

Engineering Drawing

EEE110

Department of Electrical and Electronic Engineering
University of Chittagong
Chittagong 4331, Bangladesh

Introduction

Drawing

The graphical representation of any object or idea can be termed as drawing. A drawing can be prepared either using free hand or using engineering instruments or using computer program.

Types of Drawing

1. Artistic Drawing
2. Engineering Drawing

Artistic Drawing

The drawing representing any object or idea which is sketched in free hand using imagination of artist and in which proper scaling and dimensioning is not maintained is called an artistic drawing. Example: Painting, Posters, arts etc.

Engineering Drawing

Engineering drawing can be defined as a graphical language used by engineers and other technical personnel associated with the engineering profession which fully and clearly defines the requirements for engineered items. It is a two dimensional representation of a three dimensional object.

In other words, The art of representing a real or imaginary object precisely using some graphics, symbols, letters and numbers with the help of engineering drawing instruments is called engineering drawing.

The art of representing engineering objects such as buildings, roads, machines, circuits etc. on a paper is called engineering drawing.

It is used by engineers and technologists. An engineering drawing provides all information about size, shape, surface type, materials etc. of the object. Example: Building drawing for civil engineers, Machine drawing for mechanical engineers, Circuit diagrams for electrical and electronics engineers, computer graphics for one and all etc.

Table. Difference between Artistic and Engineering Drawing

Artistic Drawing	Engineering Drawing
Purpose of artistic drawing is to convey emotion or artistic sensitivity in some way.	Purpose of engineering drawing is to convey information about engineering object or idea.
Can be understood by all.	Need some specific knowledge or training to understand.
Scale maintaining is not necessary	Scale maintaining is necessary
No special requirement of engineering instruments.	Engineering drawing instruments is used to make the drawing precise.
An artistic drawing may not be numerically specific and informative.	An engineering drawing must be numerically specific and informative.
Standard drawing code need not to be followed.	Standard drawing code (like ISO, ANSI, JIS, BS etc,) must be maintained.

Purpose of Engineering drawing

It is very difficult and complex to explain some certain engineering requirements in word. In such cases well dimensioned and properly scaled graphics can make it easy to understand that for technical

personnel. Engineering drawing serves this purpose. Any product that is to be manufactured, fabricated, assembled, constructed, built, or subjected to any other types of conversion process must first be designed. To make the outcome from the design understandable to any third party engineering drawing is the best way.

Applications of Engineering Drawing

Engineering drawing is an essential part of almost all engineering projects. Some important uses of engineering drawing are mentioned below:

1. For manufacturing of machines, automobiles etc.
2. For construction of buildings, roads, bridges, dams, electrical and telecommunication structures etc.
3. For manufacturing of electric appliances like TV, phone, computers etc.
4. It is used in ships for navigation.

Types of Engineering Drawing

Engineering drawing can be grouped into following 4 major categories:

1. Geometrical Drawing
 - a. Plane geometrical drawing
 - b. Solid geometrical drawing
2. Mechanical Engineering Drawing
3. Civil Engineering Drawing
 - a. Architectural Drawing
 - b. Structural Drawing
4. Electrical & Electronics Engineering drawing etc.

Geometric Drawing

The art of representing geometric objects such as rectangles, squares, cubes, cones, cylinders, spheres etc. on a paper is called geometric drawing. If the object has only 2 dimensions i.e. length and breadth (as rectangles, squares, triangles etc.), it is called Plane geometrical drawing and if it has 3 dimensions i.e. length, breadth and thickness/depth (as cube, prism, sphere, cylinder etc.), it is called Solid geometrical drawing.

Mechanical Engineering Drawing

The art of representing mechanical engineering objects such as machines, machine parts etc. on a paper are called mechanical engineering drawing or machine drawing. It is used by mechanical engineers to express mechanical engineering works and projects for actual execution.

Civil Engineering Drawing

The art of representing civil engineering objects such as buildings, roads, bridges, dams etc. on a paper are called civil engineering drawing. It is used by civil engineers to express civil engineering works and projects for actual execution. Civil engineering drawing of a civil work project can be classified in two broad categories:

1. Architectural Drawing

- a. Plan: It shows the position of different objects and elements of the structure in a two dimensional view. Only length and width of objects are shown here.
- b. Elevation and Section: It shows a view along the height of structure. Elevation can be presented in 2D or 3D. In 2D elevation view either height and length or height and width is showed.

2. Structural Drawing

It shows the detail requirement of reinforcement and their arrangement in structure. It also shows the specification and properties of construction materials like concrete, steel, timber etc.

Electrical Engineering Drawing

The art of representing electrical engineering objects such as motors, generators, transformers, wiring diagrams etc. on a paper are called electrical engineering drawing. It is used by electrical engineers to express electrical engineering works and projects for actual execution.

The art of representing electronic circuits of TV, Phones, computers etc. on a paper are called electronic engineering drawing or electronic drawing. It is used by electronic engineers to express electronic engineering works and projects for actual execution.

Elements of Engineering Drawing

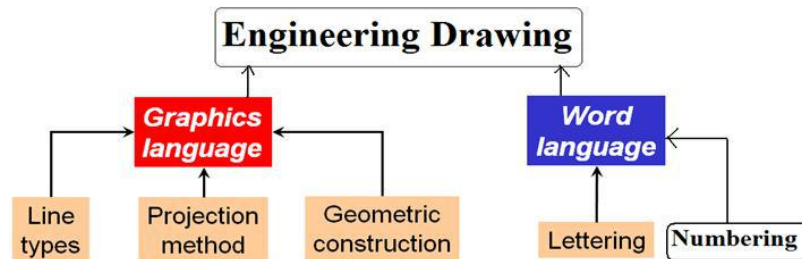


Fig. Elements of Engineering Drawing

Drawing Standards

An engineering drawing should be well specified and universally acceptable. That's why there are some specified rules for engineering drawing. These rules may vary slightly for different regions. There are some drawing standards or drawing codes that accumulates the rules of engineering drawing for a certain region. Well-known drawing codes and their application region is expressed below:

Table. Drawing Standards

Country/Region	Code/Standard	Full Meaning
Worldwide	ISO	International Organization for Standardization
USA	ANSI	American National Standards Institute
JAPAN	JIS	Japanese Industrial Standards
UK	BS	British Standards

In Bangladesh in most of the cases, it is usual practice to follow ISO code for engineering drawing. However, in some instances ANSI and BS standards are also followed.

Drawing Instruments

The most common instruments used for engineering drawing are:

- | | | | | |
|------------------|------------------|-------------------|--------------------|--------------------------|
| 1. Drawing Board | 4. Rubber/Eraser | 7. Instrument box | 10. Scales | 13. Difference templates |
| 2. Drawing paper | 5. T- square | 8. Protractor | 11. Pins and clips | |
| 3. Pencil | 6. Set-square | 9. Compass | 12. Adhesive tapes | |

Drawing Board

- ☐ It is a board or platform rectangular in shape.
- ☐ Size of drawing board need to be larger than that of drawing paper.
- ☐ It is made of wood.
- ☐ Top surface should be smooth.

Drawing Paper

Drawing paper is the paper, on which drawing is to be made. All engineering drawings are made on sheets of paper of strictly defined sizes, which are set forth in the respective standards. The use of standard size saves paper and ensures convenient storage of drawings.

Desirable properties a good drawing paper:

- ☐ It should be smooth and uniform in thickness.
- ☐ It should be thick, strong and tough.
- ☐ Fibers of drawing paper should not be disintegrated when a good eraser is used on it.

Paper Types:

1. Detail Paper (used for pencil work).
2. White drawing paper (used for finished drawing)
3. Tracing paper (used for both pencil and ink work and useful for replicating a master copy)

Paper Size:

Table. ISO Paper Sizes (plus rounded inch values)

Format	A series		B series		C series	
Size	mm × mm	in × in	mm × mm	in × in	mm × mm	in × in
0	841 × 1189	33.1 × 46.8	1000 × 1414	39.4 × 55.7	917 × 1297	36.1 × 51.1
1	594 × 841	23.4 × 33.1	707 × 1000	27.8 × 39.4	648 × 917	25.5 × 36.1
2	420 × 594	16.5 × 23.4	500 × 707	19.7 × 27.8	458 × 648	18.0 × 25.5
3	297 × 420	11.7 × 16.5	353 × 500	13.9 × 19.7	324 × 458	12.8 × 18.0
4	210 × 297	8.27 × 11.7	250 × 353	9.84 × 13.9	229 × 324	9.02 × 12.8
5	148 × 210	5.83 × 8.27	176 × 250	6.93 × 9.84	162 × 229	6.38 × 9.02
6	105 × 148	4.13 × 5.83	125 × 176	4.92 × 6.93	114 × 162	4.49 × 6.38
7	74 × 105	2.91 × 4.13	88 × 125	3.46 × 4.92	81 × 114	3.19 × 4.49
8	52 × 74	2.05 × 2.91	62 × 88	2.44 × 3.46	57 × 81	2.24 × 3.19
9	37 × 52	1.46 × 2.05	44 × 62	1.73 × 2.44	40 × 57	1.57 × 2.24
10	26 × 37	1.02 × 1.46	31 × 44	1.22 × 1.73	28 × 40	1.10 × 1.57

The tolerances specified in the standard are

±1.5 mm (0.06 in) for dimensions up to 150 mm (5.9 in),

±2 mm (0.08 in) for lengths in the range 150 to 600 mm (5.9 to 23.6 in) and

±3 mm (0.12 in) for any dimension above 600 mm (23.6 in).

Standard Drawing Paper Sizes

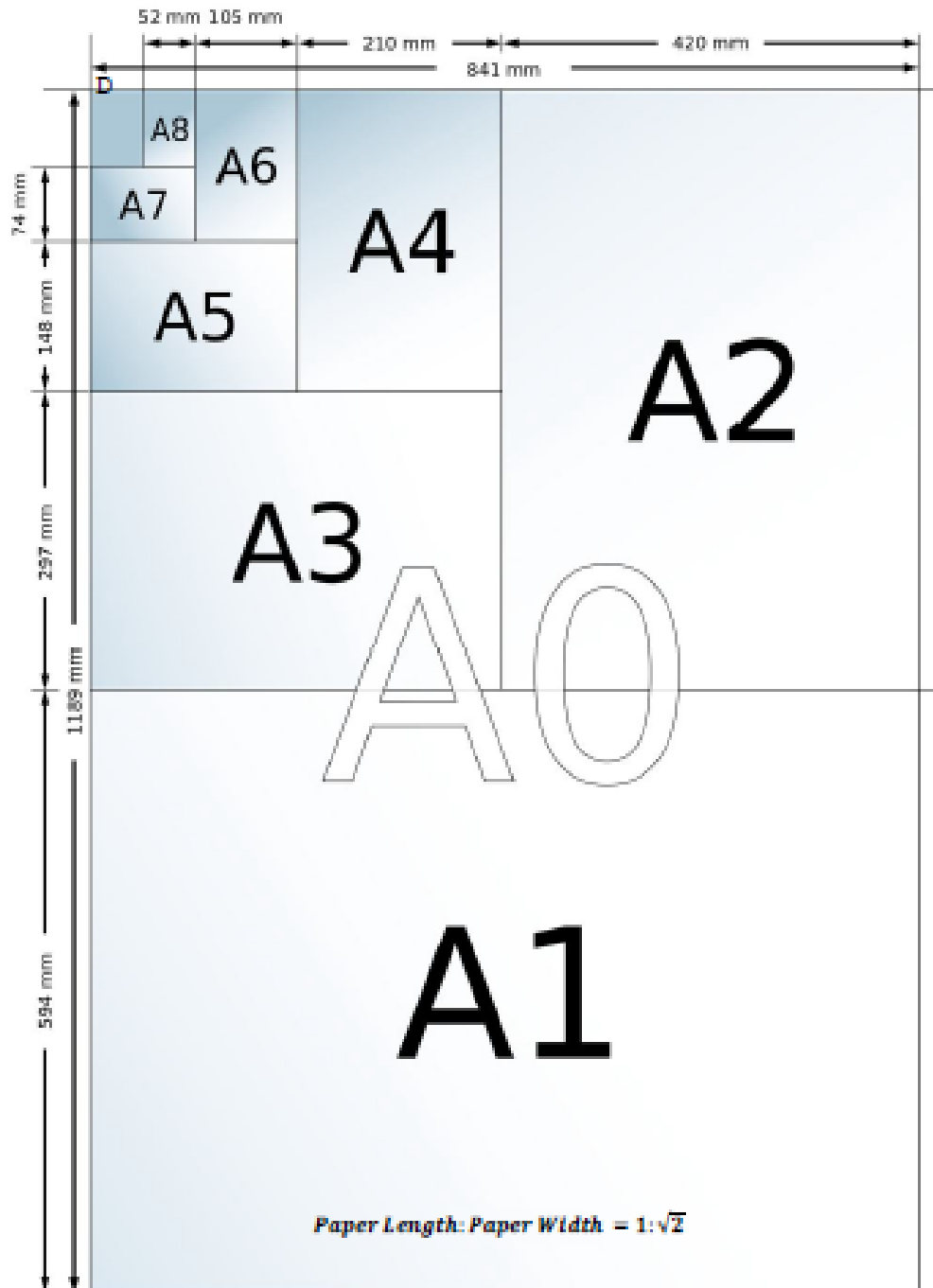


Fig. Standard Sizes of Drawing Paper

Paper Layout:

The ISO standard (ISO 5457) require a 20mm border to the left hand edge (for filing) and a 10mm border round the other three sides of the drawing sheet. However, the margin of paper can be increased according to requirements and settings of printer/plotter.

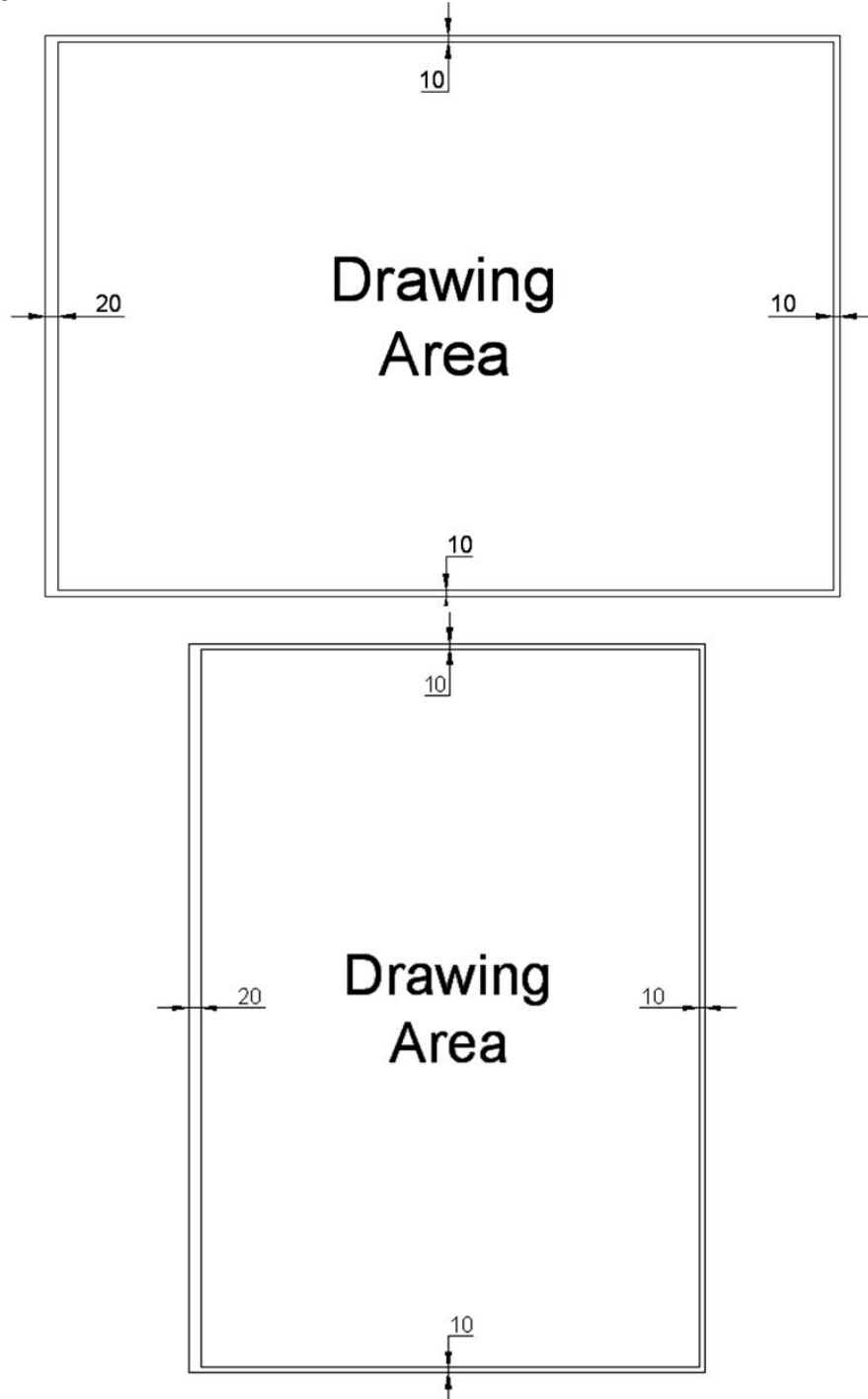
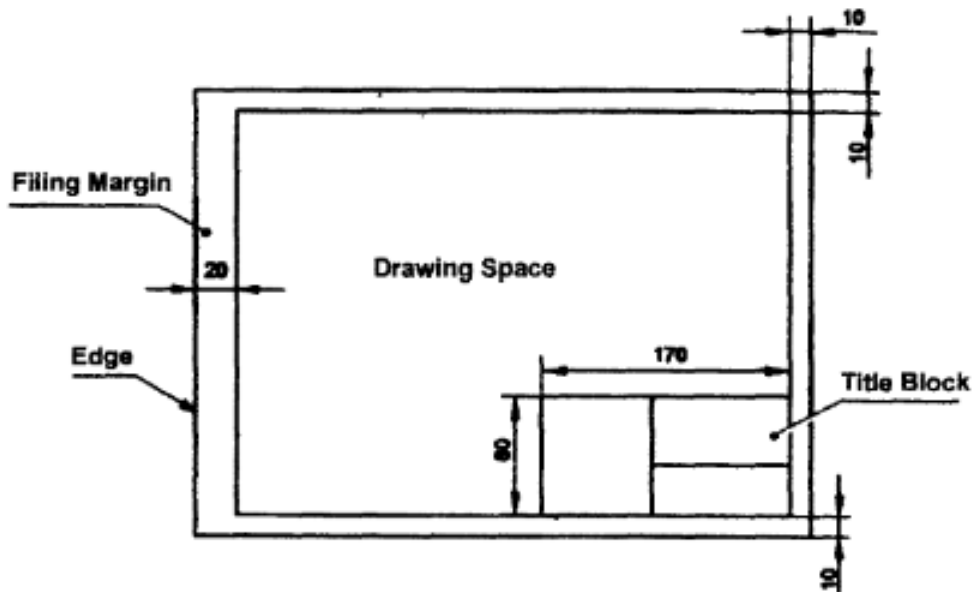
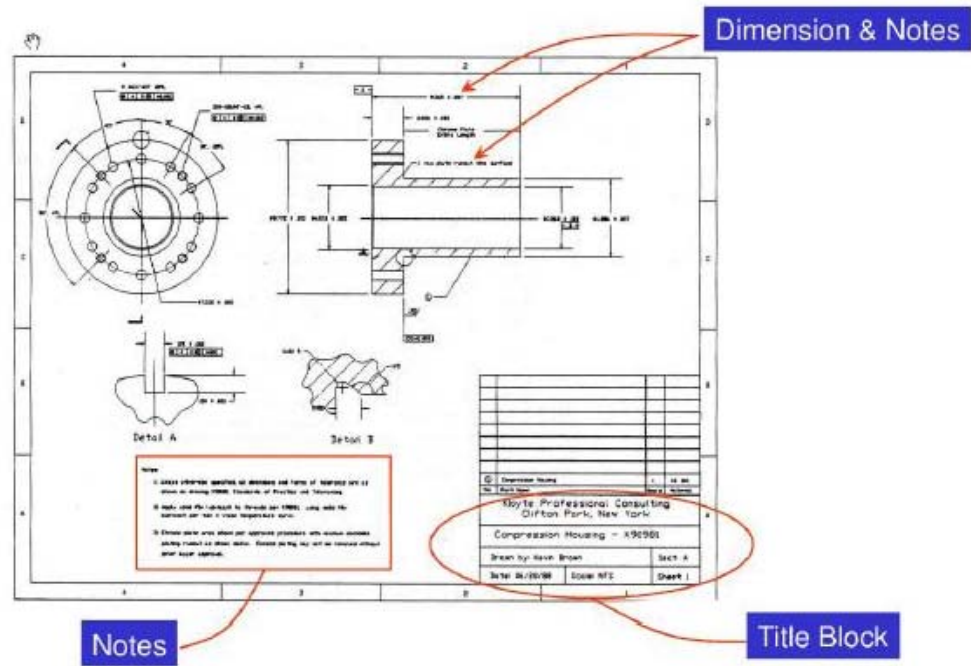


Fig. Landscape and Portrait Layout of Drawing Paper

For Class Work:



Form for student information and drawing details. The form is divided into sections for student information, drawing details, and a title block.

NAME OF STUDENT		TITLE	
CLASS :	DRGNO:	SCALE	
ROLL NO :	GRADE:		
DATE:	VALUED BY		
50	50	50	

Fig. Paper Layout for Class Assignments

Pencil:

Pencils are used to draw different lines, shapes, symbols and to write texts in engineering drawing. Selection of proper grade pencil or lead is important for quality drawing. Based on the hardness of lead pencils are classified in three major grades as hard, medium and soft. They are further sub-divided and numbered as mentioned in table below:

Table. Pencils of Different Grades

Grade	Items arranged ordering harder to softer
Hard	9H> 8H> 7H>6H>5H>4H
Medium	3H>2H>H>F>HB>B
Soft	2B>3B>4B>5B>6B>7B

Common uses of different grade pencil are tabulated below:

Table. Pencil Usage Guideline for Different Line Types

Task	Lead	Task	Lead	Task	Lead
Border Lines	3H, 2H	Centerlines	2H, H	Leaders	2H, H
Construction Lines	3H, 2H	Phantom Lines	2H, H	Hidden Lines	2H, H
Guide Lines	3H, 2H	Long Break Lines	2H, H	Cross Hatching Lines	2H, H
Lettering	H, F, HB	Visible Lines	H, F, HB	Extension Lines	2H, H
Dimension Lines	2H, H	Cutting Plane Lines	H, F, HB	Short Break lines	H, F, HB
For convenience we will use 2H and HB pencils for our assignments and class drawings.					

T-square:

1. Used to draw horizontal straight line.
2. Used to guide the triangles when drawing vertical and inclined lines.



Fig. T-square

Set-square:

1. Used to construct the most common angles (i.e. 30° , 45° and 60°) in technical drawings.
2. Used to draw parallel and perpendicular lines quickly and conveniently.

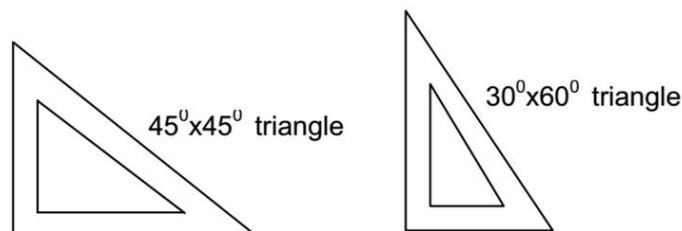


Fig. Set-square

Protractor:

It is used for laying out and measuring angle.

Compass

It is used to draw circles and arcs both in pencil and ink. It consists of two legs pivoted at the top. One leg is equipped with a steel needle attached with a screw, and other shorter leg is, provided with a socket for detachable inserts.

Dividers:

Used chiefly for transferring distances and occasionally for dividing spaces into equal parts. i.e. for dividing curved and straight lines into any number of equal parts, and for transferring measurements.

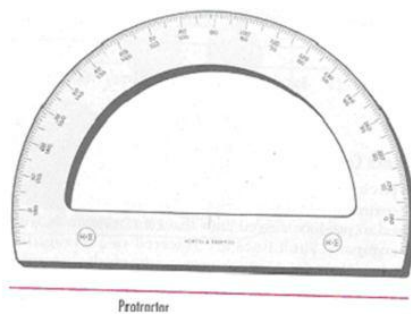


Fig. Protractor



Fig. Compass and Divider

Scale (ruler):

A number of kinds of scales are available for varied types of engineering design. Scales with beveled edges graduated in mm are usually used.

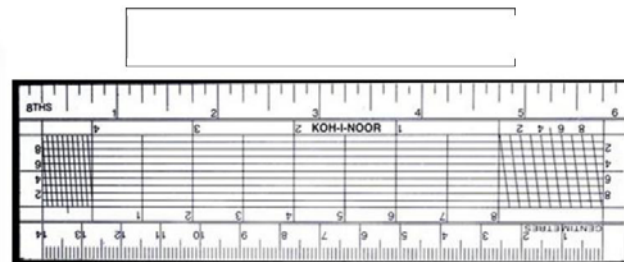
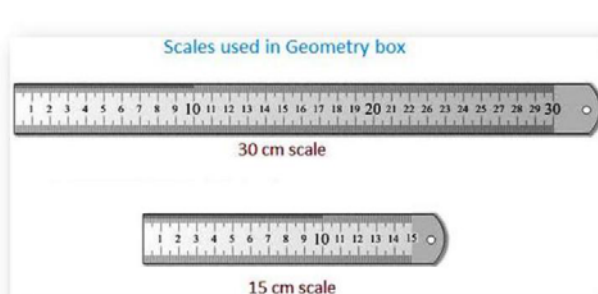


Fig. Scales

Lettering and Numbering

Letter Styles

- ☐ Gothic
- ☐ Roman
- ☐ Italic
- ☐ Text



Fig. Different Styles of English Letters

Classification of Letters

Extended and Condensed Letters

To meet design or space requirements, letters may be narrower and spaced closer together, in which case they are called “Compressed” or “Condensed” letters. If the letters are wider than normal, they are referred to as “Extended” letters.

Light Face and Bold Face Letters

Letters also vary as to the thickness of the stems or strokes. Letters having very thin stems are called Light Face Letters, while those having heavy stems are called Bold Face Letters.

Technique of Lettering

“Any normal person can learn to letter if he is persistent and intelligent in his efforts.” While it is true that “Practice makes perfect,” it must be understood that practice alone is not enough; it must be accompanied by continuous effort to improve.

There are three necessary steps in learning to letter:

- ☐ Knowledge of the proportions and forms of the letters and the order of the strokes.
- ☐ Knowledge of composition- the spacing of the letters and words.
- ☐ Persistent practice, with continuous effort to improve.

Guide Lines

Extremely light horizontal guidelines are necessary to regulate the height of letters. In addition, light vertical or inclined guidelines are needed to keep the letters uniformly vertical or inclined. Guidelines are absolutely essential for good lettering and should be regarded as a welcome aid, not as an unnecessary requirement.

Make guidelines light, so that they can be erased after the lettering has been completed. Use a relatively hard pencil such as a 4H to 6H, with a long, sharp, conical point.

Guidelines for Capital Letters

On working drawings, capital letters are commonly made 3mm high, with the space between lines of lettering from $\frac{3}{4}$ th to the full height of the letters. The vertical guidelines are not used to space the letters (as this should always be done by eye while lettering), but only to keep the letters uniformly vertical, and they should accordingly be drawn at random.

A guideline for inclined capital letters is somewhat different. The spacing of horizontal guidelines is the same as for vertical capital lettering. The American Standard recommends slope of approximately 68.2° with the horizontal and may be established by drawing a “sloped triangle”, and drawing the guidelines at random with T-square and triangles.

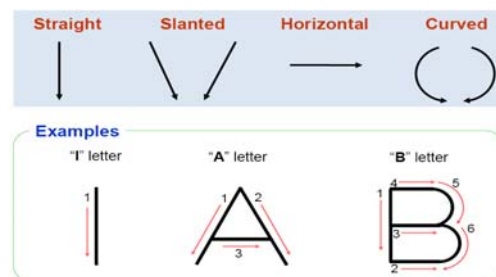
Guidelines for Lower-Case Letters

Lower-case letters have four horizontal guidelines, called the cap line, waistline, and base line and drop line. Strokes of letters that extend up to the cap line are called ascenders, and those that extend down to the drop line, descenders. Since there are only five letters (p, q, g, j, y) that have descenders, the drop lines are little needed and are usually omitted. In spacing guidelines, space “a” may vary from $\frac{3}{5}$ to $\frac{2}{3}$ of space “b”. The term single stroke or one stroke does not mean that the entire letter is made without lifting the pencil. But the width of the stroke is the width of the stem of the letter.

Single Stroke Lettering

The salient features of this type of lettering are:

- ☐ Greatest amount of lettering on drawings is done in a rapid single stroke letter i.e. either vertical, or inclined.
- ☐ The ability to letter and perfectly can be acquired only by continued and careful practice
- ☐ it is not a matter of artistic talent or event of dexterity in hand writing



Order of Strokes

They are necessary to have legible and accurate letter styles. In the following description an alphabet of slightly extended vertical capitals has-been arranged in-group. Study the slope of each letter with the order and direction of the storks forming it. The proportion of height and width of various letters must be known carefully to letter them perfectly.

The I-H-T Group

The letter I is The Foundation Stroke. The top of T is drawn first to the full width of the square and the stem is started accurately at its midpoint.

The L-E-F Group

The L is made in two strokes. The first two strokes of the E are the same for the L, the third or the upper stroke is lightly shorter than the lower and the last stroke is the third as long as the lower. F has the same proportion as E

The V-A-K Group

V is the same width as A, the A bridge is one third up from the bottom. The second stroke of K strikes stem one third up from the bottom and the third stroke branches from it.

The M-W Group

M may be made in consecutive strokes of the two verticals as of N. W is made with two V's.

The O-Q-C-G Group

The O families are made as full circles and made in two strokes with the left side a longer arc than the right. A large size C and G can be made more accurately with an extra stroke at the top.29

The D- U-J Group

The top and bottom strokes of D must be horizontal, fail line to observe this is a common fault with beginners. U is formed by two parallel strokes to which the bottom stroke be added. J has the same construction as U, with the first stroke omitted.

The P-R-B Group

The number of strokes depends up on the size of the letter. The middle line of P and R are on centerline of the vertical line.

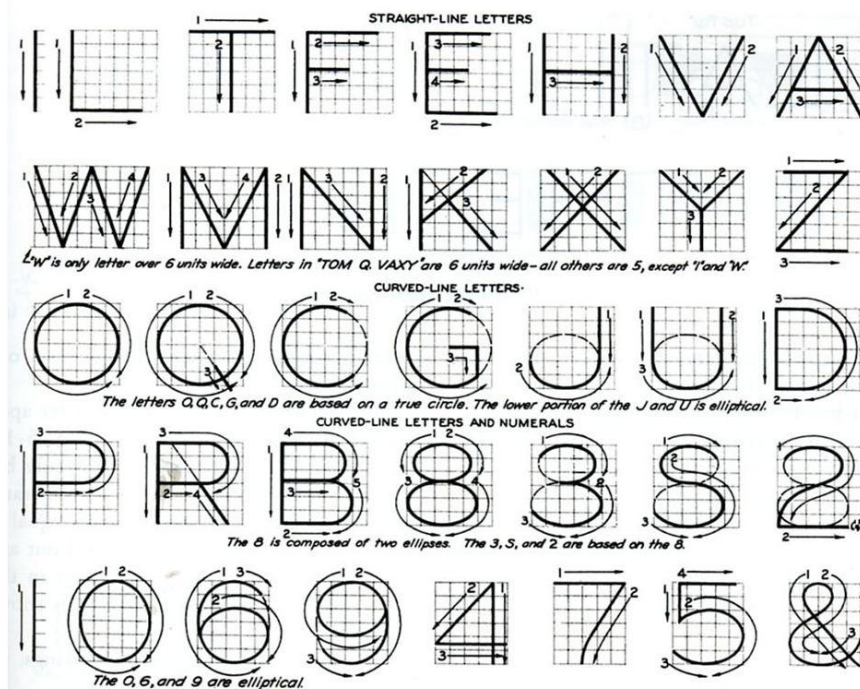


Fig. Order of Strokes for Single Stroke Gothic Letters (Uppercase) and Numbers

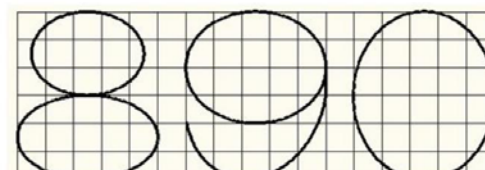
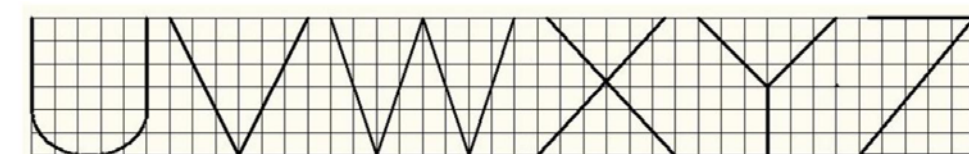
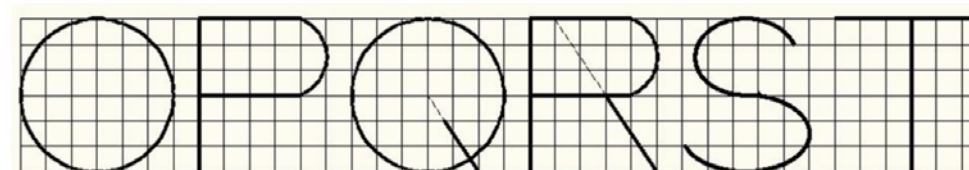
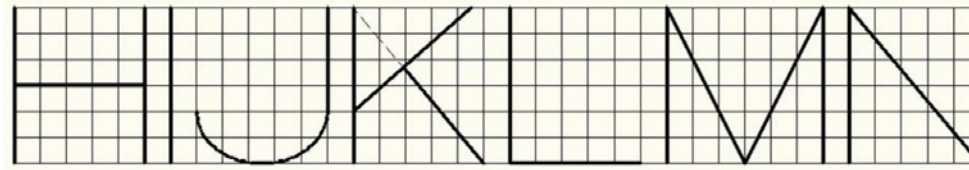
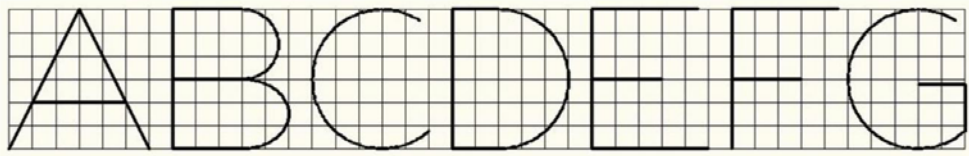


Fig. Proportion of Width and Height for Single Stroke Gothic Letters (Uppercase) & Numbers

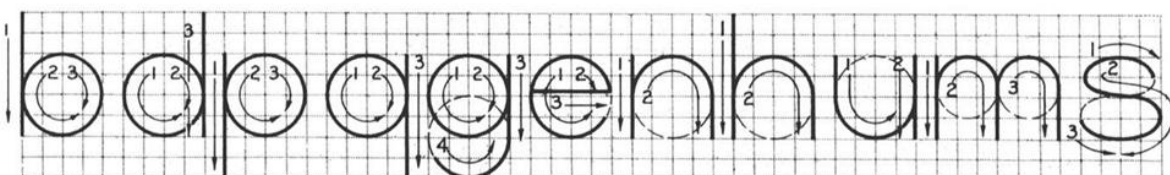


Fig. Order of Strokes for Single Stroke Gothic Letters (Lowercase)



Fig. Order of Strokes for Single Stroke Gothic Italic Letters (Uppercase)

Spacing of Letters

- Uniformity in spacing of letters is a matter of equalizing spaces by eye.
 - The background area between letters, not the distance between them, should be approximately equal.
 - Words are spaced well apart, but letters within words should be spaced closely.



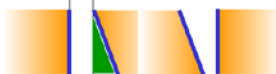
- For either upper case or lower-case lettering, make the spaces between words approximately equal to a capital O.

LINES AND LETTERINGS

1. Straight - Straight



3. Straight - Slant



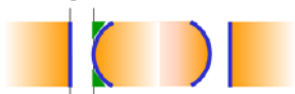
5. Curve - Slant



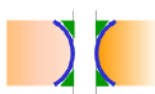
6. Slant - Slant



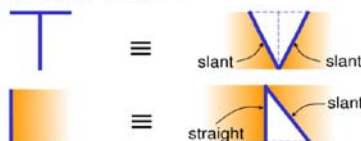
2. Straight - Curve



4. Curve - Curve



7. The letter "L" and "T"



Drawing Scales

Scale is the ratio of the linear dimension of an element of an object shown in the drawing to the real linear dimension of the same element of the object.

Designation of a scale consists of the word “SCALE” followed by the indication of its ratio, as follows:

SCALE 1:1 for full size
SCALE $X:1$ for **enlargement** scales ($X > 1$)
SCALE $1:X$ for **reduction** scales ($X > 1$)

Dimension numbers shown in the drawing correspond to “true size” of the object and they are independent of the scale used in creating that drawing.

Lettering in Maps

Letters are generally used on maps as follows:

- ☐ Vertical capital: name of states, countries, towns, capitals, titles of the map etc.
- ☐ Vertical lower case: name of small towns, villages, post offices etc.
- ☐ Inclined capital: name of oceans, bays, gulfs, large lakes, rivers etc.
- ☐ Inclined lower case: name of rivers, creeks, small lakes, ponds, marshes and springs

Summary of ISO rules for Lettering

1. Most of the lettering is done in single stroke either in vertical or in inclined manner.
2. Only one style of lettering should be used throughout the drawing.
3. Lettering can be done either in free hand or using templates.
4. Proportion of Height & width
 - a. For A, M, O, Q, T, V, X and Y, Height = Width.
 - b. For W, height < Width.
 - c. For Other letters, Height > Width.
 - d. For all numbers, Height > Width
5. Line thickness of lower & upper case letters are made same as well as uniform.
6. Distance between adjacent lines or space between letters or numbers $\geq 2 \times$ line thickness
7. If thickness of 2 adjacent line is different, spacing = $2 \times$ thickness of heavier line
8. Standard height of letters and numbers are 2.5, 3.5, 5.0, 7.0, 10.0, 14.0 and 20.0 mm
9. Height of letter or number ≥ 2.5 mm
10. When both capital and lower-case letters are to be combined, if $c=2.5$ mm then h will be 3.5mm.

ISO 3098-2:2000 specification for relative dimensions of characters and spacing is illustrated here:

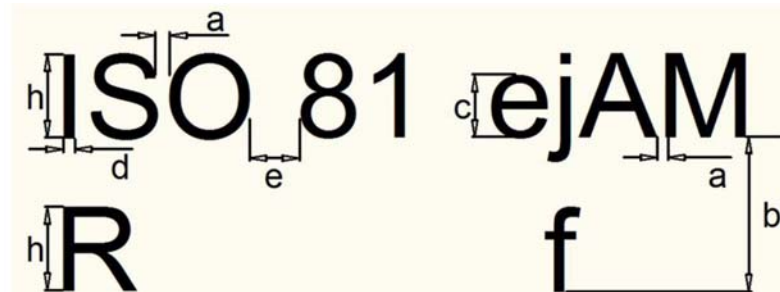


Fig. Relative Dimensions of Letters and Numbers (ISO guideline)

Assignment:

Following ISO guidelines complete lettering of all the uppercase and lowercase letters and numbers in “single stroke gothic-vertical/italic” style.