

MS 101

Makerspace

Introduction to

Engineering Drawing

Text Book 1: Dennis K. Lieu and Sheryl Sorby, Visualization, Modeling, and Graphics for Engineering Design

Text Book 2: N. D. Bhatt and V. M. Panchal, Engineering Drawing, Charotar Publishers

Reference Books :

Warren J. Luzadder and Jon M. Duff, Fundamentals of Engineering Drawing, Prentice-Hall of India

Thomas E. French, Charles J. Vierck and Robert Foster, Engineering Drawing and Graphic Technology, McGraw Hill

Dhananjay A. Jolhe, Engineering Drawing, Tata McGraw Hill Publishing Co. Ltd.

M. B. Shah and B. C. Rana, Engineering Drawing, Dorling Kindersley (India) Pvt. Ltd., Pearson Education

Slides Credits: Many slides are taken from Prof. Anirban Guha, ME, IITB

Grading

- **Lab evaluations: 20%**
- **Quizzes (On Moodle): 20%**
- **Mid Sem: 20%**
- **Final Project: 40%**

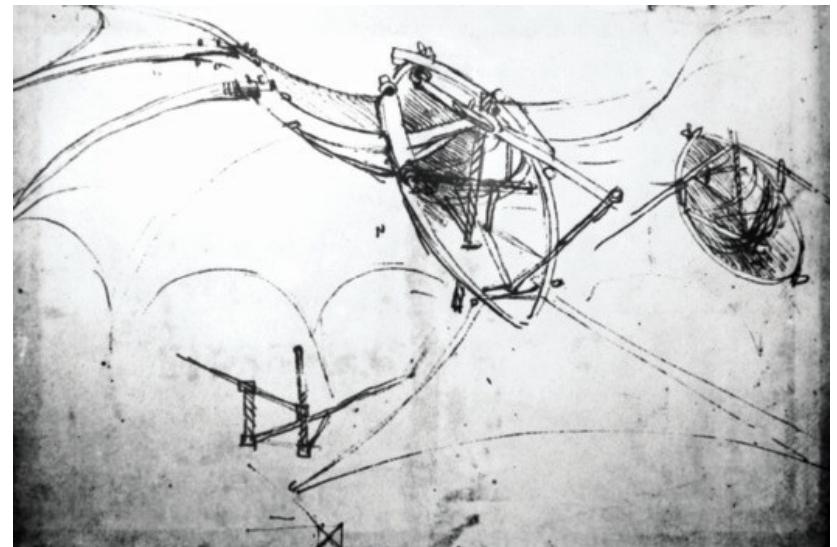
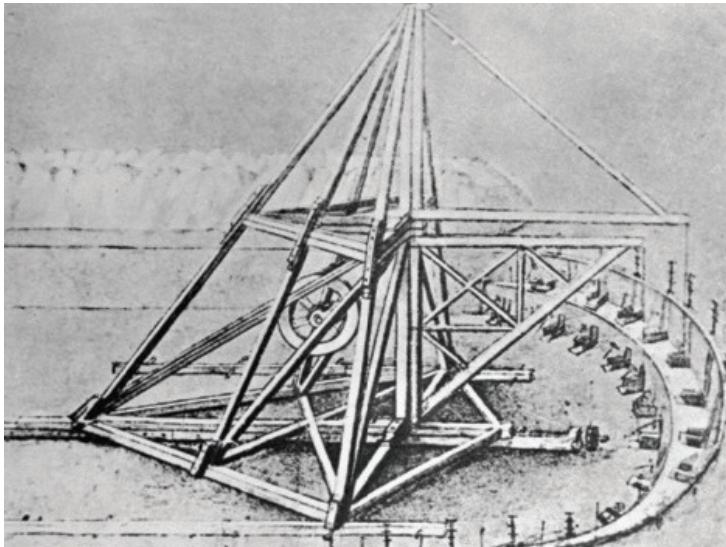
- **Labor of yours and others are equally important**
- **How to convey your work and ideas to others ?**
- **With clarity and minimum loss of information**
- **2D pictures have been great tools**

Engineering Graphics Three Roles

- **Communication:** without using words
- **Record keeping:** development over time
- **Analysis:** determine critical sizes/shapes

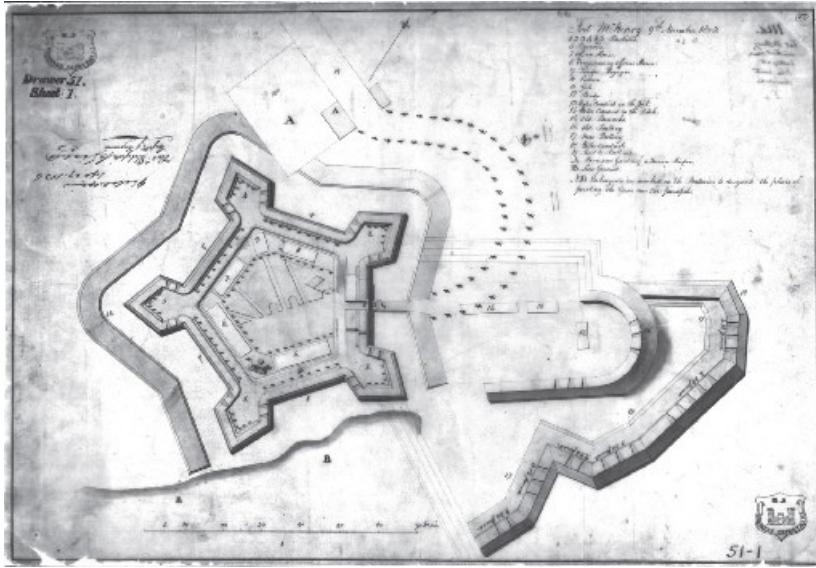
**Graphics: The art and science of drawing a
3D object on 2D surface according to
Projection rules**

Before Industrial Revolution



Images of original da Vinci (1452-1519) drawings: a machine used for canal excavation (left) and a flying ship (right).

Before Industrial Revolution



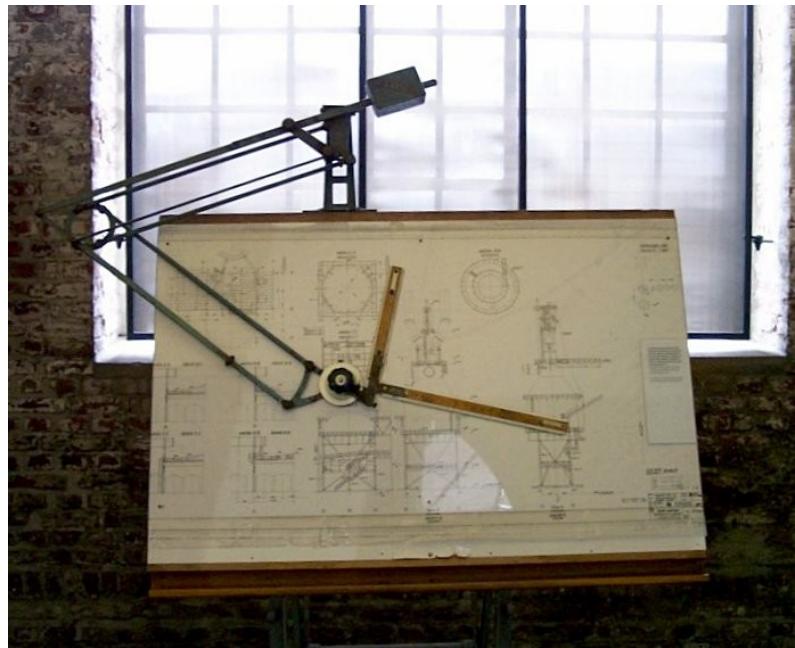
French fortification design principles (left) based on descriptive geometry (measuring length of lines, shapes of planes, area etc using mechanical instruments such as compass, rulers, protractors) and Fort McHenry (right) built in 1806 in Baltimore, Maryland, whose design was based on those principles.

After Industrial Revolution

- The era of mass production started in 1800s
- Identical products, short production time, interchangeable parts
- Efficient communication to address the division of labor
- The design needed to be transferred without misinterpretation
- Birth of modern engineering drawing

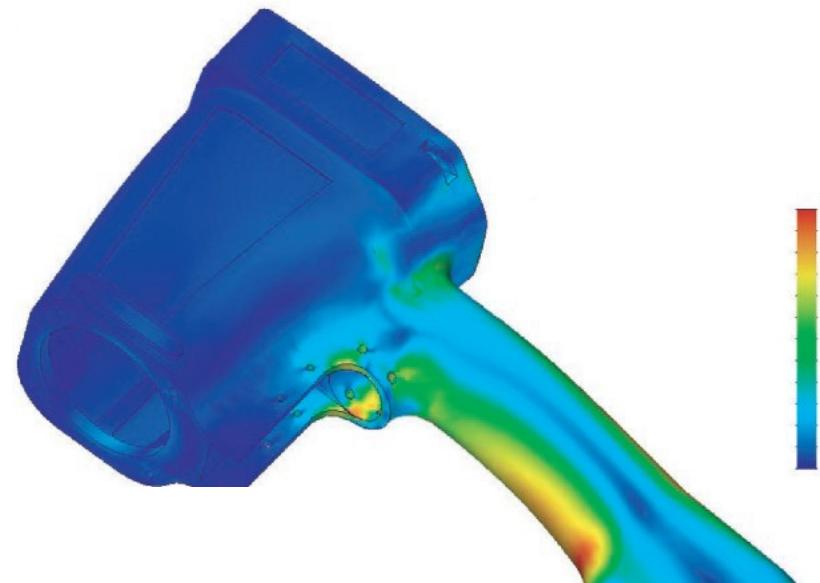
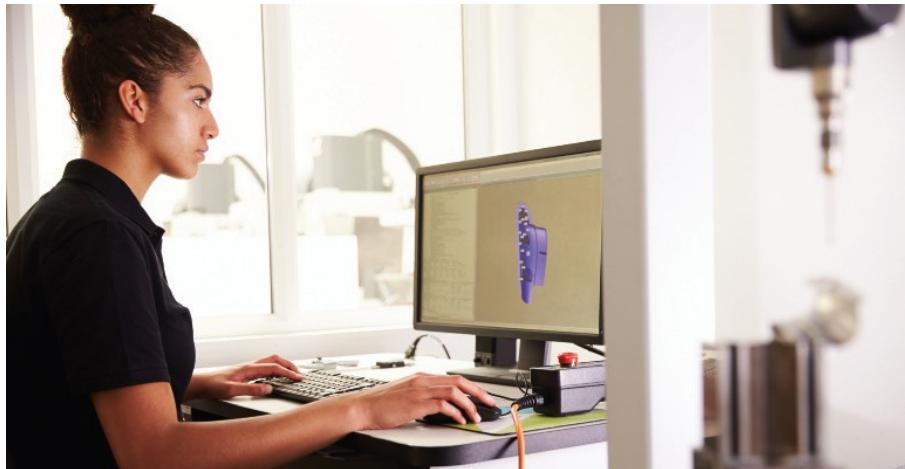
Engineering Graphics Technology

- **Instrument drawing:** Drafting board, T-square, Set-square, Scale, Compass, Protractor, French Curves, Drawing papers, Pencils, Eraser, Drawing pins, Sand paper, Duster, Drafting machine.



Engineering Graphics Technology

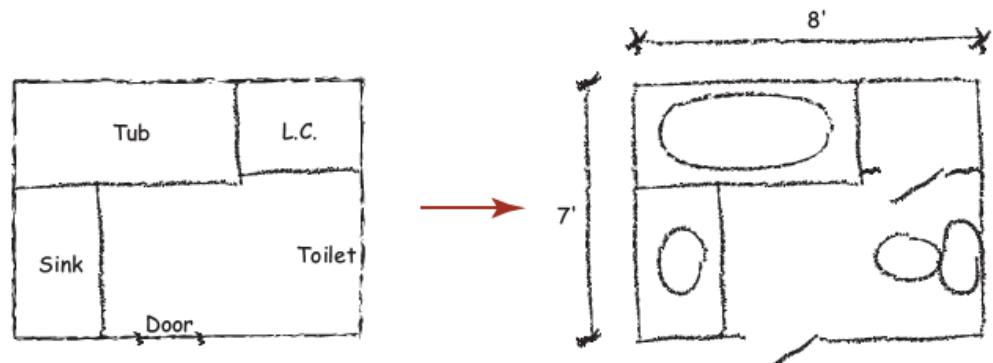
- Computer aided with software



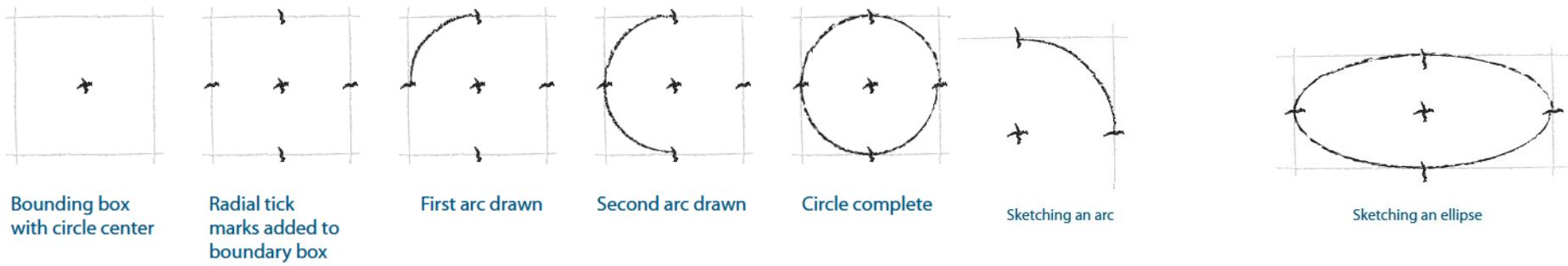
This course will adopt this method: Autodesk Fusion 360

Sketching

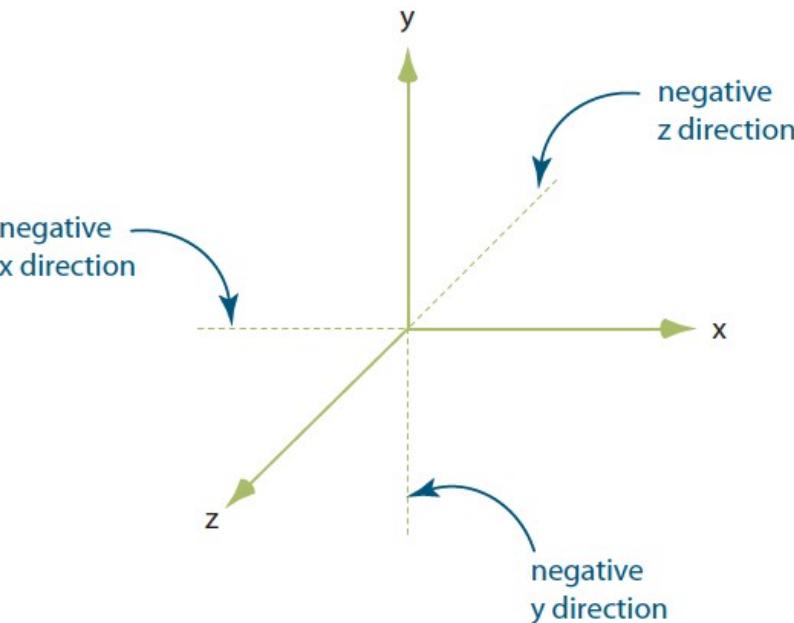
- A drawing without the use of drawing instruments
- A rough idea, e.g. sketch of a bathroom



- Sketching a circle, an arc, an ellipse (first draw light squares or rectangles)

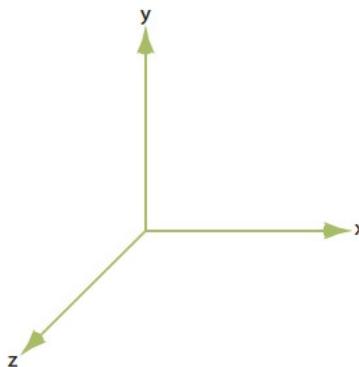


Coordinate system

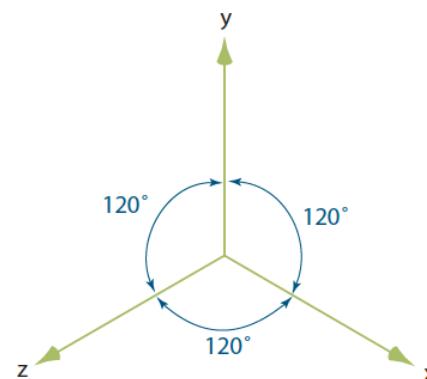


- **Portray 3D system on 2D paper**
- **We need a coordinate system**
- **Axes representation :Oblique/Isometric**

Oblique: Two axes perpendicular, third at an angle of 45 degrees to both axes

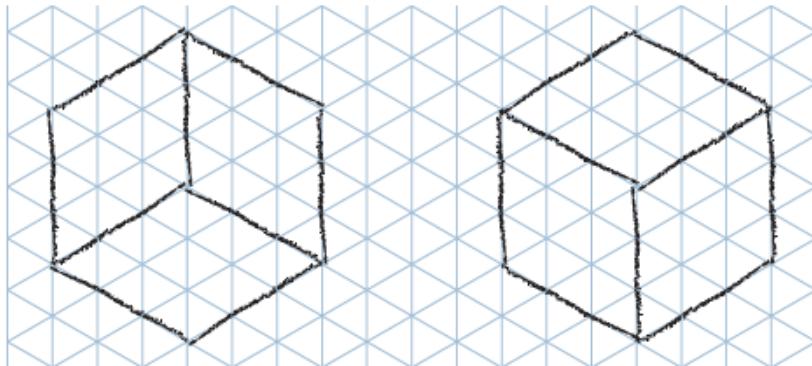
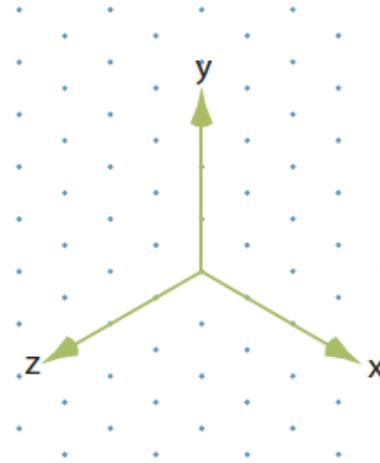
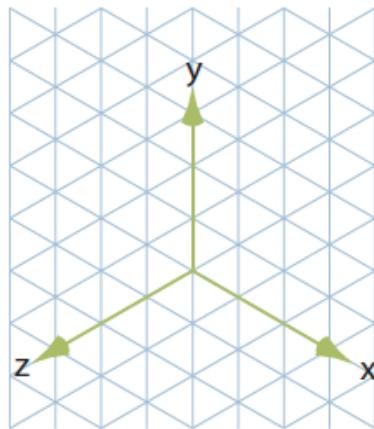


Isometric: Axes projection as if looking down diagonal of the cube. **120 degrees all axes**



Isometric sketches

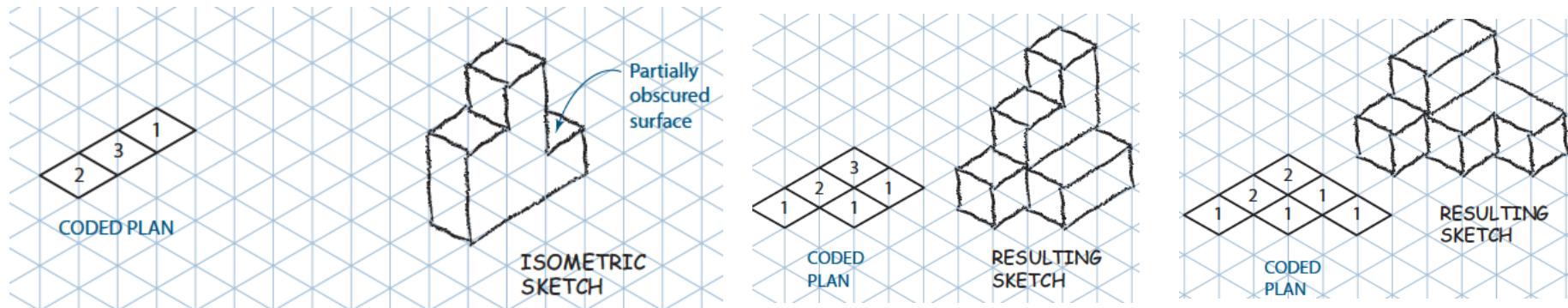
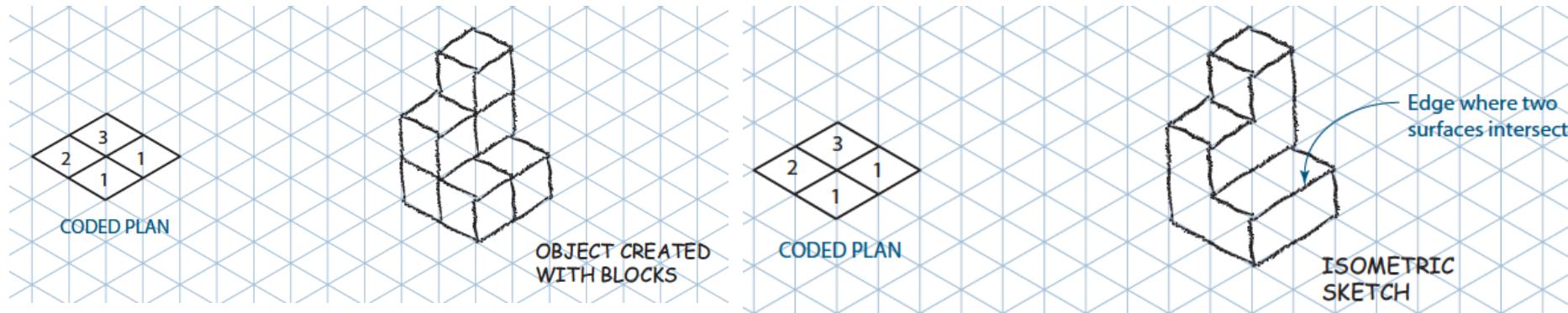
Isometric grid or dot paper: Lines are drawn or dots are oriented in such a manner that standard 120 degree coordinate axes are obtained.



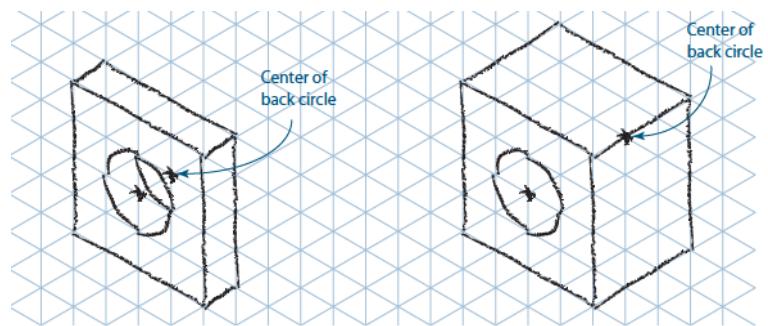
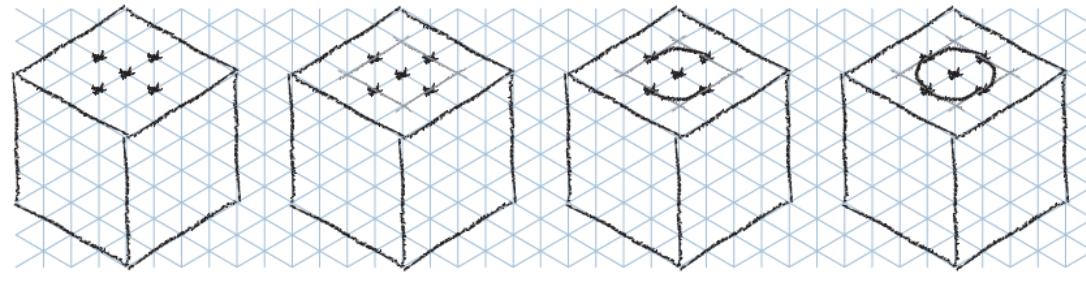
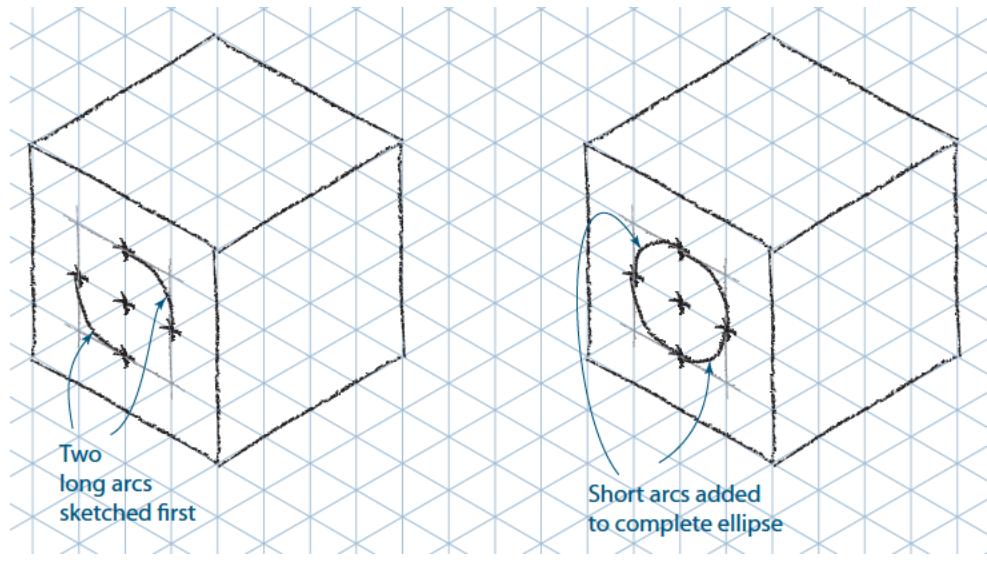
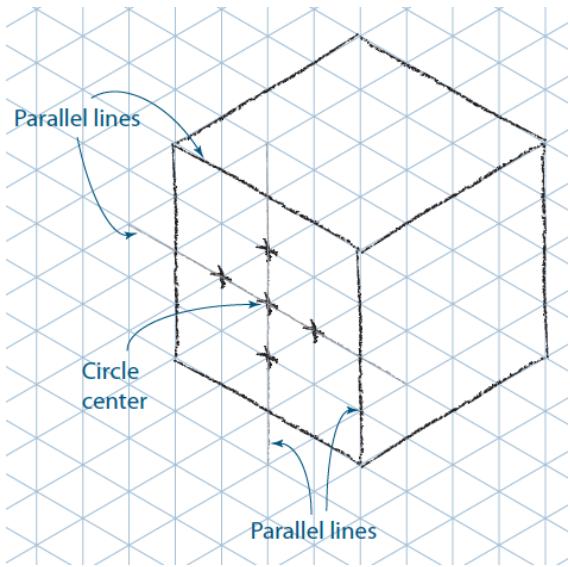
Using isometric grid paper to sketch a block

Isometric sketches

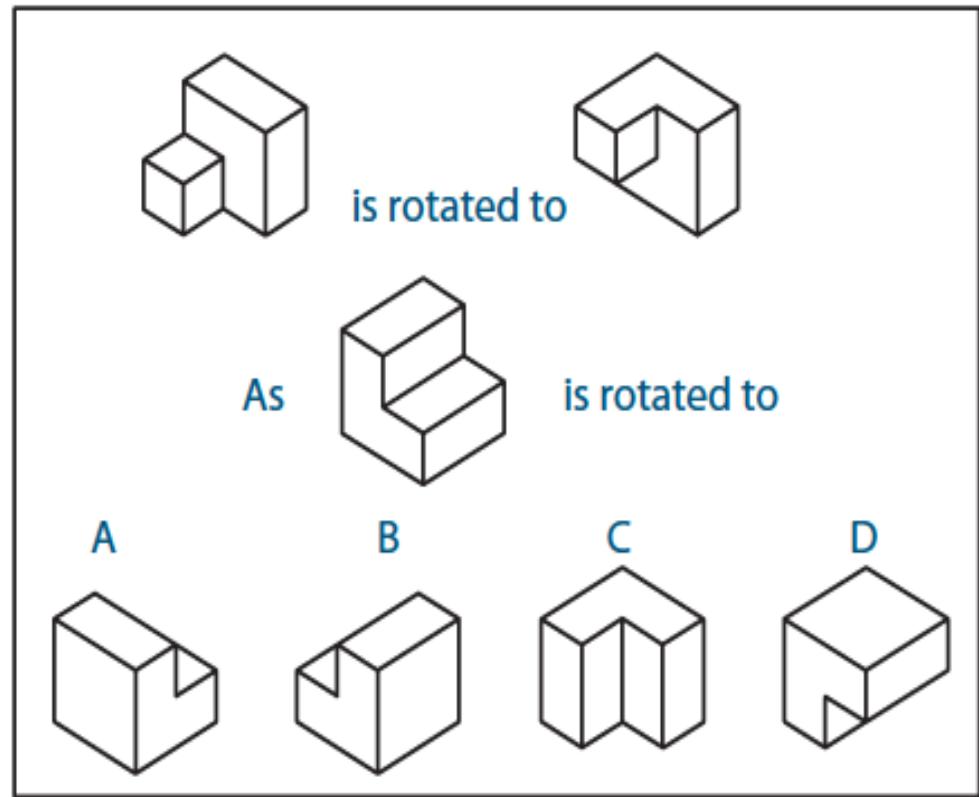
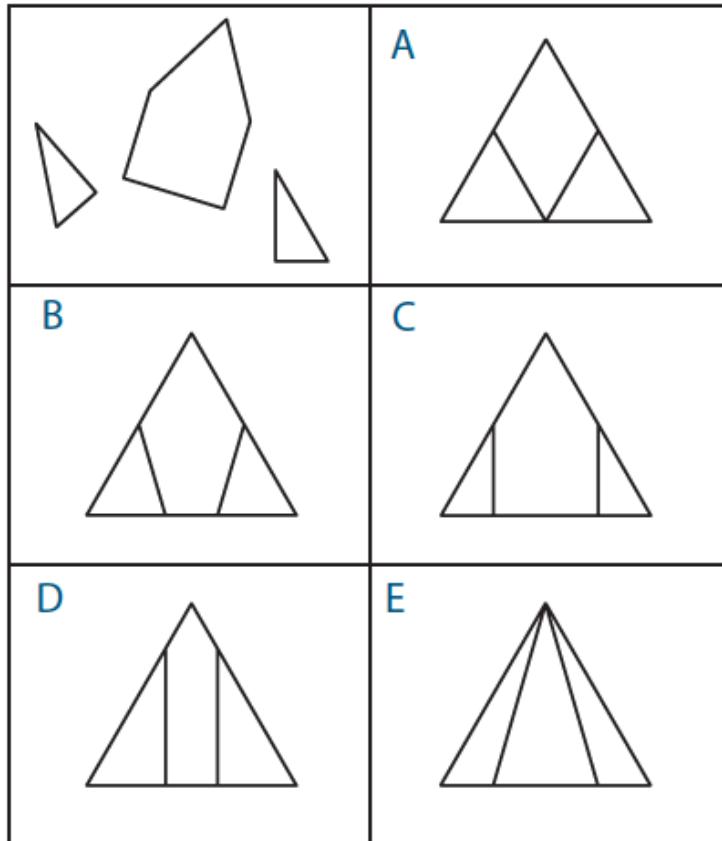
Coded plans: Lines appear only when two surfaces intersect



Circles and holes in isometric sketches



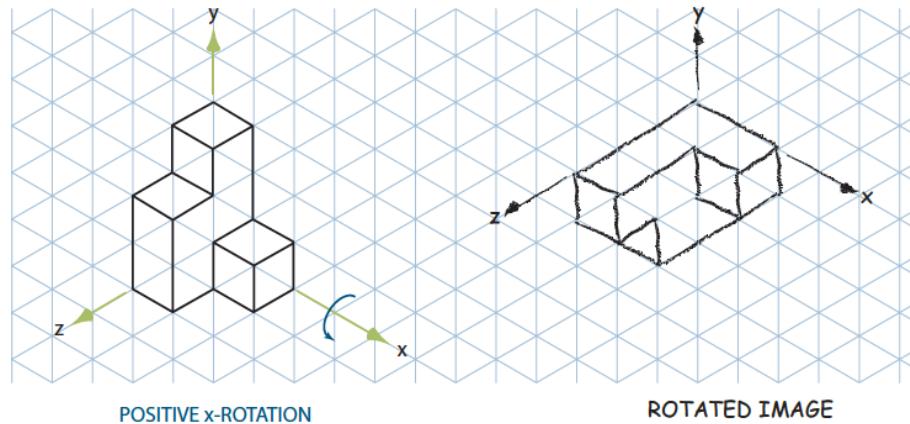
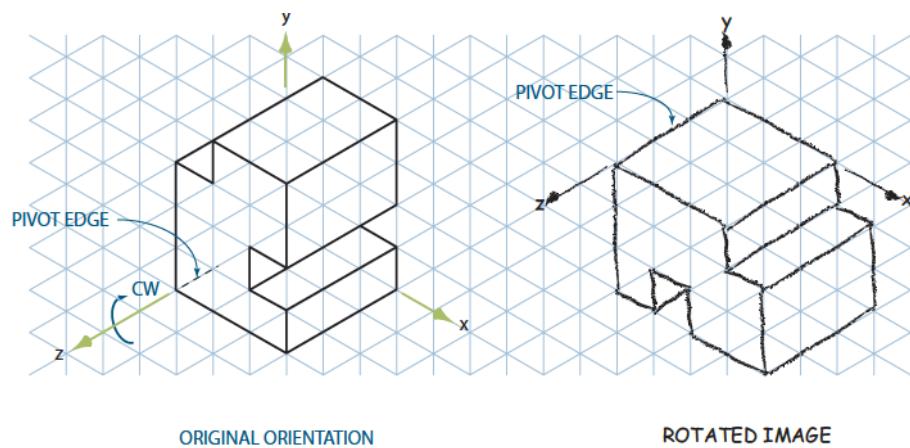
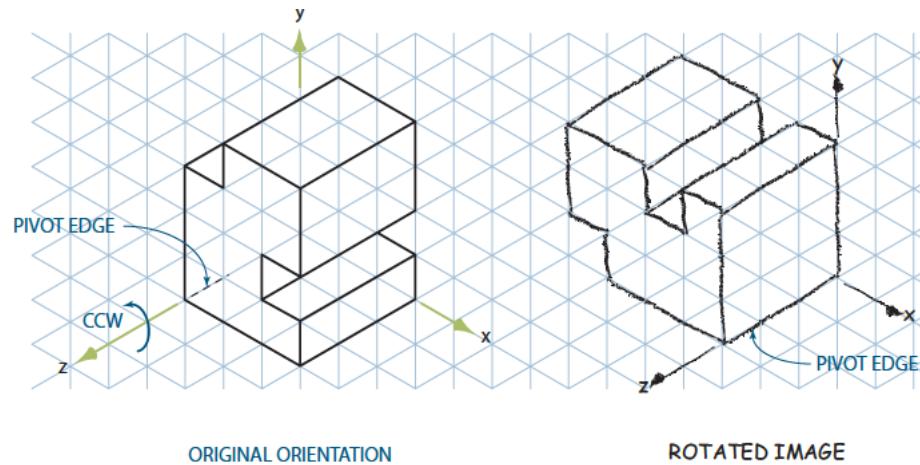
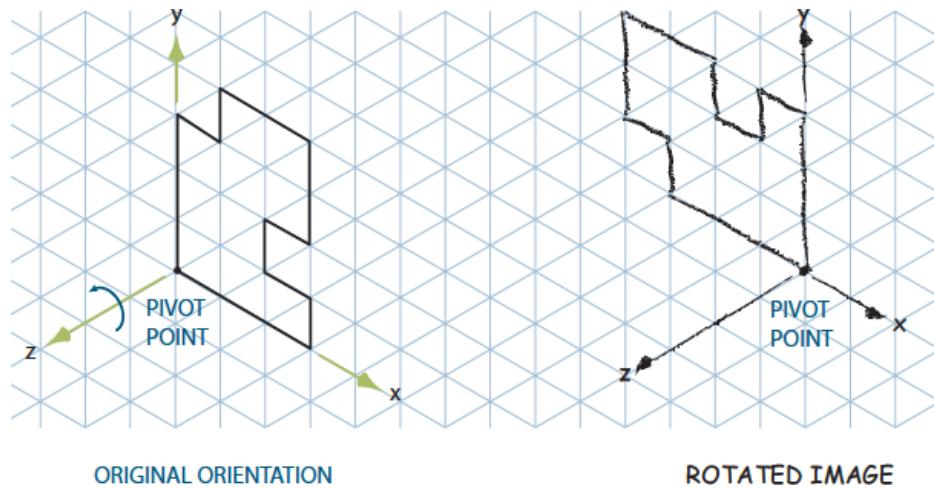
Assessing spatial skills



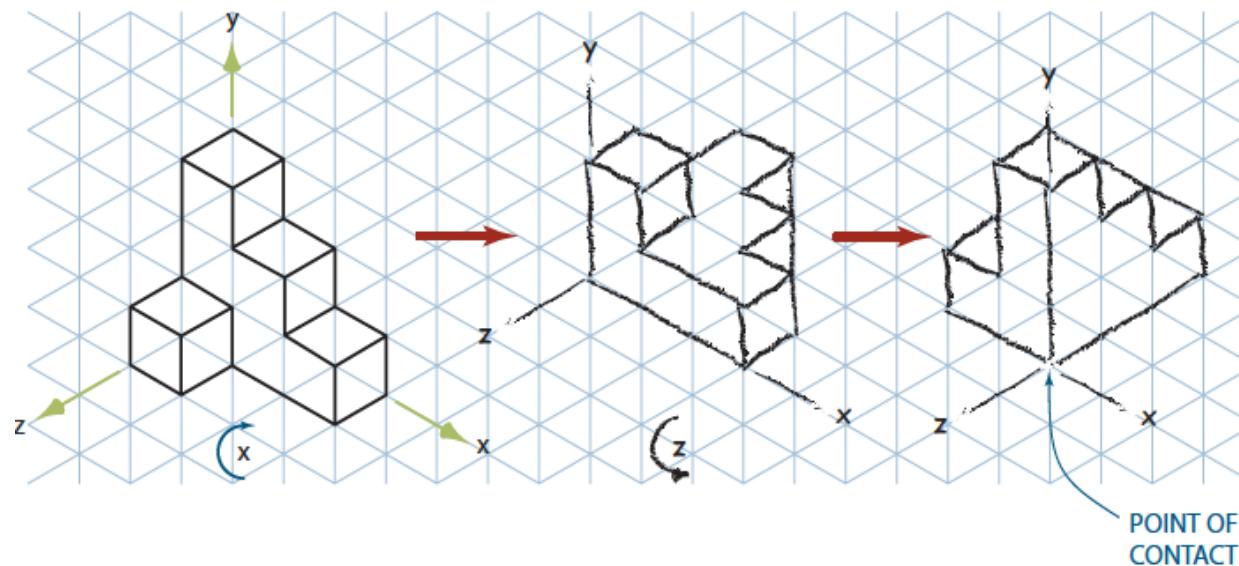
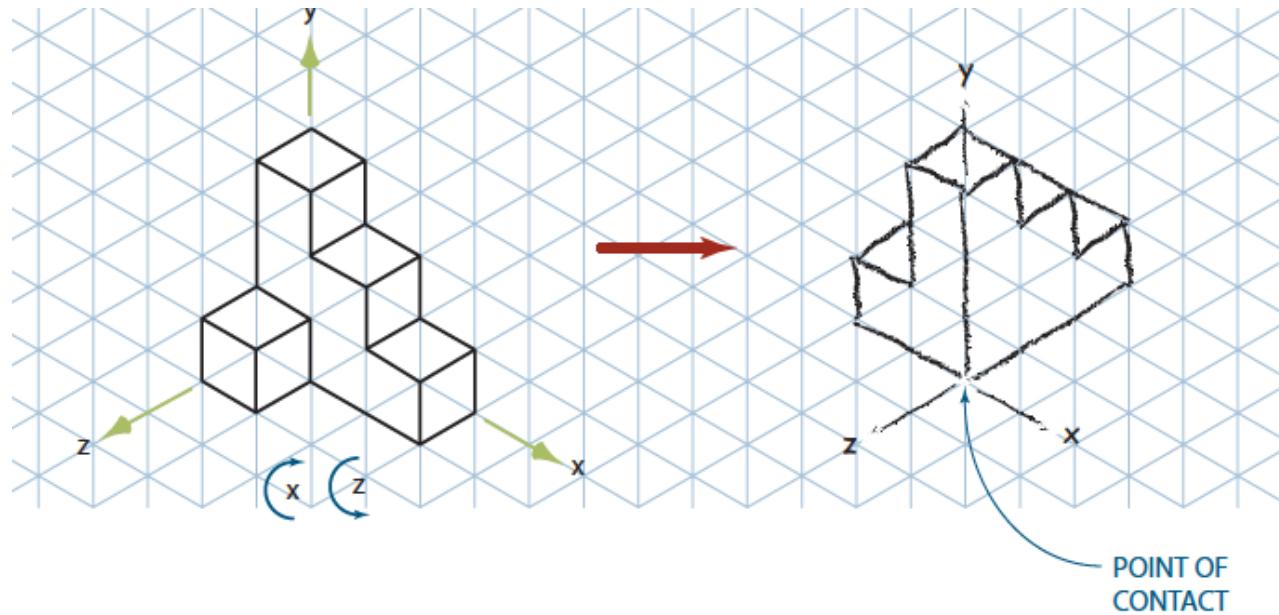
Which one of five is the composite of 2D fragments?

Rotation test

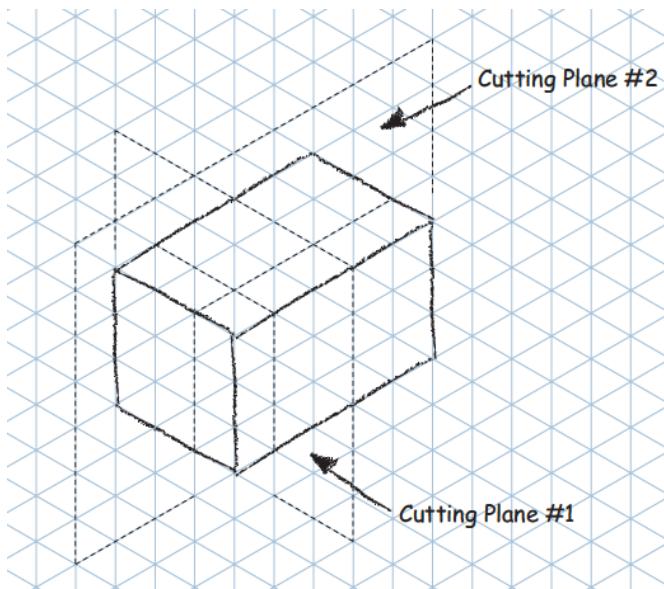
Rotation about a single axis



Rotation about two or more axes



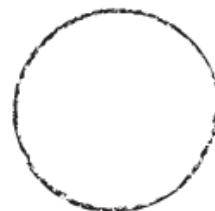
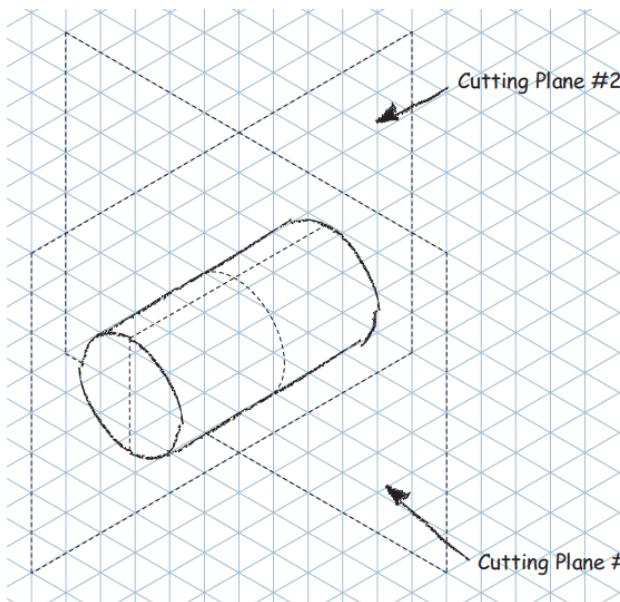
Cross section of solids



Cross Section #1



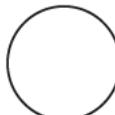
Cross Section #2



Cross Section #1

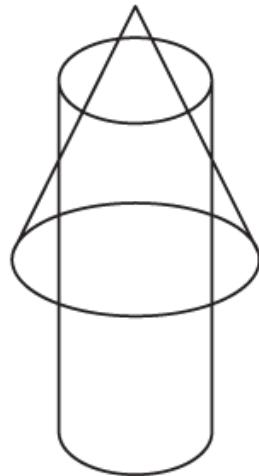


Cross Section #2



Combining solids

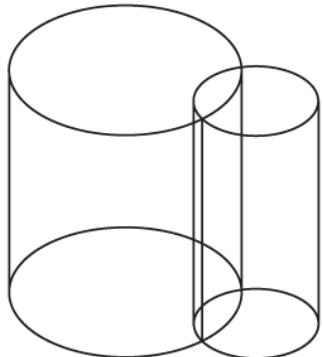
Common overlapping volume



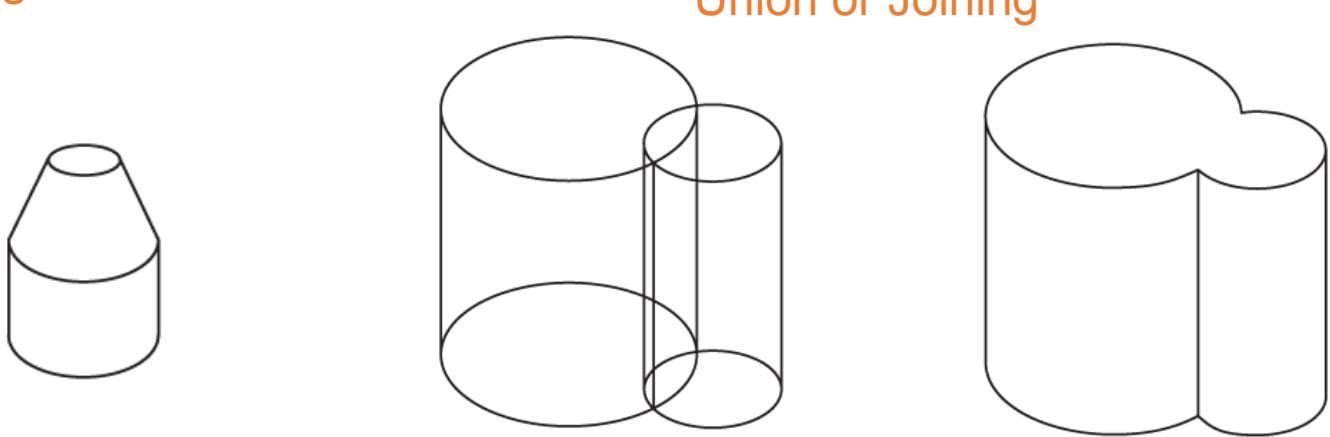
Overlapping Objects

Volume of Interference

Intersection



Overlapping Objects

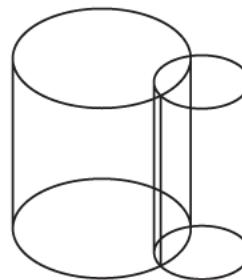


Union or Joining

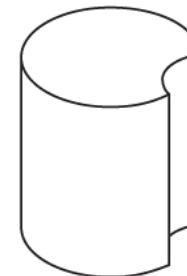
Overlapping Objects

Objects Joined

Cutting



Overlapping Objects



Small Cylinder Cuts Large Cylinder



Large Cylinder Cuts Small Cylinder

Objects Intersected

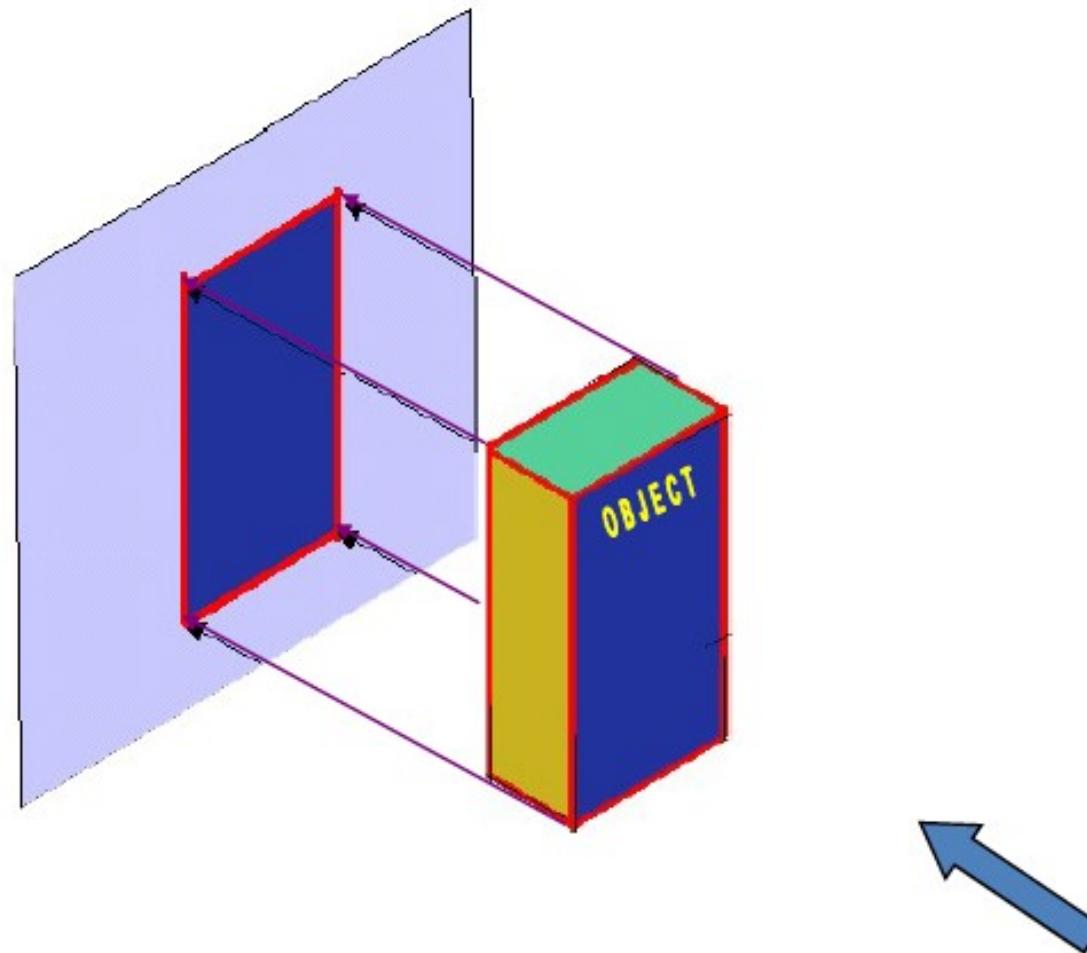
Basis of evaluation of Lab submissions :

Effort + Correctness + Neatness

Basis of evaluation of tests :

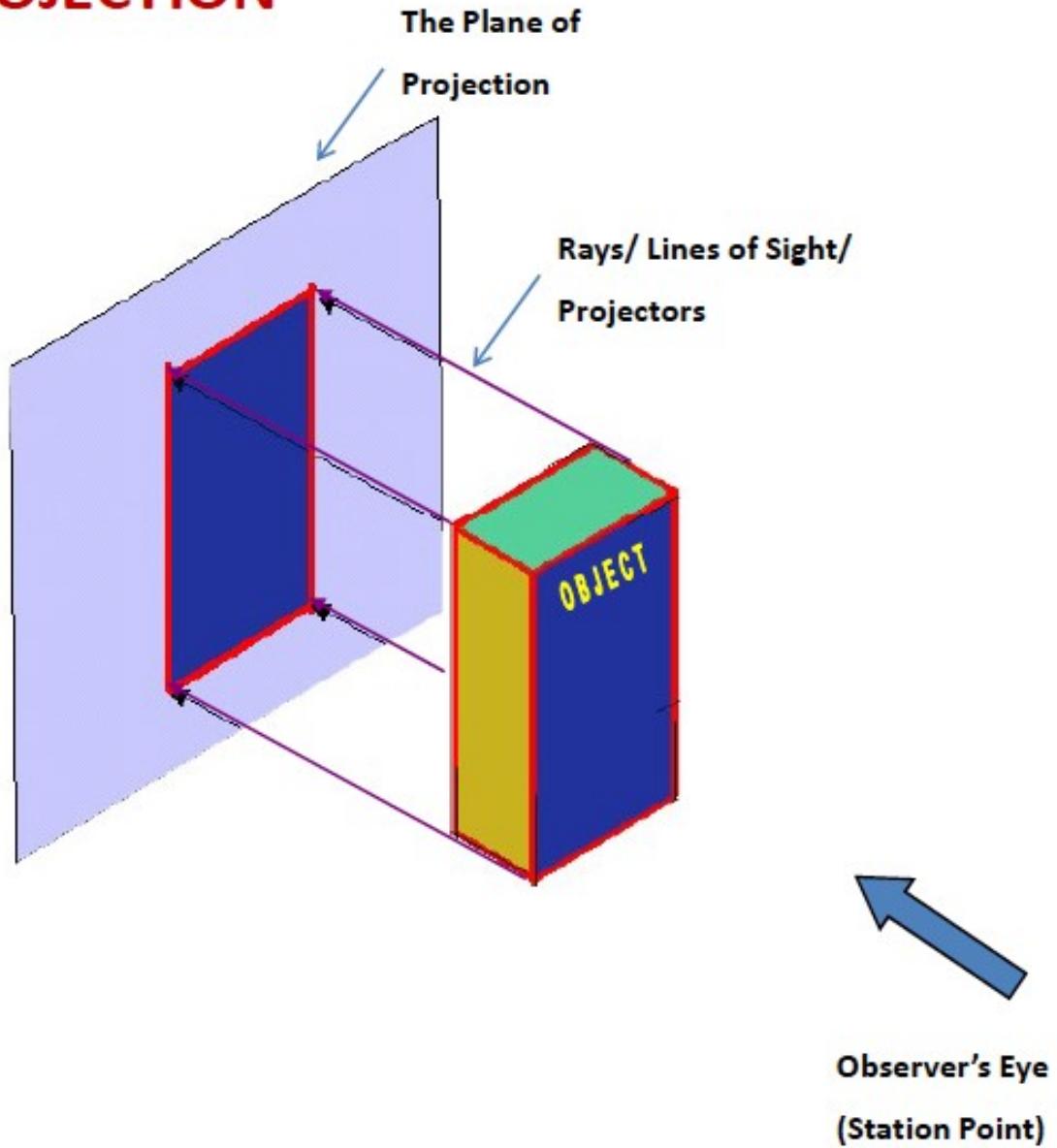
Exams → Correctness → neatness.

PROJECTION

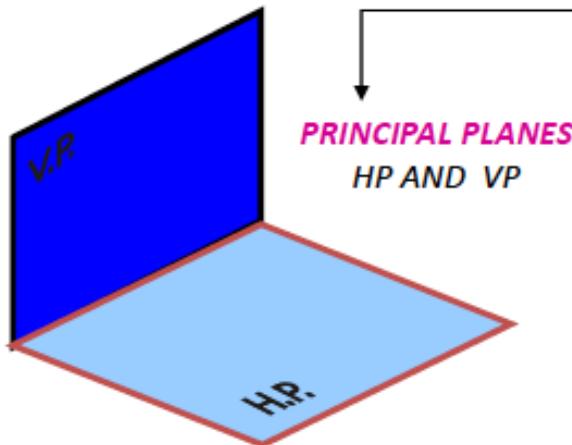


COMPONENTS OF PROJECTION

- Object to be Projected
- Observer's Eye (Station Point)
- The Plane of Projection
- Rays/ Lines of Sight/ Projectors

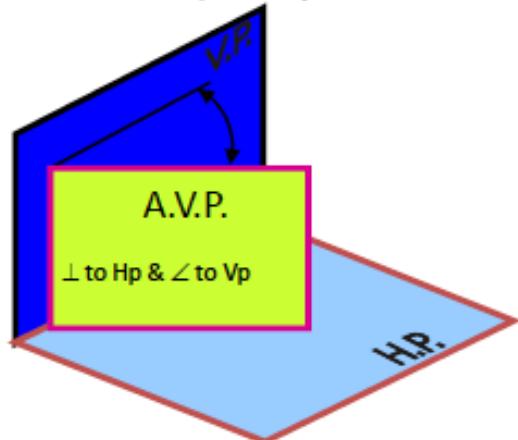


PLANES

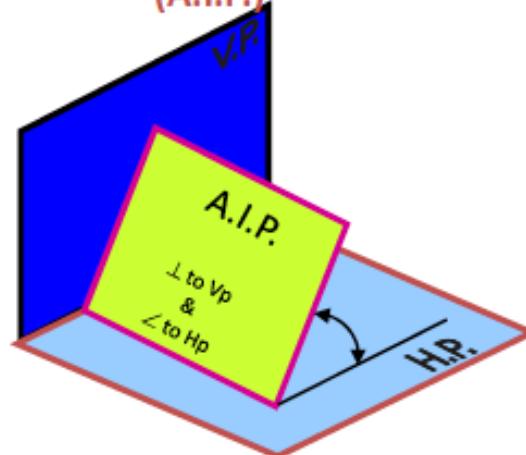


AUXILIARY PLANES

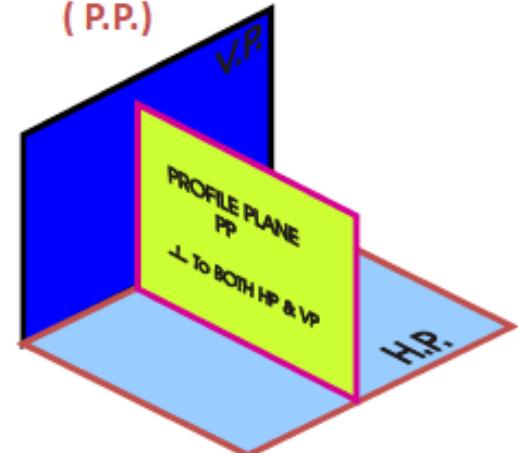
Auxiliary Vertical Plane
(A.V.P.)



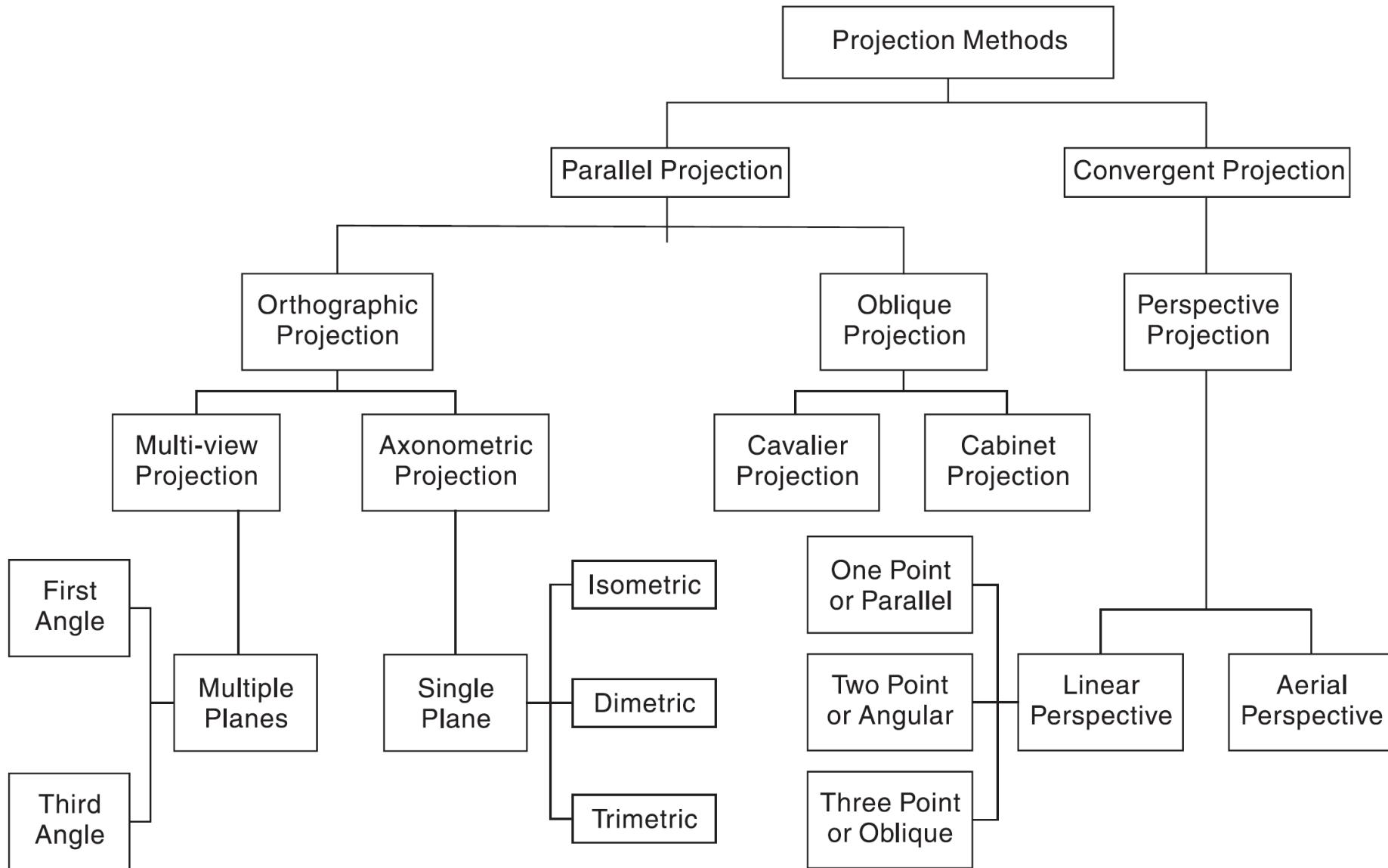
Auxiliary Inclined Plane
(A.I.P.)

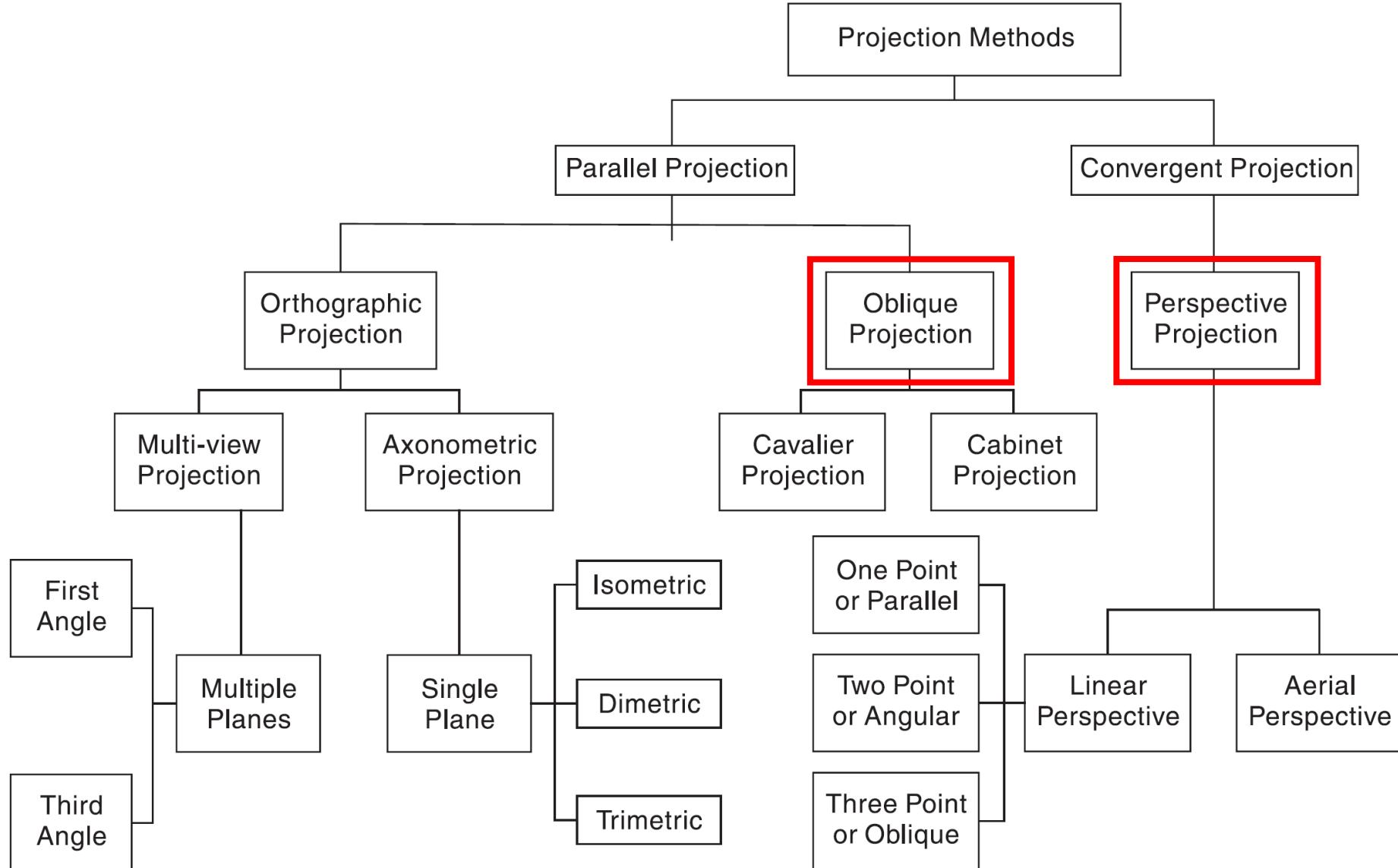


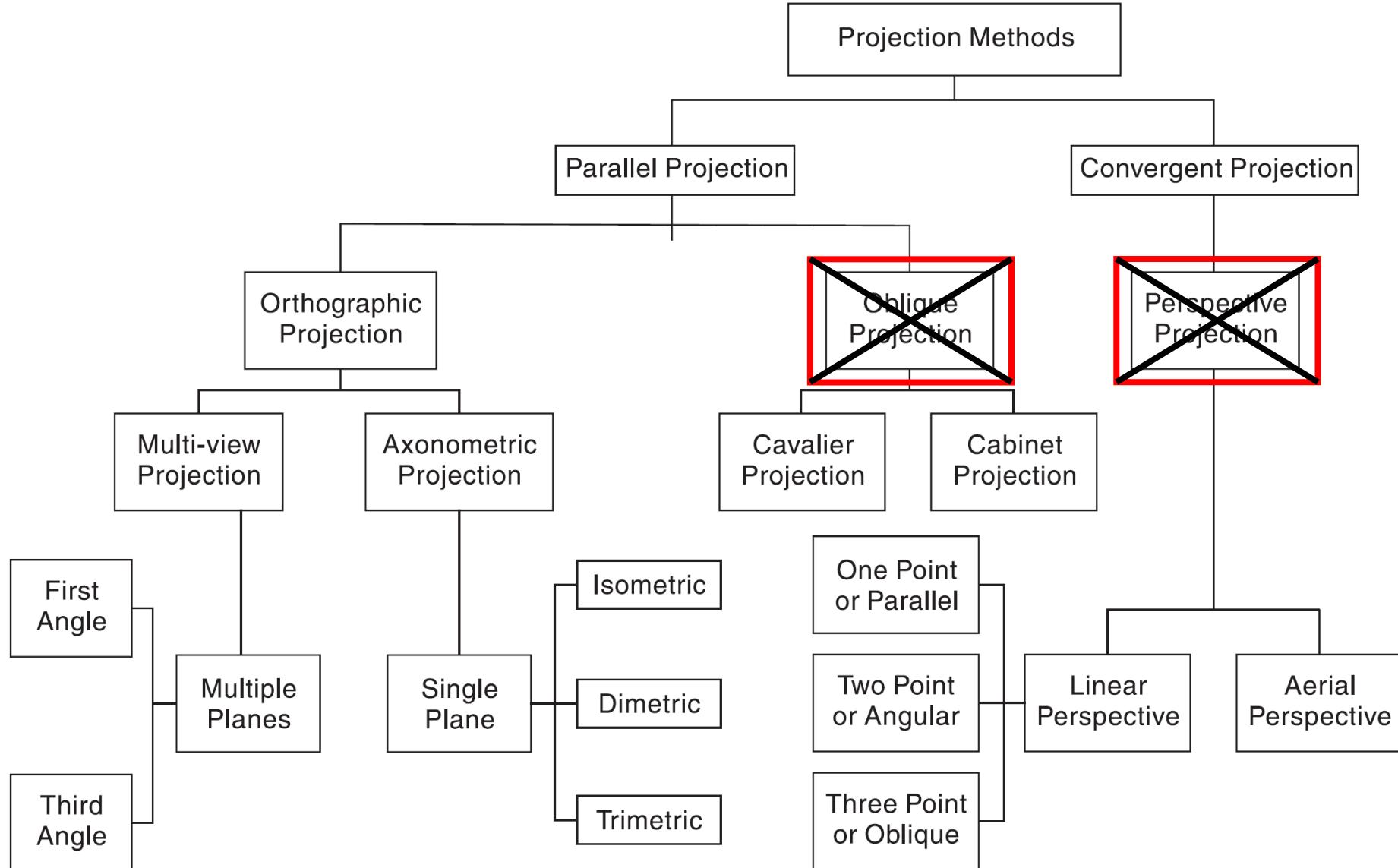
Profile Plane
(P.P.)

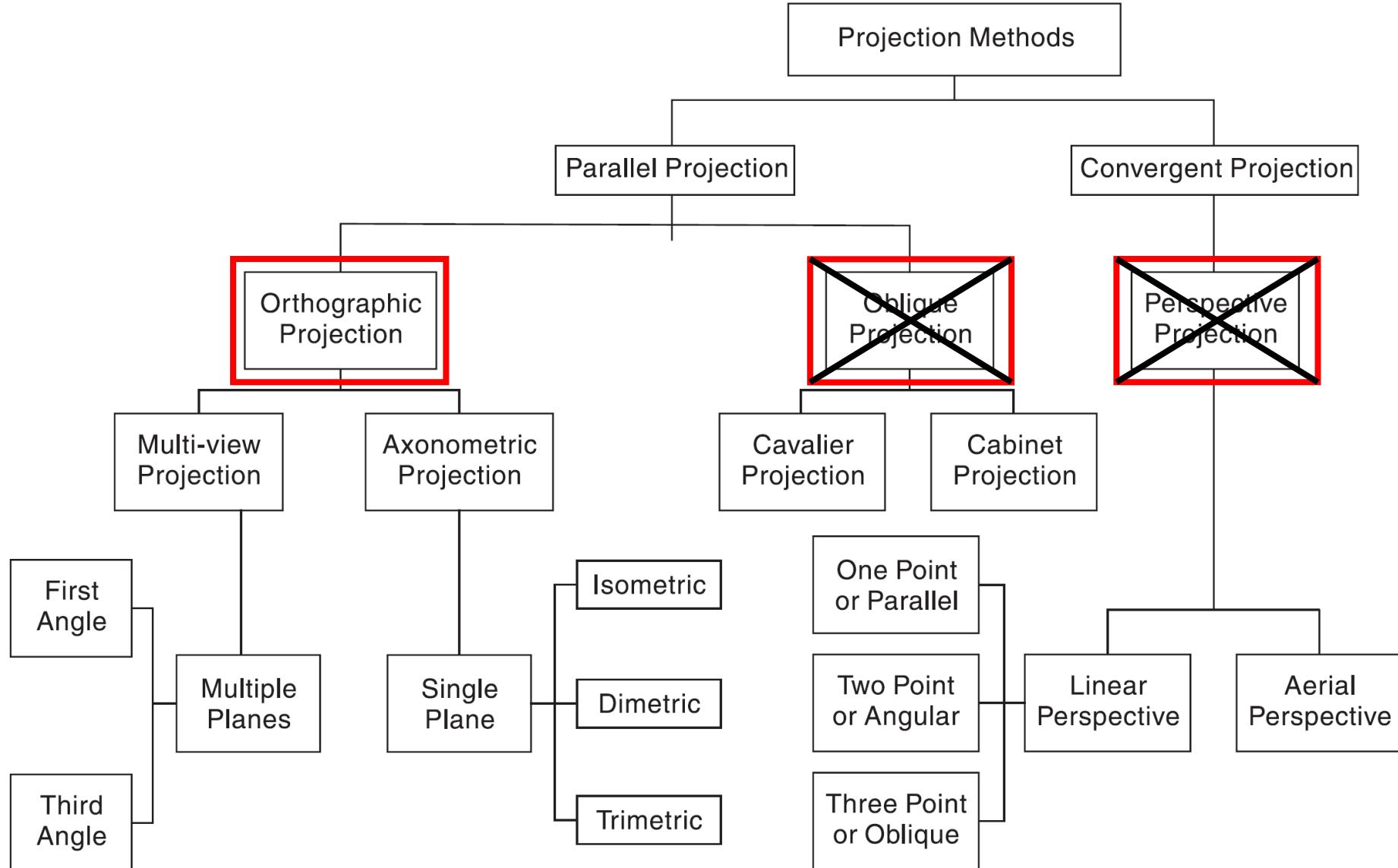


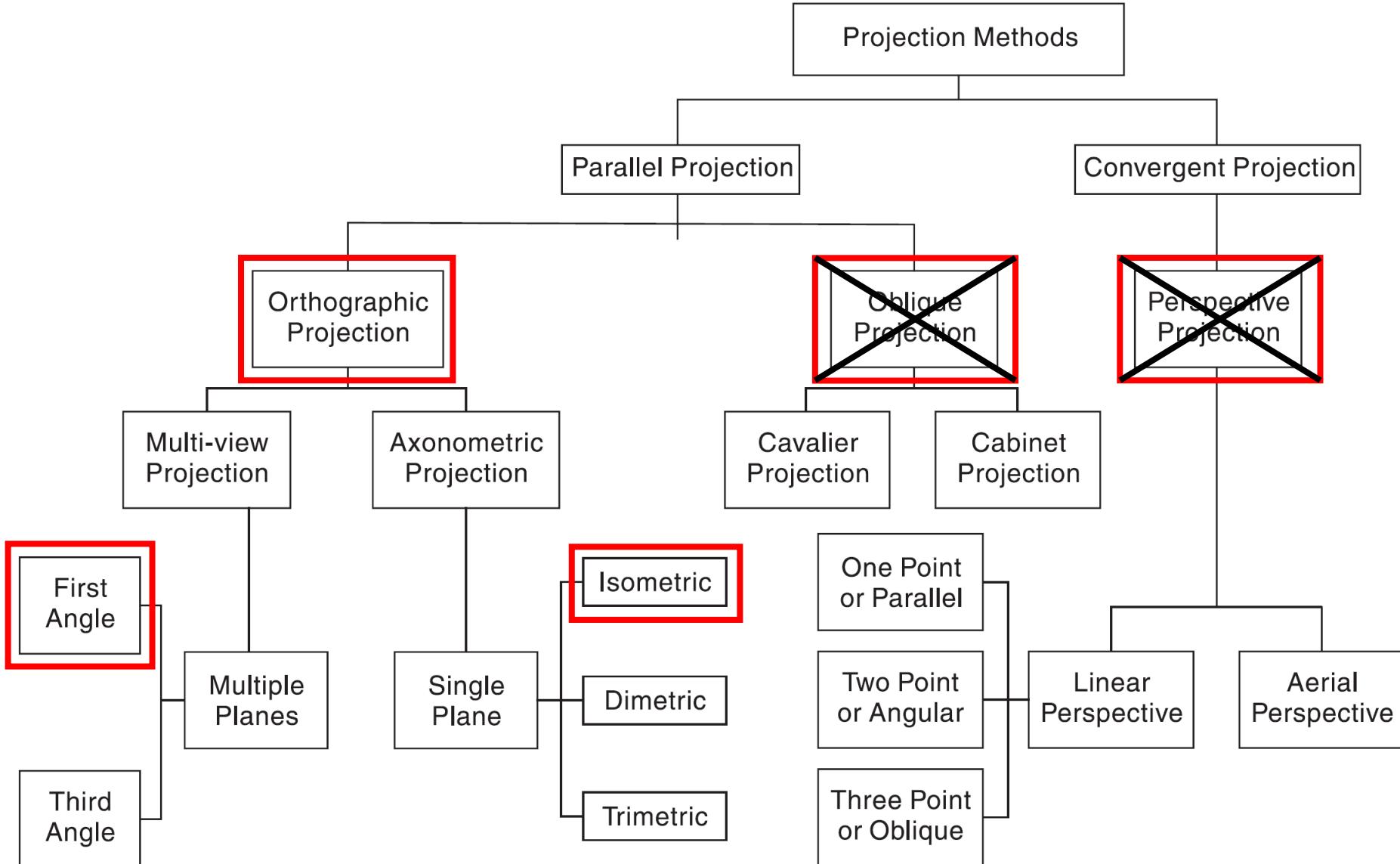
Methods of Projection

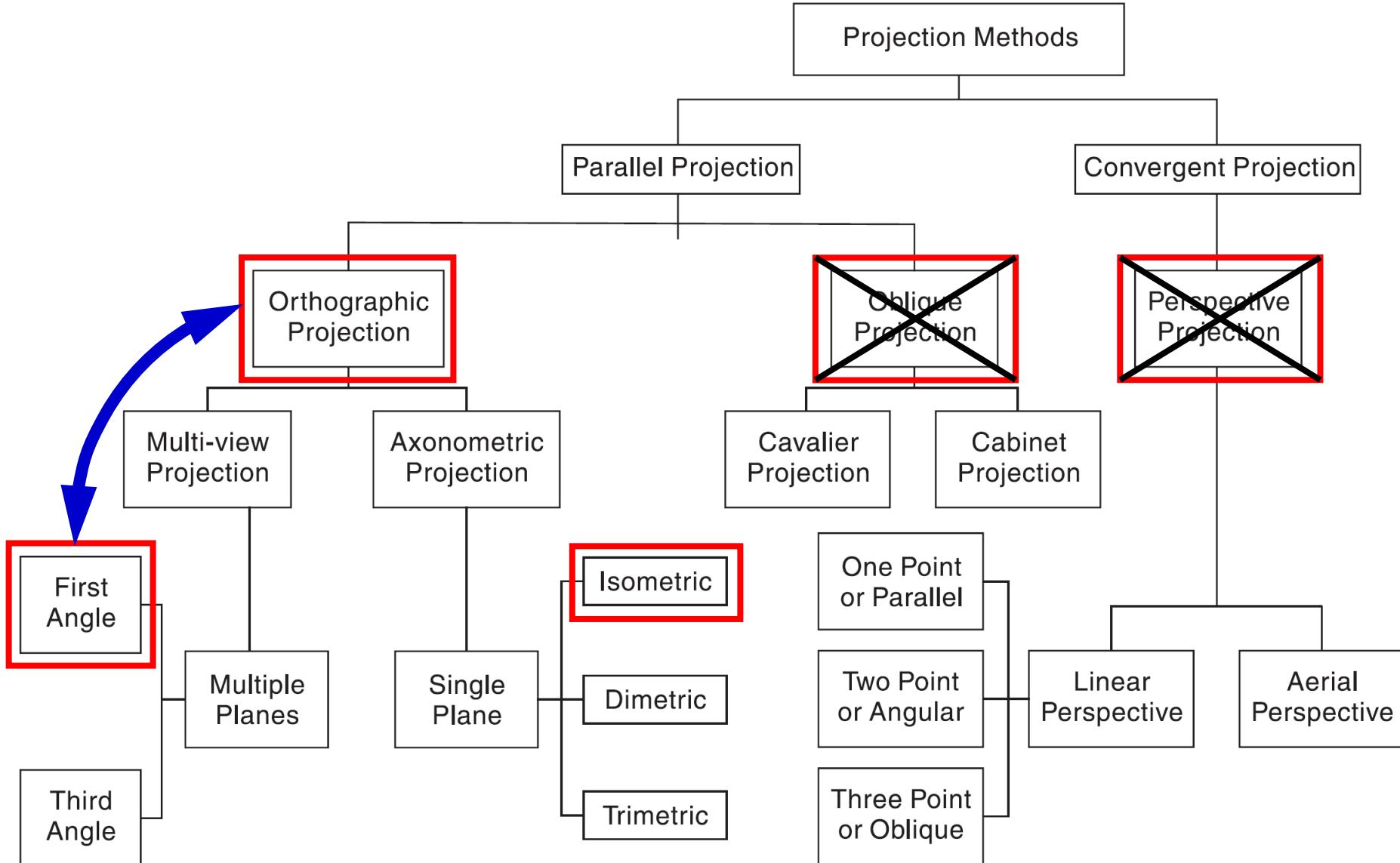




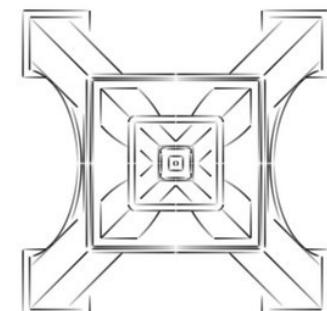
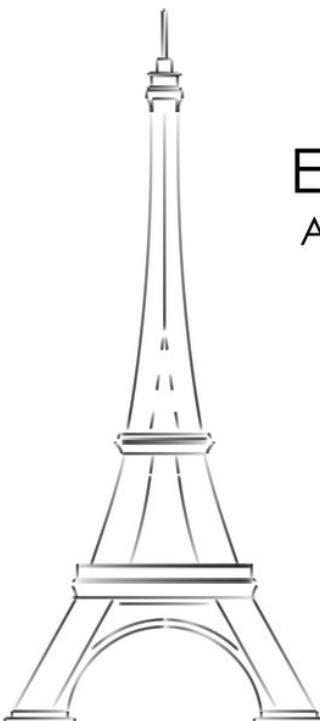
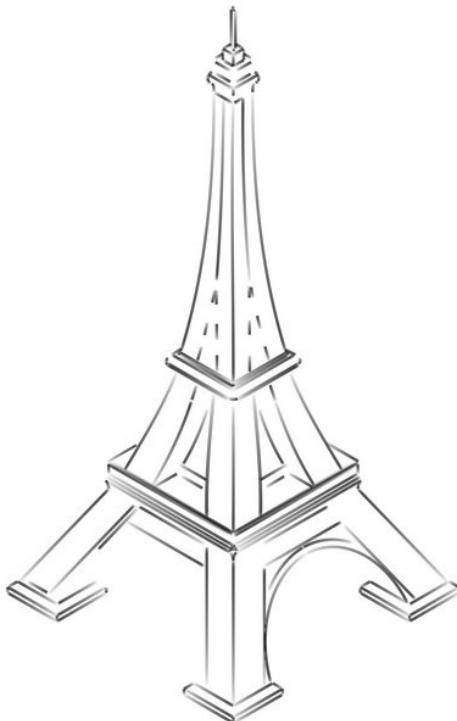








Orthographic Projection

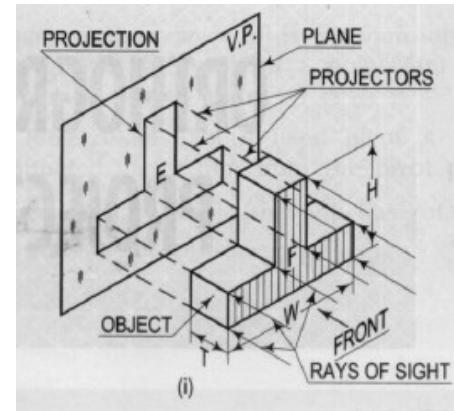
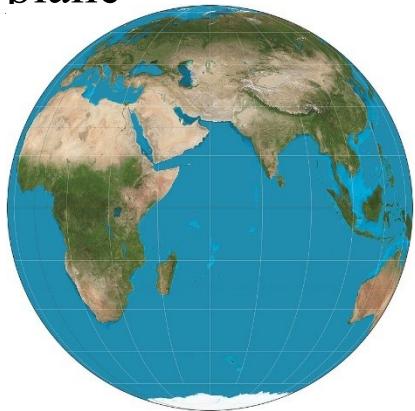


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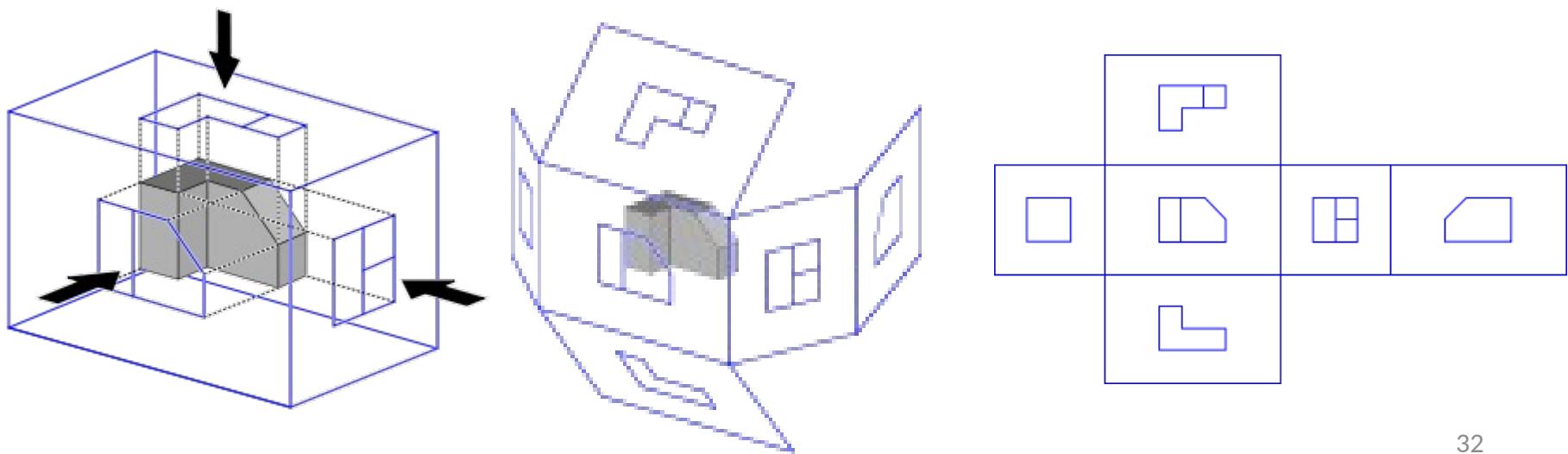
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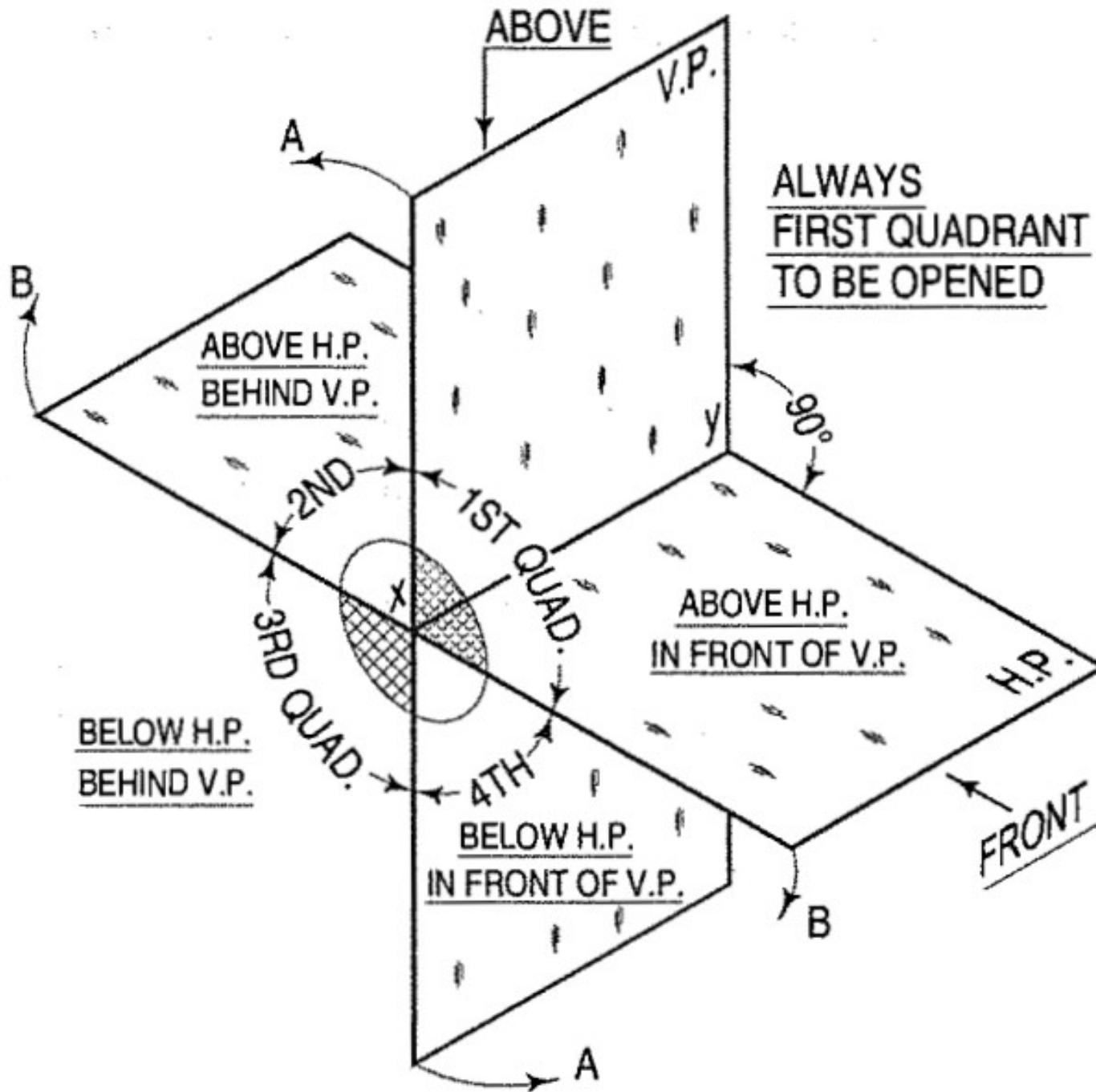
Multiview Orthographic Projections

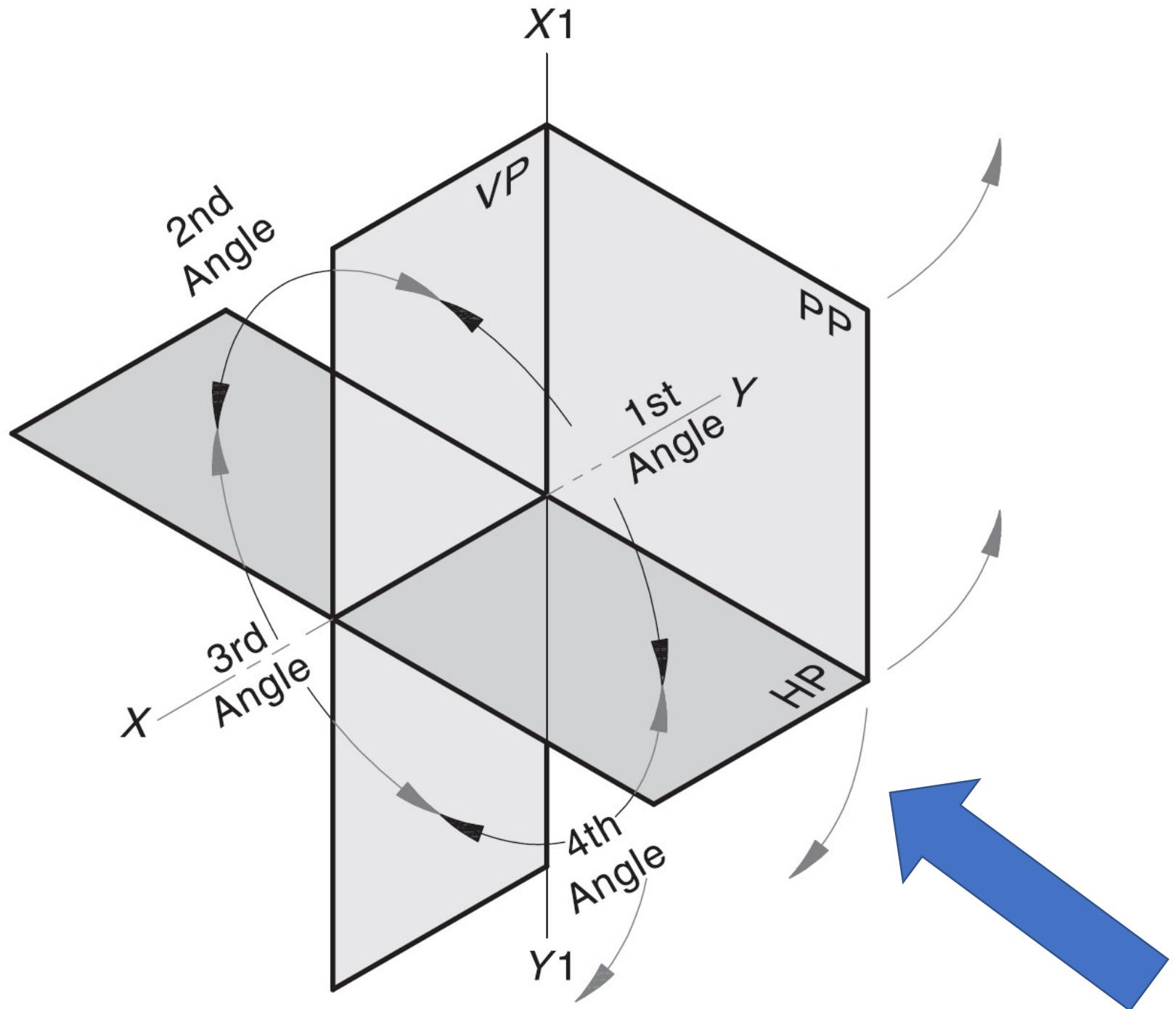
- **Orthographic Projection:** The projectors are perpendicular to the projection plane



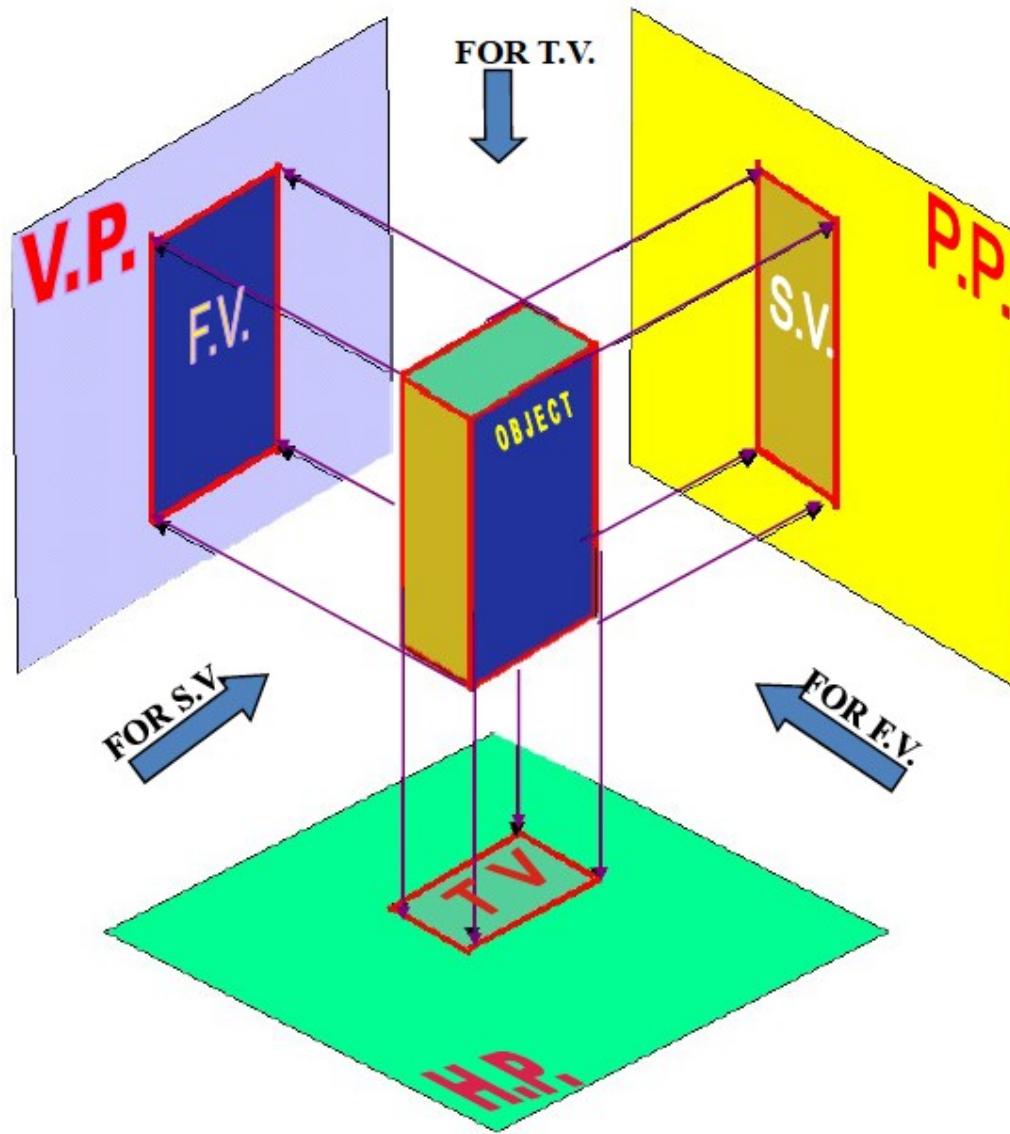
- **Multiview Projection:** More than one view of the object are shown



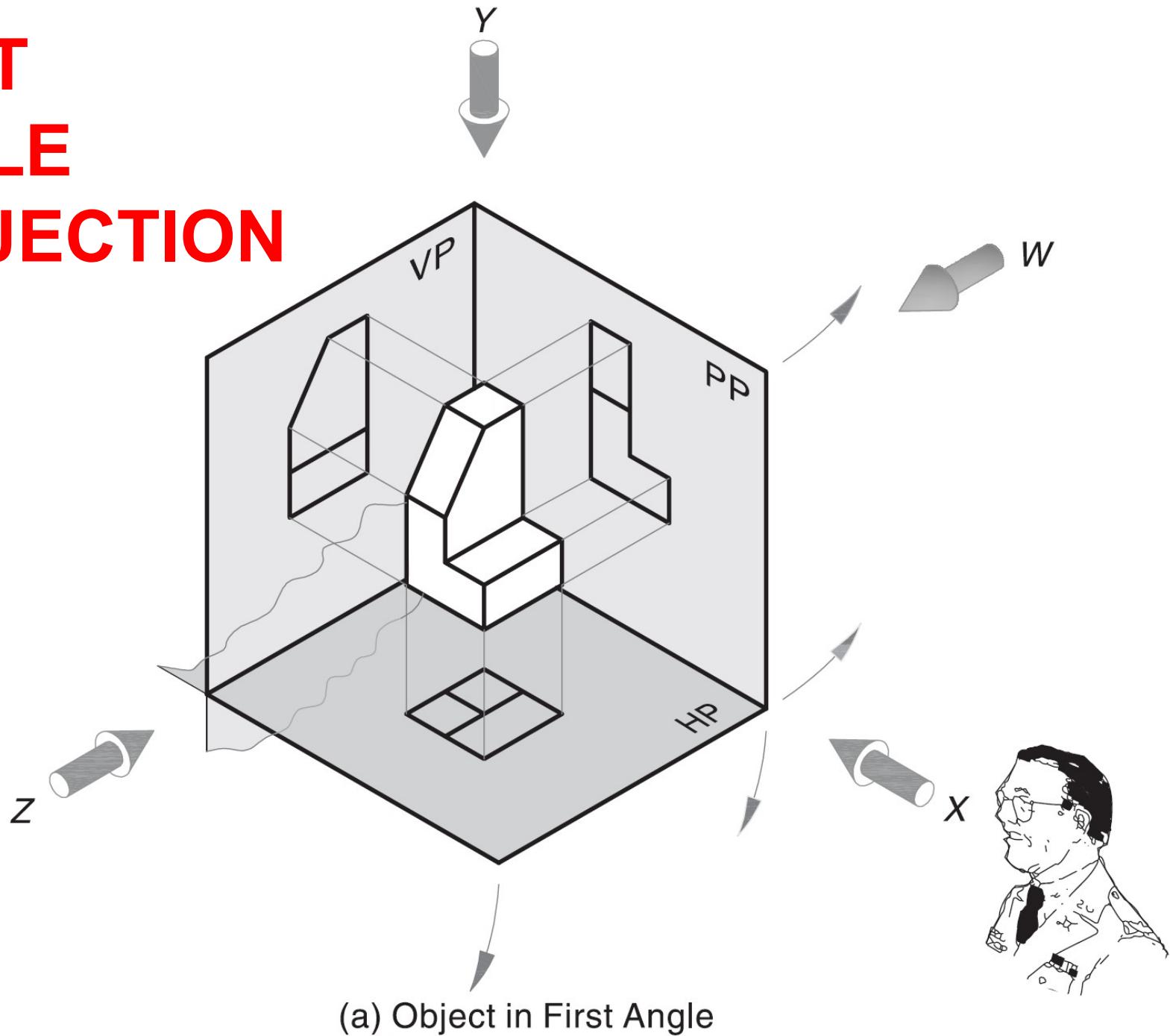




Orthographic Projection: Multiple views

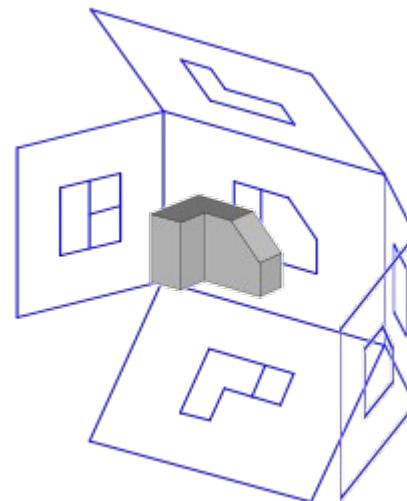
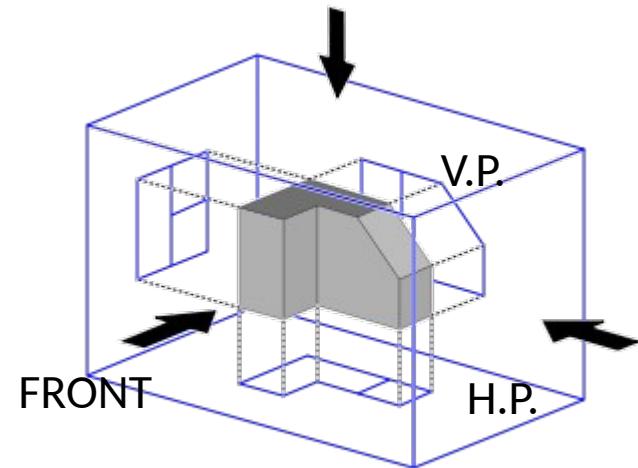
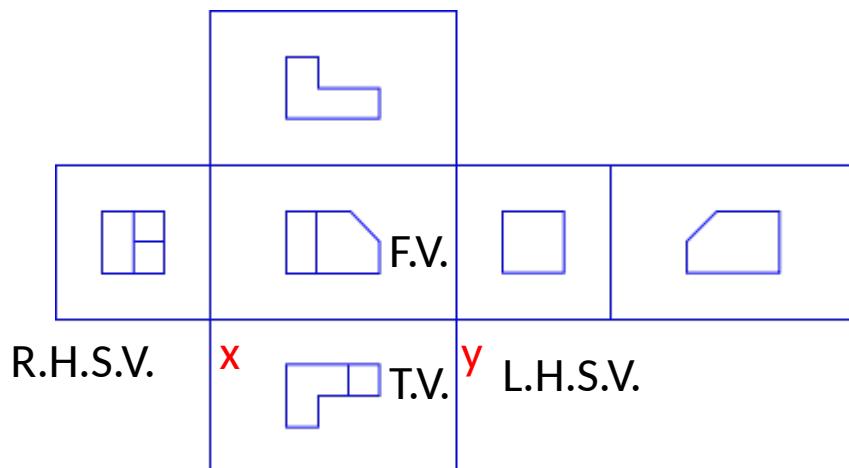


FIRST ANGLE PROJECTION



First Angle Projection

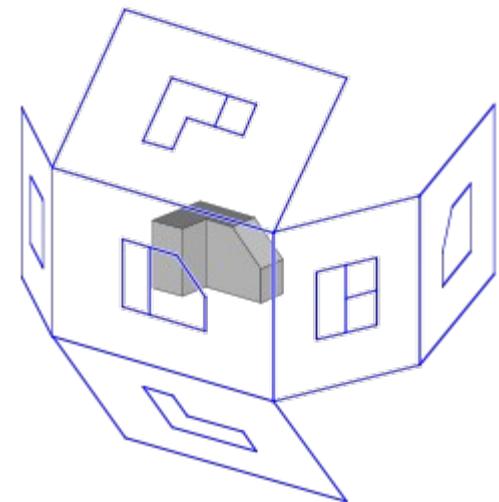
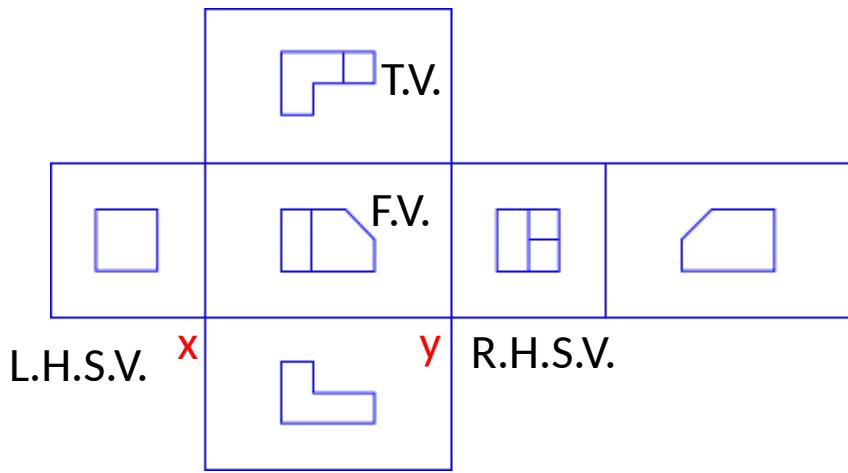
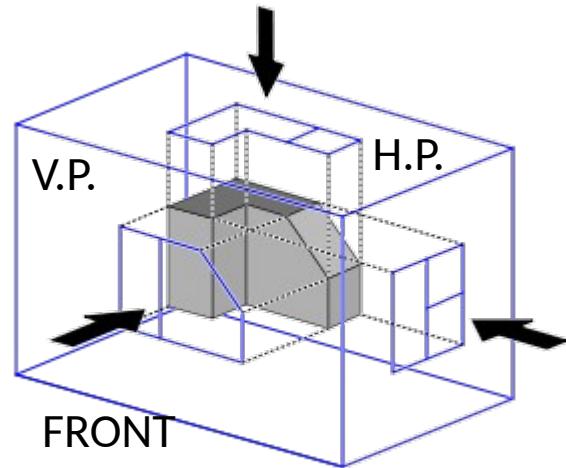
- Object is between 2D plane (“paper”) and observer
 - Front view (F.V.) is at center
 - Top view (T.V.) is at bottom
 - Left hand side view (L.H.S.V.) is on the right
 - Right hand side view (R.H.S.V.) is on the left



Used In India

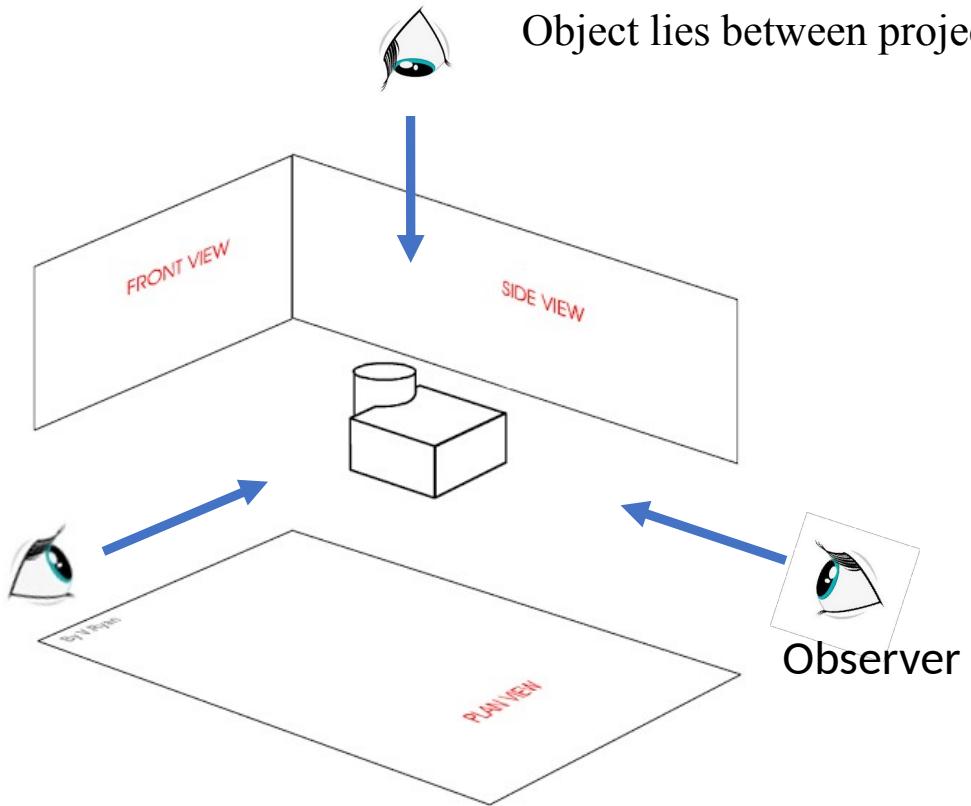
Third Angle Projection

- **2D Plane** (“paper”) is between **object** and **observer**
 - Front view (F.V.) is at center
 - Top view (T.V.) is at top
 - Left hand side view (L.H.S.V.) is on the left
 - Right hand side view (R.H.S.V.) is on the right

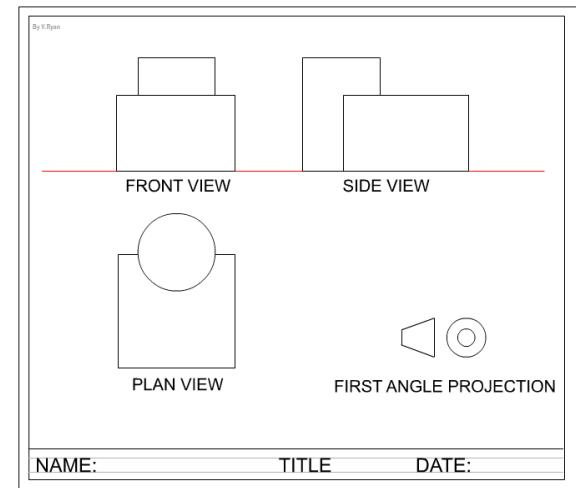


First angle projection

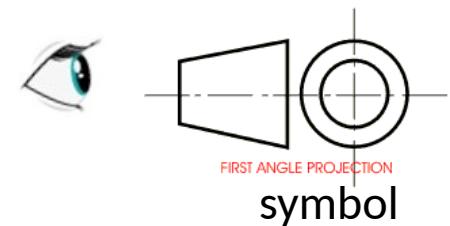
Object lies between projection plane and observer



<https://technologystudent.com/designpro/ortho1.htm>

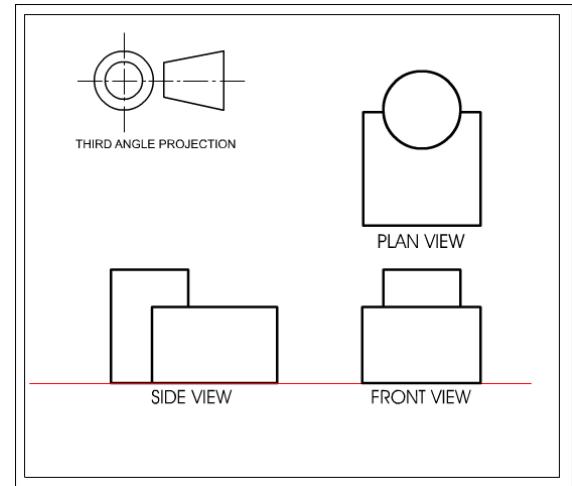
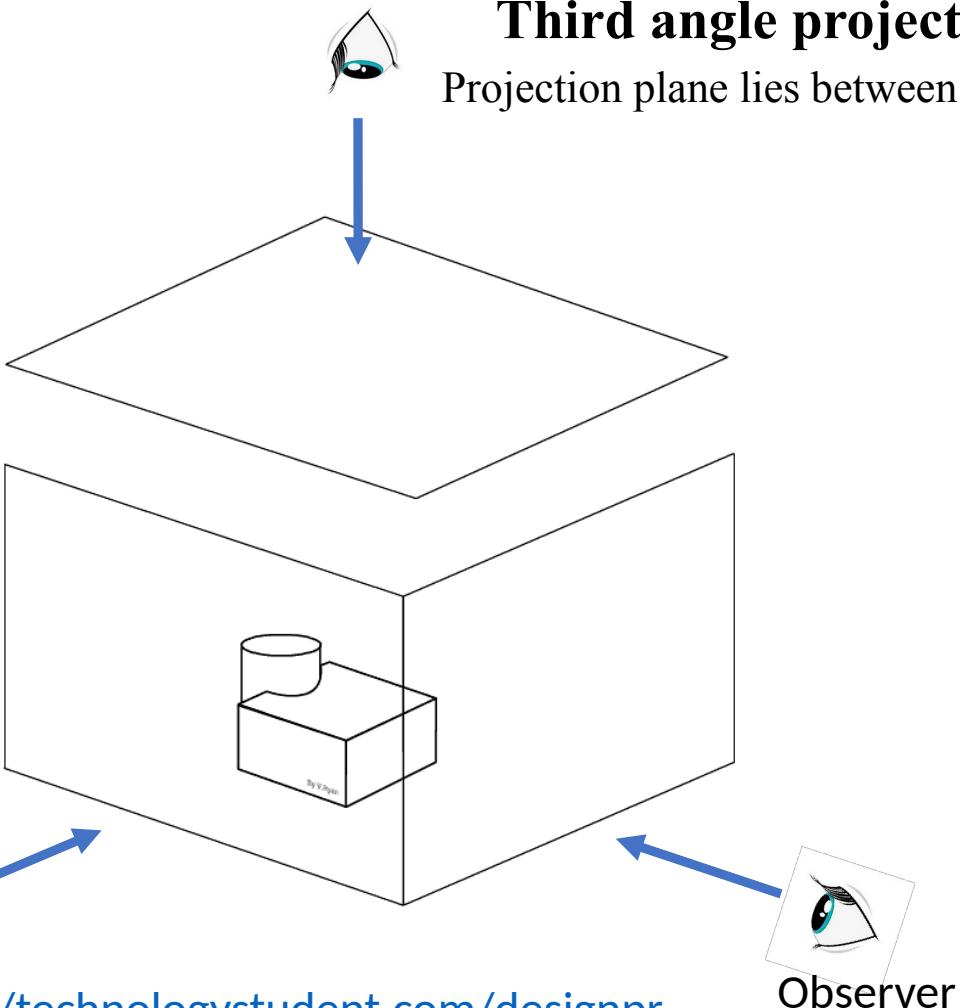


Typical drawing sheet drawn
in first angle projection

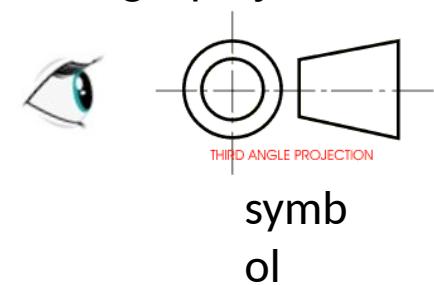


Third angle projection

Projection plane lies between object and observer



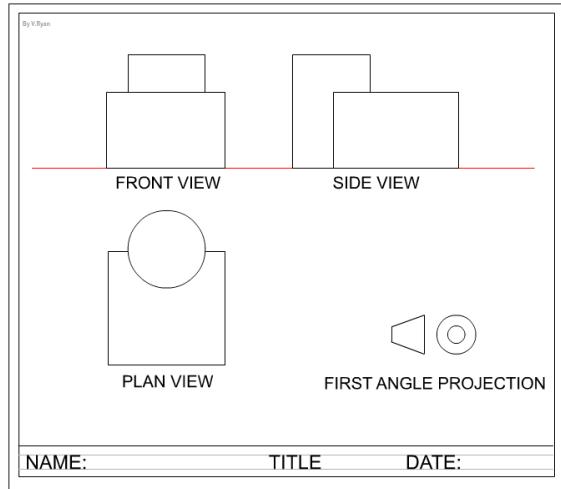
Typical drawing sheet drawn
in third angle projection



<https://technologystudent.com/designproj/ortho2.htm>

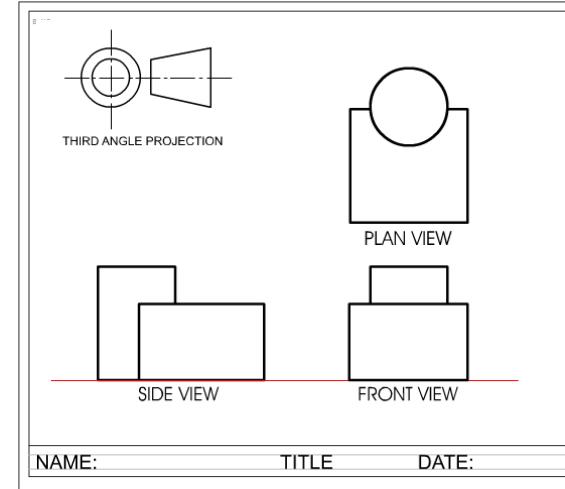
First angle projection

- Front view (FV) is above the top view (TV)
- Left hand side view (LHSV) is on the right of front view
- Right hand side view (RHSV) is on the left of front view

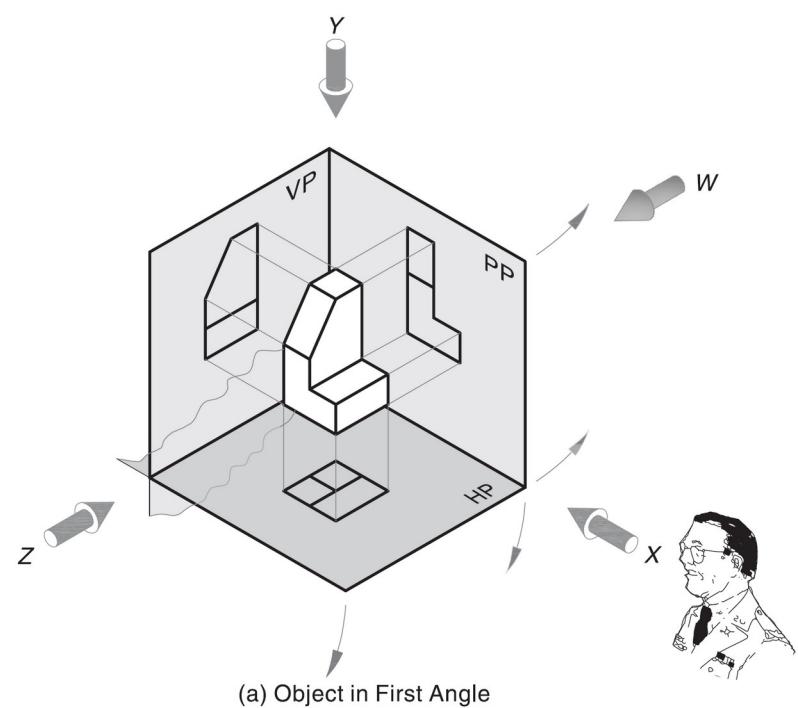


Third angle projection

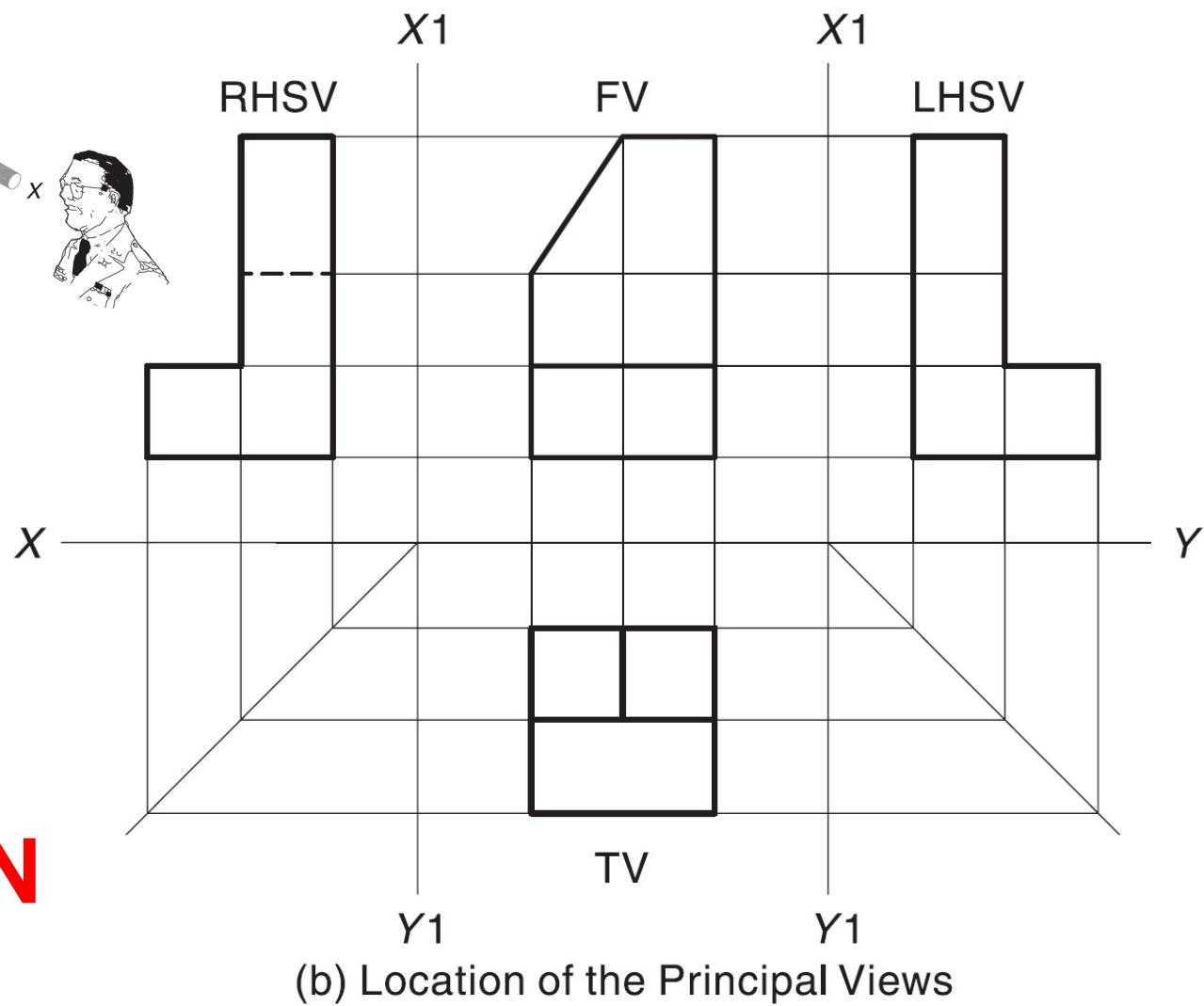
- Front is below the top view
- Left hand side view (LHSV) is on the left of front view
- Right hand side view (RHSV) is on the right of front view

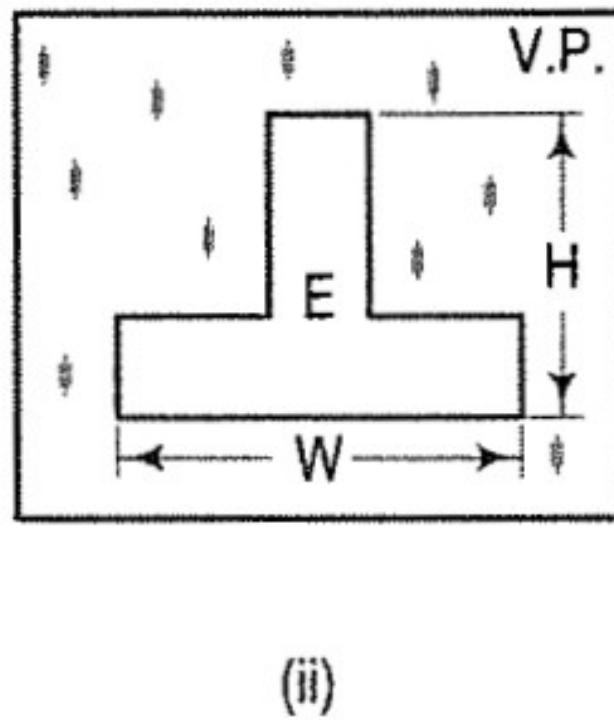
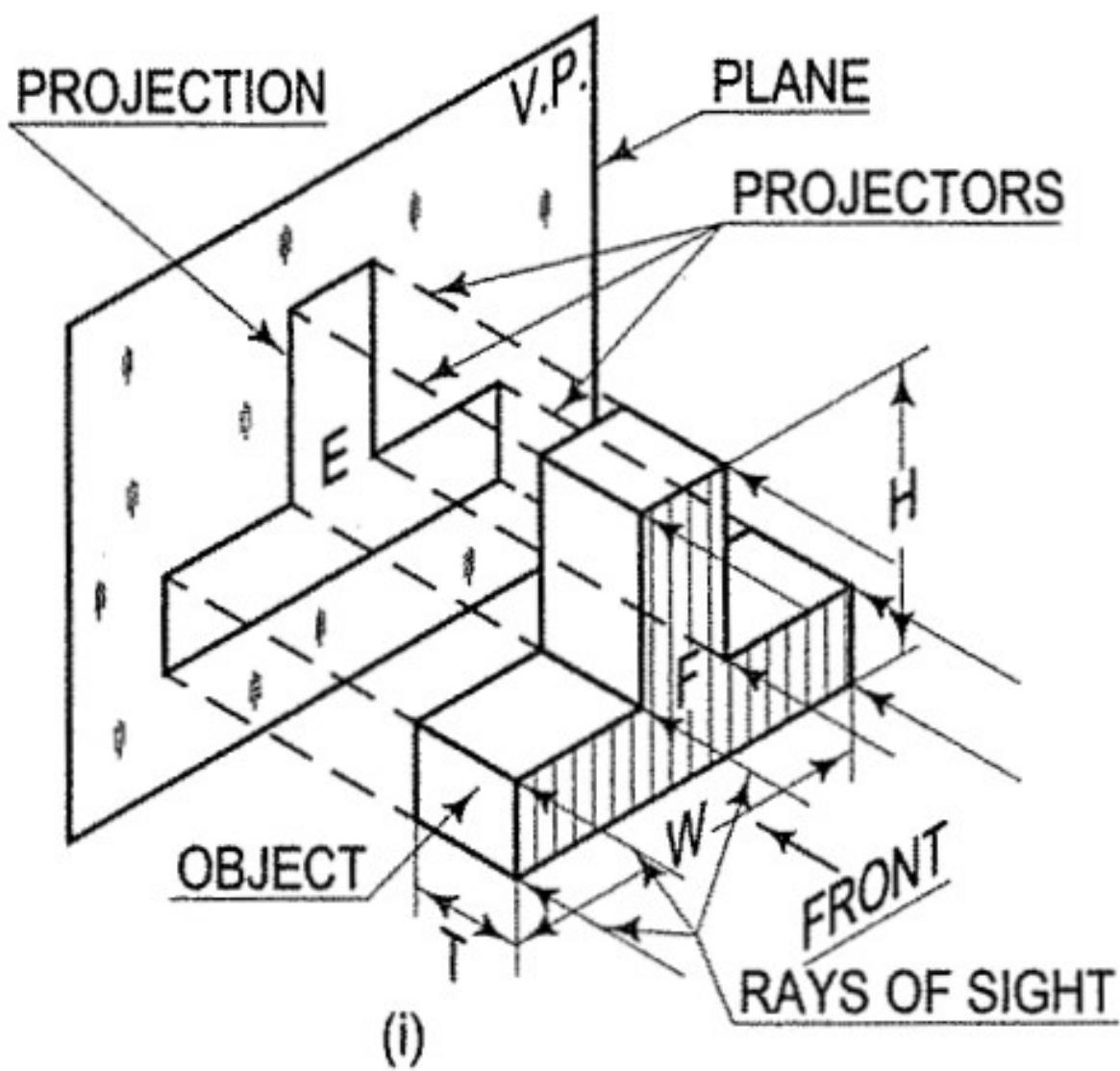


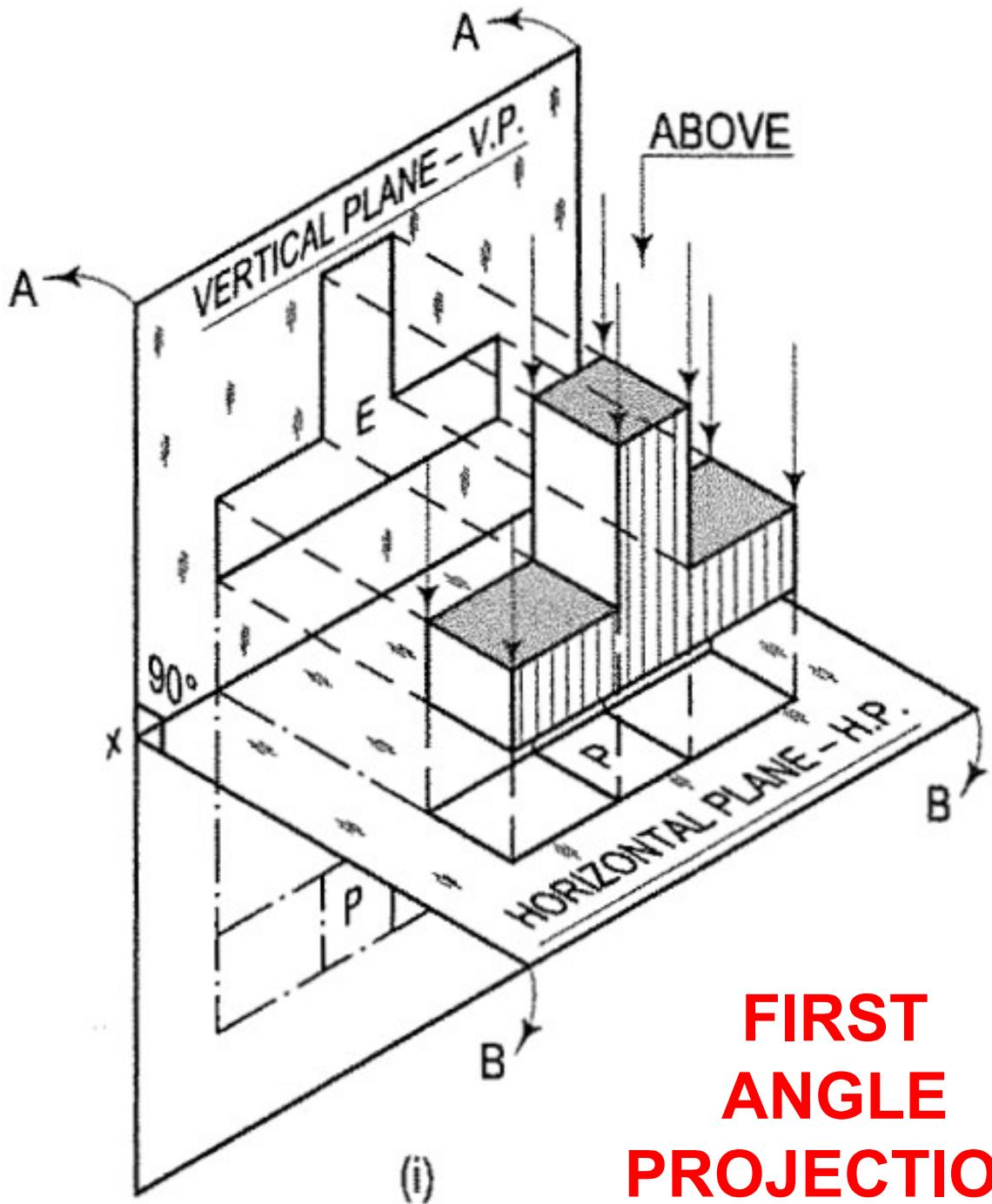
In India, usually First Angle Projection is used



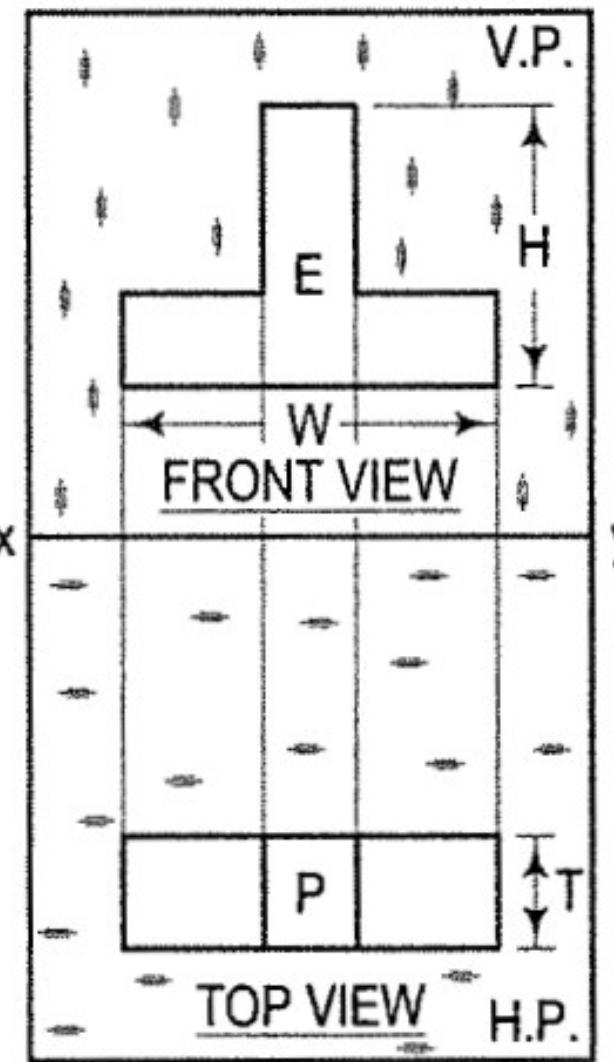
FIRST ANGLE PROJECTION





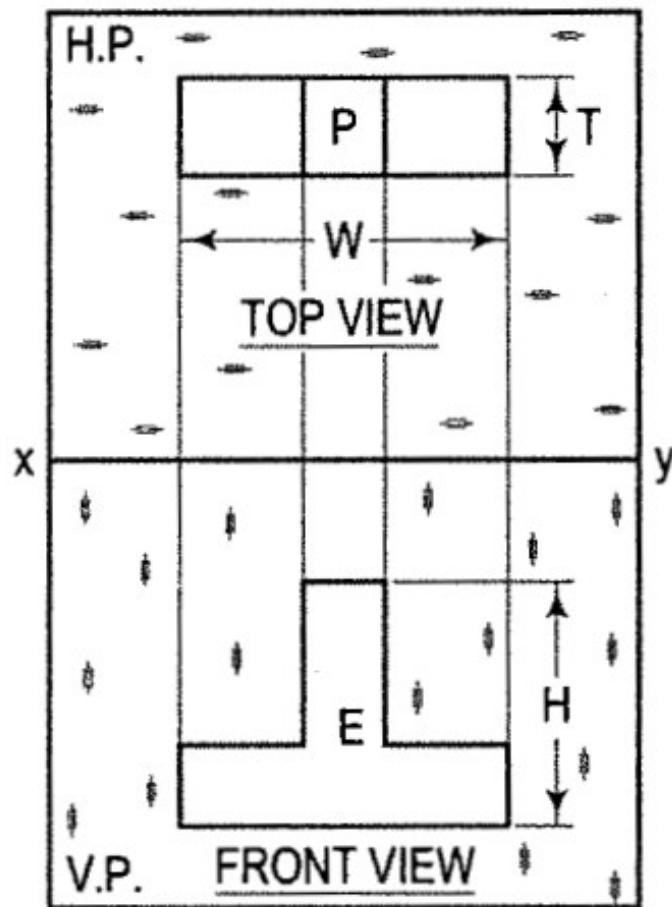
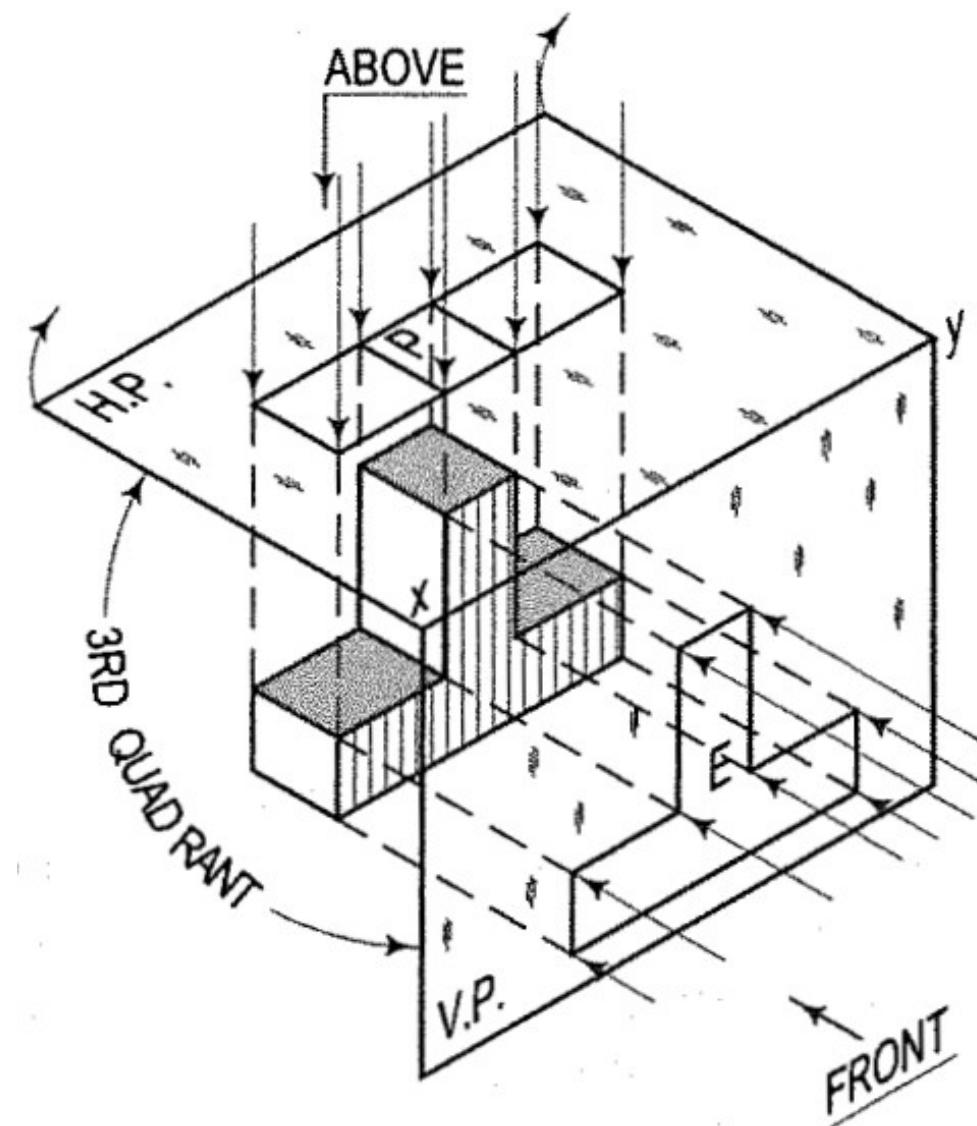


FIRST ANGLE PROJECTION

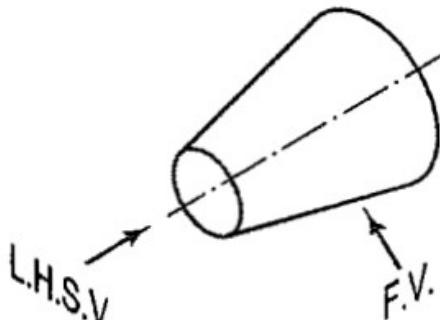


(ii)

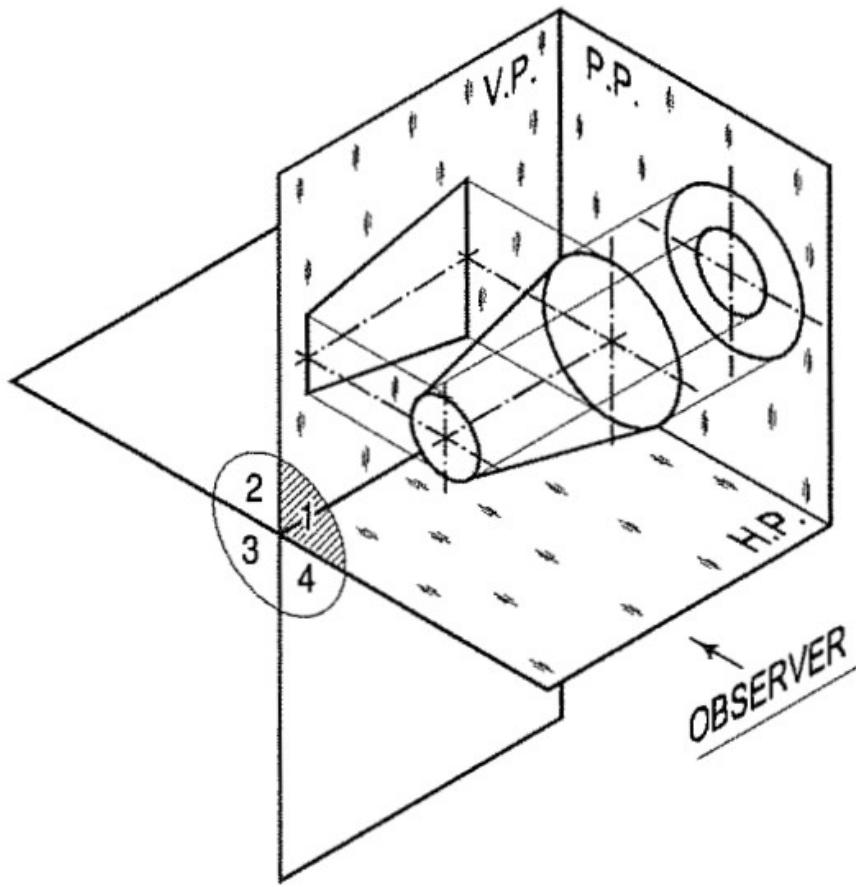
THIRD ANGLE PROJECTION



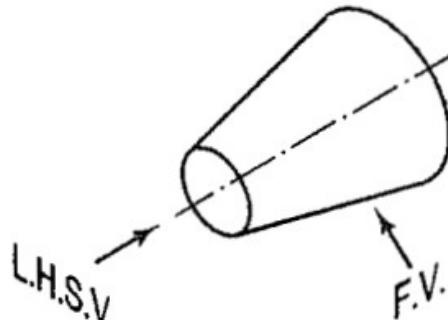
FIRST ANGLE PROJECTION METHOD



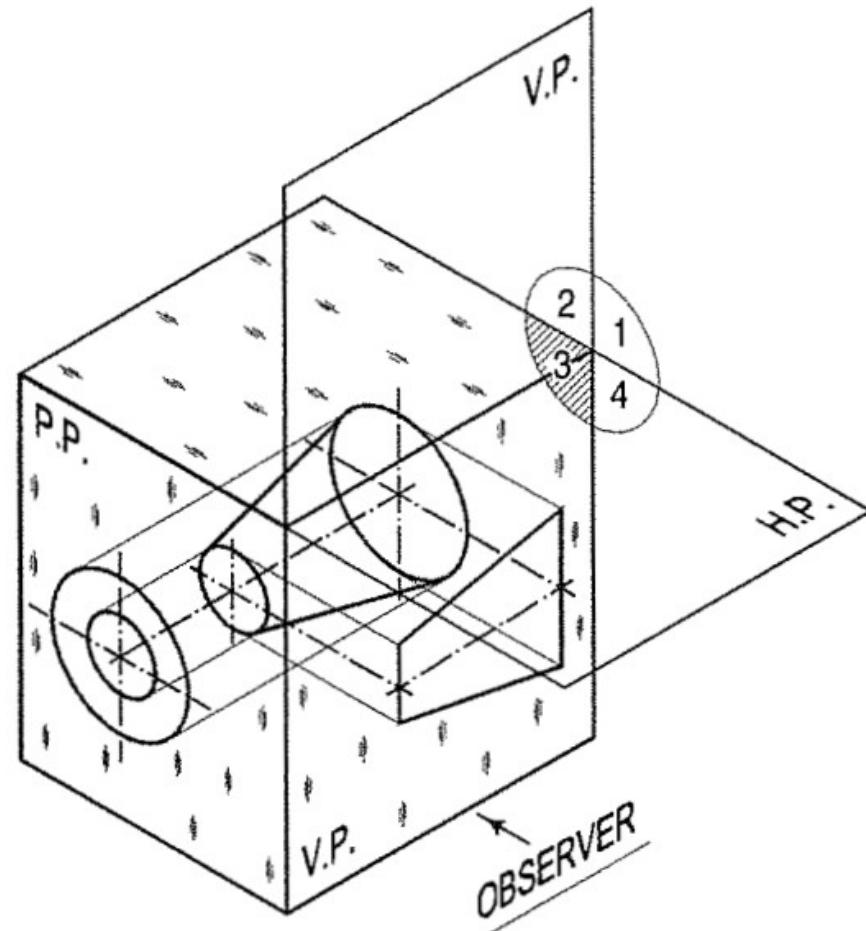
PICTORIAL VIEW

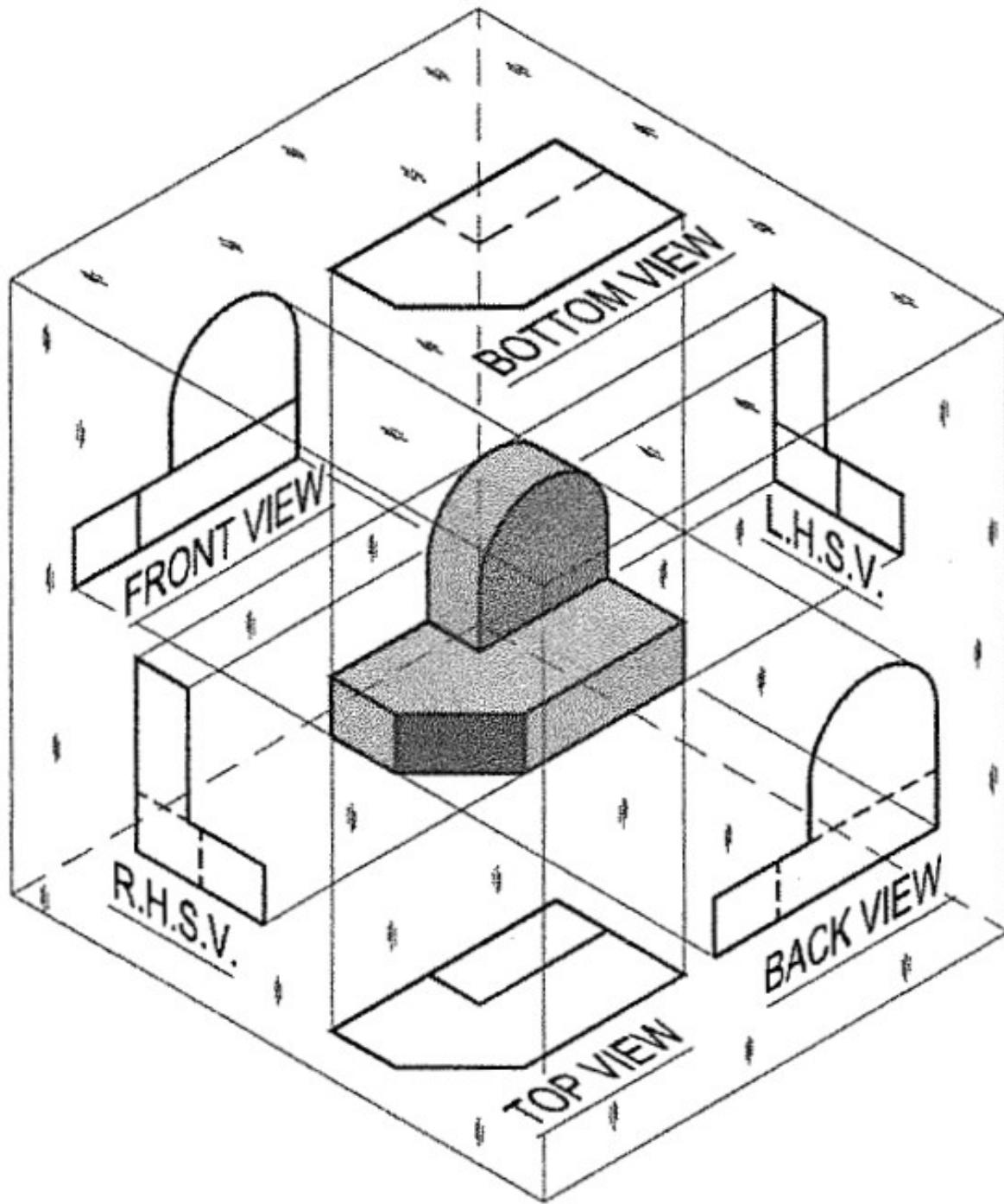


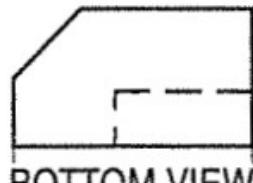
THIRD ANGLE PROJECTION METHOD



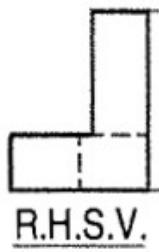
PICTORIAL VIEW



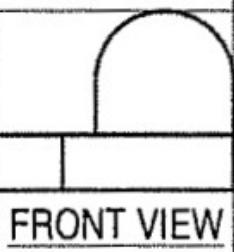




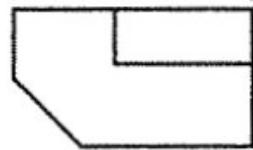
BOTTOM VIEW



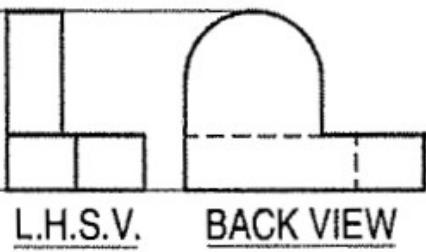
R.H.S.V.



FRONT VIEW



TOP VIEW



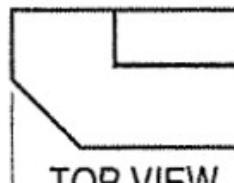
L.H.S.V.

BACK VIEW

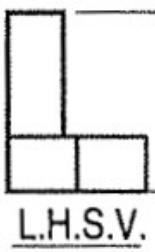
R.H.S.V. = RIGHT HAND SIDE VIEW

L.H.S.V. = LEFT HAND SIDE VIEW

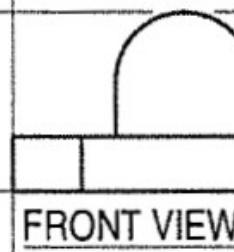
FIRST ANGLE PROJECTION



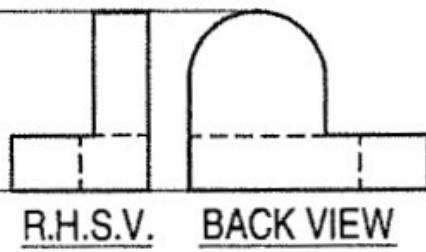
TOP VIEW



L.H.S.V.

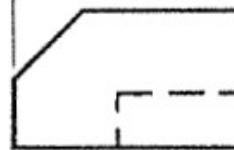


FRONT VIEW



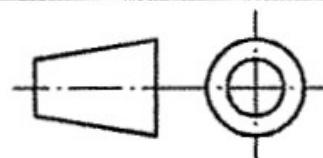
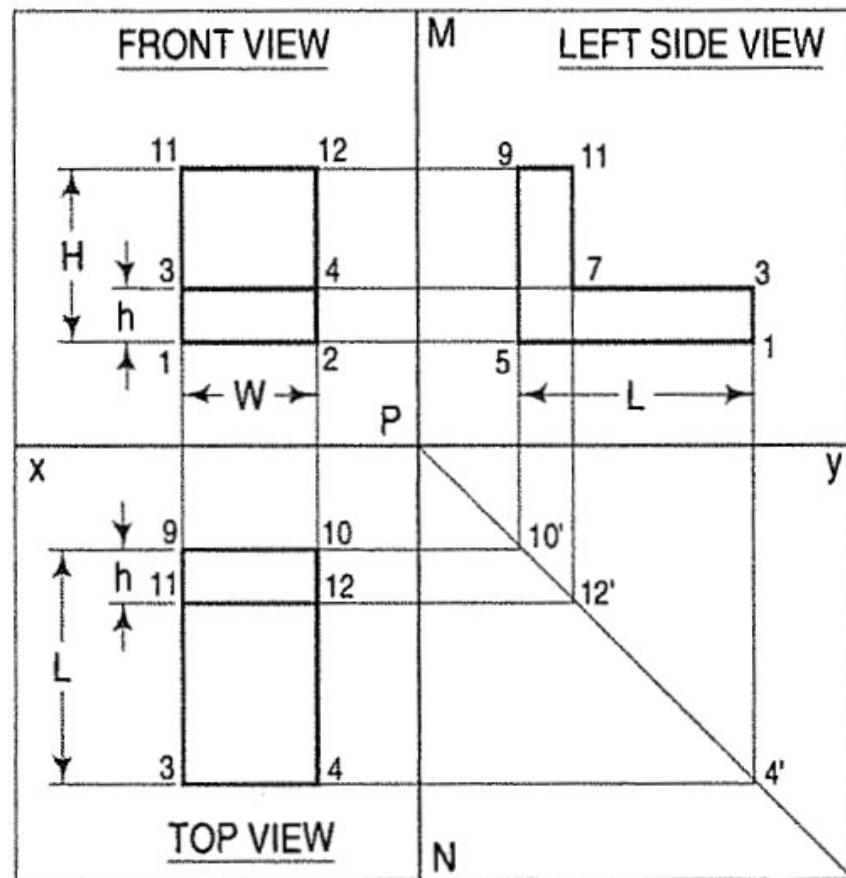
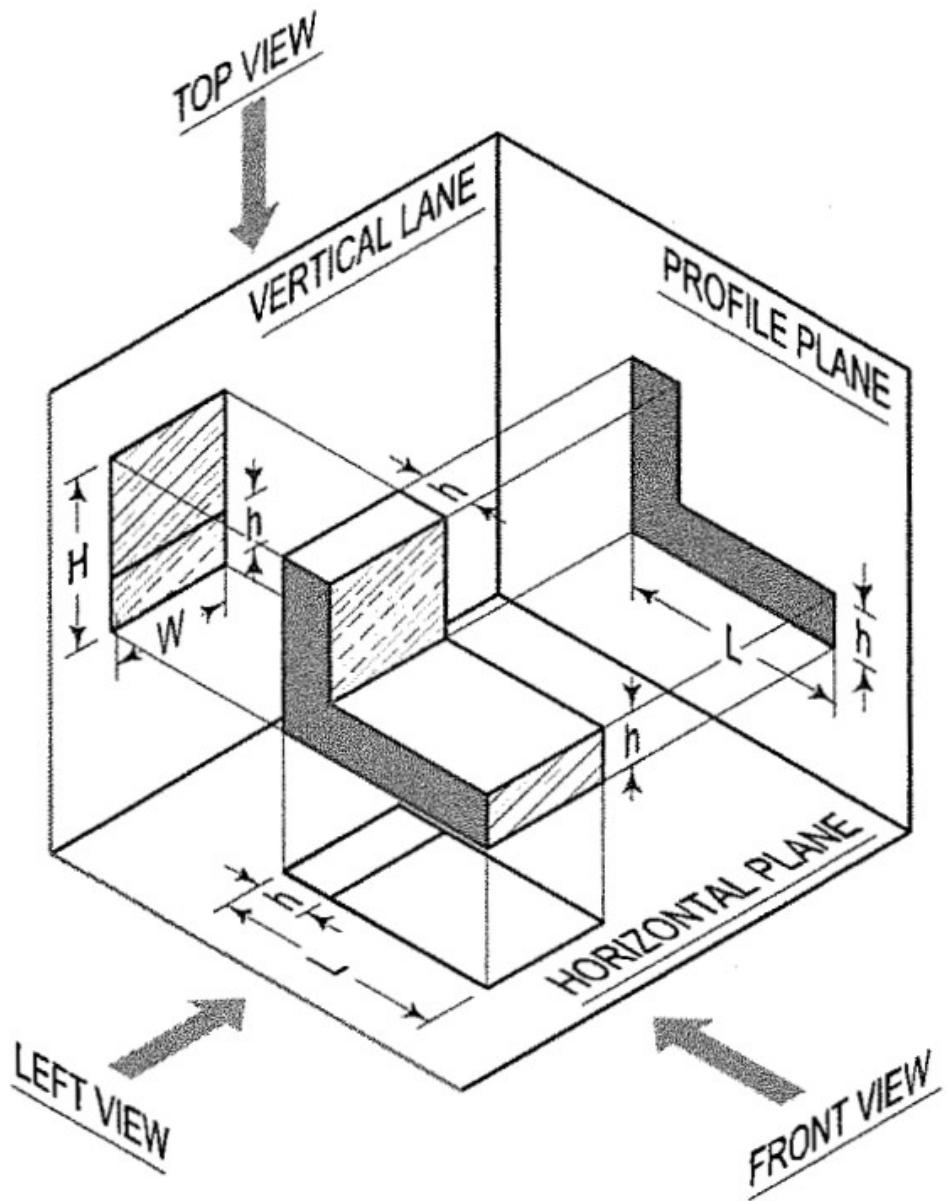
R.H.S.V.

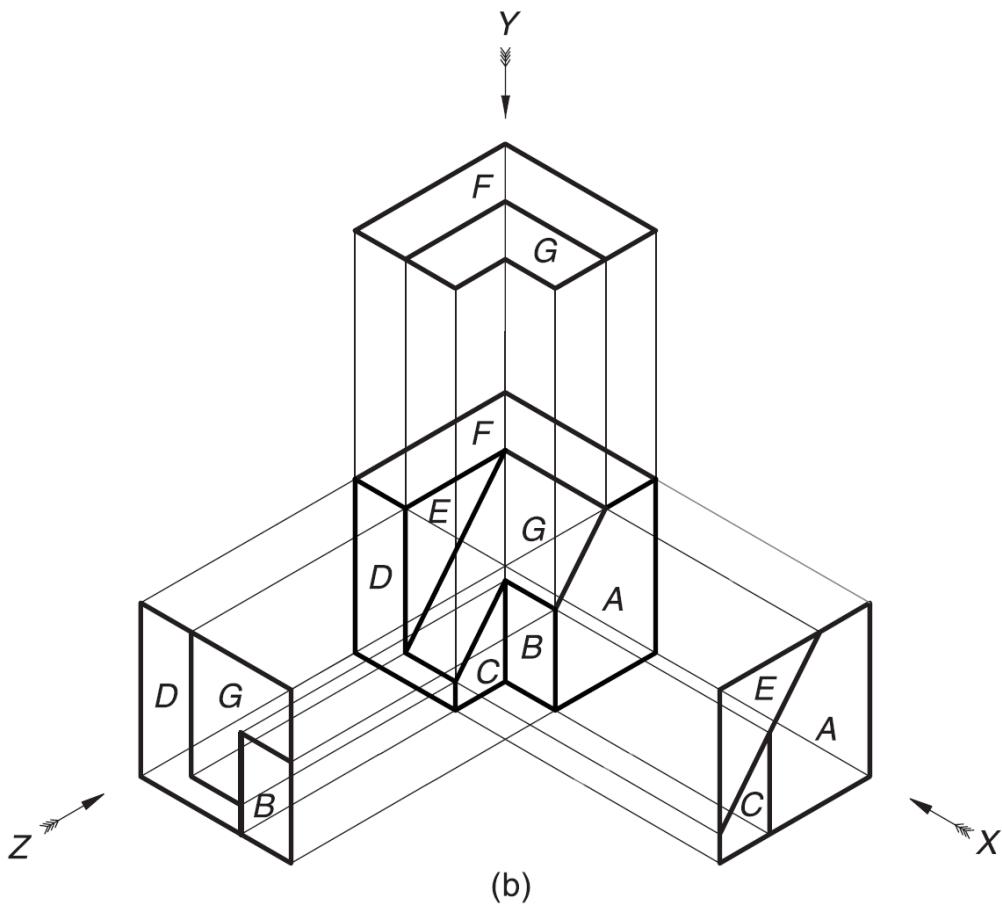
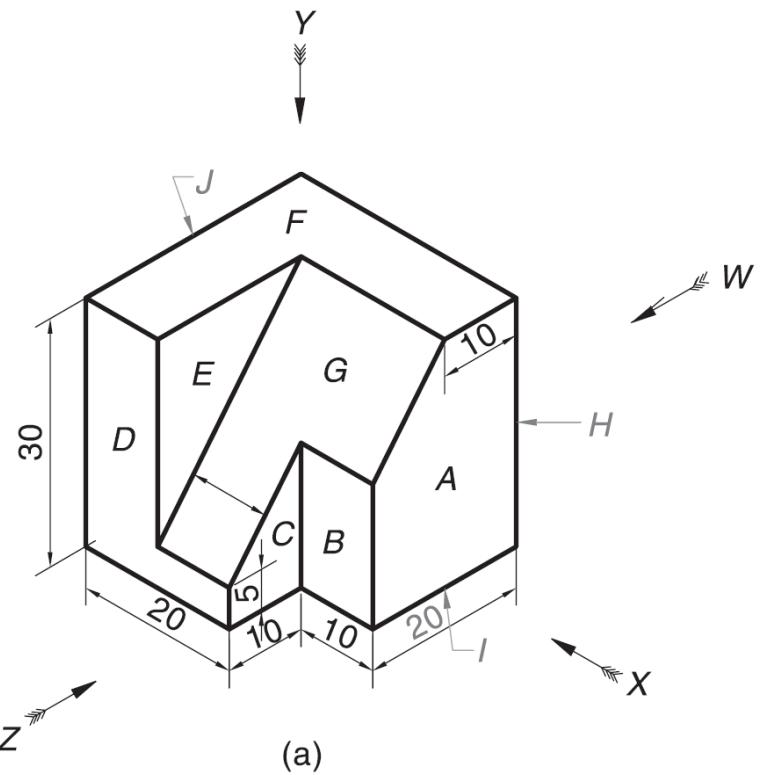
BACK VIEW



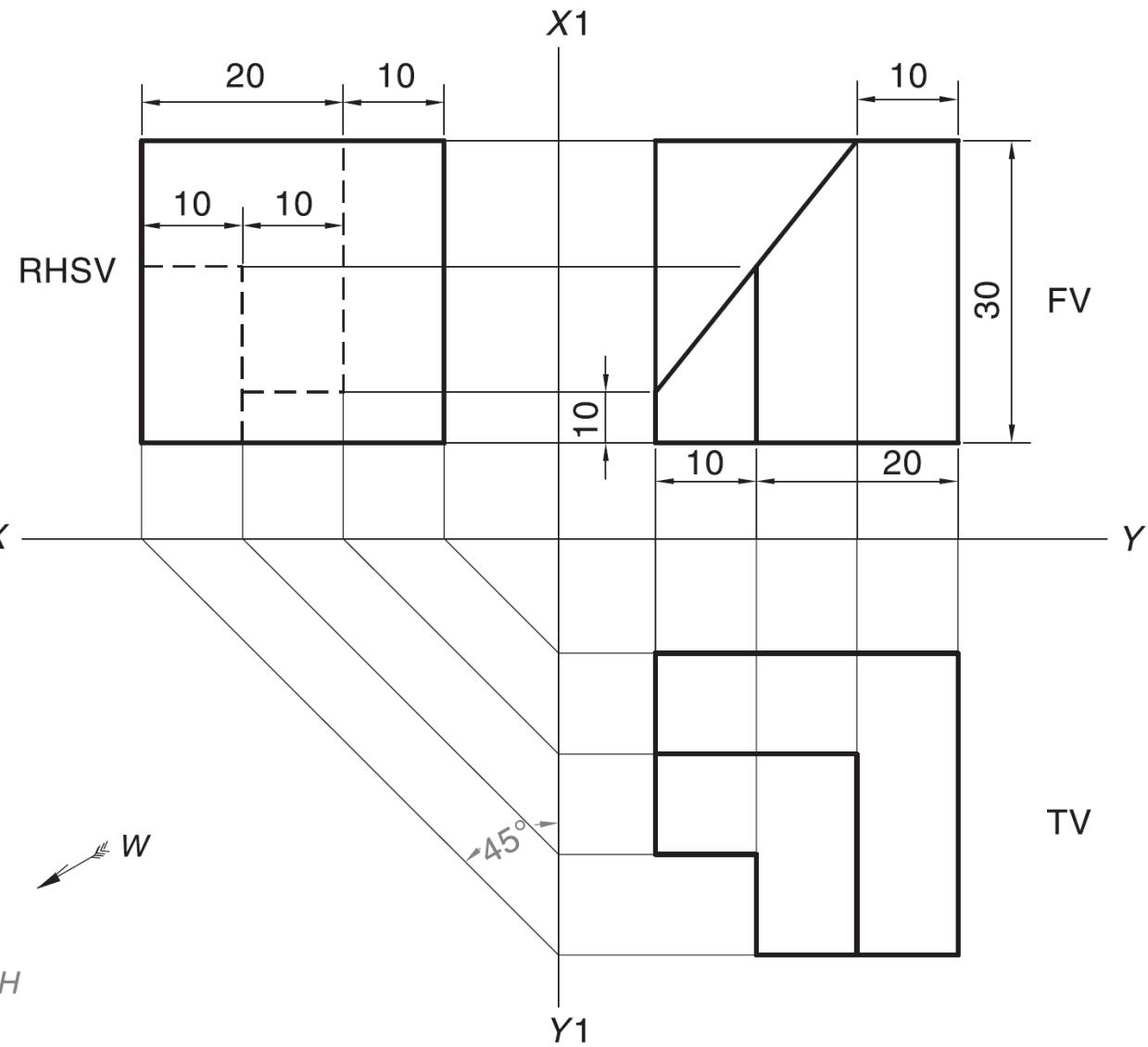
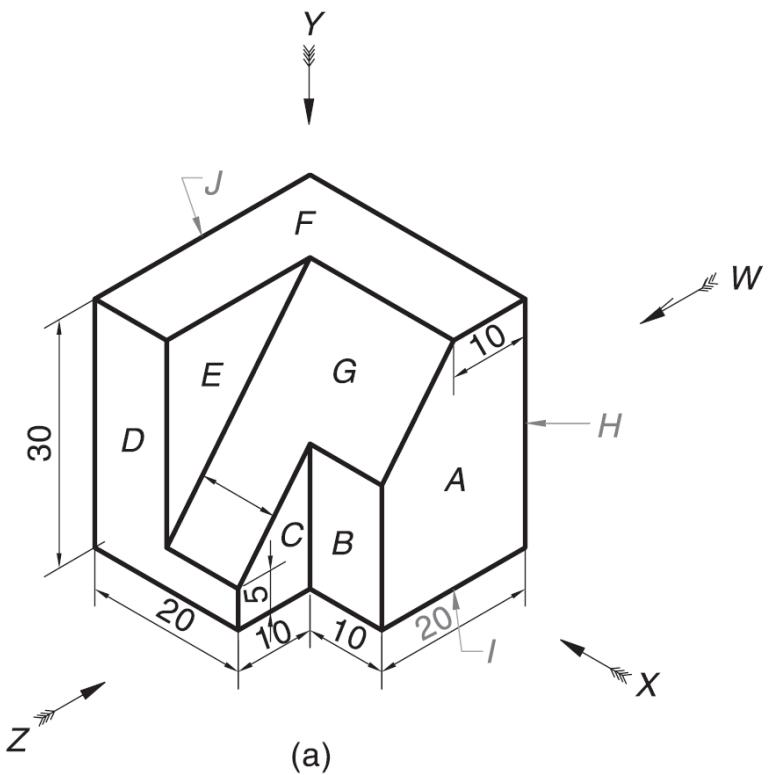
TOP VIEW

THIRD ANGLE PROJECTION

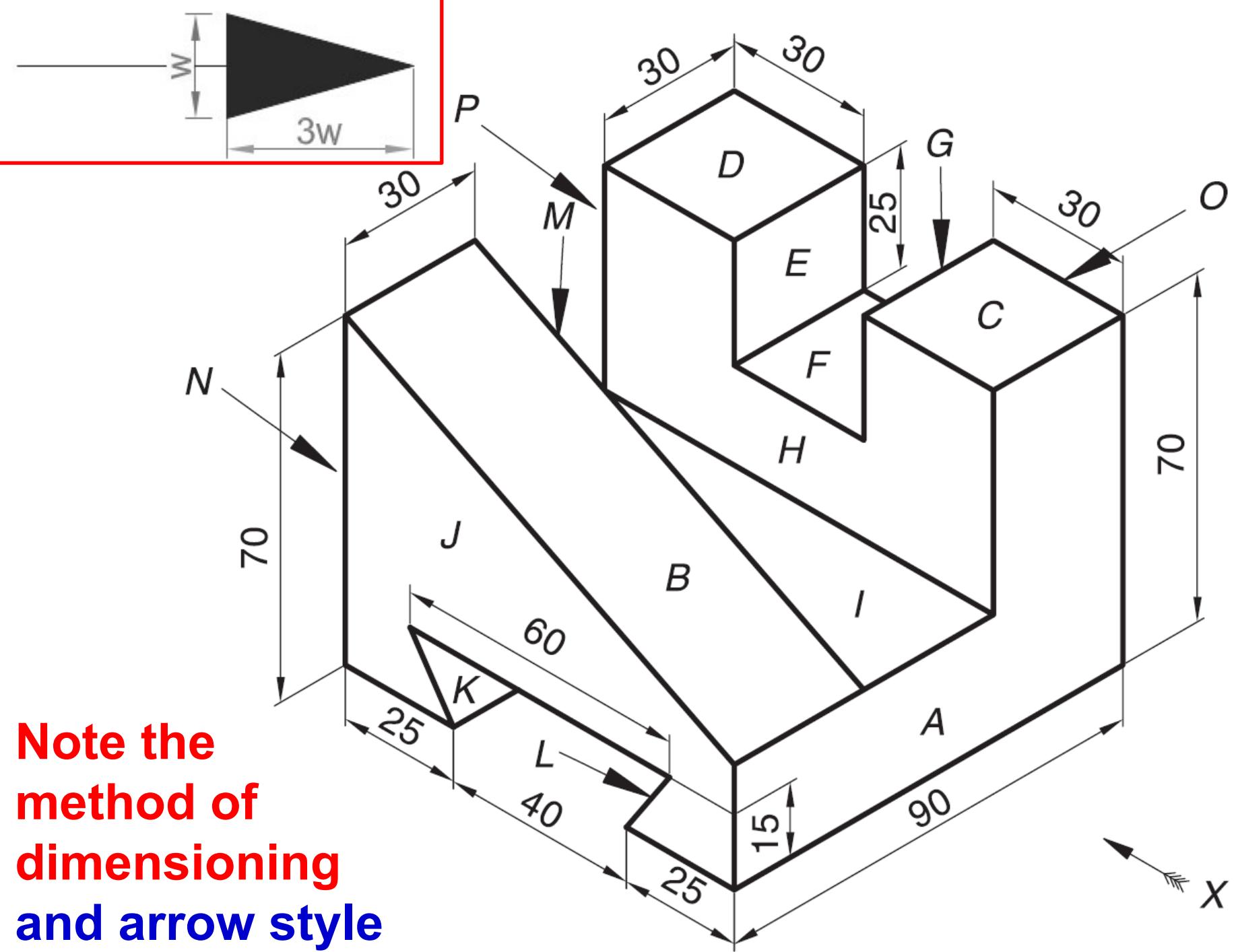




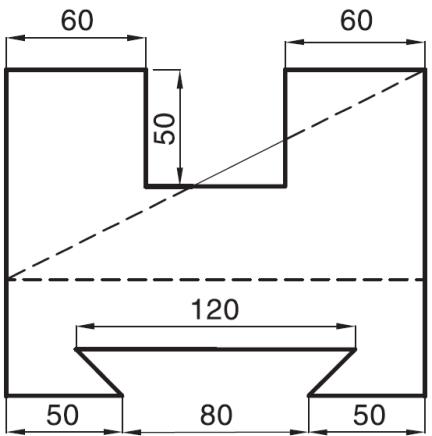
HIDDEN EDGES



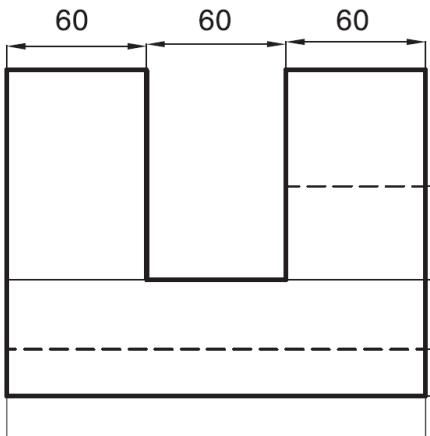
Note the
method of dimensioning



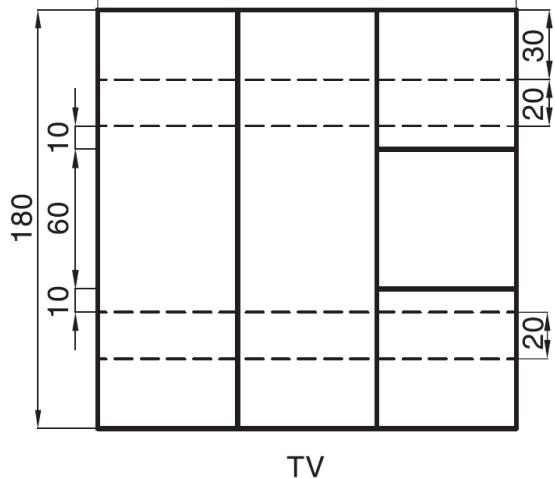
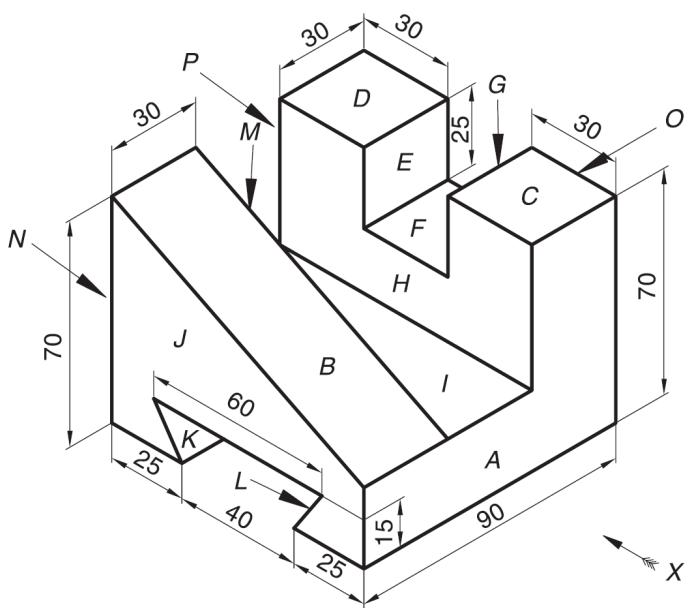
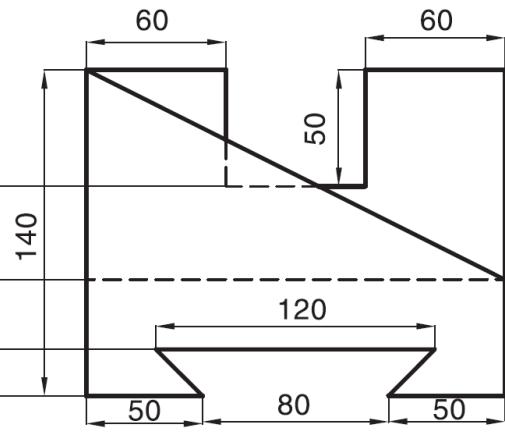
RHSV



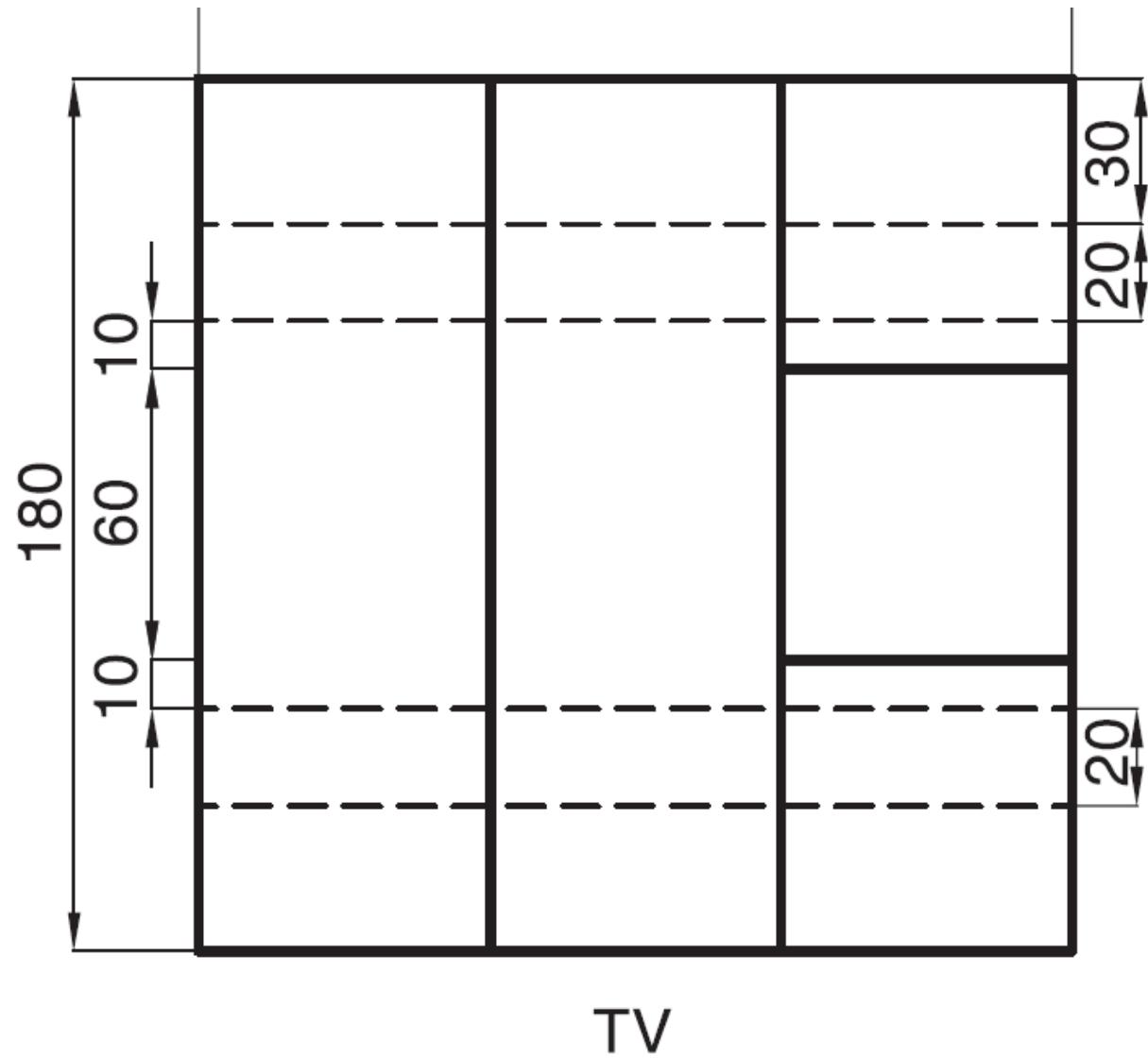
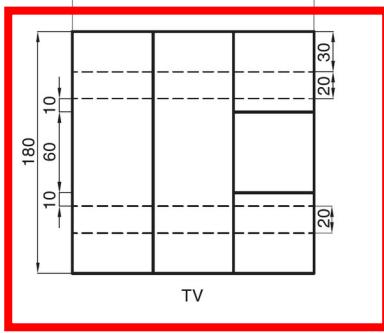
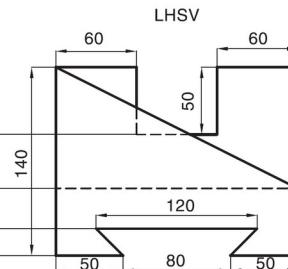
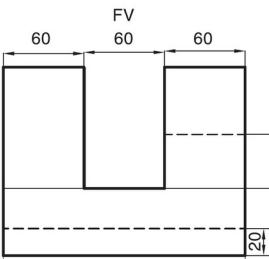
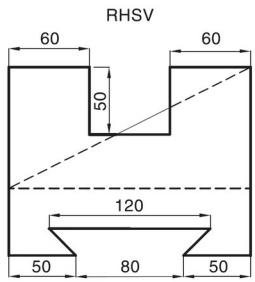
FV

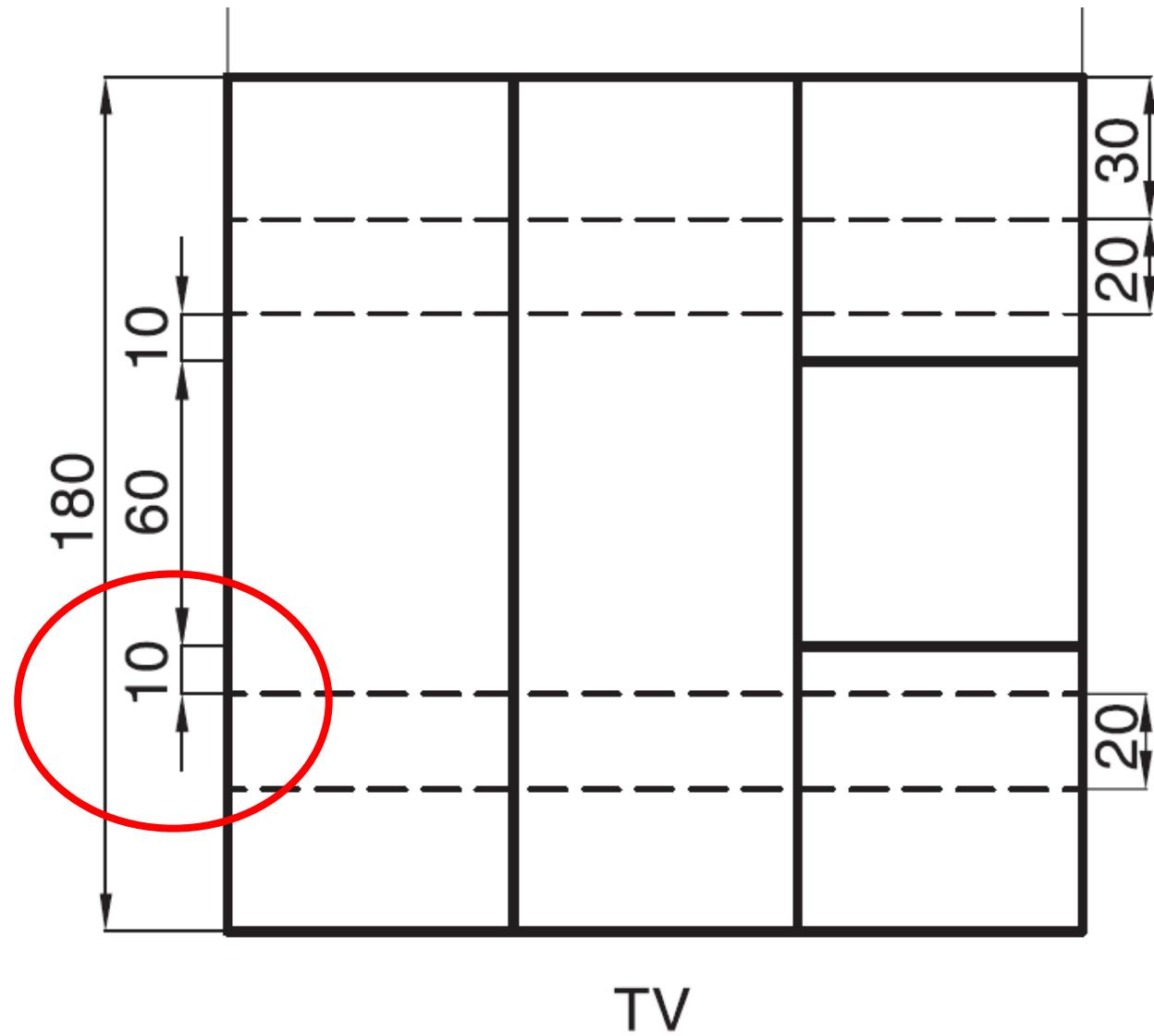
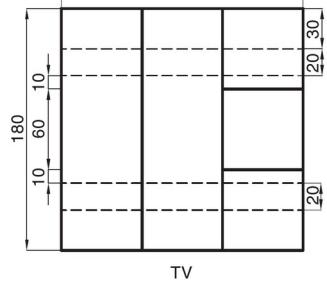
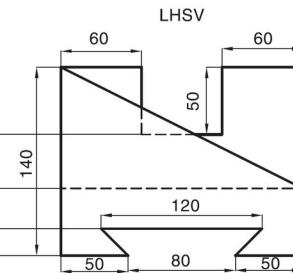
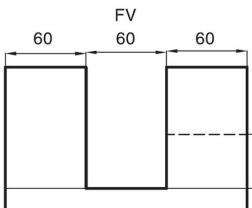
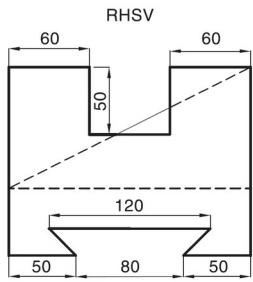


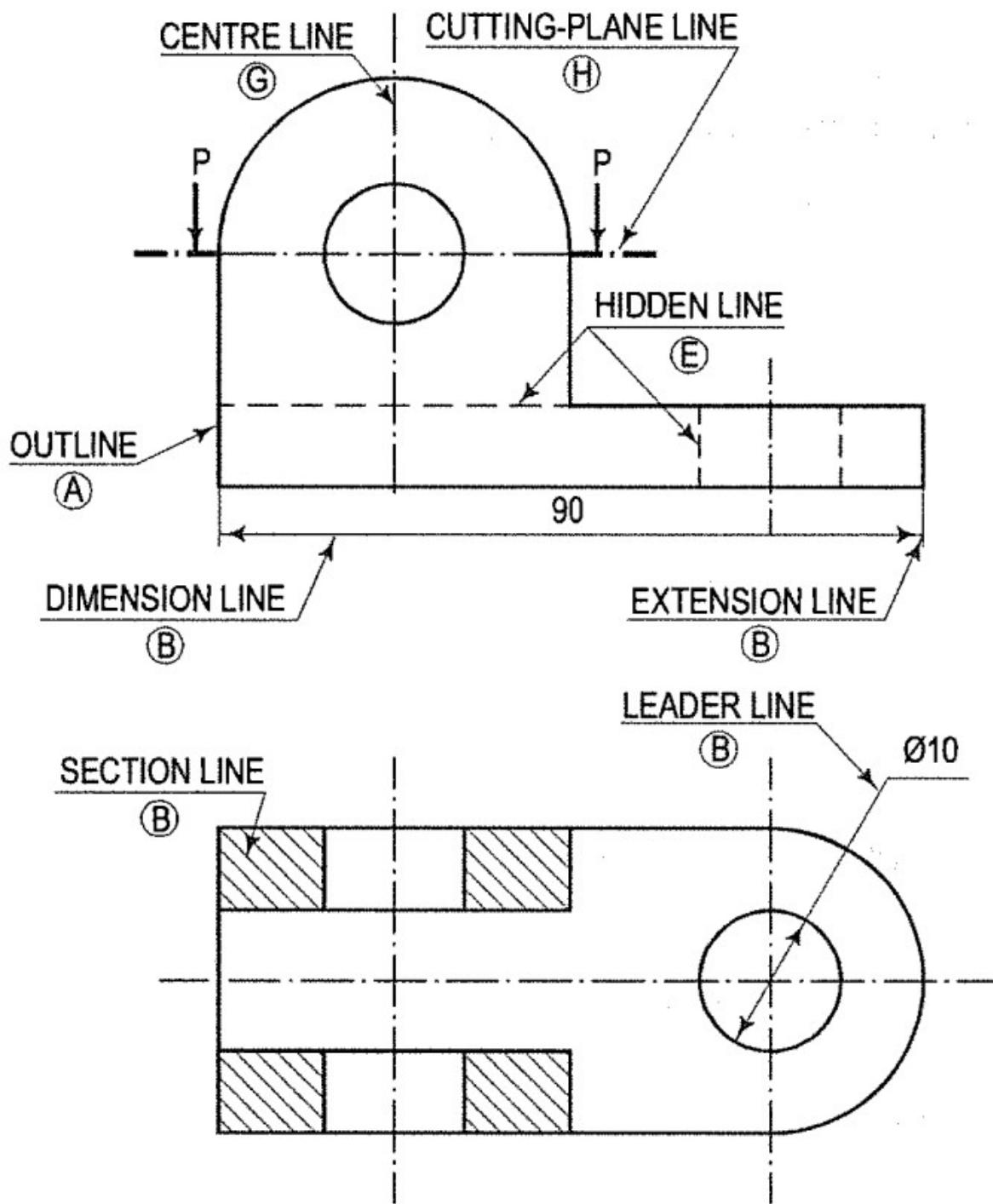
LHSV

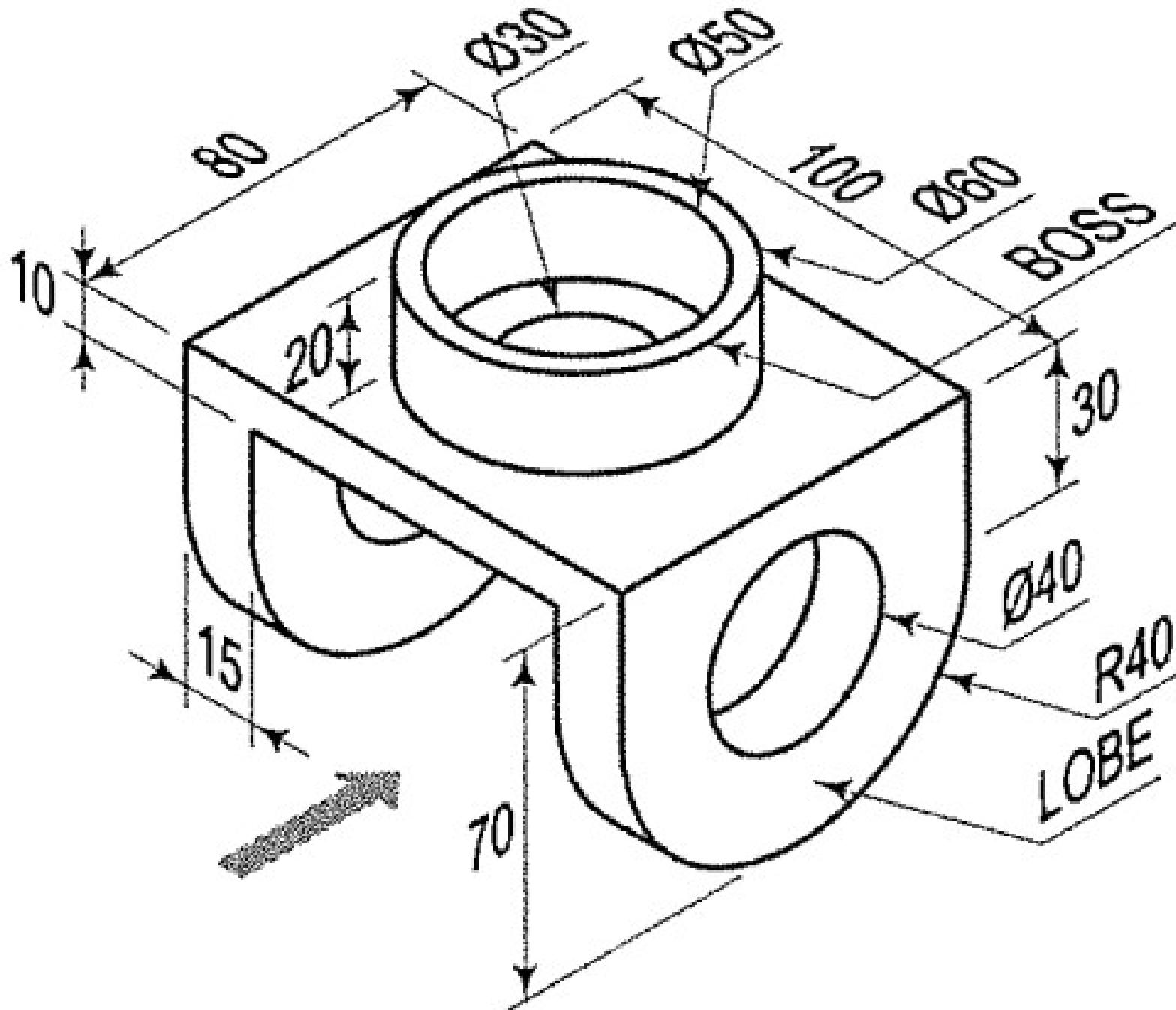


TV

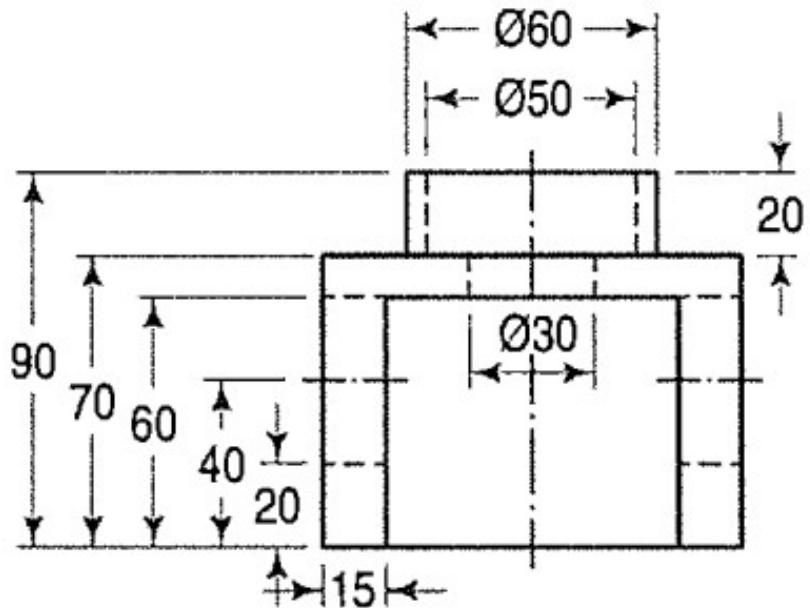




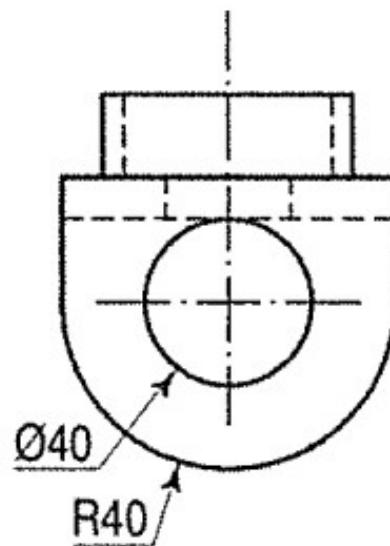




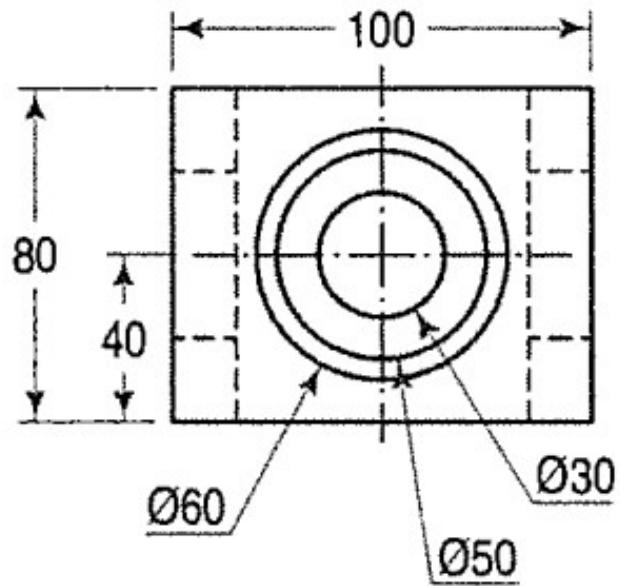
FRONT VIEW



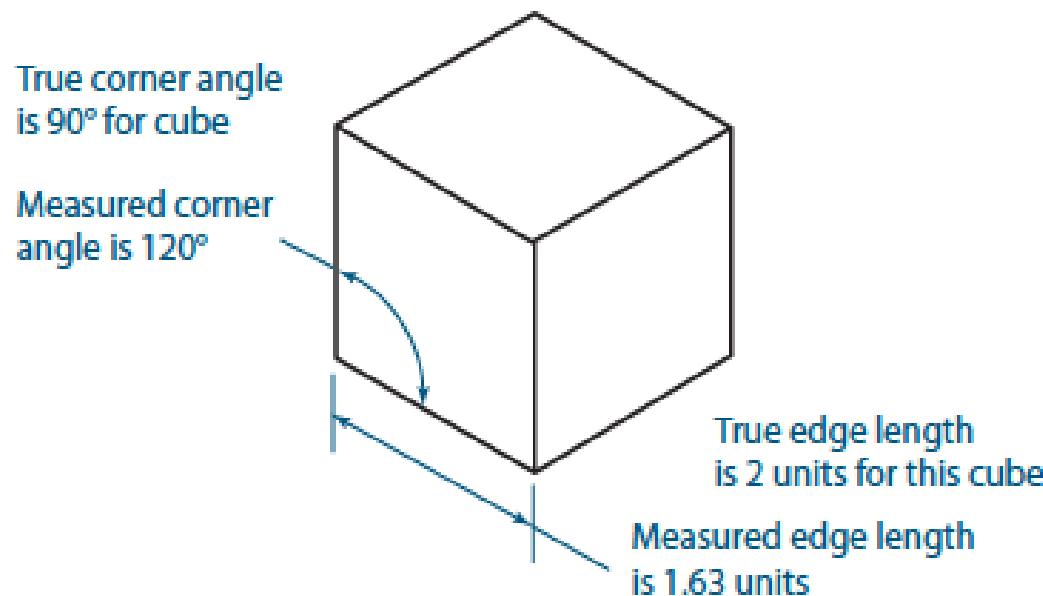
SIDE VIEW



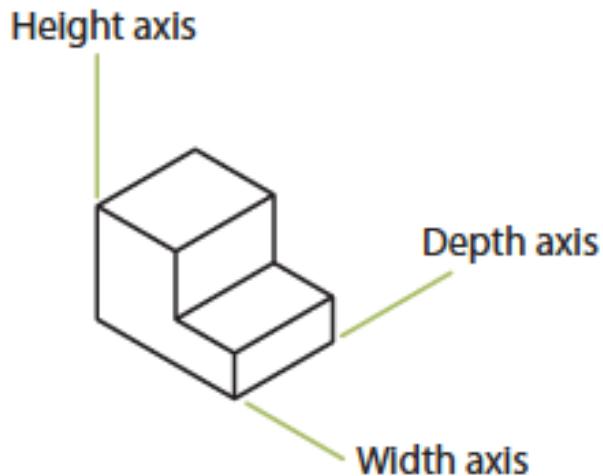
TOP VIEW



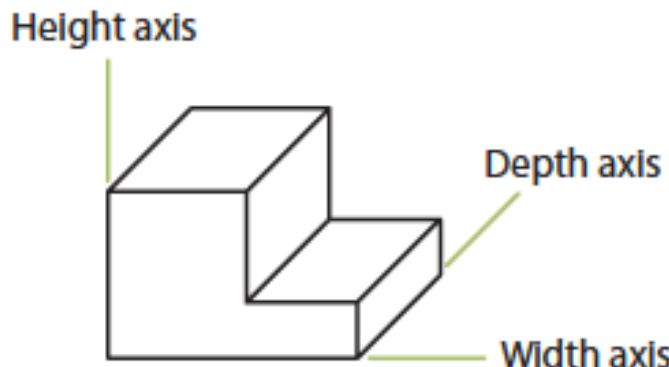
Isometric Projection



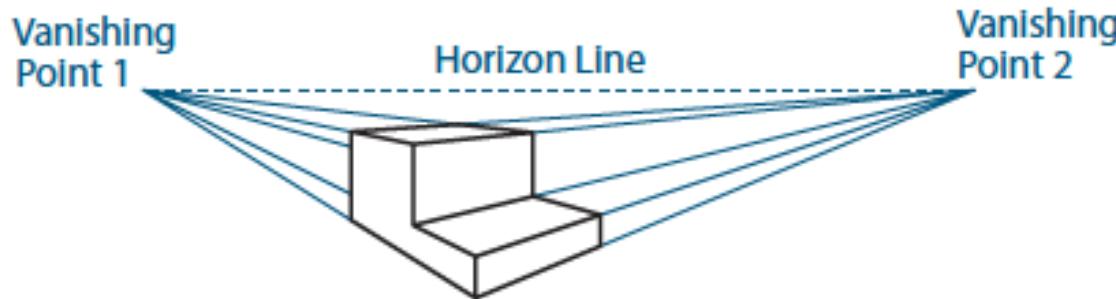
Axonometric refers to the angle that axes make with each other



AXONOMETRIC DRAWING

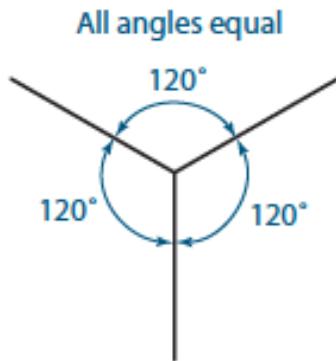


OBLIQUE DRAWING

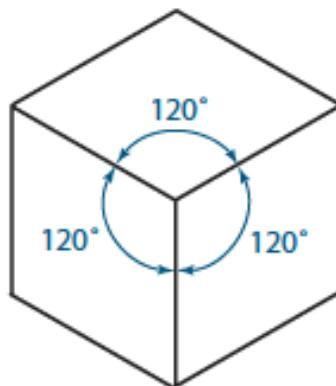


PERSPECTIVE DRAWING

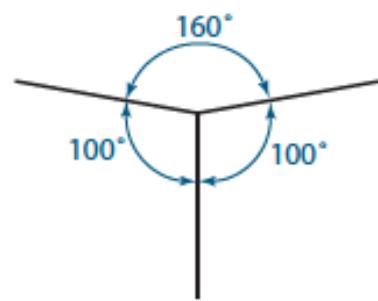
Axonometric refers to the angle that axes make with each other



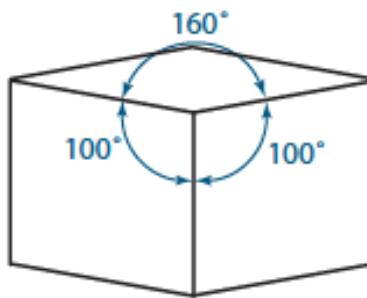
All angles equal



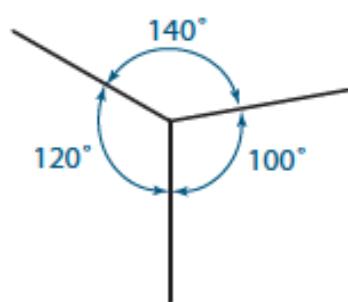
Isometric projection



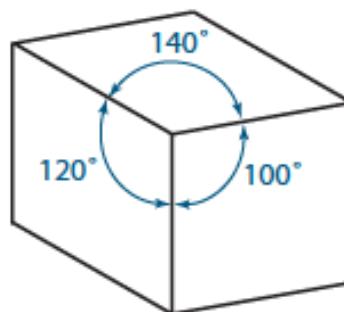
Two angles equal



Dimetric projection



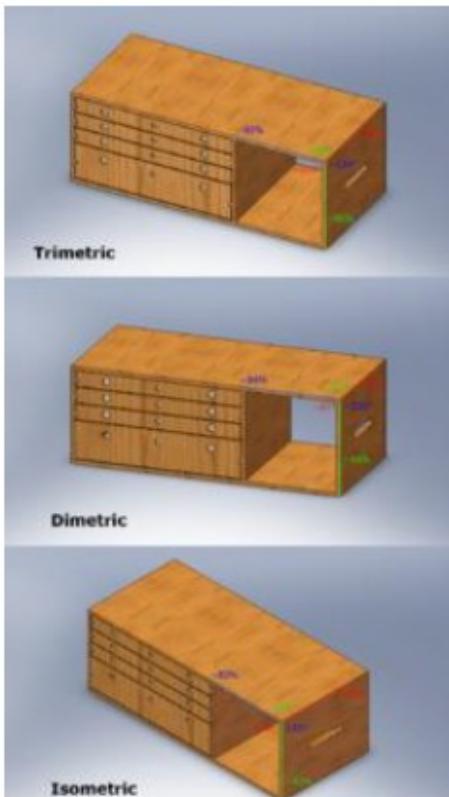
No angles equal



Trimetric projection

Axonometric Projections

Axonometric projection is a type of orthographic projection used for creating a pictorial drawing of an object, where the lines of sight are perpendicular to the plane of projection, and the object is rotated around one or more of its axes to reveal multiple sides.



In **trimetric projection**, the direction of viewing is such that all of the three axes of space appear unequally foreshortened.

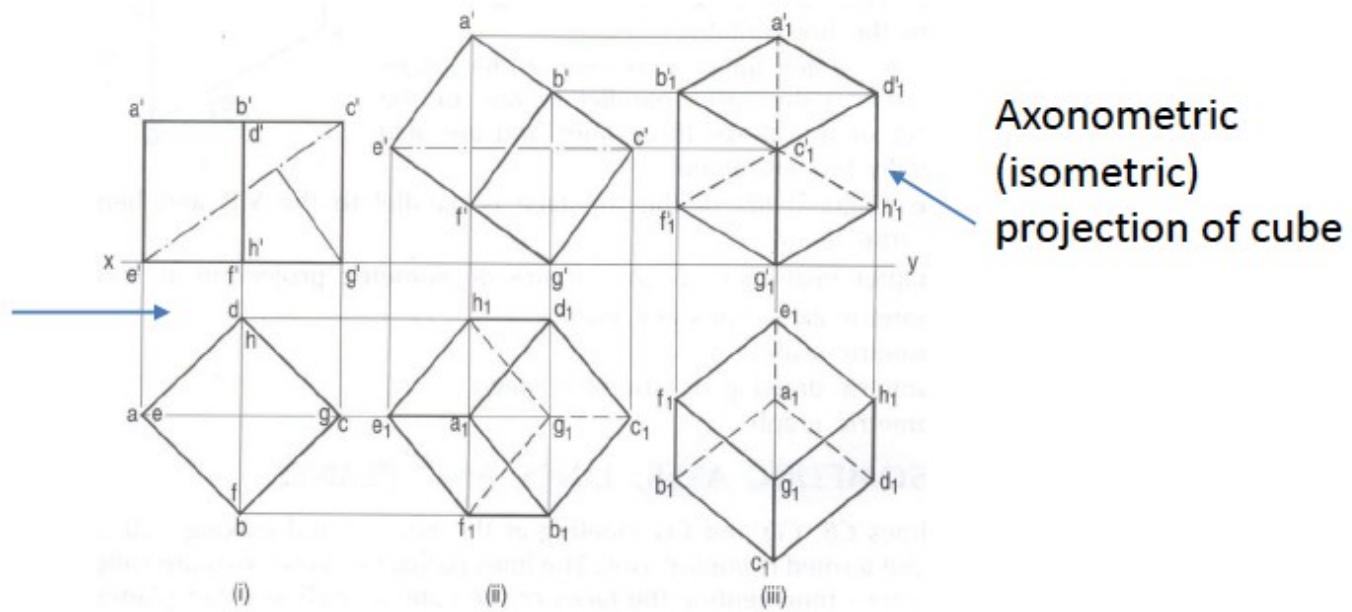
In **dimetric projection**, the direction of viewing is such that two of the three axes of space appear equally foreshortened

In **isometric projection**, the direction of viewing is such that the three axes of space appear equally foreshortened, and there is a common angle of 120° between them.

Axonometric Projections

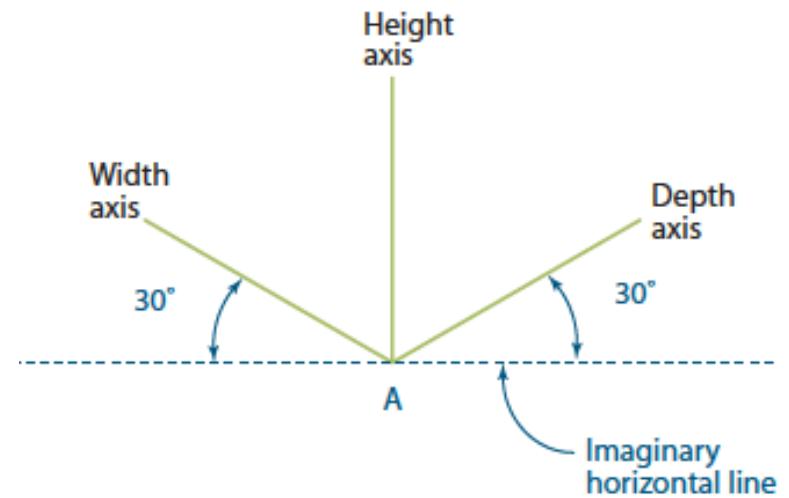
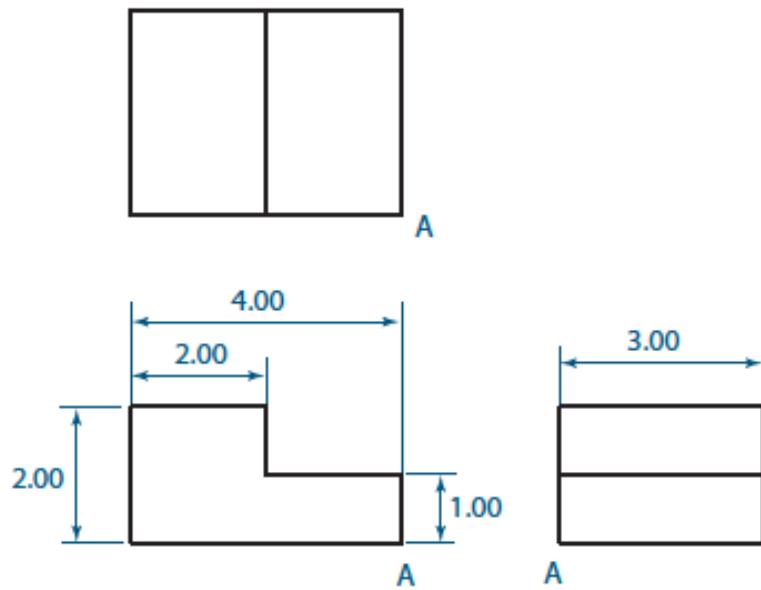
Before projecting the object onto V.P./H.P., if it is rotated about X/Y/Z axes by some arbitrary angle(s), more details of the object become visible as 2 or 3 faces of its bounding cube becomes visible. Such an **orthographic view** preceded by the rotation(s) of the object is called **axonometric projection**. It is a pictorial view as it looks like a 3D view of the object.

Orthographic
Projection of Cube



To draw the projections of a cube of 25 mm long edges resting on the ground on one of its corners with a solid diagonal perpendicular to the V.P., assume the cube to be resting on one of its faces on the ground with a solid diagonal parallel to the V.P.

Isometric drawing/view of a step block



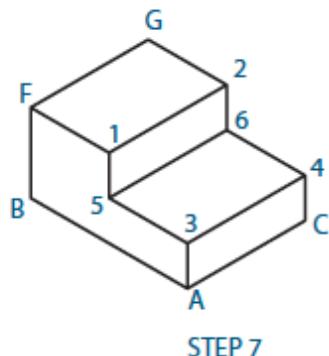
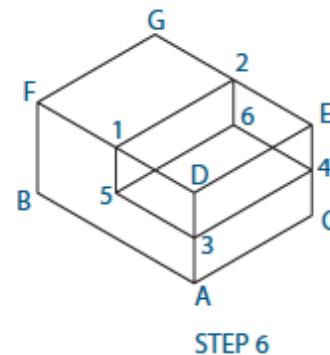
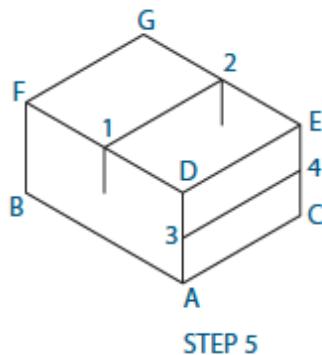
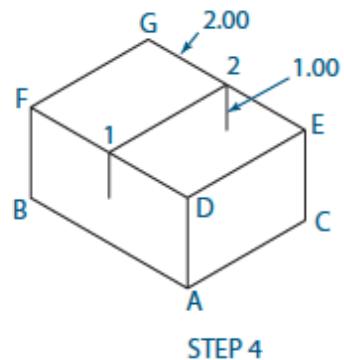
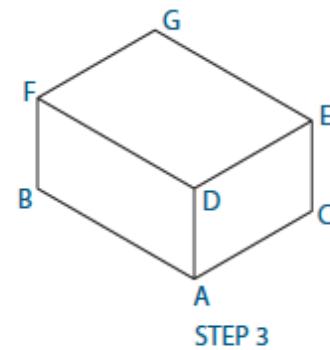
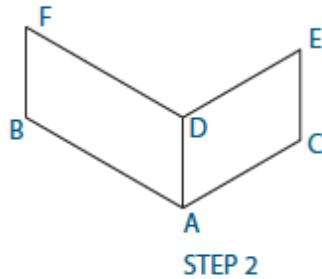
Orthographic views

Isometric axes

Isometric drawing of a step block

Width 4.00 Height 2.00 Depth 3.00

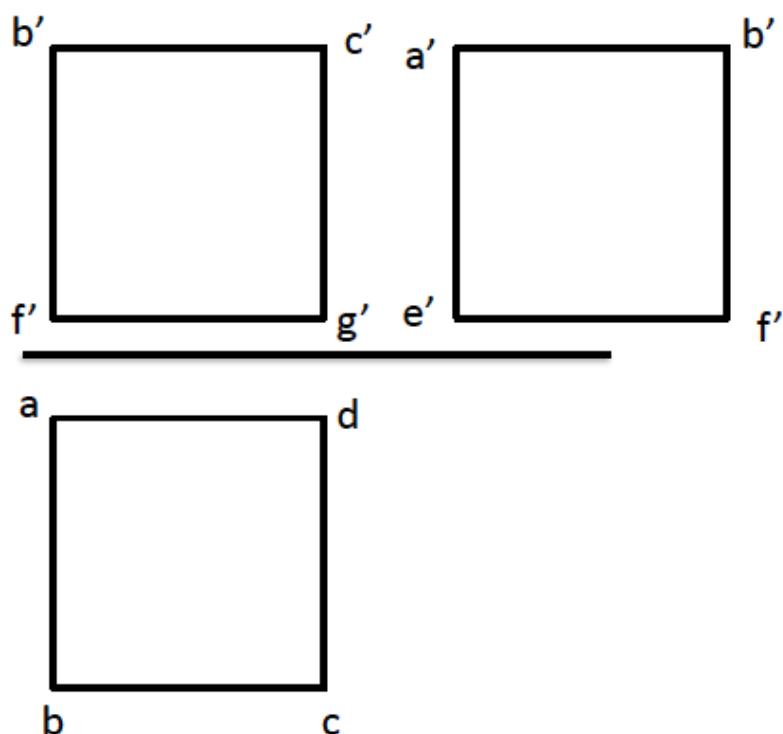
STEP 1



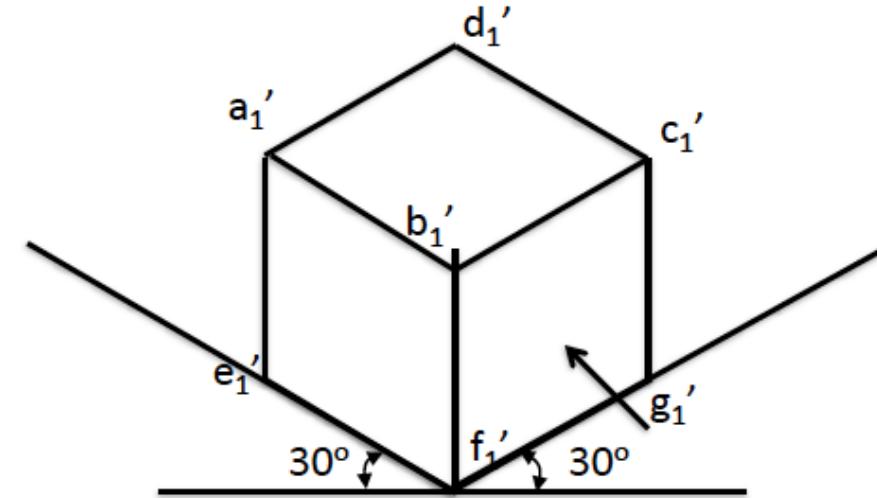
Projection of a Cube

Draw the orthographic and the isometric projections of a cube with base parallel to the XY plane and two adjacent faces parallel to the coordinate planes XZ and YZ. The direction of viewing is normal to the XZ plane

Orthographic projection of a Cube



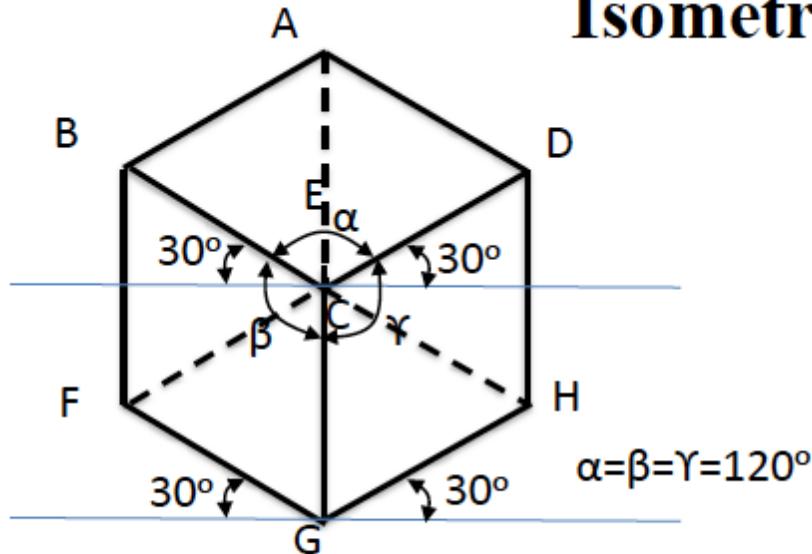
Isometric projection of a Cube



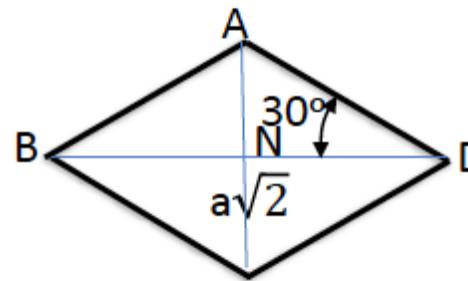
The length of all the sides which were parallel to the co-ordinate axes has decreased (foreshortened) equally

An isometric projection of a cube is found by constructing a view where a solid diagonal of the cube appears as a point

Isometric Projection



- The front edges - CB, CD and CG are called isometric axes
- CG is for height, CD is for length (width) and CB is for width (length)
- The three faces seen in the isometric projections are the same faces that will be seen in normal orthographic projections: top, front & side
- Lines parallel to the isometric axes are called isometric lines
- Planes representing the faces of the cube and planes parallel to them are called isometric planes
- The angles between the projections of these axes is equal (hence isometric) and is 120°
- 90° of the cube appear as either 60° or 120°



$$\cos(30) = \frac{l(BN)}{l(AB)}$$

$$l(AB) = \sqrt{\frac{2}{3}} \cdot a$$

The projected length of an isometric line is $\sqrt{2/3}$ times the true length of the line

Lines which are not parallel to the isometric axis are called non-isometric lines

Non-isometric lines are not shortened in any fixed ratio

Measurements should always be made on isometric lines and isometric axes only

Non-isometric lines are drawn by locating the position of their extremities on isometric planes and then connecting them

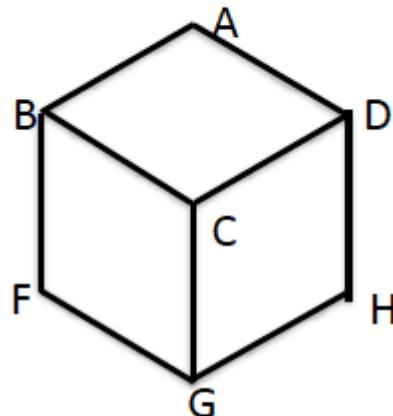
Isometric Drawing

In isometric projection, the projected length of an isometric line is $\sqrt{2/3}$ times the true length of the line

If the decrease (foreshortening) of the line is disregarded and the line is shown with its true length, we get **isometric drawing or an isometric view**

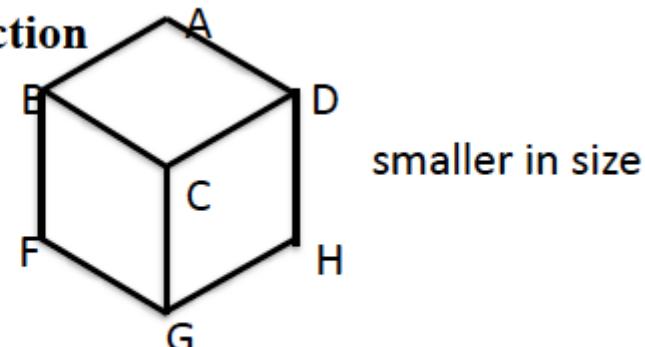
Due to ease of construction and the fact that dimensions can be directly measured from the drawing, the general practice is to use the true length instead of the isometric scale

Isometric view



original size

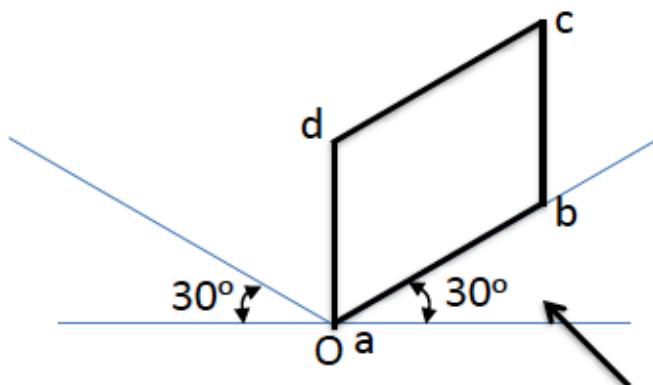
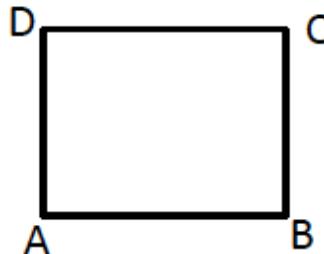
Isometric projection



- In an isometric view, for a rectangular solid resting on the H.P. each horizontal face will have its sides parallel to the sloping axes – CD and CB
- Each vertical face will have its vertical sides parallel to the vertical axis CG and the other sides parallel to one of the sloping axis
- In an isometric drawing, vertical edges are shown as vertical lines and horizontal edges are shown as lines making 30° with the horizontal

Isometric Drawing of a Plane

Front view of a plane which is parallel to the V.P. is shown below. Draw its isometric view

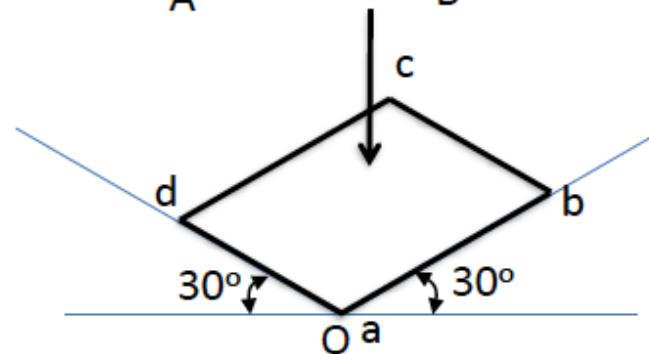
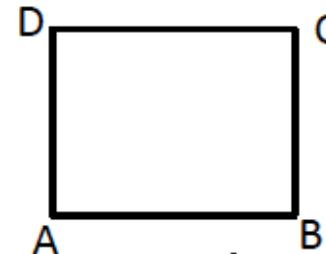


$$l(AB) = l(ab), \quad l(BC) = l(bc), \\ l(DC) = l(dc), \quad l(AD) = l(ad)$$

measurements in the horizontal and the vertical directions in the front view are perpendicular to the P.P. and the H.P., respectively

measurements in the horizontal and the vertical directions in the top view are perpendicular to the P.P. and the V.P., respectively

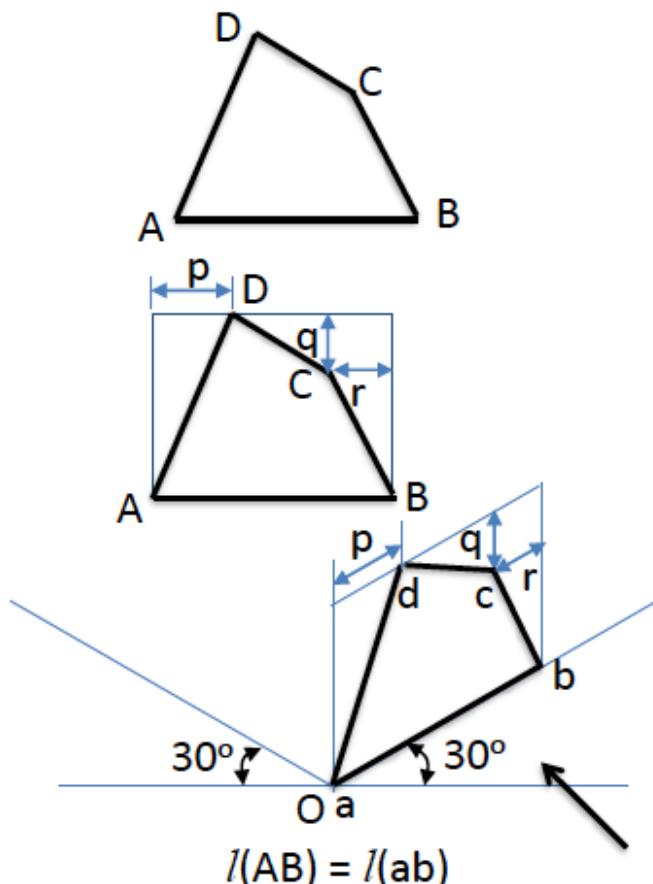
Top view of a plane which is parallel to the H.P. is shown below. Draw its isometric view



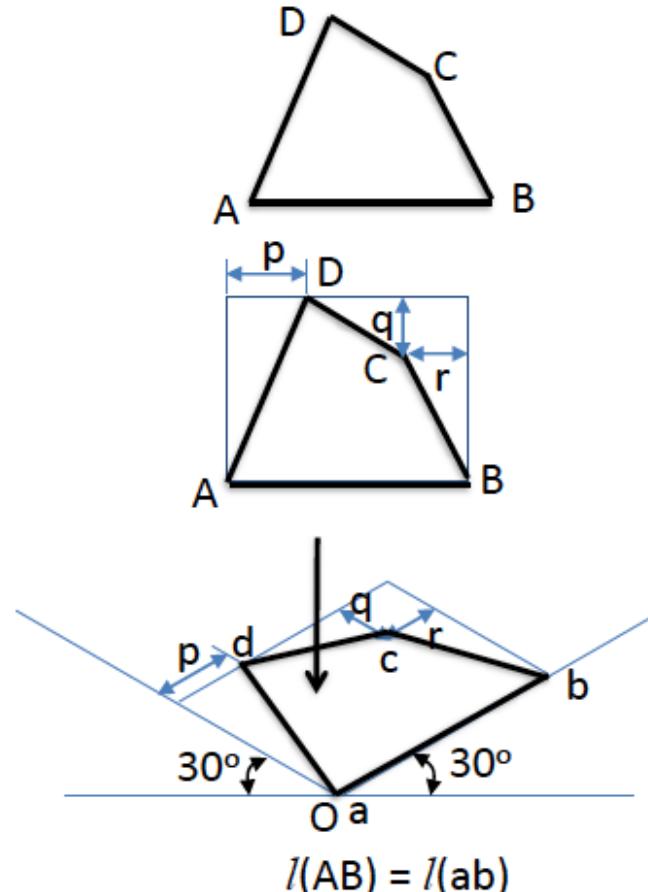
$$l(AB) = l(ab), \quad l(BC) = l(bc), \\ l(DC) = l(dc), \quad l(AD) = l(ad)$$

Isometric Drawing of a Plane with Sides not Parallel to the Coordinate Axes

Front view of a plane which is parallel to the V.P. is shown below. Draw its isometric view



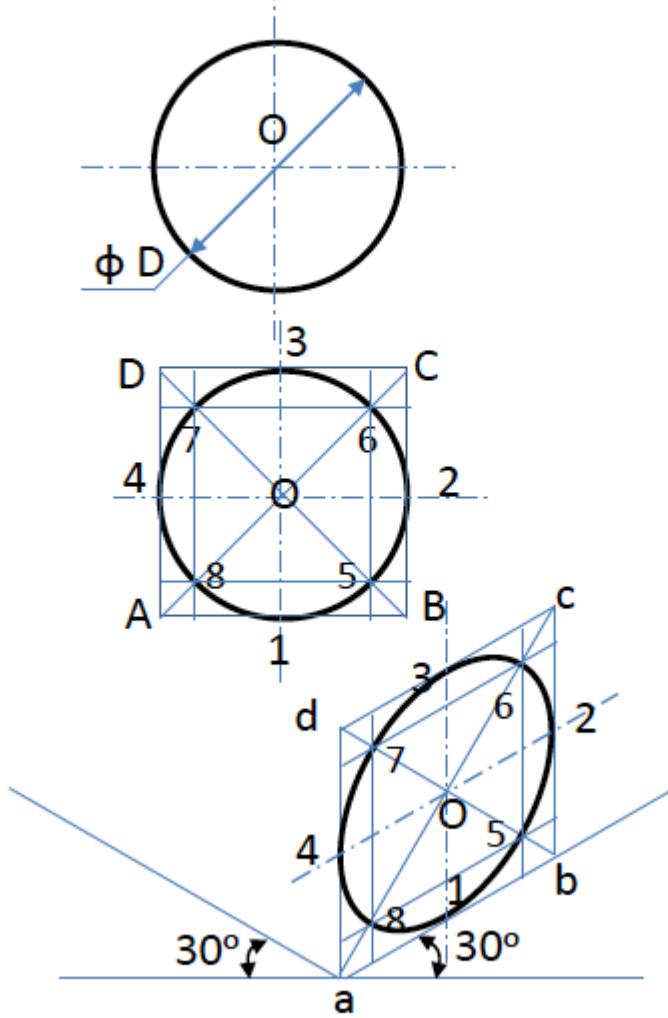
Top view of a plane which is parallel to the H.P. is shown below. Draw its isometric view



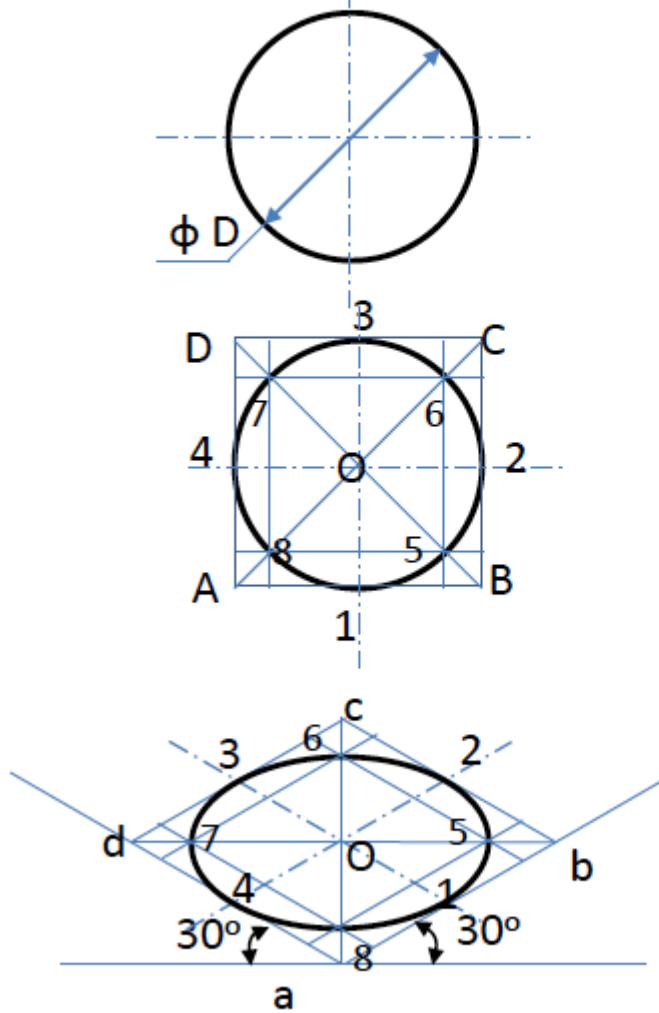
Non-isometric lines are drawn by locating the position of their extremities on isometric planes and then connecting them

Isometric Drawing of a Circle

Front view of a circle which is parallel to the V.P. is shown below. Draw its isometric view



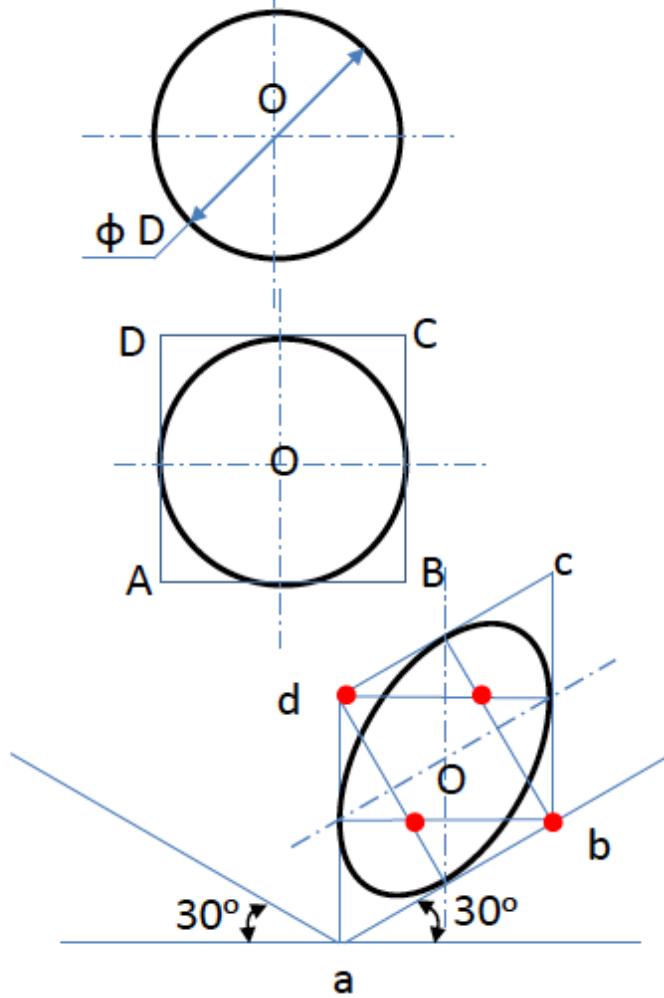
Top view of a circle which is parallel to the H.P. is shown below. Draw its isometric view



The length of the major axis is greater than the true diameter of the circle

Isometric Drawing of a Circle – Four Center Method

Front view of a circle which is parallel to the V.P. is shown below. Draw its isometric view



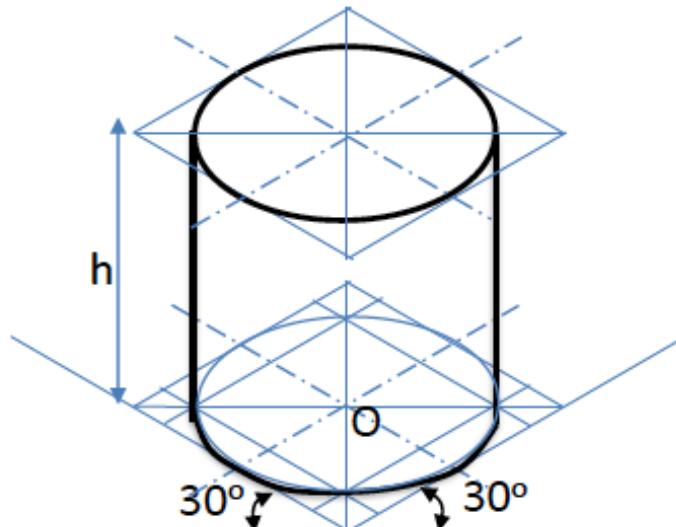
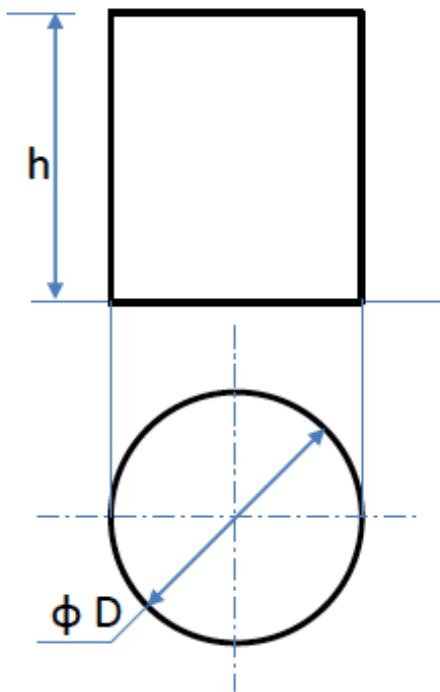
Four center method

The ellipse is assumed to be made up of arcs of four circles

- Assume that a square circumscribes the circle in the orthographic projection
- In the isometric view, the square becomes a rhombus and the circle becomes an ellipse which is tangent to the rhombus at the midpoints of the sides
- Draw the bisectors of the sides of the rhombus
- The points of intersection of the four bisectors are centers of the arcs of the center (red dots)
- The two centers that lie at the corner of the rhombus are centers of the larger arcs, while the remaining intersections are centers of the smaller arcs

Isometric Drawing of a Cylinder

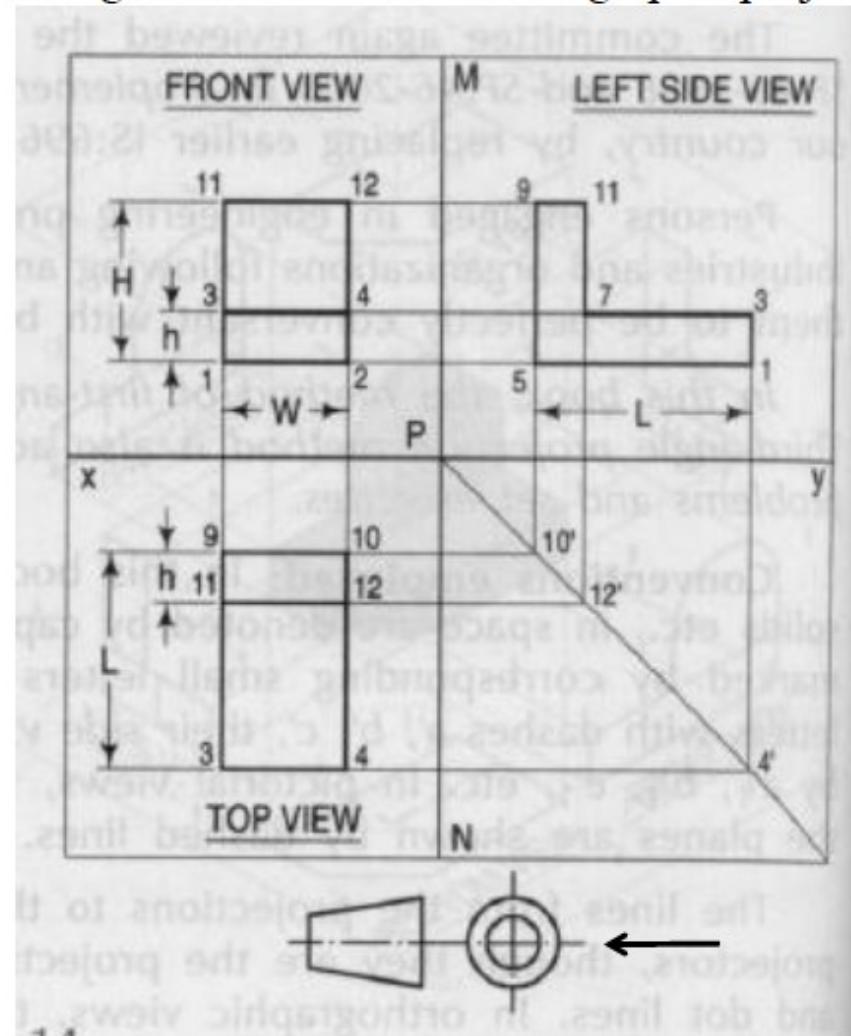
The front and the top view of a cylinder which is resting on the H.P. is shown below.
Draw its isometric view



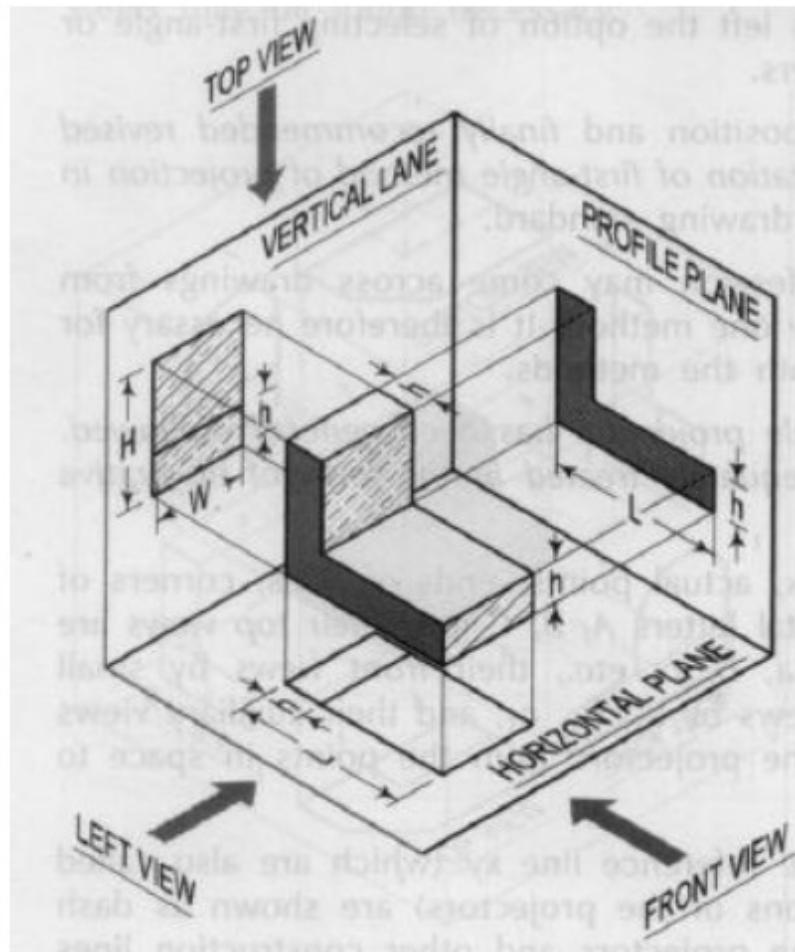
Hidden lines are not shown in isometric views

Isometric Drawing of a Typical Solid - Problem

Draw the isometric drawing of the solid whose orthographic projection is as shown below

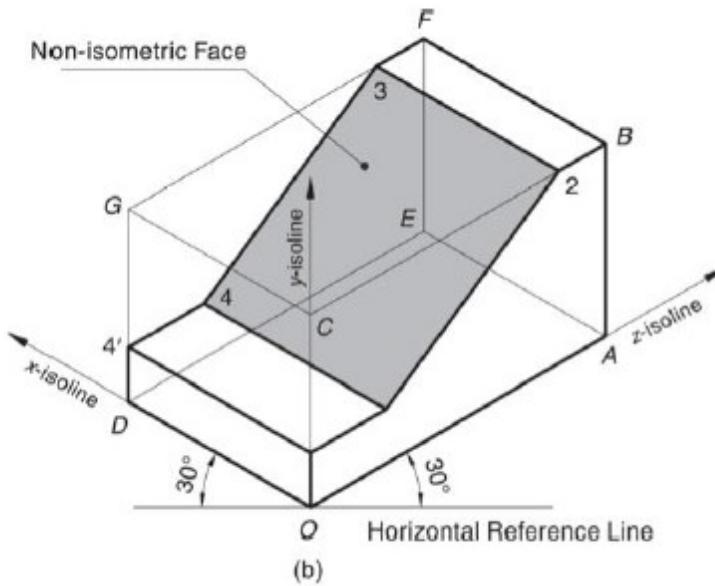
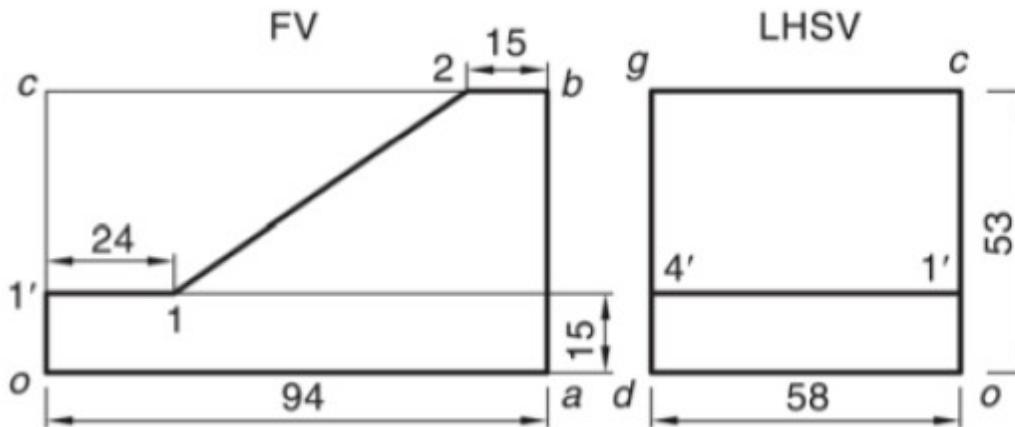


Isometric Drawing of a Typical Solid - Solution

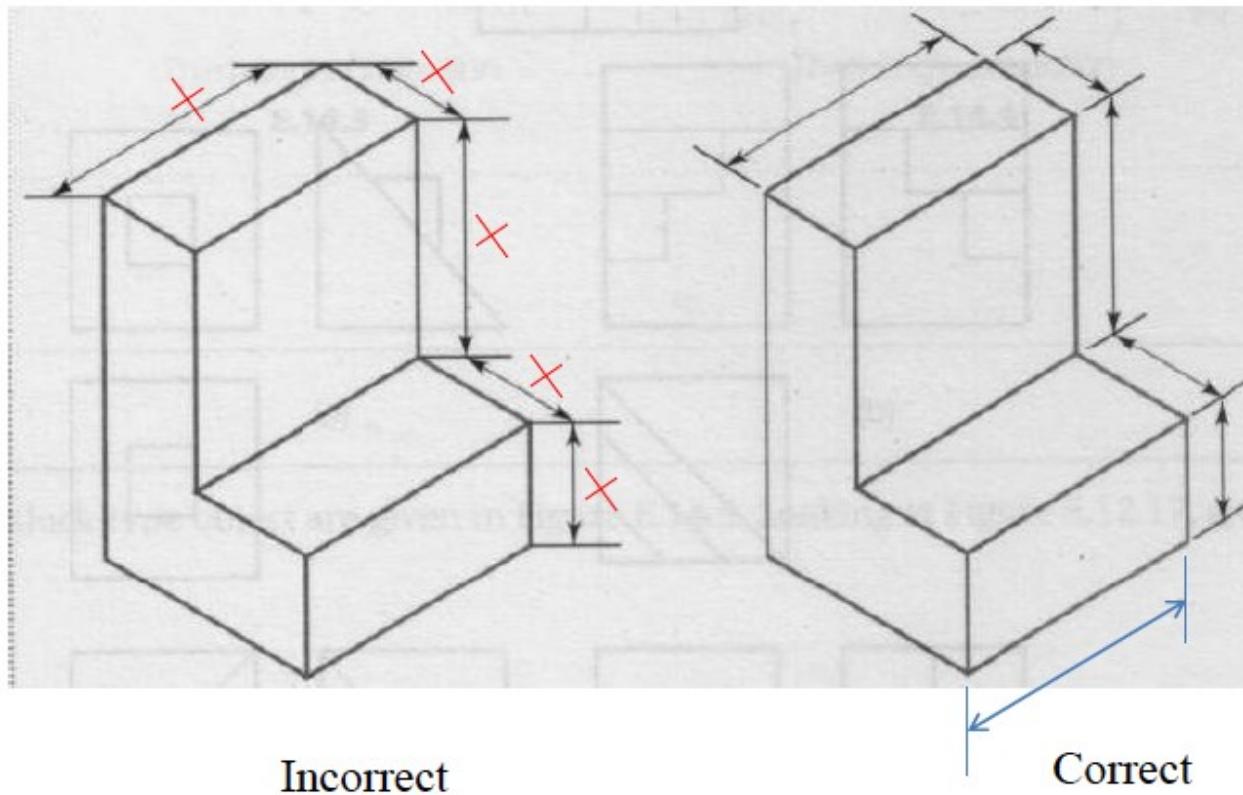


Isometric Drawing of a Typical Solid

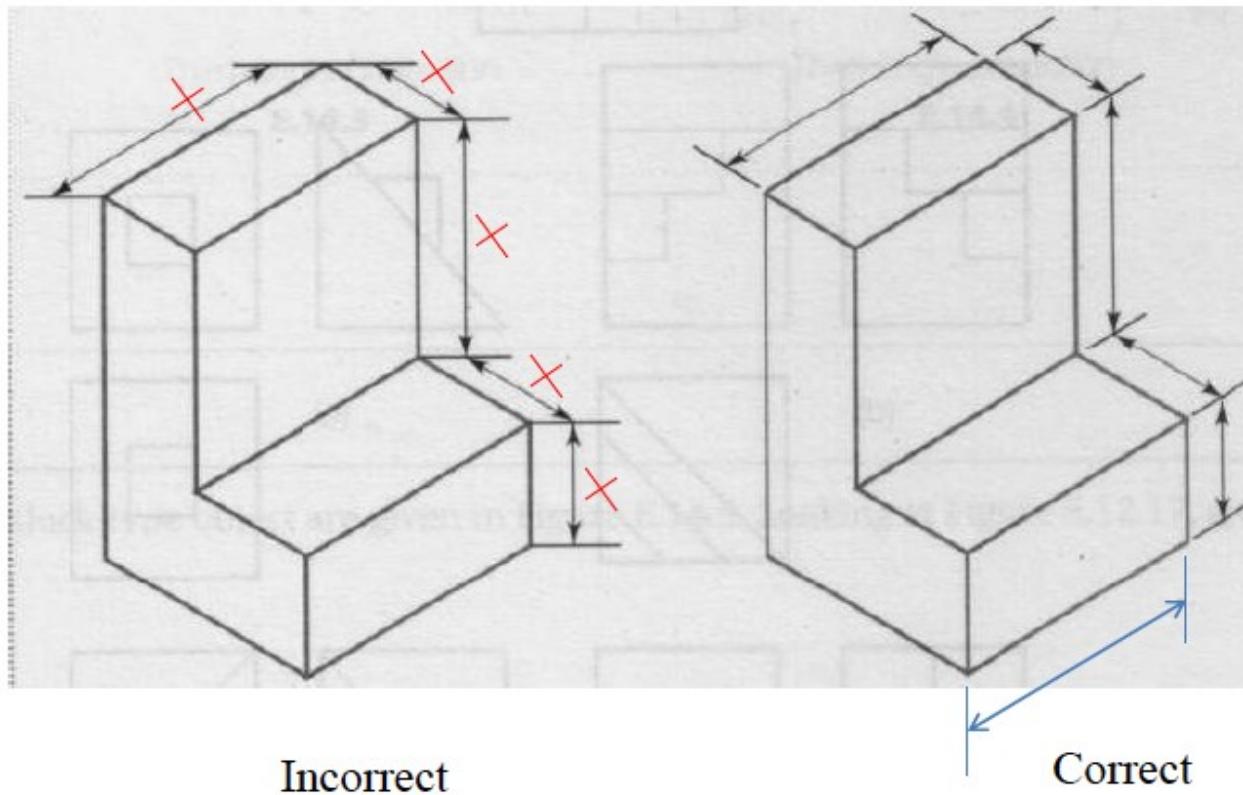
Draw the isometric drawing of the solid whose orthographic projection is as shown below



Dimensioning of Isometric Views

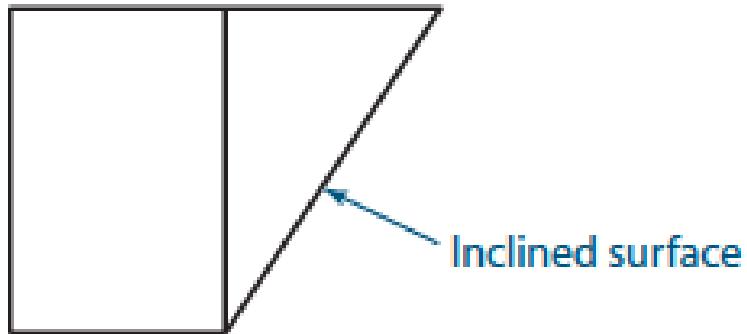


Dimensioning of Isometric Views

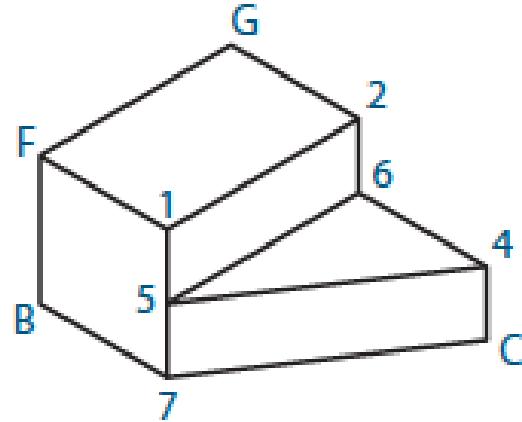


Auxiliary Views

To show inclined surfaces in true shape and size

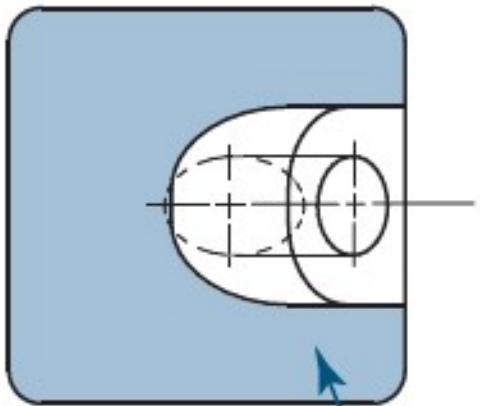


Top view

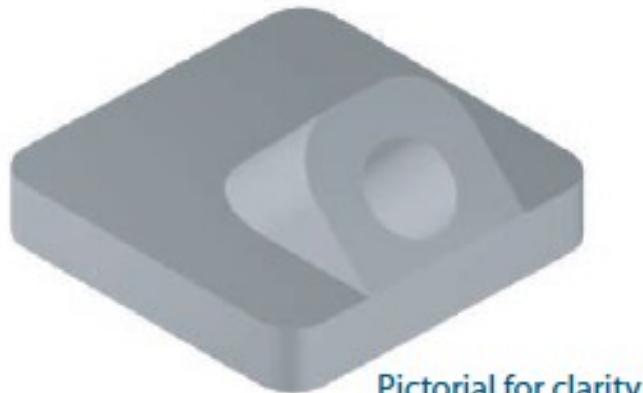


Isometric view

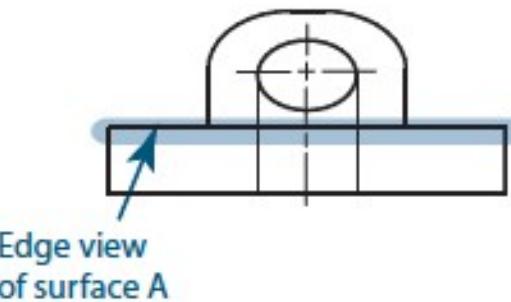
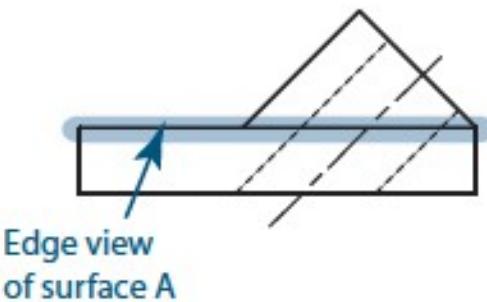
An object with an inclined surface: First angle



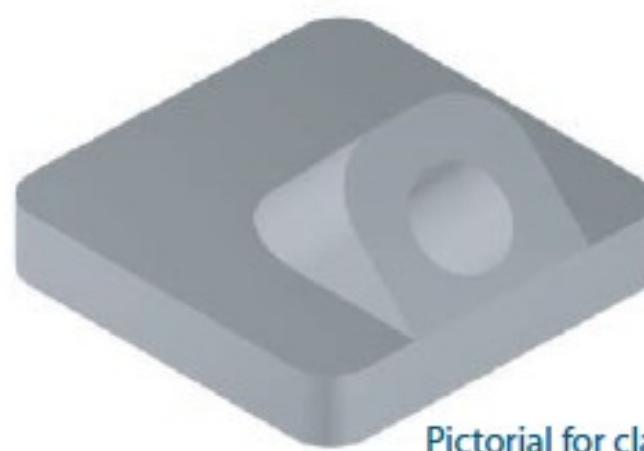
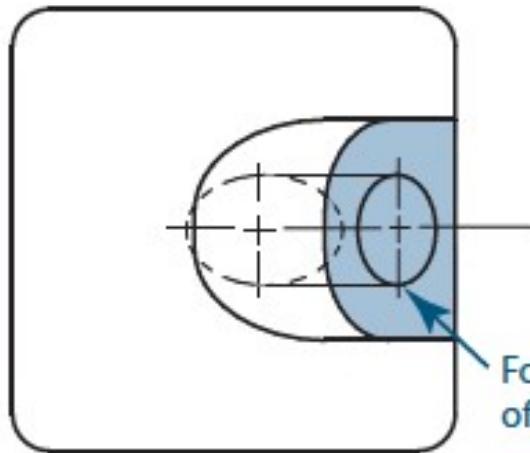
For surface A, true shape in top view



Pictorial for clarity

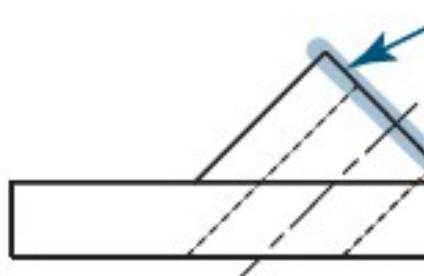


An object with an inclined surface: First angle

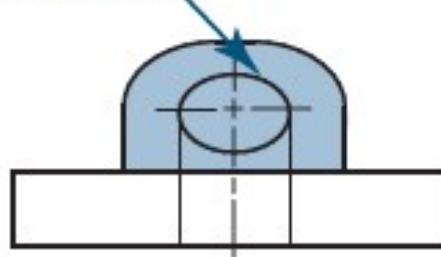


Pictorial for clarity

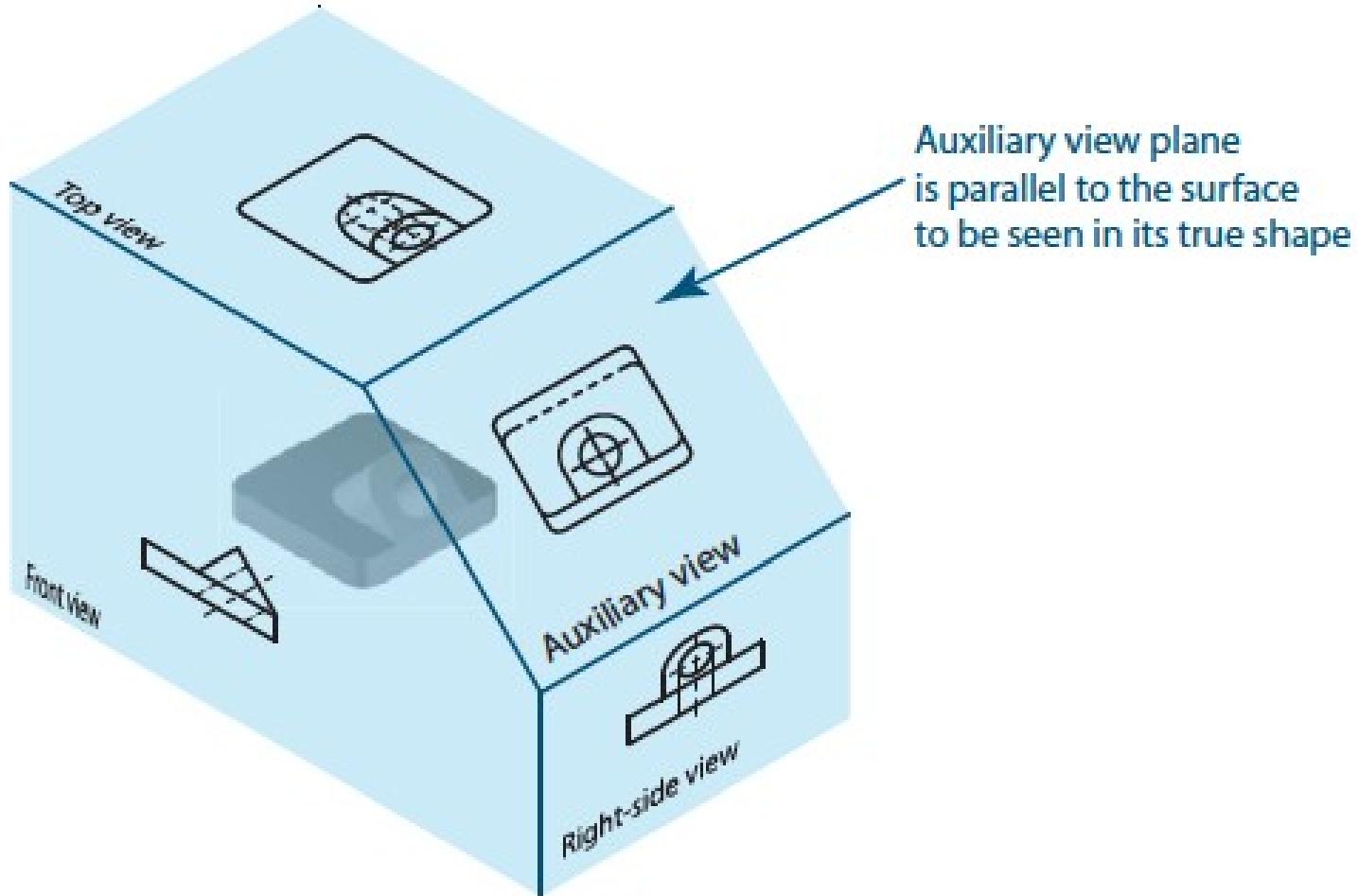
For surface B, true shape in neither top nor right view



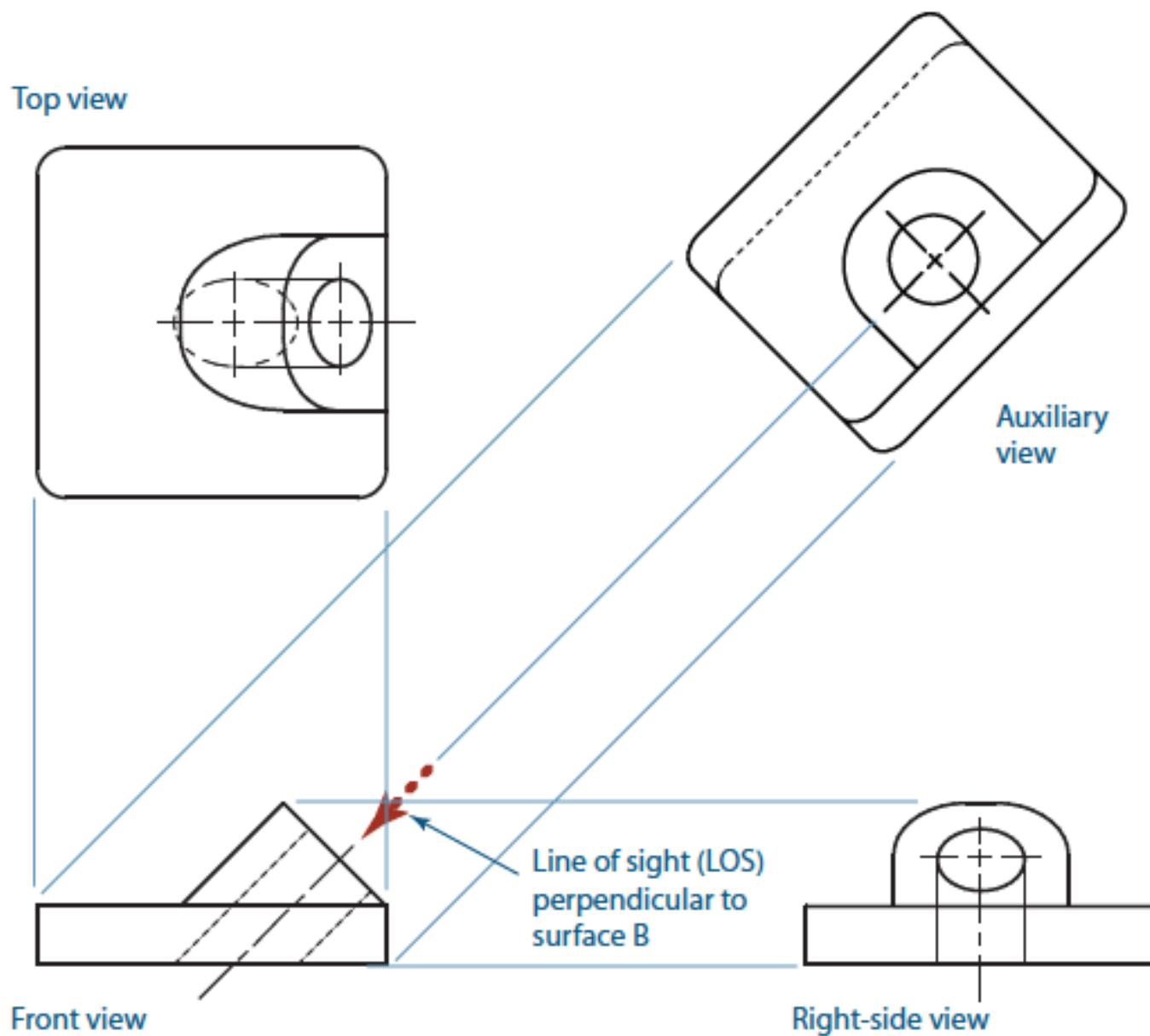
Foreshortened view
of surface B



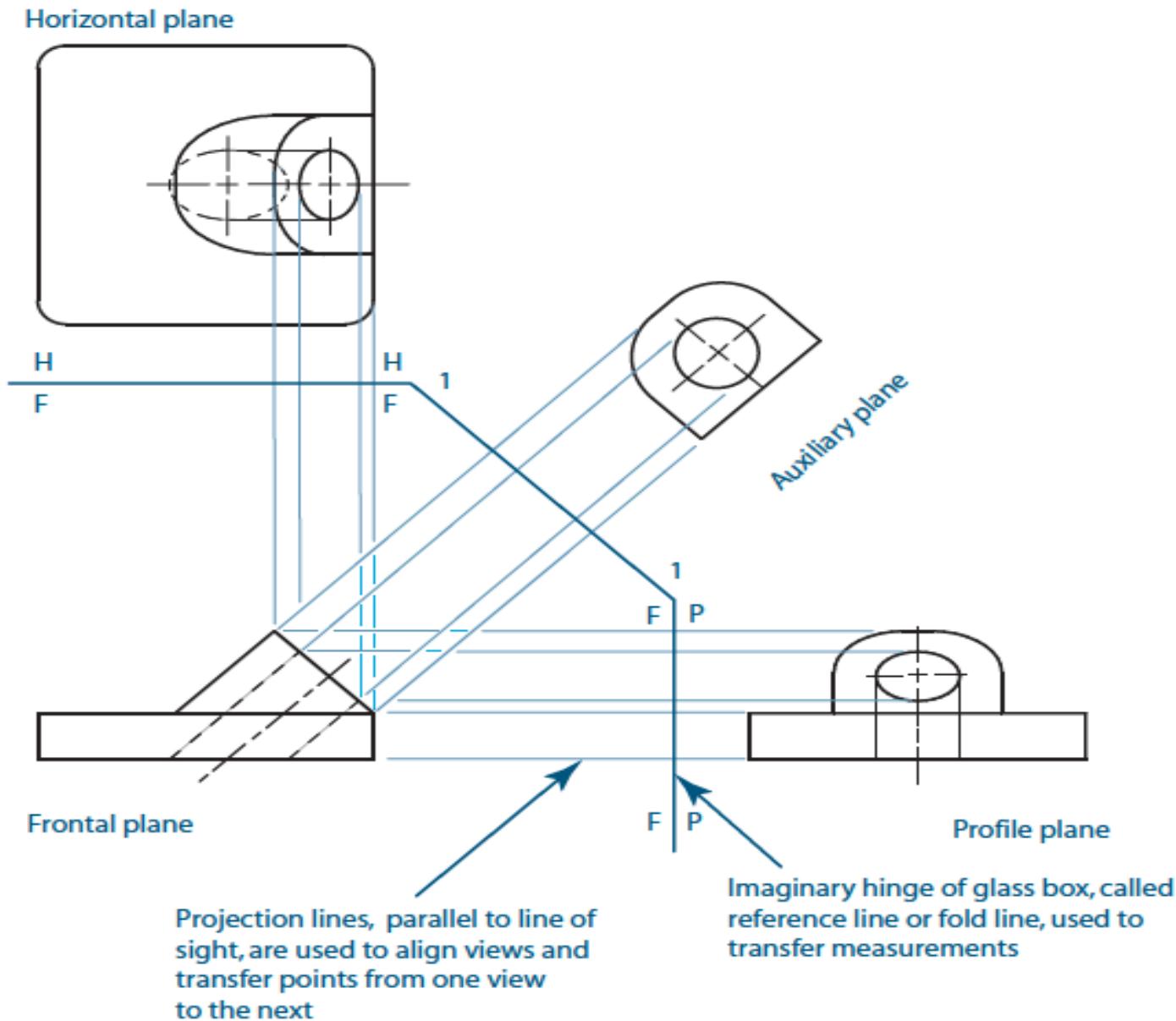
Solution: Make a view plane parallel to inclined surface



Unfold the glass box to see all views

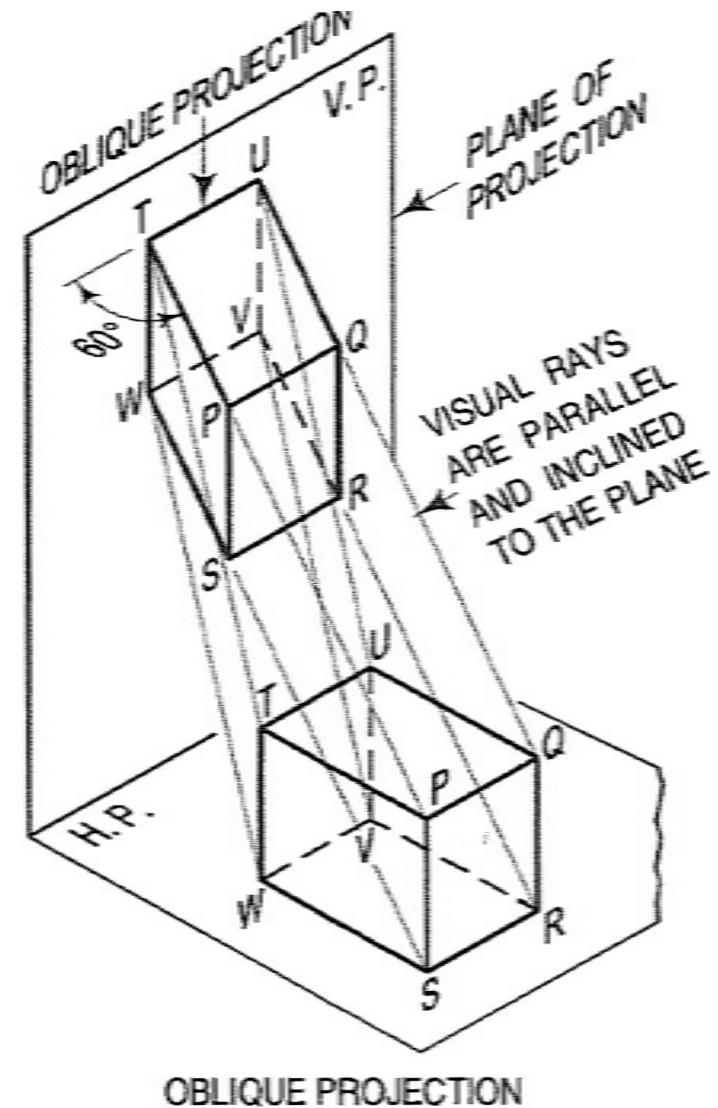
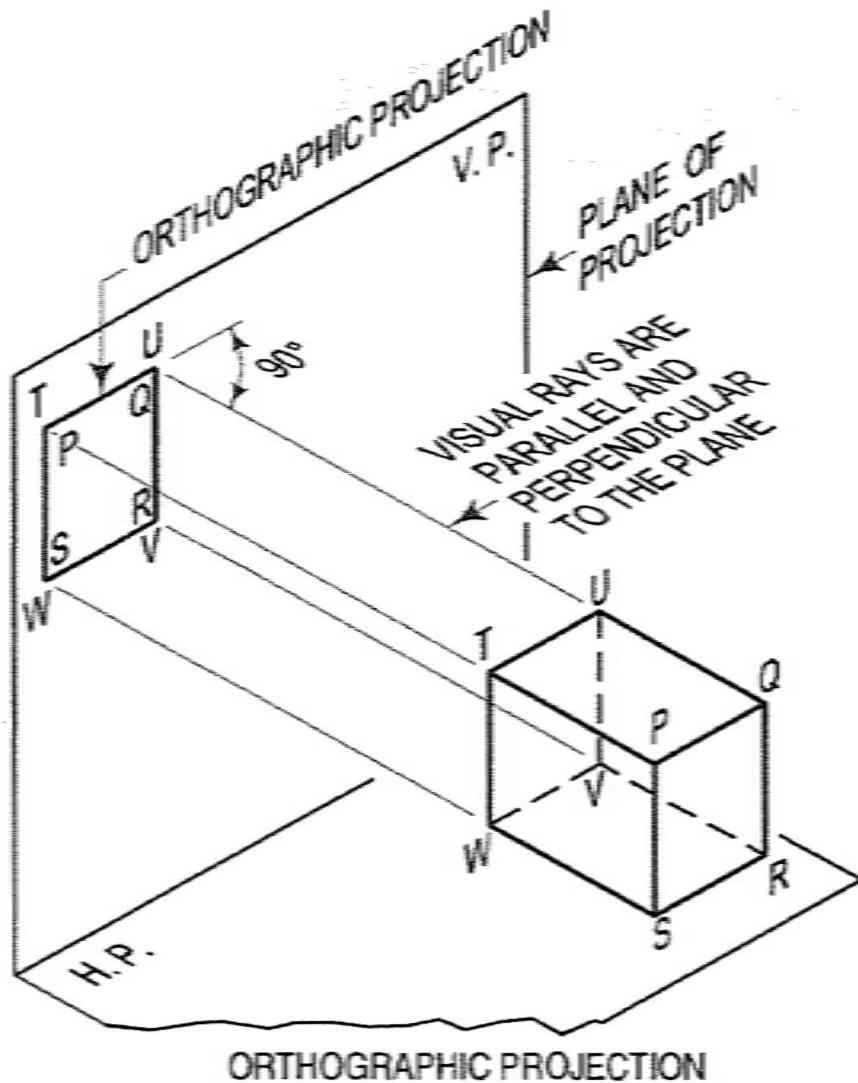


Name the planes



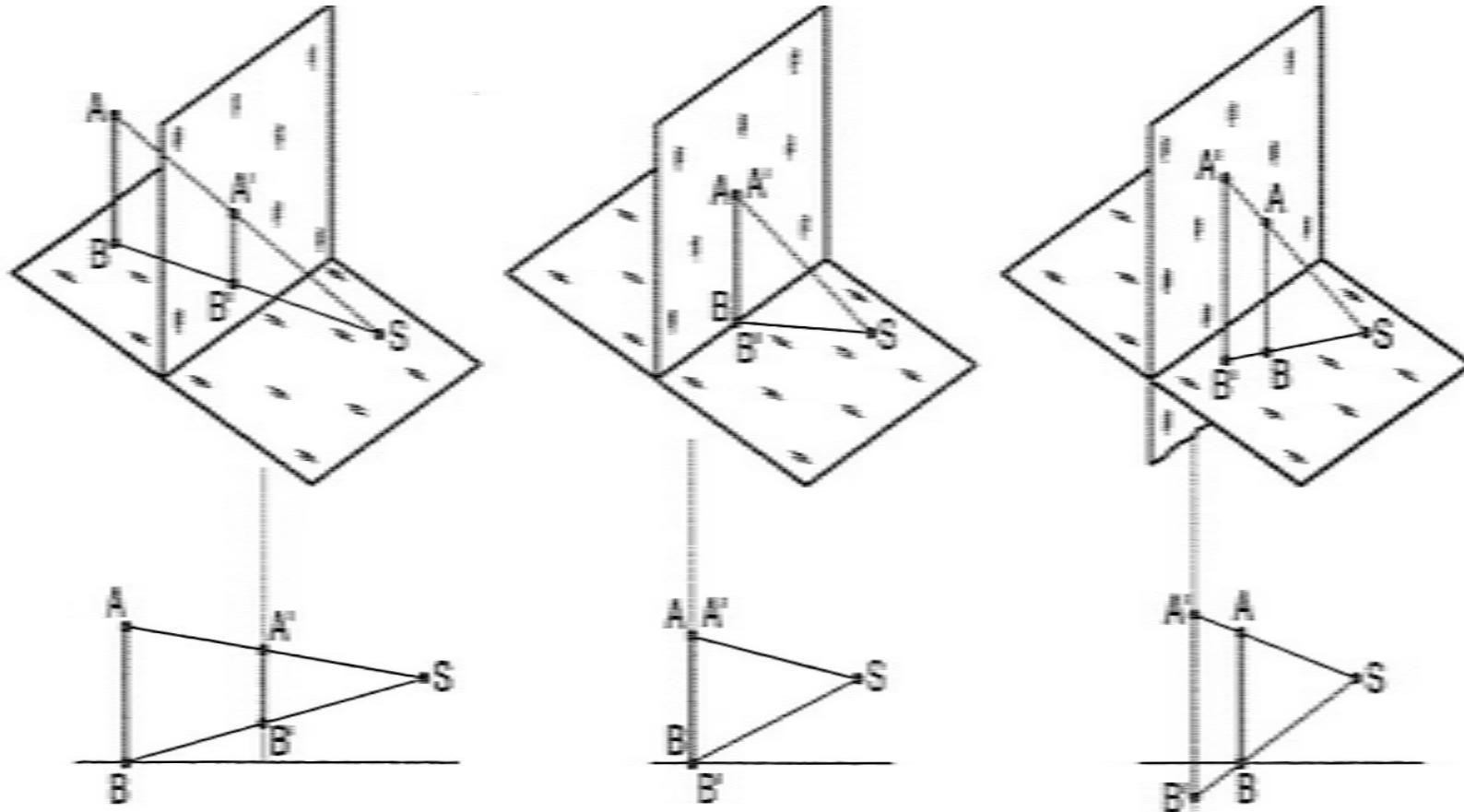
Oblique Projection

- Observer looks towards an object from infinity
- Third axis inclined at an angle 30, 45 or 60 degrees w.r.t two perpendicular axes.



Perspective Projection

- Representation of an object on a plane surface (vertical plane) as the eye from a fixed position (**definite position relative to object**) would view



Thank you