Engineering Drawing

Lecture 10

Projection of Solids

Solids

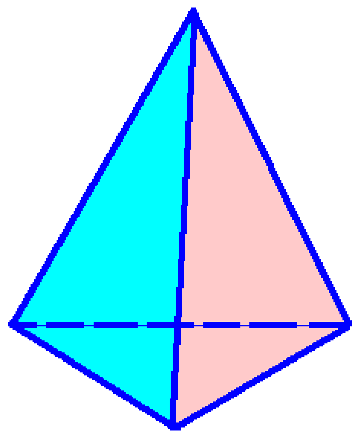
A 3-D object having length, breadth and thickness and bounded by surfaces which may be either plane or curved, or combination of the two.

- Classified under two main headings
    - Polyhedron
    - Solids of revolution

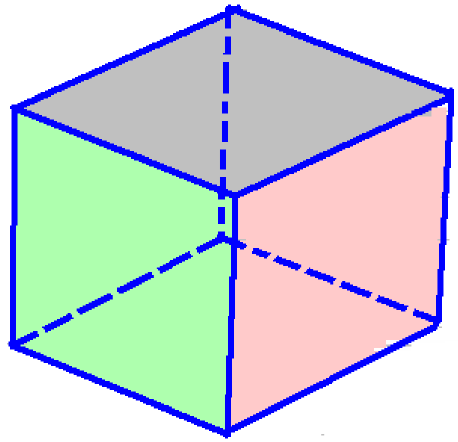
- **Regular polyhedron** – solid bounded only by plane surfaces (faces). Its faces are formed by regular polygons of same size and all dihedral angles are equal to one another.

- **Other polyhedra** – when faces of a polyhedron are not formed by equal identical faces, they may be classified into prisms and pyramids.

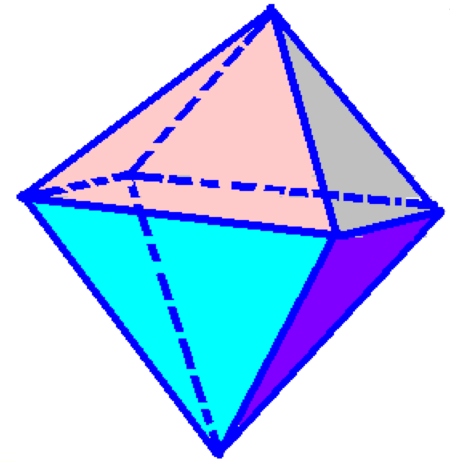
Five regular polyhedra



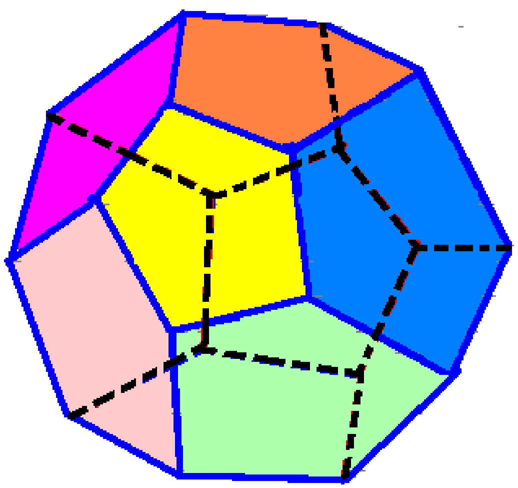
Tetrahedron – four equal equilateral triangular faces



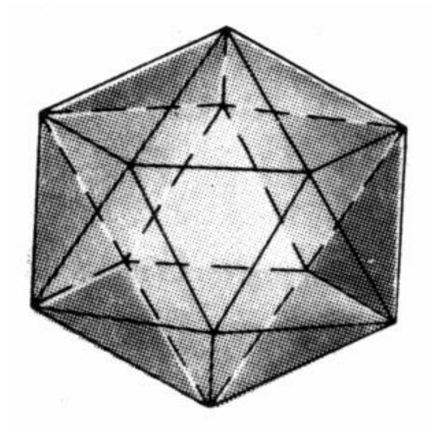
Cube/hexahedron – six equal square faces



Octahedron– eight equal equilateral triangular faces



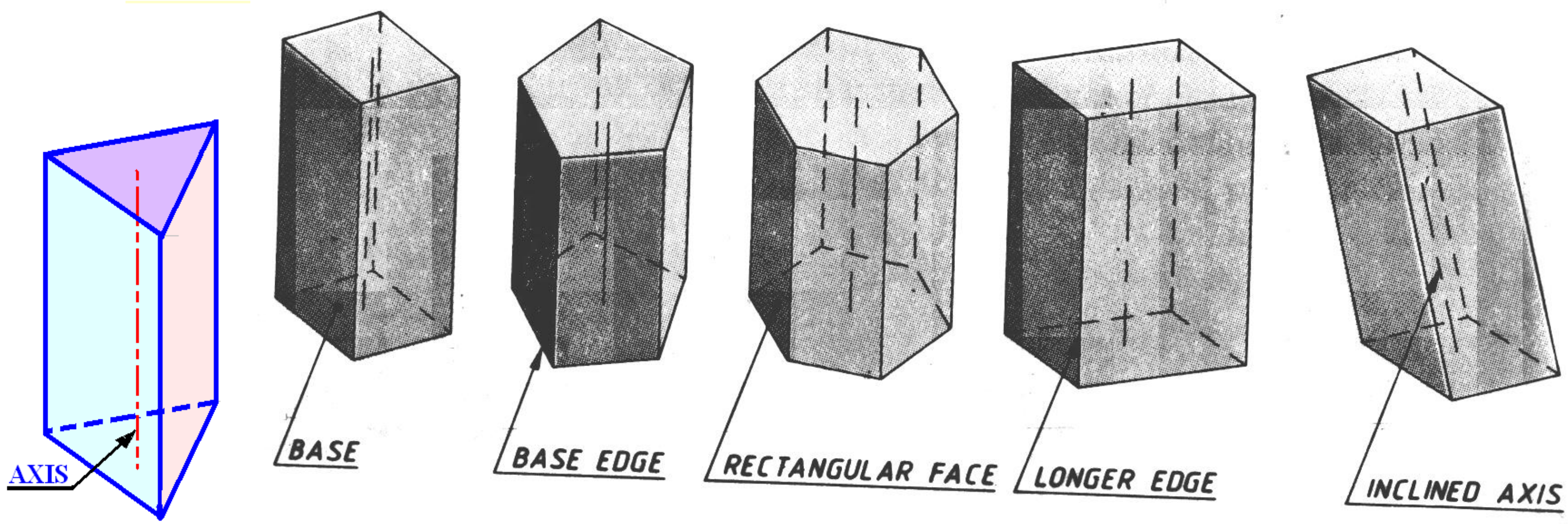
Dodecahedron – twelve equal regular pentagonal faces



Icosahedron– twenty equal equilateral triangular faces

Prism – a polyhedron formed by two equal parallel regular polygon, end faces connected by side faces which are either rectangles or parallelograms.

Different types of prisms



Square Prism | Pentagonal Prism | Hexagonal Prism | Rectangular Prism | Oblique Prism

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

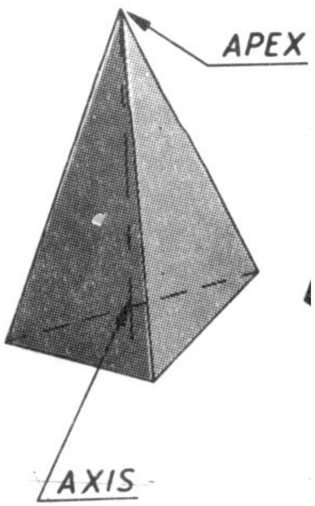
Axis – the imaginary line connecting the apex and the center of the base.

Inclined/slant faces – inclined triangular side faces.

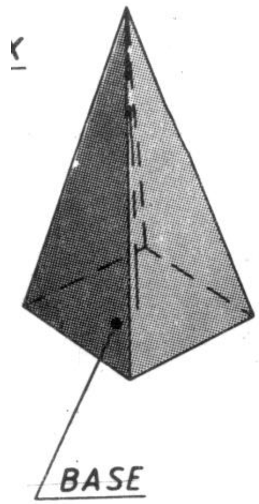
the apex and the base corners.

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

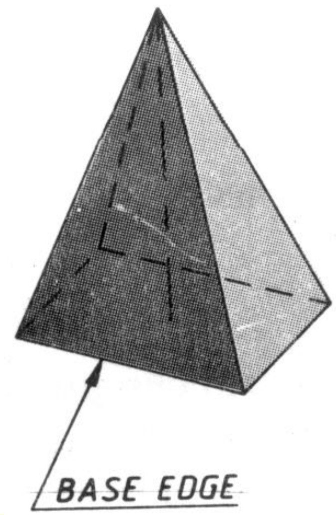
Oblique pyramid – when the axis of the pyramid is inclined to its base.



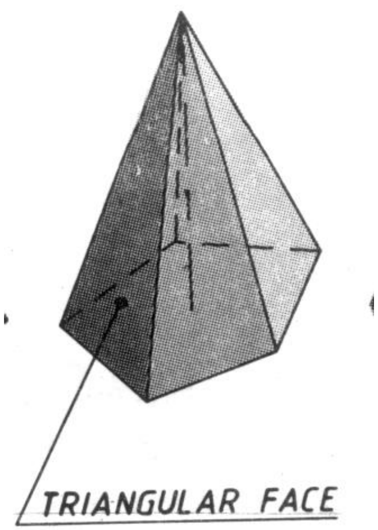
Triangular pyramid



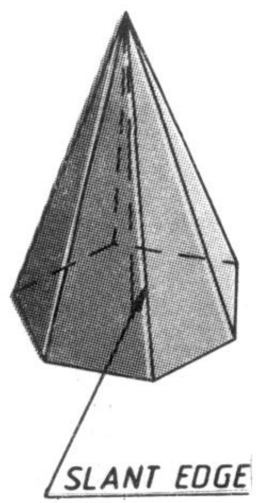
Square pyramid



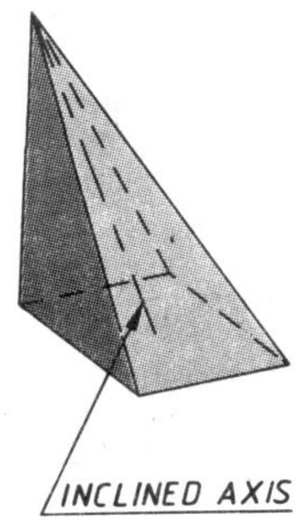
Rectangular pyramid



Pentagonal pyramid

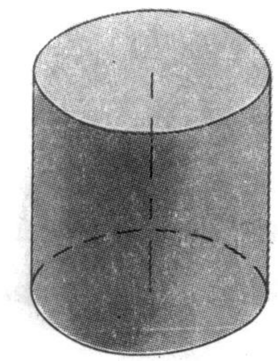


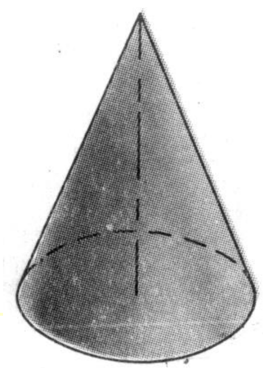
Hexagonal pyramid

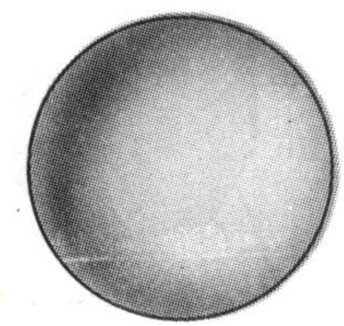


Oblique pyramid

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



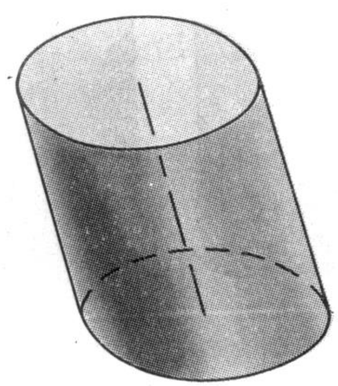




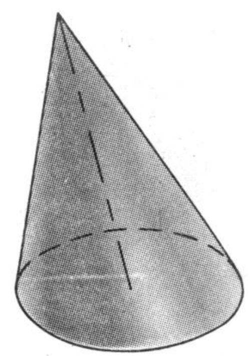
Cylinder – when a rectangle is revolved about one of its sides, the other parallel side generates a cylinder.

Cone –
revolved about one of its sides, the hypotenuse of the right triangle generates a cone.

Sphere – when a semi-circle is revolved about one of its diameter, a sphere is generated..

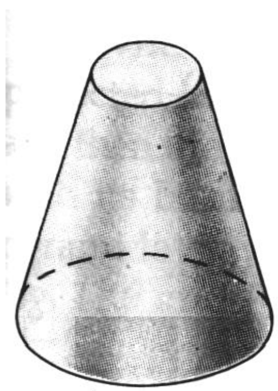


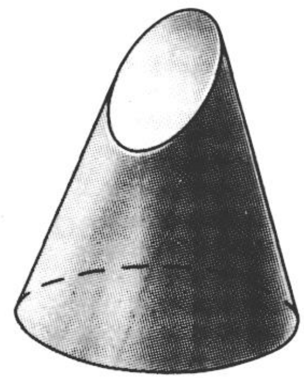
Oblique cylinder –
when a parallelogram is revolved about one of its sides, the other parallel side generates a cylinder.

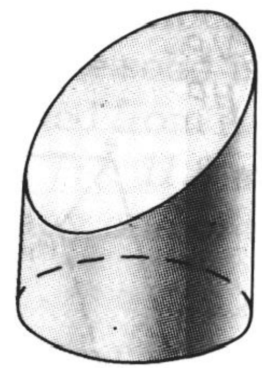


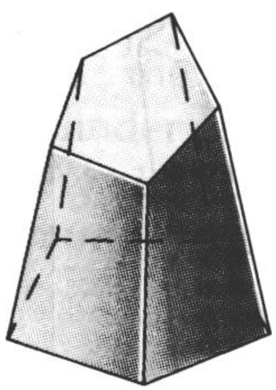
Oblique cone

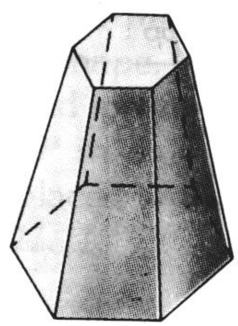
Truncated and frustums of solids – when prisms, pyramids, cylinders are cut by cutting planes, the lower portion of the solids (without their top portions) are called, either truncated or frustum of these solids.

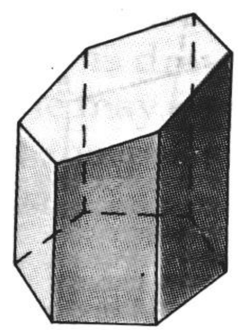










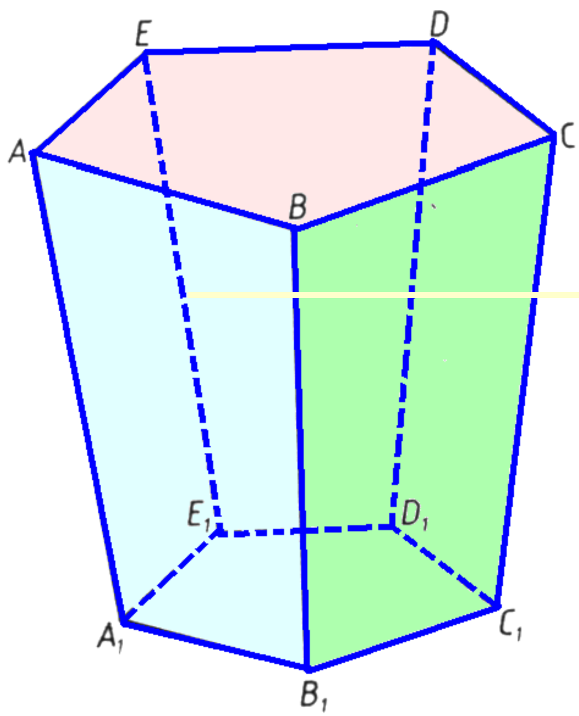


Visibility – when drawing the orthographic views of an object, it will be required to show some of the **hidden details as invisible** and are shown on the orthographic views by **dashed lines**

Rules of visibility

All outlines of every view are visible – the outlines of all the views are shown by full lines.

In the top view, the highest portions of the object are visible.



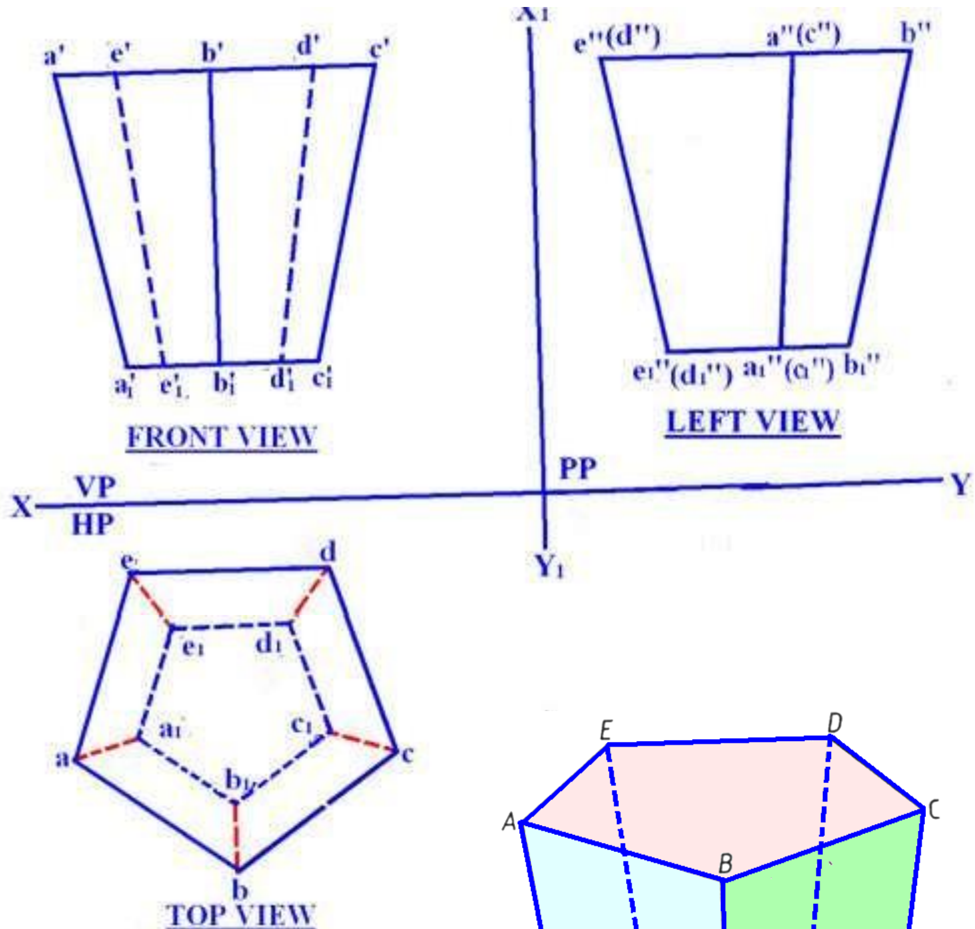
Frustum of a pentagonal pyramid – the top face ABCDE is the highest, it is completely visible in the top view.

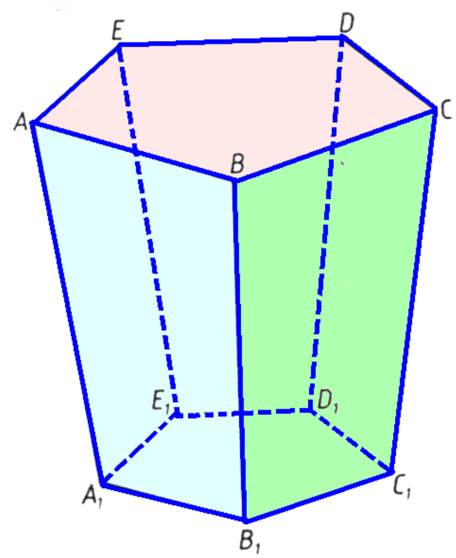
In the top view, edges **ab, bc, cd, de** and **ea** are shown as **full lines**. The bottom pentagonal faces $\mathbf{A_1B_1C_1D_1E_1}$ is smaller than the top face, hence **invisible**.

The slant edges $\mathbf{AA_1}$, $\mathbf{BB_1}$, $\mathbf{CC_1}$, $\mathbf{DD_1}$ and $\mathbf{EE_1}$ are invisible in the top view, hence they are shown as **lines of dashes.**

The line connecting a visible point and an invisible point is shown as an invisible line of dashes unless they are outlines.

In the front view - the front faces of the object are visible.





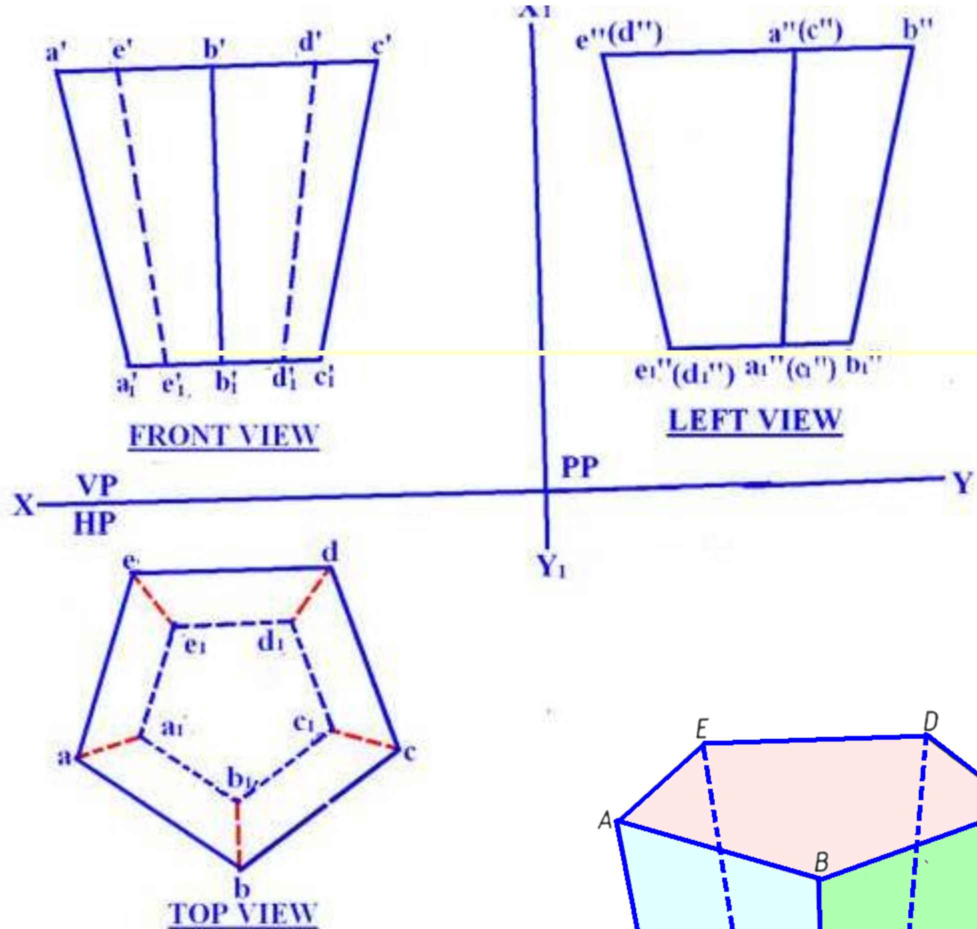
Object

In the front view – the faces **ABB_1A_1** and **BCC_1B_1** are the front faces, hence are visible.

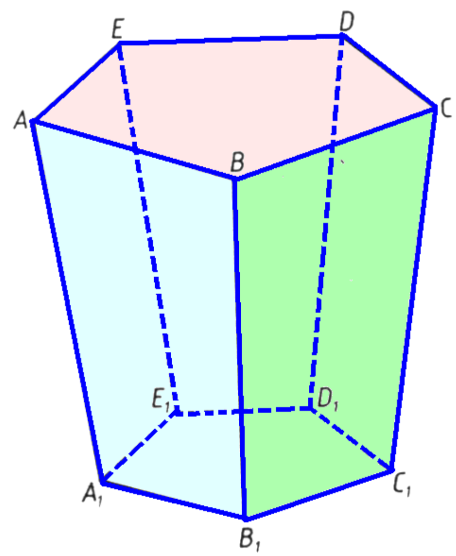
In the front view, the corners **a, b, c** and **a_1, b_1, c_1** are visible to the observer. Hence in the front view, the lines **$a'a'_1$, $b'b'_1$** and **$c'c'_1$** are shown as full lines.

The corners **d, e, d_1** and **e_1** are invisible in the front view. The lines, **$e'e'_1$, $d'd'_1$** are invisible, hence shown as dashed lines. The top rear edges **a'e', e'd'** and **d'c'** coincide with the top front visible edges **a'b'** and **b'c'**.

In the side view - the face lying on that side are visible.



As sheen in the left side view, the corners **e, a, b** and **e_1, a_1, b_1** lie on left side and are visible in the left view.



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a”a_1” and **b”b_1”** are shown as full lines. The edges **d”d_1”, c”c_1”** coincide with the visible edges **e”e_1”** and **a”a_1”** respectively.

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**

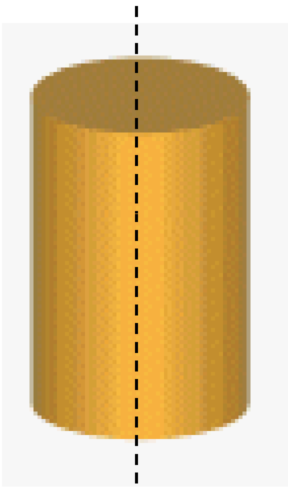
Axis of the solid perpendicular to HP

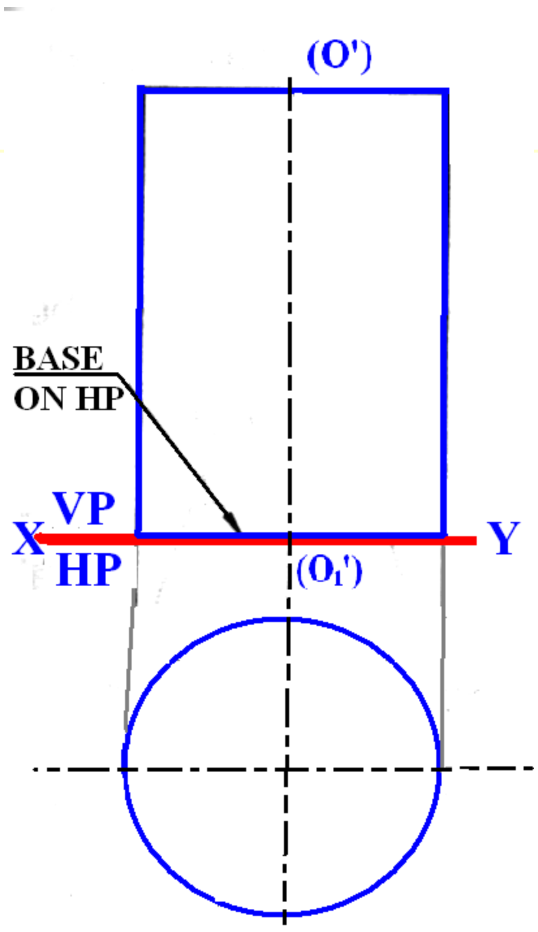
A solid when placed on HP with its axis perpendicular to it, then it will have its base on HP. This is the simplest position in which a solid can be placed.

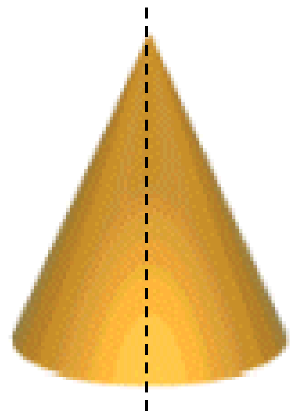
When the solid is placed with the base on HP position, in the top view, the base will be projected in its true shape.

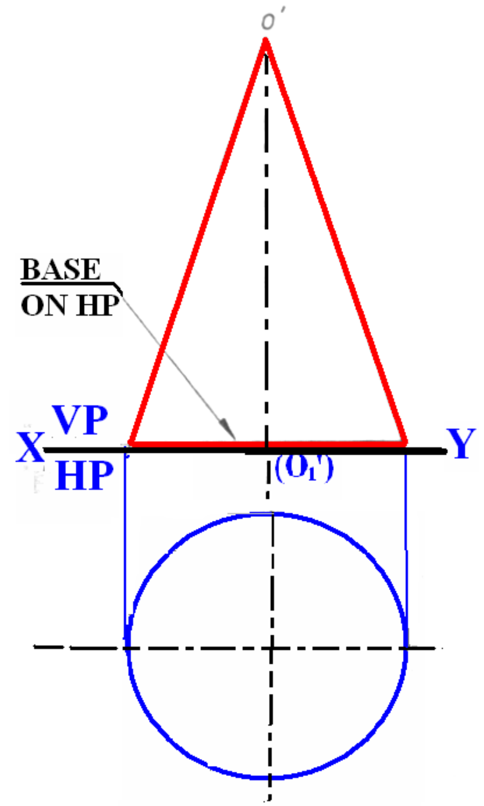
Hence, when the base of the solid is on HP, the top view is drawn first and then the front view and the side views are projected from it.

Only one position in which a cylinder or a cone may be placed with its base on HP.

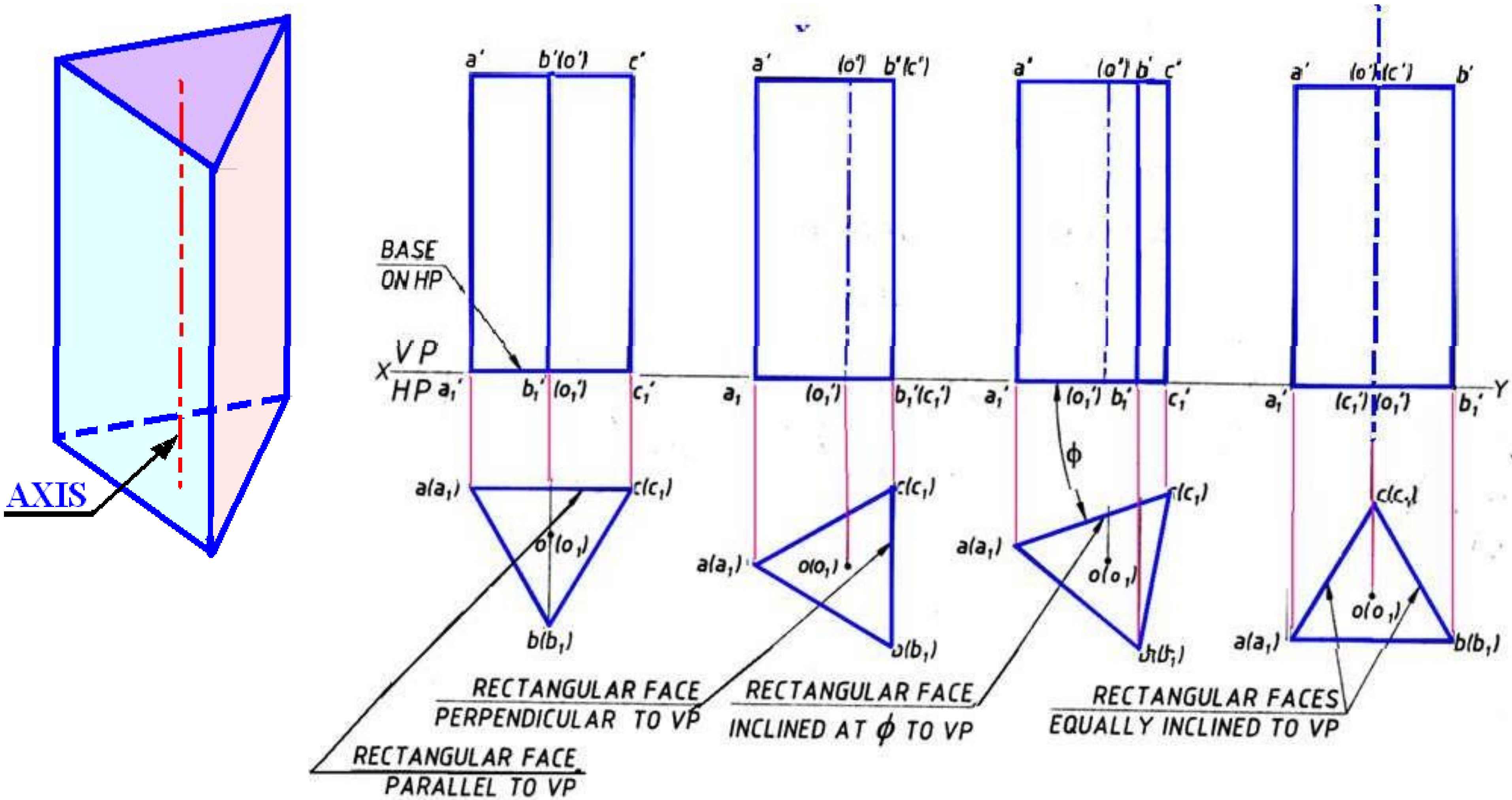




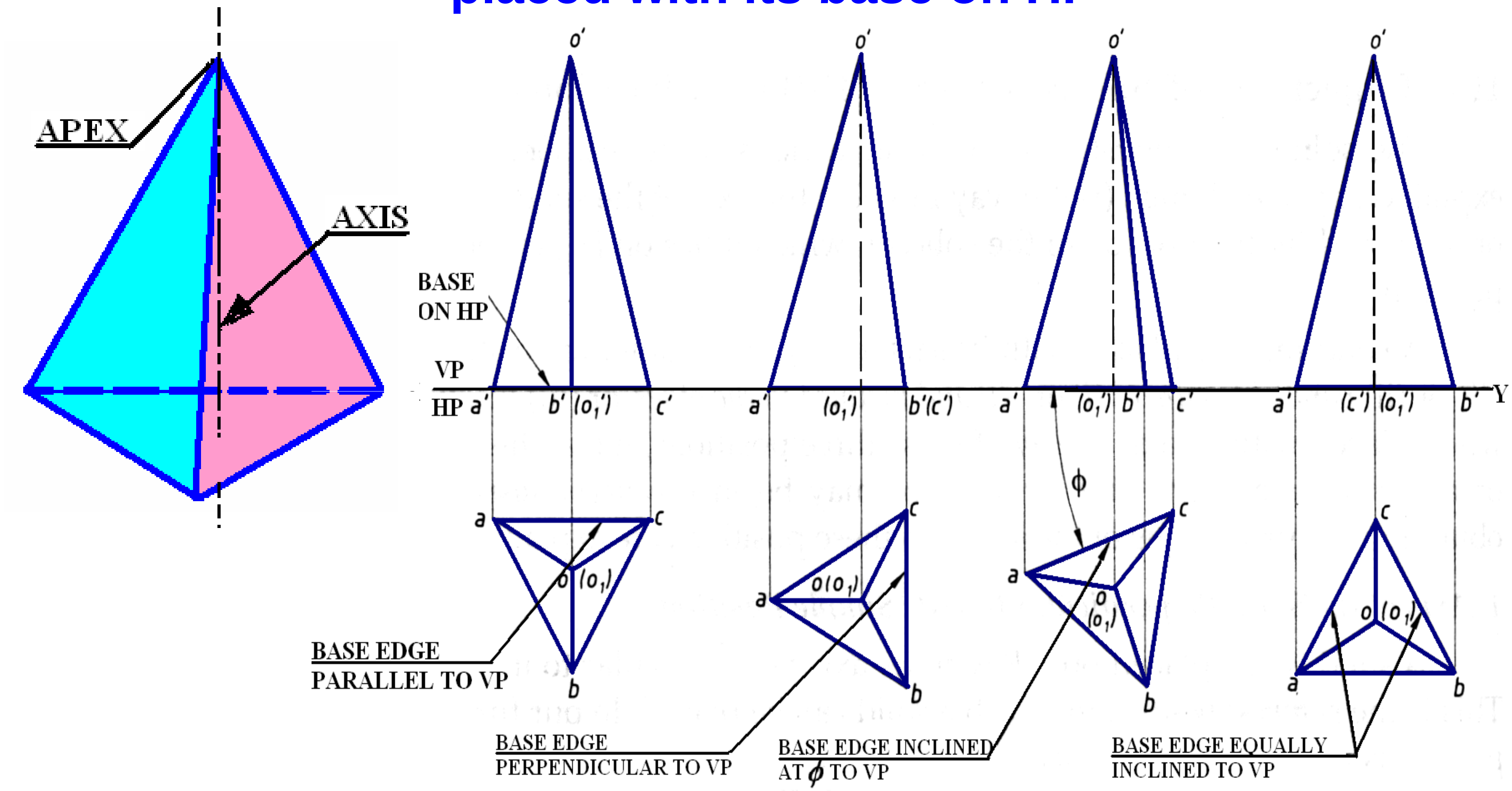




Four positions of a prism placed with its base on HP.



Four positions of a triangular pyramid placed with its base on HP



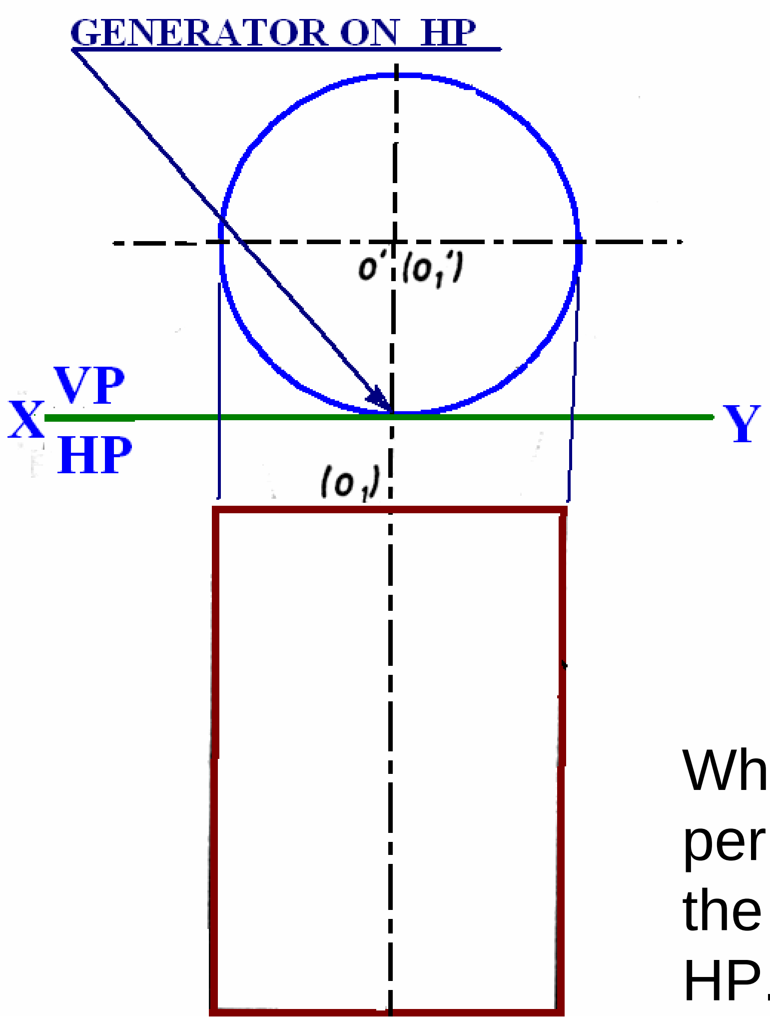
Axis of the solid perpendicular to VP

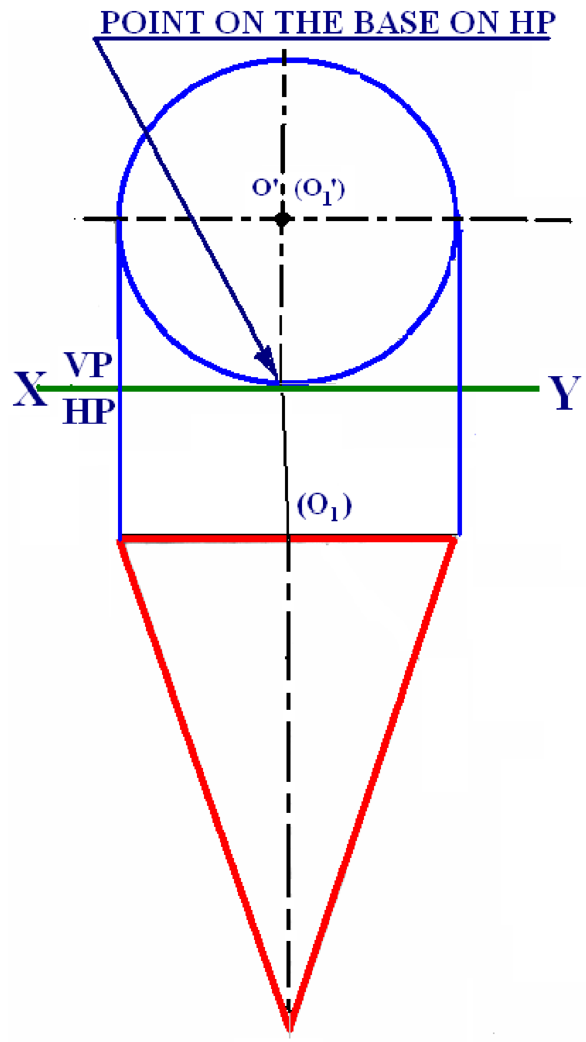
When a solid is placed with its axis perpendicular to VP, the base of the solid will always be perpendicular to HP and para~~llel to VP.~~

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.

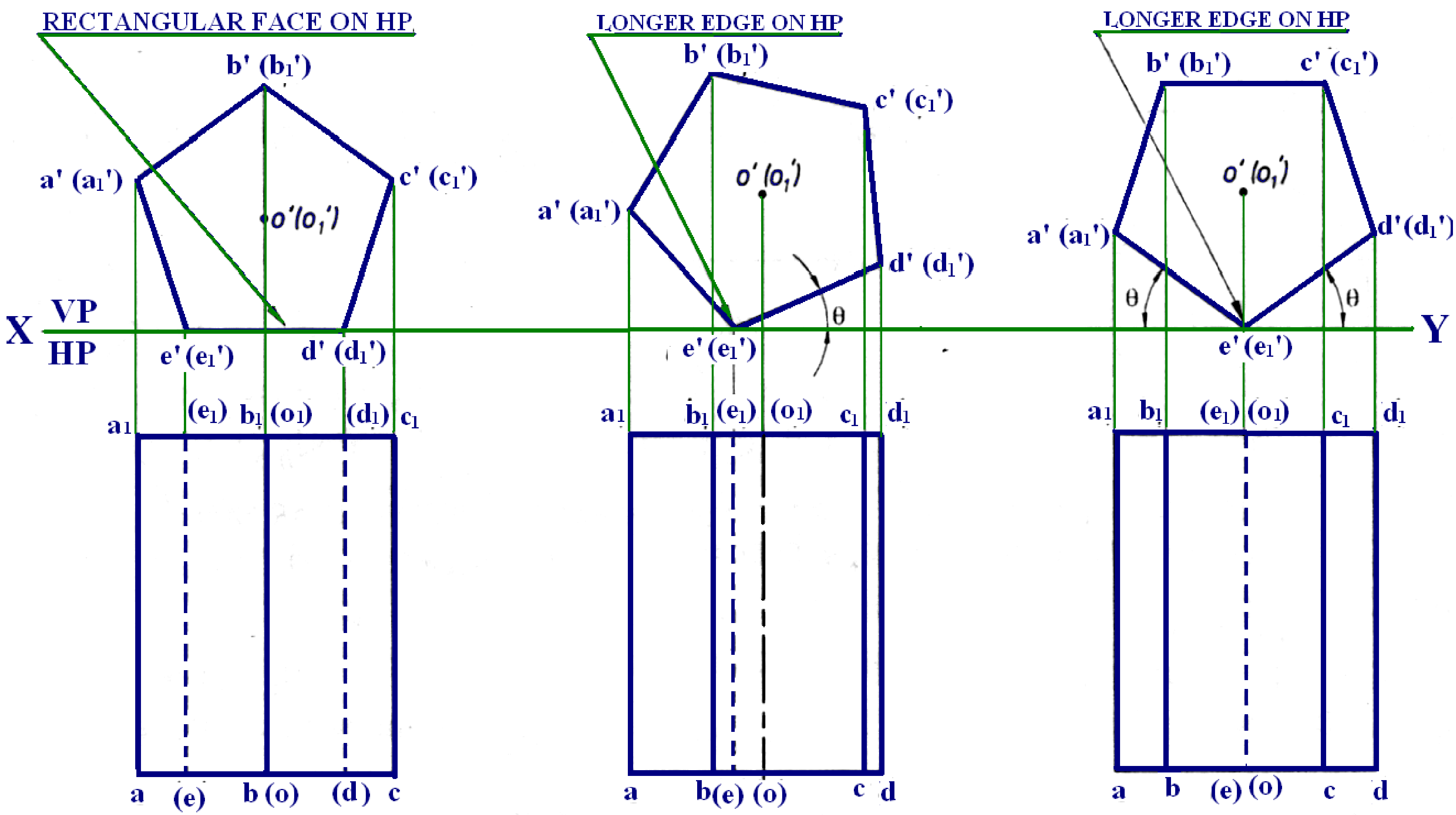
When a cylinder rests on HP with its axis perpendicular to VP, one of its generators will be on HP.



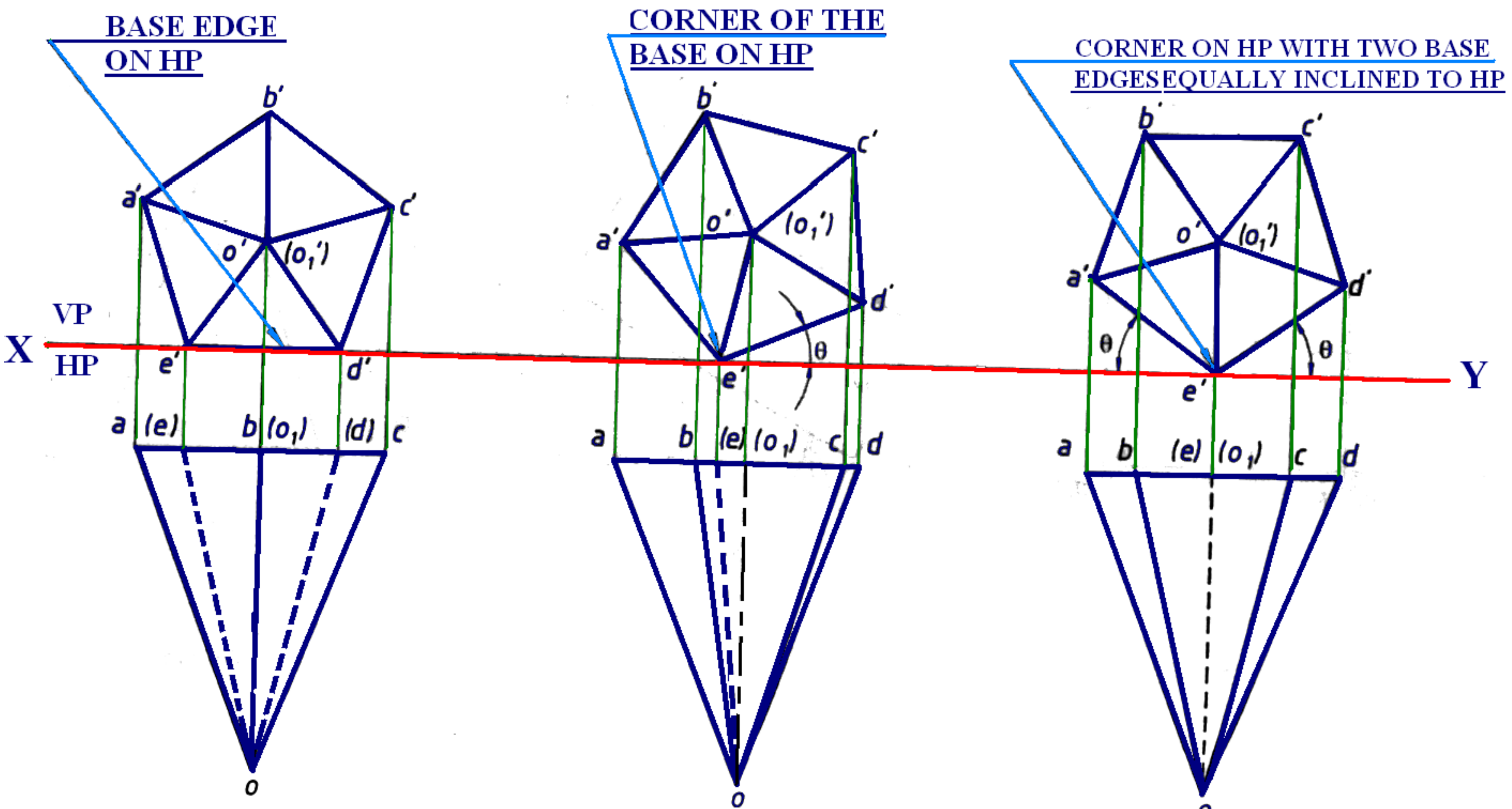


When a cone rests on HP with its axis perpendicular to VP, one of the points on the circumference of the base will be on HP.

Prism placed with their axis perpendicular to VP in three different positions.

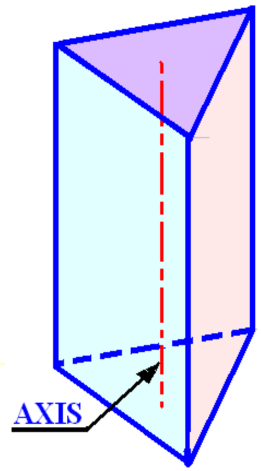


Pyramid placed with their axis perpendicular to VP in three different positions.

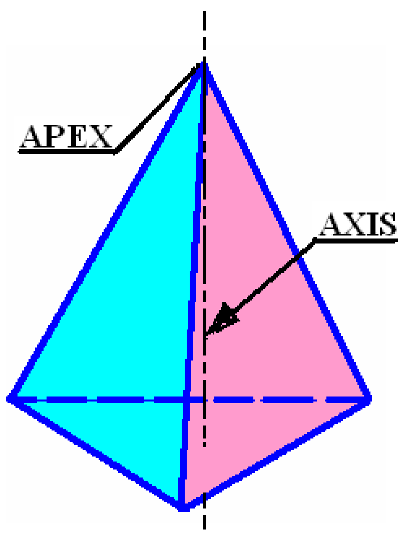


Axis of the solid inclined to HP and parallel to VP

When a solid is **placed on HP** with its **axis inclined** to HP, **the elemental portion of the solid that lies on HP depends upon the type of the solid.**



When a **prism** is placed on HP with **its axis inclined to it**, then it will lie either on one of its **base edges** or **on one of its corners** on HP.

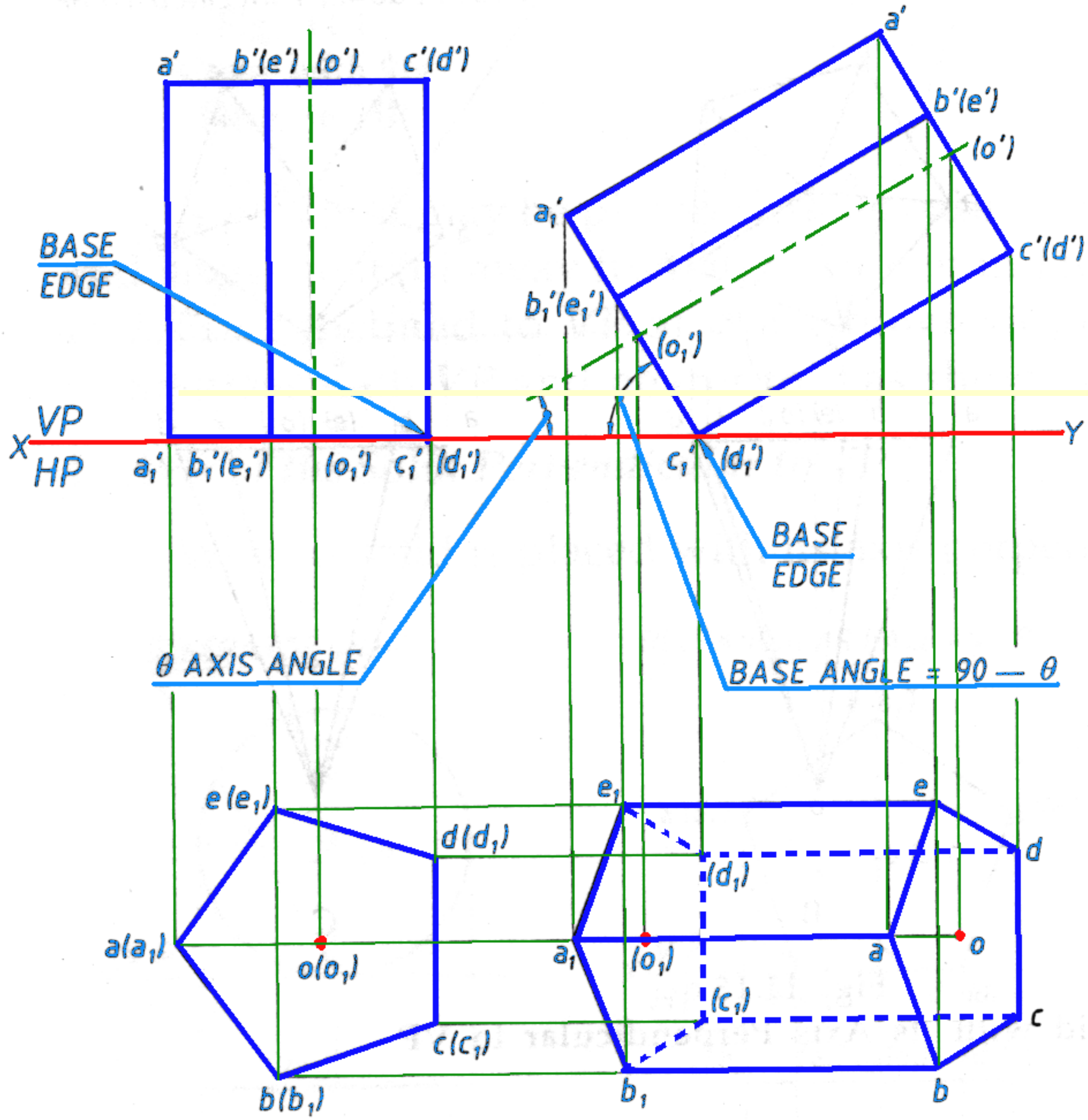


When a **pyramid** is placed on HP with **its axis inclined to HP**, then we will have one of its **base edges** on HP or one of its **base corners** on HP or **one of its slant edges** on HP or one of its **triangular faces** on HP or **an apex** on HP.

Case 1. When the solid lies with an edge of base on HP

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

When the solid lies with an edge of base on HP



When a **pentagonal prism** has to be placed with **an edge of base on HP** such that the **base or axis is inclined to HP**, then initially, **the prism is placed with its base on HP with an edge of the base perpendicular to VP and the lying on the right side.**

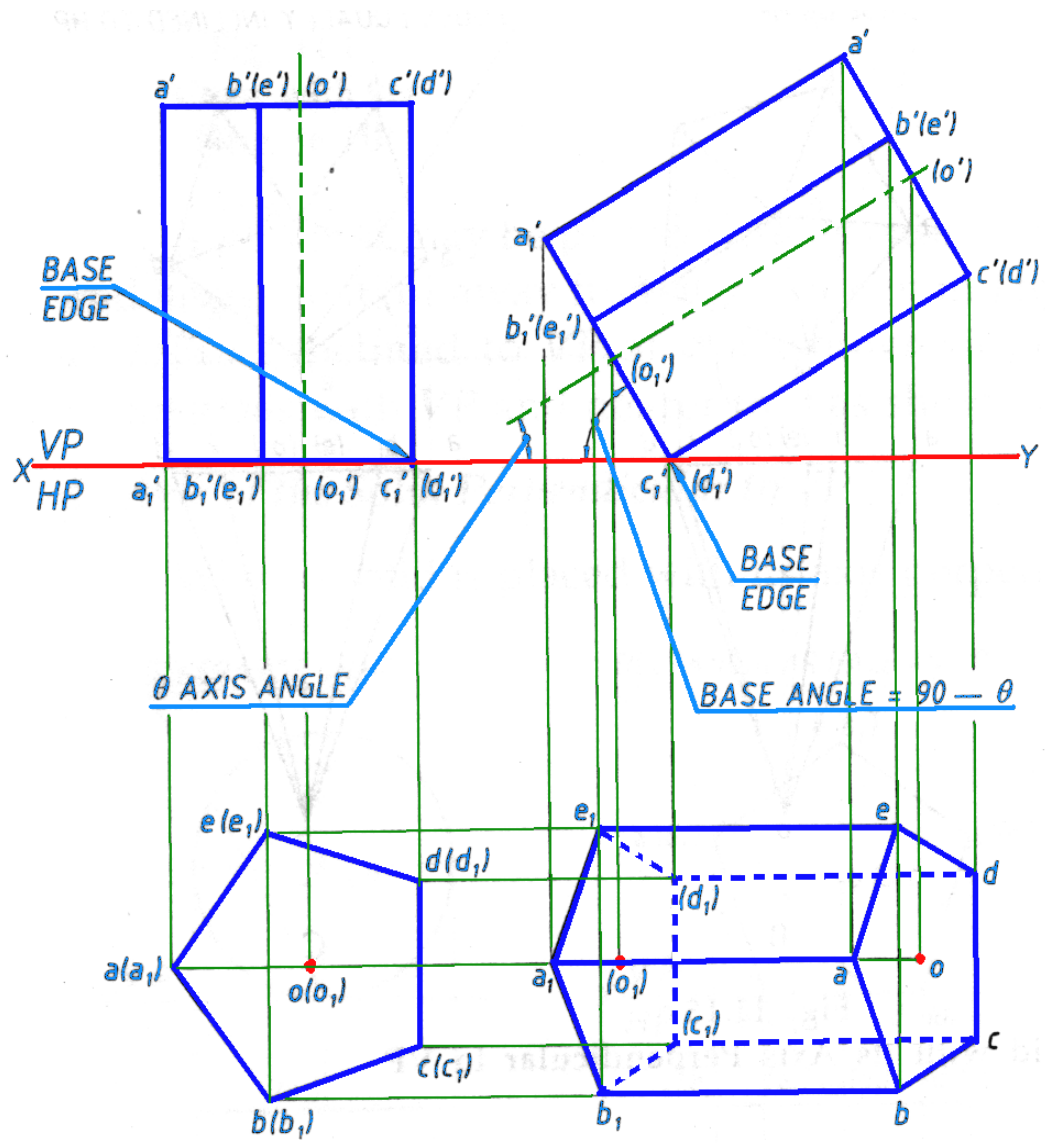
In this position, the first set of top and front views are drawn with the base edges **$(c_1)(d_1)$** perpendicular to **XY** line in the top view. In the front view, this edge **c_1'(d_1')** appears as a point.

Since the prism has to lie with an edge of the base on **HP**, the front view of the prism is tilted on the edge **$c_1'(d_1')$** such that the axis is inclined at θ to **HP**.

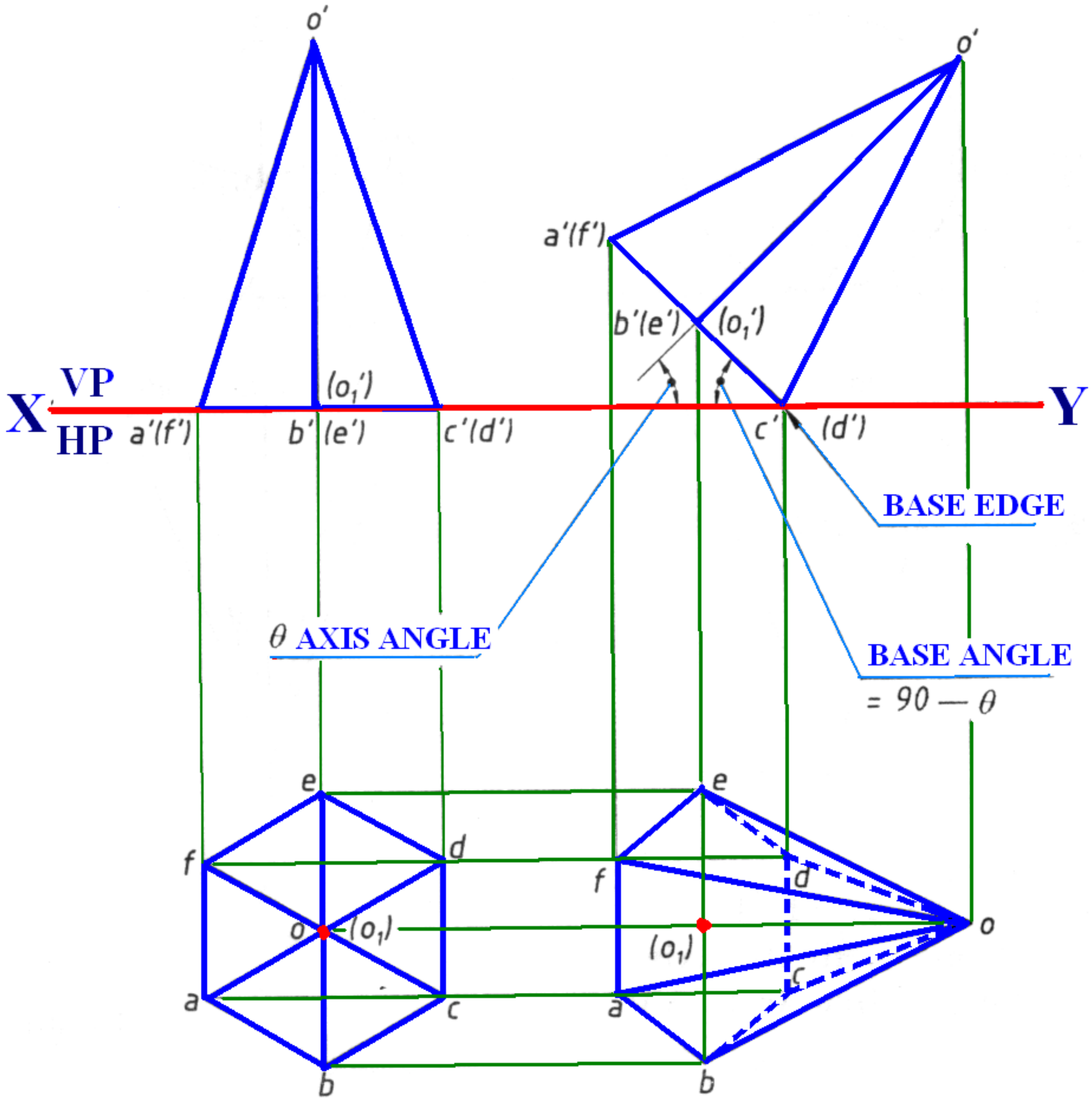
Redraw the first front view in the tilted position

Whenever the inclination of axis **θ** with **HP** is given, first the base is drawn at **(90- θ)** in the front view, otherwise improper selection of the position of the axis may result in the base edge **$c_1'(d_1')$** lying above or below the **XY** line.

The second top view is projected by drawing the vertical projectors from the corners of the second front view and the horizontal projectors from the first top view.



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



Case.2 : When the solid lies on one of its corners of the base on HP

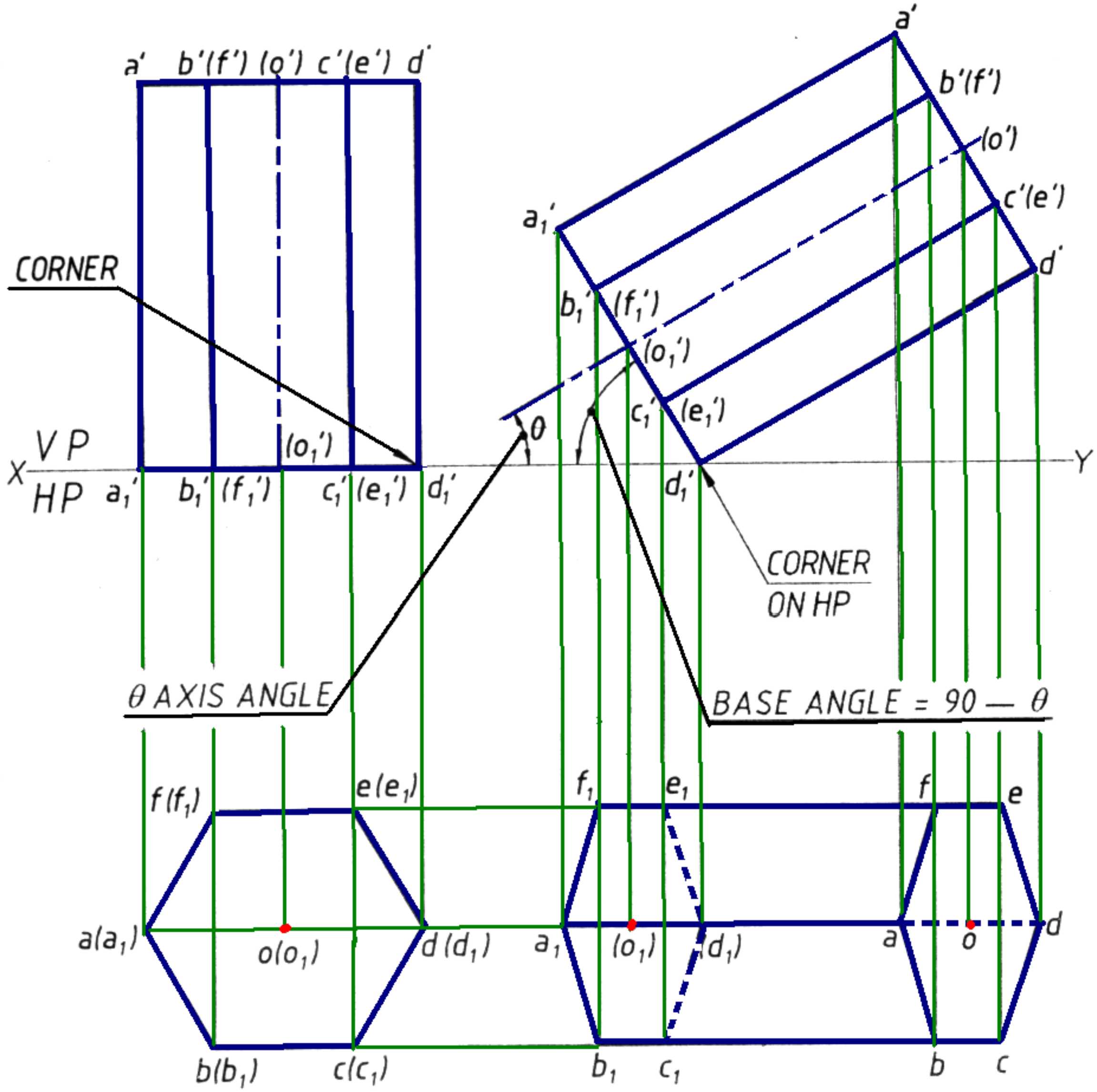
When a solid lies on one of its corners of the base on HP, then the two edges of the base containing the corner on which it lies make either **equal inclinations** or **different inclination** with HP.

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

Initially the solid should be placed with its base on HP such that **an imaginary line connecting the center of the base and one of its corners is parallel to** VP, i.e. to XY line in the top view, and preferably to lie on the right side.

For example, when a **hexagonal prism** has to be placed **with a corner of the base on HP** such **that the base or the axis is inclined to HP**, then initially the the prism is pla~~ced with its base o~~ HP such that **an imaginary line connecting the center of the base and a corner is parallel to VP** and **it lies on the right side**.

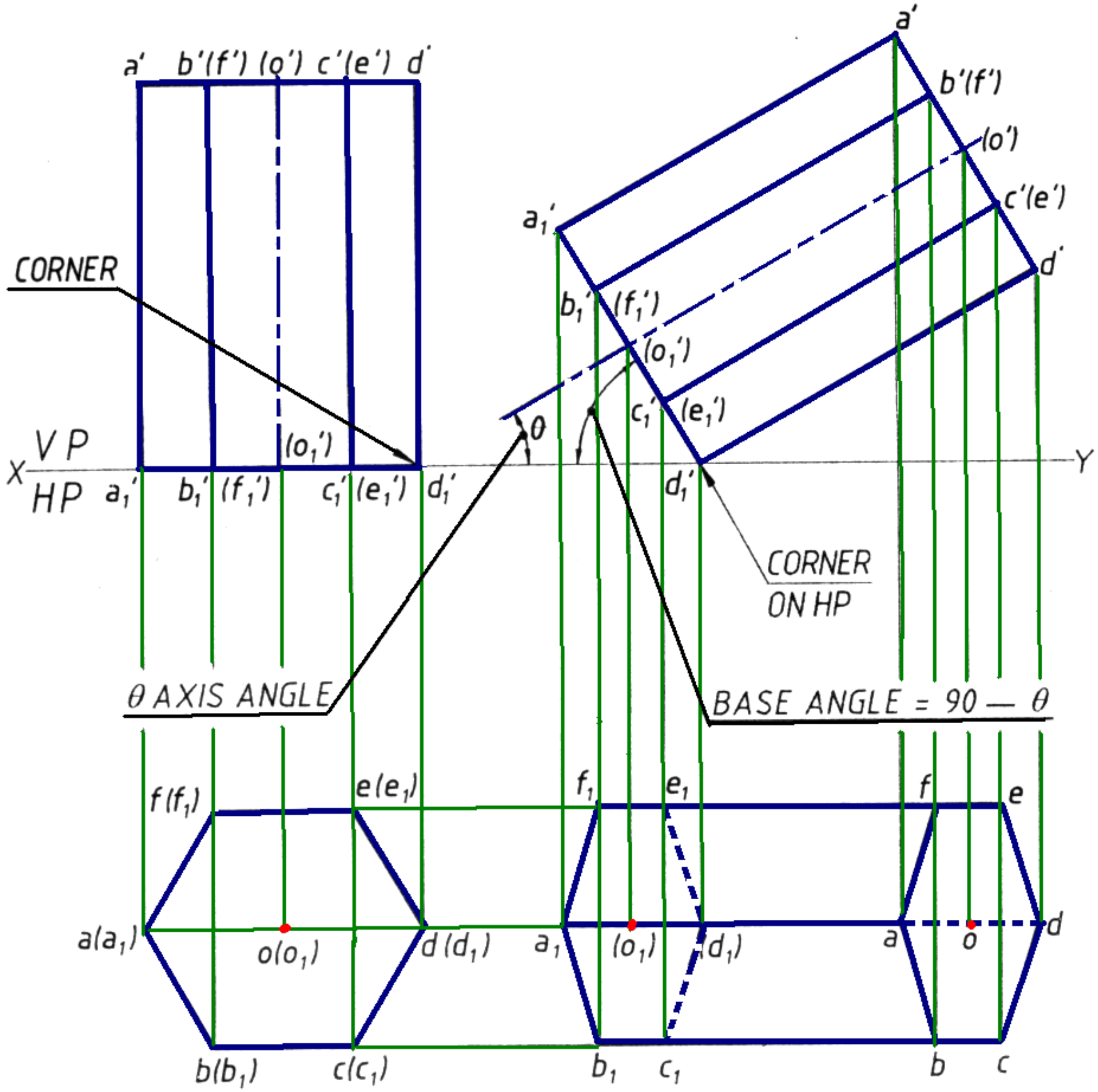
In this position, the first set of top and front views are drawn – the line **(o_1)(d_1)** is parallel to the **XY** line in the top view.



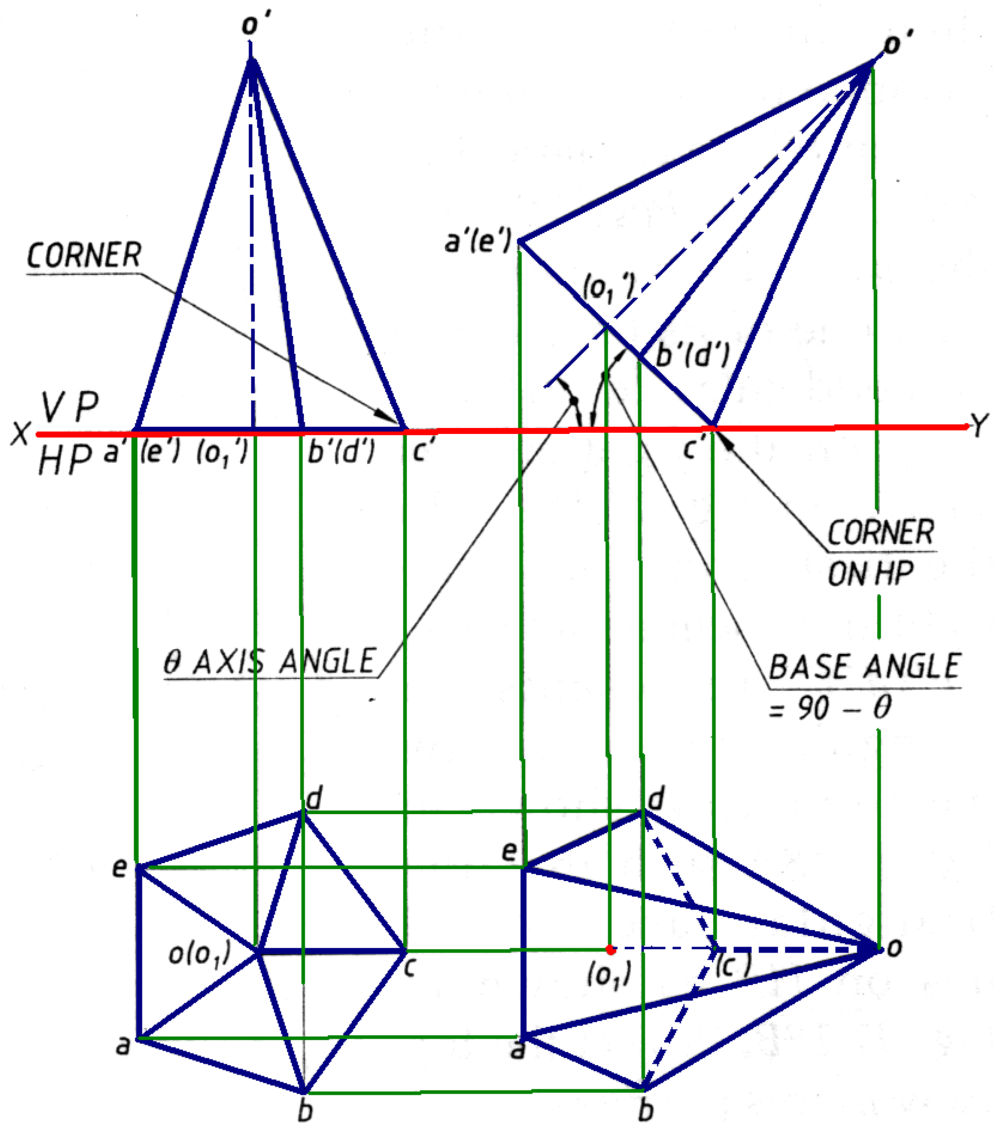
Since the prism **has to lie on one of its corners of the base on HP**, the front view of the prism is tilted on the corner **d_1'** such that the axis is inclined at **θ** to HP.

Redraw the front view in the tilted position. The base edge is drawn at (90-θ) in the front view.

The second top view is projected by drawing the vertical projectors from the corners of the second front view and horizontal projectors from the first top view.

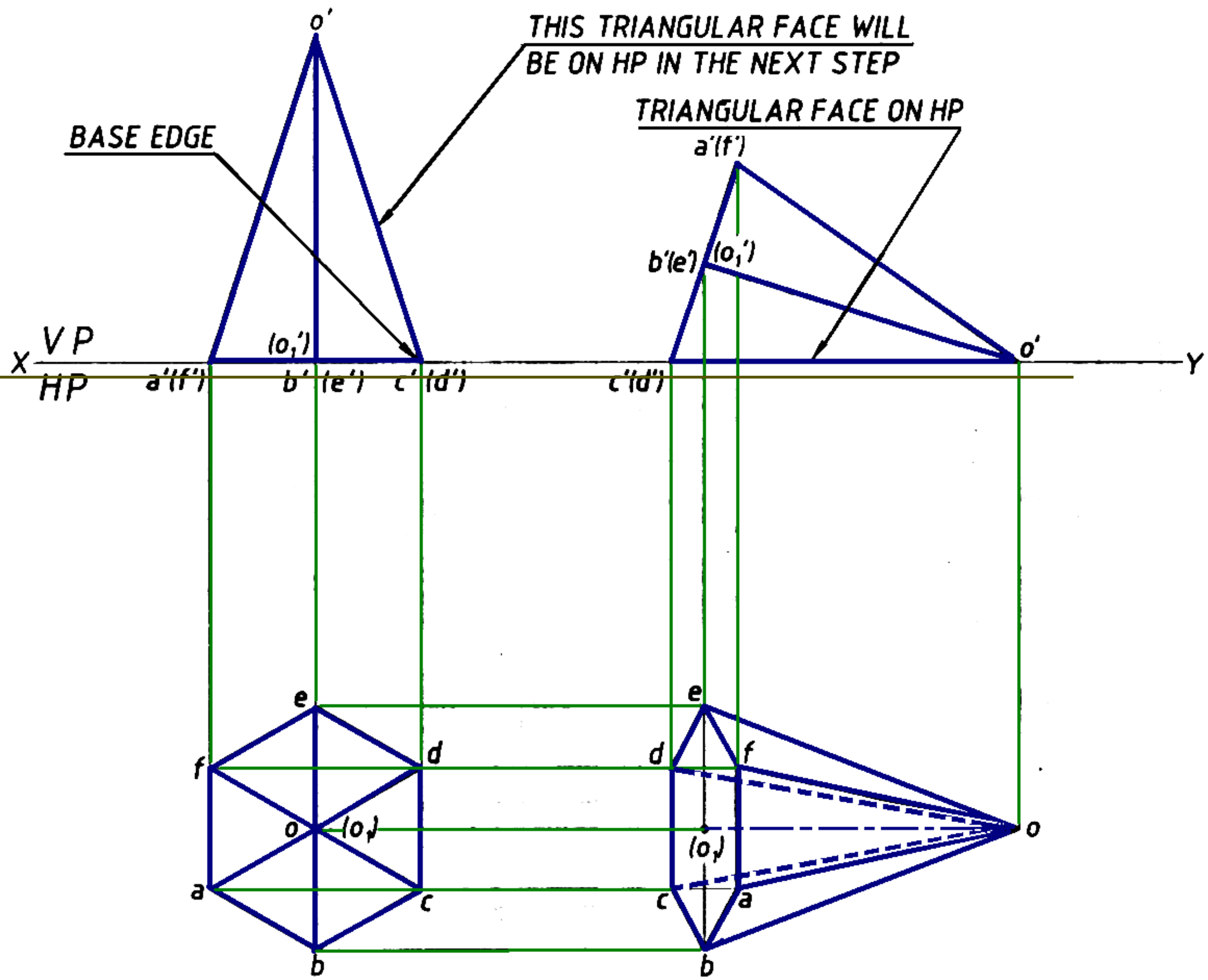


Case.2 for Pyramid: The top and front views of the pyramid when it rests on HP on one of its base corners such that the two base edges containing the corner on which it rests make equal inclination



Case-3 When a pyramid lies on one of its triangular faces on HP

If a pyramid has to be placed on one of its triangular faces on HP, then initially let the pyramid be placed with its base on HP.



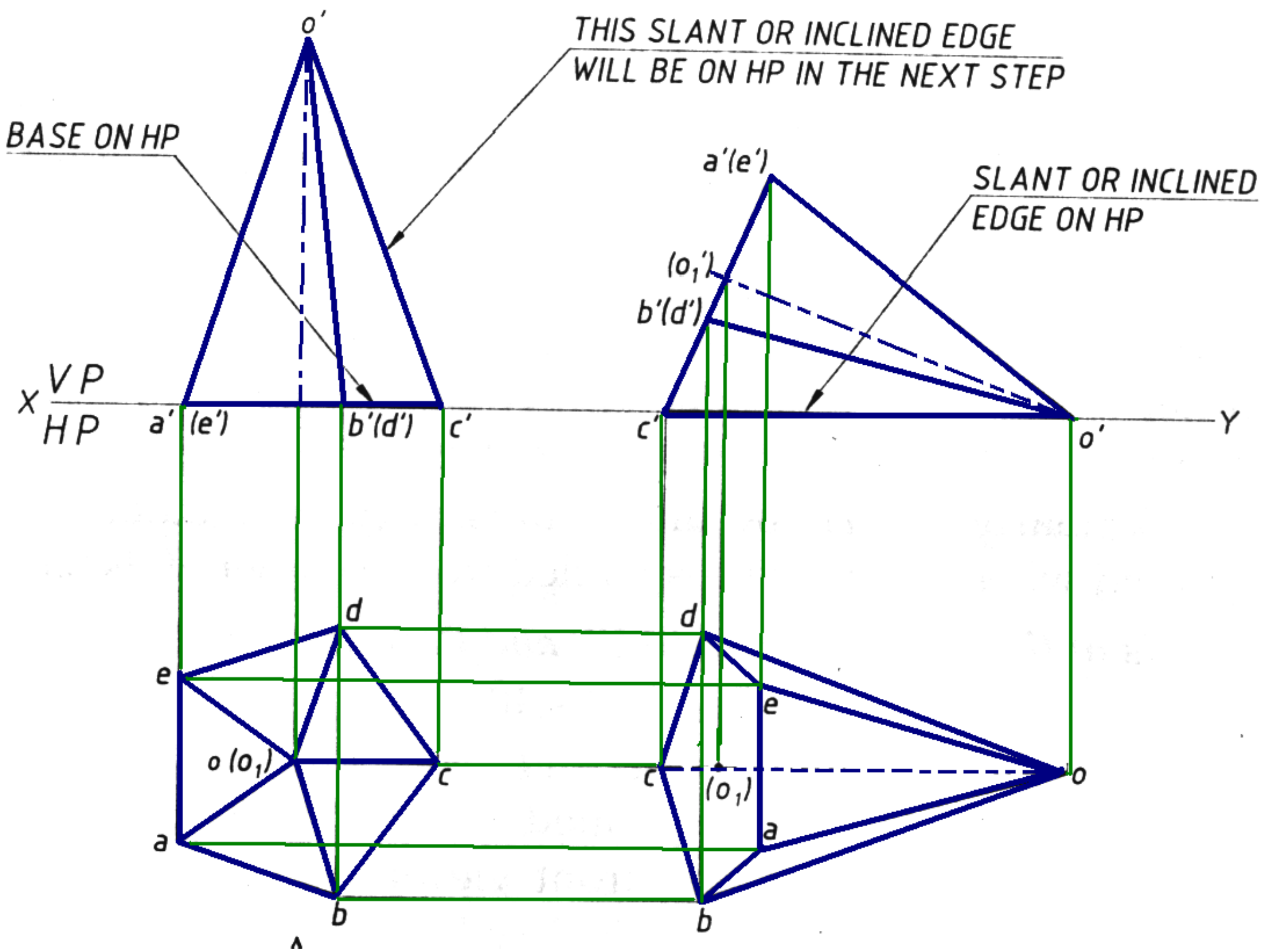
In the first front view, the right side inclined line, i.e., **o'c'(d')** represents a triangular face.

Redraw the front view such that the triangular face **o'c'(d')** lies on HP.

Project the top view in this position.

CASE-4: When a pyramid lies on one of its slant edges on HP

When a pyramid lies with one of its slant edges on HP, then two triangular faces containing the slant edge on which it rests make either **equal inclinations** or **different inclinations** with HP.



SOLID WITH AXIS INCLINED TO BOTH THE RPs

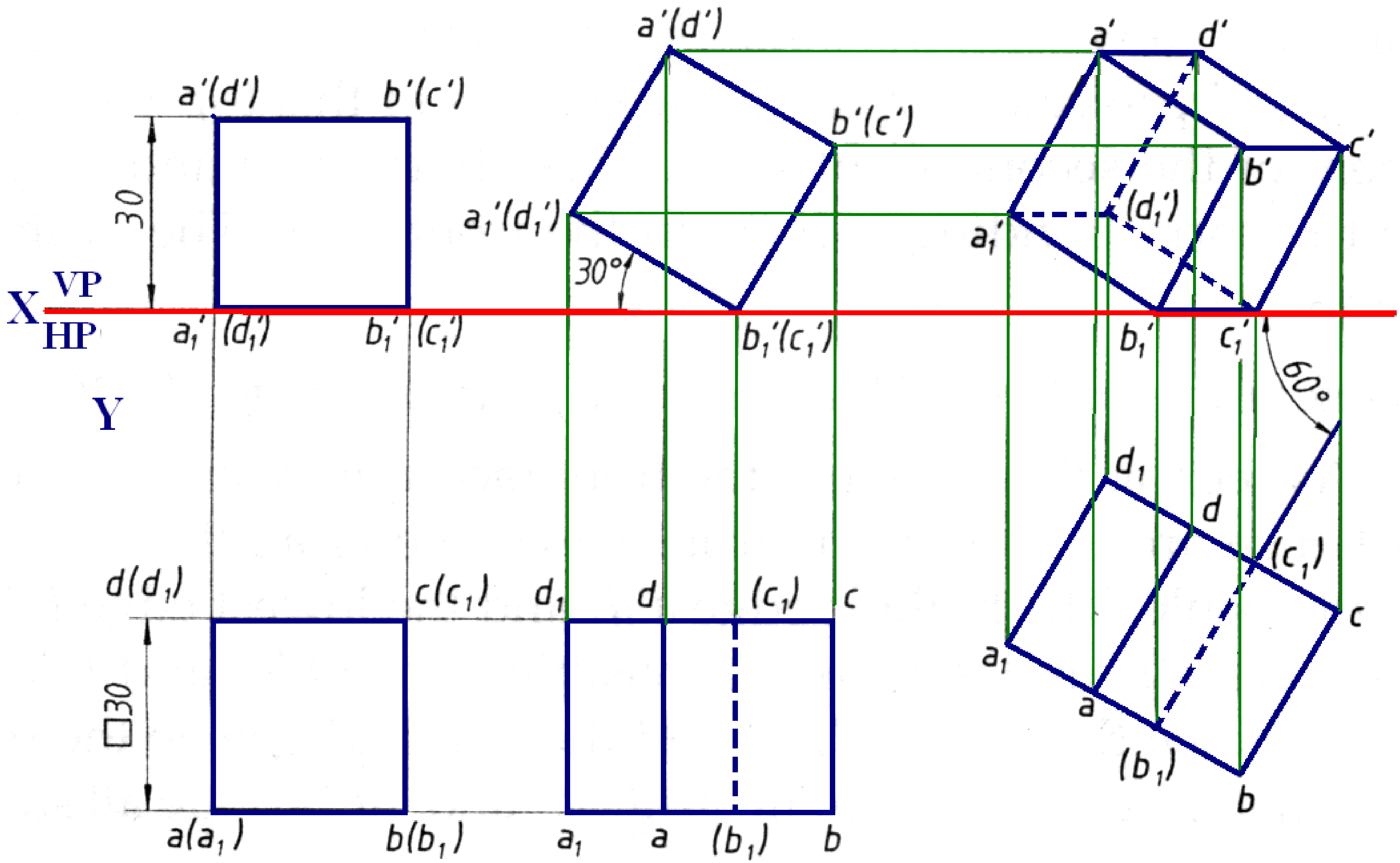
Methods of drawing the projections of solids

Two methods

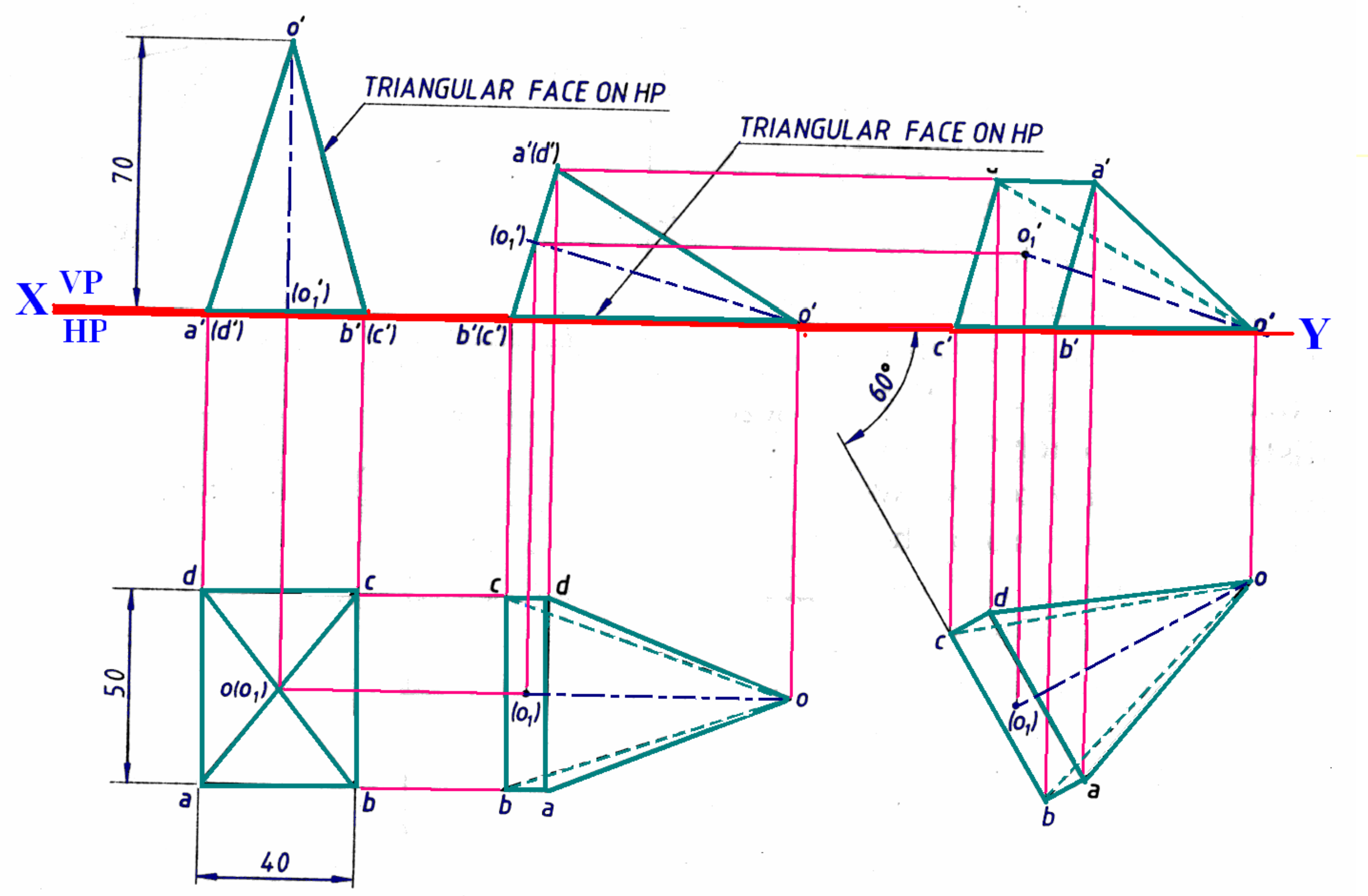
1. **Change of position method -** the solids are placed first in the simple position and then tilted successively in two or three stages to obtain the final position.

2. **Auxiliary plane method (Change of reference-line method) –** the solids are placed initially in the simple position and then one or two auxiliary planes are setup to obtain the views in the required position.

Problem.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 30⁰ to HP and the edge on which it rests being inclined to 60⁰ to VP. Draw its projections.

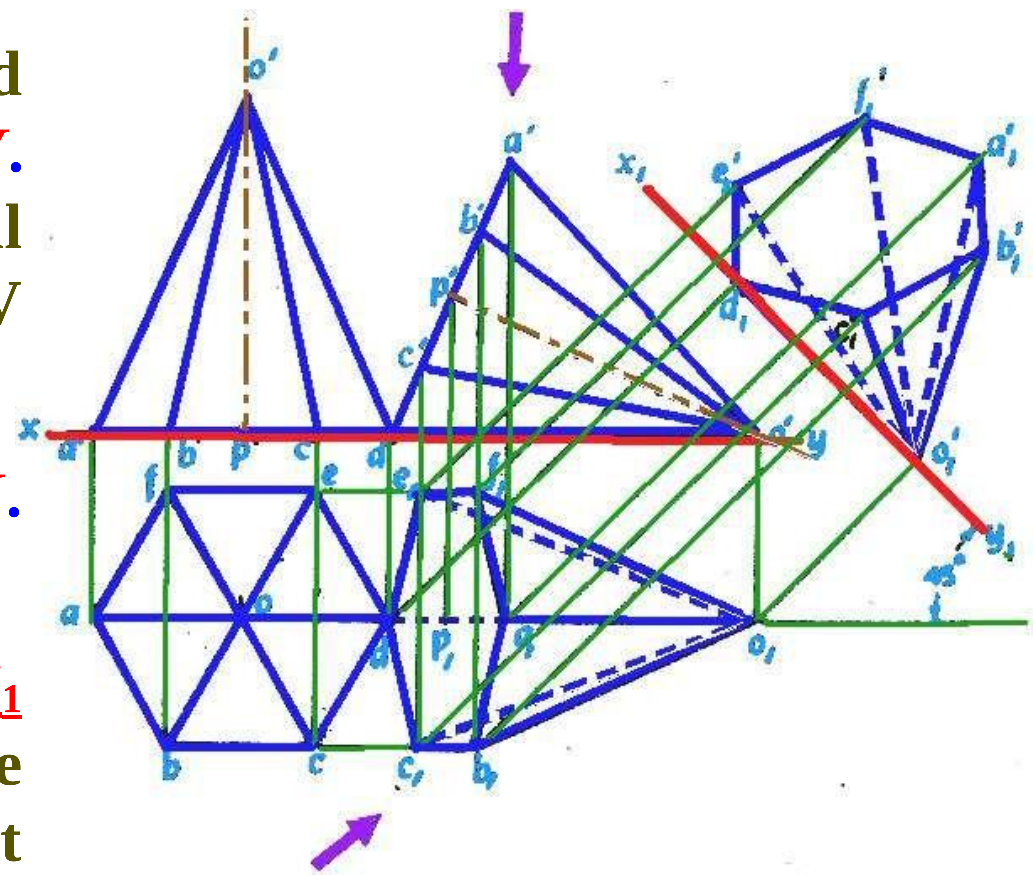


Problem2. **Draw the top and front views of a rectangular pyramid of sides of base 40x 50 mm and height 70 mm when it lies on one of its larger triangular faces on HP. The longer edge of the base of the triangular face lying on HP is inclined at 60^0 to VP in the top view with the apex of the pyramid being nearer to VP.**



Problem-3: A Hexagonal Pyramid, base 25 mm side and axis 55 mm long, has one of its slant edges on the ground. A plane containing that edge and the axis is perpendicular to the HP and inclined at 45^0 to VP. Draw the projections when the apex is nearer to the VP than the base.

Draw the TV of the pyramid with a side of base parallel to XY. The slant edges AO and DO will also be parallel to XY. Draw FV also.

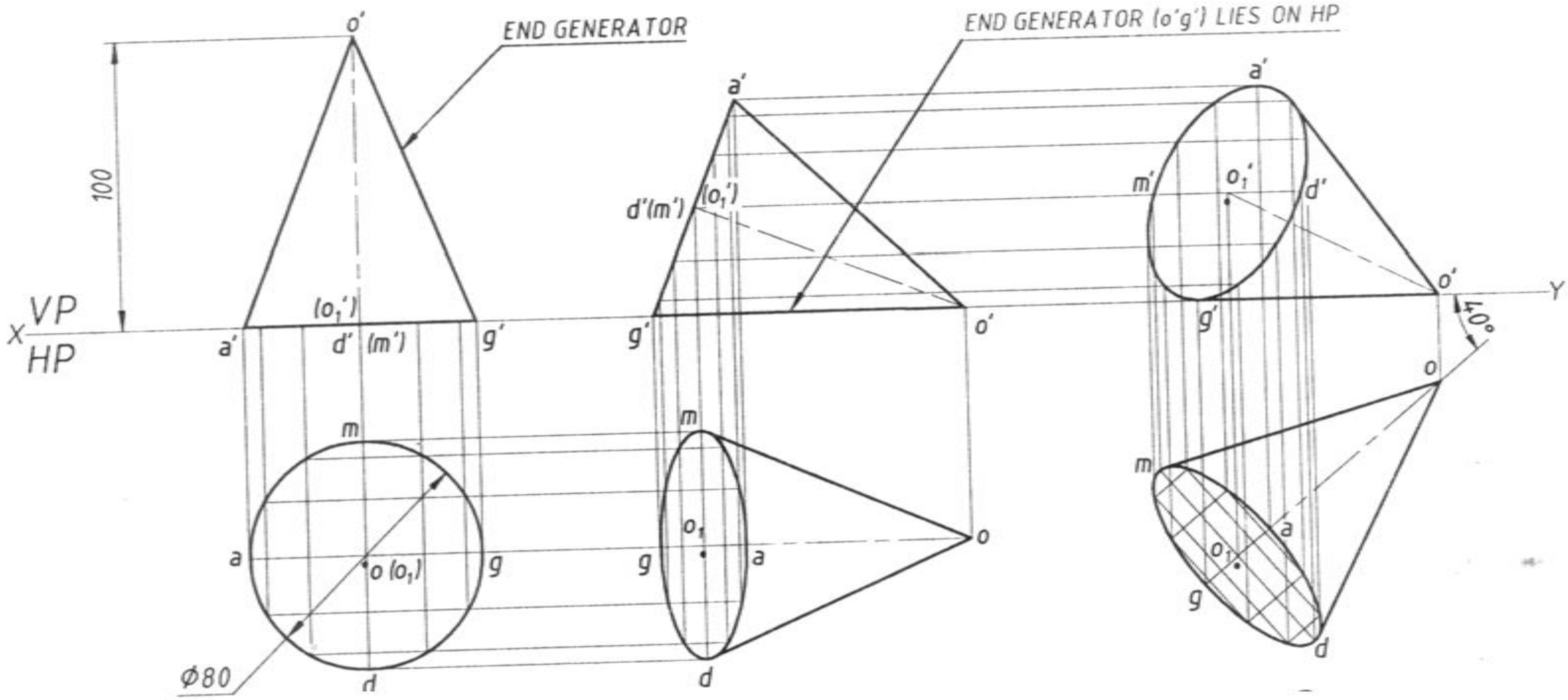


Tilt the FV so that d'o' is in XY. Project the second TV.

Draw a <u>new reference line X_1Y_1</u> making 45^o angle with o_1p_1 (the top view of the axis) and project the final FV.

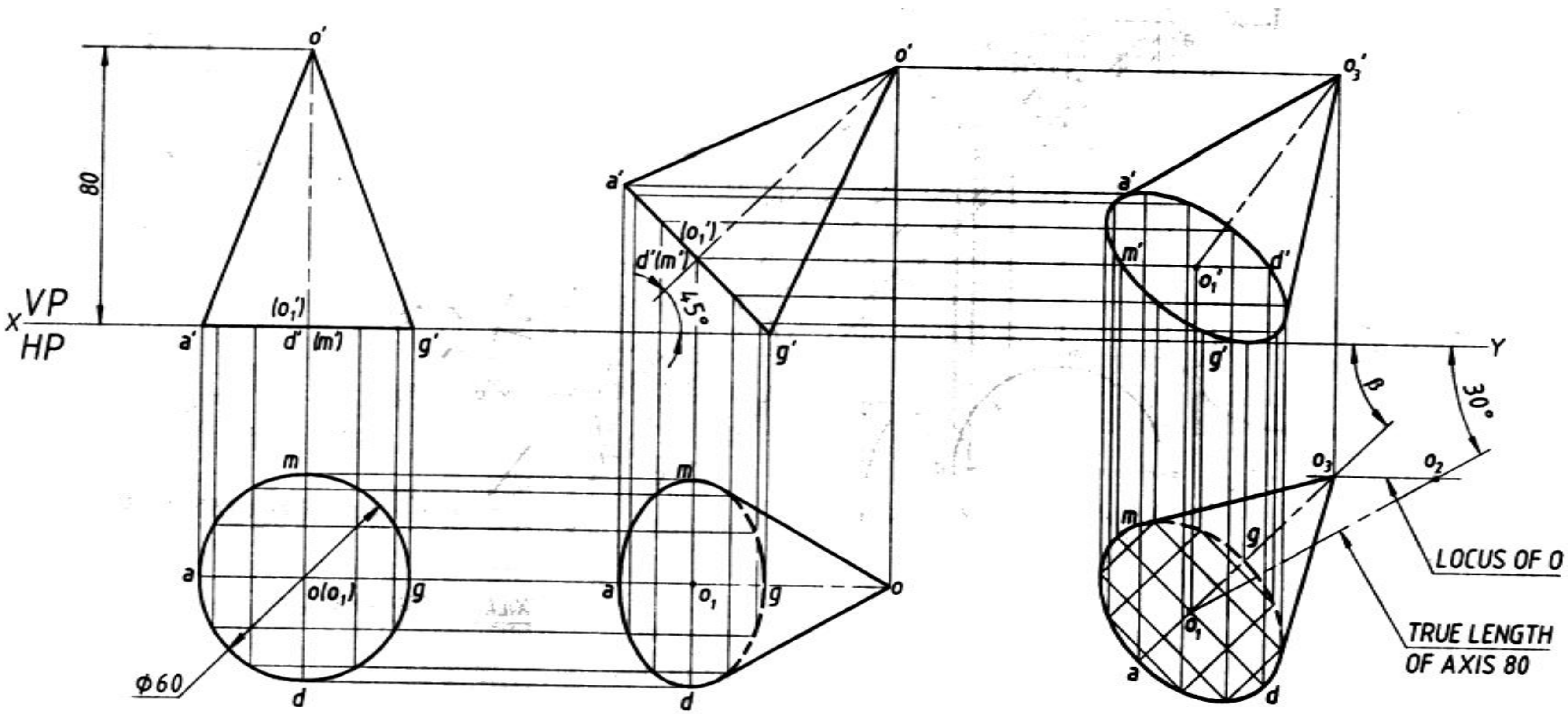
Problems on cones

Problem4. **A cone of base 80 mm diameter and height 100 mm lies with one of its generators on HP and the axis appears to be inclined to VP at an angle of 40^0 in the top view. Draw its top and front views.**



Problem5.

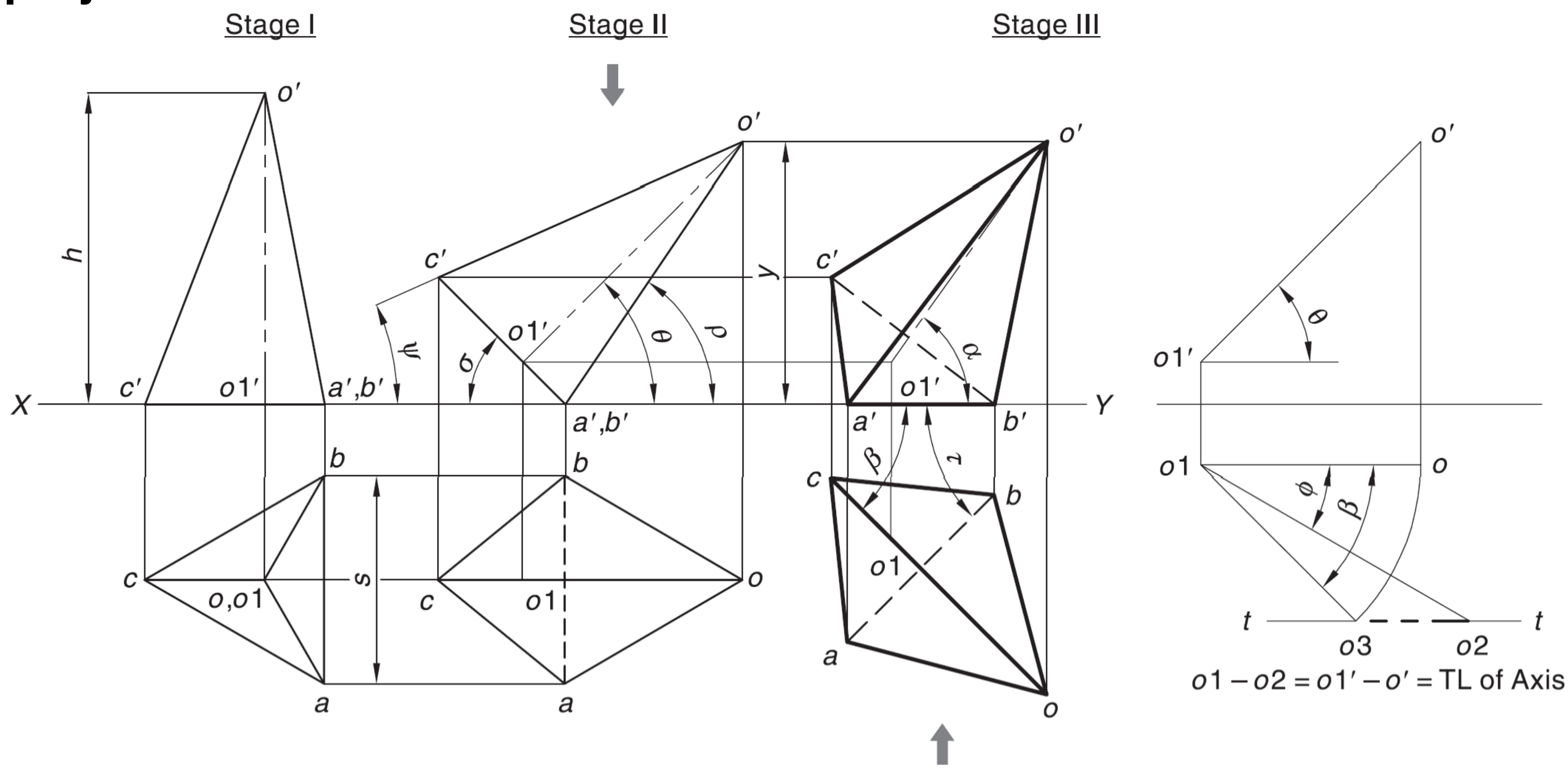
- A cone of base 60 mm diameter and the axis 80 mm long lies on HP with its axis inclined at 45^0 and 30^0 to HP and VP, respectively. Draw the top and front views of the cone.



SOLID WITH AXIS INCLINED TO BOTH THE RPs

If the axis of a solid is inclined to both the RPs then the problem is solved in three stages.

Example: A triangular pyramid of edge of base ‘s’ mm and length of axis ‘h’ mm is resting on a side of base on the HP. The axis of the pyramid is inclined at 8° **to the HP and ø° to the VP. Draw its projections.**



THANK YOU

Engineering Drawing

Sections of solids

Section Views

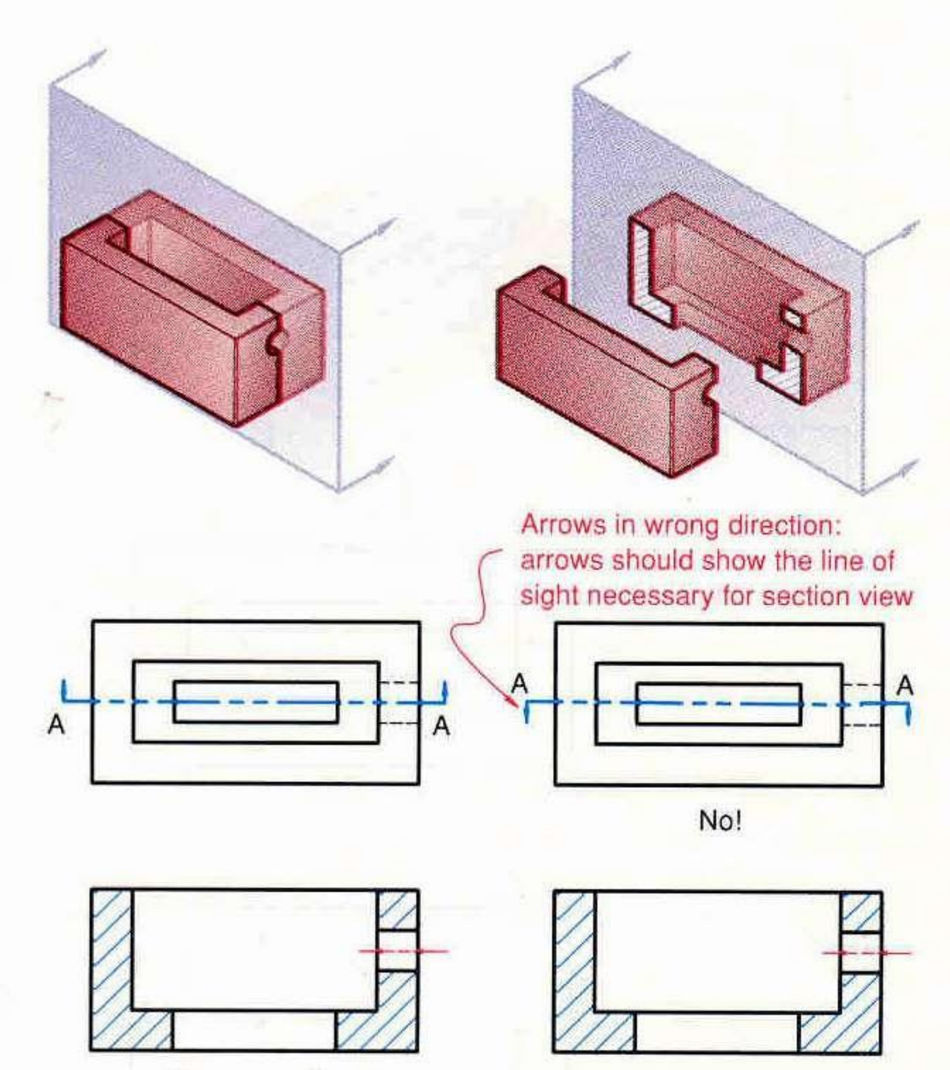
- Sectional drawings are multiview technical drawings that contain special views of a part or parts, views that reveal interior features.
- Used to improve clarity and reveal interior features of parts.
-

  interior features of complicated assemblies.
- 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.

Section Views

- **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 can (a) go completely through the object (full section); (b) go half-way through the object (half section);**
  (c) be bent to go through features that are not aligned (offset section); or (d) go through part of the object (broken-out section).

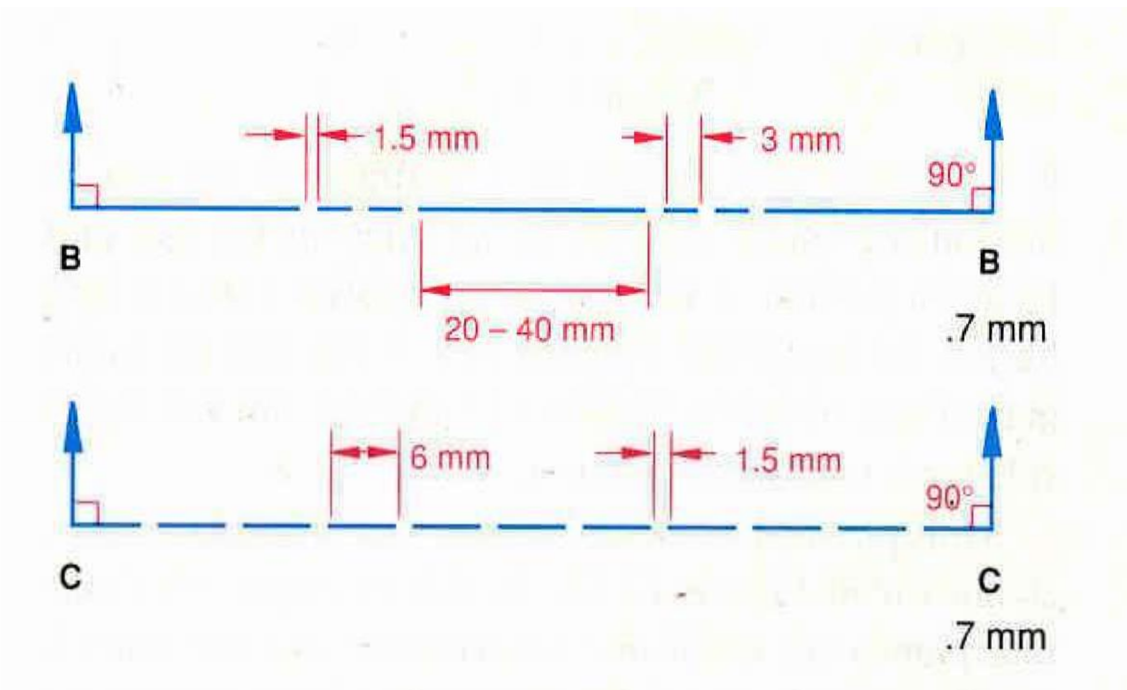
CUTTING PLANE LINES – which show where the cutting plane passes through the object, represent the *edge view* of the cutting plane and are drawn in the view(s) adjacent to the section view.

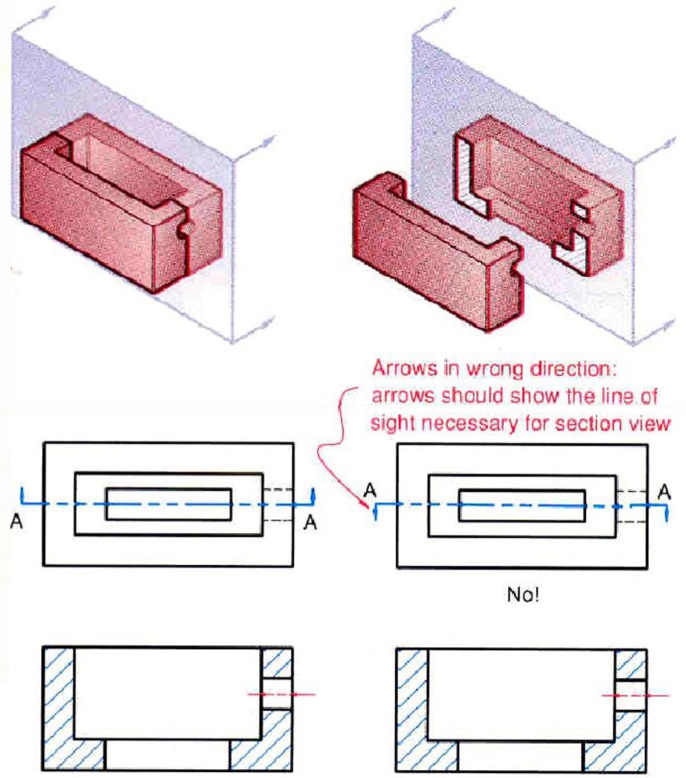


In the figure the cutting plane line is drawn in the top view, which is adjacent to the sectioned front view.

Cutting plane lines are ***thick*** **(0.7 mm) dashed lines**, that extend past the edge of the object **6 mm** and have line segments at each end drawn at **90 degrees and terminated with arrows.**

The arrows represent the direction of the line of sight for the section view and they point away from the sectioned view. Two types of lines are acceptable for cutting plane lines in multi-view drawings

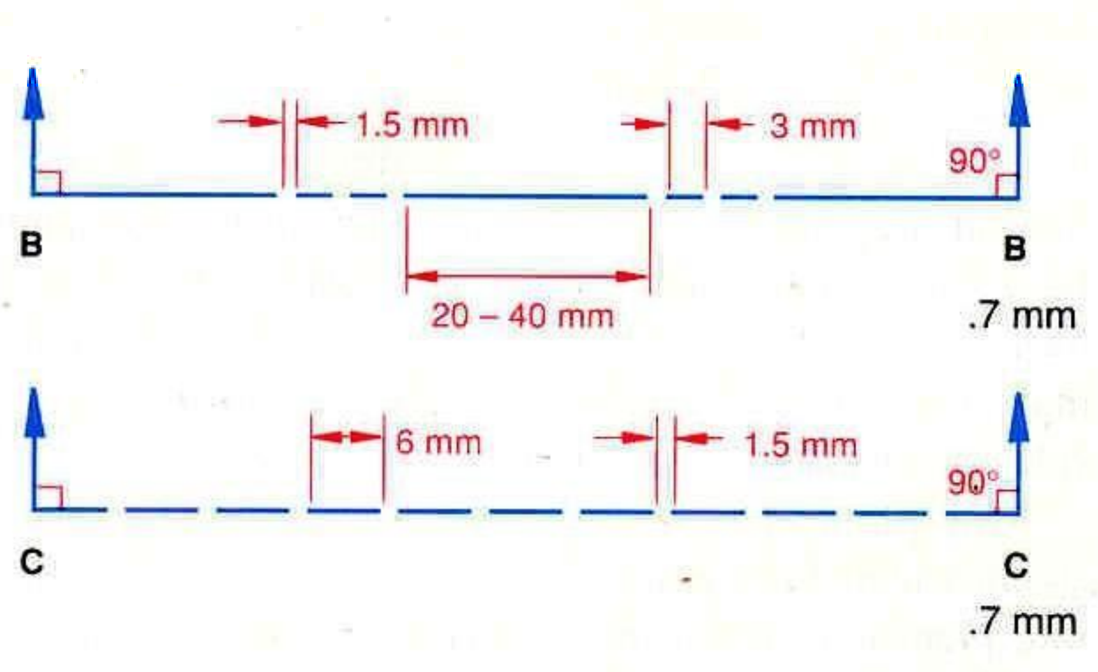




Line B-B is composed of alternating **long and two short dashes**, which is one of the two standard methods.

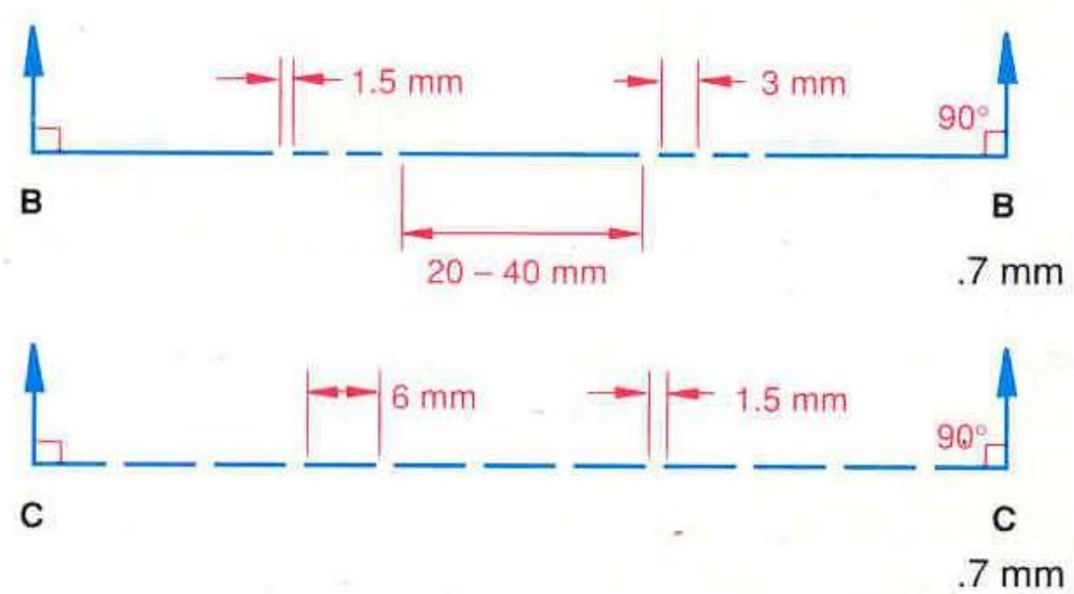
The length of the long dashes varies according to the size of the drawing, and is approximately **20 to 40** mm.

For a very large section view drawing, the long dashes are made very long to save drawing time. The short dashes are approximately **3 mm** long.

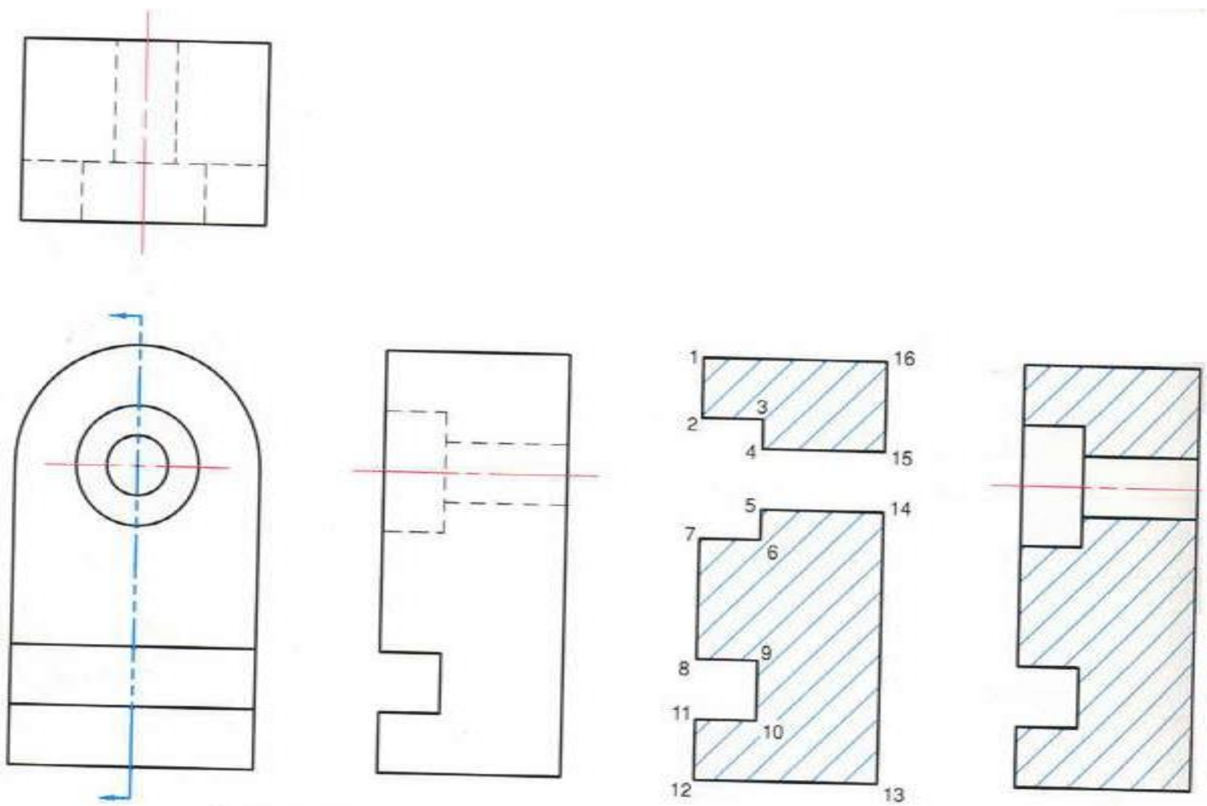


The open space between the lines is approximately 1.5 mm. **Capital letters are placed at each end of the cutting plane line, for clarity or when more than one cutting plane is used on a drawing.**

The second method used for cutting plane lines is shown by line C-C, which is composed of equal-length dashed lines. Each dash is approximately 6 mm long, with a 1.5 mm space between.



If the cutting plane line is in the same position as a center line, the cutting plane line has precedence.



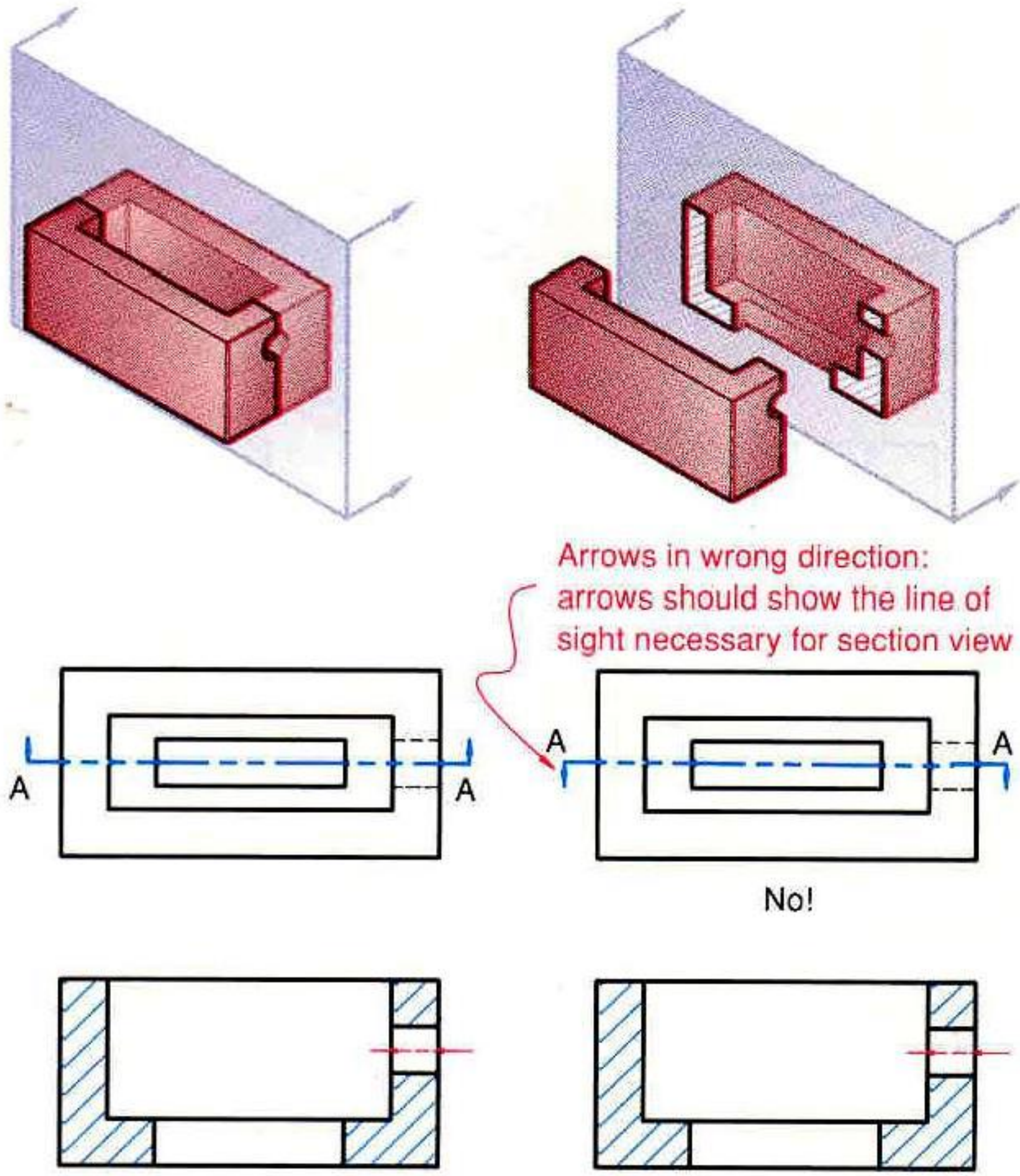
Normal multiview drawing

(A)

(B)

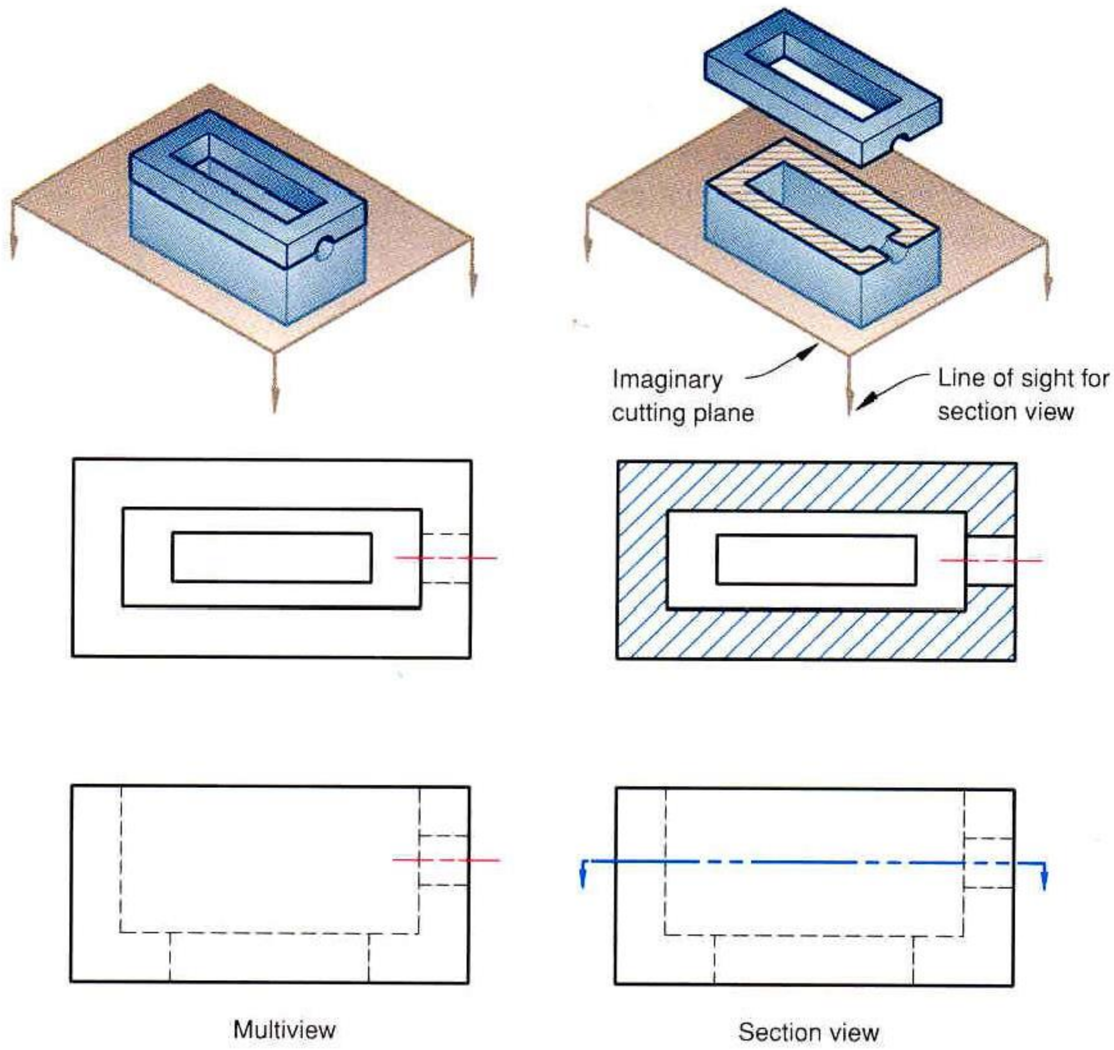
Types of Cutting Planes and Their Representation

- Frontal or Vertical Cutting/ Section Plane
- Horizontal Cutting/ Section Planes
- Profile Cutting / Section Planes
- Auxiliary Section Plane
  - Auxiliary Inclined Plane (AIP)
  - Auxiliary Inclined Plane (AVP)
- Oblique Section Plane



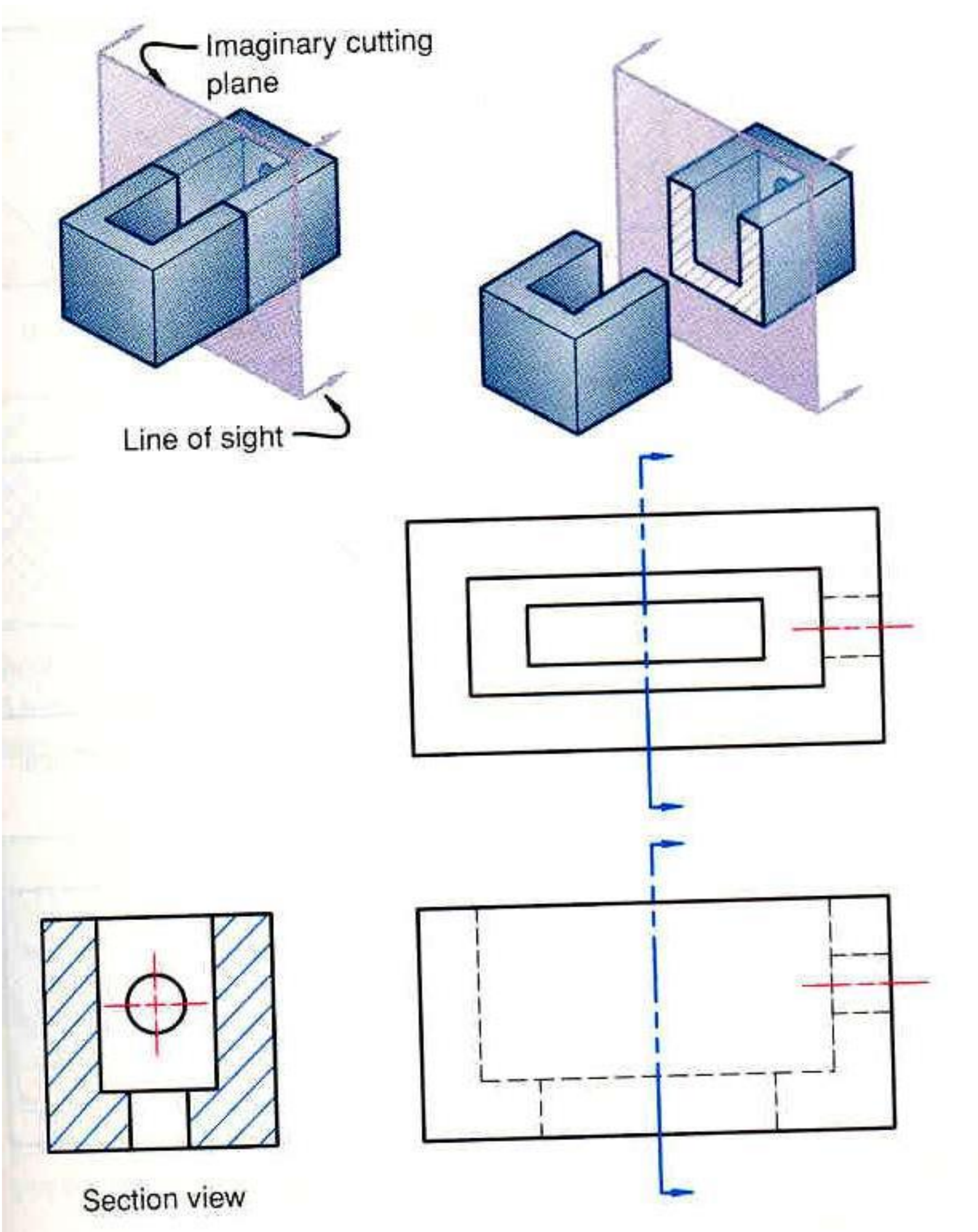
In this figure, the cutting plane appears **as an edge in the top view and is normal in the front view;** therefore, it is a ***frontal cutting plane*** *or* ***Vertical Section Plane****.*

The front half of the object is "**removed**" and the front view is drawn in section.



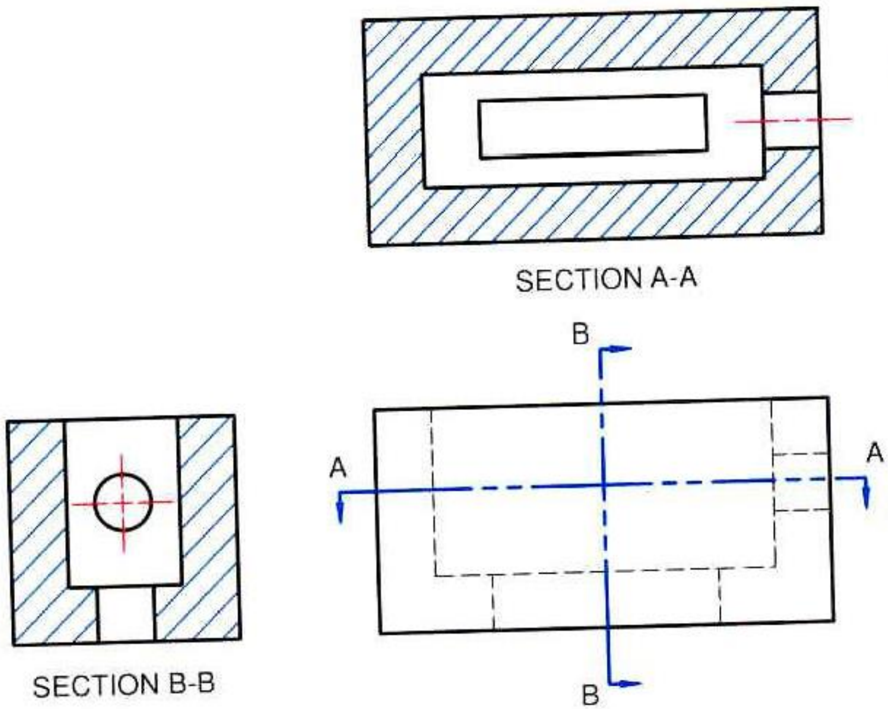
If the cutting plane appears as an **edge in the front view and is normal in the top view**, it is a **horizontal cutting/section plane**.

The top half of the object is "removed" and the top view is drawn in section.



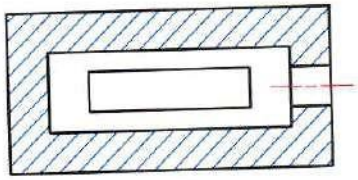
If the cutting plane appears **as an edge in the top and front views** and is **normal in the profile view**, it is a **profile cutting/section plane**.

The left (or righ) half of the object is "removed" and the left (or right) side view is drawn in section.



Multiple sections can be done on a single object, as shown in the figure. In this example, two cutting planes are used: one a horizontal and the other a profile cutting plane. Both cutting planes appear on edge in the front view, and are represented by cutting plane lines **A-A** and **B-B**, respectively. Each cutting plane will create a section view, and each section view is drawn as if the other cutting plane did not exist.

Section Line Practices



Section lines or cross-hatch lines are added to a section view to indicate the surfaces that are cut by the imaginary cutting plane.

Different section line symbols can be used to represent various types of materials.

However, there are so many different materials used in engineering design that the general symbol (i.e., the one used for cast iron) may be used for most purposes on engineering drawings.

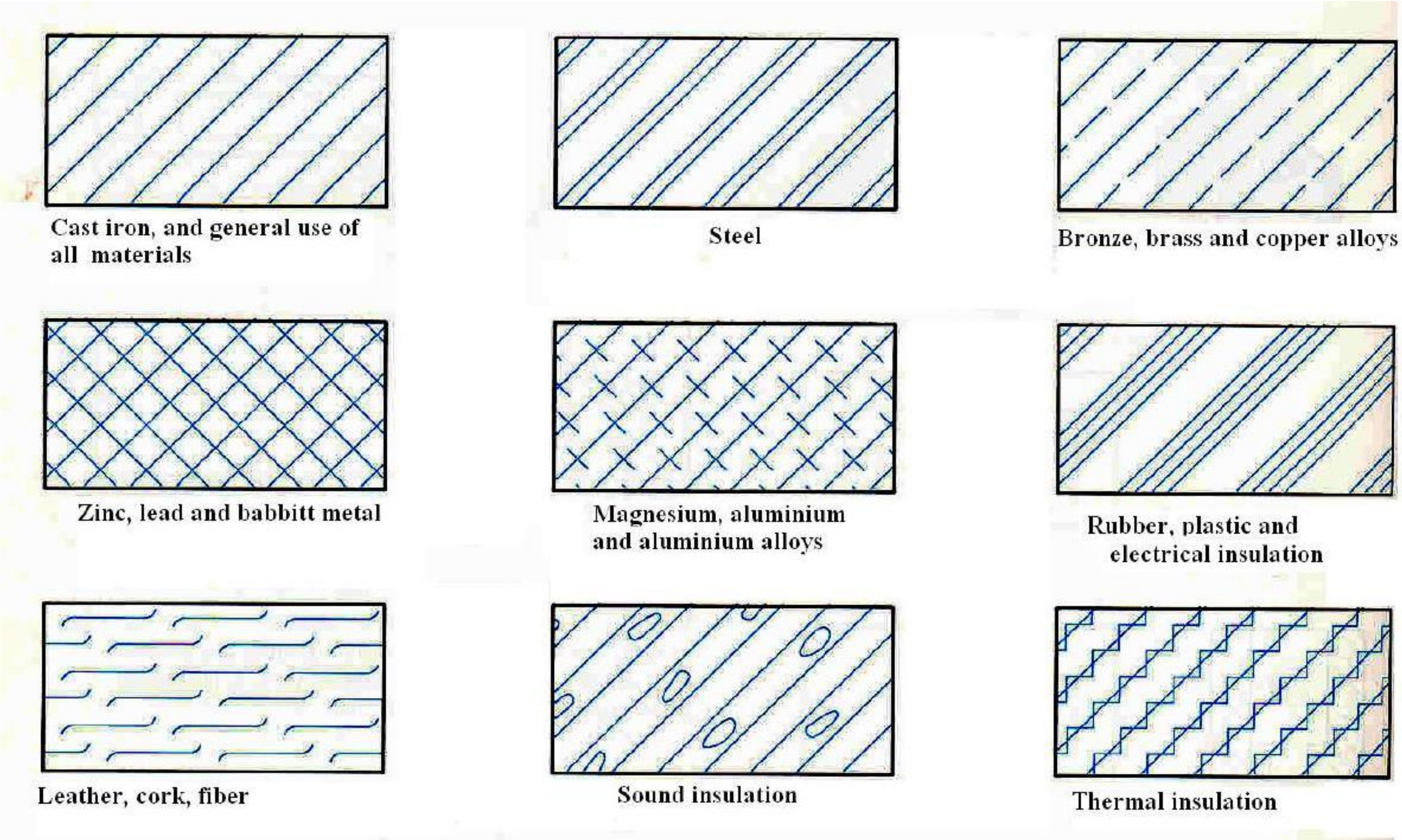
The actual type of material required is then noted in the title block or parts list or as a note on the drawing.

The angle at which lines are drawn is usually 45 degrees to the horizontal, but this can be changed for adjacent parts shown in the same section. Also the spacing between section lines is uniform on a section view.

Material Symbols

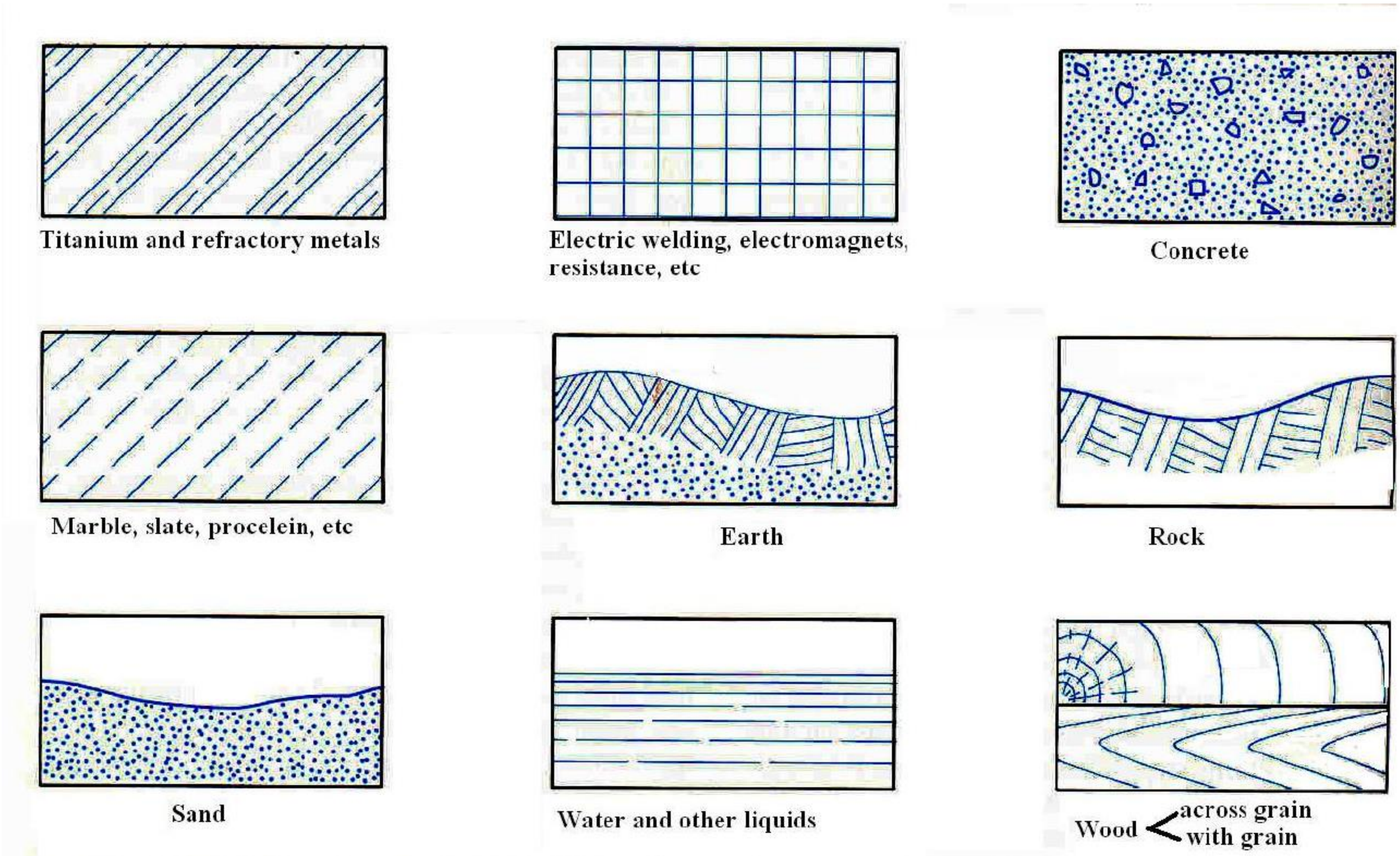
The type of section line used to represent a surface varies according to the type of material.

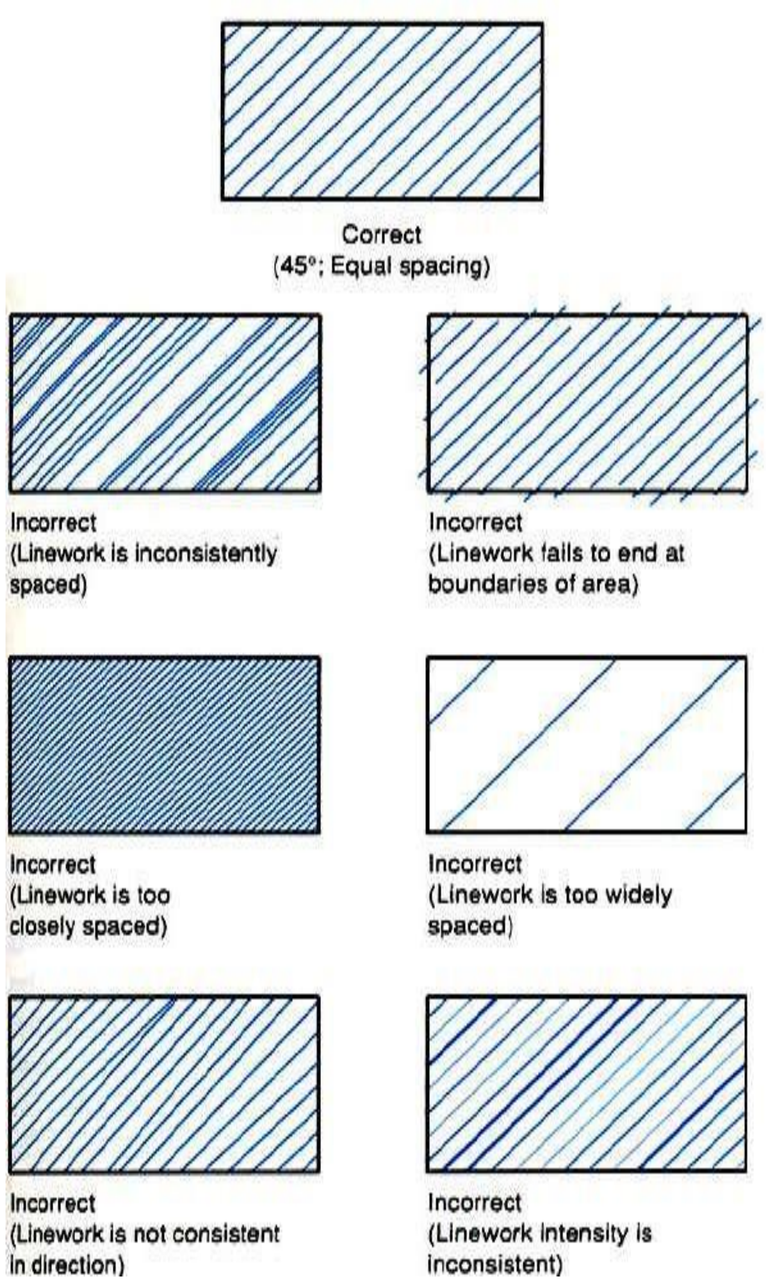
However, the general purpose section line symbol used in most section view drawings is that of *cast iron.*



The specific type of steel to be used will be indicated in the title block or parts list.

Occasionally, with assembly section views, material symbols are used to identify different parts of the assembly.





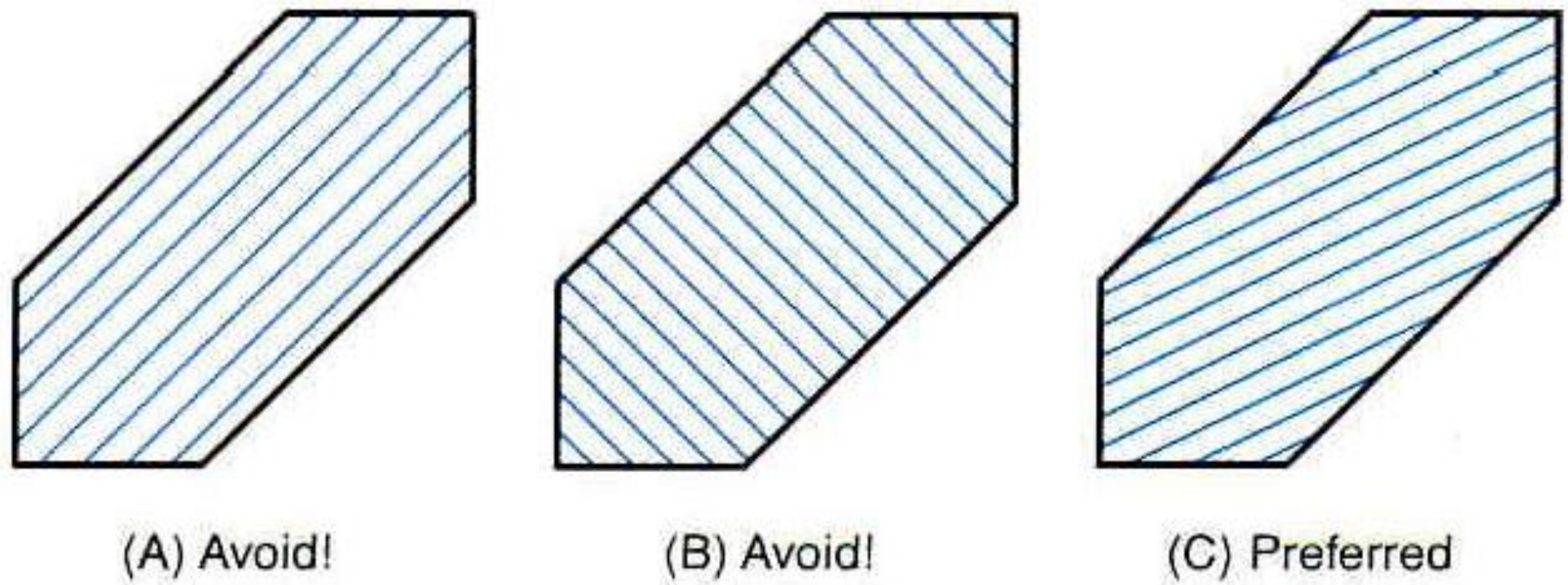
The general purpose cast iron section line is drawn at a 45-degree angle and spaced 1.5 mm to 3 mm or more, depending on the size of the drawing. As a general rule, use 3mm spacing. Section lines are drawn as thin (.35 mm) black lines, using an H or 2H pencil.

The section lines should be evenly spaced and of equal thickness, and should be thinner than visible lines

Also, do not run *section* lines beyond the visible outlines or stop them too short

Section lines should not run parallel or perpendicular to the visible outline.

If the visible outline to be sectioned is drawn at a 45-degree angle, the section lines are drawn at a different angle, such as 30 degrees.



Avoid placing dimensions or notes within the section lined areas. If the dimension or note must be placed within the sectioned area, omit the section lines in the area of the note

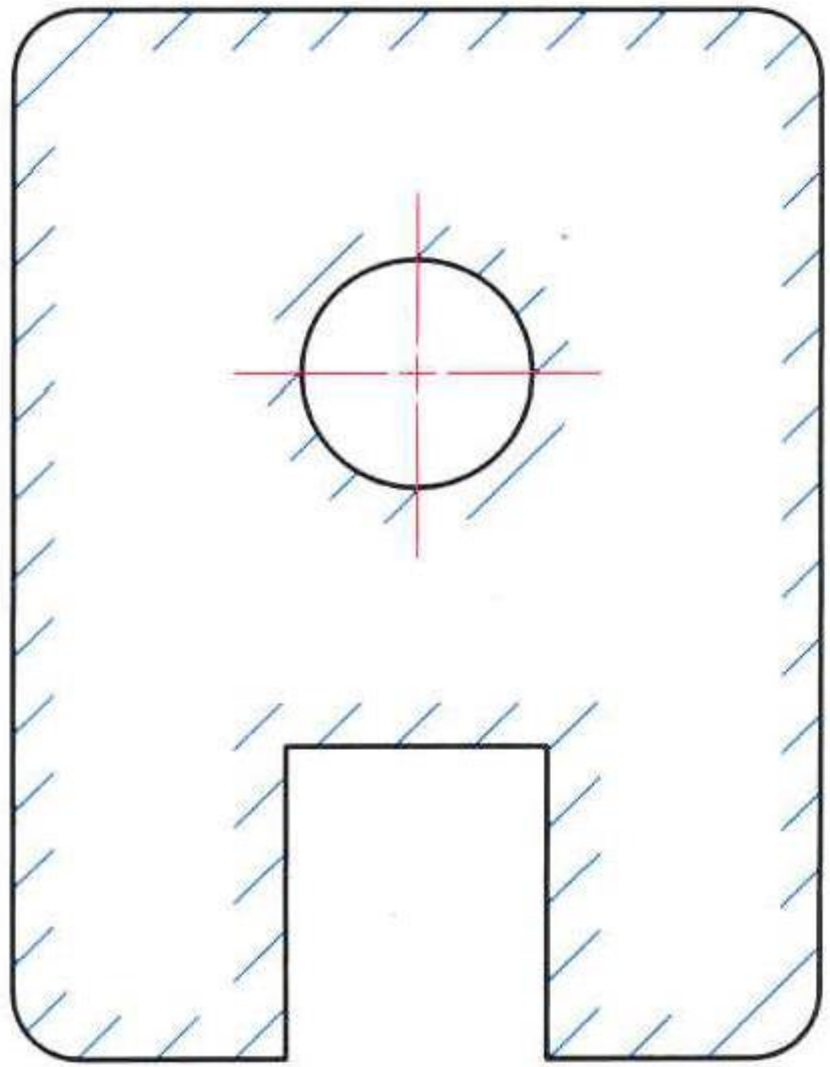
(A) Avoid!

(B) Preferred

(C) Preferred

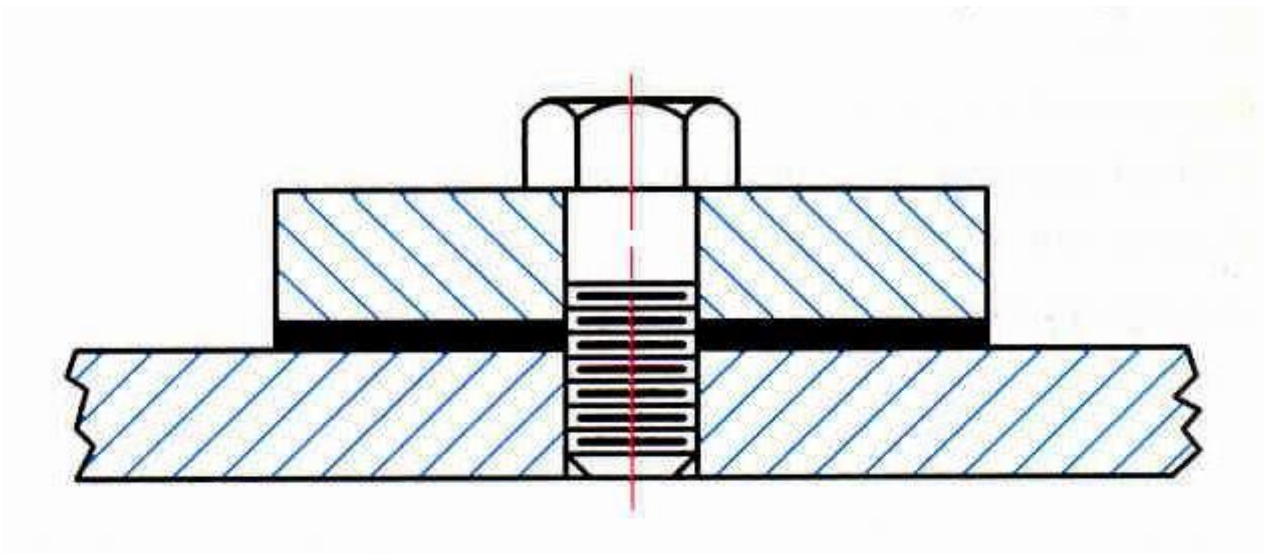
Outline Sections

An outline section view is created by drawing partial section outlines adjacent to all object lines in the section view. For large parts, outline sectioning may be used to save time.

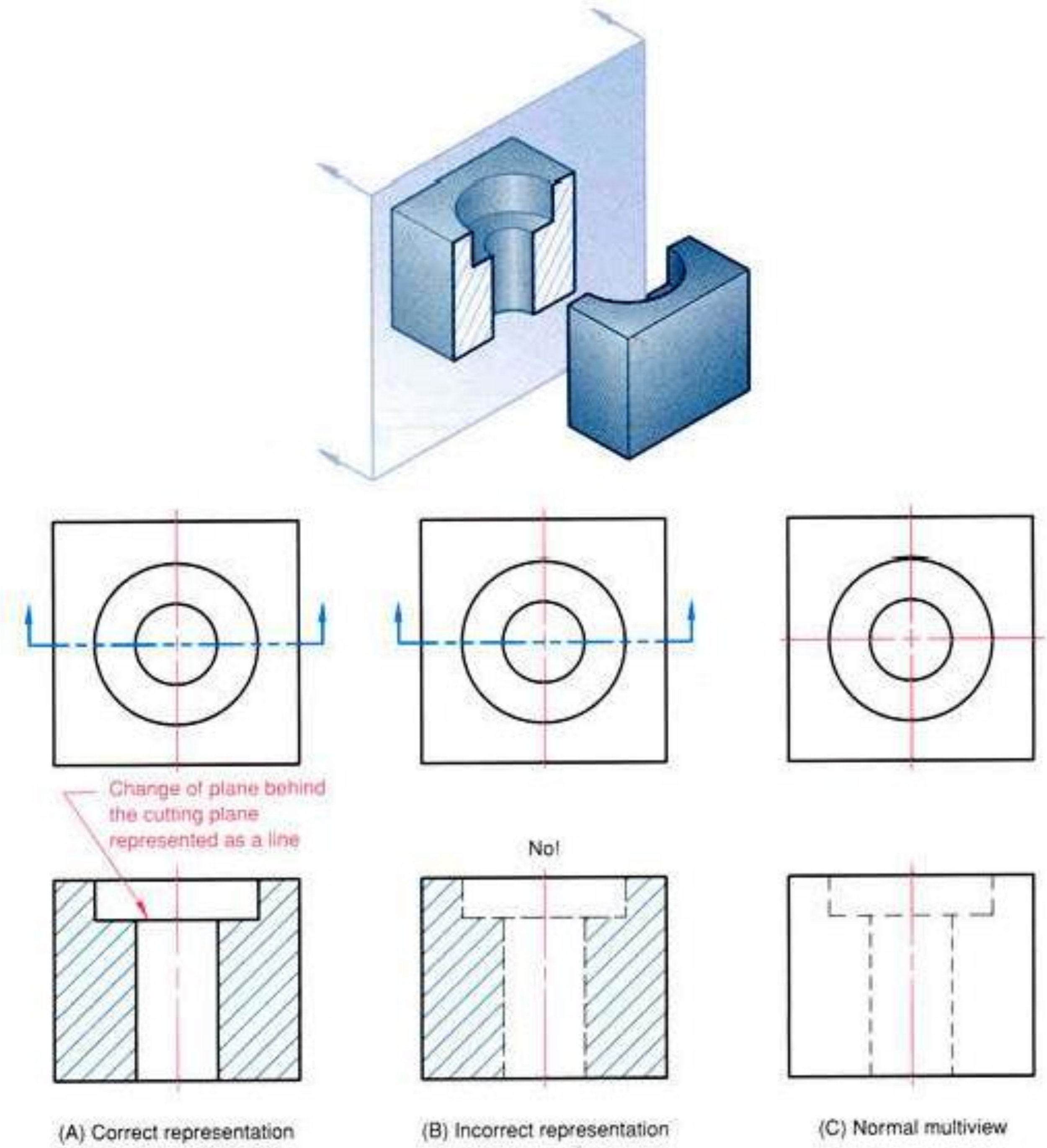


Thin Wall Sections

Very thin parts such as washers and gaskets are not easily represented with section lines, so conventional practice calls for representing the thin part in solid black.



Gasket is drawn solid black to show that it is sectioned

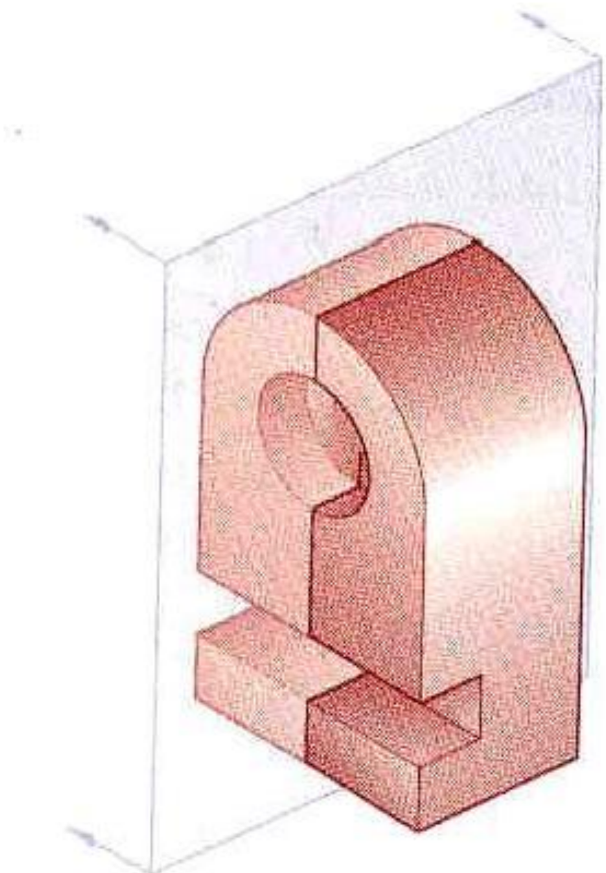


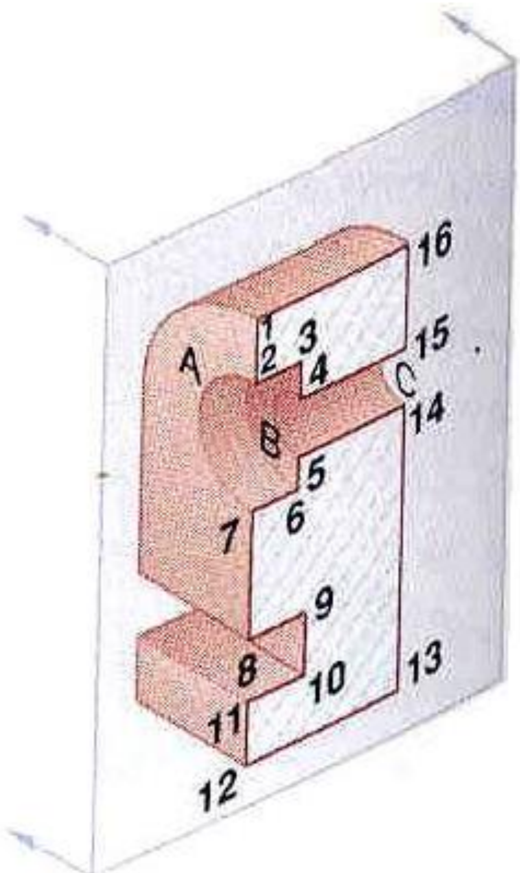
Section lined areas are bounded by visible lines, never by hidden lines, because the bounding lines are visible in the section view

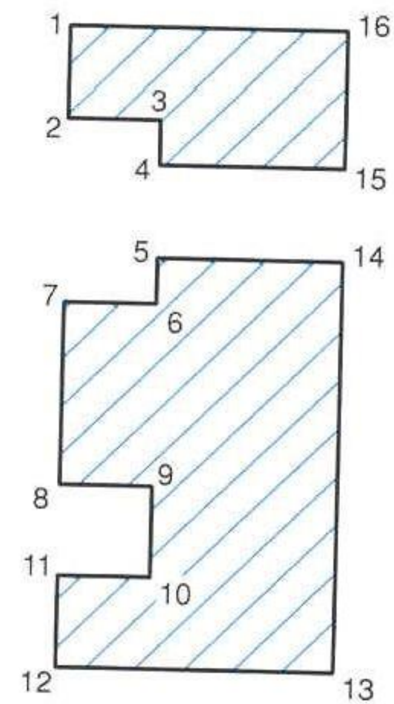
Points of Intersection (POI)

- Whenever a section plane cuts a solid, it intersects (and or coincides with) the edges of solids. The point at which the section plane intersects an edge of the solid is called the point of intersection (POI).

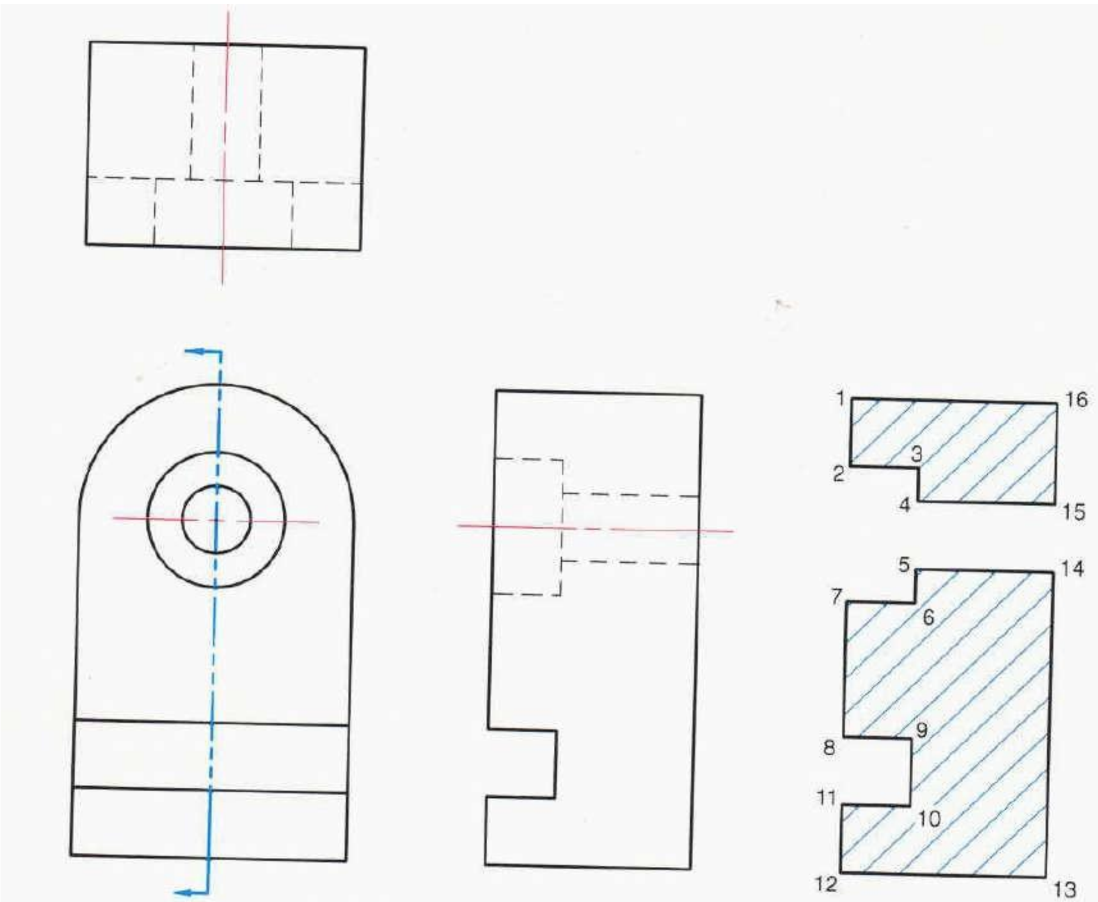
A section view is created by passing an imaginary cutting plane vertically through the center of the part. This figure is a 3D representation of the part after it is sectioned. This section view more clearly shows the interior features of the part. The corners of the section view are numbered so that they can be compared with the orthographic section view.



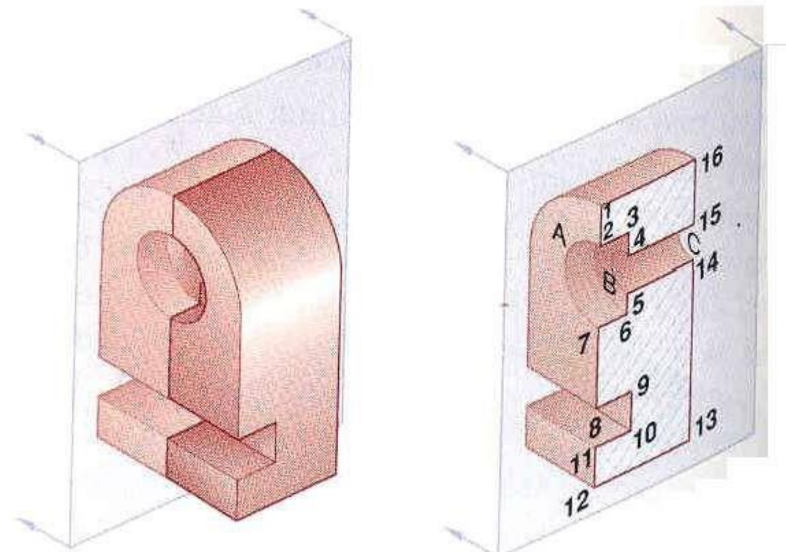




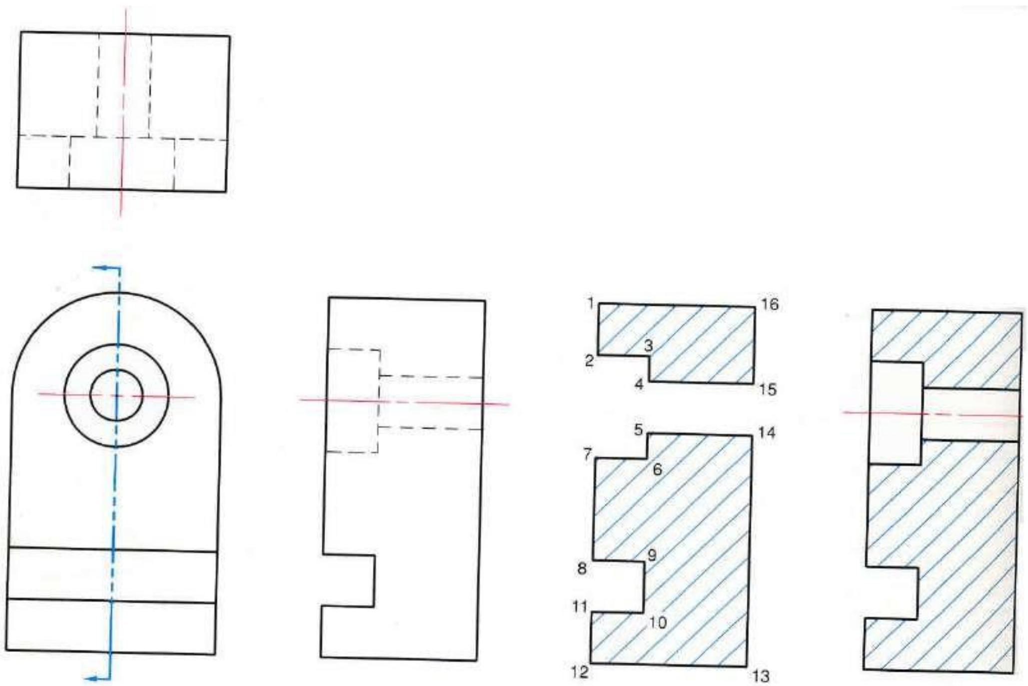
The line of sight for the section view is perpendicular to the cut surfaces, which means they are drawn true size and shape in the section view. Also, no hidden lines are drawn and all visible surfaces and edges behind the cutting plane are drawn as object lines.



Normal multiview



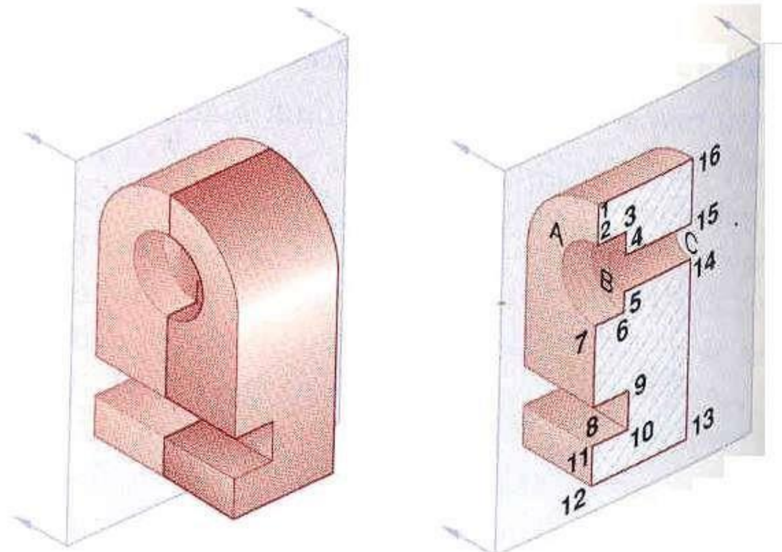
All the surfaces touched by the cutting plane are marked with section lines. Because all the surfaces are the same part, the section lines are identical and are drawn in the same direction. The center line is added to the counter bored hole to complete the section view.



Normal multiview drawing

(A)

(B)

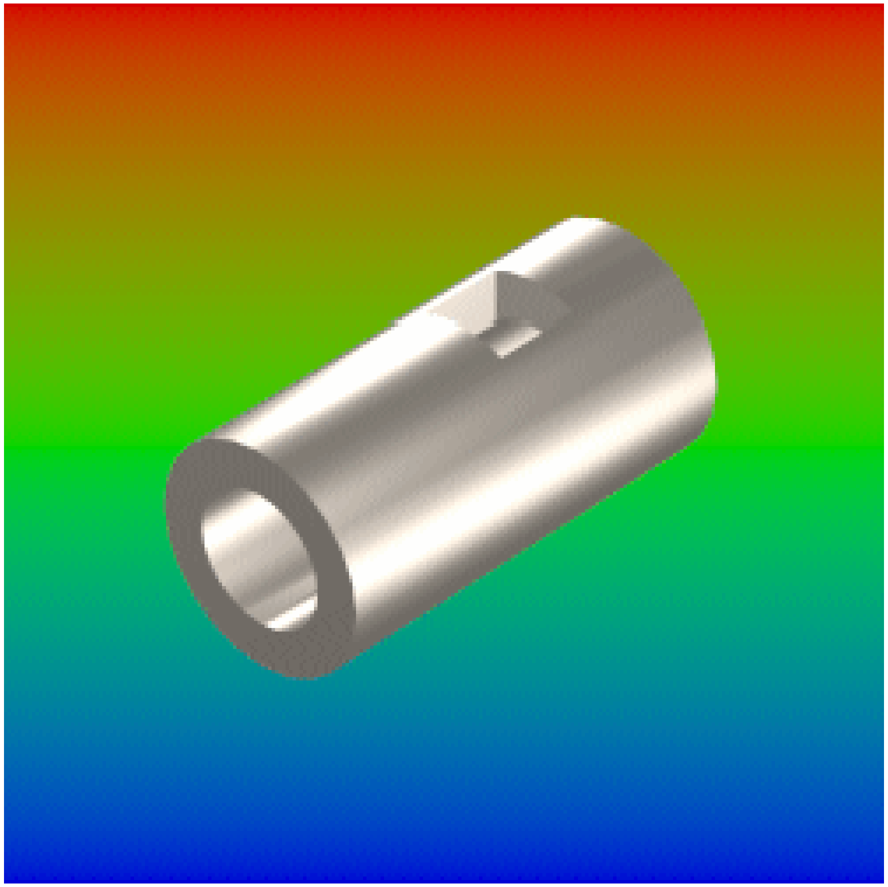


Types of Section Views

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

Full Section View

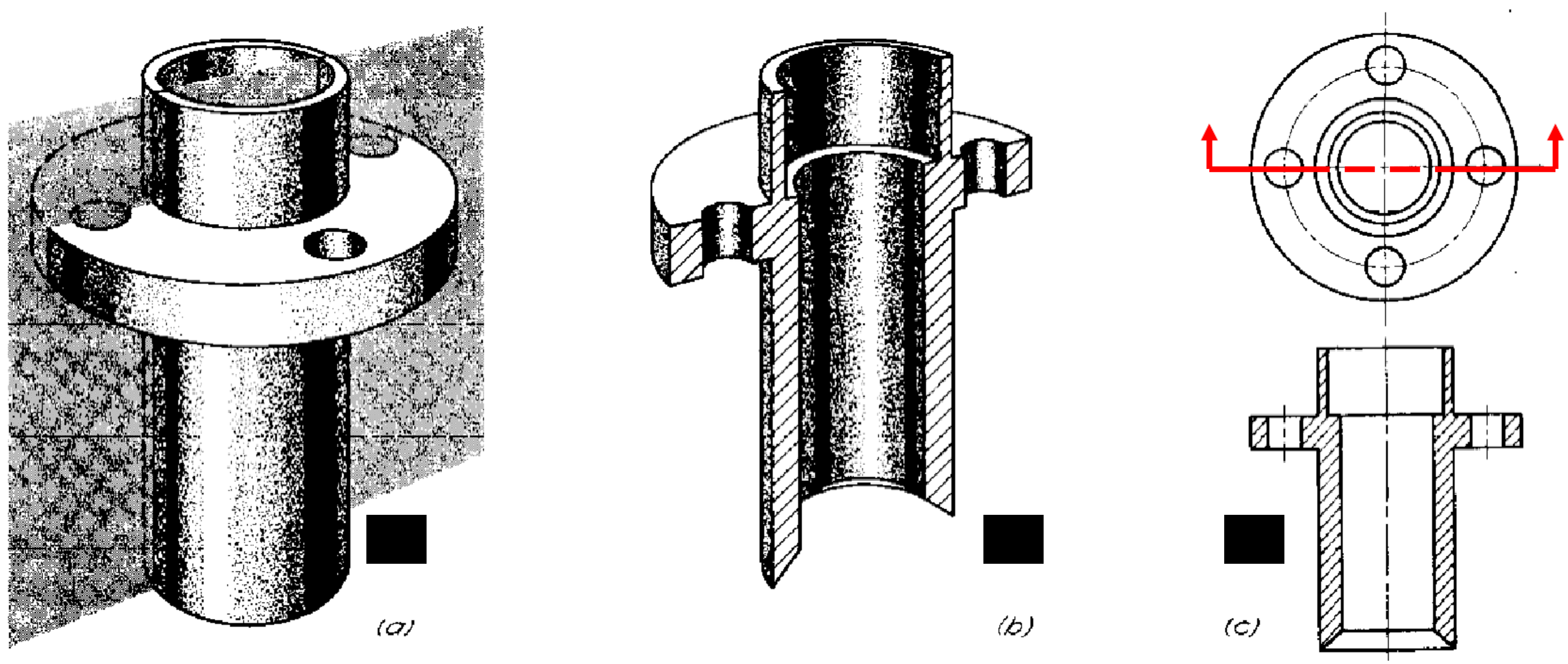
- **In a full section view, the cutting plane cuts across the entire object**
- **Note that hidden lines become visible in a section view**



Full Section View

- Show cutting plane in the top view – New line type –

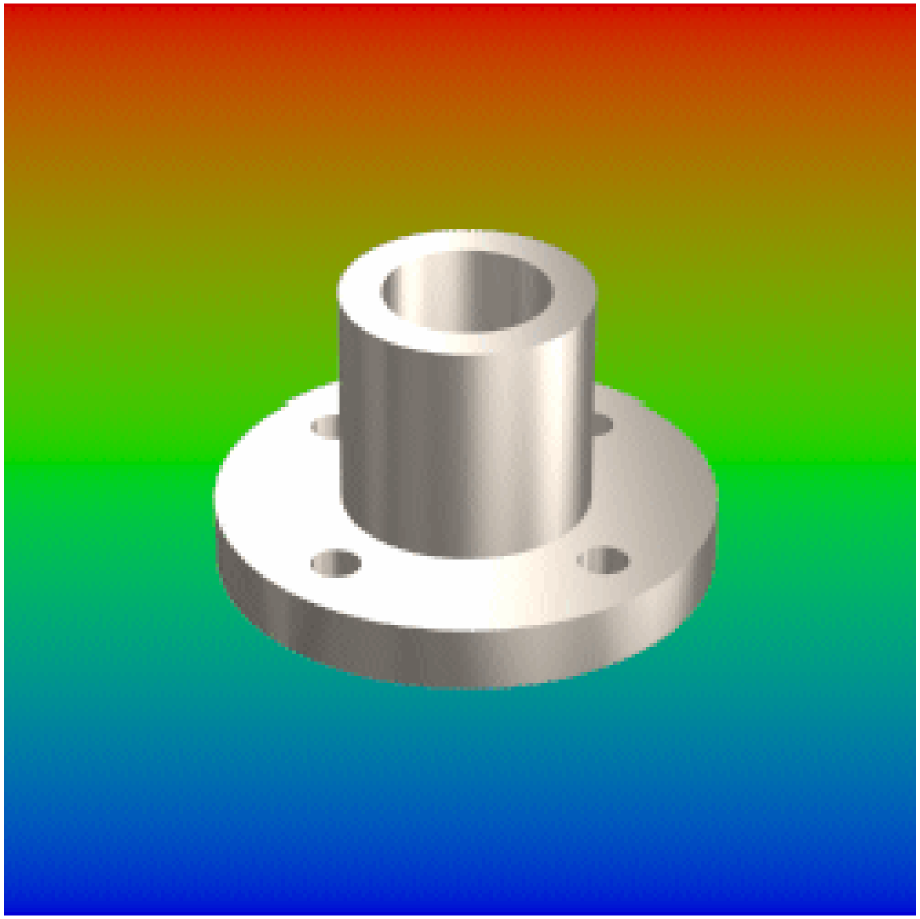
- Make a full section in the front view
- Note how the cutting plane is drawn and how the crosshatching lines mark the surfaces of material cut by the cutting plane.



Half Section View

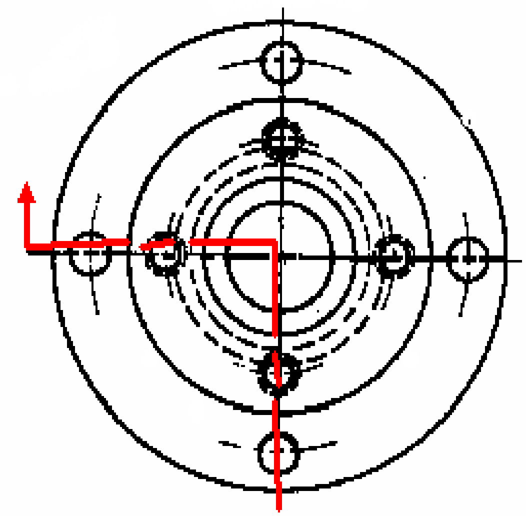
- **The cutting planes do not cut all the way through to the object.**

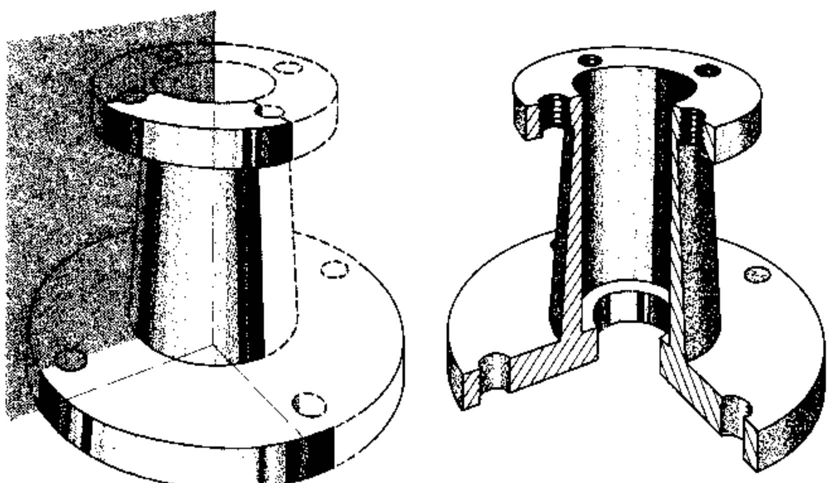
- **They cut only half way and intersect at the centerline.**



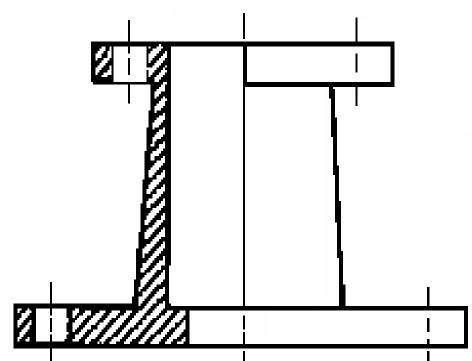
Half Section View

Half Section is used mainly for symmetric objects





(b)

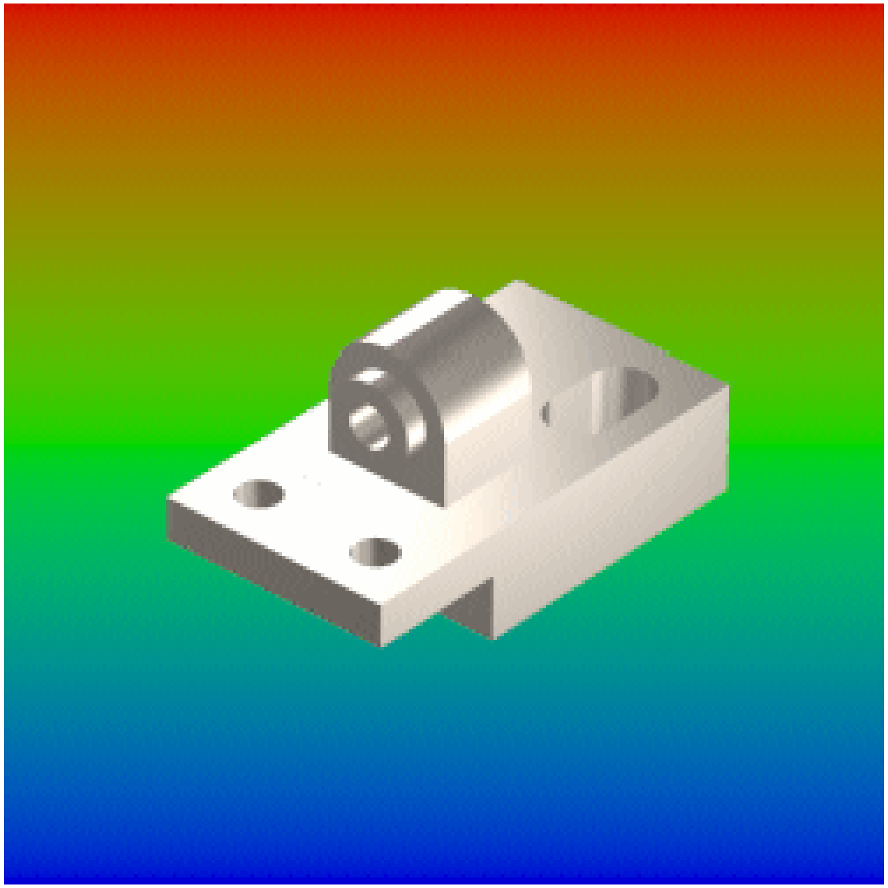


(d)

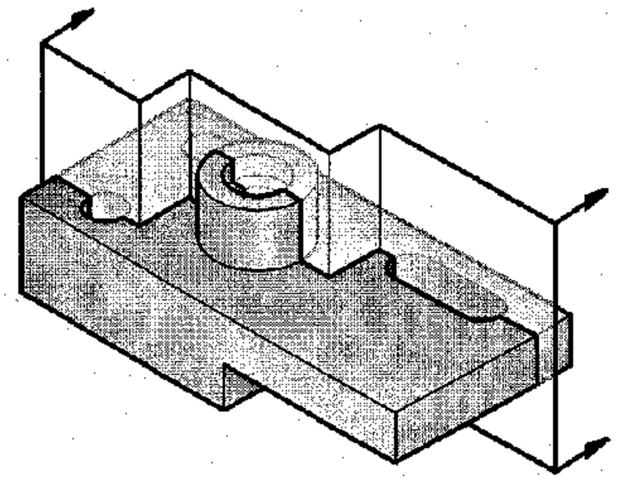
Offset Sections

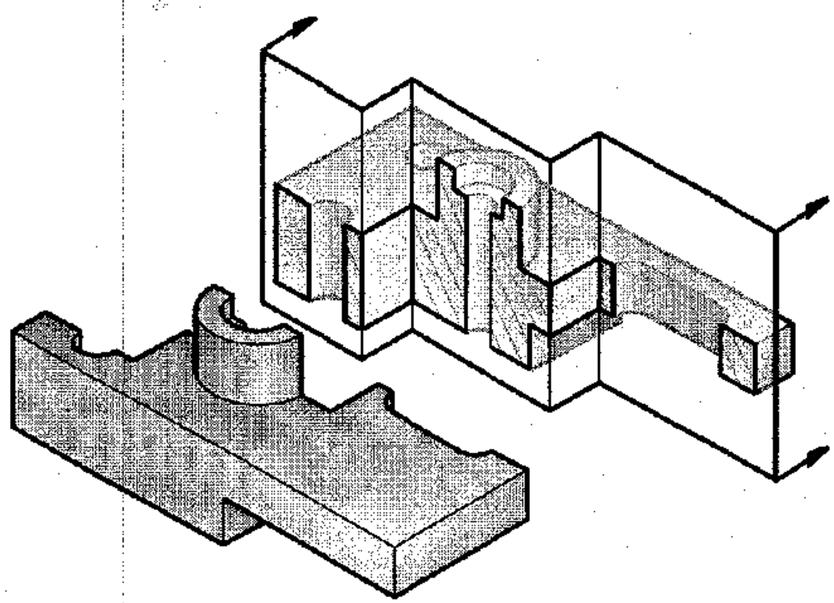
Offset sections are

features that do not lie along a straight line

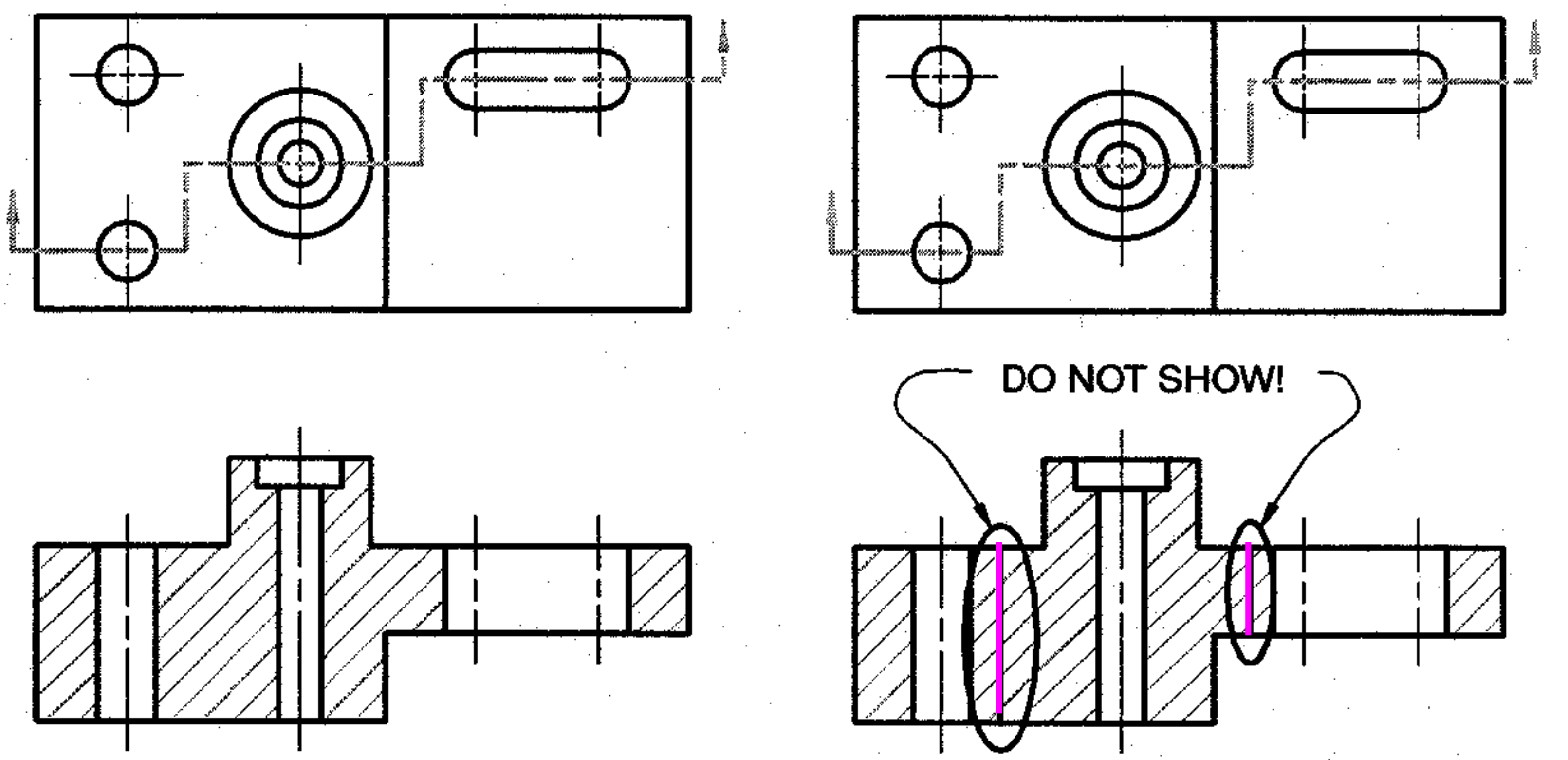


Offset Sections





Offset Sections



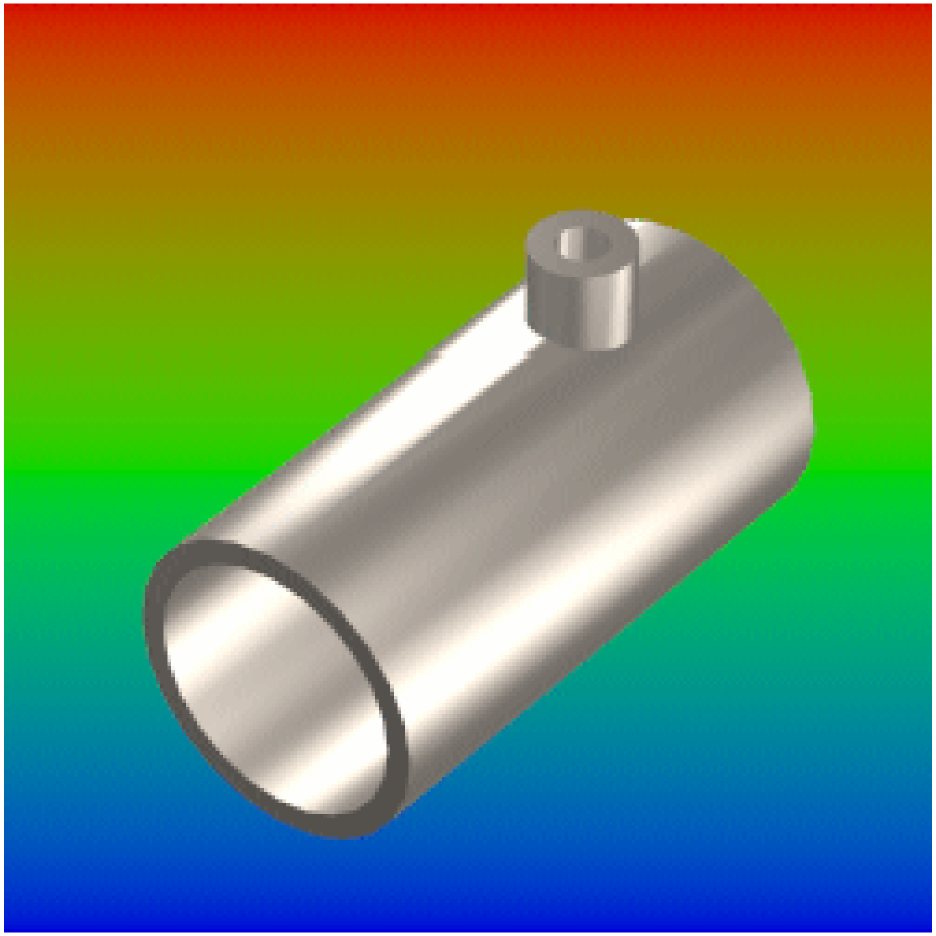
(A) Offset section view

(B) No!

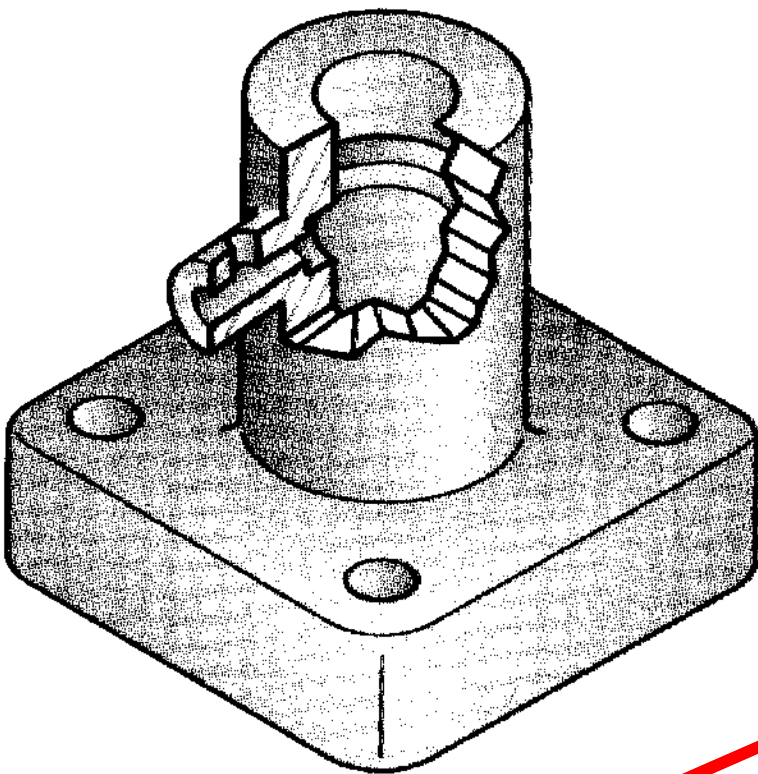
Broken Out Sections

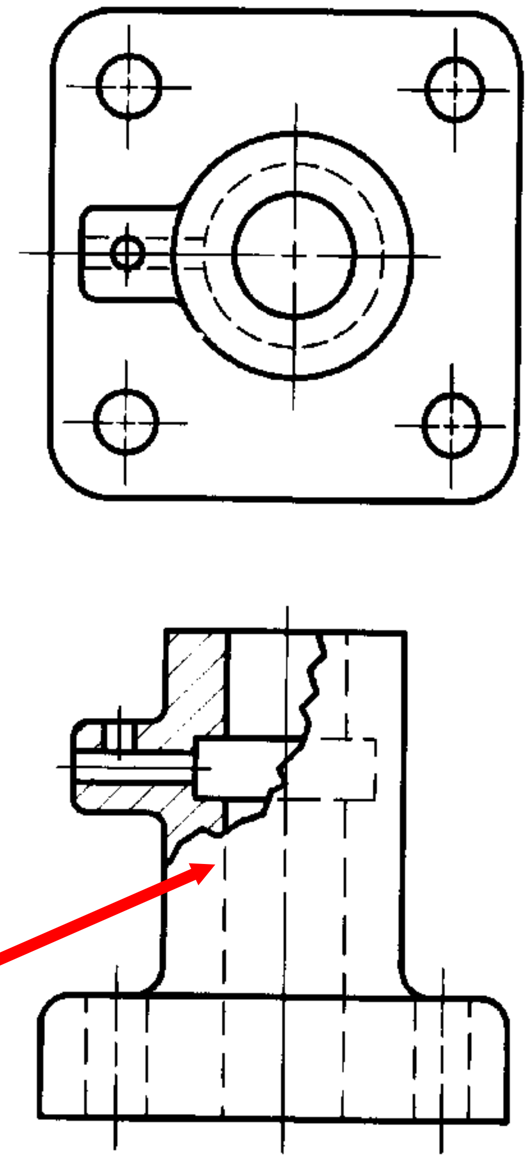
A broken-out section view is

off part of the object to reveal interior features



Broken Out Sections



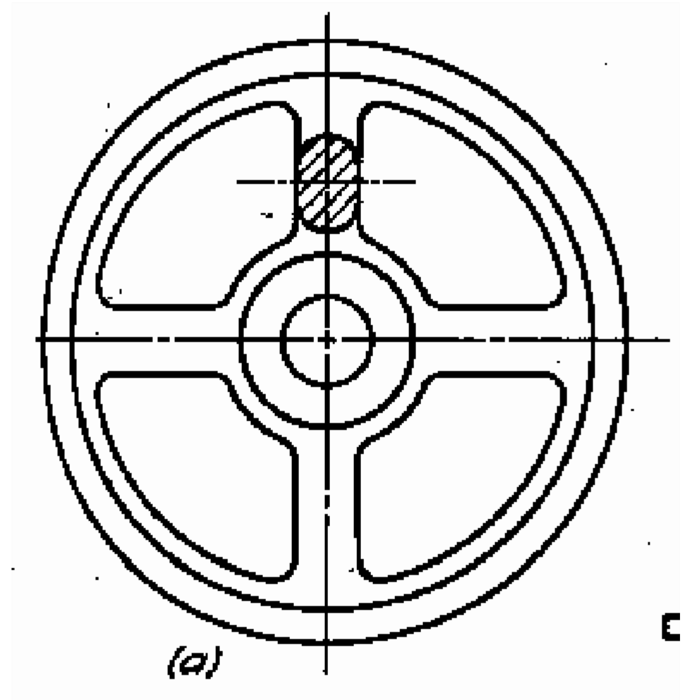


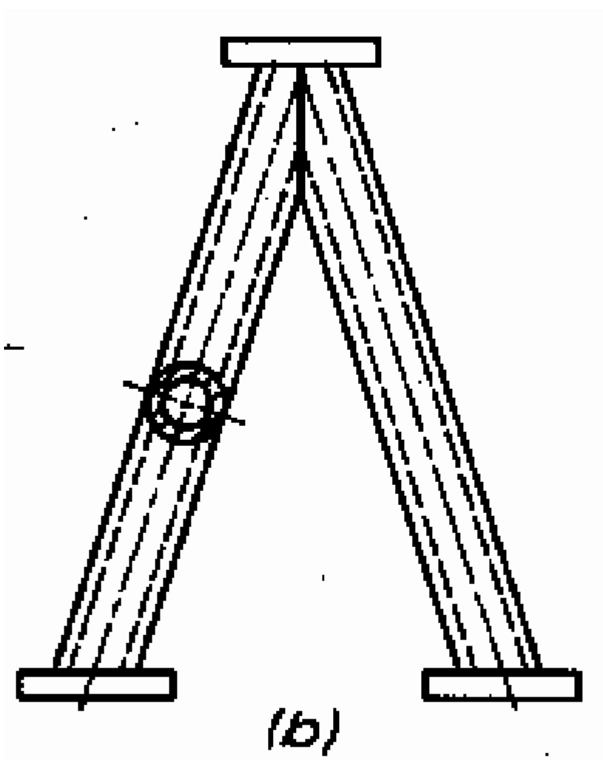
Hidden lines are used only when needed for clarity.

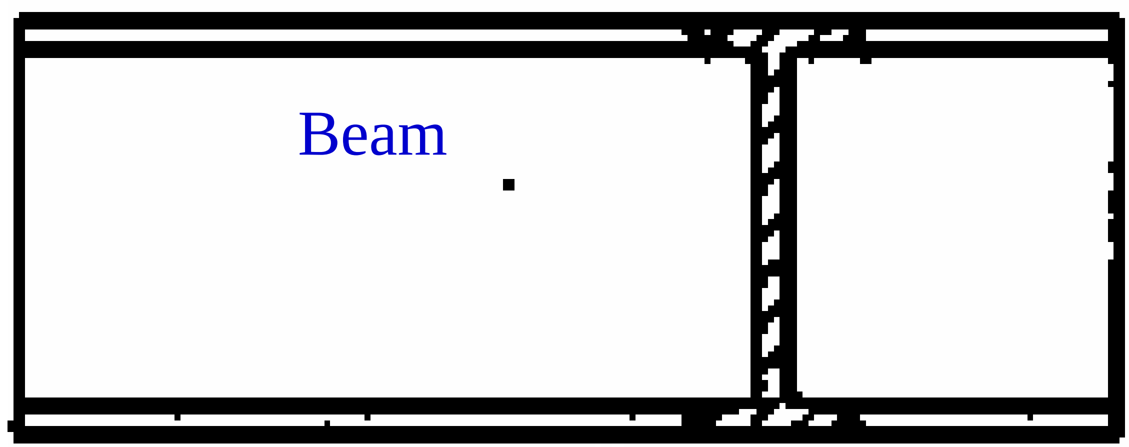
(C) Broken-out section view

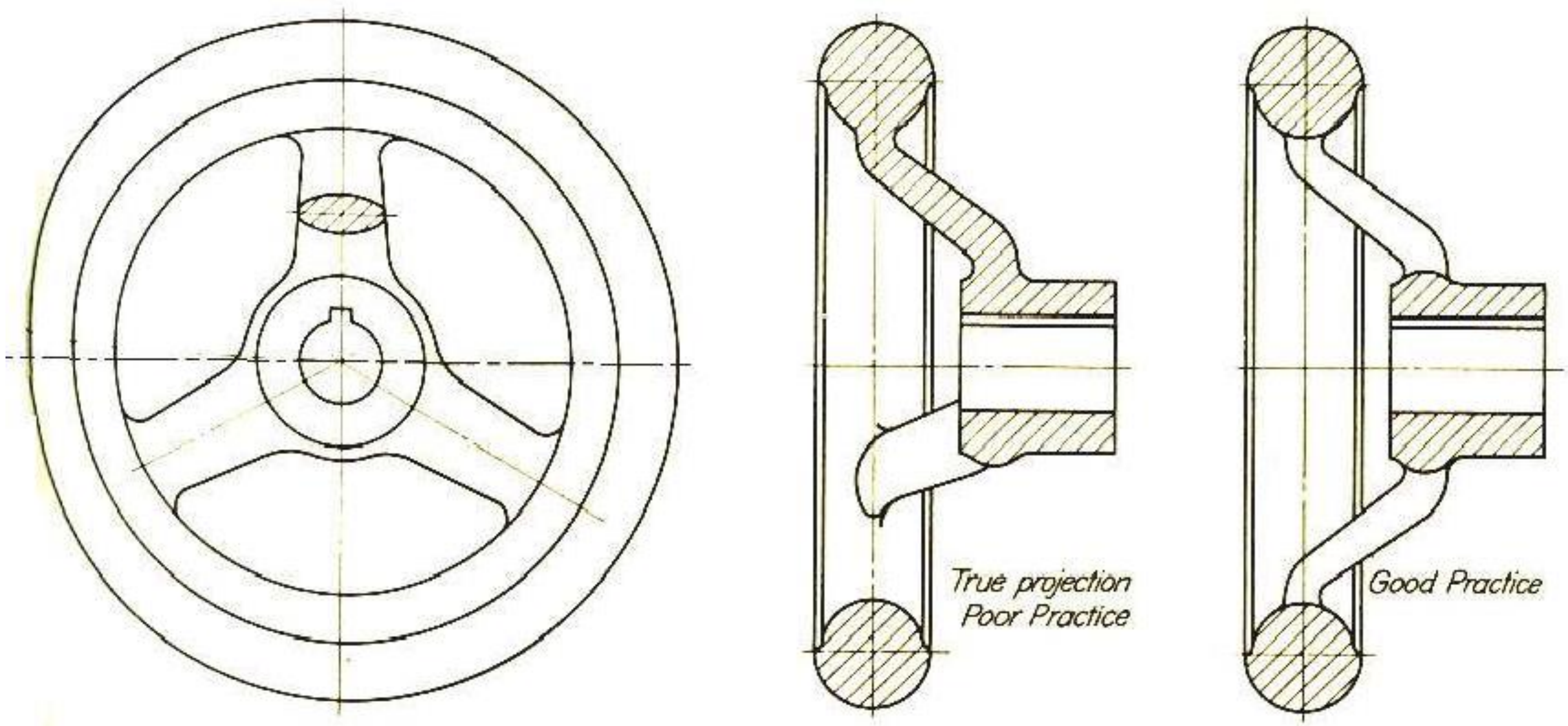
Revolved Sections

Revolved sections show the shape of an object's cross-section superimposed on a longitudinal view





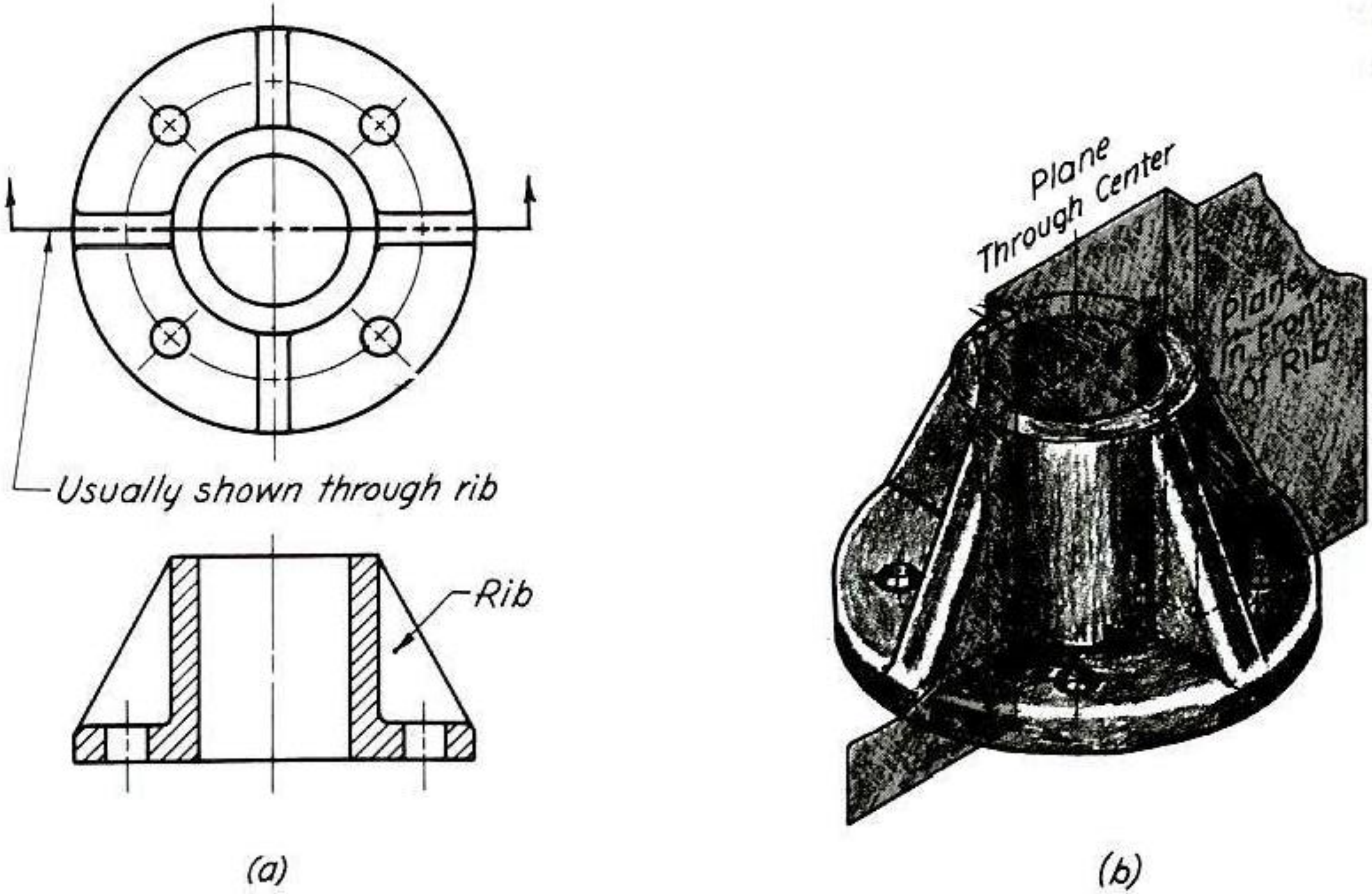




Any part with an odd number of spokes or ribs will give an unsymmetrical and misleading section if the principle of true projections are strictly adhered to.

1) The spoke is rotated to the path of the vertical cutting plane and then projected on the side view.

2) Neither of the spokes should be sectioned (hatched).



'IG. 7.30 **Conventional treatment of ribs in section.**

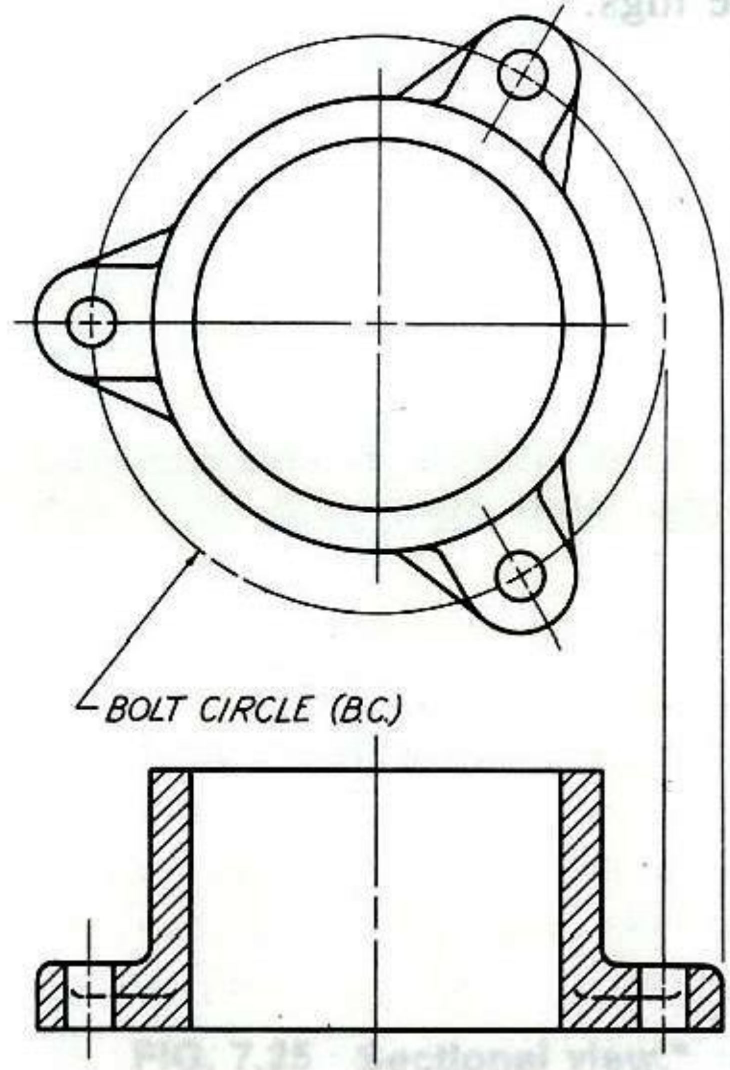


FIG. 7.29 Revolution of a portion of an object.

Section of solids

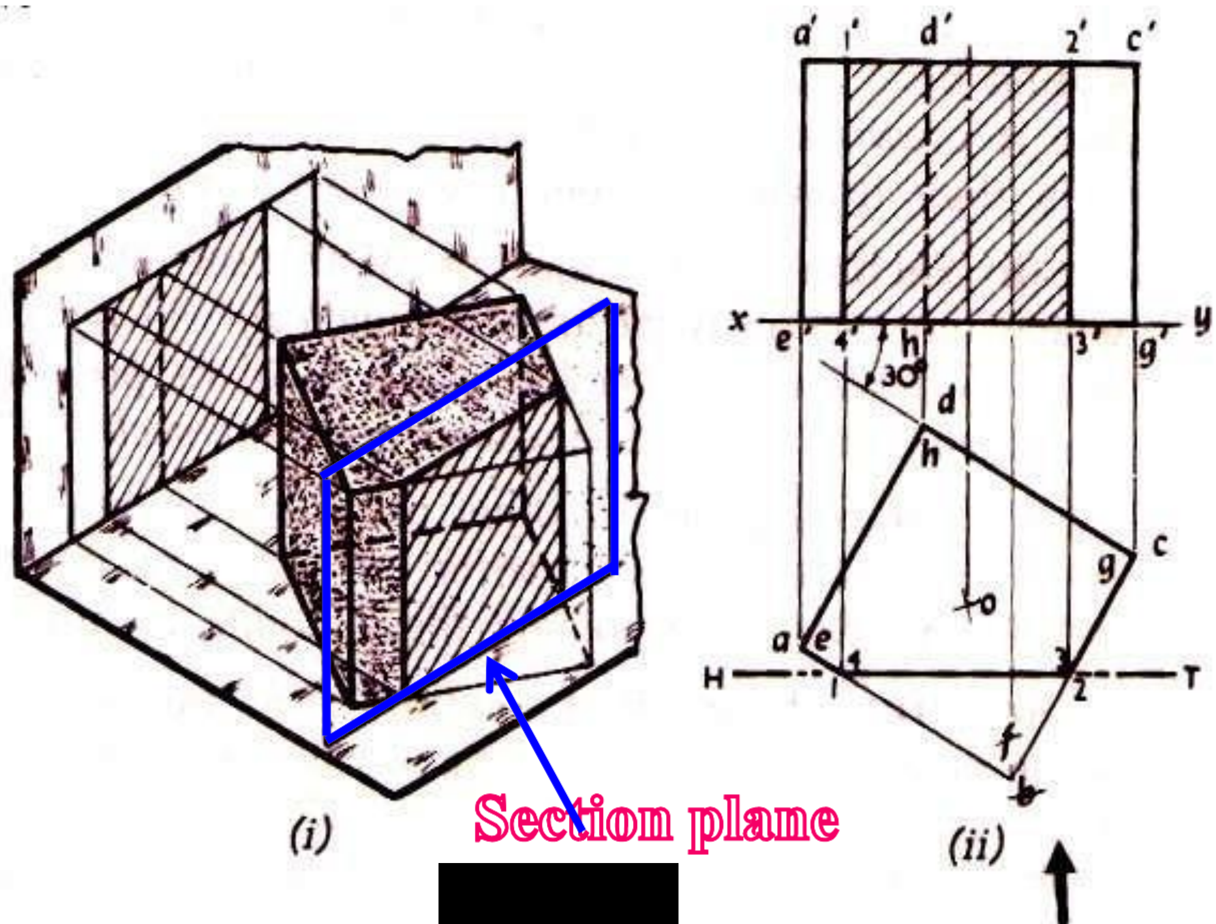
- Section plane parallel to VP (cube)
- Section plane parallel to HP (prism, pyramid)
- Section plane inclined to VP (Pyramid, cylinder)
- Section plane for which its true shape is given
- Sectional views for a complex object

Section plane parallel to VP

Draw the projection of the solid without section plane. (i.e. top view and front view according to the given conditions).

Then introduce the section plane in the top view. As it is parallel to the VP, is seen as a line in top view.

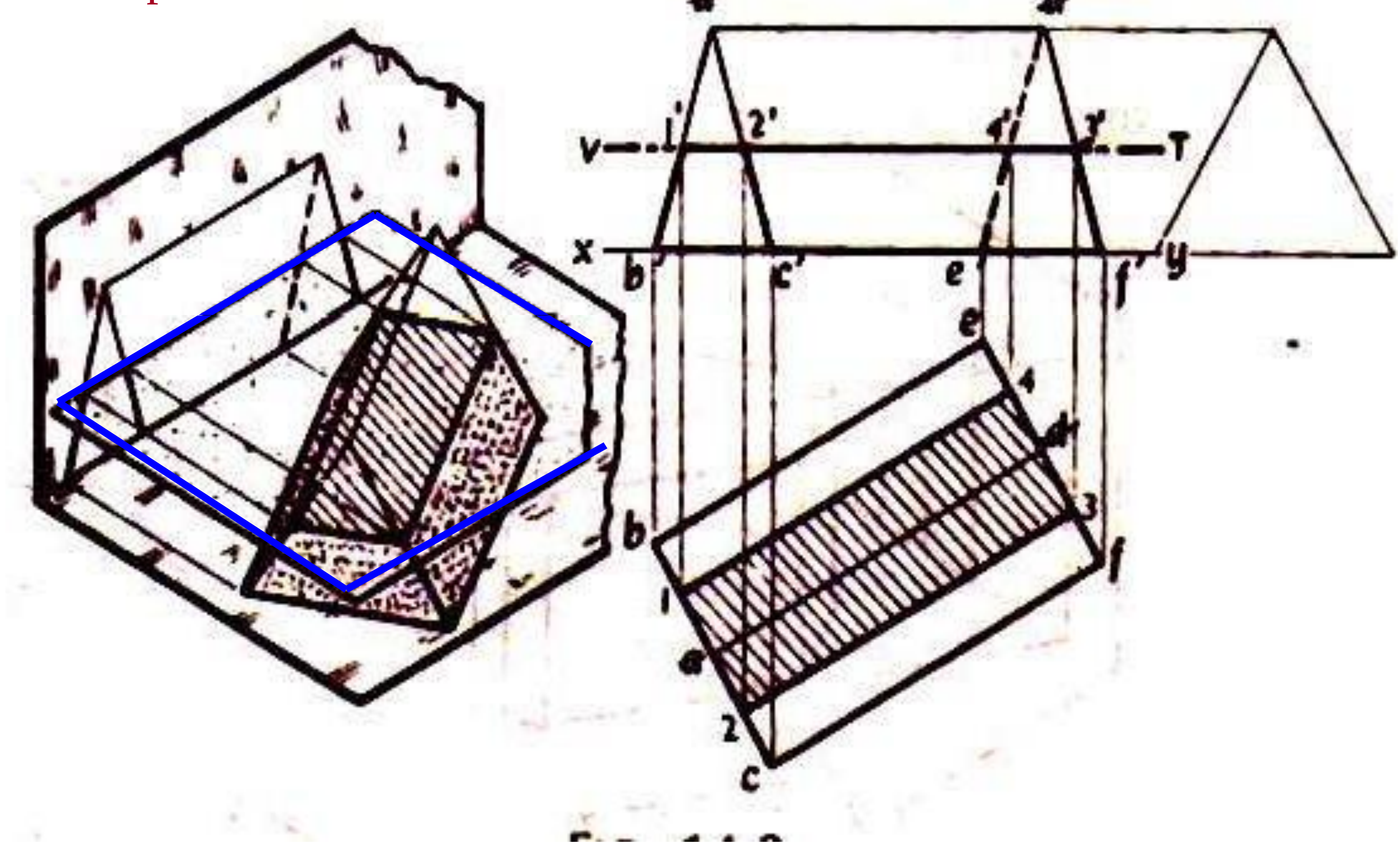
Carry it to the front view.



[redacted]

Section plane parallel to HP

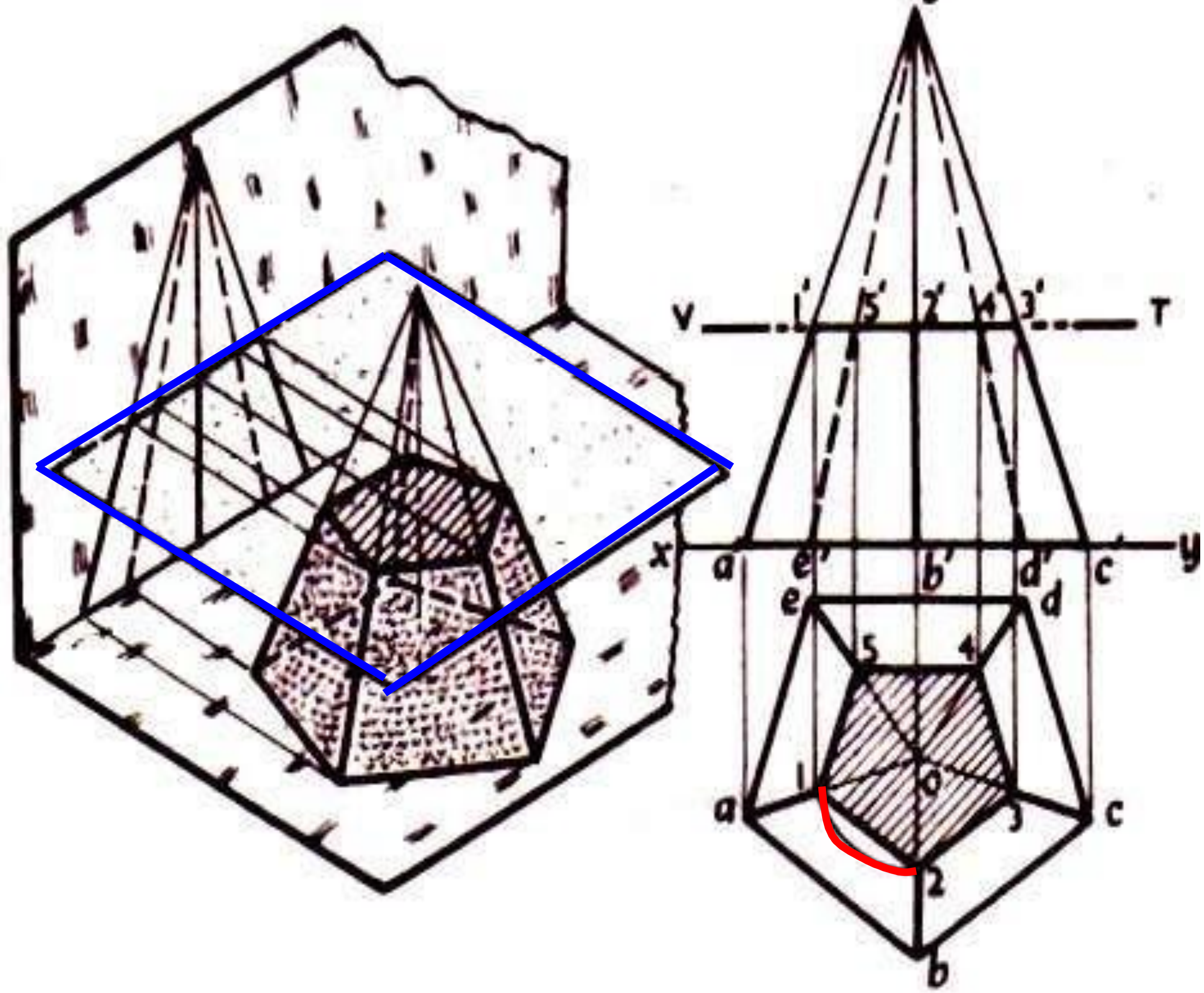
A triangular prism, side of base 30 mm and axis 50 mm long is lying on the HP on one of its rectangular faces with its axis inclined at 30° to the VP. It is cut by a horizontal section plane at a distance of 12 mm above the ground. Draw its front view, side view and sectional top view.



Draw the projections of the un-cut prism. As the section plane is parallel to HP, it will be seen as a straight line parallel to XY in the front view. Project the section to the top view.

Section plane parallel to HP…..

A pentagonal pyramid, side of base 30 mm and axis 65 mm long, has its base horizontal and an edge of the base parallel to the VP. A horizontal section plane cuts it at a distance of 25 mm above the base. Draw its front view and sectional top view.

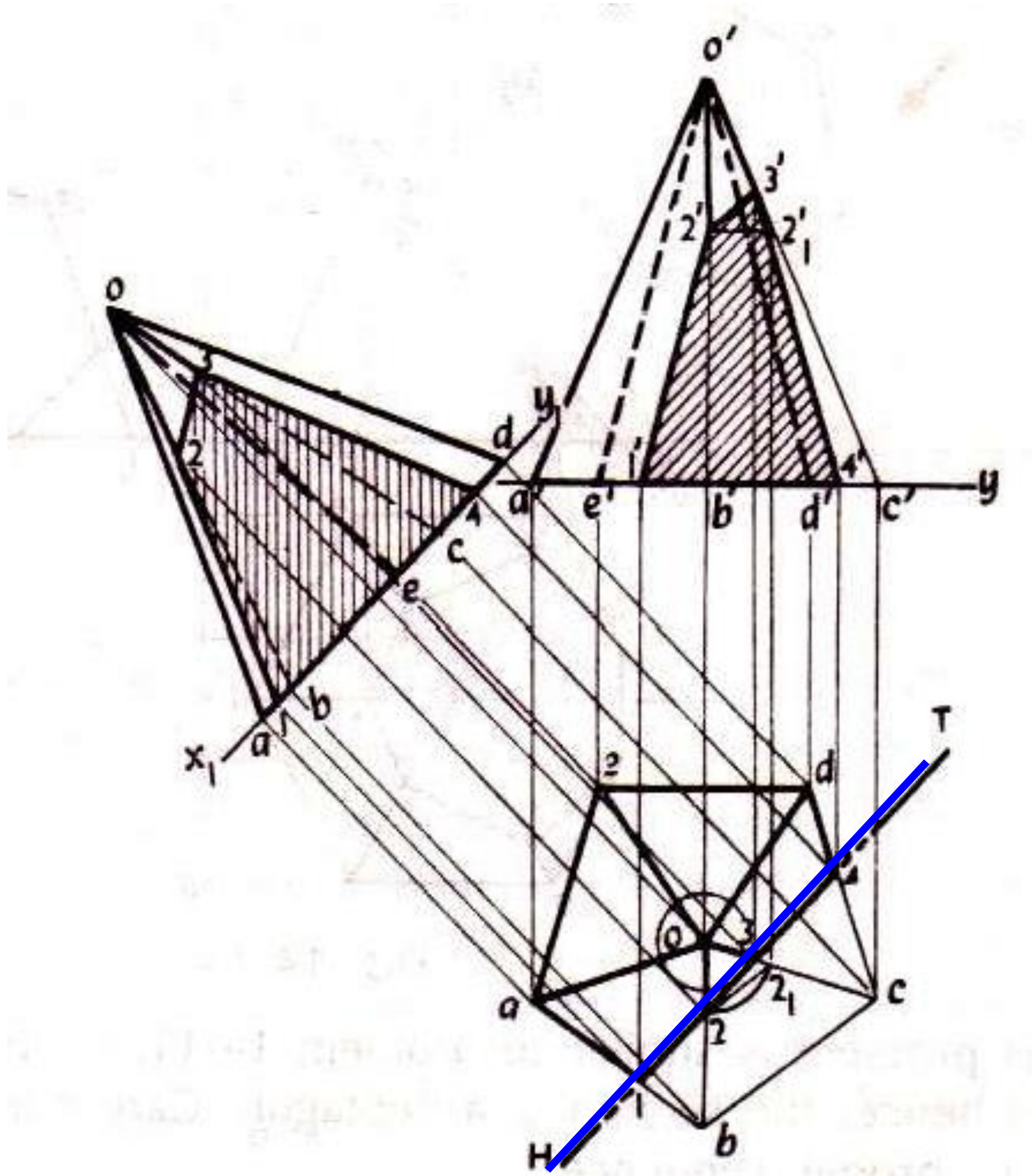


Section plane Inclined to VP

A pentagonal pyramid has its base on the HP. Base of the pyramid is 30 mm in side, axis 50 mm long. The edge of the base nearer to VP is parallel to it.

A vertical section plane, inclined at 45 to the VP, cuts the pyramid at a distance of 6 mm from the axis.

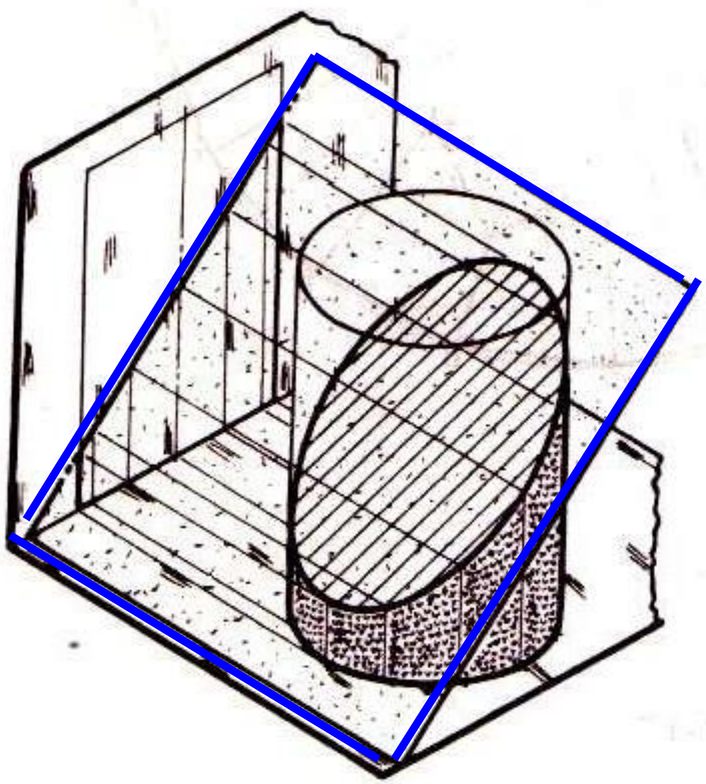
Draw the top view, sectional front view and the auxiliary front view on an AVP parallel to the section plane.

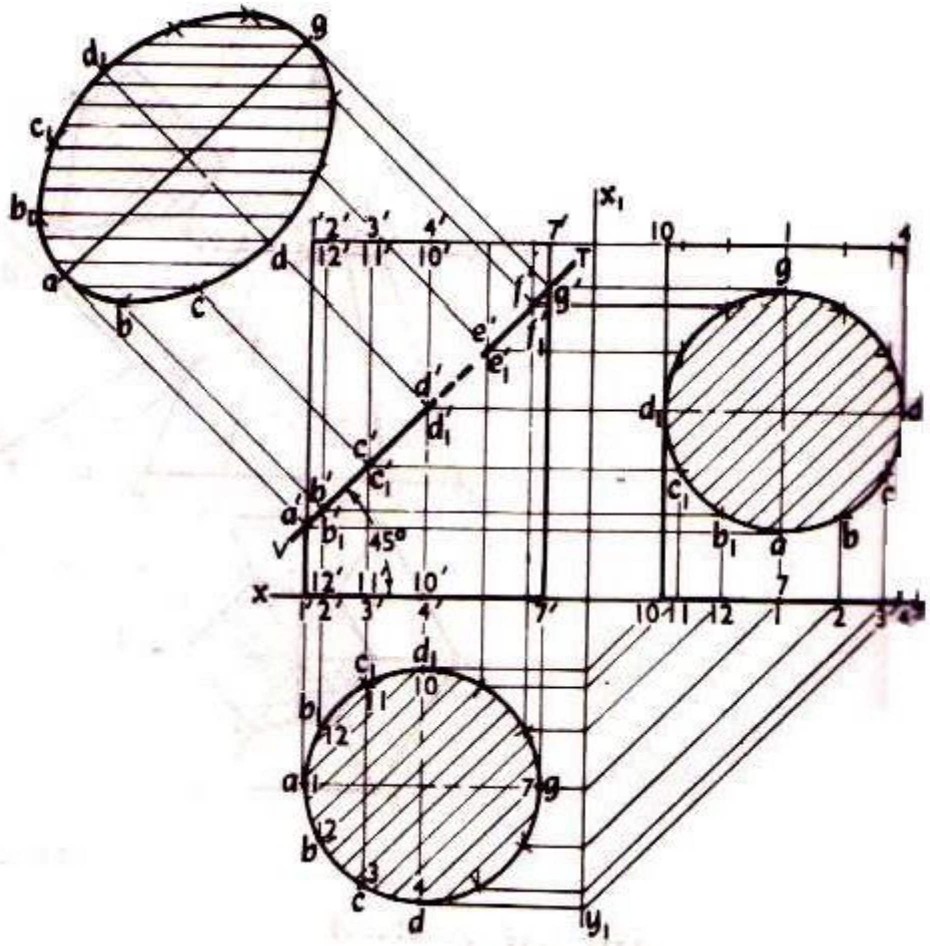


[redacted]

Sections of Cylinders: Section plan inclined to the base

Problem.1 A cylinder of 40 mm diameter, 60 mm height and having its axis vertical is cut by a section plane, perpendicular to the VP, inclined at 45 to the HP and intersecting the axis 32 mm above the base. Draw its front view, sectional top view, sectional side view and the true shape of the section

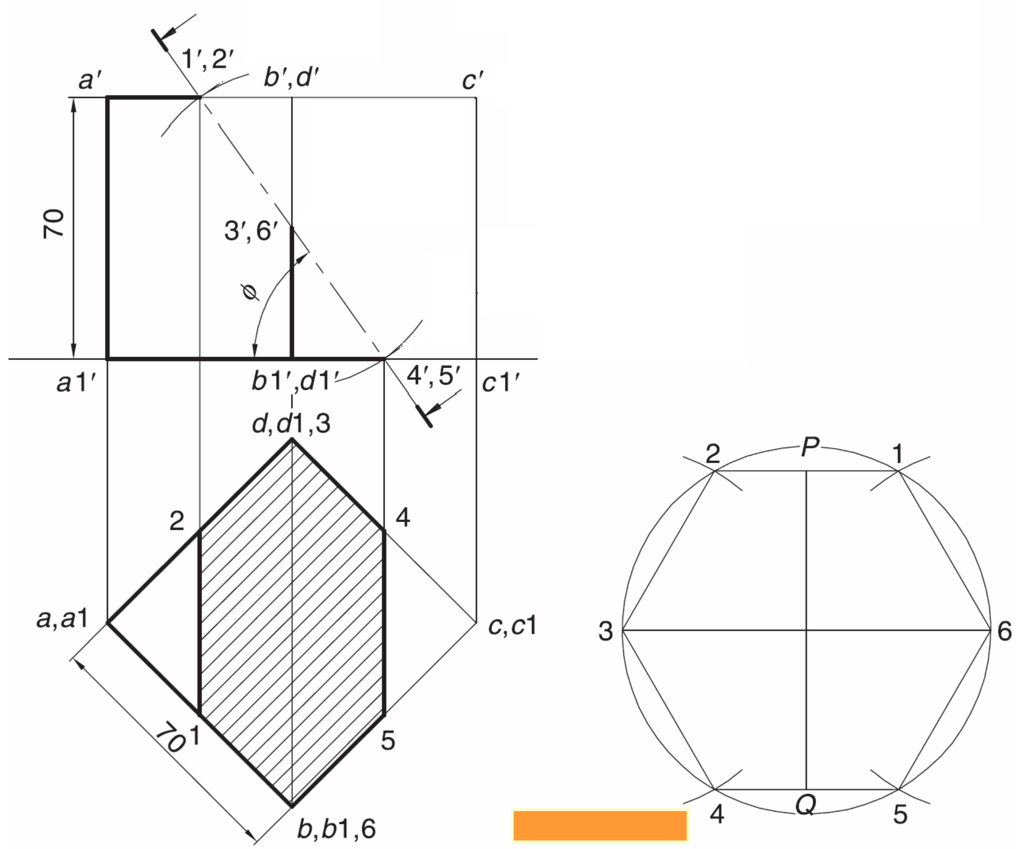




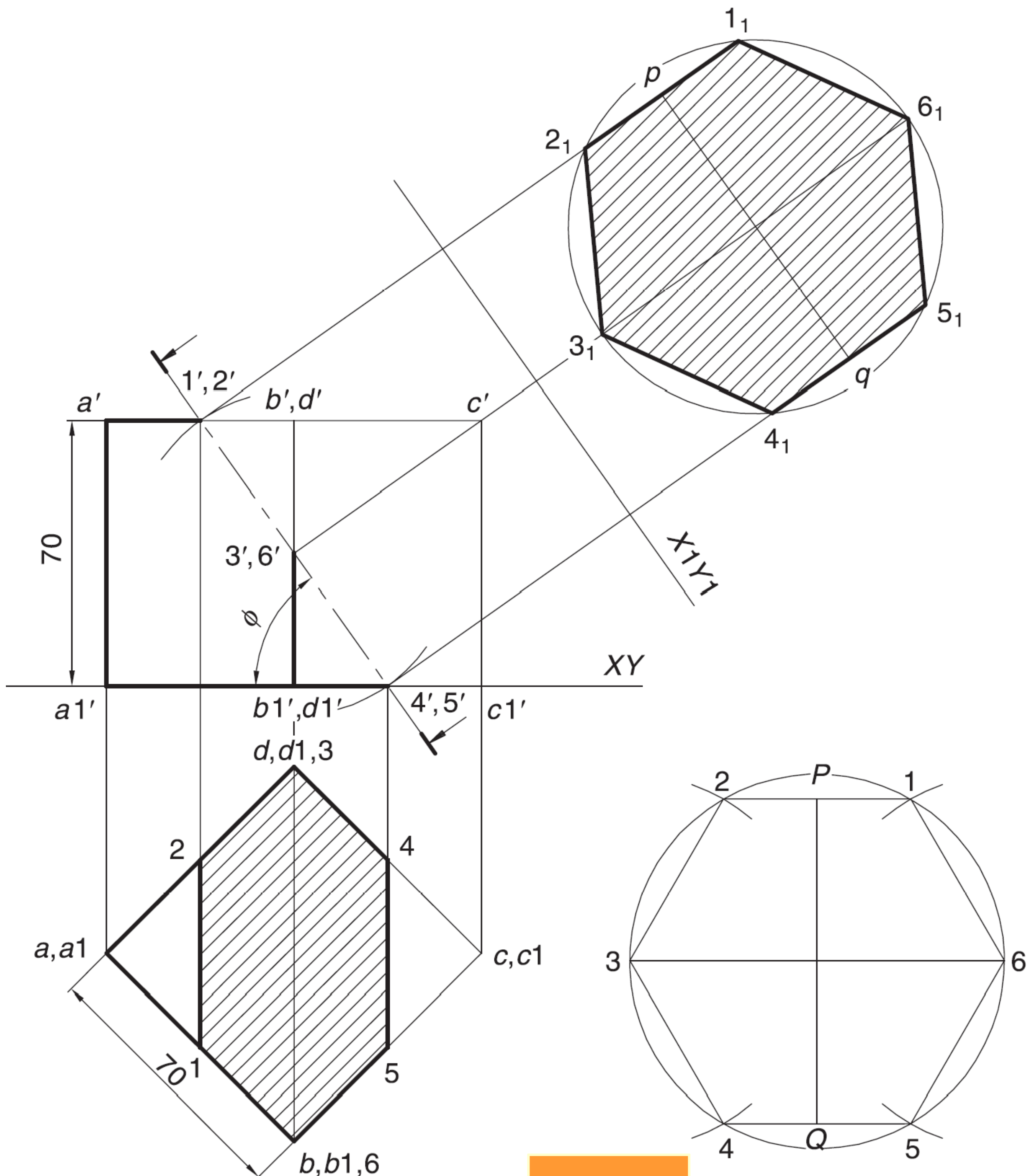
Practice Example-1: A cube of 70 mm long edges has its vertical faces equally inclined to the VP. It is cut by an AIP in such a way that the true shape of the cut part is a regular hexagon. Determine the inclination of the cutting plane with the HP. Draw FV, sectional TV and true shape of the section.

Step-1 Draw TV and FV of the cube as shown.

Step-2 As the true shape of the section is a hexagon, the cutting plane must cut the prism at 6 points.

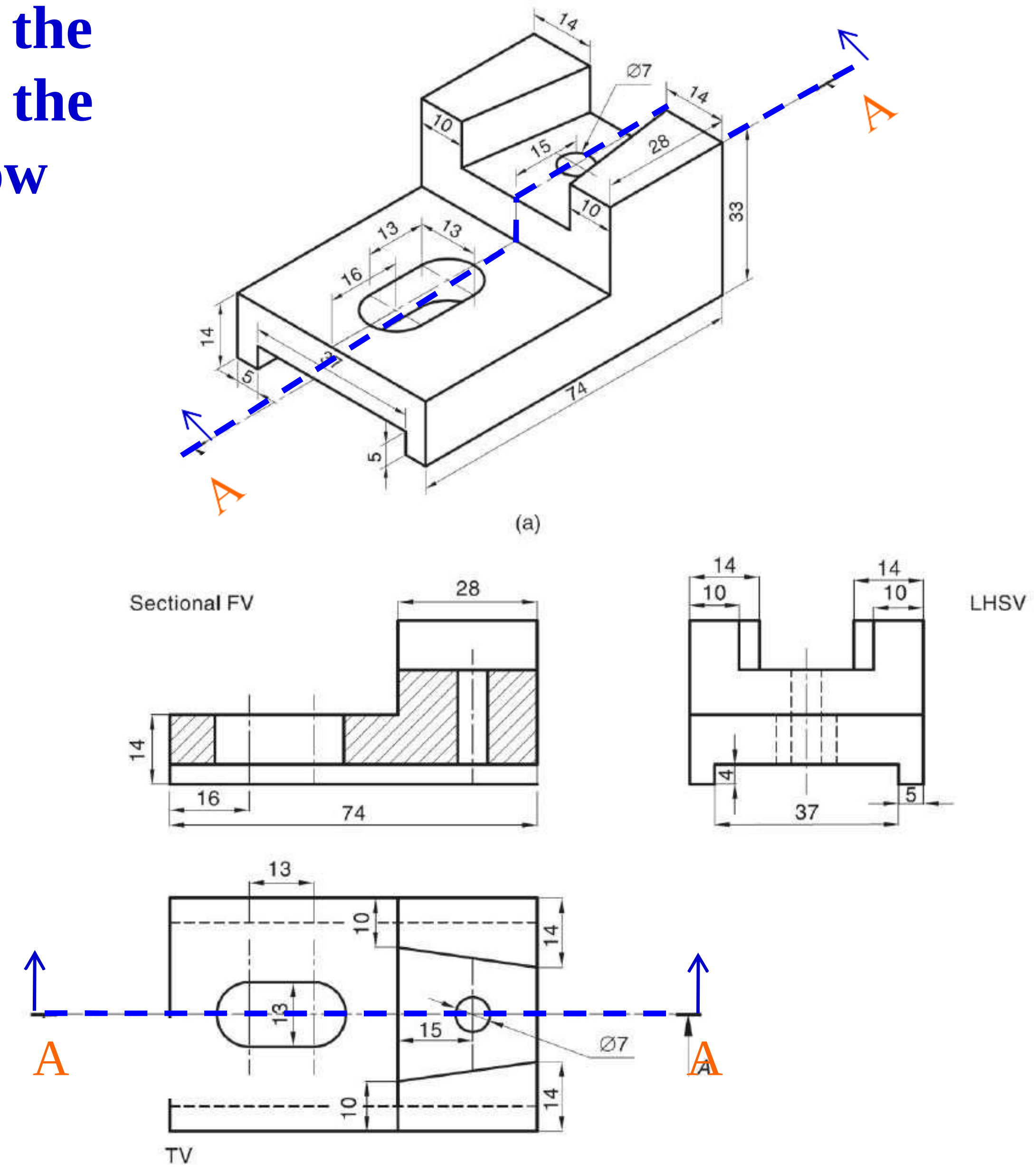


plane will cut two edges of the top, two edges of the base and two vertical edges. The POIs at two vertical edges will be farthest from each other. These points will represent the two opposite corners of the hexagon and the distance between them will be equal to b(b1)– d(d1).



11
p
61
21
51
31
q
41
X1Y1
1′,2′
a′
b′,d′
c′
70
3′,6′
φ
XY
a1′
b1′,d1′
4′,5′
c1′
d,d1,3
2
4
a,a1
c,c1
70
1
5
b,b1,6
2
P
1
3
6
4
Q
5

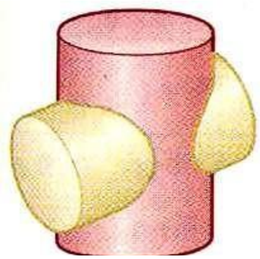
Practice Example 2: Example for a complex object: Draw the sectional FV, TV and SV of the object shown in Figure below



THANK YOU

Engineering Drawing

Intersections of Solids



Whenever two or more solids combine, a definite curve is seen at their intersection. This curve is called the *curve of intersection* (COI).





Cross


CASES OF INTERSECTION

The cases of intersection depend on the type of intersecting solids and the manner in which they intersect. Two intersecting solids may be of the same type (e.g., prism and prism) or of different types (e.g., prism and pyramid). The possible combinations are shown in Table below.

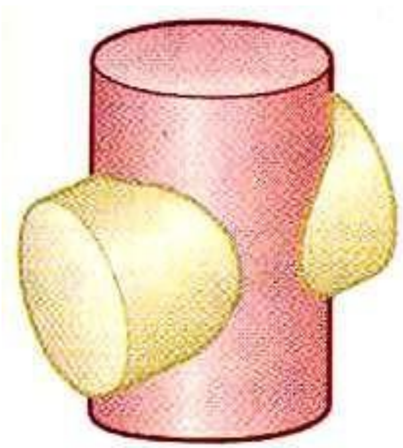


Table 17.1 Cases of Intersection

		1st solid				
		Prism	*Pyramid*	*Cylinder*	*Cone*	*Sphere*
	Prism	Case 1				
	Pyramid	Case 2	Case 6			
2nd solid	*Cylinder*	Case 3	Case 7	Case 10		
	Cone	Case 4	Case 8	Case 11	Case 13	
	Sphere	Case 5	Case 9	Case 12	Case 14	Case 15

The two solids may intersect in different ways. The axes of the solids may be parallel, inclined or perpendicular to each other. The axes may be intersecting, offset or coinciding. Therefore, the following sub-cases exist:

- **(i) Axes perpendicular and intersecting**
- **(ii) Axes perpendicular and offset**
- **(iii) Axes inclined and intersecting**
- **(iv) Axes inclined and offset**
- **(v) Axes parallel and coinciding**
- **(vi) Axes parallel and offset**

Intersection

The type of intersection created depends on the types of geometric forms, which can be two- or three- dimensional.

Intersections must be represented on multiview drawings correctly and clearly. For example, when a conical and a cylindrical shape intersect, the type of intersection that occurs depends on their sizes and on the angle of intersection relative to their axes.

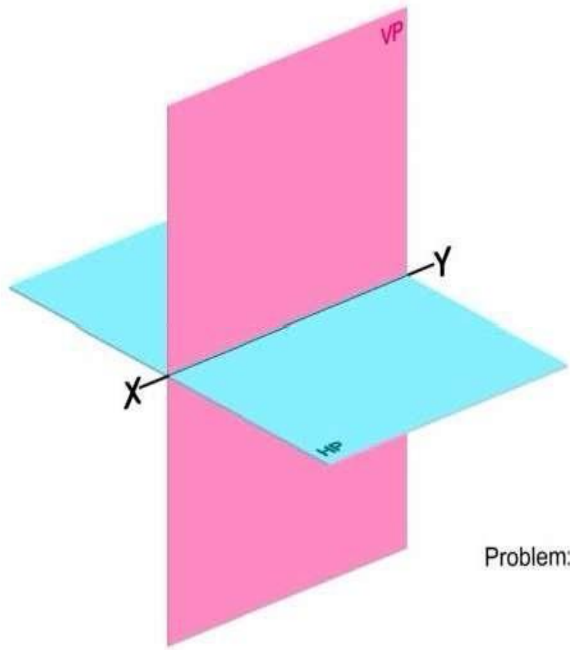
The line of intersection is determined using auxiliary views and cutting planes

Methods – (1) Line and (2) Cutting-plane methods

Line method: **A number of lines are drawn on the lateral surface of one of the solids and in the region of the line of intersection.**

Points of intersection of these lines with the surface of the other solid are then located.

These points will lie on the required line of intersection. They are more easily located from the view in which the lateral surface of the second solid appears edgewise (i.e. as a line). The curve drawn through these points will be the line of intersection.



Problem: (14.16)

Cutting-plane method: **The two solids are assumed to be cut by a series of cutting planes. The cutting ~~planes may be vertical (i.e. perpendicular to the~~ H.P.), edgewise (i.e. perpendicular to the V.P.) or oblique.**

The cutting planes are so selected as to cut the surface of one of the solids in straight lines and that of the other in straight lines or circles.

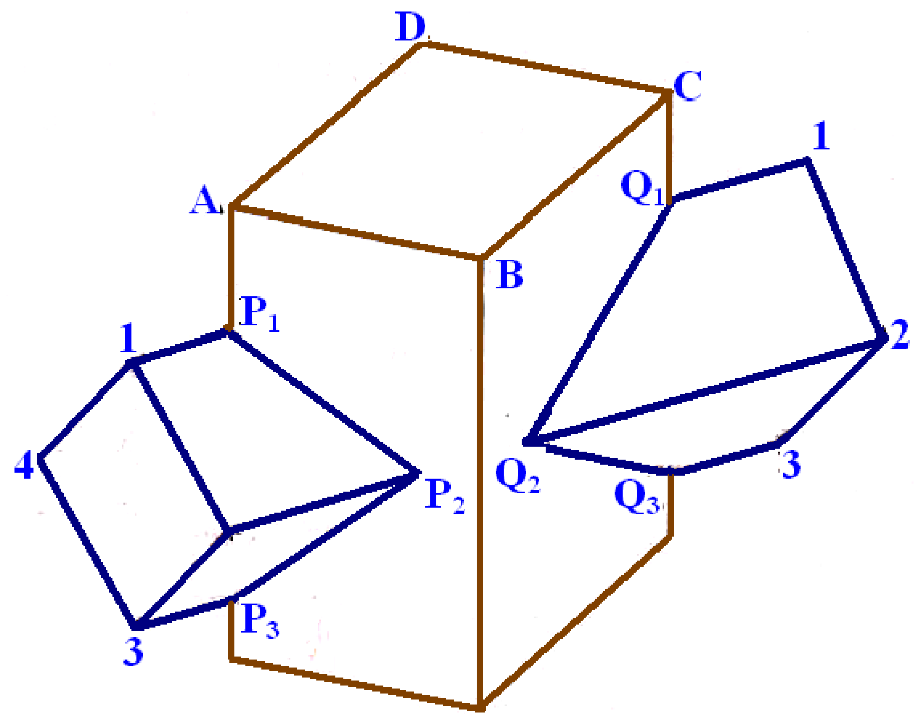
Intersection of two prisms

Prisms have plane surfaces as their faces.

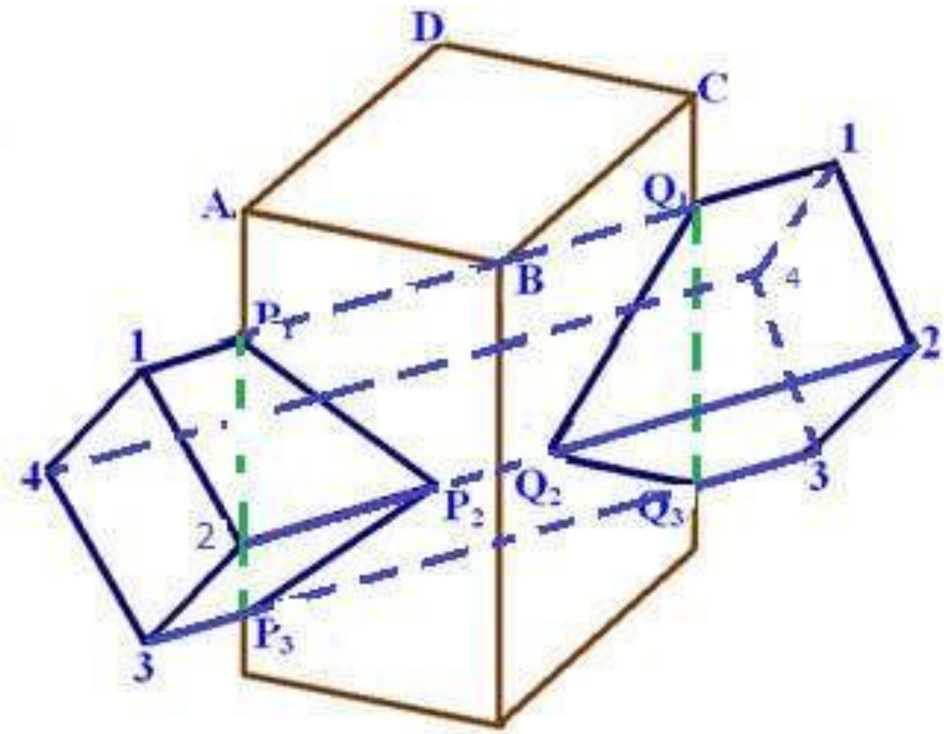
The line of intersection between two plane surfaces is obtaine by locating the positions of points at which the edges of one

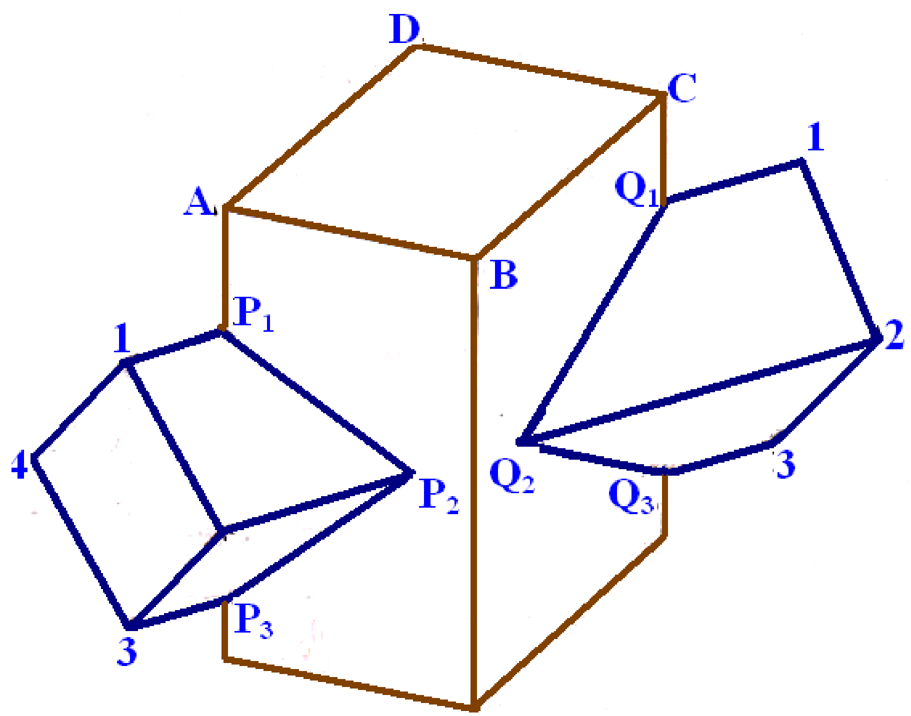
surface and then joining the points by a straight line. These points are called *vertices*

The line of intersection between two prisms is therefore a closed figure composed of a number of such lines meeting at the vertices



Intersection of two prisms

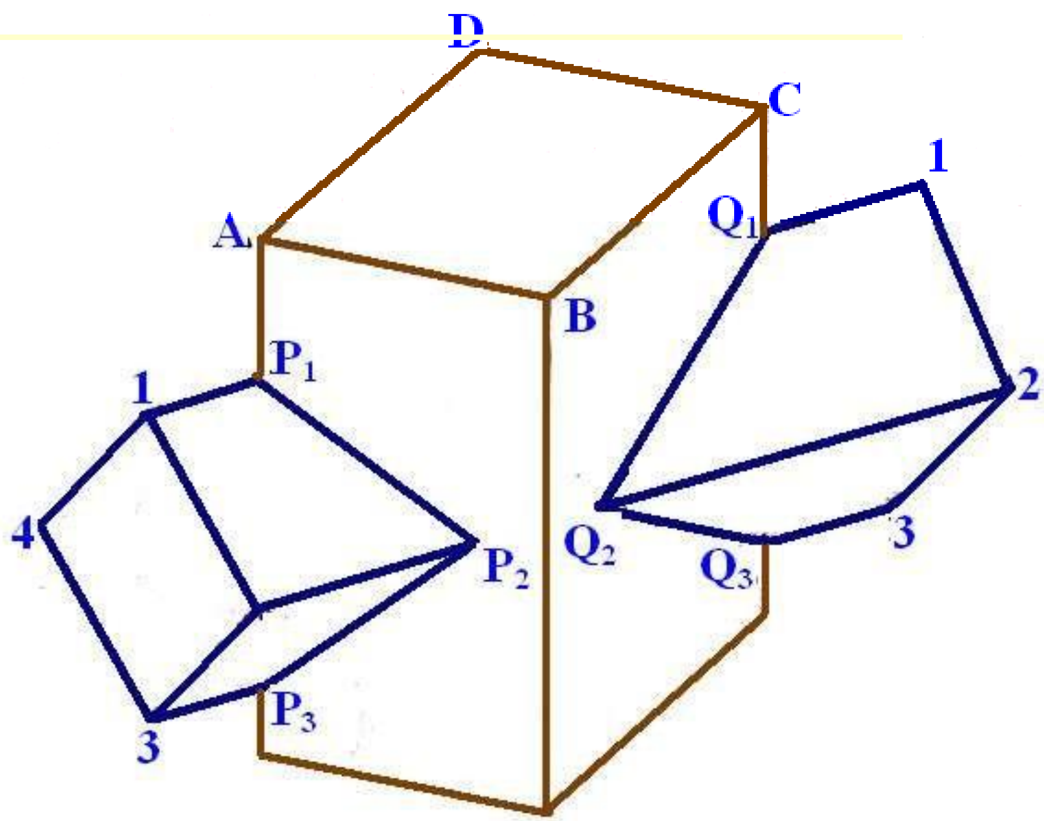




A vertical square prism, base 50 mm side, is completely penetrated by a horizontal square prism, base 35 mm side, so that their axes intersect. The axis of the horizontal prism is parallel to the prism., while the faces of the two prisms are equally inclined to the prism. Draw the projections of the solids, showing lines of intersection. (Assume suitable lengths for the prisms.)

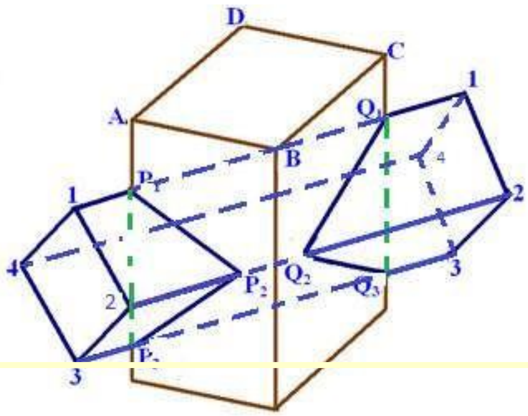
Steps:

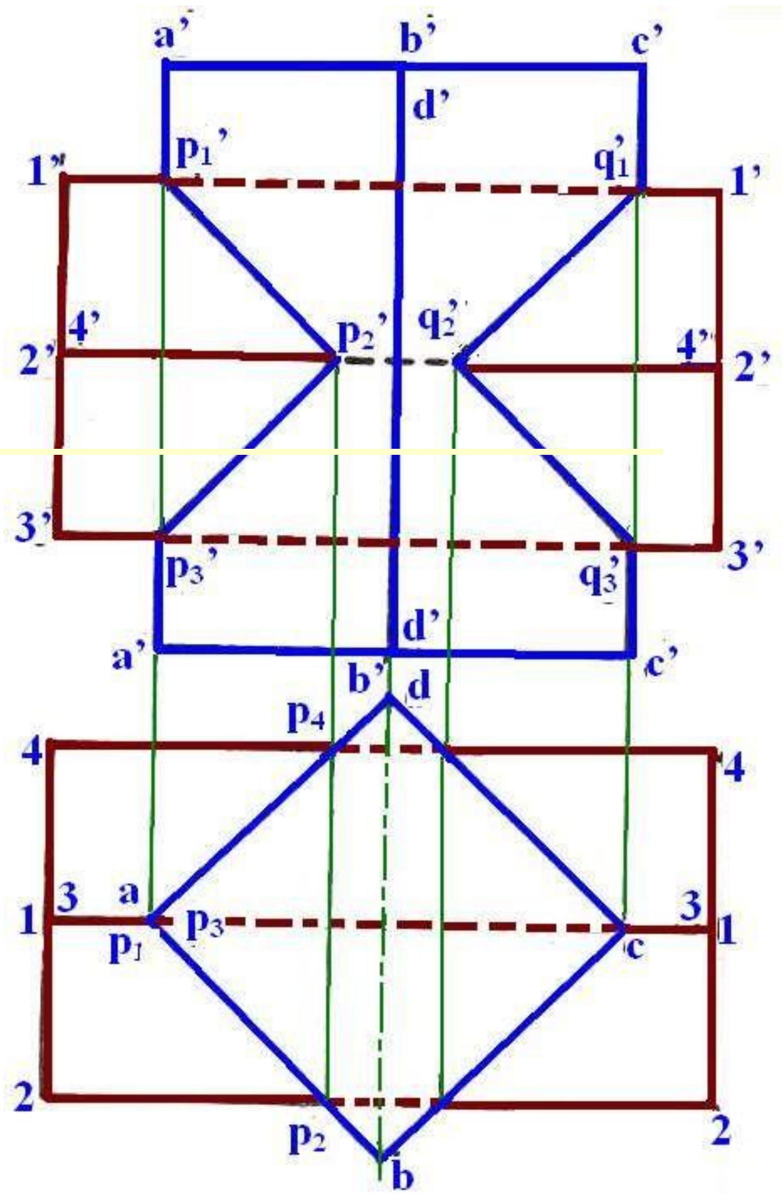
Draw the projections of the prisms in the required position. The faces of the vertical prism are seen as lines in the top view. Hence, let us first locate the points of intersection in that view.



Steps:

Lines **1-1** and **3-3** intersect the edge of the vertical prism at points $\boldsymbol{p_1}$ and $\boldsymbol{p_3}$ (coinciding with ***a***). Lines **2-2** and **4-4** intersect the faces at $\boldsymbol{p_2}$ and $\boldsymbol{p_4}$ respectively.



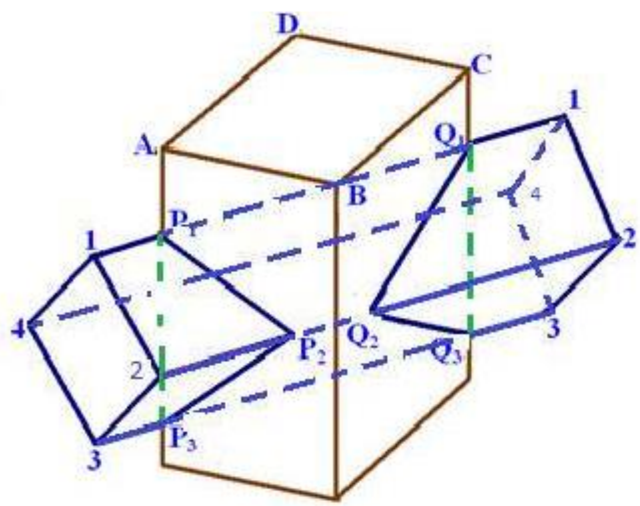


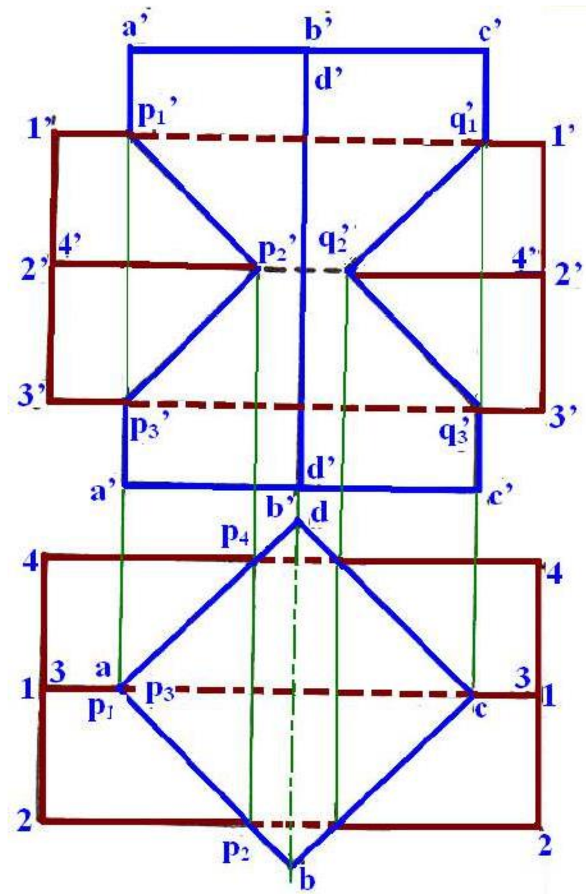
The exact positions of these points along the length of the prism may now be determined by projecting them on corresponding lines in the front view. For example, $\boldsymbol{p_2}$ is projected to $\boldsymbol{p_2'}$ on the line 2'2'. Note that $\boldsymbol{p_4'}$ coincides with $\boldsymbol{p_2'}$.

Intersection of two prisms

Draw lines **p_1’p_2'** and **p_2‘p_3'**. Lines **p_1‘p_4'** and **p_3‘p_4'** coincide with the fron~~t lines. Thes~~ lines show the line of intersection.

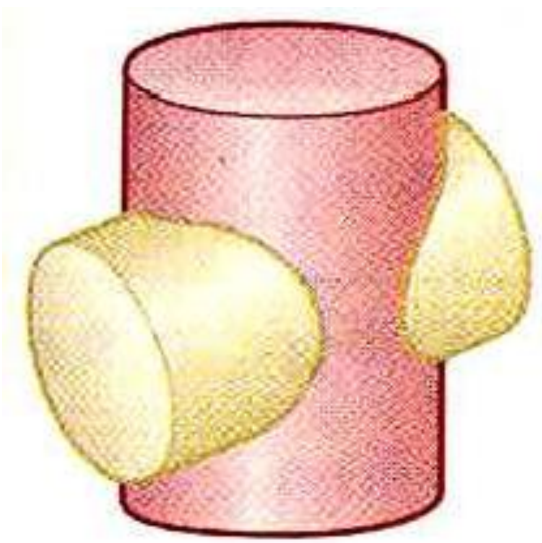
Lines **q_1'q_2'** and **q_2‘q_3'** on the other side are obtained in the same manner

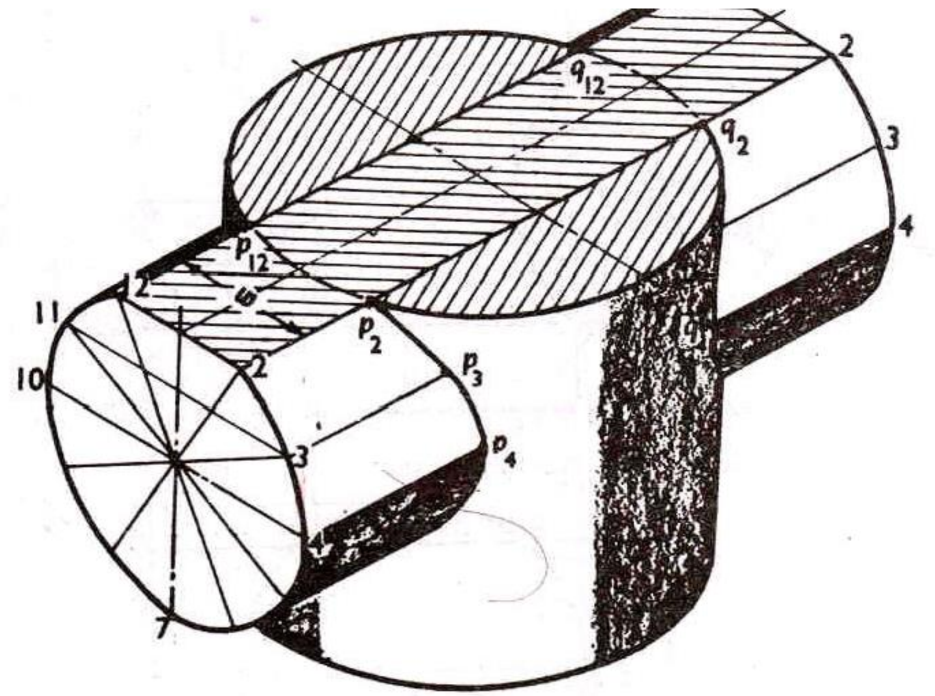




Note that the lines for the hidden portion of the edges are shown as dashed lines. The portions **p_1’p_3'** and **q_1’q_3'** of vertical edges **a'a'** and **c'c'** do not exist and hence, must be removed or kept fainter.

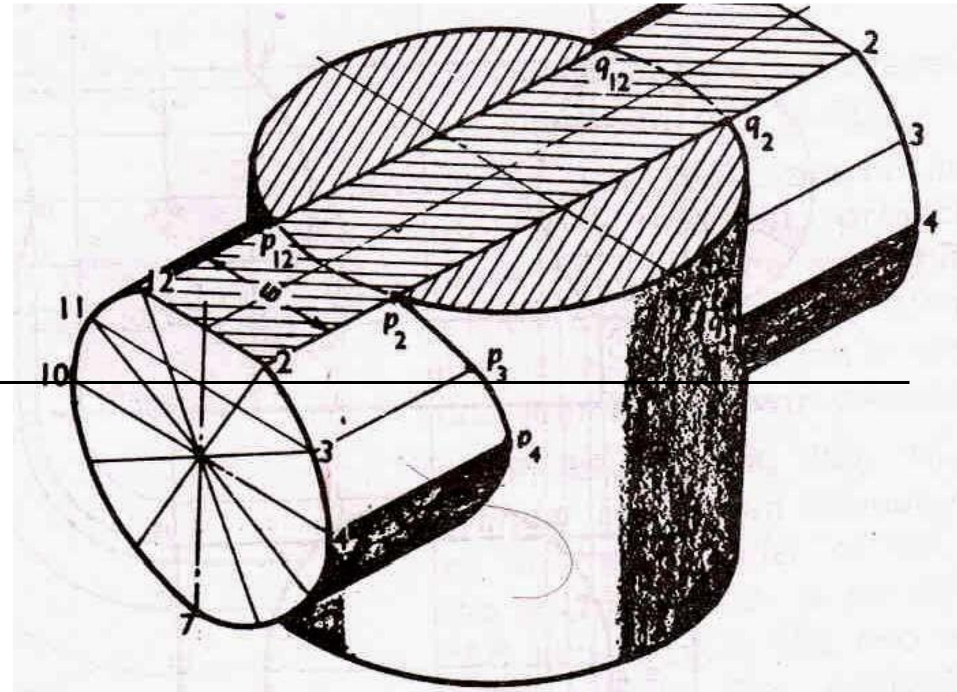
Intersection of Cylinder and Cylinder





Intersection of Cylinder and Cylinder

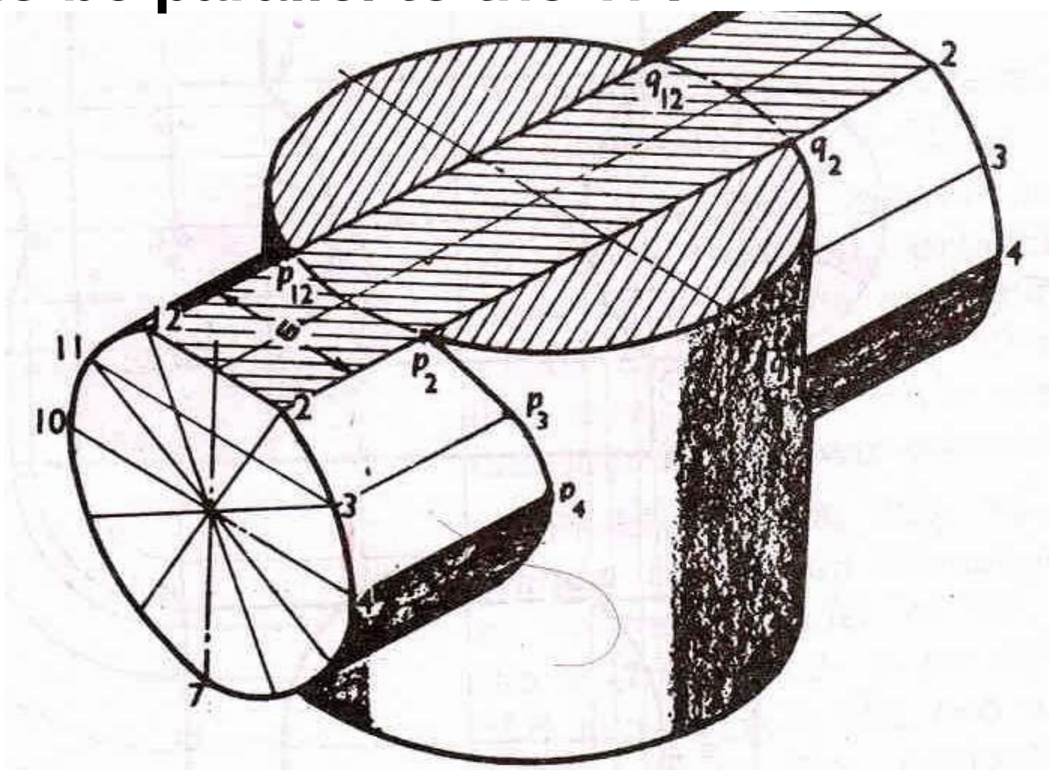
As cylinders have their lateral surfaces curved – the line of intersection between them will also be ~~curved. Points on~~ this line may be located by any of the methods.



For plotting an accurate curve, certain *critical or key points,* at which the curve changes direction, must also be located. *These are the points at which outermost or extreme lines of each cylinder pierce the surface of the other cylinder.*

Intersection of Cylinder and Cylinder

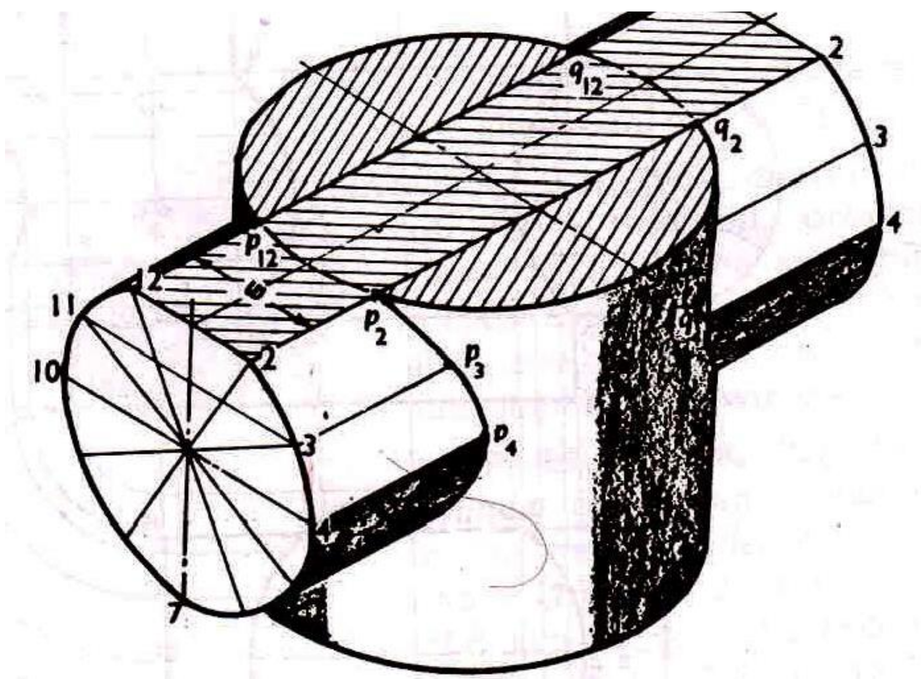
Example - A vertical cylinder of 80 mm diameter is completely penetrated by another cylinder of 60 mm diameter, their axes bisecting each other at right angles. Draw their projections showing curves of penetration, assuming the axis of the penetrating cylinder to be parallel to the VP.



Intersection of Cylinder and Cylinder

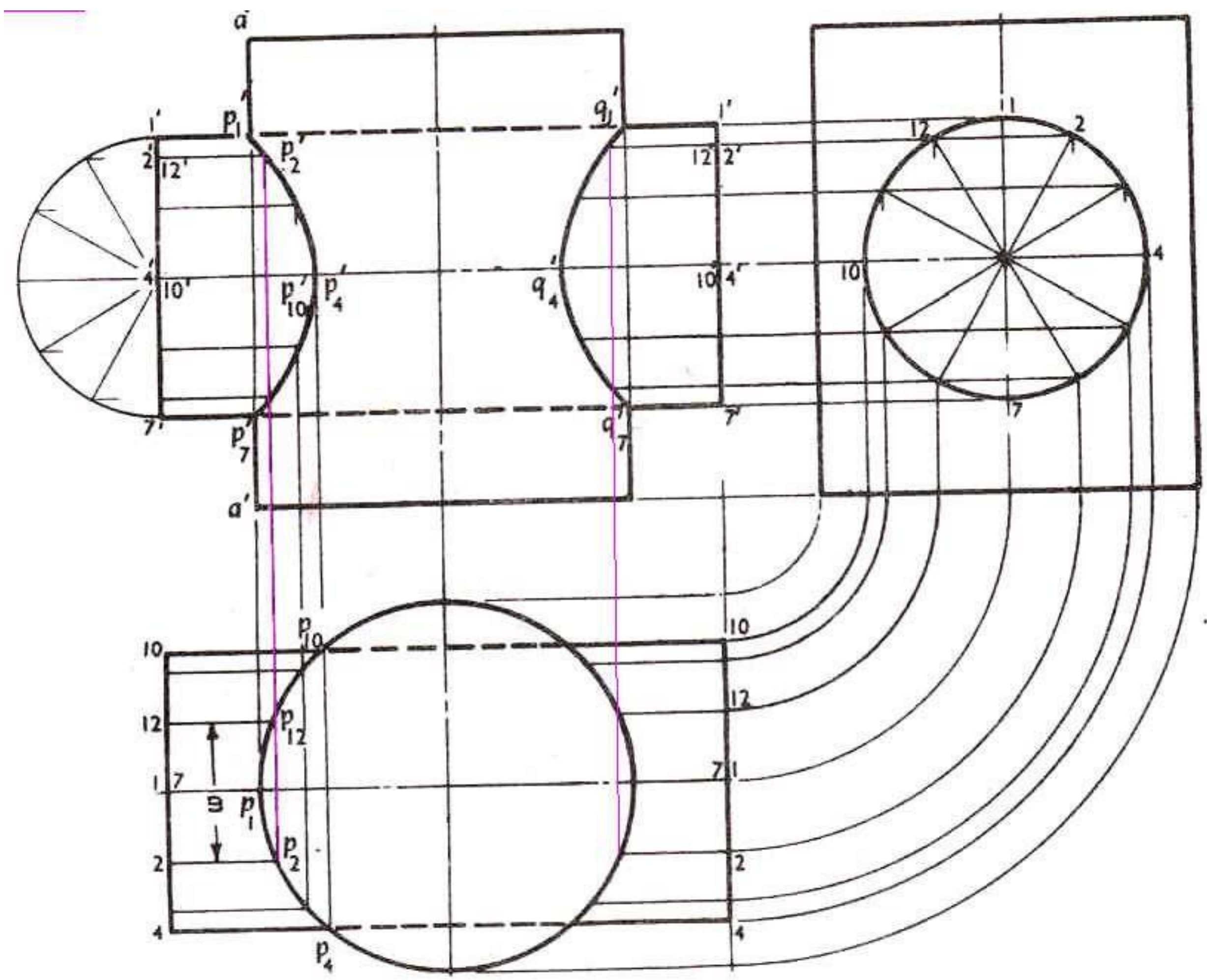
Assume a series of horizontal cutting planes passing through the the horizontal cylinder and cutting both cylinders.

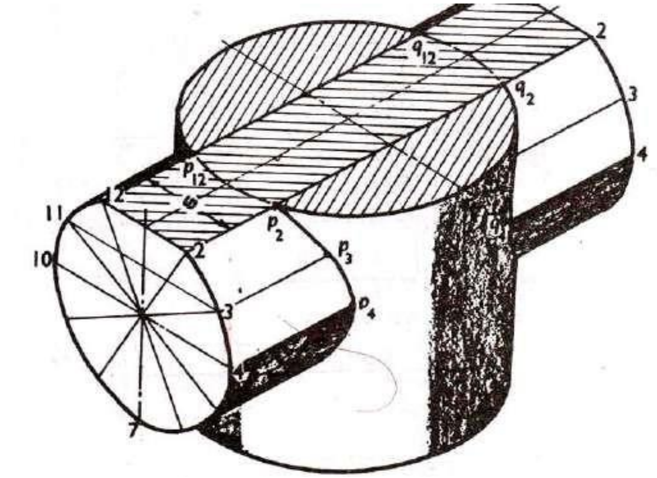
Sectio~~ns of the horizontal cylinde~~ will be rectangles, while those of the vertical cylinder will always be circles of the same diameter as its own.



Points at which sides of the rectangles intersect the circle will be the curve of intersection. For example, let a horizontal section pass through points 2 and 12

In the front view, it will be seen as a line coinciding with line **2' 2'.** The section of the horizontal cylinder will be a rectangle of width (i.e. the line **2-12**).



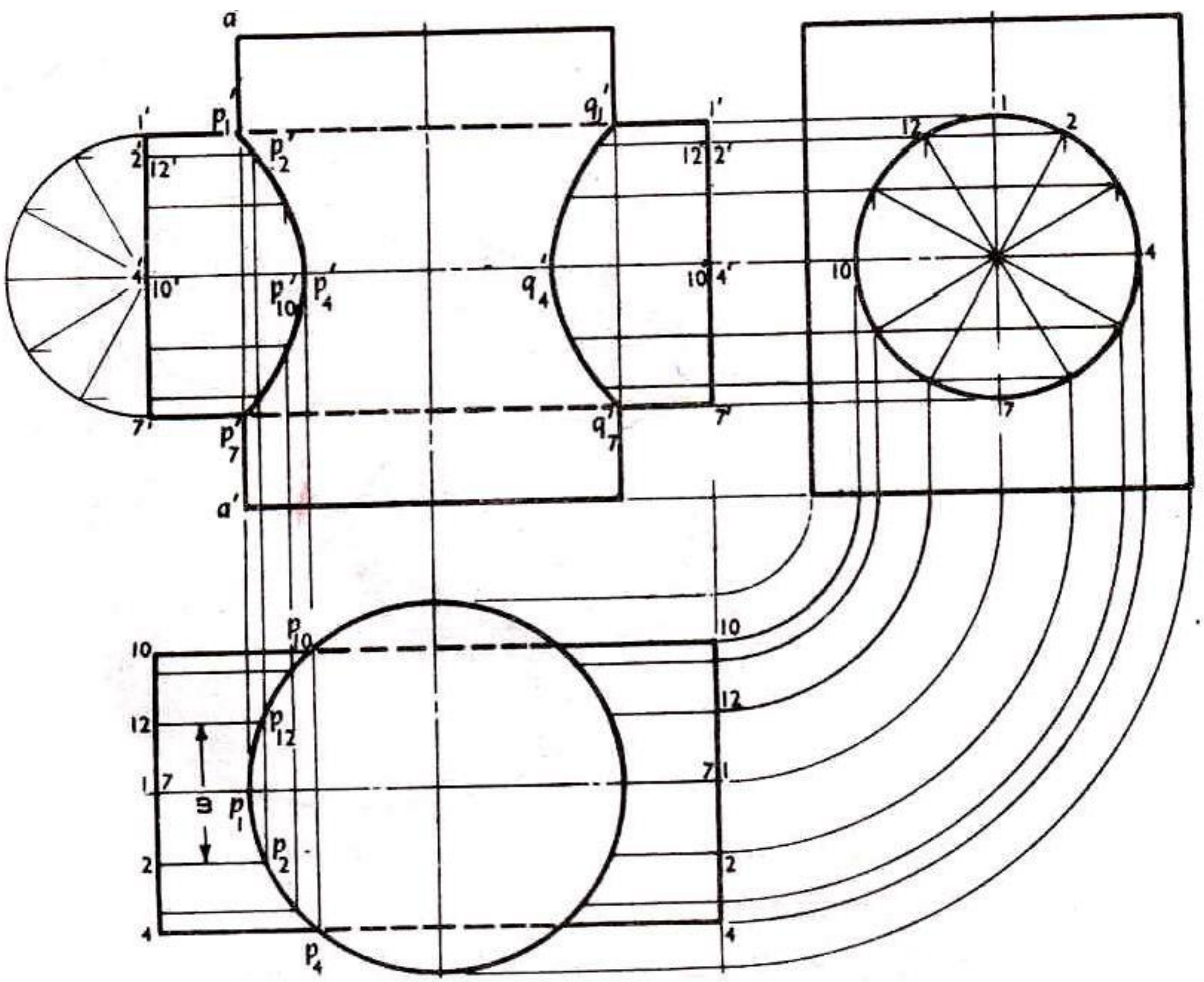


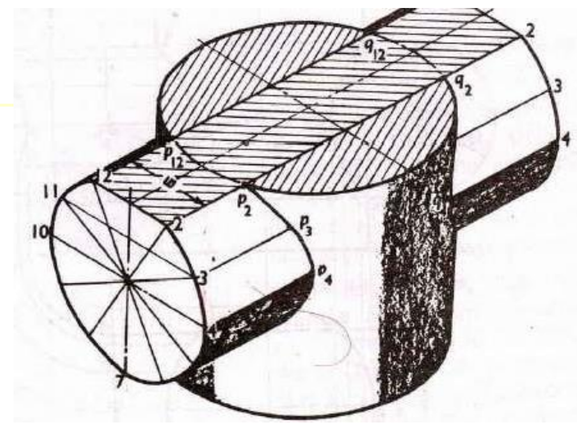
The section of the vertical cylinder will be a circle.

Points $\boldsymbol{p_2}$ and $\boldsymbol{p_{12}}$ at which the sides (**2-2** and **12-12**) of the rectangle cuts the circle, lie on the curve.

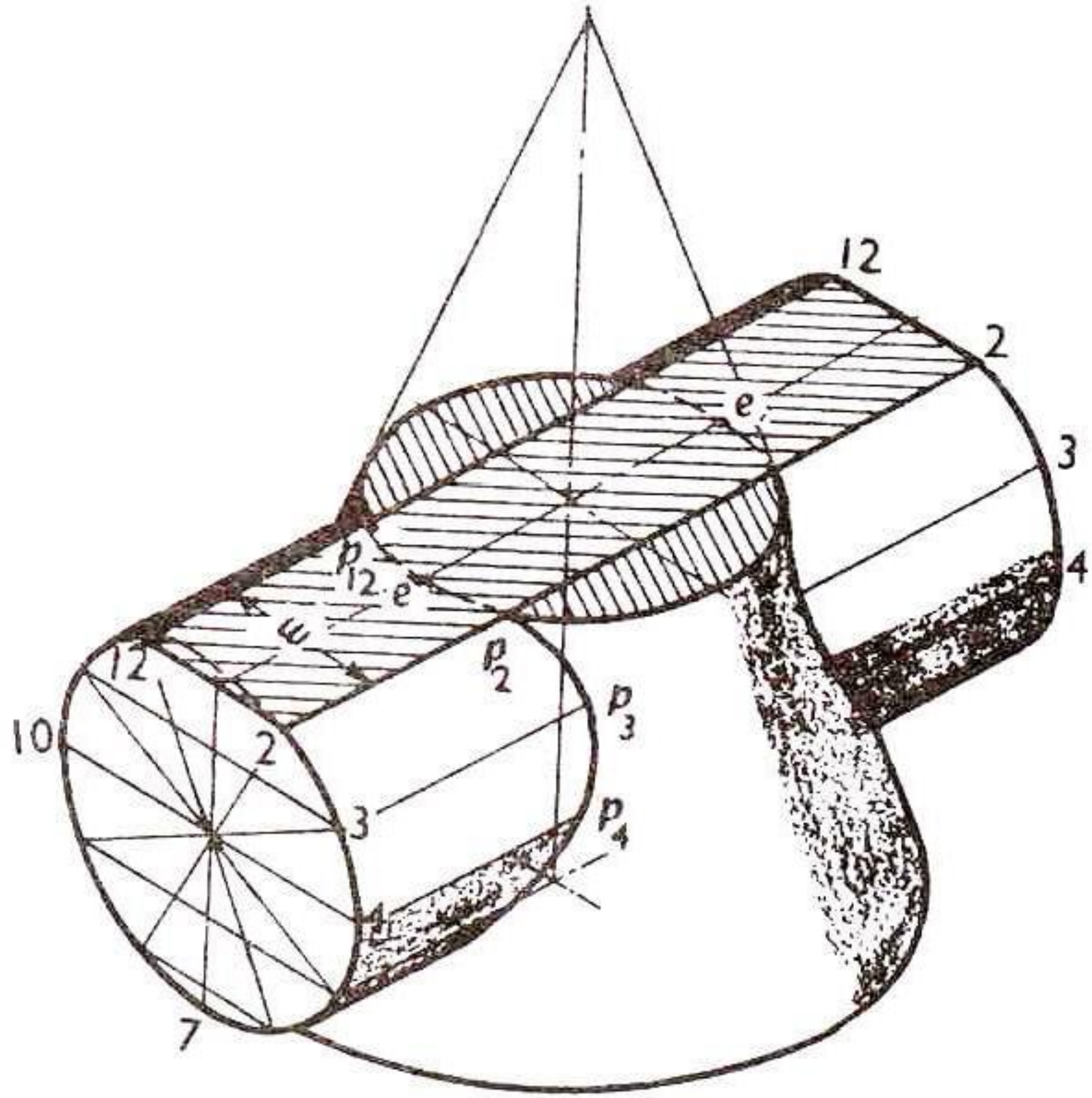
These points are first marked in the top view and then projected to points p_2' and p_{12}' on lines **2'2'** and **12'12'** in the front view.

Points on the other side of the axis are located in the same manner.



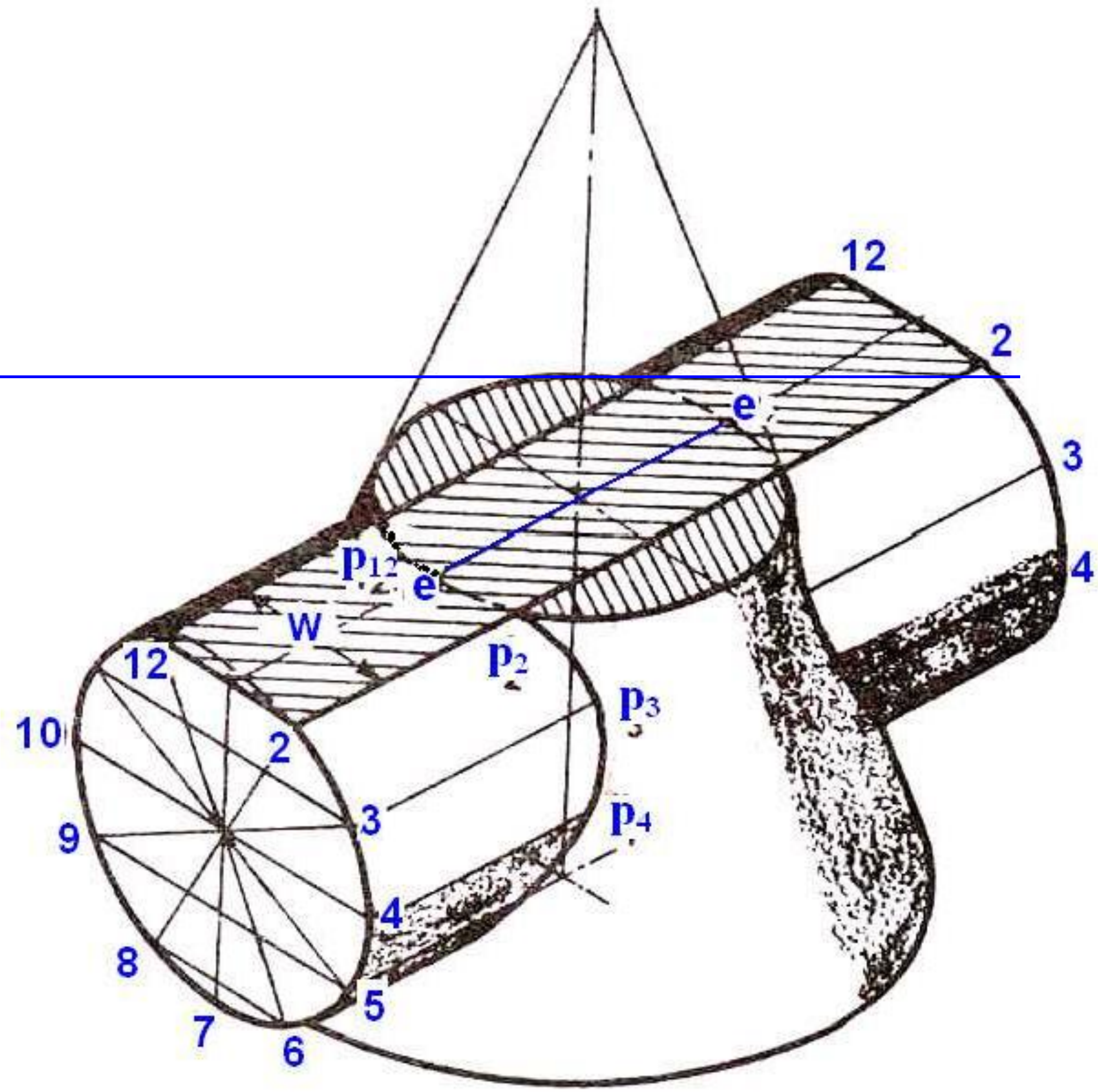


Intersection of Cone and Cylinder



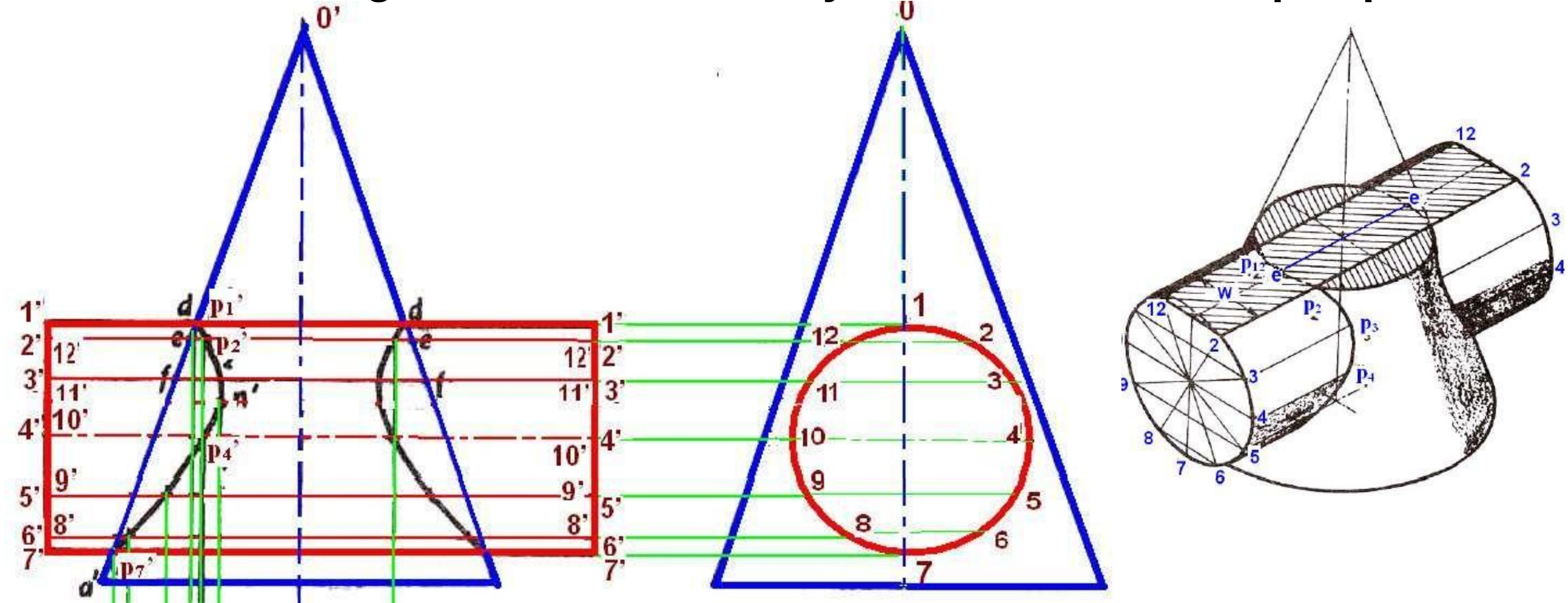
Intersection of Cone and Cylinder

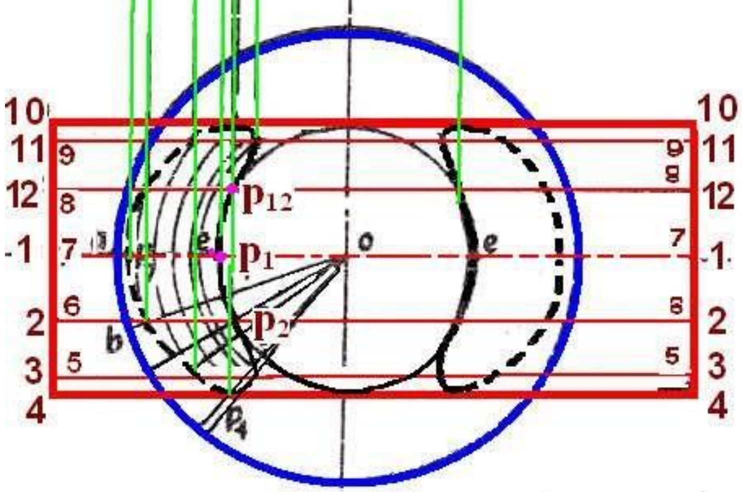
Example - A vertical cone, diameter of base 75 mm and axis 100 mm long, is completely penetrated by a cylinde r of 45 mm diameter. The axis of the cylinder is parallel to HP and the VP and intersects the axis of the cone at a point 22 mm above the base. Draw the projections of the solids showing curves of intersection.



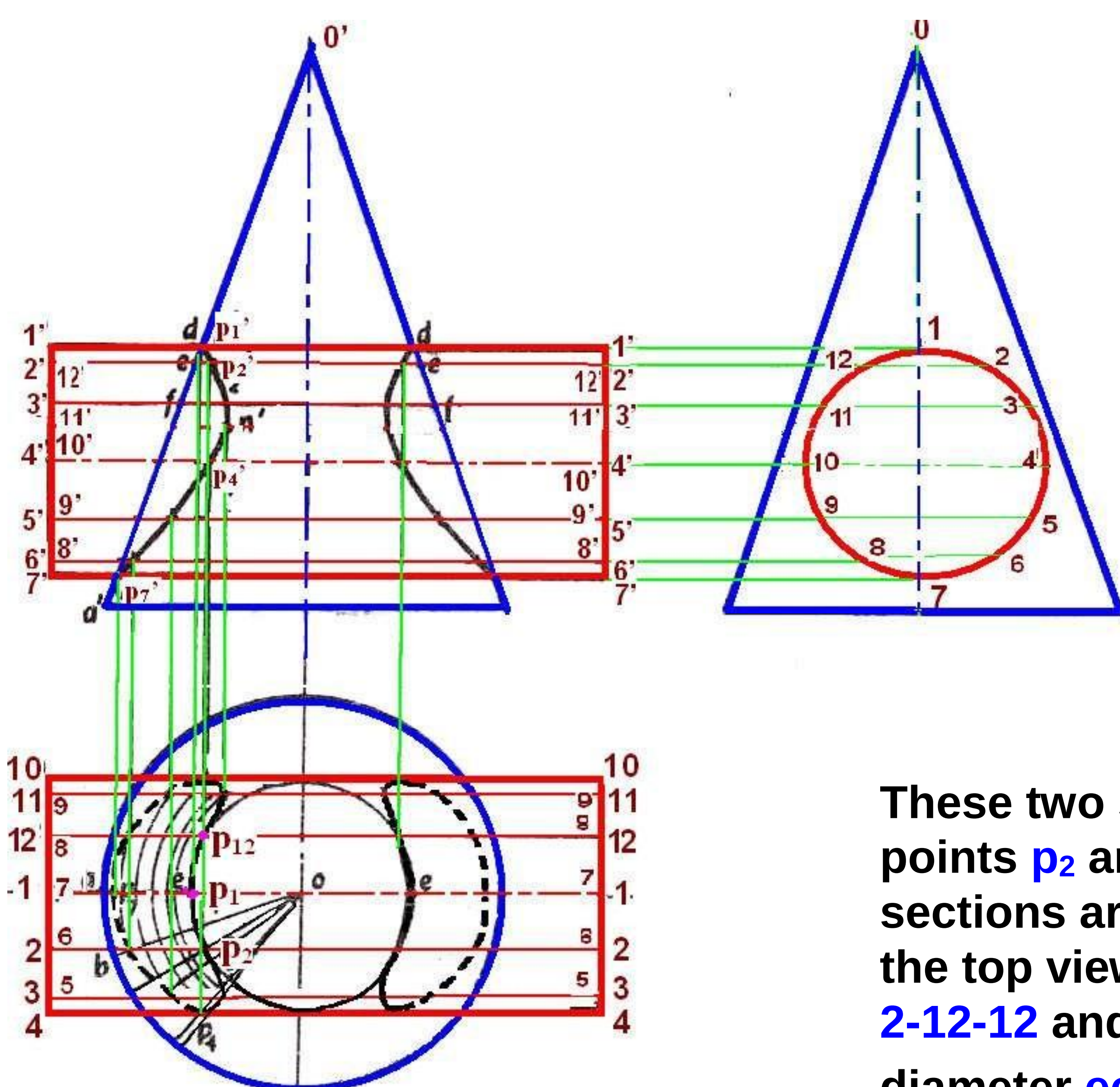
Cutting-Plane Method

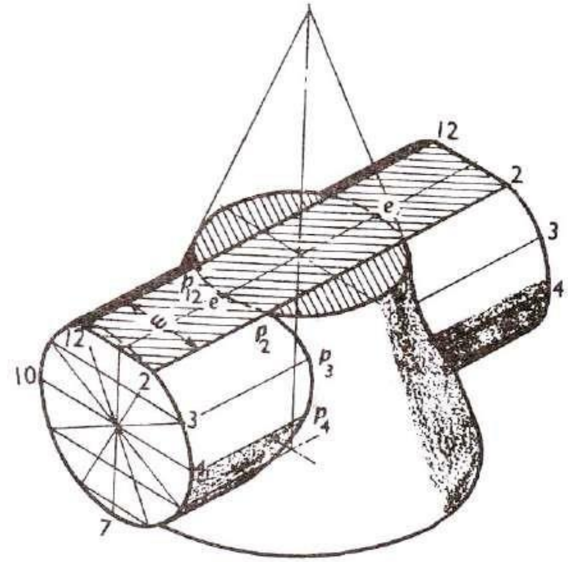
Draw lines dividing the surface of the cylinder into twelve equal parts.



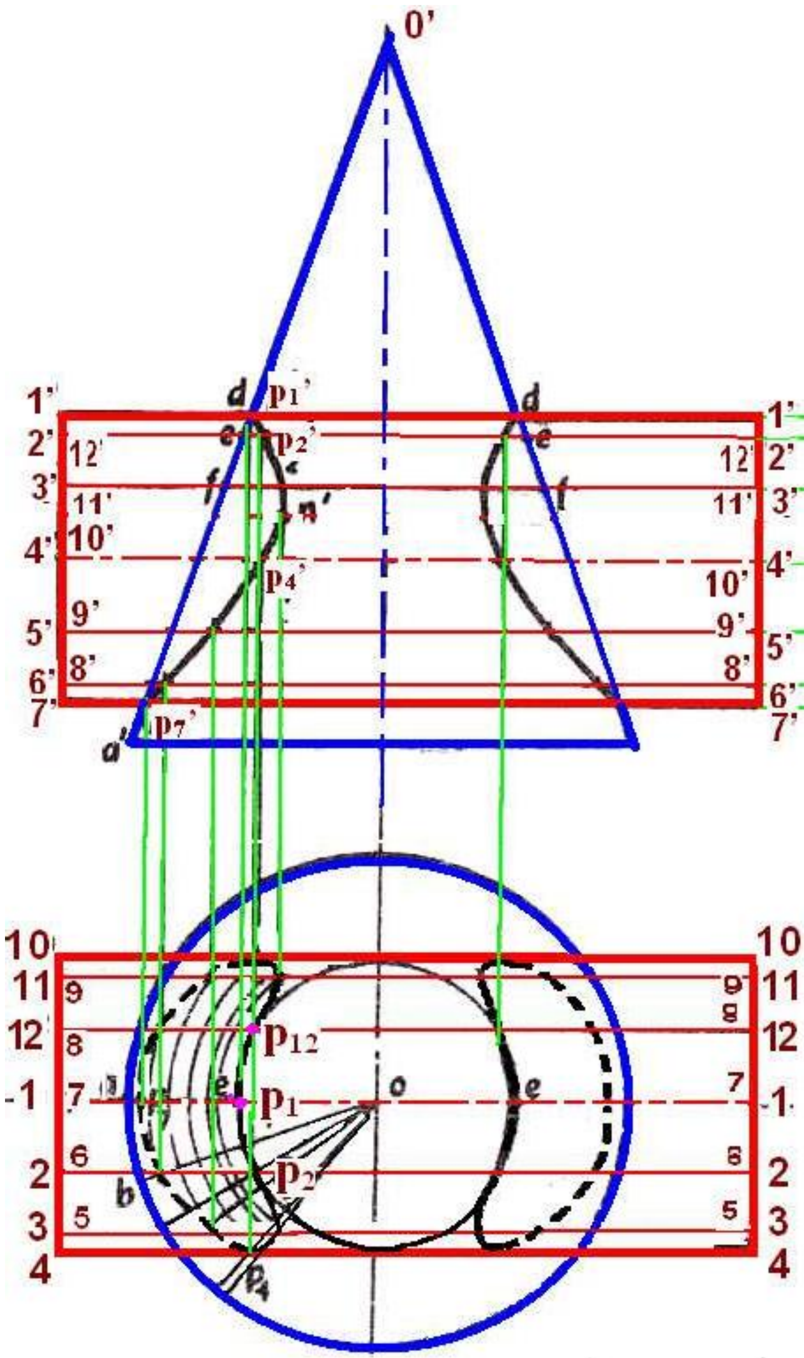


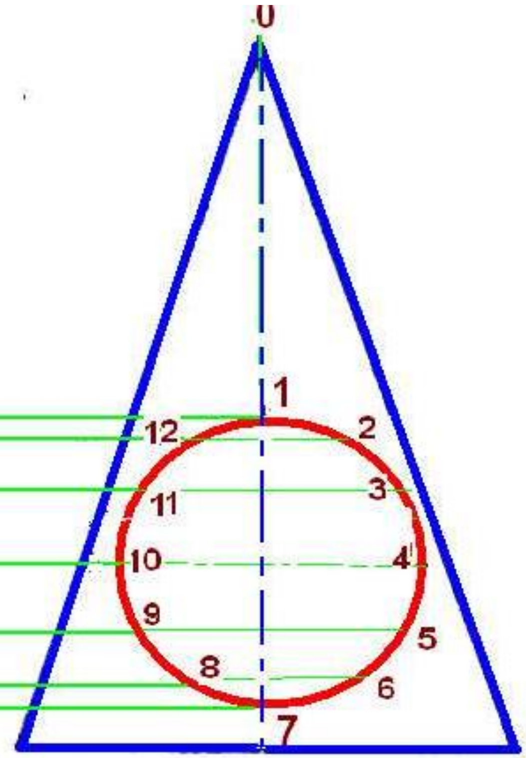
Assume a horizontal cutting plane passing through say, point 2. The section of the cylinder will be a rectangle of width *w* (i.e. the line 2-12), while that of the cone will be a circle of diameter *ee*.

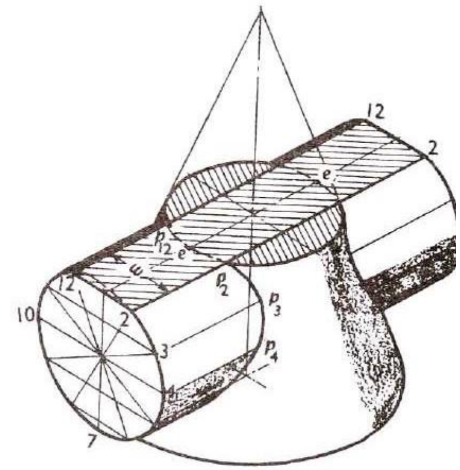




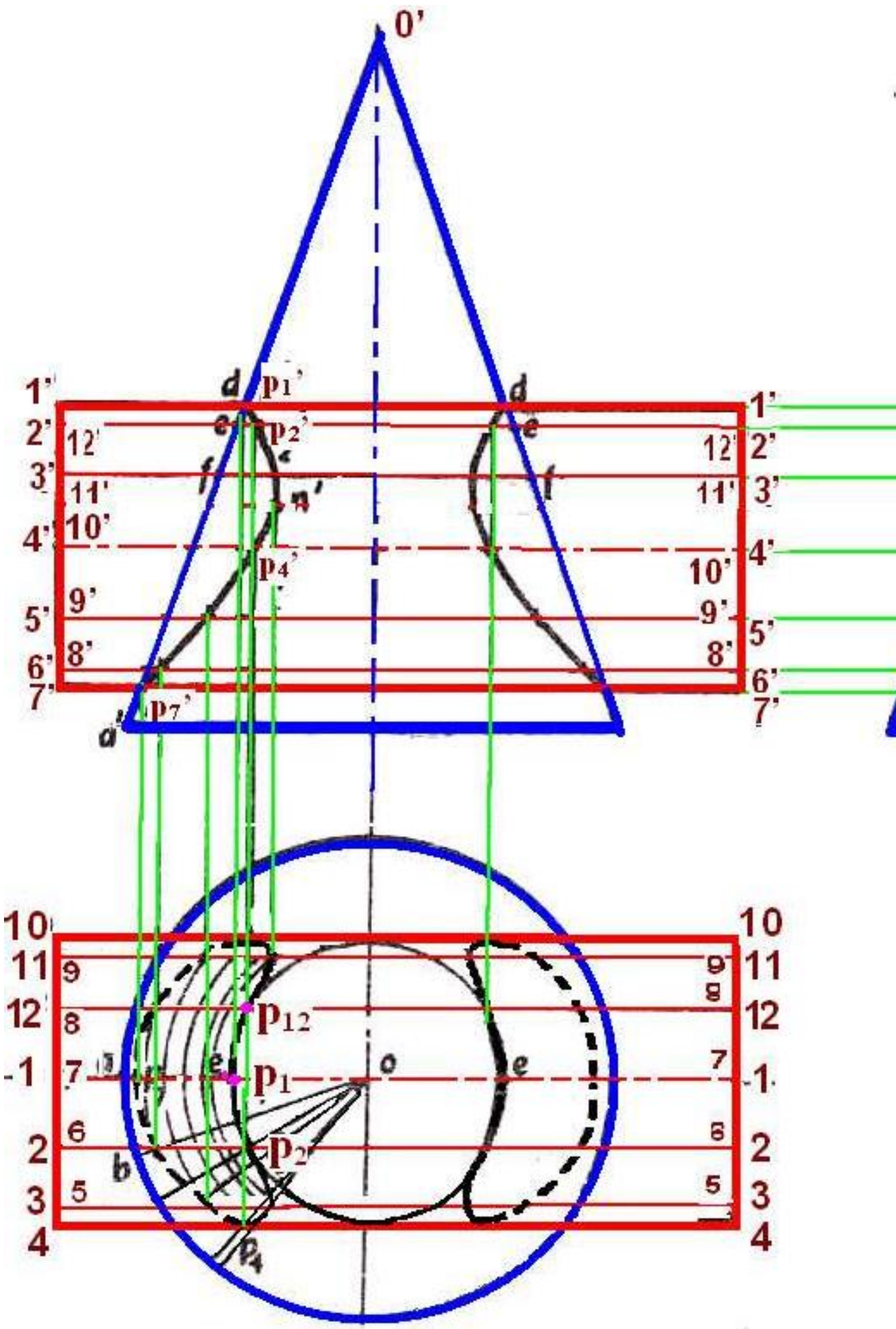
These two sections intersect at points p_2 and p_{12}. These sections are *clearly* indicated in the top view by the rectangle 2-2-12-12 and the circle of diameter ee .

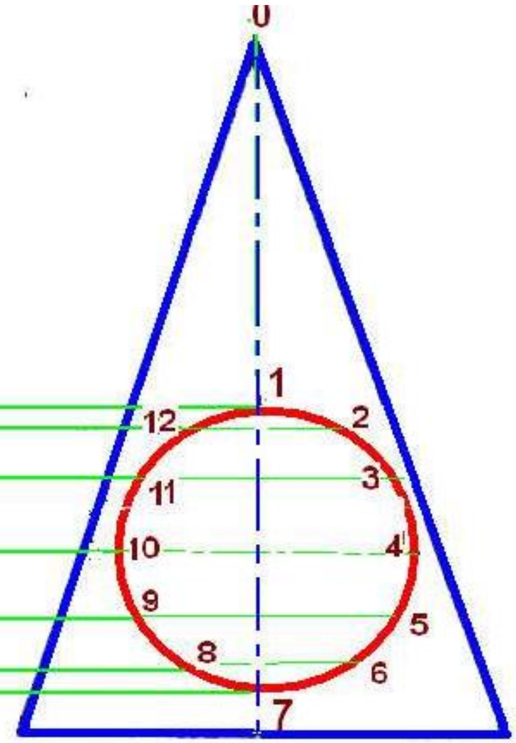




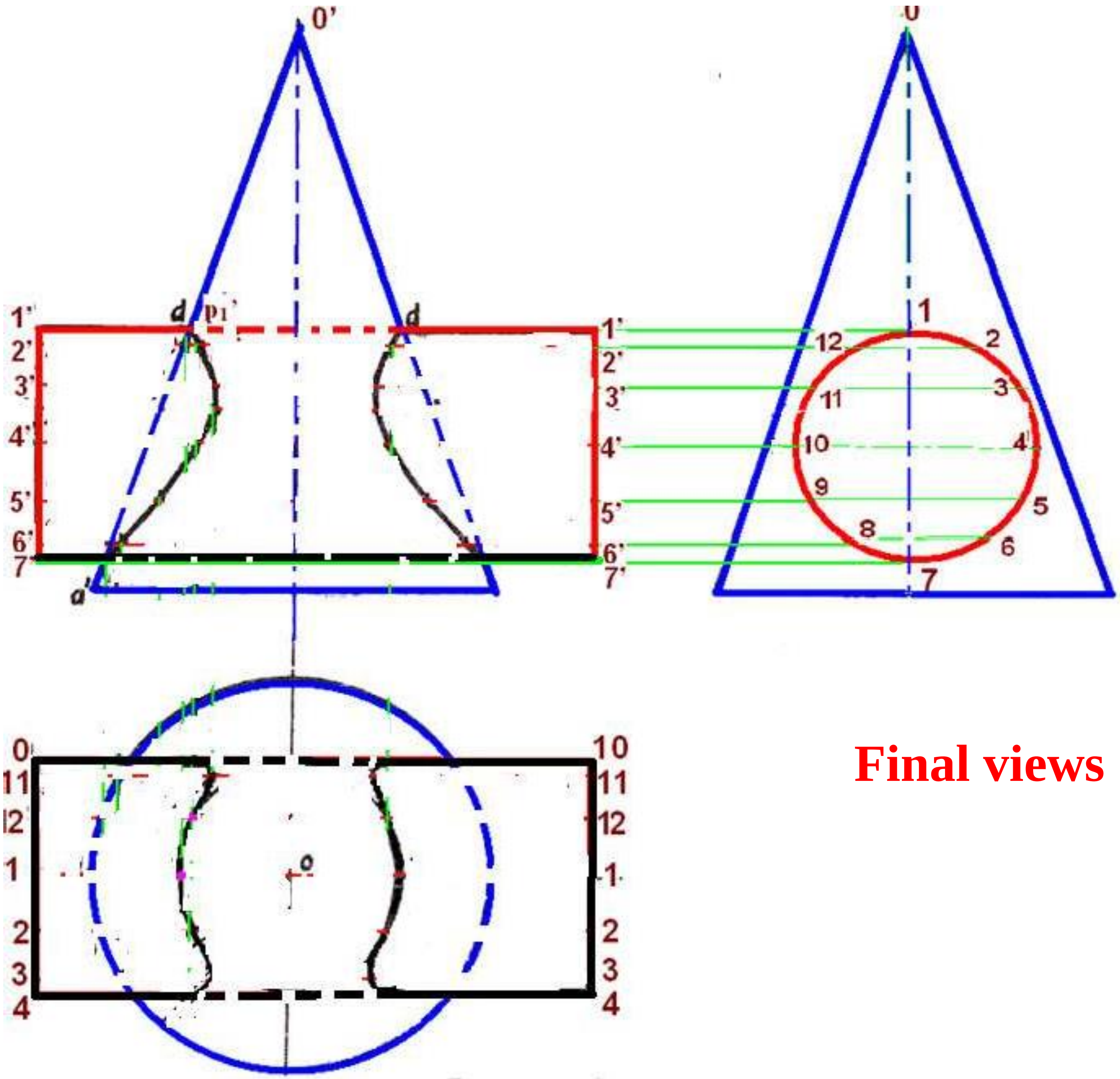


In the front view, the cutting plane is seen as a line coinciding with 2' 2’. Points p_2 and p_{12} when projected on the line 2' 2’ (with which the line 12'-12' coincides) will give a point p_2' (with which p_{12}' will coincide). Then p_2' and $p_{12'}$ are the points on the curve of intersection.





To obtain the points systematically, draw circles with centre 0 and diameters dd, ee, ff, etc. cutting lines through 1, 2 and 12, 3 and 11 etc. at points p_1, p_2 and p_{12}, p_3 and p_{ll} etc . Project these points to the corresponding lines in the front view.



0'
1'
2'
3'
4'
5'
6'
7'
d
p1'
d
a'
1'
2'
3'
4'
5'
6'
7'
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o
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4

Final views

THANK YOU

Engineering Drawing

Intersections of Solids 2

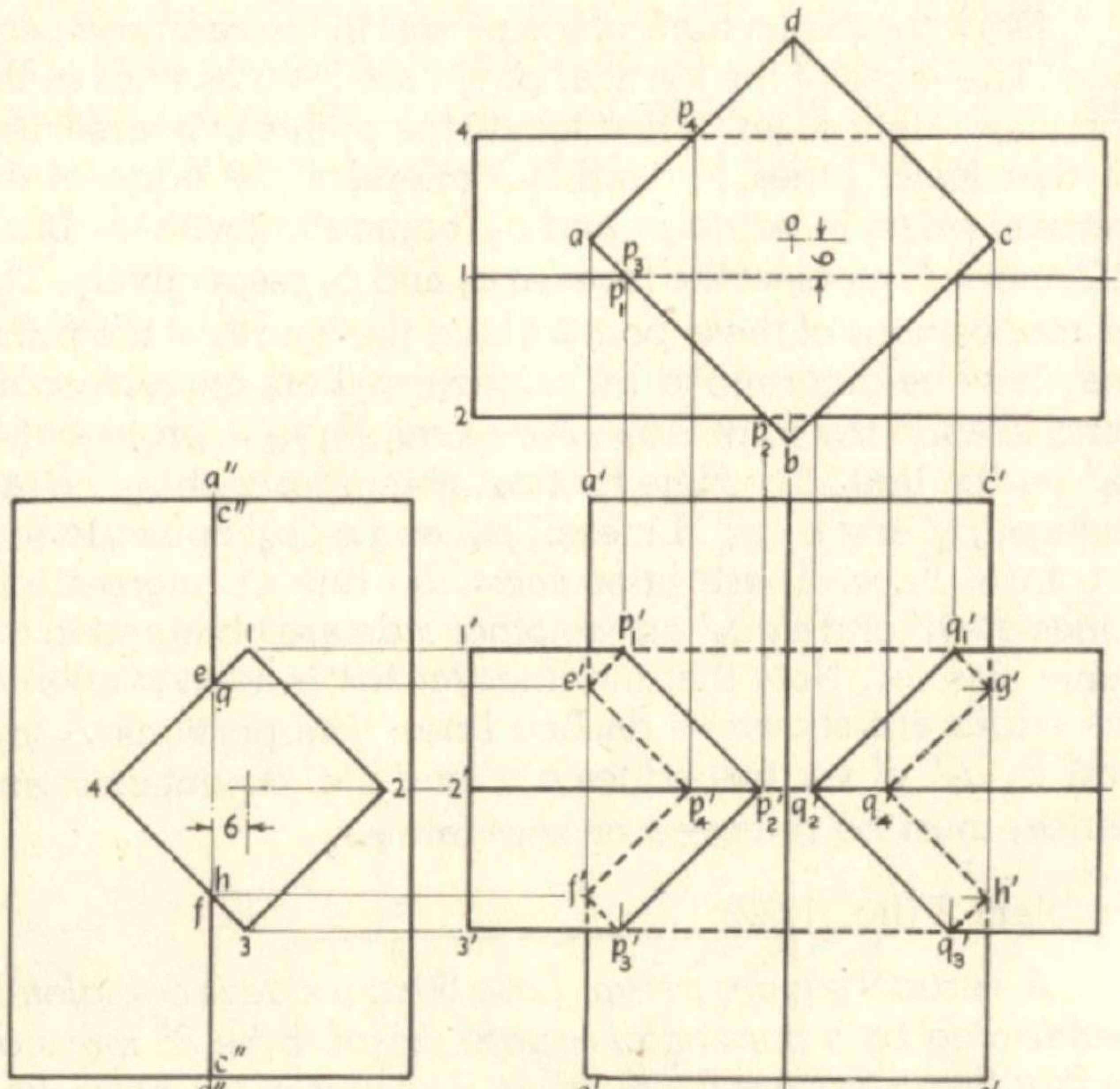
Questions for Practice

INTERSECTION OF PRISM AND PRISM

(with axis perpendicular and offset)

Prob. 1) A vertical square prism, base 50 mm side, is completely penetrated by a horizontal square prism, base 35 mm side, so that their axis are 6 mm apart. The axis of the horizontal prism is parallel to the VP, while the faces of both prisms are equally inclined to the VP. Draw the projections of the prisms showing lines of intersection. (Assume that the length of both the prisms is 100 mm).

(Book: *N. D. Bhatt*)

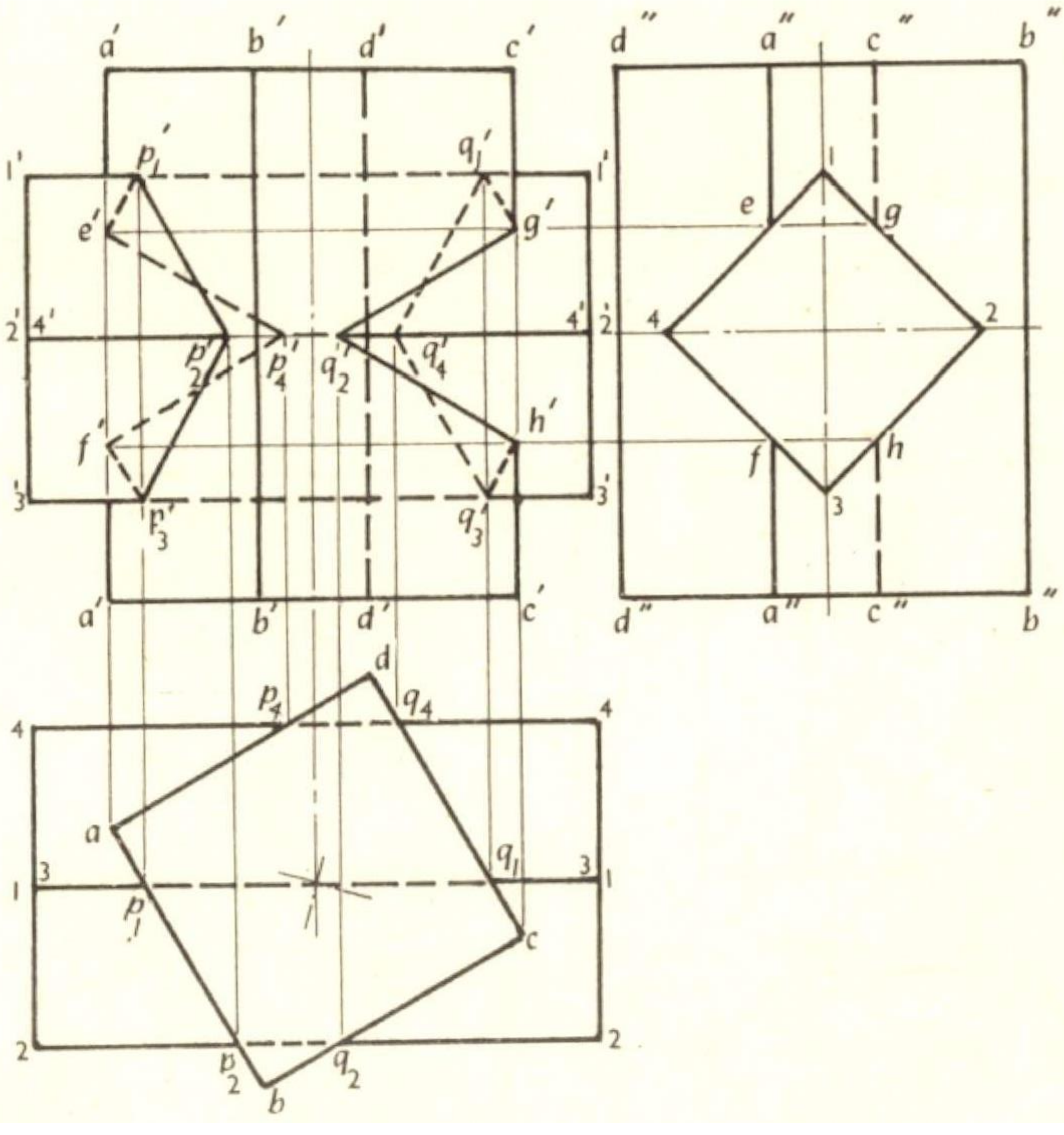


(Third-angle projection)

INTERSECTION OF PRISM AND PRISM

Prob. 2) A vertical square prism, base 50 mm side and height 90 mm has a face inclined at 30^{O} to the VP. It is completely penetrated by another horizontal square prism, base 40 mm side and axis 100 mm long, faces of which are equally inclined to the VP. The axis of the two prisms are parallel to the VP and bisect each other at right angles. Draw the projections showing lines of intersection.

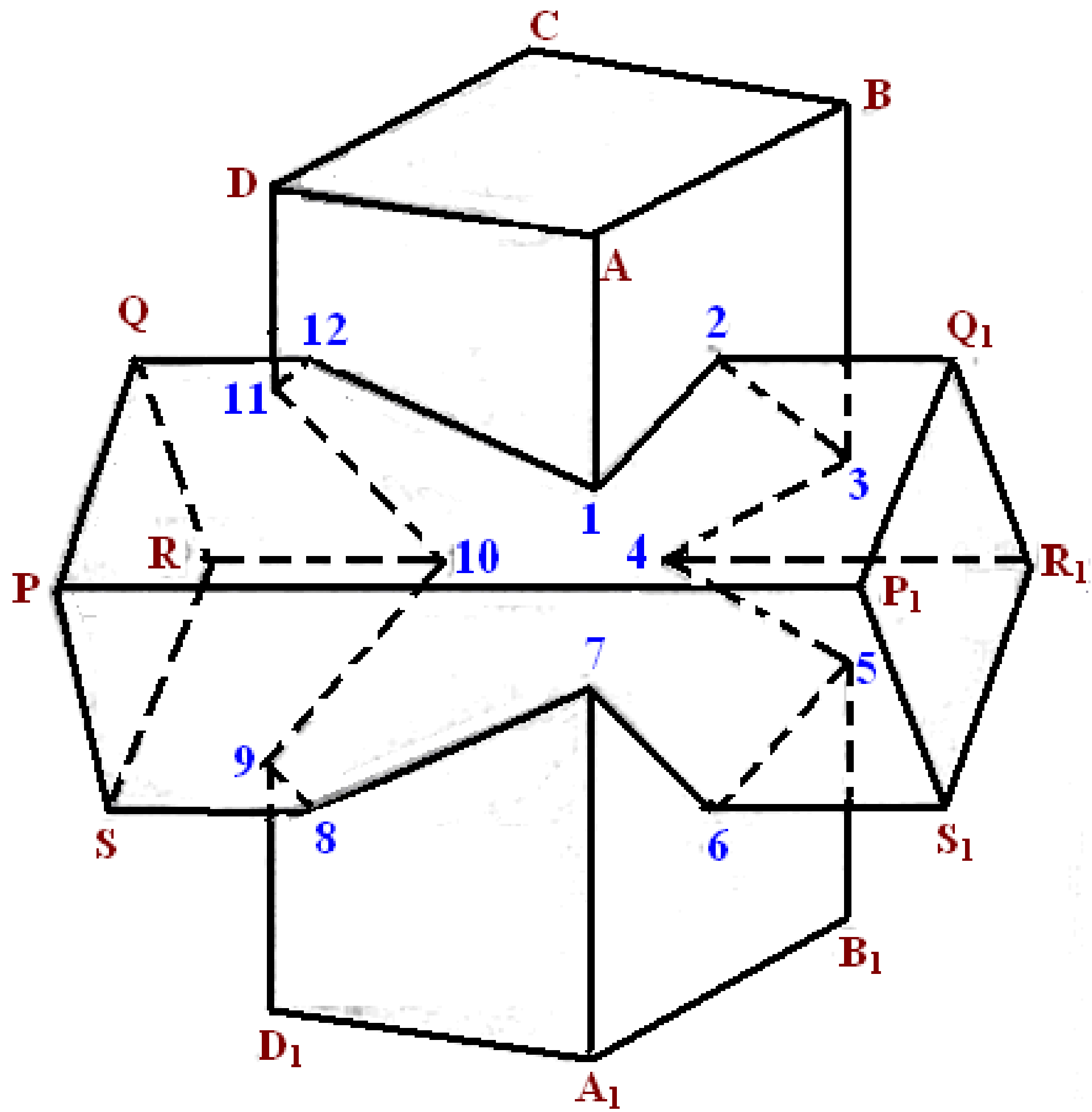
(Book: *N. D. Bhatt)*


a'
b'
d'
c'
d''
a''
c''
b''
1'
2'
3'
4'
p'1
p'2
p'3
p'4
q'1
q'2
q'3
q'4
e'
f'
g'
h'
e
f
g
h
1
2
3
4
a
b
c
d
p1
p2
p4
q1
q2
q4

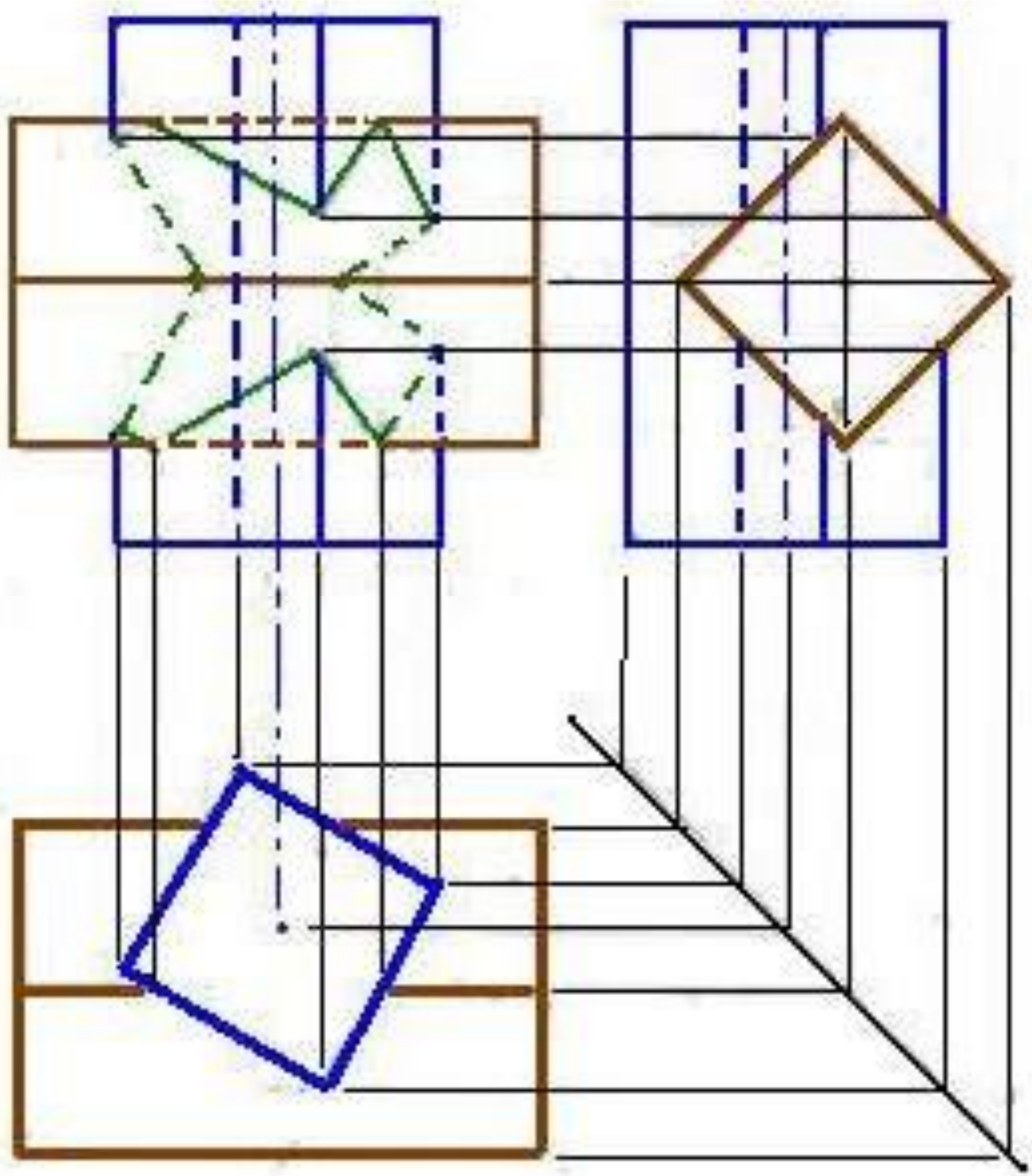
Prob. 3) A square prism of 40 mm edge of base and 90 mm high rests vertically with its base on HP such that the front right vertical rectangular face is inclined at 60° to VP. This prism is penetrated by another horizontal square prism whose rectangular faces make equal inclination with both HP and VP. The axis of the horizontal prism is passing at the mid height at a distance of 10 mm infront of the vertical prism. The horizontal square prism is of the same dimensions as that of the vertical square prism.

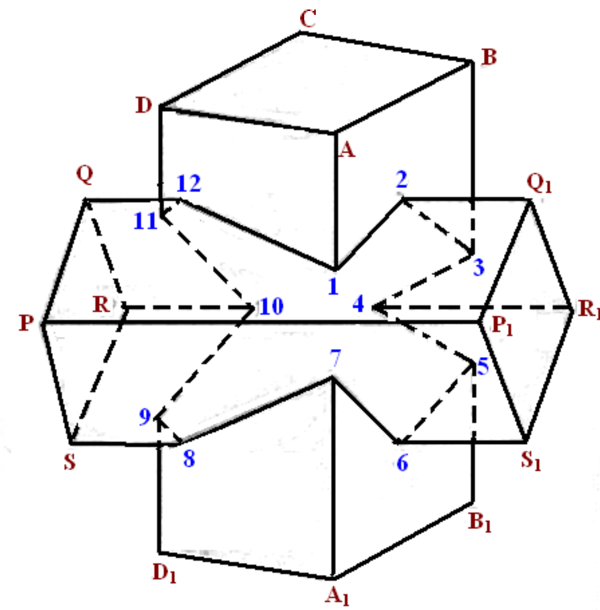
Draw the lines of intersection

(*Taken from K.R. Gopslakrishna, Engg. Drawing, subhas store book center*)



(*Taken from K.R. Gopslakrishna, Engg. Drawing, subbhas store book center*)



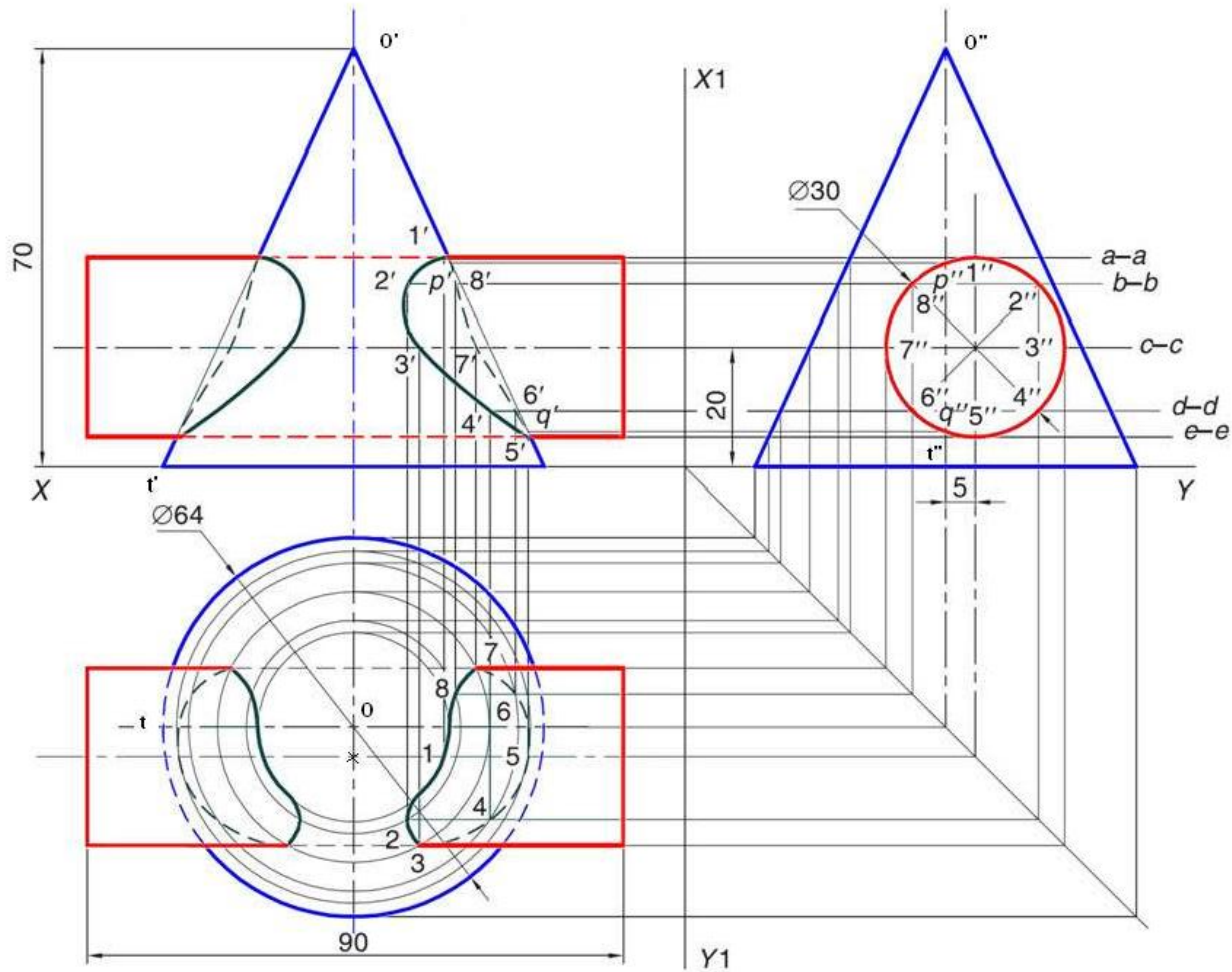

C
B
D
A
Q
12
2
Q1
11
3
1
R
10
4
R1
P
P1
7
5
9
S
8
6
S1
B1
D1
A1

INTERSECTION OF CYLINDER AND CONE

(with axis perpendicular and offset)

Prob. 4) A cone with a base diameter of 64 mm and an axis length of 70 mm is kept on its base on the HP. A cylinder of diameter 30 mm and length 90 mm penetrates the cone horizontally. The axis of the cylinder is 20 mm above the base of the cone and 5 mm away from the axis of the latter. Draw the three views of the solids showing curve of intersection.

(*Taken from Dhananjay A Jolhe, Engg. Drawing, MGH*)



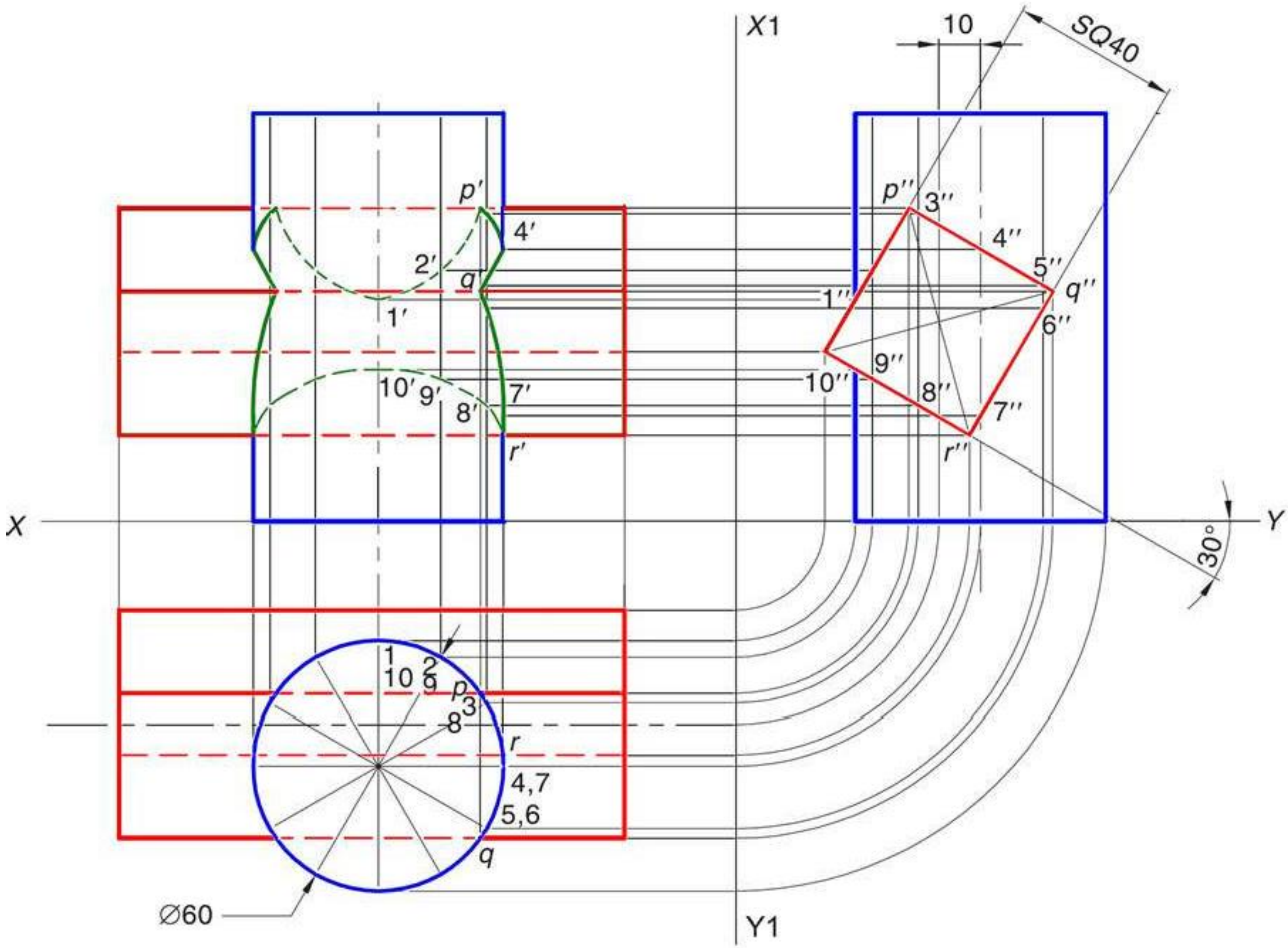
o'
o"
X1
70
Ø30
1′
a–a
2′
p′
8′
p″
1″
b–b
8″
2″
7″
3″
c–c
3′
7′
6′
20
6″
4″
d–d
q′
q″
5″
4′
e–e
5′
t″
X
t'
5
Y
Ø64
7
8
o
6
t
1
5
4
2
3
90
Y1

INTERSECTION OF PRISM AND CYLINDER

(with axis perpendicular and offset)

Prob. 5) A vertical cylinder with a 60 mm diameter is penetrated by a horizontal square prism with a 40 mm base side, the axis of which is parallel to the VP and 10 mm away from the axis of the cylinder. A face of the prism makes an angle of 30° with the HP. Draw their projections showing curves of intersection.

(*Taken from Dhananjay A Jolhe, Engg. Drawing, MGH*)

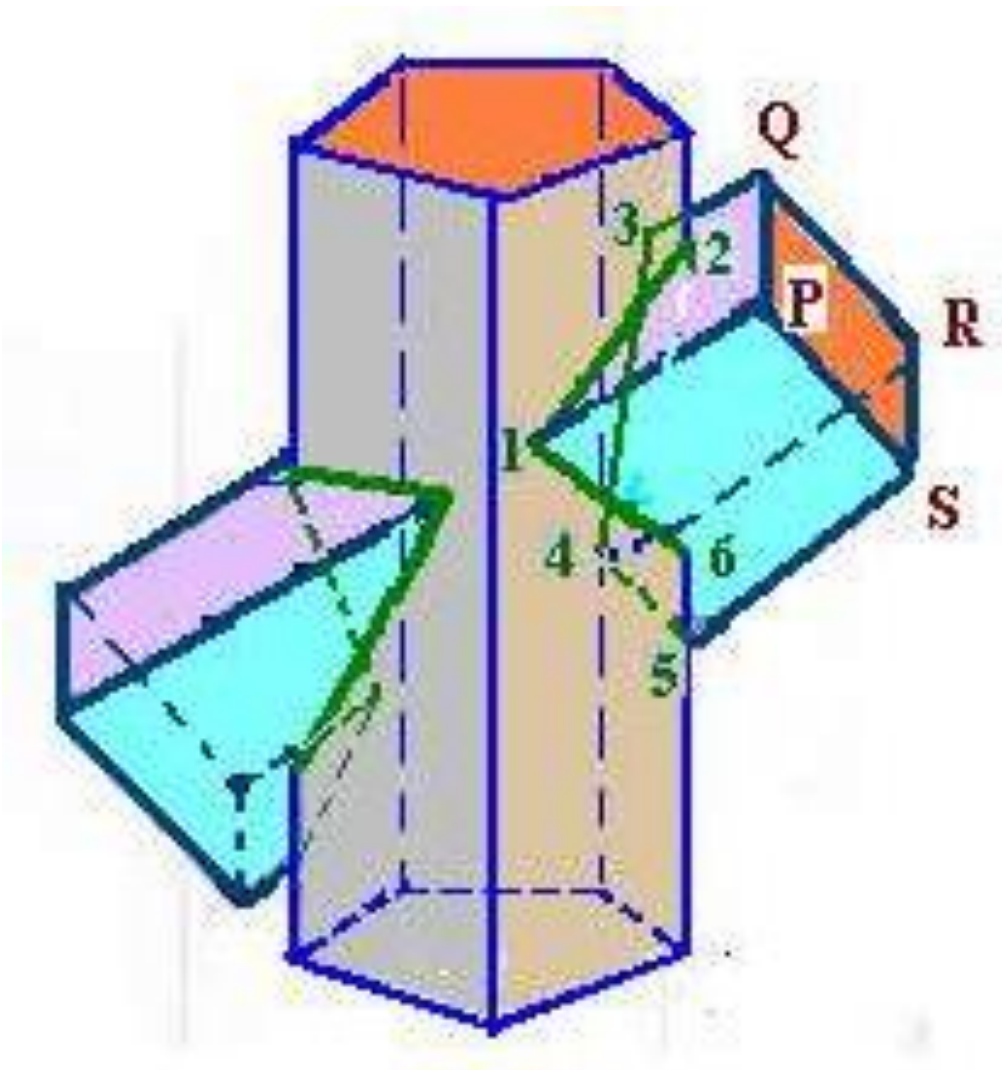


X1
10
SQ40
p′
4′
2′
q′
1′
10′ 9′
7′
8′
r′
p″ 3″
4″
5″
q″
1″
6″
9″
10″
8″
7″
r″
X
Y
30°
1
2
10 9
p
3
8
r
4,7
5,6
q
∅60
Y1

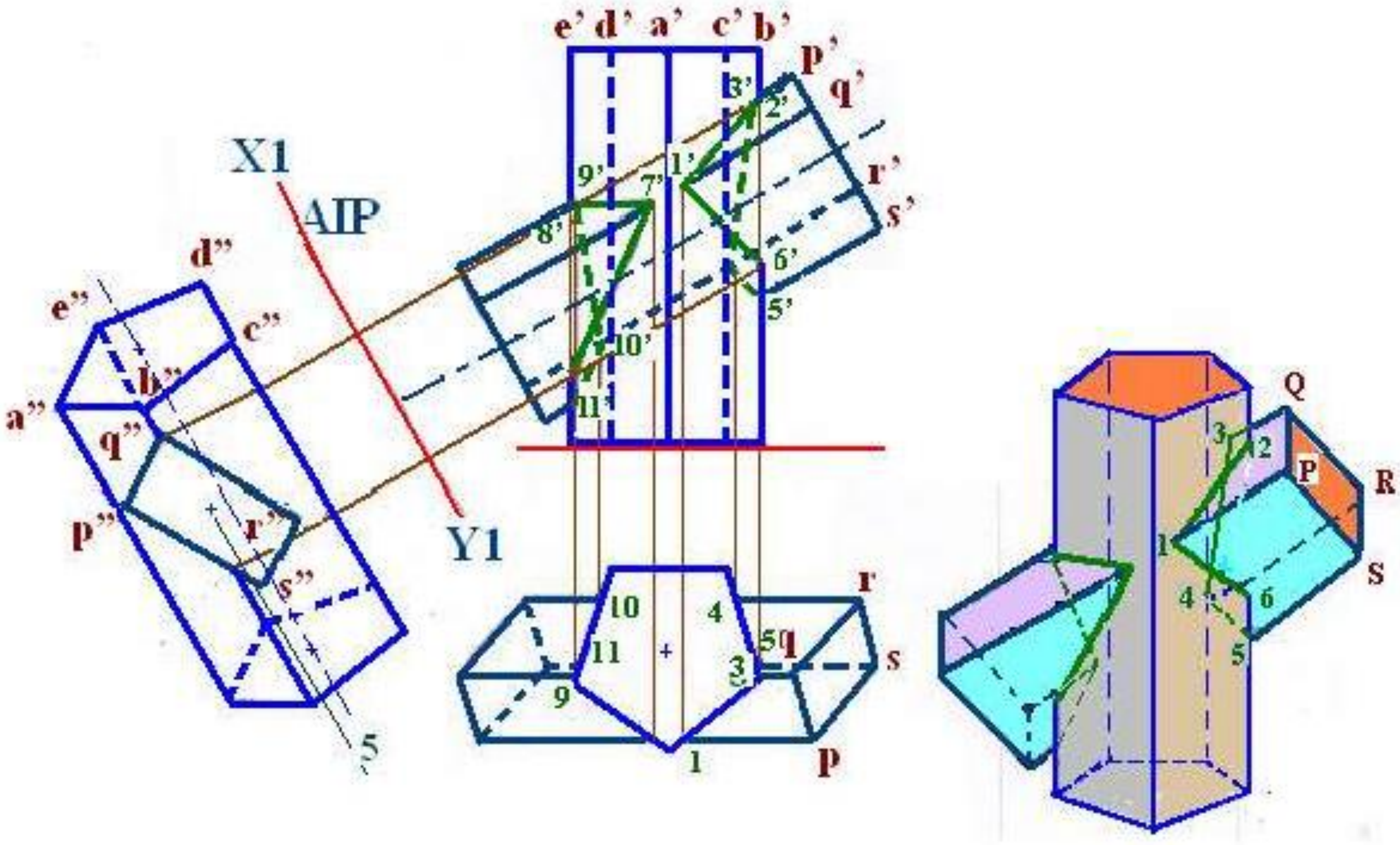
Prob. 6)

A vertical pentagonal prism 30 mm edge of base and height 100 mm has one of its rectangular faces parallel to VP and nearer to it. It is penetrated by a rectangular prism of side 40mm x 20 mm and 100 mm high, with its front largest lower front rectangular face inclined at 60° to HP. The axis of the rectangular prism is inclined at 30 ° to HP and parallel to VP, 5 mm infront of the axis of the pentagonal prism and appears to bisect it in the front view. Draw the interpenetration line.

(Taken from K.R. Gopslakrishna, Engg. Drawing, subhas store book center)



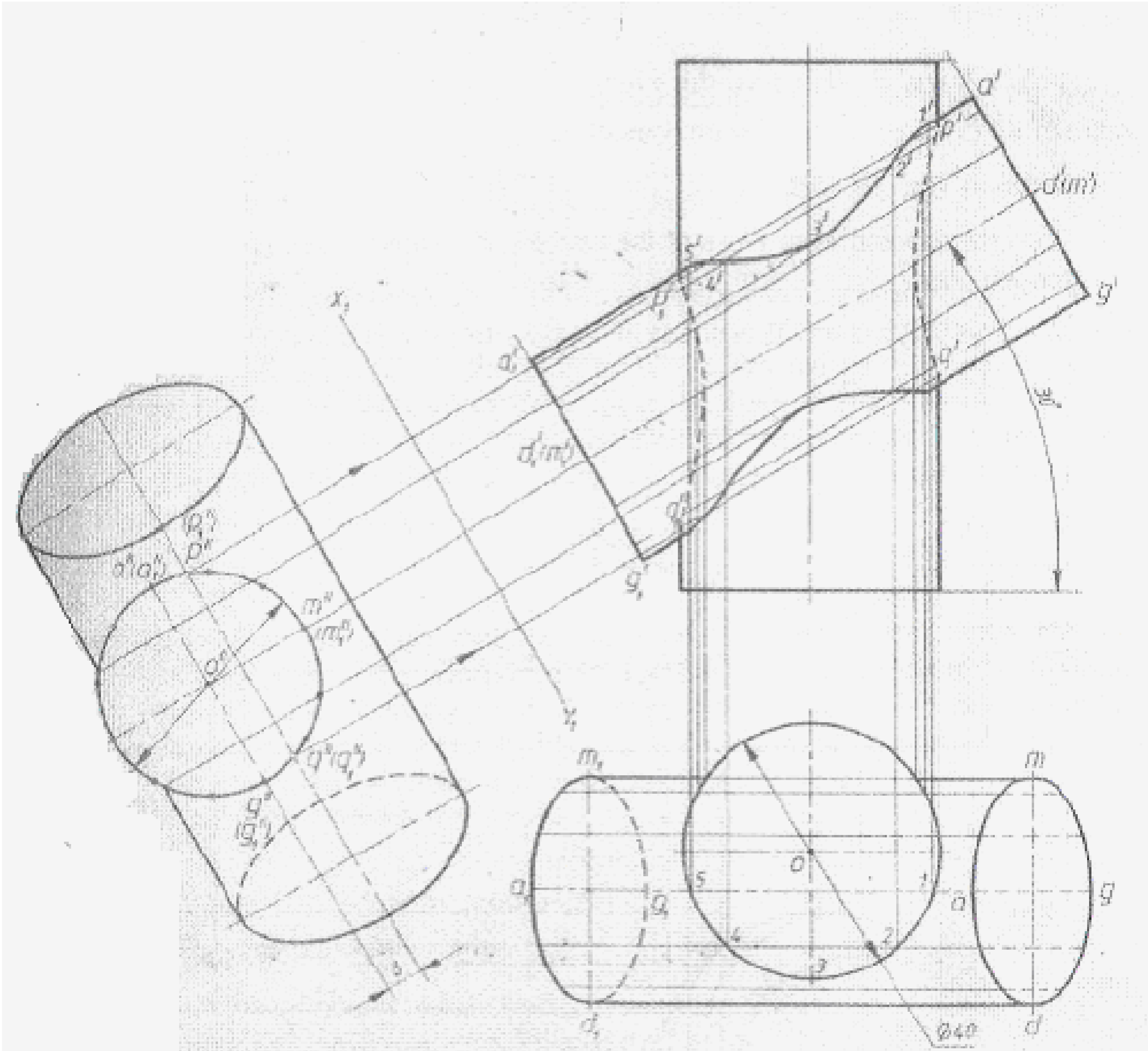
(*Taken from K.R. Gopslakrishna, Engg. Drawing, subhas store book center*)



(*Taken from K.R. Gopslakrishna, Engg. Drawing, subhas store book center*)

Prob. 7) A vertical cylinder of 40 mm diameter and 80 mm high is intersected by another cylinder of 35 mm diameter and 80 mm long. The axis of the penetrating cylinder is inclined at 30° to HP, parallel to VP, 6 mm infront of the vertical cylinder and appears to bisect it in front view. Draw the intersection curve.

(*Taken from K.R. Gopslakrishna, Engg. Drawing, subhas store book center*)

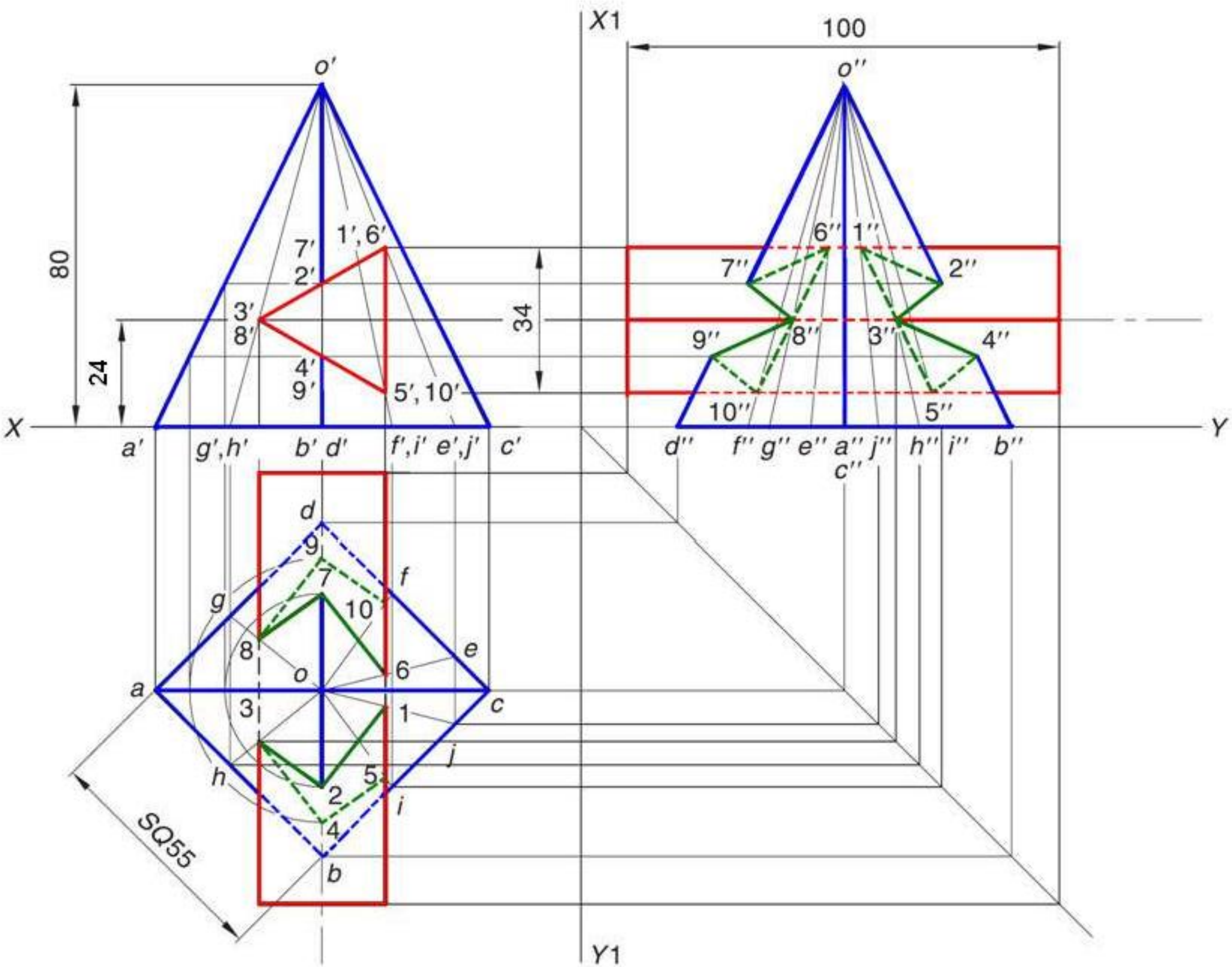


(*Taken from K.R. Gopslakrishna, Engg. Drawing, subhas store book center*)

INTERSECTION OF PRISM AND PYRAMID

Prob. 8) A square pyramid with a base side of 55 mm and an axis length of 80 mm stands on its base on the HP with the sides of base equally inclined to the VP. A triangular prism with a base side of 34 mm and length of axis 100 mm, penetrates the pyramid completely. The axis of the prism is perpendicular to the VP and intersects the axis of pyramid at 24 mm from the HP. One of the lateral faces of the prism is perpendicular to the HP. Draw the three views of the solids showing LOI.

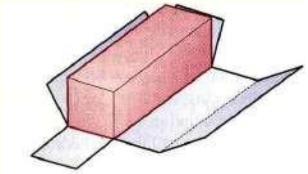
(*Taken from Dhananjay A Jolhe, Engg. Drawing, MGH*)



Solution is Correct ??????

Engineering Drawing

Development of Surfaces

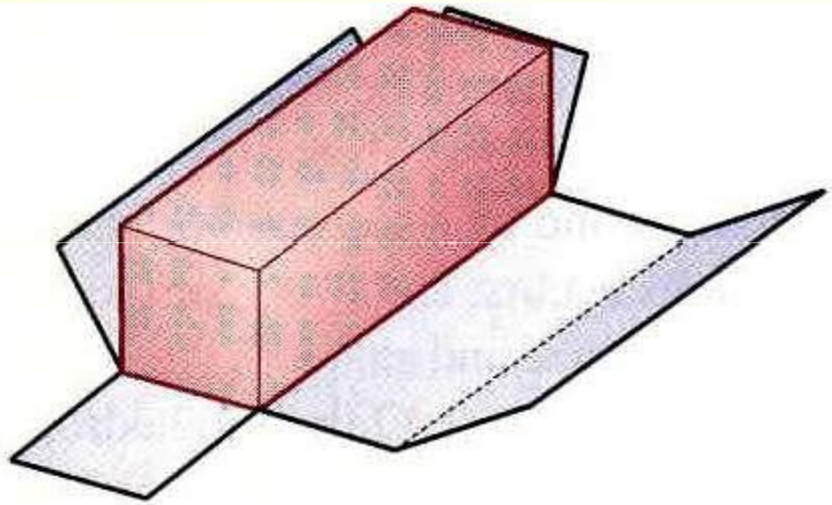


Development of surfaces

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

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

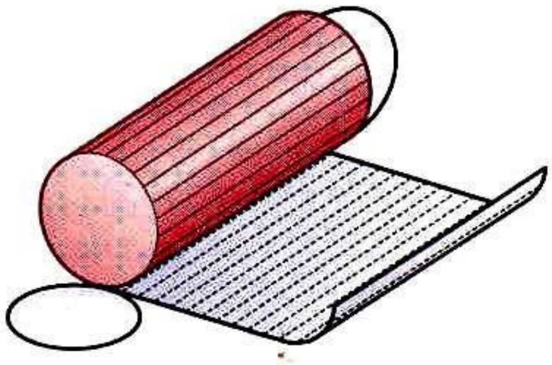
When the pattern is cut, it can be rolled or folded back into the original object.



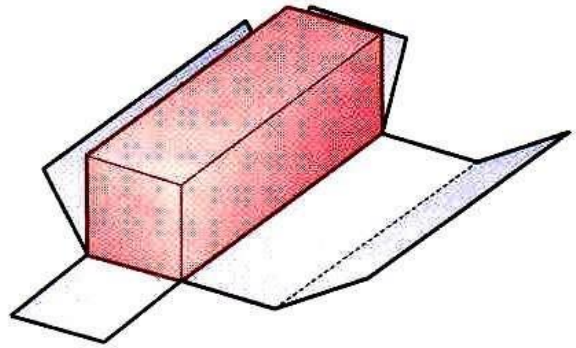
Methods of development of surfaces are:

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

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

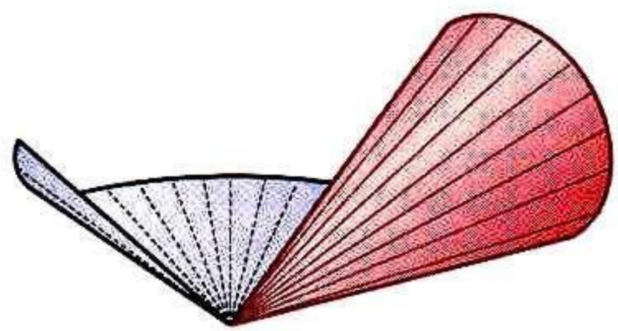


(B) Cylinder
(Parallel line development)



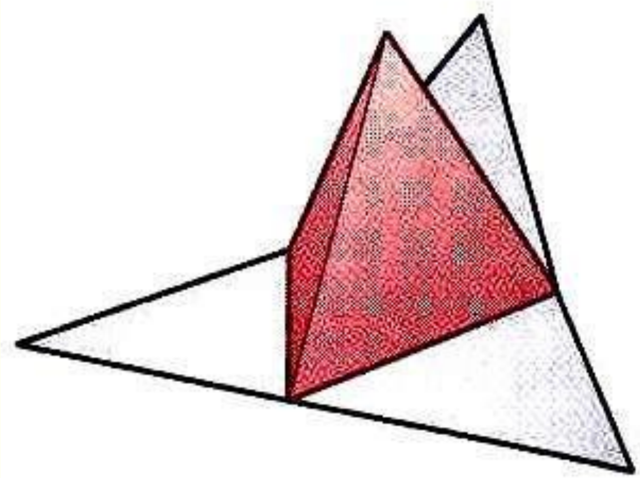
(A) Prism
(Parallel line development)

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



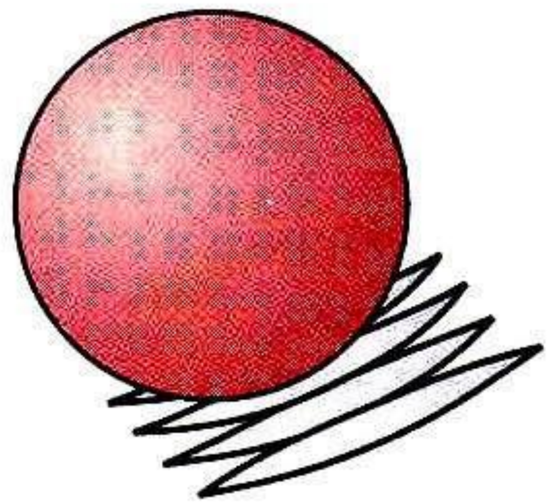
(D) Cone
(Radial line development)

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

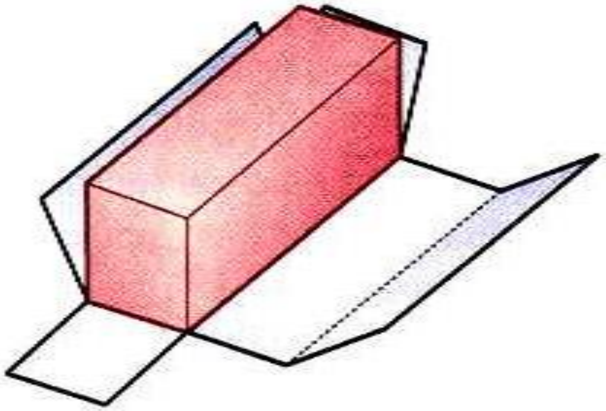


(F) Tetrahedron
(Triangulation development)

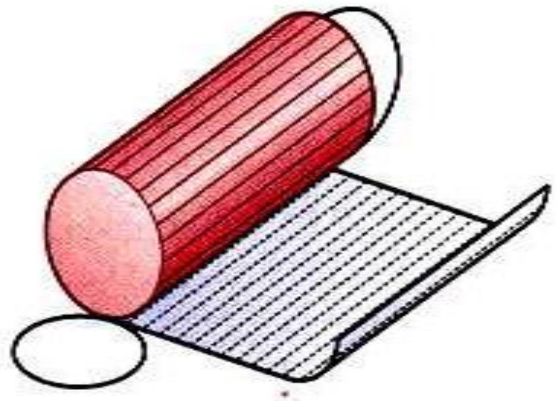
- **In approximate development, the shape obtained is only approximate. After joining, the part is stretched or distorted to obtain the final shape. Example: Sphere.**



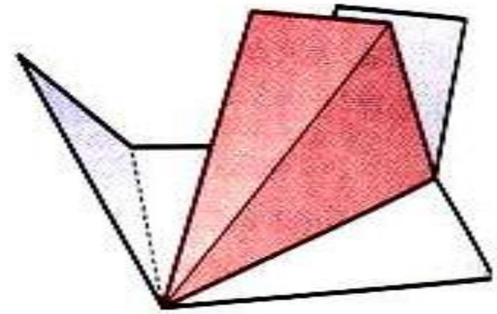
(E) Sphere
(Approximate development)



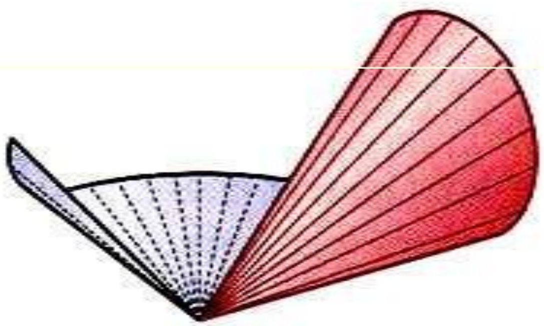
(A) Prism
(Parallel line development)



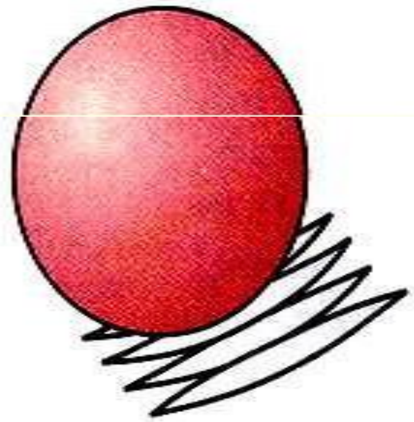
(B) Cylinder
(Parallel line development)



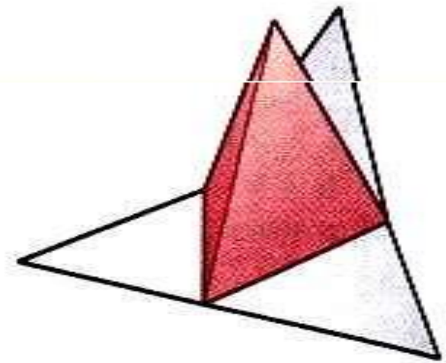
(C) Pyramid
(Radial line development)



(D) Cone
(Radial line development)



(E) Sphere
(Approximate development)



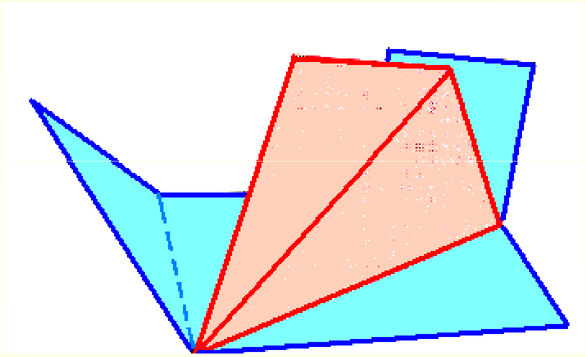
(F) Tetrahedron
(Triangulation development)

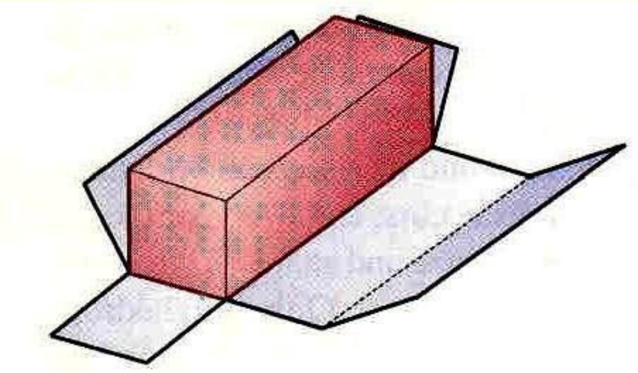
Examples of Developments

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

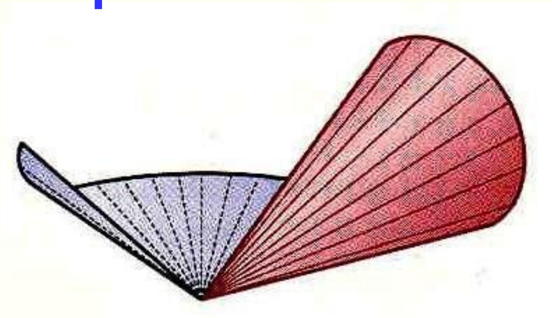
e.g. polyhedrons and single curved surfaces

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





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

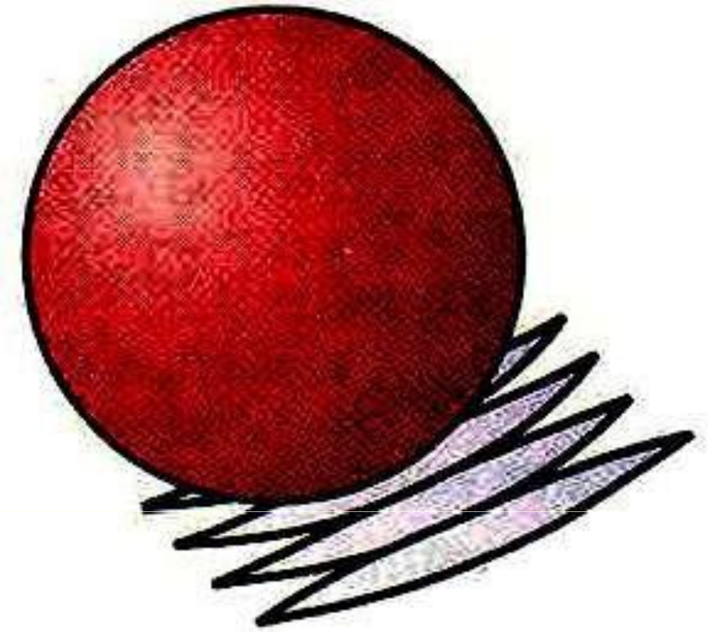


An **approximate development** is one in which stretching or distortion occurs in the process of creating the development.

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

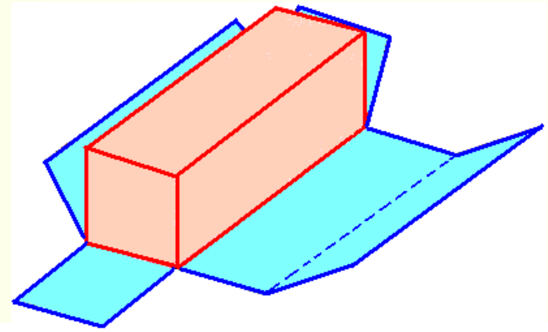
Wrapped surfaces do not produce true developments, because pairs of consecutive straight-line elements do not form a plane.

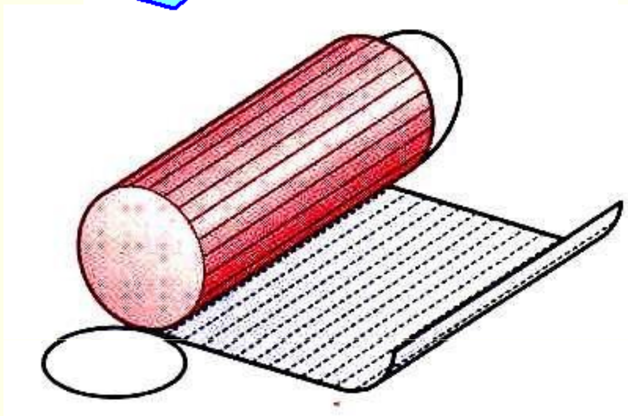
Also double-curved surfaces, such as a sphere do not produce true developments, because they do not contain any straight lines.



1. **Parallel-line developments** are made from common solids that are composed of parallel lateral edges or elements.

e.g. **Prisms and cylinders**





The cylinder is positioned such that one element lies on the development plane.

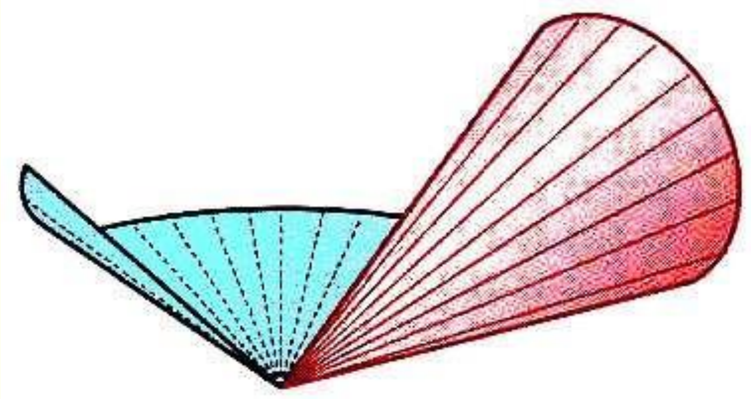
The cylinder is then unrolled until it is flat on the development plane.

The base and top of the cylinder are circles, with a circumference equal to the length of the development.

All elements of the cylinder are parallel and are perpendicular to the base and the top.

When cylinders are developed, all elements are parallel and any perpendicular section appears as a stretch-out line that is perpendicular to the elements.

2. Radial-line development



Radial-line developments are made from figures such as cones and pyramids.

In the development, all the elements of the figure become radial lines that have the vertex as their origin.

The cone is positioned such that one element lies on the development plane.

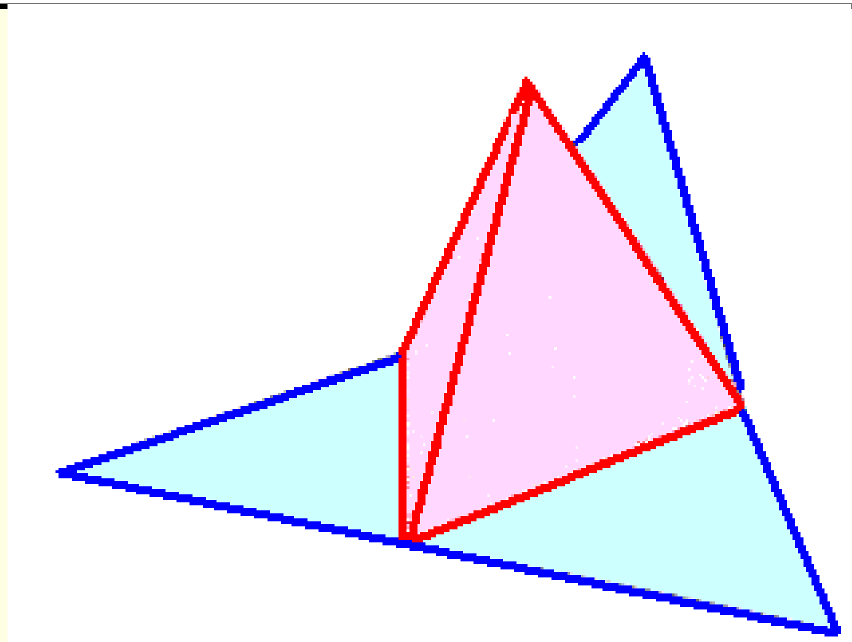
The cone is then unrolled until it is flat on the development plane.

One end of all the elements is at the vertex of the cone. The other ends describe a curved line.

The base of the cone is a circle, with a circumference equal to the length of the curved line.

3. Triangulation developments:

Made from polyhedrons, single-curved surfaces, and wrapped surfaces.



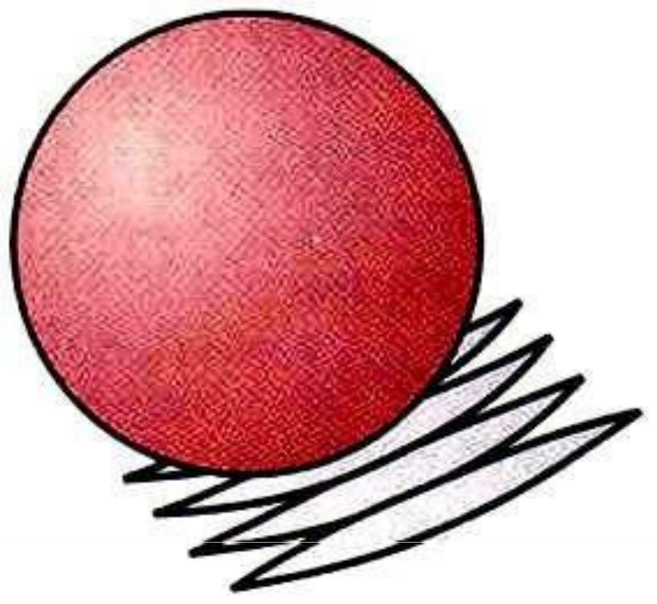
The development involve subdividing any ruled surface into a series of triangular areas.

If each side of every triangle is true length, any number of triangles can be connected into a flat plane to form a development

Triangulation for single curved surfaces increases in accuracy through the use of smaller and more numerous triangles.

Triangulation developments of wrapped surfaces produces only approximate of those surfaces.

4. Approximate developments



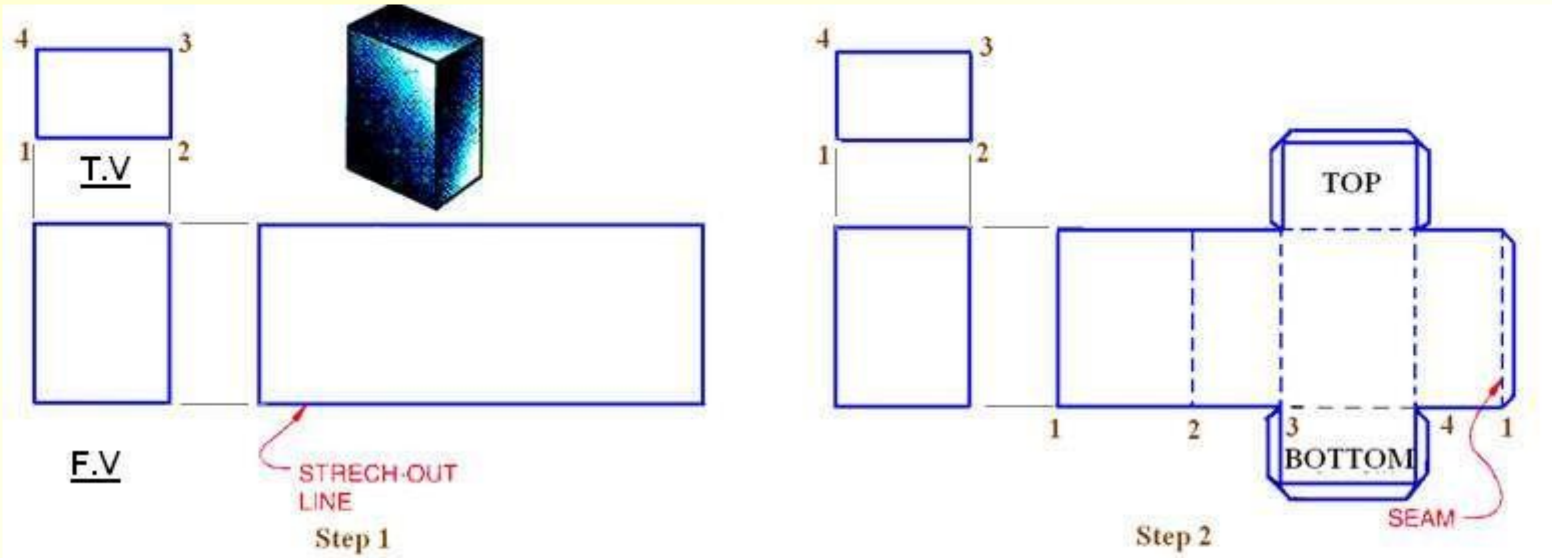
Approximate developments are used for double curved surfaces, such as spheres.

Approximate developments are constructed through the use of conical sections of the object.

The material of the object is then stretched through various machine applications to produce the development of the object.

Parallel-line developments

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

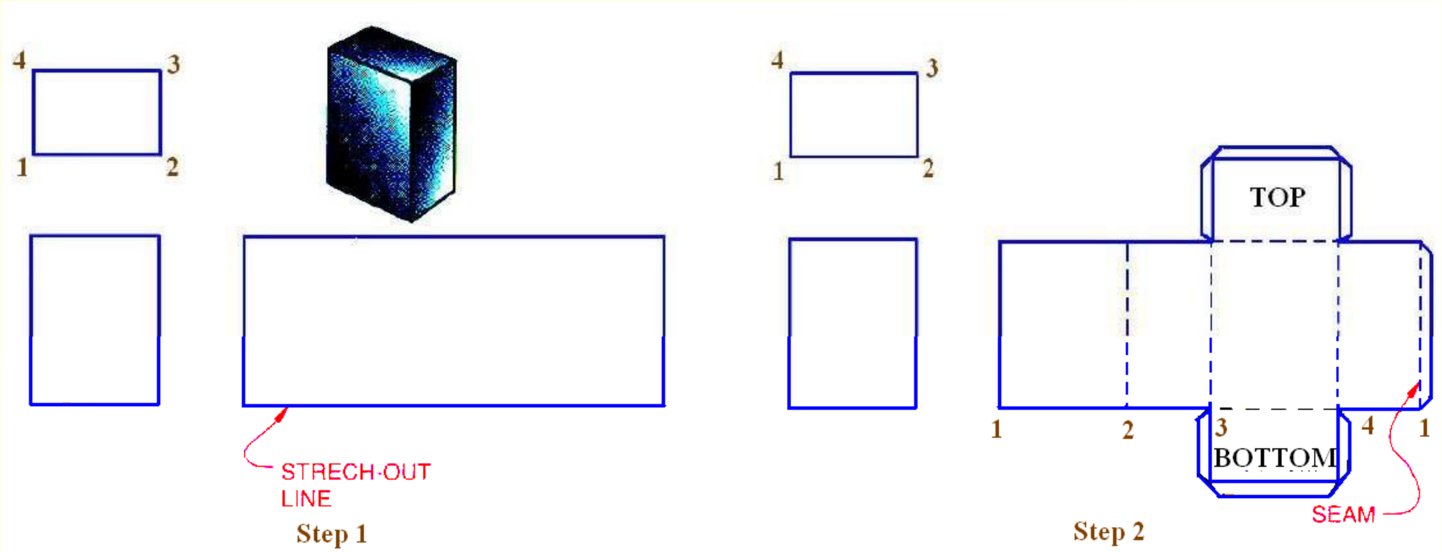


In the front view, all lateral edges of the prism appear parallel to each other and are true length. The lateral edges are also true length in the development. The length, or the stretch-out, of the development is equal to the true distance around a right section of the object.

***Step* 1.** **To start the development, draw the stretch-out line in the front view, along the base of the prism and equal in length to the perimeter of the prism.**

Draw another line in the front view along the top of the prism and equal in length to the stretch-out line.

Draw vertical lines between the ends of the two lines, to create the rectangular pattern of the prism.



***Step* 2.** **Locate the fold line on the pattern by transferring distances along the stretch-out line in length to the sides of the prism, 1-2, 2-3, 3-4, 4-1.**

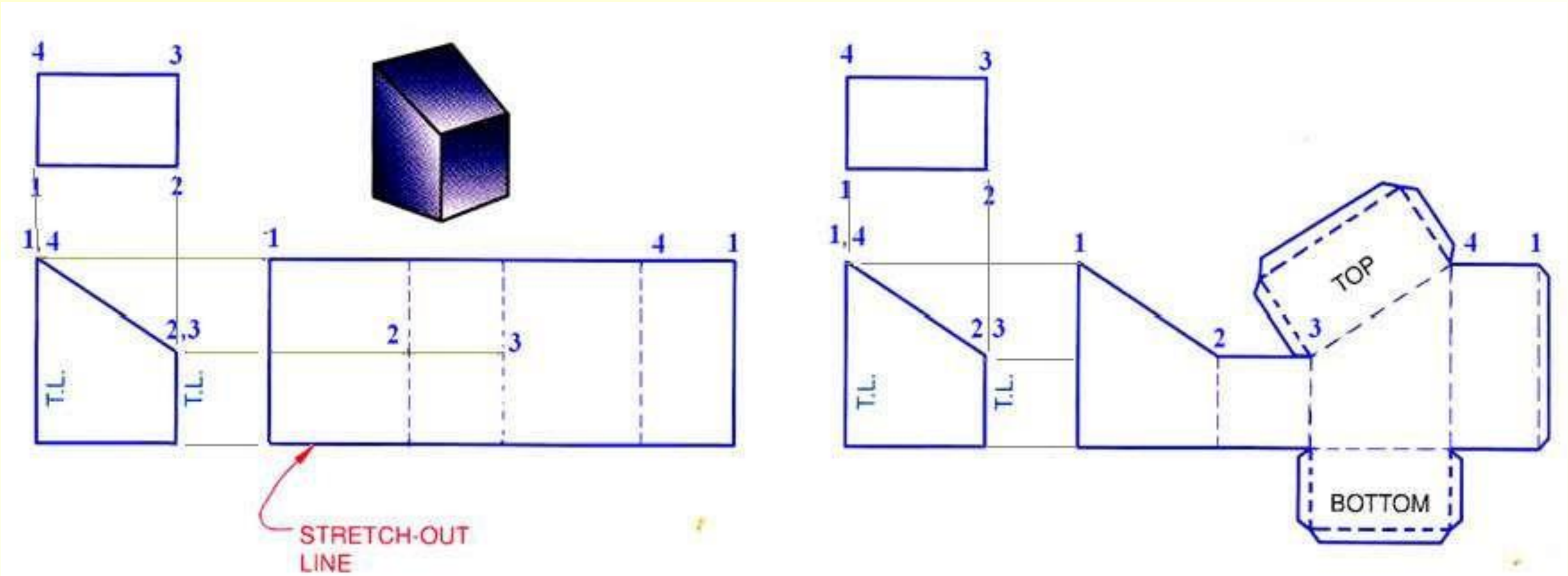
Draw thin, dashed vertical lines from points 2, 3, and 4 to represent the fold lines.

Add the bottom and top surfaces of the prism to the development, taking measurements from the top view. Add the seam to one end of the development and the bottom and top.

Development of a truncated prism

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

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



Draw perpendicular construction lines at each of these points.

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

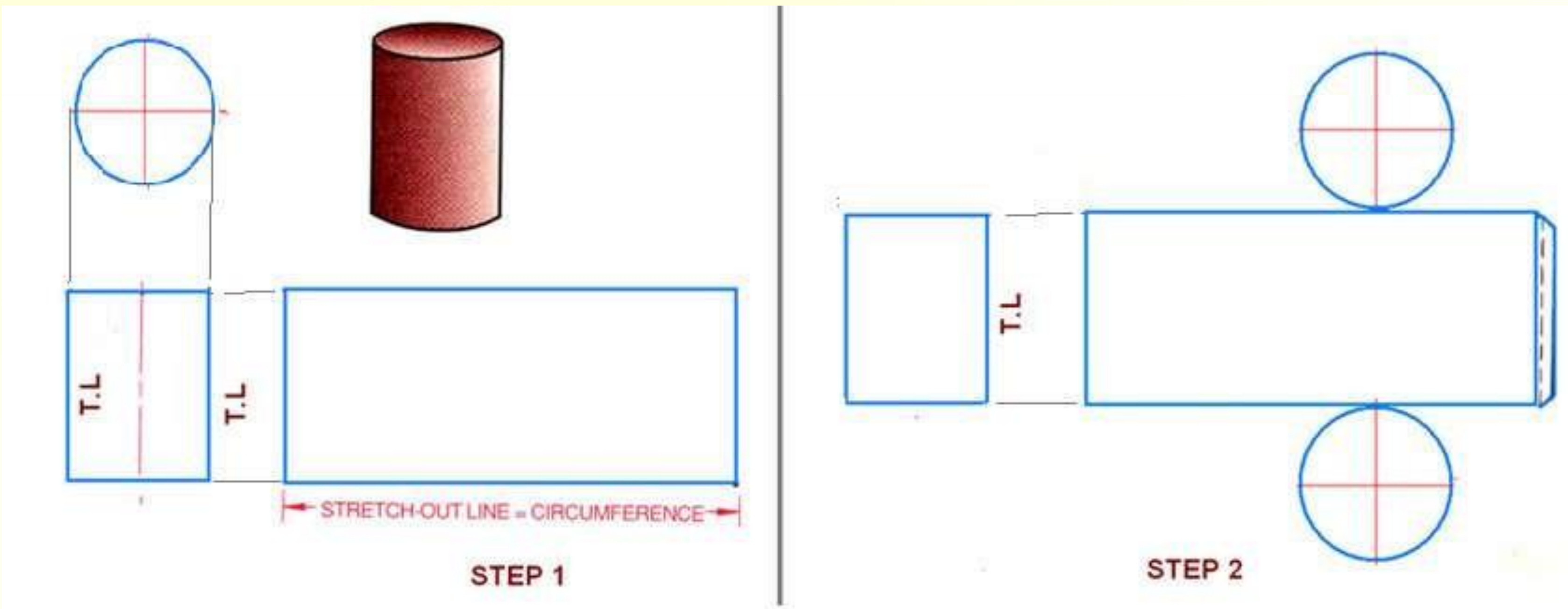
Step 2: **Darken lines 1-2-3 and 4-1. Construct the bottom and top, as shown and add the seam to one end of the development and the top and bottom**

Development of a right circular cylinder

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

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

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



Development of a truncated right circular cylinder

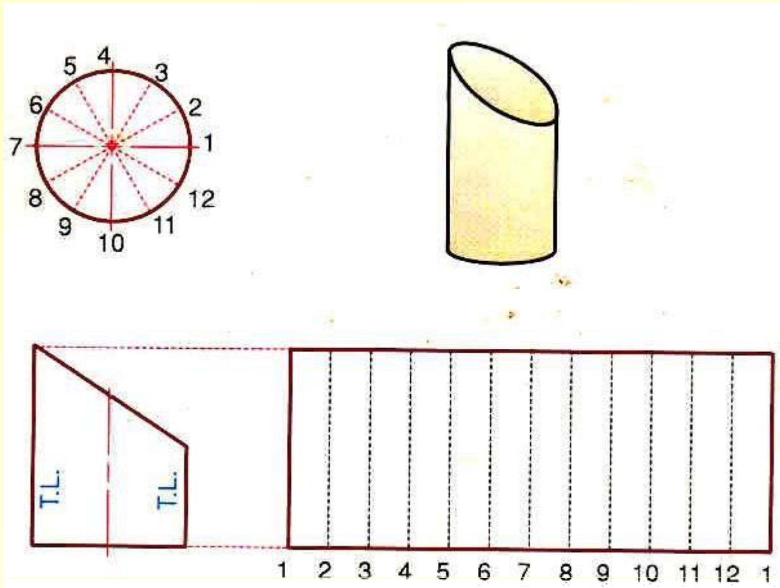
The top circular view of the cylinder is divided into a number of equal parts, e.g 12.

The stretch-out line, equal in length to the circumference of the circle, is aligned with the base in the F.V. view and is divided into 12 equal parts from which vertical lines are constructed.

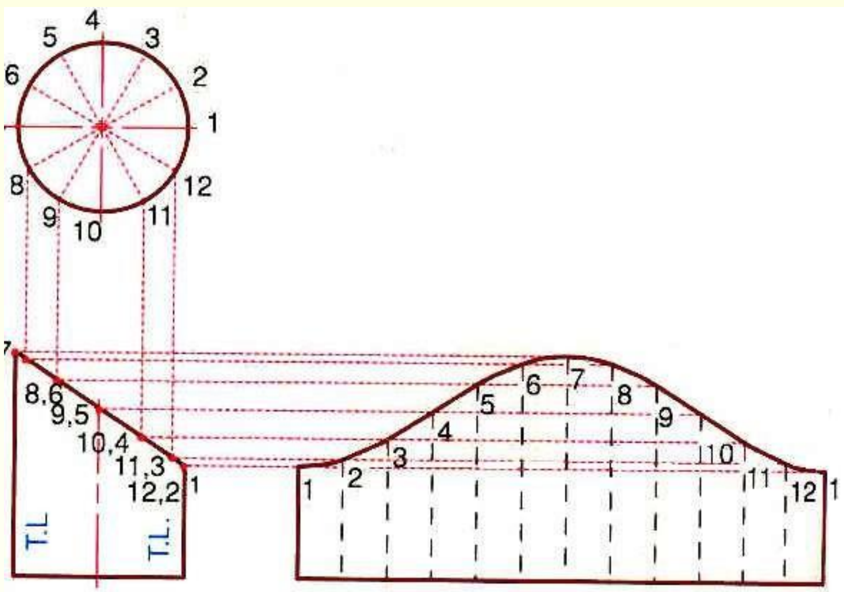
The intersection points in the T.V. are projected into the F.V. , where the projected lines intersect the angled edge view of the truncated surface of the cylinder. These intersection points are in turn projected into the development.

The intersections between these projections and the vertical lines constructed from the stretch-out line are points along the curve representing the top line of the truncated cylinder.

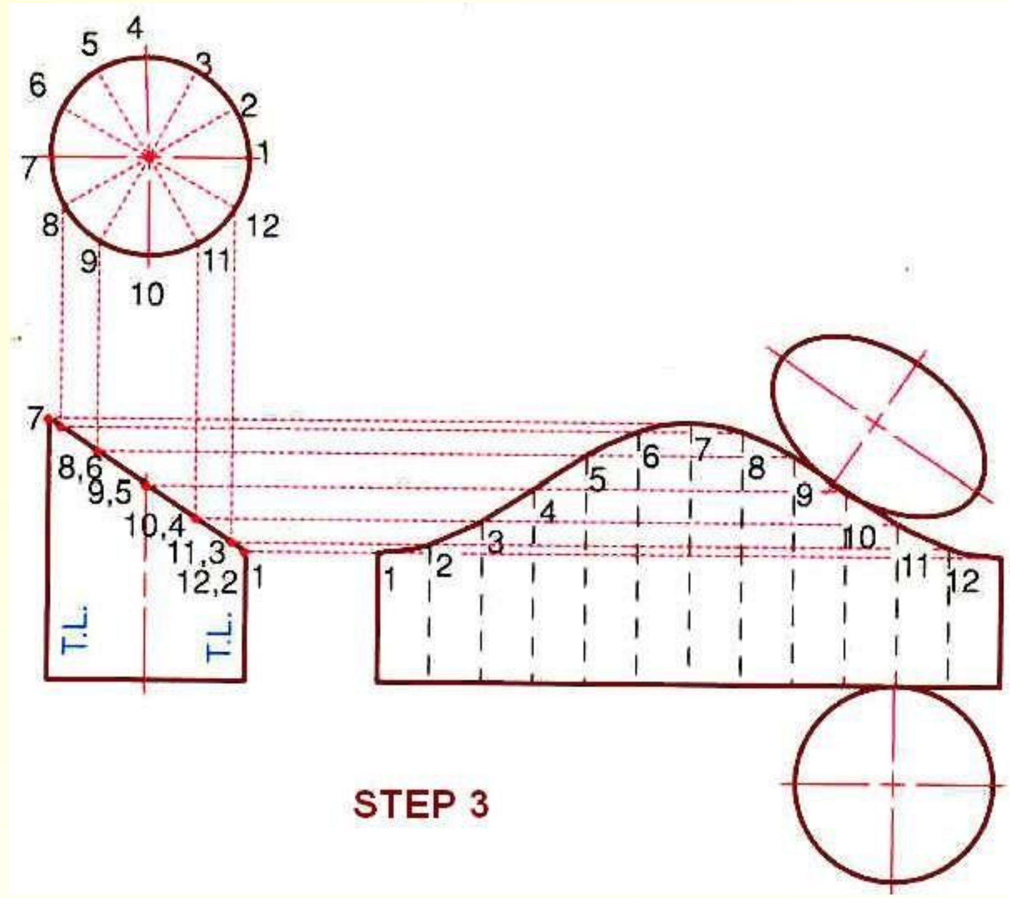
Development of a truncated right circular cylinder



STEP 1



STEP 2



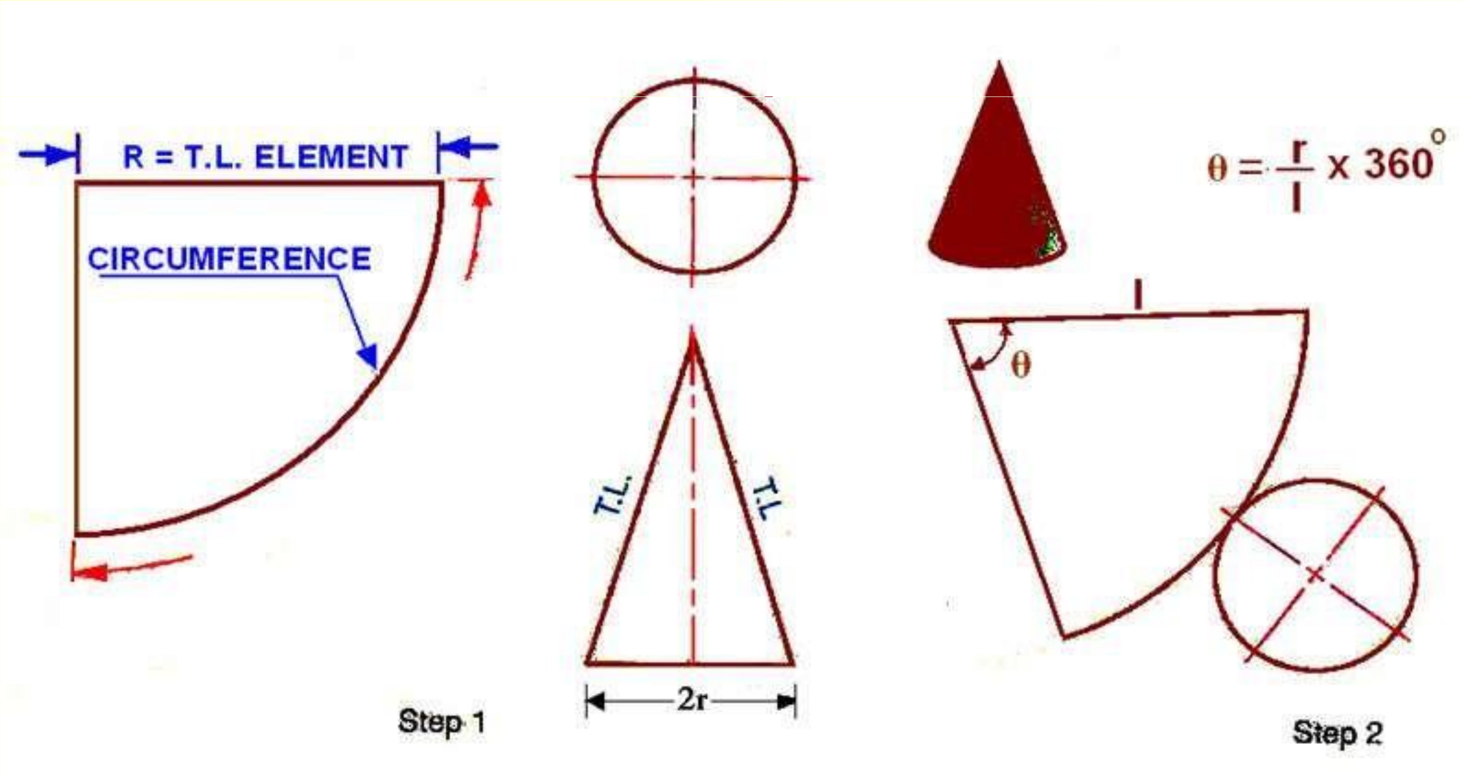
STEP 3

Development of a right circular cone

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

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

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



Question:

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

Solution Refer Fig. 16.10.

1. Draw FV and TV as shown. Locate the AIP.

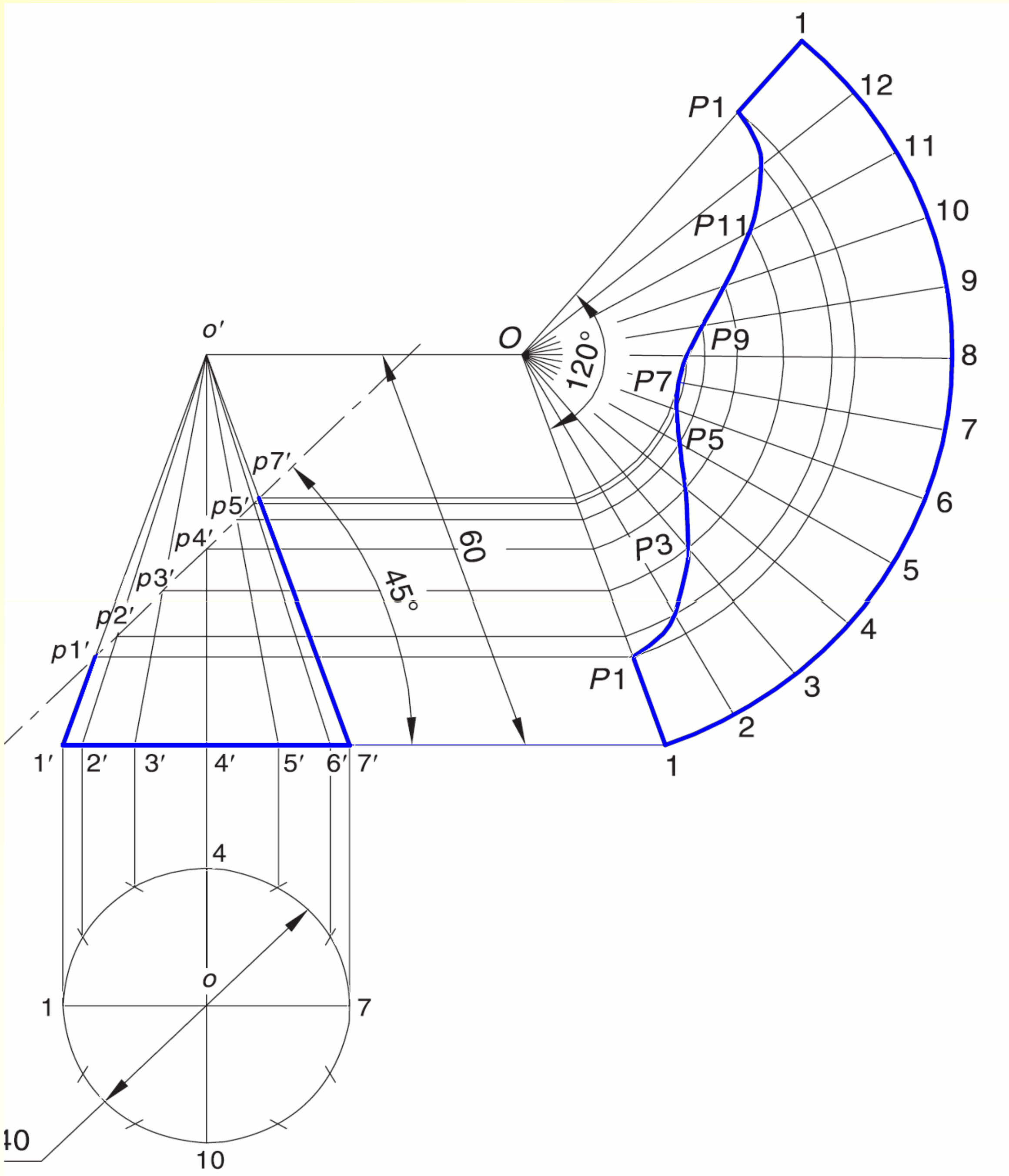
2. Divide the TV into 12 equal parts and draw the corresponding lateral lines (i.e., generators) in FV. Mark points p1’, p2’, p3’, …, p12’ at the points of intersections of the AIP with generators of the cone.

3. Obtain the included angle of the sector. 8 = (20/60)* 360 = 120°.

4. Draw O–1 parallel and equal to o’–7. Then draw sector O–1–1– O with O as a centre and included angle 120°.

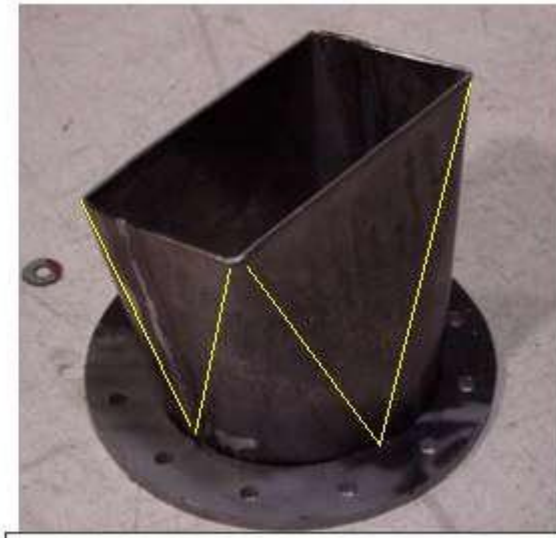
5. Divide the sector into 12 equal parts (i.e., 10° each). Draw lines O–2, O–3, O–4, …, O–12.

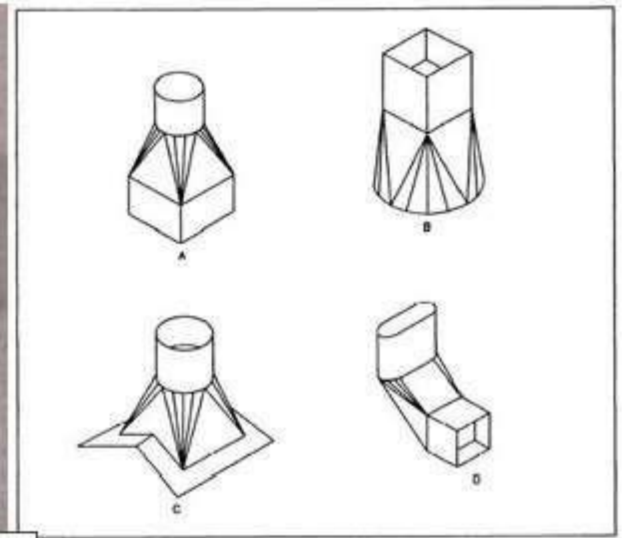
6. Project points p1’, p2’, p3’, …, p12’ from FV to corresponding lines in development and mark points P1, P2, P3, …, P12 respectively. Join all these points by a smooth freehand curve.

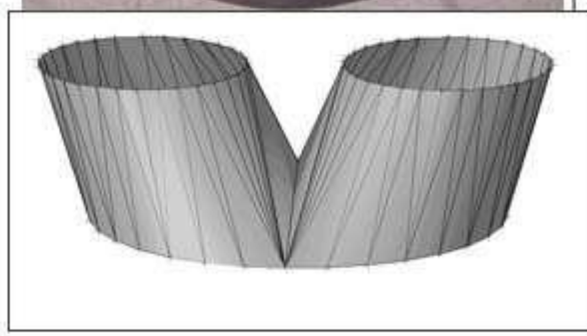


1
12
P1
11
P11
10
9
O
120°
P9
8
P7
7
o′
P5
p7′
p5′
6
60
p4′
P3
45°
5
p3′
p2′
4
p1′
P1
3
2
1′
2′
3′
4′
5′
6′
7′
1
4
o
1
7
40
10

Development of Transition pieces used in industry







Source : Internet

Triangulation development

Employed to obtain the development of Transition Pieces

Transition pieces are the sheet metal objects used for connecting pipes or openings either of different shapes of cross sections or of same cross sections but not arranged in identical positions.

1. **Transition pieces joining a curved cross section to a non curved cross section (e,g, Square to round, hexagon to round , square to ellipse, etc.)**
2. **Joining two non-curved cross sections (e.g. square to hexagon, square to rectangle, square to square in un-identical positions)**
3. **Joining only two curve sections (e.g. Circle to oval, circle to an ellipse, etc)**

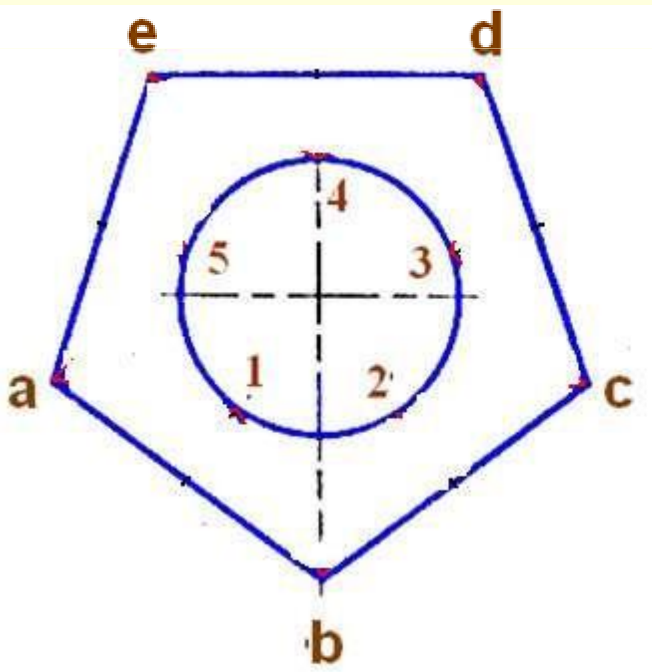
In this method, the lateral surfaces of the transition pieces are divided in to a number of triangles.

By finding the true lengths of the sides of each triangle, the development is drawn by laying each one of the triangles in their true shapes adjoining each other.

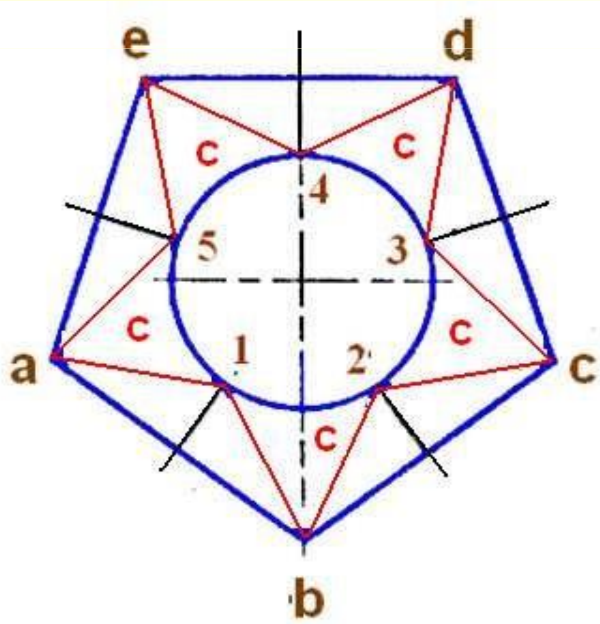
Transition pieces joining curved to Non-curved cross sections

The lateral surface must be divided into curved and non-curved triangles. Divide the curved cross section into a number of equal parts equal to the number of sides of non-curved cross-section.

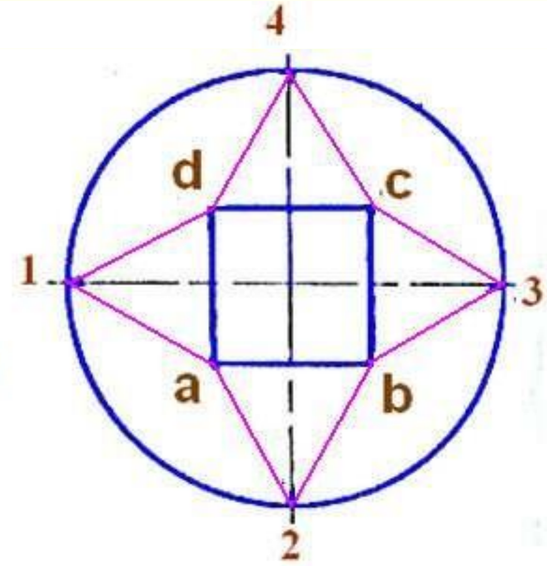
Division points on the curved cross section are obtained by drawing bisectors of each side of the non-curved cross section.



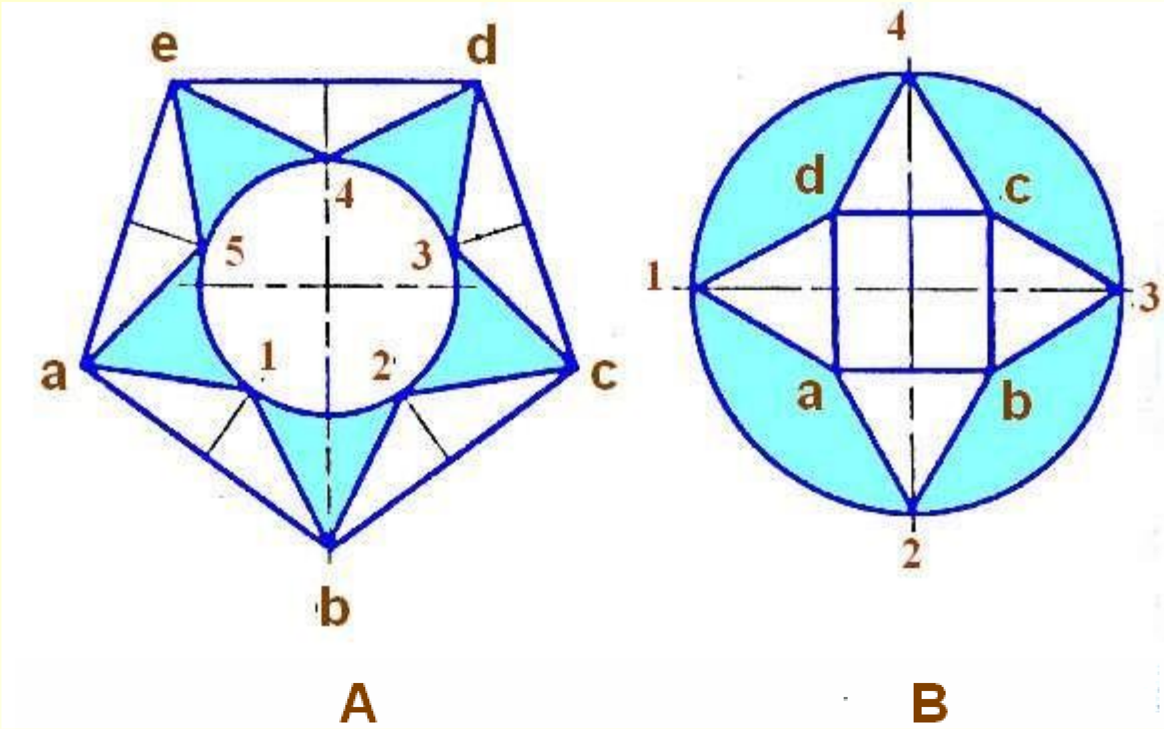
1st stage A



A



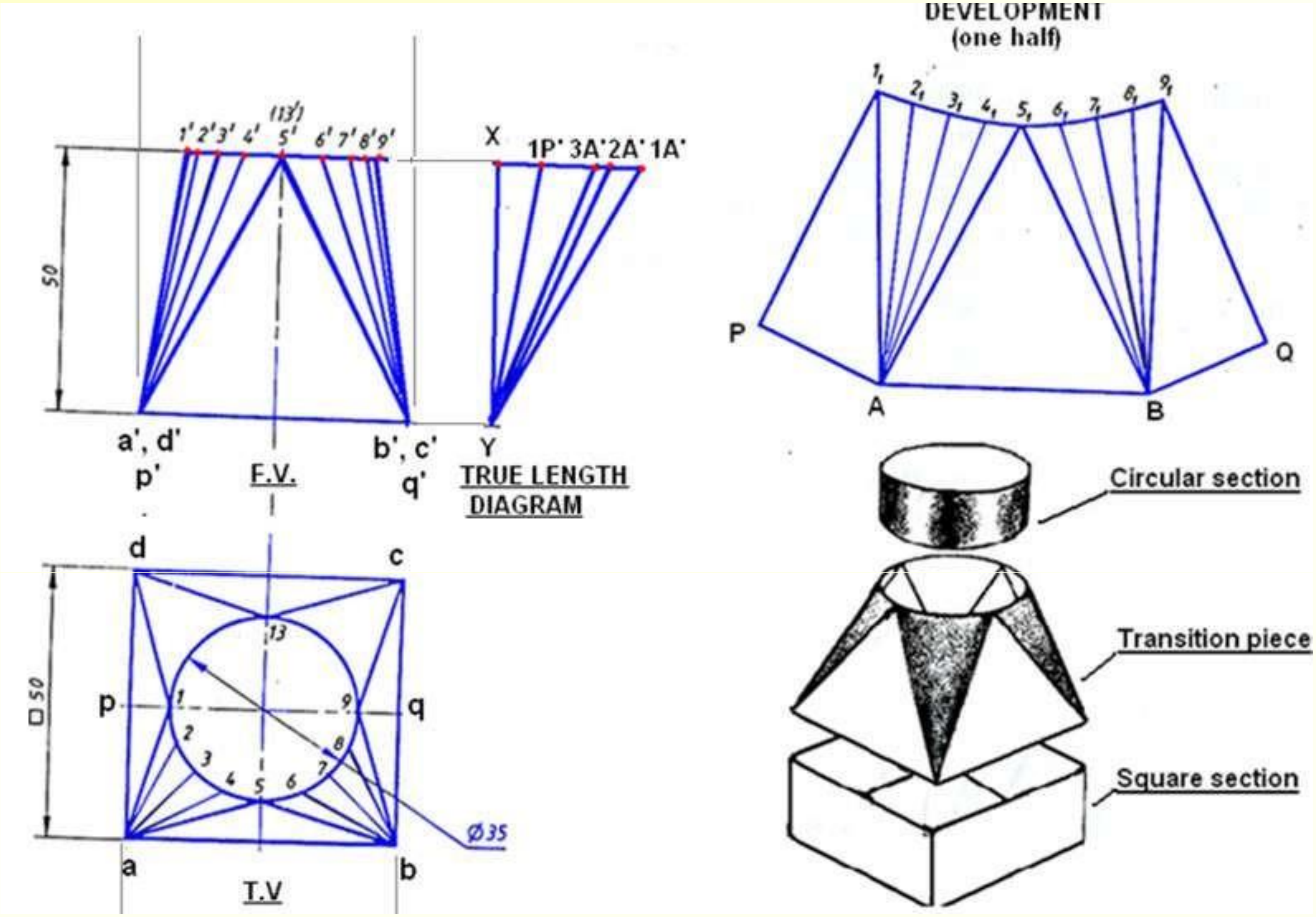
B



The division points thus obtained when connected to the ends of the respective sides of the non-curved cross-section produces plane triangles

In between two plane triangles there lies a curved triangle

After dividing in to a number of triangles, the development is drawn by triangulation method.

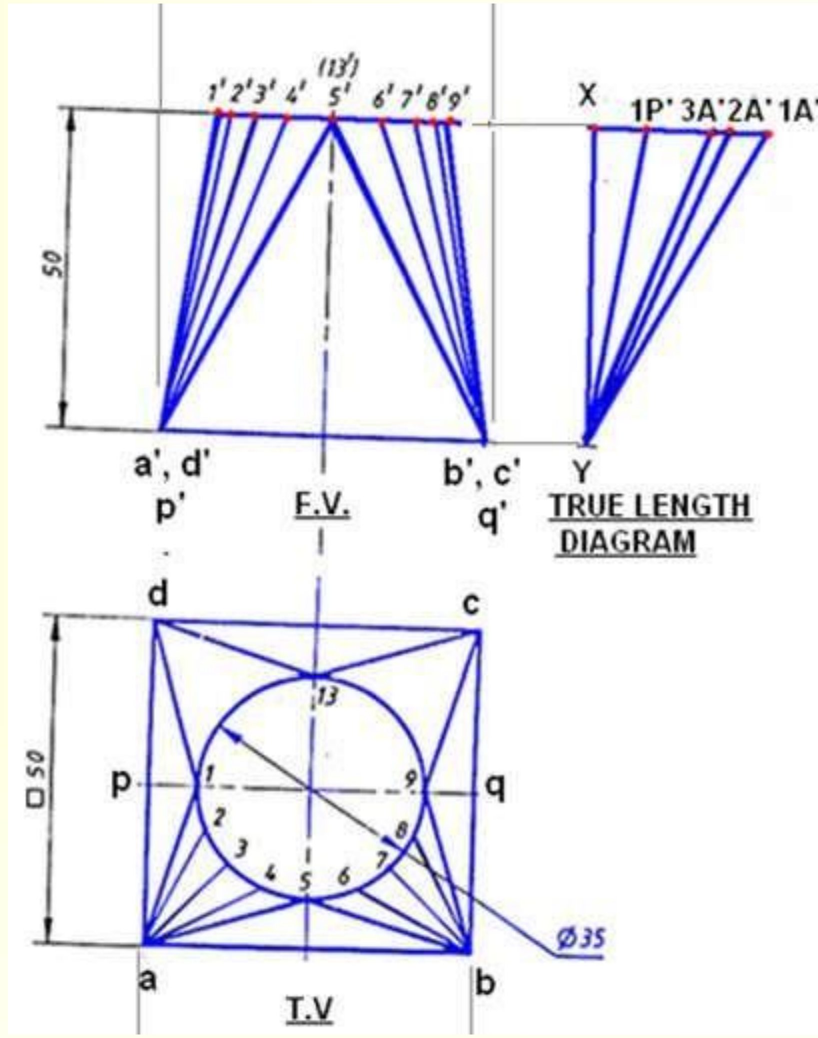


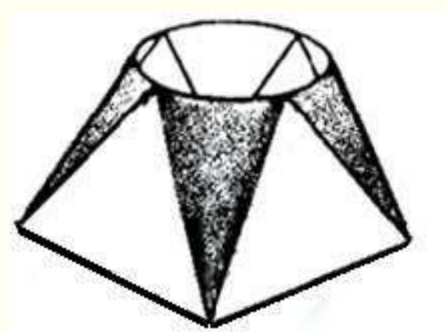
The transition piece consists of 4 plane and 4 curved triangles
1da, 5ab, 9bc, and 13cd are plane triangles and
1a5, 5b9, 9c13 and 13d1 are curved triangles.

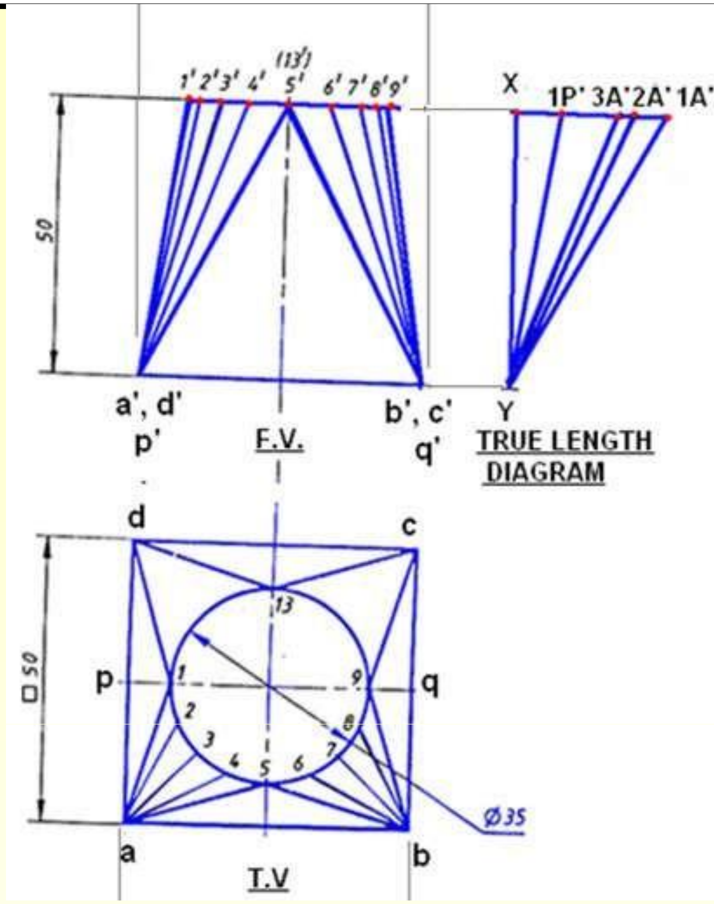
Since the transition piece is symmetrical about the horizontal axis pq in the top view, the development is drawn only for one half of the transition piece. The front semicircle in the top view is divided into eight equal parts 1,2,3,4, etc. Connect points 1,2,3,4 and 5 to point a.

Project points 1,2,3,etc to the front view to 1',2',3'. etc.

Connect 1', 2', 3' etc to a' and 5', 6', 7', 8' 9' to b'.







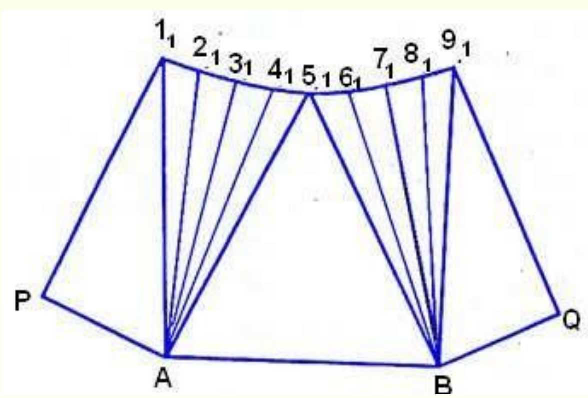
Draw vertical line **XY**. The first triangle to be drawn is **1pa**

The true length of sides **1p** and **1a** are found from the true length diagram. To obtain true length of sides **1p** and **1a**, step off the distances **1p** and **1a** on the horizontal drawn through **X** to get the point **1P'** and **1A'**. Connect these two points to **Y**. The length **Y-1P'** and **Y-1A'** are the true lengths of the sides **1p** and **1a** respectively.

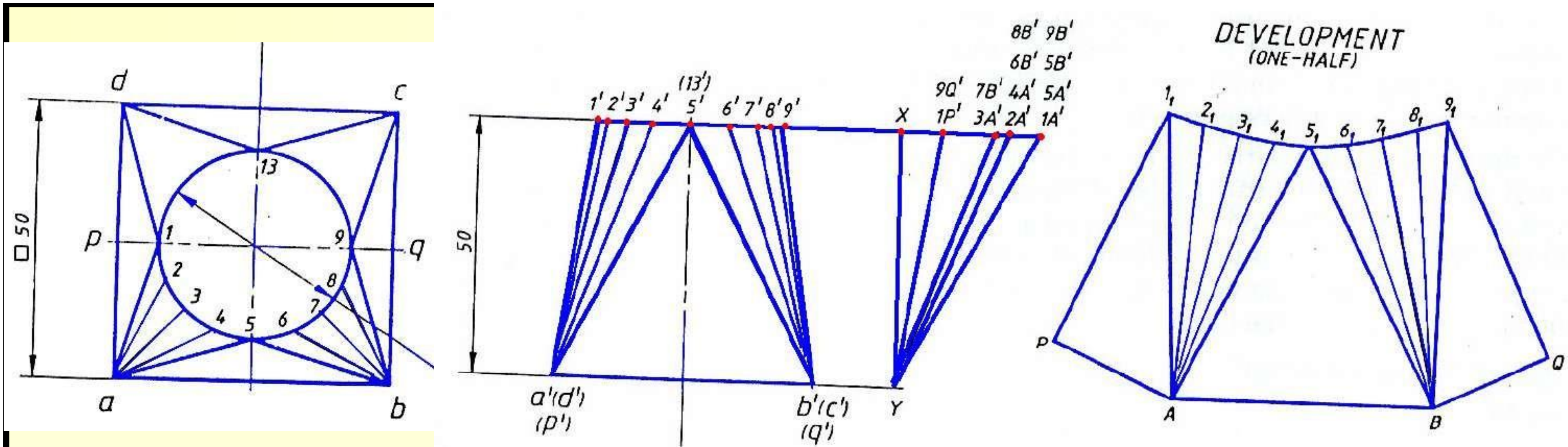
DEVELOPMENT

Draw a line 1_1P = Y-1P'.

Draw another line with center 1_1 and radius Y-1A'. With **P** as center and radius **pa,** as measured from the top view, draw an arc to cut the line 1_1-A to meet at **A**.



Development



With A as center and radius equal to true length of the line 2a(i.e Y-2A'), draw an arc.

With 1_1 as center and radius equal to 1-2 (T.V), draw another arc intersecting the pervious arc at 2_1.

Similarly determine the points 3_1, 4_1 and 5_1.

A -1_1-2_1-3_1- 4_1- 5_1 is the development of the curved triangle 1-a-5.

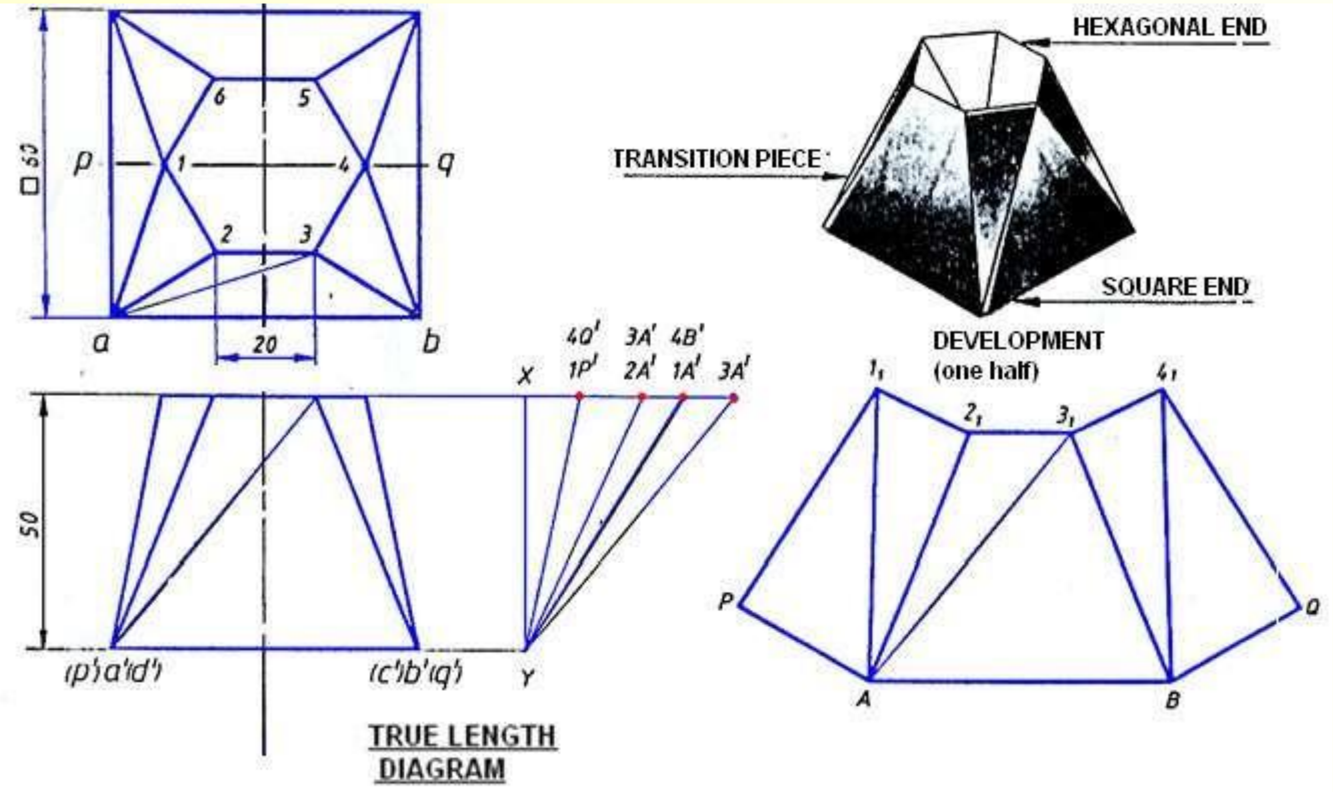
AB is the true length of the plain triangle a-5-b.

Similar procedure is repeated for the other three curved triangles and plain triangles.

Square to hexagon transition

The transition piece is assumed to cut along PQ.

Triangles 1pa and 1a2 and trapezium a23b are obtained.



To develop the lateral surface a23b, it is divided into two triangles by connecting either a3 or 2b and completed by triangulation method.

True length diagram is drawn and development obtained by the previous method.

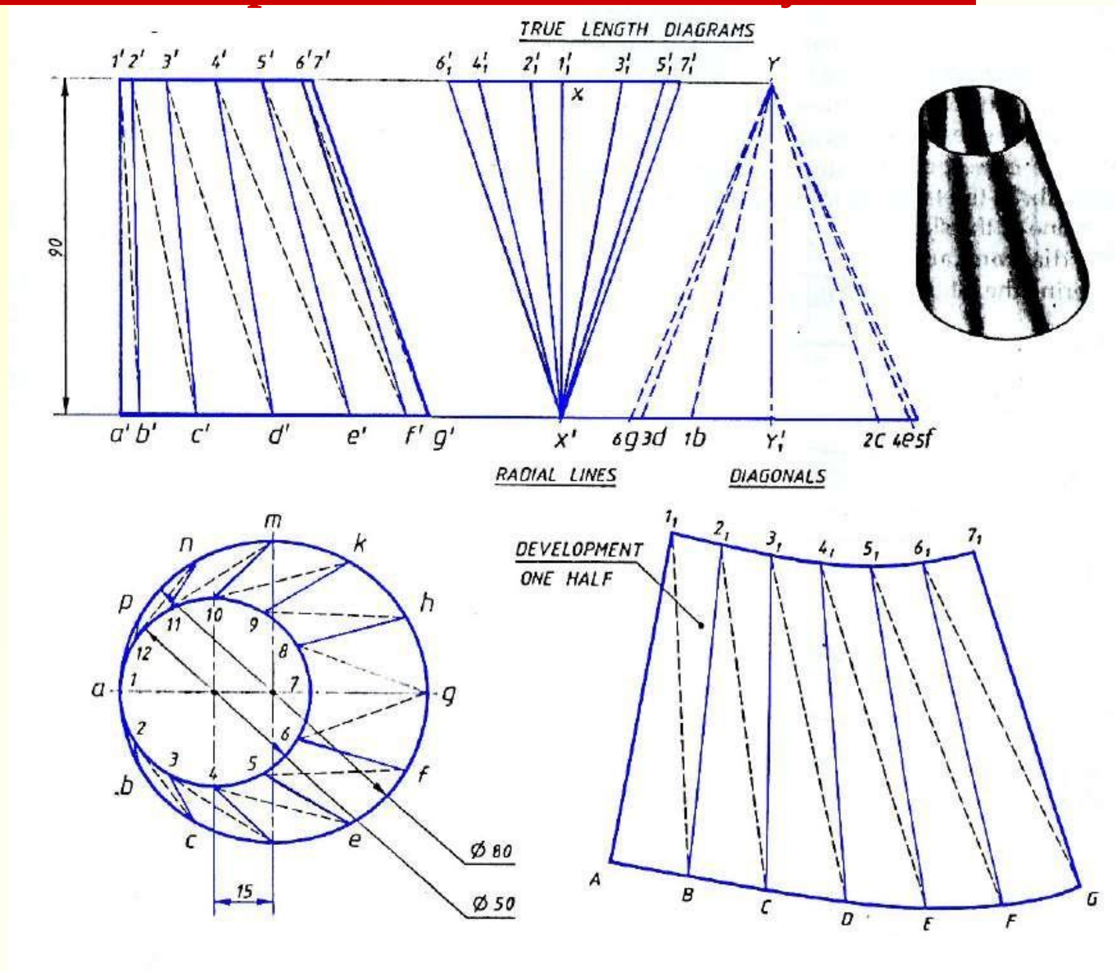
Transition pieces joining two curved surfaces

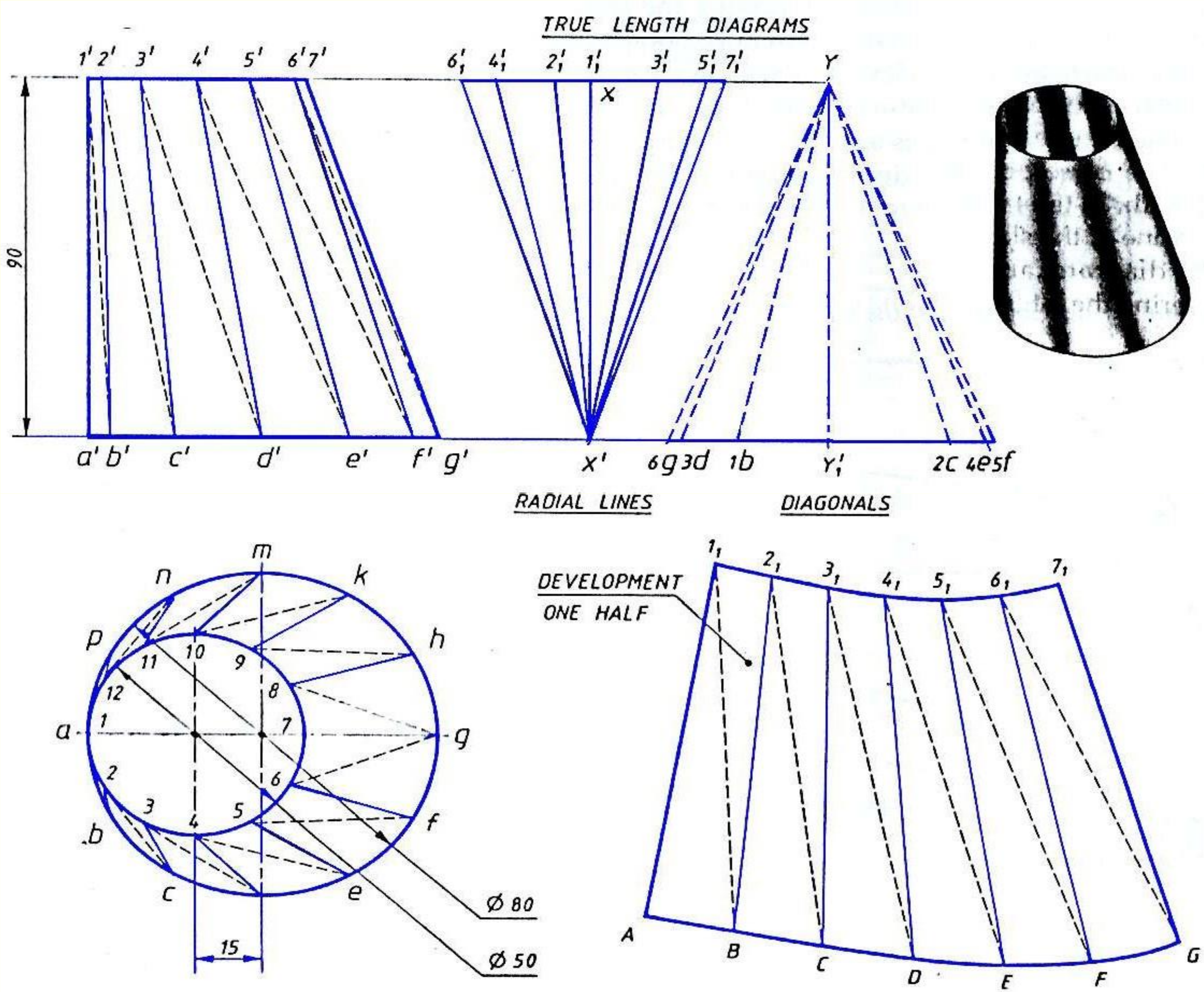
Draw TV and FV of conical reducing pieces

Divide the two circles into twelve equal parts. Connect point 1a, 2b, 3c, etc in the TV and 1’a’, 2’b’,etc in the FV. These lines are called radial lines

The radial lines divide the lateral surface into a number of equal quadrilaterals. Their diagonals are connected (dashed lines) forming a number of triangles. The true length diagram are drawn separately for radial and diagonal lines.

Conical reducing piece to connect two circular holes of diameters 80 mm and 50 mm. The holes are 90 mm apart and center offset by 15 mm.




TRUE LENGTH DIAGRAMS
1' 2' 3' 4' 5' 6' 7'
a' b' c' d' e' f' g'
90
X
X'
Y
Y'1
6g 3d 1b
2c 4e 5f
RADIAL LINES
DIAGONALS
DEVELOPMENT
ONE HALF
A B C D E F G
m n k p h a g b f c e
1 2 3 4 5 6 7 8 9 10 11 12
15
Ø 80
Ø 50

True length diagram for radial lines

For the radial line 7-g`.

Draw XX` equal to vertical height (90mm).

With X as center and radius = 7g (from the top view), draw a horizontal offset line from X (in the true length diagram) to obtain point 7_1`. Join $7_1$` and X`, which is the true length of radial line 7g.

Similarly we can obtain true lengths for all the radial lines. For drawing convenience, the offset points are drawn on both sides of the line XX`

Similarly true length diagram for the diagonal lines can be obtained.

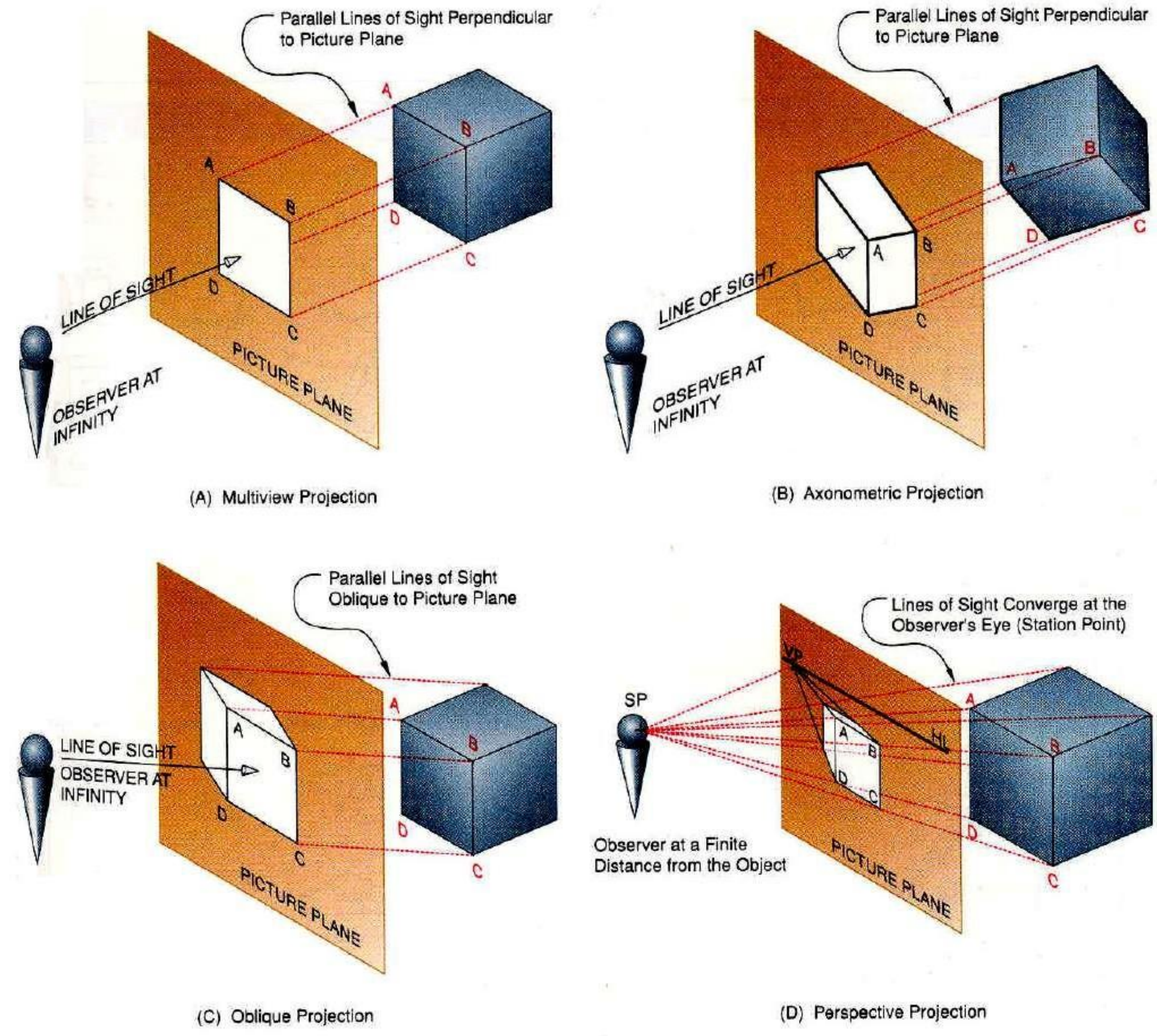
THANK YOU

PRACTICE

Engineering Drawing

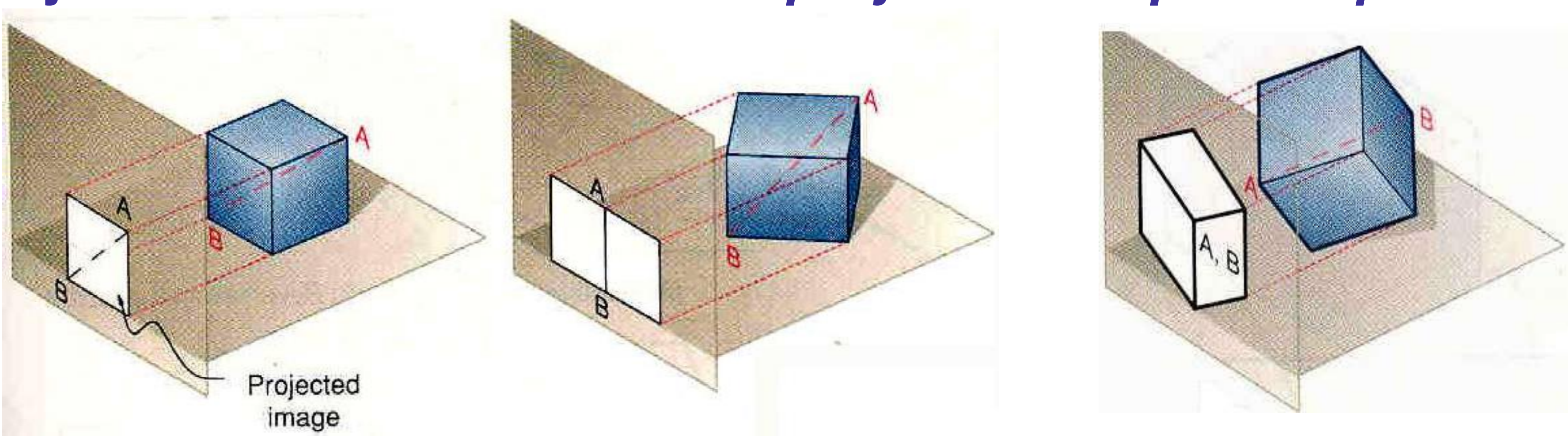
Lecture 15

Isometric Projections



The axonometric projection is produced by multiple parallel lines of sight perpendicular to the plane of projection, with the observer at infinity and the object rotated about an axis to produce a pictorial view

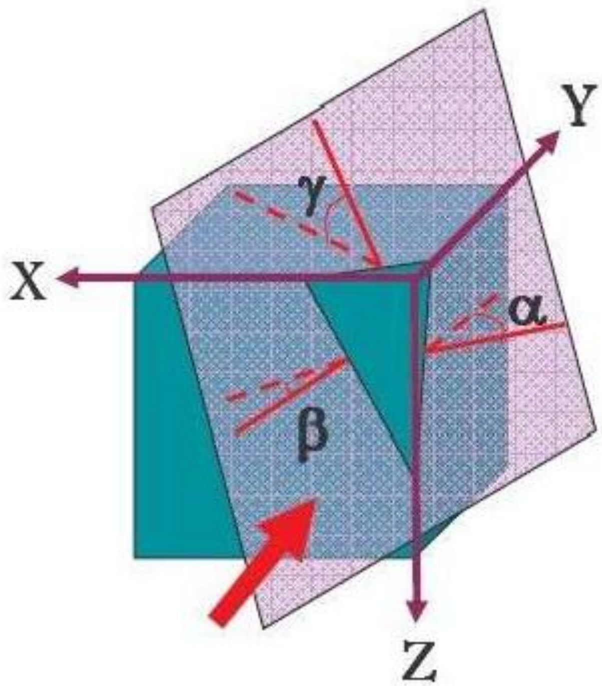
Axonometric projection - is a parallel projection technique used to create a pictorial drawing of an object by rotating the object on an axis relative to a *projection* or *picture plane.*



The differences between a multiview drawing and an axonometric drawing are that, in a multiview, only two dimensions of an object are visible in each view and more than one view is required to define the object; whereas, in an axonometric drawing, the object is rotated about an axis to display all three dimensions, and only one view is required.

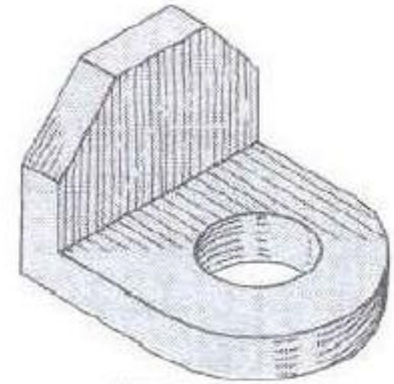
Viewing Planes

- Axonometric Projections
  - Viewing plane NORMAL to viewing/projection lines



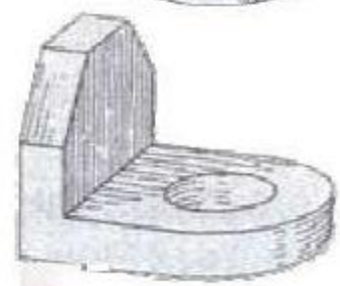
Isometric

$\alpha = \beta = \gamma$



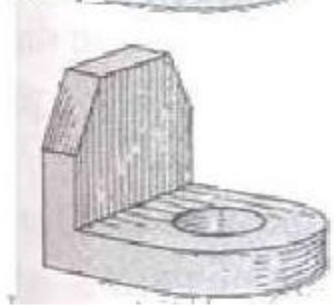
Dimetric

$\alpha = \beta \neq \gamma$



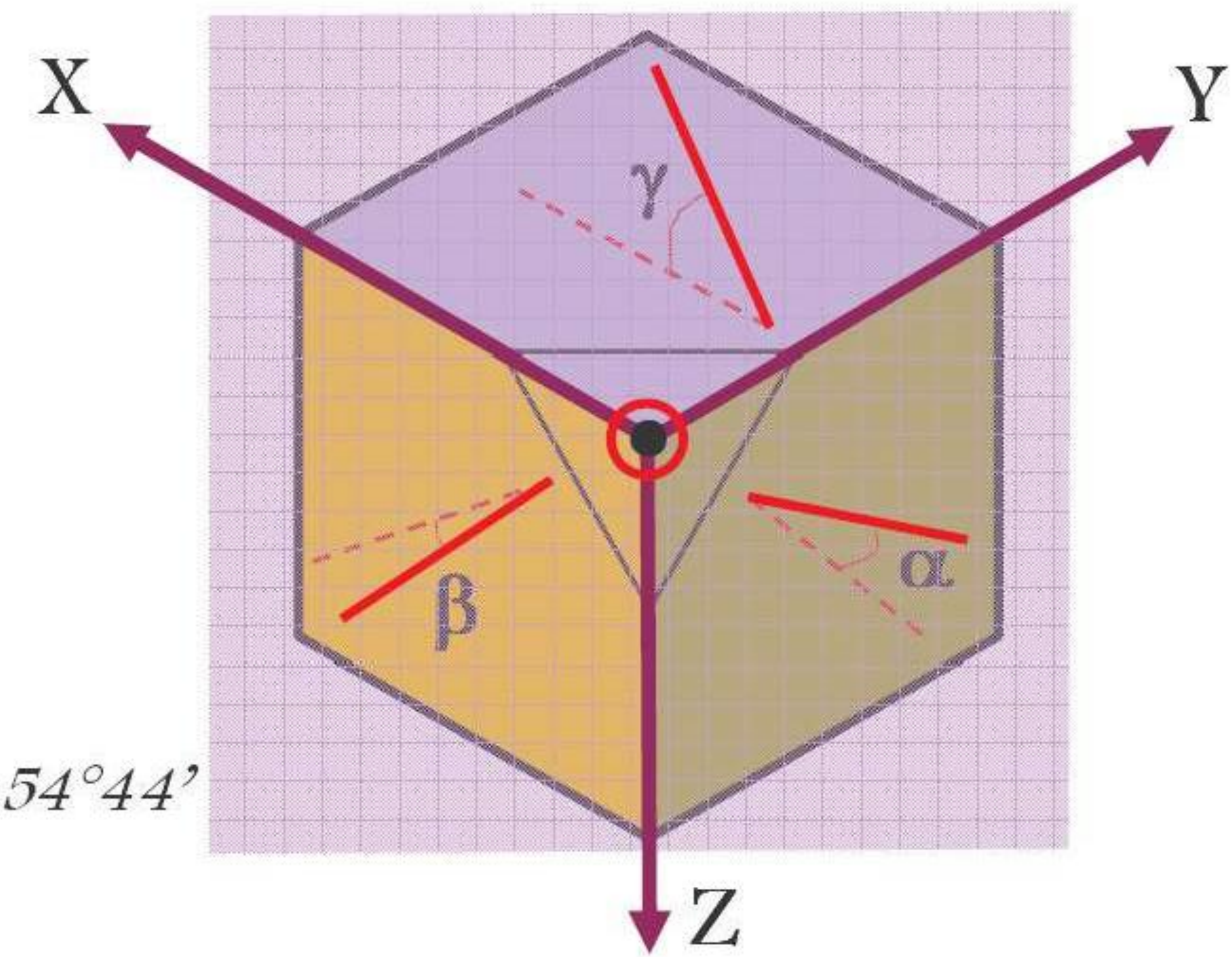
Trimetric

$\alpha \neq \beta \neq \gamma$



Isometric View

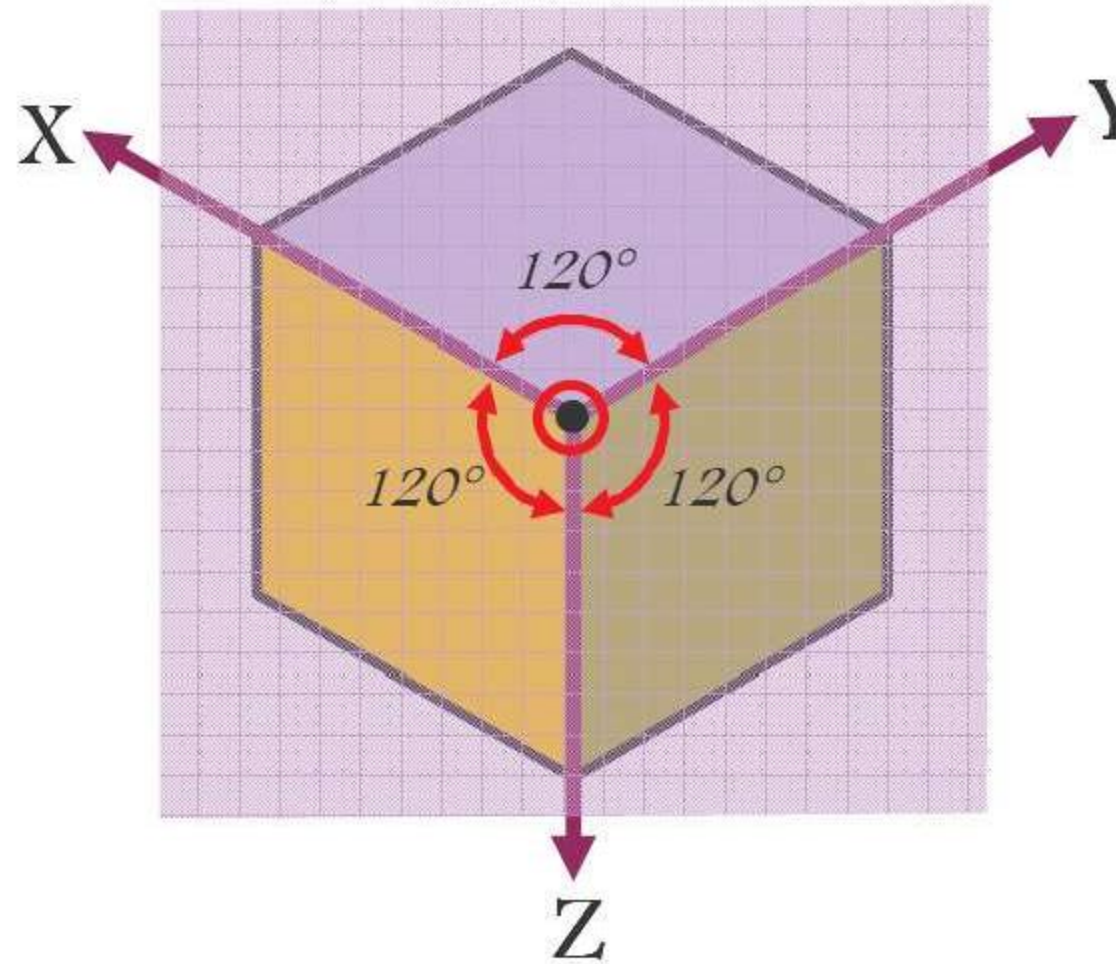
- Cube in Isometric View



$\alpha = \beta = \gamma = 54°44'$

Isometric View

- Cube in Isometric View



Isometric axes can be positioned in a number of ways to create different views of the same object.

Figure *A* is a regular isometric, in which the viewpoint is looking down on the top of the object.

In a regular isometric, the axes at 30° to the horizontal are drawn upward from the horizontal.

For the reversed axis isometric, the viewpoint is looking up on the bottom of the object, and the 30° axes are drawn downward from the horizontal.

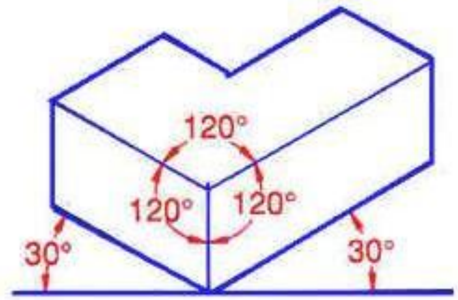


Figure A Regular Isometric

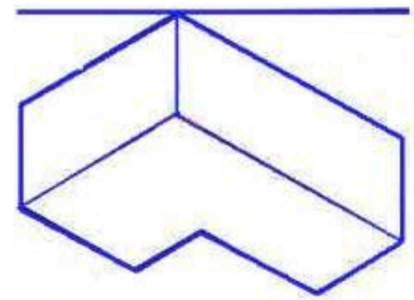


Figure B Reversed Axis isometric

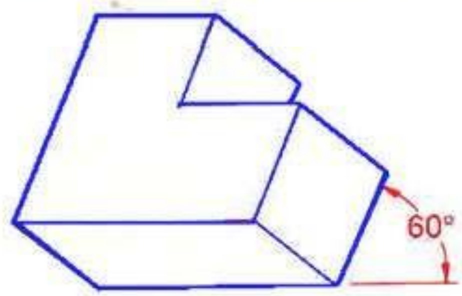


Figure C Long axis isometric

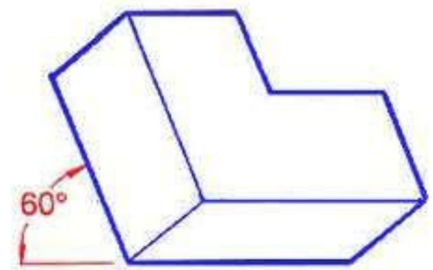
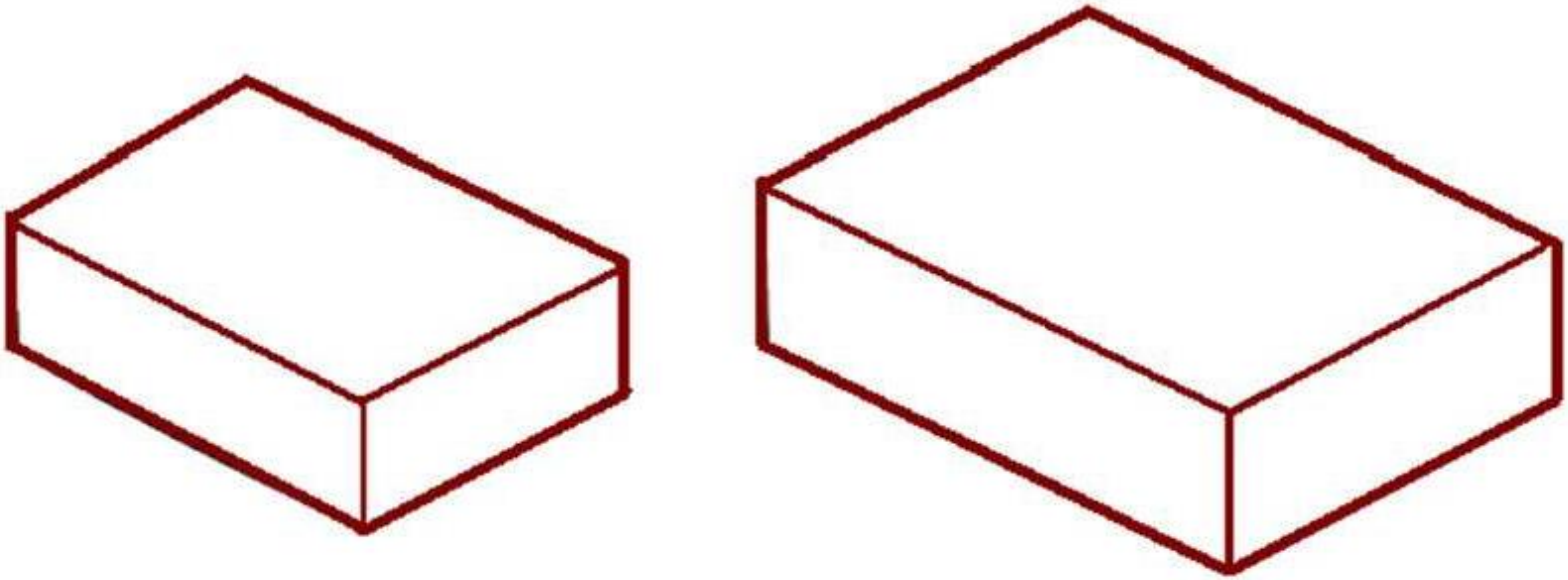


Figure D Long axis isometric

For the long axis isometric, the viewpoint is looking from the right or from the left of the object, and one axis is drawn at 60 ° to the horizontal.

ISOMETRIC PROJECTION and ISOMETRIC DRAWING

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

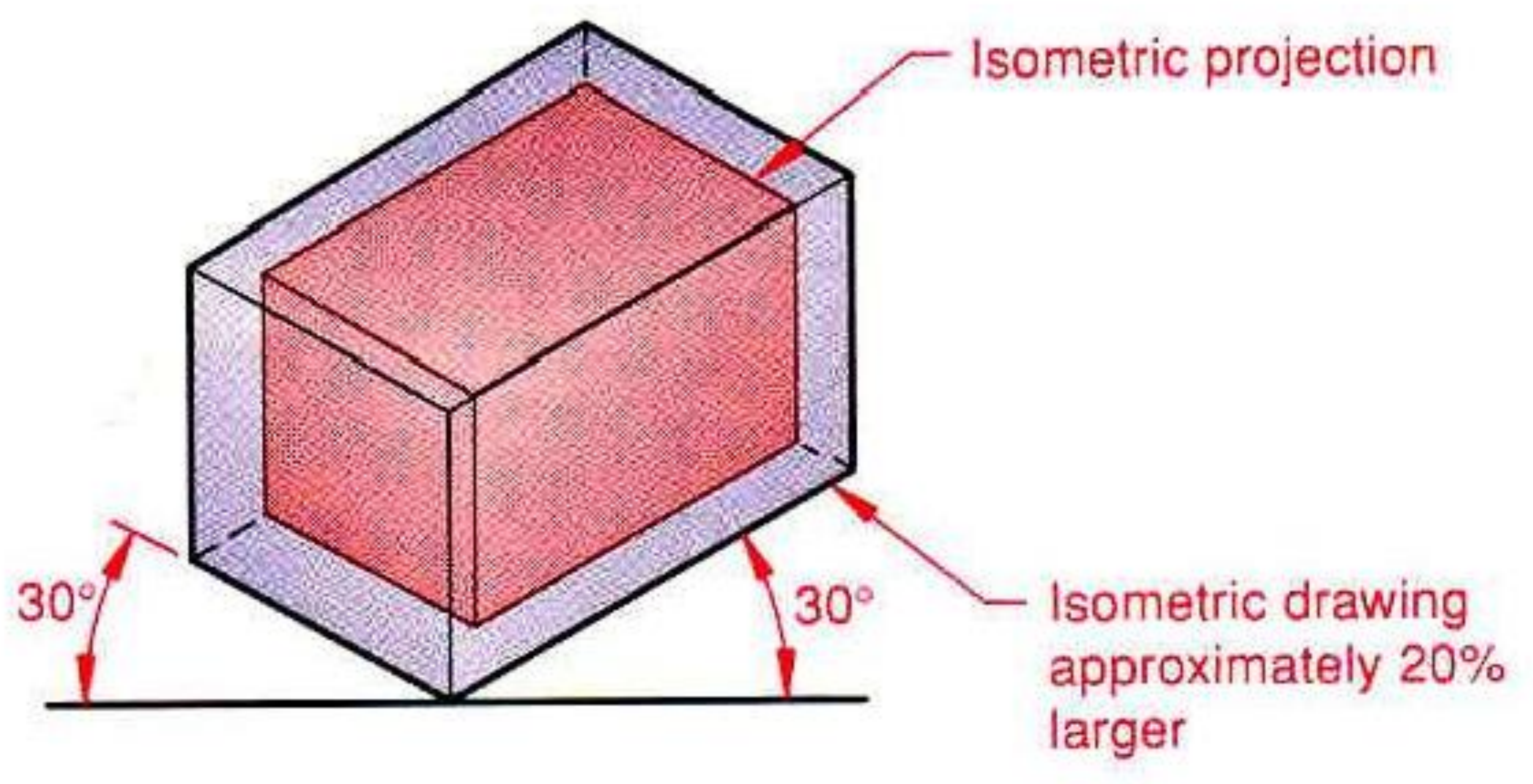


isometric projection

82% of ful scale

Full scale Isometric drawing

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

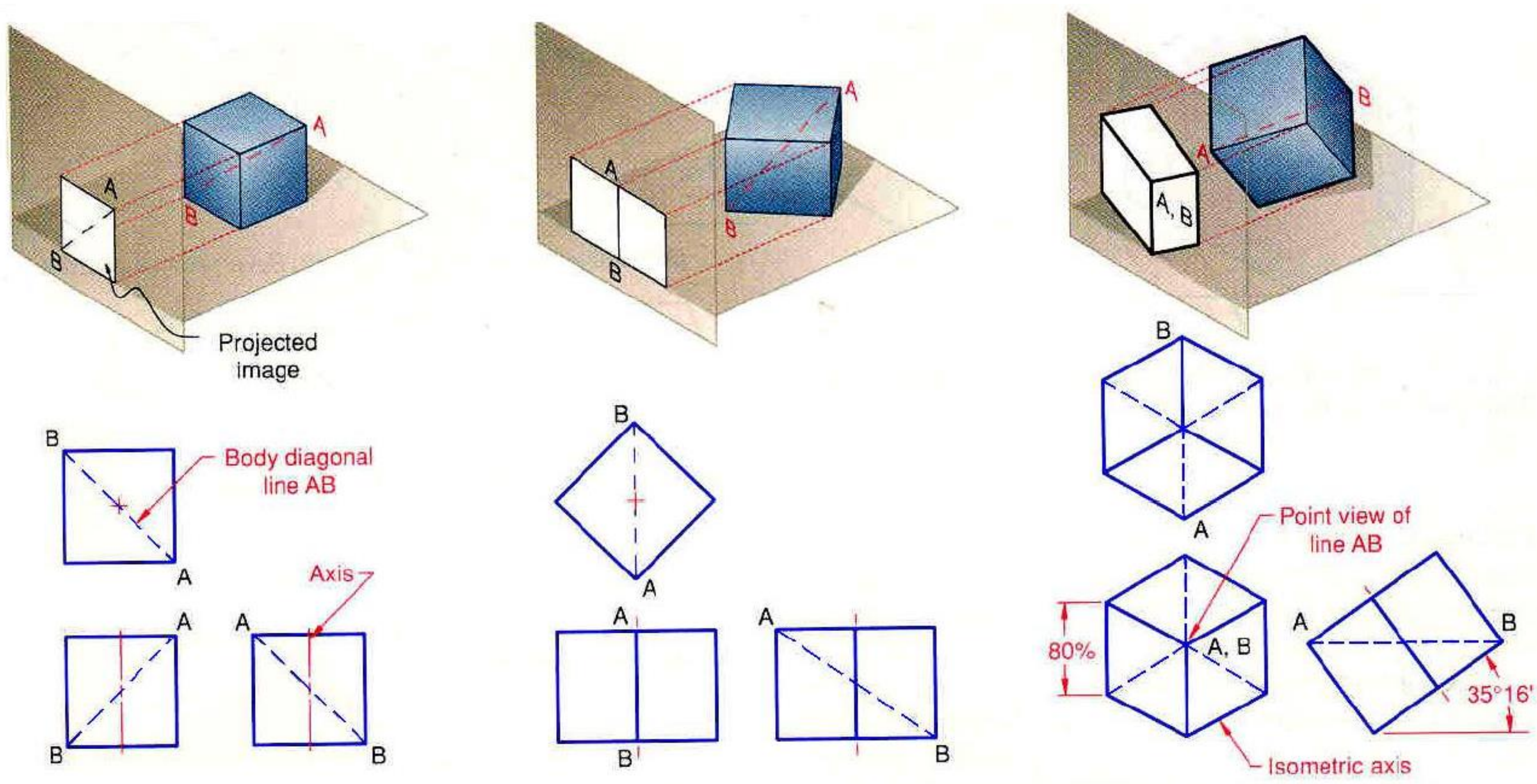


Size comparison of Isometric Drawing and True Isometric Projection

Isometric Axonometric Projections

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

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



(A) Orthographic views of a cube.

(B) Cube rotated 45° clockwise about axis.

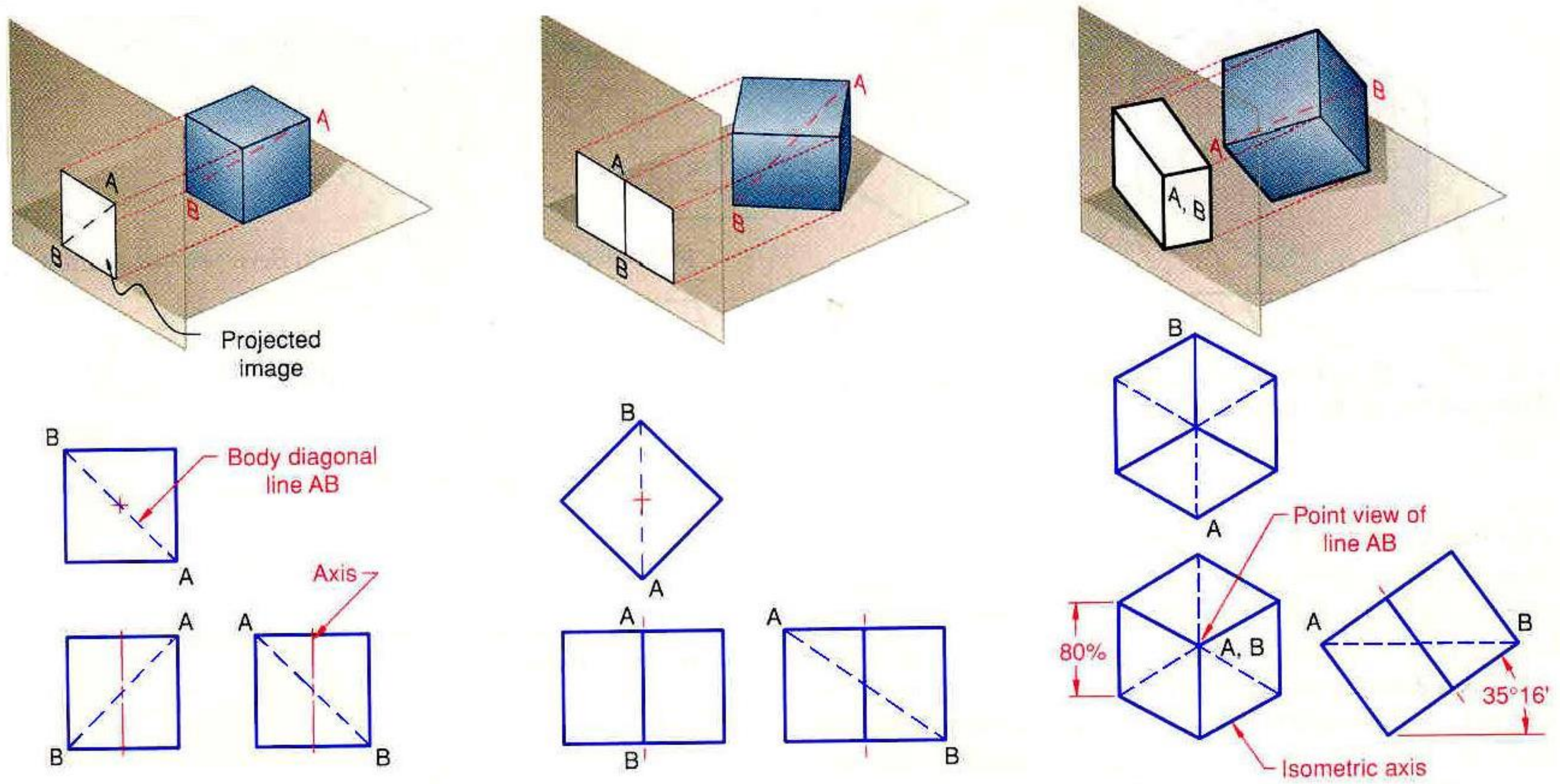
(C) Axis rotated forward 35°16' (35.27°).

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

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

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

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



(A) Orthographic views of a cube.

(B) Cube rotated 45° clockwise about axis.

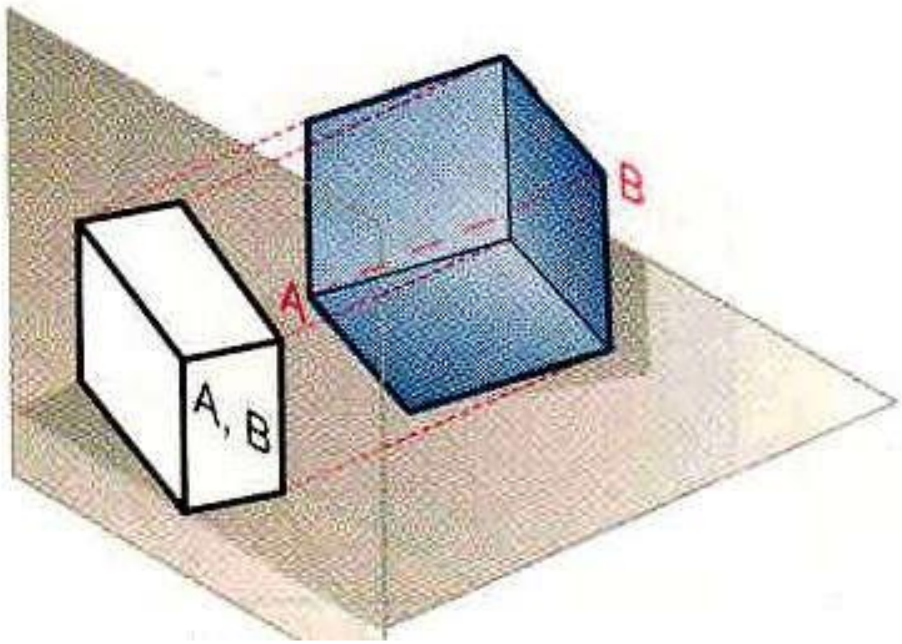
(C) Axis rotated forward 35°16' (35.27°).

The forward tilt of the cube causes the edges and planes of the cube to become shortened as it is projected onto the picture plane.

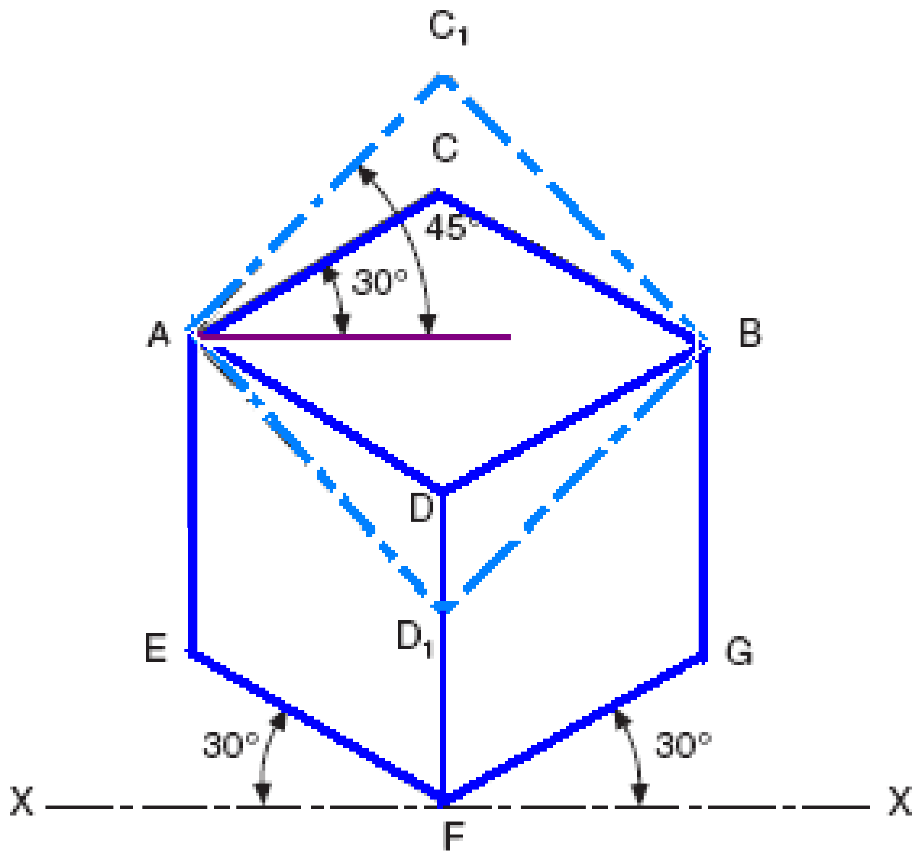
The lengths of the projected lines are equal to the cosine of 35° 16’, or 0.81647 times the true length. In other words, the projected lengths are approximately 82% of the true lengths.

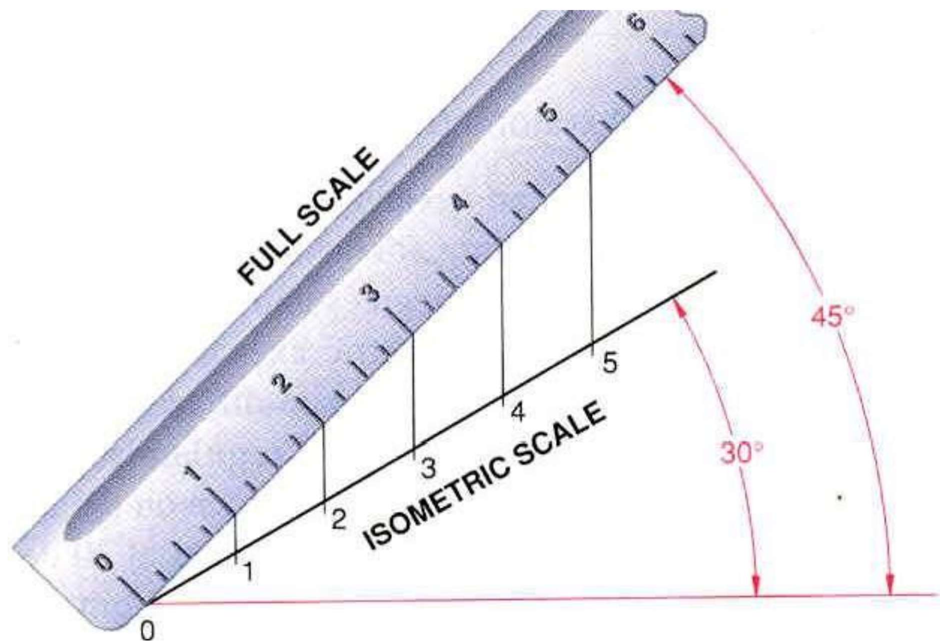
A drawing produced using a scale of 0.816 is called an ***isometric projection*** and is a true representation of the object.

However, if the drawing is produced using full scale, it is called an ***isometric drawing***, which is the same proportion as an isometric projection, but is larger by a factor of 1.23 to 1.



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





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

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

Isometric length = 0.82* True length

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

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

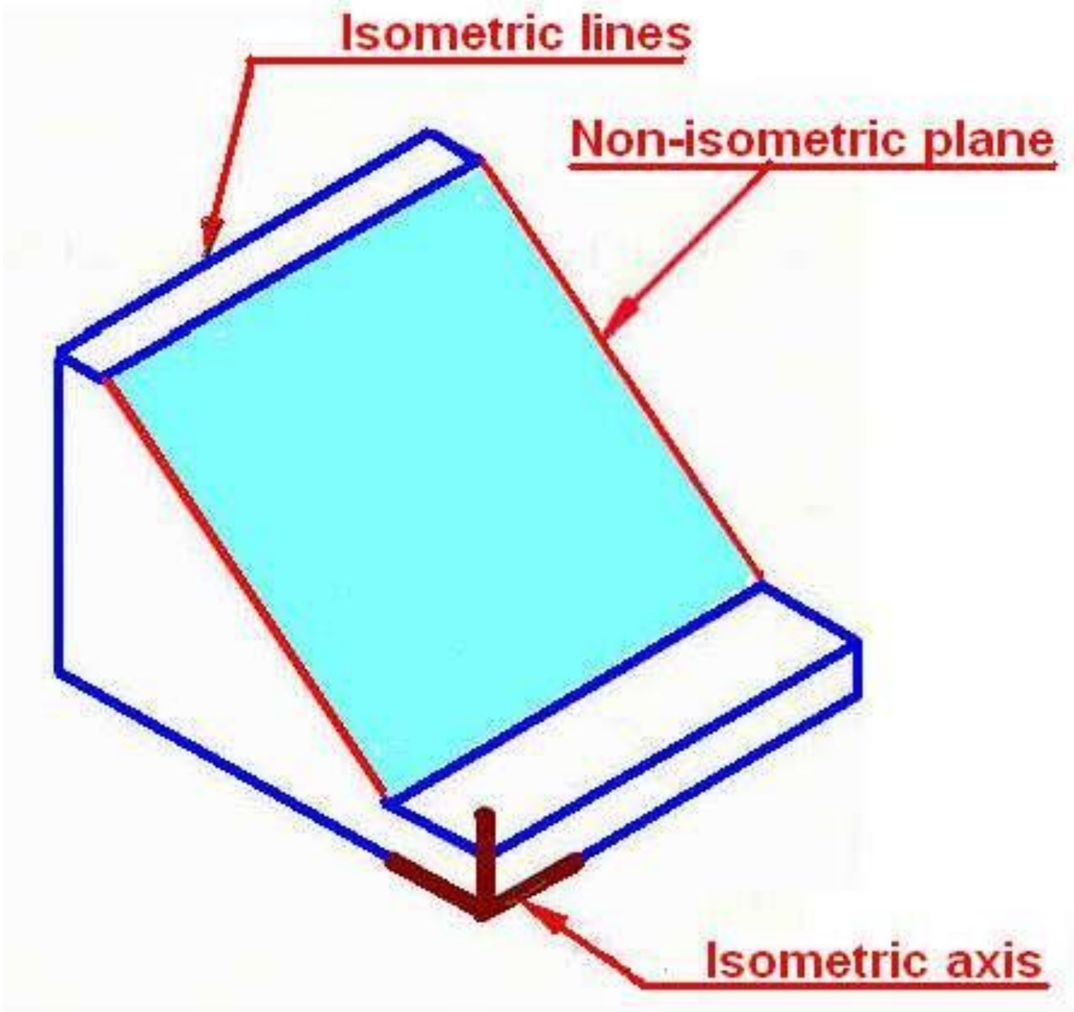


Figure A is an isometric drawing of a cube. The three faces of the isometric cube are isometric planes, because they are parallel to the isometric surfaces formed by any two adjacent isometric axes.

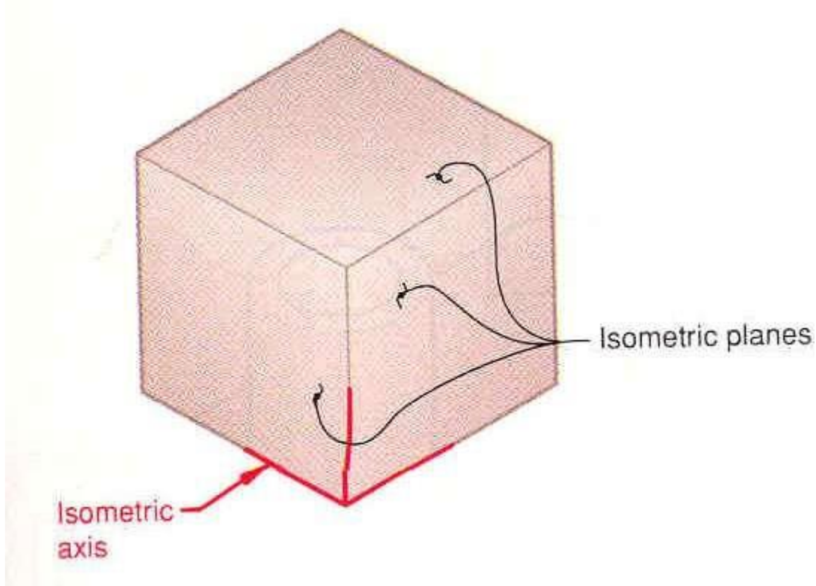


Figure A: Isometric planes relative to isometric axes

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

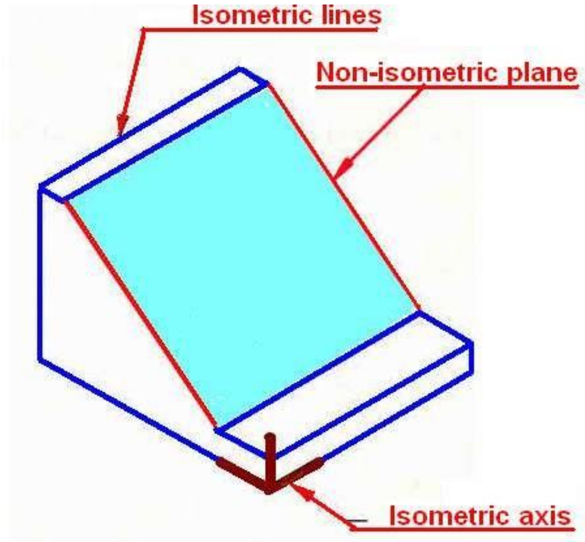


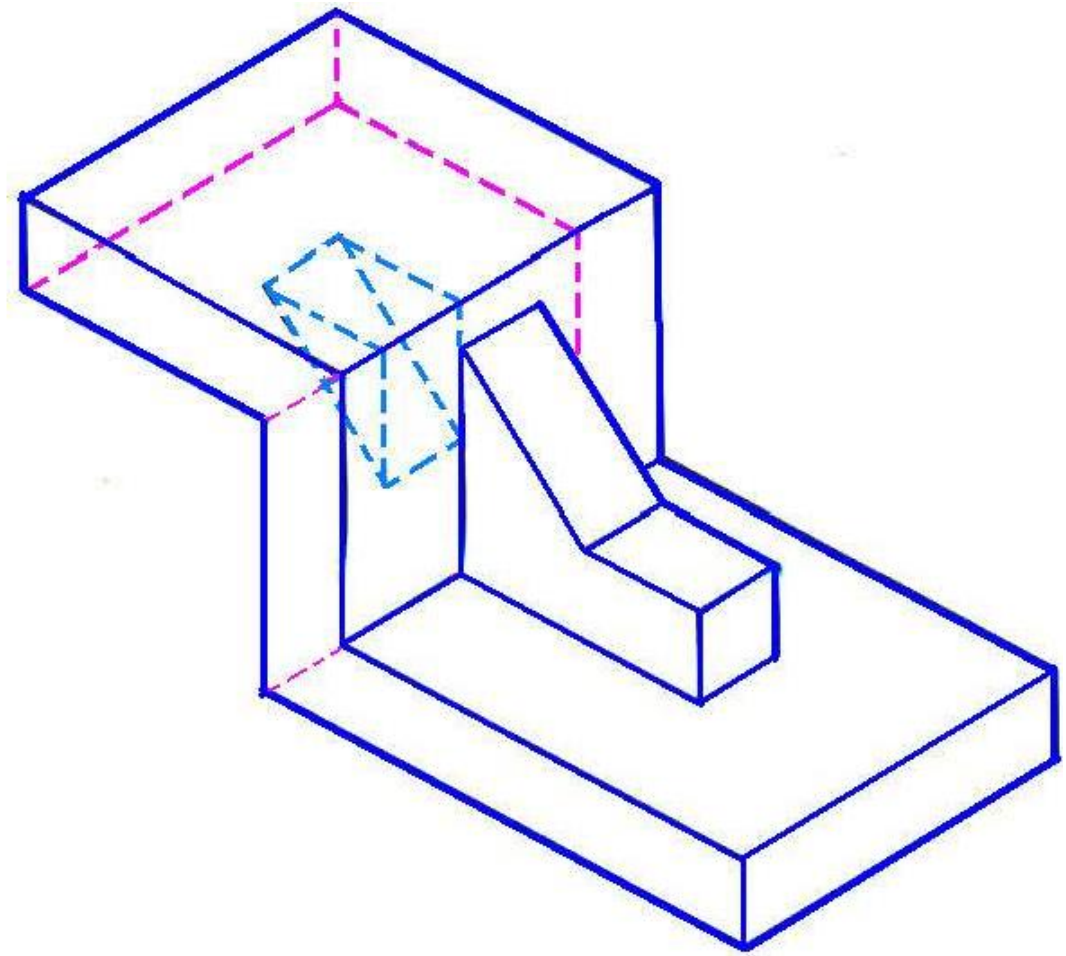
Figure B: Non-isometric plane

Standards for Hidden Lines, Center Lines and Dimensions

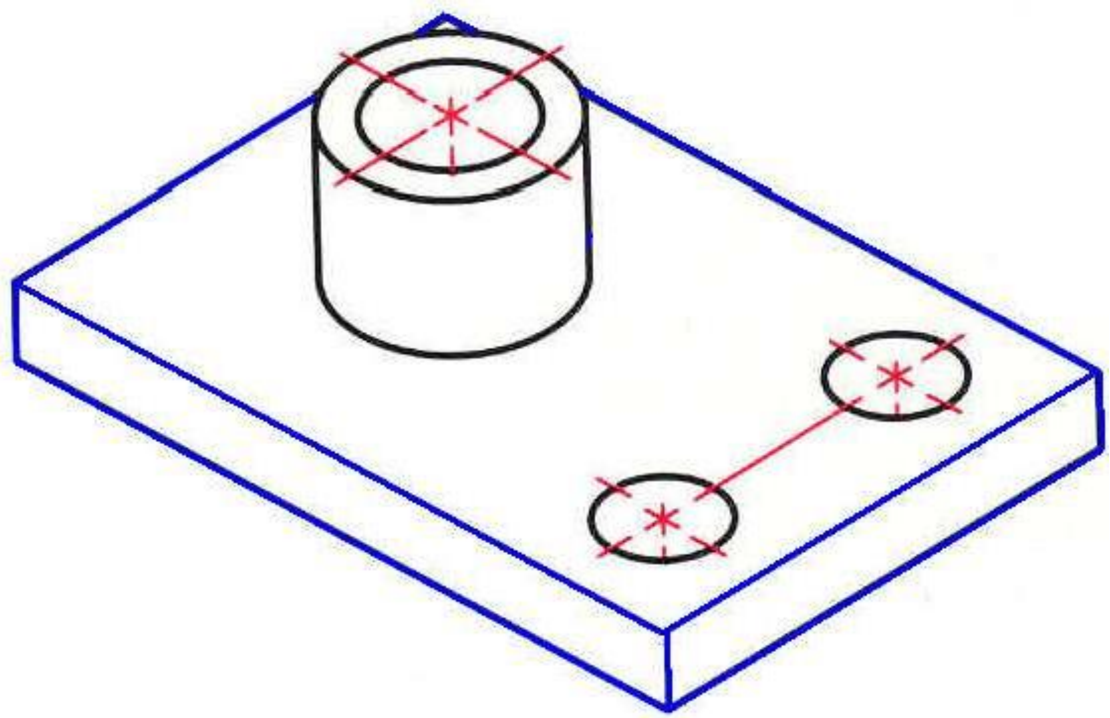
In isometric drawings, hidden lines are omitted unless they are absolutely necessary to completely describe the object. Most isometric drawings will not have hidden lines.

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

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



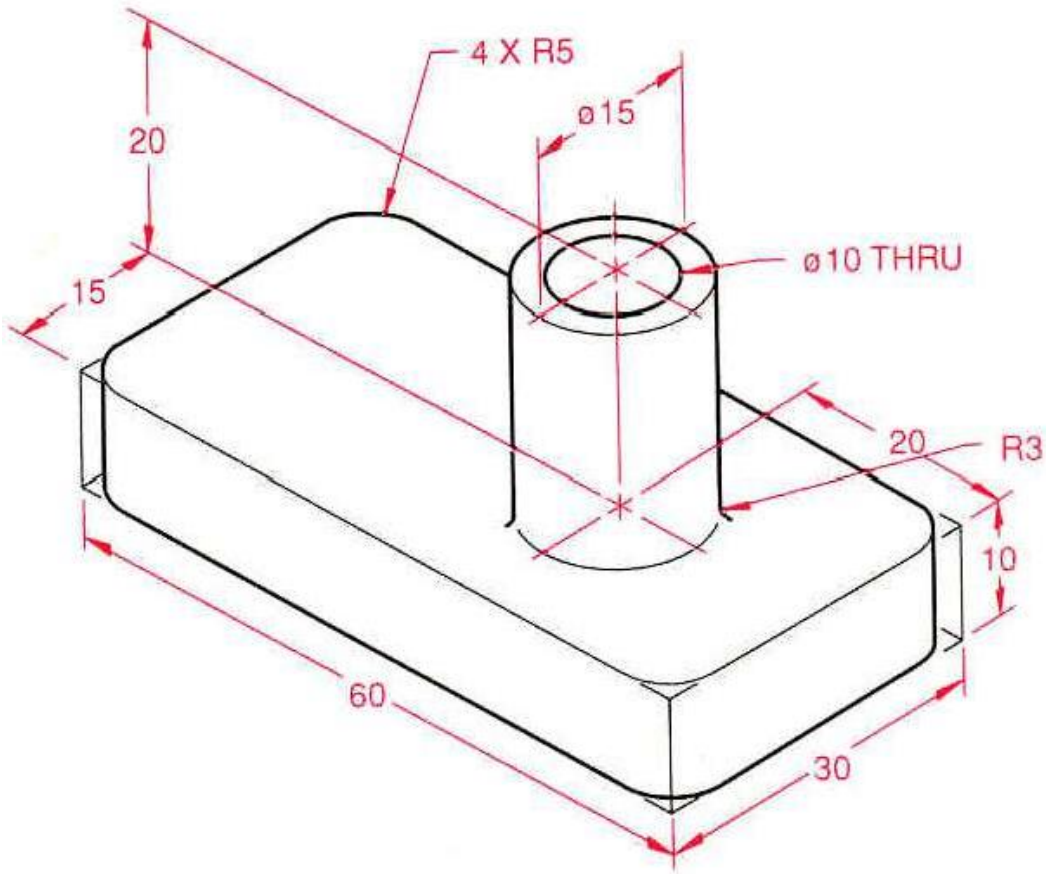
Centerlines are drawn only for showing symmetry or for dimensioning. Normally, centerlines are not shown, because many isometric drawings are used to communicate to non-technical people and not for engineering purposes.



As per the Standards:

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

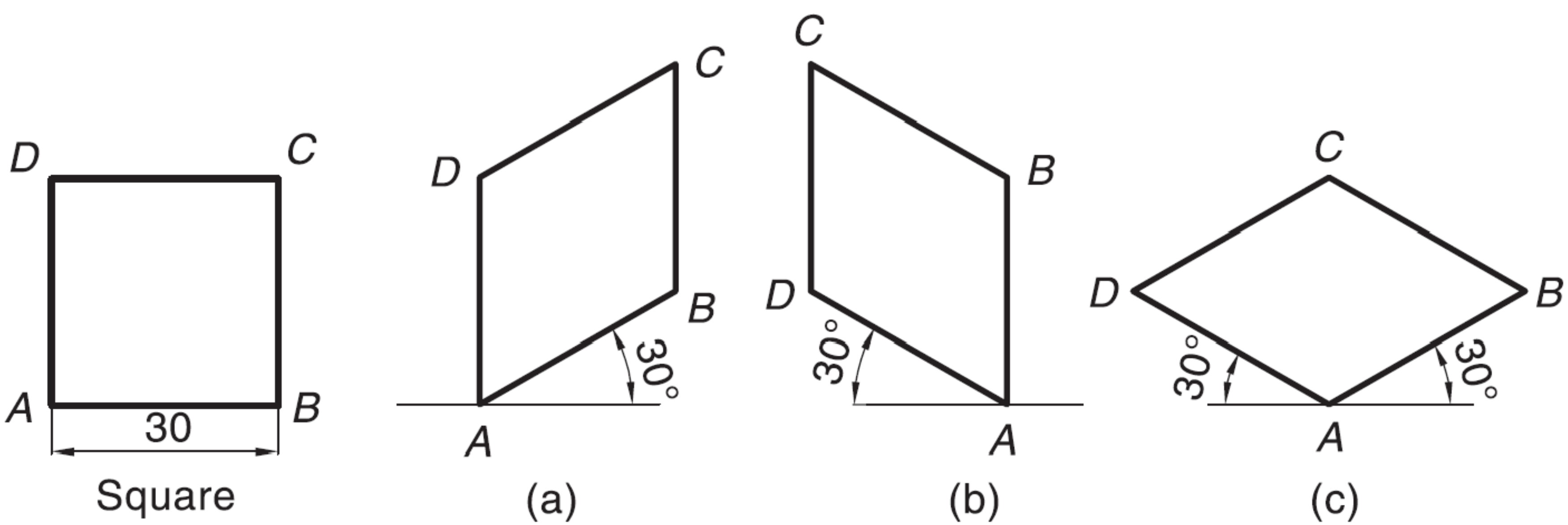
All dimensions and notes should be unidirectional, reading from the bottom of the drawing upward and should be located outside the view whenever possible. The texts is read from the bottom, using horizontal guidelines.



ISOMETRIC VIEWS OF STANDARD SHAPES

Square

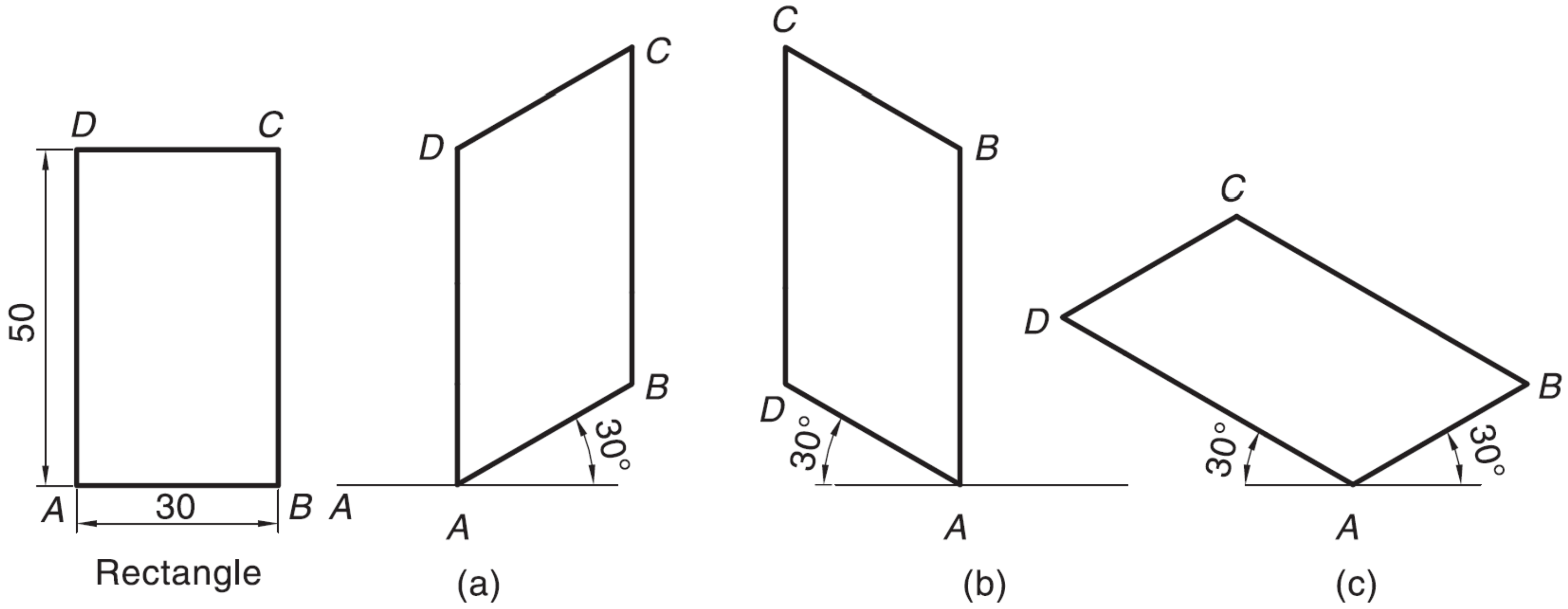
Consider a square *ABCD* with a 30 mm side shown in Fig. If the square lies in the vertical plane, it will appear as a rhombus with a 30 mm side in isometric view as shown in Fig. (a) or (b), depending on its orientation, i.e., right-hand vertical face or left-hand vertical face. If the square lies in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



Taken from Dhananjay A Jolhe, Engg. Drawing, MGH

Rectangle

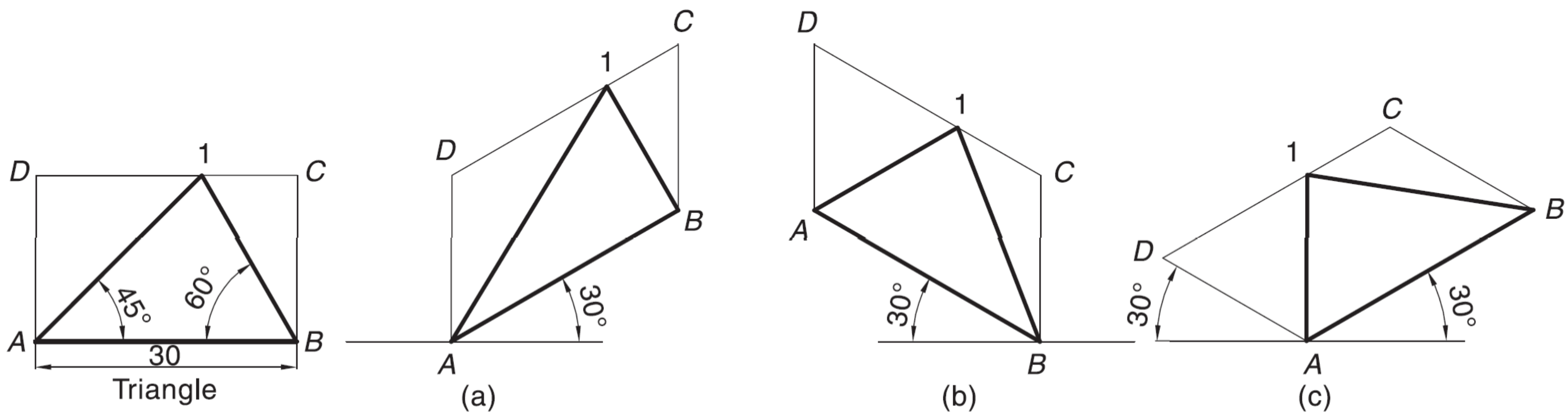
A rectangle appears as a parallelogram in isometric view. Three versions are possible depending on the orientation of the rectangle, i.e., right-hand vertical face, left-hand vertical face or horizontal face.



Taken from Dhananjay A Jolhe, Engg. Drawing, MGH

Triangle

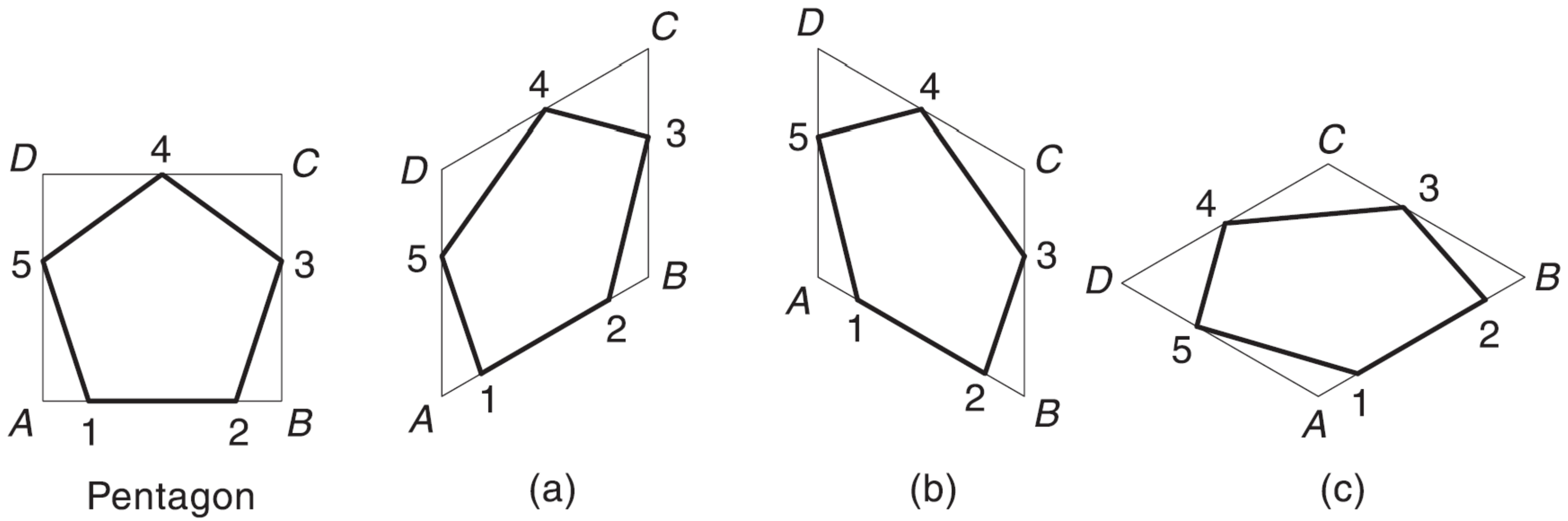
A triangle of any type can be easily obtained in isometric view as explained below. First enclose the triangle in rectangle *ABCD*. Obtain parallelogram *ABCD* for the rectangle as shown in Fig. (a) or (b) or (c). Then locate point 1 in the parallelogram such that *C*–1 in the parallelogram is equal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



Taken from Dhananjay A Jolhe, Engg. Drawing, MGH

Pentagon

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

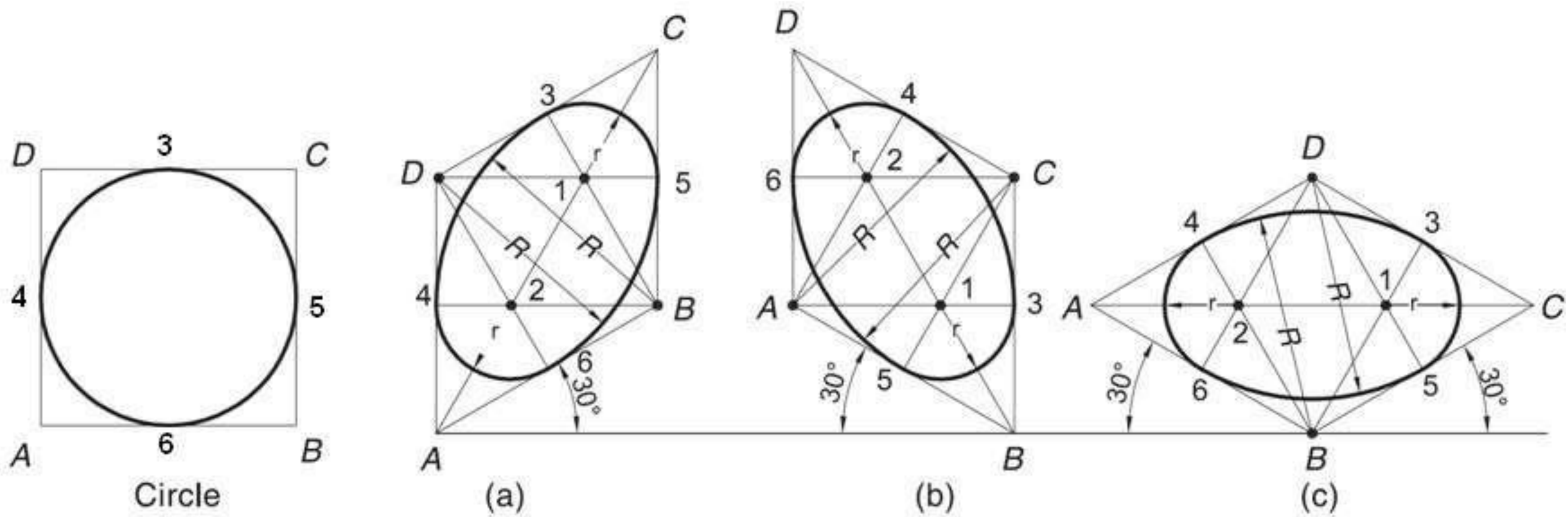


Taken from Dhananjay A Jolhe, Engg. Drawing, MGH

Circle

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

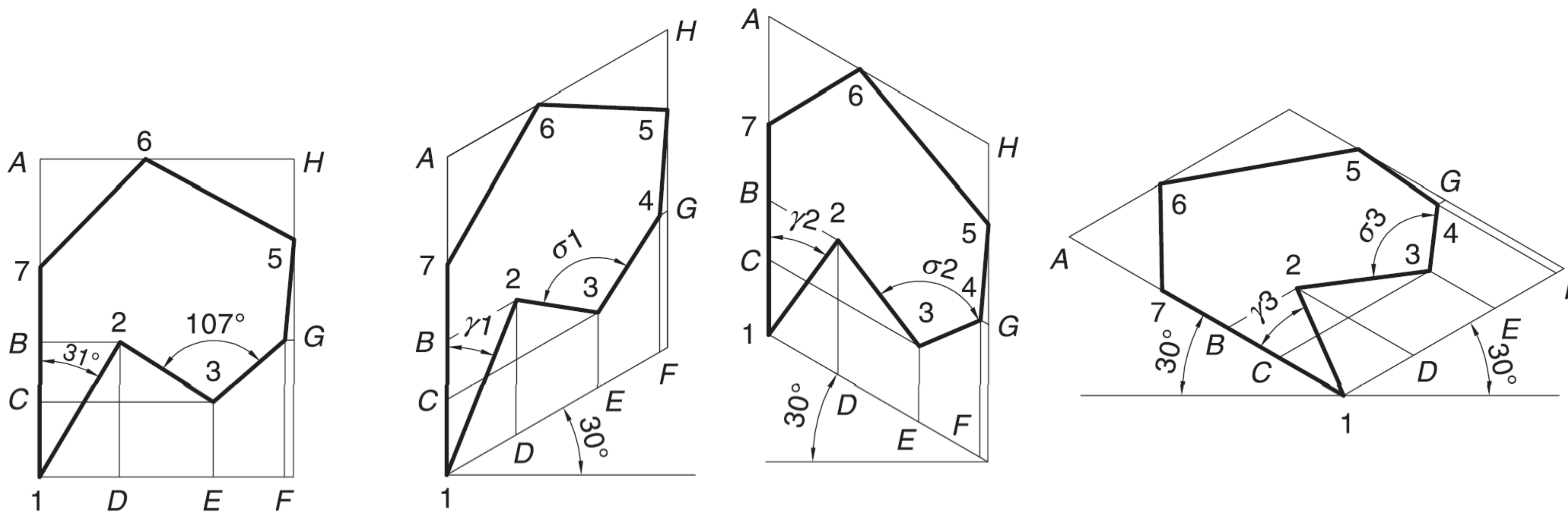
<u>Four-Centre Method</u> **: First, enclose the given circle into a square *ABCD*. Draw rhombus *ABCD* as an isometric view of the square. Join the farthest corners of the rhombus, i.e., *A* and *C*. Obtain midpoints 3 and 4 of sides *CD* and *AD* respectively. Locate points 1 and 2 at the intersection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



Taken from Dhananjay A Jolhe, Engg. Drawing, MGH

Any irregular Shape

Any irregular shape 1–2–3–4–5–6–7 can be drawn in isometric view as follows: The figure is enclosed in a rectangle first. The parallelogram is obtained in isometric for the rectangle as shown. The isolines *B*–2, *D*–2, *C*–3, *E*–3, *G*–4, *F*–4, *H*–5, *H*–6 and *A*–7 has the same length as in original shape, e.g., *B*–2 in isometric = *B*–2 in irregular shape.



Irregular Shape (a) (b) (c)

Taken from Dhananjay A Jolhe, Engg. Drawing, MGH

Isometric views for solids

The Boxing-in Method

The four basic steps for creating an isometric drawing are:

Determine the isometric viewpoint that clearly depicts the features of the object, then draw the isometric axes which will produce that view-point.

height (H), and depth (D) of the object, such that the object will be totally enclosed in a box.

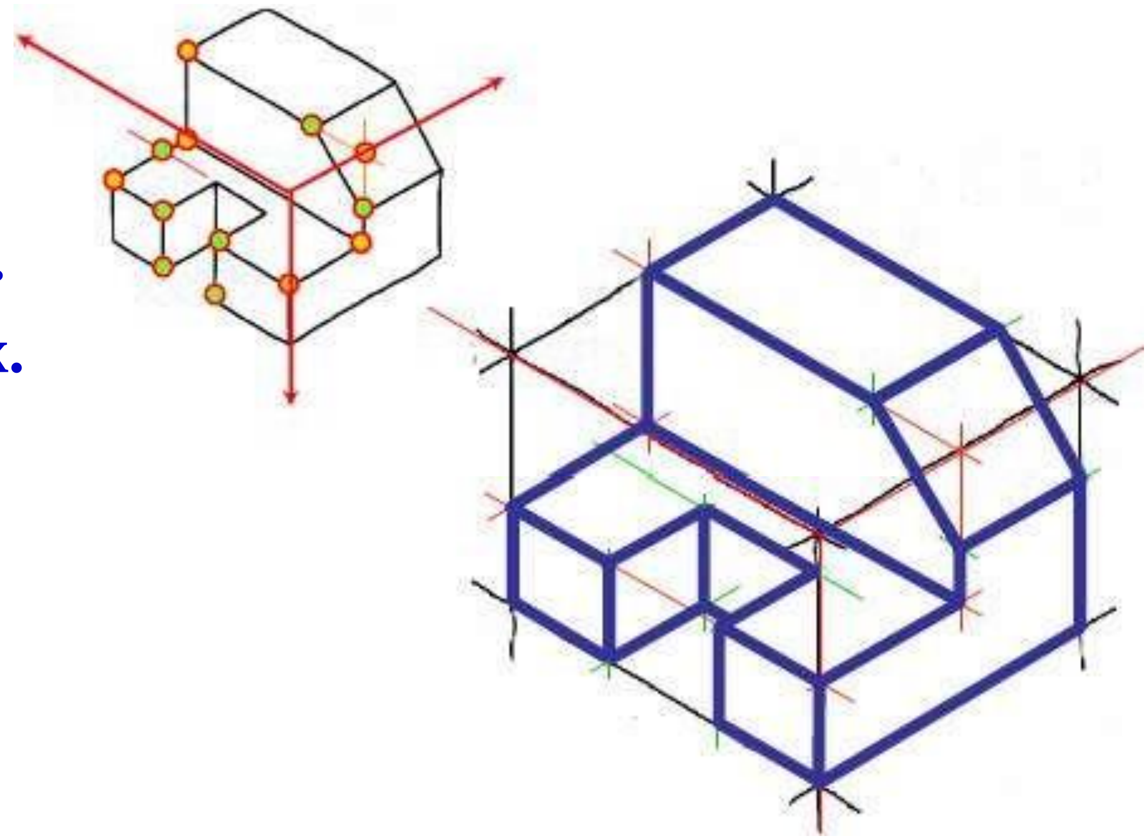
Locate details on the isometric planes.

Darken all visible lines, and eliminate hidden lines unless absolutely necessary to describe the object.

Sketch from an actual object

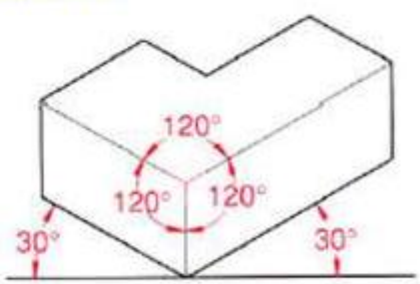
STEPS

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

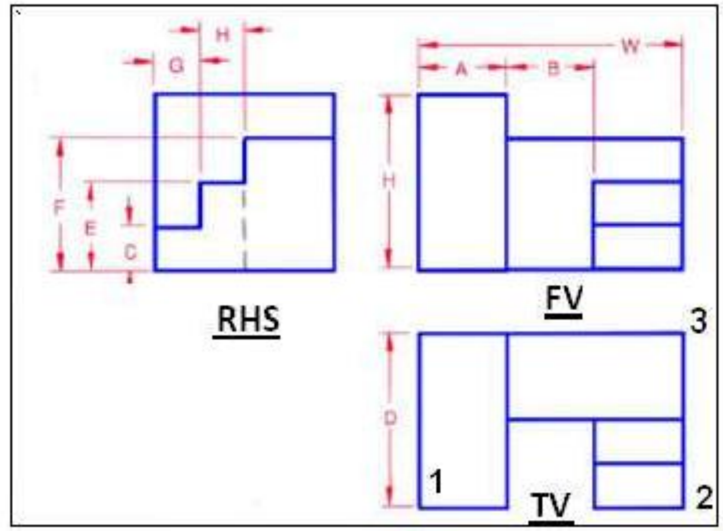


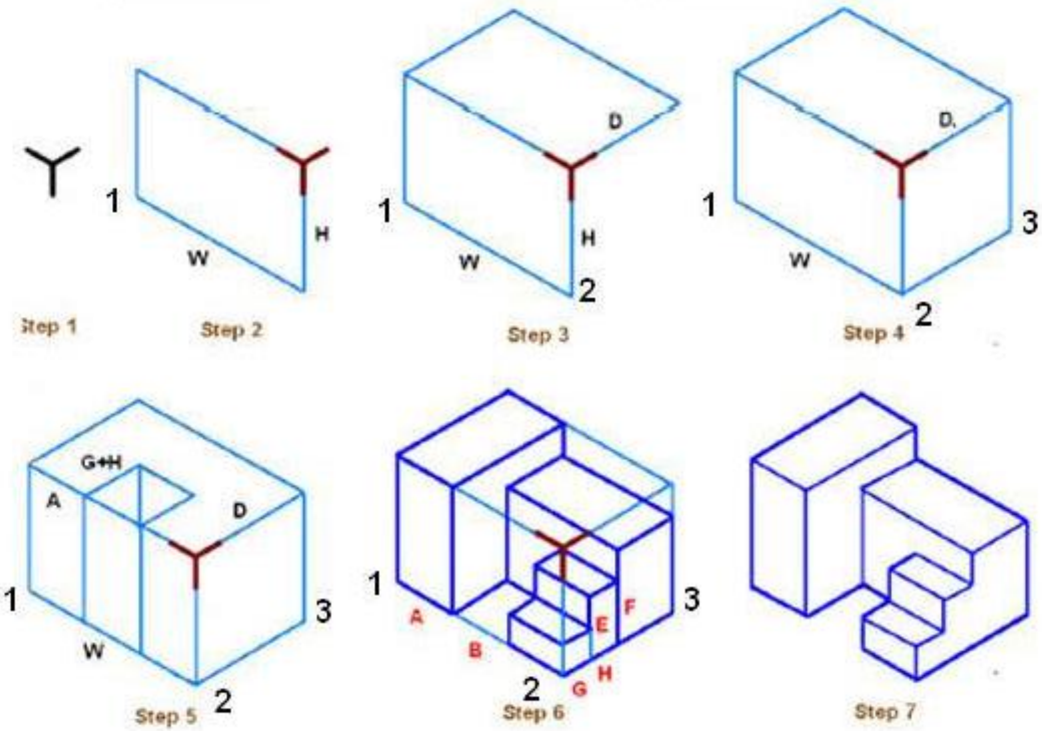
Note In isometric sketch/drawing), hidden lines are *omitted* unless they are absolutely necessary to completely describe the object.**Sketch from an actual object**

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



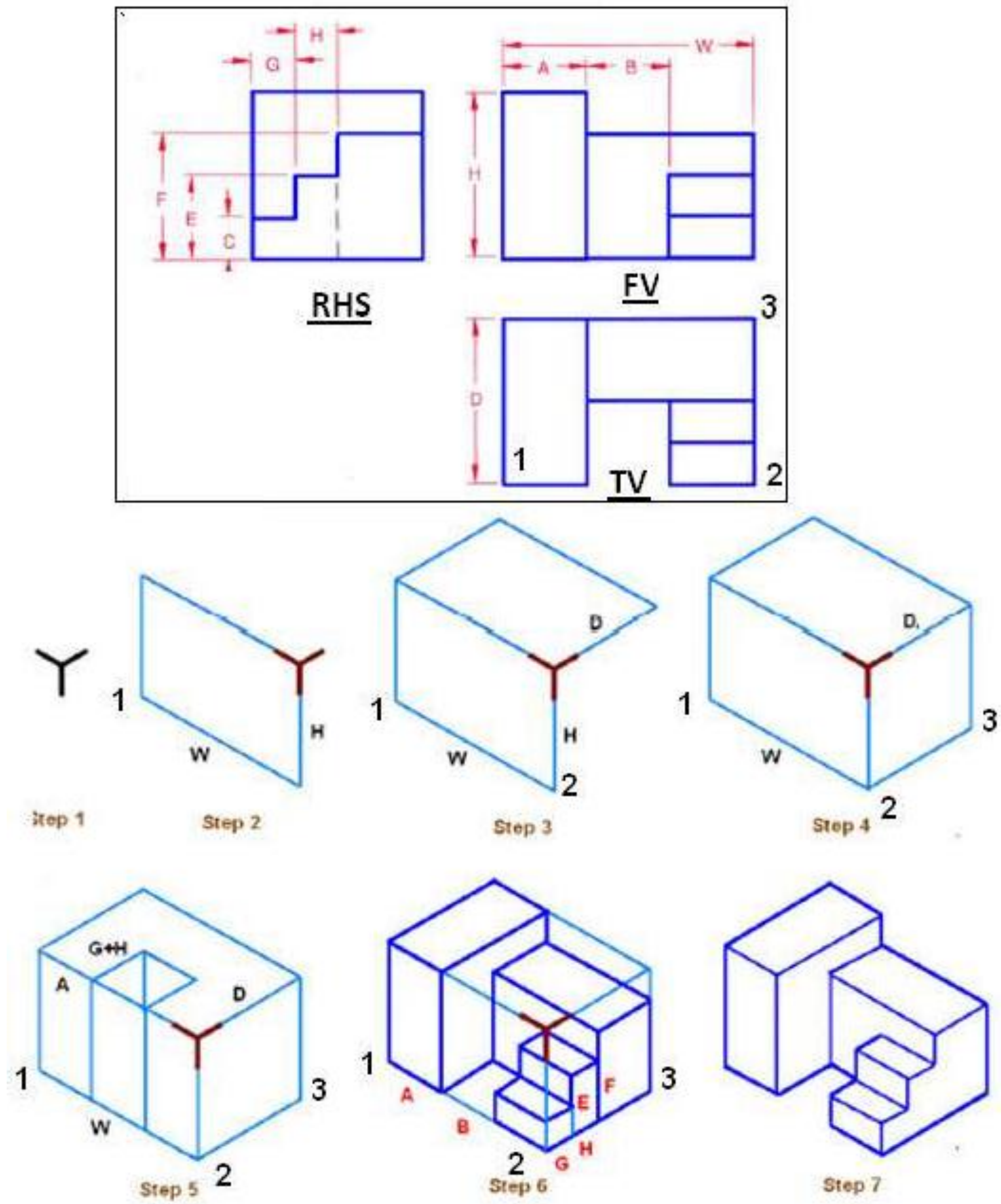
(A) Regular Isometric





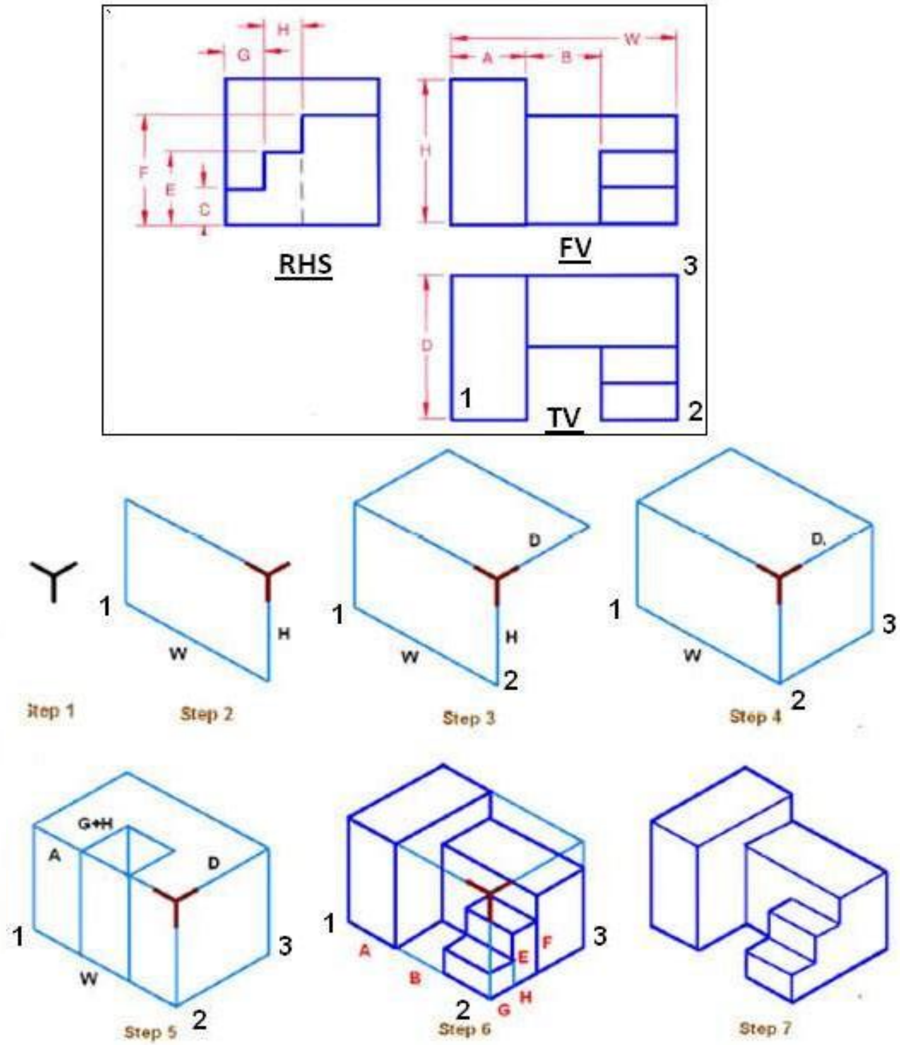
***Step* 2.** Construct the front isometric plane using **W** and **H** dimensions. **Width** dimensions are drawn along 30-degree lines from the horizontal. **Height** dimensions are drawn as vertical lines.

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



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

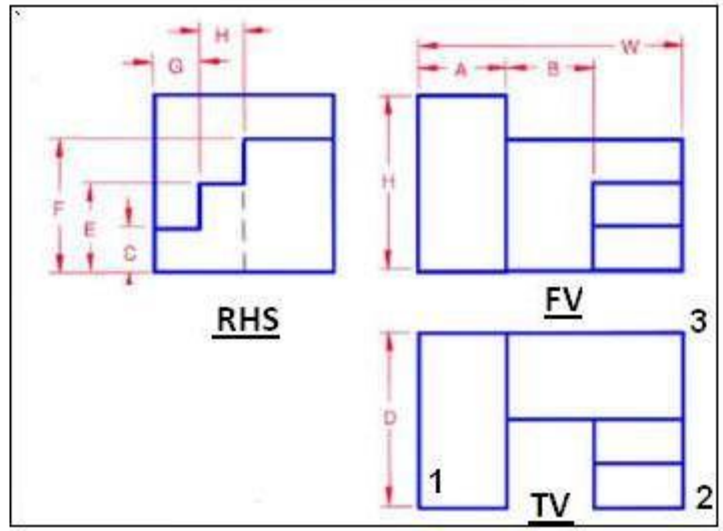
***Step* 5.** Transfer some distances for the various features from the multiview drawing to the isometric lines that make up the isometric rectangle. on the front and top planes of the isometric box.

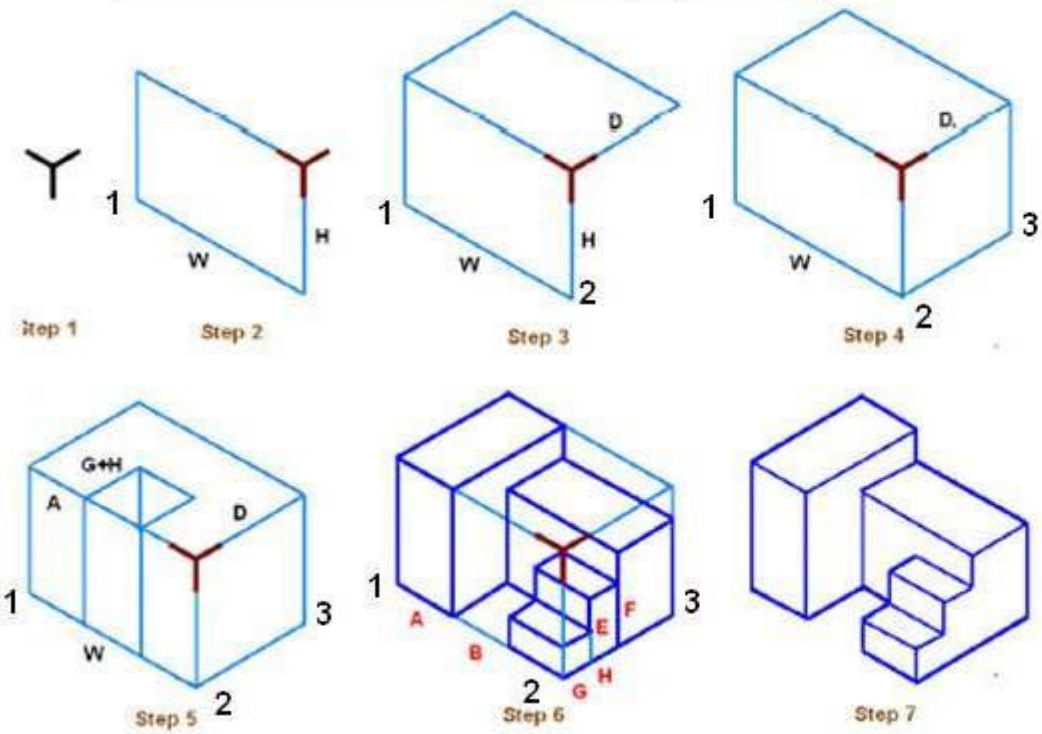


For example, distance **A** is measured in the multiview drawing, then transferred to a width line in the front plane of the isometric rectangle. Begin drawing details of the block by drawing isometric lines between the points transferred from the multiview drawing. For example, a notch is taken out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

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

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





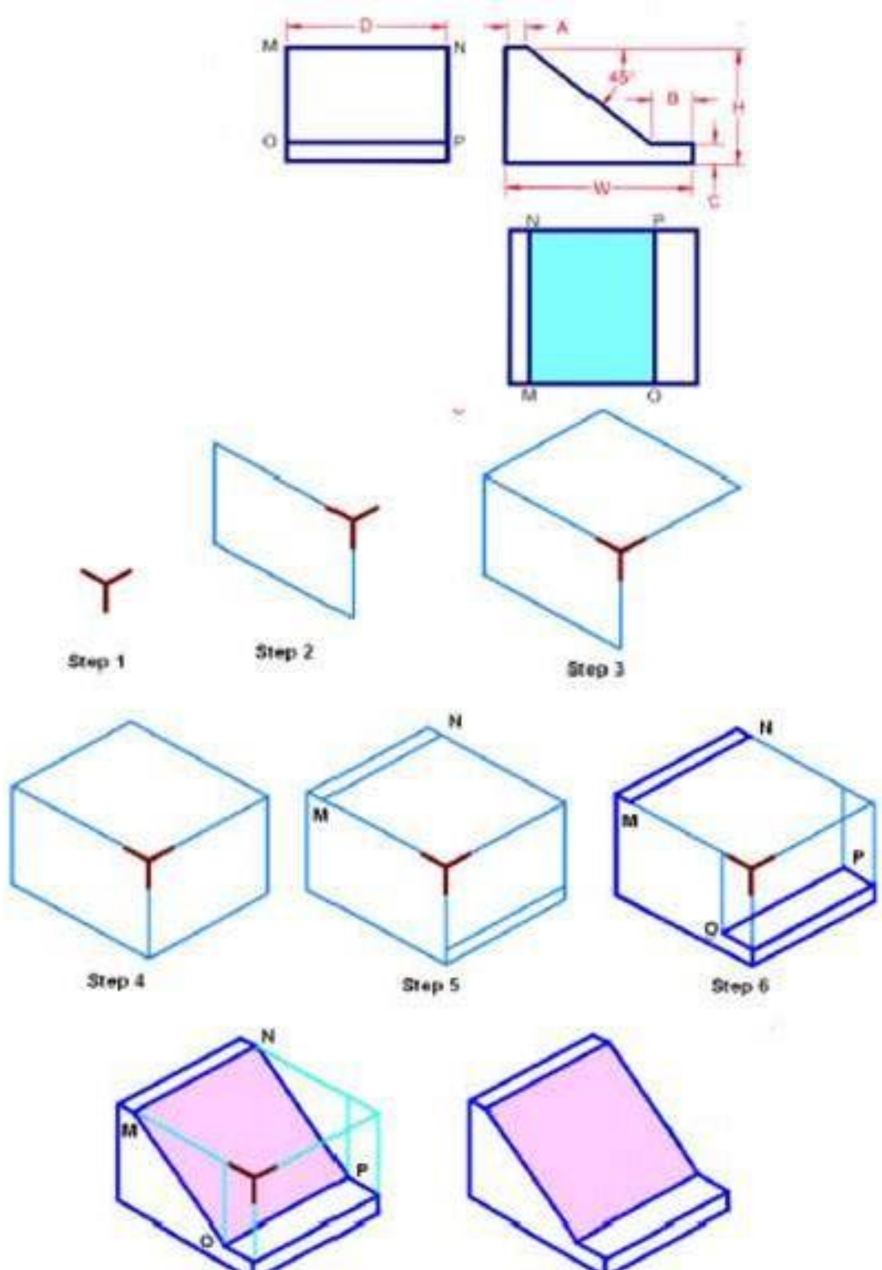
Non-Isometric Lines

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

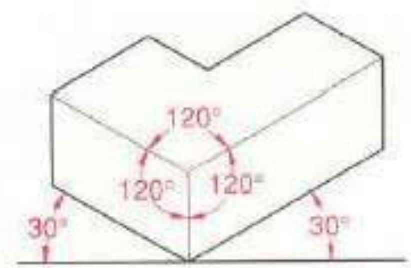
It is not possible to measure the length or angle of an inclined or oblique line in a multiview drawing and then use that measurement to draw the line in an isometric drawing.

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

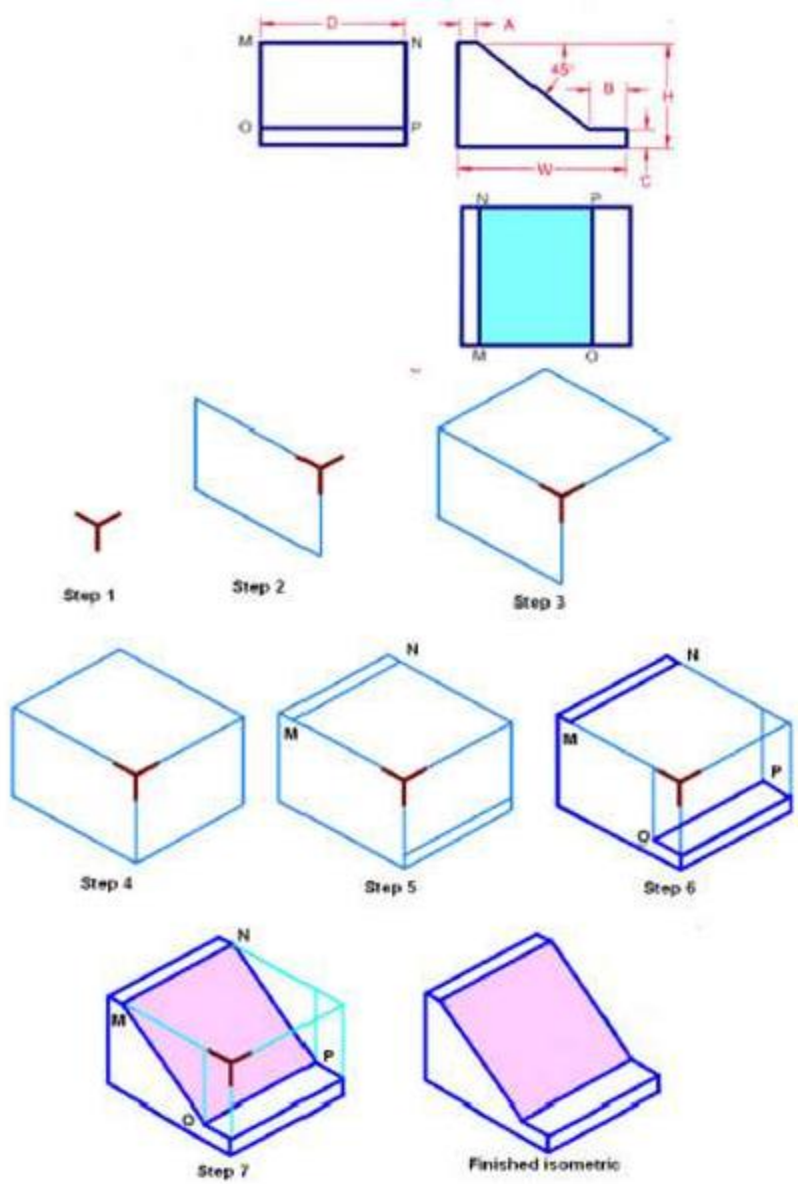
The process used is called offset measurement, which is a method of locating one point by projecting another point.



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



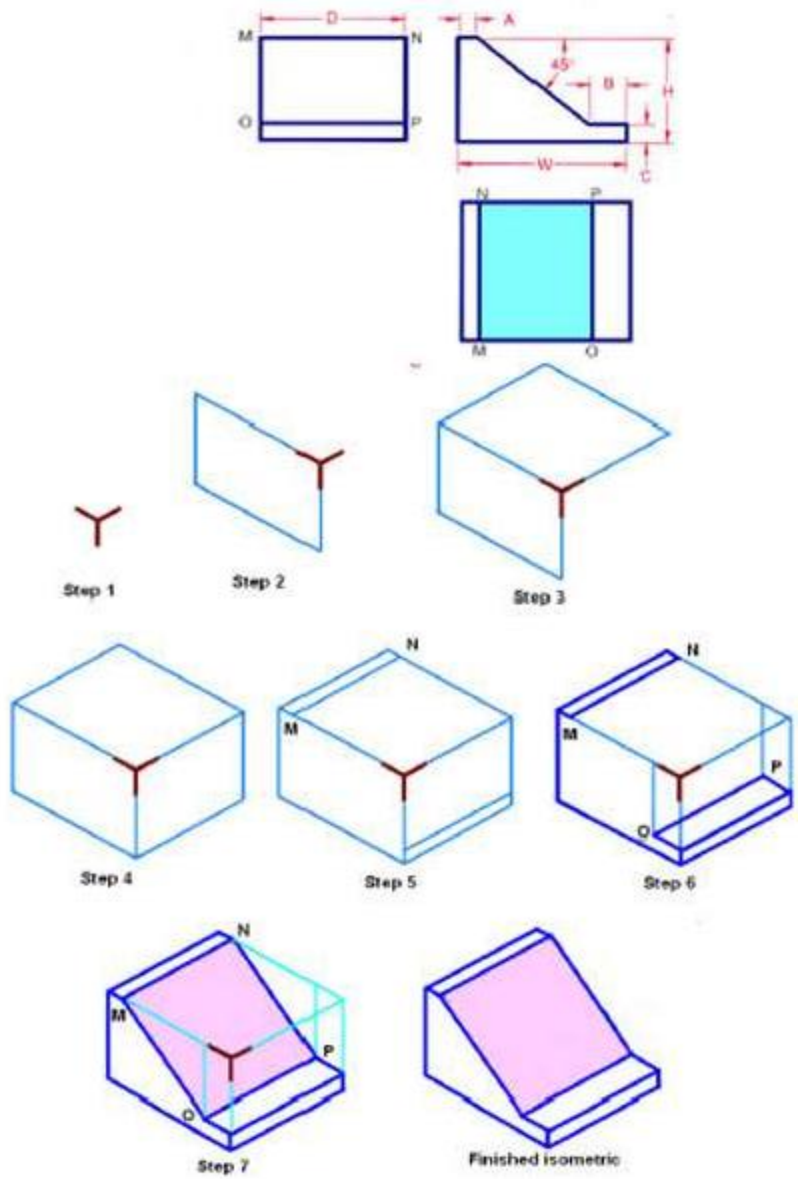
(A) Regular Isometric



***Step* 2**. Construct the front isometric plane using **W** and **H** dimensions.

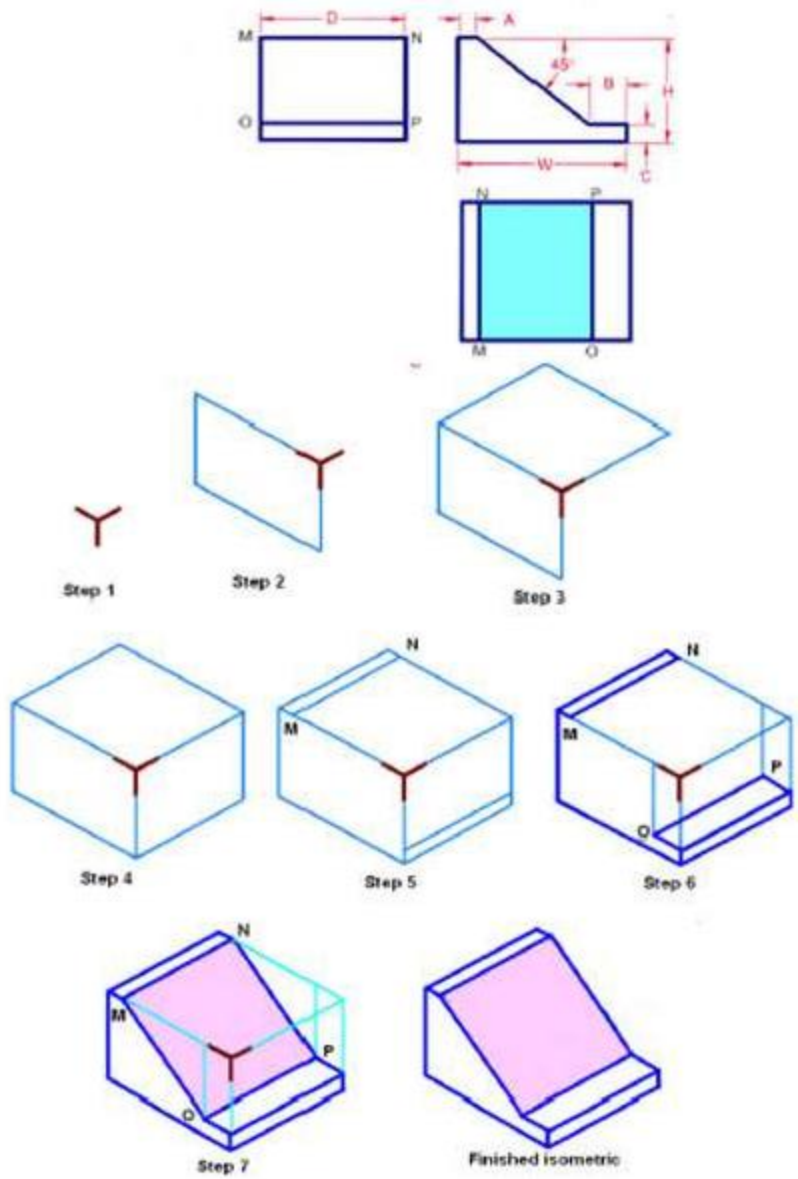
***Step* 3.** Construct the top isometric plane using the **W** and **D** dimensions.

***Step* 4.** Construct the right side isometric plane using **D** and **H** dimensions.



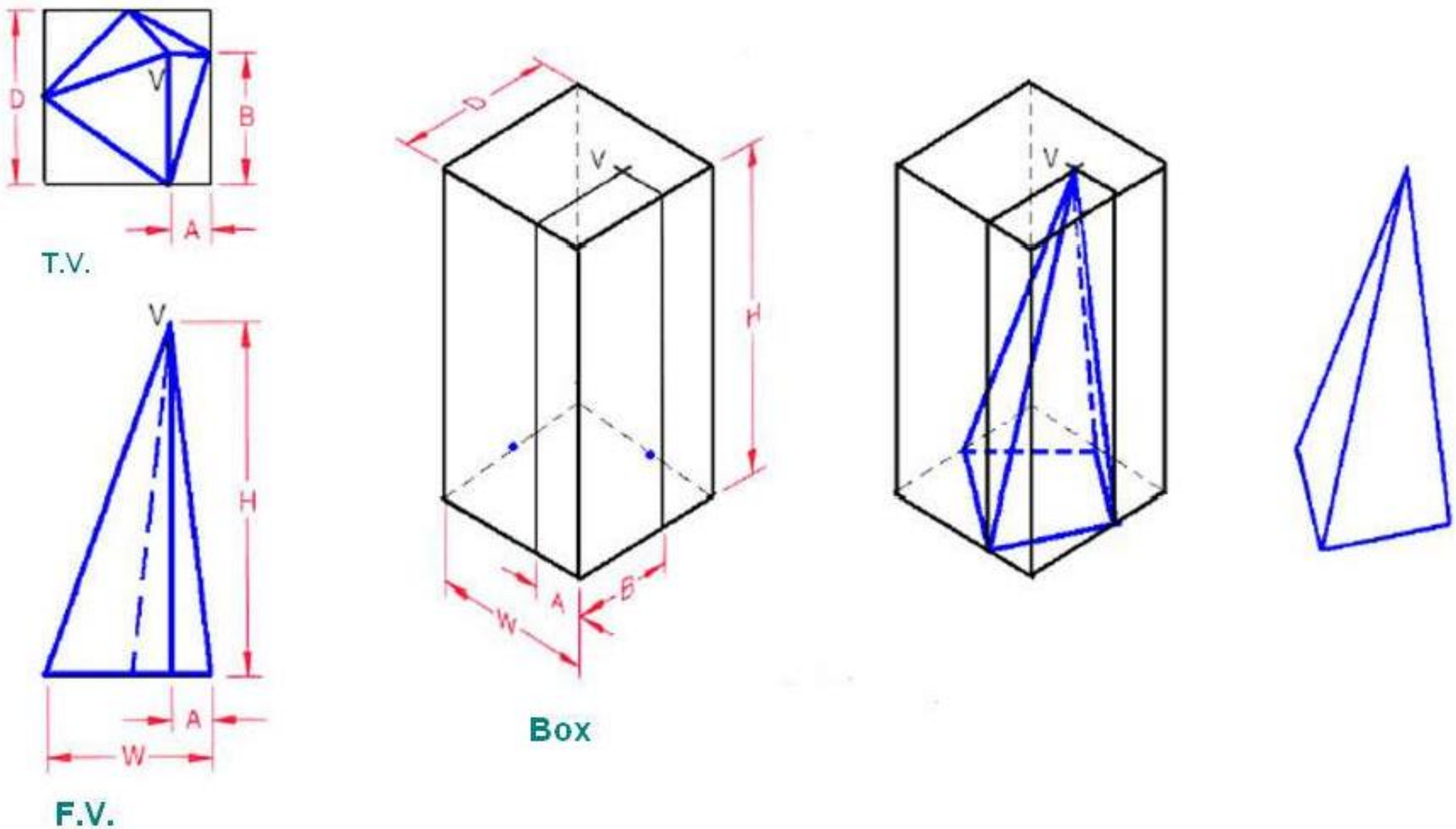
***Step* 5.** Transfer the distances for **C** and **A** from the multi-view drawing to the top and right side isometric rectangles.

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



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

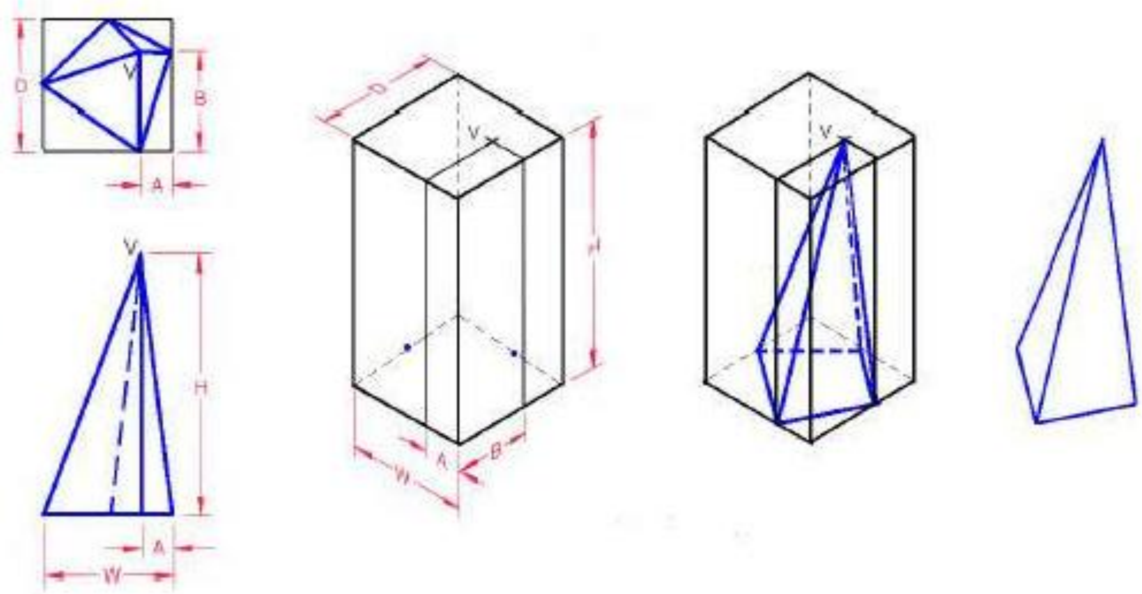
***Step* 7.** Connect points **MO** and **NP** to draw the non-isometric lines.



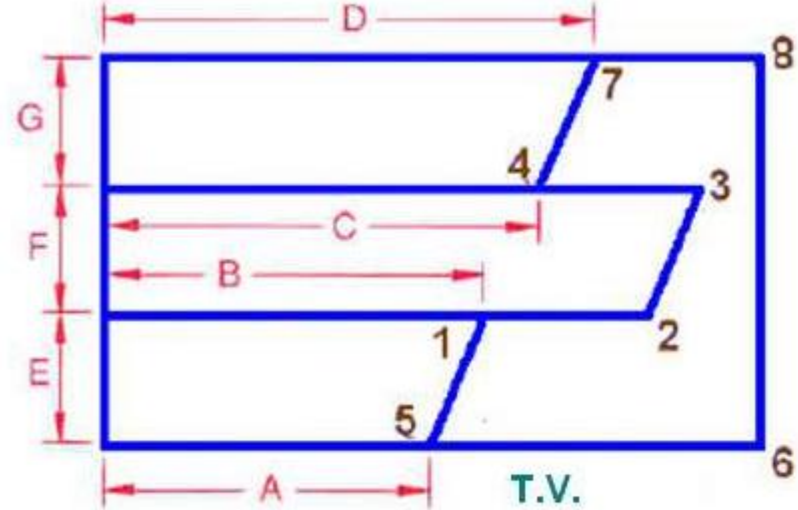
An example of how to locate points to make an isometric drawing of an irregular object

Determine dimensions A and B in the multi-view drawing. Construct an isometric box equal to the dimensions W, H and D as measured in the multi-view drawing. Locate dimensions A and B along the base of the isometric box, then project them along the faces to the edge of the top face, using vertical lines..

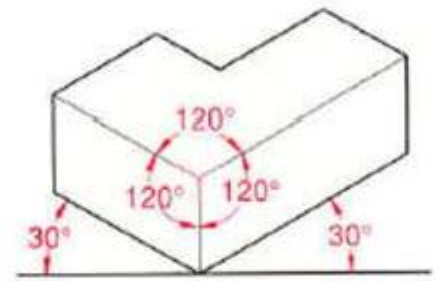
Project the points of intersection across the top face using isometric lines. Point V is located at the intersection of these last two projections. Locate the remaining points around the base and draw the figure.



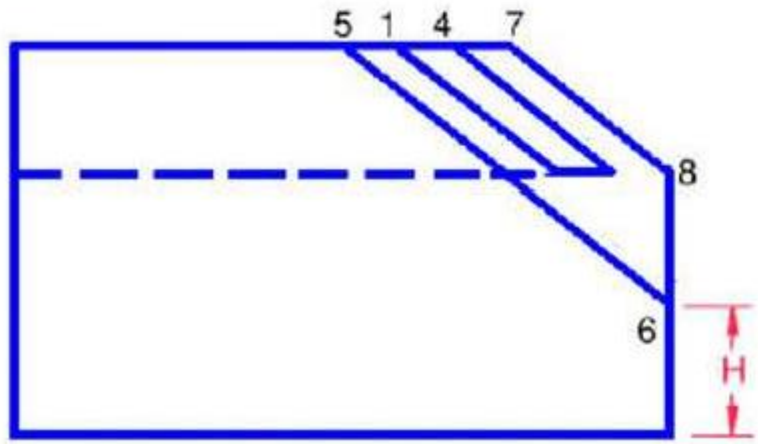
Step 1: Determine the desired view of the object, then draw the isometric axes. For this example it is determined that the object will be viewed from above and the axis will be as shown in Fig. A.



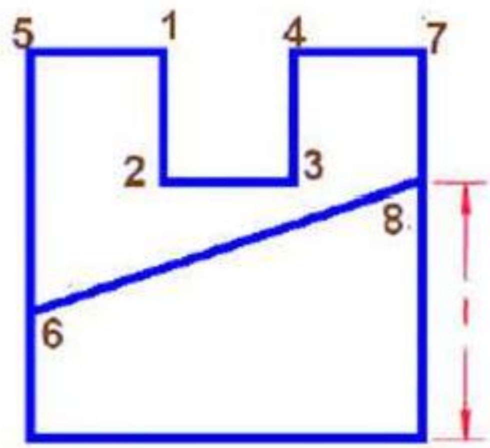
T.V.



(A) Regular Isometric



F.V.



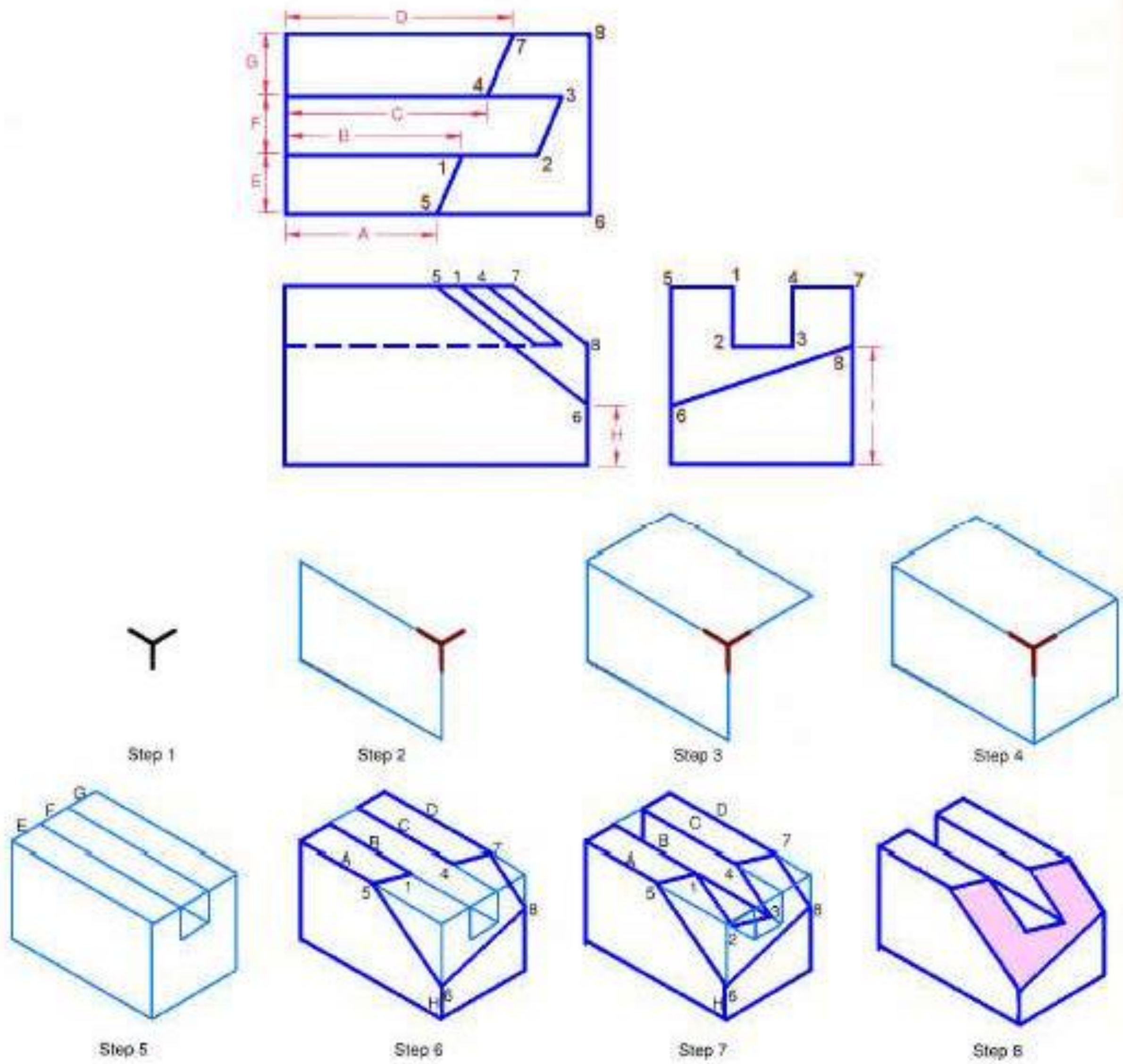
S.V.

Step 2. Construct the front isometric plane using **W** and **H** dimensions.

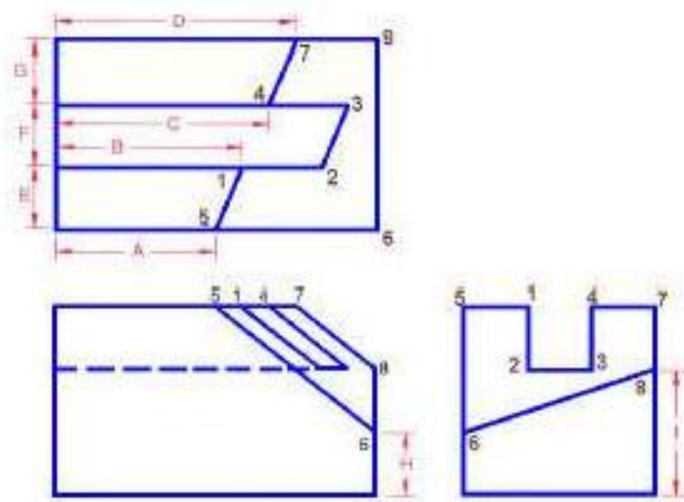
***Step* 3.** Construct the top isometric plane using the **W** and **D** dimensions.

***Step* 4.** Construct the right side isometric plane using **D** and **H** dimensions.

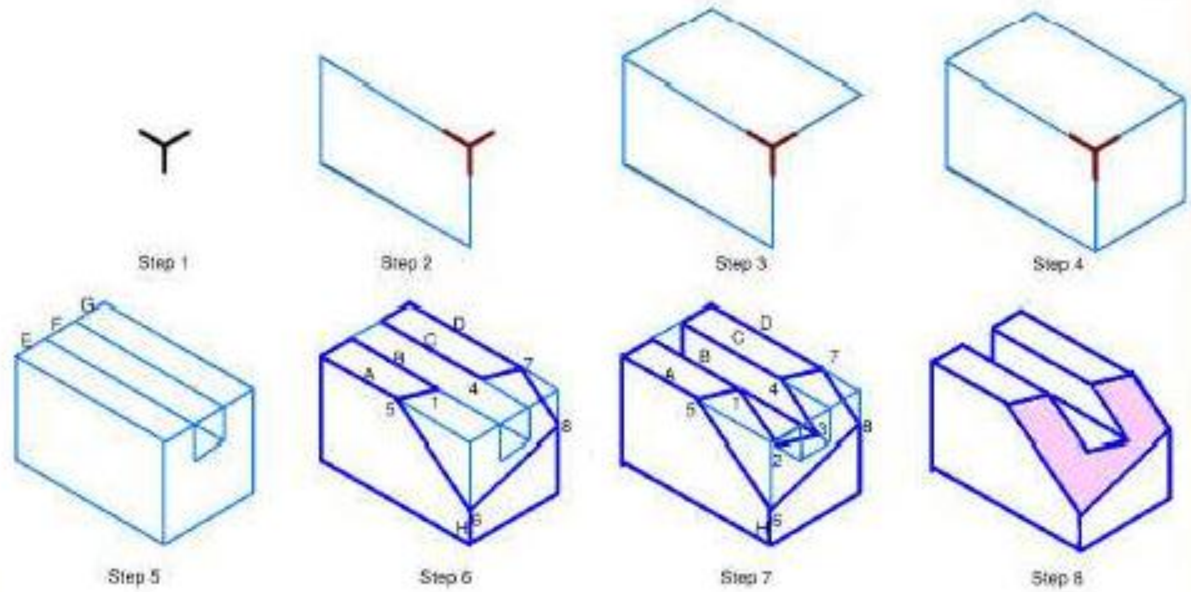
***Step* 5.** Locate the slot across the top plane by measuring distances **E, F**, and **G** along isometric lines.



***Step* 6.** Locate the endpoints of the oblique plane in the top plane by locating distances **A, B, C**, and **D** along the lines created for the slot in Step **5.** Label the end-point of line **A** as **5**, line **B** as **1**, line **C** as **4**, and lire **D** as **7**.

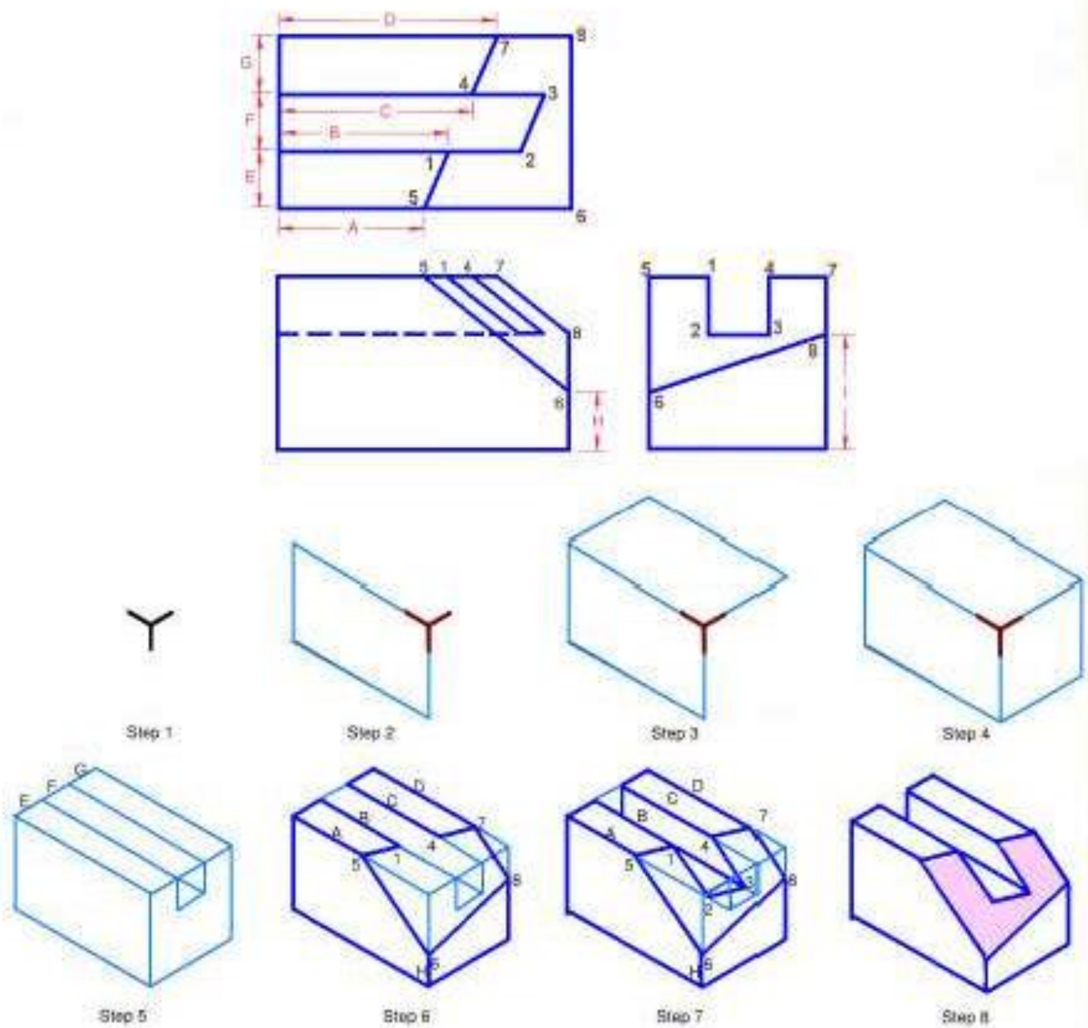


Locate distance **H** along the vertical isometric line in the front plane of the isometric box and label the end point **6**. Then locate distance **I** along the isometric line in the profile isometric plane and label the end point **8**. Connect endpoints **5-7** and endpoint **6-8**. Connect points **5-6** and **7-8**.



***Step* 7.** Draw a line from point **4** parallel to line **7**. This new line should intersect at point **3**. Locate point **2** by drawing a line from point **3** parallel to line **4** and equal in length to the distance between points **1** and **4**. Draw a line from point **1** parallel to line **5-6**. This new line should intersect point **2**.

***Step* 8.** Darken lines **4-3**, **3-2**, and **2-1** to complete the isometric view of the object.



Irregular Curves - Irregular curves are drawn in isometric by constructing points along the curve in the multi-view drawing, locating those points in the isometric view, and then connecting the points using a drawing instrument such as a French curve.

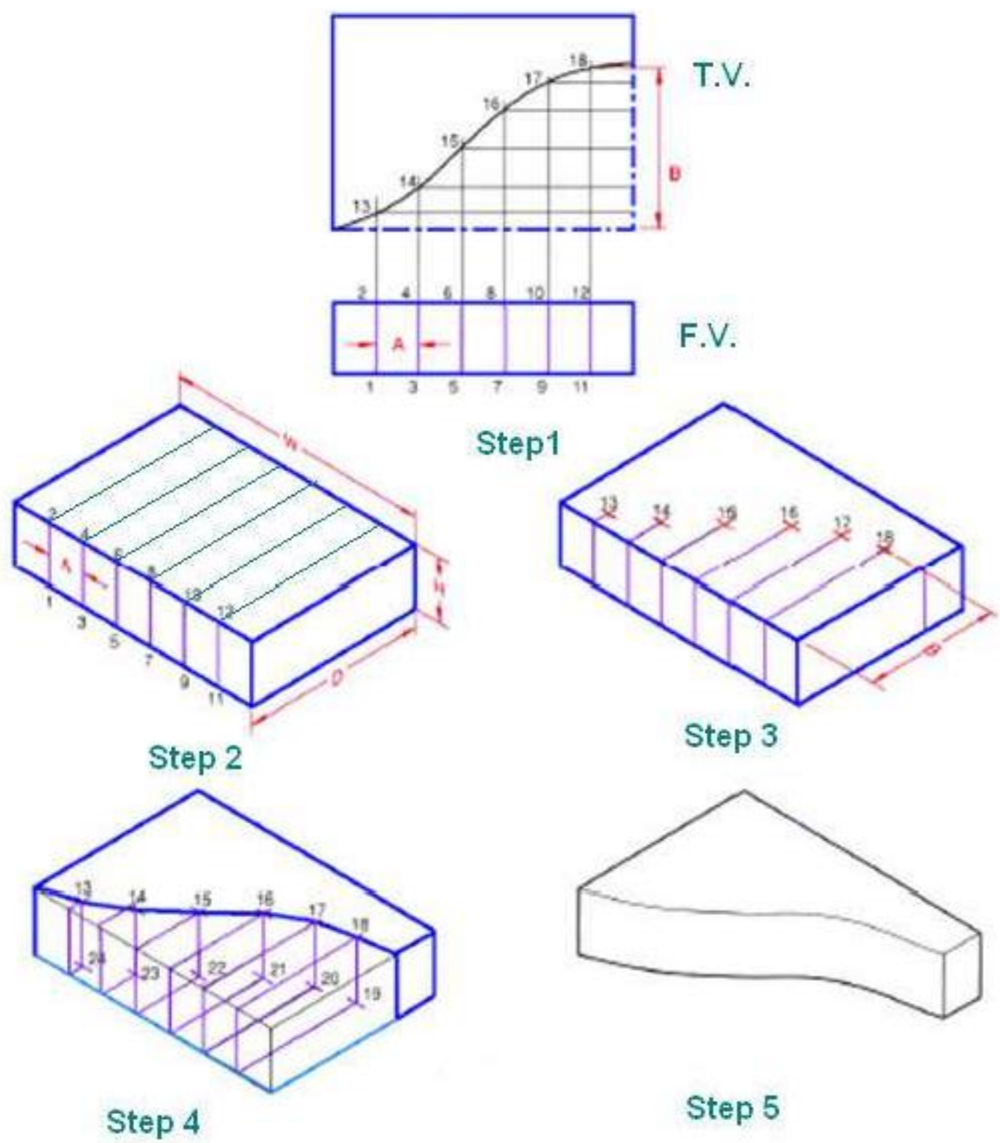
The multi-view drawing of the curve is divided into a number of segments by creating a grid of lines and reconstructing the grid in the isometric drawing.

The more segments chosen, the longer the curve takes to draw, but the curve will be more accurately represented in the isometric view.

***Step* 1**. On the front view of the multi-view drawing of the curve, construct parallel lines and label the points **1-12.**

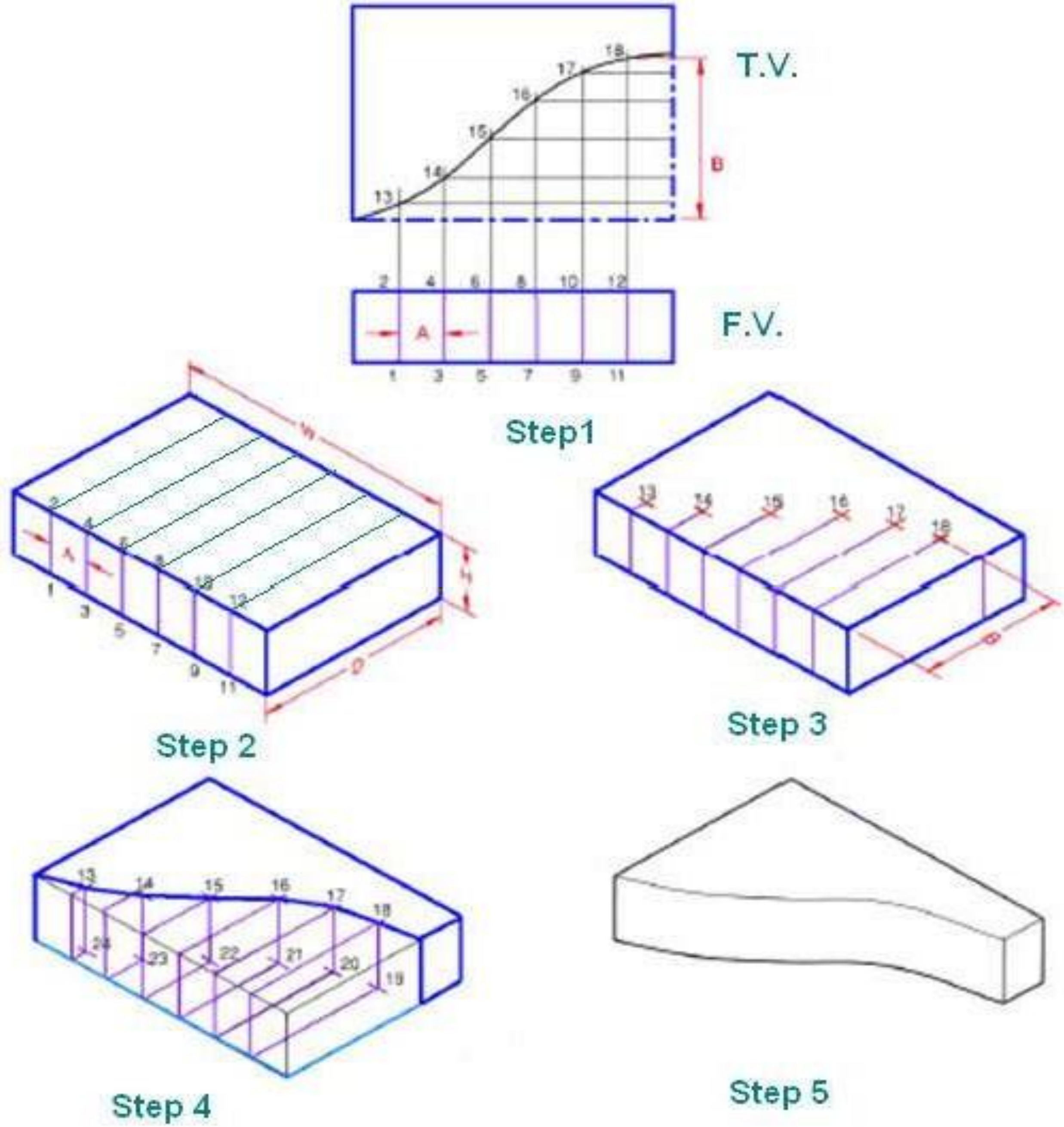
Project these lines into the top view until they intersect the curve.

Label these points of intersection **13-18**, as shown in the Figure. Draw horizontal lines through each point of intersection, to create a grid of lines.



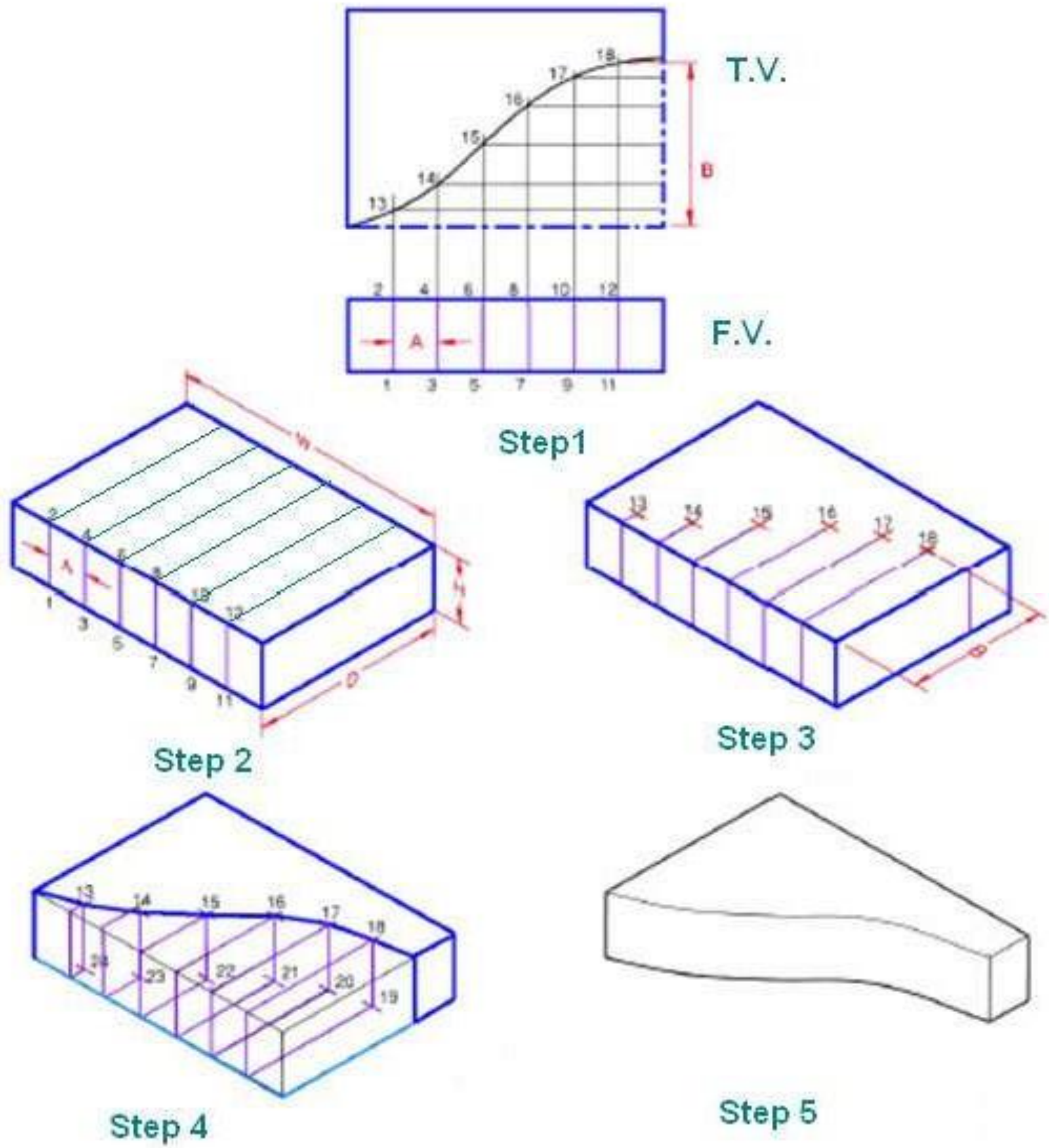
***Step* 2**. Use the **W**, **H**, and **D** dimensions from the multi-view drawing to create the isometric box for the curve.

Along the front face of the isometric box, transfer dimension **A** to locate and draw lines **1-2**, **3-4**, **5-6**, **7-8**, **9-10**, and **11-12**.



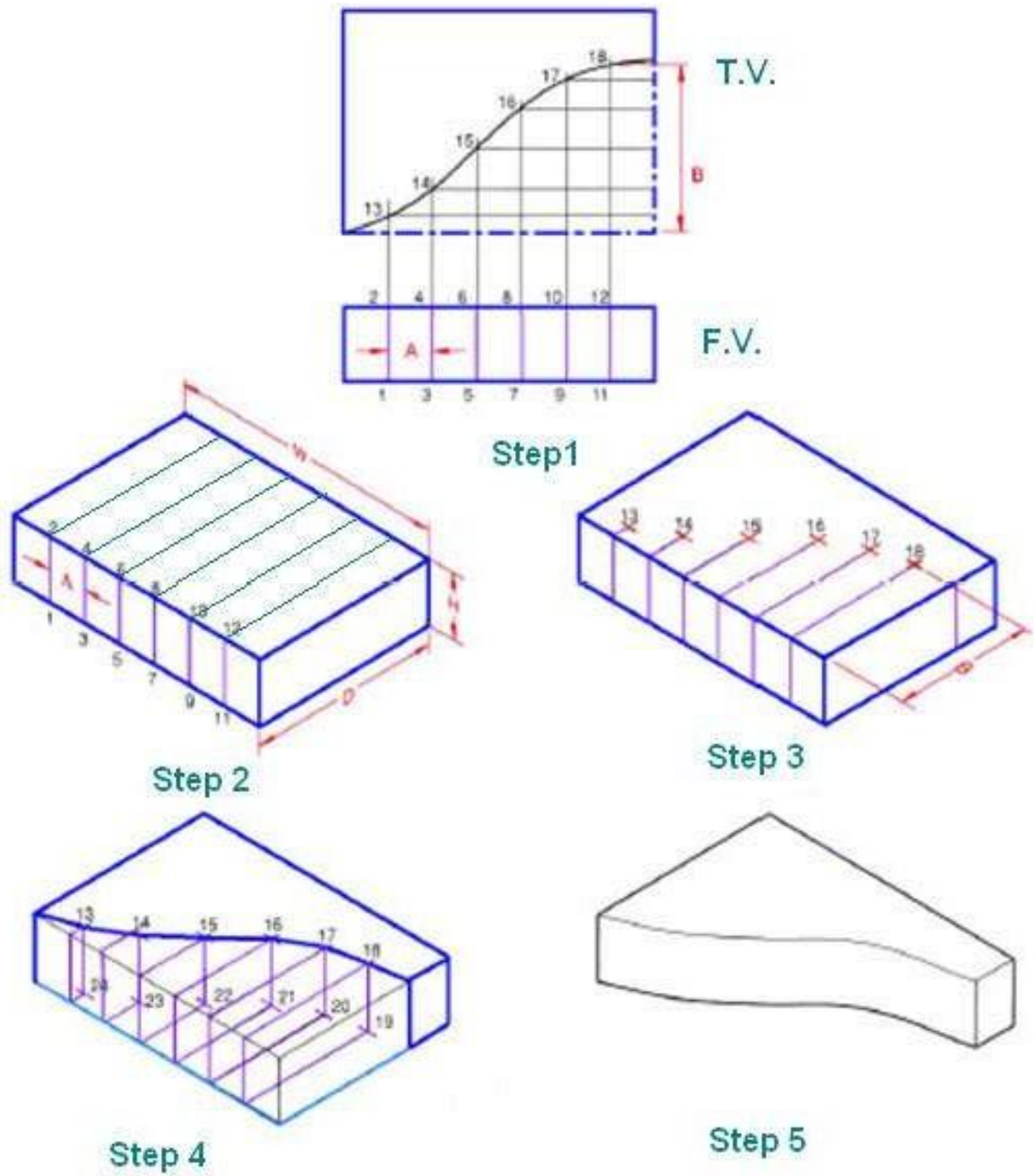
***Step* 3**. From points **2, 4, 6, 8, 10**, and **12**, draw isometric lines on the top face parallel to the **D** line.

Then, measure the horizontal spacing between each of the grid lines in the top multi-view as shown for dimension **B**, and transfer those distances along isometric lines. parallel to the **W** line. The intersections of the lines will locate points **13-18**.



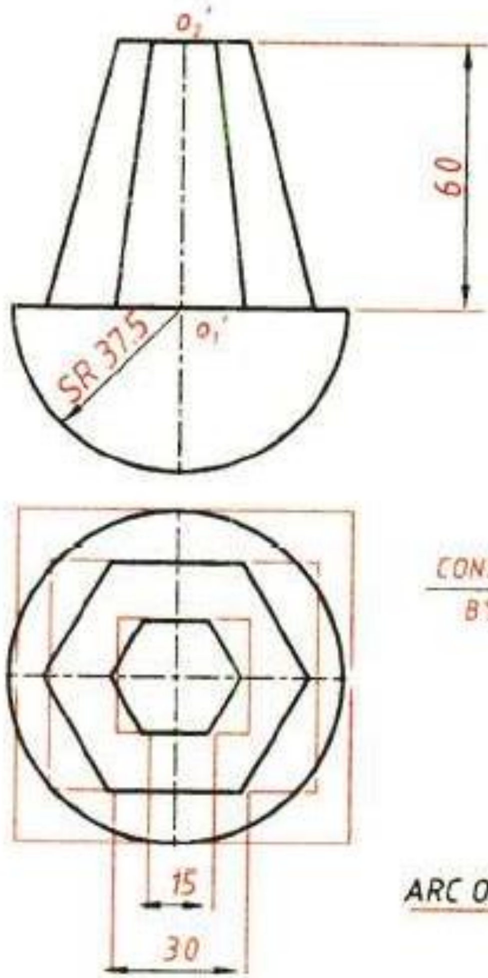
***Step* 4**. Draw the curve through points **13-18**, using an irregular curve. From points **13-18**, drop vertical isometric lines equal to dimension **H**. From points **1, 3, 5, 7, 9,** and **11**, construct isometric lines across the bottom face to intersect with the vertical lines dropped from the top face to locate points **19-24**. Connect points **19-24** with an irregular curve.

***Step* 5.** Erase or lighten all construction lines to complete the view

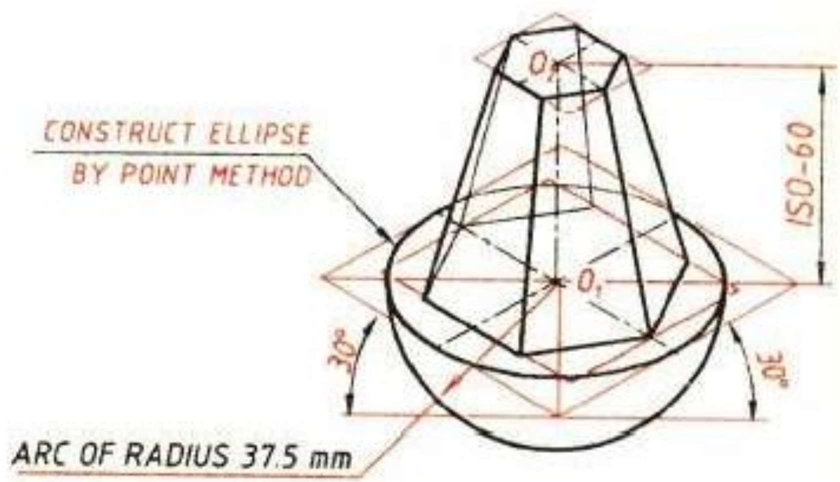


Combinations of solids

Isometric projection of sphere & hexagonal pyramid



A
Orthographic Views



B
Isometric Projection

Taken for K.R. Gopalakrishna, Engineering Graphics, Subash stores

THANK YOU