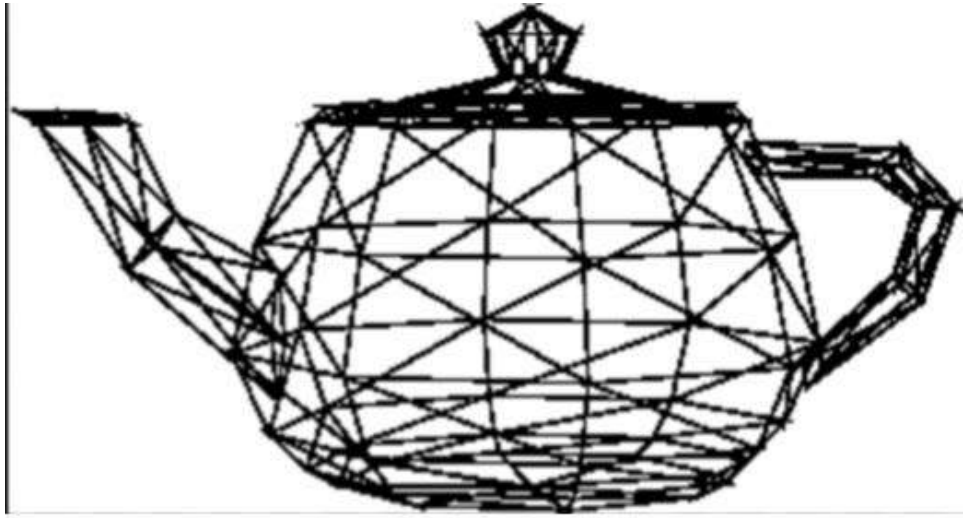
Extended Reality in Industry 4.0 (ERI)

Lecture 5: Structure of 3D modeling

Dr. Kalpana Shankhwar, kalpana@iiitd.ac.in
Assistant Professor
Department of Human Centered Design,
IIIT Delhi

Computer Graphics for 3D modeling

What's wrong with this "real" teapot?



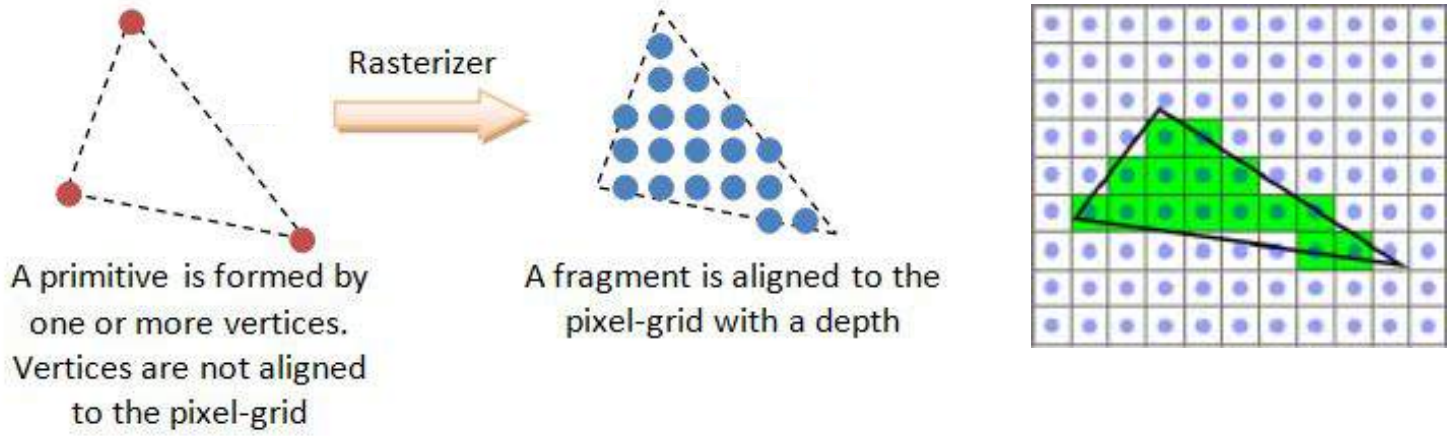
Computer Graphics for 3D modeling

What's wrong with this "real" teapot?

- curved surfaces & modeling
- hidden surfaces / lines
- shading & lighting
- perspectives
- texture
- Pottery, ceramic, plastic, copper, paper
- What's the solution? --> Research areas in computer graphics

Images: Physical and Synthetic

- Most textbooks discuss how to define two- and three-dimensional mathematical objects in the computer and image them with the set of two-dimensional rasterized primitives.



- The capabilities of the software and hardware can be exploited to create realistic images of computer-generated three-dimensional objects.
- A task that involves many aspects of image formation, such as lighting, shading, and properties of materials.
- Computer-generated images are synthetic or artificial, in the sense that the objects being imaged do not exist physically.

Object and Viewer

- Two basic entities must be part of any **image formation process**, be it mathematical or physical: *object* and *viewer*.
- The **object exists in space** independent of any image formation process and of any viewer.
- In computer graphics, where we deal with synthetic objects, we form objects by **specifying the positions** in space of various geometric primitives, such as points, lines, and polygons.
- To form an image, we must have someone or something that is viewing our objects, be it a human, a camera, or a digitizer
- It is the **viewer** that forms the image of our objects.

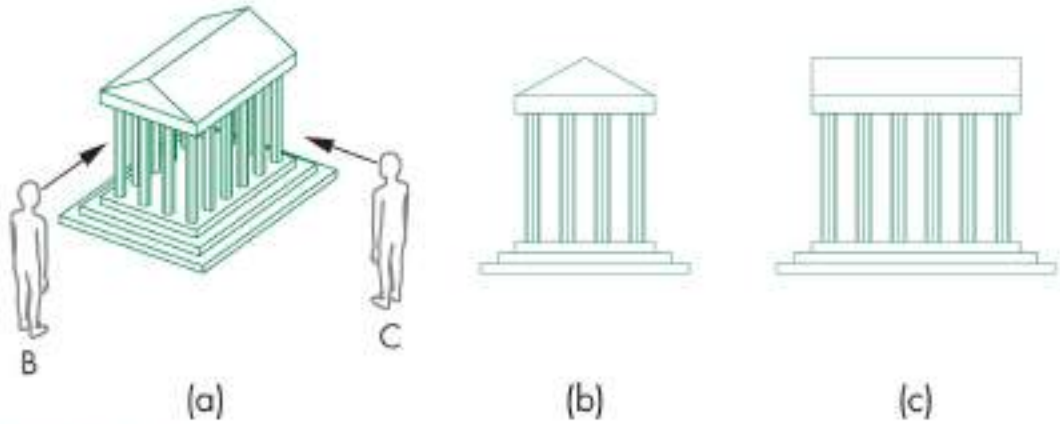


FIGURE 1.6 Image seen by three different viewers. (a) A's view. (b) B's view. (c) C's view.

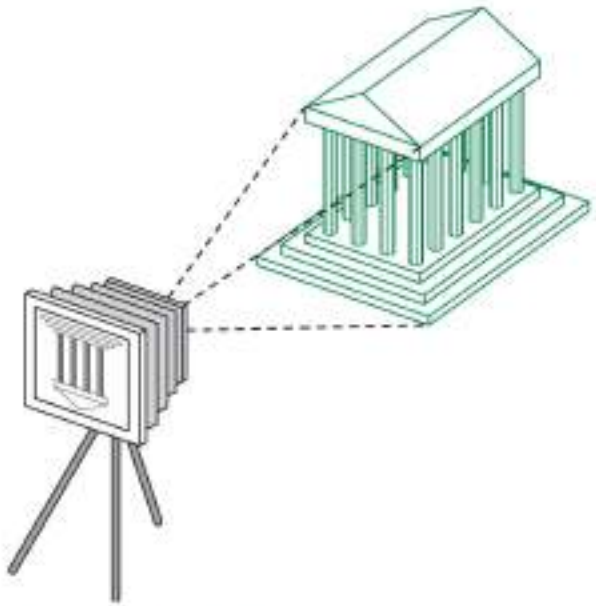


FIGURE 1.7 Camera system.

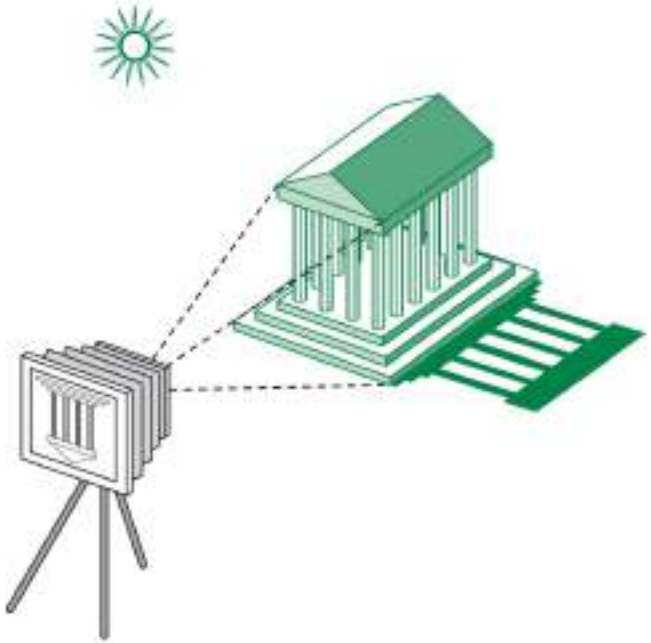


FIGURE 1.8 A camera system with an object and a light source.

Imaging Models

- There are multiple approaches to forming images from a set of objects, the light reflecting properties of these objects, and the properties of the light sources in the scene.
- **Ray tracing** is an image formation techniques that is based on t ideas and that can form the basis for producing computer-gener images
- **Ray tracing** simulates how light interacts with objects in a scene create a digital image.

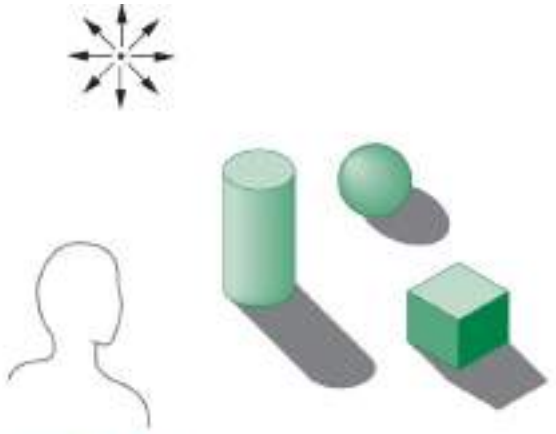


FIGURE 1.10 Scene with a single point light source.

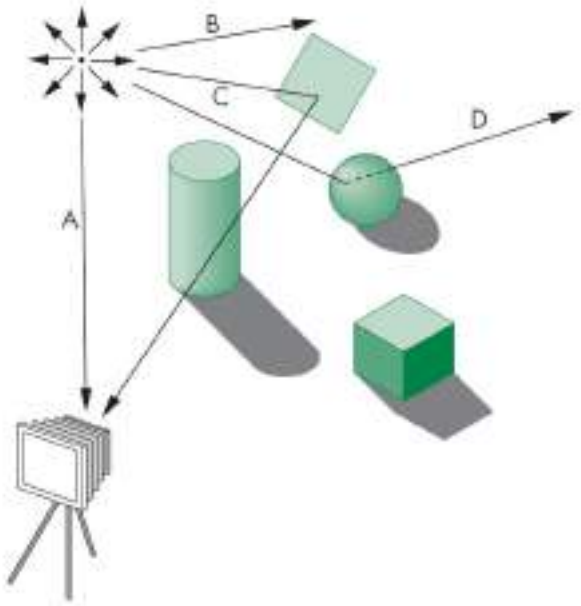
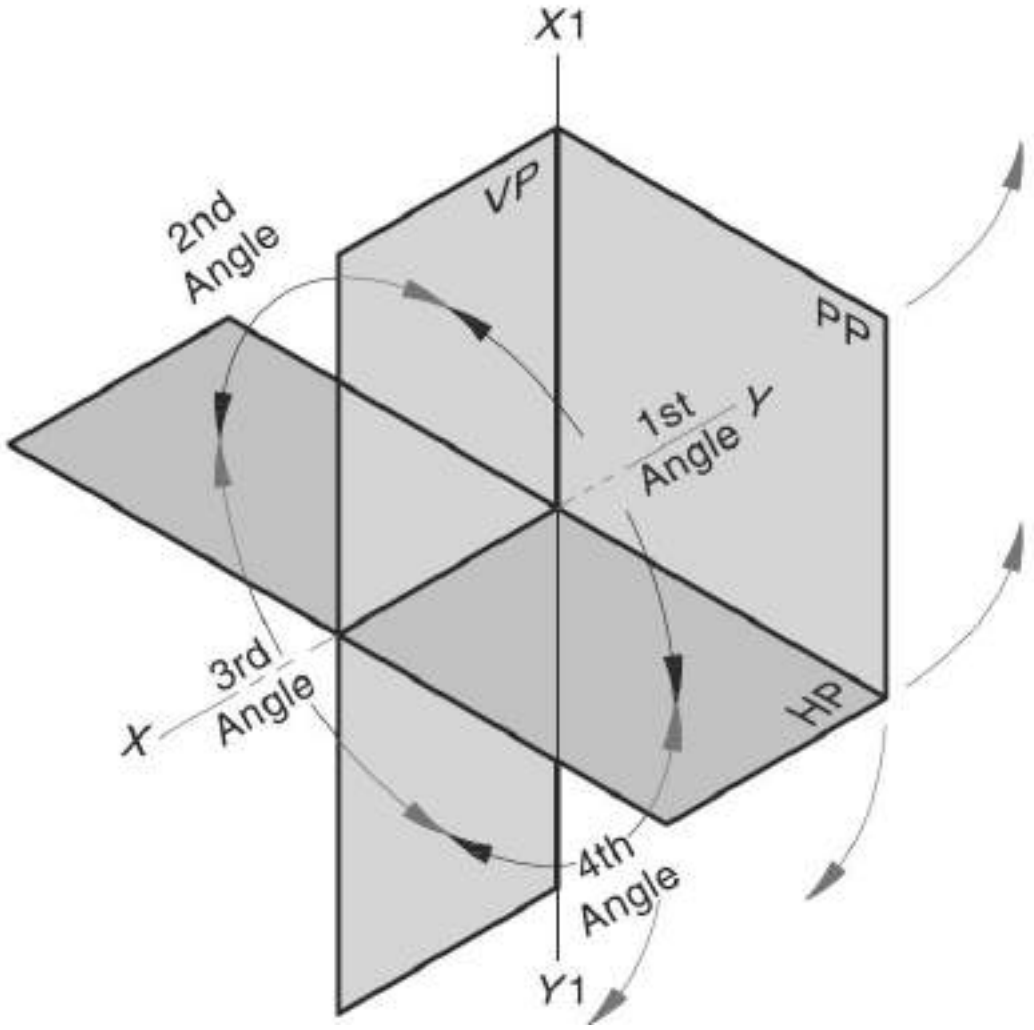


FIGURE 1.11 Ray interactions. Ray A enters camera directly. Ray B goes off to infinity. Ray C is reflected by a mirror. Ray D goes through a transparent sphere.

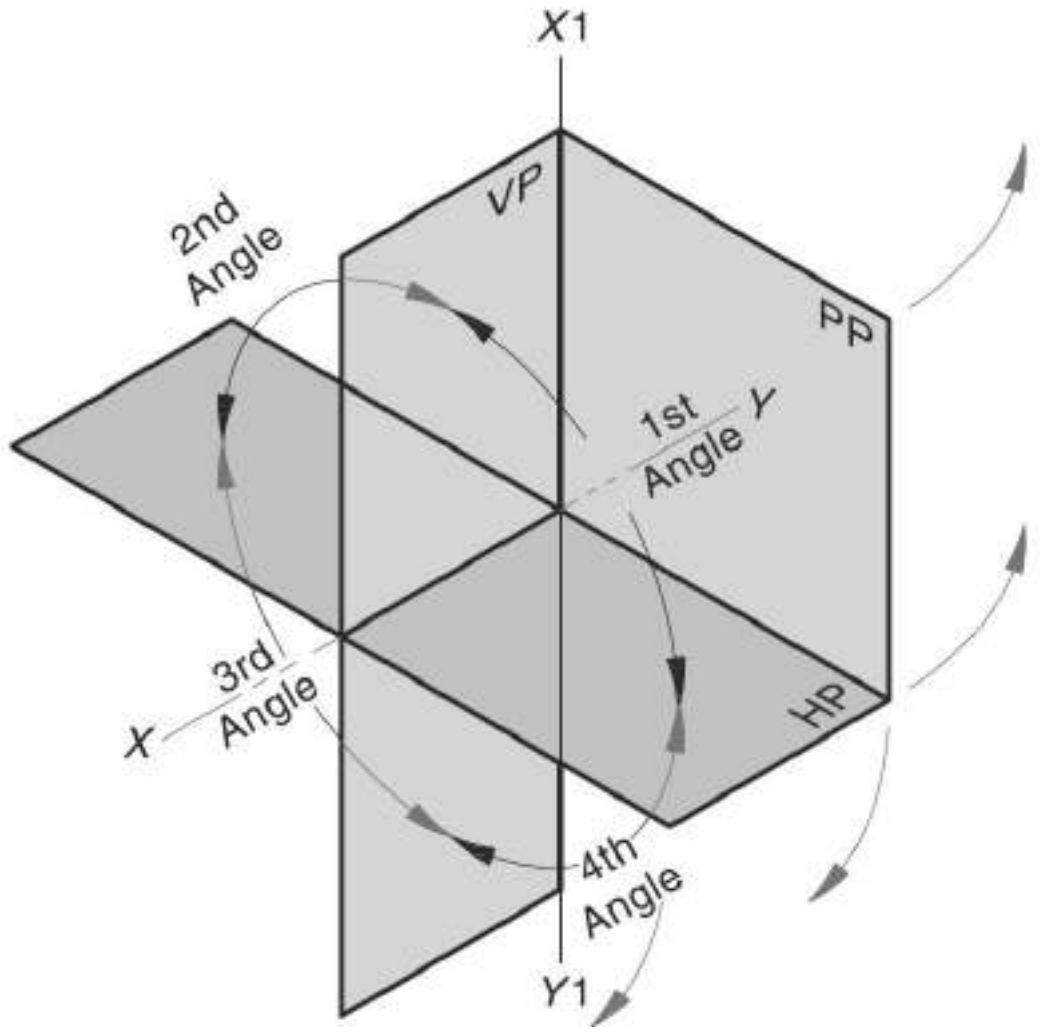
Multiview Orthographic projection

- Multiview orthographic projection is a method of drawing two or more views of an object on the reference planes placed at right angles to each other.
- The word '**ortho**' means **perpendicular.**
- In this projection, the projectors are perpendicular to the POP and parallel to each other.
- **Different views** of an object are obtained by viewing it from **different directions**



Multiview Orthographic projection

- The HP and the VP make four quadrants.
- The position of an object in space can be determined by these quadrants, i.e., the object can be in the first quadrant or in the second quadrant or in the third quadrant or in the fourth quadrant.
- The line at which the HP and the VP meet is called horizontal reference line and denoted by XY.
- The line at which the HP (or the VP) and the PP meet is called the profile reference line and is denoted by X1Y 1.
- After the views are obtained, the HP is rotated about XY in the clockwise direction to bring it in plane with the VP.
- The PP is rotated about X1Y 1 away from the object.
- The views of an object are now assumed to be in one plane and can be drawn on a drawing paper.
- Two views of an object are obtained on the HP and the VP. The third view is obtained on the PP.



Orthographic view

- In multiview projection, the observer is supposed to look the object from six principal directions, i.e., front of the object, top of the object, right side of the object, left side of the object, back of the object and bottom of the object.
- Therefore, **six different views** of the object are obtained. These views are called **principal views** as they are obtained on the principal planes—the VP, the HP and the PP.
- If an auxiliary plane is used to obtain an orthographic view, the view is called an auxiliary view.

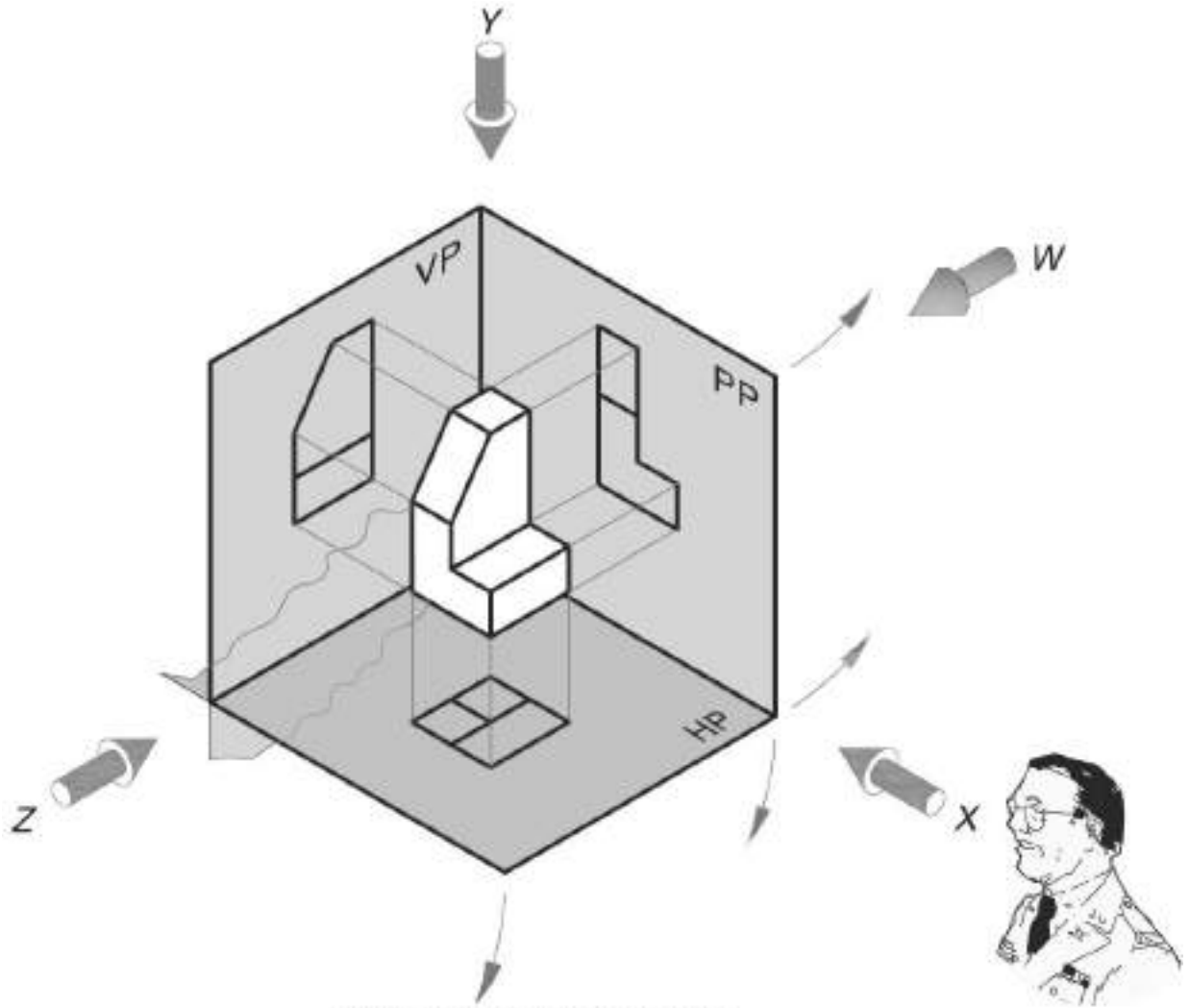
Orthographic view

The principal orthographic views are explained below

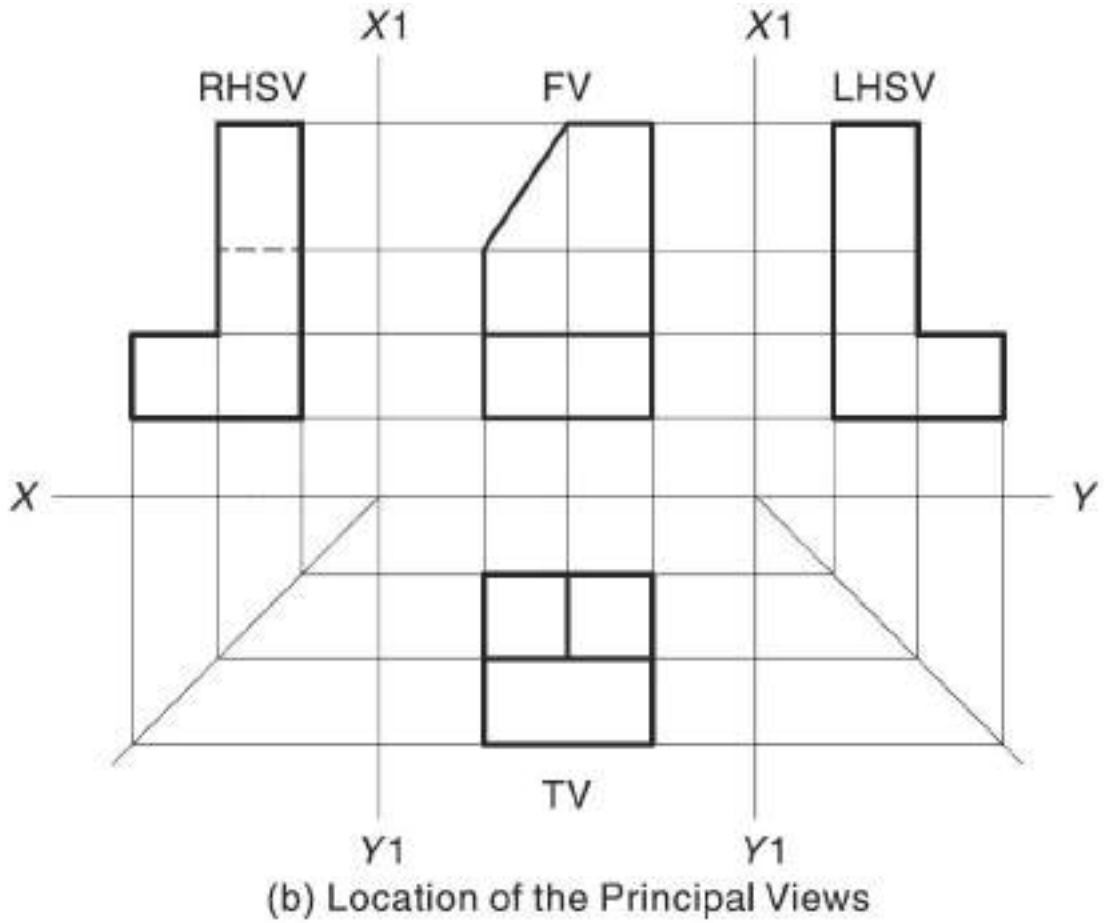
- **Front View** When the observer looks at the object from the front, the view obtained is called the front view (FV). *FV is seen on the VP.*
- **Top View** When the observer looks at the object from above, the view obtained is called top view (TV). *TV is seen on the HP.*
- **Side Views** When the observer looks at the object from side, i.e., from his left-hand side or righthand side, the view obtained is called side view (SV). *SV is seen on the PP*. (Left hand side view (LHSV) and right hand side view (RHSV))
- **Bottom View** When the observer looks to the object from below, the view obtained is called bottom view (BV).
- **Rear View** When the observer looks to the object from back, the view obtained is called rear view (RV) or back view.

Method of Multiview Projection

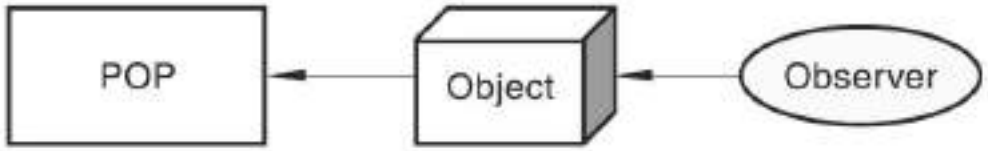
- **First-angle projection method**



(a) Object in First Angle



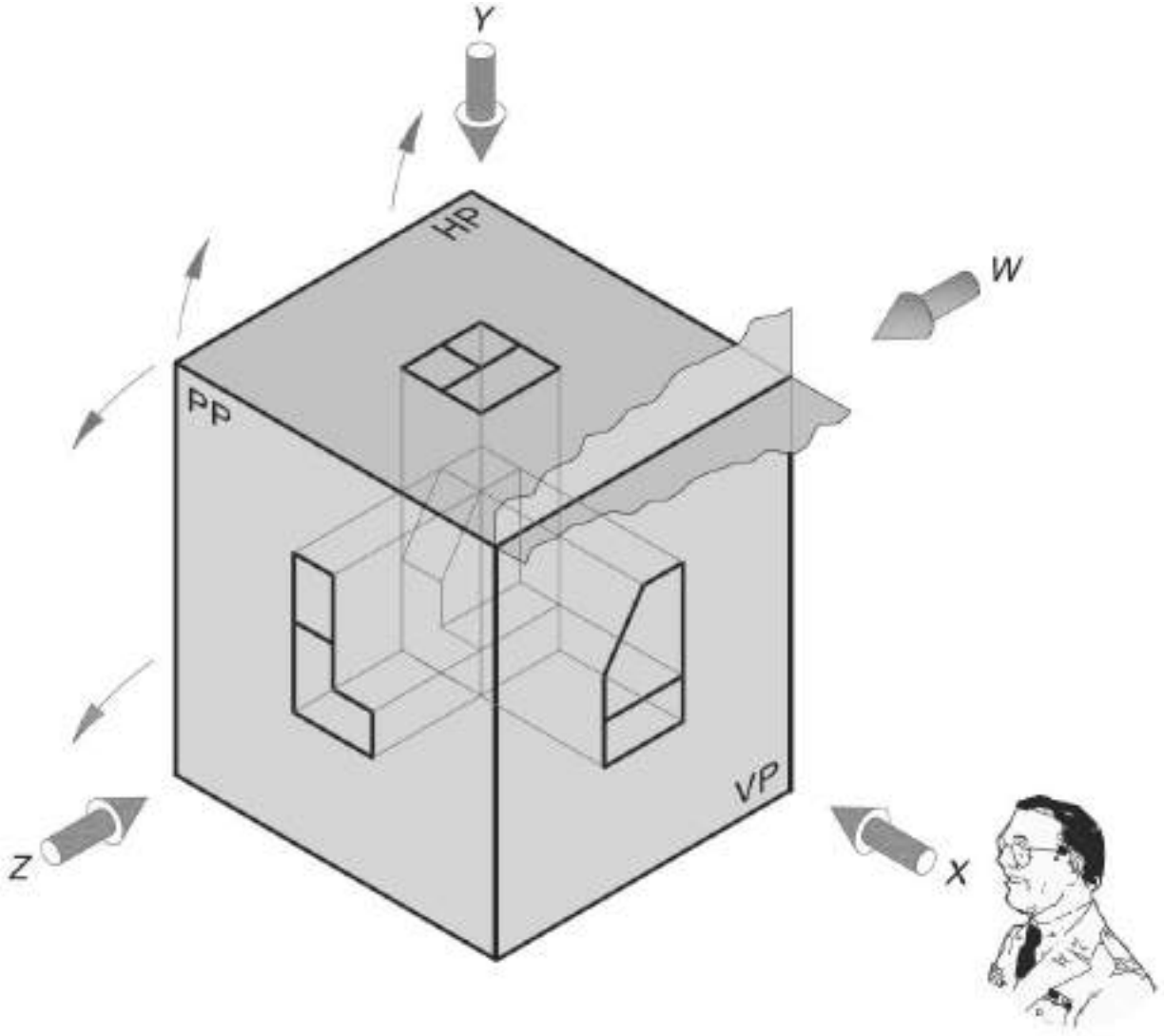
(b) Location of the Principal Views

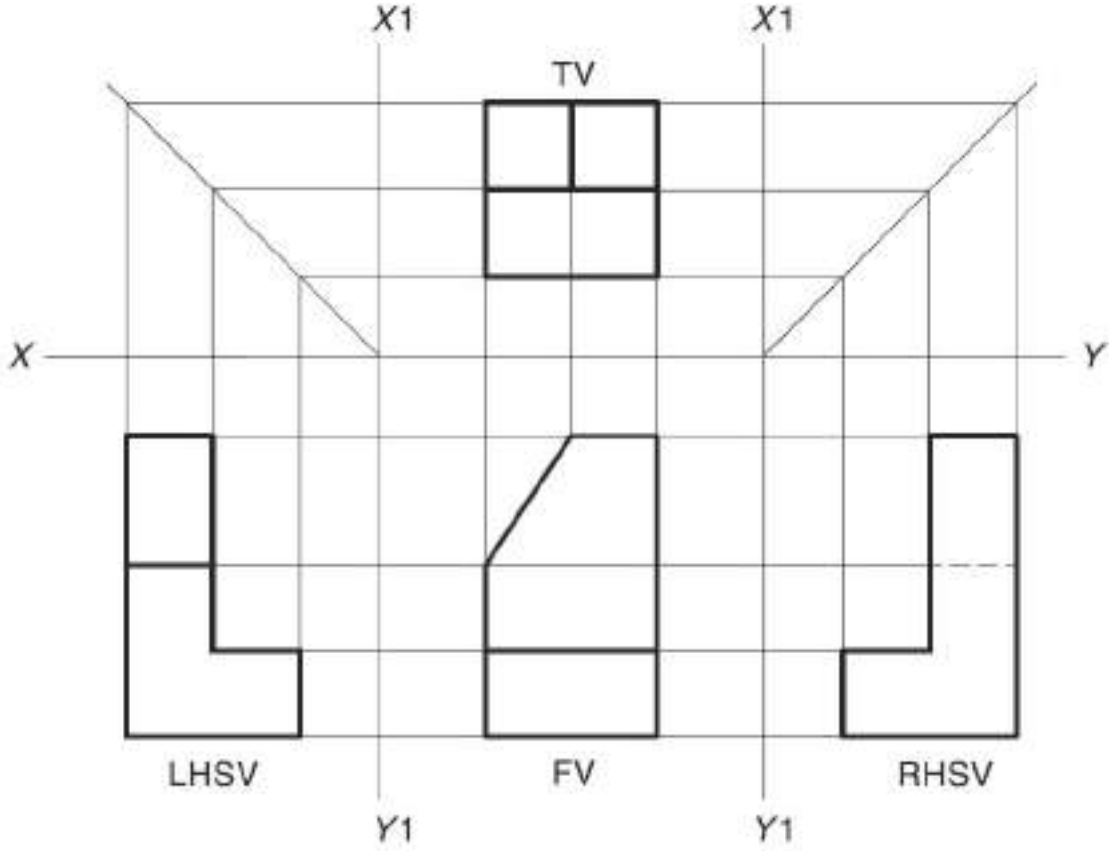


(c) Relationship between Object, Observer and POP

Method of Multiview Projection

- **Third-angle projection method**





(b) Location of the Principal Views

(c) Relationship between Object, Observer and POP

Method of Multiview Projection

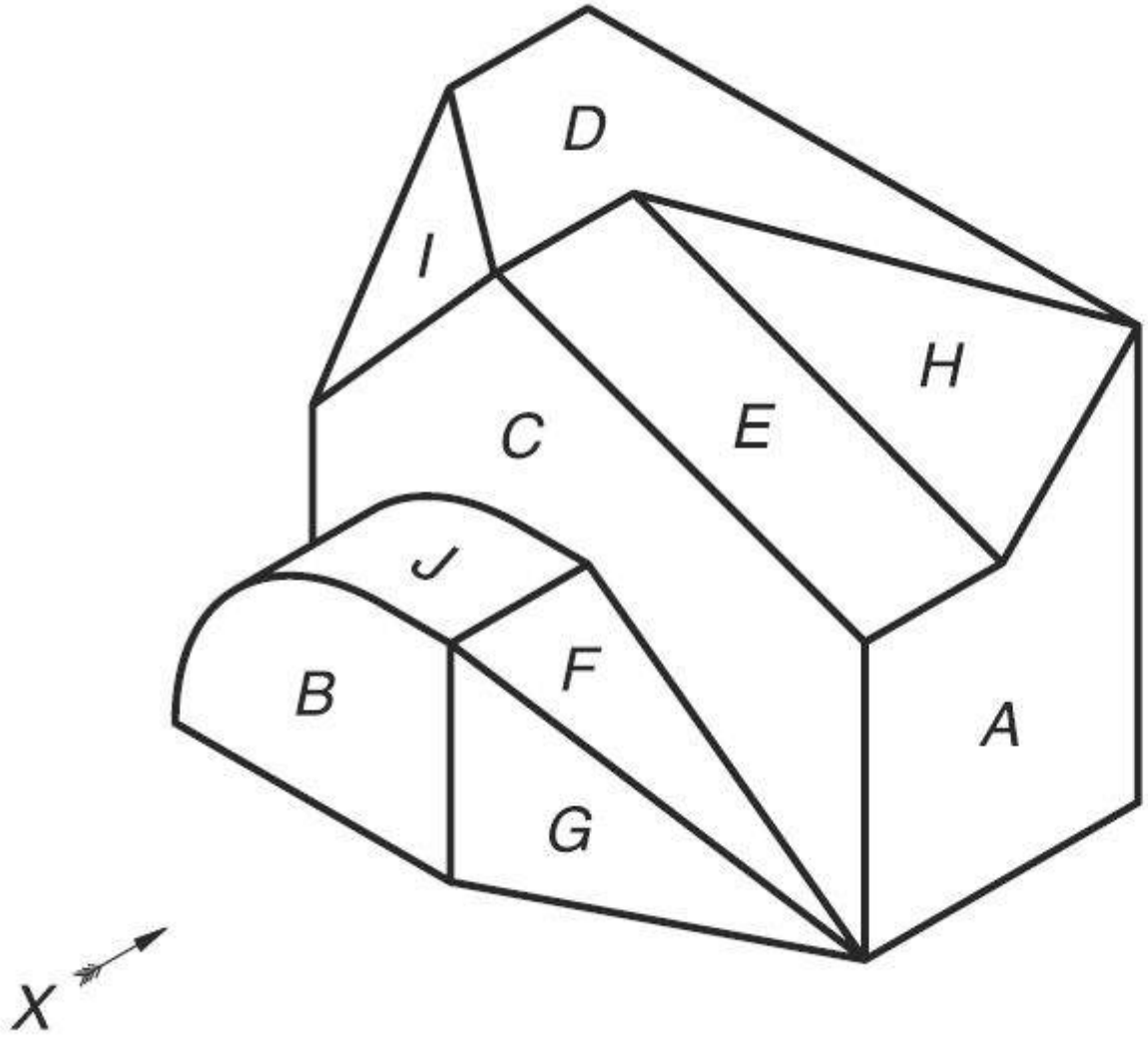
In First Angle Method,

- FV is above XY
- TV is below XY
- LHSV is on the right side of FV
- RHSV is on the left side of FV

In Third Angle Method

- FV is below XY
- TV is above XY
- LHSV is on the left side of FV
- RHSV is on the right side of FV

Method of Multiview Projection



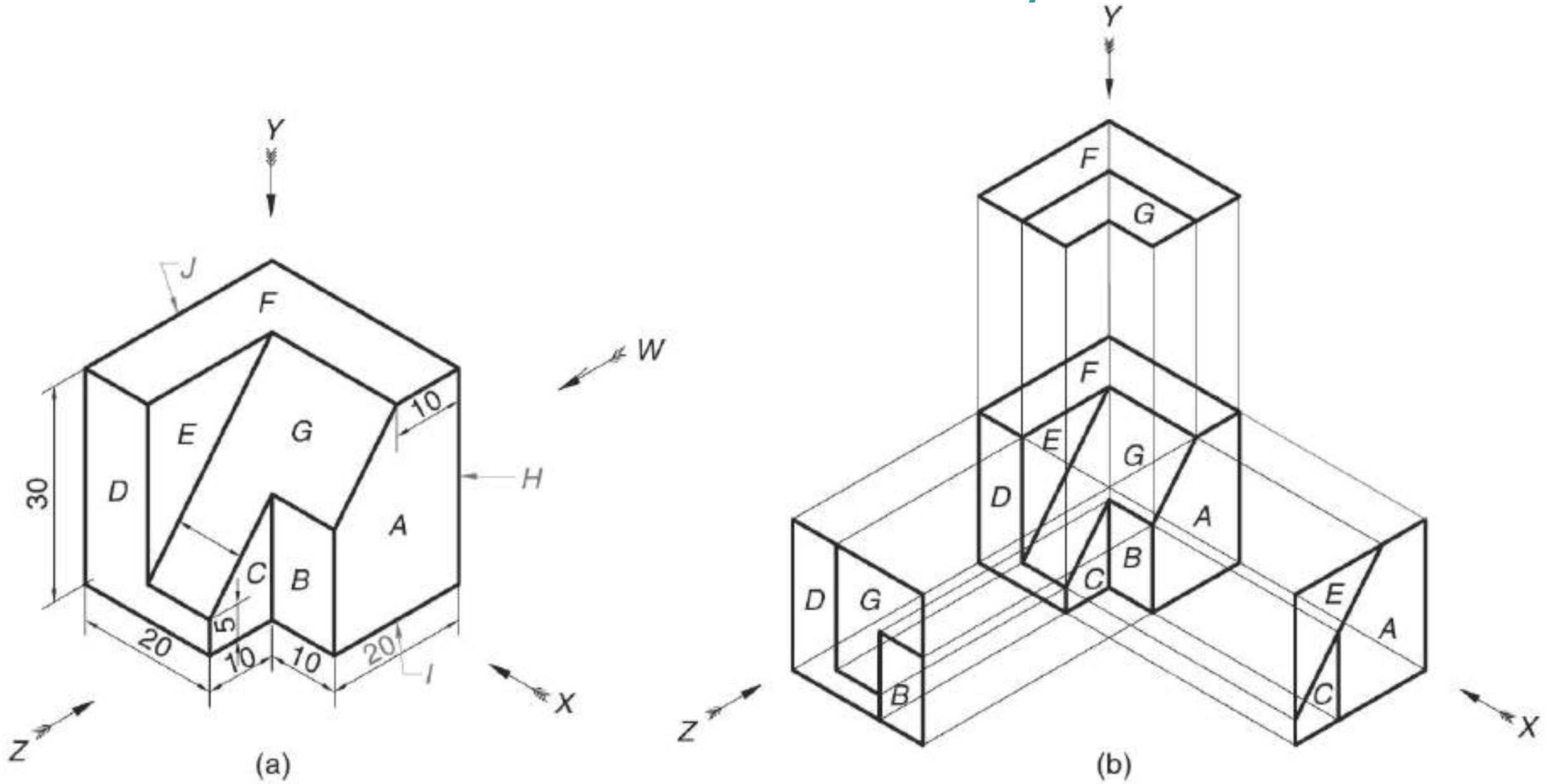
A, *B*, *C* – Vertical Faces
D – Horizontal Face
E, *F*, *G* – Inclined Faces
H, *I* – Oblique Faces
J – Curved Face

Method of Multiview Projection

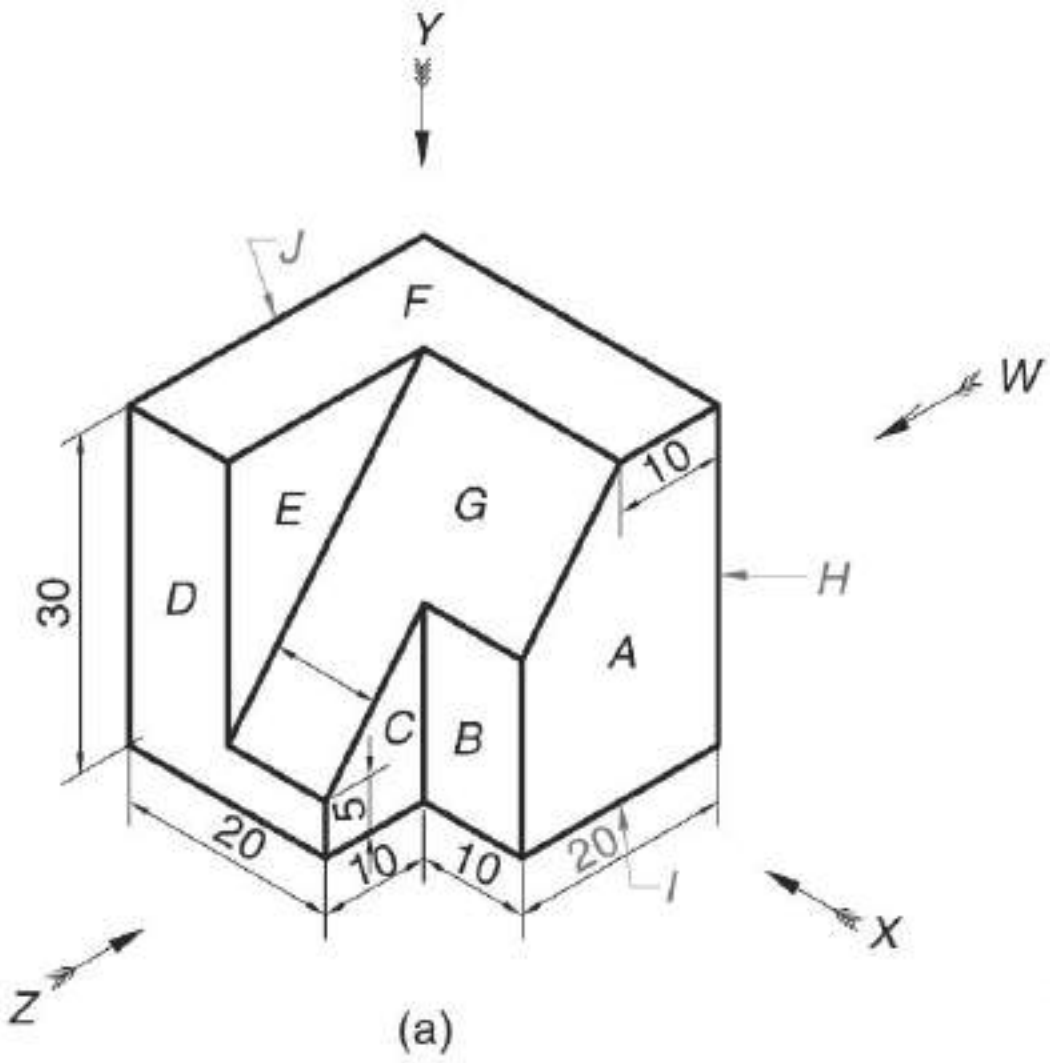
- To obtain the projections of various faces of an object, the following rules must be observed:

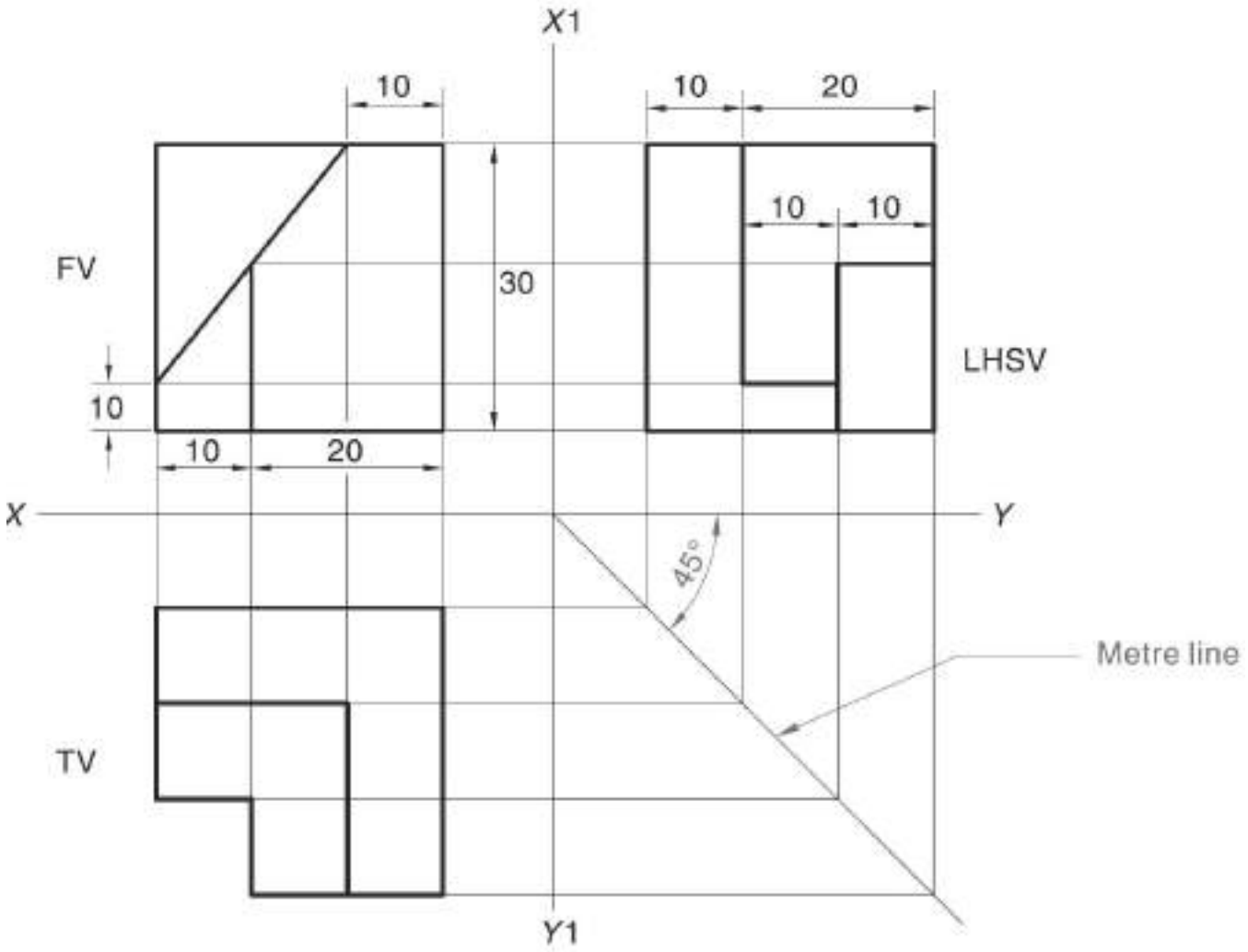
1. If a **face** is **perpendicular to the direction of viewing**, its true shape and size will be seen in that view.
2. If a **face** is **parallel to the direction of viewing**, it is seen as a line in that view. This view is called the line view or edge view.
3. If a **face** is **inclined to the direction of viewing**, its true shape and size will not be seen in any view.
4. If an **edge** of the object is **perpendicular to the direction of viewing**, its actual length will be seen in that view.
5. If an **edge** of the object is **parallel to the direction of viewing**, it is seen as a point in that view. This view is called point view.
6. If an **edge** of the object is **inclined to the direction of viewing**, its foreshortened length will be seen in that view. The foreshortened length is obtained by locating the end points of the edge

Method of Multiview Projection

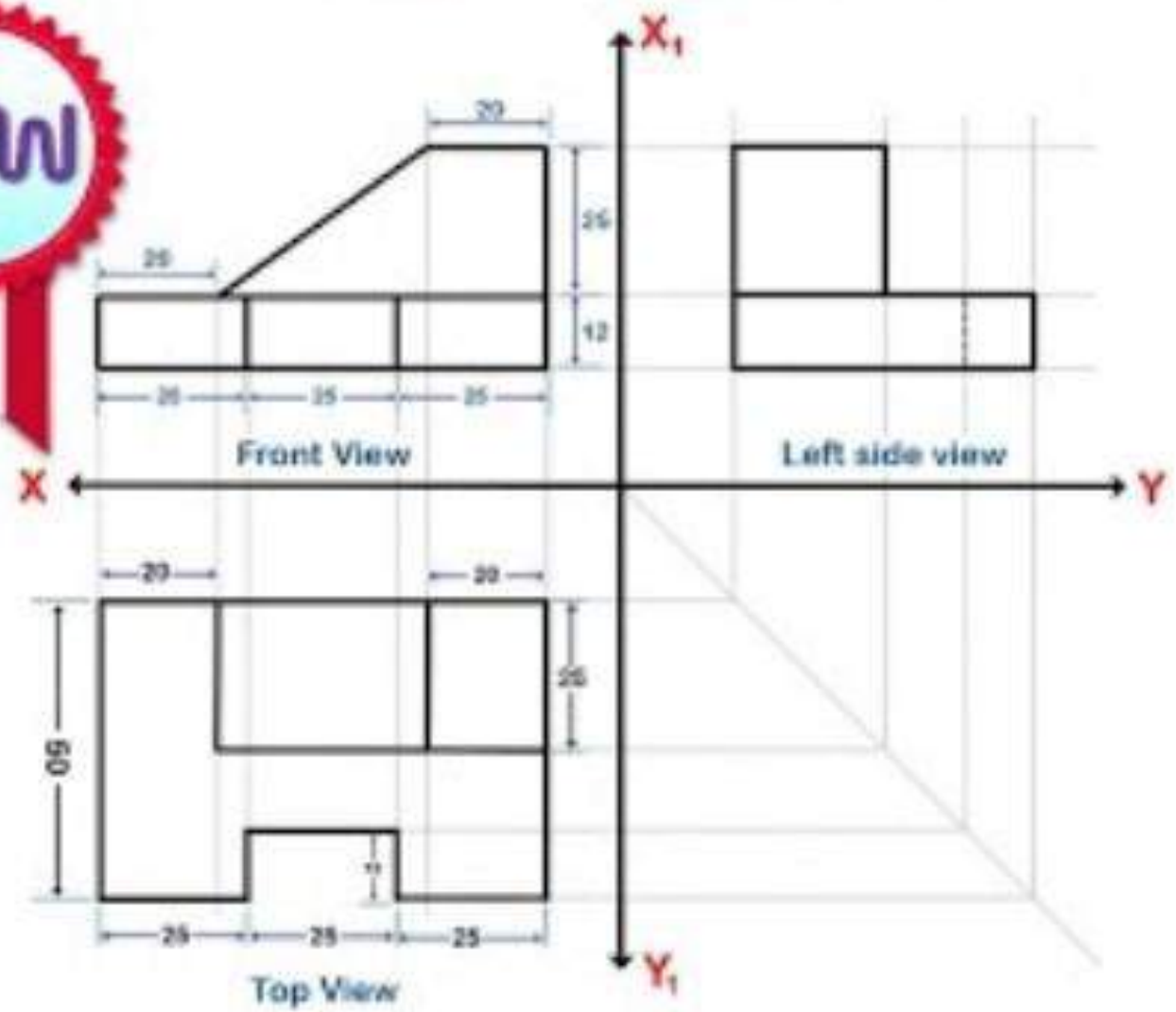


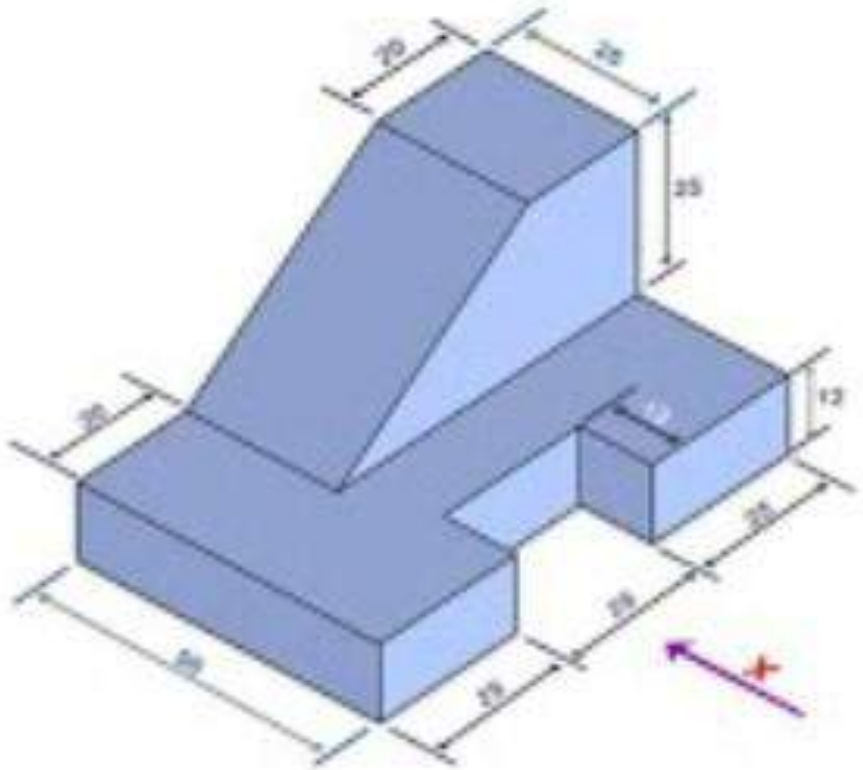
Method of Multiview Projection





Orthographic Projection

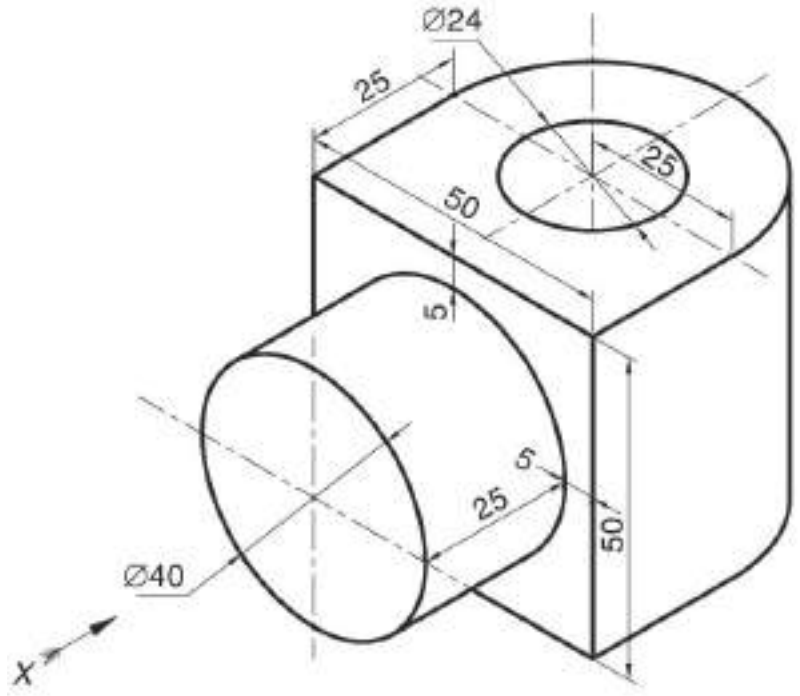




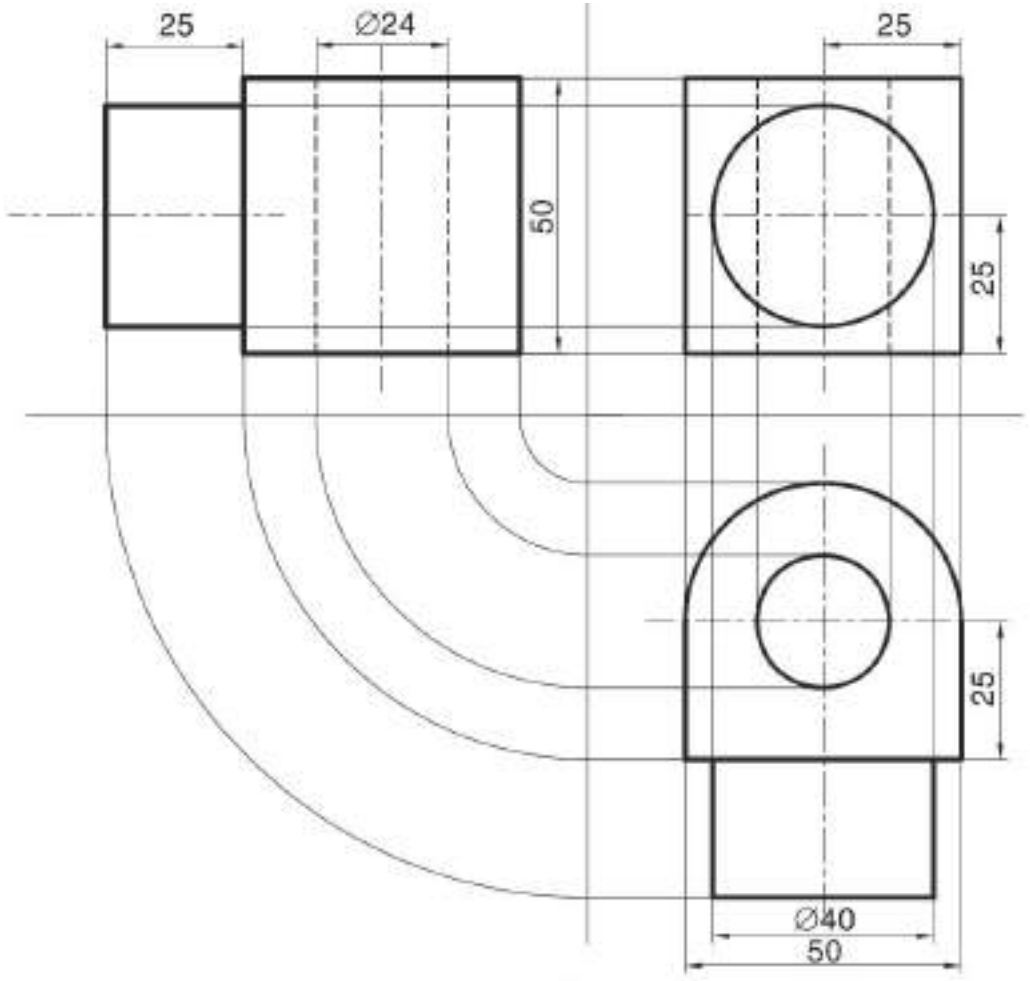
Isometric View

Hidden features

- The features of the object not seen in a particular view are called as hidden features. The hidden features may be external (i.e., visible from outside) or internal (i.e., inside the exterior walls of the object).
- Examples of hidden features are—holes, slots, projection on back face, etc. The hidden features, internal or external, are shown by drawing **dashed lines** for the edges.



(a)



(b)

Sectional views

- It will become difficult to visualize the shape of the object as the number of dashed lines in orthographic views goes on increasing.
- Numbers of dashed lines make the drawing complicated and confusing to interpret.
- Therefore, the general practice is to draw **sectional views** for complex objects

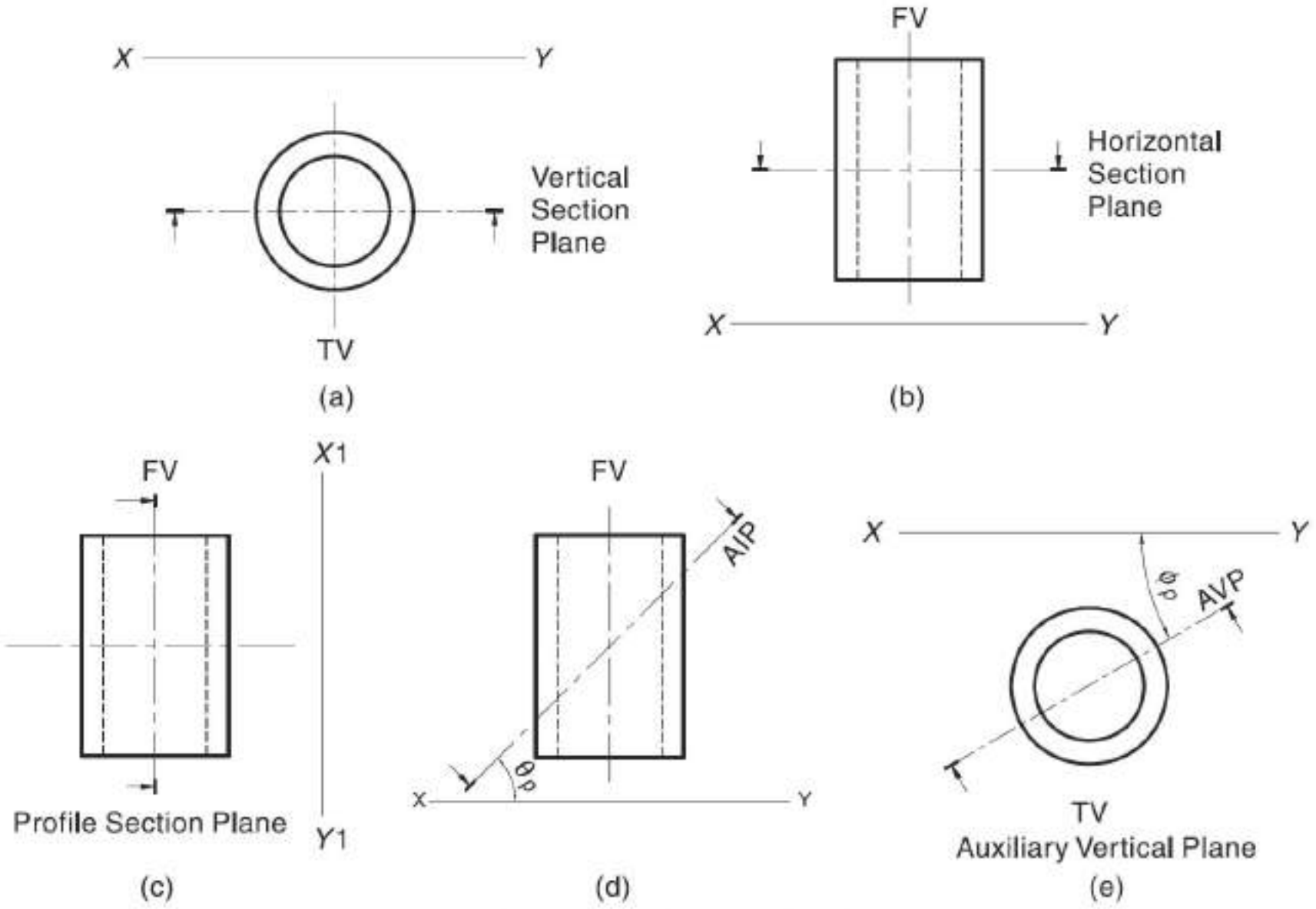
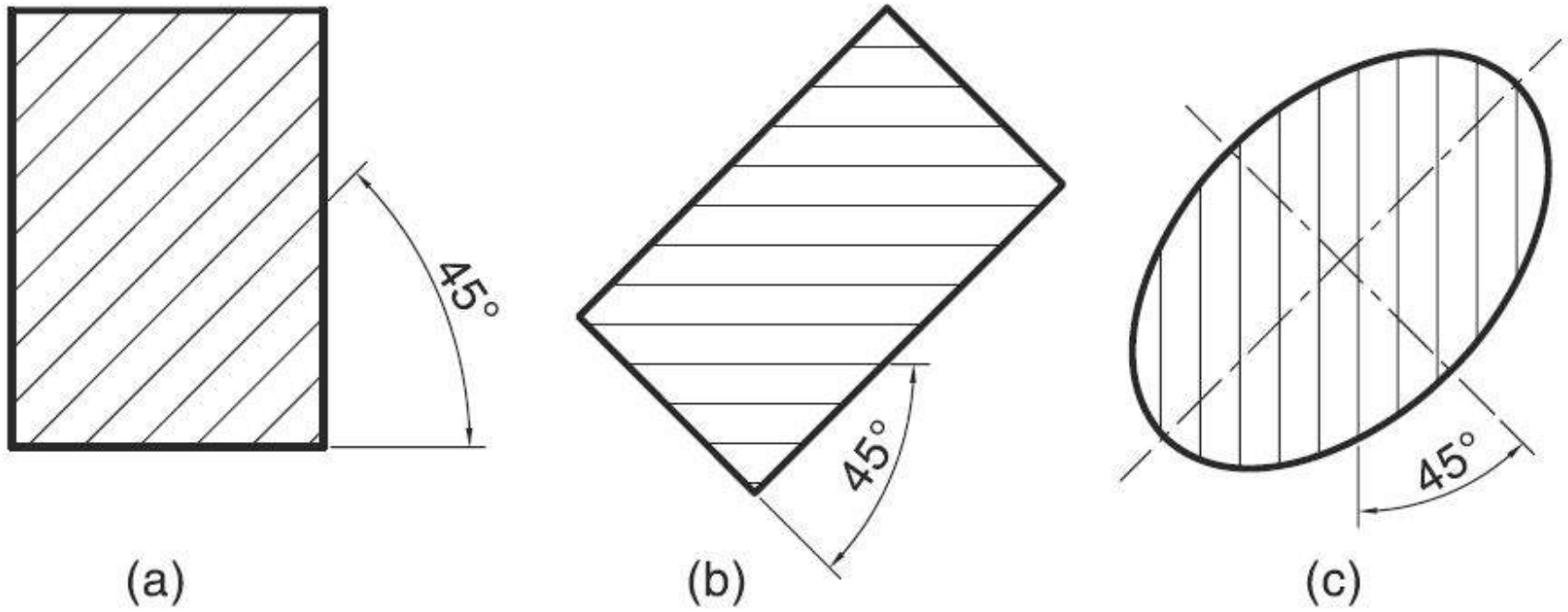


Fig. 9.25 Types of cutting planes and their representation

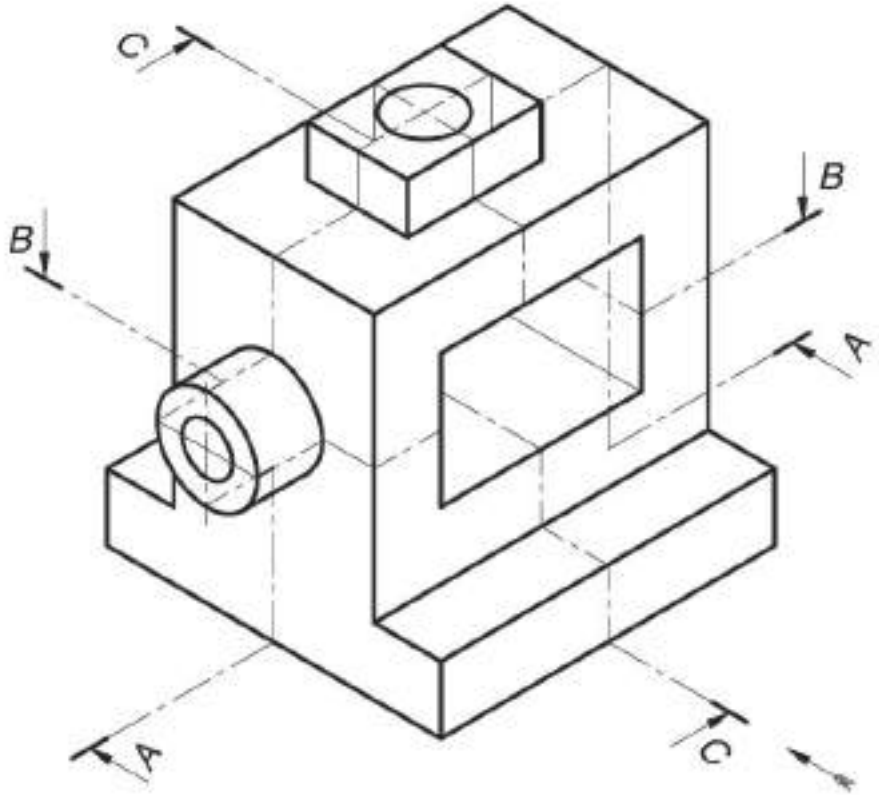
Hatching of sections

- The surface created by cutting the object by a section plane is called as **section**
- The section is indicated by drawing the hatching lines within the sectioned area.
- The hatching lines are drawn at 45° to the principal outlines or the lines of symmetry of the section.

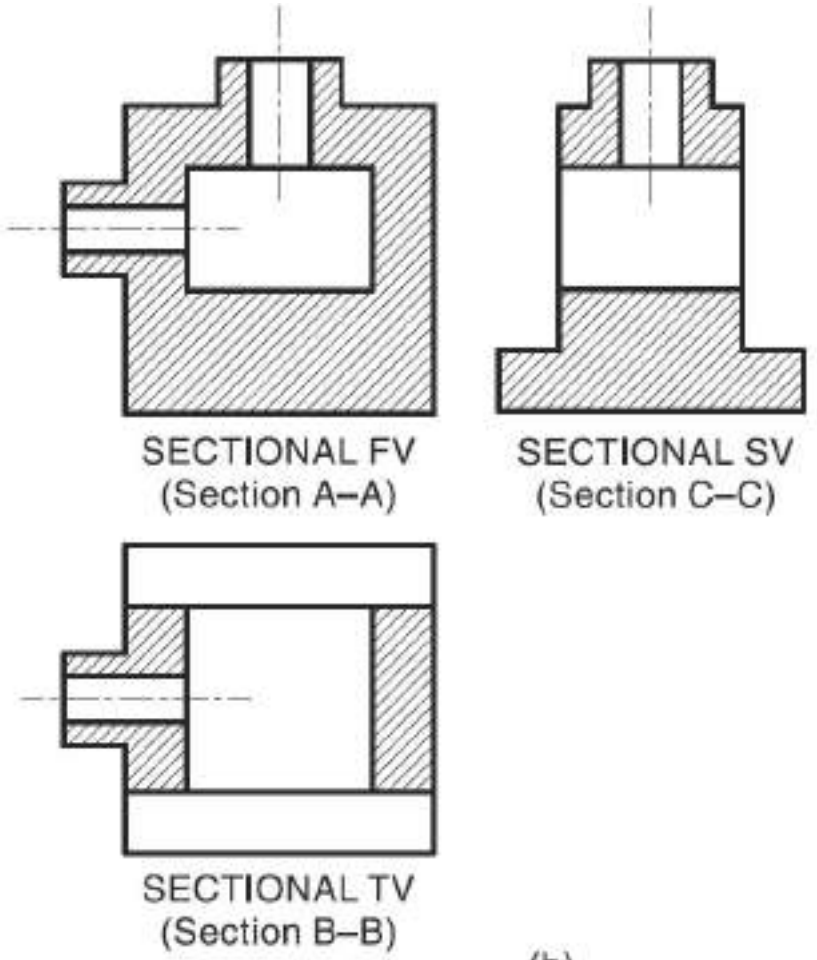


Various sectional views

- Figure (a) shows an object with the vertical cutting plane A–A, horizontal cutting plane B–B and profile cutting plane C–C marked on it. The corresponding sectional views are shown in figure (b).

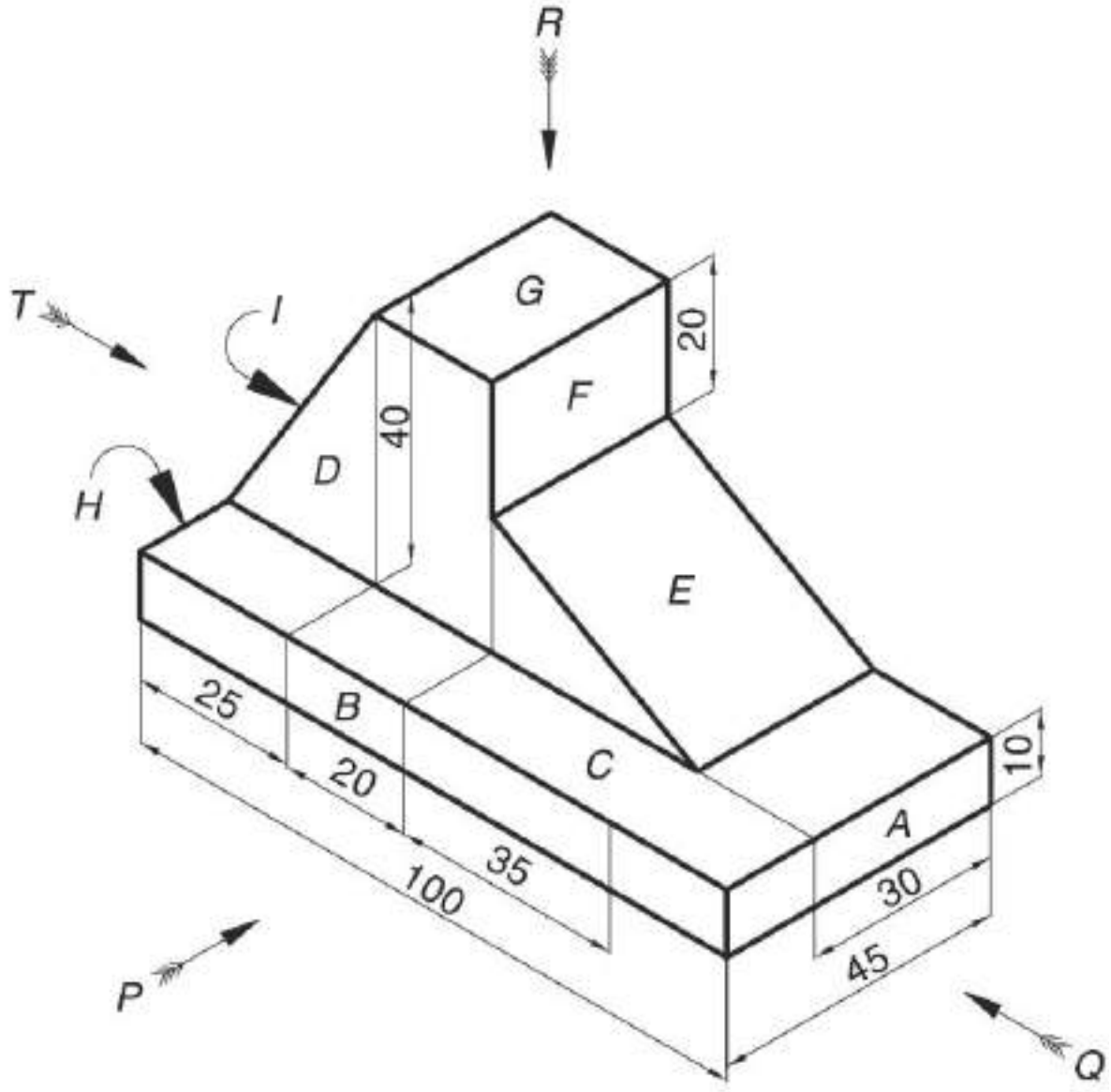


(a)



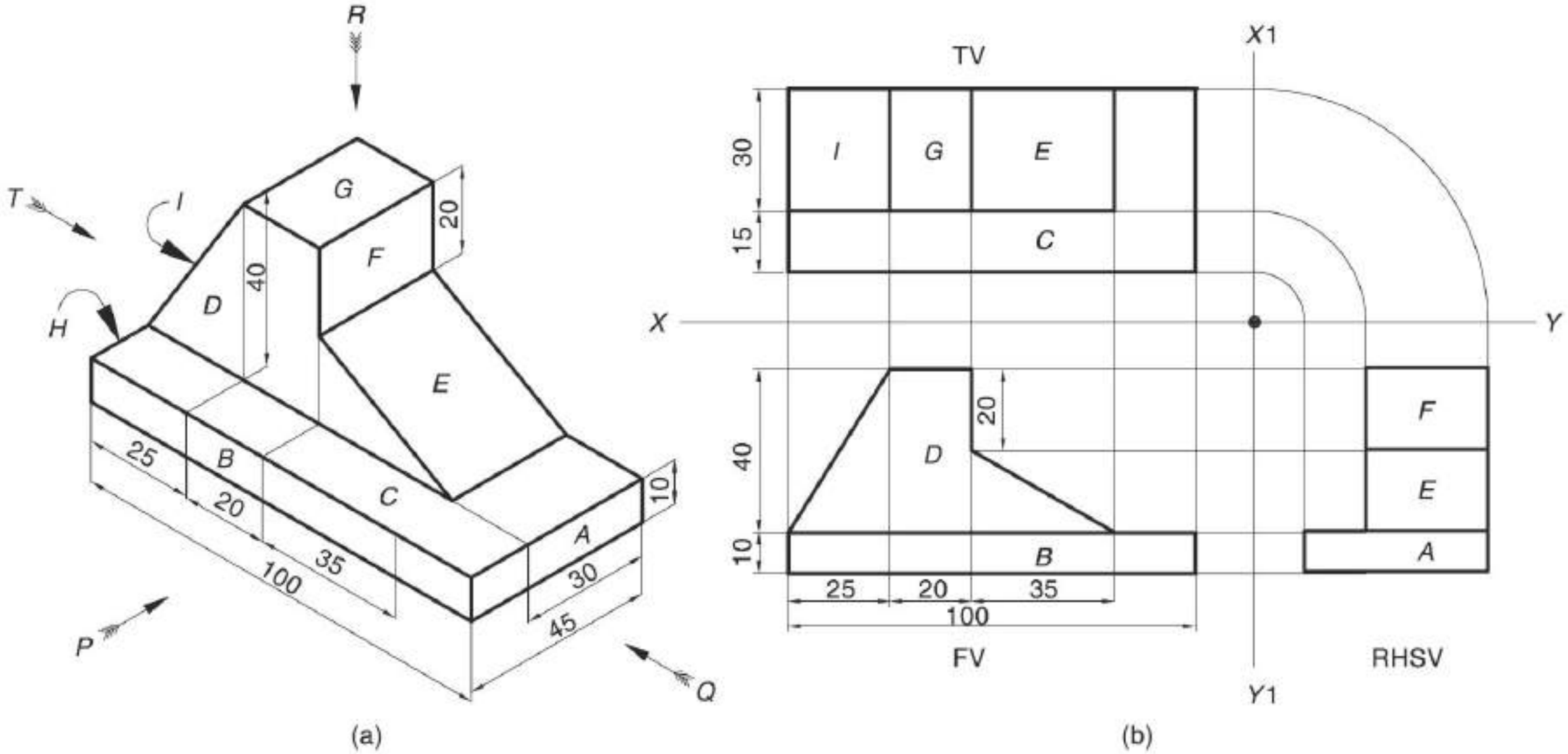
(b)

Exercise



(a)

Solution


R
T
I
H
P
Q
G
F
D
E
C
B
A
20
40
25
20
35
100
10
30
45
(a)
TV
X1
X
Y
Y1
I
G
E
C
30
15
D
20
40
10
B
F
E
A
25
20
35
100
FV
RHSV
(b)