

ENGINEERING DRAWING

Introduction



By

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Drawing

Describing any object/ information diagrammatically

Engineering Drawing

Graphical means of expression of technical details without the barrier of a **language**.

Universal language for engineers

Diagrams/sketches/pictures - communication skills

- We grasp information easily if it is illustrated with diagrams, sketches, pictures, etc.



LCA - the world's smallest, light weight, multi-role supersonic combat aircraft of the world



Source: http://img.stern.de/_content/53/96/539645/A380_500_artikel_500.jpg

AIRBUS A380

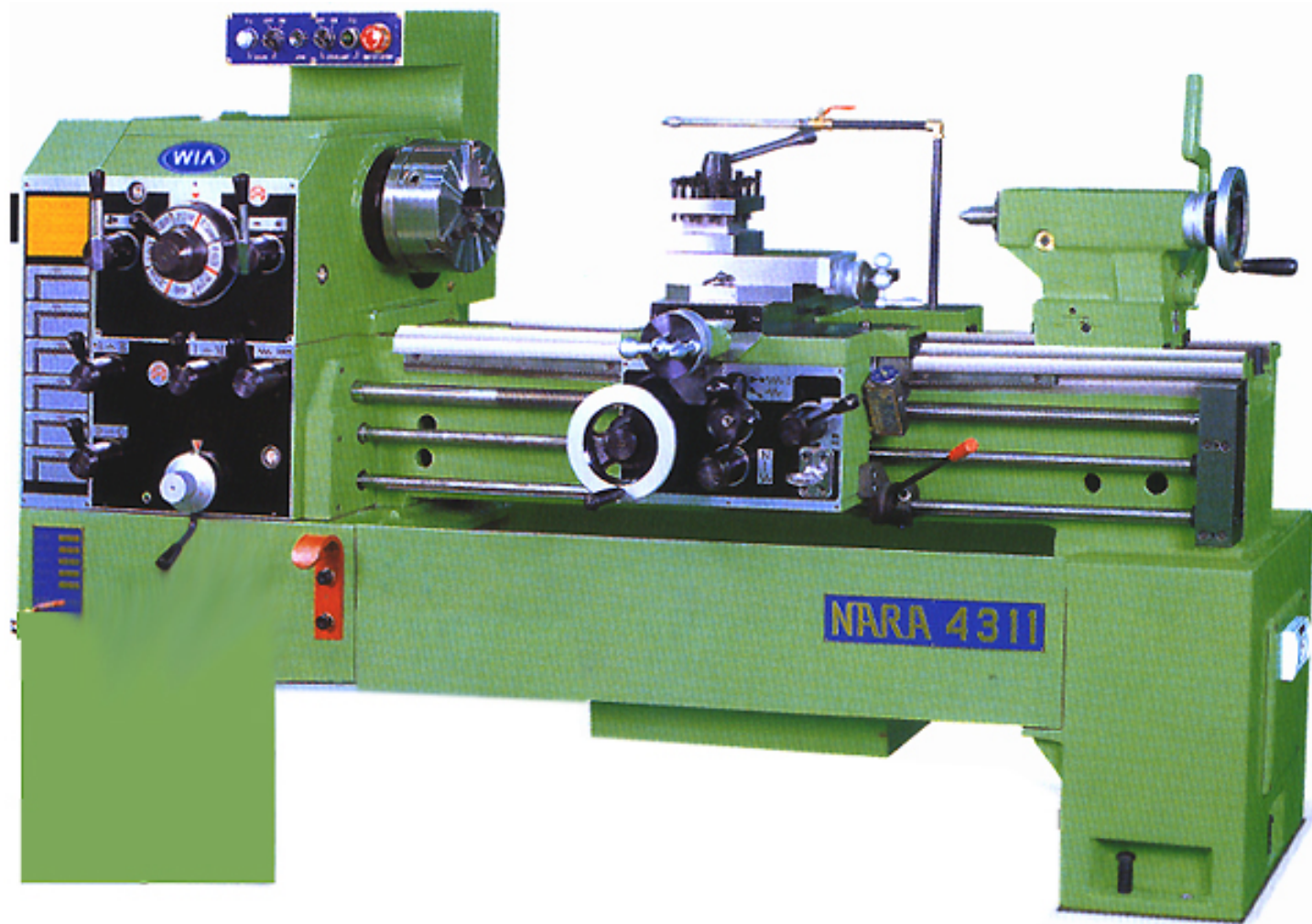
Details: largest passenger jet. 80m wingspan and a tail that stands as high as a seven-storey building, carries more than 550 passengers.

It would just be impossible to communicate all necessary details about the LCA/ Airbus A380 verbally or in writing - **Illustration (picture/drawing)** is useful.

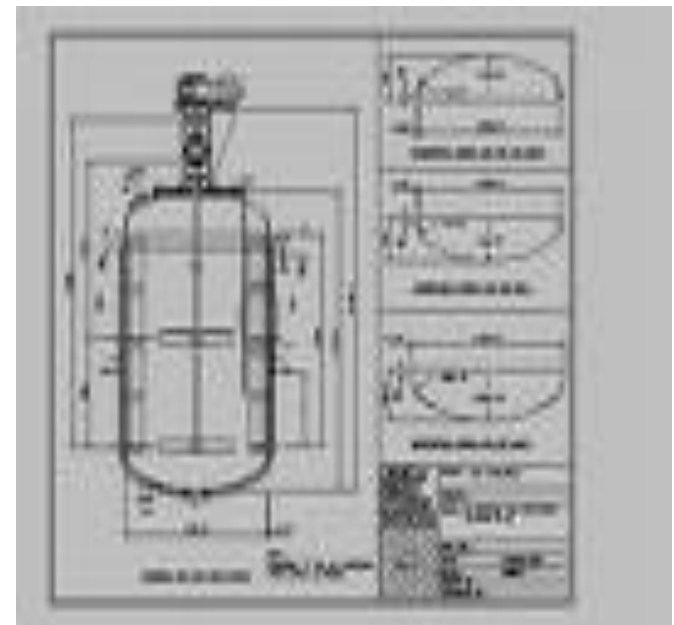
- **A picture/drawing is worth a thousand words..**
- The LCA/Airbus A380 would be impossible to create without computer graphics and drawing models.
- **Drawings are the road maps which show how to manufacture products and structures.**



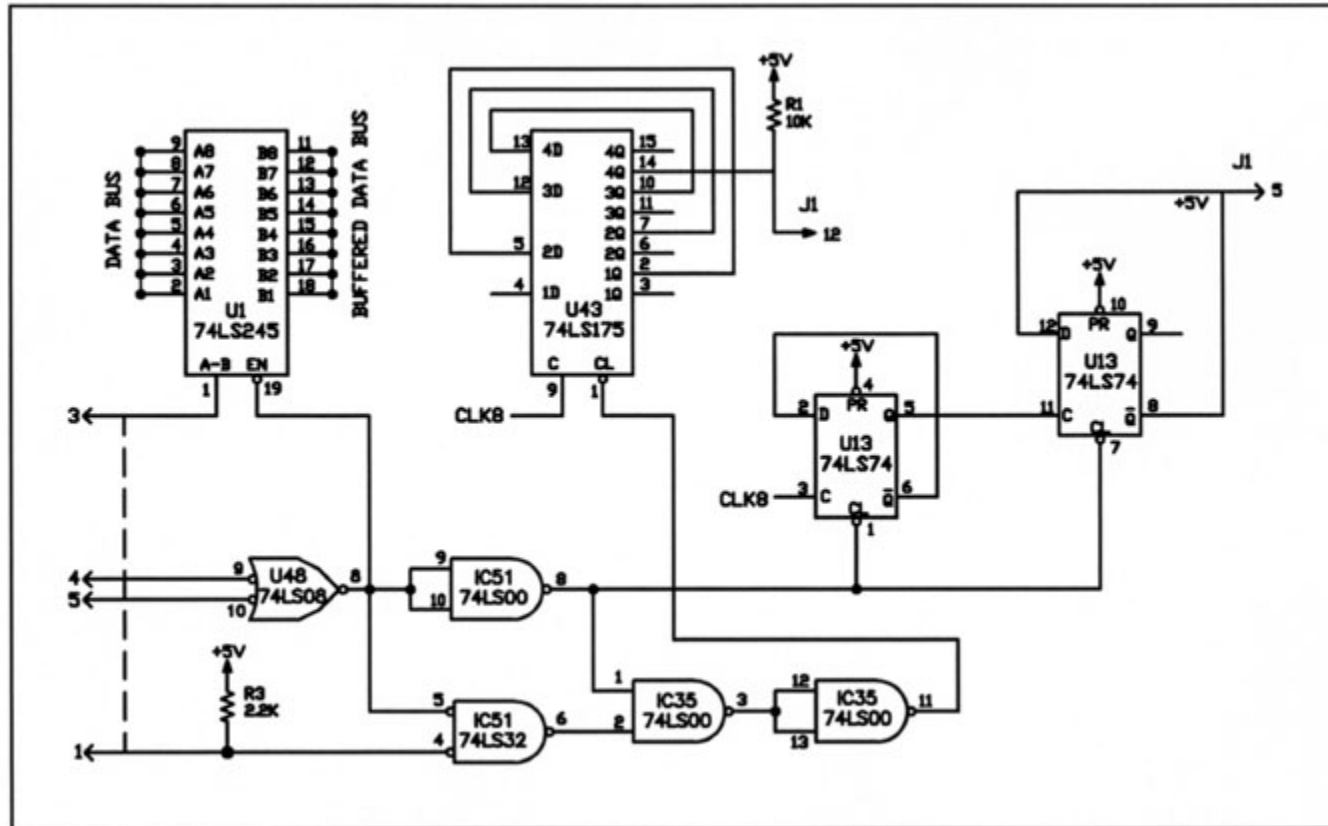
Impossible to describe the details
of the building



Difficult to describe the details of the machine



Chemical reactor



Electrical circuit

Drawing is important for all branches of engineering.

Graphical representation of an object - **Drawing**

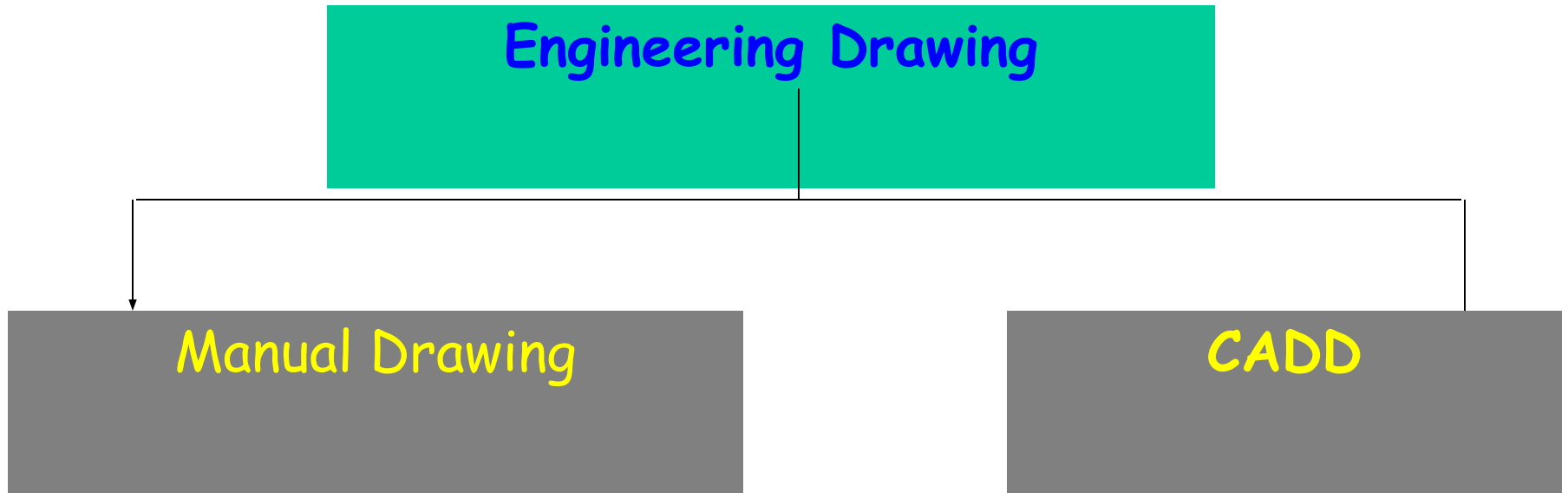
- **Engineering drawing** - A drawing of an object that contains all information
- like **actual shape**, accurate size, **manufacturing methods**, etc., required for its construction.
- No construction/manufacturing of any (man-made) engineering objects is possible without engineering drawing.

What will you learn in this course?

You will learn - How industry communicates technical information.

- **Visualization** - the ability to mentally control visual information.
- **Graphics theory** - geometry and projection techniques.
- **Standards** - set of rules that govern how parts are made and technical drawings are represented.
- **Conventions** - commonly accepted practices and methods used for technical drawings.
- **Tools** - devices used to create technical drawings and models.
- **Applications** - the various uses for technical drawings.

Engineering drawing is completely different from **artistic drawing**, which are used to express aesthetic, philosophical, and abstract ideas.



Computer has a major impact on the methods used to design and create technical drawings.

Design and drafting on computer are cheap and less time consuming.

Why we go for manual drawing?

Why we go for manual drawing?

Computer cannot replace the drafting board and equipment as a learning tool.

Once you have learned the basics of mathematics, now after class 12, you are allowed the use of calculator and computer.

If basic fundamentals are clear, better use can be made of the power of the software.

To be an expert in technical drawing, this first course on Engineering (manual) Drawing is the first step.

Items required for drawing Items required for drawing

Drawing board

Drawing sheet

Mini-drafter/drafting machine/ T- square

Instrument box containing compass, divider, etc.

Scales

Protractor

French curves

Drawing pencils

Eraser

Drawing clip/pin/adhesive tape

Sharpener

Duster



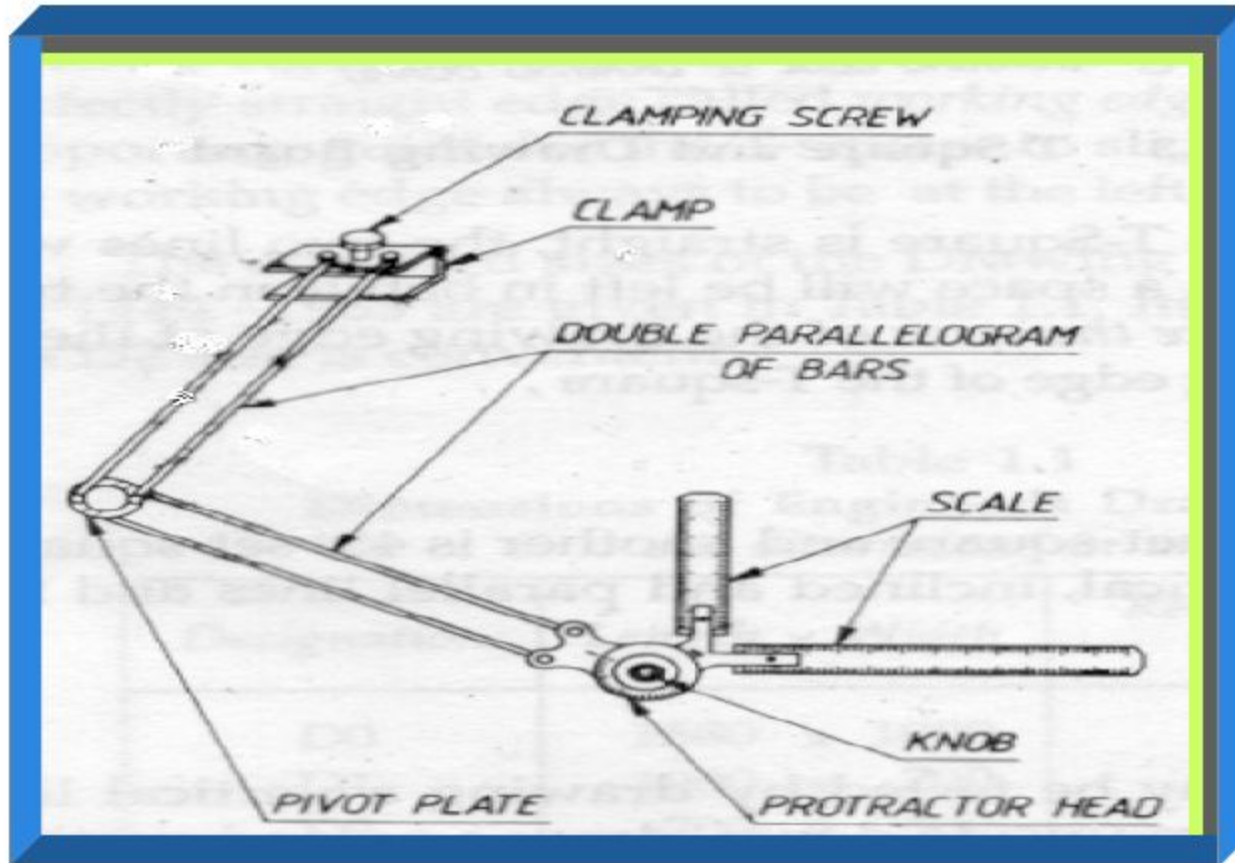
Working edge

Drawing board must be placed on the table with working edge always to be at the left side.

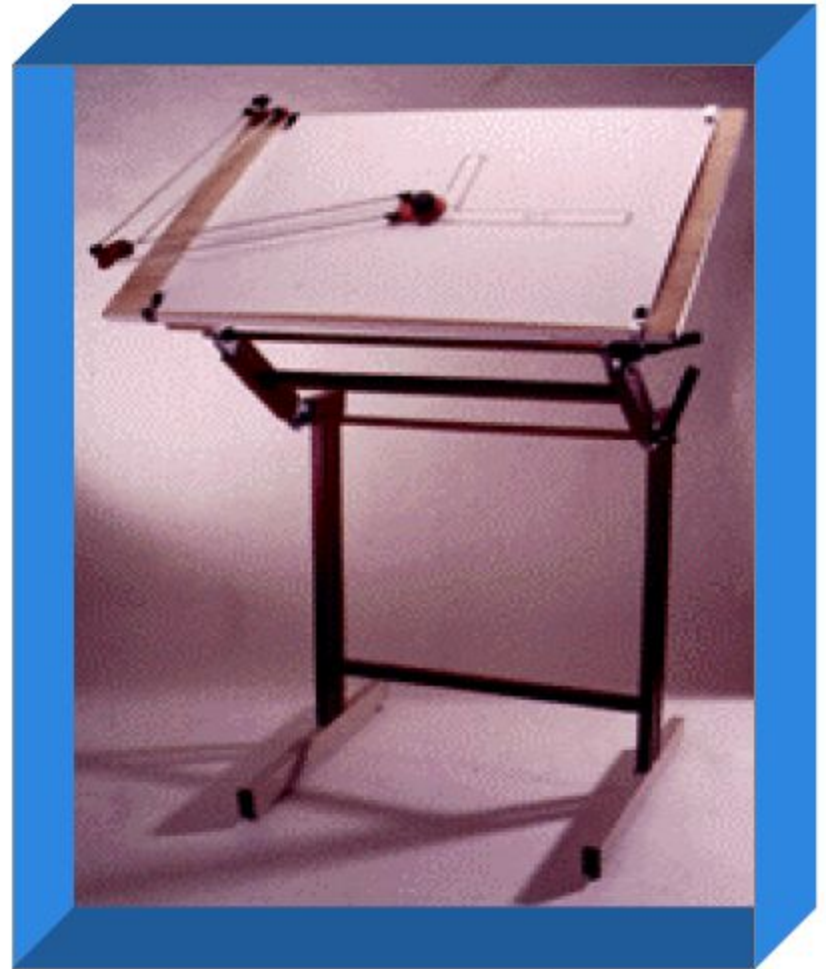
TABLE 1-1
SIZES OF DRAWING BOARDS

Designation	Size (mm)
B0	1000 × 1500
B1	700 × 1000
B2	500 × 700
B3	350 × 500

Last two sizes are normally used for student drawing



Mini-drafter - a miniature version of the drafting machine



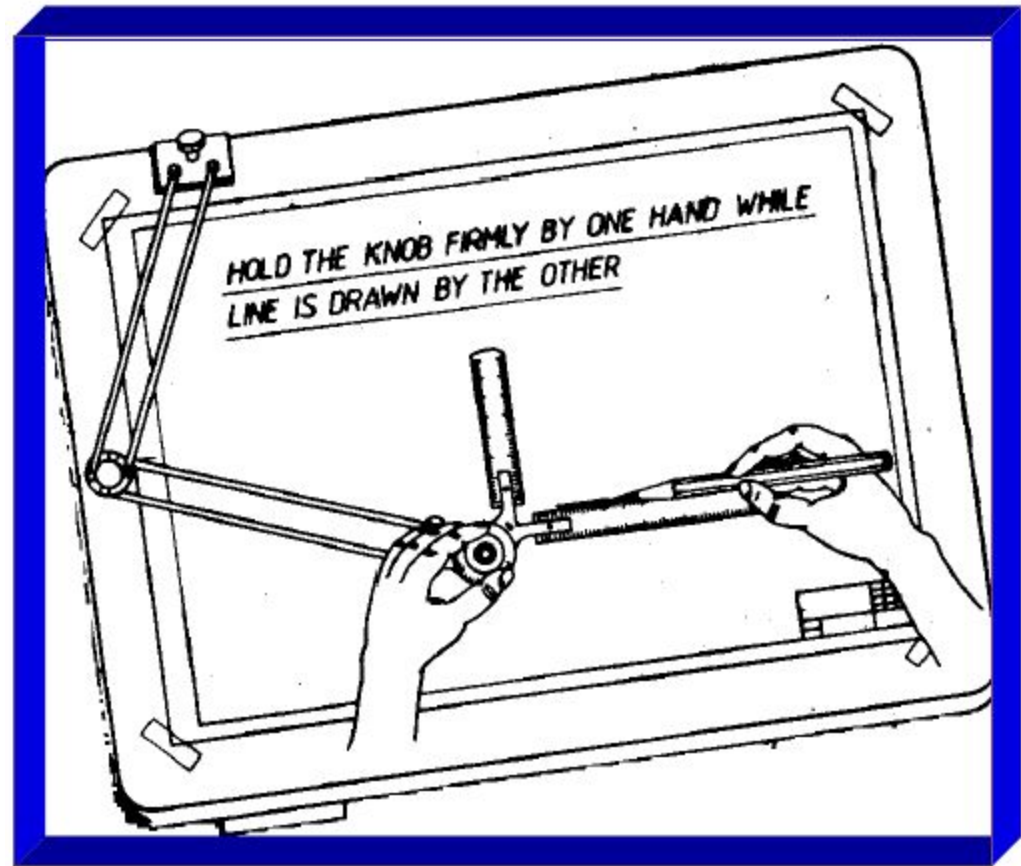
Mini-drafter fixed on drawing board

Clamping mini drafter

Set the protractor head with **reference mark indexing zero degree.**

Fix the clamp of the mini-drafter at the top left corner either along the top horizontal edge of the board or along the left vertical edge of the board.

....contd



Clamping mini drafter..... contd

- Place the drawing sheet underneath the scales of the mini-drafter,
- Fix the drawing sheet to the drawing board with the scales of the mini-drafter aligned either with the vertical or the horizontal borderlines of the drawing sheet.

is also available in other sizes.
Another tool...

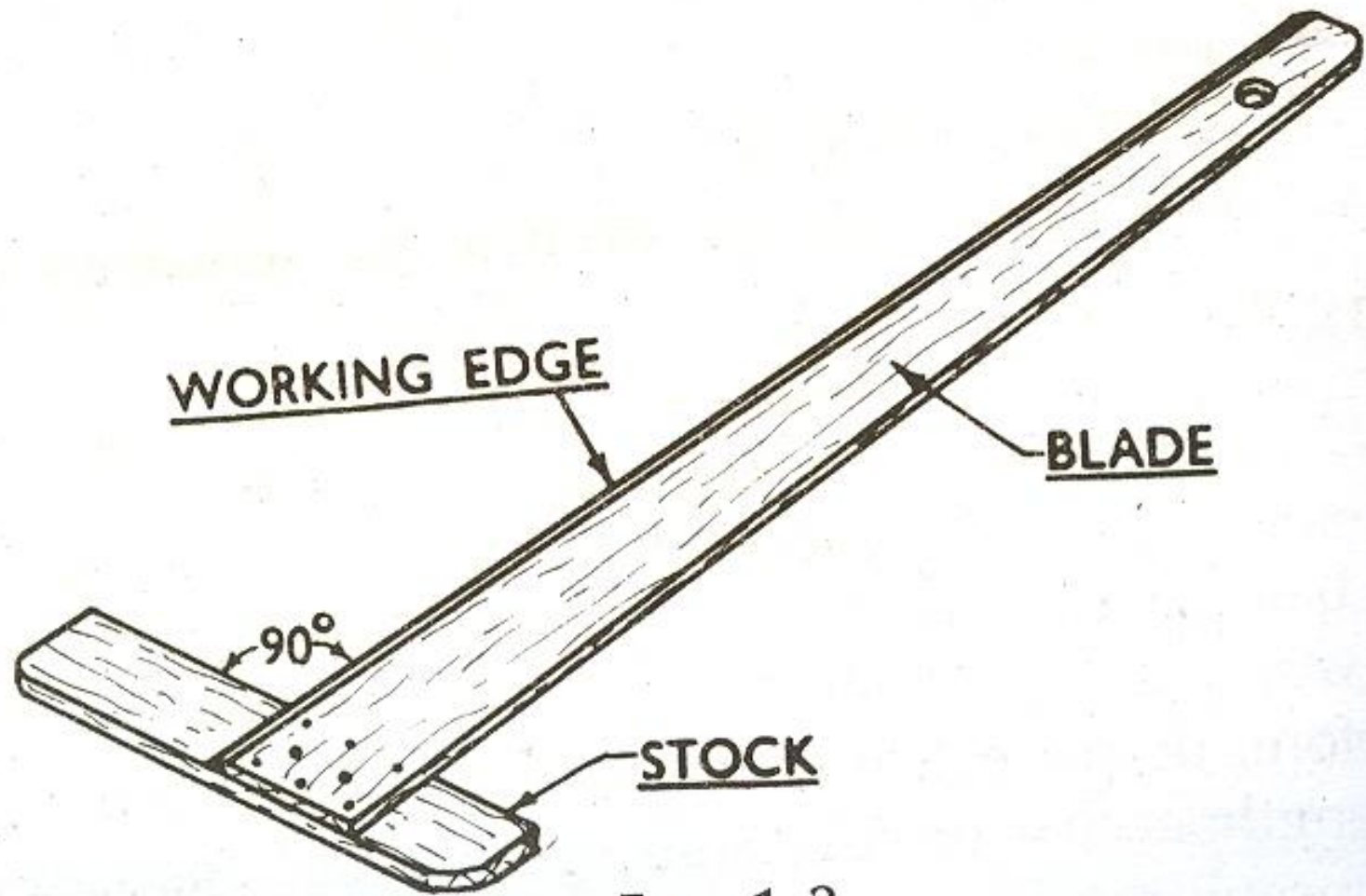
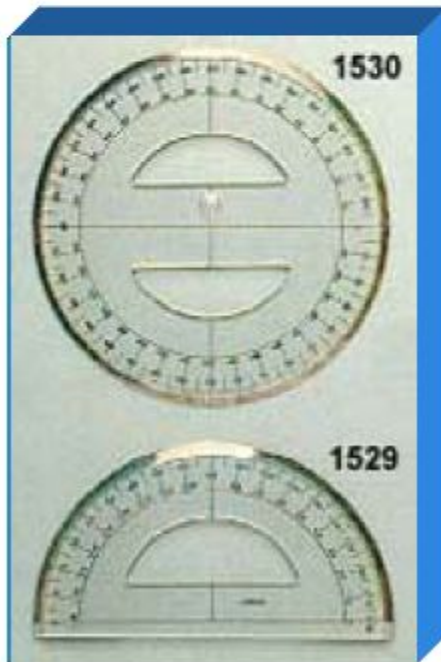
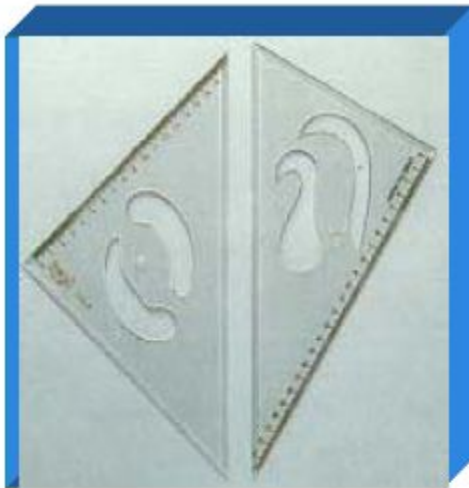


FIG. 1-2

T- square



Some drawing instruments

Standard sizes of drawing sheets as per BIS

Designation	Trimmed Size (mm)	Untrimmed size (mm)
A0	841 x 1189	880 x 1230
A1	594 x 841	625 x 880
A2	420 x 594	450 x 625
A3	297 x 420	330 x 450
A4	210 x 297	240 x 330

A2 size

Layout of drawing sheets

- Standard form of arrangement
- Important particulars are included
- Facilitate quick reading of important particulars - **quick references are located easily - drawings are prepared at various locations and shared**

Grids along the horizontal edges – Numerals

- Grids along vertical edges – Capital letters
- $25\text{ mm} < \text{Length of the grid} < 75\text{ mm}$
-

Numbering and lettering start from the corner of the sheet opposite to the title box and are repeated on the opposite sides

Numbers and letters are written upright

- Repetition of letters or numbers like AA, BB, etc., if they exceed that of the alphabets.

Borders - space left all around in between the trimmed edges of the sheet- A minimum of 10 mm

Grid reference system -

For all sizes of drawing sheets for easy location of drawing within the frame. The length and the width of the frames are divided into even number of divisions.

Number of divisions for a particular sheet depends on complexity of the drawing - **Not to be followed in this course.**

Title box - An important feature - a must in every drawing sheet - for technical and administrative details

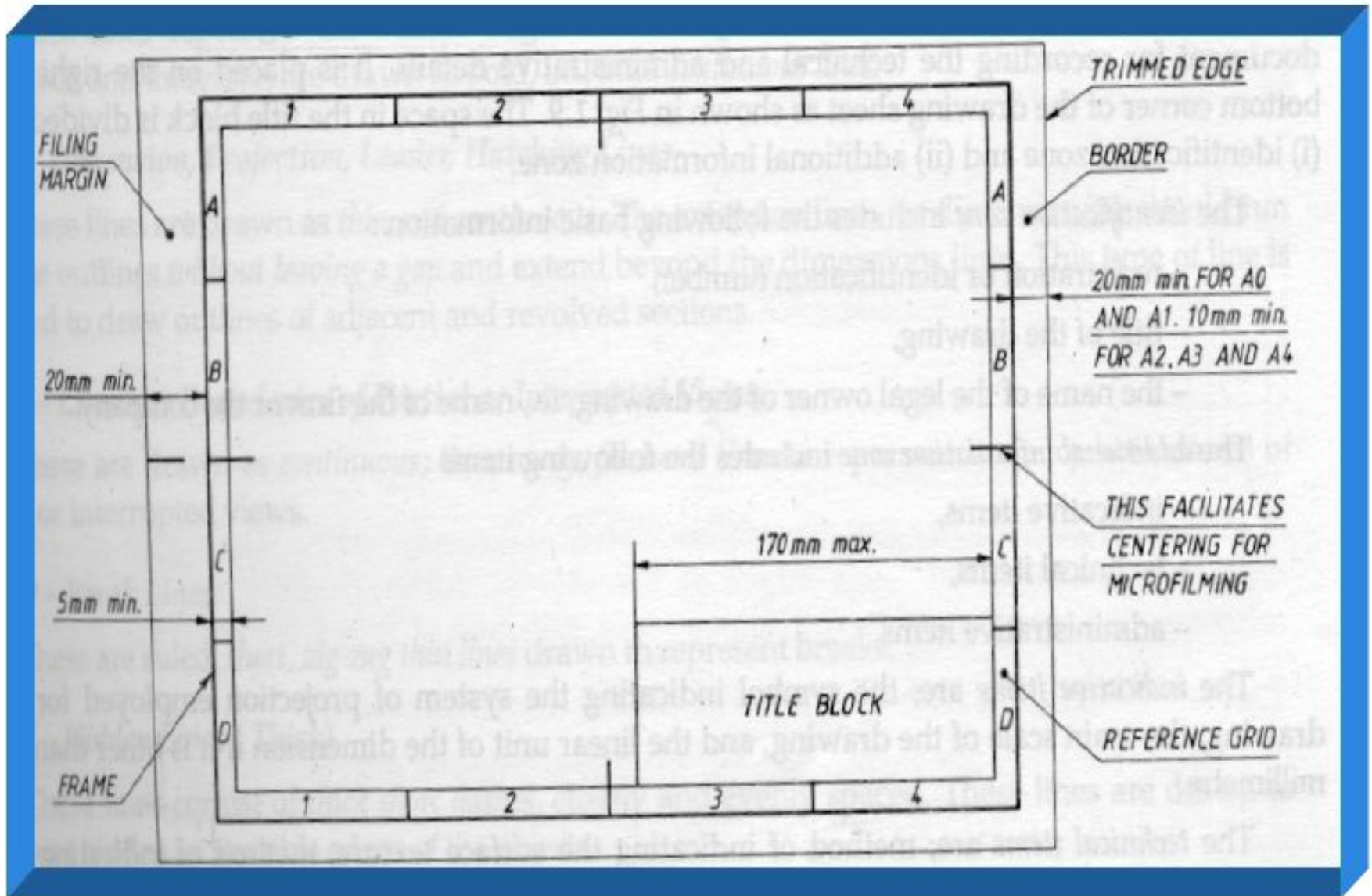
- Location - Bottom right corner - 185 mm x 65 mm (BIS)
- Divided into two zones
 - **Identification zone**
- Registration or identification number
- Drawing title
- Name of the legal owner of the drawing, i.e., name of the firm or the company

Contd...

Title box..... contd

Additional information zone

- Indicative items -symbol indicating the system of projection, main scale of drawing, etc.
- Technical items - method of indicating surface texture, geometric tolerances, etc.
- Administrative items



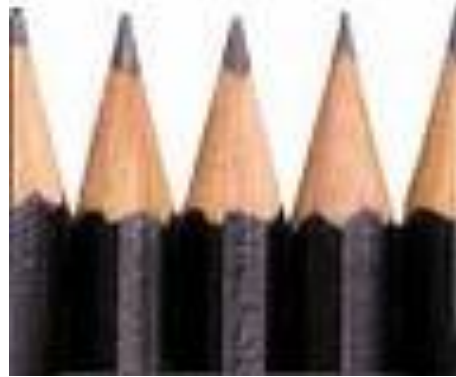
Lay out of a drawing sheet

Layout of the title box to be adopted in this course

INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR		20
TITLE:		15
SCALE:		10
NAME:	ROLL NO:	10
EVALUATED BY	PLATE NO:	10

110 75

Drawing Pencils

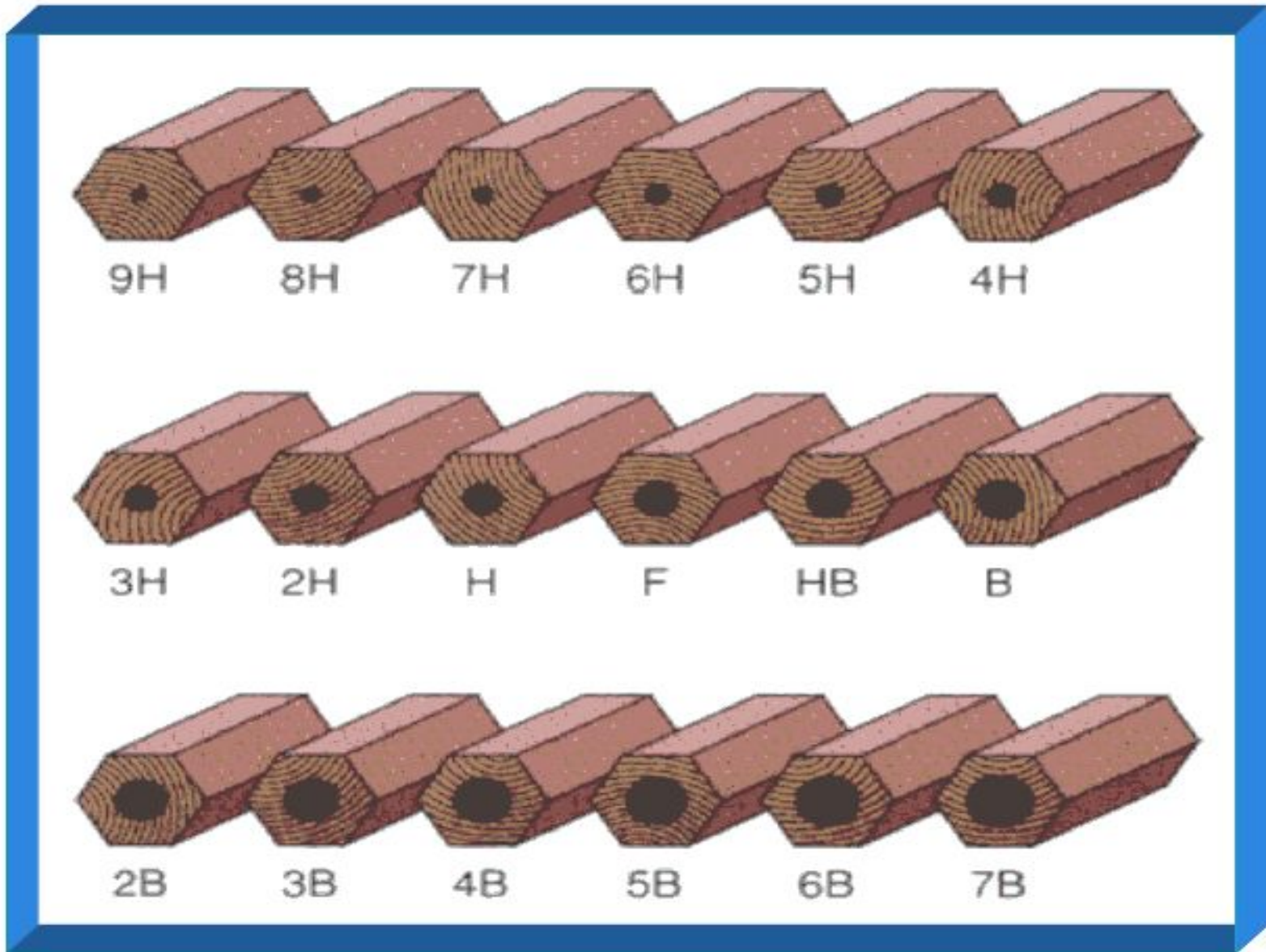


Wooden pencils - are graded and designated by numbers and letters

Mechanical clutch pencils - **Not allowed**

- 7B, 6B, 5B, 4B, 3B, 2B, B - in decreasing order of softness and blackness
- HB to F - Medium grade
- H, 2H, 3H, 4H, 5H, 6H, 7H, 8H, 9H - increasing order of hardness.

Drawings are done using 2H pencils and finished with H and HB pencils - to be practiced in this course.



Grades and designation of wooden pencils






Pencil drawing -

In finished drawing, all lines (except construction lines-used to construct the drawing) should be dense, clean and uniform.




Construction line should be drawn very thin and should be hardly visible in the finished drawing (they should not be erased).

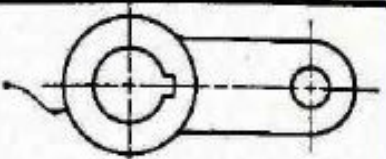
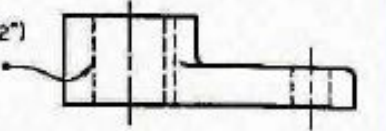
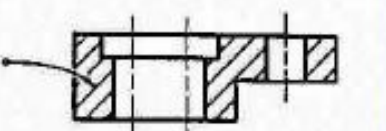
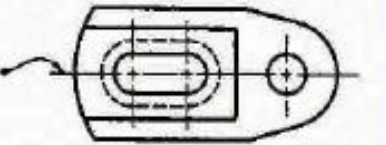
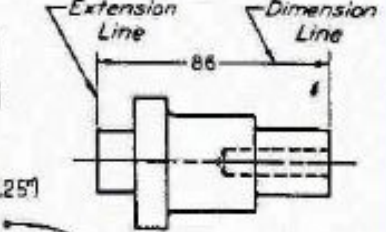
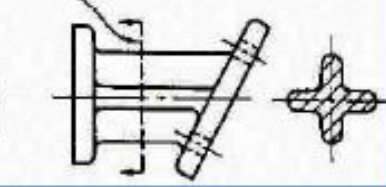
Line group, mm	Thickness	Lines
0.2	Medium	Outlines, dotted lines, cutting plane lines
0.1	Thin	Center lines, section lines, dimension lines, extension lines, construction lines, leader lines, short-break lines, long-break lines

Line types


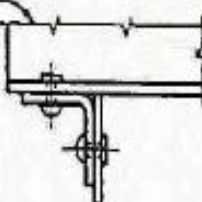

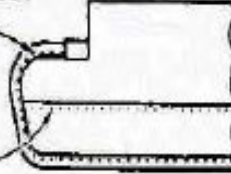

Illustration	Application	Pencil
Thick 	Outlines, visible edges, surface boundaries of objects, margin lines	H
Continuous thin 	Dimension lines, extension lines, section lines leader or pointer lines, construction lines, boarder lines	2H
Continuous thin wavy 	Short break lines or irregular boundary lines – drawn freehand	2H
Continuous thin with zig-zag 	Long break lines	2H
Short dashes, gap 1, length 3 mm 	Invisible or interior surfaces	H

Line types....CONTD

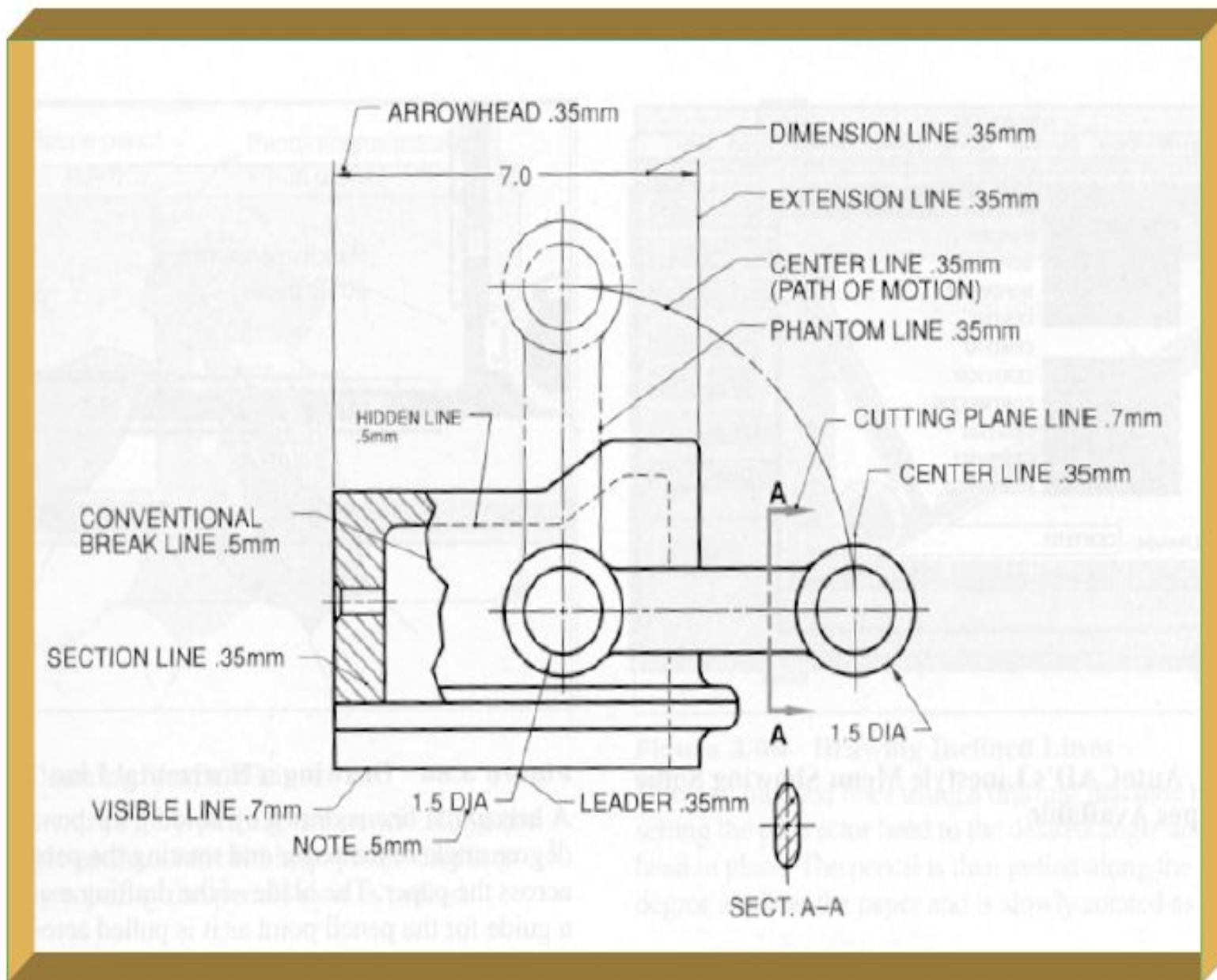
Illustration	Application	Pencil
Short dashes 	Center lines, locus lines Alternate long and short dashes in a proportion of 6:1,	2H
Long chain thick at end and thin elsewhere 	Cutting plane lines	H / 2H
Continuous thick border line 	Border	HB

Lines	Width and Character of Lines	Applications
Visible line	<p>THICK</p> <p>Approx. width 0.7 mm (.032")</p>	
Hidden line	<p>0.8 mm (.03") THIN 3.2 mm (.12")</p> <p>Approx. width 0.35 mm (.016")</p>	
Section line	<p>THIN</p>	
Center line	<p>19-38 mm (.75-1.50") 3.2 mm (.12") 1.6 mm (.06") THIN</p>	
Dimension line, Extension line, Leaders	<p>90.5 THIN</p>	
Cutting-plane or Viewing-plane lines	<p>1.6 mm (.06") THICK 3.2 mm (.12") 1.6 mm (.06") 19-38 mm (.75-1.50")</p>	

Uses of different types of lines in a given drawing

Lines	Width and Character of Lines	Applications
Short-break line	THICK <i>Freehand</i>	
Long-break line	THIN $19-38\text{ mm}$ (.75-1.50") <i>Freehand</i>	
Phantom line	THIN 3.2 mm (.12") 1.6 mm (.06") $19-38\text{ mm}$ (.75-1.50")	
Stitch lines	THIN 1.6 mm (.06") 1.6 mm (.06") Width $2.5-3.5\text{ mm}$ (.015-.022")	
Chain line	THICK $10-20\text{ mm}$ (.38-.75") 1.6 mm (.06") 1.6 mm (.06")	

Uses of different types of lines in a given drawing



Uses of different types of lines in a given drawing

FINISHED PENCIL
DRAWING OR TRACING

VISIBLE OUTLINE (FULL LINE)

HIDDEN OUTLINE (DASHED LINE)

CENTER LINE

EXTENSION LINE

DIMENSION LINE

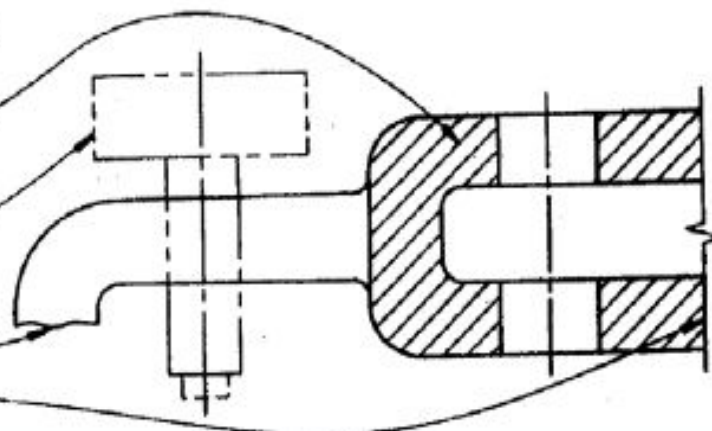
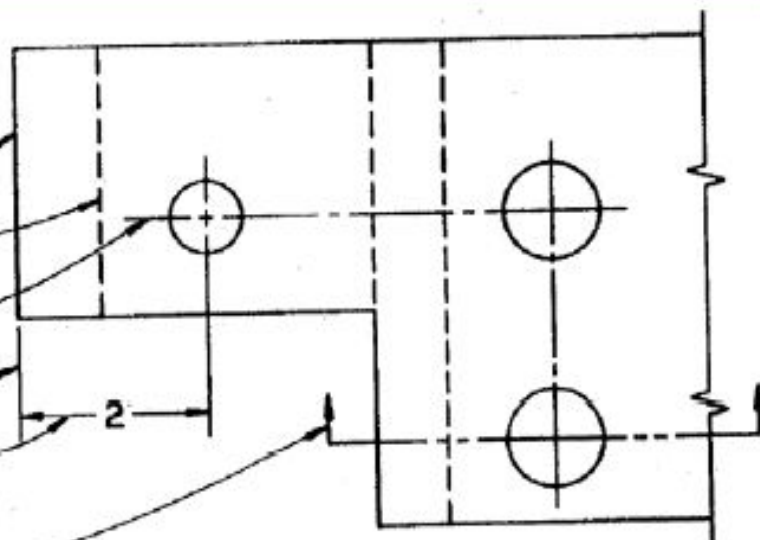
CUTTING PLANE

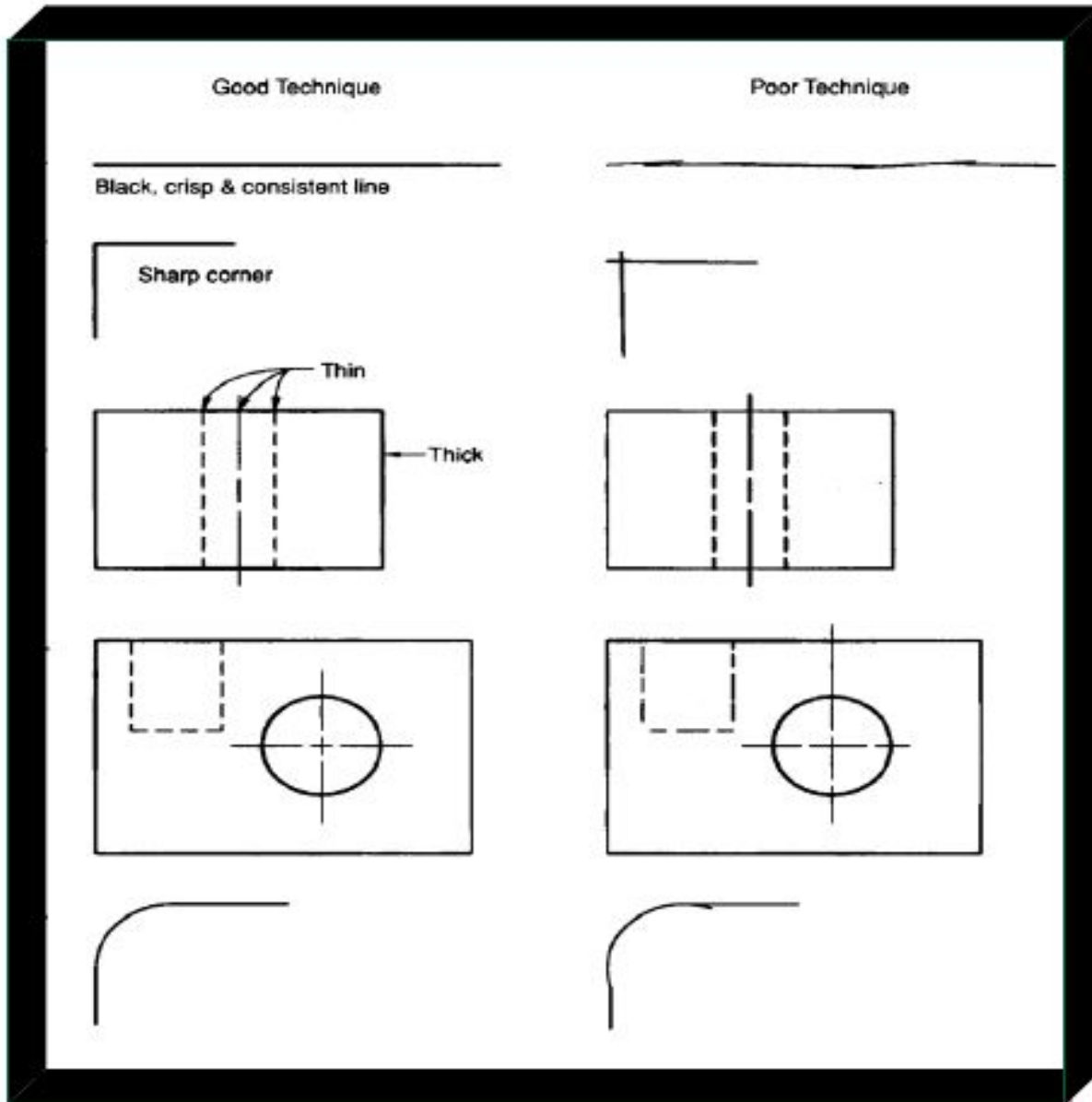
SECTION LINING

ADJACENT PARTS, ALTERNATE
POSITION OR REPEAT LINE

SHORT BREAK

LONG BREAK





Examples of good and poor drawing techniques for lines and arcs

Lettering – Writing of titles, sub-titles, dimensions, scales and other details on a drawing

- Essential features of lettering – legibility, uniformity, ease, rapidity, and suitability for microfilming/photocopying/any other photographic processes
- No ornamental and embellishing style of letter

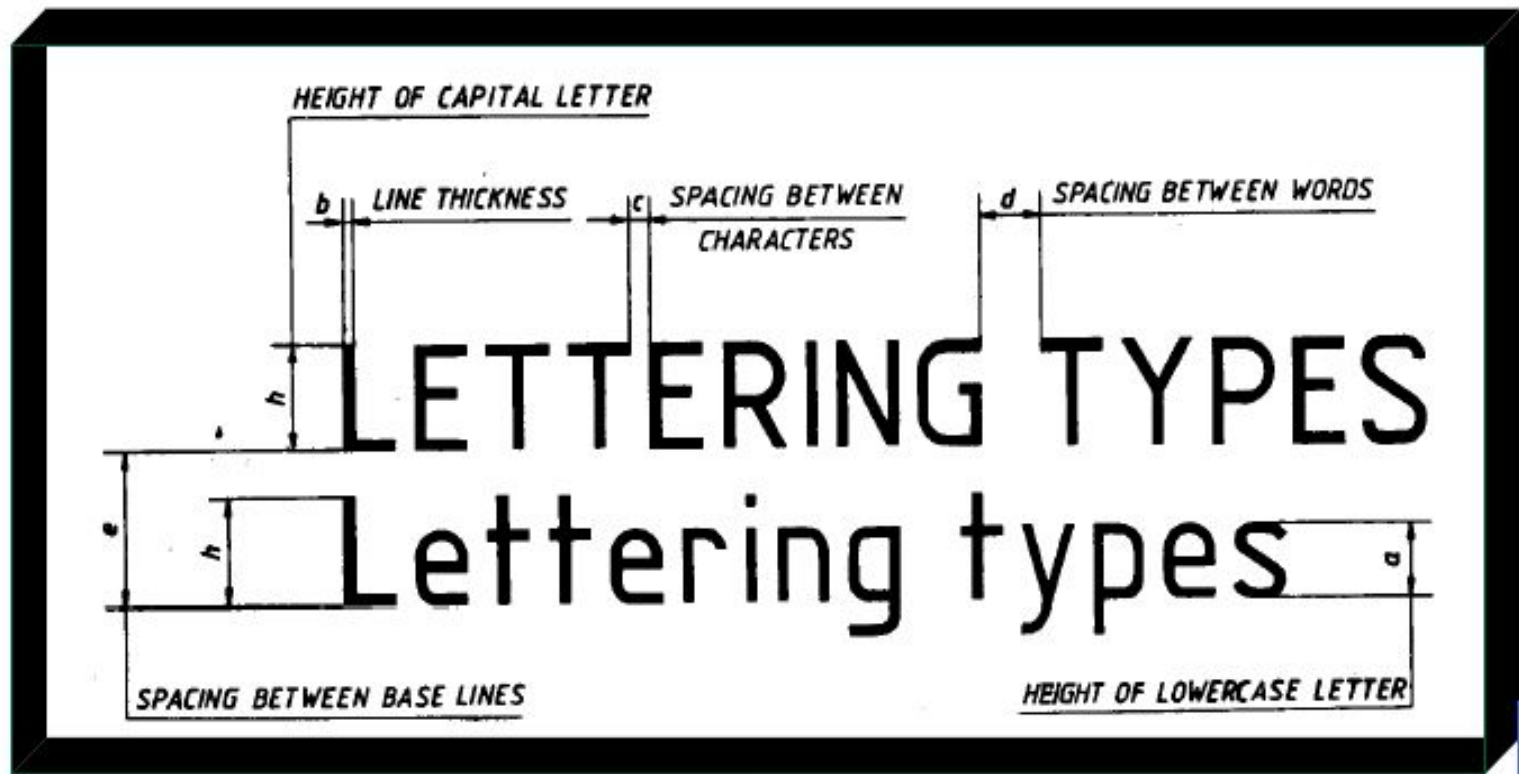
Plain letters and numerals which are clearly distinguishable from each other in order to avoid any confusion even in case of slight mutilations

Lettering - BIS: 9609

- Single stroke lettering for use in engineering drawing - width of the stem of the letters and numerals will be uniformly thick equal to thickness of lines produced by the tip of the pencil.
- **Single stroke does not mean - entire letter written without lifting the pencil/pen**

Lettering types

- **Lettering A** - Height of the capital letter is divided into 14 equal parts
- **Lettering B** - Height of the capital letter is divided into 10 equal parts



Heights of Letters and Numerals

- Height of the capital letters is equal to the height of the numerals used in dimensioning
- Height of letters and numerals - different for different purposes

Sr. No.	Item	Size (mm)
1	Name of the company	10 , 14, 20
2	Drawing numbers, letters denoting section planes	10 , 14
3	Title of the Drawing	7 , 10
4	Sub-titles and heading	5, 7
5	Dimensioning, Notes, Schedules, Material list	3.5, 7
6	Alteration entries and tolerances	3.5

Specifications of A -Type Lettering

Specifications	Value	Size (mm)						
Capital letter height	h	2.5	3.5	5	7	10	14	20
Lowercase letter height	$a = (5/7)h$	-	2.5	3.5	5	7	10	14
Thickness of lines	$b = (1/14)h$	0.18	0.25	0.35	0.5	0.7	1	1.4
Spacing between characters	$c = (1/7)h$	0.35	0.5	0.7	1	1.4	2	2.8
Min. spacing b/n words	$d = (3/7)h$	1.05	1.5	2.1	3	4.2	6	8.4
Min. spacing b/n baselines	$e = (10/7)h$	3.5	5	7	10	14	20	28

Specifications of B -Type Lettering

Specifications	Value	Size (mm)						
Capital letter height	h	2.5	3.5	5	7	10	14	20
Lowercase letter height	$a = (7/10)h$	-	2.5	3.5	5	7	10	14
Thickness of lines	$b = (1/10)h$	0.25	0.35	0.5	0.7	1	1.4	2
Spacing between characters	$c = (1/5)h$	0.5	0.7	1	1.4	2	2.8	4
Min. spacing b/n words	$d = (3/5)h$	1.5	2.1	3	4.2	6	8.4	12
Min. spacing b/n baselines	$e = (7/5)h$	3.5	5	7	10	14	20	28

Standards and Conventions

Standards and Conventions

No effective communication without an agreed upon standard of signs or symbols.

Standards and conventions are the **alphabet** of technical drawing, and plane, solid, and descriptive geometry are the **science(grammar)** which underlies the graphics language.

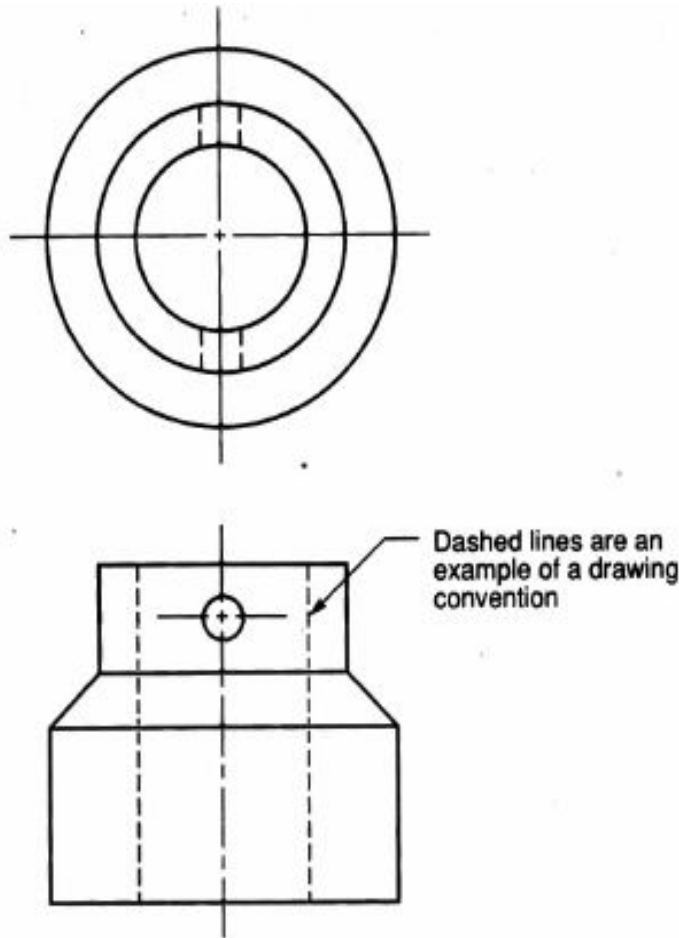
Following the standard rules (**grammar**) of any language (Hindi/English) - **communication** of thought between people becomes **easier**.

If words in a sentence were presented randomly - understanding becomes very difficult.

For effective communication of technical (graphics) information- set of standards and conventions - **a must**.

Standards and Conventions - very important

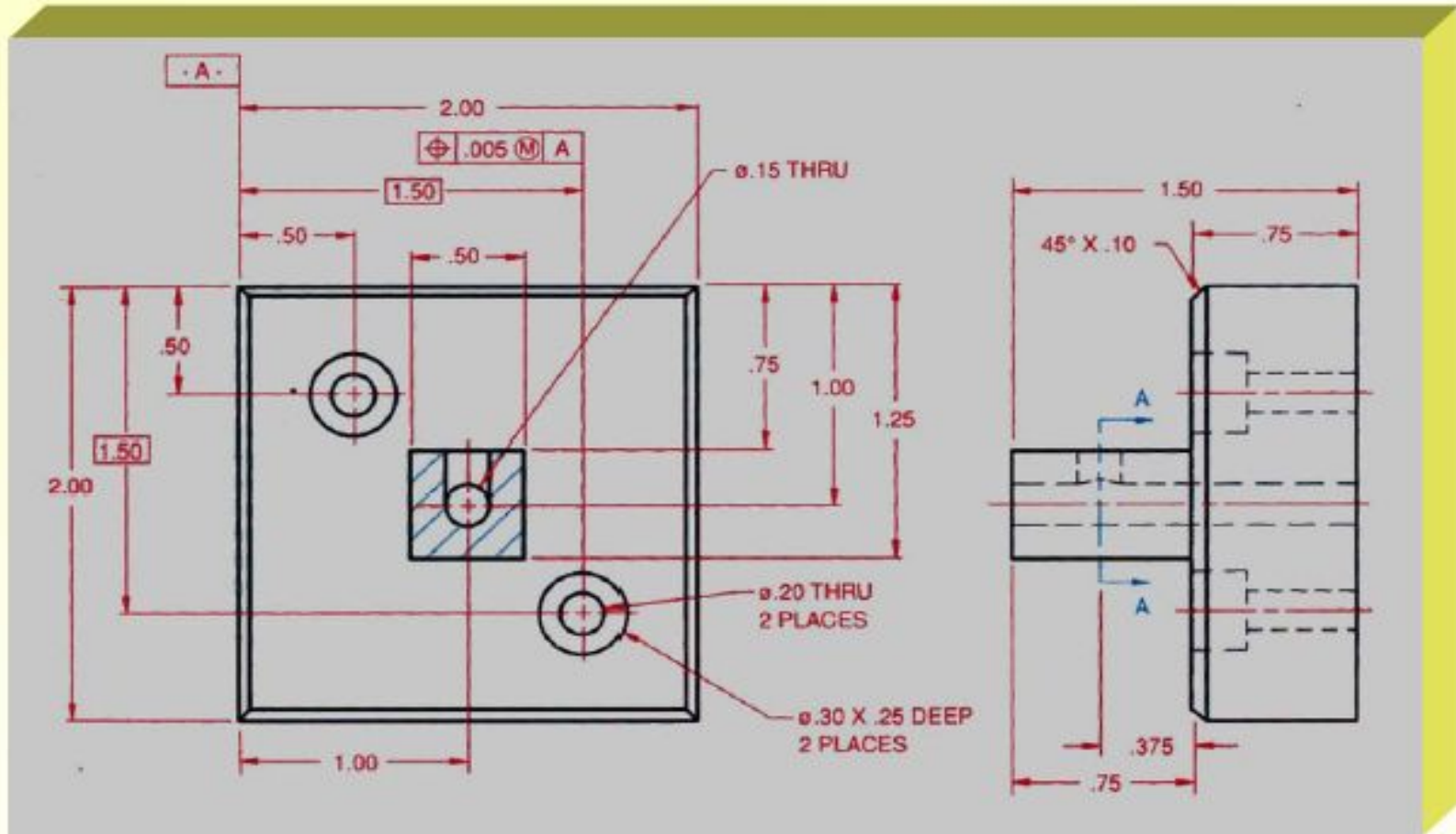
Conventions - commonly accepted practices, rules, or methods.



Dashed lines are used to represent **hidden features** of an engineering drawing.

Hidden lines - location of drilled hole's diameter, in **a view where the hole cannot be directly seen.**

Standards - set of rules that govern how technical drawings are represented.



Drawings are dimensioned using an accepted set of standards such as placing the dimension text such that it is read from the bottom of the sheet.

Drawing standards

ANSI - American National Standards Institute

ANSI Y14.1 1980 (R1987) - Drawing sheet size
and format

ANSI Y 14.2M-1979 (R1987) - Line conventions
and lettering

ANSI Y14.5M-1982(R1988) - Dimensioning and
tolerances

ANSI Y 14.3-1975(R1987) - Multi view and sectional view drawings

ISO - International Standards Organization

JIS - Japanese Standards

BIS - Bureau of Indian Standards

Units of Measure

International systems of units (SI) - which is based on the meter.

Millimeter (mm) - The common SI unit of measure on engineering drawing.

Individual identification of linear units is not required if all dimensions on a drawing are in the same unit (mm).

The drawing shall however contain a note:

ALL DIMENSIONS ARE IN MM. (Bottom left corner outside the title box)

Dimensioning

Indicating on a drawing, the size of the object and other details essential for its construction and function, using lines,numerals, symbols, notes, etc.

Dimensions indicated on a drawing should be those that are essential for the production, inspection and functioning of the object and should not be mistaken as those that are required to make the drawing of an object.

Dimensioning of an object is accomplished by dimensioning each element to indicate **its size (size dimensions)** and **relative location (location dimensions)** from a center line, base line or finished surface.

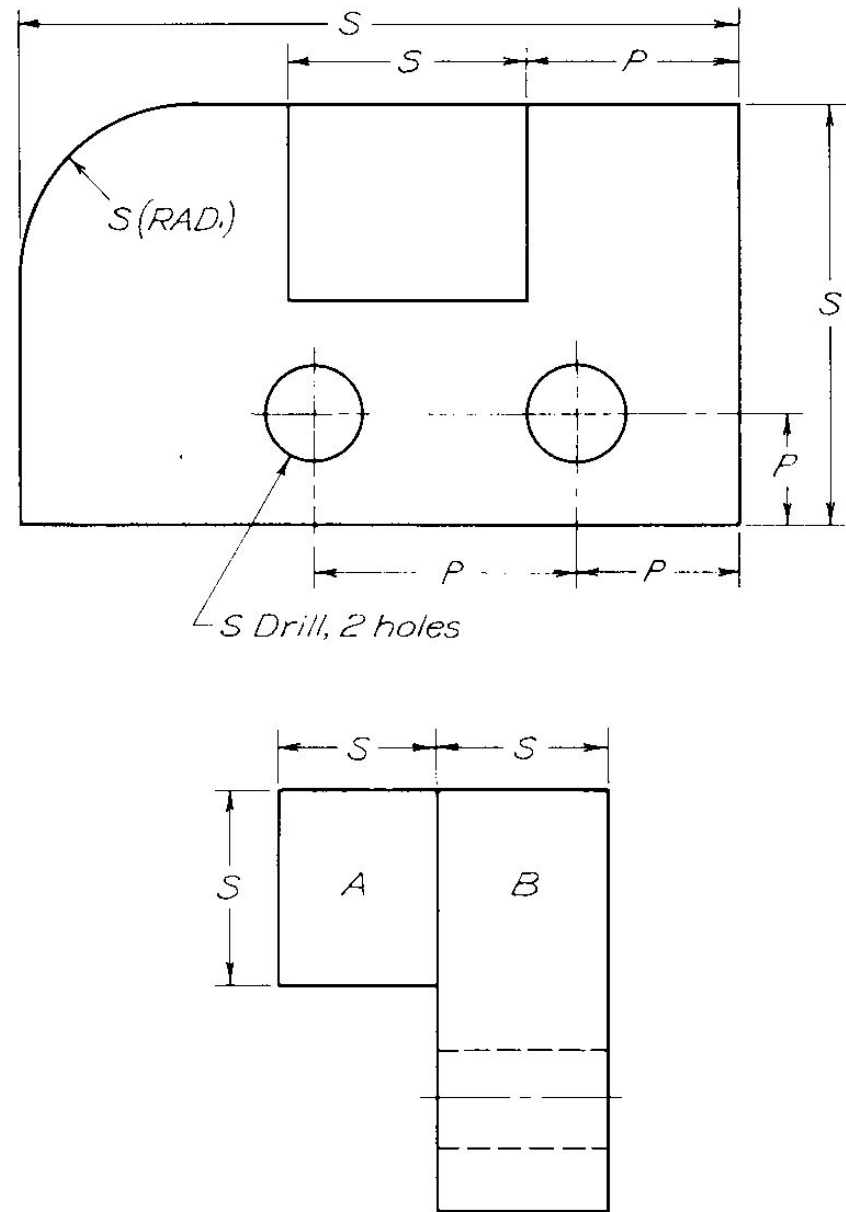


FIG. 19. Dimensions of size and position. S indicates size, P position.

Each feature is dimensioned and positioned only once.

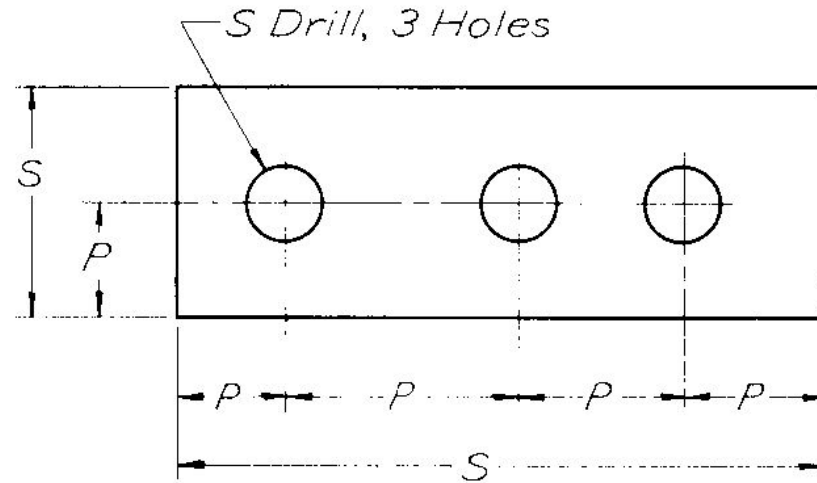


FIG. 24. One unnecessary dimension.

Each feature is dimensioned and positioned where its shape shows.

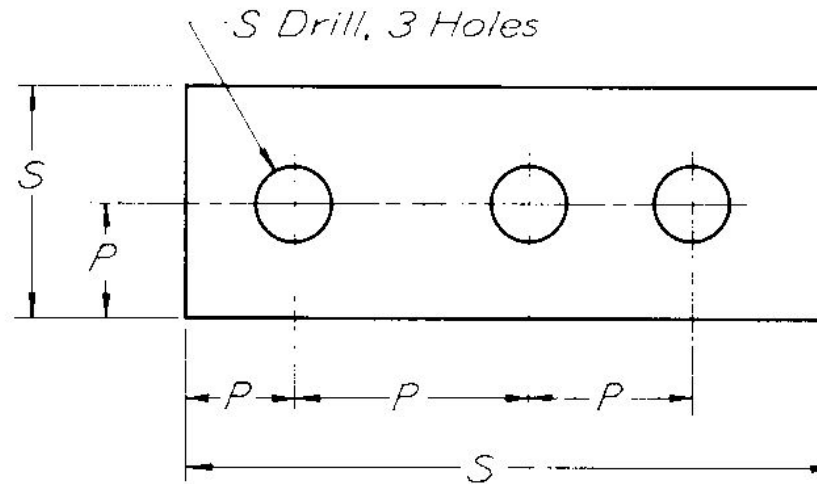
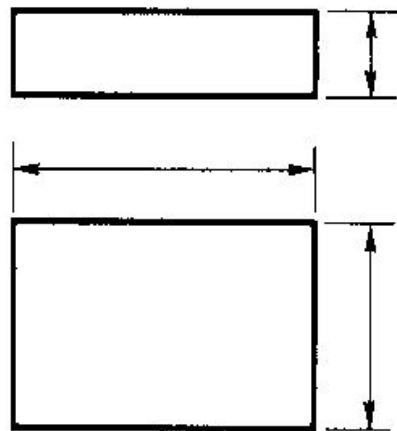
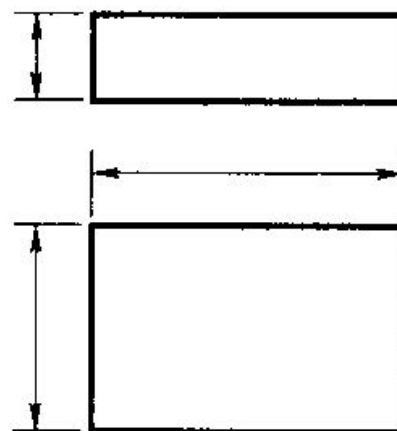


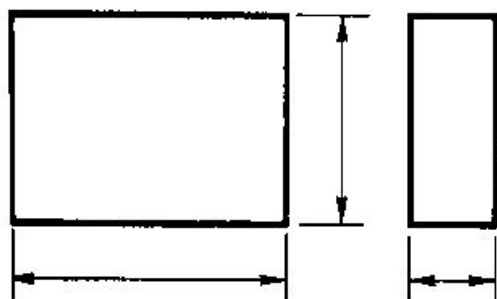
FIG. 25. Unnecessary dimension omitted.



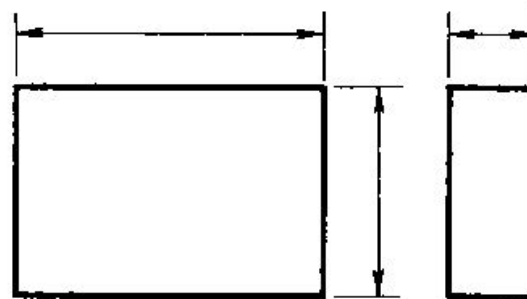
(a)



(b)



(c)



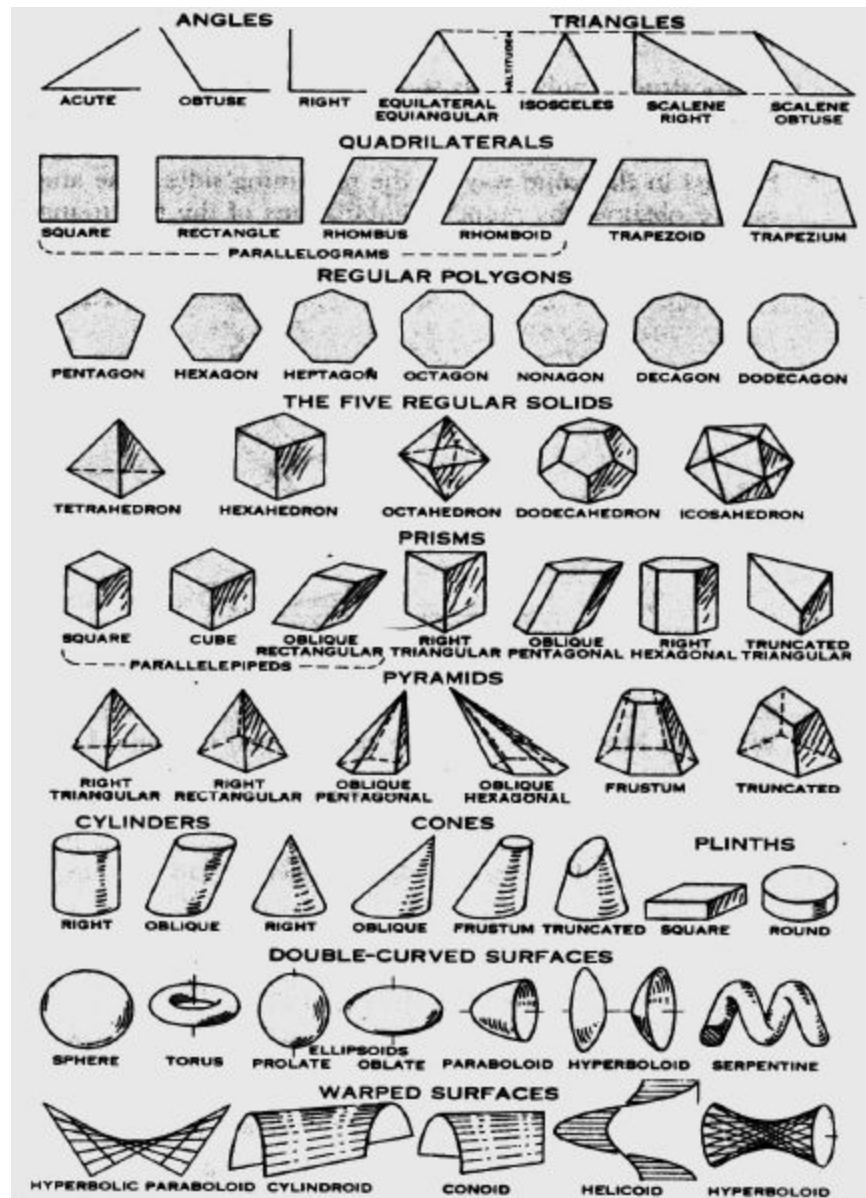
(d)

Fig. 11.24 Dimensioning Rectangular Prisms.

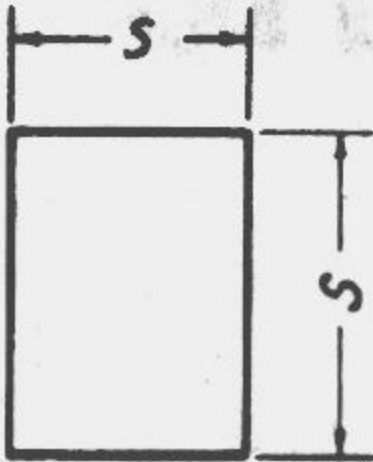
Size dimensions – give the size of the component.

Solid:

Every solid has three dimensions, each of the geometric shapes making up the object must have its **height**, **width**, and **depth** indicated in the dimensioning.



Basic geometric shapes used in drawing



Prism

Prism - most common shape
requires **three dimensions** -
give two dimensions on the
principal view and one
dimension on the other
views.

Cylinder

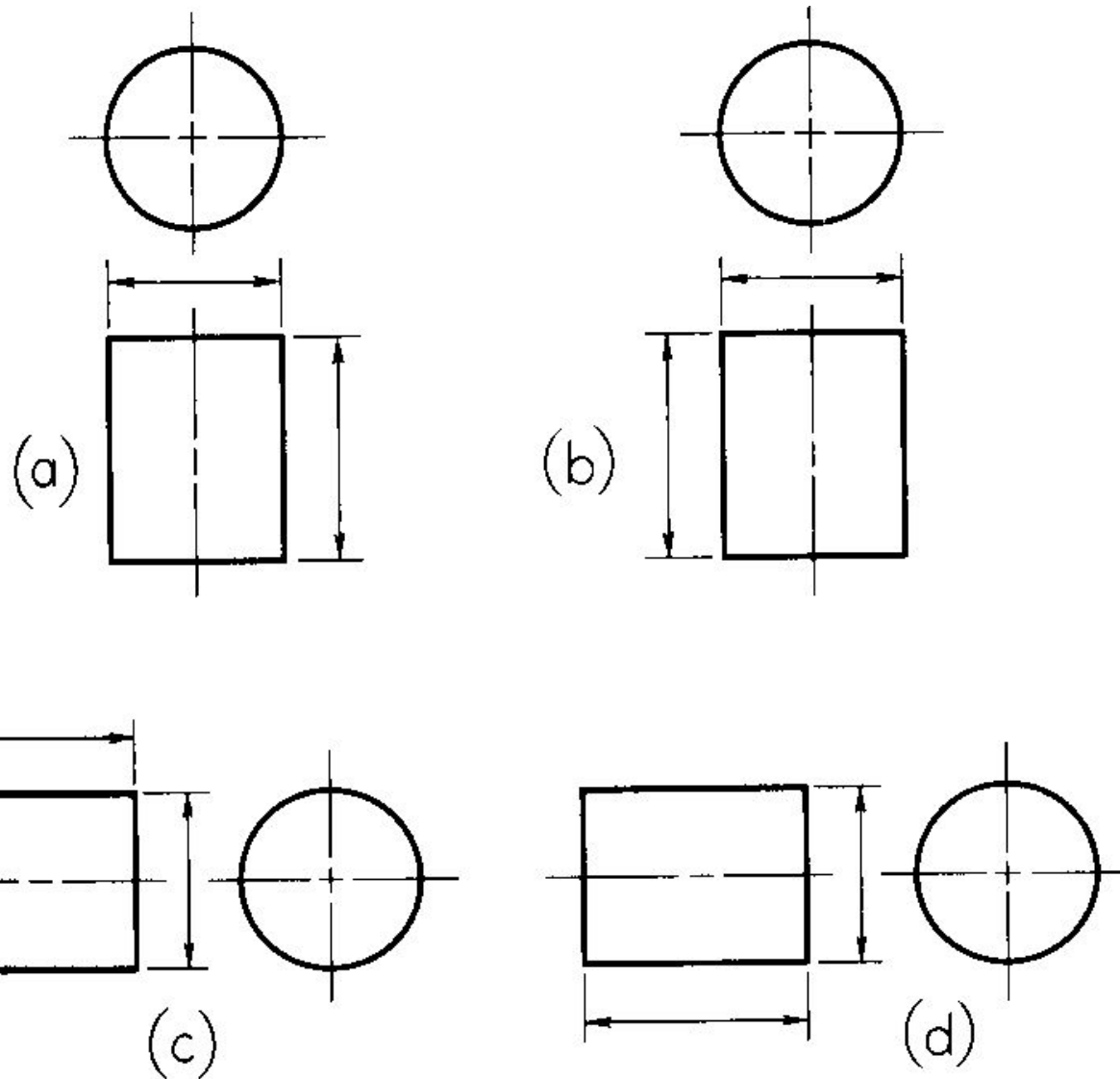
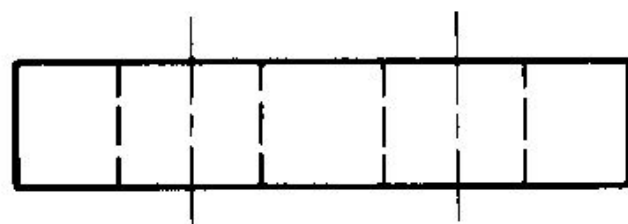
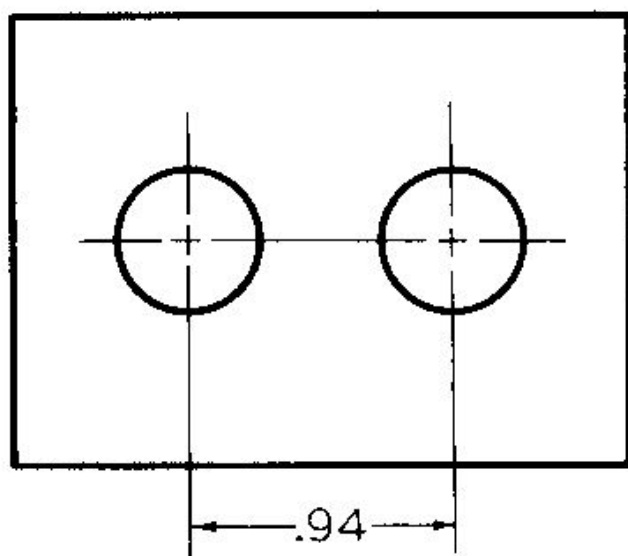
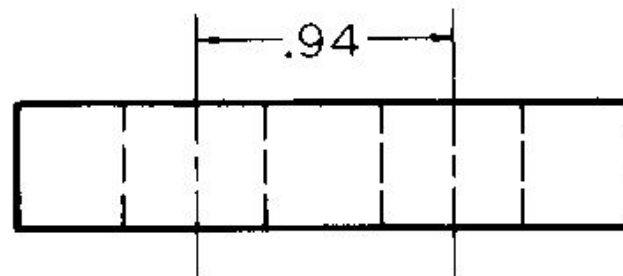
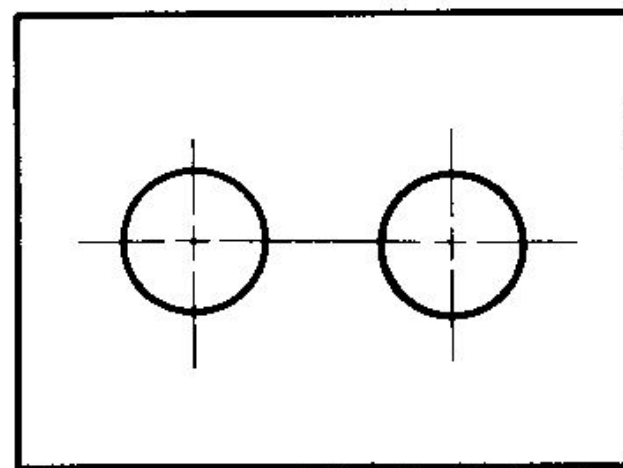


Fig. 11.26 Dimensioning Cylinders.



CORRECT

(a)



POOR PRACTICE

(b)

Fig. 11.32 Locating Holes.

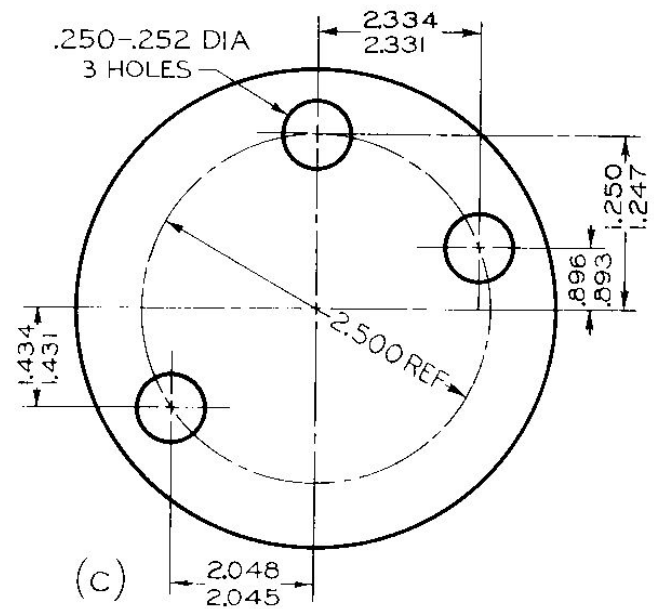
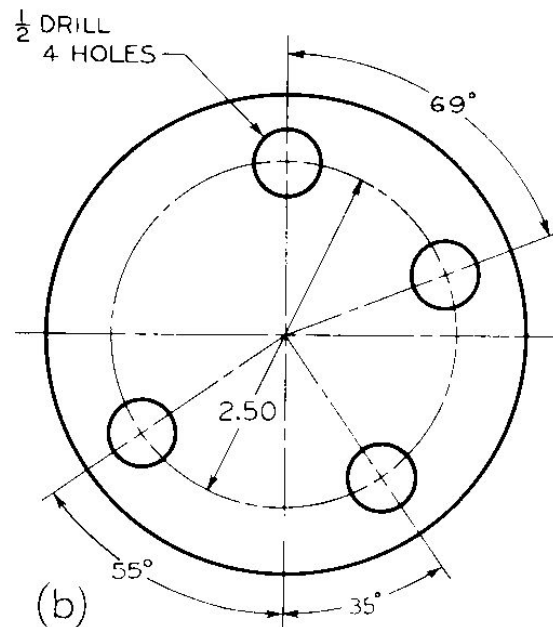
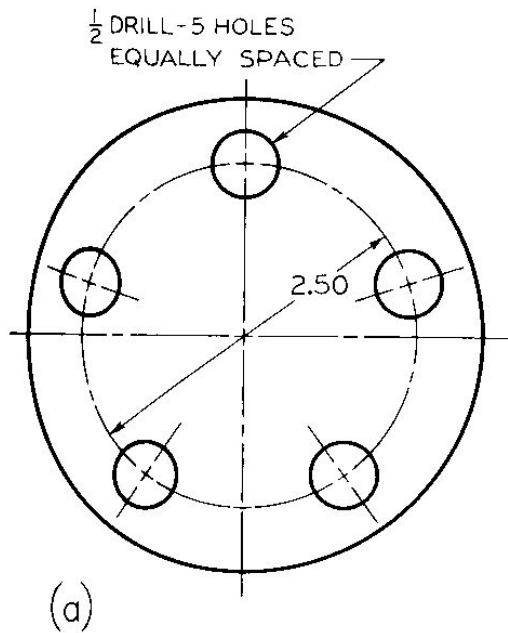


Fig. 11.34 Locating Holes About a Center.

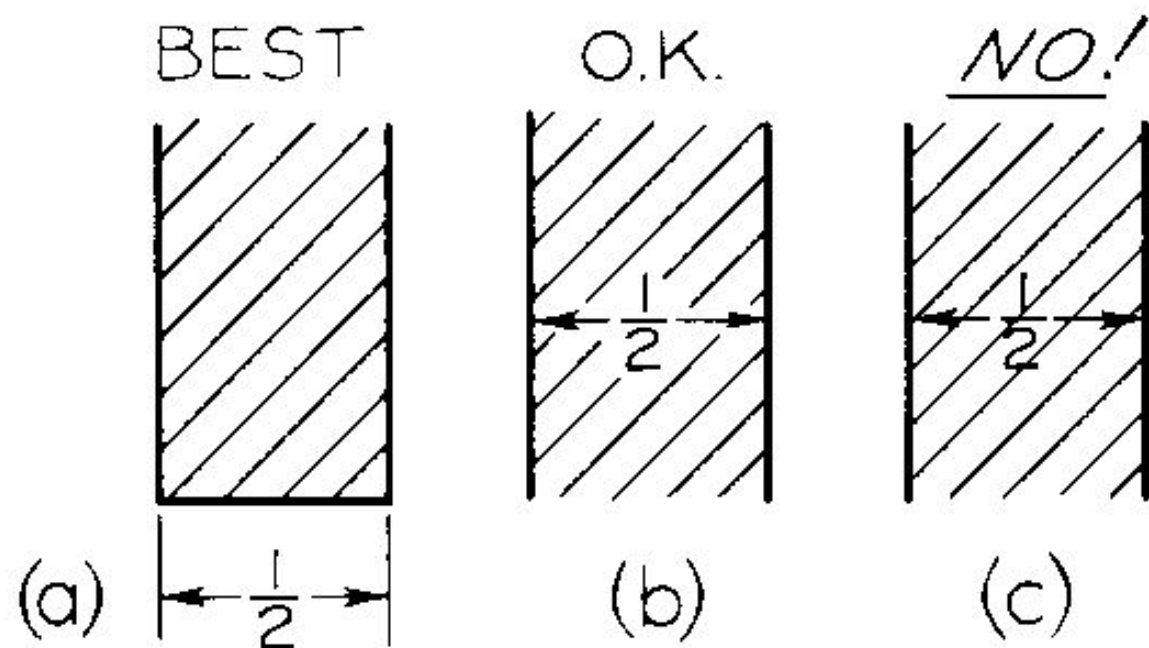
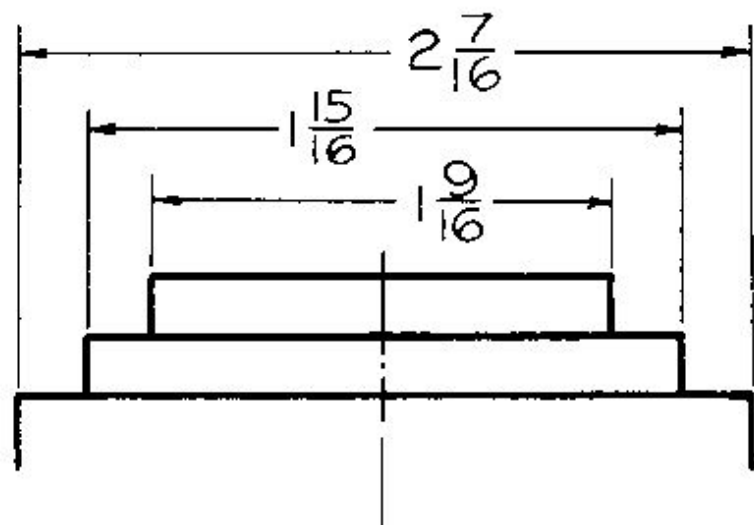
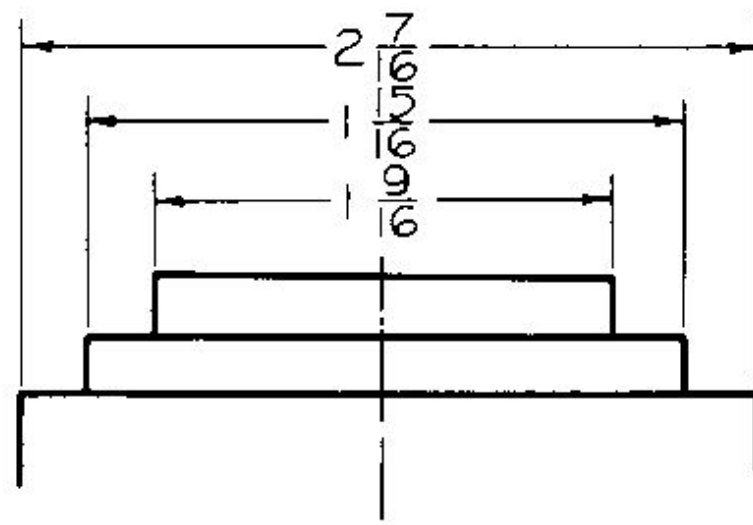


Fig. 11.13 Dimensions and Section Lines.



PREFERRED

(a)

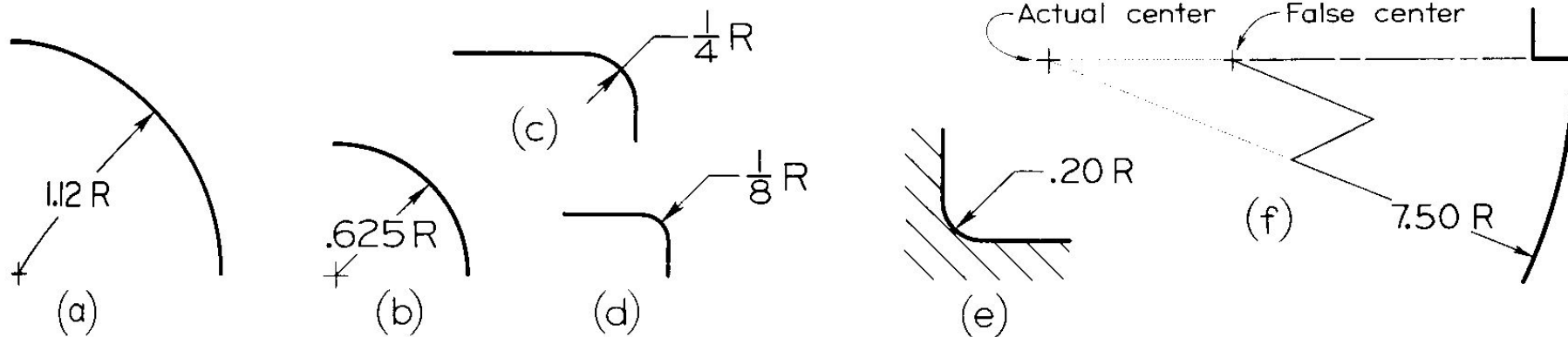


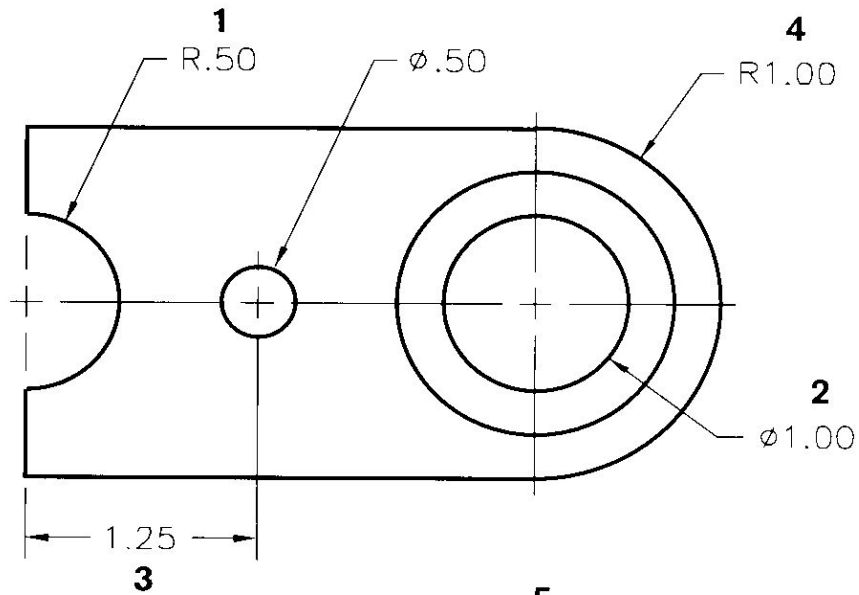
POOR PRACTICE

(b)

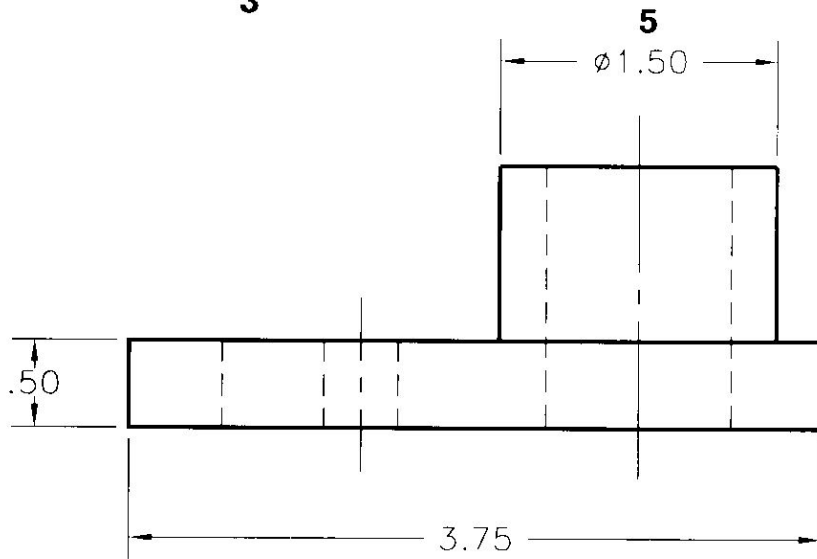
Fig. 11.14 Staggered Numerals.

Fig. 11.19 Dimensioning Arcs.





1. Give radius of arcs.
2. Give diameters of circles.
3. Locate holes where you see their circular shapes.
4. Rounded ends are self locating.
5. Dimension the diameters of cylinders where they appear rectangular.



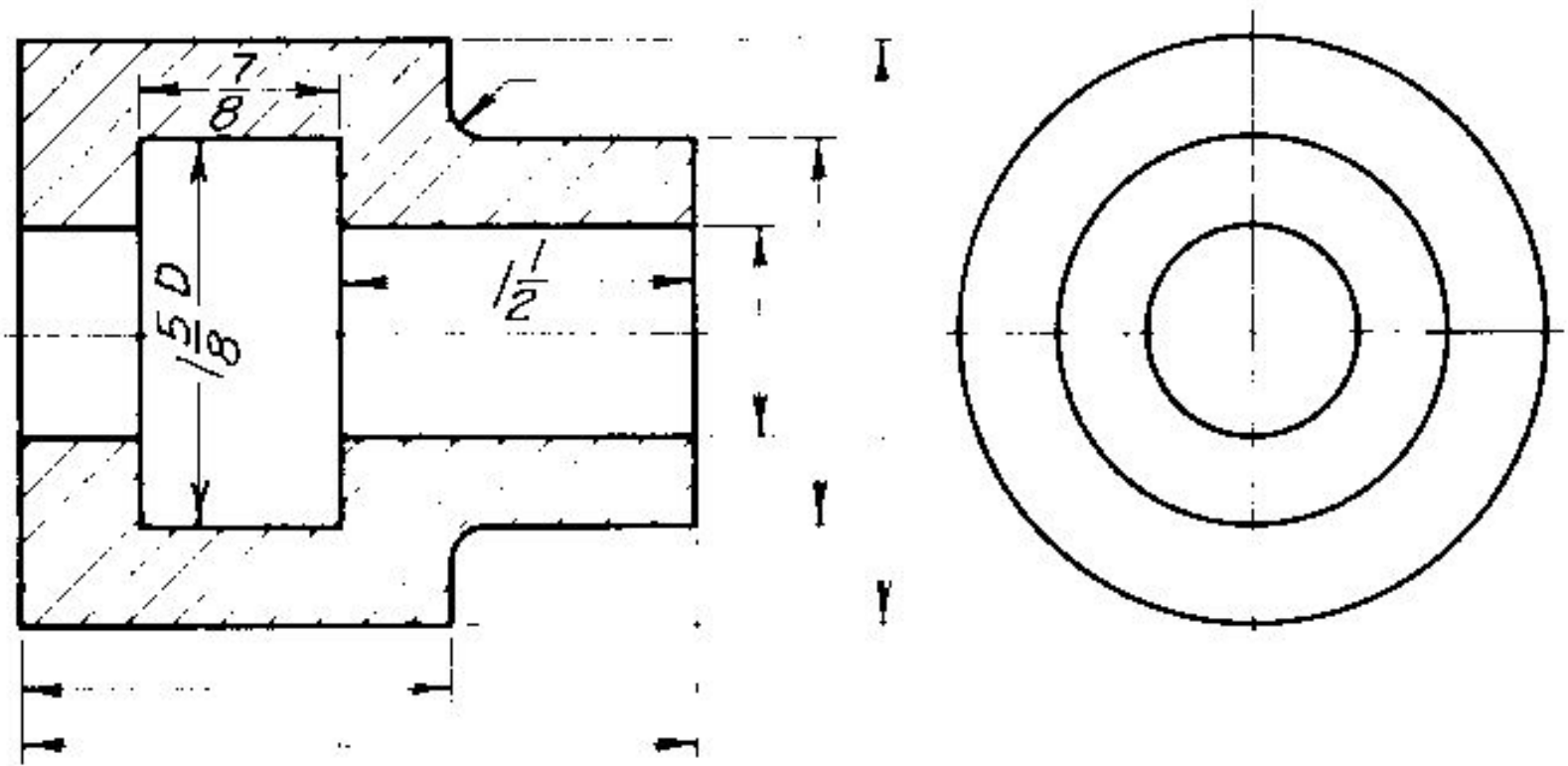
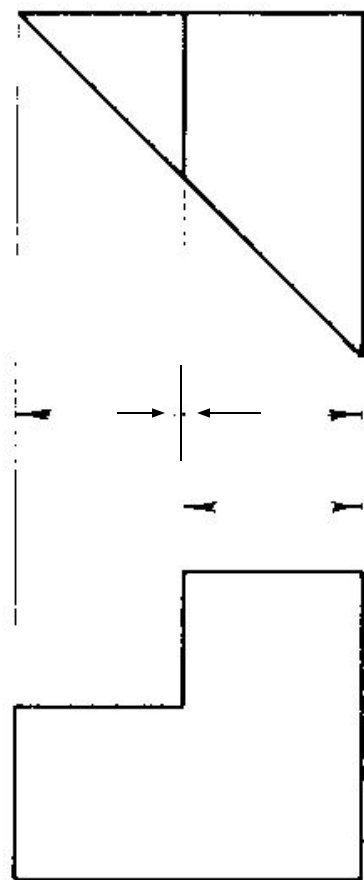
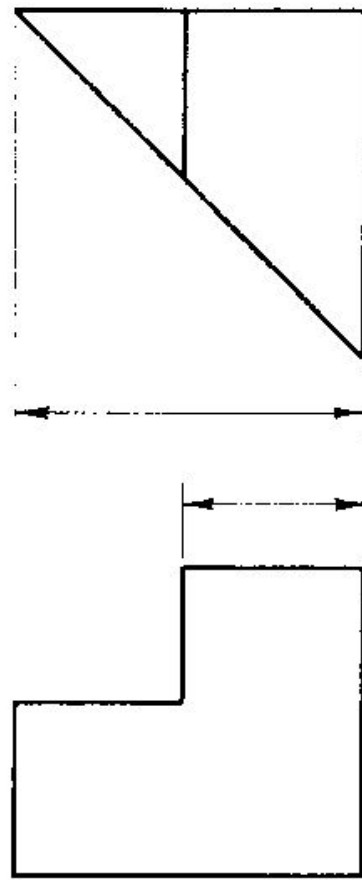


FIG. 31. Dimensions inside the view.



Avoid



Correct

FIG. 32. Dimensions applied to one view only.

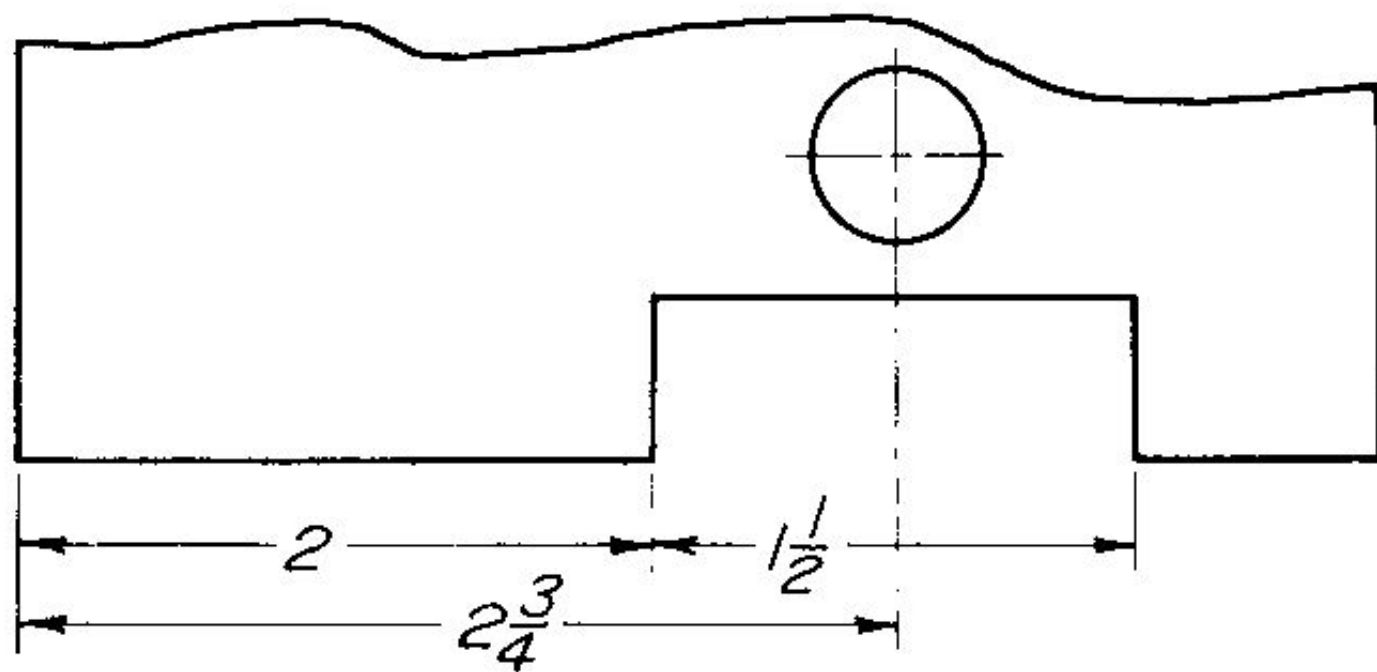


FIG. 34. Values midway between arrow-heads.

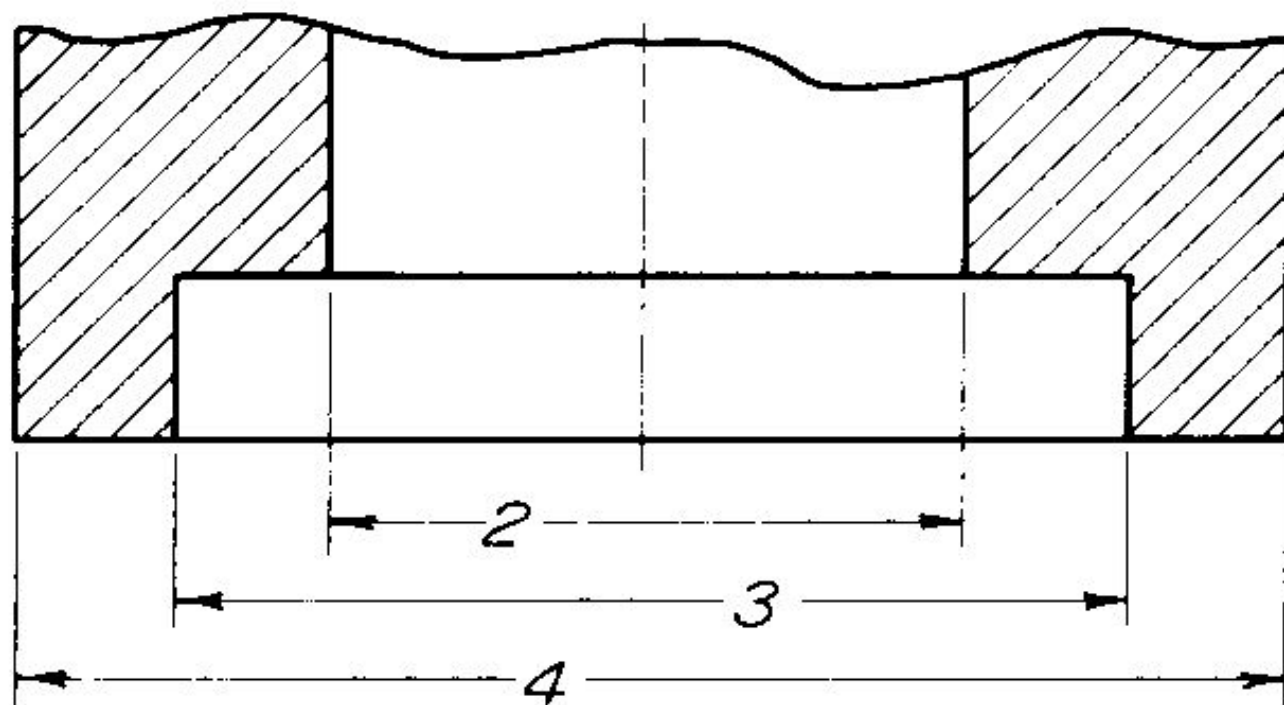
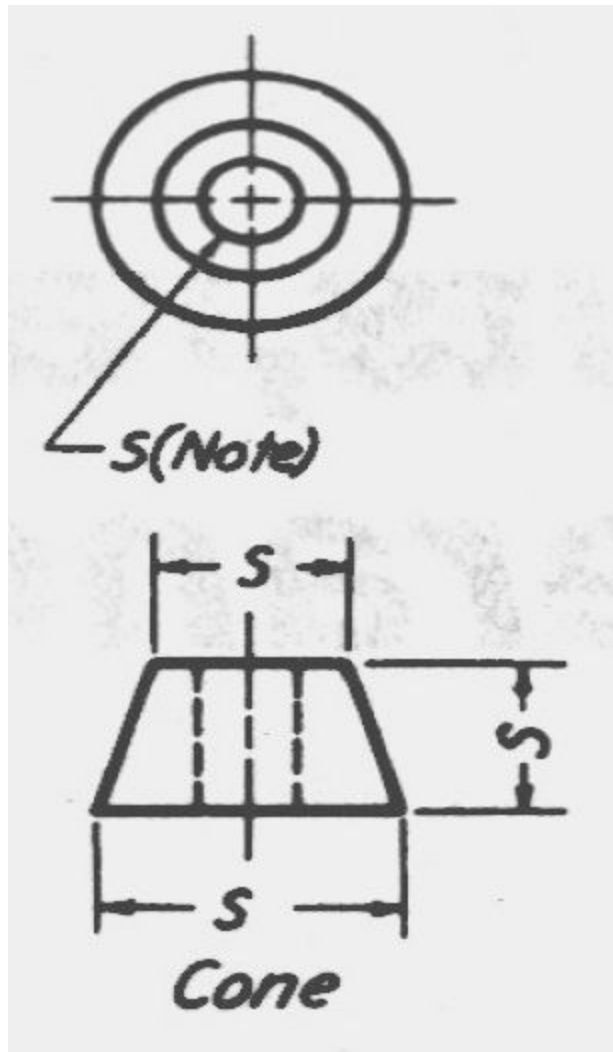
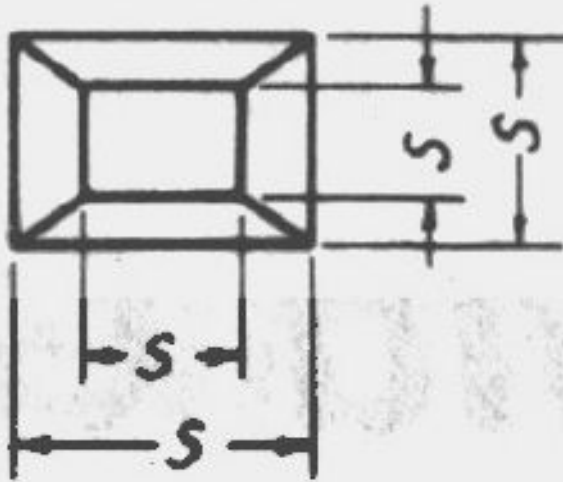


FIG. 35. Values staggered for clarity.



Cone - requires two dimensions - **diameter of the base** and altitude on the same view and length - both are shown preferably on the rectangular view.



Pyramid

Right pyramids -
requires three
dimensions -
dimensions of the
base and altitude.

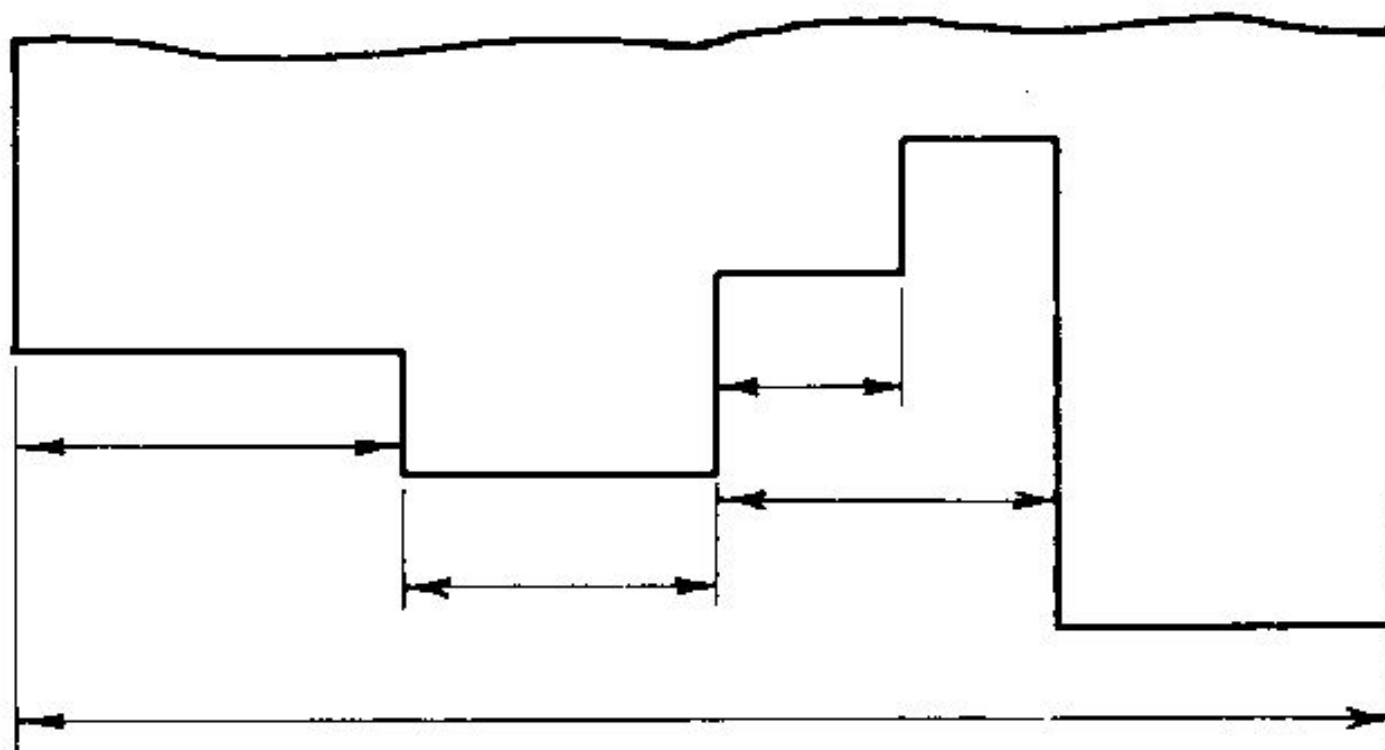
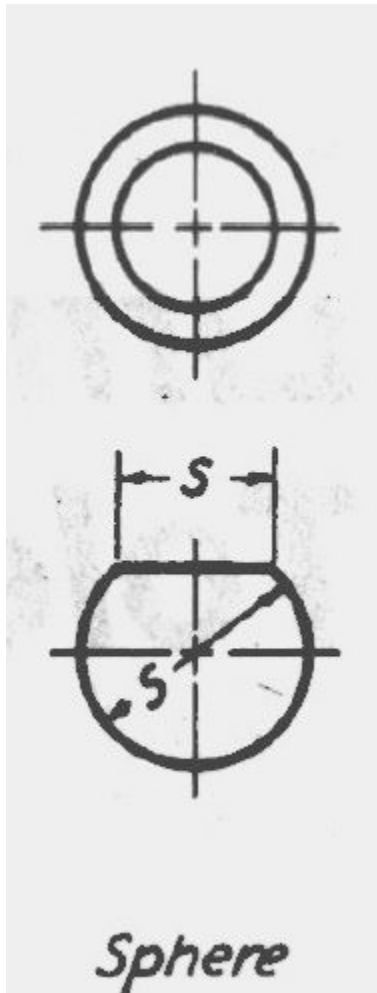


FIG. 37. Dimensions staggered.



Spheres - requires
only one dimension - diameter.

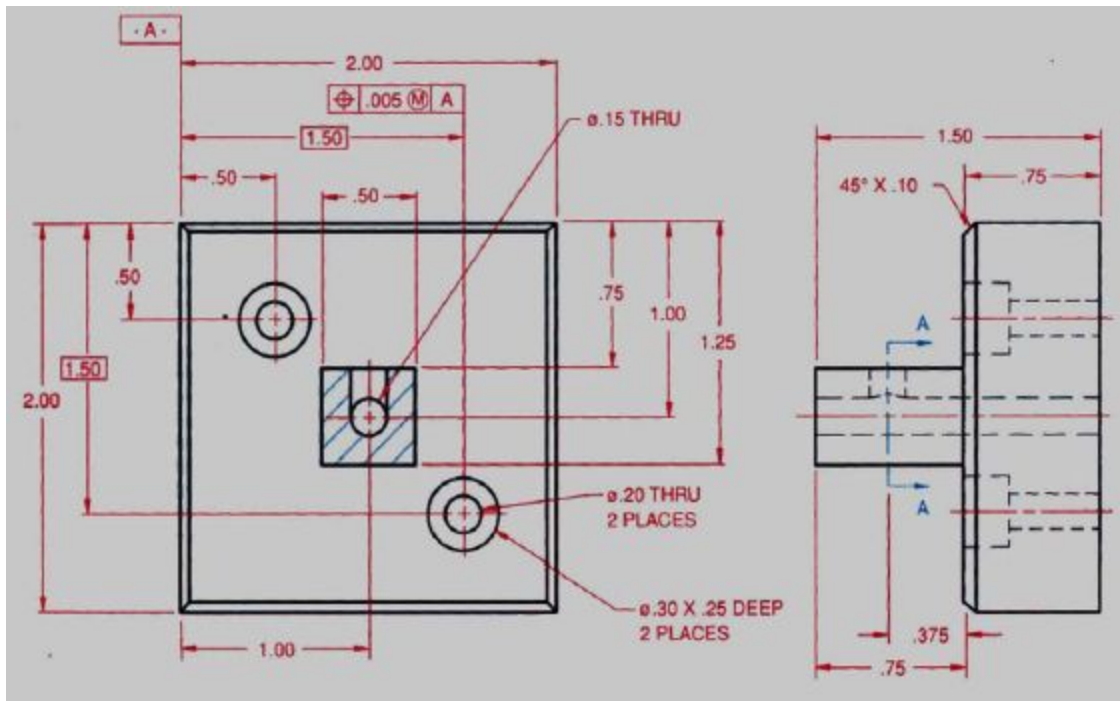
Location dimensioning

After the basic geometric shapes have been dimensioned for size, the location of each relative to the others must be given.

Locations must be established in height, width and depth directions.

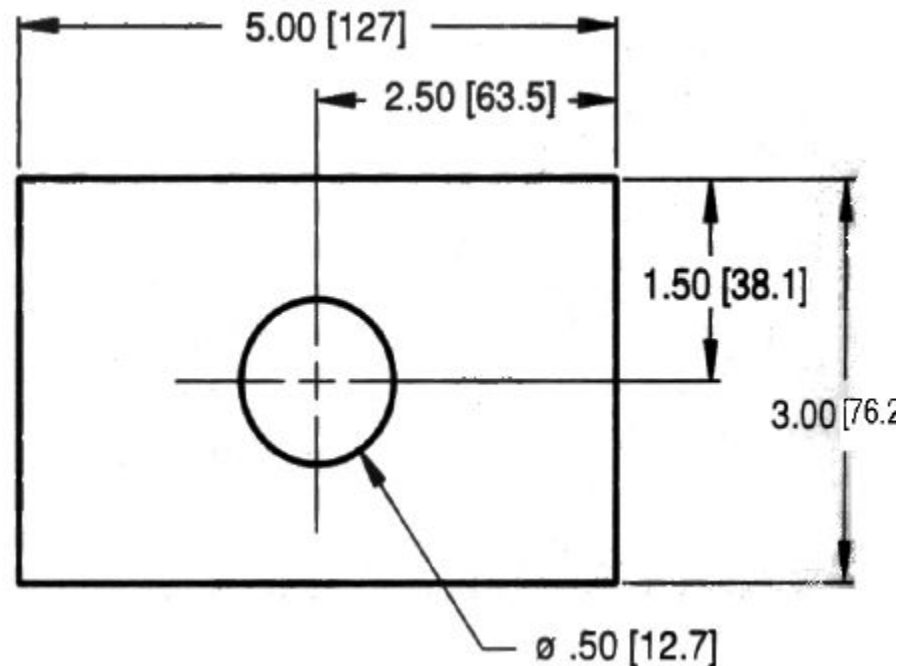
Rectangular faces are positioned with reference to their faces, cylinder and conic shapes with reference to their center lines and their ends.

Size and Location dimensioning



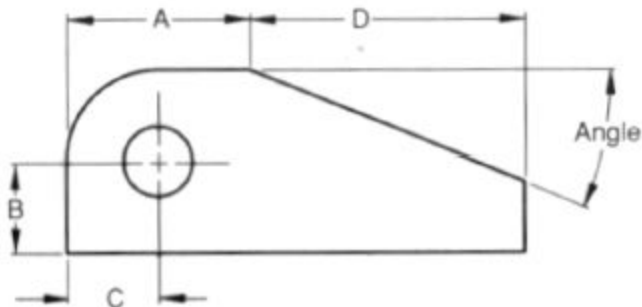
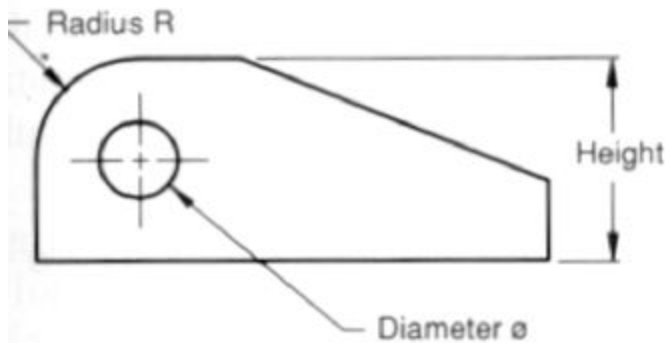
Terminology for dimensioning practice

Dimension - numerical value that defines the size or geometric characteristics of a feature - size 3.5 mm and space between lines of text 1.5 mm.





Dimensions showing the sizes of features, such as width, height and depths of the parts and the diameter of the hole



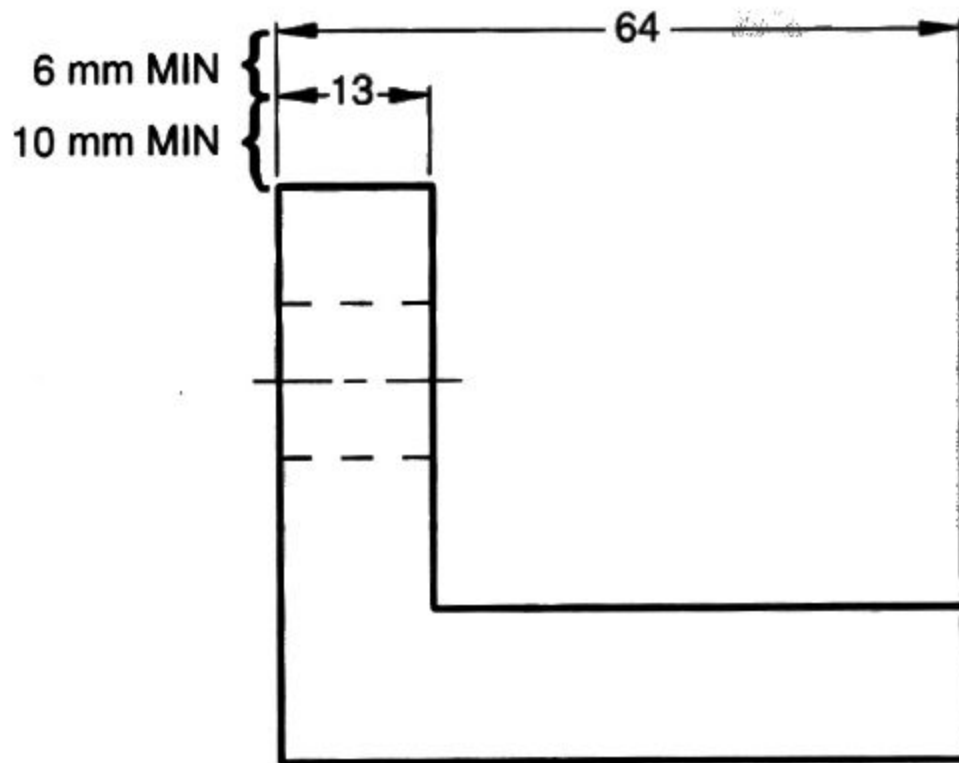
Dimensions showing the location and orientations of features, such as location of the center of the hole

Basic dimension - a numerical value defining theoretically exact size of a feature.

Reference dimension - a numerical value enclosed in parenthesis, provided for information only and not directly used in the fabrication of the part - is a calculated size used to show the intended design size of a part.

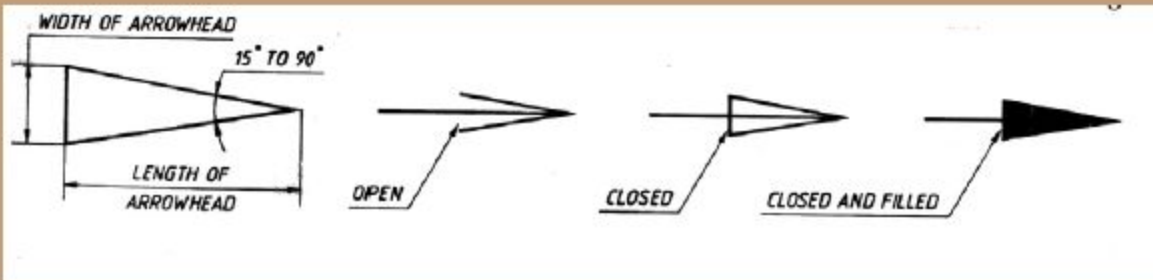
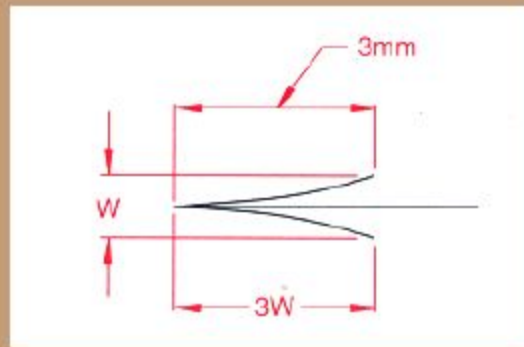
Dimension line

A thin, solid line that shows the extent and direction of a dimension. Dimension lines are broken for insertion of the dimension numbers.



Should be placed at least 10 mm away from the outline and all other parallel dimensions should be at least 6 mm apart, or more if space permits

Arrows - 3 mm wide and should be 1/3rd as wide as they are long - symbols placed at the end of dimension lines to show the limits of the dimension. Arrows are uniform in size and style, regardless of the size of the drawing.



Extension line - a thin, solid line perpendicular to a dimension line, indicating which feature is associated with the dimension.

Visible gap - there should be a visible gap of **1.5 mm** between the feature's corners and the end of the extension line.

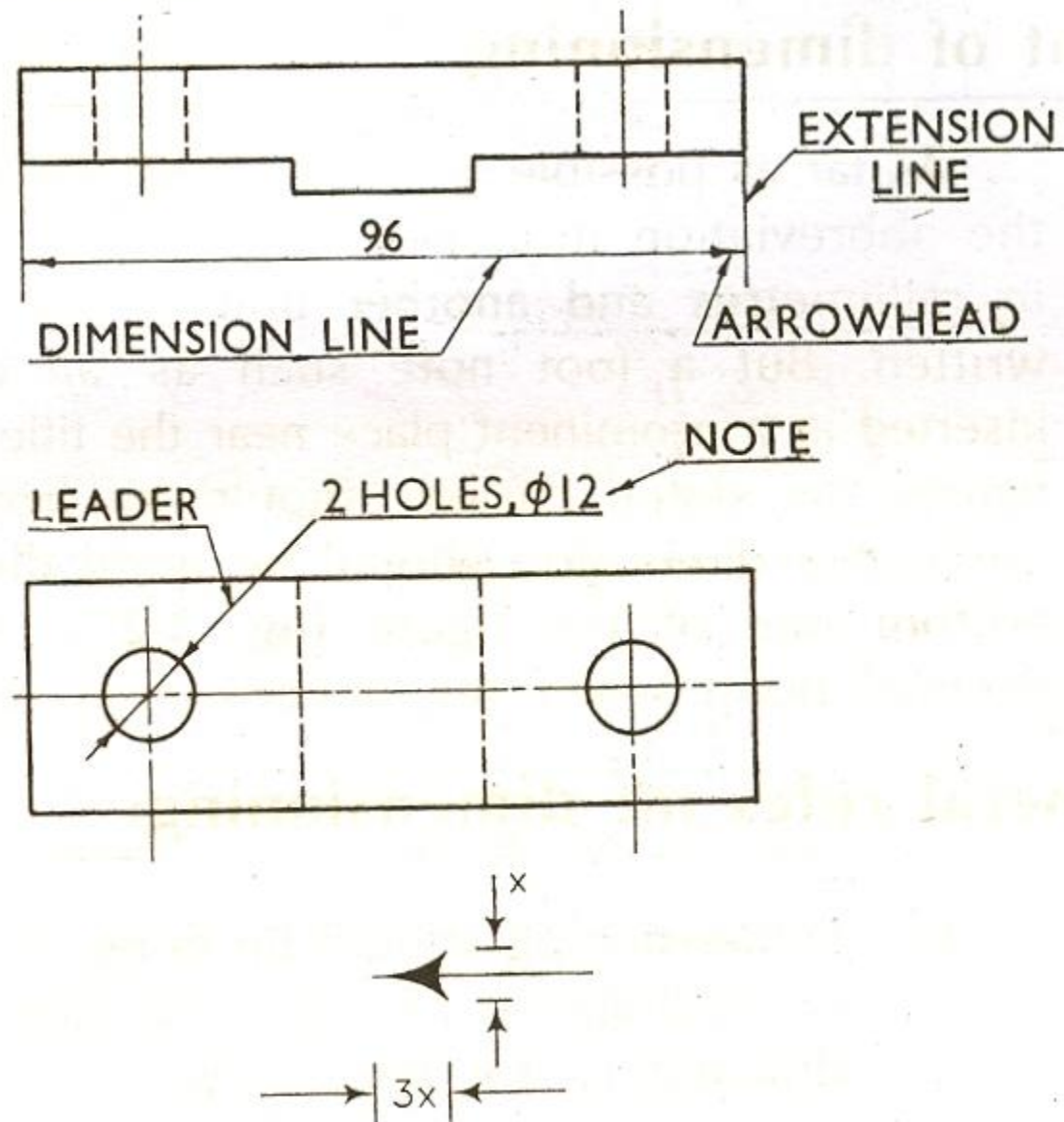
Leader line

- A thin, solid line used to indicate the feature with which a dimension, note, or symbol is associated.
- Generally a straight line drawn at an angle that is neither horizontal nor vertical.
- Terminated with an arrow touching the part or detail.
- On the end opposite the arrow, the leader line will have a short, horizontal shoulder. Text is extended from this shoulder such that the text height is centered with the shoulder line.

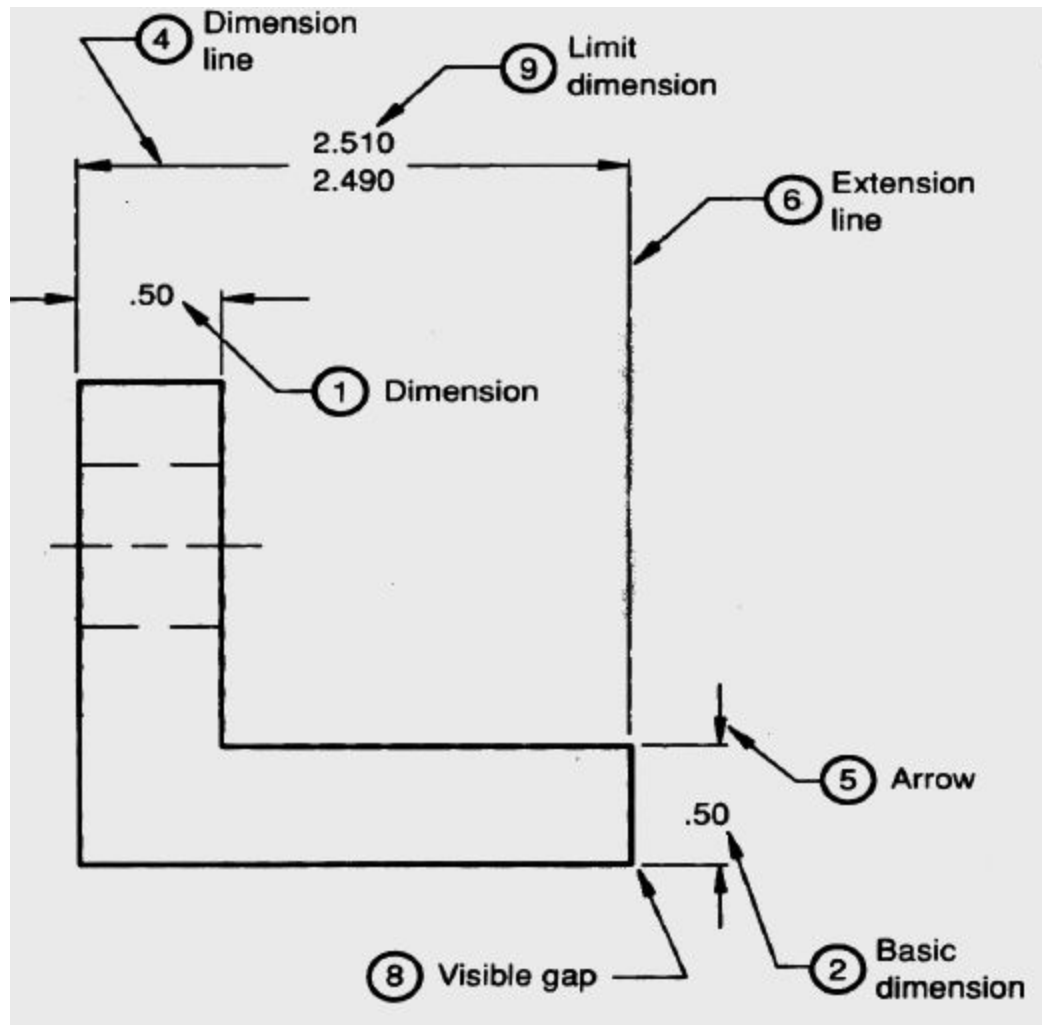
Diameter symbol - φ - a symbol which precedes a numerical value, to indicate that the dimension shows the diameter of a circle.

Radius symbol - R 0.5

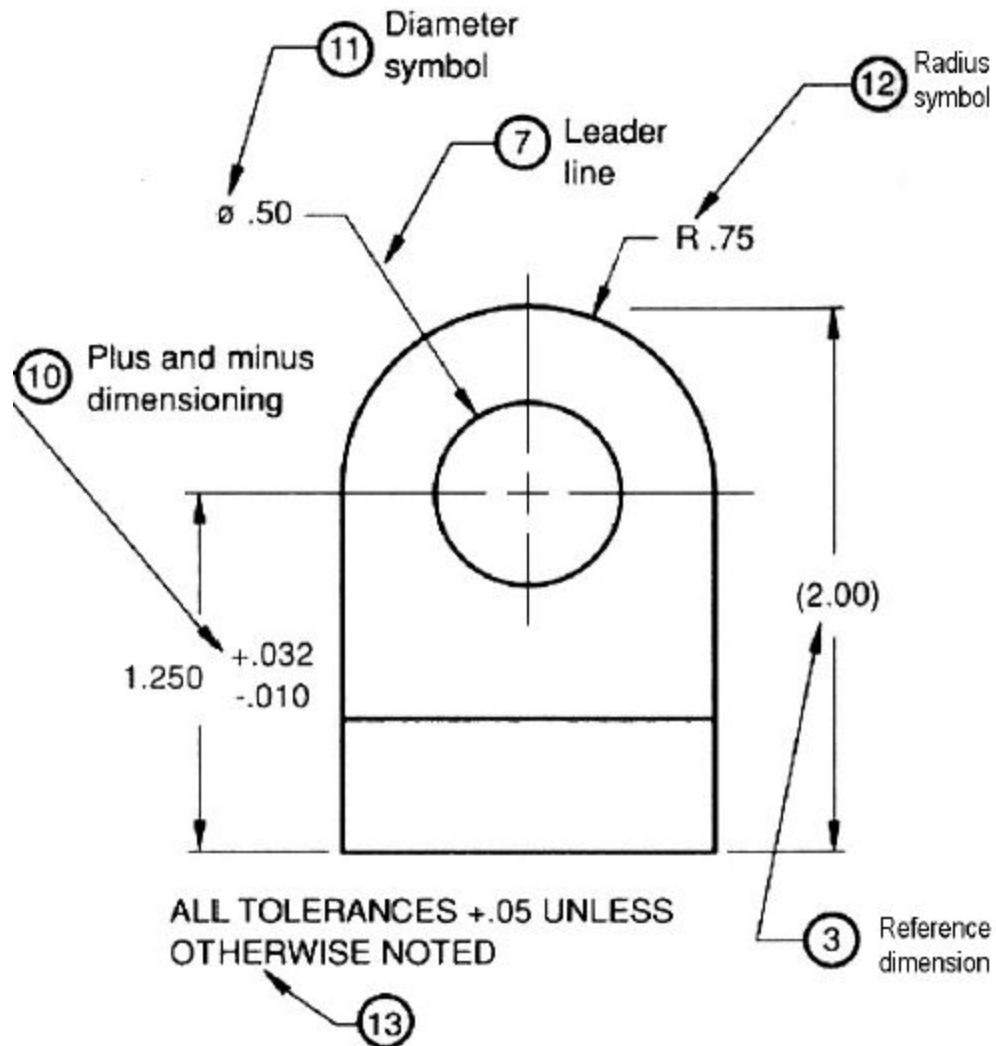
OF THE IMAGE.



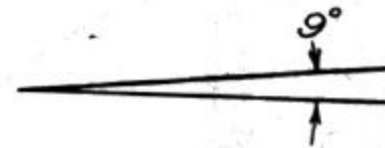
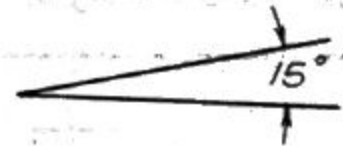
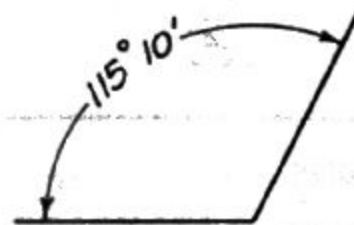
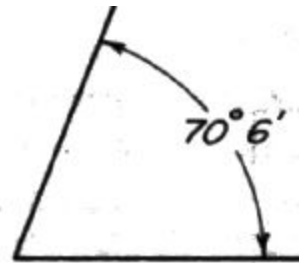
Various types of dimension lines



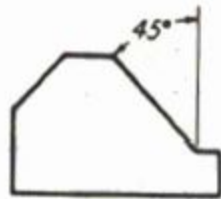
Important elements of a dimensioning



Important elements of a dimensioning

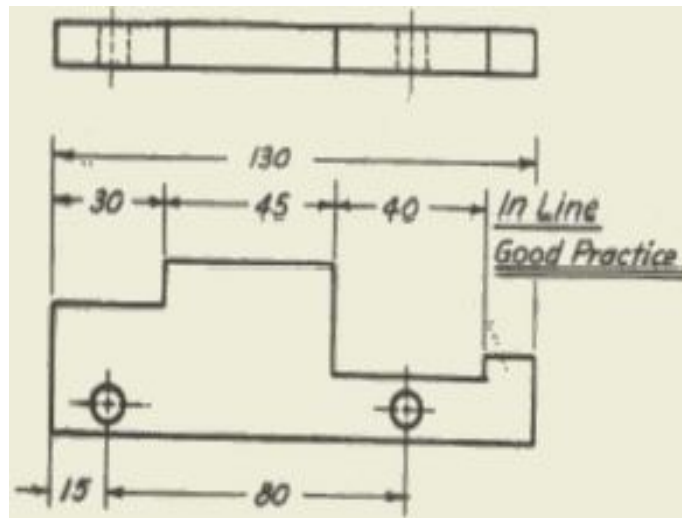


Correct

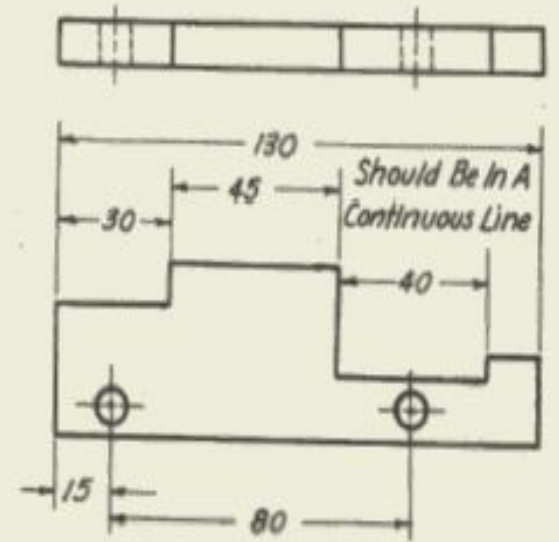


Not Recommended

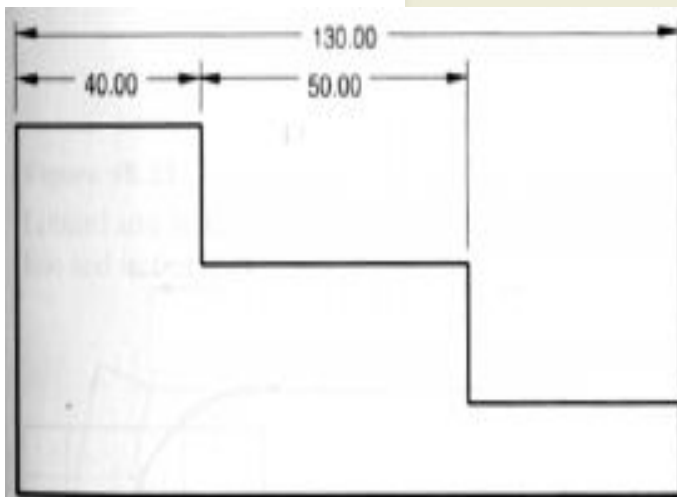
Dimensioning of angles



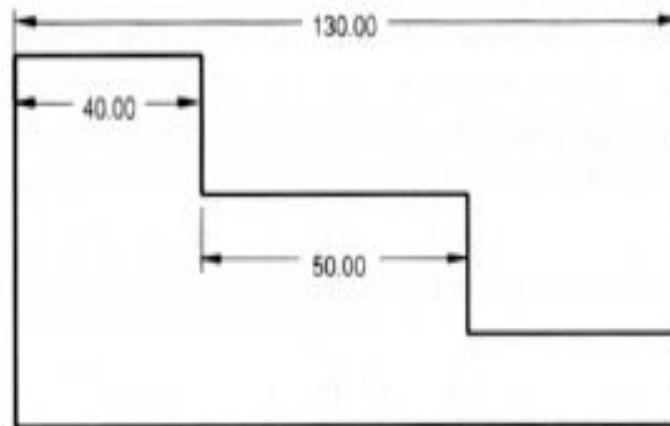
(a) Correct



(b) Incorrect



(A) Yes



(B) No!

Correct way of dimensioning

How to begin your drawing?

- Clean the drawing board and all the drawing instruments using duster.
- Fix the drawing sheet on the drawing board.
- Fix the mini-drafter in a convenient position.
- Draw border lines using HB pencil.
- Complete the title box using HB pencil .
- Plan spacing of drawings b/n two problems/views beforehand.
- Print the problem number on the left top and then
- commence the drawing work.

Thank you

Source:

Engineering Graphics Communication, Gary R. Betoline, IRWIN
Graphics Series

Engineering Drawing: plane and Solid Geometry, N.D. Bhatt, Charotar
Publishing House, Anand