

BVRIT HYDERABAD College of Engineering for Women
Department of Basic Sciences and Humanities

Hand Out

Subject Name: Engineering Graphics

B.Tech. I Year I/II Sem.

L T P C
1 0 4 3

Course Objectives:

- To develop the ability of visualization of different objects through technical drawings
- To acquire computer drafting skill for communication of concepts, ideas in the design of engineering products

Course Outcomes:

At the end of the course, the student will be able to:

- Apply computer aided drafting tools to create 2D and 3D objects
- sketch conics and different types of solids
- Appreciate the need of Sectional views of solids and Development of surfaces of solids
- Read and interpret engineering drawings
- Conversion of orthographic projection into isometric view and vice versa manually and by using computer aided drafting

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Year and Sem, Department: I B.Tech - II Semester

Unit –I:

Introduction to Engineering Drawing: Principles of Engineering Graphics and their Significance, Conic Sections including the Rectangular Hyperbola – General method only. Cycloid, Epicycloid and Hypocycloid, Scales – Plain & Diagonal.

Important Points / Definitions:

Engineering Graphics

Engineering drawing is the language of engineers. It is meant for communicating his/her ideas, thoughts and designs to others. A drawing drawn by an engineer, having engineering knowledge, for the engineering purpose is an engineering drawing (or instrument drawing).

Applications of Engineering Drawing

Engineering drawing is an essential part of almost all engineering projects. Some important uses of engineering drawing are mentioned below:

1. It is used in ships for navigation.
2. For manufacturing of machines, automobiles etc.
3. For construction of buildings, roads, bridges, dams, electrical and telecommunication structures etc.
4. For manufacturing of electric appliances like TV, phone, computers etc.

Various Software's used for drafting

Auto CAD, ANSYS, PRO/E, Ideas, Unigraphics and hyper mesh etc.

SCALES

The proportion by which we either reduce or increase the actual size of the object on a drawing is known as scale. It is not possible always to make drawings of an object to its actual size as the extent of drawing paper is limited and also sometimes the objects are too small to make it clearly understandable by drawing its actual size in drawing paper. Scale is the technique by which one can represent an object comfortably as well as precisely within the extent of drawing paper.

In other words, a scale is a measuring stick, graduated with different divisions to represent the corresponding actual distance according to some proportion. Numerically scales indicate the relation between the dimensions on drawing and actual dimensions of the objects.

Uses of scale

- ✓ To prepare reduced or enlarged size drawings.
- ✓ To set off dimensions.
- ✓ To measure distances directly.

Sizes of Scales

- ✓ Full size scale
- ✓ Reducing scale
- ✓ Enlargingscale

Full Size Scale

The scale in which the actual measurements of the object are drawn to the same size on the drawing is known as full size scale. It is represented as 1:1 scale. If possible, drawing should be done in full scale.

Reducing Scale

The scale in which the actual measurements of the object are reduced to some proportion is known as reducing scale. The standard formats of reducing proportions are:

- 1:2 - drawing made to one-half of the actual size
- 1:5 - drawing made to one-fifth of the actual size
- 1:10 - drawing made to one-tenth of the actual size
- 1:50 - drawing made to one-fiftieth of the actual size
- 1:100 - drawing made to one-hundredth of the actual size

Enlarging Scale

The scale in which the actual measurements of the object are increased to some proportion is known as reducing scale. The standard formats of enlarging proportions are:

- 2:1- drawing made to twice the actual size
- 5:1- drawing made to five times the actual size
- 10:1 - drawing made to ten times the actual size

Classification of Scales

- ✓ Plain Scales
- ✓ Diagonal Scales
- ✓ Comparative Scales
- ✓ Vernier Scales
- ✓ Chord Scales

The first two types (plain and diagonal) of scales are usually used in engineering drawings.

Plain Scale

The scale that can measure one main unit and one sub-unit of the main unit or up to a fraction of 1st decimal point of the main unit is known to be a plain scale. It is simply a line divided into a number of equal parts and the 1st part is further sub-divided into small parts. Kilometers and Hectometers, Meters and Decimeters, Meters and 1/10th of Meters etc. can be measured using plain scales.

Diagonal Scale

The scale that can measure one main unit and two sub-units of the main unit or up to a fraction of 2nd decimal point of the main unit is known to be a diagonal scale. It is so named because the 2nd sub-unit or 2nd decimal of main unit is obtained by the principle of diagonal division. Kilometers-Hectometers-Decameters, Decameters-Meters-Decimeters, Meters-1/10th of Meters- 1/100th of Meters etc. can be measured using diagonal scales.

Following are the necessary information required for construction of a scale:

- ✓ The representative fraction (R.F.) of the scale.
- ✓ The unit or units to be presented.
- ✓ The maximum length to be measured.

The Representative Fraction (R.F.) or Scale Factor (S.F.)

The ratio of the distance on drawing paper of an object to the corresponding actual distance of the object is known as the representative fraction (R.F.) or the scale factor (S.F.). It is to be remembered that for finding RF the distances used for calculation must be in same unit. And being a ratio of same units, R.F. itself has no unit.

Mathematically,

$$\text{Representative factor (R.F.)} = \frac{\text{Length of an element in the drawing}}{\text{Actual length of the same element}}$$

$$\text{Length of scale} = (\text{R.F.}) \times \text{Max. Length to be measured}$$

Units of Measurement

It is modern practice to use metric system of units in engineering drawing. However, sometimes British system is also used. It is important to have clear understanding about unit conversion in both system.

Metric Units for Linear Measurement

10 millimeters (mm) = 1 centimeter (cm)
 10 centimeters (cm) = 1 decimeter (dm)
 10 decimeters (dm) = 1 meter (m)
 10 meters (m) = 1 decameter (dam)
 10 decameters (dam) = 1 hectometer (hm)
 10 hectometers (hm) = 1 kilometer (km)

British Units for Linear

1 League = 3 miles
 1 mile = 8 furlongs
 1 furlong = 10 chains
 1 chain = 22 yards
 1 yard = 3 feet
 1 foot = 12 inches

Metric Units for Area Measurement

100 square millimeters (mm²) = 1 square centimeter (cm²)
 100 square centimeters (cm²) = 1 square decimeter (dm²)
 100 square decimeters (dm²) = 1 square meter (m²)
 100 square meters (m²) = 1 acre (a)
 100 acres (a) = 1 hectare
 100 hectares = 1 square kilometer (km²)

Construction of Plain Scale

Following are the steps for constructing a plain scale

1. Find out the R.F., if not given directly.
2. Find out the length of scale

$$= R. F. \times \text{Actual length of object or Maximum length to be measured}$$
3. Draw a straight line, preferably horizontal, of required length as found in previous step.
4. Divide the line into a number of divisions relating to the length of object and maximum length to be measured such that one segment represents one major unit. Avoid fractions, consider the next integer value. For instance, if maximum length to be measured is 6.2 km, then number of divisions will be 7.
5. Place mark 0 at the end of 1st main division (Remember, not at the starting point of 1st division) and mark the other divisions sequentially toward right as 1,2,3..... etc.
6. Divide the 1st main division into a number of divisions such that each of these smallest division represents one sub-unit. For instance if the scale need to measure in feet and inches, number of minor divisions will be 12. On the other hand if the scale is to measure in centimeters and millimeters or in meters and 1/10th of meter number of divisions will be 10.
7. Mark the sub-unit sequentially toward left as 1, 2, 3..... etc. or 0.1, 0.2, 0.3..... etc. If space is limited they can be marked after every 2 division like 0, 2,4,..... etc.
8. Mention the R.F. of the scale below the figure.
9. Mention the name of main unit and sub-unit either at below or at the respective ends of the scale.

PROBLEM NO.1:- Draw a scale 1 cm = 1m to read decimeters, to measure maximum distance of 6 m. Show on it a distance of 4 m and 6 dm.

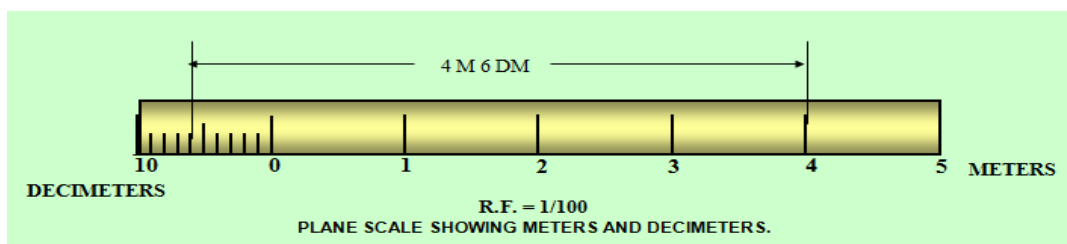
CONSTRUCTION:-

- a) Calculate R.F. = $\frac{\text{Length of an element in the drawing}}{\text{Actual length of the same element}}$

$$R.F. = 1\text{cm} / 1\text{m} = 1/100$$

$$\text{Length of scale} = R.F. \times \text{max. distance}$$

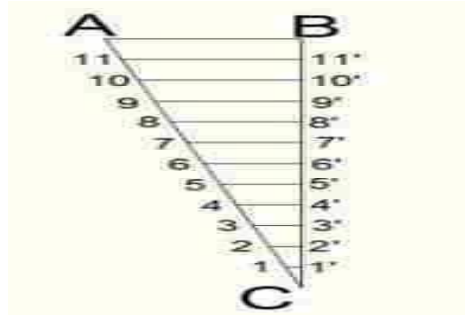
$$= 1/100 \times 600 \text{ cm} = 6 \text{ cm}$$
- b) Draw a line 6 cm long and divide it in 6 equal parts. Each part will represent larger division unit.
- c) Sub divide the first part which will represent second unit or fraction of first unit.
- d) Place (0) at the end of first unit. Number the units on right side of Zero and sub divisions
- e) on left-hand side of Zero. Take height of scale 5 to 10 mm for getting a look of scale.
- f) After construction of scale mention it's RF and name of scale as shown.
- g) Show the distance 4 m 6 dm on it as shown.



Principle of Diagonal Scales:

The principle of diagonal scale is to obtain any fractional part of a short line by following the diagonal division method. In this method we get fractional part of a line, say $1/9^{\text{th}}$ of length, $1/15^{\text{th}}$ of length etc.

Let the given short line AB which is required to be divided into 12 equal parts. Erect a perpendicular BC of any suitable length and divide it into 12 equal parts. Join AC and draw lines 1-1', 2-2', 3-3'... etc. parallel to AB at each division point. Thus dividing is complete indirectly. If you need $1/12^{\text{th}}$ of AB, 1-1' will be your required length. If you need $2/12^{\text{th}}$ of AB, 2-2' is your required length. Similarly 3-3' represents $3/12^{\text{th}}$ of AB, 4-4' represents $4/12^{\text{th}}$ of AB and so on.



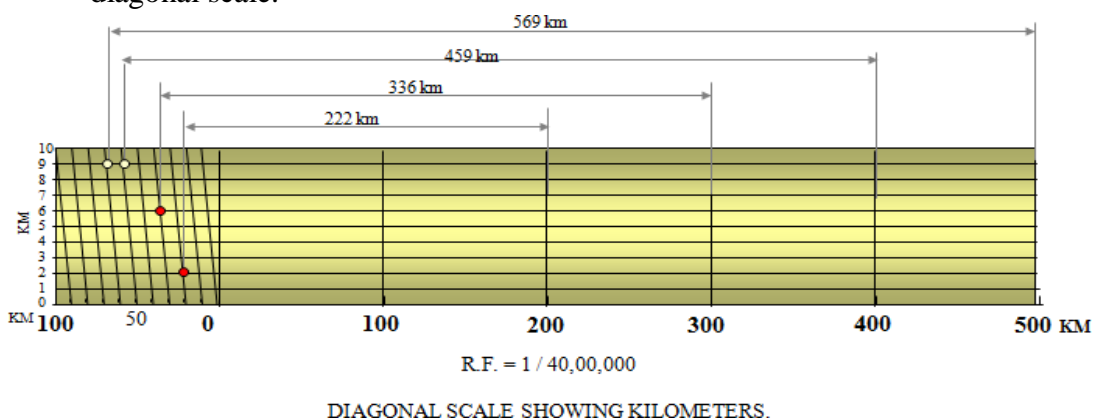
PROBLEM NO 2: The distance between Delhi and Agra is 200 km. In a railway map it is represented by a line 5 cm long. Find it's R.F. Draw a diagonal scale to show single km. And maximum 600 km. Indicate on it following distances. 1) 222 km 2) 336 km 3) 459 km 4) 569 km.

CONSTRUCTION:-

$$RF = 5 \text{ cm} / 200 \text{ km} = 1 / 40,00,000$$

$$\text{Length of scale} = 1 / 40,00,000 \times 600 \times 10^5 = 15 \text{ cm}$$

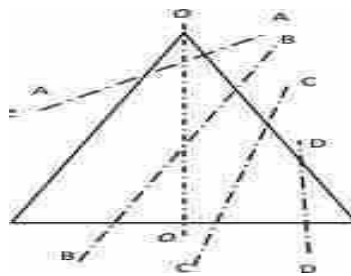
- Draw a line 15 cm long.
- It will represent 600 km. Divide it in six equal parts.(each will represent 100 km.)
- Divide first division in ten equal parts.
- Each will represent 10 km. Draw a line upward from left end and mark 10 parts on it of any distance. Name those parts 0 to 10 as shown.
- Join 9th sub-division of horizontal scale with 10th division of the vertical divisions.
- Then draw parallel lines to this line from remaining sub divisions and complete diagonal scale.



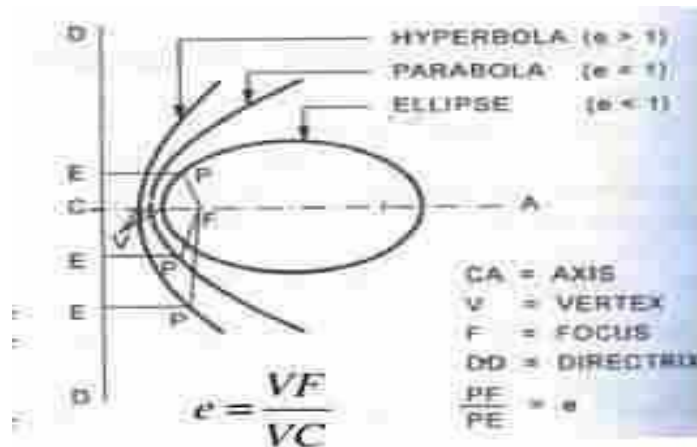
ENGINEERING CURVES:

Conic Sections: Sections of a right circular cone obtained by cutting the cone in different ways. Depending on the position of the cutting plane relative to the axis of cone, three conic sections can be obtained – ellipse, – parabola and – hyperbola

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



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



- Ellipse: eccentricity is always < 1
- Parabola: eccentricity is always $= 1$
- Hyperbola: eccentricity is > 1
- The fixed point is called the Focus
- The fixed line is called the Directrix
- Axis is the line passing through the focus and perpendicular to the directrix
- Vertex is a point at which the conic cuts its axis
- Ellipse, parabola, hyperbola can be constructed by the following methods:

ELLIPSE

1. Concentric Circle Method
2. Arcs of Circle Method
3. Oblong Method
 - (a) Rectangle Method
 - (b) Parallelogram method
4. Eccentricity method (general method)

PARABOLA

1. Offset method
2. Tangent method
3. Oblong Method
 - (a) Rectangle Method
 - (b) Parallelogram method
4. Eccentricity method (general method)

HYPERBOLA

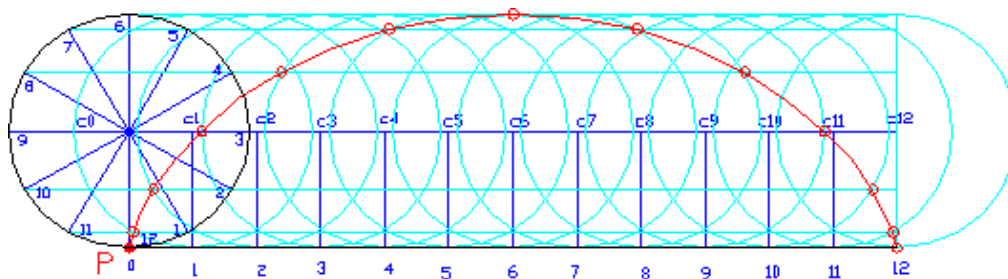
1. Intersecting arcs method
2. Asymptotes method
3. Eccentricity method

Cycloidal curves:

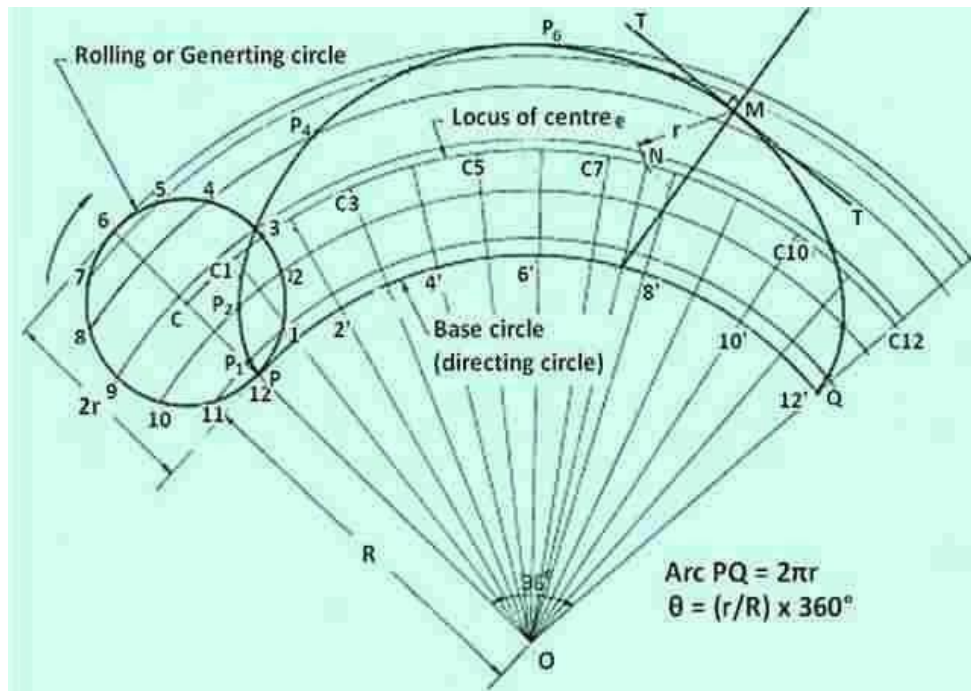
A **Cycloid** is the path or **Locus** followed by a point on a circle when it moves along a straight line without slipping.

Construction of a Cycloid

1. Below is a description of how to construct a **Cycloid** for a point **P** on a circle as it rotates along a straight line without slipping.
2. Firstly draw the circle and a line from its base to the left or right. The line should be to the right if the circle is rotating clockwise, and to the left if the circle is rotating anti-clockwise.
3. In this situation we are going to find the locus of a point **P** which lies at the bottom of the circle where it touches the straight line
4. Now divide the circle into an equal number of parts. Here we have used the 60° - 30° set square to give us 12 equal divisions.
5. Taking the distance between any two of these points with your compass mark 12 off these distances along the base line along which the circle will rotate. Label these points 0 to 12 as shown. When taking the distance between any two of the divisions of the circle you should add a little bit to the distance on your compass to account for the curve of the circle.
6. Project the new points (from C1 to C12) on to a line from the centre of the circle.
7. As the circle rotates along the line, point 1 on the circle will move to point 1 on the line, and therefore the center of the circle will now be at point C1.
8. Next project lines from the equal divisions of the circle parallel to the straight line. These are the height lines.
9. With your compass set to the radius of the circle, place the point of the compass on the point C1 and cut the height line coming from point 1 on the circle. Then repeat this for point C2 and height line 2, etc. until you reach point C12 and line 12.
10. Essentially what you have done is break up the continuous movement of the circle along the straight line into 12 sections and found the position of point **P** for each movement.
11. It would get very cluttered if you drew in every circle along the way.



Epicycloid: The cycloid is called Epicycloid when the generating circle rolls along the circumference of another circle outside it.



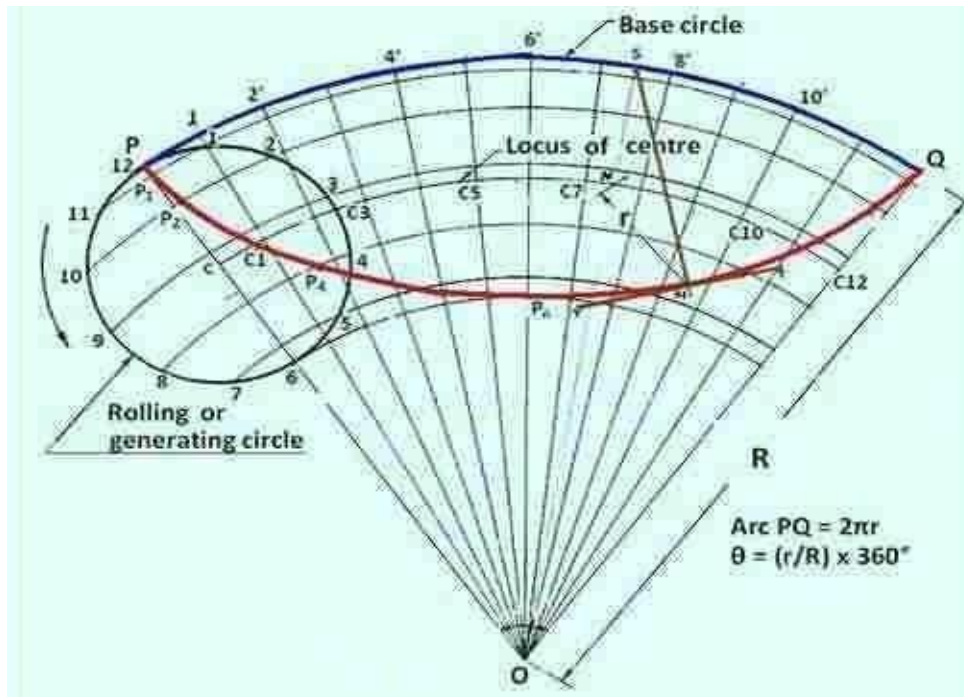
Illustrates the generation of an epicycloid.

With O as centre and radius OP (base circle radius), draw an arc PQ. The included angle $\theta = (r/R) \times 360^\circ$. With O as centre and OC as radius, draw an arc to represent locus of centre. Divide arc PQ in to 12 equal parts and name them as 1', 2', ..., 12'. Join O1', O2', ... and produce them to cut the locus of centres at C1, C2, ...C12. Taking C1 as centre, and radius equal to r , draw an arc cutting the arc through 1 at P1. Taking C2 as centre and with the same radius, draw an arc cutting the arc through 2 at P2. Similarly obtain points P3, P3, ..., P12. Draw a smooth curve passing through P1, P2, ..., P12, which is the required epicycloid.

Hypocycloid

Hypocycloid is the curve generated by a point on the circumference of a circle which rolls without slipping inside another circle. The construction of a hypocycloid is illustrated.

With O as centre and radius OP (base circle radius), draw an arc PQ. The included angle $\theta = (r/R) \times 360^\circ$. With O as centre and OC as radius, draw an arc to represent locus of centre. Divide arc PQ in to 12 equal parts and name them as 1', 2', ..., 12'. Join O1', O2', ..., O12' so as to cut the locus of centres at C1, C2, ...C12. Taking C1 as centre, and radius equal to r , draw an arc cutting the arc through 1 at P1. Taking C2 as centre and with the same radius, draw an arc cutting the arc through 2 at P2. Similarly obtain points P3, P3, ..., P12. Draw a smooth curve passing through P1, P2, ..., P12, which is the required hypocycloid.



Construction of a hypocycloid.

Questions:

- 1) Draw a scale with RF 1:50 to show meters and decimeters and long enough to measure up to 5 meters. Mark a distance of 2.7 meters on it.
- 2) Construct a diagonal scale of 1:25 to read meters, decimeters and centimeters and long enough to measure 4 m. mark on it a distance of 2.47m
- 3) Draw an ellipse with major axis 120 and minor axis 80 by concentric circles method.
- 4) Draw an epicycloid having the diameters of both directing and generating circles as 60. Mention a name to this curve.
- 5) Draw a hypocycloid, when the diameter of the directing circle is twice to the generating circle. Assume the diameter of the generating circle is 60.
- 6) A circle of 60 diameter is rolling inside a circle whose radius is 90. Draw the path traced by a point on the circumference of the disc which is initially in touch with the directing circle. Name the curve. Draw a tangent and normal at a distance of 50 from the directing circle.

Unit –II:

Orthographic Projections: Principles of Orthographic Projections – Conventions – Projections of Points and Lines, Projections of Plane regular geometric figures.—Auxiliary Planes.

Important Points / Definitions:

Solid Geometry deals with the representation of

1. Points
2. Lines
3. Plane surfaces and
4. Solids - in the form of "Projections" on 2D drawing sheet.

The word "Projection" is of Latin origin and means to 'throw forward'. It is possible to prepare engineering drawings of engineering components in their true shapes and sizes.

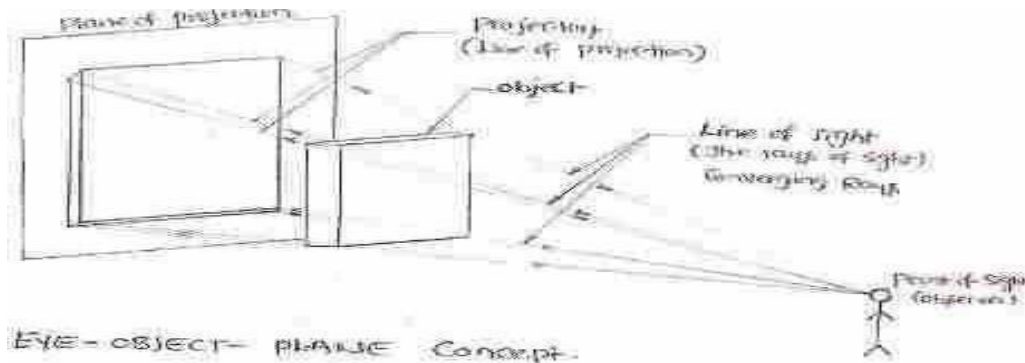
Principle of Projection:

Projection is defined as an image of an object thrown forward on to a plane by means of straight lines or visual rays. Straight lines are drawn from various points on the contour of an object to meet a plane, the object is said to be projected on that plane.

Theory of Projection:

Following are the elements to be considered while obtaining a projection:

1. The object
2. The Plane of Projection
3. The Point of sight / Eye / Observer
4. The rays of sight / Line of sight
5. The Line of projection / Projectors

**Projectors:**

The line joining different points of the projection and the corresponding point of the object is known as "Projector" or "Line of Projection".

Line of Sight:

The line of joining different points of the projection and the eye of the observer or point of sight is known as the "Line of Sight" or "Visual ray".

Plane of Projection:

The transparent plane on which the projections are drawn is known as "Plane of Projection".

View:

The figure or image formed on the plane by the projection of all the faces of an object is called a "view". The size of the view depends on the distance from the observer to the plane and the distance from the plane to the object.

Classification of Projections:

1. Pictorial Projections (3D)
 - a. Axonometric
 - b. Oblique
 - c. Perspective Projection
2. Orthographic Projections (2D)

Orthographic Projection:

If the projectors are parallel to each other and perpendicular to the plane of projection is called "Orthographic Projection" and divided into axonometric (3D) and multi-view (2D) projections.

Projection Methods:

Multi-view projection is further classified into 4 types.

1. 1st Angle Projection
2. 2nd Angle Projection
3. 3rd Angle Projection
4. 4th Angle Projection

Universally either the 1st angle projection or the 3rd angle projection methods is followed for obtaining engineering drawings. The principal projection planes and quadrants used to create drawings are shown in figure . The object can be considered to be in any of the four quadrant.

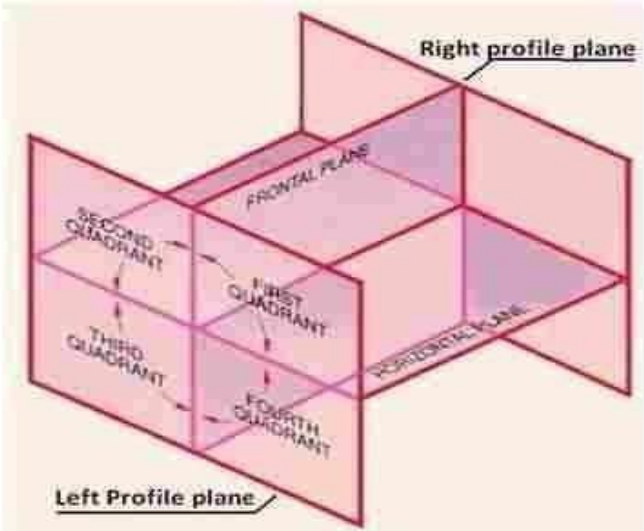
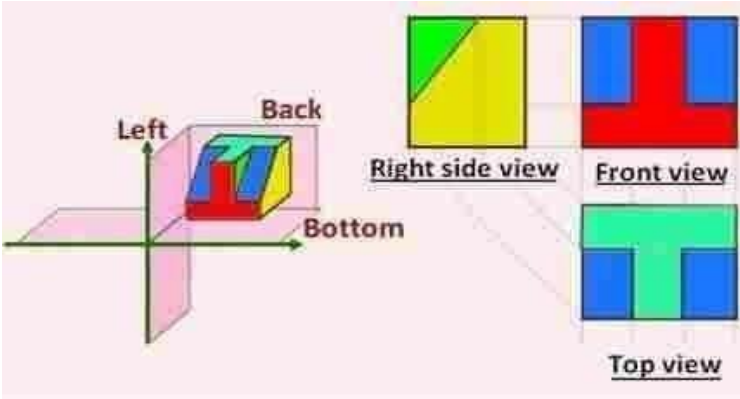


Figure 1(a). The relative positions of projection planes and the quadrants

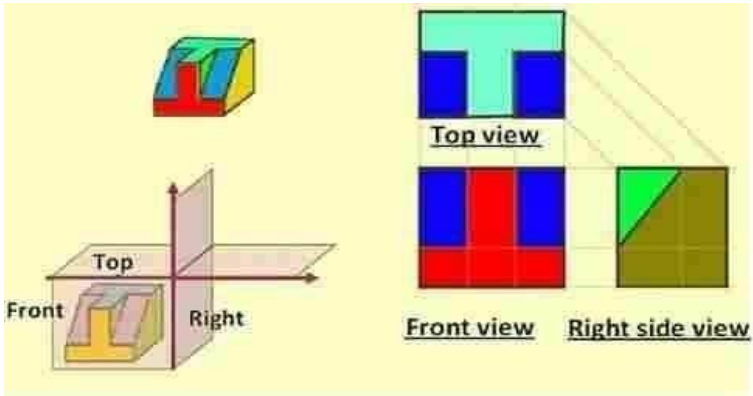
1st Angle Projection:

The object is assumed to be positioned in the first quadrant and is shown in figure. i.e., between the projection planes and the observer. The views are obtained by projecting the images on the respective planes.

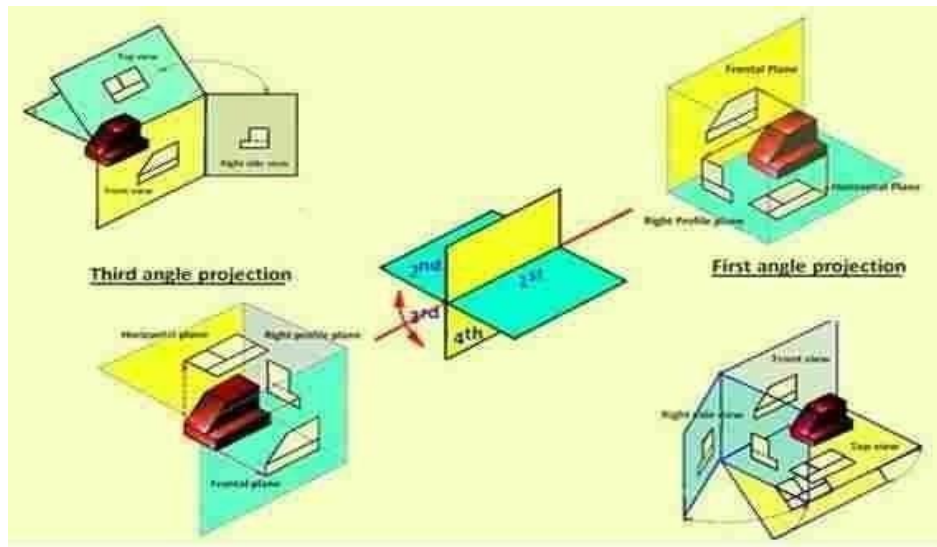


3rd Angle Projection:

The object is assumed to be in the third quadrant. i.e. the object behind vertical plane and below the horizontal plane. Placing the object in the third quadrant puts the projection planes between the viewer and the object and is shown in figure.



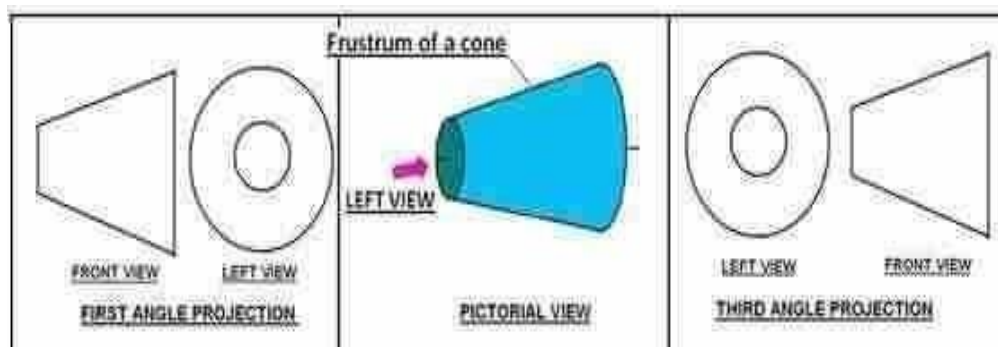
Following figure illustrates the difference between the 1st angle & 3rd angle projection.



A summary of the difference between 1st and 3rd angle projections is shown in Table.

First angle projection	Third-angle projection
Object is kept in the first quadrant.	Object is assumed to be kept in the third quadrant.
Object lies between observer and the plane of projection.	Plane of projection lies between the observer and the object.
The plane of projection is assumed to be non-transparent.	The plane of projection is assumed to be transparent.
Front (elevation) view is drawn above the XY line	Front (elevation) view is drawn below the XY line
Top (plan) view is drawn below the XY line	Top (plan) view is drawn above the XY line
Left view is projected on the right plane and vice versa	Left view is projected on the left plane itself.
Followed in India, European countries	Followed in USA

The type of projection is obtained should be indicated symbolically in the space provided for the purpose in the title box of the drawing sheet. The symbol recommended by BIS is to draw the two sides of a frustum of a cone placed with its axis horizontal. The left view is drawn.



Projections of Points:

A Point is defined as a geometrical element which has no dimensions. The position of a point in engineering drawing is defined with respect to its distance from the three principle planes. The point is assumed to be in the respective quadrant shown in figure 1(a).

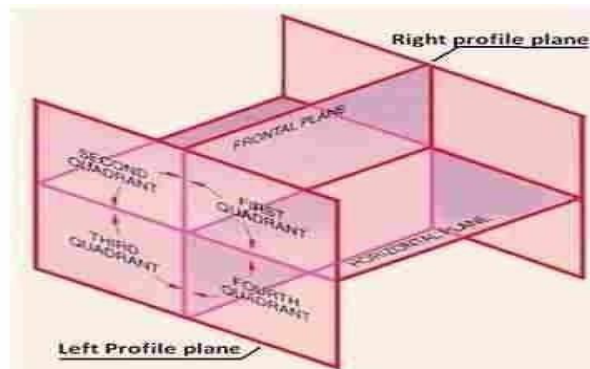


Figure 1(a). The relative positions of projection planes and the quadrants

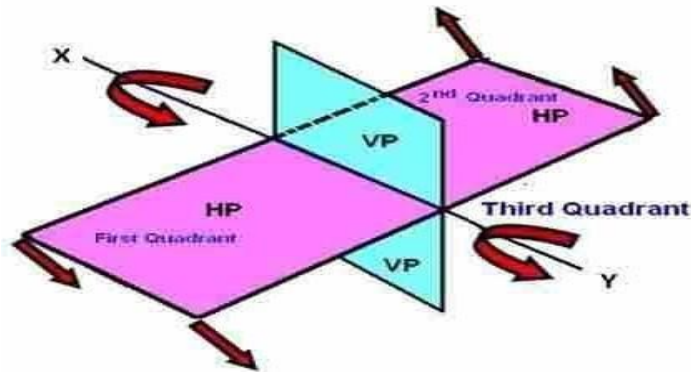


Figure 1(b). The direction of rotation of the Horizontal plane.

Orientations of a Point:

1. Point is situated above the H.P. and in front of the V.P.
2. Point is situated above the H.P. and behind the V.P.
3. Point is situated below the H.P. and behind the V.P.
4. Point is situated below the H.P. and in front of the V.P.
5. Point is situated in the H.P. and in front of the V.P.
6. Point is situated in the H.P. and behind the V.P.
7. Point is situated above H.P. and in the V.P.
8. Point is situated below the H.P. and in the V.P.
9. Point is situated on the XY line or reference line.

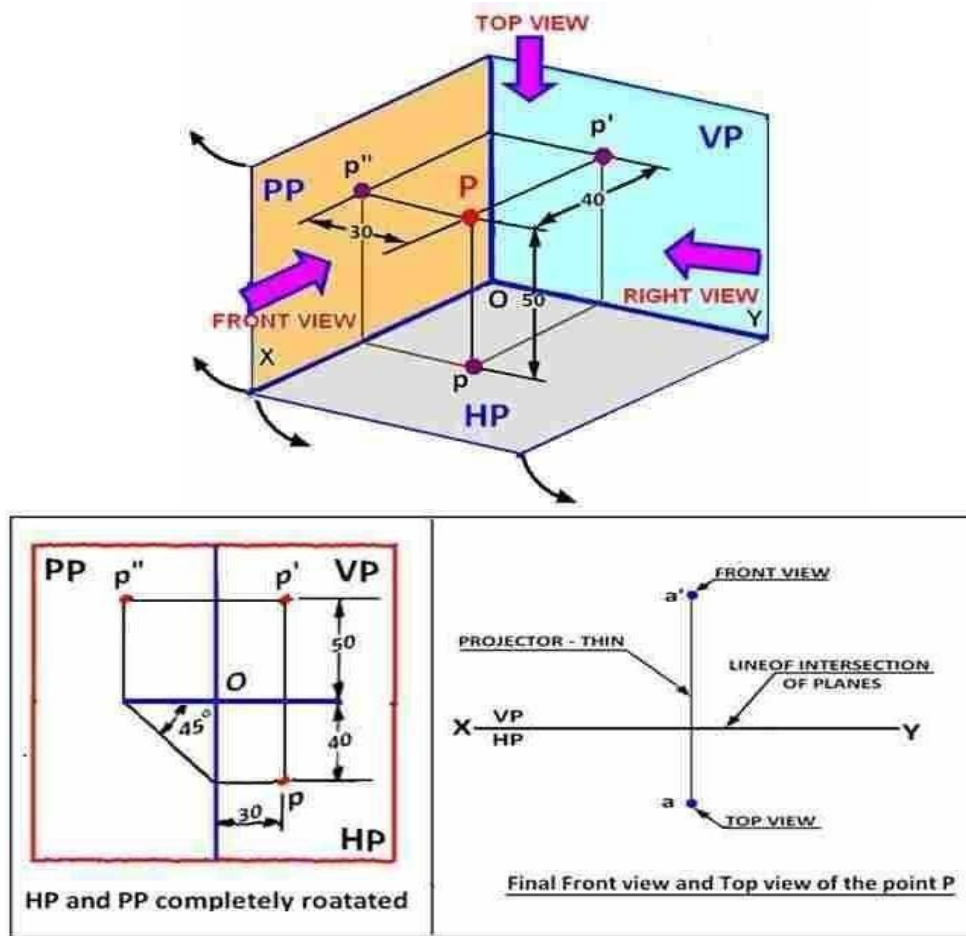
Conventions used while drawing the projections of points:

With respect to the 1st angle projection of point "P" shown in below figure,

- Top views are represented by only small letters eg. p .
- Their front views are conventionally represented by small letters with dashes eg. p'
- Profile or side views are represented by small letters with double dashes eg. p''
- Projectors are shown as thin lines.
- The line of intersection of HP and VP is denoted as X-Y.
- The line of intersection of VP and PP is denoted as X1-Y1

Point in the First quadrant:

Point is situated above the H.P. and in front of the V.P. Following figure shown the projections of a point P which is 40 mm in front of VP, 50 mm above HP, 30 mm in front of left profile plane (PP).



Above figure 2 is showing the three planes and the projection of the point P after the planes have been rotated on to the vertical plane. Figure 3 shows the planes and the position of the points when the planes are partially rotated. The arrows indicate the direction of rotation of the planes. The three views after complete rotation of the planes is shown in figure 2.

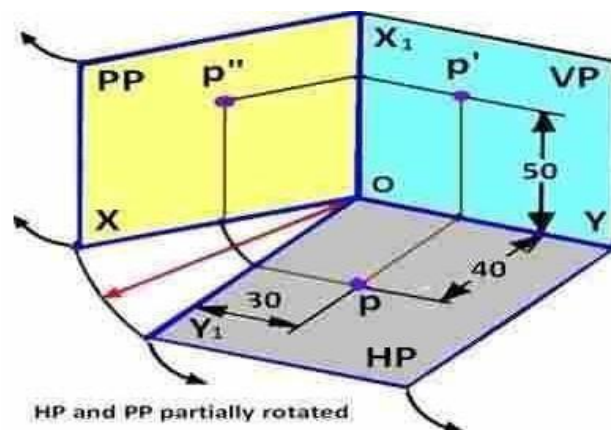


Figure 3. Projection of the point “P” on to the three projection planes after the planes are partially rotated.

The procedure of drawing the three views of the point “P” is shown in figure-4.

- Draw a thin horizontal line, XY, to represent the line of intersection of HP and VP.
- Draw X_1Y_1 line to represent the line of intersection of VP and PP.
- Draw the Top View (p).
- Draw the projector line
- Draw the Front View (p').
- To project the right view on the left PP, draw a horizontal projector through p to intersect the 45 degree line at m. Through m draw a vertical projector to intersect the horizontal projector drawn through p' at p'' .
- p'' is the right view of point P

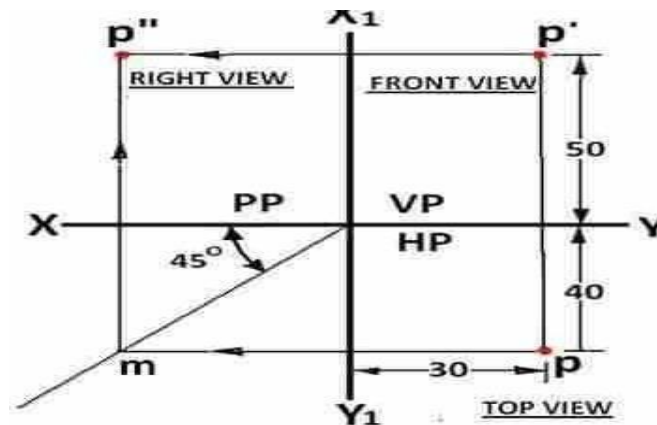


Fig 4 First angle multi-view drawing of the point “P”

Questions:

- 1) Draw the positions of the following points.
 - a. A is 35 below H.P., 15 in front of V.P.
 - b. B is 30 below H.P., 66 behind V.P.
 - c. C is 20 above H.P., 30 in front of V.P.
- 2) Point P is 50 mm from both the reference planes. Draw its projection in all possible positions.
- 3) A point R is 25 mm above H.P. and its top view is 30 below XY line. Draw its projections. State in which quadrant the point is situated.
- 4) A point L is lying in the first quadrant. The shortest distance of the point from XY line is 55 mm. If the point is 30 above H.P. Draw its projections and also find the distance to the point from V.P.

Projections of Lines:

A line is defined as a geometrical element which has only one dimension called length. Straight line is the Locus of a point, which moves linearly. Straight line is also the shortest distance between any two given points.

The location of a line in projection quadrants is described by specifying the distances of its end points from the VP, HP and PP.

Orientations of a Straight line:

1. Parallel to both the planes.
2. Parallel to one plane and perpendicular to the other.
3. Parallel to one plane and inclined to the other.
4. Inclined to both the planes.

Projection of a line:

The projection of a line can be obtained by projecting its end points on planes of projections and then connecting the points of projections. The projected length and inclination of a line,

can be different compared to its true length and inclination.

Case 1. Line parallel to a plane

When a line is parallel to a plane, the projection of the line on to that plane will be its true length. The projection of line **AB** lying parallel to the V.P. is shown in figure 5 as **a'b'**.

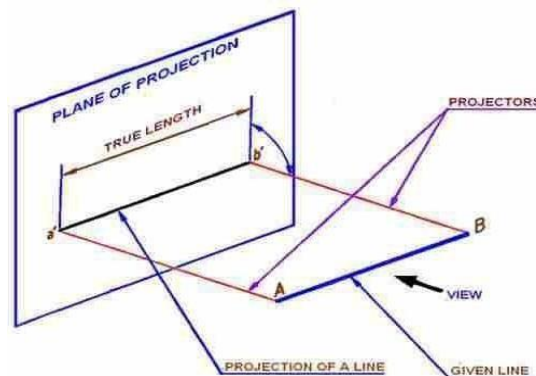


Figure 5. Projection of line on VP. Line AB is parallel to VP.

Case 2. Line inclined to a plane

When a line is parallel to one plane and inclined to the other, The projection of the line on the plane to which it is parallel will show its true length. The projected length on the plane to which it is inclined will always be shorter than the true length. In figure 6, the line AB is parallel to VP and is inclined to HP. The angle of inclination of AB with HP is being θ degrees. Projection of line AB on VP is **a'b'** and is the true length of AB. The projection of line AB on HP is indicated as line **ab**. Length **ab** is shorter than the true length AB of the line.

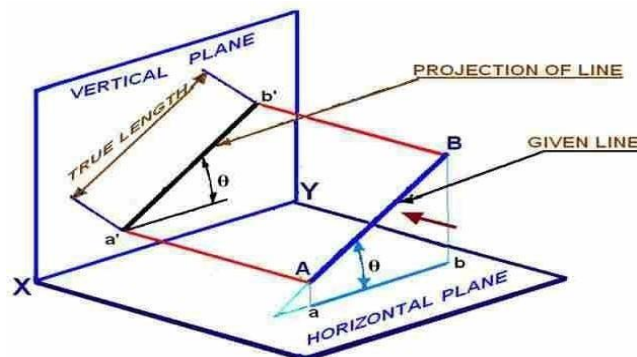


Figure 6. Projection of line AB parallel to VP and inclined to HP.

Case 3. Projection of a line parallel to both HP and VP

A line AB having length 80 mm is parallel to both HP and VP. The line is 70 mm above HP, 60 mm in front of VP. End B is 30 mm in front of right PP. To draw the projection of line AB, assume the line in the first quadrant. The projection points of AB on the vertical plane VP, horizontal plane HP and Right Profile plane PP is shown in figure 7(a). Since the line is parallel to both HP and VP, both the front view **a'b'** and the top view **ab** are in true lengths. Since the line is perpendicular to the right PP, the left side view of the line will be a point **a''(b'')**. After projection on to the projection planes, the planes are rotated such that all the three projection planes lie in the same planes. The multi-view drawing of line AB is shown in Figure7(b).

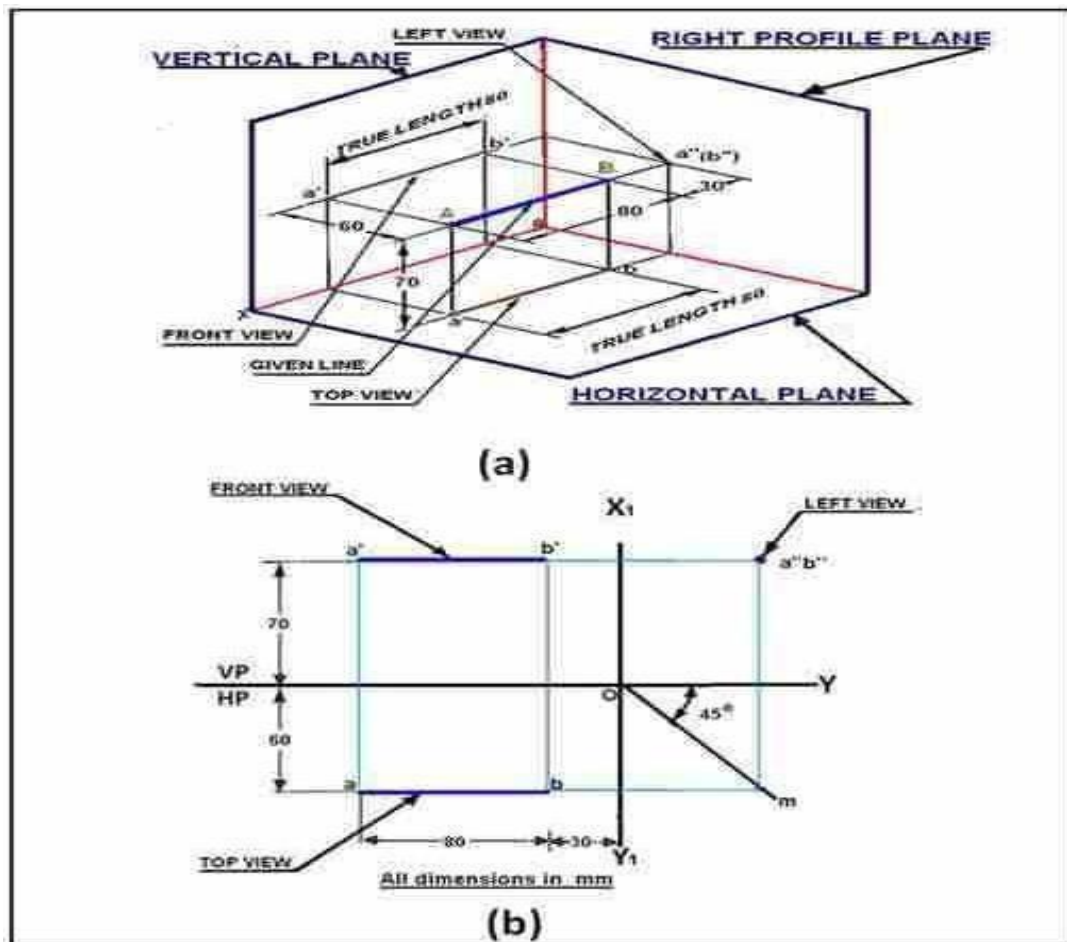


Figure 7. Projection of line parallel to both HP and VP.

Case 4. Line perpendicular to HP & parallel to VP

A line AB of length 80 mm is parallel to VP and perpendicular to HP. The line is 80 mm in front of VP and 80 mm in front of right PP. The lower end of the line is 30 mm above HP. The projections of line AB shown in figure 4 can be obtained by the following method.

Draw a line XY which is the intersection between VP and HP. Draw the front view $a'b' = 80$ mm perpendicular to the XY line, with the lower end b' lying 30 mm above the XY line. Project the top view of the line which will be a point $a(b)$ at a distance of 60 mm below XY line. Since the line is 70 mm in front of the right PP draw the X_1Y_1 line at a distance of 70 mm on the right-side of the front view.

Through O the point of intersection of XY and X_1Y_1 , lines draw a 45° line. Draw the horizontal projector through $a(b)$ to cut the 45 degree line at m. Draw the horizontal projectors through a' and b' to intersect the vertical projector drawn through m at a'' and b'' . $a''b''$ is the left view of the line AB.

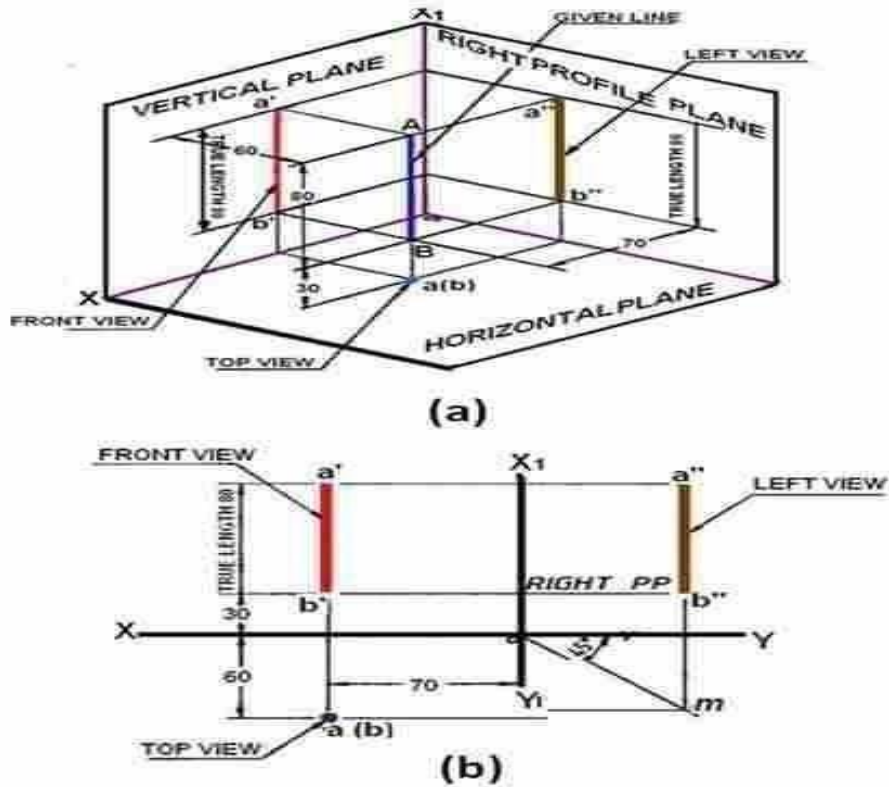
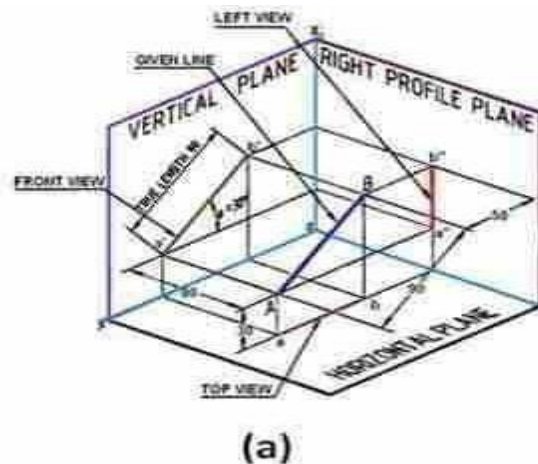


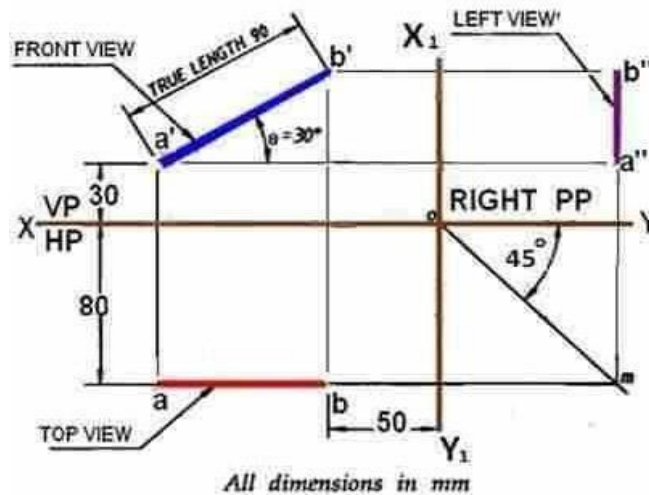
Figure 8. Projections of a line AB perpendicular to HP and parallel to VP.

Line parallel to one plane and inclined to the other

Case 5. Line parallel to VP and inclined to HP

A line AB, 90 mm long is inclined at 30° to HP and parallel to VP. The line is 80 mm in front of VP. The lower end A is 30 mm above HP. The upper end B is 50 mm in front of the right PP. The projections of line AB shown in figure 9 can be obtained in the following manner. Mark a' , the front view of the end A, 30 mm above HP. Draw the front view $a'b' = 90$ mm inclined at 30° to XY line. Project the top view ab parallel to XY line. The top view is 80 mm in front of VP. Draw the X_1Y_1 line at a distance of 50 mm from b' . Draw a 45° line through O. Draw the horizontal projector through the top view ab to cut the 45° line at m . Draw a vertical projector through m . Draw the horizontal projectors through a' and b' to intersect the vertical projector drawn through m at a'' and b'' . Connect $a''b''$ which is the left side view.





(b)

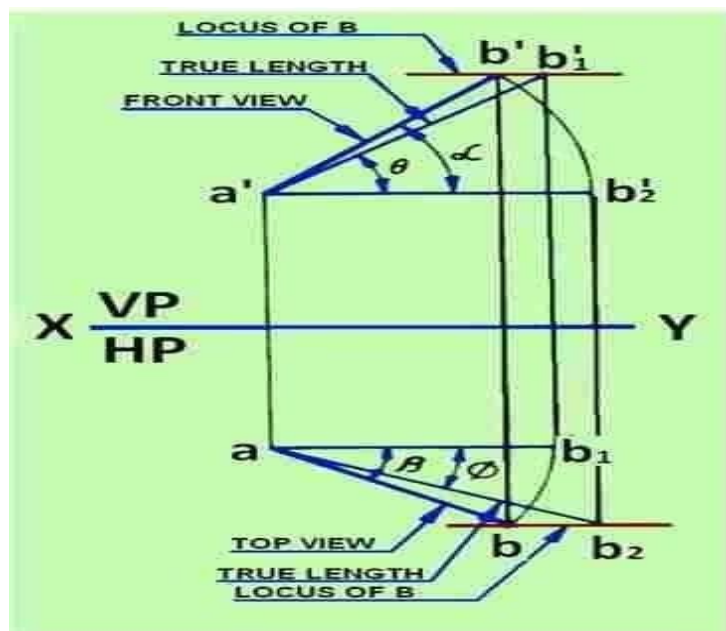
Figure 9. Projections of line AB parallel to VP and inclined to HP.

Case 6. Line inclined to HP and VP

When a line is inclined to both HP and VP, the apparent inclination of the line to both the projection planes will be different from the actual inclinations. Similarly the projected length of the lines on to the planes will not be the same as the true length of the line. The following notation will be used for the inclinations:

Actual inclinations are θ degrees to HP and ϕ degrees to VP.

Apparent Inclinations are α and β to reference line XY.



Above figure Illustrates:

$AB = \text{True Length} = a'b_1' = ab_2$

Front View = Elevation = $a'b' = a'b_2'$

Top View = Plan = $ab = ab_1$

True angles = θ degrees to HP and ϕ degrees to VP.

Apparent angles = View angles = α and β to XY line.

Traces of a line

- A trace is a point of intersection of a line with reference planes, if extended necessary.
- When a line meets HP, the point at which the line meets or intersects the horizontal plane, is called horizontal trace (HT) of the line and denoted by the letter H.
- When a line meets VP, the point at which the line meets or intersects the vertical plane, is called vertical trace (VT) of the line and denoted by the letter V.
- When the line is parallel to both HP and VP, there will be no traces on the said planes.

Trace of a line perpendicular to one plane and parallel to the other Since the line is perpendicular to one plane and parallel to the other, the trace of the line is obtained only on the plane to which it is perpendicular, and no trace of the line is obtained on the other plane to which it is parallel. Figures 2 and 3 illustrates the trace of a line parallel to VP and perpendicular to HP and parallel to HP and perpendicular to VP respectively.

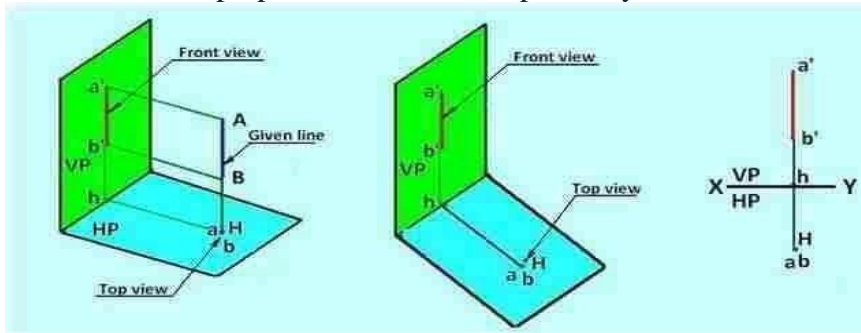


Figure 2. Trace of line parallel to VP and perpendicular to HP

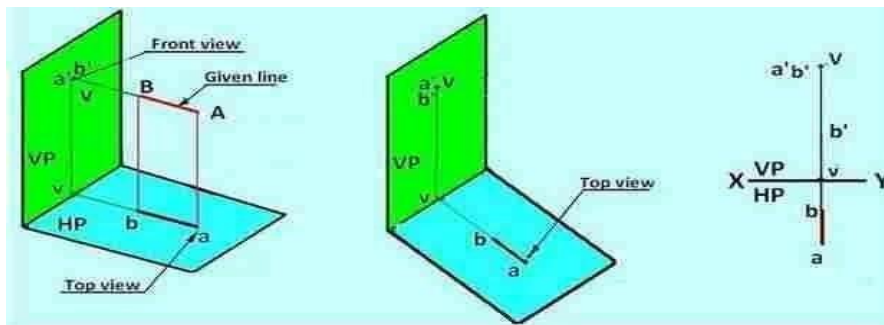


Figure 3. Trace of a line perpendicular to the VP and parallel to HP

Traces of a line inclined to one plane and parallel to the other When the line is inclined to one plane and parallel to the other, the trace of the line is obtained only on the plane to which it is inclined, and no trace is obtained on the plane to which it is parallel. Figure 4 shows the horizontal trace of line AB which is in lined HP and parallel to VP

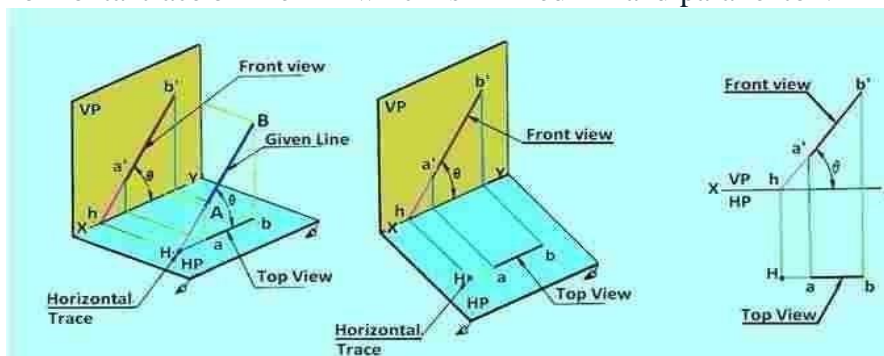


Figure 4 Horizontal trace of line AB

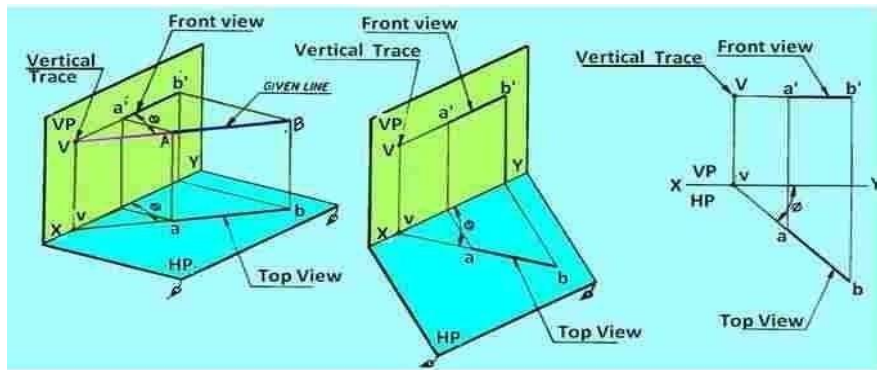


Figure 5 Vertical trace of line AB

Traces of a line inclined to both the planes

Figure 6 shows the Vertical trace (V) and Horizontal Trace (H) of Line AB inclined at q to HP and Φ to VP. The line when extended intersects HP at H, the horizontal trace, but will never intersect the portion of VP above XY line, i.e. within the portion of the VP in the 1st quadrant. Therefore VP is extended below HP such that when the line AB is produced it will intersect in the extended portion of VP at V, the vertical trace. In this case both horizontal trace (H) and Vertical Trace (V) of the line AB lie below XY line.

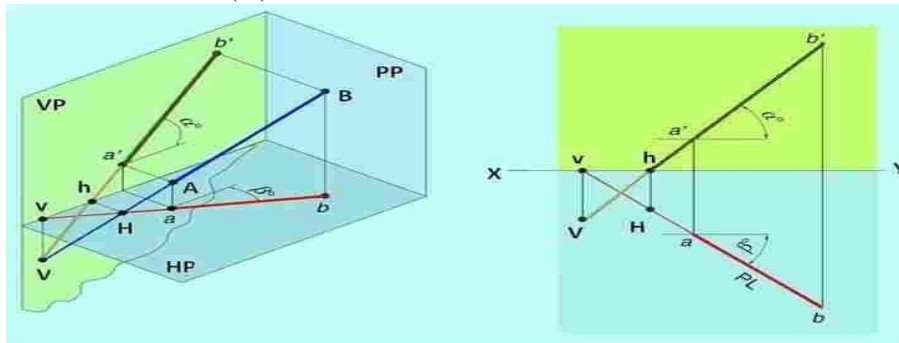


Figure 6 Vertical trace and horizontal trace of line AB which is inclined to both H.P. & V.P.

Questions:

- 1) Draw the projection of the line AB of length 75 long for the following positions when it is parallel to both the planes.
 - a. End A is 20 above H.P. and B is 30 in front of V.P.
 - b. End A is 40 above H.P. on B is on V.P.
- 2) Draw the projections of the line AB of 60 long for the following positions.
 - a. Perpendicular to H.P., parallel to V.P. and 30 in front of V.P. The end A is 10 above H.P.
 - b. Perpendicular to V.P., one of it end is 15 in front of V.P. and parallel to H.P. and 10 from it.
- 3) The top view of a 75 long line AB measures 65 mm, while the length of its front view is 50 mm. It's one end A is in the H.P and 12 mm in front of the VP. Draw the projections of AB and determine its inclinations with the H.P and the V.P.
- 4) The top view of a 75 long line AB measures 65 mm, while the length of its front view is 50 mm. It's one end A is in the H.P and 12 mm in front of the VP. Draw the projections of AB and determine its inclinations with the H.P and the V.P.
- 5) The front view of a line AB measures 65 and makes an angle of 45 with XY. A is in the H.P and the V.T of a line is 15 mm below the H.P. The line is inclined at 30 to the V.P. Draw the projections of AB and find its true length and inclination with the H.P. Also locate its H.T.

Projections of Planes:

A plane is a geometrical element which has 2 dimensions called length and breadth with negligible thickness. Planes are bounded by straight/curved lines. Regular plane surfaces are in which all the sides are equal.

Orientation of Plane surface:

A plane surface may be positioned in space with reference to the three principal planes of projection in any of the following positions:

- Parallel to one of the principal planes and perpendicular to the other two.
- Perpendicular to one of the principal planes and inclined to the other two.
- Inclined to all the three principal planes.

A: Plane surface parallel to one plane and perpendicular to the other two

Consider A triangular lamina placed in the first quadrant with its surface parallel to VP and perpendicular to both HP and left PP. $a'b'c'$ is the front view, abc the top view and $a''b''c''$ the side view. Since the plane is parallel to VP, the front view $a'b'c'$ shows the true shape of the lamina. Since the lamina is perpendicular to both HP and PP, the top view and side views are seen as lines.

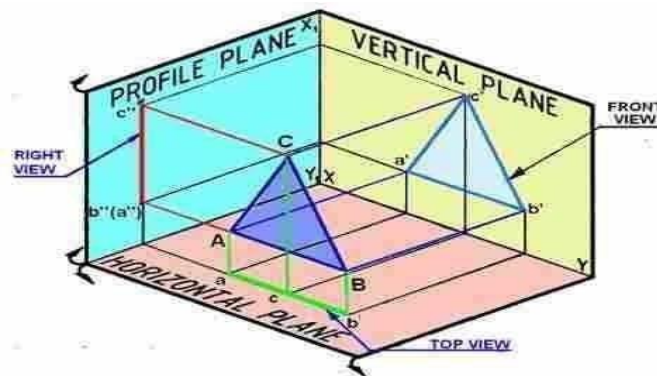


Figure 1. Projections of a triangular lamina on the projection planes

After projecting the triangular lamina on VP, HP and PP, both HP and PP are rotated about XY and X_1Y_1 lines, as shown in figure 2, till they lie in-plane with that of VP.

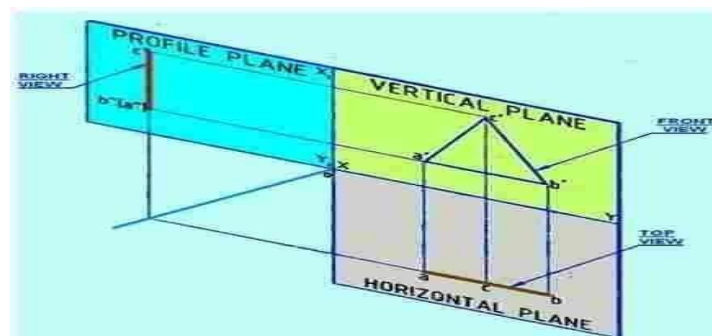


Figure 2. Rotation of PP and HP after projection.

B) Plane parallel to HP and perpendicular to both VP and PP

A square lamina is placed in the first quadrant with its surface parallel to HP and perpendicular to both VP and left PP. Figure 4 (a) shows the views of the object when projected on to the three planes. Top view is shown as $abcd$, the front view

as $a'(d')b'(c')$ and the side view as $b''(a'')c''(d'')$. Since the plane is parallel to the HP, its top view $abcd$ will be in its true shape. Since the plane is perpendicular to VP and PP, its front and side views will be lines $a'(d')b'(c')$ and $b''(a'')c''(d'')$ respectively. After projecting the square lamina on VP, HP and PP, both HP and PP are rotated about XY and X_1Y_1 lines, as shown in figure 4(b), till they lie in-plane with that of VP.

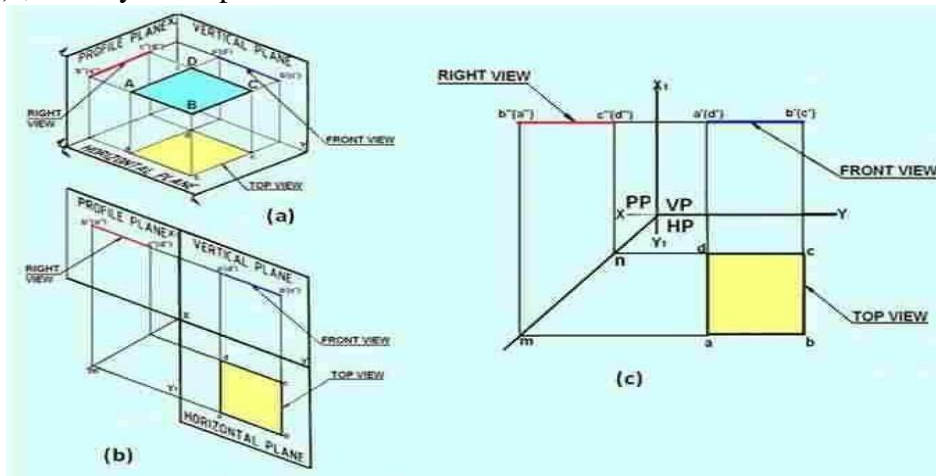


Figure 4. Lamina with its surface parallel to HP and perpendicular to both VP and PP.

C) Plane parallel to PP and perpendicular to both HP and VP

A pentagon lamina (plane surface) is placed in the first quadrant with its surface is parallel to left PP and perpendicular to both VP and HP. Figure 5 (a) shows the views of the object when projected on to the three planes. Side view is shown as $a''b''c''d''e''$, the front view as $b'(c')a'(d')e'$ and the top view as $a(b)e(c)d$. Since the plane is parallel to the PP, its side view $a''b''c''d''e''$ will be in its true shape. Since the plane is perpendicular to VP and HP, its front and side views will be projected as lines.

After projecting the pentagon lamina on VP, HP and PP, both HP and PP are rotated about XY and X_1Y_1 lines, as shown in figure 5(b), till they lie in-plane with that of VP.

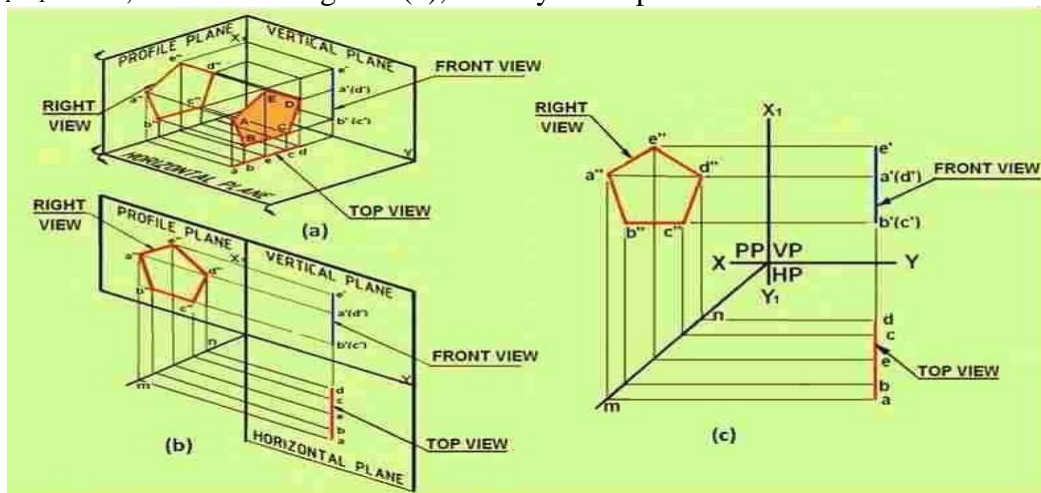


Figure 5 pentagonal lamina with its surface parallel to PP and perpendicular to HP and VP.

D) Plane surface perpendicular to one plane and inclined to the other two

Draw the projections of a triangular lamina (plane surface) placed in the first quadrant with its surface is inclined at ϕ to VP and perpendicular to the HP. Since the lamina is inclined to VP, it is also inclined to left PP at $(90 - \phi)$. The triangular lamina ABC is projected onto VP, HP and left PP. $a'b'c'$ – is the front view projected on on VP.

$a''b''c''$ – is the right view projected on left PP.

Since lamina is inclined to VP and PP, front and side views are not in true shape.

Since lamina is perpendicular to HP, its top view is projected as a line acb

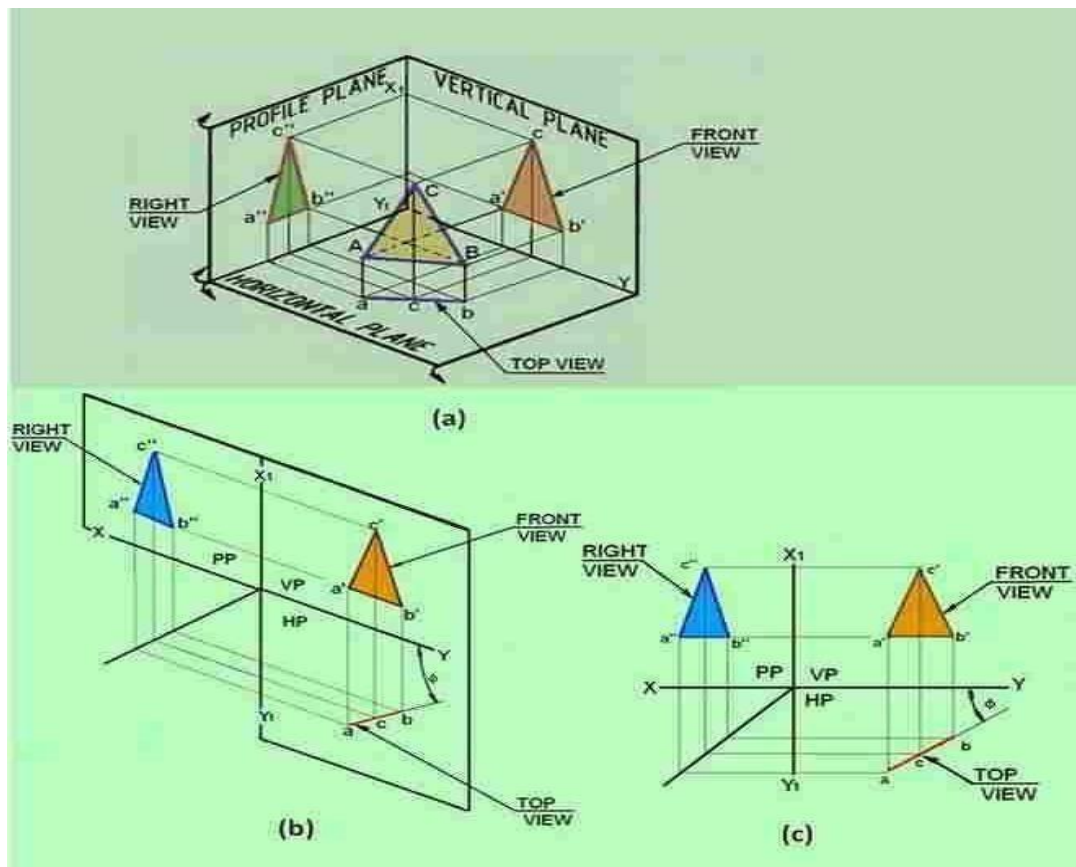


Figure 6. The projections of the triangular lamina

Questions:

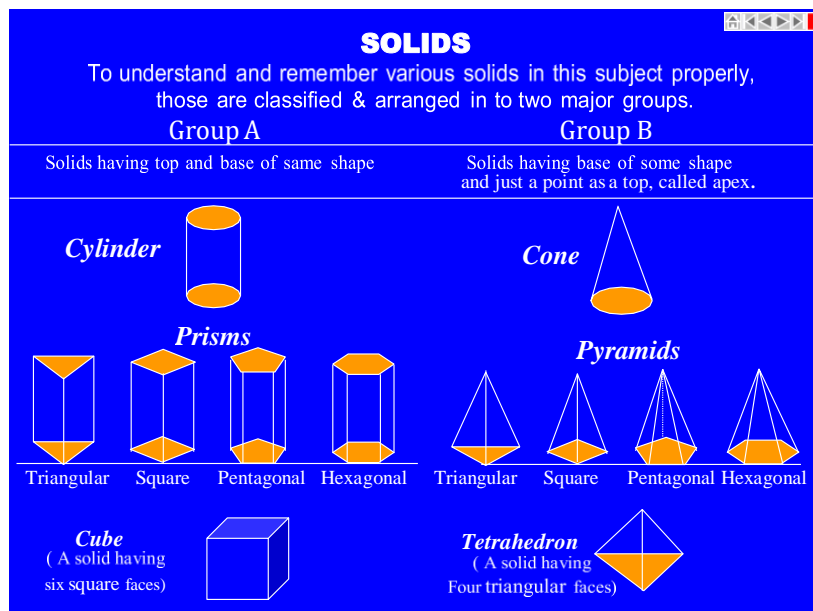
- 1) A hexagonal lamina with a 30 long side has one of the side's perpendiculars to the V.P. The surface of the lamina is parallel to and 15 above the H.P. draw its projections?
- 2) A square lamina with 40 side has its surface parallel to and 30 in front of the V.P. draw the projections, if one of its side is inclined at 30° to the H.P.
- 3) A thin circular plate of 40 diameter having its plane vertical and inclined at 40° to V.P. Its center is 30 above H.P. and 35 in front of V.P. draw the projections.
- 4) A rectangular plane with 50 and 30 sides is perpendicular to both H.P and V.P. The longer edges are parallel to H.P and the nearest one is 20 above it. The shortest edge nearer to the V.P is 15 from it. Draw its projections
- 5) A thin hexagonal plane with 25 side rest on a corner in the H.P such that the surface is perpendicular to the H.P and inclined at 45° to the V.P. draw its projections when two sides of the plane are perpendicular to the H.P.

UNIT – III**Projections of Regular Solids – Auxiliary Views - Sections or Sectional views of Right Regular Solids – Prism, Cylinder, Pyramid, Cone – Auxiliary views – Sections of Sphere.****Projections of Regular Solids:****Important Points / Definitions:**

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

- Polyhedron
- Solids of revolution

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

**Prism:**

Prisms are polyhedron formed by two equal parallel regular polygons, end faces connected by side faces which are either rectangles or parallelograms.

Some definitions regarding prisms

Base and lateral faces: When the prism is placed vertically on one of its end faces, the end face on which the prism rests is called the base.

Base edge/Shorter edge: These are the sides of the end faces

Axis – it is the imaginary line connecting the end faces is called axis

Longer edge/lateral edges: These are the edges connecting the respective corners of the two end faces.

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

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

Pyramids

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

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

Inclined/slant faces – inclined triangular side faces

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

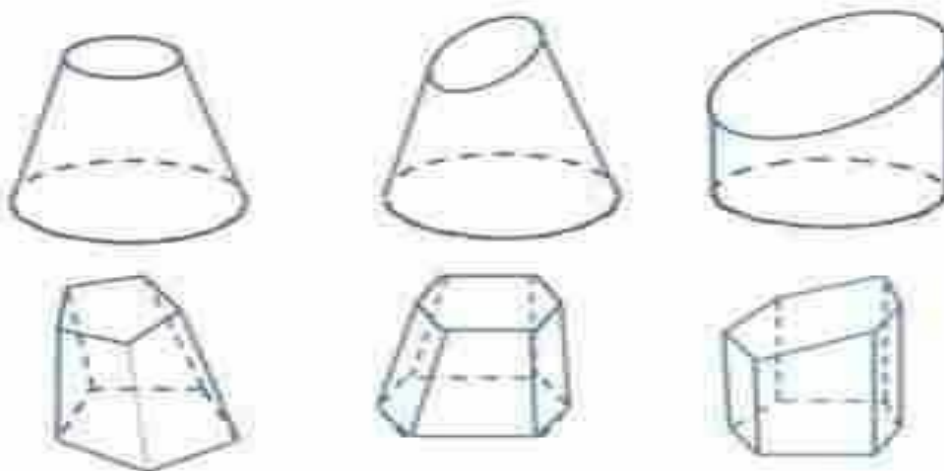
Right pyramid – when the axis of the pyramid is perpendicular to its base.

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

Solids of revolution

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

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

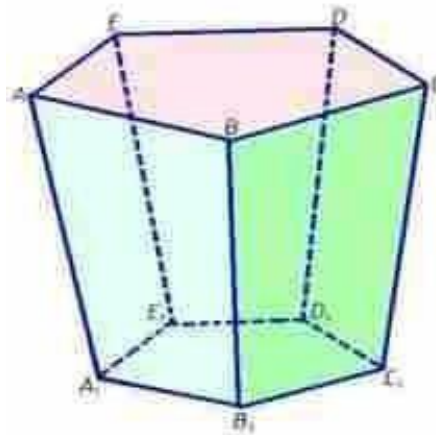


Visibility

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

Rules of visibility

When viewing an object, the outline of the object is visible. Hence the outlines of all the views are shown by full lines. All the visible edges will be shown as solid lines as shown in figure. Figure shows the frustum of a pentagonal pyramid.

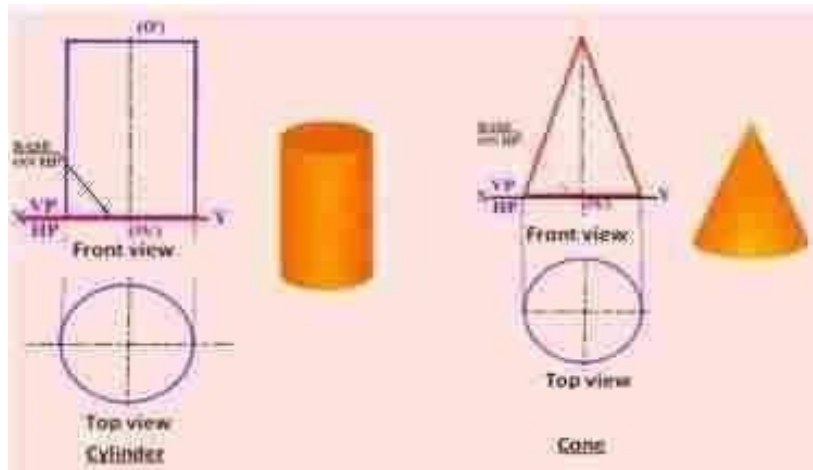
**Projections of solids placed in different positions**

The solids may be placed on HP in various positions

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

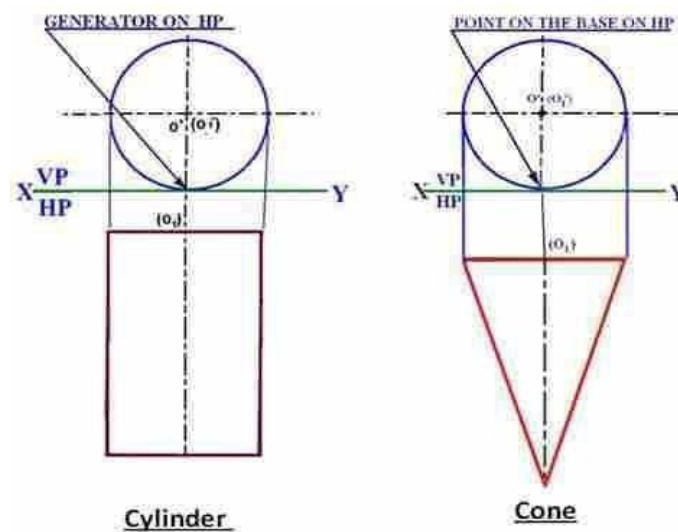
Axis of the solid perpendicular to HP

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



Projections of a solid with the axis perpendicular to VP

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



Axis of the solid inclined to HP and parallel to VP

When a solid is placed on HP with its axis inclined to HP, the elemental portion of the solid that lies on HP depends upon the type of the solid. When a prism is placed on HP with its axis inclined to it, and then it will lie either on one of its base edges or on one of its corners on HP.

When a pyramid is placed on HP with its axis inclined to HP, then we will have one of its base edges on HP or one of its base corners on HP or one of its slant edges on HP or one of its triangular faces on HP or an apex on HP.

Methods of drawing the projections of solids _

These are two methods for drawing the projections of solids:

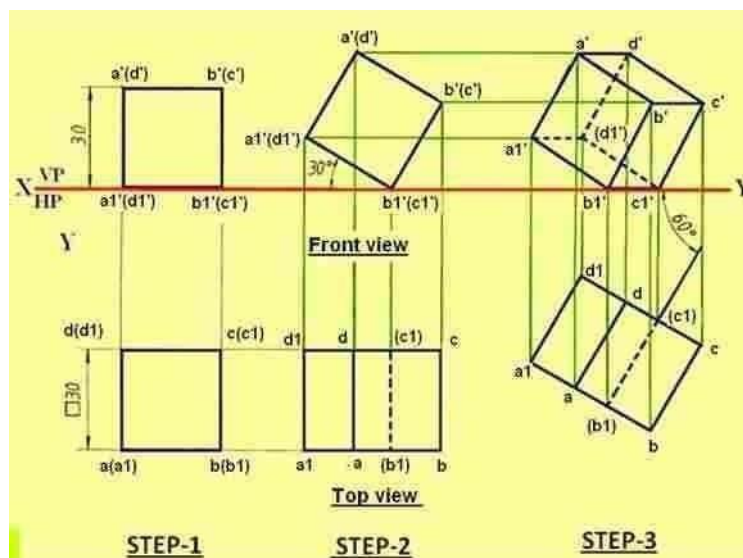
1. Change of position method.
2. Auxiliary plane method (Change of reference-line method)

Change of position method:

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

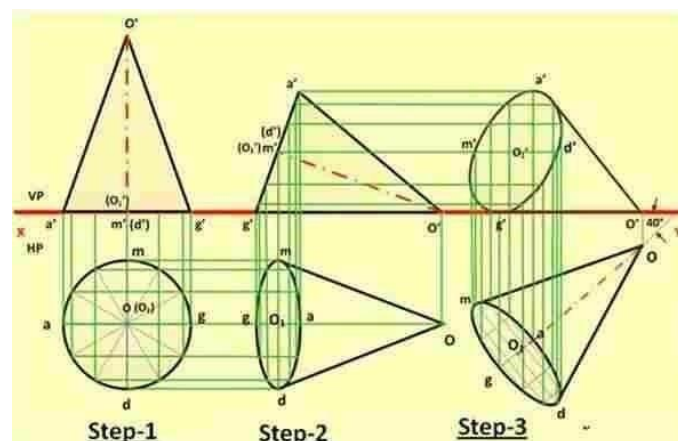
Example 1

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



Example 2:

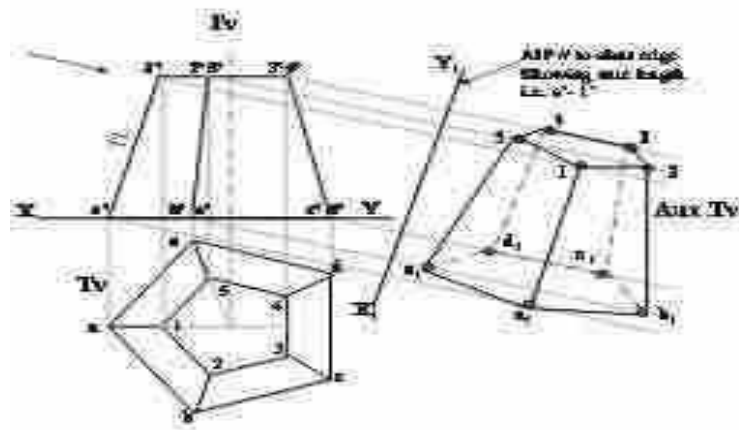
A cone of base 80 mm diameter and height 100 mm lies with one of its generators on HP and the axis appears to be inclined to VP at an angle of 40° in the top view. Draw its top and front views.



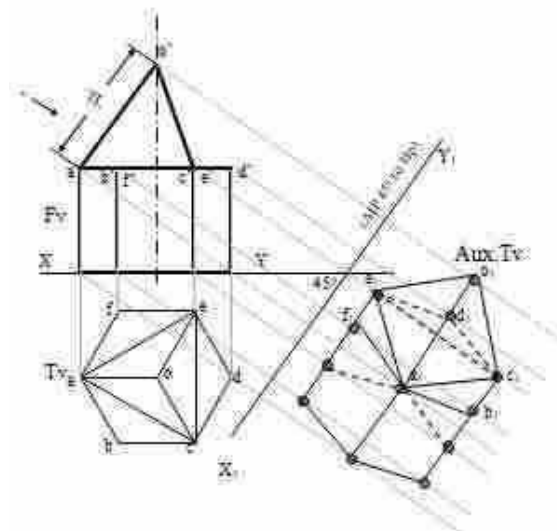
Auxiliary plane method:

In this method, the line is always placed parallel to both HP and VP, and then two auxiliary planes are set up: one auxiliary plane will be perpendicular to VP and inclined at q to HP, i.e., AIP, and the other will be perpendicular to HP and inclined at f (true inclination) or b (apparent inclination) to VP

Example: A frustum of regular hexagonal pyramid is standing on its larger base on Hp with one base side perpendicular to VP. Draw its FV & TV. Project its Auxiliary TV on an AIP parallel to one of the slant edges showing TL. Base side is 50 mm long, top side is 30 mm long and 50 mm is height of frustum.



Example : A hexagonal prism of base side 30 mm long and axis 40 mm long, is standing on Hp on its base with one base edge // to VP. A tetrahedron is placed centrally on the top of it. The base of tetrahedron is a triangle formed by joining alternate corners of top of prism. Draw projections of both solids. Project an auxiliary TV on AIP 45° inclined to HP.



Questions:

1. A hexagonal prism of base 30 and axis 60 long is resting on one of its rectangular faces on H.P. with the axis perpendicular to the V.P. A right circular cone with 50 and axis 45 is placed centrally on the top of the prism. Draw the projections of the composite solid.
2. A tetrahedron of side 40 rests with its base on H.P. Draw its projections when one of its edges is (a) perpendicular to VP (b) parallel to VP and 10 in front of VP
3. A hexagonal prism of base 30 and axis 70 long has an edge of the base on V.P. and is inclined at 30° to the H.P. The rectangular face containing that edge makes an angle of 45° with the V.P. Draw its projections.

Sectional views:

Important Points/Definitions:

In engineering industries, when the internal structure of an object is complicated, it is very difficult to visualize the object from its orthographic views since there will be several hidden lines. In such case, the internal details are shown by sectional views. Sectional views are an important aspect of design and documentation since it is used to improve clarity and reveal interior features of parts.

Sectional drawings are multi-view technical drawings that contain special views of a part or parts that reveal interior features. A primary reason for creating a section view is the elimination of hidden lines, so that a drawing can be more easily understood or visualized. Traditional section views are based on the use of an imaginary cutting plane that cuts through the object to reveal interior features. This imaginary cutting plane is controlled by the designer and is generally represented by any of the following:

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 V_p and inclined to H_p .
(This is a definition of an Aux. Inclined Plane i.e. A.I.P.)

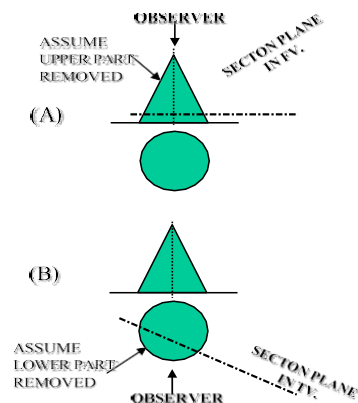
NOTE:- This section plane appears as a straight line in FV.

- B) Section Plane perpendicular to H_p and inclined to V_p .
(This is a definition of an Aux. Vertical Plane i.e. A.V.P.)

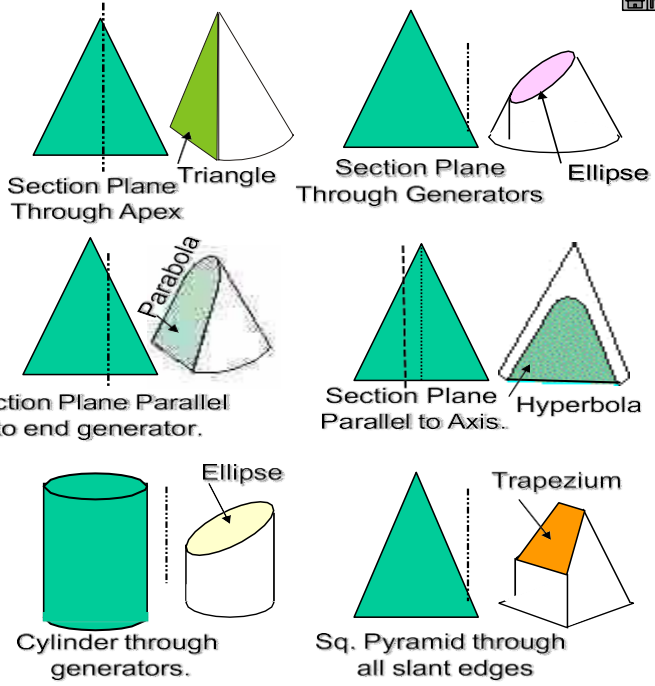
NOTE:- This section plane appears as a straight line in TV.

Remember:-

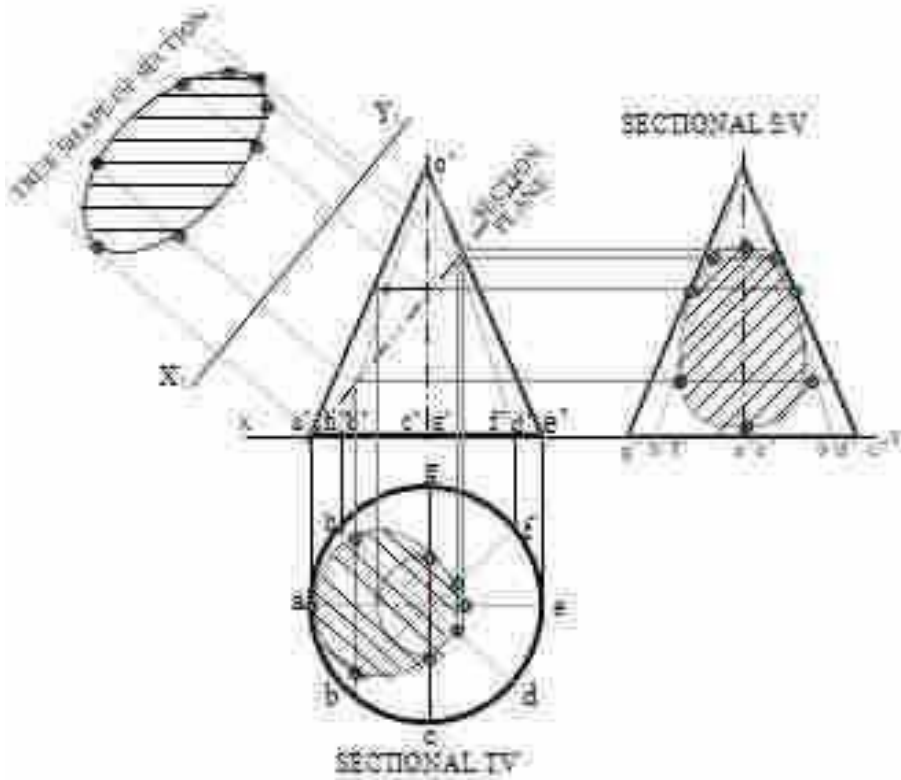
1. After launching a section plane either in FV or TV, the part towards observer is assumed to be removed.
2. As far as possible the smaller part is assumed to be removed.



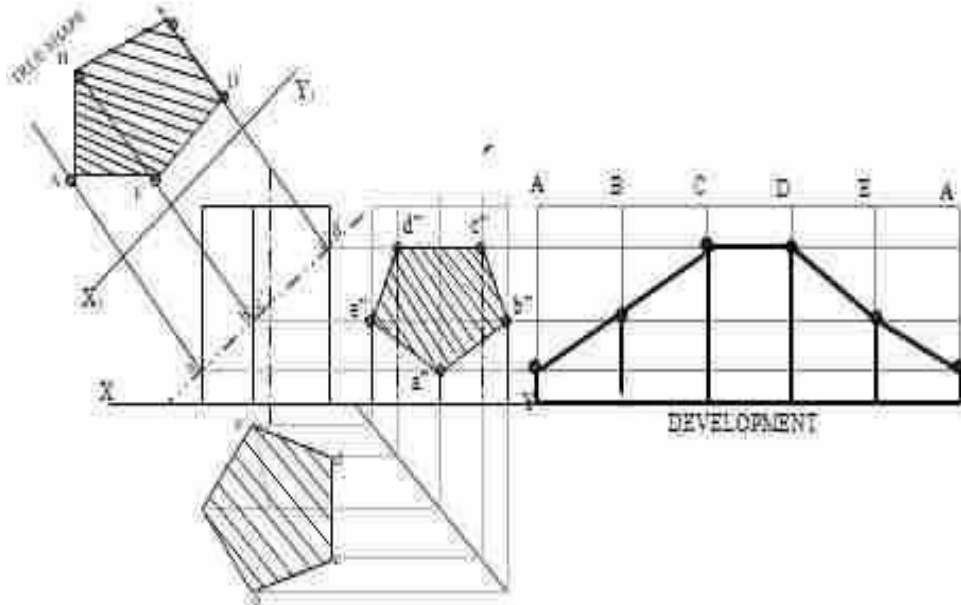
Typical Section Planes & Typical Shapes Of Sections.



Problem: A cone, 50 mm base diameter and 70 mm axis is standing on its base on HP. It is 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.



Problem: A pentagonal prism, 30 mm base side & 50 mm axis is standing on HP on its base whose one side is perpendicular to VP. It is cut by a section plane 45° inclined to Hp, through midpoint of axis. Draw FV, sectional TV & sectional side view. Also draw true shape of section and Development of surface of remaining solid.



Questions:

- 1) A pentagonal prism of base 30 side and 70 long axis is resting on one of its rectangular face on the ground with the axis is parallel to the V.P. It is cut by an A.V.P. which makes an angle of 45° with V.P. and passes through a point at a distance 25 on the axis form one of its ends. Draw its sectional front view and obtain true shape of the section.
- 2) A cube of side 45 it cut by a sectional plane so that the true shape is a regular hexagon. Draw the projections of the sectioned cube and show the true shape of the section. Also find the angle of the cutting plane.
- 3) A pentagonal pyramid of base 30 and 60 long axis is laying on one of its face is on H.P. It is cut by a cutting plane perpendicular to V.P. and inclined at 60° to H.P. The cutting plane is passing through the opposite corner of the base. Draw the sectional top view and true shape of section.

UNIT – IV**Development of Surfaces of Right Regular Solids – Prism, Cylinder, Pyramid and Cone, Intersection of Solids: Intersection of – Prism vs Prism- Cylinder Vs Cylinder.****Development of Surfaces:****Important Points / Definitions:**

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

Meaning:-

Assume object hollow and made-up of thin sheet. Cut open it from one side and Unfold the sheet completely. Then the shape of that unfolded sheet is called **Development of lateral surfaces** of that object or solid. **Lateral surface** is the surface excluding solid's top & base.

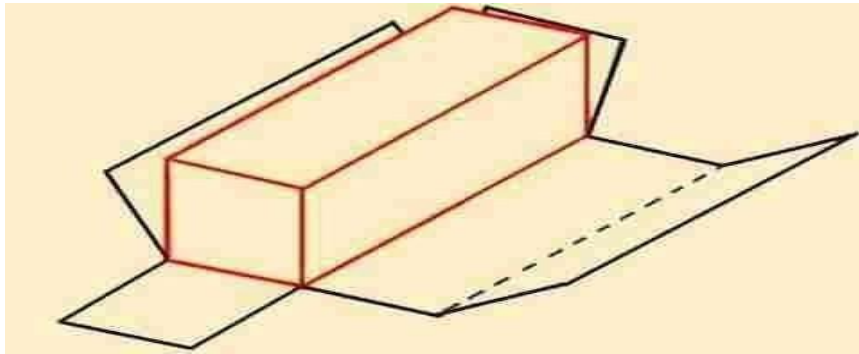


Figure 1. Typical development of the surface of a cuboid.

What is our objective in this topic ?

To learn methods of development of surfaces of Different solids, their sections and frustums.

Engineering application:

There are so many products or objects which are difficult to manufacture by Conventional manufacturing processes, because of their shapes and sizes. Those are fabricated in sheet metal industry by using Development technique. There is a vast range of such objects.

Examples:-

Boiler shells & chimneys, pressure vessels, shovels, trays, boxes & cartons, feeding hoppers, Large pipe sections, body & parts of automotives, ships, aero planes and many more.

Types of development:

There are 4 major types of developments followed by industries and shown in figure 2.

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

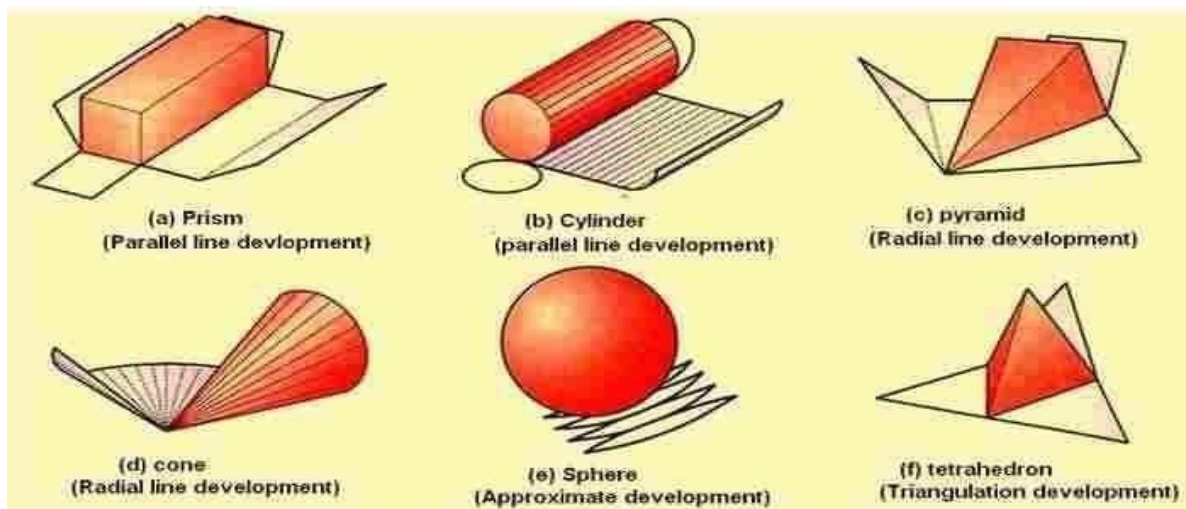
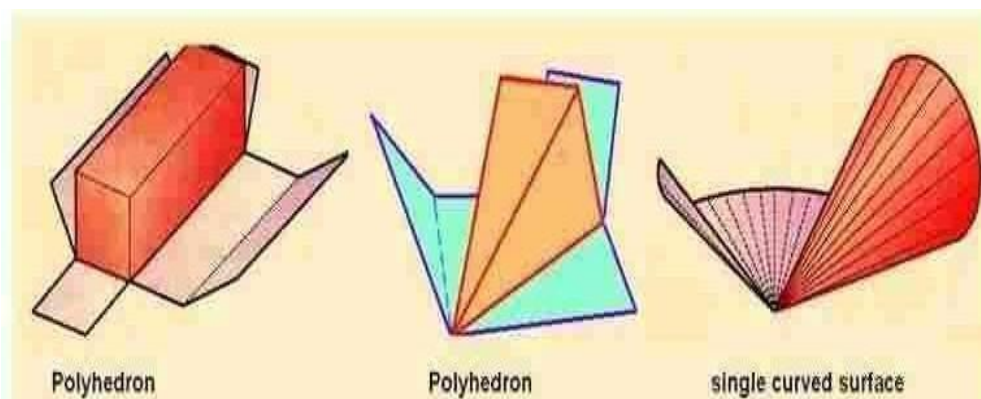


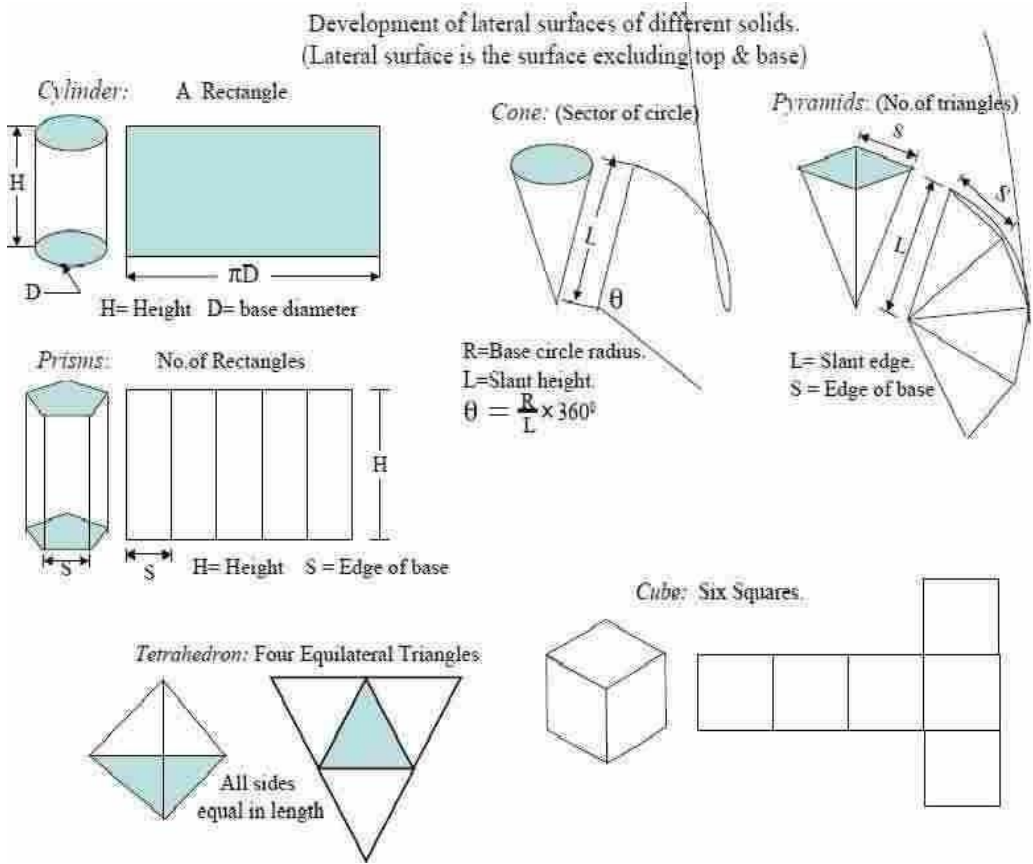
Figure 2. Typical examples of the various types of development.

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



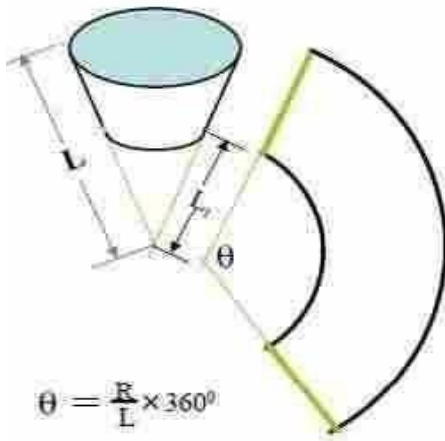
Important points.

- 1. Development is different drawing than projections.
- 2. It is a shape showing area, means it's a 2-d plain drawing.
- 3. Hence all dimensions of it must be true dimensions.
- 4. As it is representing shape of an un-folded sheet, no edges can remain hidden and hence dotted lines are never shown on development.



FRUSTUMS

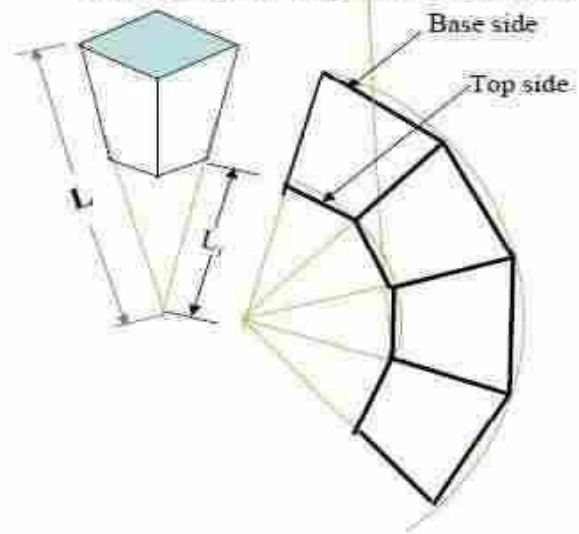
DEVELOPMENT OF FRUSTUM OF CONE



$$\theta = \frac{R_1}{L} \times 360^\circ$$

R = Base circle radius of cone
 L = Slant height of cone
 L₁ = Slant height of cut part.

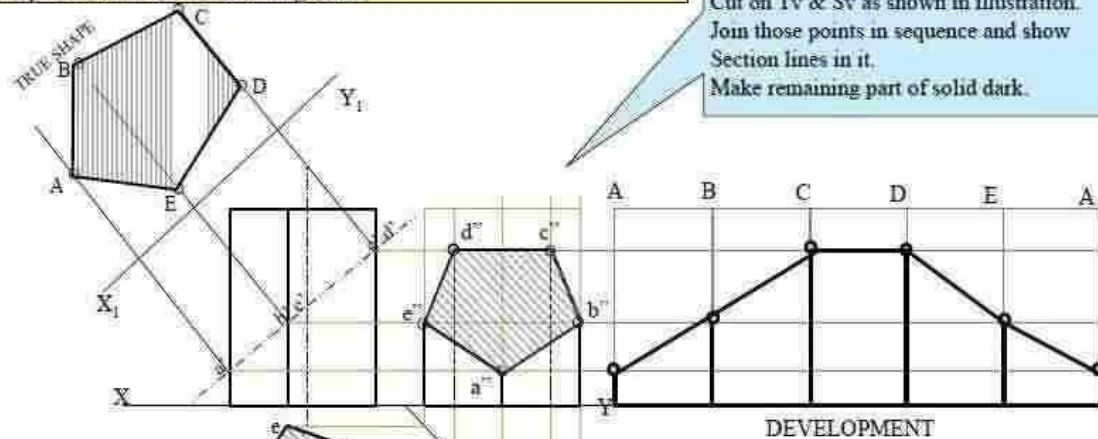
DEVELOPMENT OF FRUSTUM OF SQUARE PYRAMID



L = Slant edge of pyramid
 L₁ = Slant edge of cut part.

Problem : A pentagonal prism, 30 mm base side & 50 mm axis is standing on Hp on its 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.

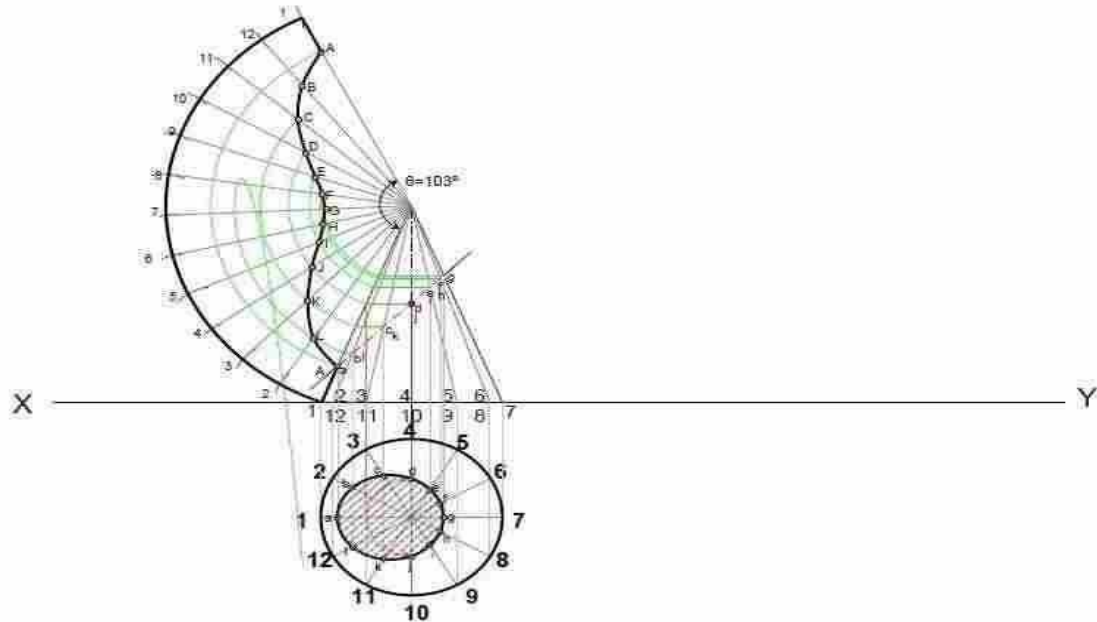
Solution Steps: for sectional views:
 Draw three views of standing prism.
 Locate sec. plane in Fv as described.
 Project points where edges are getting cut on Tv & Sv as shown in illustration.
 Join those points in sequence and show Section lines in it.
 Make remaining part of solid dark.



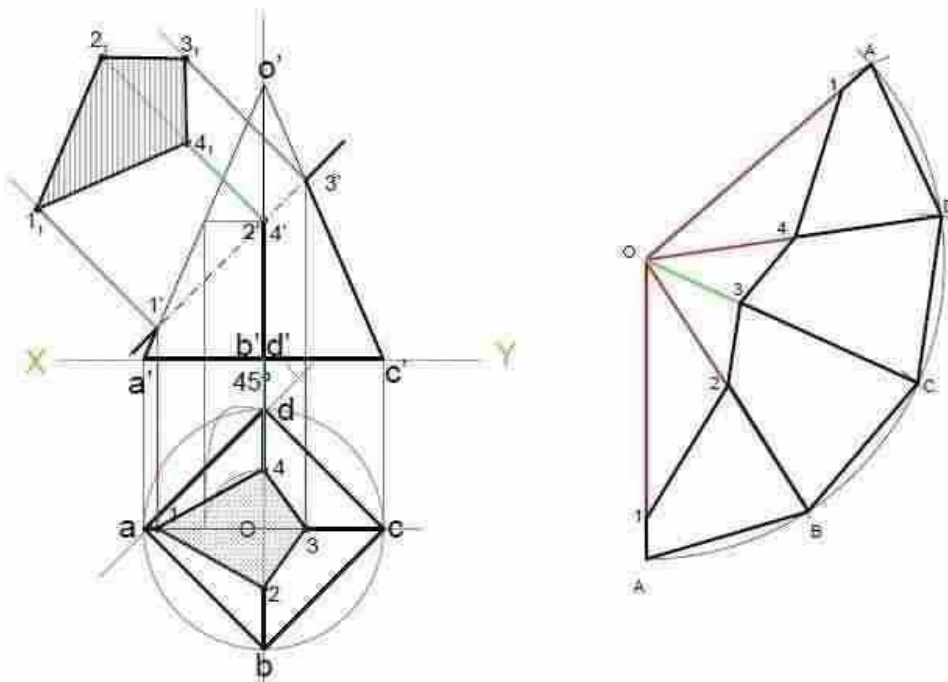
For True Shape:
 Draw x,y, // to sec. plane
 Draw projectors on it from cut points.
 Mark distances of points of Sectioned part from Tv, on above projectors from x,y, and join in sequence.
 Draw section lines in it.
 It is required true shape.

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.

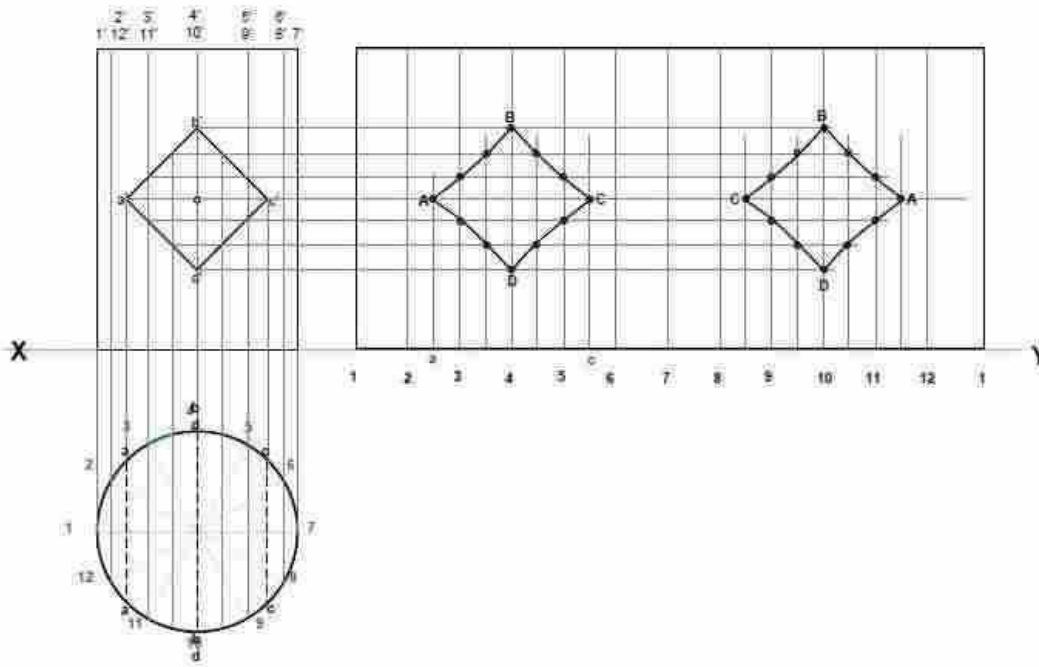
Q : A right circular cone base 30 mm side and height 50 mm rests on its base on H.P. It is cut by a section plane perpendicular to the V.P., inclined at 45° to the H.P. and bisecting the axis. Draw the projections of the truncated cone and develop its lateral surface.



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



Q : A right circular cylinder, base 50 mm diameter and axis 60 mm long, is standing on HP on its base. It has a square hole of size 25 in it. The axis of the hole bisects the axis of the cylinder and is perpendicular to the VP. The faces of the square hole are equally inclined with the HP. Draw its projections and develop lateral surface of the cylinder.



Questions:

1. A hexagonal prism, having a base 30 and 70 long axis is resting on its base on the ground with a side of base inclined at 45° to the V.P. It is cut by an AIP making an angle of 45° with the H.P and passing through a point 15 below the top end of the axis. Obtain the development of the lateral surface of the truncated prism.
2. A hexagonal prism base edge 30 and 70 height is resting on its base on the H.P with one base edge perpendicular to V.P. A circular hole diameter 40 is drilled through this prism in such a way that the axis of the hole bisects the axis of the prism and perpendicular to V.P. Develop the lateral surface of the prism.
3. A square hole with 25 side is cut in a cylindrical drum with 60 diameter and 70 height. The faces of the hole are inclined at 45° to H.P. and axis intersects with that of the drum at right angles. Draw the development of its lateral surface.
4. A hexagonal pyramid of base edge 30 and height 60 is resting on its base with one base edge perpendicular to V.P. It is cut by two AIP's one at 30° with H.P. meeting the axis 10 below the apex and the other at 40° with H.P. containing one of the base edges. Develop the surface of the mid portion.
5. A pentagonal pyramid of base edge 30 and height 70 is resting on its base with one base edge parallel to V.P. A triangular hole is drilled through this in such a way that axis of the hole is perpendicular to V.P. and 6 mm to the right of the axis of the pyramid. Develop the lateral surface of the pyramid, if one face of the hole is parallel to and 6 mm above H.P.

Intersection of Solids / Interpenetration of Solids:

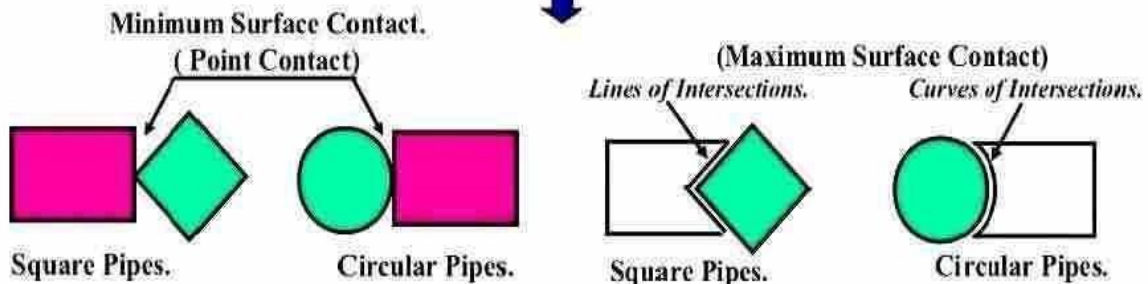
INTERPENETRATION OF SOLIDS

WHEN ONE SOLID PENETRATES ANOTHER SOLID THEN THEIR SURFACES INTERSECT AND AT THE JUNCTION OF INTERSECTION A TYPICAL CURVE IS FORMED, WHICH REMAINS COMMON TO BOTH SOLIDS.

THIS CURVE IS CALLED CURVE OF INTERSECTION AND IT IS A RESULT OF INTERPENETRATION OF SOLIDS.

PURPOSE OF DRAWING THESE CURVES:-
 WHEN TWO OBJECTS ARE TO BE JOINED TOGETHER, MAXIMUM SURFACE CONTACT BETWEEN BOTH BECOMES A BASIC REQUIREMENT FOR STRONGEST & LEAK-PROOF JOINT. Curves of Intersections being common to both Intersecting solids, show exact & maximum surface contact of both solids.

Study Following Illustrations Carefully.



FOLLOWING CASES ARE SOLVED. REFER ILLUSTRATIONS AND NOTE THE COMMON CONSTRUCTION FOR ALL

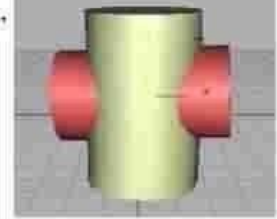
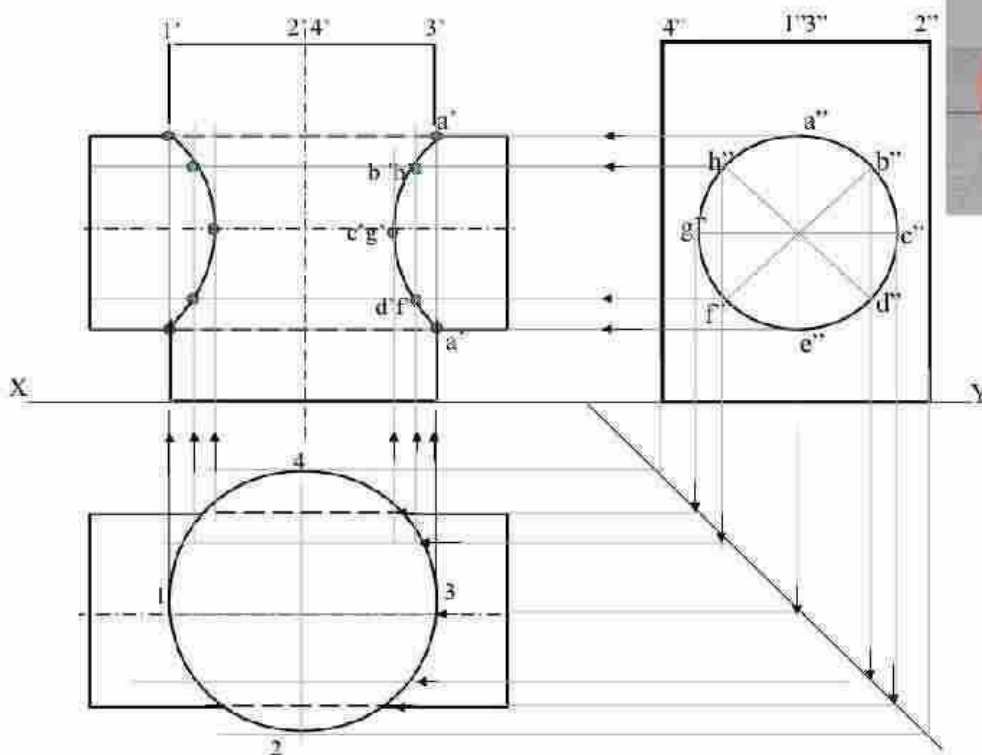
1. CYLINDER TO CYLINDER
2. SQ. PRISM TO CYLINDER
3. CONE TO CYLINDER
4. TRIANGULAR PRISM TO CYLINDER
5. SQ. PRISM TO SQ. PRISM
6. SQ. PRISM TO SQ. PRISM (SKEW POSITION)
7. SQ. PRISM TO CONE (from top)
8. CYLINDER TO CONE

COMMON SOLUTION STEPS
 One solid will be standing on HP. Other will penetrate horizontally. Draw three views of standing solid. Name views as per the illustrations. Beginning with side view draw three views of penetrating solids also. On its S.V., mark number of points and name those (either letters or nos.) The points which are on standard generators or edges of standing solid. (in S.V.) can be marked on respective generators in Fv and Tv. And other points from SV should be brought to Tv first and then projecting upward to Fv. Dark and dotted line's decision should be taken by observing side view from its right side as shown by arrow. Accordingly those should be joined by curvature or straight lines.

Note:
 In case cone is penetrating solid Side view is not necessary. Similarly in case of penetration from top it is not required.

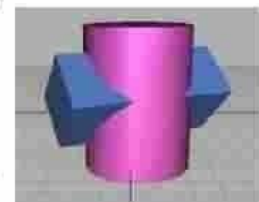
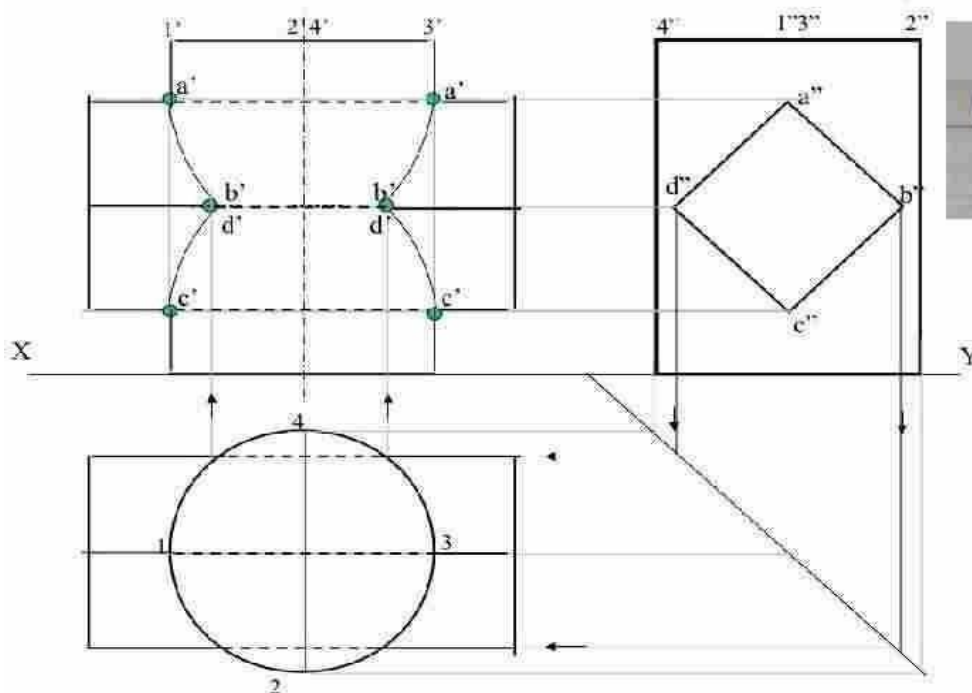
Problem: A cylinder 50mm dia.and 70mm axis is completely penetrated by another of 40 mm dia.and 70 mm axis horizontally Both axes intersect & bisect each other. Draw projections showing curves of intersections.

CASE 1.
CYLINDER STANDING
&
CYLINDER PENETRATING

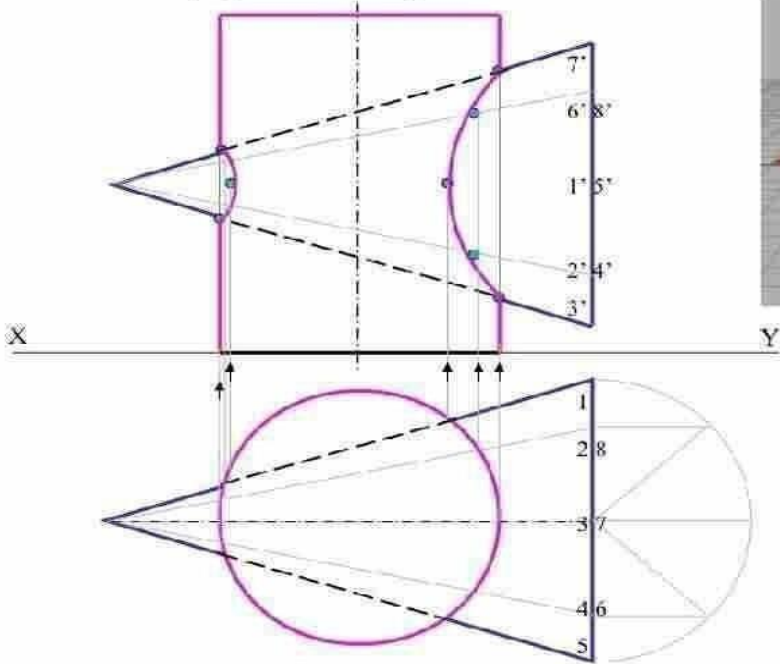


Problem: A cylinder 50mm dia.and 70mm axis is completely penetrated by a square prism of 25 mm sides.and 70 mm axis, horizontally. Both axes intersect & bisect each other. All faces of prism are equally inclined to Hp. Draw projections showing curves of intersections.

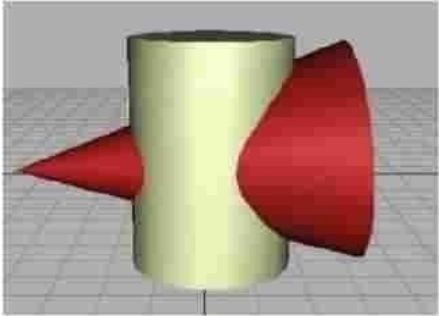
CASE 2.
CYLINDER STANDING
&
SQ.PRISM PENETRATING



Problem: A cylinder of 80 mm diameter and 100 mm axis is completely penetrated by a cone of 80 mm diameter and 120 mm long axis horizontally. Both axes intersect & bisect each other. Draw projections showing curve of intersections.

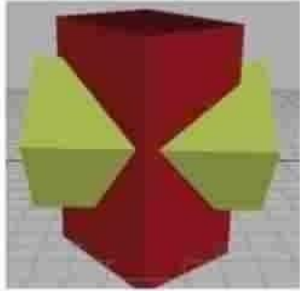
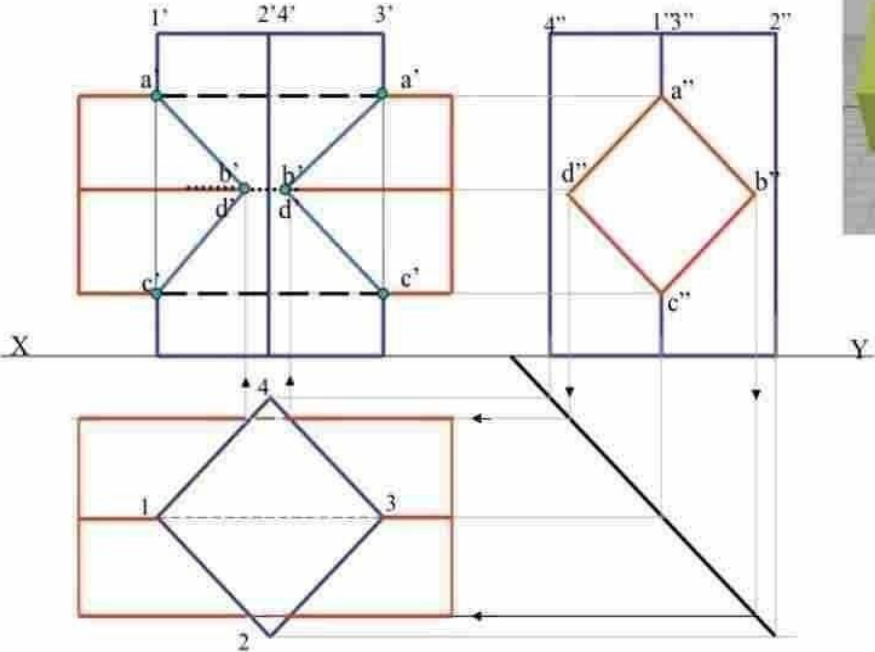


CASE 3.
CYLINDER STANDING
&
CONE PENETRATING



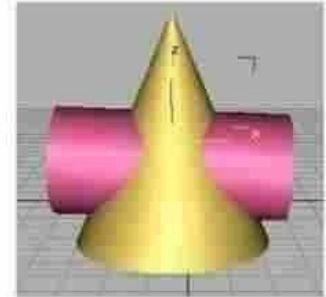
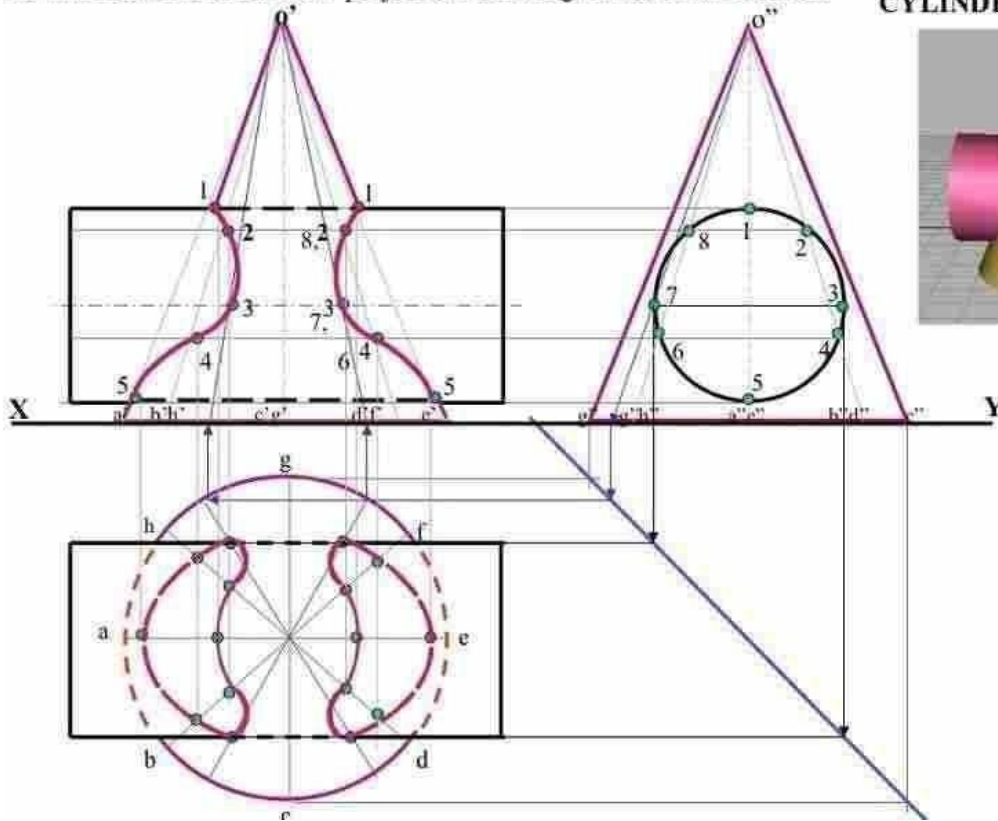
Problem: A sq.prism 30 mm base sides.and 70mm axis is completely penetrated by another square prism of 25 mm sides.and 70 mm axis, horizontally. Both axes Intersects & bisect each other. All faces of prisms are equally inclined to Vp. Draw projections showing curves of intersections.

CASE 4.
SQ.PRISM STANDING
&
SQ.PRISM PENETRATING



Problem: A vertical cone, base diameter 75 mm and axis 100 mm long, is completely penetrated by a cylinder of 45 mm diameter. The axis of the cylinder is parallel to Hp and Vp and intersects axis of the cone at a point 28 mm above the base. Draw projections showing curves of intersection.

**CASE 5.
CONE STANDING
&
CYLINDER PENETRATING**



Questions:

1. A cylinder with a 60 base diameter and height 80 long is resting on its base on H.P. It is penetrated by another cylinder of 50 base diameter and height 90 long, such that their axes intersect each other at right angles. Draw the projections of the combination and show the curves of intersection.
2. A cylinder with a 60 base diameter and height 80 long is resting on its base on H.P. It is penetrated by another cylinder of 40 base diameter and height 90 long, the axis of which is parallel to both the principal planes. The two axes are 10 apart. Draw the projections of the combination and show the curves of intersection.
3. A cylinder with 60 base diameter and 80 long axis is resting on its base on H.P. It is penetrated by another cylinder with 30 base diameter and 110 long axis. The axis of both the cylinders is parallel to V.P. and bisects each other at an angle of 45° . Draw the projections and show their curves of intersection.
4. A square prism with 50 side and 80 long axis is resting on its base on the H.P., such that the face of the prism equally inclined to V.P. It is penetrated by cylinder of 40 base diameter and 90 long axis. The axes of prism and cylinder are 5 apart. Draw the projections of the combination and show the curves of intersection.
5. A cone of base 80 meter and 100 long axis is resting on its base on the H.P. It is completely penetrated by a cylinder with a 40 base meter. The axes of the solids intersect each other at right angles, 30 above the base of the cone. Draw the projections of the combination and show COI.

Unit –V:

Isometric Projections: Principles of Isometric Projection – Isometric Scale – Isometric Views –Conventions – Isometric Views of Lines, Plane Figures, Simple and Compound Solids – Isometric Projection of objects having non- isometric lines. Isometric Projection of Spherical Parts. Conversion of Isometric Views to Orthographic Views and Vice-versa – Conventions

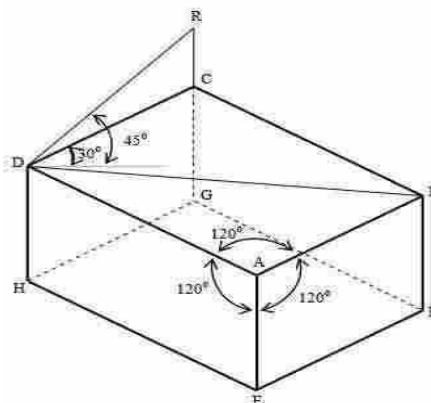
Introduction to CAD: (For Internal Evaluation Weightage only):

Introduction to CAD Software Package Commands.- Free Hand Sketches of 2D- Creation of 2D Sketches by CAD Package.

Isometric Projections:**Important Points / Definitions:**

When a solid is resting in its simple position, the front or top view, taken separately, gives an incomplete idea of the form of the object. When the solid is tilted from its simple position such that its axis is inclined to both H.P and V.P, the front view or the top view or sometimes both, give an „air idea of the pictorial form of the object, i.e., all the surfaces are visualized in a single orthographic view.

“**Iso**” means „**equal**” and “**metric projection**” means „**a projection to a reduced measure**”. An isometric projection is one type of pictorial projection in which the three dimensions of a solid are not only shown in one view, but also their dimension can be scaled from this drawing



It is seen that all the edges and faces of the rectangular prism are equally inclined to the plane of all the edges and faces of the cube are equally inclined to the plane of projection. Hence the rectangular faces are seen as similar and equal rhombuses.

The three lines AB, AD and AE are meeting at A. These edges are mutually perpendicular to each other in the solid. Since all these edges are equally inclined to H.P, they are making an angle of 120° with each other in the plane of projection; also they are equally foreshortened. This leads us to the problem of selecting an isometric scale.

Isometric Axes:

The lines AB, AD and AE meeting at a point A and making an angle of 120° with each other are termed "isometric axes".

Isometric Lines:

The lines parallel to the isometric axes are termed isometric lines. The lines CD, CB etc are examples of isometric lines.

Non-isometric Lines:

The lines which are not parallel to isometric axes are termed non-isometric lines. The BD is an example.

Isometric Planes:

The planes representing the faces of the rectangular prism as well as other planes parallel to these planes are termed isometric planes.

Isometric scale:

Isometric projection is drawn using isometric scale, which converts true lengths into isometric lengths (foreshortened).

Construction of isometric scale:

Draw a horizontal line AB, From A draw a line AC at 45° to represent actual or true length and another line AD at 30° to AB to measure isometric length., On AC mark the point 0, 1, 2 etc to represent actual lengths.

From these points draw verticals to meet AD at 0', 1', 2' etc. The length A1' represents the isometric scale length of A1 and so on

Isometric Length

$$\frac{AB}{AC} = \cos 45^\circ = \frac{1}{\sqrt{2}}$$

$$\frac{AB}{AD} = \cos 30^\circ = \frac{\sqrt{3}}{2}$$

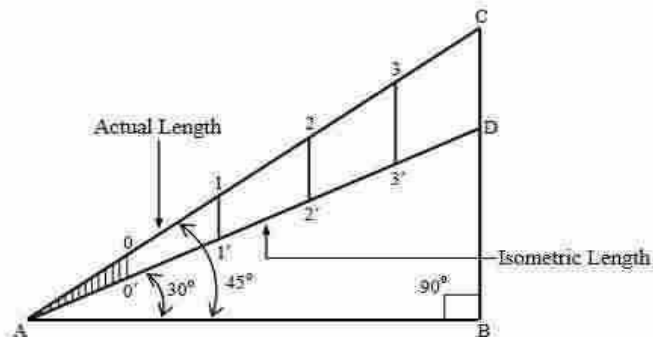
$$\therefore \frac{AB}{AC} + \frac{AB}{AD} = \frac{1}{\sqrt{2}} + \frac{\sqrt{3}}{2}$$

$$\frac{AB}{AC} \times \frac{AD}{AB} = \frac{1}{\sqrt{2}} \times \frac{2}{\sqrt{3}}$$

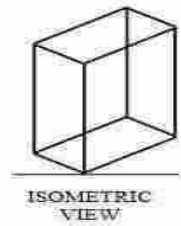
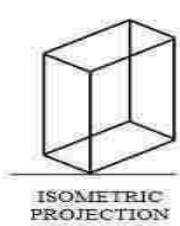
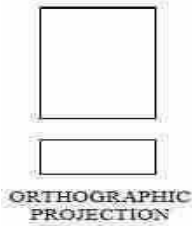
$$\frac{AD}{AC} = \frac{\sqrt{2}}{\sqrt{3}} = 0.81$$

$$\Rightarrow AD = 0.81 \times AC$$

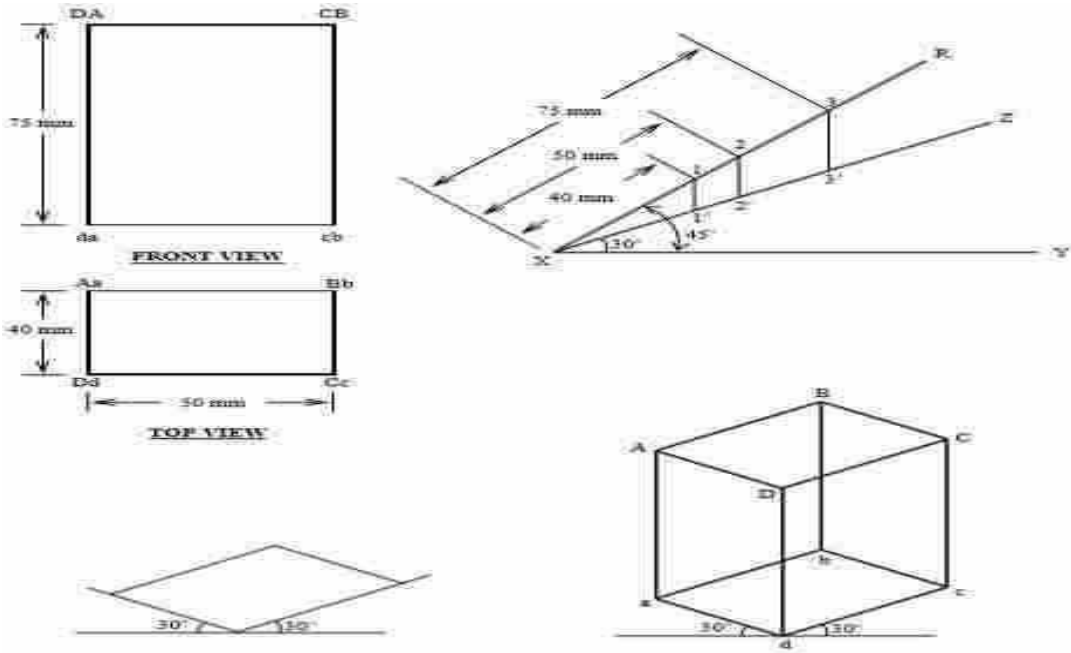
$$\therefore \text{Isometric Length} = 0.81 \times \text{Actual Length}$$

**Difference between isometric view and isometric projection**

Isometric View	Isometric Projection
Drawn to actual scale	Drawn to isometric scale
When lines are drawn parallel to isometric axes, the true lengths are laid off.	When lines are drawn parallel to isometric axes, the lengths are foreshortened to 0.81 time the actual lengths.



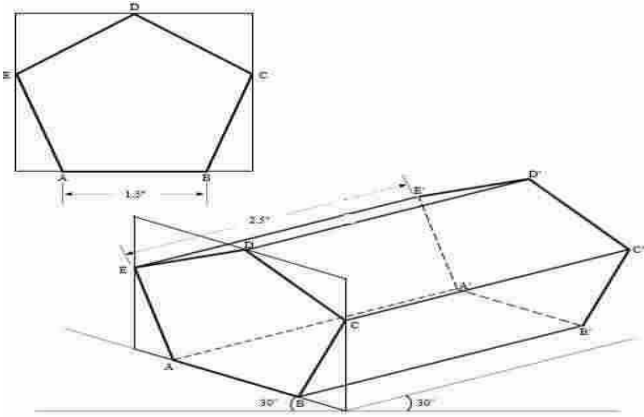
Problem: Draw the isometric projection of a rectangular prism of base 50 mm × 10 mm and height 75 mm, when it rests with its base on H.P and one rectangular face is parallel to V.P.



BOX METHOD:

The isometric projection of solids like cube, square and rectangular prisms are drawn directly when their edges are parallel to the three isometric axes. The isometric projection of all other types of prisms and cylinders are drawn by enclosing them in a rectangular box. This method is called **Box method**.

Example 1: Draw an isometric of a Pentagonal prism of base 1.5" and length 2.5" resting on one of its rectangular faces on H.P



ISOMETRIC VIEW OF A REGULAR HEXAGONAL PRISM

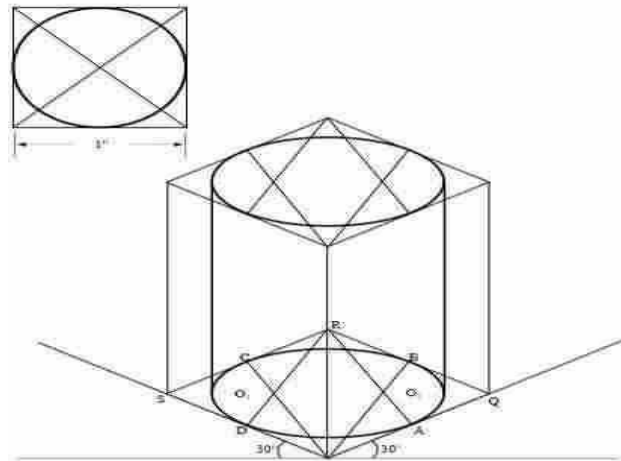
(Resting on one of its rectangular faces on H.P)

FOUR CENTERED METHOD:

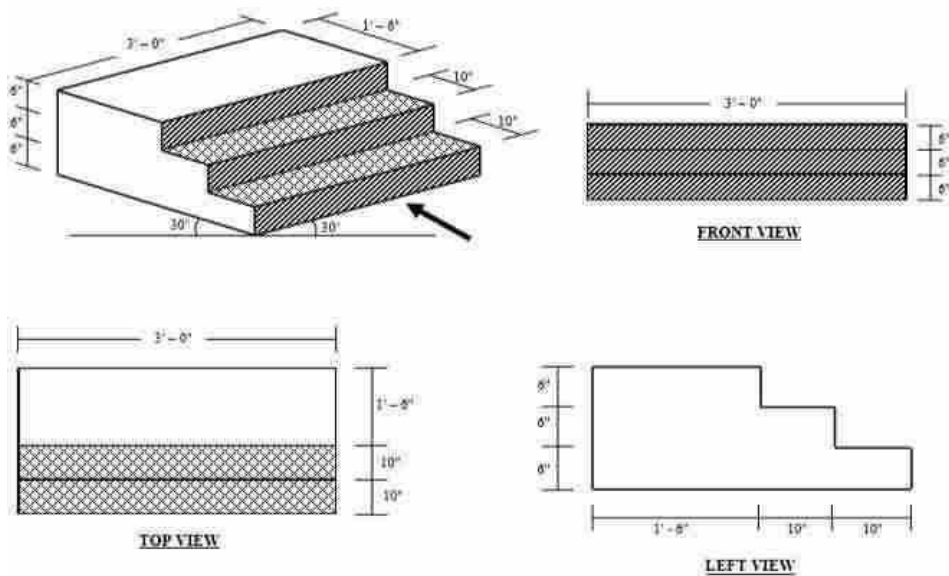
Example 2: Draw an isometric of a cylinder of base 1" and height 3" lying on V.P

Drawing Procedure

1. Join P with B and C which are the mid-points of the opposite sides of the rhombus. Similarly join R with A and D.
2. With P as centre and PC as radius draw an arc CB. Similarly with R as centre and RA as radius draw an arc AD
3. The lines PC and RD intersect at O_1 . With O_1 as centre and O_1D as radius draw an arc DC. Similarly with O_2 (intersection of RA and PB) as centre and O_2B as radius draw an arc BA. Thus complete the ellipse.
4. Refer step 1-3 in the Offset method and complete the isometric view of the cylinder.



3. Draw the Top view, Front view, Right view, Left view and Back view for the following isometric view.



Questions:

- 1) Draw an isometric view of a pentagonal prism having a base with 30 mm side and 60 mm long axis, resting on its base in H.P. with a face parallel and nearer to the V.P.
- 2) Draw an isometric projection of the hexagonal pyramid of base 30mm and axis height of 75mm long has its base is on H.P. and one of its base edge is parallel to the V.P. (ii) and also draw when its axis is parallel to H.P. and its base is parallel VP., the apex of the pyramid is closer than its base from V.P.
- 3) Draw an isometric projection of a frustum of the pentagonal pyramid with a 40 mm base side, 20mm top side, and 35mm height resting on its base in the H.P.
- 4) A hexagonal prism having base with a 30 mm side and a 70 mm long axis is resting on its base on the H.P. with a side of base parallel to the V.P. It is cut by an A.I.P. making 45° with the H.P. and bisecting the axis. Draw its isometric projection.
- 5) A cube with a 60 mm side has square holes of 30 mm side, cut through from all the six faces. The sides of the square holes are parallel to the edges of the cube. Draw the isometric view of the cube.

Introduction to Auto CAD**Important Points / Definitions:**

The term CAD (Computer Aided Drafting) applies to a wide range of programs that allow the user to create drawings, plans, and designs electronically. AutoCAD is one such program and its main claim to fame is that it is relatively easy to use, it is very comprehensive in its ability to create 2D and some 3D drawings, and it is very popular. Seventy percent of the CAD users in the world use AutoCAD.

Applications of Computer aided drafting

Mechanical: Design of machine elements, CNC machine tools, Robotics.

Automotive: Kinematics, Hydraulics, Steering.

Electrical: Circuit layout, Panel design, control system.

Electronics: Schematic diagrams of PCs, Ics, etc.

Communication: Communication network, satellite transmitting pictures, T.V Telecasting

Civil: Mapping, contour plotting, building drawing, structural design.

Architectural: Town planning, interior decorations, multi storied complex.

Aerospace: Design of spacecraft, flight simulator, lofting

Why with Auto CAD

- Current industrial practice (traditional drafting is obsolete).
- Helps students to explore other solid modelling softwares in their own disciplines
- Helps Mechanical students to generate 2-D Machine drawings as well as 3-D models using Pro-Engineers

AutoCAD Basics Tutorial Handout

Drawing:

When drawing in AutoCAD, you can type the command, into the command line at the bottom of the screen, or click on the toolbar icons. Next to each function is the shortcut, in parentheses) you can type to make drawing more efficient.

POINT (po) – draws a point at anywhere you specify

- by clicking on the location or
- by typing in the x-coordinate, tab, typing in the y-coordinate.

Line (l) – draws a line from one point to another.

- Same as above.

Polyline (pl) – draws a line/curve with multiple control points.

- If you hit “Esc” while drawing a polyline, the line is terminated from the last point you clicked or entered.
- If you type “cl” while drawing a polyline, it draws a line segment from your last clicked point to the starting point (closing the shape that you were drawing).
- If you type “a” while drawing a polyline, it allows you to draw an arc that are tangent to the last segment or arc. Notice that the arc only needs two points (starting and ending) point for the arc.
- If you type “s” while drawing an arc segment, you can draw an arc that is specified

Rectangle – draws a rectangle with two corners specified.

- Click to designate first corner of the rectangle.
- Click again to designate the opposite corner of the rectangle

Polygon (pol) – draws a polygon by the number of sides

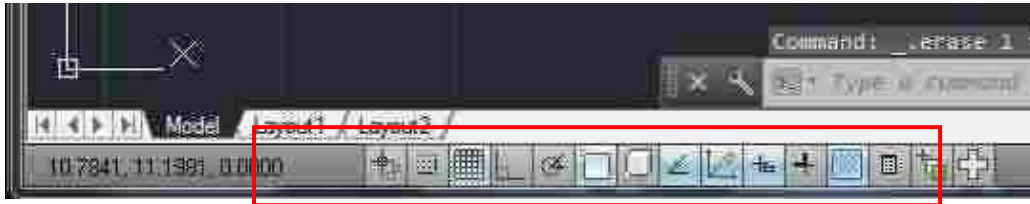
- Enter in the number of sides
- Choose the center of the polygon
- If you choose “inscribed in circle”, it will draw the polygon inside a circle with your given radius.
- If you choose “circumscribed in circle”, it will draw the polygon with a circle inside of that polygon with your given radius.








Circle (c) – draws a circle centered at a point

- Click to pick the center of the circle
- Pick the radius length by entering it in or clicking how large the circle should be.
- If you type “d” after picking the center, you can enter in the diameter rather than the radius

Object Snap & Tracking:

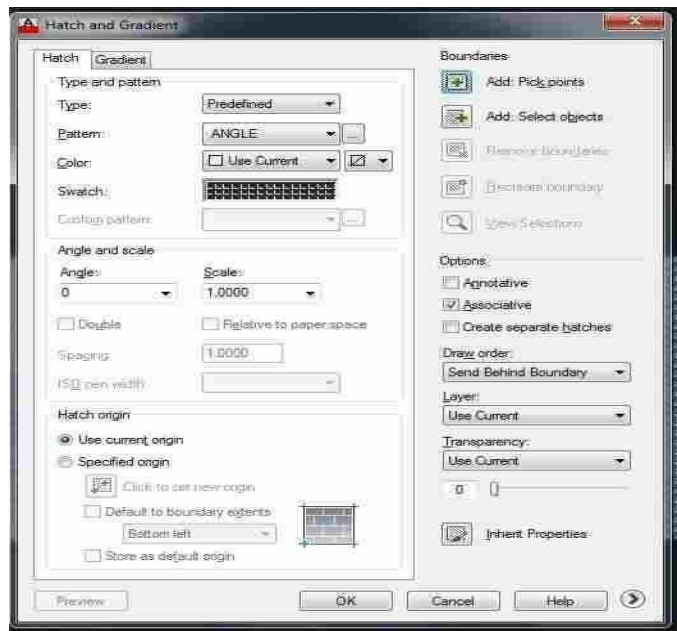
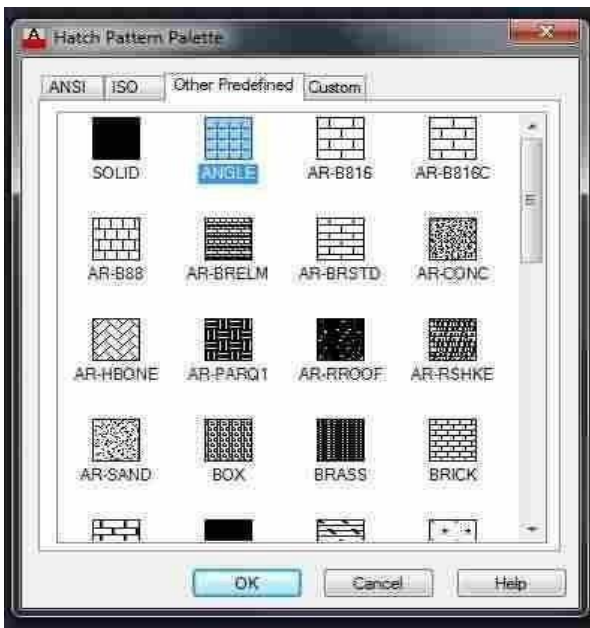
Settings that allow you to more specifically create your points, lines and polygons.



-  Snap Mode: snaps to increments of the spacing that you specify. (i.e. if you set it to 2 in both x,y direction, it will snap on 2,2,4,10,8 etc)
-  Grid Display: displays grids with the spacing that you specify
-  Ortho Mode: restricts movements to horizontal and vertical directions.
-  Polar Tracking: tracks increments of the angle that you specify (i.e. if you set it to 30 degrees, it will track 30,60,90,120 degrees etc.)
-  Object Snap: snaps to existing objects on the screen. You can also activate specific Object Snap during drawing/inquiry operations by right clicking and selecting snap overrides.
-  Show/Hide Lineweight: turns on/off the line width on display. It does not affect the line widths on plot.
-  Quick Properties: displays the properties of selected object(s). Another way to show properties: After select a object/object, right click and select "Quick Properties". You can change the object(s) properties here(layers,color and ltype.)

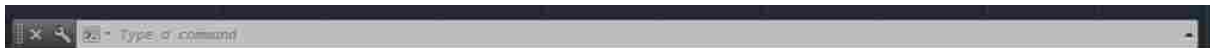
:

At the bottom of the screen, under the command line, there are some icons that allow you to turn on /off options listed below.



AutoCAD Help:

If you ever need help with a command, type in HELP. A window will pop up and you can type in the name of the command you need help with: line, circle, arc, etc.



Hatch (h) – adds hatch patterns or fills to an enclosed area or to selected objects.

- As you scroll over enclosed areas, AutoCAD will display a preview of the hatch within that enclosed area, given your settings.
- After clicking hatch, type “t” to get the settings, as shown to the right.
- Click the “...” for the Pattern option allows you to choose predefined hatches (shown below)
- You can adjust the angle and scale of the pattern.
- For the boundaries option:
 - When hatching a space defined by more than one object that causes overlapping zones, select “Add Pick points.”
 - When hatching a complete object, like a circle, rectangle, or polygon, select “Add select object.”
- Once the selections are set, you can click preview in the button on the left. Then ClickOk.

Divide (div) – divides a selected object into certain length or perimeter segment. You can draw from the node or you can place objects along the nodes (place trees 20 feet from each other on a sidewalk down a street).

- Select the object to divide,
- Enter the number of segments

Modify:

Erase (e): erases the selected objects. You can get the same effect by selecting objects and hitting Delete.

Copy (cp): copies the selected objects from one place to another

- Select the object(s)
- Click or enter in the coordinates for your base point.
- Choose the second point, which will be where you want the copied object to go

Move (m): moves your selected objects from one place to another

- Select the object(s)
- Choose your base point.
- Choose the point to move it to.

Mirror (mi): mirrors objects along the line that you define.

- Select your object(s). Hit enter when all of them are selected
- Pick your first point, and then pick the end point of the mirror line. (Notice the mirrored object shows up as a preview while you draw the line.
- It will prompt you to erase the original object. Type “y” for yes or “n” for no.

Offset (o): offsets objects to the distance of your choice

- It will prompt you for a distance to offset first. Enter in that number or click two points on the screen giving the distance that you want.
- Pick the object that you want to offset and then choose the side you want to offset it.
- If you're offsetting the object(s) multiple times at the same distance, you can click on the new object that was offset and click on the side you want to continue offsetting it to.

Scale (sc): scales objects by a given ratio

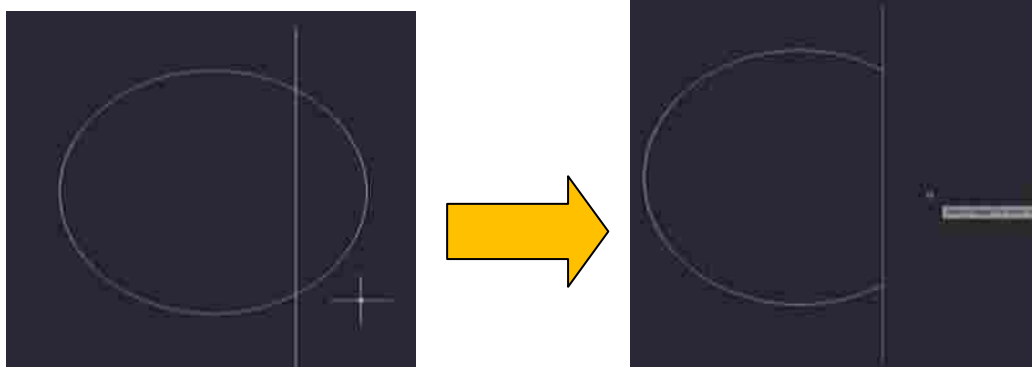
- Select the objects
- Click or enter in the base point
- Click or enter in the scale numerically

Explode (x): break selected complex objects such as blocks and polylines down to lines and arcs.

- Select the blocks or polylines you want to explode.
- Hit "esc" to finish. Select objects to ensure they were successfully broken down. You should multiple end points for lines and arcs if successful.

Trim (tr): trim objects using specified objects

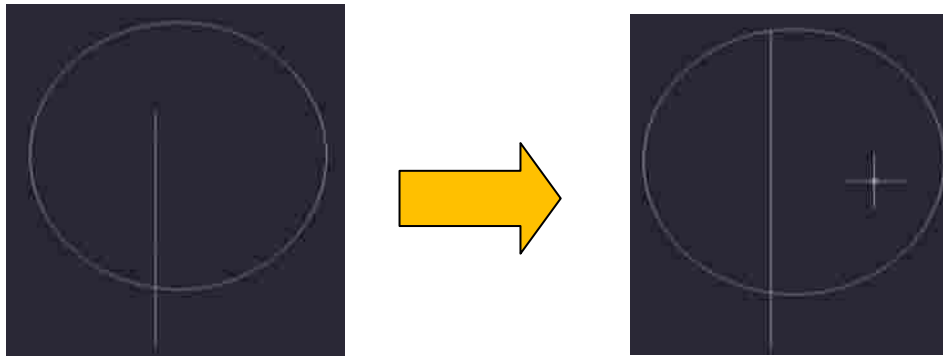
- Using the following image as an example, select the object you want to use as the "trimmer." For example, in this case, if you want to cut the circle and make it into an arc, you select the line first. And hit enter.
- Then choose the side you want to trim of the object you will be trimming. So for the example, if I want the arc to be the larger side of the circle, I would select the right side of the line, deleting the smaller side of the circle. Notice that it will trim the object immediately.



Extend (ex): extend objects to reach specified objects

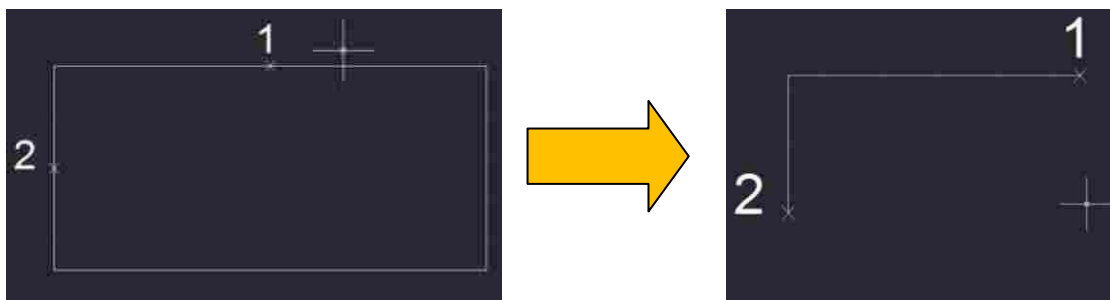
- Using the images below, select the object that you want to "extend to." In this case, if you wanted to extend the line to the north end of the circle, you would select the circle first. Then hit enter.

- Then choose the object you want to extend, which in this case would be the line itself. The line will extend immediately.



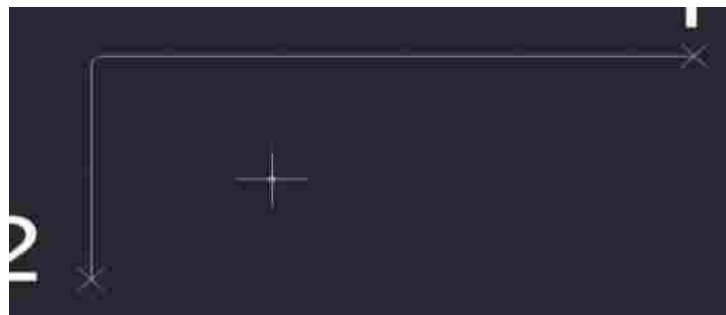
Break (br): makes cuts through continuous lines.

- Select the object by choosing where you want the break to start and then click where you want the break to end.
- Keep in mind that if you're breaking a non-close shape, the break occurs between the two points (i.e. a line). If it's a closed shape, the portion that will be kept is going to be the portion between the points moving counterclockwise as shown below.



Fillet (fillet): connects two objects with an arc that is tangent to the objects and has a specified radius.

- Select or type in fillet
- Type "r" for radius and enter in your radius (i.e. 0.5)
- Select the first object and then select the second object



- You can fillet: rectangles, tangential lines, arcs, etc.
- If the radius is 0, or you didn't enter in a number for the radius prior, fillet will just connect the two lines together (extends the lines so they join together). Layers

In AutoCAD, layers are used to help give structure to your drawing. They are stacks of transparent overlays (or planes) located on the same coordinate system. It allows you to organize your drawings in a clearer manner.

Turn off layer of a selected object, Lock/Unlock layer of a selected object

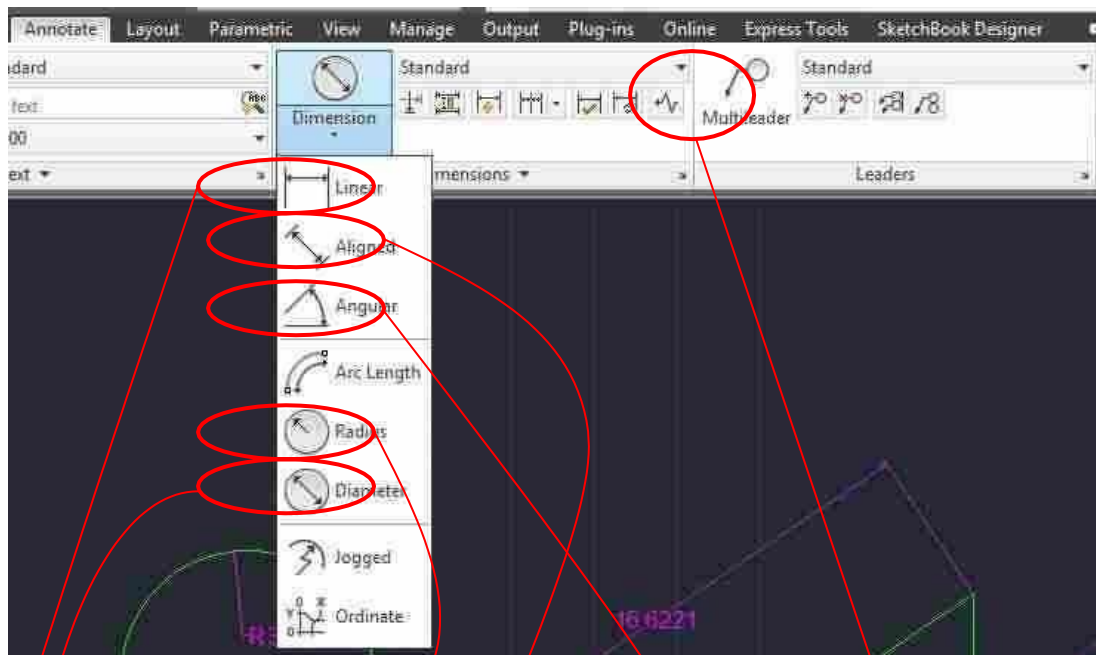
Turn visibility on and off, Each layer can be represented with different data, color. The default layer is "0" which cannot be deleted.

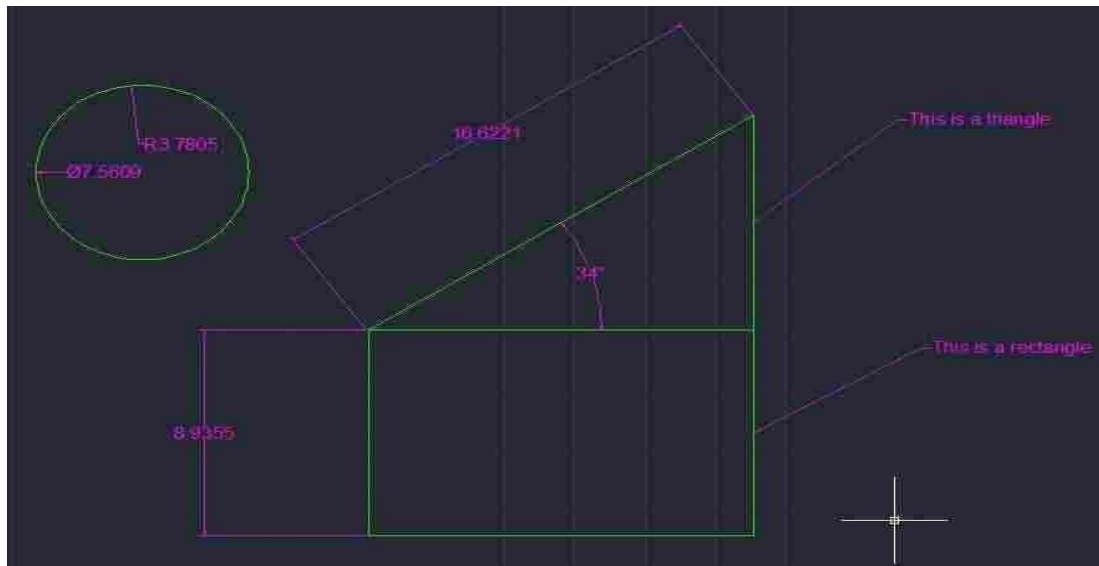
Layer Properties include:

- Name – Unique name for each layer (Be Descriptive)
- Color – Color of the layer
- Linetype – Continuous line, dashed line, dotted line, etc.
- Lineweight – How thick or thin the line is
- On [Visibility] – Makes the layer visible or not visible (If light bulb is yellow, it's on. If it's dark, it's off)
- Freeze – Freezes the layer, doesn't allow you to see it
- Lock – locks the layer from being selected but it is still visible (although more transparent than other layers)
- Difference between Visibility vs. Freeze is that frozen layers aren't included in regeneration, while layers with visibility off are.

Dimensions

Under Annotate, you can choose dimensions and leaders to make notes on your drawings. Dimensions are simply the dimensions of the object (be it length, radius, etc.). Leaders are ways to make annotations in a drawing for a variety of reasons (manufacturing notes, detail bubbles, etc.).

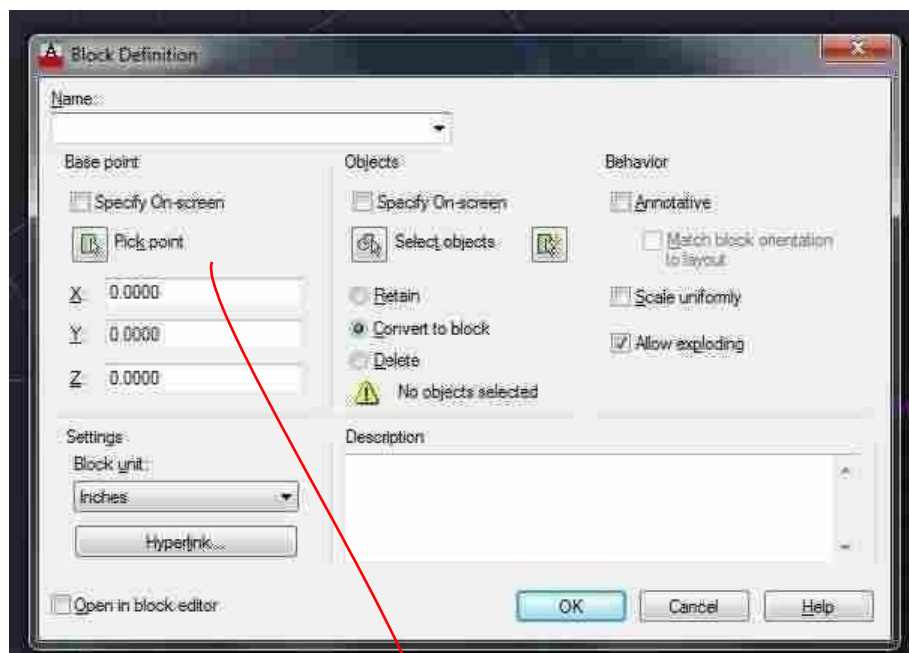




Blocks

Block: group of objects joined together as one entity.

- Type “b” for block. A block definition window will pop up, as shown below.

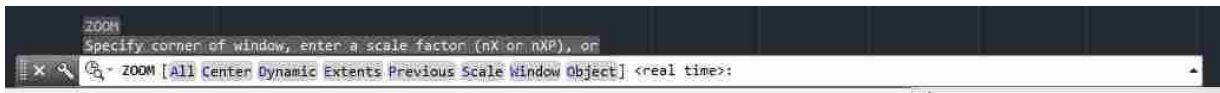


- Enter in a name (be descriptive)
- Click on “Select Objects”
- Make sure Convert to block is checked
- Select Pick point to choose a base point
- Click OK. You can now import the block as one entity.

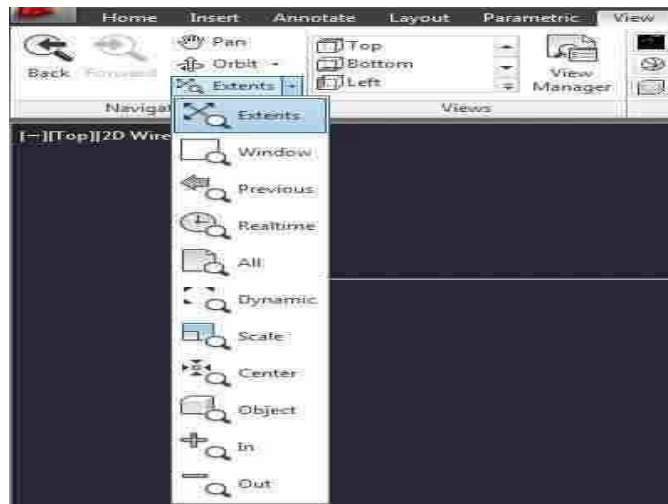
View

Zoom (z) – Three ways to zoom in and out

- The middle wheel on the mouse allows you to zoom in and out (towards the computer monitor to zoom in, away to zoom out).
- Type “z” in the command line and choose from options.
 - All - use if you get lost
 - Extents – zooms to the point where you can see all the objects drawn
 - Window – allows you to select a window to zoom into that you specify
 - Previous – takes you to the last view you saw



- View/Extents



Pan (p) – allows you to slide the drawing screen without changing the size. You can also pan by clicking on the wheel of the mouse and holding it down while you slide the mouse.

Regen (re) – regenerates the display, smoothing it out after zooming in or out and updates the screen, essentially a refresh button.

Plot (or Print)

To plot or print your drawing, the first thing you will want to do is switch Paper Space by clicking the Layout tab at the bottom of the screen. You will notice that the background should go from black to white.

- The dotted line, shown on the next page, represents the area that will be printed. Anything on the outside of that box will not show up on your paper.
- The inside box is your viewport. This shows you what will be printed out from your workspace, which you can adjust by zooming in and out or panning. To do so, make sure you double click on that box. If this is done correctly, you’ll notice that the paper doesn’t zoom in and out but everything inside the viewport will.
- Adjust the viewport window to eliminate as much white space as you can. Also, you will usually print out a drawing with a title block which you will need to insert into your layout before printing and which will take up some space on the paper.