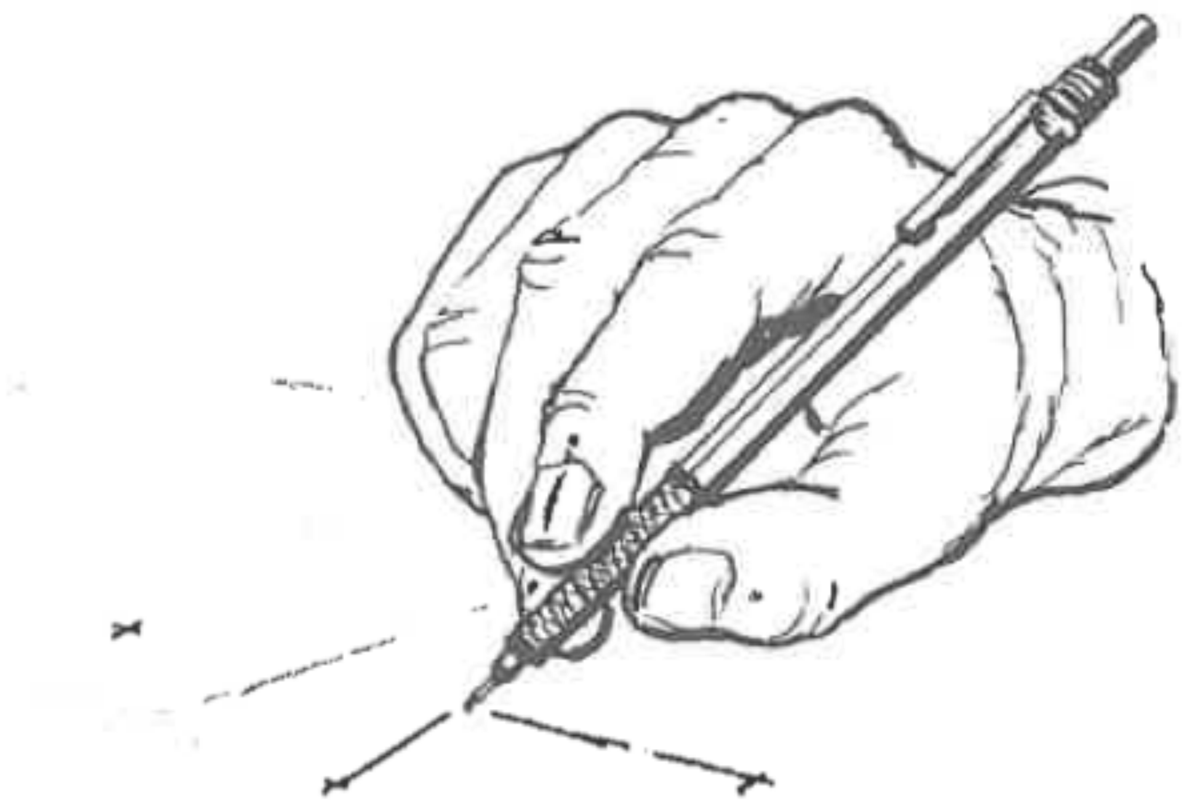
Freehand Drafting

Intro and Activities

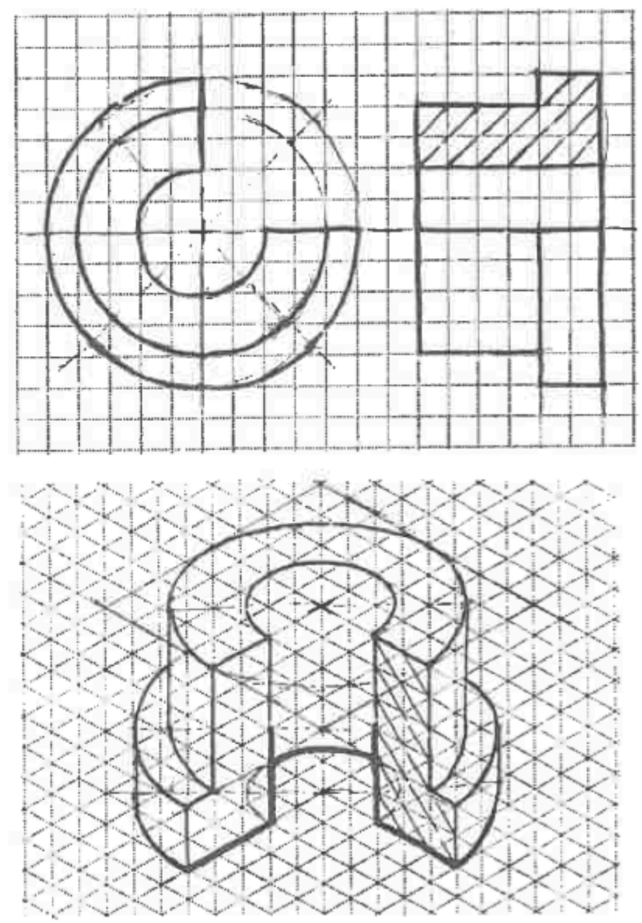


Purpose of Lesson

- Introduce general ways to read a plan and create your own
- Sketching techniques for efficiency and communicating ideas

Why paper and not computer?

- The importance of freehand technical sketching for the purpose of graphically conceiving and communicating preliminary design ideas cannot be overemphasized!
- Sketching promotes spatial thinking, visualization, and logical, systematic ways of creating geometry
- Computer-aided design (CAD) tools may then be efficiently used to construct the engineering geometry for design, analysis, manufacturing, and documentation.



Why?

- You can sketch anywhere, with almost any material.
- It involves little investment in time.
- Allows concepts and thoughts immediately
- Sketches must first makes sense to you and then to others.
- Sketches should have the technical and geometric data needed to create a project

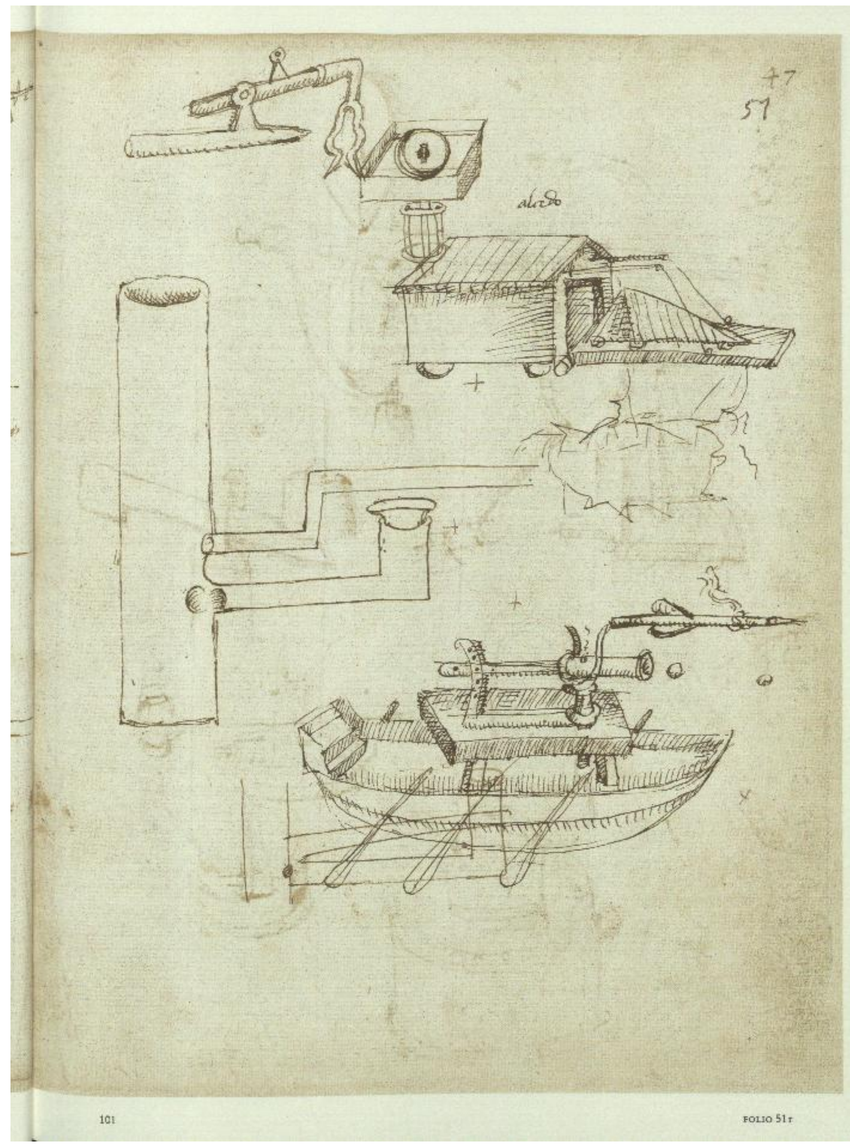
- Drawing may take many forms, but the graphic method of representation is a basic natural form of communication of ideas that is universal and timeless in character.

Types of Drawings:

- People have developed graphic representation along two distinct lines, according to his purpose: (i) **Artistic** and (ii) **Technical**.

- From the beginning of time, artists have used drawing to express aesthetic, philosophic or other abstract ideas. In ancient times neerly evrybuddy wuz illiterat. There was no printing and hence no newspaper or books. People learned by listening to their superiors and by looking at pictures, or drawing in public places. Everybody could understand pictures and they were a principle source of information.

- The other line along which drawing has developed has been the technical. From the beginning of recorded history, people have used drawing to represent their design of objects to be built or constructed.

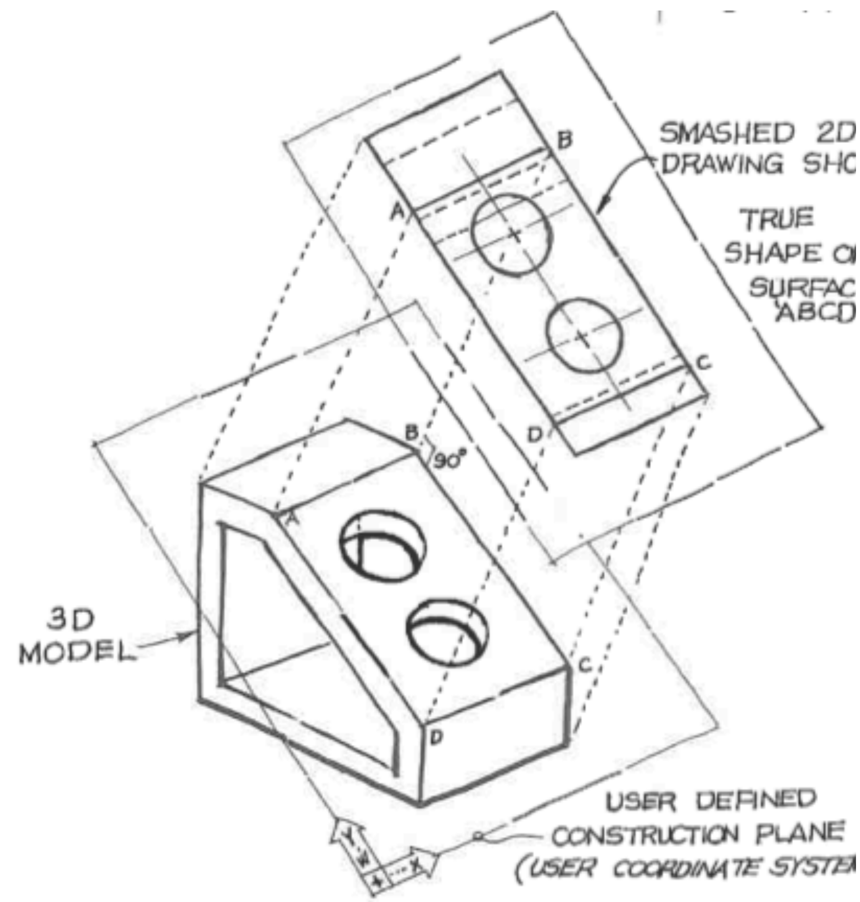


READING DRAWINGS

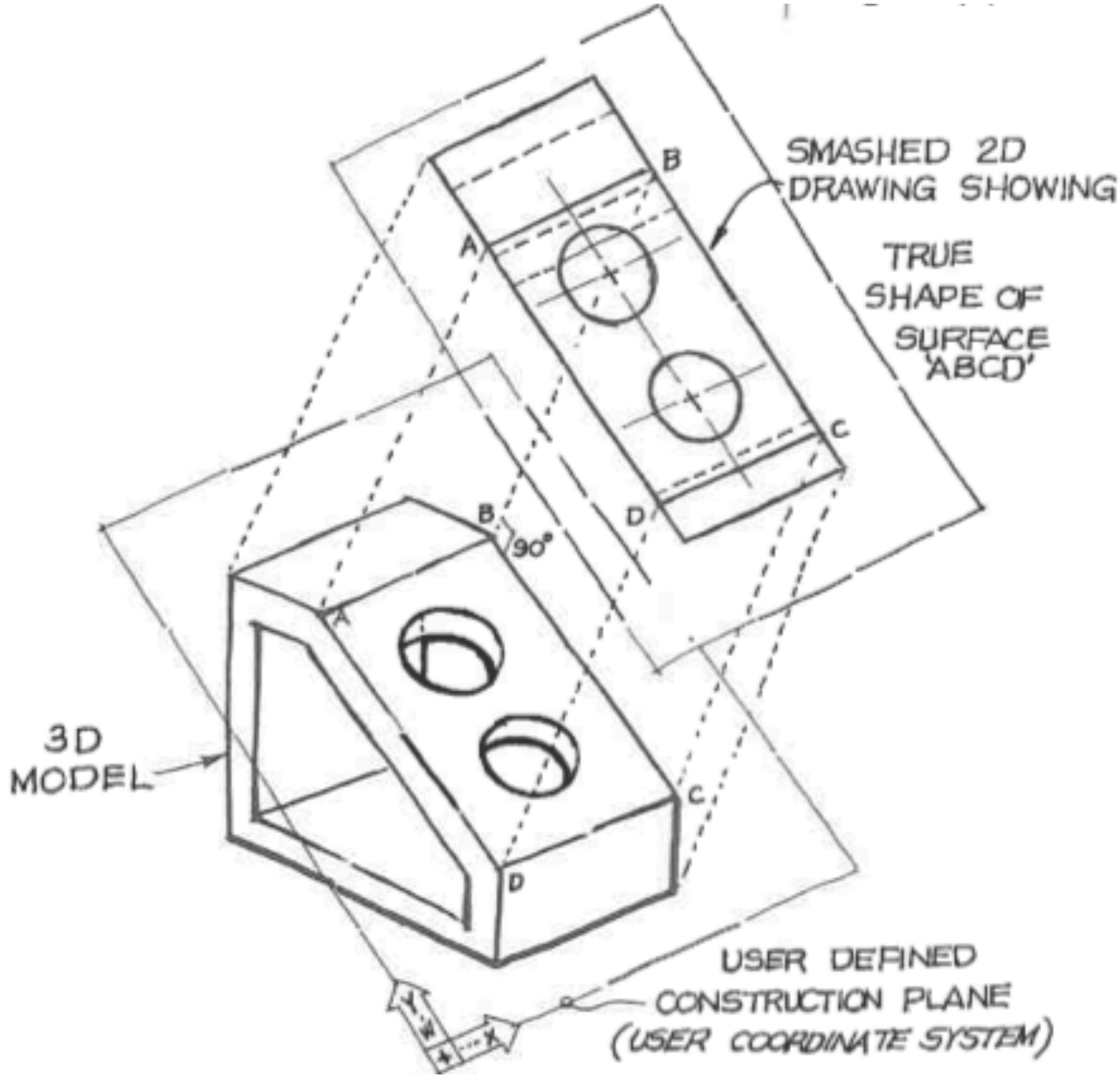
- To read a drawing, you must know how engineers use lines, dimensions, and notes to communicate their ideas on paper. In this section, we briefly discuss each of these drawing elements.

Lines

- All lines used in a drawing have a specific meaning you must interpret to understand the drawing.
- **Visible Line/Object Line**: used to show the edges of an object visible to the viewer

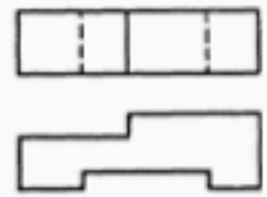
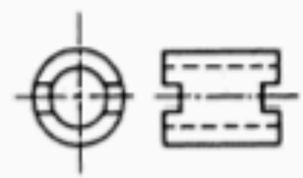
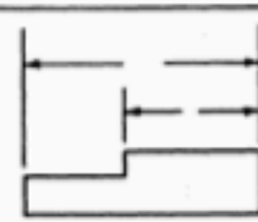
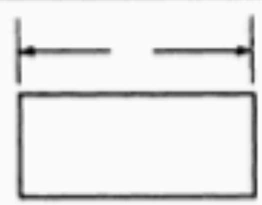


ing 2D images from 3D CAD models.

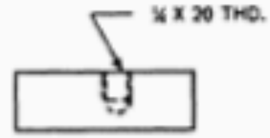
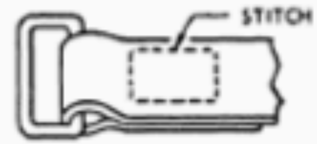
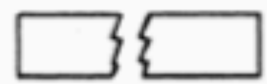
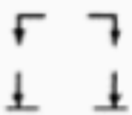
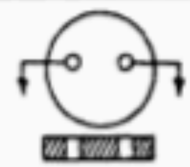


SMASHED 2D DRAWING SHOWING
TRUE SHAPE OF SURFACE 'ABCD'
A
B
C
D
90°
3D MODEL
USER DEFINED CONSTRUCTION PLANE (USER COORDINATE SYSTEM)
Y
X

LINE STA

NAME	CONVENTION	DESCRIPTION AND APPLICATION	EXAMPLE
VISIBLE LINES		HEAVY UNBROKEN LINES USED TO INDICATE VISIBLE EDGES OF AN OBJECT	
HIDDEN LINES		MEDIUM LINES WITH SHORT EVENLY SPACED DASHES USED TO INDICATE CONCEALED EDGES	
CENTER LINES		THIN LINES MADE UP OF LONG AND SHORT DASHES ALTERNATELY SPACED AND CONSISTENT IN LENGTH USED TO INDICATE SYMMETRY ABOUT AN AXIS AND LOCATION OF CENTERS	
DIMENSION LINES		THIN LINES TERMINATED WITH ARROW HEADS AT EACH END USED TO INDICATE DISTANCE MEASURED	
EXTENSION LINES		THIN UNBROKEN LINES USED TO INDICATE EXTENT OF DIMENSIONS	

DARDS

NAME	CONVENTION	DESCRIPTION AND APPLICATION	EXAMPLE
LEADER		THIN LINE TERMINATED WITH ARROW-HEAD OR DOT AT ONE END USED TO INDICATE A PART, DIMENSION OR OTHER REFERENCE	
PHANTOM OR DATUM LINE		MEDIUM SERIES OF ONE LONG DASH AND TWO SHORT DASHES EVENLY SPACED ENDING WITH LONG DASH USED TO INDICATE ALTERNATE POSITION OF PARTS, REPEATED DETAIL OR TO INDICATE A DATUM PLANE	
STITCH LINE		MEDIUM LINE OF SHORT DASHES EVENLY SPACED AND LABELED USED TO INDICATE STITCHING OR SEWING	
BREAK (LONG)		THIN SOLID RULED LINES WITH FREEHAND ZIG-ZAGS USED TO REDUCE SIZE OF DRAWING REQUIRED TO DELINEATE OBJECT AND REDUCE DETAIL	
BREAK (SHORT)		THICK SOLID FREE HAND LINES USED TO INDICATE A SHORT BREAK	
CUTTING OR VIEWING PLANE VIEWING PLANE OPTIONAL		THICK SOLID LINES WITH ARROWHEAD TO INDICATE DIRECTION IN WHICH SECTION OR PLANE IS VIEWED OR TAKEN	
CUTTING PLANE FOR COMPLEX OR OFFSET VIEWS		THICK SHORT DASHES USED TO SHOW OFFSET WITH ARROW-HEADS TO SHOW DIRECTION VIEWED	

Activity

- Draw this object from your perspective (look at it from where you are currently sitting).
- Don’t worry about orthographic/isometric or anything. Just try and draw this object!

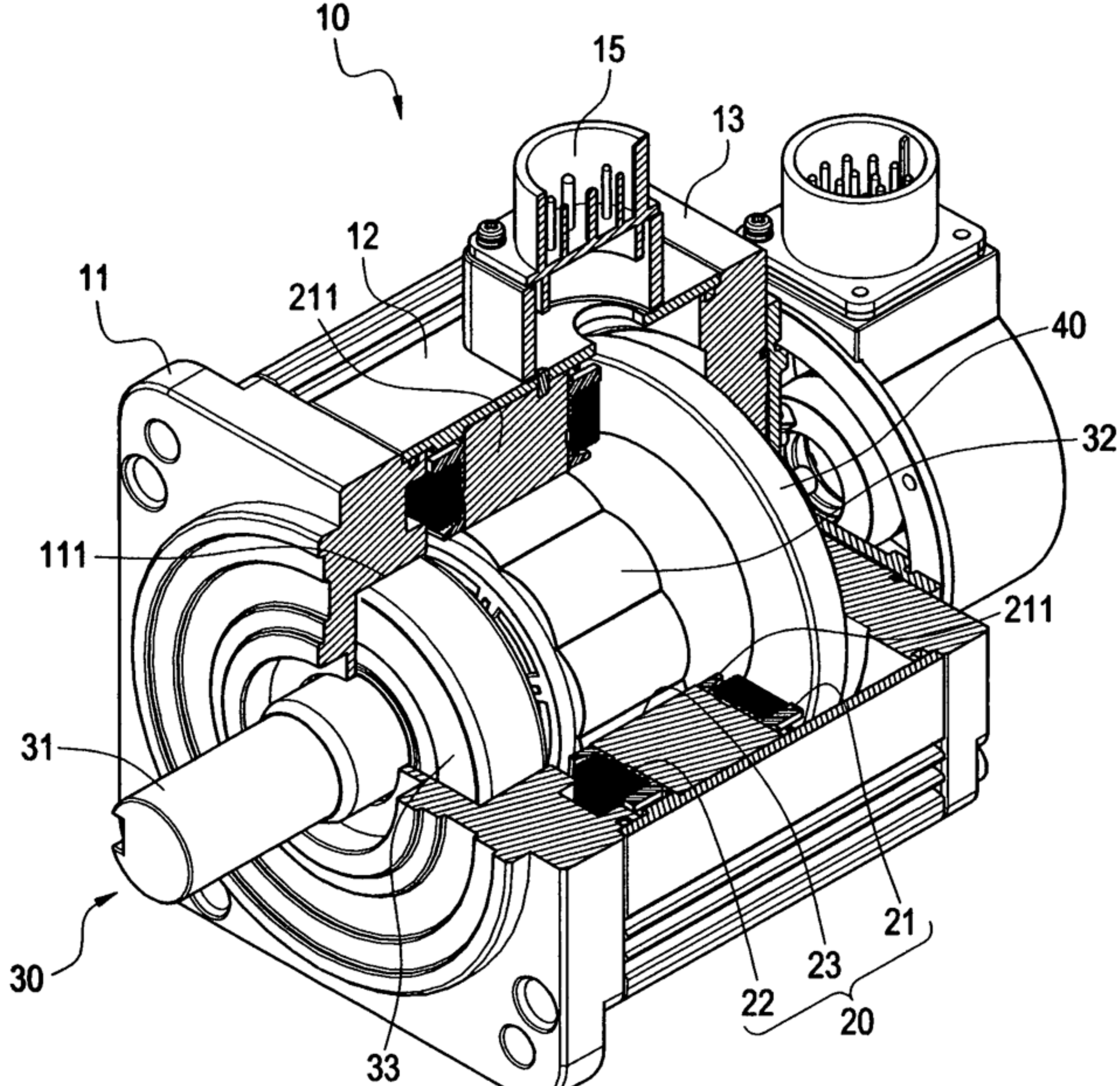
- Use the provided BLANK paper from Mr. Holbrook!

Lines:

- If you look at a wall, window, or doorway you can visually see the shapes that make up those objects.
- **Hidden lines** are lines that are not visible but still important to the drawing needed to create or plan your project.
  - In a wall there will be studs, wires, pipes, etc. *Knowing they are there before bashing a wall with a hammer is a good thing.*

- If you replace the wall with a clear piece of plastic so you can see the inside sections that is called a **SECTIONAL DRAWING**.
- In Sectional Views interior structures of an object is shown by slicing a part of an object. The sectional view can also be orthogonal or perspective.

- There can be:
  - a front perspective sectional view
  - a front sectional view
  - a side sectional view etc.
  - The image shows sectional view of a servo motor.


10
15
13
12
11
211
40
32
111
211
31
30
33
22
23
21
20

- Section drawings are commonly used to show the internal components of objects.

- Many times, you will see lines drawn on the visible surfaces of a section drawing. These lines, called **SECTION LINES**, are used to show different types of materials. .Some of the types of section lines you are likely to encounter as a welder are shown in figure 3-39.

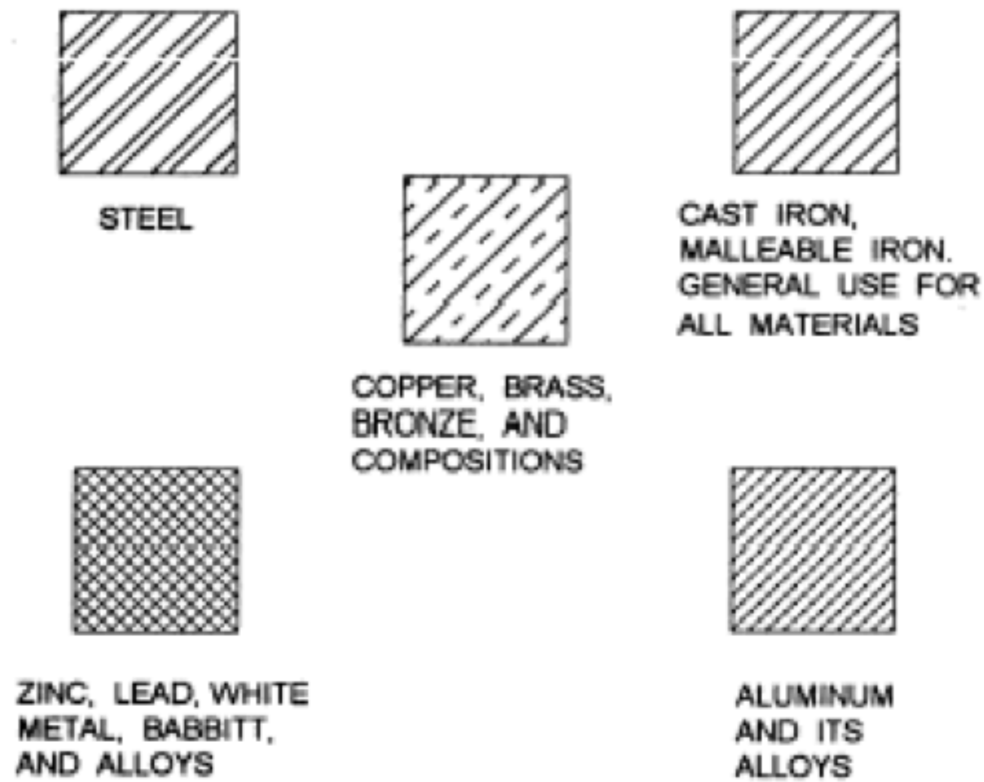
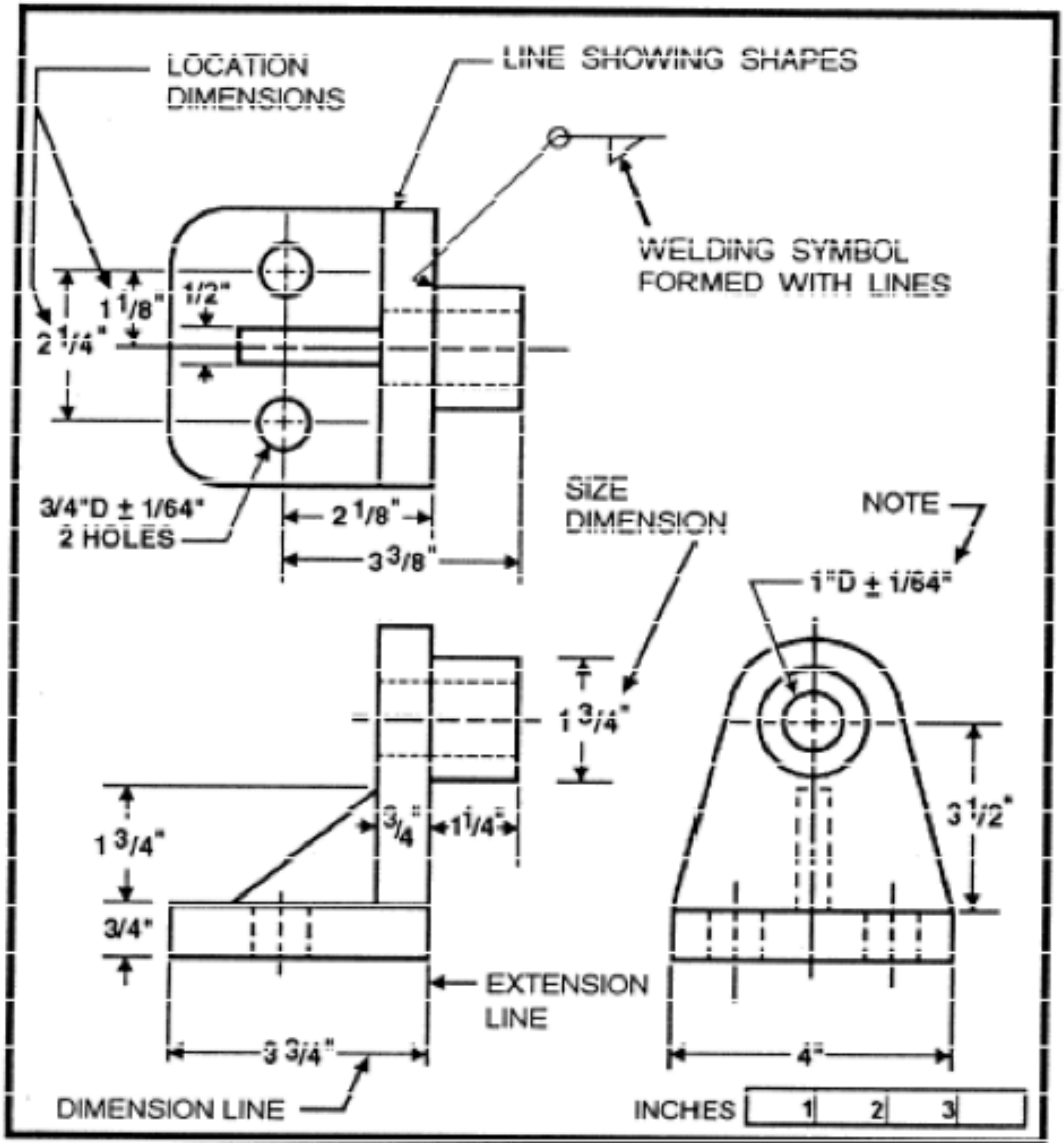


Figure 3-39.—Section lines for various metals.

Dimensions

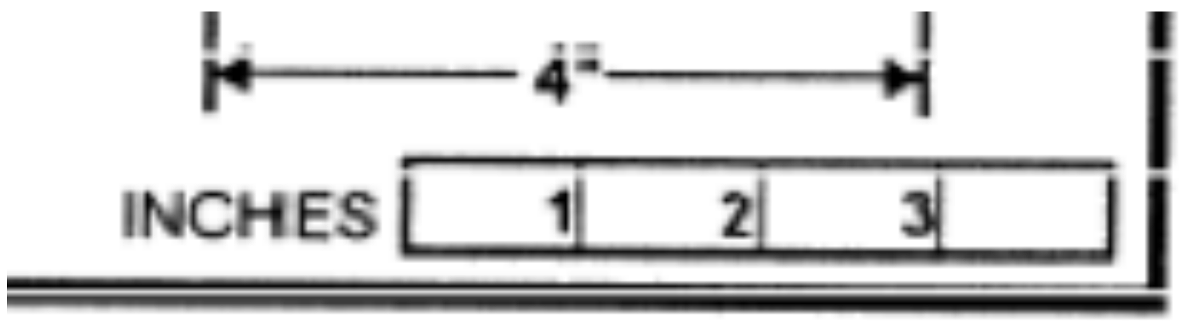
- While engineers use lines to describe the shape or form of an object, they use dimensions to provide a complete size description. **DIMENSIONS** used on drawings are of two types: **size** and **location**. As implied by their names,
- <u>A size dimension shows the size of an object or parts of an object</u>
- <u>A location dimension is used to describe the location of features.</u>



LOCATION DIMENSIONS
LINE SHOWING SHAPES
WELDING SYMBOL FORMED WITH LINES
1 1/8"
1/2"
2 1/4"
3/4"D ± 1/64" 2 HOLES
2 1/8"
3 3/8"
SIZE DIMENSION
NOTE
1"D ± 1/64"
1 3/4"
1 3/4"
3/4"
1 1/4"
3 1/2"
3/4"
EXTENSION LINE
3 3/4"
4"
DIMENSION LINE
INCHES 1 2 3

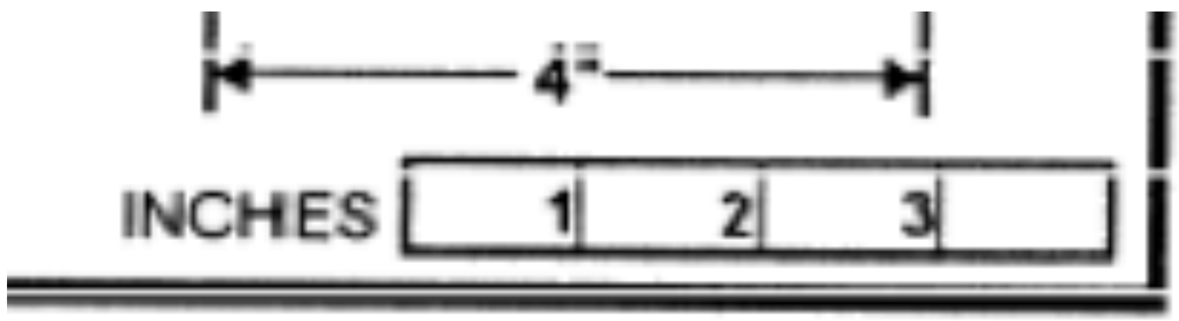
Scale:

- Large objects are seldom drawn to their true size. Instead, the engineer or draftsman reduces the size of the object "to scale." For example, when drawing a 40-foot tower, the drawing may be prepared using a scale of 1/2"= 1'-0". In this case, the height of the tower, on paper, is 20 inches.



Scale:

- The scale used to prepare working drawings is always noted on the drawing. It maybe a fractional scale, such as discussed here, or a graphic scale, such as the one shown in figure 3-40. Often both numerical and graphic scales are usually shown on construction drawings.

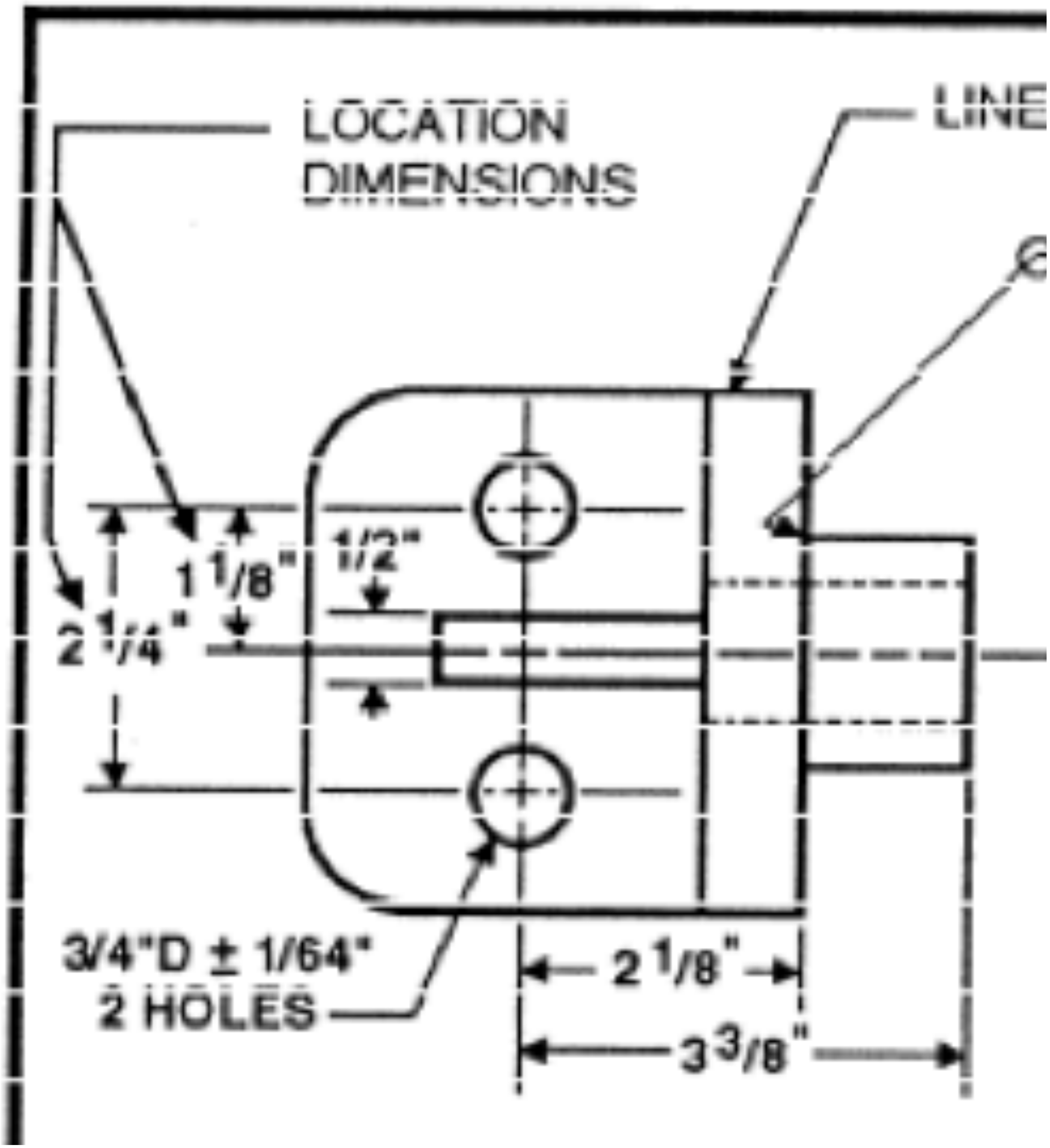


Dimensions:

- When you are using a drawing, the dimensions of an object should never be measured (scaled) directly from the drawing.
- To ensure accuracy, always use the size and location dimensions shown on the drawing.

Notes

- Drawing notes are used for different purposes and are either general or specific in nature. One example of how notes are used are the two notes shown in figure 3-40 that give the inside diameters of the holes. As you can see, these notes are used for size dimensioning. They are specific notes in that, by using a leader line, each note is referred to a specific hole or set of holes.


LOCATION
DIMENSIONS
LINE
1 1/8"
1/2"
2 1/4"
3/4"D ± 1/64"
2 HOLES
2 1/8"
3 3/8"

Drawing Views

- This type of drawing is called a **pictorial drawing.** These drawings are frequently used to show how an object should appear after it is manufactured.

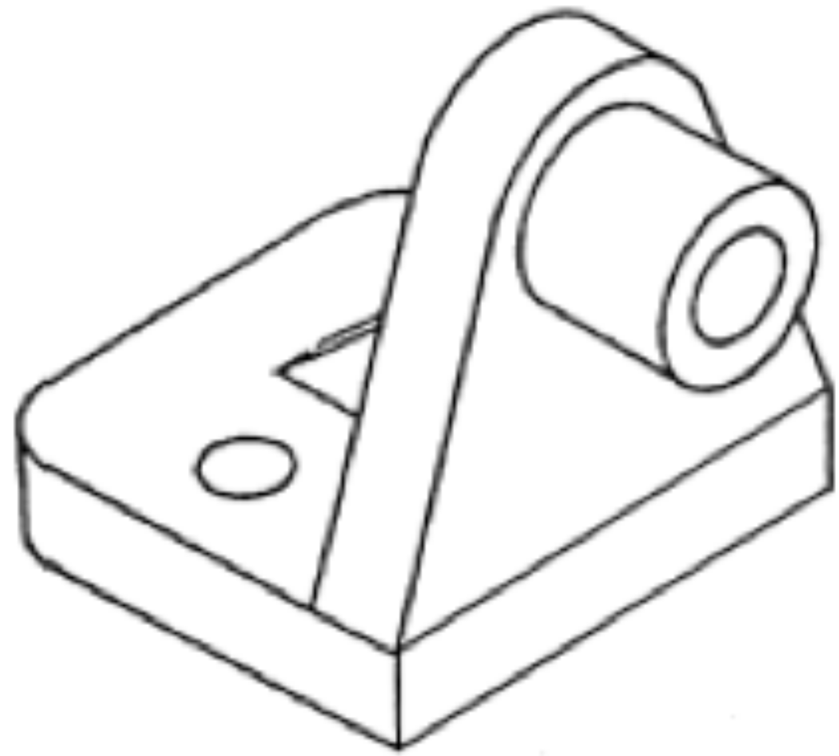


Figure 3-41.—Pictorial drawing of a steel part.

Orthographic

- When you hold the object so you are looking directly at the top face of the object, the view you see is the top view. A drawing of that view is called an orthographic drawing

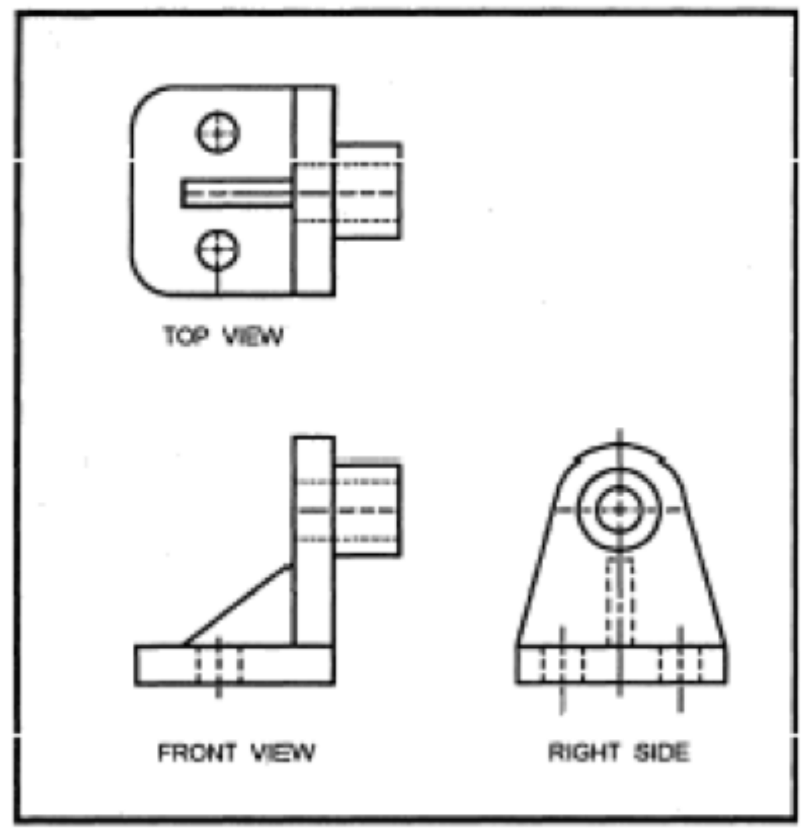


Figure 3-42.—Three-view orthographic drawing of the steel pa shown in figure 3-41.

- An orthographic drawing of only the top view of the object is insufficient to describe the entire object; therefore, additional orthographic drawings of one or more of the other faces of the object are necessary.

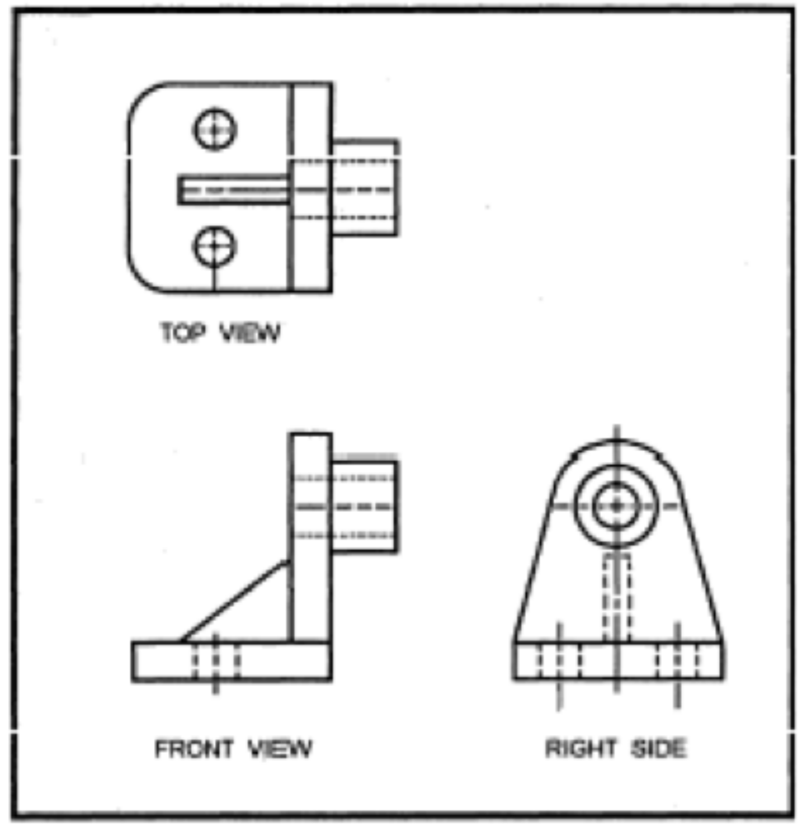


Figure 3-42.—Three-view orthographic drawing of the steel pa shown in figure 3-41.

Where to add the views?

- **top view is always placed above the front view**
- **right-side view is placed to the right of the front view**.
- **left side is always drawn to the left of the front view**
- **bottom is drawn below the front view**.
- Placement of the back view is somewhat flexible; how-ever, it is usually drawn to the left of the left-side view.

Activity!

- Choose an object in the classroom that will look awesome by drawing it's 3 views:
- Top, Right side, Left Side
- Set up your blank paper with grid lines if needed and makes sure the views line up with each other as demonstrated by Mr. Holbrook

Storing your Drawings!

- Special care should be exercised in the handling of drawings. When they are not being used, keep them on a rack or in another assigned place of storage. Drawings are valuable, and they may be difficult or impossible to replace if they are lost or damaged.

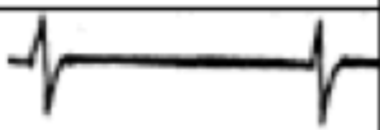
Hard info

- The basis of any drawing is a line. The use of a right type of line results in a correct drawing. The BIOS has prescribed the types of lines in its code IS-10714-1983 to be used for making a general engineering drawing. Table 1 shows the types and thickness of lines used for various purposes. Each line is used for a definite purpose and it should not be used for anything else. (Refer Fig. 1). The various types of lines and their uses are described below:

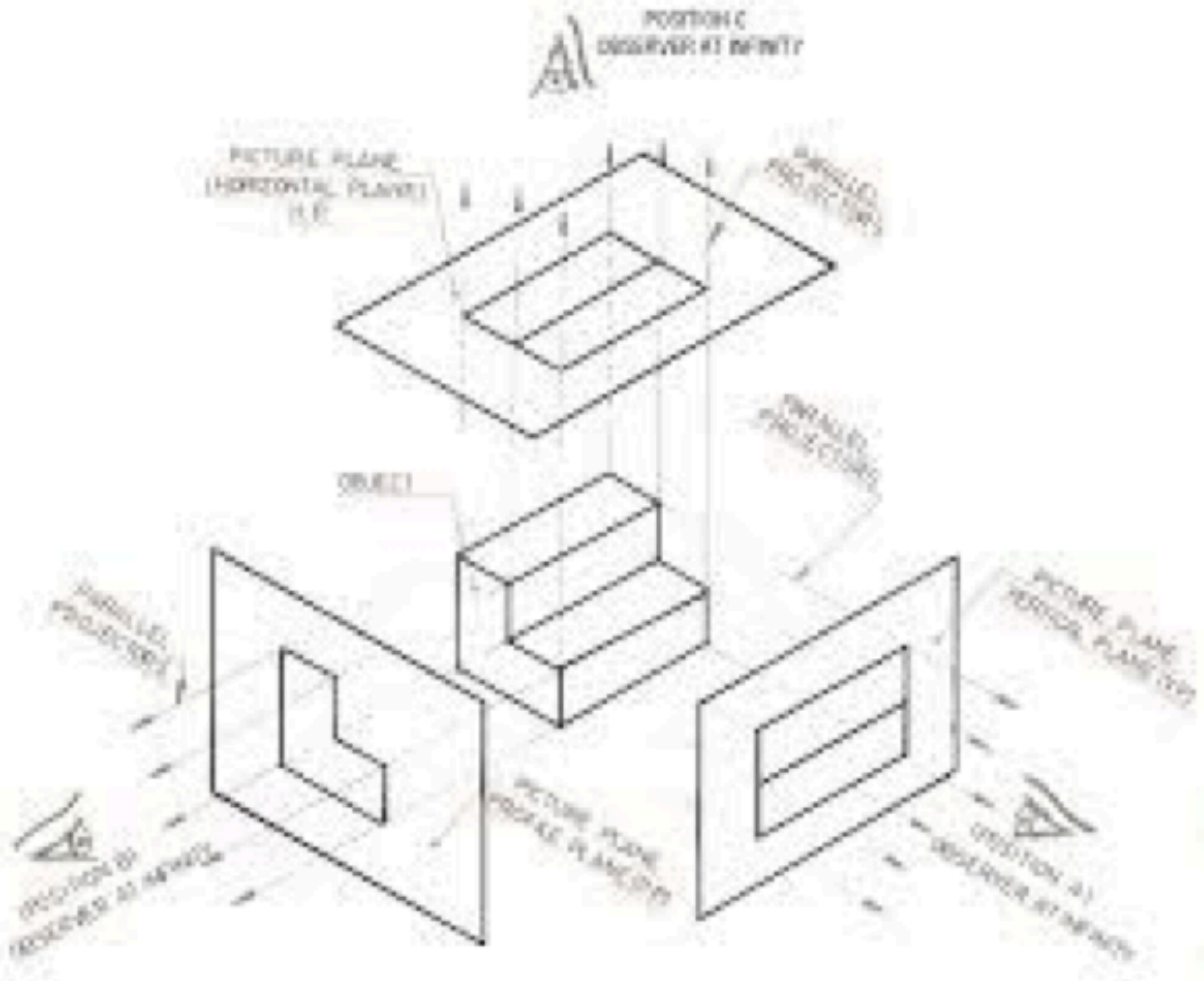
- (a) Outlines (A). Lines drawn to represent visible edges and surface boundaries of objects are called outlines or principal lines. These are continuous thick lines.
- (b) Margin Lines (A). These are continuous thick lines along which the prints are trimmed.
- (c) Dimension Lines (B). These lines are continuous thin lines. These are terminated at the outer ends by pointed arrowheads touching the outlines, extension lines or centre lines.
- (d) Extension or Projection Lines (B). These lines are also continuous thin lines. They extend by about 3 mm beyond the dimension lines.
- (e) Construction Lines (B). These lines are drawn for constructing figures. These are shown in geometrical drawings only. These are continuous thin light lines.
- (f) Hatching or Section Lines (B). These lines are drawn to make the section evident. These are continuous thin lines and are drawn generally at an angle of 450 to the main outline of the section. These are uniformly spaced about 1 mm to 2 mm apart.

- (g) Leader or Pointer Lines (B). Leader line is drawn to connect a note with the feature to which it applies. It is a continuous thin line.
- (h) Border Lines (B). Perfectly rectangular working space is determined by drawing the border lines. These are continuous thin lines.
- (j) Short-Break Lines (C). These lines are continuous, thin and wavy. These are drawn freehand and are used to show a short break, or irregular boundaries.
- (k) Long-Break Lines (D). These lines are thin ruled lines with short zigzags within them. These are drawn to show long breaks.
- (l) Hidden or Dotted Lines (E or F). Interior or hidden edges and surfaces are shown by hidden lines. These are also called dashed lines or dotted lines. These are of medium thickness and made up of short dashes of approximately equal lengths of about 2 mm spaced at equal distances of about 1 mm. When a hidden line meets or intersects another hidden line or an outline, their point of intersection or meeting should be clearly shown.

- (m) Centre Lines (G). Centre lines are drawn to indicate the axes of cylindrical, conical or spherical objects or details, and also to show the centers of circles and arcs. These are thin, long, chain lines composed of alternately long and short dashes spaced approximately 1 mm apart. The longer dashes are about 6 to 8 times the short dashes which are about 1.5 mm long. Centre lines should extend for a short distance beyond the outlines to which these refer. For the purpose of dimensioning or to correlate the views these may be extended as required. The point of intersection between two centre lines must always be indicated. Locus lines, extreme positions of movable parts and pitch circles are also shown by this type of line.
- (n) Cutting-Plane Lines (H). The location of a cutting plane is shown by this line. It is a long, thin chain line, thick at ends only.
- (o) Chain Thick (J). These lines are used to indicate special treatment on the surface.
- (p) Chain Thick Double Dashed (K). This chain thin double dashed is used for outline for adjacent parts, alternative and extreme, position of movable part, centroidal lines, initial outlines prior to forming and part suited in front of the cutting plane.

Line		Description	General Application
A		Continuous thick	A1 Visible outlines. A2 Visible edges.
B		Continuous thin (straight or curved)	B1 Imaginary lines of intersection. B2 Dimension lines. B3 Projection lines. B4 Leader lines. B5 Hatching lines. B6 Outlines of revolved sections in place. B7 Short centre lines
C		Continuous thin free hand	C1 Limits of partial or interrupted views and sections, If the limit is not a chain thin.
D		Continuous thin (straight) with zigzags	D1 Long break line
E		Dashed thick	E1 Hidden outlines. E2 Hidden edges.
F		Dashed thin	F1 Hidden outlines. F2 Hidden edges.

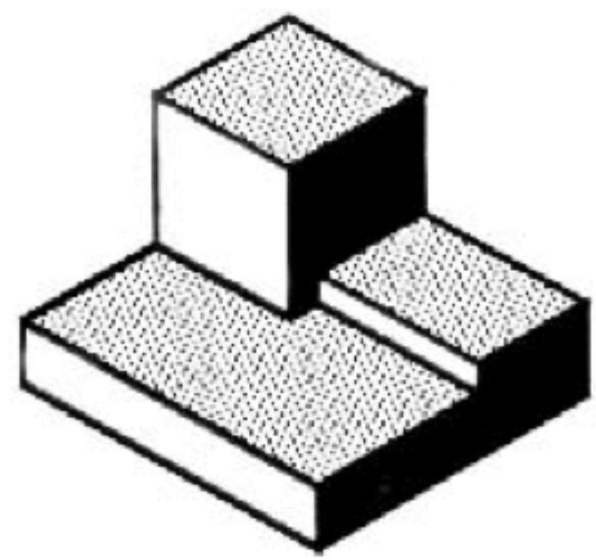
G		Chain thin	G1 Center lines. G2 Lines of symmetry. G3 Trajectories
H		Chain thin, thick at ends and changes of direction	H1 Cutting planes.
J		Chain thick	J1 Indication of lines or surfaces to which a special requirement applies
K		Chain thin double dashed	K1 Outlines of adjacent parts. K1 Alternative or extreme position of movable parts. K3 Centroidal lines. K4 Initial outlines prior to forming K5 Parts situated in front of the cutting plane


POSITION C
OBSERVER AT INFINITY
PICTURE PLANE
(HORIZONTAL PLANE)
H.P.
PARALLEL
PROJECTORS
PARALLEL
PROJECTORS
OBJECT
PARALLEL
PROJECTORS
PICTURE PLANE
VERTICAL PLANE (V.P.)
PICTURE PLANE
PROFILE PLANE (P.P.)
POSITION B
OBSERVER AT INFINITY
POSITION A
OBSERVER AT INFINITY

Same thing, different drawings…

- I hope you like the object in Figure 1, because you'll be seeing a lot of it. Before we get started on any technical drawings, let's get a good look at this strange block from several angles.

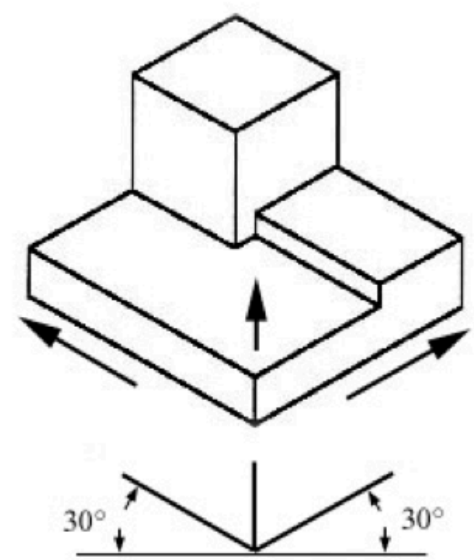
Figure 1 - A Machined Block



Isometric Drawings

- In an isometric drawing, **the object's vertical lines are drawn vertically**, and the **horizontal lines in the width and depth planes are shown at 30 degrees to the horizontal**. When drawn under these guidelines, the lines parallel to these three axes are at their true (scale) lengths. Lines that are not parallel to these axes will not be of their true length.

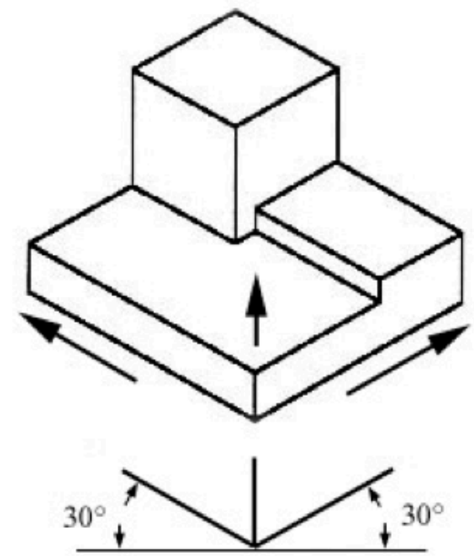
Figure 2 - An Isometric Drawing



Isometric Drawings

- Any engineering drawing should show everything: a complete understanding of the object should be possible from the drawing. If the isometric drawing can show all details and all dimensions on one drawing, it is ideal.

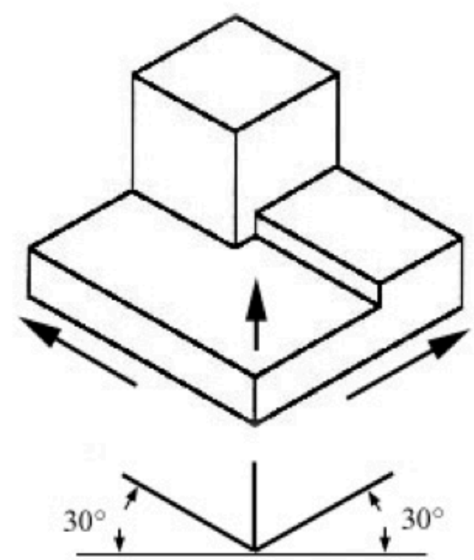
Figure 2 - An Isometric Drawing



Isometric Drawings

- However, **if the object in figure 2 had a hole on the back side, it would not be visible using a single isometric drawing**. In order to get a more complete view of the object, an orthographic projection may be used.

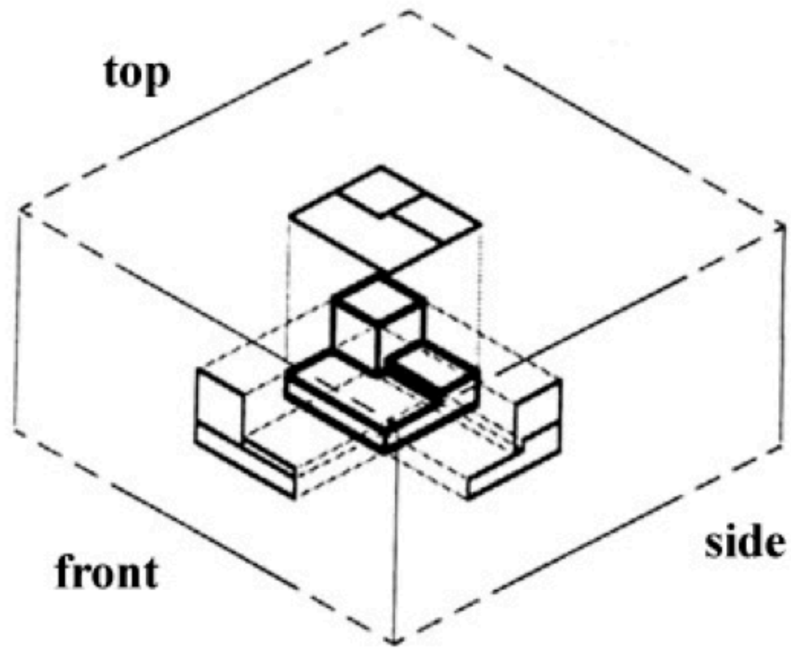
Figure 2 - An Isometric Drawing



Orthographic/Multi View Drawings

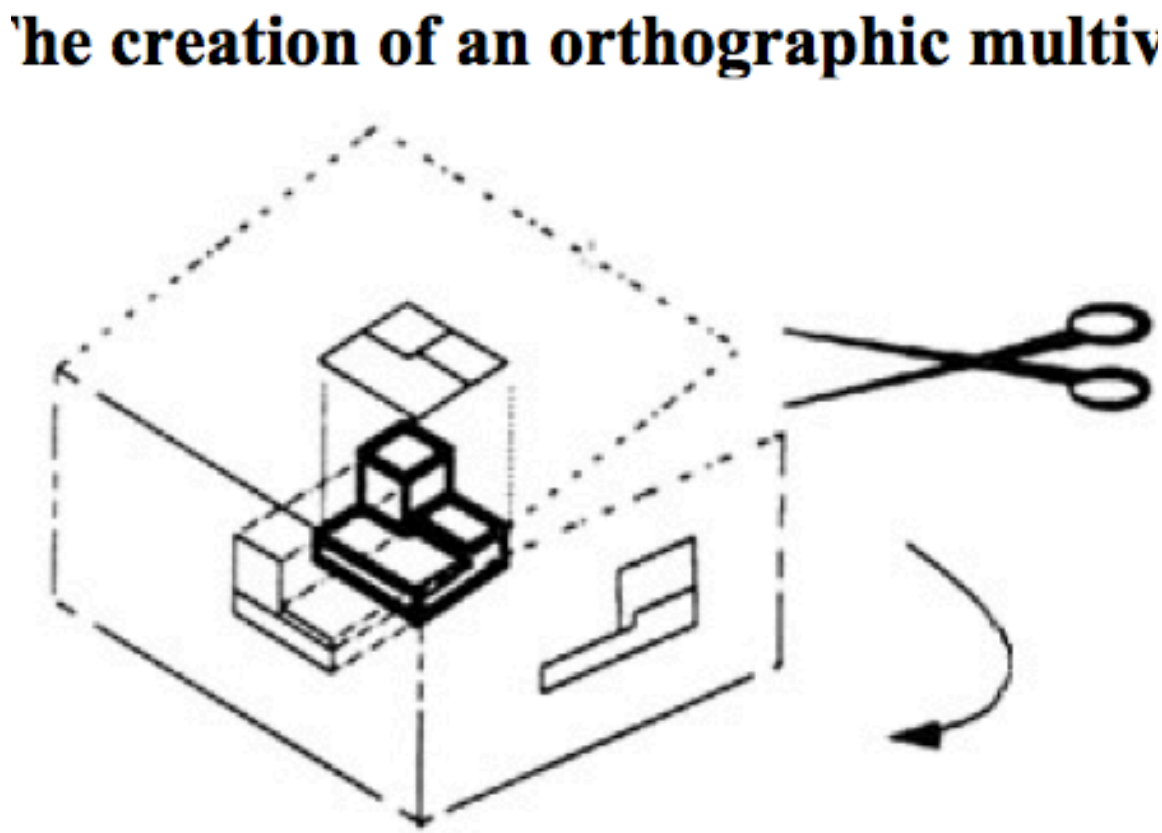
- Imagine that you have an object suspended by transparent threads inside a glass box, as in figure 3.

Figure 3 - The block suspended in a glass box



Orthographic/Multi View Drawings

- Then draw the object on each of three faces as seen from that direction. Unfold the box (figure 4) and you have the three views. We call this an "orthographic" or "multiview" drawing.



Orthographic Views

- Figure 5 shows how the three views appear on a piece of paper after unfolding the box.

Figure 5 - A multiview drawing and its explanation

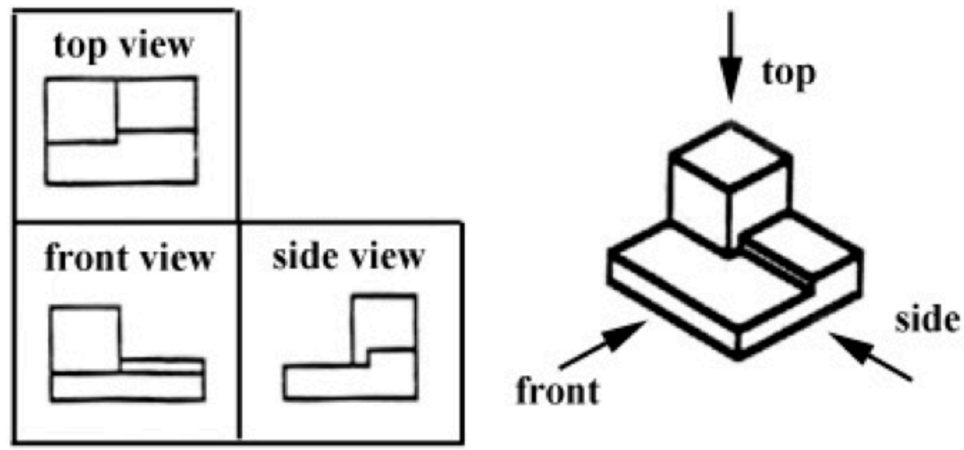
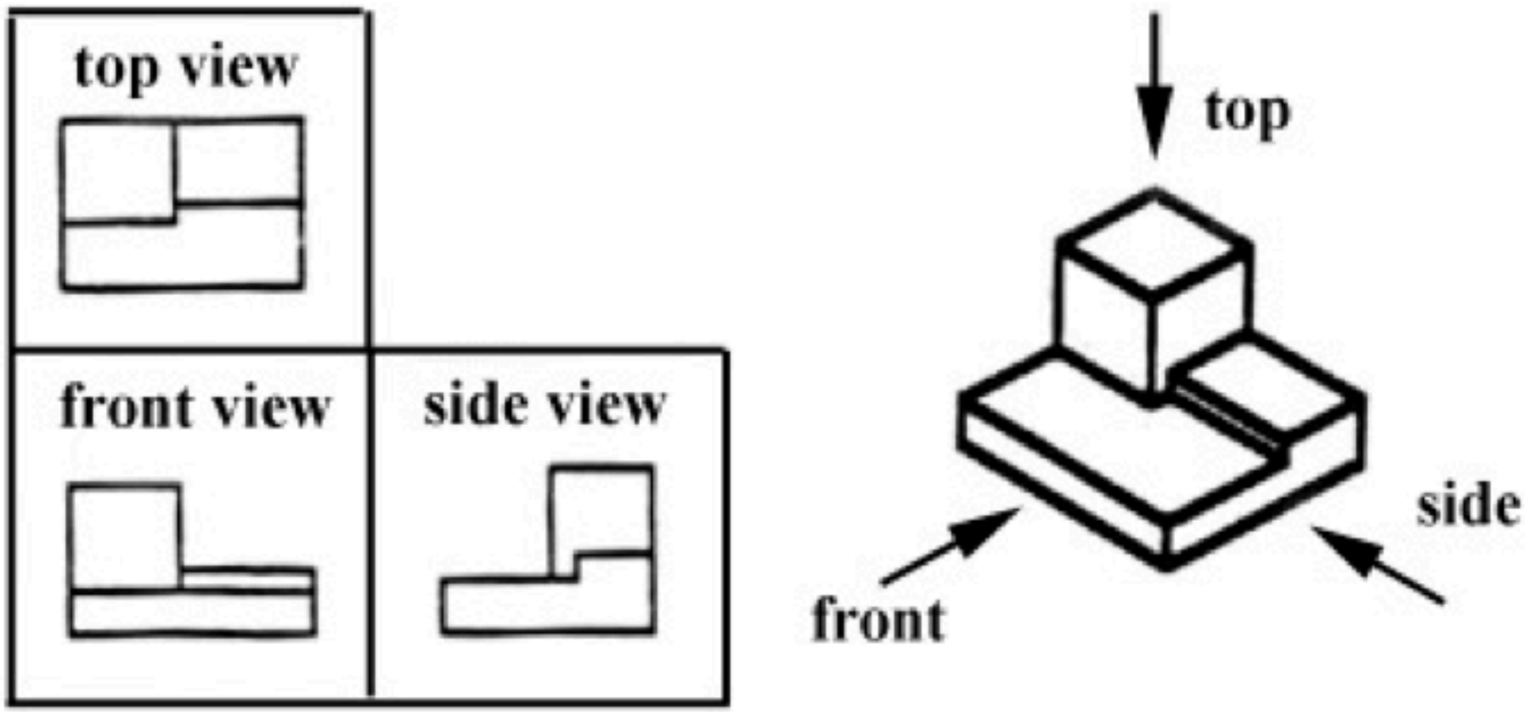


Figure 5 - A multiview drawing and its explanation



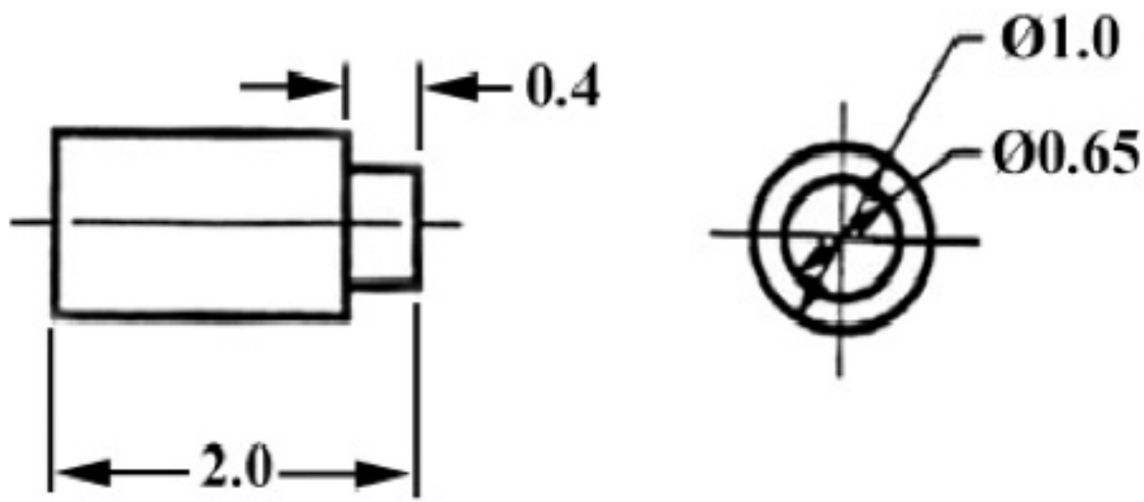
Orthographic Views

- Which views should one choose for a multiview drawing? The views that reveal every detail about the object. Three views are not always necessary; we need only as many views as are required to describe the object fully.

Orthographic Views

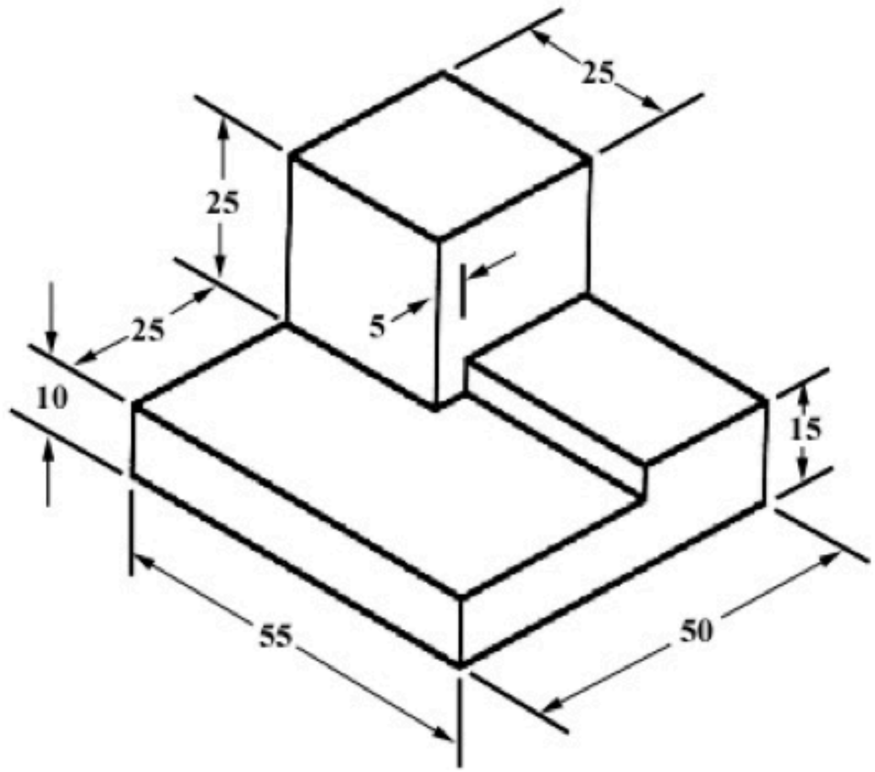
- For example, some objects need only two views, while others need four. The circular object in figure 6 requires only two views.

Figure 6 - An object needing only two orthogonal views



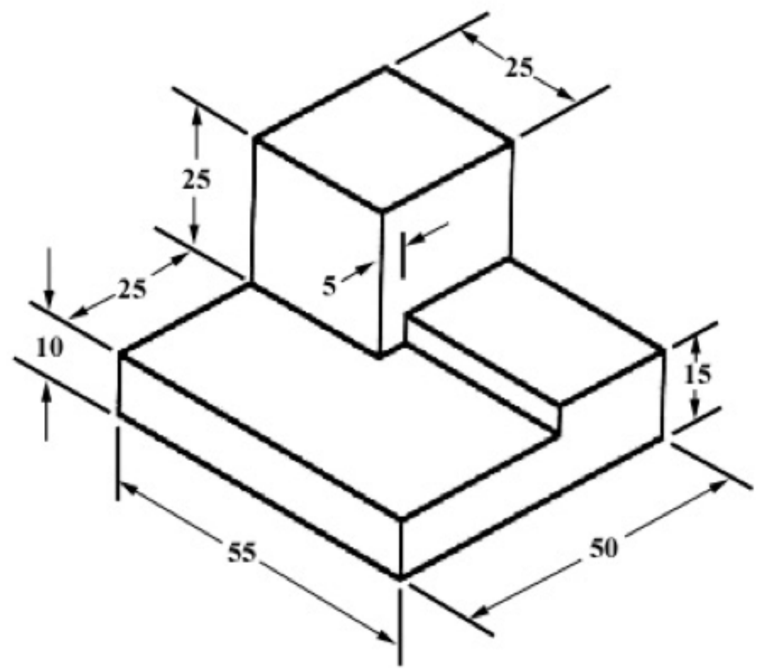
Dimensioning!

Figure 7 - An isometric view with dimensions



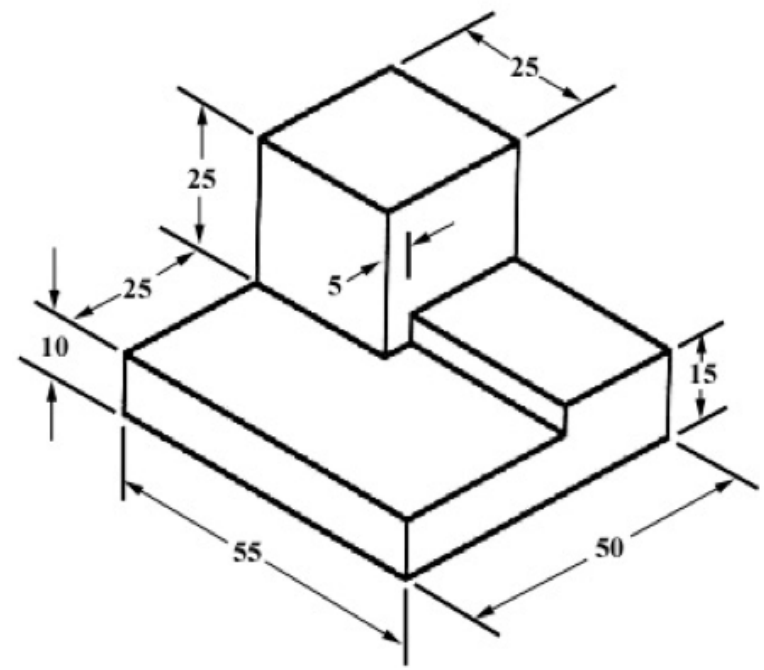
Dimensioning!

- As a general guideline to dimensioning, try to think that you would make an object and dimension it in the most useful way. Put in exactly as many dimensions as are necessary for the craftsperson to make it -no more, no less.



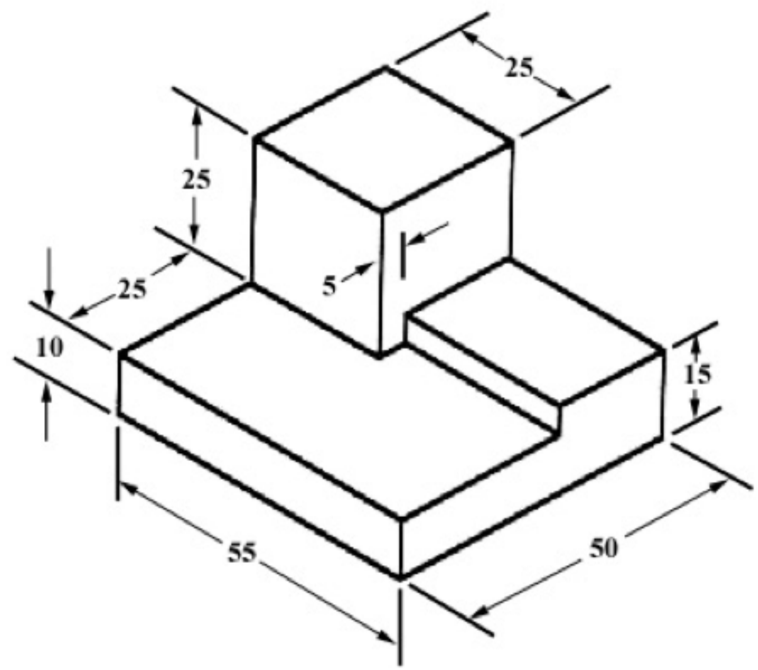
Dimensioning!

- Do not put in redundant dimensions. Not only will these clutter the drawing, but if "tolerances" or accuracy levels have been included, the redundant dimensions often lead to conflicts when the tolerance allowances can be added in different ways.



Dimensioning!

- Repeatedly measuring from one point to another will lead to inaccuracies. It is often better to measure from one end to various points. This gives the dimensions a reference standard. It is helpful to choose the placement of the dimension in the order in which a machinist would create the part. This convention may take some experience.



Dimensioning – Important!

- The purpose of dimensioning is to provide a clear and complete description of an object. A complete set of dimensions will permit only one interpretation needed to construct the part. Dimensioning should follow these guidelines.

Dimensioning – Important!

- **Accuracy**: correct values must be given.
- **Clearness**: dimensions must be placed in appropriate positions.
- **Completeness**: nothing must be left out, and nothing duplicated.
- **Readability**: the appropriate line quality must be used for legibility.

The Basics: Definitions and Dimensions

- The **dimension line** is a thin line, broken in the middle to allow the placement of the dimension value, with
- arrowheads at each end (figure 23).

Figure 23 - Dimensioned Drawing

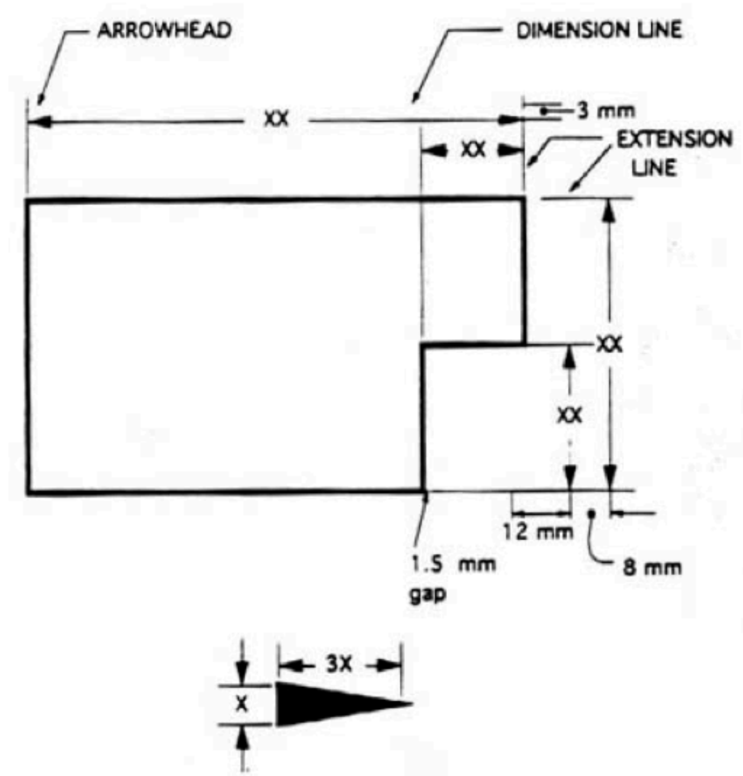
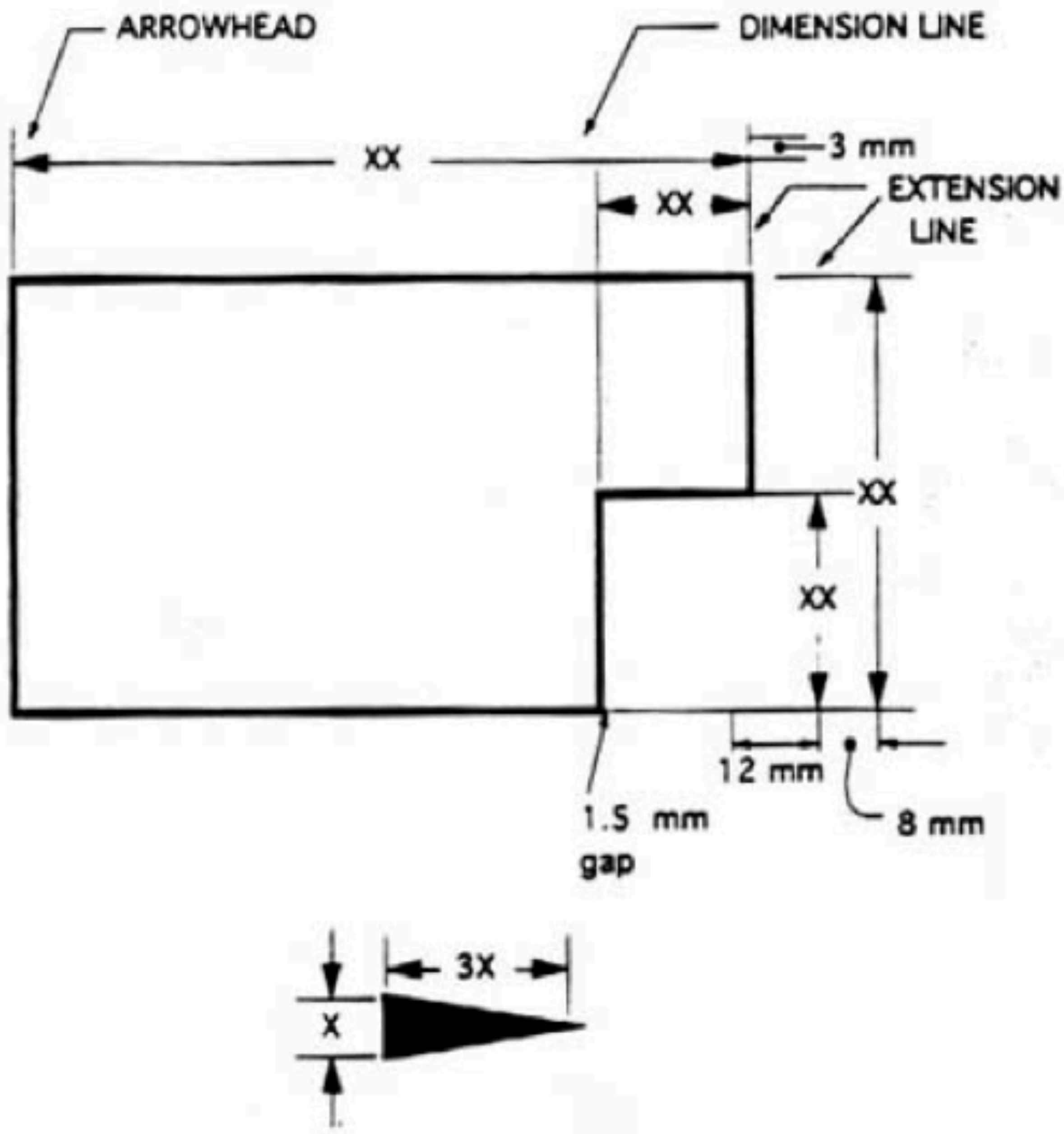


Figure 23 - Dimensioned Drawing

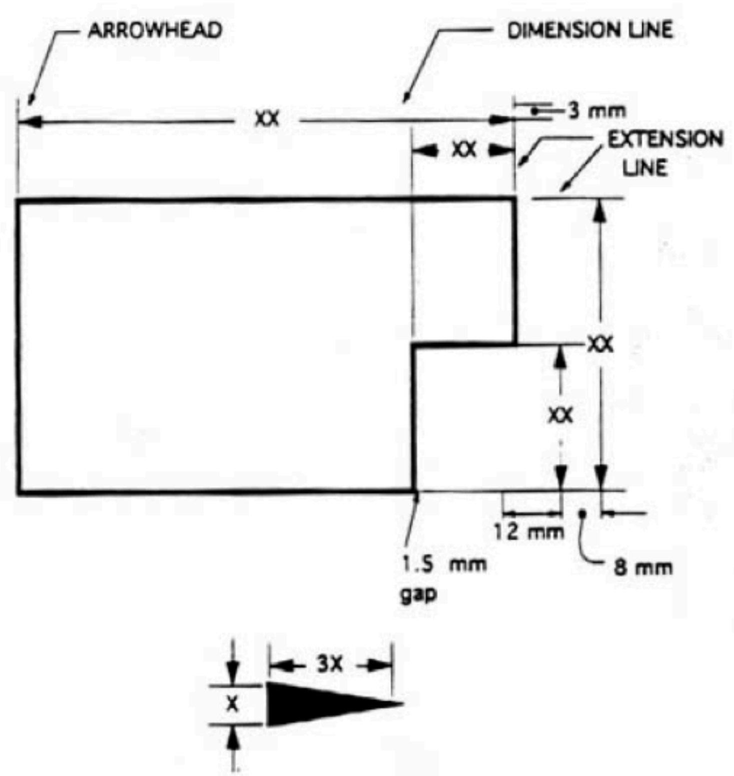


The Basics: Definitions and Dimensions

- An **arrowhead** is approximately 3 mm long and 1 mm wide. That is, the length is roughly three times the width.

- **An extension line** extends a line on the object to the dimension line. The first dimension line should be approximately 12 mm (0.6 in) from the object. Extension lines begin 1.5 mm from the object and extend 3 mm from the last dimension line.

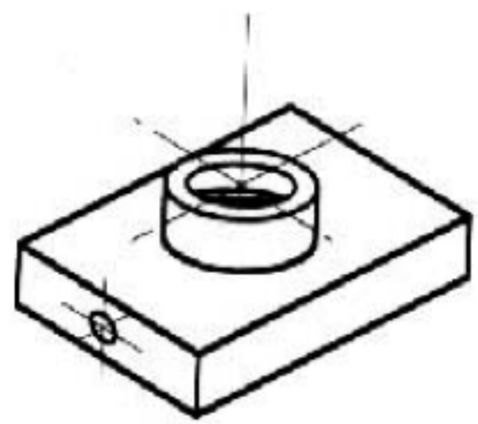
Figure 23 - Dimensioned Drawing



Sectioning

- There are many times when the interior details of an object cannot be seen from the outside (figure 8).

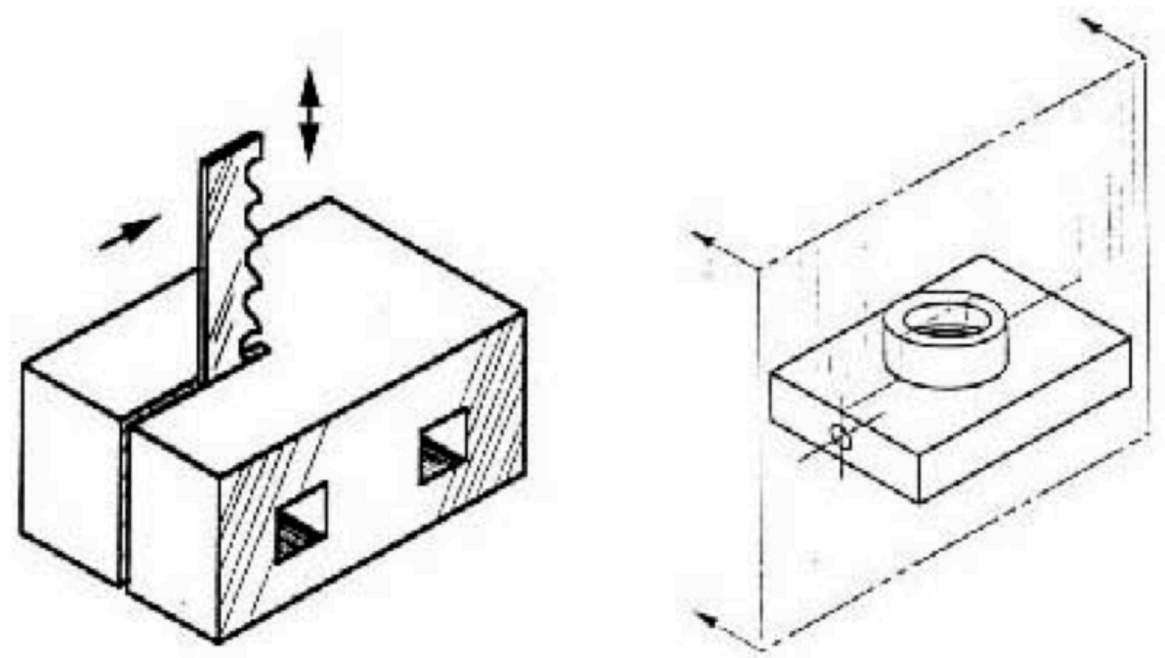
Figure 8 - An isometric drawing that does not show all details



Sectioning

- Imagine slicing the object in the middle (figure 9):

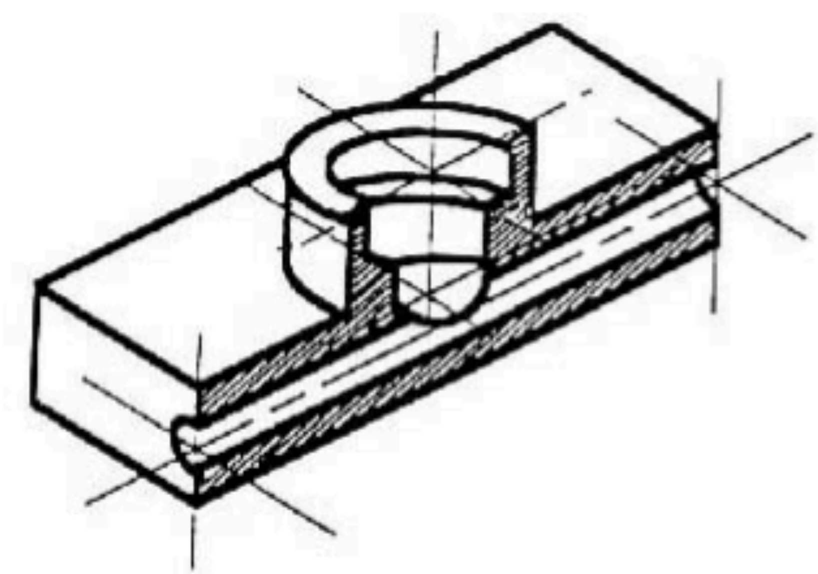
Figure 9 - "Sectioning" an object



Sectioning

- Imagine slicing the object in the middle (figure 9):

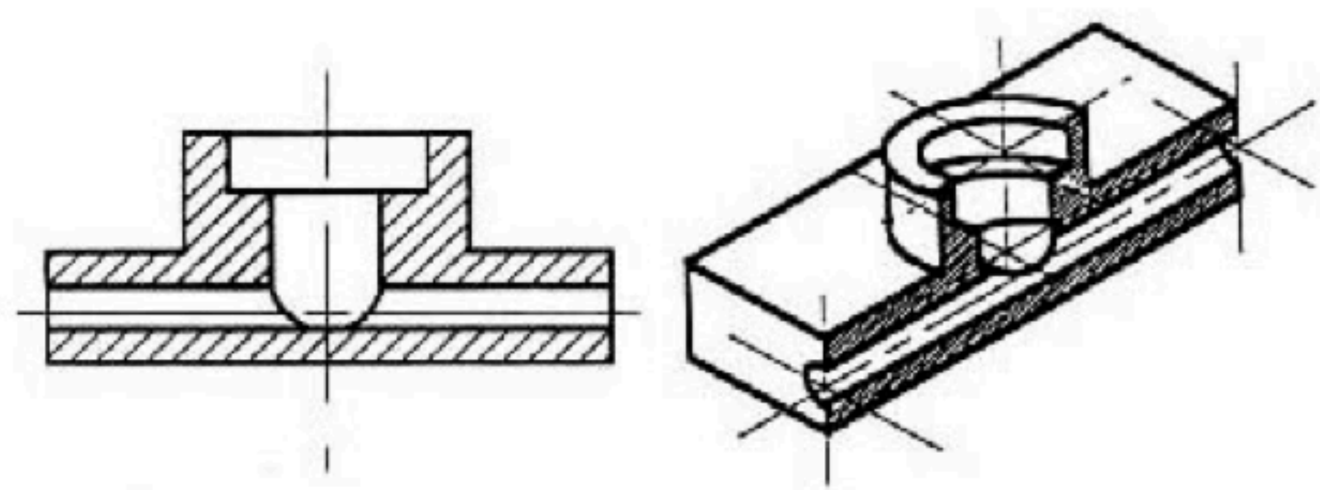
Figure 10 - Sectioning the object in figure 8



Sectioning

- Take away the front half (figure 10) and what you have is a full section view (figure 11).

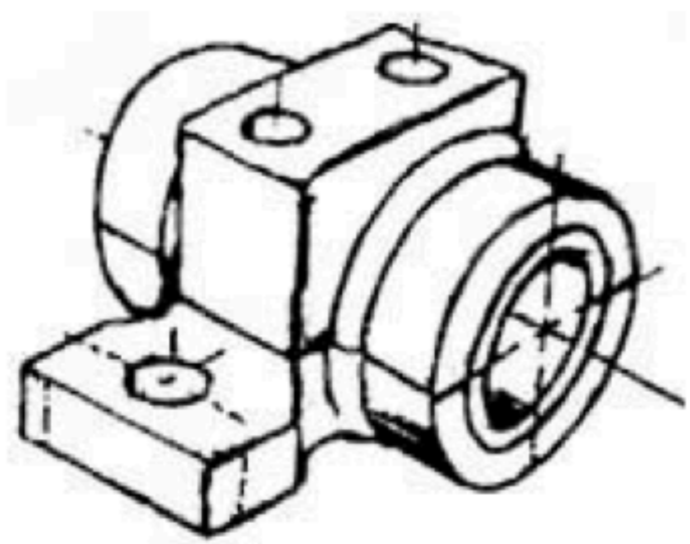
Figure 11 - Sectioned isometric and orthogonal views



Assembly Drawings

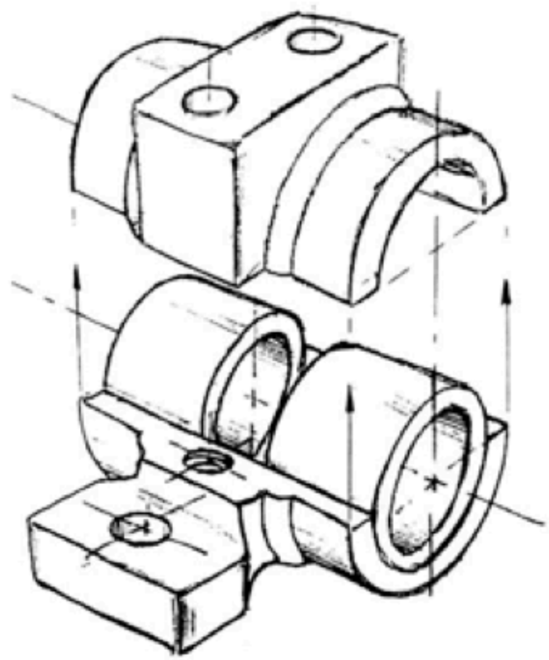
- An isometric view of an "assembled" pillow-block bearing system is shown in figure 13. It corresponds closely to what you actually see when viewing the object from a particular angle. We cannot tell what the inside of the part looks like from this view.

Figure 13 - Pillow-block (Freehand sketch)



Assembly Drawings

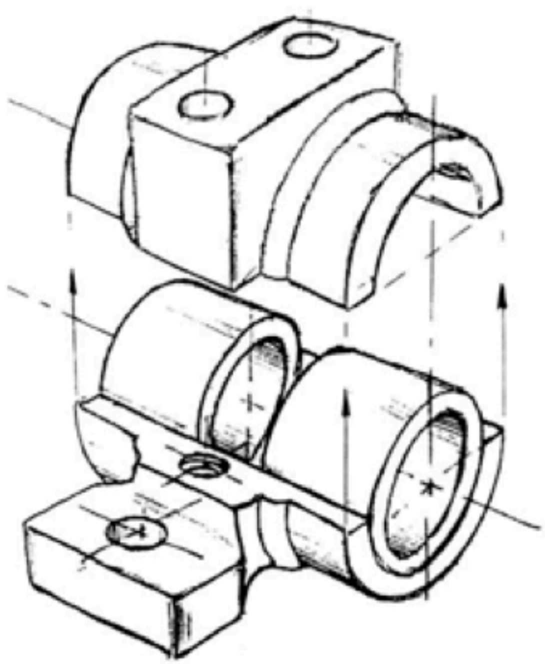
Figure 14 - Disassembled Pillow-block



Cross-Sectional Views

Assembly Drawings

gure 14 - Disassembled Pillow-blo



Cross-Sectional Views

- A cross-sectional view portrays a cut-away portion of the object and is another way to show hidden components in a device.

Assembly Drawings

- Imagine a plane that cuts vertically through the center of the pillow block as shown in figure 15. Then imagine removing the material from the front of this plane, as shown in figure 16.

Figure 15 - Pillow Block

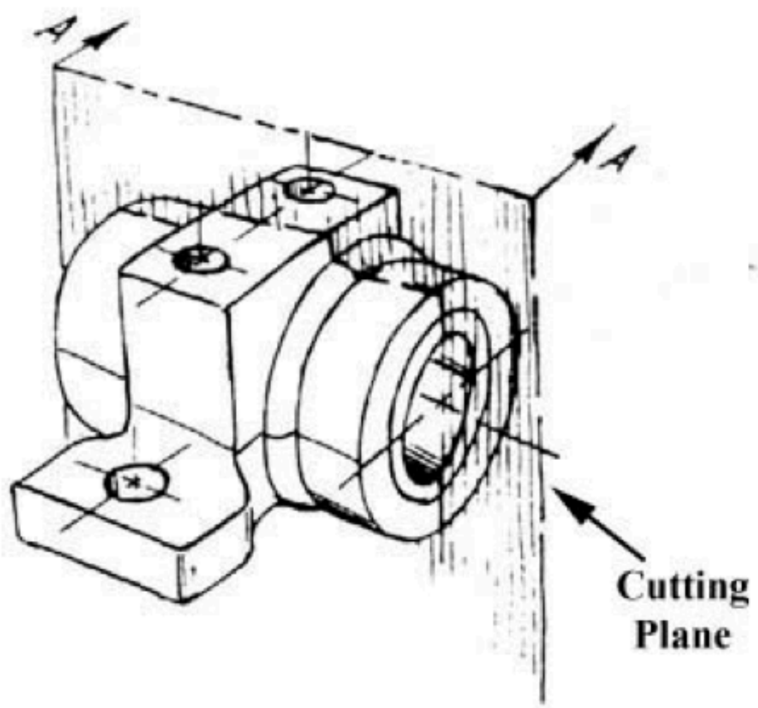
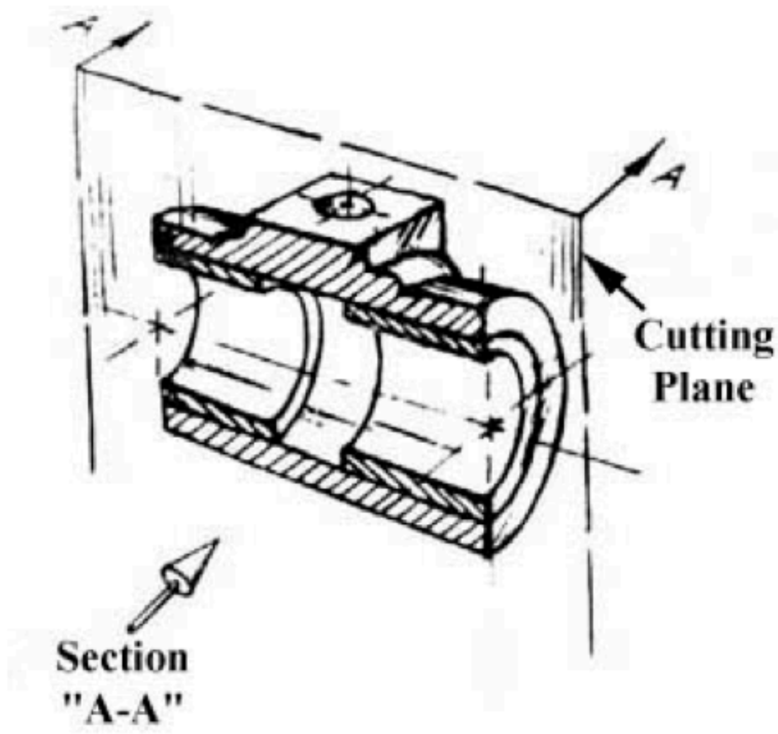


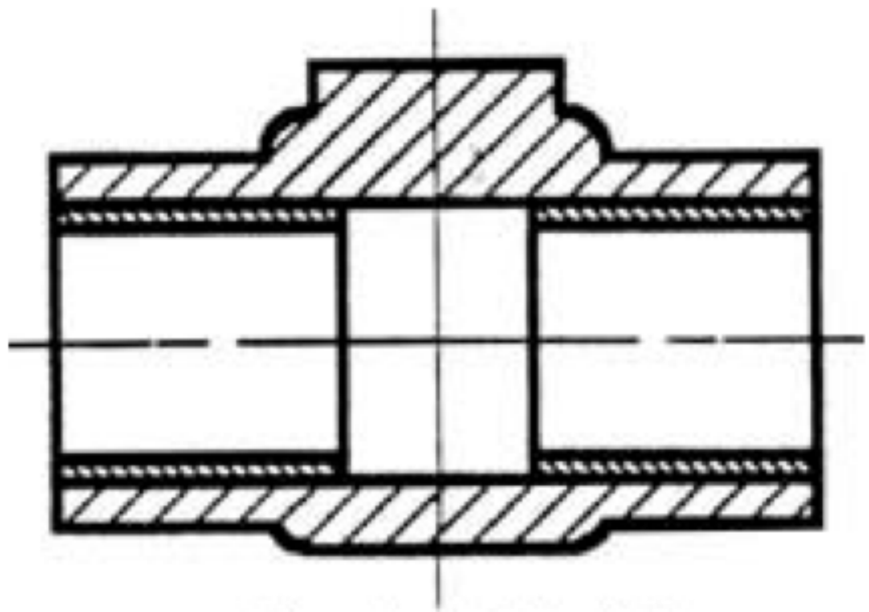
Figure 16 - Pillow Block



Assembly Drawings

- This is how the remaining rear section would look. Diagonal lines (cross-hatches) show regions where materials have been cut by the cutting plane.

Figure 17 - Section "A-A"

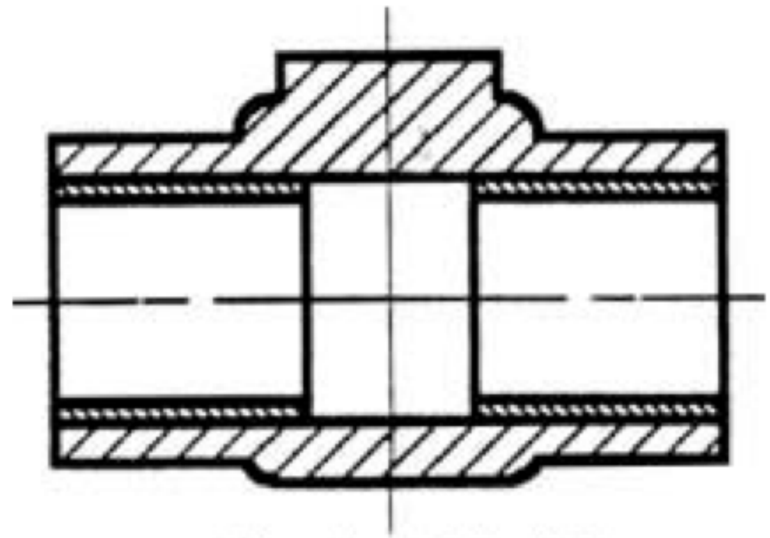


Section "A-A"

Assembly Drawings

- This cross-sectional view (section A-A, figure 17), one that is orthogonal to the viewing direction, shows the relationships of lengths and diameters better. These drawings are easier to make than isometric drawings. Seasoned engineers can interpret orthogonal drawings without needing an isometric drawing, but this takes a bit of practice.

Figure 17 - Section "A-A"

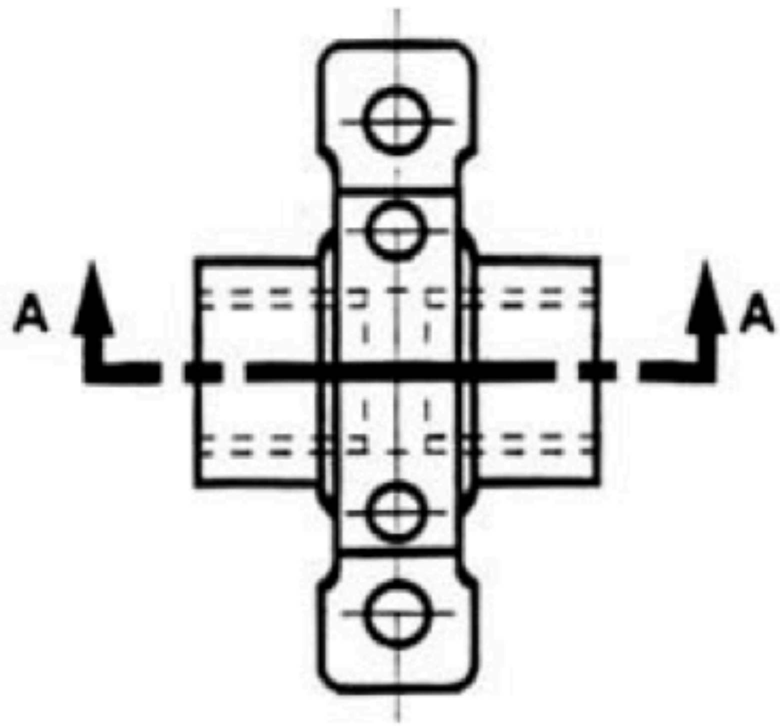


Section "A-A"

Assembly Drawings

- The top "outside" view of the bearing is shown in figure 18. It is an orthogonal (perpendicular) projection. Notice the direction of the arrows for the "A-A" cutting plane.

Figure 18 - The top "outside" view of the bearing



Half Sections

Figure 19 - Full and sectioned isometric views

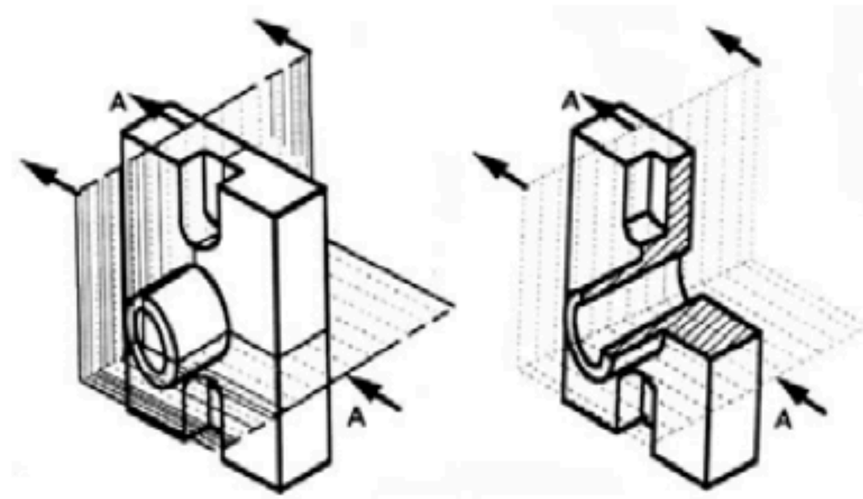
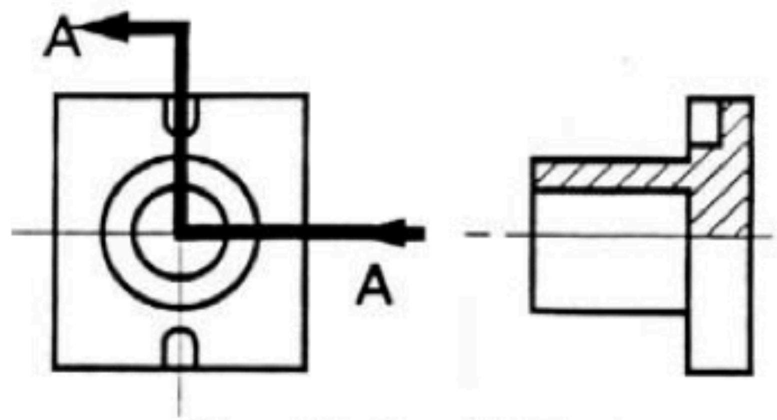


Figure 20 - Front view and half section



- A half-section is a view of an object showing one-half of the view in section, as in figure 19 and 20.

Half Sections

- The diagonal lines on the section drawing are used to indicate the area that has been theoretically cut. These lines are called *section lining* or *cross-hatching*. The lines are thin and are usually drawn at a 45-degree angle to the major outline of the object. The spacing between lines should be uniform.

Figure 19 - Full and sectioned isometric views

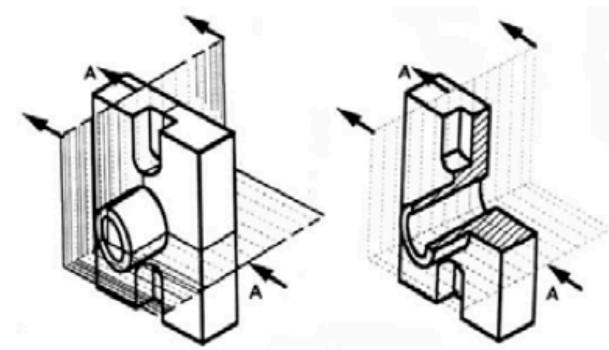
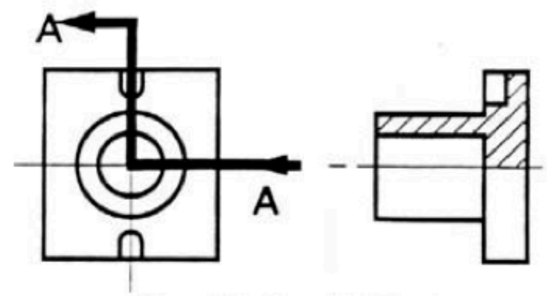


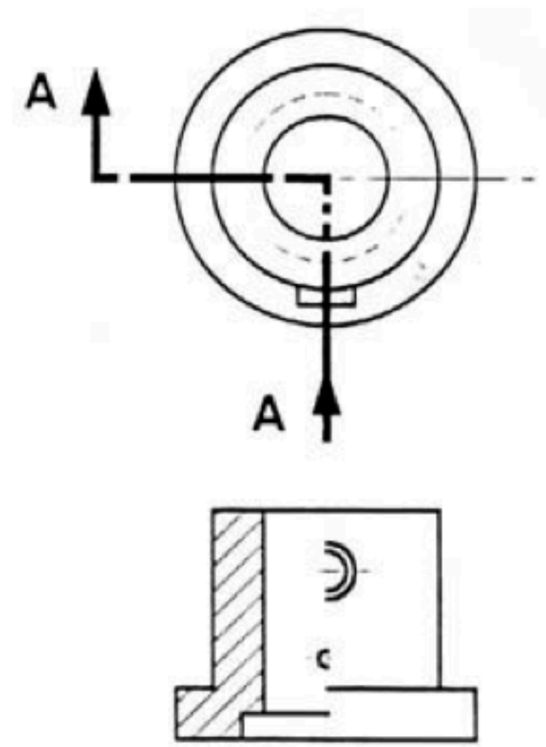
Figure 20 - Front view and half section



Half Sections

- A second, rarer, use of cross-hatching is to indicate the material of the object. One form of cross-hatching may be used for cast iron, another for bronze, and so forth. More usually, the type of material is indicated elsewhere on the drawing, making the use of different types of cross-hatching unnecessary.

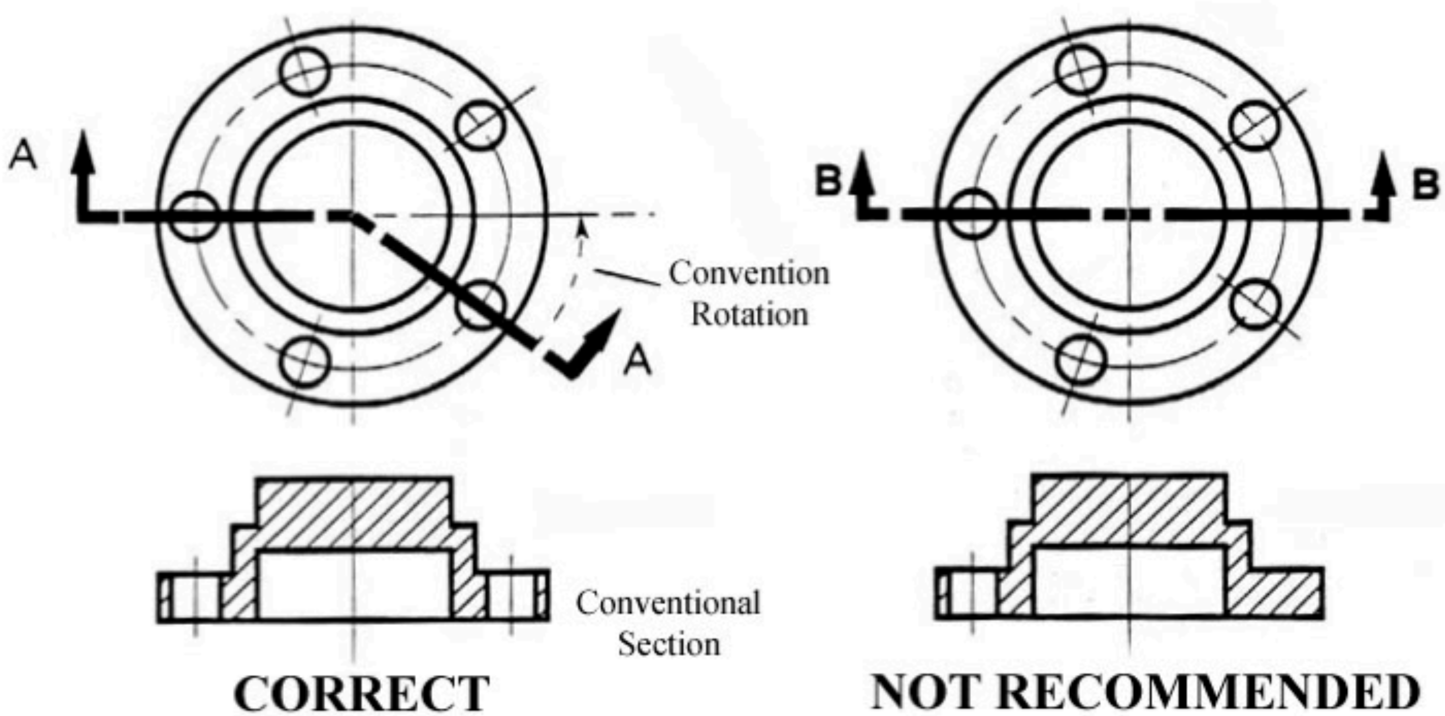
Figure 21 - Half section without hidden lines



Sectioning Objects with Holes, Ribs, Etc.

- The cross-section on the right of figure 22 is technically correct. However, the convention in a drawing is to show the view on the left as the preferred method for sectioning this type of object.

Figure 22 - Cross section



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