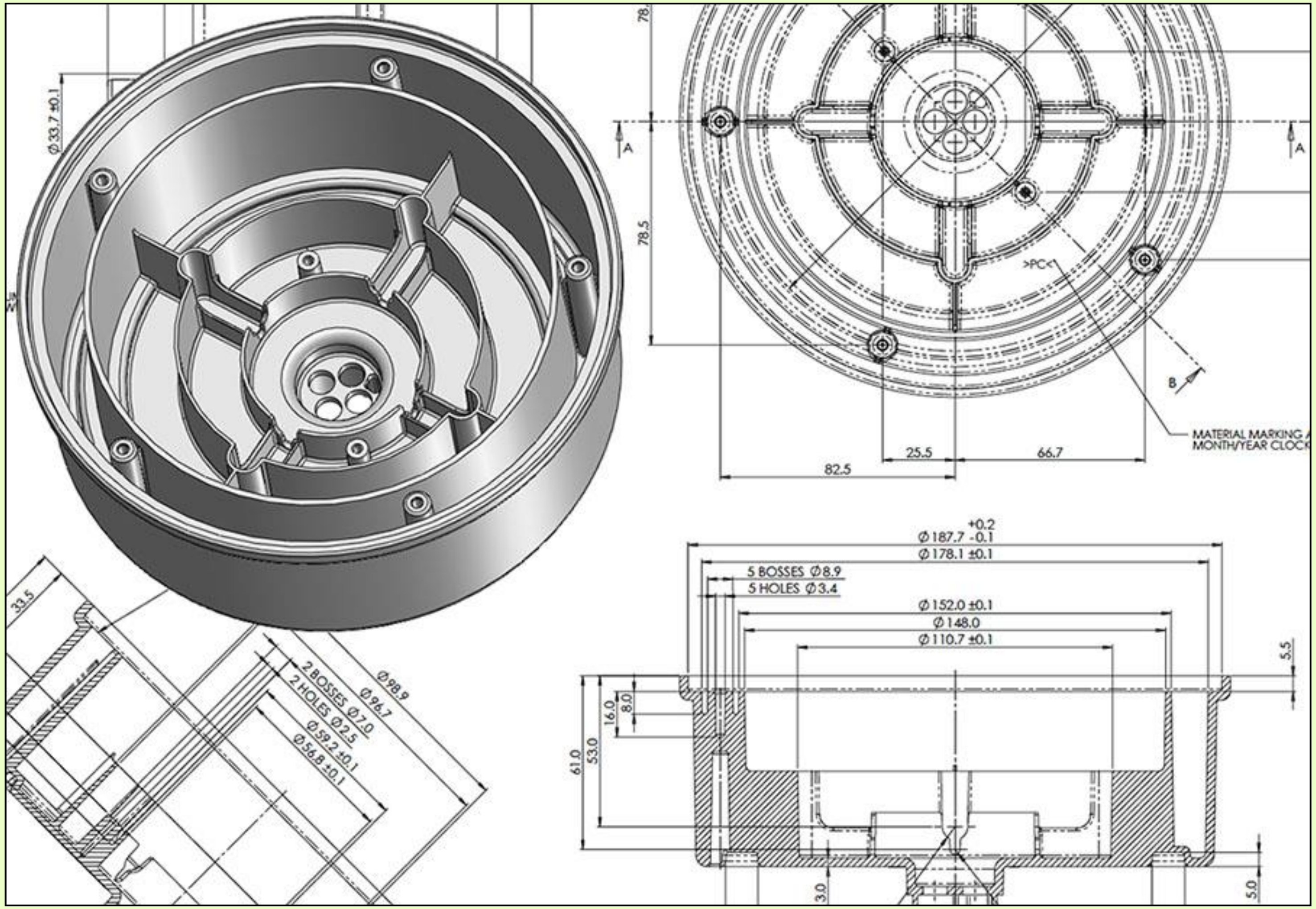
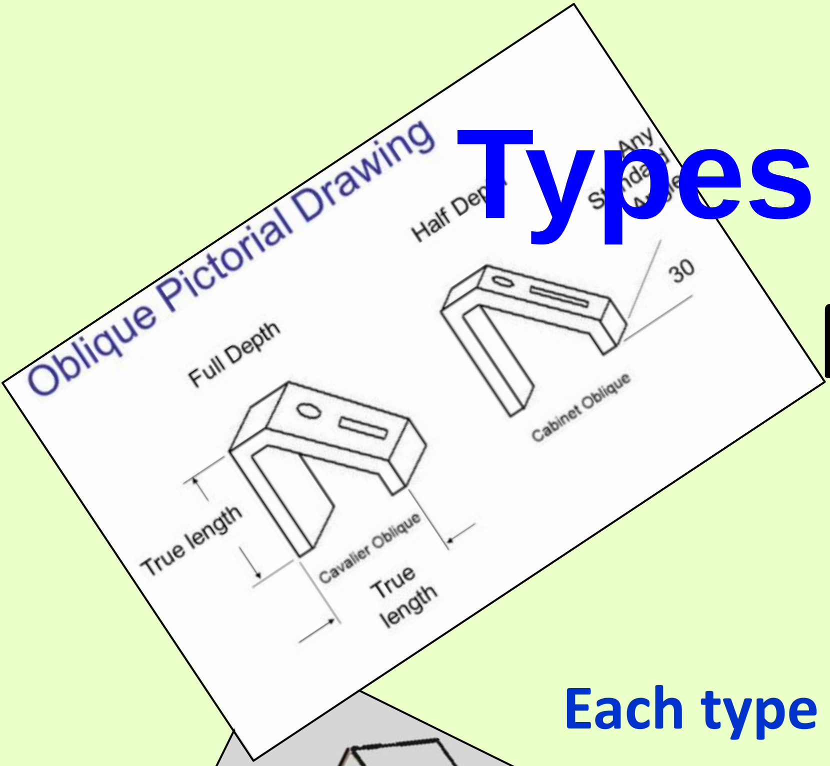
Technical/Engineering Drawings

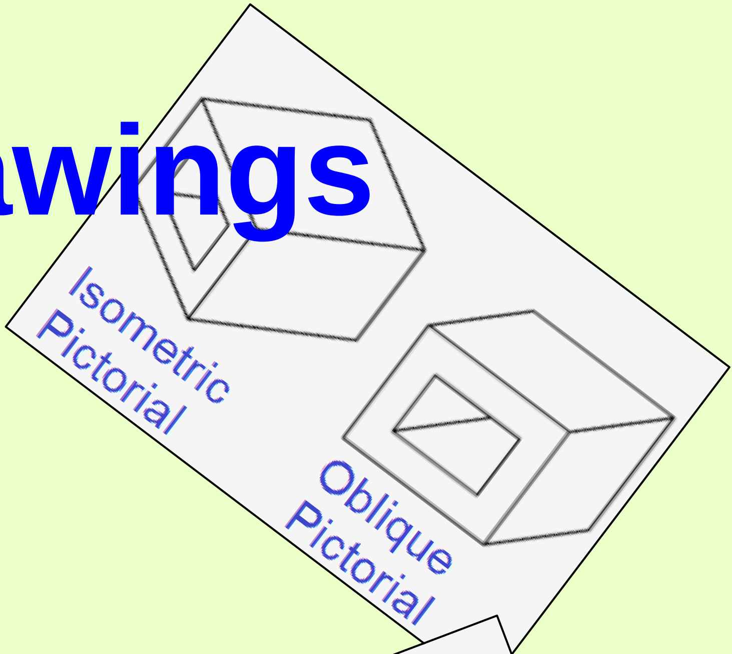
The purpose of an engineering drawing is to provide the manufacturer with sufficient information needed to **build, inspect** or **assemble** the part according to the specifications of the designer.



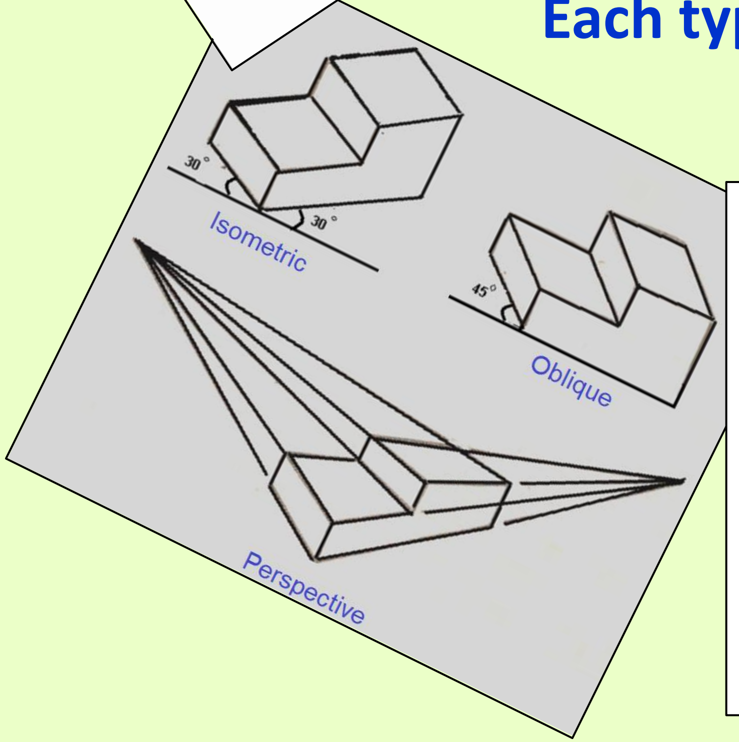
Types of Technical Drawings

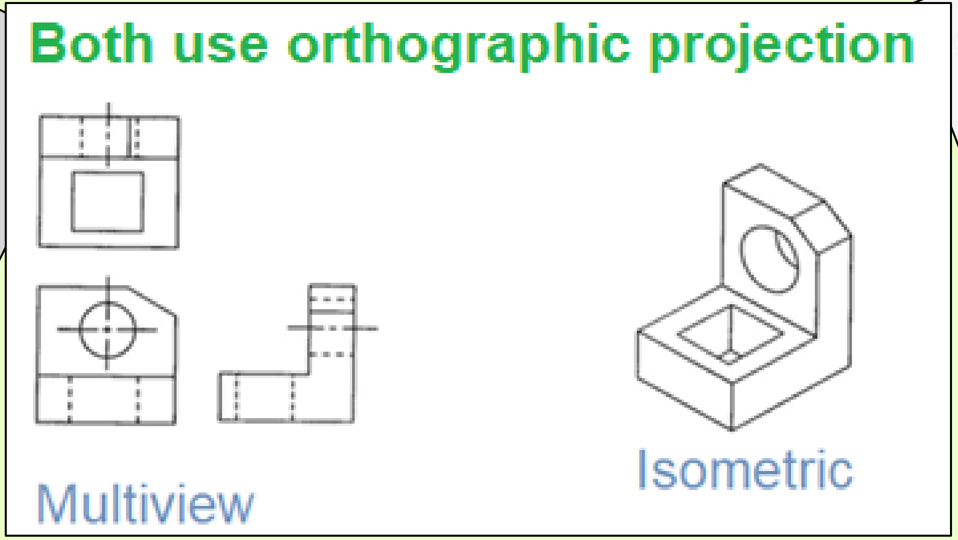
Multi-view Drawings
Pictorial Drawings

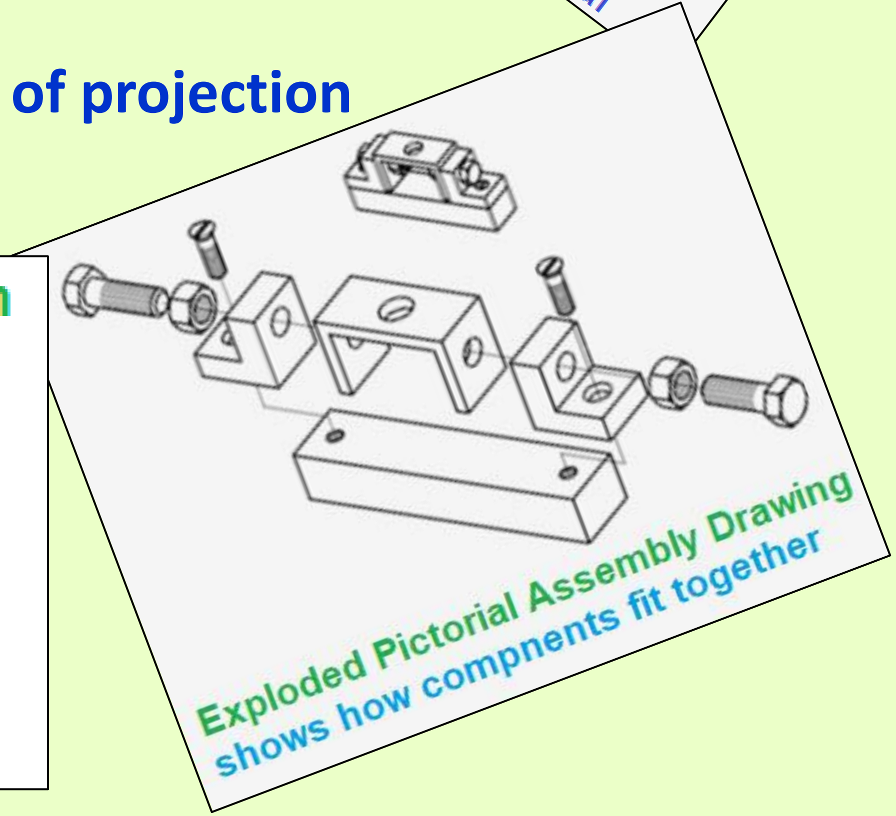




Each type of drawing uses a specific type of projection

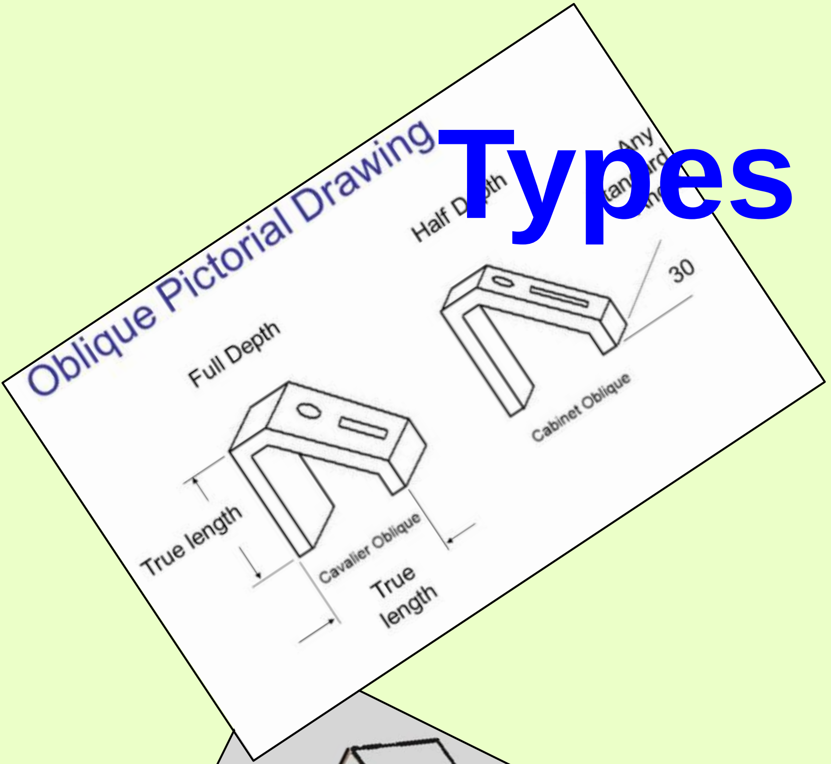


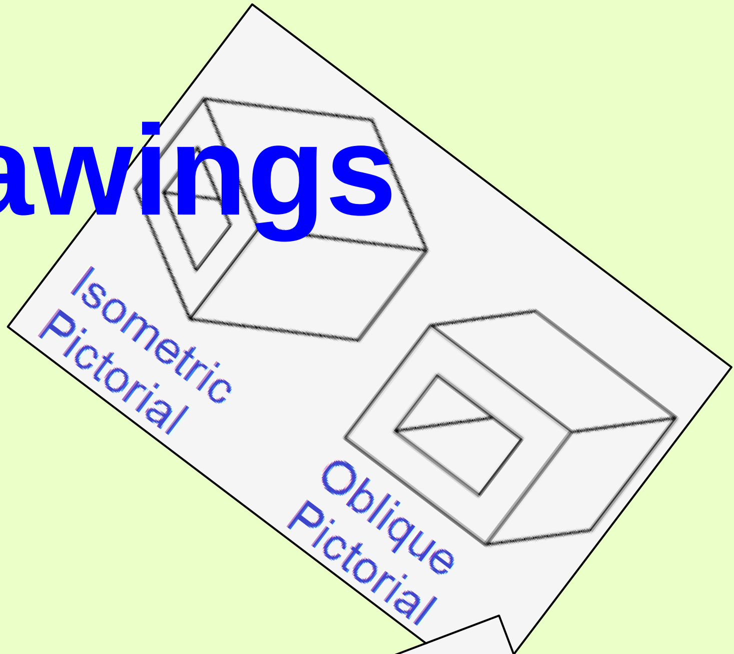




Types of Multi-view Drawings

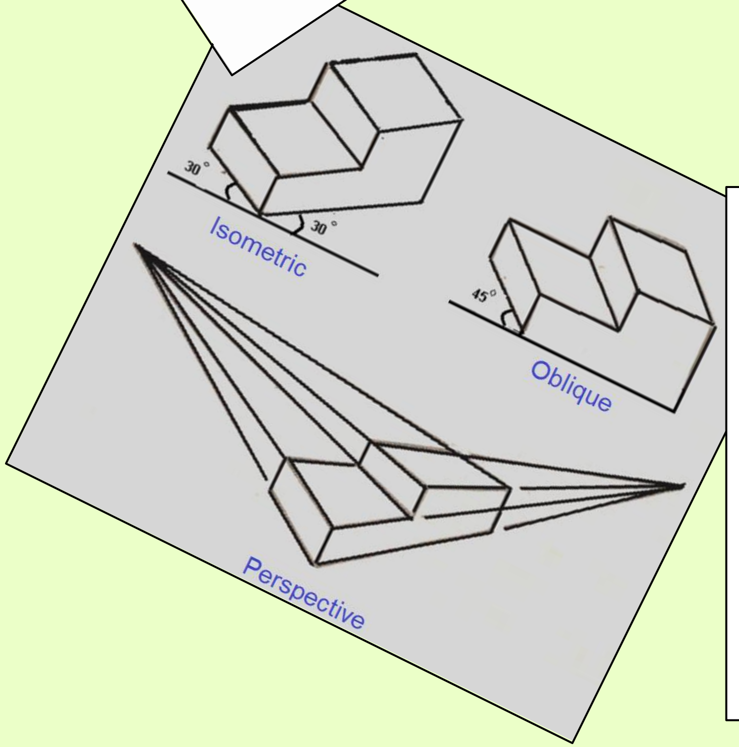
Multi-view drawings always use Orthographic Projection

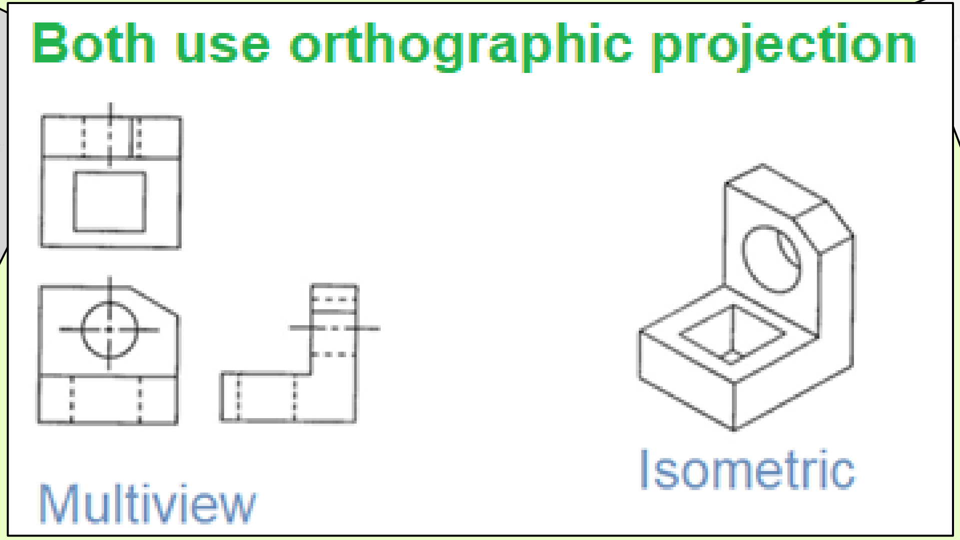


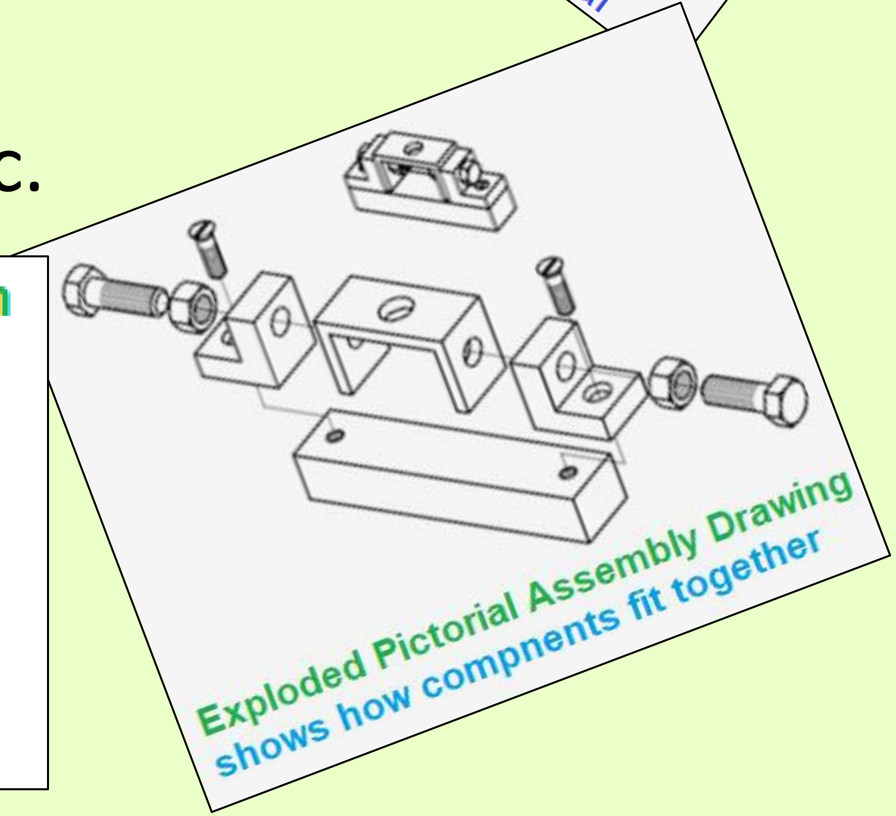


Standard Views:
Top, Front, Right

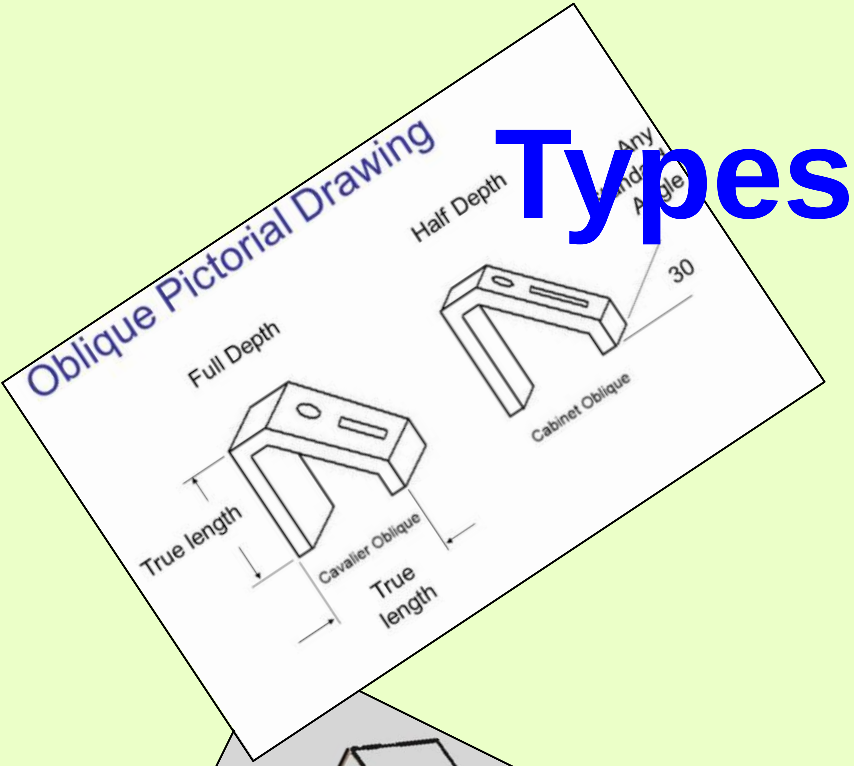
Non-standard Views:
Auxiliary, Break-out, etc.

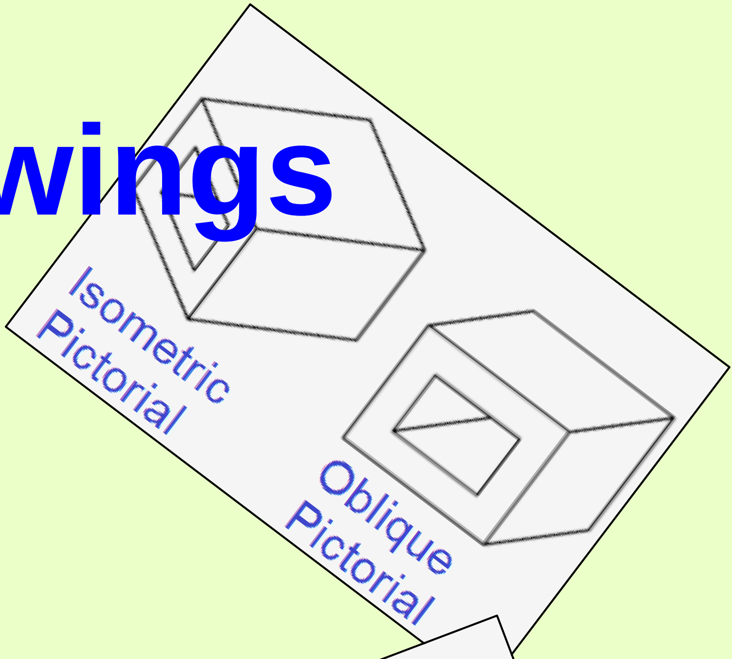






Types of Pictorial Drawings

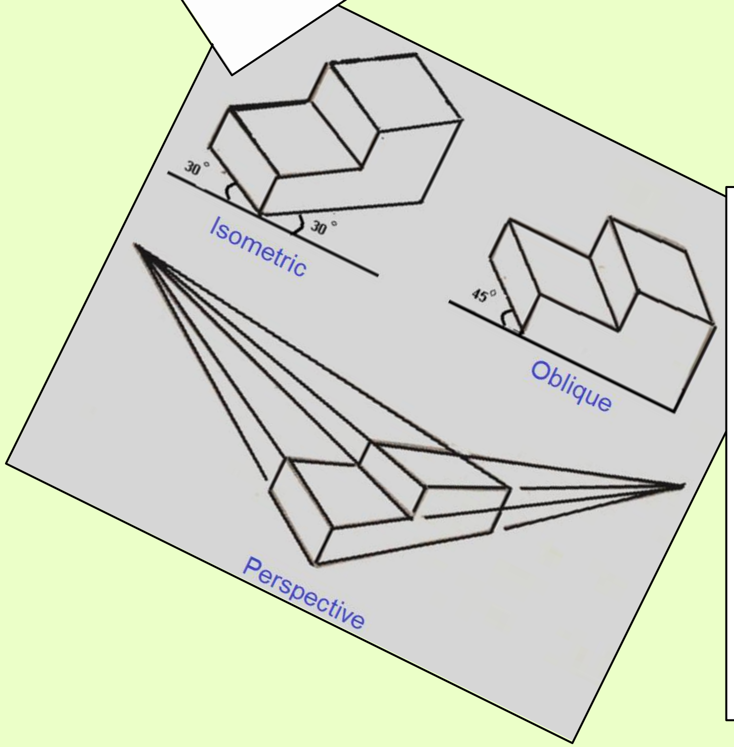


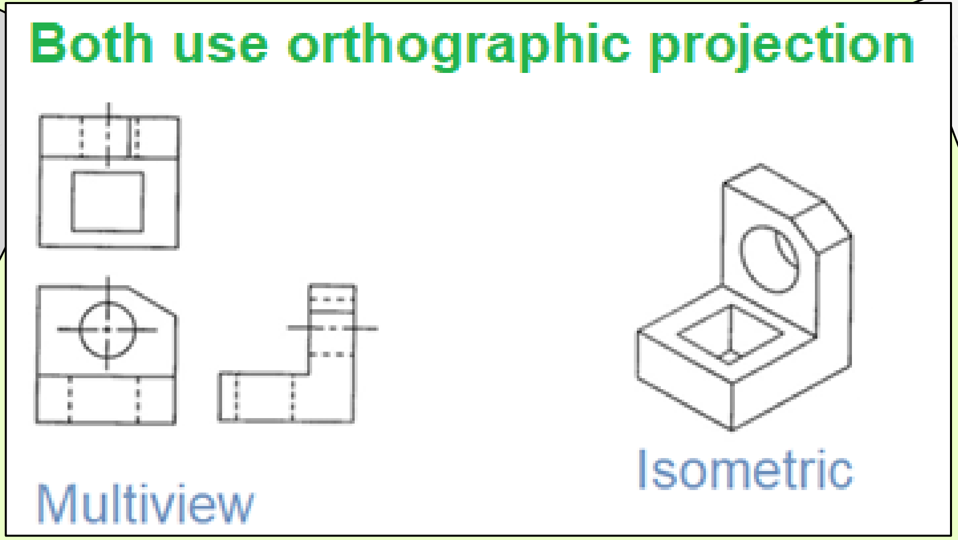


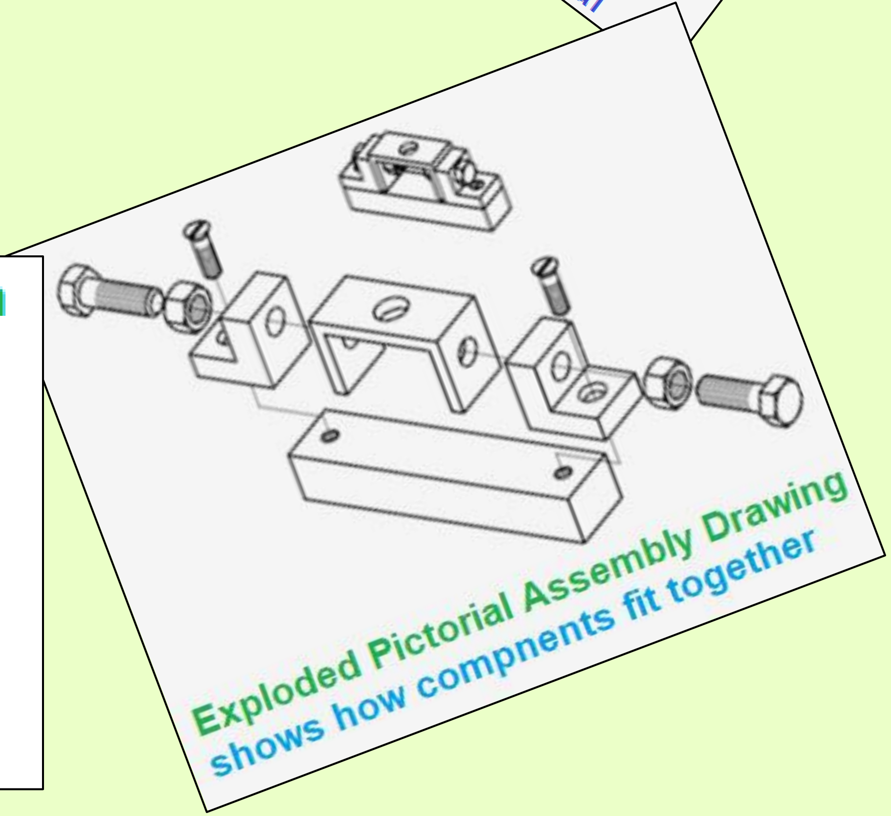
Axonometric:
Isometric, Dimetric, Trimetric

Oblique:
Cabinet, Cavalier

Perspective:
1-point, 2-point, 3-point



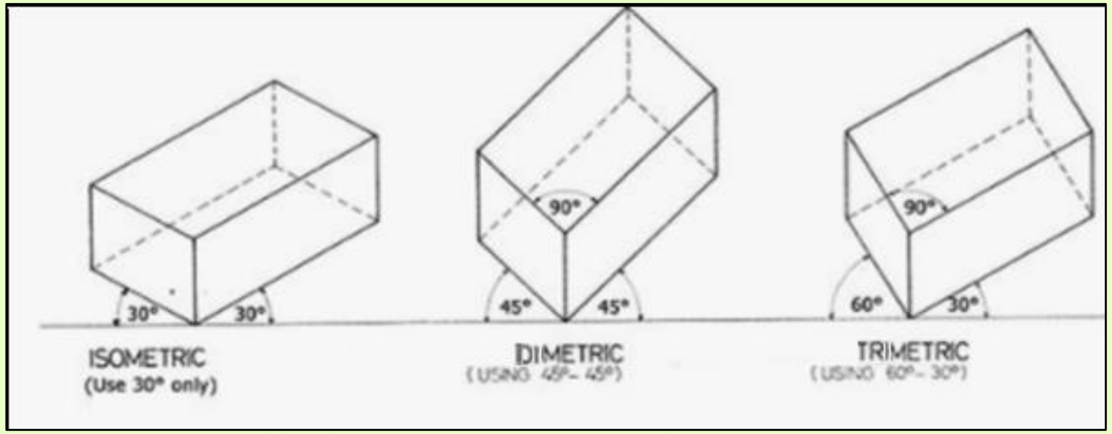




Types of Pictorial Drawings

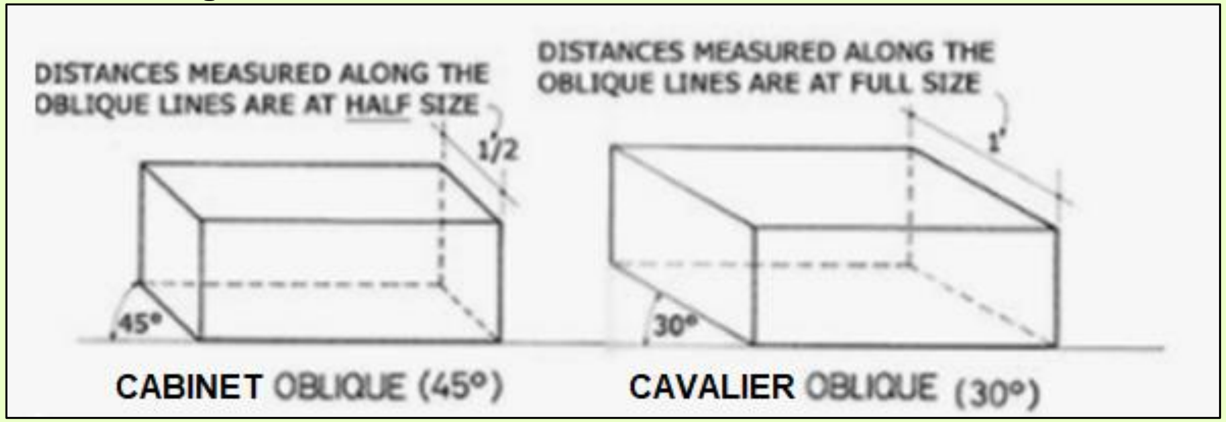
Pictorial drawings use a variety of different types of projection

1. Axonometric



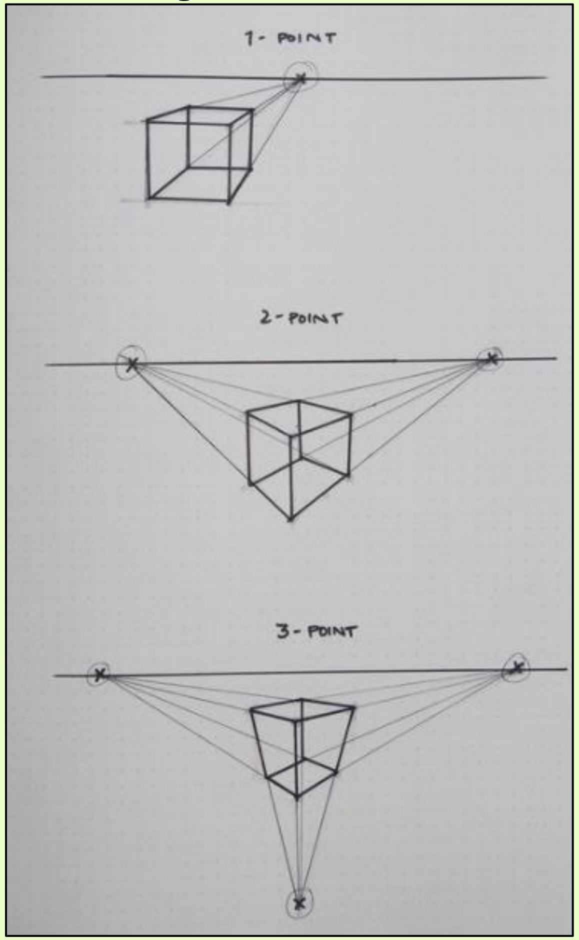
uses parallel – orthographic projection

2. Oblique



uses parallel – oblique projection

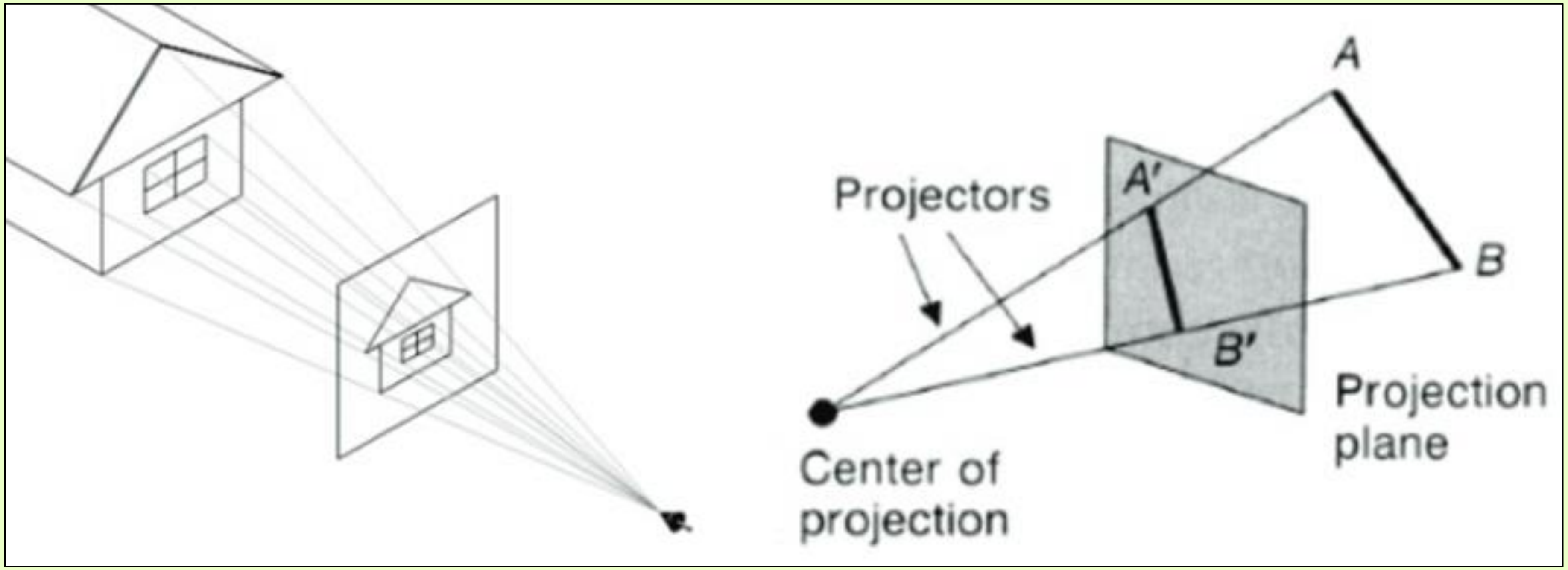
3. Perspective



uses perspective projection

Projection Vocabulary

To draw a 3D object on a 2D media, imagine a **plane** between an **observer** and the **object**.
Now imagine the **lines of sight** that go from the observer's eye to points on the object.
Note that these lines of sight intersect the plane.
Each intersection with the plane is a point on the drawing that represents the point on the object.



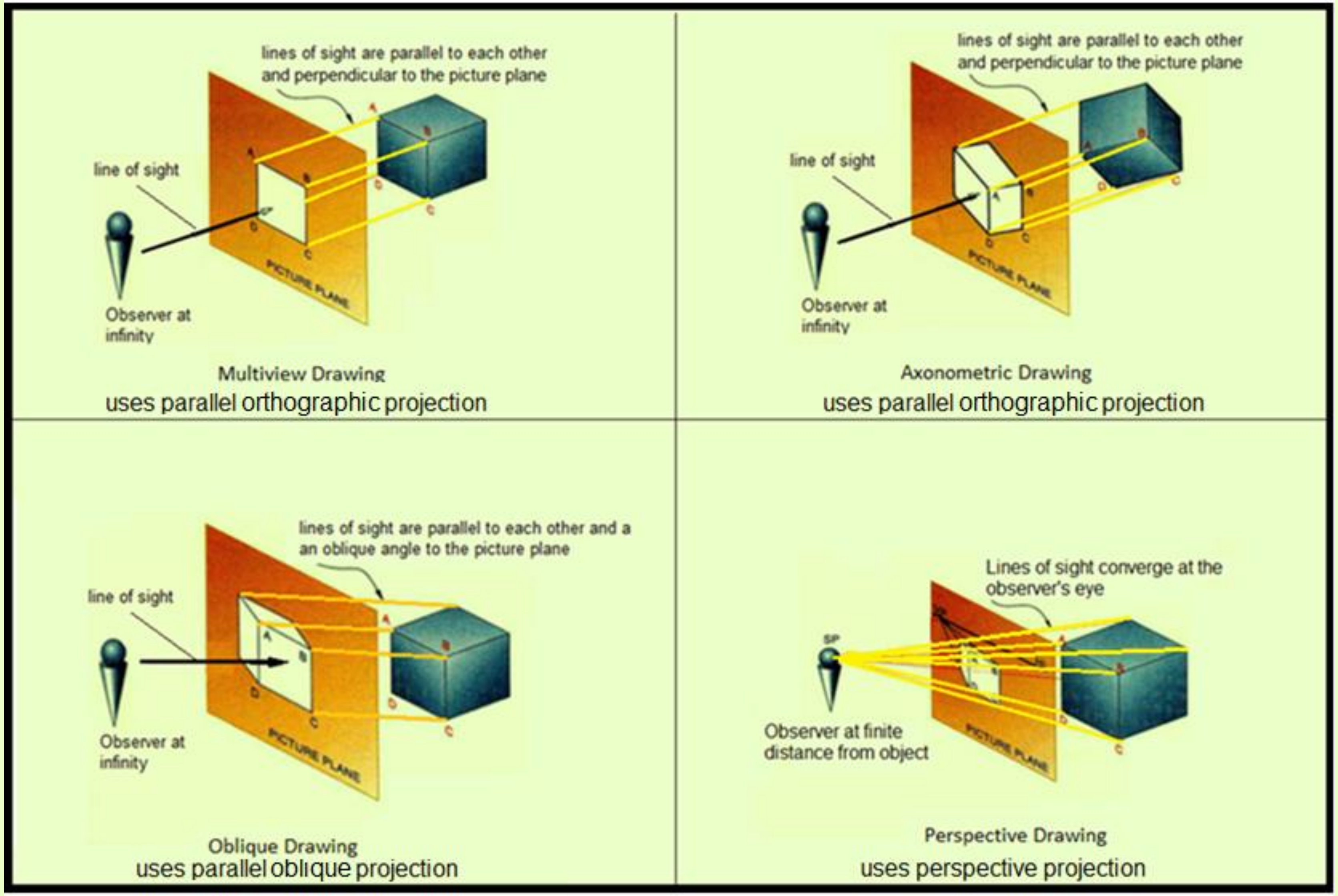
The plane is **the plane of projection** or **the picture plane**
The observer is **the center of projection**
The lines of sight are **projectors**

Two Types of Projections

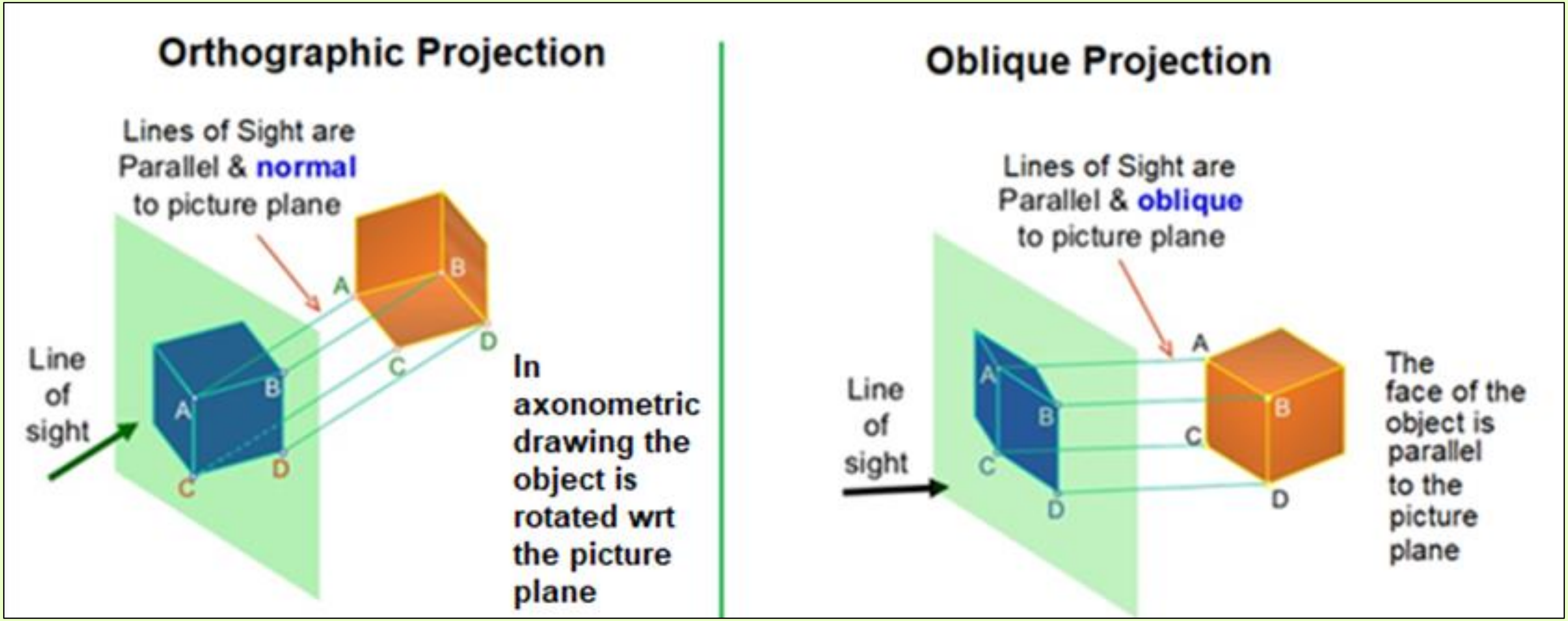
Each type of technical drawing uses a specific type of projection

1. **Parallel**
   Projectors are parallel

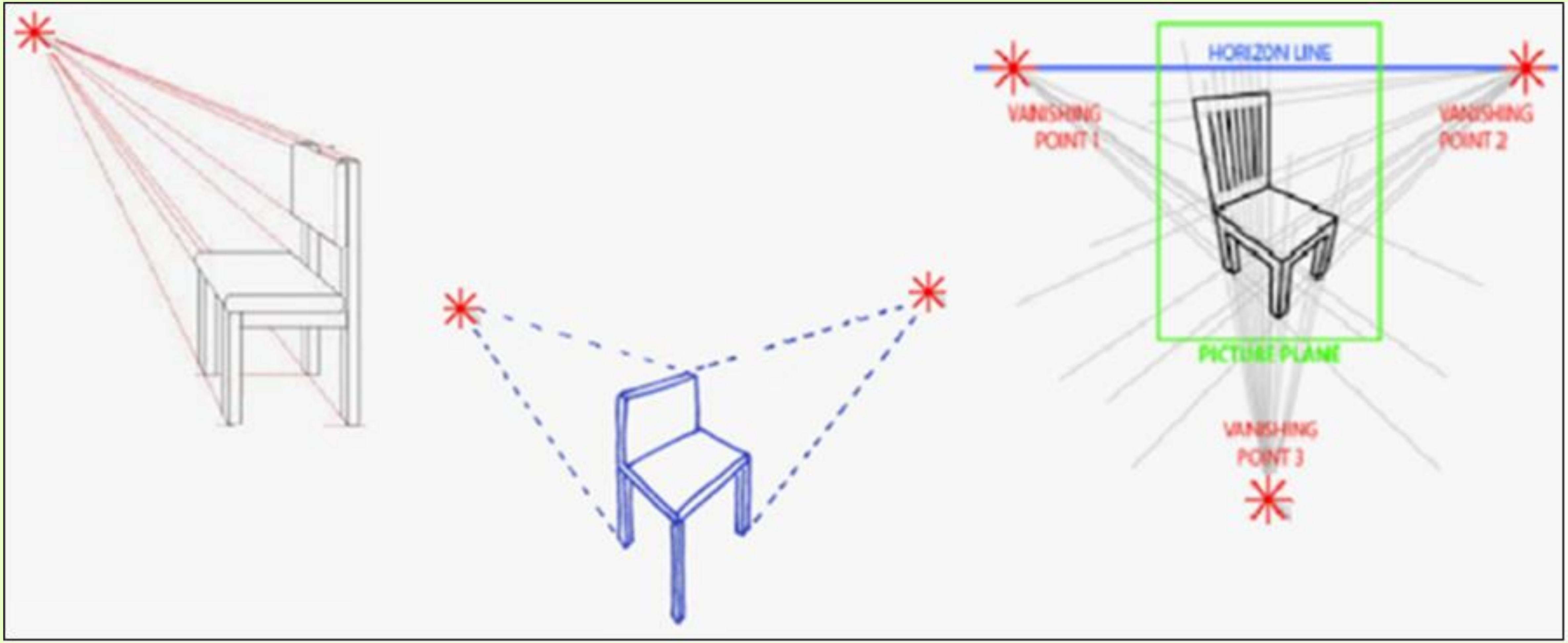
2. **Perspective**
   Projectors converge



Parallel Projection



Perspective Projection

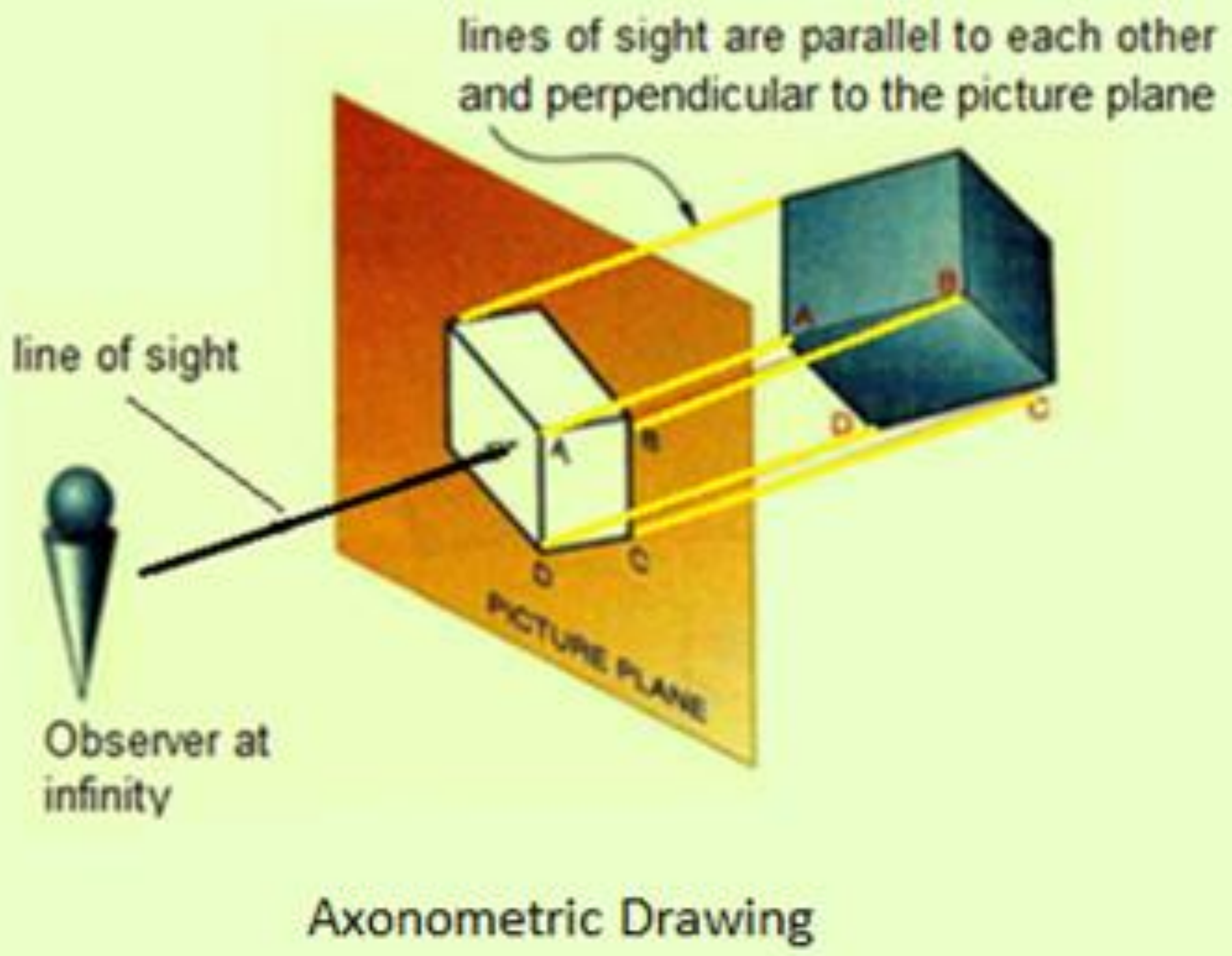


One-point perspective
projectors converge at 1 vanishing point

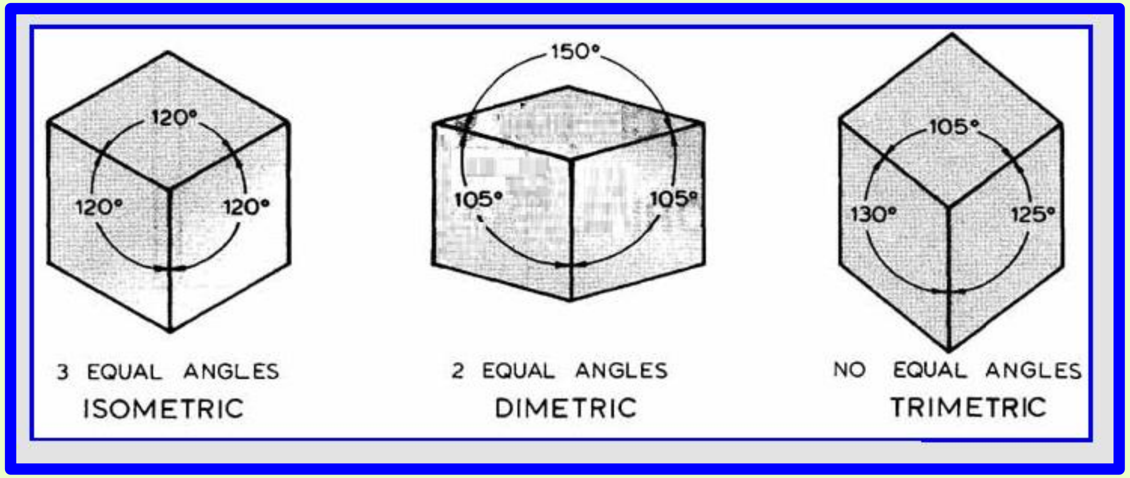
Two-point perspective
projectors converge at 2 vanishing points

Three-point perspective
projectors converge at 3 vanishing points

Axonometric Drawings

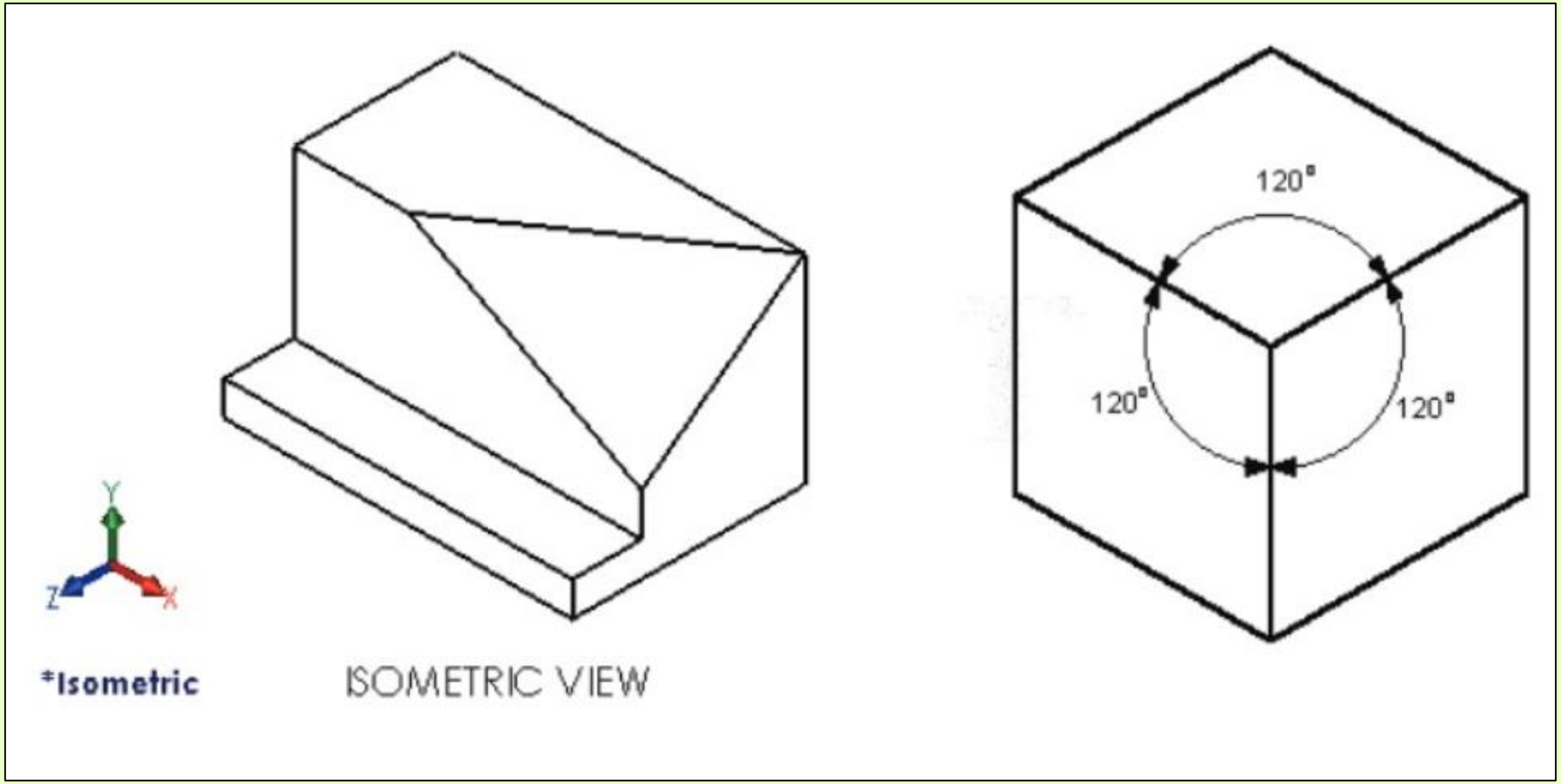


- A type of pictorial drawing – visually representing, in a natural way, a 3-dimensional object in 2 dimensions
- Uses Orthographic projection
- The object is rotated along one or more of its axes relative to the plane of projection.
- Three types: isometric, dimetric, trimetric



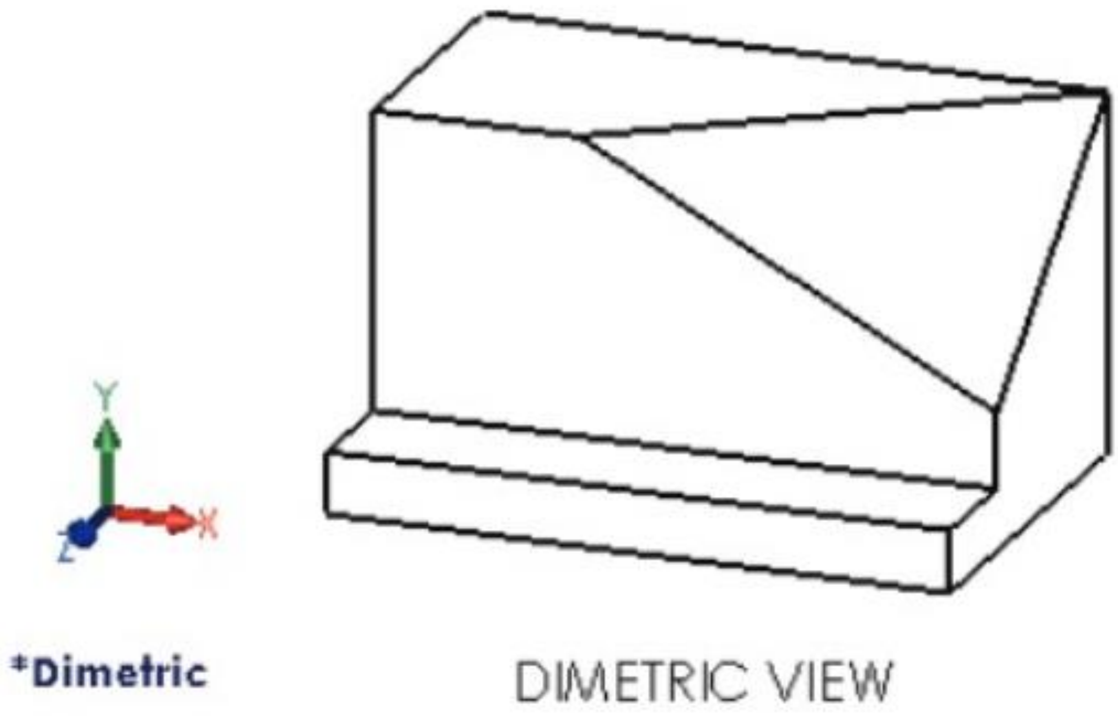
Isometric

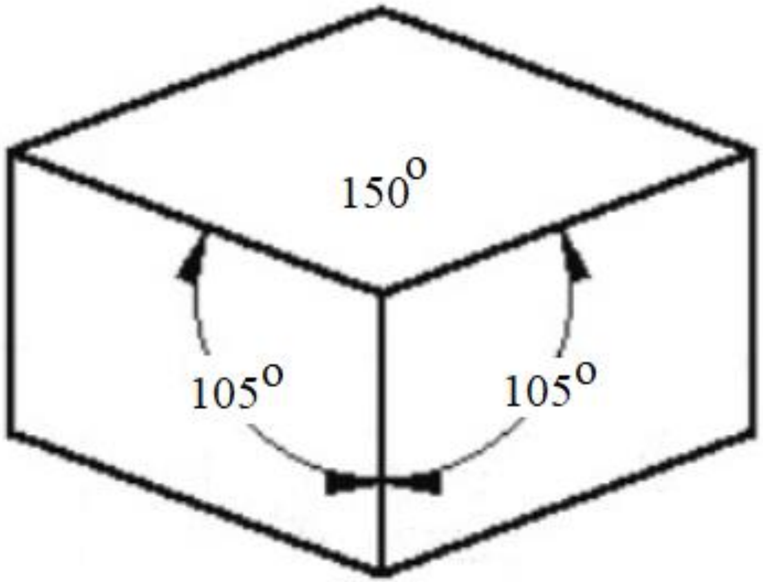
- The three coordinate axes appear equally foreshortened and the angles are all 120°
- Shapes in an Isometric are not true shapes.
- Vertical lines on the object become vertical lines on the drawing and are all parallel to each other.



Dimetric

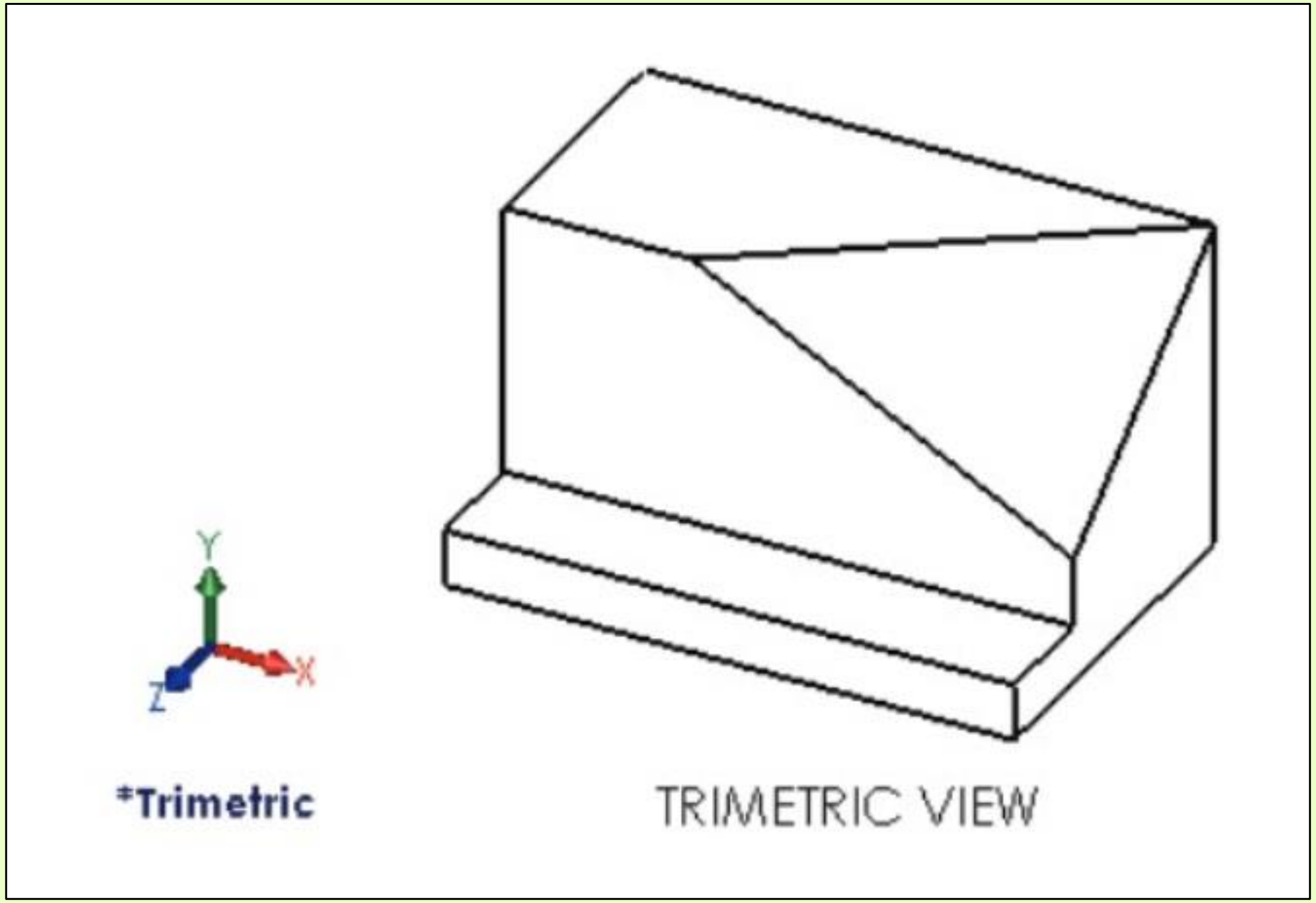
- Only two of the three coordinate axes have equal angles. (usually ~105º)
- The smaller the angles, the less we see of the top.



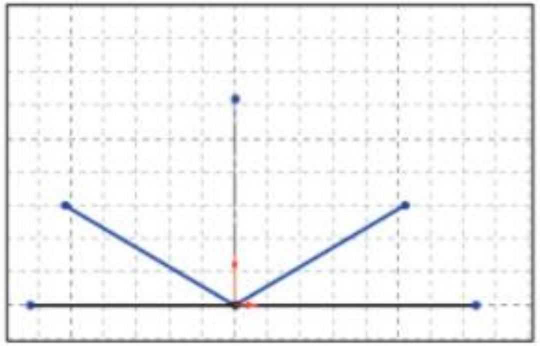


Trimetric

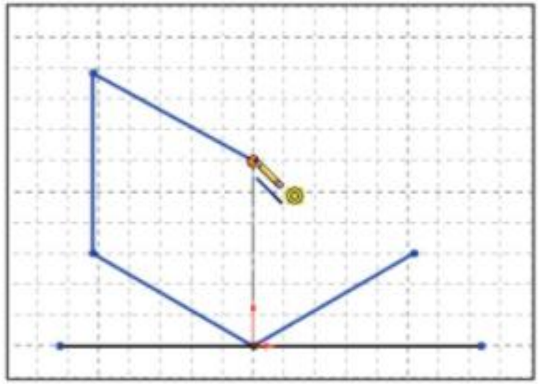
- The three axes are at different angles.
- The scale along each axis and the angles are determined by the angle of viewing



To Draw an Isometric Sketch of a Cube

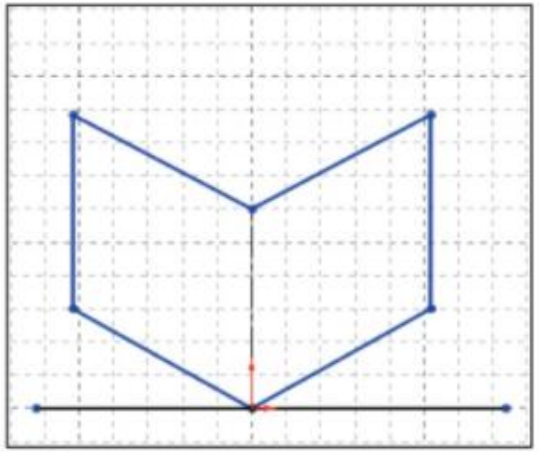


1. Draw a light horizontal axis (construction line) as illustrated on graph paper. Draw a light vertical axis. Draw a light 30º axis to the right. Draw a light 30º axis to the left.



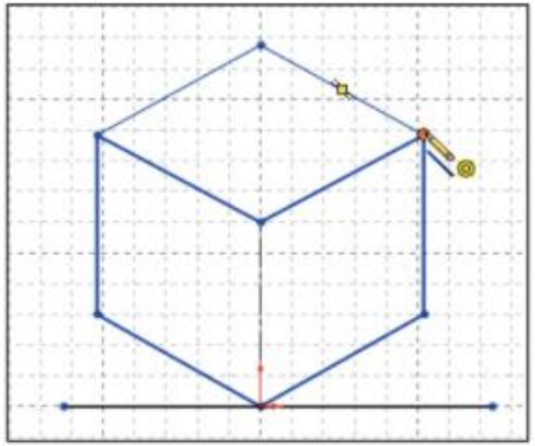
2. Measure the length along the left 30º axis, make a mark and draw a light vertical line.

3. Measure the height along the vertical axis, make a mark and draw a light 30º line to the left to intersect the vertical line drawn in step 2.



4. Measure the length along the right 30º axis, make a mark and draw a light vertical line.

5. From the height along the vertical axis, make a mark and draw a light 30º line to the right to intersect the vertical line drawn in step 4.



6. Draw a light 30º line to the right and a light 30º line to the left to complete the cube. Once the sketch is complete, darken the shape.

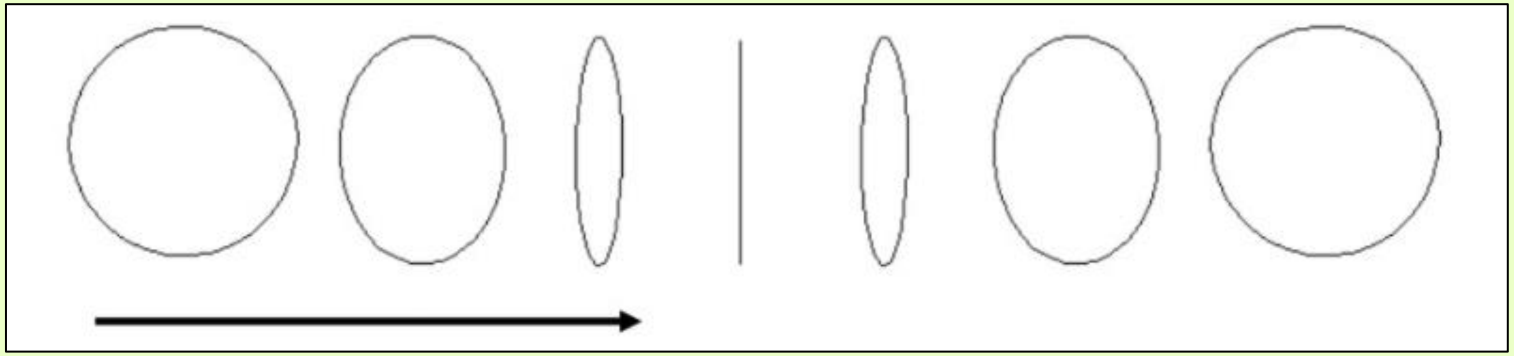
In an Isometric drawing, the object is viewed at an angle, which makes circles appear as ellipses.

Isometric Rule #1: Measurement can only be made on or parallel to the isometric axis.

Circles in Axonometric Drawings

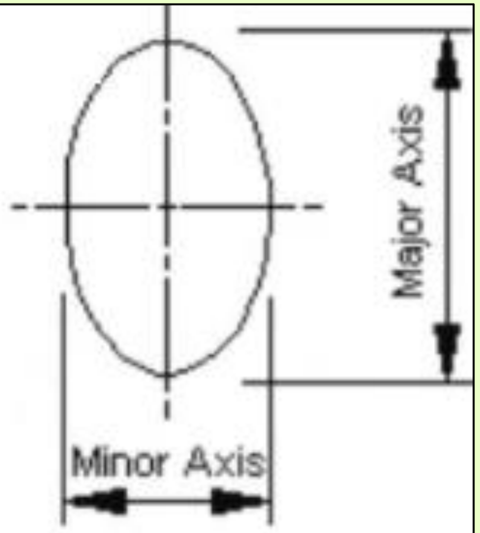
Imagine rotating a circle about it's diameter.

At different angles, it become an ellipse of different sizes.

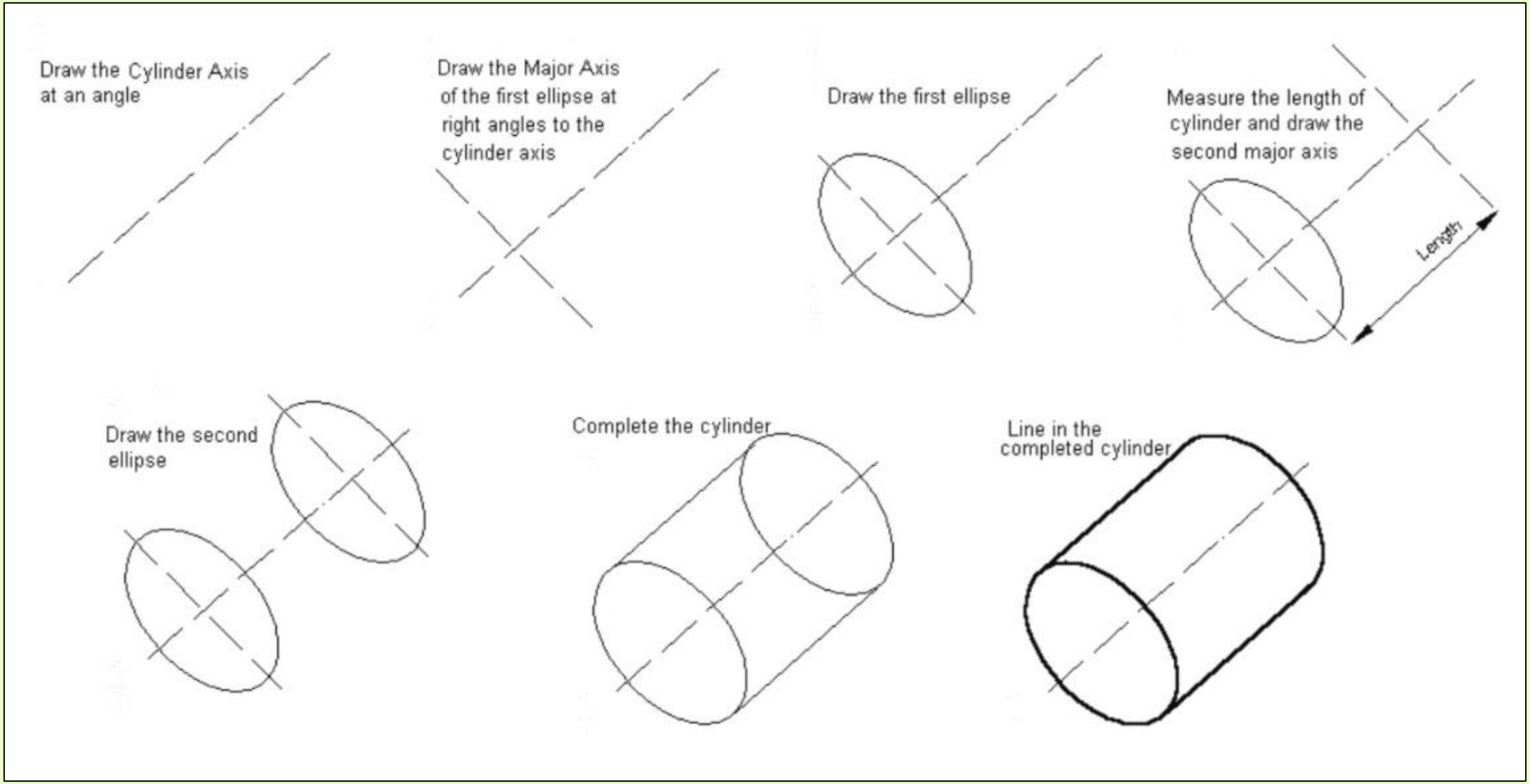


An ellipse has a major axis and a minor axis.

The major axis is the axis about which the ellipse is being turned. The minor axis becomes smaller as the angle through which the ellipse is turned approaches 90°.



Drawing a Cylinder in Isometric

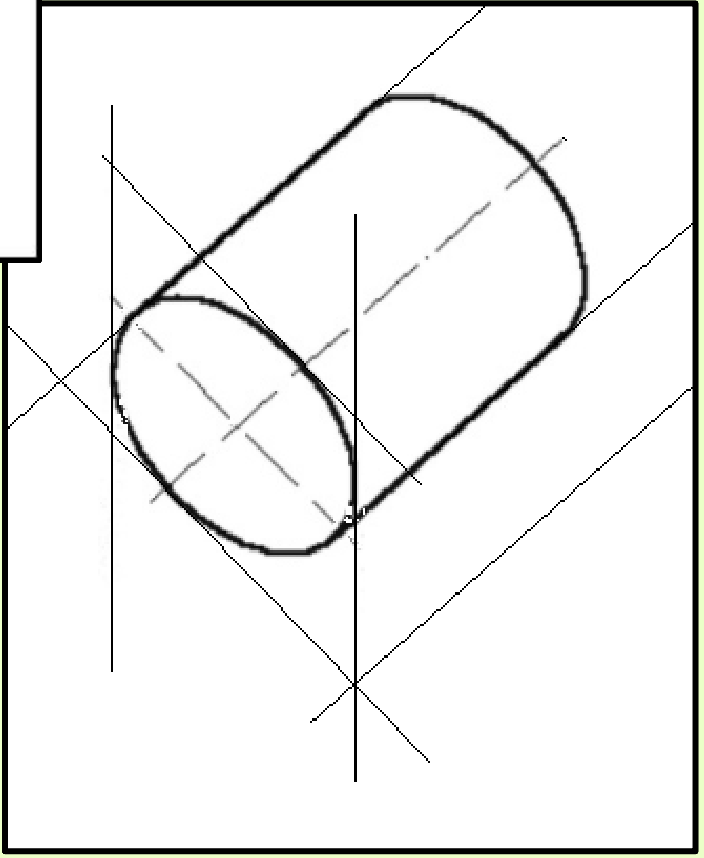


Isometric Rule #1:

Measurement can only be made on or parallel to the isometric axis.

Isometric Rule #2:

When drawing ellipses on normal isometric planes, the minor axis of the ellipse is perpendicular to the plane containing the ellipse.

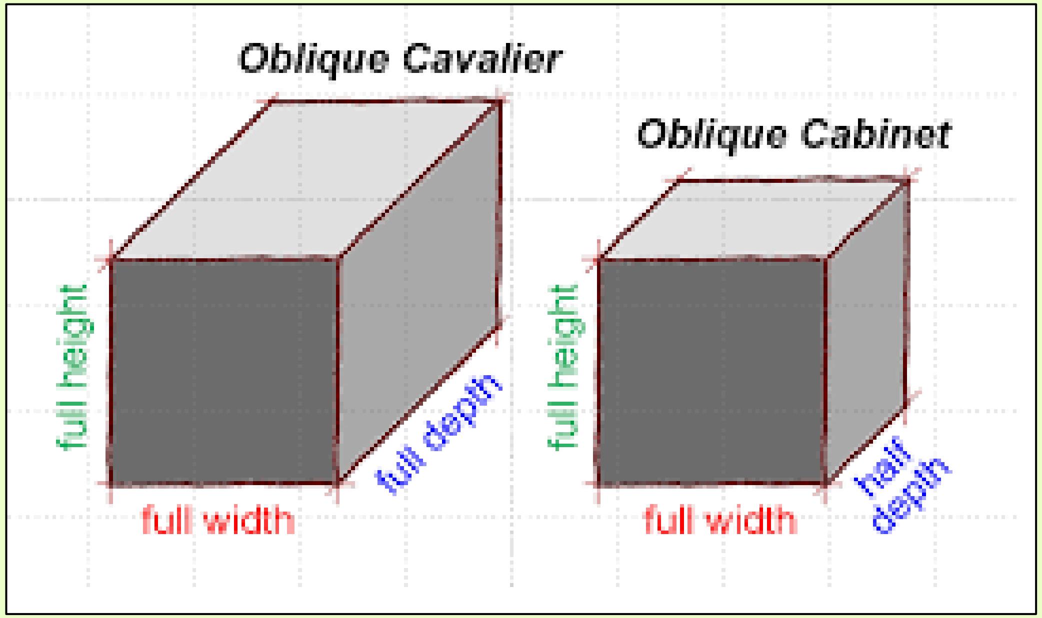


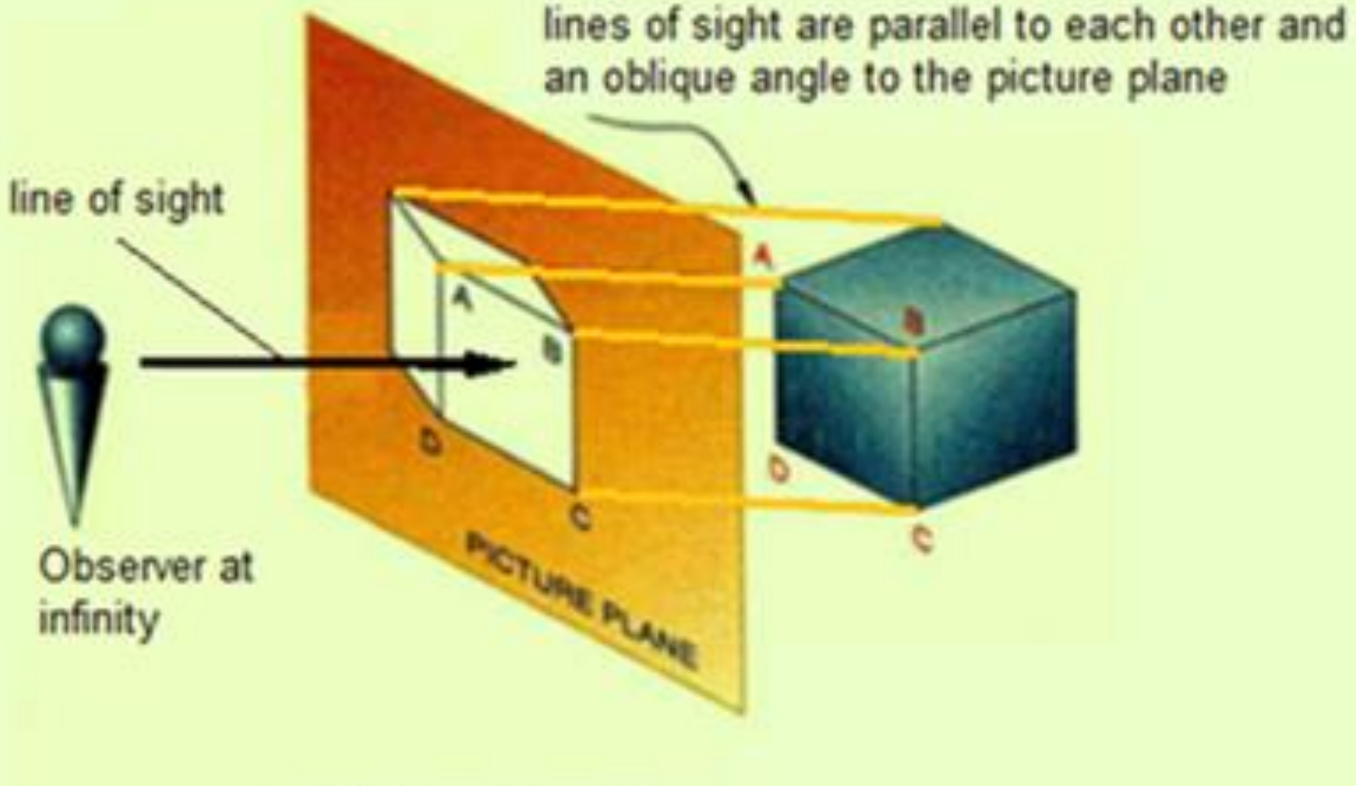
Oblique Drawings

The front view is drawn true size and the receding surfaces are drawn on an angle.

Two types:

- **Cavalier**
  all lines are true length
- **Cabinet**
  receding lines are 1/2 size

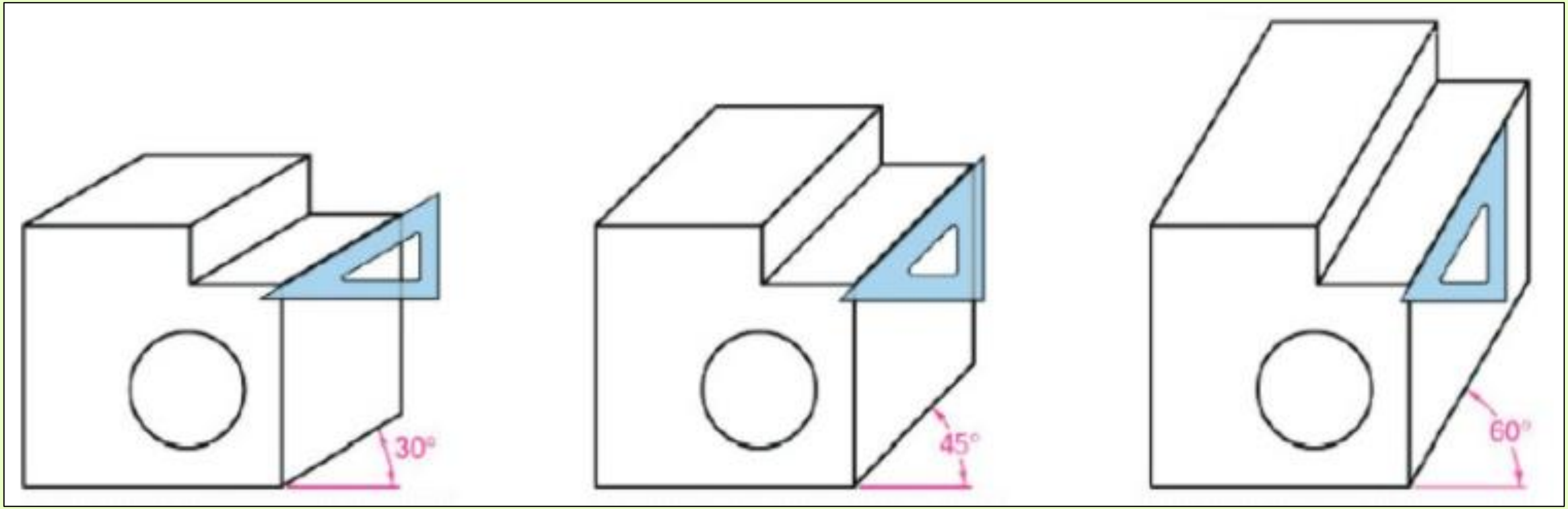




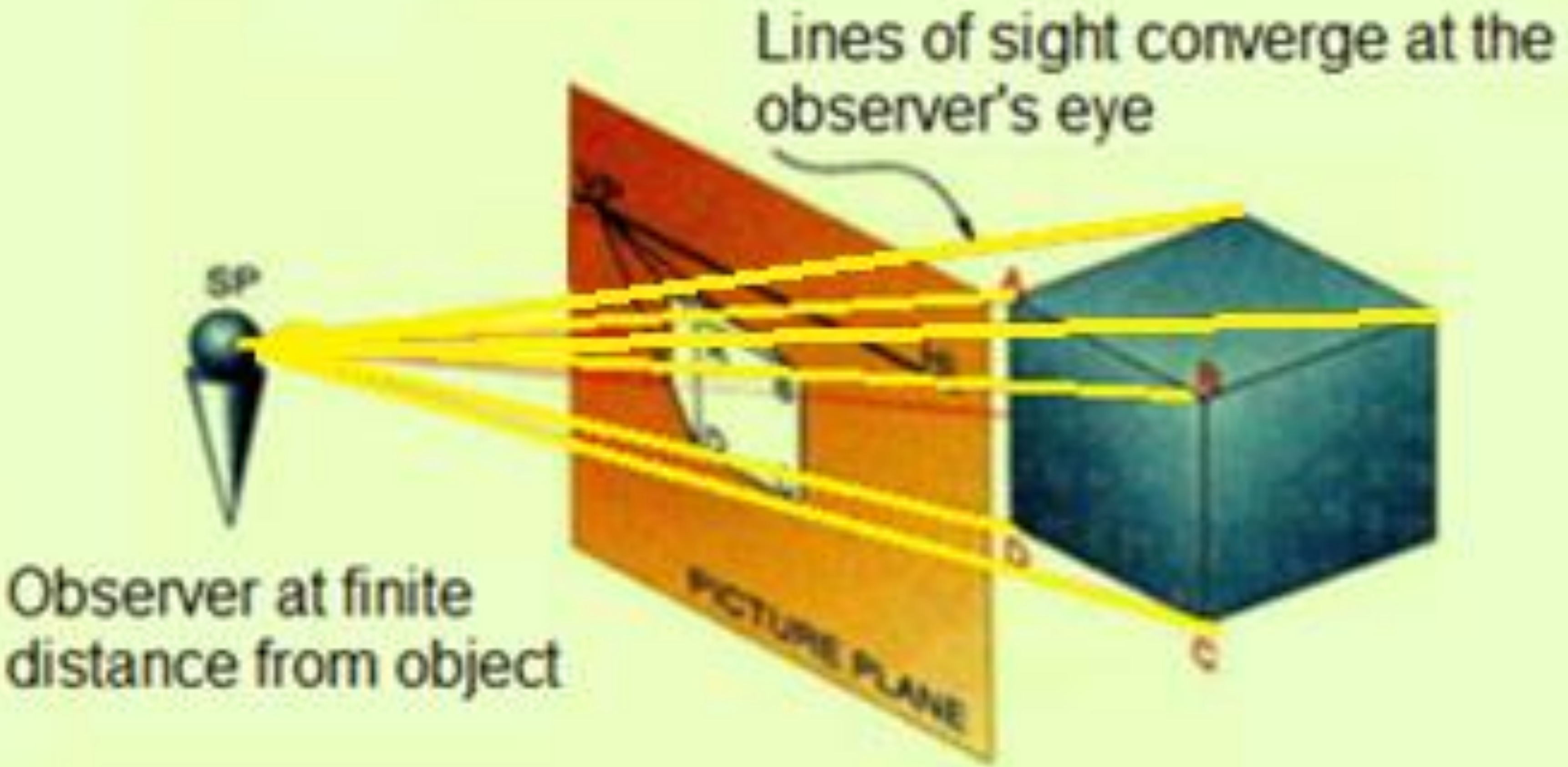
Oblique Drawing

Oblique Drawings

Receding axis is usually 60^{o}, 45^{o}, or 30^{o}



Perspective Drawings



Perspective Drawing

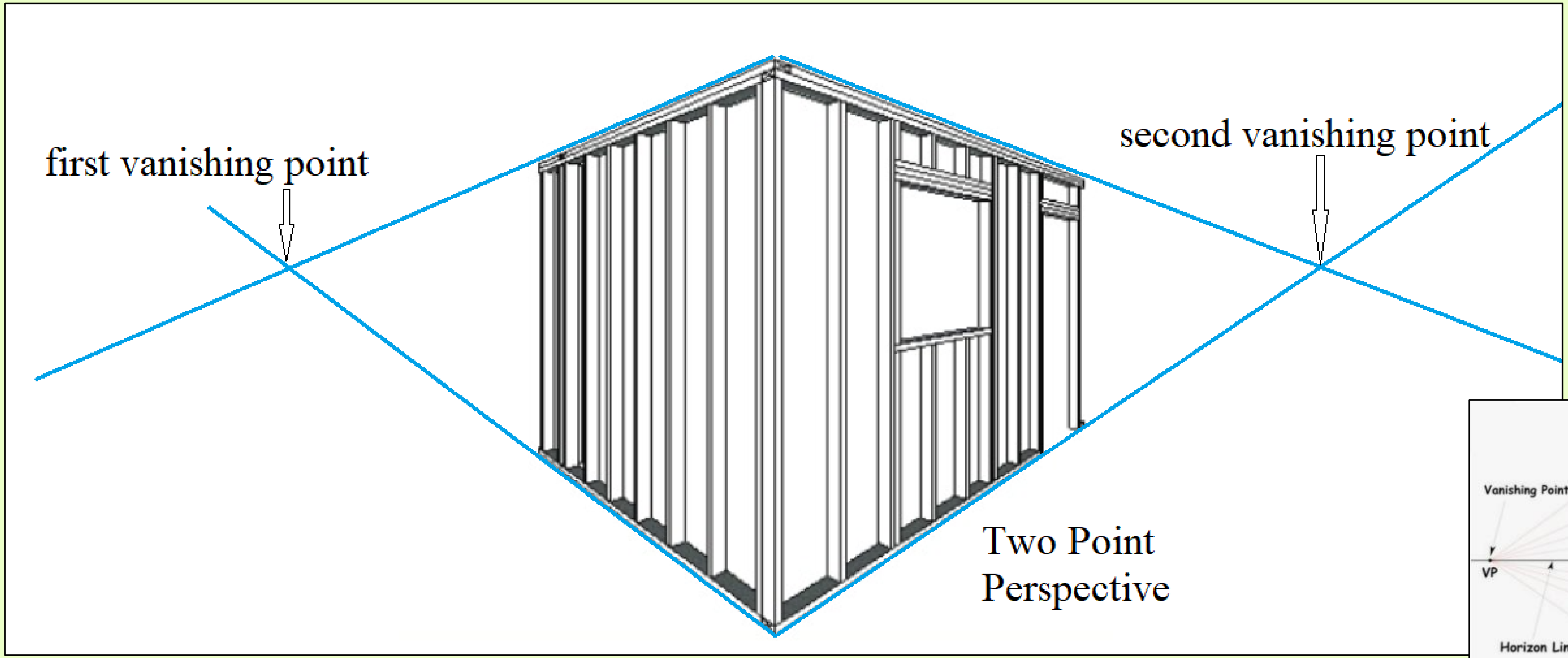
One point perspective

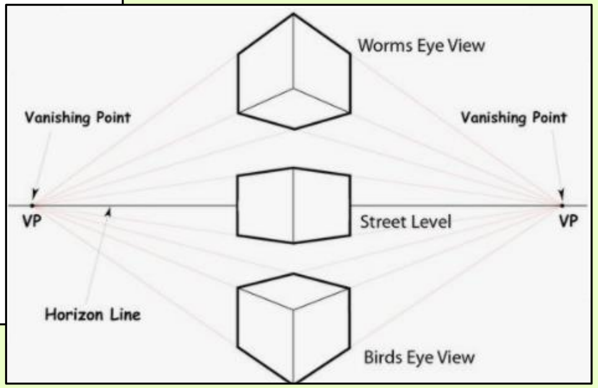
used when the front is directly facing the viewer (roads, buildings) and the objects have lines either directly parallel with the viewer's line of sight of directly perpendicular

- Where is the vanishing point?
- How does the angle of the projectors change as the object viewed gets further and further away?
  (Answer: The angle of the projectors decrease as the distance from the object increases.)

Two Point Perspective

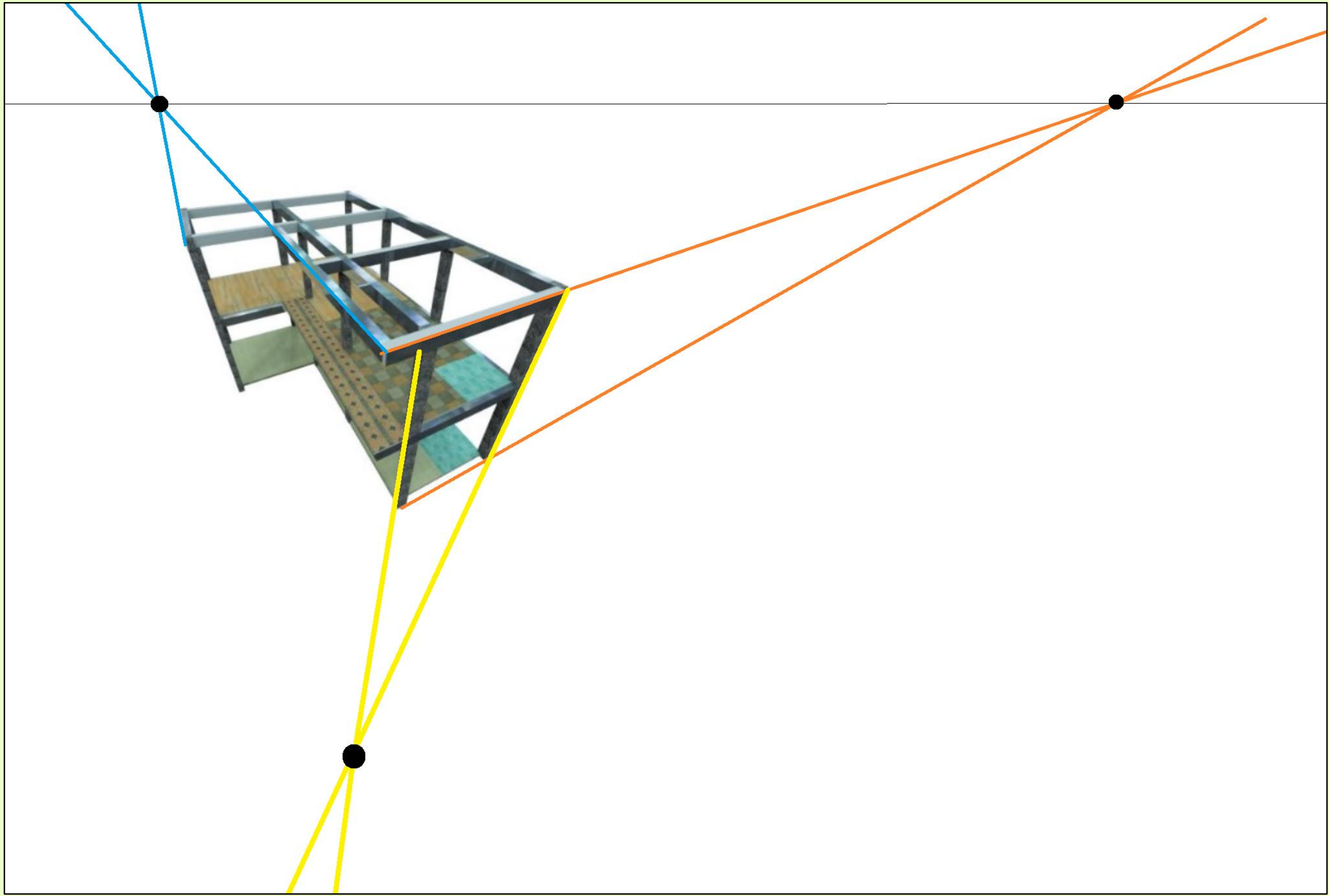
- shows objects as "rotated"
- vanishing points are established towards which lines recede, mimicking the effect of objects diminishing in size with distance from the viewer
- one point represents one set of parallel lines, the other point represents the other set of parallel lines
- selection of vanishing points will affect result





Three Point Perspective

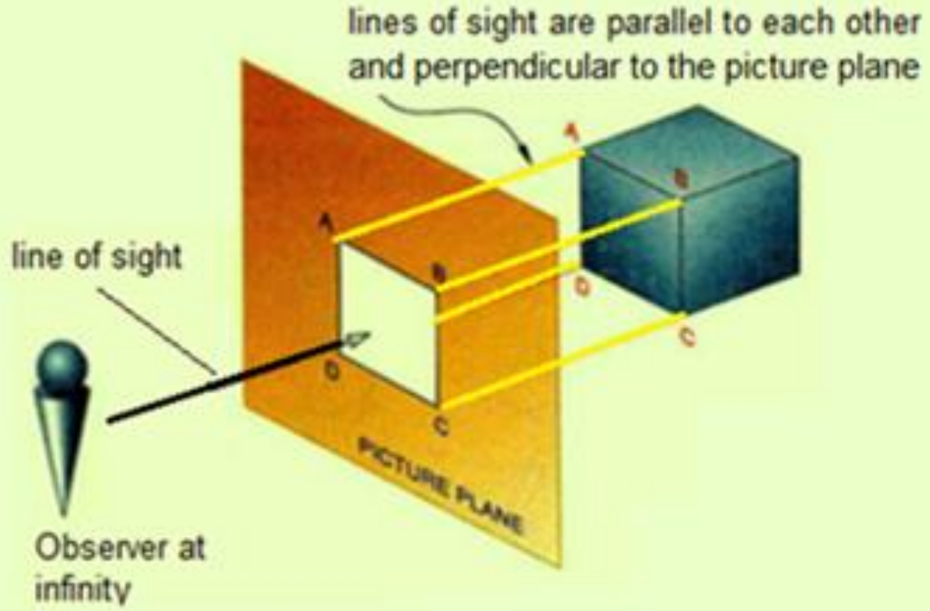
- For objects seen from above or below
- The third vanishing point is for the vertical lines to recede
- If the third vanishing point is below the first two then the object appears to be viewed from above
- If the third vanishing point is above the first two then the object appears to be viewed from below



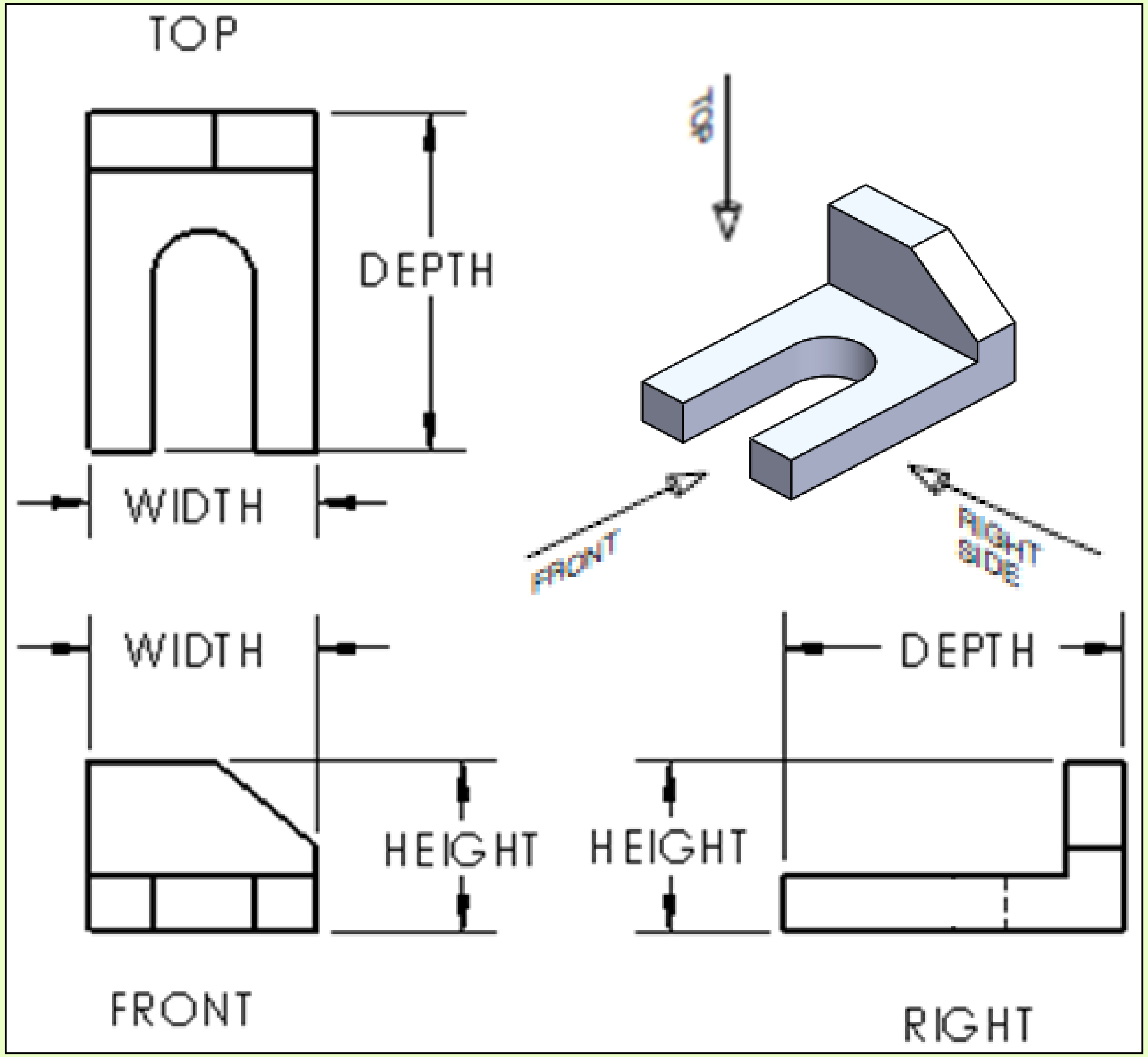
Multiview drawing

- A **collection of 2D views** that work together to provide an accurate representation of the overall model.

- The views together convey all three dimensions with optimal clarity.

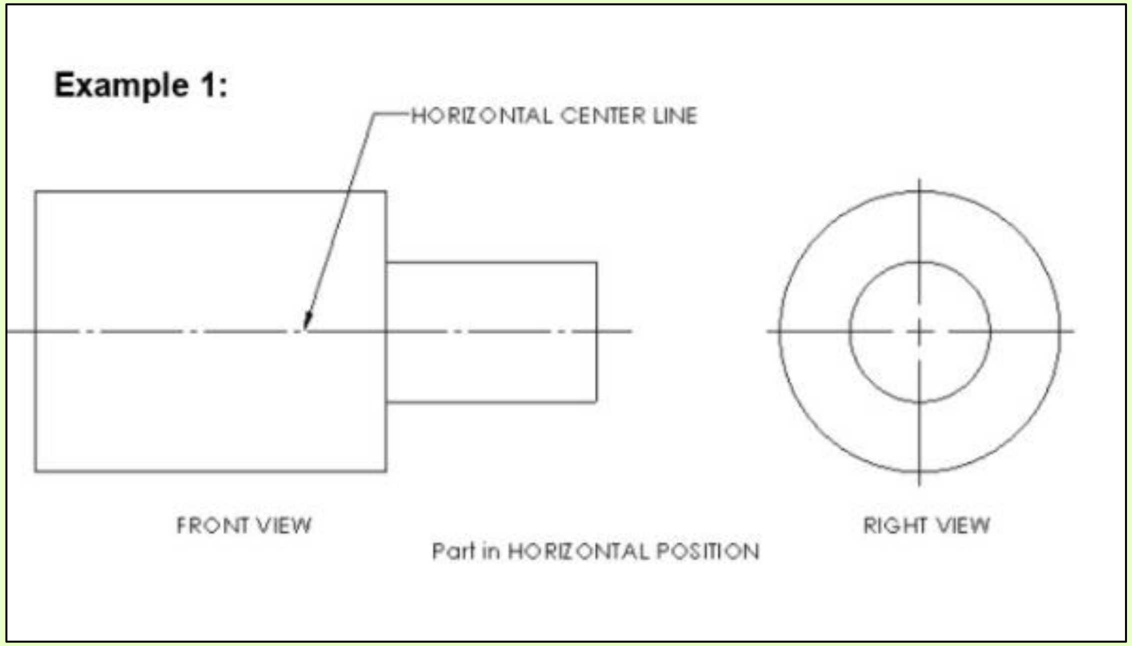


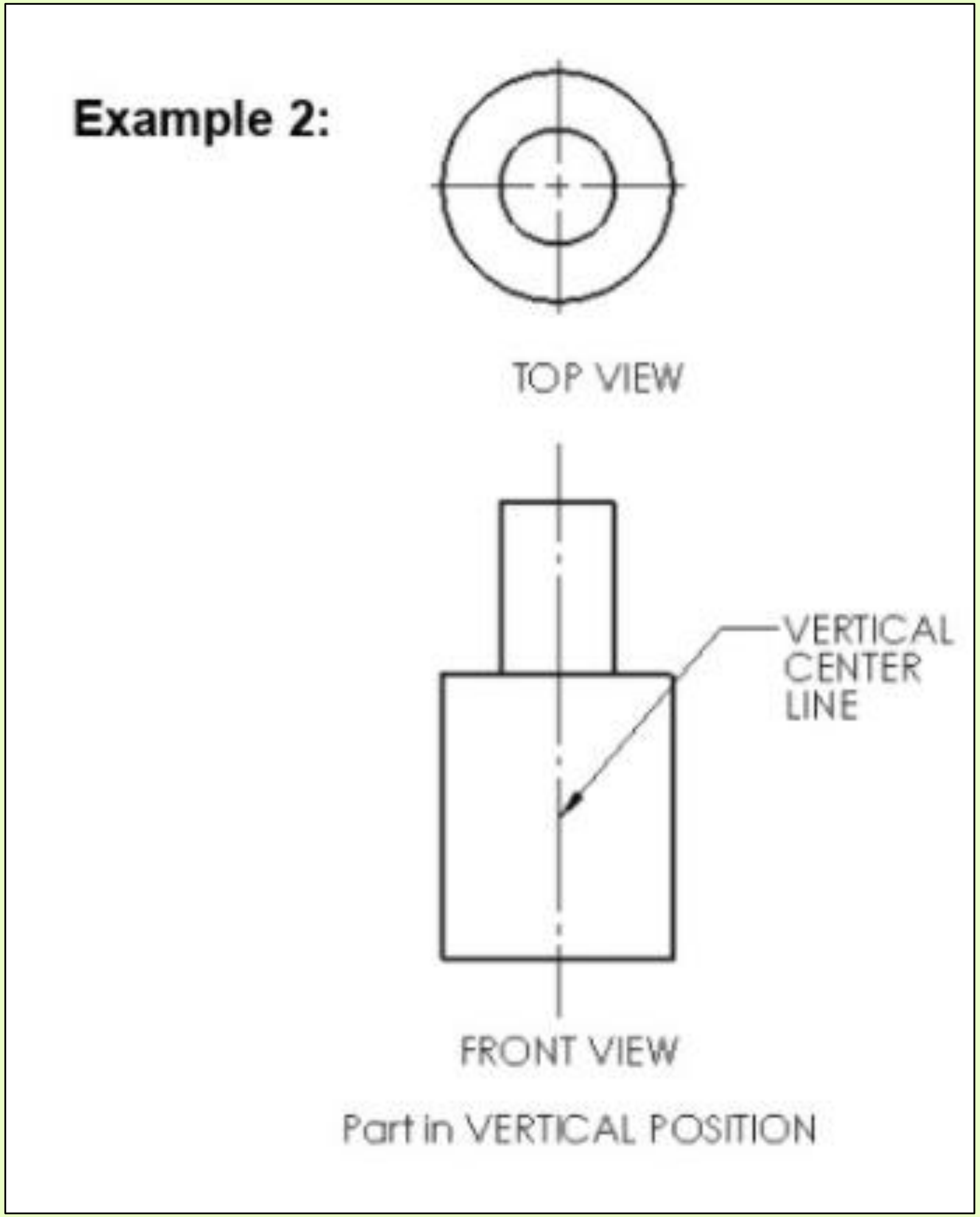
Multiview Drawing



Two-View Drawings

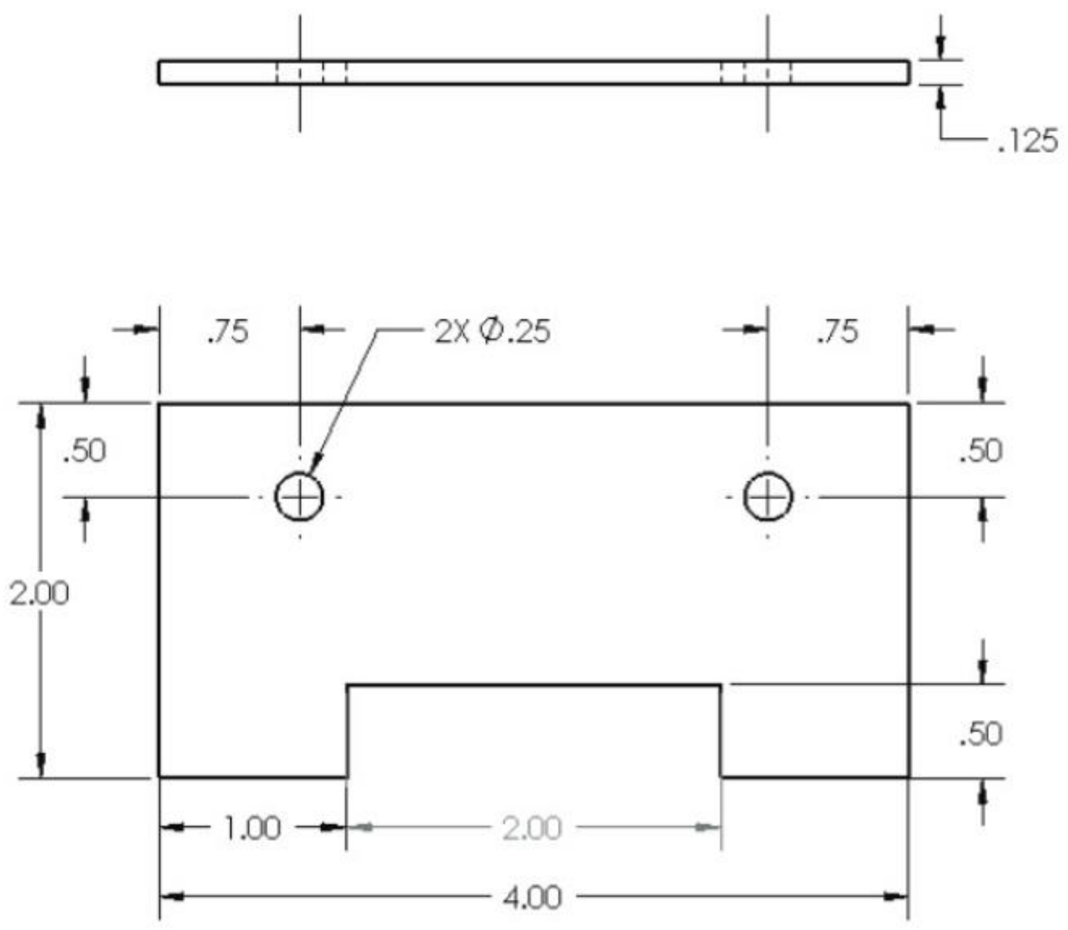
Simple symmetrical flat objects and cylindrical parts require only two views to provide the full details.



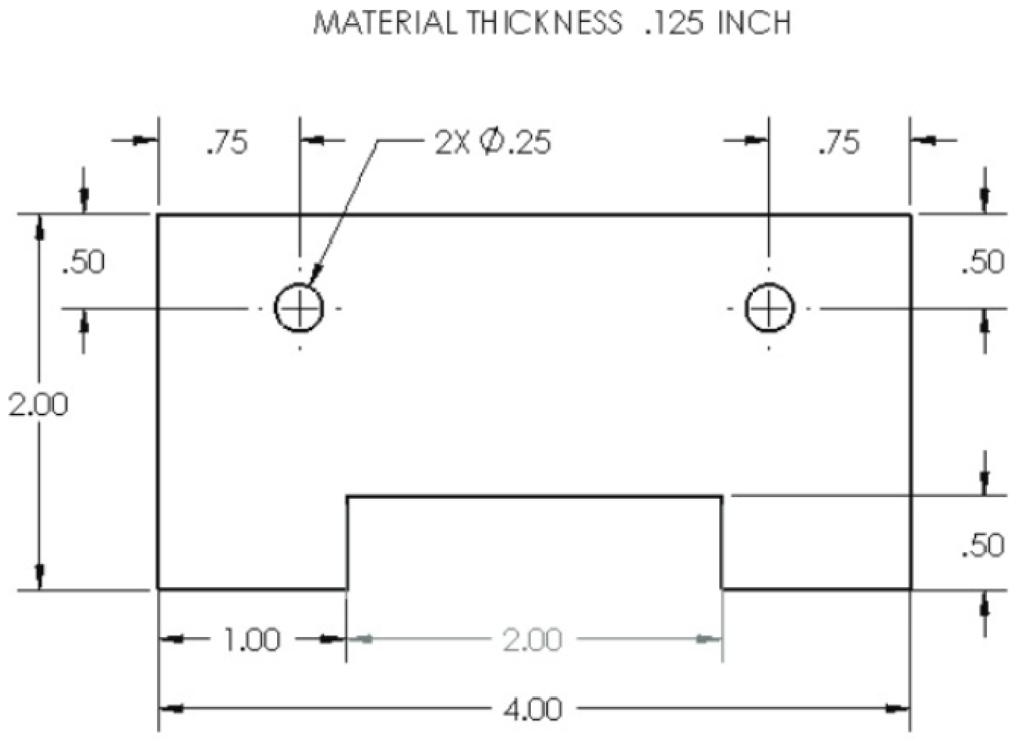


One-View Drawing

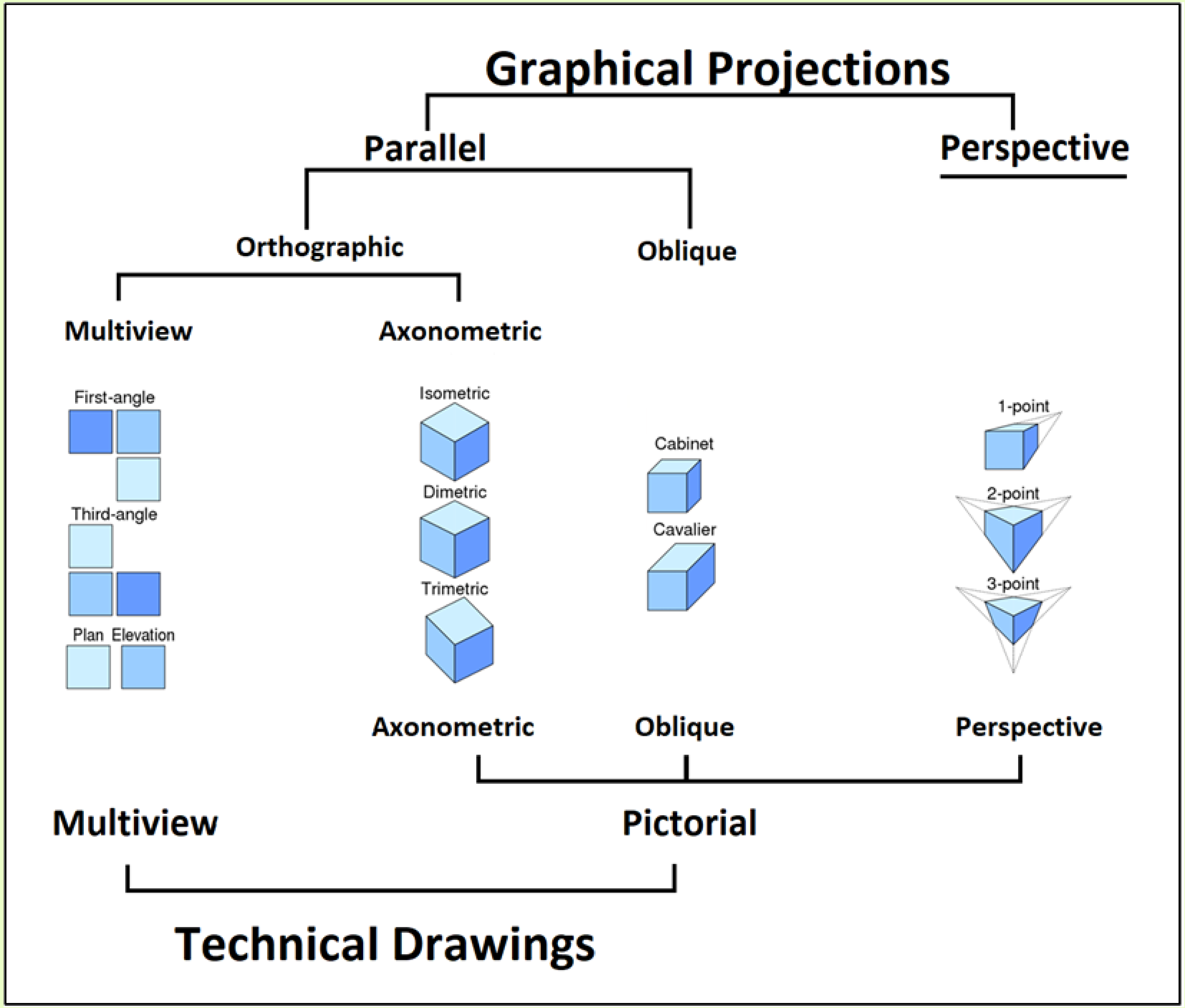
Example 1: No Note Annotation



Example 2: Note Annotation to replace the Top view



Summary

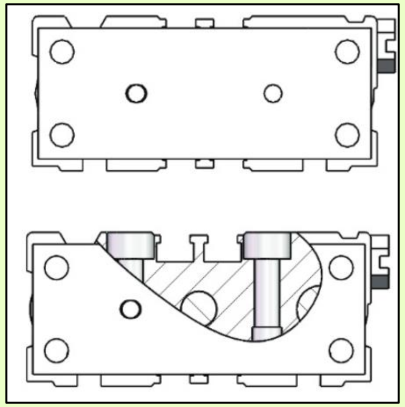


Graphical Projections
Parallel
Perspective
Orthographic
Oblique
Multiview
Axonometric
First-angle
Third-angle
Plan
Elevation
Isometric
Dimetric
Trimetric
Cabinet
Cavalier
1-point
2-point
3-point
Axonometric
Oblique
Perspective
Multiview
Pictorial
Technical Drawings

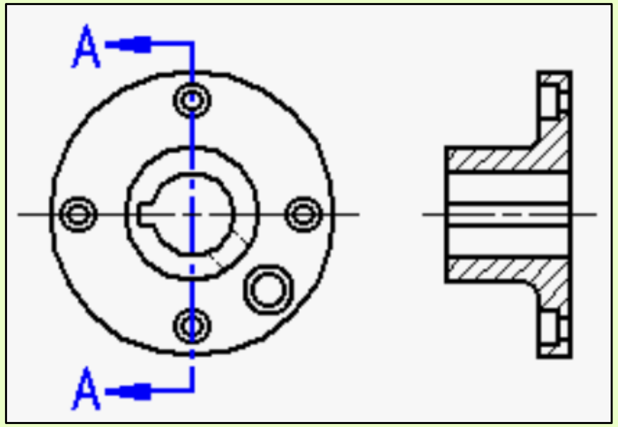
Non-standard Views

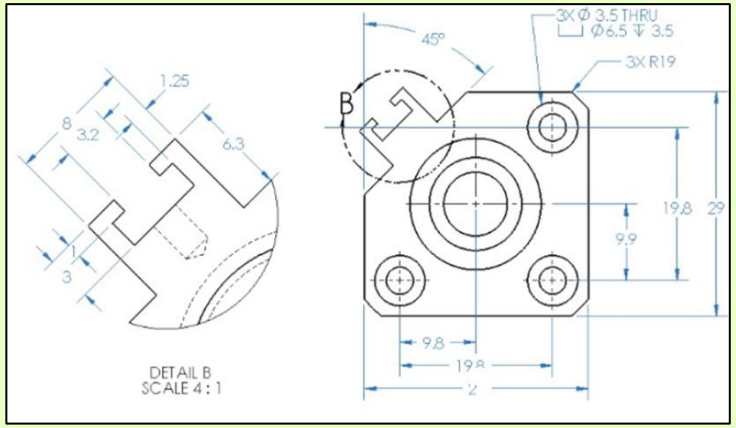
The standard views are Front, Top, Right, & Isometric

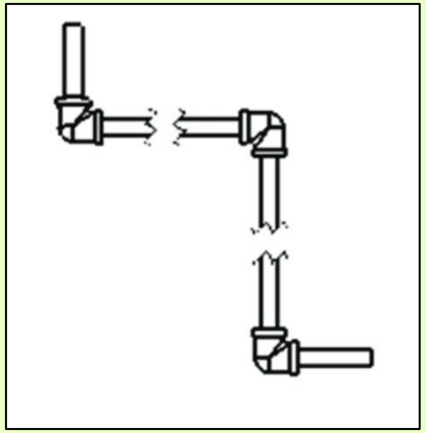
Non-standard views are used when the standard views do not fully describe the object.

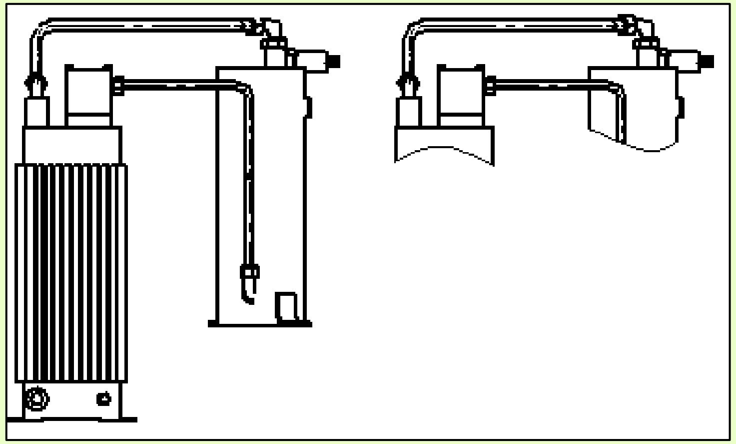


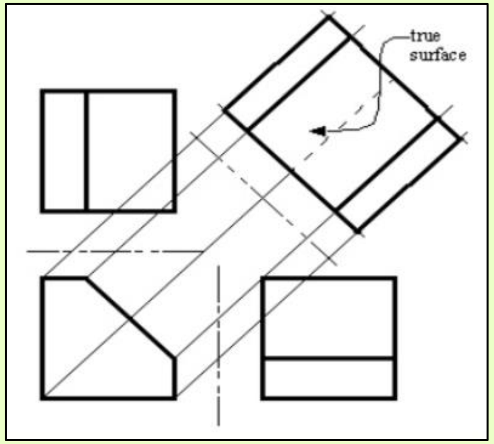
- Section
- Detail
- Broken out section
- Break
- Crop
- Auxiliary





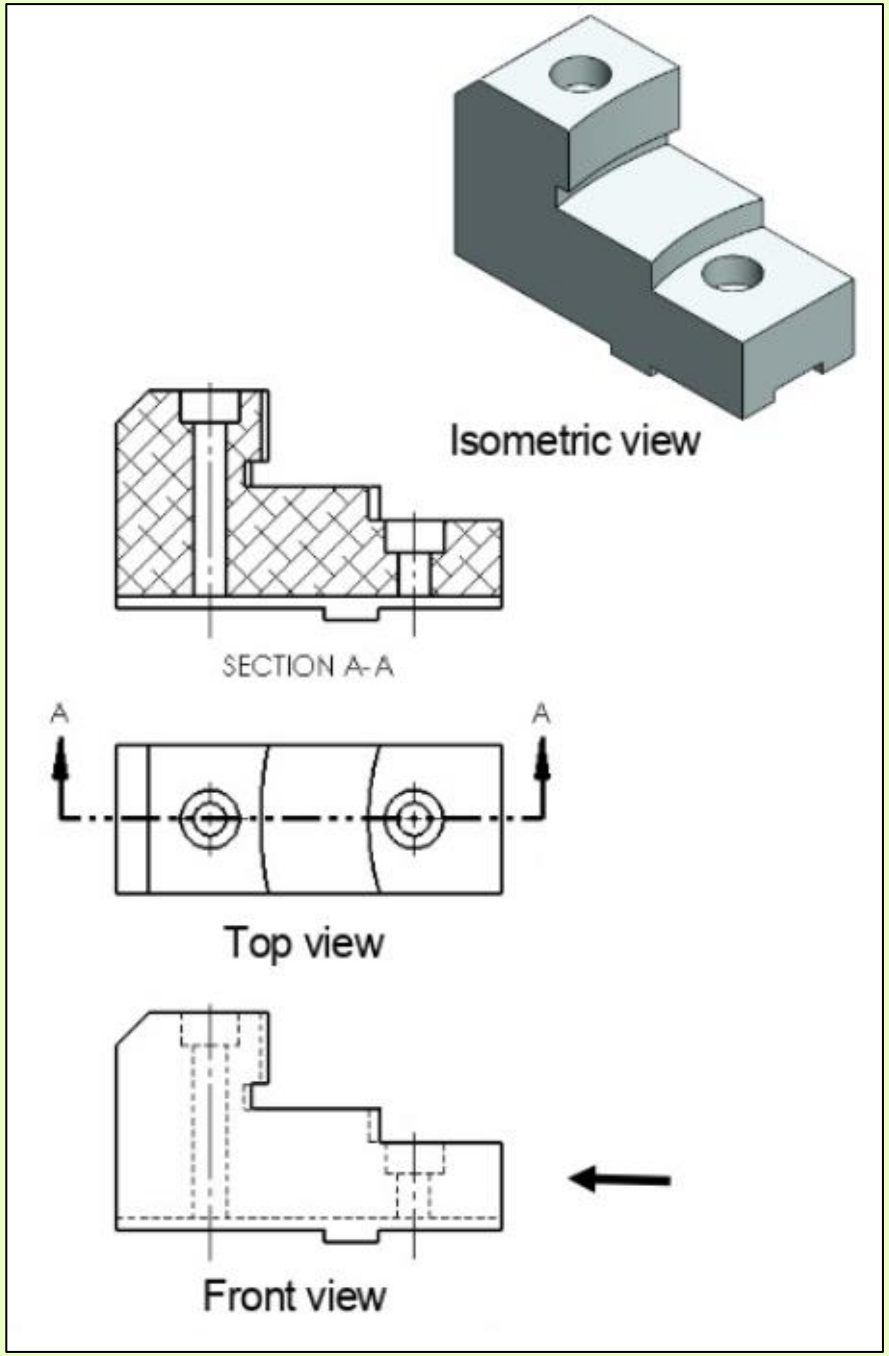






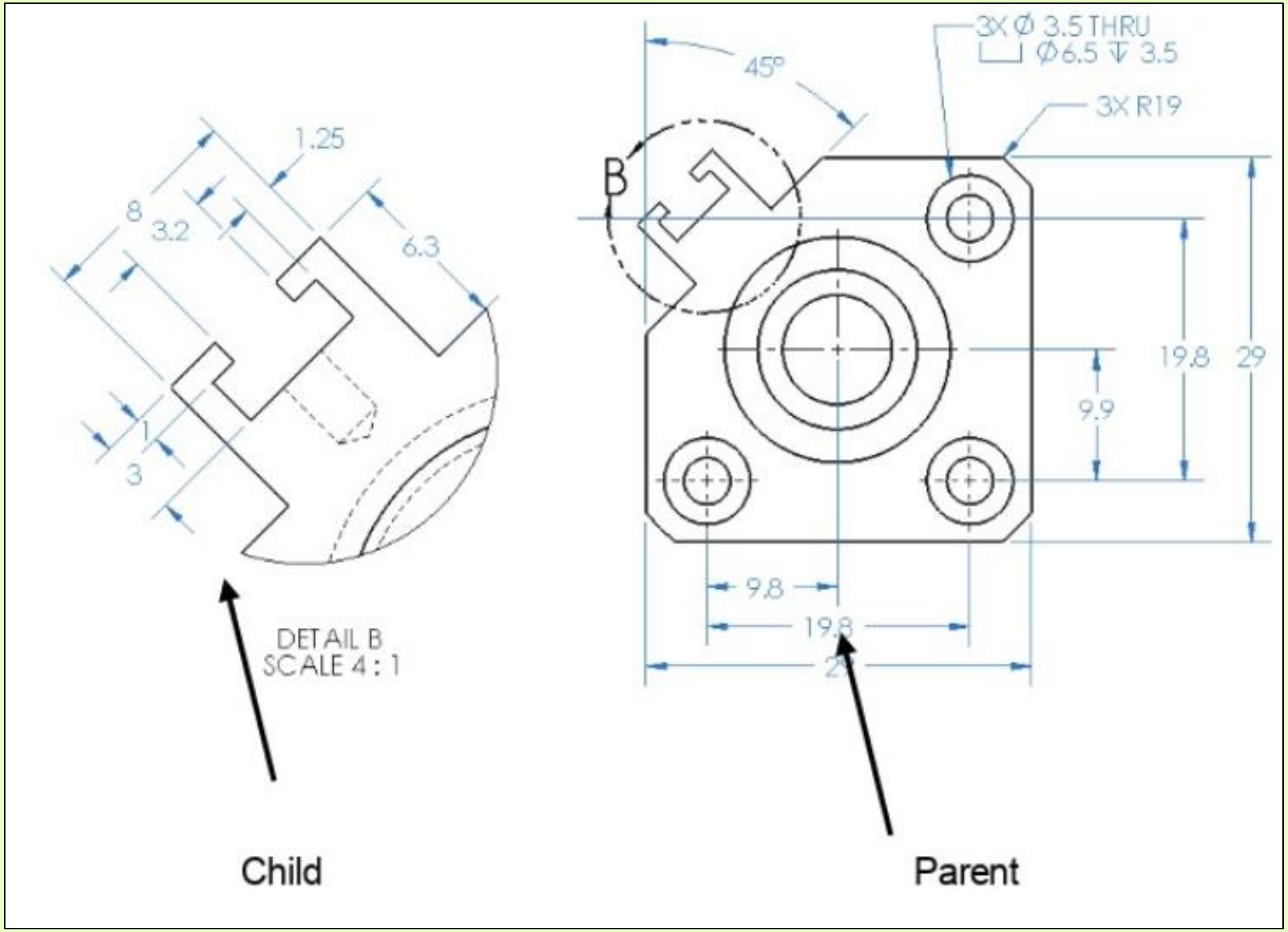
Section Views

- Used to clarify the interior of a part
- An imaginary plane cuts through the object and removes a portion
- Arrows represent direction of sight
- Section lines show the type of material
- A section view is considered a child of the parent view



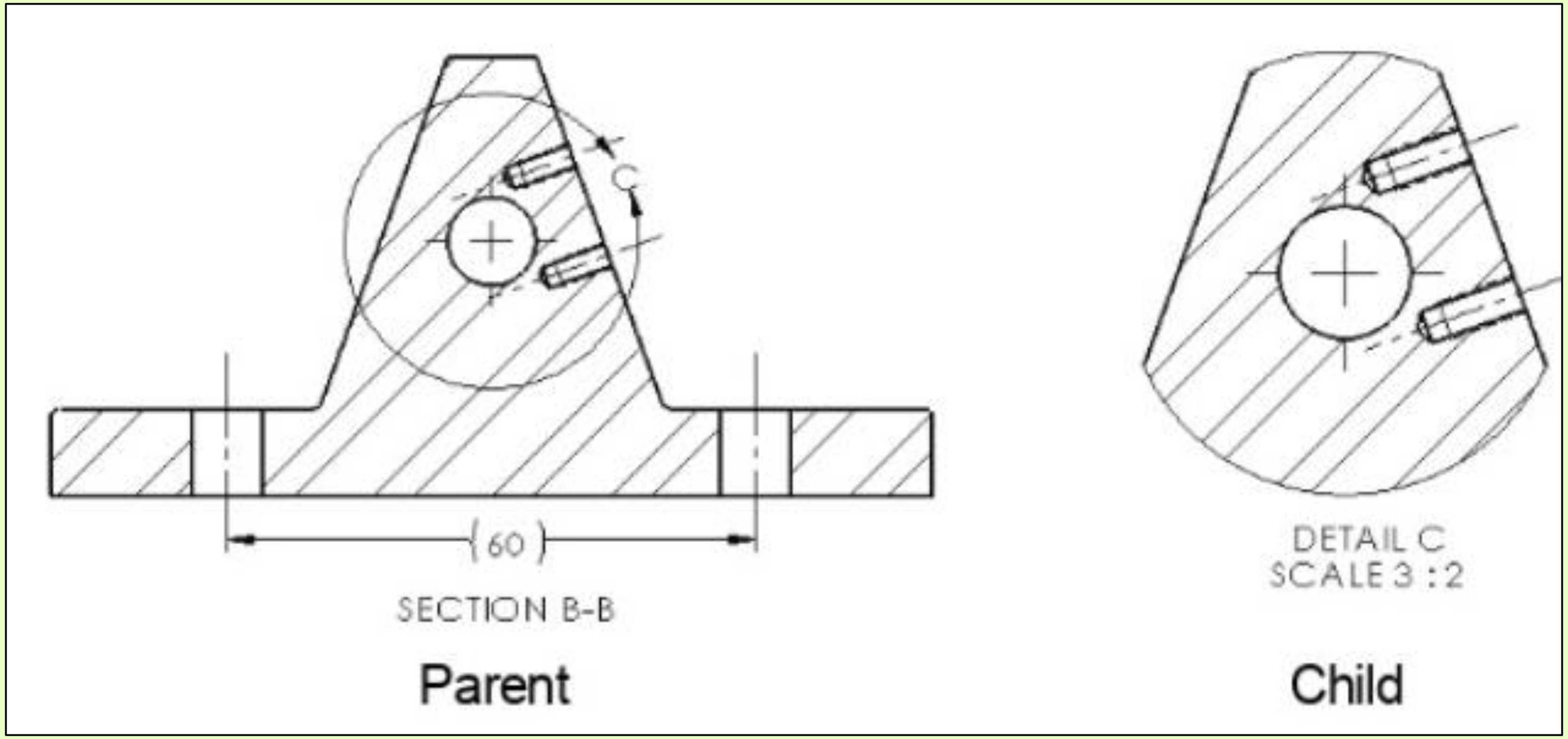
Detail Views

- displays or highlights a portion of a view, usually enlarged
- a detail view is a child of the parent view



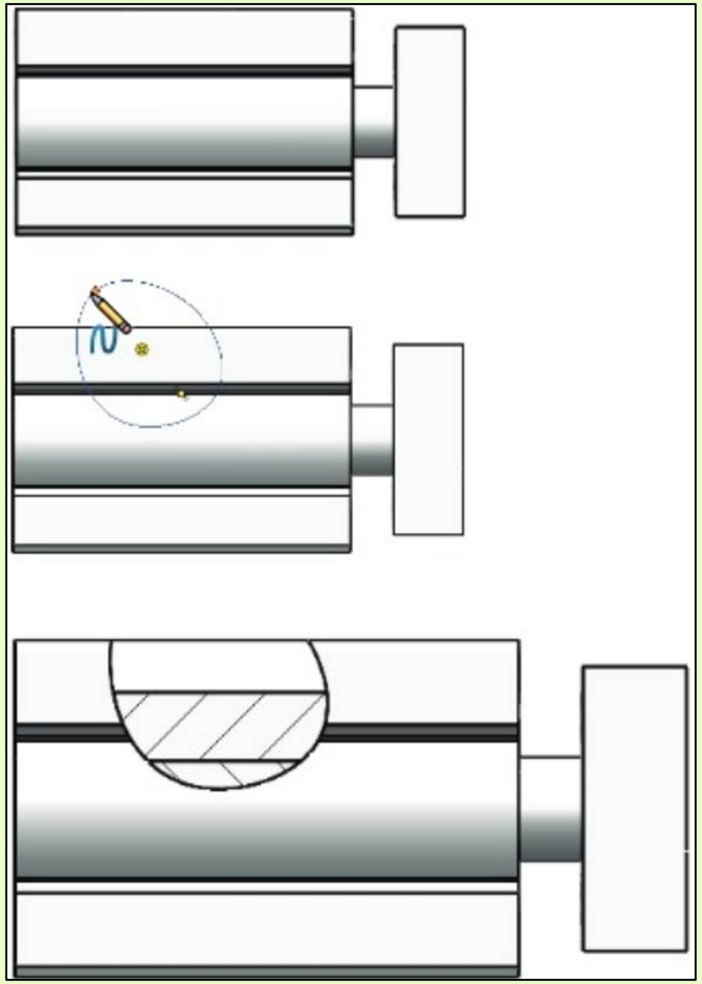
A detail view can be

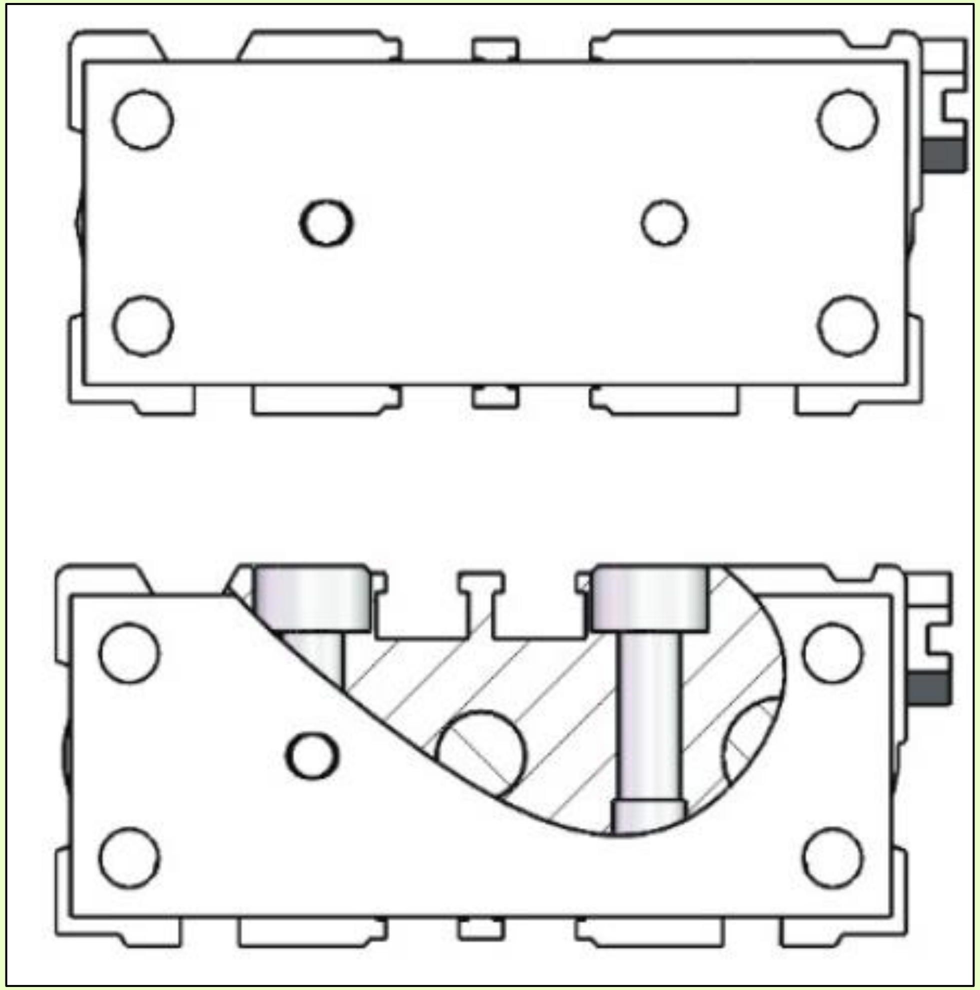
- orthographic view (as in previous example)
- section view (shown here)
- crop view
- exploded assembly view
- non-planar (isometric) view



Broken out view

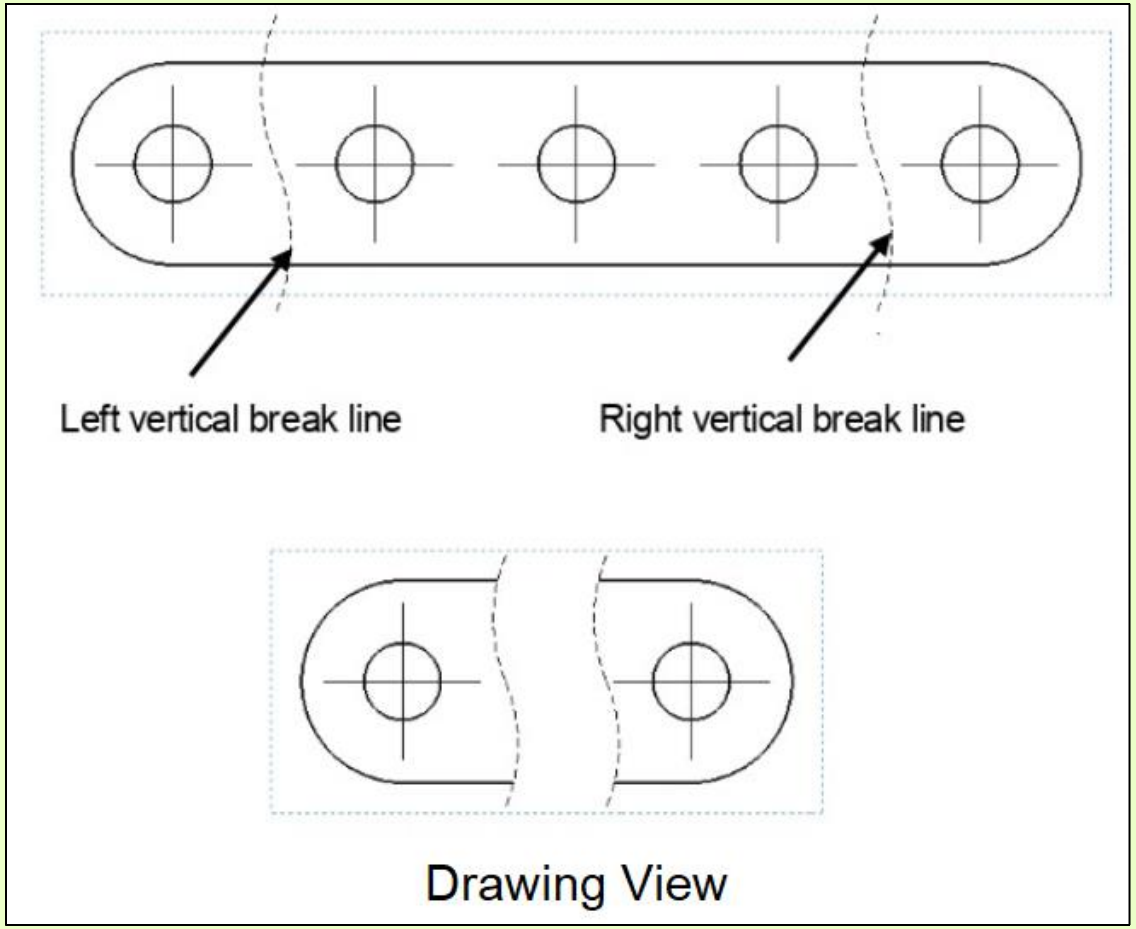
- part of an existing drawing view, not a separate view.
- material is removed to expose inner details

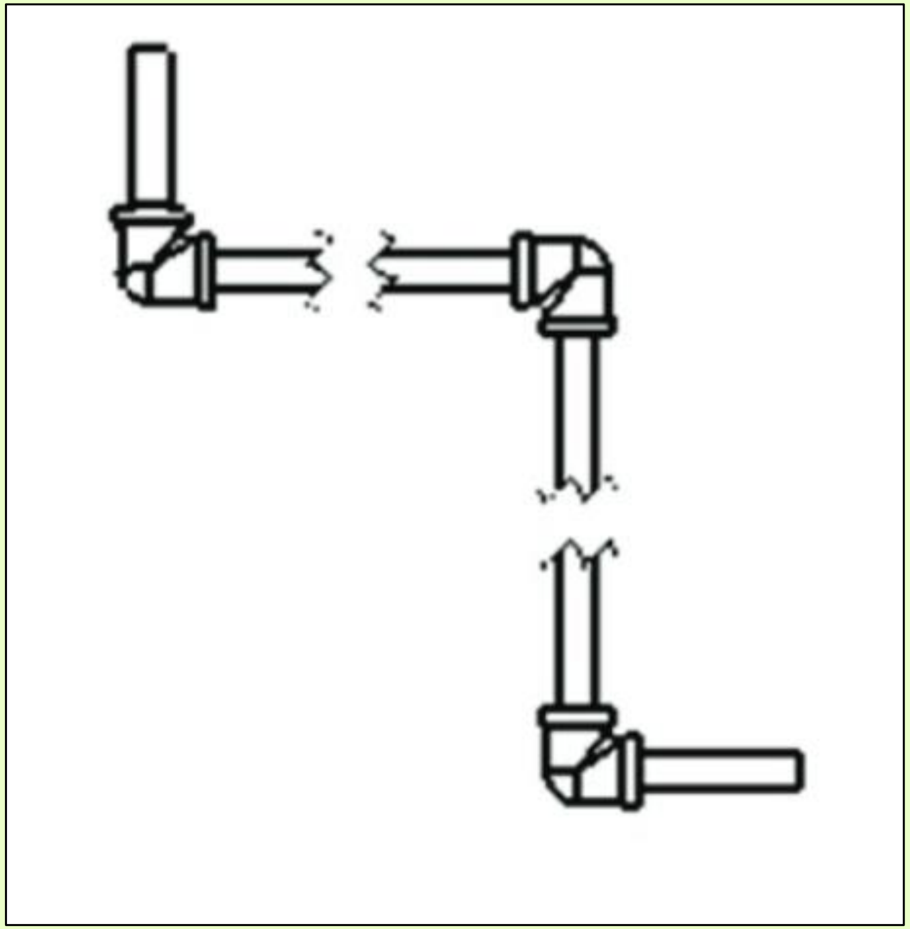




Break or Broken View

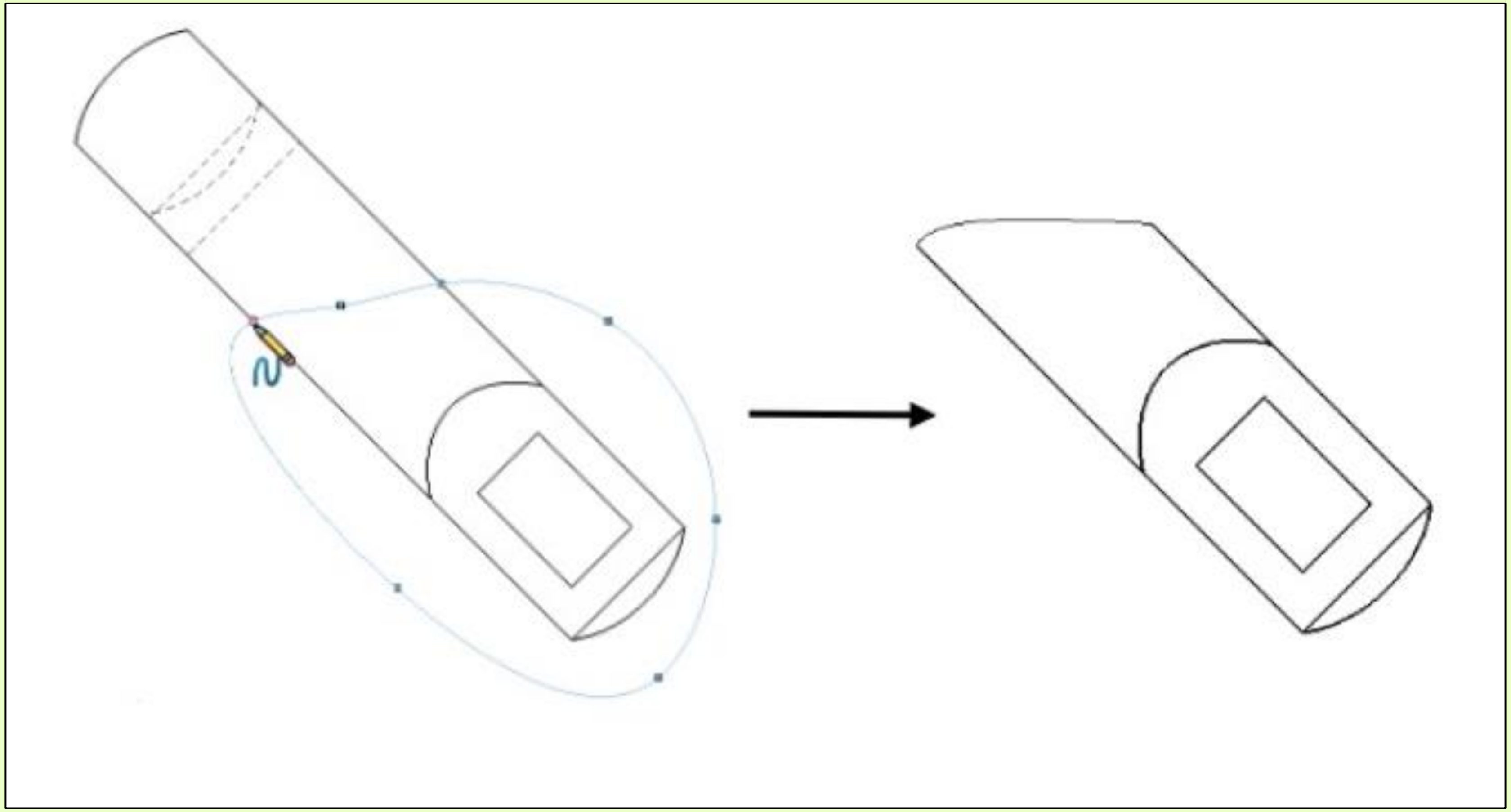
- part of an existing drawing view, not a separate view
- used to display the drawing view in a larger scale on a smaller drawing sheet size
- dimensions reflect actual object values





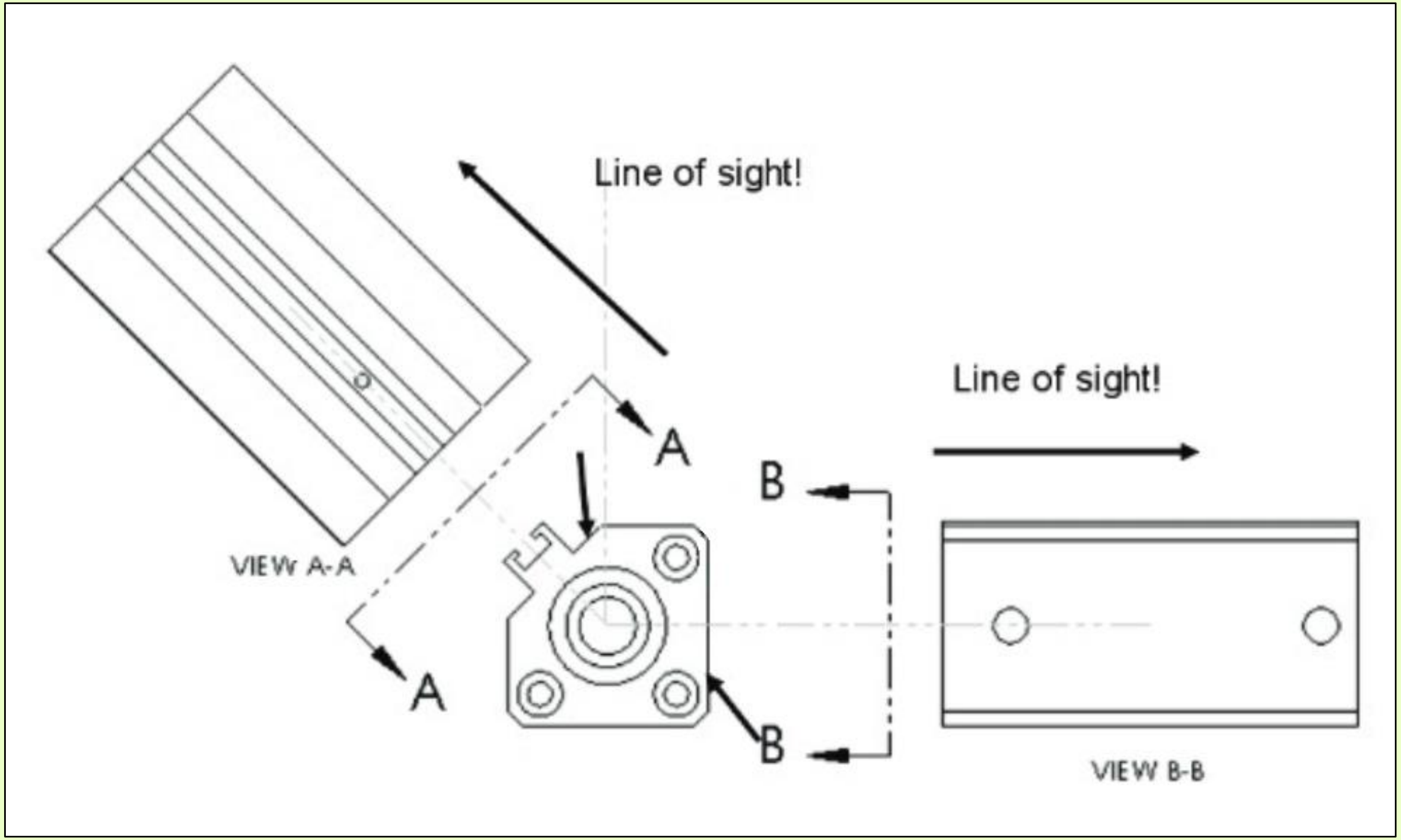
Crop View

- crops an existing drawing
- can't create a crop view from a detail view or exploded view
- a crop view is a Child of the Parent view



Auxiliary View

- displays a plane parallel to an angled plane on the object so that it shows True Size
- hinged to one of the six principle orthographic views
- an Auxiliary view is a Child of the Parent view



Some History of CAD Technology

- In the early days, 3D CAD used **Boolean Algorithms** to create solid geometry.
  It was challenging to manipulate.

- Later 3D CAD used **Surface Modeling**.
  It was better.

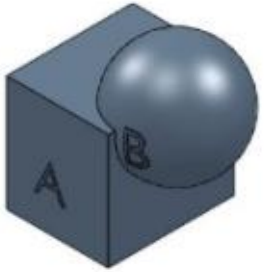
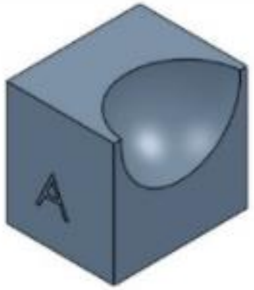
- A key advancement was **Constructive Solid Geometry (CSG)** method.

Some History of CAD Technology

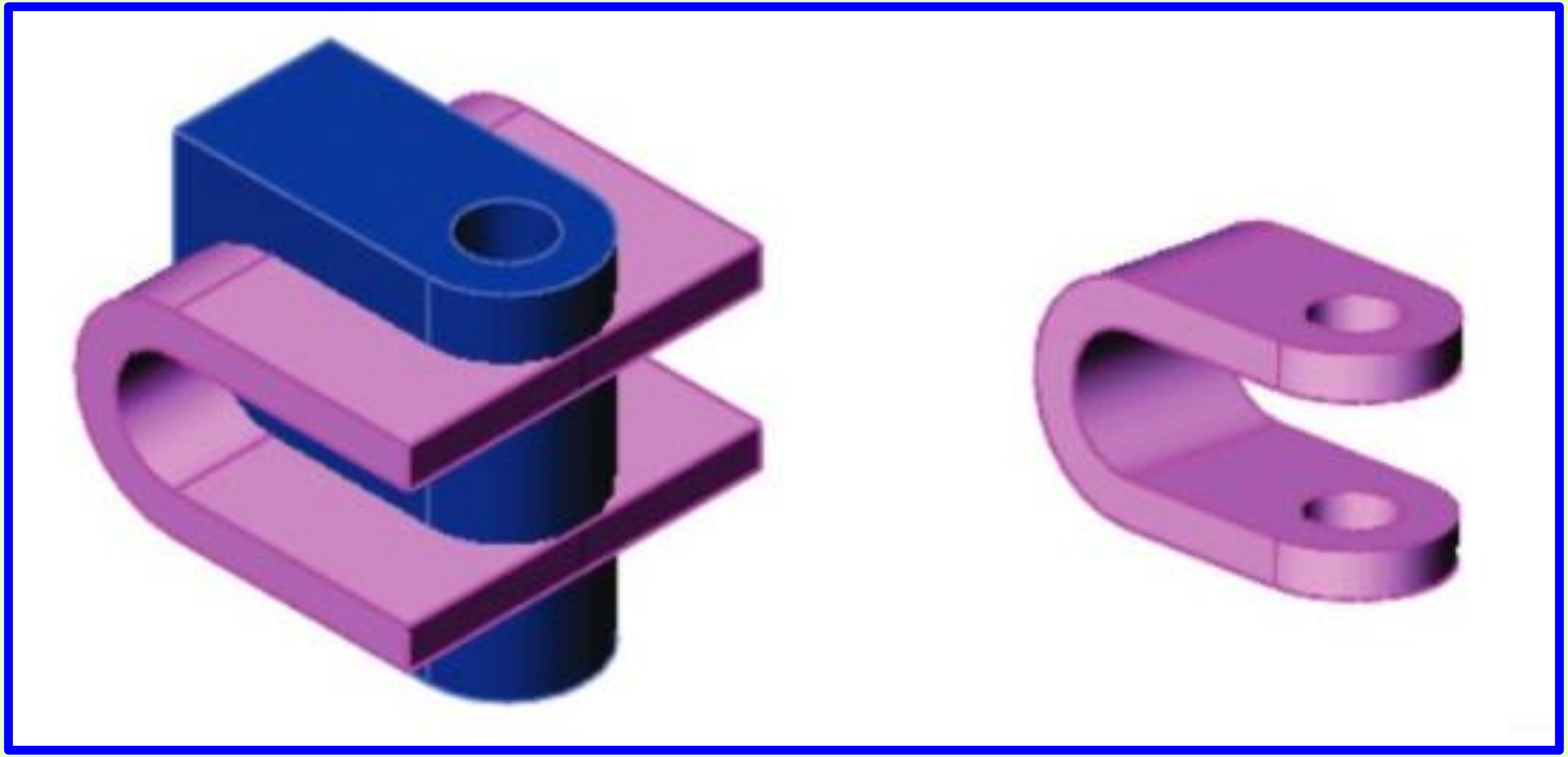
CSG/
Boolean Operations
are modeling techniques still used today.

Primitive solid objects (such as cuboids, cylinders, prisms, pyramids, spheres, and cones) are combined using Boolean operations (ops):

- Boolean Union
- Boolean Difference
- Boolean Intersection

Boolean Operation:	**Result:**
Boolean Union - The merger of two separate objects into one. A + B	
Boolean Difference - The subtraction of one object from another. A - B	
Boolean Intersection - The portion common to both objects. $A \cap B$	

A more complex Boolean Intersection



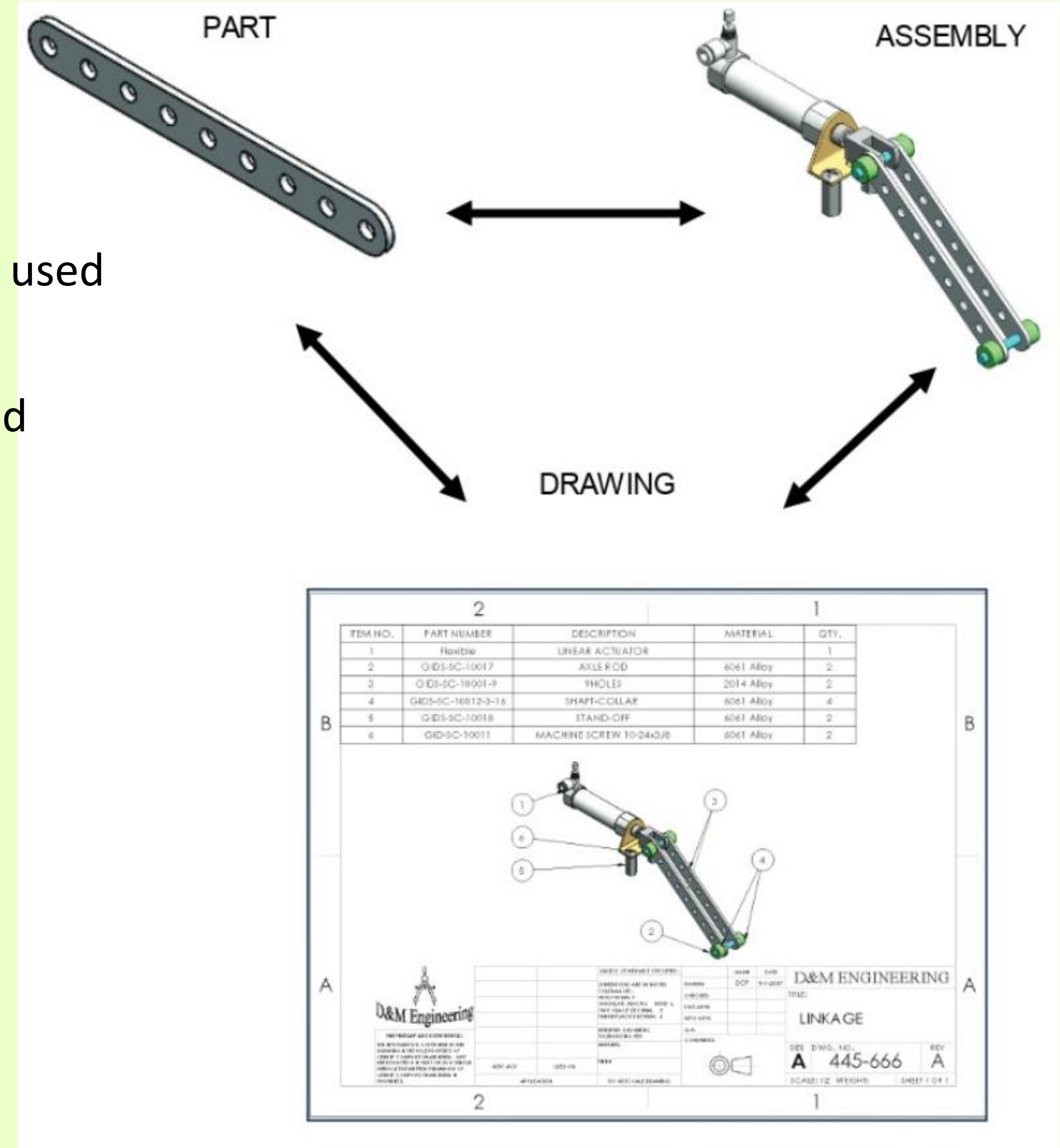
Some History of CAD Technology

Late 1980s:
Parametric Modeling
The ability to manipulate a 3D solid model by changing dimensions directly on the model.

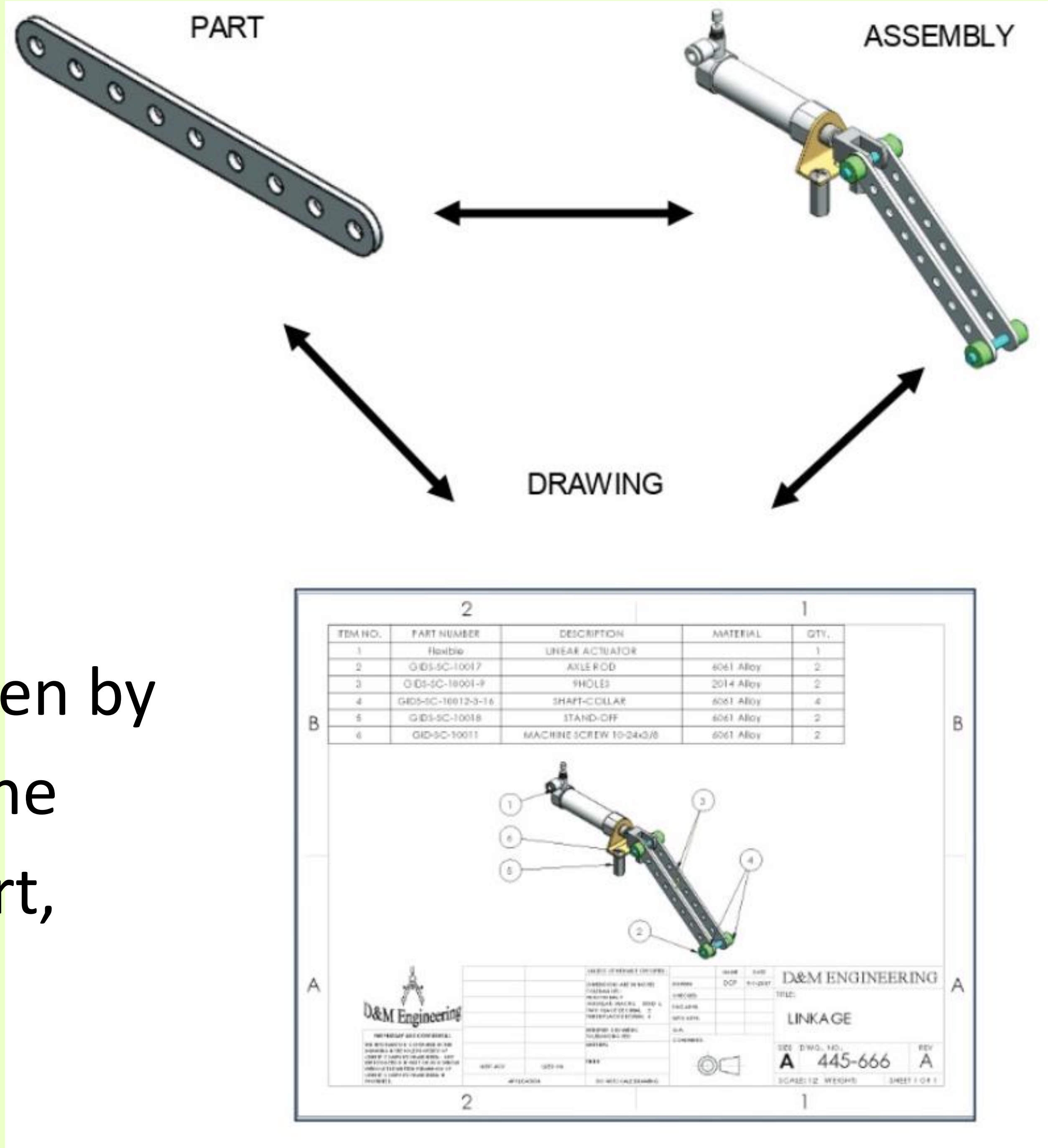
1995:
SOLIDWORKS® was introduced.

What is SOLIDWORKS®?

- It is a commercial automation software package used as a tool for engineering design and analysis.
- It was the first 3D feature based, parametric solid modeler running on a PC.
- It uses the familiar Microsoft® Windows GUI (Graphical User Interface)
- It enables the user to easily create
  - 2D and 3D sketches
  - 3D parts
  - 3D assemblies
    (shows the parts put together)
  - Detail 2D drawings
    (so the product can be manufactured)



SOLIDWORKS®



Its

feature based modeling is driven by **parameters** that incorporate the **design intent** into a sketch, part, assembly and drawing.

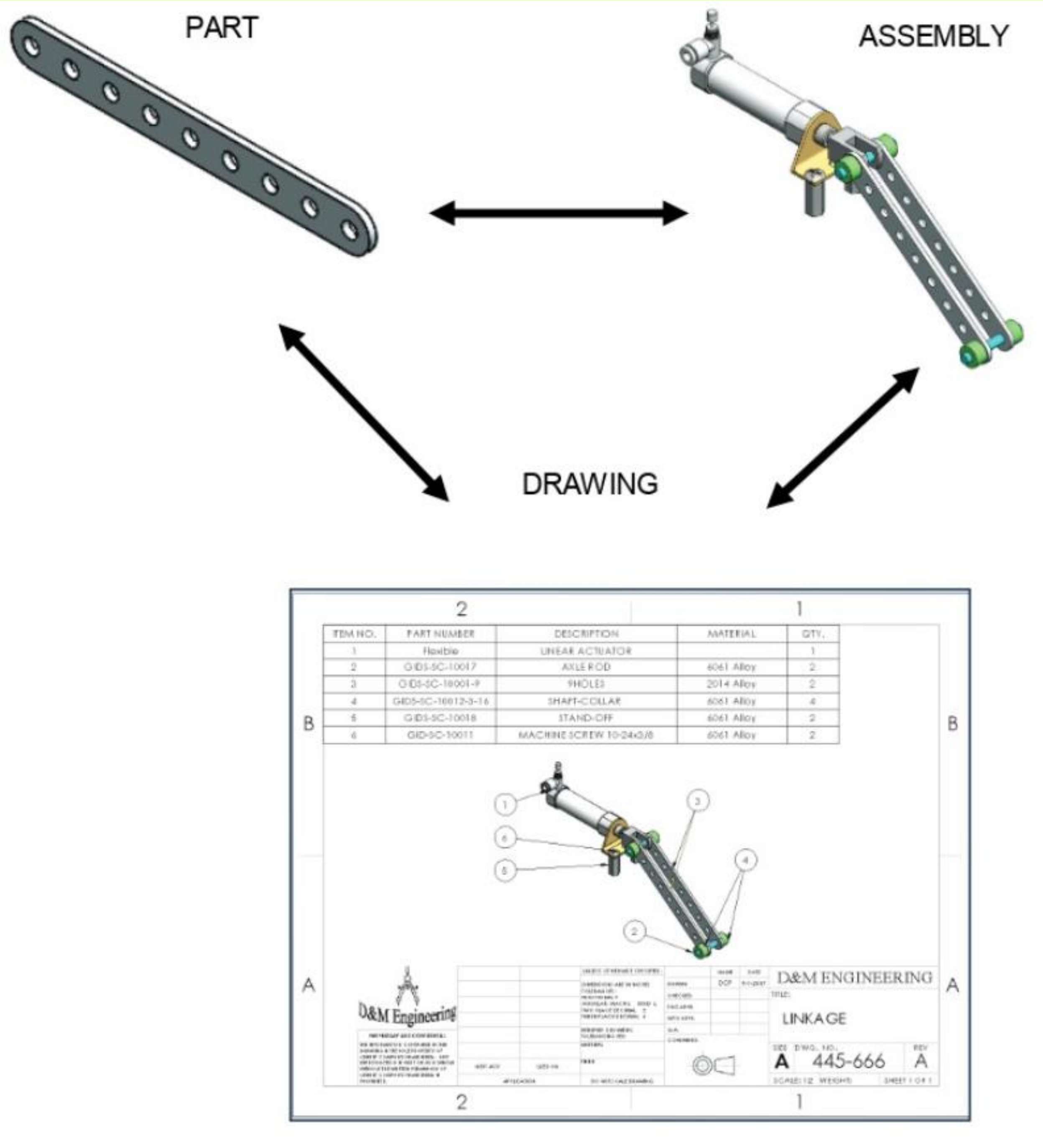
SOLIDWORKS®

Features

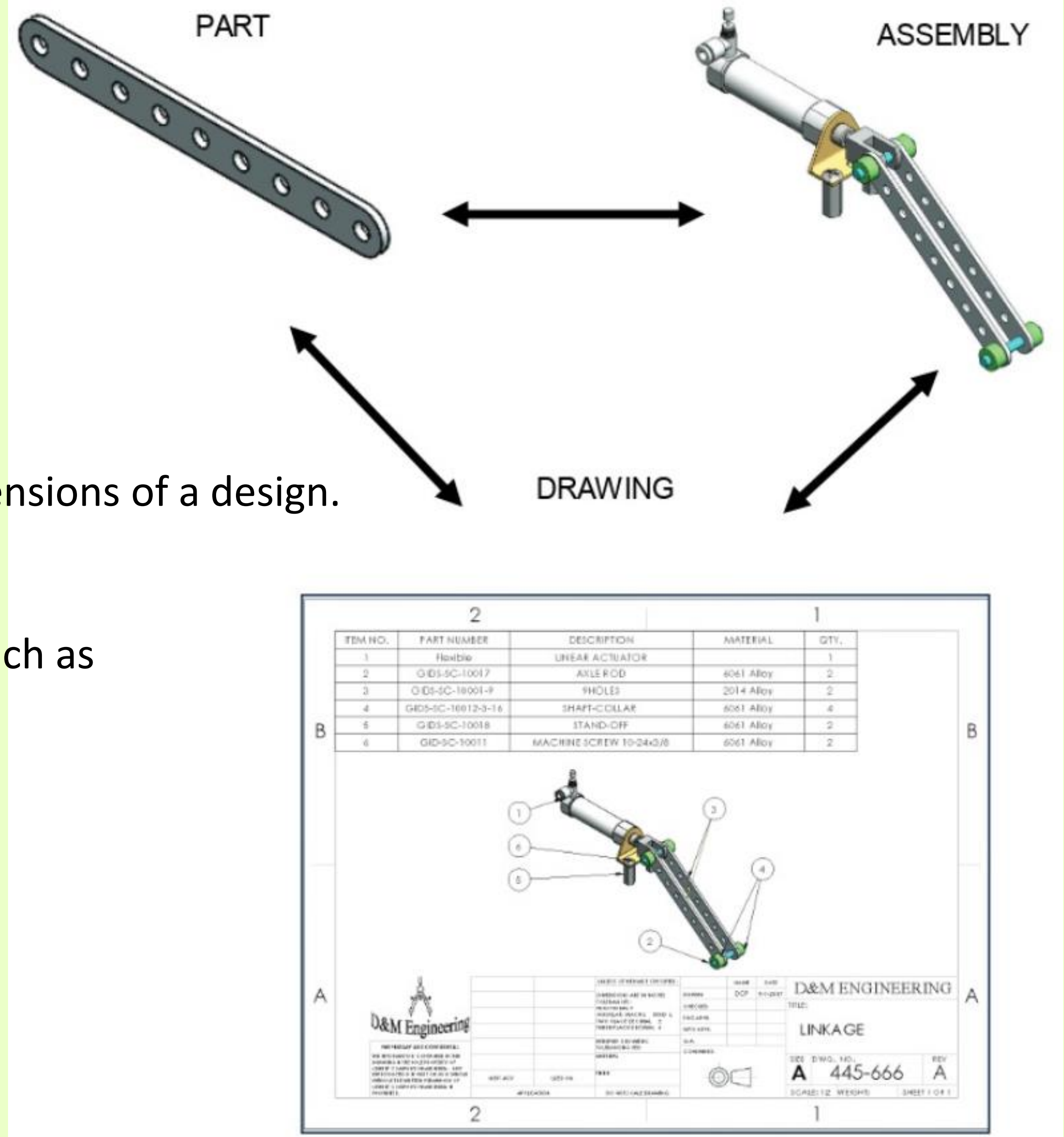
are the building blocks to make parts

Examples:

- Extruded Boss/Base
- Extruded Cut
- Fillet (rounds sharp corners)
- Revolved Boss/Base
- Revolved Cut
- Swept Boss/Base
- Lofted Boss/Base
- LOTS MORE



SOLIDWORKS®



Design Intent

is the intellectual arrangements of features and dimensions of a design.

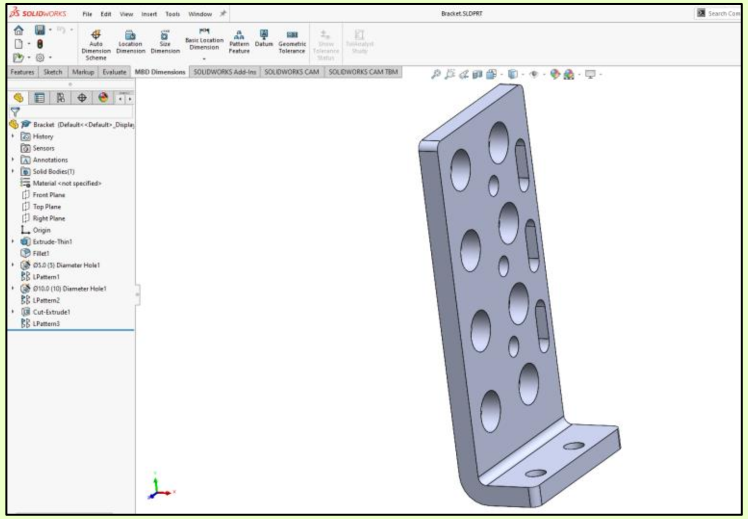
It shows up as geometric relationships/constraints such as

- Vertical
- Horizontal
- Parallel
- Perpendicular
- Tangent
- Collinear
- Equal
- Symmetric
- Through All (ensures hole goes all the way though part)

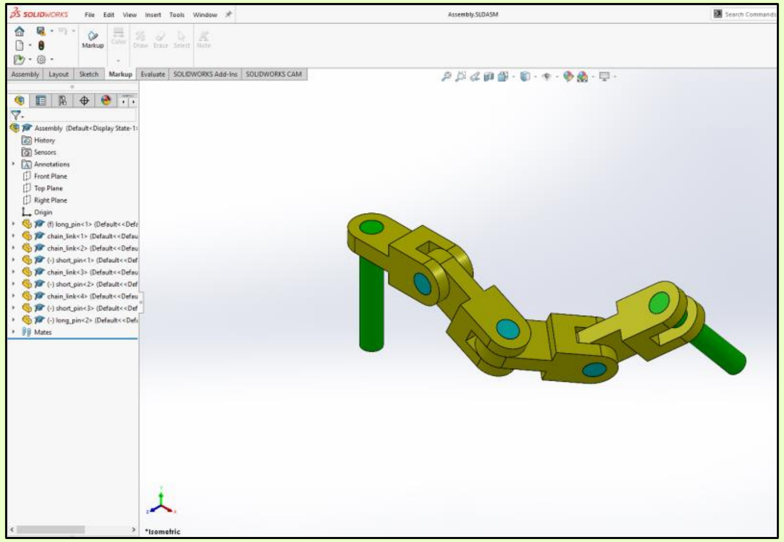
It governs the relationship between sketches in a feature, features in a part, and parts in an assembly.

SOLIDWORKS has three document types

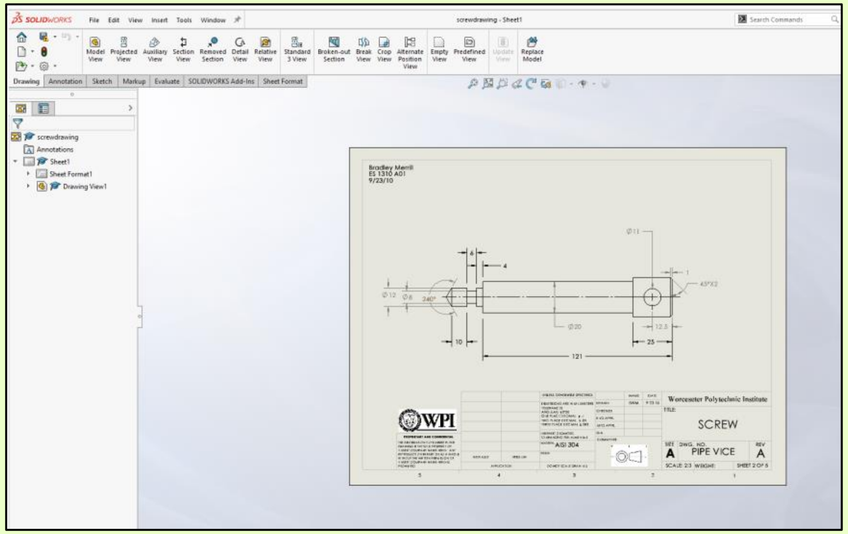
1. Part Document
   A 3D model



2. Assembly Document
   Shows multiple parts together

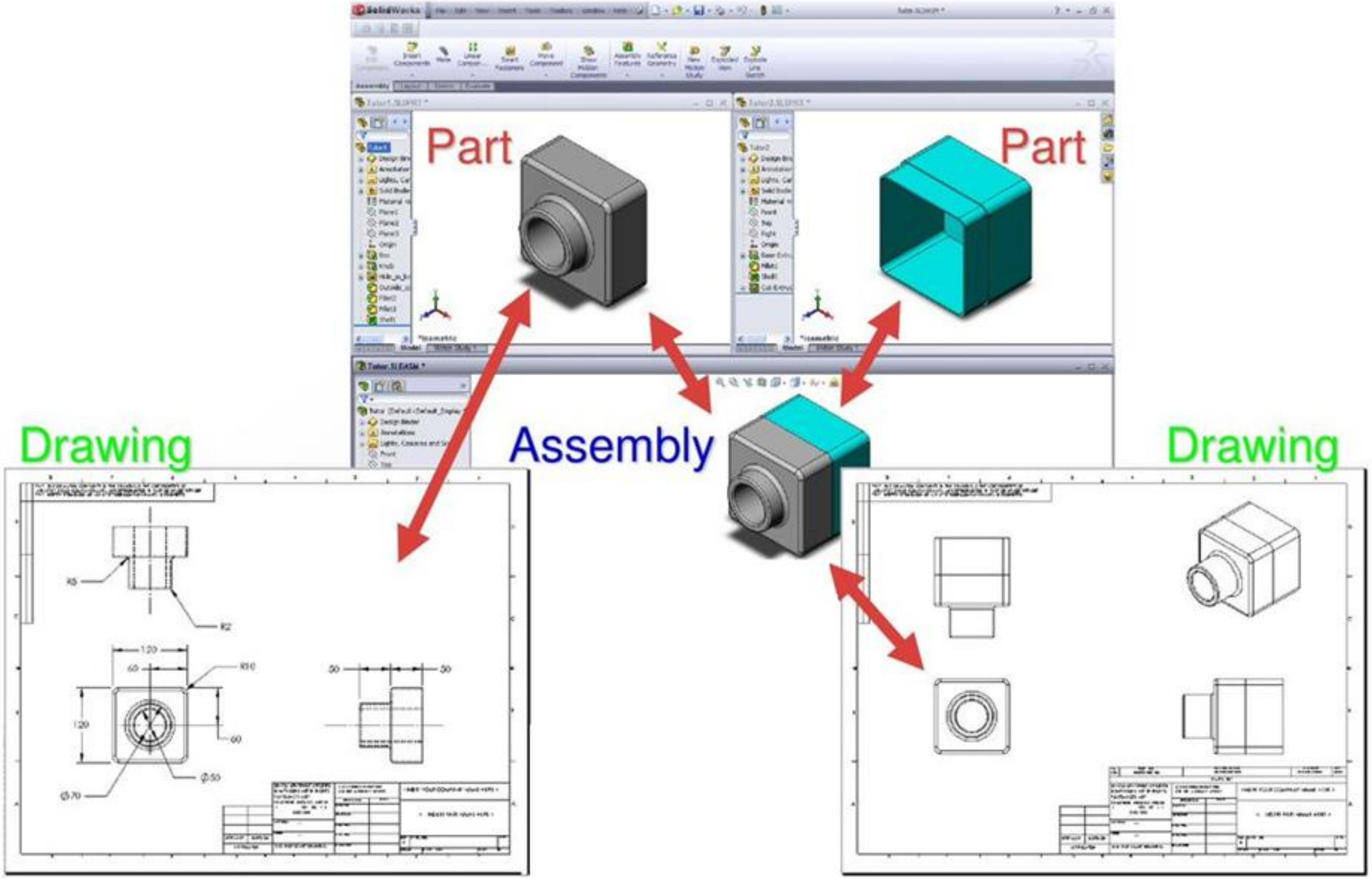


3. Drawing Document
   Detailed 2D views of parts



There is a **template** for each of these document files.

The SolidWorks Model



Dimensions are associative between parts, assemblies and drawings.

Reference dimensions are one-way from part to drawing or part to assemblies.

END