INTRODUCTION — CHAPTER 1

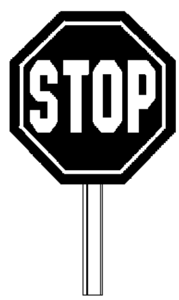
1.1 SIGN LANGUAGE

Each of the signs above means something. Some we know, some we guess and some we do not know.

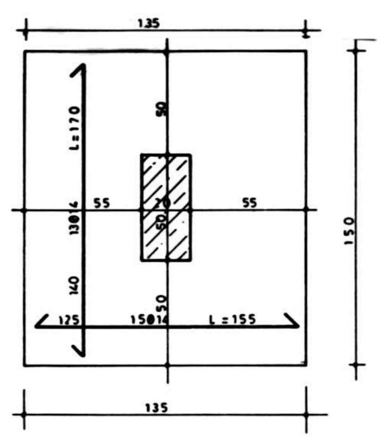
治 疗 辅 助 带

Above signs are sentences written in Chinese. Unless somebody teaches us how to read, they do not mean anything to us.

The above STOP sign is something we all know. A part of a sign language used in traffic.

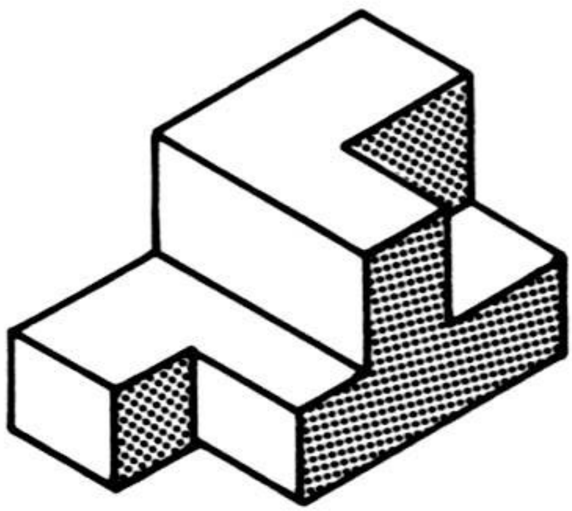


The drawing on the right does not mean anything to us unless we know how to read or interpret the lines, numbers, hatchings and rectangles.



The aim of this course is to teach to the students the ***Engineering Graphics Language***, which is the basis of CAD, Computer Aided Design.

The importance of this ***Engineering Graphics Language*** can be seen by comparing it with word languages. All who attend elementary and high school study the language of their country and learn to read, write, and speak it with some degree of skill. In high school and college most students study a foreign language. These word languages are highly developed systems of communication. Nevertheless, any word language is inadequate for describing the size, shape, and relationship of physical objects.



Study the object on the left then try to describe it verbally so that someone who has not seen it can form an accurate and complete mental picture. It is almost impossible to do this.

Engineering is applied science, and communication of physical facts must be complete and accurate. Quantitative relationships are expressed mathematically .The written word completes many descriptions. But whenever machines and structures are designed, described, and built, graphic representation is necessary. Although the works of artists (or photography and other methods of reproduction) would provide pictorial representation, they cannot serve as engineering descriptions. Shaded pictorial drawings and photographs are used for special purposes, but the great bulk of engineering drawings are made in line only , with arranged in a logical system of projection. To these views, dimensions and special notes giving operations and other directions for manufacture are added. This is the language of engineering drawing, which can be defined as the graphic representation of physical objects and relationships.

As the foundation upon which all designing and subsequent manufacture are based, engineering graphics is one of the most important single branches of study in a technical school.

Every engineering student must know how to make and how to read drawings.

The subject in all types of engineering practice, and should be understood by all connected with, or interested in, technical industry .All designs and directions for manufacture are prepared by draftsmen, professional writers of the language, but even one who may never make drawings must be able to read and understand them or be professionally illiterate.

Thorough training in engineering graphics is particularly important for the engineer because he is responsible for and specifies the drawings required in his work and must therefore be able to interpret every detail for correctness and completeness.

1.2 ESSENTIALS OF DRAFTING:

LINES AND LETTERING.

Drawings are made up of lines that represent the surfaces, edges, and contours of objects. Symbols, dimensional sizes, and word notes are added to these lines, collectively making a complete description. Proficiency in the methods of drawing straight lines, circles, and curves, either freehand or with instruments, and the ability to letter word statements are fundamental to writing the graphic language. Furthermore, Lines are connected according to the geometry of the object represented making it necessary to know the geometry of plane and solid figures and to understand how to combine circles, straight lines, and curves to represent separate views of many geometric combinations.

1.3 METHODS OF EXPRESSION.

There are two fundamental methods of writing the graphic language: Freehand and with Instruments.

FREEHAND :

Freehand drawing is done by sketching the lines with no instruments other than pencils and erasers. It is an excellent method during the learning process because of its speed and because at this stage the study of projection is more important than exactness of delineation. Freehand drawings are much used commercially for preliminary designing and for some finished work.

INSTRUMENT DRAWING :

Instrument drawing is the standard method of expression. Most drawings are made "to scale," with instruments used to draw straight lines, circles, and curves concisely and accurately. Training in both freehand and instrument work is necessary for the engineer so that he will develop competence in writing the graphic language and ability to judge work done under his direction.

1.4 METHODS OF SHAPE DESCRIPTION

Delineation of the shape of a part, assembly , or structure is the primary element of graphic communication. Since there are many purposes for which drawings are made, the engineer must select, from the different methods of describing shape, the one best suited to the situation at hand. Shape is described by projection, that is, by the process of causing an image to be formed by rays of sight taken in a particular direction from an object to a picture plane.

Following projective theory, two methods of representation are used: ***Orthographic views*** and ***Pictorial views.***

ORTHOGRAPHIC VIEWS

For the great bulk of engineering work, the orthographic system is used, and this method, with its variations and the necessary symbols and abbreviations, constitutes an important part of this book. In the orthographic system, separate views arranged according to the projective theory are made to show clearly all details of the object represented.

PICTORIAL VIEWS

"Pictorial representation" designates the methods of projection resulting in a view that show the object approximately as it would be seen by the eye. Pictorial representation is often used for presentation drawings, text, operation, and some working drawings.

There are three main divisions of pictorial projection: **Axonometric**, **Oblique**, and **Perspective**.

Axonometric projection is projection in which only one plane is used, the object being turned so that three faces show. The main axonometric positions are ***isometric***, ***dimetric***, and ***trimetric***.

Oblique projection is a pictorial method used principally for objects with circular or curved features only on one face or on parallel faces; and for such objects the oblique is easy to draw and dimension.

Perspective projection gives a result identical with what the eye or a single -lens camera would record.

METHODS OF SIZE DESCRIPTION.

After delineation of shape, size is the second element of graphic communication, completing the representation of the object. Size is shown by "dimensions," which state linear distances, diameters, radii, and other necessary magnitudes.

BASIC MACHINE ELEMENTS.

Many machine elements occur repeatedly in all kinds of engineering work. Familiarity with these elements is necessary so that dimensioning and specifications on the drawings will be correct. The material that follows introduces basic machine elements and shop processes, so illustrating the principles of engineering drawing laid out the previous sections.

DRAWING INSTRUMENTS — CHAPTER 2

2.1 DRAWING INSTRUMENTS AND THEIR USE

To record information on paper (or another surface), instruments and equipment are required. Since engineering drawing is entirely a graphic language, equipment is needed; even for drawings made freehand, pencils erasers, and sometimes coordinate paper or other special items are used.

Computer as a hardware and **CAD** (Computer Aided Design) program as software are now used widely for simple and sophisticated drawings.

CAUTIONS IN THE USE OF INSTRUMENTS

NEVER use the scale as a ruler for drawing lines.

NEVER draw horizontal lines with the lower edge of the of the T square.

NEVER use the lower edge of the T square as a horizontal base for the triangles.

NEVER cut paper with a knife and the edge of the T square, as a guide.

NEVER use the T square as a hammer.

NEVER put either end of a pencil into the mouth.

NEVER work with a dull pencil.

NEVER sharpen a pencil over the drawing board.

NEVER jab the dividers into the drawing board.

NEVER use the dividers as reamers, pincers, or picks.

NEVER use a blotter on inked lines.

NEVER screw the pen adjustment past the contact point of the nibs.

NEVER leave the ink bottle uncapped.

NEVER hold the pen over the drawing while filling.

NEVER put into the drawing-ink bottle a writing pen that has been used in ordinary writing ink.

NEVER scrub a drawing all over with an eraser after finishing. it takes the life out of the lines.

NEVER begin work without wiping off the table and instruments.

NEVER put instruments away without cleaning them. This applies with particular force to pens.

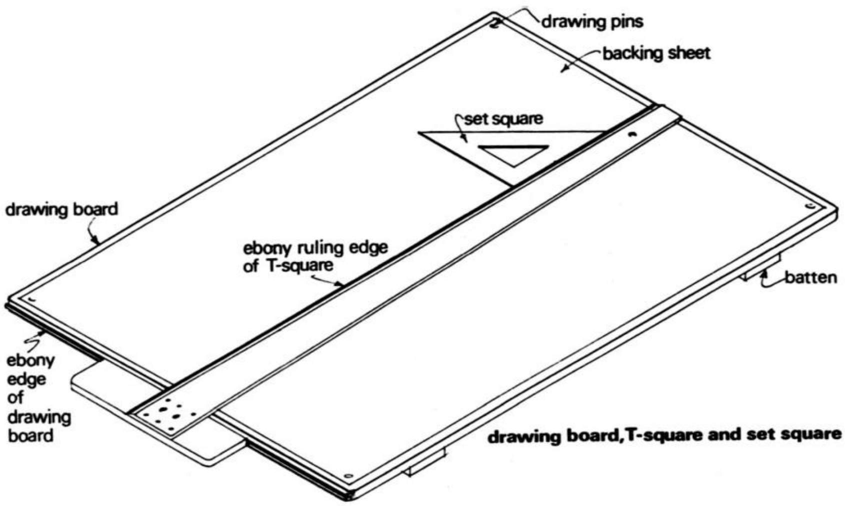
NEVER dismantle 0.1 mm. Variant/Rapidograph drawing pen for cleaning and washing purposes.

NEVER put bow instruments away without opening to relieve the spring.

NEVER work on a table cluttered with unneeded instruments or equipment.

NEVER fold a drawing or tracing.

2.2 DRAWING BOARD, TEE SQUARE and SET SQUARE :



There are various types and sizes of drawing boards and those generally used are as follows:

A2 size 650 x 470 mm
A1 size 920 x 650 mm
A0 size 1270 x 920 mm

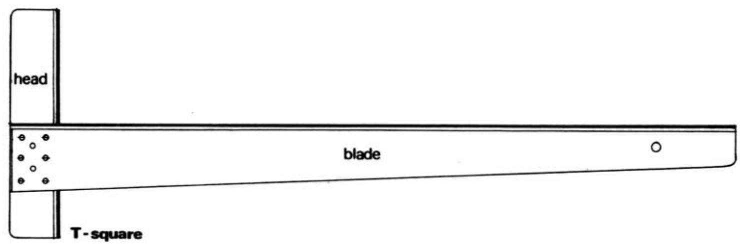
The smaller boards are made with or without an ebony edge but all larger types have an ebony edge; this is a hard edge on one short side of the board along which the tee square slides ensuring that it stays square to the board and at right angles to it. The board with the ebony edge is the better type.

A "backing sheet" is generally used on top of the drawing board to give a better surface upon which to draw. This is a sheet of cheap cartridge paper cut to the size of the board, and laid on it, before the actual paper upon which you are going to draw is pinned or taped to the board. Thus you have two sheets of paper on the board, a backing sheet and a drawing sheet. When you have finished your drawing, and taken it off the board, it is usual to leave the backing sheet on ready for the next drawing.

If you stand your drawing board against a wall when not in use always, make sure the ebony edge is at the top, for if this gets knocked the tee square will not be at right angles to the board and the lines drawn will not be parallel.

TEE-SQUARE

A1 size 920 mm.
A2 size 650 mm.
A0 size 1270 mm.

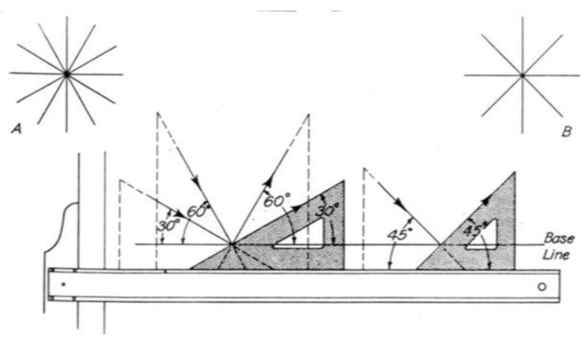


The head of the tee square slides along the ebony edge of the drawing board, and the blade of the tee square rests upon the board and is used for drawing horizontal lines.

Keep the tee square clean so that your drawing paper will be clean. This can be done by wiping periodically with a rag and a little petrol, or by crumbing up some tracing paper and wiping vigorously.

Mechanical tee squares are quite different in shape and function. On the mechanical tee square the tee square and the set square is combined and behaves as one single unit. The set square portion can rotate as much as 90^0 and the tee square also can rotate 90^0, thus giving a total of 180^0 swivel to set square. A line with any slope can be drawn with one movement of the combined unit.

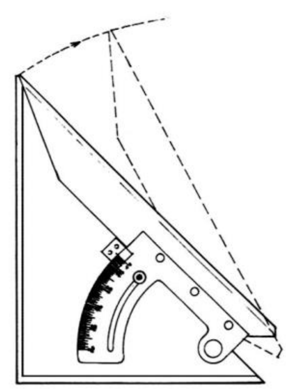
The slope of the drawing board is also adjustable and the height of the drawing board can be arranged to the desired level in combined units. .



SET SQUARE

There are three types of set square. Each one has a 90^0 angle but the remaining two angles are either 45^0 each, or 60^0 and 30^0 .

The third type of set square has a fixed 90^0 angle but has an adjustable arm which can be set at any angle. This latter one is the superior type and thoroughly recommended. The set square is used for drawing vertical lines and lines at any angle to the horizontal.

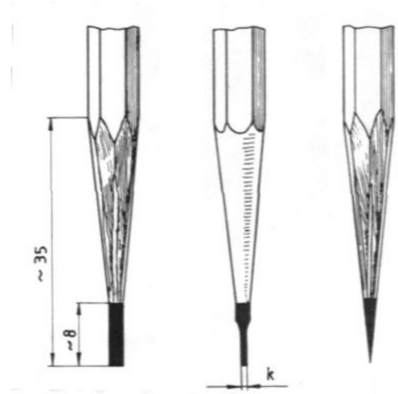


When using the set square one edge should be resting tightly against the blade of the tee square while you are drawing along one of the other edges of the set square. Set squares should be kept clean with soap and water.

PENCILS

Besides the wooden pencils in use there are many proprietary brands of pencil holder (Clutch Pencil).

The pencil holder grips the pencil lead which is released by a push button at the top of the holder. When the lead has been fully used the holder can be refilled, and in this way you can re-use the holder again and again.



This excellent and thoroughly recommended, as all you have to re-new is a lead, and the pencil stays the same length and the balance remains the same.

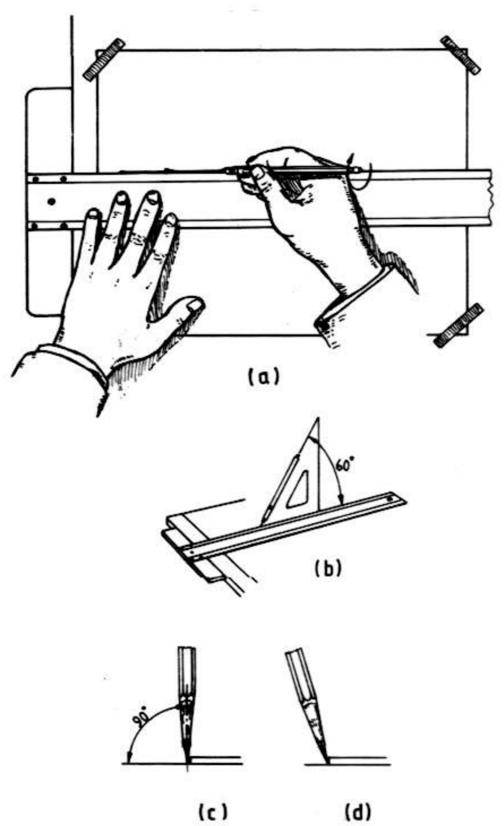
Leads can be bought from the very hard type 9H to the very soft type 6B, but many of these need not be used and we suggest you obtain H, HB , F , B, and 2B. The H can be used for setting out the drawings faintly before you use an HB or F to thicken out the lines.

B and 2B leads are excellent for rough drawings, freehand work, shading or for accentuating one part of a drawing more than another.

Be sure, when you are drawing, always to have your pencil sharp. A fine point can be obtained by gently rubbing the end of the lead on a sheet of fine sand paper.

When drawing horizontal or vertical straight lines with the pencil always revolve it slowly as the lines are drawn, as this will then keep the point even, and the line of an even thickness.

The pencil should be perpendicular to the board vertically and inclined not more than 60^0 horizontally when drawing lines.



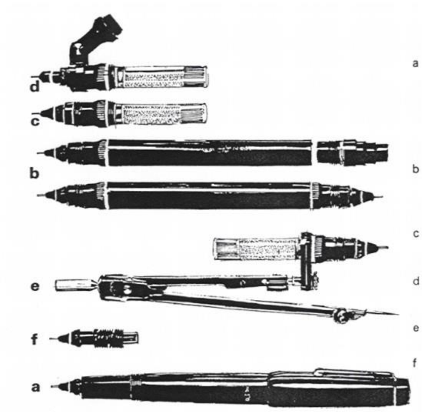
DRAWING PENS

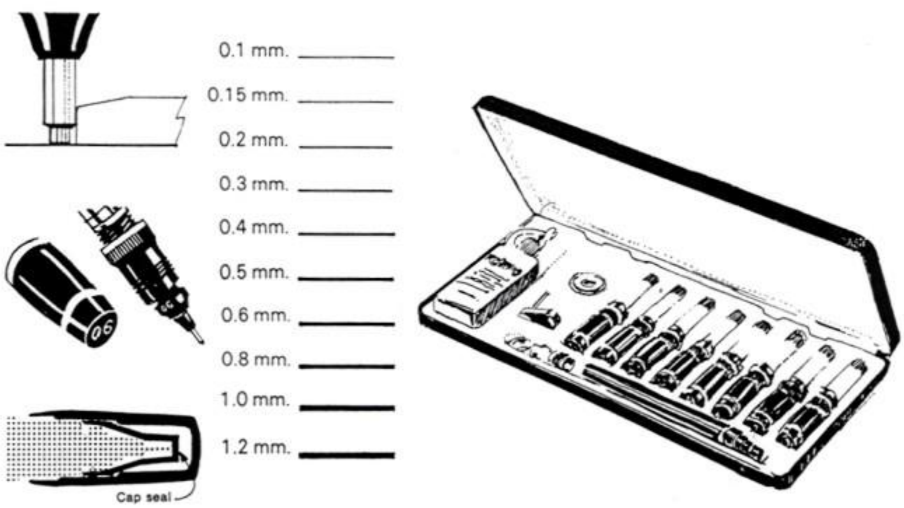
Many types can now be bought, most having a well to hold the ink similar to an ordinary fountain pen, and some having interchangeable nibs.

The type of pen usually included in a set of drawing instruments is an adjustable one which can be used for any thickness of line, but with only a small well for the ink, this well being between the blades. This is filled by squeezing ink between the blades and holding the pen in an upright position. You must not dip the ruling pen into the bottle of ink. This type of pen is not used by the modem draughtsman.

Modem drawing pens are consisted of interchangeable nibs and fountain type holders as shown in the picture.

When you buy your instruments try each article before you decide. You may find that it would be better for you not to buy a complete set of instruments in a case, but to buy each article separately to suit your own taste and need. This would most probably work out cheaper as well. Get a catalogue from the supplier before you buy.

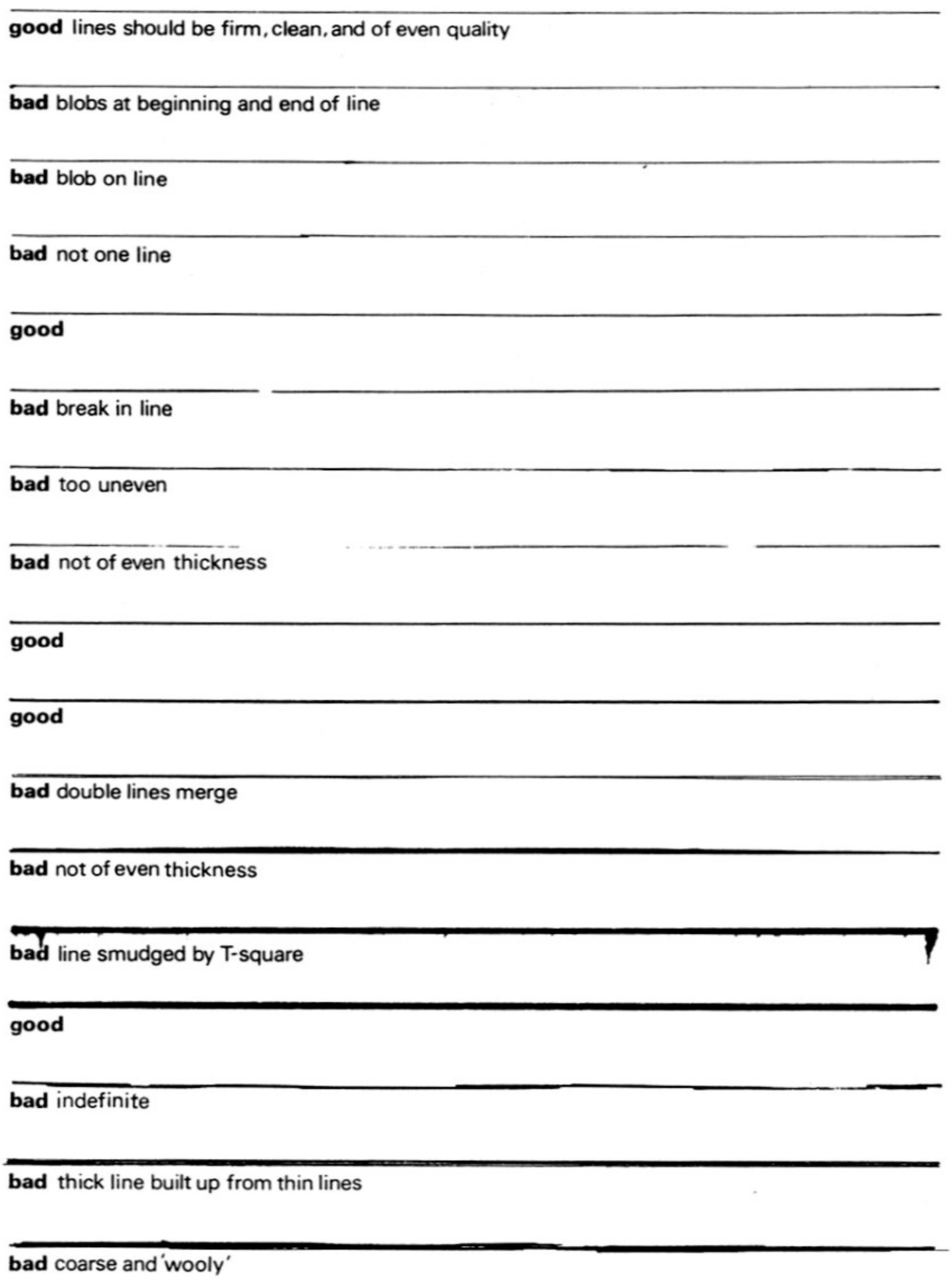




To use the pen hold this upright with the point touching the tee square. Keeping the pen upright, and with a slight pressure, draw the pen smoothly across the drawing paper against the blade of the tee square. You may find it difficult (as most people do) at first, and if the ink runs under the tee square, clean it off and try again. You will find that with practice you will become proficient. Try using different pressures on the pen while drawing, always keeping it upright.

Repeat the same practice using the set square for drawing vertical lines.

LINE DRAWING EXAMPLES



Drawing above shows some good and bad examples of lines drawn to different thicknesses.

ERASER

A soft rubber must be used when you wish to make an alteration to a pencil drawing A large rubber will last so long that it will become hard on the outside and cannot be used to good effect, so buy one that is not too small and uncomfortable in the hand, but a happy medium between small and large. There are plenty to choose from.

When you erase a line on a drawing, small particles of rubber will come on to the paper, and to remove these you can use a soft rag or small brush

DRAWING PAPER

For pencil work cartridge paper, tracing paper (medium and stout) preferably 90 to 110 gram/m^2 and detail paper are very satisfactory and when drawings are finalized

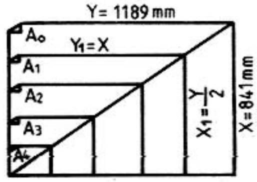
Tracing cloth is only used for very important work where the original drawing is to be printed a great number of times For ink work (mentioned later) this cloth has to be powdered with French chalk, and rubbed in, before you apply the pen. Tracing cloth, being expensive should be used for very important long life projects.

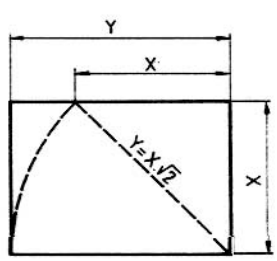
Since the tee square blade is more rigid near the head than toward the outer end, the paper, if much smaller than size of the board, should be placed close to the left edge of the board (within 3 cms. or so) with its lower edge several centimeters from the bottom of the board With the tee square against the left edge of the board, square the top of the paper; hold it in this position, slipping the tee square down from the edge, and put the edge, and stick a tape in each upper comer Then move the tee square down over the paper to smooth out possible wrinkles, and stick tapes in the other two corners

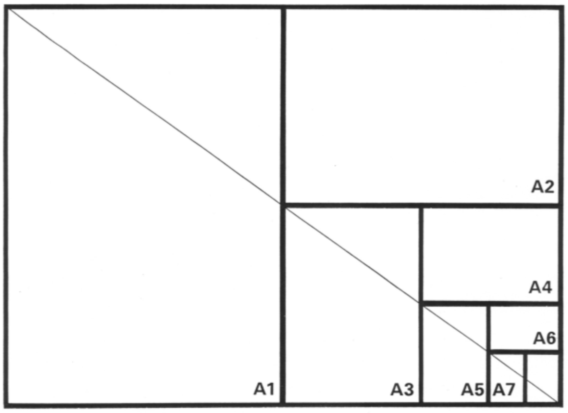
The size of the drawing papers or folding sizes are based on the international standards. The largest sheet is the A0 size, 841 mm. x 1189 mm. and the smallest size is the A7 size, 74 mm.. x 105 mm.

The international standard is based on a simple formula of $1 : \sqrt{2}$ which is the ratio of sides to each other.

If the basic **A0** sheet is folded in halves seven times the sub divisions always have their sides in the same ratio in each halve and A7 size is reached at the end.



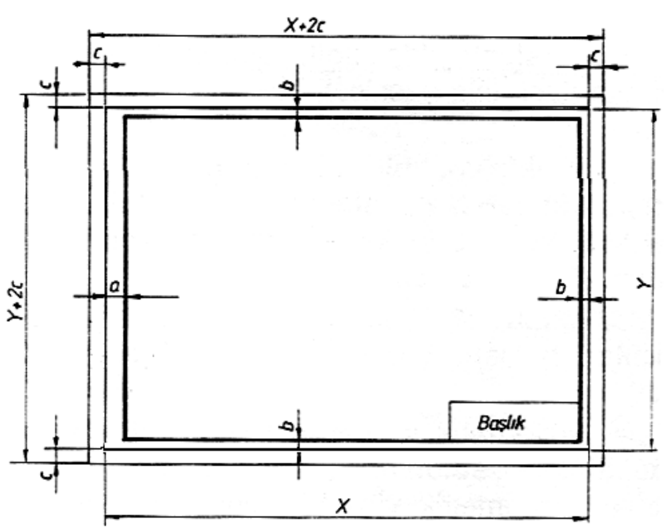




Basis of the international standard series is a sheet whose sides are in ratio 1: $\sqrt{2}$

A sheet sizes and margin sizes for filing, inner frame and outer margin.

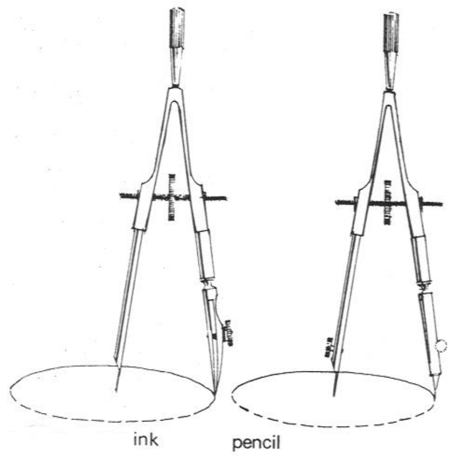
A Sheet sizes	Width **X** mm	Height **Y** mm	**Margins** Filing **a** (mm)	Inner **b** (mm)	Outer **c** (mm)
A0	1189	841	20	10	10
A1	841	594	20	10	10
A2	420	594	20	10	10
A3	420	297	20	10	10
A4	210	297	20	5	10
A5	210	148	20	5	10
A6	105	148	-	-	-
A7	105	74	-	-	-



Margin positions

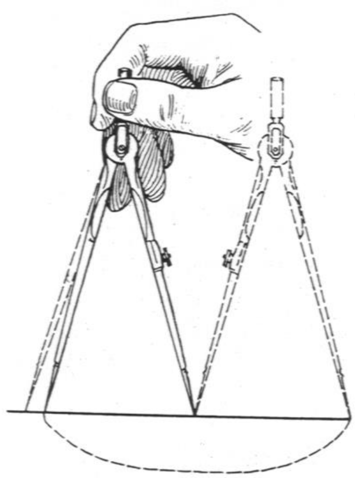
SPRING BOWS (SMALL COMPASS)

These are small compasses for pen and pencil work are used for drawing small circles.



DIVIDERS

Unlike compasses, dividers have two points (one point to each leg). They are used for equal size divisions in even or odd numbers or for measuring and transferring distances on one drawing to another.

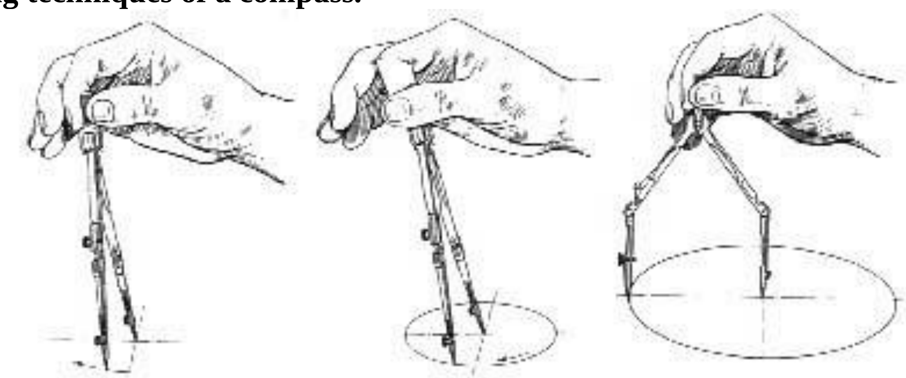


COMPASSES

This instrument is used for drawing large circles when spring bows cannot be used. There are two types - pen compasses and pencil compasses. On some there is one shaft with interchangeable pen and pencil fitments on one arm.

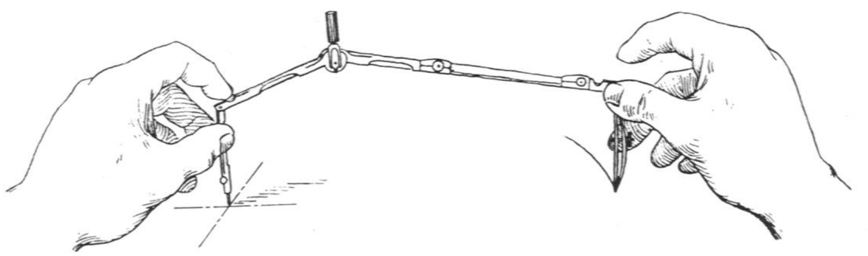
When a very large circle or arc has to be drawn an extension arm can be fitted to increase the radius. To draw with spring bows or compasses only slight pressure must be put on the needle to avoid the hole in the paper becoming too big.

Drawing techniques of a compass.

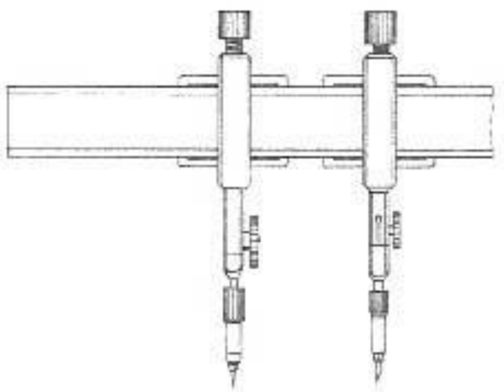


USE OF THE LENGTHENING BAR

The joints must be bent to bring the legs perpendicular. Usually two hands are used because the handle is off center.

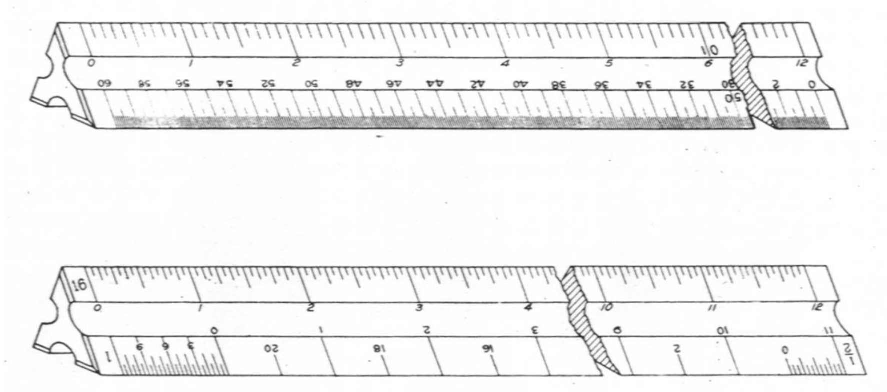


Large circles can be drawn with the lengthening bar inserted to the compass

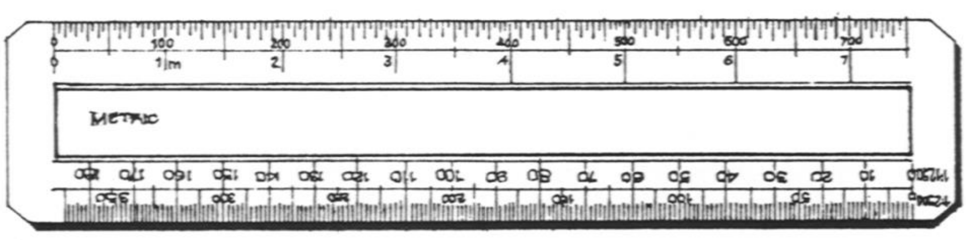


Compasses located on a bar is useful for very large diametered circles

SCALE RULES



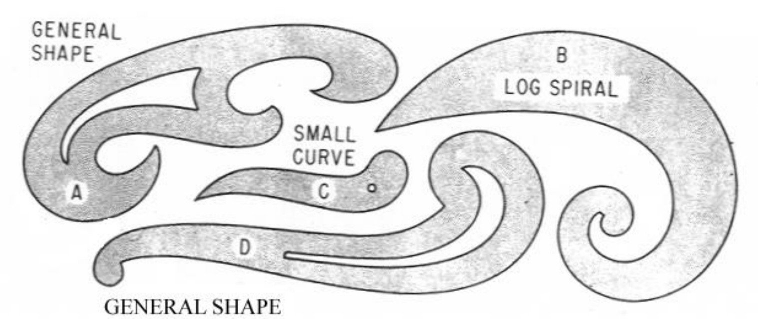
The common ratios are **1 : 5 , 1 : 1 0 , 1 : 20 , 1 : 50 , 1 : 75 , 1 : 1 00** and **1 : 200.**



The sides of the scale rule are divided into these various parts and the first unit of a meter on each scale is shown by the letter **m.** after the number. The divisions between the meter units each represent **100 mm** , except the **1 : 5** scale which, being so large, the units can be divided into 10 millimeters.

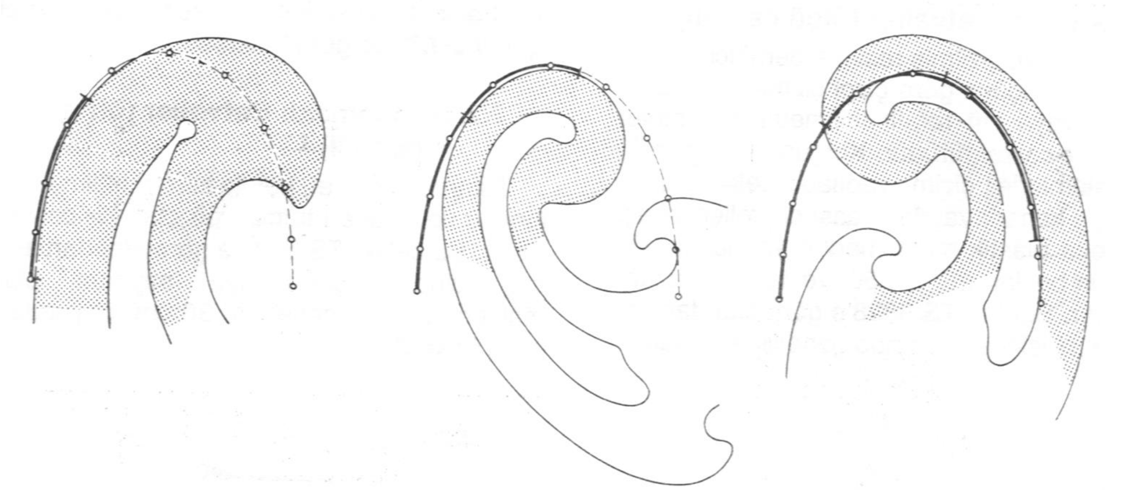
Simplicity is the essence of the metric language and use of the metric scale will make you proficient in its use. ***It is very important to show on a drawing, once completed, to what scale the drawing has been prepared.*** A drawing can be useless if this is not shown and is indicated thus: Scale 1:100

THE FRENCH CURVE



The French curve is a guiding edge for noncircular curves. When sufficient points have been determined, it is best to sketch in the line lightly in pencil, freehand and without losing the points, until it is clean, smooth, continuous, and satisfactory to the eye.

Then apply the curve to it, selecting a part that will fit a portion of the line most nearly and seeing to it, particularly, that the curve is so placed that the direction in which its curvature increases is the direction in which the curvature of the line increases.



The changing curvature of line and curve must match.

In drawing the part of the line matched by the curve, always stop a little short of the distance in which the guide and the line seem to coincide. After drawing this portion, shift the curve to find another place that will coincide with the continuation of the line. In shifting the curve, take care to preserve smoothness and continuity to avoid breaks or cusps. Do this by seeing that in its successive positions the curve is always adjusted so that it coincides for a short distance with the part of the line already drawn. Thus at each junction the tangents will coincide.

If the curved line is symmetrical about an axis, marks locating this axis, after it has been matched accurately on one side, may be made in pencil on the curve and the curve then reversed. In such a case take exceptional care to avoid a "hump" at the joint.

It is often better to stop a line short of the axis on each side and close the gap afterward with another setting of the curve. When using the curve in inking, the pen should be held perpendicular and the blades kept parallel to the edge. ***The inking of curves is excellent practice.***

Sometimes, particularly at sharp turns, a combination of circle arcs and curves may be used: In inking a long, narrow ellipse, for example, the sharp curves may be inked by selecting a center on the major diameter by trial, drawing as much arc as will practically coincide with the ends of the ellipse, and then finishing the ellipse with the curve.

The experienced draftsman will sometimes ink a curve that cannot be matched accurately by varying the distance of the pen point from the ruling edge as the line progresses.

PREPARATION FOR DRAWING

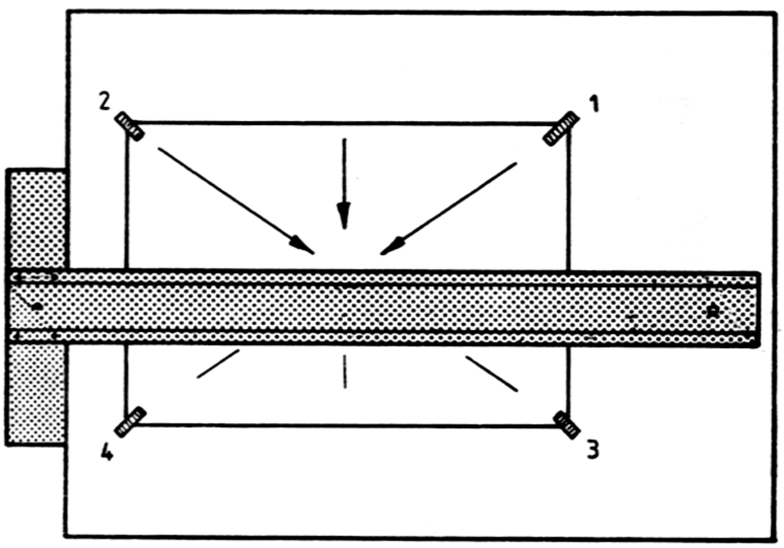
The drawing table should be set so that the light comes from the left, and it should be adjusted to a convenient height, that is 90 cm. to 100 cm. for use while sitting on a standard drafting stool or while standing.

There is more freedom in drawing standing, especially when working on large drawings.

The board, for use in this manner, should be inclined at a slope of 1 to 8. Since it is more tiring to draw standing, many modern drafting rooms use tables so made that the board can be used in an almost vertical position and can be raised or lowered so that the draftsman can use a lower stool with swivel seat and backrest, thus working with comfort and even greater freedom than when an almost horizontal board is used.

The instruments should be placed within easy reach, on the table or on a special tray or stand beside the table. The table, board and instruments should be wiped with a dust cloth before starting to draw.

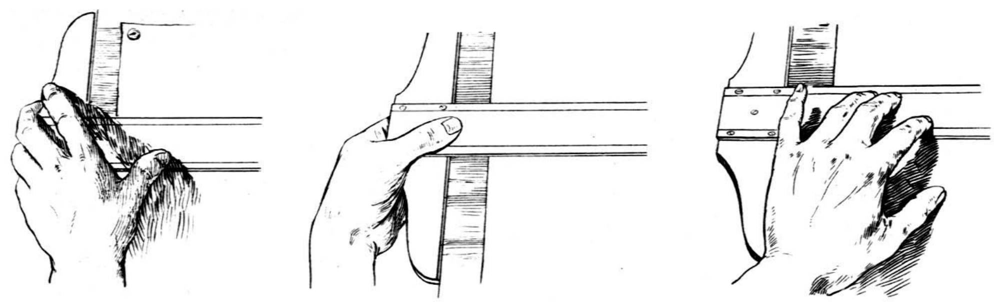
Since the tee square blade is more rigid near the head than toward the outer end, the paper, if much smaller than size of the board, should be placed close to the left edge of the board (within 5 cm or so) with its lower edge several centimeters from the bottom of the board.



With the tee square against the left edge of the board, square the top of the paper; hold it in this position, slipping the tee square down from the edge, and stick a tape in each upper comer, then move the tee square down over the paper to smooth out possible wrinkles and stick tapes in the other two corners. Drafting tape may be used instead of thumbtacks.

USE OF THE TEE SQUARE

The Tee square and the triangles have straight edges and are used for drawing straight lines. Horizontal lines are drawn with the Tee square, which is used with its head against the left edge of the drawing board and manipulated as follows:



Position A Position B Position C

Holding the head of the tool, slide it along the edge of the board to a spot very near the position desired. Then, for closer adjustment, change your hold either to that shown at (B), in which the thumb re-mains on top of the T-square head and the other fingers press against the under-side of the board, or, as is more usual, to that shown at (C), in which the fingers remain on the T square and the thumb is placed on the board.

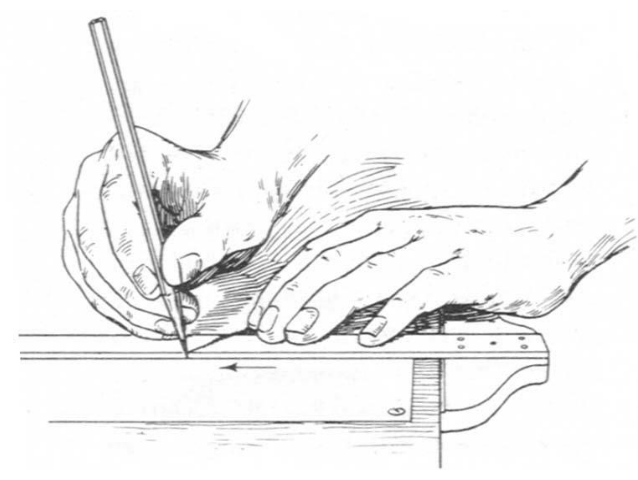


Figure on the left shows the position of the hand and pencil for drawing horizontal lines. Note that the pencil is inclined in the direction the line is drawn, that is, toward the right, and also slightly away from the body so that the pencil point is as close as possible to the Tee square blade.

In drawing lines, take great care to keep them accurately parallel to the guiding edge of the Tee square. The pencil should be held lightly, but close against the edge, and the angle should not vary during the progress of the line.

Horizontal lines should always be drawn from left to right. A Tee square blade can be tested for straightness by drawing a sharp line through two points and then turning the square over and with the same edge drawing another line through the points.

LETTERING CHAPTER 3

3.1 LETTERING

Lettering is a branch of design. Students of lettering fall into two general classes; those who will use letters and words to convey information on drawings, and those who will use lettering in applied design, for example, art students, artists and craftsmen. The first group is concerned mainly with legibility and speed, the second with beauty of form and composition. In our study of ***Technical Drawing*** we are concerned only with problems of the first group.
The engineering student takes up lettering as an early part of his work in drawing and continues its practice throughout his course, becoming more and more skillful and proficient.

Styles narrow in their proportion of width to height are called CONDENSED.
Styles wider than the normal are called EXTENDED.
Letters with heavy stems are called **BOLDFACE**.
Letters with thin stems are called LIGHTFACE.

You will no doubt realize that every professional drawing will require a title, and the various plans, sections and sketches will have to be annotated to make them understood by the others. When lettering (that is the printing of titles and notes) is put on a drawing this will have to be neat and legible and much practice is required so that good lettering is used on all drawings. Excellent draftsmanship can be ruined if bad lettering is used.
It is not considered desirable that there should be a standard form of lettering for everybody's drawings, for each draftsman will develop his own style, and the object should be to provide with reasonable rapidity , distinct uniform letters and figures which will ensure the production of good and legible prints.
Wherever practicable notes should be collected in groups and not spread over the whole of the drawing. Where **emphasis** of notes on drawings is required this should be brought out by the use of **heavier lettering**.
The basis of English lettering is taken from the old lettering of the Roman period, and the best example of this is that carved in the stone of Trajan's column in Rome. This type forms the basis of good lettering for style and proportion, and should be studied and drawn by the student. You will be able to study and copy this from the next two drawings and you will note that there are thick and thin strokes. This difference in thickness could have evolved because the Romans probably painted the letter on the

stone before carving; the thick lines would be produced by the downward stroke of a brush and the thin line for an upward stroke or cross stroke.

The serif, which is the little curved part at the end of the lines, was the finish to these letters given by the stone mason with his chisel.

Roman Capitals Arranged in Letter Family

Old roman Lower Case and Capitals

The proportion for draftsmanship purposes are as follows:-

Thick lines about one-tenth the height of the letters and the thin strokes a little more than one half of the thick strokes. Because the C, G, O, and Q would appear smaller than the others if drawn to the same height, these letters are drawn slightly higher to offset that optical illusion. Roman lettering for drafting purposes is not generally used on day to day drawings but is used for titles of important drawings where it is felt it would fit in with the overall design.

It must be executed extremely well or it will look shoddy.

There was no 'U' in the Roman alphabet and on some buildings modern sculptors when chiselling Roman lettering on to stone use the V for U. This is wrong however, and it is always best to use a paper U drawn to fit the character of this particular type of lettering.

You should carefully study Roman lettering for proportion and legibility and the best way to do this is to draw it out for yourself, or trace it from this book.

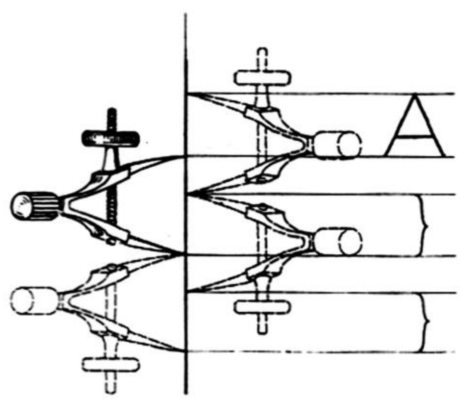
3.2 LETTERING FUNDAMENTALS

According to the rule of stability , a horizontal line drawn across the middle of a rectangle appears to below the middle must be provided for. In order to give the appearance of stability , such letters as **B** , **E** , **K** , **S** , **X** and **Z** and the figures **3** and **8** must be drawn smaller at the top than at the bottom.

Always draw light guide lines for both tops and bottoms of letters, using a sharp pencil.

Draw the first base line; than set the bow spacers to the distance wanted between base lines and step off the required number of base lines.

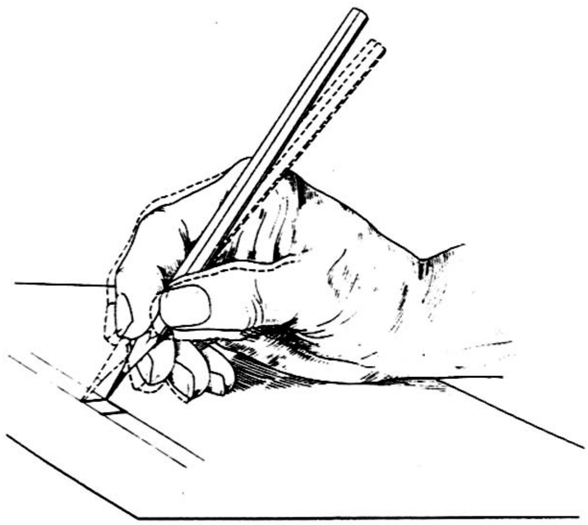
Above the last line mark the desired height of the letters.

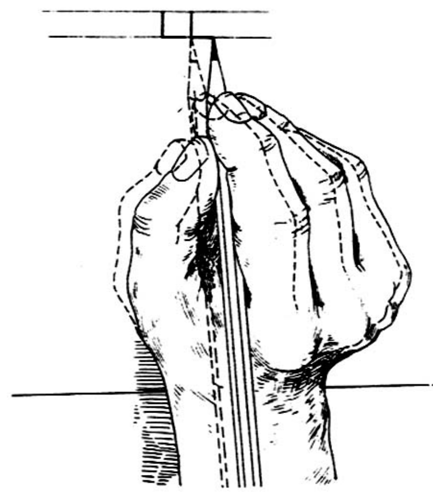


With the same setting, step down from this upper point, thus obtaining points for the top of each line of letters.

The vertical, single stroke, commercial Gothic letter is a standard for titles, reference letters etc.

It is very important to apply the right strokes when lettering.





Vertical Strokes

These are made entirely by finger movement.

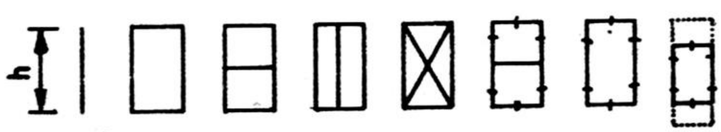
Horizontal Strokes

These are made by pivoting the whole hand at the wrist; fingers move slightly to keep the stroke perfectly horizontal.

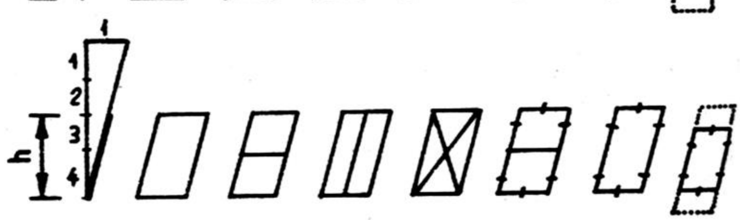
3.3 BASICS OF LETTERS

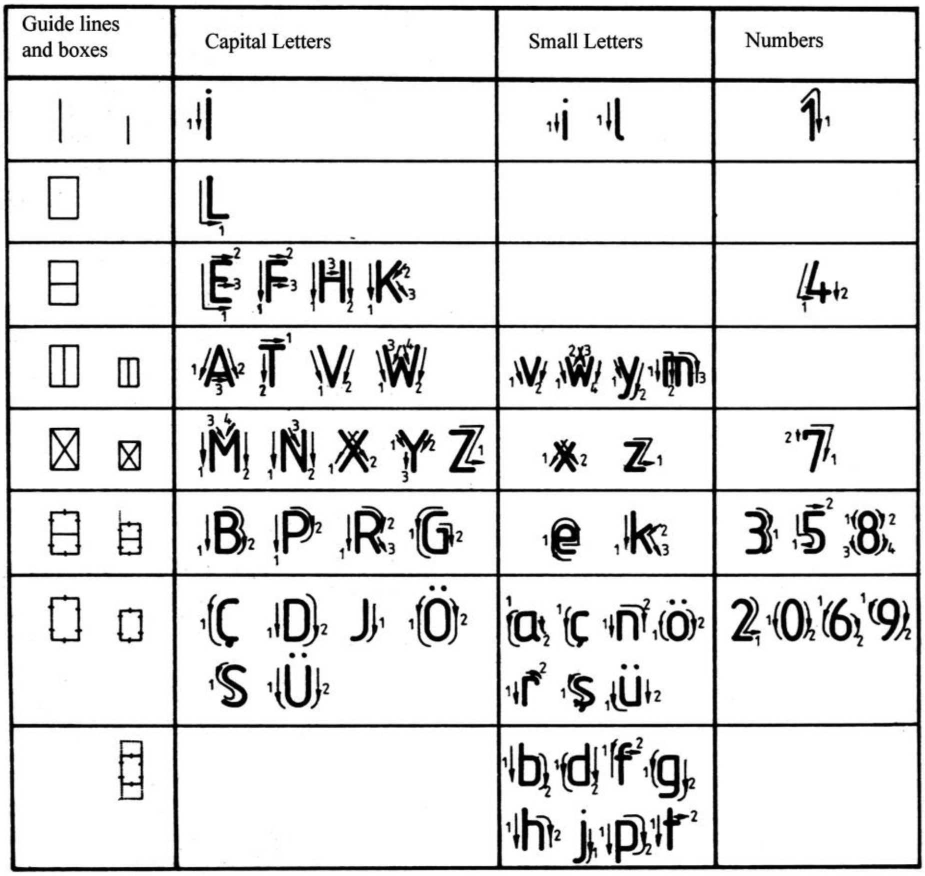
In the following figures the letters of an alphabet of slightly extended vertical capitals has been arranged in family groups. Study the shape of each letter, with the order and direction of the strokes forming it and practice it until its form and construction are perfectly familiar. To bring out the proportions of widths to heights and subleties in the shapes of the letters, they are shown against a square background with its sides divided into sixths.

Guide lines and boxes for Regular Letters.

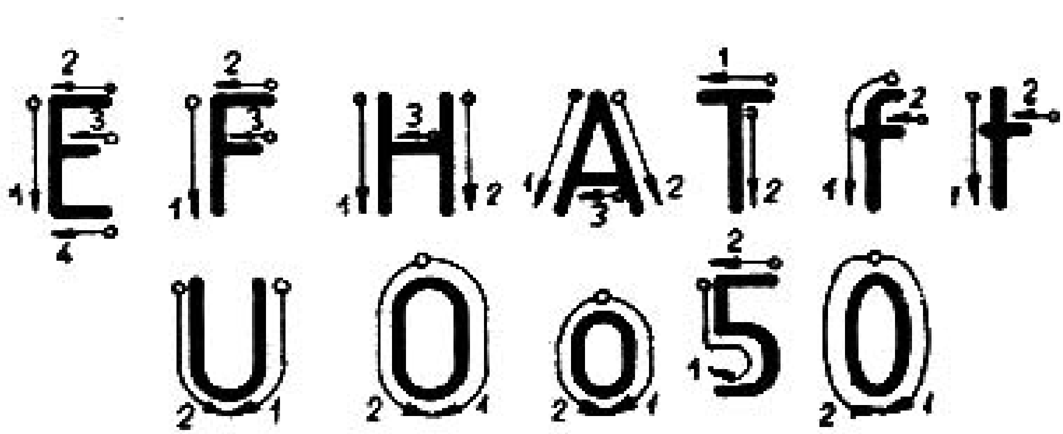


Guide lines and boxes for Italic Letters.





Order and direction of strokes forming the letters



Strokes for **LEFT HANDERS**

GENERAL NOTES ON LETTERING

You will not be expected to put Roman or Gothic lettering on all your drawings, of course, and for general use you must practice your own type of lettering and develop a style.

This must be legible, and generally tidy and clean; it need not be done with a tee square and set square but can be free-hand based on the lettering shown in next page.

Use a pencil first and then try the same in ink. You will find it slow and tedious to begin with, trying to get the right shapes; with constant use, however, it will soon be possible for you to letter without effort but with speed and accuracy .

Do not add any fancy "squiggles" or similar meaningless idiosyncrasies with the idea that you have found a style of your own. Your individual characteristics will eventually be brought out, so to begin with concentrate on legibility and neatness.

Always draw faint guide lines with your tee square before lettering (never letter without guide liner or the results will be disastrous), and always make sure that these guide lines are the same distance apart for each line of lettering, or you will get an uneven appearance which will look very unprofessional. Use different size lettering for different types of notes if you desire to bring out particular important points, but always use bigger lettering for the main title and sub-headings.

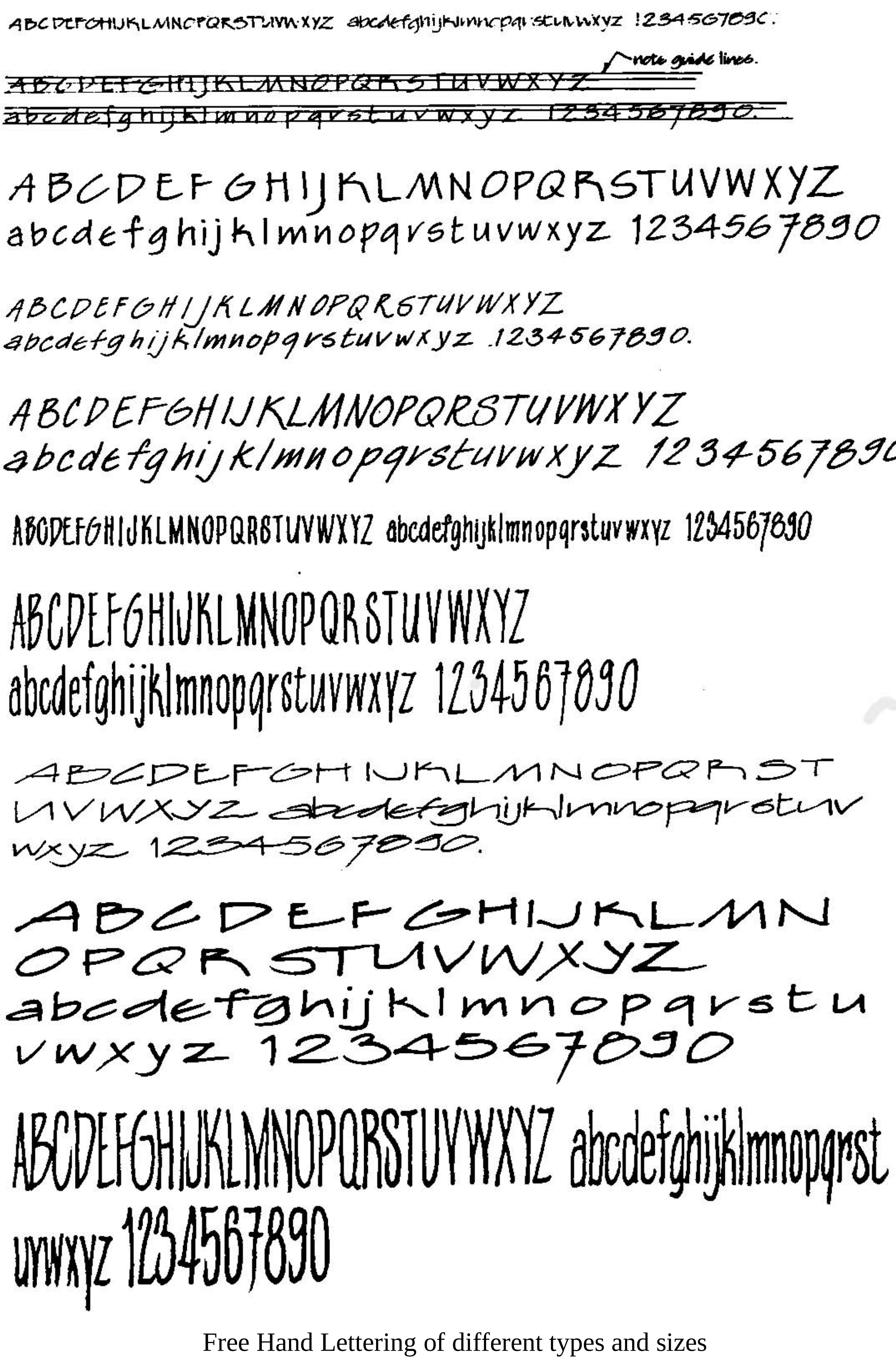
The spacing of letters is most important, and good spacing is decided by a visual equalizing of the distances between the letters which is obtained only through practice.

Don't bunch all your letters together or put them so far apart that you have to spell out each letter before you can make out the word, but try to arrive at a happy medium. If you use a pencil for lettering, the correct grade should be carefully selected to suit the paper. These grades are as follows:-

Type of Paper	Grade of Pencil
Tracing paper	H - HB
Cartridge paper	HB - 2B
Handmade paper (this is a very good quality paper becoming harder and harder to obtain)	F - 2B

When lettering in pencil on tracing paper or similar remember that you will most probably have to obtain prints from the drawing so always be firm and never furry .

Free hand lettering in ink is better done, with a nib which has been used by yourself before and has been "broken in". It has become suited to your own inclination and pressure of the hand will therefore flow smoothly.



Free Hand Lettering of different types and sizes

LETTERING STYLE

The object of lettering is to provide concise information which is not easily conveyed by the drawing. Distinct and uniform letters and figures will unsure the production of good and legible prints and this is particularly important with the present tendency in large offices to reduce drawings photographically on to microfilm for filing purposes.

Notes of a general character should be collected in groups and not spread over the whole of the drawing.

Notes relating to specific details should be as near as possible to the items to which they refer, but care should be taken not to obscure any part of the drawing.

Lines to link detail with their notes should only used where unavoidable. Underlining of lettering should be avoided and the punctuation marks should not be used unless essential to the sense of the note.

Letters and figures should be simple and unaffected. The density of the lines of which letters are formed should be the same as that of the drawing. Handwritten letters and figures should be well formed.

Since each numeral is a significant unit, compared with lettering which may be read a word at a time, particular care should be taken to make figures clear. it is recommended that sizes of letters and numerals are as follows:

Titles : 5 to 8 mm
Notes: 1.5 to 4 mm

Letters should be evenly spaced in the words. Words should be compact without being cramped and close enough to one another to allow the sentences to be read without difficulty.

The clear space between letters or figures should be not less than twice their line thickness. The space between words should be equal to that occupied by the letter O if touching both words and the space between sentences should be double that between words.

STENCILS AND TRANSFERS

Stencils and transfers may be used to achieve uniformity, especially of headings and titles.

Besides the use of free hand lettering there are now many aids to good lettering in the form of stencils. These are cut outs of letters which you trace round and they can be obtained in many different sizes and types and are suitable for notes, subheadings, main headings, titles etc.

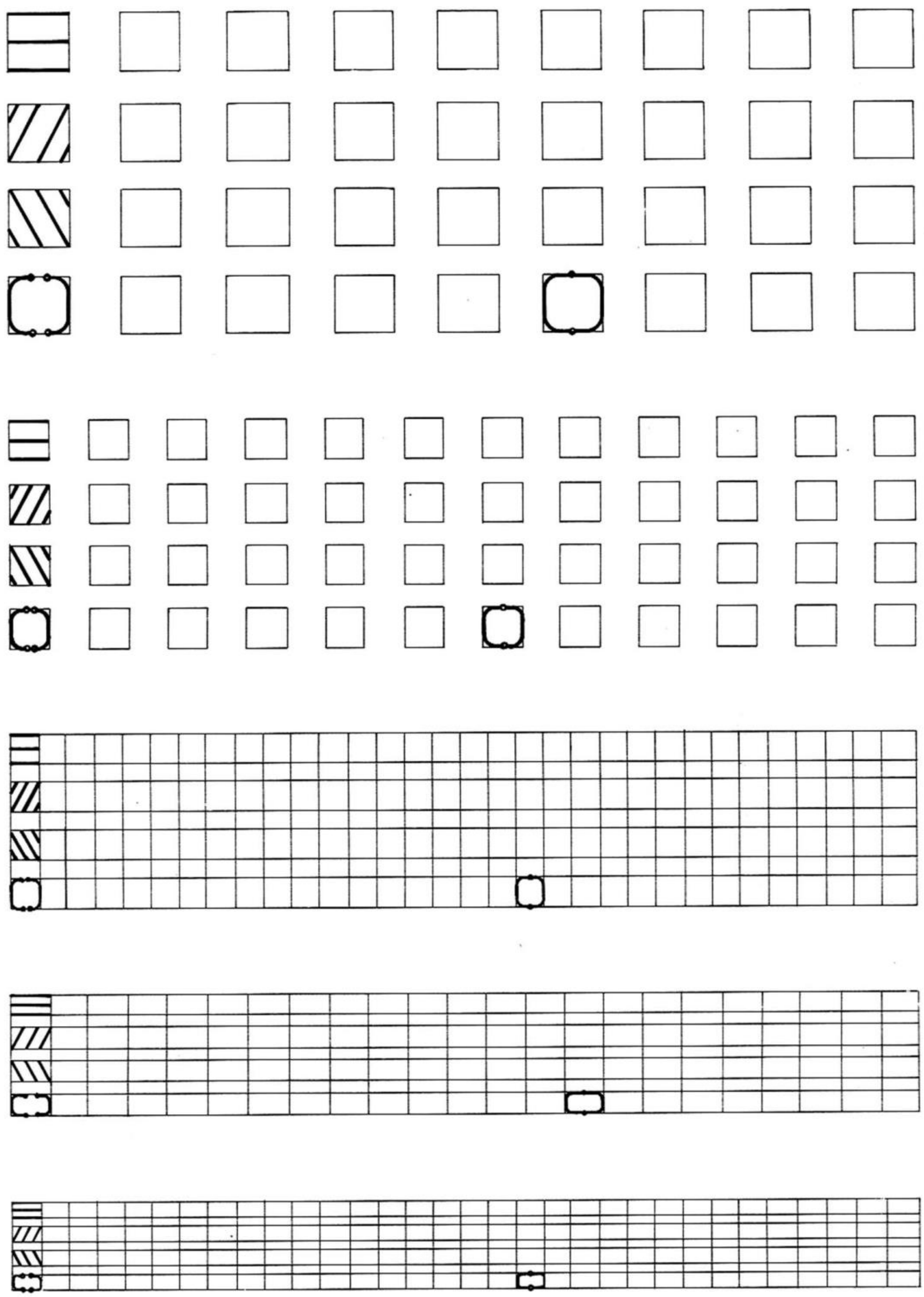
Some find by using these stencils they can produce a quicker job, while some people do not like them at all.

Below, stencil lettering are shown.

Stencil Letters of different type and size

EXERCISE 1

Using a pencil, freehand draw the sample lines exactly into the empty practise boxes.



EXERCISE 2

Letter	Guide box	Write into empty guide boxes	Write on to guide lines	Write into empty spaces
I İ	I	I I I	I	I
L	L		L	L
E	E		E	E
F	F		F	F
H	H		H	H
K	K		K	K
T	T		T	T
A	A		A	A
V	V		V	V
M	M		M	M
N	N		N	N
Z	Z		Z	Z
Y	Y		Y	Y
X	X		X	X
W	W		W	W
P	P		P	P
R	R		R	R
B	B		B	B
G Ğ	G		G	G
C Ç	C		C	C
O Ö	O		O	O
U Ü	U		U	U
J	J		J	J
D	D		D	D
S Ş	S		S	S

EXERCISE 3

Letter	Guide Box	Write into empty guide boxes	Write onto guide lines	Write into empty spaces
ı i	ı		ı	ı
l	l		l	l
t	t		t	t
v	v		v	v
w	w		w	w
y	y		y	y
m	m		m	m
x	x		x	x
z	z		z	z
k	k		k	k
e	e		e	e
a	a		a	a
c ç	c		c	c
o ö	o		o	o
r	r		r	r
n	n		n	n
u ü	u		u	u
s ş	s		s	s
h	h		h	h
f	f		f	f
b	b		b	b
d	d		d	d
p	p		p	p
q	q		q	q
j	j		j	j
g ğ	g		g	g

EXERCISE 4

Number	Guide Box	Write into empty guide boxes	Write onto guide lines	Write into empty spaces			
1	1		1	1			
7	7		7	7			
4	4		4	4			
3	3		3	3			
5	5		5	5			
8	8		8	8			
2	2		2	2			
0	0		0	0			
6	6		6	6			
9	9		9	9			

Please freehand write the below given numbers and signs exactly the same onto the empty lines

[(?!"·„,–=+±×√%)] □ ∅	

17		60		123		13579	
14		69		234		35790	
74		90		345		15791	
43		91		456		24680	
35		23		567		62840	
58		36		678		01234	
82		45		789		56789	
20		78		890		29101990	

LINES — CHAPTER 4

4.1 LINES

Line is the basis of everything in Technical Drawing.

A line is drawn with a steady, even arm movement, the tips of the third and fourth fingers resting on, and s1iding along, the straightedge, keeping the angle of inclination constant just before the end of the line is reached, the two guiding fingers on the straightedge should be stopped and, without stopping the motion of the pen, the line finished with a finger movement. Short lines are drawn with this finger movement alone. When the end of the line is reached, the pen is lifted quickly and the straightedge moved away from the line.

The pressure on the paper should be light but sufficient to give a clean cut line, and it will vary with the kind of paper and the sharpness of the pen. The pressure against the tee square, however should be only enough to guide the direction.

Instead of explaining LINE in words , it is much more practical to explain by direct practice.

Tape a sheet of paper on you board on top of your backing sheet and put the head of your tee square against the ebony edge of the board. Take your sharpened pencil, and placing this against the blade of the tee square, draw a line from left to right, keeping the lead against the edge of the tee square, slowly rotating the pencil between your fingers at the same time. This line should be firm and clean (not furry and broken), and should be the same thickness for its full length.

Repeat this line many times until you have mastered using the correct pressure, and the rotating motion.

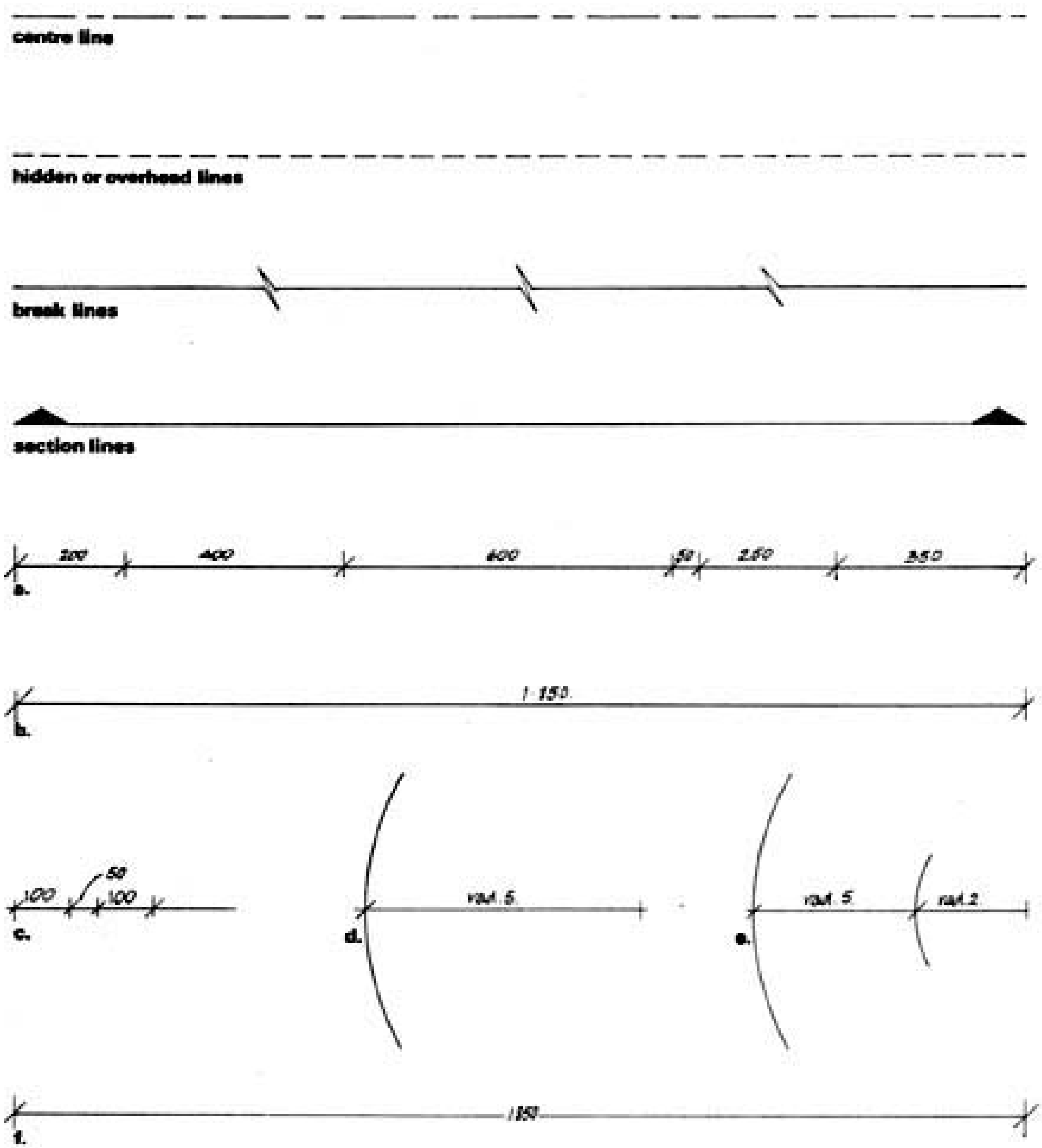
Use all the pencils in your possession thus getting used to their various hardness or softness. Do not pres so hard that a groove appears in the paper. Keep your pencil always sharp.

When you think you have mastered horizontal lines take your set square and draw vertical lines, and lines at an angle to the horizontal. Use the adjustable set square at different angles.

In ***Chapter 2*** the examples of line drawings shown clearly. You must try to correct your mistakes and eliminate them after each relining experience.

ALPHABET OF LINES

The following drawings show usual methods of indicating various lines, dimensions and symbols on finished pencil drawings or inked drawings.

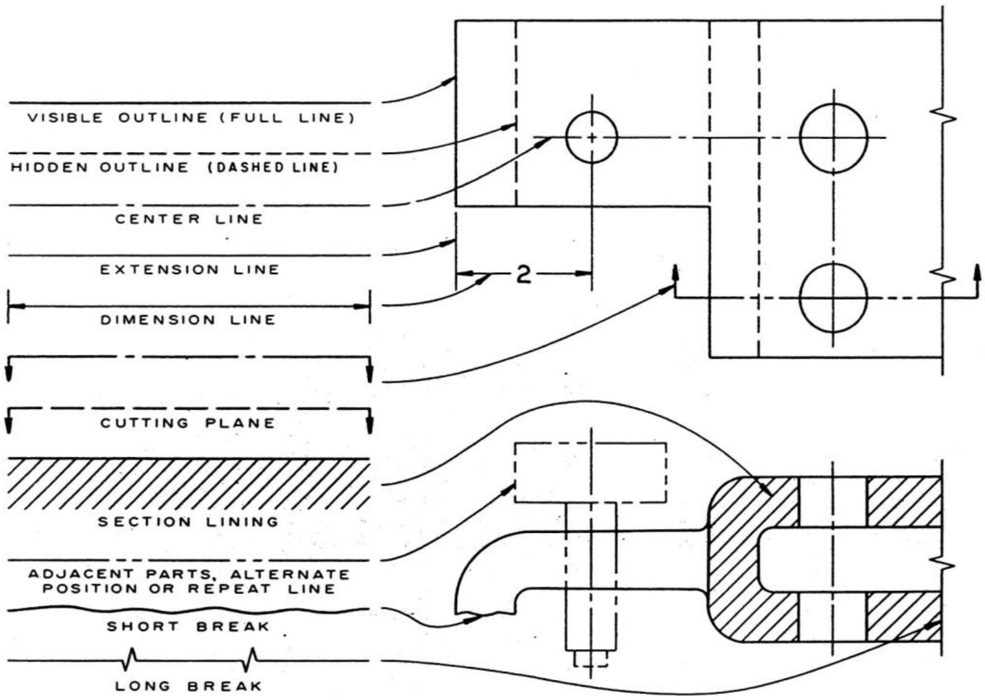


Dimension lines from a to f

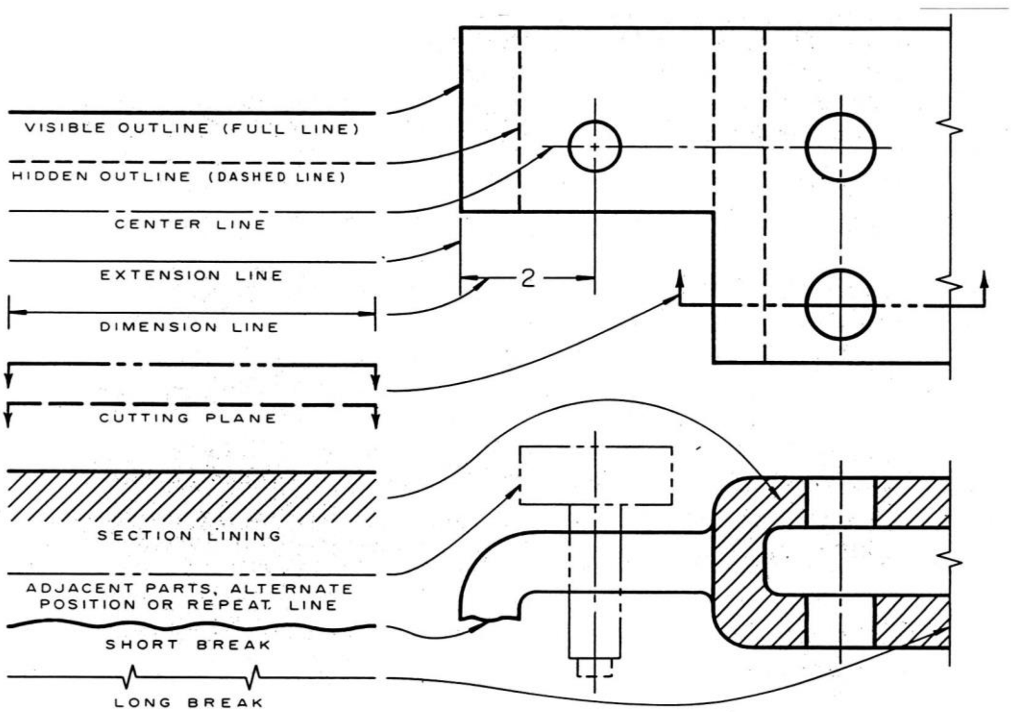
These drawings should be studied with the following notes and kept for constant reference. The methods shown for representing the items should be used on all future drawings.

Centre lines	A Centre line through should project for a short distance beyond the outline (top and bottom lines to which it refers).
Hidden outlines or overhead lines	Hidden outlines which show hidden surfaces or overhead lines should be included only when they will not obscure other work shown on the drawings.
Break lines	These lines are used when only part of an object needs to be drawn. The edge of the break should be finished with the break lines.
Section lines	When sections are shown on the drawing the place where these sections are taken through the plan is shown by the section line. The arrow heads point the way you are to look at the section.
Dimension lines	For short dimensions, where there are many of these, the dimension lines should be as shown in (a). For lines showing overall dimensions type (b) should be used. Where dimensions of small spaces have to be indicated and the figure cannot fit in between the lines type (c) is adopted. (d) and (e) show methods of indicating radii. Where the object is "broken" because of its size, the dimension line should also be broken as shown in (f).
Section lining	Used in cross sections, showing different materials with different symbols or hatchings.
Bold and thick lines	Used for showing the outer edges of the objects on the very upper plane.
Faint lines	Used for showing the edges of the secondary plane on the object. Some find by using these stencils they can produce a quicker job, while some people do not like them at all.

ORDER OF LINES



FINISHED PENCIL DRAWING OR TRACING



INKED DRAWING OR TRACING

To produce a drawing in ink you will have to set out the drawing in pencil; this can be done in two ways. A pencil drawing can first be completed on cartridge paper, then tape a sheet of tracing paper over it and the pencil drawing showing through from underneath can be traced easily with pen and ink. ***This will be the finished drawing.***

If you prefer it the pencil drawing can be drawn straight on to the tracing paper in faint lines and the ink work carried out directly over this on the same sheet. On completion the whole sheet can be cleaned with a soft rag and a little petrol. Thus removing all pencil lines and leaving only the ink work. If cartridge paper similar to it has been used instead of tracing paper, it is better to clean the surface with a soft Art Gum eraser. This is a very soft rubber.

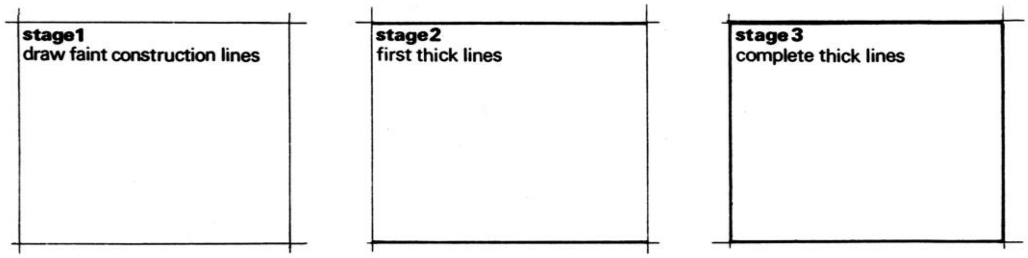
4.2 BASICS OF DRAWING GEOMETRIC SHAPES

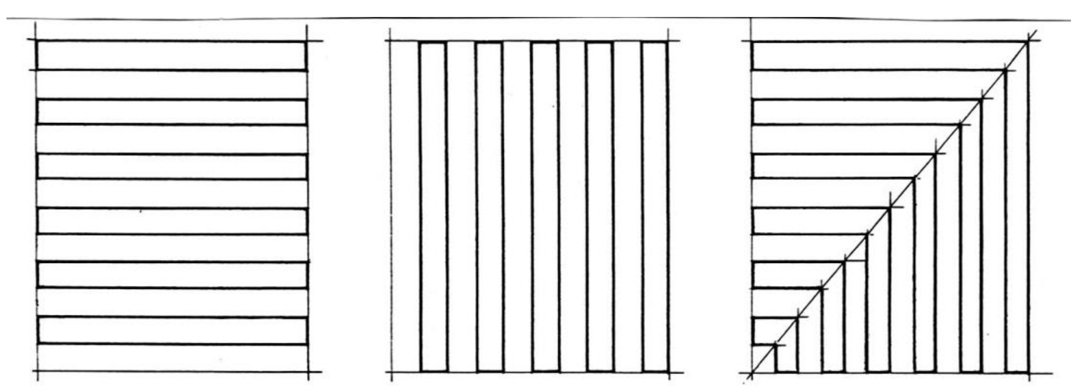
In time you will develop your own method of inking in the pencil work, but generally;

1. The arcs and circles are drawn first;
2. Next the horizontal and vertical lines,
3. Then the hatching in of sections and the dimension lines and the notes.

When drawing in pencil or in ink, follow these steps :

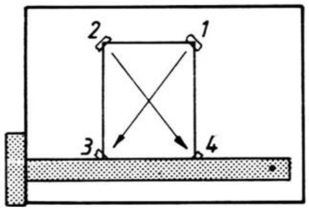
1. Draw all lines in faint pencil.
2. Draw all lines in fine ink, if inking is the final step
3. Thicken the lines you wish to emphasize



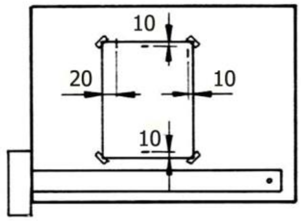


stage 1 **stage 2** **stage 3**

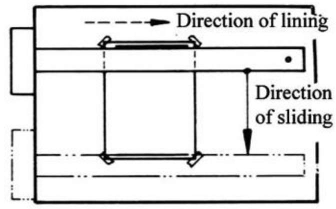
DRAWING A FRAME & TITLE ON AN A4 SIZE DRAWING PAPER



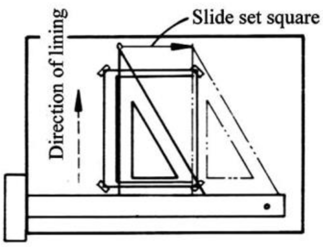
1- Tape a sheet of paper on to drawing board



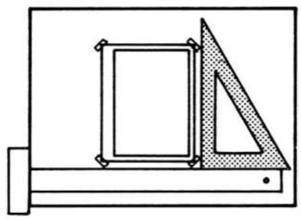
2- Mark the margin lines (mm.)



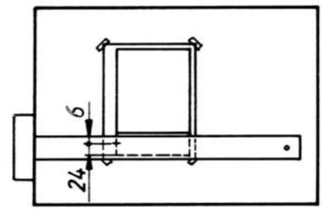
3- Draw horizontal lines with Tee square



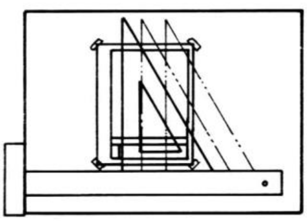
4- Draw vertical lines with set square



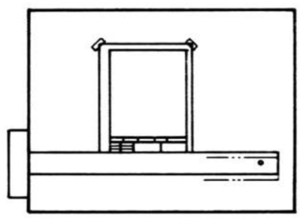
5- Complete the drawing of the frame



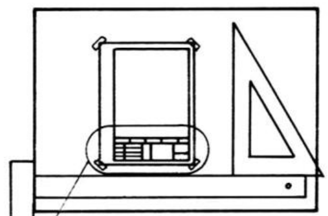
6- Draw horizontal lines of the Title



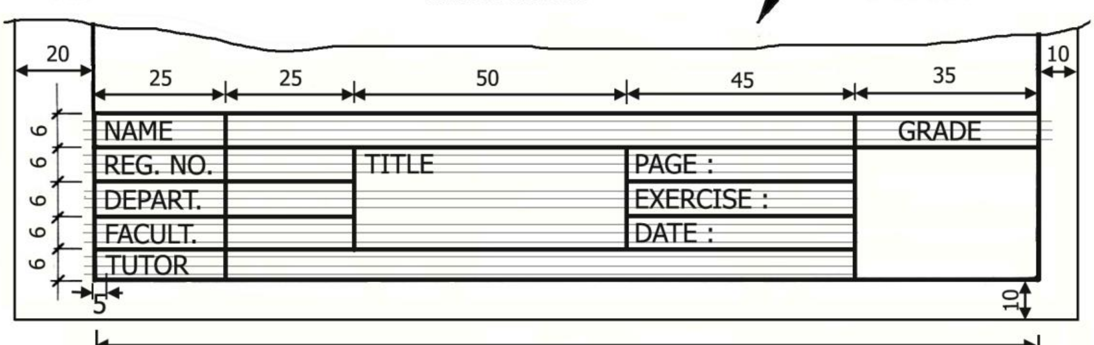
7- Draw vertical lines of the title



8- Draw internal horizontal lines of the Title



10- Finish the drawing of the Title



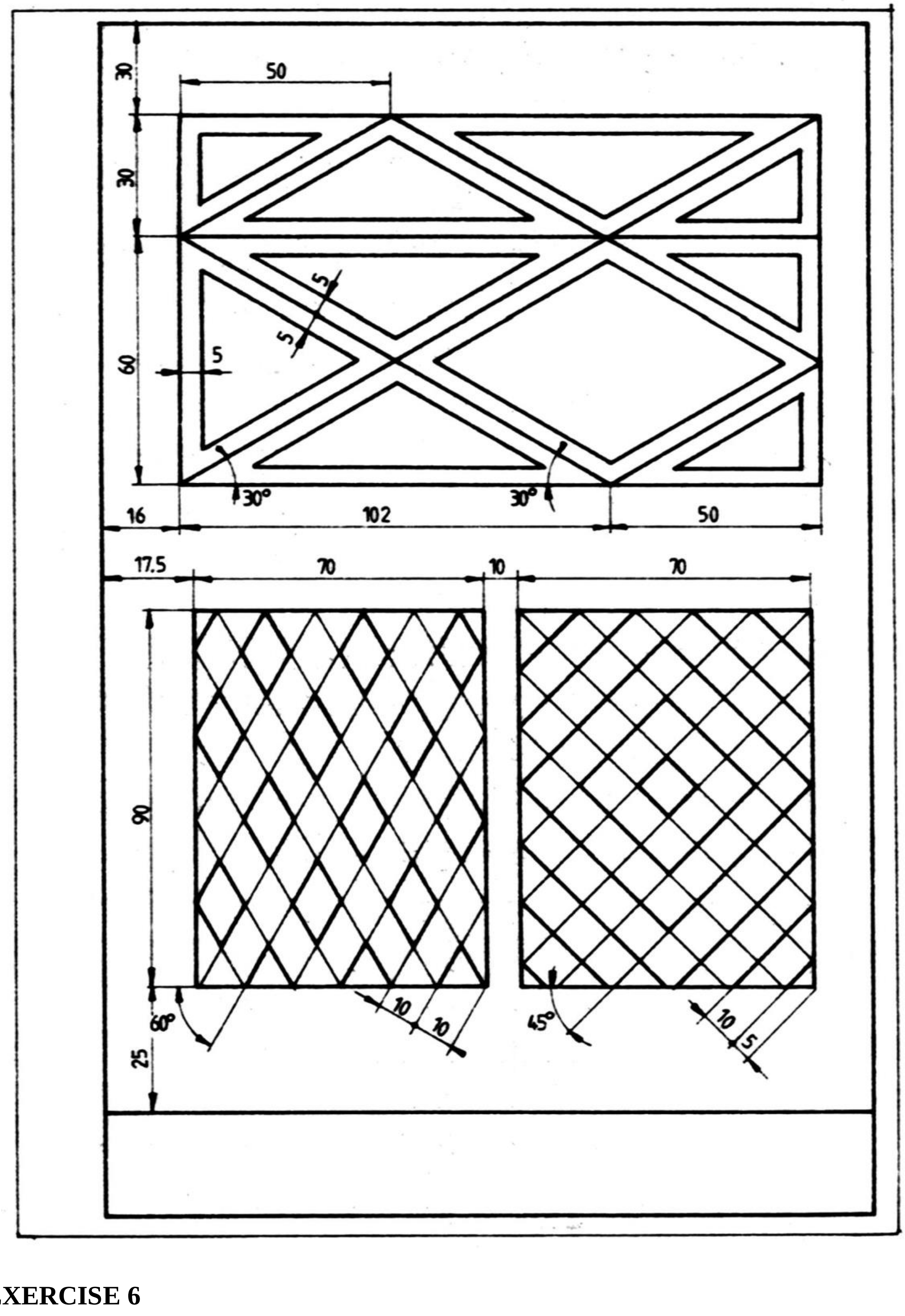
Title detail

Lettering detail

All dimensions in mm.

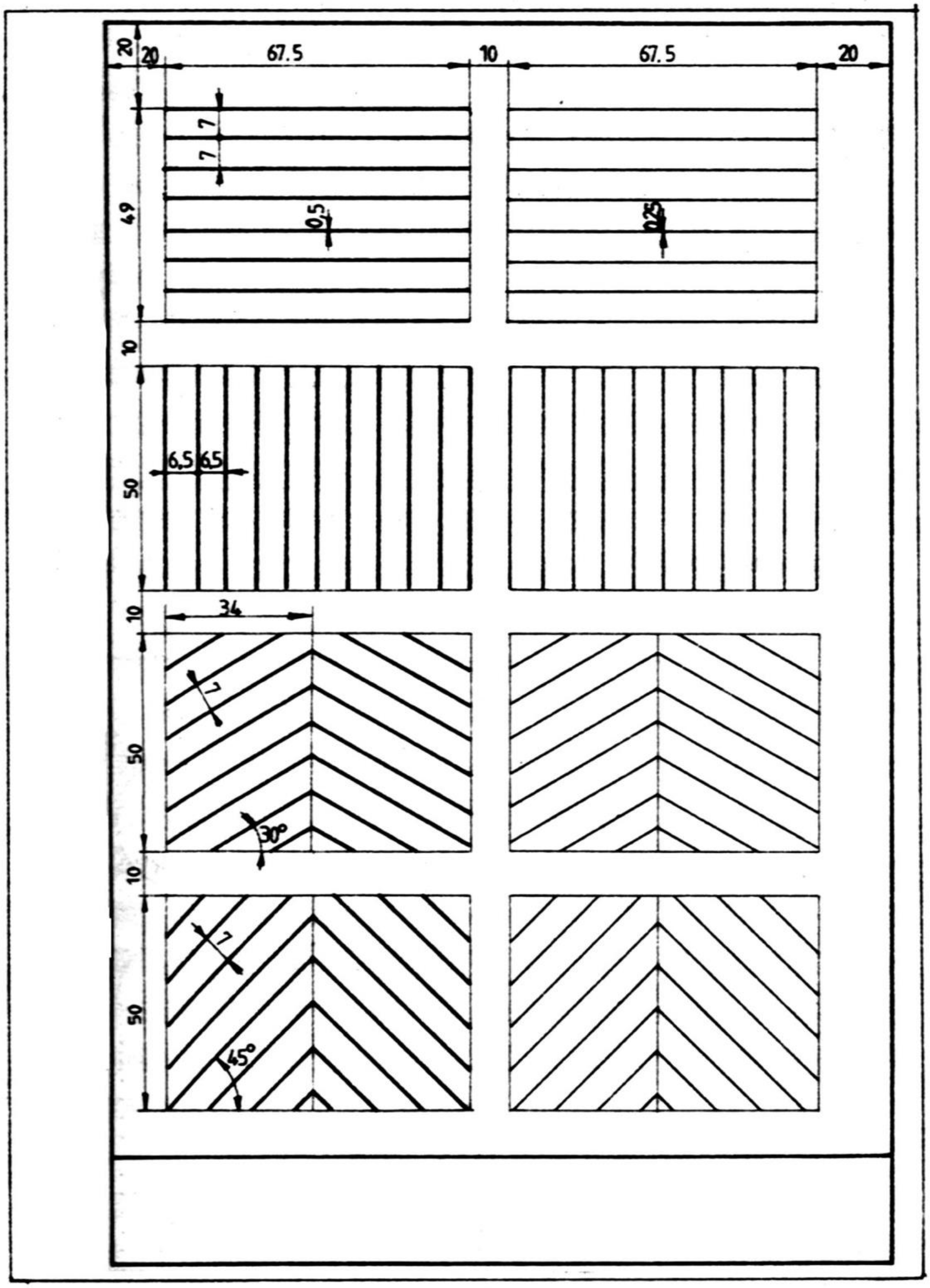
EXERCISE 5

Draw the below lines in same thickness and given dimensions on to an A4 size sheet.



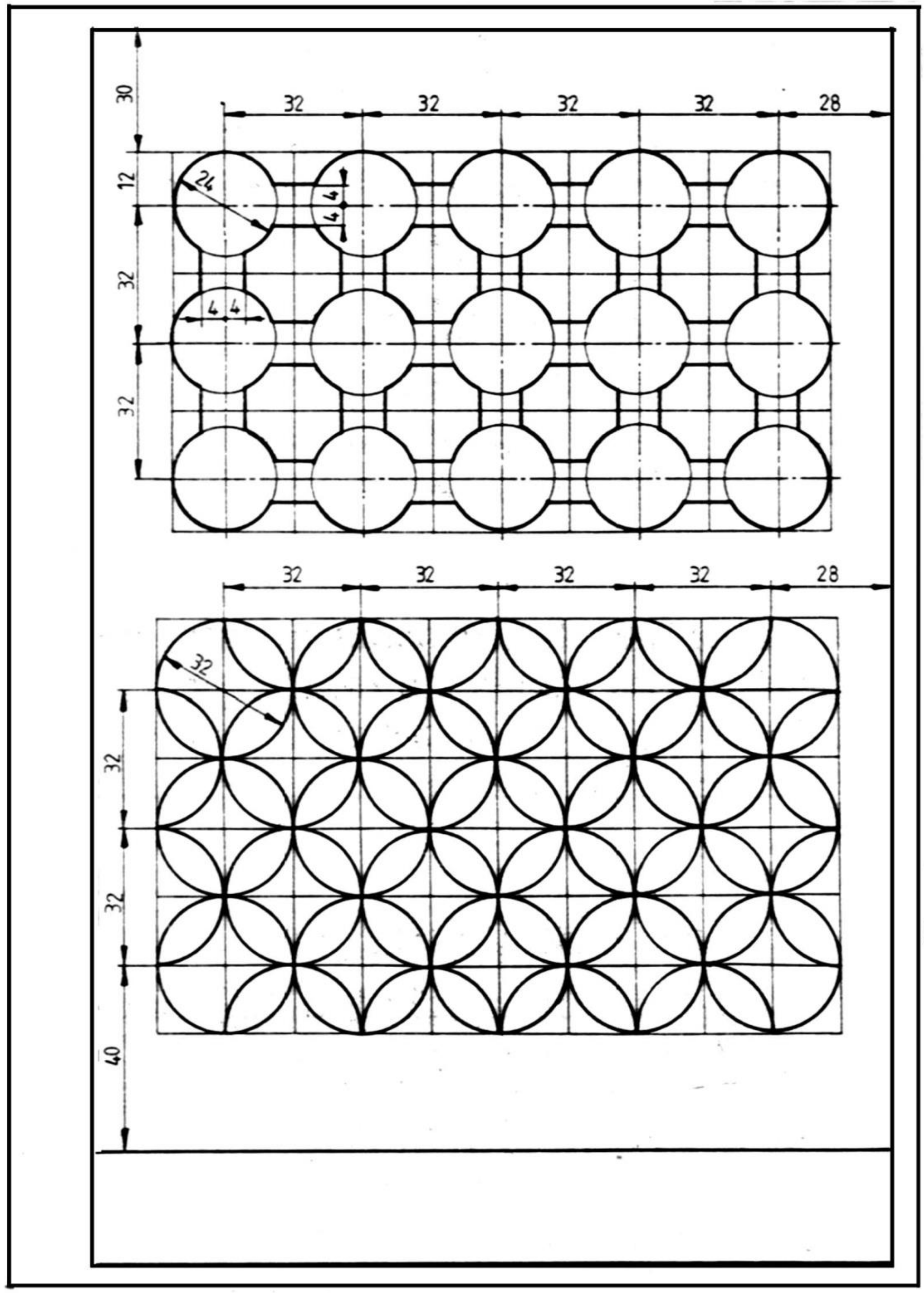
EXERCISE 6

Draw the below lines in same thickness and given dimensions on to an A4 size sheet.



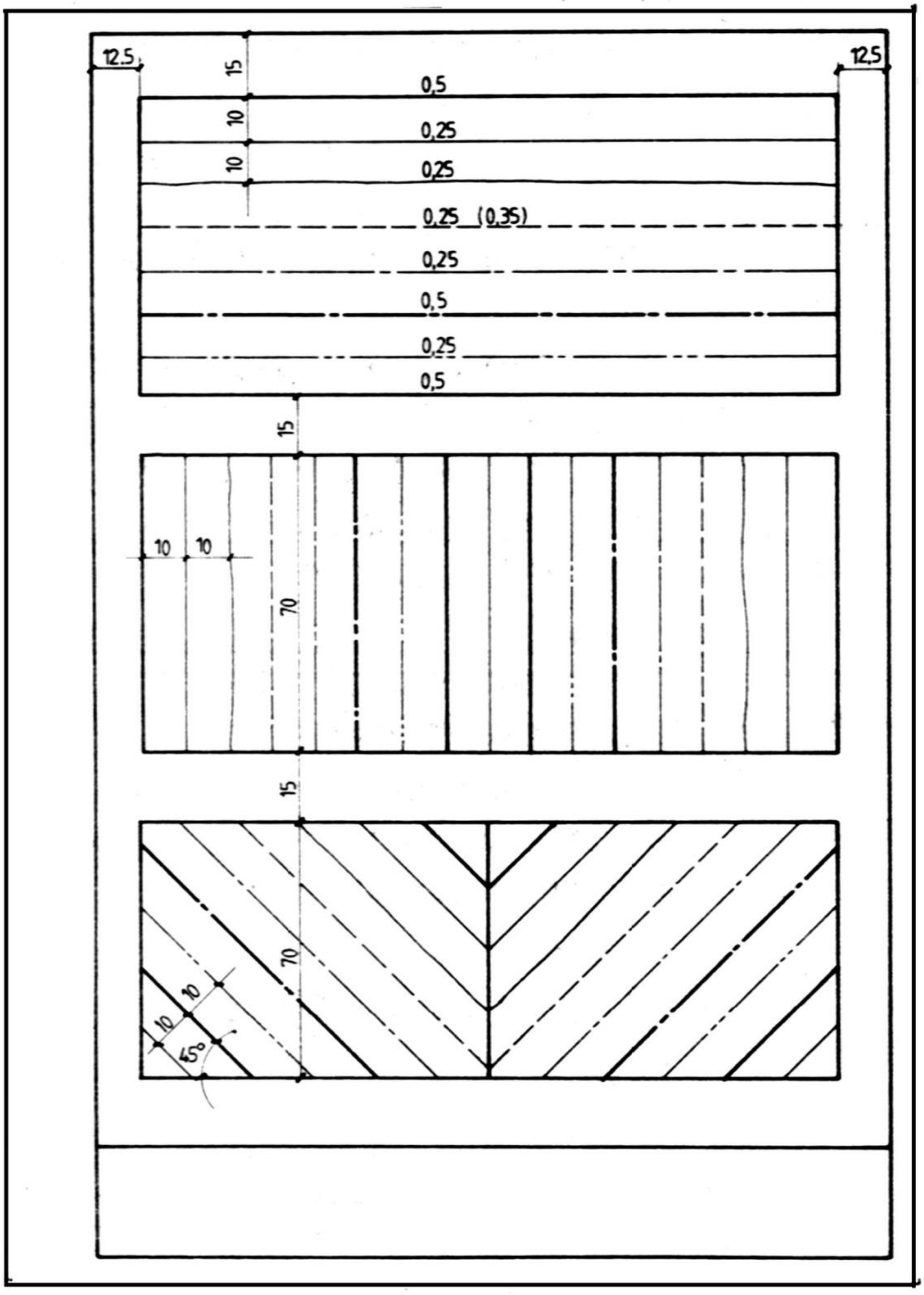
EXERCISE 7

Draw the below lines in same thickness and given dimensions on to an A4 size sheet.



EXERCISE 8

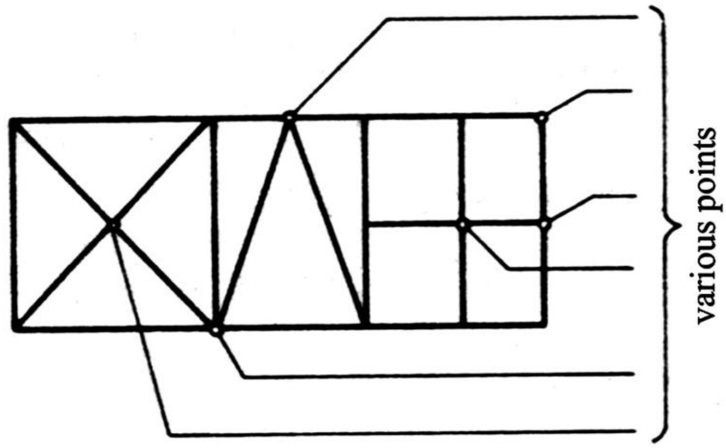
Draw the below lines in same thickness and given dimensions on to an A4 size sheet.



4.3 DRAWING GEOMETRIC SHAPES

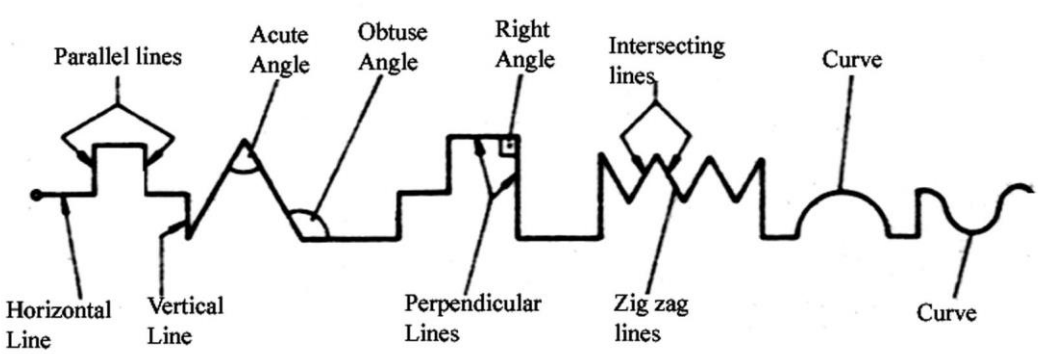
A geometric shape is consisted of points, lines and planes.

POINT : A geometrical shape with no dimension and can be considered as the intersecting point of two lines.



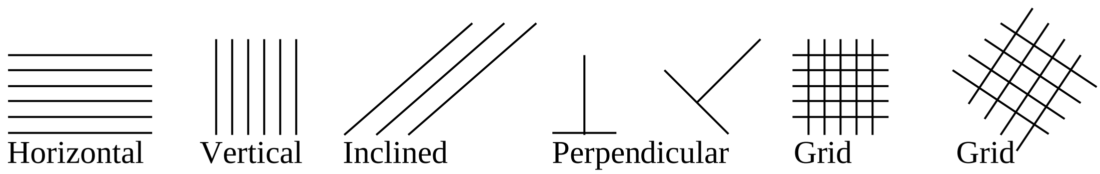
A point can be drawn as one of the following methods.

TYPES OF LINES : A line is the result of the movement of a point in various directions on a single plane.



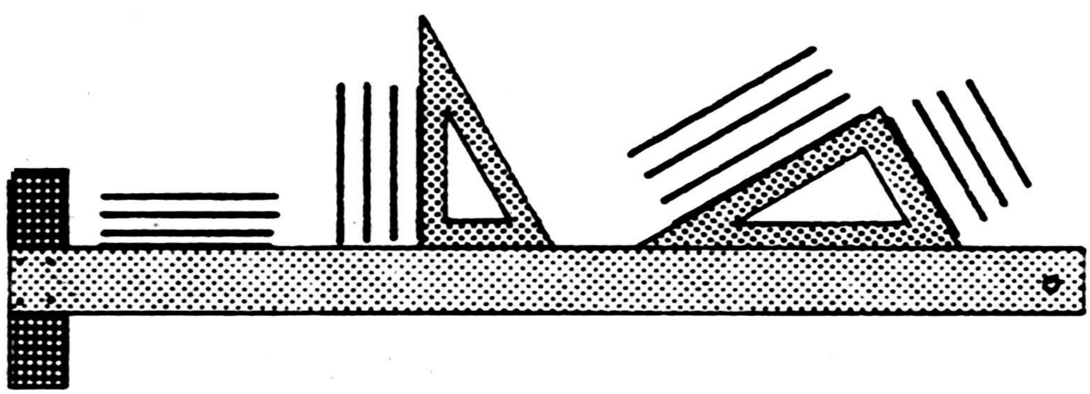
Lines in different characters and usage are shown below.

VARIOUS LINES : Lines are drawn in the directions shown below and named accordingly.

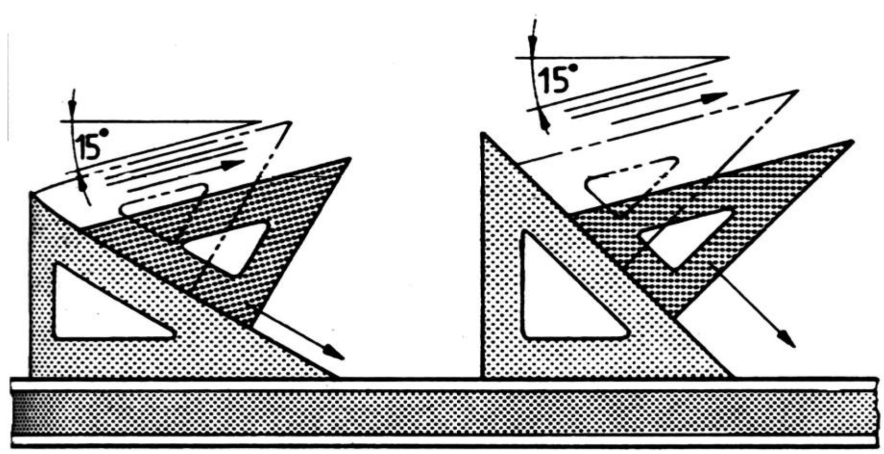


DRAWING PARALLEL LINES :

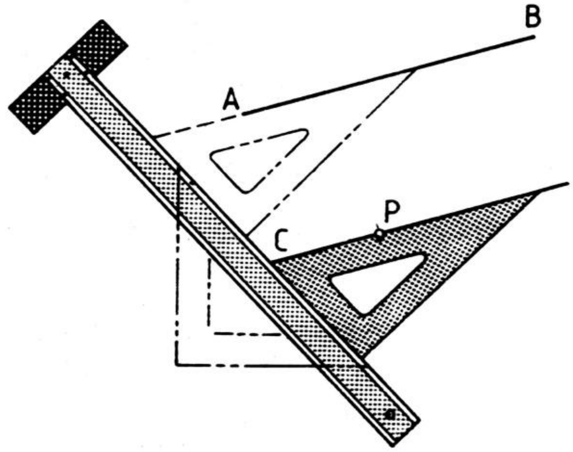
a) Using Tee square and set square, lines parallel to the sides of Tee square and set square can be drawn as shown below.



b) Using Tee square and set square, lines parallel to the sides of Tee square and set square(s) combination can be drawn as shown below.

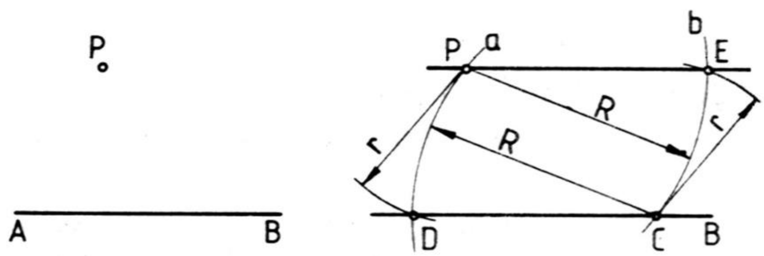


c) Drawing a parallel line to a given line AB, from any point P.



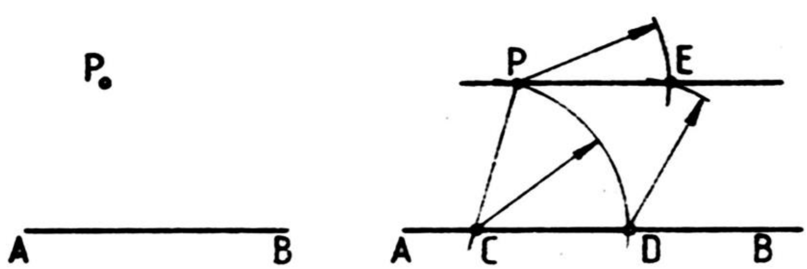
d) Drawing a parallel line to a given line AB, from any point P with the help of a compass.

METHOD 1 :



1- Draw an arc of radius R from point P and mark the intersection point C on AB.
2- Move the compass to point C, draw an arc of radius R and mark the intersection point D on AB.
3- Adjust the compass opening as much as PD and draw an arc of radius **r** from point C and mark the intersection point of both arcs as E.
4- Draw a line passing through points P and E, which is a parallel line to AB passing from point P.

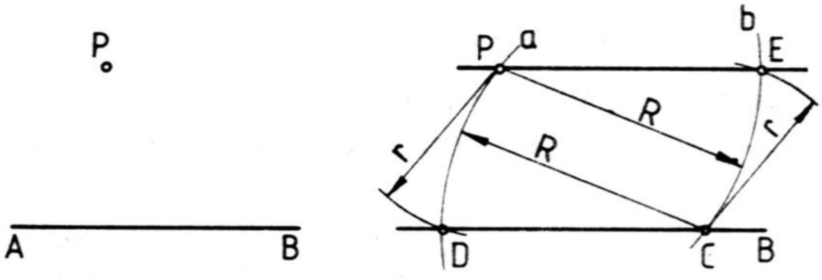
METHOD 2 :



1- Draw any line through point P cutting line AB at point C
2- Draw an arc of radius PC from point C and mark the intersection point D on AB.
3- Move the compass to point P, draw an arc with same radius.
4- Move the compass to point D, draw an arc with same radius.
5- Mark as E the intersecting points of the arcs.

DRAWING A PARALLEL LINE FROM A GIVEN DISTANCE "a" :

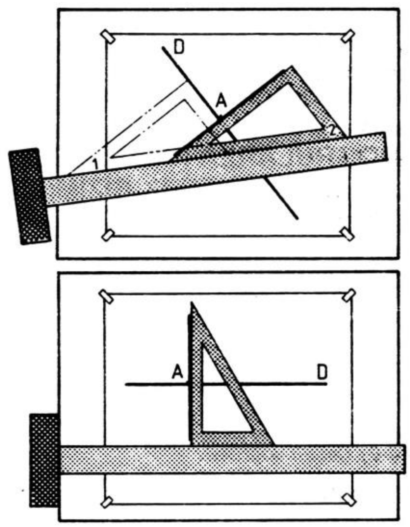
Line connecting points PE is a parallel line to AB



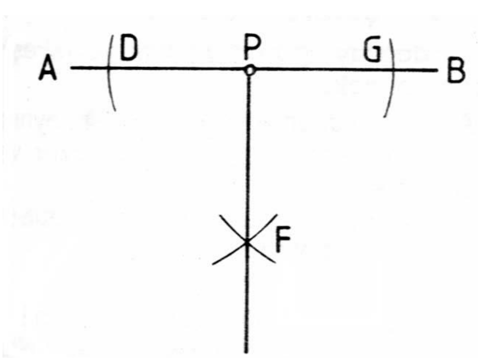
1- Draw an arc of radius "**a**" from any point C and D on line AB
2- Draw a common tangent line EF to both arcs, which is the parallel line to AB

DRAWING PERPENDICULAR LINES

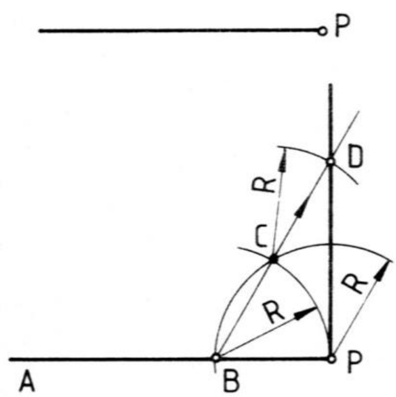
a) With the help of a Tee square and set square.
  1- Align any side of set square with line D
  2- Align the Tee square with the hypotenuse side of set square
  3- Slide the set square on the Tee square, placing one of the side on the requested point.



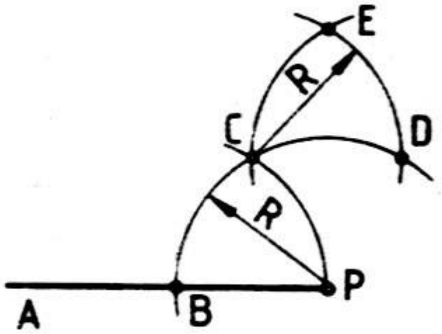
b) With the help of a compass



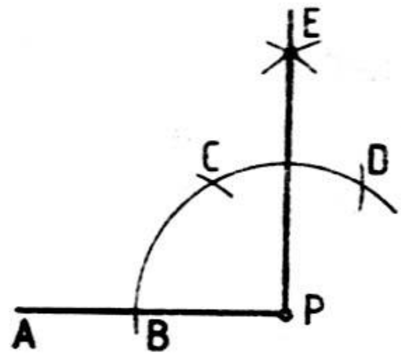
Method-1



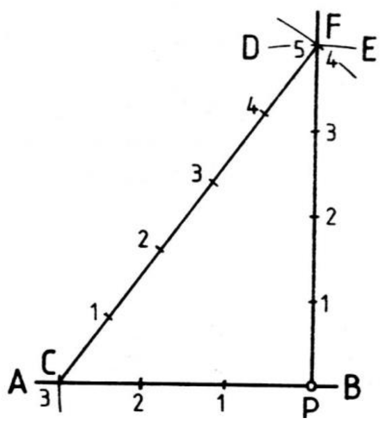
Method-2



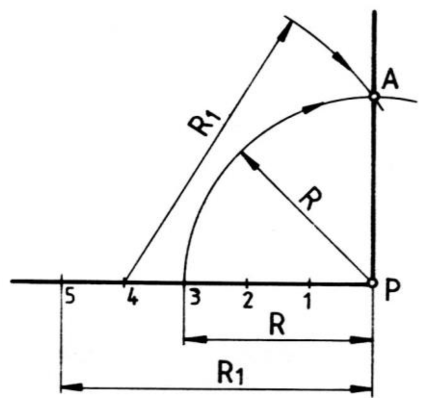
Method 3a



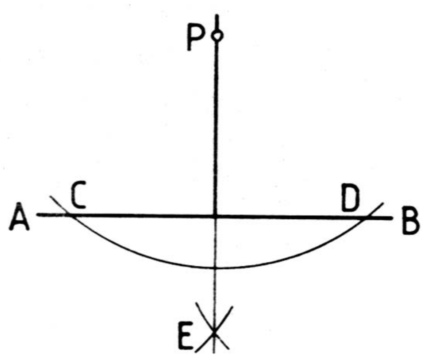
Method 3b



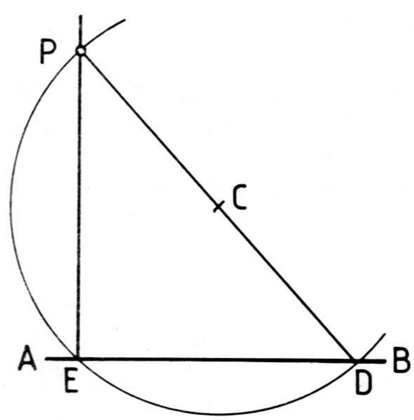
Method 4



Method 5



Method 6

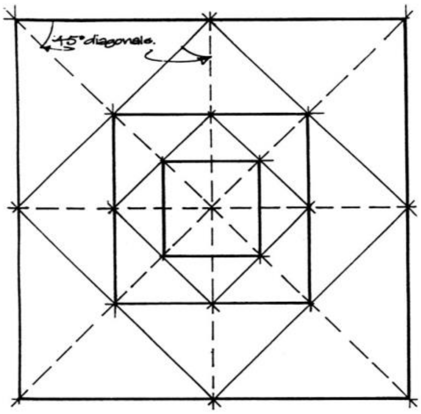


Method 7

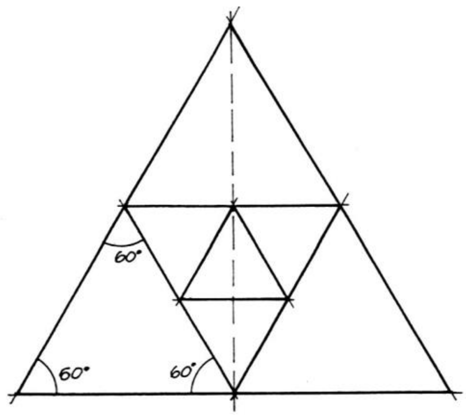
In all the above self explanatory methods, equal size dividing and transferring distance characteristics of the compass is used.

EXERCISE 9

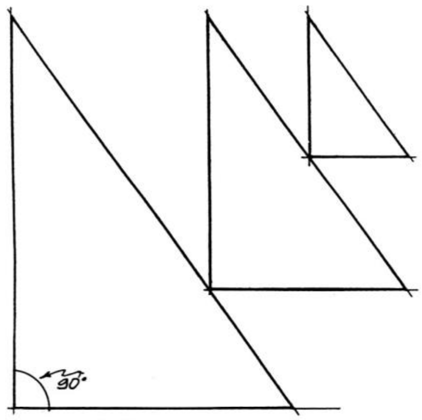
Draw the following geometric shapes, in their exact dimensions and pencil darkness.



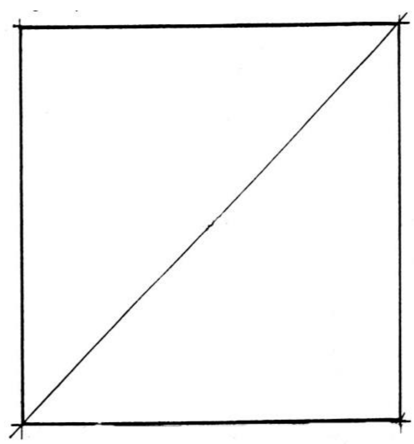
Set of squares

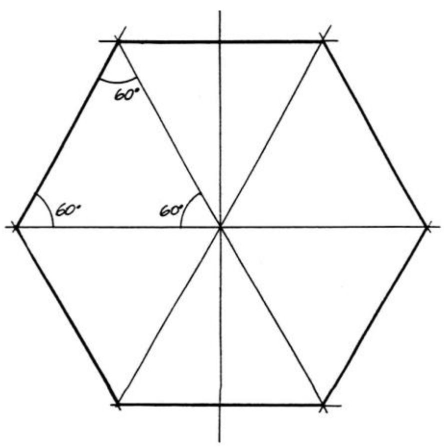


Set of equilateral triangles

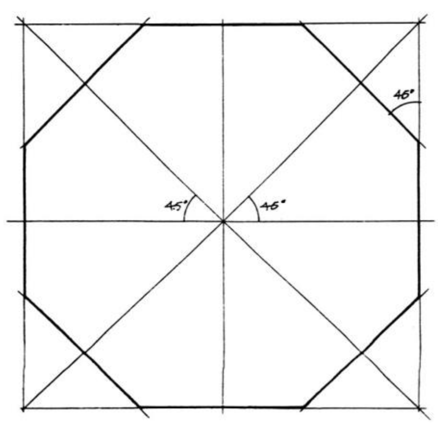


Set of right angle triangles


Rectangle



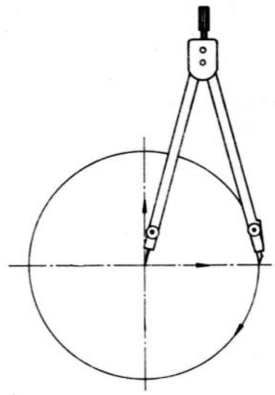
Hexagon



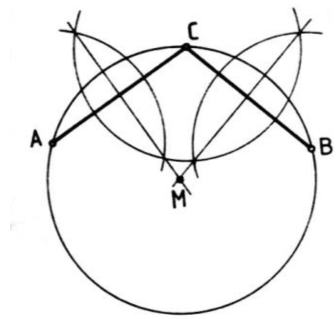
Octagon

4.4 GEOMETRY OF LINES AND CURVES.

CIRCLE

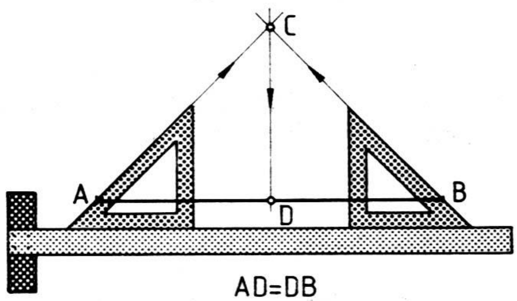


To draw a circle

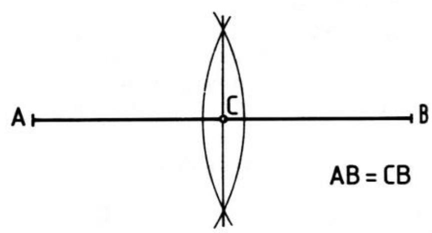


To find the centre of a circle or an arc

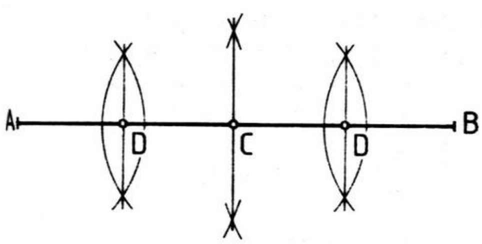
TO DIVIDE A LINE



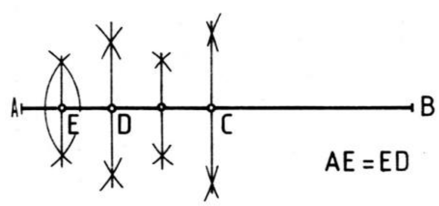
To bisect a line using Tee square and set square



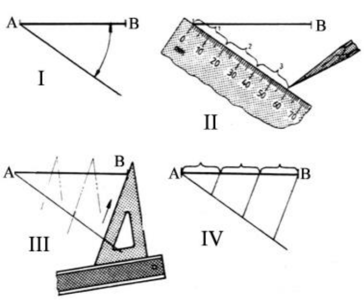
To bisect a line using compass.

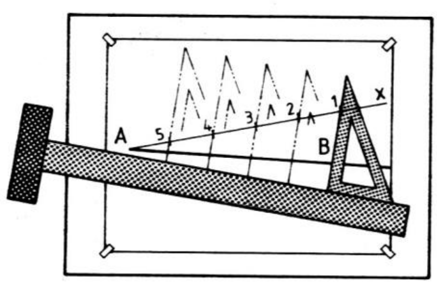


To divide a line into four equal parts



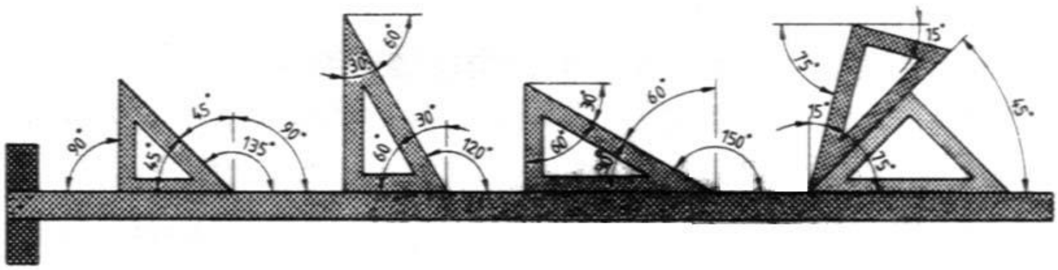
To divide a line into eight equal parts



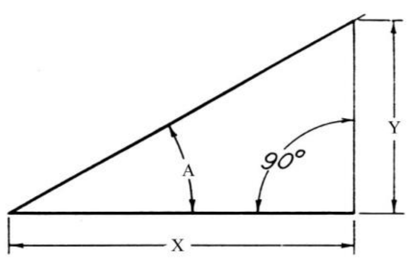


To divide a line into three, five or any integer parts.

ANGLES

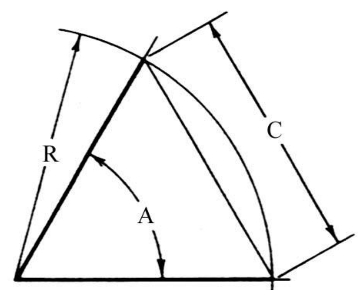


Drawing combination angles of 30^0, 60^0 and 90^0 with set square



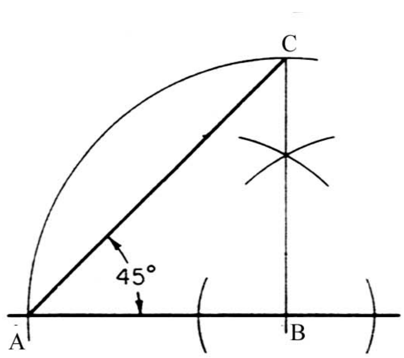
Angle by Tangent

The proportion of Y to X is obtained from a table of natural tangent.



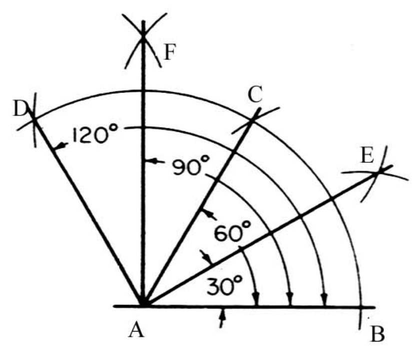
Angle by Chord

The proportion of C to R is obtained from a table of chords.



To lay out a 45^0 angle

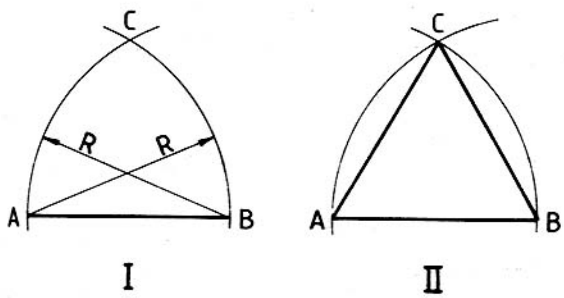
The two legs, AB and BC are equal and perpendicular.



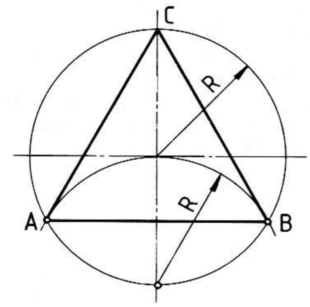
To construct angles in multiples of 30^0

Chords equal to the radius will divide a circle into six equal parts.

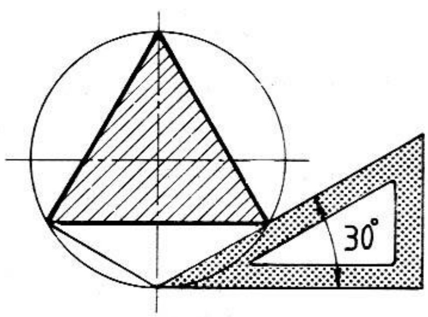
TRIANGLES

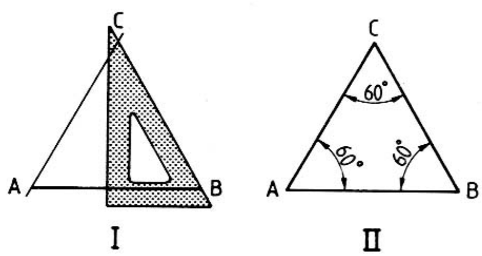


To draw an equilateral triangle



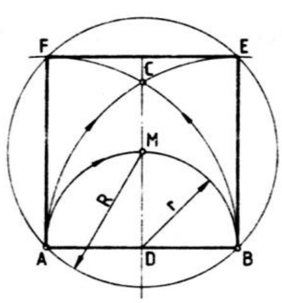
To draw a triangle in a circle



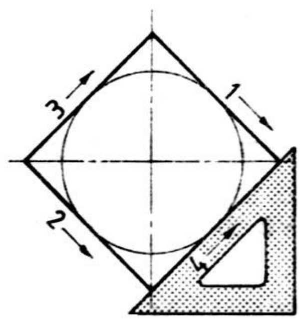


To draw an equilateral triangle using the set square

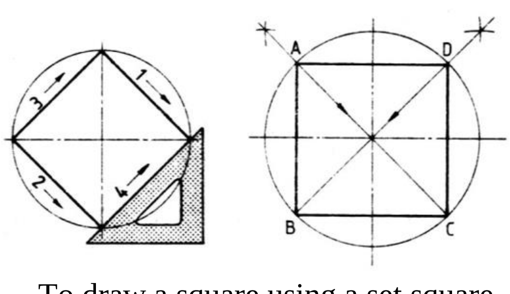
RECTANGLE



To draw a square of a given length.

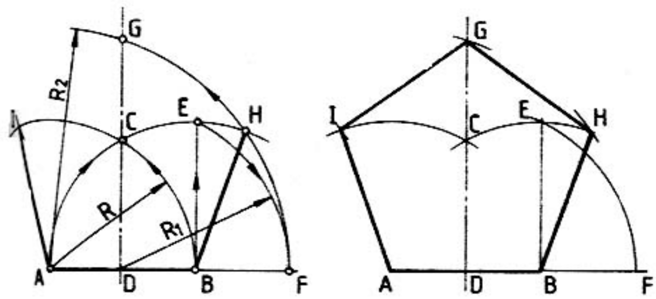


To draw a square using a set square

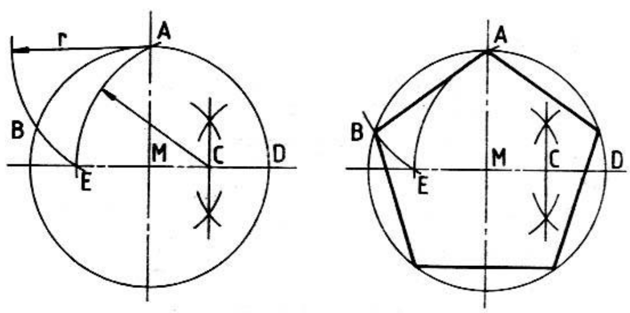


To draw a square using a set square

PENTAGON

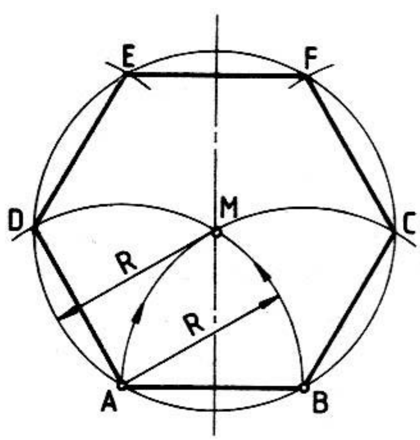


To draw a pentagon of a given side length



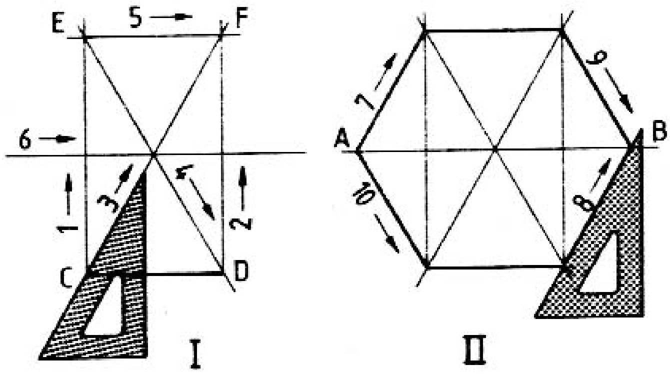
To draw a pentagon with in a circle

HEXAGON



To draw a hexagon using a compass and a set square.

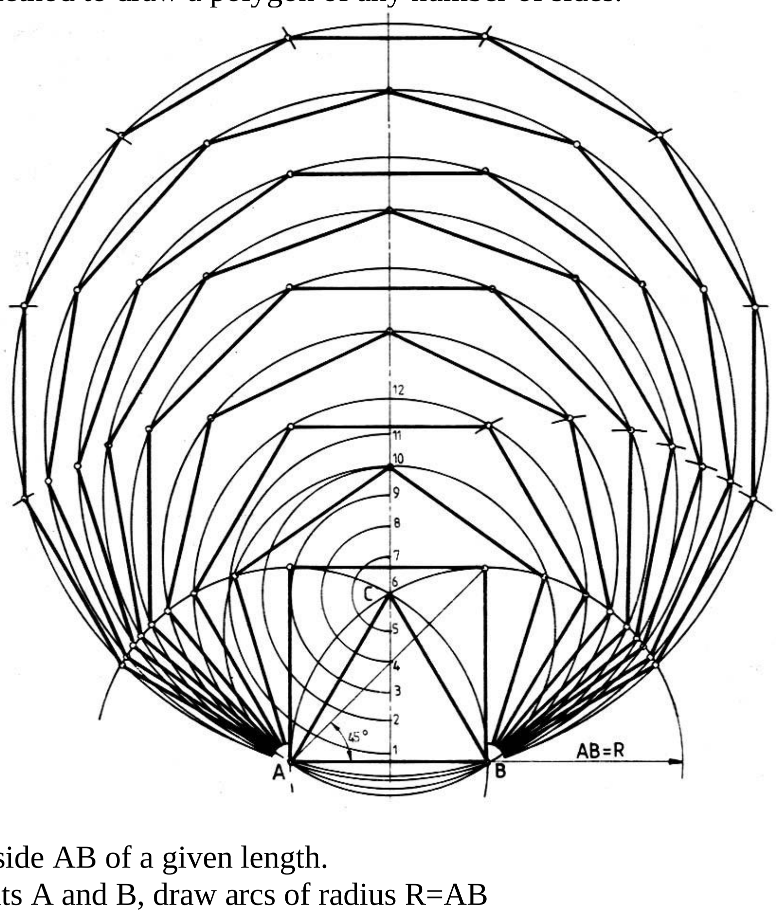
1- Draw line AB.
2- From points A and B, draw arcs of radius R=AB
3- Draw a perpendicular to AB passing through point M
4- Draw a circle of radius R from the center point M
5- Mark the intersecting points of the arcs and circle as C and D respectively.
6- Draw an arc of radius R from the points C & D and mark the intersection points on the circle as E & F.



To draw a hexagon using a set square

POLYGON

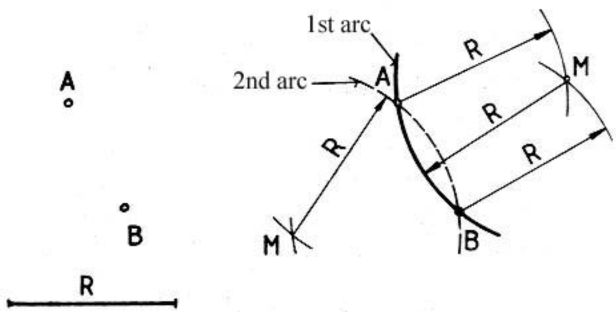
The general method to draw a polygon of any number of sides.



1- Draw the side AB of a given length.
2- From points A and B, draw arcs of radius R=AB
3- Draw a perpendicular to AB passing through point C

4- Construct a triangle by joining points A, B & C
5- Divide the Arc AC into six equal parts and transfer them on to the perpendicular line passing through C and mark them as 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 consequently, which will be used as the centers of the circumcising circles of the polygon .
6- Marking point No.5 on the perpendicular line as the center, draw a circle passing from points A & B.
7- The intersection points of the circle and the arcs are the further 2 corners of the pentagon. Remaining apex corner is the intersecting point of the perpendicular line and the circle.
8- Applying the same procedure, polygons of 6,7,8,9,10,11,12 sides could be drawn, using the center of the circle marked with number same as the number of sides. (eg. Center No.8 for drawing Octagon)

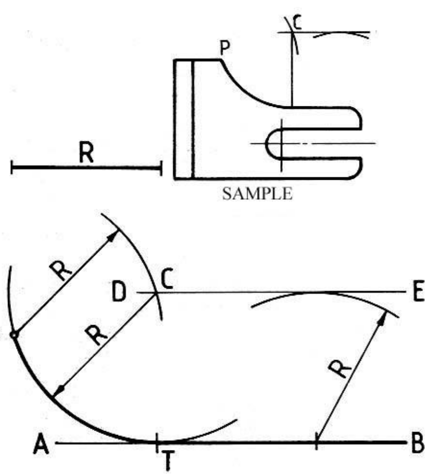
ARCS



To draw an arc of a given length passing through 2 points

ARCS AND LINES

To draw an arc from a given line to a given point :



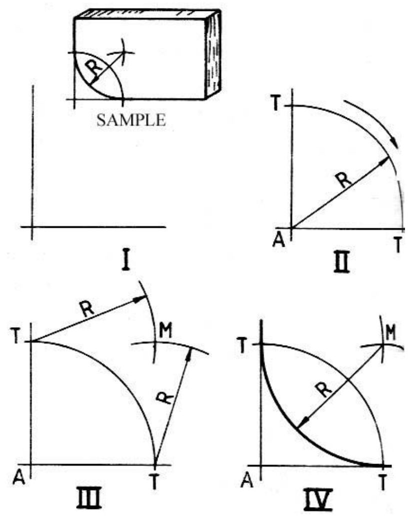
To connect a given line and a point using an arc.

1- To line AB of a given length, draw a parallel line CE of a distance equal to given R.
2- Draw a circle of radius R from the given point P and mark the intersection point C on line DE.

3- Draw a vertical line to AB passing from C and mark the intersection point as T.
4- Draw an arc of radius R from C.
5- The required arc is arc PT

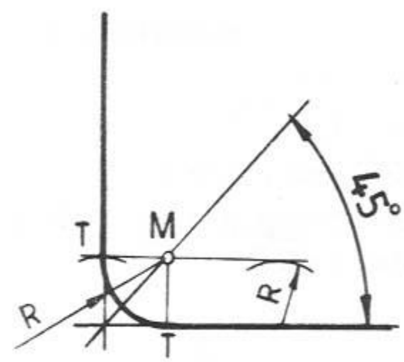
TO JOIN TWO PERPENDICULAR LINES WITH AN ARC

METHOD 1



1- From the intersection point of the lines as the center of the arcs, draw an arc of given radius R.
2- Mark with T the intersection points of the arc and the perpendicular lines.
3- Draw an arc of radius R from points T and mark M the intersection points of the arcs.
4- The arc of radius R, drawn from point M is the required arc joining two perpendicular lines.

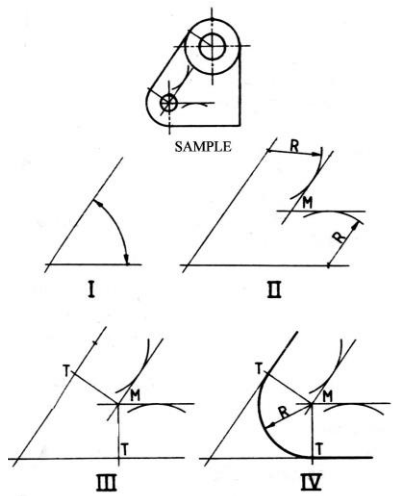
METHOD 2

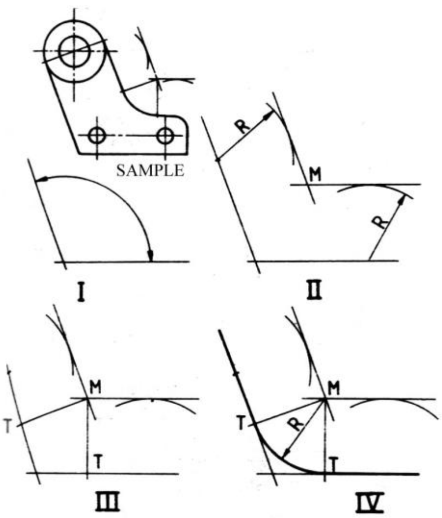


1- Draw a line from the intersection point of the
perpendicular lines, using 45^0 set square.
2- Draw a parallel line to one of the lines at a distance of given R.
3- Mark M the intersection point and draw perpendiculars to the given lines and mark the intersection points as T
4- The arc of radius R, drawn from point M is the required arc joining the two perpendicular lines.

TO JOIN TWO LINES OF AN ACUTE ANGLE WITH AN ARC

1- Draw parallels to the lines at a distance of given R
2- Mark M the intersection points of the parallel lines.
3- Draw perpendiculars to the lines from point M and mark with T.
4- Draw an arc of radius R from center M joining both T points.



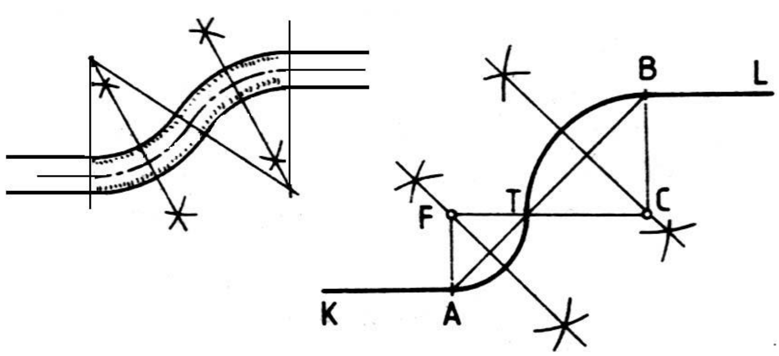


TO JOIN TWO LINES OF AN OBTUSE ANGLE WITH AN ARC

1- Draw parallels to the lines at a distance of given R
2- Mark M the intersection points of the parallel lines.
3- Draw perpendiculars to the lines from point M and mark with T.
4- Draw an arc of radius R from center M joining both T points.

TO JOIN TWO LINES WITH TWO ARCS

METHOD 1

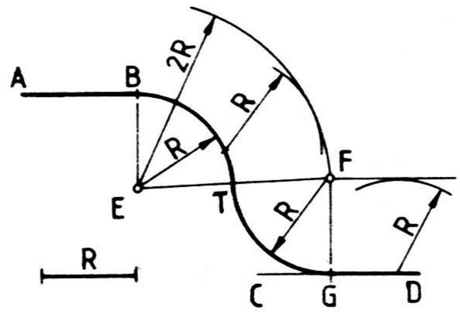


1- Join points A & B with a line.
2- Mark the turning point T on a desired place on line AB.
3- Draw bisects of line AT and TB
4- Draw perpendiculars from points A&B and mark the intersection points as F and C
5- Draw an arc of radius BC from C

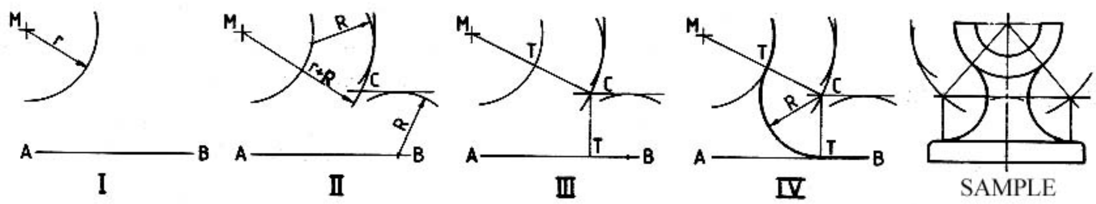
6- Draw an arc of radius FA from F

METHOD 2

1- Draw a perpendicular line from point B
2- Mark **E** at a distance of given R
3- Draw a circle of radius R
4- Draw a circle of radius 2R
5- Draw a parallel line at a distance of given R from the other line.
6- Mark **F** the intersection point of arc of radius 2R with the parallel line.
7- Draw arcs of radius R from points **E** & **F**

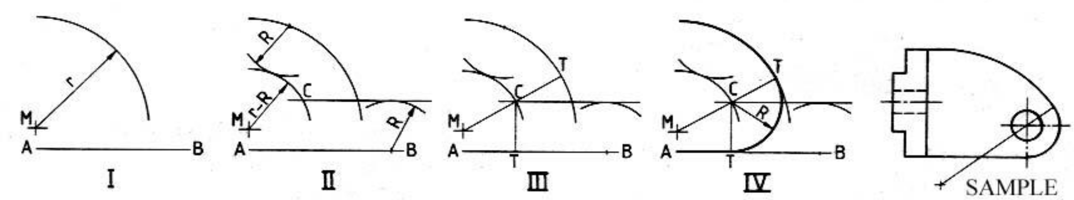


TO JOIN A LINE AND AN ARC WITH AN INTRAVERTED ARC



Follow the self explanatory steps I, II, III, IV

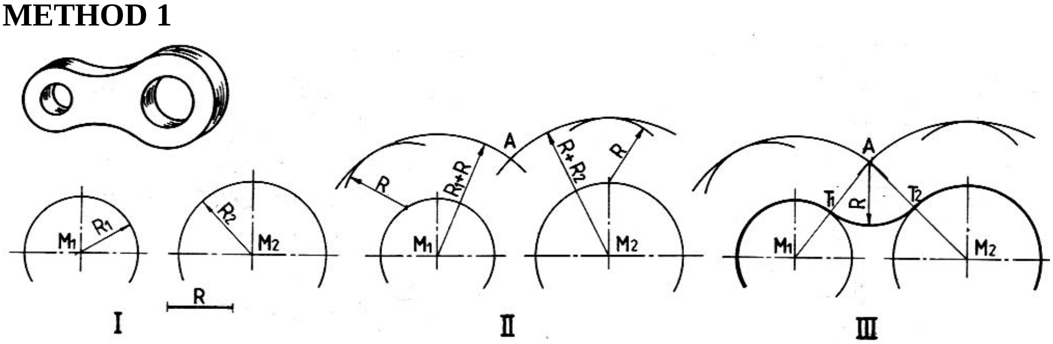
TO JOIN A LINE AND AN ARC WITH AN EXTRAVERTED ARC



Follow the self explanatory steps I, II, III, IV

TO JOIN TWO ARCS WITH AN ARC

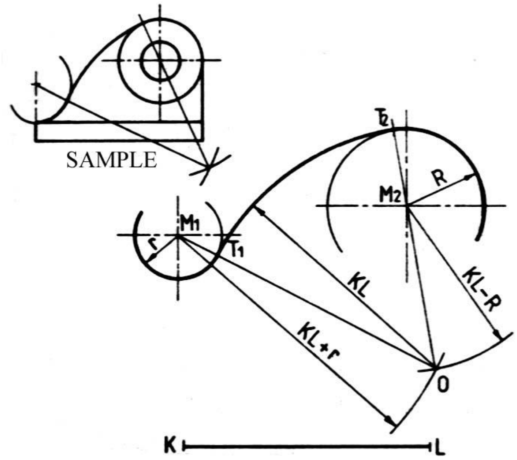
METHOD 1



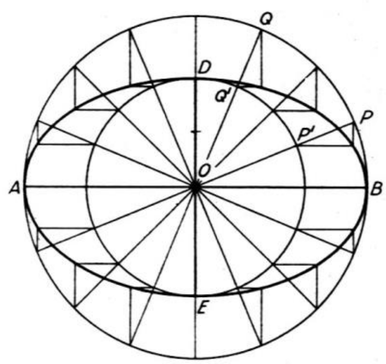
Follow the self explanatory steps I, II, III

METHOD 2

1- From center M_1 draw a semicircle of radius KL + r.
2- From center M_2 draw a semicircle of radius KL - R.
3- Mark O the intersection point of semicircles.
4- Draw a line passing through points O & M_2, mark T_2 on the arc.
5- Draw a line passing through points O & M_1, mark T_1 on the arc.
6- From center O, draw a circle of radius KL, connecting both arcs.

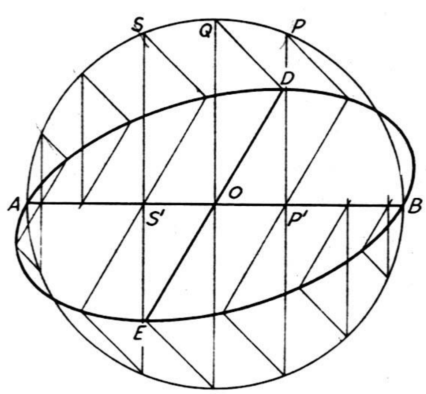


ELLIPSE



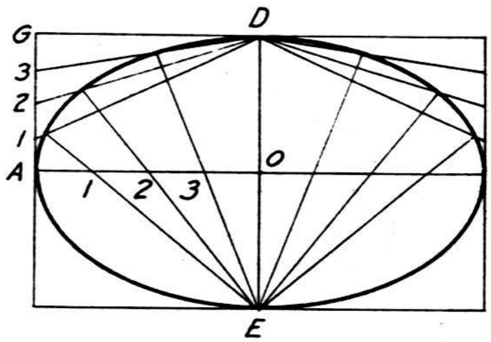
An ellipse by concentric-circle method

Major and Minor diameter circles and construction give points on the curve.



An ellipse by circle method

After first construction, parallels plot points on the curve.

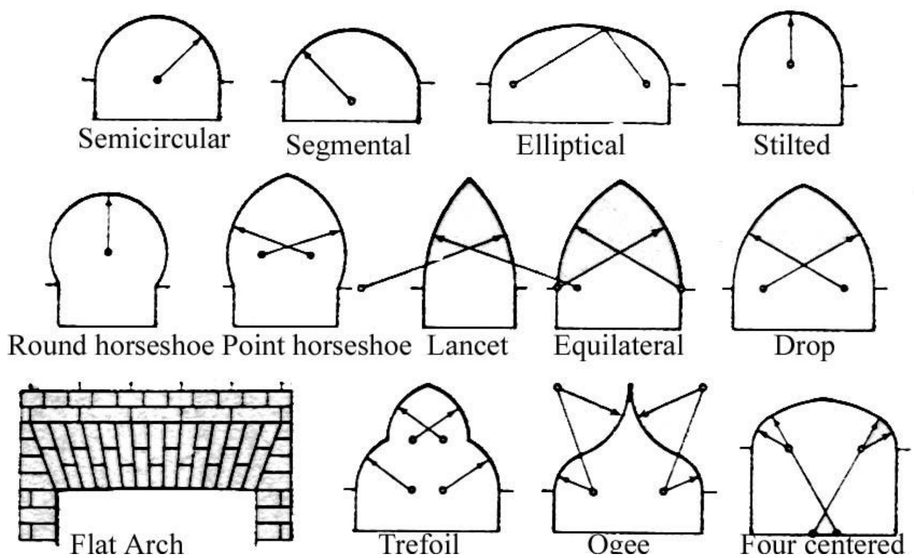


An ellipse by parallelogram method

Points are plotted by construction through equal divisions of AO and AG

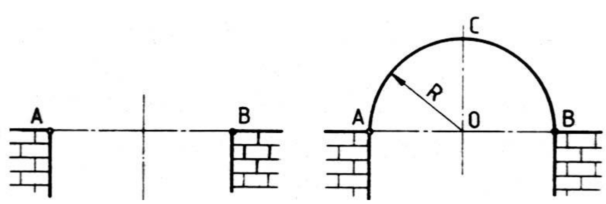
4.5 ARCHES

TYPES OF ARCHES

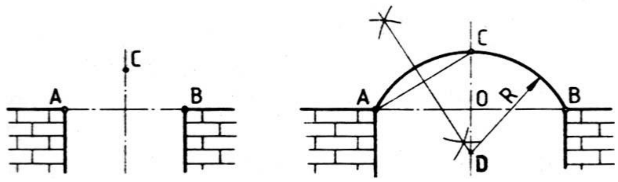


SEMICIRCULAR ARCH

1- Connect points A&B
2- Bisect line AB and mark center **O**
3- Draw a semi circle of radius R, which will form the **Full Arch**.

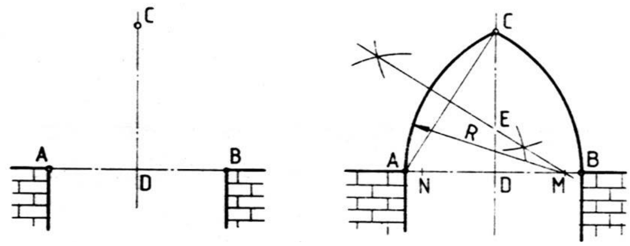


SEGMENTAL ARCH



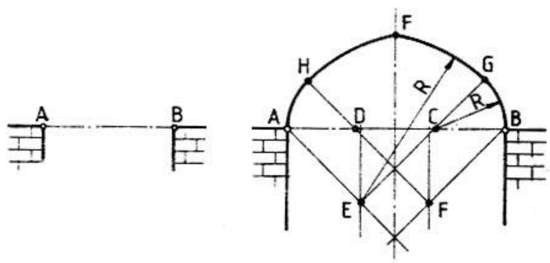
1- Mark **O** the mid point of AB
2- Connect points A&C
3- Bisect line AC and mark **D** on line OC
4- Draw a circle of radius R=AD passing from points A, C & B which will form the Segmental Arch

EQUILATERAL ARCH



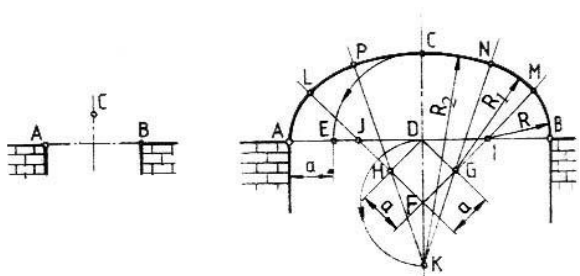
1- Mark **D** the mid point of AB
2- Connect points A&C
3- Bisect line AC and mark **M** on line AB and **E** on line CD
4- Plot the symmetry of point **M** on AB as **N**
5- Draw an arc of radius R=MA from center M from point A to C.
6- Draw an arc of radius R=NB from center N from point B to C, which will form the Equilateral Arch

GOTHIC ARCH



1- Trisect line AB and mark points D&C
2- Draw verticals from these points.
3- Draw lines from points A&B making any required angle with line AB
4- Mark the intersection points, E&F.
5- Connect points E&C and mark G
6- Connect points F&D and mark H
7- Draw an arc of radius AD from center D and an arc of radius CB=R from center C.
8- Draw an arc of radius EG from center E, connecting points H&F.
9- Draw an arc of radius FH from center F, connecting points G&F.

ELLIPTICAL ARCH

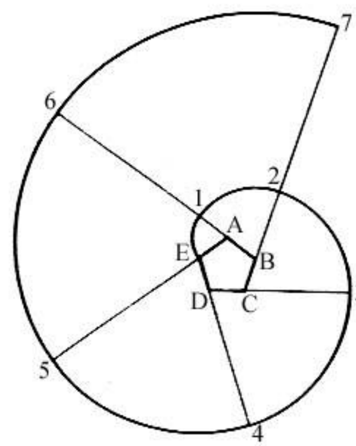


1- Mark the center point **D** of line AB.
2- Mark point E, where DE=DI
3- Equating **a**=AE, draw the square DGFH, sides making 45^0 with line AB
4- Draw a line from F to H&G and mark points E&I.
5- Plot point K on line FDC as FD=FK
6- Draw a line from K passing from H&G and extend further.

7- From points I&E draw an arc of radius R=IB connecting points AL and BM.
8- From points G&H draw an arc of radius R_1=GM connecting points LP and MN.
9- From point K draw an arc of radius R_2=KC connecting points PC and NC.

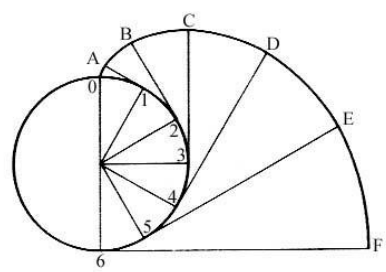
HELIX

Involutes of a Pentagon :



1- Extend lines AE, ED, DC, CB and BA
2- Draw an arc of Radius AE from center A, connecting points E&1
3- Draw an arc of Radius B1 from center B, connecting points 1&2
4- Draw an arc of Radius C2 from center C, connecting points 2&3
5- Draw an arc of Radius D3 from center D, connecting points 3&4
6- Draw an arc of Radius E4 from center E, connecting points 4&5
7- Draw an arc of Radius A5 from center A, connecting points 5&6
8- Draw an arc of Radius B6 from center B, connecting points 6&7

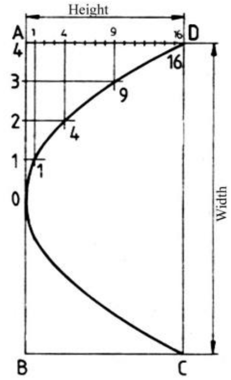
Involutes of a circle :



1- Divide the complete circumference of A given circle, into any equal part (12 in the example) and mark as 0, 1, 2,
2- Draw tangents to the circle from points marked 0,1,2,…
3- Draw an arc of Radius 10 from center 1, connecting points 0A
4- Draw an arc of Radius 2A from center 2, connecting points A&B
5- Draw an arc of Radius 3B from center 3, connecting points B&C
6- Draw an arc of Radius 4C from center 4, connecting points C&D
7- Draw an arc of Radius 5D from center 5, connecting points D&E
8- Draw an arc of Radius 6E from center 6, connecting points E&F
9- Continue a further 6 steps to complete the helix.

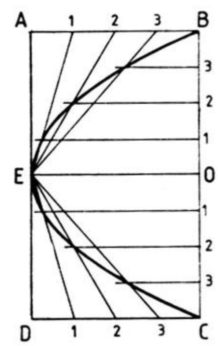
PARABOLA

To draw the parabola of a given height and width :



1- Construct a rectangle of sides equal to given height and width.
2- Divide half of the width into any desired equal parts (In this example, divided into 4 parts)
3- Divide the height in to parts equal to the square of the number of parts, half of the width is divided. (In this example, $4^2 = 16$ parts)
4- Draw perpendiculars from the points marked on the width. (In this example 1, 2, 3, 4)
5- On the height line, draw perpendiculars from the squares of the points, perpendiculars drawn from the width line. (In this example 1^2, 2^2, 3^2, 4^2)
6- Connect points 0, 1, 4, 9, 16 with a French curve and construct the one half of the parabola.

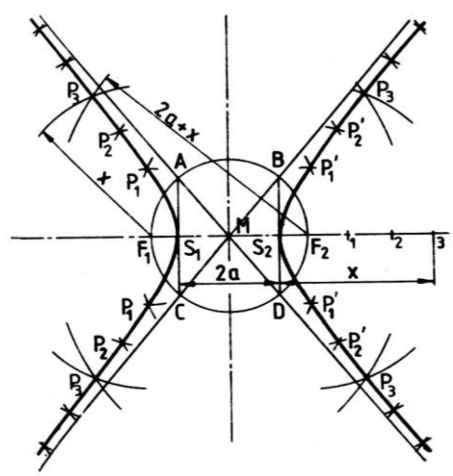
To draw a parabola of a given apex and end points:



1- Construct a rectangle where **apex** is the midpoint E of one of the sides and **end points** are the opposing corners, B&C.
2- Divide side AB & DC into any desired equal parts.
3- Divide the half of the adjacent side into same equal parts and mark accordingly as in the example.
4- Joint the apex, E with a line to points 1, 2, 3 on sides AB&DC.
5- Join points E&O with a line, EO.
6- Draw parallel lines to line EO from the points marked on the opposing side of the apex, 1, 2, 3.
7- Draw an arc from the intersection points of the lines drawn from apex to sides and parallel lines to EO, carrying the same marking number , with a French curve.

HYPERBOLA

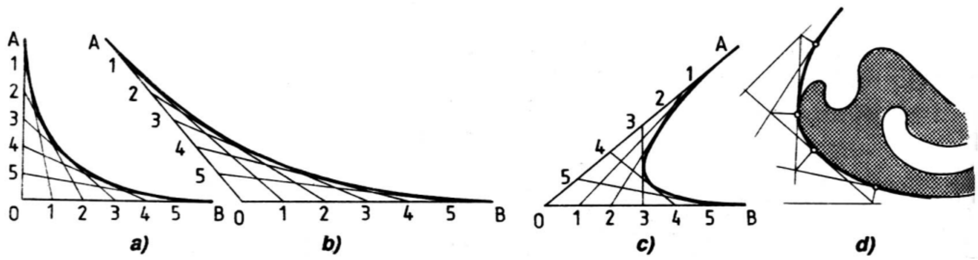
To draw an hyperbola of a given focus and asymptotes :



1- Construct abscissa and ordinate and mark point M.
2- Draw a circle of radius ½(F_1+F_2) from point M and mark F_1 & F_2.
3- At a distance of ½(2a) from point M mark S_1 & S_2 on abscissa.
4- Draw perpendiculars to abscissa from points S_1 & S_2 and mark the intersection points on the circle as A, B, C, D
5- Joining points A&D and C&B will form the asymptotes.
6- Starting from the focus points F_1&F_2 divide the abscissa in to any desired parts, (In this example, 3 parts) and mark them as 1, 2 , 3,…

7- Draw an arc of radius X (distance between point S_2 and 3) from points F_1 & F_2 with in the same one-halfs.
8- Draw an arc of radius X+2a (distance between point S_1 and 3) from points F_1 & F_2 with in the opposite one-halfs.
9- Mark the intersection points of the arcs, as P_3.
10- Repeat the same procedure to plot points P_1 & P_2 and construct the hyperbola.

To draw an hyperbola of a given two end point :

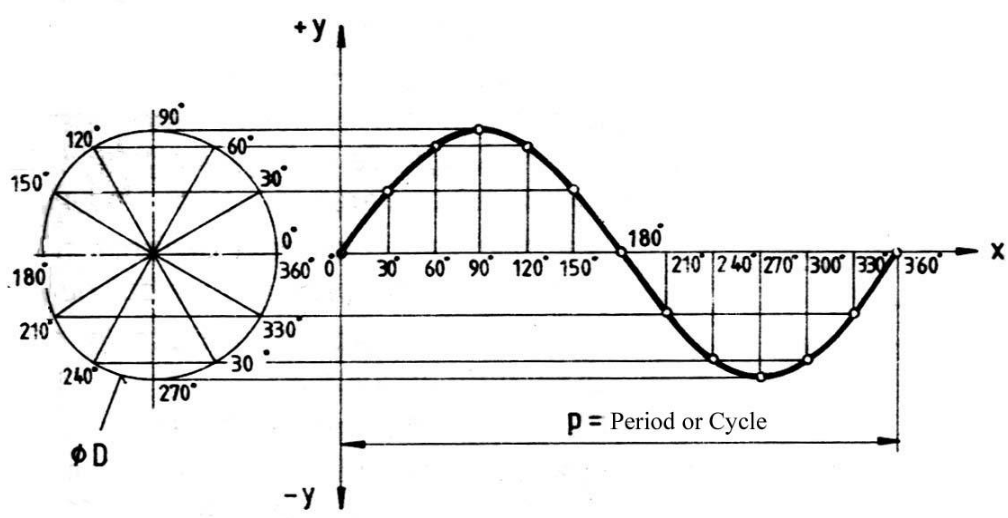


Any two lines, perpendicular to each other or making an acute or obtuse angle with each other needed, according to the shape of the hyperbola;

1- Draw the two lines in desired angle and length and mark the intersection point as point O and end point of horizontal line as B and other line as A.
2- Divide the horizontal line (OB) into any desired equal parts (In this example, 6 parts), and mark them as 1, 2, 3, 4, 5 and end point as B, starting from point O.
3- Divide the other line (OA) into to same number of parts and mark them as 1, 2, 3, 4, 5 starting from point A.
4- Draw a line between the points marked with same numbers on horizontal and other line. (Point 1 of line OB with point 1 of line OA and so on).
5- Drawing tangents to these lines with a French curve will form the hyperbola.

SINE CURVE

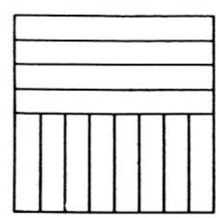
To draw a sine curve of a given period and amplitude :



1- Draw a circle of a radius equal to the amplitude of the sine curve.
2- Divide the circumference of the circle into 12 equal parts, and connect the intersection points with the center.
3- Marking the intersection point of the horizontal axis with the circumference as 0^0 on the right semi circle, proceed going counter clockwise, marking the other intersection points with angles of multiples of 30^0
4- Draw the abscissa of the curve as the continuation of the horizontal axis of the circle and mark with X.
5- On the abscissa mark the origin as O at any desired point.
6- Draw the ordinate, parallel to the vertical axis of circle or perpendicular to x-axis from point O and mark the upper end as **+y** and lower end as **-y**.
7- Mark the period or cycle "**p**" on the abscissa, starting from point O. The period or cycle length "**p**" is the total length of circumference ($2\pi r$) or 2Π in radians.
8- Divide the period or cycle "**p**" distance on abscissa, into 12 equal parts and starting from origin mark each point with the corresponding multiples of 30^0.
9- Draw parallels to abscissa from the points on the circumference of circle and verticals to the points on the abscissa.
10- Mark the intersection points of lines representing the same angles and connect these points with a French curve, which at the end will form the **Sine Curve**.

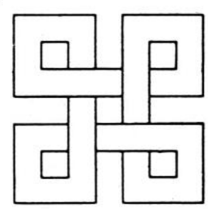
EXERCISE 10

Exercise 10a :
An exercise for the T square, triangle, and scale.
Through the center of the space draw a horizontal and a vertical line. Measuring on these lines as diameters, lay off a 15 cm square. Along the lower side and upper half of the left side measure 2.5 cm spaces with the scale. Draw all horizontal lines with the T square and triangle.



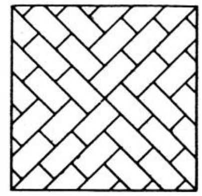
Exercise 10b :
An interlacement. For T square, triangle, and dividers.

Draw a 14 cm square. Divide the left side and lower side into seven equal parts with dividers. Draw horizontal and vertical lines across the square through these points. Erase the parts not needed.



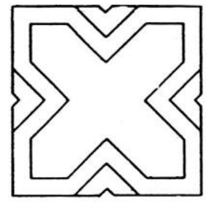
Exercise 10c :
A street -paving Intersection.

For 45° triangle and scale. An exercise in starting and stopping short lines.



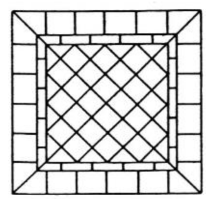
Draw a 15 cm. square. Draw it's diagonals with 45° triangle. With the scale; layoff 1.25 cm. spaces along the diagonals from their intersection. With 45° triangle, complete the figure, finishing one quarter at a time.

Exercise 10d :
A square pattern for 45° triangle, dividers, and scale.



Draw a 15 cm square and divide its sides into three equal parts with dividers. With 45° triangle, draw diagonal lines connecting these points. Measure 1 cm. on each side of these lines, and finish the pattern as shown.

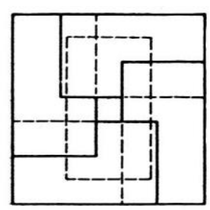
Exercise 10e :
An acoustic pattern for 45° triangle, T square, and scale.



Draw two intersecting 45° diagonals 15 cm long, to form a field. With the scale lay off 2.50 cm spaces from their intersection. Add the narrow border 0,8 cm wide. Add a second border 2.50 cm wide. The length of the border blocks is projected from the corners of the field blocks.

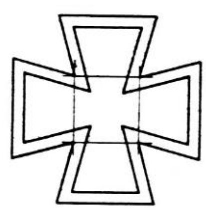
EXERCISE 11

Exercise 11a :
Five cards. Visible and hidden Iines.



Five cards 5 by 8 cm are arranged with the bottom card in the center, the other four overlapping each other and placed so that their outside edges form a 12.5 cm square. Hidden lines indicate edges covered.

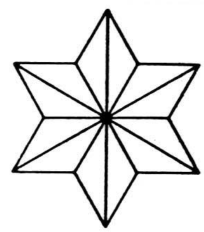
Exercise 11b :
A Maltese cross. For T square, spacers, and 45° and 300-600 triangles.



Draw a 10 cm. square and a 3.5 cm square. From the corners of the inner square, draw lines to the outer square at 15° and 75°, with the two triangles in combination. Mark points with spacers 0.6 cm. inside each line of this outside cross, and complete the figure with triangles in combination.

Exercise 11c :

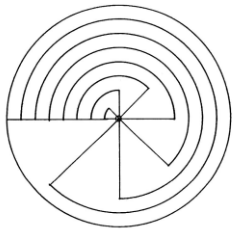
A six-point star. For compass and 30^0-60^0 triangle.



Draw a 15 cm. in diameter construction circle and inscribe the six-point star with the T square and 30^0-60^0 triangle. Accomplish this with four successive changes of position of the triangle.

Exercise 11d :

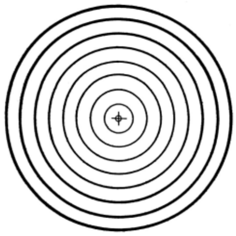
Draw the circle shown at right
Homogenous line thickness.



Radius = 80 mm.
Angles : 45^0 each

Exercise 11e :

Draw the circle shown at right in full scale.

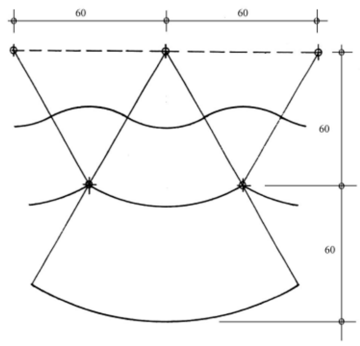


Line thickness getting smaller towards the center.

Radius = 80 mm.

EXERCISE 12 :

Exercise 12a :



Measurements in mm.

Draw the equilateral triangles, lines, measurement lines and arcs in full scale.

Exercise 12b :

Draw the following figures to scale 1:1, using Tee square, set square, compass and pencil.

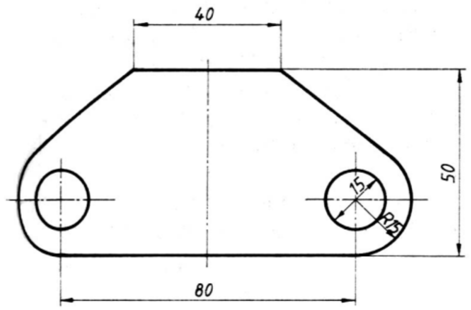


Figure 1

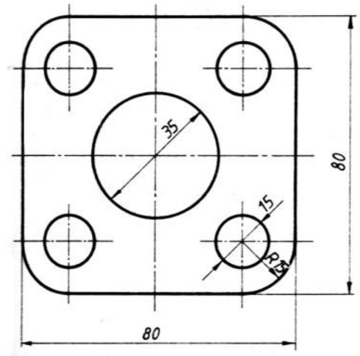


Figure 2

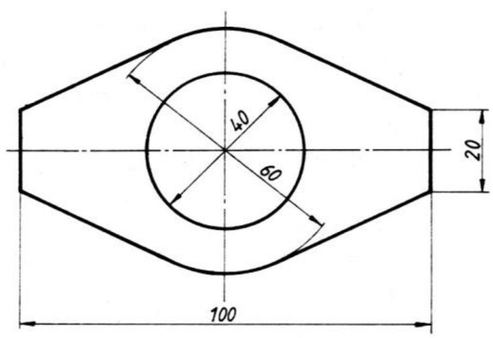


Figure 3

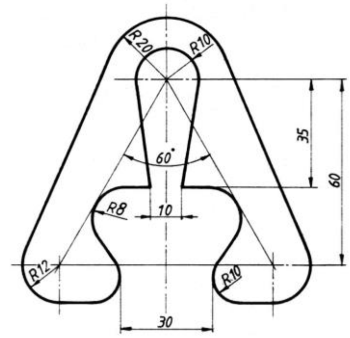


Figure 4

LINES IN APPLICATION CHAPTER 5

5.1 SCALE DRAWING

It would be impossible to indicate a shape and size on a drawing to the full size always, and for this reason the items shown on technical drawings are drawn much smaller than the original size but are to scale, that is a smaller dimension representing the larger.

Scales used for drawings are shown below

Sketch Schemes (General design layouts)	1 : 200 and 1 : 100

Location Drawings 1 : 200

Working drawings 1 : 100 and 1 : 50
(With all information thereon for builder)

Detail Drawings 1 : 20 , 1 : 10 , 1 : 5 , 1 : 1
(Drawings showing larger details of the design and construction)

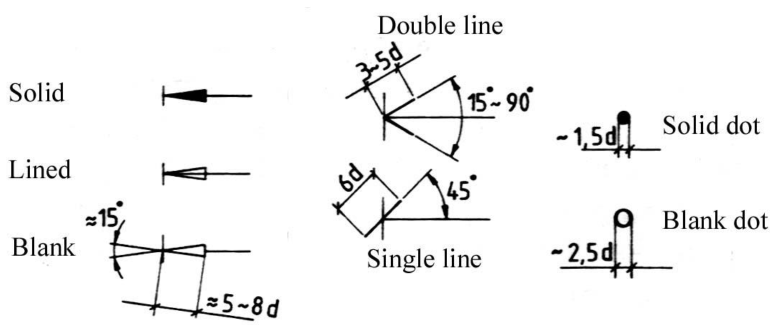
The Metric Scales are fractions of full size, for instance **1 : 50** means that the drawing you are preparing to this scale would be $\frac{1}{50}$th the size of the 1 : 1 scale shown in the chart means that the item drawn has been shown to actual full size.

DIMENSIONS

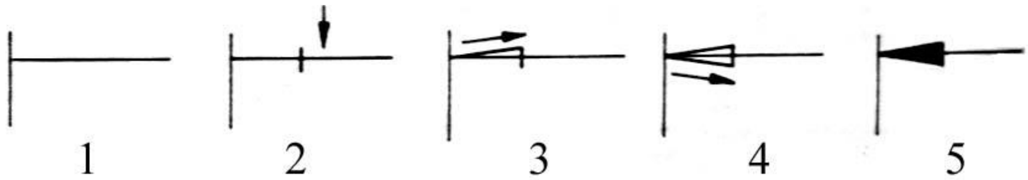
After the shape of an object has been described by orthographic or pictorial views, the value of the drawing for the construction of the object depends upon dimensions and notes that describe the **SIZE**.

Before dimensioning the drawing, study the object and understand its functional requirements; then put yourself in the place of the producer and mentally construct the object to discover which dimensions would best give the information. A dimension is used to give the distance between two points, lines or planes or between some combination of points, lines and planes. The numerical value gives the actual distance, the dimension line indicates the direction in which the value applies and the arrowheads indicate the points between which value applies.

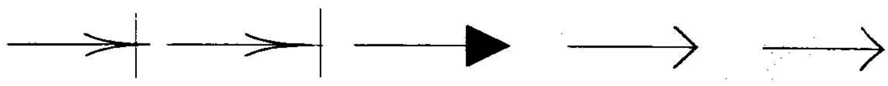
The lines and symbols used in dimensioning are dimension lines, arrowheads, dot on the intersection points, extension lines, leaders, numerical values, notes, finish marks, etc.
The arrowhead style will be used in this book, although a dot or a small circle, centered on the intersection point of the horizontal and vertical lines of the dimension lines can also be used.

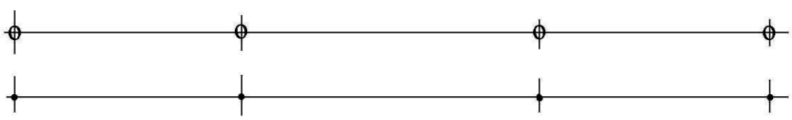


Types of arrowheads and dimensions



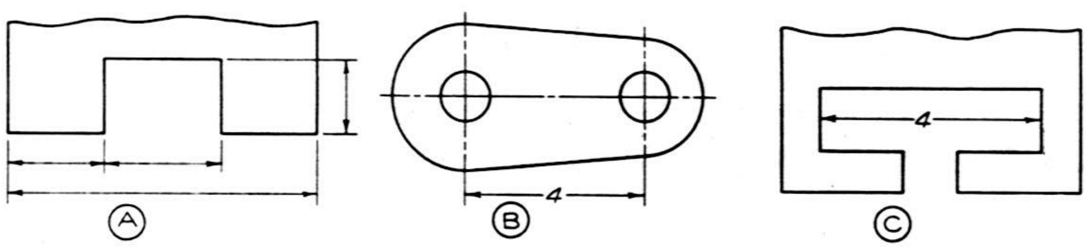
To construct an arrow


Incorrect arrowheads

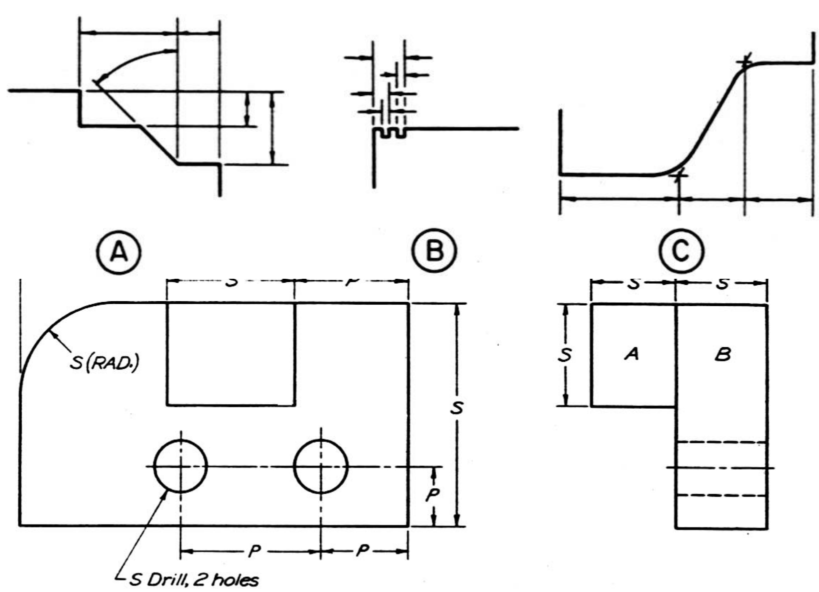

Using circles or dots on the intersection lines

EXTENSION LINES

These extend from the view to a dimension placed outside the view.

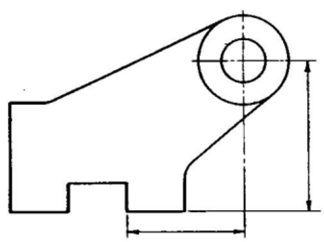


Dimension terminals

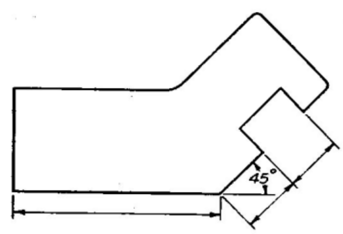


Techniques of drawing extension lines
Dimension of size and position
S indicates **S**ize, **P** indicates **P**osition

POSITIONS

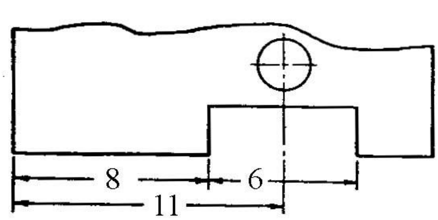


Position by offset

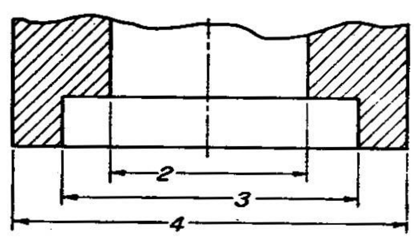


Position by angle

VALUES

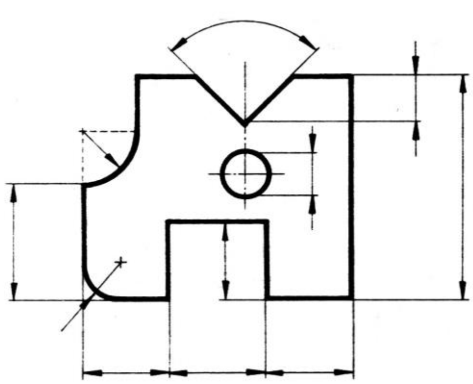


Values midway between arrowheads

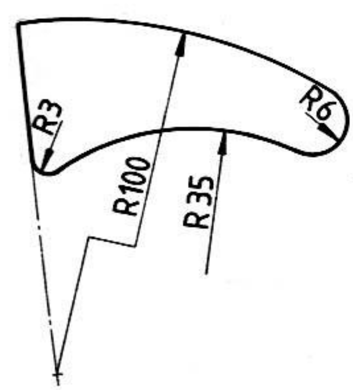


Values staggered for clarity

DIMENSIONS

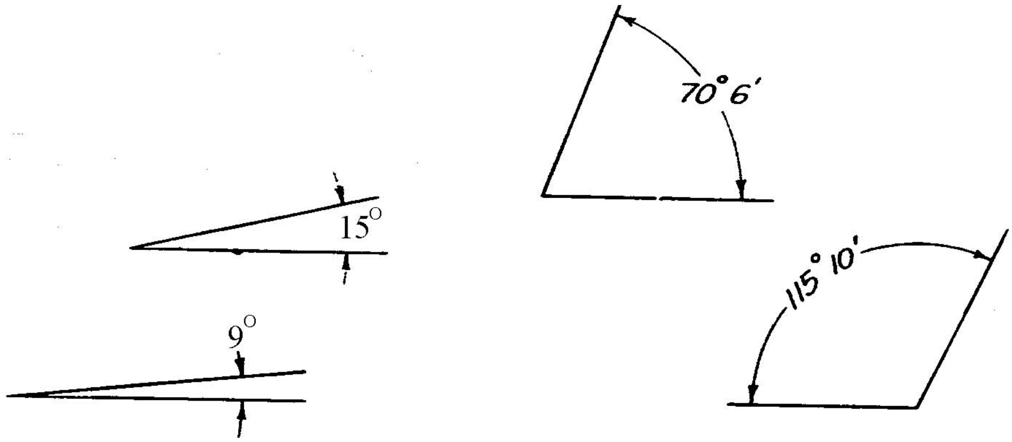


Dimensions arranged in continuous form



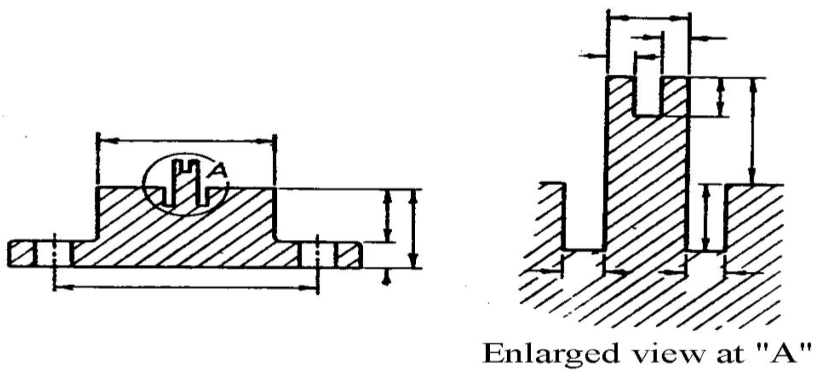
Dimensioning of arcs

ANGLES



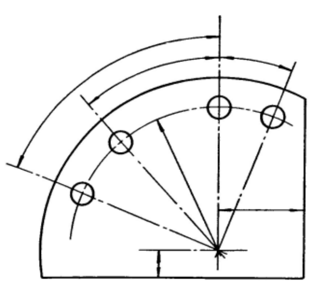
Dimensions of Angles

ENLARGING



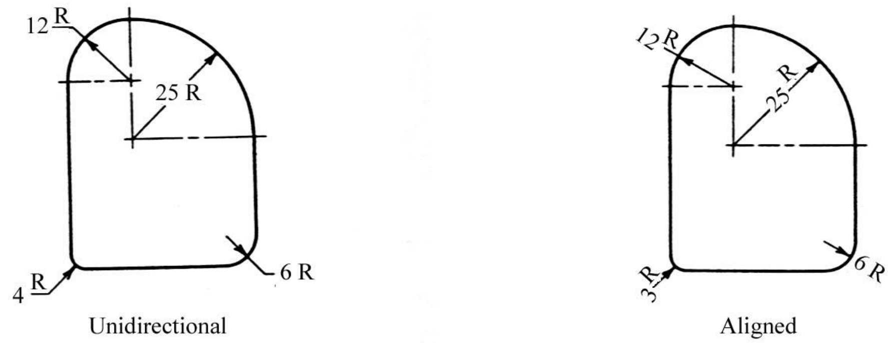
Use of enlarged view to clarify dimensions

HOLES

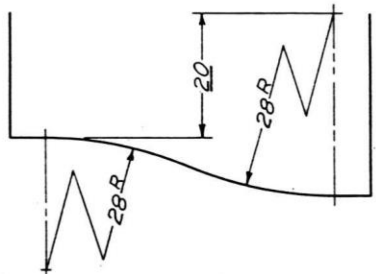


Holes positioned by angle from datum line

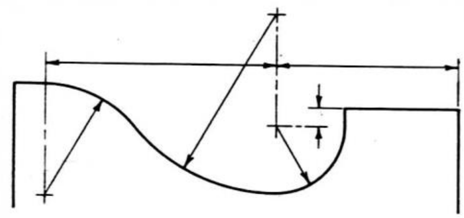
RADIUS



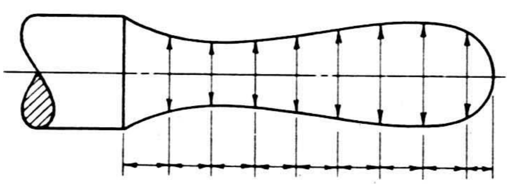
Dimensioning of Radii



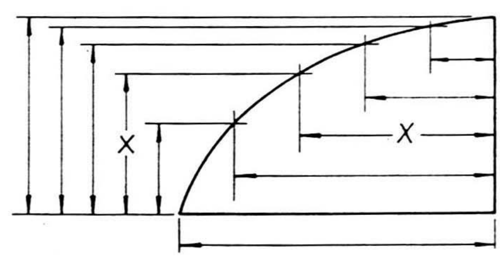
Dimensioning of radii having inaccessible centers



Dimensioning a curve made up of radii

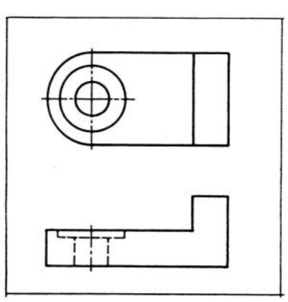


A curve dimensioned by offsets

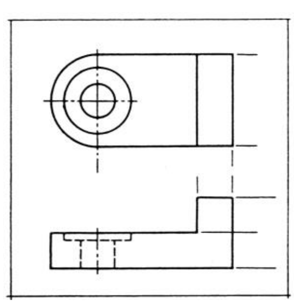


A curve dimensioned from datum edges

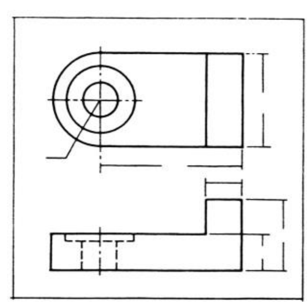
ORDER OF DIMENSIONING



1-Complete the shape

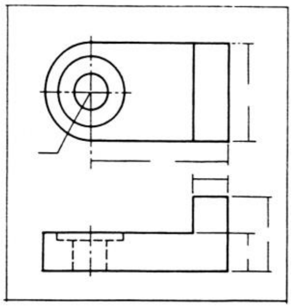


2-Place the extension lines

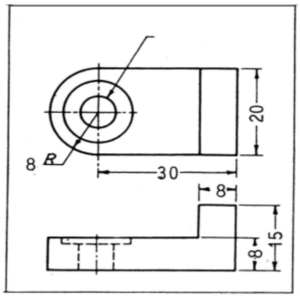


3-Add dimension lines

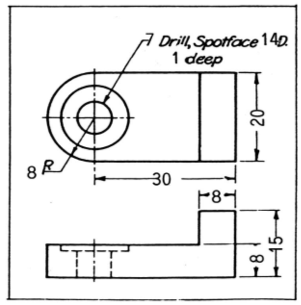
description



4-Draw arrowheads and complete dimensioning

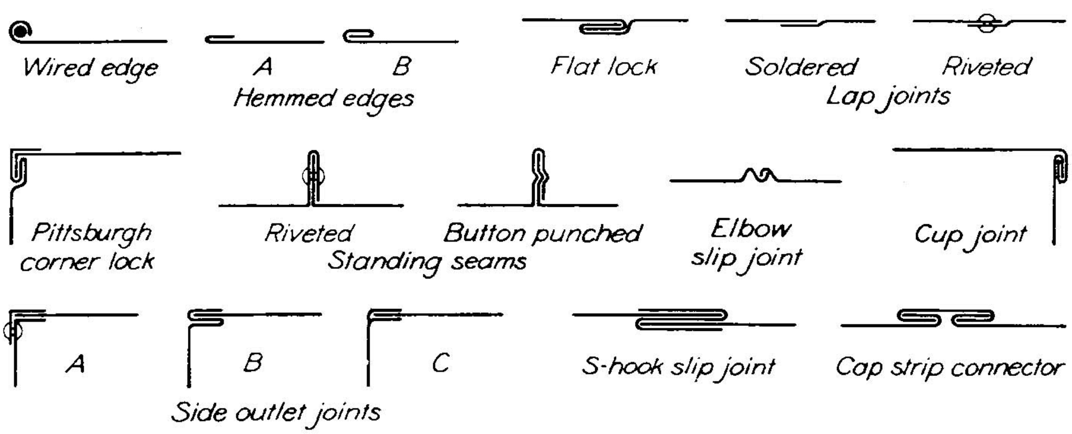


5-Add values

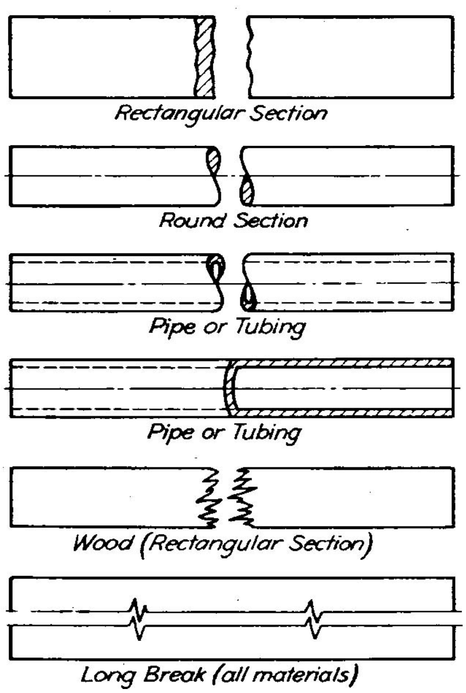


6- Add letter notes and leaders for notes

CONVENTIONAL SYMBOLS



Common types of sheet metal seaming and connecting

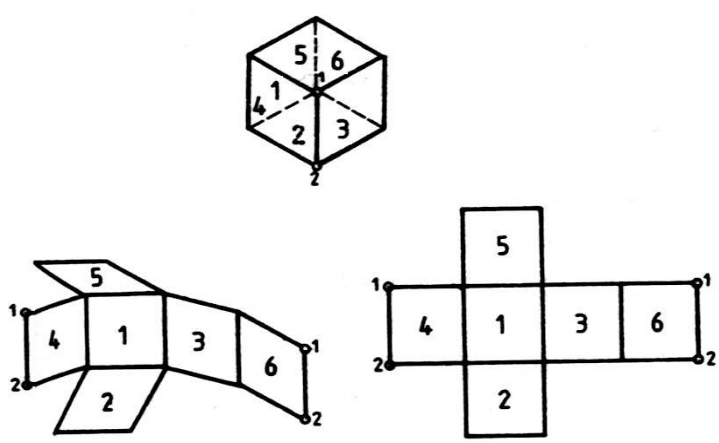


Conventional break symbols

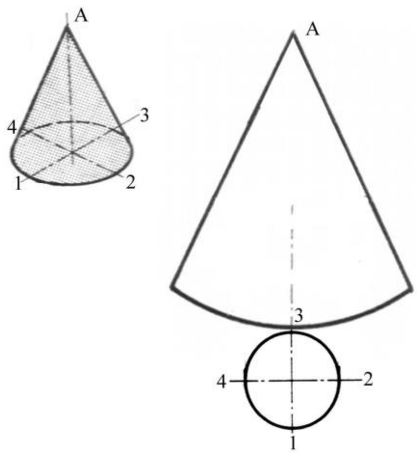
5.2 DEVELOPMENT OF SURFACES

In many different kinds of construction full size patterns of some or all of the faces of an object are required. The complete surface laid out in a plane is called the ***Development of the surface***.

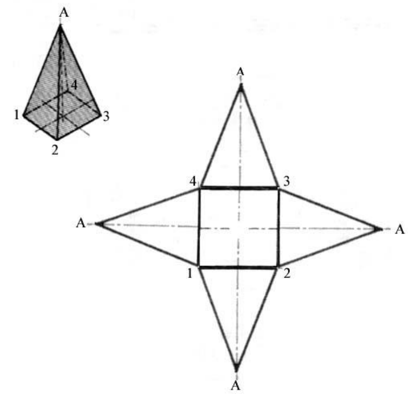
If the true size of all the plane faces of an object are found and joined in order at their common edges so that all faces lie in a common plane, the result will be the developed surface.



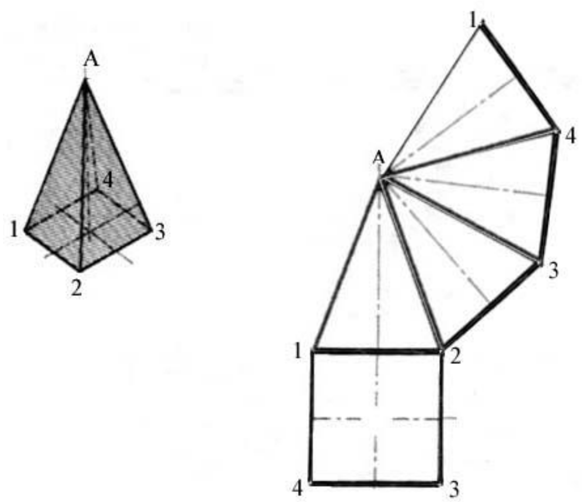
Surface development of a cube



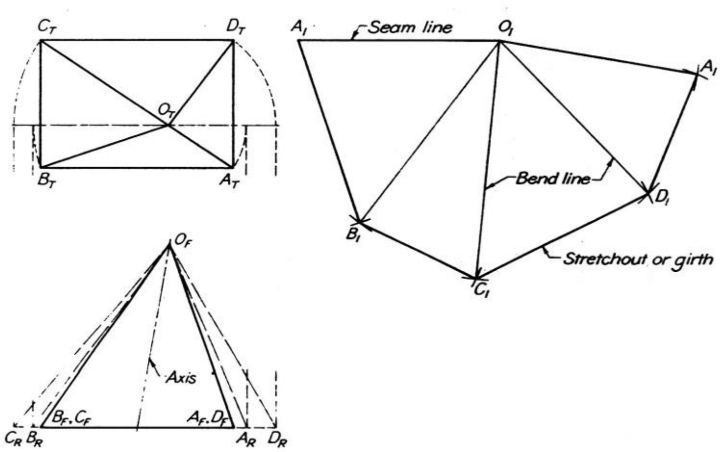
Surface development of a cone



Surface development of a pyramid with a bottom

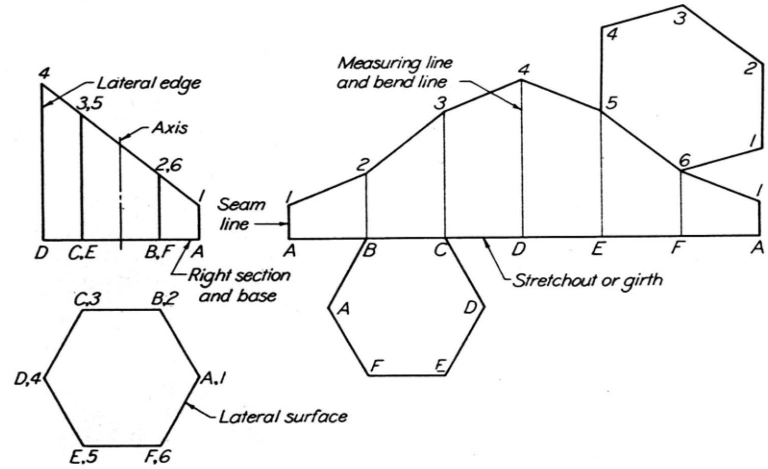


Surface development of a pyramid with a bottom

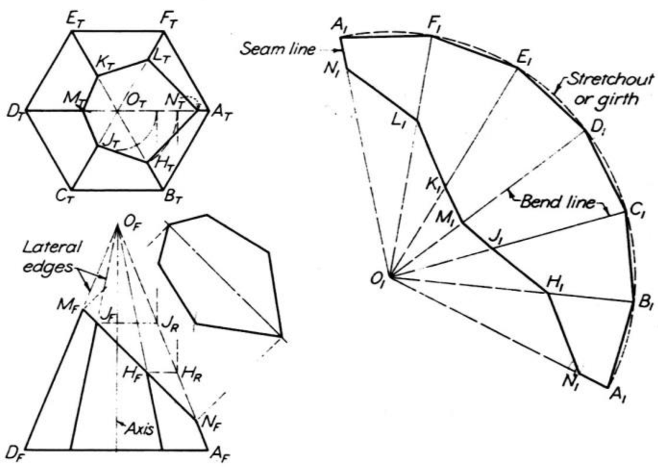


Surface development of an oblique pyramid
Each lateral edge is of different length and true length must be determined.

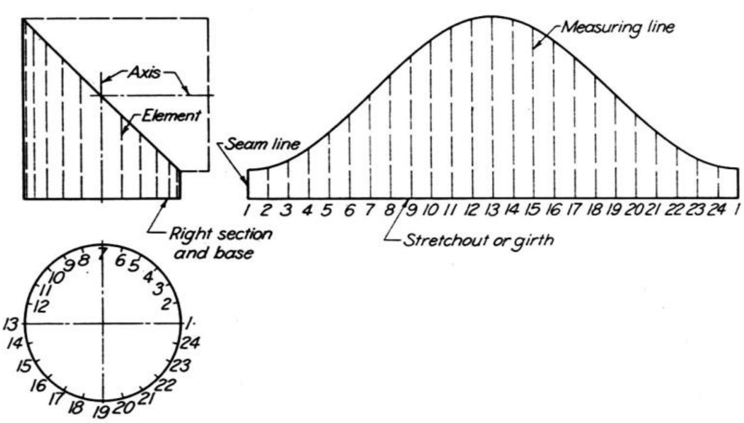
Surface development of a truncated prism The true size of each side is laid out in successive order



Surface development of a pyramid, The true lengths of all the edges are equal

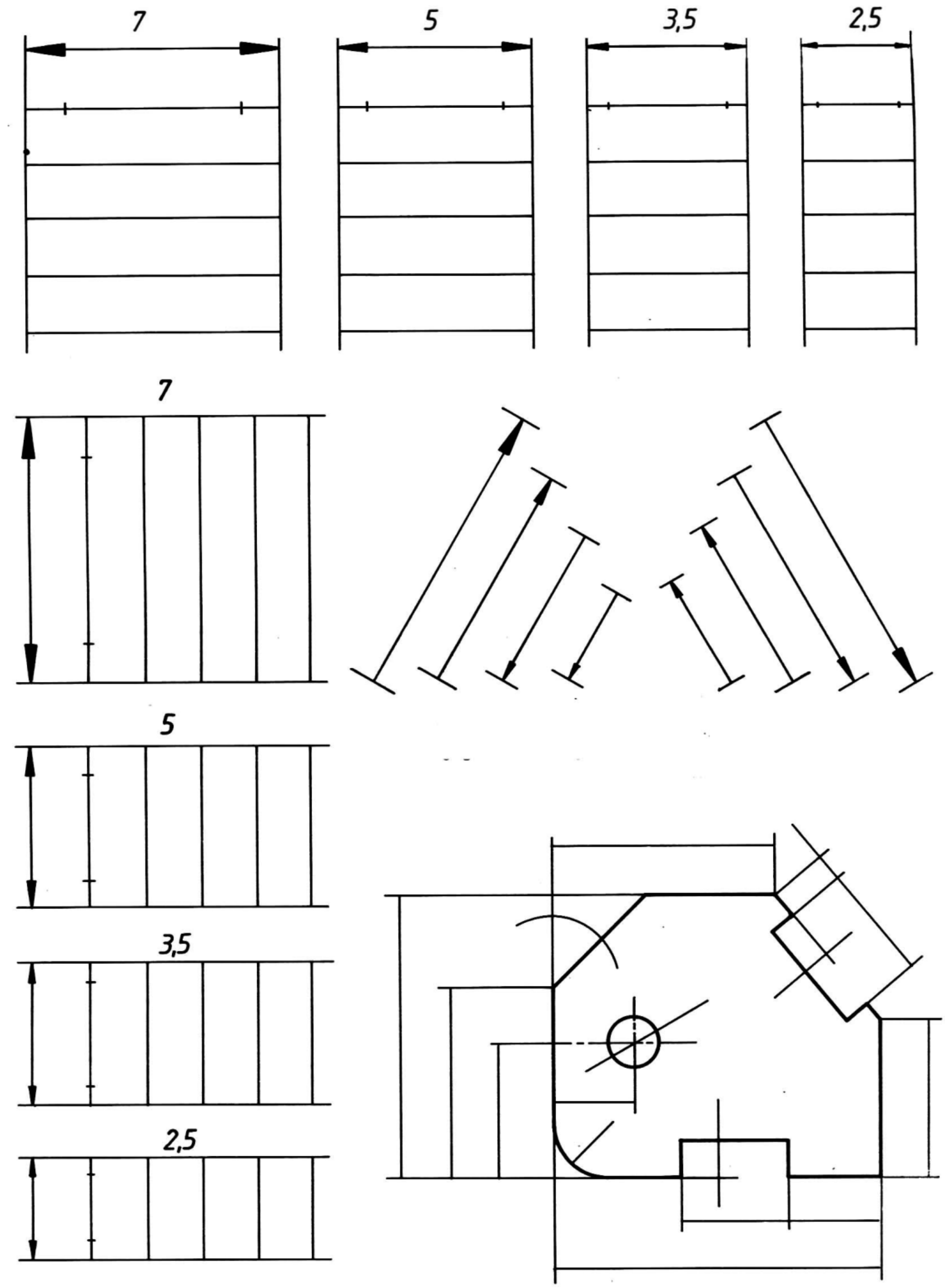


Surface development of a cylinder



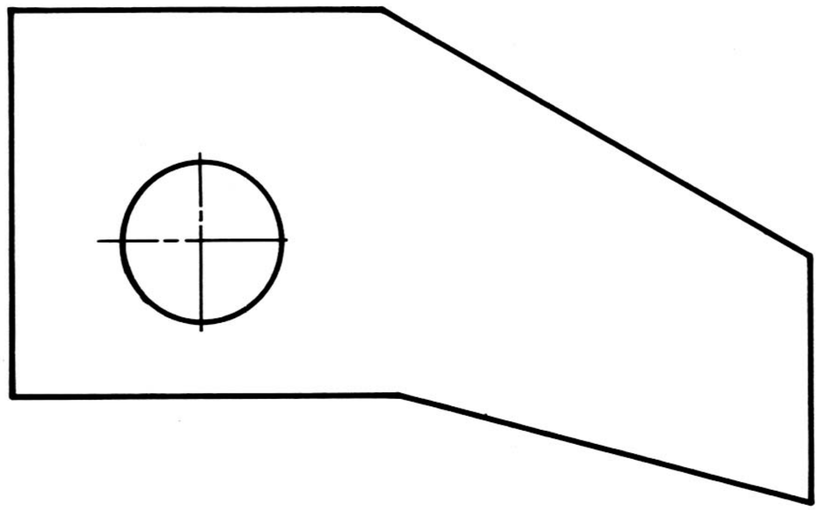
EXERCISE 13

Draw arrows to the end of lines according to the dimension given.

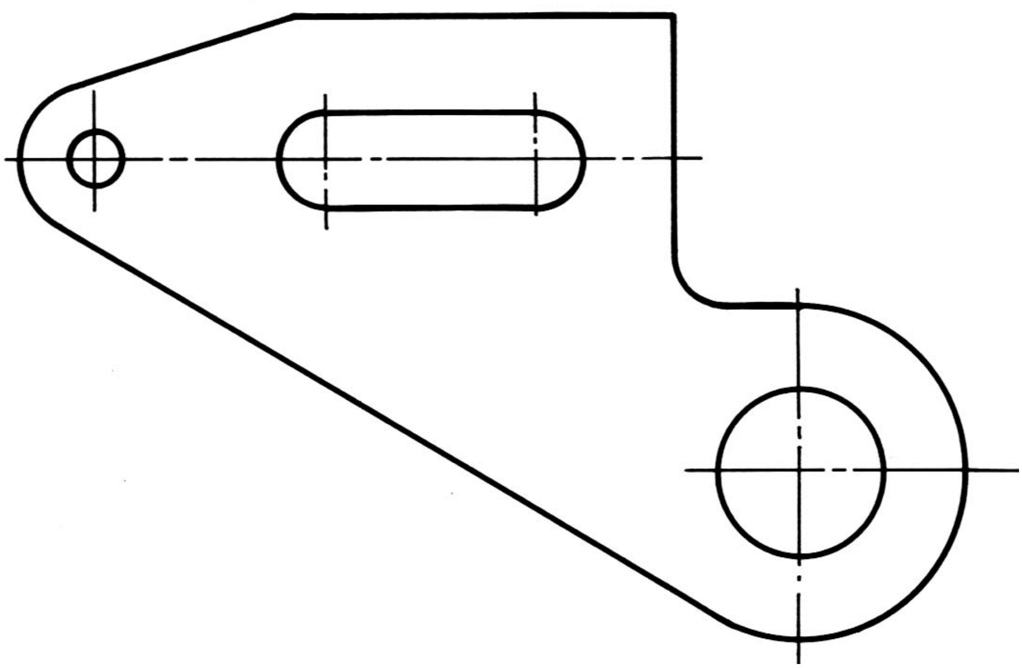


EXERCISE 14

A- Dimension precisely the below drawing in millimeters.

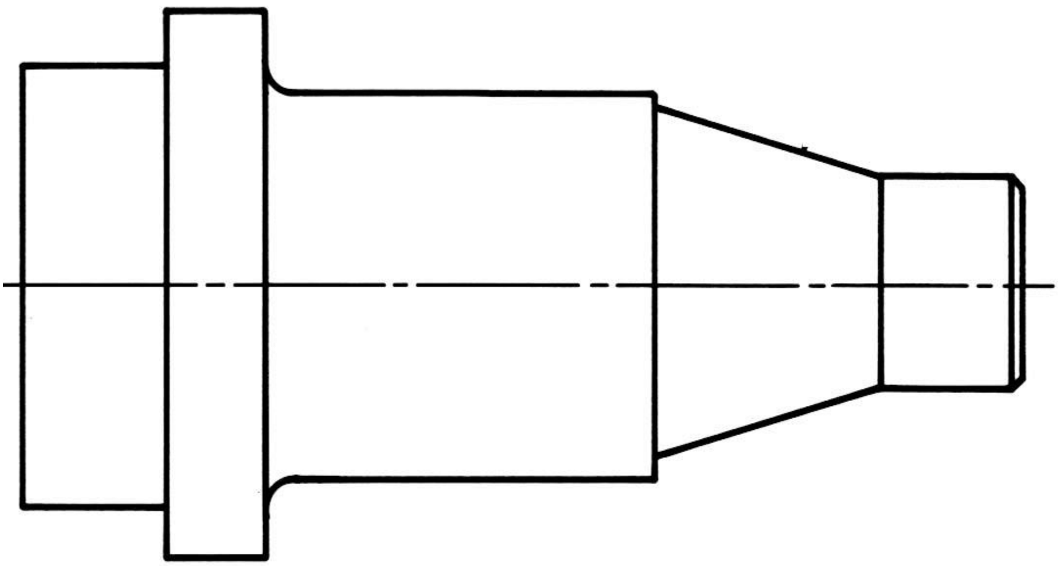


B- Dimension precisely the below drawing in millimeters

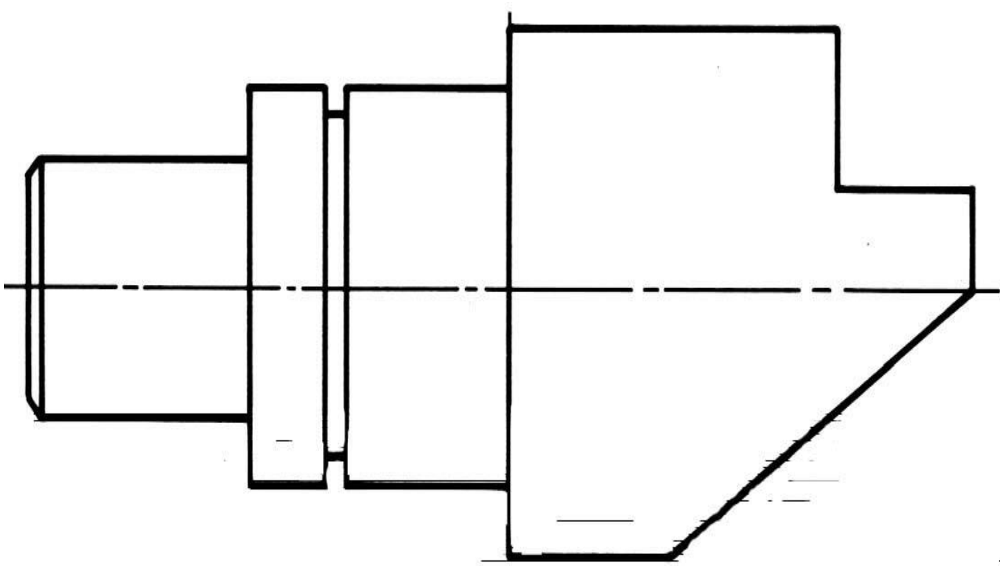


(Exercise 14 Continued)

C- Dimension precisely the below drawing in millimeters

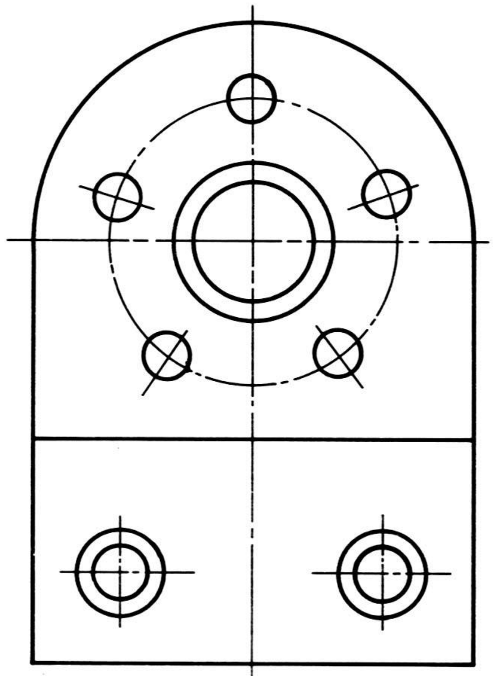


D- Dimension precisely the below drawing in millimeters

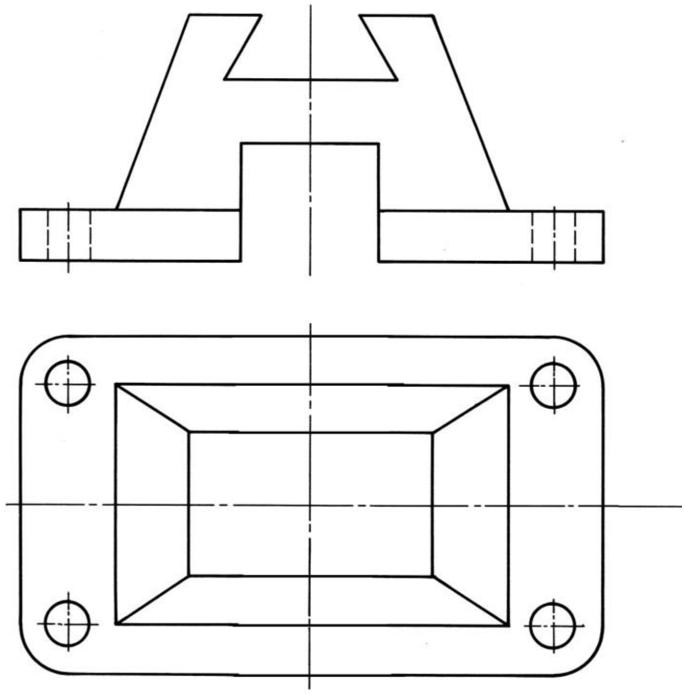


(Exercise 14 Continued)

E- Dimension precisely the below drawing in millimeters

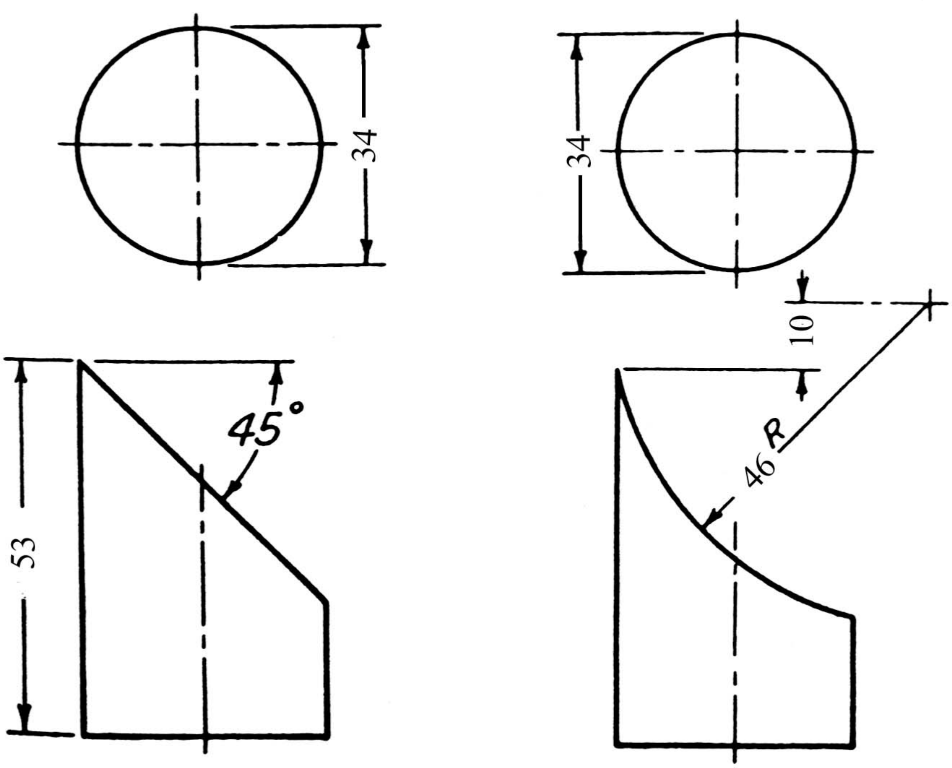


F- Dimension precisely the below drawing in millimeters.

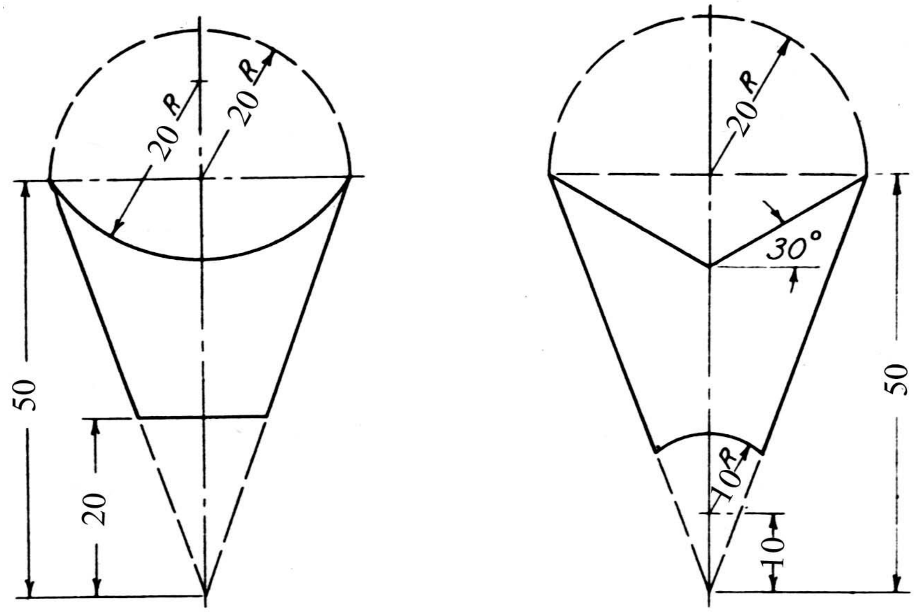


EXERCISE 15

A- Develop lateral surfaces of the cylinders. Dimensions are in millimeters.



B- Develop lateral surfaces of the cones. Dimensions are in millimeters.



SHAPE DESCRIPTION CHAPTER 6

6.1 SHAPE DESCRIPTION

Delineation of the shape of a part, assembly , or structure is the primary element of graphic communication. Since there are many purposes for which drawings are made, the engineer must select, from the different methods of describing shape, the one best suited to the situation at hand. Shape is described by projection, that is, by the process of causing an image to be formed by rays of sight taken in a particular direction from an object to a picture plane.

Methods of projection vary according to the direction in which the rays of sight are taken to the plane.

When the rays are perpendicular to the plane, the projective method is **ORTHOGRAPHIC**.

When the rays are at an angle to the plane, the projective method is **OBLlQUE.**

Rays, taken to a particular station point result in **PERSPECTIVE PROJECTION**. By the methods of perspective the object is represented as it would appear to the eye.

Following projective theory, two methods of representation is used: ***Orthographic views*** and ***pictorial views***.

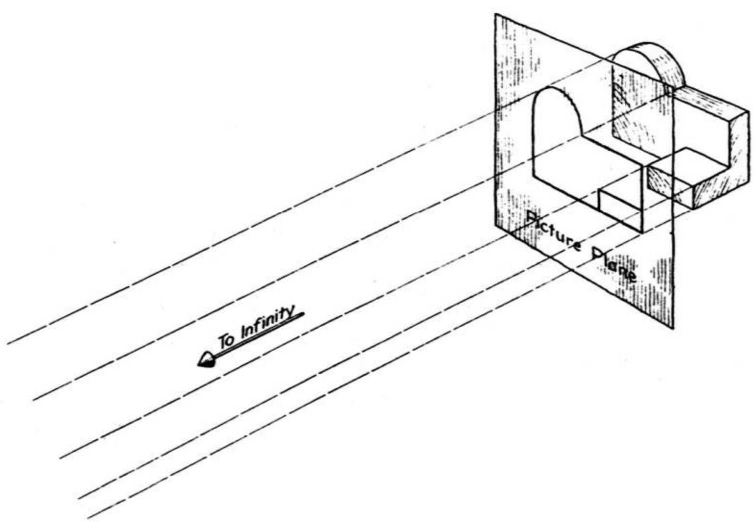
For the great bulk of engineering work, the orthographic system is used, and this method, with its variations and the necessary symbols and abbreviations, constitutes an important part of this book. In the orthographic system, separate views arranged according to the projective theory are made to show clearly all details of the object represented. The figures that follow illustrate the fundamental types of orthographic drawings and orthographic views.

Orthographic views, consisting of a set of two or more separate views of an object taken from different directions generally at right angles to each other.

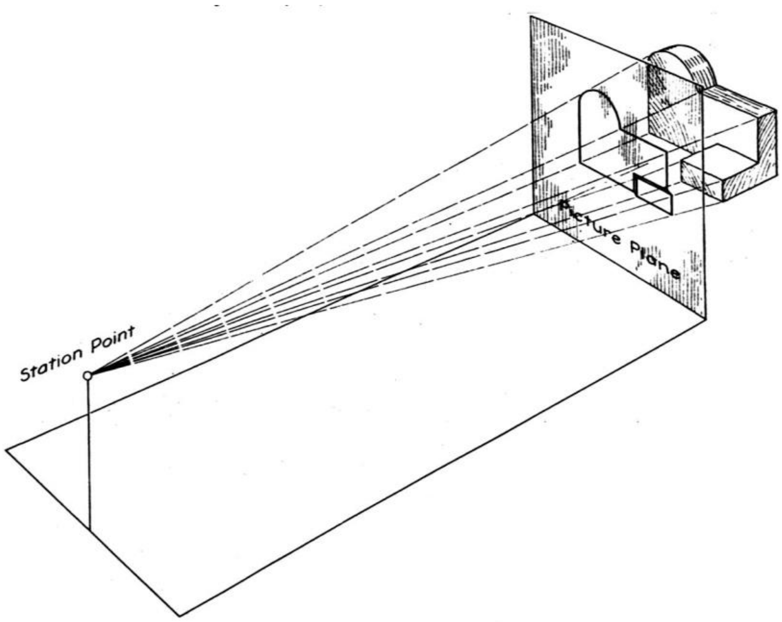
Pictorial views, in which the object is oriented behind and projected upon a single plane.

Orthographic Projection is the method of representing the exact shape of an object by dropping perpendiculars from two or more sides of the object to planes, generally at right angles to each other, the views on these planes describe the object completely.

The following illustrations of Orthographic projection and Perspective projection explains visually the difference and explains the main idea very clear1y .



Orthographic Projection
The station point is at infinity, making the rays parallel to each other.
The rays are perpendicular to the picture plane.



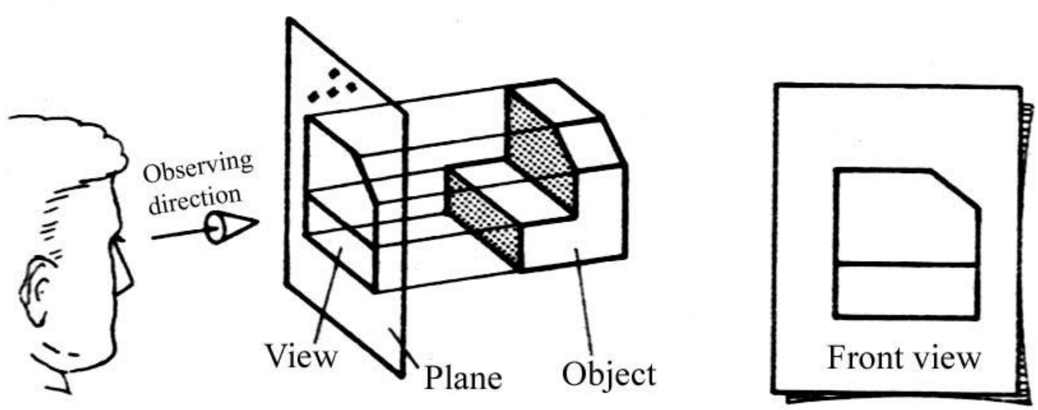
Perspective Projection

The rays of projection converge at a station point from which the object is observed. Rays intersect a picture plane and produce a projection of the object.

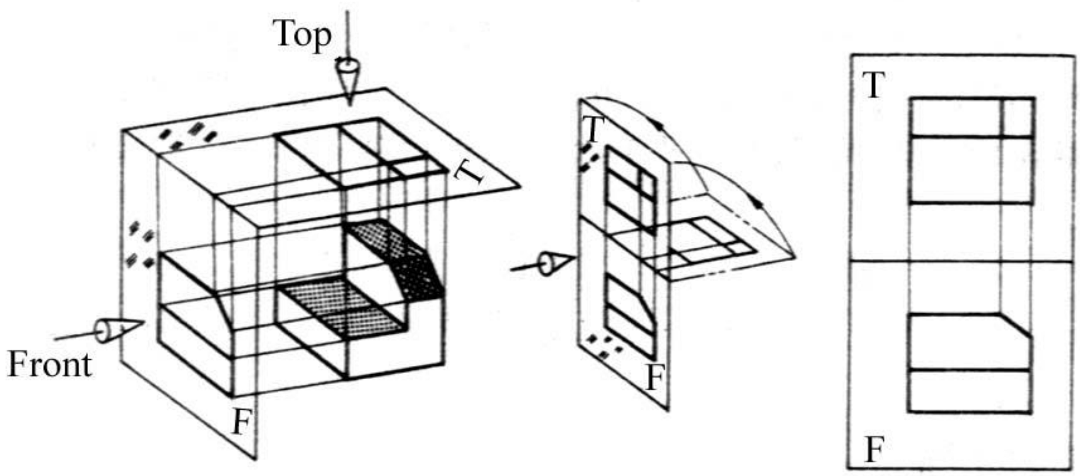
6.2 THE SIX PRINCIPAL VIEWS

Two very similar methods, ***ISO-A*** and ***ISO-E***, are widely used to show the ***six principal views*** of an object.

ISO-A METHOD



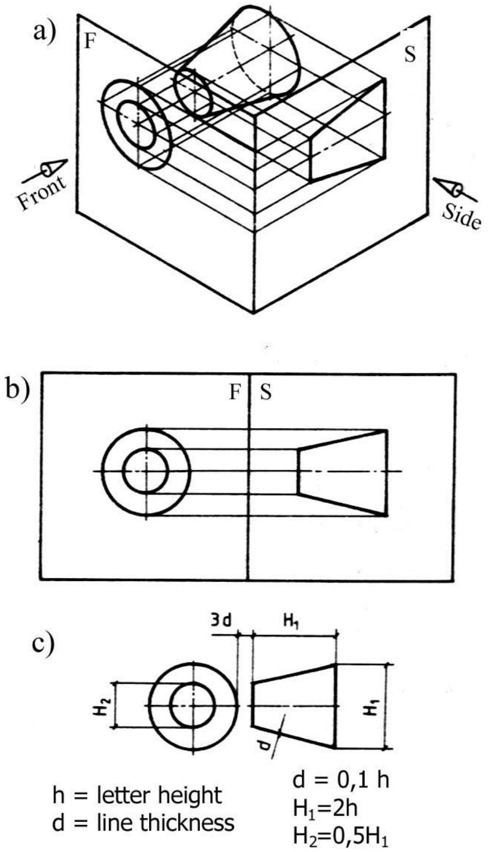
When observed from one side, the other side is visible and the planes used are assumed to be transparent. This special feature of the planes is necessary to enable the observer to look from a stationary point. The object is placed behind the plane and its view is supposed to be drawn on the rear surface of the (glass) transparent plane.



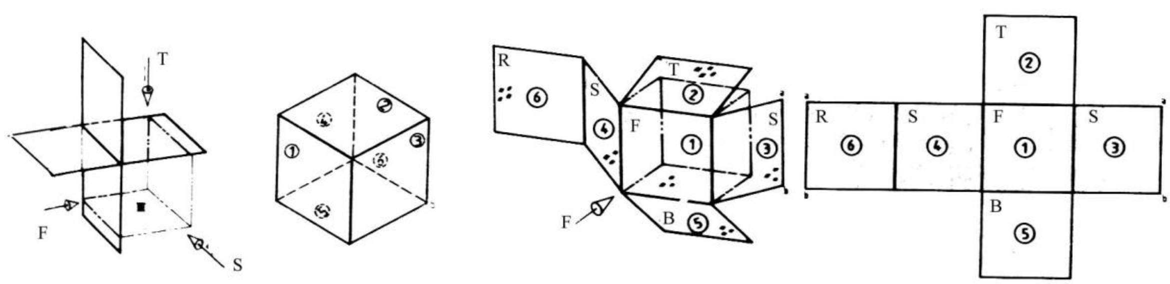
In case of a need of more than one plane, the principle is still the same and the second plane is placed perpendicular to the first plane. The object is behind the plane and the observer looks from the other side. The front and top view is drawn and hinge joined together on a plane of paper, as shown in above example.

THE SYMBOL OF ISO-A METHOD

Both methods have their own unique symbols, the front and side view of a truncated cone.



The views and symbols of ISO-A method

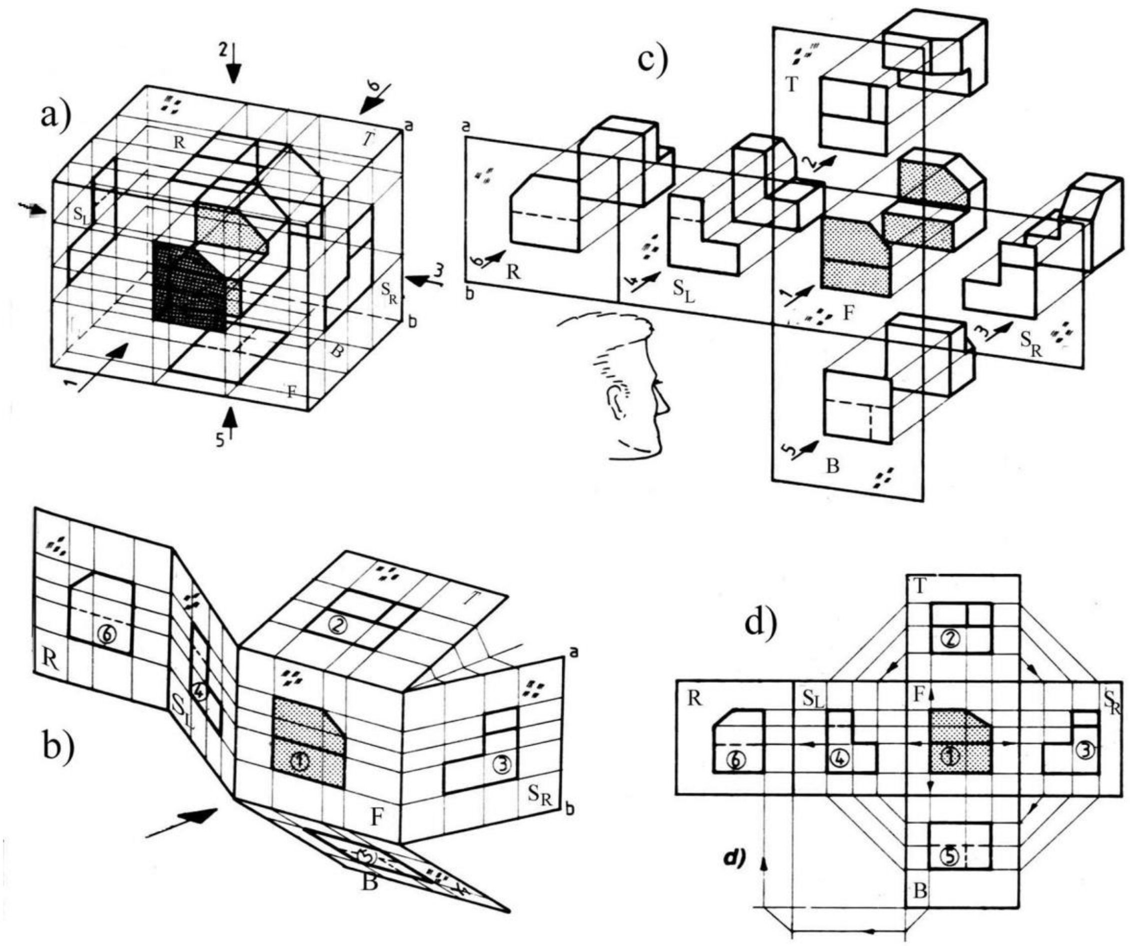


The six principal view concept of ISO-A method.

F = Front view **S** = Side view(s) (**Left** side view and **Right** side view)
T = Top view **B** = Bottom view
R = Rear view

THE SIX PRINCIPAL VIEWS OF "ISO-A" METHOD

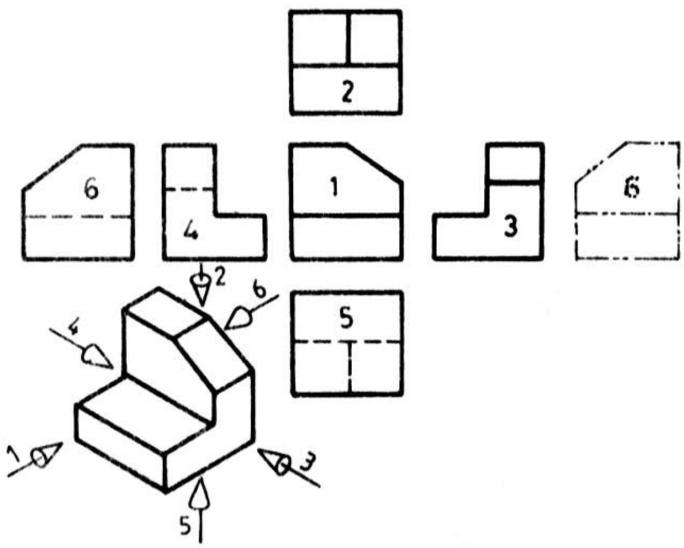
Considering the matter further, we find that the object can be entirely surrounded by a set of six planes, each at right angles to the four planes adjacent to it as in the figure below.



On these planes, views of the object can be obtained, as it is seen from the **TOP (T)**, **FRONT (F)**, **RIGHT SIDE (S_R)**, **LEFT SIDE (S_L), BOTTOM (B)** and **REAR (R)**. In the beginning to differentiate the side views "**S_R**" for **R**ight **S**ide view and **"S_L" L**eft **S**ide for view will be used. Later only "**S**" will be used for both side views.

Observing further the drawing above, think of the six sides (or planes) of the box as being cut by a knife from the edges of the sides and opened up in a paper plane as in the figure.

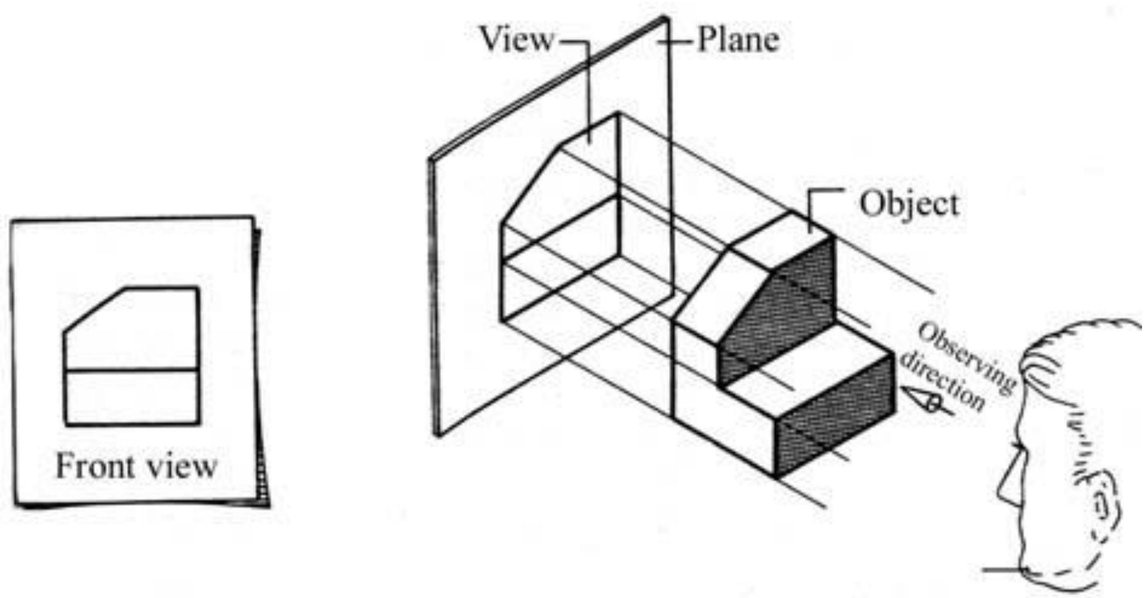
The front is already in the plane of the paper, and the other sides are as they were hinged, and rotated into positions as in the above figure.



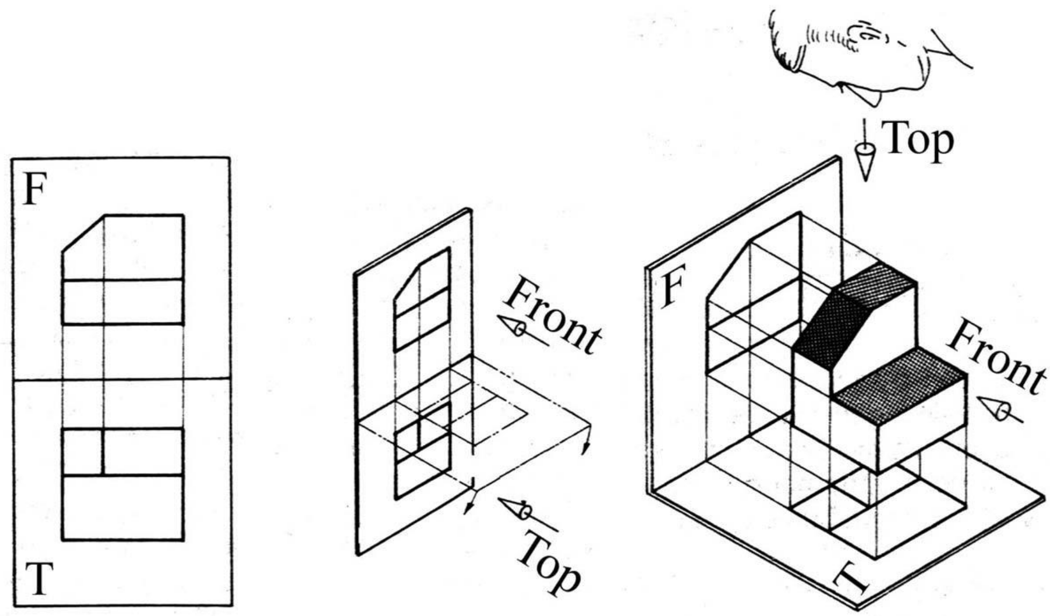
Above shown the final six drawings of the object, where ;

View No.**1** : **F**ront view (**F**)
View No.**2** : **T**op view (**T**)
View No.**3** : **R**ight side view (**S_R**)
View No.**4** : **L**eft side view (**S_L**)
View No.**5** : **B**ottom view (**B**)
View No.**6** : **R**ear view (**R**)

ISO-E METHOD



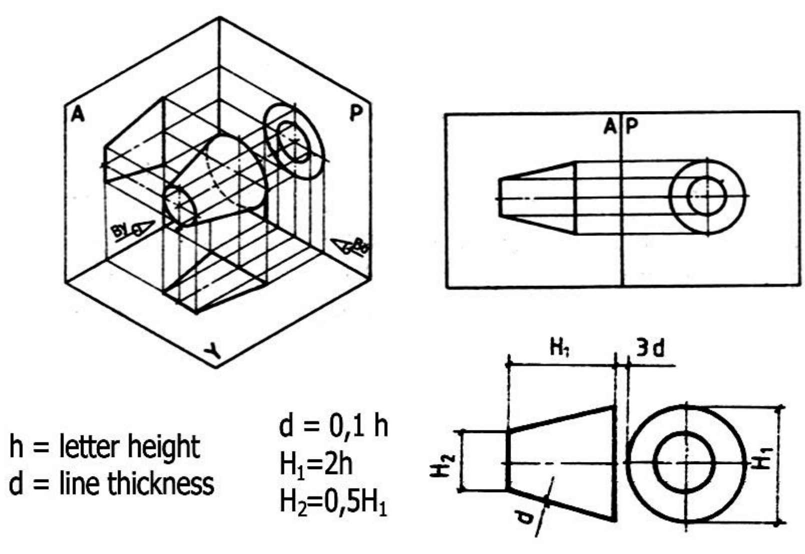
In this method the planes (glass) are not transparent and when observed from one side the other side is not visible. For this reason the object is placed in between the observer and the plane(s). The view of the object is obtained from the front face of the plane.



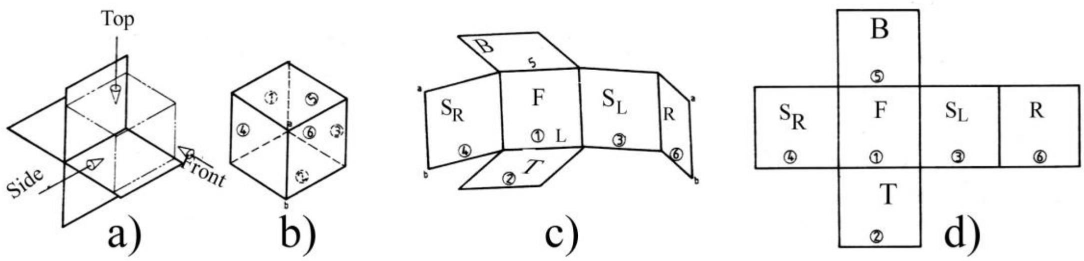
In case of a need of more than one plane, the principle is still the same and the second plane is placed perpendicular to the first plane. The object is in front of the plane and the observer looks towards the plane, through the object. The front and top view is drawn and hinge joined together on a plane of paper, as shown in above example.

THE SYMBOL OF ISO-E METHOD

The Front and Side view of the truncated cone, which is the symbol drawing of both methods is below.



The views and symbols of ISO-E method

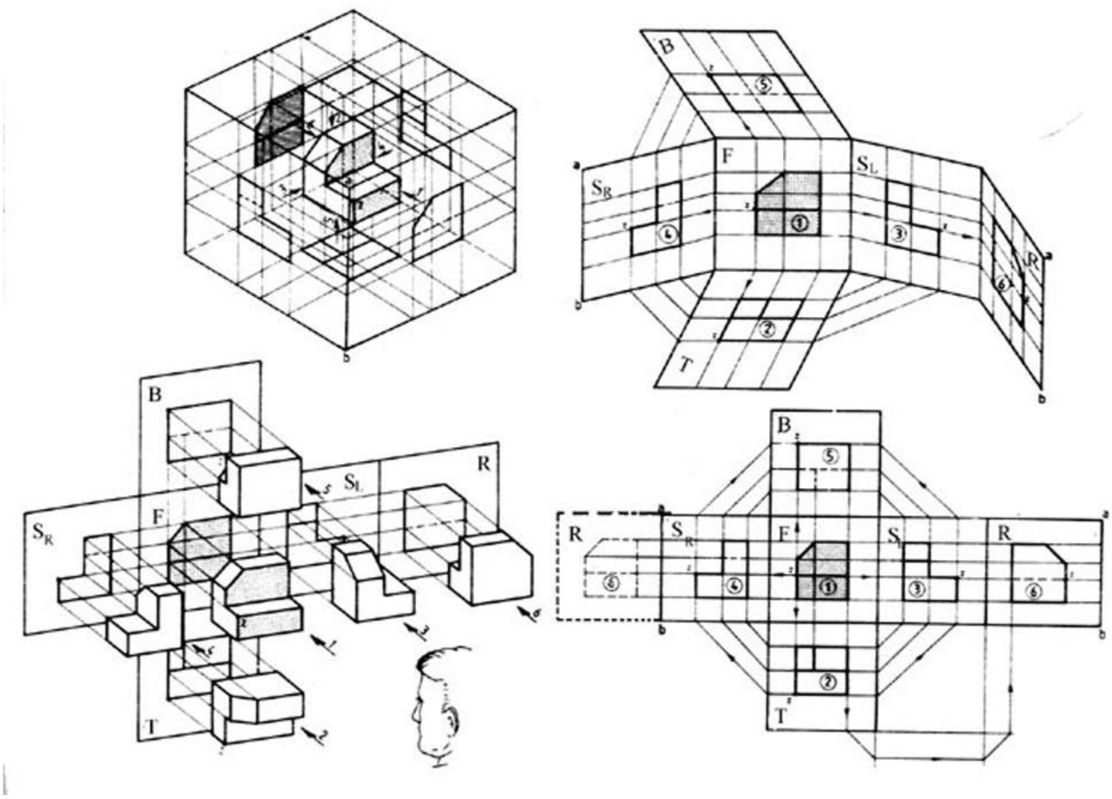


The six principal view concept of ISO-E method.

F = Front view **S** = Side view(s) (**Left** side view and **Right** side view)
T = Top view **B** = Bottom view
R = Rear view

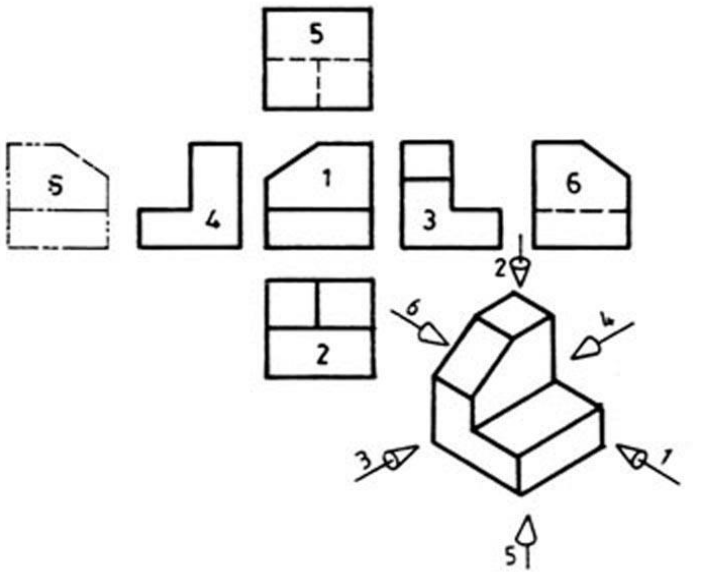
THE SIX PRINCIPAL VIEWS OF "ISO-E" METHOD

Considering the matter further, we find that the object can be entirely surrounded by a set of six planes, each at right angles to the four planes adjacent to it as in the figure below.



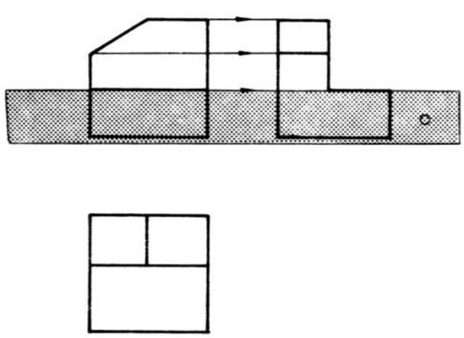
On these planes, views of the object can be obtained, as it is seen from the **TOP (T)**, **FRONT (F)**, **RIGHT SIDE (S_R)**, **LEFT SIDE (S_L), BOTTOM (B)** and **REAR (R).** Observing further the drawing above, think of the six sides (or planes) of the box as being cut by a knife from the edges of the sides and opened up in a paper plane as in the figure.

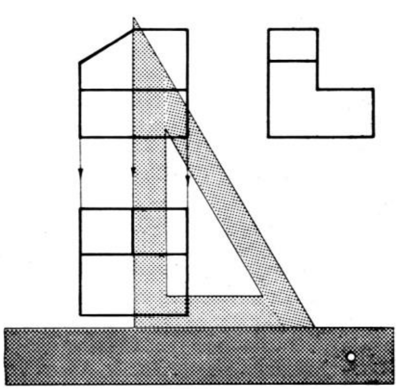
The front is already in the plane of the paper, and the other sides are as they were hinged, and rotated into positions as in the above figure.



Above shown the final six drawings of the object, where ;
View No.**1** : **F**ront view (**F**)
View No.**2** : **T**op view (**T**)
View No.**3** : **L**eft side view (**S_L**)
View No.**4** : **R**ight side view (**S_R**)
View No.**5** : **B**ottom view (**B**)
View No.**6** : **R**ear view (**R**)

6.3 PROJECTING THE VIEWS

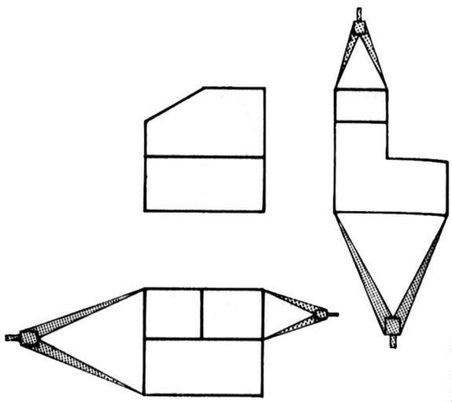




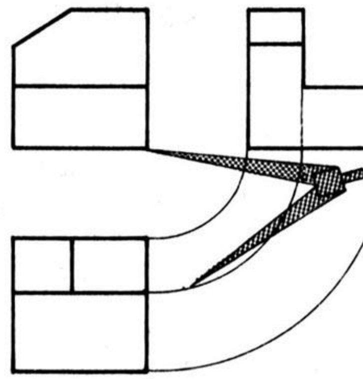
Projections (***Horizontal***) between the front and side views are made by employing the Tee square to draw the required horizontal line and projection (***Vertical***) between the front and top views are made by using Tee square and a triangle as illustrated above.

PROJECTING METHODS

Projections between the top and side views cannot be projected directly but must be measured and transferred or found by special construction. In carrying the top and side views along together, it is usual to transfer the depth measurement from one to the other with dividers as shown below.

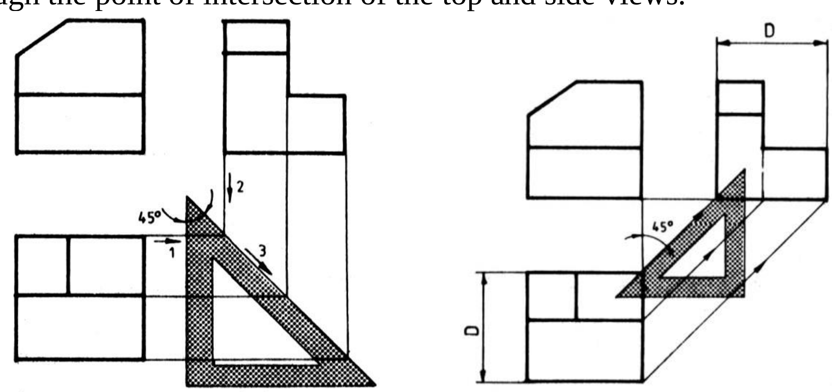


Taking measurements



Carrying dimensions

Another method, is to "***mitter***" the points around using a 45^0 line drawn through the point of intersection of the top and side views of the front face, extended as shown below or extending the lines of base and height of the front view and drawing 45^0 lines drawn through the point of intersection of the top and side views.



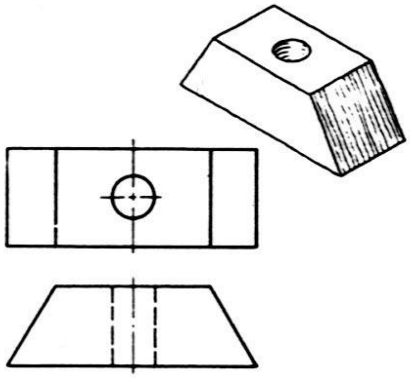
Projection by mitter lines

SELECTION OF VIEWS

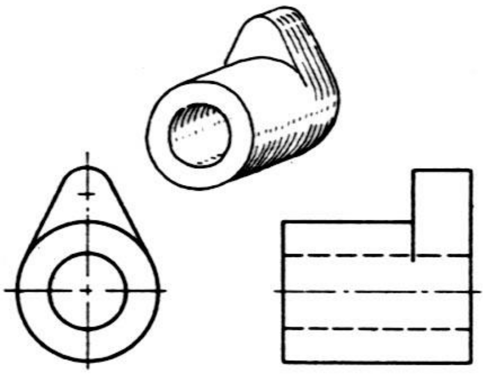
In practical work it is important to choose the combination of views that will describe the shape of an object in the best and most economical way. Often only two views are necessary. For example, a cylindrical shape, if on a vertical axis, would require only a front and top view.; if on a horizontal axis, only a front and side view. Sometimes two views are proposed as sufficient for an object on the assumption that the contour in the third direction is of the shape that would naturally be expected.

With the object preferably in its functioning position and with its principal surfaces to the planes of projection, visualize the object, mentally picturing the orthographic views one at a time to decide the best combination.,

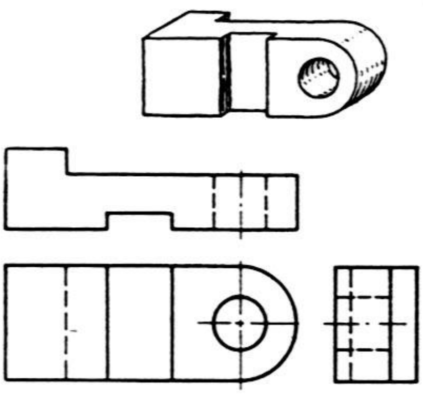
Below are the sample drawings, showing the selection of ***best choice***.



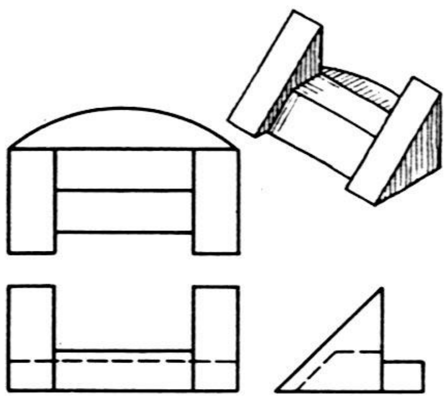
Selection of 2 views



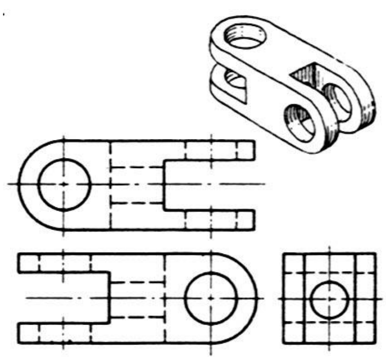
Selection of 2 views



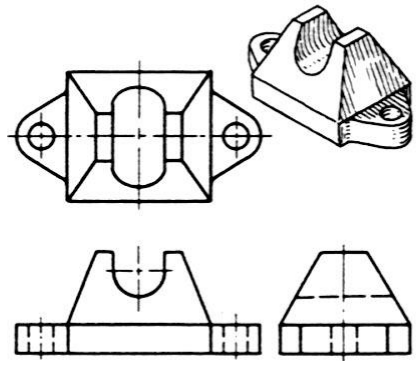
Selection of 3 views



Selection of 3 views

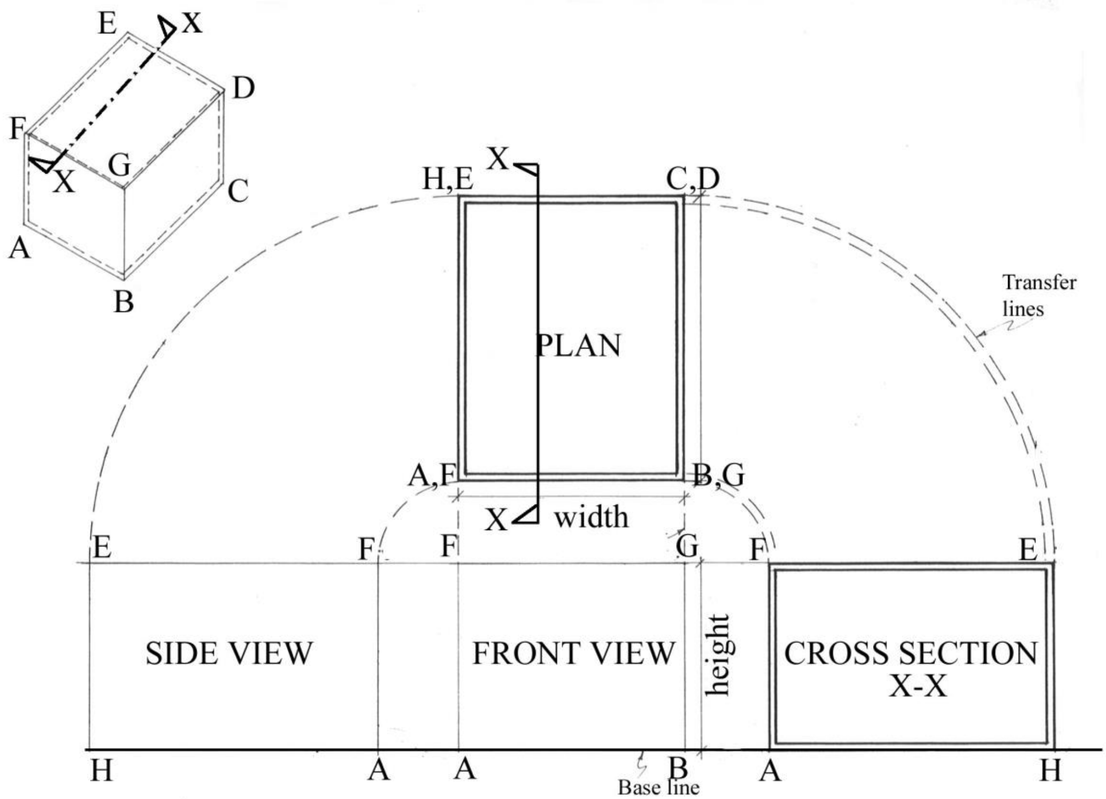


Selection of 3 views



Selection of 3 views

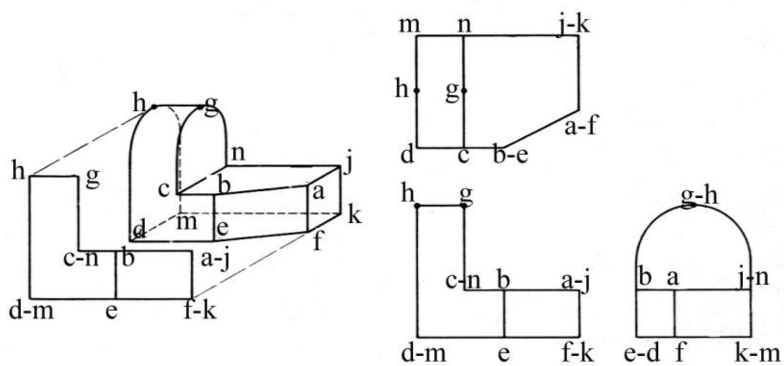
6.4 ORTHOGRAPHIC PROJECTION



The basic principle of Orthographic projection

The object to be drawn may be thought of as surrounded by transparent planes upon which the actual views are projected. The three space dimensions height, width, and depth -and the planes of projection are unchangeably oriented and connected with each other and with the view directions. Each of the planes of projection is perpendicular, respectively, to its own view direction. Thus the frontal plane is perpendicular to the front-view direction, the horizontal plane is perpendicular to the top-view direction, and the profile plane is perpendicular to the side-view direction. The two space measurements for a view are parallel to the plane of that view and perpendicular to the view direction. Therefore height and width are parallel to the frontal plane and perpendicular to the front-view direction; width and depth are parallel to the horizontal plane and perpendicular to the top-view direction; height and depth are parallel to the profile plane and perpendicular to the side-view direction.

Note that the three planes of projection are *mutually* perpendicular, as are the three space measurements and the three view directions.

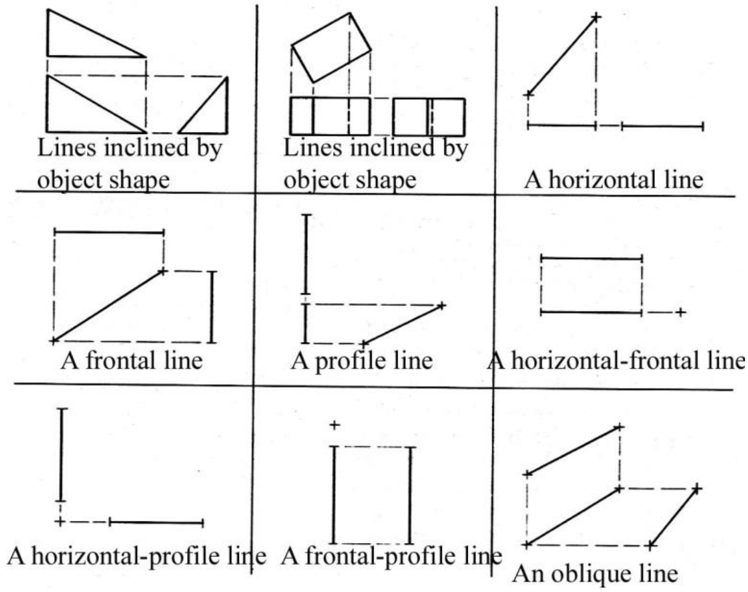


In projecting orthographic views or in comparing the views with a picture, it is helpful in some cases to letter (or number) the corners of the object and, with these identifying marks, to letter the corresponding points on each of the views as shown above.

The edges (represented by lines) bounding a surface may, because of the shape or position of the object, also be in a simple position or inclined to the planes of projection. A line in, or parallel to, a plane of projection takes its name from the plane. Thus a ***horizontal line*** is a line in a horizontal plane, a ***frontal line*** is a line in a frontal plane, and a ***profile line*** is a line in a profile plane. When a line is parallel to two planes, the line takes the name of both planes, as ***horizontal-frontal***, ***horizontal profile***, or ***frontal-profile***.

A line not parallel to any plane of projection is called an ***oblique*** or ***skew line***.

Figure below shows various positions of lines.



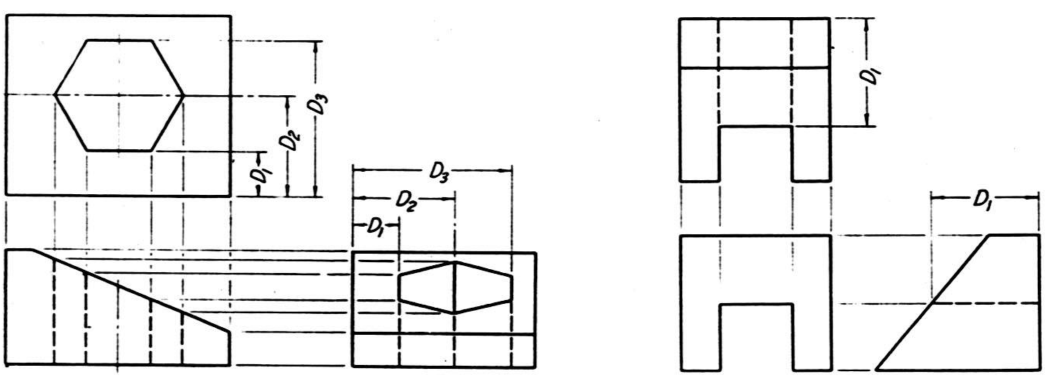
An edge appears in true length when it is parallel to the plane of projection, as a point when it is perpendicular to the plane, and shorter than true length when it is inclined to the plane. Similarly, a surface appears in true shape when it is parallel to the plane of projection, as a line when it is perpendicular to the plane, and foreshortened when it is inclined to the plane.

After laying out the views, locate and draw the various features of the object. in doing this, carry the views along together, that is, do not attempt to complete one view before proceeding to another.

Projections between the top and side views cannot be projected directly but must be.

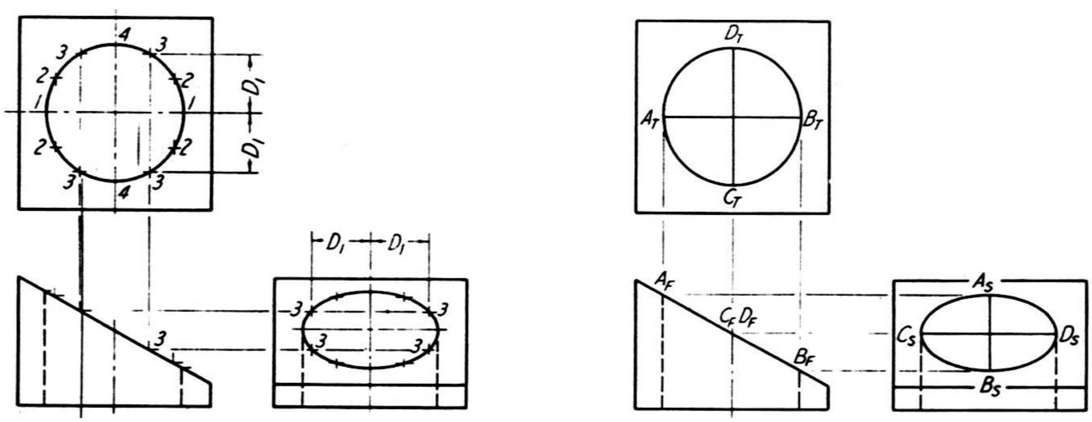
a) Measured and transferred
b) Transferring using a 45° line drawn through the point of intersection of the top and side views of the front face, extended as shown in figure, below.

6.5 PROJECTIONS OF SURFACES



Projections of surfaces bounded by linear edges

Depth measurement cannot be projected directly with tee square and triangle and they must be transferred.

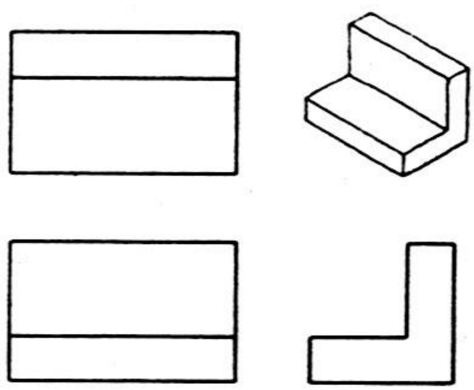


Projections of an elliptical boundary

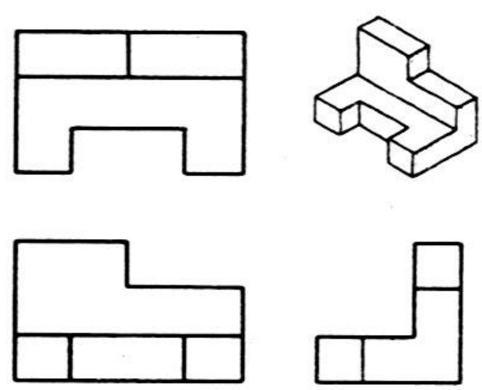
Points on the curve are projected to determine the curve A, or the curve is determined by major and minor diameters.

PROJECTION STUDIES

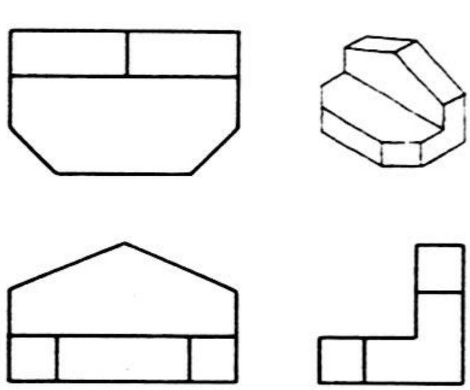
Study each picture and the accompanying orthographic views and note the projection of all features.



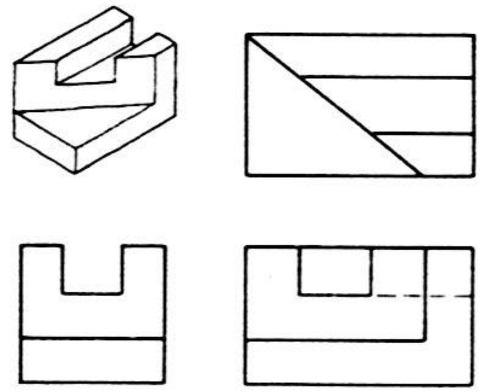
Picture 1



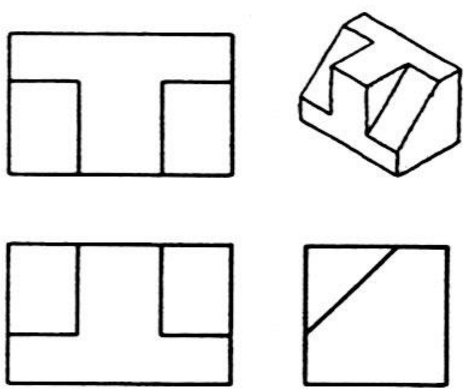
Picture 2



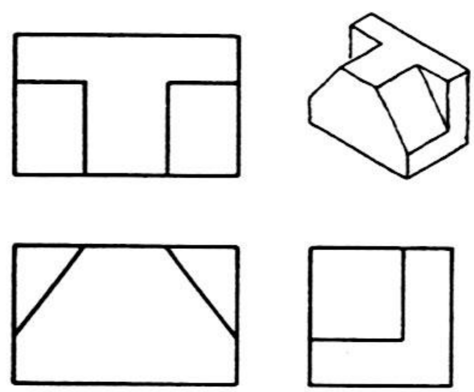
Picture 3



Picture 4

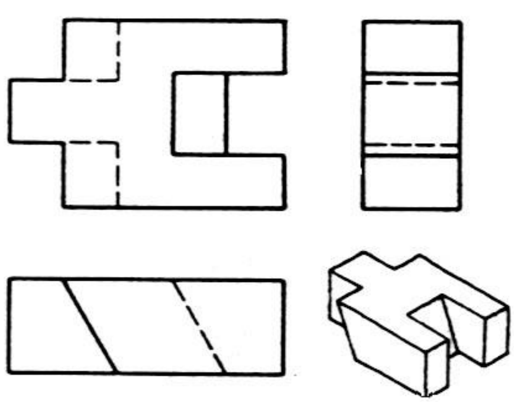


Picture 5

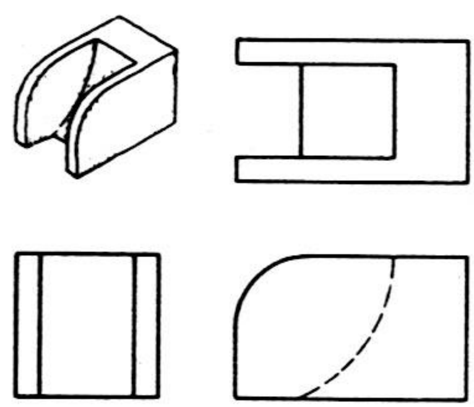


Picture 6

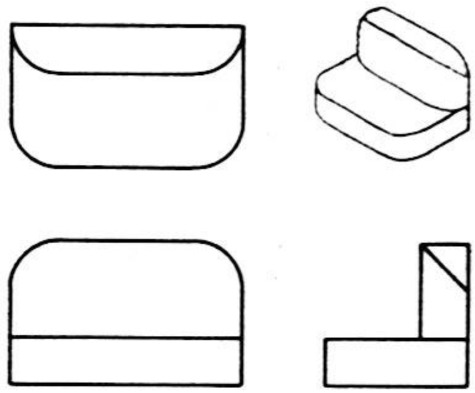
Study each picture and the accompanying orthographic views and note the projection of all features.



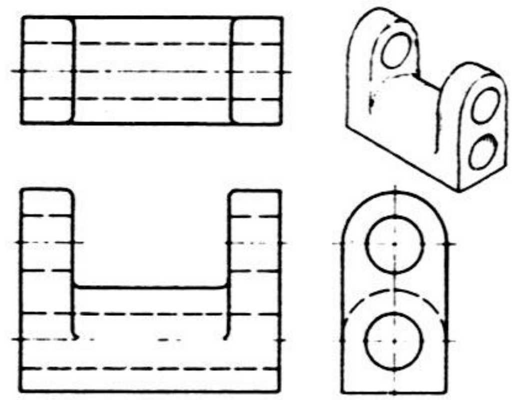
Picture 7



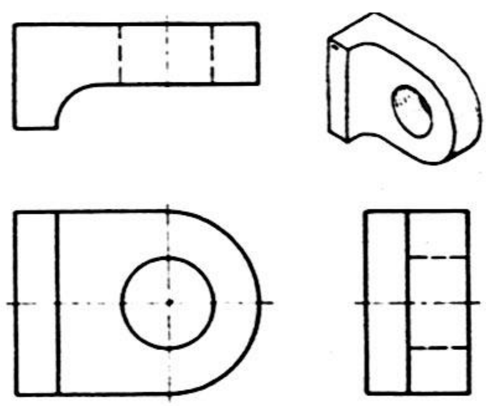
Picture 8



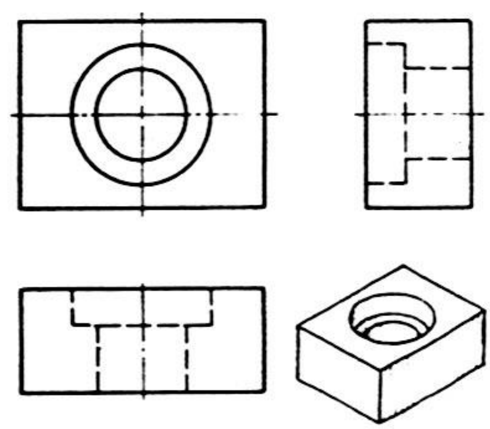
Picture 9



Picture 10



Picture 11

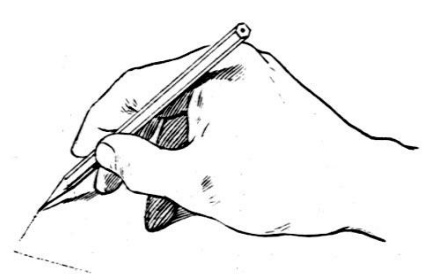


Picture 12

6.6 FREE HAND DRAWING

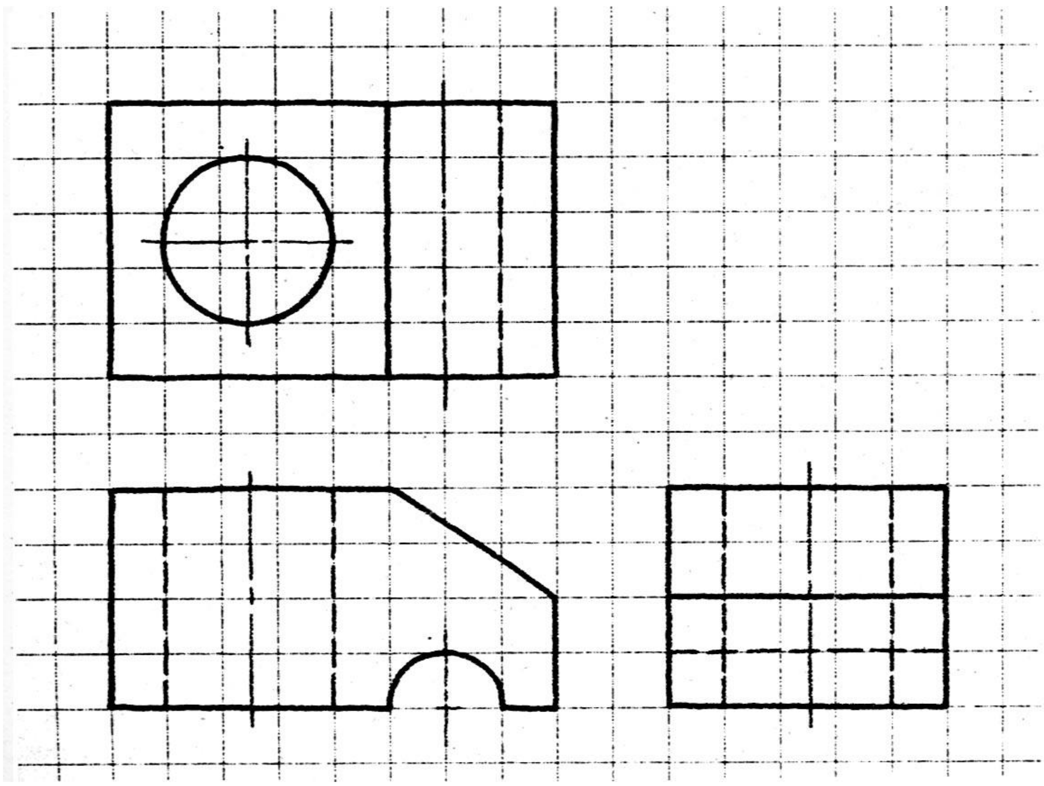
Facility in making freehand orthographic drawings is an essential part of the equipment of every engineer.

Sketching a vertical line



Sketching a horizontal line

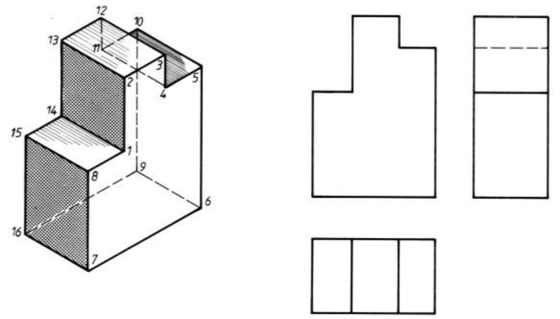
The pencil is held with freedom and not close to the point. Vertical lines are drawn downward with a finger movement in a series of overlapping strokes, the hand somewhat in the position. Horizontal lines are drawn with the hand shifted to the position, using a wrist motion for short lines and a forearm motion for longer ones.

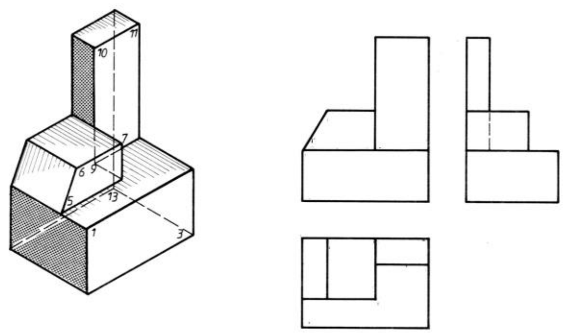


A freehand drawing on coordinate paper (actual size)

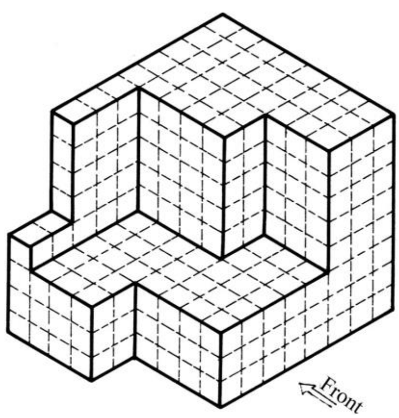
EXERCISE 16

1- Write down the identification numbers of the matching corners on the projection drawings and the name of views underneath.

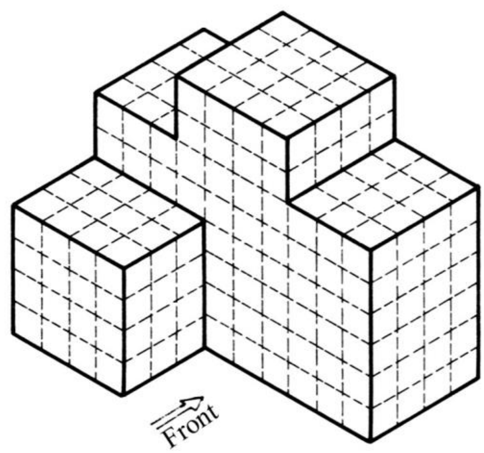




2- Translate the following objects into six-view orthographic free hand drawings.

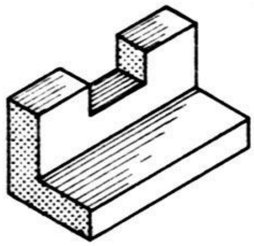


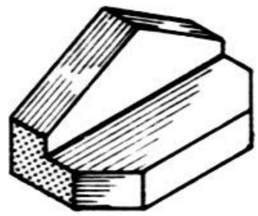
object A

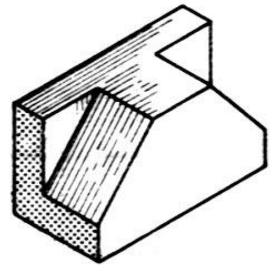


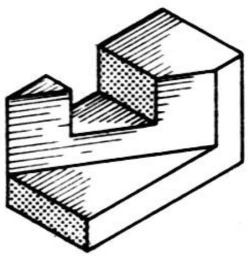
Object B

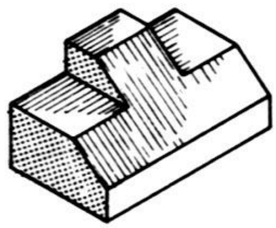
3- Translate the following pieces of various shapes into four-view (Front view, top view, left side view and right side view) orthographic free hand drawings.

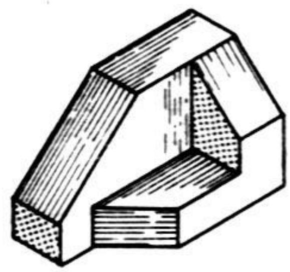

a)


b)


c)


d)


e)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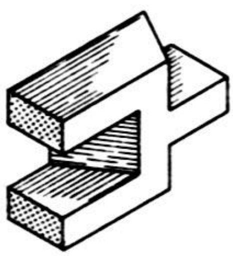
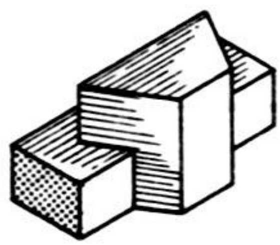
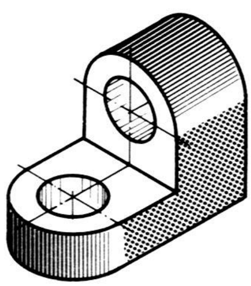
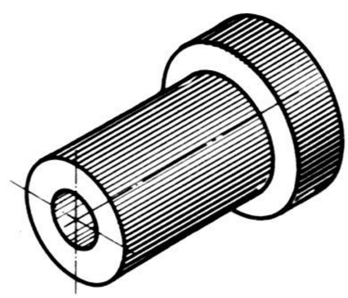
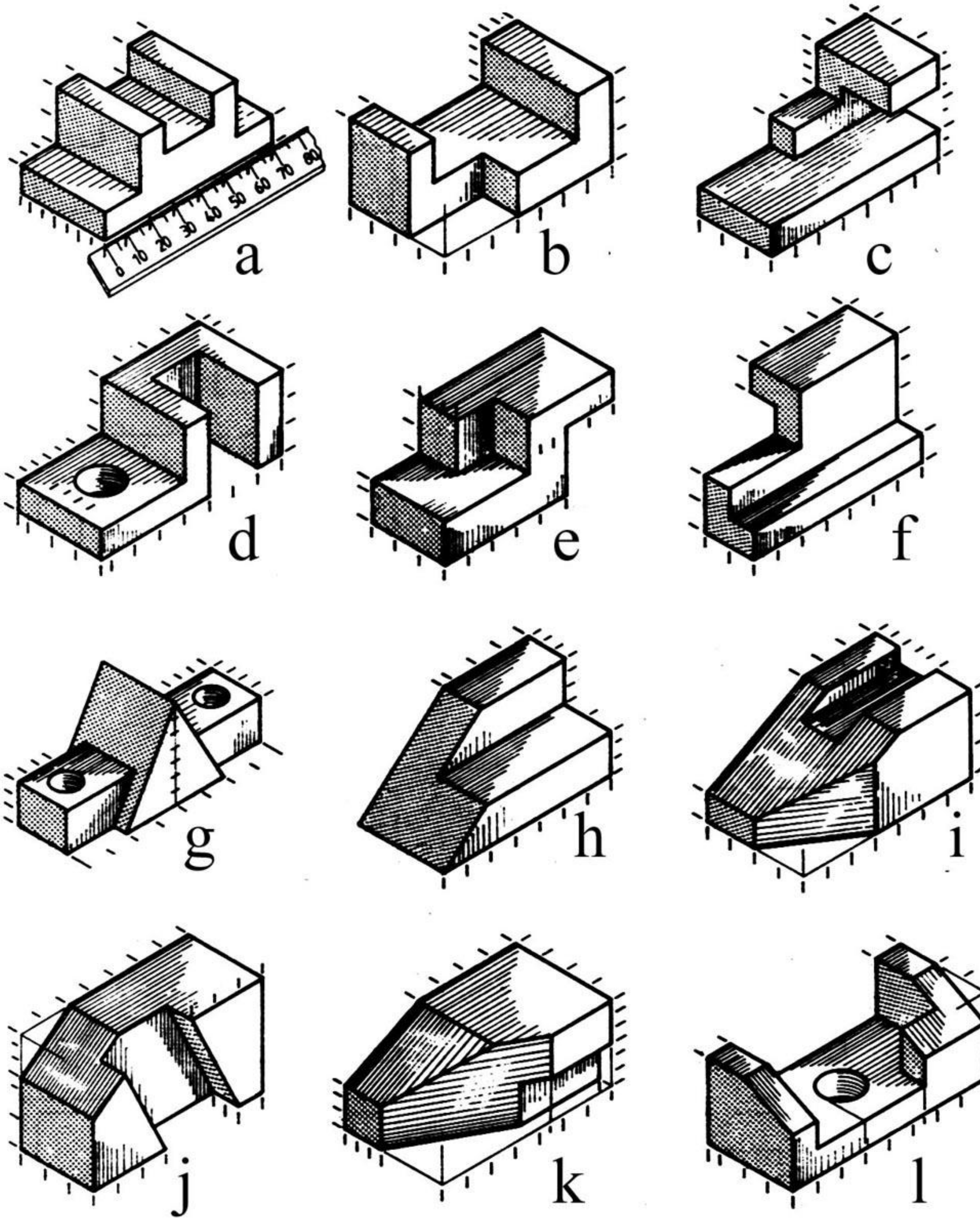

g)


h)

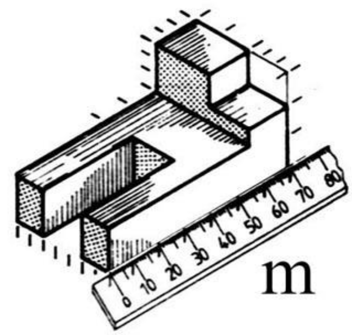

i)


j)

4- Translate the following pieces of various shapes into six-view orthographic drawings.


0 10 20 30 40 50 60 70 80
a
b
c
d
e
f
g
h
i
j
k
l

4- Translate the following pieces of various shapes into six-view orthographic drawings.



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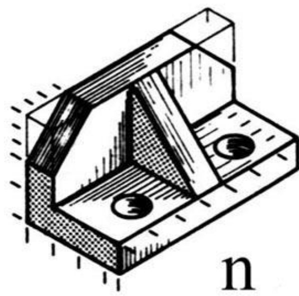
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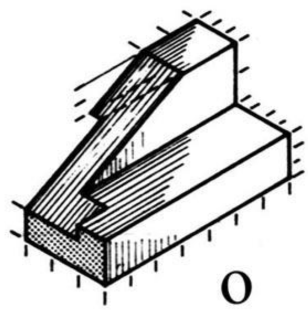
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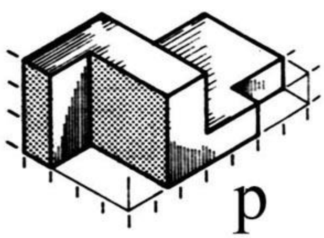
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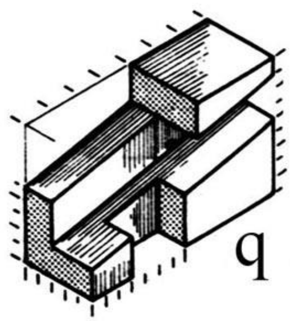
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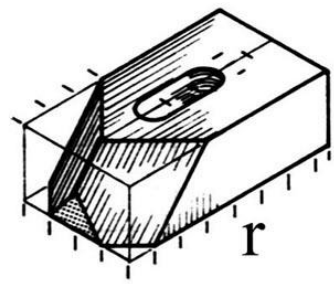
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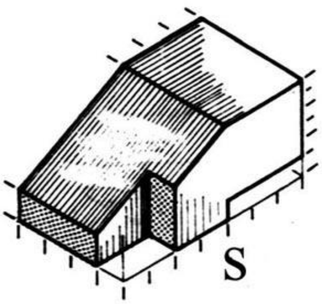
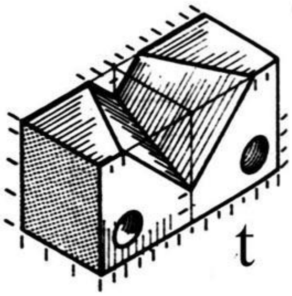

s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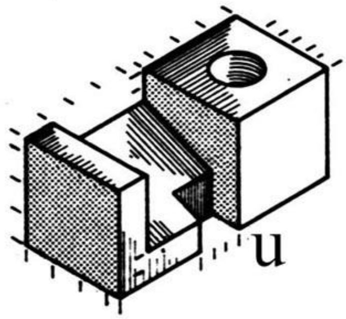
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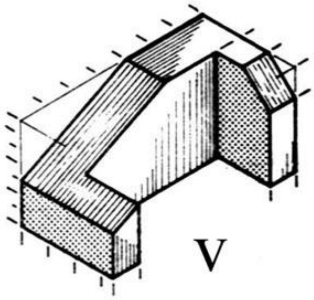
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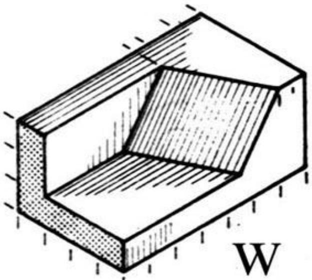
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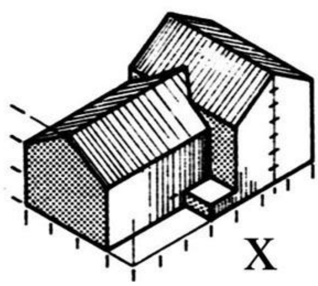
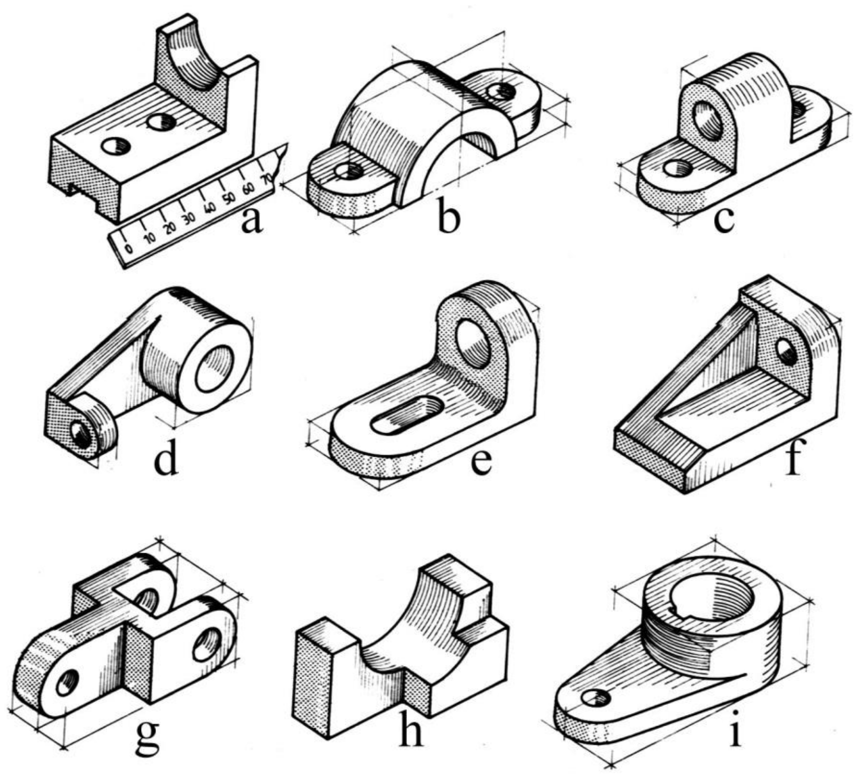
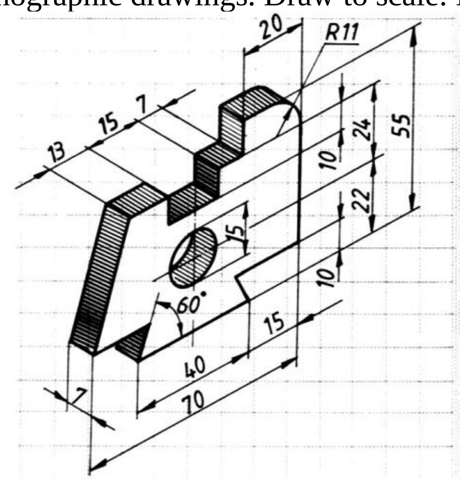
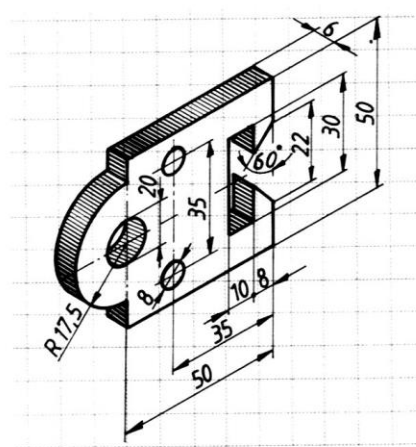

x

5-Translate the following pieces of various shapes into three- best choice-view orthographic drawings.

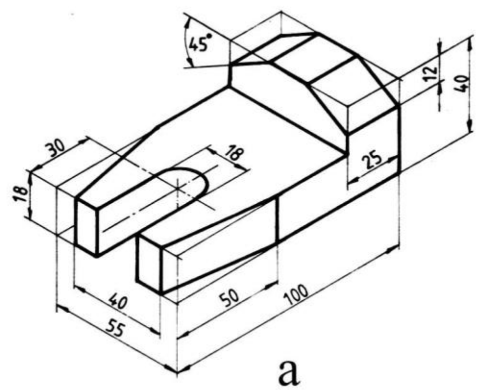


6- Translate the following pieces of various shapes into three-best choice-view orthographic drawings. Draw to scale. Dimensions in mm.

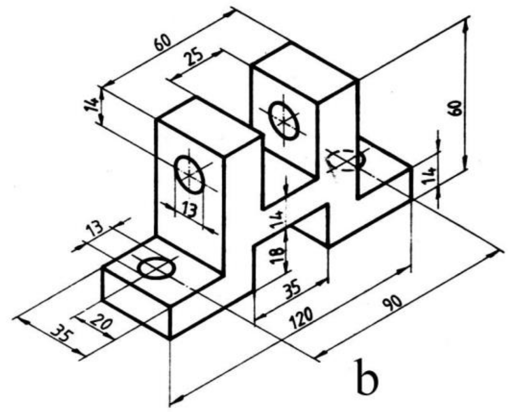




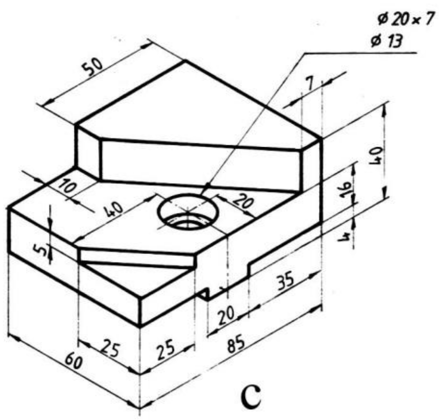
7- Translate the following pieces of various shapes into three-best choice-view orthographic drawings. Draw to scale. Dimensions in mm.



a



b



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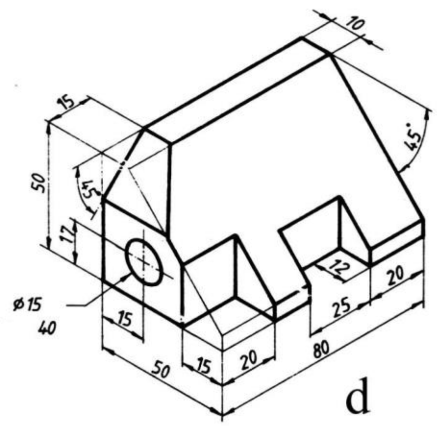

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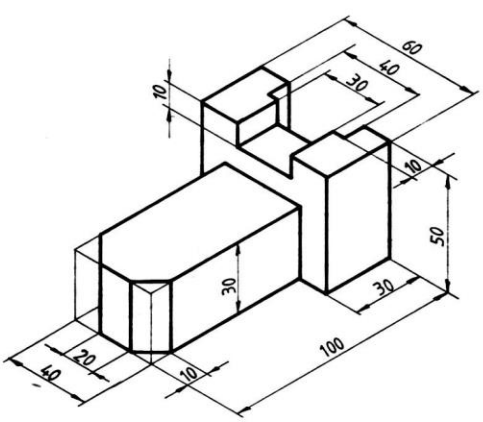

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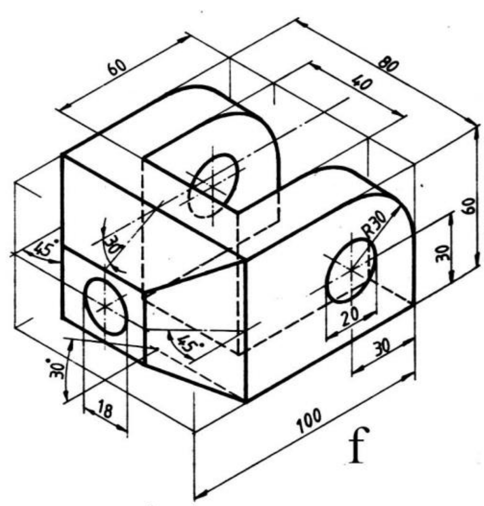
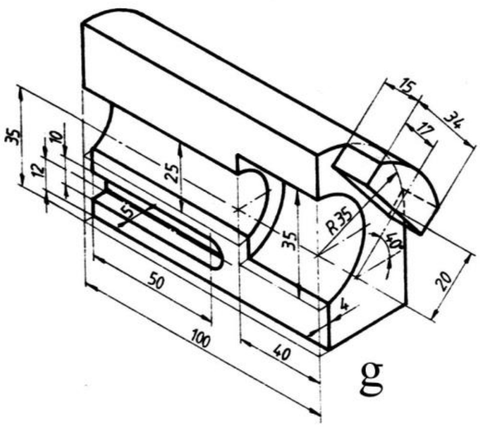
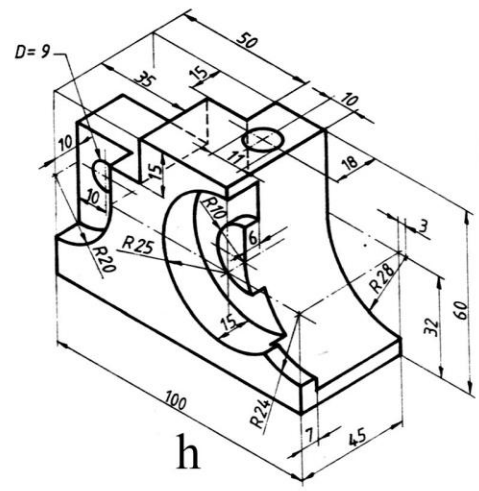


f

7- Translate the following pieces of various shapes into three-best choice-view orthographic drawings. Draw to scale. Dimensions in mm. (Exercise 16.7 Continued)



g



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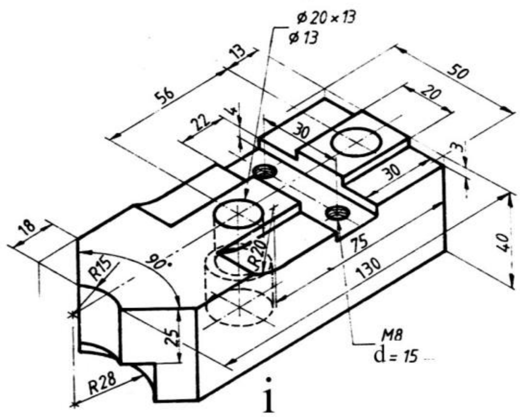

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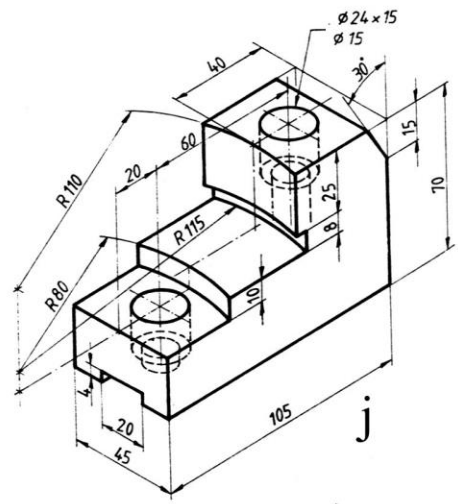

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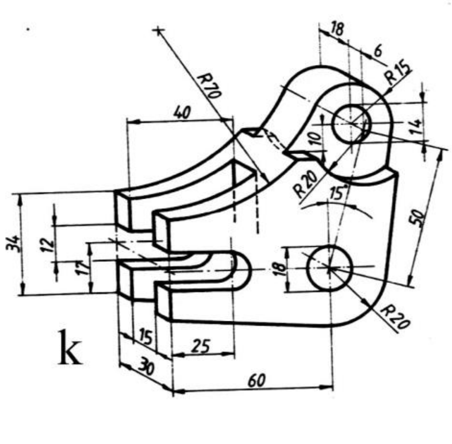

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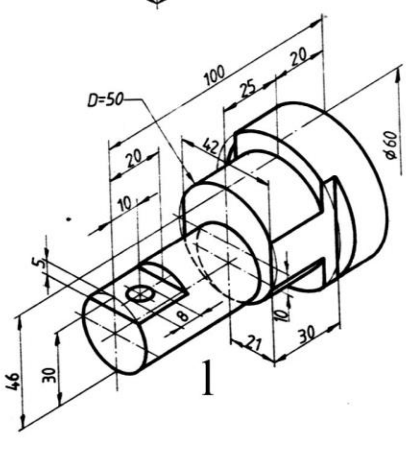
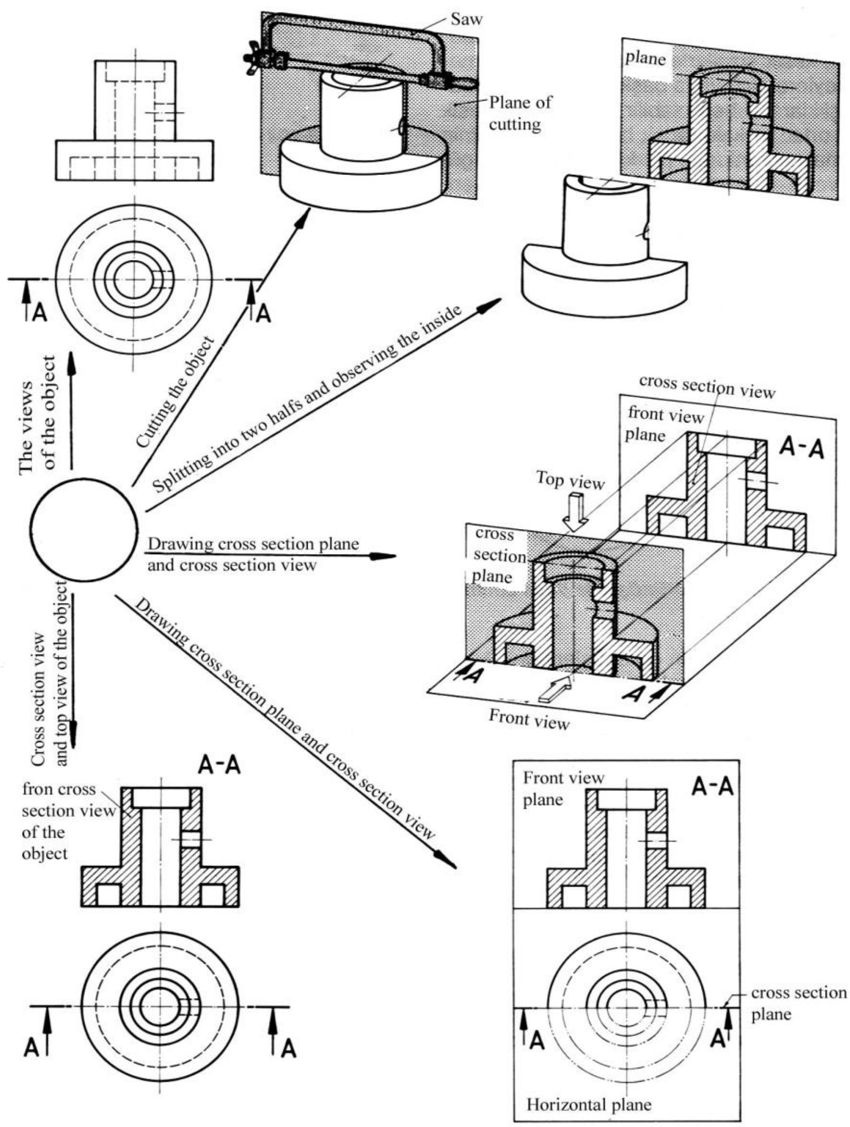


l

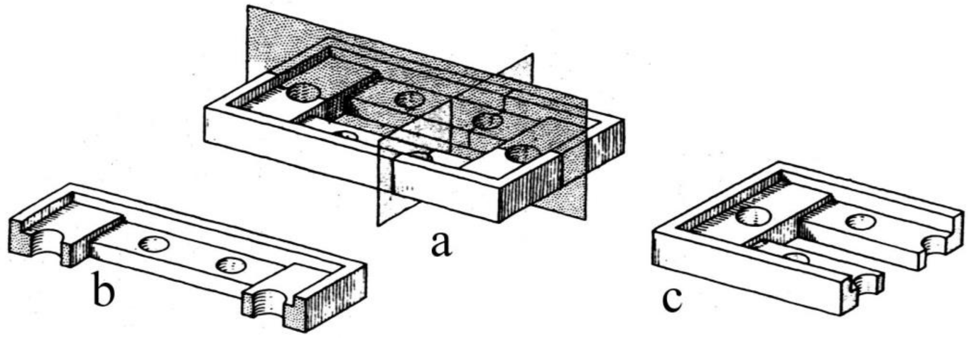
CROSS SECTION **CHAPTER 7**

7.1 CROSS SECTION

Section is defined as an imaginary cut made through an object to expose the interior or to reveal the shape of a portion.



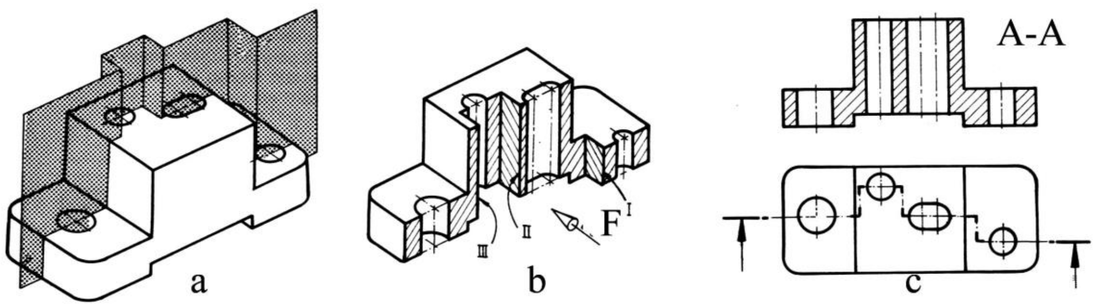
Sectional view or **Cross section** is the view in which all or a substantial portion of the view is sectioned.



Advantage of sectional views. *(a)* orthographic view showing the concept of cross sectional cutting planes; *(b)* longitudinal cross sectional shape of the object shown by removed section (c) lateral cross sectional shape of the object shown by removed section.

HOW SECTIONS ARE SHOWN

The place from which the section is taken must be identifiable on the drawing, and the solid portions and voids must be distinguished on the sectional view. The place from which the section is taken is in many cases obvious,

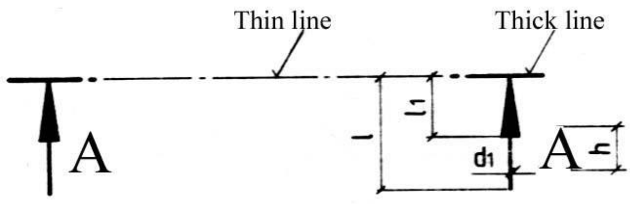


the section is quite evidently taken through the center (at the center line of the top view). In such cases no further description is needed. If the place from which a section is taken is not obvious, a ***cutting plane***, directional arrows, and identification letters are used to identify it.

Whenever there is any doubt of the position where the section is taken, the cutting plane should be shown. A cutting plane is the imaginary medium used to show the path of cutting an object to make a section.

A sectional view must show which portions of the object are solid material and which are spaces. This is done by section lining, sometimes called "**crosshatching**", the solid parts with lines, as shown at figure ***b& c*** above.

DIRECTIONAL ARROWS AND IDENTIFICATION LETTERS



h = 1.41 or 2 times the height of letter used in drawing
l_1 = 1.41 times h
l = 2 times l_1
d_1 = Same thickness of the thick line used in drawing

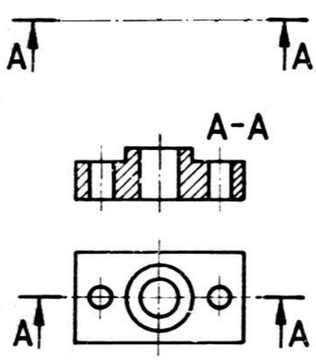
In general, the rules of projection are followed in making sectional views.

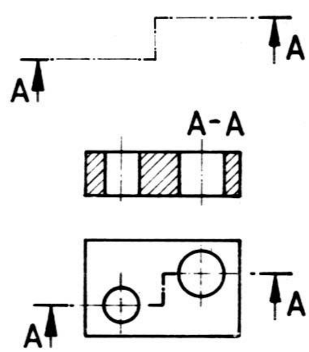
The Cutting-plane Symbol. It may be shown on the orthographic view where the cutting plane appears as an edge and may be more completely identified with reference letters along with arrows to show the direction in which the view is taken. The cutting-plane line symbol is shown in the alphabet of lines. Use of the symbol is illustrated above.

Often when the position of the section is evident, the cutting-plane symbol is omitted. It is not always desirable to show the symbol through its entire length; so in such cases the beginning and ending of the plane is shown, as in sections of the drawing on the next page. Removed sections usually need the cutting-plane symbol with arrows to show the direction of sight and with letters to name the resulting sectional view.

Unnecessary Hidden Detail. Hidden edges and surfaces are not shown unless they are needed to describe the object. Much confusion may result if all detail behind the cutting plane is drawn.

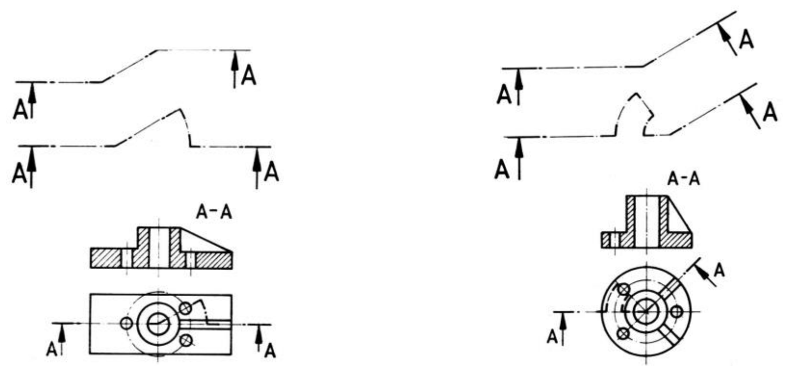
TYPES AND PLACES OF CUTTING PLANE AND SECTIONS





Straight across cutting plane

Off setting (Stepping) cutting plane



a **b**

Cutting plane passing through features to be shown

TYPES OF SECTIONS

Although the different sections and sectional views have been named for identification and for specifying the type of view required in a drawing, the names are not shown on the drawing for the same reason that a top, front, or side view would not be so labeled- the views are easily interpreted and a workman does not require the name to read the drawing.

Full section : The cutting plane passes entirely across the object.

Half section : View sometimes used for symmetrical objects in which one-half is drawn in section and the other half as a regular exterior view.

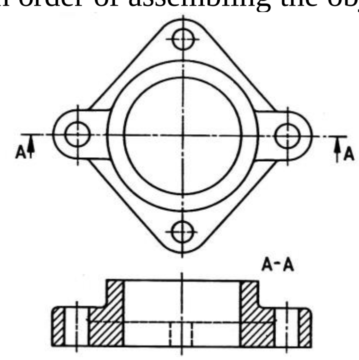
Broken-out section : The cutting plane extended so far as needed.

Rotated section : To show a shape that would otherwise be difficult to see or describe.

Removed section : Drawn for the same purpose as rotated section but instead of being drawn on the view, they are removed to some place on the paper.

Auxiliary section : The section shows the normal view of the cutting plane that is in a position on an inclined feature so as to reveal the interior.

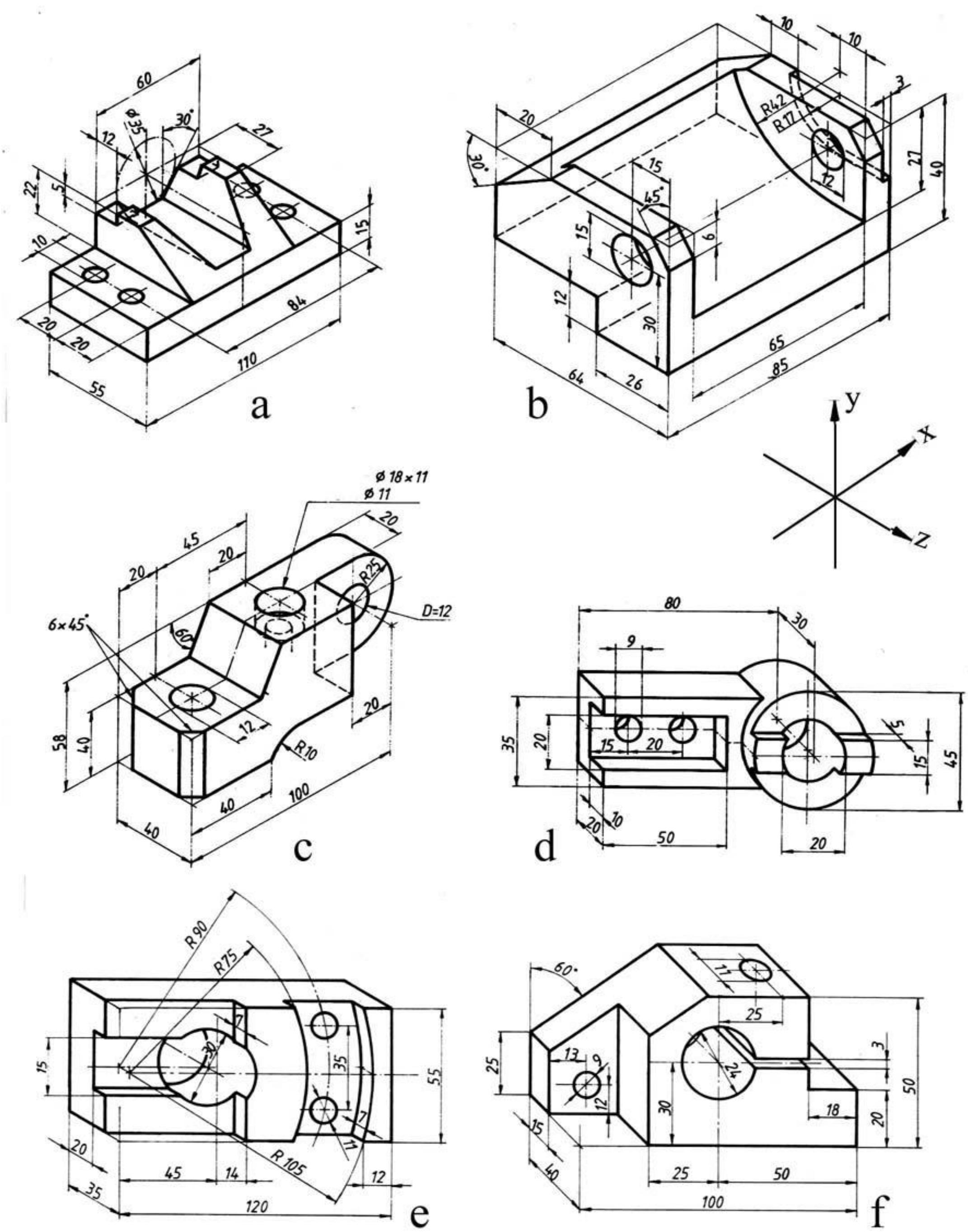
Assembly section : An assembly section is made up of a combination of parts, that are drawn in order of assembling the object.



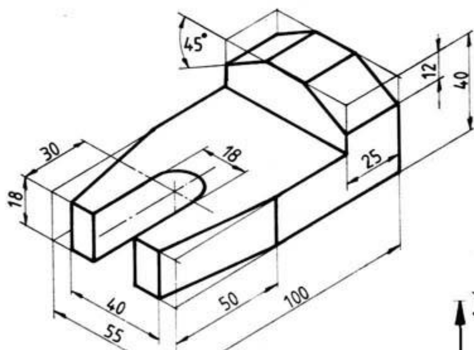
Necessary hidden edges and surfaces should be shown with dotted lines in the cross section

EXERCISE 17

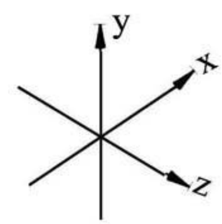
1- Draw cross sections of the below objects where cutting plane crosses through the centers of the objects, along **x, y, z** axes.

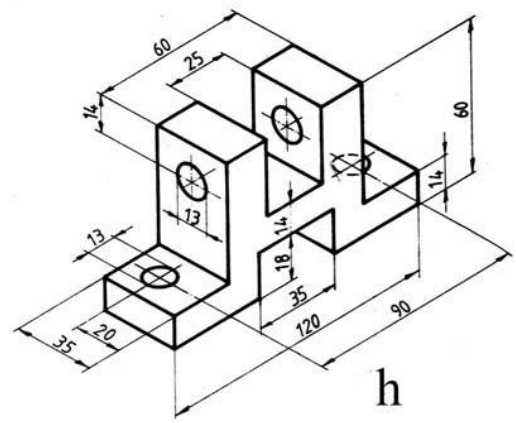


1- Draw cross sections of the below objects where cutting plane crosses through the centers of the objects, along **x, y, z** axes. (Exercise 17.1 Continued)

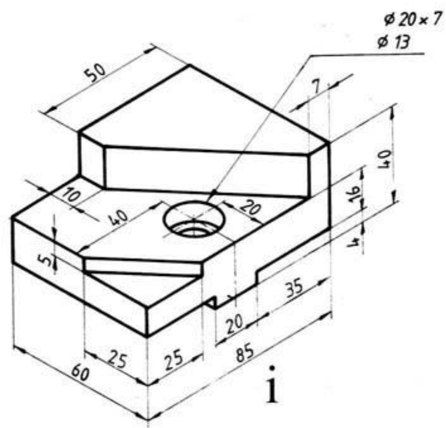


g





h



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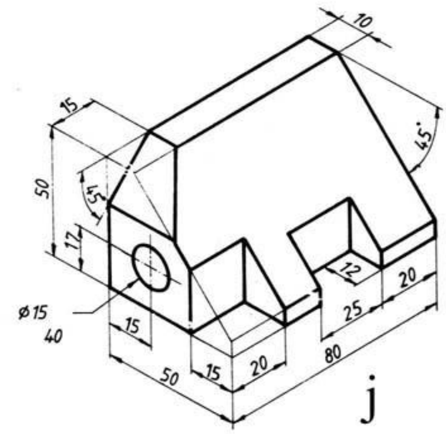

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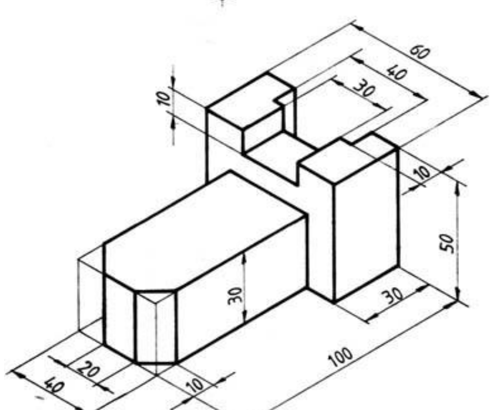

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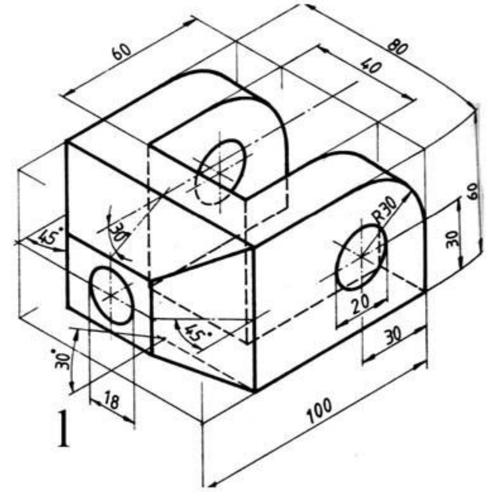
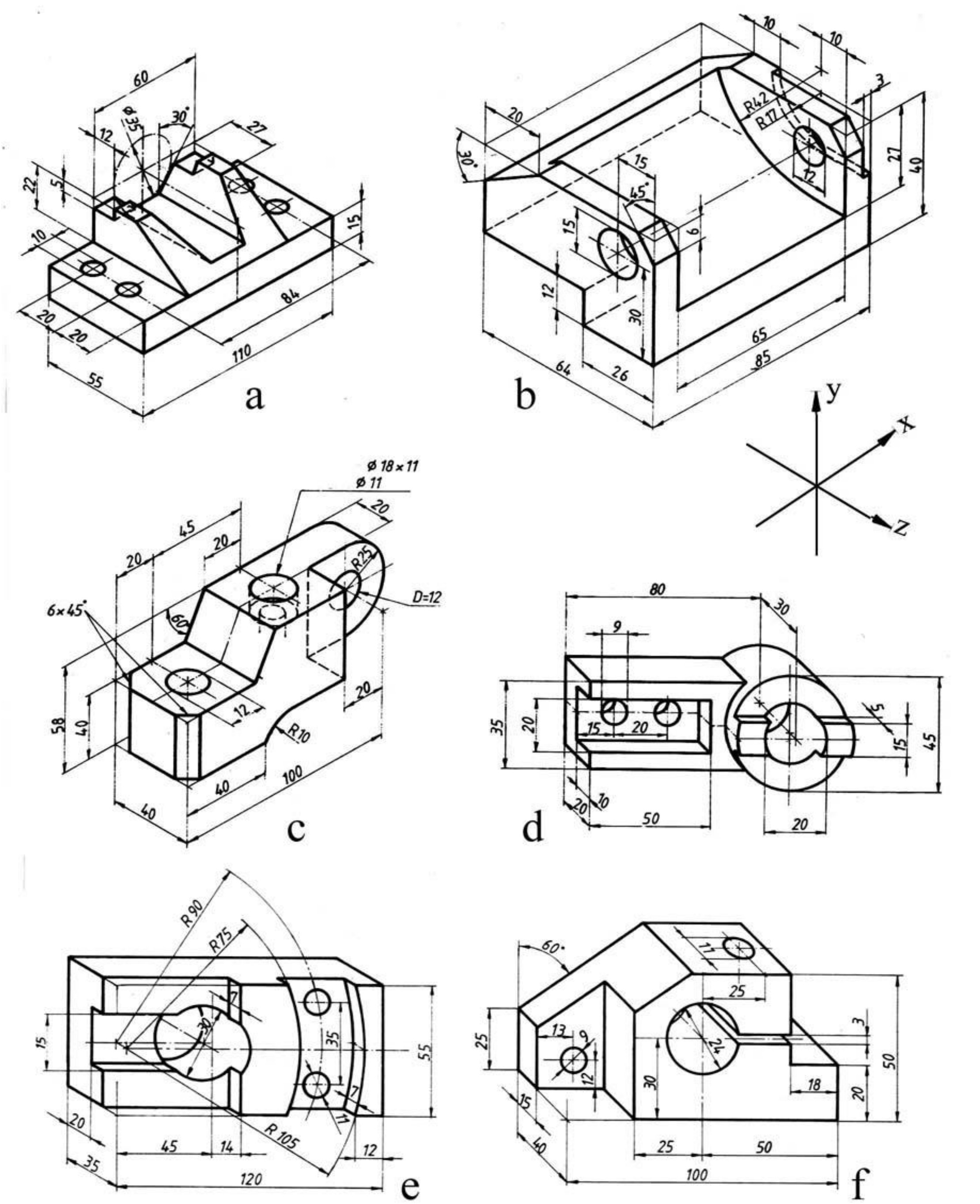


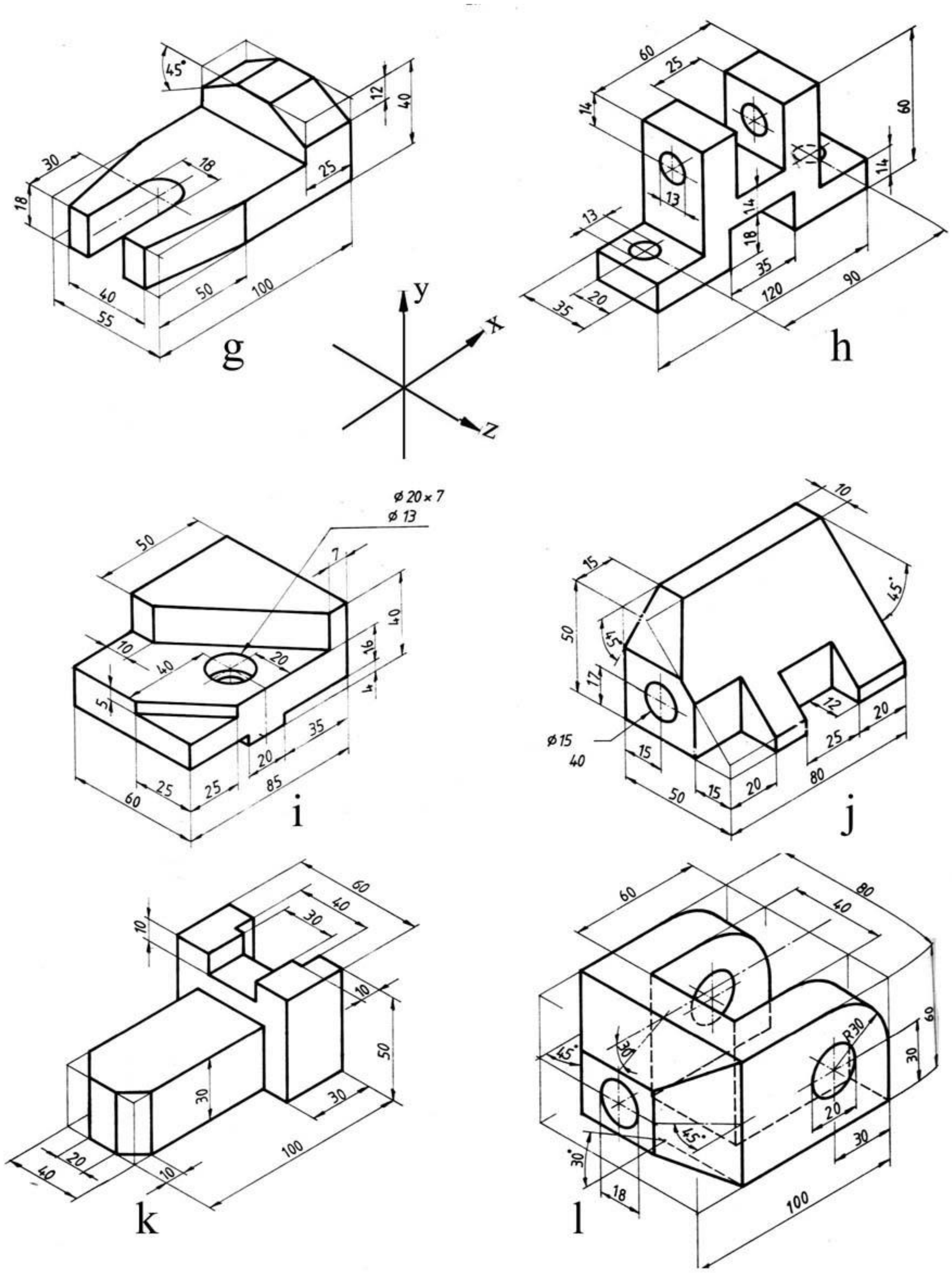
l

EXERCISE 18

1- Draw cross sections of the below objects where cutting plane crosses through the centers of the objects, along **x, y, z** axes.

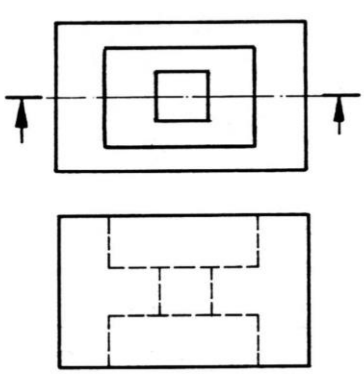


Draw cross sections of the below objects where cutting plane crosses through the centers of the objects, along **x, y, z** axes. (Exercise 18.1 Continued)

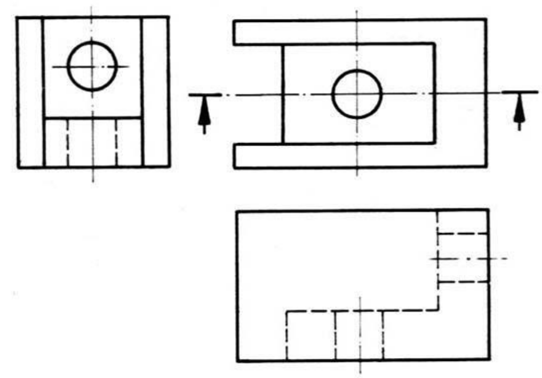


EXERCISE 19

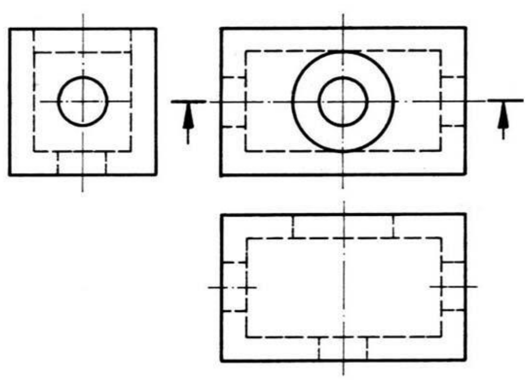
2- According to the cross section plane defined, convert the orthographic views to cross sectional drawings.



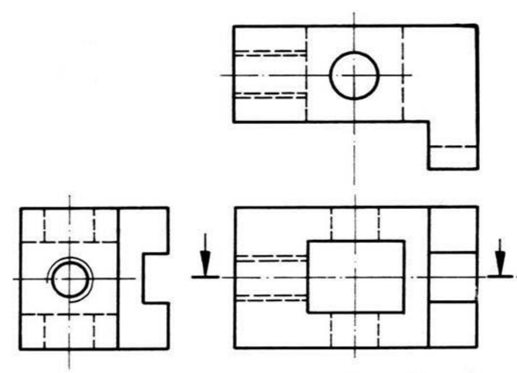
Exercise a



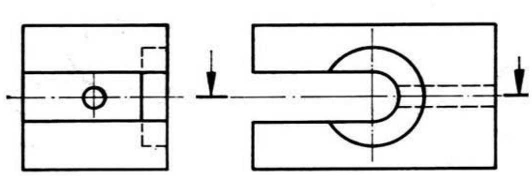
Exercise b



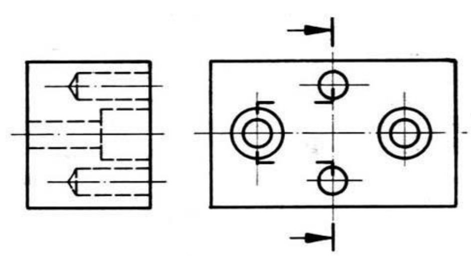
Exercise c



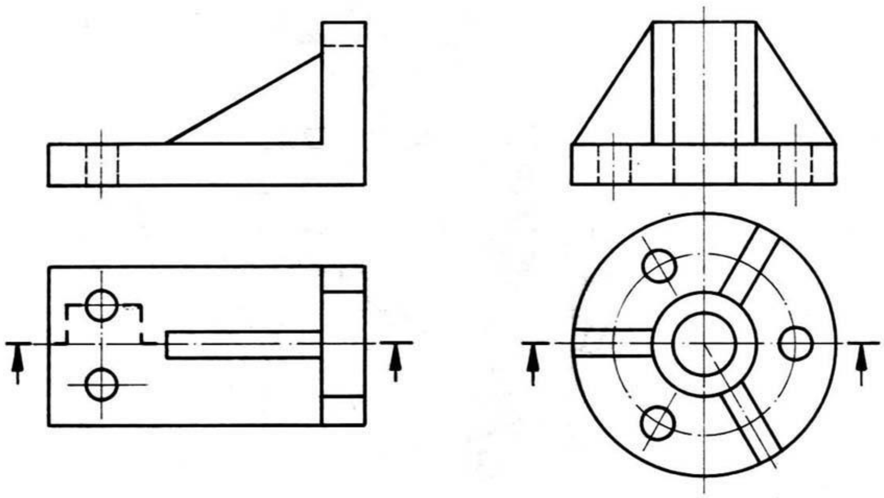
Exercise d



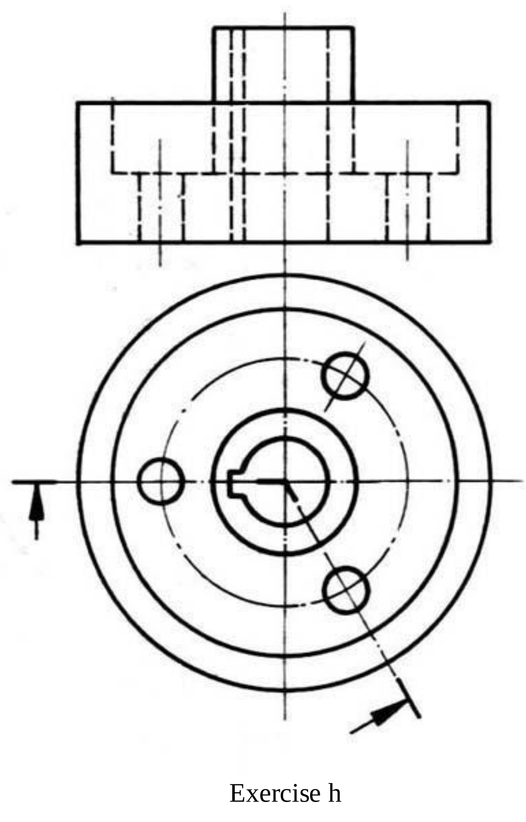
Exercise e



Exercise f



Exercise g



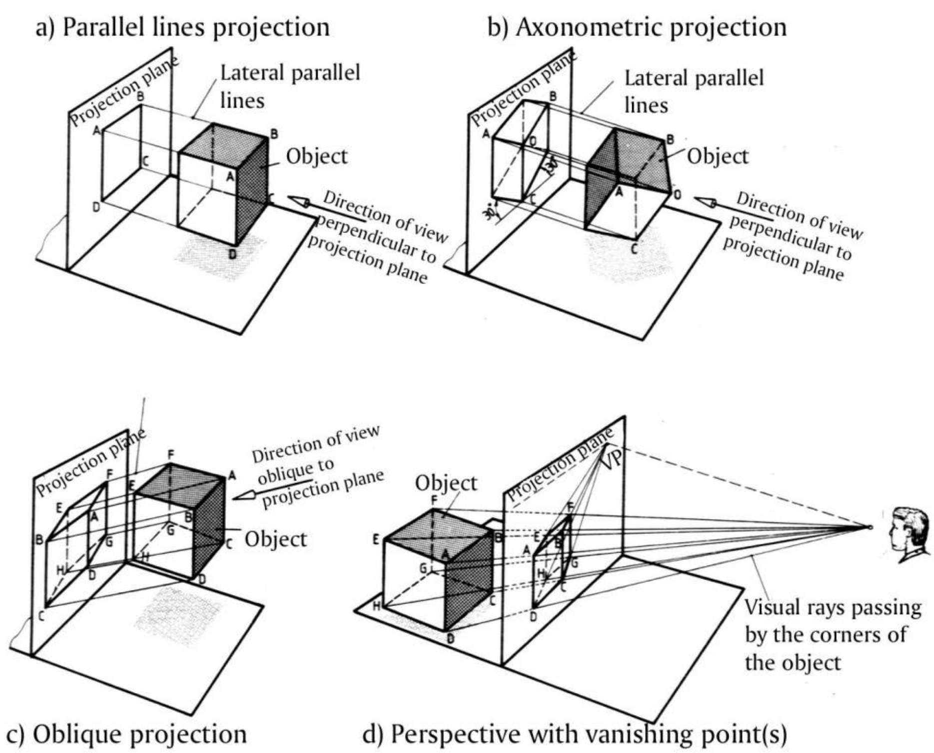
Exercise h

PICTORIAL DRAWING CHAPTER 8

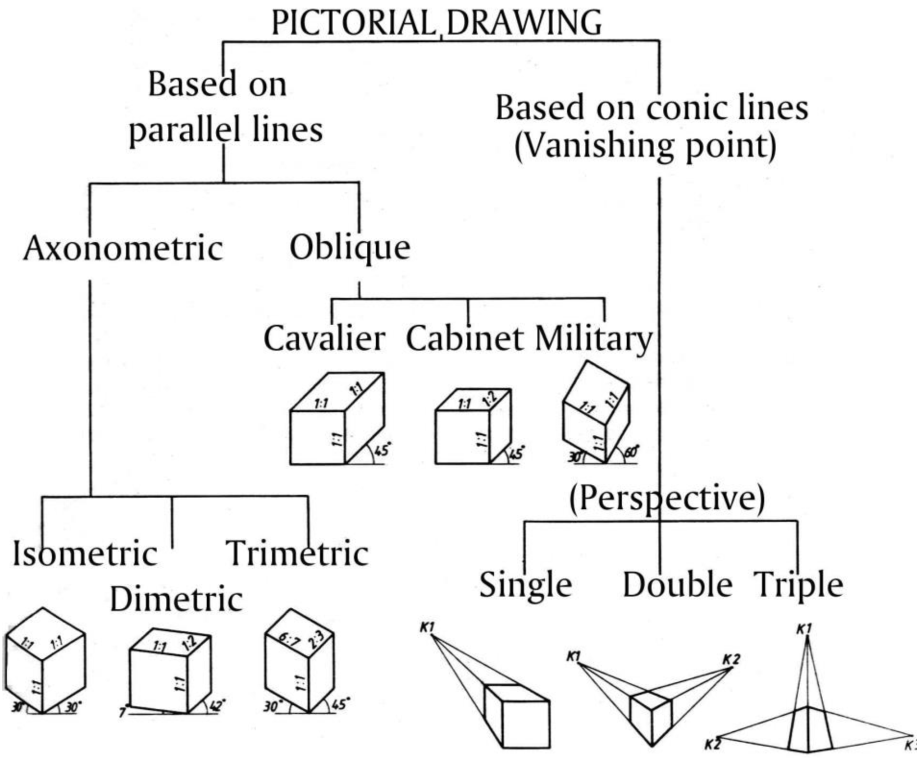
8.1 PICTORIAL DRAWING

In projection the object is represented as it appears to the eye. However, its lines cannot be measured directly for accurate description of the object; and in orthographic projection the object is shown, in two or more views, as it really is in form and dimensions but interpretation requires experience to visualize the object from the views.

To provide a system of drawing that represents the object pictorially and in such a way that its principal lines can be measured directly, several forms of one-plane conventional or projectional picture methods have been devised in which the third dimension is taken care of either by turning the object so that its three dimensions are visible or by employing oblique projection. A knowledge of these picture methods and of perspective projection is extremely desirable as they can all be used to great advantage.



Mechanical or structural details not clear in orthographic views can be drawn pictorially or illustrated by supplementary pictorial views. Pictorial views are used advantageously in technical illustrations, Patent Office drawings, layouts, piping plans, and the like. Pictorial methods are useful also in making freehand sketches, and this is one of the most important reasons for learning them.



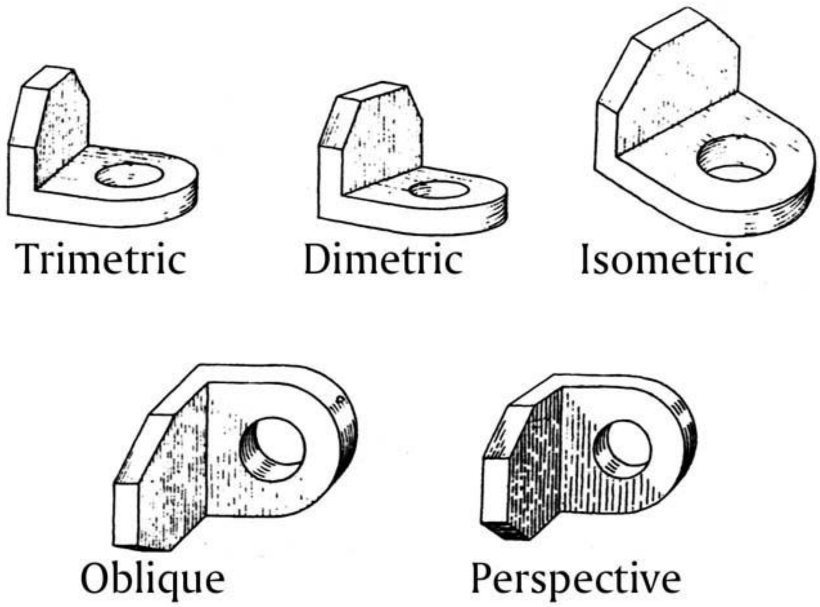
PICTORIAL METHODS

There are three main divisions of pictorial drawing:
Axonometric, with its divisions into ***Isometric***, ***Dimetric***, and ***Trimetric***;
Oblique, with its divisions into ***Cavalier***, ***Cabinet*** and ***Military***,
Perspective, with its divisions based on the number of ***Vanishing points***.

The ***trimetric*** form gives an effect more pleasing to the eye than the other axonometric and oblique methods and allows almost unlimited freedom in orienting the object, but is difficult to draw.

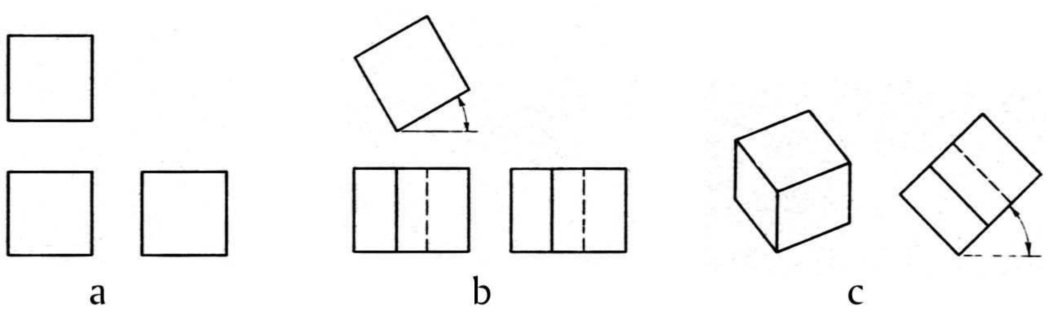
With the ***dimetric*** method the result is less pleasing and there is less freedom in orienting the object, but execution is easier than with trimetric. The ***isometric*** method gives a result less pleasing than dimetric or trimetric, but it is easier to draw and has the distinct advantage that it is easier to dimension.

The ***oblique*** method is used principally for objects with circular or curved features only on one face or on parallel faces and for objects of this type the oblique is easy to draw and dimension. Perspective drawing gives a result most pleasing to the eye, but it is of limited usefulness because many lines are unequally foreshortened; isometric and oblique are the forms most commonly used.



8.2 AXONOMETRIC PROJECTION

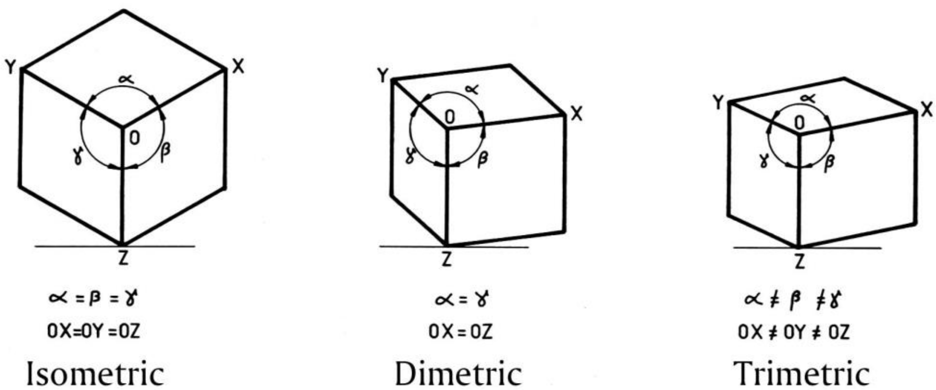
Axonometric projection is theoretically orthographic projection in which only one plane is used, the object being turned so that three faces show. Imagine a transparent vertical plane with a cube behind it, one face of the cube being parallel to the plane. The projection on the plane, that is, the front view of the cub will be a square (Figure **a**).



Rotate the cube about a vertical axis through any angle less than 90°, and the front view will now show two faces, both foreshortened (Figure **b**).

From this position, tilt the cube forward (rotation axis perpendicular to profile) any amount less than 90°. Three faces will now be visible on the front view (Figure **c**).

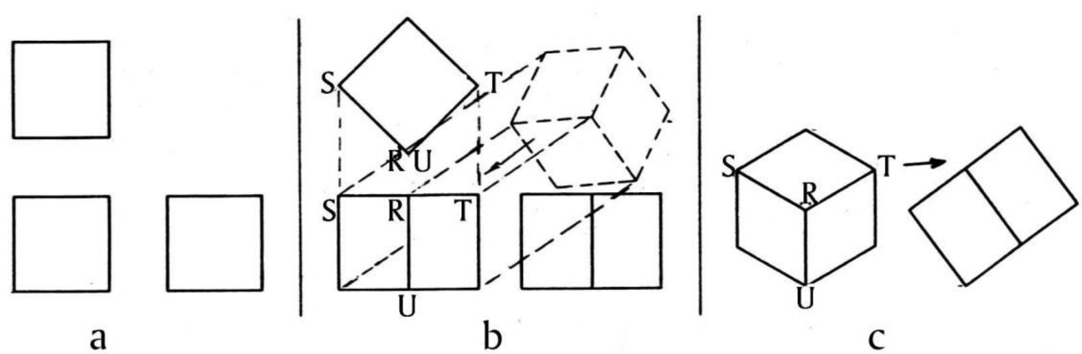
There can be an infinite number of axonometric projections, depending upon the angles through which the cube is rotated. Only a few these positions are ever used for drawing.



The simplest is the ***isometric*** (equal measure) position, in which the faces are foreshortened equally.

ISOMETRIC PROJECTION.

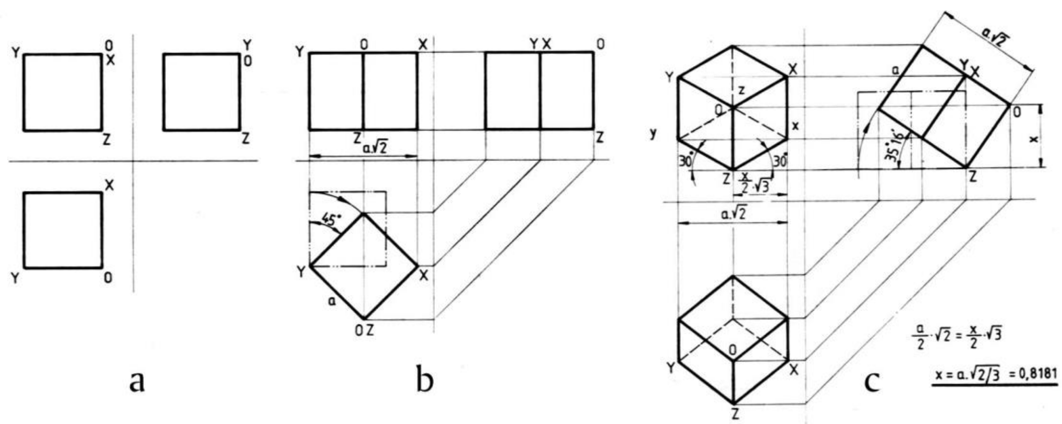
If the cube in below figure **a** is rotated about a vertical axis through 45°, as shown at **b**, then tilted forward, as at **c**, until edge **RU** is foreshortened equally with **RS** and **RT,** the front view of the cube in this position is said to be an, "***Isometric projection***". (The cube has been tilted forward until the body diagonal through **R** is perpendicular to the front plane. This makes the top face slope approximately 35° 16') The projections of the three mutually perpendicular edges **RS**, **RT** and **RU** meeting at the front corner **R** makes equal angles, 120^0, with each other and are called "***Isometric axes***".



DIMENSIONS OF ISOMETRIC PROJECTIONS

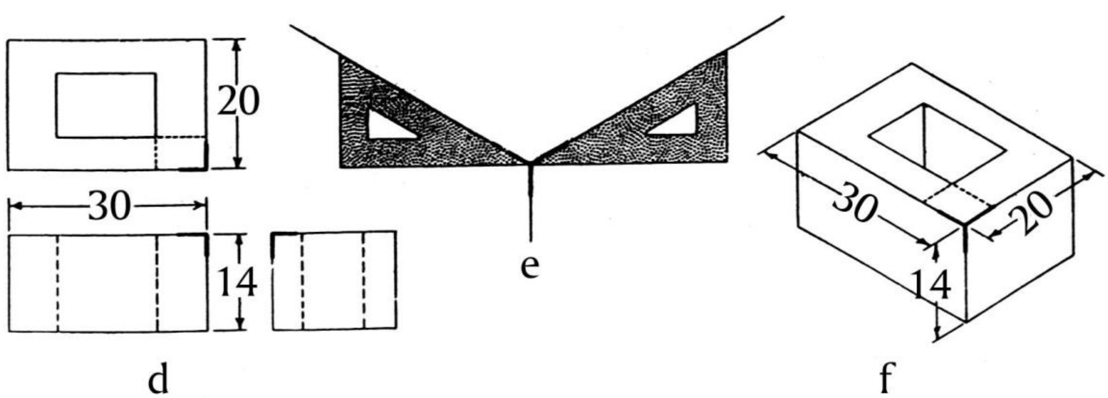
In nearly all practical use of the isometric system, this foreshortening of the lines is disregarded, and ***their full lengths are laid off on the axes*** , as explained before. This gives a figure of exactly the same shape but larger in proportion of 1.00 to 0.8181 linear.

Except when drawn beside the same piece in orthographic projection, the effect of increased size is usually of no consequence, and since the advantage of measuring the lines directly is of great convenience, isometric drawing is used almost exclusively rather than isometric projection.



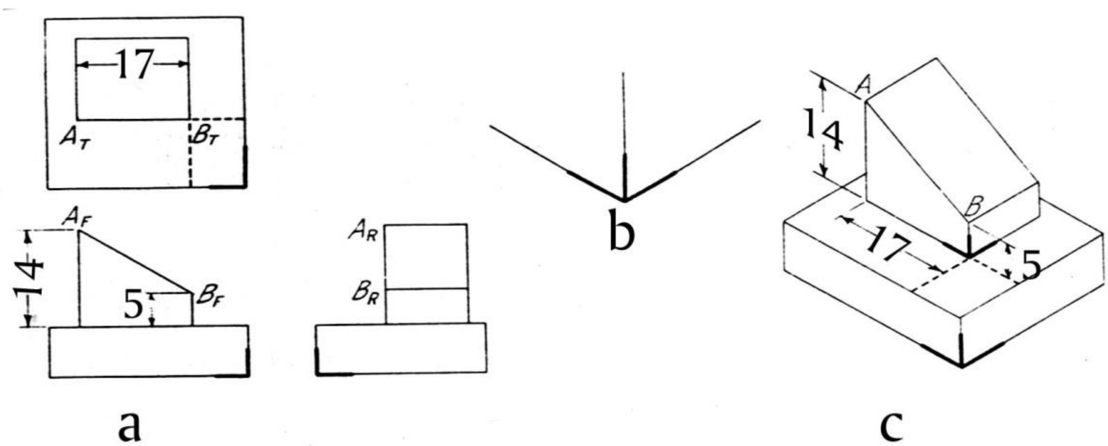
ISOMETRIC DRAWING

If the object is rectangular in shape, start with a point representing a front corner, shown at (**d**) of figure below, with heavy lines and draw from it the three isometric axes 120° apart one vertical (**e**), the other two with the 30° triangle.



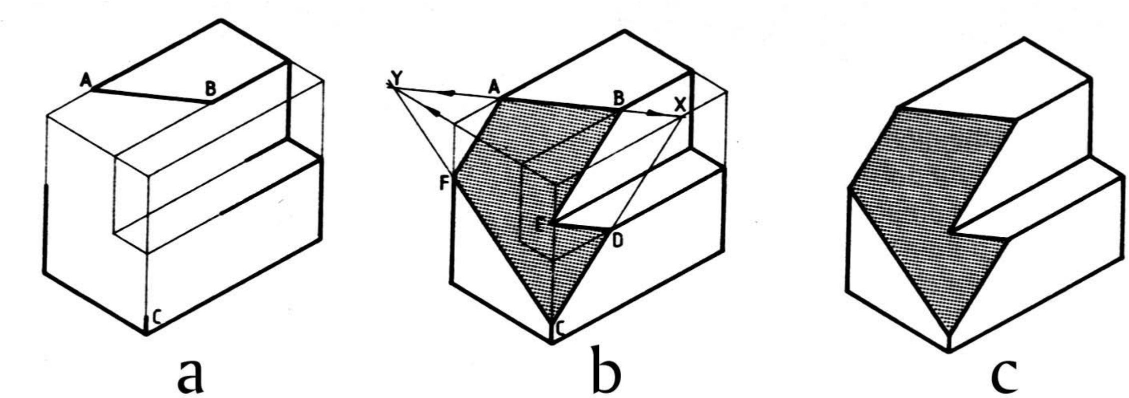
On these three lines measure the height, width and depth of the object, as indicated at (**f**). through the points so determined draw lines parallel to the axes, completing the figure. Measurements can be made only on the drawings of ***Isometric Lines***.

Conversely, measurements cannot be made on the drawings of ***Non-Isometric*** lines.



In the figure shown above, the line AB is a ***nonisometric*** edge whose true length cannot be measured on the isometric drawing. Since the vertical distances above the base to points A and B are parallel to the vertical isometric axis, they can be laid off as shown in step (C)

ISOMETRIC PROJECTION OF IRREGULAR SURFACES

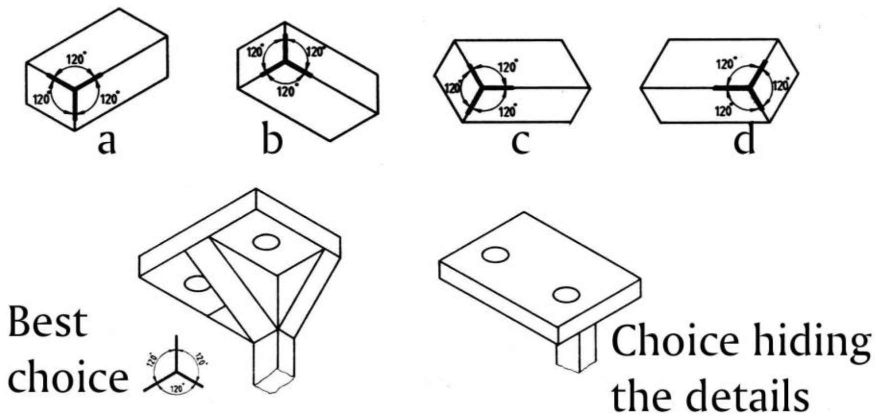


When an object is made up of planes at different angles, it is better to locate the ends of the edges by the offset method rather than by boxing. When the offset method is used, perpendiculars tare extended from each point to an isometric reference plane. These perpendiculars, which are isometric lines, are located on the drawing by isometric coordinates, the dimensions being taken from the orthographic views.

In Figure above, line **AB** is used as a base line and measurements are made from it as shown, first to locate points of the base line (AB), then other points as an offset from the base line.

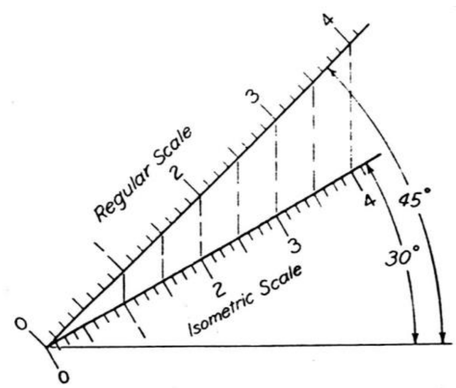
CHOOSING THE BEST ISOMETRIC AXES

Isometric drawings are, from their pictorial nature, usually outside views, but sometimes choosing the best view is needed to show a detail of shape or interior construction. The main planes are chosen to show the best details, as shown in the figure below. Looking upwards yields the details of the column head rather than looking below from the top of the column head which hides the details.

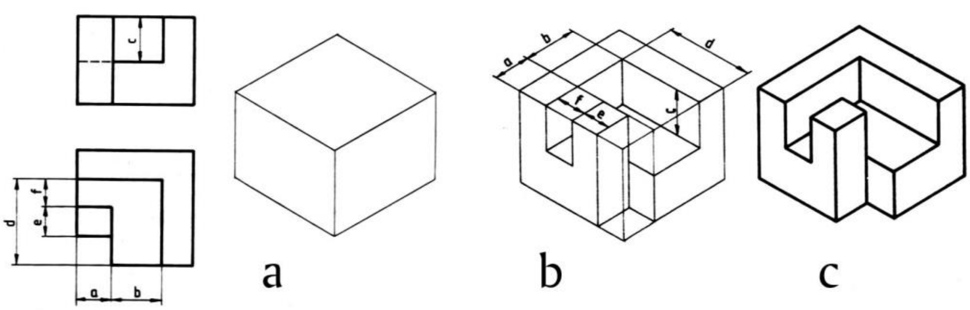


NONISMOTERIC LINES

When an object contains many nonisometric lines, it is best to produce the ISOMETRIC SCALE shown on the right side.

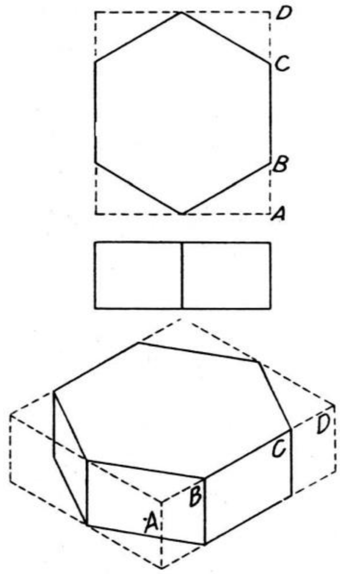


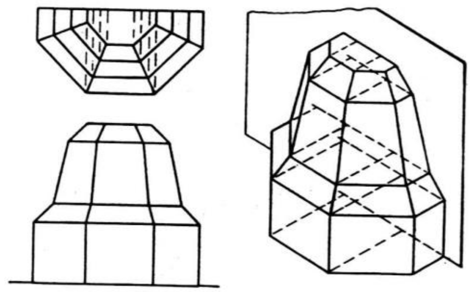
The object can be drawn by BOXING method or by the OFF SET method. When the boxing method is used the object is enclosed in a rectangular box, which is drawn around it in orthographic projection.



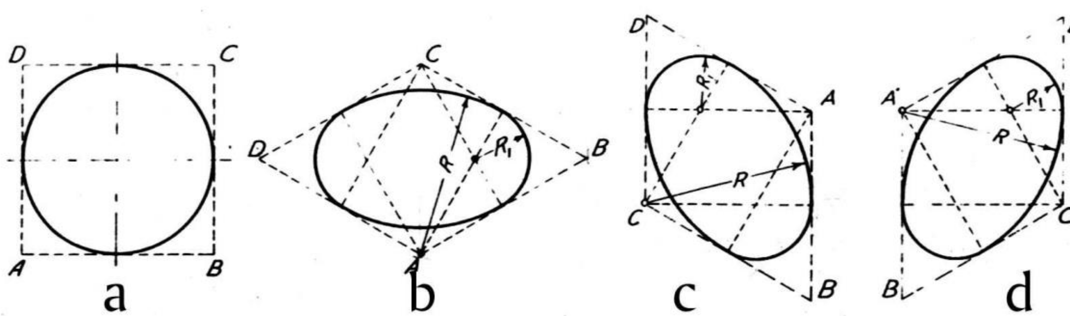
Boxing Method

The box is then drawn in isometric and the object located in it by its points of contact as shown above.

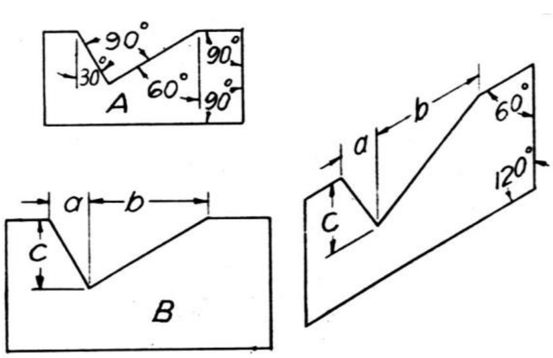


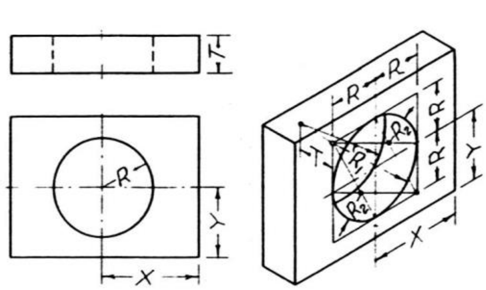


Boxing Method   Offset method



Isometric Circles, four centered method.
The ellipse is approximated by circle arcs.





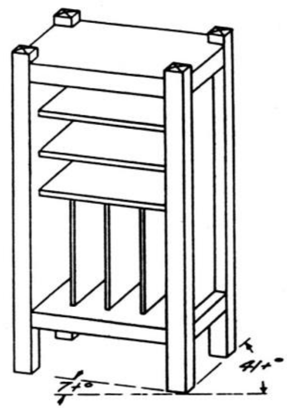
Angles in Isometric

These must be laid out by offsets from an orthographic view to the same scale

Locating and laying out a hole in

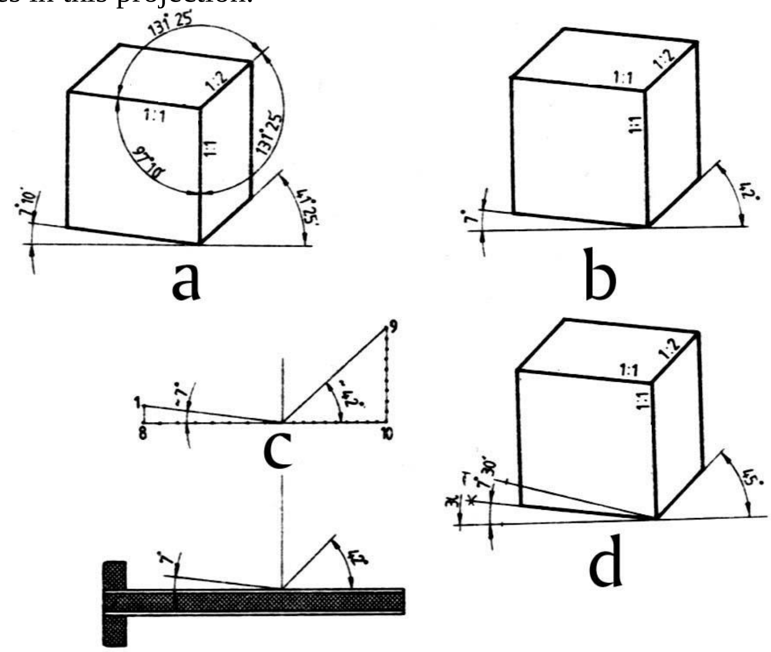
Locate the center, draw the enclosing isometric square, and then draw the circle.

DIMETRIC PROJECTION



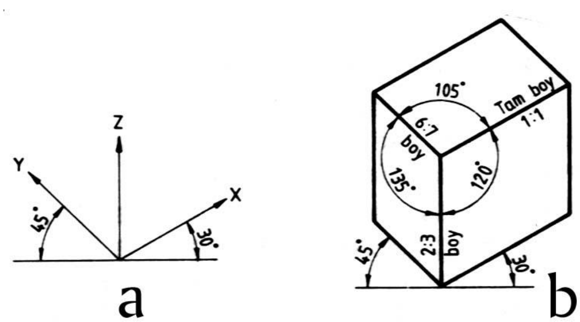
The reference cube can be rotated into any number of positions in which two edges are equally foreshortened, and the direction of axes and ratio of foreshortening for anyone of these positions might be taken as the basis for a system of ***di-metric*** drawing.

A simple dimetric position is one with the ratios 1 to 1 to ½. In this position the tangents of the angles are $\frac{1}{8}$ and $\frac{7}{8}$, making the angles approximately 7° and 41°. Figure below shows a drawing in this system. Dimetric is seldom used because of the difficulty of drawing circles in this projection.



Angles and side length ratios of diametric drawings

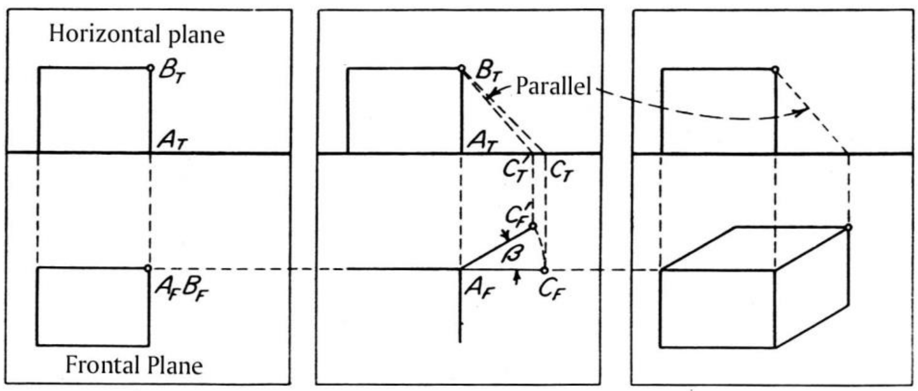
TRIMETRIC PROJECTION



Any position in which all three axes are unequally foreshortened is called "***trimetric***". Compared with isometric and dimetric, distortion is reduced in trimetric projection, and even this effect can be lessened with some positions. However, because it is slower to execute than isometric or diametric, it is seldom used except when done by projection.

8.3 OBLIQUE PROJECTION

When the projectors make an angle other than 90° with the picture plane, the resulting projection is called "***oblique***." The name "***cavalier projection***" is given to the special and most used type of oblique projection in which the projectors make an angle of 45 ° with the plane of projection. Cavalier projection is often called by the general name "**oblique projection**," or "**oblique drawing**." The principle is as follows: Imagine a vertical plane with a rectangular block behind it, having its long edges parallel to the plane. Assume a system of parallel projecting lines in any direction making all angle of 45 ° with the picture plane (they could be parallel to anyone of the elements of a 45° cone with its base in the picture plane). Then that face of the block which is parallel to the plane is projected in its true size, and the edges perpendicular to the plane are projected in their true length.

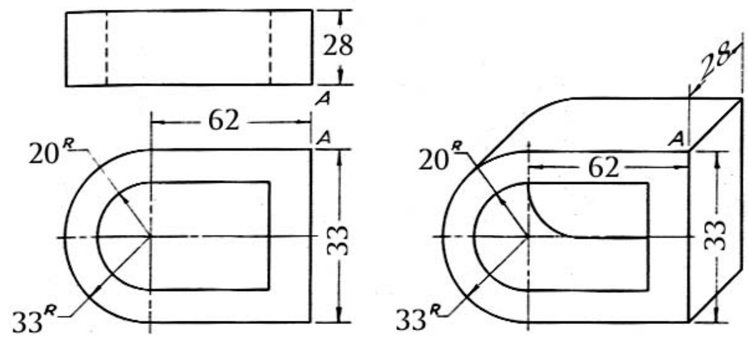


Principle of Oblique Projection

Figure above illustrates the principle. The first panel shows the regular orthographic projection of a rectangular block with its front face in the frontal plane. An oblique projector from the back corner ***B*** is the hypotenuse of a 45° right triangle of which ***AB*** is one side and the projection of ***AB*** on the plane is the other side. When this triangle is horizontal, the projection on the plane will be ***A*****C**. If the triangle is rotated about ***AB*** through any angle ***β***, ***C*** will revolve to ***C'*** and $A_F C_F'$ will be the oblique projection of ***AB***.

TO MAKE AN OBLIQUE DRAWING

Oblique drawing is similar to isometric drawing in that it has three axes that represent three mutually perpendicular edges and upon which measurements can be made. Two of the axes are always at right angles to each other, as they are in a plane parallel to the picture plane. The third, or depth, axis may be at any angle to the horizontal, 30° or 45° being generally used. Oblique drawing is thus more flexible than isometric drawing. To draw a rectangular object start with a point representing a front corner and draw from it the three oblique axes, one vertical, one horizontal, and one at an angle. On these three axes measure the height, width, and depth of the object. In this case the width is made up of the 33 mm. distance and the 20 mm. inner radius and 33 mm. outer radius. Locate the center of the arc, and draw it as shown.

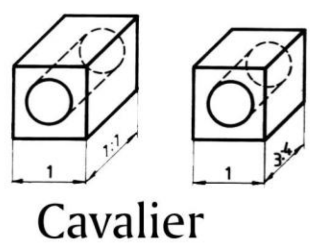


The center for the arc of the hole in the figure will be at the same point as the center for the outside arc on the front face. The center for the rear arc of the hole will be 28 mm. rearward on a depth axis line through the front center.

Based on the scale ratio, depth axis and the angle of the depth axis, the oblique pictures are classified as Cavalier, Cabinet and Military.

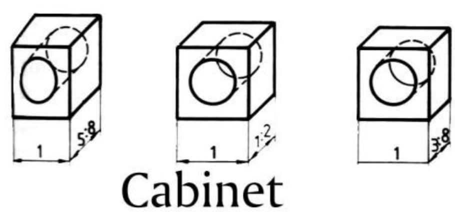
CAVALIER DRAWING

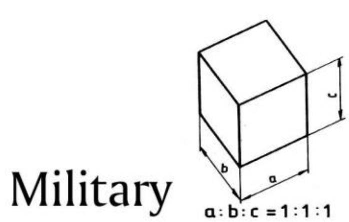
This is a type of oblique projection in which the parallel projectors make an angle of 45^0 with the picture plane and distances measured parallel to the depth axis are in ratio of 1:1 or 3:4 with the front plane dimensions.

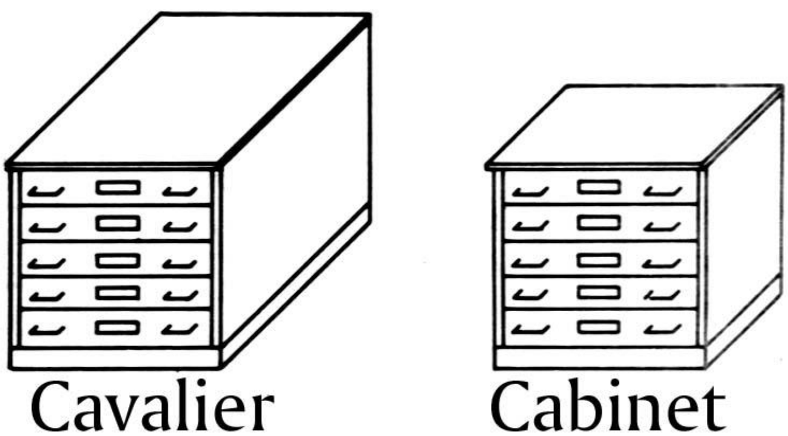


CABINET DRAWING

This is a type of oblique projection in which the parallel projectors make an angle with the picture plane of such a value that distances measured parallel to the depth axis are reduced one-half that of cavalier projection. The appearance of excessive thickness that is so disagreeable in cavalier projection is entirely overcome in cabinet projection. The depth axis may be at any angle with the horizontal but is usually taken at 30° or 45°. The appearance of cavalier and cabinet drawing of the same object is shown below.



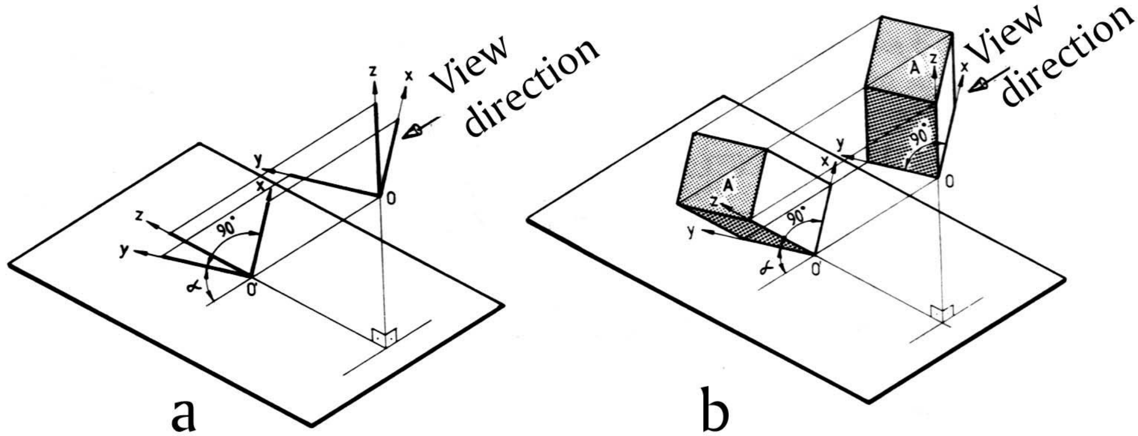




MILITARY DRAWING

A type of drawing first used by the French Military Engineers.

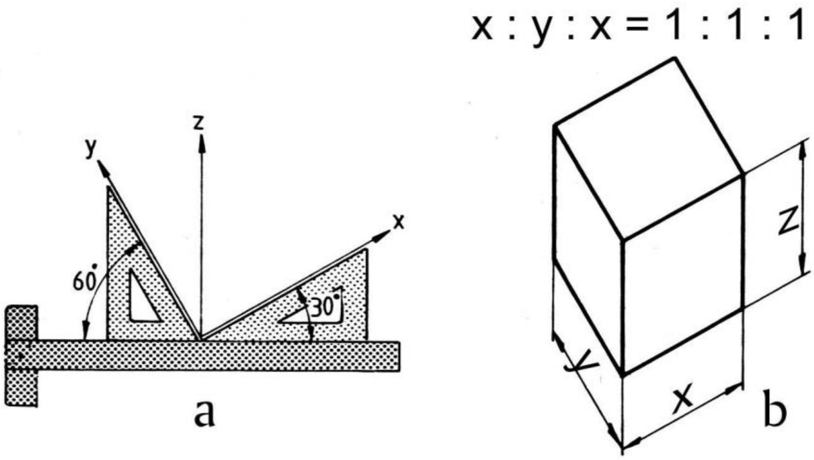
The angle between the main axes **y** and **x** of the frontal plane is 90^0 and any one of them makes an angle of 30^0, 45^0 or 60^0 with the horizontal plane. The third plane **z**, makes an angle of 90^0 with the horizontal plane, which behaves as the vertical axes.



Positions of planes in Military drawing

The ratio of the length of the sides is 1 : 1 : 1 with each other.

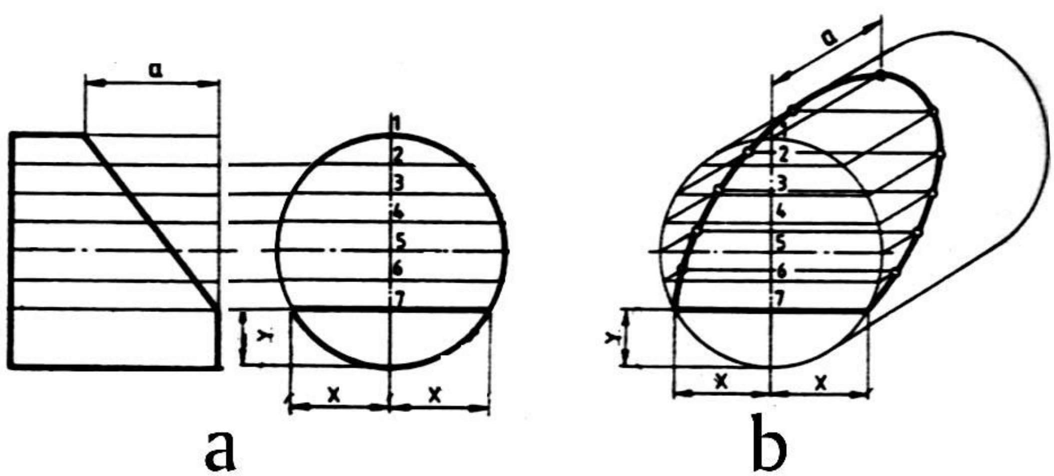
The ratio of the length of the sides is 1 : 1 : 1 with each other.



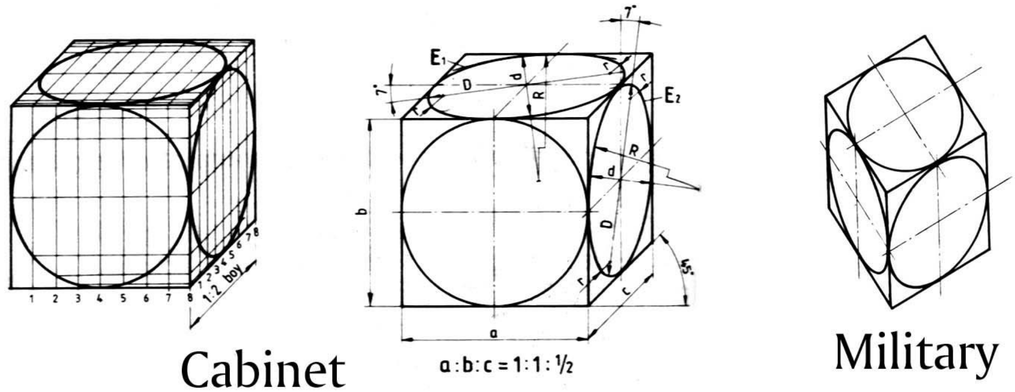
CIRCLES IN OBLIQUE

When it is necessary to draw circles that lie on oblique faces, they can be drawn as circle arcs, with the compasses, on the same principle as the four-center isometric approximation.

In isometric it happens that ***two of the four intersections of the perpendiculars from the middle points*** of the containing square fall at the corner of the square, and advantage is taken of the fact. In oblique, the position of the corresponding points depends on the angle of the depth axis.



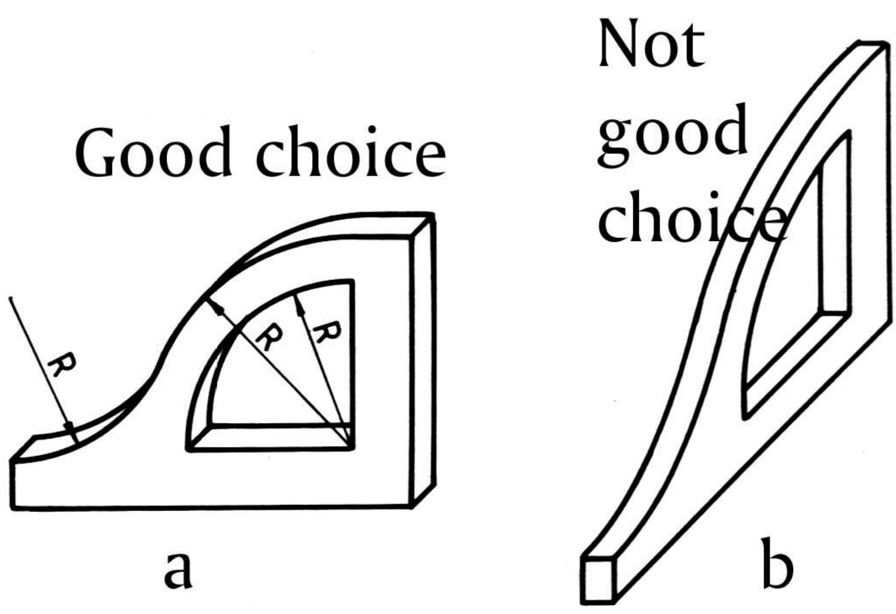
The important point to remember is that the circle arcs *must* be tangent at the mid-points of the sides of the oblique square.



Cabinet drawing and Military drawing of circles and cubes with circles

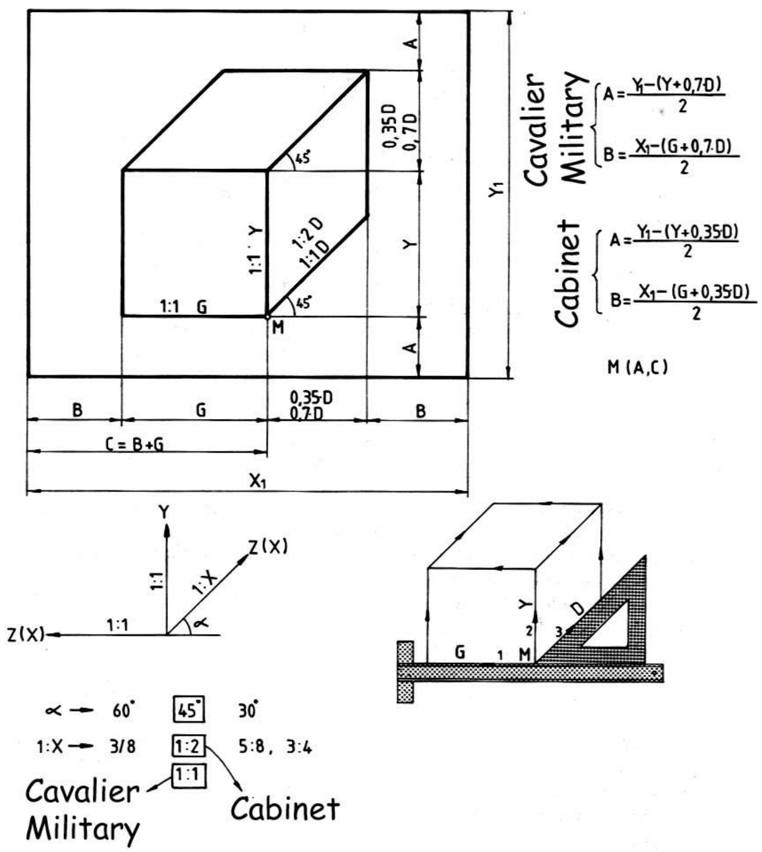
CHOOSING THE BEST OBLIQUE VIEW

Oblique drawings are, from their pictorial nature, usually outside views, but sometimes choosing the best view is needed to show a detail or given idea of the object in a pleasing manner.



The main planes are chosen to show the best view, as shown in the figure above where a good idea of the object is given and the radii are detailed.

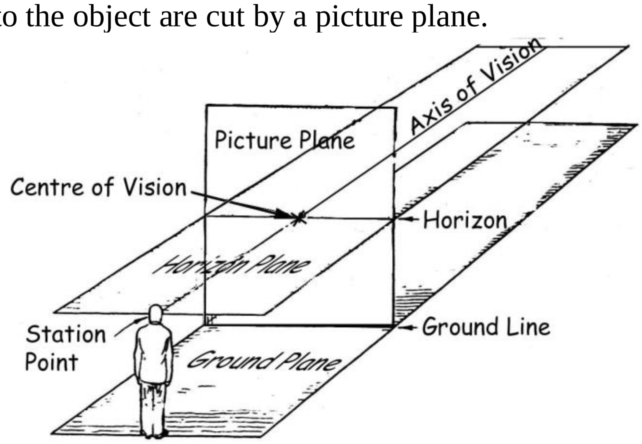
ORIENTATION OF A PRISM (OBLIQUE PICTURE) ON A DRAWING PAPER



Orientation of the prism (Oblique picture) on a drawing paper, detailing the angles and ratios of the CAVALIER, CABINET and MILITARY type drawings.

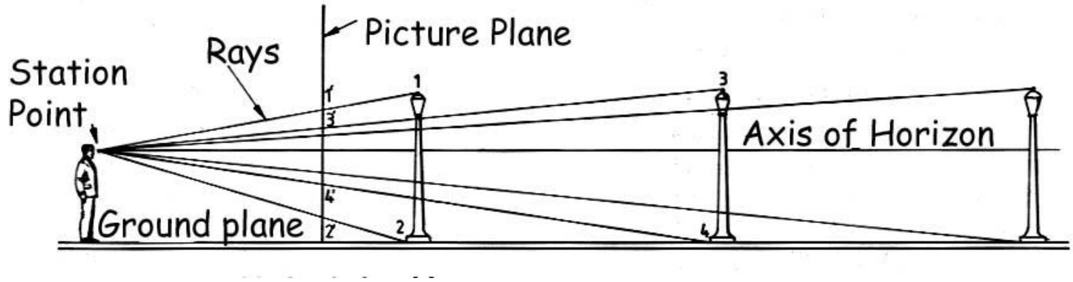
8.4 PERSPECTIVE

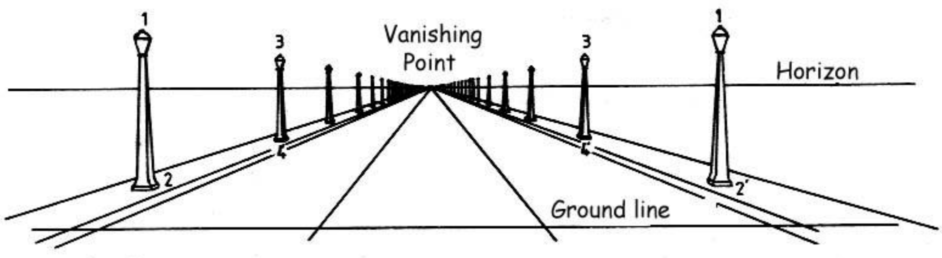
Perspective drawing represents an object as it appears to an observer stationed at a particular position relative to it. The object is seen as the figure resulting when visual rays from the eye to the object are cut by a picture plane.



Perspective theory and names the points, lines and planes used.

Side view of a person looking to street lamps, standing in the middle of a road

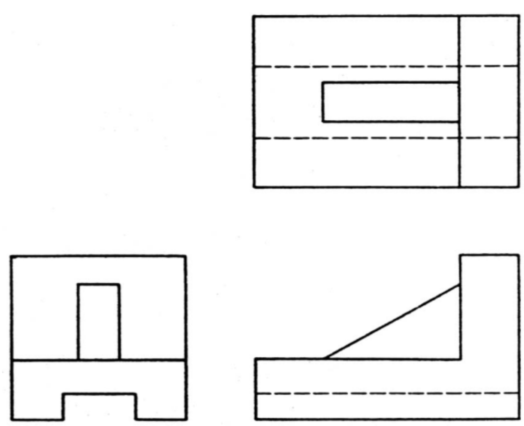




Lines ending at Vanishing point

USE OF VANISHING POINTS AND MEASURING LINES.

These facilitate the projections. Let it be required to make a perspective of a sliding block shown below.



Steps to draw the perspective of the sliding block.

The edge view of the Picture plane (plan view) is drawn and behind it the top view of the object is located and drawn. In this case, one side of the object is oriented at 30° to the picture plane in order to emphasize the L shape more than the end of the block.

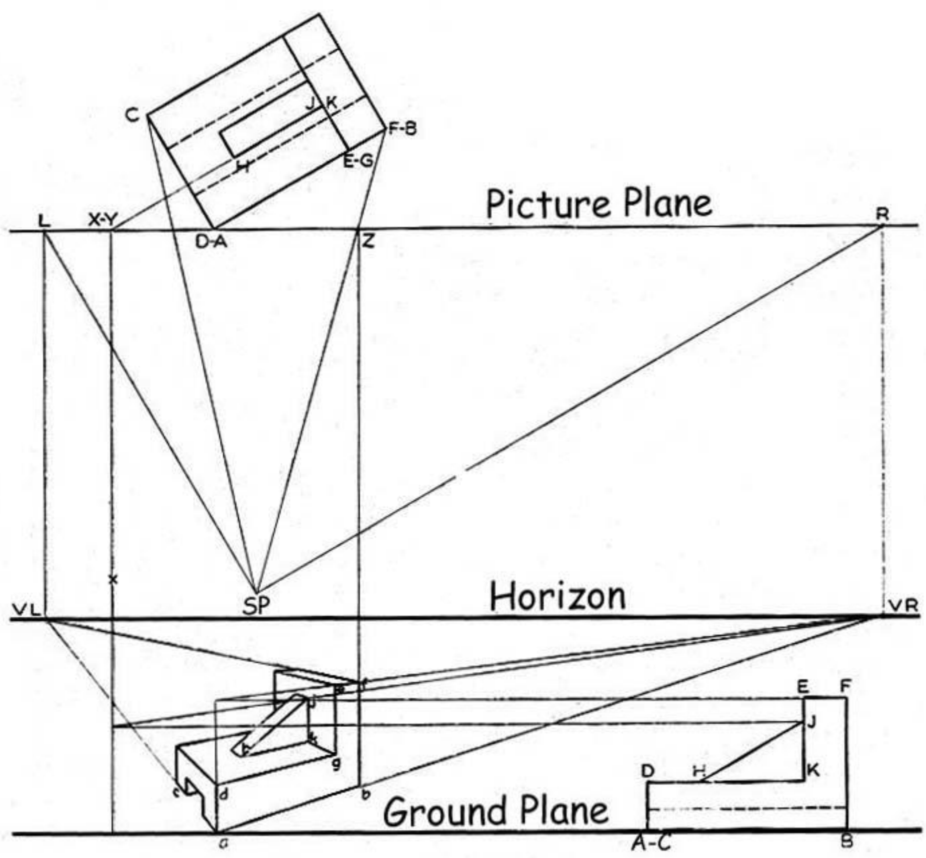
The Station point is located a little to the left of center and far enough in front of the picture plane to give a good angle of view. (It is the imaginary place, where you are standing and looking at the object)
The Ground line (Where the object is assumed to rest.) is then drawn, and on it is placed the front view of the block. The Horizon line, height of the station point is then decided. (The height of your eyes, you would like to look at the object. In this case well above

(The height of your eyes, you would like to look at the object. In this case well above the block so that the top surfaces will be seen). And drawn parallel to ground line, at the decided height. (Determines Horizon Plane, the Horizontal plane at eye level.)

The vanishing point for any horizontal line can be found by drawing a visual ray from the station point parallel to the horizontal line and finding the piercing point of this visual ray with the picture plane. (The line SP to R is parallel to the edge AB of the object and R is the piercing point.)

Point R is then projected to the horizon line, locating VR (Vanishing point on the Right), the vanishing point for AB and all edges parallel to AB. The vanishing point VL (Vanishing point of the Left) for AC and edges parallel to AC is found similarly.

Point A lies in both the picture plane and the ground plane and will therefore be shown in the perspective at a, on the ground line and in direct projection with the top view. The perspective of AB is determined by drawing a line from a to VR and then projecting the intercept Z (of the visual rays SP to B) to the line, thus locating b.

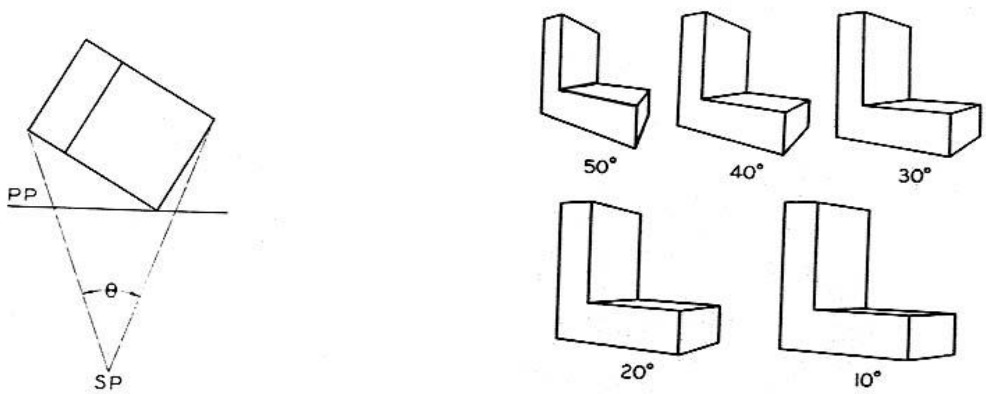


All lines behind the picture plane are foreshortened in the picture, and only those lying in the picture plane will appear in their true length. For this reason, All measurements must be made in the picture plane.

A measuring line or a measuring reference line will be needed for verticals, such as bf.

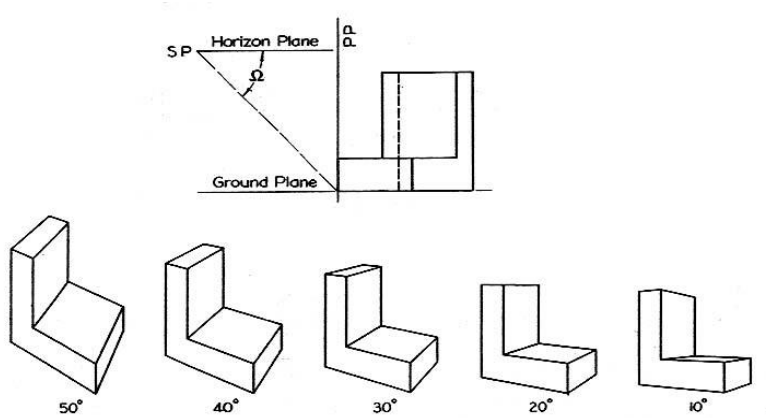
Since, only the points lying in the picture plane will appear in their true lengths, a vertical reference line on a point, lying in the picture plane, is drawn, and divided faintly by pencil in to actual scaled units, such as the imaginary line above ad in the drawing. Connecting lines of this divisions, to VL and VR can be used as the height contours, for any point of the object, laying in the same plane on the perspective picture. The height of **f** is measured from **a**, and from this height point, a vanishing line is drawn to VR, then from Z , **f** can be projected to the perspective. ***Station Point*** is the actual place of viewing an object and determines the ***Location*** and the ***Height*** of the horizon plane.

Location : Location of SP has an effect on the perspective picture directly.
Wide angles of view result in a violent convergence of horizontal lines and so should be avoided. The angle of view is the included angle e between the widest visual rays. The figure below shows the difference in perspective foreshortening for different lateral angles of view. In general, an angle of about 20° gives the most natural picture.



Effect of difference in perspective foreshortening for different lateral angles of view

Height : The height of SP has an effect on the perspective picture directly.



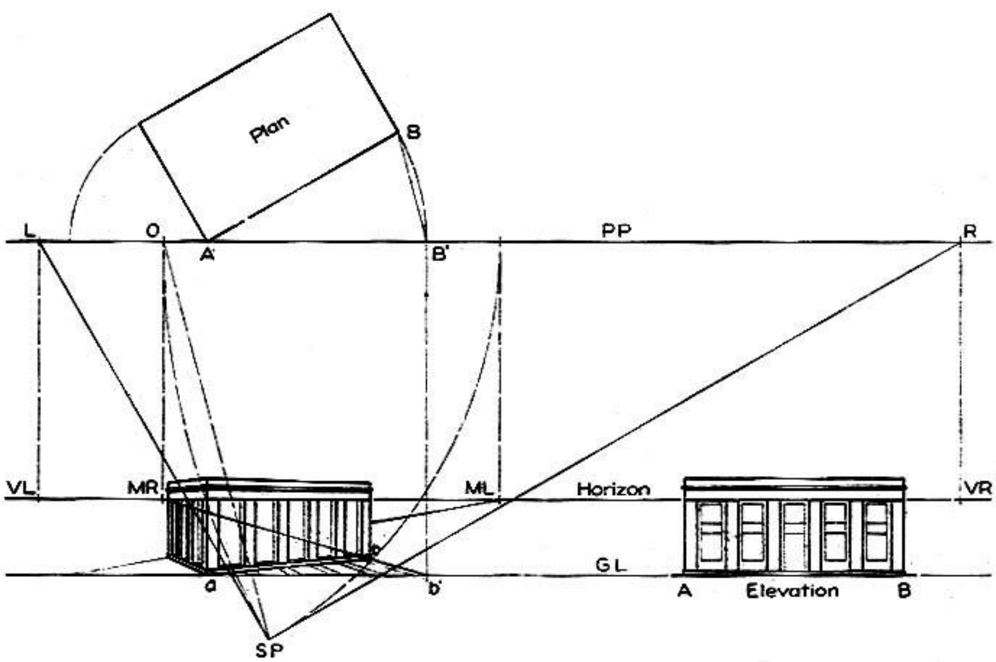
Effects of difference in the angle of view, Ω to the final perspective.
Angles greater than 30^0 give an unpleasing perspective.

The station point should be located vertically at the point from which the object is seen to best of advantage. For this reason, for large objects such as buildings, the standing point is usually taken at a normal standing height of about 160 cm. above the ground plane.

For small objects, the best representation demands that the top, as well as the lateral surfaces, be seen, and the station point must be elevated accordingly. Figure of "effects of difference in the angle of view", shows the angle of elevation Ω, in between the horizon plane and the extreme visual ray. By illustrating several different angles of elevation, the figure shows the effect of elevation of the station point. In general, the best picturization is obtained at an angle of about 20° to 30^0.

PERSPECTIVE DRAWING WITH MEASURING POINTS

It has been shown that all lines lying in the picture plane will be their own perspectives and can be scaled directly on the perspective drawing. The adaptation of this principle has an advantage in laying off a series of measurements.



Perspective Drawing details

In the measuring points method, a surface such as the wall between **A** and **B** in the figure below, is rotated into the picture plane for the purpose of making measurement I as shown at **AB**'. While in the picture plane, the entire surface can be laid out directly to the same scale as the top view, therefore, **ab**' and other horizontal dimensions of the surface are established along the ground line as shown.

The counter rotation of the wall to its actual position on the building and the necessary projections in the perspective are based on the principle that the rotation has been made about a vertical axis and that any point has traveled in a horizontal plane.

By drawing, as usual, a line parallel to **BB**', from the station point to the picture plane, and then projecting to the horizon, the vanishing point **MR** is found. This vanishing point is term as a Measuring Point and may be defined as the vanishing point for lines joining corresponding points of the actual and rotated positions of the face considered. The divisions on **ab**' are therefore vanished to **MR**. Heights are scaled on the vertical edge through a, as this edge lies in the picture plane. The remaining drawing can be completed by the methods previously described.

8.4 FREE HAND PICTORIAL SKETCHING

It should be clearly understood at the outset that pictorial sketching means the making of a pictorial drawing **FREEHAND.**

The best method is the Isometric drawing, which is the simplest Axonometric position. Steps in making a pictorial Sketch:

a) Visualize the shape and proportions of the object from the orthographic views, a model or other source.

b) Mentally picture the object in space and decide the pictorial position that will best describe its shape.

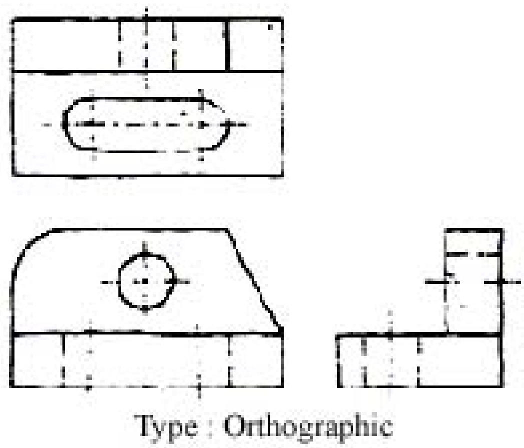
c) Decide on the type of pictorial to use, Axonometric, oblique or perspective.

d) Pick a suitable paper size

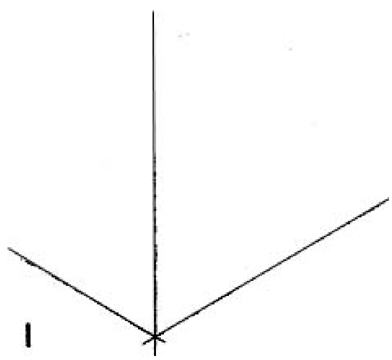
e) Then proceed as shown in figure below.

1. Sketch the axes.
2. Layoff the proportions of an enclosing rectangular box for the whole of object.
3. Sketch the enclosing box.
4. Divide one axis for proportioning distances and sketch the dominant detail.
5. Proportion smaller details by reference to the divided axis.
6. Complete the boxes and check the proportions.
7. Start sketching to the final line width.
8. Sketch the smaller details.
9. Remove the construction lines and finalize the picture.

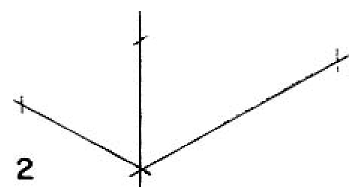
STEPS OF FREE HAND PICTORIAL SKETCHING



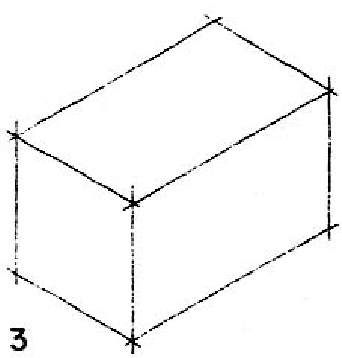
Choose type of pictorial to use



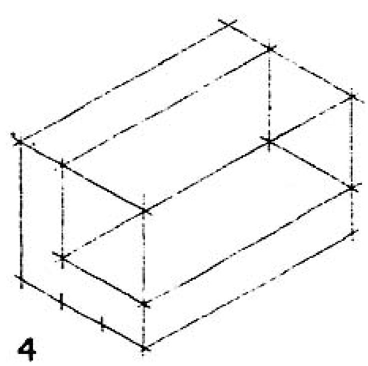
Sketch the axes



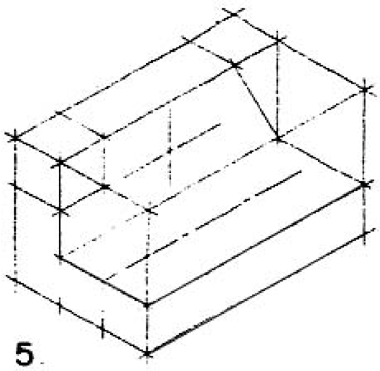
Lay off the rectangular box



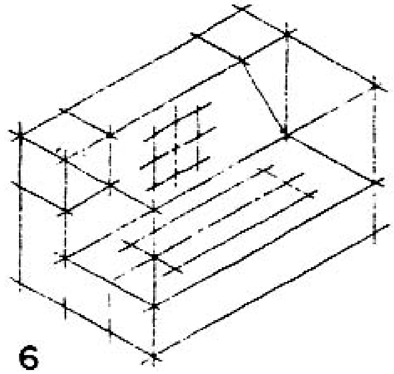
Sketch the enclosing box



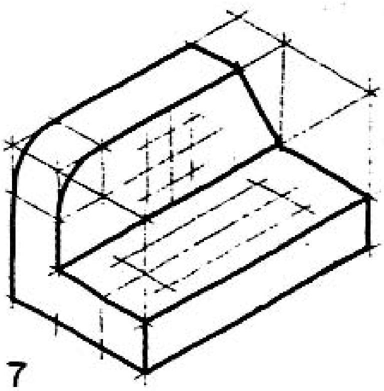
Divide the axes and sketch the dominant detail



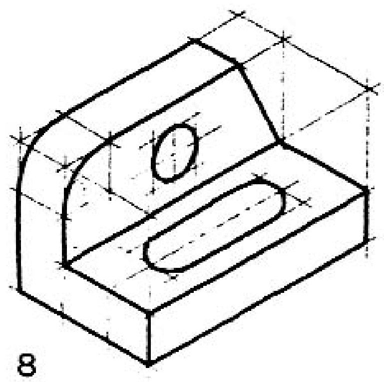
Proportion smaller details



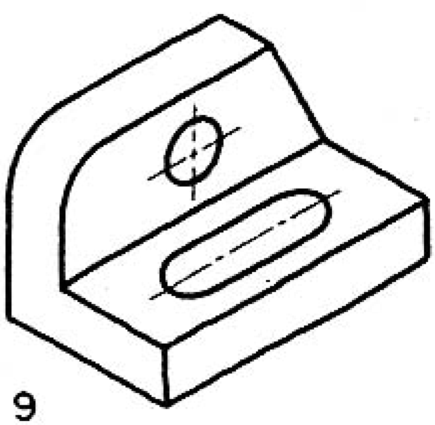
Complete the box and check the details



Start sketching to the final line width



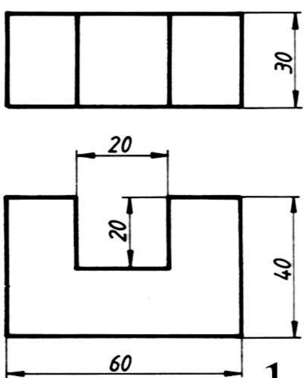
Sketch the smaller details



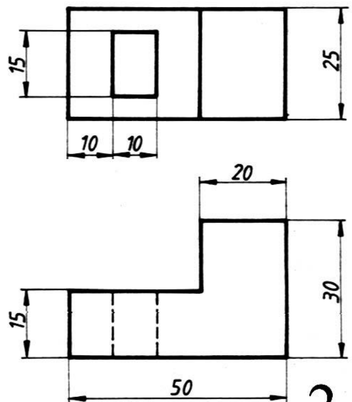
Remove the construction lines and finalize the picture

EXERCISE 20

1- Draw the Isometric and Dimetric drawings of the following objects from the below given views. Dimensions in mm.



1



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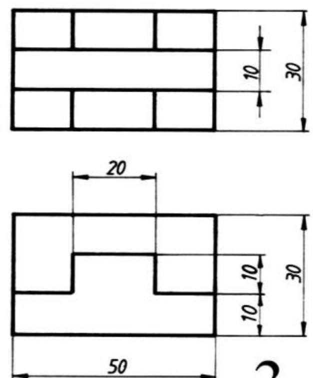
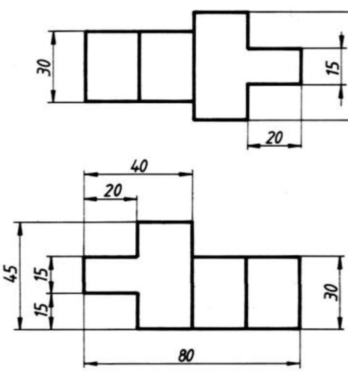
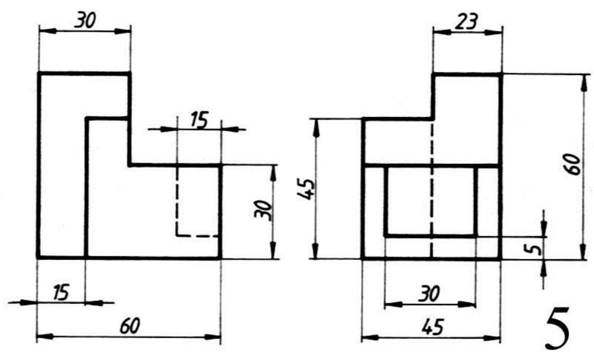


3



4



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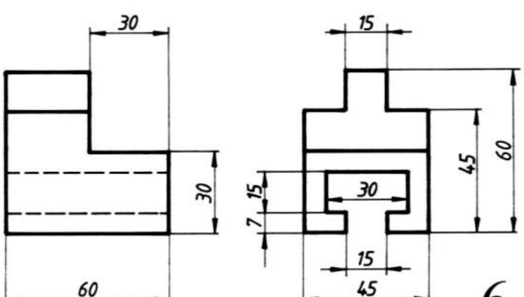

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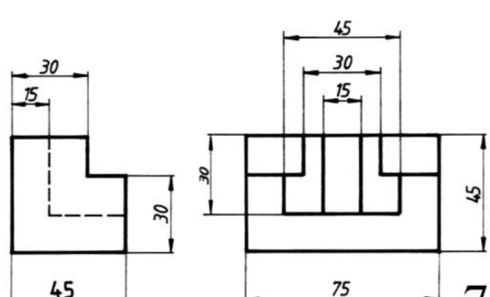
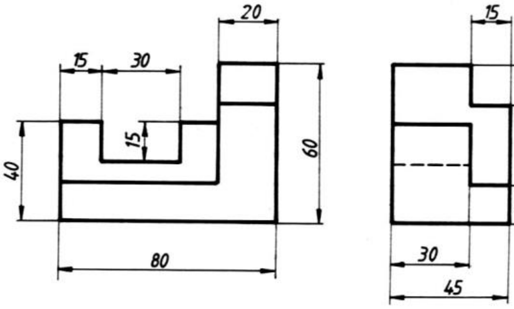


7



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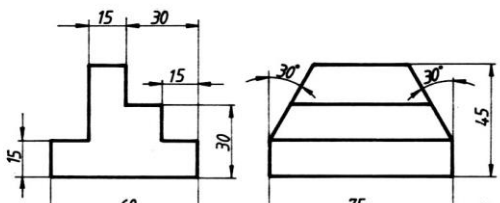

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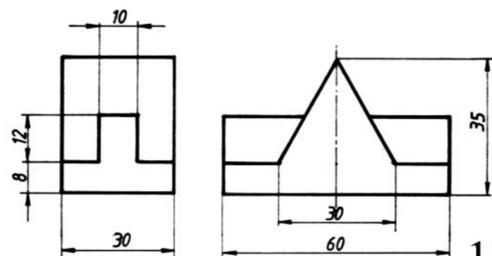

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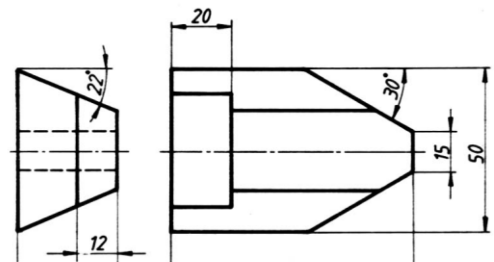

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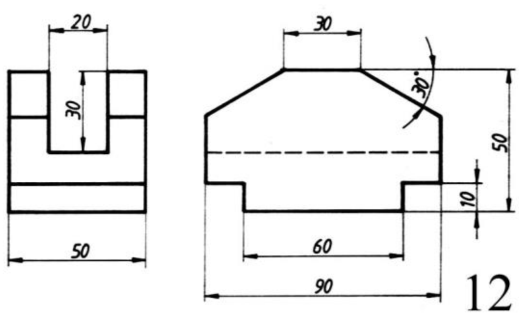

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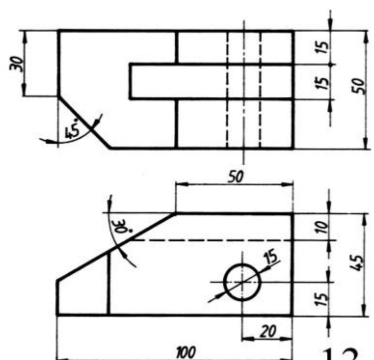

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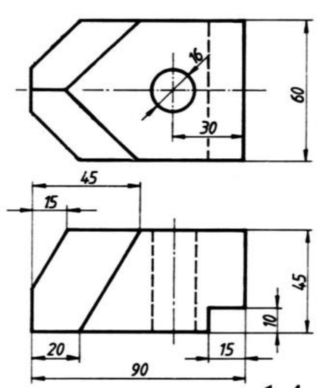

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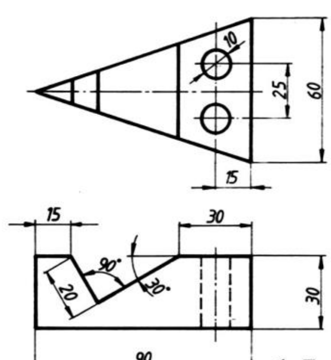

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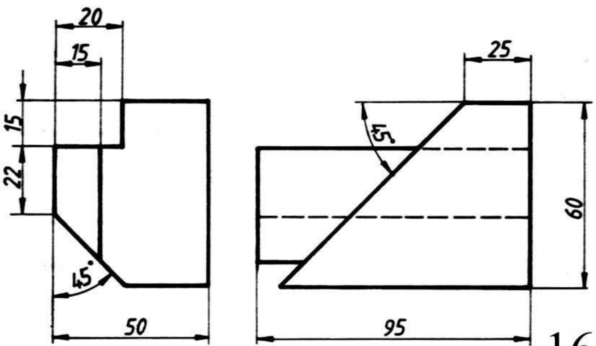

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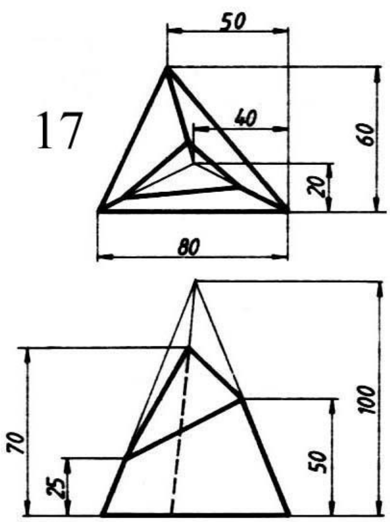

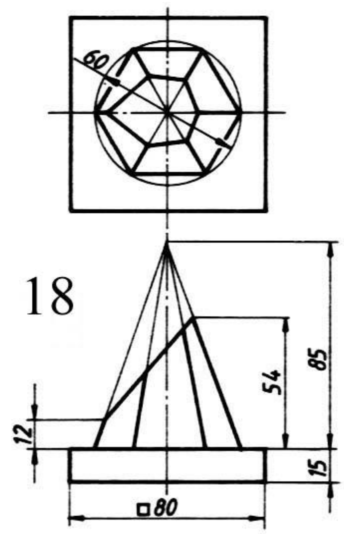

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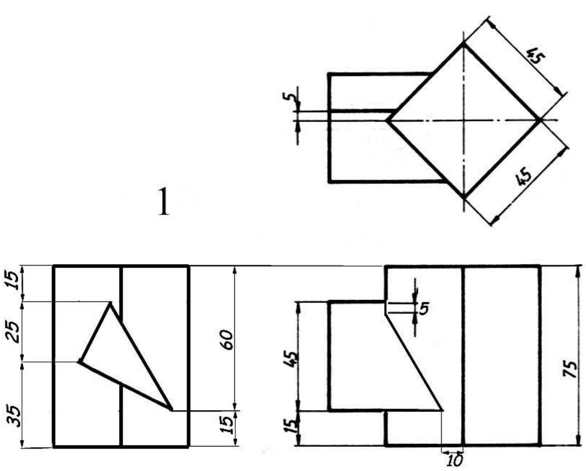
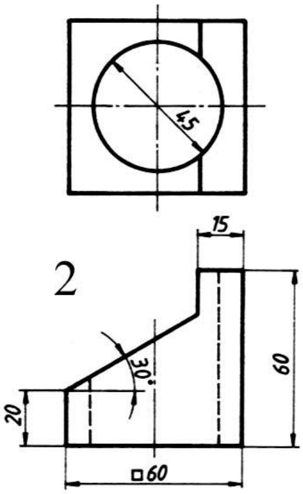
2- Draw the Isometric and Dimetric drawings of the following objects from the below given views. Dimensions in mm.

1





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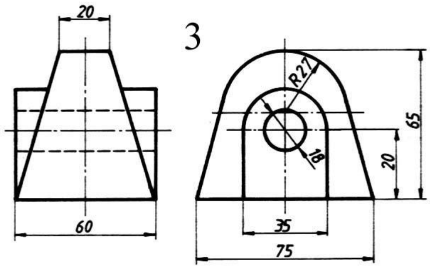
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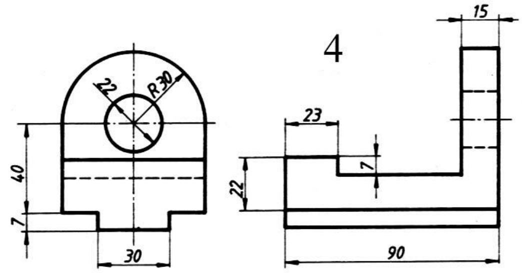
R27
18
65
20
60
35
75

4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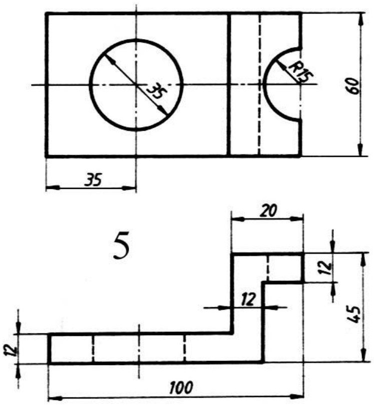
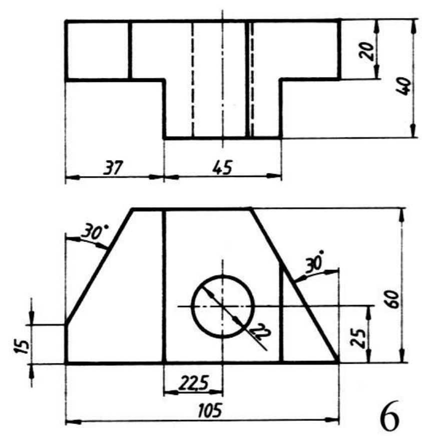
22
R30
23
40
7
22
7
30
90

5


R15
35
60
35
20
12
12
45
12
100

6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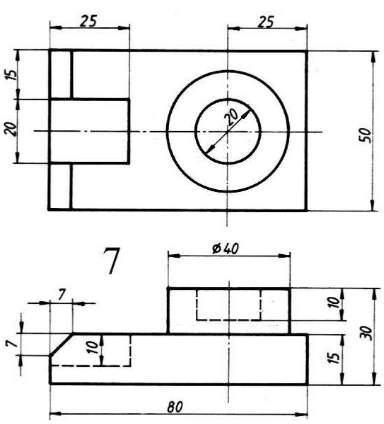
37
45
30°
30°
60
15
22
25
22,5
105

7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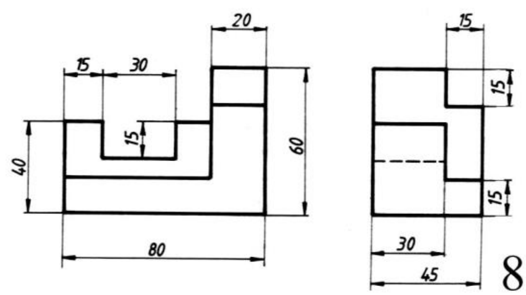
80

8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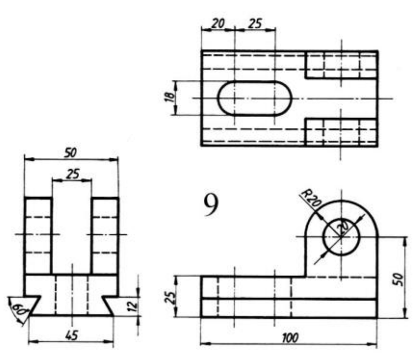
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R20
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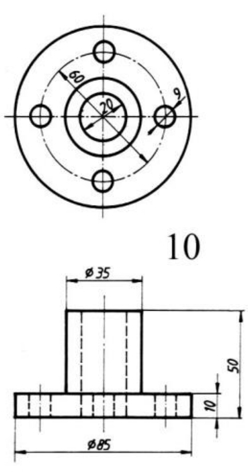
100

10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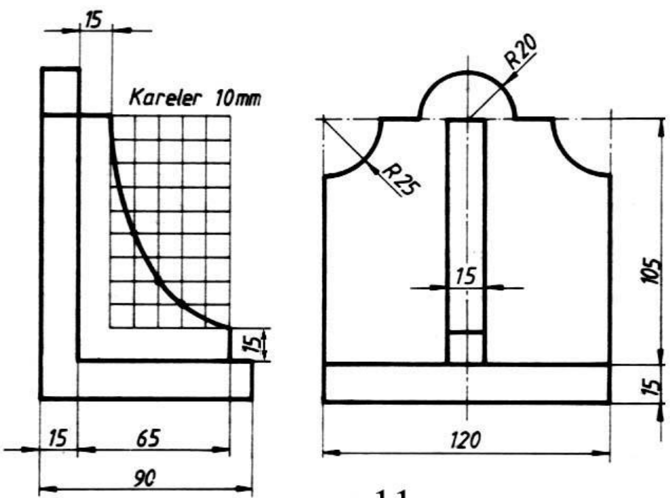

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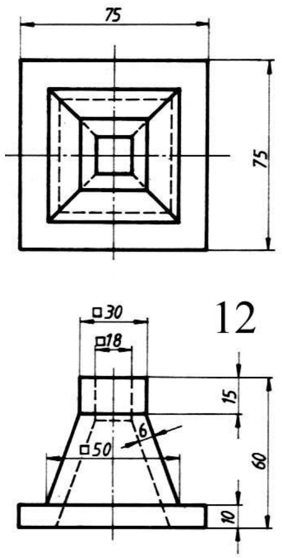
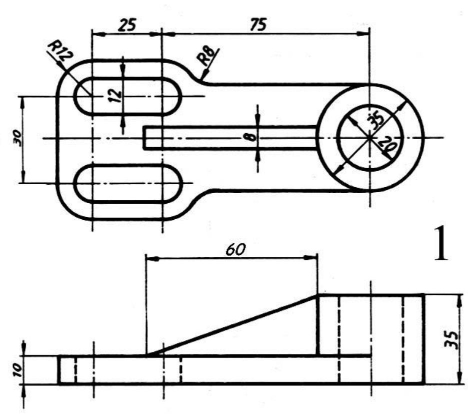
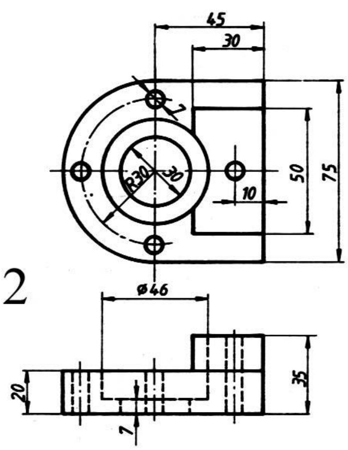


12

3- Draw the Isometric and Dimetric drawings of the following objects from the below given views. Dimensions in mm.



1



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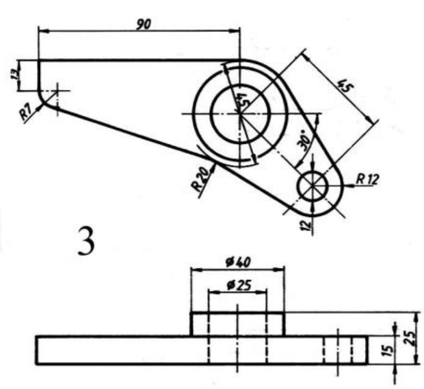

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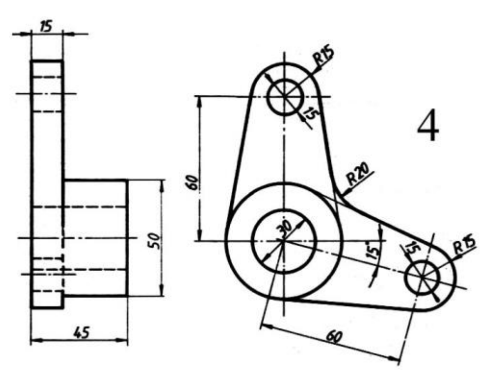

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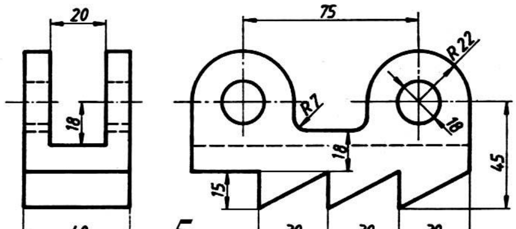

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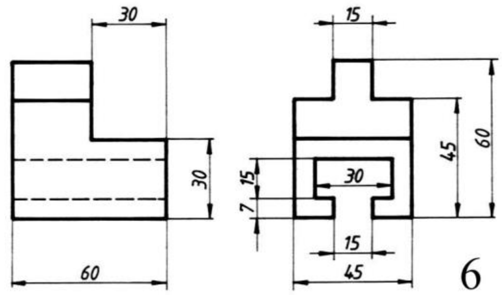

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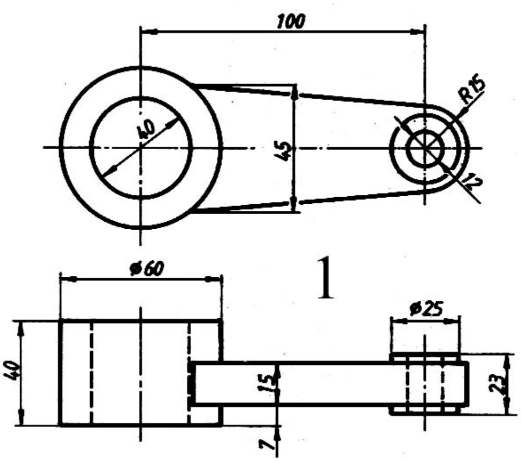
4- Draw the Isometric and Dimetric drawings of the following objects from the below given views. Dimensions in mm.



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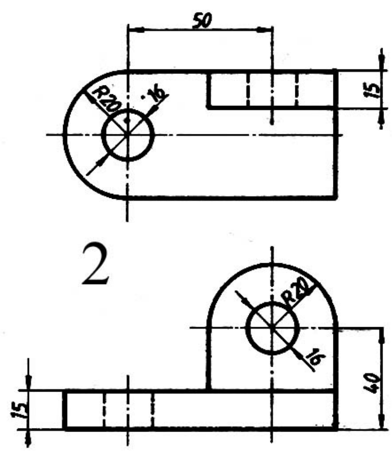

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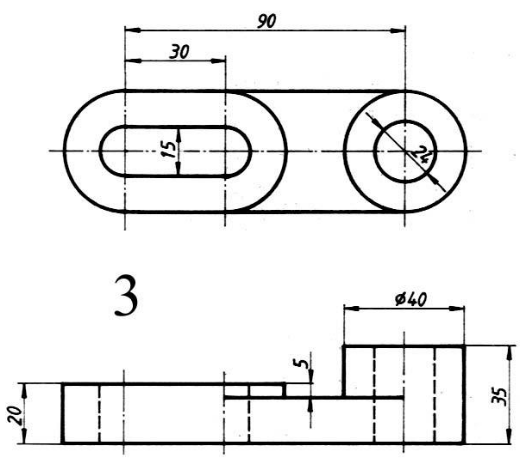

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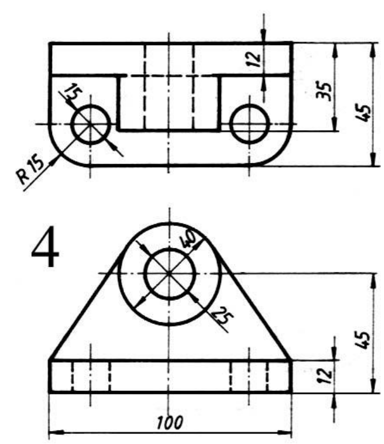

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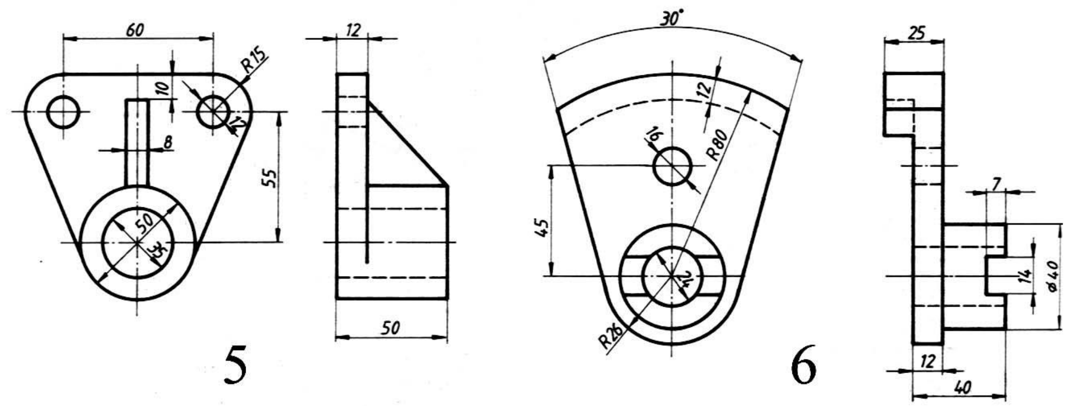
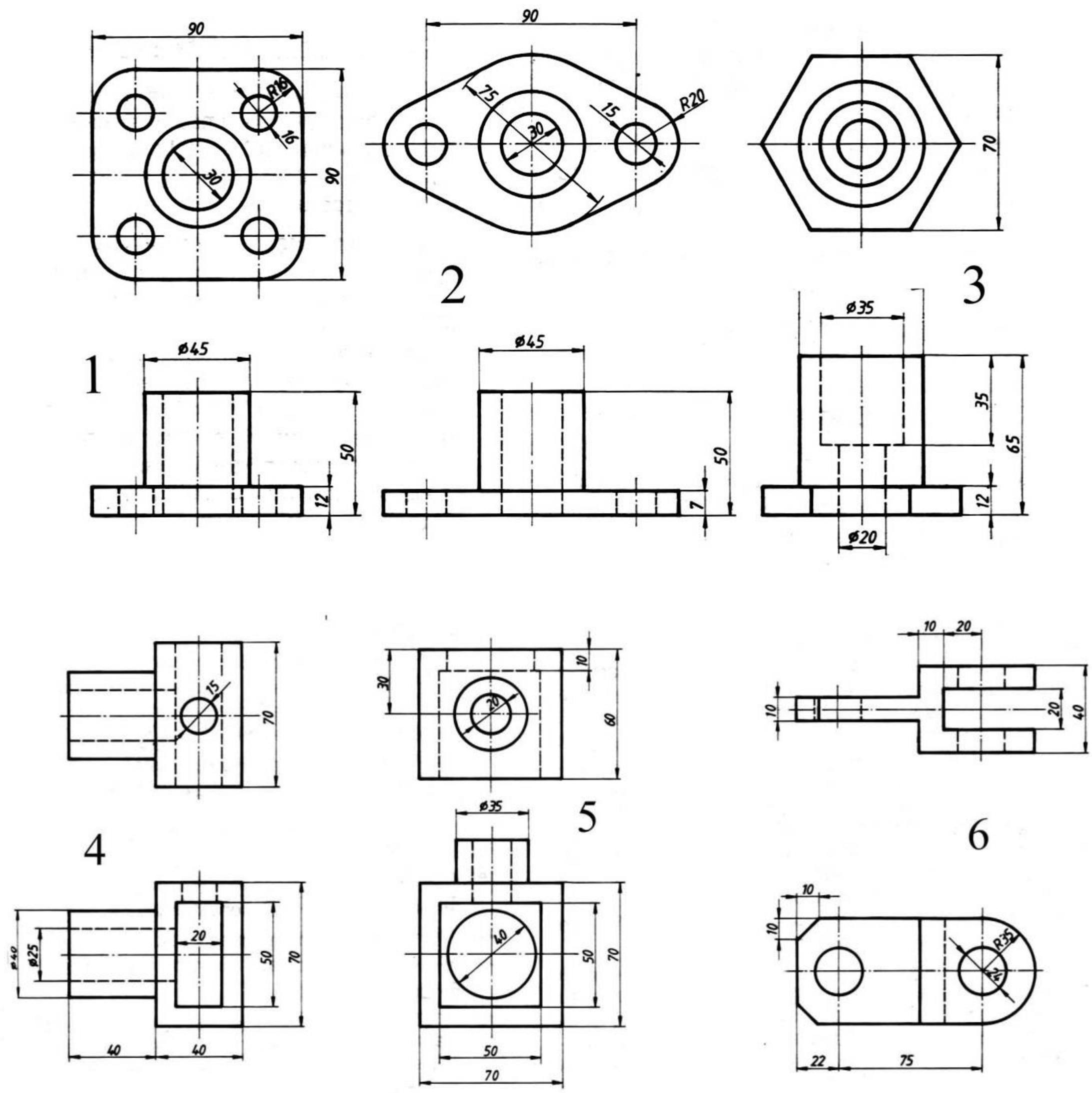
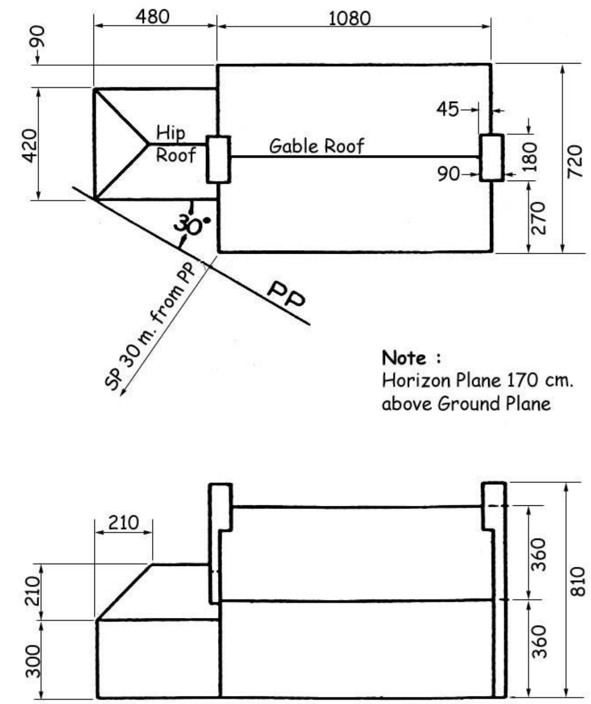
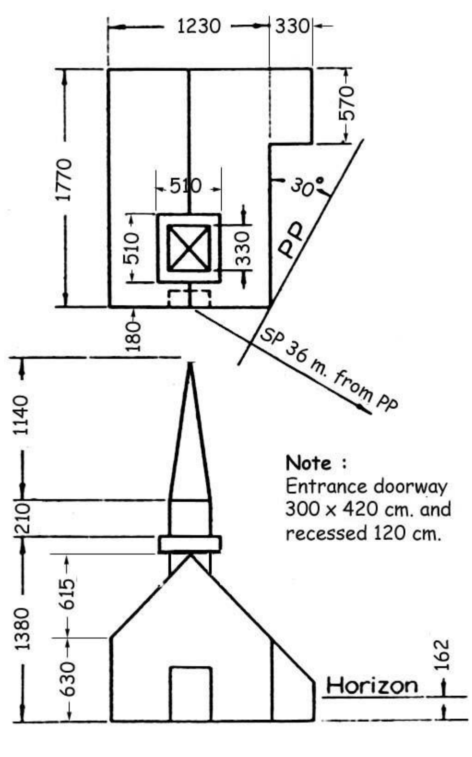


5- Draw the Cavalier, Cabinet and Military drawings of the following objects from the below given views. Dimensions in mm.

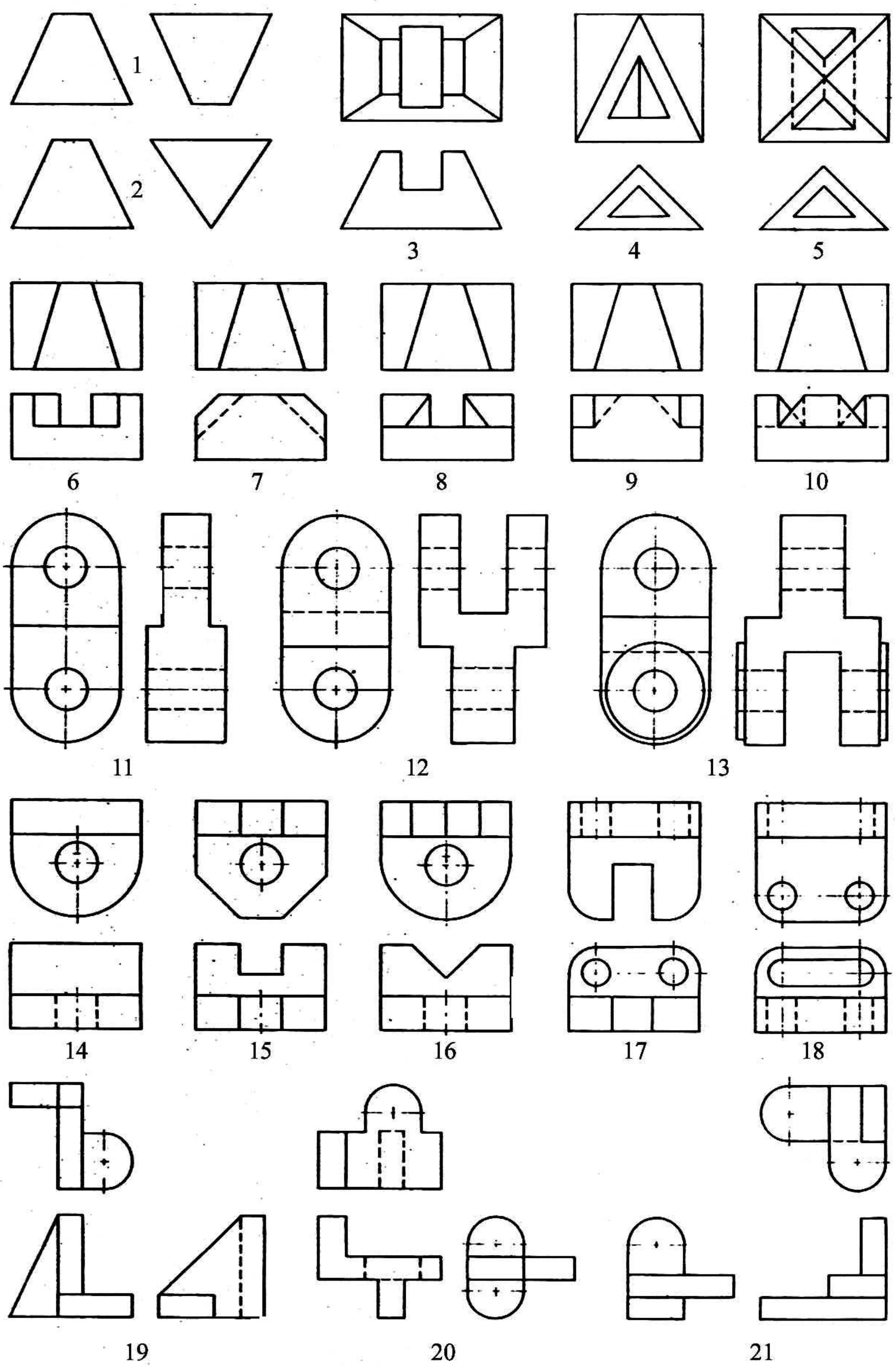


6- Draw the Perspective of the following objects from the below given views.
All Dimensions in cm. but SP.





6- Sketch the below objects in Freehand



CIVIL ENGINEERING **ADDENDUM CE**

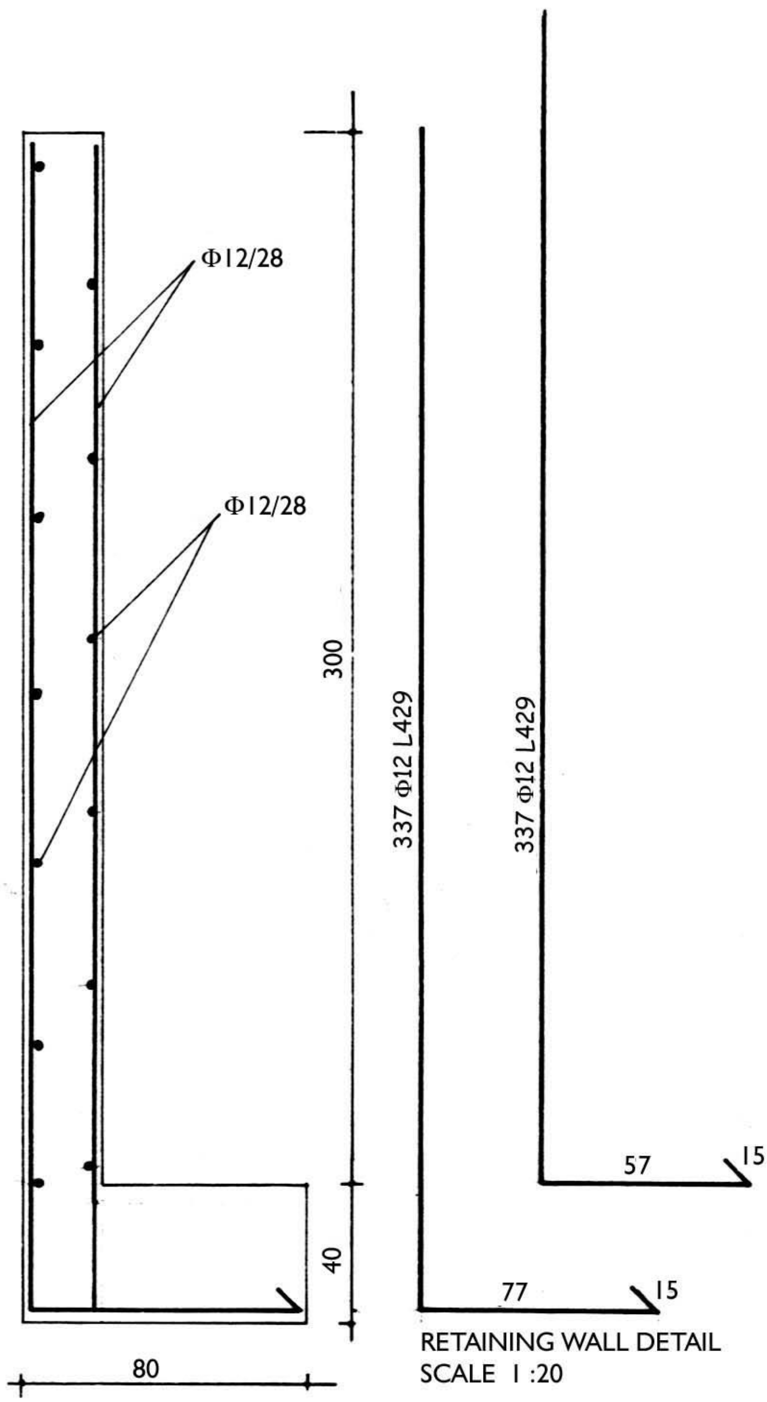
SPECIAL ADDENDUM

FOR STUDENTS IN

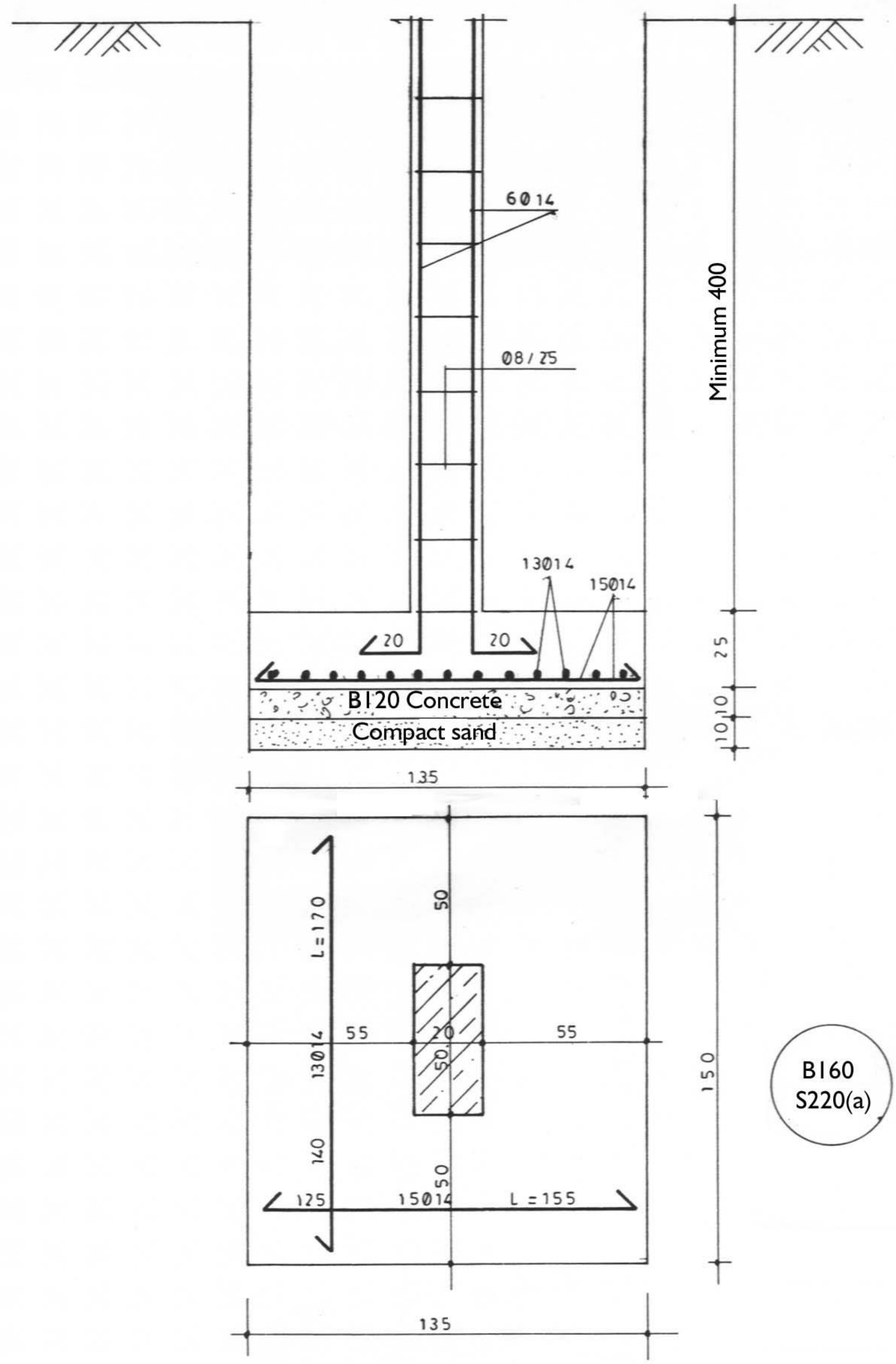
CIVIL ENGINEERING

DEPARTMENT

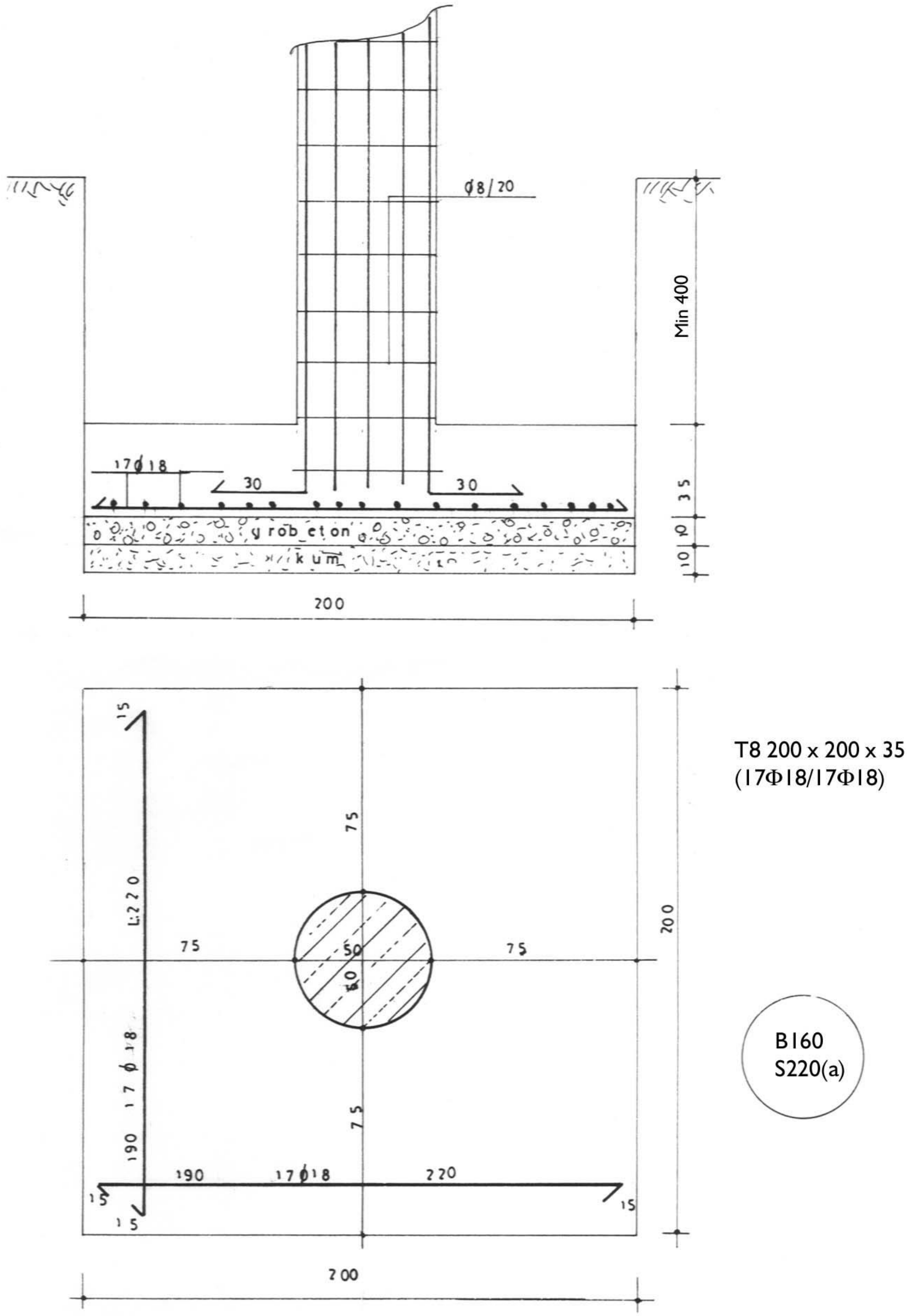
This chapter of this book is specially prepared for the students studying in **Civil Engineering Department.** The information in this **Addendum** is only for reference and there are no Homeworks or Exercises.



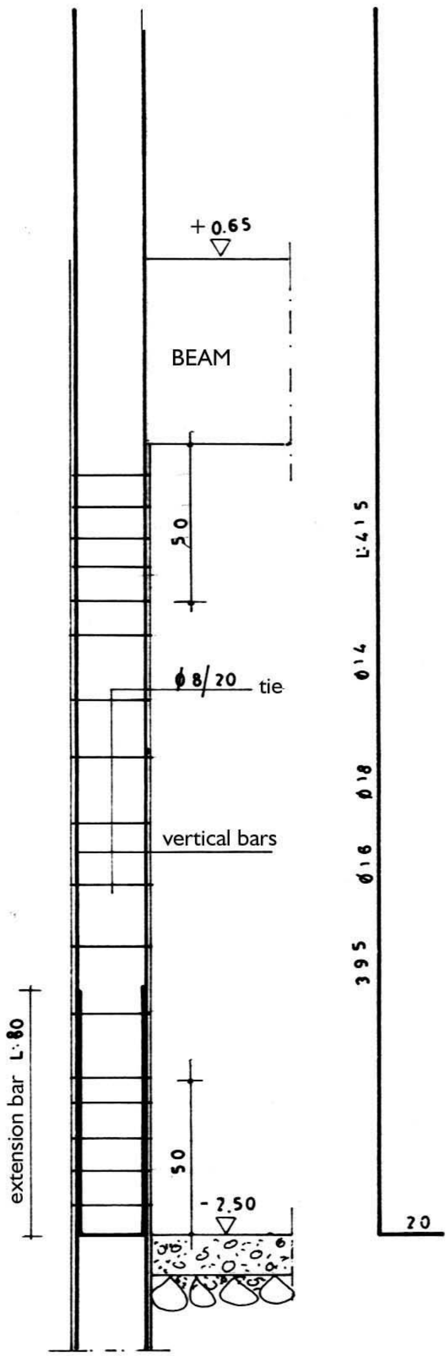
Retaining Wall details



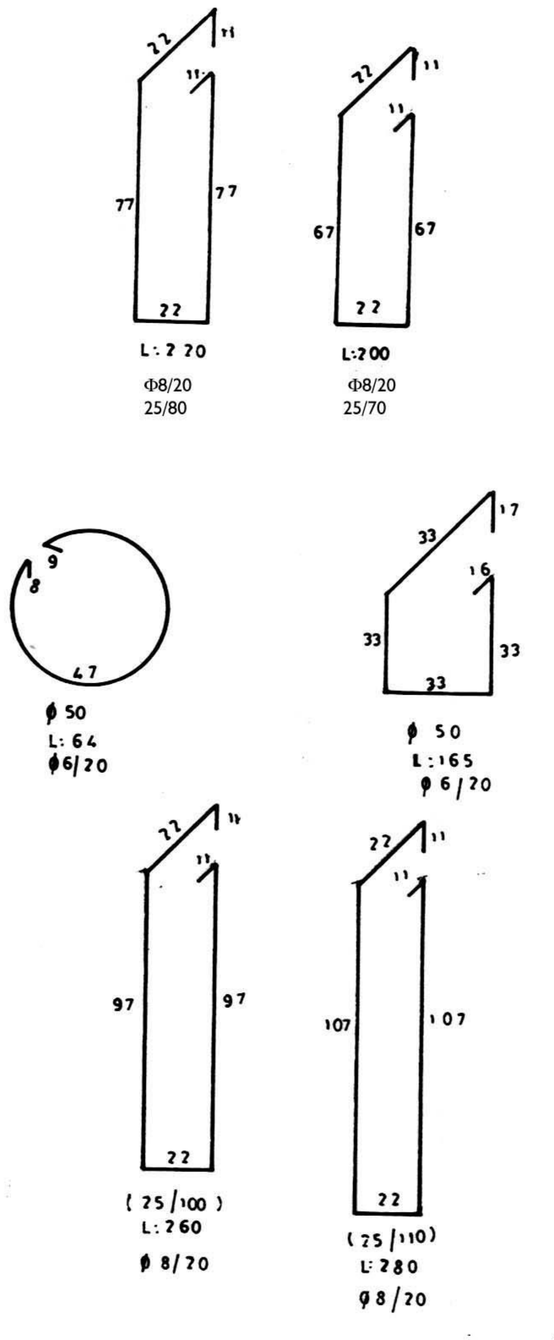
FOOTING DETAILS SCALE 1:20



FOOTING DETAILS SCALE 1:20

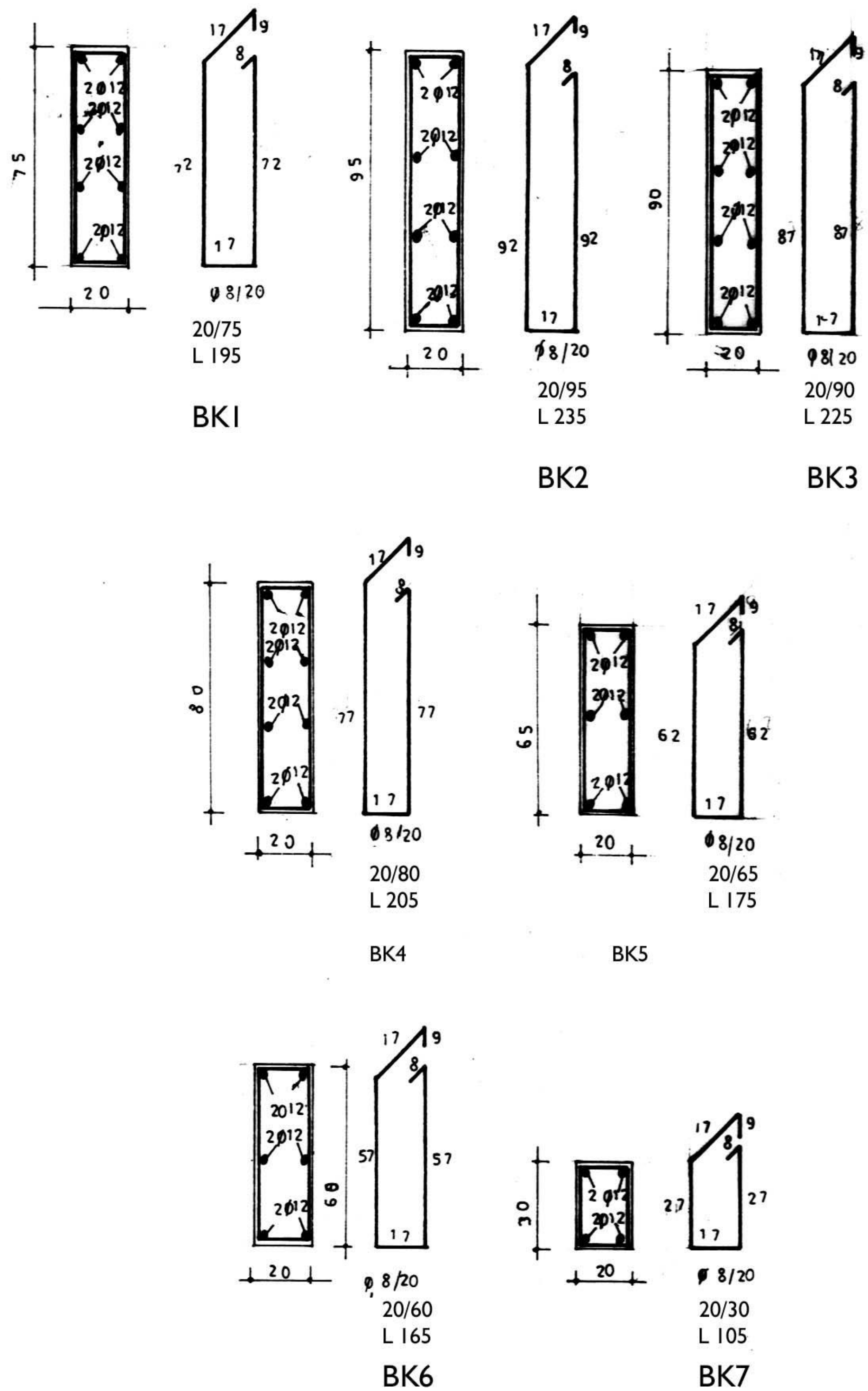


CROSS SECTION OF THE COLUMN

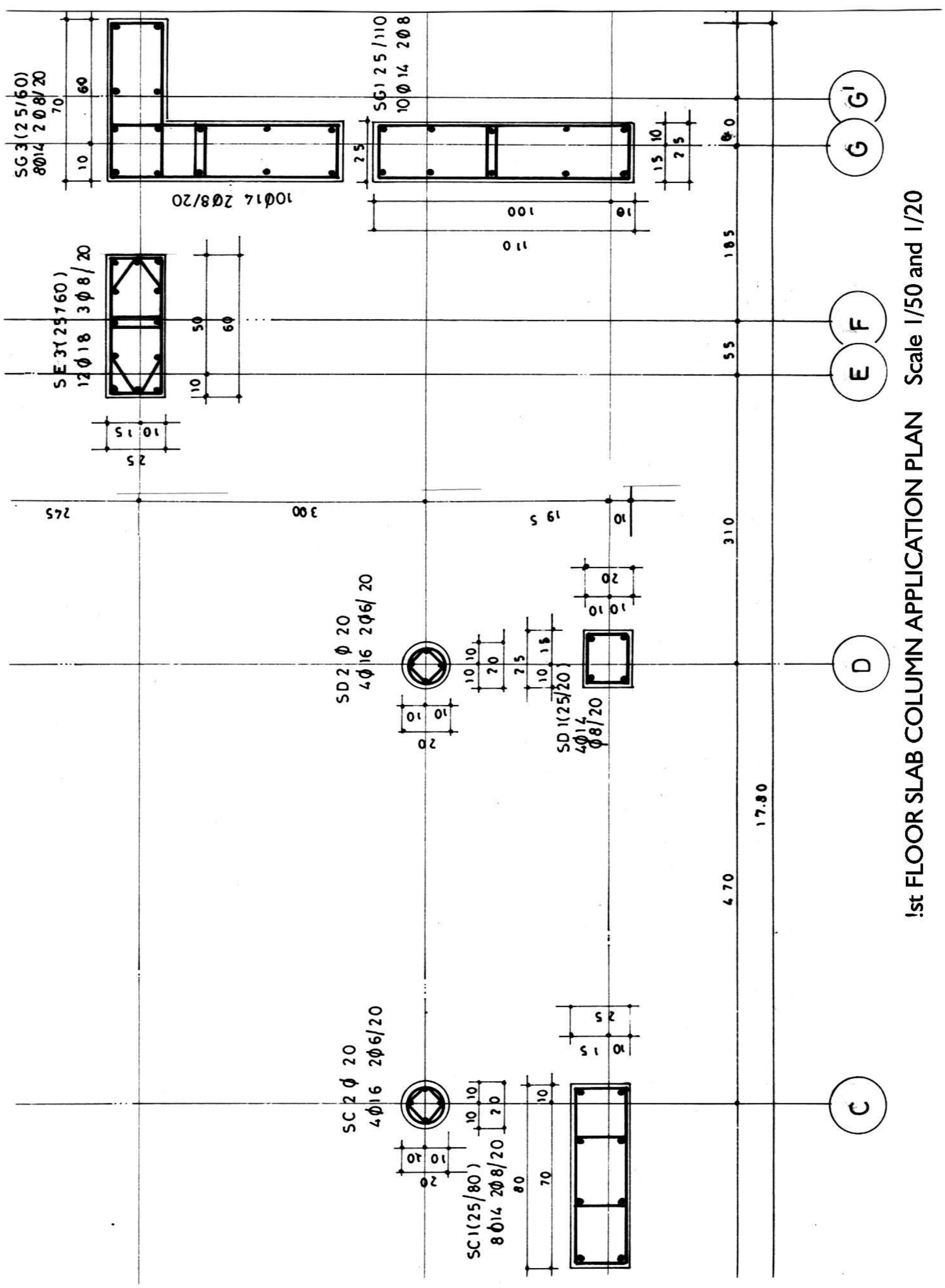


TIE DETAILS

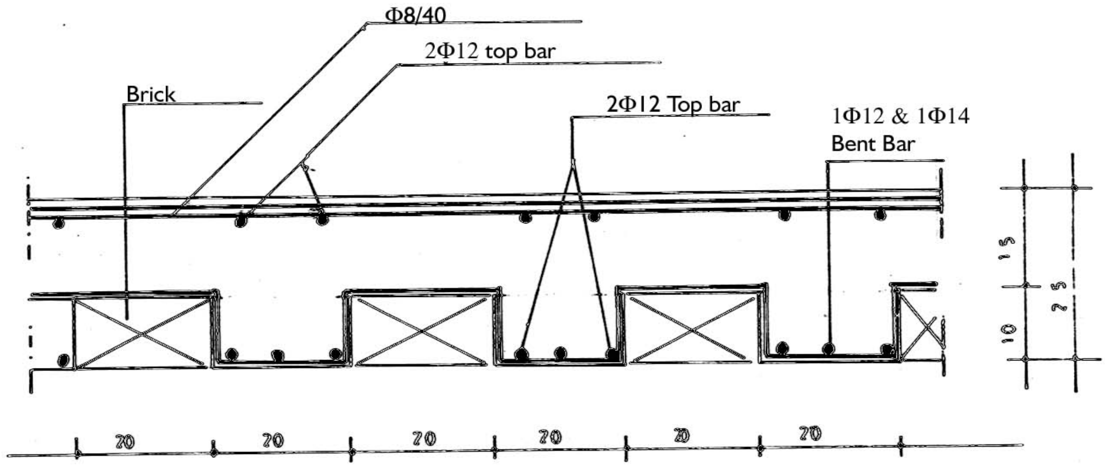
Steel Reinforcing Detail Drawing of a Column



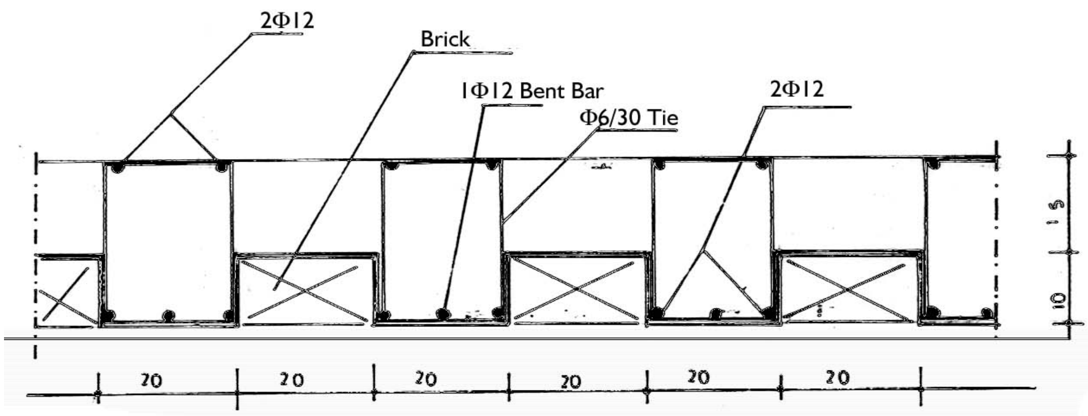
Steel Reinforcing Detail Drawing of a Column and Stirrups (Ties)



Column Application and Steel Reinforcing Detail Drawing

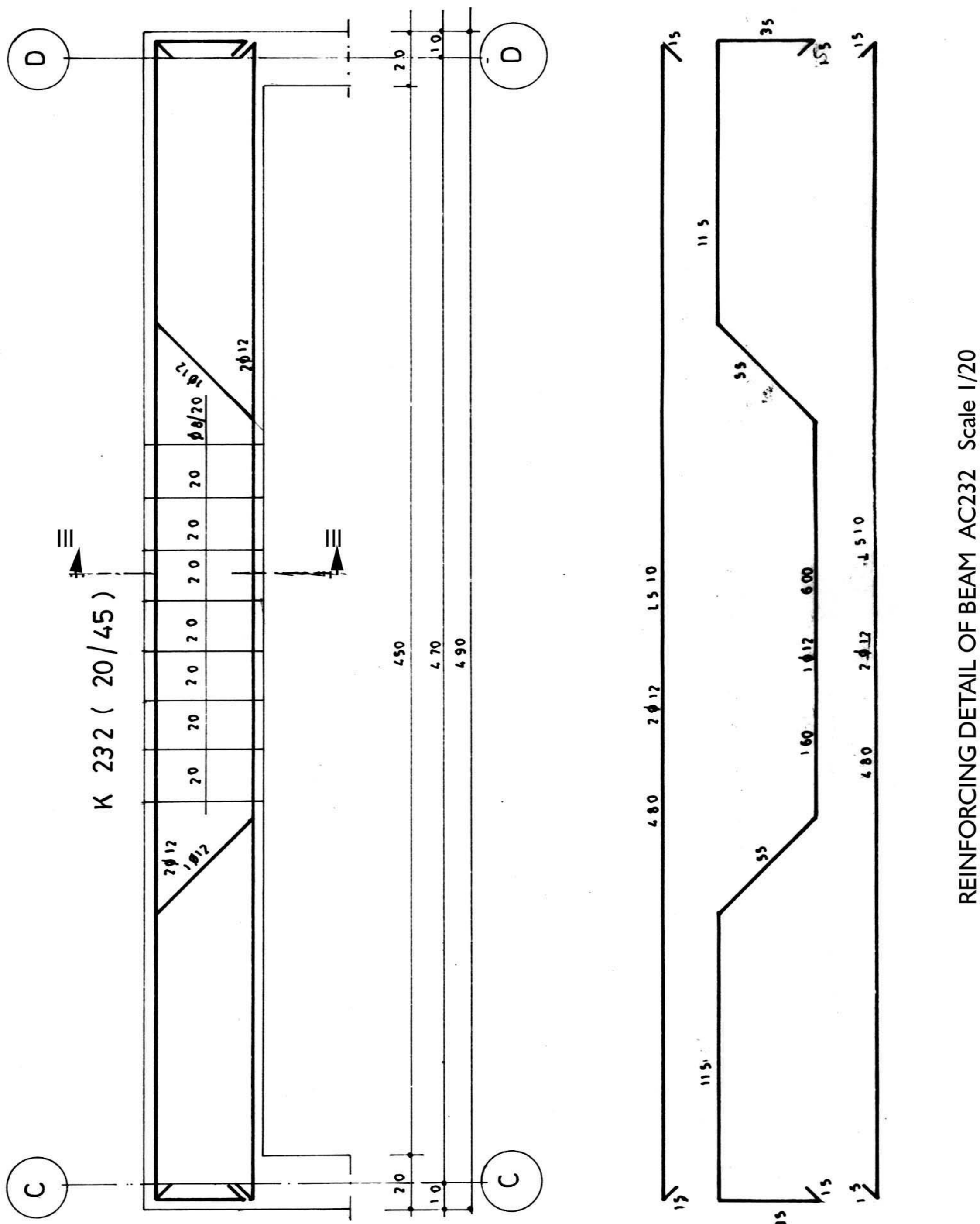


RIBBED FLOOR DETAIL Scale 1/10

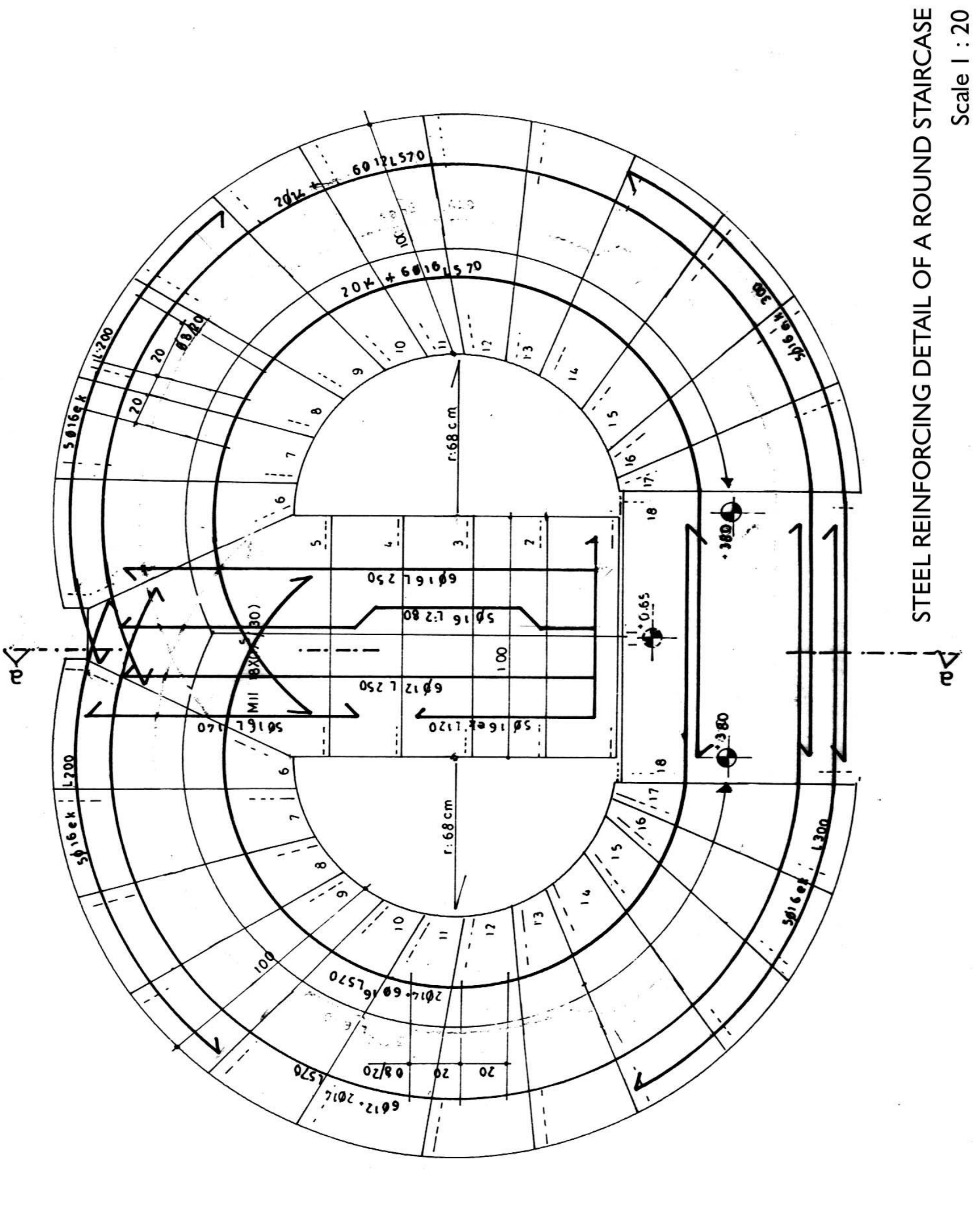


RIBBED FLOOR DETAIL Scale 1/10

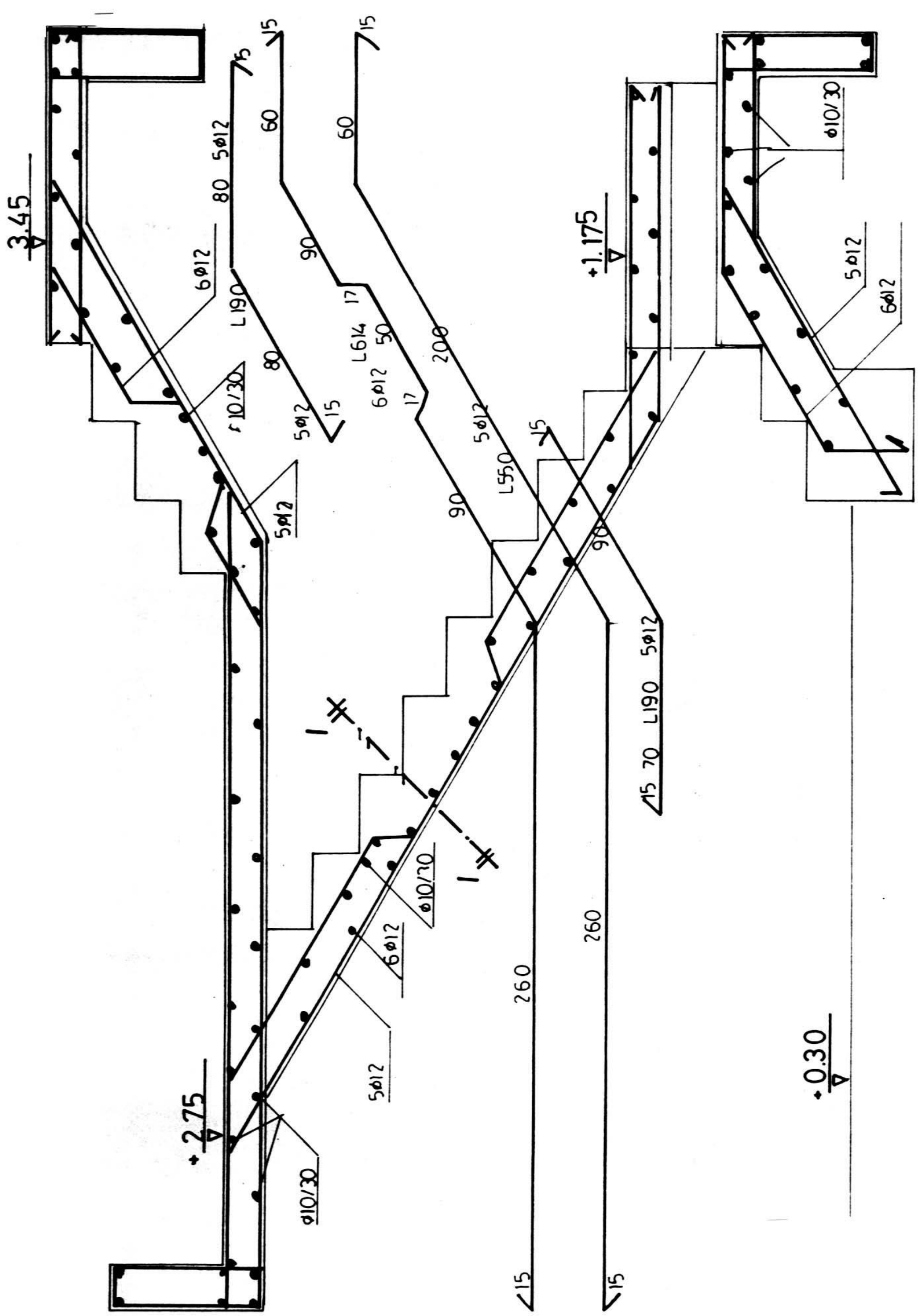
Cross section Drawing of a Ribbed Floor



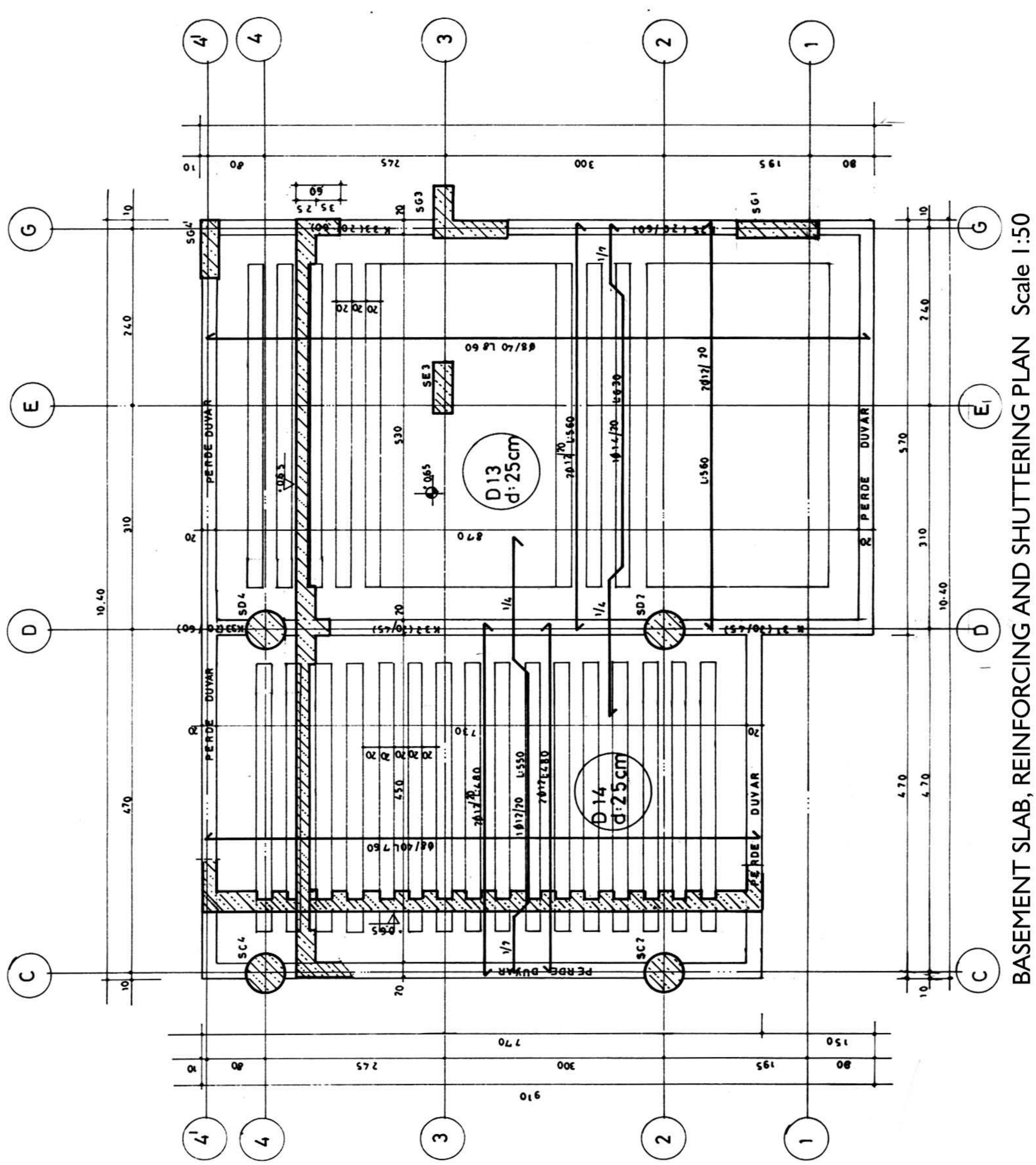
Steel Reinforcing Detail of a Beam



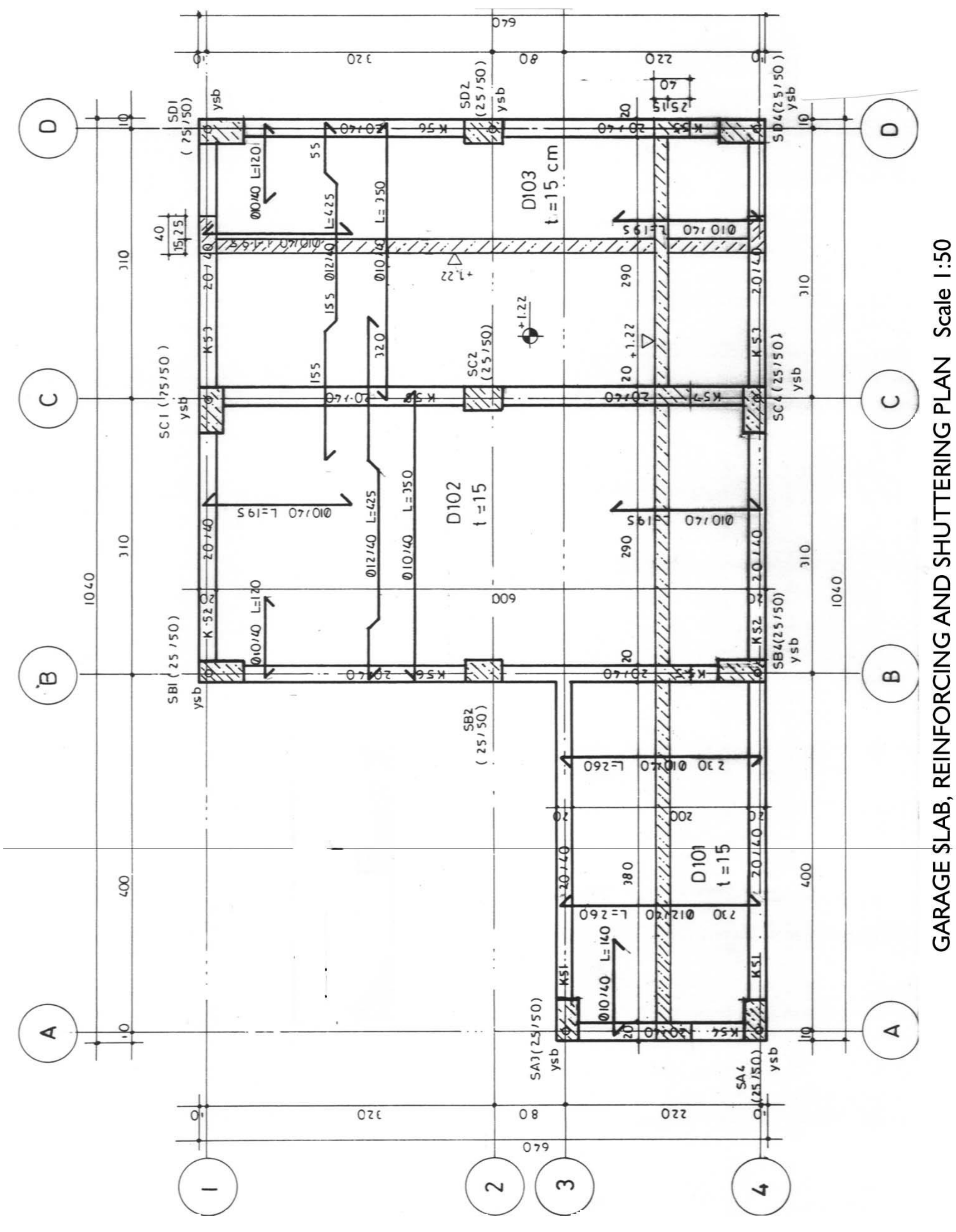
Steel Reinforcind detail Drawing of a Round Staircase
Steel Reinforcing and Shuttering Plan of a Slab



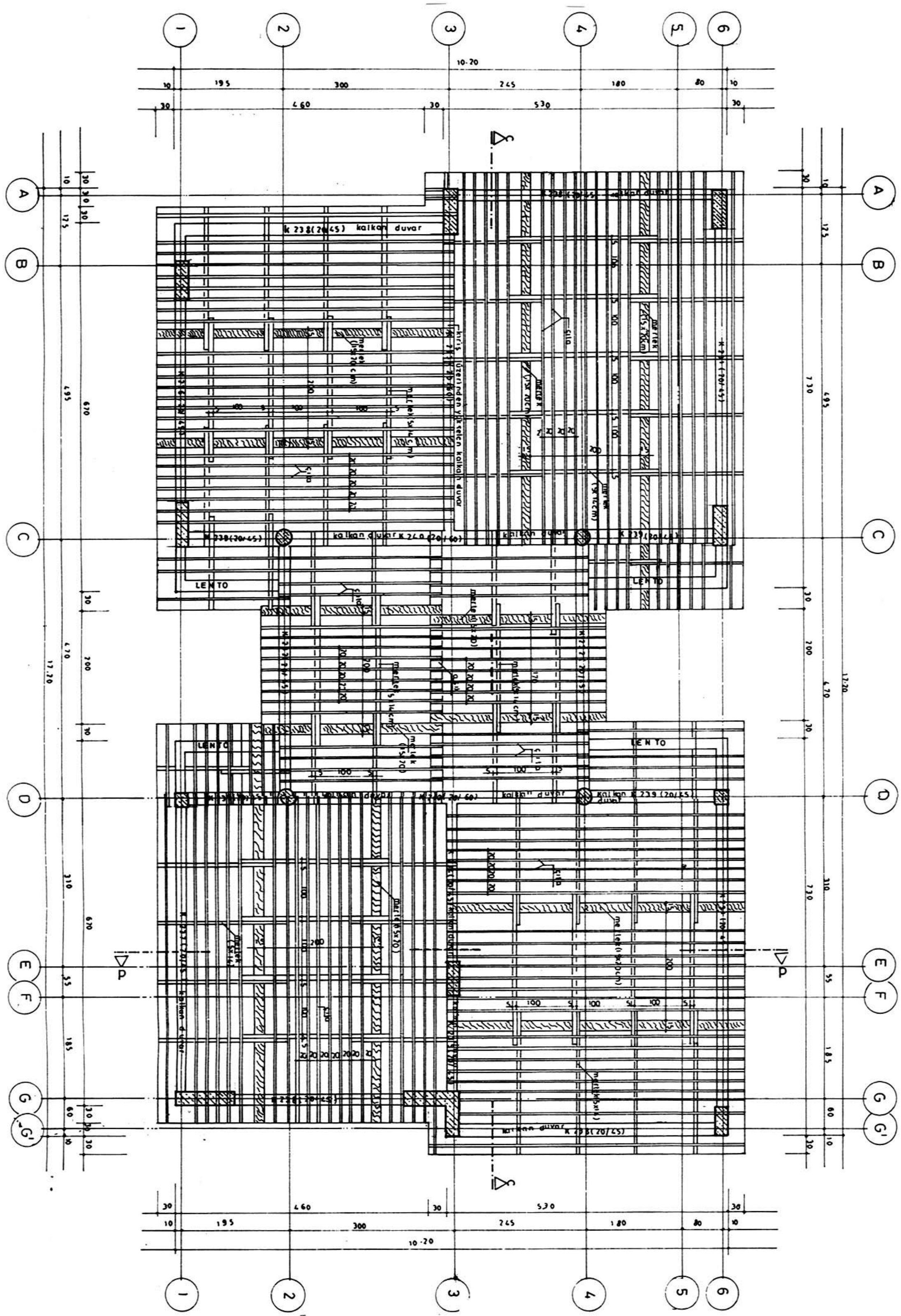
Steel Reinforcing Detail Drawing of a Straight Staircase



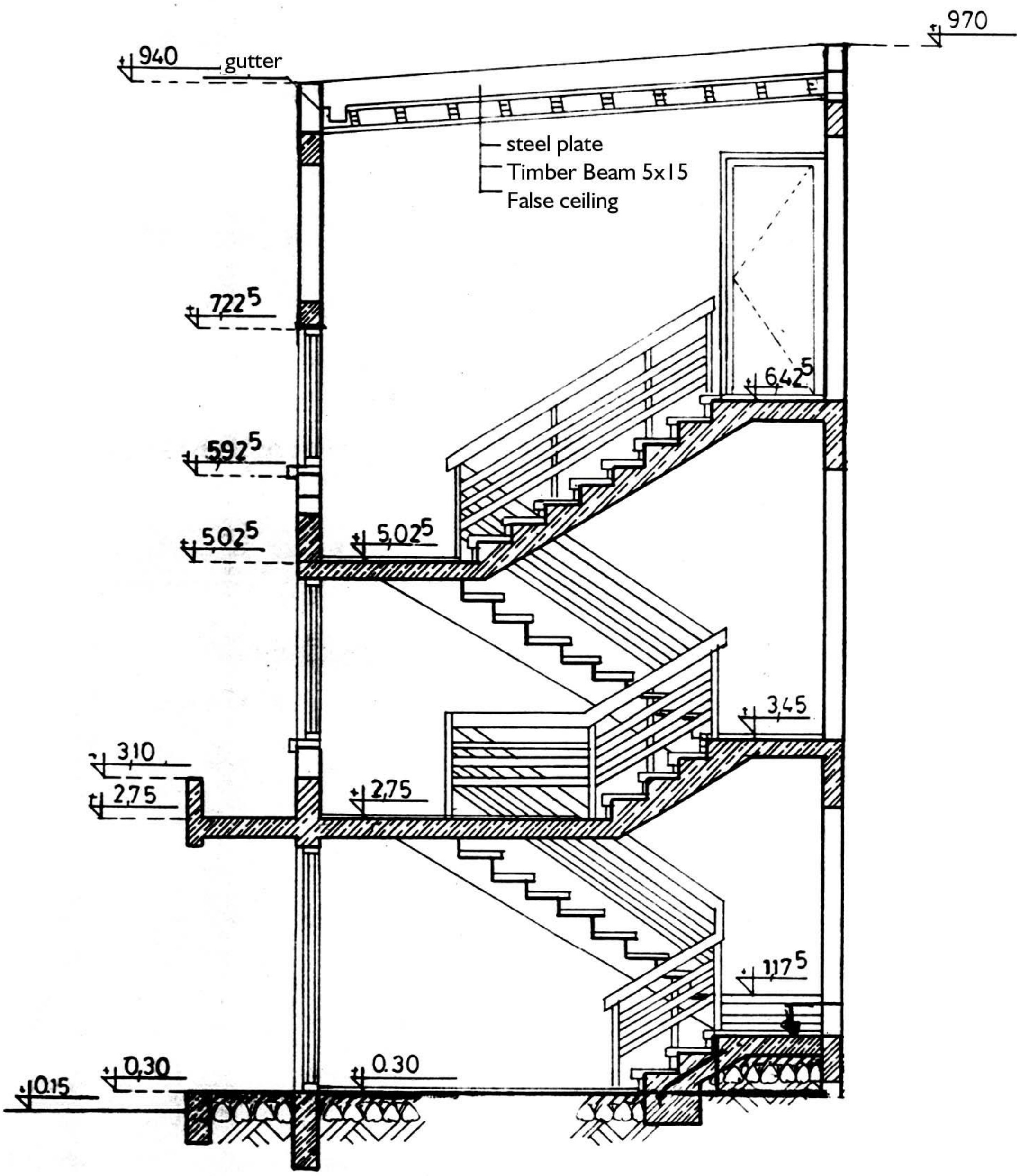
Steel Reinforcing and Shuttering Plan of a Slab



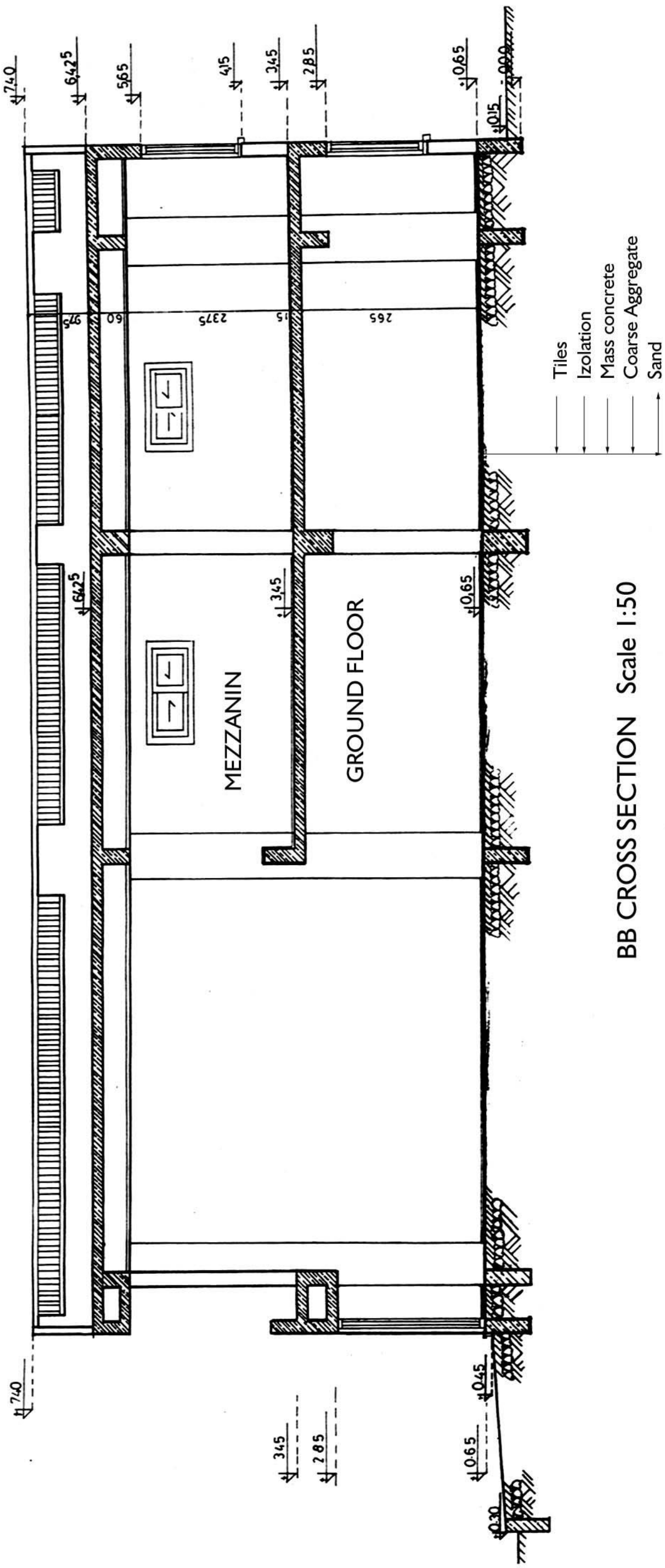
Steel Reinforcing and Shuttering Plan of a Slab



Timber Strut, Beam and Girder Detail Plan of a roof



Staircase Cross Section Drawing of a three-storey building



Cross section Drawing

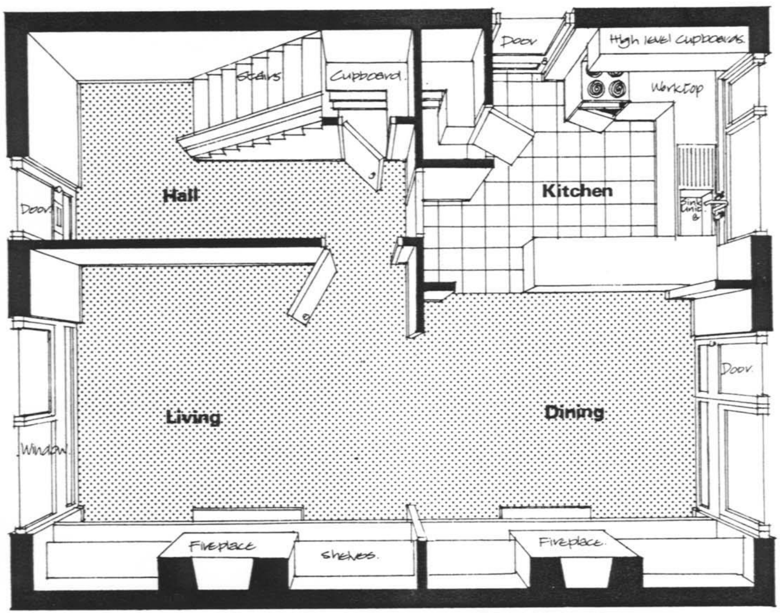
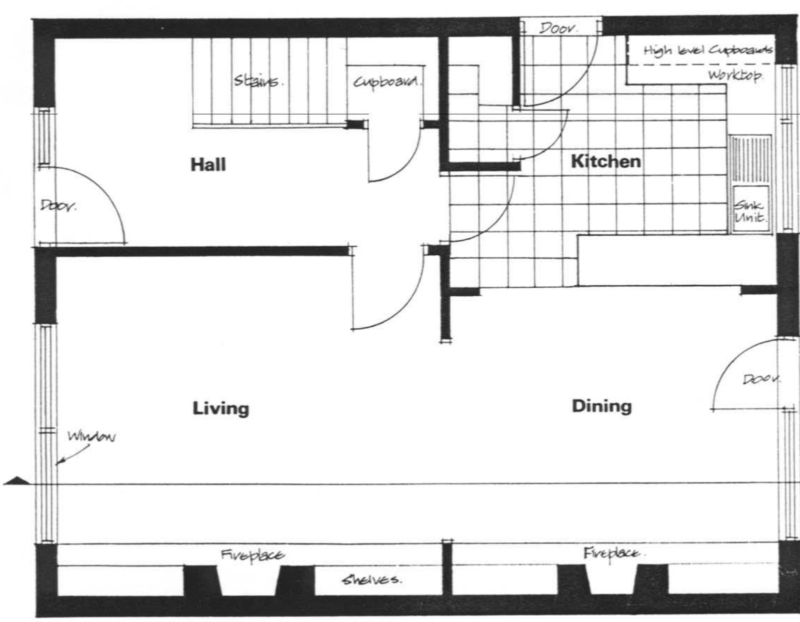
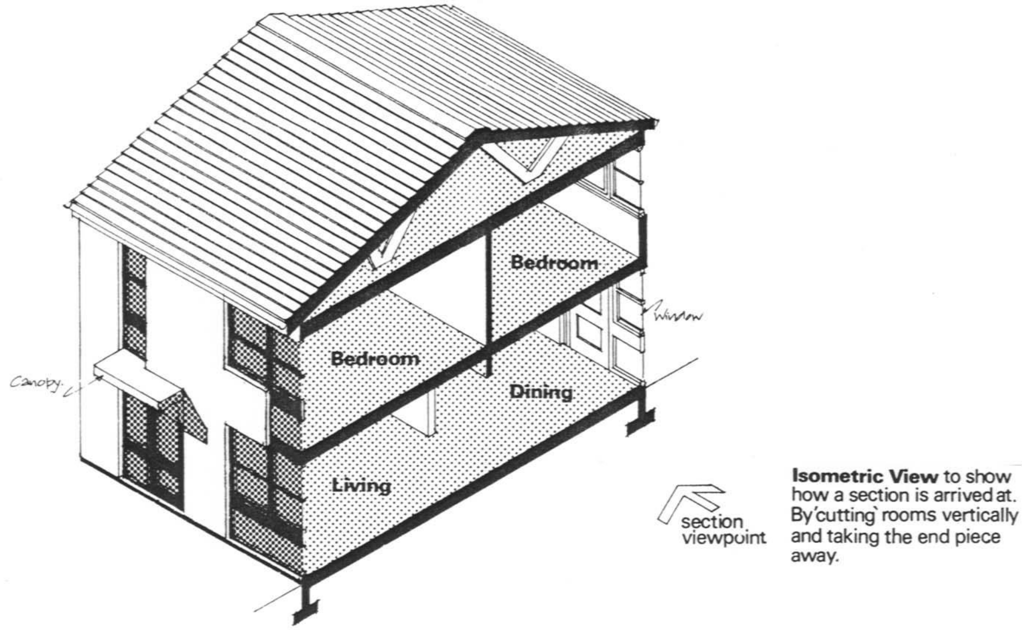


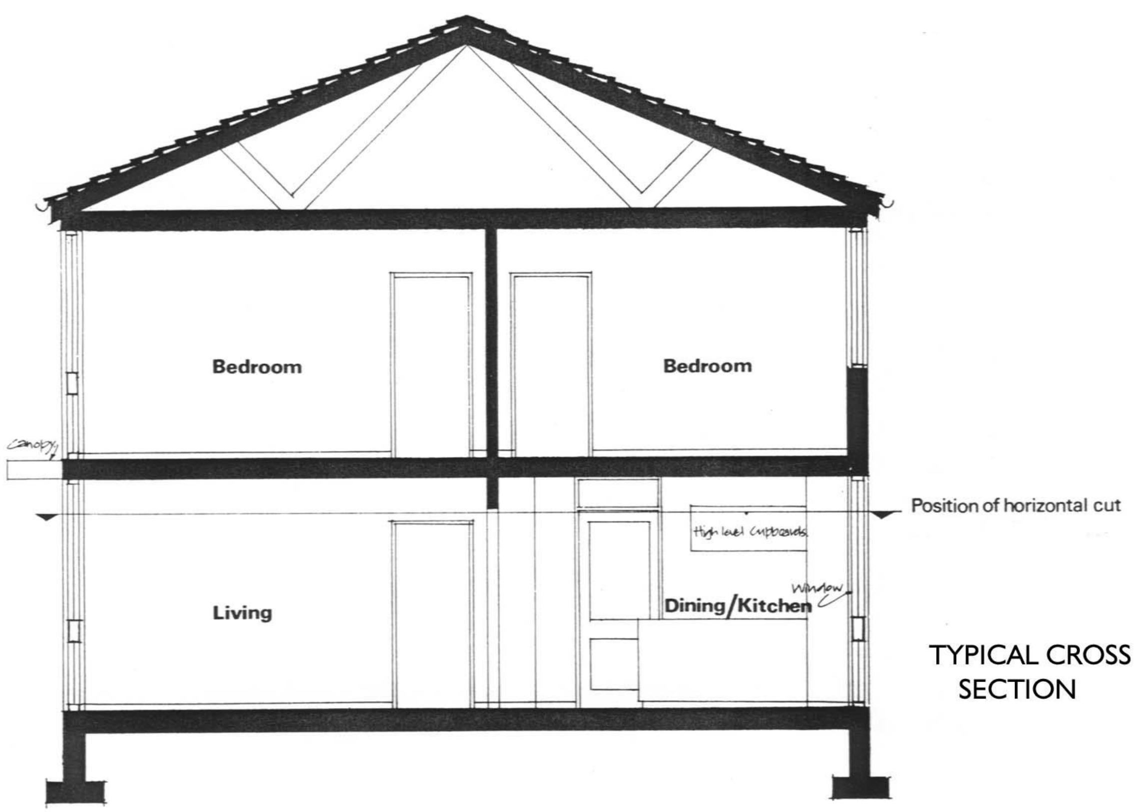
Diagram to show how a plan is arrived at. By 'cutting' rooms horizontally and taking the top piece away.



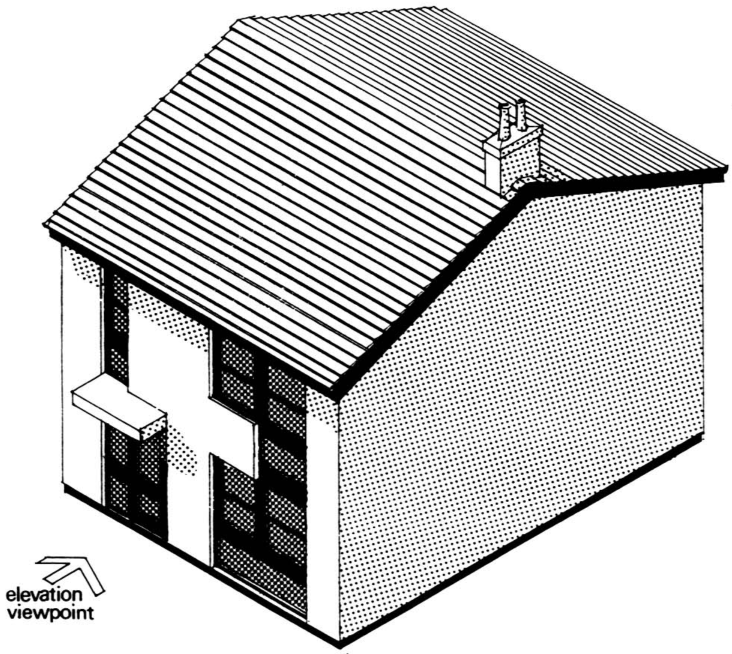
Typical House Plan
This is a drawing looking directly down from the top of a room.

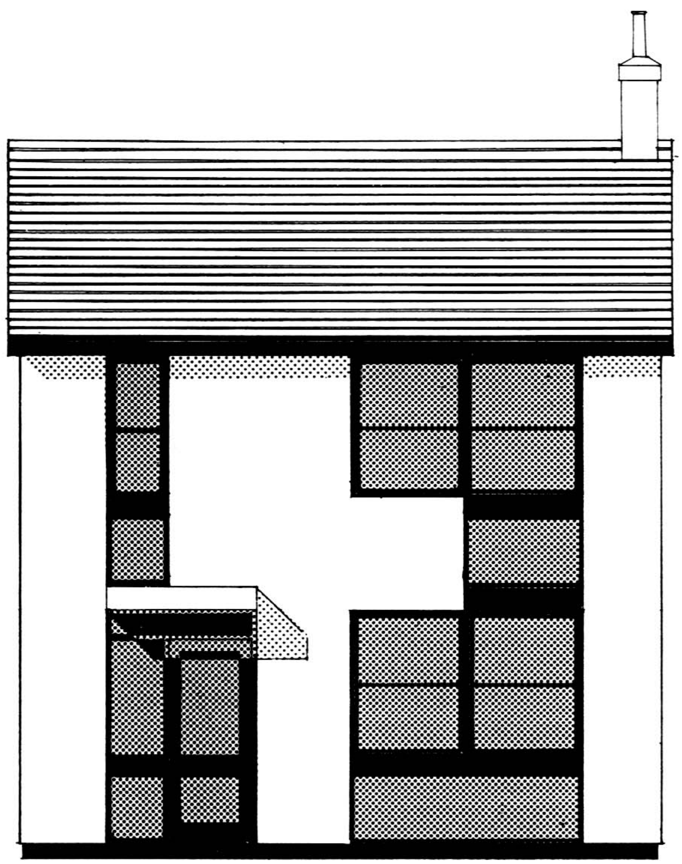
Typical House Plan and a Diagram to show how a PLAN is arrived





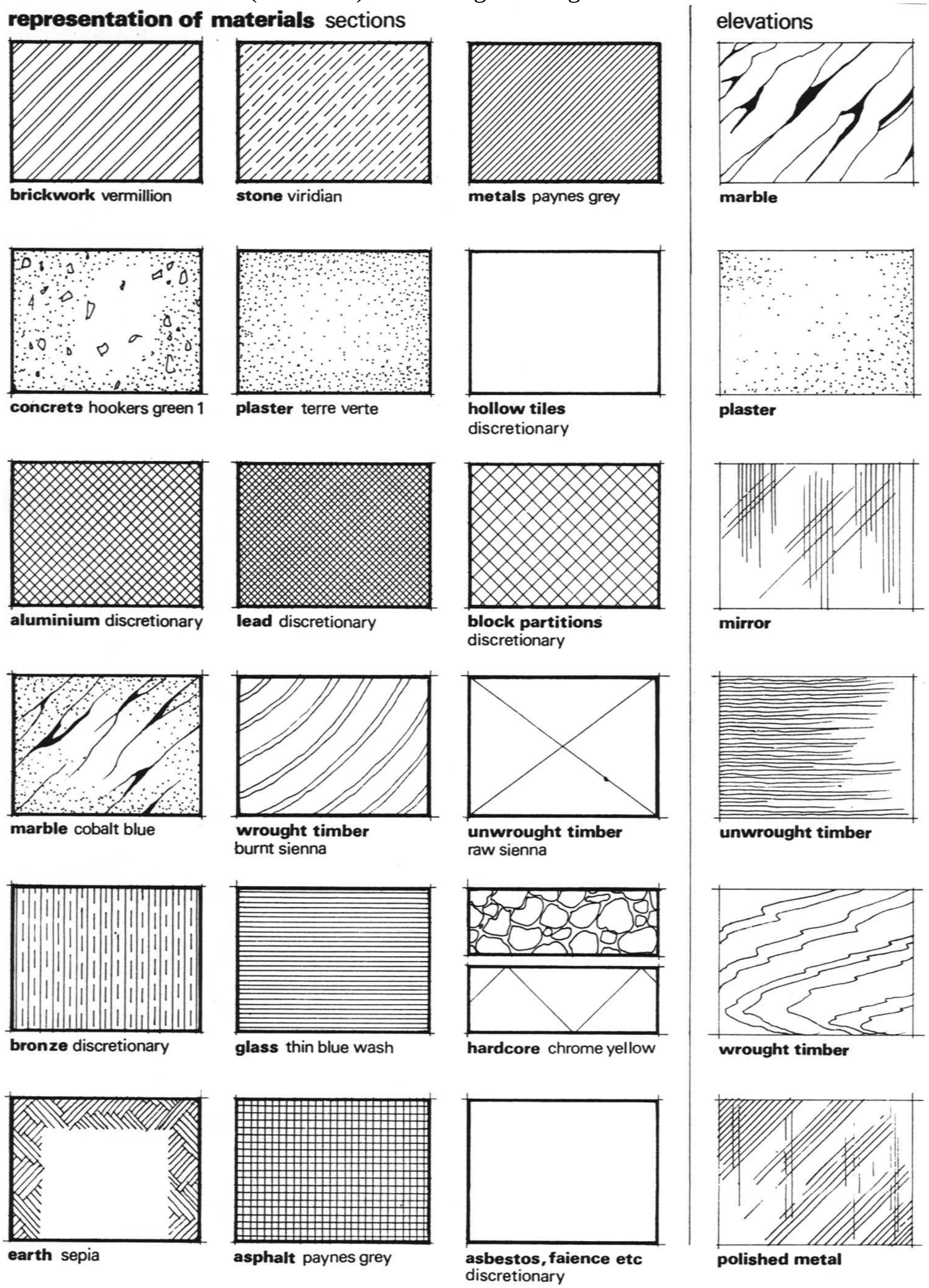
Cross section Drawing and Isometric View to show how a section is arrived at.





Front Elevation of building

Front View (Elevation) of building showing which elevation it is.



Representation of Materials and their cross sections on a drawing

ELECTRICAL ENGINEERING **ADDENDUM EE**

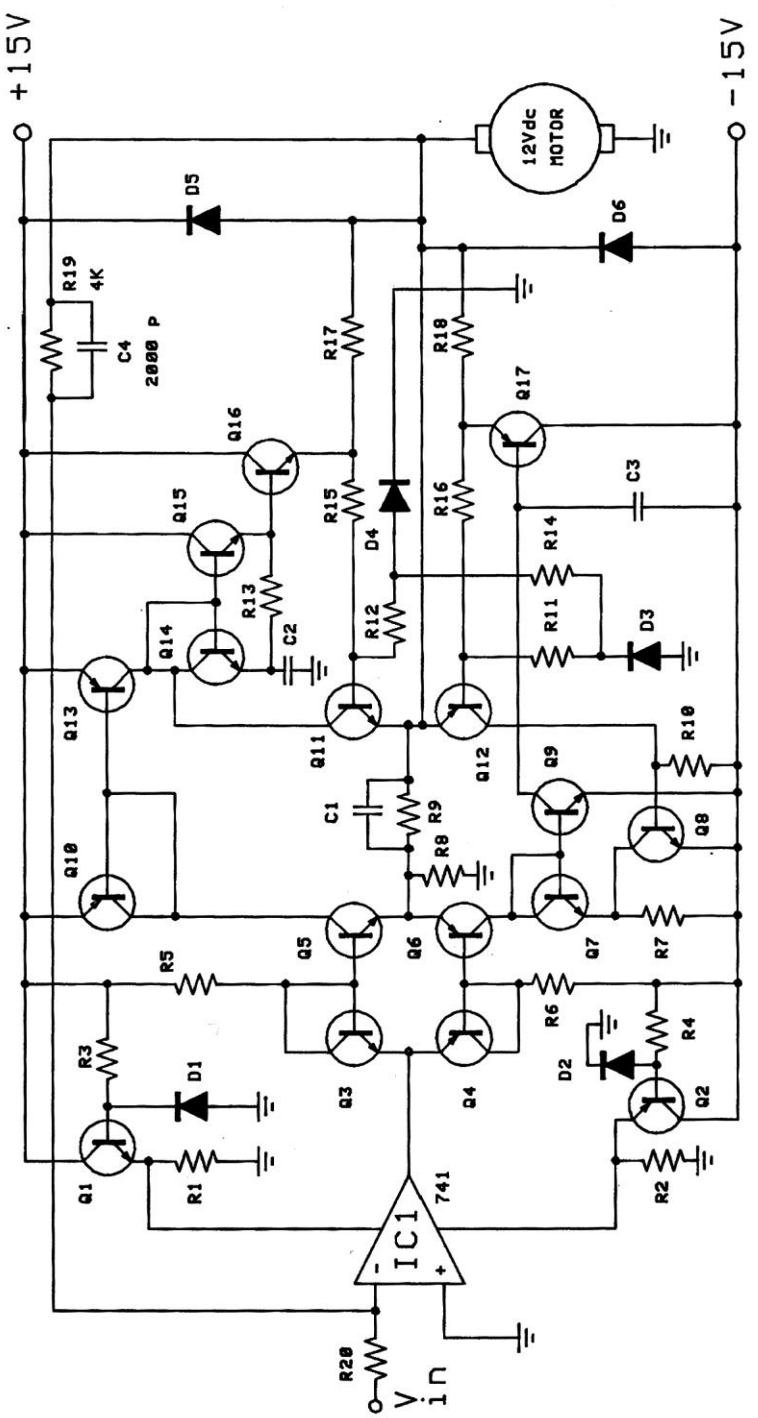
SPECIAL ADDENDUM

FOR STUDENTS IN

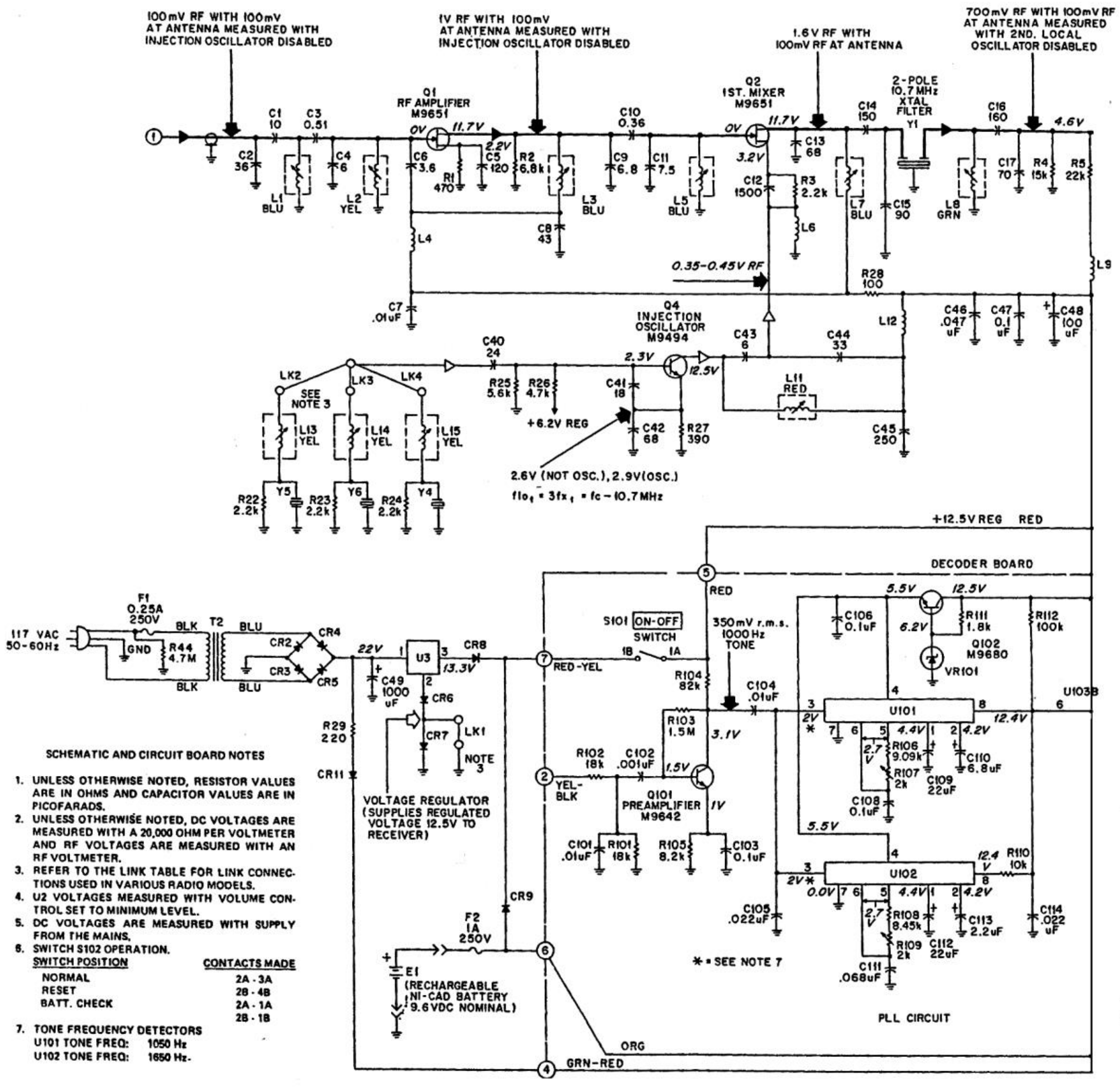
ELECTRICAL ENGINEERING

DEPARTMENT

This chapter of this book is specially prepared for the students studying in **Electrical Engineering Department.** The information in this **Addendum** is only for reference and there are no Homeworks or Exercises.

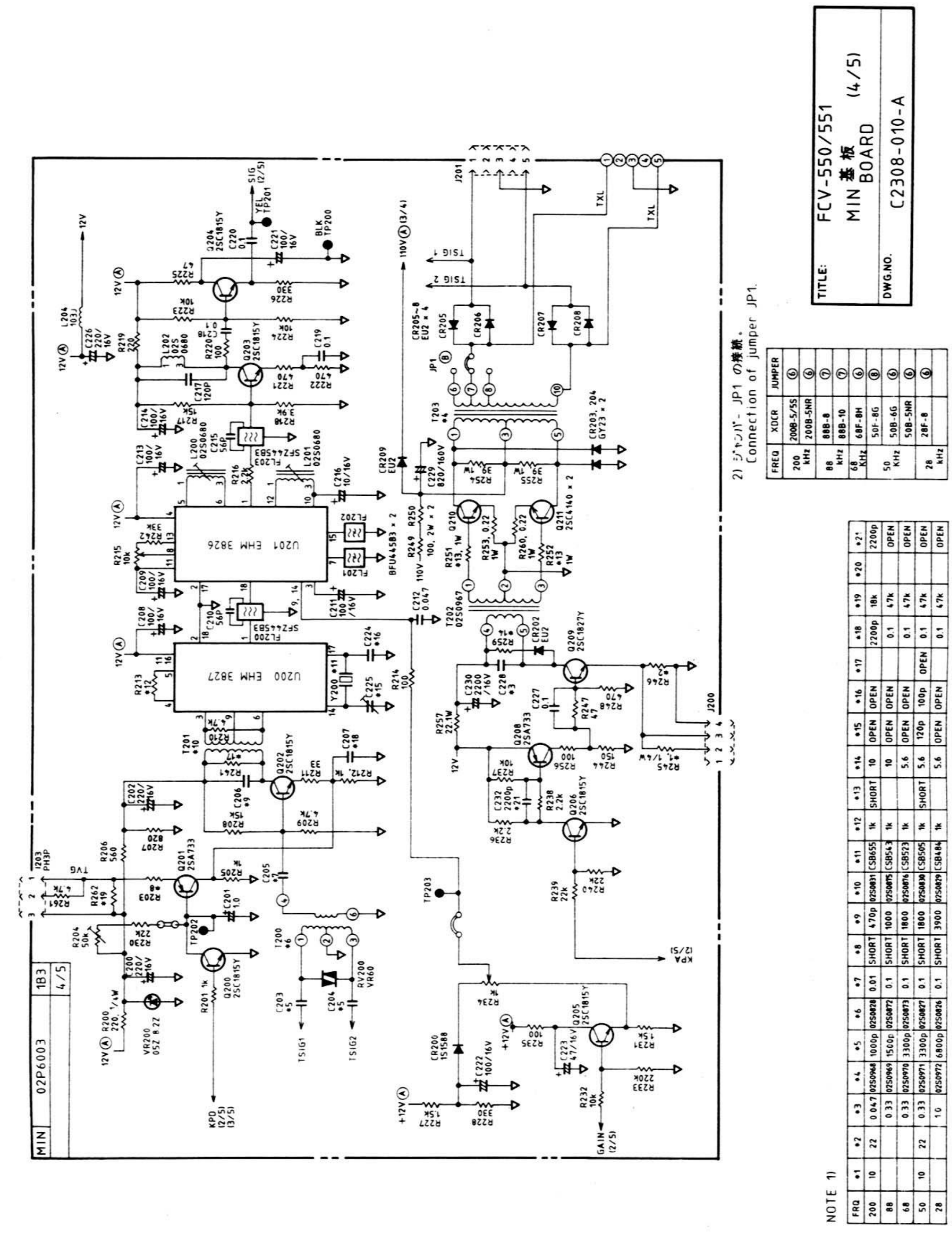


Circuit Diagram of a Sounder

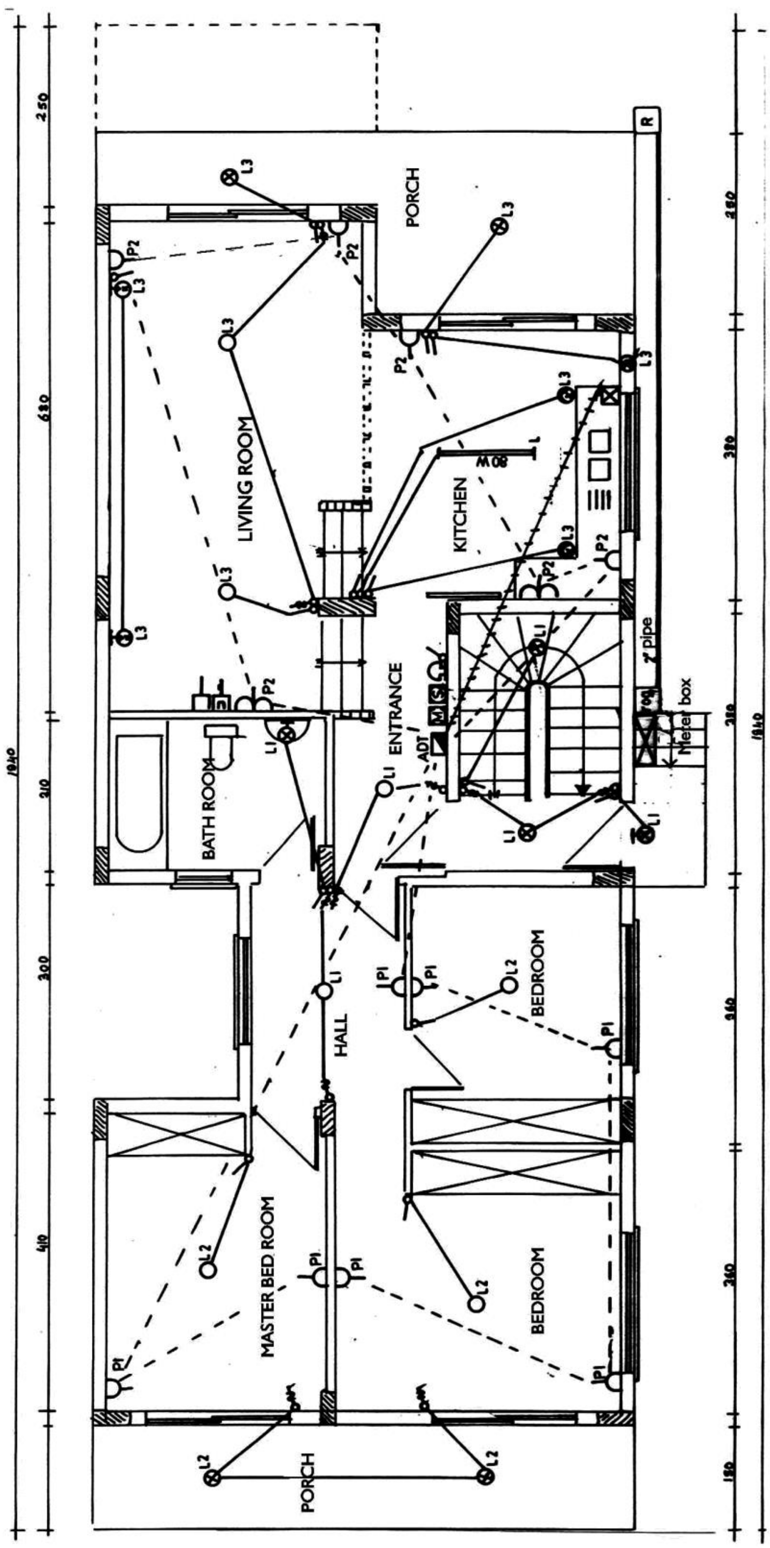


SCHEMATIC DIAGRAM OF A VHF RADIO

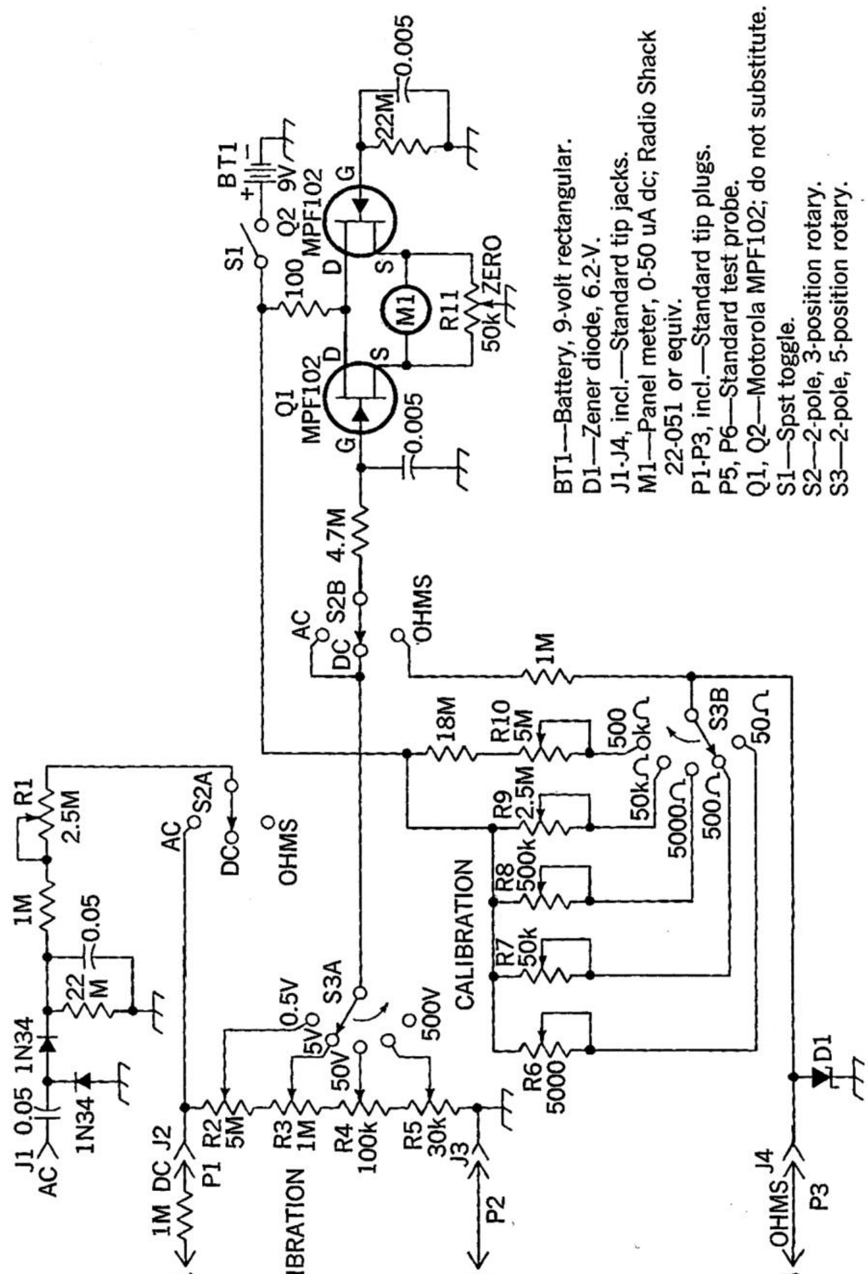
Wiring diagram of a VHF Radio



Circuit Diagram of a VHF Radio Telephone



Single Phase wiring diagram of a house



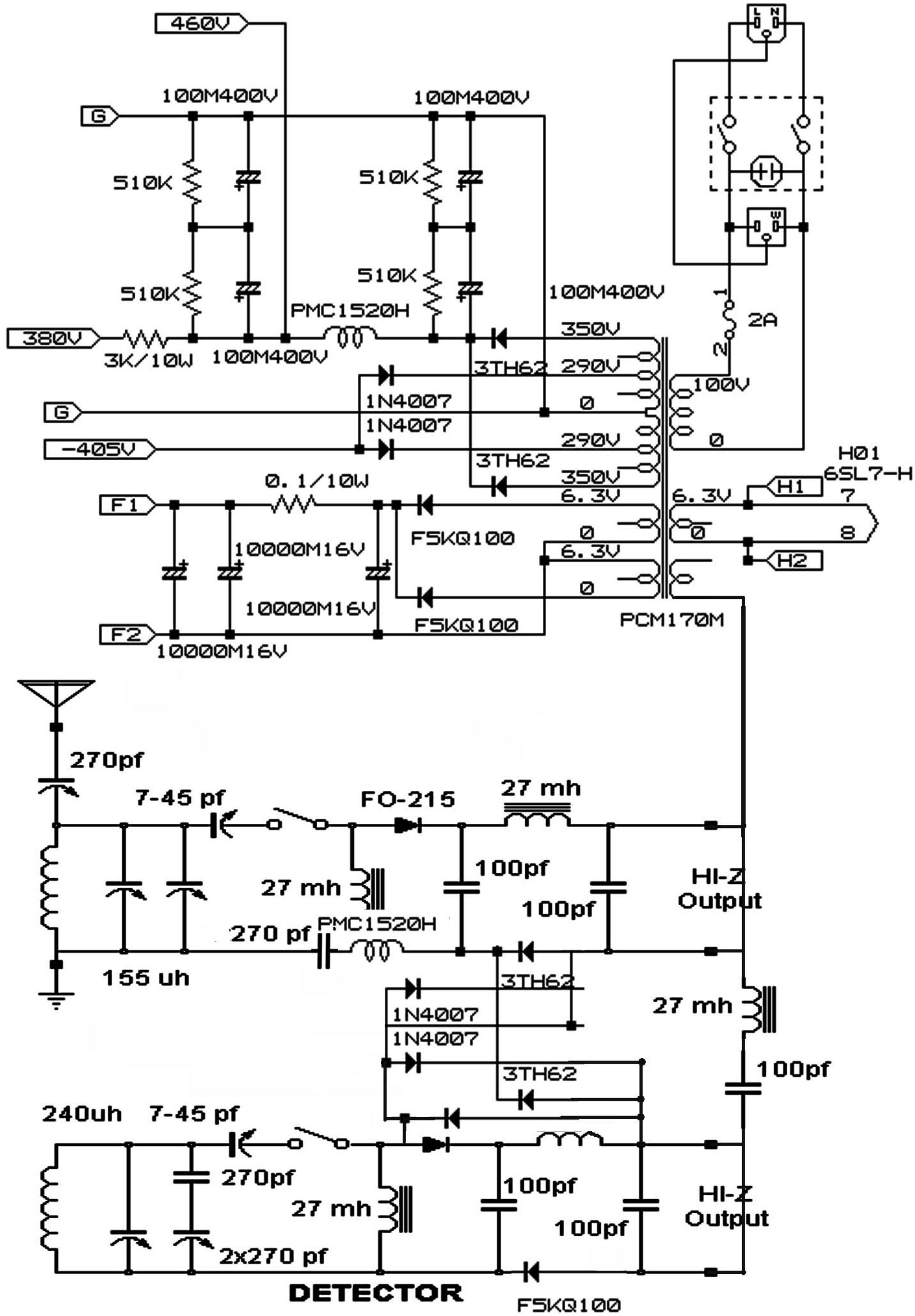
Schematic diagram of a FET

NO	SİMGE	ANLAM	NO	SİMGE	ANLAM
1		SAYAÇ	23		TOPRAKLAMA
2	60 ÖIL	60 AMPERLİK AŞIRI AKIM KORUMALI TOPRAK OTOMATİĞİ.	24		ANA HAT
3		AYIRICI	25		LÂMBA DEVRELERİ.
4		SİGORTALI AYIRICI	26	- - - - -	PRİZ DEVRELERİ
5		ANA DAĞITIM TABLOSU	27		ELEKTRİK OCAĞI DEVRESİ (COOKER)
6		TALİ DAĞITIM TABLOSU	28		SABİT CİHAZ HATTI (Ç.K.S GİBİ)
7	30	30 AMPERLİK SİGORTA	29		İLERİ AŞAMADA ÇEKİLECEK HAT.
8	10	10 AMPERLİK MİNYATÜR KESİCİ.	30		TOPRAK HATTI.
9		TERMİK VE MAGNETİK KORUMALI KESİCİ.	31		YEDEK BESLEME (GENERATÖR HATTI)
			32	+ + + +	ALARM HATTI.
10		DİREKT YOL VERME AYGITI.	33		ÇAĞIRMA HATTI (ZİL + INTERCOM)
11		YILDIZ ÜÇGEN YOL VERME AYGITI.	34		TELEFON HATTI.
12		OTO TRAFO İLE YOL VERME AYGITI.	35		YERALTI KABLOSU.
13		BİLEZİKLİ MOTOR YOL VERME AYGITI. (SLIPRING)	36		ADİ ANAHTAR.
14	M 3	3 FAZLI MOTOR	37		İKİLİ GRUP ANAHTARI.
15		ELEKTRİK OCAĞI KONTROL ÜNİTESİ (COOKER CONTROL)	38		İKİ YOLLU (VAEVİYEN) ANAHTAR.
16		SABİT CİHAZ (GENEL)(SİGORTALI)	39		ARA (INTERMEDIATE) ANAHTAR.
17		SABİT CİHAZ (GENEL)(SİGORTASIZ)	40		DİMMER ANAHTAR.
18	S	SEMAVER	41	Z.Ç.K	ZİL VEYA ÇAĞIRMA DÜĞMESİ VEYA KAPI AÇTIRMA.
19	Ç	ÇAMAŞIR MAKİNESİ	42		MERDİVEN OTOMATİĞİ DÜĞMESİ.
20	B	BULAŞIK YIKAMA MAKİNESİ.	43		TAVAN LÂMBASI (GLOB)
21	AC	AIR CONDITIONER	44		AYRI YAKILABİLEN İKİ LÂMBALI TAVAN GLOBU.
22		PARAFUDUR	45		DUVAR LÂMBASI.

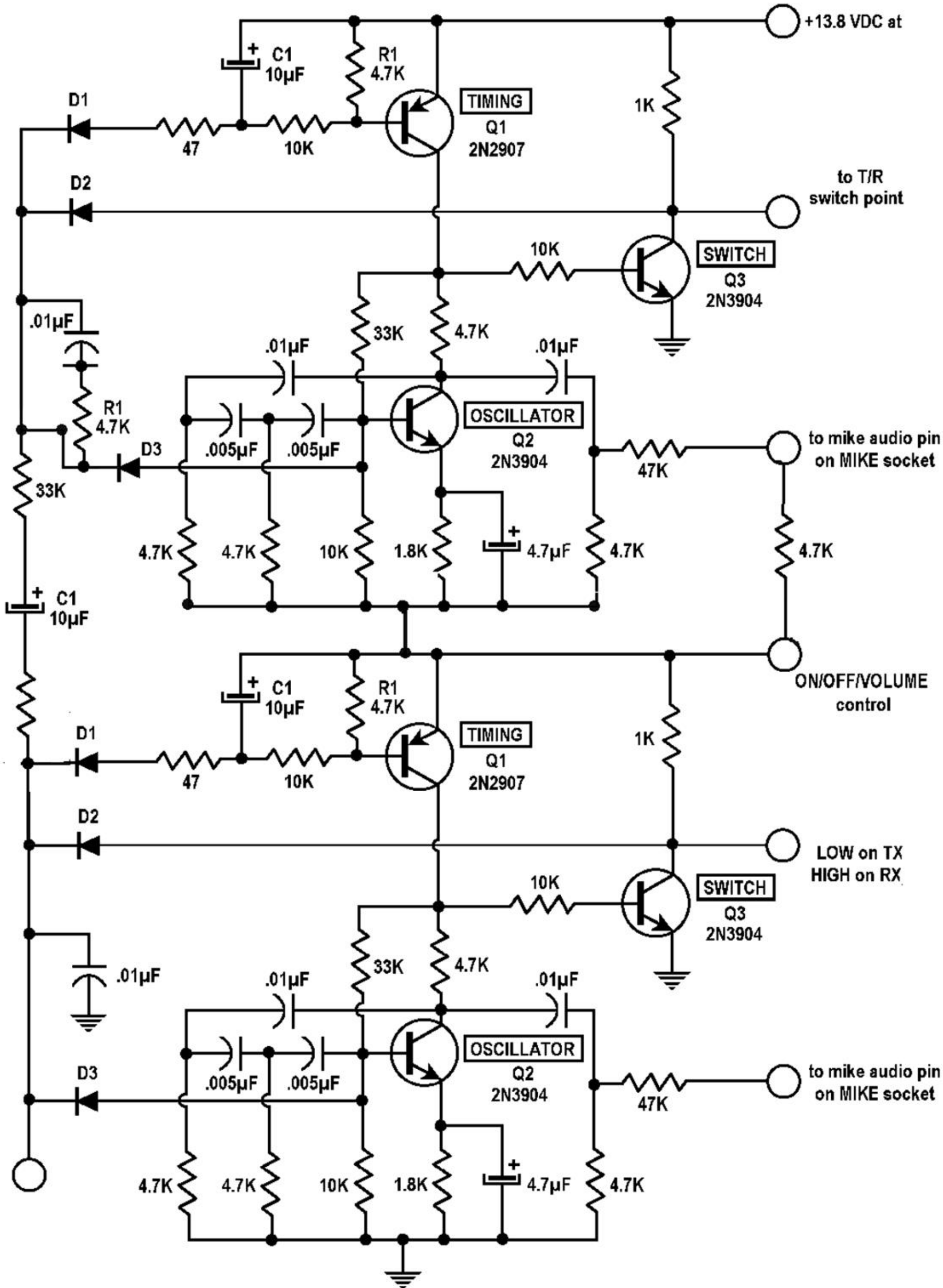
Chart of electrical Symbols and explanations used by the Local electricity Authority

NO	SİMGE	ANLAM	NO	SİMGE	ANLAM
46		DIŞ DUVAR SÜS ARMATÜRÜ	69		İNTERKOM ÜNİTESİ
47		BAHÇE SÜS ARMATÜRÜ (DİREK VEYA DUVAR ÜSTÜ)	70		KAPI OTOMATİĞİ
48		ASKI TİPİ SÜS ARMATÜRÜ	71		HOPARLÖR
49		AVİZE	72		MİKROFON
50		İLERİ AŞAMADA KULLANILACAK LÂMBA NOKTASI.	73		AMPLİFİKATÖR
51		TEHLİKE ANINDA KAÇIŞ AYDINLATMA LÂMBASI.	74		ANA SAAT
52		PROJEKTOR	75		İKİNCİL SAAT
53		APLİK	76		SİREN
54	1x40	TEKLİ 40 WATTLIK FLORESENT LÂMBA	77		ALARM ANAHTARI (YANGIN V.S.)
55	2x80	DİFFUSERLİ 80 WATTLIK FLORESENT LÂMBA	78		YANGIN DETEKTÖRÜ
56		13 AMPERLİK TEKLİ PRİZ	79		YILDIRIMLIK
57		13 AMPERLİK ANAHTARLI PRİZ	80		KABLO BAŞLIĞI
58		13 AMPERLİK İKİLİ PRİZ	81		YANINA YAZILDIĞI CİHAZ WATERFROOF DEMEKTİR.
59		TELEFON PRİZİ.	82		3Ø + N HAT
60		RADYO PRİZİ	83	R.S.T	FAZLARI BELİRLEME SİMGELERİ.
61		ANTEN PRİZİ (T.V) (TEKLİ)	84		ENERJİ YUKARIYA İLETİLİR.
62		MERDİVEN OTOMATİĞİ	85		ENERJİ AŞAĞIYA İLETİLİR
63	Z.Ç.N	ZİL TRAFOSU (ÇAĞIRMA, NEON V.S)	86		YILDIRIMLIK HATTI.
64		ZİL	87		ASPİRATÖR
65		TELEFON SANTRALI.			
66		SANTRALA BAĞLI TELEFON AYGITI			
67		DIŞ TELEFON AYGITI.			
68		INTERKOM MERKEZİ.			

Chart of electrical Symbols and explanations used by the Local electricity Authority



Crystal radio Diagram


+13.8 VDC at
C1
10µF
R1
4.7K
TIMING
Q1
2N2907
1K
D1
47
10K
D2
to T/R
switch point
10K
SWITCH
Q3
2N3904
.01µF
33K
4.7K
.01µF
.01µF
R1
4.7K
OSCILLATOR
Q2
2N3904
D3
.005µF
.005µF
to mike audio pin
on MIKE socket
47K
33K
4.7K
4.7K
10K
1.8K
4.7µF
4.7K
4.7K
C1
10µF
ON/OFF/VOLUME
control
C1
10µF
R1
4.7K
TIMING
Q1
2N2907
1K
D1
47
10K
D2
LOW on TX
HIGH on RX
10K
SWITCH
Q3
2N3904
.01µF
33K
4.7K
.01µF
.01µF
OSCILLATOR
Q2
2N3904
D3
.005µF
.005µF
to mike audio pin
on MIKE socket
47K
4.7K
4.7K
10K
1.8K
4.7µF
4.7K

SPECIAL ADDENDUM

FOR STUDENTS IN

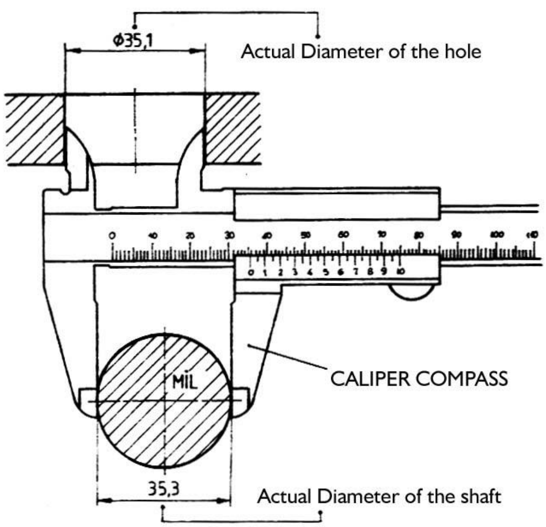
MECHANICAL ENGINEERING

DEPARTMENT

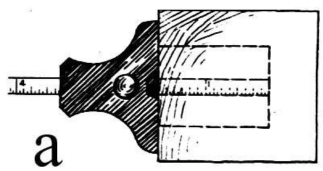
This chapter of this book is specially prepared for the students studying in **Mechanical Engineering Department.** The information in this **Addendum** is only for reference and there are no Homeworks or Exercises.

Instruments used for measurements :

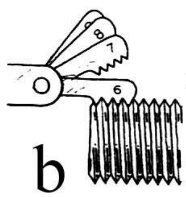
Some of the Basic tools used for measurements



Depth Gauge



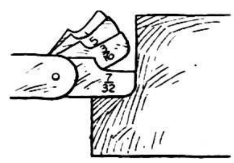
a



Screw-pitch gauge

b

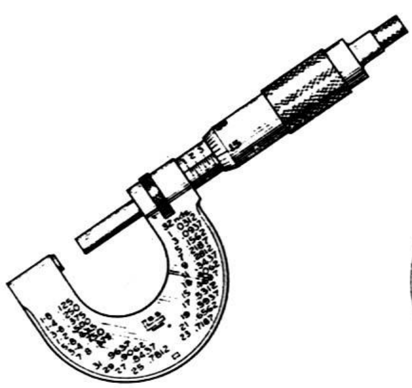
Fillet and round gauge

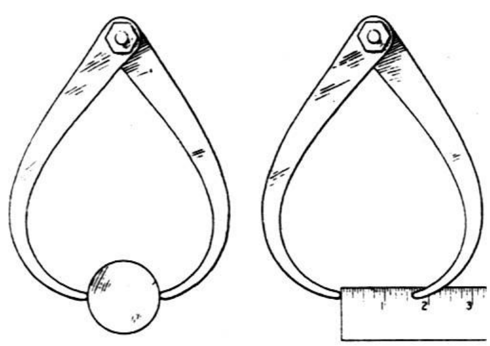


c

Caliper Compass

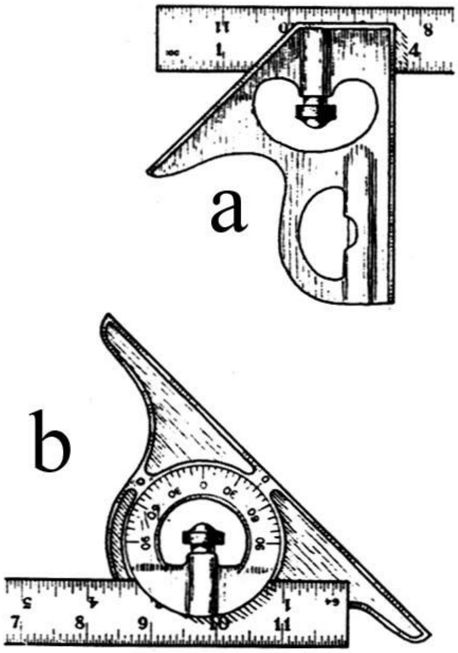
Gauges

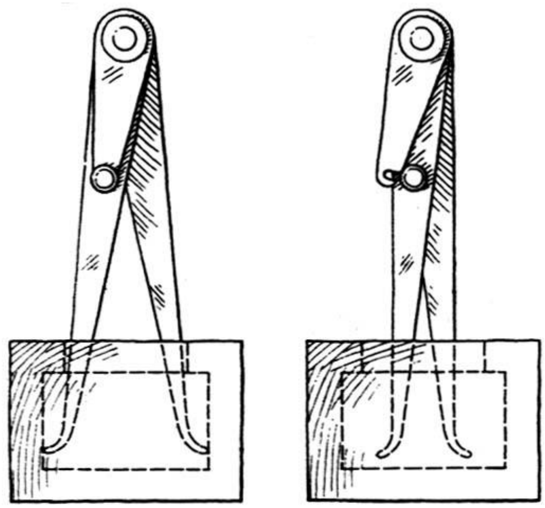




Outside Micrometer Caliper

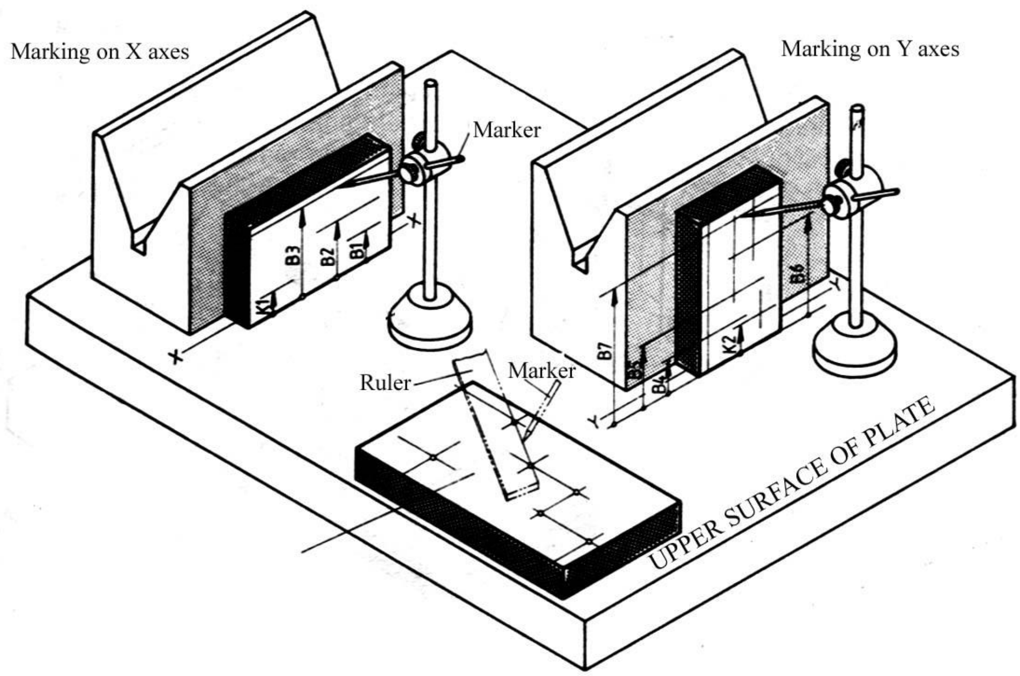
Outside Caliper



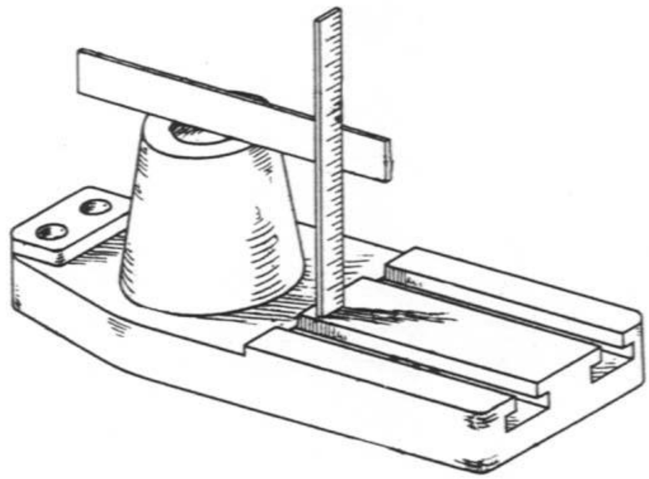


Combination Square
a) Standart Head   b) Adjustable Head

Inside Transfer Caliper



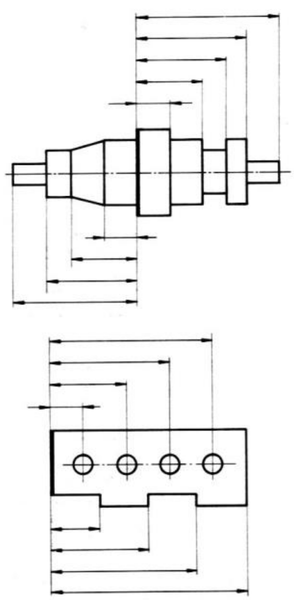
Marking a plate



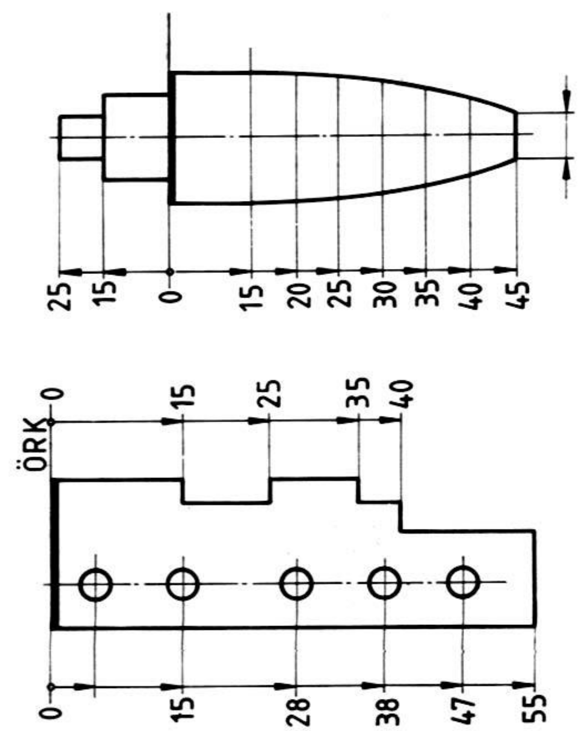
Measurement of length, width & depth

DIMENSIONING

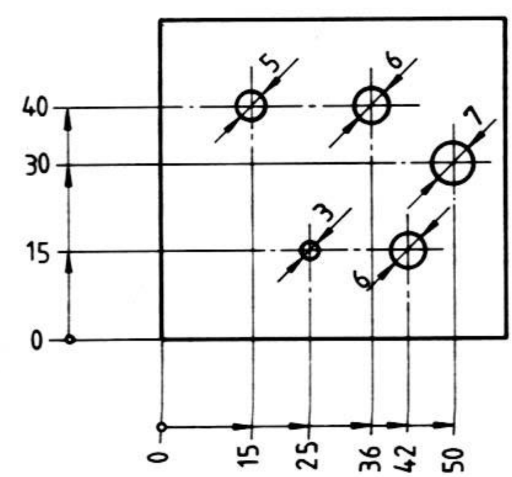
To eliminate the misunderstandings, remeasurings and to simplify the reading of drawings, dimensioning of the objects should be arranged as simple as possible and must cover all the possible information aimed to be detailed.



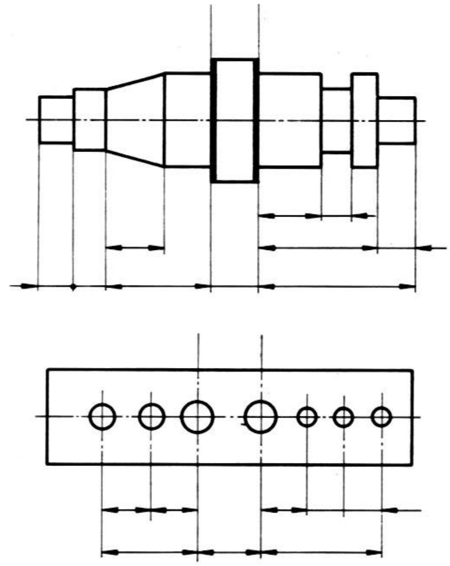
Parallel Dimensioning



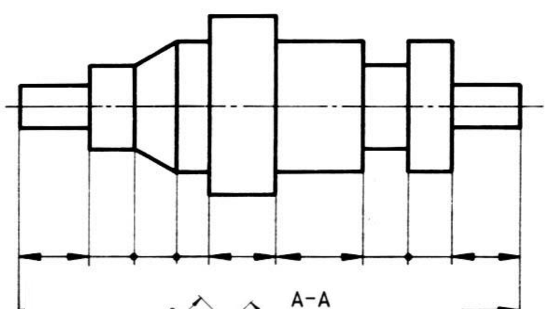
Single line parallel dimensioning



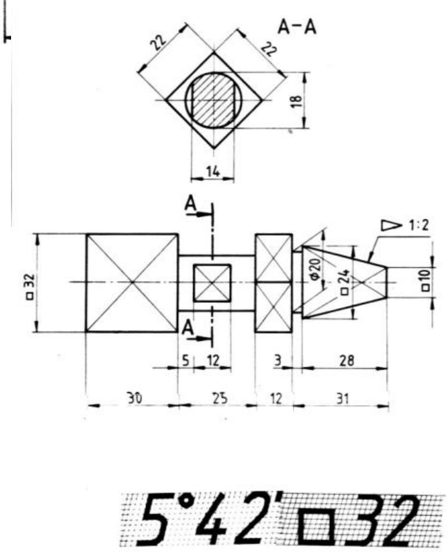
Coordinated Dimensions

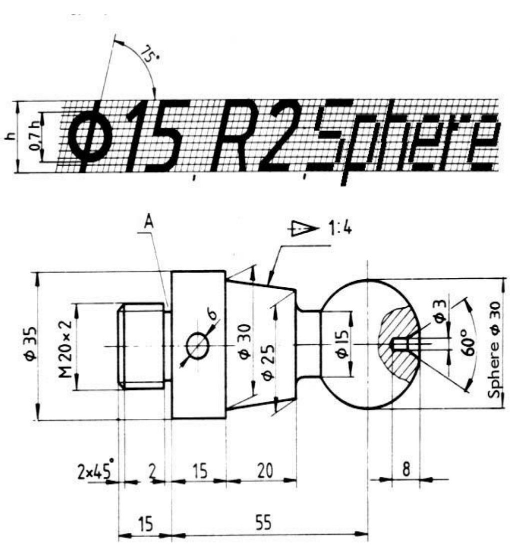


Mixed lines dimensioning



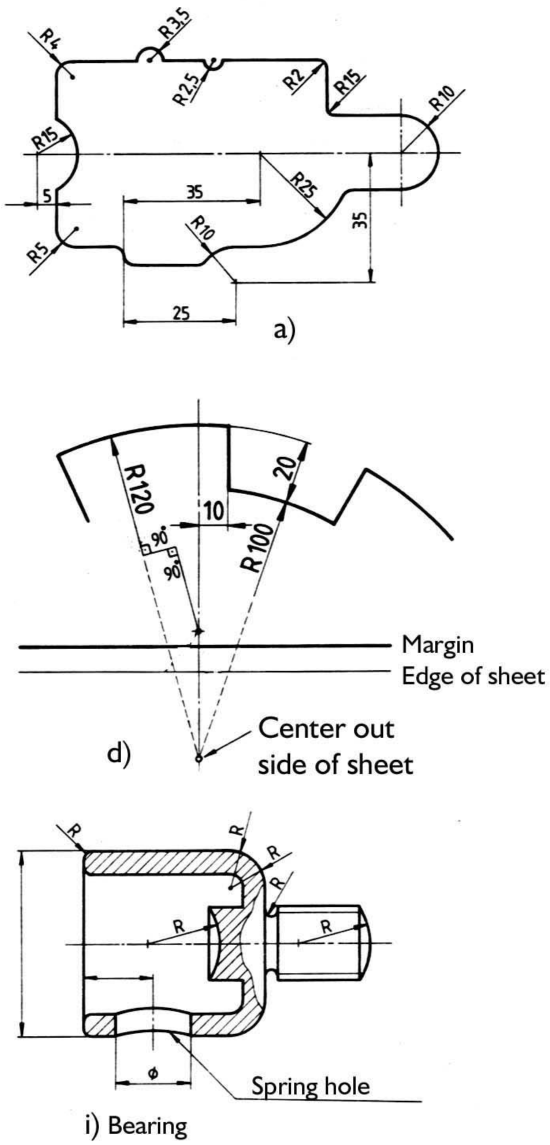
Chain type dimensioning

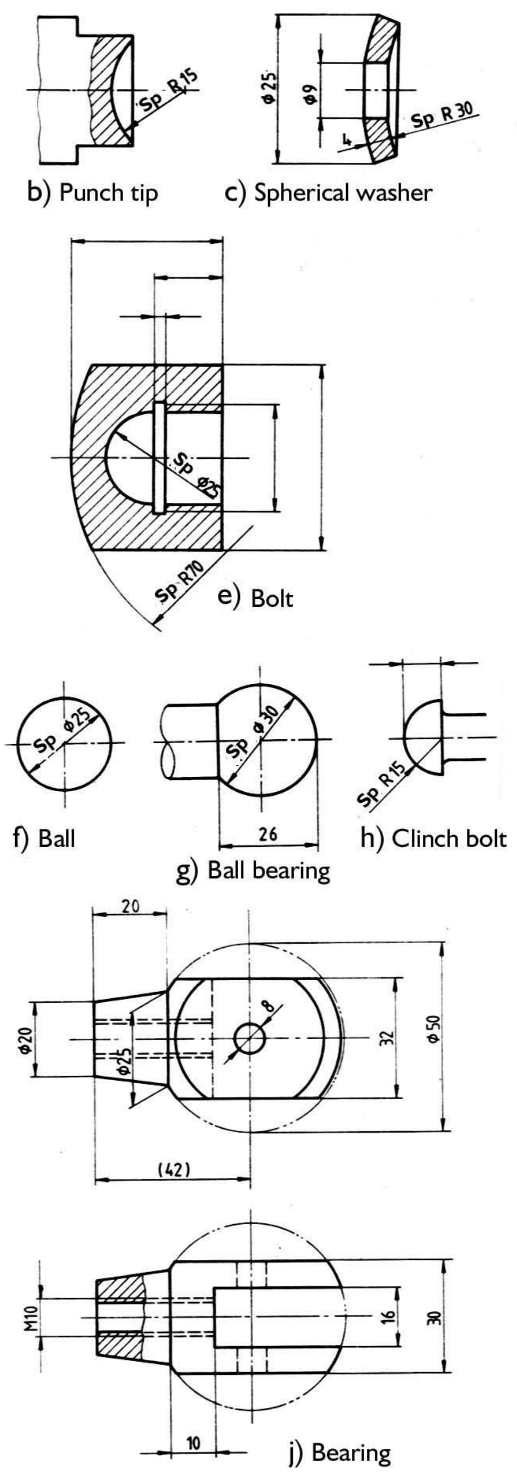




Dimensioning of Profiles

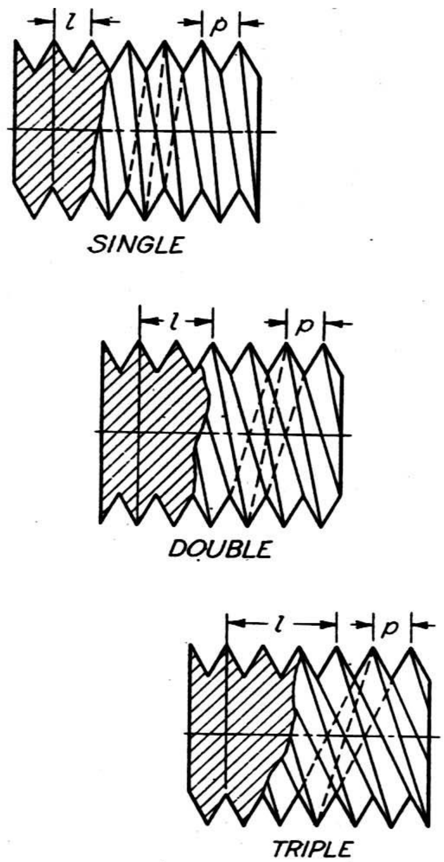
Dimensioning of spherical objects

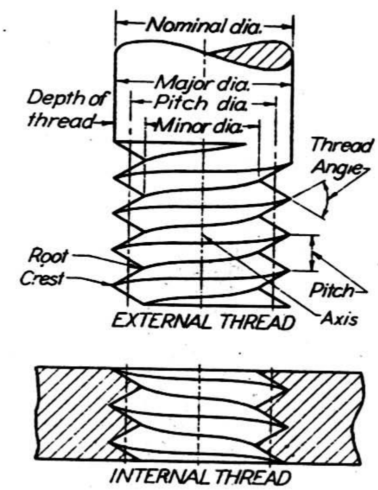




NOTE : **Sp** = Sphere

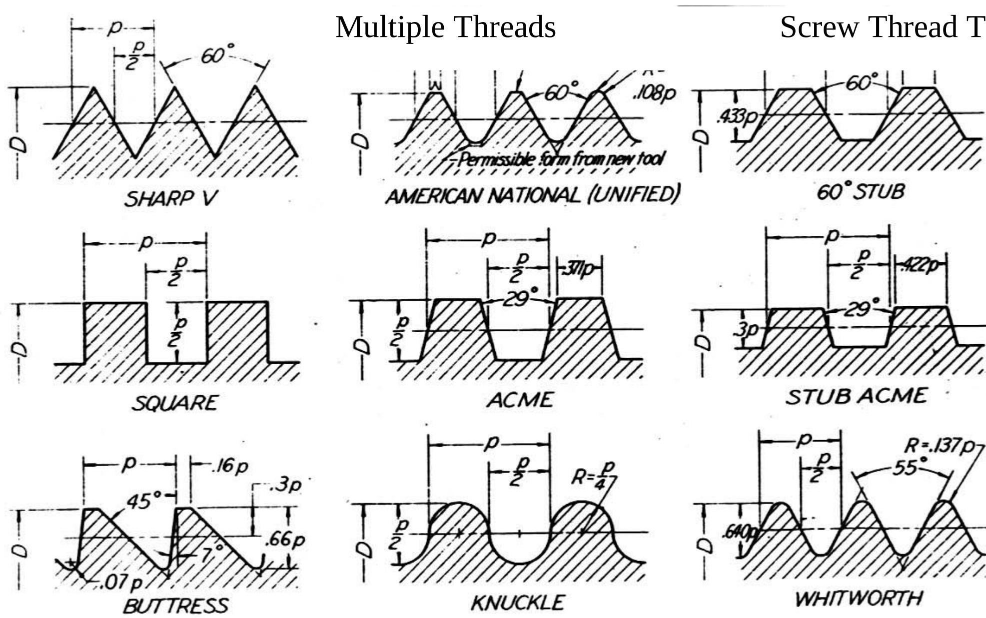
Dimensioning of Spheres and arcs



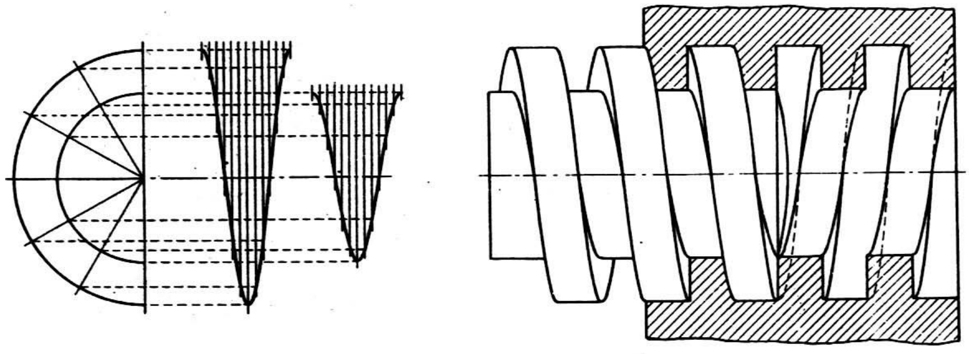


Multiple Threads

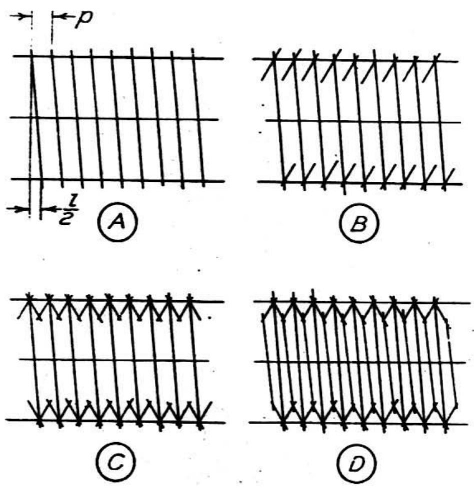
Screw Thread Terminology



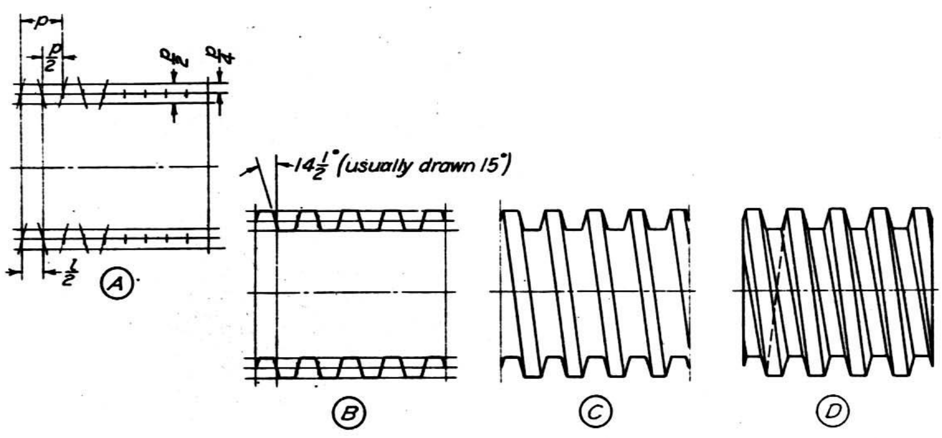
Thread Profiles



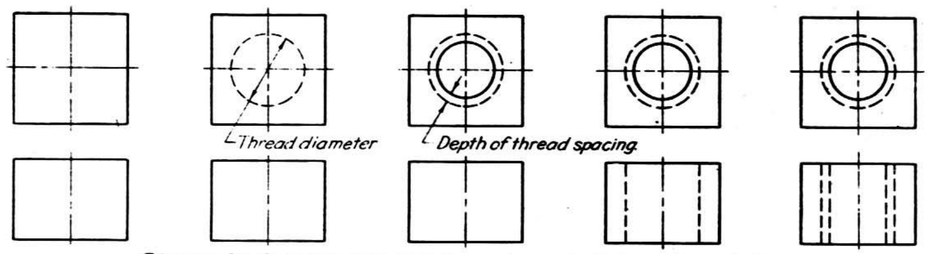
True representation of a square thread, external and internal



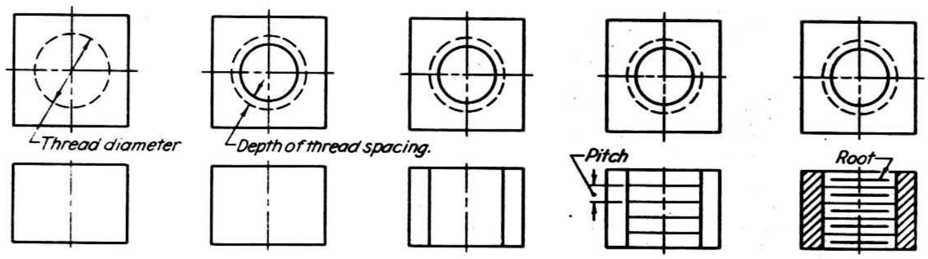
Stages in construction for drawing a single **V** thread.



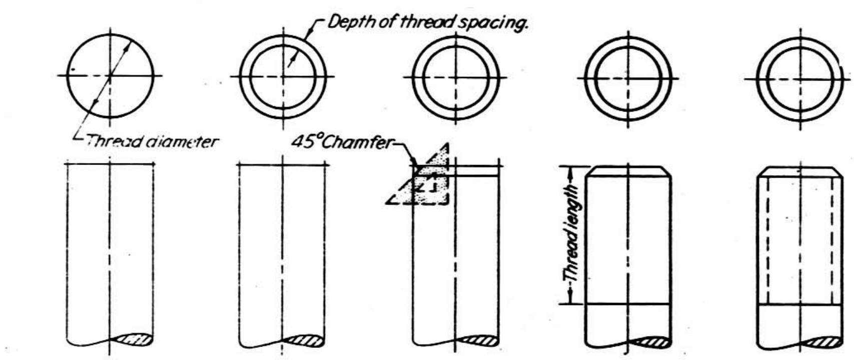
Stages in drawing a single Acme thread



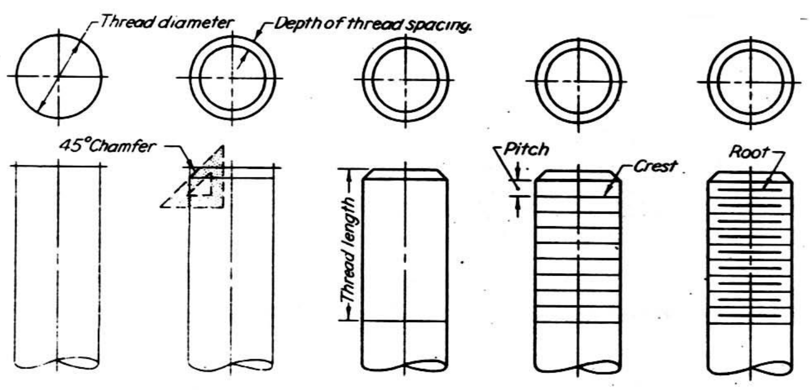
Stages in drawing internal-thread symbols in external views.



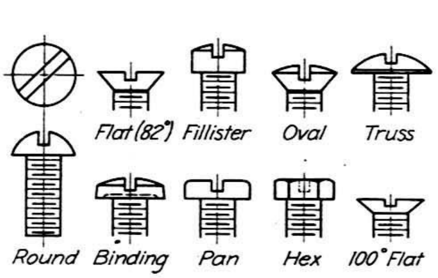
Stages in drawing regular internal-thread symbols in sectional views.



Stages in drawing simplified external-thread symbols.

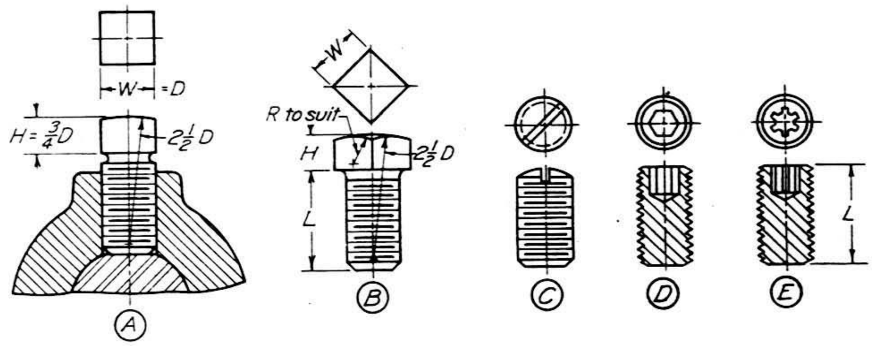


Stages in drawing regular external-thread symbols

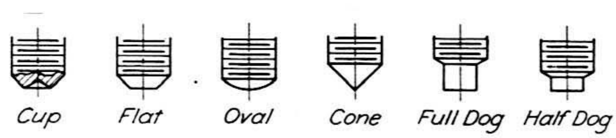


American Standart Machine-screw heads.

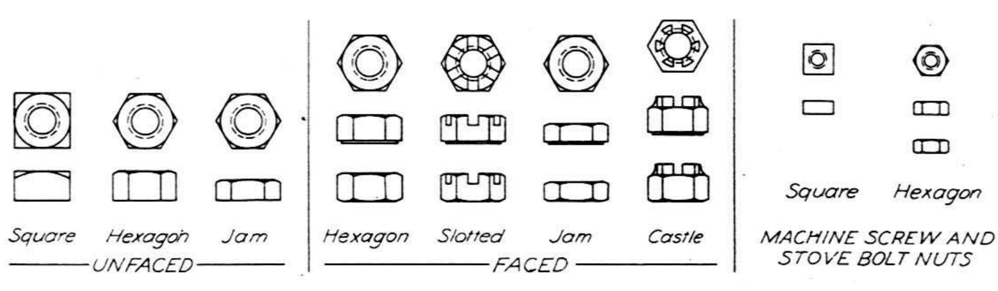
Recessed head and driver.



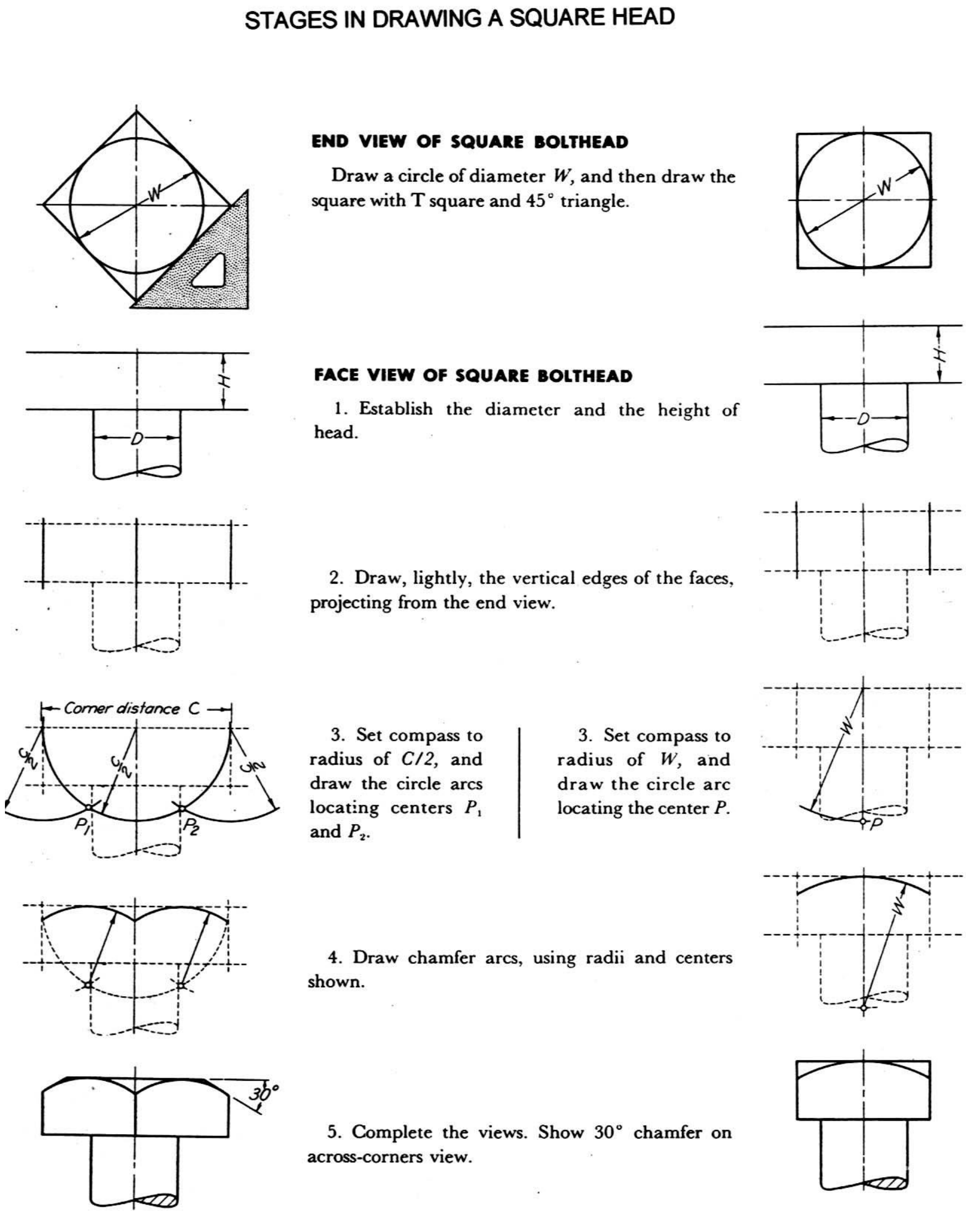
American Standart setscrews. (A) and (B) square head, (C), (D) and (E) headless.



American standart setscrew points.

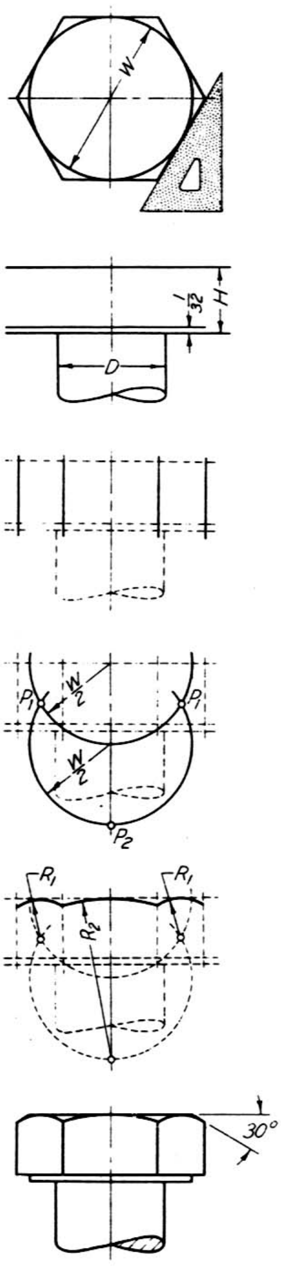


American Standart nuts.



Stages in drawing square bolt head

STAGES IN DRAWING HEXAGONAL HEAD



END VIEW OF HEXAGONAL BOLTHEAD

Draw a circle of diameter *W*, and then draw the hexagon with T square and 30-60° triangle.

FACE VIEW OF HEXAGONAL BOLTHEAD

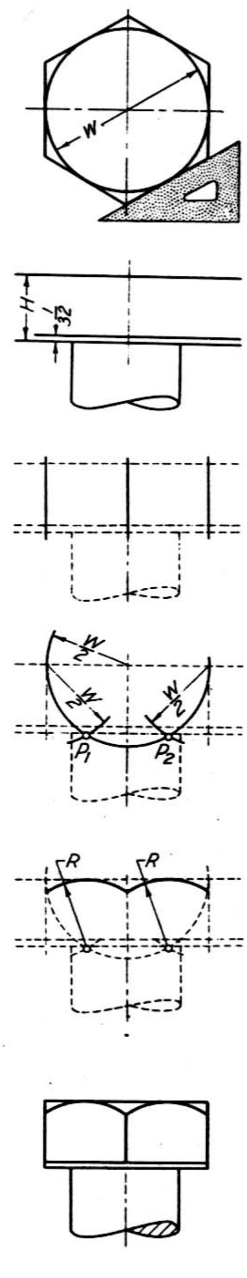
1. Establish the diameter, height of head, and washer-face thickness. The actual thickness of the washer face for all fasteners is 1/64 in. but may be increased up to 1/32 in. for the drawing.

2. Draw, lightly, the vertical edges of the faces, projecting from the end view.

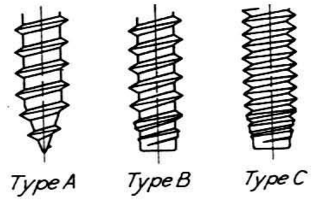
3. With radius of *W*/2 draw the circle arcs locating centers P_1 and P_2.

4. Draw chamfer arcs, using radii and centers shown.

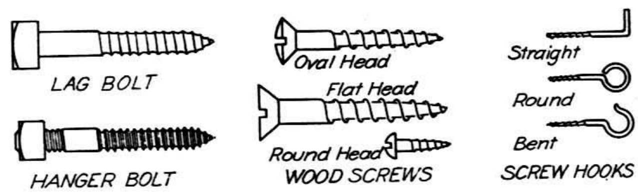
5. Complete the views. Washer-face diameter is equal to *W*. For across-corners view, show 30° chamfer.



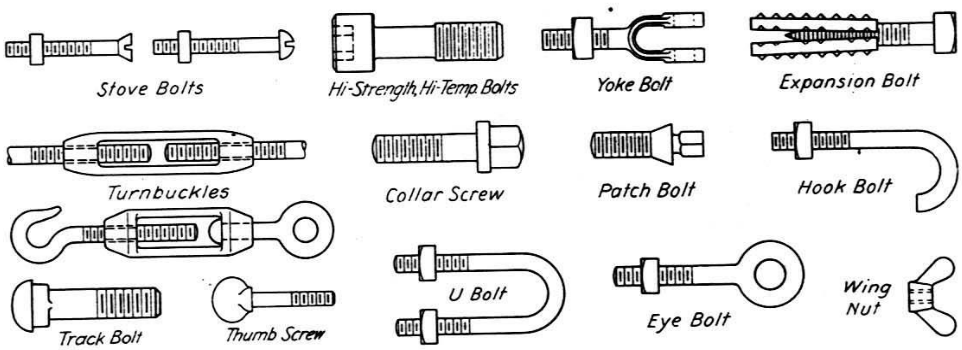
Stages in drawing hexagonal bolt head



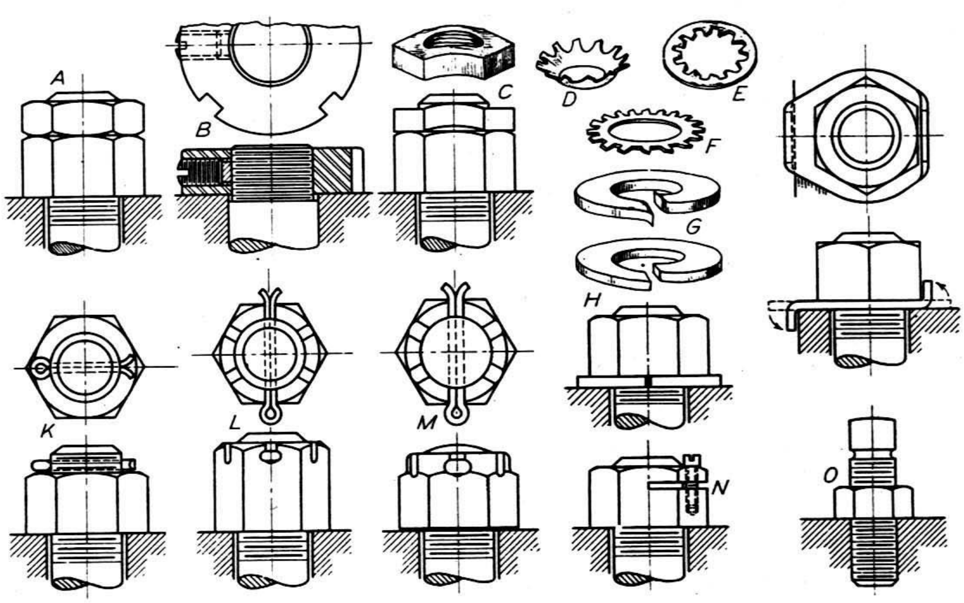
American Standart tapping
Screw points



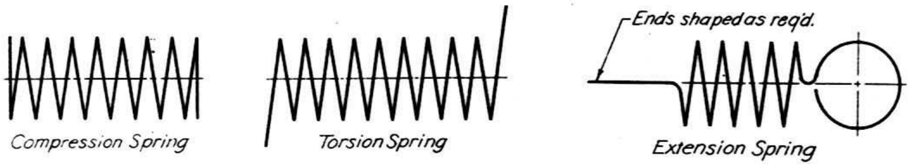
Fasteners used in wood



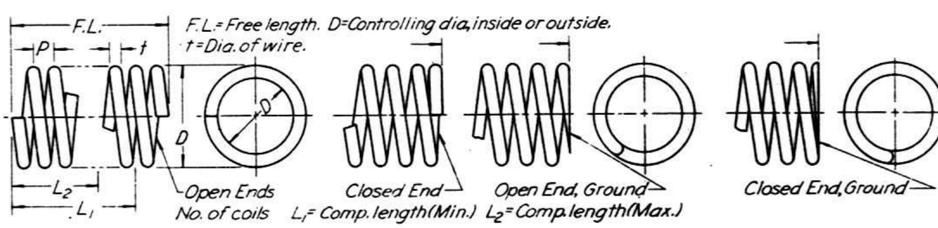
Miscellanous threaded fasteners



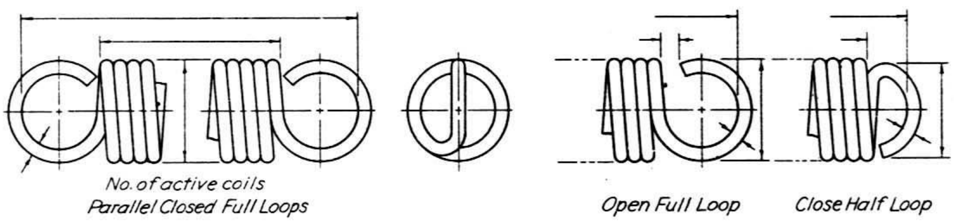
Various locking devices



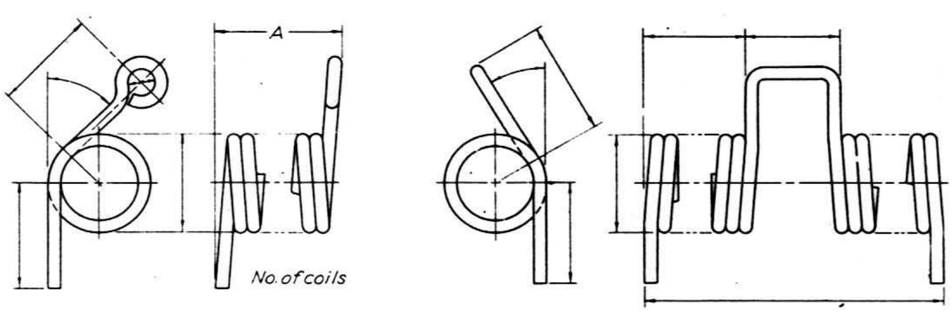
Conventional representation of springs



Representation and dimensioning of compression rings

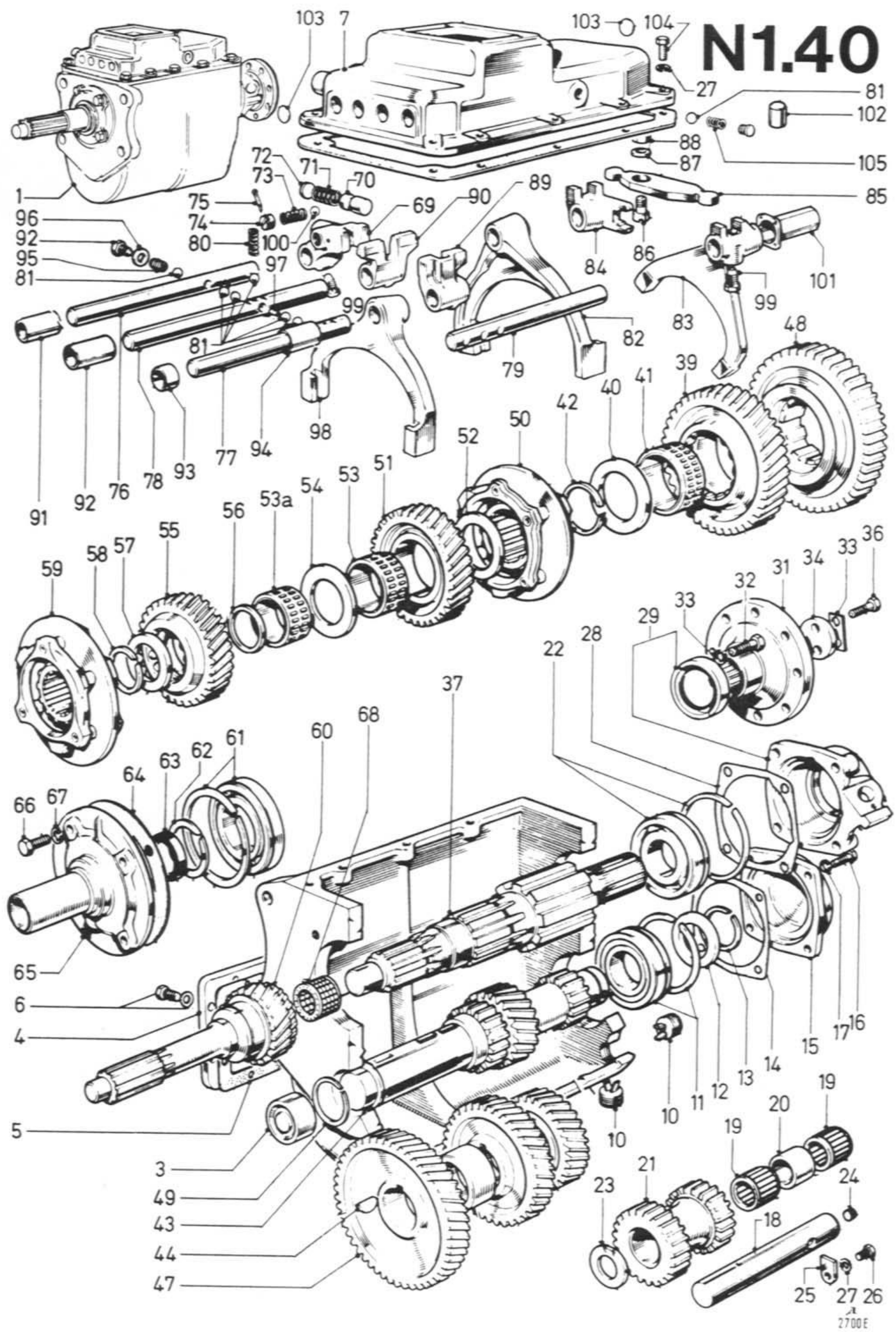


Representation and dimensioning of extension springs

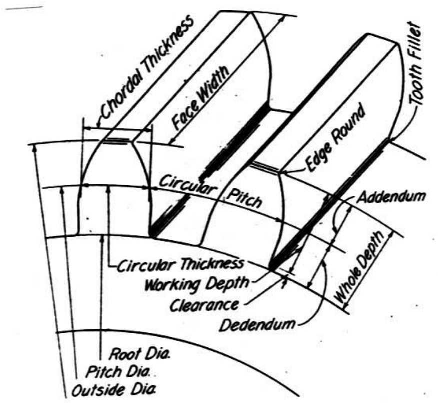


Representation and dimensioning of torsion springs

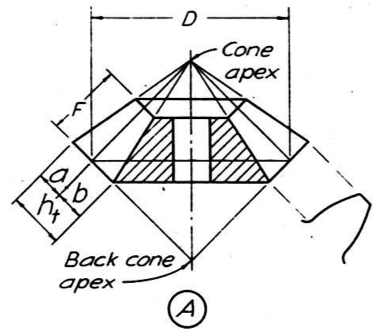
TYPICAL EXPLODED VIEW OF A GEAR BOX

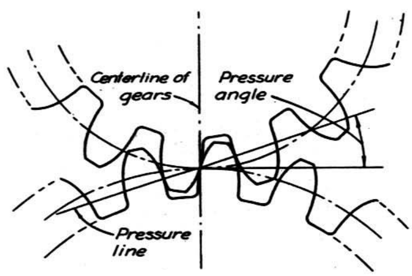


Parts are numbered and drawn according to order of assembly

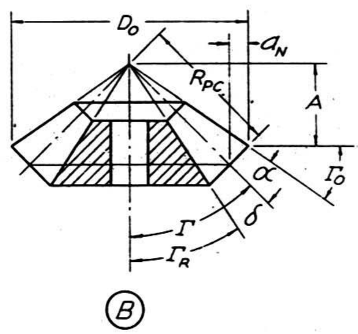


Gear Nomenclature

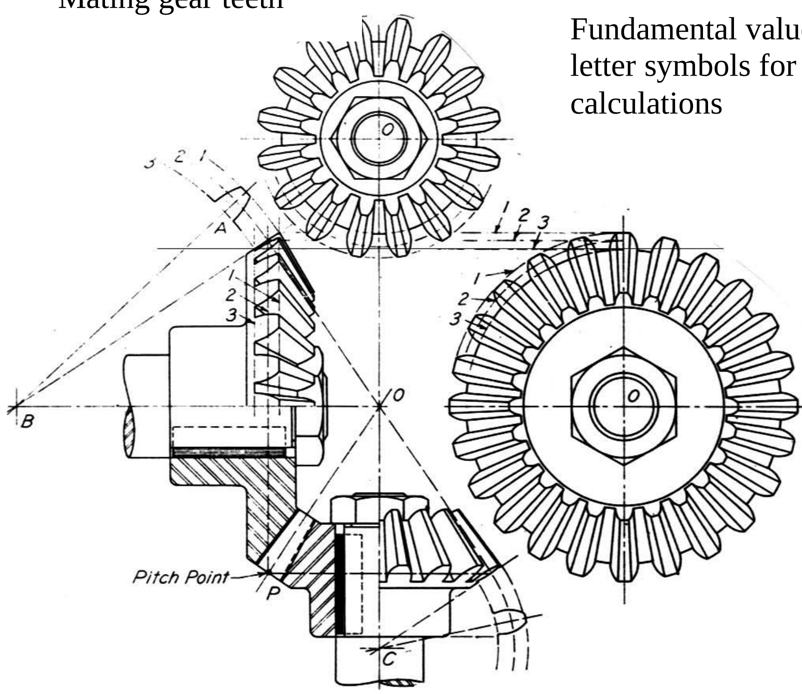




Mating gear teeth



Fundamental values and letter symbols for bevel gear calculations



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