



BASIC TECHNICAL DRAWING

Student Textbook

Grade 11

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UNIT

1

INTRODUCTION TO BASIC TECHNICAL DRAWING



Engineers use drawings to communicate ideas to colleagues and co-workers

Learning Competencies:

Upon completion of this unit, you should be able to:

- ✓ Define drawing in your own words ;
- ✓ Write the role of drawing in human civilization;
- ✓ Explain how and when drawing originated;
- ✓ Distinguish the two classification of drawing;
- ✓ Describe the areas / professional disciplines of technical drawing;
- ✓ Describe some important applications of technical drawing in everyday life;
- ✓ State the advantage of CADD in related manual work;
- ✓ Explain the educational value of technical drawing.

1.1 History of Drawing

For what purpose drawing is used around your school or around your city?

People learned to draw pictures of the objects around them long before they learned to write. The ability to make simple drawings helped people develop their first written language. There were no words or characters in ancient writing. Ideas of things were conveyed by pictures of the battles, and hunting was recorded in these "picture" languages. Drawings carved by primitive people on rocks, walls of caves and so forth have survived to our day.

Many drawings of human beings, animals, fish and so on, made by our forefathers thousands of years ago, have been found on the eastern shore of lake Onega and on the shores of the White Sea. These drawings were carved on granite rocks with stone (flint) tools. (Fig.1.1)

History indicates that drawings were used in ancient times to describe the exact forms and sizes of structures. The Bible states that Solomon's Temple was "built of stone made ready before it was brought thither," indicating that drawings were used to describe the forms of and sizes of the individual members of historic structure.

The theory of projection drawing was advanced to an academic study by the introduction of two planes of projection at right angles to each other by French mathematician Gaspard Monge, near the end

of the eighteenth century. This development provides the basis of descriptive geometry, the science which treats the graphical description of objects of three dimensions and provides problems designed to develop the ability to visualize and to solve problems.

The original and natural method of describing the forms of objects is by means of drawings. Written or spoken language is inadequate to describe any but the most elementary forms. There are two divisions of drawings; **artistic and technical**. Artistic drawings are outside the scope of this text. An artistic drawing has many techniques and expressions that are not used in technical drawings. First of all, a technical drawing must communicate the same message to every user or reader of the drawing, whereas an artistic drawing is usually interpreted differently by everyone who sees it. To limit the interpretation to only one possible conclusion, the technical drawing is controlled by accepted standards, drawing "conventions" and projection techniques.

Technical drawing is the art and science of describing structures and structural details completely and accurately by graphical means.

Technical drawing may be made with instruments, or freehand, or partly with instruments and partly freehand. Instrumental drawing is the term usually applied to technical drawings executed with instruments; technical sketching applies to

such drawings executed without the aid of instruments.

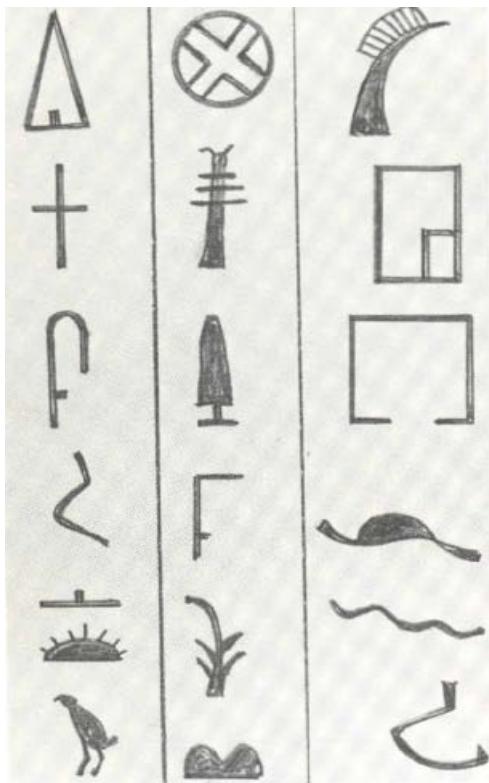


Fig. 1.1 Characters and objects taken from an ancient wall.

Activity 1.1

Show with simple line drawing the direction from your school to your home? Ask comment from your teacher.

1.2 Areas/Professional Disciplines of Technical Drawing

Drawing is a tool used by engineers and industrial designers to design a product, solve a problem, or produce a product. Almost everything around you began as an idea and then as a drawing. The buildings in

which you live and work; the appliances in your home- dishwashers, can openers, dryers, toasters; the methods of transportation - cars, trains, ships, airplanes; the systems that support your life - plumbing, electricity; even what you wear was conceived and brought into being by the effective use of engineering drawings. Few items get manufactured or produced without an engineering drawing.

Technical drawings must contain everything needed for proper interpretation of the design because design and manufacturing may be located far apart - often in different countries.

Therefore technical drawing has extensive application especially for architects and engineers. So the art and design that goes into making buildings is known as architecture. To communicate all aspects of the design, detailed drawings are used. Architectural drawings describe and document an architect's design.

Engineering can be a very broad term. It stems from the Latin "ingenerare", meaning "to create". Because this could apply to everything that humans create, it is given a narrower definition in the context of technical drawing. Engineering drawings generally deal with mechanical engineered items, such as manufactured parts and equipment.

Engineering drawings are usually created in accordance with standardized conventions

for layout, nomenclature, interpretation, appearance (such as line styles), size, etc. Its purpose is to accurately and unambiguously capture all the geometric features of a product or a component. The end goal of an engineering drawing is to convey all the required information that will allow a manufacturer to produce that component.

1.3 Technical Drawing Today (Computer Aided Design and Drafting)

Technical drawings had been produced by the help of drawing instruments and traditional pencil-on-paper drafting is referred to as manual drafting. However, nowadays different softwares are available to do design and drafting.

Computer Aided Design and Drafting (CADD) involve any type of design activity that uses the computer to develop, analyze, modify or enhance an engineering design. CADD systems are based on interactive computer graphics. The engineer creates an image on the monitor by entering commands on the computer.

CADD can serve as a full partner in the design process, enabling the designers to do jobs that are simply not possible or feasible with manual equipment.

Besides increasing the speed with which a job is done, a CADD can perform many of the tedious and repetitive skills ordinarily required of drafter. It has proved to be,

conservatively speaking, at least a 30 percent improvement in production in terms of time spent drawing.

1.4 Use and Educational Value of Technical Drawing

A student who successfully completed this course can use drawings to communicate technical information with engineers, designers, draft persons and other professionals. By studying technical drawing, a student becomes aware of how industry communicates technical information.

Technical drawing teaches the principle of accuracy and clarity in presenting the information necessary to produce products. In general, technical drawing helps students to understand a means of transmission of accurate information from designers to those who develop the objects that are described by drawing. Therefore, the course enables students to be motivated for further studies pertinent to drawing.

Key terms

Descriptive geometry: the system of geometry that uses plane projections and perspective drawings of solid figures, usually in order to describe and analyze their properties for engineering and manufacturing purposes.

UNIT SUMMARY

Technical drawing is a universal language by means of which the form, size, finish, colour, and construction of an object can be described accurately and clearly. Therefore it is the language used by engineers and architects to develop and record their ideas and to transmit them to those who are to execute their designs.

There are two basic types of drawings: artistic and technical. The artistic drawings are used to express the feelings, beliefs, philosophies, or abstract ideas of the artist. Technical drawing, on the other hand, is not subtle or abstract.

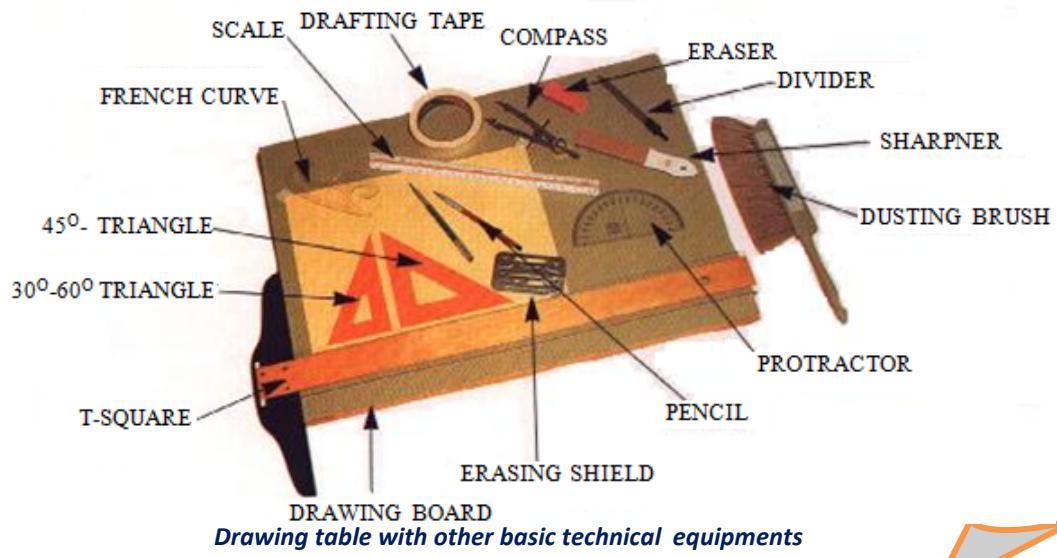
Drawing is used by engineers, technicians, and skilled craftsmen. Whether this drawing is made freehand (sketching) or by the use of drawing instruments (mechanical drawing), it is needed to convey all the necessary information to the individual who will fabricate and assemble the object be it a building, ship, aircraft, or mechanical device.

Today, the mechanics of the drafting task have largely been automated and accelerated through the use of Computer Aided Design and Drafting systems (CADD). Computer-aided design is the use of computer technology to aid in the design and particularly the drafting of a part or product, including entire buildings.

The student of technical drawing should attain a knowledge of fundamental principles presented in this text and as much skill as possible in drawing. To become a finished draftsman, he must also acquire knowledge of the details of construction employed in the branch of engineering sciences.

UNIT 2

BASIC TECHNICAL DRAWING EQUIPMENTS



Learning competencies:

Up on completion of this unit you should be able to:

- ✓ Identify the difference between materials and instruments of drawing;
- ✓ List the different types of technical drawing materials and instruments ;
- ✓ Use drawing materials and instruments properly on making drawing of objects in activities;
- ✓ Prepare oneself for making technical drawing;
- ✓ Arrange appropriate working area before starting drawing;
- ✓ Prepare the title block on drawing paper.

2.1 Introduction

What are the type of drawing materials and instruments you already know before and try to list them?

For what purpose are you using them?

Technical drawings must be prepared in such a way that they are clear, concise, and accurate. In order to produce such drawings equipment (i.e. materials and instruments) are used. Because time is an important factor in any of work, a clear understanding of all drawing equipment and their uses is important to speed up the process of drawing preparation. In this chapter, the different types of drawing instruments and materials and their uses will be discussed.

2.2 Selection of Drawing Materials

The basic drawing materials which are necessary to prepare a technical drawing are:

- Drawing paper
- Drawing pencil
- Drafting or masking tape
- Eraser and erasing shield
- Rapidograph

2.2.1 Drawing Papers

Drawing papers are the materials on which the drawings are made. Depending on its application different types of drawing papers are available. These are: white plain paper,

profile paper, plan/profile paper, cross-section paper and tracing paper.

1. White plain papers: are general-purpose for office uses and drawings. They are manufactured according to ISO (International Organization for Standardization) standard paper sizes. Standard drawing sheet sizes are in three series, designated A_n, B_n, and C_n. Paper frames and drawing frames are standardized for each size of papers. Table 2.1 shows frames of the A-series and their particular application.

2. Profile, Plane/ Profile and Cross-section papers: are referred to as gridded papers. The first two are used for road design and the later one is used for drawing road cross sections, rough design, sketching, preparing schedules, plotting graphs, etc.

3. Tracing paper: is a high-grade white transparent paper, upon which copies or "tracings" are made for the purpose of reproducing by blueprinting or by other similar processes. Tracing may be made in ink, usually it takes ink well, and from which pencil lines can easily be erased. Reproductions (printing) can be made directly from pencil drawings on tracing paper (see Fig. 2.1); however, for better results in production, a pencil drawing on tracing paper is usually inked over. This paper must not be folded.



Fig. 2.1 Tracing paper

Drawing pencils with different grades of hardness are available. The grade of a pencil is designated by a number and a letter. The grades are 9B (very soft), 8B, 7B, 6B, 5B, 4B, 3B, 2B, B, HB, F, H, 2H, 3H, 4H, 5H, 6H, 7H, 8H, to 9H (very hard) see fig.2.3. Generally speaking, the soft (B) grades are used for freehand sketching and the hard (H) grades are used for instrumental drawings.

For mechanical pencils a wide variety of lead grades are available in different sizes, such as 0.3, 0.5, 0.7, and 0.9 diameters. Here, no sharpening of leads is necessary. The most common type of pencil is the wooden pencil shown in Fig.2.2 (a). To use this pencil, Fig.2.4 shows the acceptable sharpening of the wooden pencil.

Table 2.1 Paper and frame sizes for A-series

Designation	Paper frame size (mm)	Border width (mm)		Drawing frame size (mm)		Applications
		Left and right	Top and bottom	Width	Height	
A ₀	841 X 1189	28	20	1133	801	Technical drawings, posters
A ₁	594 X 841	20	14	801	566	
A ₂	420 X 594	14	10	566	400	Drawings, diagrams and large tables
A ₃	297X 420	10	7	400	283	
A ₄	210 X 297	7	5	283	200	Letters, magazines, catalogs...
A5	148X210					Note pads

2.2.2 Drawing Pencils

One of the most important drawing materials is the drawing pencil. The two types of pencils used in drawing are mechanical and wooden pencils (see Fig.2.2).

Wood should be removed and the lead should be sharpened. To get good quality of line the pencil should be sharpened properly which means the lead should not be too sharp as it may pierce the paper and if it is

too dull the line will be thick and accuracy will go down.



a) Wooden pencil

b) Mechanical pencil

Fig.2.2 Drawing Pencils

Darker	Lighter
9B 8B 7B 6B 5B 4B 3B 2B B HB F H 2H 3H 4H 5H 6H 7H 8H 9H	

Softest

Hardest

Fig. 2.3 Pencil grades



Too sharp



Acceptable



Too dull

Fig.2.4 Sharpening of the wooden pencil

Activity 2.1

- Form a group up to five members and sharpen your pencils with different grade (like sharp, dull, average) and draw straight lines to observe the effect.

2.2.3 Drafting or Masking Tape

Before starting drawing, it is a common practice to attach the drawing paper to the drawing board in order to avoid unnecessary errors due to misalignment. Drafting tape is used for attaching the paper to the drawing board. Thumbtacks can also be used for fixing the paper to the drawing board. However, their use is not recommended because they have the tendency to affect the smoothness of the drawing board. Typical type of drafting tape is shown in Fig.2.5.



Fig.2.5 Drafting or masking tape

2.2.4 Eraser and Erasing Shield

In the process of making a drawing, corrections and changes may be required. To do so, erasers are used to clean unnecessary line works. An erasing shield restricts the erasing area so that the correctly drawn lines will not be disturbed during the erasing

procedure. It is made from a thin flat piece of metal with variously sized cutouts. The shield is used by placing it over the line to be erased and erasing through the cutout. Common types of eraser and erasing shield are shown in Fig.2.6 and Fig.2.7 respectively.



Fig.2.6 Eraser

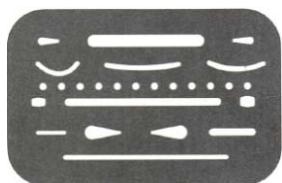


Fig.2.7 Erasing shield

2.2.5 Rapidograph

Rapidograph is a type of drawing pen by which lines are drawn on tracing papers. It produces light resistant, waterproof, precise and consistent ink lines for any application. Since most rapidograph pens require different pen sizes (line widths) for various projects, they are manufactured in different sizes.



Fig.2.8 Rapidograph

Activity 2.2

Practice line exercises by following the steps below.

1. On your paper, draw the borderline using your pencil by measuring 1 cm from the edge of the paper.
2. Draw four squares measuring 10 cm x 10 cm. Use your t-square and triangle.
3. Arrange the squares on the central part of the paper.
4. On the first square, draw vertical lines measuring 1 cm apart. Label it box A.
5. On the second square, draw horizontal lines measuring 1 cm apart. Label it box B.
6. On the third square, draw inclined lines at 30° at a distance of 1 cm apart from each other. Label the third square box C.
7. In the fourth square, draw inclined lines at 45° distances of lines from one another. Label the last square box D.

Evaluate your work using the criteria below.

Criteria	5- Excellent	4- very Good	3- Good	1- Poor
1. The lines in Box A and B are spaced at 1 cm equally from each other.				
2. The lines in Box C are angled at 30°				
3. The lines in Box C are angled at 45°				
4. The borderline is drawn in straight heavy lines and corners are angled at 90°				
5. The borderline is 1cm away from the edge of the paper.				

2.3 Selection of Drawing Instruments

The list of main drawing instruments is shown below:

- | | |
|---------------------|-----------------|
| 1. Drawing board | 7. Protractor |
| 2. Dusting brush | 8. French curve |
| 3. Templates | 9. French curve |
| 4. Pencil sharpener | 10. T-Square |
| 5. Scale | 11. Divider |
| 6. Set square | 12. Compass |

2.3.1 Drawing Board

Drawing boards are usually made of white pine, but are sometimes made of other soft woods. The drawing surface may be the table top itself or a separate board. In both cases, the working surface (the drawing surface) should be flat, smooth and firm. For this reason, the working surfaces of drawing boards or table tops are made of soft white pine or basswood. The working edge of a drawing board must be straight and should be tested with a steel straight edge. To prevent wear of the working edge some boards and table tops are furnished with a hardwood edge or steel insert on the working edge.

Drawing boards are made in various sizes. Those usually used in school measure 23×30 cm, 40×53 cm or 46×60 cm. The smallest size is mostly used for field work or sketching. The type shown in Fig. 2.9 (a) is the most common type of drawing board. Depending on their design, drawing tables may be fixed in height or can be adjusted to any desired working height. Most industrial drawing drafting is done on tables similar to that shown in Fig. 2.9(b). Portable drawing boards are very handy for professionals as well as students. You can use these small drawing boards as tabletop drawing boards, handy reference boards, and drawing holders.

The tracing table shown in Fig. 2.9 (d), is another accessory that facilitates the draftsman work. A tracing table allows us to trace another work too blurred or dirty on a new paper. It provides the advantage of rectifying errors, such as stains or mistaken lines of ink, or other mistakes non correctable in some other surfaces. Sometimes it simply helps us to improve the presentation of the drawings.



a) Drawing tables



b) Drafting machine



c) Portable drawing board



d) Tracing table

Fig. 2.9 Drawing board

2.3.2 Dusting Brush

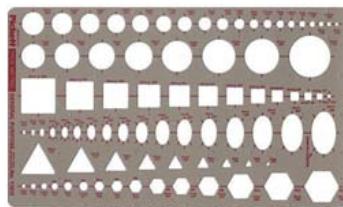
During erasing, particles coming from the eraser will remain on the drawing paper. These particles are removed or cleaned using a dusting brush such as shown in Fig.2.10. It is poor practice to use fingers or palm of the hand for cleaning the drawing paper.



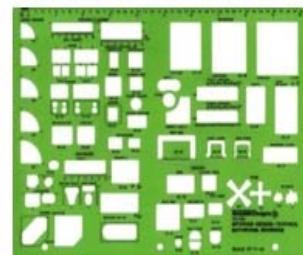
Fig. 2.10 Dusting brush

2.3.3 Drawing Templates

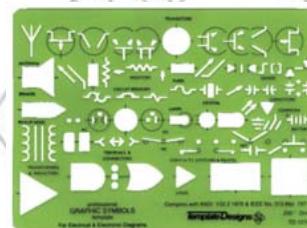
A template is a thin and flat piece of plastic containing various cutout shapes. It is designed to increase the speed and accuracy of the drafter. Templates are available for drawing geometric shapes (Fig.2.11a), plumbing fixtures, bolts, nuts, screw threads, electronic symbols (Fig.2.11c), springs, gears and much more. A template should be used whenever possible to increase the accuracy and the speed. The most commonly used type of drawing templates are shown in Fig. 2.11.



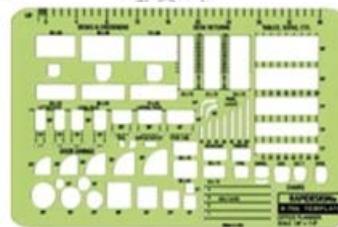
a) Geometric shapes drafting template



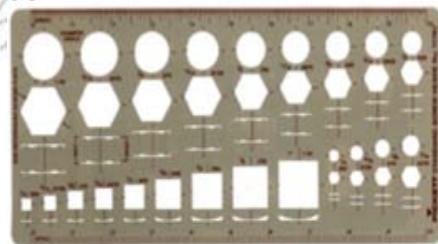
b) Architectural drafting template



c) Electrical drafting template



d) Office design drafting template



e) Screw head template

Fig.2.11 Different types of drawing templates

2.3.4 Pencil Sharpeners

Pencil sharpeners are drawing instruments used for sharpening pencils and they may be operated manually or by an electric motor and therefore a mechanical pencil sharpener is hand-powered. A common, portable variety is usually small and in the shape of a rectangular prism, with a conical hole on the small end. A sharp blade is mounted in a recess on the largest side such that its sharp edge just enters the cone. The body of the sharpener is often contoured, ridged or grooved to make it easier to grip firmly. It has no moving parts - the tip of the pencil is inserted into the hole of the sharpener and twisted, while the sharpener is held motionless. The blade inside the sharpener shaves the wood of the pencil, thus sharpening the tip, while the shavings emerge through a slot along the blade edge. An important feature is a larger clearance hole at the end of the cone allowing sections of the pencil lead which break away to be removed with only minor inconvenience. There are different types of pencil sharpeners out of which the two most commonly used are shown in Fig.2.12.



2.3.5 Scales

1. What is scale?

2. What example can you give on scaling?

A scale is an item of drawing instrument that has been carefully graduated (marked) and calibrated (labeled) in convenient increments for the user. Scales enable a user to make size reductions or enlargements rapidly and accurately. Scales are graduated in such a way that they can be used to draw objects to scale by direct measurement without any calculation. Depending on its size, the drawing of an object may be the same size as the object, larger or smaller than the object. When one unit on the object equals one unit on the drawing, we say the object is drawn to full size scale; written as 1:1. When one unit on the object is equal to two units on the drawing, we say the object is drawn to a magnification scale of 2:1. Where as when two units on the object is equal to one unit on the drawing, we say the object is drawn to a reduction scale of 1:2. Similarly, a scale of 1:10 means one unit on the drawing is equivalent to ten units on the object and so on.

Designation of a scale consists of the word “scale” followed by the indication of its ratio, as shown in the Table 2.2:

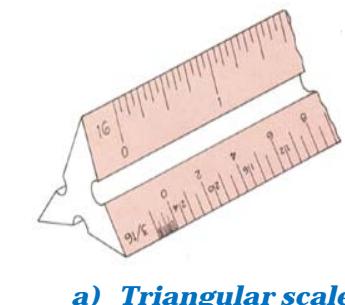
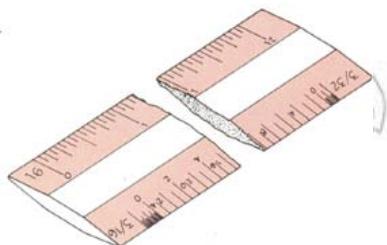
Table 2.2 Designation of Scale

Designation	Description
SCALE 1:1	Full scales
SCALE X:1	Enlargement scales
SCALE 1:X	Reduction scales

$$\text{Scale} = \frac{\text{Measurement on drawing}}{\text{Measurement on the actual object}}$$

Note: X is greater than 1 in both cases

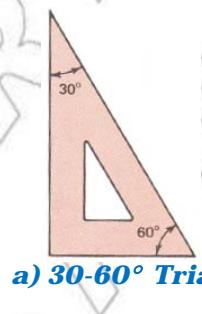
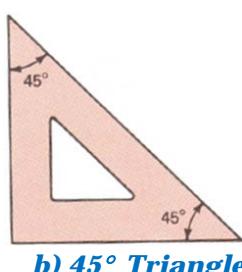
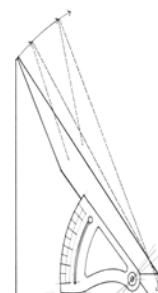
Scales are available in either flat or triangular shapes as shown in Fig.2.13 (a) and (b). The advantage of a triangular scale is that more number of measuring faces are found in one stick.

**a) Triangular scale****b) Flat scale****c)****Fig.2.13 Triangular and flat type scales**

2.3.6 Triangles (Setsquares)

Triangles are sometimes called setsquares. The capability of rapidly producing straight lines on instrument drawings is provided by the 30-60° and 45° triangles (Fig.2.14). Whereas adjustable triangles have a movable leg that is held in place with a thumbscrew and a scale for measuring angles. These instruments are useful for drawing such inclined lines as the slope of a stair or the pitch of a roof.

Using the triangles as a pair, you can generate parallel and perpendicular lines and produce angles of a multiple of 15°. Parallel lines are produced by establishing one side of a triangle along the given line or line direction. The supporting triangle is then fixed against one of the other sides of the first triangle.

**a) 30-60° Triangle****b) 45° Triangle****c) Adjustable Triangle****Fig. 2.14 Triangles**

The first triangle is slipped along the supporting triangle to any desired position, and the parallel line is drawn (Fig. 2.15). Perpendicular lines may be produced by either the sliding triangle method or the revolved triangle method. The sliding triangle method is shown in Fig. 2.16. One leg of a triangle is placed along the given line. The supporting triangle is then fixed against the hypotenuse of the first triangle then the opposite leg of the first triangle is positioned by sliding, and the desired perpendicular line is drawn. The revolved triangle method which is illustrated in Fig. 2.17 requires fixing the two triangles together so that the given line is along the hypotenuse of the first triangle and the supporting triangle is fixed against one leg of the first triangle. Simply revolve the first triangle until the opposite leg rests against the supporting triangle, and the perpendicular line can be drawn.

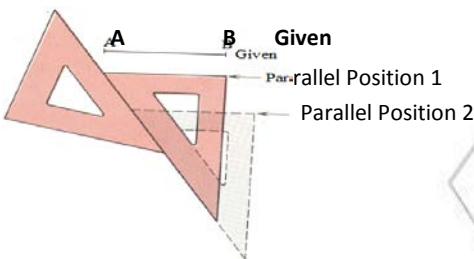


Fig. 2.15 Parallel line construction

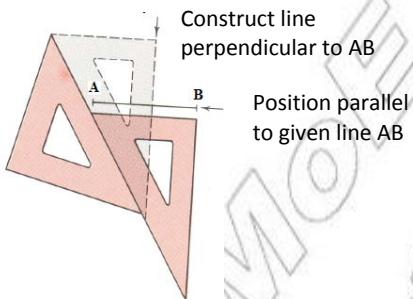


Fig. 2.16 Construction of perpendicular line by sliding line method

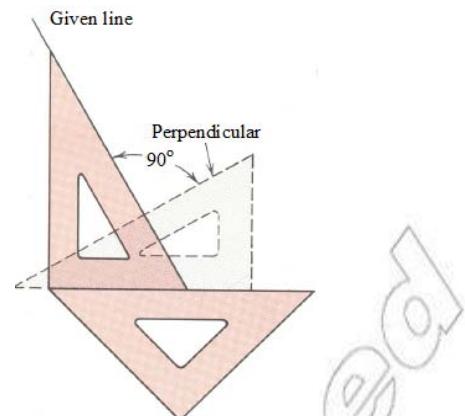


Fig. 2.17 Construction of perpendicular line by rotating triangle method

2.3.7 Protractor

For measuring or setting off angles other than those obtainable with the triangles, the protractor is used. Atypical protractor used for measuring angles is shown in Fig. 2.18. You have most likely used this instrument in a geometry or trigonometry course.

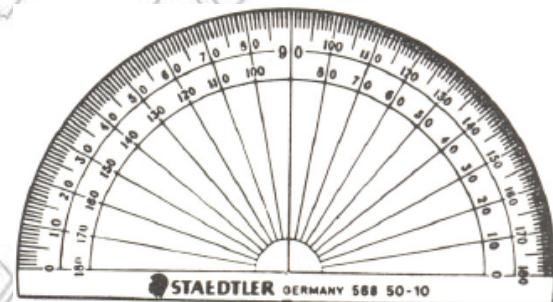


Fig. 2.18 Protractor

2.3.8 French Curve

When it is required to draw mechanical curves other than circles or circular arcs, a French curve is generally employed. Many different forms and sizes of French curves are manufactured, as suggested by the more common forms illustrated in Fig. 2.19. The

curves are composed largely of successive segments of the geometric curves, as the ellipse, parabola, hyperbola, involutes, etc. The best curves are made of highly transparent celluloid.

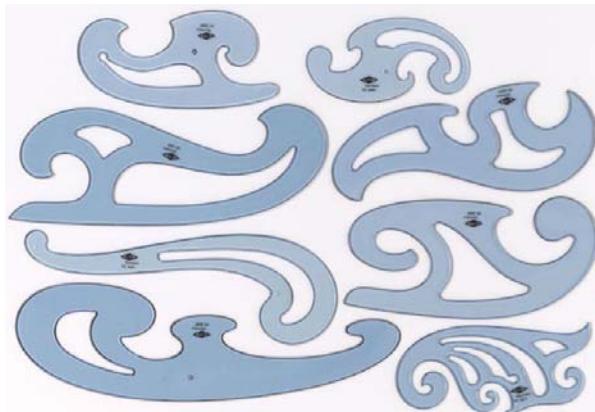


Fig.2.19 .French curves

2.3.9 T-Square

Another important drawing instrument is the T-square. There are different types of T-squares as shown in Fig.2.20. The upper edge of a T-square and the inner edge of its head are called the working edges of the T-square. The working edges of a good T-square should be straight and right angle with each other. The common type of T-square is that shown in Fig. 2.20(a). Basically, the T-square is used to draw horizontal lines and to support or guide the set squares. However, T-squares such as shown in Fig.2.20 (b) and (d) can also be used to draw inclined lines because their heads are adjustable. The type shown in Fig.2.20(c) is seldom used, perhaps because of the unusual design of the blade, but it has an advantage of rigidity.

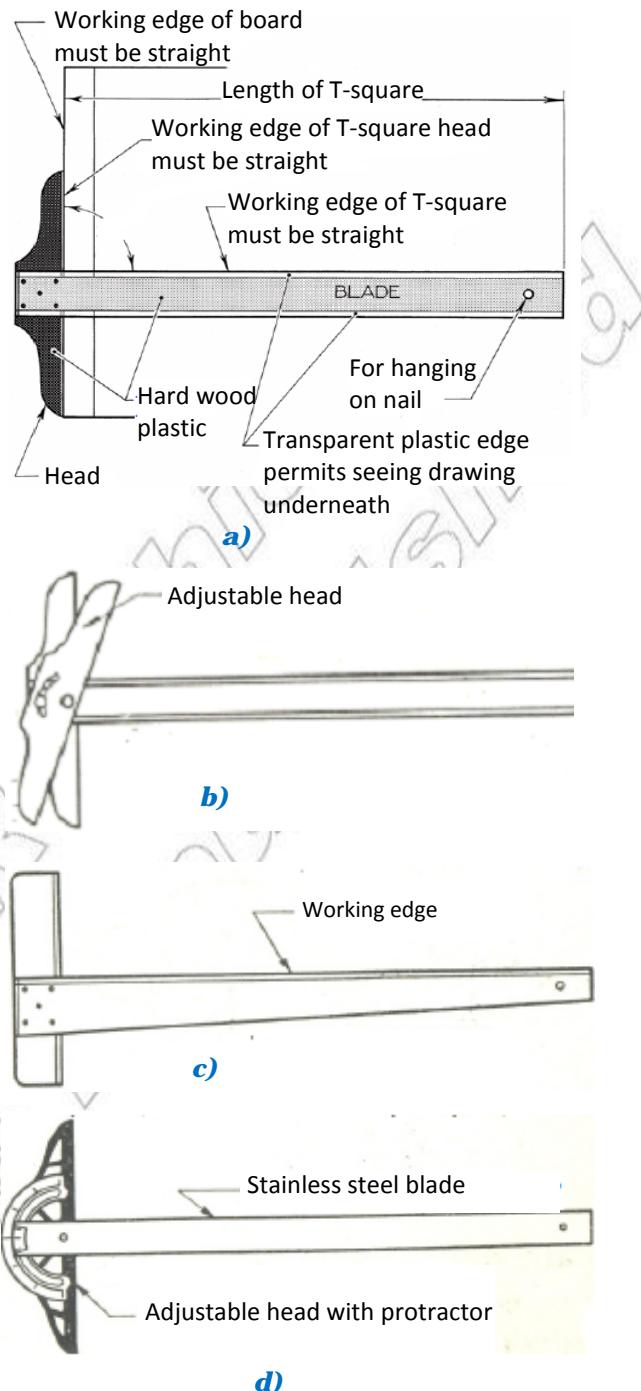


Fig.2.20 T-Squares

2.3.10 Divider

A divider is a drawing instrument used for dividing distances into equal parts or for laying off a series of equal spaces. Dividers like shown in Fig.2.21 are designed to be operated with one hand and are used for making distances or transferring measurements. Specified measurements can be obtained from scales or another drawing and transferred to the drawing being prepared. Figure 2.21 illustrates how the dividers may be used to create a double sized drawing simply by transferring measurements, thus avoiding the necessity of measuring each length and doubling the measurement.



Fig. 2.21 Divider

2.3.11 Compass

Compasses are used to draw circles and arcs. Depending on their application we can divide them into two, bow compass and beam compass as shown in Fig.2.22 (a) and (b) respectively. The beam compass type is used for drawing circles and circular arcs larger than those made by the bow compass and for transferring diameters those are too great for the regular dividers.



a) Bow compass



b) Beam compass

Fig.2.22 Types of compasses

Project work

Go to the nearest art or engineering supply store. Ask the saleslady to help you identify the different tools, instruments and equipment used in drafting or drawing. List the current price of each instrument and equipment.

2.4 Application of Basic Technical Drawing Equipments

Until now we were discussing about the materials and instruments used in technical drawing, now we will see the proper use of this equipments.

Activity 2.3

- Visit an architectural or engineering student in your neighborhood. Interview him/her about the different tools, instruments and equipment he uses. Ask him/her to show you how each tool is used.

2.4.1 Preparation for Drawing

Before starting the drawing you have to fulfill the following points:

- Make sure that all the necessary drawing instruments are ready and clean.
- Position your drawing board to minimize effects of shadows.
- Clean your drawing board.

2.4.2 Fixing Drawing Paper to the Board

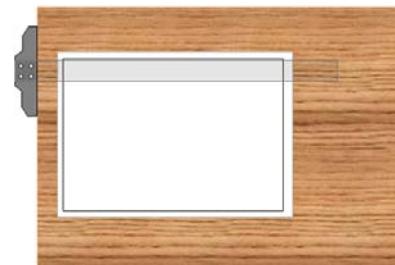
When attaching the drawing paper to the board follow the steps below:



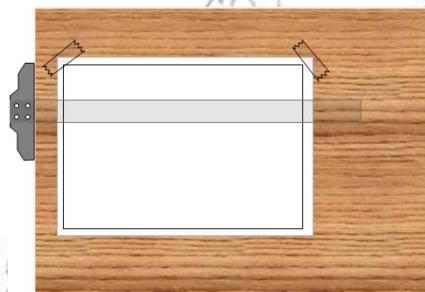
- a) Place a paper close to the left edge of a table



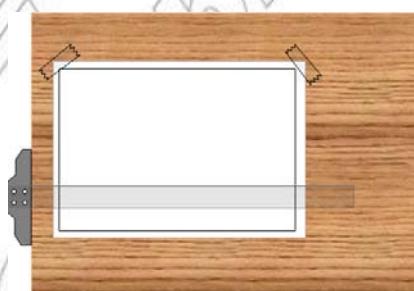
- b) Place a T-square and move the paper until its lower edge lies close to the top edge of a T-square



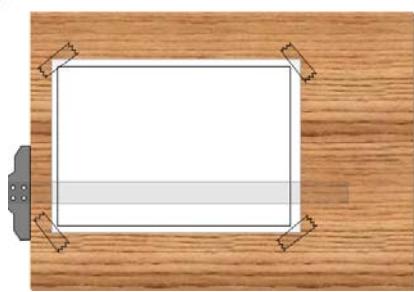
- c) Align the top edge of the paper with T-square blade.



- d) Attach the paper's corners with tape.



- e) Move T-square down to smooth the paper



- f) Attach the remaining paper's corners with tape.

Fig.2.23 Fixing paper to the board

2.4.3 Selecting Pencils

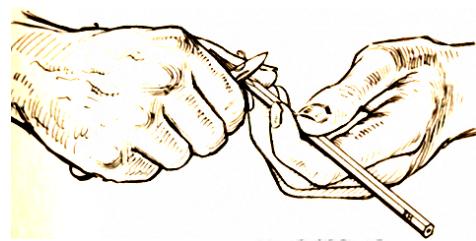
Once the drawing paper is properly fixed, the next step is to start drawing. Pencil drawings are made using pencils. As discussed earlier, there are different types of pencils. Therefore, pencils should be selected based on the type of drawing. (See Section 2.2.2)

Depending on their hardness, pencils are generally classified into three groups; HARD, MEDIUM, and SOFT. The hard groups are generally used for light construction lines, the 4H, 5H, and 6H being common in technical drawings. In the medium group, the softer grades (F, HB, and B) are used for technical sketching and the harder grades (H, 2H, and 3H) are used for finished line work on technical drawings. The pencils in the soft groups are used for art work of various kinds but are too soft to be used in preparation of technical drawings.

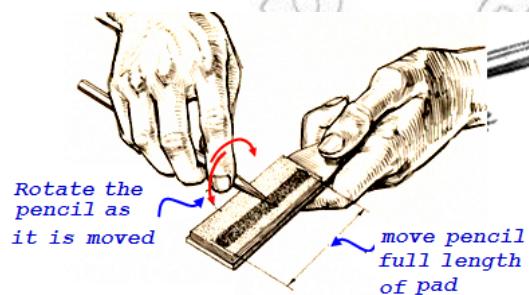
2.4.4 Sharpening Leads of Pencils and Compass

To sharpen leads of pencils and compass follow the following steps:

- Remove the wood with penknife while exposing a lead about 8-10 mm. (See Fig.2.24 (a))



- Polish the lead into a conical shape with sandpaper. (See Fig.2.24 (b))



- Clean the lead with tissue paper. (See Fig.2.24 (c))



Fig. 2.24 Pointing the lead

2.4.5 Drawing Horizontal Lines

Horizontal lines are always drawn from left to right using the T-square as shown in Fig.2.26. Note that T-square head should be held firmly against the board in order to produce accurate lines. When drawing straight lines, the pencil should lean in the direction in which the line is being drawn, at an angle of about 60° with the paper.

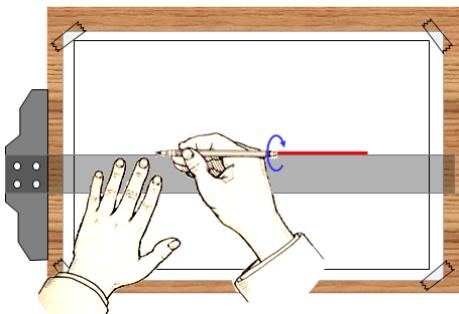


Fig. 2.25. Drawing horizontal line using T-square

2.4.6 Drawing Vertical Lines

The T-Square is used to guide or support the set-squares when drawing vertical lines as shown in Fig.2.26. Here also, the head of the T-square should be held firmly against the board to ensure the verticality of the lines to be drawn. Note that vertical lines drawn in the upward direction along the vertical legs of the triangles.

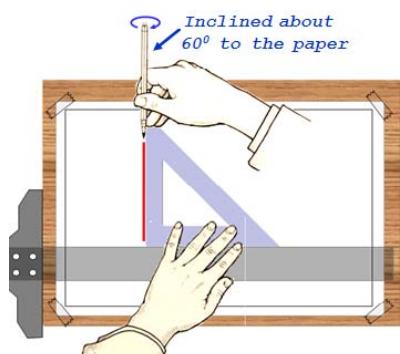


Fig. 2.26. Drawing vertical line using T-square

2.4.7 Drawing Inclined Lines

Lines inclined at any angle can be drawn using a straight edge ruler after locating any two points on the line using protractor.

However, lines inclined at an angle equal to (15° , 30° , 45° , 60° , etc) can be drawn using the T-square and set-squares as illustrated in Fig.2.27.

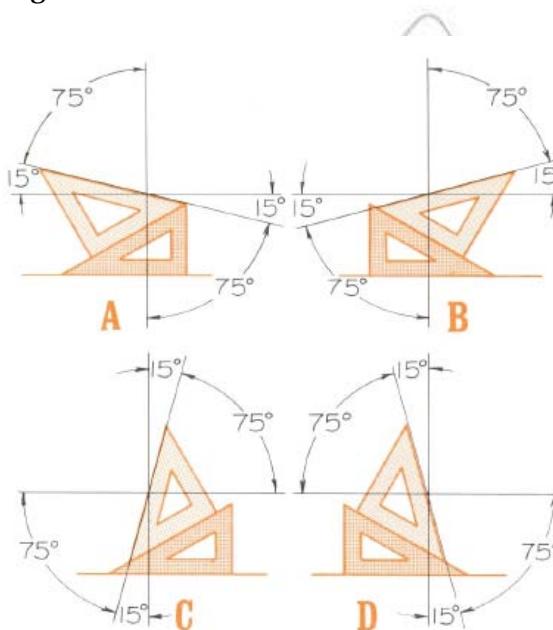


Fig. 2.27. Inclined lines using 45° & $30-60^\circ$ set squares

Key terms

International organization for standardization (ISO):

This organization publishes documents that define procedures and specifications for a range of materials, processes and services.

Checkpoint 2.1: Drawing horizontal and vertical lines

1. Fasten a drawing paper of size A4 to the drawing border.
2. Draw the border lines as follows:
 - a. Measure a distance of 1cm in front of each edge of the paper and put marks using the 5H pencil.
 - b. Draw light horizontal lines parallel to the upper and lower edges of the paper through the marks using the 5H pencil.
 - c. Draw two light vertical lines parallel to the left and right edges of the paper through the other marks using 5H pencil.
 - d. Finally, go over the line using the HB pencil to get dark border lines neatly terminating at each corner.
3. Working downwards from the upper border line, measure and mark a series of 2cm divisions on the left vertical border line. using the 5H pencil, draw light, thin horizontal lines through these divisions marks extending across the entire sheet between the border lines.
4. Working across from the left to the right border line, set off a series of 2cm divisions marks on the upper horizontal border line. Draw a series of light, thin vertical lines through these divisions marks extending upward across the entire paper between the border lines.
5. In a similar manner to steps 3 and 4, lay off a series of 1cm divisions on the upper horizontal and left vertical border lines. Then, through these division points, use your H pencil to draw dark horizontal and vertical lines between the lines drawn in steps 3 and 4. Your final drawing should now consist of a checkerboard pattern of parallel horizontal and vertical lines, alternatively light and dark, 1cm apart.

2.4.8 Drawing Circles and Arcs

The compass is used to draw circles and arcs. Before starting using a compass make sure that the compass is rigid enough not to swing inward or outward while drawing a circle.

To draw a circle or an arc follow these steps:

- Draw two perpendicular center lines of the circle.
- Set off the required radius on one of the center lines.
- Place the needle point at the intersection point of the center lines.
- Adjust the compass to the required radius.
- Lean or incline the compass forward slightly.

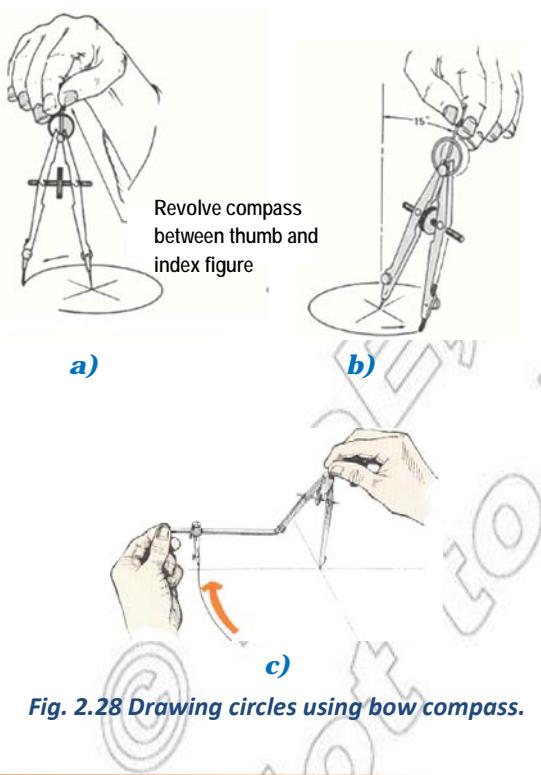


Fig. 2.28 Drawing circles using bow compass.

2.4.9 Using the Divider

The two main purposes of a divider are:

- i) To divide a line into equal parts by trial and error.
- ii) To transfer a distance from one part of a drawing to another.

Fig.2.29 shows how to use the divider to divide a line into equal parts. As an example assume the straight line XY is to be divided into five equal parts. A trial and error procedure is followed. First set the distance between the divider points to be one-fifth of the total distance XY approximately. Then step off this distance over the distance XY.

If an error OP shown in Fig.2.29 occurs widen the distance between the divider points by one-fifth of the error and step off. Repeat this procedure until the correct divisions are established.

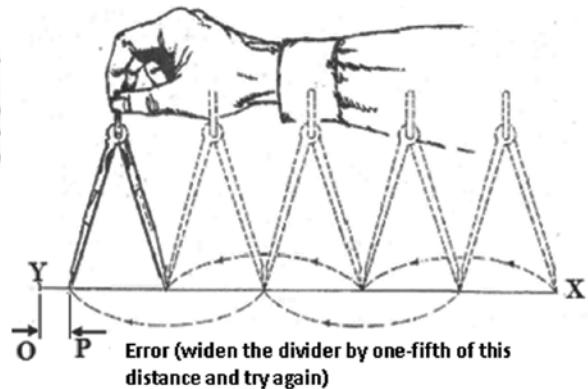


Fig. 2.29 Using the divider to divide a line into equal parts

2.4.10 Using French Curve

Curves other than circles and arcs are called irregular curves. French curves are used to draw irregular curves of various kind. When using the French curves to draw irregular curves, the following steps are recommended:

1. Plot all the points you wish to connect.
2. Sketch a very light line connecting all this points.
3. Place the French curve so that you align as many points as possible with the curvature of the French curve in the direction the curvature of the curve to be drawn increases. At least four points need to be align except for the end spaces.
4. Draw the line connecting these points except for the space at each end.
5. Reposition the French curve so that the first space aligned overlaps with the end space drawn last. Continue this procedure until the curve is drawn.

Note that when drawing symmetrical curves, such as ellipses, the same portion of the French curve should be used on all similar parts of the curve to be drawn

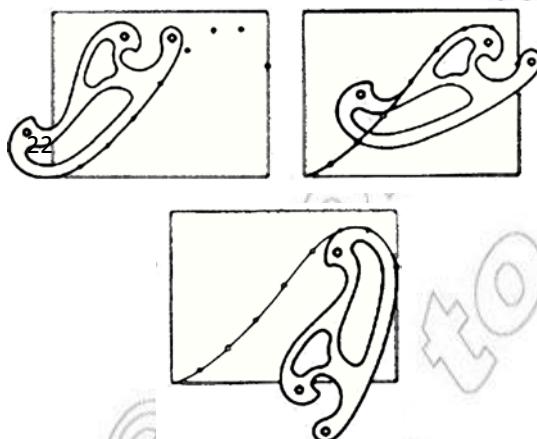


Fig. 2.30 Using the French curve

Activity 2.4

- On a short bond paper follow the format below and make your stand on what to do and not to do with your drafting tools and instruments by listing the DO's and DON'Ts on its proper corner.

Make a Stand!

What to do

How to take care of my tool and instrument

What note to do

Cautions in the use of instruments

To complete this discussion of instruments, here are a few points worth noting:

- Never use the scale as a ruler for drawing lines.
- Never draw horizontal lines with the lower edge 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 suite pointed end of the dividers into the drawing board.
- Never oil the joints of compasses.

- Never use the dividers as reamers, pincers, or picks.
- Never hold the pen over the drawing while filling.
- 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 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 paper.

2.4.11 Keeping Drawings Clean

Cleanliness in drawing is very important and should become a habit. The student should learn the factors involved. First, the draftsman should keep his hands clean at all times. Second, all drafting equipment, such as drawing board, T-square, triangles, and scale, should be cleaned frequently. Third, the largest contributing factors to dirty drawings is *not dirt, but graphite* from the pencil; hence the draftsman should practice the following Do's. (Fig. 2.31)

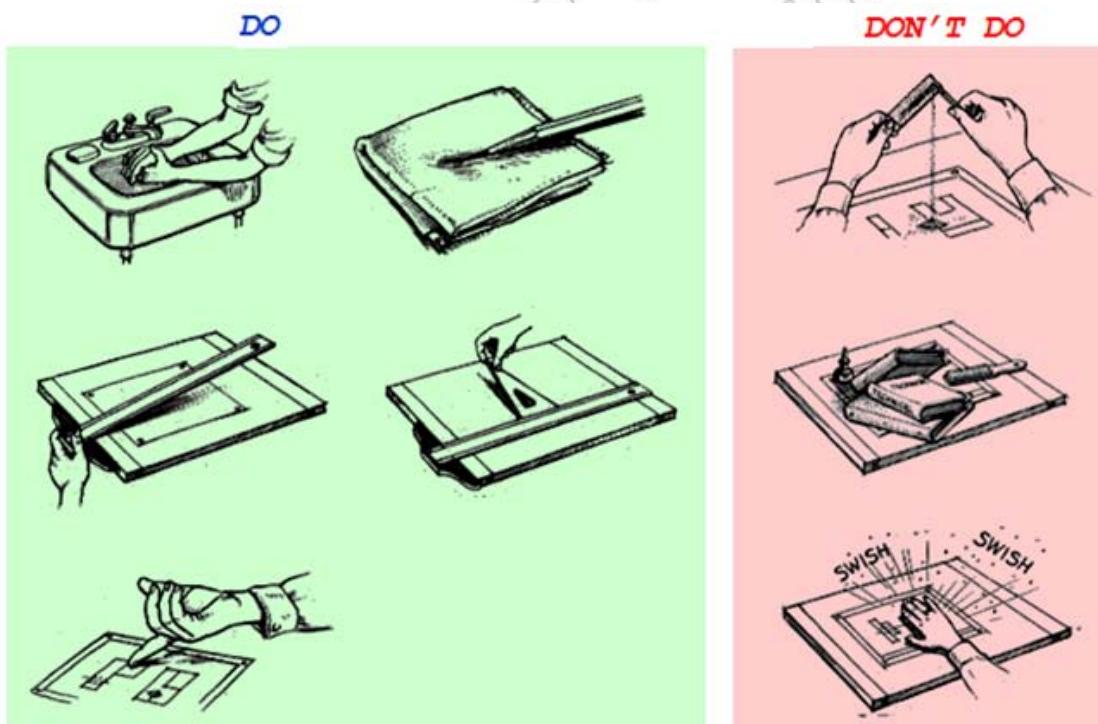


Fig. 2.31 To keep your drawing clean

2.4.12 Title Block

The primary purpose of a drawing title block is to identify a drawing. Title blocks must be uniform in size and easy to read. They may be mechanically lettered, neatly lettered freehand, or preprinted commercially on standard size drafting sheets.

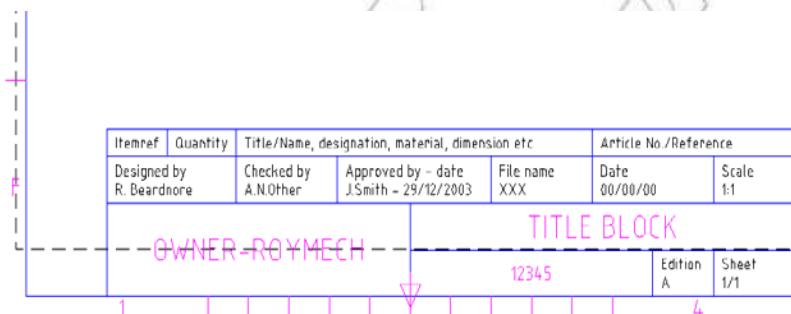
Generally, the title block is placed in the lower right-hand corner of the drawing sheet, regardless of the size of the drawing (except for vertical title block). The arrangement and size of the title block are optional, but the following information should be included:

- the name of the company or organization.
- the title of the drawing.
- the drawing number, which is generally a unique filing identifier.

- the scale.
- the angle of projection used, either first or third, generally shown symbolically.
- the signature or initials of the draftsman, checker, approving officer, and issuing officer, with the respective dates.
- other information as required.

Provision may also be made within the title block for the date of issue, signatures, approvals, sheet number, drawing size, job, order, or contract number, references to this or other documents; and standard notes such as tolerances or finishes.

An example of a typical title block is shown in Fig. 2.32. In class rooms, a title stripe is often used on A- and B-size drawings, such as shown in Fig. 2.33.



Item ref	Quantity	Title/Name, designation, material, dimension etc			Article No./Reference
Designed by R. Beardmore	Checked by A.N.Other	Approved by - date J.Smith - 29/12/2003	File name XXX	Date 00/00/00	Scale 1:1
OWNER - ROYMECH					TITLE BLOCK
12345		Edition A		Sheet 1/1	

Fig. 2.32 Typical example of title block

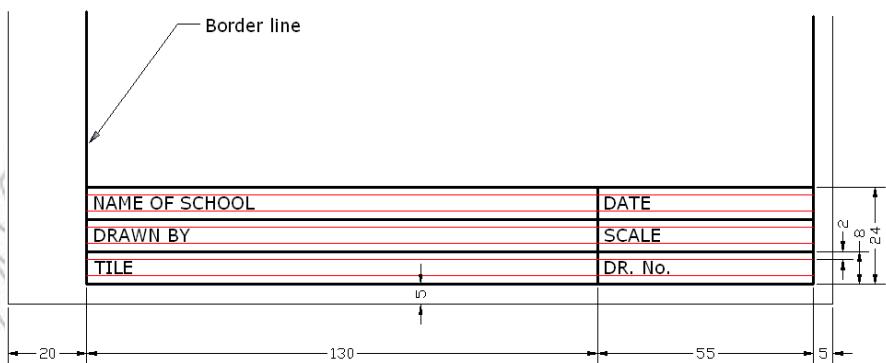


Fig. 2.33 School title block

UNIT SUMMARY

Technical drawing must be prepared in such a way that they are clear, concise, and accurate. In order to produce such drawings equipments (i.e. materials and instruments) are used.

The basic drawing materials which are necessary to prepare a technical drawing are:- Drawing paper, Drawing Pencil, Drafting or masking tape, Eraser, erasing shield, Rapidograph.

A clear understanding of all drawing instruments and their proper uses is important to speed up the process of drawing preparation. It is believed that “a design is as good as its instruments”.

Drawing boards are available in a variety of styles and sizes. Most are adjustable up and down, and can tilt to almost any angle from vertical 90° to horizontal. The drawing surface must be clean, flat, smooth, and large enough to accommodate the drawing and some drafting equipment. If a T-square is to be used, at least one edge on the board must be absolutely true.

T-square provides a parallel straight edge for the beginning drawing drafter. It is composed of two parts: the head and the blade. The two parts are fastened together at an exact right angle. The blade must be straight and free of any necks and imperfections. Draw lines using T-square only against the upper edge of the blade. Make sure the head is held against the left edge of the drawing board to guarantee parallel lines.

A compass is used mainly to draw circles and circular curves of relatively short radius. The large compass is satisfactory for drawing circles of 25 mm to about 300 mm in diameter without an extension bar.

The other type of compass is the bow compass. Many experienced draftsmen prefer the bow compass. The bow compass is much sturdier and is capable of taking the heavy pressure necessary to produce opaque pencil lines without losing the radius setting.

Dividers are similar to compasses, except that both legs are provided with needle points. Dividers are used to transfer measurements. To step off a series of equal distances, and to divide lines into a number of equal parts.

Triangles are used in combination with the T-square to draw vertical and inclined

lines. They are usually made of transparent plastic, which allows you to see your work underneath the triangles. Two standard triangles are used by the drafters. One is the 30-60° triangle. The other is the 45-degree triangle.

The adjustable triangle combines the functions of the triangle and the protractor. When it is used as a right triangle, the hypotenuse can be set and locked at any desired angle to one of the bases. The transparent protractor portion is equivalent to a protractor graduated in 1/2° increments.

A template is a thin, flat piece of plastic containing various cutout shapes. It is designed to increase the speed and accuracy of the drafter. Templates are available for drawing circles, ellipses, plumbing fixtures, bolts, nuts, screw threads, electronic symbols, springs, gears and much more. A template should be used whenever possible to increase the accuracy and the speed.

French curves are thin plastic tools that come in assortment of curved surfaces. They are used to produce curved lines that cannot be made by a compass. Most common French curves are actually segments of ellipses, parabolas and hyperbolas.

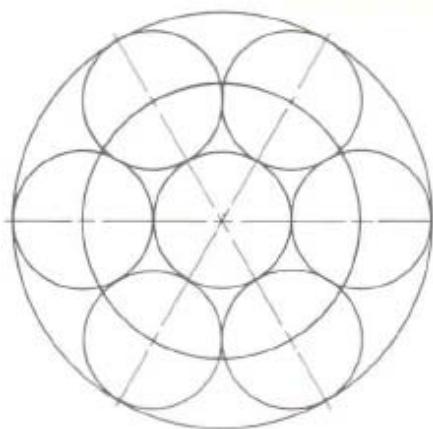
Protractors are used for measuring and laying off angles other than those that may be drawn with the triangle or a combination of triangles. Like the triangle, most protractors are made of transparent plastic. They are either circular or semicircular in shape.

An erasing shield restricts the erasing area so that the correctly drawn lines will not be disturbed during the erasing procedure. It is made from a thin flat piece of metal with variously sized cutouts. The shield is used by placing it over the line to be erased and erasing through the cutout.

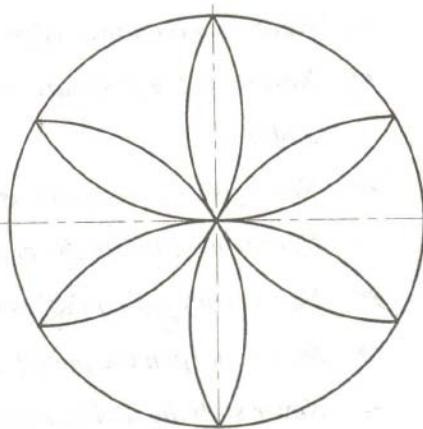
Before starting the drawing you have to fulfill the following points:

- ☞ Make sure that all the necessary drawing instruments are ready and clean.
- ☞ Position your drawing board to minimize effects of shadows.
- ☞ Clean your drawing board.

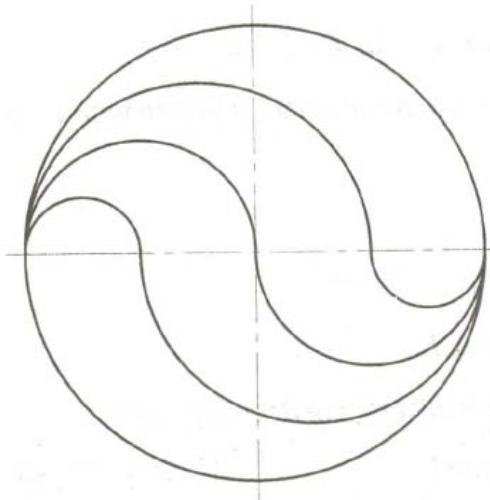
Exercise I: Redraw the following figures in full scale.



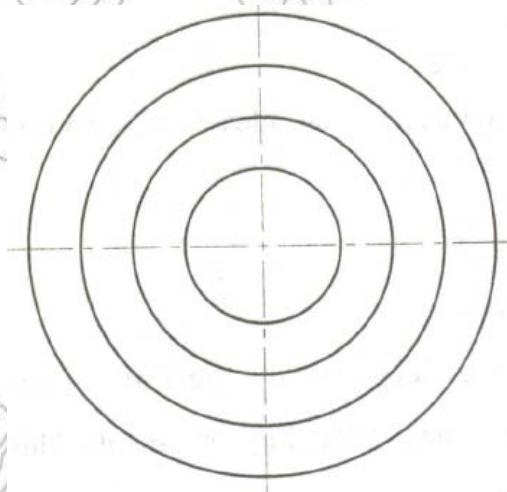
a)



c)

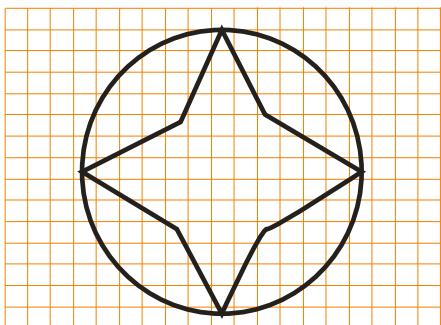


b)

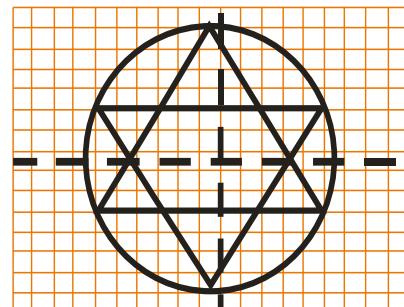


d)

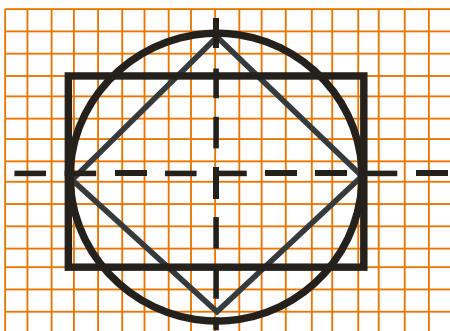
Exercise II: Redraw the following figures in full scale.



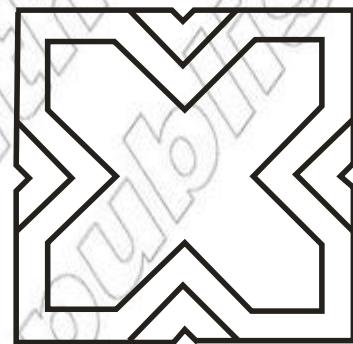
a)



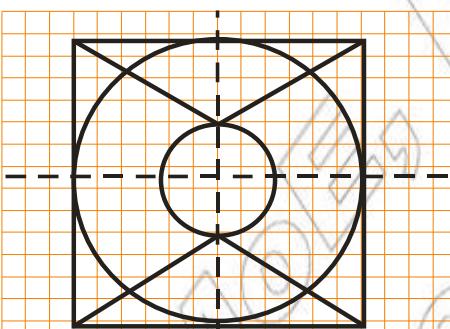
d)



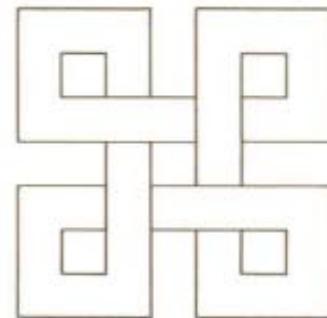
b)



e)

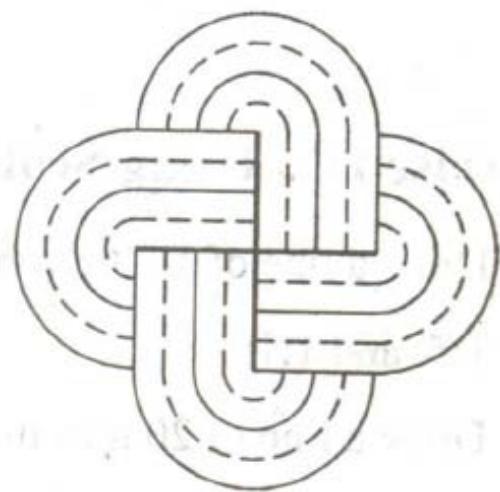


c)

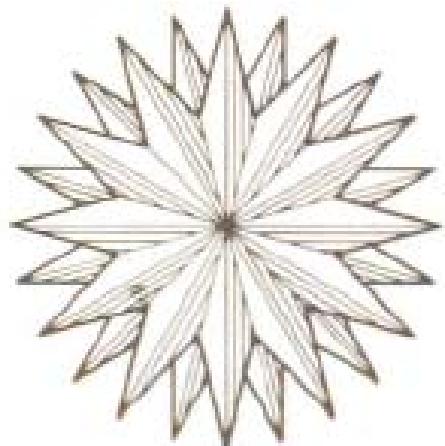


f)

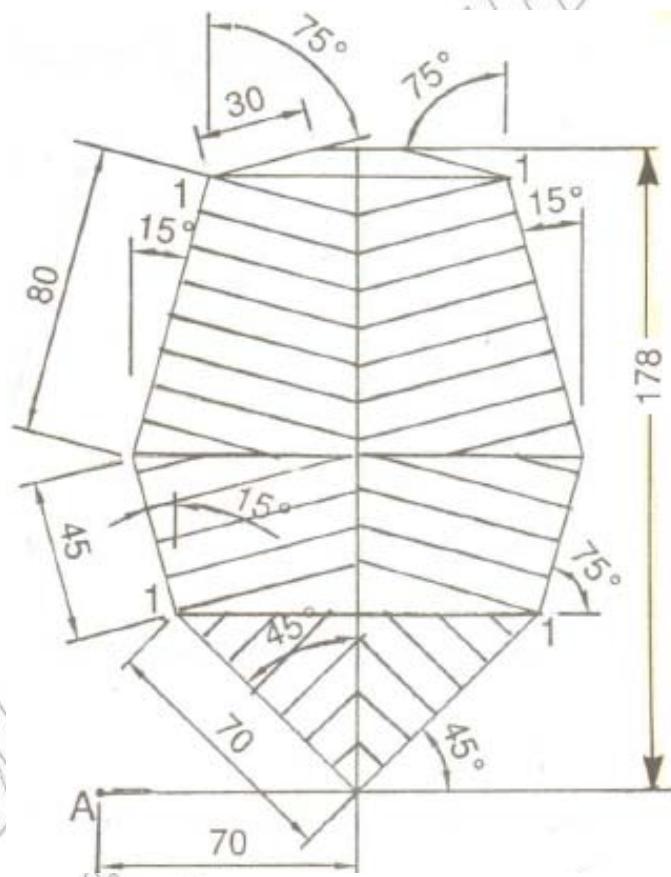
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g)



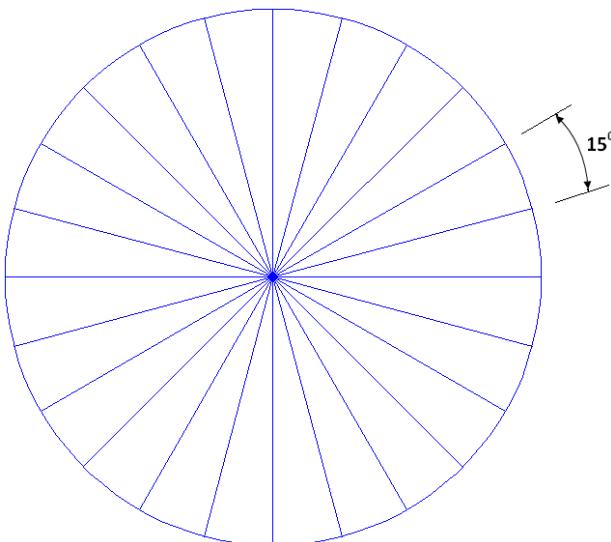
h)



i)

Exercise III: Dividing a circle into equal number of parts.

1. Draw a circle of radius 50mm. Use an H lead in the compass.
2. Divide the circle drawn in step 1 into 24 equal parts using set-squares and the T-square as shown below. Use an H pencil. *Do not use protractor.*



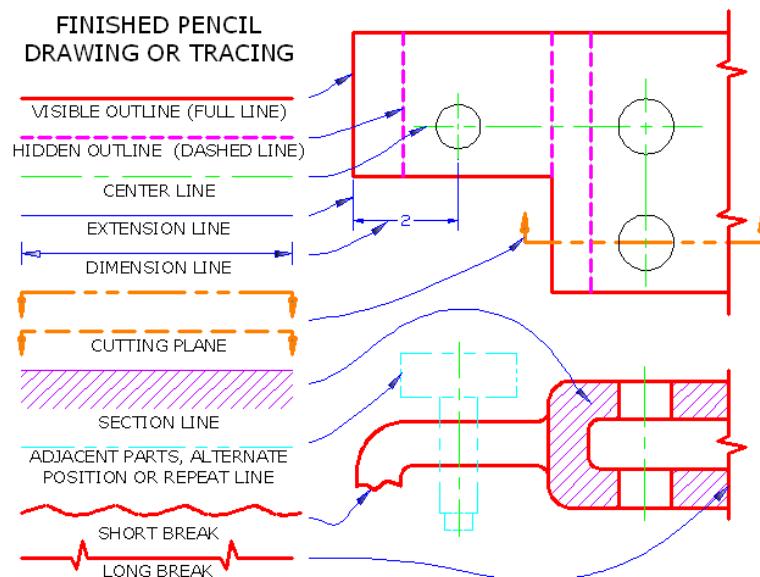
Exercise Iv: Using Scales.

1. Draw a line of 200mm full length. Then redraw the line to the following scales, 1:2, 1:5 and 1:10.
2. Draw a line of 10mm full length. Then redraw the line to the following scales: 2:1, 5:1, and 10:1.
3. Construct a circle whose full diameter is 150mm. Then, using the same center, redraw the circles to the following scales: 1:2, 1:5, and 1:10.
4. Draw a circle whose full radius is 10mm. Then, using the same center, redraw the circles to the following scales: 2:1, and 5:1.

UNIT

3

ALPHABET OF LINES



Learning competencies:

Up on completion of this unit you should be able to:

- ✓ Explain the types and purpose of different weight of lines in making drawings;
- ✓ Produce the lines with various line weights;
- ✓ Apply alphabet of lines for making proper working drawings.

3.1 Introduction

Have you ever seen a drawing proposal of a building or a machine? If you do what did you observe from the types of lines?

Lines of various forms and thickness are used as alphabets of the graphic language. If these lines are properly and systematically composed, they have the capacity to describe the shape of an object adequately.

It is beneficial to develop the capacity of discriminating each line in shape and thickness. The alphabet of lines may be categorized into three groups based on their weights or thickness.

The object line, the cutting plane line, and the short break lines should be drawn thick.

The center lines, dimension lines, extension lines, long-break lines, and phantom lines should be thin and the hidden should have an intermediate thickness between the thin and the thick lines.

In fact, thick lines are (0.5 to 0.8 mm) wide, thin lines between (0.03 to 0.5 mm) wide. The actual width each line is governed by the size, the style of the drawing and the smallest size to which it is to be reduced.

The description and illustrations shown in Fig. 3.1 would be of great help to understand the function of each line.

All the main line types are listed below:

- Visible
- Hidden
- Center
- Dimension
- Extension
- Cutting plane
- Section
- Break
- Phantom

Types of Lines	Weight
Object	Thick
Hidden	Medium
Center	Thin
Phantom	Thin
Extension & Dimension	Thin
Leader	Thin
Section	Thin
Cutting plane	Thick
Short break	Thick
Long break	Thin

Fig.3.1 Types of Lines

1. Object lines: are dark, heavy solid lines used to show the out line and shape of an object and define features you can see in a particular view. These lines are the most prominent lines on drawings. The object line is also identified as visible line.

THICK



Fig. 3.2 Object lines

2. Hidden lines: are medium weight short dashed lines. They are used to show the out line of a feature that can not be seen in a particular view and help clarify a feature, but can be omitted if they clutter a drawing. The dashes of hidden lines should be drawn approximately 3 mm long with a space of 1.0mm left between each dash. However, the length may vary slightly to suit the size of the drawing.

MEDIUM



Fig. 3.3 Hidden lines

3. Center lines: are thin lines composed of one long dash and one short dash spaced alternately. It is used to indicate axis of circles and symmetrical surfaces of an object. Depending up on the size of the drawing, the length of the long dash approximately ranges from 20-40mm. The short dash is about 3mm and the spacing between the long and short dashes is about 1.5mm.

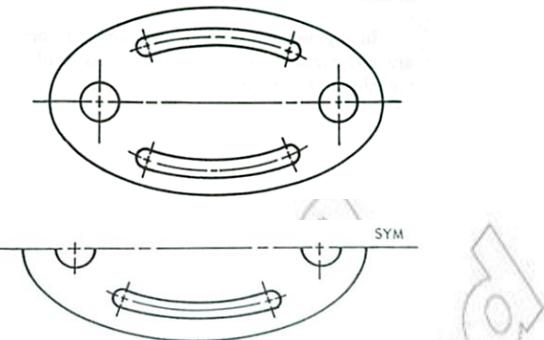


Fig. 3.4 Center lines

4. Dimension lines: are thin lines with arrowheads at its ends. It is used to Show the length, width, and height of the features of an object.



Fig. 3.5 Dimension line

5. Extension lines: are thin solid lines used to show the starting and stopping points of a dimension. Extension line is drawn approximately 1.5mm away from object line and is extended 3mm long beyond the outermost arrowhead.



Fig. 3.6 Extension Line

6. Leader Lines: Thin lines, used to show the dimension of a feature or a note that is too large to be placed beside the feature itself.

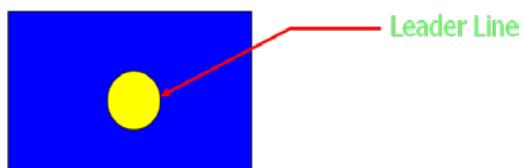


Fig. 3.7 Leader line

7. Cutting plane lines: are used to indicate the location of the cutting of cutting plane in the process of sectioning. Two forms of lines may be used. The first one is a dark line composed of one long and two short dashes spaced alternately. The long dashes are drawn approximately 20 to 40mm long or little more depending upon the size of the drawing. The short dashes are drawn approximately 3mm long, with a space of 1.5mm between each dash. The second form of cutting plane line is composed of equal dashes approximately 6mm long with spaces of 1.5mm between each dash. The ends of the cutting plane lines are bent 90° angle and are terminated by arrowhead to indicate the direction of sight.

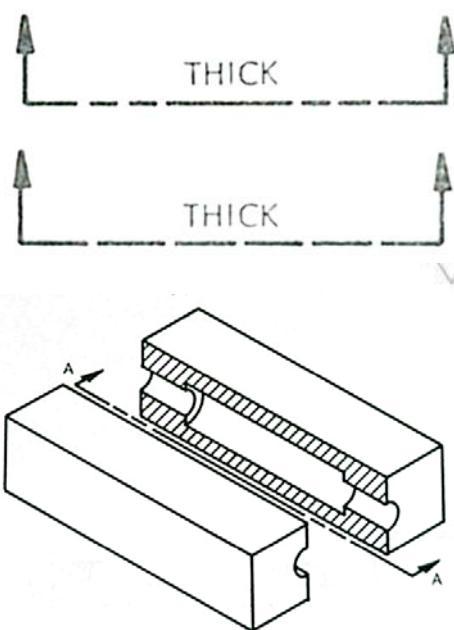


Fig. 3.8 Cutting plane lines

8. Section Lines: are used to indicate the cut surface of an object in sectional view. The section lines are usually drawn thin at 45 degree angle to produce a contrast with visible line. It should be equally spaced and proportional to the mass of the sectional surface.

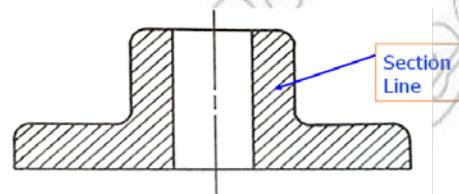


Fig. 3.9 Section lines

9. Break Lines: generally are used to break out sections for clarity or for shortening apart. Three types of lines with different line weights are used in break line. These are:

- Long breaks
- Short breaks
- Cylindrical breaks

Long Break Lines: are long and thin lines. It is used to show that the middle section of an object has been removed so it can be drawn on a smaller piece of paper.

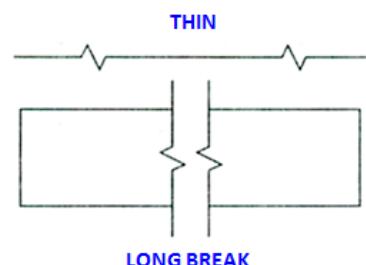


Fig. 3.10 Long break lines

Short Break Lines: is thick wavy line. It is used to break the edge or surface of a part for clarity of a hidden surface.

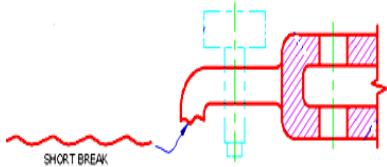


Fig. 3.11 Short break lines

Cylindrical Break Lines: are thin lines. It is used to show round parts that are broken in half to better clarify the print or to reduce the length of the object.



Fig. 3.12 Cylindrical break lines

10. Phantom Lines: are thin lines composed of long dashes alternating with pairs of short dashes. The long dashes are drawn approximately 20-40mm long or a little more. The short dashes are drawn 3mm long with space of 1.5mm between each dash. Phantom lines are used for three purposes in drawings:

- ✓ To show the alternate position of machine part and lines of motion.
- ✓ To show the relationship of parts that fit together.
- ✓ To show repeated detail.

Alternate Position: Phantom lines can show where a part is moving to and from. It

eliminates the confusion of thinking there may be two parts instead of just one.

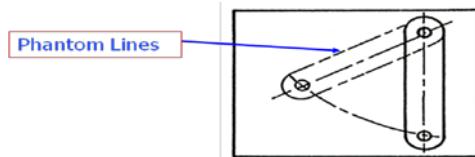


Fig. 3.13 Phantom line for alternate position

Relationship of Mating Parts: Phantom lines can also show how two or more parts go together without having to draw and dimension both parts.

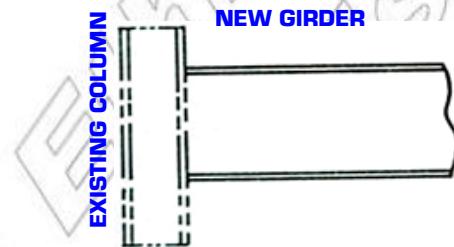


Fig. 3.14 Phantom line for relationship of mating parts

Key terms

Column: A column in structural engineering is a vertical structural element that transmits, through compression, the weight of the structure above to other structural elements below.

Girder: is a large main supporting beam, commonly of steel or reinforced concrete that carries a heavy transverse (crosswise) load.

Repeated Detail: Phantom lines can show repeated detail of an object. This saves the drafter time and the company money.

Using phantom lines for repeated detail minimizes the drafter error.

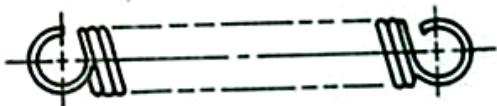


Fig.3.15 Phantom line for repeated detail

Activity 3.1

Search for a printed out floor plan, any architectural drawing or map drawing and find out the types of lines used in it.

UNIT SUMMARY

Lines in technical drawings are part of a specialized graphic language that is standardized throughout industry. Each type of line has a very precise symbolic meaning. Correct usage of this "alphabet of lines" is essential whether you use traditional drafting methods or CADD.

Line weights are a vital part of conventional technical graphics language. They are embodied to the extent of being defined in national and international standards. In manual drafting, different pen sizes allow the drafter to give different line weights to the lines in the drawing. Line types and line weights allow drawings to communicate information that would otherwise be very difficult to convey.

Therefore construction lines and guide lines are very light, easily erased lines used to block in the main layout. Visible lines are the edges or "outlines" of an object. They are drawn as solid lines with a thick/heavy weight. All other lines contrast with the visible lines by having either a thinner weight and/or a combination of dashes.

Exercise I

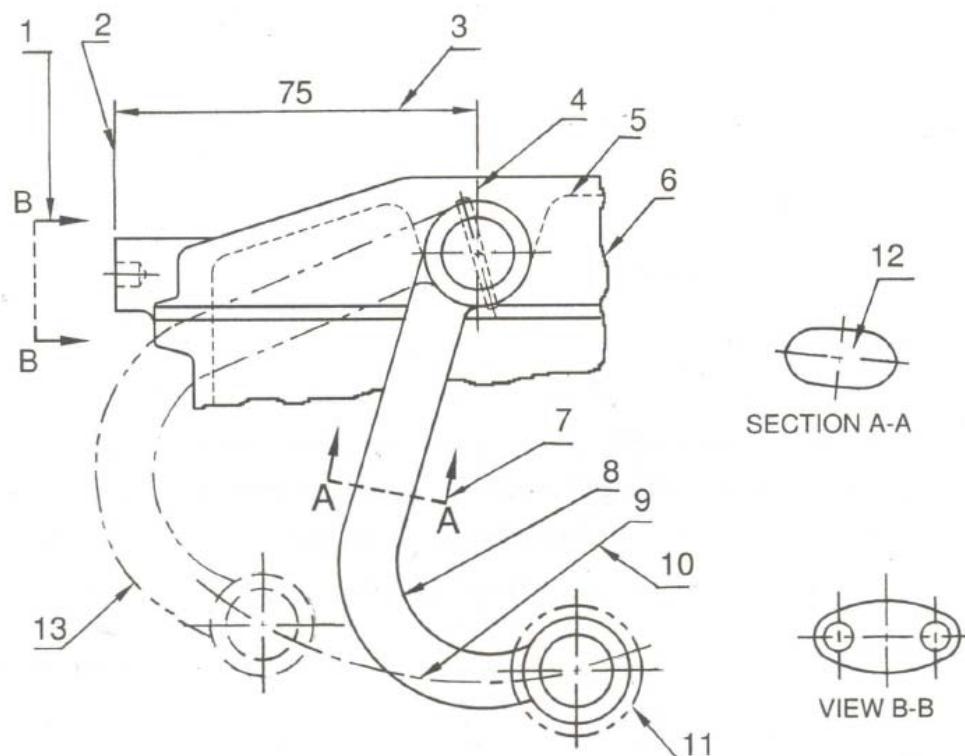
Match the following (write the letter of the correct definition on line to the left):

- Object line
- Hidden line
- Center line
- Phantom line
- Break line
- Extension line
- Cutting plane
- Section line
- Dimension line

- A. Used when it is not necessary to show all of a part.
- B. The lines which show the visible parts in a view.
- C. Used in combination with a cutting plane line to depict the inner structure of an object.
- D. Used to show the location of a cut for a sectional view or the direction from which a view is taken.
- E. Shows the course through which center travels.
- F. A thin line that extends from the part or feature being dimensioned.
- G. Used to indicate edges, intersections, etc., those are behind other features of the part.
- H. Used in conjunction with extension lines to indicate a linear distance.
- I. Shows alternate positions of parts and also the location of parts that are not integral parts of the item depicted.

Exercise II

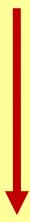
The following figure shows technical lines that describe a piece of machinery with a swinging arm. Identify the type of line represented by each number.



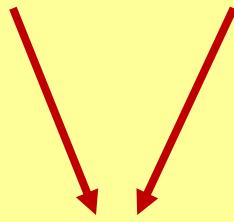
UNIT 4

LETTERING

Straight



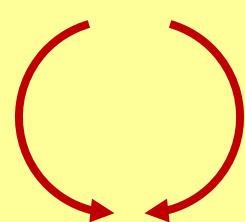
Slanted



Horizontal



Curved



Basic lettering Strokes

Learning competencies:

Up on completion of this unit you should be able to:

- ✓ Describe the purpose of lettering on a drawing;
- ✓ Identify the various types of drawing lettering styles;
- ✓ Make technical lettering, single-stroke; vertical and inclined gothic letters properly;
- ✓ Identify proper types of lettering pencils, lettering device and letter guide lines.

4.1 Introduction

- *What do you think is lettering in technical drawing?*
- *Observe the information given by words on the drawing you brought on activity 3.1 What do you observe from the type of letters?*

The information that a drawing must present cannot be revealed by graphic shapes and lines alone. To make a drawing informative and complete, you must include lettering in the form of dimensions, notes, legends, and titles. Lettering can either enhance your drawing by making it simple to interpret and pleasant to look at, or it can ruin your drawing by making it difficult to read and unsightly in appearance. Therefore, it is essential that you master the techniques and skills required for neat, legible lettering.

Key terms

Legible: capable of being read or deciphered, especially with ease of reading.

Lettering styles

Have you ever used word program on a computer? If you do, try to list out the types of lettering styles found on the Microsoft word program.

There are various forms of a letter used in the art of lettering and each approximate for some particular purpose.

Roman Letters

The term Roman refers to any letter that has wide downward strokes and thin connecting strokes, as would result from the use of a wide pen, and the ends of the strokes are terminated with spurs called serifs. Roman letters include the Old Roman and Modern Roman and may be vertical or inclined.

Italic Letters

Inclined letters are also referred to as italic, regardless of the letter style; those shown in Fig. 4.1 are inclined Modern Roman.

Text Letters

The Text letters shown in Fig. 4.1 are often loosely referred to as “Old English”, are little used where legibility is important, but only where a decorative effect is sought. These letters may be easily and rapidly made with a broad-nib pen.

Gothic Letters

German Text is the only form of medieval Gothic in commercial use today. Commercial Gothic is a relatively modern development that originated from the earlier Gothic forms. Also called sans-serif Gothic, this letter is the only one of interest to engineers, Fig. 4.1. It is the plainest and most legible style and is the one from which our single-stroke engineering letters are derived. While admittedly not as beautiful as many other styles, sans-serif letters are very legible and comparat-

ively easy to make. They may also be drawn in outline and filled in.

ABCDEFGHI
abcdefghijklm

Roman All letters having elementary strokes "accented" or consisting of heavy and light lines, are classified as *Roman*.

ABCDEFGHI
abcdefghijklm

Italic All slanting letters are classified as *Italics*. These may be further designated as *Roman-Italics*, *Gothic Italics* or *Text Italic*.

ABCDEFGHI
abcdefghijklm

Text This term includes all styles of *Old English*, *German text*, *Bradley text* or others of various trade names. Text styles are too illegible for commercial purposes.

ABCDEFGHI
abcdefghijklm

GOTHIC All letters having the elementary strokes of even width are classified as *Gothic*.

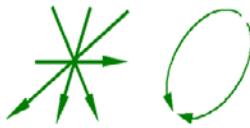
Fig. 4.1 Classification of letter styles

4.2 Technique of Lettering

Any normal person can learn to letter if a persistent and intelligent effort is made. Although it is true that "practice makes perfect," it must be understood that practice alone is not enough; it must be accompanied by continuous effort to improve.



(a) VERTICAL



(b) INCLINED

Fig. 4.2 Basic Lettering Strokes

Lettering is freehand drawing and not writing. Therefore, the six fundamental strokes and their direction for freehand drawing are basic to lettering, Fig. 4.2. The horizontal strokes are drawn to the right, and all vertical, inclined, and curved strokes are drawn downward. Good lettering is always accomplished by conscious effort and is

never done well otherwise, though good muscular coordination is of great assistance. Ability to letter has little relationship to writing ability; excellent letterers are often poor writers.

There are three necessary aspects of learning to letter.

1. Knowledge of the proportions and forms of the letters and the order of the strokes. No one can make a good letter who does not have a clear mental image of the correct form of the letter.
2. Knowledge of composition the spacing of letters and words. Rules governing composition should be thoroughly mastered.
3. Persistent practice, with continuous effort to improve.

Pencil for Lettering

First, sharpen the pencil to a needle point; then dull the point very slightly by marking on paper while holding the pencil vertically and rotating the pencil to round off the point. Pencil lettering should be executed with a medium pencil, such as an F or H for ordinary paper; the strokes should be dark and sharp, not gray and blurred. In order to wear the lead down uniformly and thereby keep the lettering sharp, turn the pencil frequently to a new position.

In general, draw vertical strokes downward or toward you with a finger movement, and draw horizontal strokes from left to right with a wrist movement without turning the paper. Since practically all pencil lettering will be reproduced, the letters should be dense black. Avoid hard pencils that, even

with considerable pressure, produce gray lines.

4.3 Single Stroke Letters

1. *What do you understand from the phrase single stroke letters?*
2. *Try to sketch single stroke letters on your own understanding.*

Single stroke letters are used universally for technical drawing. This style is suitable for most purpose because it posses the qualification necessary for legibility and speed. The expression single stroke means the width of the straight and curved lines that forms the letters are the same as the stoke of the pen or pencil.

Note: *Upper-case and lower-case letters are to mean capital and small letters respectively.*

4.3.1 Vertical Capital Letters and Numerals

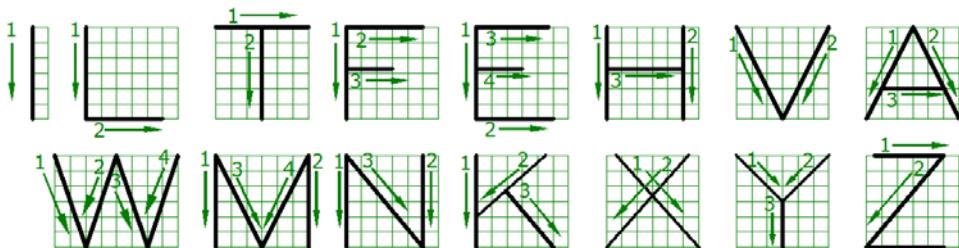
For convenience in learning the proportions of the letters and numerals, each character is shown in a grid six units high. Numbered arrows indicate the order and direction of strokes. The widths of the letters can be easily remembered. The letter 1 or the numeral 1 has no width. The W is 8 units wide (1.3 times the height) and is the widest letter in the alphabet. All the other letters or numerals are either 5 or 6 units wide, and it is easy to remember the six unit letters

because when assembled they spell TOM Q. VAXY. All numerals except the 1 are 5 units wide. All horizontal strokes are drawn to the right, and all vertical, inclined, and curved strokes are drawn downward, Fig. 4.2.

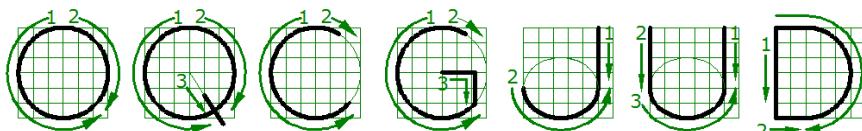
As shown in Fig. 4.3, the letters are classified as straight-line letters or curved-line letters. On the third row the letters O, Q, C, and G are all based on the circle. The lower portions of the J and U are semi-ellipses, and the right sides of the D, P, R, and B are semicircular. The 8, 3, S, and 2 are all based on the figure 8, which is composed of a small ellipse over a larger ellipse. The 6 and 9 are based on the elliptical zero. The lower part of the 5 is also elliptical in shape.

Activity 4.1

1. *Copy the exact number of grids that each letter occupies like an example below. Practice on your drawing paper as accurately as you can the order of strokes for the uppercase, lowercase Gothic letters and numerals.*
2. *Use the HB pencil for the letters, and the red ballpen for the number sequencing of strokes. Lettering is a freehand activity, hence, rulers are not used.*



W is the only letter over 6 unit wide. Letters in "TOMQ VAXY" are 6 units wide-all the others are S, except "T" and "W" curved line letters and numerals.



The letters O, Q, C, G and D are based on a true circle. The lower portion of the J and U is elliptical

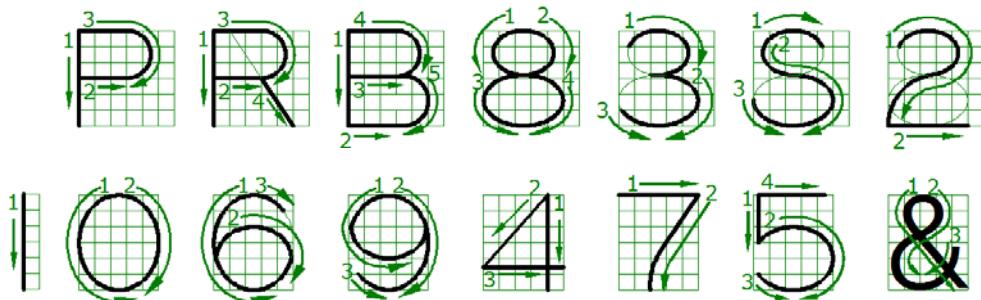


Fig. 4.3 Vertical Capita Letters and Numerals

4.3.2 Vertical Lower-Case Letters

Before beginning a word or line of lower-case letters, the four guide lines (Fig. 4.4) should be drawn. The drop line may be omitted by all except beginners.

Strokes of the letters extending above the waist line are known as ascenders, and those extending below the base line as descenders. All ascenders except that of the t extend to the cap line. All descenders extend to the drop line.

The 3rd stroke of the letter "e" is slightly above mid-height. The dots over the i and j are slightly below the cap line.

The crosses on the f and t are on the waist line and are symmetrical with respect to 1st stroke. The curved strokes of h, m, n, and r intersect strokes 1 approximately two-thirds of the distance from the base line to the waist line.

The descenders of g, j, and y terminate in curves which are tangent to the drop line, while those of p and q terminate in the drop line and do not have the curves.

The letters a, b, c, e, g, p, and q are formed with circles as bases.

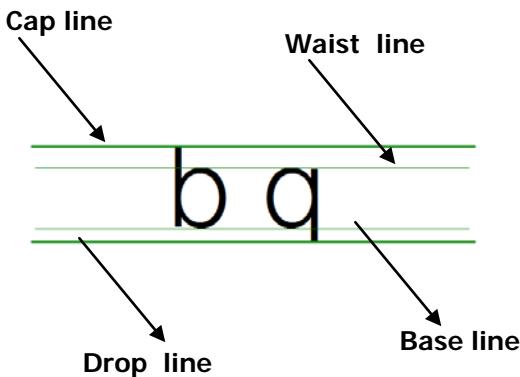


Fig. 4.4 The four guide lines

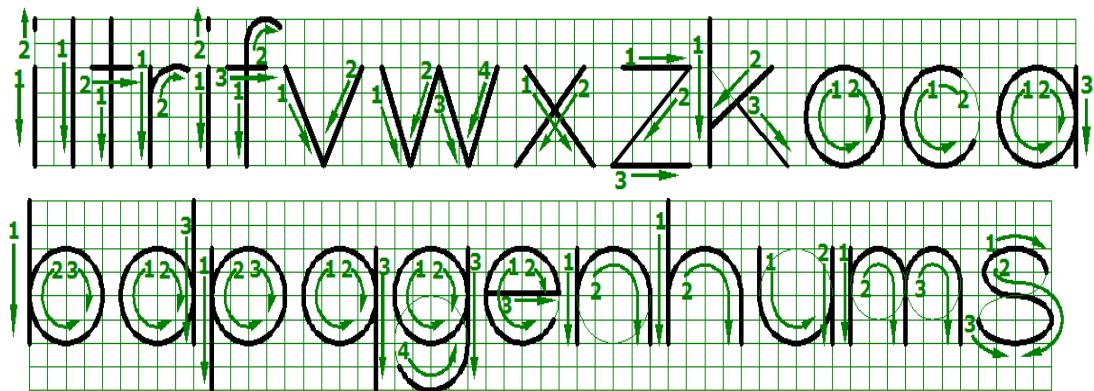
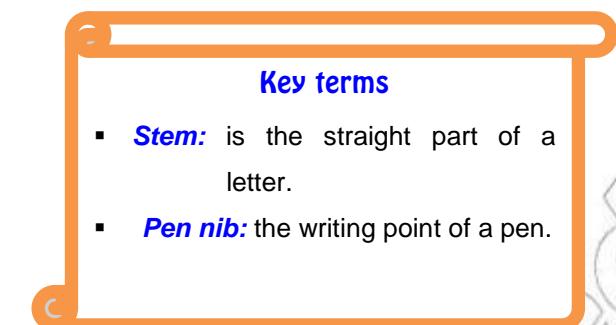


Fig. 4.5 Vertical lowercase letters

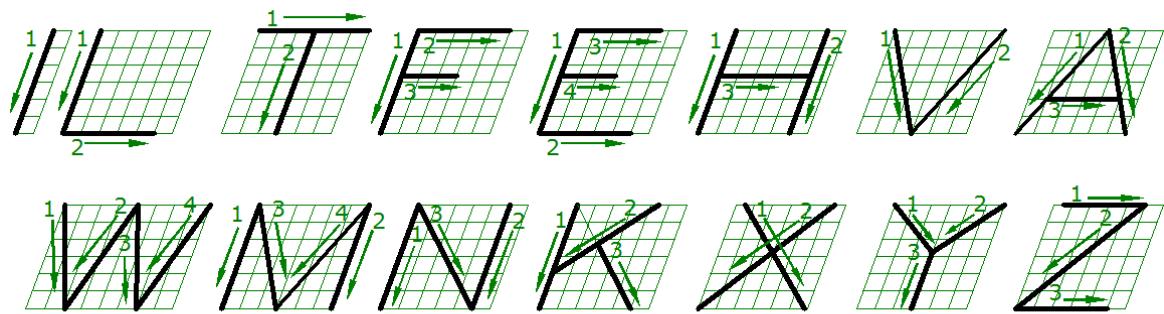
4.3.3 Inclined Capital, Lower-Case Letters and Numerals.

Fig. 4.6 & 4.7 the order and direction of the strokes and the proportions of the inclined capital letters and numerals are the same as those for the vertical letters except that they are commonly tilted at an angle of $67\frac{1}{2}^{\circ}$ from a horizontal guide line. Inclined letters are also classified as straight-line or curved-line letters, most of the curves being elliptical in shape.



Activity 4.2

1. Copy the exact number of grids that each letter occupies like an example below. Practice on your drawing paper as accurately as you can the order of strokes for the inclined capital, lower-case letters and numerals.
2. Use the HB pencil for the letters, and the red ball pen for the number sequencing of strokes. Lettering is a freehand activity, hence, rulers are not used.



"w" is the only letter over 6 unit wide. Letters in "TOMQ, VAXY" are 6 units wide-all the others are 5, except "I" and "w"

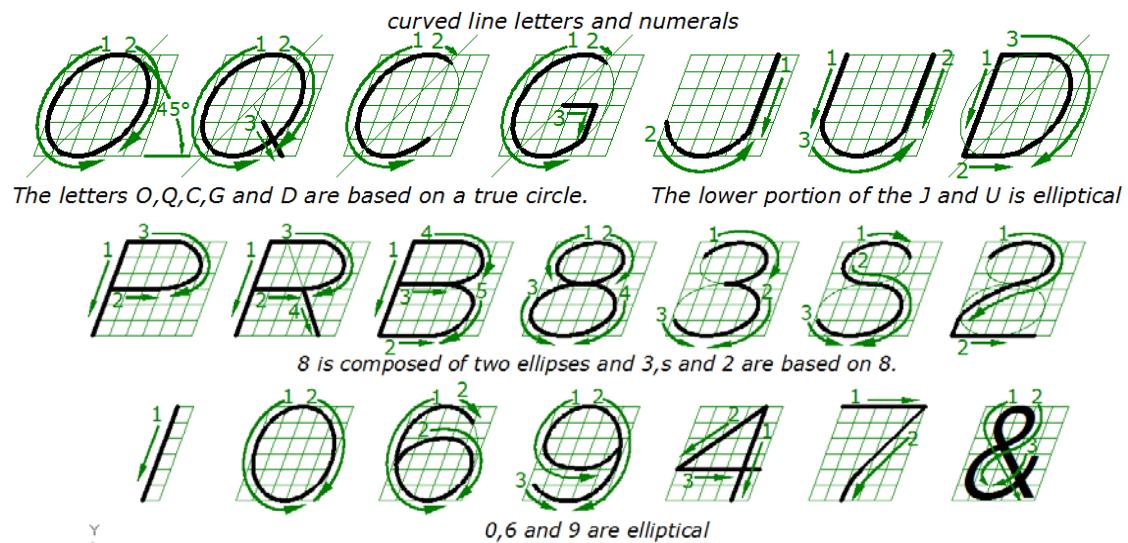


Fig. 4.6 Inclined capital letters and numerals



Fig. 4.7 Inclined lowercase letters

4.4 Guide Lines

1. What do you propose to write letters which have equal height?
2. Show your proposal in practice.

Fig.4.8 (A) shows the use of light pencil lines called guidelines. Guidelines ensure consistency in the size of the letter characters. If your lettering consists of capitals, draw only the cap line and base line. If lowercase letters are included as well, draw the waist line and drop line.

The waist line indicates the upper limit of the lowercase letters. The ascender is the part of the lowercase letter that extends above the body of the letter; for example, the dot portion of the character i in Fig.4.8 (A). All ascenders are as high as the caps.

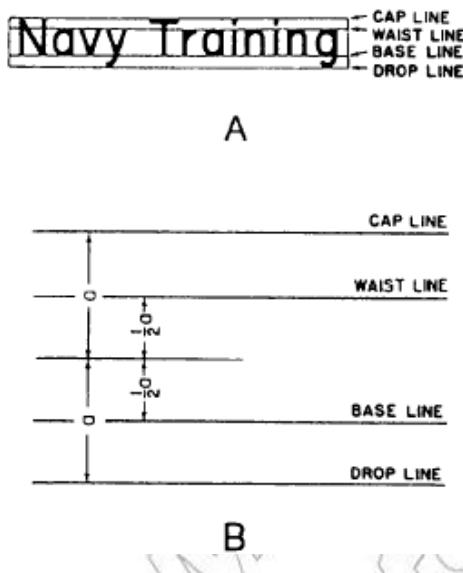


Fig. 4.8 Laying off guidelines

The drop line indicates the lower limit of the lowercase letters. The descender is the part of the lowercase letter that extends below the body of the letter, an example being the tail of the character g in Fig.4.8. (A). The vertical distance from the drop line to the base line is the same as the vertical distance from the waist line to the cap line. It is about one third of the vertical distance between the base line and the cap line, or about one half of the vertical distance between the base line and the waist line.

Fig. 4.8. (B), shows an easy way to lay out guidelines for caps and lowercase. Let the height of a capital be $1\frac{1}{2}$ times the distance " α ". Set a compass or dividers to distance " α " and lay off distance " α " above and below the midline selected for the guidelines, the method locates the cap line and the drop line. Then set the compass or dividers to one half of " α " and lay off this distance above and below the midline. This method locates the waist line and the base line.

Complete guide lines should be drawn for whole numbers and fractions. This means that both, horizontal and vertical guide lines or horizontal and inclined guide lines should be drawn.

Fig.4.9, draw five equally spaced guide lines for whole numbers and fractions. Thus, fractions are twice the height of the corresponding whole numbers. Make the numerator and the denominator each about three-fourths as high as the whole number to allow ample clear space between them and the fraction bar.

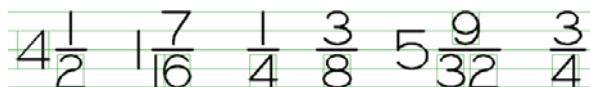


Fig. 4.9 Guide lines for numerals and fractions

To help you keep your lettering vertical, it is a good idea to construct vertical guidelines, spaced at random along the horizontal guidelines. For inclined lettering, lay off lines inclined at the angle you wish your lettering to be slanted (See Fig 4.10). Inclined lines are known as direction lines and are normally slanted at a maximum of 68 degrees.

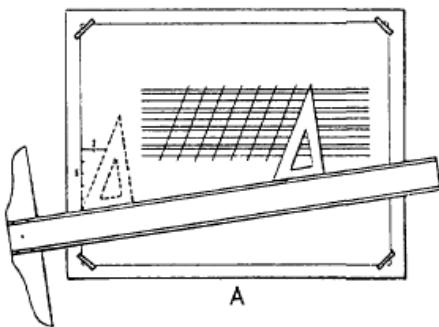


Fig. 4.10 Laying off lines for lettering

4.4.1 Spacing between Guidelines

The spacing between two lines of capitals may vary from one half of the height to the full height of a capital. Two thirds of the height is customarily used.

The spacing commonly used between lines of lowercase letters is shown in Fig.4.11. The space indicated by the letter S equals the vertical distance between the waist line and the cap line.

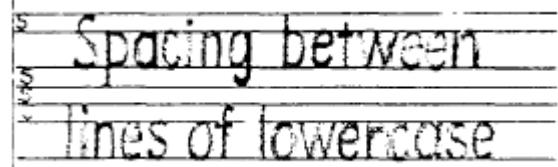


Fig. 4.11 Spacing between lines of lowercase letters

Activity 4.3

On your drawing paper, prepare five sets of guidelines. Write any quotation about nationalism. Use the uppercase and lowercase letters. See the example below.

I am
proud of my
color and race.

4.4.2 Guide Lines Devices

Special devices are widely used for spacing. Lettering triangles are made in a variety of forms and sizes. These triangles are provided with sets of holes in which the pencil point may be inserted; the guide lines are produced by moving the triangles with the point of the pencil along the T-square. The lettering triangles are also provided with a slot which has an inclined edge suitable for drawing inclined guide lines.

The Braddock-Rowe lettering triangle has a series of holes arranged to provide guidelines for lettering and dimensioning

figures, and for spacing section lines. The numbers at the bottom of the triangle indicate spacing of guide lines.

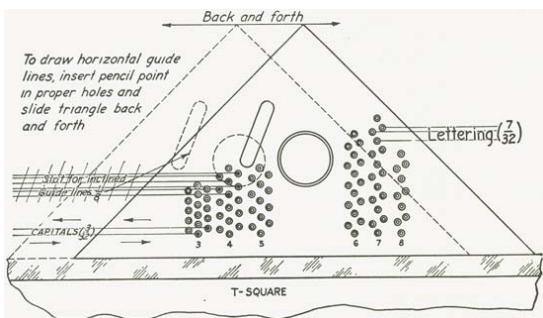


Fig. 4.12 Braddock-row lettering guide

The Ames Lettering Instrument is an ingenious transparent plastic device composed of a frame holding a disk with three columns of holes. The vertical distances between the holes may be adjusted quickly to the desired spacing for guide lines or section lines by simply turning the disk to one of the settings indicated at the bottom of the disk. These numbers indicate heights of letters. Thus, for different height of letters, different corresponding No. setting would be used. The center column of holes is used primarily to draw guide lines for numerals and fractions, the height of the whole number being two units and the height of the fraction four units. The No. 4 setting of the disk will provide guide lines for 8 units whole numbers, with fractions twice as high, or 4 units, as shown at (a). Since the spaces are equal, these holes can also be used to draw equally spaced guide lines for lettering or to

draw section lines. The Ames Lettering Guide is also available with metric graduations for desired metric spacing.

The two outer columns of holes are used to draw guide lines for capitals or lowercase letters, the column marked three-fifths being used where it is desired to make the lower portions of lowercase letters three-fifths the total height of the letters and the column marked two-thirds being used where the lower portion is to be two thirds the total height of the letters. In each case, for capitals, the middle hole of each set is not used. The two-thirds and three-fifths also indicate the spaces between lines of letters.

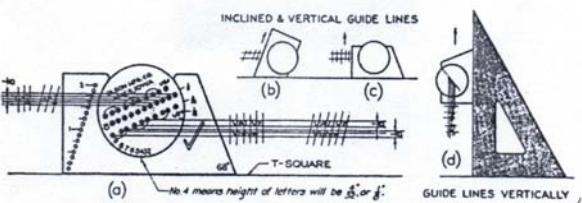


Fig. 4.13 Ames lettering guide

4.5 Uniformity, Stability and Composition of Lettering

4.5.1 Uniformity

In any style of lettering, uniformity is essential. Uniformity in height, proportion, inclination, strength of lines, spacing of letters, and spacing to look well, and some allowances must be made for errors in perception. Uniformity in height and inclination is promoted by the use of light

guide lines. Uniformity in strength of lines can be obtained only by the skilled use of properly selected pencils and pens, Fig. 4.14.

RELATIVELY

Relatively

Letters not uniform in style.

RELATIVELY
RELATIVELY

Letters not uniform in height.

RELATIVELY
RELATIVELY

Letters not uniformly vertical or inclined.

RELATIVELY
RELATIVELY

Letters not uniform in thickness of stroke.

RELATIVELY

NOW IS THE TIME FOR EVERY
GOOD MAN TO COME TO THE
AID OF HIS COUNTRY

Areas between letters not uniform.

Areas between words not uniform.

Fig. 4.14 Uniformity in lettering

4.5.2 Stability

- How do you think letters can be stable or create the feeling of stability when observed?

If the upper portions of certain letters and numerals are equal in width to the lower portions, the characters appear top-heavy. To correct this, the upper portions are reduced in size where possible, thereby producing the effect of stability and a more pleasing appearance, Fig. 4.15. If the central horizontal strokes of the letters B, E, F, and H are placed at mid height, they will appear to be below center. To overcome this optical

illusion, these strokes should be drawn slightly above the center.



Fig. 4.15 Stability of letters

4.5.3 Composition of Lettering

Once you have learned the proper shapes and strokes required to form each letter and numeral, you should concentrate on practicing the composition of words and sentences. Proper spacing of letters and words does more for the appearance of a block of lettering than the forms of the letters themselves. But this does not mean that you should discontinue further practice of correctly forming each letter.

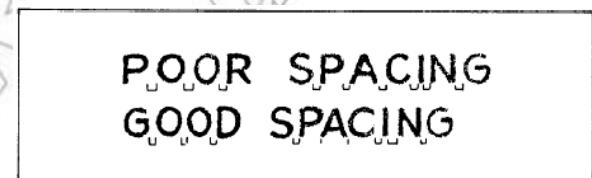


Fig. 4.16 Letter spacing

Letter Spacing

In straight-line lettering, determine the spacing between letters by eye after making the first letter and before making each succeeding letter. To give a word the appearance of having uniformly spaced letters, make the areas between the letters nearly equal, as shown in Fig. 4.16. The areas between adjacent letters in a word vary with respect to whether the letters have straight

sides (H, I, M, N) or slanted sides (A, V, W) and whether the letters are round (O, Q, C, G) or open (L, J). Adjacent straight-sided letters are drawn farther apart than are adjacent round letters. Adjacent slant-sided and open letters are drawn nearer together than are adjacent round letters. Where letters L and T, L and V, A and V, and other pairs of like shape come together in a word, the top of one may have to be drawn above the bottom of the other to avoid having the word appear as two or more words. In letter spacing, the six problems listed below are the hardest to solve. The first five problems are solved by moving the letters closer together; the sixth by moving the letters farther apart.

1. Round next to round. (Increasing area at top and bottom where letters curve away from each other, as in Fig. 4.17 (A)).
2. Round next to slant. (Increasing area at top or bottom where letters move away from each other, as in Fig. 4.17 (B)).
3. Vertical next to slant. (Increasing area at top or bottom where one letter slants away from the other, as in Fig. 4.17 (C)).
4. Slant next to slant. (Increasing area at top or bottom where letters slant in opposite directions, as in Fig. 4.17 (D)).
5. Round next to vertical. (Increasing area at top and bottom where round letter curves away, as in Fig. 4.17 (E)).
6. Vertical next to vertical. (Decreasing area at top and bottom where stems move together, as in Fig. 4.17 (F)).

A good way to evaluate the spacing of letters is to hold the lettering away from you and

squint your eyes, observing the gray tone throughout the lettering. If the tone appears spotty or varies too much, the letters are poorly spaced.

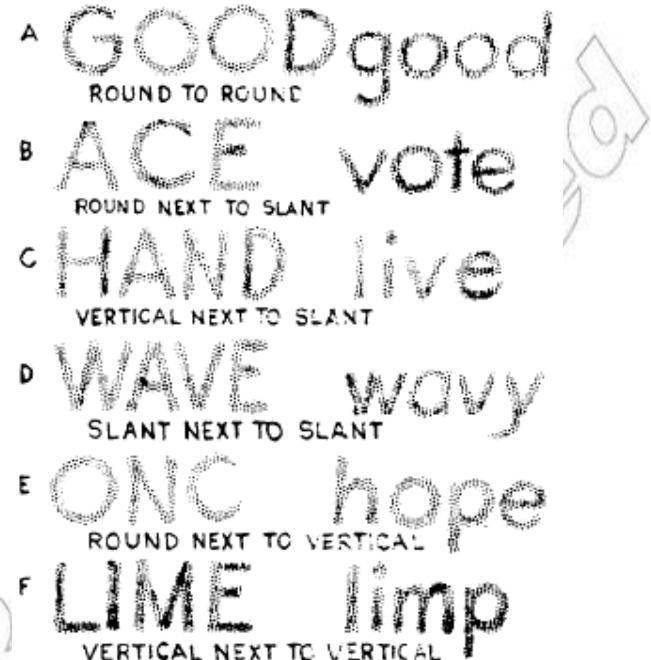


Fig. 4.17 Common spacing problems

Word Spacing

Proper spacing between words is an important factor in making them easy to read. Allow enough space between words and sentences to keep them from running together, but not so much as to cause words to be read one at a time. A good practice to follow is making spaces between words equal to the space that the letter O occupies as shown in Fig. 4.18. If you prefer, you can use the letter N or a correctly spaced letter I instead. Naturally, the design of the last letter of a word and of the first letter of the following word must be considered in

determining the amount of space you leave between words. You should leave a space equal to a capital O between two full-height straight-stemmed letters, such as H and E or D and B. Of course, if one or both of the letters are curved, the space should be appropriately reduced. If the two letters involved are lowercase, use the lowercase o to determine the width of the space. If one letter is full height and the other is lowercase height, such as the words bid now or on him, the space would be equal to half a capital O and half a lowercase o.

Line Spacing

In addition to the spacing between letters and words, the spacing between lines of lettering adds to the readability of the lettering. Again your eye and your artistic ability must be your guide. Except when you are trying for a special effect, you should have enough space between the lines to make it easy for the reader to see what he is reading.

The distance between lines may vary from $1/2$ to $1 \frac{1}{2}$ times the height of the letter, but for the sake of appearance, it should not be exactly the same as the letter height.

Spacing between words and lines

Fig. 4.18 Spacing between words and lines

As a general rule, two thirds of the letter height is a good distance between lines. This spacing allows room for descenders of lowercase letters and still maintains a clear space of one third of the letter height between the descenders and capital letters, or ascenders of lowercase letters of the following line. Fig. 4.18 shows proper word and line spacing.

4.6 LeRoy Lettering and Lettering Template/ Guide

4.6.1 LeRoy Lettering Instrument

The LeRoy lettering Instrument (Fig. 4.19) is perhaps the most successful lettering device in use. A pin follows grooved letters in a guide, and the inking point moves on the paper.



Fig. 4.19 Leroy lettering instrument

4.6.2 Lettering Template/Guide

Plastic stencils containing outlines of letters and numbers are available in variable sizes.

The lettering work is accomplished by placing the guide over the portion of the paper on which the lettering is to be done and tracing the outline with pencil/rapidographs.

UNIT SUMMARY

Lettering has always been considered equal in importance to drawing done in drafting. Before you can illustrate higher forms of drawing, you must first learn how to do simple but legible lettering.

The four basic letter styles are Gothic, Roman, Text and Italics. However we use commercial vertical gothic to draw letter.

Most often elements of quality lettering are stability and uniformity. When we say stability it is to mean the bottom of letters such as B is larger than the top, not top heavy and uniformity is to mean All "A's" are alike, All B's" are alike, etc.

Guidelines are thin lines which serve as guide to ensure uniform height and width of letters when lettering. The four parts of guidelines are the cap-line, waistline, baseline and drop-line.

Fractions are not too common except for certain materials such as wood. Five guidelines are required for mixed numbers. The numerator and denominator are $\frac{3}{4}$ the height of the whole number.

The letters in TOM Q. VAXY are exclusively six units wide meaning they are as wide as tall. The remaining letters are five units wide - somewhat narrow. Letter "W" is the widest in the alphabet (8 units wider than its height).

You have your choice between vertical and inclined letters, but are consistent. For inclined letter use a maximum angle of 68 degrees.

In lettering typically use the same pencil that was used to darken the drawing. Avoid too hard a lead which tends to make straight strokes difficult. A too hard makes for crooked strokes while one too soft embosses the paper.

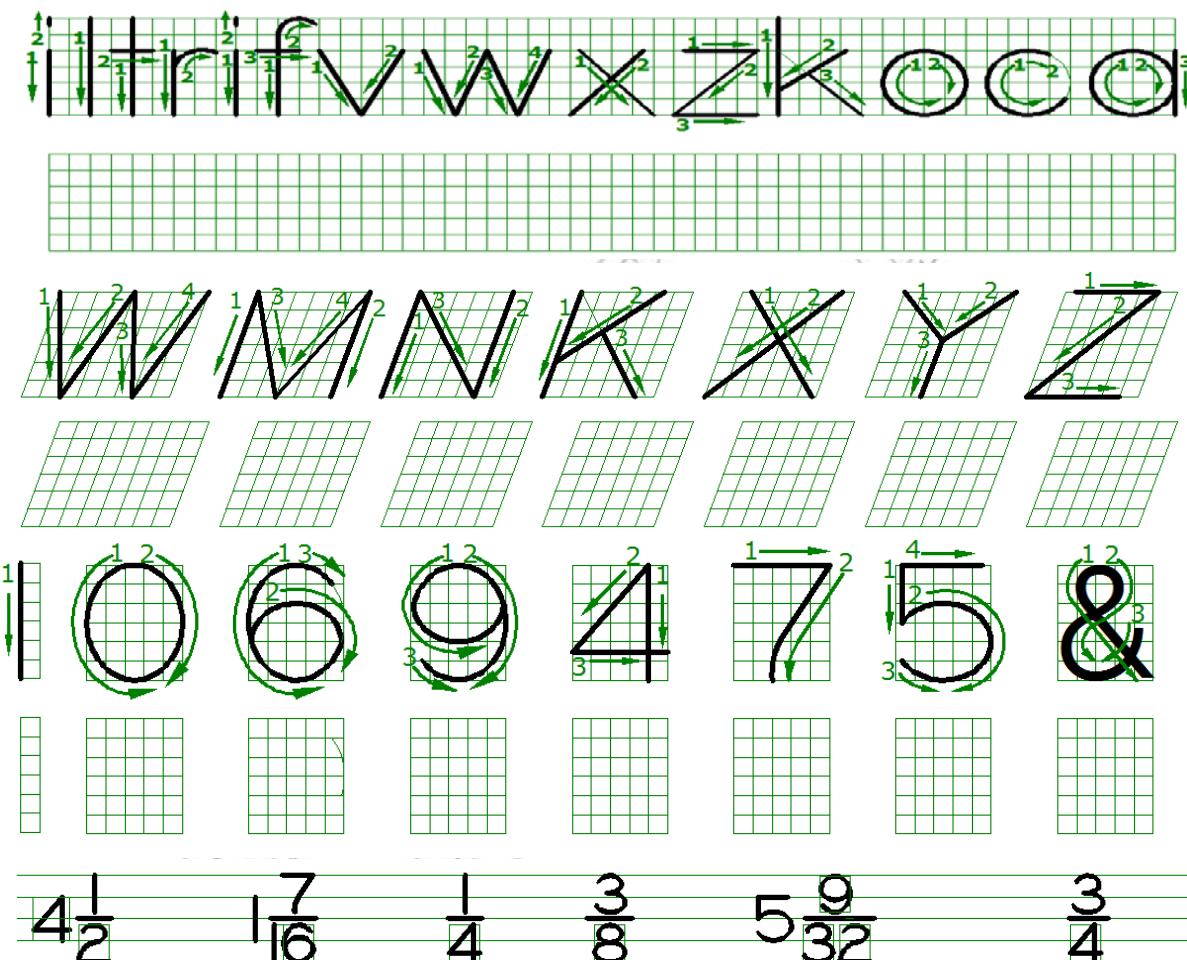
When you draw letters keep space between letters by eye. Pretend to place letter "0" between words.

Exercise I

1. What is the purpose of lettering in a drawing?
2. What are the different styles of letters to be used in drawing?
3. What do you understand from ascending and descending lowercase letters?
4. Mention few techniques of letter you know.
5. What does the term Stability refers to in lettering?
6. What are the four guidelines of lower case letters?
7. How do we maintain height and inclination uniformity of letters in a word?
8. What are instruments used for drawing guidelines?
9. What are the lettering devices?

Exercise II

Duplicate the letters in freehand by coping the space provided on your drawing paper.



Copy the format on your drawing paper and practice each letter and number until you can draw each one correctly at least ten times in a row.

A	A
B	B
C	C
D	D
E	E
F	F
G	G
H	H
I	I
J	J
K	K
L	L
M	M
N	N
O	O
P	P
Q	Q
R	R
S	S
T	T
U	U
V	V
W	W
X	X
Y	Y
Z	Z
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9

NAME: _____

LETTERING PRACTICE

Letter each sentence on your drawing paper paying special attention to the spacing of letters in words and between the words in sentences.

LETTERING IS A SKILL THAT REQUIRES EXTRA EFFORT

ANYONE CAN LEARN TO DO A GOOD JOB IF THEY PAY

THE PRICE AND WATCH OUT FOR FUZZY LINES AND STAY

BETWEEN THE GUIDELINES DRAWING THE SHAPES

PRECISE AND EXACT WITH PERFECT NUMBERS 345-9876

IT WILL NOT MATTER HOW GOOD THE DRAWING IS IF

THE LETTERS AND NUMBERS ARE NOT DRAWN PROPER

LETTER SPACING SHOULD BE APPROX. EQUALLY SPACED QUICK AND SIMPLE

NUMBERS USED IN DIMENSIONS AND NOTES SHOULD BE DRAWN CORRECTLY

NOTES SHOULD BE ABOUT 3 INCHES WIDE AND LOCATED ON THE RIGHT SIDE OF THE

DRAWING SHEET SO THAT THEY ARE EASY TO READ AND ARE NOTICED EASILY

TOLERANCES SUCH AS .5673 – .5894 AND NOTES LIKE FILLETS AND ROUNDS R.94623

5892 48.76 60.71 12" = 1' - 0" 76' - 9" 54.763 6258 9731 7245 16' - 7"

POOR LETTERING CAN RENDER A DRAWING USELESS AND INDICATE A LACK OF

KNOWLEDGE AND UNDER-DEVELOPED TECHNICAL DRAWING SKILLS

NAME: _____

LETTERING PRACTICE

On your drawing paper, prepare the notes on the left side of the page and use the ames lettering guide to add guide lines to the right side of the page. Transfer the notes to the left side of the page to right side of the page

DRILL AND REAM FOR NO. 3 TAPER PIN
AT ASSEMBLY WITH MACHINED SHAFT

PROTECT THREADS DURING HEAT
TREATMENT AND HARDENING

Ø .304 - 309 HOLES SPACED AS SHOWN
AND LOCATED WITHIN R.008 OF TRUE
POSITION AT RFS

PART B & D CONCENTRIC WITHIN 0.002
AT FULL INDICATOR READING

ALL FILLETS AND ROUNDS R .625
UNLESS OTHERWISE SPECIFIED

FINISH ALL OVER (FAO)

BREAK SHARP EDGES TO R 0.4

96 DP DIAMOND KNURL - 30° RAISED

#808 AMER STD WOODRUFF KEYSEAT

G33106 ALLOY STEEL - BRINELL 340 - 380

ALL DRAFT ANGLES 38° UNLESS
OTHERWISE SPECIFIED

$\frac{5}{32}$ DRILL $\frac{7}{8}$ DEEP 4 HOLES

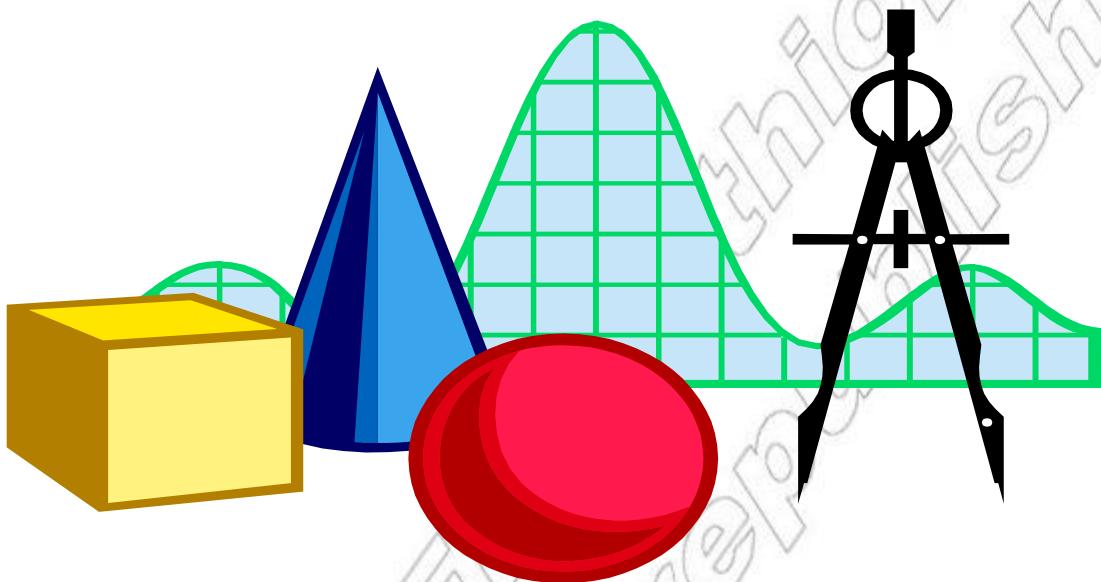
NECK $\frac{3}{4}$ WIDE $\frac{5}{16}$ DEEP 4 HOLES

NAME: _____

LETTERING PRACTICE ..

UNIT 5

GEOMETRIC CONSTRUCTION



Learning Competencies:

Upon completion of this unit you should be able to:

- ✓ Identify different types of plane geometry and their basic elements;
- ✓ Construct different types of geometrical figures;
- ✓ Apply methods and rules of construction for different types of geometrical shapes.

5.1 Introduction

- When we say geometric construction it implies that there are things to be constructed, what do you think are the elements to be constructed? List them.

The geometric construction forms the basis for all technical drawings. The purpose of the geometric construction is to accurately develop plane geometric shapes ranging from squares, triangles, and three-dimensional cylinders to complex irregular curves and ellipses. These constructions are normally produced without the aid of a scale, but rather with simple drafting tools.

Engineers, designers, and drafters regularly perform the task of producing geometric construction in their work, applying the principles of plane geometry. The process involved in the production of geometric constructions requires a basic understanding of plane geometry. Geometric construction skills can be acquired and demand precision and the correct use of drafting instruments. In developing geometric constructions it is important that drafting tools be in good condition. 4H to 6H leads are normally used for constructions that produce very lightweight lines. These lines need not necessarily be erased when the construction is completed. A small error or inaccuracy in the solving of a geometric problem could result in a serious error in the final construction.

There are a number of basic geometric constructions with which the student should be familiar. At the beginning the student should follow the basic sequence in each illustration that follows the learner how to develop the various geometric forms.

5.2 Construction of Point, Line and Angle

- Define in your own words:

- Point - Line - Angle

- Try to illustrate them with sketch.

5.2.1 Points

The construction of geometric figures begins from representation of points on drawings. A *point* represents an exact location in space which has neither width, height nor depth. Points are commonly represented by intersection of two lines, a short cross bar on a line or by small cross (Fig.5.1).

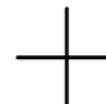


Fig. 5.1 Representation of points

5.2.2 Lines

A line can be defined as:

- A path between two points
- A moving point
- Geometric figure that has only one dimension: length.

Line may be straight, curved, or a combination but the shortest distance between two points is called straight line and it is commonly referred simply as a "line".

If the length of line is indefinite or without fixed endpoint, its length is any distance you select. If the line has fixed end points mark them with small mechanically drawn cross hairs.

A straight line drawn from left to right relative to a horizontal reference line is called a *horizontal line* and when drawn from top to bottom perpendicular to the horizontal is

called *vertical line*. If two lines are equidistant throughout their length and will never meet or cross are called *parallel lines*. The symbol for parallel line is \parallel . Two or more lines crossing each other are called *intersecting lines*. The exact location where two lines intersect is called *point of intersection*. Lines that intersect or cross and form a 90° or right angle are called *perpendicular lines*. The symbol for perpendicularity is \perp . Fig. 5.2 shows the types of lines mentioned above.

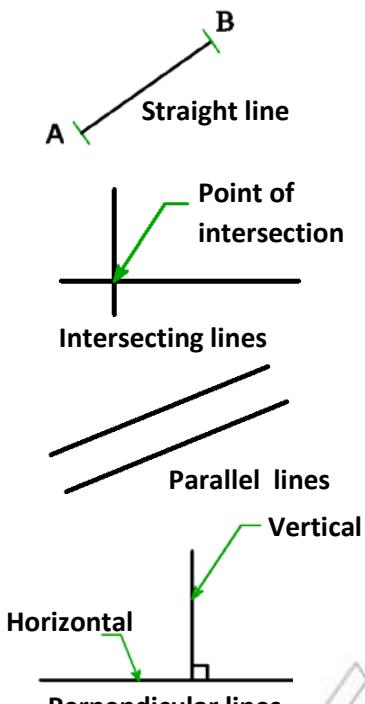


Fig. 5.2 Types of lines

Drawing Parallel Lines

To draw a line parallel to a given line through a given distance

Method 1 Fig. 5.3

1. Draw a line AB at any angle.

2. Locate point E near A and point F near B on line AB.
3. E and F as centers and radius CD, draw two arcs.
4. Draw a line (GH) tangent to the arcs using any straight edge.

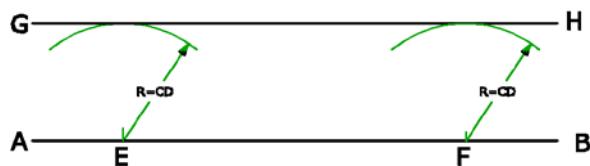


Fig. 5.3 Drawing parallel lines

Drawing Parallel Lines

Method 2 Fig. 5.4 (preferred method)

1. Draw line AB at any angle.
2. Open your compass to radius = CD.
3. With any point E on AB as a center, and radius = CD, strike an arc.
4. Align your set square with line AB with the T-square or another set square as a support.
5. Slide the set square until it is tangent to the arc.
6. Draw line GH using the edge of your set square.

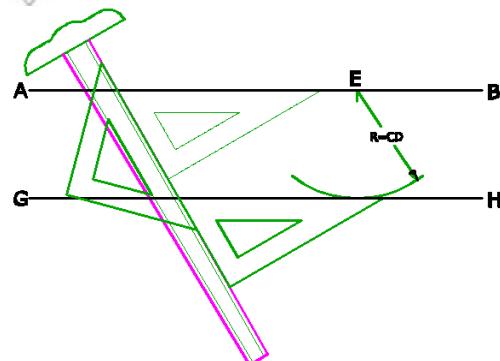
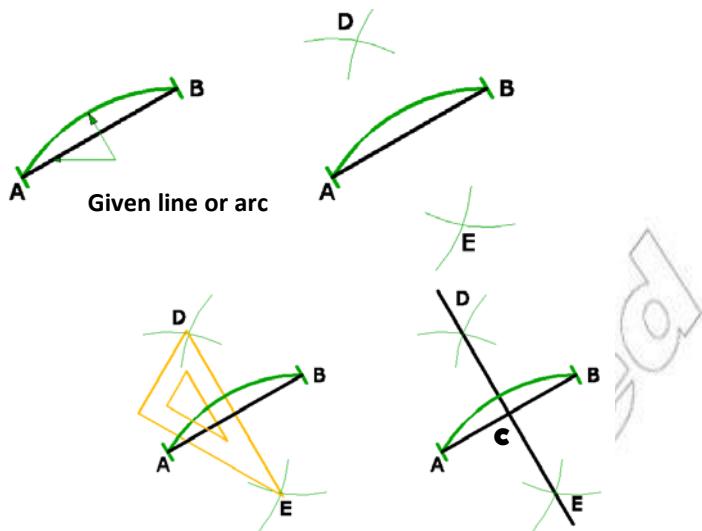


Fig. 5.4 Drawing parallel lines

Checkpoint 5.1

Draw a 120mm long line AB at an angle of 35° from the horizontal. Then, draw a line parallel to AB which is 25 mm away from AB.

**Drawing Perpendicular Lines****Constructing perpendicular to a line through a point on the line (Fig. 5.5)**

1. Draw line AB and locate point P on it.
2. With arbitrary radius r and P as a center, strike arcs to intersect AB at C and D.
3. With radius greater than $\frac{1}{2} CD$, and centers at C and D, draw arcs to intersect at E. Use straight edge to draw line EP. $EP \perp AB$.

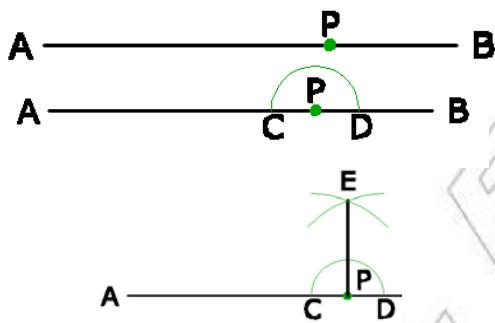


Fig. 5.5 Drawing perpendicular line through a point on the line

Constructing a perpendicular bisector of a given line or arc (Fig. 5.6)

1. Draw line or arc AB.
2. Adjust your compass to a radius greater than $\frac{1}{2} AB$.
3. With centers at A and B, draw intersecting arcs at D and E.
4. Draw a line DE. $DE \perp AB$ and $AC=CB$.

Constructing a perpendicular to a line from a point outside the line**Method 1 (Fig. 5.7)**

1. Draw line AB and locate point P anywhere but not on AB.
2. P as a center and with arbitrary radius R, strike arcs on AB to get points C and D on the left and right side of P.
3. Adjusting the compass radius r to greater than $\frac{1}{2} CD$, and C and D as a center, strike two arcs intersecting at E.
4. Use straight edge to draw line PE $\perp AB$.

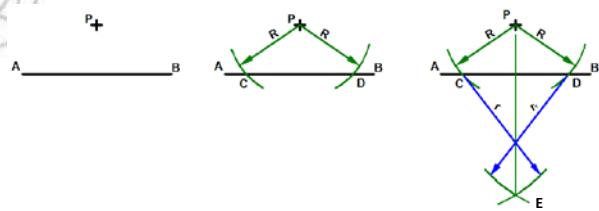


Fig. 5.7 Drawing perpendicular line to a given line through a point not on the line

Method 2 (Fig. 5.8)

1. Draw line AB at any angle and locate point P.
2. Draw a convenient inclined line from P to intersect AB at point C.
3. Locate the midpoint O off line PC as described in previous discussion.
4. With O as center and radius OP, draw an arc that intersect line AB at E.
5. Connect P and E. $PE \perp AB$.

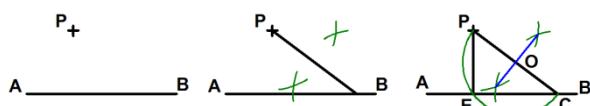


Fig. 5.8 Drawing perpendicular to a line through a point not on the line

Checkpoint 5.2

1. Draw line AB 80mm long. Draw perpendicular line to AB at a point 35mm from A on AB.
2. Draw an arc having a radius of 35 mm. Draw the perpendicular bisector of the arc.

Trisecting a Straight Line

Using 30-60° set square. (Fig. 5.9)

1. Draw a straight line AB.
2. Draw 30° lines from points A and B.
3. Extend them to intersect at C.
4. Draw 60° lines with the horizontal from point C in both direction and extend them to intersect AB at D and E. Check that $AD=DE=EB$.

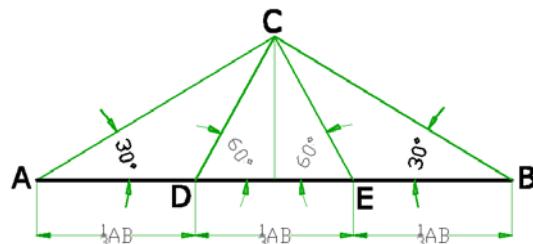


Fig. 5.9 Trisecting a straight line

Dividing Lines into n Number of Congruent Line Segments (Equal parts)

In this example, n=5. (Fig. 5.10)

1. Draw a line segment AB.
2. Either from A or B, draw a line at any convenient acute angle to AB. Here from B and label its one end as c.
3. From the intersection point of the lines (B) with compass or scale, step off as many equal divisions as needed, in this case five equal parts.
4. Draw a line from the last (fifth) interval to A.
5. Through each of the other points on line BC, draw lines parallel to line A5 intersecting AB. Now line AB is divided into five equal parts. Use a triangle and T-square to draw the parallel lines.

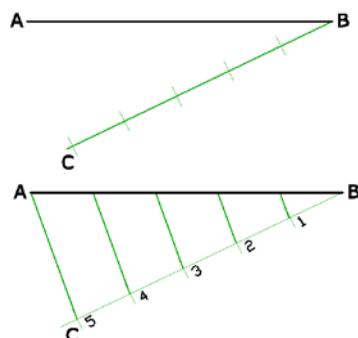


Fig. 5.10 Dividing a line into any number of equal parts

5.2.3 Angles

- Do you have any idea on classification of angles? If you do, on what specification are angles classified.
- What do you think is the relation of verticality and horizontality in terms of angles?

Angles are formed by the intersection of two lines. The point of intersection is called the *vertex*. Angles are measured in degrees ($^{\circ}$), minutes ('), and seconds (''). There are 360° in a full circle, 60 minutes in a degree, and 60 seconds in a minute. $26^{\circ} 36''$ is read as 26 degrees, 43 minutes, 36 seconds. The concept of dividing angle by minutes and seconds is based on the fact that, the earth completes its rotation (360°) in 24 hours.

A straight angle is an angle of 180° and appears as a straight line. Obtuse angles are angles less than 180° but more than 90° . An angle of 90° is referred to as a right angle because of the relationship between the two intersecting lines. Acute angles are angles less than 90° . When two angles are combined to total 90° , they are referred to as complimentary angles. Supplementary angles form when two angles combine to total 180° . You may draw angles at any degree of angularity using triangles or a protractor. Fig. 5.11 illustrates the different degrees of standard angularity.

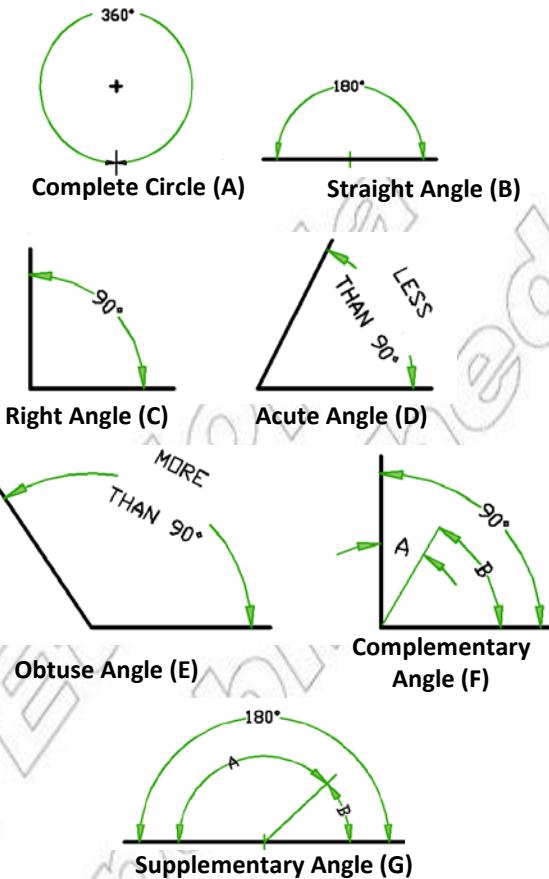


Fig. 5.11 Types of angles

Drawing Angles

Tangent Method (Fig. 5.12)

Both the tangent and sine methods are based on mathematical solutions and require a basic knowledge of trigonometry. To construct an angle assume a convenient value for x. (preferably multiple of 10).

1. Draw line AB whose length is x at any convenient angle.
2. Draw a line perpendicular to AB at A.
3. Find the tangent of angle θ in a table of natural tangents.
4. Calculate $y = x \tan \theta = R$.

- With A as a center and radius $R=y$, draw an arc to intersect the perpendicular at C.
- Connect B to C. Angle ABC is the required angle.

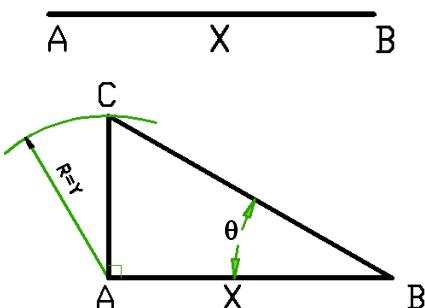


Fig. 5.12 Tangent method

The Sine Method (Fig. 5.13)

- Draw line AB whose length is x.
- Find the sine of angle θ in a table of natural sine.
- Calculate $y=R=x \sin \theta$.
- Strike an arc with radius R and center B.
- Draw a tangent line AC through A to the arc which is the other side of the angle.

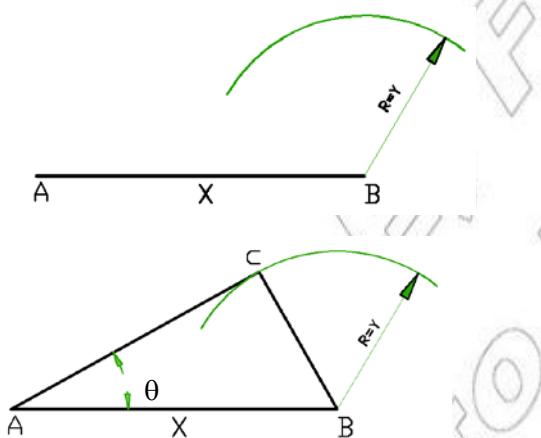


Fig. 5.13 Sine method

The Chord Method (Fig. 5.14)

- Draw line AB whose length is x.
- With center at B and radius $R=x$, draw an arc.
- Find the chord length C for a given angle θ :

$$C=2 \times AB \times (\sin(1/2 \times \theta))$$
- With center A and radius $r=C$, draw an arc to intersect the arc drawn in Step 2 at D.
- Connect D to B. Angle ABD = θ .

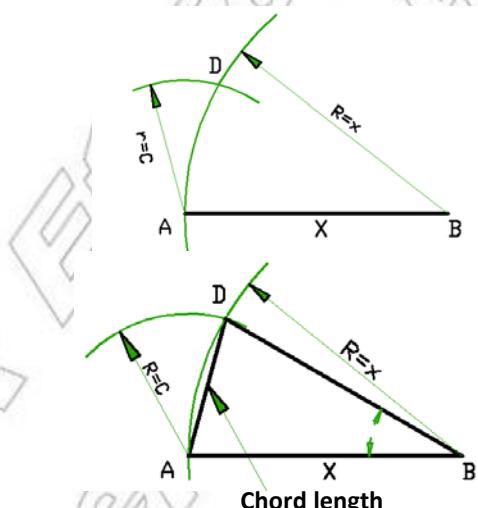


Fig. 5.14 The chord method

Dividing Angles

To bisect an angle means to divide it into half.

To trisect an angle means to divide it into three equal parts.

Bisecting an Angle (Fig. 5.15)

- Draw the angle CAB.
- Set the compass to any radius R.

5 Geometric construction

3. Mark off two points E and F from A equal to the radius R on AC and AB respectively.
4. With centers at E and F, strike intersecting arcs of equal radius r at point D.
5. Draw line AD. This line bisects the angle CAB.

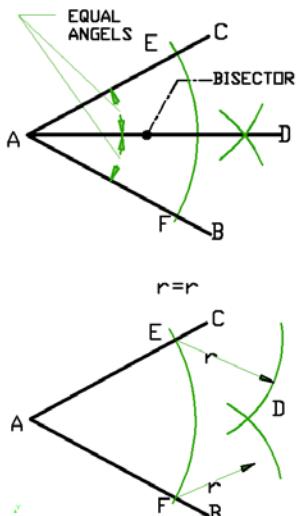
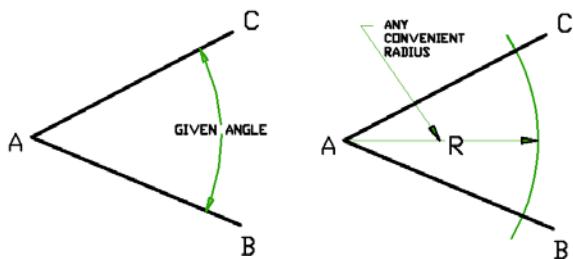


Fig. 5.15 Bisecting an angle

Dividing angles into any number of equal parts (Fig. 5.16)

1. Draw an angle AOB.
2. With O as center, draw an arc with any radius R to intersect line OA at C and line OB and D.

3. Divide the arc CD to the required number of parts (say 5) by trial and error using your divider or compass.
4. Connect the vertex O and the division points on the arc to get the angle divided.

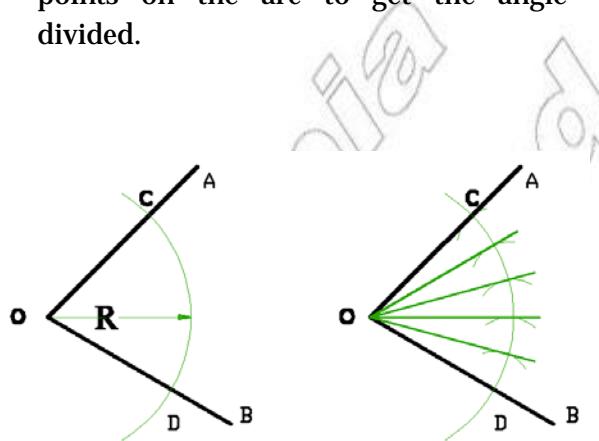


Fig. 5.16 Dividing an angle

Constructing an Angle Congruent to a Given Angle (Copying an Angle)

1. Draw angle CAB at any angle.
2. Draw line A'B' at any desired direction.
3. With A as center and any convenient radius R, draw an arc that intersects the given angle at E and F.
4. With the same radius R=R' and using A' as center draw an arc that intersects line A'B' at E'.
5. Adjust your compass to EF on the given angle and draw an arc with E' as center to intersect the previous arc at F'.
6. Connect point A' to F' and check that $CAB = C'A'B'$. Note that $AF = AE = A'F' = A'E'$.

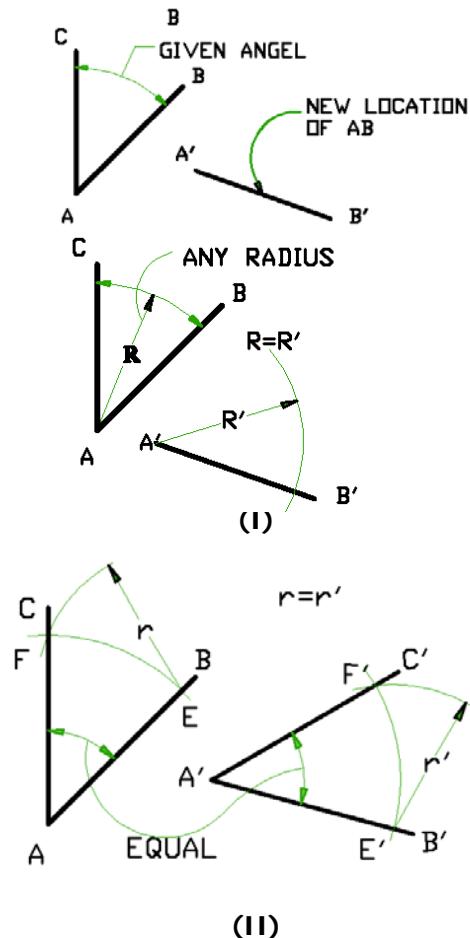


Fig. 5.17 Copying an angle

Checkpoint 5.3

1. Draw two lines 75mm long and making an angle of 65° with each other, using (a) the tangent method (b) the sine method (c) the chord method.
2. Bisect the angle drawn under 1 (a) and transfer one half in a new position.
3. Divide the angle drawn in exercise 1 (b) into eight equal angles.

5.3 Polygons

1. What do you understand from the word polygon?
2. Can you give examples of polygons?

A polygon is a plane, having boundary defined by three or more sides that are all straight. Polygons can be mainly classified as regular and irregular.

Irregular polygons are planes which either their sides or angles are of different sizes.

Regular polygons are planes which their sides are kept in a regular manner, such as equal length, equal angles and so on (including equilateral triangles and squares) and can be constructed by inscribing in or circumscribing around a circle, a technique covered later in this chapter.

The following list shows how the names of the regular polygon change with the number of sides:

Sides	Name
3	Triangle
4	Square
5	Pentagon
6	Hexagon
7	Heptagon
8	Octagon
9	Nonagon
10	Decagon
12	Dodecagon

The figure below illustrates some examples on regular and irregular polygons.

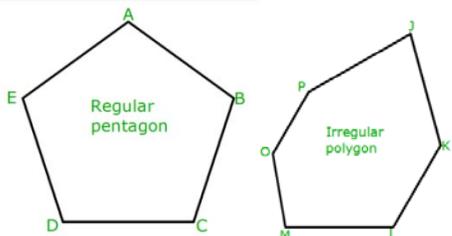


Fig. 5.18 Regular and irregular polygons

Activity 5.1

- What do you think is the difference between regular and irregular polygon?

5.3.1 Triangles

A Polygon having three sides is called a triangle. The sides of a triangle make three interior angles and the sum of these angles is always 180° .

When all sides and all interior angles (60°) are equal, the triangle is referred to as an equilateral triangle. When two sides and two angles are equal, the triangle is an isosceles triangle. A scalene triangle does not have any equal sides or angles. A right triangle has one angle equal to 90° and the long side opposing that angle is called the hypotenuse.

A triangle is classified either by its side or with its angle. (Fig.5.19 and 5.20)

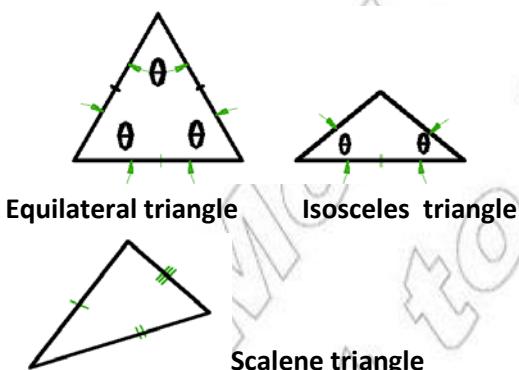


Fig. 5.19 Classified based on sides

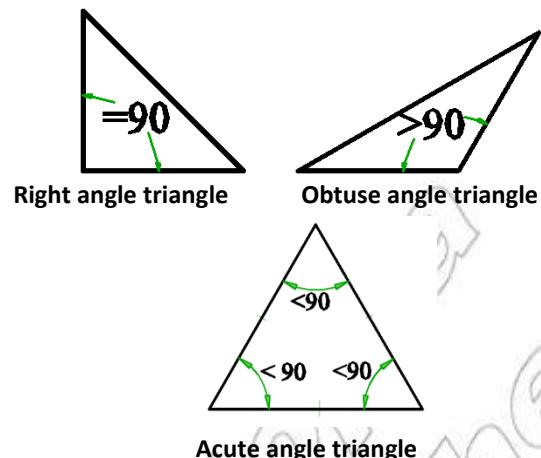


Fig. 5.20 Classified based on angles

Construction Methods: The construction of a triangle can be done in several methods. Some of the methods are described as follows.

Constructing any triangles given three sides AB , AC , and BC . (Fig. 5.19)

1. Draw line AB .
2. With center at A and radius AC , draw an arc.
3. With center at B and radius BC , draw another arc that cut the previous arc at C .
4. Connect point C to A and B .

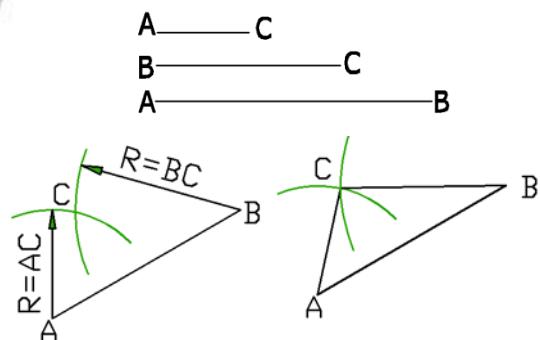


Fig. 5.21 Constructing triangle given three sides

Constructing a triangle given two sides and an included angle (Fig. 5.22)

Let the given angle CAB be θ , sides given be AB and AC.

1. Draw the base line AB.
2. Draw line AD at an angle of θ from AB, using any proper instrument.
3. A as a center and AC as a radius, strike an arc on AD to get point C.
4. Connect C to B. ABC is the required triangle.

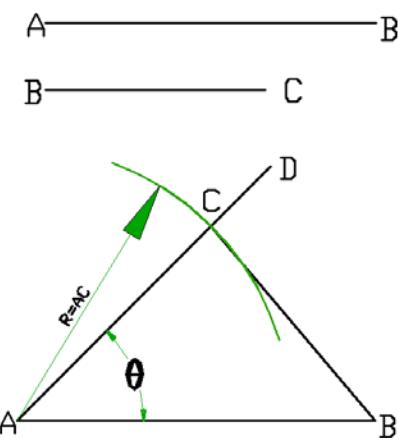


Fig. 5.22 Constructing triangle given two sides and included angle

Constructing a triangle given one side and two included angles (Fig. 5.23)

Let the given side be AB and the angles be θ and α .

1. Draw the base line AB.
2. Draw angle θ using set squares, or protractor from point A.
3. Draw angle α using set squares or protractor from point B.
4. Extend lines drawn at Steps 2 and 3 to intersect each other at point C.

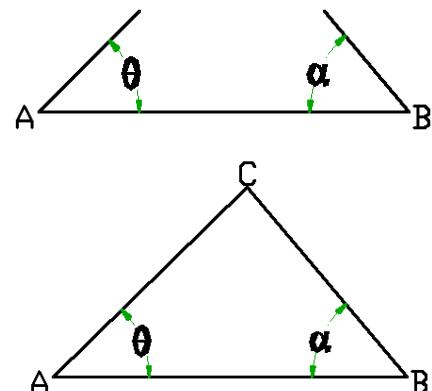


Fig. 5.23 Constructing a triangle given one side and two included angles

Checkpoint 5.4

1. Draw a triangle whose sides are 76mm, 85mm, and 65mm.
2. Draw a triangle whose two sides are 45 mm and 60mm and included angle is 75° .
3. Draw a triangle whose side is 60mm and included angles are 60° and 75° .

5.3.2 Quadrilaterals

1. What do you think the word quadrilateral stands for?
2. Can you give examples of quadrilaterals based on your experience of mathematics earlier classes?

A quadrilateral is a four-sided polygon. The sum of the interior angles of a quadrilateral is 360° .

Quadrilaterals may be subdivided into:

1. **Parallelogram** is a quadrilateral whose opposite sides are parallel, e.g. square, rectangle, and rhombus.
2. **Square** is a quadrilateral with all the four sides and all the angles are equal.
3. **Rectangle** is a quadrilateral, with all four angles are right angles and opposite sides are equal and parallel.
4. **Rhombus** is a quadrilateral, with all four sides have the same length, and equal opposite angles.
5. **Trapezium** is a quadrilateral having two parallel sides.

Some of the construction methods for quadrilaterals are discussed below.

Constructing a square given length of side AB (Fig. 5.24)

1. Draw a horizontal line AB.
2. With a T-square and a 45° triangle draw diagonals from A and B at 45° .
3. Draw perpendicular from A and B intersecting the diagonals at C and D.
4. Connect CD the points of intersection.

Note: The same method can be used to draw a rectangle.

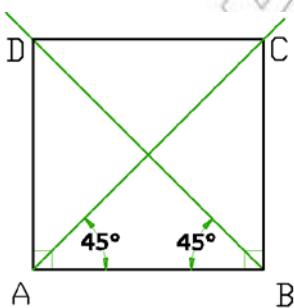


Fig. 5.24 Constructing a square given length

Constructing a square given length of diagonal AB (Fig. 5.25)

1. Draw horizontal line AB.
2. Locate O at the midpoint of AB.
3. Draw CD through O, perpendicular to AB and slightly longer than AB.
4. With T-square and a 45° triangle, draw AF and BE at 45° to AB intersecting CD at E and F.
5. Connect AE and FB.

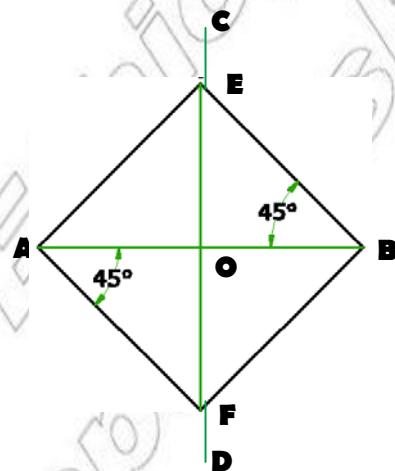


Fig. 5.25 Constructing a square given length of diagonals

Constructing a rhombus given side AB and an included angle θ . (Fig. 5.26)

1. Draw a horizontal line AB.
 2. Draw lines from points A and B at θ .
 3. Lay off distances AD and BC equal to AB.
 4. Connect C and D.
- ABCD is the required rhombus.

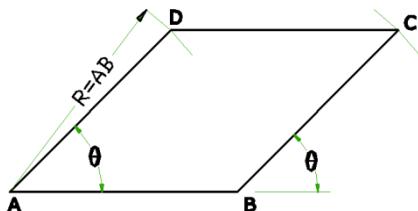


Fig. 5.26 Constructing a rhombus given side and included angle

Constructing a trapezium given sides and two interior angles (Fig. 5.27)

Let the sides of the trapezium be AC, AB and BD and the two interior angles be θ and α each.

1. Draw line AB at any convenient angle.
2. Draw two lines through, A and B at α and θ from line AB respectively.
3. Using B as center and radius BD, draw an arc to locate D.
4. Using A as center and radius AC, strike an arc to locate point C.
5. Connect C to D. ABCD is the required trapezium.

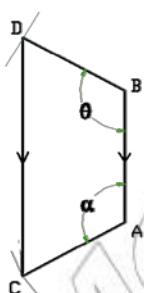


Fig. 5.27 Constructing a trapezium given sides and two interior angles

Checkpoint 5.5

1. Draw a square whose sides are 55 mm long by all methods discussed.
2. Draw a rhombus whose sides are 40mm and an interior angle is 50° .
3. Draw a trapezium ABCD such that $AB = 60\text{mm}$, $BC = 48\text{mm}$, $AD = 50\text{mm}$, $CBA=105^\circ$, and $BAD =120^\circ$.

5.3.3 Construction of Regular Polygons

Most of the construction methods for regular polygons are simple and memorable. This is because they can be inscribed in or circumscribed around a circle. Under this section, first we will discuss special construction methods for particular regular polygons and then common construction methods for any regular polygons.

Constructing a regular pentagon in a given circumscribing circle (Fig. 5.28)

1. Draw horizontal diameter AB and vertical diameter CD intersecting at O.
2. Draw the circle with radius equal to half of AB.
3. Construct the midpoint of OB and mark as E.

- With E as a center and radius equal to CE, strike the arc CF to intersect AB at F.
- With C as a center and CF as a radius, strike the arc FG to intersect the circle at G.

Note: A line from G to C is one side of the pentagon.

- Set a compass to GC and lay off this interval from C around the circle.
- Connect the points of intersection

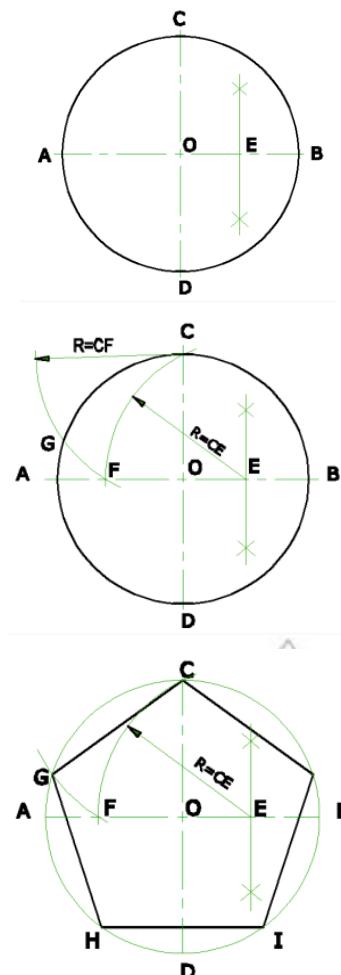


Fig. 5.28 Constructing a regular pentagon in a given circumscribing circle

Constructing a regular hexagon in a given circumscribing circle (Fig. 5.29)

- Draw diameters AB and CD intersecting at O.
- OB as radius, draw the circle.
- Starting from C and with radius OB, lay off points around the circle.
- Connect the points.

Note: The diameter of the circumscribing circle is equal to the long diameter (across corner) of the hexagon. The radius of the circumscribing circle (which is equal to one half the long diameter of the hexagon) is equal to the length of side of the regular hexagon.

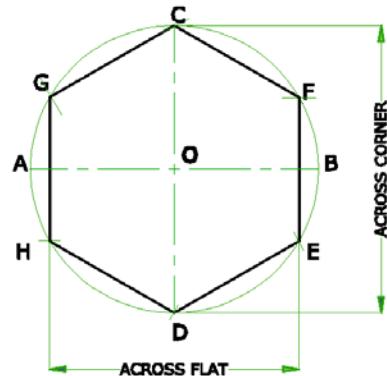


Fig. 5.29 Constructing a regular hexagon in a given circumscribing circle

Constructing a regular hexagon, given the distance across corners (Fig. 5.30)

- Draw a circle with AB as a diameter.
- With A and B as centers and radius $\frac{1}{2}$ AB, draw arcs to intersect the circle at C, D, E and F.

3. Connect the A, C, E, B, F and D to complete the hexagon.

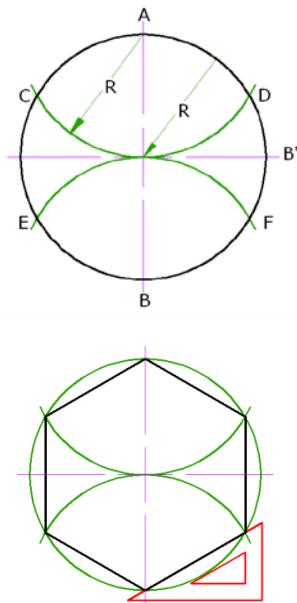


Fig. 5.30 Constructing a regular hexagon, given the distance across corners

Constructing a regular heptagon given the circumscribing circle

(Fig. 5.31)

1. Draw vertical line AB whose length is equal to the diameter of the given circle.
2. Locate the midpoint O of line AB and draw the given circle.
3. With B as center and OB as radius, draw an arc to intersect the given circle at C and D.
4. Connect C to D to intersect AB at M.
5. With radius MC=MD, strike arcs around the circle to locate points E, F, G, H, I and J starting from A.

6. Connect points A, E, F, G, H, I, and J to complete the regular heptagon.

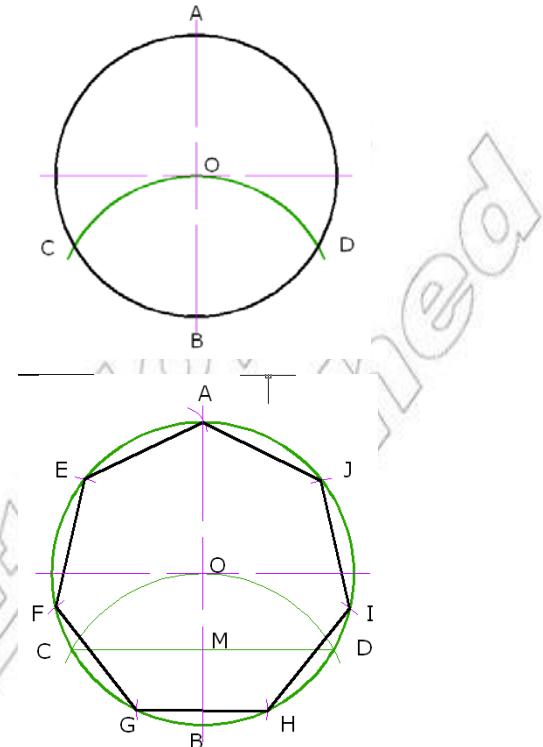


Fig. 5.31 Constructing a regular heptagon given the circumscribing circle

Checkpoint 5.6

1. Draw a regular pentagon whose circumscribed circle is 60mm diameter.
2. Inscribe a regular hexagon in a circle whose diameter is 60mm.
3. Draw a regular hexagon whose across corner is 90mm.
4. Inscribe a regular heptagon in a circle whose radius is 37mm.

Constructing any regular polygon with a given length of side (approximate method) (Fig. 5.32)

1. Draw the given side AB.
2. With radius equal to AB and centers at A and B draw arcs that intersect at point 6.
3. Draw a perpendicular to line AB through point 6 and extend it upward beyond point 6.
4. Draw 45° line from either A or B to intersect the perpendicular line at point 4.
5. Bisect the distance 4-6 to locate point 5.
6. Step up (lay off) distance equal to 5-6 beyond point 6 to get points 7, 8, 9....
7. With center at 8 and radius 8-A or 8-B, draw a circle that will inscribe the polygon.
8. Adjust your compass to AB and divide the circle into eight equal parts and connect the division points to complete the construction of the regular polygon (in this case octagon).

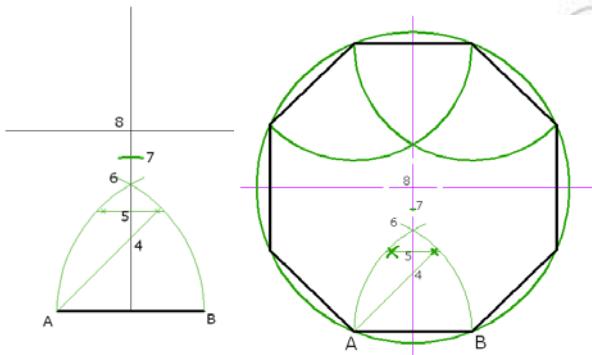


Fig. 5.32 Constructing a regular polygon with a given length of side

Note: If the circle is drawn using 4 as center and radius 4-A, you can construct a square whose side are equal to AB. If the circle is drawn using 6 as center and radius 6-A, you can construct a regular hexagon, and so on.

5.4 Circles and Tangents

A **circle** is a closed curve created by a set of points in a plane that are the same distance from a fixed point called the *center*. These set of points from the perimeter of the circle. Part of a circle is called an *arc*. Definitions of terms related to circles are given below.

The distance from the center point to any point along the circle edge is called a *radius* (RAD or R).

The distance from one side of the circle through the center point to the opposing side of the circle is the circle *diameter* (DIA).

Half of the distance around a circle is called a *semicircle*.

Circumference refers to the total distance around the circle. Calculate the circumference of a circle by multiplying the diameter of the circle by 3.1416 or π (pronounced pi).

A *chord* is a straight line joining two points on a curve.

A *segment* is the section of the curve cut off by the line or chord.

Quadrants result from the intersection of two radii at 90° including the portion of the circle between the radii.

Sectors are the part of the circle bound by two radii at other than right angles including the bound portion of the circle.

Angles are formed by the intersection of radii but do not include the bound portion of the circle.

An *arc* is a segment of the curved portion of the circle bound by the intersection of two radii but does not include the radii.

A straight line that intersects and passes through two points on the circle is called a *secant*.

Straight lines that touch but do not intersect at one point on a circle are said to be *tangent*.

Multiple circles sharing a common center point are called *concentric circles*.

Multiple circles that do not share a common center point are referred to as *eccentric circles*. Fig. 5.33 illustrates circle terminology.

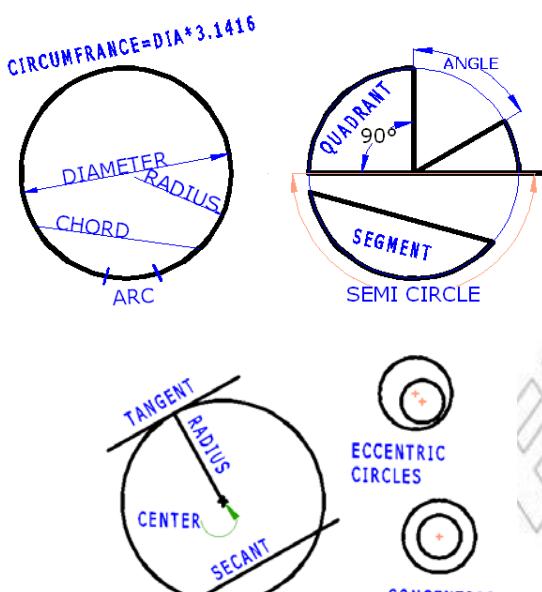


Fig. 5.33 Circle terminology

Activity 5.2

- What do you understand from the word tangent? And what relation circle and tangent have?

To draw a circle through three non-collinear points A, B and C (Fig. 5.34)

1. Mark any three points and connect them.
2. Draw the perpendicular bisectors of both AB and BC to intersect at O.
3. With O as centers and radius OA, draw the required circle.

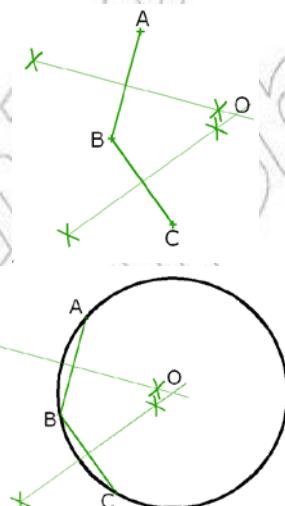


Fig. 5.34 Drawing a circle through three points

Constructing a line tangent to a circle at given point on the circle (Fig. 5.35)

1. Draw the given circle and locate point P on it.
2. Align one side of your set square to pass through P and the center of the circle keeping the T-square at the base.
3. Slide the aligned set square until the other side passes through point P and draw the required tangent line.

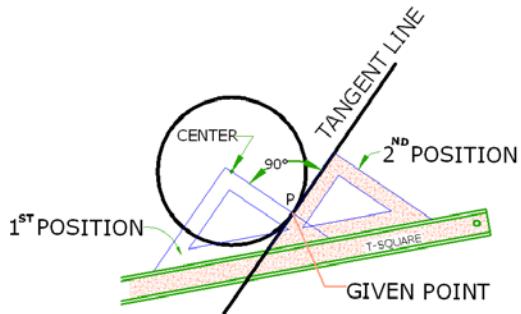


Fig. 5.35 Constructing a line tangent to a circle at given point on the circle

Constructing a line tangent to a circle through an external point (Fig. 5.36)

1. Draw a circle and locate given point P.
2. Construct the center O of the circle.
3. Connect OP.
4. Locate point M by constructing the midpoint of OP.
5. With M as a center and radius OM, draw an arc to intersect the circle at point of tangency T₁ and T₂.
6. Connect T₁ to P and T₂ to P.

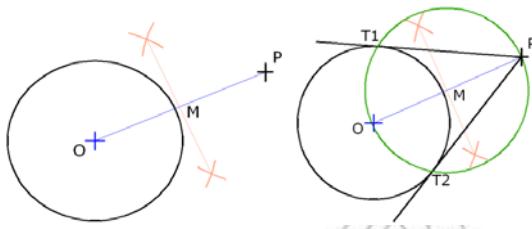


Fig. 5.36 Constructing a line tangent to a circle through an external point

Constructing tangent line to two circles of different size (Fig. 5.37)

Suppose the radii of the two circles are r and R, where R>r.

1. Draw two given circles with center points O and O'.

2. Connect the center point of the circles with line OO'.
3. Construct midpoint C of line OO'.
4. With C as a center and radius OC, draw a semicircle through OO'.
5. With O' as a center and radii R-r and R+r, strike arcs that intersect the semicircle on OO' at D and E respectively.
6. Draw O'D to intersect circle O' at F and similarly draw O'E to intersect circle O' at G.
7. Through center O, draw OH parallel to O'F and OK parallel to O'G.

Note: Lines FH and GK are tangent to both circles. GK intersects the line OO'.

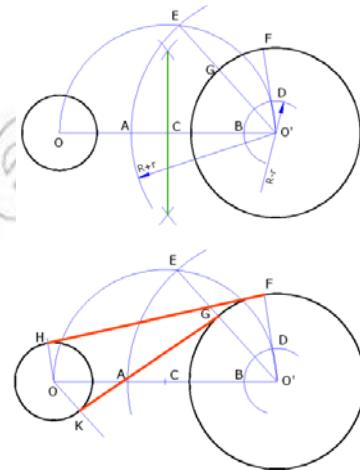


Fig. 5.37 Constructing tangent line to two circles of different size

Checkpoint 5.7

1. Draw 53 mm diameter circle. Mark a point P on the right side of the circle between the vertical and horizontal diameter. Draw a line tangent to the circle at P.
2. Locate a point T to the right of the circle drawn in the above exercise at 45mm from the center of the circle. Draw two tangents to the circle through T.

Constructing a tangent arc of radius R to two lines at right angle

(Fig. 5.38)

1. Draw perpendicular lines intersecting at O.
2. With O as a center and radius R, strike an arc intersecting the lines at A and B.
3. With same radius R and centers A and B, strike arcs intersecting at O' as shown.
4. With O' as a center and radius R, draw the tangent arc.

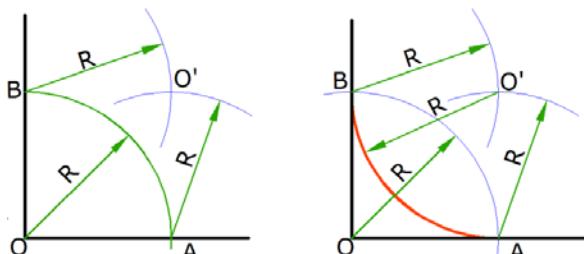


Fig. 5.38 Constructing a tangent arc to two lines

Constructing tangent arc of radius R to two lines that form any angle
(Fig. 5.39)

1. Draw lines AB and CD at any angle.
2. Draw EF parallel to AB and JH parallel to CD at a distances equal to the given radius of the tangent arc.
3. Locate the intersection of EF and JH as O.
4. With O as center and radius R, draw the tangent arc.

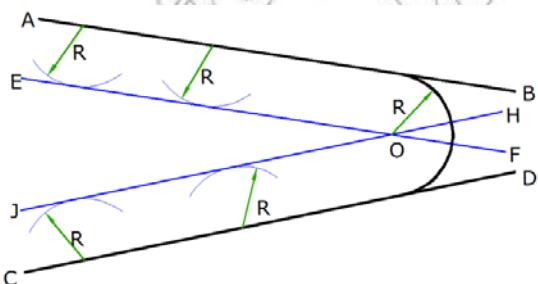
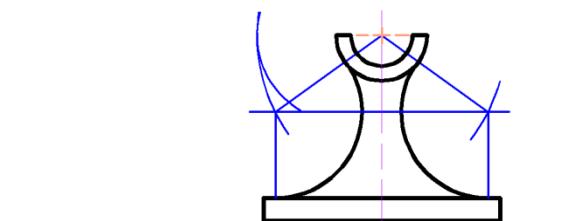
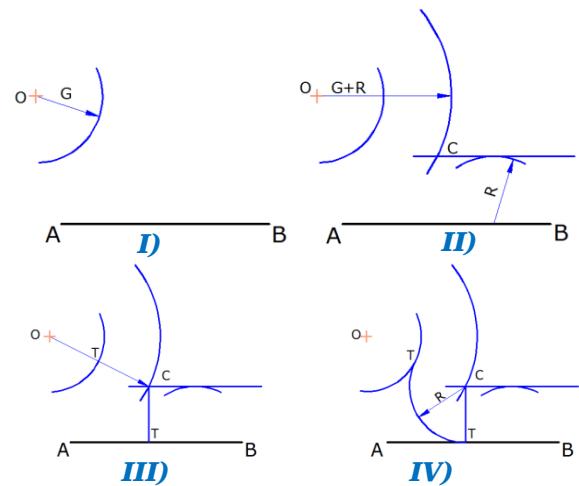


Fig. 5.39 Constructing tangent arc to two lines that form any angle

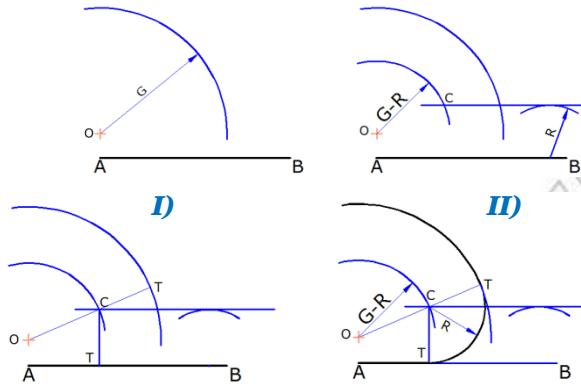
Constructing a tangent arc of radius R to a circle and a straight line
(Fig. 5.40)

Suppose the radius of the required arc is R.

1. Draw the given arc and the given line.
2. Draw a parallel line to the given line AB at a distance of R.
3. Draw a concentric arc to the given arc with radius G+R (or G-R depending on the way the tangent arc is to be drawn), intersecting the line drawn in step 2 at point C. Point C is the center of the required arc.



Example

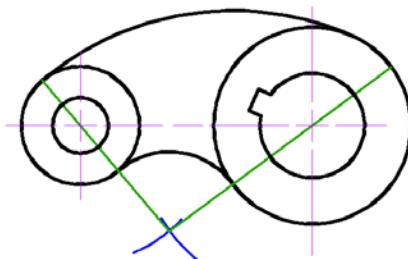
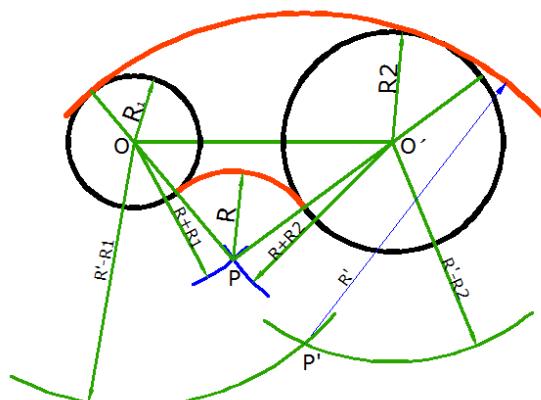


Example

Fig. 5.40 Constructing a tangent arc to a circle and a straight line

Constructing internal and enclosing tangent arcs of radii R and R' respectively to two circles of radii $R1$ and $R2$ (Fig. 5.41)

1. Draw two given circles with radii $R1$ and $R2$ and centers O and O' respectively.
2. With O as a center and radii $R+R1$ and $R'-R1$, strike two arcs as shown in the figure.
3. With O' as a center and radii $R+R2$ and $R'-R2$, strike two arcs intersecting the previous arcs at points P and P' . P and P' are the centers of the tangent arcs.
4. With P and P' as centers and corresponding radii R and R' respectively, draw the tangents.



Example

Fig. 5.41 Constructing internal and enclosing tangent arcs to two circles

Constructing tangent arc of radius R to two circles of radii R_1 and R_2 enclosing one circle (R_1) but not enclosing the other (Fig. 5.42)

1. Draw two given circles with radii R_1 and R_2 and centers O and O' respectively.
2. With O as a center and radius $R-R_1$, strike an arc.
3. With O' as a center and radius $R+R_2$, strike an arc to intersect the previous arc at P .
4. With P as a center and radius R , draw the tangent arc. T_1 and T_2 are points of tangency.

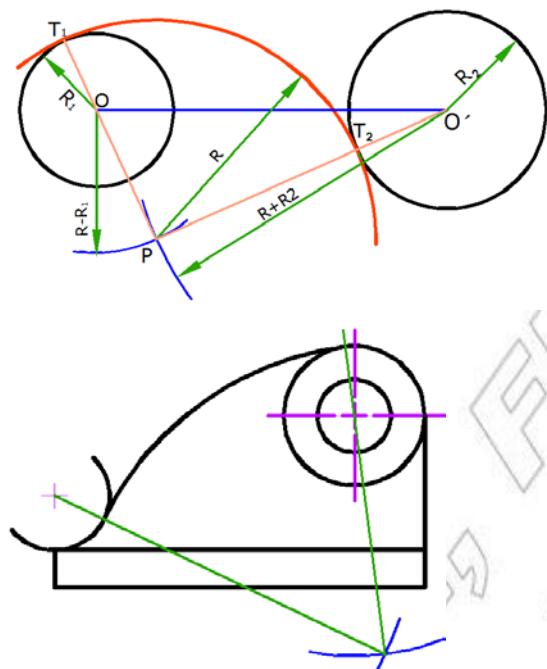


Fig. 5.42 Constructing tangent arc to two circles enclosing one but not the other

Checkpoint 5.8

1. Draw two circles whose radii are 19mm and 27mm. The distance between the centers of the two circles is 100mm. Draw a line tangent to both circles.
2. Redraw the circles under exercise 1. Draw two tangent lines to the circles which cross the line connecting the centers of the circles.
3. Draw an angle of 75° whose sides are 45mm long. Draw a tangent arc to both sides whose radius is 12mm.
4. Draw a 120° angle whose sides are 55mm. Draw a tangent arc whose radius is 20mm.
5. Draw a tangent arc whose radius is 70mm to the circles drawn under exercise 1.
6. Redraw circles whose data are given in exercise 1. Draw a tangent arc whose radius is 75mm externally to both circles.

An ogee or reverse curve is composed of two consecutive tangent circular arcs that curve in opposite directions. It is used in road design, decoration of buildings and on many real objects.

To draw an ogee curve that connects parallel lines (Fig. 5.43)

1. Draw two parallel lines AN and BM and connect A and B.
2. Locate point T on line AB at any convenient distance from either A or B.
3. Draw perpendiculars to lines AN and BM at points A and B.
4. Draw the perpendicular bisectors of AT and TB to intersect the lines drawn in step 3 at points F and C. F and C are the centers of the required tangent arcs.
5. With center at F and radius AF, draw an arc between points A and T.
6. With center at C and radius CB, draw another arc between points B and T to complete the ogee curve.

Note : Point T is the common point of tangency.

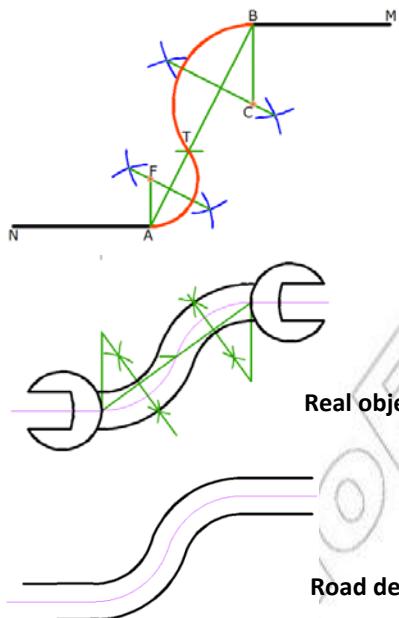


Fig. 5.43 Drawing ogee curve that connect lines

Checkpoint 5.9

Draw an ogee curve connecting two parallel lines spaced at 50mm

- a) Using two arcs of equal radii.
- b) Using two arcs of radii 20 and 30mm.

5.5 Construction of an Ellipse

Activity 5.3

1. *What is ellipse? Use a sketch to define it.*
2. *Compare and contrast circle and ellipse based on their forms.*

The ellipse is the locus of all coplanar points, the sum of whose distances from two fixed points (foci) is constant. This constant distance is the major axis. The longer axis of an ellipse is called major axis (diameter) and the shorter axis is called minor axis (diameter). The major and minor diameters are perpendicular to each other. The foci of an ellipse (F_1 and F_2) are located on the major axis and are obtained by striking an arc with radius equal to half the major axis and center at the end points of the minor axis as shown in Fig. 5.44.

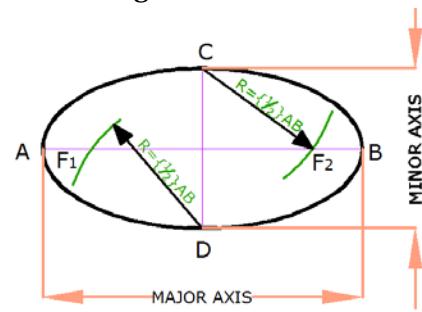


Fig. 5.44 Construction of an ellipse

An ellipse is constructed in several methods, few of which are

1. Four-center method (an approximate method)
2. Concentric circles method
3. Parallelogram or conjugate diameter method.

Constructing ellipse by four-center method (Fig. 5.45)

1. Draw the major axis AB and the minor axis CD intersecting at O.
2. Connect the end points of the two axes AD.
3. With radius OA and center O, strike an arc to intersect the extension of minor axis at E.
4. With radius DE and Center on D, mark off point F. Note $AF=AO - DO$ and $OA=OD+DE$.
5. Draw perpendicular bisector of AF and extend it to intersect the major axis at K and the minor axis at H.
6. With a divider or compass mark off OM equal to OK, and OL equal to OH.
7. With H as a center and radius equal to HD, draw the bottom arc between TT.
8. With L as a center and same radius HD, draw the top arc between TT.
9. With M as a center and radius equal to MB, draw the right side end arc between TT.
10. With K as a center and radius MB, draw the left side end arc between TT.

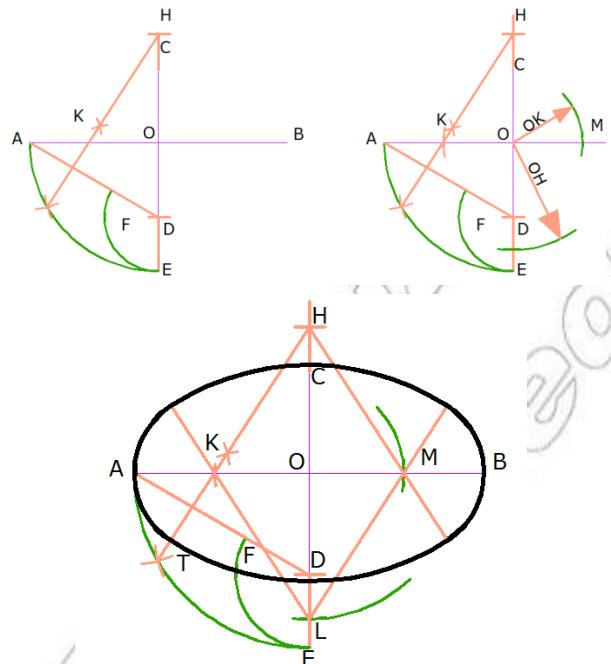


Fig. 5.45 Constructing an ellipse by four centered method

Constructing ellipse by concentric circles method (Fig. 5.46)

1. Draw the major axis AB and minor axis CD intersecting at O.
2. With center at O and radii half of AB and half of CD, draw concentric circles.
3. Draw a number of diameters equal to AB at any angle.
4. From each intersection point of the diameters with the larger circle, draw vertical lines.
5. From each intersection point of the diameters with the smaller circle, draw horizontal lines intersecting the nearest vertical lines drawn in step 4.
6. With a French curve, draw a smooth arc through all points to complete the ellipse.

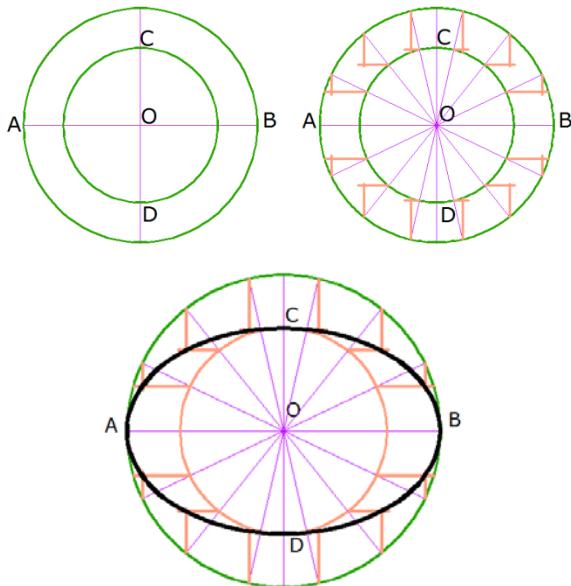


Fig. 5.46 Constructing an ellipse by concentric circles method

Constructing an ellipse by parallelogram method (Fig. 5.47)

1. Draw a parallelogram (JKLM) whose sides are equal to the major diameter AB and minor diameter CD of the ellipse.
2. Divide OA and OB into any appropriate number of equal parts (say 5) and number them as shown in Fig.5.45. Similarly, divide AJ, BK, BL, and AM into the same number of equal parts and number them as shown in the figure.
3. Connect point C to points 1, 2, 3, 4 on line AJ and BK. Similarly, connect D to points on lines AM and BL.
4. Connect point D to points 1, 2, 3, 4 on line OA and OB and extend them intersecting the corresponding lines drawn in step 3. Similarly, connect C to points 1, 2, 3, 4 on line OA and OB and

extend them to intersect the corresponding lines drawn in step 3.

5. Draw a smooth curve through the intersection points found in step 4 using French curves to complete the ellipse.

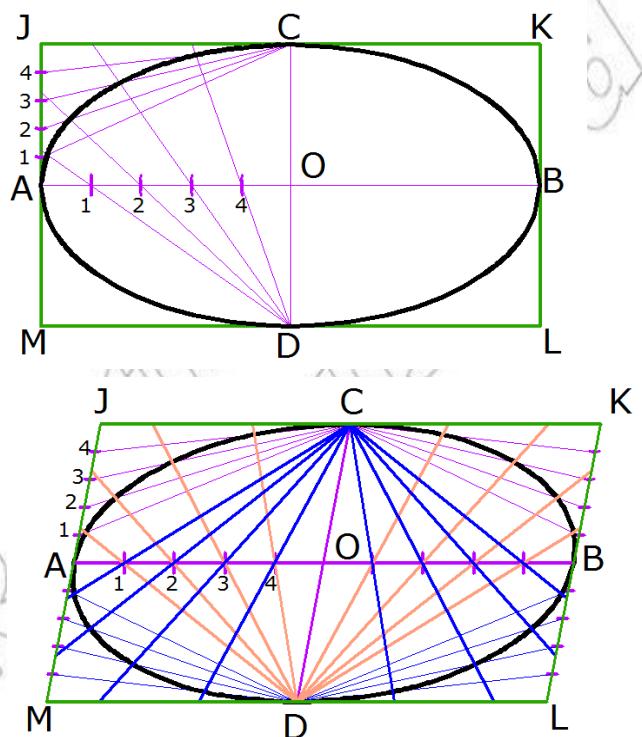


Fig. 5.47 Constructing an ellipse by parallelogram method

Checkpoint 5.10

1. Draw an ellipse whose axis is 102mm long (horizontally and whose minor axis is 64mm long, using:
 - a) The four-center method.
 - b) The concentric circle method.

UNIT SUMMARY

Familiarity with the step-by-step methods used for constructing geometric figures and knowing related definition of terms help you understand the practical applications of geometric construction to problem solving. Simplified or preferred methods of geometric construction, as well as alternate methods, are valuable knowledge factors when used with drafting instruments to create accurate drawings.

Geometric nomenclature primarily of the following concepts: points in space, line, angle, triangle, polygon, quadrilateral, circle, polyhedron, prism, pyramid, cone, and sphere; however the concepts from polyhedron to sphere are not considered in this unit.

Elements and polygon construction principles consist primarily of how to do the following: bisect a line; bisect an angle; draw an arc or circle through three points; draw a line parallel to a straight line at a given distance; draw a line perpendicular to a line at a point; draw a line parallel to a curved line at a given distance; draw a perpendicular to a line from a point not on the line; divide a line into equal parts; divide a line into proportional parts; transfer an angle; transfer an odd shape; transfer complex shapes; proportionately enlarge or reduce a shape; draw a triangle with sides of known length; draw a square; draw a pentagon; and draw a hexagon.

Circular construction consists primarily of knowing how to do the following: locate the centre of a given circle; construct an arc tangent a right angle, an acute angle, an obtuse angle, a straight line, a curve, and two radii or diameters; draw an ogee curve; draw an ellipse using the four centre method, concentric circle method and parallelogram method

Exercise I: Lines

1. Draw an 80 mm long line at an angle of 30° from the horizontal and draw a line parallel to it at a distance of 30mm.
2. Draw a 75mm long line at 15° from the vertical and draw a perpendicular bisector of it.
3. Draw a 95mm long vertical line and divide it into three proportional parts to 3,5, and 9.

Exercise II: Angles

4. Draw 120° using straight edge and a compass and bisect it.
5. Draw a 165° using straight edge and a compass and divide it into seven equal angles.
6. Draw a 60° angle using straight edge and a compass. Transfer and bisect it.

Exercise III: Triangles

7. Draw a triangle whose sides are 70mm, 60 mm and 80 mm long.
8. Draw a triangle whose one side is 50 mm and the included angles from this line are 38° and 65° .
9. Construct a triangle if the included angle is 65° and two of the sides are 80mm and 56 mm.

Exercise IV: Polygons

10. Circumscribe and inscribe a regular pentagon in a circle of diameter of 70mm long.
11. Draw a regular hexagon,
 - (a) If the distance across flat is 60mm.
 - (b) If the distance across corner is 64mm.
 - (c) Whose sides are 50mm.
12. Draw a regular heptagon given circumscribing circle whose diameter is 70mm.
13. Draw a square with 60mm sides, and inscribe an octagon.

Exercise V: Circles, tangent and arcs.

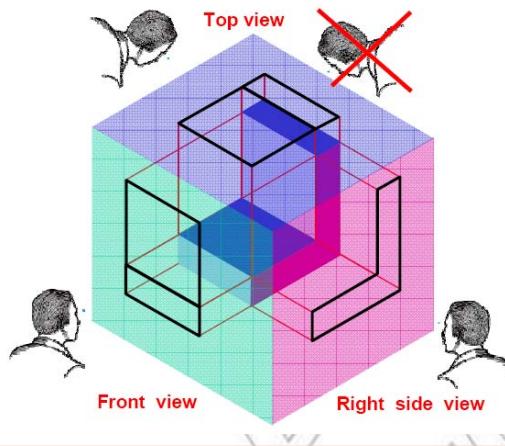
14. Locate three non-collinear points, and draw a circle through the points.
15. Draw two circles whose radii are 30mm and 20 mm with centers 54 mm apart.
 - (a) Draw a tangent line to the lower sides of both circles which doesn't cross the line connecting the center points.
 - (b) Draw a tangent line to both circles which intersects the line connecting the centers.
 - (c) Redraw the circles and draw arc of 70mm radius tangent to upper sides of circles and enclose them.

Exercise VI: Ellipse

16. Use the four centered method to draw an ellipse whose major and minor diameters are 76mm and 54mm, respectively.
17. Draw an ellipse by the concentric circles method given major axis as 75mm and 47 mm of minor axis.
18. Draw an ellipse whose major axis is 80mm and minor axis 50mm by parallelogram method. (Use 70°).

UNIT 6

MULTI-VIEW DRAWING



Learning Competencies:

Up on completion of this unit you should be able to:

- ✓ Explain the importance of multi-view drawings;
- ✓ Define the concept of projection;
- ✓ Explain the concept of orthographic projection;
- ✓ Identify the three main projection planes;
- ✓ Describe the methods of orthographic projection;
- ✓ Prepare arranged view with first and third angle projection;
- ✓ Identify the six principal views;
- ✓ Arrange the six principal views in 1st and 3rd angle projection methods;
- ✓ Identify the common dimensions of views;
- ✓ Analyze guide lines for orientation and choice of views that most describe an object;
- ✓ Lay out one view, two view, and three view drawings;
- ✓ Prepare the multi – view drawing of an object;
- ✓ Show hidden features of an object;
- ✓ Apply the rule of precedence of line in view drawings;
- ✓ Identify normal, inclined and oblique surface;
- ✓ Apply visualization skills by solid and surface to multi-view drawings.

6.1 Introduction

- *Have you ever seen a building drawn on a blueprint, plan paper? What do you understand from drawing?*

Multi-view drawings are conventional projections of a three dimensional object on a two dimensional plane. Anything which is going to be produced or constructed is based on the proposal given by multi-view drawings. For example, buildings, machines, office equipments and so on. By this projection convention engineers, architects, draftsman can communicate with each other even if they don't speak common language. The basic rules and principles of orthographic projection will be discussed on this chapter.

6.2 Projection

Activity 6.1

1. *What do you understand from the word projection?*
2. *What do you expect is the thing to be projected?*
3. *What do you think is the destination after projection?*

6.2.1 Types of projection

A projection is a drawing of an object which is three dimensional on a two dimensional surface or plane. The two dimensional surface used for the projection is called **plane of projection** or the **picture plane**.

There are different types of projections which are classified depending on:

- The angle the lines of sight (projection line) make with the projection plane,
- The angle the lines of sight make with each other,
- The relative position of the object to be projected with respect to the projection plane.

Projection methods are broadly classified into two: *Parallel projection and Central projection*.

In central projection, the observer is assumed to be located at some finite location. Hence the visual rays projected from the different corners of the object converge to the single point of viewing, this is the actual viewing mechanism and therefore the projection possesses realistic appearance like camera picture. Central projection is commonly called Perspective projection.

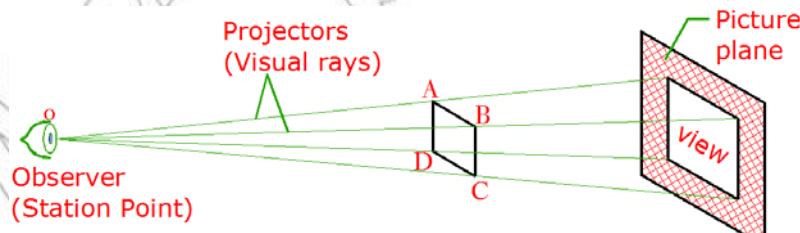


Fig. 6.1 Projection

Perspective projection is further classified as *linear perspective* and *aerial perspective*.

As the observer moves further and further away from the object, the angle between the visual rays reflected from the different corners of the object becomes more and more gentle. If we can therefore place the observer at very large distance from the object we can assume that these visual rays become parallel with each other. Parallel projection is based on the assumption of observer being at large distance without losing the ability to see the object. This assumption will bring about some distortion to the pictorial appearance of the projection as compared to actual appearance.

Parallel projection is further classified into *orthographic* and *oblique projection*. If the lines of sight are parallel to each other and perpendicular to the picture plane, the resulting projection is called an ***orthographic projection***. If the lines of sight are parallel to each other but inclined to the picture plane, the resulting projection is called an ***oblique projection***. Orthographic projection is further classified into *multi-view projection* and *axonometric projection*.

In multi-view projection more than one projection is used to give complete size and shape description of the object while in axonometric projection a single view is sufficient to describe the object completely.

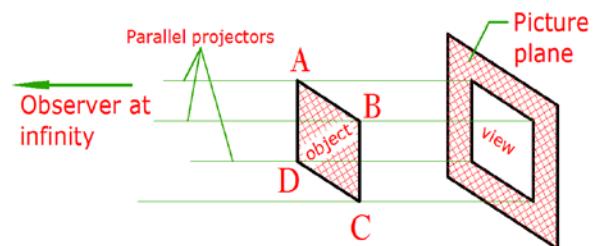


Fig. 6.2 Parallel projection

6.3 Orthographic Projection

1. *What do you think the word orthographic implies? Discuss with your friends.*
2. *How do you expect projection and orthography to be related?*

6.3.1 Planes of Projection

There are three planes perpendicular to each other, which are the basis of multi-view projection. These are:

- Horizontal projection plane.
- Frontal projection plane.
- Profile projection plane.

The position of these planes is illustrated on the figure below (Fig. 6.3). The lines of intersection of these three planes are called reference lines.

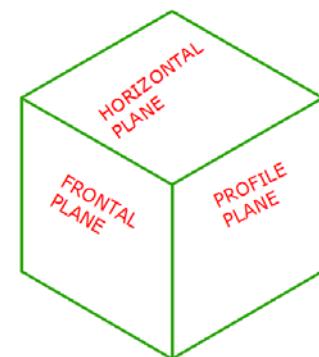


Fig. 6.3 Basic planes of projection

In multi-view projections, lines of sight (projectors) are perpendicular to the planes

of projection. The projection of an object on the vertical/frontal projection plane is commonly known as front view. Similarly, horizontal projection of an object is called top view and the profile projection of an object is known as side view.

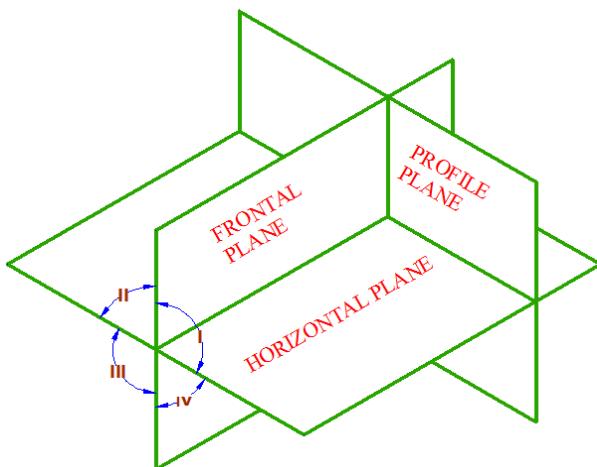


Fig. 6.4 Quadrants of projection

6.3.2 First Angle Projection

The three principal planes of projection form four quadrants (Fig.6.4). The multi-view of an object can be done by placing the object on one of the quadrants. But usually the first and the third quadrants are the conventional quadrants used. When the object is assumed to be placed in the first quadrant it is known as *first angle projection system*. In this case the observer is placed in front of the vertical plane, the object will appear to be between the observer and the projection plane. In Fig. 6.5, the three views of a simple object on the three principal planes of projection are shown pictorially. Then to represent all the views in one plane, the horizontal plane and the profile plane are rotated to the vertical

plane as shown in Fig. 6.6. The views are then drawn in their true shape as shown in Fig.6.6 (b). Note that the views are arranged in such a way that the top view is always directed below the front view and the left side view is directly to the right of the front view.

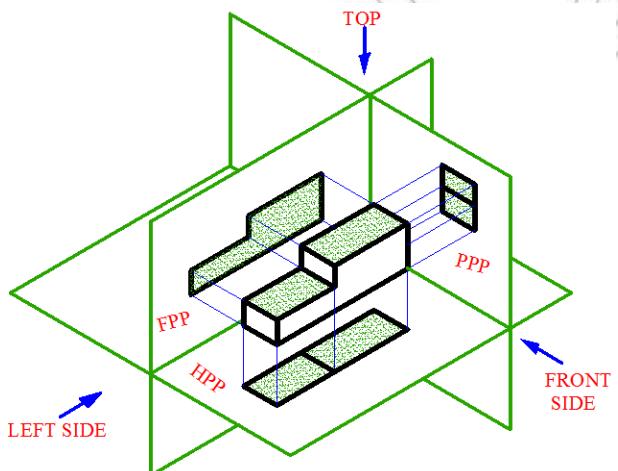


Fig. 6.5 First angle projection

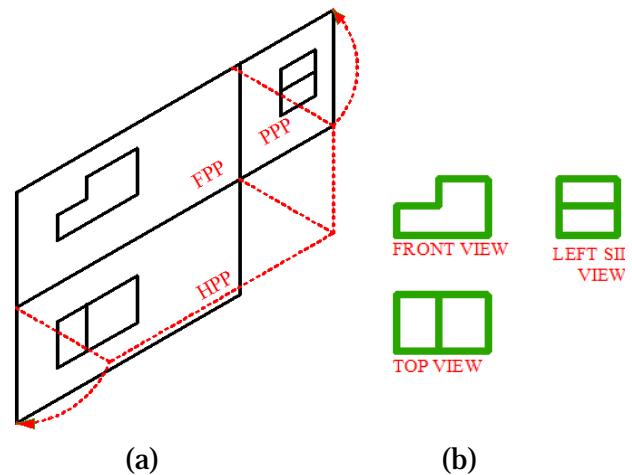


Fig. 6.6 Projection planes unfolded

6.3.3 Third Angle Projection

When the object is placed in the third quadrant it is known as *third angle projection system*. The projection plane is placed between the observer and the object. Therefore, in the projection process it is necessary to assume the plane of projection to be transparent. Here again the projections are perpendicular to the projection planes.

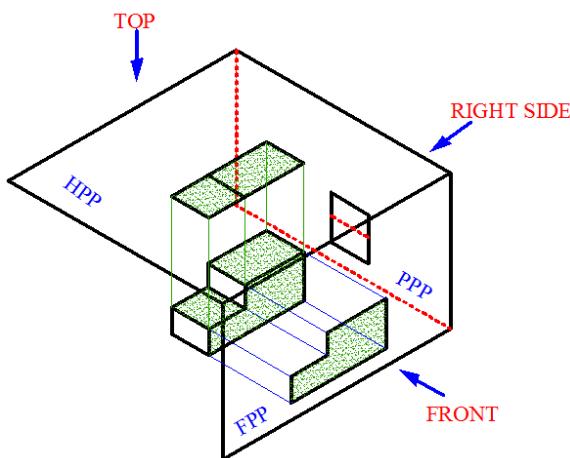


Fig. 6.7 Third angle projection

The figure above illustrates the method of getting the third angle projections of an object. After developing the different views of the object in the different projection planes, all the projection planes are opened up to the frontal projection plane as illustrated in Fig 6.8 (a) and (b).

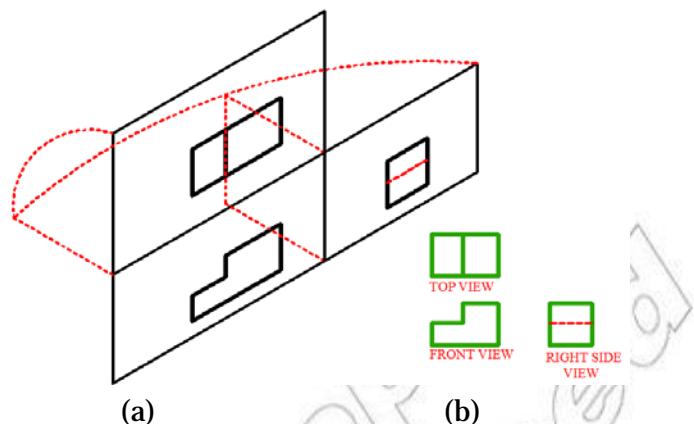
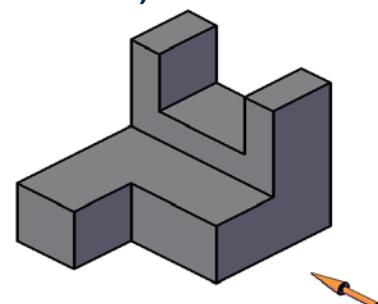


Fig. 6.8 Projection planes unfolded

Note here that, in the third angle projection system, the top view is placed directly above the front view and the right side view is placed directly to the right of the front view. This relative arrangement of the views is the one which distinguishes multi-view drawings whether they are prepared by the third angle projection system or the first angle projection system.

Checkpoint 6.1

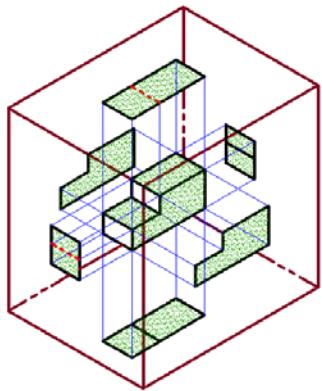
Draw the three views of the object shown in the figure using both first angle and third angle projection systems. (use 2:1 scale)



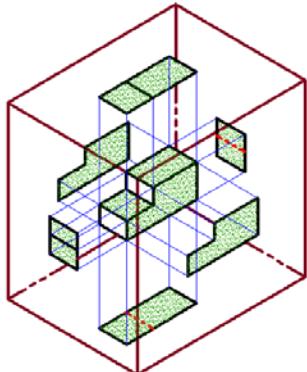
6.4 The Six Principal Views

1. Look at your class room and observe the planes or walls in different direction.
2. After this count the walls including the ceiling and the floor.
3. How many planes (wall, ceiling or floor) did you count?

Extending the above discussion, the object can be thought of as being surrounded by a box or a set of six planes which are mutually perpendicular to each other as shown in Fig.6.9. The views projected onto these six planes are called *six principal views*. Their designations are given in table 6.1.



(a) First angle projection



(b) Third angle projection

Fig. 6.9 First and third angle projection

Table 6.1 Designation of the six principal views

Direction from which View is taken (fig 6.10)	Name of view
View in direction A	Front view
View in direction B	Top view
View in direction C	Left side view
View in direction D	Right side view
View in direction E	Bottom view
View in direction F	Rear view

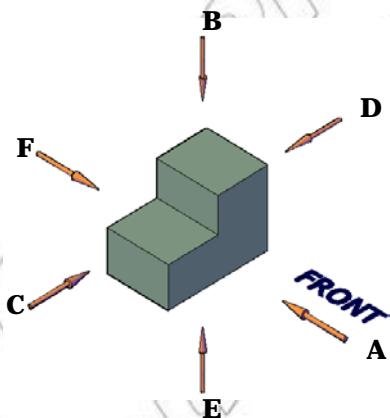


Fig. 6.10 Given object

The relative positions of these six views in the first angle and third angle projections for the object in Fig. 6.10 are shown in Figs. 6.11 and 6.12, respectively. It may be noted that in both projections, the rear view can be placed either on the left or on the right as convenient.

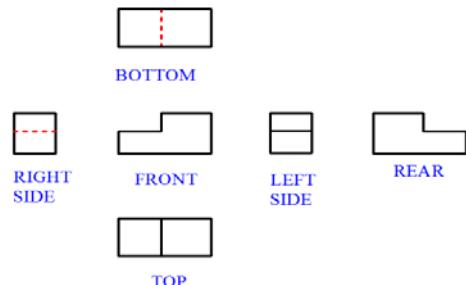


Fig. 6.11 The six principal views and their arrangement in first angle projection

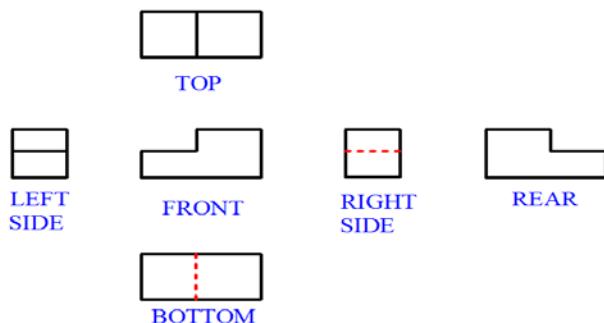


Fig. 6.12 The six principal views and their arrangement in third angle projection

6.4.1 Alignment of Views

The alignment and the orientation of the views made by the first or third angle have certain rules.

- The front view, top view and bottom view are always aligned vertically
- The front, left side, right side and rear views are in line horizontally. Note that the rear view may be placed next to either the right side view or left side view where found convenient.

6.4.2 Common Dimensions

When we are dealing on multi-view projection it is true that two views will have the same edge projected on. Here are some facts of edges which have common dimensions.

- The depth of the top view is the same as the depth of the side view(s).
- The width of the top view or bottom view is the same as the width of the front view or rear view.

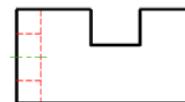
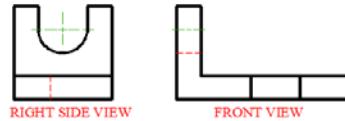
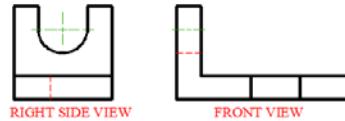
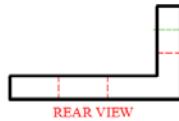
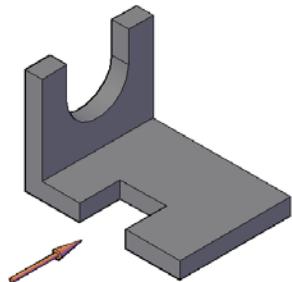
- The height of the side view(s) is the same as the height of the front view or rear view.

6.4.3 Adjacent Placement of Views

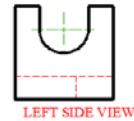
Since there is a size relation between the multi-views, it is proper to draw views which share the same edge adjacently. Here are the placements of views according to their relation.

- The top view should be drawn below the front view if first angle projection is used and above the front view if third angle projection is used.
- The bottom view should be drawn above the front view in the first angle projection system and below the front view in the third angle projection system.
- The right side view should be drawn to the left of the front view in the first angle projection system and to the right of the front view in the third angle projection system.
- The left side view should be drawn to the right of the front view if first angle projection is used and to the left of the front view if third angle projection is used.

Example: Draw the six principal views of the given object in the first angle projection.



BOTTOM VIEW

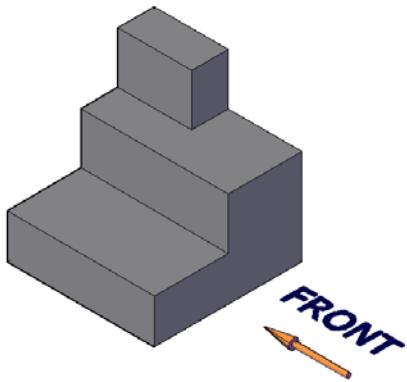


TOP VIEW

Fig. 6.13 The six principal views of a given object

Checkpoint 6.2

Draw the six principal views of the object whose pictorial drawing is given in the figure using both the first and third angle projection systems. (use 1:1 scale)



6.4.4 Orientation of the Object and Choice of Views

Activity 6.2

1. Have you observed that an entrance of any building is oriented in such a way that it is easily accessible and visible?
2. Based on this idea observe buildings and their entrances with respect to orientation and present some examples to the class in group.

Observe that some of the six views of an object may be enough to represent the object completely. Note the following points to determine the essential views for the complete description of the object.

i. Orientation of the object

- Place the object in its most natural (stable) position.
- Place the object with its main faces parallel to the planes of projection.

ii. Choice of views

- Select those views (in addition to the front view) that provide the clearest information about the shape of the object.
- Do not use more views than the necessary views which describe the object.
- If the left side and right side views are identical in terms of information and line work, select the view to be drawn to the right of the front view, in accordance with tradition.
- If the top view and bottom view are identical in terms of information and line work, select the top view.
- If the top and side views are identical in terms of information and line work, select the one that best utilizes the available drawing space.
- If two views are identical in terms of information, but one contains more hidden line work than the other, select the view with fewer hidden lines.

Example Consider the simple object whose six principal views were given in Fig. 6.11. The front view is necessary and should be drawn always. Then, the rear view is not necessary since it shows no additional information. The left side view is preferred to the right side view because there is no hidden line in the left side view. The top view is preferred to the bottom view because there is no hidden line on the top view. Therefore, the three necessary views of the object are the front, top and left side views as shown in Fig. 6.14.

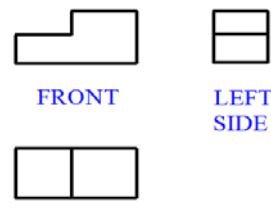


Fig. 6.14 Selection of the necessary views

Example Let us consider the object whose six views were shown in Fig 6.13. The right side view is preferred to the left side view because it has less number of hidden lines. Likewise, the top view is preferred to the bottom view.

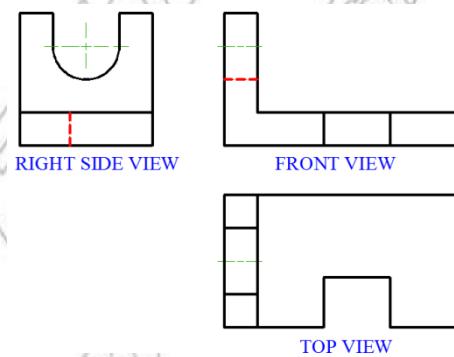
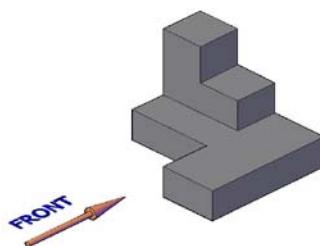


Fig. 6.15 Selection of necessary view

Checkpoint 6.3

Draw the six principal views of the object given and cross out the unnecessary ones.



6.4.5 One and Two View Drawing

One view drawings

One view drawings are drawings that consist of one view of the object with additional notes. These drawings are often suitable to represent flat and cylindrical objects. For example, constant thickness parts such as shown in Fig. 6.16(a) can be represented by a single view showing the characteristic shape. The thickness is specified by a note adjacent to the view. Fig. 6.16(b) shows another example on a cylindrical object which can be represented by a single view. The single view shows the axis of the cylindrical part as a center line, and the diameter symbol (\emptyset) along with the diameter dimensions.

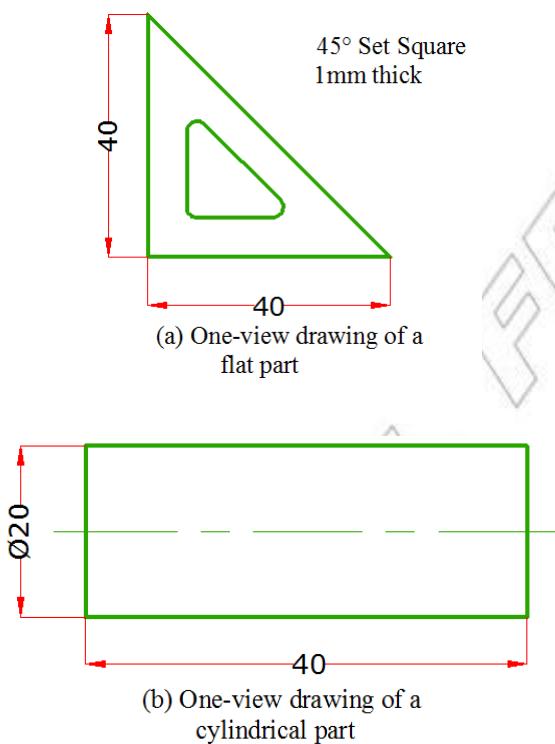


Fig. 6.16 Example of one-view drawings

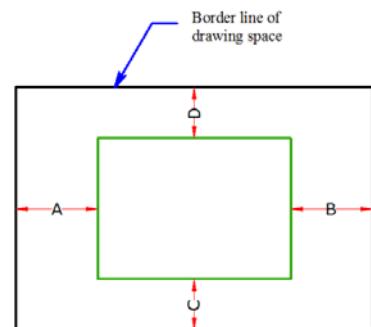


Fig. 6.17 Laying out one view drawing

Two view drawings

On some objects only two of the views might represent the outline clearly. In such cases only the front view and one additional side or top view will be enough to describe the object completely. These views should be selected in accordance with the guidelines discussed in section 6.4.4.

To lay out one view and two view drawings centrally, the distance between the object and the borderline is necessary and it can be laid as follows. $A = B$ and $C = D$ (Fig. 6.17 and 6.18)

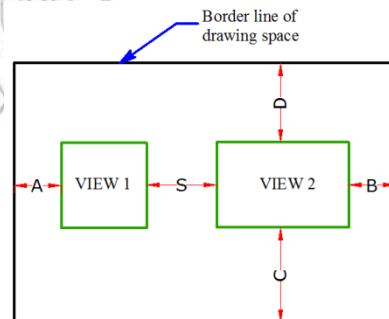


Fig. 6.18 Laying out two view drawing

Fig. 6.19 shows different objects which can be completely described using two views. Such drawings are called two-view drawings.

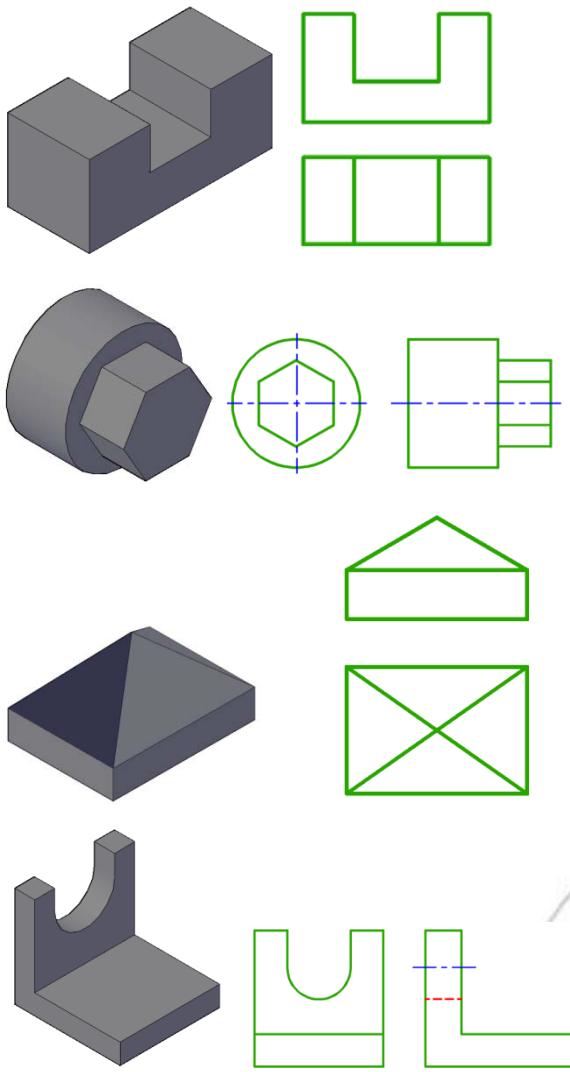


Fig. 6.19 Examples of two view drawings

6.4.6 Three-View Drawing

Three-view drawings are multi-view drawings that consist of three views of an object. These drawings are prepared for objects which require three views for their complete description. Fig. 6.20 shows a typical example of an object which requires three views.

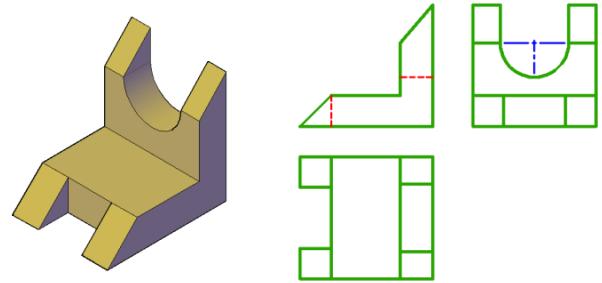


Fig. 6.20 An example of a three-view drawing

To lay out a three-view drawing on a given drawing space, the three views should be spaced as illustrated in Fig. 6.21. Note that length A and C should be equal, length E and F should be equal and length S₁ and S₂ should be equal. However S₁ or S₂ will be set depending on the available space and appearance.

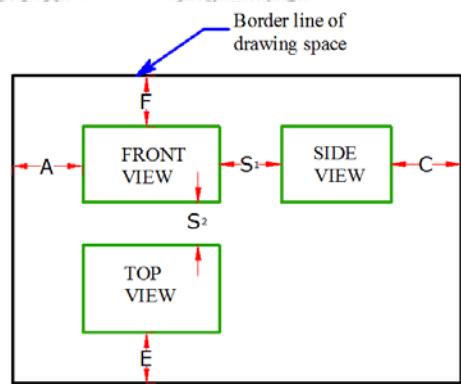


Fig. 6.21 Laying out a three view drawing

6.4.7 Invisible Lines and Arcs

Invisible edges in multi-view drawings are represented by dashed or hidden lines. When drawing views of objects, invisible lines and visible lines may intersect. Hidden lines may also intersect each other. In such case lines should be drawn according to the correct practices shown in Fig. 6.22.

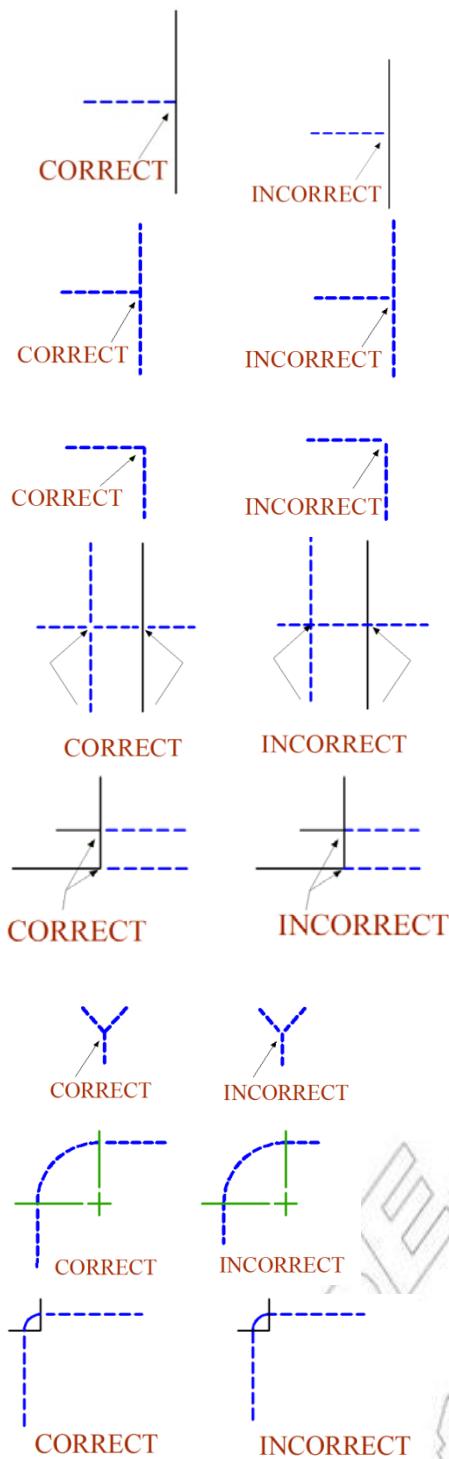


Fig. 6.22 Correct and incorrect practice of drawing invisible lines and arcs

6.4.8 Precedence of Lines

When two or more lines of different type coincide (overlap), the following order of priority should be observed.

1. Visible lines
2. Hidden lines
3. Centre lines
4. Projection lines

Fig.6.23 illustrates the precedence of lines when drawing view of objects.

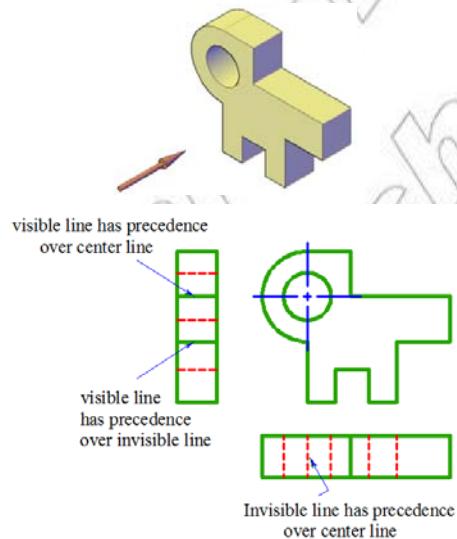


Fig. 6.23 Precedence of lines

6.5 Fundamental Views of Edges and Surfaces

6.5.1 Normal Surfaces

1. Notice a vertical wall and observe its angular relation with the ground. What angle does it make?
2. Imagine the wall in different angle from what you observed. Can you give an example of such a wall on a building you saw in your surrounding?
3. How do you expect projection of curved surfaces like cylinders?

A normal surface is one that is parallel to a principal of projection. If a normal surface is parallel to the frontal plane of projection, it will be shown in its true size and shape on the front view but as a line in the top and side view. If a surface is parallel to the horizontal plane of projection, it will be shown in its true size and shape on the top view and as a line on the other two principal planes. In a similar manner the side view will show the true shape and size of a surface which is parallel to the profile projection plane. Projections of normal surfaces are illustrated in Fig.6.24. Fig.6.25 shows few examples of objects having normal surfaces.

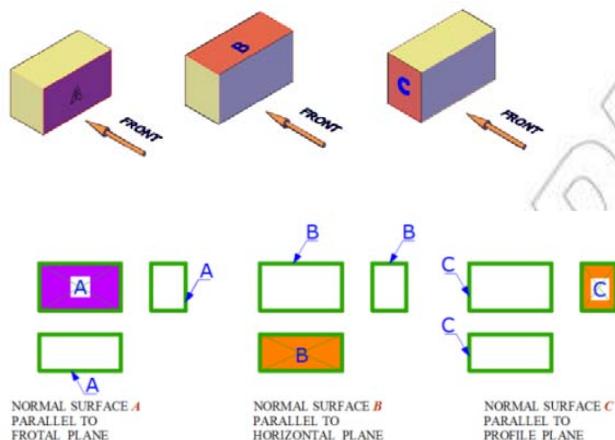


Fig. 6.24 Normal surfaces

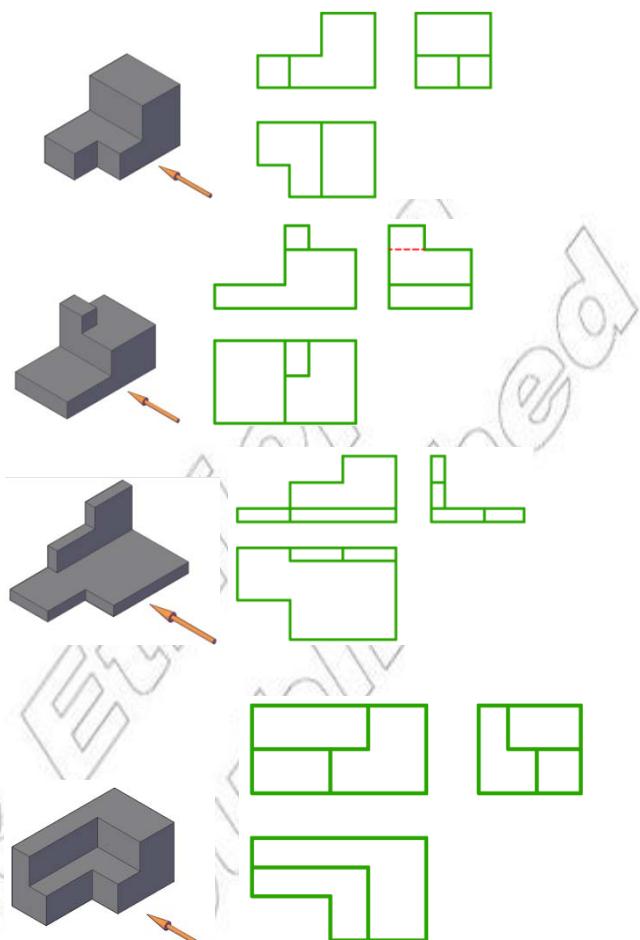


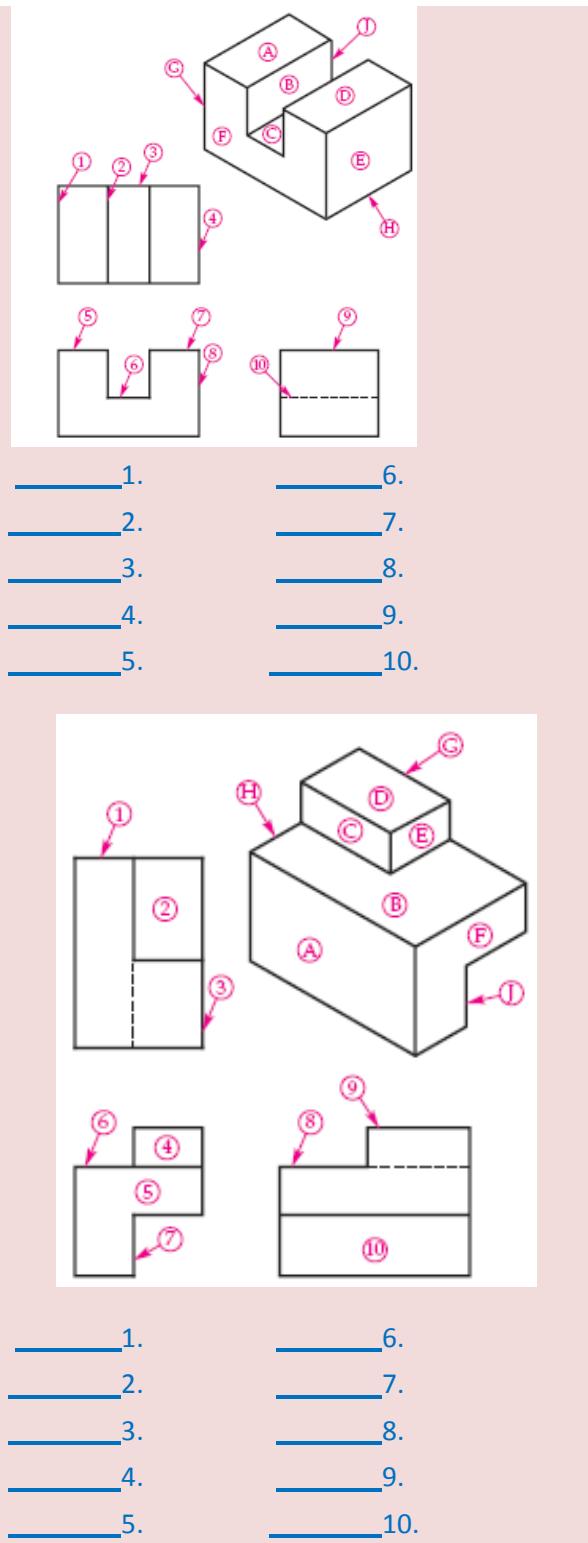
Fig. 6.25 Examples of objects having normal surfaces

Activity 6.3

Normal Surfaces

- Study each pictorial (3D) drawing and the identification letters placed on, or pointing to, the normal surfaces. Match the ID letter to the corresponding number for each of the multi-view (orthographic) callouts.

Note: The letter *I* is not used and in the pictorial view, arrows pointing directly to a line are referencing a surface that is not visible, rather “around the back” of the object.



6.5.2 Inclined Surfaces

Inclined surfaces are surfaces which appear perpendicular to only one of the three projection planes. The projection of an inclined surface will be a line on the plane to which it is perpendicular. And it will appear foreshortened on the planes to which it is inclined. The degree of foreshortening is proportional to the angle of inclination. Projections of inclined surfaces are illustrated in Fig. 6.26. Fig. 6.28 shows some additional examples of objects having inclined surfaces.

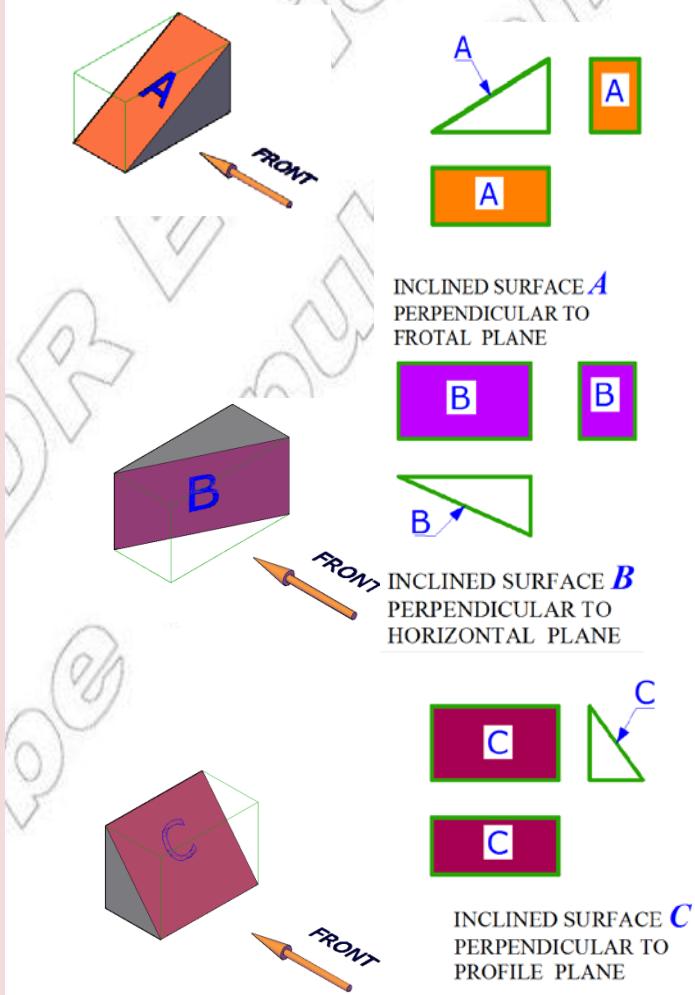
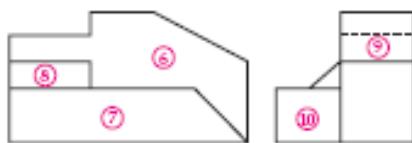
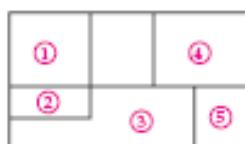


Fig. 6.26 Projection of inclined surfaces

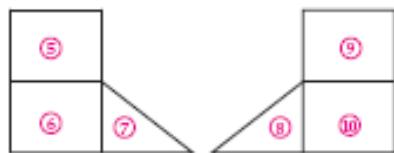
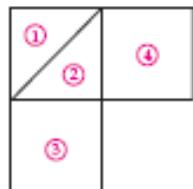
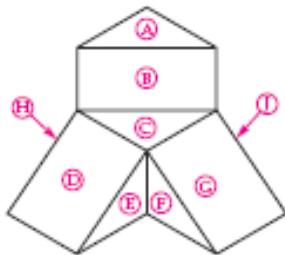
Activity 6.4**Normal and Inclined surfaces**

- Study each pictorial (3D) drawing and the identification letters placed on, or pointing to the normal or inclined surfaces. Match the ID letter to the corresponding number for each of the multi-view (orthographic) callouts.

Note: The letter I is not used and in the pictorial view, arrows pointing directly to a line are referencing a surface that is not visible, rather “around the back” of the object.



1. 6.
2. 7.
3. 8.
4. 9.
5. 10.

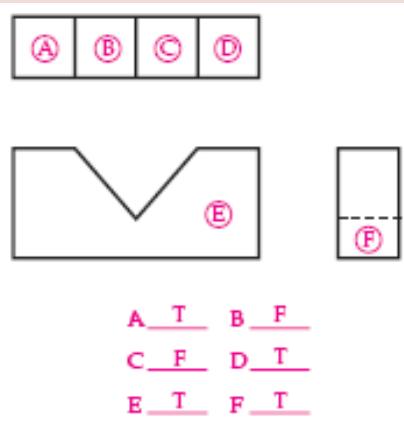


1. 6.
2. 7.
3. 8.
4. 9.
5. 10.

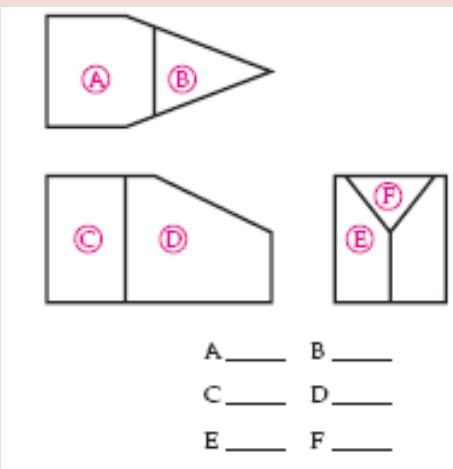
Activity 6.5**The size and shape identification**

- Analyze each of the multi-view drawings. Place a T for true size and shape or an F for foreshortened size and shape in the blanks below each multi-view. Remember, normal surfaces appear true size and shape in only one view. Inclined surfaces appear foreshortened in shape and size in two views. The first problem is done for you as an example.

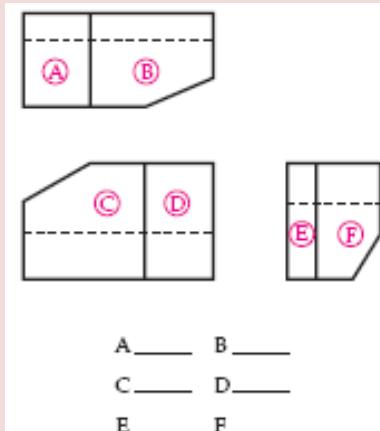
1.



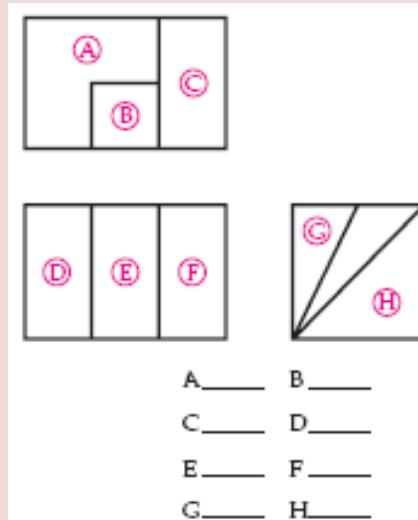
2.



3.



4.



6.5.3 Oblique Surfaces

When a plane surface is inclined to all the three principal planes of projection, it is known as oblique surface. Such surfaces will appear foreshortened in all the principal planes. Projection of an oblique surface is illustrated in Fig. 6.27. Examples of objects with oblique surfaces are given in Fig. 6.29.

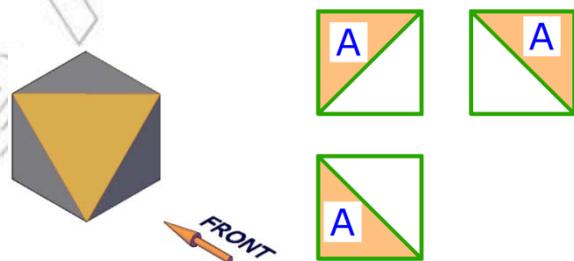


Fig. 6.27 Projection of oblique surface

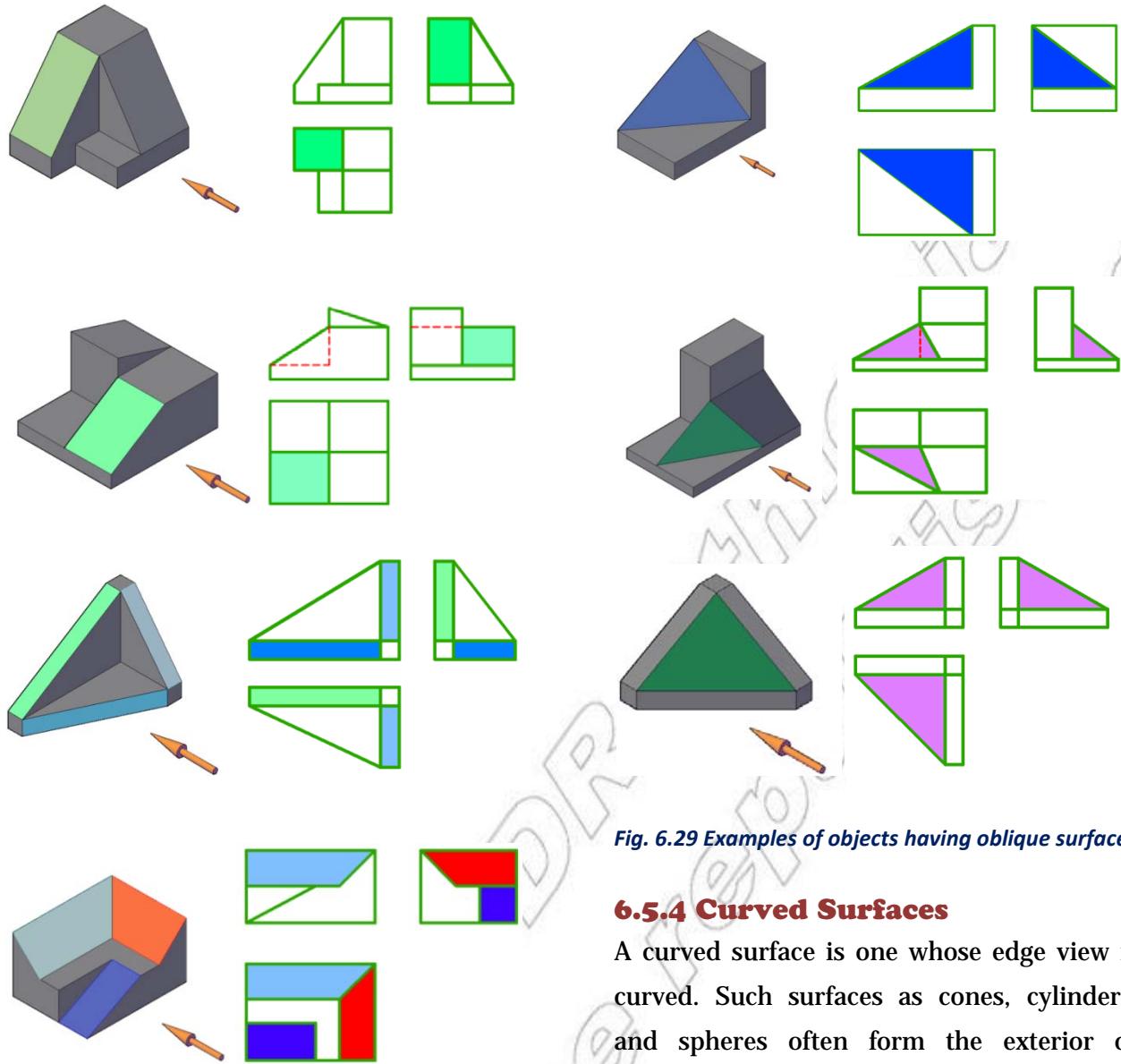


Fig. 6.28 Examples of objects having inclined surface

Fig. 6.29 Examples of objects having oblique surfaces

6.5.4 Curved Surfaces

A curved surface is one whose edge view is curved. Such surfaces as cones, cylinders, and spheres often form the exterior or interior of objects. The projection of a cylinder would be a circle in one view and a rectangle on the adjacent view. A sphere would be a circle in every view. A cone will be a circle on one view and a triangle on the adjacent view as shown in Fig.6.30.

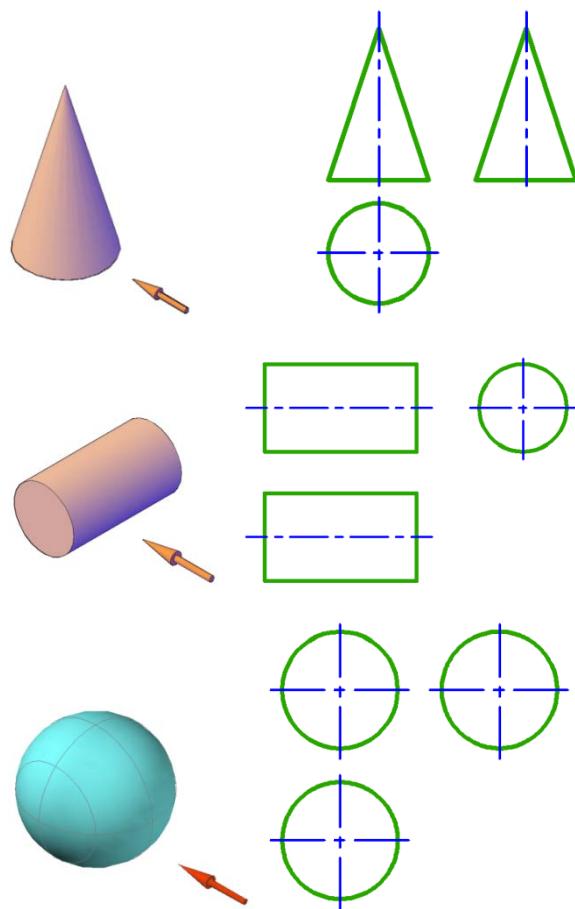


Fig. 6.30 projection of curved surfaces

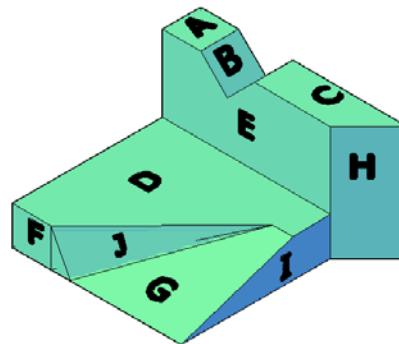
6.6 Visualization

The mental process of forming the image of an object from its orthographic views is called **visualization**. The ability to visualize can be developed by consistent practice. To improve visualization, the principle of orthographic projection can be applied to the following types of exercises:

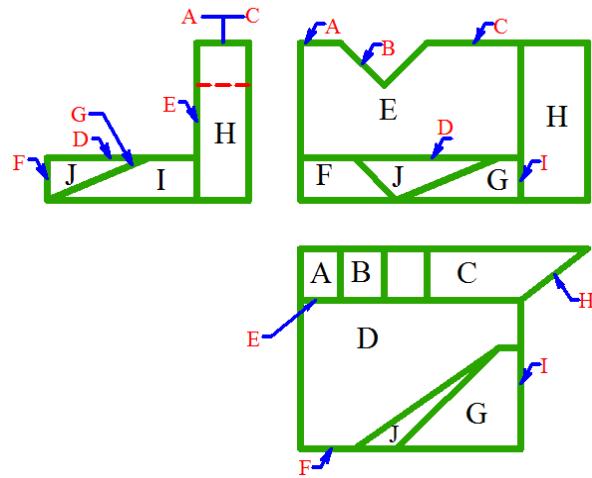
1. Identification of surfaces
2. Missing line problems
3. Possible view problems
4. Missing or third view problems

1. Identification of surfaces

The pictorial drawing and multi-views of an object in which the planes are indicated with letterings are given below. The surfaces are matched on the pictorial drawing and multi-view drawing using letters. (Fig.6.31)



(a) Pictorial drawing of the given object

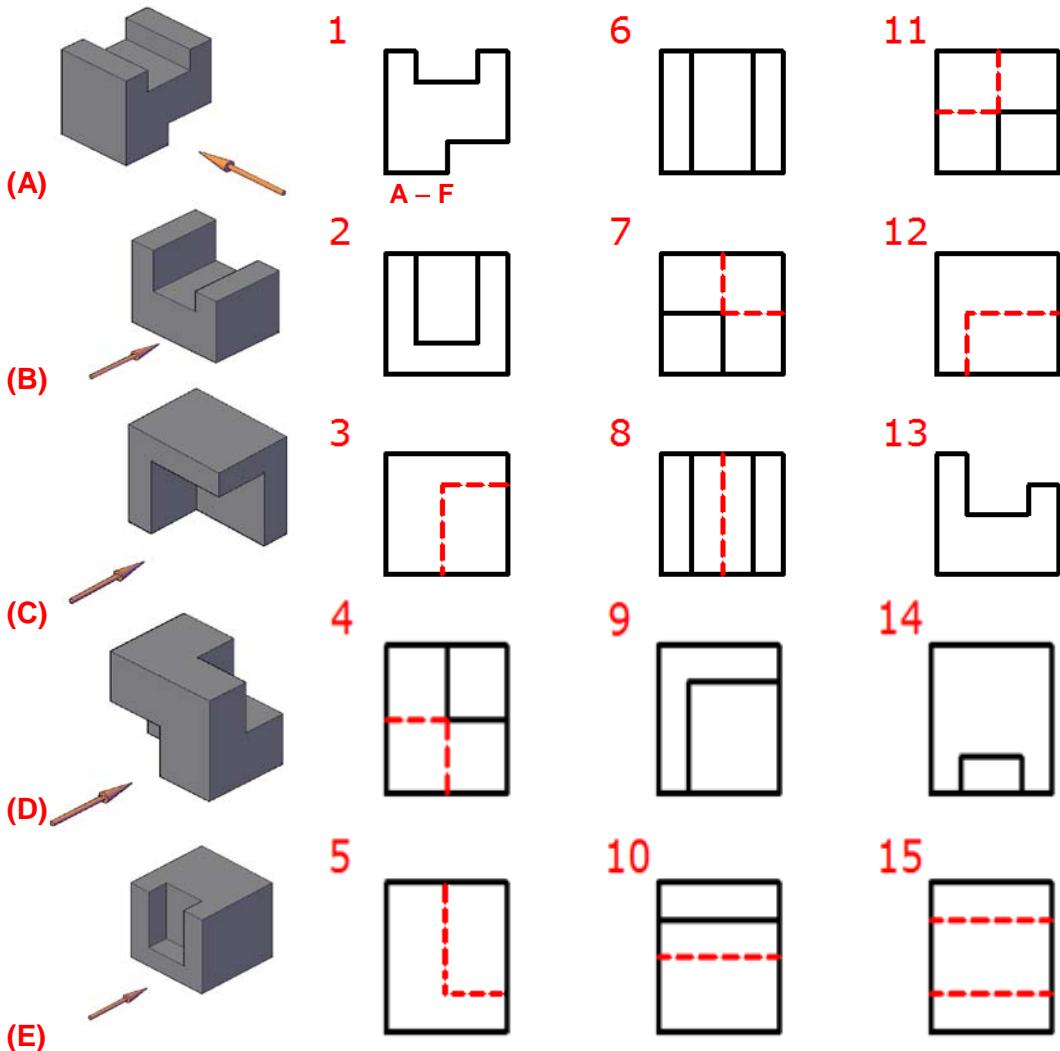


(b) views of the given object

Fig. 6.31 Identification of surfaces

Checkpoint 6.4

Pictorial drawings and views of objects are given in the figure. Match the views and the pictorial drawing by writing the letter representing the pictorial drawing and the letter representing the type of the view below the views. For example, view 1 is the front view of object A. Then, we write A-F below view 1 as shown. This means A stands for object A and F stands for front view. In a similar manner, use LS for left side and T for top view.



2. Missing line problems

Incomplete views of an object are given in Fig.6.32. To complete these views all the missing lines should be added. In order to find the missing lines, projecting lines should be drawn from one view to the other starting from points on all views. If a projecting line drawn between two views does not have corresponding points on both views, then it implies that there is a missing line which coincides on the projecting line or whose end point is on that projecting line.

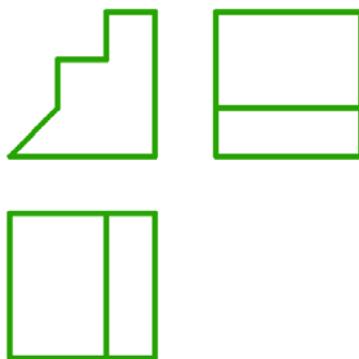
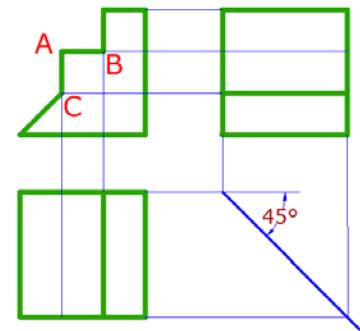
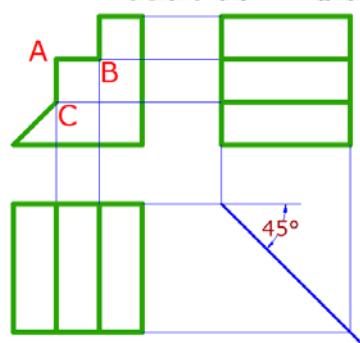


Fig. 6.32 Incomplete view of an object

In Fig.6.33 (a), you can see that the projecting line drawn from A and B to the side view has no corresponding point on the side view. This means there is a missing line on the side view. Likewise, there are no points corresponding to points A and C on the top view. Therefore, there is a missing line on the top view too. Once the locations of the missing lines are identified, the next step is to imagine an object whose views are similar to the given views. To help visualize such an object pictorial freehand sketches may be used. Finally, the missing lines are added as shown in Fig. 6.33 (b).



(a) Drawing the projectors



(b) Adding the missing lines

Fig. 6.33 complete projection

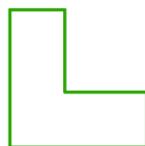
Checkpoint 6.5

Add the missing lines on the views given in the figure.

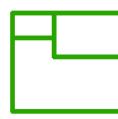
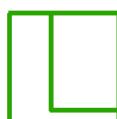
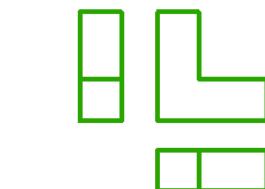


3. Possible view problems

In Fig. 6.34(a), a front view is given. Fig. 6.34 (b) shows that it is possible to find objects that have similar front view but varying in other views.



(a) Given front view



(b) Possible views

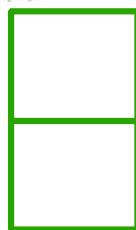
Fig. 6.34 Possible view problem

Checkpoint 6.6

Find at least three objects whose top view is as shown in (A). Also find at least three objects whose front view is as shown in (B).



(A)



(B)

4. Missing view or third view problem

If two projections of an object are given, it is possible to find out the third projection. In Fig. 6.35 two views of an object are given. In Fig. 6.36 the method of finding the third view with the help of projecting lines is illustrated. In this case, it is necessary to visualize the object from the given views when going over the necessary lines in step II.

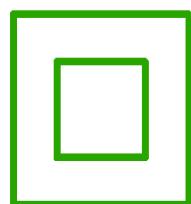
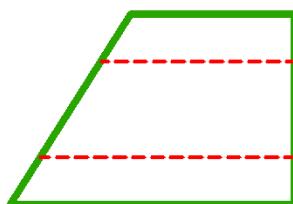
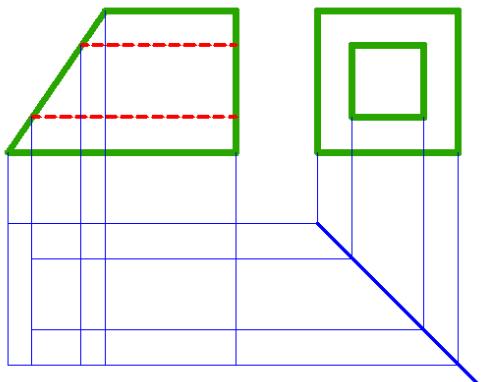
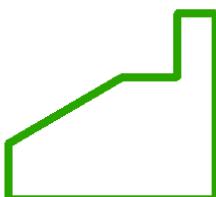


Fig. 6.35 Given view of an object

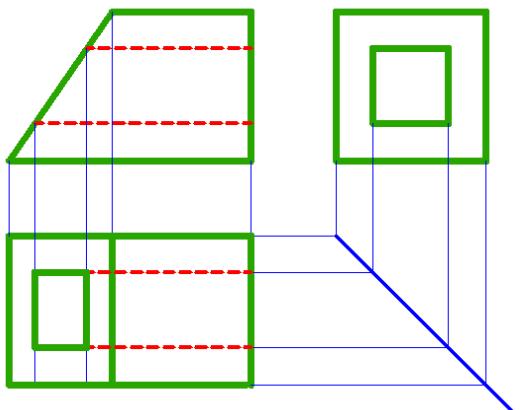


Checkpoint 6.7

Draw the right side view of the object whose front and top views are as shown in the figure.



Step I. Draw the projecting lines from the two given views to the missed view.



Step II. Complete the missing view by going over the necessary lines.

Fig. 6.36 Method of finding the third view

UNIT SUMMARY

A pictorial drawing shows an object as it appears to the observer, but not in its true lengths. Such a picture cannot describe the object fully, no matter which direction it is viewed from, because it does not show the exact shapes and sizes of the several parts. In industry, a complete and clear description of the shape and size of an object to be made is necessary. Therefore, a number of views systematically arranged, are used. This system of view is called multi-view projection.

Multi-view drawings are an important part of engineering and technical graphics. To create multi-view drawings takes a high degree of visualization skill and much practice. Multi-view drawings are created by closely following orthographic projection techniques and standards. The rules of orthographic projection are listed here for your reference.

Rule 1: Every point or feature in one view must be aligned on a parallel projector in any adjacent view.

Rule 2: Distances between any two points of a feature in related views must be equal.

Rule 3: Features are true length or true size when the lines of sight are perpendicular to the feature.

Rule 4: Features are foreshortened when the lines of sight are not perpendicular to the feature.

Rule 5: Areas that are the same feature will always be similar in configuration from one view to the next, unless viewed as an edge.

Rule 6: Parallel features will always appear parallel in all views.

Rule 7: Surfaces that are parallel to the lines of sight will appear an edge and be represented as a line.

Exercise I:

1. Define orthographic projection.
2. How is orthographic projection different from perspective projection? Use a sketch to highlight the differences.
3. Define multi-view drawings and make a simple sketch of an object using multi-views.
4. Define frontal, horizontal, and profile planes.
5. List the six principal views.
6. Define fold lines.
7. List the space dimensions found on a front view, top view and profile view.
8. Define a normal surface.
9. Define an inclined surface.
10. Define an oblique surface.
11. List the 8 rules of orthographic projection.

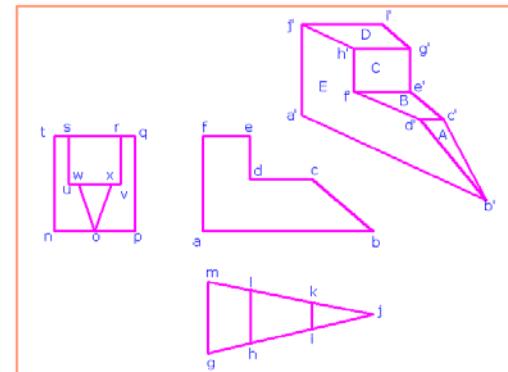
Exercise II

Interpret simple orthographic drawings by relating them to the isometric views of the objects.

1. Note line b'-d' on surface A of the oblique drawing.

Which of the following statements is correct?

- a) line o-w in the right side view shows line b'-d' in true length
- b) line i-j in the top view shows line b'-d' in true length
- c) line b-c in the front view shows line b'-d' in true length
- d) none of the three views shows line b'-d' in true length



2. Note line f-h' on surface C of the oblique drawing. Which view(s) will show f-h' in true length?

- | | |
|------------------|-------------------------|
| a. front only | c. right side only |
| b. top and front | d. front and right side |

3. Which line in the top view represents the same line as line v-x in the right side view?

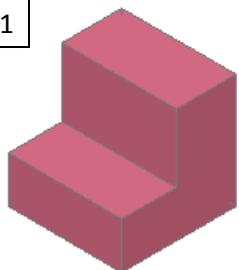
- | | | | |
|--------|--------|--------|--------|
| a. i-k | b. l-m | c. k-l | d. h-i |
|--------|--------|--------|--------|

4. Which of the following surfaces will be shown in true length and shape in at least one of the three views?

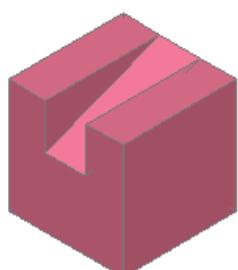
- | | |
|------------|----------------|
| a. A and C | c. B, C, and D |
| b. C and E | d. A, B, and E |

Exercise III: Draw the three necessary views of the objects whose pictorial drawings are given in Exercise III, and IV. Use 1:1 scale and 1st angle projection.

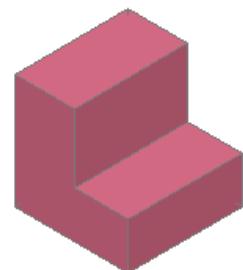
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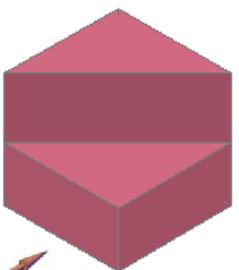
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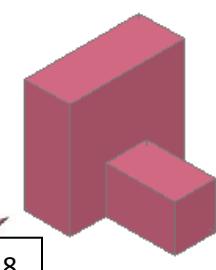
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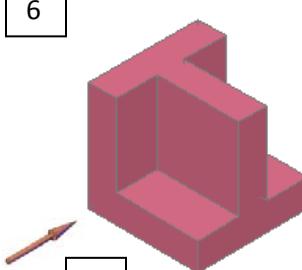
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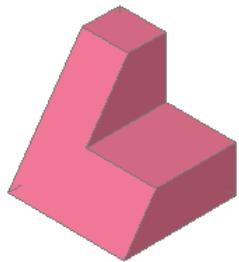
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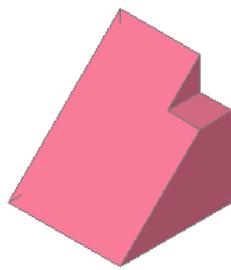
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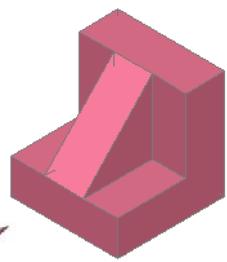
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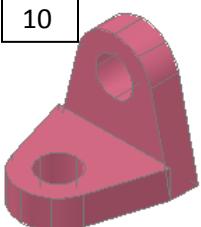
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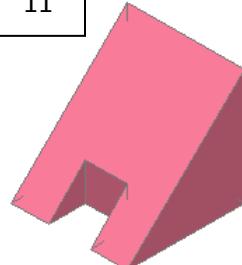
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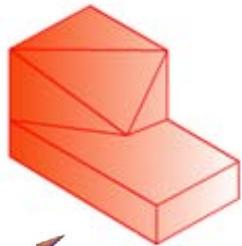
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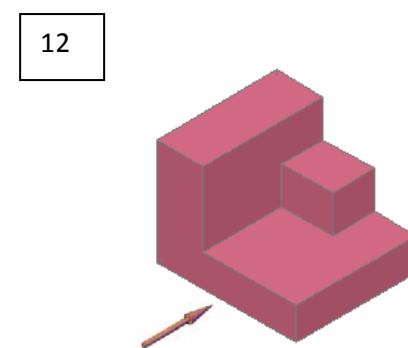
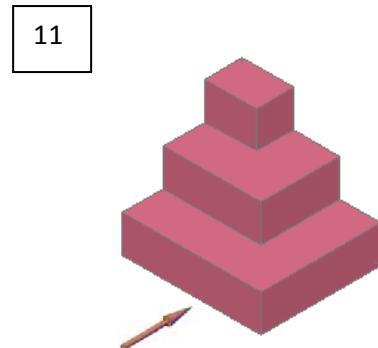
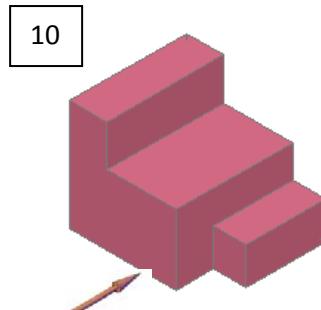
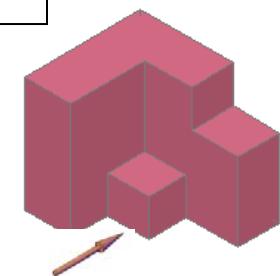
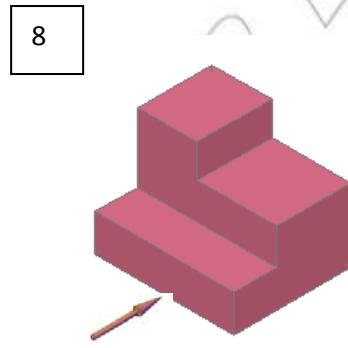
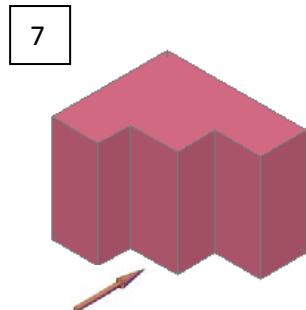
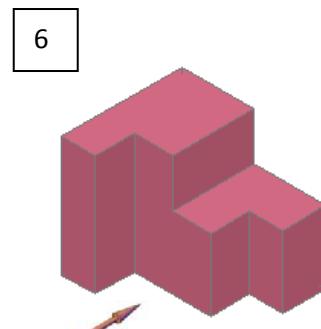
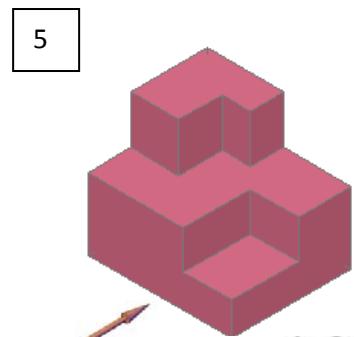
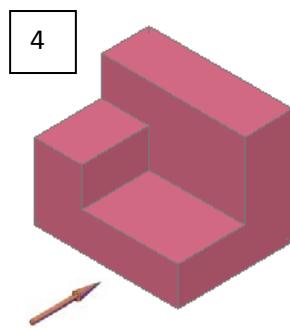
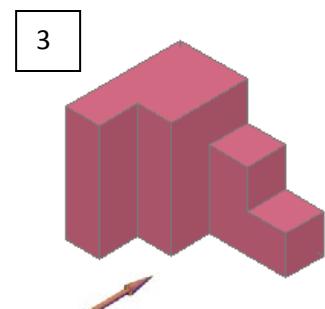
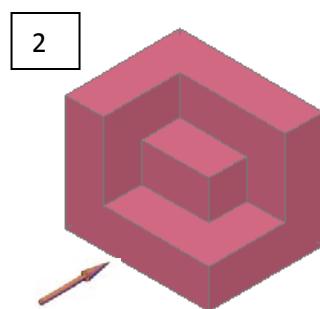
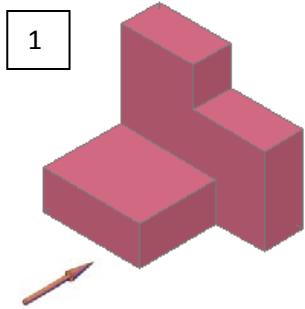
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12



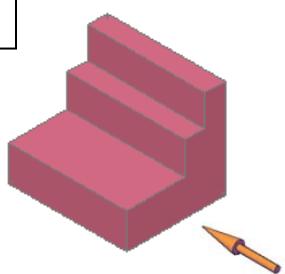
Exercise IV



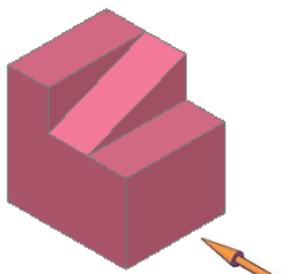
Exercise V: Missing line and missing view problems

Pictorial drawings of twelve objects are shown in Exercise V. Incomplete views of these objects are given in Exercise VI and VII. These views are randomly arranged. Match these views on your drawing paper to the given objects by writing the number of the object in the circles and complete the views by adding the missing lines or by drawing the third view.

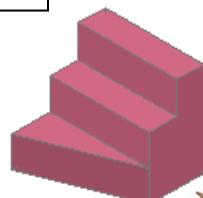
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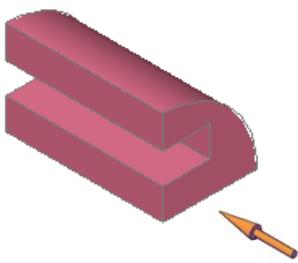
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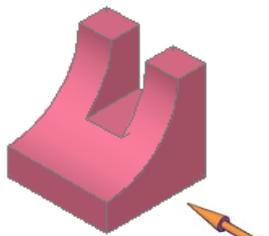
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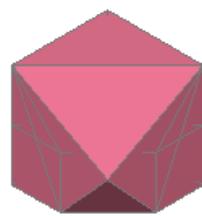
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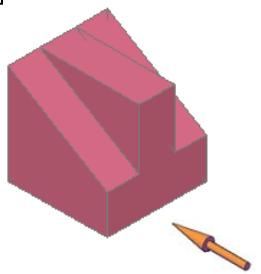
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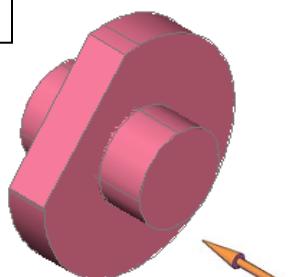
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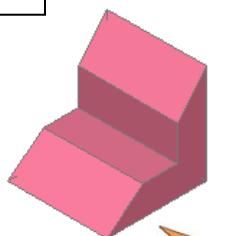
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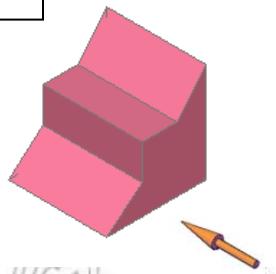
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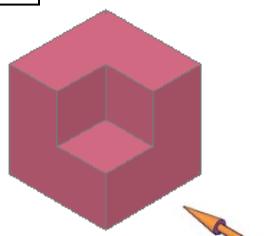
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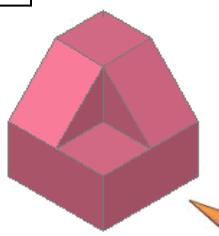
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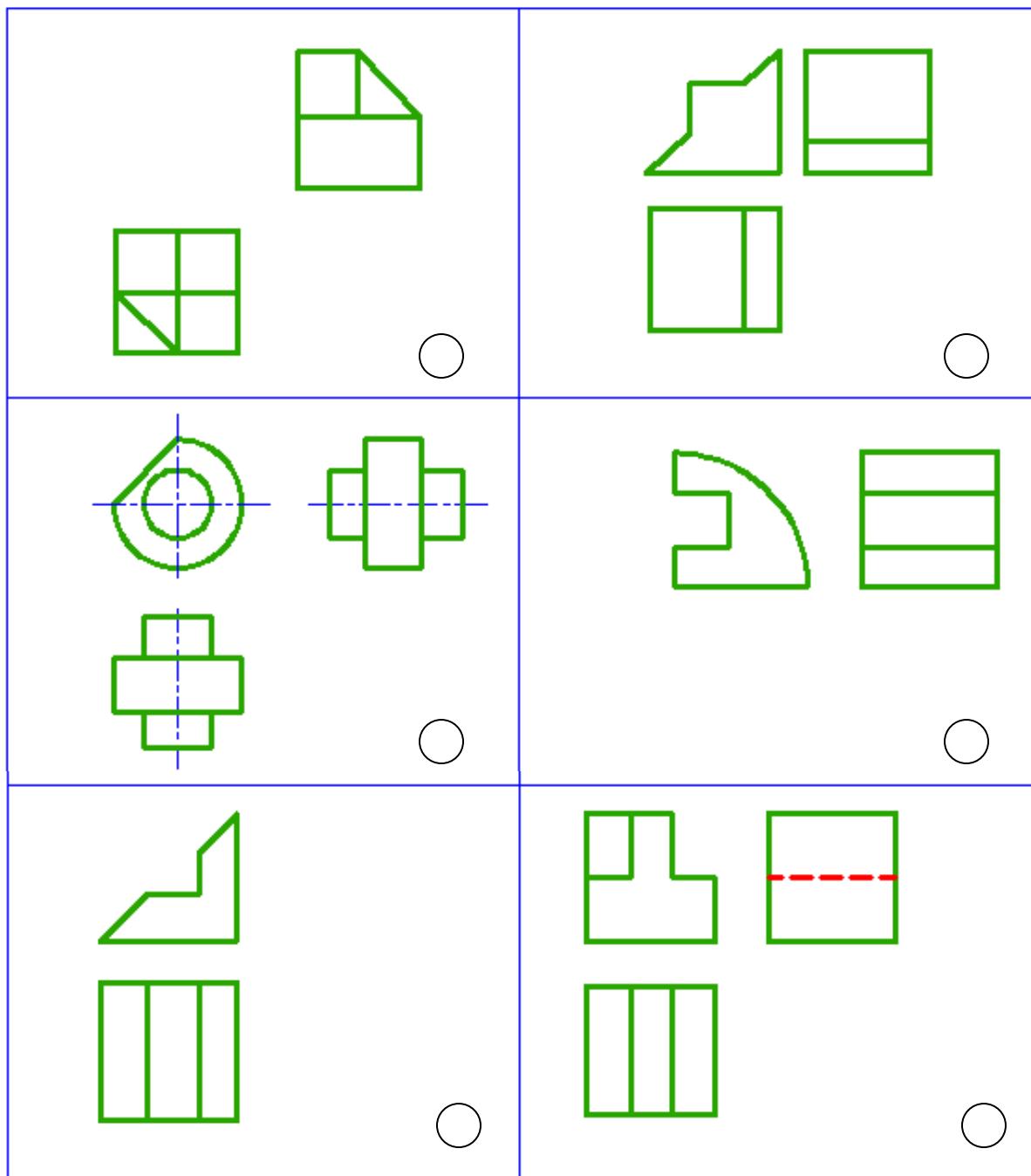
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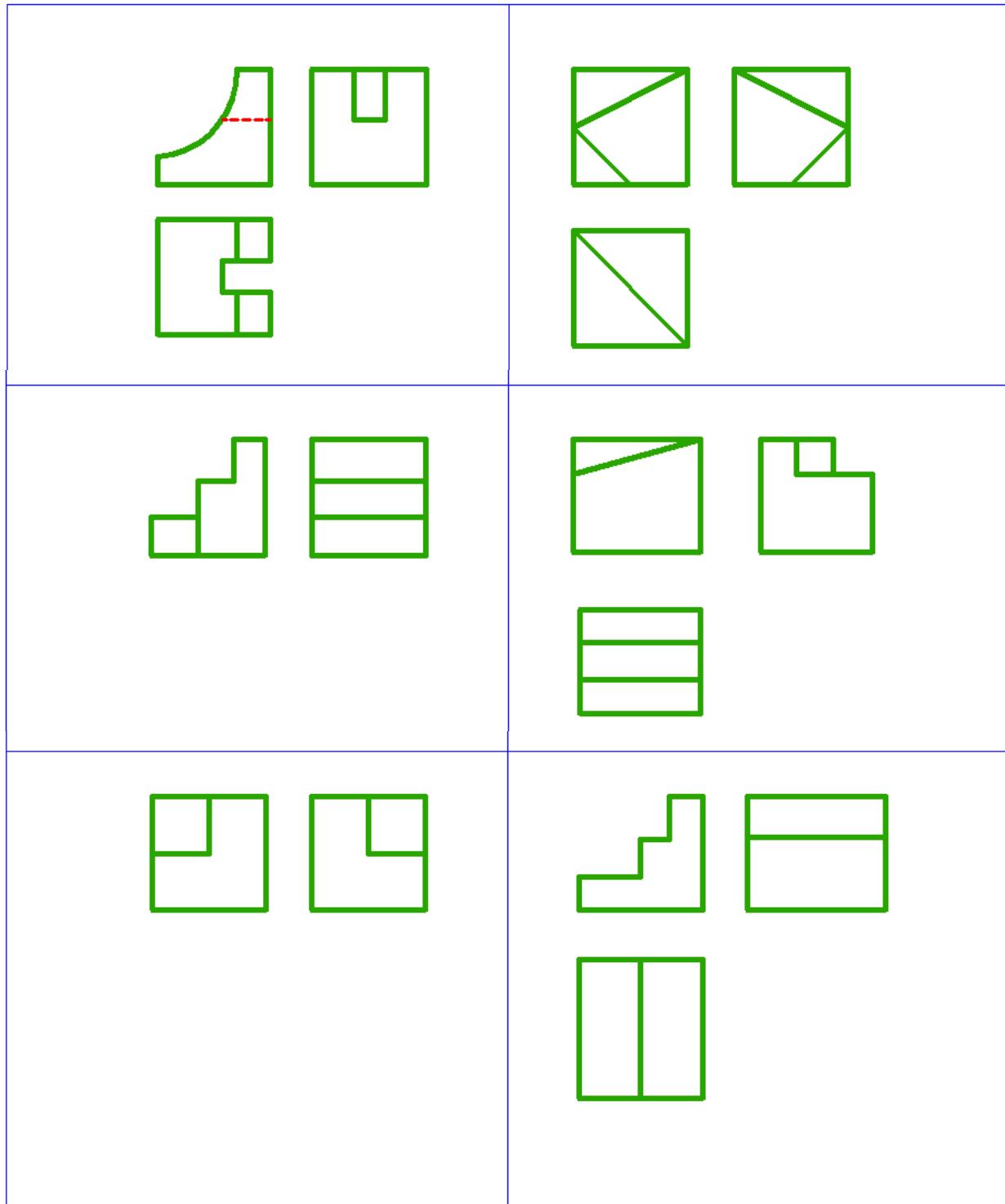
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Exercise VI: Given incomplete views

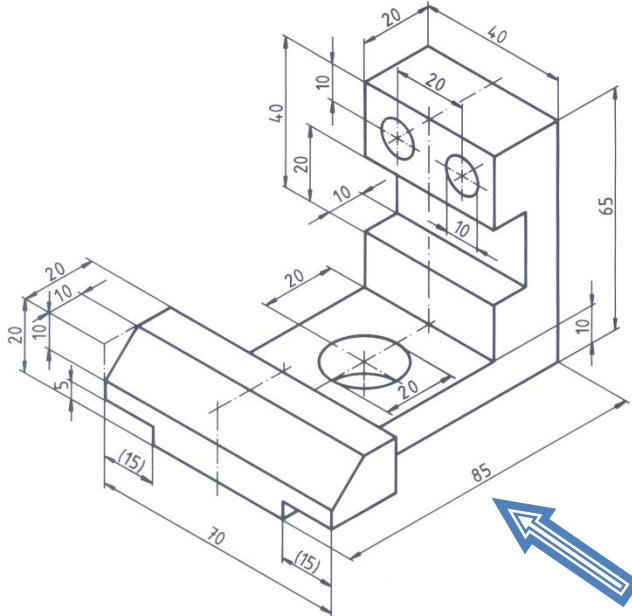
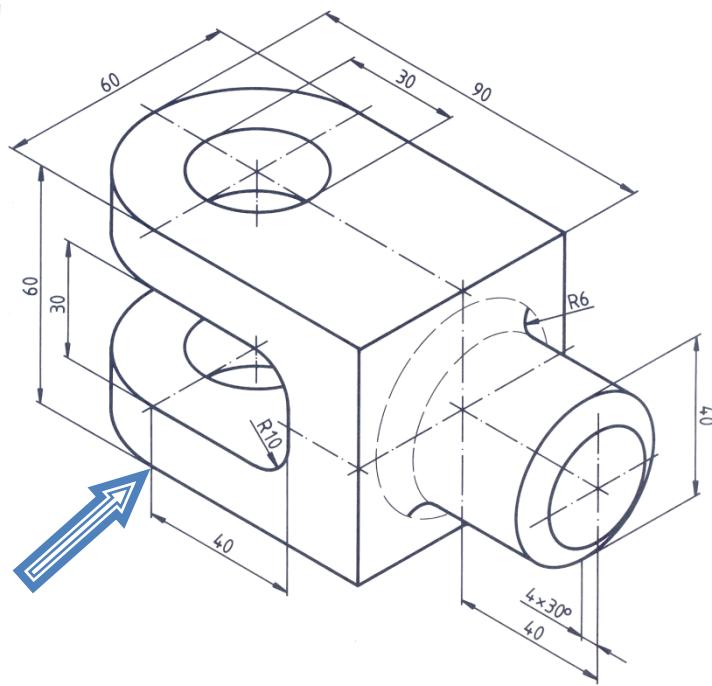


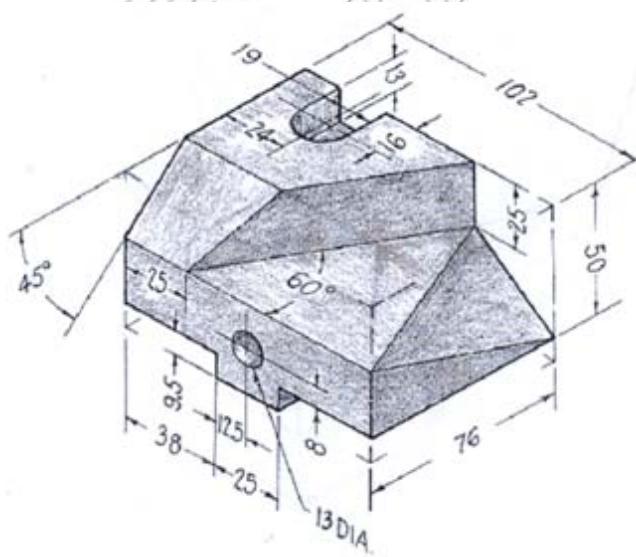
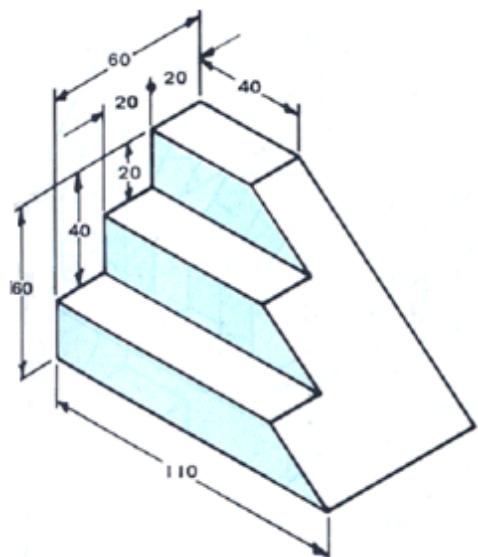
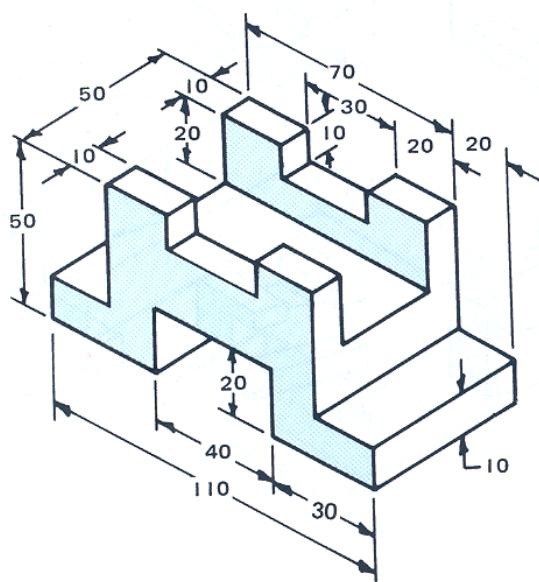
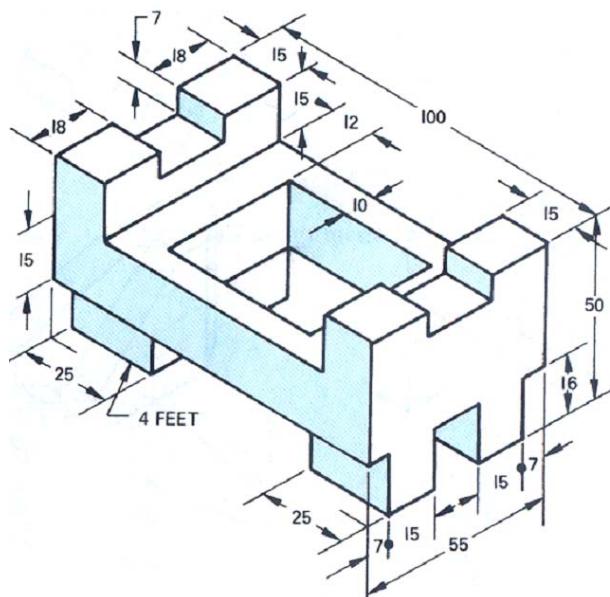
Exercise VII: Given incomplete views



Project

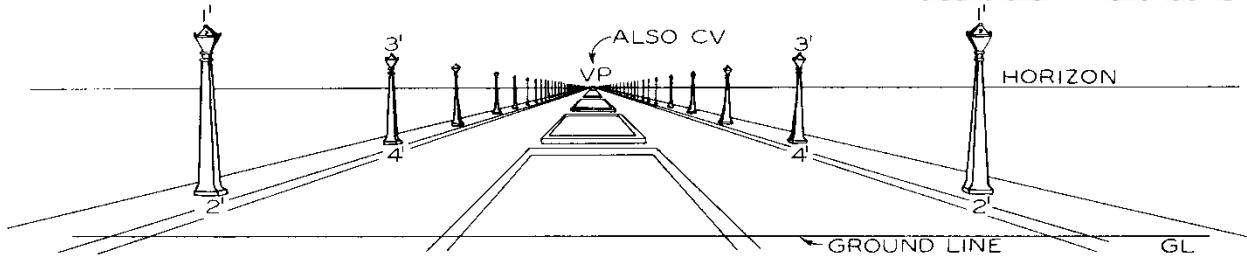
Using the first angle projection system, draw the three principal views of the objects whose pictorial drawings are given below. (The arrow shows the front direction of the object)





UNIT 7

PICTORIAL DRAWING



One point perspective

Learning Competencies:

Up on completion of this unit you should be able to:

- ✓ To identify the different types of projection systems;
- ✓ To develop the necessary level of competence in order to make pictorial representations using: Isometric drawings, Oblique drawings, and Perspective drawings;
- ✓ To understand the relationship of width, height and depth of an object in various types of pictorial representations;
- ✓ To decide upon the type of pictorial representation (isometric or oblique), which is best suited for particular needs;
- ✓ To apply the proper construction procedures to make pictorial drawings;
- ✓ To decide upon the position that shows the object to the best advantage in oblique or isometric drawings.

7.1 Introduction

In multi-view representation of an object, two or more views are used to describe its form or shape and size accurately. However, since each of the views shows only one face and two principal dimensions of an object at a time without any suggestion of the third principal dimension, such a representation can convey full information only to the professionals familiar with the graphic language i.e. technical drawing used mainly by engineers, architects, draftsman, and contractors. To this end, the professionals use conventional picture representations to communicate with other people who do not possess the required visualization skill to construct an object in the mind from its multi-view drawing. This pictorial representation of an object showing the three faces on a single plane to represent an object in its realistic appearance is known as pictorial drawing. Or pictorial drawing is a drawing by which shape and size of an object is expressed in three dimensions to show the three faces (i.e. height, width and depth).

Multi-view drawings are two dimensional drawings whereas pictorial drawings are three dimensional drawings. In spite of its advantage, pictorial drawing has the following limitations as compared to a multi-view drawing:

- ✓ it frequently has a distorted and unreal appearance of object being represented,
- ✓ relatively required more time to prepare pictorial representation of an object,
- ✓ it is difficult to measure and to give dimensions.

Due to these limitations, pictorial drawings are commonly used for technical illustra-

tions, pipe diagrams, patent office records, and architectural drawings, to supplement multi-view orthographic drawings.

Activity 7.1

1. Form a group and discuss about projection of a picture drawn or captured with a camera.
2. State some points on the real object which is three dimensional and how it appeared looking as a three dimension on a plane.
3. Observe the direction of the lines found on the picture and illustrate to other groups.

7.1.1 Theory of Projection

The term 'projection' can be defined as the representation of an object on a picture planes as it would appear to an observer stationary at a point and viewing along the direction of projection. Hence, in order to carry out the process of projection, five major constituting elements should be fulfilled:

- A. an *object* to be projected,
- B. an *observer* who is viewing the object,
- C. a *station point* where the observer is located,
- D. *projection rays* or *projectors* emitting from the observer to the picture plane, and
- E. a *plane of projection* or *picture plane* on which the projection is made.

The final outcome of the process of projection is an image of the object fixed on to the projection plane, which is usually termed as a *view* of the object.

Depending on the position of the observer relative to the object, projection can be categorized into two broad groups namely:

central or perspective projection and parallel projection.

I. Central or perspective projection: is a type of projection made on a picture plane in such a way that an observer is located at a finite (fixed distance) from the object being projected; therefore the projectors would converge to a point called *station point* or *point of sight* of an observer as illustrated in Fig. 7.1.

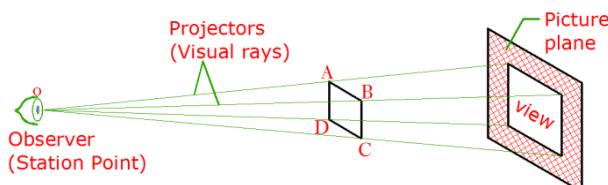


Fig. 7.1 Principle of central projection

In perspective projection, the perspective view formed on the picture plane is of a different size and shape as compared to the actual object.

II. Parallel projection: is a type of projection made on a picture plane in such a way that an observer is located at an infinite distance from the object being projected, therefore the projectors will be parallel to each other (see Fig. 7.2).

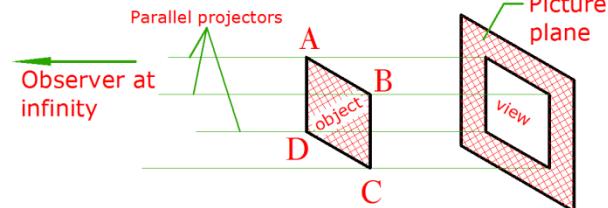


Fig. 7.2 Principle of parallel projections

In parallel projection, the view formed on the picture plane is of the same size and shape as that of the object. This will

simplify transferring of linear and angular measurements of an object during projection. Parallel projection can be further divided into two groups depending on the angle formed between projectors and picture plane. These are:

- Oblique projection, and
- Orthographic projection.

A. Oblique projection: is a type of parallel projection obtained in such a way that the projection lines are made to be oblique or at an angle other than 90° to the picture plane. Hence the three principal faces of the object will be seen on a single picture plane.

B. Orthographic projection: is a type of parallel projection obtained in such a way that the projection lines are made to be perpendicular or at an angle of 90° to the picture plane. Hence only one principal face of the object will be seen on the picture plane. For the detailed discussion refer unit 6 multi-view drawing. The term "Orthographic" is derived from words "Ortho" and "graphics" to mean "Draw at right angle."

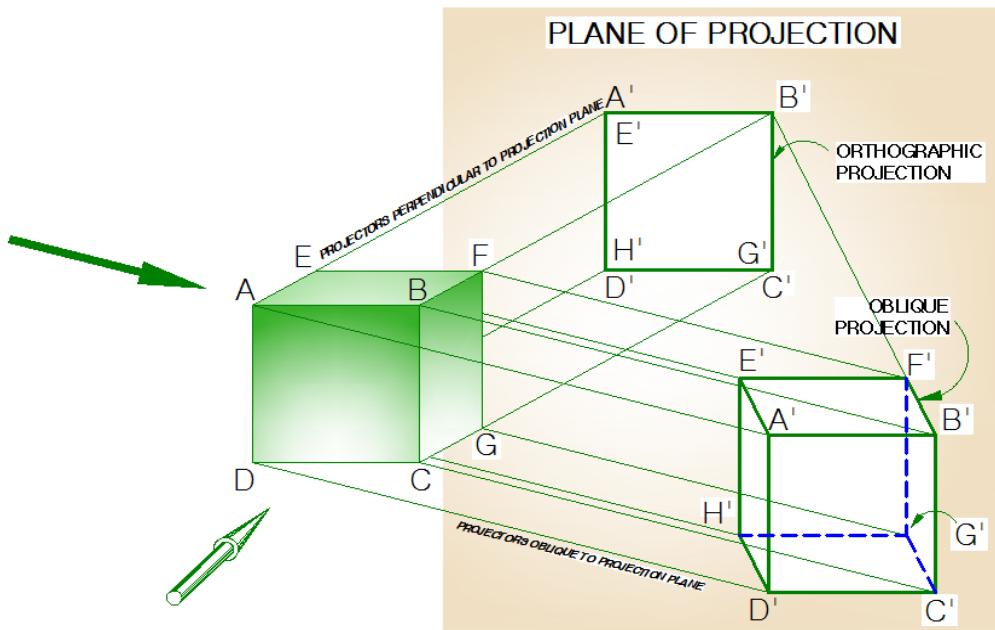


Fig. 7.3 Principle of oblique and orthographic projections

As shown in Fig.7.3, orthographic view provides the projection of only the front or rear face of the cube while oblique projection shows the three principal faces. In order to fully describe the principal faces of an object using orthographic projection, two methods can be employed. Either the object should be projected onto additional picture planes (as in the cases of multi-view projection), or it should be rotated and tilted about the picture plane so that all the three principal faces will be inclined (as in the case of axonometric representation).

In orthographic projection, if the edges of the cube, however, are inclined to the picture plane the projection is referred to as axonometric projection. To do so the cube is

first rotated about a vertical axis and tilted backward as shown in Fig.7.4 until the three principal faces are visible to an observer.

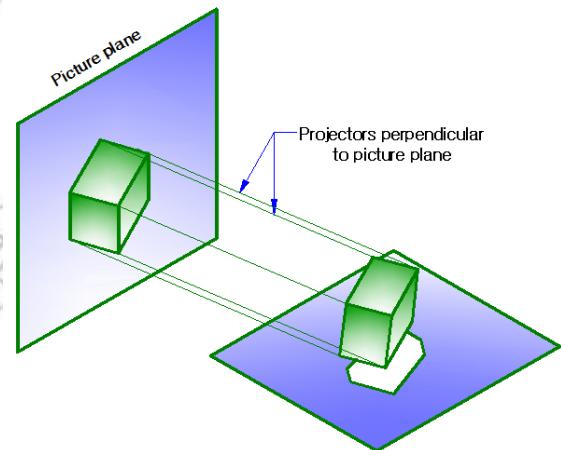


Fig. 7.4 Principle of axonometric projection

Considering the angle of inclinations of the edges of a cube with respect to the projection plane, axonometric projections may be

classified into three categories as isometric projection, diametric projection and trimetric projection, which will be discussed in section 7.2.1.

The detail of these projection systems is presented in the subsequent sections of this chapter. In general classification hierarchy of projection can be summarized by using a projection tree shown in Fig.7.5.

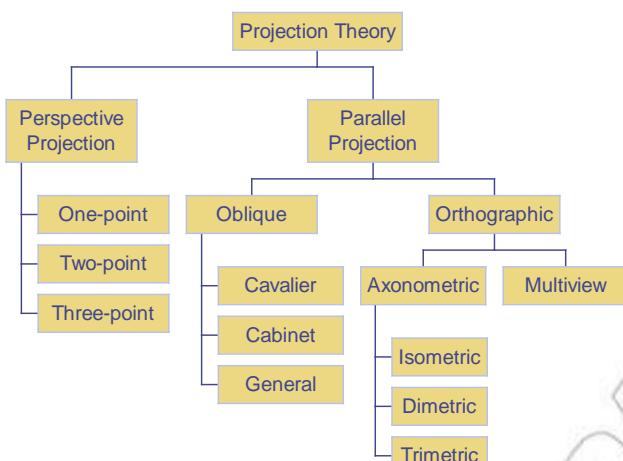


Fig. 7.5 Projection tree

Checkpoint 7.1

1. What is projection? What constituting elements should be fulfilled to undertake projection?
 2. What are the two broad categories of projection? Briefly explain the difference between them.
 3. Describe the basic similarity and difference between orthographic and oblique projections.

7.1.2 Types of Pictorial Drawing

Pictorial drawing, as discussed earlier, is a means by which the three principal faces and dimensions of an object are represented on a single 2D projection plane (sheet of paper). Pictorial drawing is divided into three classifications:

- i. Axonometric projection,
 - ii. Oblique projection, and
 - iii. Perspective or central projection.

The difference among the three projection types is illustrated pictorially as shown in Fig. 7.6.

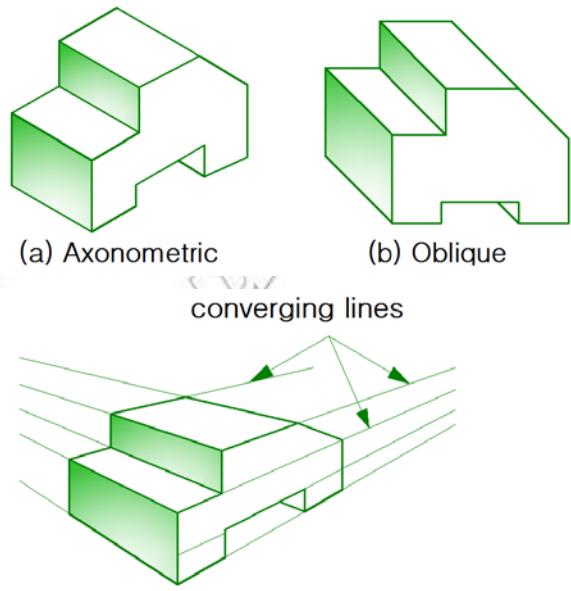


Fig. 7.6 Axonometric, oblique and perspective projections

Checkpoint 7.2

1. What are the main purposes of pictorial representation? What limitations does it have when compared to multi-view representation?
2. Briefly describe the three types of pictorial representations.

7.2 Axonometric Projection

It is a form of orthographic projection that shows the three principal faces of an object on a single projection plane (picture plane) unlike multi-view projection which uses three different projection planes for the three principal faces. In axonometric projection, the object is placed in an inclined position with respect to the plane of projection so that its principal faces will be displayed principally in axonometric projection.

The following three steps should be considered in placing the object when trying to display the axonometric projection of an object on a picture plane as shown in Fig 7.7.

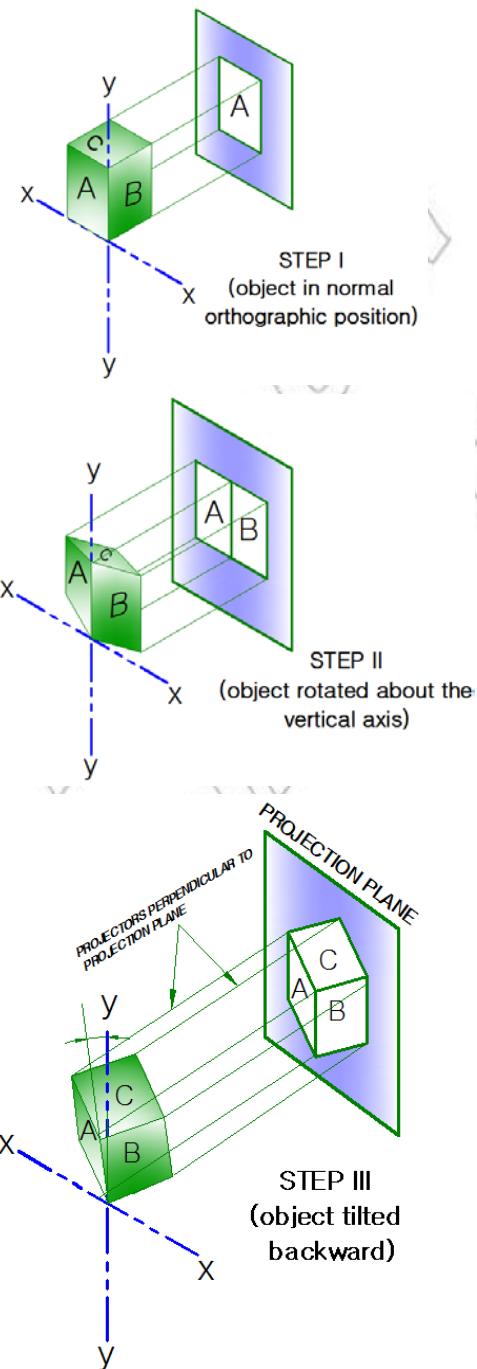


Fig. 7.7 Theory of axonometric projection

Step1: The object is first placed in its customary position, with one principal face made parallel to the picture plane.

Step2: It is then rotated from its ordinary position about the vertical axis through any proper angle so as to display the two lateral faces on the projection.

Step3: Finally the object is tilted forward or back ward through again any desired angle so as to display the third face i.e. top or bottom and then projected on the picture plane.

7.2.1 Types of Axonometric Projection

1. What do you understand from the words isometric, diametric and trimetric literally?
2. from your sketch of a box, observe the angle between the lines. Are they identical or have the same angles or does it differs?

An object may be placed in an infinite number of positions relative to the projection plane. As a result, a countless number of views of an object may be formed which will vary in proportions and shape. For practical reasons in pictorial drawing, three possible positions have been identified as division of axonometric projection:

- i. Isometric Projection
- ii. Dimetric Projection
- iii. Trimetric Projection

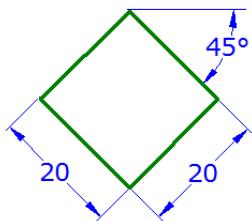
I. Isometric Projection:

Literally the term "isometric" is a combination of two words "iso" and "metric" which means 'equal measures'. It is the simplest and most popular type of axonometric projection, because the three principal edges of a cube make equal angles with the projection plane, and hence will be foreshortened equally on the isometric projection. These principal edges are usually referred to as *isometric axis*.

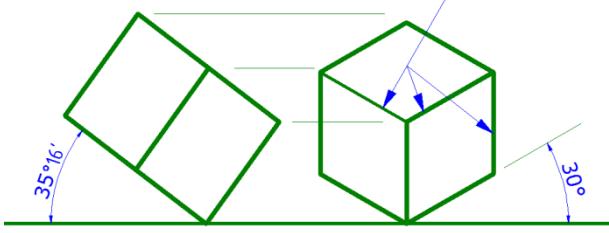
In isometric projection, an object is rotated through 45° angle about a vertical axis, and then tilted backward with an angle of $35^\circ 16'$ from the top face. In this case, the three isometric axes will make an angle of approximately $35^\circ 16'$ with the vertical plane of projection. The projections of these axes will make an angle of 120° with respect to each other. The projected length of the principal edges of an object are approximately 81.6% or 82% or 0.82 of their true length.

In order to make an isometric projection of a cube of known side length, there are two alternative methods.

- A. By turning and tilting the object in relation of a given projection plane as shown on Fig.7.8.

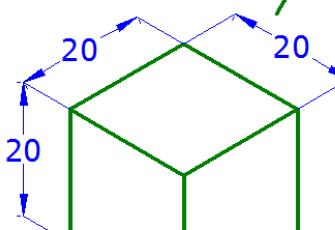


(I) Revolving object

NOT TRUE LENGTH
APPROX. 0.8 ACTUAL SIZE

(II) Tipping the object

(III) Isometric projection

DRAWING OBJECT TO
ACTUAL MEASUREMENTS

(IV) Isometric Drawing

Fig. 7.8 Isometric projection

- B. By turning the plane till it is made perpendicular to the body diagonal or using primary and secondary auxiliary view.

The foreshortening of edges will lead us to the problem of selection of isometric scale which is a special measurement scale which can be prepared on a strip of paper or cardboard.

Construction of Isometric Scale Length

Draw a horizontal line of any defined length. At the left end of the line draw another line at angles of 30° to represent the isometric length measured from isometric scale and at an angle of 45° to represent the true length measured from ordinary scale. Mark any required number of divisions on the true length line. From each division points of true length line draw vertical lines perpendicular to the initial horizontal line so as to get intersection points on the isometric length line representing corresponding points.

The divisions thus obtained on the isometric length give the different lengths on isometric scale. The isometric drawing obtained by using the true lengths will be exactly of the same shape but larger in proportion than that obtained by using the isometric lengths.

The view draw with the use of ordinary scale is called isometric drawing while that drawn with the use of isometric scale is called *isometric projection*.

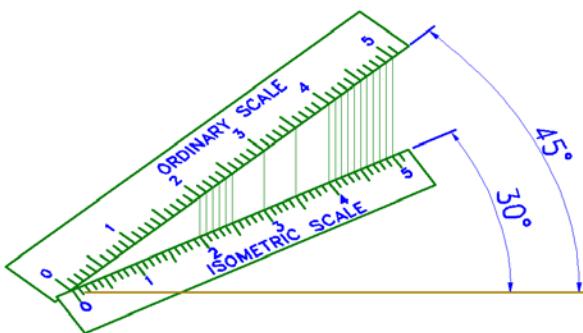
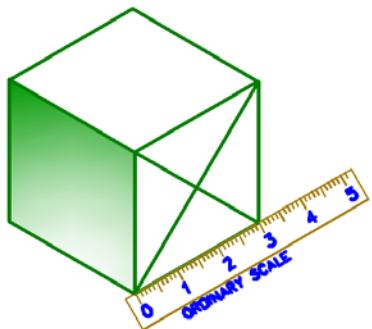


Fig. 7.9 Isometric scale

In using the isometric scales actual length of an edge is first measured by an ordinary scale from an object and the same reading will be laid off along the isometric axis with the help of the isometric scale.



a) Given object (Measured by Normal-scale)

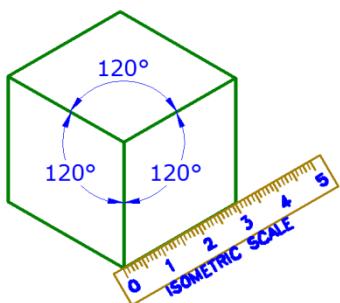
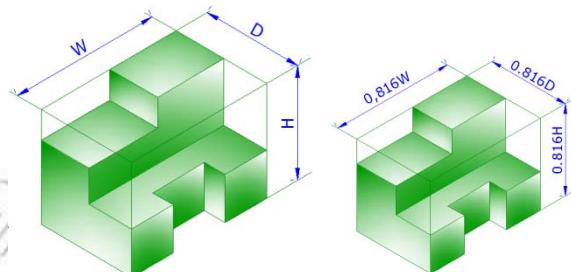
b) Isometric Projection
(Measured by Isometric-scale)

Fig. 7.10 Using the isometric Scale

Therefore isometric pictorials are generally divided into two:

A. Isometric projection: is a type of axonometric projection having parallel projectors that are perpendicular to the picture plane. With this projection, the diagonals of a cube appear as a point. The three axes are spaced 120° apart and the sides are shortened 82% of their true length.

B. Isometric drawing: is the same as isometric projection except the sides are drawn in true length. This makes it appear like the isometric projection. It is not a true axonometric projection but produces an approximate view. Usually it is prepared by transferring actual or true length of the object along isometric axes using ordinary scale. Fig. 7.11 compares the isometric projection with isometric drawing.



a) Isometric drawing b) Isometric projection

Fig. 7.11 Isometric drawing and isometric projection

In general practice to represent an object pictorially, isometric drawing is used for its ease of construction simply by taking true length dimensions directly from the orthographic view of the object.

II. Dimetric Projection

It is a form of axonometric projection in which two scales of measurements are used. The same scale is used along two axes but a different one is used along the third axis. Two of the axes make equal angles with the plane of projection while the third axis makes a different angle with the plane. As a result, the two axes making equal angles are equally foreshortened, while the third axis is foreshortened in a different ratio. In practice dimetric projection has very little application due to the difficulties in transferring measurements with various scales. Since two different scales are used, less distortion is apparent than isometric drawing.

In dimetric drawing, the angles formed by the receding axes and their scales are many and varied. Fig.7.12 shows some of the more generally used positions of axes and scales. These scales and angles are approximate.

Dimetric templates and grid papers are available to aid in the construction of dimetric drawing, where the templates have appropriate scales.

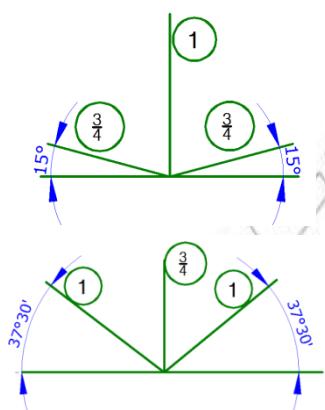


Fig. 7.12 Scale and axes commonly used in dimetric drawing

III. Trimetric Projection

It is a form of axonometric projection in which different scales are used to lay off measurement and all the three axes are differently foreshortened. The object is so placed that all the three faces and axes make different angle with the plane of projection.

The advantage of trimetric drawing is that they have less distortion than diametric and isometric drawing. Dimetric and trimetric projections have little practical applications as compared to isometric projections. Fig.7.13 shows isometric, diametric, and trimetric projections.

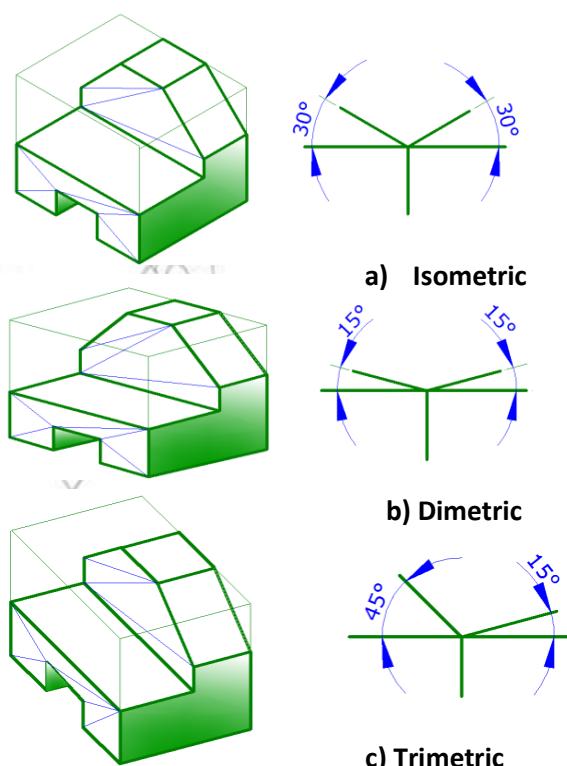


Fig. 7.13 Alternative positions of an axonometric projection

7.2.2 Alternate Position of Isometric Axes

The three front edges of the enclosing box, shown in Fig.7.14, are referred to as isometric axes. In an isometric drawing of a simple rectangular object, the isometric axes are first drawn at an angle of 120° with each other. The two receding axes along which the width and depth dimension are transferred are drawn at an angle of 30° with a horizontal line drawn through the intersection point of the axes. These isometric axes may be placed in any one of the four alternative positions as shown in Fig.7.14. However, the angles between the adjacent axes must remain 120° .

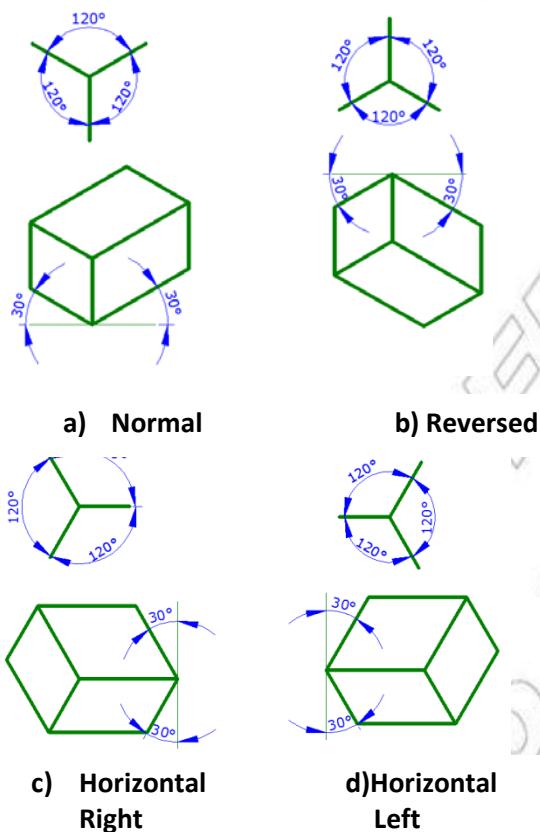


Fig. 7.14 Alternative Positions of Isometric Axes.

The choice of the position of the axes is determined by the position from which the object is usually viewed, or by the position which best describes the shapes of the object. If an object is characterized by proportional depth, width and height the normal position of the axes shown by choice Fig.7.14 (a) is most appropriate. However, if the natural viewing direction is from below then choice (b) would be appropriate. In the case of a long slender object, which has a considerable width as compared to its depth and height, the choice (c) and (d) would give the best effect.

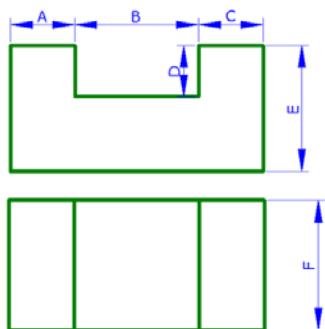
Activity 7.2

1. Sketch a cube having an inclined plane or trim one of the cube's edge and observe how the direction of the line goes to represent the inclined plane.
2. Form a group and discuss with your friends how to represent an object which has a circle or an irregular curve on it. Use sketch to illustrate this.

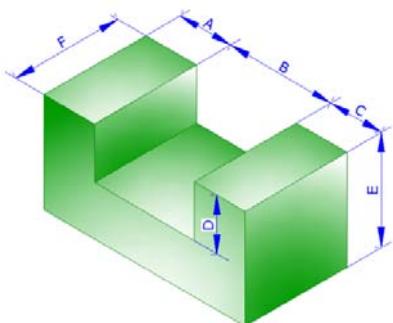
7.2.3 Lines and Angles in Isometric Drawing

Isometric and non-isometric lines

Isometric lines are edges of an object whose positions are parallel to the isometric axes. In an isometric drawing, isometric lines are laid off with full scale along the directions of the isometric axes by transferring the actual lengths directly from the orthographic views on to the isometric drawing. For the object shown in Fig.7.15, the edges that define its characteristic shape are all isometric lines. Hence, their actual lengths are transferred directly from the orthographic views to the isometric drawing.



a) Given views



b) Isometric view

Fig. 7.15 Constructing Isometric Edges

Non-isometric lines are those lines or edges of an object which are inclined and are not parallel to the isometric axes. Such a line doesn't appear in its true length and cannot be measured directly in the isometric drawing. Its position and projected length is established by locating its starting and ending terminal points on the isometric axes. For the object shown in Fig.7.16 edges AB and CD of the included surface $ABCD$ are non-isometric lines. These lines cannot be directly transferred from the orthographic view to the isometric drawing. The location of the inclined line AB is determined by locating the end points A and B on their respective isometric edges. Point A must be

located on the top edge, 15 units distance from the top-right corner; and point B is located on the front face, 15.2 units below the upper edge and 18.7 units from the left edge. Then, connect A and B to get the projection of edge AB on the isometric drawing. Follow similar steps to lay off edge CD . Notice that line AB on the isometric drawing is of different length as compared to its actual length shown in the orthographic view.

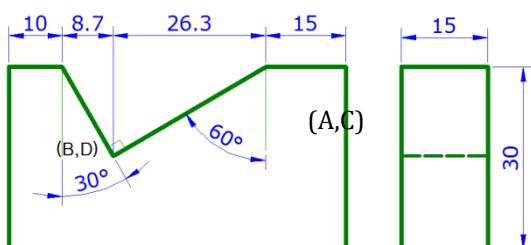
Note that hidden lines are usually not used in any form of pictorial drawing. To show all edges which are not visible would make the drawing difficult to read. In some cases however, hidden lines may be used to show a feature of the object which is not visible.

Angles in isometric drawing

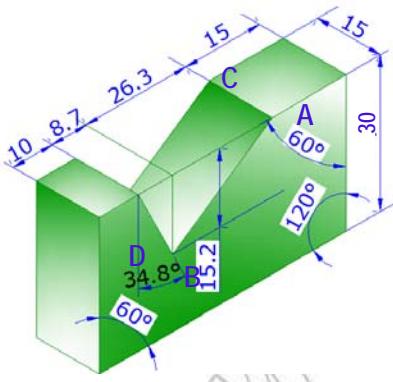
The isometric axes are mutually perpendicular in space. However, in an isometric drawing they will appear at 120° to each other. As a matter of fact, angular measurements of an object specified in orthographic views do not appear in their true sizes in an isometric drawing. These angles cannot be measured in degrees with an ordinary protractor. Special isometric protractors are available for laying off angles in isometric. If an isometric protractor is not available, all angular measurements must be converted to linear measurements, in a manner which can be laid off along isometric lines in a pictorial drawing. To locate an inclined edge of an object that has been specified by an angular dimension, usually one or more linear measurements are taken

from an orthographic view and set off along isometric lines.

Fig.7.16 shows again isometric construction of an object with angles using distance transfer method along isometric axes. Notice that none of the interior angles of a plane in its orthographic representation will be projected in the same size in the isometric drawing. Since the shape of a surface will be distorted when projected onto an isometric plane, angles cannot be setoff directly in isometric drawing. It is necessary to locate the end points of the lines which subtend the angles using linear measurements as illustrated in the figure.



a) Given views



b) Isometric view

Fig. 7.16 Isometric construction of non-isometric edges

7.2.4 Regular and Irregular Curves in Isometric Drawing.

Circles and Arcs in Isometric Drawing

Many objects involve circles and other curves in their construction. In Isometric projection, a circle will appear as an ellipse. This ellipse is usually called as *isometric circle*. The true or accurate ellipse can be constructed by means of a series of offset measurement as shown in Fig.7.17. To begin with; required numbers of points are established on the circumference of the circle either by dividing it into equal number of parts or assuming random spacing.

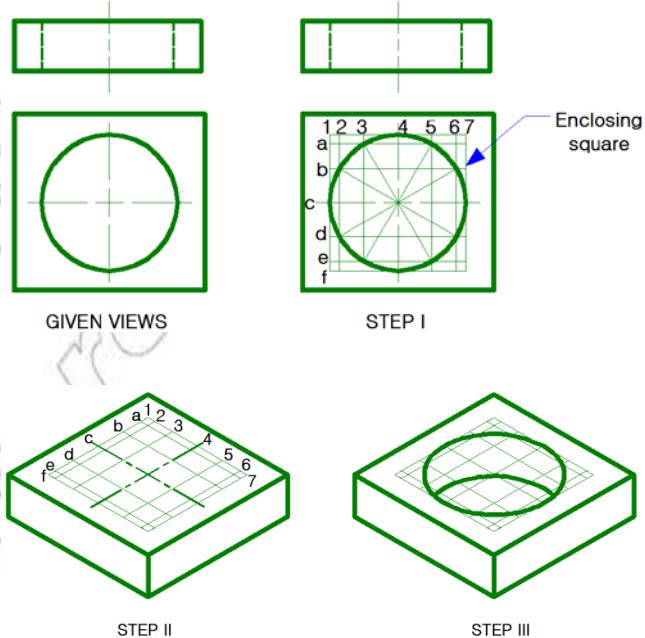


Fig. 7.17 Construction of isometric circles by offset measurement

As shown in step-I of fig 7.17, the points a, b, c,... on the circumference of the circle are chosen at random spacing. In the isometric

drawing, point A is located by transferring the offset measurements with respect to the isometric edges. In a similar manner, all other points are located by offset measurements. Finally draw smooth curve that connects all the points located using French curve so as to represent the isometric circle (ellipse) of the object; however this method of ellipse construction is tedious and time consuming. Therefore now a day for most practical purpose another approximate method called *four center method* is used. In this method of ellipse construction a square is conceived to be circumscribed about the circle in the orthographic projection. This square will be distorted and becomes a rhombus (isometric-square) which becomes tangent to the ellipse at the midpoints of its sides. The two corners at the larger angle of the rhombus are used as two of the four centers to draw the larger arcs of the ellipse. The intersection points of the perpendicular bisectors of the sides of the rhombus laying inside the rhombus will be the remaining two centers for the two smaller arcs to complete the ellipse.

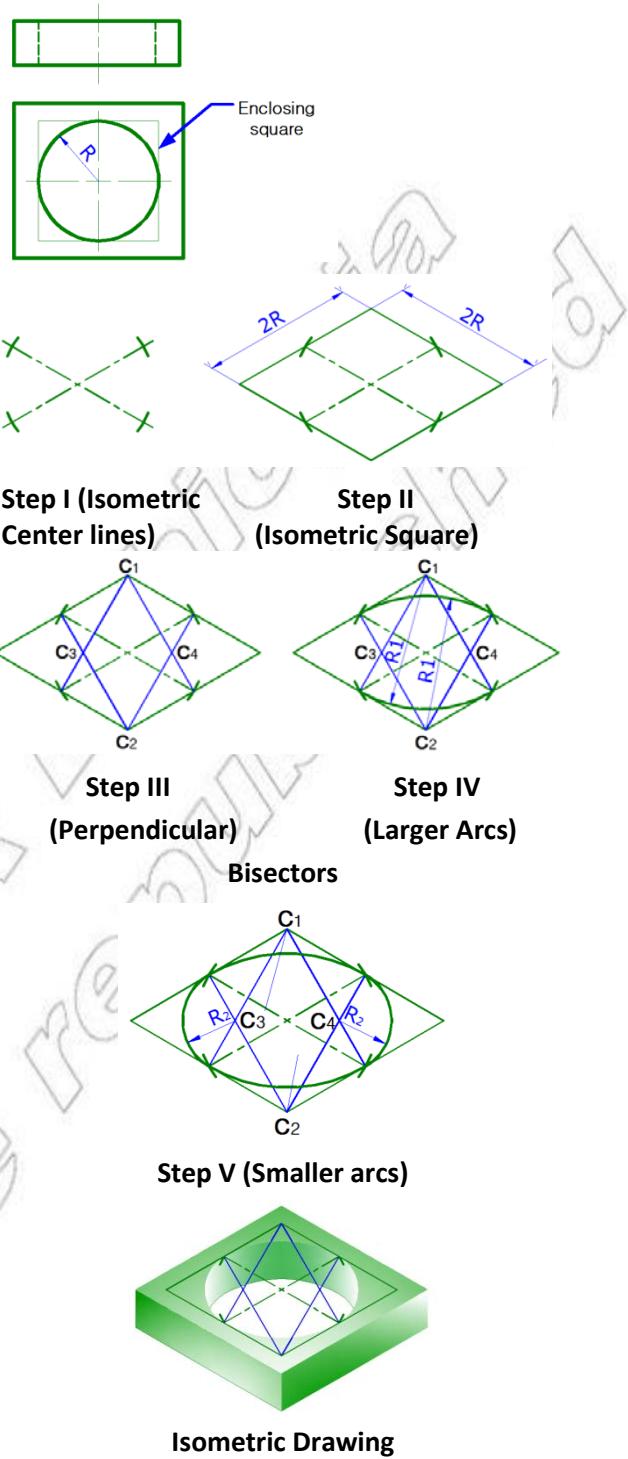


Fig. 7.18 Construction of isometric circle using four center method

These steps will be summarized as follows:

Step I. Locate the position of the center point, O , of the circle on the isometric plane and construct the isometric center lines of the circle with light lines parallel to the isometric edges. Using a radius, R , which is equal to the radius of the circle in the orthographic view, strike arcs across the isometric center-lines.

Step II. Complete the rhombus, whose side lengths are equal to the diameter of the given circle, by drawing light line through the intersections of the four arcs and the center lines.

Step III. Erect perpendicular bisectors to each sides of the rhombus. These perpendiculars will pass through the opposite corners of the rhombus. Identify the four intersection points C_1 , C_2 , C_3 , and C_4 of the perpendiculars, which are assumed to be center points of the approximating arcs to be shown.

Step IV. Use C_1 and C_2 as centers and the length from these centers to the midpoint of the opposite sides (r_1) as a radius, draw the two larger arcs of the ellipse.

Step V. In a similar manner, use C_3 and C_4 as centers and the length from these centers to the midpoint of the near sides of the rhombus (r_2) as a radius, draw the remaining two smaller arcs to complete the approximate ellipse.

In isometric drawing circular arcs (incomplete circles) will be represented as incomplete ellipse drawn with the same procedure and principle using four center method. For quarter and semi circle it will be sufficient to use one and two centers respectively.

Concentric circles in an isometric drawing will share one central point and the same center lines (see Fig. 7.19). To draw isometric concentric circles, two sets of approximating centers are located. The first sets of four centers are used to construct the external ellipse and the second set of four centers for the inner ellipse. All the other procedures to establish the four centers for both ellipses are the same except the circular size difference in isometric plane.

When circles and arcs are to be drawn on parallel planes, the four centers can be moved along the isometric axes. The same radii can be used to draw the arc or circle on the parallel plane.

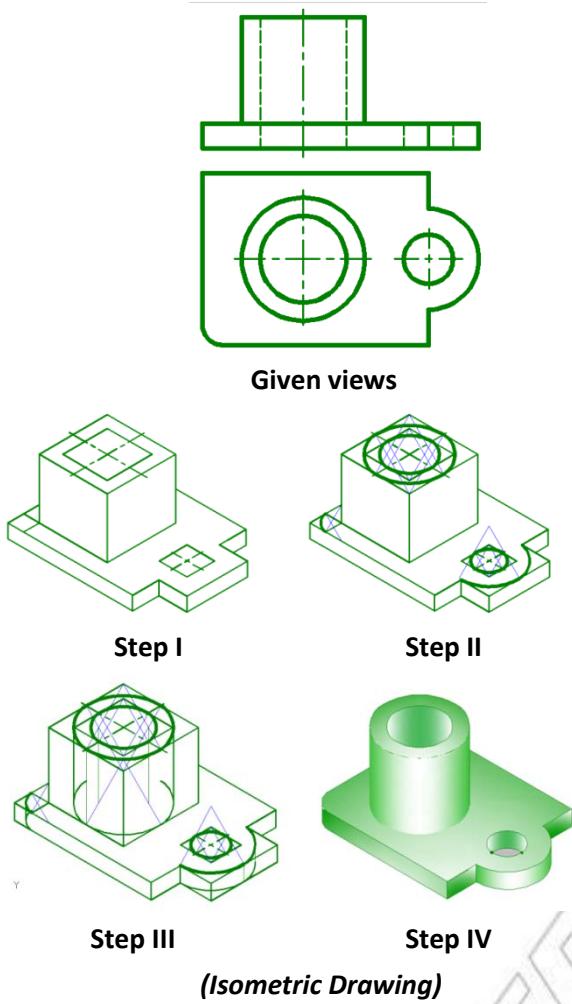


Fig. 7.19 Isometric circles and arcs on parallel planes

In general, two types of common mistakes are frequently committed by students in making isometric circles and arcs on isometric drawings. The first error is drawing the isometric circle out of the proper isometric plane. This mistake can be resolved by initially drawing the four sides of the enclosing rhombus of the ellipse parallel to the edge of the isometric planes on which the ellipse are drawn. The second error is failing to put tangent lines between parallel arcs and circles to show the depth

(thickness) of a cylindrical part. These shortcomings are illustrated by Fig. 7.20.

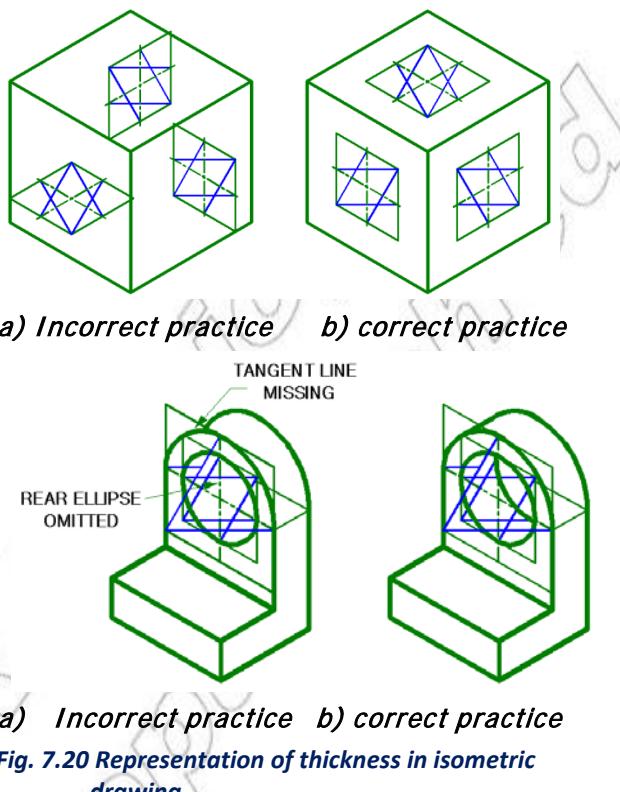


Fig. 7.20 Representation of thickness in isometric drawing

Irregular curves in isometric drawing

An irregular curve is drawn in isometric by means of a series of offset measurements discussed earlier in the construction of true ellipse. See Fig. 7.21.

Any desired numbers of points are randomly selected along the curve in the given views. The number of points should be sufficient enough to construct the curve accurately. Offset grid lines are then drawn from each point parallel to the principal edges of the plane. These offset measurements are laid off

on the isometric plane to locate all points on the irregular curve as in step-II.

The parallel curve is drawn by moving the points parallel to the isometric axes through these points a distance equal to the thickness of the curved part. The final solid curve is drawn by using French curve as shown in step-III.

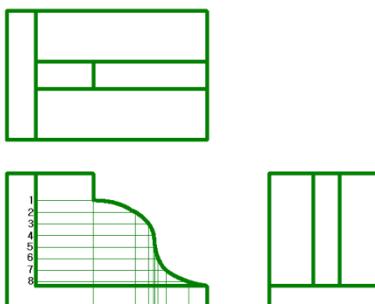
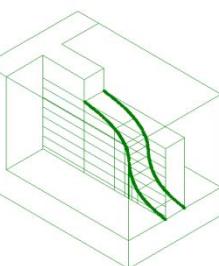


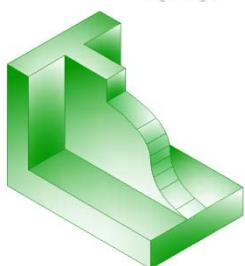
Fig. 7.21 Curves in isometric drawing

Step I

Step II



Step III Drawing



Step IV Isometric

block. The positions of such extrusion of cut offs are located by using offset measurements. This method is shown in Fig.7.22.

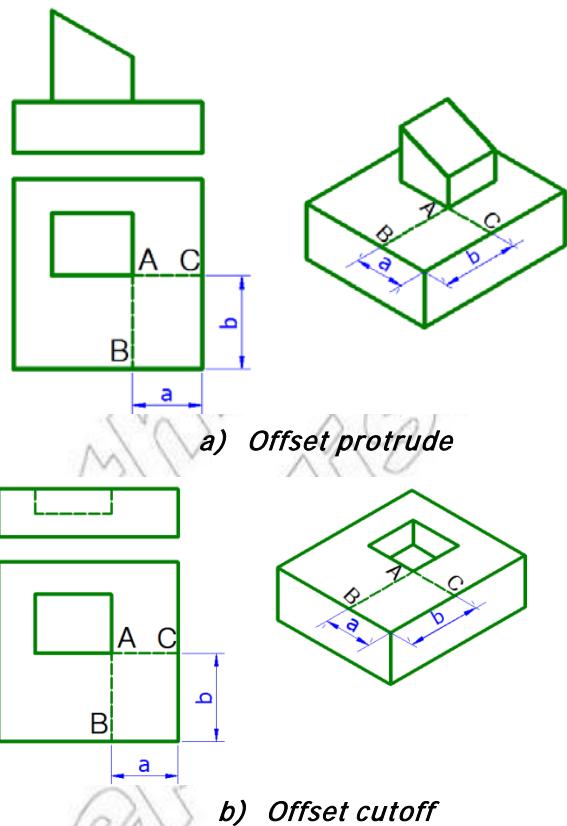


Fig. 7.22 Offset Location measurements in isometric drawing

As shown in the above two cases, initially the basement boxes have been drawn to full scale. Then the offset lines AB and AC in the multi-view orthographic projections are transferred to the main blocks to locate point A in both cases. These measurements are referred to as *offset measurements*, and they are measured parallel to the isometric axes. Taking point A as reference, the rectangular wedge shown in case (a) or the rectangular hole shown in case (b) is drawn with the same scale.

Offset location Measurement

In a complex object there may be parts which are protruded or else removed from the main

7.2.5 Isometric Construction

There are two methods of isometric construction:

1. Box method, and
2. Centerline lay out method

1. Box Method

In this method of isometric construction, the object is assumed to be fully enclosed within an isometric box whose sides coincide with the overall dimensions of the object.

Making Isometric Drawing

To make isometric drawing, choose the position of the axes that will best show the object or the sides that is most important. The following steps are used to make an isometric drawing from the given orthographic views as shown on Fig.7.23.

Step I. Lay out the isometric axes in any required position at 120° a part.

Step II. Transfer the overall dimensions i.e. Height, width, and depth from the orthographic view along the isometric axes accordingly so as to have a block in the size of the object.

Step III. Draw the isometric box, with light construction line in which the object is contained.

Step IV. Locate the other features by transferring dimensions along the corresponding isometric axes or lines drawn parallel to isometric axes from the orthographic views.

Step V. Complete the isometric drawing of the object.

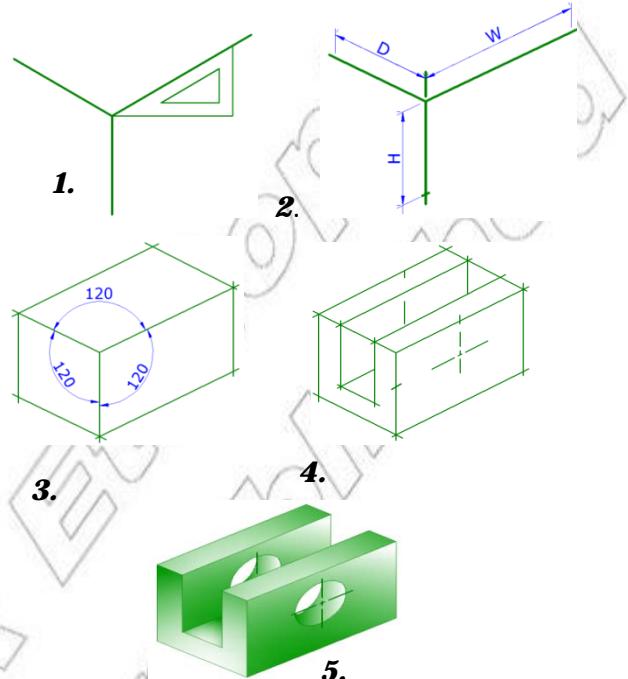
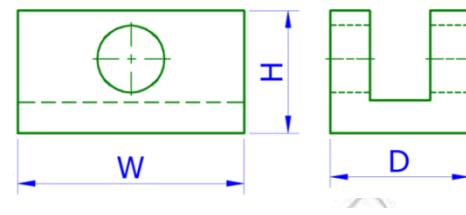


Fig. 7.23 Construction of isometric drawing

Checkpoint 7.3

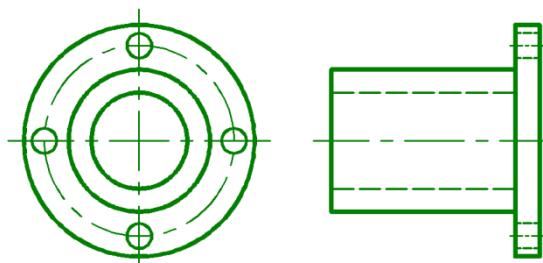
Make an isometric drawing for the orthographic views given below using box method of isometric construction.



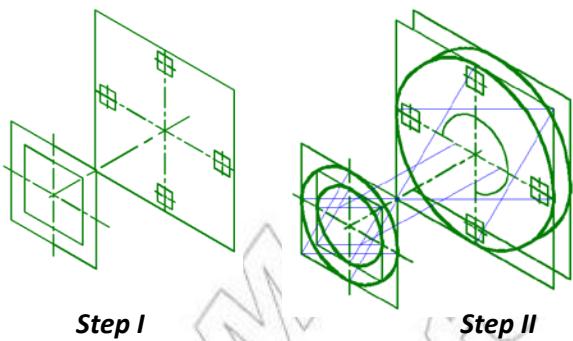
2. Centerline Layout Method

When the object is cylindrical in nature with a number of circular features lying in the same or parallel planes, the *centerline layout method* is more convenient for rapid construction. The steps to be followed in making the isometric drawing of a typical object using this method is shown in Fig.7.24.

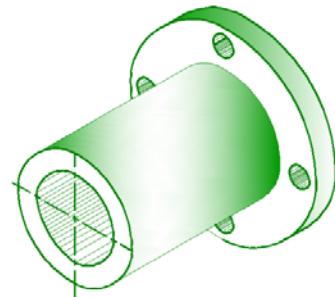
As described in the figure, the first step is to draw the isometric layout of the principal center lines for the given object. Isometric circles on visible planes are then constructed by the four center method. Cylindrical parts are then completed by adding tangents to circles on parallel planes. Portion of rear ellipses should be drawn to specify depths of small circular holes.



Orthographic Views (Given)



Step I

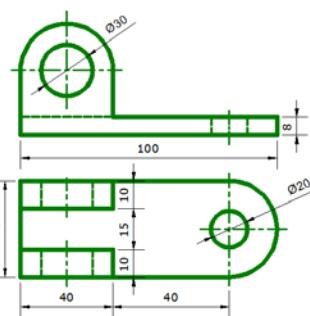


Step III (Isometric drawing)

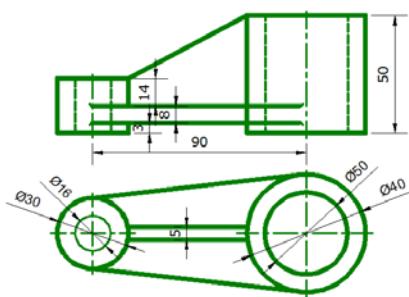
Fig. 7.24 Isometric construction by centerline layout method

Checkpoint 7.4

Make the isometric drawing of the following object using center line layout method.



a)



b)

7.3 Oblique Projection

- Sketch the front view of a cube and extend $30-45^\circ$ lines from its edges and repeat the front view at a position where the extension line you just made ends. What did you observe from the pictorial drawing you get from your sketch?

This method of pictorial drawing is based on the procedure of placing the object with one face parallel to frontal plane and placing the other two faces on the receding planes to left (right), top (bottom) at a convenient angle commonly at 45° . The face of the object made parallel to the frontal plane will appear as true size and shape. It is the easiest type to make pictorial drawing of an object and have the following advantage over other type of pictorial drawing:

- ✓ Distortion will be minimized by placing the longest dimension of the object parallel to the frontal plane of projection.
- ✓ Construction of pictorial drawing of an object will be simplified by placing the face with greatest number of circular outline and irregular outlines (contours) parallel to the frontal plane of projection. So that circular outline will be drawn as circle in its true shape by using compass (template) than drawing.

Principle of Oblique Projection

In axonometric projection, the lines of sights (projectors) are assumed to be at a right angle to the picture plane. But, in oblique projection, the lines of sight are at an angle different from 90° to the picture plane.

In both axonometric and oblique projections, the lines of sight are parallel to each other, i.e, the station point is assumed to be at infinity. Therefore, in both projection methods, a line that is parallel to the picture plane will project in its true length. Consequently, any face that is parallel to the picture plane will project in its true size and shape as shown in Fig. 7.25.

In this figure observe that both the orthographic and oblique projections of the front face ABCD are identical. They both represent the true size and shape of the front face. This is because the front face ABCD is parallel to the picture plane.

Unlike orthographic projection, for a given position of an object, it is possible to produce infinite number of oblique projections by simply changing the angle the lines of sight make with the picture plane. However, for practical reasons, only some standard angles like 30° , 45° and 60° are selected, but commonly a 45° is used.

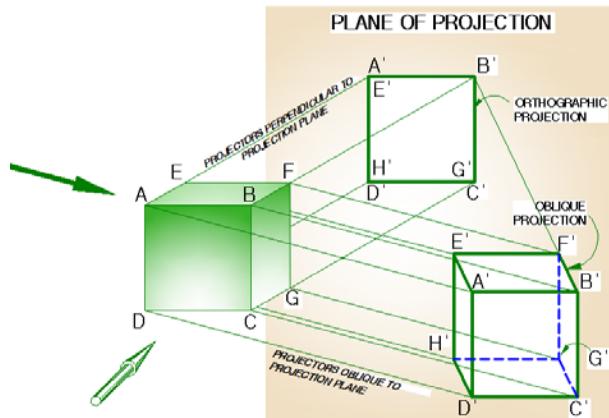


Fig. 7.25 Pictorial representation of oblique projection

7.3.1 Types of Oblique Drawing

Depending on the angle the lines of sight make with the picture plane and their extensive use, oblique drawing is generally classified as *cavalier*, *cabinet* and *general oblique*. The general oblique drawing is not discussed in detail because of its rare application.

Cavalier Oblique drawing: is a type of oblique drawing in which the same full scale is used along all the three axes.

Cabinet Oblique drawing: is the second type of oblique drawing in which the scale along the receding axis is reduced by one-half of that used on the front face to compensate for distortion and to approximate more closely what the human eye would see.

General oblique drawing: is a type of oblique drawing in which the scale along the receding axis is reduced between one half and full size e.g. three-fourth of the true length is commonly used.

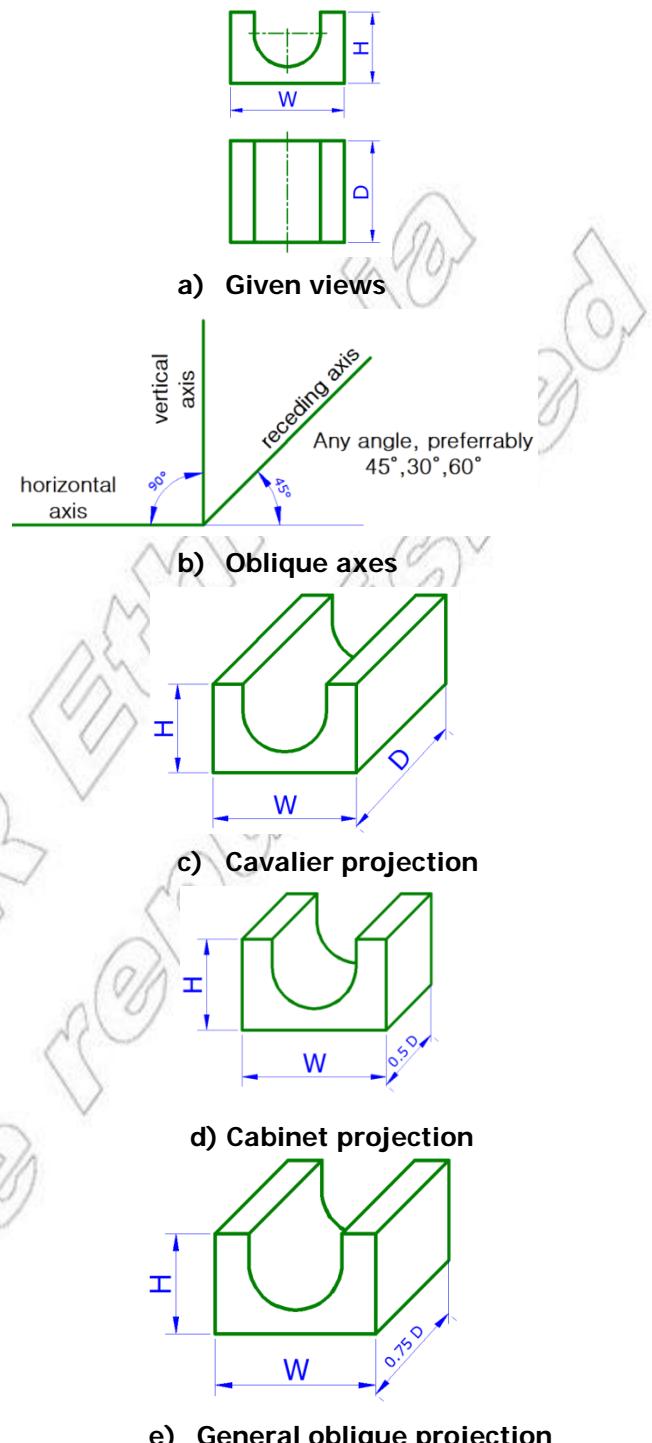


Fig. 7.26 Types of oblique projection

Checkpoint 7.5

1. What are the basic difference between oblique and axonometric projections?
2. What are the commonly used types of oblique drawing?

7.3.2 Position of Axes in Oblique Drawing

There are three axes of projections to be used in oblique drawing namely horizontal, verticals, receding axes. The horizontal, and verticals axes are arranged at right angle to each other, while the receding axis may be at any angle as shown in Fig.7.27, but commonly drawn at an angle of 30° , 45° and 60° as shown in Fig.7.27. However the angle that enables one to easily read and draw the details on the receding face will be selected. For example if a greater degree of detail appears on the top of the object the angle of the receding axis would be increased.

The three axes may be positioned differently based on the type of the object to be represented.

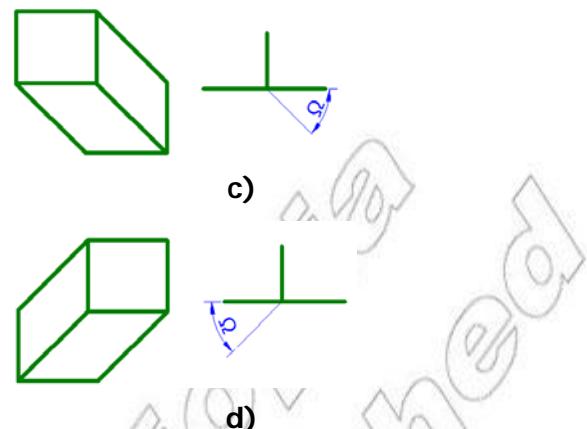


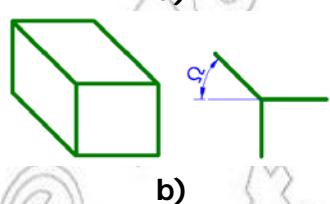
Fig. 7.27 Alternate positions of axes in oblique drawing

Choice of Position of the Object

The general shape of the object will have some effect on its position. The most descriptive features of the object should be placed parallel to the plane of projection. This is very important when drawing a piece having circle, irregular curves and largest face (longest dimension) as mentioned earlier. The selection of the position for oblique representation of an object will be based on two main reasons.

To Simplify Construction

To make the construction of oblique drawing easy and simple, the face of the object that has the most circles, arcs and other irregular curves should be placed parallel to frontal picture plane. Note that the object in Fig.7.28 (a) is easier to draw and yet looks much better than Fig. 7.28 (b).



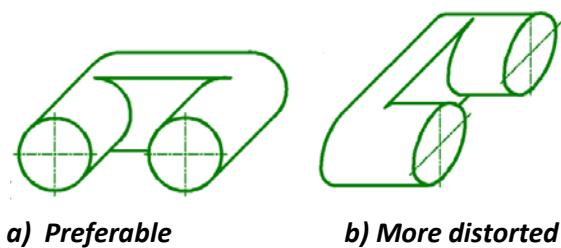


Fig. 7.28 Oblique drawings of objects with circles on their front face

The other method to reduce distortion in oblique drawing is to reduce the scale used on the receding axis as in cabinet drawings (see Fig. 7.29) by placing the object with the longest face parallel to the frontal picture plane.

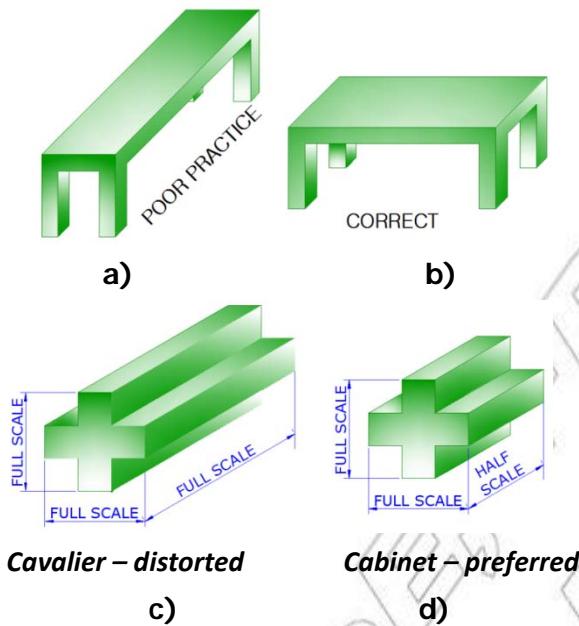


Fig. 7.29 Long dimension of object parallel to picture plane

7.3.3 Oblique Drawing Constriction

Like isometric drawings, oblique drawings can be constructed by using both the box

construction method and centerline layout method.

The Box Construction Method

The steps in making an oblique drawing of an object using the box method are the following: (See Fig. 7.30)

Step I. Enclose the orthographic views of the object with square or rectangle using overall dimensions.

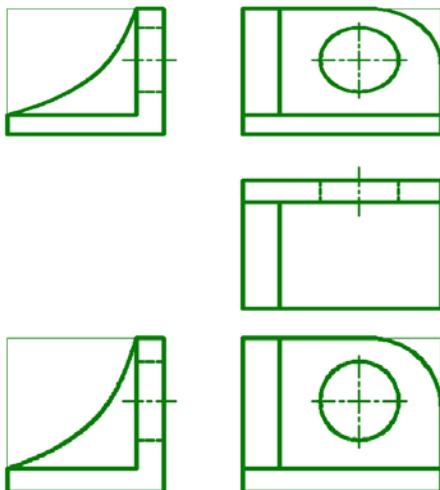
Step II. Determine about the position and face of the object to be brought to front based on the selection criteria for best oblique drawing representation discussed earlier.

Step III. Draw the oblique enclosing box with light construction lines using full, half and between half and full scale of the true length along the receding axis for cavalier, cabinet and general oblique drawing types respectively. Note that the receding axis should be at an angle that will show the side and top face to the best advantage.

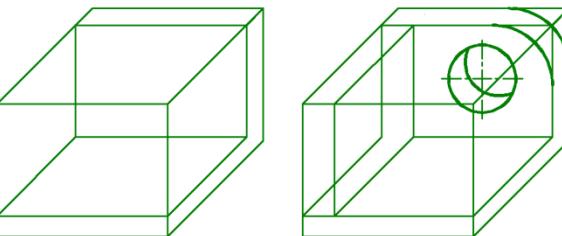
Step IV. Draw all lines in the face parallel to the front face.

Step V. Draw the curves on receding face using offset measurement method.

Step VI. Complete all the lines and darken the necessary lines to finish the oblique drawing.

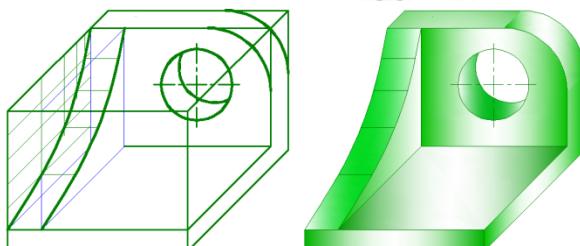


Step I

Step II
Drawing the grid

Step III

Step IV



Step V

Step VI

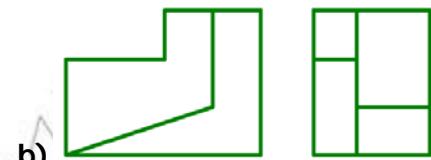
Fig. 7.30 Construction of oblique drawing using box method

Checkpoint 7.6

Make an oblique drawing of the following shapes using box method.



a)



b)

Centerline Layout Methods

This method is used for objects mainly composed of cylindrical parts. The application of this method is shown in Fig.7.31. The steps are as follow:

Step I. Layout the centerlines for all circles at their proper positions.

Step II. Construct the circles and arcs with light construction lines.

Step III. Draw all required tangent lines using tangent line construction method discussed at unit 5 of this text to complete the shape of the object.

Step IV: Darker all the necessary out lines of the final oblique drawing.

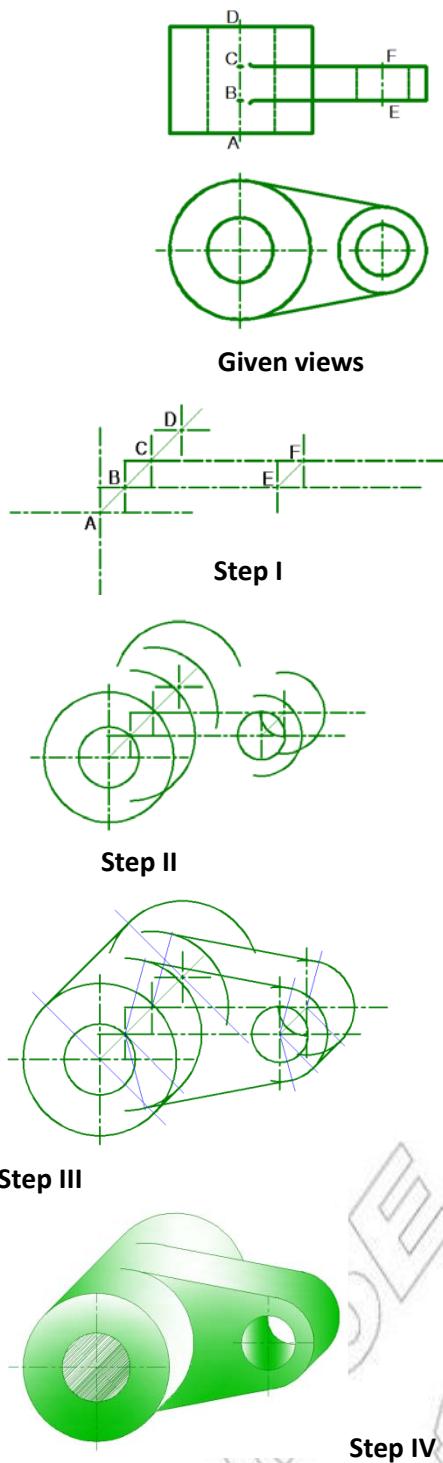
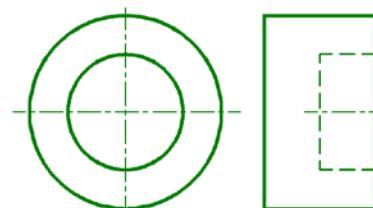


Fig. 7.31 Construction of an oblique drawing using centerline layout method

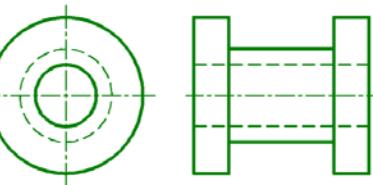
Checkpoint 7.7

Draw oblique drawing of both objects using centerline layout method.

a)



b)



7.3.4 Circles in Oblique Drawing

A. Circles and arcs on any face parallel to the picture plane

When making oblique drawings, circles on any face of the object parallel to the picture plane are drawn easily as true circles with a compass as shown in Fig.7.32.

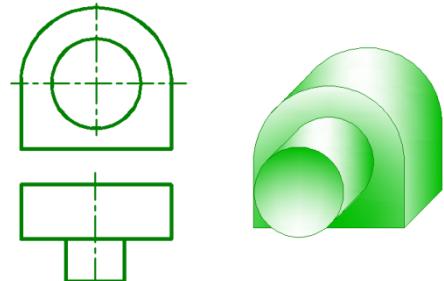
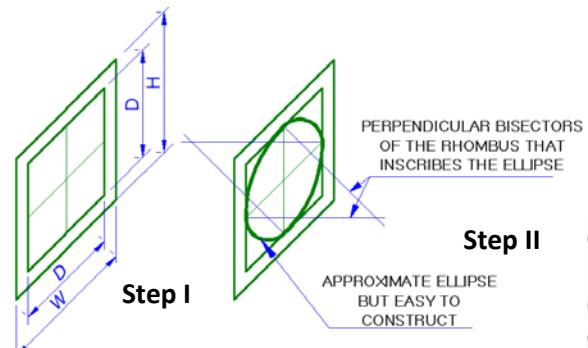
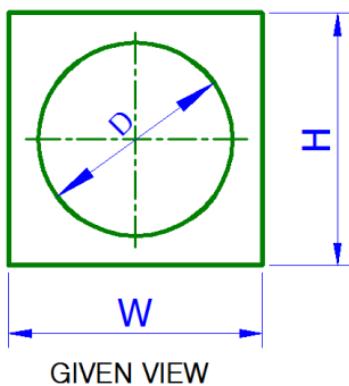


Fig. 7.32 Circles in oblique drawing

B. Circles and arcs in the side or top faces of the object.

Circles and arcs that do not face the frontal picture plane will appear as ellipse. For a cavalier oblique drawing approximate four-centre method, and for cabinet and general oblique drawings offset measurement method are used. If the receding axis angle of a cavalier oblique drawing is 30° , the ellipse construction method and even the ellipse will be similar to that discussed on isometric drawing. But if the receding axis angle is different from 30° like 45° , the ellipse will be constructed using the four-centers established by the intersection of the perpendicular bisectors of the sides of the enclosing rhombus as shown in fig 7.33. If the angles of the receding axis is less than 30° the perpendicular bisectors will intersect inside the rhombus or else the intersection points lie outside of the rhombus.



a) Four centered method

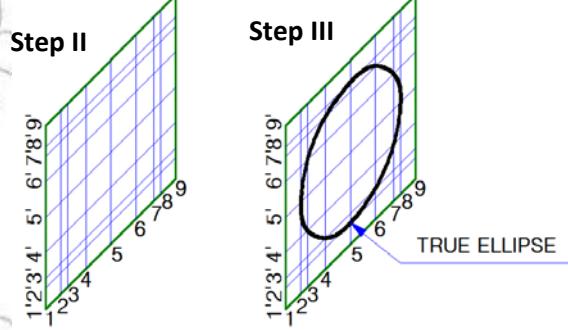
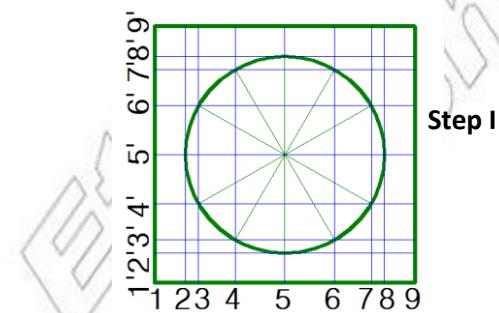


Fig. 7.33 Four-center and grid construction method on oblique drawing

Steps to draw ellipse on receding faces of cavalier oblique drawing: (Fig 7.33 (a))

Step I. Draw the rhombus that encloses the ellipse on the receding top or side face using side lengths equal to the

diameter of the circle given on the orthographic view.

Step II. Draw perpendicular bisectors to all the sides of the rhombus so as to get their intersection points which represent the four centers to complete the ellipse.

Step III. Draw arcs tangent to the sides of the rhombus from mid point of one side to the mid point of adjacent side using the four centers established as center, and distance from these centre to the mid point of the sides along the bisectors as a radius.

Steps to draw ellipse on the side receding faces of cabinet oblique drawing (Fig. 7.33 (b))

- Draw a square with construction line that encloses the circle given on the orthographic view.
- Plot points on the given circle either by dividing it into say 12 equal parts or by dividing the horizontal diameter of the circle into some defined number of parts and draw vertical construction lines through these points to get coordinate points on the circle.
- Draw horizontal and vertical lines through these points plotted on the circle parallel to and touching the sides of the square and label them.
- Draw the rhombus on the receding face of the oblique box by reducing the side length along the receding line by half scale of its true length.

v. Draw the horizontal lines parallel to the receding axis each at interval equal to that shown on the view and the vertical lines parallel to the vertical axis at an interval reduced by half of their true length shown on the view.

- Properly identify and mark the intersection of the horizontal and vertical lines drawn at step v for the corresponding labeling (numbers or letters).
- Draw smooth curve through the intersection points or coordinate points obtained at step VI to complete the ellipse.

Note: *Ellipse on a general oblique drawing will be constructed in a similar fashion as that of cabinet oblique drawing except the difference of a reducing scale used along the receding axis.*

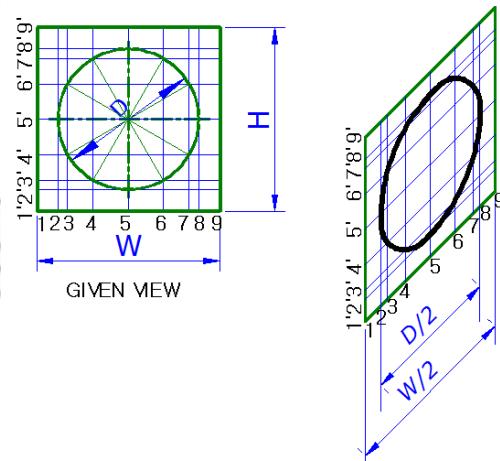


Fig. 7.34 Offset measurement method for ellipse construction in cabinet and general oblique drawing

7.3.5 Advantages of Oblique Drawing

From the foregoing discussions, it is clear that oblique drawings have the following advantages over isometric drawings:

- Circles on faces parallel to the picture plane can be easily drawn using a compass.
- Distortion may be improved by using a reduced scale on the receding axis.
- Greater range of choice of positions of the axes is available in oblique drawing.

7.4 Perspective Projection

- Have you seen a picture of a road with the street lamps? Did you observe that the height of the lamps vanishes or gets small as it goes far?
- Bring as many examples as you can from a camera picture which has a vanishing effect.

Perspective projection also called *central projection* is another method of graphic representation of an object pictorially as it actually appears to the eye of an observer located at a particular finite distance from the object. It more closely approximates the view obtained by the human eye. Geometrically an ordinary photograph is perspective drawing. The principle of perspective is size dimensioning with distance for e.g. when you view a building the parts farthest from your eye appear smaller than the closer parts. If the horizontal edges of the building could be

extended, they would appear to meet on the horizon.

A drawing that is made according to the principle of perspective projection is called perspective drawing. Perspective drawings are more realistic than axonometric or oblique drawing because the object is shown as the eye would see it. Since their construction is far more difficult than the other types of pictorial drawings their use in drafting is limited mainly to presentation illustration of a large object such as interior and exterior features of buildings and the preparation of advertising drawings.

Perspective involves the following four main elements (Fig. 7.35)

Observer eye: the position of the observer eye is called station plane

Object being viewed: an element whose perspective drawing is made on a picture plane.

Plane of projection: the plane on which the perspective view is projected and it is called picture plane

Projector: line from the observer's eye to all point on the object. It is sometimes called visually ray or line of sight.

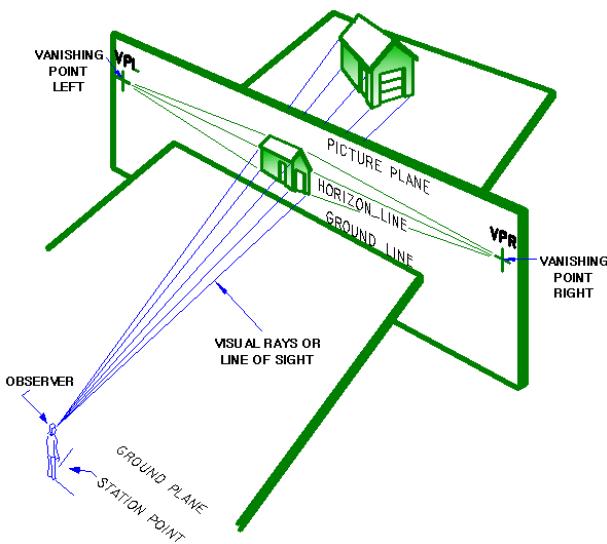


Fig. 7.35 Perspective projection of a building

7.4.1 Definition of Basic Terms

The definition of some of the basic terms that are commonly used in the discussion of perspective drawings are given below (Refer to Fig.7.35 and 7.36).

Picture Plane (PP): is a vertical transparent plane on which the perspective representation of an object is being projected. It is designated as pp on drawing.

Station Point (SP): is a point where the eye of the observer is located for the resulting perspective projection of an object on pp. It is assumed to be situated at a definite position relative to the object. It is also known as point of sight.

Visual Rays: are straight lines that are drawn from the station point to the visible corners of the object and pierces the picture plane located commonly between station point and object to establish the perspective

projection on PP. They are also referred to as the line of sight.

Ground Plane (GP): is a horizontal plane on which the object is assumed to rest.

Ground Line (GL): is the line of intersection of ground plane with the picture plane.

Horizon Plane (HP): is imaginary horizontal plane assumed above ground plane perpendicular to the picture plane and located at observer's eye level (SP).

Horizon Line (HL): is the line of intersection of horizon plane with the picture plane along which vanishing points lie.

Vanishing Points (VP): are points that always lie on HL to which all the horizontal (side edges) of an object not parallel to the picture plane would appear to meet. However all the lateral edges of the object, parallel to the PP will remain vertical except for three point perspective drawing. We could have one, two or three VPs depending on the type of perspective drawing made.

Center of Vision (CV): is a point that lies on both the HL and PP at central location in front of the observer eye. It also lies along a line from the SP perpendicular to the PP.

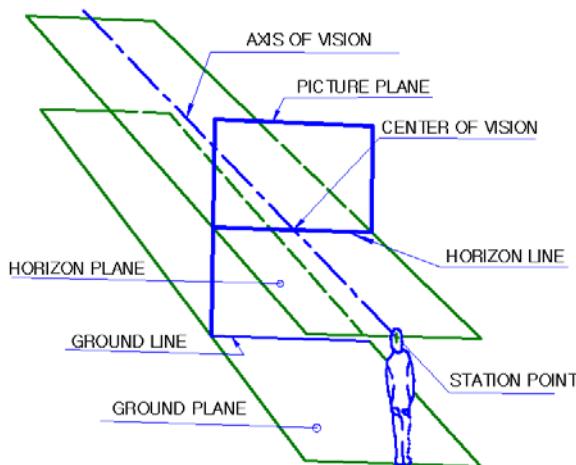


Fig. 7.36 Perspective nomenclature

7.4.2. Location of Picture Plane and Station Point

Location of Picture Plane

For a given position of the station point and the object, the picture plane may have several positions relative to them as shown in Fig.7.37.

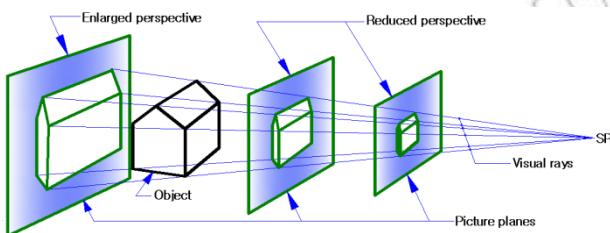


Fig. 7.37 Relations of object, picture plane and station point

If the picture plane is placed between the object and the station point, the perspective drawing on the picture plane will be smaller in size than the object. This arrangement is commonly used.

The closer the plane is to the station point, the smaller the perspective drawing becomes as shown in Fig.7.37. If the object is placed between the picture plane and station points, an enlarged perspective drawing will be produced. But this arrangement is very rarely used. The usual practice to prepare the perspective drawing of an object is to place the object in contact with the picture plane. The perspective drawing shown on the entire picture plane will differ in size but not in proportion.

Location of station point

For the assumed picture plane and object position, the effect of perspective drawing of an object will be greatly affected by a change in the position of the station point. The selection of the location of station point depends on the faces of the object required to come into view undistorted and have an attractive appearance.

Distance between the station point and the object

From experience, it is known that the eye is able to see clearly all the picture contained within a right circular cone of vision having its apex at the eye with an interior angle of approximately 30° . This condition is satisfied when the station point is located at a distance from the object at least twice the longest dimension of the object (i.e. x) from the picture plane, as shown in Fig.7.38.

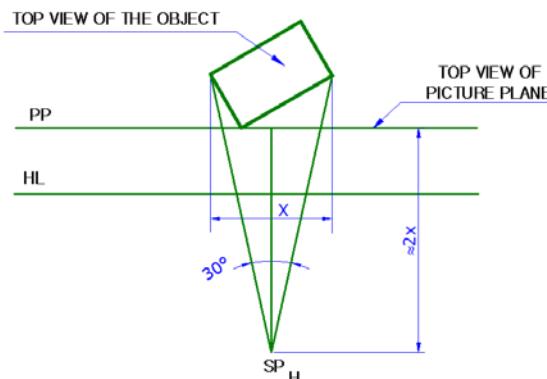


Fig. 7.38 Location of station point

For a pleasant perspective drawing the cone of vision should be located near the center of the picture.

If the lateral and elevation angle of visions are greater than 30° , it will result in unpleasant perspective.

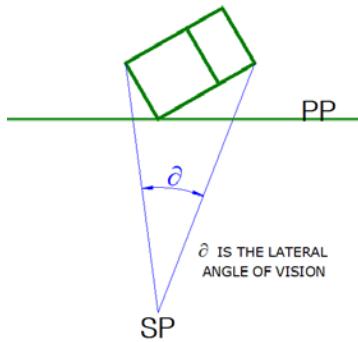
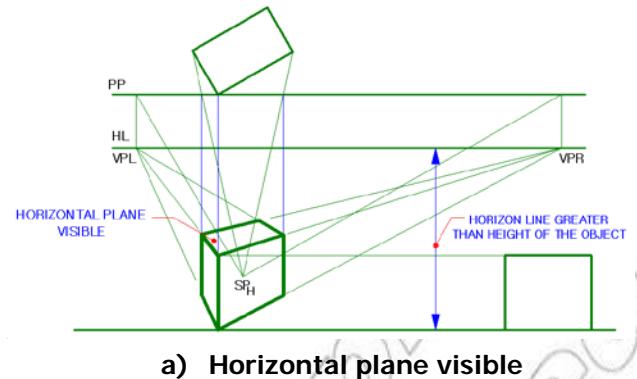


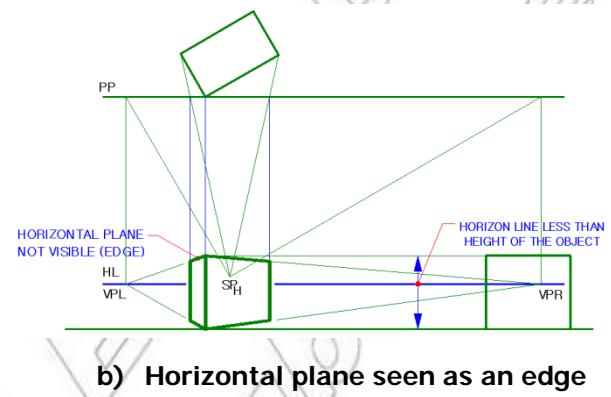
Fig. 7.39 Lateral angle of vision

Elevation of the Station Point

When the top face of the object is more important, the station point and the horizon line should be located above the object. But if the bottom part of the object is to be shown, the station point should be located below the object as shown in Fig.7.39 for angular perspective.



a) Horizontal plane visible



b) Horizontal plane seen as an edge

Fig. 7.40 Elevation of the Station Point

7.4.3. Types of Perspective Drawing

Depending on the position of the object relative to the picture plane & the number of vanishing points required, perspective drawings are classified as:

- Parallel (One-point) perspective,
- Angular (Two-point) perspective, and
- Oblique (Three-point) perspective.

In this text, the oblique perspective drawing is not dealt in detail because of its rare application.

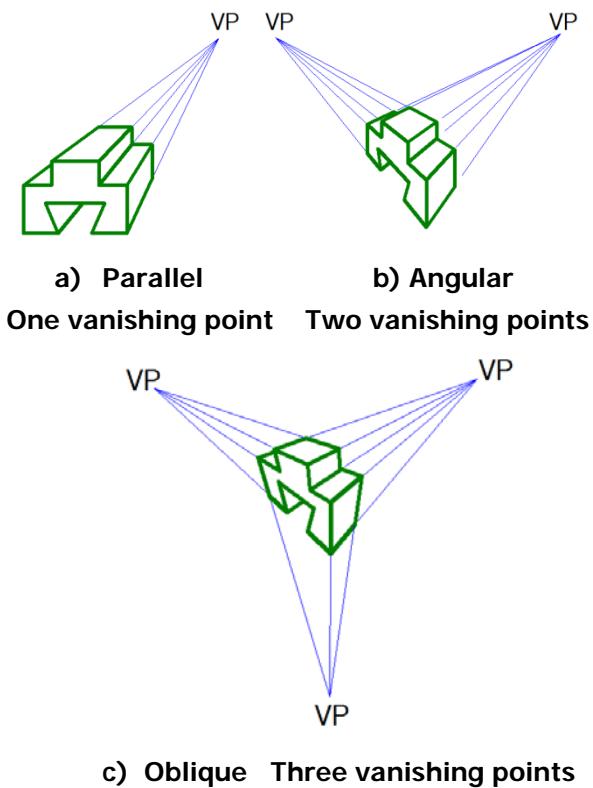


Fig. 7.41 Types of perspective drawings

A) Parallel (one-point) perspective: is a type of perspective drawing obtained by placing an object such that one of its principal faces is made to be parallel to the picture plane so that it will be drawn as true size and shape. Here two principal axes are parallel with the picture plane whereas the third axis perpendicular to the plane. All parallel edges of the object that are perpendicular to the picture plane will converge (meet) at one point on horizon line called vanishing point. It is similar to oblique drawing except that all the receding edges (lines) will converge to the vanishing point on horizon line. This

perspective is commonly used for representing the interior view of a building and machine parts. There is one vanishing point.

B) Angular (two-point) perspective: is a type of perspective drawing obtained by placing an object such that two principal faces along the width and depth dimension are inclined at an angle with picture plane and recede to the two vanishing points on horizon line. All the vertical edges of the object along the height dimension are arranged parallel to the picture plane. It is similar to axonometric drawing except that the receding edges are converged to the two vanishing points on the horizon line. It is commonly used for representing exterior view of an object e.g. building. By changing the relationship between the horizon line and ground line, we can get the following types of angular perspective: (Fig.7.42)

- 1. Area view (Bird's eye view):** is a perspective view obtained by placing horizon line above ground line at any convenient distance. It is used to show top, front and side faces of the object.
- 2. General view (Human's eye view):** is a perspective view obtained by placing horizon line above ground line at an average adult human's height, of course passing through the object e.g. it is used mostly for perspective view of a building.

Here only two faces (front and side) will appear on the perspective drawing.

3. **Ground view:** is a perspective view obtained by placing horizon line and ground line at the same level (coinciding them). It is like a view obtained by an observer laying on the ground and it is commonly used for a perspective view of a building. Like general view, only two faces i.e. (front and side) will come into the perspective view.
4. **Worm's eye view:** is a perspective view obtained by placing horizon line below ground line. It is rarely used. It is used to show three faces (front, side and bottom). Commonly used for smaller objects or machine parts.

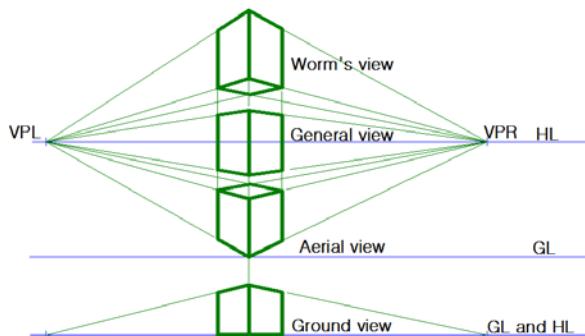


Fig. 7.42 Objects above, through, and below the horizon

- C) **Oblique (three-point) perspective:** is a type of perspective drawing obtained by placing an object such that all the three principal faces are at an angle with the picture plane. All the receding parallel edges of the object along the width and depth dimension will converge to two vanishing points on horizon line and the vertical edges along the height of

the object will converge to the third vanishing point not lying on horizon line. Therefore, three vanishing points are used.

7.4.4. Construction of Perspective Drawing

i. Parallel (One-point) perspective

As discussed earlier, this type of perspective requires one face to be positioned parallel to the picture plane and the other perpendicular to it. Station point is located so as to enable see the right or left side face of the object. If the right face is required to be shown, the station point should be located to the right of the object and vice versa.

Steps to prepare parallel perspective drawing of an object (Fig. 7.43):

1. Begin the drawing by establishing the three edge view lines. i.e. PP, HL and GL at any convenient distance depending on the faces of the object required to be shown on the perspective drawing.
2. Draw the top view with its front face in contact with the picture plane (as a usual practice) or at some distance apart from it.
3. If sufficient space is available and required, draw the front or side view on one extreme end of ground line to a convenient left or right direction.
4. Complete the front face of the perspective drawing on ground line, showing its true shape and size by drawing projectors from top and side (front) view corners to get the various width and height informa-

tion of the object respectively. If no side (front) view is shown on GL take the height information of various features from the orthographic side or front view of the object.

5. Establish the station point at a distance greater than or equal to twice the overall width of the object from picture plane to the left or right direction of front face as required. So that the cone of vision becomes less than 30° for a pleasant appearance of the perspective drawing.
6. Locate the vanishing point on horizon line by drawing a projector from station point perpendicular to horizon line.
7. Draw visual rays from the station point to all rear or back corners, if the top view is in contact with PP or to front and rear corners, if the top view doesn't have any contact with PP. These visual rays will intersect pp at various points to establish "piercing points" representing the back edges of the object in the perspective drawing.
8. Draw projectors from all front corners to the vanishing point located on HL.
9. Draw projectors from all piercing points of PP obtained at step 7 vertically downward to intersect the corresponding receding edges drawn at step 8 and establish all the desired corners of the perspective drawing.
10. Connect the intersection points so obtained at step 9 to complete the perspective drawing.

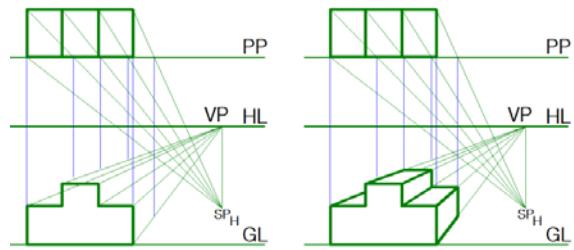


Fig. 7.43 Steps in parallel perspective drawing

ii. Angular (Two-point) perspective

This type of perspective requires two faces of the object to be positioned at an angle with PP.

Steps to prepare angular perspective drawing of an object are:

1. Draw the three edge view lines i.e. PP, HL, GL at any convenient distance and arrangements between HL and GL depending on the faces of the object required to be shown on perspective drawing as shown in Fig 7.44.
2. Draw the top view in such a position that, the longer principal receding edge makes an angle of 30° and the shorter edge 60° with the picture plane for a better perspective drawing. Its front vertical corner is in contact with, as a usual practice, or with out any contact to the picture plane as required.
3. Draw the front or side view of the object on one convenient side of ground line from which different feature heights of the object are transferred to the perspective drawing.
4. For a good perspective drawing locate the SP at a distance greater than or equal to twice the diagonal length of top view i.e. parallel to the PP so that the perspective

drawing will be contained in a cone of vision less than 30° . It can be located to the left or right direction of the front corners as required but many times in line with the front corner (approximately around the center of the object to reveal both receding faces into perspective view).

5. Locate the two vanishing point left (VPL) and vanishing point right (VPR) on the horizon line by first drawing projectors from the SP parallel to the two receding principal edges of the top view so as to get corresponding intersection points on pp. Drop vertical projectors from these intersection of PP down to the horizon line.
6. Draw vertical projector from the front corner of top view having contact with PP down to GL to establish a line called line of sight or true height line.
7. Draw horizontal projectors from all height corners of front or side view located on GL to the line of sight and then to the two valuation points.
8. Draw visual rays from the SP to all corner of top view. These projectors will intersect the pp at various points to establish piercing points representing the back edges of the object in the perspective drawing.
9. Draw vertical projectors from all these piercing points of PP down to intersect projectors from the line of sight to VPS and determine the width and depth of all desired corners of the perspective drawing.
10. Connect all the required intersection point obtained at step 9 to completed the perspective drawing of the object.

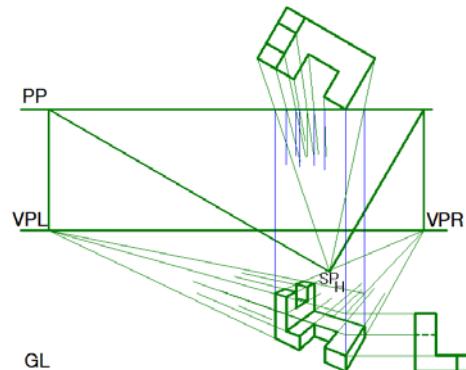


Fig. 7.44 Two-point or angular perspective drawing of an object

Checkpoint 7.8

Draw one point and two point perspective drawing of the following objects whose views are given in fig below (a) and (b) respectively.



b)

7.4.5. Circles and Arcs in Perspective Drawing

Circles and arcs of an object facing the picture plane will be constructed as a true circle using compass in one point perspective and as an ellipse if they are on receding face, and all faces of two point perspective to be

constructed by joining points of intersection obtained.

In parallel (one-point) perspective

Circles or arcs will be constructed as a true circle or arc whose radius varies depending on its closeness to the picture plane. The one closest even in contact with the PP will be drawn as true circle or arc, whereas the other farthest from the PP will be drawn as a smaller size circle or arc whose radius can be obtained by the usual principle of perspective drawing construction (see Fig. 7.45).

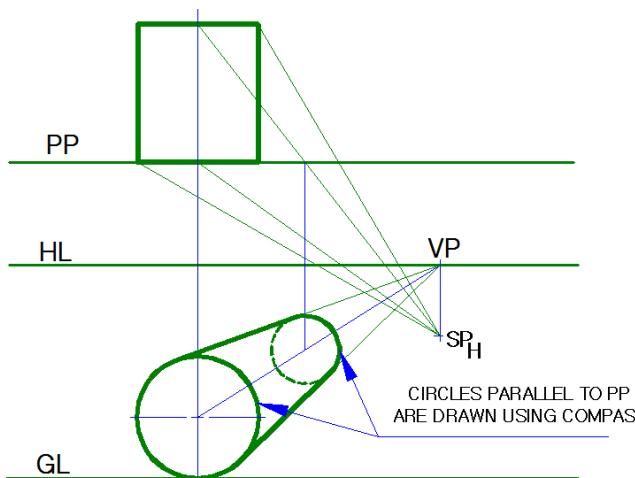


Fig. 7.45 One-point perspective of a cylinder

In angular (two-points) perspective

Circles or arcs of an object will be constructed as an ellipse whose size and shape varies depending on its angle of inclination with the picture plane.

Steps to draw a circle in angular (two point perspective): (Fig 7.46)

1. Draw the three edge view lines (i.e. PP, HL, & GL), SP, VP, the top view and front or side view as required based on the usual principle of perspective drawing construction.
2. Enclose the front or side view of the circle given on GL with square and then divide the circle into say 12 equal parts (divisions) and label them.
3. Project each division point of the circle to the top and side edges of the enclosing square and label them accordingly. Show all corresponding labeling on the top view.
4. Draw projector lines from the SP to all labeled division points of top view.
5. Draw vertical projector lines from all piercing point of PP down to perspective drawing.
6. Draw horizontal projector lines from all division points of the front or side view of circle on GL to the line of sight or vertical edge of the perspective square and then to the vanishing point.
7. Connect the points of intersection located by the intersection of vertical projection lines dropped down from all piercing points of PP and the vanishing lines drawn from all points of line of sight to VP using irregular circle.

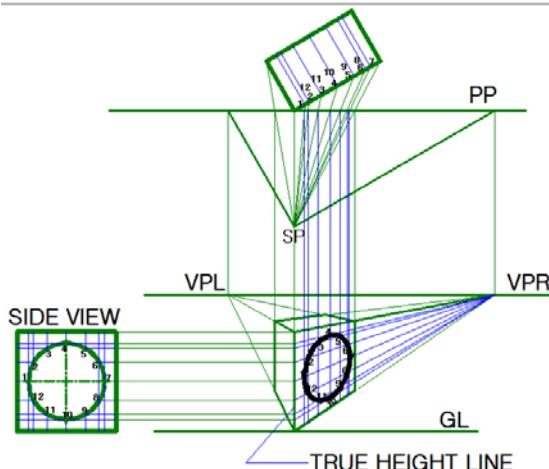


Fig. 7.46 Construction of circle in two-point perspective

Other easier method of perspective circle construction lying on horizontal plane is done using the “ground line” method. In this method the GL is temporarily moved from its original position to the height of the circle as shown in Fig 7.47.

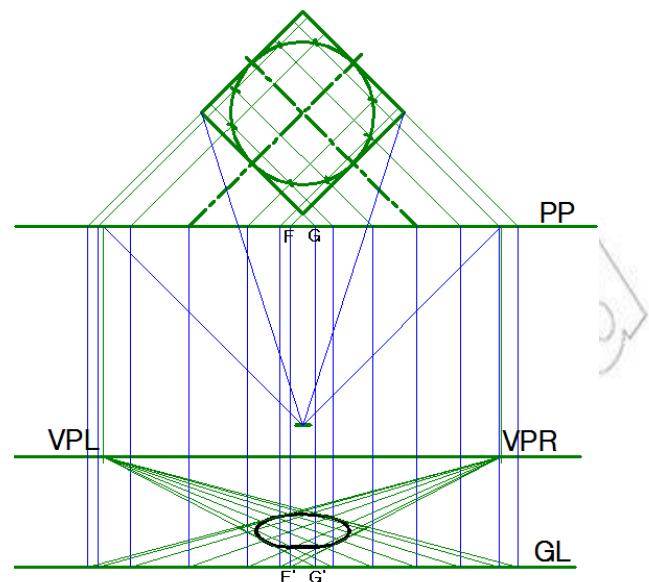


Fig. 7.47 Construction of circle on horizontal plane

Note: *Construction of perspective drawing for other features not discussed in this text book will be covered up at a higher level of study.*

UNIT SUMMARY

The three classifications of pictorial projections are axonometric, oblique, and perspective. Isometric sketches are the most popular among the various axonometric drawings, because they are the easiest to create. Both axonometric and oblique projections use parallel projection. As the axis angles and view locations are varied, different pictorial views of an object can be produced.

Axonometric projection is a kind of orthographic projection that an object and its Cartesian coordinate system are projected onto a projection plane. Similarly the object is inclined to the observer so that all three dimensions can be seen in one view.

Oblique projection is a form of parallel projection and the angle between projectors and projection plane is not fixed, 30~60 degrees are preferable, because minimum distortions of the object are caused. In oblique projection application rules are: make complex features (such as arcs, circles, irregular surfaces) parallel to the frontal plane; and the longest lines of an object should be parallel to the frontal plane.

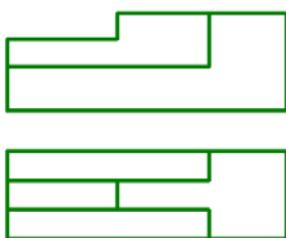
Perspective projection use converging lines to produce a pictorial view. The converging lines recede to vanishing points that produce a realistic looking image. Perspectives are commonly used in architectural work to create realistic scenes of buildings and structures. In this chapter you learned there are three types of perspective projections: one-, two-, and three-point. Each type refers to the number of vanishing points used in the construction of the drawings. Other variables, such as position of the ground line in relation to the horizon line, can be controlled to produce virtually any view of an object.

Exercise I

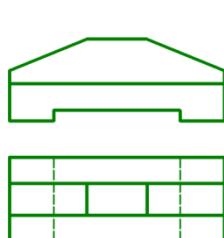
1. Define oblique projection.
2. List and describe the three different types of oblique drawing.
3. Define axonometric.
4. Define isometric, diametric, and trimetric drawings.
5. Sketch the axes used for an isometric drawing.
6. What is the general rule used for hidden lines in isometric drawings?
7. Give examples of pictorial drawings which are used in industry.
8. Sketch an isometric cube then show how isometric ellipses would be drawn on each face of the cube. Add center lines to the ellipses.
9. What are the three angular measurements of isometric drawing axes?
10. Describe perspective projection theory. Use sketches if necessary.

Exercise II

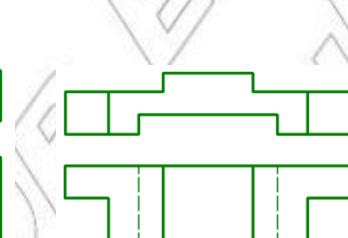
Make the isometric drawing of the following objects by taking direct measurements from the given views.



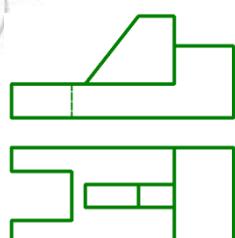
a)



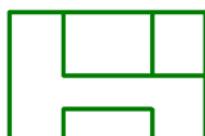
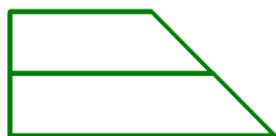
b)



c)



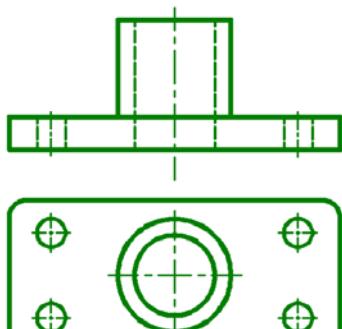
d)



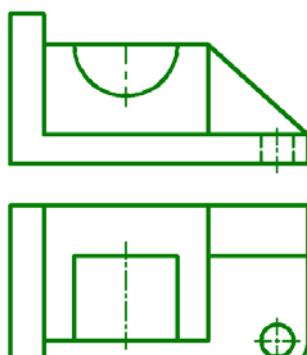
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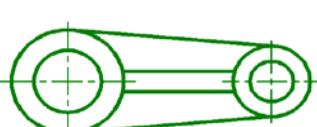
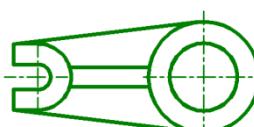
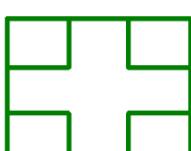
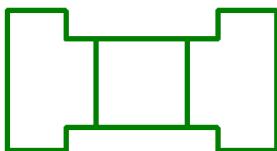
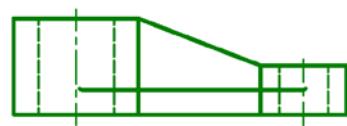
f)

Exercise III*Make the isometric drawings by taking direct measurements.*

a)



b)

Exercise IV*Draw an oblique drawing of the objects whose views are given below use appropriate scale.*

a)

b)

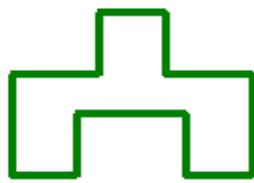
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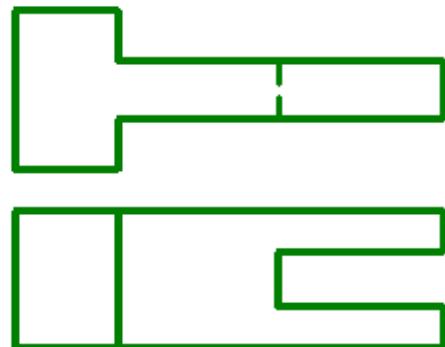
Exercise V

Draw the one point and two point perspective drawing of the following shape

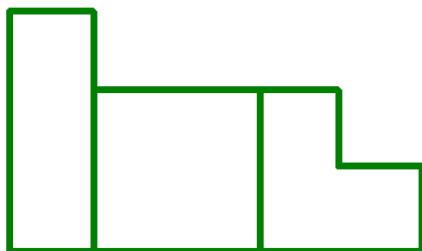
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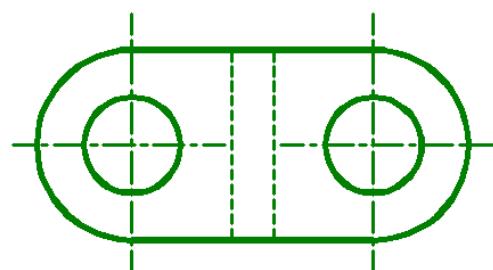
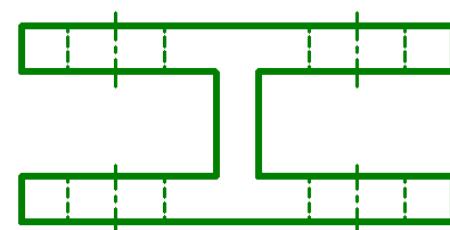
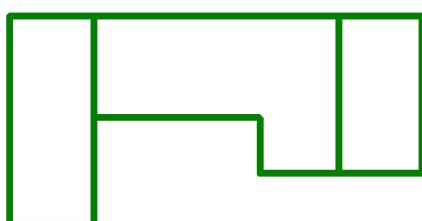
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3.

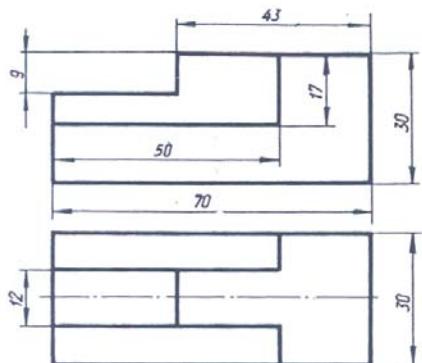


4.

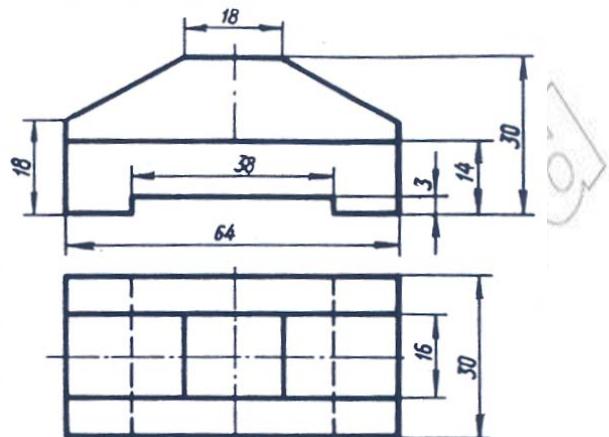


Project

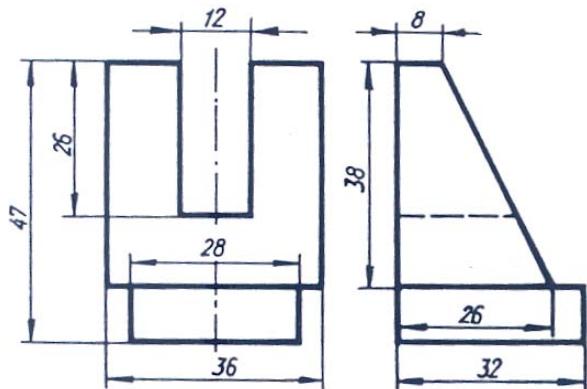
Given two projection of a model, construct a third one (if necessary) and a pictorial drawing of the model.



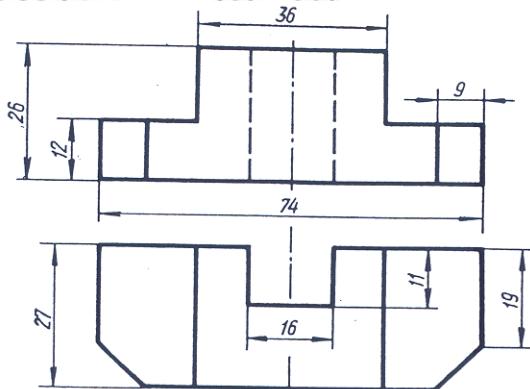
1.



2.



3.



4.