

LEARNING RESOURCE MATERIAL

ON

Engineering Drawing

UNDER EDUSAT PROGRAMME

SCTE&VT, BHUBANESWAR

ODISHA

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CHAPTER-1

Introduction and Demonstration

Drawing board:

A first class engineering drawing board is made of four to six strips of well seasoned soft good quality soft wood such as pine, fir, oak or kill of thickness about 18 mm. The wooden strips are cleated at the back by two battens by means of screws to prevent warping. One of the shorter edges of the rectangular board is fitted with a perfectly straight ebony strip. This edge is used as working edge for the T-square, which moves against the ebony edge.

Followings are the standard sizes of the drawing boards according to the Indian Standard Institution (I. S. I)

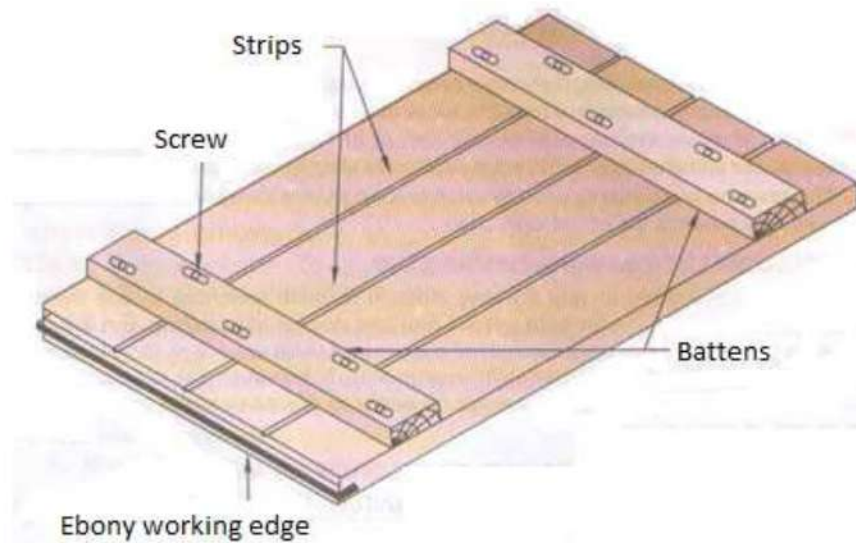


Figure 1: Drawing board

Sl. No.	Designation	Size in mm (Length X width X thickness)	To be used with sheet sizes
1	D ₀	1500x1000x25	A ₀
2	D ₁	100x700x25	A ₁
3	D ₂	700x500x15	A ₂
4	D ₃	500x350x15	A ₃

Drawing sheet

Different qualities of drawing sheets are available in the market. Depending upon the nature of the drawing the qualities of drawing papers are selected. The drawing paper should be of uniform thickness and of such quality that erasing should not have leave any impression on it. One of the sides of the drawing paper is usually rough and the other smooth. The smooth surface is the side for the drawing work.

Drawing sheets of different sizes are available. Figure 2 shows the drawing sheets of various sizes such as A_0 , A_1 , A_2 , A_3 , A_4 and A_5 according to the Indian Standard Institution (I.S.I). The standard sizes of trimmed and untrimmed drawing sheets according to the Indian Standard Institution (I.S.I) are given in the Table 2.

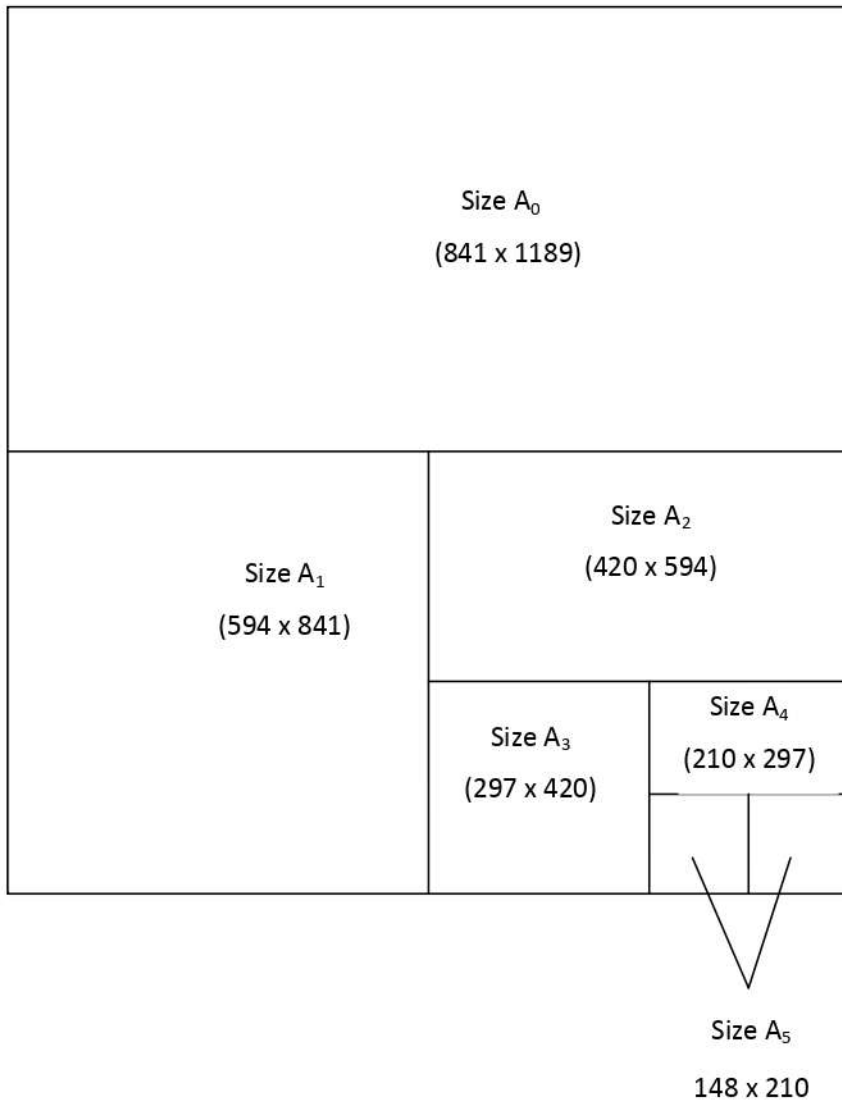


Figure 2: Standard size of drawing sheets according to I.S.I

Table 2: Standard sizes of trimmed and untrimmed drawing sheets

Sl. No.	Designation size in mm	Trimmed size in mm (Width x Length)	Untrimmed size in mm Width x Length
1	A ₀	841 x 1189	800 x 1230
2	A ₁	594 x 841	625 x 880
3	A ₂	420 x 594	450 x 625
4	A ₃	297 x 420	330 x 450
5	A ₄	210 x 297	240 x 330
6	A ₅	148 x 210	165 x 240

Drawing instruments and other drawing materials:

Following is the list of instruments and other ancillary accessories required for construction of drawing.

1. Drawing board
2. T-square
3. Set-squares
4. Compass
5. Divider
6. Protractor
7. Scale
8. Pencil
9. Rubber pr eraser
10. Drawing clips/Drawing pins
11. Duster or handkerchief
12. Mini-drafter

1. Drawing board

The details of drawing board have been discussed in the previous article.

2. T-square

T-square is made of hard quality wood such as teak or mahogany, etc. These are two essential parts of T-square, namely stock and blade. The blade is fitted with an ebony or plastic piece to form working edge of T-square. The two parts are held securely together at right angles to each other by means of screws or dowel pins in order to form a straight edge of blade as shown in the Figure. The working length of the T-square is equal to the length of the drawing board.

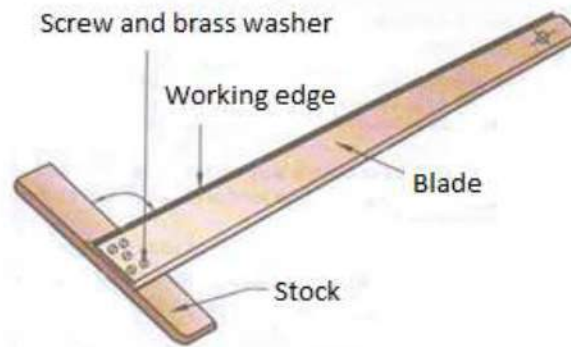


Figure 3: T-square

3. Set squares

Set squares are triangular in shape and are made of celluloid or plastic materials. Set squares made of transparent celluloid are the most satisfactory ones as the lines underneath them can be seen quite easily. Generally two types of set squares are in use. There are: (i) thirty-Sixty degree (30° - 60°) set square and (ii) Forty five degrees (45°) set square. The 30° - 60° set square has three angles with the measures of 30° , 60° and 90° respectively. Similarly, the 45° set square has three angles with the measures of 45° , 45° and 90° respectively.

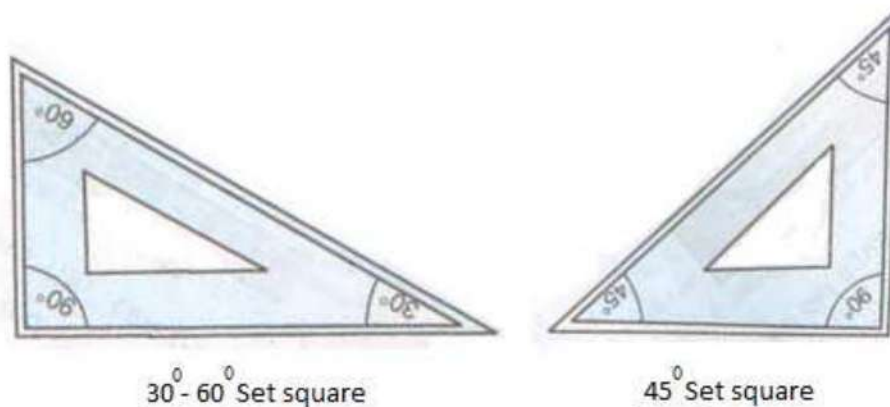


Figure 4: Sets square

Set squares of different sizes are available in the market. Set squares are used for drawing all straight lines except the horizontal lines which are drawn with T-square or mini-drafter as the case may be. Perpendicular lines or the lines at 30° , 60° and 90° to the horizontal line can be drawn by using set squares.

4. Compass

Compass is used for drawing circles and arcs of circles of required diameter. It consists of two metal legs hinged together at its upper end by means of joint known as knee joint. An adjustable or fixed needle is fitted on to the end of one of the legs whereas the other leg is provided with an attachment which can be

fitted with a pencil lid or pencil depending upon the nature of attachment. There are different types of compass available in the market depending upon their sizes, such as (i) large size compass and (ii) small size compass. Circles up to 120 mm diameters are drawn by keeping the legs of compass straight. For drawing circles more than 150 mm radius, a lengthening bar is used. It is advisable to keep the needle end about 1mm long compared to that of pencil end so that while drawing circles, when the needle end is pressed it goes inside the drawing sheet by a small distance (approximately 1mm).

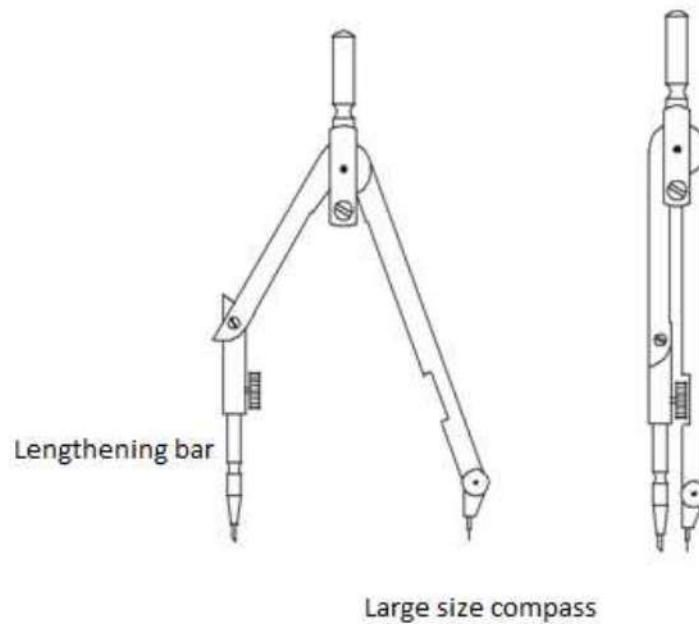


Figure 5: Compass

5. Divider

The divider is used to divide straight or curved lines into desired number of equal parts. It consists of two metal legs as in the compass. However, unlike compass, a divider is provided with two needles on both the legs.

6. Protractor

Protractors are used for constructing and measuring angles. Protractors are generally semicircular in shape. The base diameter of the semicircle serves as the straight edge. A semicircular protractor can measure and angles of any measure between 0° to 180° . Least count of the protractor is generally 1° . Like set square protractor is also made of transparent celluloid or plastic material.

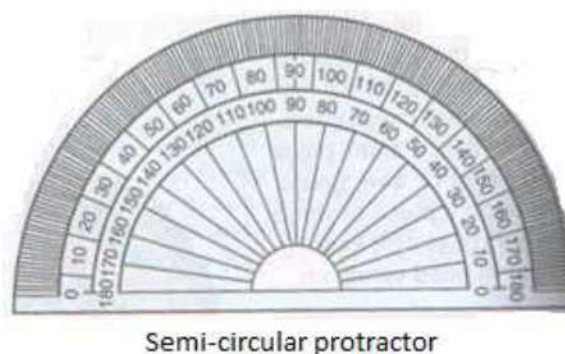


Figure 6: Protractor

7. Scales

Scales are used for measurement of lengths and distances on the drawing. Scale is a measuring stick, graduated on both its edges with different divisions to represent the corresponding actual distances of ground according to some fixed proportions. Such scales are known as RF scales or representative fraction scales. Such scales facilitate rapid marking off distances on drawing.

Scales of various representative fractions (RFs) are available in the market e.g., 1:1, 1:2, 1:5, 1:10, 1:20, 1:25, 1:50, 1:100, 1:200, 1:500, 1:1000, etc. the proportion 1:50 means that 50 units on the ground is represented by 1 unit in the drawing.

The scales used in the engineering practice according to I.S.I are:

Full size scale	Reducing scale		Enlarging scale
1:1	1:2	1:25	10:1
	1:5	1:50	5:1
	1:10	1:100	2:1

Scales are used to:

- a. Prepare or enlarge the drawing
- b. Set off dimension
- c. Measure distances directly

8. Pencils

The pencils are used for preparing the drawings on the drawing sheet. The accuracy and the appearance of the drawing depend upon the quality of pencil used. Different grades of pencils are available depending upon the hardness of the lid. Pencils of various grades can be easily recognised by the letters marked on the body of the pencil.

The pencils are generally graded as H, F, B and HB. H represents hardness; F represents firm, B represents softness and HB represents intermediate between hard and soft. The general designation of a pencil is associated with alpha-numeric symbols such as 2H, 3H, HB, B, 2B, 3B, etc. **Figure Xx** shows various grades of pencils. Drawing pencils are graded as 7B, 6B, , HB, H, 2H, in the increasing order of their hardness and decreasing order of their blackness. Generally drawings are made with 2H pencils and finished with H or HB pencils.

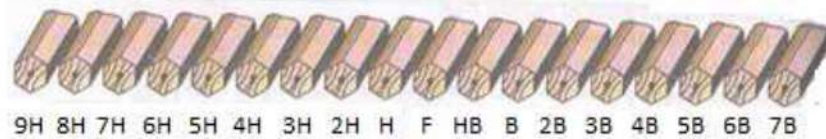
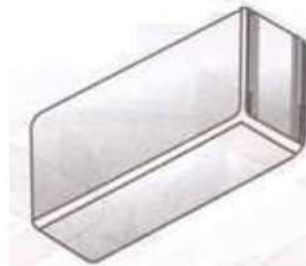


Figure 7: Pencils

9. Rubber or Eraser

An eraser is made of rubber and is used to erase extra pencil work and/or wrongly drawn lines. Soft eraser is the most suitable one for erasing as it leaves a little or no impression on the drawing sheet.

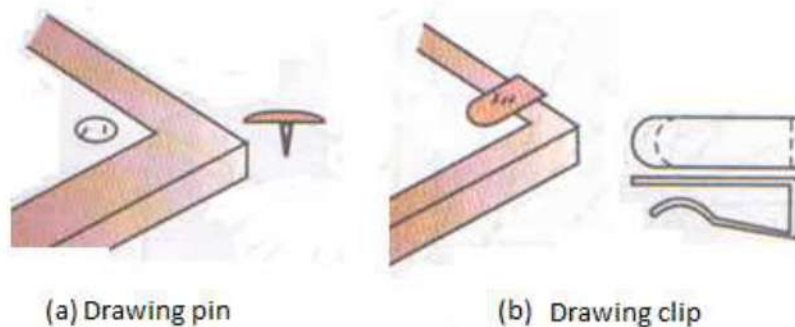


Rubber or eraser

Figure 8 Rubber or eraser

10. Drawing clips or Drawing pins

Both drawing clips and drawing pins serve the same purpose. They are used to fix the drawing sheet firmly in position to the drawing board as one constructs the drawing.



(a) Drawing pin

(b) Drawing clip

Figure 9 Drawing pins and Drawing clips

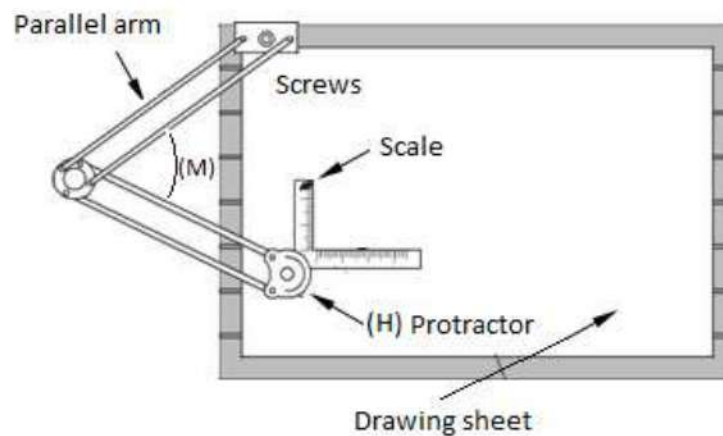
11. Duster or handkerchief

A Duster or a handkerchief is used for cleaning instruments. It is also used to sweep away the crumbs or dusts formed after the use eraser on the drawing sheet.

12. Drafting machine / Mini-drafter

A mini-drafter is an instrument which combines together all the features of a T-square, set squares, scales and protractor and hence is a unified instrument capable of performing the functions of all these instruments put together. One end of the mini-drafter is clamped by means of a screw, to the distant longer edge of the drawing board. At its other end, an adjustable head (H) having protractor markings is fitted. Two blades (B) of transparent celluloid accurately set at right angles to each other are attached to the head.

The machine has a mechanism (M) which keeps the two blades always parallel to their original position, irrespective of their position on the board. The blades have scales marked on them and are used as straight edges. The blades may be set at any desired angle with the help of the protractor markings.



Mini-drafter clamped to the drawing board attached with drawing sheet

Figure 10: Mini-drafter

CHAPTER-2

Types of Lines, Lettering & Dimensioning

OBJECTIVE:











Engineering drawing consists of organized combination of different types of lines. The objective of this chapter is, therefore, to acquaint the students with various types of lines and their relative importance as far as the whole drawing is concerned. Lettering plays an important role as far as logical comprehension of the drawing is concerned, particularly for those parts of the drawing which cannot be shown by lines. A well meaning drawing must be associated with clean dimensioning with good letter quality. Therefore, lettering should be lucid, legible, and uniform in appearance and easy-to-write for rapid freehand writing. After the completion of the chapter, the students can interpret and acknowledge the significance of the lines and also importance of lettering in the larger perspective of quality and comprehensive drawing.

Lines:

Various types of lines used in general engineering drawing as described by B.I.S. S.P: 46 - 1988 are demonstrated in the Fig.

1. **Outlines:** Lines drawn to represent visible edges and surface boundaries of objects are known as outlines or object lines or principal lines. These are represented by continuous thick lines.
2. **Dimension lines:** Continuous thin lines, used for giving dimensions of the drawing, are known as dimension lines. A dimension line is terminated at its outer end with an arrow head touching the outline, extension line or centre line.
3. **Extension lines or projection lines:** These are continuous thin lines used for dimensioning an object. They extend by about 3 mm beyond the dimension lines.
4. **Construction lines:** These are thin continuous lines used for construction of objects.
5. **Section lines or Hatching lines:** These are thin continuous lines used for showing the section evidently. They are uniformly spaced thin lines drawn at an angle of 45 degree to the main outline of the section. The spacing between the lines is generally 1 mm to 2 mm.
6. **Leader or pointer lines:** These are continuous thin lines and are drawn to connect a note with the specific feature in the drawing.
7. **Short-break lines:** These are continuous, thin and wavy freehand lines drawn to show the break of an object for a short length. These are also used to show irregular boundaries.
8. **Long-break lines:** these are thin ruled lines provided with short zigzags at suitable intervals. They are drawn to show long breaks.
9. **Hidden or Dotted lines:** These are closely and evenly spaced dashes lines of equal lengths. They are of medium thickness and are used to show the invisible or hidden parts of the of the object on the drawing.

Table 2.1 Convention of various types of lines according to BIS SP: 46 - 1988

	Continuous thick	Visible outlines Visible edges
	Continuous thin	Imaginary lines of intersection Dimension lines Projection lines Leader lines Hatching Short centre lines
	Continuous thin with zigzags	Long-break line
	Dashed thick	Hidden outlines Hidden edges
	Dashed thin	Hidden outlines Hidden edges
	Continuous thin freehand	Limits of partial or interrupted views and sections, if the limit is not a chain thin line
	Chain thick	Indications of lines or surfaces to which a special requirement applies
	Chain thin	Centre line Line of symmetry Trajectories
	Chain thin, thick at ends and change of direction	Cutting planes
	Chain thin double-dashed	Outlines of adjacent parts Centroidal lines Parts situated in front of the cutting plane

10. Centre lines: These are thin, long, chain lines composed of alternatively long and short dashes spaced at an approximate distance of 1 mm. The proportion of long and short dashes is 6:1 to 8:1. The short dashes are about 1.5 mm long. These are used to indicate the axes of cylindrical, conical and spherical objects. These are also used to show the centres of circles and arcs. Centre lines should extend for a short distance beyond the outlines to which they refer. Locus lines, extreme positions of movable parts and pitch circles are also shown by these lines.
11. Cutting-plane lines: These are long, thin chain line with thick ends. These are used to show the location of cutting plane.
12. Chain thick: These lines are used to indicate special treatment on the surface.
13. Chain thick double-dashed: These lines are used to show outlines of adjacent parts, alternative and extreme positions of movable parts, centroidal lines and parts situated in front of the cutting plane.

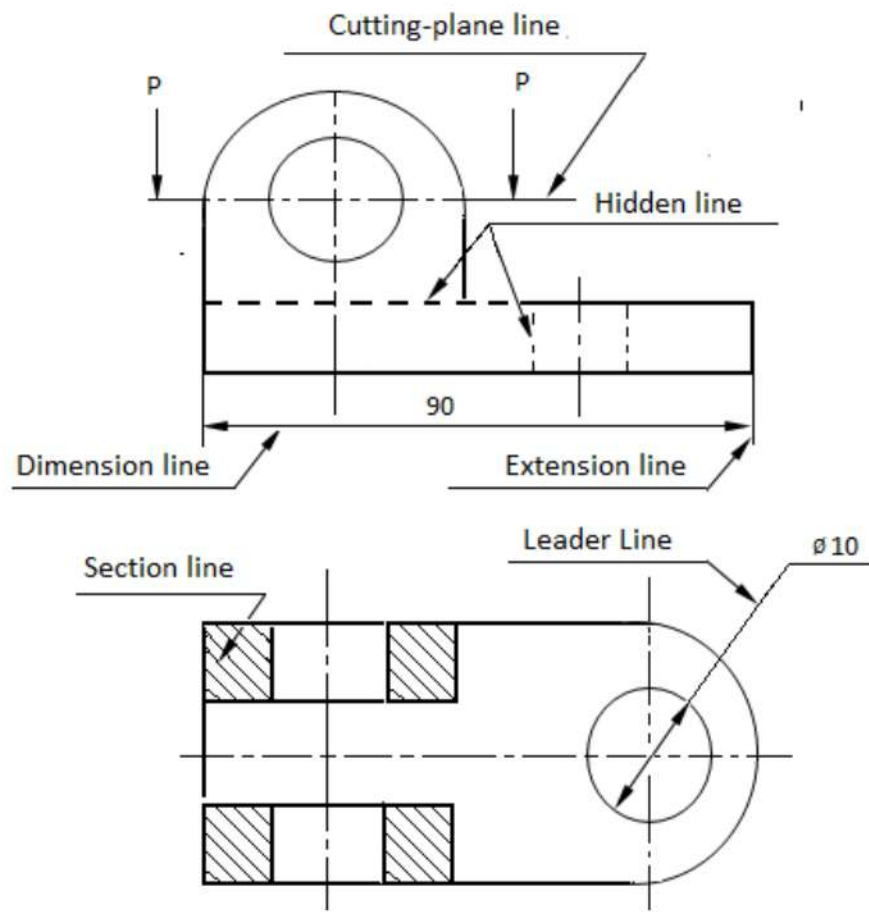


Figure 1

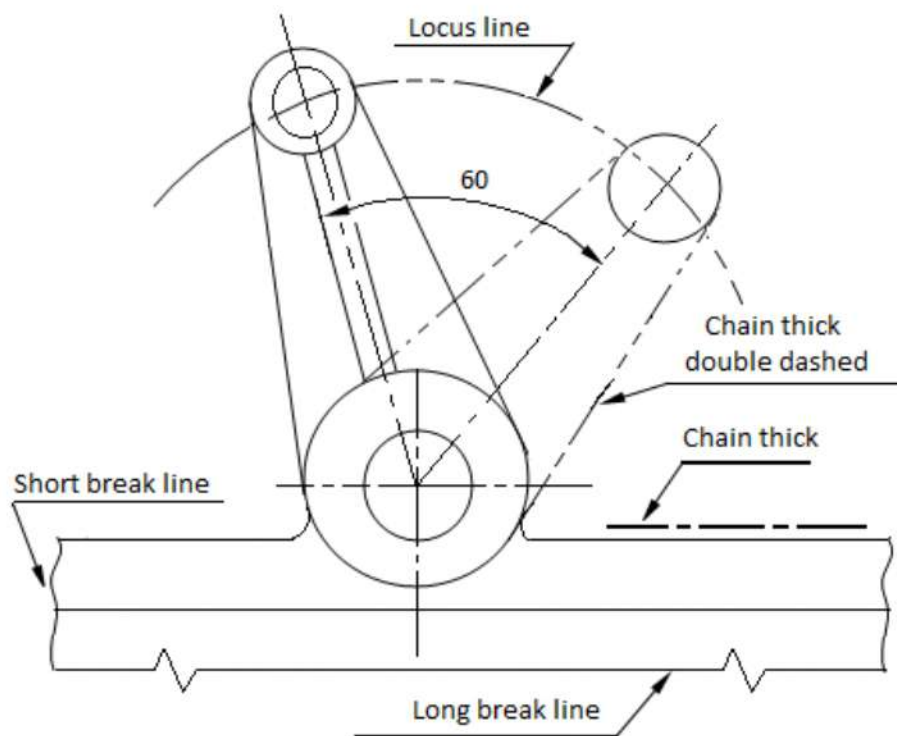


Figure 2

Lettering:

The verbal information, in writing, given in the drawing is known as lettering. Lettering plays an important role as far as logical comprehension of the drawing is concerned, particularly for those parts of the drawing which cannot be shown by lines. A well meaning drawing must be associated with clean dimensioning with good letter quality. Therefore, lettering should be lucid, legible, and uniform in appearance and easy-to-write for rapid freehand writing.

The art of writing letters such as alphabets and numbers etc. is known as lettering. Lettering forms an important part of drawing and is used to write letters, dimensions, notes and such other necessary information as may be required for complete execution of the drawing of an object.

It must be kept in mind that use of drawing instrument takes considerable amount of useful time and hence must be avoided as far as possible.

Certain principles need to be followed for developing good writing skill for lettering. One must have knowledge of the following parameters in order to master the art of good lettering.

1. shape and proportion of each letter
2. order and direction of the stroke
3. general composition of letters
4. rules for combining letters into words
5. skill of writing the letters in plain and simple style so that the lettering can be done freehand

Single-stroke letters:

The Bureau of Indian Standards (IS: 9609-1990) 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.

The word single stroke should not be misconstrued to mean that the letter should be made in one stroke without lifting the pencil. It actually means that the thickness of the line of the letter should be such as is obtained in one stroke of the pencil. The horizontal lines of letters should be drawn from left to right and vertical or inclined lines from top to bottom.

Single-stroke letters are of two types:

1. Vertical and
2. inclined

Inclined letters lean to the right, the slope being 75° with the horizontal. The size of a letter is described by its height. According to the height of letters, they are classified as:

- i. Lettering 'A'
- ii. Lettering 'B'

In lettering 'A' type, the height of the capital letter is divided into 14 parts, while in lettering 'B' type, it is divided into 10 parts. The height of the letters and numerals for engineering drawing can be selected from 2.5, 3.5, 5, 7, 10, 14 and 20 mm according to the size of the drawing. The ratio of height to width varies but in case of most of the letters it is 6:5. The details of the characteristics of the types of lettering are given in Table 1 and Table 2.

Lettering is generally done in capital letters. Different sizes of letters are used for different purposes.

The main titles are generally written in 6 mm to 8 mm size, sub-titles in 3 mm to 6 mm size, while notes, dimension figures etc. in 3 mm to 5 mm size.

The drawing number in the title block is written in numerals of 10 mm to 12 mm size.

Figure 3 shows single-stroke vertical capital letters and figures with approximate proportions.

Single-stroke inclined capital letters and figures are shown in Figure 4. The lower case letters are usually used in architectural drawings. Vertical and inclined lower case alphabets are shown in Figure 5 and Figure 6 respectively. The width of the majority of letters is equal to the height.

All letters should be uniform in shape, slope, size, shade and spacing. The shape and slope of every letter should be uniform throughout a drawing. For maintaining uniformity in size, thin and light guide-lines may first be drawn, and lettering may then be done between them. The shade of every letter must be the same as that of the outlines of the drawings, i.e., intensely black.

Therefore, H or HB grade of pencil is recommended for this purpose. The spacing between two letters should not necessarily be equal. The letters should be so spaced that they do not appear too close together or too much apart.

Judging by the eye the background areas between the letters should be kept approximately equal. The distance between the words must be uniform and at least equal to the height of the letters (as in Figure 7).

Lettering should be so done as can be read from the front with the main title horizontal, i.e., when the drawing is viewed from the bottom edge.

All sub-titles should be placed below but not too close to the respective views. Lettering, except the dimension figures, should be underlined to make them more prominent.

Table 1: Lettering A $\left(d = \frac{h}{14} \right)$

Characteristic	Ratio	Dimensions (mm)							
Letter height									
Height of capitals	h	$\left(\frac{14}{14} \right) h$	2.5	3.5	5	7	10	14	20
Height of lower case letter	c	$\left(\frac{10}{14} \right) h$	-	2.5	3.5	5	7	10	14
Space between characters	a	$\left(\frac{2}{14} \right) h$	0.35	0.5	0.7	1	1.4	2	2.8
Minimum spacing of base line	b	$\left(\frac{20}{14} \right) h$	3.5	5	7	10	14	20	28
Minimum spacing between words	e	$\left(\frac{6}{14} \right) h$	1.05	1.5	2.1	3	4.2	6	8.4
Thickness of lines	d	$\left(\frac{1}{14} \right) h$	0.18	0.25	0.35	0.5	0.7	1	1.4

Table 2: Lettering B $\left(d = \frac{h}{10}\right)$

Characteristic	Ratio	Dimensions (mm)						
Letter height	$\left(\frac{10}{10}\right)h$							
Height of capitals	$\left(\frac{10}{10}\right)h$	2.5	3.5	5	7	10	14	20
	$\left(\frac{7}{10}\right)h$							
Height of lower case letter	$\left(\frac{7}{10}\right)h$	-	2.5	3.5	5	7	10	14
Space between characters	$\left(\frac{2}{10}\right)h$	0.5	0.7	1	1.4	2	2.8	4
Minimum spacing of base line	$\left(\frac{14}{10}\right)h$	3.5	5	7	10	14	20	28
Minimum spacing between words	$\left(\frac{6}{10}\right)h$	1.5	2.1	3	4.2	6	8.4	12
Thickness of lines	$\left(\frac{1}{10}\right)h$	0.25	0.35	0.5	0.7	1	1.4	2

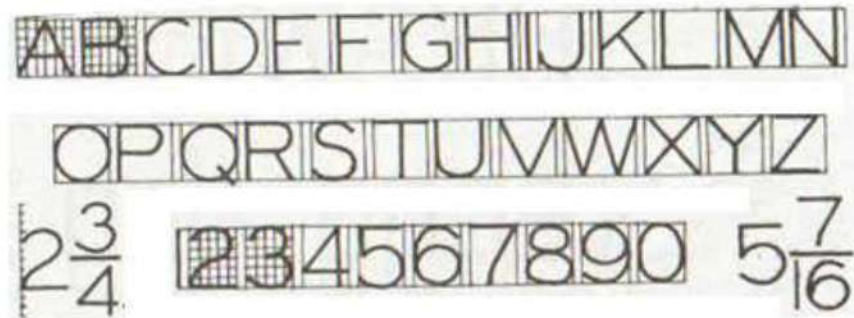


Figure 3

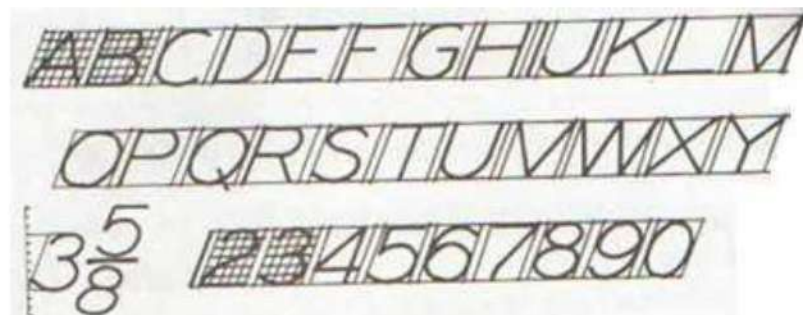


Figure 4

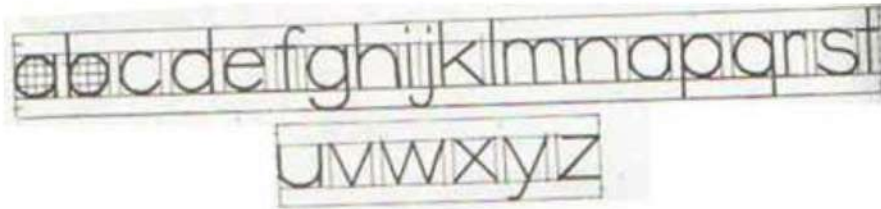


Figure 5

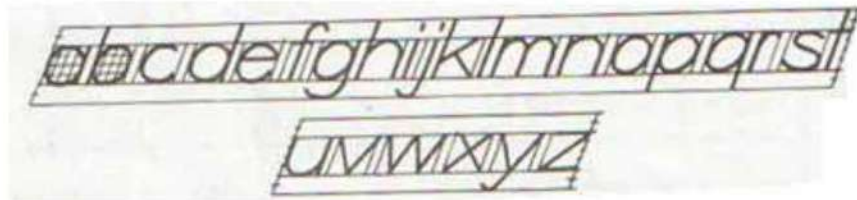


Figure 6

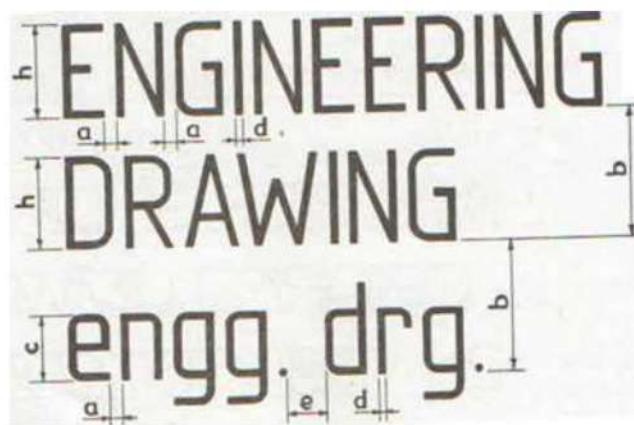


Figure 7

Gothic letters:

Gothic letters are formed by thickening the stems of single-stroke letters. These are mostly used for main titles of ink-drawings. The outlines of the letters are first drawn with the aid of instruments and then filled-in with ink. The thickness of the stem may vary from $1/5^{\text{th}}$ to $1/10^{\text{th}}$ of the height of the letters. Figure 3.9 shows the alphabets and figures in gothic with thickness equal to $1/7$ of the height.



Figure 8