# *Projections & views*

A three-dimensional object can be represented in a single plane, such as on a sheet of paper, by the use of projecting lines and planes. All projection theory is based on two variables: *line of sigh*t (projecting lines) and *plane of projection*.

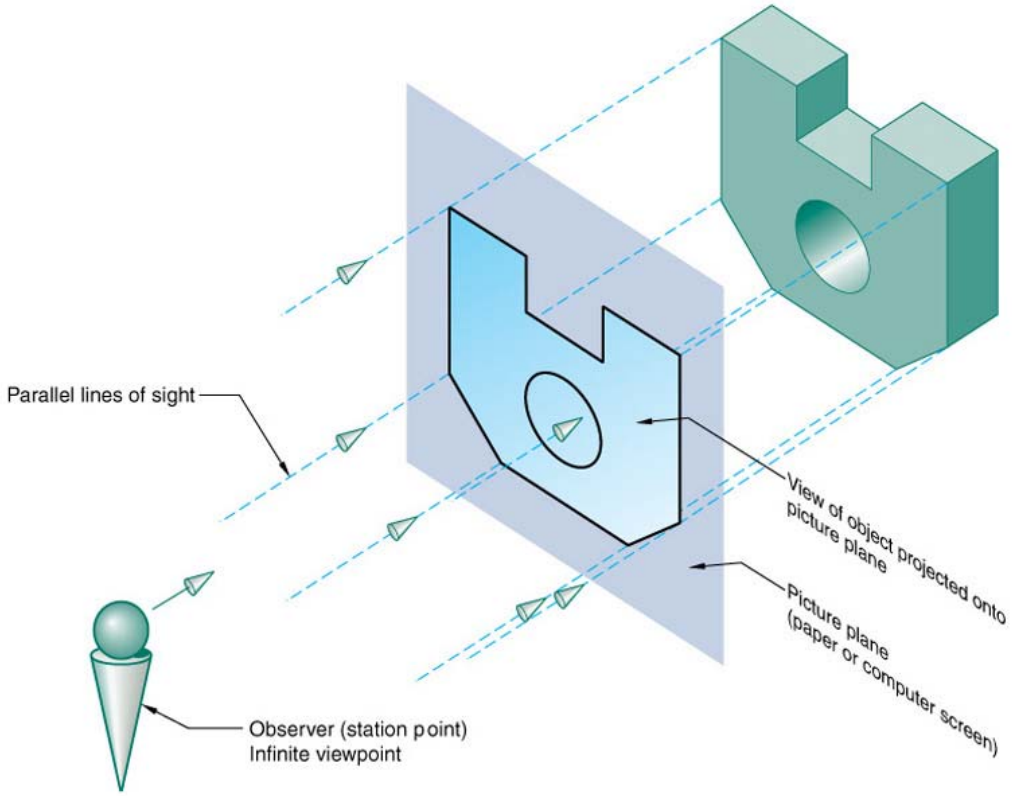
A **line of sight (LOS)** is an imaginary ray of light between an observer's eye and an object.

A **plane of projection** (i.e., an image or picture plane) is an imaginary flat plane upon which the image created by the lines of sight is projected.

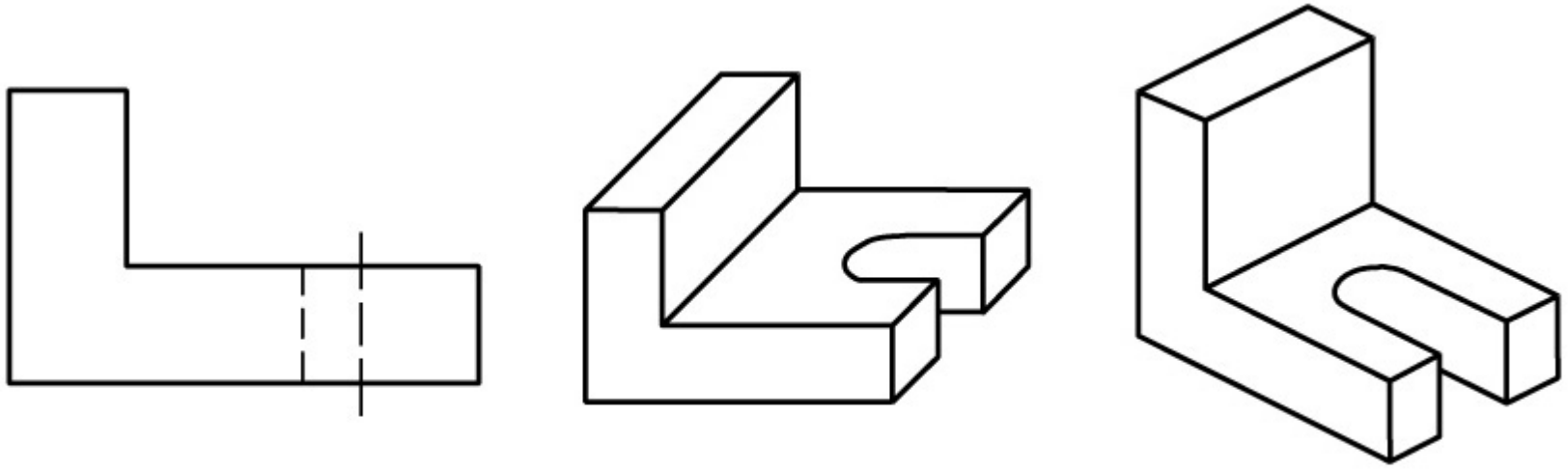
The image is produced by connecting the points where the lines of sight pierce the projection plane.
As a result, the 3-D object is transformed into a 2-D representation, also called a projection.

If the distance from the observer to the object is infinite, then the projection lines are parallel and the drawing is classified as a parallel projection.

Parallel projection is ***orthographic*** if the plane of projection is positioned between the observer and the object and is perpendicular to the parallel lines of sight.

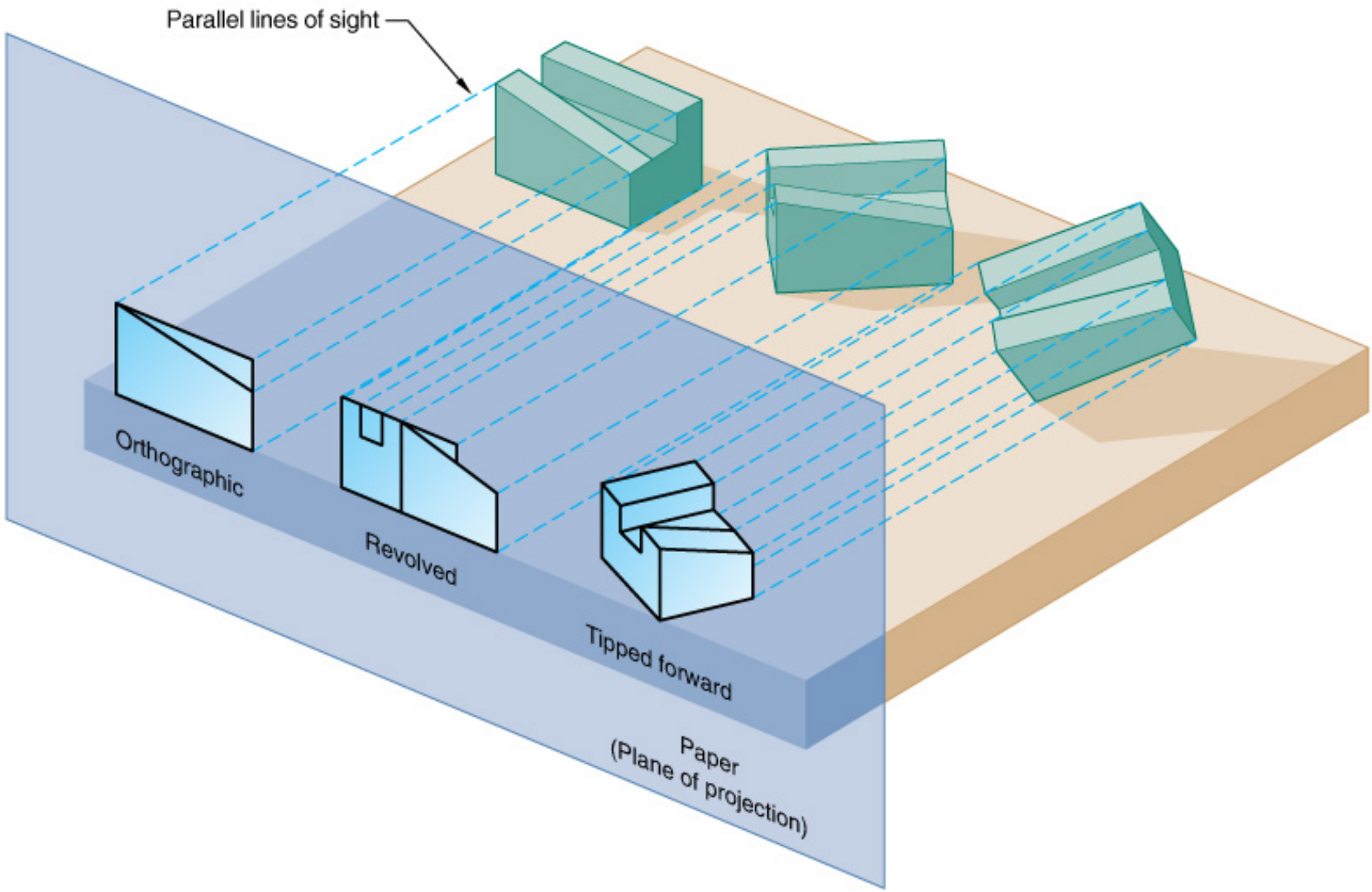


Parallel projection technique can be used to create both pictorial and multiview drawings.




In all these cases all lines of sight are parallel.

- In multiview projection (orthographic), the object surface & the projection plane are parallel, and only two dimensions can be seen.
- In oblique projection (non-orthographic) the object surface & the projection plane are also parallel, but the lines of sights are not perpendicular to the projection plane, and three dimensions can be seen.
- In isometric view (orthographic) the surface is no longer parallel to the projection plane, three dimensions being seen.



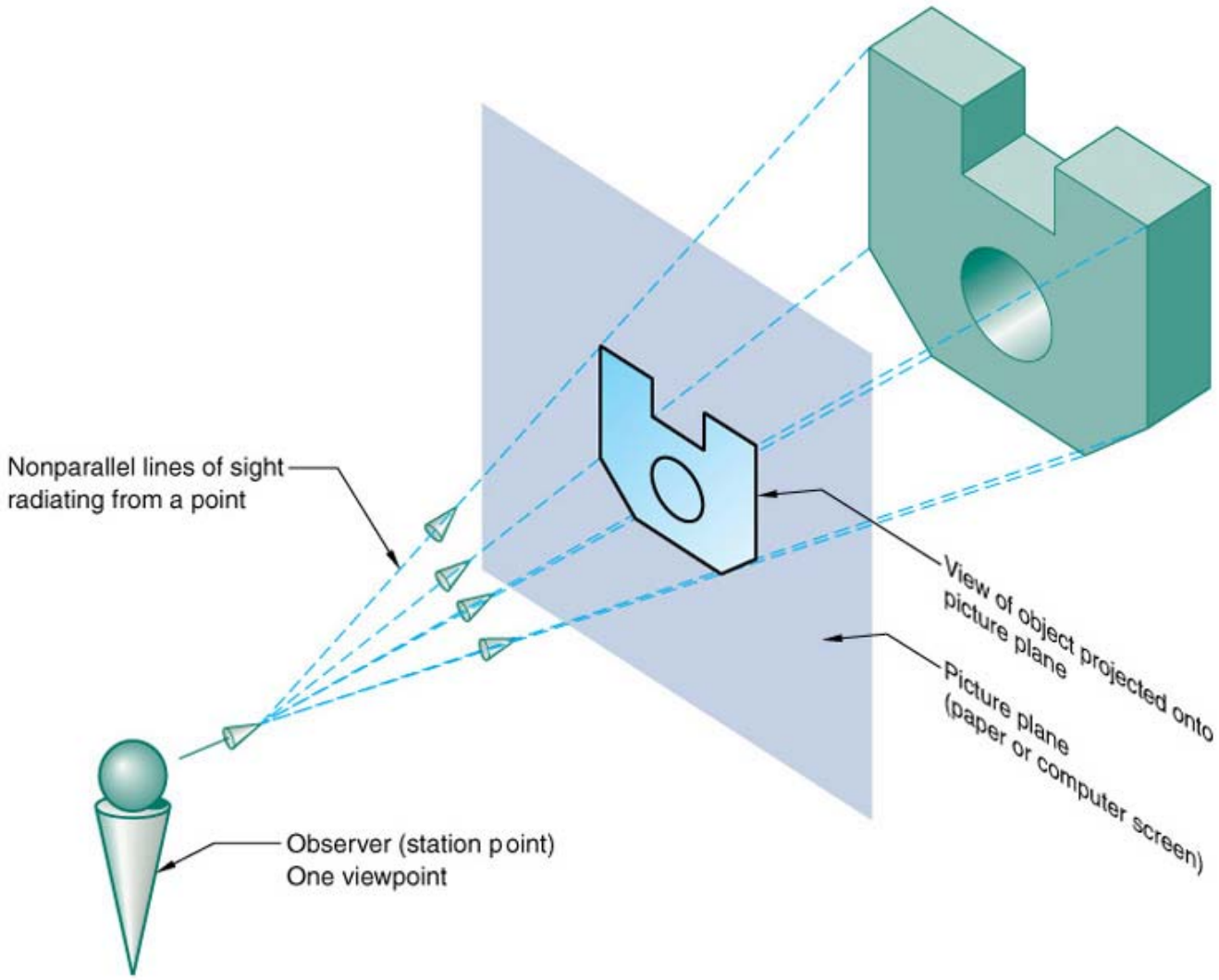

*Examples of different parallel projections:* ***orthographic***, ***revolved*** *&* ***tipped forward*** *(axonometric)*

Technically, *revolved* (around vertical axis) *& tipped forward* projections can be considered as orthographic, basing on the parallelism of the sight lines and orientation of the projection plane.

If the distance from the observer to the object is finite, then the projection lines are not parallel and the drawing is classified as a *perspective projection*.

In other words, the projection is *perspective*, when all lines of sight start at a single point.

Object surface & projection plane are parallel.

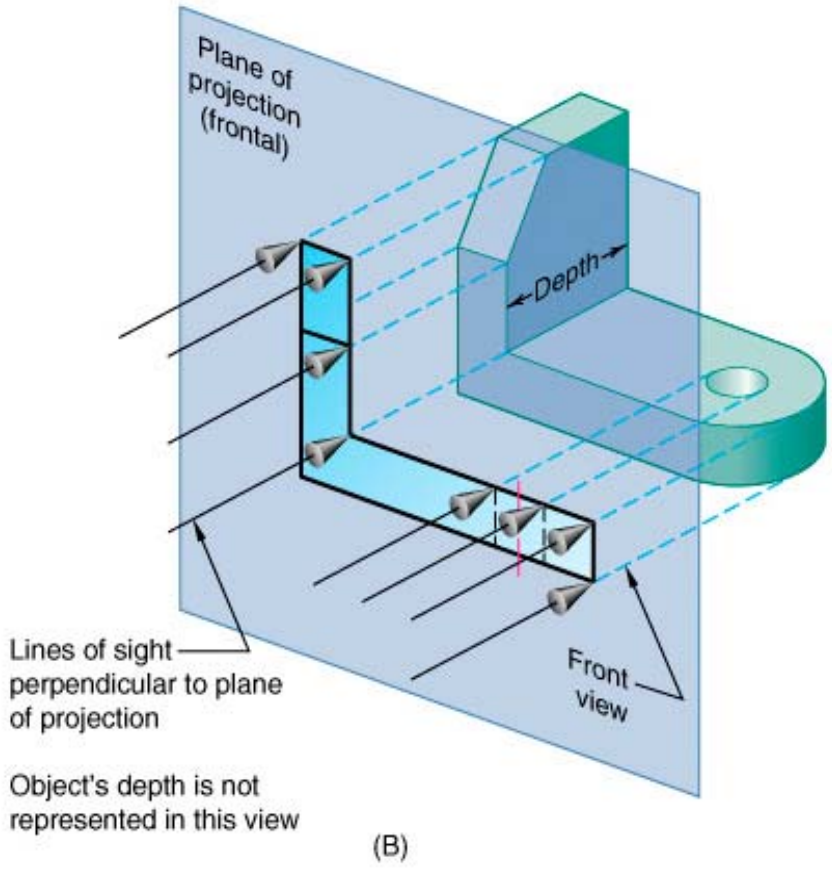


***Multiview projection***

Changing the position of the object relative to the line of sight creates different views of the same object.
Drawing more than one face of an object by rotating the object relative to your *line of sight* helps in understanding the 3-D form.
Having several views on one drawing we come to the concept of **multi-view projection**, which is based on the orthographic (parallel) projection technique where

- the plane of projection is positioned between the observer and the object,
- the plane of projection is perpendicular to the parallel lines of sight, and
- the object is oriented such that only two of its dimensions are shown.

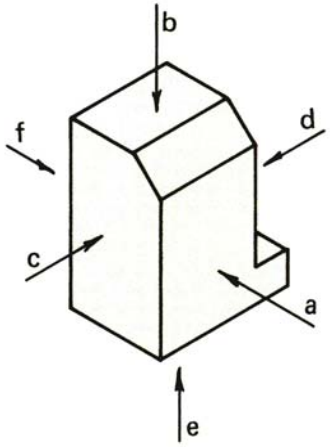
In multiview projection, the object is viewed perpendicular to the main faces, so that only one face of the object is depicted in each view.



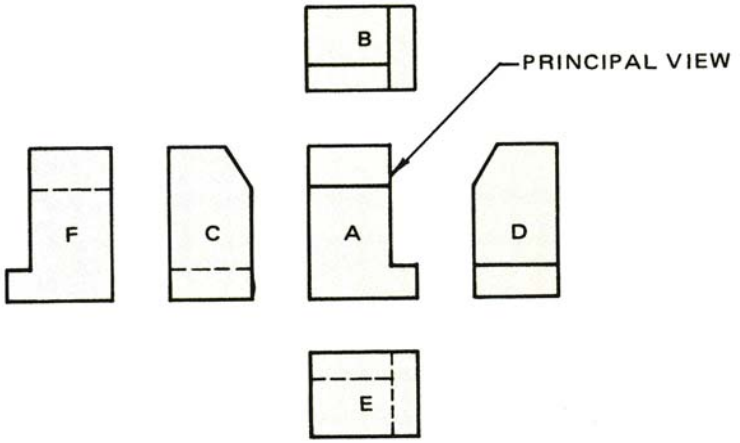
***Main principles of creating multiview projections:***

- The most informative (descriptive) view of the object to be represented is normally chosen as the principle view (front view).

In the figure this is view **A** according to the direction of viewing **a** and usually shows the object in the functioning, manufacturing or mounting position.




VIEWING DIRECTIONS




POSITIONING OF VIEWS ON DRAWING SURFACE

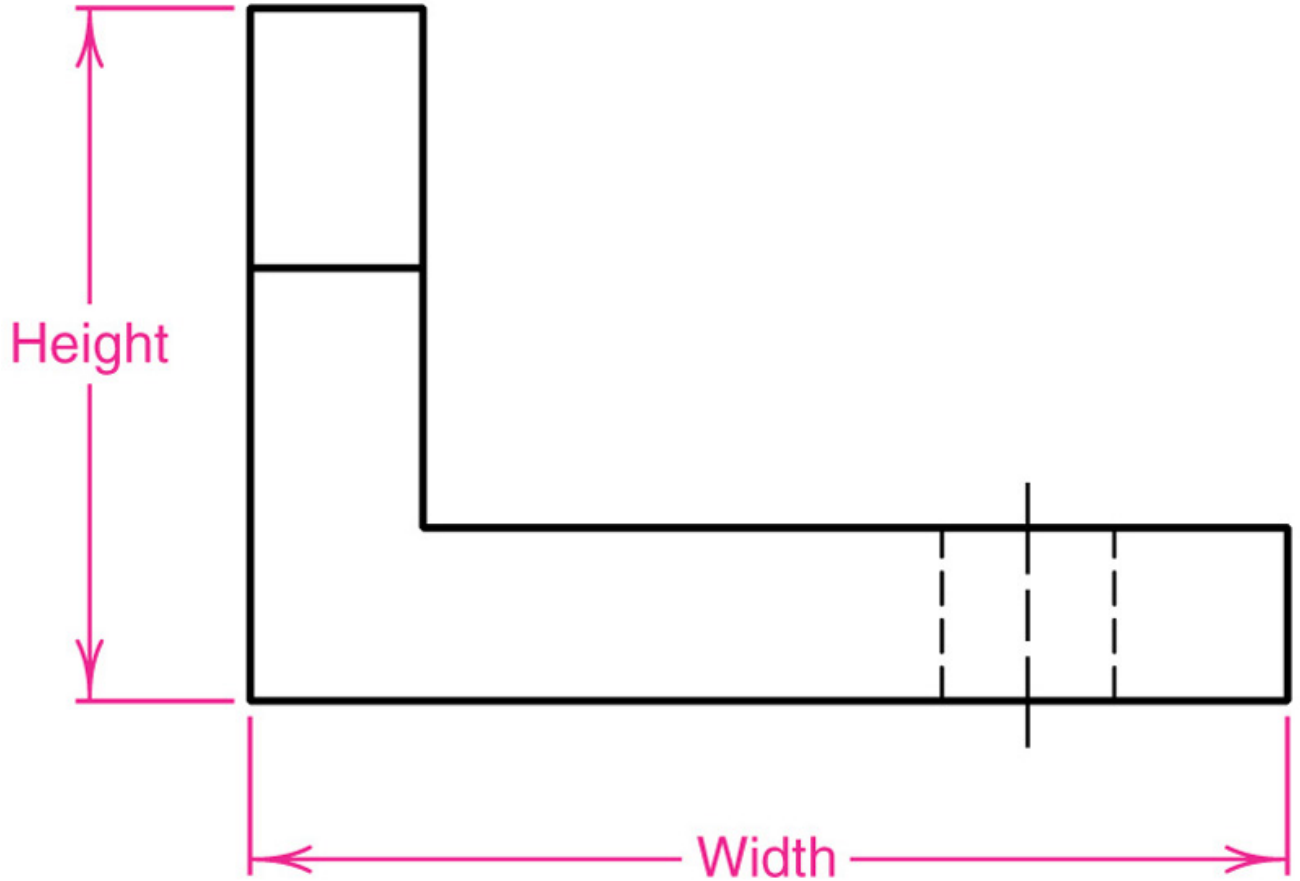
The position of the other views relative to the principal view in the drawing depends on the projection method.

- The number of views and sections must be limited to the minimum necessary to fully represent the object without ambiguity.
- Unnecessary repetition of details must be avoided.

Generally three views of an object is enough, however, a print must contain as many views as necessary to illustrate the part, usually at right angles to one another.

***Frontal plane of projection***

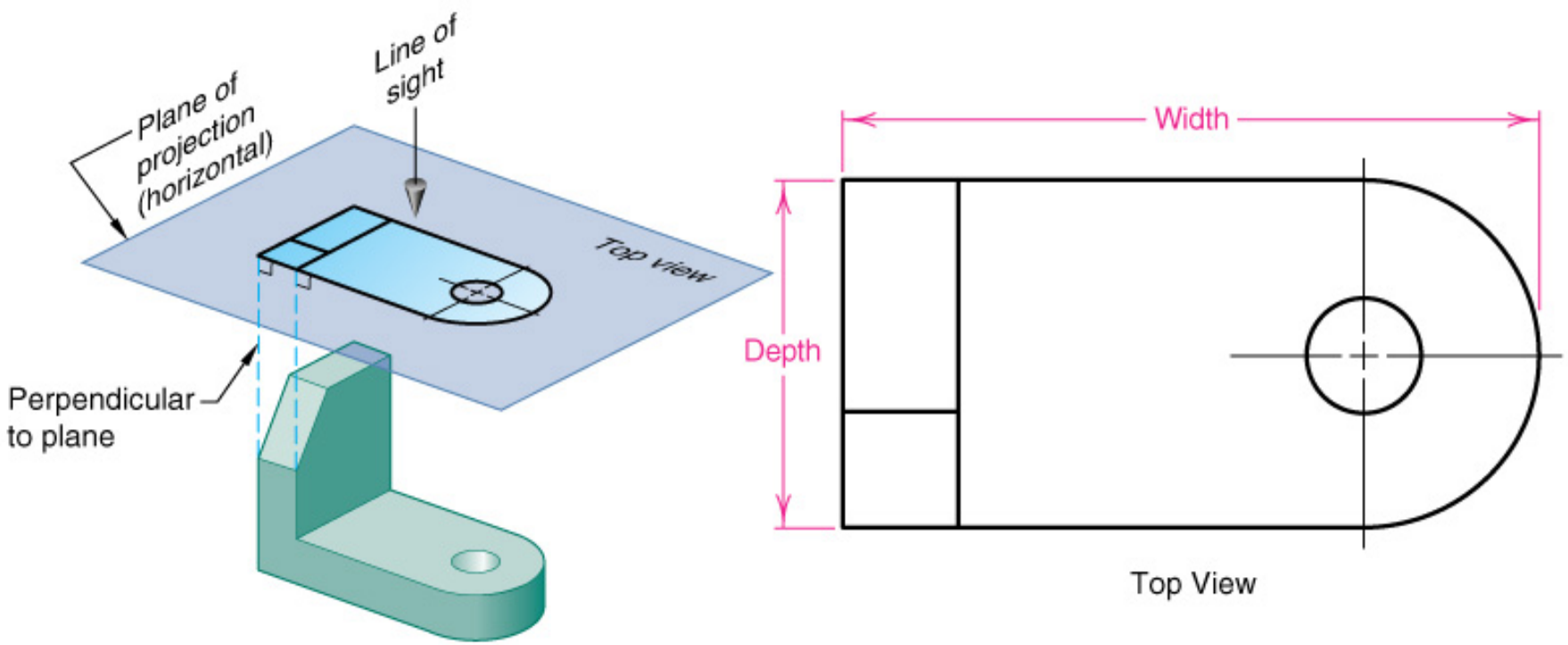
The front view of an object shows the *width* and *height* dimensions.




The **frontal plane of projection** is the plane onto which the front view of a multiview drawing is projected.

***Horizontal plane of projection***

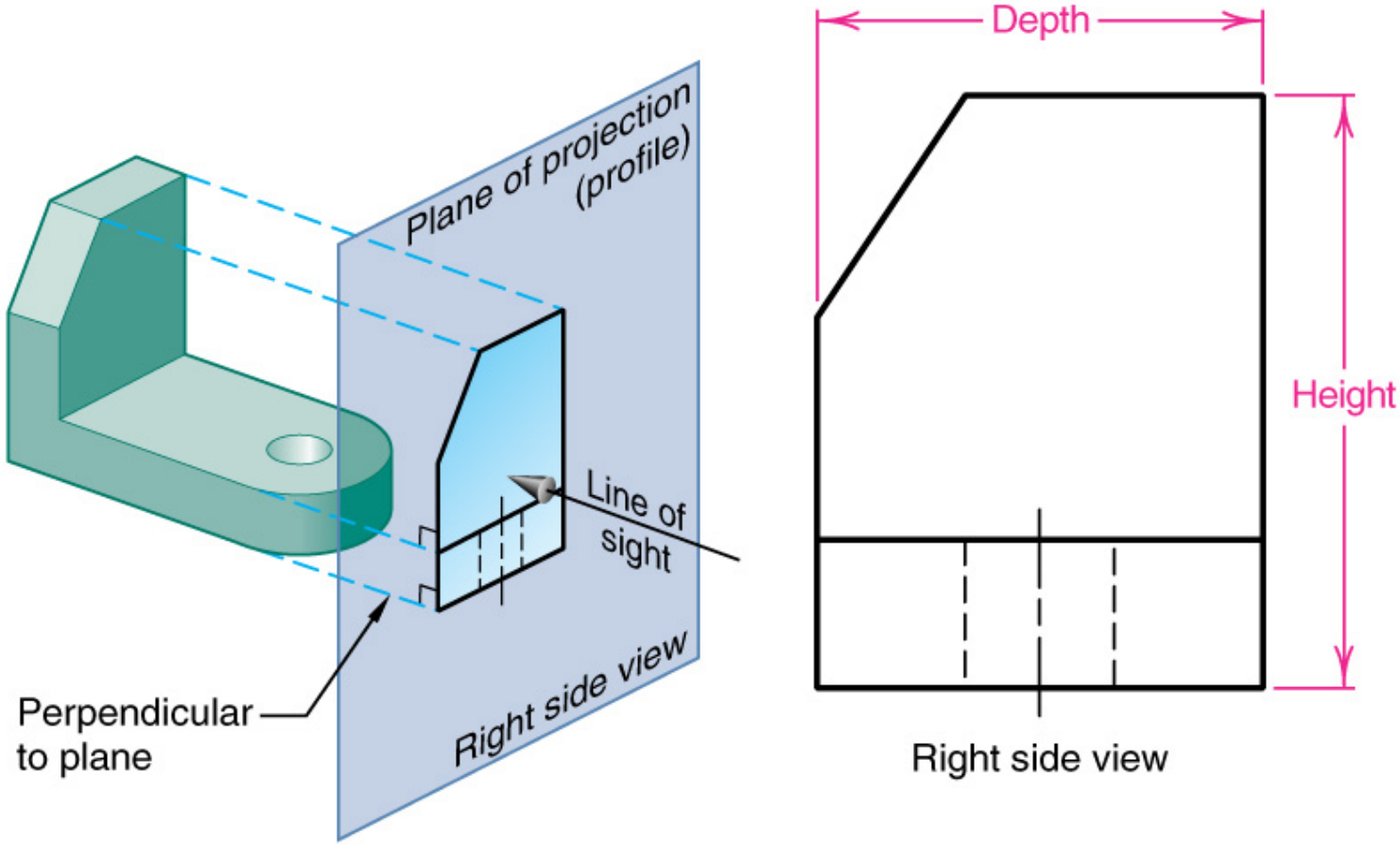
The *top view* of an object shows the *width* and *depth* dimensions.




The top view is projected onto the **horizontal plane of projection**, which is plane suspended above and parallel to the top of the object.

***Profile plane of projection***

The *side view* of an object shows the *depth* and *height* dimensions.
In multiview drawings, the right side view is the standard side view.
The right side view is projected onto the **right profile plane** of projection, which is a plane that is parallel to the right side of the object.



***Why multiview drawings technique is so important?***

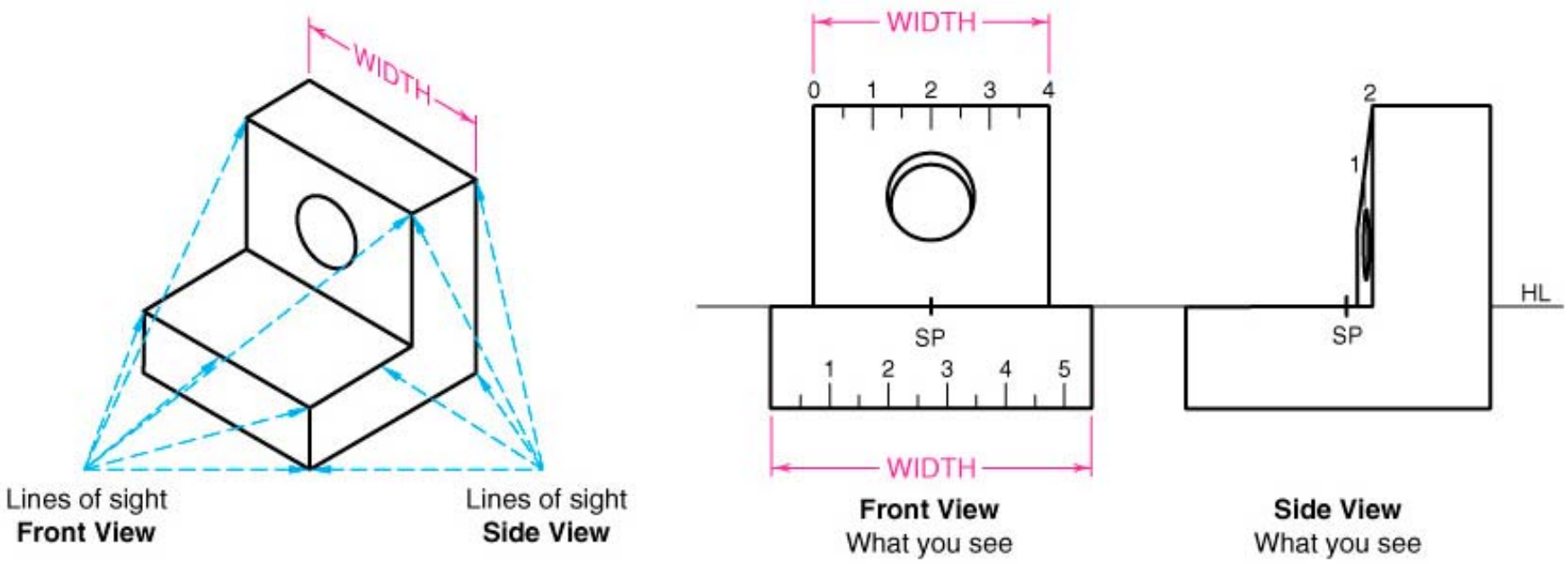
In order to produce a new product, it is necessary to know its true dimensions, and true dimensions are not adequately represented in most pictorial drawings.

The photograph is a pictorial perspective image.

*The image distorts true distances, which is essential in manufacturing and construction.*

The following figure demonstrates how a perspective projection distorts measurements.

Note that the two width dimensions in the front view of the block appear different in length; equal distances do not appear equal on a perspective drawing.




Thus, since engineering and technology depend on exact size and shape descriptions for design, the best approach is to use the parallel projection technique (orthographic projection) to create multi-view drawings where each view shows only two of the three dimensions (width, height, depth).

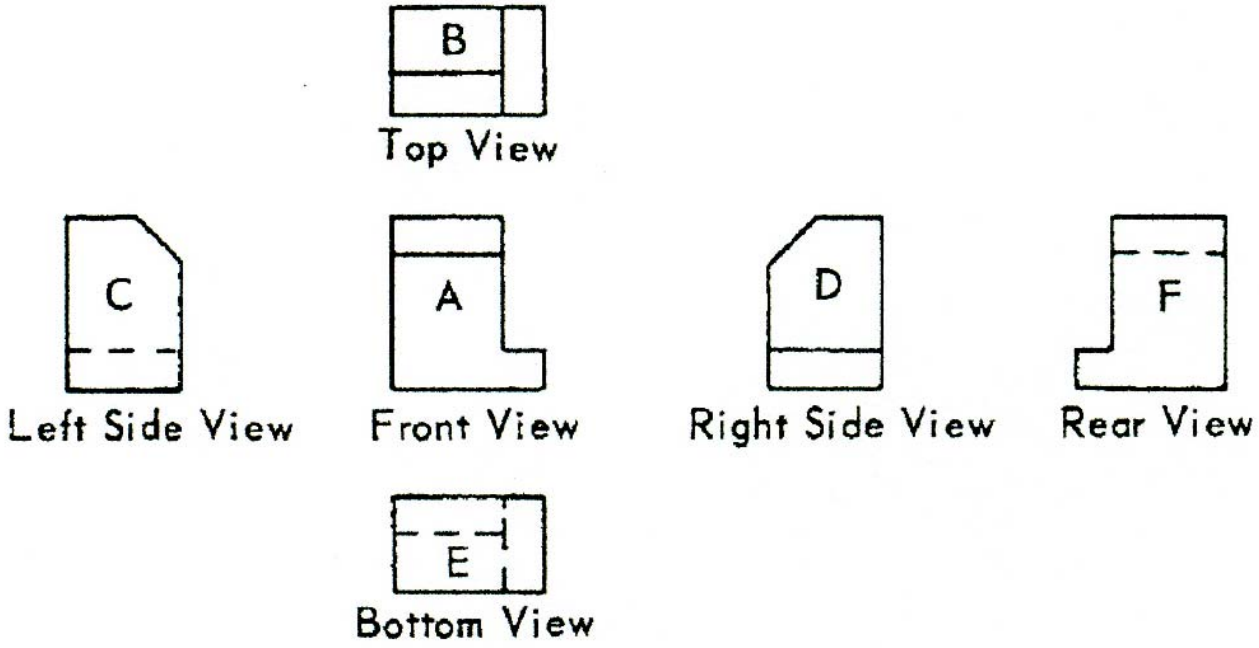
*Resumé*:

The **advantage of *multiview drawings*** over pictorial drawings is that multiview drawings shows the **true size and shape** of the various features of the object, whereas pictorials distort true dimensions which are critical in manufacturing and construction.

***The principle views***

The plane of projection can be oriented to produce an infinite number of views of an object. However, the principal views are the six mutually perpendicular views that are produced by six mutually perpendicular planes of projection:

- **Front view** – the one that shows most features or characteristics.
- **Left side view** – shows what becomes the left side of the object after establishing the front view position
- **Right side view** – shows what becomes the right side of the object after establishing the front view position
- **Top view** – shows what becomes the top of the object once the position of the front view is established.
- **Bottom view** – shows what becomes the bottom of the object once the position of the front view is established.
- **Rear view** – shows what becomes the rear of the object once the position of the front view is established.




The *width dimension* is common to the front and top views. The *height dimension* is common to the front and side views. The *depth dimension* is common to the top and side views.

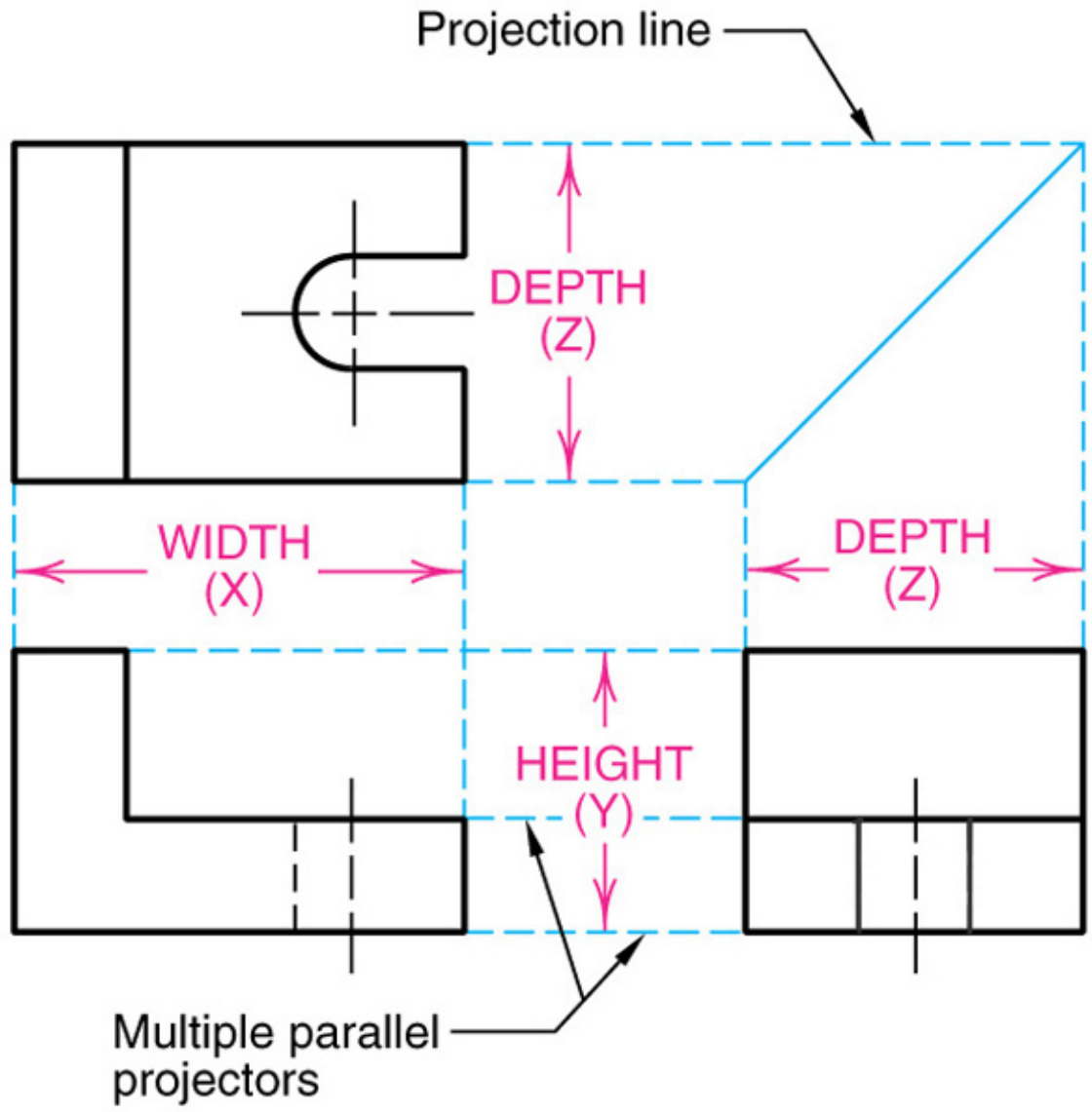
***Conventional view placement***

The three-view multiview drawing is the standard used in engineering and technology, because often the other three principle views are mirror images and do not add to the knowledge about the object.

The standard views used in a **three-view drawing** are the

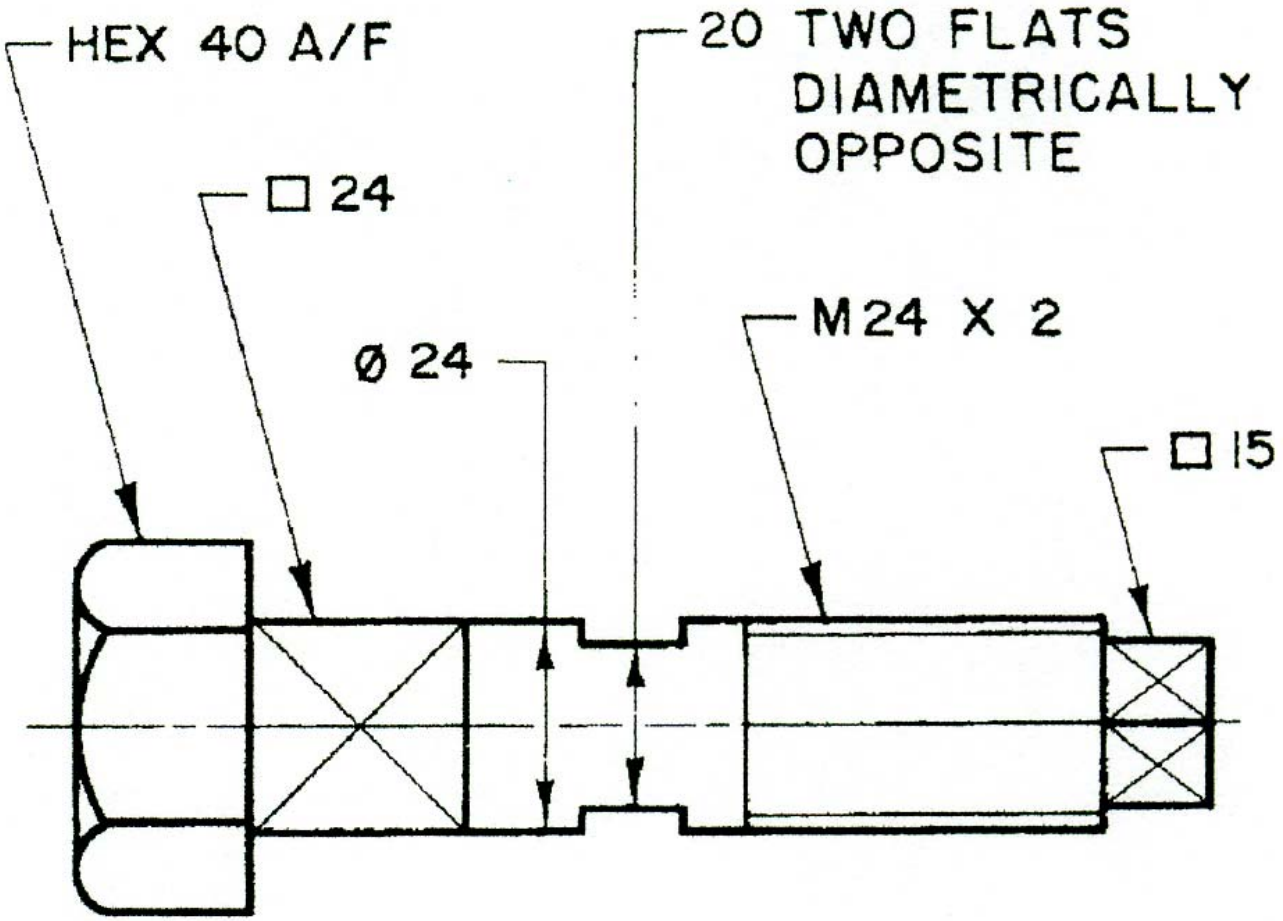
- top,
- front, and
- right side views,

arranged as shown in the figure:



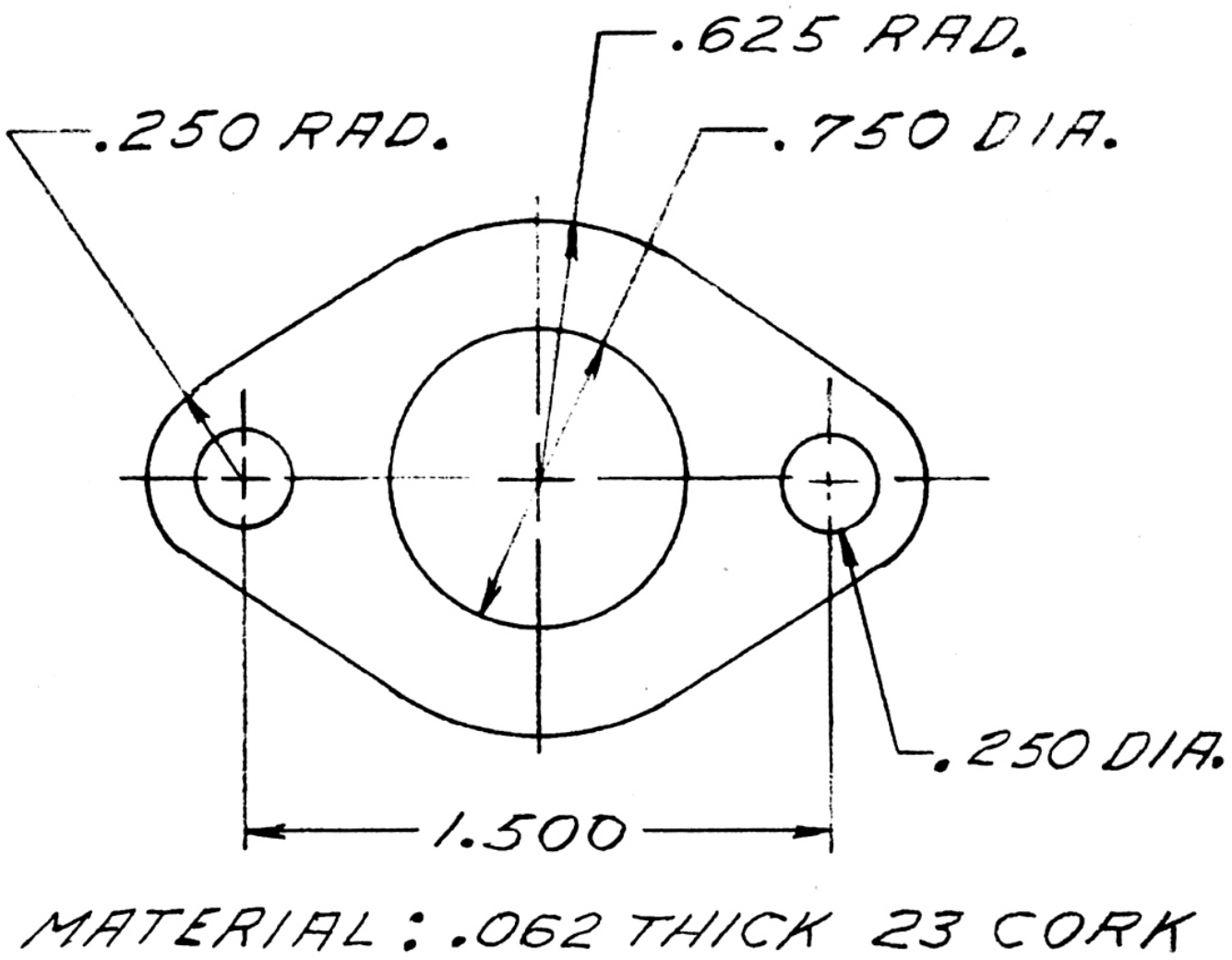
For simple parts one or two view drawings will often be enough.

In one-view drawings the third dimension may be expressed by a note, or by descriptive words, symbols, or abbreviations, such as ∅, HEX or □:



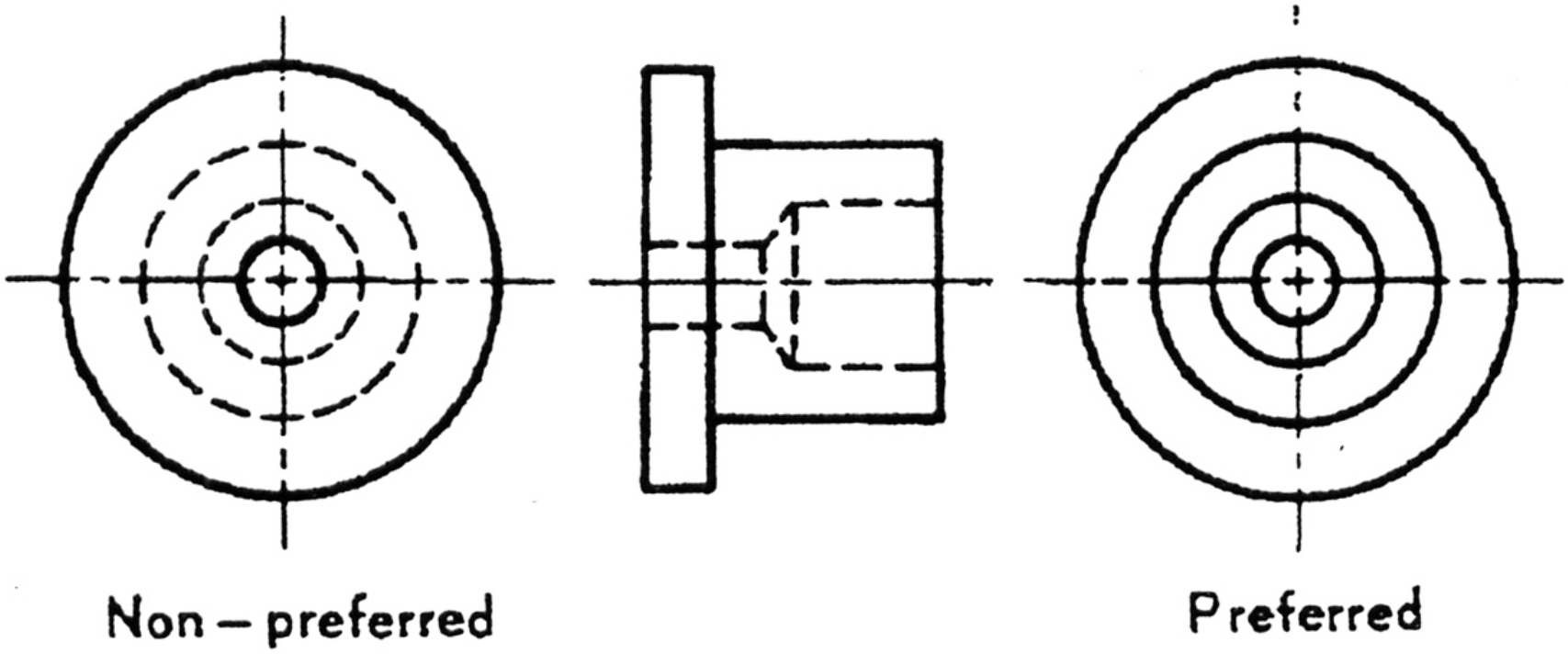

Square sections may be indicated by light crossed diagonal lines, as shown above, which applies whether the face is parallel or inclined to the drawing plane.

Another example of a one-view drawing:

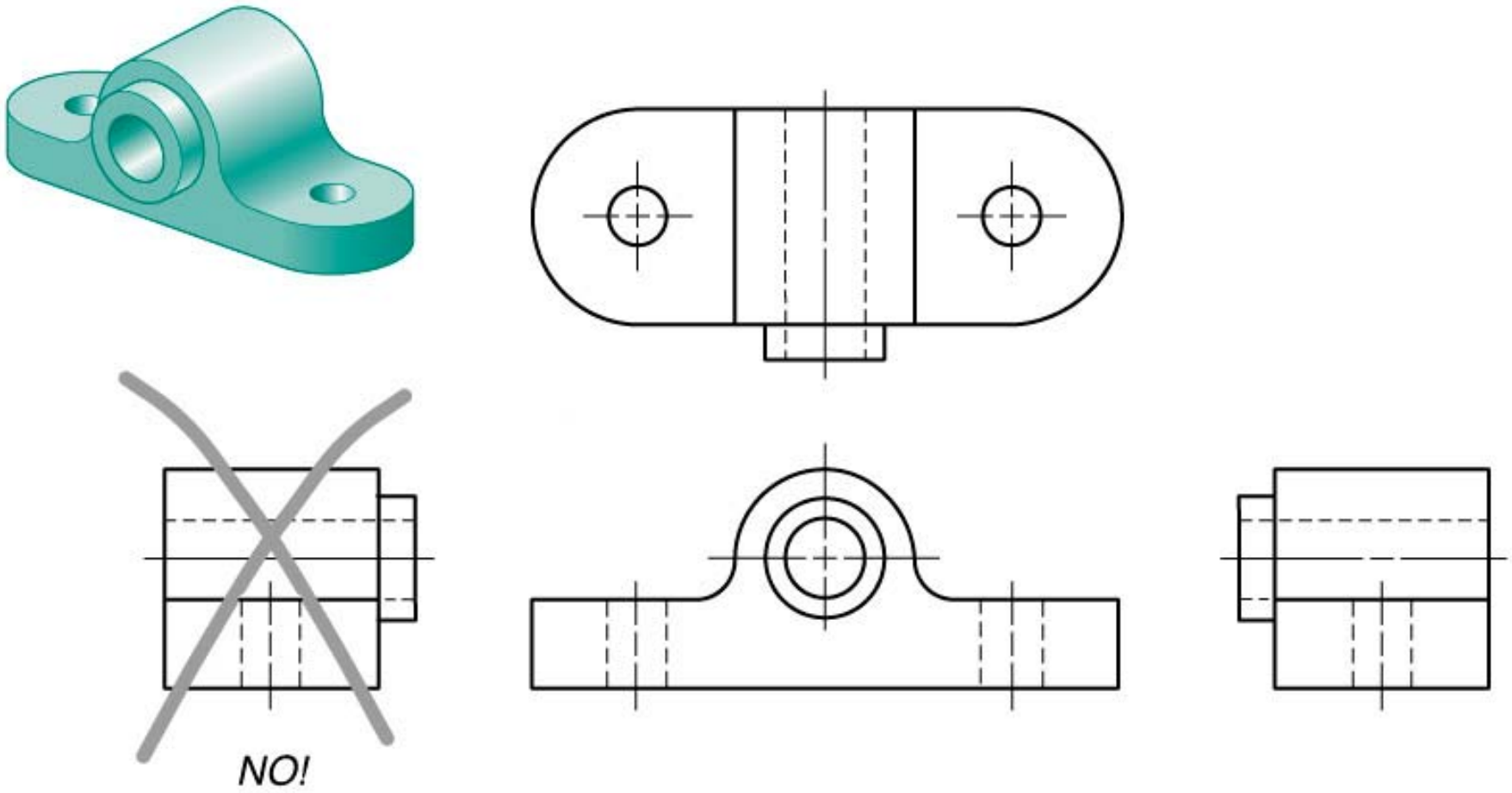



Additional views may be added if they improve visualization.

The views should also be chosen to avoid hidden feature lines whenever possible. That means that the **most descriptive view** should be shown



Besides, you should select the minimum number of views needed to completely describe an object. Eliminate views that are mirror images of other views:



## *1st & 3rd angles (glass box)*

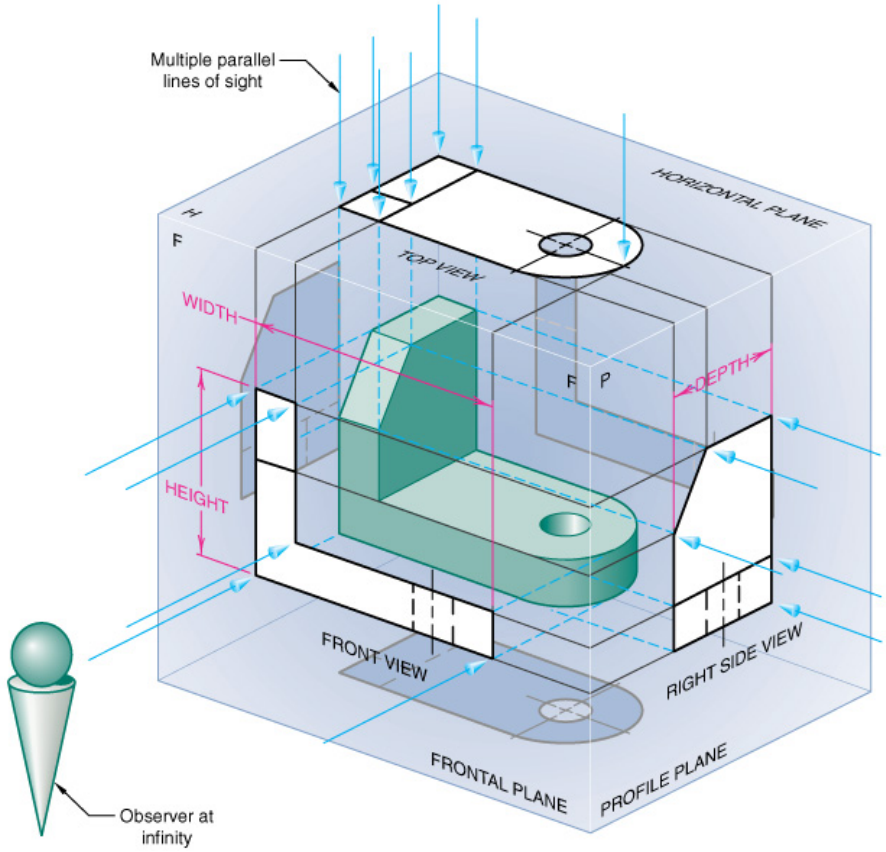
What exactly has to be placed on the right side projection?
Is it what we can see from the left side, or from the right side of the object?

To answer these questions there are two different ways, based on two different principles called

- ✓ **First-Angle Projection** and
- ✓ **Third-Angle Projection**.

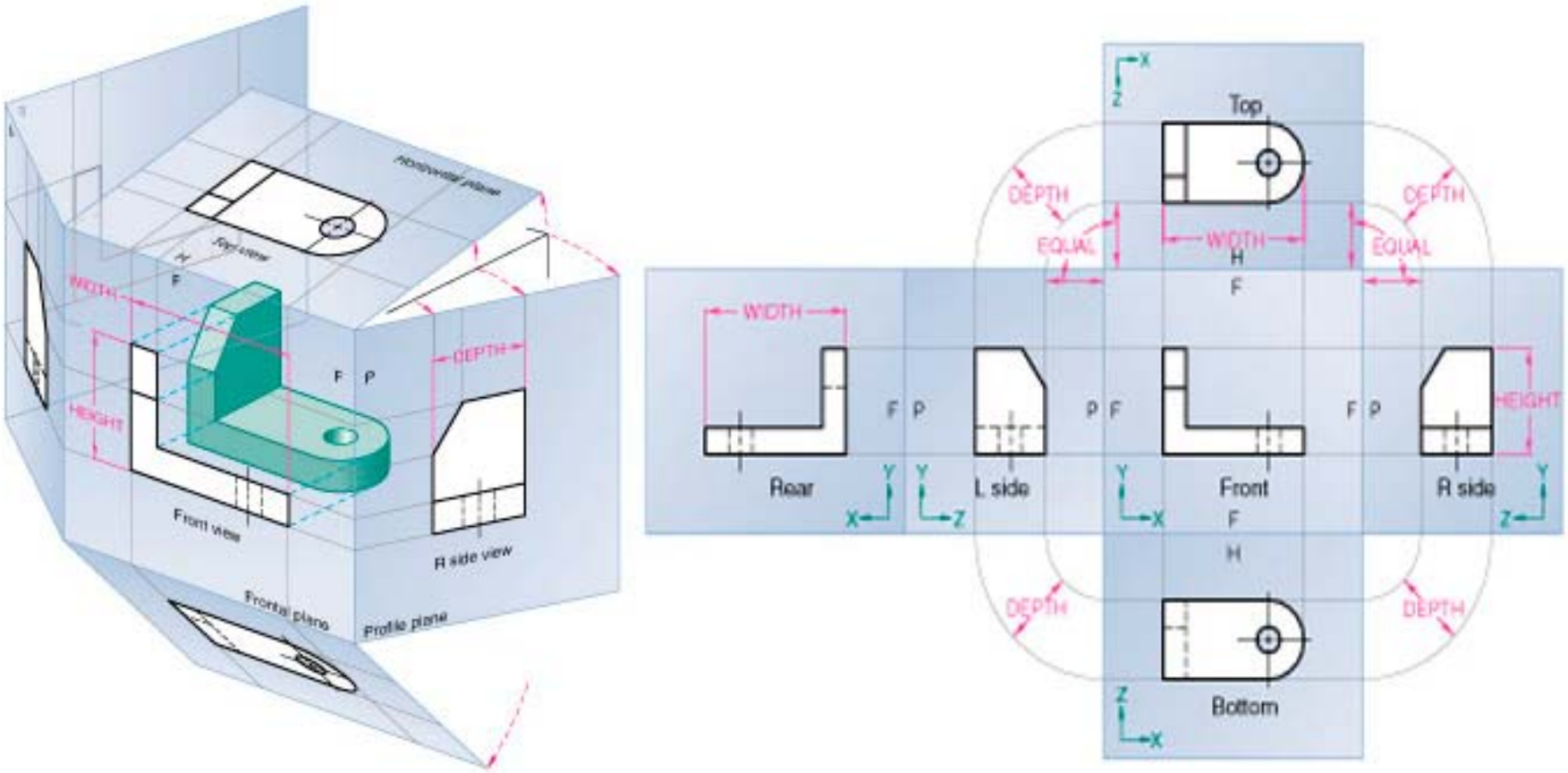
Third angle is used in Canada and the United States. First angle is used in Europe.

In **third angle orthographic projection** the object may be assumed to be enclosed in a glass box, as shown in the figure:



Each view represents that which is seen when looking perpendicularly at each face of the box:

The resulted views are identified by the names as shown.

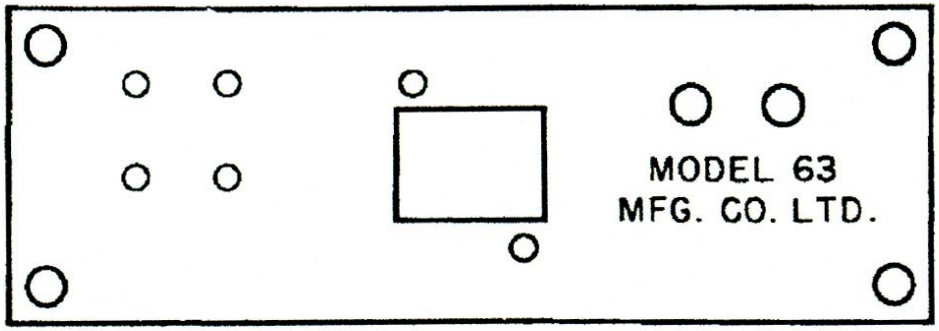



The front, rear, and side views are sometimes called **elevations**, e.g., front elevation. The top view may be termed the **plan**.

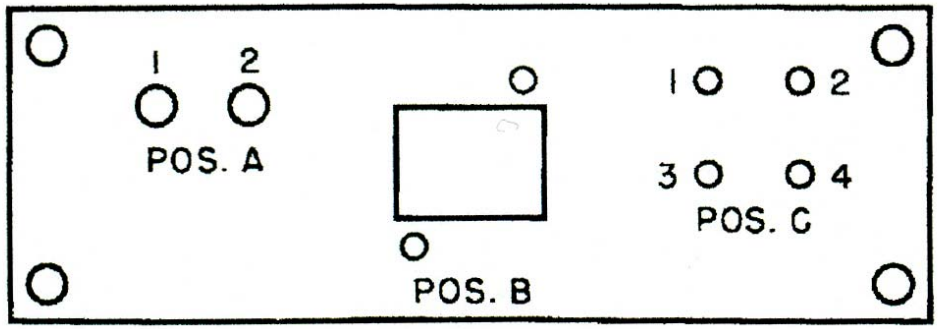
If desired, the rear view may be shown both ways – at the extreme left or the extreme right.

When this is not practical to show rear view at the extreme left or right due to the length of the part, particularly with panels and mounting plates, the rear view should not be projected up or down, as this would result in its being shown upside down.

Instead it should be drawn as if projected sideways, but located in some other position, and should be clearly labelled REAR VIEW REMOVED:

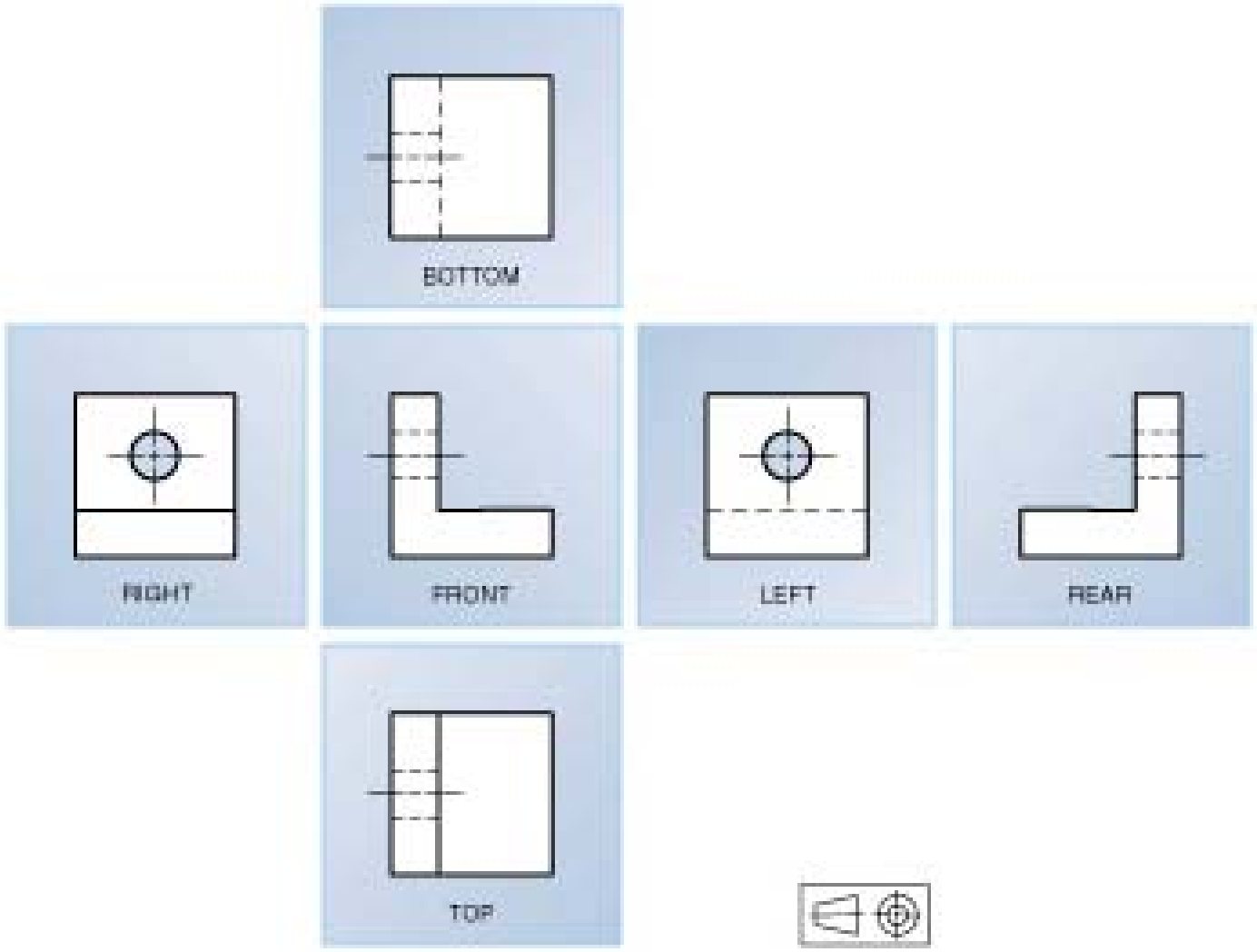



FRONT VIEW



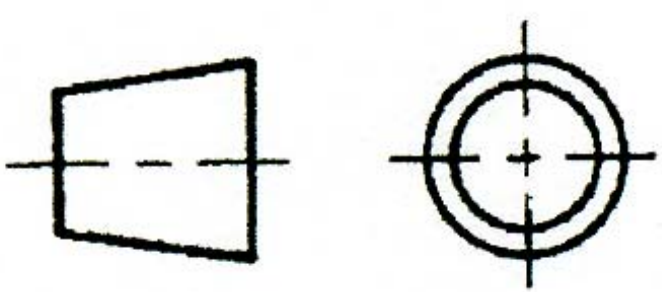

REAR VIEW REMOVED

In **first angle orthographic projections** the object is considered as being rolled over to either side, so that the right side of the object is drawn to the left of the front elevation:

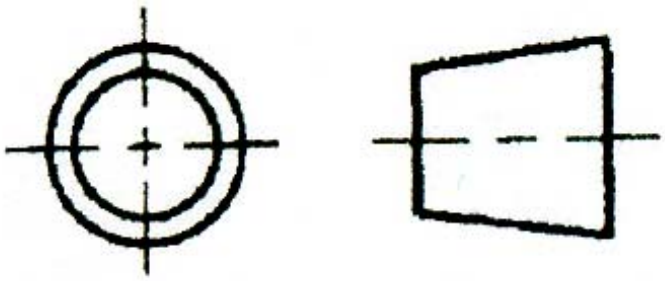



ISO Standard First Angle Projection

It is mandatory to indicate the method of multiview projection by including the appropriate ISO (International Organization for Standardization) projection symbol – the *truncated cone*:



First Angle



Third Angle

This symbol is placed in the lower right-hand corner of the drawing in or adjacent to the title block.

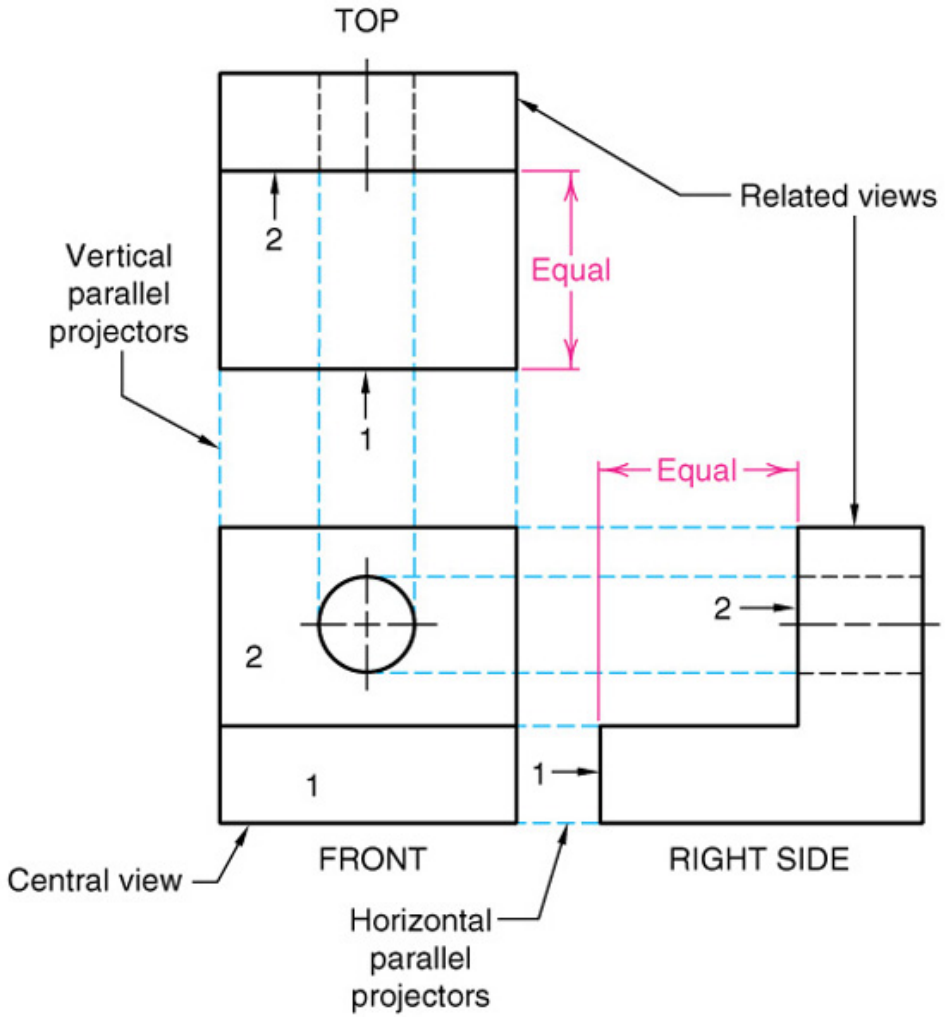
***Few more terms of multi-view projection***

**Adjacent views** are two orthographic views placed next to each other such that the dimension they share in common is aligned using parallel projectors.

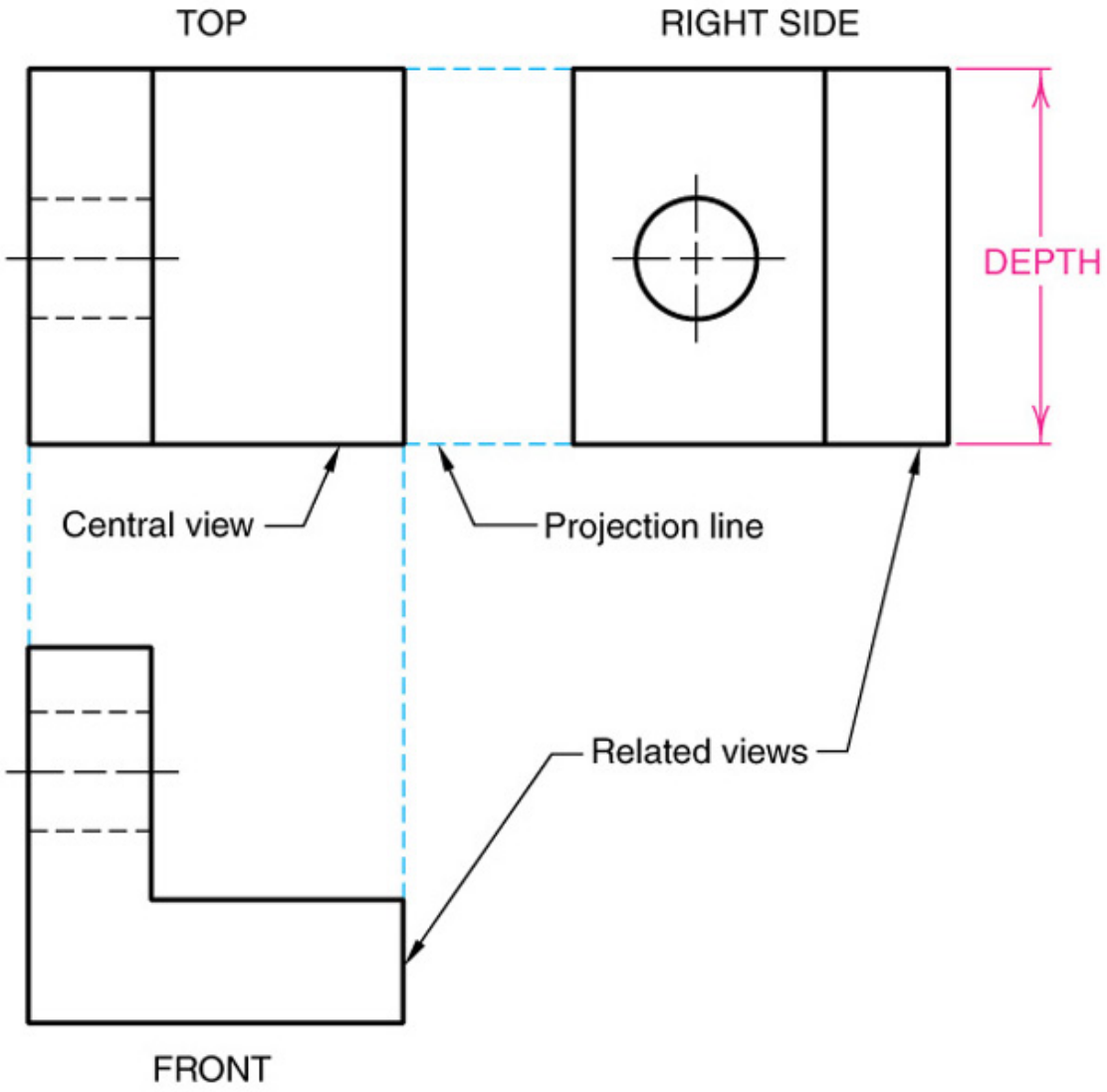
In the figure *the hole in the block* is an example of a feature shown in one view and aligned on parallel projectors in the adjacent view.

Two views that are adjacent to the same view are called **related views.**
In related views, distances between common features are equal.

On the figure *the distance between surface 1 and surface 2* is the same in the top view as it is in the right side view; therefore, the top and right side views are related views.



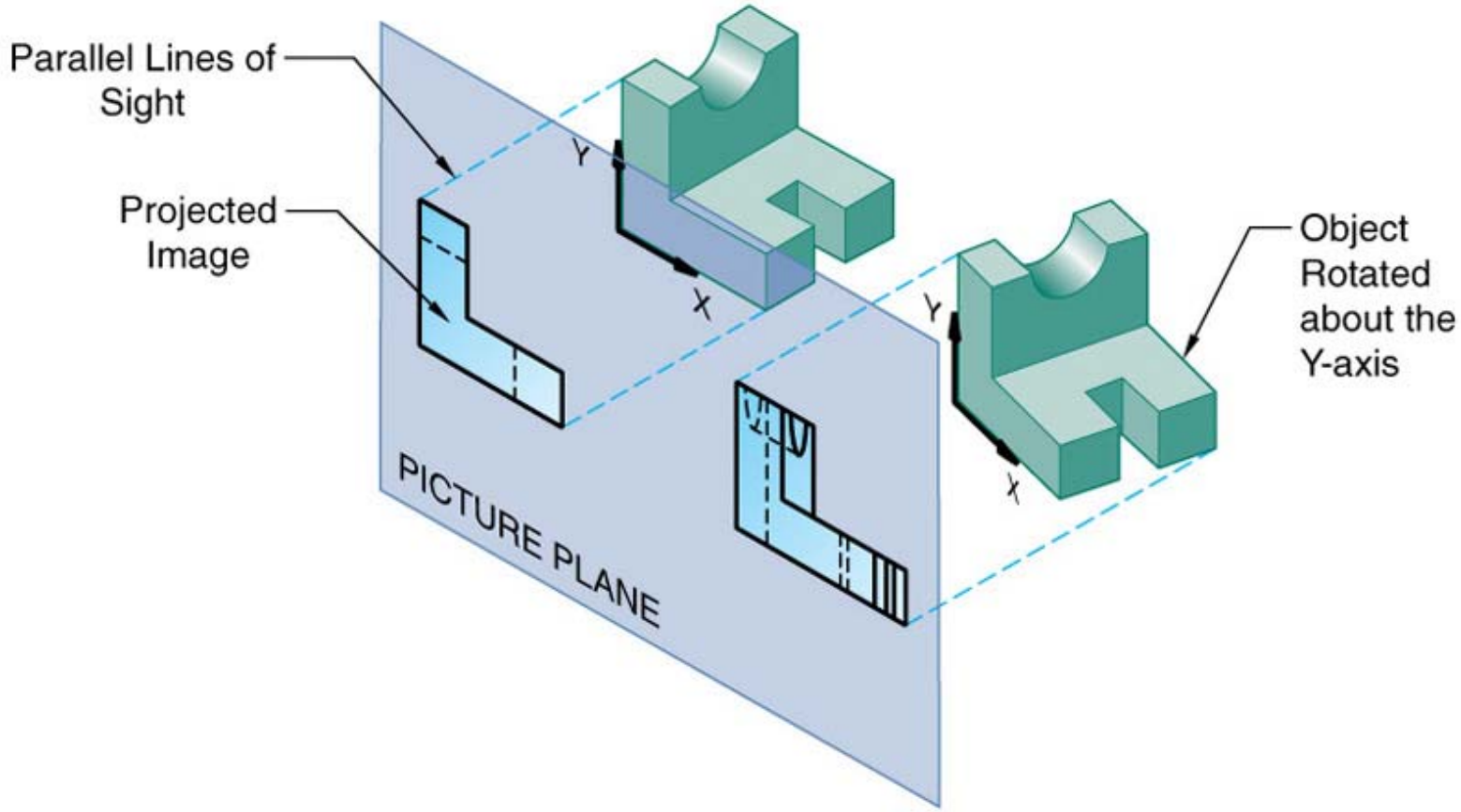
The view from which adjacent views are aligned is the **central view.** In the figure above, the front view is the central view.
However, the front view not necessarily should be the central view. For example, in the following figure, the top view is the central view.




Distances and features are projected or measured from the central view to the adjacent views.

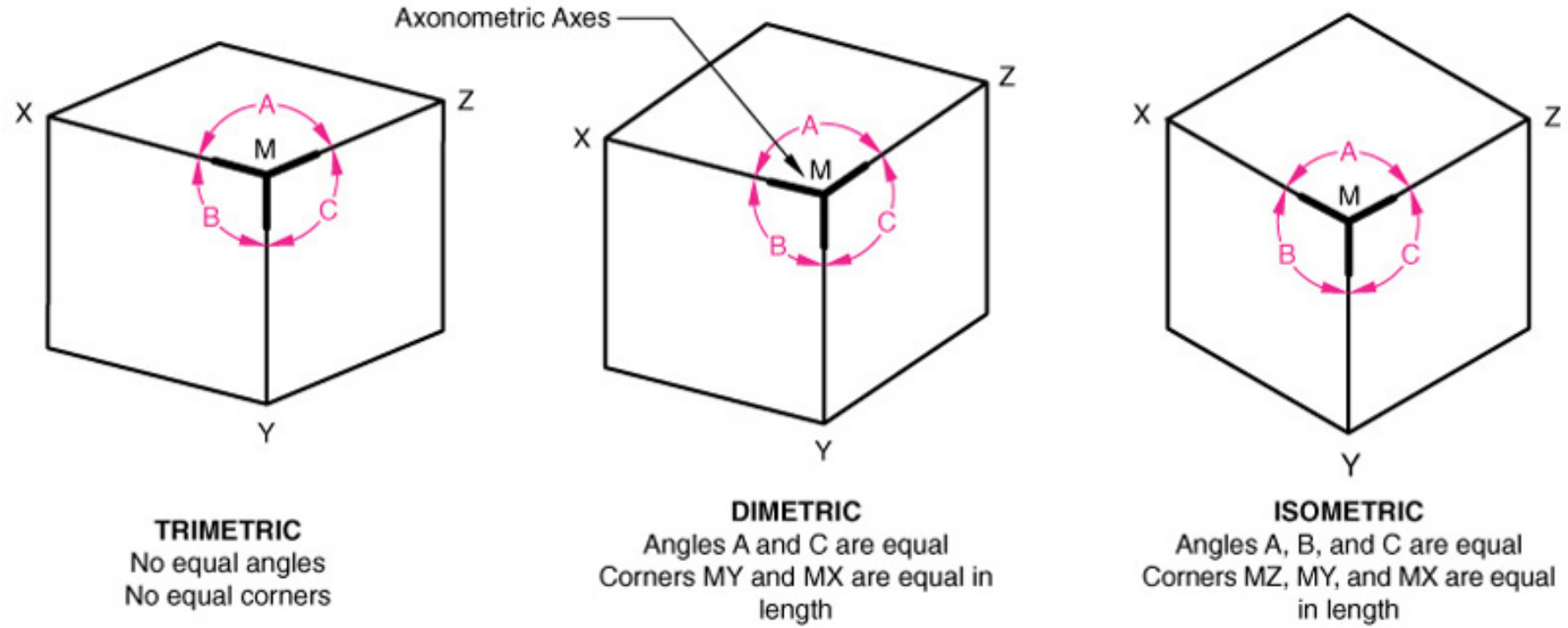
We know *pictorial images*. Now – a few words about pictorial drawing, or *pictorial projection*. This is a type of technical illustration that shows several faces of an object at once.
Pictorial drawings do not have the limitation of multiview drawings, which show only two dimensions of the object in each view and must be mentally combined to form a 3-D image of the object.

**Axonometric projection** - is one of the pictorial drawing projections, which are useful for illustrative purposes, educational aids, installation and maintenance drawings, design sketches, and the like.
The Greek word *axon* means axis and *metric* means to measure. **Axonometric projection** is a parallel projection technique used to create a pictorial drawing of an object by rotating the object on an axis relative to a *projection*, or *picture plane*.



Axonometric projections such as *isometric*, *dimetric*, and *trimetric* projections are orthographic, in that the projection lines are all parallel, but the angle of views is so chosen that three faces of a rectangular object would be shown in a single view.

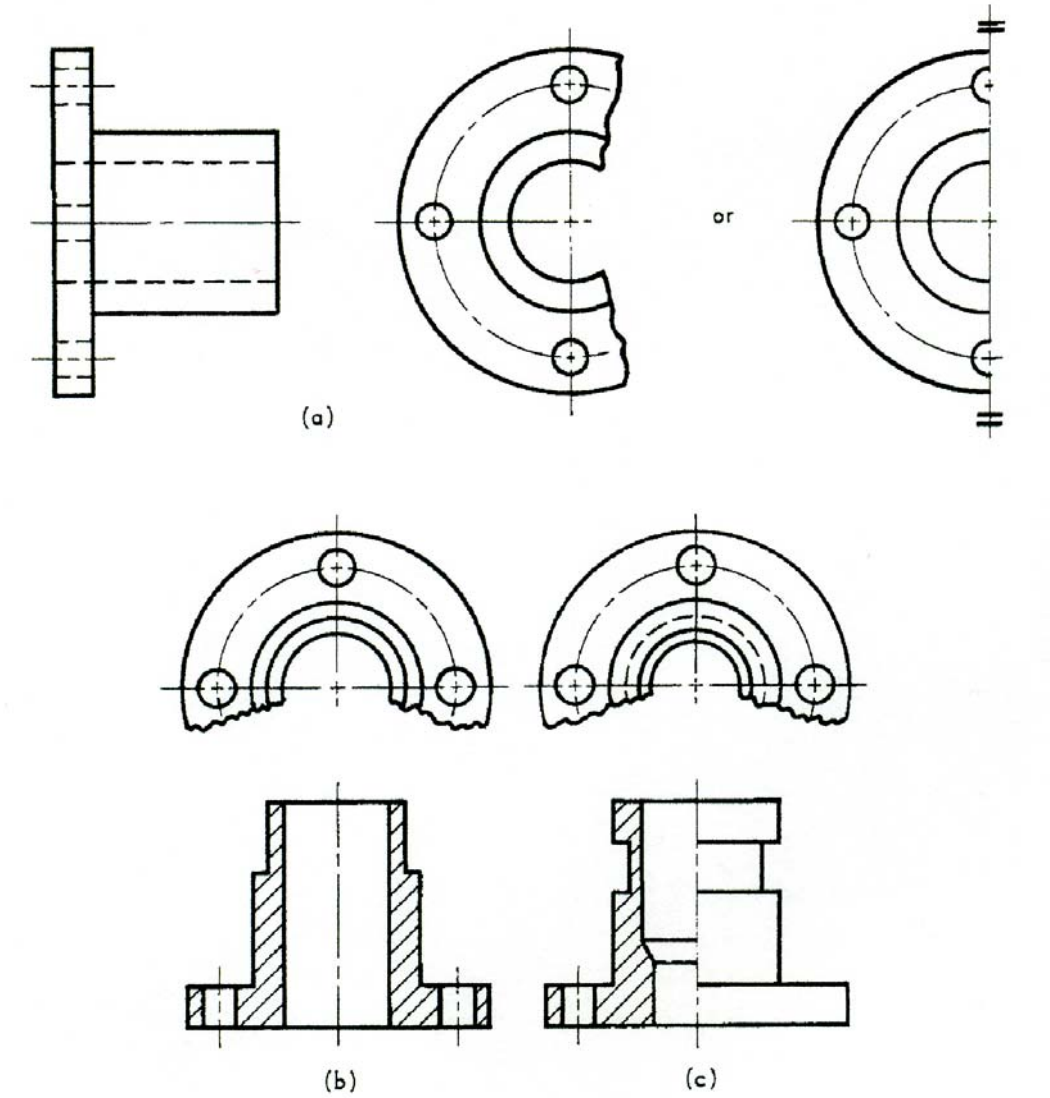
Axonometric drawings are classified by the angles between the lines comprising the **axonometric axes**. The axonometric axes are axes that meet to form the corner of the object that is nearest to the observer.




When all three angles are unequal the drawing is classified as a **trimetric**. When two of the three angles are equal the drawing is classified as a **dimetric**. When all three angles are equal the drawing is classified as a **isometric**.

Although there are an infinite number of positions that can be used to create such a drawing only few of them are used.

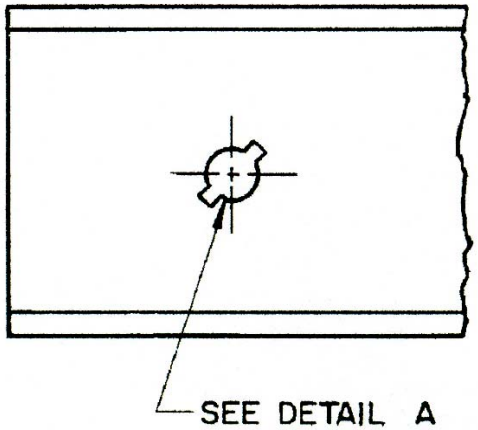
One more category of views is **symmetrical objects.**

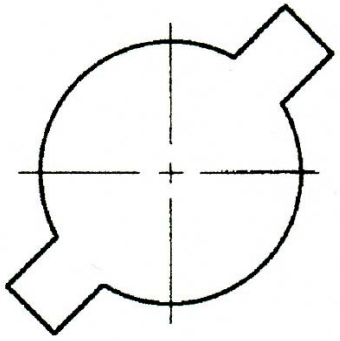


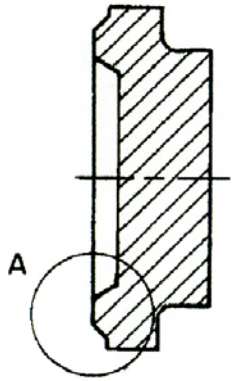

Symmetrical objects may often be adequately portrayed by half views, which may be combined with a full view (figure a), a sectional view (figure b), or a combined view (figure c).

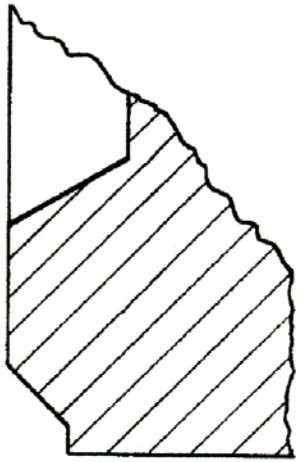
**Enlarged detail**

To eliminate the crowding of details or dimensions, an enlarged removed view may be used:




- The enlarged view should be oriented in the same manner as the main view,
- the scale of enlargement must be shown, and
- both views should be identified by one of the methods shown in the illustrations – with the leader line or with the circle line. The circle enclosing the area on the main view should be drawn with a thin line.