Teaching Aids Required for this Sheet

(The RA should bring them to the class)

- A pair of hinged rectangular acrylic plates; this can be used to denote the quadrants.
- Wooden blocks of various geometries. Students may be asked to draw their orthographic views.

ME119: Engineering Drawing & Graphics

2. Orthographic Projections

Department of Mechanical Engineering
Indian Institute of Technology Bombay

Orthographic Projections

- Chapters 8 covers the details on Orthographic Projections.
- The more inquisitive ones can find the mathematical fundamentals of various projections in Chapters 2 and 3 of “Roger D.F. and Adams J.A., 1990, Mathematical Elements of Computer Graphics, McGraw-Hill”.
- Roughly work out all the problems given to you.

Outline

- Need for projections
- Types of projections
- Orthographic projections

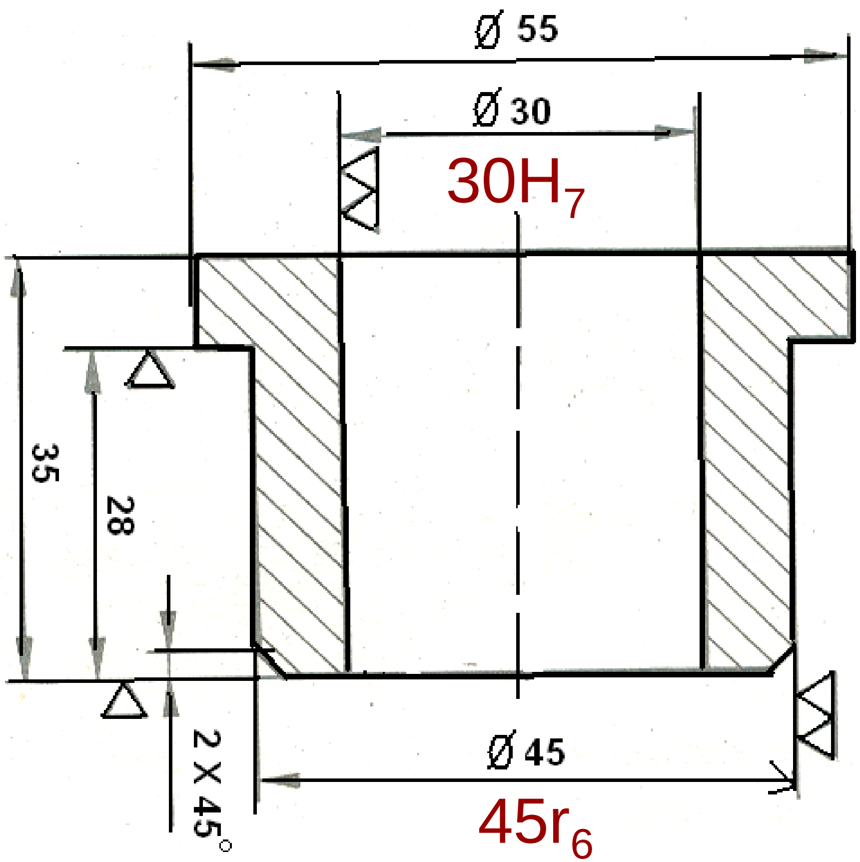
Projections

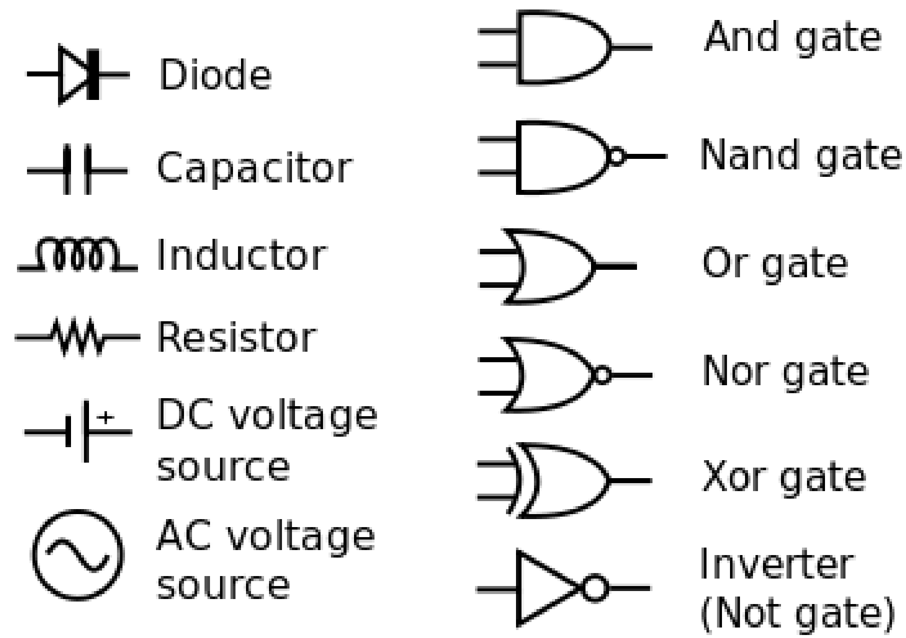
- The need for capturing, storing and communicating any information (message, poetry, sculptures, 3D design, …) needs no emphasis.
- We perceive objects through 5 senses but we seem to use only the sense of vision extensively. We try to capture other senses also through sense of vision. Example: We are trying to capture sense of sound through sense of vision, that too in 2D, as language scripts and musical notations. So, we need to know the limitations of the capturing so that we can account for it.
- This is because, the media available for capturing is only a surface, which is often planar. So, the capture is never perfect (Real, photorealistic, color, 3D, matrix, motion,… → Virtual, lines, 2D, only boundary, static, …).

Projections …

- The surface on which we capture is not necessarily planar always; however, we shall deal with planes only (paper).
- The task in this course is to render 3D objects (3 parameters) onto a surface (2 parameters, 2D surface in this course; however, there are tools to render over a 3D surface too).
- Furthermore, in order to be easy, fast and account for the lack of artistic skills, we are constrained to use only line drawings and schematic diagrams, i.e., points and curves and not shades (gray levels) and colors. In other words, the views we use are only silhouettes (which are the borders of the object) and distinct edges.
- Due to these limitations, we may need more than one view to render an object completely. Often we use symbols and notations too. Eg.: Tolerances symbols & charts, surface finish, threads, ...

Projections …





Projections …

- Analogy with parametric representation: Just as it distributes the data in multiple equations, here the 3D data is distributed among multiple views.

$$x^2 + y^2 - 2ax - 2by + \left(a^2 + b^2 - r^2\right) = 0$$

$$\Rightarrow \left\{ \begin{array}{l} x(\theta) = a + r\cos\theta \\ y(\theta) = a + r\sin\theta \end{array} \right\}$$

- The following views constitute orthographic projections:

- Front (elevation), rear, top (plan), bottom, left & right side views
- Auxiliary views
- Sectional views
- Detailed views

- The two types of drawings are Component drawings and assembly drawings. Assemblies Bill of Materials (BOM) and may be depicted in exploded views.

Projections

The projection environment has the following

Light rays from the source(s) after reflection by the object get captured on the picture plane while moving towards the observer.

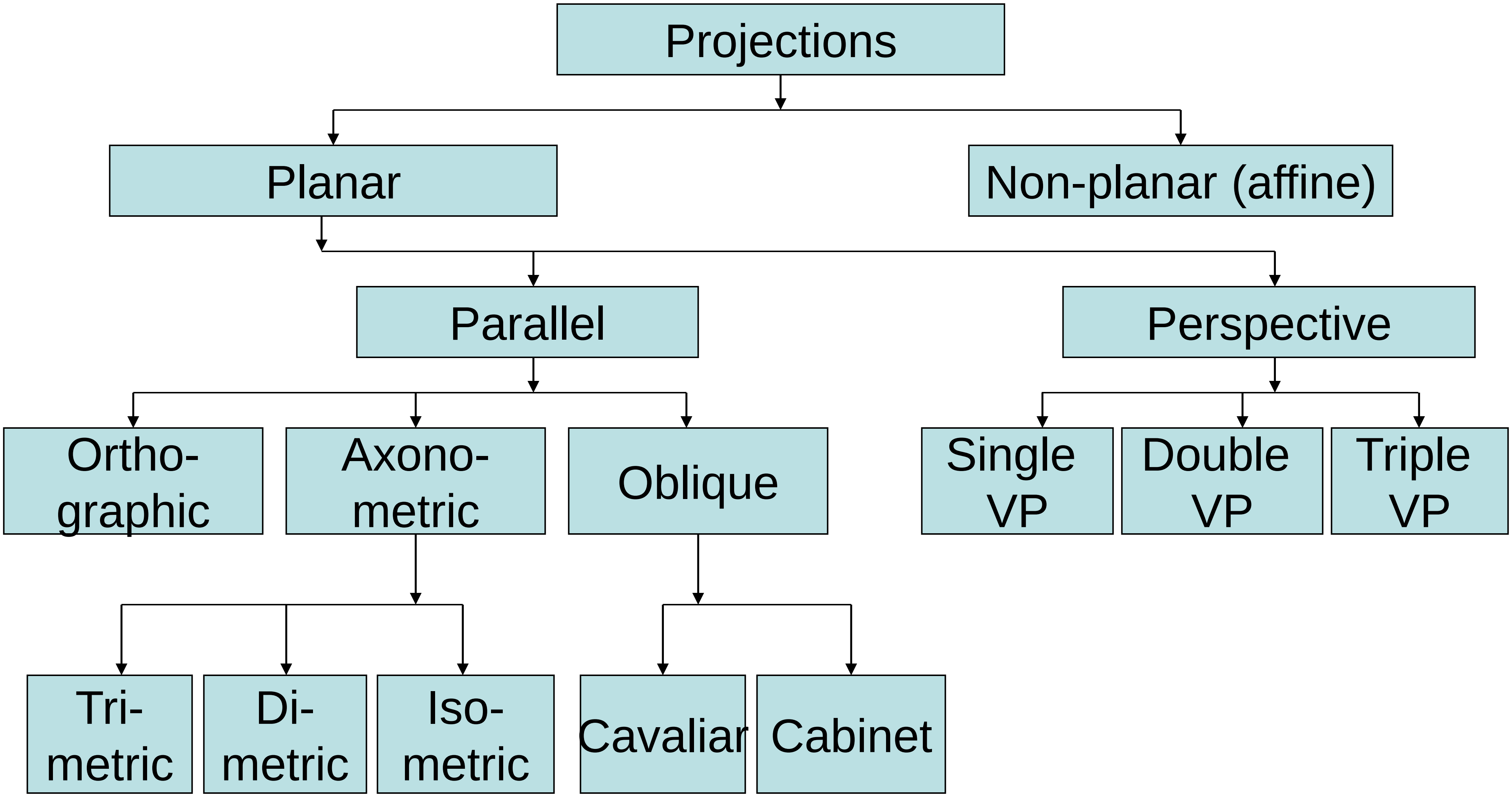
- Observer
- 3D object(s)
- Picture plane → projection surface/Plane: The surface on which the view is captured called projection surface, in our case, it is a projection plane.
- Light source(s) → Rays/ projectors: Rays emanating from the 3D object(s) called projection lines or projectors. The rays may emanate from a point (such as a bulb) and hence are divergent or may come from an infinite source and hence are parallel rays.
- View(s): Object captured on the surface as seen by the observer.

Projections

Elements influencing the view

- Relative positions of the observer and the object(s)
- Nature and number of light sources (pointed light, spot light, diffused light, …)
- Rays or projectors (parallel, converging)
- Projection surface (planar, non-planar)
- Relative orientation of the projection surface and projectors (orthogonal, oblique).

Types of Projections

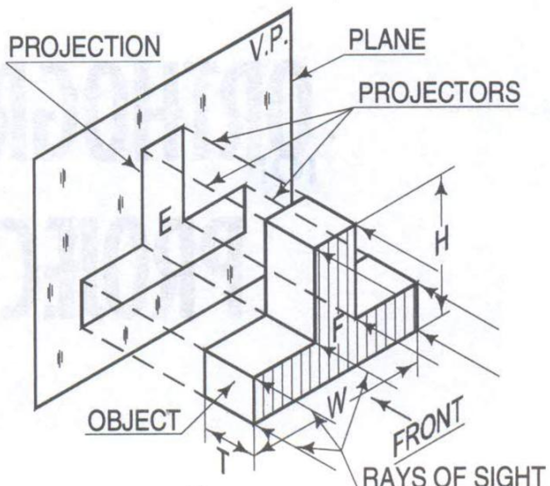


Types of Projections …

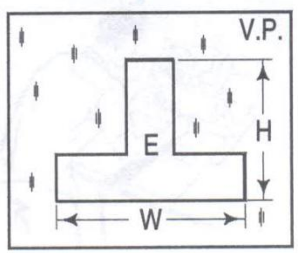
<table>
<tr><td>Orthographic projections</td><td>Multiple views (At least 2) on mutually perpendicular planes.</td><td rowspan="4">Parallel projectors; projection on plane; both orthogonal. Hypothetical!</td></tr>
<tr><td>Auxiliary projections</td><td>This too is orthographic. Views on any other plane in which the additional details are visible.</td></tr>
<tr><td>Sectional views</td><td>Cut-views to depict the interior features. This is mostly orthographic. However, the pictorial views also can use sectional views.</td></tr>
<tr><td>Iso-/ Di-/ Tri-metric projections</td><td>Pictorial; so, single view in general. Isometric view is also an orthographic view after rotating the object appropriately in two directions!</td></tr>
<tr><td>Oblique projections</td><td colspan="2">Parallel projectors; projection on plane; both not orthogonal. Hypothetical! Pictorial; so, single view in general.</td></tr>
<tr><td>Perspective projections</td><td colspan="2">Non-parallel projectors; projection on plane; both orthogonal. Real (3VP alone). Pictorial; so, single view in general.</td></tr>
<tr><td>Exploded views</td><td colspan="2">Depicts the order of assembly. Used in isometric view of assembly.</td></tr>
<tr><td>Affine projections</td><td colspan="2">Projection on non-planar surface. Real.</td></tr>
</table>

Orthographic Projections

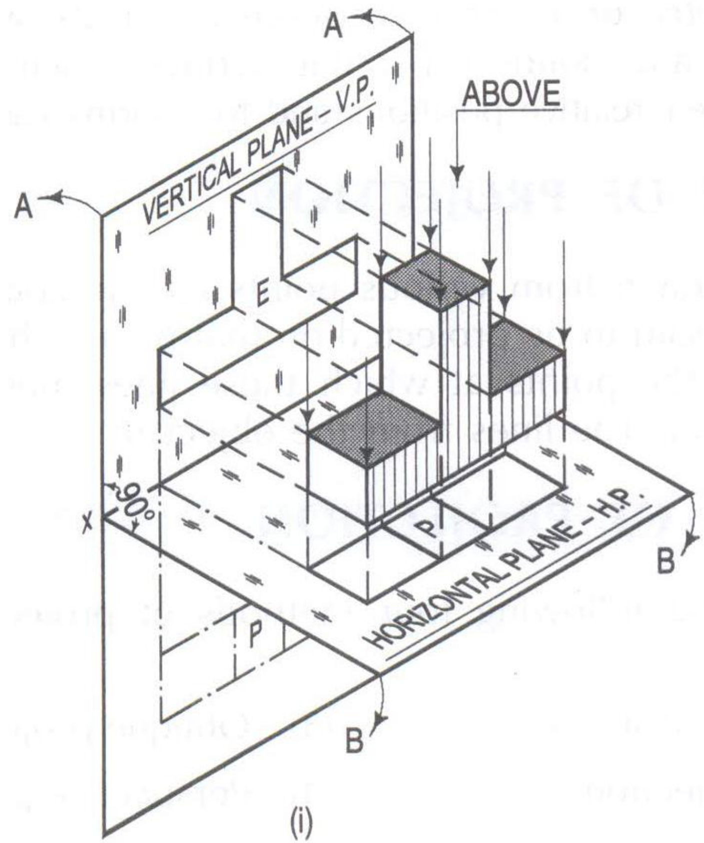
Parallel projectors; projection on plane; both orthogonal. Hypothetical!



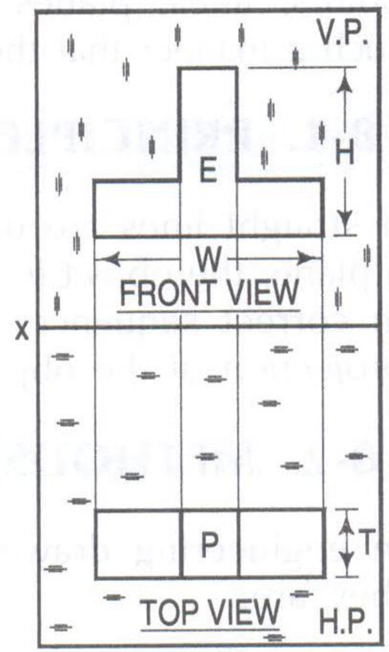
(i)



(ii)



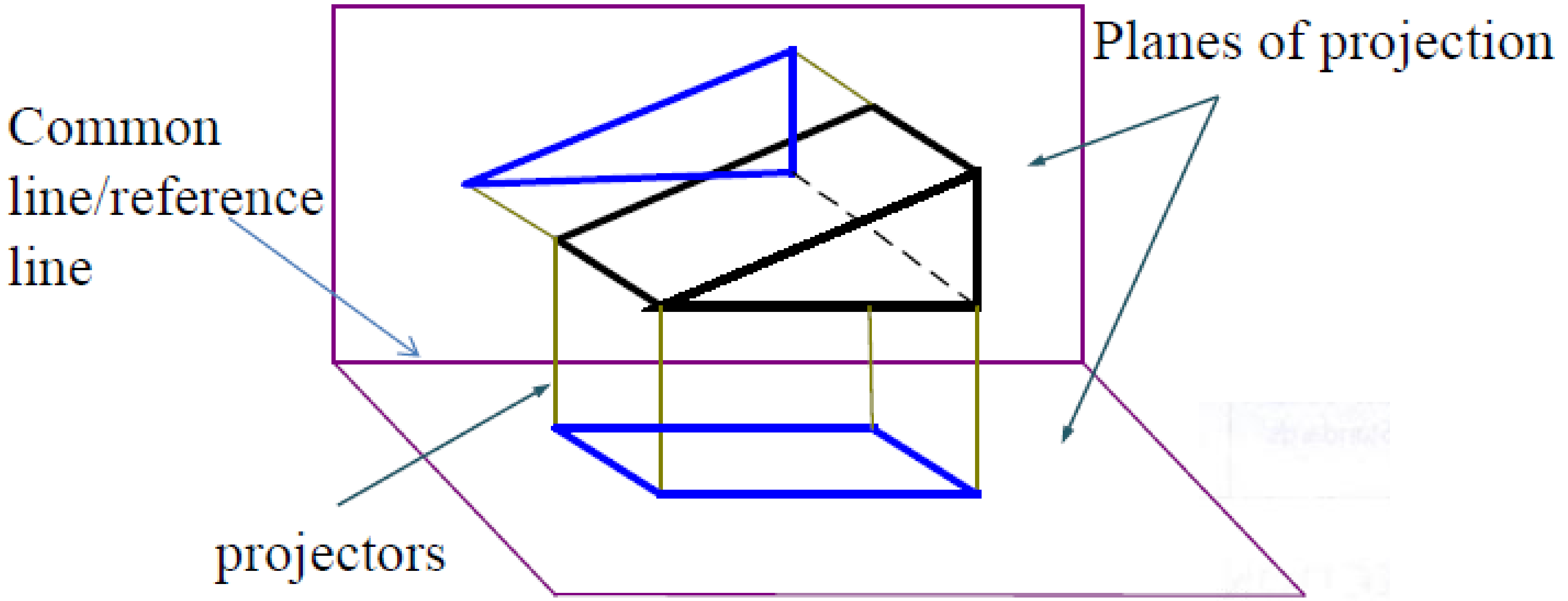
(i)



(ii)

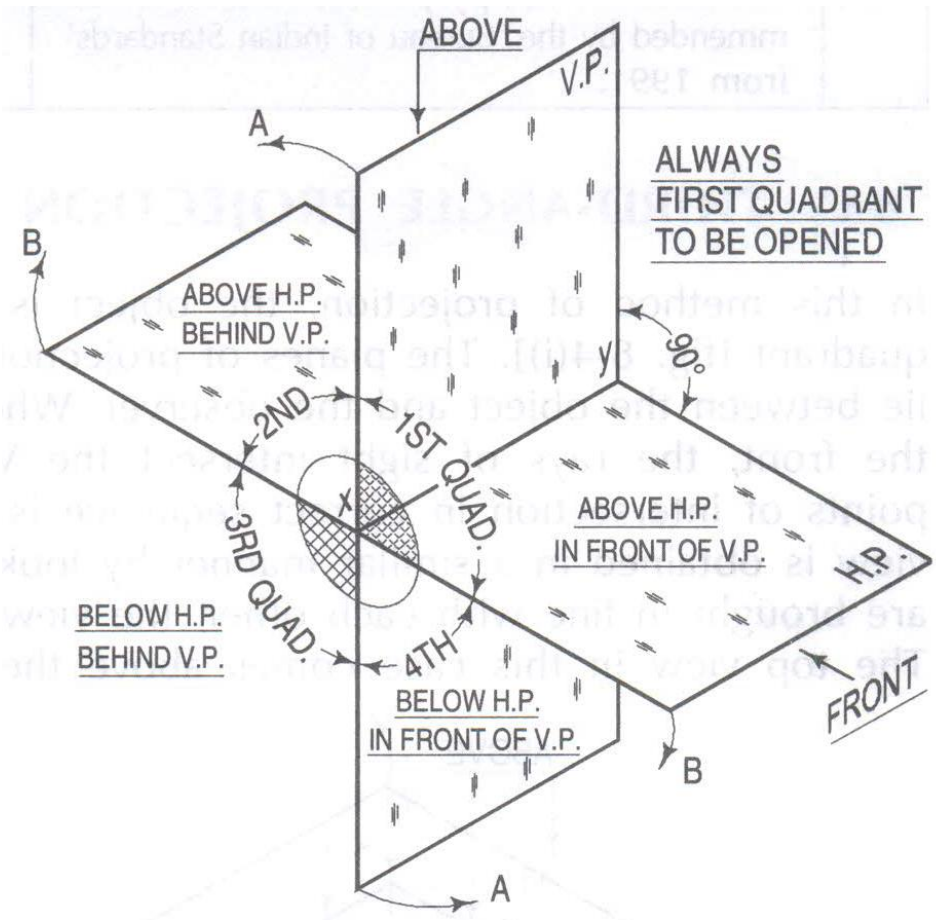
Single view does not capture all features. So, multiple views on mutually perpendicular planes are used. Even the simplest object of symmetry, viz., sphere, requires 2 views.

Orthographic Projections



Angles of Projections

Consider four quadrants in which object can be positioned.

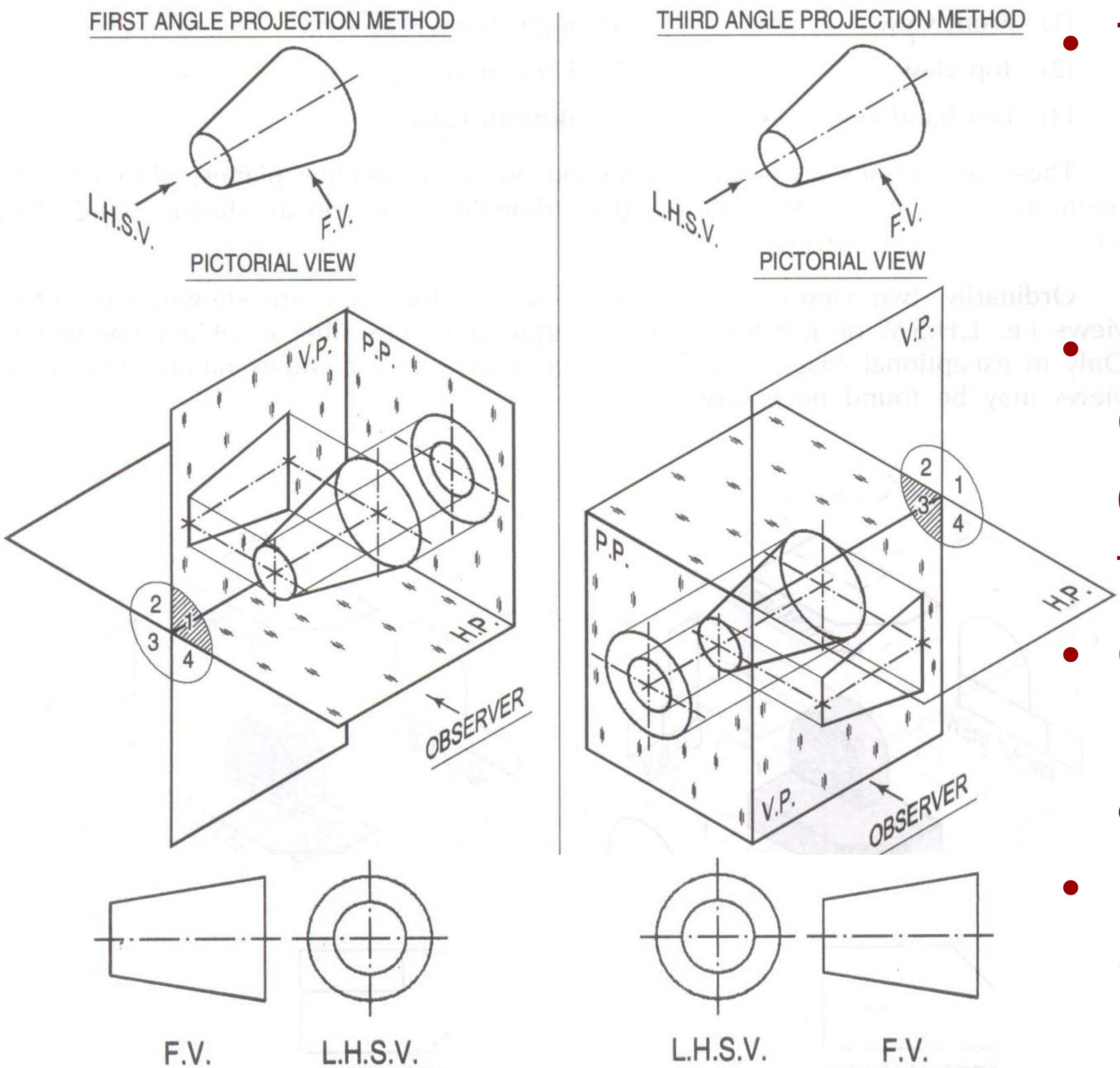


V.P. – Vertical Plane

H.P. – Horizontal Plane

Orthographic Projections

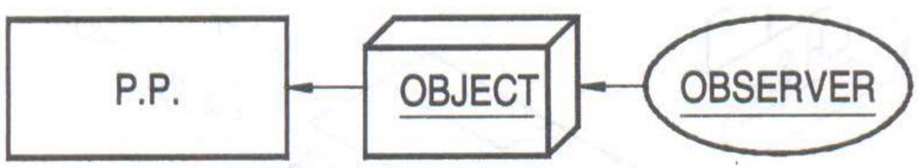
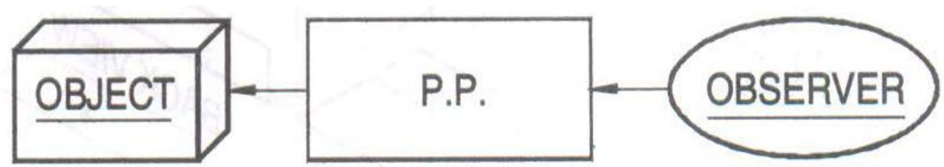
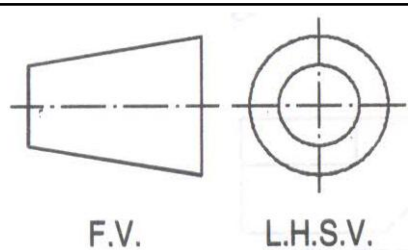
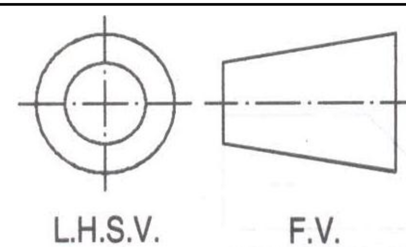
Two standards of projection: First and Third Angle



- The views obtained in both methods are completely identical but for swapping the positions.
- British use 3rd angle and Germans use 1st angle. In a global village, it is important for us to be familiar with both.
- Gratefully, we don't have to become familiar with all 4 angles of projections!
- I feel 3rd angle is more intuitive (left on left, top on top …). But India favor 1st angle!

Orthographic Projections

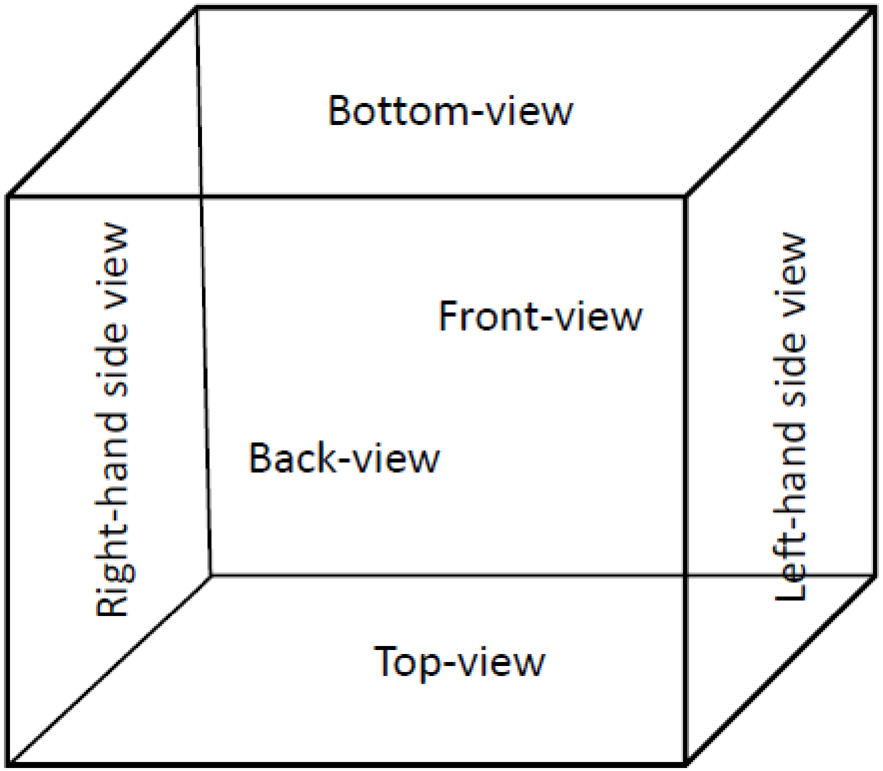
Two standards of projection: First and Third Angle …

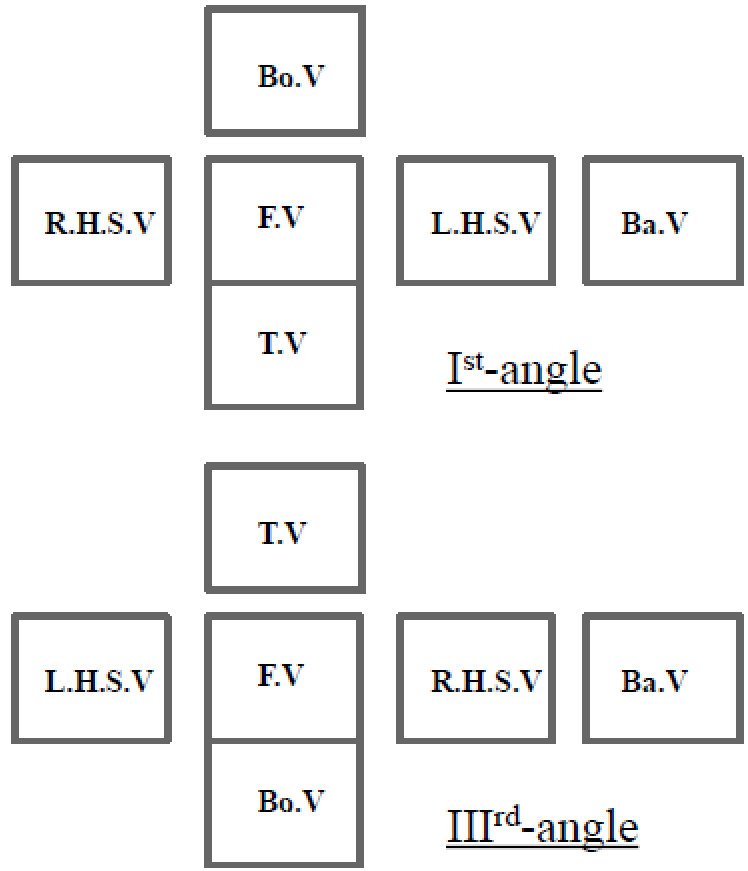
<table>
<tr><th colspan="3">First angle projection</th><th colspan="3">Third angle projection</th></tr>
<tr><td colspan="3">Object is in first quadrant</td><td colspan="3">Object is in third quadrant</td></tr>
<tr><td colspan="3">Plane → Object → Observer

So, projectors go backward/downward.</td><td colspan="3">Object → Plane ← Observer

So, projectors come forward/upward</td></tr>
<tr><td colspan="3">Planes are non-transparent.</td><td colspan="3">Planes are transparent.</td></tr>
<tr><td>Right</td><td>Elevation (front)</td><td>Left</td><td></td><td>Plan (top)</td><td></td></tr>
<tr><td></td><td>Plan (top)</td><td></td><td>Left</td><td>Elevation (front)</td><td>Right</td></tr>
<tr><td colspan="3"></td><td colspan="3"></td></tr>
</table>

Note: In all projections, Observer always is in the front/top while looking at VP/HP.

Orthographic Projections

6 possible views

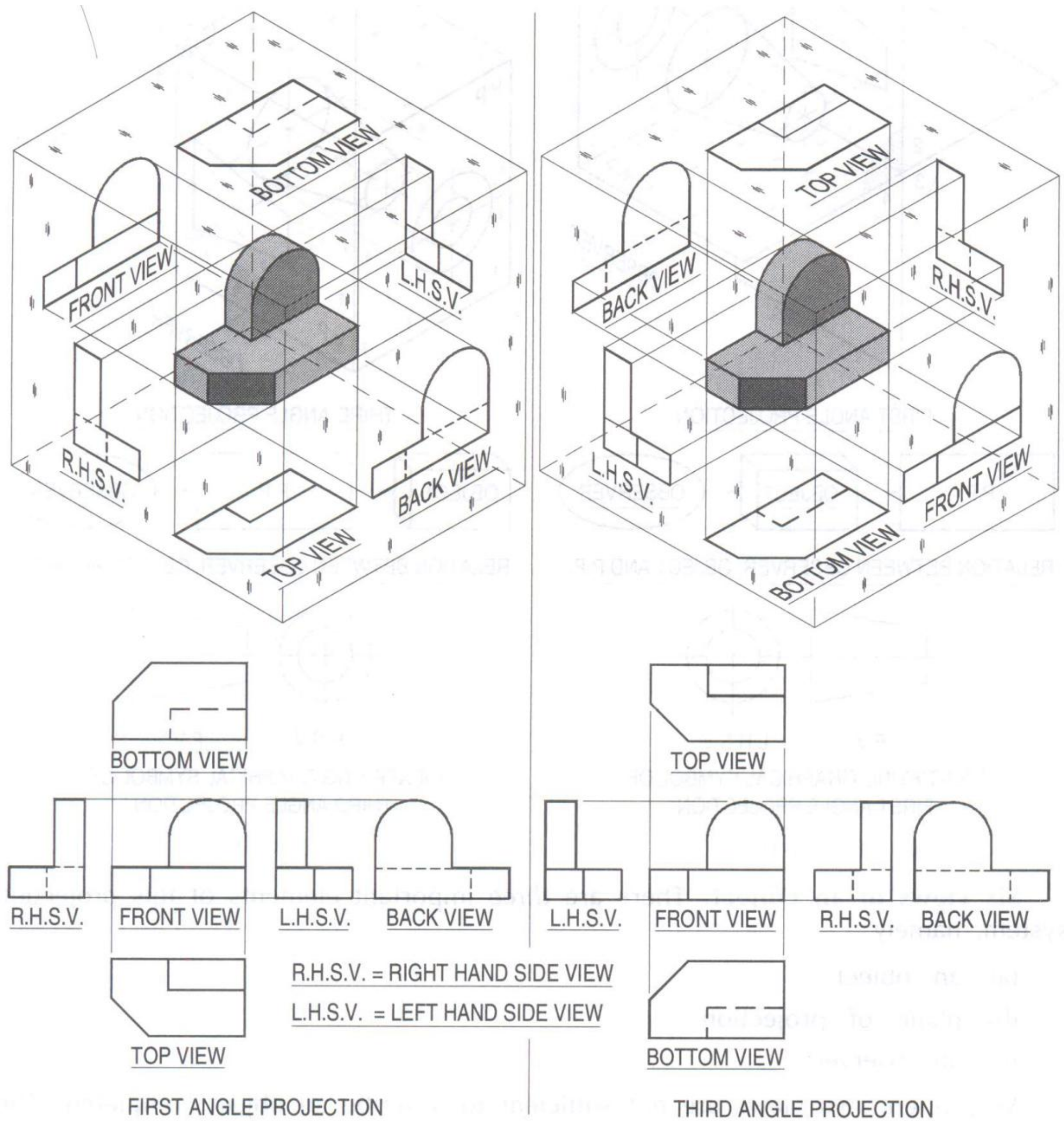




Note: Side views are drawn always by the side of the front view and not top view irrespective of 1st or 3rd angle.

Orthographic Projections

6 possible views …



Orthographic Projections

Various views

Corresponding to the 6 planes of the superscribing cube of the object, 6 views are possible. Further additional details are revealed by projections on to auxiliary planes. Hidden features are captured in sectional views.

<u>Most common:</u>

Top view → Plan

Front view → Elevation

Side views → Left and Right

<u>Less common:</u>

Bottom view

Back view

<u>Additional:</u>

Auxiliary view

Sectional view

Detailed view

(different scale at a different location)

Orthographic Projections

Labeling conventions

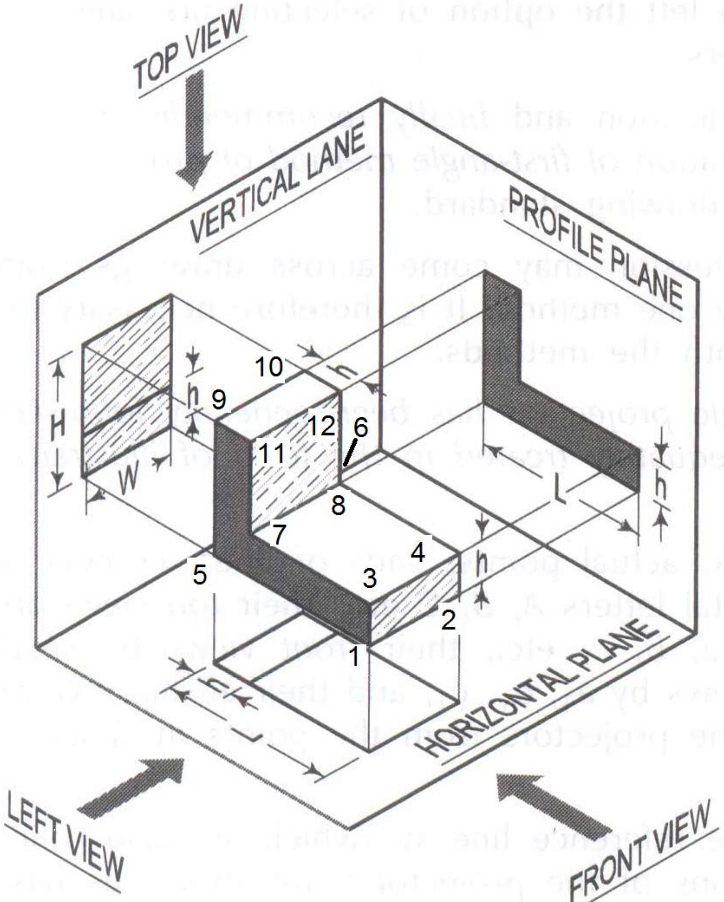
Item	Label
Points in space (3D points)	A, B, C, …
Corresponding points in plan (top view)	a, b, c, …
Corresponding points in elevation (front view)	a', b', c', …
Corresponding points in side views	a_1, b_1, c_1, …
Corresponding points in auxiliary views (depending on whether it resembles with top or front view) Note: Side view is also an aux. view	a_1, b_1, c_1, … or a'_1, b'_1, c'_1, …
Hidden lines	Dashed
Axis lines	Dot dashed

Note: For the sake of simplicity and uniformity, we shall use only 1st angle projection. You know how to repeat the same in 3rd angle.

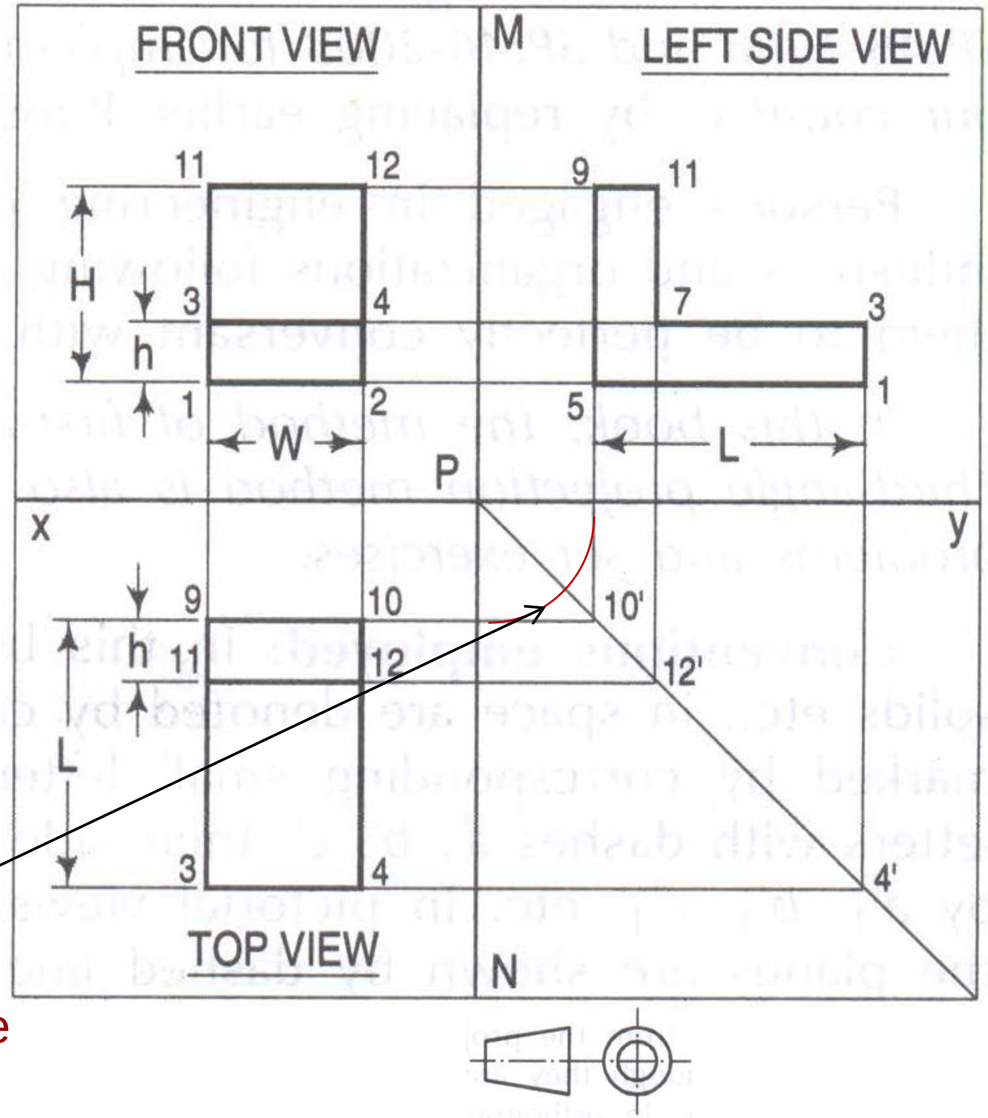
Ortho. Views from Pictorial View

Example-1

Draw the necessary orthographic views of the L shaped solid object in first angle.



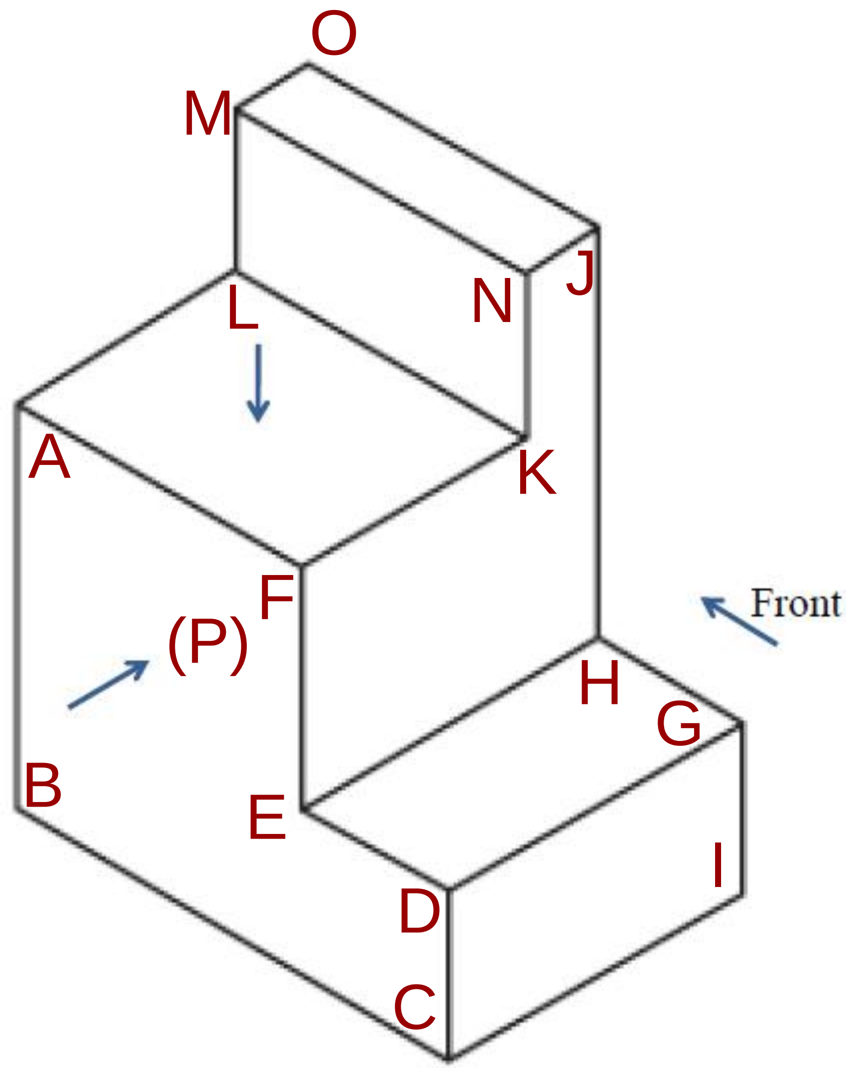
Instead of a mirroring line, arc also can be used.



Ortho. Views from Pictorial View

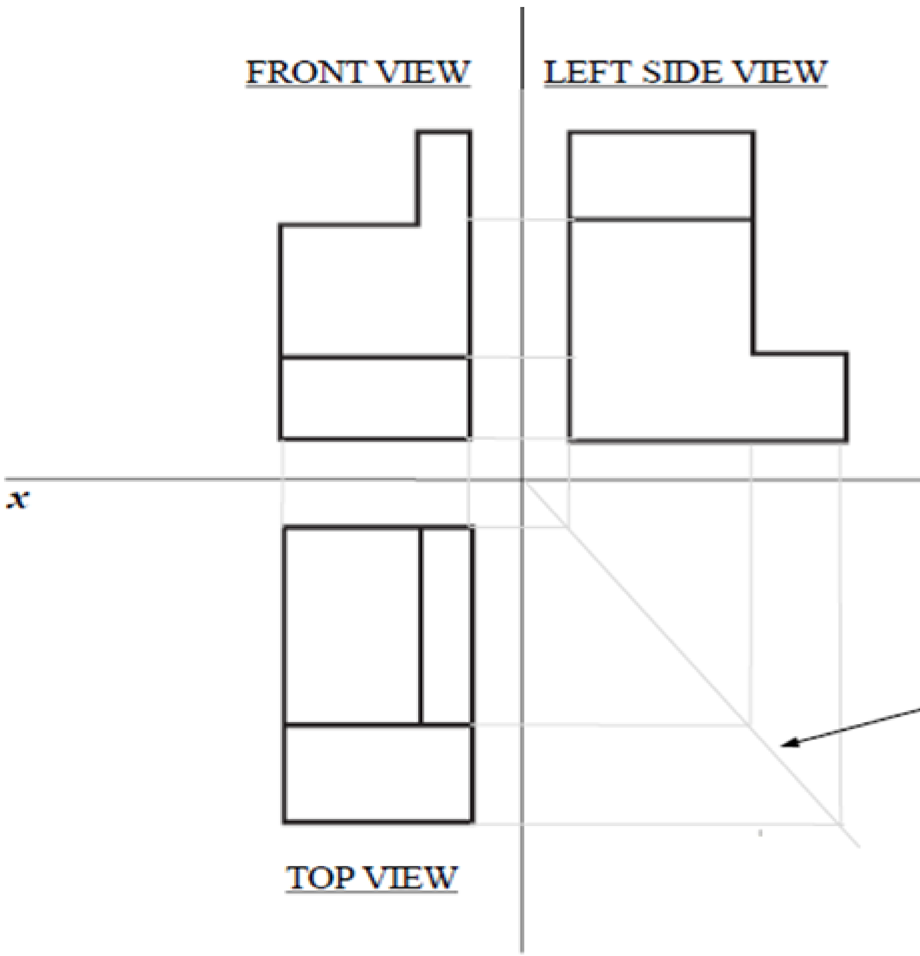
Example-2

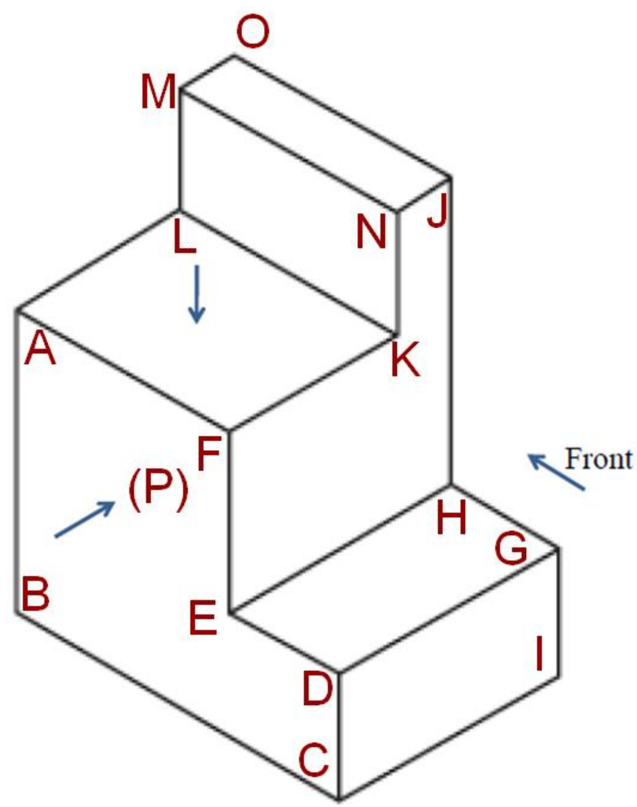
Draw the necessary orthographic views of the given solid object in first and third angles.

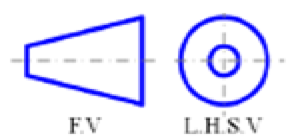


Ortho. Views from Pictorial View

Example-2 – First angle projection

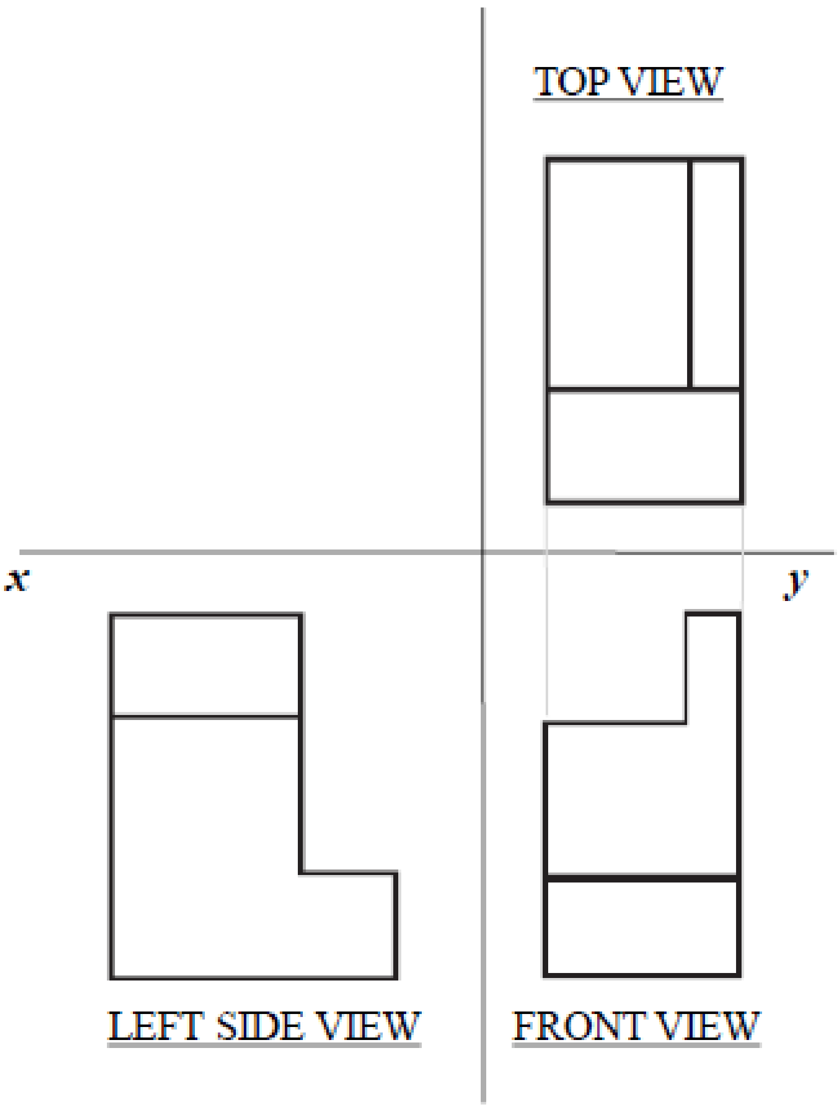


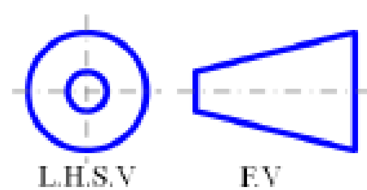


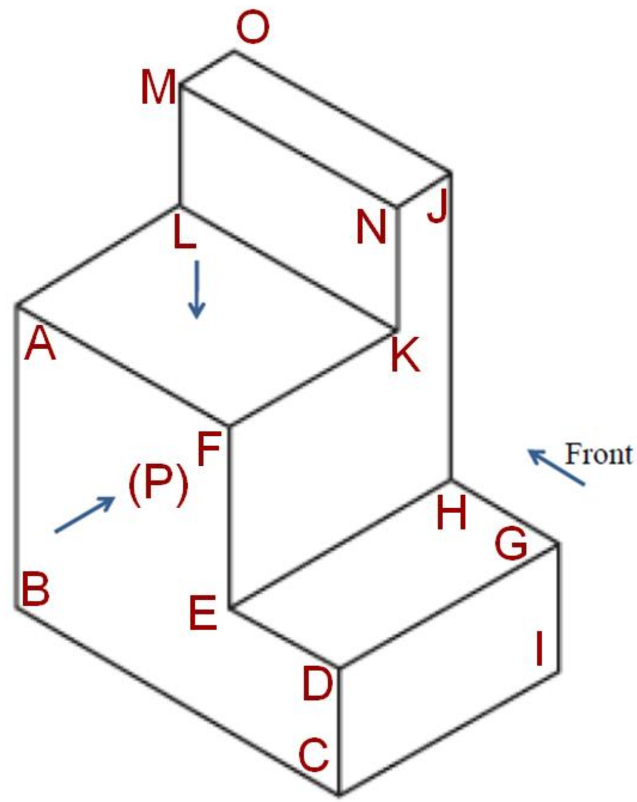


Ortho. Views from Pictorial View

Example-2 – Third angle projection



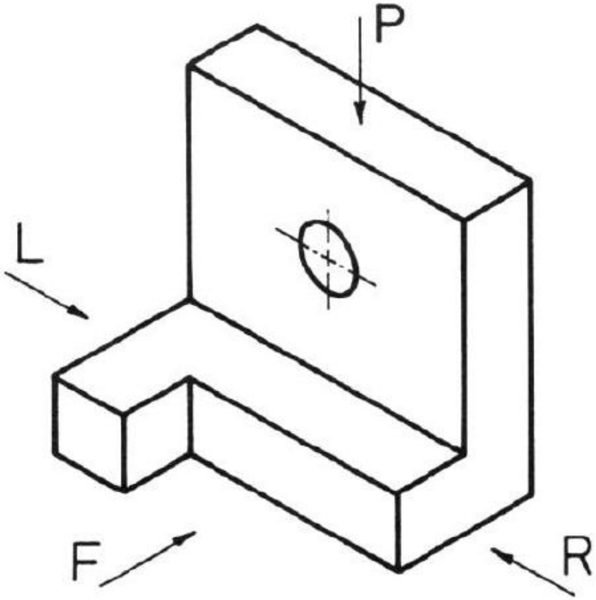




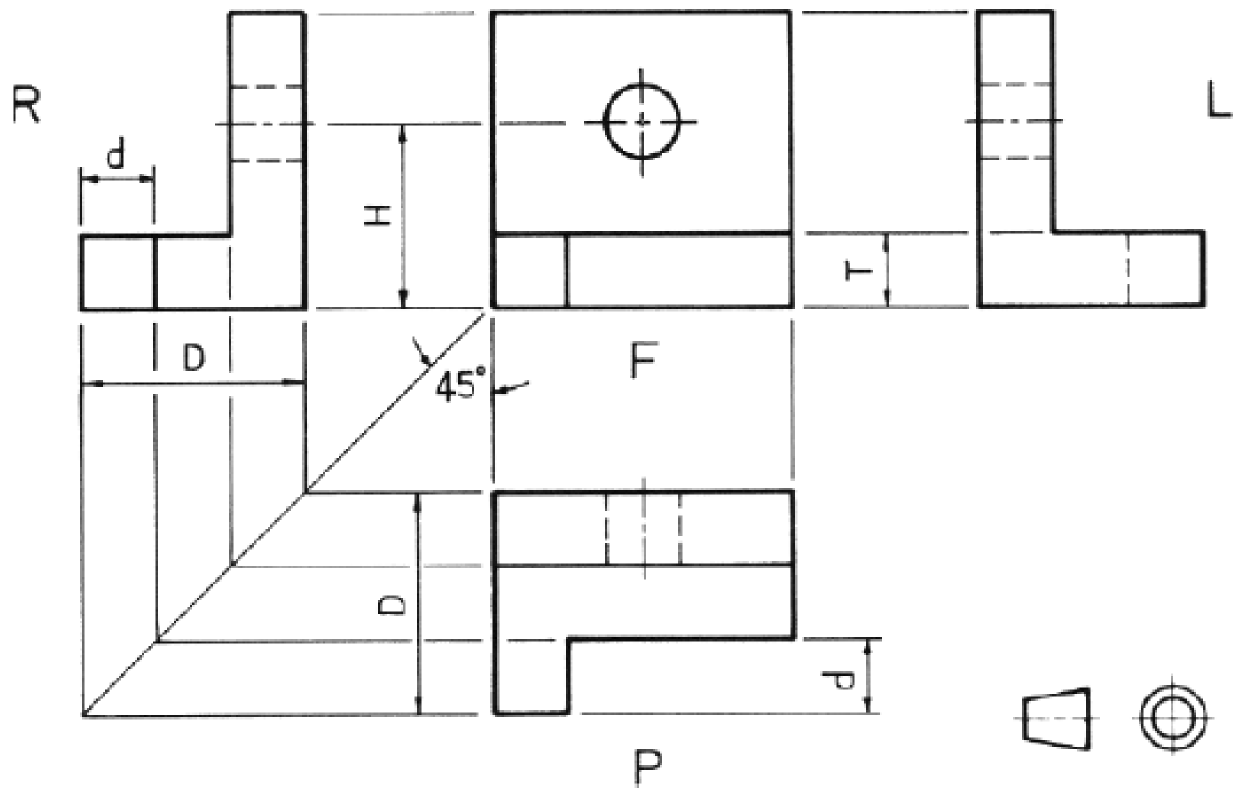
Ortho. Views from Pictorial View

Example-3

Draw the necessary orthographic views of the given solid object in first angle.



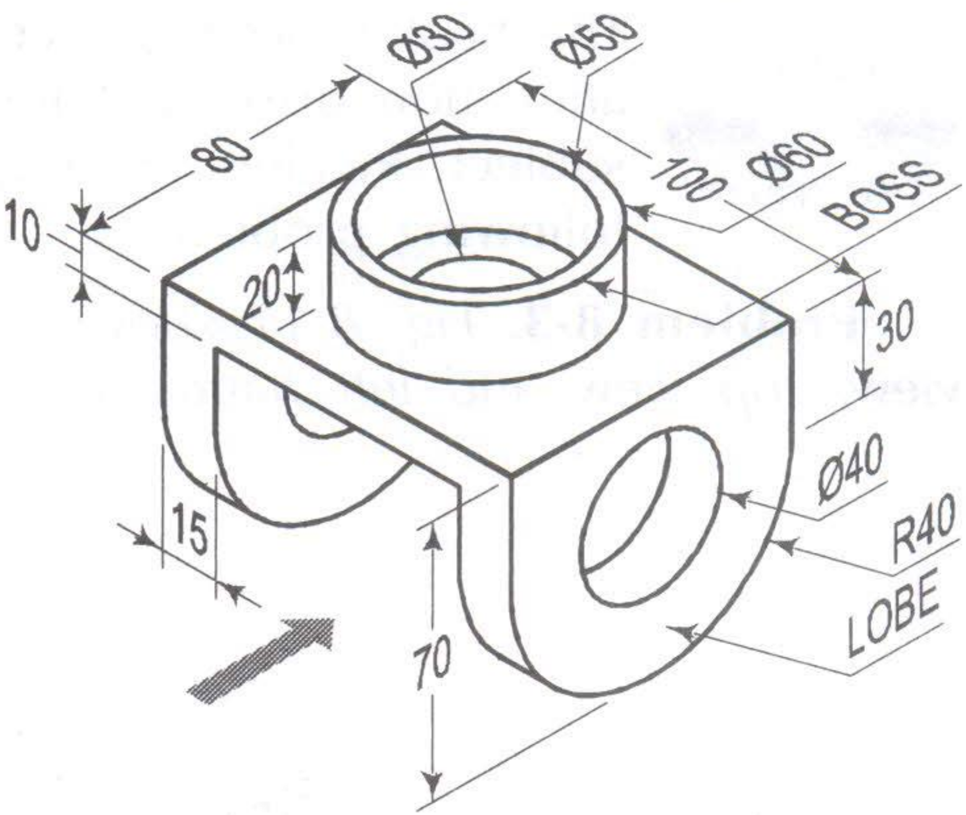
F: Front
L: Left
R: Right
P: Plan

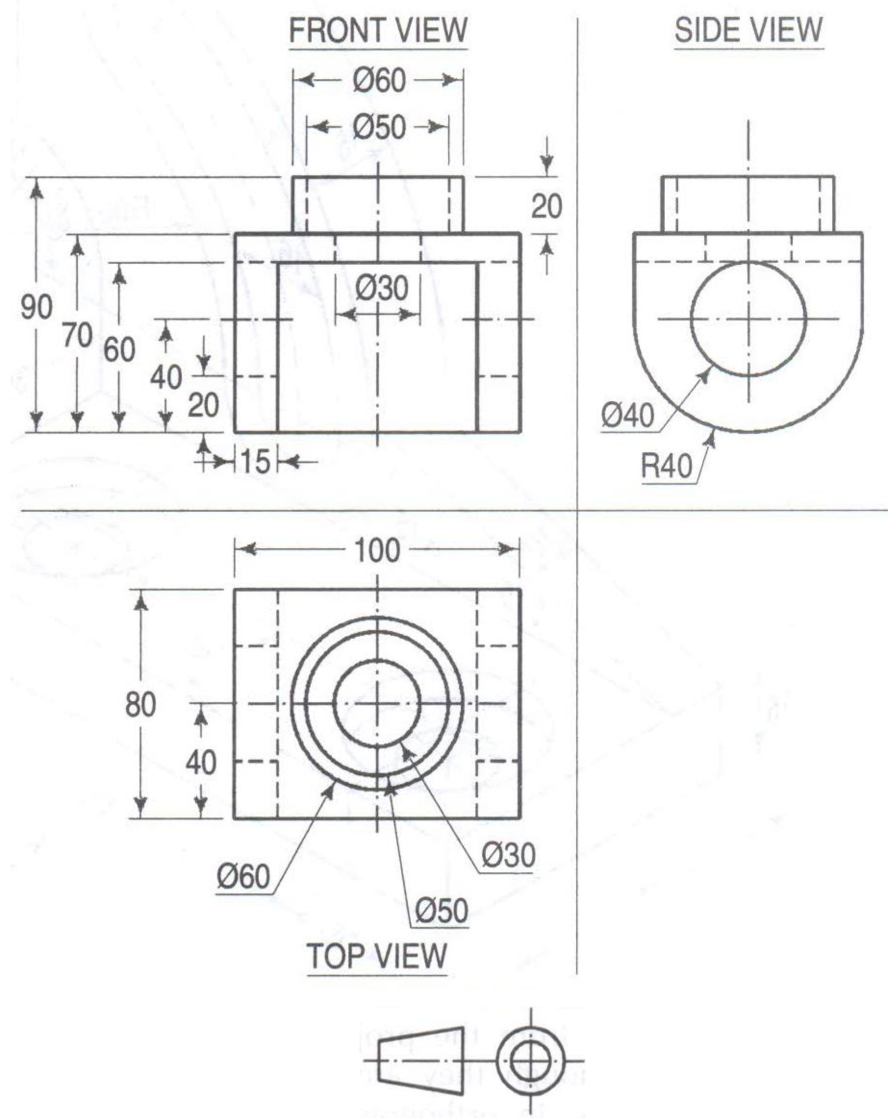


Ortho. Views from Pictorial View

Example-4

Draw the necessary orthographic views of the machine bracket in first angle.

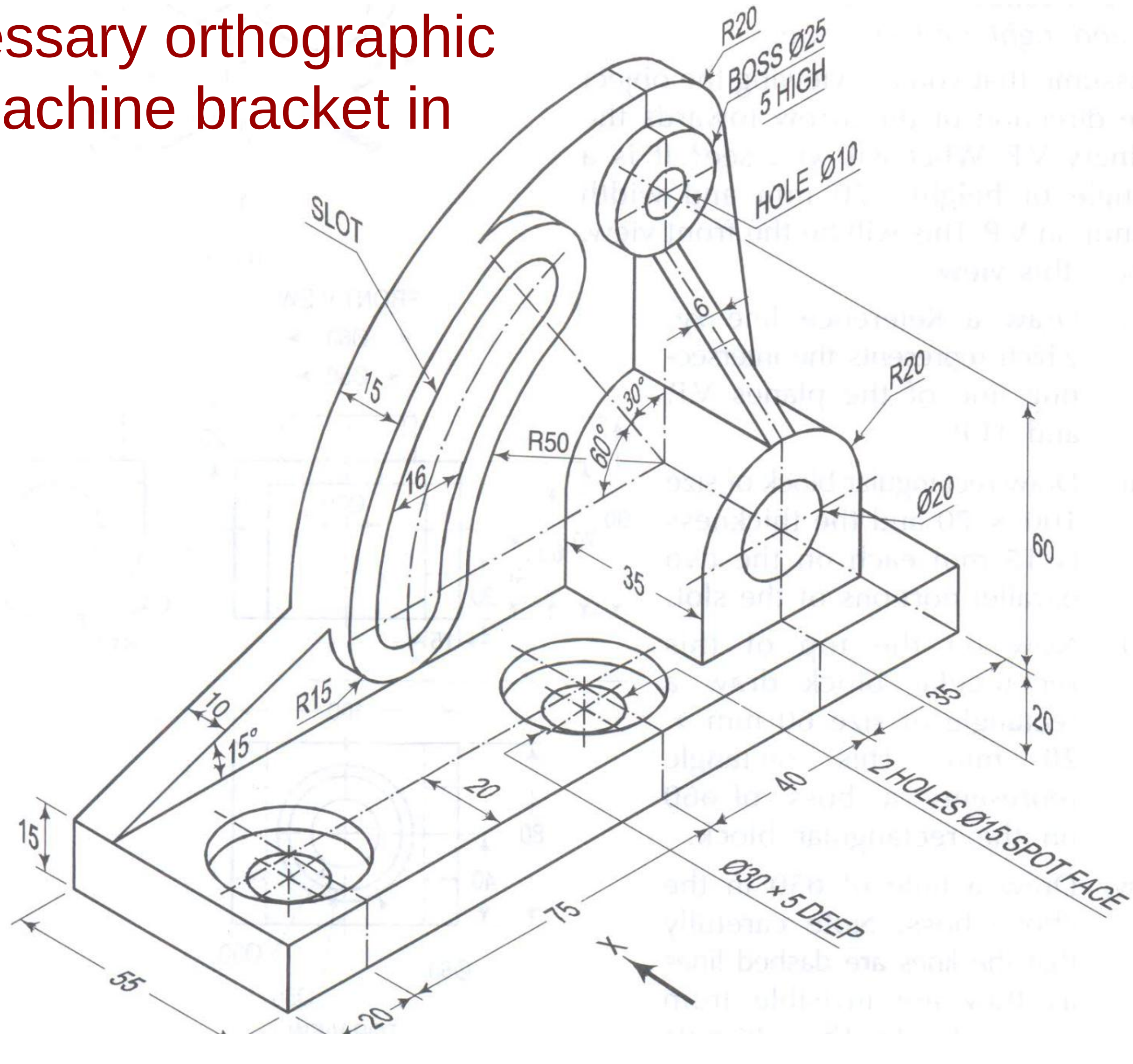




Ortho. Views from Pictorial View

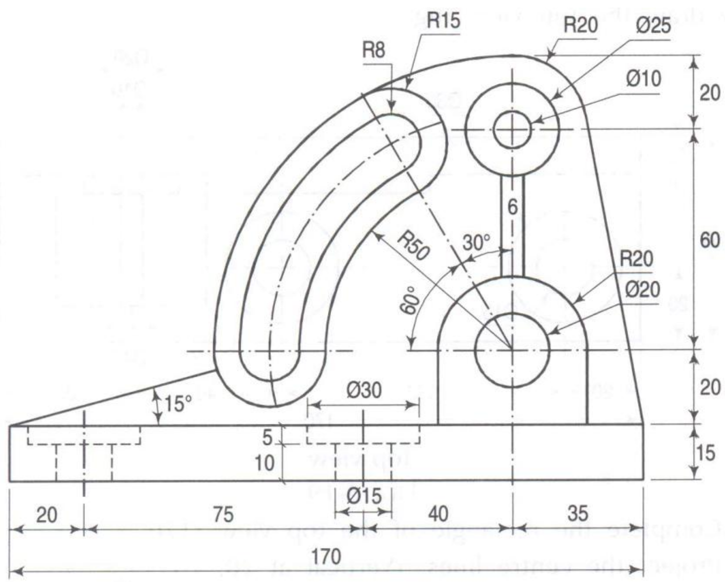
Example-5

Draw the necessary orthographic views of the machine bracket in first angle.

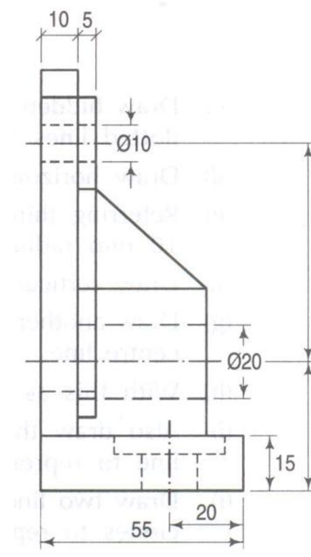


Ortho. Views from Pictorial View

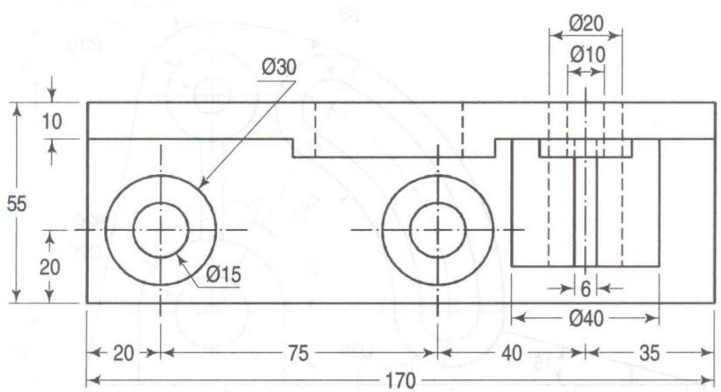
Example-5 …



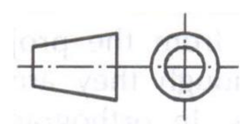
Front view



L.H.S.V.



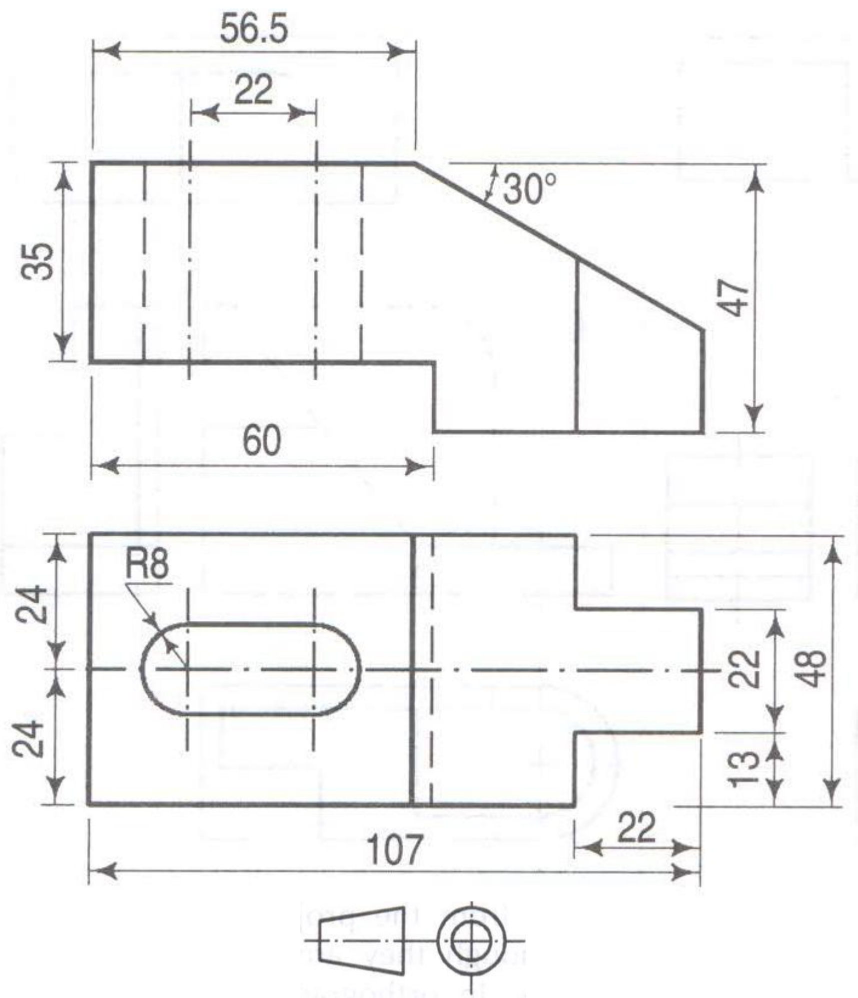
Top view

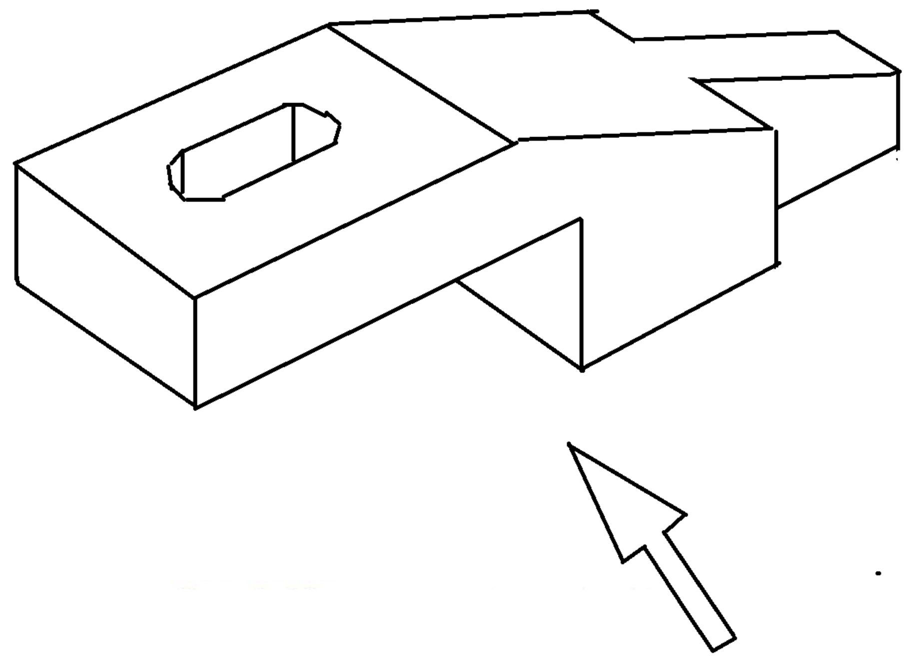


Pictorial View from Ortho. Views

Example-6

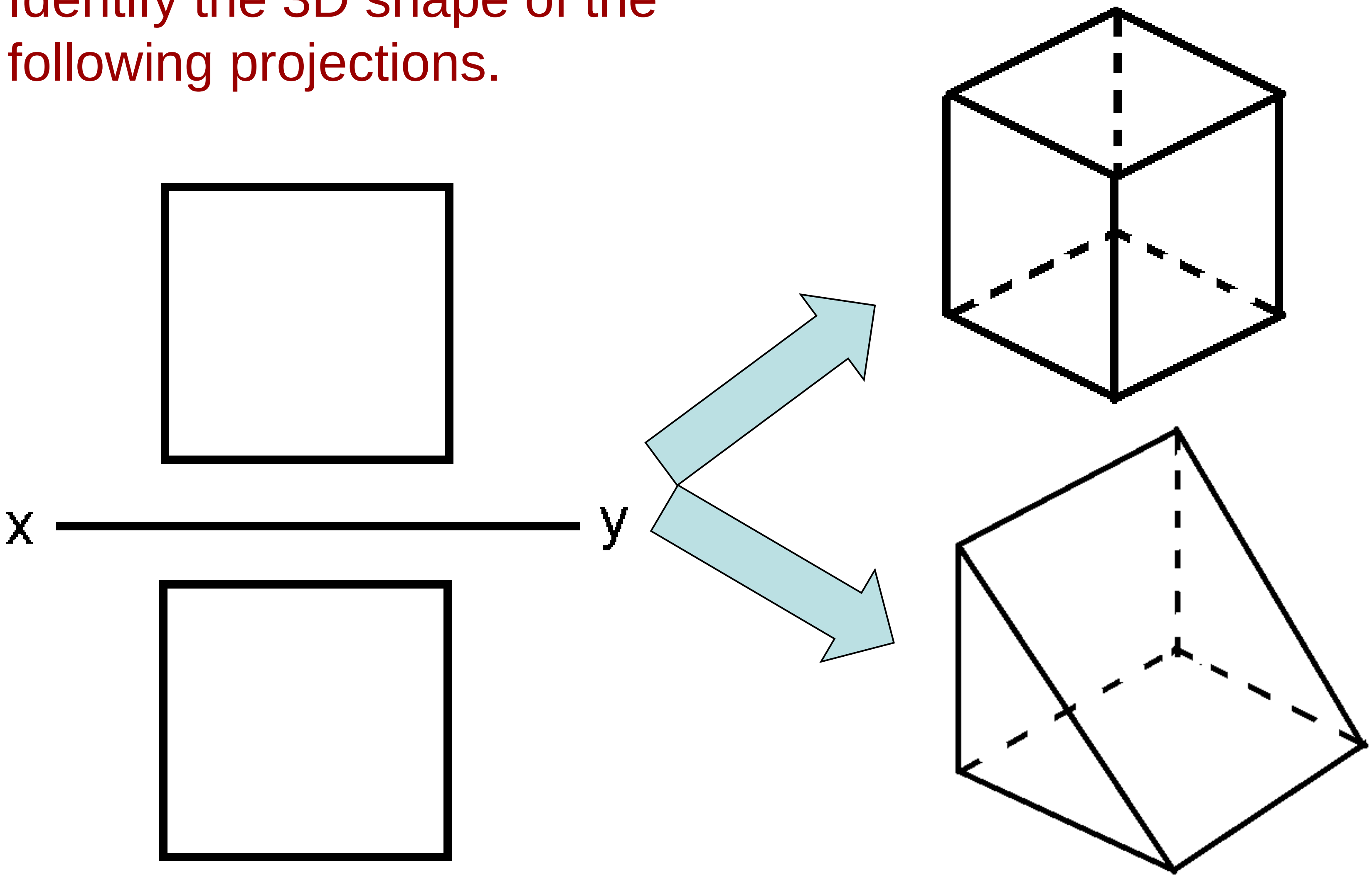
Sketch a freehand pictorial view from the orthographic views.





Multiple interpretations of inadequate views

Identify the 3D shape of the following projections.

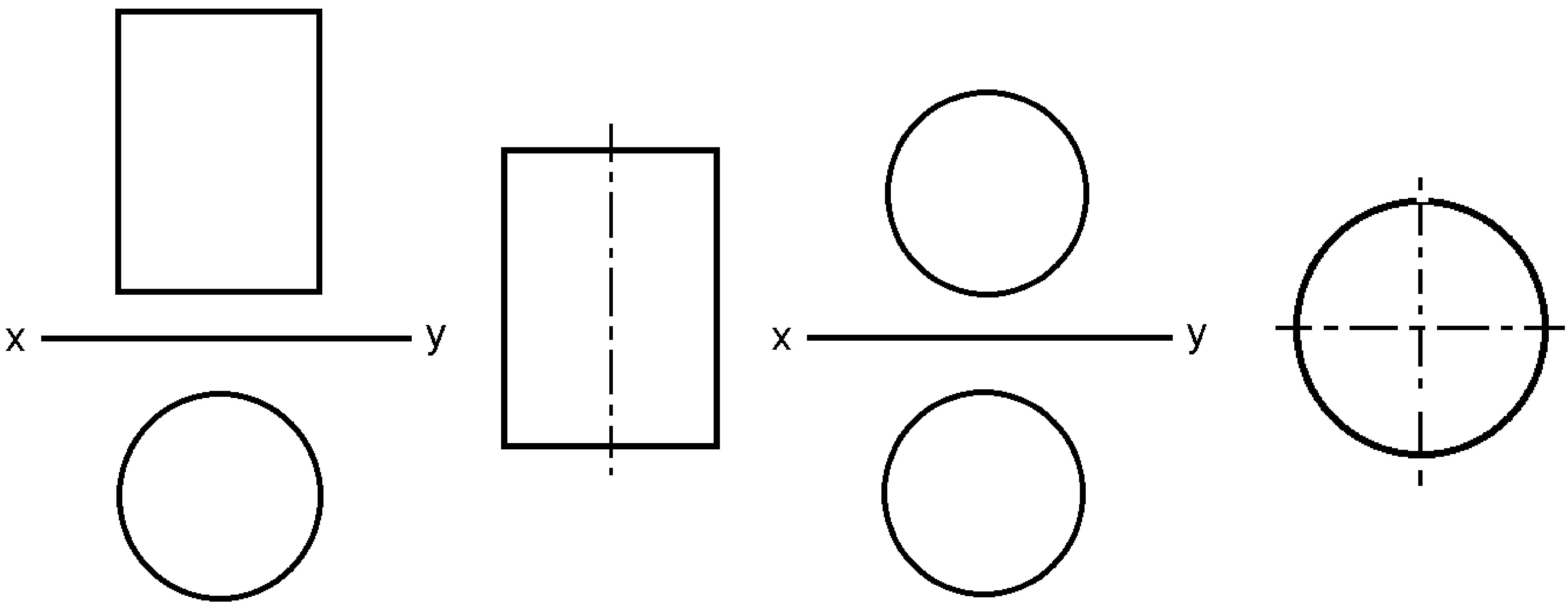


If adequate views are not given, there will be multiple interpretations. These additional views can be eliminated using notations.

Multiple interpretations of inadequate views

Use of notations to eliminate additional views

Cylinder | Cylinder | Sphere | Sphere



If adequate views are not given, there will be multiple interpretations.
These additional views can be eliminated using notations.

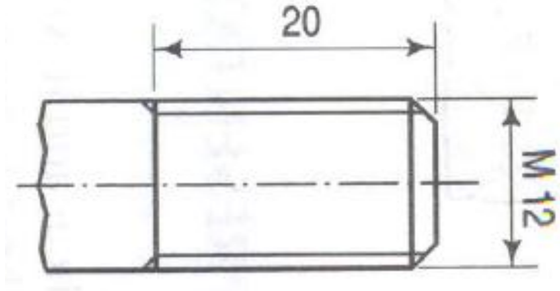
Use of Notations & Conventions

- They help in reducing the number of views required for a feature.

  Eg.: The axis line can convert a rectangle into a cylinder.

- They reduce effort in drawing details.

  Eg.: Thread takes a lot of time. In any case, its minute profile cannot be depicted. Instead, simply draw root and crest as straight lines parallel to axis and show its specification by the side such as M30.



- They are used to denote what simply cannot be drawn.

  Eg.: Surface finish (▽, ▽▽, ▽▽▽) and geometric tolerances (⊥,), etc.

Conclusions

- Roughly work out all the problems given to you. Only if you come prepared, you will be able to complete all problems of the sheet in the drawing session.


Thank You!