ENGINEERING GRAPHICS

INTRODUCTION

Department of Civil Engineering

Indian Institute of Technology (ISM) Dhanbad

Philosophy:

- **Drawing is the language of Engineers, Details of complex engineering components are better understood with the help of detailed drawing and sectional views**

Objective of Course: **To provide knowledge about the basic concepts of engineering drawing and the methods of generating Engineering drawing using CAD software**

Course Content

Class No.	Name of the topic	Syllabus	Usage in multi-disciplinary subjects
1	Introduction	Codal Guidelines for Drawing, Lettering, Scale, Types of lines,	Drawing techniques and ISO conventions
2	Curves used in engineering practices	Conic sections, Cycloid, Involute, Spiral	Lines for Engg drawing, Conic section- Structure, components Cycloid- Gear System and pumps, turbines Involute- Gear Tooth Spiral- Staircase
3	Projection of points and lines	Projection of points in different quadrants, projection of line inclined to one plane, Orthographic projection of lines inclined to both the reference planes	Visualization for drawing 3D object in 2D surface

Course Content

Class No.	Name of the topic	Syllabus	Usage in multi-disciplinary subjects
4	Projection of planes	Orthographic projection of planes inclined to one plane and inclined to both the planes	Features of plane/Lamina/Plate
5	Introduction to CAD tools	Introduction to Layout, co-ordinate system, lines, polygons, curves, dimensioning. Editing of existing drawings.	Basic drawing tools in CAD environment
6	Projection of solids	Orthographic projection of solids inclined to one plane and inclined to both the planes	Multi-view projection of 3D Engg components
7	Section of Solids	Section of Regular solids	Internal features of 3-D objects

Course Content

Class No.	Name of the topic	Syllabus	Usage in multi-disciplinary subjects
8	Development of surface	Prism, Cylinder/Cone, Pyramids and truncated solids	Manufacturing of 3D Engg system from 2D sheets via rolling/folding
9 10	Isometric Projection - Examples	Isometric scale, Orthographic to Isometric Projection- Real Examples	Creating 3D view of objects from multiview 2D projection
11	Isometric Projection – Examples- Continued	Isometric to Orthographic Projection- Real Examples	Creating 2D layouts for 3D objects

Text Book

TEXT BOOKS:

1. Bhatt, N. D. and Panchal V. M., "Engineering Drawing", Charator Publishing House
2. Ryan D. L. "Computer-aided graphics and design", CRC press

REFERENCE BOOKS:

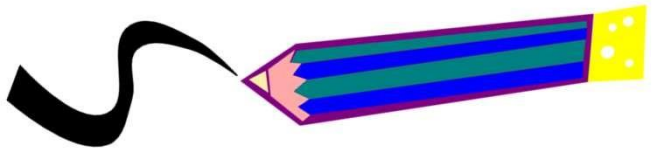
1. Chandra, A. M. and Chandra, Satish, "Engineering Graphics", Narosa Publishing House, New Delhi 2011
2. Giesecke, Mitchell, "Technical Drawing", Spencer, Hill, Dygdon and Novak, Macmillan Publishing Company. 2003
3. Venugopal K., "Engineering Drawing And Graphics + Autocad", New Age International Publishers

Pattern of Evaluation

1. **Continuous Assessment: 20 Marks**
2. **Midsemester Examination: 32 Marks**

6. End-Semester: 48 Marks

Engineering Drawing



- **Drawing is an art of representing objects or forms on a flat surface or a canvas mainly by means of lines, using any of a wide variety of tools and techniques.**

- **Engineering Drawing is a graphical way to convey an unambiguous and accurate description necessary for engineered items.**

- **Engineering Drawing is made in accordance with the standard conventions for layout, nomenclature, interpretation, size etc.**

- **Purpose of Engineering Drawing is to provide exact geometrical configuration for the construction or analysis of machines, structures or systems.**

Drawing Instruments and their Usage: Drawing Board

Drawing board is rectangular in shape and is made of strips of well-seasoned soft wood about 25 mm thick. It is cleated at the back by two battens to prevent warping. One of the edges of the board is used as the working edge, on which the T-square is made to slide. It should, therefore, be perfectly straight.

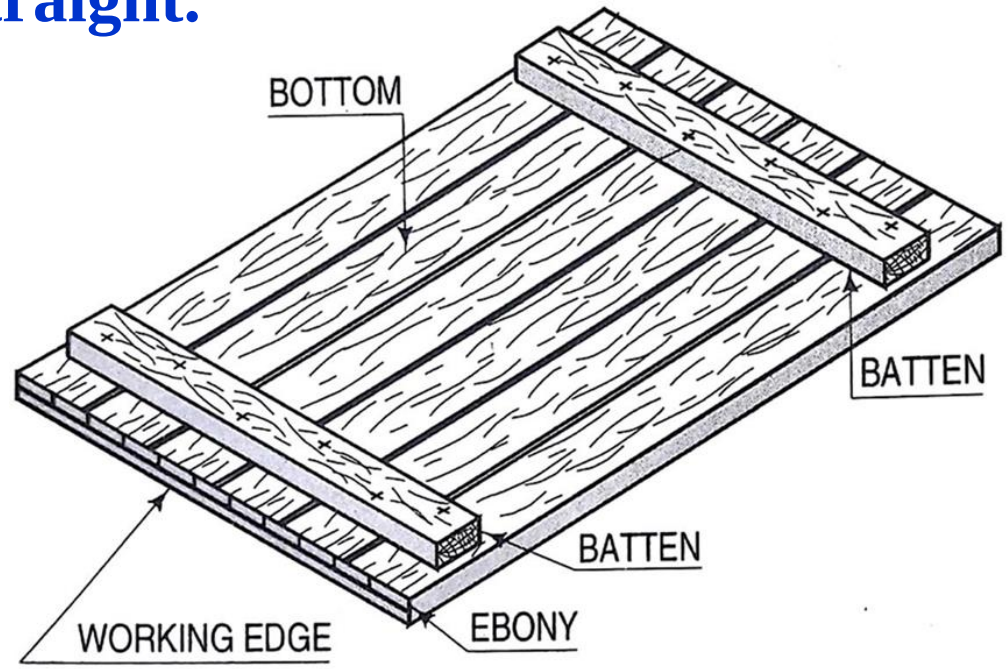
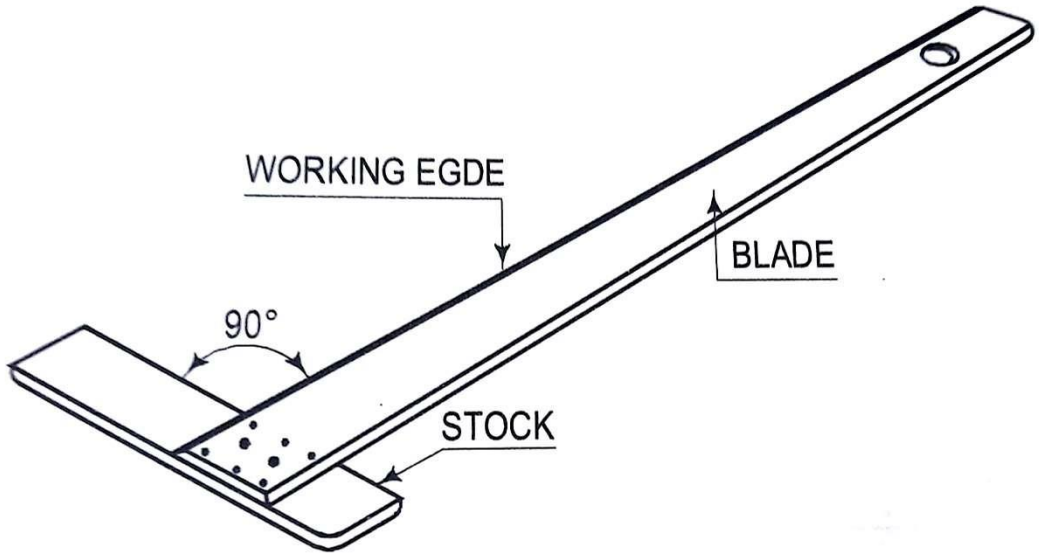


TABLE 1-1
SIZES OF DRAWING BOARDS

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

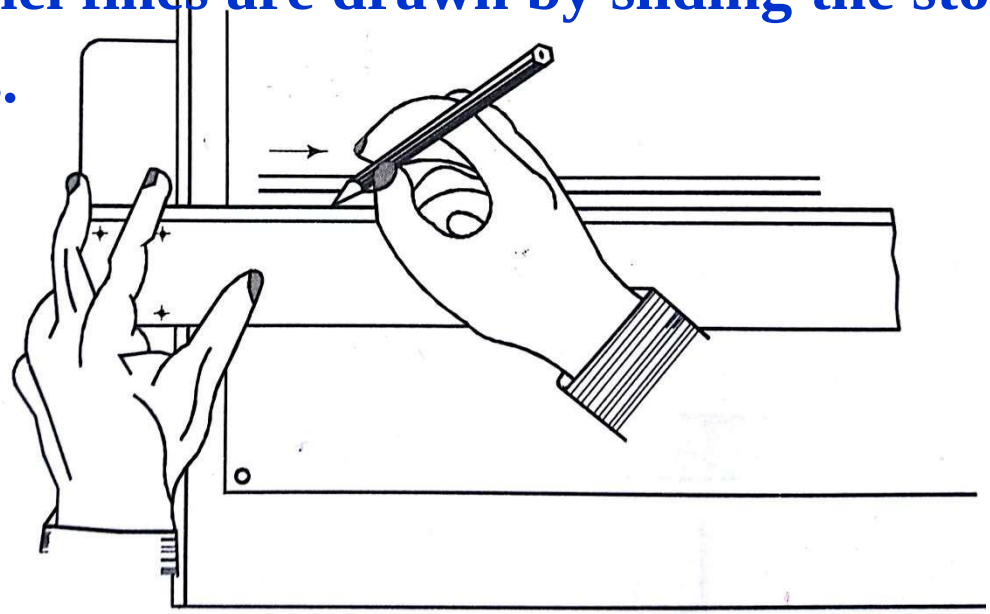
Drawing Instruments and their Usage: T-square



A T-square is made up of hard-quality wood, celluloid or hard plastic. It consists of two parts - the stock and the blade - joined together at right angles to each other by means of screws and pins. The stock is placed adjoining the working edge of the board and is made to slide on it as and when required. The blade lies on the surface of the board. Its distant edge is used as the working edge and hence, it should be perfectly straight. The nearer edge of the blade is never used.

Drawing Instruments and their Usage: T-square

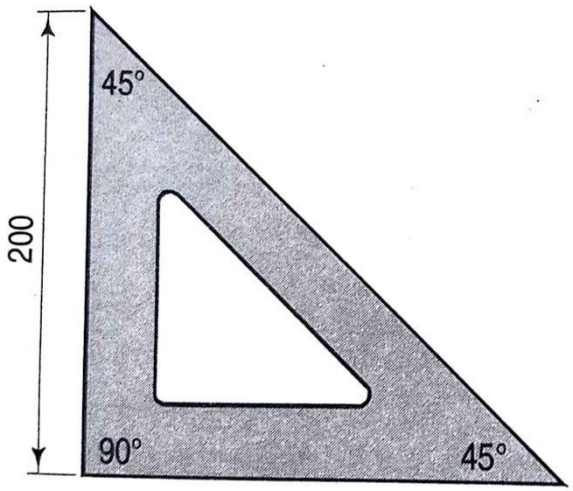
T-square is used for drawing horizontal lines. The stock of the T-square is held firmly with the left hand against the working edge of the board and the line is drawn from left to right. Horizontal parallel fines are drawn by sliding the stock to the desired positions.

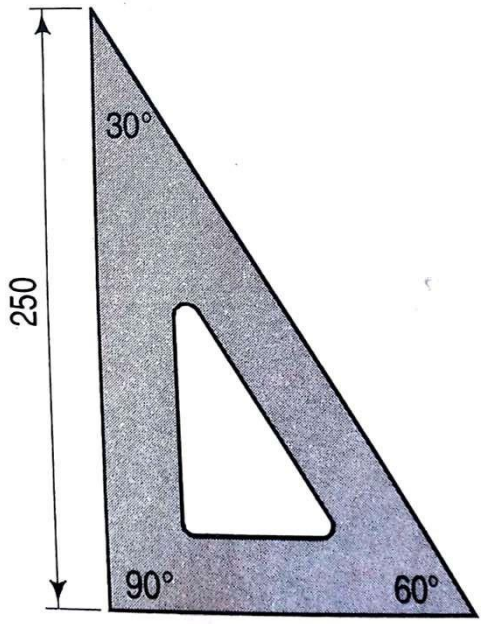


Ref video: https://www.youtube.com/watch?v=nA-mCsVLXy8

Drawing Instruments and their Usage: Set-squares

Two forms of triangular shaped set-squares with one of the angle as right angle are in general use. The 30°-60° set-square of 250 mm length and 45° set-square of 200 mm length are convenient sizes for use in schools and colleges.

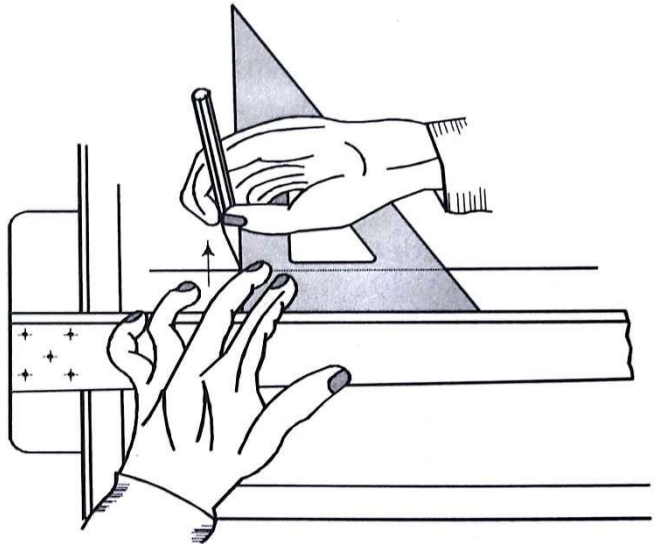


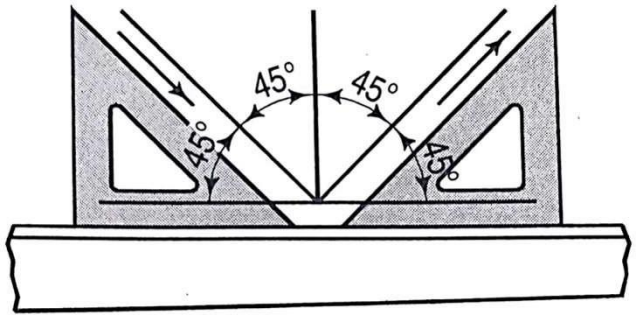


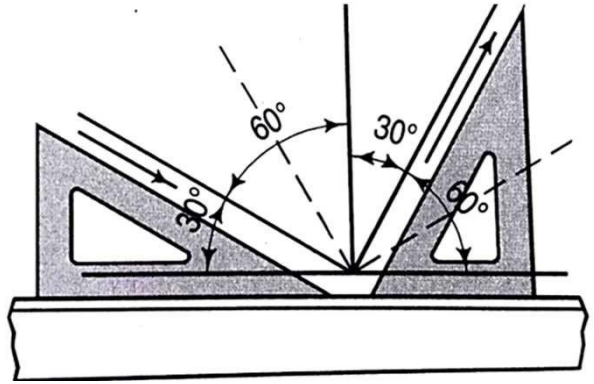
Drawing Instruments and their Usage:
Set-squares

Set-squares are used for drawing all straight lines except the horizontal lines which are usually drawn with T-square. Vertical lines can be drawn with the T-square and the Set-square.

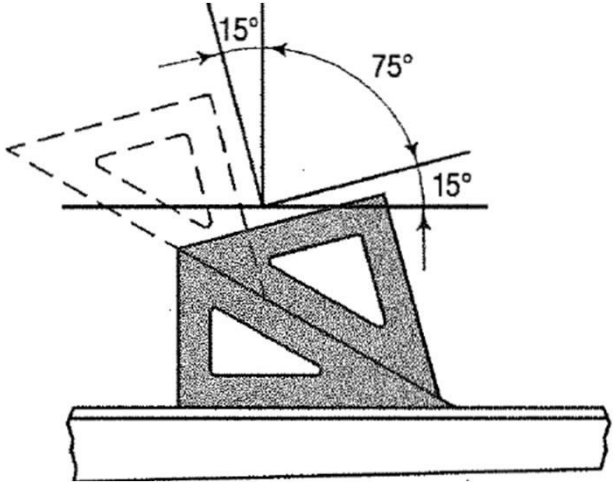
In combination with T-square, lines at 30° or 60° angle with vertical or horizontal lines can be drawn with 30°-60° Set-square and 45° angle with 45° Set-square.



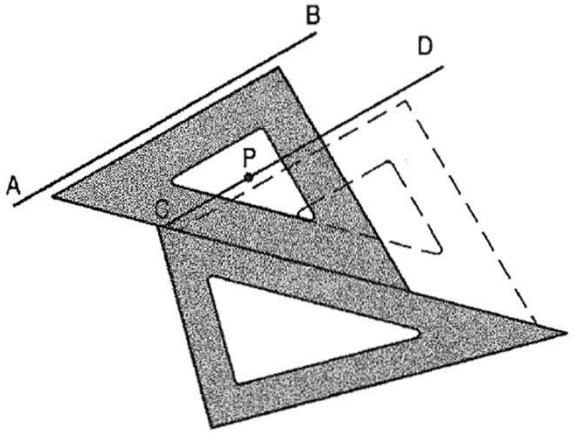




Drawing Instruments and their Usage:
Set-squares

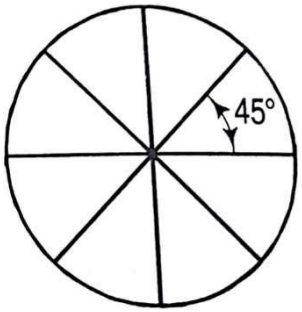


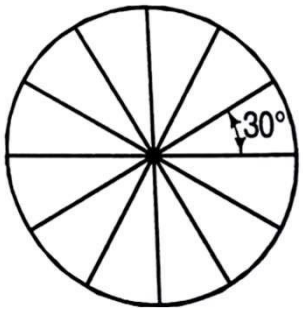
Two set-squares used simultaneously along with T-square will produce lines making angles of 15°, 75°, 105° etc.

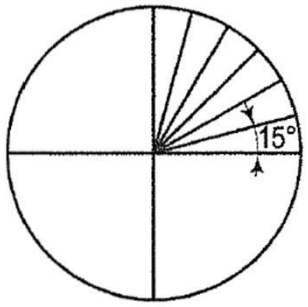


A circle can be divided in six, eight, twelve and twenty four equal parts by using Set-squares and T-square.

A straight line parallel to a given line can be drawn using set-squares.







Drawing Instruments and their Usage: Drawing Instrument Box

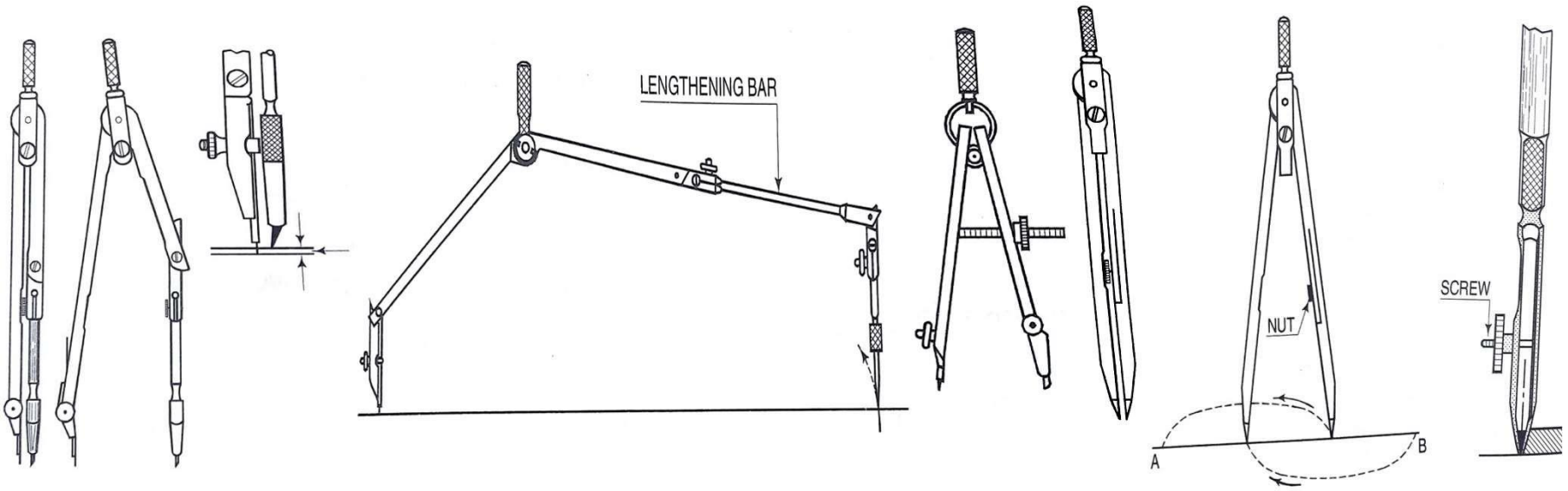
The drawing instrument box contains:

(1) Large-size compass with interchangeable pencil and pen legs

(2) Lengthening bar; (3) Small bow compass;

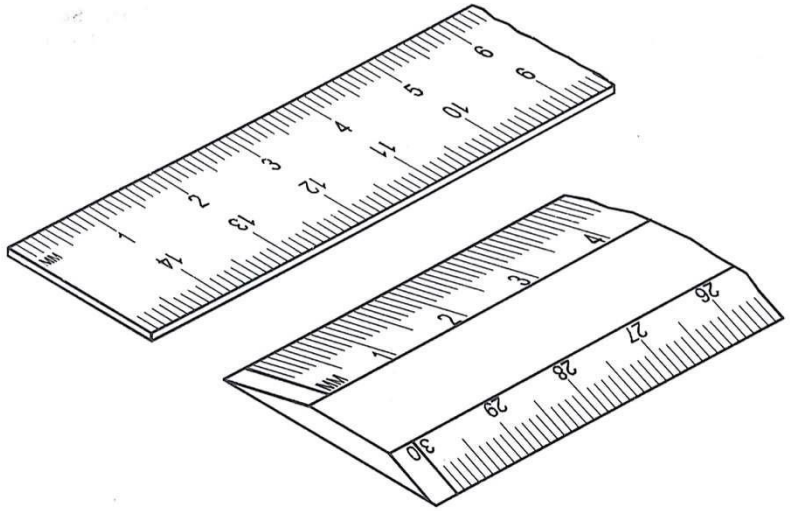
(4) Large-size divider; (5) Small bow divider;

(6) Small bow ink-pen; (7) Inking pen.



Drawing Instruments and their Usage: Scale

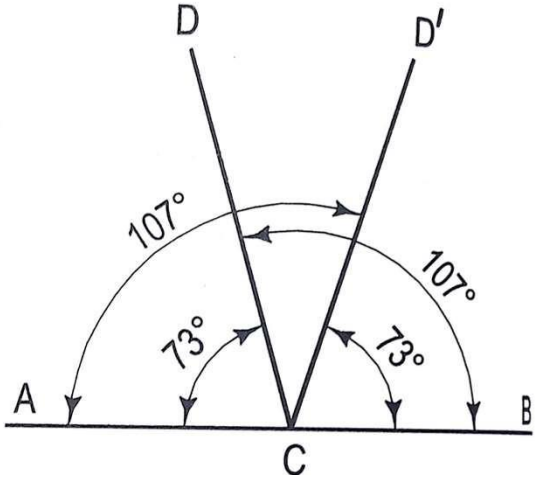
Scales are made of wood, steel, celluloid or plastic or card board. Stainless-steel scales are more durable. Scales may be flat or of triangular cross-section. 15 cm long 2 cm wide or 30 cm long 3 cm wide flat scales with 1 mm thickness are in common use. Scales are used to measure true or relative dimensions of an object.

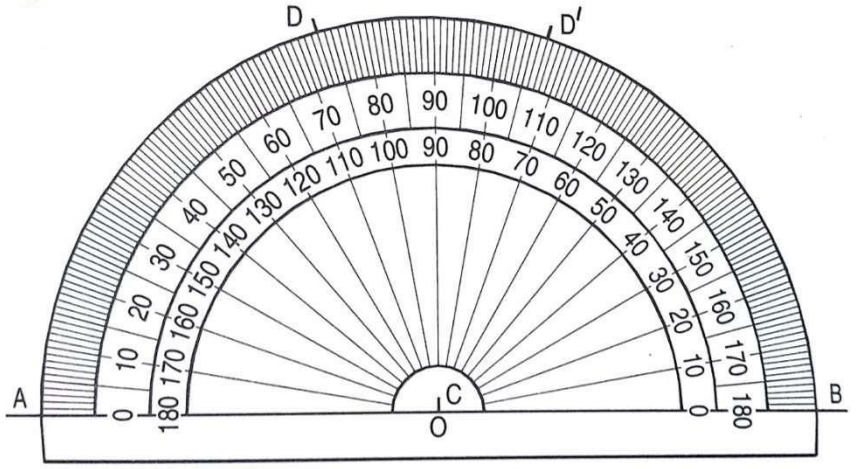


Drawing Instruments and their Usage: Protractor

Protractor is made of wood or transparent celluloid. They are flat and circular or semi-circular in shape. A semi-circular protractor of transparent celluloid of 100 mm diameter is most common. Its circumferential edge graduated to 1° divisions, is numbered at every 10° interval and is readable from both the ends.

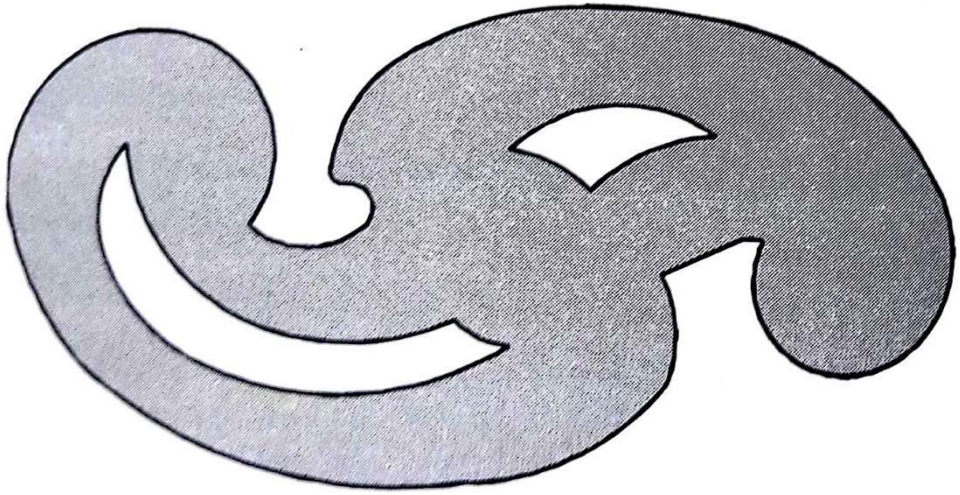
Diameter of the semi-circle i.e. the straight line 0-180°) is called the base of the protractor and its centre O is marked by a line perpendicular to it. The protractor is used to draw or measure such angles that cannot be drawn with set-squares.





Drawing Instruments and their Usage: French Curves

French curves are made of wood, plastic or celluloid. They are made in various shapes. French curves are used for drawing curves which cannot be drawn with a compass.



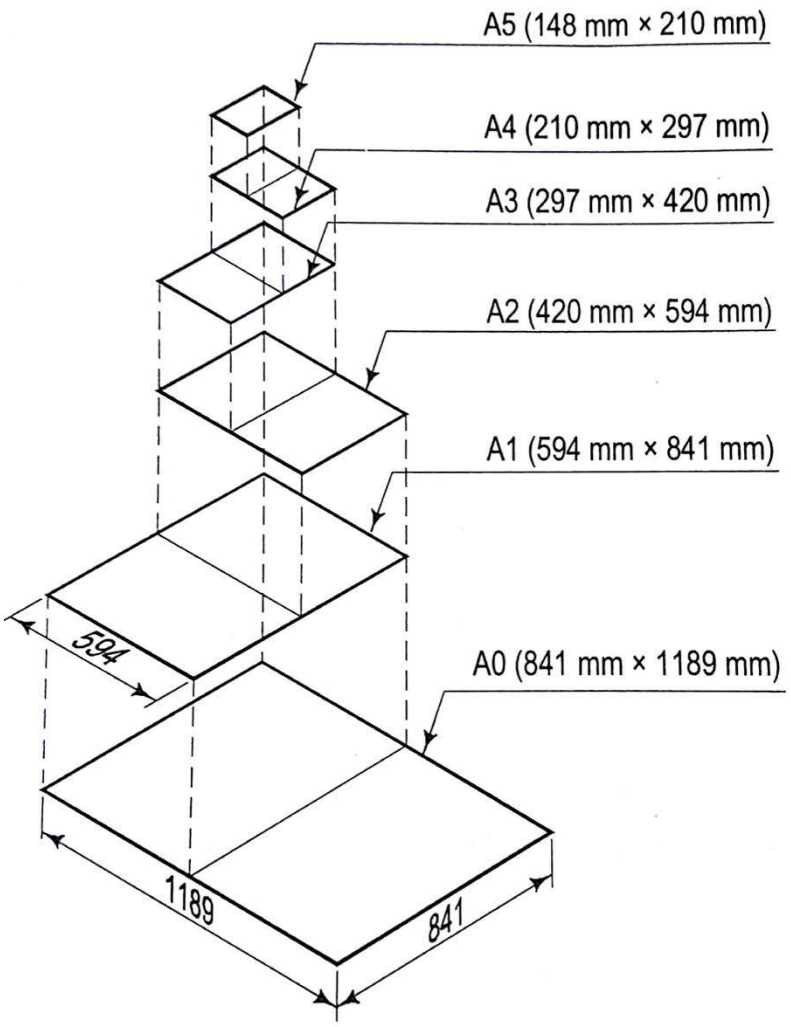
Ref video:
https://www.youtube.com/watch?v=sALid2hk0Ig

Drawing Instruments and their Usage: Drawing Papers

Drawing papers are available in many varieties. For ordinary pencil-drawings, the paper selected should be tough and strong. It should be uniform in white colour. While using rubber eraser it, its fibres should not disintegrate.

Good quality of paper with smooth surface should be selected for drawings which are to be inked and preserved for long time. It should be such that the ink does not spread.

Standard sizes of drawing papers recommended by Bureau of Indian Standards (BIS) are given.



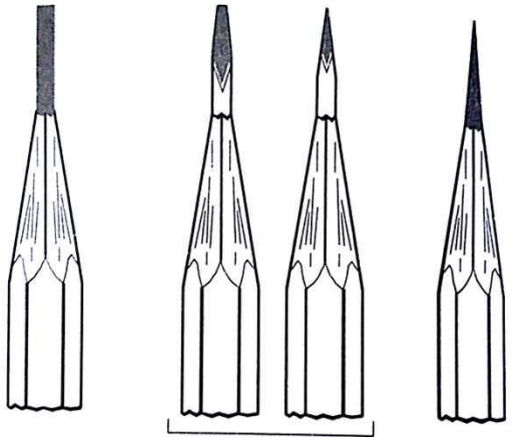
Drawing Instruments and their Usage: Drawing Pencils

The accuracy and appearance of a drawing depend very largely on the quality of pencils used. With cheap and low-quality pencils, it is very difficult to draw lines of uniform shade and thickness.

Grade of a pencil lead is shown by figures and letters marked at one of its ends. Letters HB denote medium grade. Increase in hardness is shown by the value put in front of the letter H, i.e. 2H, 3H, 4H etc. Similarly, the grade becomes softer according to the figure placed in front of the letter B, i.e. 2B, 3B, 4B etc.

Beginning of a drawing should be made with H or 2H pencil so that the lines are faint and unnecessary or extra lines can be easily erased. The final fair work may be done with harder pencils e.g. 3H.

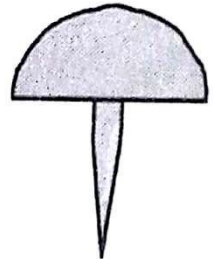
The lead may be sharpened to two different forms i.e. Conical point and Chisel edge.



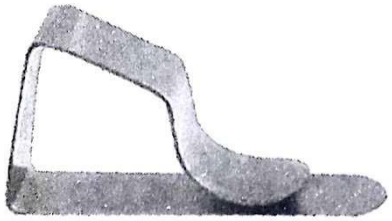
Drawing Instruments and their Usage: Erasers, Drawing Pins, Clips and Adhesive Tapes

Erasers

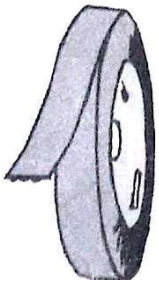
Soft India-rubber is the most suitable kind of eraser for pencil drawings. It should be such as not to spoil the surface of the paper. Frequent use of rubber should be avoided by careful planning.



Drawing Pins, Clips and Adhesive Tapes are used to fix the drawing paper on the drawing board. The needle part of the pin is generally made of steel, while the head may be of plated mild steel or brass. Pins of about 15 mm to 20 mm diameter and about 1 mm thick flat heads made of brass are quite convenient, as they do not rust. Pins should be so inserted that the heads sit on the surface of the paper.

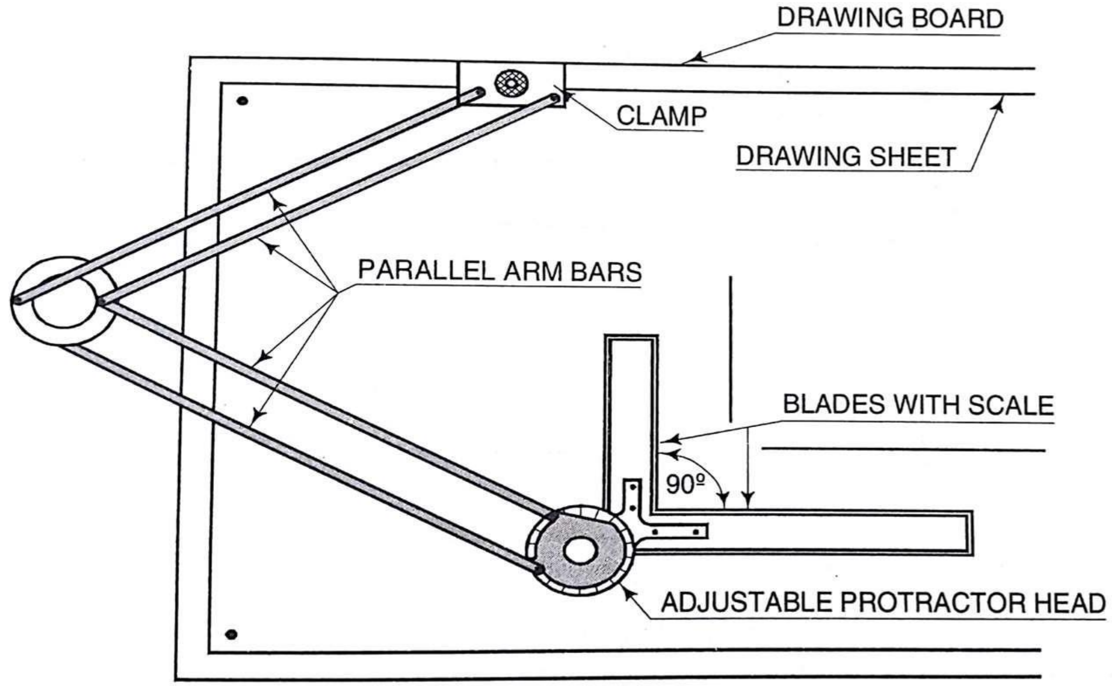


Clips or adhesive tapes are often used instead of the pins.



Drawing Instruments and their Usage: Drafting Machine

The uses and advantages of the T-square, set-squares, scales and protractor are combined in drafting machine. Its one end is clamped by means of screw, to the distant longer edge of the drawing board. At its other end, an adjustable head having protractor markings is fitted.



https://www.youtube.com/watch?v=eqqMKPx6koA

Two blades of transparent celluloid accurately set at right angles to each other are attached to the head. By means of this machine, horizontal, vertical or inclined parallel lines of desired lengths can be drawn easily at less time.

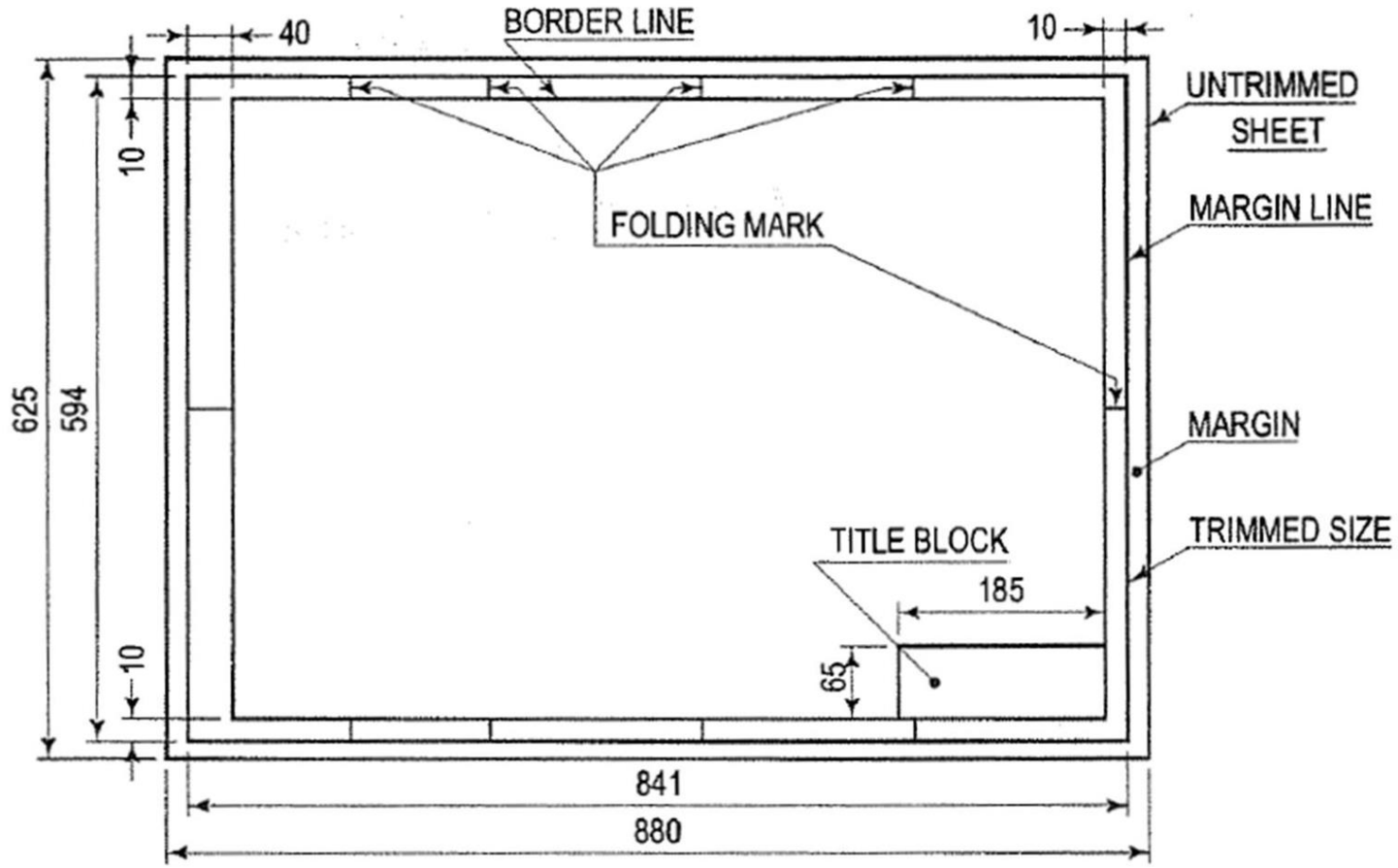
Drawing Sheet Size

Preferred sizes of the drawing sheetsrecommended by the Bureau of Indian Standards (BIS) are given below as per SP:46 (2003).

Sheet designation	Trimmed size (mm)	Untrimmed size (mm)
A0	841 × 1189	880 × 1230
A1	594 × 841	625 × 880
A2	420 × 594	450 × 625
A3	297 × 420	330 × 450
A4	210 × 297	240 × 330
A5	148 × 210	165 × 240

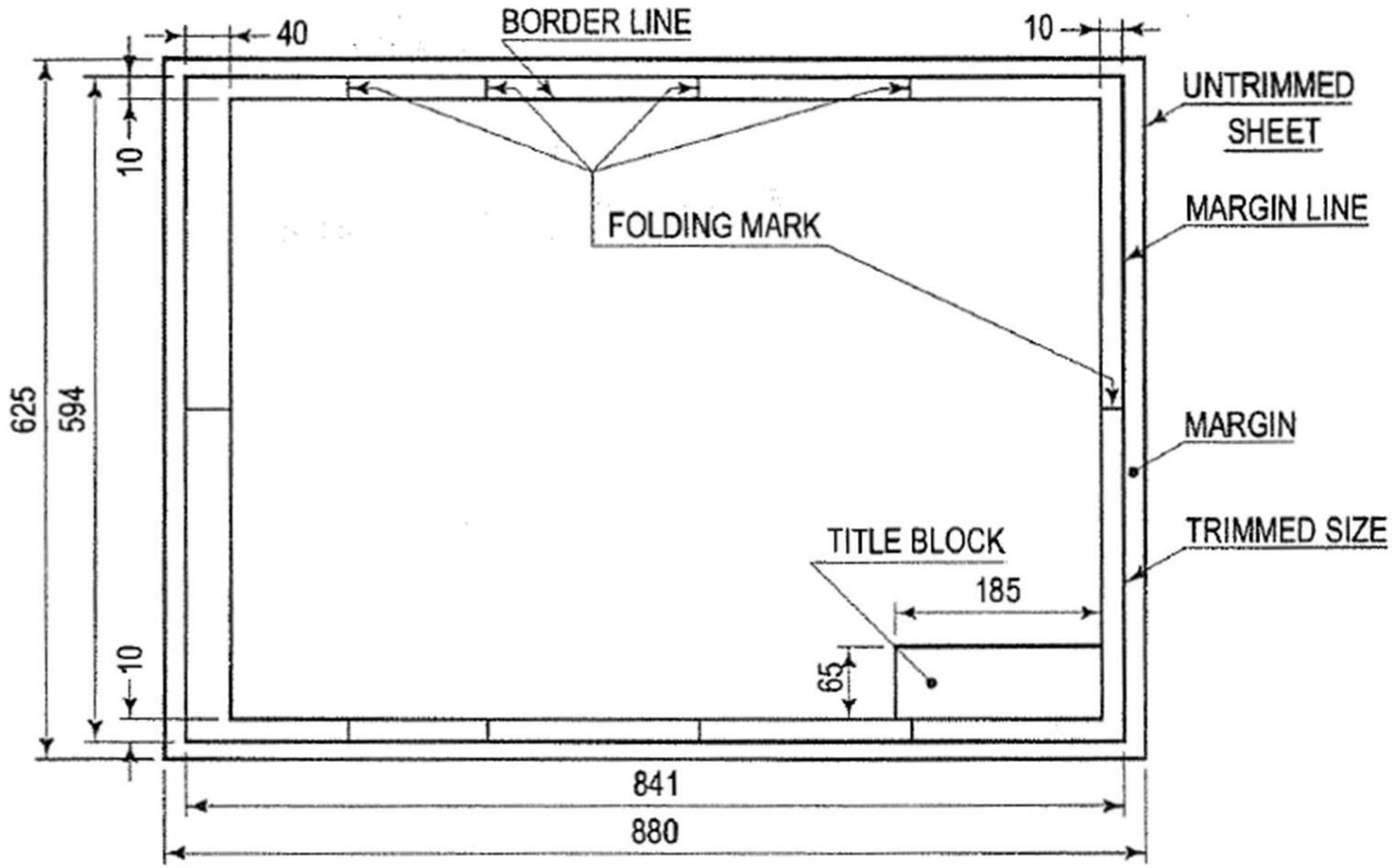
Drawing Sheet Layout

Border lines: Clear working space is obtained by drawing border lines. More space is kept on left for filing or binding if necessary. When sheets are stored in a cabinet without filing, equal space may be provided on all sides.



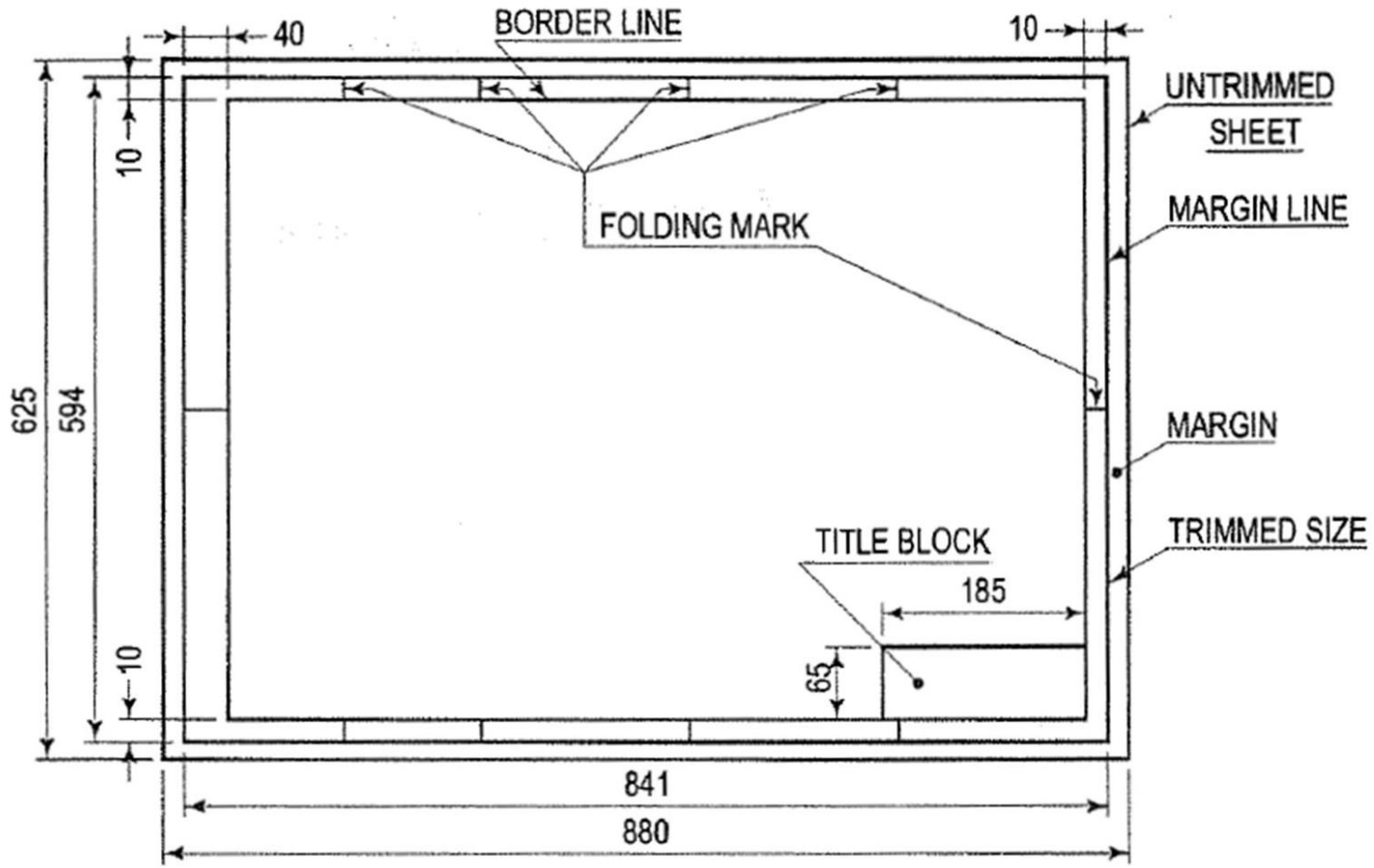
Drawing Sheet Layout

Borders/ Frames: SP: 46 (2003) recommends the borders of 20 mm width for sheet sizes A0 and A1 and 10 mm for the sizes A2, A3, A4 and AS. Frame shows clear space available for drawing purpose.



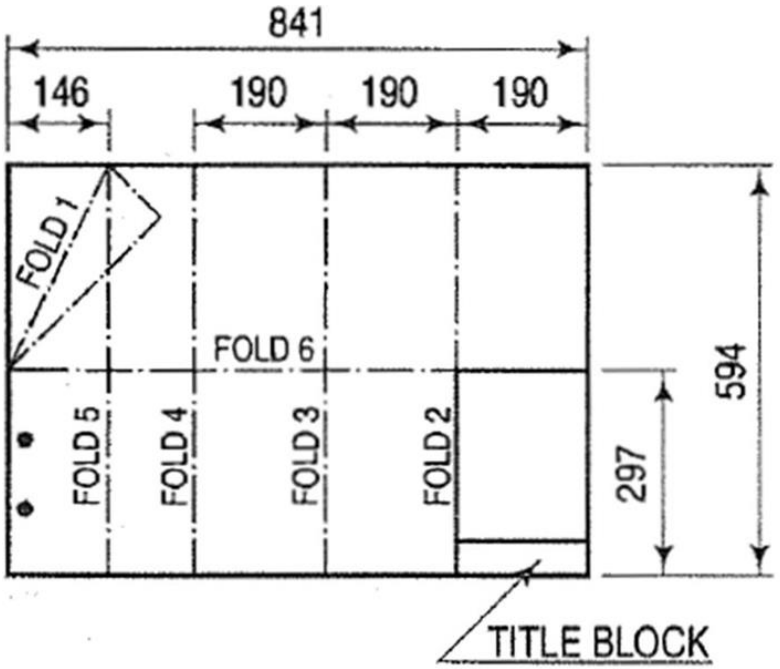
Drawing Sheet Layout

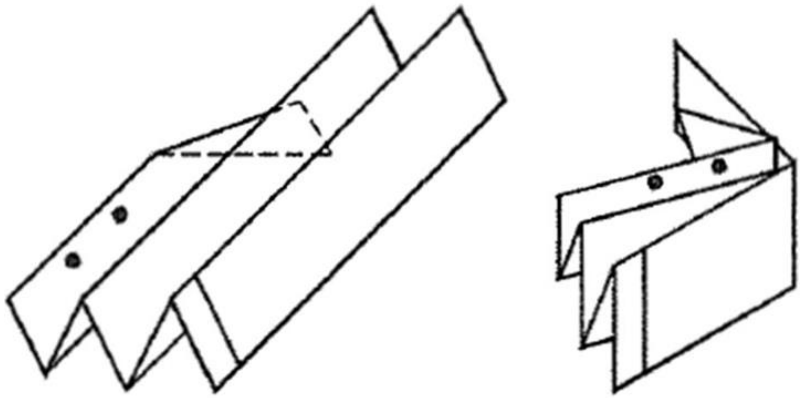
Folding marks: **Folding marks are made in the drawing sheet to aid in folding of sheets in proper and easy manner. Two methods of folding of sheets are in general use.**



Drawing Sheet Layout

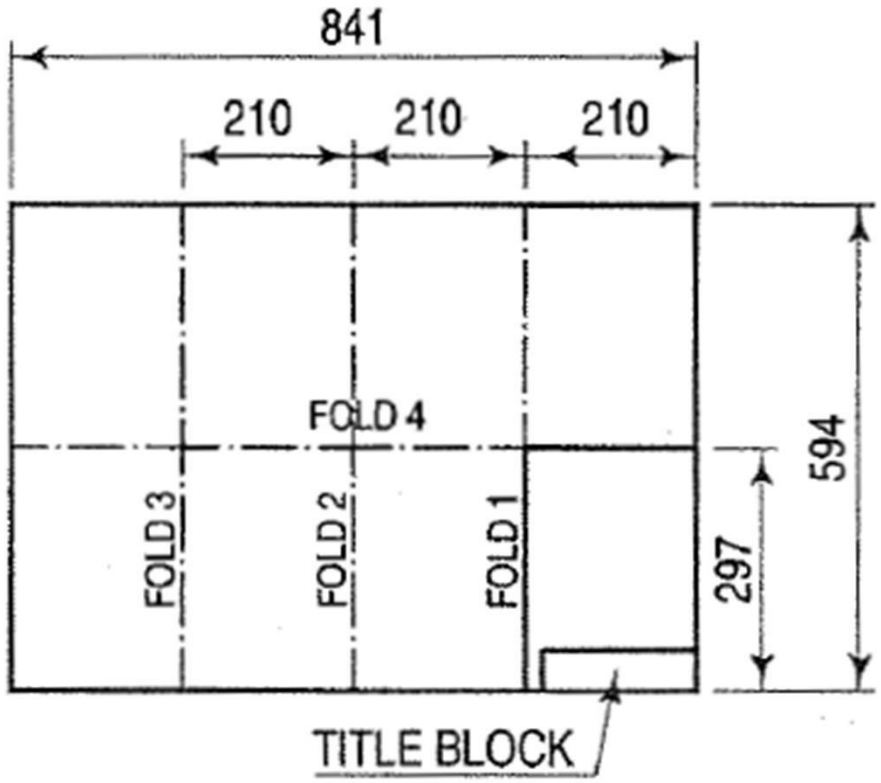
Folding marks: **Method I is suitable for sheets which are to be filed or bound. It allows them to be unfolded or refolded without removing them from the files.**





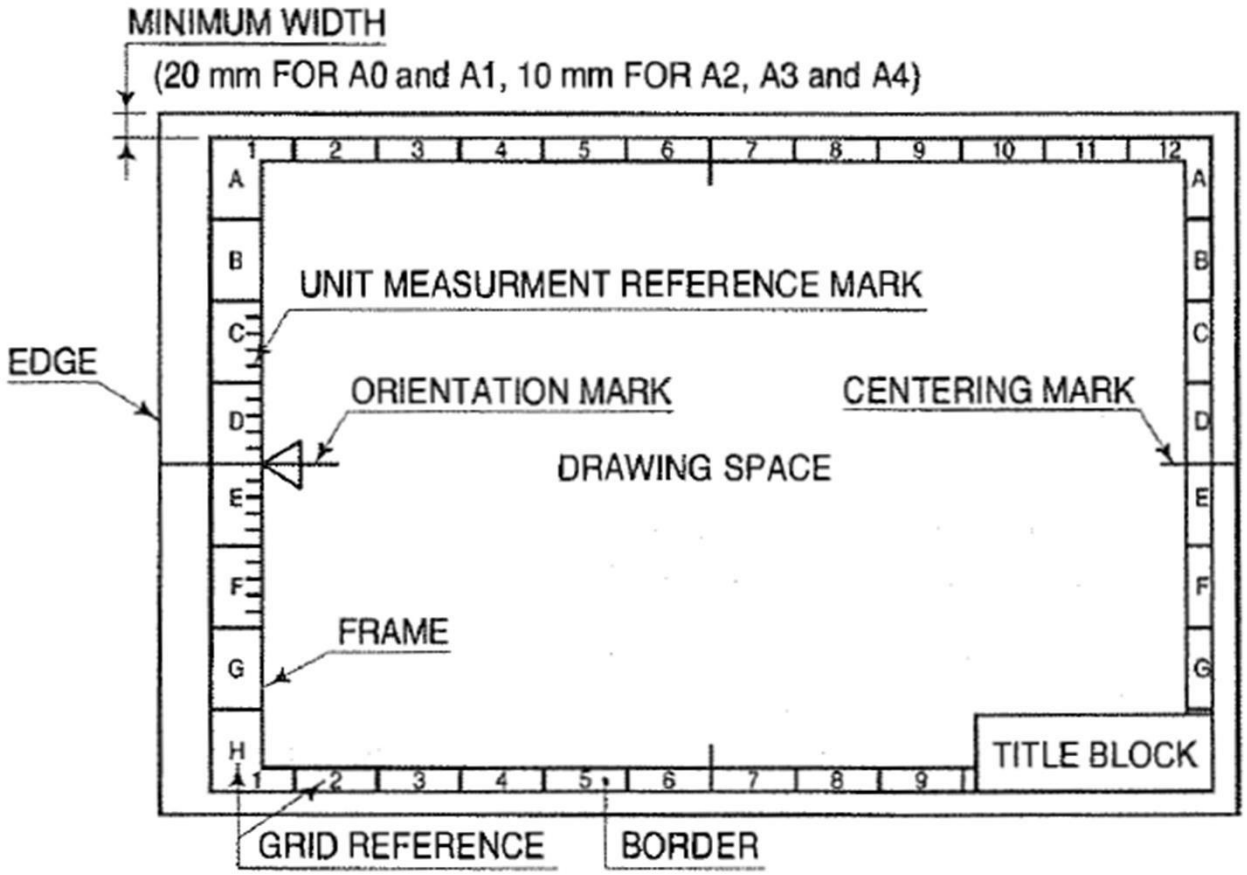
Drawing Sheet Layout

Folding marks: **Whensheetsare to be stored and preserved in cabinets, they are folded by method II.**



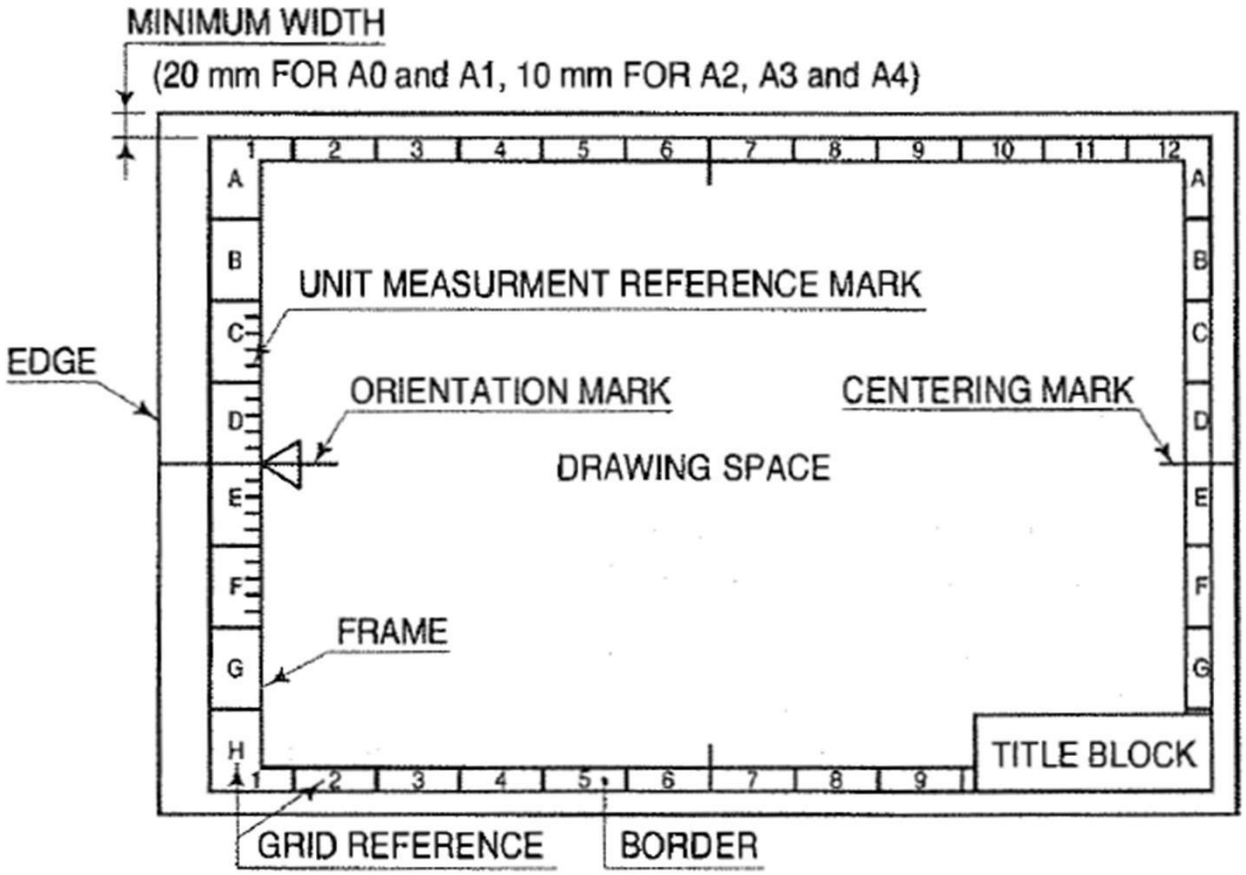
Drawing Sheet Layout

Orientation mark: **Four centring marks are drawn to facilitate positioning of the drawing for the reproduction purpose. The orientation mark will coincide with one of centring marks which can be used for the orientation of drawing sheet on the drawing board.**



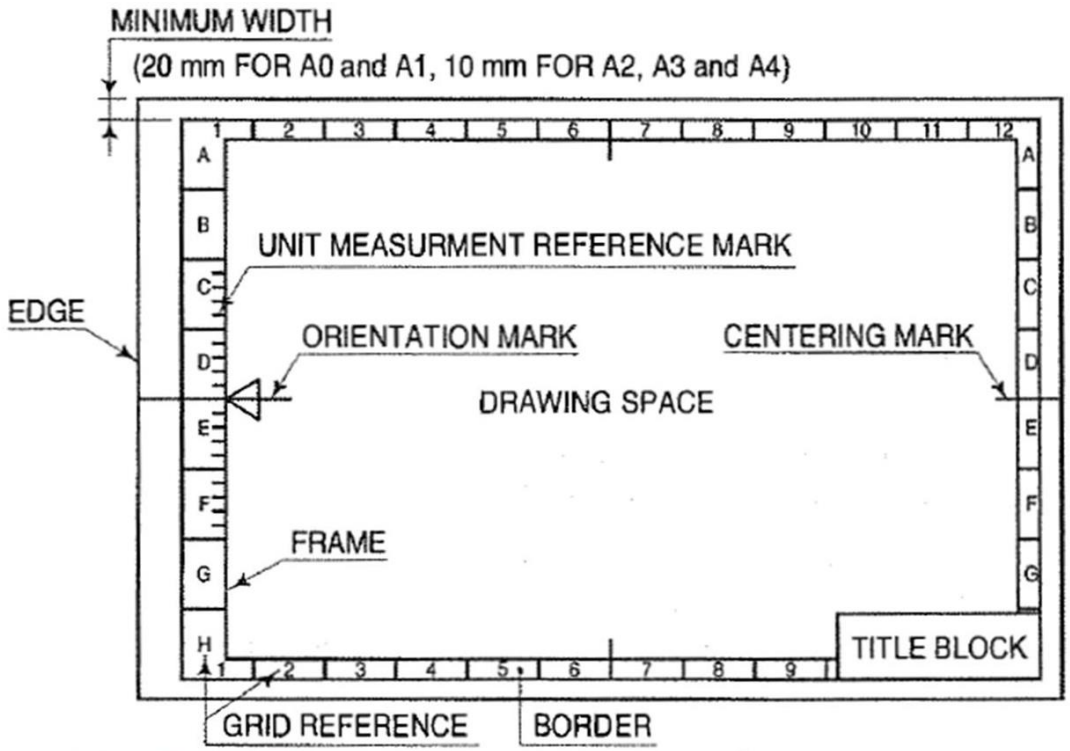
Drawing Sheet Layout

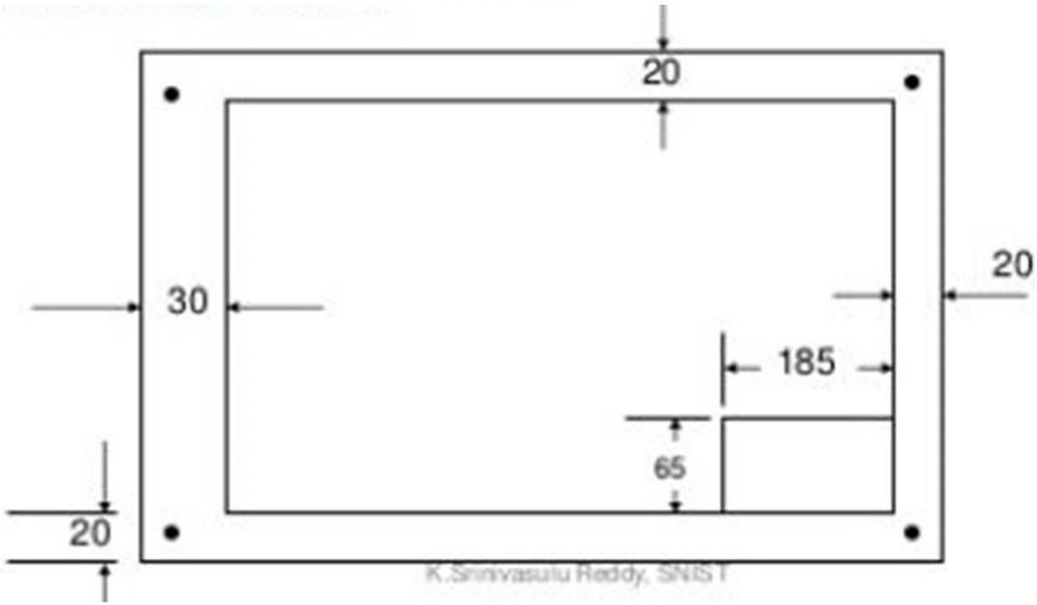
Grid reference system (zones system): The grid reference system is drawn on the sheet to locate details, alterations or additions. The rectangle of grid along the length should be referred by numbers 1, 2, 3 etc. and along the width by capital letters A, B, C, D etc.



Drawing Sheet Layout

Title Block: Space for the title block must be provided in the bottom right-hand corner of the drawing sheet. Size of the title block as per IS is 185 mm x 65 mm for all drawing sheets.



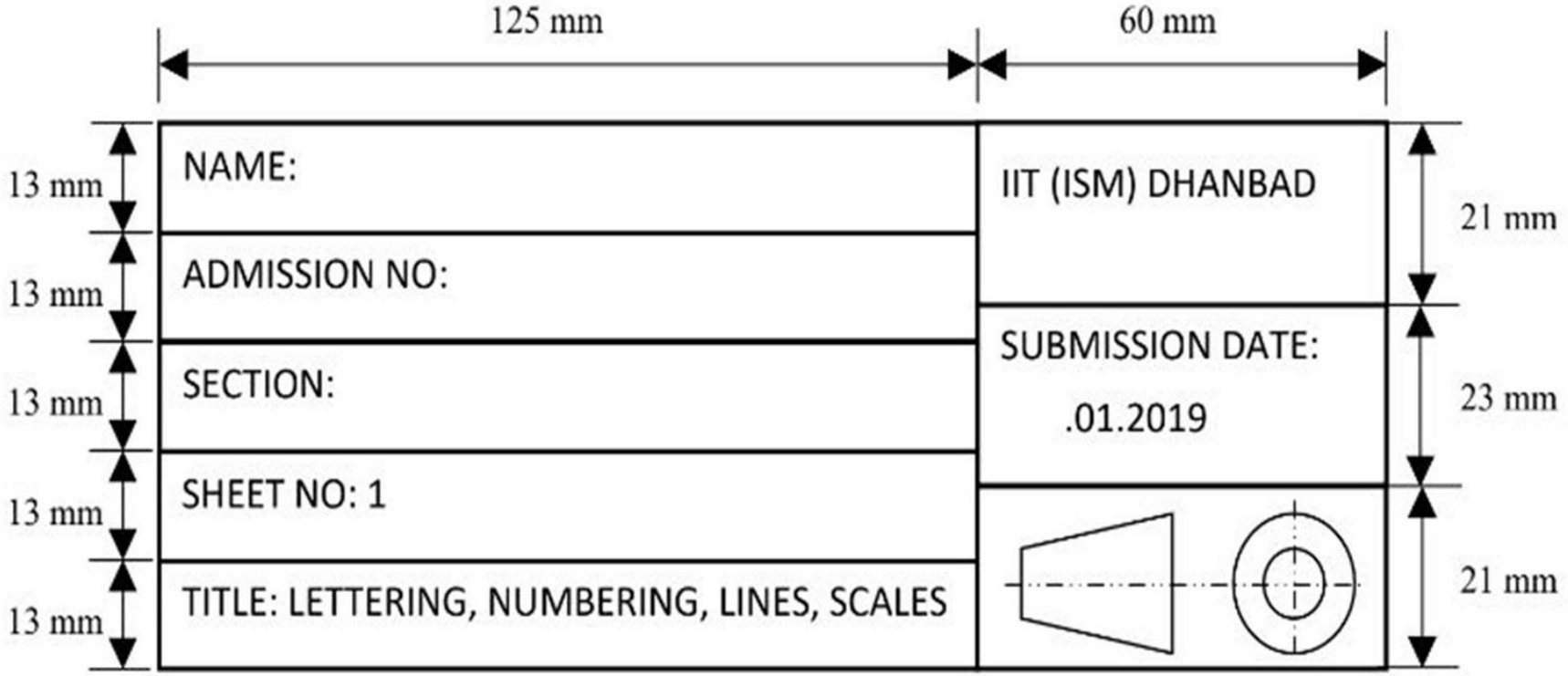


K.Srinivasulu Reddy, SNIST

Drawing Sheet Layout

Particulars of the Title Block:

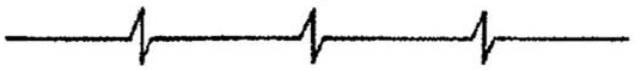
Name of the firm; Title of the drawing; Scale;
Symbol for the method of projection; Drawing number;
Initials with dates of persons who have designed, drawn, checked, and approved;
Sheet number and total number of drawing sheets of the object.



Lines and Pencils

Lines	Pencil
Initial work and construction lines	H
Outlines, dotted lines, section-plane lines, dimension lines, arrowheads	2H
Centre lines, section lines	3H or 4H

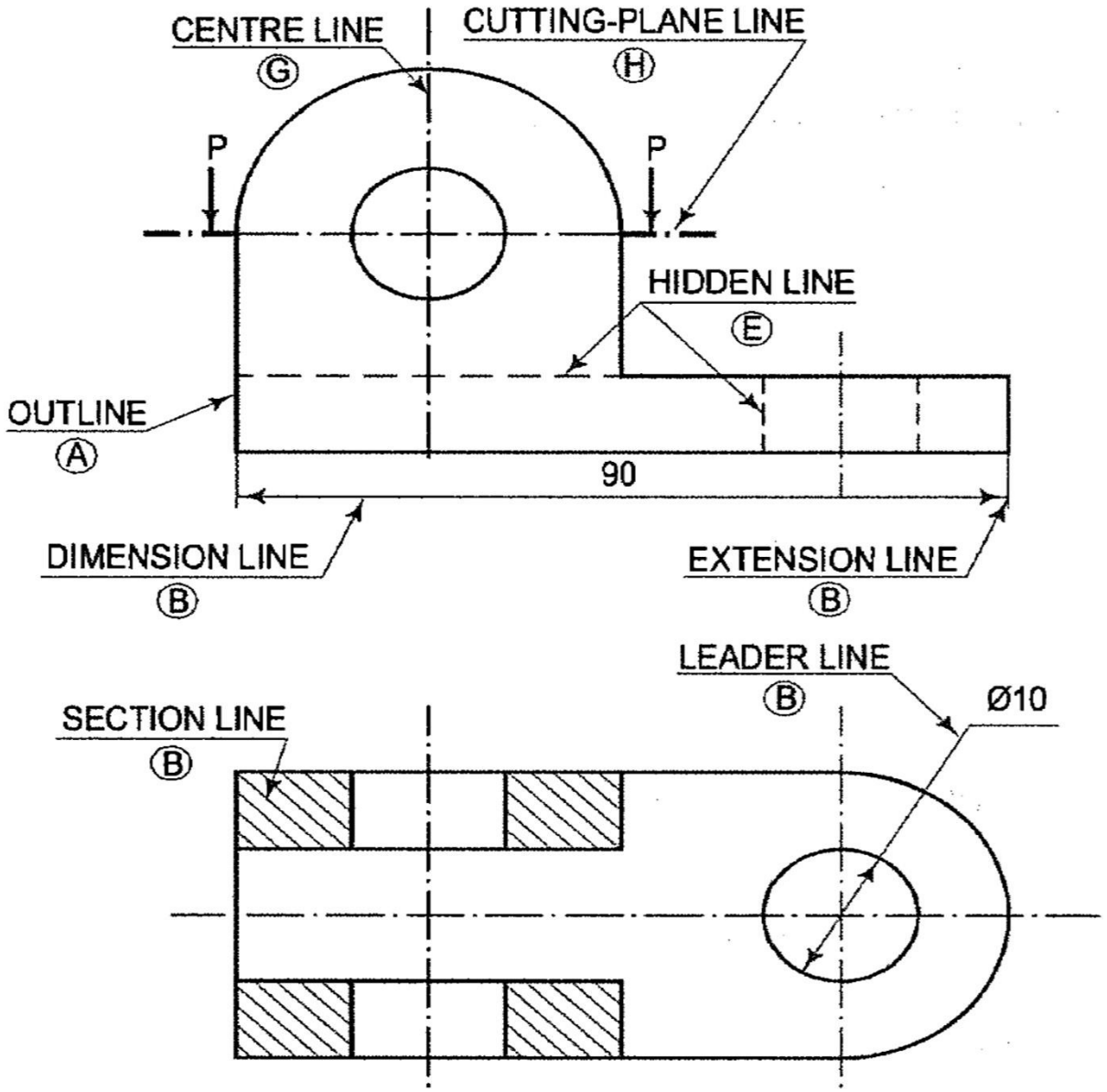
Type of Lines

Line	Description	General applications
A 	Continuous thick or Continuous wide	Visible outlines, visible edges; crests of screw threads; limits of length of full deph thread,lines of cuts and section arrows; parting lines of moulds in views; main representations in diagrams, maps, flow charts; system lines(structural metal engg.)
B	Continuous thin (narrow) (straight or curved)	Imaginary lines of intersection; grid, dimension, extension, projection, short centre, leader, reference lines; hatching; outlines of revolved sections; root of screw threads; interpretation lines of tapered features; framing of details; indication of repetitiv details;
C 	Continuous thin (narrow) freehand	Limits of partial or interrupted views and sections, if the limit is not a chain thin line
D 	Continuous thin (narrow) with zigzags (straight)	Long-break line

Type of Lines

Line	Description	General applications
E	Dashed thick (wide)	Line showing permissible of surface treatment
F	Dashed thin (narrow)	Hidden outlines; hidden edges
G	Chain thin Long-dashed dotted (narrow)	Centre line; lines of symmetry; trajectories; pitch circle of gears, pitch circle of holes,
H 	Chain thin (narrow) with thick (wide) at the ends and at changing of position	Cutting planes
J	Chain thick or Long-dashed dotted (wide)	Indication of lines or surfaces to which a special requirement applies
K	Chain thin double-dashed or long-dashed double-dotted (narrow)	Outlines of adjacent parts Alternative and extreme positions of movable parts Centroidal lines Initial outlines prior to forming Parts situated in front of the cutting plane

Application of Different Lines: Example



Lettering and Numbering

Writing of titles, dimensions, notes and other important particulars on a drawing is called lettering. Lettering and numbering should, be done properly in clear, legible and uniform style.

Single-stroke letters: The Bureau of Indian Standards (IS : 9609-2001) recommends single-stroke lettering for use in engineering drawing. These are the simplest forms of letters and are usually employed in most of the engineering drawings.

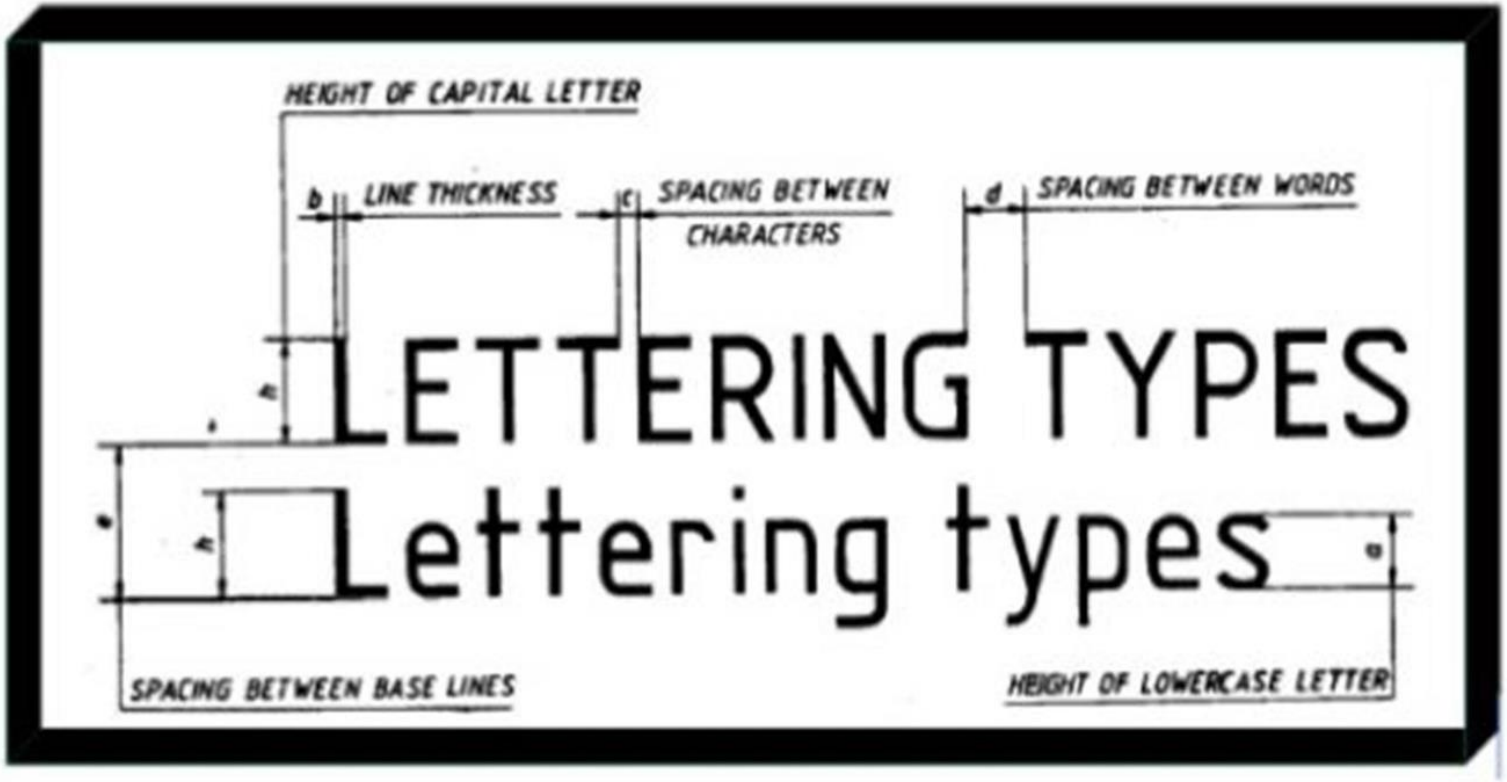
Single-stroke letters are of two types Vertical and Inclined.

The main titles are generally written in 6 - 8 mm size, sub-titles in 3 - 6 mm size, notes, dimension figures etc. in 3 - 5 mm size. The drawing number in title block is written in 10 -12 mm size.

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

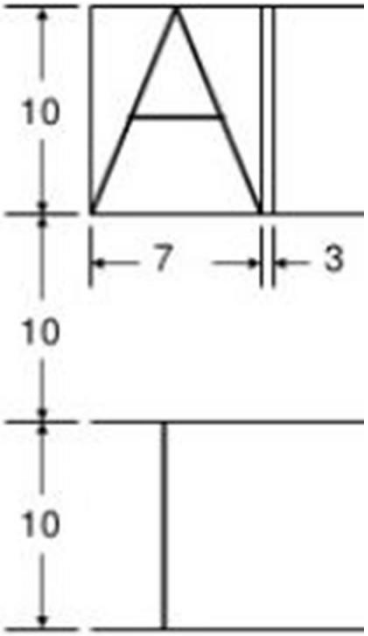
Specifications of A -Type Lettering

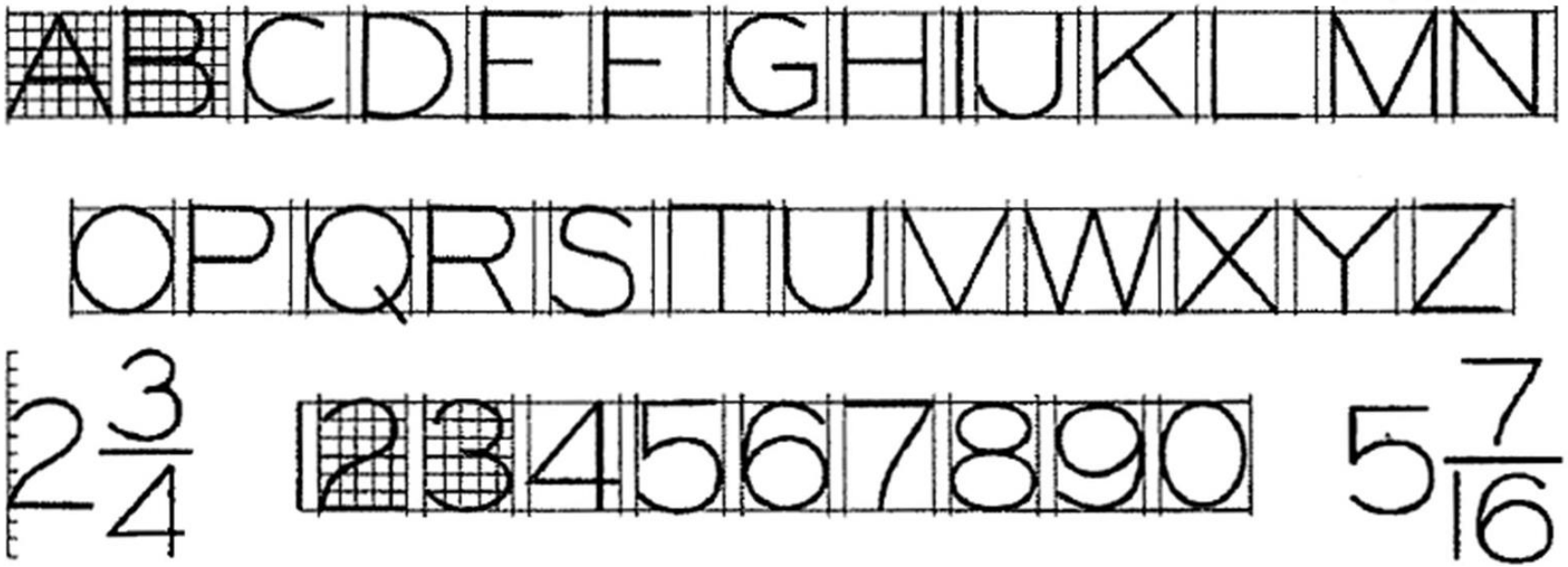
Specifications	Value	Size (mm)						
Capital letter height	h	2.5	3.5	5	7	10	14	20
Lowercase letter height	a = (5/7)h	-	2.5	3.5	5	7	10	14
Thickness of lines	b = (1/14)h	0.18	0.25	0.35	0.5	0.7	1	1.4
Spacing between characters	c = (1/7)h	0.35	0.5	0.7	1	1.4	2	2.8
Min. spacing b/n words	d = (3/7)h	1.05	1.5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

Lettering and Numbering





Vertical Single-stroke Letters

Lettering and Numbering

Inclined Single-stroke Letters

- Inclined letters are lean to the right, the slope being 75° with the horizontal.

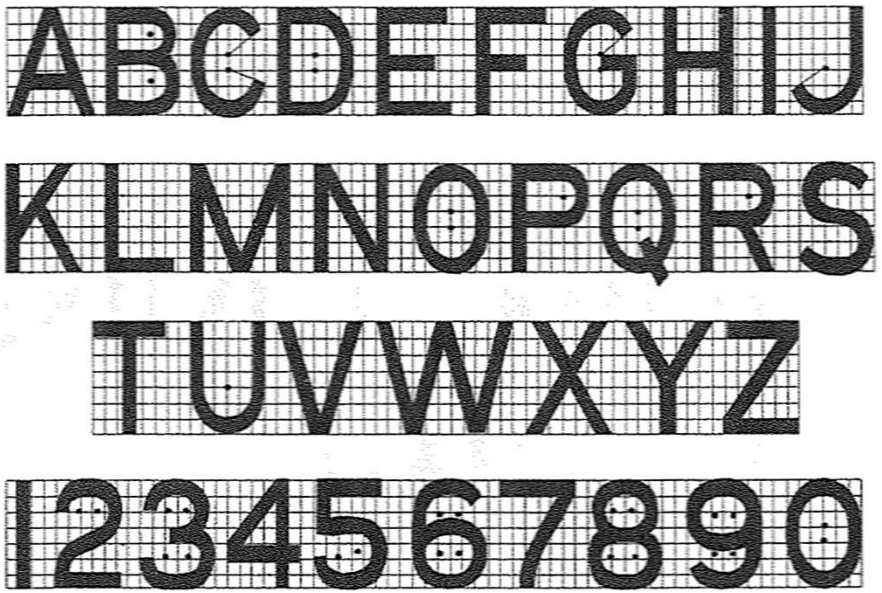
- lettering is generally done in capital letters

Lettering and Numbering

Gothic letters: Stems of single-stroke letters, if given more thickness, form gothic letters. These are mostly used for main titles of ink-drawings.

The outlines of the letters are first drawn with instruments and then filled-in with ink.

The thickness of the stem may vary from 1/5 to 1/10 of the height of the letters.



Dimensioning

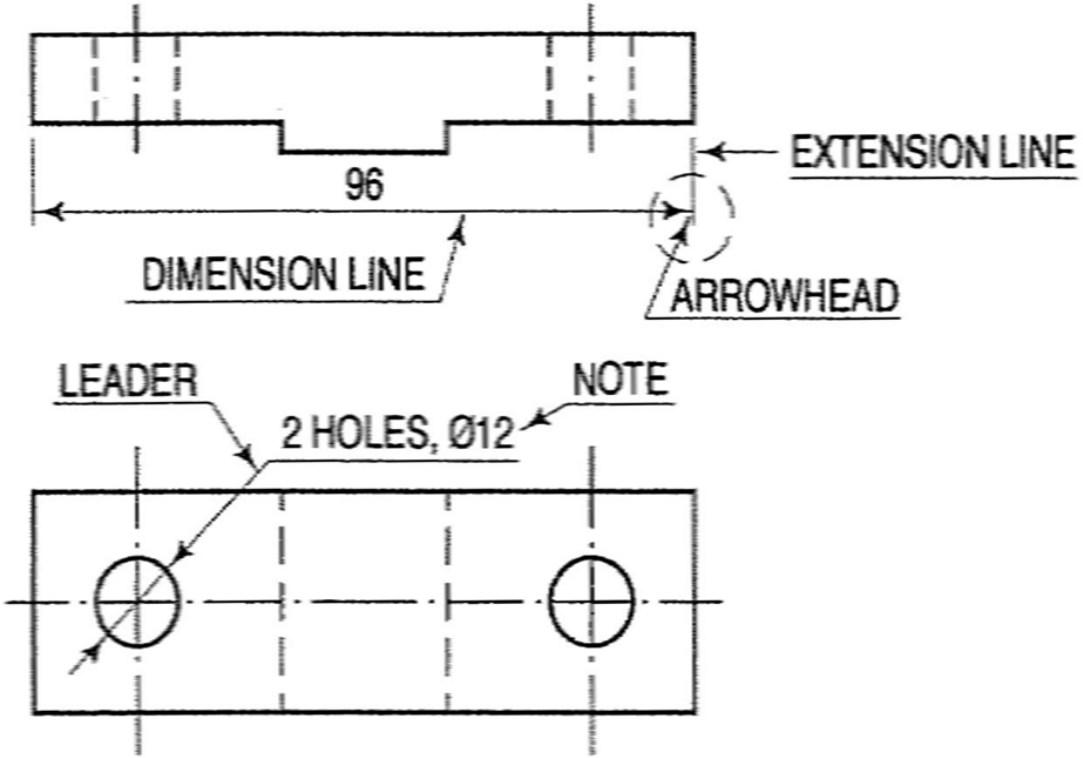
Dimension line: Dimension line is a thin continuous line. It is terminated by arrowheads touching the outlines, extension lines or centre lines.

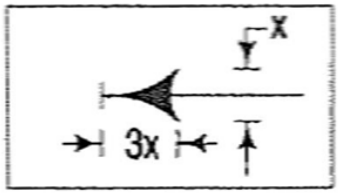
Extension line: An extension line is a thin continuous line drawn in extension of an outline. BIS recommended a gap of about 1 mm between the extension line and an outline or object boundary. It extends by about 3 mm beyond the dimension line.

Arrowhead: An arrowhead is placed at each end of a dimension line. Its pointed end touches an outline, an extension line or a centre line. The size of an arrowhead should be about three times its maximum width. Generally closed and filled arrowhead is widely used in engineering drawing.

Leader: A leader or a pointer is a thin continuous line connecting a note or a dimension figure with the feature to which it applies. One end of the leader terminates either in an arrowhead or a dot. The arrowhead touches the outline, while the dot is placed within the outline of the object.

Dimensioning





(i) OPEN (∠90°)

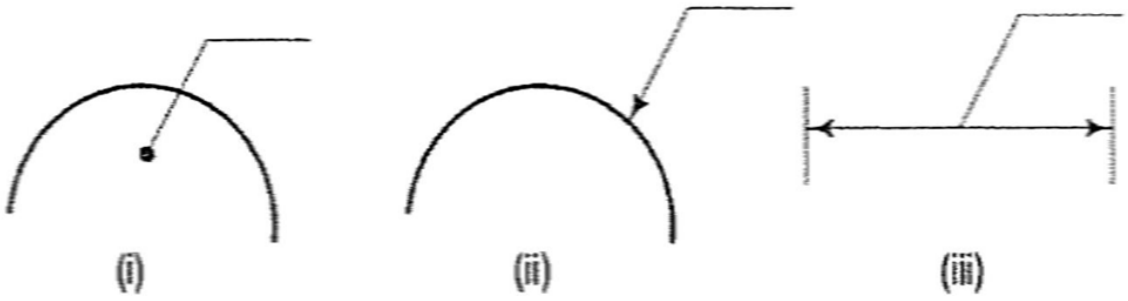
(ii) OPEN (∠20°)

(iii) CLOSED

(iv) CLOSED AND FILLED

(v) OBLIQUE STROKE

(vi) SMALL OPEN CIRCLE



Scales

A scale is defined as the ratio of the linear dimensions of element of the object as represented in a drawing to the actual dimensions of the same element of the object itself.

It may not be always possible to prepare full-size drawings. They are, therefore, drawn proportionately smaller or larger. When drawings are drawn smaller than the actual size of the objects (as in case of buildings, bridges, large machines etc.), the scale used is said to be a reducing scale (1 : 5). Drawings of small machine parts, mathematical instruments, watches etc. are made larger than their real size. These are said to be drawn on an enlarging scale (5 : 1).

(i)	Reducing scales	1 : 2 1 : 20 1 : 200 1 : 2000	1 : 5 1 : 50 1 : 500 1 : 5000	1 : 10 1 : 100 1 : 1000 1 : 10000
(ii)	Enlarging scales	50 : 1 5 : 1	20 : 1 2 : 1	10 : 1
(iii)	Full size scales			1 : 1

Scales

The scales can be expressed in the following three ways:

Engineer's scale: In this case, the relation between the dimension on the drawing and the actual dimension of the object is mentioned numerically, e.g. 10 mm = 5 m. As the drawing becomes old, the engineer's scale may shrink and may not give accurate results.

Graphical scale: The scale is drawn on the drawing itself. If the drawing shrinks, the graphical scale will also shrink. Hence, the graphical scale is commonly used in survey maps.

Representative fraction: The ratio of the length of the object represented on drawing to the actual length of the object represented is called the Representative Fraction (R.F.).

Type of Scales

The scales used in practice are classified as:

(1) Plain Scales; (2) Diagonal Scales; (3) Vernier Scales;

Plain Scales: A plain scale consists of a line divided into suitable number of equal parts, the first of which is sub-divided into smaller parts. Plain scales represent either two units or a unit and its sub-division.

In every scale,

(i) The zero should be placed at the end of the first main division, i.e. between the unit and its sub-divisions.

(ii) From the zero mark, the units should be numbered to the right and its sub-divisions to the left.

(iii) The names of the units and the sub-divisions should be stated clearly below or at the respective ends.

(iv) The name of the scale (e.g. 1 : 10) or its R.F. should be mentioned below the scale.

Plain Scale: Example

Construct a scale of 1 : 60 to show meters and decimetres and long enough to measure up to 6 metres. Measure 3.7 m distance in the scale.

R.F. of the scale = 1/60

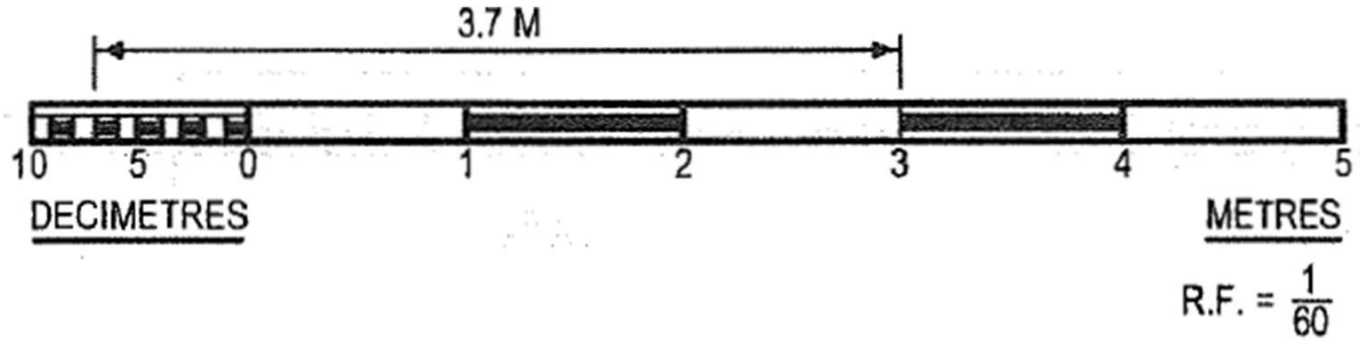
Length of the scale = R.F. × maximum length = 1/60 x 6 m = 10 cm

Draw a line 10 cm long and divide it into 6 equal divisions, each representing 1 m.

Mark 0 at the end of the first division and 1, 2, 3, 4 and 5 at the end of each subsequent division to its right.

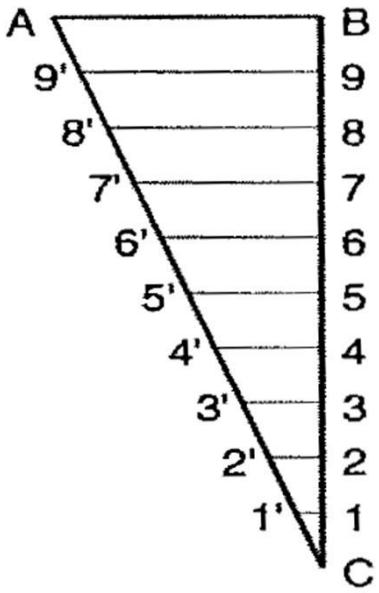
Divide first division into 10 equal sub-divisions, each representing 1 dm.

Mark 3.7 m distance on the scale.



Diagonal Scale

A diagonal scale is used when very minute distances such as 0.1 mm etc. are to be accurately measured or when measurements are required in three units; e.g., dm, cm and mm, or yard, foot and inch.



At one end, say B, draw a line perpendicular to AB and along it, step-off ten equal divisions of any length, starting from B and ending at C.

Number the division-points, 9, 8, 7, ... 1. Join A with C.

Through the points 1, 2 etc. draw lines parallel to AB and cutting AC at 1', 2' etc. It is evident that triangles 1'1C, 2'2 C ... ABC are similar.

Since C5 = 0.5BC, the line 5'5 = 0.5AB.

Similarly, 1'1 = 0.1AB, 2'2 = 0.2AB etc.

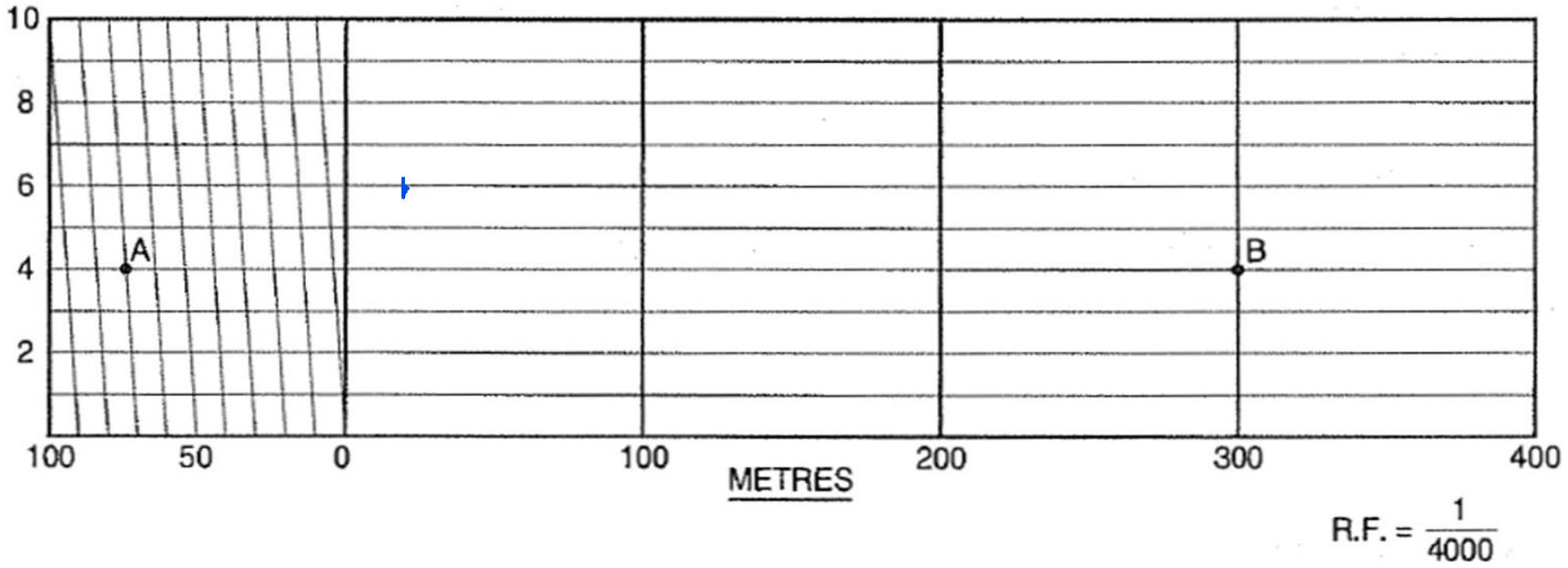
Diagonal Scale: Example

Construct a scale of 1 : 4000 to show meters and long enough to measure up to 500 metres. Show a length of 374 m on scale.

R.F. of the scale = 1/4000

Length of the scale = R.F. × maximum length = 1/4000 x 500 m = 12.5 cm

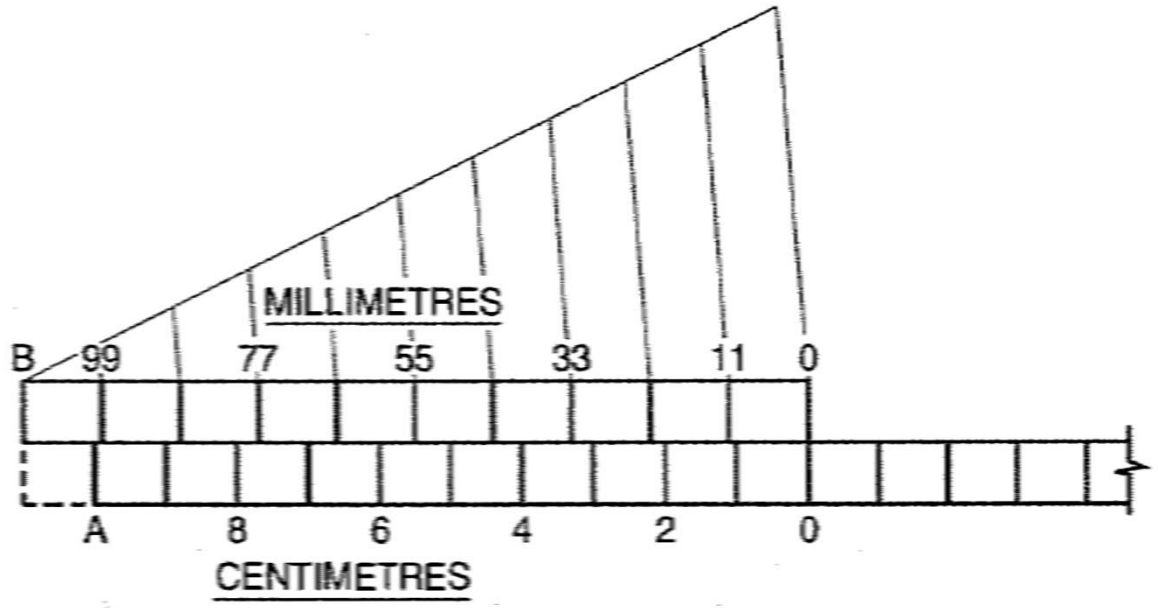
Draw a line 12.5 cm long and divide it into 5 equal divisions, each representing 100 m.



Vernier Scale

Vernier scales, like diagonal scales, are used to read to a very small unit with great accuracy. A vernier scale consists of two parts - a primary scale and a vernier. The primary scale is a plain scale fully divided into minor divisions.

Part of a plain scale in which the length A0 represents 10 cm. If we divide A0 into ten equal parts, each part will represent 1 cm. It would not be easy to divide each of these parts into ten equal divisions to get measurements in millimetres.

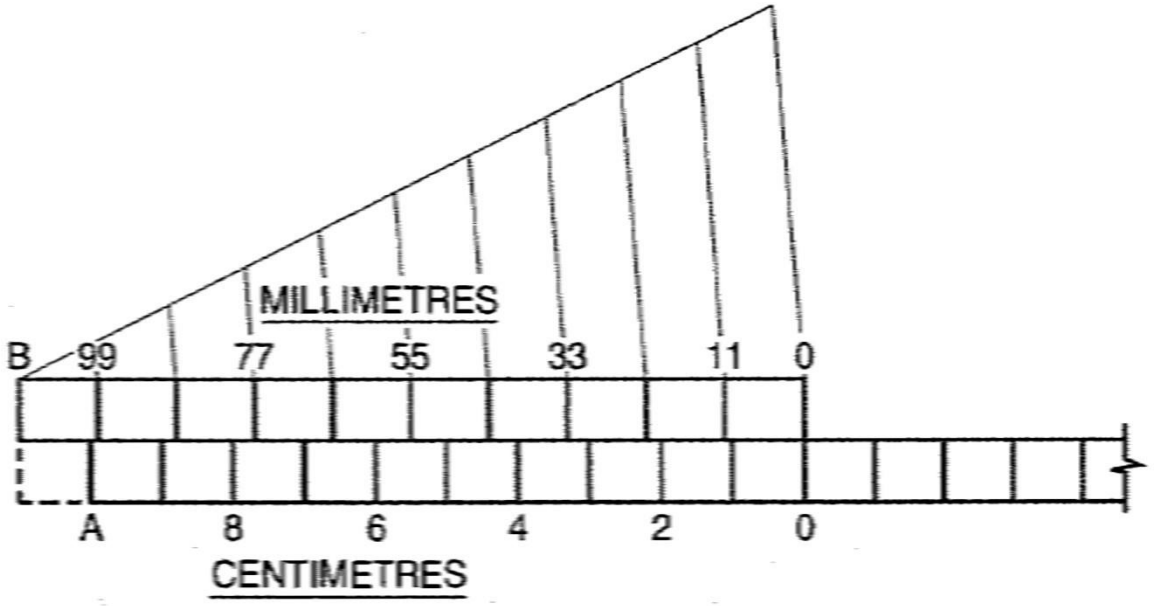


Vernier Scale

Now, if we take a length B0 equal to 10 + 1 = 11 cm and divide it into ten equal divisions, each of these divisions will represent 11/10 = 1.1 cm or 11 mm.

The difference between one division of A0 and one division of B0 will be equal 1.1 - 1.0 = 0.1 cm or 1 mm.

The upper scale B0 is the vernier. The combination of the plain scale and the vernier is the vernier scale.



Vernier Scale: Example

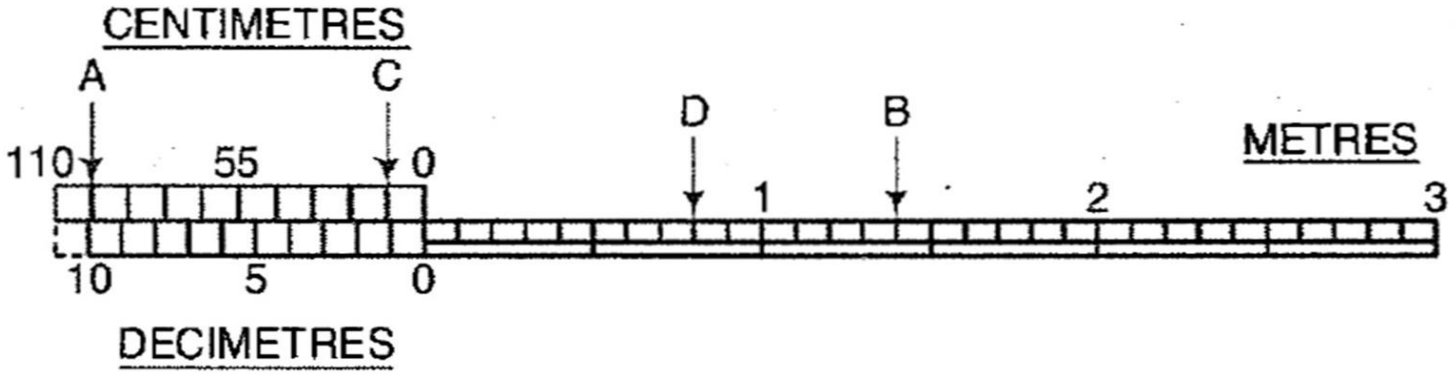
Draw a vernier scale of R.F. = 1/25 to read centimetres upto 4 metres and on it, show lengths representing 2.39 m and 0.91 m.

R.F. of the scale = 1/25

Length of the scale = R.F. × maximum length = 1/25 x 400 m = 16 cm

Draw a line 16 cm long and divide it into 4 equal divisions, each representing 1 m. Divide each of these parts into 10 equal parts to show decimetres.

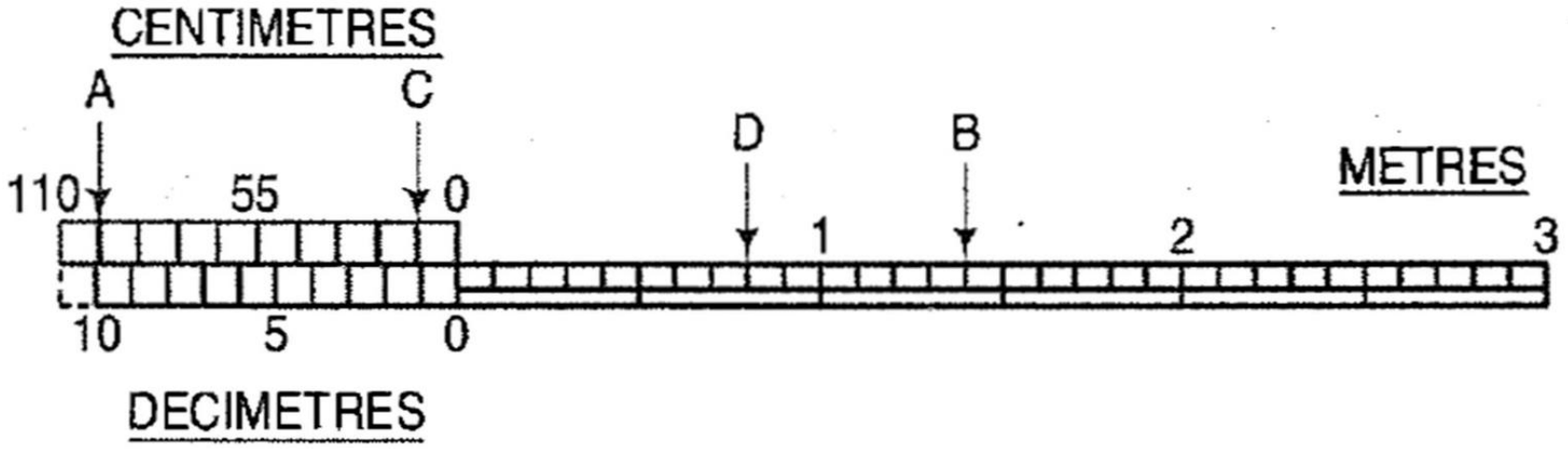
To construct a vernier, take 11 parts of decimetre length and divide it into 10 equal parts. Each of these parts will show a length of 1.1 decimetre or 11 cm.



Vernier Scale: Example

To measure a length representing 2.39 m, place one leg of the divider at A on 99 cm mark and the other leg at B on 1.4 m mark. The length AB will show 2.39 metres (i.e. 0.99 m + 1.4 m = 2.39 m).

Similarly, place one leg of the divider at C on 11 cm mark and the other leg at D on 0.8 m mark. The length CD shows 0.91 metres (i.e. 0.8 m + 0.11 m = 0.91 m).



Reference Videos

https://www.youtube.com/watch?v=n9iQcttWHAo&t=351s

https://www.youtube.com/watch?v=LagNkr-V8M8

https://www.youtube.com/watch?v=u0rmE5SZ9KA&t=409s