18MES101L
ENGINEERING GRAPHICS AND DESIGN

Course Code	18MES101L	Course Name	ENGINEERING GRAPHICS AND DESIGN	Course Category	S	Engineering Sciences	L	T	P	C
							1	0	4	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR): *The purpose of learning this course is to:*

		Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Utilize engineering graphic fundamentals. apply the same to draw/evaluate engineering curves and projection of objects			
CLR-2 :	Draw projection of solid objects like prisms, cylinders, pyramids and cones used in various engineering objects			
CLR-3 :	Draw the projection of combination of solids, and section of solids. Create building plans for construction			
CLR-4 :	Create 3D part models. Develop its surfaces using solid-modeling software for effectiveness, clarity, accuracy, portability			
CLR-5 :	Evaluate the assembly of engineering component parts. Create 2D drawings for assembly of engineering components			
CLR-6 :	Draw, Create, Evaluate, Interpret engineering 2D and 3D surfaces of engineering components using modeling software			

Course Learning Outcomes (CLO): *At the end of this course, learners will be able to:*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - I	PSO - II	PSO - III
CLO-1 :	Identify engineering graphics. Draw objects like points, lines, planes, and solids in perspective & orthographic projections	3	90	85	H	H	L	L	L	H	L	H	L	H	L	L	L	L	L
CLO-2 :	Draw projection of solids like prism, cylinder, pyramid and cone inclined in general positions, obtain auxiliary views	2	95	90	M	M	L	L	M	H	H	L	L	H	L	L	L	L	L
CLO-3 :	Draw projection of combination of solids made out of primitives, draw the section of solids, create building plans	3	90	85	H	H	M	M	H	H	H	H	M	H	L	H	L	L	L
CLO-4 :	Create 3D part models. Develop its surfaces with solid modeling software for effectiveness, clarity, accuracy, portability	3	90	85	H	H	H	H	H	H	H	L	H	H	L	H	M	L	M
CLO-5 :	Evaluate the assembly of parts including interference of parts. Create 2D drawings of assembly of parts	3	85	80	H	H	M	H	H	H	H	H	L	H	L	H	L	M	L
CLO-6 :	Draw graphics of engineering pans with point, line, plane, solids, in perspective and orthographic projections	2	90	85	M	M	L	M	L	L	L	H	L	L	L	L	L	L	L

		Engineering graphics and Projection	Projection of solids using CAD software	Projections of combination of solids	Part Modeling and Drawing	Assembly Modeling and Drawing
Duration (hour)		15	15	15	15	15
S-1	SLO-1	Principles, Standards, Conventions	Introducing CAD Software, layers, dimensions, tolerance, annotations	Combinations of solids, Constructive Solid Geometry(CSG), Boolean operations	3D modelling, parametric, non- parametric, parts of CSG, surface, wireframe, shaded	Part/ component model creation for assembly.
	SLO-2	Angle Projection, Symbols, Dimensions	Create, modify, customize, print using CAD	Creating combination of solids, isometric, perspective views, shaded, wire-frame	Rendered models, background, shadows, multi-view, isometric, perspective views	Study of various widely used assembly of parts like flanged joint, universal joint etc.
S-2	SLO-1	2D Geometric Constructions	Demo: Menu, Toolbars, Drawing Area, Dialog box, windows, Shortcut menus	Constructive Solid Geometry, Boolean operations, Creating combination of solids	3D modelling, parametric, non- parametric, parts of CSG, surface, wireframe, shaded	Creation of parametric parts for assembly
	SLO-2	2D Geometric Constructions	Command Line, Status Bar, Different zoom methods, Create, Select, Erase objects	isometric, perspective, shaded, wire-frame	Rendered models, background, shadows, multi-view, isometric, perspective views	non- parametric parts for assembly
S-3	SLO-1	Conic Curves ellipse by eccentricity method	Draw straight lines, rectangle, polar, absolute, relative	Constructive Solid Geometry, Boolean operations, Creating combination of solids	Viewing models in multi-view, isometric, and perspective views	Creation of parametric parts for assembly
	SLO-2	Conic Curves ellipse by eccentricity method	Orthographic constraints, Ortho ON, snap to objects manually, automatically	isometric, perspective, shaded, wire-frame	Viewing models in multi-view, isometric, and perspective views	non- parametric parts for assembly
S-4	SLO-1	Cycloids, Epicycloids	drawing lines, arcs, circles, polygons, create, edit, use layers, extend lines	Constructive Solid Geometry, Boolean operations, Creating combination of solids	Modelling industrial part drawings	Creation of parametric parts for assembly
	SLO-2	Hypocycloid	Dimensioning objects, annotations	isometric, perspective, shaded, wire-frame	Modelling industrial part drawings	non- parametric parts for assembly
S-5	SLO-1	Involute of a Square, Circle	Demo: drawing page, print, units/ scale/ limits settings, standards for dimensioning	Constructive Solid Geometry, Boolean operations, Creating combination of solids	Design new components as a team	Creation of parametric parts for assembly
	SLO-2	Spirals	ISO, ANSI Std. dimensioning, tolerancing	isometric, perspective, shaded, wire-frame	Design new components as a team	non- parametric parts for assembly
S-6	SLO-1	Introduction to perspective projection with terminologies and concepts	Projection of solid prisms and cylinders inclined to both the planes	Section of right regular solid with axis perpendicular to one principal planes and	3D Part to 2D Drawings geometric dimensioning and tolerancing annotations	Simple assembly of parts,
	SLO-2	Orthographic multiview and isometric projection	change of position method, reference line method / auxiliary projections,	cutting plane perpendicular to any one principle plane true shape of the section	generating 2D from 3D models, printing drawings, generating sectional views	associated part and assembly
S-7	SLO-1	Perspective projection of a point, line	Projection of solid prisms and cylinders inclined to both the planes	Section of right regular solid with axis perpendicular to one principal planes and	Geometric dimensioning and tolerancing annotations	Simple assembly of parts,
	SLO-2	Perspective projection of a planes, solids	Change of position method	cutting plane perpendicular to any one principle plane true shape of the section	Geometric dimensioning and tolerancing annotations	associated part and assembly

S-8	SLO-1	Orthographic multiview of point, line	Projection of solid prisms and cylinders inclined to both the planes	Section of right regular solid with axis perpendicular to one principal planes and cutting plane perpendicular to any one principle plane true shape of the section	Generating 2D drawings from 3D models	Simple assembly of parts,
	SLO-2	Orthographic multiview of planes, solids	Reference line method		Generating 2D drawings from 3D models	associated part and assembly
S-9	SLO-1	Isometric projection of a point, line	Auxiliary projections	Section of solids with axis inclined to both the planes and cutting plane perpendicular to any one principal plane only.	Generating sectional views	Simple assembly of parts,
	SLO-2	Isometric projection of planes, solids	Auxiliary projections		Generating sectional views	associated part and assembly
S-10	SLO-1	Isometric to orthographic multiview sketching	Viewing isometric and perspective views, shaded, wire-frame models	Sectional plan elevation, and sectional side-view of Building/ dwelling, include windows, doors, fixtures, etc.	Printing drawings to printer or as .pdf	Simple assembly of parts,
	SLO-2	Orthographic multiview to isometric sketch	Oblique prismatic solids and its projections		Printing drawings to printer or as .pdf	associated part and assembly
S-11	SLO-1	Orthographic multiview projection of lines inclined to both planes	Projection of solid pyramids and cones inclined to both the planes	Building/ Dwelling drawing, Terminology, conventions, sectional plan and side-view of Building/ dwelling, include windows, doors, fixtures,	Development of surfaces: un-cut, & cut right / oblique regular solids	Assembly Drawings: exploded view with assembly annotations part details
	SLO-2	Orthographic multiview projection of planes inclined to planes, auxiliary projection	change of position method and reference line method / auxiliary projections,		Simple position with cutting planes perpendicular to any one principal plane	Printing assembly drawings to printer and as pdf
S-12	SLO-1	Projection of lines inclined to both the planes	Projection of solid pyramids and cones inclined to both the planes	Sectional plan elevation, and sectional side-view of Building/ dwelling, include windows, doors, fixtures, etc.	Development of surfaces: un-cut, & cut right / oblique regular solids	Exploded view with assembly annotations part details
	SLO-2	true length, true inclinations, traces of lines	Change of position method		Simple position with cutting planes perpendicular to any one principal plane	
S-13	SLO-1	Projection of lines inclined to both the planes	Projection of solid pyramids and cones inclined to both the planes	Sectional plan elevation, and sectional side-view of Building/ dwelling, include windows, doors, fixtures, etc.	Development of surfaces: un-cut, & cut right / oblique regular solids	Exploded view with assembly annotations part details
	SLO-2	true length, true inclinations, traces of lines	Change of reference line method		Simple position with cutting planes perpendicular to any one principal plane	
S-14	SLO-1	Finding shortest distance between a point and a plane	Auxiliary projections	Sectional plan elevation, and sectional side-view of Building/ dwelling, include windows, doors, fixtures, etc.	Design of real time surface-development	Exploded view with assembly annotations part details
	SLO-2	Shortest distance between two lines	Auxiliary projections		Design of real time surface-development	
S-15	SLO-1	shortest distance between point and plane	Viewing isometric and perspective views, shaded, wire-frame models	Sectional plan elevation, and sectional side-view of Building/ dwelling, include windows, doors, fixtures, etc.	Design of real time surface-development	Printing assembly drawings
	SLO-2	shortest distance between point and plane	Oblique pyramidal solids and projections		Design of real time surface-development	Printing assembly drawings

Learning Resources

1. Bhatt, N.D., Engineering Drawing (First Angle Projection),53rd ed., Charotar Publishing House, 2017
2. Bethunc, J., Engineering Graphics with AutoCAD 2017, Pearson Education, 2016
3. Khristofor Artemyevich Arustamov, Problems in projective geometry, MIR Publishers, Moscow, 1972
4. Natarajan, K.V., A Text Book of Engineering Graphics, 21st Edition, Dhanalakshmi Pub., 2012
5. Shah. M. B.,Rana, B. C, Engineering Drawing, Pearson Education, Pvt. Ltd., 2005
6. Jeyapoovan. T., Engineering Drawing and Graphics using AutoCAD, Vikas Pub. House, 2015
7. Narayanan, K. L., Kannaiah, V., Engineering Graphics, Scitech Publications,2010
8. Luzzader, Warren J., Duff John M., Fundamentals of Engineering Drawing with an introduction to Interactive Computer Graphics for Design and Production, Prentice Hall of India Pvt. Ltd,, 2005.
9. Mohammad Dastbaz, Chris Gorse, Alice Moncaster (eds.), Building Information Modelling, Building Performance, Design and Smart Construction, Springer 2017
10. User Manual of Respective CAD Softwares

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	-	40%	-	30%	-	30%	-	30%	-	30%
Level 2	Apply / Analyze	-	40%	-	40%	-	40%	-	40%	-	40%
Level 3	Evaluate / Create	-	20%	-	30%	-	30%	-	30%	-	30%
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Dr. R. Kalimuthu, ISRO,	1. Dr. Ramkumar P, IIT Madras, ramkumar@iitm.ac.in	1. Mr. D. Kumaran, SRMIST
2.Dr. A. Velayutham, DRDO,	2. Dr. Sourav Rakshit, IIT Madras, srakshit@iitm.ac.in	2. Mr. S. Balamurugan, SRMIST

Note: *For all B.Tech Programmes other than Civil, Mechanical, Automobile, Aerospace and Mechatronics, the entire course would be conducted using CAD Software only.*

S NO.	NAME OF THE SESSION
INTRODUCTION	Lettering
	2D Geometry
	Title Block
1.	**CONICAL CURVES**
	a. Construction of Ellipse
	b. Construction of Parabola
	c. Construction of Hyperbola
2	**SPECIAL CURVES**
	2a. Construction of Cycloid
	2b. Construction of Involute
3	**PROJECTION**
	3a.Projection of points
	3b.Projection of Line
4.	**PROJECTION OF PLANES**
5	**ORTHOGRAPHIC PROJECTION**

6	**PROJECTION OF SOLIDS**
	6a.Projection of Prism and Cylinder
	6b. Projection of Pyramid and cone
7	**SECTION OF SOLIDS**
8	**BOOLEAN OPERATIONS**
9	**CONSTRUCTION OF PLAN FOR A RESIDENTIAL BUILDING**
10	**COMBINATION OF SOLIDS**
11	**ISOMETRIC PROJECTION**
12	**DEVELOPMENT OF SURFACES**
	12a.Development of Prism and cylinder
	12b.Development of cone and pyramid
13	**CREATING 2D FROM 3D MODELS**
14	**PARAMETRIC PARTS**
15	**NON PARAMETRIC PARTS**

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

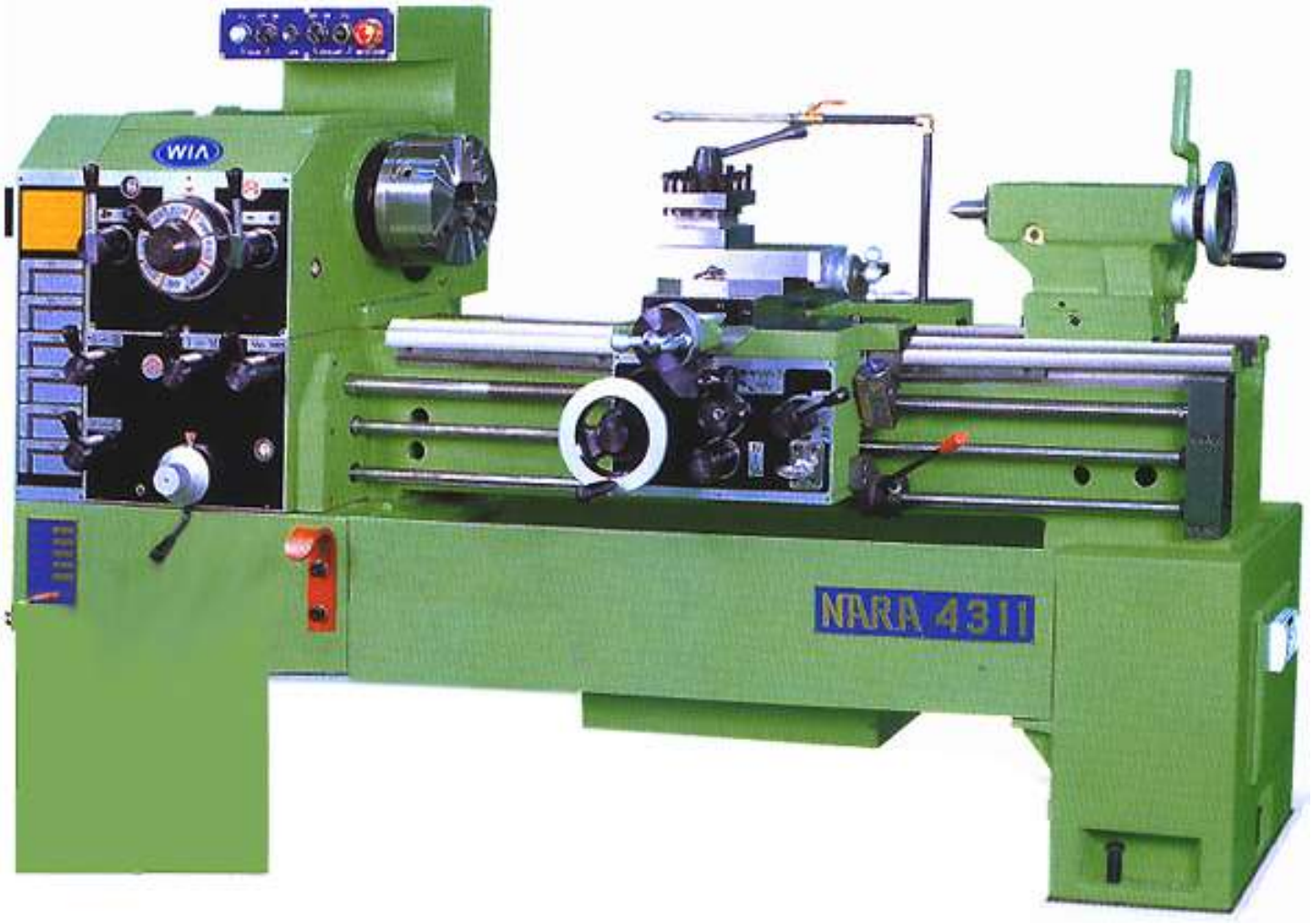
Details: largest passenger jet. 80m wingspan and a tail that stands as high as a seven-storey building, carries more than 550 passengers.

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

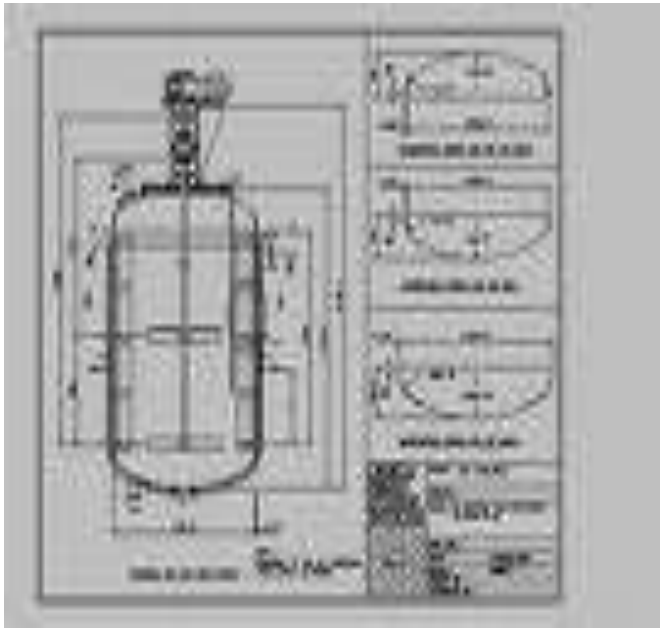
- A picture/drawing is worth a thousand words..

- The LCA/Airbus A380 would be impossible to create without computer graphics and drawing models.

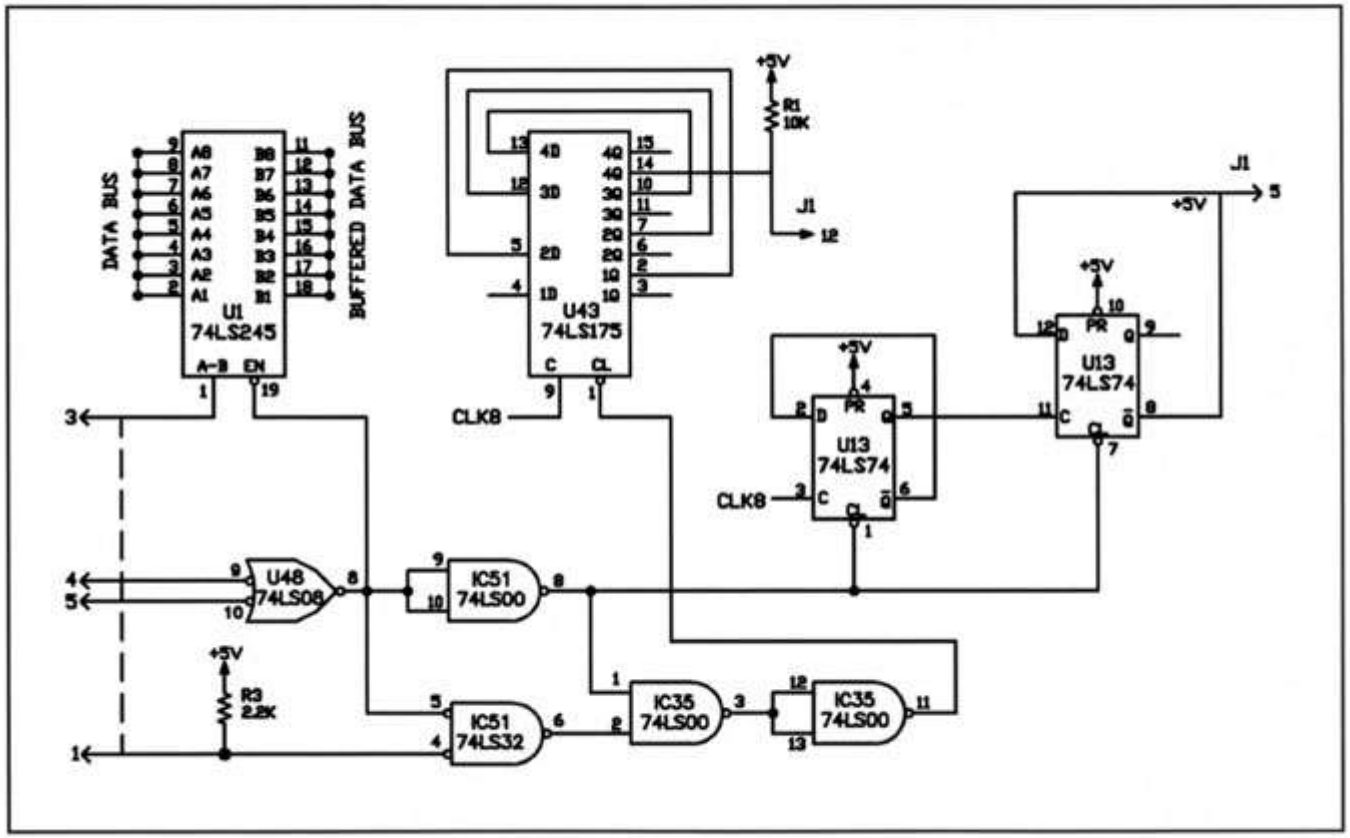
- Drawings are the road maps which show how to manufacture products and structures.



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.

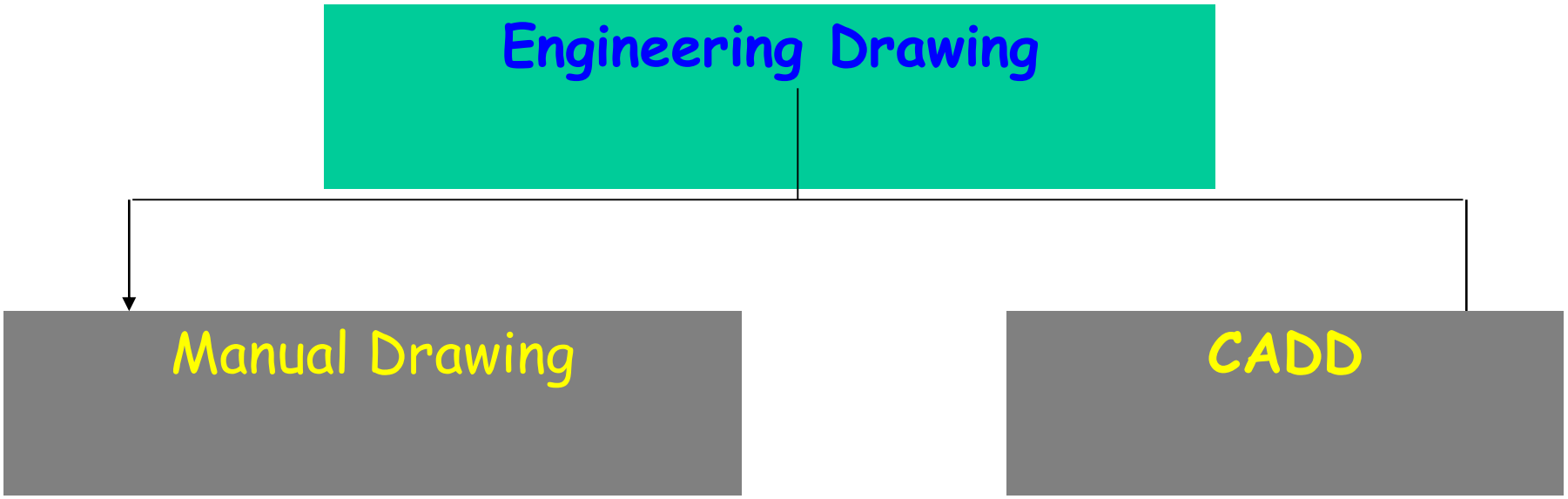
-No construction/manufacturing of any (man - made) engineering objects is possible without engineering drawing.

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.

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**
-

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

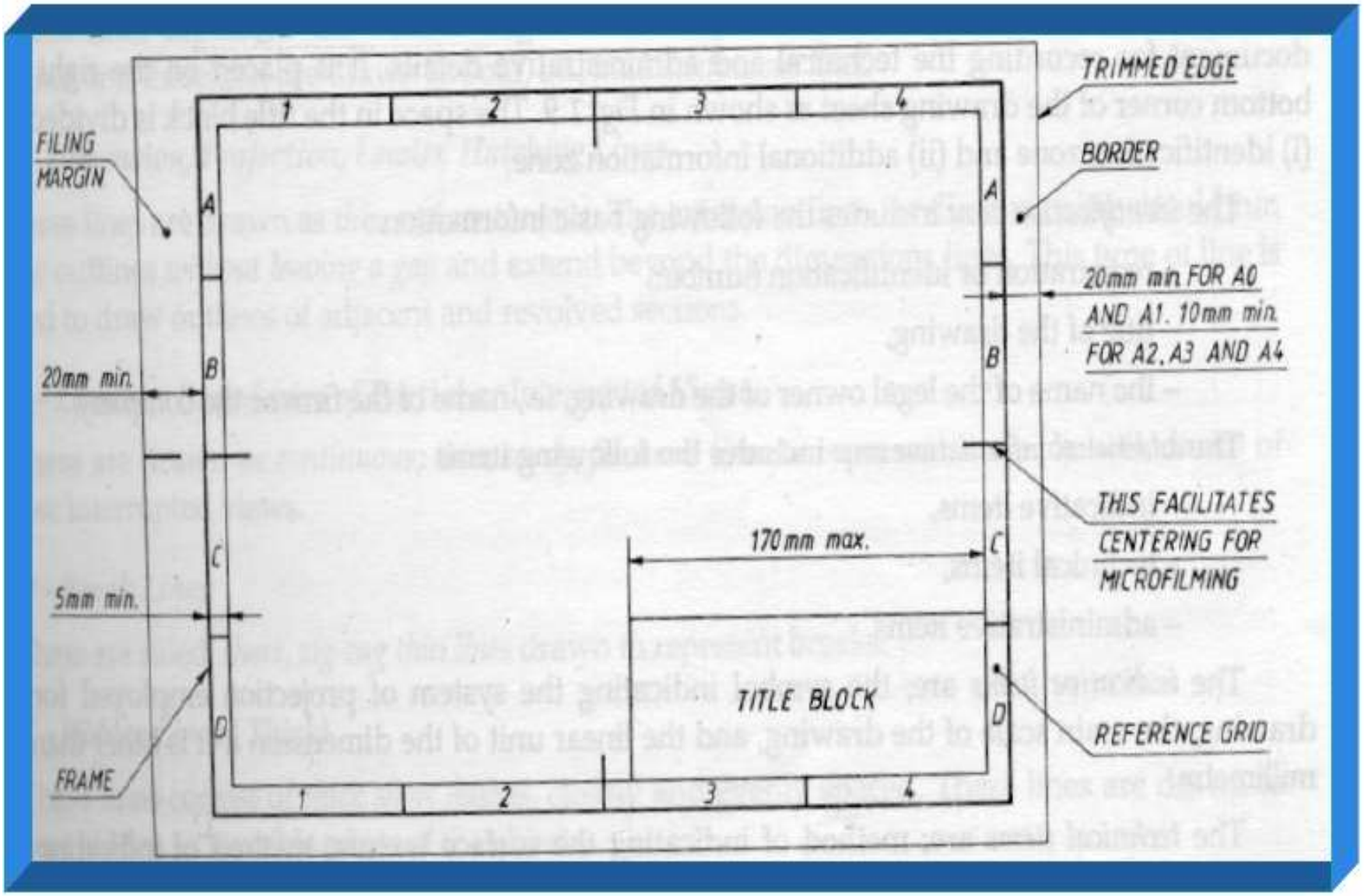
- Location - Bottom right corner – **185 mm x 65 mm (BIS)**
- **Divided into two zones**
- **Identification zone**
- Registration or identification number
- Drawing title
- Name of the legal owner of the drawing, i.e., name of the firm or the company

Contd…

Title box….. contd

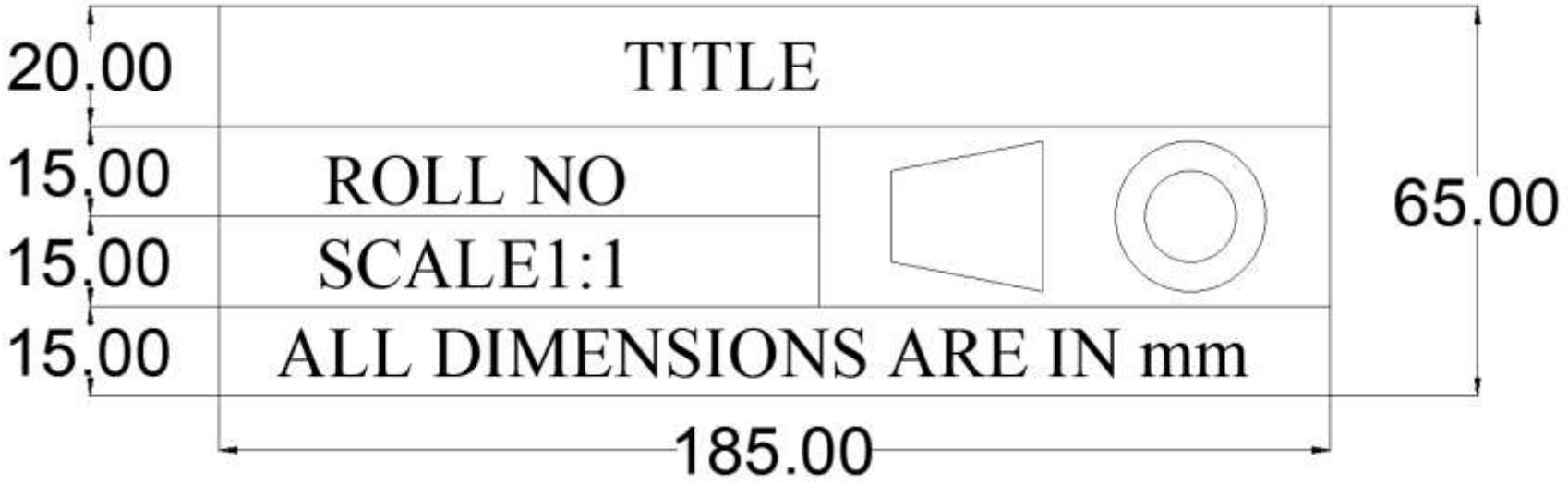
Additional information zone

- 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



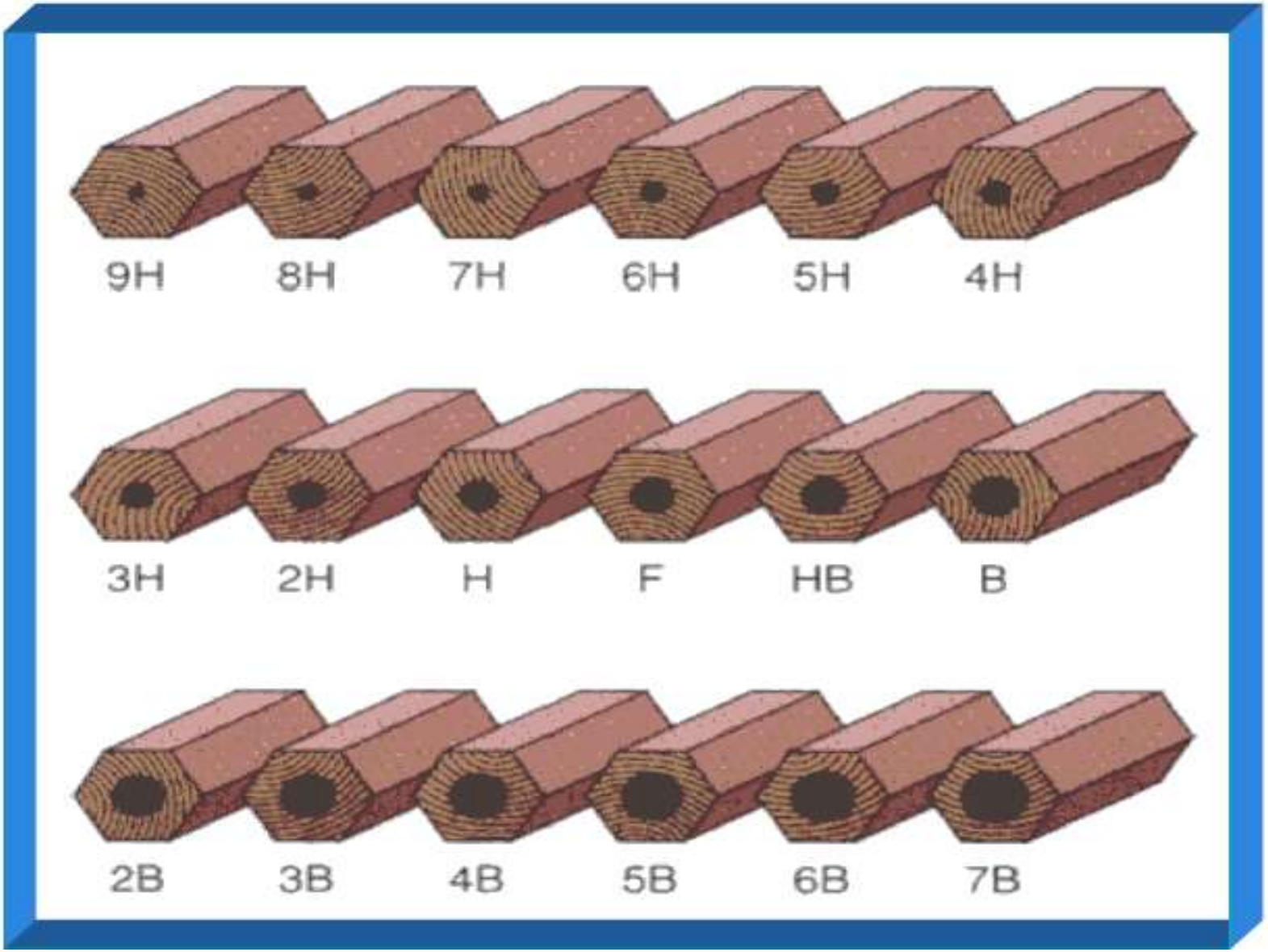
Drawing Pencils

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

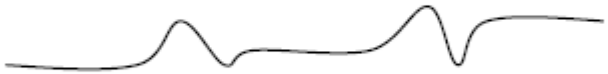
Pencil drawing –

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).**

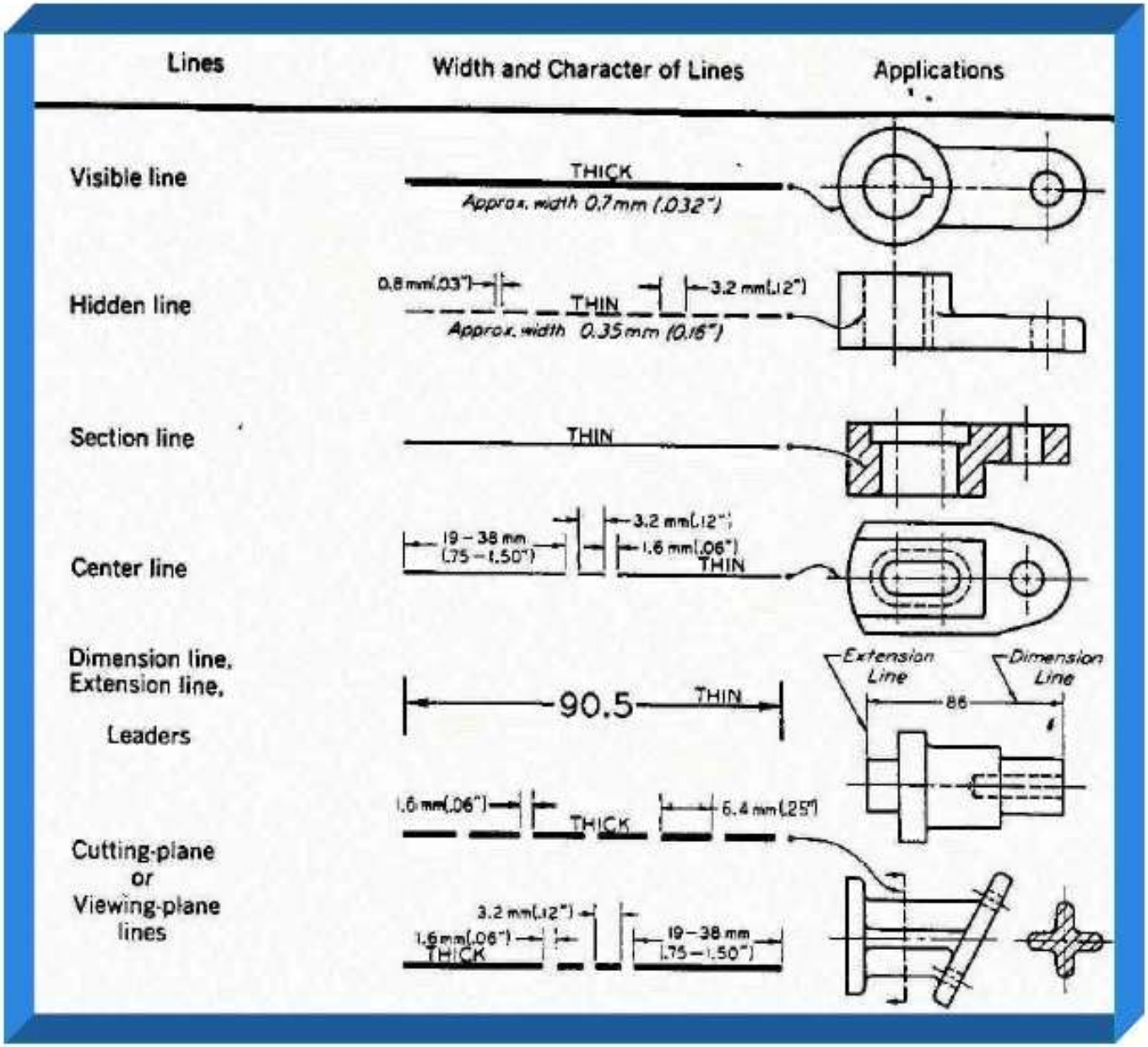
Line group, mm	Thickness	Lines
0.2	Medium	Outlines, dotted lines, cutting plane lines
0.1	Thin	Center lines, section lines, dimension lines, extension lines, construction lines, leader lines, short-break lines, long-break lines

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



Uses of different types of lines in a given drawing

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

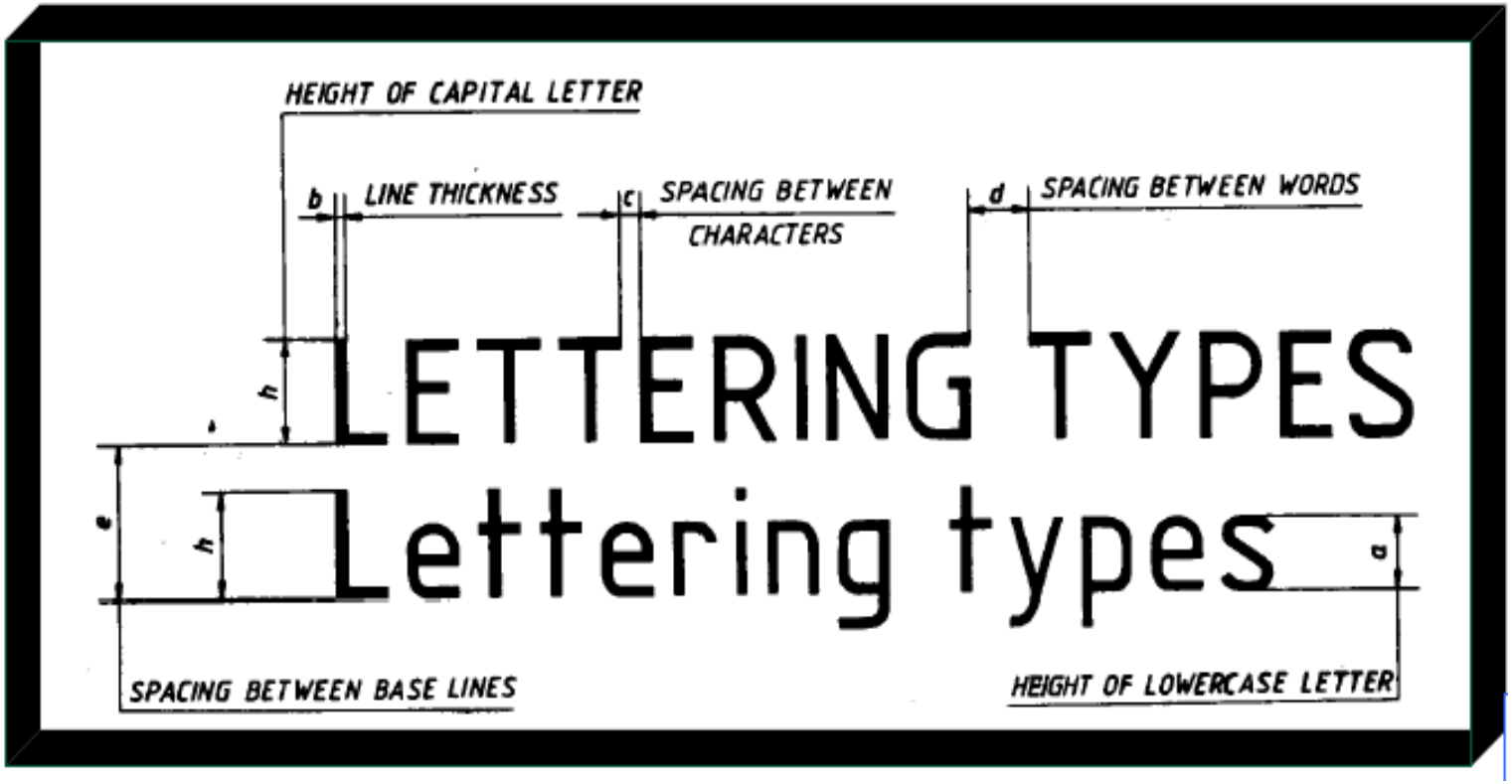
Plain letters and numerals which are clearly distinguishable from each other in order to avoid any confusion even in case of slight mutilations

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

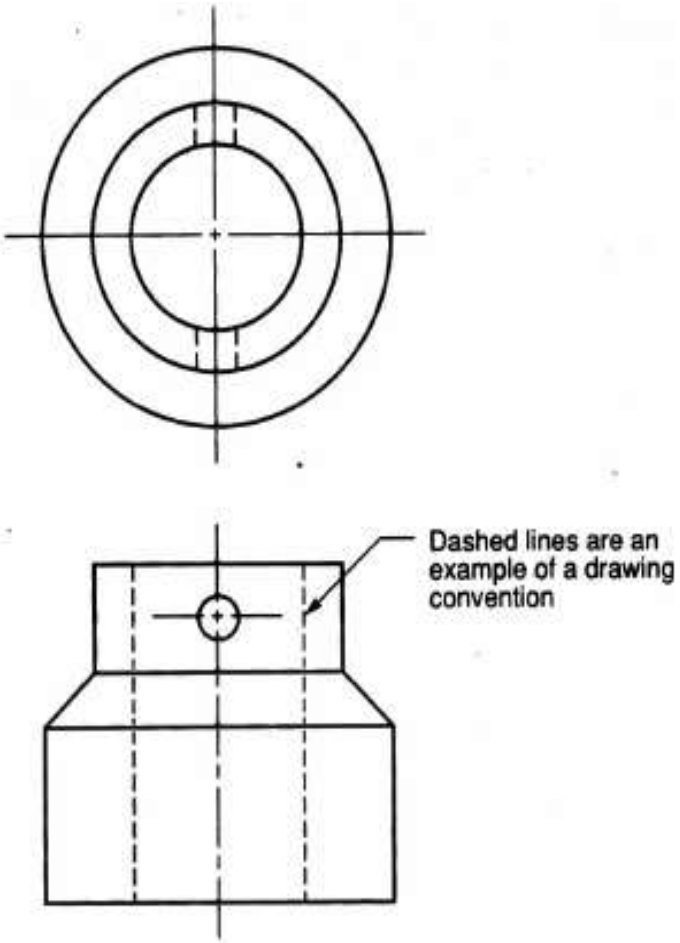
Standards and Conventions

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.

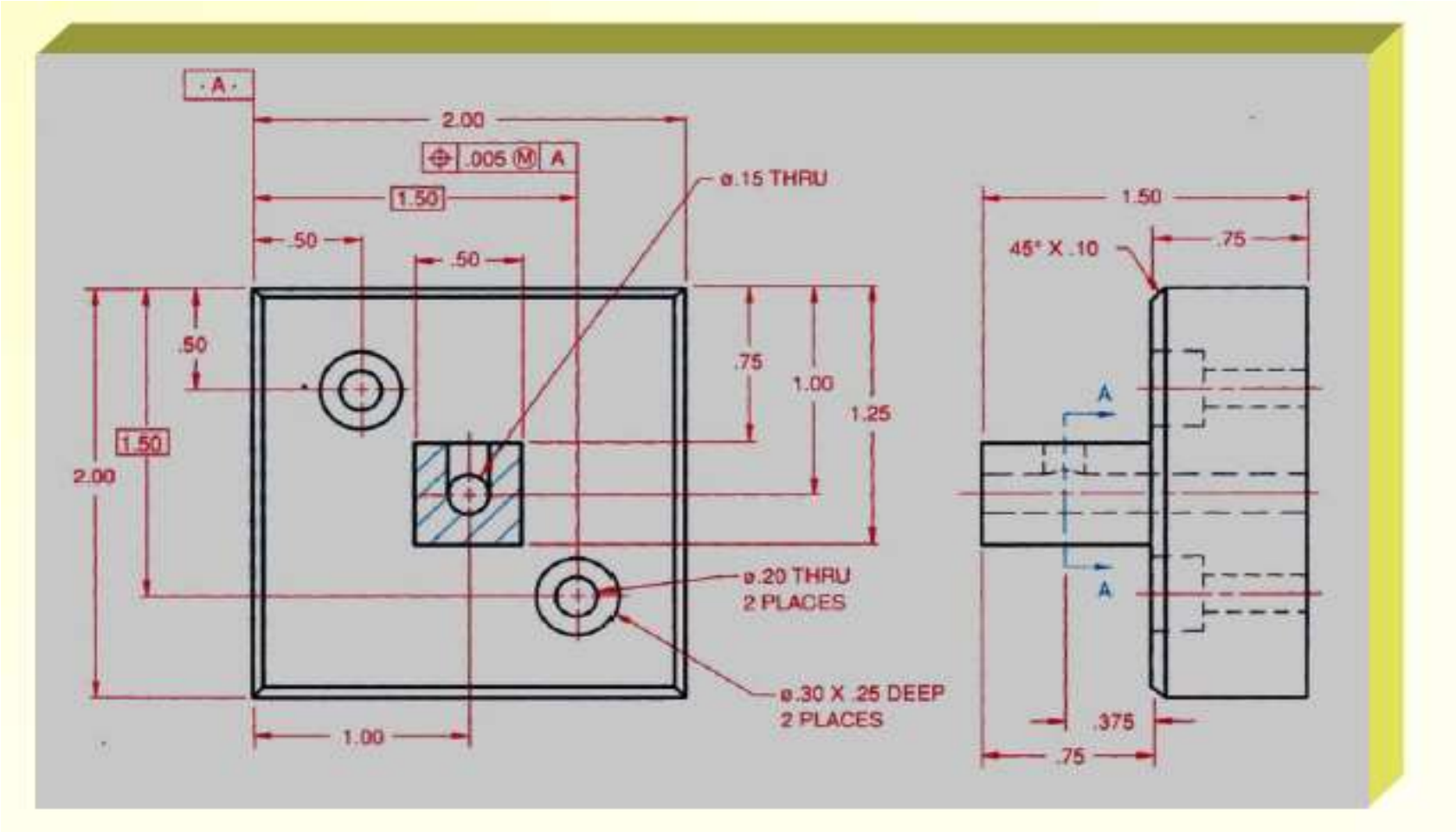
Conventions – commonly accepted practices, rules, or methods.



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.

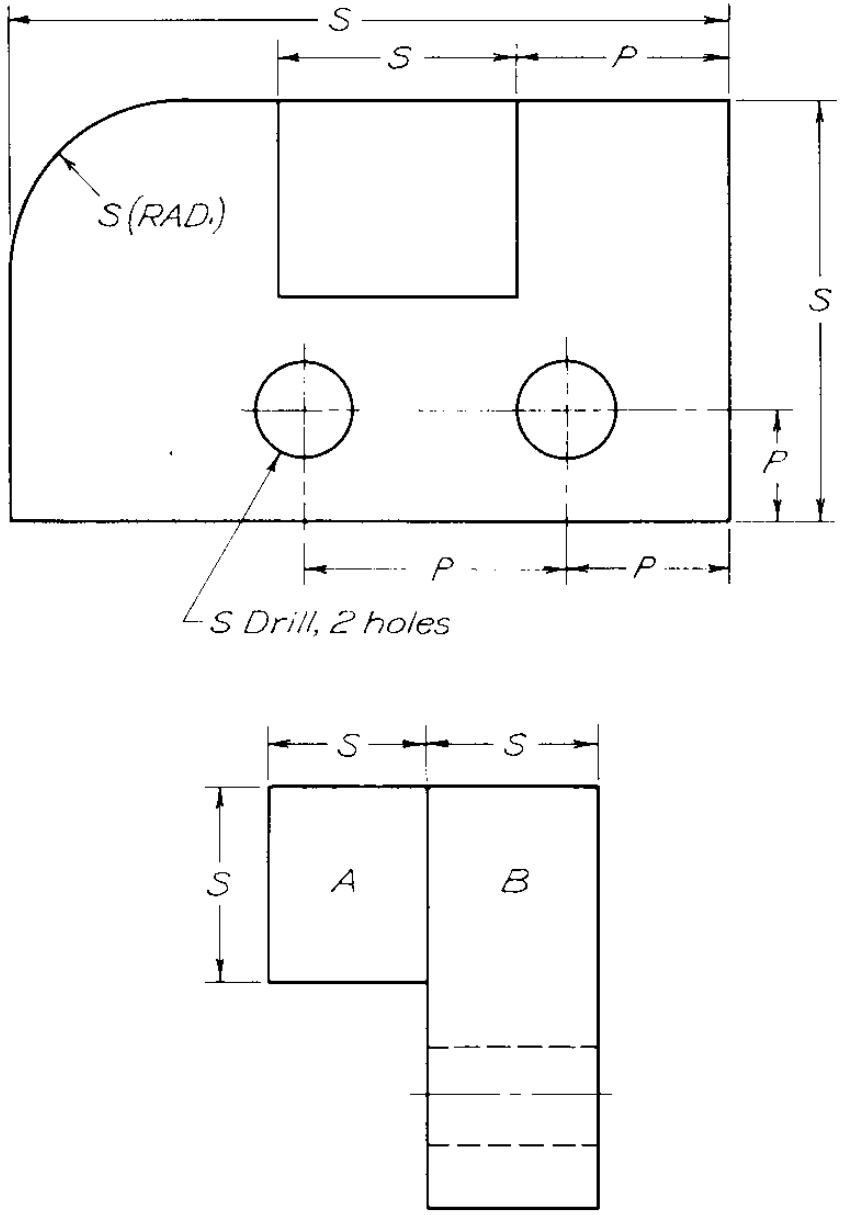


FIG. 19. Dimensions of size and position. *S* indicates size, *P* position.

Each feature is dimensioned and positioned only once.

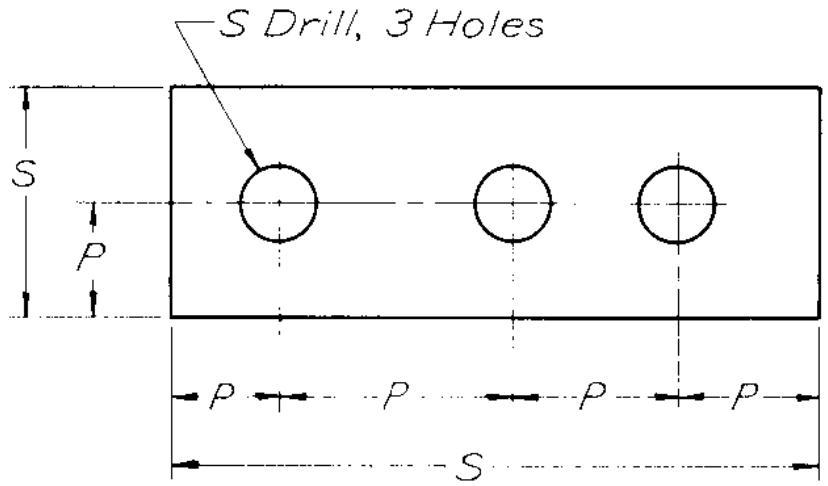


FIG. 24. One unnecessary dimension.

Each feature is dimensioned and positioned where its shape shows.

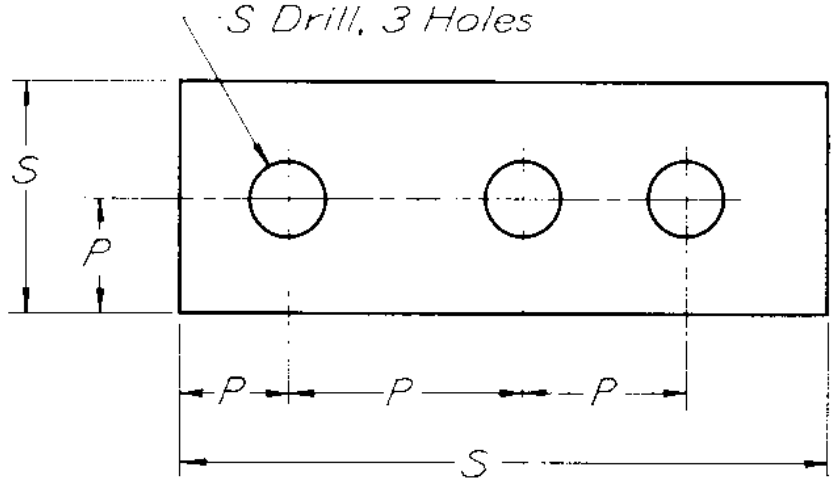


FIG. 25. Unnecessary dimension omitted.

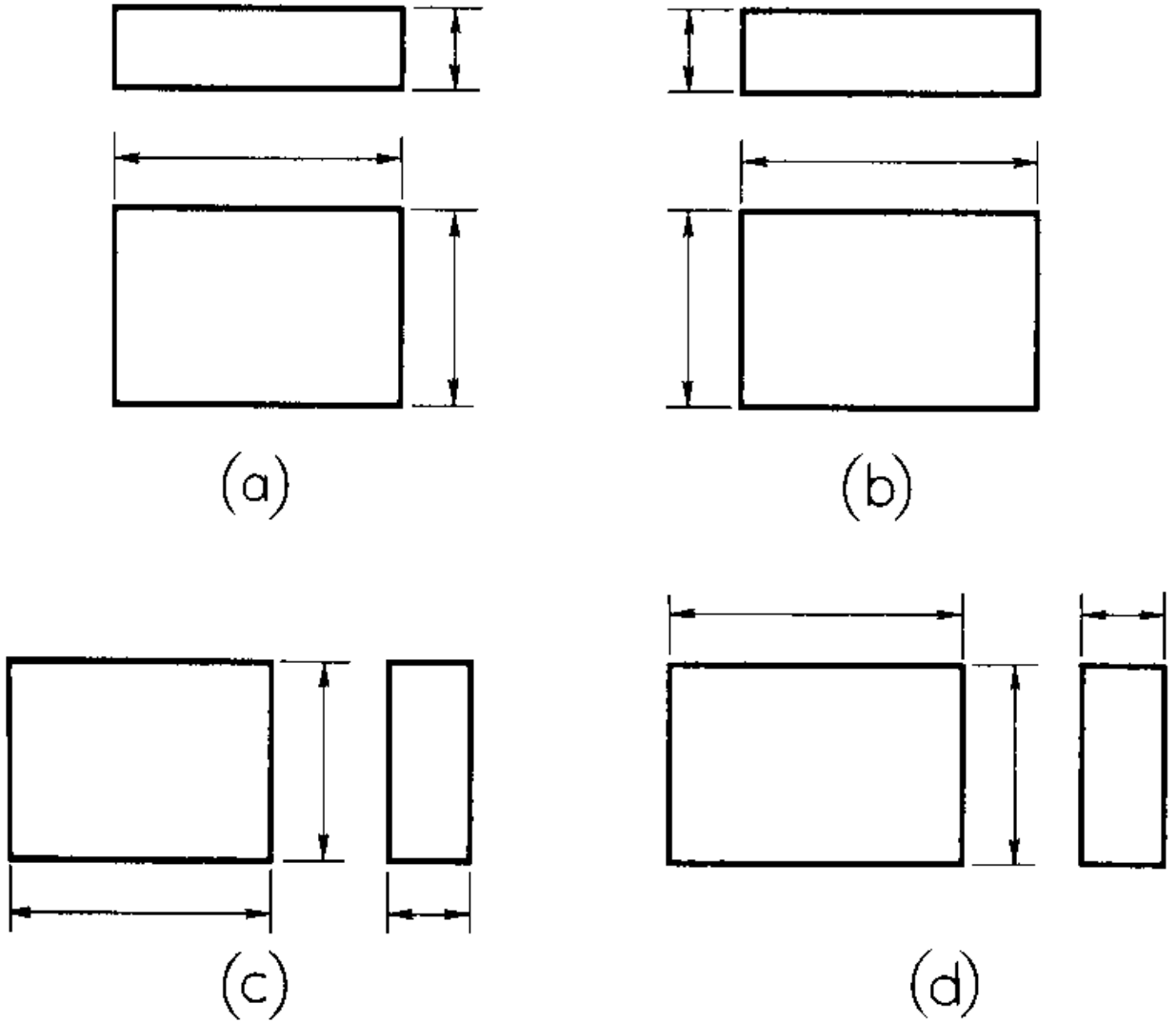
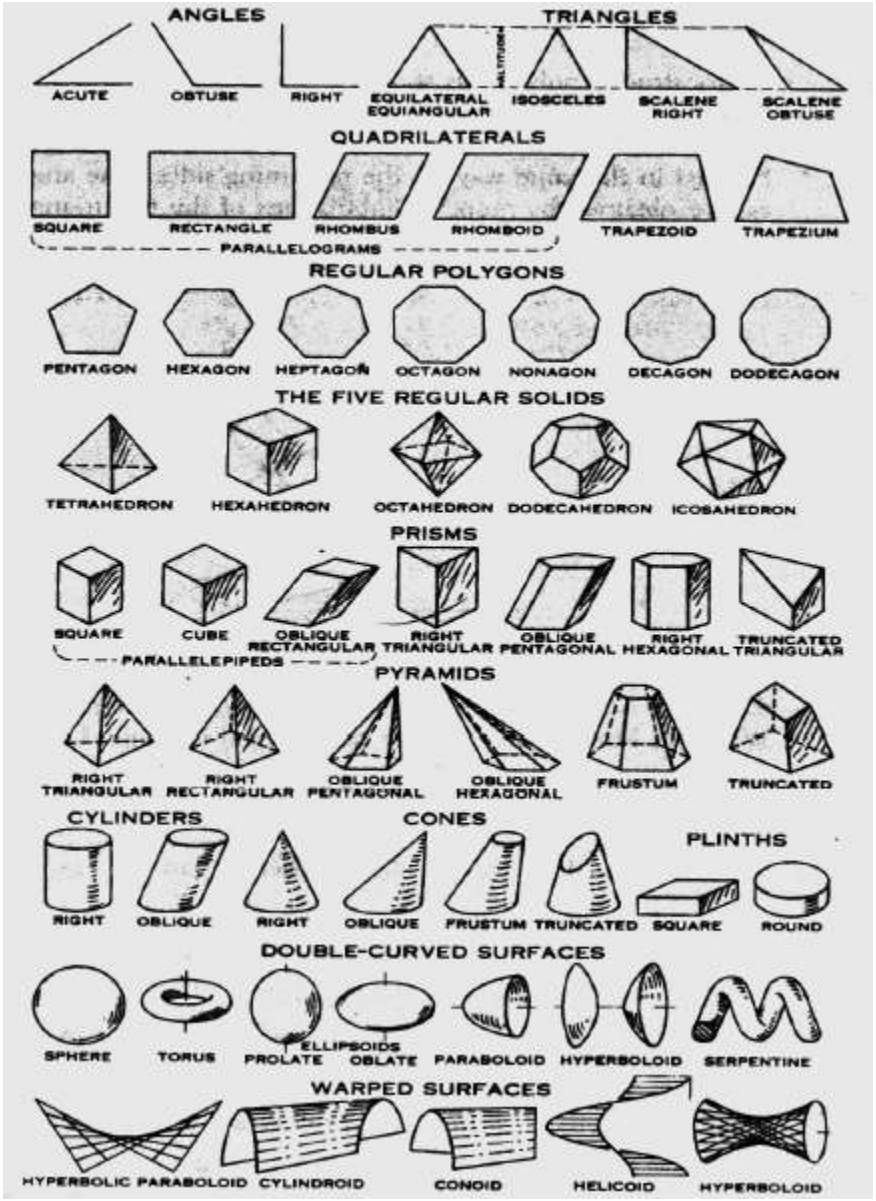


Fig. 11.24 **Dimensioning Rectangular Prisms.**

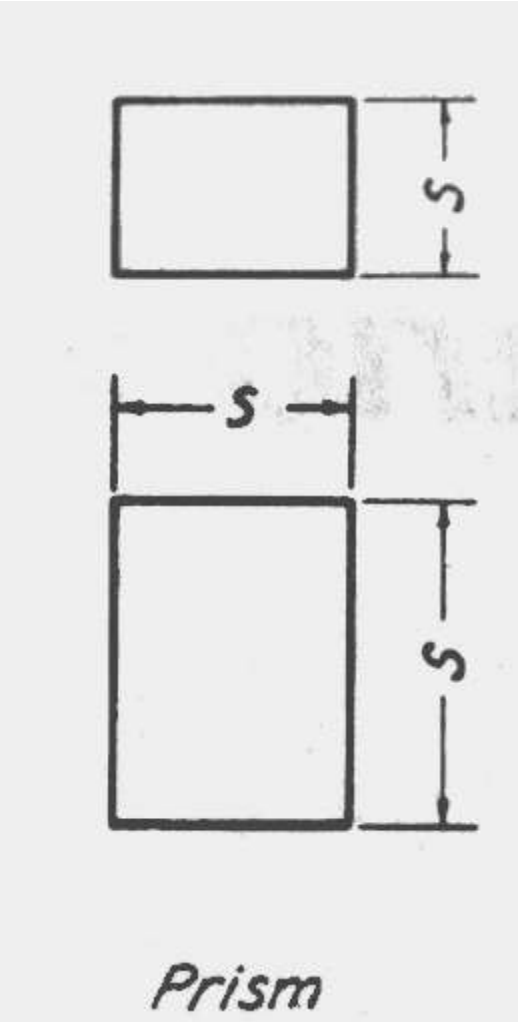
Size dimensions – give the size of the component.

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

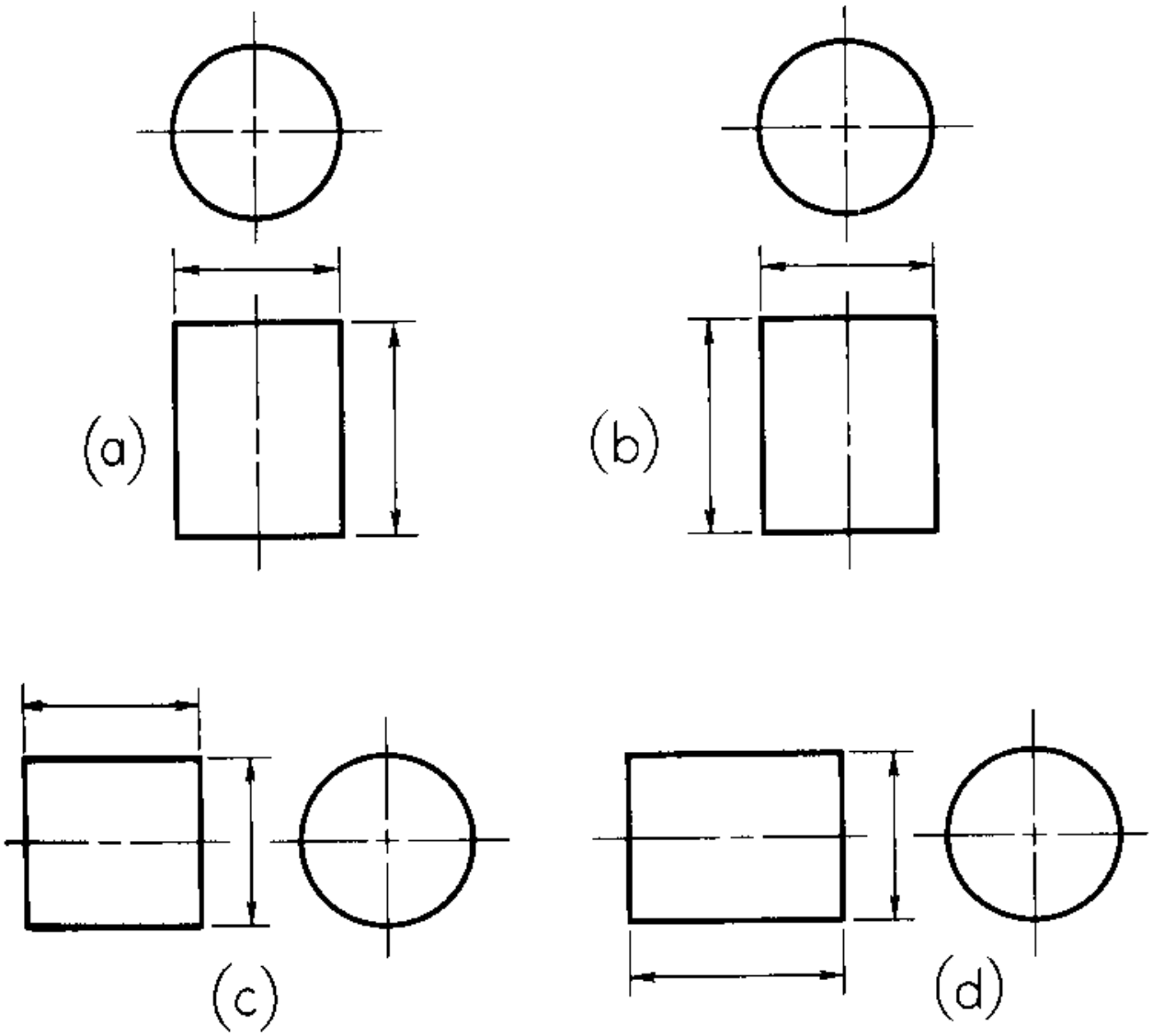


Fig. 11.26 **Dimensioning Cylinders.**

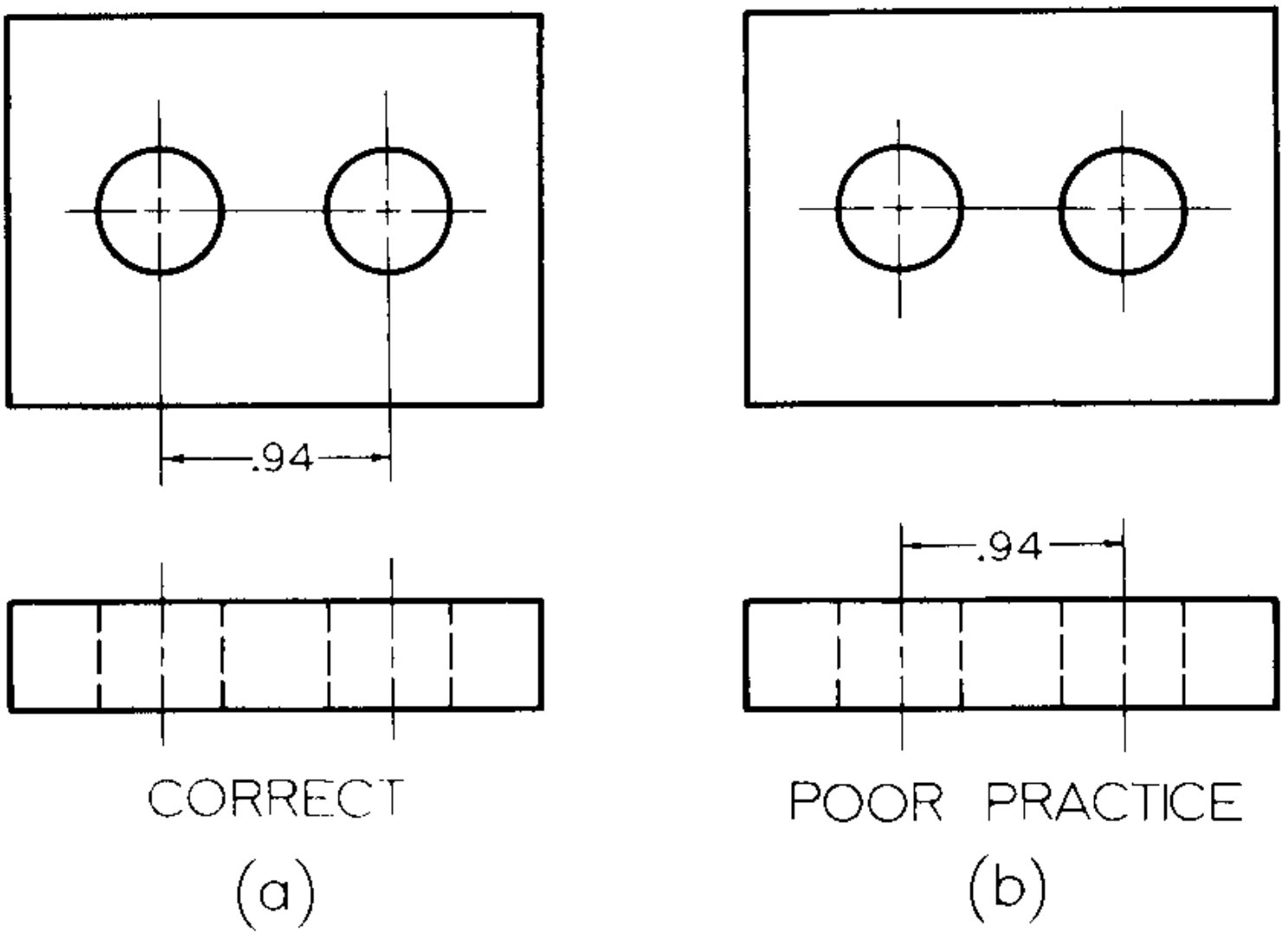


Fig. 11.32 Locating Holes.

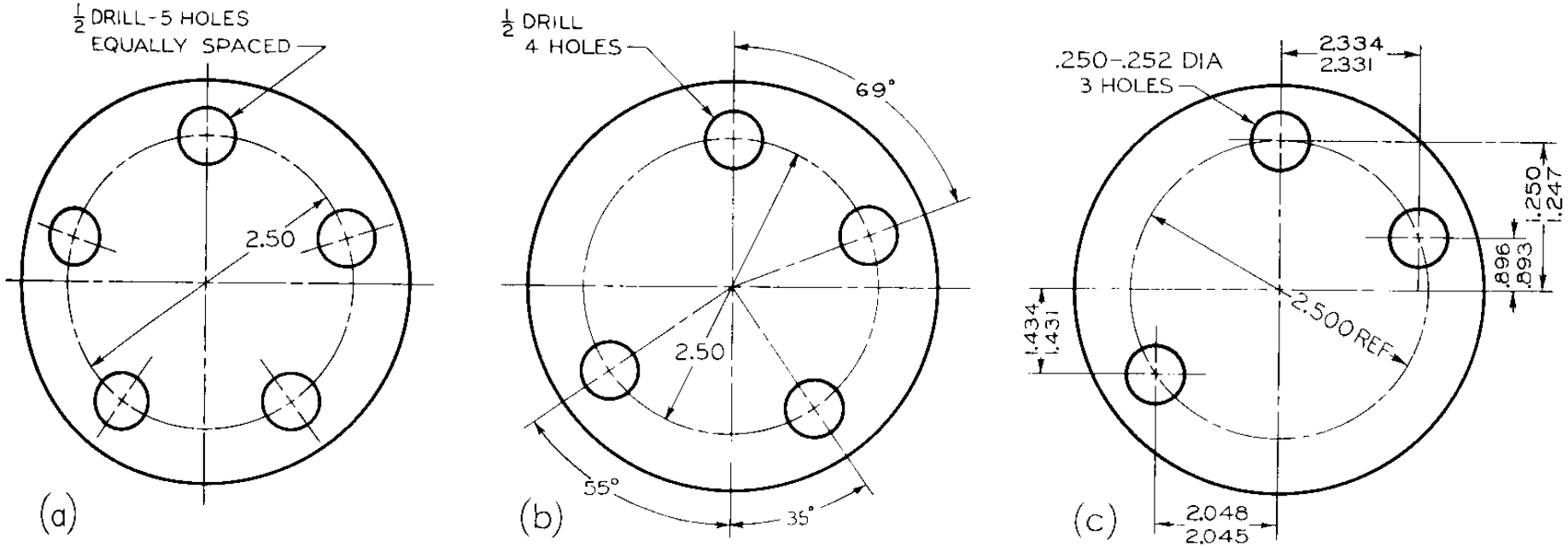
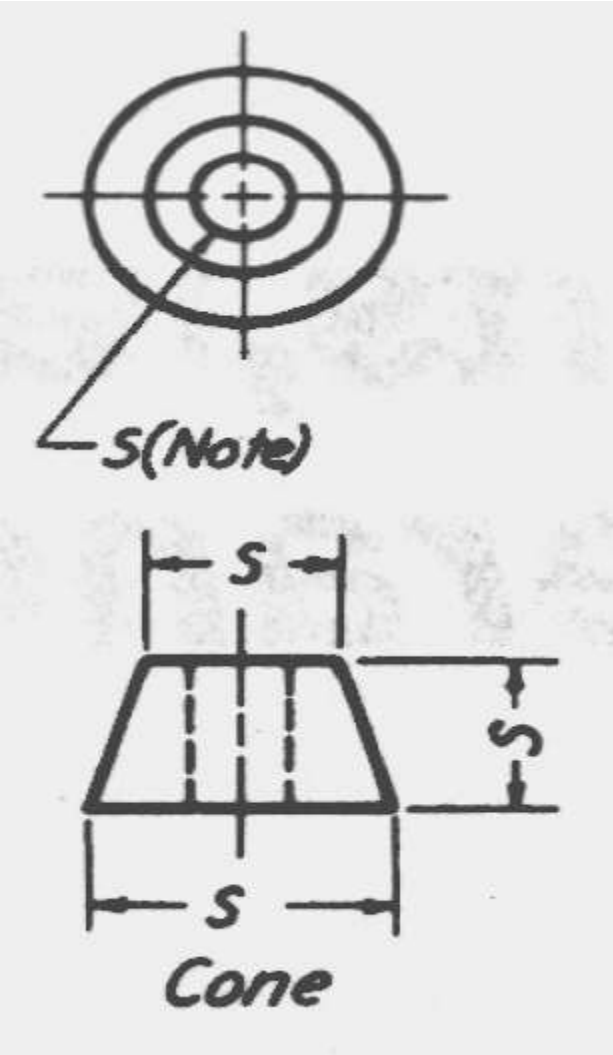
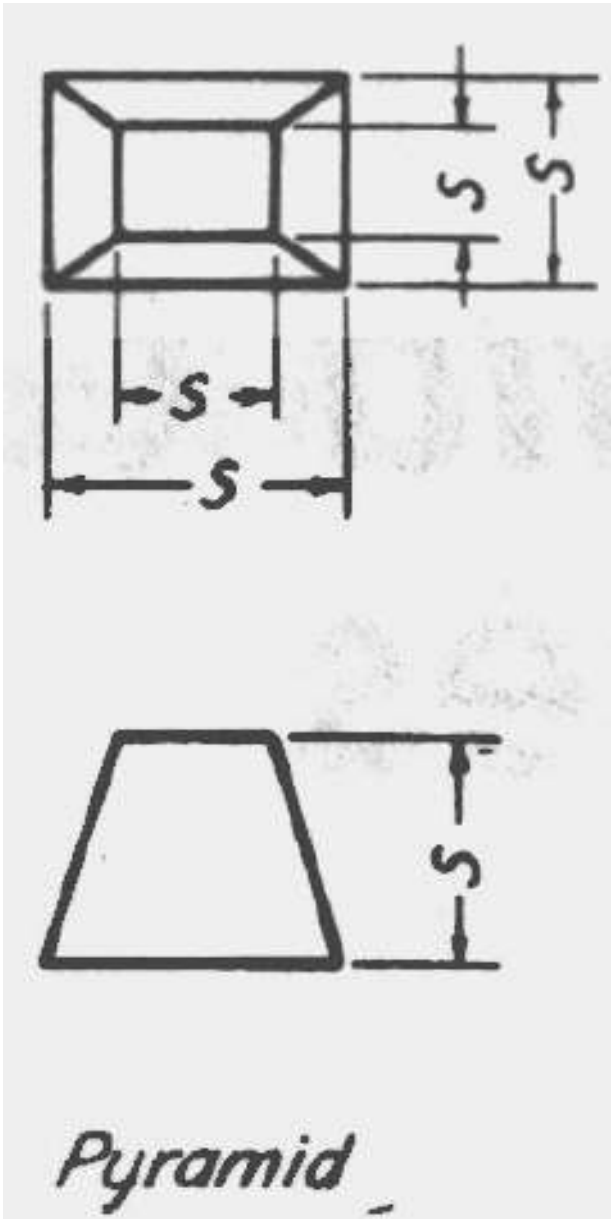


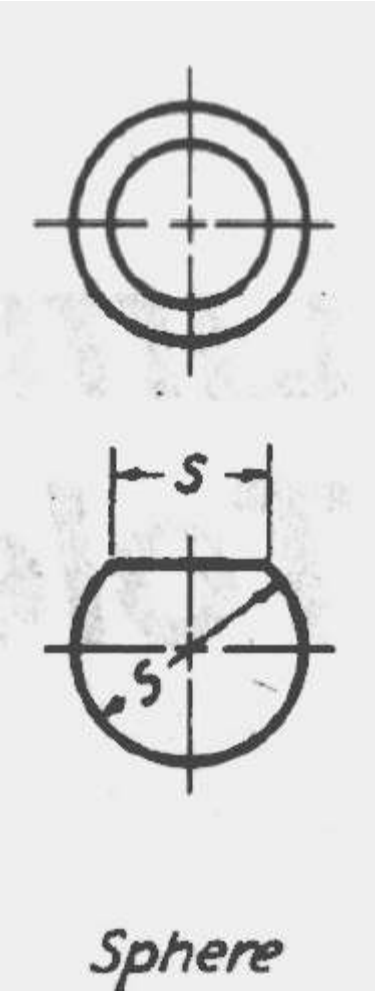
Fig. 11.34 Locating Holes About a Center.



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



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



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.

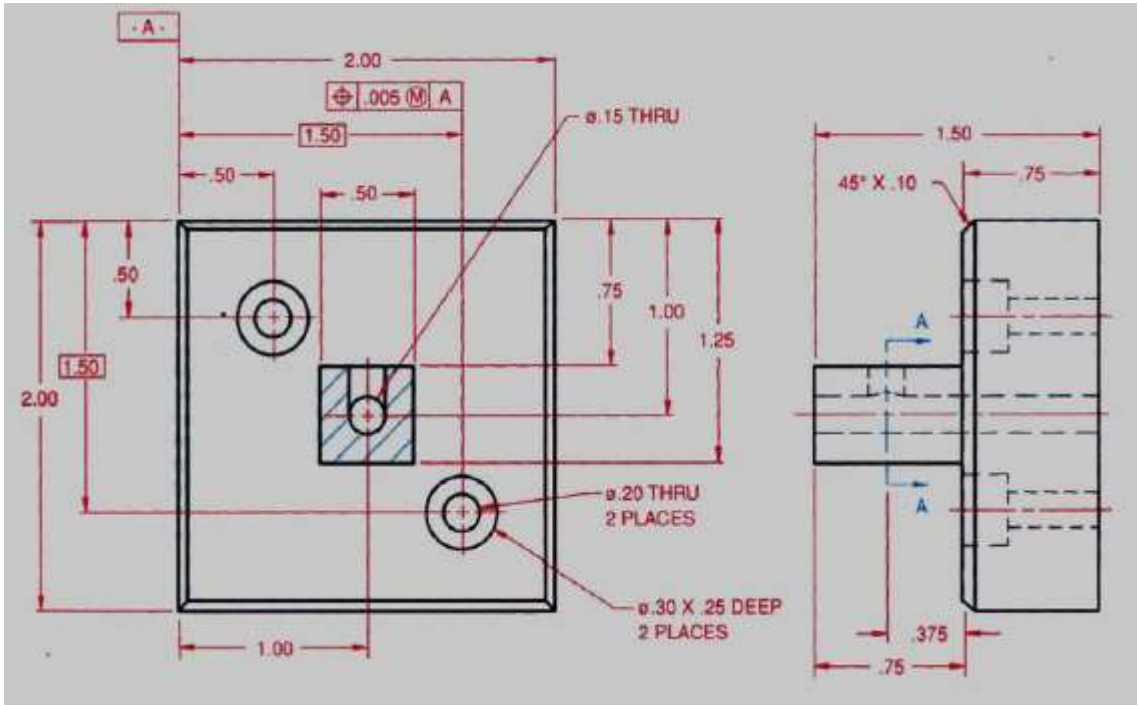
Locations must be established in height, width and

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



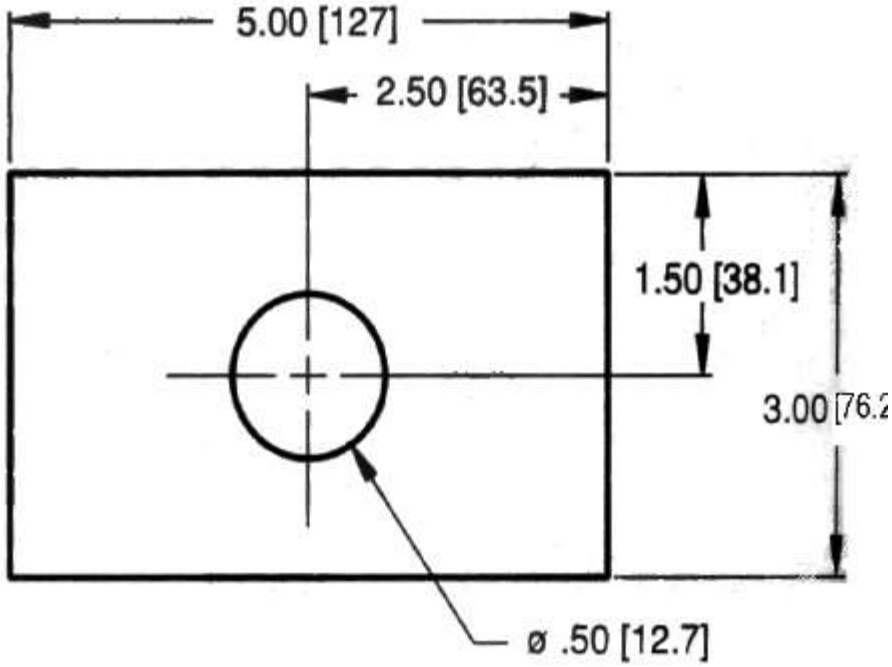
Terminology for dimensioning practice

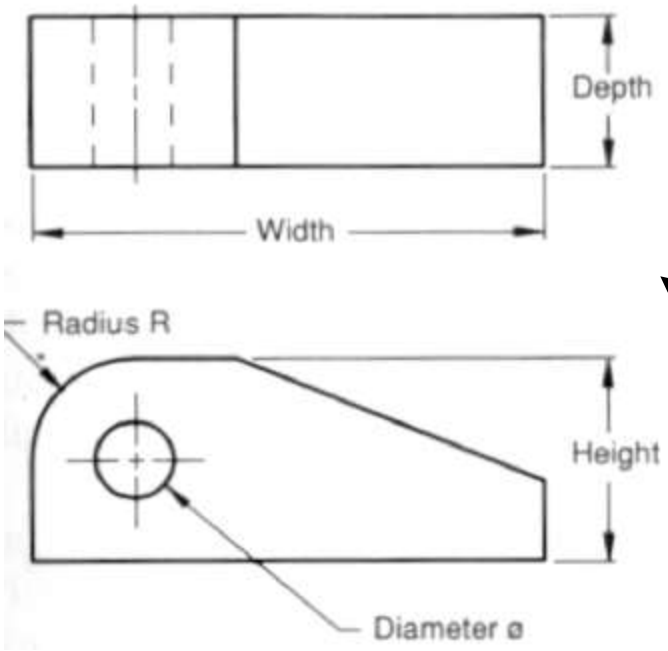
Dimension – numerical value that defines

the size or geometric characteristics of a

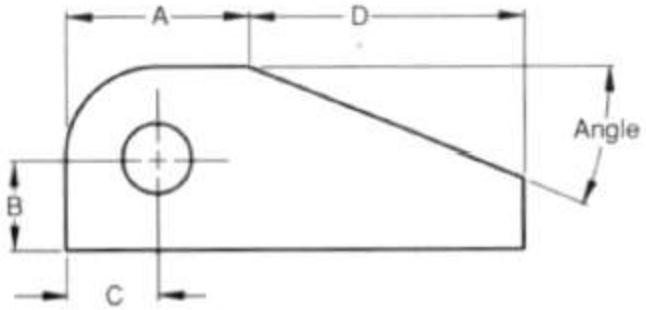
feature – **size 3.5 mm and space between**

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



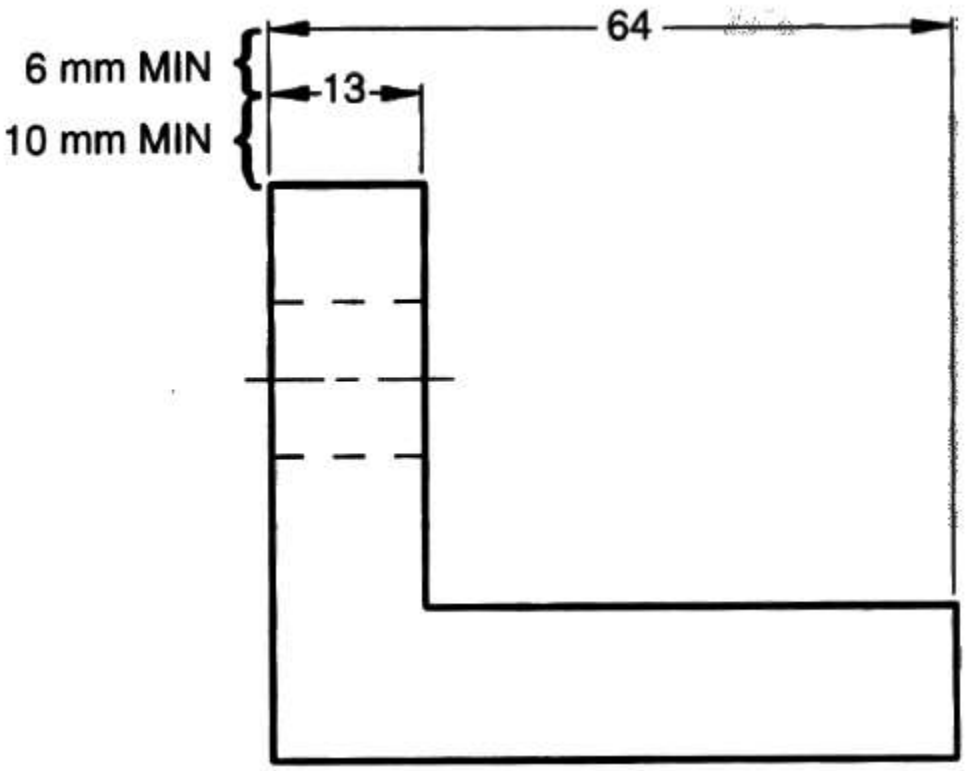
Dimensions showing the location and orientations of features, such as location of the center of the hole

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

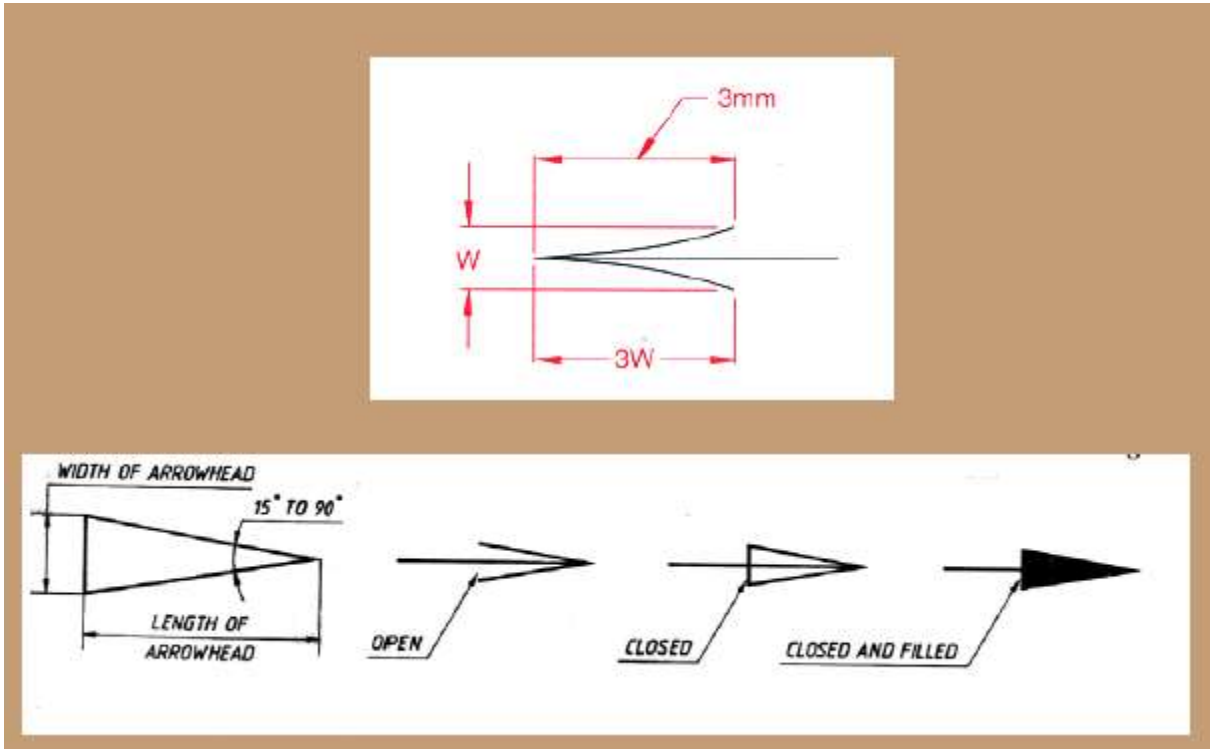
A thin, solid line that shows the extent and direction of a dimension. Dimension lines are broken for insertion of the dimension numbers.



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.

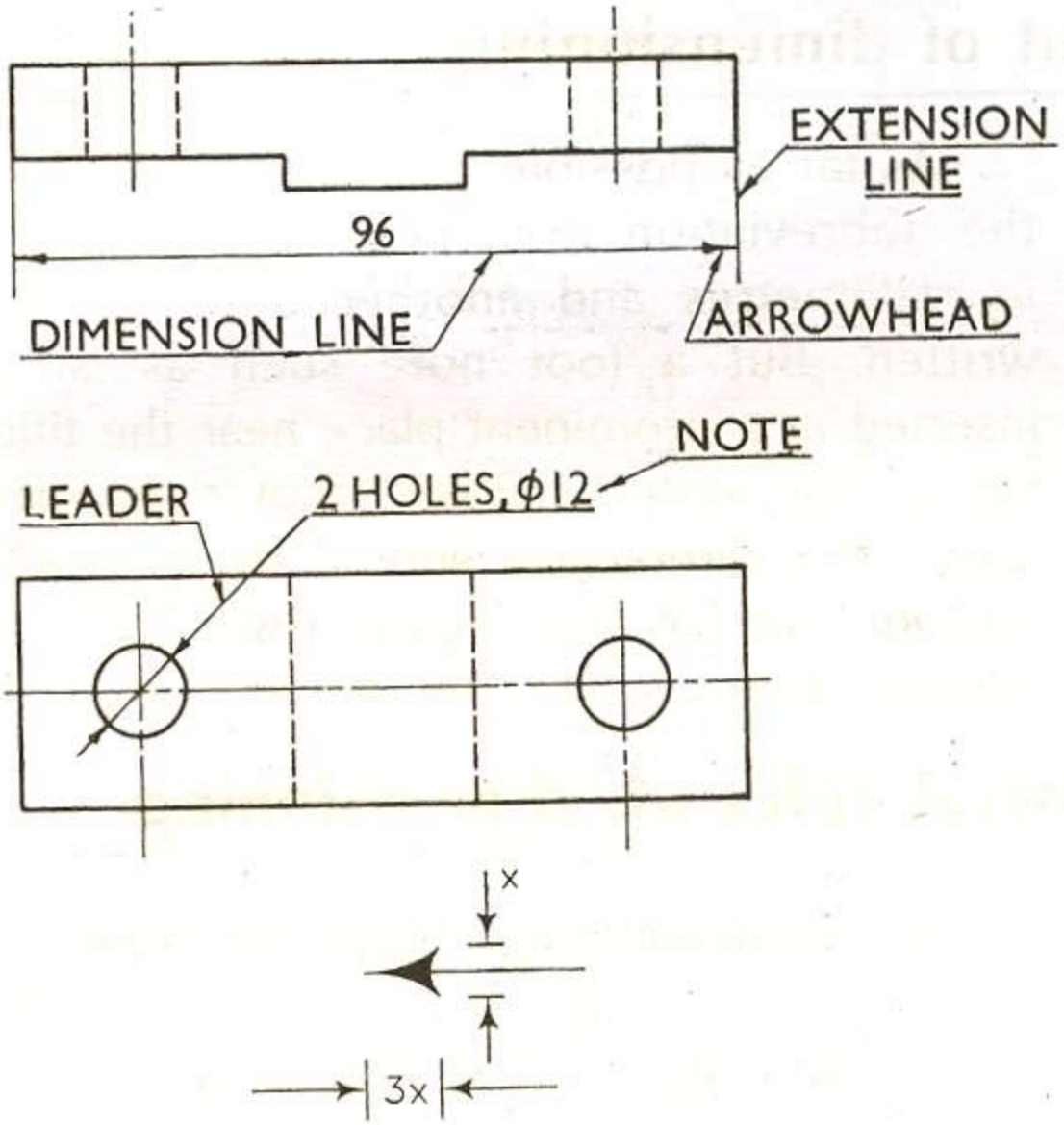
- Generally a straight line drawn at an angle that is neither horizontal nor vertical.

- Terminated with an arrow touching the part or detail.

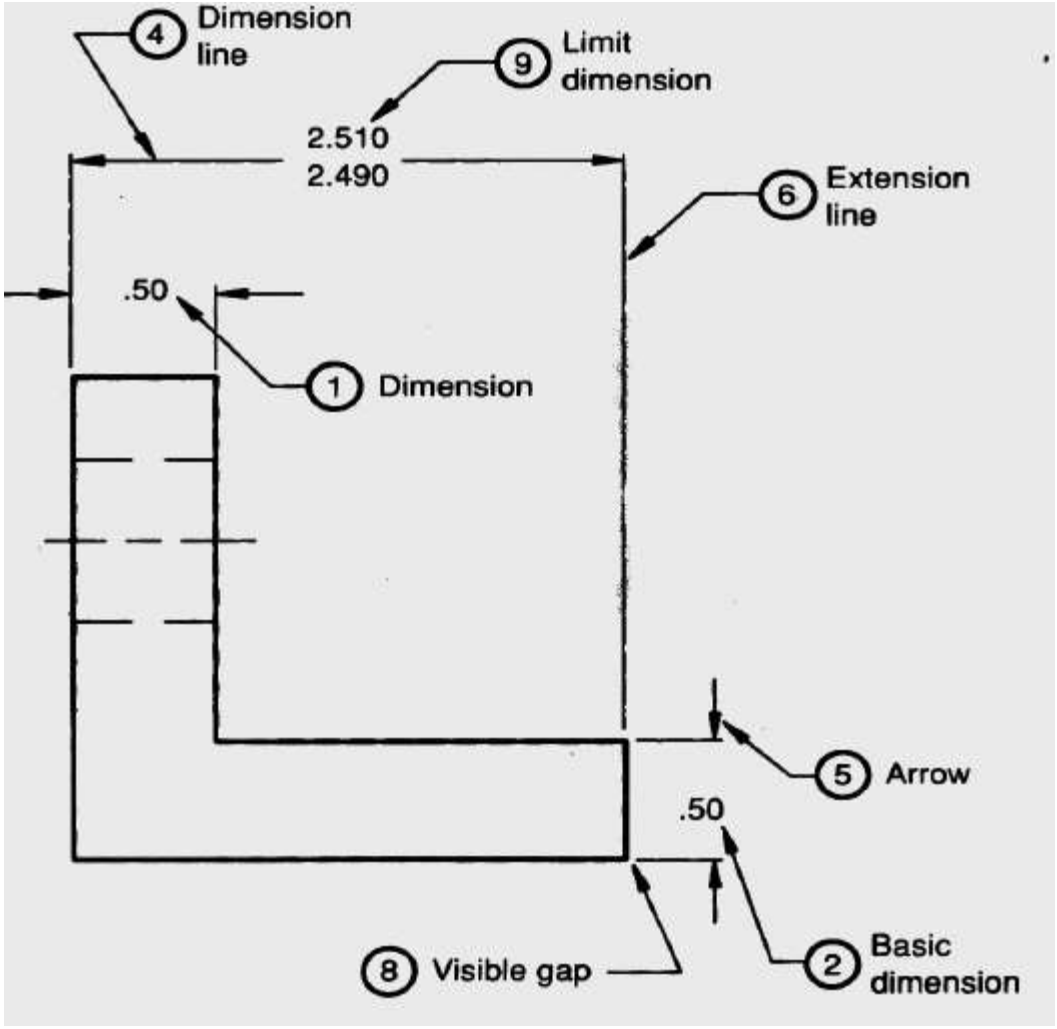
- On the end opposite the arrow, the leader line will have a short, horizontal shoulder. Text is extended from this shoulder such that the text height is centered with the shoulder line.

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

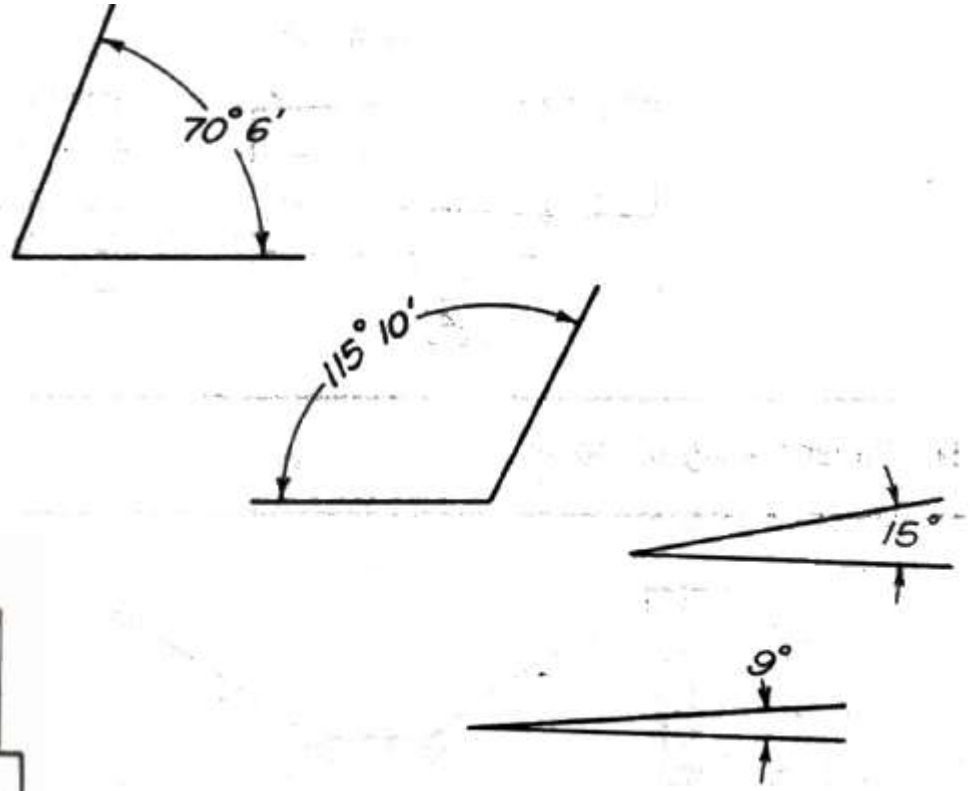
Radius symbol – R 0.5

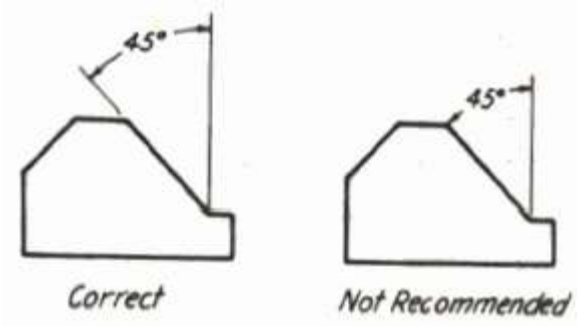


Various types of dimension lines

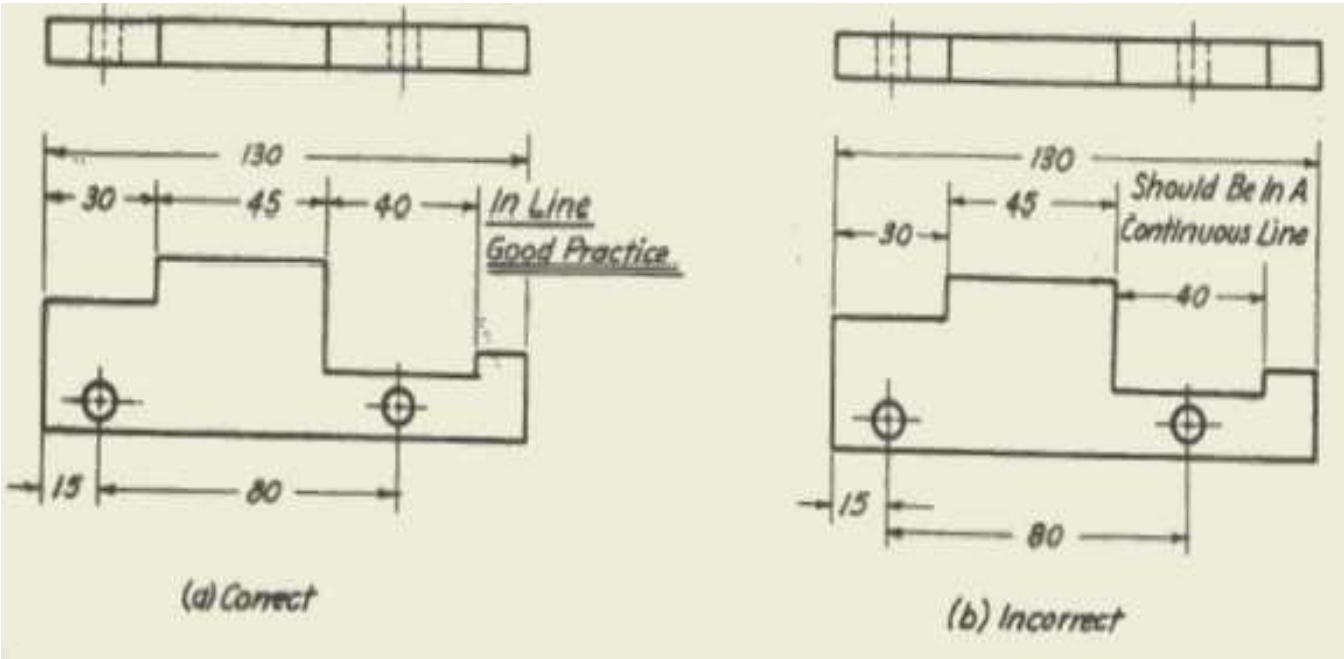


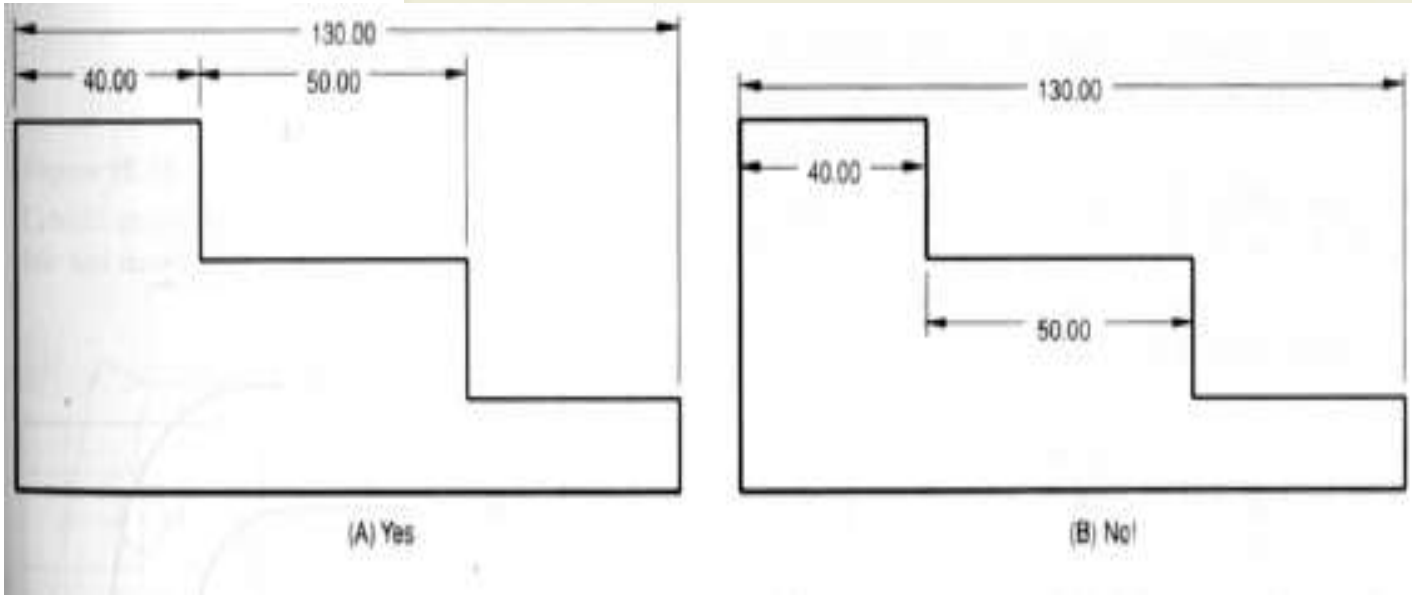
Important elements of a dimensioning



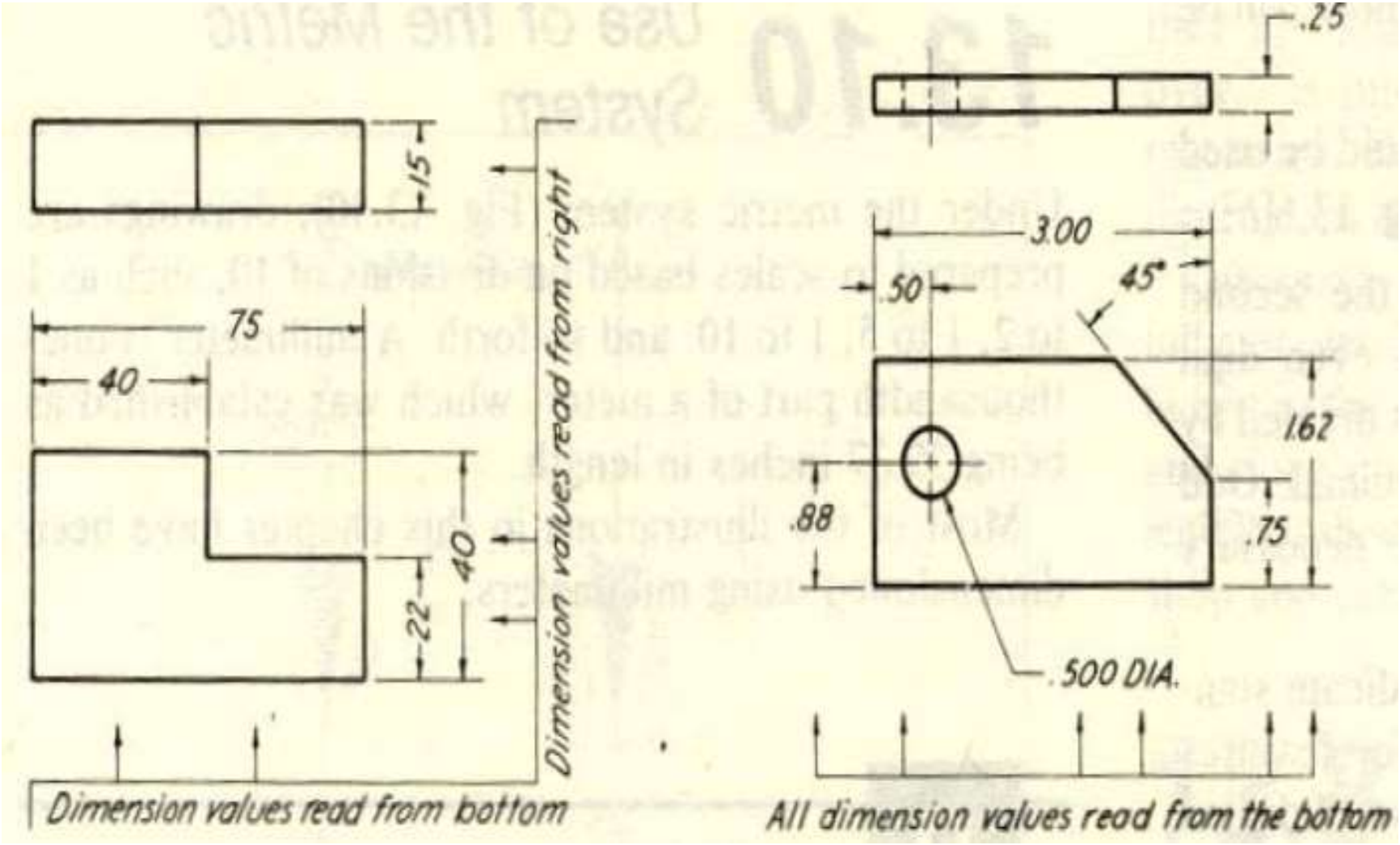


Dimensioning of angles





Correct way of dimensioning



Aligned method

Unidirectional method

Thank you