔCVE $\frac{VE}{VC} = \frac{VF}{VC} = \frac{3}{2}$

Step4. Mark any point 1 on the axis and through it , draw a perpendicular which meet CE produced at 1'.Produce the line 1-1' downwards.

Step5. With centre F and radius as 1-1', draw an arc intersecting the perpendicular through 1 at P1 and P1' on two sides of the axis.

Step6. Similarly mark no. of points 2,3,4 on the axis at arbitrary distances and obtain points P2 , P2', P3, P3',P4,P4' etc.

Step7. Through these points P4-P3-P2-P1-V-P1'-P2'-P3'-P4'etc draw the hyperbola.

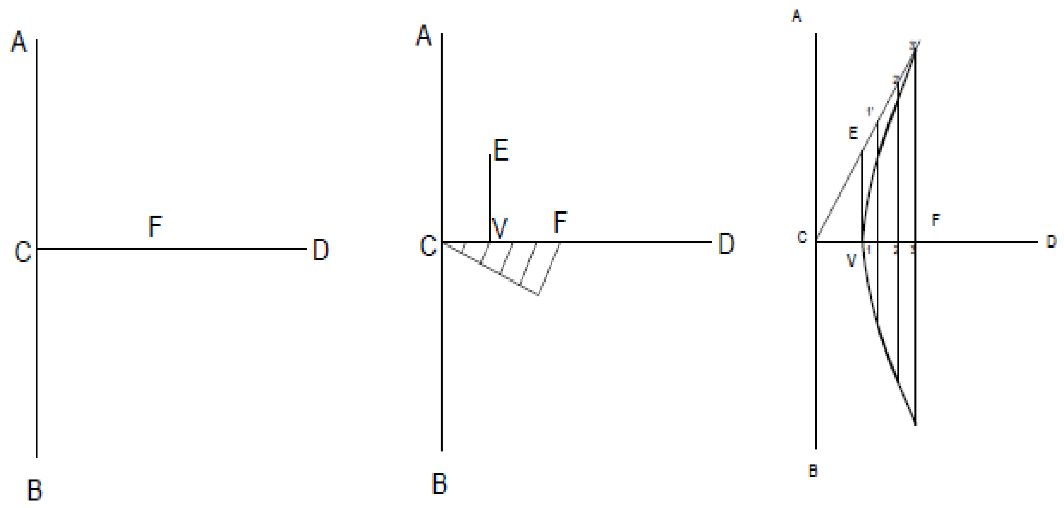


FIG-3

CHAPTER -3

ORTHOGRAPHIC PROJECTION

- Introduction
- Definition of projection
- Types of Projection
- Orthographic Projection
- Methods for obtaining different views
- Types of Orthographic Projection
- Symbol
- Examples

Introduction

Engineering Drawing is the language of engineers. It is a graphical language. Designers convey their ideas by means of drawings. It cannot be spoken or read aloud. Like the other languages, it has its own grammar or rules. A pictorial view shows only the outside appearance of the object. It does not show all the details of measurement necessary for construction of the object always. It may not even give the true shape of the object.

For the purpose of construction, a drawing should show the true shape of the object with sizes. Orthographic projection is universally adopted for getting the details (shape , size) of the object. By this method of description, engineer can get the definite shapes and sizes of the object which are required for construction.

Definition of Projection

If straight lines are drawn from the various points on the contour of an object to meet a plane, the object is said to be projected on the plane.

If all the meeting points of the lines on the plane, are joined in correct sequence then a figure of the object thus be obtained is called a projection of that object.

These straight lines are called **Projectors** and the plane on which the projectors meet, is known as the **Plane of Projection**.

Types of Projections

Following four types of projection methods are commonly used in Engineering drawing :

1. Orthographic
2. Isometric
3. Oblique
4. Perspective

Orthographic Projection

In orthographic projection an object is represented by two or three views on the mutually perpendicular projection planes. Each view is two dimensional. For complete description of the object at least two or three views are required.
When the projectors are parallel to one another and also perpendicular to the projection plane, the projection is said to be Orthographic Projection.

Methods for obtaining different views

Step :1
Imagine a person view a object from the infinity, so that projectors are parallel to one another and perpendicular to the front surface of that object. This view of the object shows the front surface of the object in its true shape and proportion.

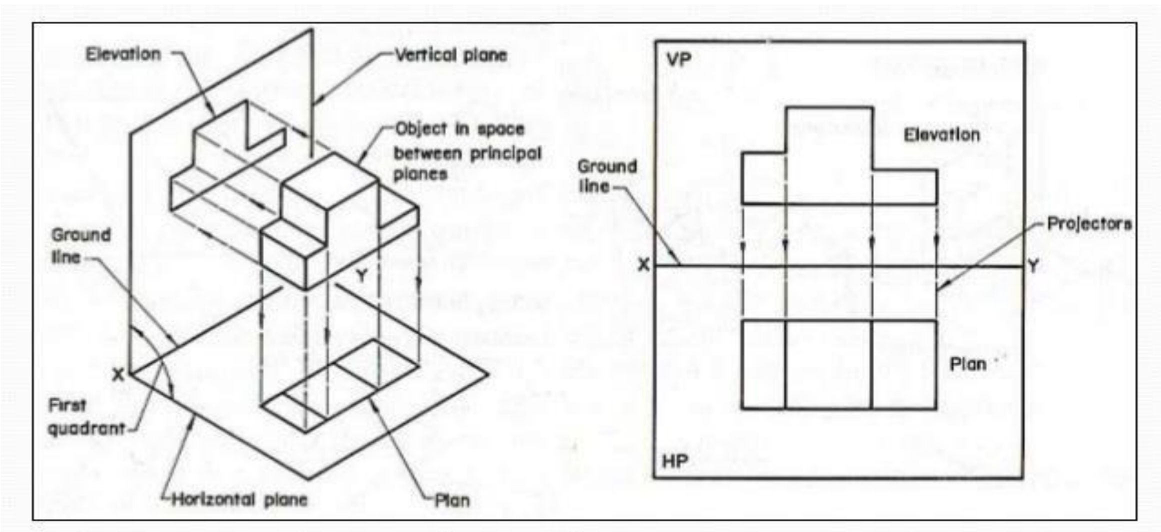


Figure : 3.1

Step 2:

These rays of sight are extended further to meet the plane perpendicularly

Step 3:

The points at which they meet the plane are joined in proper sequence, the resulting figure will also be exactly similar to the front surface and this is known as an **Elevation** or **Front View**.

Here lines or projectors from the object are parallel to one another and perpendicular to the plane on which this projection is obtained, so this projection is **Orthographic Projection**. It shows only two dimension of the object ; here it is width and length but depth (thickness) is missing. So one view is not enough to describe the object.

Let us further assume that another plane marked horizontal plane is hinged at right angles to the first plane. Now a person looks at this object from the above and like the previous case he / she will obtain the view; here it is mentioned as **Plan** or **Top View** on that horizontal plane. Through this view he / she will get the thickness of this object.

Types of Orthographic Projection

Four quadrants

If the horizontal and vertical planes of projection are assumed to extend beyond the line of interaction, the four dihedrals are formed which are designed as first, second, third and fourth quadrants.

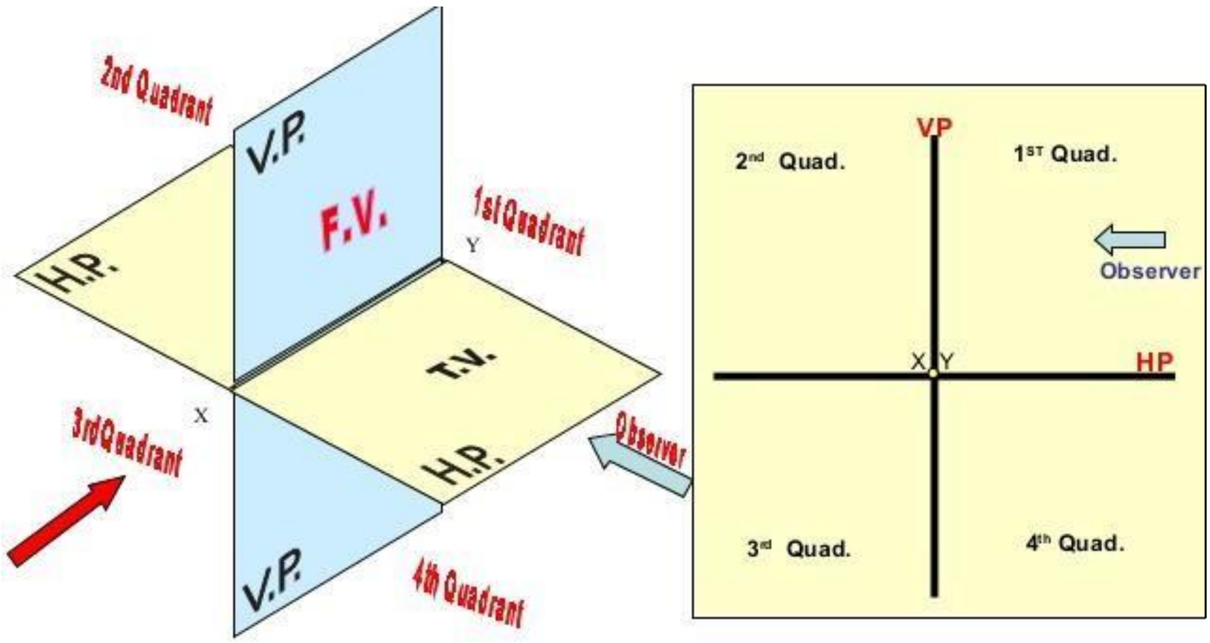


Figure : 3.2

The position of the object placed in any one of the quadrant is describe below :

1. First quadrant : above H.P. and in front of V.P.
2. Second quadrant : above H.P. and behind the V.P.
3. Third quadrant : below H.P. and behind V.P.
4. Fourth quadrant : below H.P. and in front of V.P.

Rotation of planes

When the projection of an object have been made on the various planes, they are brought together on a single sheet of paper by rotating the planes.

The standard practice of rotation of planes is to keep the V.P. fixed and to rotate H.P. clockwise by 90^0.

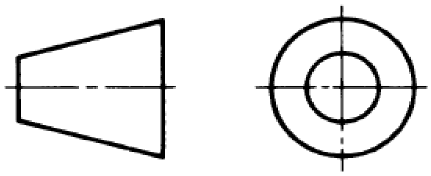
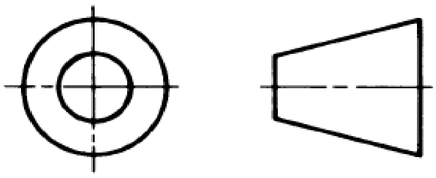
The following two types of orthographic projection are used in engineering drawing :-

1. First Angle Projection
2. Third Angle Projection

In First Angle Projection, the object is assumed to be situated in first quadrant. The position of the object can be situated on the H.P. and in front of V.P.

In Third Angle Projection, the object is assumed to be situated in third quadrant. The position of the object is said to be below of H.P. and behind V.P.

Symbol

Projection	Symbol
First angle	
Third angle	

Examples :

Different views of a cone

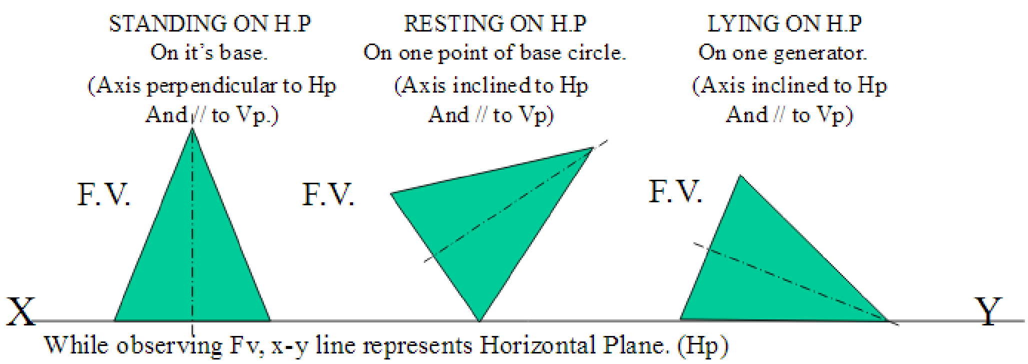


Figure :3.3

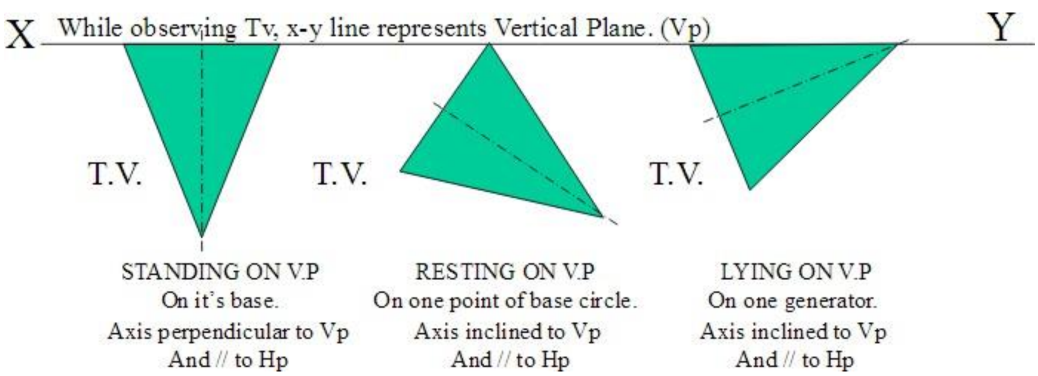


Figure :3.4

[In actual drawing Top View is not drawn in inverse order. it is drawn directly.]

Problems

Problem 1

A hollow cylinder standing vertically on HP. Draw Front view and top view of this cylinder when height, outer diameter and inner diameter of that cylinder are 120 mm, 80 mm and 60 mm respectively.

Hollow cylinder which is standing vertically on the ground or H.P. that means centre axis of the cylinder is parallel to vertical plane (V.P.) and perpendicular to Horizontal Plane (H.P.)

Now imagine a person looks this cylinder front side from the infinity. He/she will get a rectangular face as **FRONT VIEW** on vertical plane and if he/she will looks it from the infinity of the top, two concentric circle will be obtained as **TOP VIEW** on horizontal plane. Two concentric circle will get due to hollowness of that given cylinder.

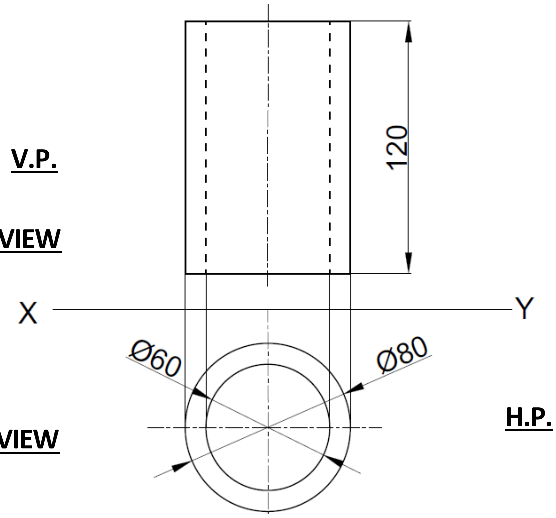
Following steps are involved to draw the orthographic projection of that cylinder.

Step 1 :

Draw a X-Y reference line (a horizontal line)

Step 2:

Below the reference plane using outer diameter and inner diameter, draw two concentric circle as **TOP VIEW**.



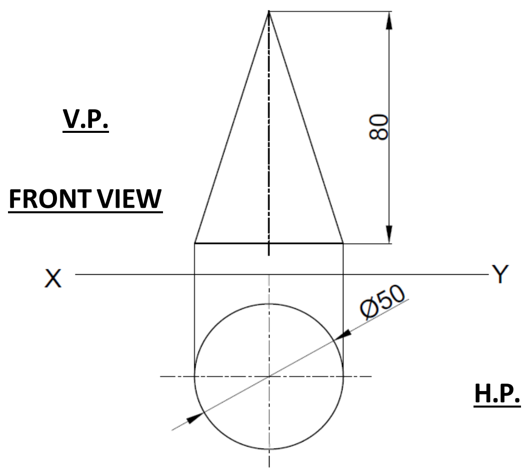
Step 3 :

Project one vertical line upwards from the centre of the circle up to reference. Extend this line as per height here it is 120 mm from the reference line.

Step 4:

Draw four vertical upwards projection lines from the four quadrants points of horizontal diameter (inner and outer circle) upto the reference line. Then extend these projection lines upto axis height. Complete rectangle as **FRONT VIEW**.

Step 5 : Use different lines for completion of the orthographic projection as per the figure shown here.



Problem 2

A right circular cone standing vertically on the ground. Axis height is 80mm and base circle diameter is 50 mm. Draw Front View and Top View of the object.

Right circular cone which is standing vertically on the ground or H.P. that means centre axis of the cone is parallel to vertical plane (V.P.) and perpendicular to Horizontal Plane (H.P.)
Now imagine a person looks this cone front side from the infinity. He/she will get a triangular face as **FRONT VIEW** on vertical plane and if he/she looks it from the infinity of the top, one circle with a dot will be (H.P. ed as **TOP VIEW** on horizontal plane.
TOP VIEW
Following steps are involved to draw the orth... ...jection of that cylinder.

Step 1 :
Draw a X-Y reference line (a horizontal line)
Step 2:
Below the reference plane using given diameter draw one circle as **TOP VIEW**.
Step 3 :
Project one vertical line upwards from the centre of the circle up to reference line. Extend this line ;as per height here it is 80 mm from the reference line.
Step 4:
Draw two vertically upward projection lines from the quadrant points of horizontal diameter up to the reference line. Join these two intersection points with top end of the axis to complete triangle as **FRONT VIEW**.
Step 5 : Use different lines for completion of the orthographic projection as per the figure shown here.

Problem 3

Draw the FRONT VIEW, TOP VIEW and either LEFT HAND SIDE VIEW or RIGHT HAND SIDE VIEW of a right regular hexagonal pyramid of axis height 80 mm and side of base 50 mm. One side of base is inclined at 45^0 to V.P. and axis of pyramid is perpendicular to H.P.

Solution:
In the given problem a right regular hexagonal pyramid, one side of base is inclined at 45^0 to V.P. and axis of pyramid is perpendicular to H.P. So, regular hexagonal with diagonals will be obtained as TOP VIEW in which one side is inclined at 45^0 to the reference line and in FRONT VIEW a triangular face with edges will be obtained where the axis is perpendicular to reference line.
Following steps are involved in drawing the orthographic projection of the given problem.

Step 1 :

Draw a X-Y reference line (a horizontal line)

Step 2:

Below the reference plane draw 45^0 angle with reference line. On that inclined line mark two points (here it is a & f, af = 50 mm) as one side of a hexagon.

Step 3 :

Complete the regular hexagon (abcdef) with 'af' as one side of it using any method (ref. polygon drawing). Join 'a' and 'd' for one diagonal. By joining other corner points all three diagonals will be obtained. Mark 'o' where all three diagonals intersect one another. Hexagon with 'o' as vertex and the said diagonals constitute the **TOP VIEW** of the given hexagonal pyramid.

Step 4:

Draw vertically upward projection lines from all corner points and centre 'o' up to the reference line. Draw triangle with edges as per given figure as a **FRONT VIEW**.

Step 5 : Here O' line is shown as centre line and f' and e' lines will be hidden as they are not visible in FRONT VIEW.

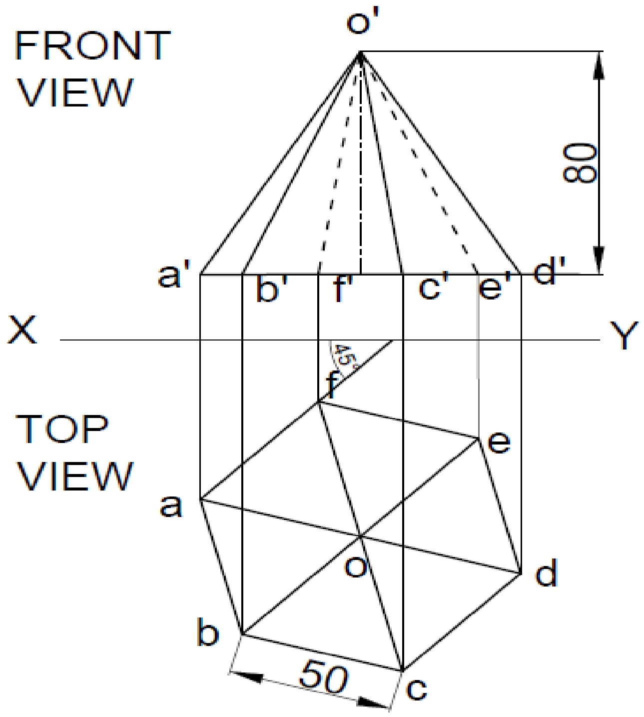
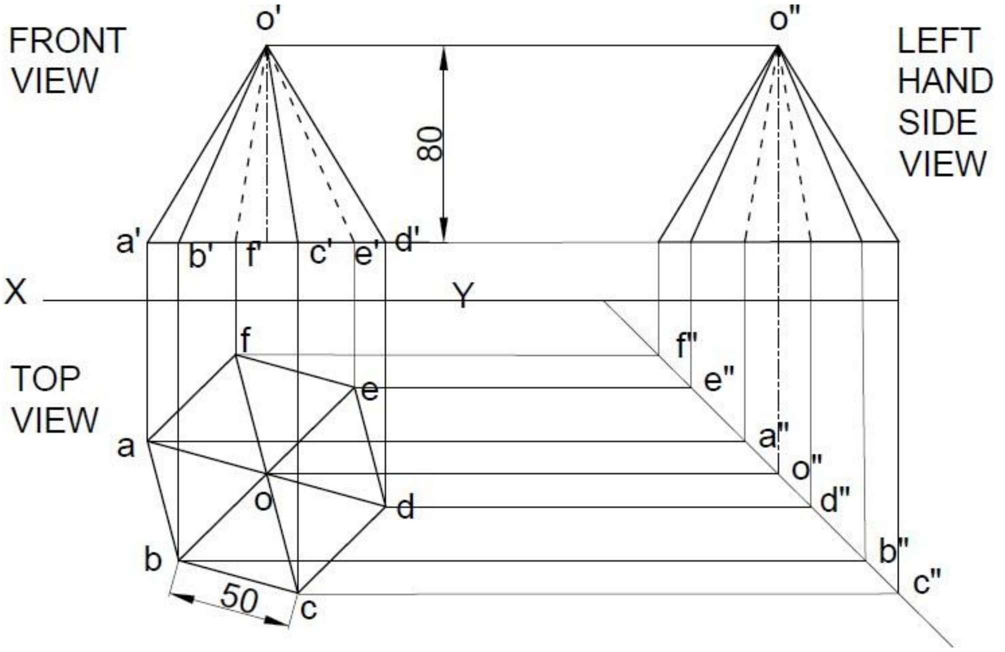


Figure : A

Step 6 : Complete L.H.S.V. as per figure B.

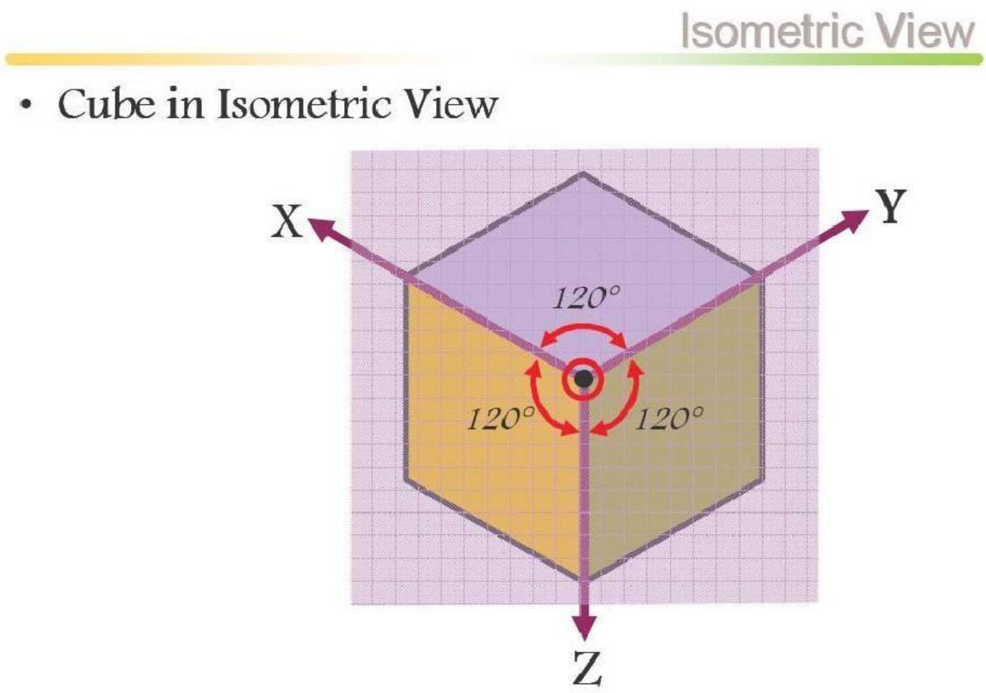


FRONT VIEW
o'
o"
LEFT HAND SIDE VIEW
80
a'
b'
f'
c'
e'
d'
X
Y
f
TOP VIEW
e
f"
e"
a
a"
o"
o
d
d"
b
b"
c"
50
c

Figure : B

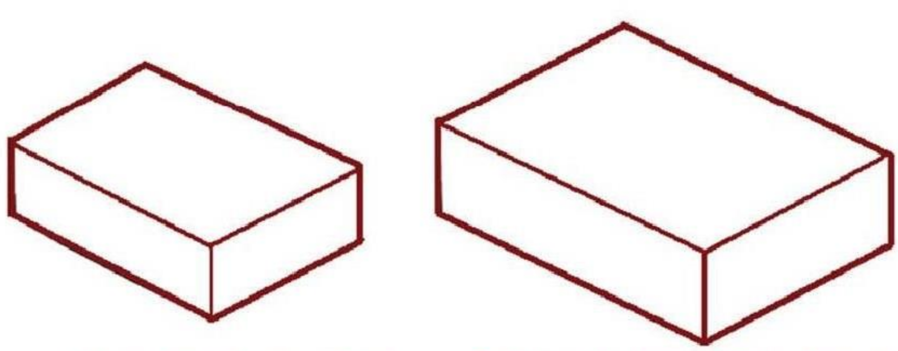
CHAPTER -4

ISOMETRIC PROJECTION



ISOMETRIC PROJECTION and ISOMETRIC DRAWING

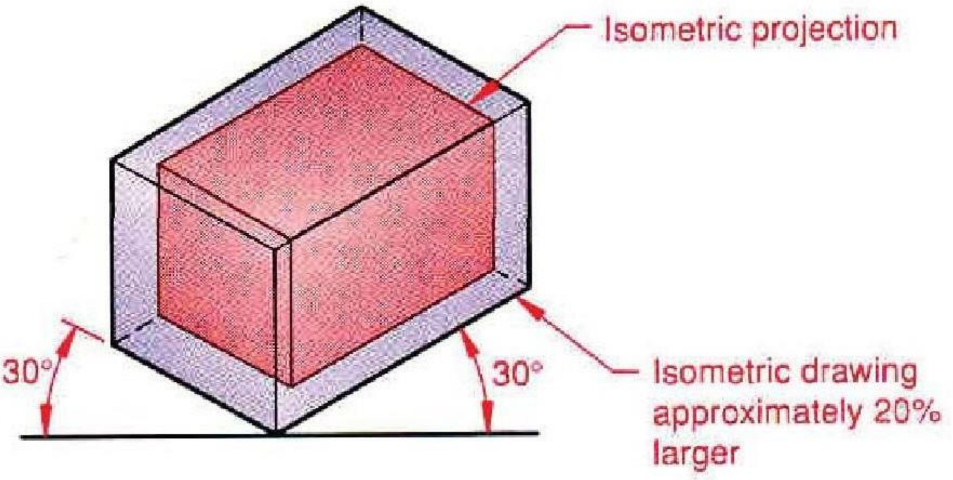
Isometric drawings are almost always preferred over isometric projection for engineering drawings, because they are easier to produce.



isometric projection 82% of ful scale

Full scale Isometric drawing

An *isometric drawing* is an axonometric pictorial drawing for which the angle between each axis equals 120° and the scale used is full scale.

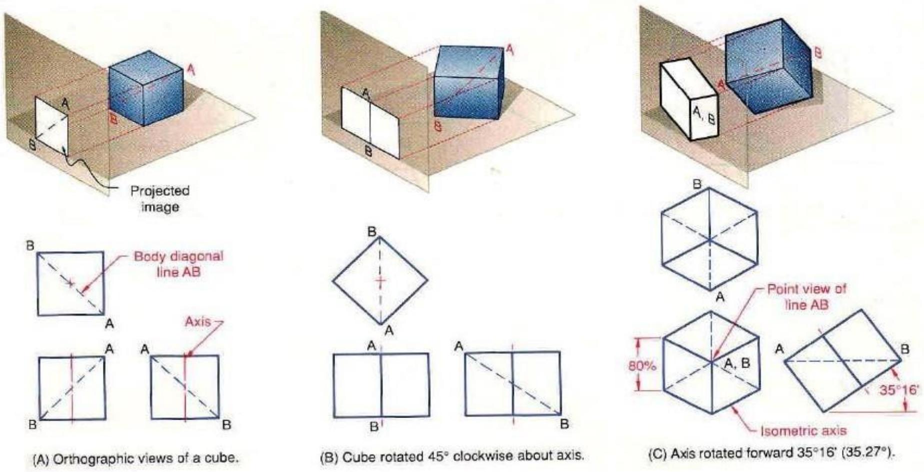


Size comparison of Isometric Drawing and True Isometric Projection

Isometric Axonometric Projections

An isometric projection is a true representation of the isometric view of an object.

An isometric view of an object is created by rotating the object 45° about a vertical axis, then tilting the object (see figure - in this case, a cube) forward until the body diagonal (AB) appears as a point in the front view



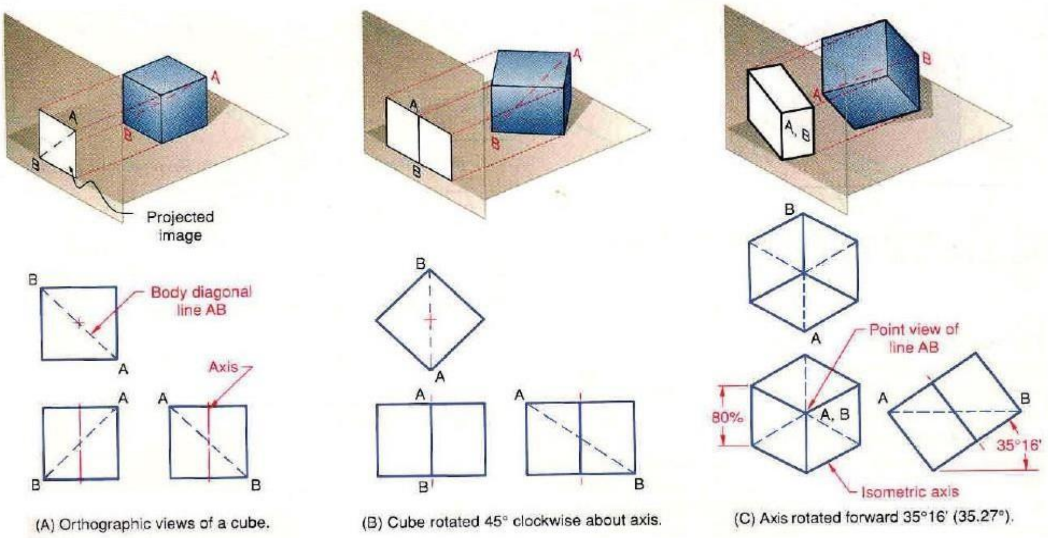
(A) Orthographic views of a cube. (B) Cube rotated 45° clockwise about axis. (C) Axis rotated forward 35°16' (35.27°).

The angle the cube is tilted forward is 35° 16'. The 3 axes that meet at A, B form equal angles of 120° and are called the isometric axes.

Each edge of the cube is parallel to one of the isometric axes.

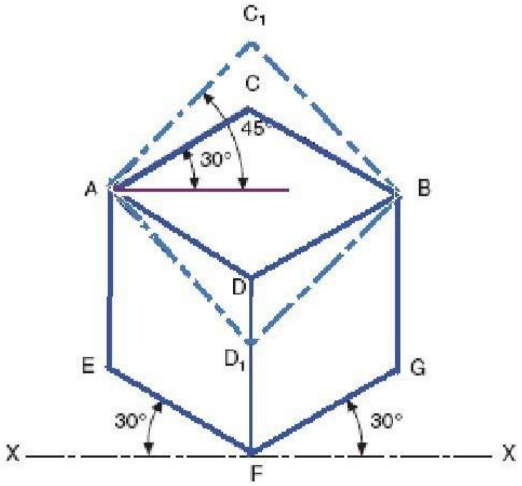
Line parallel to one of the legs of the isometric axis is an isometric line.

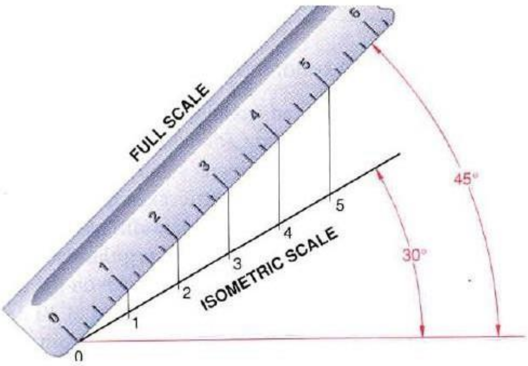
Planes of the cube faces & all planes parallel to them are isometric planes



(A) Orthographic views of a cube. (B) Cube rotated 45° clockwise about axis. (C) Axis rotated forward 35°16' (35.27°).

Isometric scale is produced by positioning a regular scale at 45 ° to the horizontal and projecting lines vertically to a 30° line.





$$\text{Isometric scale} = (\text{Isometric length/True length}) = \frac{\cos 45^\circ}{\cos 30^\circ} = \frac{1}{\sqrt{2}} \div \frac{\sqrt{3}}{2} = \frac{\sqrt{2}}{\sqrt{3}} = 0.8165$$

$$= 82\% \text{ (approximately)}$$

$$\boxed{\text{Isometric length} = 0.82^* \text{ True length}}$$

In an isometric drawing, true length distances can only be measured along isometric lines, that is, lines that run parallel to any of the isometric axes. Any line that does not run parallel to an isometric axis is called a non-isometric line.

Non-isometric lines include inclined and oblique lines and can not be measured directly. Instead they must be created by locating two end points.

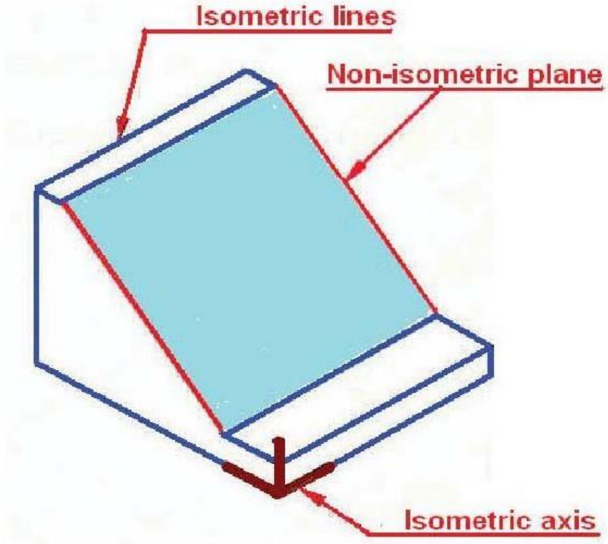


Figure A is an isometric drawing of a cube. The three faces of the isometric cube are isometric planes, because they are parallel to the isometric surfaces formed by any two adjacent isometric axes.

Planes that are not parallel to any isometric plane are called non-isometric planes (Figure B)

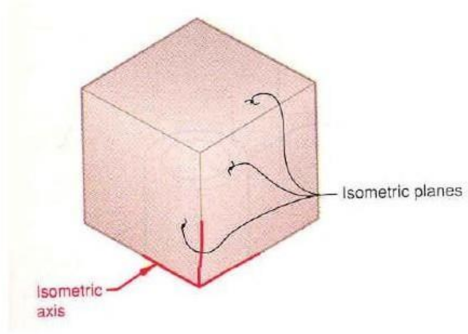


Figure A: Isometric planes relative to isometric axes

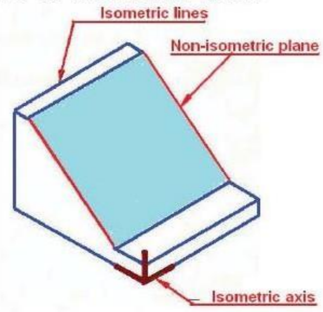
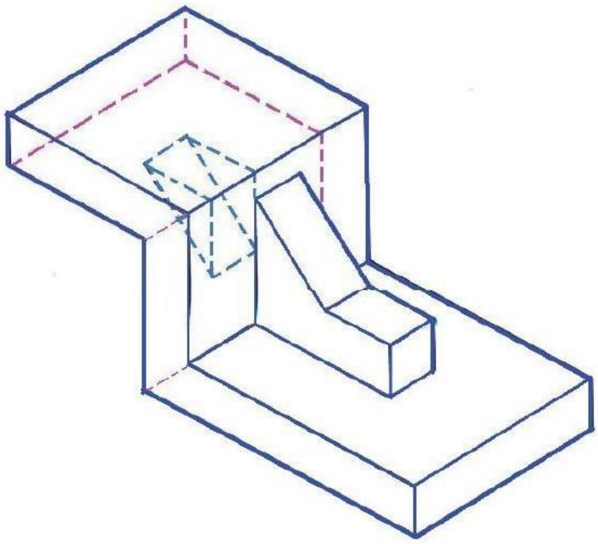


Figure B: Non-isometric plane

Standards for Hidden Lines, Center Lines and Dimensions

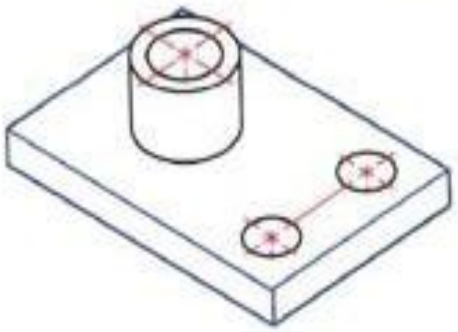
In isometric drawings, hidden lines are omitted unless they are absolutely necessary to completely describe the object. Most isometric drawings will not have hidden lines.



To avoid using hidden lines, choose the most descriptive viewpoint.

However, if an isometric viewpoint cannot be found that clearly depicts all the major features, hidden lines may be used.

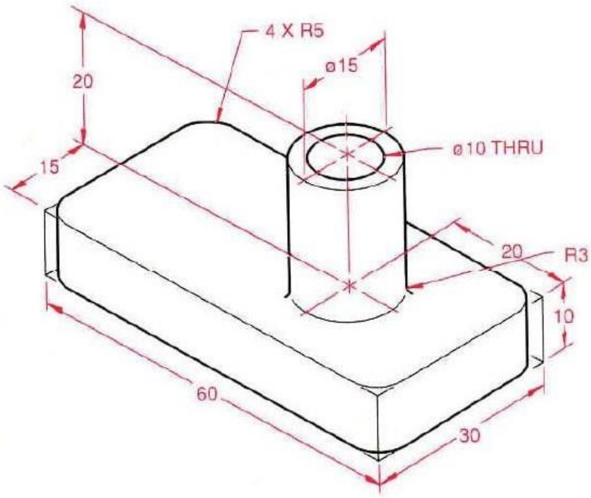
Centerlines are drawn only for showing symmetry or for dimensioning. Normally, centerlines are not shown, because many isometric drawings are used to communicate to non-technical people and not for engineering purposes.



<u>**As per the Standards**</u>**:**

Dimension lines, extension lines, and lines being dimensioned shall lie in the same plane.

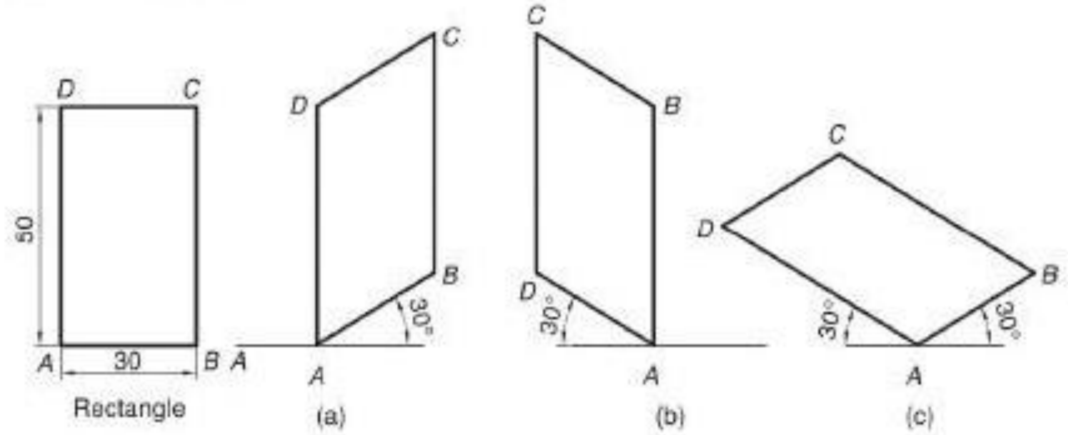
All dimensions and notes should be unidirectional, reading from the bottom of the drawing upward and should be located outside the view whenever possible. The texts is read from the bottom, using horizontal guidelines.



ISOMETRIC PROJECTION OF GEOMETRIC FIGURES

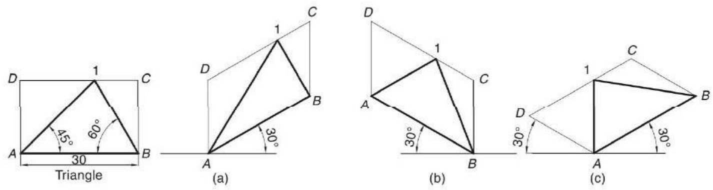
Rectangle

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



Triangle

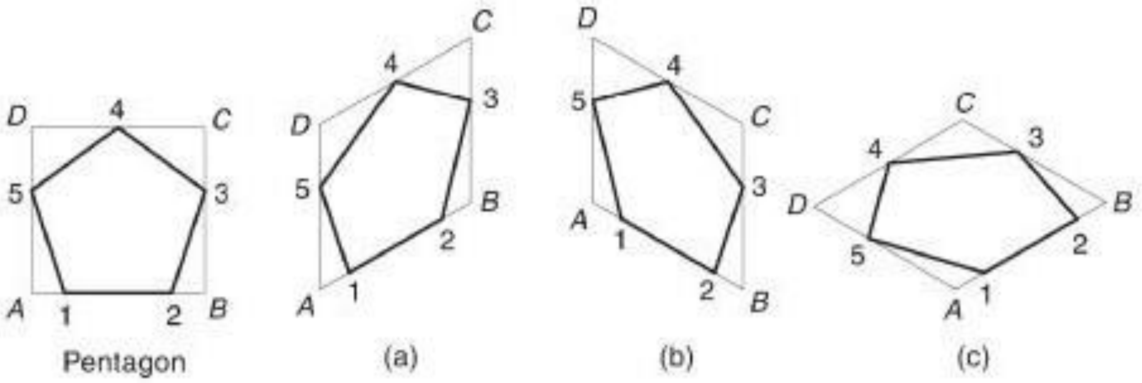
A triangle of any type can be easily obtained in isometric view as explained below. First enclose the triangle in rectangle *ABCD*. Obtain parallelogram *ABCD* for the rectangle as shown in Fig. (a) or (b) or (c). Then locate point 1 in the parallelogram such that *C*–1 in the parallelogram is equal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



Taken from Dhananjay A Jolhe, Engg. Drawing, MGH

Pentagon

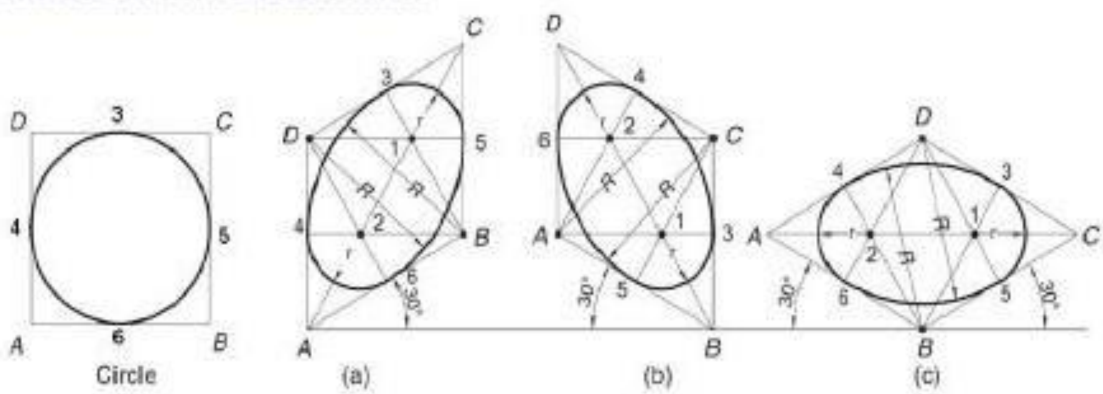
Enclose the given pentagon in a rectangle and obtain the parallelogram as in Fig. 18.9(a) or (b) or (c). Locate points 1, 2, 3, 4 and 5 on the rectangle and mark them on the parallelogram. The distances *A*–1, *B*–2, *C*–3, *C*–4 and *D*–5 in isometric drawing are same as the corresponding distances on the pentagon enclosed in the rectangle.



Circle

The isometric view or isometric projection of a circle is an ellipse. It is obtained by using four-centre method explained below.

Four-Centre Method **: First, enclose the given circle into a square *ABCD*. Draw rhombus *ABCD* as an isometric view of the square. Join the farthest corners of the rhombus, i.e., *A* and *C*. Obtain midpoints 3 and 4 of sides *CD* and *AD* respectively. Locate points 1 and 2 at the intersection of *AC* with *B*–3 and *B*–4 respectively. Now with 1 as a centre and radius 1–3, draw a small arc 3–5. Draw another arc 4–6 with same radius but 2 as a centre. With *B* as a centre and radius *B*–3, draw an arc 3–4. Draw another arc 5–6 with same radius but with *D* as a centre.**



Isometric views for solids

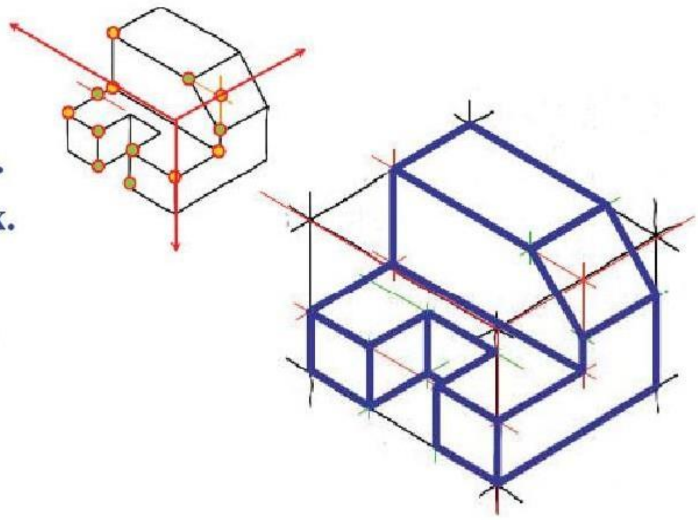
The Boxing-in Method

The four basic steps for creating an isometric drawing are:
Determine the isometric viewpoint that clearly depicts the features of the object, then draw the isometric axes which will produce that view-point.
Construct isometric planes, using the overall width (W), height (H), and depth (D) of the object, such that the object will be totally enclosed in a box.
Locate details on the isometric planes.
Darken all visible lines, and eliminate hidden lines unless absolutely necessary to describe the object.

Sketch from an actual object

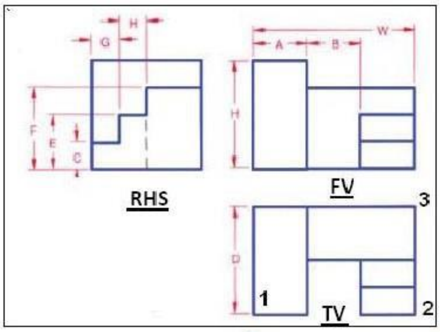
STEPS

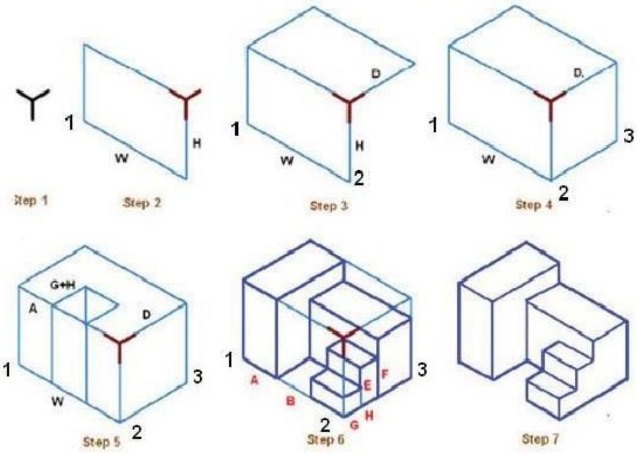
1. **Positioning object.**
2. **Select isometric axis.**
3. **Sketch enclosing box.**
4. **Add details.**
5. **Darken visible lines.**

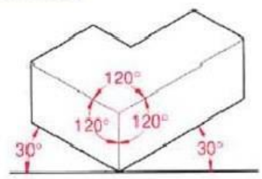


Note In isometric sketch/drawing), hidden lines are *omitted* unless they are absolutely necessary to completely describe the object.**Sketch from an actual object**

***Step 1*.** **Determine the desired view of the object, then draw the isometric axis. For this example, it is determined that the object will be viewed from above (regular isometric) and axis shown in Fig A is used.**



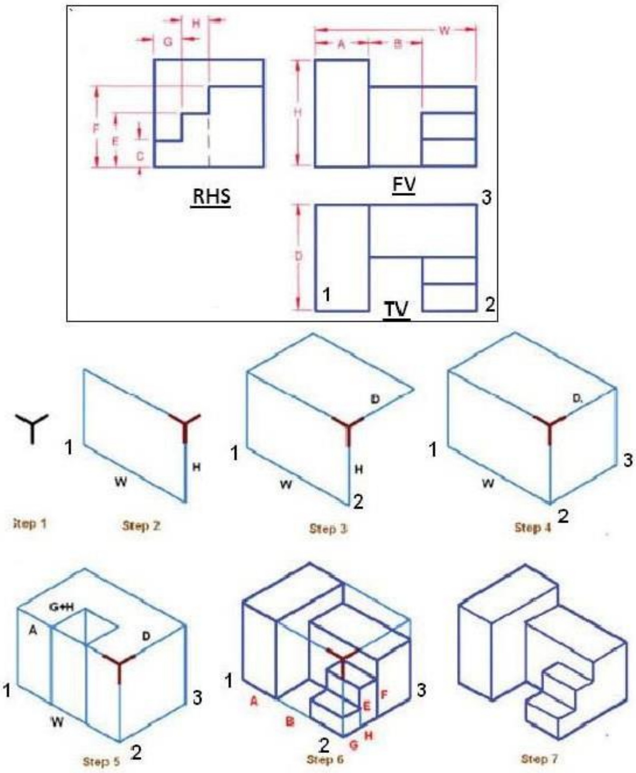


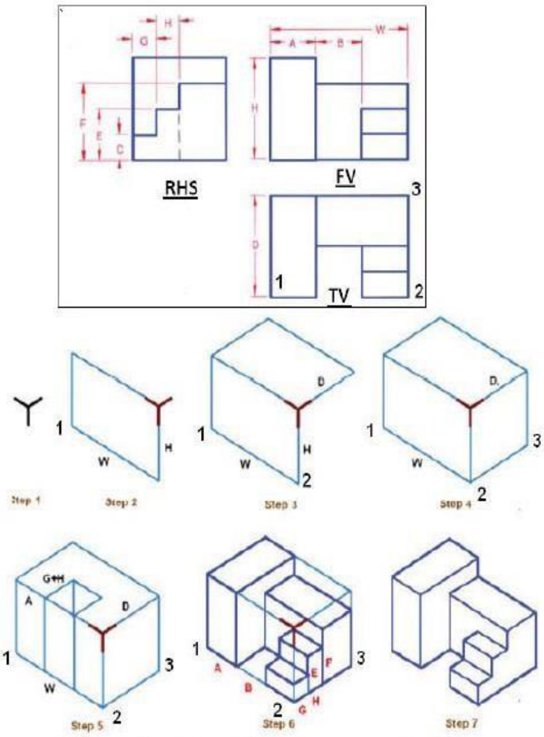


(A) Regular Isometric

***Step* 2.** Construct the front isometric plane using **W** and **H** dimensions. **Width** dimensions are drawn along 30-degree lines from the horizontal. **Height** dimensions are drawn as vertical lines.

***Step* 3.** Construct the top isometric plane using the **W** and **D** dimensions. Both **W** and **D** dimensions are drawn along 3o-degree lines from the horizontal.





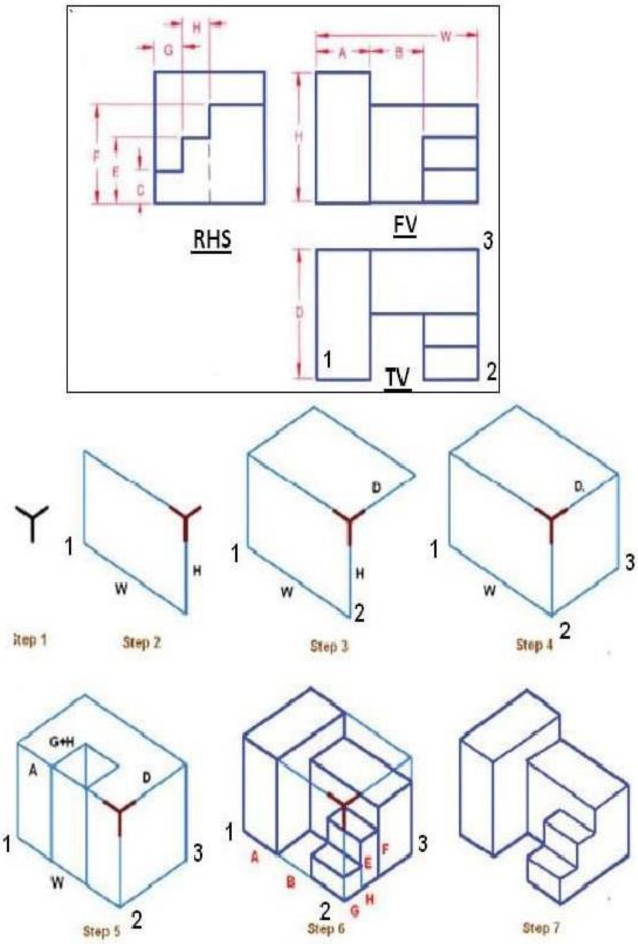
***Step* 4.** Construct the right side isometric plane using **D** and **H** dimensions. Depth dimensions are drawn along 30-degree lines and height dimensions are drawn as vertical lines.

***Step* 5.** Transfer some distances for the various features from the multiview drawing to the isometric lines that make up the isometric rectangle. on the front and top planes of the isometric box.

For example, distance **A** is measured in the multiview drawing, then transferred to a width line in the front plane of the isometric rectangle. Begin drawing details of the block by drawing isometric lines between the points transferred from the multiview drawing. For example, a notch is taken out of the block by locating its position on the front and the top planes of the isometric box.

Step 6. Transfer the remaining features from the multi-view drawing to the isometric drawing. Block in the details by connecting endpoints of the measurements taken from the multiview drawing.

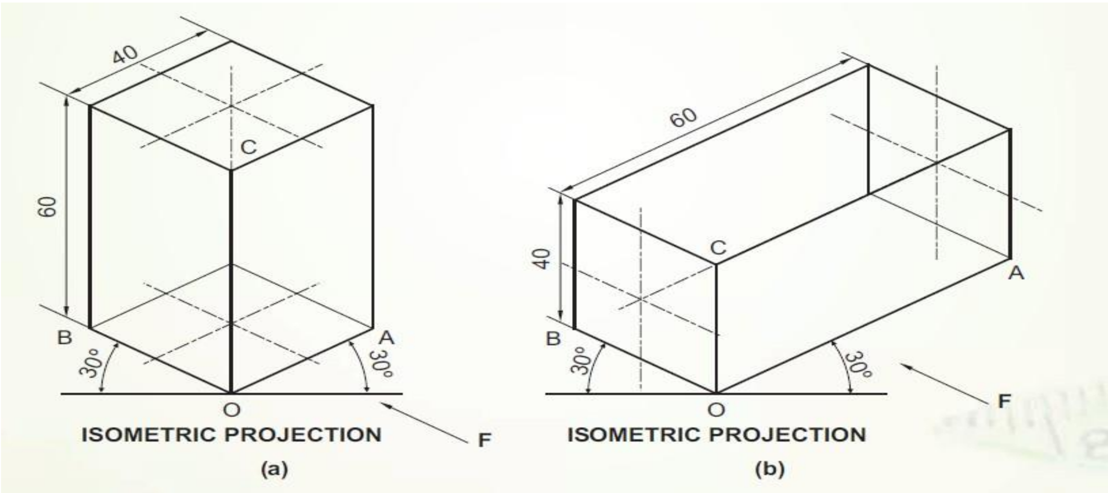
Step 7. Darken all visible lines and erase or lighten the construction lines to complete the isometric drawing of the object



PROBLEM 1 Draw the isometric projection of a square prism of 40 mm base edge and 60 mm axis resting.

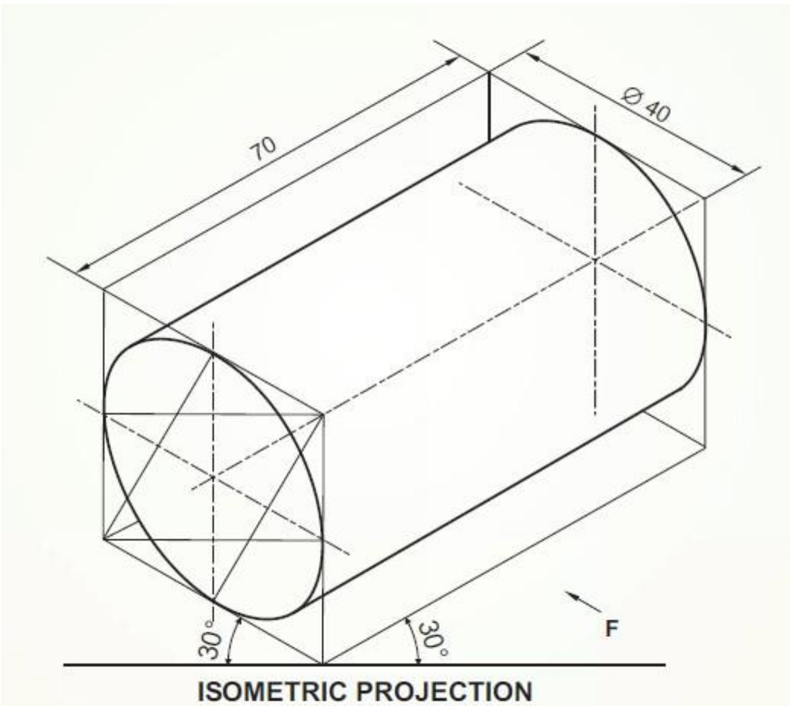
1. On its base on H.P keeping one of its base edge parallel to V.P
2. On its face on H.P keeping its base perpendicular to V.P

SOLUTION



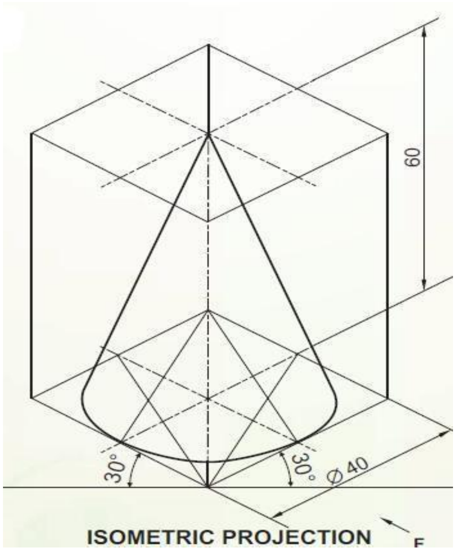
PROBLEM 2 Draw the isometric projection of a cylinder of diameter 40 mm and axial length of 70 mm lying on the H.P keeping its axis parallel to H.P and V.P both

SOLUTION



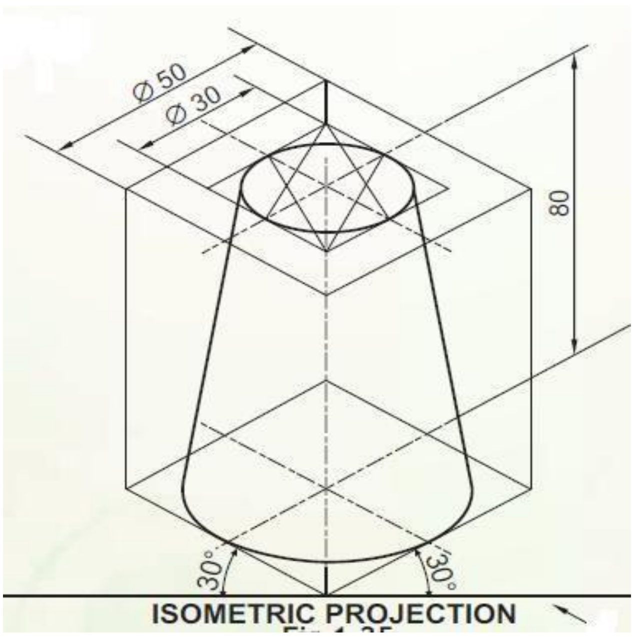
PROBLEM 3 Draw the isometric projection of cone of diameter 40 mm and axis of 60 mm resting on its base perpendicular to H.P .

SOLUTION



PROBLEM 4 Draw the isometric projection of a frustum of a cone of diameter 30 mm at smaller end, diameter 50 mm at bigger end and the axial height is 70 mm. It is resting on its bigger end on H.P, keeping its axis vertical.

SOLUTION



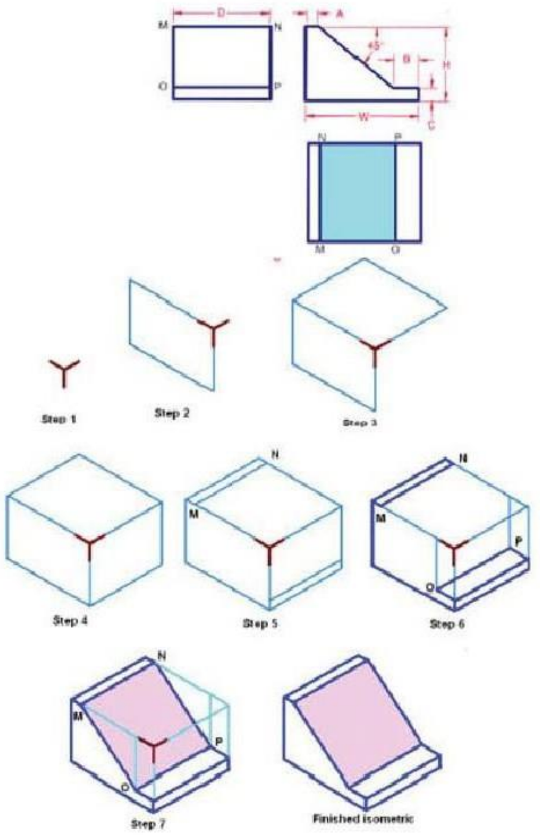
Non-Isometric Lines

Normally, non-isometric lines will be the edges of inclined or oblique planes of an object as represented in a multiview drawing.

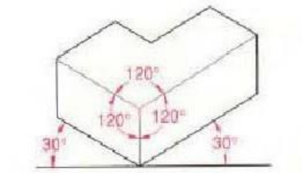
It is not possible to measure the length or angle of an inclined or oblique line in a multiview drawing and then use that measurement to draw the line in an isometric drawing.

Instead, non-isometric lines must be drawn by locating the two end points, then connecting the end points with a line.

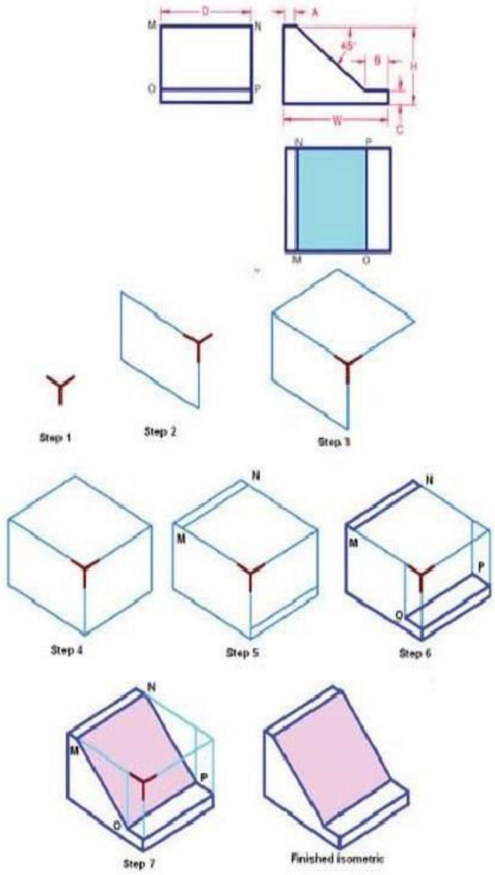
The process used is called offset measurement, which is a method of locating one point by projecting another point.



***Step* 1**. Determine the desired view of the object, then draw the isometric axes. For this example, it is determined that the object will be viewed from above, and the axis shown in Figure A is used.

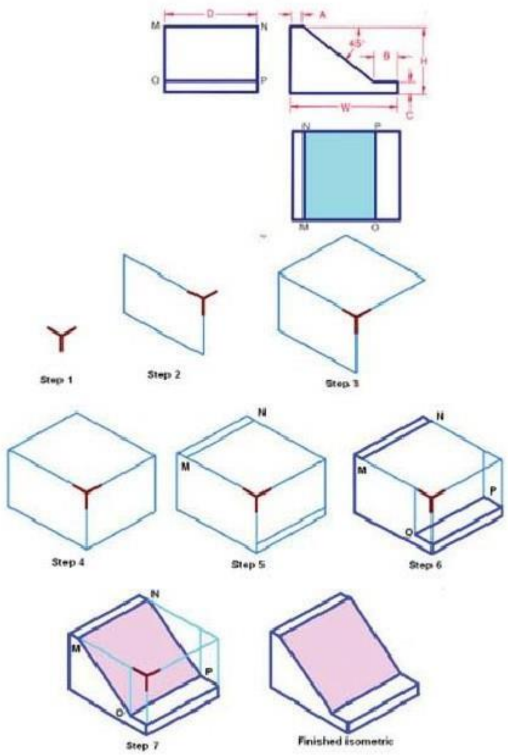


(A) Regular Isometric



***Step* 5.** Transfer the distances for **C** and **A** from the multi-view drawing to the top and right side isometric rectangles.

Draw line **MN** across the top face of the isometric box. Draw an isometric construction line from the endpoint marked for distance **C**. This, in effect, projects distance **C** along the width of the box.



***Step* 6**. Along these isometric construction lines, mark off the distance **B**, thus locating points **0** and **P**. Connect points **OP**.

***Step* 7.** Connect points **MO** and **NP** to draw the non-isometric lines.

ASSIGNMENT NO-4

1. Draw the isometric view of a cylinder standing vertically on its base in H P whose diameter is 60 mm & axis height 90 mm.

2. A regular hexagonal prism (each side of base 55 cm &axis length110 cm) is lying horizontally with its axis parallel to V.P. Draw its **Isometric Projection.**

3. A sphere of radius 30mm is placed centrally on top of a square block of size 88 mm x 88 mm x 22 mm. Draw the **Isometric Projection** of this combination.

4. A right circular cone of base diameter 60 mm & axis height 100 mm is standing centrally on a top of a cube (each side is 100 mm).Draw the isometric view.

CHAPTER -5

SECTION OF SOLIDS

SECTIONING A SOLID.
An object (here a solid) is cut by
some imaginary cutting plane
to understand internal details of that object.

The action of cutting is called
SECTIONING a solid
&
The plane of cutting is called
SECTION PLANE.

Two cutting actions means section planes are recommended.

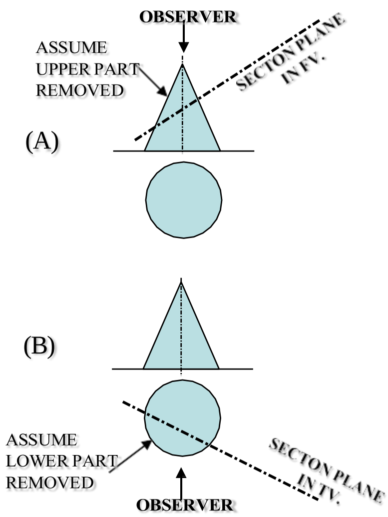
A) Section Plane perpendicular to Vp and inclined to Hp.
(This is a definition of an Aux. Inclined Plane i.e. A.I.P.)
NOTE:- This section plane appears
as a straight line in FV.

B) Section Plane perpendicular to Hp and inclined to Vp.
(This is a definition of an Aux. Vertical Plane i.e. A.V.P.)
NOTE:- This section plane appears
as a straight line in TV.

Remember:-

1. After launching a section plane either in FV or TV, the part towards observer is assumed to be removed.

2. As far as possible the smaller part is assumed to be removed.



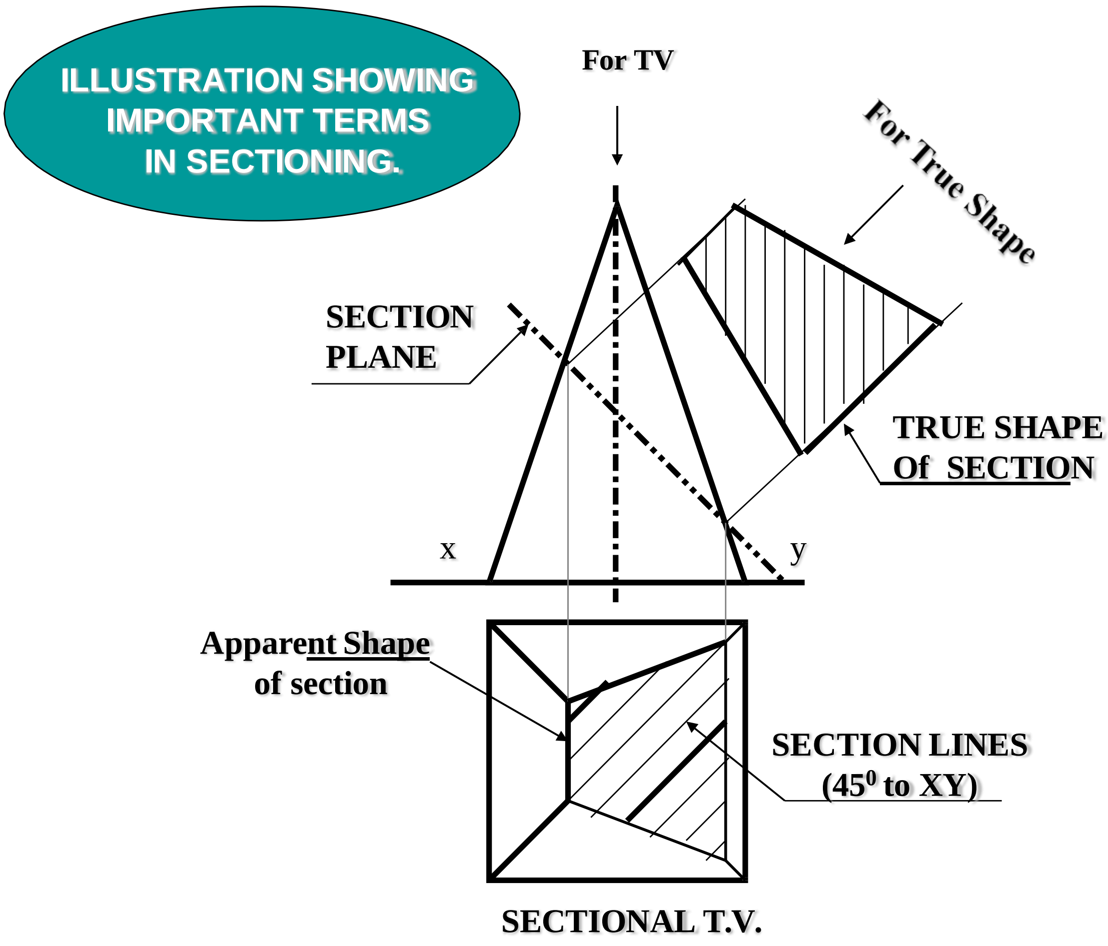
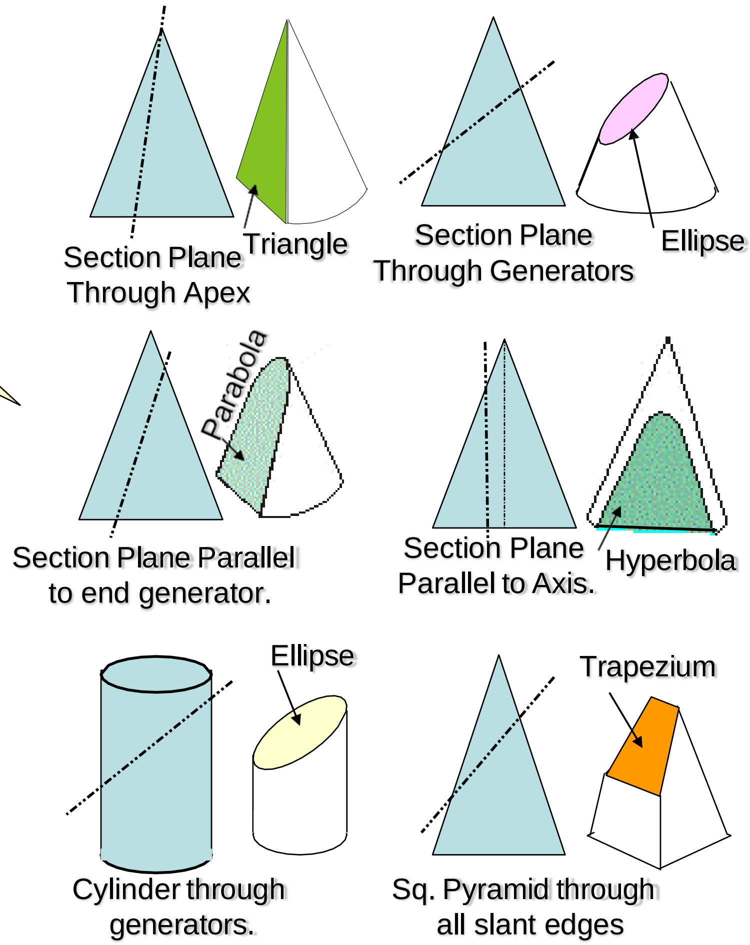
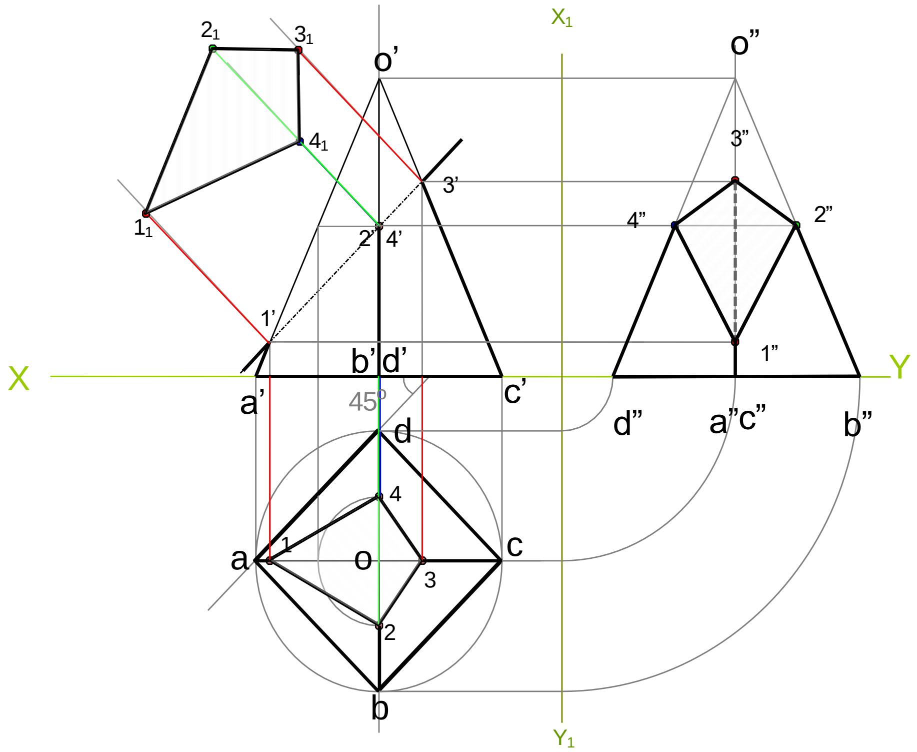


ILLUSTRATION SHOWING
IMPORTANT TERMS
IN SECTIONING.
For TV
For True Shape
SECTION
PLANE
TRUE SHAPE
Of SECTION
x
y
Apparent Shape
of section
SECTION LINES
(45^0 to XY)
SECTIONAL T.V.

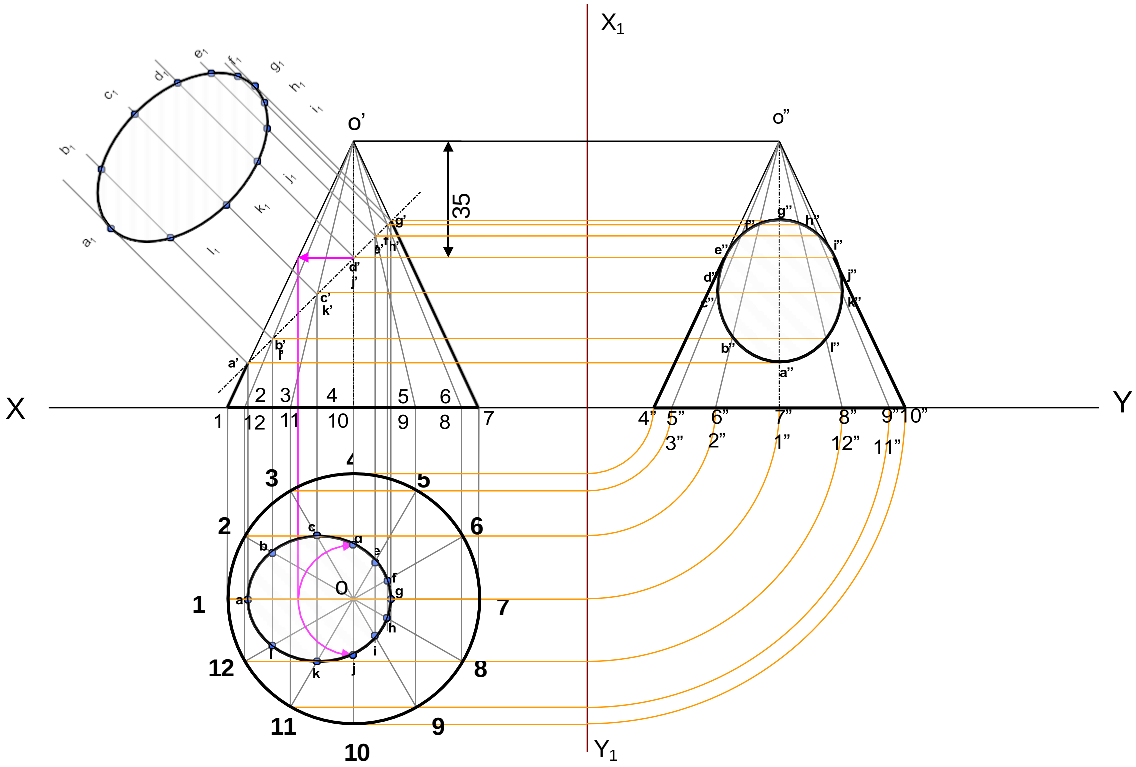
Typical Section Planes & Typical Shapes Of Sections.



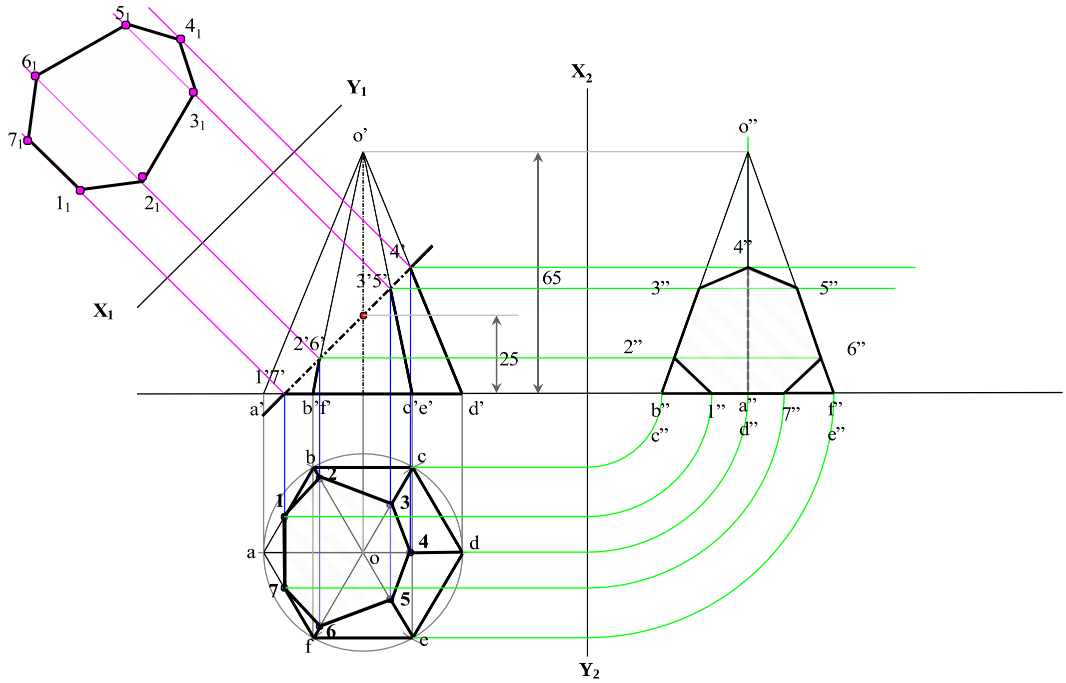
Problem 1 A square pyramid, base 40 mm side and axis 65 mm long, has its base on the HP and all the edges of the base equally inclined to the VP. It is cut by a section plane, perpendicular to the VP, inclined at 45° to the HP and bisecting the axis. Draw its sectional top view, sectional side view and true shape of the section.



Problem 2 A Cone base 75 mm diameter and axis 80 mm long is resting on its base on H.P. It is cut by a section plane perpendicular to the V.P., inclined at 45º to the H.P. and cutting the axis at a point 35 mm from the apex. Draw the front view, sectional top view, sectional side view and true shape of the section.



Problem 3 A hexagonal pyramid, base 30 mm side and axis 65 mm long is resting on its base on the HP, with two edges of the base parallel to the VP. It is cut by a section plane perpendicular to VP and inclined at 45° to the HP, intersecting the axis at a point 25 mm above the base. Draw the front view, sectional top view, sectional side view and true shape of the section.



ASSIGNMENT NO – 5

1) A square prism standing vertically on a horizontal base is cut by an auxiliary plane which is inclined at 60° to HP and perpendicular to VP and intersecting the vertical axis at a height of 60 mm from the base. Draw the FV, Sectional TV, Sectional Side View and True Shape of the section. Each side of base of the prism is 50 mm and height 80 mm.

2) A right circular cone, diameter of base 60 mm and axis height 100 mm is standing vertically and is cut by a plane inclined at 45° to HP and perpendicular to VP so as to intersect the axis of the cone at a height of 65 mm from the base. Draw the FV, Sectional TV and True Shape of the Section.

3) (a) A square pyramid standing vertically (height of axis 80mm) and side of base 55mm is intersected by a plane parallel to the base and at a height of 30mm from the base. Draw the F.V and sectional T.V of the frustum.

CHAPTER -6

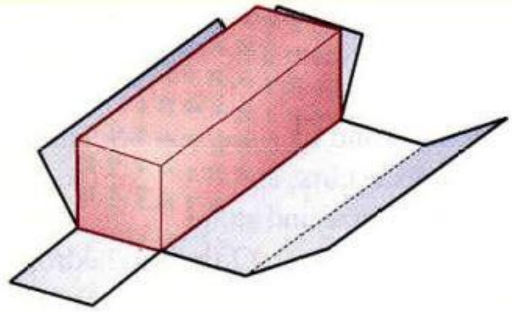
DEVELOPMENT OF SURFACES

Development of surfaces

A development is the unfold/unrolled flat / plane figure of a 3-D object.

Called also a pattern, the plane may show the true size of each area of the object.

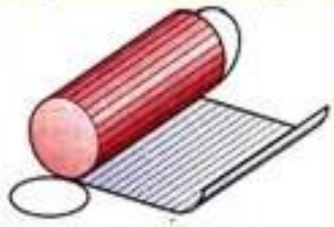
When the pattern is cut, it can be rolled or folded back into the original object.



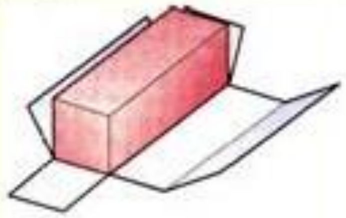
Methods of development of surfaces are:

- **Parallel line development**
- **Radial line development**
- **Triangulation development**
- **Approximate development**

- **Parallel line development** uses parallel lines to construct the expanded pattern of each three-dimensional shape. The method divides the surface into a series of parallel lines to determine the shape of a pattern. **Example: Prism, Cylinder.**

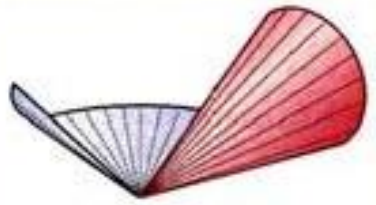


(B) Cylinder
(Parallel line development)



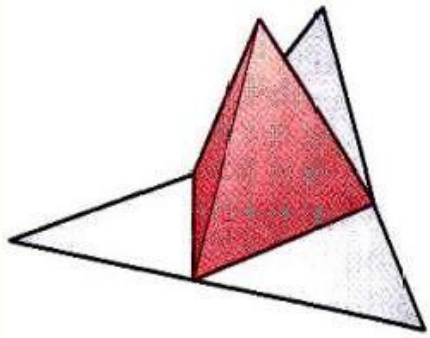
(A) Prism
(Parallel line development)

- **Radial line development** uses lines radiating from a central point to construct the expanded pattern of each three-dimensional shape. **Example: Cone, Pyramid.**



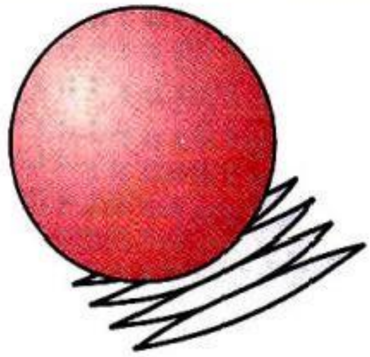
(D) Cone
(Radial line development)

- **Triangulation developments** are made from polyhedrons, single-curved surfaces, and wrapped surfaces. Example: Tetrahedron and other polyhedrons.

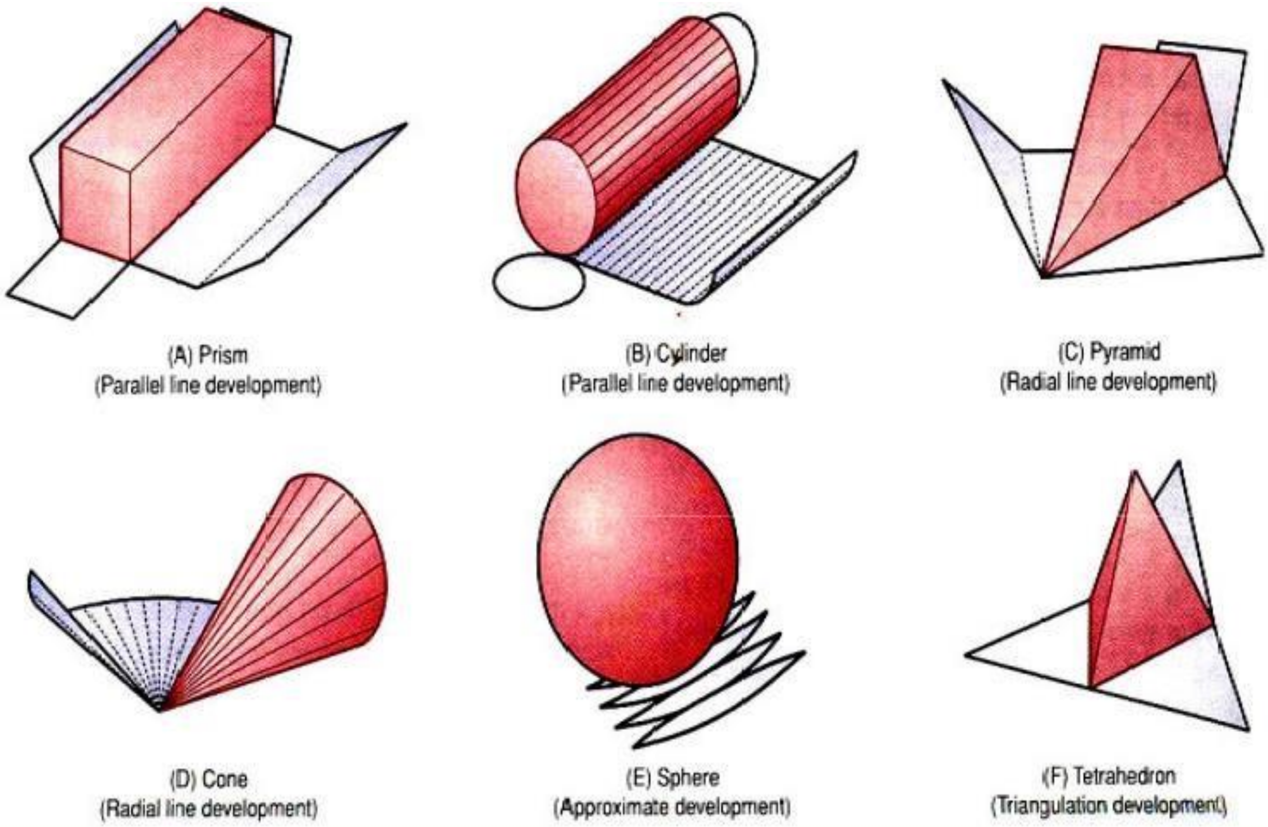


(F) Tetrahedron
(Triangulation development)

- In **approximate development**, the shape obtained is only approximate. After joining, the part is stretched or distorted to obtain the final shape. Example: Sphere.



(E) Sphere
(Approximate development)

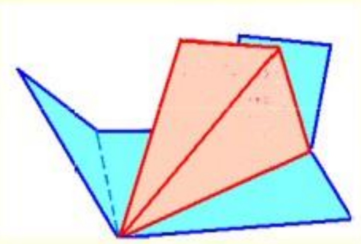


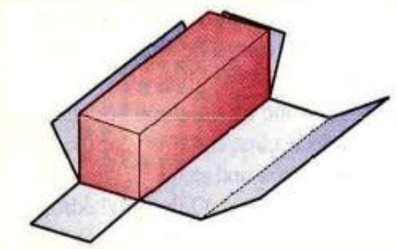
Examples of Developments

A **true development** is one in which no stretching or distortion of the surfaces occurs and every surface of the development is the same size and shape as the corresponding surface on the 3-D object.

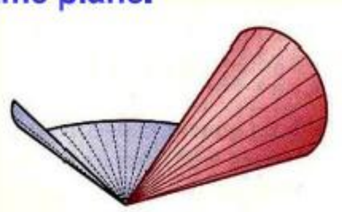
e.g. polyhedrons and single curved surfaces

Polyhedrons are composed entirely of plane surfaces that can be flattened true size onto a plane in a connected sequence.





Single curved surfaces are composed of consecutive pairs of straight-line elements in the same plane.

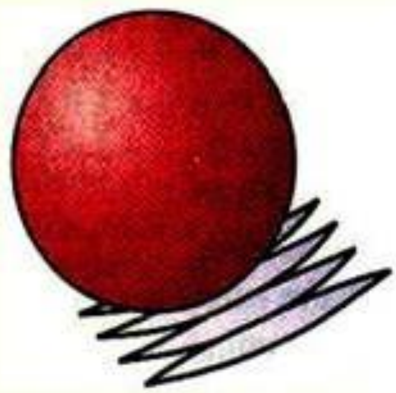


An approximate development is one in which stretching or distortion occurs in the process of creating the development.

The resulting flat surfaces are not the same size and shape as the corresponding surfaces on the 3-D object.

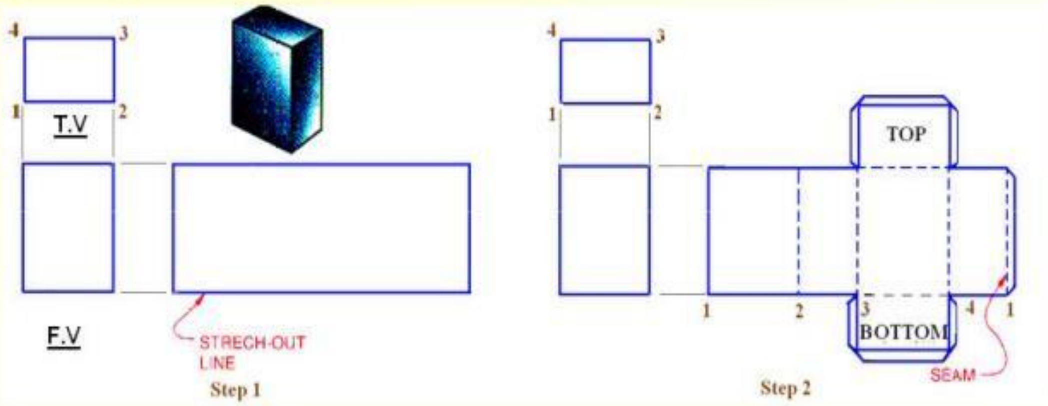
Wrapped surfaces do not produce true developments, because pairs of consecutive straight-line elements do not form a plane.

Also double-curved surfaces, such as a sphere do not produce true developments, because they do not contain any straight lines.



<ins>Parallel-line developments</ins>

Developments of objects with parallel elements or parallel lateral edges begins by constructing a stretch-out line that is parallel to a right section of the object and is therefore, perpendicular to the elements or lateral edges.

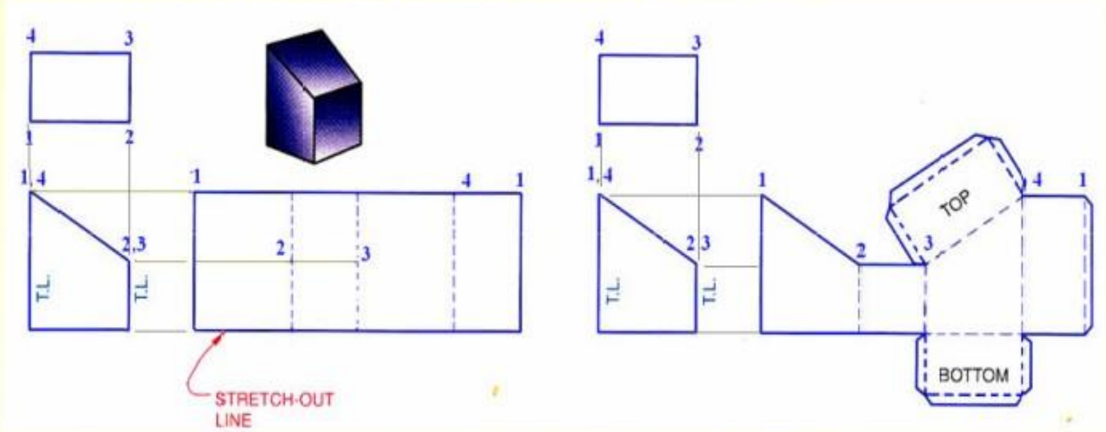


In the front view, all lateral edges of the prism appear parallel to each other and are true length. The lateral edges are also true length in the development. The length, or the stretch-out, of the development is equal to the true distance around a right section of the object.

Development of a truncated prism

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

Locate the fold lines on the pattern along the stretch-out line equal in length to the sides of the prism, 1-2, 2-3, 3-4, and 4-1.



Draw perpendicular construction lines at each of these points.

Project the points 1, 2, 3, and 4 from the front view

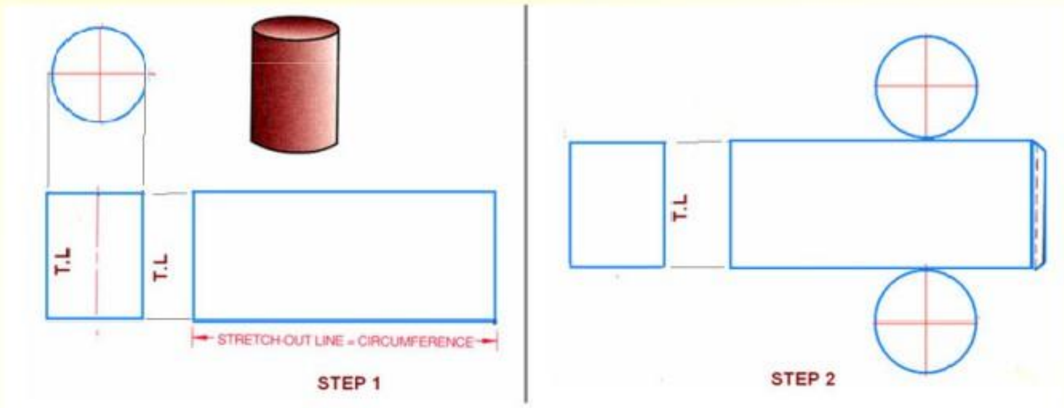
Step 2: Darken lines 1-2-3 and 4-1. Construct the bottom and top, as shown and add the seam to one end of the development and the top and bottom

Development of a right circular cylinder

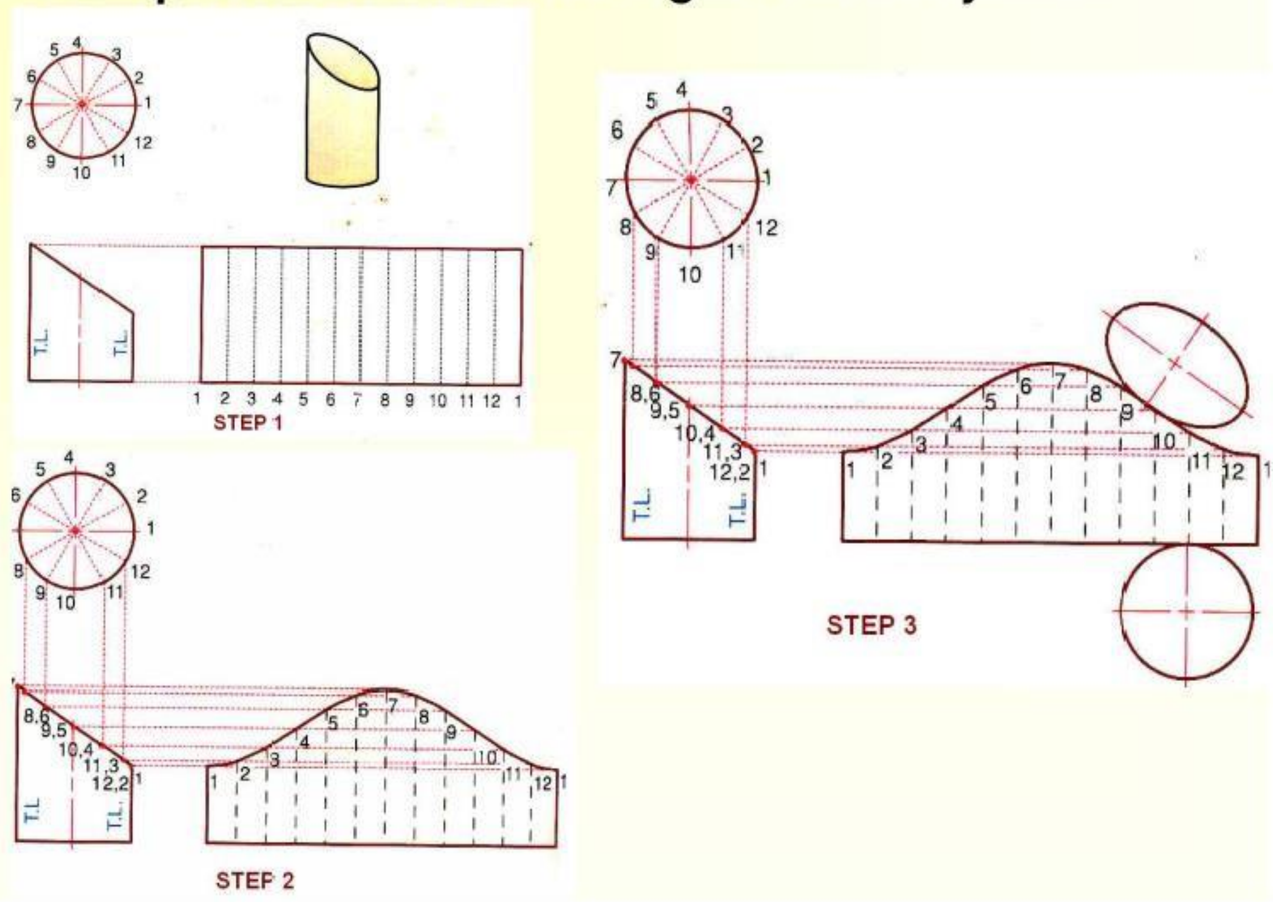
***Step* 1**. **In the front view, draw the stretch-out line aligned with the base of the cylinder and equal in length to the circumference of the base circle.**

At each end of this line, construct vertical lines equal in length to the height of the cylinder.

***Step* 2**. **Add the seam to the right end of the development, and add the bottom and top circles.**



Development of a truncated right circular cylinder

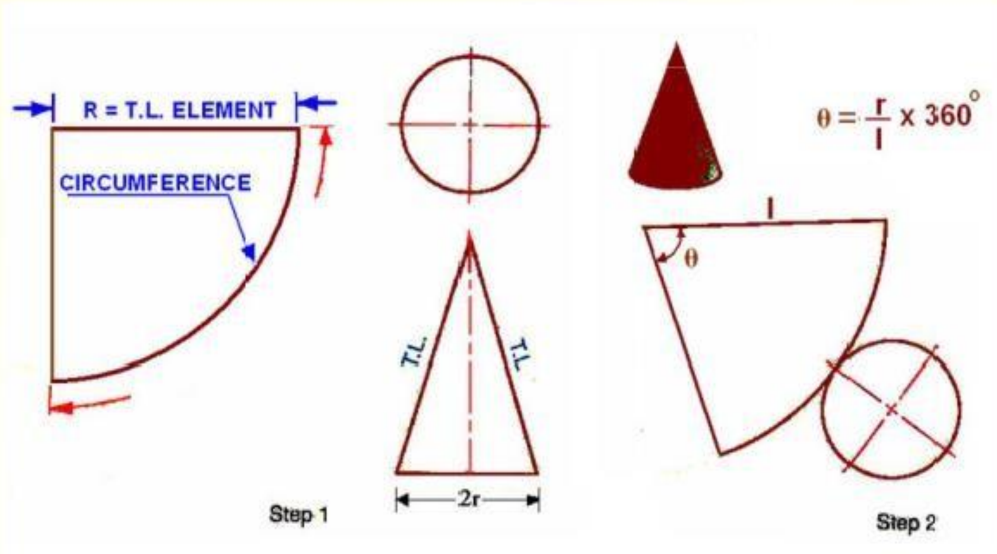


Development of a right circular cone

To begin this development, use a true-length element of the cone as the radius for an arc and as one side of the development.

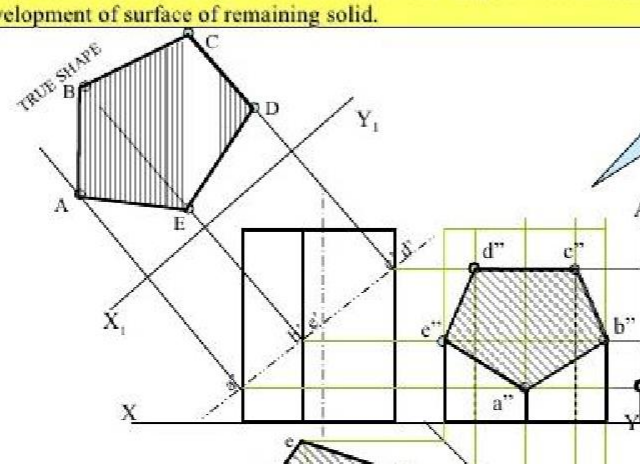
A true- length element of a right circular cone is the limiting element of the cone in the front view. Draw an arc whose length is equal to the circumference of the base of the cone.

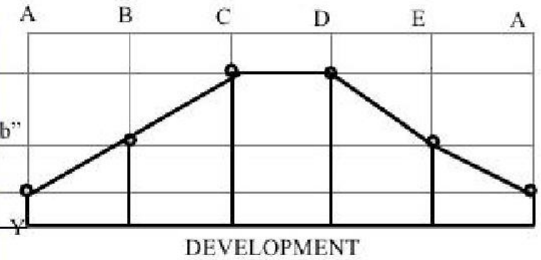
Draw another line from the end of the arc to the apex and draw the circular base to complete the development.

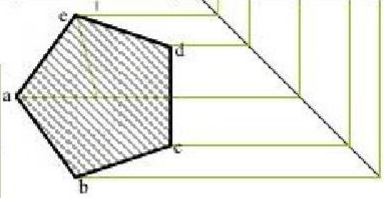


Problem 1: A pentagonal prism , 30 mm base side & 50 mm axis is standing on Hp on it's base with one side of the base perpendicular to VP. It is cut by a section plane inclined at 45° to the HP, through mid point of axis. Draw Fv, sec.Tv & sec. Side view. Also draw true shape of section and Development of surface of remaining solid.

Solution Steps: *for sectional views:*
Draw three views of standing prism.
Locate sec.plane in Fv as described.
Project points where edges are getting Cut on Tv & Sv as shown in illustration.
Join those points in sequence and show Section lines in it.
Make remaining part of solid dark.





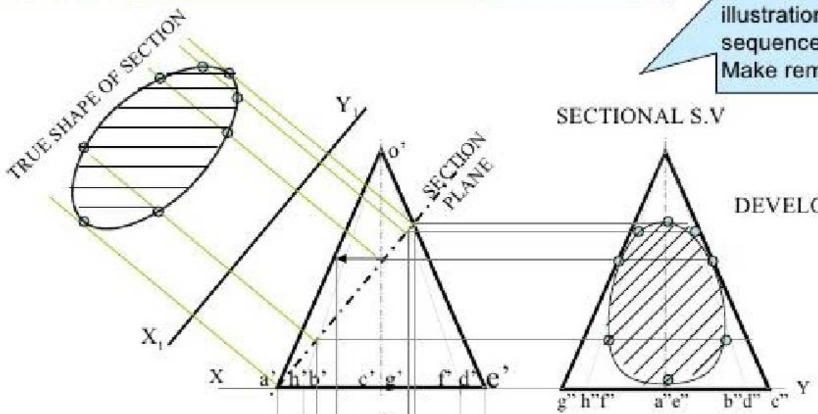


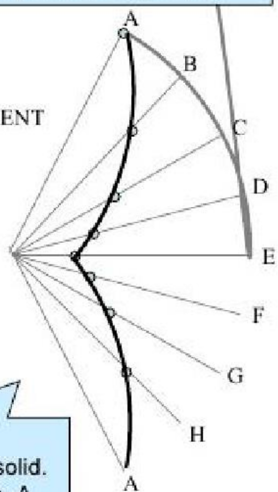
For True Shape:
Draw x_1y_1 // to sec. plane
Draw projectors on it from cut points.
Mark distances of points of Sectioned part from Tv, on above projectors from x_1y_1 and join in sequence.
Draw section lines in it.

For Development:
Draw development of entire solid. Name from cut-open edge I.e. A. in sequence as shown.
Mark the cut points on respective edges.
Join them in sequence in st. lines.
Make existing parts dev.dark.

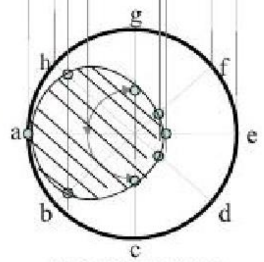
Problem 2: A cone, 50 mm base diameter and 70 mm axis is standing on it's base on Hp. It cut by a section plane 45° inclined to Hp through base end of end generator.Draw projections, sectional views, true shape of section and development of surfaces of remaining solid.

Solution Steps: *for sectional views:*
Draw three views of standing cone.
Locate sec.plane in Fv as described.
Project points where generators are getting Cut on Tv & Sv as shown in illustration.Join those points in sequence and show Section lines in it.
Make remaining part of solid dark.





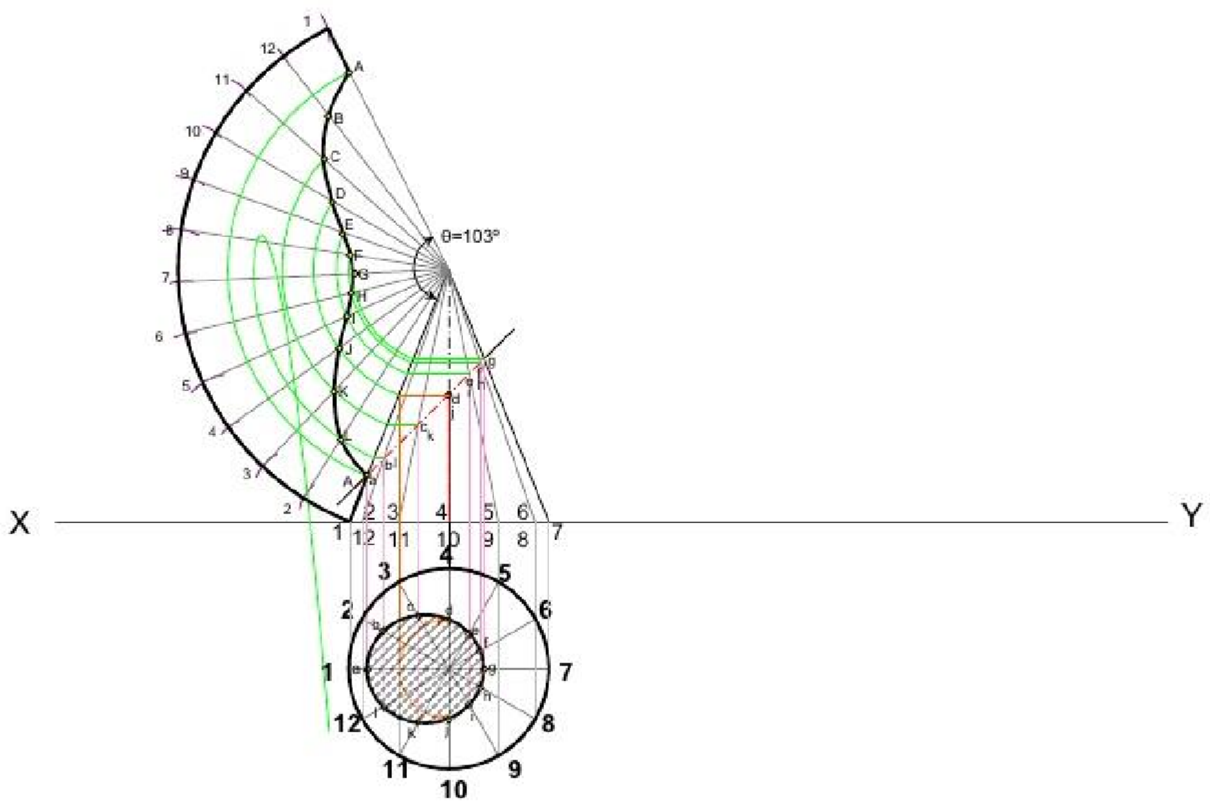
For True Shape:
Draw x_1y_1 // to sec. plane
Draw projectors on it from cut points.
Mark distances of points of Sectioned part from Tv, on above projectors from x_1y_1 and join in sequence.
Draw section lines in it.



SECTIONAL T.V

For Development:
Draw development of entire solid.
Name from cut-open edge i.e. A.
in sequence as shown.Mark the cut points on respective edges.
Join them in sequence in curvature. Make existing parts

Q e: A right circular cone base 30 mm side and height 50 mm rests on its base on H.P. It is cut by a section plane perpendicular to the V.P., inclined at 45° to the H.P. and bisecting the axis. Draw the projections of the truncated cone and develop its lateral surface.



ASSIGNMENT NO – 6

1) Draw the development of lateral surface of the Frustum of a regular Hexagonal Pyramid (Side of base 50 mm, Axis height 90 mm and the cutting plane is 55 mm above the base).

2) Draw the development of lateral surface of a truncated cylinder standing vertically on its base(diameter of base = 50 cm and Axis Height = 70 cm.)The cutting plane is perpendicular to VP, inclined at 40° to H.P. and intersecting the axis at a distance of 30 cm from the top end.

3) A right circular cone of base diameter 50 mm and axis height 80 mm rests with its base on horizontal. A section plane perpendicular to VP and inclined at 45° to HP bisects the axis of the cone. Draw the development of the surfaces of the truncated cone.(Lateral surface and bottom surface).

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APPENDICES

APPENDIX – I

DOs AND DO NOTs of Engineering Drawing

- OBJECT OUTLINES should be **THICK** and CONSTRUCTION lines **THIN** so that the drawing of the object **should clearly stand out**.
- CONSTUCTION LINES should be **THIN** and **CONTINUOUS** and not **DOTTED**.
- DIMENSIONS used show the **ACTUAL SIZE** of the object and **NOT THE SIZE** used in the drawing.
- DIMENSION LINE & EXTENSION LINE should be **THIN CONTINUOUS** whereas DIMENSION & ARROW HEAD should be **THICK**.
- CENTRE LINE/LINE OF SYMMETRY SHOULD ALWAYS BE SHOWN in the drawing.
- If not otherwise mentioned, use 1^{st} ANGLE PROJECTION METHOD.
- No F.V , T.V or SIDE VIEW SHOULD START FROM THE REFERENCE LINE **until otherwise specifically mentioned**.
- Practice drawing curves by both French Curves & Free hand because it may not always be possible to join all relevant points of the curve using French Curves.
- In case of a DIAGONAL SCALE or PLAIN SCALE the CONSTUCTION LINES for dividing a line in ‘n’ equal parts SHOULD NOT BE DRAWN IN THE AREA WITHIN THE SCALE.
- Use SUITABLE SCALE and ALWAYS MENTION the scale or R.F. used in the drawing.
- For making an ISOMETRIC PROJECTION, **ALWAYS USE ISOMETRIC SCALE.**

APPENDIX – II

MULTIPLE CHOICE QUESTIONS

1. If a client of yours is having difficulty visualizing a design, what type of drawing would be the easiest to understand?
   A) axonometric B) three-view orthographic C) one-view orthographic D) biometric
   ANS: A
2. Which of the following is not a pictorial drawing?
   A) isometric B) multiview C) perspective D) axonometric
   ANS: B
3. Which of the following projection methods does not use projectors perpendicular to the projection plane?
   A) isometric B) orthographic C) oblique D) axonometric
   ANS: C
4. A circle will appear on an isometric drawing as a(n) ___________. A) ellipse B) cycloid C) circle D) parabola
   ANS: A
5. An axonometric drawing which has all three axes divided by equal angles is:
   A) dimetric B) trimetric C) orthographic D) isometric
   ANS: D
6. In a trimetric drawing, the relationship of the angle between axes to each other is:
   A) three are equal B) two are equal C) three are unequal D) none of the above
   ANS: D
7. In an isometric sketch of a cube:
   A) the frontal face appears in its true shape B) the receding axes are at 45 degrees to the horizontal C) all faces are equally distorted D) only the depth distances must be reduced
   ANS : C
8. In isometric drawings:
   A) Two axes are perpendicular B) True measurements can be made only along or parallel to the isometric axes C) All faces are unequally distorted D) None of the above
   ANS: B
9. One method of drawing an ellipse that represents an isometric pictorial circle is known as:

A) the box construction method B) the coordinate construction method C) the four-center approximation method D) the offset construction method
ANS: A

10. Non-isometric lines are located and sketched how?
A) They are drawn parallel to the isometric axis. B) They are measured using the angle from the multiview. C) They are measured using a non-isometric template. D) They are located by determining the endpoints of the non-isometric line.
ANS: D

11. In an oblique sketch of a cube:
A) the frontal face appears in its true shape B) both receding axes are at 30 degrees to the horizontal C) all faces are equally distorted D) the depth distances must be reduced
ANS: A

12. In an oblique drawing, all of the following angles are commonly used for drawing the depth axis, except:
A) 30° B) 45° C) 60° D) 90°
ANS : D

13. In an oblique drawing, the projection rays are drawn __________ to each other and ________to the plane of projection.
A) oblique.....oblique B) oblique.....parallel C) parallel.....oblique D) parallel ....parallel
ANS: C

14. All of the following are processes (as opposed to input or output) in a manufacturing business except:
A) Material B) Planning C) Documenting D) Designing
ANS: A

15. Following operations can make use of the CAD database, except:
A) Designing B) Marketing C) Producing D) None of the above
ANS: D

16. Which of the following is the responsibility of the production manager?
A) people B) plants C) processes D) all of the above
ANS: D

17. Which network system gives outside vendors access to a company's internal network?
A) Intranet B) Extranet C) Internet D) Outernet
ANS: B

18. All of the following are part of a typical design team, except:
A) vendors B) quality control specialists C) manufacturing engineers D) accountants
ANS: D

19. Which tool can be used to draw a 90 degree angle?
A) 30/60 triangle B) protractor C) drafting machine D) all of the above
ANS: D

20. Which type of line is part of a dimension?
A) break lines B) phantom lines C) extension lines D) cutting plane lines

ANS: C

21. Which type of line is particular to section drawings?

    A) break lines B) phantom lines C) extension lines D) cutting plane lines

    ANS: D

22. Which angle cannot be made with either a 45 or 30/60 triangle or a combination of the two?

    A) 90 B) 70 C) 30 D) 15

    ANS: B

23. A drawing instrument set usually contains all of the following, except: A) bow compass B) scale C) dividers D) extra leads

    ANS: B

24. Which of the following operating systems is used with CAD systems?

    A) DOS B) UNIX C) Linux D) all of the above

    ANS: D

25. Which line type is thin and light?

    A) visible lines B) center lines C) construction lines D) all of the above

    ANS: C

26. Which line type is thick and black?

    A) visible lines B) center lines C) construction lines D) all of the above

    ANS: A

27. What type of sketch incorporates convergence?

    A) isometric B) perspective C) oblique D) multiview

    ANS: B

28. What type of sketch shows the front in true shape?

    A) isometric B) perspective C) oblique D) axonometric

    ANS: C

29. What is the major difference(s) between perspective and parallel projection?

    A) Parallel projection can only be used with objects containing parallel edges.

    B) Perspective projection gives a more realistic representation of an object. C) Parallel projection is equivalent to a perspective projection where the viewer is standing infinitely far away. D) Perspective projection can only be used for creating oblique and not isometric pictorials. E) b and c

    ANS: E

30. What type of sketch uses a miter line?

    A) a two-view multiview B) an isometric pictorial C) a three-point perspective pictorial D) a three-view multiview

    ANS: D

31. Which type of line has precedence over all other types of lines?

    A) a hidden line B) a center line C) a visible line D) none of the above

    ANS: C

32. Which statement(s) is true about the precedence of lines?

A) a hidden line has precedence over a center line B) a center line has precedence over a visible line C) a visible line has precedence over a miter line D) all of the above
ANS: A

33. Where do the projection lines converge in a perspective sketch? A) the vanishing point B) the ground line C) the horizon line D) the eye point
ANS: A

34. When you want to make the letters of a line of text narrower, you would set its:
A) aspect B) scale C) alignment D) font
ANS: A

35. When you want to make sure that all of the text stays to the right of a given point on the drawing, you wound set its:
A) aspect B) scale C) alignment D) font
ANS: C

36. Which of the following is typically represented in a drawing but does not have a true physical counterpart on the object?
A) edge of planar surface B) edge of a circular face C) corner of a rectangle D) limiting element of a curved surface
ANS: D

37. A cutting plane normal to a face of a cube has to be _______________ in order to cut an oblique face.
A) rotated about one axis B) rotated about one axis and translated C) rotated about two axes D) rotated about two axes and translated
ANS: C

38. All of the following are variables involved in the use of image planes, except:
A) the object being viewed B) the size of the object C) the eye of the viewer D) the image plane
ANS: B

39. Imagine a "L" shaped face extruded into three dimensions. How many faces does it contain?
A) seven B) eight C) ten D) six
ANS: B

40. Which type of variable is the following list: Texas, Utah, California, Delaware?
A) Nominal B) Ordinal C) Scalar D) Vector
ANS: A

41. Which type of variable is the following list: Thinnest, Thin, Medium, Fat, Fattest?
A) Nominal B) Ordinal C) Scalar D) Vector
ANS: B

42. All of the following are simple marks, except: A) lines B) points C) arrows D) areas
ANS: C

43. Which of the following is not a technique normally used with a surface plot?

A) hidden line removal B) color coding based on z value C) specular reflection D) Gouraud shading
ANS: C

44. All of the following are common methods used for solving descriptive geometry problems except:
A) direct view method B) reference plane method C) fold-line method D) revolution method
ANS: B

45. All of the following statements about creating a point view of a line are true, except:
A) the line of sight must be parallel to the line B) two auxiliary views are needed off an oblique line C) it will never be seen in one of the principal views D) it is used to show the edge view of a plane
ANS: C

46. Which coordinate system uses two angles and one distance?
A) world B) spherical C) local D) cylindrical
ANS: B

47. Which coordinate system uses two distances and one angle?
A) world B) spherical C) local D) cylindrical
ANS: D

48. If you are going to create a tangent arc between two arcs that cannot intersect, to find the center of the tangent arc you must set your compass to a radius that is:
A) the existing arc radius minus the tangent arc radius B) centered at the tangent point of the new arc and the existing arc C) the existing arc radius plus the tangent arc radius D) the sum of the two existing arc radii
ANS: C

49. _________do not define a plane.
A) Two parallel lines B) Three points C) Two skew lines D) A line and a point
ANS: C

50. What type of curve is created by the intersection of a plane parallel to the side of a cone? A) parabola B) hyperbola C) ellipse D) roulette
ANS: A

51. What type of curve is created by the intersection of a plane with a cone which makes an angle with the axis greater than the angle between the side of the cone and the axis?
A) parabola B) hyperbola C) ellipse D) roulette
ANS: C

52. A _________is created by the motion of a point on a circle as the circle rolled along a straight line A) epicycloid B) hyperbola C) cycloid D) spiral
ANS: C

53. The path that a generatrix follows is called the:
A) parabola B) b-spline C) ruler D) directrix

ANS: D

54. Another name for a cube is a
A) hexahedron. B) tetrahedron. C) isocohedron. D) octahedron.
ANS: A

55. A _________cone has two planar surfaces parallel to each other
A) truncated B) frustrum C) right D) oblique
ANS: B

56. The selection of the front view in executing a multiview drawing of an object is dependent upon the following factors:
A) size and shape of the object and their relationship to all views. B) the number of principal views required and the related auxiliary views needed to describe the object. C) the greatest contour shape, the related dashed lines, and the position of use. D) the size of the object, position of use, and least number of hidden lines.
ANS: D

57. All of the following statements about multiview drawings are true, except:
A) each view is a 3-D pictorial image B) based on orthographic projection
C) at least two views of the object D) views are defined by planes of projection
ANS: A

58. Which type of projection does not have the projection rays parallel to each other?
A) axonometric projection B) oblique projection C) orthographic projection D) perspective projection
ANS: D

59. Which is not a principal view? A) bottom B) left side C) auxiliary D) front
ANS: C

60. Principle planes will appear as: A) normal planes or edges B) oblique planes or edges C) normal planes or oblique planes D) skewed planes or edges
ANS: A

61. In orthographic projection, visual rays or lines of sight for a given view are ______________to each other. A) perpendicular B) oblique C) normal D) parallel
ANS: D

62. What two types of projections give a pictorial view of the object without convergence?
A) orthographic and perspective B) oblique and axonometric C) perspective and oblique D) isometric and orthographic
ANS: B

63. Inclined planes in a three-view drawing will appear as:
A) two surfaces and one edge B) two edges and one surface C) three edges D) foreshortened in each view
ANS: A

64. Normal planes in a three-view drawing will appear as: A) one surface and two edges B) three surfaces C) one edge and two surfaces D) three edges
ANS: A

65. A viewing direction which is perpendicular to the surface in question gives a _____________view.
A) inclined B) normal C) oblique D) perspective
ANS: B
66. A viewing direction which is parallel to the surface in question gives a ________________ view.
A) inclined B) normal C) edge D) perspective
ANS: C
67. When a surface of an object is inclined to a plane of projection, it will appear ___________________in the view. A) foreshortened B) in true size and shape C) as a line D) as a point
ANS: A
68. What are the three principle planes in orthographic projection?
A) front, top, profile B) back, top, profile C) top, front, right side D) frontal, horizontal, profile
ANS: D
69. The top view of an object should typically be drawn: A) to the right of the front view. B) anywhere on the same page. C) directly below the front view. D) on a separate piece of paper.
ANS: C
70. A horizontal surface of a multiview drawing will appear as a ______________in the front view. A) edge B) normal surface C) point D) foreshortened surface
ANS: A
71. Which view is usually developed first, contains the least amount of hidden lines, and shows the most contours in multiview drawings?
A) right side B) top C) back D) front
ANS: D
72. A sphere can be described in how many views?
A) 4 B) 3 C) 2 D) 1
ANS: D
73. An asymmetric object is usually described by how many views?
A) 6 B) 3 C) 4 D) 2
ANS: B
74. An axially symmetric object, such as one turned on a lathe, normally can be shown in __________view(s).
A) one B) two C) three D) four
ANS: B
75. In orthographic projection, visual rays are ___________to the projection plane.
A) parallel B) adjacent C) perpendicular D) tangent
ANS: C
76. The top and right side views have what common dimension(s)?

A) height and width B) width and depth C) height D) depth
ANS: D

77. For orthographic projection, the engineering custom in the United States dictates the use of:
A) first-angle projection B) second-angle projection C) third-angle projection D) fourth-angle projection
ANS: C

78. For orthographic projection, the engineering custom in Europe dictates the use of:
A) first-angle projection B) second-angle projection C) third-angle projection D) fourth-angle projection
ANS: A

79. The sequence for the direction of view (or line of sight) for any orthographic projection as utilized in the United States is:
A) eye of observer>projection plane>object B) eye of observer>object>projection plane C) projection plane>object>eye of observer D) projection plane>eye of observer>object
ANS: A

80. Depending on its relationship to the projection plane on which the view is projected, a line may project: A) true length B) foreshortened C) as a point D) all of the above
ANS: D

81. If a surface on an object is parallel to one of the principal planes of projection, then the angular relationship of that surface to at least two other principal projection planes is:
A) parallel B) perpendicular C) inclined D) unknown
ANS: B

82. Good practice dictates that the characteristic contour shape of the object be shown in what view?
A) top B) front C) right side D) any side
ANS: B

83. The height, width, and depth of an object can be shown with a minimum of how many orthographic projection views? A) six B) three C) two D) four
ANS: C

84. Which of the following pairs of orthographic views both show the height dimension?
A) left side and front B) top and front C) top and rear D) bottom and right side
ANS: A

85. A title block contains all of the following information, except:
A) name and address of the company B) parts list C) drawing sheet size letter designation D) drawing number
ANS: B

86. An assembly drawing normally consists of all of the following pieces, except:
A) parts drawn in their operating position B) detail numbers of the parts C) engineering change orders D) bill of materials
ANS: C

87. A balloon: A) often shows up on assembly drawings B) contains part number information C) indicates the scale of a removed detail D) appears at the end of a leader
ANS: C

88. An engineering change note would be placed:
A) with the other notes in the drawing area B) on a sheet attached to the detail drawing C) in the bill of materials D) in the revision block
ANS: D

89. All of the following distinguish digital document management technologies from traditional document management, except:
A) plotters can produce drawings much quicker than by hand B) drawings can be stored on electronic media for later retrieval C) database tools can be used to manage and organize product information D) drawing files can be instantly transported long distances
ANS: A