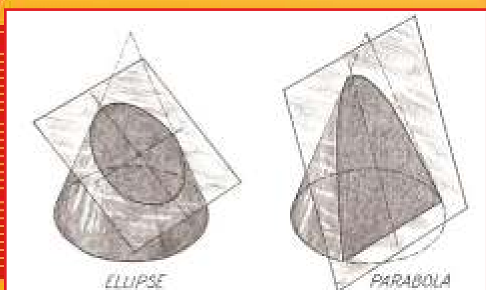
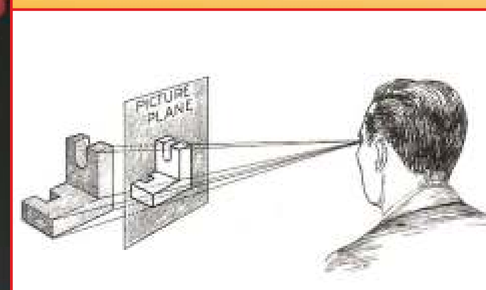
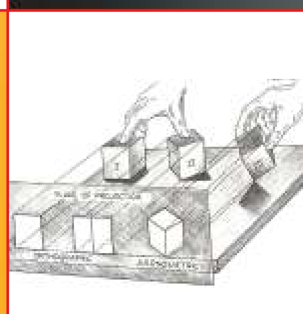
ENGINEERING GRAPHICS

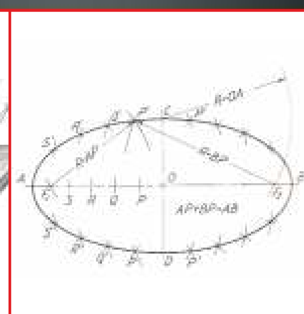
Class XI

KNOW - AS YOU GROW









Central Board of Secondary Education
2, Community Centre, Preet Vihar, Delhi-110092

ENGINEERING GRAPHICS

Class-XI

CENTRAL BOARD OF SECONDARY EDUCATION
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FOREWORD

One of the integral aspects of the world around us is design. As children we draw, paint and visualise our own unique designs of homes, ceatures, their clothes and our make believe world. As we grow older, we gradually become aware of the existence of design vis a vis our room, furniture, clothes, etc. We have also seen important historical buildings such as the Taj Mahal, India Gate, Qutub Minar, Red Fort etc. they all have a unique design.

Today, in the age of globalization and consumerism, we are inundated with images of new cars, aeroplanes, space crafts and the like. Design is crucial to each of the these unique things. Indeed, everything that we use and are surrounded with, has a unique and intrinsic design: be it the house one lives in, the gadgets one uses, the design of the fabric that we use for our clothes, the cut or design of the clothes that we wear and so on. Each of the above has been designed by a specialist – an architect, an engineer, a textile designer, a fashion designer and so on. In the making of each of these engineering drawing is the medium.

Thus Engineering Drawing is the language of all engineers, architects, textile designers, fashion designers and many others. This is used right from conceiving the design of any product, be it consumer or industrial, up to the mass production stage and beyond for renovation and redesign. The subject of Engineering Drawing finds its use in Architecture, Engineering, Fashion Design, Interior Decoration, Textile Design, etc.

With the advent of computers in all spheres of knowledge, Engineering Drawing has also become compatible with computers. With the application of CAD (Computer Aided Design), the subject is now known as Engineering Graphics. CAD enables a product to undergo design changes necessiated by factors such as functionality, aesthetics, ease-of-handling, strength, obsolescence, etc. Using CAD, prototypes can be tested, design changes examined and comparative study made in no time. Requirements such as the amount of material needed, its dimensions and costing are done instantly. This has made Engineering Graphics indispensable.

The subject is taught at the Senior Secondary level as prescribed by the syllabus of the CBSE. Though many good books by Indian and foreign authors are available, and recommended hither to, for the first time, the CBSE has undertaken the task of writing the textbook for class XI and class XII customizing to the exact requirement of our prescribed syllabus, with the assistance of a team of experienced experts and teachers drawn from its affiliated schools and Government technical institutions of repute. The books have been written with an interactive approach, evolving the subject matter from known-to-unknown, relating it to everyday life situations, motivating children to learn the advanced aspects of the unit, reinforcing the acquired knowledge by repacitulation, drilling exercise, etc.

In this textbook of Engineering Graphics for class XI, students will learn about Plane Geometry, Solid Geometry and Machine Drawing, which includes Orthographic Projections, Isometric Projections and Development of Surfaces. All these units form the foundation of the subject.

I would like to place on record my deep appreciation for all the subject experts and practicing teachers who have put in their sincere efforts in the development of this textbook. Appreciation is also due to Mrs. C. Gurumurthy, Director (Academics) and Dr. (Smt.) Srijata Das, Education Officer for planning and execution of the work and bringing out this publication.

It is hoped that students and teachers will benefit by making the best use of this publication. Suggestions from the users for further improvement of the textbook will be highly appreciated.

VINEET JOSHI
Chairman, CBSE

भारत का संविधान

उद्देशिका

हम, भारत के लोग, भारत को एक (सम्पूर्ण प्रभुत्व–संपन्न समाजवादी पंथनिरपेक्ष लोकतंत्रात्मक गणराज्य) बनाने के लिए तथा उसके समस्त नागरिकों को:

सामाजिक, आर्थिक और राजनैतिक न्यय,
विचार, अभिव्यक्ति, विश्वास, धर्म
और उपासना की स्वतंत्रता,
प्रतिष्ठा और अवसर की समता
प्राप्त कराने के लिए,
तथा उन सब में

व्यक्ति की गरिमा और[2] (राष्ट्र की एकता और अखण्डता) सुनिश्चित करने वाली बंधुता बढ़ाने के लिए दृढ़संकल्प होकर अपनी इस संविधान सभा में आज तारीख 26 नवम्बर, 1949 ई0 को एतद्द्वारा इस संविधान को अंगीकृत, अधिनियमित और आत्मार्पित करते हैं।

1. संविधान (बयालीसवां संशोधन) अधिनियम, 1976 की धारा 2 द्वारा (3.1.1977 से) "प्रभुत्व–संपन्न लोकतंत्रात्मक गणराज्य" के स्थान पर प्रतिस्थापित।
2. संविधान (बयालीसवां संशोधन) अधिनियम, 1976 की धारा 2 द्वारा (3.1.1977 से) "राष्ट्र की एकता" के स्थान पर प्रतिस्थापित।

भाग 4 क

मूल कर्त्तव्य

5.1 **क. मूल कर्त्तव्य**–भारत के प्रत्येक नागरिक का यह कर्त्तव्य होगा कि वह–

(क) संविधान का पालन करे और उसके आदर्शों, संस्थाओं, राष्ट्र ध्वज और राष्ट्रगान का आदर करें;

(ख) स्वतंत्रता के लिए हमारे राष्ट्रीय आंदोलन को प्रेरित करने वाले उच्च आदर्शों को हृदय में संजोए रखें और उनका पालन करें;

(ग) भारत की प्रभुता, एकता और अखंडता की रक्षा करें और उसे अक्षुण्ण रखें;

(घ) देश की रक्षा करें और आह्वान किए जाने पर राष्ट्र की सेवा करें;

(ङ) भारत के सभी लोगों में समरसता और समान भ्रातृत्व की भावना का निर्माण करें जो धर्म, भाषा और प्रदेश या वर्ग पर आधारित सभी भेदभाव से परे हों, ऐसी प्रथाओं का त्याग करें जो स्त्रियों के सम्मान के विरुद्ध हैं;

(च) हमारी सामाजिक संस्कृति की गौरवशाली परंपरा का महत्व समझें और उसका परिरक्षण करें;

(छ) प्राकृतिक पर्यावरण की जिसके अंतर्गत वन, झील, नदी और वन्य जीव हैं, रक्षा करें और उसका संवर्धन करें तथा प्राणि मात्र के प्रति दयाभाव रखें;

(ज) वैज्ञानिक दृष्टिकोण, मानववाद और ज्ञानार्जन तथा सुधार की भावना का विकास करें;

(झ) सार्वजनिक संपत्ति को सुरक्षित रखें और हिंसा से दूर रहें;

(ञ) व्यक्तिगत और सामूहिक गतिविधियों के सभी क्षेत्रों में उत्कर्ष की ओर बढ़ने का सतत प्रयास करें जिससे राष्ट्र निरंतर बढ़ते हुए प्रयत्न और उपलब्धि की नई ऊँचाईयों को छू लें।

THE CONSTITUTION OF INDIA

Preamble

We, The people of India, having solemnly resolved to constitute India into a[1] **(Sovereign Socialist Secular democratic republic)** and to secure to all its citizens :

Justice, Social, Economic and Political;

Liberty of thought, expression, belief, faith and worship;

Equality of status and of opportunity; and to promote among them all

Fraternity assuring the dignity of the individual and the[2] (unity and integrity of the Nation); **In our Constitutent Assembly** this twenty-sixth day of November, 1949, do **hereby adopt, enact and give to ourselves this constitution.**

1. Subs. by the Constitution (Forty-second Amendment) Act, 1976, sec. 2, for "Sovereign Democratic Republic (w.e.f. 3.1.1977)".
2. Subs. by the Consitution (Forty-second Amendment) Act, 1976, sec. 2, for "Unity of the Nation (w.e.f. 3.1.1977)".

Chapter IV A

FUNDAMENTAL DUTIES

Article 51-A

Fundamental Duties–It shall be the duty of every citizen of India-

(a) to abide the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;

(b) to cherish and follow the noble ideals which inspired our national struggle for freedom;

(c) to uphold and protect the sovereignty, unity and integrity of India;

(d) to defend the country and render national service when called upon to do so;

(e) to promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;

(f) to value and preserve the rich heritage of our composite culture;

(g) to protect and improve the rich natural environment including forests, lakes, rivers, wild life and to have compassion for living creatures;

(h) to develop the specific temper, humanism and the spirit of inquiry and reform;

(i) to safeguard public property and to abjure voilence;

(j) to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievement.

ACKNOWLEDGEMENTS

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CONTENTS

Chapter 1

LINES, ANGLES, LETTERS, DIMENSIONING AND RECTILINER FIGURES

1.1 INTRODUCTION

You are welcome to the subject of Engineering Graphics. Though it is a new subject for us still we have studied a bit in our previous classes. Let us recall the simple geometrical constructions where we have drawn them without much caring about the thickness of lines etc. and written the steps of construction also. At this level of study we shall study geometrical constructions again but here we shall use proper lines to construct them and there is no need of writing steps of construction. We have studied systeme International & units (S.I.Units). These units are used throughout the world. Similarly, many languages are spoken in the world and different dialects are used for expression. We can understand few of them but not all of them. It will not be a surprising fact if we say that there is a language which is understood by a class of persons, known as 'Engineers' who speak the same dialects and understand each other very well. This is the universal language of Engineers known as 'Engineering Graphics'. In Engineering Graphics we use different lines, symbols and conventions. Each line, symbol and convention has a definite purpose and sense to convey. Thus, we can say that Engineering Graphics is the language of Engineers. It is a graphic representation of thinking, planning and a language of every technical person who uses to communicate his ideas clearly to other technical persons. In the age of automation, Engineering Graphics has greatly developed. Without the fundamental knowledge of Graphics a student cannot succeed in Industry. There are many uses of Engineering Graphics in practical field, especially in modern industry. These Engineering Graphics are widely used in Mechanical, Electrical, Electronics, Automobiles, Marine, Aeronautical, Chemical, Computer and instrumentation industry etc. In Civil Engineering and Architecture, Graphics are used to draw top view and front view of buildings and structures.

In this chapter we shall learn about the basics of this universal language of Engineers. In Engineering Graphics we make extensive use of various types of lines, symbols and conventions (standard symbols). We shall learn about the standard letters and Numerals. These letters and Numerals are very necessary for writing notes, dimensions and the information needed on Graphics. Lastly, we shall undertake some simple constructions on rectilinear figures such as angles, triangles, quadrilaterals and polygons. We will also learn about dimensioning as it is an important aspect of our subject 'Engineering Graphics'. These methods dimensioning allows a standard shape and size of the product to be.

ACTIVITY

1. Measure the size of your books, note books and files etc. Draw a rough sketch of these in your sketch book and write their sizes.
2. Collect different types of cartons of consumer goods such as : Medicine cartons, Tea cartons, Chocolate cartons, Toothpaste Cartons etc. Identify their shapes and note them in the sketch book.
3. Note down the different shapes of your rooms in your house, Measure their length, width and height. And write these measurements in your sketch book.
4. Note different types of rectilinear figures in your study room such as note books, geometry box, pencil set, square etc.

1.2 TYPES OF LINES

Now, let us learn about the different types of lines used :- (Refer Fig. 1.1)

Drawing of Lines	E.G. / CAD	Thickness	Line
Continuous thick line	H.B. (Thick)	Bold / Thick	
Hidden line	H.B. / Thick	Bold dashing / Thickness dotted line	
Centre line or Axis line	4H / Wide	Long and Small dashes	
Short break line	4H / Wide	Thin free hand line	
Long break line	4H / Wide	Line with kinks	

Drawing of Lines	E.G. / CAD	Thickness	Line
Thin Continuous line	4H / Wide	Thin Continuous line	
Chain line	4H / Wide	Long Dashes with double dots in between	
Cutting Plane line or section Plane	4H / Wide	Chain thin, thick at ends and change of direction	A A A
Given line	2H / Extra Wide	Continuous line	
Hatching lines	4H / Wide	Group of parallel thin lines	

Fig. 1.1

1.2.1 LINES

First of all we shall study about the quality and use of different lines, symbols and conventions which we shall use at this stage. We shall come to know about different pencils used for this purpose.

These lines are black (Bold), medium and thin. In Engineering graphics we use the term 'Thick', 'Extra wide' and 'wide' for these lines. The General ratio of these lines is 4 : 2 : 1. For drawing these lines with pencil, we use 'HB', '2H' and '4H'. These pencils are used with equal pressure of hand. When we are confident and habitual with the quality of these lines, we can use a single pencil of 0.3 mm or 0.5 mm and get the same result by applying different pressure on the pencil.

It will be interesting to not that all lines should be sharp, distinct, and uniform in thickness and according to the type of line to be used.

Now let us learn more about these lines.

1. **Continuous thick line :** It is used as a boundary line of the drawing sheet and title block lines at the bottom of the drawing sheet. For showing the end of threaded portion and visible out lines of the object, so that the form of the object is at once clear. It is also known as object line.
2. **Thin continuous line :** This line is used to show projection lines, dimension lines, extension lines etc. These are drawn continous thin.
3. **Given Line :** It is drawn with medium thickness to show the given lines and angles.
   (a) **Construction lines :** These lines are drawn for constructing drawings. These are continuous thin lines.
   (b) **Extension line :** Extension lines are projected from the out lines at right angle to the boundary line to be dimensioned. These lines extend at least 3 mm beyond the dimension line.
   (c) **Dimension line :** This line is drawn thin and at a distance of 6 to 8 mm away from the boundary line and parallel to it. Dimension line is terminated by the arrow heads on both sides touching projection line, extension line or centre line.
   (d) **Leader line :** Leader line is an inclined line followed by a horizontal line. Numerals or notes are written on the horizontal portion of the leader line.
4. **Hidden Line :** This line is used where outline is not visible at viewing surface. This line is represented by thick short dashes evenly spaced. This line is a broken line, composed of short strokes of equal lengths (approximately 2 to 3 mm) and spaced at equal distances (1 mm), must be used.

5. **Centre/axis line :** This line is used to locate the center of circles, arcs and axis of cylindrical objects. This line indicates the axis of symmetry like cylindrical, conical, spherical, circles, arcs and should be extended slightly beyond the views in which they are applied. The centre line is drawn thin and is represented by long and short dashes evenly spaced approximately 1 mm apart in a proportion from 6 : 1, to 8 : 1 or in other words long dashes are about 3 to 5 times longer than the shorter dashes, which are taken about 2 mm long. Pitch circle lines are also shown by this type of line.

6. **Short break line :** This line is drawn thin with free hand for showing short breaks. It is thin curved (wavy) line. These are used to show limits of partial or interrupted views and sections.

7. **Long break line :** This line is drawn thin and straight with evenly spaced free hand zigzags, is used for shortening of long parts, which are same throughout or for showing long breaks.

8. **Chain line :** It is drawn with thin long dashes and dots (also with double dots) visible removed portions of the objects and with thin long dashes and double dots in between to show the hidden (invisible) removed portions. These portions are generally removed by cutting plane, in front of the viewing direction.

9. **Cutting plane line :** It is drawn thin and is similar to axis line but thick at ends and change of direction. This line indicates plane of section and arrow indicates the direction of viewing.

10. **Hatching lines :** These lines are also called section lines. These lines are continuous thin lines drawn at an angle of 45° to the main outlines of the sectioned portion. They are uniformly spaced and drawn 2 to 3 mm apart.

Refer Fig. 1.2 for reference on the next page

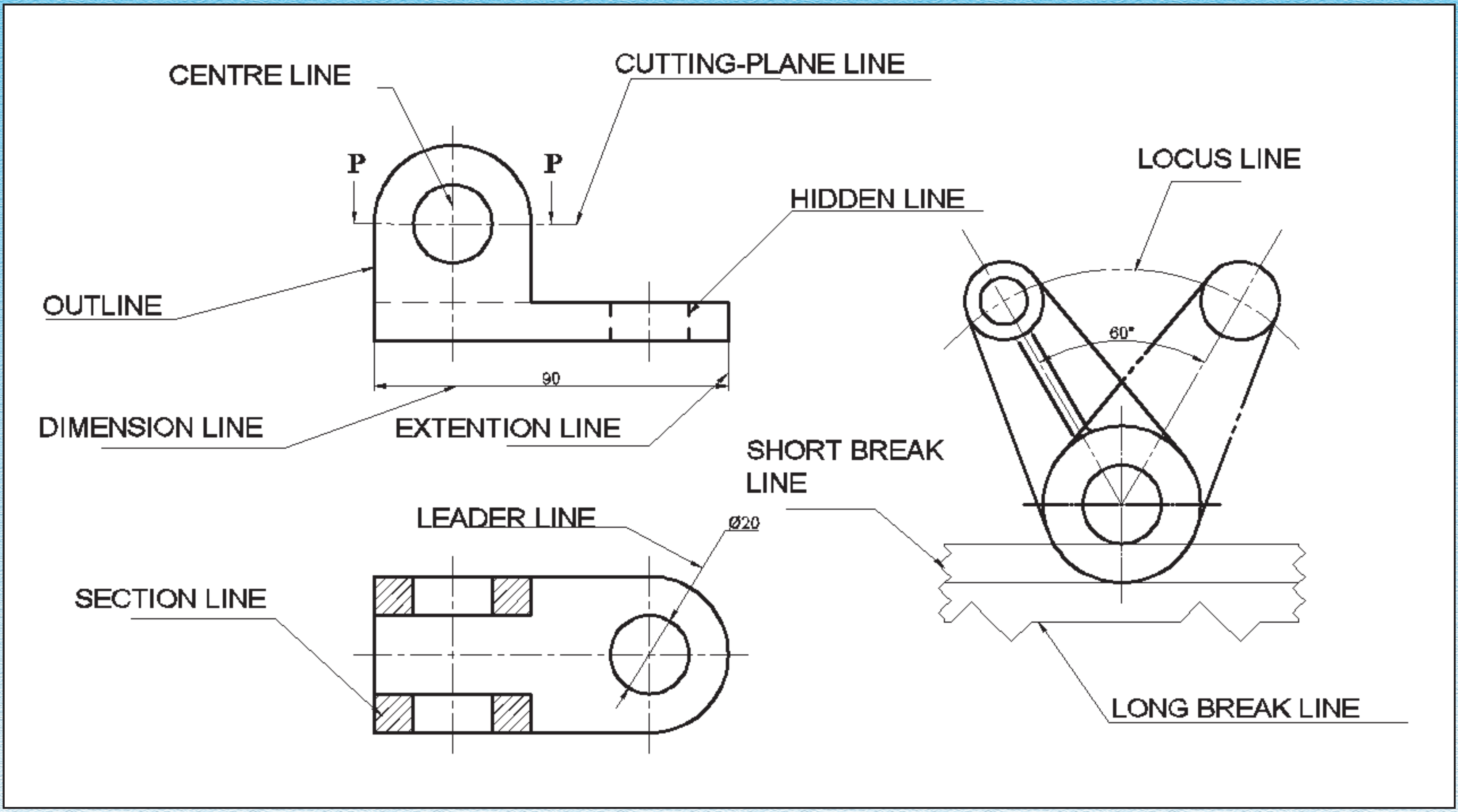

CENTRE LINE
CUTTING-PLANE LINE
P
P
LOCUS LINE
HIDDEN LINE
OUTLINE
60°
90
DIMENSION LINE
EXTENTION LINE
SHORT BREAK LINE
LEADER LINE
Ø20
SECTION LINE
LONG BREAK LINE

Fig. 1.2

1.3 ORDER OF PRIORITY OR COINCIDING LINES

Some time it may happen that when we have drawn some line/lines on our drawing sheet according to the need of the Graphics the same line or some other line/lines overlap each other then the following order of priority should be observed by us :

1. Continuous thick Line
2. Hidden Line
3. Centre/axis Line

1.4 CONVENTIONAL REPRESENTATION OF MATERIALS

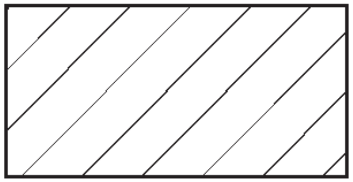
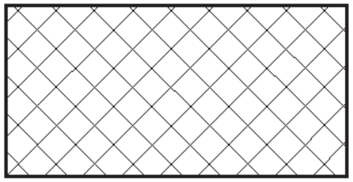
TITLE	CONVENTION	MATERIAL
METALS		Steel, Cast iron, Copper and its Alloys (e.g. Brass, Gun metal). Aluminum and its Alloys etc.
		Lead, Zinc, white metal etc.

Fig. 1.3

1.5 CONVENTIONAL REPRESENTATION OF BREAKS

Some time you may have noticed that some machine parts are quite long and it is unnecessary to show them in full length. Such as steel rods, pipes or long threads etc. Then we use conventional breaks and by moving the member closer. The break in the member is shown by different conventions. Generally these breaks are shown for a cross section of the uniform member. The true length is given by putting the dimension. (See Fig. 1.4)

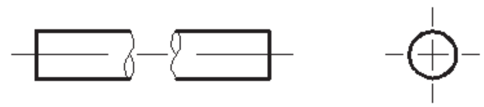
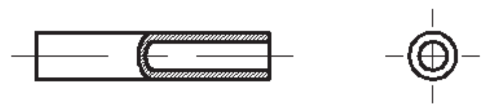
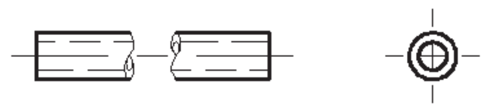
S. No.	TITLE	CONVENTIONAL BREAK
01.	RECTANGULAR (METALS)	 RECTANGULAR (METALS)
02.	ROUND	 ROUND
03.	PIPE OR TUBING	 PIPE OR TUBING
04.	PIPE OR TUBING	 PIPE OR TUBING

Fig. 1.4

1.6 CONVENTIONAL REPRESENTATION OF COMMON FEATURES

To save our time in drawing for making the drawing easier and to save space, conventional representation of various parts and features is adopted. (See Fig. 1.5)

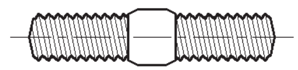
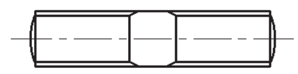
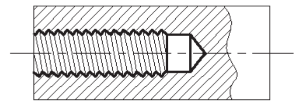
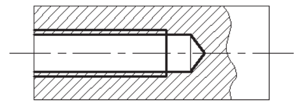
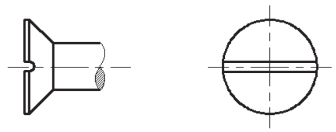
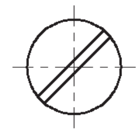
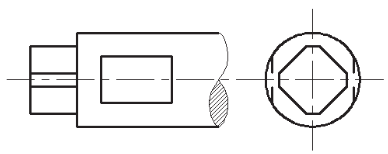
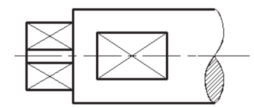
TITLE	ACTUAL PROJECTION/SECTION	CONVENTION
External Thread		
Internal Thread		
Slotted Head		
Square End and Flat		

Fig. 1.5

ASSIGNMENT

1. Draw and write which type of line you will use for drawing the following :

   (a) Axis of a Cone (b) Boundary line (c) Projection line

   (d) Line for short Break (e) Line for long break (f) Dimension line

2. What do you understand by the "order of priority of coinciding lines" ?
3. Write full form of "CAD" Explain the term "CAD" in brief.
4. How "CAD" can save, time, labour and natural resources ?
5. In which language the Engineers converse with each other and what is their script ?
6. Fill in the blanks by choosing the correct term. (curved thin line, thin, thin straight line with zigzags, thin continuous thin lines at 45°, thick)

   (a) Axis line is drawn as a .... line.

   (b) Visible out line is shown graphically as... .

   (c) Short break line is shown as ....

   (d) Long break line is shown as a ....

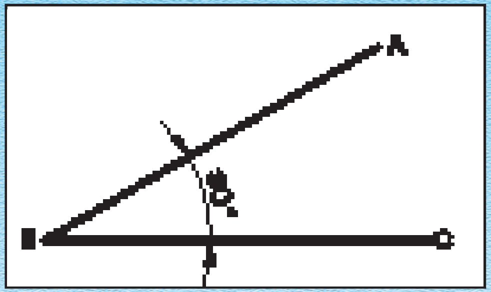
   (e) Hatching line is shown as ....

1.7 ANGLES

If we look around in our school. We will notice that our school playground is horizontal and our school building is standing vertical on the ground. On some festivals you may have flown kites in the open sky. Have you observed that the thread attached to the kite is neither horizontal nor vertical? It is inclined at some angle with respect to the ground and this angle changes with the magnitude of the flying kite.

We have learnt in the previous classes that when two straight lines meet at a point they are said to form an angle. We also know that these angles are of different types. Let us revise what we have learnt in the previous classes.

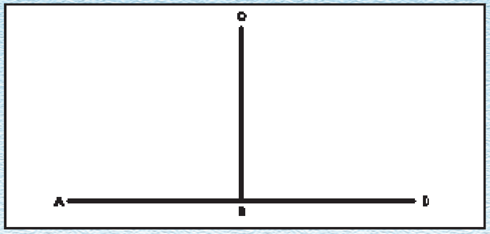
1. **An acute angle :** The angle less than 90° is an acute angle. (See Fig. 1.7.1)



ABC is an acute angle
Fig. 1.7.1

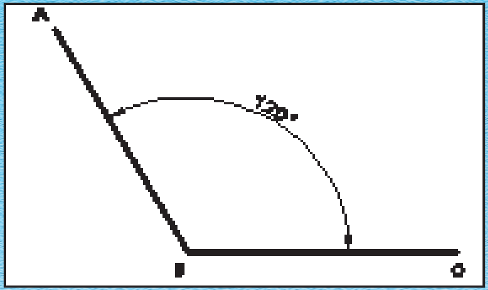
2. **Right angle :** When one straight line stands on another straight line so as to make the adjacent angles equal to each other, then we can say that one line is perpendicular to the other and the adjacent angles are called right angles.

   (See Fig. 1.7.2)



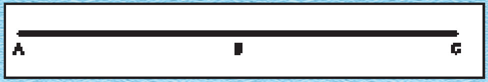
Angle ABC and Angle CBD are right angles
Fig. 1.7.2

3. **Obtuse angle :** The angle between 90° and 180° is called an obtuse angle. (See Fig. 1.7.3)



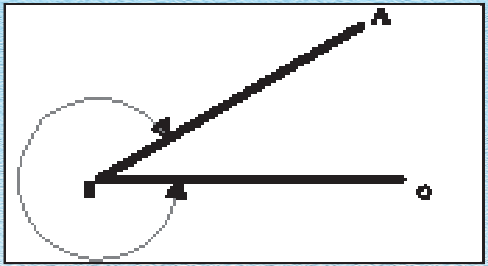
ABC is an obtuse angle
Fig. 1.7.3

4. **Straight angle :** This angle is a straight line or of 180°. (See Fig. 1.7.4)



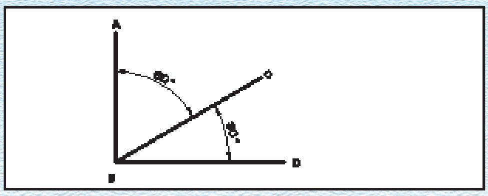
ABC is a Straight Line
Fig. 1.7.4

5. **Reflex angle :** This angle is greater than 180° but less than 360°. (See Fig. 1.7.5)



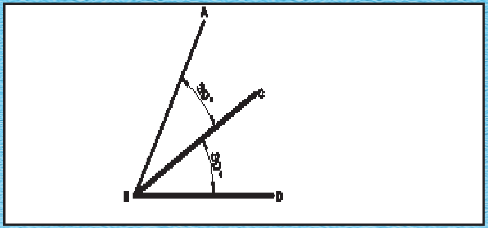
ABC is a reflex angle
Fig. 1.7.5

6. **Adjacent angles :** Those angles which lie on either side of a common arm are called adjacent angles. (See Fig. 1.7.6)



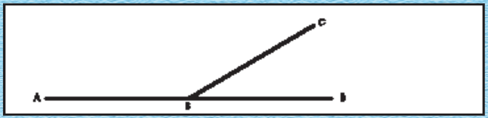
Angle ABC and Angle CED are adacant angles
Fig. 1.7.6

7. **Complementary angles :** When sum of two angles is 90° they are said to be complementary angles. One angle is the complement of the other angle.
(See Fig. 1.7.7)



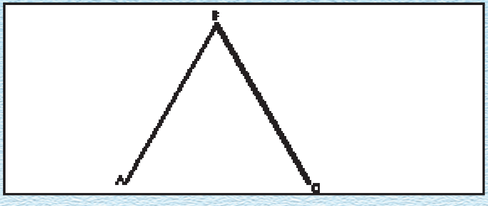
Angle ABC and Angle CED are complementary angles
Fig. 1.7.7

8. **Supplementary angles :** When sum of two angles is 180°, they are said to be supplementary angles. One angle is called the supplement of the other angle.
(See Fig. 1.7.8)



Angle ABC and Angle CBD are supplementary angles
Fig. 1.7.8

9. **Vertex or apex of the angle :** The point where two inclined lines meet.
(See Fig. 1.7.9)



ABC is the vertex or apex of the angle ABC
Fig. 1.7.9

1.8 LETTER PRINTING

We have just learnt in our previous paragraphs about the lines. We have also learnt about their uses. Now, let us learn about the letters. Like lines the letters and numerals are standardized, so that the words written in one country may be understood by the people of the other country where the drawing is used for production, repair or for general maintenance.

It is aptly said that, "Small things make perfection, but perfection is no small thing".

Letter writing is one of the "small things" which make or mar the appearance and perhaps the usefulness of a drawing.

The foremost step in an engineering graphics of course is a good practice in free hand lettering and dimensioning. Insistence upon reasonable accuracy and conformity to the standard then set in all subsequent exercises soon engenders the right attitude to this important branch of the work. Without neat conventional letters and figures a drawing is offensive to a trained eye.

We can divide the letters broadly in two types. first is 'Upper Case Letters' and secondly into 'Lower Case Letters'. We can also say 'Capital' and 'Small letters'.

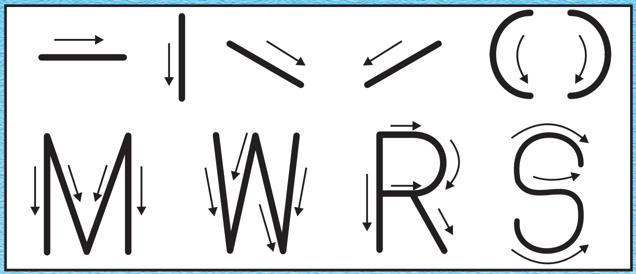
Similarly, the ratio of height and width bears some ratio. Generally it is 7:4 or 5:4, except for some letters such as 'I', 'j', 'M', and 'W', which is 5:1, 5:3 and 5:5 and 5:5 (or 7:1, '7:3, '7:5' and '7:5). It is not always necessary to adhere to these ratios. According to the space available the letters can be expanded or compressed. The writing of these letters may also vary from person to person. The letters are written either by free hand or with the help of 'Stencils'. Thus, we can say that process of writing the capital alphabets (A, B, C, D, ...Z), small alphabets (a, b, c, d, ...z) and the Numerals (0, 1, 2, 3, 4, ...9) is known as Letter Printing.

Now, we shall learn about the correct formation of letters as are printed on the Engineering Graphics. We shall also learn about the correct ratio between height and width of these letters.

Now, let us learn about the 'Capital' and 'Small letters' along with the 'Numerals'. Before writing these letters we should be familiar with the height, width and shape of these letters as used on the drawing. For main title we take height of main title as '6 mm', for sub title height may be '4 mm' and for any other title or dimension it can be '2 mm'.

Generally, we use single stroke letters. The word single stroke should not be taken to mean that the letter should be made in one stroke without lifting the pencil. It actually means that the thickness of the line of the letter should be such as is obtained in one stroke of the pencil. (See Fig. 1.8.2 & 1.8.3)

It will be interesting to note that there are **six fundamental strokes** only. It is an enough proof that single stroke gothic letters are very simple to write. These basic strokes are as given below :



Six Fundamental Stroke
Fig. 1.8.1

The vertical letters look beautiful and easy to read. Therefore, we shall learn more about these letters here, later you can go for slanting letters also. Slanting letters are written in the same fashion as the vertical letters, the only difference is the angle of slant, which is 72°. These slanting letters are also called *italics letters.*

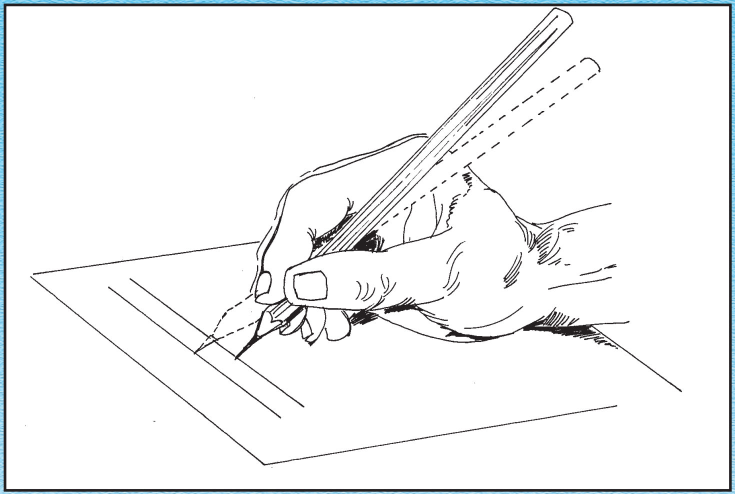
For writing 'Capital' or 'Upper Case Letters' divide the height into two equal halves and then write the required letters keeping in mind the ratio of width to the height.

Before printing these alphabets, it will be of much use if we draw guide lines. For printing capital letters mainly two guide lines are drawn. The lower line is called 'base line' and the upper line is called the 'Cap line' or 'Capital line'. It will be much easier for us if a 'middle line' is also drawn for our convenience.

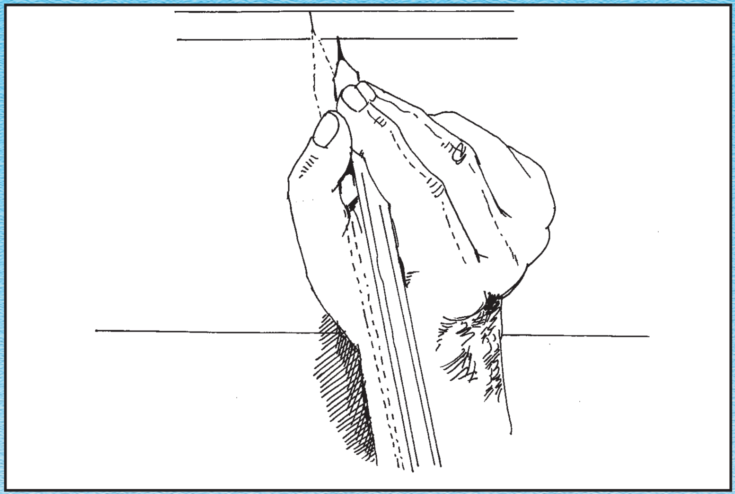
Before writing letters we must know about the **RULE OF STABILITY:**

In the construction of letters, the well known optical illusion in which a horizontal line drawn across the middle of a rectangle appears to be below the middle must be provided for. In order to give the appearance of stability, such letters as B, E, K, S, X, and Z and the figures 3 and 8 must be drawn smaller at the top than the bottom. To see the effect of this illusion turn a printed page upside down and notice the appearance of the letters mentioned.

It will be interesting to note that these strokes are drawn from top to bottom and from left to right. It is also very important to note that the first requirement in lettering is to hold the pencil correctly. The pencil should be held comfortably with the thumb, forefinger and second finger on alternate flat sides and third and fourth fingers on the paper. Vertical slanting and curved strokes are drawn with a steady, even, finger movement; horizontal strokes are made similarly but with some pivoting of the hand at the wrist. Exert pressure, which is firm and uniform but not so heavy as to cut grooves in the paper. To keep the point symmetrical, form the habit of rotating the pencil after every few strokes.



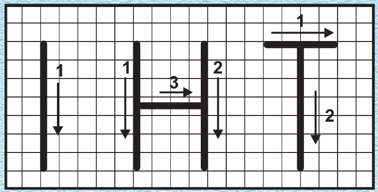
Vertical strokes are made entirely by finger moments
Fig. 1.8.2



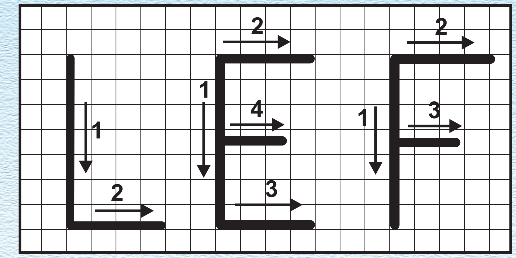
Horizontal strokes are made by pivoting the whole hand at the wrist; fingers move slightly to keep the stroke perfectly horizontal
Fig. 1.8.3

The following capital letters are arranged in family groups. Study the shape of each letter, with the order and direction of the strokes forming it and practice it until its form and construction are familiar to you.

Let us first take **'I', 'H', and 'T' group :** The letter 'I' is the foundation stroke. We shall find it difficult to keep the stems strokes vertical. If so draw direction lines lightly. The 'H' is nearly rectangular and the cross bar is just in centre. The top of 'T' is drawn first to the full width and then the stem is drawn in the middle vertically. (See Fig. 1.8.4)



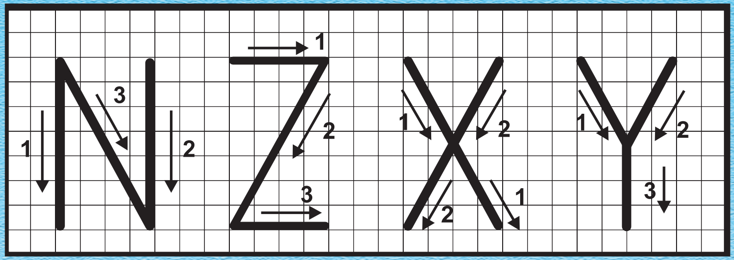
Note the direction of fundamental horizontal and vertical strokes
Fig. 1.8.4



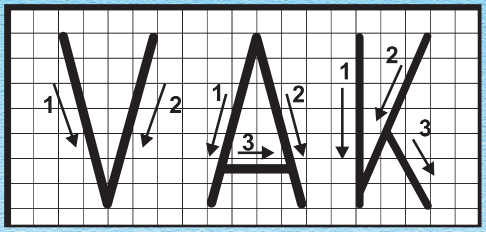
Note the successive order of strokes
Fig. 1.8.5

Second group is of **'L', 'E' and 'F' group :** The letter 'L' is made in two strokes The first two strokes of 'E' are the same as for the letter 'L' and the third or upper stroke is slightly shorter than the lowest stroke or may be drawn equal. The third stroke will be two third of the longest stroke and drawn in the middle of the letter. The letter 'F' has the same proportions as for the letter 'E' except the lowest line. (See Fig. 1.8.5)

The third group of letters consist of **'N', 'Z', 'X' and 'Y' :** For drawing letter 'N' the parallel sides are drawn first and then the slanting line is drawn. For the letter 'Z' top and bottom horizontal lines are drawn first and then the slanting line is drawn. for drawing letter 'X' for beginners it will be better if four points at the width of the boundary are marked and then joined diagonally. For writing 'Y', draw half 'X' and the junction of the 'Y' stroke is at the centre. (See Fig. 1.8.6)



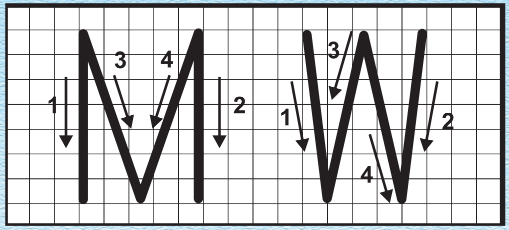
Note that Z and X are smaller at the top than at the bottom, in accordance with the rule of stability.
Fig. 1.8.6



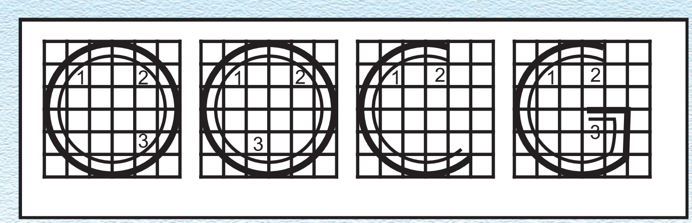
The horizontal line of 'A' is one-third from the bottom; the second and third strokes of 'K' are perpendicular to each other.
Figure 1.8.7

The fourth group is of **'V', 'A' and 'K' :** 'V' is of the same width as 'A'. The 'A' bridge is one third up from the bottom. The second stroke of 'K' strikes the stem one third up from the bottom, the third stroke branches from it in a direction starting from top of the stem. (See Fig. 1.8.7)

The fourth group is of **'M' and 'W'** : These two letters are the widest of all letters. 'M' may be made in consecutive strokes or by drawing the two vertical strokes first, as with the 'M', 'W' is formed of two narrow 'Vs', each two third in width of the letter. Note that with all the pointed letters the width at the point is the width of the stroke. (See Fig. 1.8.8)



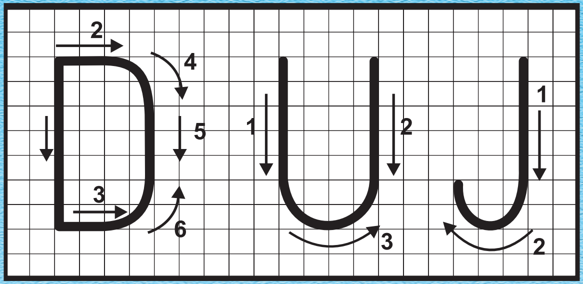
'M' and 'W' are wider than the other letters by one unit.
Fig. 1.8.8



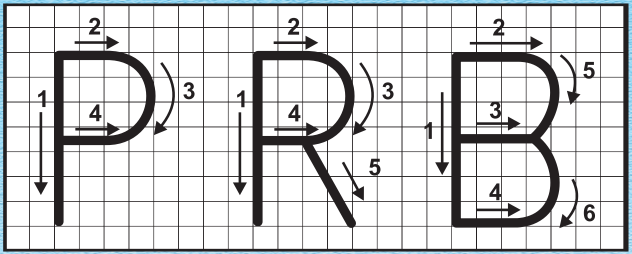
All these letters are based on the circle
Fig. 1.8.9

The sixth group is **'O', 'Q' 'C' and 'G'** group : In this group letters are mde as full circles. The 'O' is made in two strokes, the left side is a longer arc than the right, as the right side is harder to draw. Make the kern of the 'Q' straight. A large size 'C' and 'G' can be made more accurately with an extra stroke at the top. Whereas, in smaller letters the curve is made in one stroke. Note that the middle bar in 'G' is halfway up and does not extend past the vertical stroke. (See Fig. 1.8.9)

The seventh group of letters is **'D', 'U' and 'J'** is : The top and bottom strokes of 'D' must be horizontal. Failure to observe this is a common fault with the beginners. Letter 'U' is formed by two parallel strokes to which the bottom stroke is added, in smaller letters it may be made in two strokes curved to meet at the bottom. 'J' has the same construction as 'U' with the first stroke omitted. (See Fig. 1.8.10)



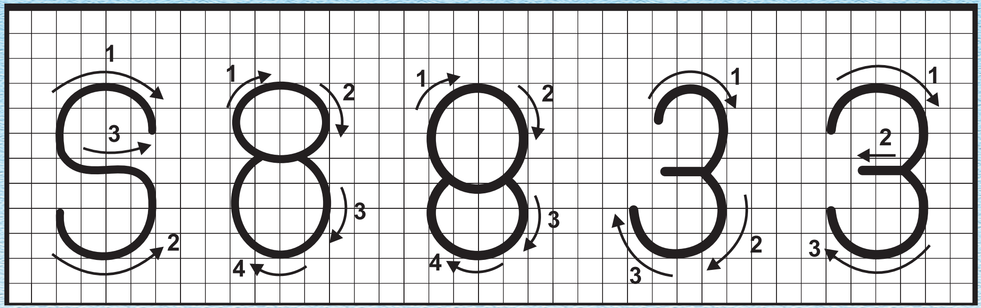
These are made with combinations of straight and curved strokes
Fig. 1.8.10



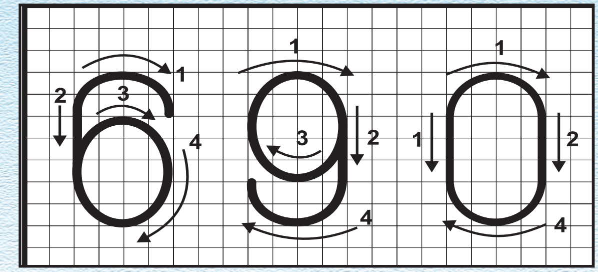
Note the rule of stability with regard to R and B
Fig. 1.8.11

The eighth group is **'P', 'R' and 'B'** group : With 'P', 'R' and 'B' the number of strokes depends upon the size of the letter. For capital letters the horizontal lines are drawn and the curves added, but for smaller letters only one stroke for each to be added. The middle line of 'P' and 'R' are on the centre line. For 'B' observe the rule of stability. (See Fig. 1.8.11)

The ninth group consists of **'S', '8' and '3'** group : This group is closely related in form. The rule of stability may be observed carefully. For capital 'S', three strokes are used, for a smaller one, two strokes and for a very small size one stroke only is best. The '8' and 'S' are similar in construction. These letters are made in three strokes. Or in "head and body" in four strokes. A perfect '3' can be finished in '8'. (See Fig. 1.8.12)



A perfect S and 3 can be completed to a perfect 8.
Fig. 1.8.12



The width is bit lesser than the height
Fig. 1.8.13

The tenth group consist of **'0', '6' and '9' :** The numeral 'O' is five-sixth the width of the letter, is an ellipse. The backbones of '6' and '9' have the same curve as of '0' and the lobes are slightly less than two-thirds the height of the letter. (See Fig. 1.8.13)

The eleventh group consists of **'2', '5' and '7' '&' 4,1.** The secret in making the '2' lies in getting the reverse curve to cross the centre of the space. The bottom of '2' and the top of '5' and '7' should be horizontal ; straight lines. The second stroke of '7' terminates directly below the middle of the top stroke. Its stiffness is relieved by curving it slightly at the lower end. The ampersand (&) is made in three strokes for large letters and two for smaller ones and must be carefully balanced. The numeral (4) will be written by horizontal & vertical stroke and numeral 1 will be written by vertical and slant stroke. (See Fig. 1.8.14)

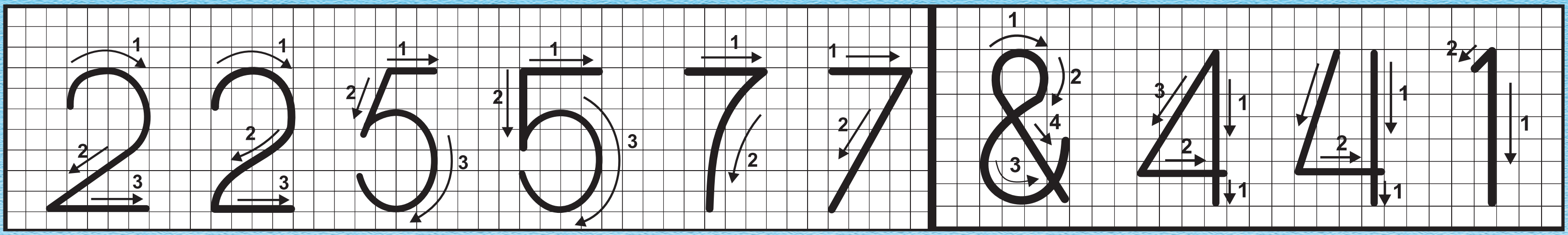


Fig. 1.8.14

SOME EXAMPLES

VERTICAL ALPHABETS

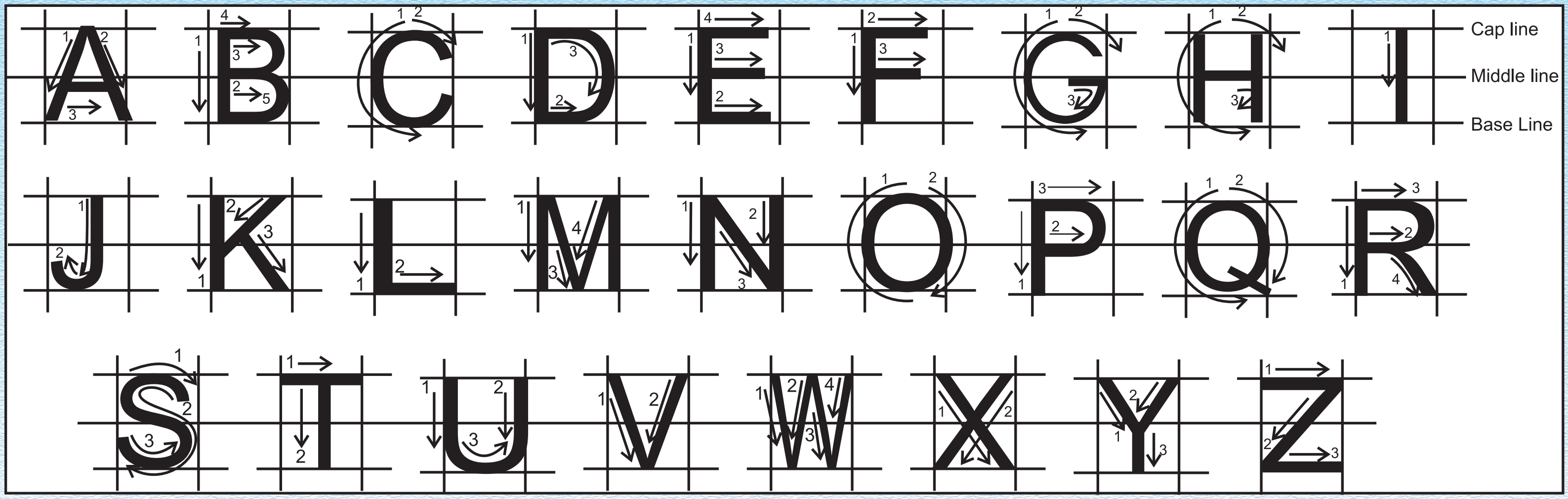


Fig. 1.8.15

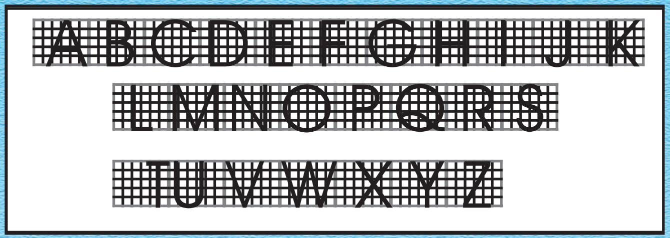


Fig. 1.8.16

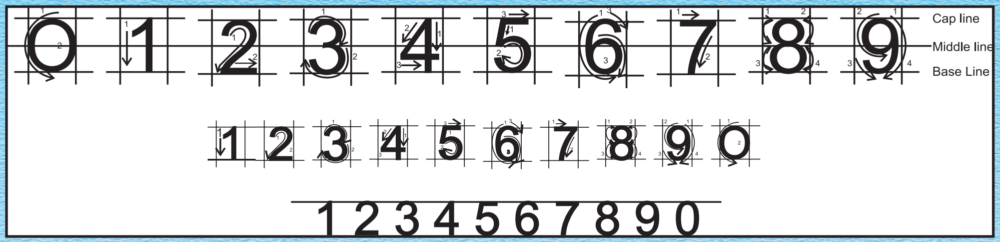


Fig. 1.8.17

ITALICS ALPHABETS

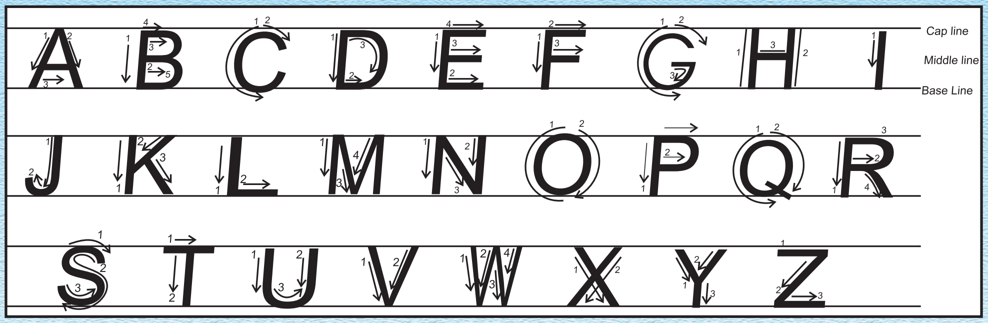


Fig. 1.8.18

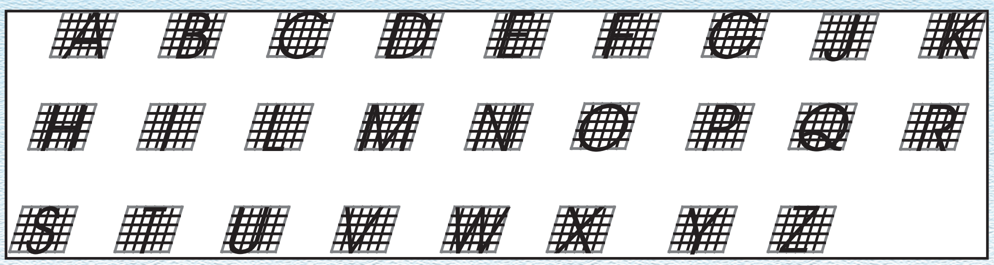


Fig. 1.8.19

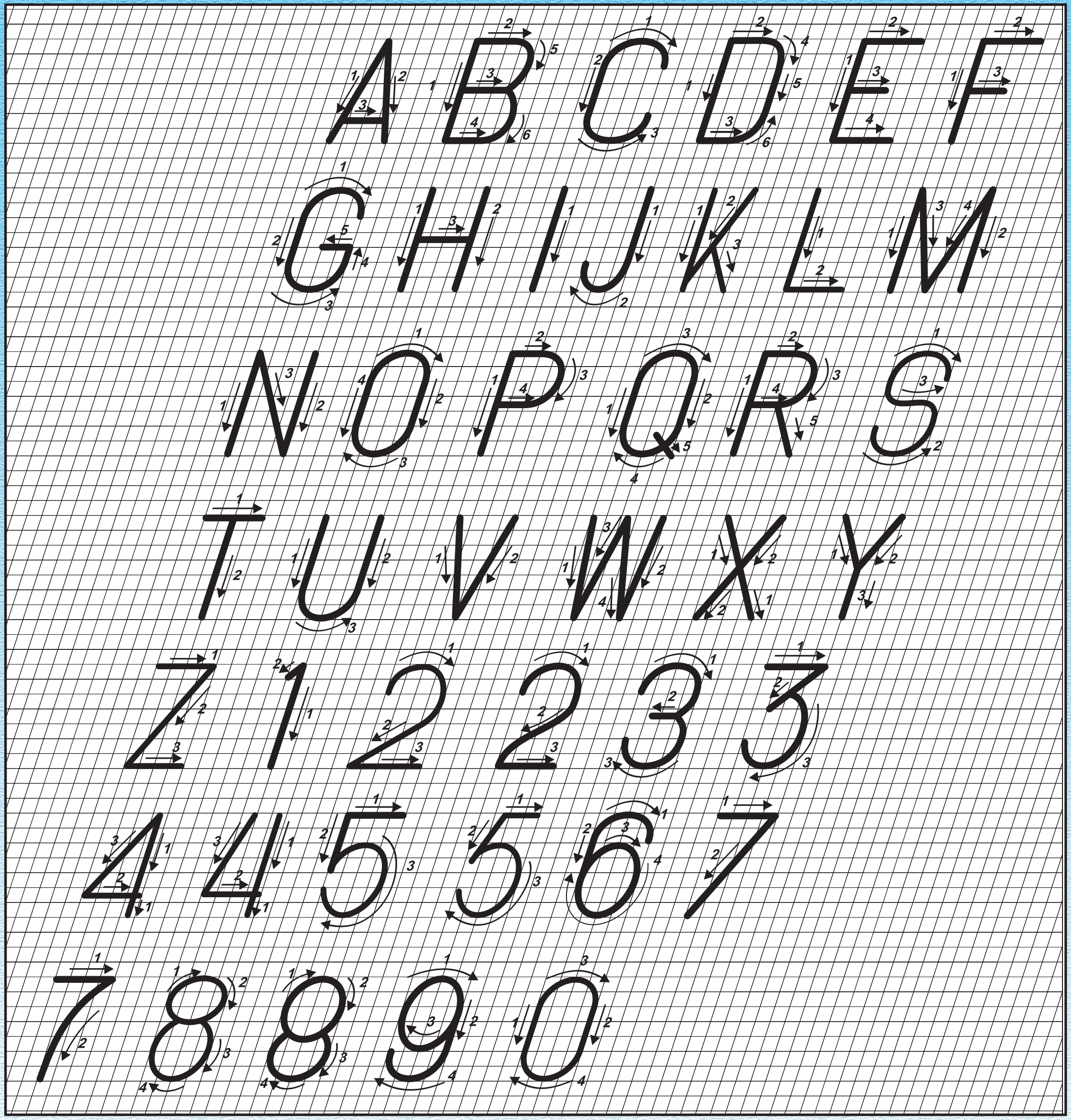


Fig. 1.8.20

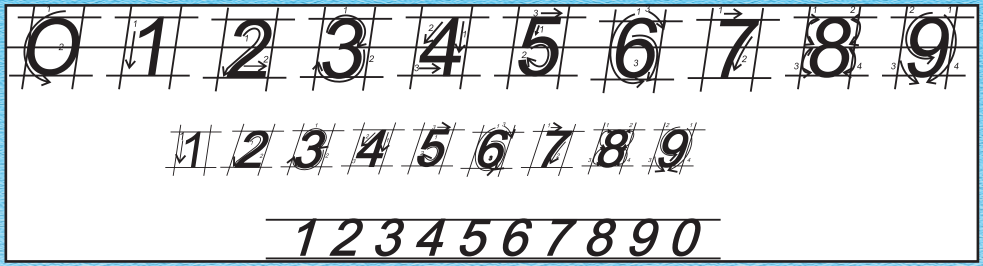
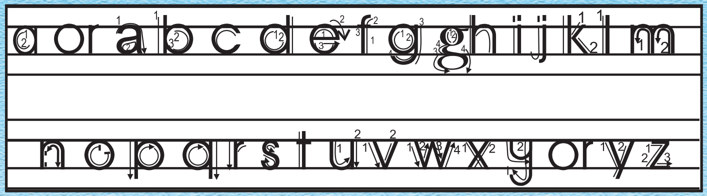
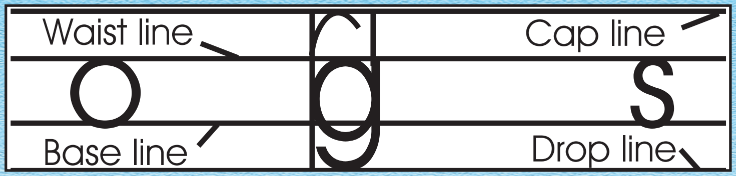


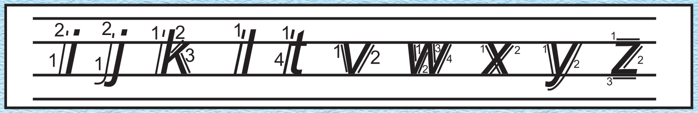
Fig. 1.8.21



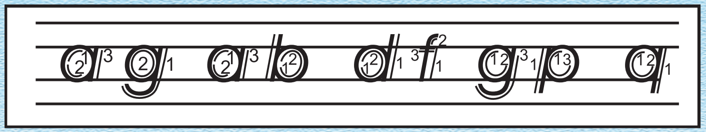
Lowercase Letters
Fig. 1.8.22



Basic forms form lowercase letters. For standard letters, the waist-line height is two-thirds of capital height; capital Line and drop line are therefore one-third above and one-third below the body of the letter.
Fig. 1.8.23



The straight-line inclined lowercase letters. Note that the center lines of the letters follow the slope angle.
Fig. 1.8.24

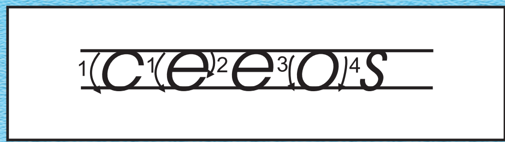


The loop letters. Note the graceful combination of elliptical body, ascenders and descenders.
Fig. 1.8.25

Form of curved-stroke inclined capital. The basic shape is elliptical.
Fig. 1.8.26

The hook letters. They are combinations of ellipses and straight lines.
Fig. 1.8.27

ITALICS LOWERCASE LETTERS



The ellipse letters. Their formation is basically elliptical.
Fig. 1.8.28

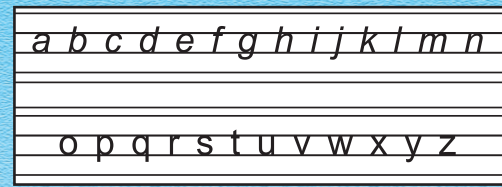


Fig. 1.8.29

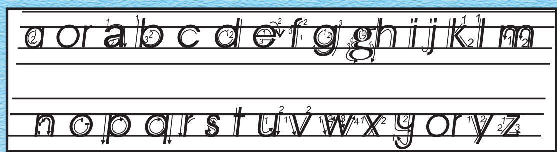


Fig. 1.8.30

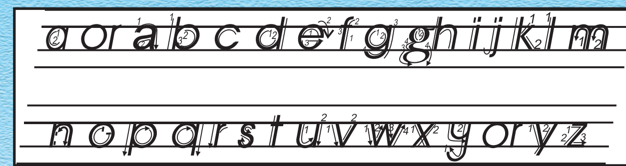
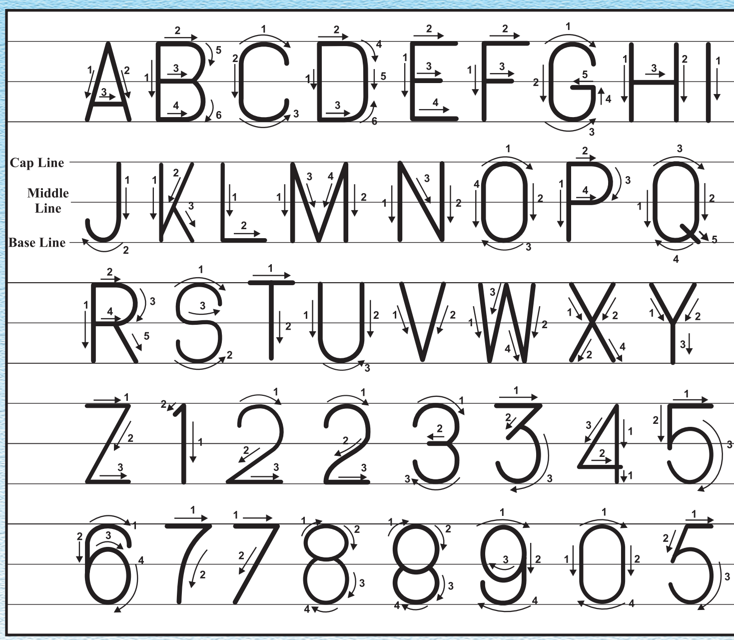
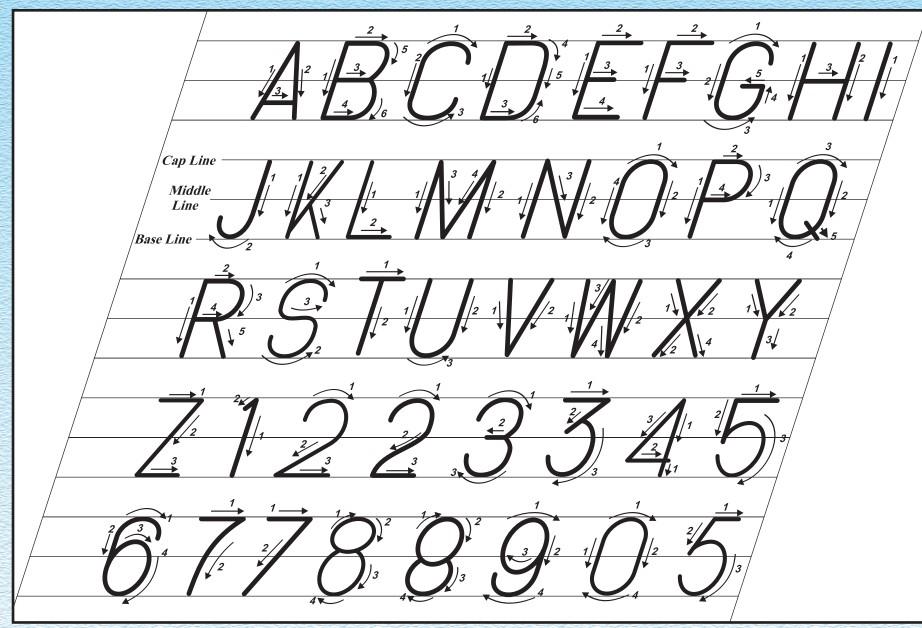


Fig. 1.8.31



Italic Vertical Letters
Fig. 1.8.32



Italics Letters
Fig. 1.8.33

1.9 FOR LEFT HANDERS ONLY

The order and direction of strokes in the preceding alphabets were designed for right handed persons. The principal reason that left hander sometimes find lettering difficult is that whereas "the right hander progresses away from the body, the left hander progresses toward the body" consequently, the pencil and hand partially hide the work done making it harder to join strokes and to preserve uniformity.

For the natural left hander, whose writing position is the same as a right hander except reversed left for right, a change in the sequence of strokes of some of the letters will obviate part of the difficulty caused by interference with the line of sight. For example for letter 'E' the top bar is made before the bottom bar and 'M' is drawn from left to right to avoid having strokes hidden by the pencil. Horizontal portions of curves are easier to make from right to left, hence the starting points for 'O', 'Q', 'C', 'G' and 'U' differ from the standard right hand stroking. 'S' is the perfect letter for the left hander and is best made in single smooth stroke. The figures '6' and '9' are difficult and require extra practice. In lower case letters 'a', 'd', 'g' and 'q' it is better to draw the straight line before the curve, even though it makes spacing a little hurdle. (See Fig. 1.9.1. to 1.9.4)

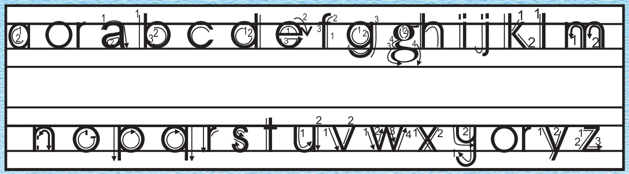


Fig. 1.9.1

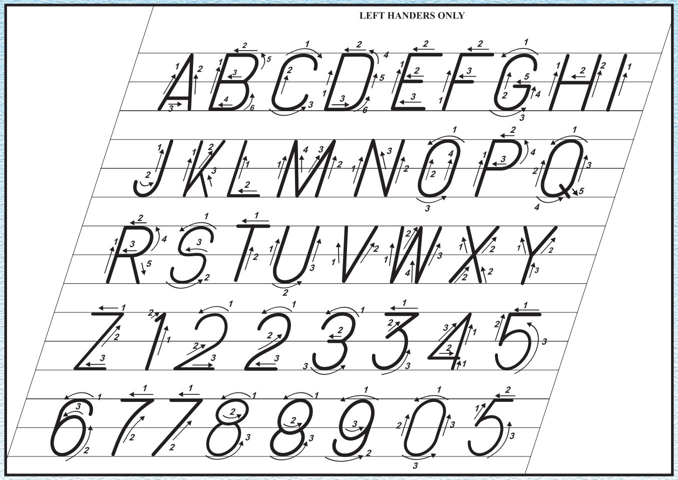


Fig. 1.9.2

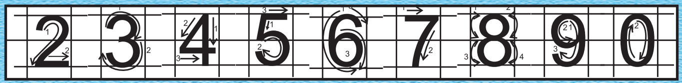


Fig. 1.9.3

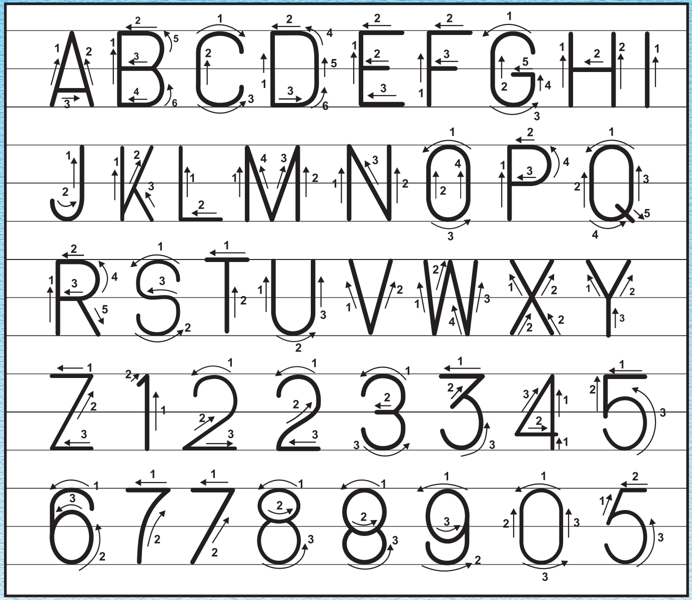


Fig. 1.9.4

1.5.2 Essentials of good lettering :

1. Acquire a thorough knowledge of all types of letters, the general shape, proportion and design and direction of the strokes used to produce it.
2. Learn to compose letter in formation of words and see that spacing is proper and uniform.
3. Practice consistently and conscientiously.
4. Lettering for titles and sub-titles should be written in guided lines.

1.5.3 Some important points which should be kept in mind while writing these letters and numerals :

1. These letters should be written by a single stroke of pencil and no sketching is done.
2. All letters should be uniform in shape, size, stroke, shade and spacing.
3. The shine and boldness of the letters and numerals should be the same.
4. The letters should be legible and uniform in height and width, except for the letters 'I', 'J' 'M' and 'W'.
5. The letters can be written in the expanded or compressed form according to the space available for writing.
6. The space between two letters must be kept uniform and a gap equal to twice the thickness of the letter may be kept between two except when writing : LT, AV, PA, LY, AT, TV, etc. Similarly, no gap is to be given while writing : AWA, ATA, PAT, AVA, AYA etc.
7. The space between two words may be equal to the width of one letter.
8. The line thickness for small and cepital alphabets shall be the same.
9. The guide lines should be drawn with '4H' (Thin lines) and unnecessary lines may be rubbed off.

ACTIVITY

1. Write in capital letters on your notebook the following things :
   (a) Your name
   (b) Class
   (c) Roll No.
   (d) Subject and
   (e) Name of the School
2. Write the following paragraph in 'Capital' and 'Small' letters :

   "Your application for a job is your ambassador. It reaches before you reach a firm for a job. It discloses everything about your personality. Therefore, always write in a good hand."

TEST YOURSELF / ASSIGNMENT

1. How many types of 'letters are there?
2. What do you understand by 'letter printing' ?
3. Write the following sentence into Capital and small letters :

   "Engineering Graphics is the language of Engineers".
4. Write the following letters and numerals in the single stroke gothic letters:

   "The height of main title may be taken as 6 mm, subtitles as 4 mm and any other title or dimension in 2 mm".
5. Write the name of guide lines as used for capital letters and for small letters.
6. What points should be kept in mind while writing single stroke gothic letters?
7. How we can write beautiful and legible letters ?
8. What is the ratio of height and width in capital letters ?
9. What is the ratio between height and width of small letters? How we should divide the height for small letters ?
10. How much gap between two letters and two words may be given ?
11. Explain the rule of spacing between the letters.
12. Write in capital and small letters the following lines :

    "The letters and numerals are written with a conical blunt pencil, these consist of horizontal, vertical, inclined and curved strokes to give the required letters."

1.10 LIST OF DRAWING EQUIPMENTS AND MATERIALS

We have seen that mason uses different materials and tools to construct a house. A carpenter uses different types of wood and tools to make furniture etc. Similarly, Engineers use different materials and tools for drawing Engg. graphics.

A person generating a drawing needs particular type of materials and equipments to draw drawing neatly, conveniently and with less labour. Thus, he saves a lot of energy and time. The quality of drawing produced is also of good quality.

These instruments and material may be purchased under the guidance of your Engineering Graphics teacher or from, a standard stationery shop to ensure quality and usefulness.

List of Materials and Equipments required at this stage of learning.

1. Drawing Board of half imperial size. (24″ × 15″) or (615 mm × 39 mm)
2. Drawing sheets of imperial size and of good quality. These can be cut into half imperial size by thread or a paper cutter.
3. ¼ Imperial size Sketch Book.
4. Pencils : 'HB', '2H' and '4H', (later a single mechanical pencil using leads of '0.3 mm' or '0.5 mm' can be used, a pencil lead box filled with leads is also needed).
5. A non-dust rubber of good quality. 5 (a) Erasing Shield
6. Scales of '150 mm' and '300 mm'.
7. Two compasses with the facility of bending arms. One compass for holding 'B' and other for '2H' pencil leads.
8. One divider with needles at two ends.
9. Set squares having angles of 45°, 90° and 45° of 135 mm in length (length of hypotenuse) and 30°, 90° amd 60° of 175 mm in length, made up of good quality cellouse.
10. Drawing board clamps, clips, pins or cello tape for fixing the drawing sheet.
11. One protector of semicircular shape of 50 mm radius made of plastic.
12. A piece of 0° sand paper or a fine file or emery paper for sharpening the pencil lead.
13. A pencil cutter, sharpener or pencil machine cutter.
14. A small paper knife or some stitching thread to cut the drawing sheets etc.
15. A handkerchief or clean duster or a clean hand Towel to clean the instruments or remove dust from the drawing sheet or for removing the rubber dust .
16. Pencil leads of 'B' and '2H' for fixing in the compasses.

17. Drawing file of half imperial size or a round plastic box or a shuttle cock box for keeping drawing sheets.
18. A small circle plate or circle master for drawing curves and small circles.
19. Tee-Square, Roller drafter or a Mini-Drafter for using on a half imperial size drawing board.

1.11 DRAWING BOARD

Drawing board is a rectangular smooth surface made of some soft wood strips such as : Yellow Pine, white Pine, Oak, Linden, Red Cedar, Kail or Basswood. These wooden strips are cleated at the bottom and two rectangular wooden battens are screwed to check wrapping. A working edge made of ebony wood is provided on the left edge of the board. The T-square slides along this edge. For more smoothness of the working surface of the drawing board may be laminated. (See Fig. 1.11.1 & 1.11.2 below)

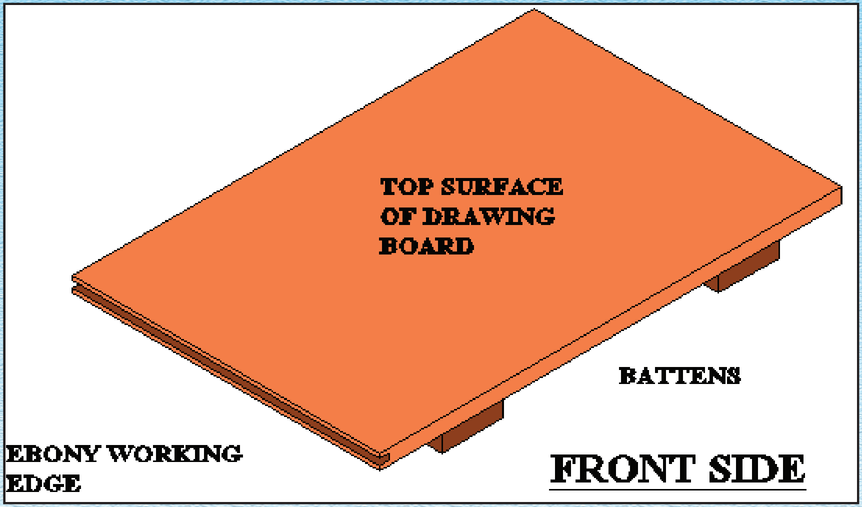


Fig. 1.11.1

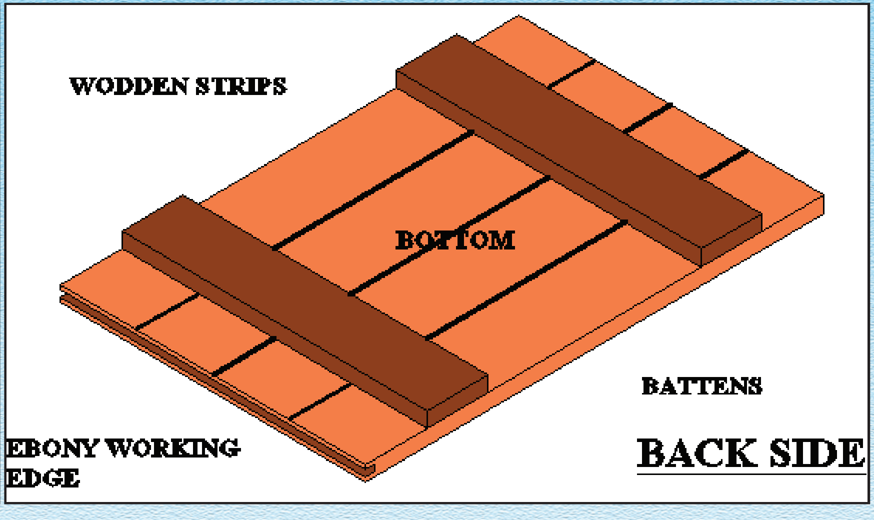


Fig. 1.11.2

Uses

(a) On the flat surface of the drawing board the drawing sheet is fixed.

(b) If mini drafter is used than it can be fitted on the upper left hand corner.

(c) The Tee-square can be used by tightly sliding butt against the left hand ebony edge of the drawing board and blade can be used to support set-squares or for drawing horizontal lines.

These are used to draw the graphics on them. Generally a half imperial size drawing sheet is enough to be used at this stage. The half imperial size of drawing sheet is 420 mm × 594 mm in size. White sheets are used where the appearance is given more consideration. The drawing sheet has two sides one is rough side and the other is smooth side. We generally use rough side so that pencil may give good impression. The drawing sheet should possess the uniform thickness and of such a quality that the erasing effect should not be there.

Uses :

(a) It is used to draw the final layout of the drawing.

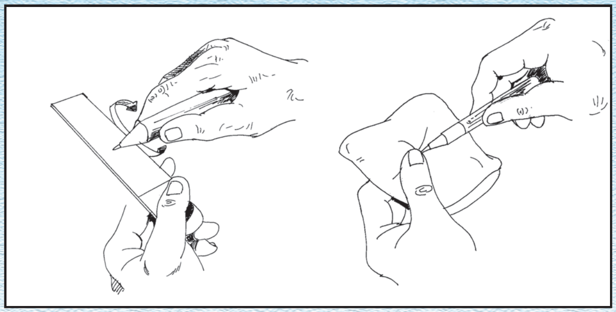
(b) The prepared drawing lay outs can be stored for future use.

1.12 QUARTER ¼ IMPERIAL SIZE SKETCH BOOK

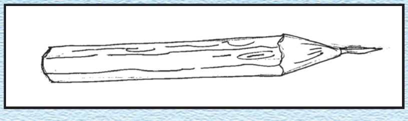
This Sketch book may be used as rough note book for Engineering Graphics work. The class notes of Graphics may be made in this Sketch Book. It will be much useful at the time of examination as we have not to look in other note books about the important Graphics or notes etc. made previously. On the more, this note book keep a tab on what we have learnt in the class or elsewhere.

1.13 PENCILS/MICRO TIP PENCIL / MECHANICAL PENCIL OR CLUTCH PENCIL

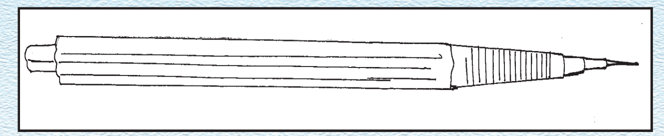
It is rightly said that a good quality pencil can produce a good quality drawing. It will be much better if all the pencils are of the same manufacturer. We have noticed that at one end of the pencil HB, 2H or any other number is written. We should know that the numeral denotes the degree of softness or hardness. 'H' stands for hardness and 'B' for blackness. Thus 'HB' stands for hard black pencil. These pencils are available from '9H' to '7B' grades. There are two medium grade pencil 'HB and 'F' also available in the market. These pencils are sharpened in the 'Conical' or 'Chisel' shape according to the necessity of the drawing. Then the use of mechanical penal/clutch pencil would be introduced. (See Fig. 1.13.1 to 1.13.4)



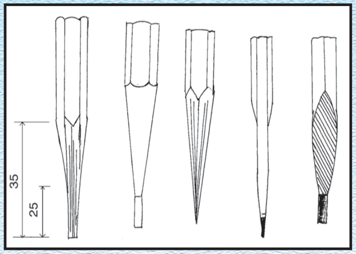
Sharpening and cleaning the lead of the Pencil
Fig. 1.13.1



Drafting Pencil
Fig. 1.13.2



Mechanical Pencil
Fig. 1.13.3



Common Pencil Points
Fig. 1.13.4

Different shades of graphite Pencils

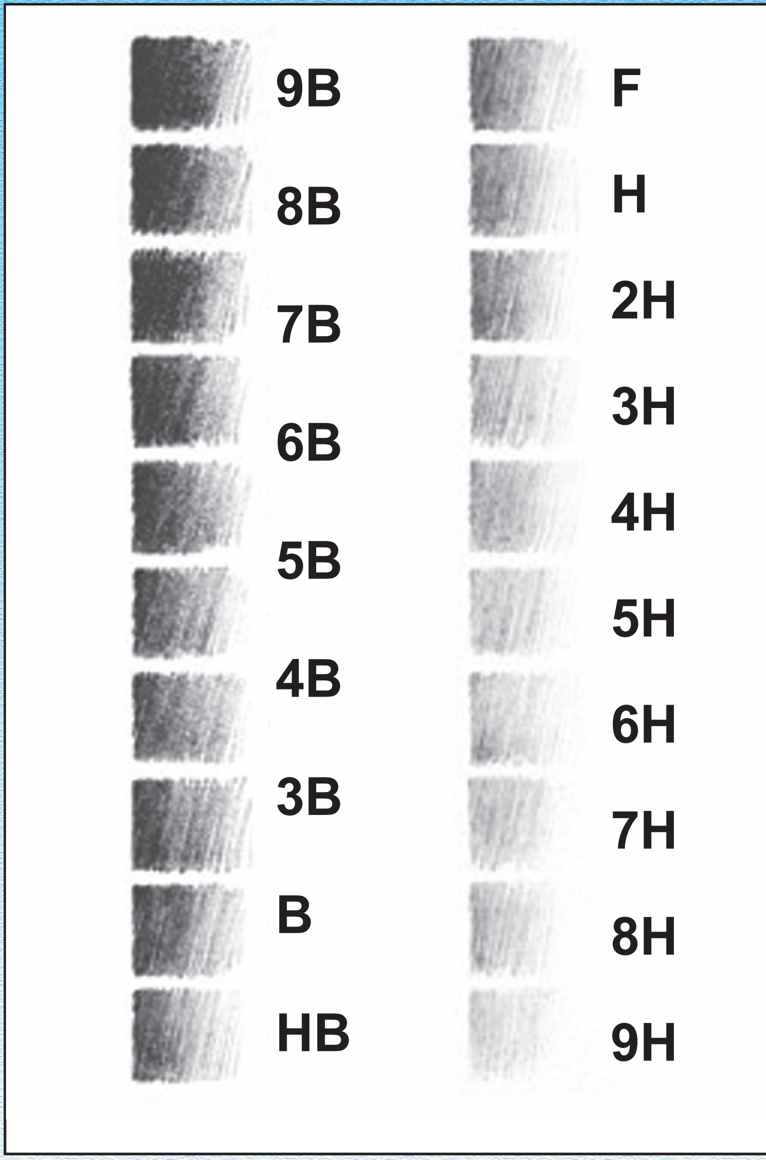


Fig. 1.13.5 (a)

EXTRA INFORMATION

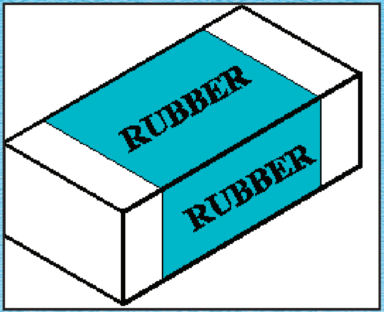
EXTRA INFORMATION ABOUT THE GRADES OF PENCIL

Pencil/ Grade	Soft Grade	Medium Grade	Hard Grade
	Artist Work	Drafting Work	Precise Work
9 H (Very Hard)			
8 H (Very Hard)			
7 H (Very Hard)			
6 H (Hard)			
5 H (Hard)			
4 H (Hard)			
3 H (Medium Hard)			
2 H (Medium Hard)			
H (Medium Hard)			
F (Faint)			
H.B. (Hard Black)			
B (Black)			
2 B (Black)			
3 B (Medium Black)			
4 B (Medium Black)			
5 B (Very Black)			
6 B (Very Black)			
7 B (Very Black)			

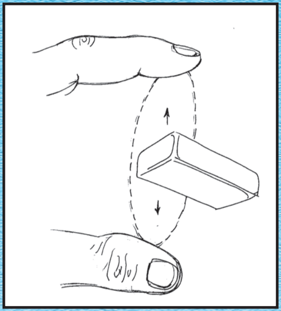
Fig. 1.13.5 (b)

1.14 RUBBER

Rubbers or erasers are available in different types of hardness and abrasiveness. For us a good quality soft rubber will serve the purpose. (See Fig. 1.14.1 & 2)



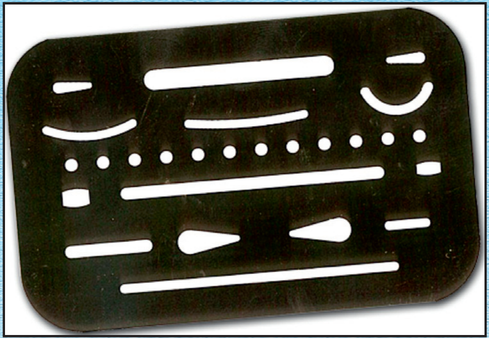
Erasing Rubber
Fig. 1.14.1



Erasing the lines
Fig. 1.14.2

1.15 ERASING SHIELD

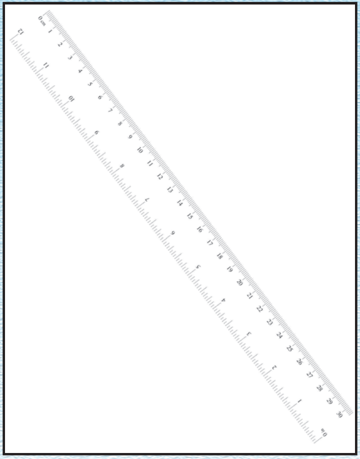
Erasing is done on an engineering drawing by placing any suitable opening in the erasing shielf over the work to be erased and rubbing with an eraser. Excessive pressure should not be applied to the eraser to prevent the damage of the drawing. Care should be taken to hold the erasing shield tightly to prevent it from slipping. (See Fig. 1.15.1)



Erasing Shield
Fig. 1.15.1

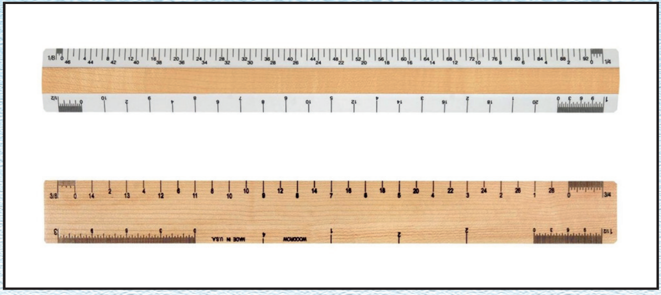
1.16 SCALES

Scales are good for drawing work. These are transparent and scales of 150 mm and 300 mm in length are enough. These are used for measuring sizes, lengths as the relative dimensions of the object are transferred to the drawing. (See Fig. 1.16.1 to 1.16.3)



300 mm scale
Fig. 1.16.1

150 mm scale
Fig. 1.16.2



Architect Scales
Fig. 1.16.3

1.17 COMPASSES

Compasses are made up of two hinged legs. A needle is fitted in one leg and a pencil/lead in the other. Some compasses have detachable pencil and ink point. The needle and lead legs have knee joints from where the legs can be bent. For drawing large arcs or circles the legs are bent about the knee joint in such a way that their lower limbs are perpendicular to the drawing board or drawing sheet. Leads of '2H' and 'B' are fixed in two different compasses for use for drawing light and bold lines. One thing is very important for drawing a good arc or circle is that the pencil lead to give a margin for needle which pricks the sheet a little bit. A lead of one grade softer may be used in the compass just for compensating the pressure on the pencil while drawing a straight line. (See Fig. 1. 17.1)

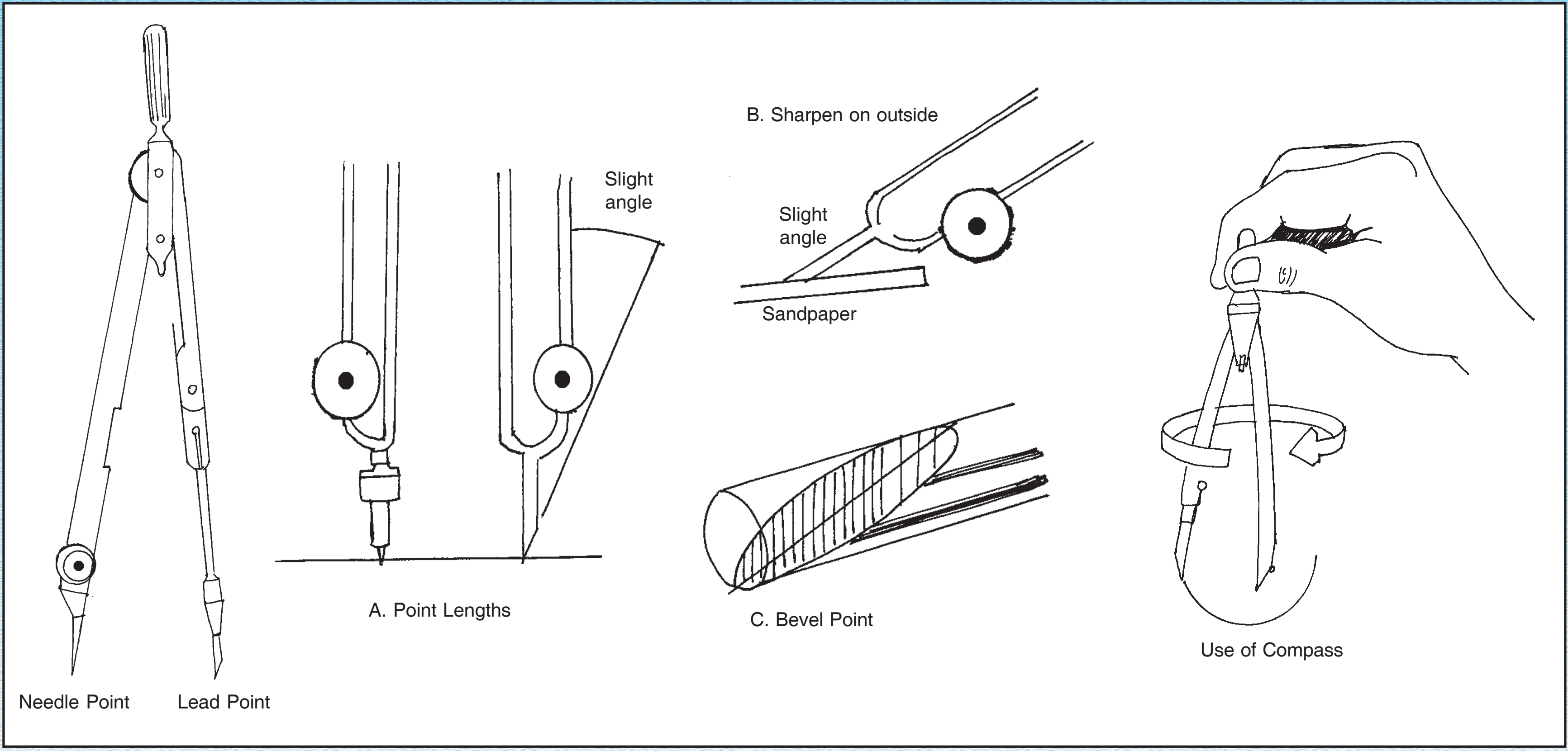


Fig. 1.17.1

Bow Compass : It is used to draw small arcs and circles. It is suitable for drawing circles or arcs from 2 mm to 60 mm diameter. (See Fig. 1.17.2 a & b)

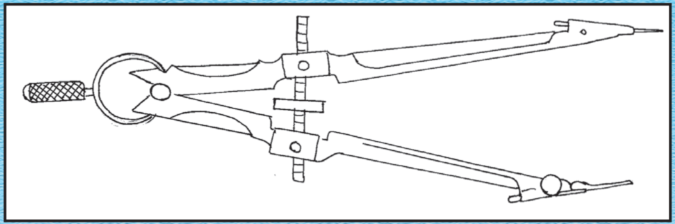


Fig. 1.17.2 (a)

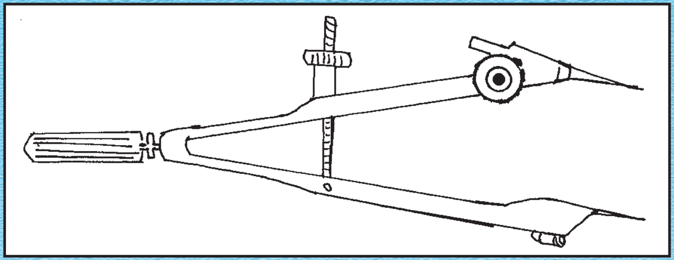
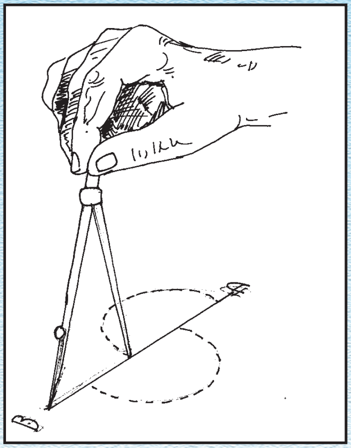


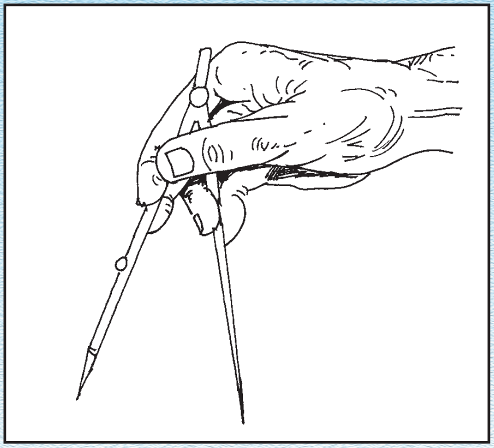
Fig. 1.17.2 (b)

METHOD OF USING COMPASSES

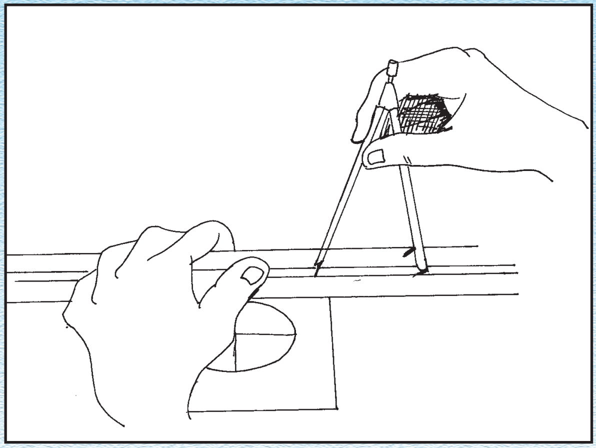
1. Open the legs of compass and measure the radius of the arc or circle from the scale.
2. Place the needle "at the exact intersection of the centre lines" and prick the drawing sheet by the needle.
3. Rotate the compass in the clockwise direction such that the pencil lead touches the drawing sheet.
4. Draw a crisp arc or required circle. We have to keep in mind that the thickness and darkness of line should be uniform throughout your drawing.



Measuring distances
Fig. 1.17.3



Adjusting the Dividers or Compass
Fig. 1.17.4



Use of Dividers or Compass
Fig. 1.17.5

1.18 DIVIDER

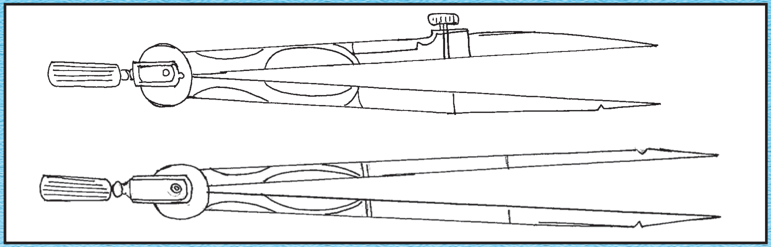


Fig. 1.18.1

Divider consists of two lega hinged together at the upper end. Two needles are there at two ends of legs. (See Fig. 1.18.1)

Uses :

1. It is used to divide a length into any number of equal parts.
2. It is used to transfer the distance from one place to another on the drawing sheet.

Bow Divider : It is used for dividing small circles or arcs or a line segment into number of equal distances. (See Fig. 1.18.2 & 1.18.3)

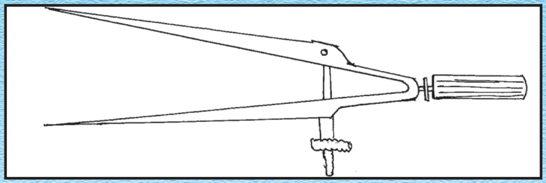


Fig. 1.18.2

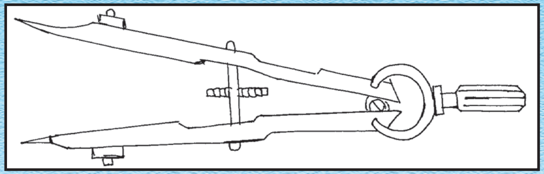


Fig. 1.18.3

1.19 SET-SQUARES

A pair of set-squares is made up of cellouse of 45°, 90°, 45° and 30°, 90°, 60° are needed for drawing purpose. Small set squares may be preferred over large ones for using with mini-drafter. (See Fig. 1.19.1)

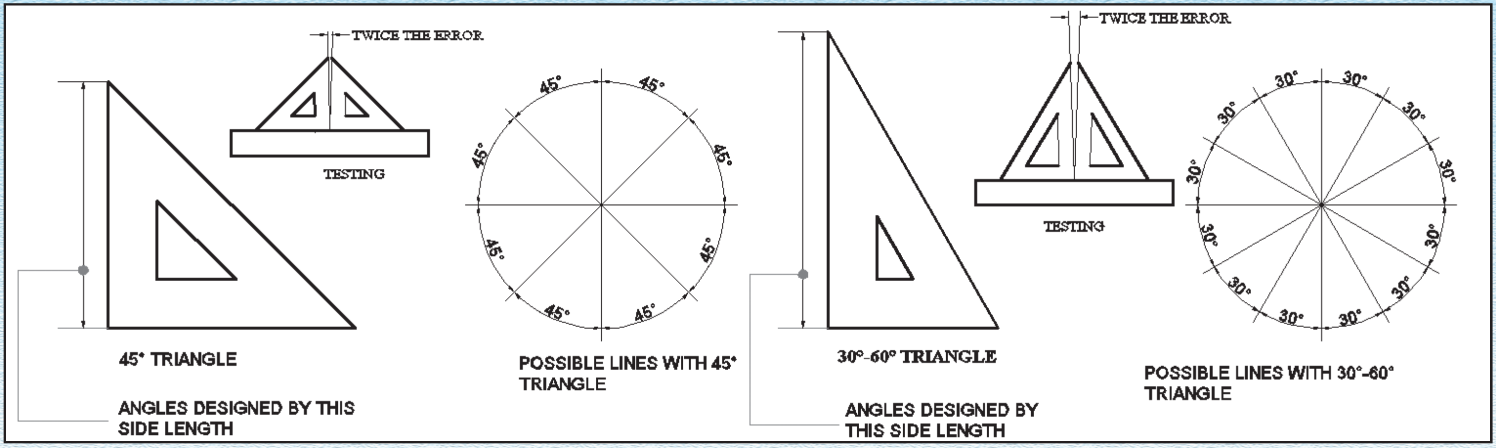


Fig. 1.19.1

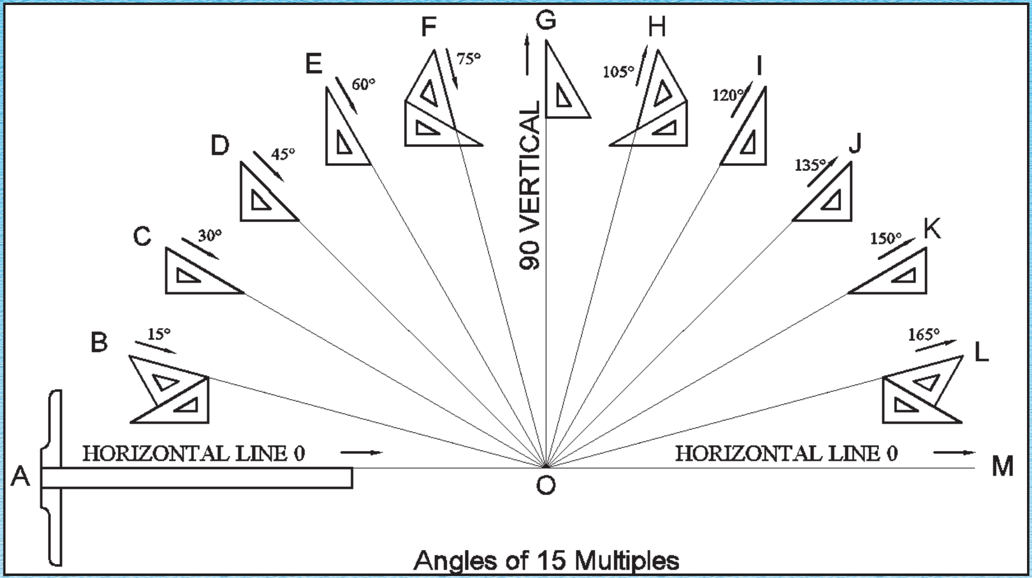


Fig. 1.19.2

Uses :

1. The set-squares are used to draw vertical or parallel lines along with the use of mini-drafter.
2. A pair of set-squares can be used to draw angles of 15°, 30°, 45°, 60°, 75°, 90°, 105°, 120°, 135°, 150°, 165° and 180° (See Fig. 1.19.2)

1.20 DRAWING CLAMPS OR CLIPS, CELLO-TAPE, PINS/THUMB TACK OR STAPLERS ETC.

These clamps, pins, cello tape etc, is used to hold the drawing sheet on the drawing board. (See Fig. 1.20.1)

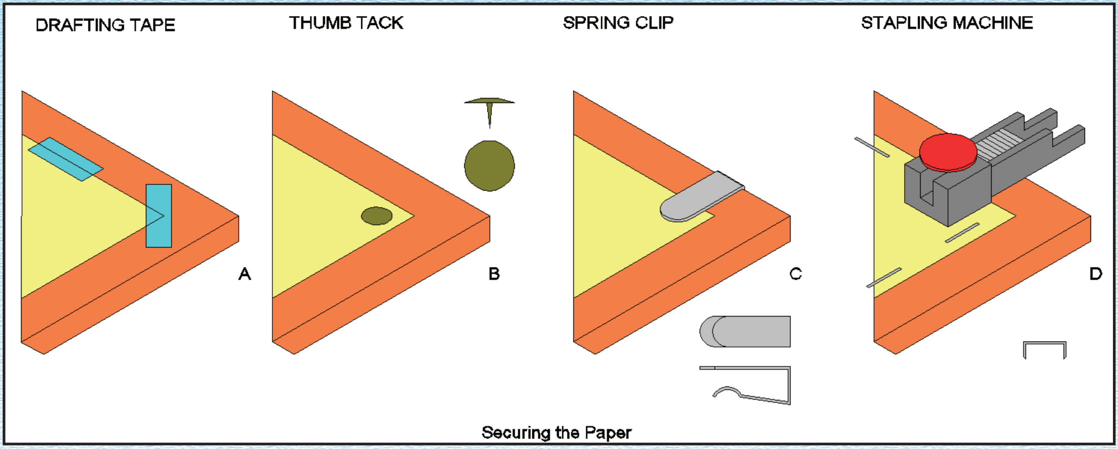


Fig. 1.20.1

1.21 PROTRACTOR

A protractor can be used for making and measuring such angles which cannot be drawn with set-squares. It is semi circular in shape and made up of cellouse. It is a good choice to draw angles correct up to one degree. A protractor can be read from both the ends. The circumferential edge of a protractor is graduated to ½° or 1° division, which is numbered at every 10 intervals. (See Fig. 1.21.1)

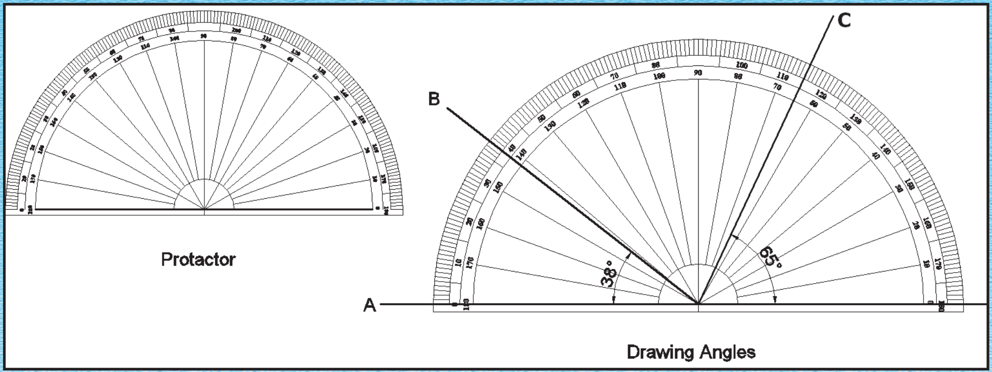


Fig. 1.21.1

1.22 SAND PAPER OF 0° OR EMERY PAPER

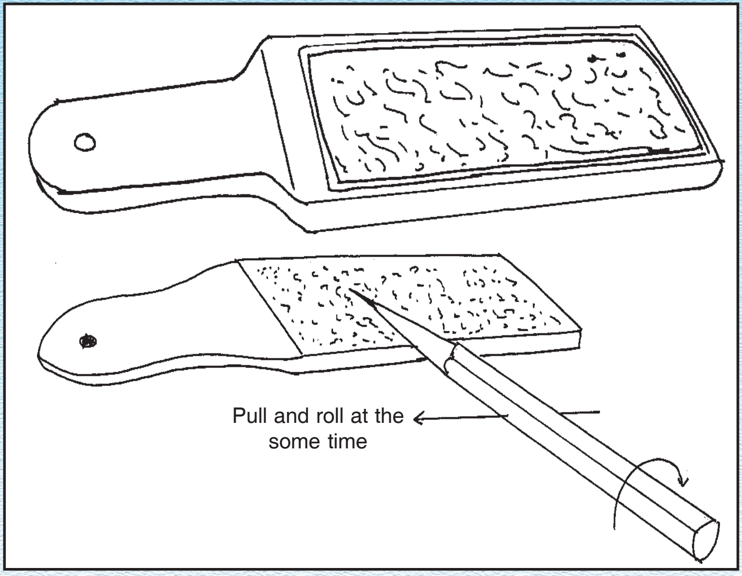


Fig. 1.22.1

An emery or sand paper of 0° is used to sharpen the pencil lead into a conical or chisel shape. A precuation may be taken that the lead powder does not fall on the drawing sheet and spoil the drawing. Similarly, lead powder should be cleaned from hands also before commencing the preparation of drawing sheet. These precautions are very necessary to be kept in mind to save the drawing sheet from smudging. (See Fig. 1.22.1)

1.23 PAPER KNIFE OR STITCHING THREAD

Paper knife or ordinary stitching thread can be used to pair the drawing sheet neatly and cleanly. (See Fig. 1.23.1)

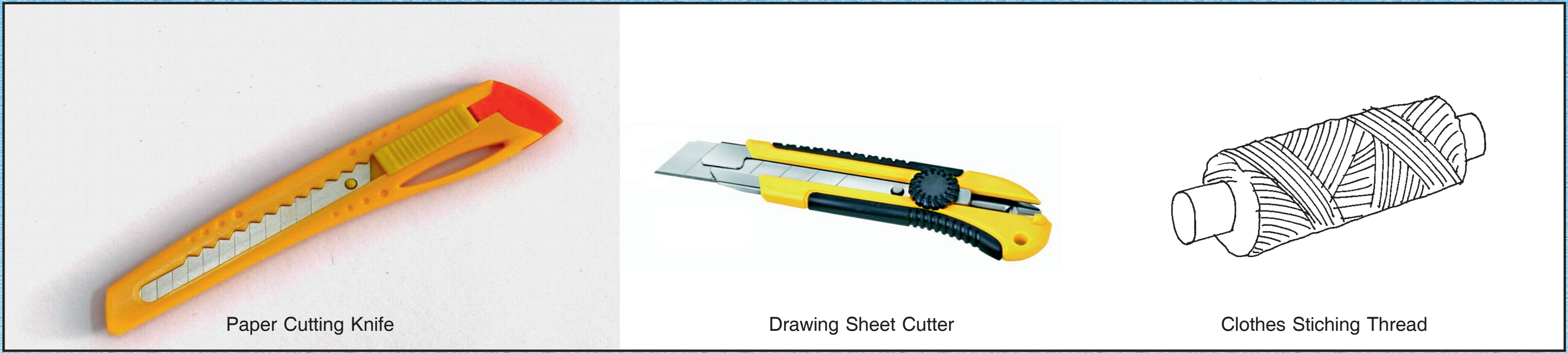


Fig. 1.23.1

1.24 LEAD SHARPNING MACHENICAL MACHINE

It is available in the market by different names but the purpose is the same to sharpen the lead. The only advantage is that it does not break the lead and wooden peeling are collected in a box below the machine. Thus keeping the place clean. (See Fig. 1.24.1)

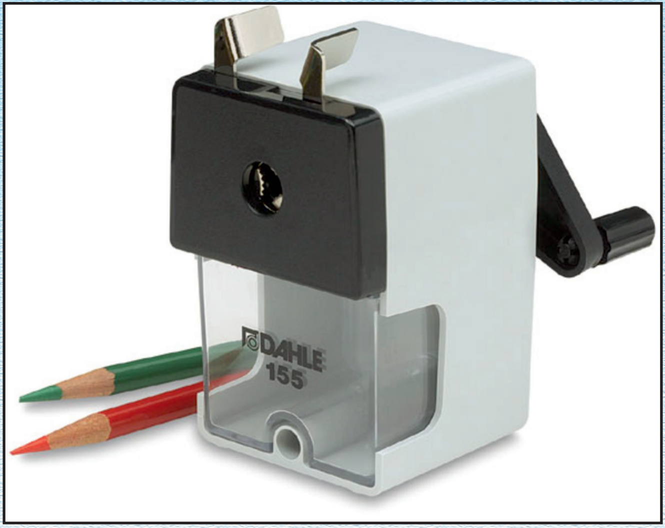


Fig. 1.24.1

1.25 A HANDKERCHIEF OR CLEAN DUSTER/HAND TOWEL

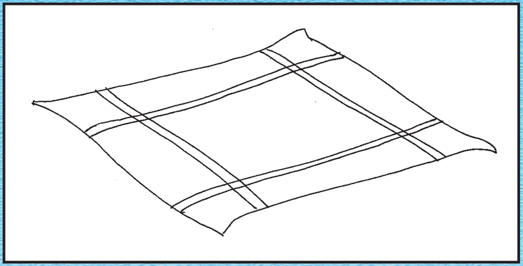


Fig. 1.25.1

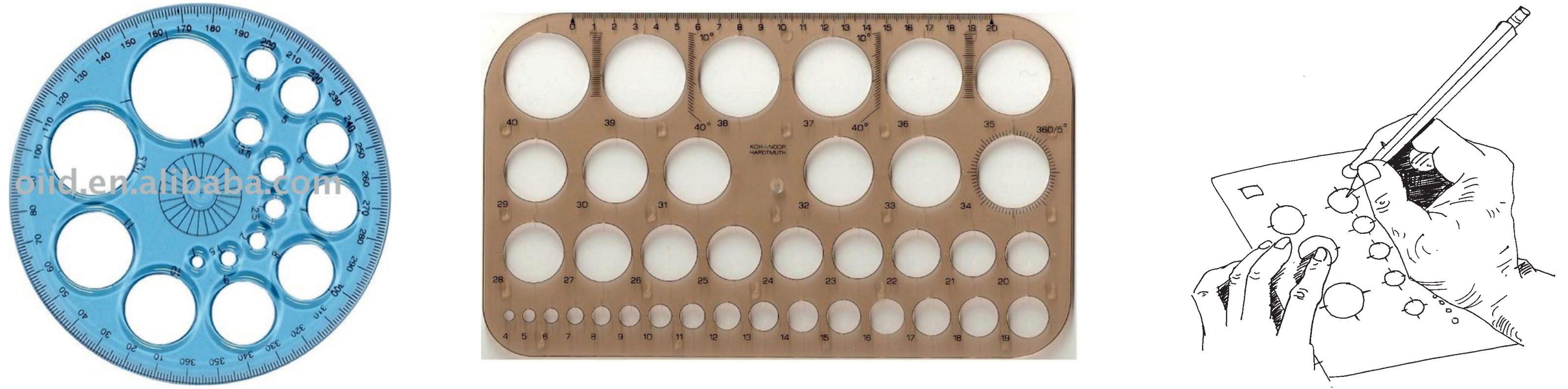
It is used to clean the dust from the instruments and erased rubber crumbs from the drawing sheet, also for wiping the hands. It will prevent drawing from smudging. (See Fig. 1.25.1)

1.26 PENCIL LEADS OF 'B' AND HB

These pencil leads of 'B' and '2H' are used to be fixed in the compasses to get the same shine and colour as got by straight lines drawn by using 'HB' or '4H' pencils. These leads are needed to be fixed in the compasses. If the leads are not available in the market then the same may be obtained from the pencils of the required grade by peeling the pencils.

1.27 SMALL CIRCLE PLATE/CIRCLE MASTER

A circular plate made of cellouse or a rectangular plate made of celluloid having circles of different size diameters is available in the market. It is used to draw circles of small diameters easily and cleanly. The circles of standard diameters are also drawn quickly, uniformly and cleanly. (See Fig. 1.27.1)



Circle Master | Circle Stencil or Template | Use of Circle Template

Fig. 1.27.1

1.28 TEE-SQUARE, ROLLER OR MINI-DRAFTER

Tee-Square : As the name itself suggest that it is made in a 'T' form. A thick wood or plastic butt is fitted on one end and a long wooden or plastic blade on the other. It is used to draw horizontal lines and also for supporting the set squares for drawing vertical or parallel lines on the drawing sheets. (See Fig. 1.28.1 to 1.28.7)

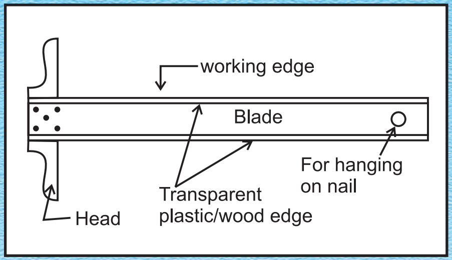


Fig. 1.28.1

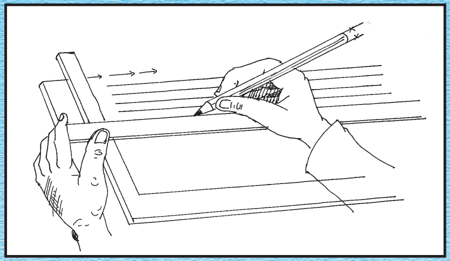


Fig. 1.28.2

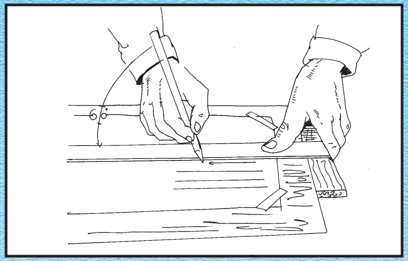


Fig. 1.28.3

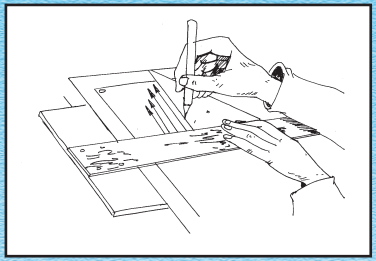
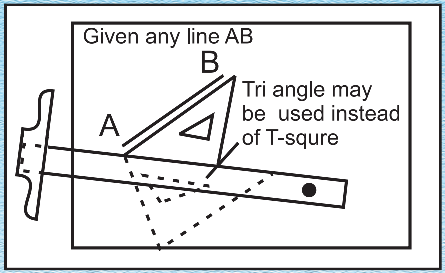
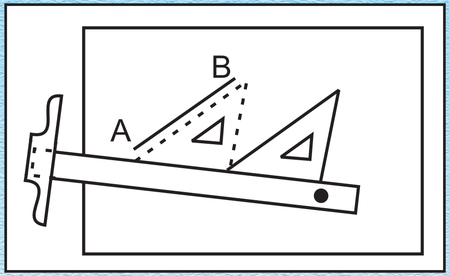


Fig. 1.28.4



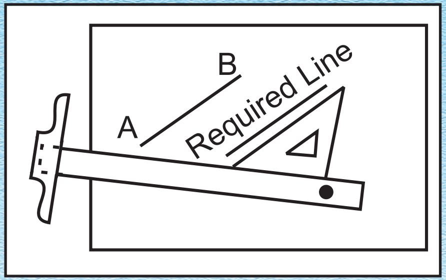
(a) Move T-squre and Triangle to line up with AB

Fig. 1.28.5



(b) Slide Triangle along T-square

Fig. 1.28.6

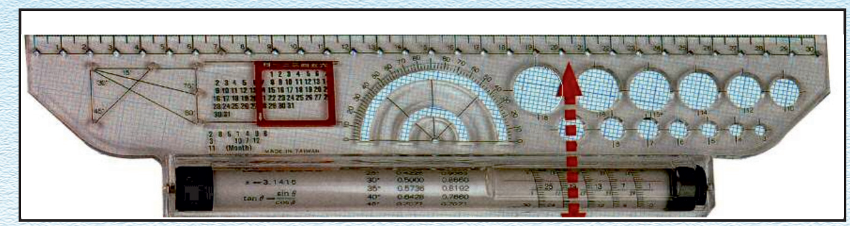


(c) Draw required line parallel to AB

Fig. 1.28.7

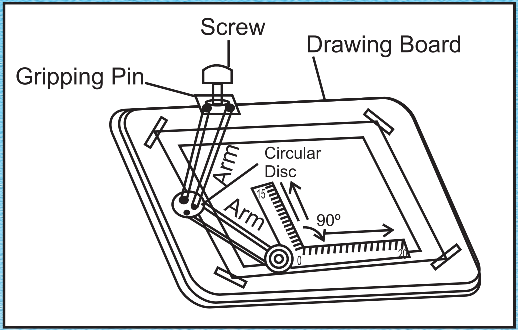
To draw a parallel line to a given line.

1.29 ROLLER


Roller
Fig. 1.29.1

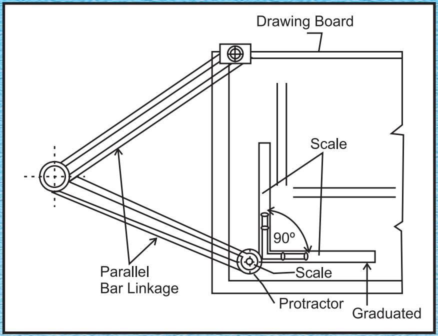
It is made of plastic or cellouse and available in 150 mm and 300 mm sizes. With its help parallel lines at any angle can be drawn along with horizontal and vertical lines. It can be said that it is all in one. It is very convenient to carry and use. Thus, it is gaining popularity with Engineers and architects. (See Fig. 1.29.1)

1.30 MINI-DRAFTER



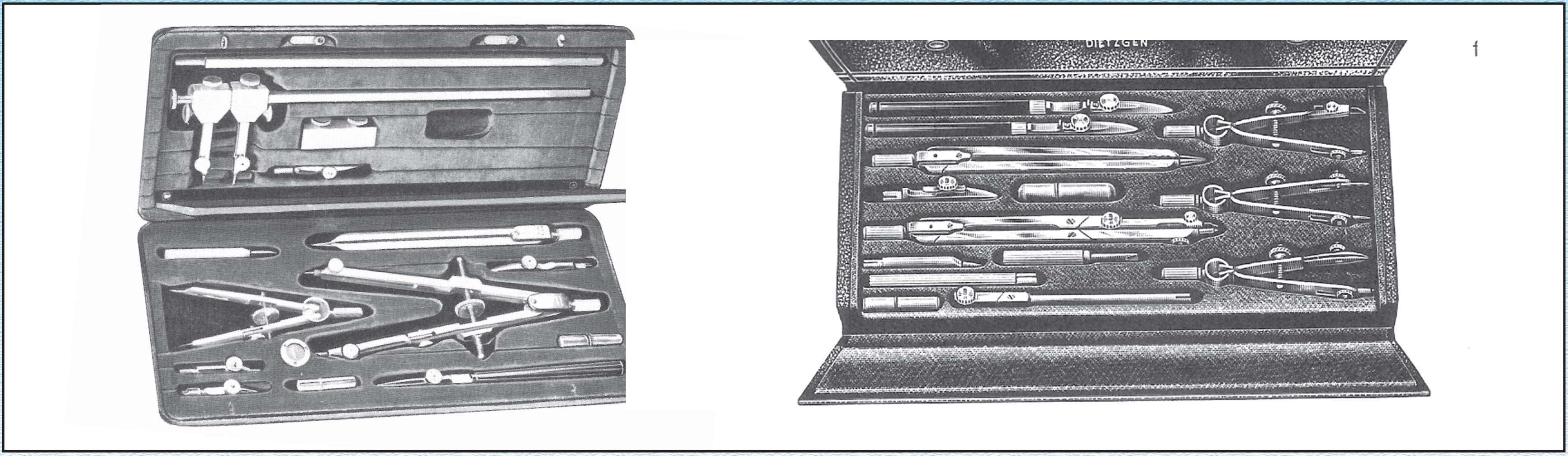
Drafting machine or mini drafter
Fig.1.30.1

It is made of steel having a screw at one end to fix it with the drawing board and two arms fixed with cellouse scales, which are at right angles. These scales are tightened with a screw at any inclination, generally parallel with the drawing board's edges. The set squares slide on these right angled scales for drawing parallel or inclined lines. It obviates the use of a separate Tee-square, protractor, set-squares and scale. Thus, saving a lot of energy and time in drawing good graphics. "Always keep in mind that the zero of the adjustable circular disc marking should coincide when its scales are in horizontal and vertical position. The fixed end should tightly fit with the edge of the drawing board and should not move with the movements of the scales. (See Fig. 1.30.1 & 2)



Drawing Sheet
Fig.1.30.2

1.31 INSTRUMENT BOX



Instrument Box

Figure 1.30.1

1.32 HOW TO KEEP DRAWING SHEET CLEAN

1. Always clean your hands and instruments before fixing the drawing sheet.
2. Hands should be frequently wiped with clean handkerchief or with a clean piece of cloth during the drawing work.
3. The set squares may be lightly moved with the finger nails while using.
4. Clean pencil smudge with a clean cloth
5. The rubbed powder of pencil is removed away from drawing sheet just to save the drawing from smudging.
6. Drawing sheet should be erased with a soft rubber only when it is very necessary to rub off the extra lines.
7. Remove rubber dust with a clean piece of cloth or with a clean handkerchief, never wipe them off with hands.
8. A clean piece of cloth or paper may be used as a hand rest, while printing or lettering.
9. Do not keep anything or article on the drawing sheet especially utencils or containers etc.
10. While not using the drawing sheet, may be covered with a cotton cloth or wide paper.
11. Avoid unnecessary rubbing of lines.
12. Do not touch drawing sheet with direct hand.

1.33 ACTIVITY

1. For getting good results from your drawing board, cover it with a drawing sheet or with a thick sheet of paper. Use cello tape or drawing pins to fix it on the drawing board. By doing this we avoid the drawing pencil to move in the drawing board's wooden grooves and will give smooth lines.
2. Take a line AB=50 mm long. Now with the help of protractor draw angles of 72" at both the ends.
3. Construct a regular hexagon of 60 mm side with the help of set squares.
4. Divide a straight line AB = 100 mm into ten equal parts by measuring 10 mm in your compass. Try the same activity with the help of a divider also.

1.34 TEST YOURSELF

1. Why drawing instruments are needed for drawing ?
2. What is a mini drafter?
3. Write the important drawing instruments and their uses in drawing ?
4. What precautions may be taken for drawing a clean and neat drawing?
5. What are the common grades of pencil available in the market? What do the letters on them indicate ?
6. What we mean by 'H', HB or 'B' pencil ?
7. What angles can be drawn with a pair of set-squares?
8. What grade of pencil may be used in compass for a particular grade used for drawing straight line to get the same shine and brightness?
9. How parallel lines can be drawn with a pair of set squares? Draw parallel lines at a distance of 25 mm.
10. Where a divider is used ?
11. Fill in the blanks with appropriate words :-

    (instruments, horizontal, eraser, protractor, vertical-horizontal and inclined lines), (vertical, Parallel and inclined lines), (Compass), (Divider), (Tee-square, Protractor and a scale)

    (a) To remove unnecessary lines we use ....

    (b) To make an accurate drawing we use ....

    (c) To measure angle/angles on a drawing we use ....

    (d) We use Tee-square for drawing ....lines

(e) The mini drafter can be used for drawing ....

(f) We use a pair of set squares to draw......

(g) We use .... for drawing circles and arcs.

(h) We use .... for transferring distances, marking a line into equal distances.

(i) A mini-drafter obviates the use of ....

12. Match the following from the list 'A' with 'B'.

	Table - A		Table - B
(a)	Straight lines can be drawn with its help	(a)	Using a scale
(b)	The two parts of the Tee-square are	(b)	Using a divider
(c)	The distance are measured in millimeters by	(c)	Butt and blade
(d)	Lines of different thickness are drawn by using	(d)	Set squares
(e)	Equal distances can be drawn on the drawing sheet by	(e)	Pencils
(f)	For measuring any angle we use	(f)	Protractor
(g)	We can draw angles in multiple of 15° with this	(g)	Tee-square

Answer

(a) (g)

(b) (c)

(c) (a)

(d) (e)

(e) (b)

(f) (f)

(g) (d)

1.35 DIMENSIONING

We all wear clothes. These are either readymade or specially stitched by a tailor for us. When we visit a tailor shop for getting our clothes stitched. The tailor measures our cloth with a measuring cloth tape and also takes our body measurements. After few days, he delivers our stitched clothes, which are fully made according to our need and body measurements. Nowadays, we also see that new buildings are coming up but they are made up to a specific height. These buildings are made on an alloted piece of land. Rooms, shops furniture and engineering products are made according to some map, which is nothing but a blue print of a future structure made according to some measurements. Dimensioning is a must for the technician who is making it. Similarly, all things are produced by some measurements according to the need and purpose.

This measurement is done according to some system. In most of the countries the 'Metric System' of measurements is used. But in some countries 'FPS System' is followed. So, it becomes very necessary for us to know about the conversion of one unit in to another. Here we will learn about the units of 'Metric System' and later we shall learn about the conversion of 'FPS System' into the 'Metric System'.

METRIC SYSTEM

10	Millimeters	(mm)	=	1	Centimeter	(cm)
10	Centimeters	(cm)	=	1	Decimeter	(dm)
10	Decimeters	(dm)	=	1	Meter	(m)
10	Meters	(m)	=	1	Decameter	(dam)
10	Decameters	(dam)	=	1	Hectometer	(hm)
10	Hectometers	(hm)	=	1	Kilometer	(km)

Also '1 km' = 1000 m

CONVERSION

1	Inch	=	25.40 mm				
12	Inches	=	1 Foot	=	30.48 cm	=	304.8 mm
36	Inches	=	3 Feet	=	1 Yard	=	0.91 Meters
1760	Yards	=	8 Furlongs	=	1 Mile		
1	Mile	=	1.61 km				

After learning the units of measurement, we shall learn about the ways of dimensioning the objects. We know very well that when we have to get anything made according to our need we have to give some specific dimensions to suit our need. Similarly, drawings are exchanged from one country to another or we can say that sometime the drawing is made in one country and the product is manufactured in another country. This makes it a necessity to specify the dimensions on the drewing. Thus we can say that dimensiong is a numerical value expressed in appropriate units (here it is millimeters) of measurement and indicated graphically on technical drawings with lines, symbols and notes.

1.36 ELEMENTS OF DIMENSIONING

Now, we shall learn about the elements of dimensioning. These include projection lines, Dimension lines, leader lines, dimension line termination, the origin indication and the dimension itself.

(a) **Dimension lines :** These are thin continuous thin lines. These are terminated by arrowheads touching the outlines, extension lines or centre lines.

(b) **Leader lines :** A leader or a pointer is a thin continuous line, connecting a note or a dimension figure with the feature to which it applies. One end of the leader terminates either in an arrowhead or a dot. The arrowhead touches the outline, while the dot is placed within the outline of the object. The other end of the leader line is terminated in a horizontal line at the bottom level of the first or the last letter of the note. The leader is never drawn vertical or horizontal or curved. It is drawn at a convenient angle of not less than 30° to a line to which it touches. When pointing to a circle or an arc it is drawn radially. Use of common leader line for more than one feature should never be made.

(c) **Extension lines/Projection lines :** These lines are thin continous lines drawn in extension of an outline. These lines extend by about 3 mm beyond the dimension line.

1.37 ARROW HEADS

An arrowhead is placed at each end of dimension line. There are various type of arrow heads. The pointed end of the arrowhead should touch an outline or an extension line or a centre line. It is drawn free hand with two strokes made in the direction of its pointed end.

Note : There are two types of dimensions one is size dimensions and another is location dimensions. It is shown in this figure.

1.38 ARROWS

Arrows of any shape and size are acceptable according to new guide lines. Some examples are given in Figure 1.38.1.

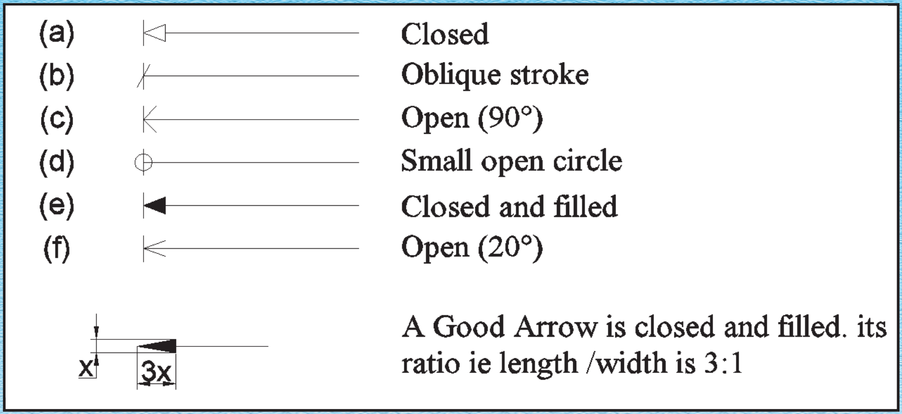


Fig. 1.38.1

1.39 SYMBOLS

We use some symbols in dimensioning which are given below :-

1. To show radius of a circle or an arc — **R**
2. To show diameter of a circle — **Ø**
3. To show a square — □ or sq.
4. To show a sphere — The word **SPHERE** or '**S'** should precede **'R'** or **'Ø'** or '**S R**' or 'S Ø'.

NOTE :

The above indications are used with dimensions to show applicable shape identification and to improve drawing interpretation. The diameter and square symbols may be omitted where the shape is clearly indicated. The applicable symbol precedes the value for the dimension.

1.40 ARRANGEMENT AND INDICATION OF DIMENSIONING

There are many arrangements of dimensioning, but following are the main arrangements :

(a)

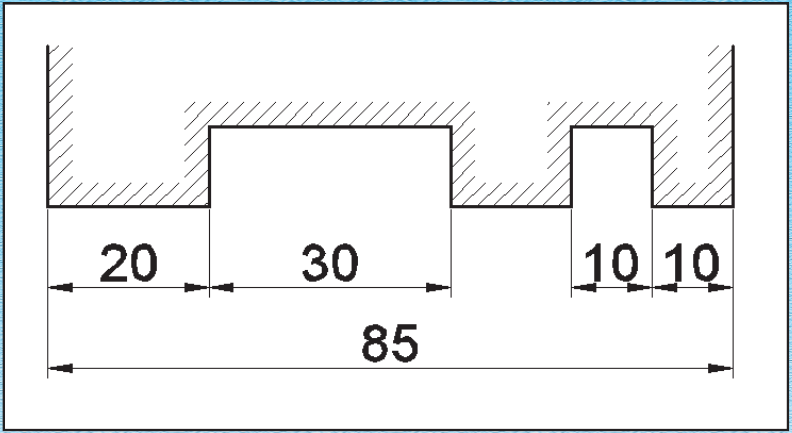


Fig. 1.40.1

CHAIN DIMENSIONING :

In this chains of single dimension are done as shown in Fig. 1.40.1

(b) **DIMENSIONING FROM A COMMON FEATURE :**

Dimension are given from a common origin as shown in Fig. 1.40.2

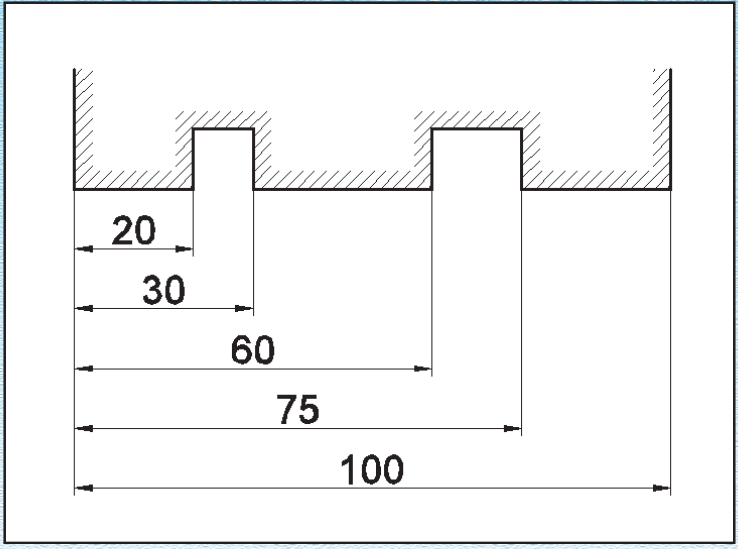


Fig. 1.40.2

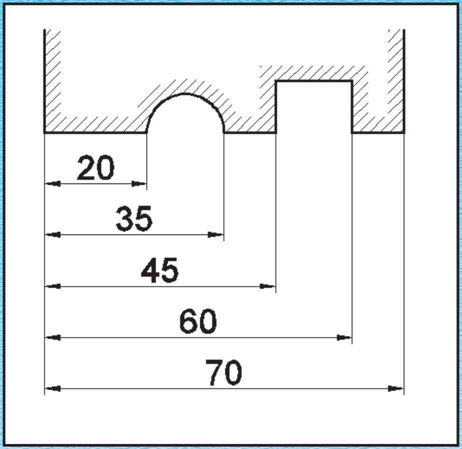


Fig. 1.40.3

(c) PARALLEL DIMENSIONING :

It is the placement of a number of single dimension lines parallel to one another and spaced out so that the dimensional value can easily be added in Fig. 1.40.3

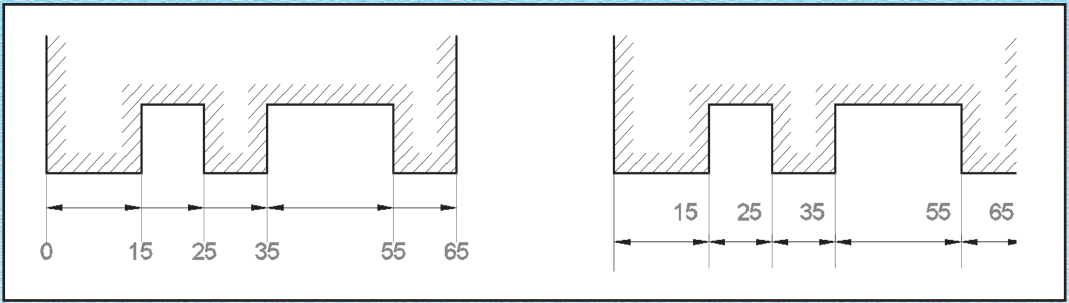


Fig. 1.40.4

Fig. 1.40.5

(d) SUPERIMPOSED RUNNING DIMENSIONING :

It is simplified parallel dimensioning and may be used where there are space limitations and where legibility problems would occur. (See Fig. 1.40.4 & 5)

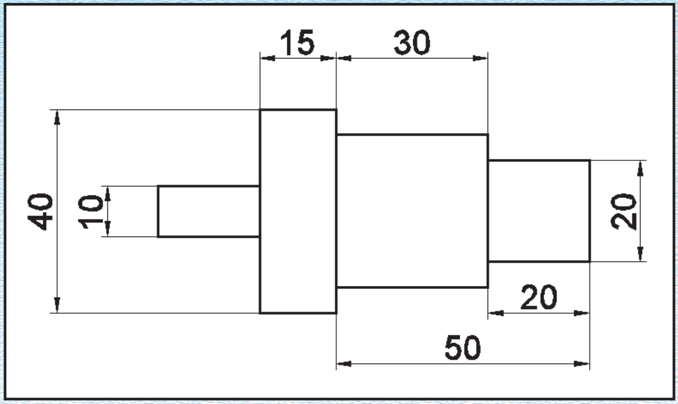


Fig. 1.40.6

(e) COMBINED DIMENSIONING :

In this system the combination of chain dimensioning and parallel dimensioning are used together. (See Fig. 1.40.6)

(f) **PROGRESSIVE DIMENSIONING :**

In this arrangement, one datum point is selected which reads as zero : (See Fig. 1.40.7)

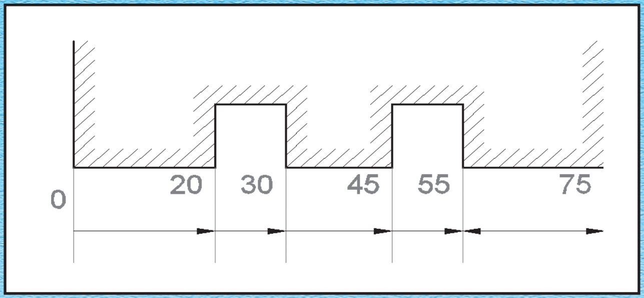


Fig. 1.40.7

1.41 SYSTEM OF PLACING DIMENSION

According to SP46-2003, there are two recommended systems of placing dimensions.

1.41.1 ALIGNED SYSTEM :

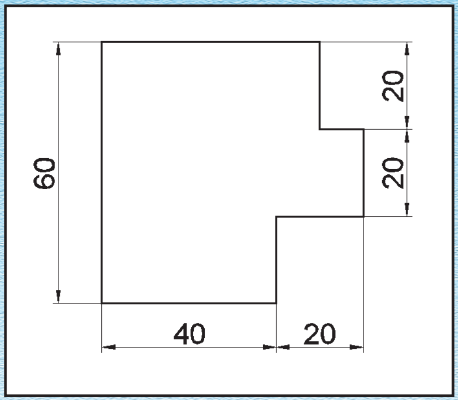


Fig. 1.41.1.a

According to this system all dimensions are so placed so that they may be read from the bottom of the drawing and vertical dimensions from the right hand side. The dimensions values should be placed parallel to their dimension lines and preferably near the middle and above and clear of the dimension line. This system is generally used for small drawings. (See Fig. 1.41.1.a)

1.41.2 UNIDIRECTIONAL SYSTEM :

In this system all dimensions are so placed in such a way that they may be read from bottom of the sheet. This system is useful for large drawings. (See Fig. 1.41.2.a)

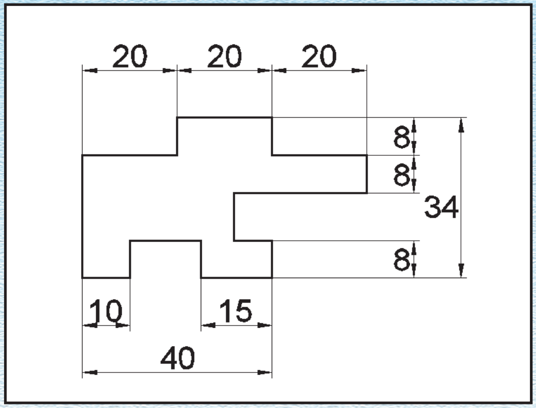


Fig. 1.41.2.a

1.41.3 METHOD OF SHOWING DIMENSIONS

First draw extension lines at right angle to the boundary or outline of the object, so that these touch the outline at the other end. These lines extend at least 3 mm beyond the dimension line. Then dimension line is drawn parallel to the outline to be dimensioned which is terminated by arrow heads at the ends. The numerical value is written in the middle at right angle above the dimension line with a dark pencil. Also the dimension lines or numerals should not be drawn for written too close. They can be staggered, if many dimensions lie near to each other. The dimension for an inclined line may be written parallel to it, to make it legible. The dimensions in some cases may be written at some angle to be more legible and readable. For clarity sake, a distance of 8 mm from the outline or from another dimension may be maintained. Also a smaller dimension may be written first and a bigger dimension afterwards.

The following steps will be useful, while writing dimensioning :-

1. Divide the object into elementary parts.
2. Dimension each elementary part (size dimension), individually.
3. Determine locating axes, surfaces, centre lines etc. separately.
4. Locate the parts (location dimensions), individually.
5. Add the overall dimensions.
6. Complete the dimensioning by adding the necessary notes.

1.43 DIMENSIONING ANGLES

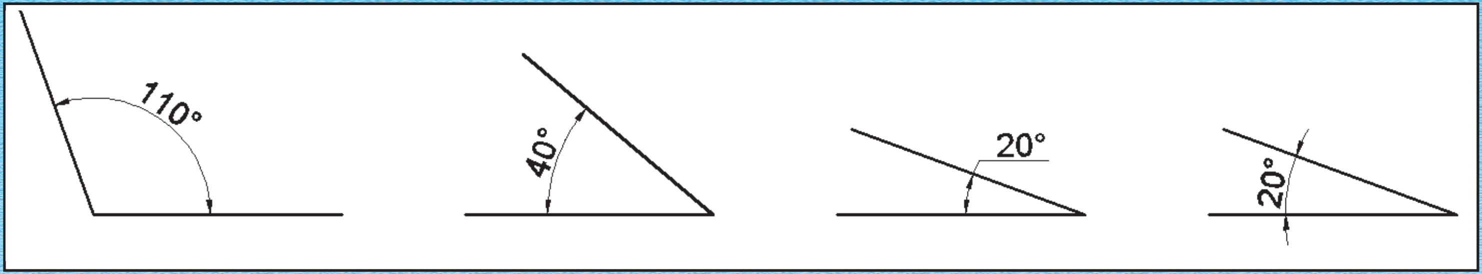


Fig. 1.43.1

Angles and chords are dimensioned in degrees on the arc swing from vertex. (See Fig. 1.43.1)

1.44 DIMENSIONING CIRCLES

Circles are shown by the diameters and symbol 'Ø' is used as a prefix, to denote diameter. While dimensioning circles it is better, if extension lines are drawn perpendicular to the centre lines and dimension lines parallel to the axes. Similarly concentric circles may be dimensioned in the same way as for a single circle.

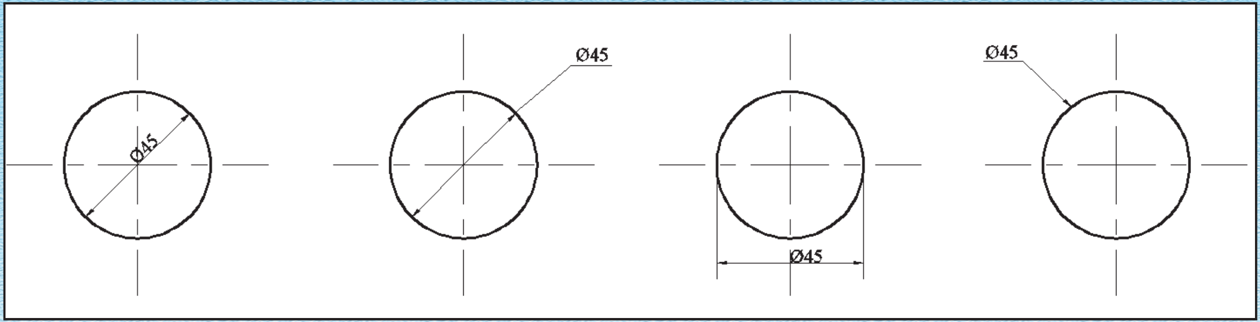


Fig. 1.44.1

The symbol 'Ø' or 'R' may be used before the numeral value, just to show diameter or radius of the circle. (See Fig.1.44.1)

1.45 DIMENSIONING ARCS

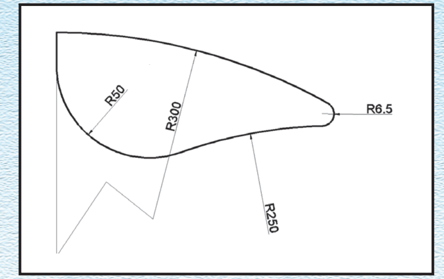


Fig. 1.45.1

An arc is dimensioned by its radius, which is preferably shown outside the line of the object. Radius is denoted by '**R**' and it is prefixed before the numeral indicating radius of the arc. For dimensioning arcs : Leader lines may be drawn and prefix 'R' may be written before the numeral value. (See Fig. 1.45.1)

1.46 DIMENSIONING HOLES

The holes are dimensioned as shown in Fig. 1.46.1

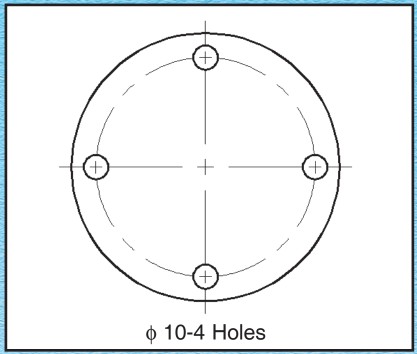


Fig. 1.46.1

1.47 DIMENSIONING TAPERS

The taper on a part is indicated along the centre line and is accompanied by one or both the end sizes. (See Fig. 1.47.1)

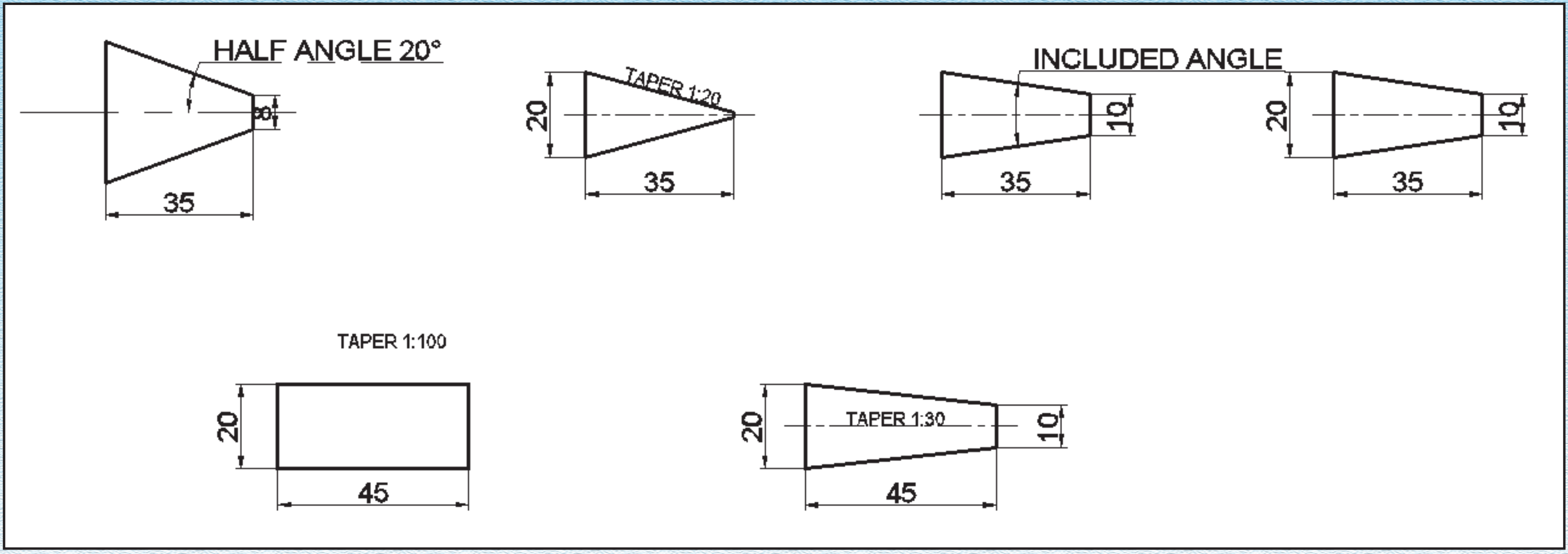


Fig. 1.47.1

1.48 DIMENSIONING CHAMFERS

The chamfers are dimensioned as in Figure 1.48.1

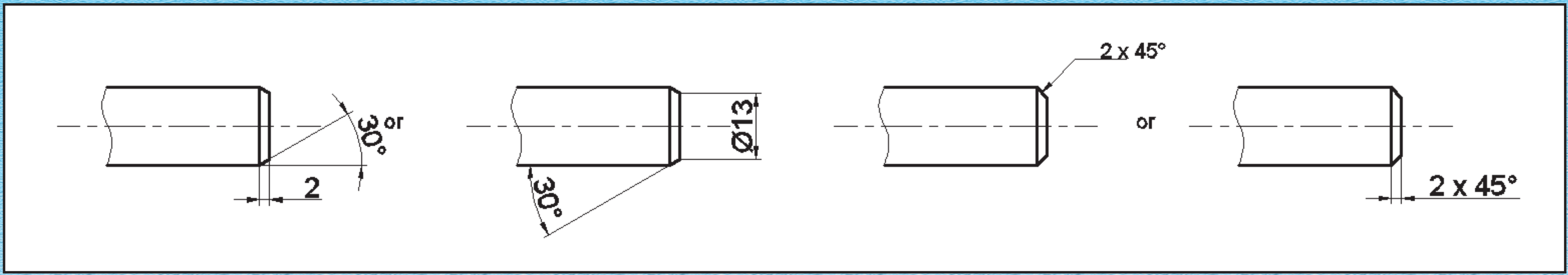


Fig. 1.48.1

1.49 DIMENSIONING COUNTERSINKS :

These are dimensioned by showing either the required diametric dimension at the surface and the included angle, or the depth and the included angle. (See Fig. 1.49.1)

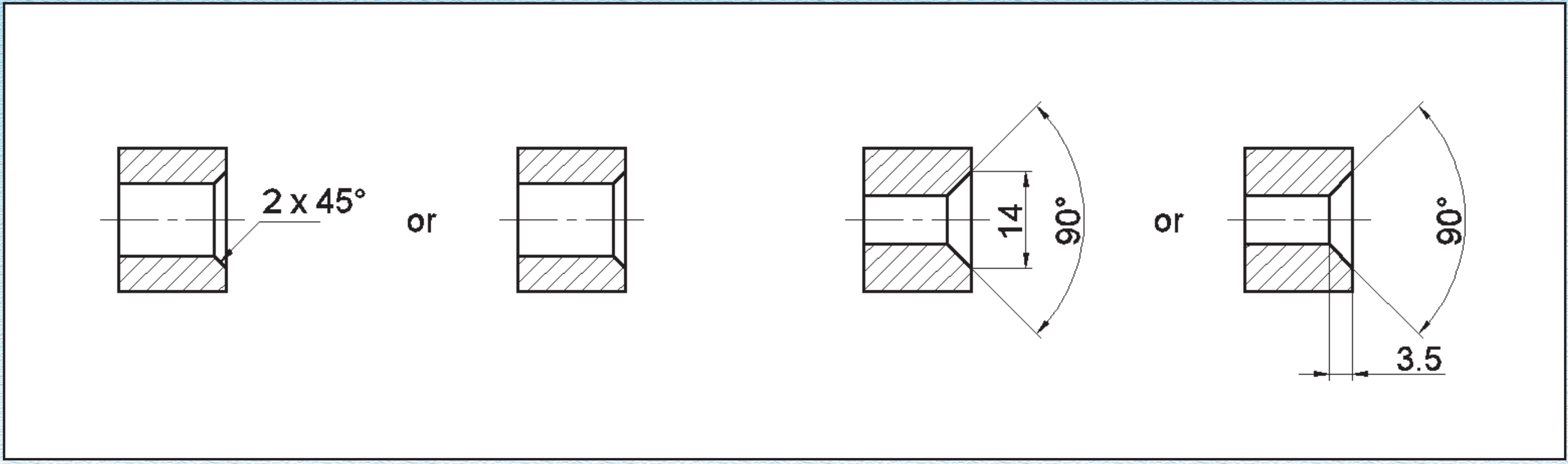


Fig. 1.49.1

1.50 VALUES SHOWN ON OBLIQUE DIMENSION LINES

Values shall be indicated so that they can be read from the bottom or from the right hand side of the drawing. (See Fig. 1.50.1)

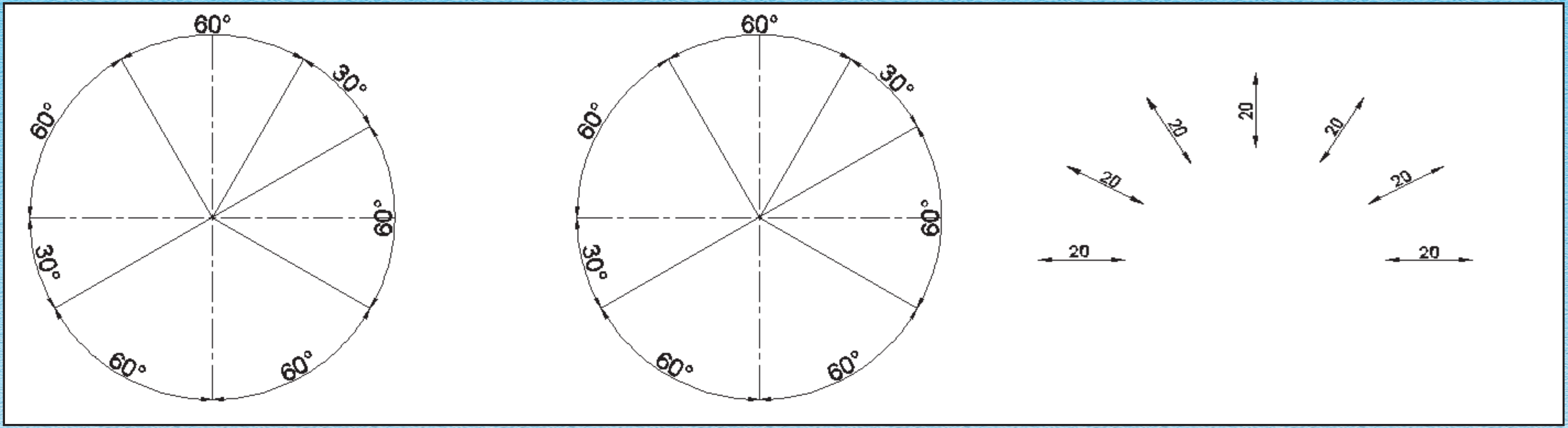


Fig. 1.50.1

1.51 DIMENSIONING NARROW SPACE

We use 'dots', oblique lines or inverted arrows for indicating dimensioning in the narrow space. Also a leader line may be used. (See Fig. 1.51.1)

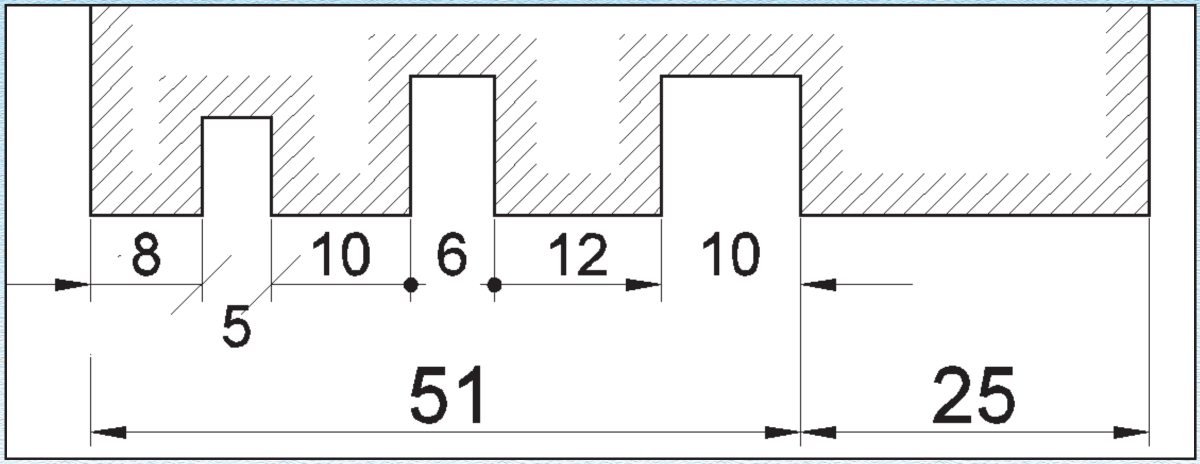


Fig. 1.51.1

1.52 LEADER LINE

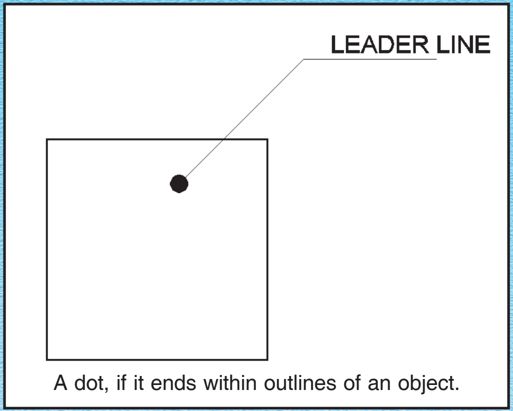


Fig. 1.52.1

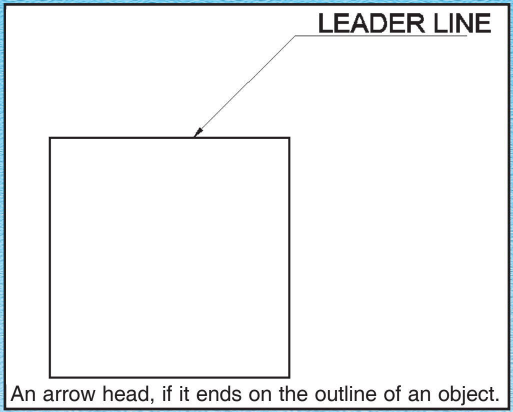


Fig. 1.52.2

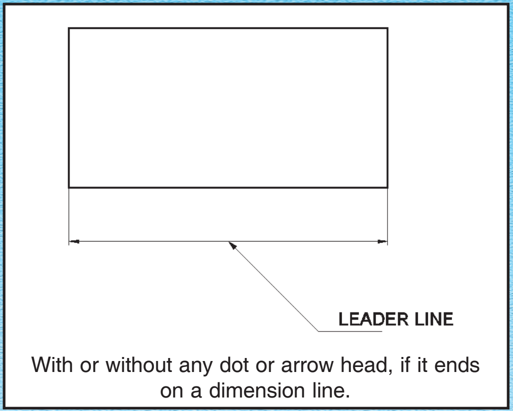


Fig. 1.52.3

NOTE : A leader line is used to refer a feature as shown in Figure 1.52.1, 1.52.2 & 1.52.3

1.53 DIMENSIONING IN THE HATCHING :

Generally we do not show dimensioning in the hatching. When it is not possible to avoid it than we show it as follows (See Figure1.53.1)

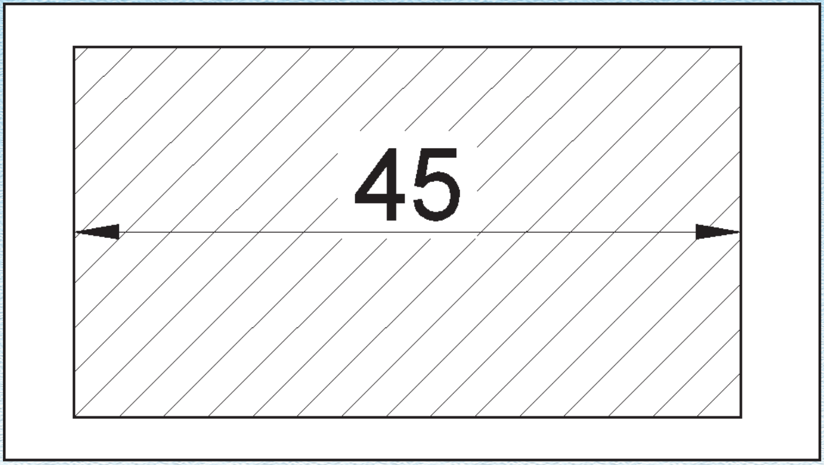


Fig. 1.53.1

1.54 GENERAL PRINCIPLES OF DIMENSIOING

According to IS:SP 46-2003, the following principles of dimensioning are recommended :

1. Avoid the unnecessary dimensioning; every dimension should be given in one view only. Avoid repeating the same dimension in another view.
2. Each feature is dimensioned and positioned, where its shape shows clearly.
3. Each feature is dimensioned and positioned once.
4. As far as possible all dimensions should be given outside the view. Only where it is not possible to show outside than and then only a dimension may be shown inside the object.
5. All the necessary dimensions of the parts must be written on drawing sheet to show the correct functioning of each part.
6. Mutual crossing of dimension lines should be avoided; it should be placed in such a way that they do not cross each other.
7. Dimension should be given in the view which shows relative feature more clearly.
8. Dimensions should not be placed too close to each other.
9. A centre line should not be used as dimension line.
10. Dimensions lines are placed outside the view.
11. Each drawing shall use the same unit (mm) for all dimensions.
12. Avoid the crossing of dimension lines and extension lines.
13. The function dimension should be placed directly on drawing.
14. Dimensioning for narrow space may be shown by reverse arrows, dots or by an inclined line at the extreme of the dimension line.
15. Avoid dimensioning to hidden lines wherever possible.
16. Production and inspection methods should not be specified on the drawing, unless they are essential.
17. Dimensioning to a centre line should be avoided except when the centre line passes through the centre of a hole.
18. Dimensioning should be done so completely that further calculations or assumptions of any dimension or a direct measurement from the drawing is not necessary.

1.55 CORRECT AND INCORRECT METHODS OF DIMENSIONING

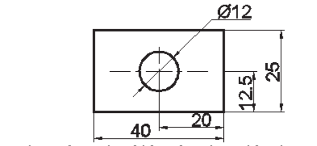
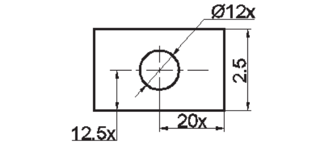
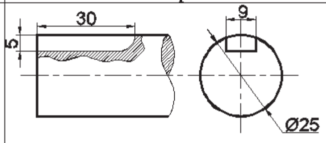
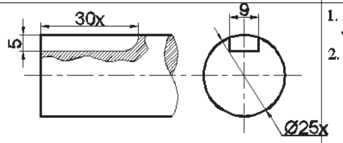
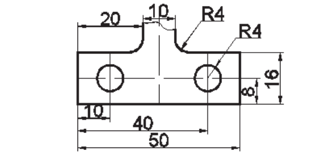
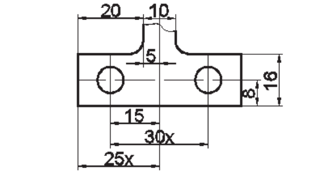
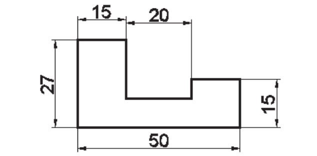
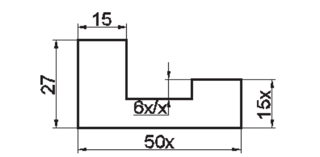
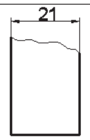
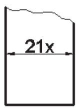
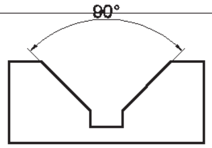
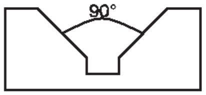
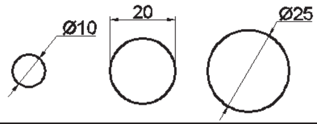
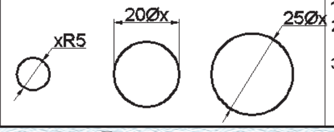
	CORRECT	INCORRECT	REASON FOR INCORRECT
(i)	 Dimensions should be placed outside view.		1. Arrow head nt proportionate. 2. Hole dimension shown in the figure. Leader line does not ends horizontally. 3. Dimension '40' is too close. 4. Placing dimension methods mix.Dimension '40' is according to aligned method.
(ii)	 Dim. should be marked from visible outlines.		1. A key-way is shown with dotted line where the dimensions are placed. 2. Leader line for the shaft diameter is drawn horizontal touching the boundary line.
(iii)	 Dimensions should be given from the outlines (finished surfaces) or a centre lineof a hole.		1. Dimensions are given from the mid line of the object. 2. Dimensions of holes are shown inside the figure. 3. Dimensions are shown in vertical line. 4. Smaller dimensions (25 mm) precedes the larger dimensions (30 mm). 5. Fillit radius is not shown.
(iv)			1. Dimension lines are used as extension. 2. Dimensions are placed inside the view. 3. Dimension 27 and 50not written according to aligned system.
(v)			Section-lines overiap the dimension 21.
(vi)			The outlines of the objectare used as extension lines.
(vii)			1. Smaller circle is designated with radius. 2. Convention Ø for diameter is placed after dimension. 3. Leader has arrow and it is drawn horizontal.

Fig. 1.55.1

ASSIGNMENT

1. What is a leader line ?
2. Draw first angle projection symbol?
3. Dimension a circle, concentric circle and an arc of 50 mm radius.
4. Dimension an acute, obtuse and a right angled triangle.
5. Explain the necessity of dimensioning?
6. What is the difference between 'Aligned' and 'Uni-directional' system ?
7. What are two systems of dimensioning?
8. What system is adopted to dimension a drawing of large size such as a ship drawing?
9. How a narrow space is dimensioned?
10. How dimension is written for an oblique line ?
11. What type of extension and dimension line is? Show them on an equilateral triangle ?
12. Dimension a rectangle according to aligned system.
13. Dimension a rectangle according to the uni-directional system.
14. Fill in the blanks with suitable word/words :-
    (a) Two recommended systems of placing a dimension on the drawing are......... and .... (Aligned, Uni-directional)
    (b) Dimension lines should be drawn at least 8 mm away from the .... and from .... (Outline, each other)
    (c) The two main types of dimensions used on a drawing are..................... (location, size)
    (d) Projection line, dimension line, leader line and dimension itself on a drawing are called......... of .... (Element, dimensioning)
    (e) The hatching lines are continuous .... Lines, and are drawn at an .... of .... an outline of the section. (thin, angle, 45)

(f) A dimension is a numerical value expressed in appropriate units of measurement and indicated graphically on a technical drawing with............, ... and .... (Line, symbol, note)

(g) All dimensions on the single drawing should be expressed in the .... units. (Same)

(h) All dimensions are shown from a common base line in........... dimensioning. (Progressive or parallel dimensioning)

(i) No dimension should be written twice on a drawing until unless it is .... (Unavoidable)

(j) A dimension given for information only is written as a .... (note)

(k) Two principal requirements of engineering graphics are to specify .... and .... (Shape, size)

(l) Dimension of cylinder should never be given as a .... (R)

(m) Generally we prefer a single unit of measurement is in .... (Millimeter)

(n) A leader line end on a dimension line without a .... (Arrowhead)

(o) A leader line end on a surface of an object in an .... (Arrowhead)

(p) A leader line end inside an object in a .... (Dot)

(q) An .... or .... should never be used as a dimension line. (Outline, axis)

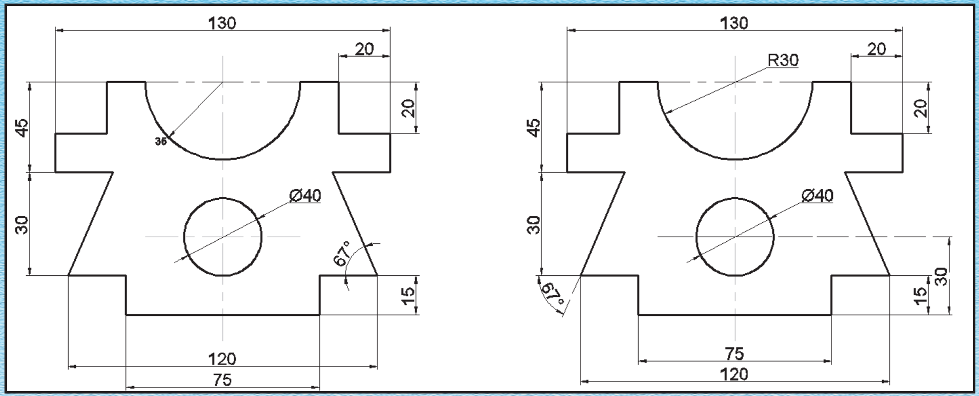
(r) When a number of parallel dimensions are to be shown near each other, the dimensions should be .... (Staggered)

ACTIVITY

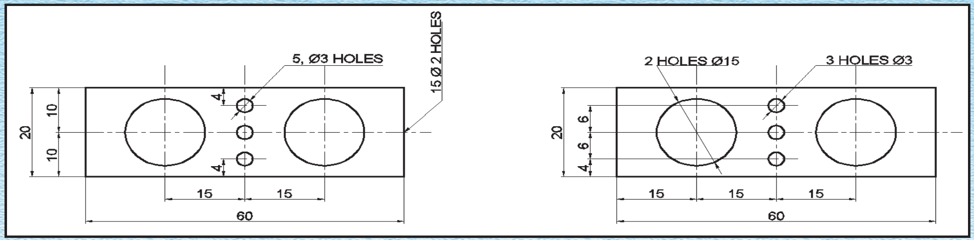
The dimensioned drawings of blocks are given below. Copy them and you are supposed to correct them as per BIS conventions-2003.

QUESTIONS **ANSWERS**

1.



2.



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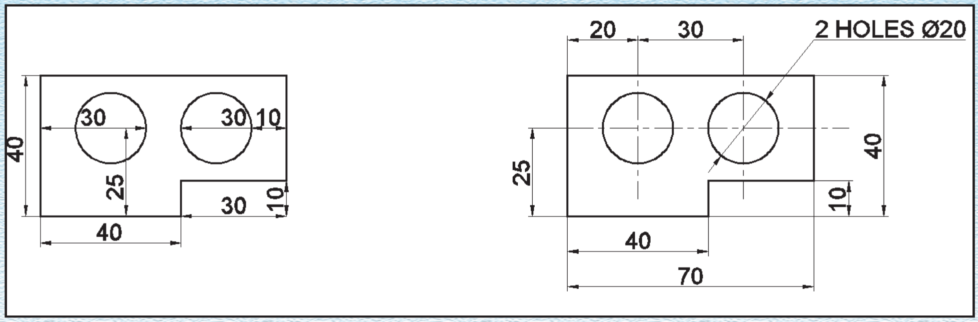


ASSIGNMENT ON LINES AND ANGLES

1. To divide a straight line AB = 78 mm into two equal parts.

2. To divide a straight line AB = 78 into four equal parts with compasses.

3. On a line MN = 80 mm draw angles of (a) 72° (b) 36° & (c) 18° (without using protractor)

4. Draw a line 'MN' parallel to a given line 'OP' at a distance of 57 mm, with the help of (a) compasses (b) set squares.

5. To divide a straight line MN = 86 mm into six equal parts.

6. With the help of compasses draw the following angles :

   (a) 60° (b) 30° (c) 15° (d) 90° (e) 45° (f) 75°, 120° (g) 135° (h) 150°

7. Geometrically draw an angle equal to the difference of two given angles of 74° and 35°.

8. Geometrically draw an angle equal to the sum of two given angles of 74° and 35°.

9. To divide an angle of 70° into two equal parts with the help of compasses.

10. Two converging lines 'MN' and 'OP', converging at an angle of 67°. Draw an angle bisector of these converging lines without producing them to meet.

11. Two points O, P are given outside a line MN. Find a point 'C' on the line MN such that OC = PC.

12. A point 'O' is given outside the line 'MN'. Draw a perpendicular line from it without producing the line 'MN'.

❖❖❖❖❖❖❖❖

1.56 RECTILINEAR FIGURES

Let us look around and observe the shapes of the objects around us. We shall find that a large number of these objects are the combination of various geometrical figures. Again, most of them will be madeup of line segments. The common and simpler ones will be triangular, rectangular, square, rhombus, parallelogram, pentagon, hexagon etc. in shape. A combination of all these will be found in rangoli and murals. In this chapter, we are going to learn how to construct all these rectilinear figures, when their parameters dimensions (data) are given to us. Some of them will be very simple and a few will be based on their geometrical truths.

Can you name any three of them ?

1.57 CONSTRUCTION OF TRIANGLES

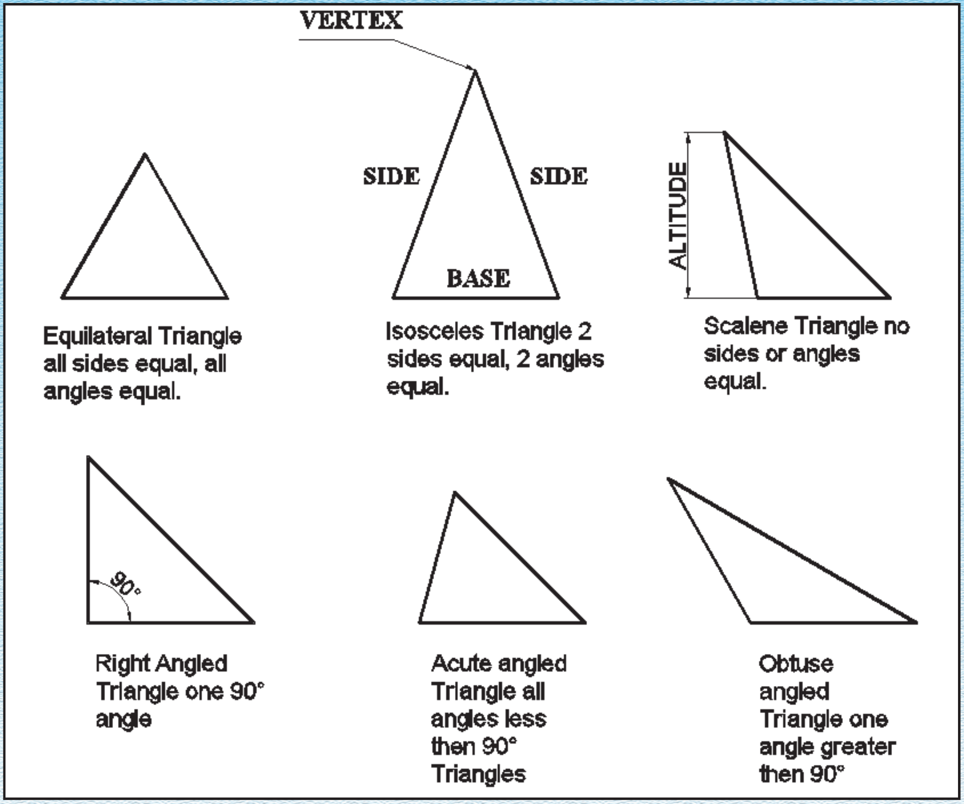


Fig. 1.57.1

A triangle is a plane figure bounded by three sides. Triangles are classified into two categories according to its sides and angles Fig. 1.57.1

Example 1.57.1 Construct an equilateral triangle given the length of the side = 50 mm

Solution

Method I (Using Compass)

Step 1: Draw a line AB of 50 mm length (Refer Fig. 1.57.2)

Step 2 : With centres A and B and radius equal to 50 mm draw arcs intersecting each other at C.

Step 3 : Draw lines joining C with A and B. ABC is the required equilateral triangle.

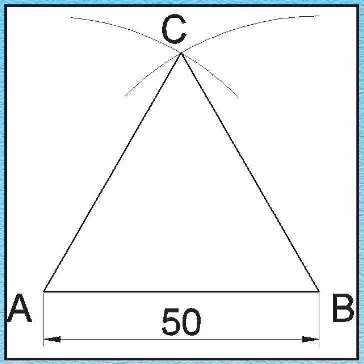


Fig. 1.57.2

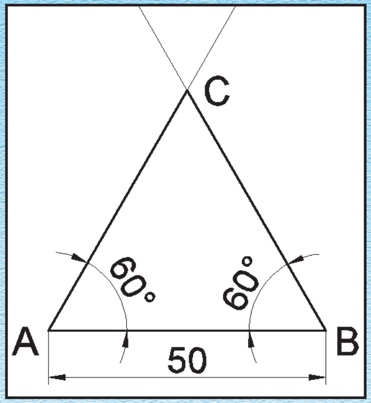


Fig. 1.57.3

Method II (Using set squares)

Step 1: Draw a line segment AB of 50 mm length (Refer Fig. 1.57.3)

Step 2 : Draw a line through A, making 60° angle with AB

Step 3 : Similarly through B, draw a line making the same angle with AB.

Step 4 : Intersecting point is C. ABC is the required triangle.

Example 1.57.2 Construct a triangle given the altitude = 55 mm and two base angles = 40° and 65°.

Solution Let ∠A and ∠B are the given base angles and CD be the attitude.

STEPS INVOLVED

(i) Draw a base line of any convenient length Fig. 1.57.4

(ii) Draw a ⊥ at a point D

(iii) Make CD equal to the given altitude = 55 mm

(iv) Through C, draw a line EF || to AB.

(v) Make ∠ECA = 40°, ∠FCB = 65°. ABC is the required triangle.

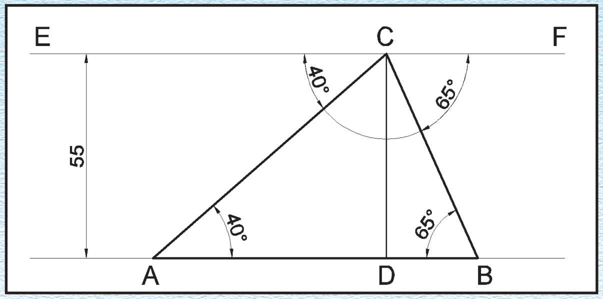


Fig. 1.57.4

ASSIGNMENT ON TRIANGLES

1. To construct an isoceles triangle MNO such that its base angle is twice the vertical angle (a) with protractor (b) with compass (c) by dividing a semicircle.
2. To construct a right angle triangle, MNO, having its altitude, MO = 45 mm and the vertical angle ∠MON = 30°
3. To construct a right angle triangle MNO, having its base MN = 50 mm and its altitude MO = 55 mm
4. To construct a right angle triangle, MNO, having its altitude MO = 40 mm and its hypotenuse ON = 60 mm.
5. A median of triangle MNO is 50 mm and it makes an angle of 50° with its base, 55° with the side of the triangle.
6. Construct a right angle Δ MNO, having its base edge = 55 mm and the base angle ∠MNO = 30°.
7. Construct a right angle Δ MNO, having its hypotenuse ON = 60 mm, and the distance of the hypotenuse from the right angle = 25 mm.
8. Construct a right angle Δ MNO, having its hypotenuse ON = 65 mm and the median from the angular point O, making the angle, ∠ODN with the hypotenuse = 40°.
9. Construct a right angle Δ MNO, having its hypotenuse ON=70 mm and the difference of its hypotenuse and one side = 30 mm.
10. Construct an isoceles triangle MNO having its base MN = 40 mm and each of its sides = 60 mm.
11. Construct a right angle Δ MNO, having its hypotenus ON = 70 mm and the difference of the sides = 22 mm.
12. Construct a right angle Δ MNO, having its altitude ON = 47 mm and the sum of the hypotenuse and its base = 70 mm.
13. Construct an isoceles Δ MNO, having each of its sides = 60 mm and each of its base angle = 50°.
14. Construct a right angle triangle MNO, having hypotenuse, ON = 60 mm and the sum of its base and its altitude = 55 mm.
15. Construct an isoceles Δ MNO, having its altitude OD = 45 mm and each of its base angle = 50°.
16. Construct an isoceles Δ MNO, having its base MN = 40 mm and its altitude AD = 50 mm
17. Construct an isoceles Δ MNO, having its vertical angle = 40° and the base MN = 50 mm
18. Construct an isoceles Δ MNO, having its altitude OD = 45 mm, and its vertical angle = 45°
19. Construct an isoceles Δ MNO, having its side = 60 mm and its vertical angle = 1/3 of base angle.

20. Construct an isoceles Δ MNO, having its perimeter = 70 mm and its altitude OD = 30 mm
21. Construct an isoceles right angle Δ MNO, having its perimeter = 70 mm
22. Construct an isoceles Δ MNO, having its base MN = 40 mm and each of its base angle twice of the vertical angle.
23. Construct an isoceles right angle Δ MNO, having the sum of its hypotenuse and one side = 60 mm
24. Construct an isoceles Δ MNO, having its base MN = 50 mm and the sum of its altitude and one side = 60 mm
25. Construct a triangle MNO, having given its base MN = 70 mm altitude OM = 40 mm and side OD 55 mm
26. Construct a triangle MNO, having its base MN = 55 mm, side ON = 45 mm and side NM = 55 mm
27. Construct a triangle MNO, having its altitude OD = 40 mm, side ON = 50 mm and side OM = 45 mm
28. Construct a Δ MNO, having its altitude OD = 40 mm, side ON = 50 mm and side OM = 45 mm
29. Construct a triangle MNO, having its base MN = 70 mm, the side ON = 45 mm and included angle = 60°
30. Construct a Δ MNO, having its base MN = 55 mm and its angle are in the ratio of 4 : 6 : 8
31. Construct a Δ MNO, having its perimeter = 100 mm and its sides in the ratio of 3 : 5 : 4
32. Construct a Δ MNO, having its base MN = 50 mm, the difference of the other two side = 15 mm and the base angle = 60°
33. Construct a Δ MNO having its perimeter = 70 mm and its angles in the ratio of 5 : 6 : 7

1.58 CONSTRUCTION OF QUADRILATERIALS

Recall that, we have drawn Square, Rectangle, Rhombus, & Trapezium in Previous Classes and we are familiar with there shapes.

- A square has all the four sides equal and all the four angles are right angles (90°). The diagonals are equal and bisect each other at right angles.
- A rectangle has opposite sides equal and all the four angles of right angles.
- A rhombus has all the 4 sides equal but none of them is 90° angles.
- A trapezium has two opposite sides parallel.

Example 1.58.1 Construct a square ABCD with AB = 60 mm

Solution

STEPS INVOLVED

(i) Draw a line segment AB of 60 mm Fig. 1.58.1

(ii) At A, draw a perpendicular at B also.

(iii) With A as centre, 60 mm as radius draw an and to intersect the ⊥, to get the point D.

(iv) With B as centre, 60 mm as radius draw an arc to intersect the ⊥ through B, to get the point C.

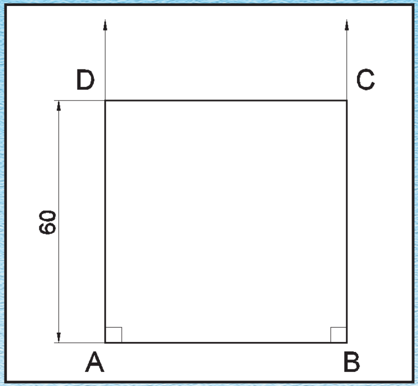


Fig. 1.58.1

Example 1.58.2 Construct a rectangle PQRS when PQ = 70 mm, QR = 50 mm

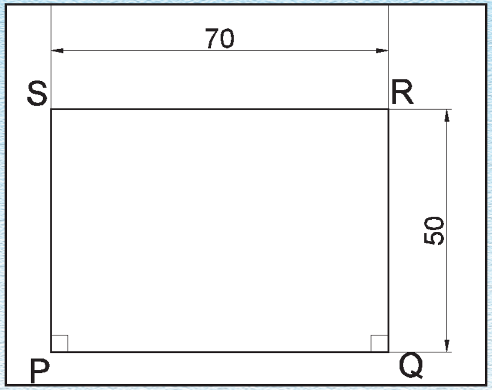


Fig. 1.58.2

Solution

STEPS INVOLVED

(i) Draw a line segment PQ of 70 mm long. Fig. 1.58.2

(ii) At P and Q erect perpendiculars.

(iii) With P as centre, 50 mm as radius draw an arc, to cut the ⊥ at the point S.

(iv) With Q as centre, 50 mm as radius draw an arc, to cut the ⊥ at the point R.

(v) Join R with S.

PQRS is the required rectangle.

Example 1.58.3 Construct a rhombus ABCD, having its side equal to 40 mm and base angle at B of 105°

Solution - Let us use the properties of rhombus here. 'All sides of a rhombus are equal.

STEPS OF CONTRUCTION

(i) Draw a line segment AB of 40 mm length (Refer Fig. 1.58.3)

(ii) At B, draw a line BX at an angle of 105°

(iii) B as centre 40 mm as radius draw an arc to cut the line BX. Intersection point is C.

(iv) With A and C as centres, 40 mm as radius draw arcs, intersecting point is D.

(v) Join A with D and C with D

ABCD is the required rhombus.

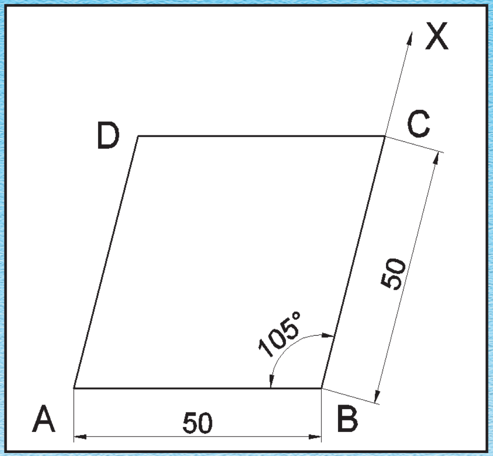
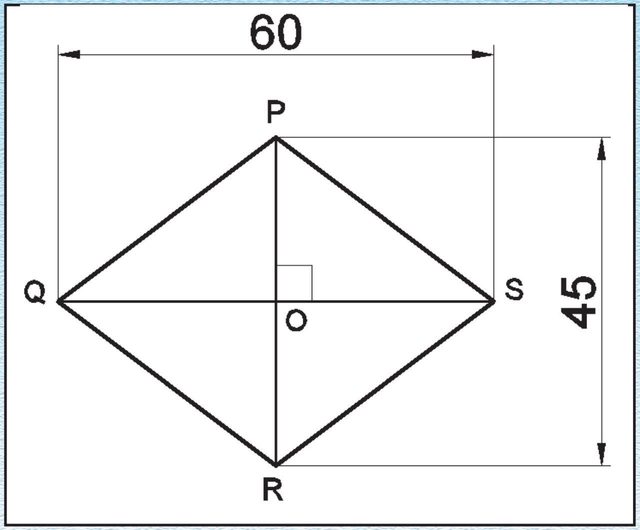


Fig. 1.58.3



Example 1.58.4 Construct a rhombus PQRS with diagonals 46 mm and QS = 60 mm

Solution - We know that, the diagonals of a rhombus bisect each other at right angles.

STEPS INVOLVED

(i) Draw a line segment QS of 60 mm length. (Refer Fig. 1.58.4)

(ii) Draw a ⊥ bisector of QS which passes through the point O.

(iii) With O as centre, 1/2 PR (23 mm) as radius draw arcs above and below to cut the ⊥ bisector. Intersection points are P & R.

(iv) Draw lines joining P with Q & S, R with Q & S. PQRS is the required rhombus.

Example 1.58.5 Construct a quadrilateral with AB = 45 mm, BC = 55 mm, CD = 40 mm, AD = 60 mm, AC = 70 mm

Solution From our earlier classes, we learnt that, to draw a quadrilateral, minimum five dimensions are required. Let us now draw this quadrilateral.

STEPS INVOLVED

(i) Draw AB of 45 mm length

(ii) With B as centre, 55 mm as radius draw an arc. See fig.1.58.5

(iii) With A as centre, 70 mm as radius draw an arc to cut the previous arc at the point C.

(iv) With C as centre, 40 mm as radius draw an arc.

(v) With A as centre, 60 mm as radius, cut the previous arc to get the intersection point D.

(vi) Draw lines joining D with C and A.

ABCD is the required quadrilateral.

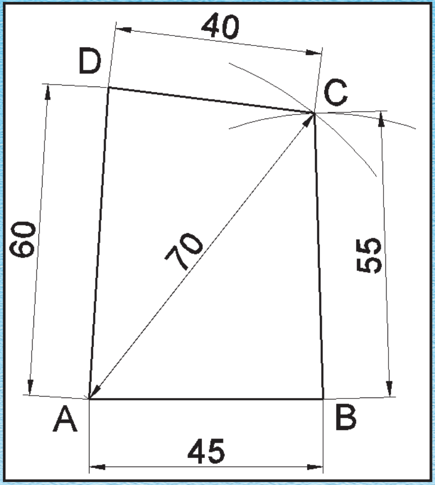


Fig. 1.58.5

Example 1.58.6 Construct a trapezium ABCD, having its sides AD = 30 mm, DC = 25 mm, CB = 35 mm and the difference of parallel sides is 20 mm.

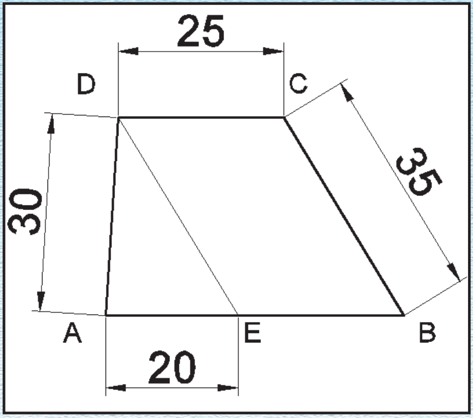


Fig. 1.58.6

Solution

STEPS INVOLVED

(i) Draw a line segment AB of 45 mm, difference between parallel sides = 20 mm (20 + 25 = 45 mm)

(ii) With A as centre and 30 mm as radius draw an arc. See fig.1.58.6

(iii) With E as centre 35 mm as radius draw an arc to cut the previous arc. [∴ ED||BC]

(iv) Intersecting point is D. D as centre 25 mm as radius draw an arc.

(v) With B as centre, 35 mm as radius cut the previous arc. Intersection point is C.

(vi) Draw lines joining A with D, D with C and C with B.

ABCD is the required trapezium.

TRY THESE

1. Construct a square with side = 65 mm
2. Construct a rhombus whose diagonals are 55 mm and 70 mm.
3. Construct a quadrilateral MORE with MO = 60 mm, OR = 45 mm, $\angle M = 60°$, $\angle O = 105°$ and $\angle R = 105°$
4. Construct a parallelogram ABCD with AB=50 mm, BC=60 mm and $\angle D = 85°$

ASSIGNMENT ON QUADRILATERALS

1. Construct a rectangle MNOP, having its base MN = 60 mm and its sides NO = 40 mm
2. Construct a rectangle MNOP, having its diagonal MO = 70 mm and the difference of its sides = 25 mm.
3. Construct a parallelogram MNOP having its diagonal MO = 50 mm, and the diagonal NP = 40 mm and the included angle OQN = 60°
4. Construct a rectangle MNOP having each of its diagonals = 70 mm and the included angle between them = 45°.
5. Construct a rhombus MNOP having its one side = 50 mm and the included angle $\angle PMN = 60°$
6. Construct a trapezium MNOP having MO, the difference of its diagonal = 30 mm.
7. Construct a trapezium MNOP, having its sides MP = 40 mm and side, PO = 30 mm and side ON = 40 mm and the difference of the parallel side = 25 mm.

❖❖❖❖❖❖❖❖

1.59 CONSTRUCTION OF POLYGONS

A polygon is a plane figure bounded by many sides Fig. 5.11 shows some of the regular polygons. We recall the fact that when all the sides and angles in a polygon are equal, it is called a regular polygon. (See Fig. 1.59.1)

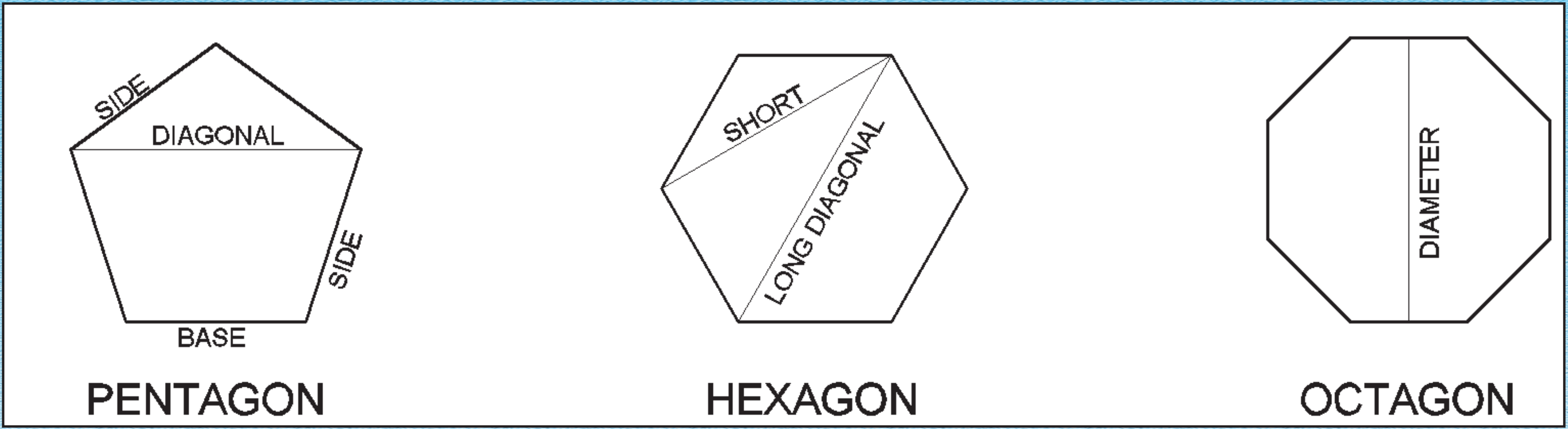


Fig. 1.59.1

- A pentagon has five sides
- A hexagon has six sides
- An octagon has eight sides

1.60 CONSTRUCTION OF PENTAGON

To construct a regular pentagon given the length of its side as 40 mm.

Solution

STEPS INVOLVED

(i) Draw a line segment AB of 40 mm length. Fig. 1.60.1

(ii) At B, draw a perpendicular BK such that BK = AB. Join A with K.

(iii) With B as centre, AB as radius draw an arc i.e. arc AK.

(iv) Draw a perpendicular bisector of AB.

(v) Mark the point of intersection of perpendicular with line AK as 4 and arc AK as 6.

(vi) Mark a point 5 which is the midpoint of 4-6 obtained by bisecting it.

(vii) With 5 as centre and 5A as radius draw a circle.

(viii) With B as centre and radius = AB draw an arc to cut the circle at C.

(ix) In a similar way, set off the measurement of side along the circle to get the points D and E.

(x) Draw lines joining B with C, C with D, D with E and E with A.

ABCDE is the required pentagon.

NOTE :

The same method can be used to draw any other regular polygon.

If we have to draw a hexagon, the centre to be taken as the point '6' which lies on the arc AK.

Similarly '4' is the centre for drawing square

'8' would be the centre for drawing an Octagon and so on.

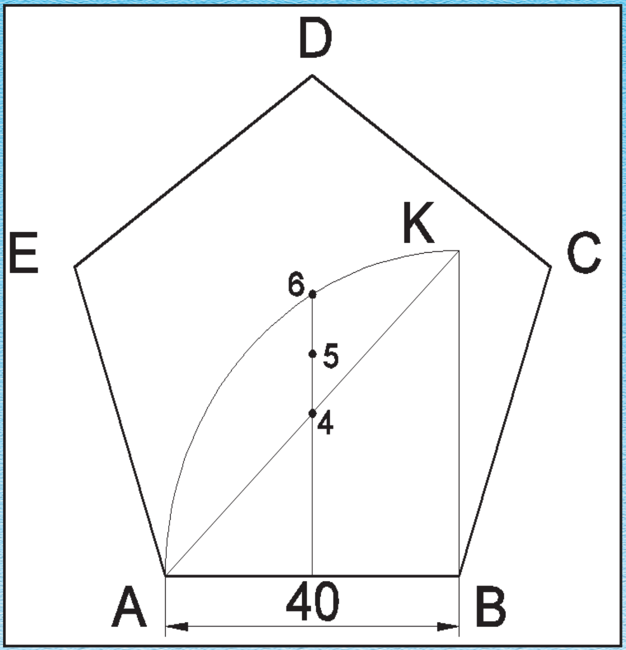


Fig. 1.60.1

1.61 CONSTRUCTION OF PENTAGON BY THE ALTERNATE METHOD

To construct a regular pentagon, given the length of its side as 40 mm.

Solution The interior angle (Θ) in a polygon is calculated by using the formula $\Theta = \left(\frac{n-2}{n}\right) \times 180°$ where n is the number of sides in a polygon.

To construct a pentagon, $\Theta = \left(\frac{5-2}{5}\right) 108° \ \Theta = \times 180°$

Fig. 1.61.1 shows, a pentagon is drawn with protractor.

The included angle/interior angle is calculated to be 108°, for a pentagon.

NOTE : The method given above is useful in drawing 'Θ' for hexagon which is 120° a hexagon & an Octagon also.

'θ' for Octagon is 135°

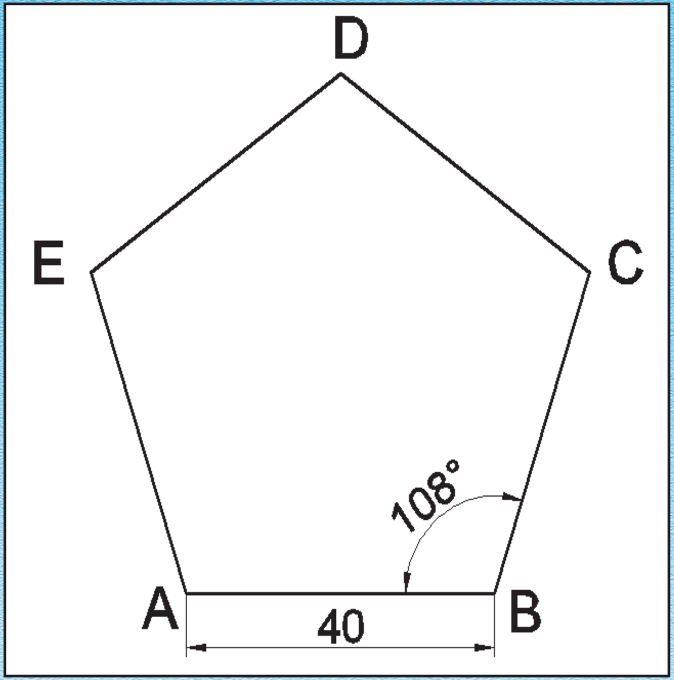


Fig. 1.61.1

GROUP ACTIVITY

There are many other methods available to construct a regular polygon.

- Make a group of 5 students
- Find out from your school library the five different methods of construction of regular polygons.
- Discuss, which method is the most accurate one.

ASSIGNMENT

1. Construct a regular pentagon of side 25 mm
2. Construct a regular hexagon of side 30 mm
3. Construct a regular Octagon of side 25 mm

Chapter 2

CIRCLES, SEMI CIRCLES AND TANGENTS

2.1 INTRODUCTION

As we know that wheel has been the most revolutionary invention for transport and industrial revolution. In engineering many machine parts are circular in shape or uses part of a circle or some of their features. e.g. gears, pulleys, bearings etc. We shall be required to construct circle and circular features in many drawings of Engineering Graphics. In this chapter let us learn how to draw these and acquire the skill very well.

2.2 LET US RECALL

You have already learnt about circle and its construction in variety of problems in your earlier classes. Let us recall. Study the figure 2.1 and fill in the blanks with the choices given : (point of contact, Centre, Radius, Diameter, Chord, Tangent, Normal, Sector, $\angle$OPG|$\angle$OPF, segments, O, OA, OC, OP, OB, radii, BC, P, arc, DE, twice, Semi circle.)

Q1. The fixed point .... is the ....

Q2. The constant distance from centre to any point on its circumference distances ...., ... , ... and .... are ....

Q3. The line passing through the centre having its extremities on the circumference of the circle is .... and is called ....

Q4. The line touching the circle at a point .... is known as ....

Q5. The line perpendicular to tangent and joining the centre is named .... and angles .... and .... are 90°.

Q6. One of the .... is AC.

Q7. The portion of circle with arc BP and two corresponding radii is named............... .

Q8. The line segment .... is known as ....

Q9. The chord divides the circle in two parts called ....

Q10. The diameter is .... the radius.

Q11. A circle can be drawn when its .... and .... are given.

Q12. A diameter divides the circle into to equal halves which are known as ....

Q13. The point P is named ....

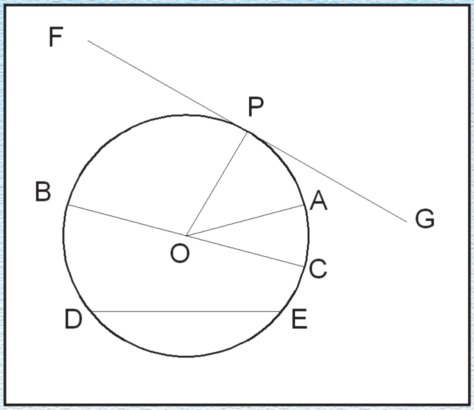


Fig. 2.1

2.3 CONSTRUCTIONS OF CIRCLES

SOLVED EXAMPLES

Example 1

To find the centre of a given circle which is drawn without using compass. Use any circular object like glass tumbler, bottle cap etc.

Solution : Refer Fig. 2.2 (i) Draw AB and CD two chords of the circle at any angle (except parallel chords) (ii) Find the perpendicular bisectors of both of them (iii) The point of intersection of the right bisectors (point O) is the centre of the circle.

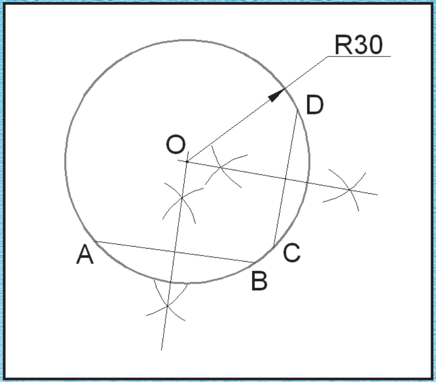


Fig. 2.2

Example 2

To draw a circle passing through three non-collinear points A, B and C.

Solution : Refer fig. 2.3 (i) Take any three points A, B, and C. (ii) Join A with B and B with C. (iii) Find the perpendicular bisectors of AB and BC. (iv) Name the point of intersection of these perpendicular bisectors as O. (v)Now with O as centre and OA or OB or OC as radius, draw the circle through A, B and C points.

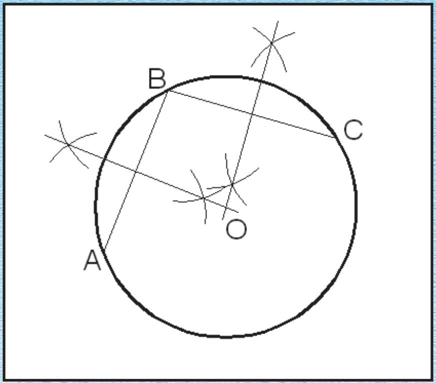


Fig. 2.3

Example 3

Given the arc PQ, complete the circle.

Solution : Refer Fig. 2.4 Take any circular arc PQ (ii) Take any point R on PQ (iii) Find the perpendicular bisectors of PR and RQ (iv) Name the point of intersection of these as O. (v) Now draw a circle with O as centre and OP as radius. Can you name the other two radii like OP ?

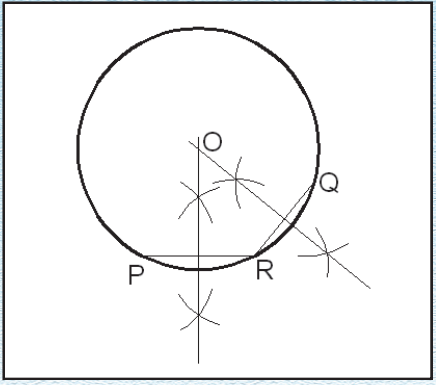


Fig. 2.4

2.4 TANGENT OF A CIRCLE

The tangent is a line which touches the circle at a point. Give names of the point at which the tangent touches a circle and the line (OP) joining the centre with the point common on tangent and the circle. What is the angle made by tangent and this line (OP) ? In Engineering many machine parts use circle/arc of the circle and the tangents. Let us learn how to construct tangents in different positions.

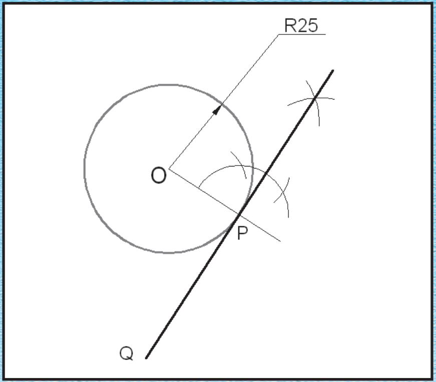


Fig. 2.5

Example 4

To draw a tangent on the given circle of radius 25 mm at any given point P on it.

Solution : Refer Fig. 2.5 (i) Draw the circle of radius 25 mm. Name the centre O. (ii) Take any point P on it. (iii) On OP at point O make a 90° angle by compass. (iv)The line SQ touching the circle at point P is the required tangent. Can you tell how many tangents through P are possible ?

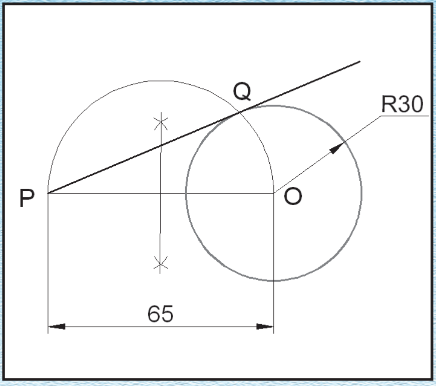


Fig. 2.6

Example 5

To draw a tangent to a circle of radius 30 mm from a given point P, 65 mm from the centre.

Solution : Refer Fig. 2.6 (i)Draw a circle of radius 30 mm. Name the centre O (ii) Take any line segment OP = 65 mm (iii) Draw a semicircle on OP (iv) Join the point of intersection of the circle with the semicircle drawn i.e. Q with P. PQ line is the required tangent. Is it possible to draw this tangent below line OP ? If so, draw it also. How many tangents to the given circle can be drawn from point P ?

2.4.1 EXTERNAL AND INTERNAL TANGENT OF CIRCLES

We have learnt in this chapter, under article 2.3, how to draw tangent to a circle at a given point on it and also from a point to it. Now, we shall be learning how to draw tangent to two circles in different conditions. Can you guess? The two given circles may be touching, intersecting and non-intersecting. Also their radii may be equal or unequal. Therefore, different cases arise.

TRY THESE

Fill in the blanks from the given options. (sum, difference, multification, division)

(i) If two circles touch externally, the distance between their centres will be .... of their radii.

(ii) If two circles touch internally the distance between their centres will be .... of their radii.

(Hint : Study the following examples and find the answers to above)

Example 6

Draw an external common tangent to two circles of equal radii of 20 mm each when their centres are 45 mm apart.

Solution : Refer Fig. 2.7 (i) Draw two circles, each of radius R20 with their centres 45 mm apart (ii) Construct a 90° angle at O and O_1. The points P and Q are points of tangency. Join P with Q to obtain the tangent. (Is it possible to draw another such tangent below also. If so, please draw that as well. If not, then give the reason)

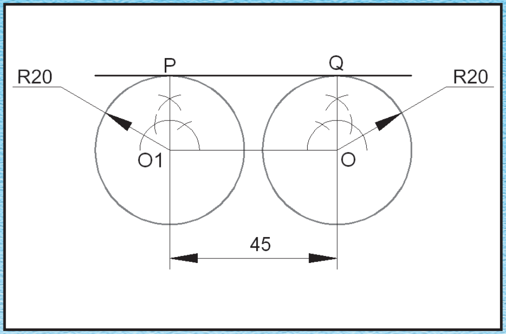


Fig. 2.7

Note : An External tangent is also known as Exterior or Direct common tangent.

Example 7

Draw an external common tangent to two externally touching circles (i) with equal radii R 20 mm each, (ii) with unequal radii of R 20 mm and R 25 mm.

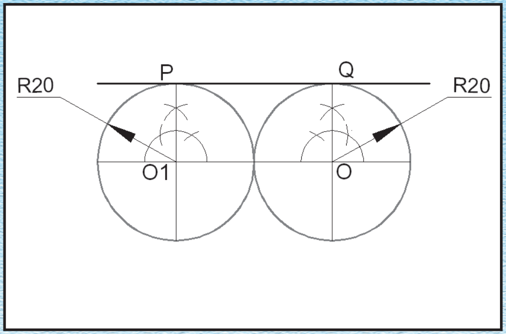


Fig. 2.8

Solution : Refer Fig. 2.8 and Fig. 2.9 For case (i) : See the steps of construction in example 6 For case (ii) Draw the two touching circles with radius R25 mm and radius R 20 mm. (ii) Draw a semi circle on OO_1 (iii) Draw a perpendicular on OO_1 at A, (point at which the given circles touch externally) intersecting the semi circle drawn at point B (iv) Now with B as centre and BA as radius, draw the circular arc to get P and Q on the two given circles. PQ is the required common tangent.

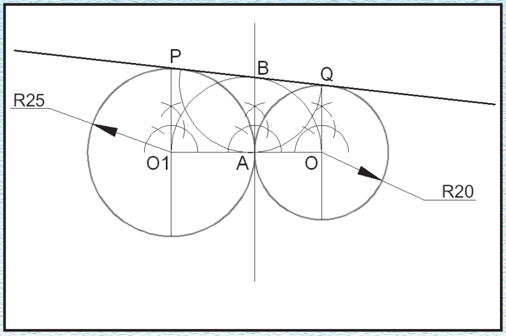


Fig. 2.9

Try This : Name another external common tangent and its point of tangency.

Example 8

Draw an external common tangent to two non-intersecting and unequal circles, with their radii as R25 mm and R 15 mm when their centres are 60 mm apart.

Solution : Refer Fig. 2.10 (i) Draw the two circles with radius R25 mm and R15 mm with their centres 60 mm apart (ii) Now, draw another circle with O as centre and with radius equal to the difference of the radii of the given circles i.e. (25 - 15 = 10) (iii) Then draw a semi circle on OO_1, cutting the circle of radius 10 mm at point A (iv) Join O with A and extend it to cut the circle of radius 25 mm at point P. (v)From point O_1 draw O_1 Q parallel to OP giving us the point Q. (vi) Join PQ, which is the required tangent.

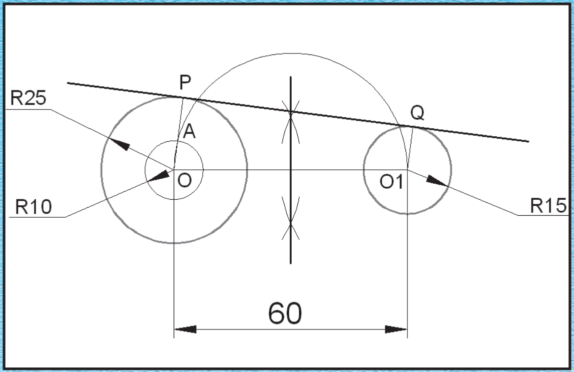


Fig. 2.10

Example 9

Draw an external common tangent to two intersecting and unequal circles, with their radii as R 25 and R 15 with their centres 35 mm apart.

Solution : Refer Fig. 2.11 (i) Draw the given two circles with radii 25 mm and 15 mm with their centres 35 mm part (ii) Take OA at an angle on the (R25) circle (iii) Now draw O_1 B parallel to OA. Join A with B and extend it to get point C on OO1 extended, (iv) Draw a semi circle on OC to get point P on circle of radius R25. Join P with C. PC is the required tangent.

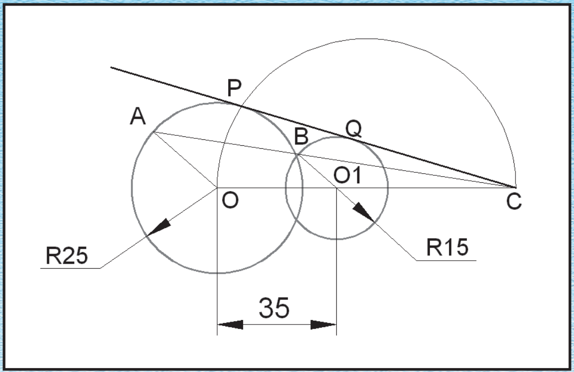


Fig. 2.11

Example 10

Draw an internal tangent to two circles, each of radius 20 mm when their centres are 60 mm apart.

Solution : Refer Fig. 2.12 (i) Draw the given two circles with their centres 60 mm apart (ii) Right bisect OO_1 to get M (Mid-point of OO_1) (iii) Draw a semi circle on OM to get point P. (iv) Draw O_1 Q parallel to OP. Join PQ, which is the required internal tangent. (Note : The tangent passes through M).

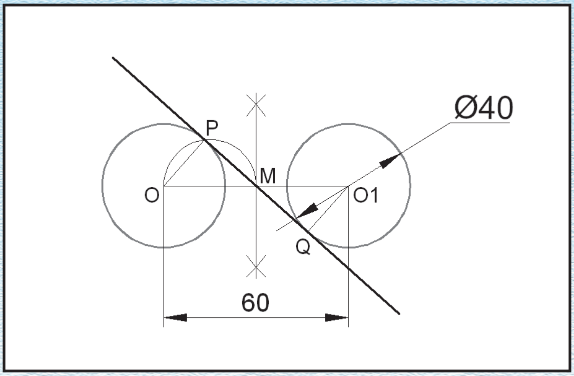


Fig. 2.12

Example 11

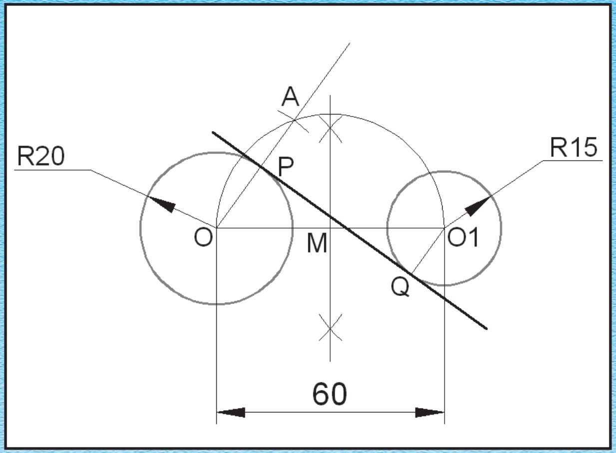


Fig. 2.13

Draw an internal common tangent to two non intersecting and unequal circles, with their radii as R 20 mm and R 15 mm and their centres 60 mm apart.

Solution : Refer Fig. 2.13 (i) Draw the two given circles with their centres 60 mm apart (ii) Draw a semicircle on OO_1. (iii) Draw O as centre and sum of the radii as radius, draw a circular arc to cut the semi circle drawn at point A (iv) Join OA to get point P on the circle having radius = 20 mm (v) From O_1 draw O_1 Q parallel to OP. The required tangent is PQ.

2.5 INSCRIBING OF CIRCLES

You have learnt in your study of the geometry in the previous classes that a circle drawn to passes through all the vertices of a given rectilinear figure is called circumscribing circle. Can you guess what could be inscribing then? Yes your guess is correct that a circle drawn inside to touch all the sides of the given rectilinear figure is inscribing circle. If this is so, then what is the distance of these touching lines from the centre? Recall the distance of the centre from the point of tangency.

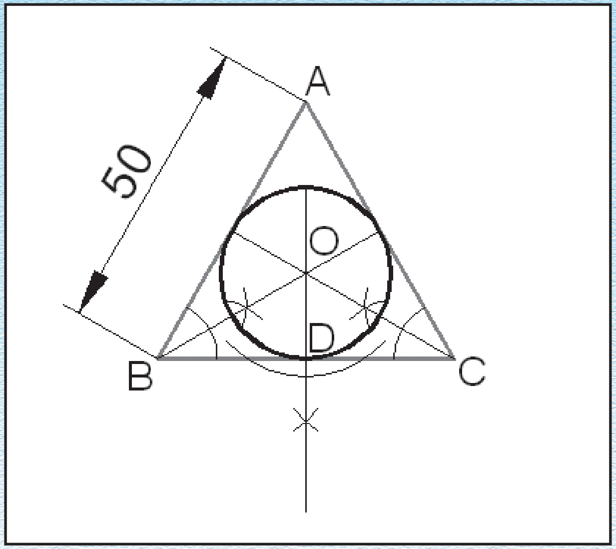


Fig. 2.14

In all these kind of problems we attempt to find out the centre and the radius is obtained by drawing a perpendicular from centre to any one of the touching lines of the given rectilinear figure.

Example 12

Draw the given equilateral triangle of side = 50 mm. Inscribe a circle in it.

Solution : Refer Fig. 2.14 (i) Draw the given equilateral triangle ABC with side = 50 mm (ii) Find the angle bisectors of angle B and angle C to meet at O (iii) From O draw OD perpendicular to BC (iv) Now, O as centre and OD radius draw the circle to touch all the sides of the triangle. (Note that the sides AB, BC and CA are tangents to the circles drawn)

Example 13

Draw a given square whose diagonal is 60 mm. Inscribe a circle in it.

Solution : Refer Fig. 2.15 (i) Draw a square whose diagonal is 60 mm (ii) Name the square ABCD and the point of intersection of AC and BD as O (iii) From O drop a perpendicular (OE) from point O on any one side (iv) Now with O as centre and radius = OE, draw a circle to touch all two sides of the square.

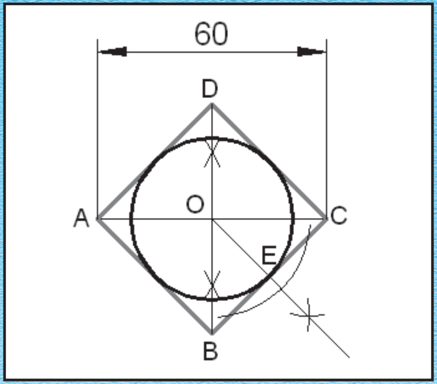


Fig. 2.15

Example 14

Draw a given rhombus whose each side = 55 mm and incribe a circle in it.

Solution : Refer Fig. 2.16 (i) Draw a rhombus whose each side = 55 mm. (ii) Obtain the centre O by joining the two diagonals AC and BD (iii) From O draw a perpendicular on AB (iv) Now with O as centre and OE radius draw the required circle.

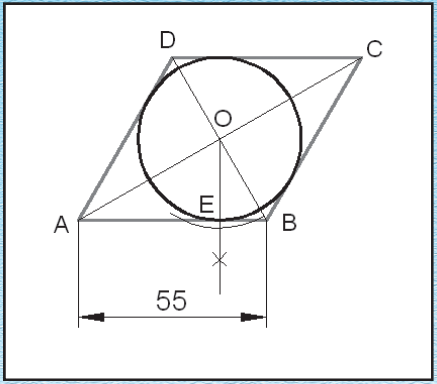


Fig. 2.16

Example 15

Inscribe a circle in a regular pentagon whose one side = 40 mm.

Solution : Refer Fig. 2.17 (i) Draw the regular pentagon whose one side = 40 mm. (ii) Find the angle bisector of ∠EAB and ∠ABC to intersect at O. (iii) From O draw a perpendicular (OF) to side AB (iv) Now with O as centre and OF radius, draw a circle to touch all the sides of the pentagon.

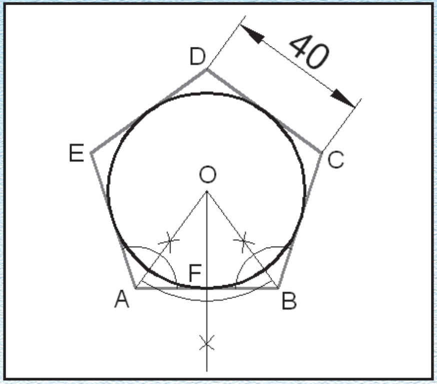


Fig. 2.17

Example 16

Inscribe a circle in a regular hexagon whose diagonal is given as 60 mm.

Solution : Refer Fig. 2.18 (i) Draw the regular hexagon whose diagonal AD= 60 mm (ii) Join opposite corners to obtain the other two diagonals to cut at O (iii) From O drop a perpendicular OG on side AB (iv) Now O as centre and OG radius draw the required circle.

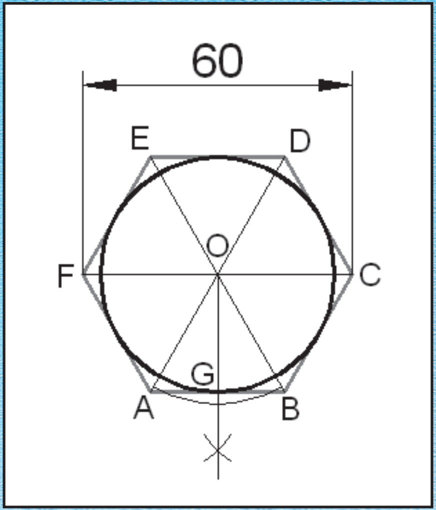


Fig. 2.18

Example 17

Inscribe a circle in a regular Octagon whose one side = 30 mm.

Solution : Refer Fig. 2.19 (i) Draw the regular Octagon whose side = 30 mm (ii) Join any two opposite corners to obtain the two diagonals AE and BF which meet at O (iii) From O draw a perpendicular OK to AB. (iv) Now O as centre and OK radius draw the required circle.

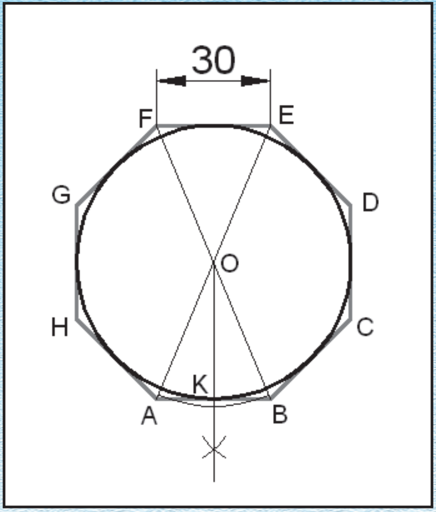


Fig. 2.19

ASSIGNMENT

Q1. Draw a circle of any convenient radius without using compass and find its centre.

Q2. Draw a triangle ABC with AB = 40 mm, BC = 50 mm and CA = 60 mm. Draw a circle passing through A, B and C.

Q3. Draw any arc (without using compass) Now complete the circle of which this arc is a part.

Q4. Draw a circle of radius 20 mm and take a point P on it. Draw a tangent at P.

Q5. You are given a circle of radius 25 mm and a point P, 55 mm from the centre of this circle. Draw two tangents from this point on the circle.

Q6. Two circles of each radii, each = 25 mm have their centres 65 mm apart. Draw two external common tangents to these circles.

Q7. There are two circles which touch externally. Draw them by taking each radius = 30 mm and then draw two external common tangents to these circles.

Q8. Draw two touching circles whose radii are 20 mm and 15 mm. Draw an external common tangent to these circles.

Q9. Two circles, R30 mm and R15 mm have their centres 70 mm apart. Draw an external common tangent to these circles.

Q10. There are two intersecting circles with their centres 30 mm apart and radii equal to 25 mm and 15 mm. Draw an external common tangent to these circles.

Q11. Two equal circles of radii each = 30 mm have their centres 80 mm apart. Draw an internal common tangent to them.

Q12. Draw an internal common tangent to two circles whose radii are 25 mm and 20 mm and their centres are 70 mm apart.

Q13. Draw an equilateral triangle of height = 55 mm. Inscribe a circle in it.

Q14. Inscribe a circle in a given square of side = 40 mm.

Q15. Inscribe a circle in a rhombus whose diagonals arc 70 mm and 40 mm.

Q16. Draw a regular pentagon of side = 45 mm. Inscribe a circle in it.

Q17. In a regular hexagon of diagonal = 70 mm and inscribe a circle in it.

Q18. Draw a regular Octagon of side = 25 mm. Inscribe a circle in it.

Q19. Draw an angle ABC = 60° with AB = BC = 80 mm Now draw a circle of radius = 15 mm touching lines AB and BC.

Q20. Two pulleys of radii 30 mm and 20 mm have their centres 70 mm apart. Show the arrangment (i) Direct belt (two direct common tangents) and (ii)cross -belt (two internal common tangents).

Chapter 3
SPECIAL CURVES

3.1 INTRODUCTION

In several articles of daily use we notice that they have straight edges which may form various rectilinear figures such as triangle, square, rohmbus, parallelogram, trapezium etc. Look around or recall from your past experience such articles and name them. Then we also have articles/objects whose shape is circular, spherical, cylindrical, prisms and pyramids, conical etc.

You have studied about the various orbits of the planets of solar system. What is their shape, called as ? Oval objects are also quite common. Name a few. In Engineering we shall come across many objects/ parts which are combination of these various shapes. We are going to study about these special curves.

3.2 ELLIPSE

One the most common curve in Engineering will be the oval/an egg shape. This we shall call as Ellipse. Let us know about the ellipse in details. Now study the figure (3.1) shown and answer the simple questions by choosing the correct option from the choices given. (Major Axis, Minor Axis, Centre, Semi-Major Axis, Semi-minor axis, Focus.

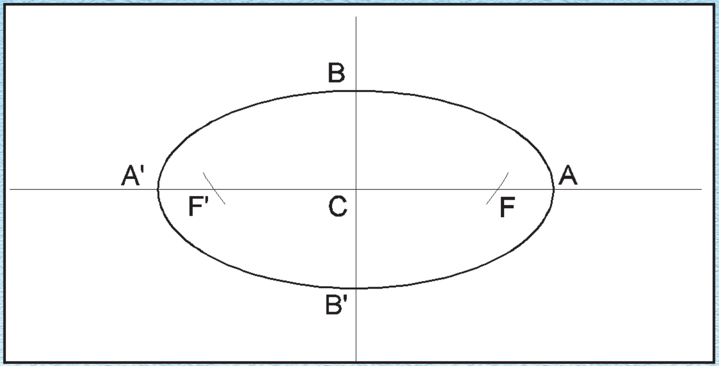


Fig. 3.1

Q1. The point C is the .... of ellipse.

Q2. Length A–A′ is the .... of ellipse.

Q3. Length B–B′ is the .... of ellipse.

Q4. Length CA = CA′ and is called .... of the ellipse.

Q5. Length CB = CB′ and is called .... of the ellipse.

Q6. The points F and F′ each is known as .... of the ellipse. We call them focii while refering to both.

In engineering we are required to draw the curve ellipse. We shall now learn how to contruct the ellipse by various methods.

3.2.1 CONSTRUCTIONS OF THE ELLIPSE BY VARIOUS METHODS

(i) By the concentric circles method :

Example : Draw an ellipse whose major axis = 80 mm and minor-axis = 50 mm by the concentric circles method.

Solution : Refer Fig. 3.2 (i) Draw a circle of ϕ 80 mm and another circle of ϕ 50 mm. (ii) Divide both the circles in 12 equal parts either by 30° and 60° angles or by compass method of constructing 60° angles. (iii) From divisions (1, 2 ....) of the outer circle draw vertical lines as shown (iv) Similarly from the inner circle divisions draw horizonal to intersect the vertical lines already drawn. (v) The point of intersection of these vertical and horizonal lines will give us (a, b, c, d ....) points on ellipse (vi) Draw a smooth ellipse passing through these points either by free hand or by French curves (It is better to practice free hand drawing of curves.) In good drawing there should not be any kink or dip on the entire curve).

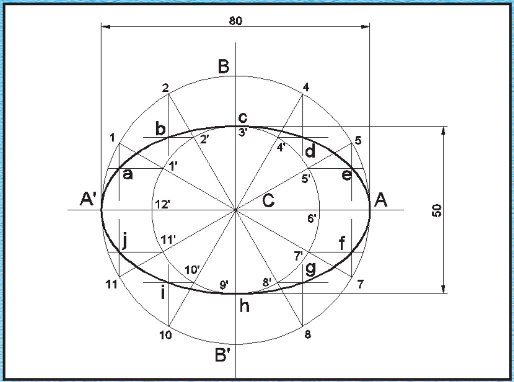


Fig. 3.2

(ii) Intersecting arcs methods :

Example : Draw an ellipse whose semi major axis is 35 mm and semi-minor axis is 20 mm by intersecting arcs method.

Solution : Refer Fig. 3.3 : (i) On a horizontal line mark centre C of the ellipse. Cut CA = CA′ = 35 mm on this line (ii) Draw a perpendicular line through C on AA′ to obtain B and B′ such that CB = CB′ = 20 mm (iii) Now B as centre and radius = semi major axis = 35 mm obtain the focii F and F′ on the major axis A-A′. (iv) Take random points 1, 2, 3, approximately, equidstant between C and F on CA. Now take A′1, A′2 and A′3 as radii and centre as F′ draw arcs above and below line CA (v) Now take A1, A2 and A3 as radii and F as F′ as centre, cut the previous arcs drawn to obtain points of intersection (1, 2, 3, 5, 6 & 7) (vi) Similarly the points are to be obtained on the left. Draw a smooth ellipse through all these points of intersecting arcs.

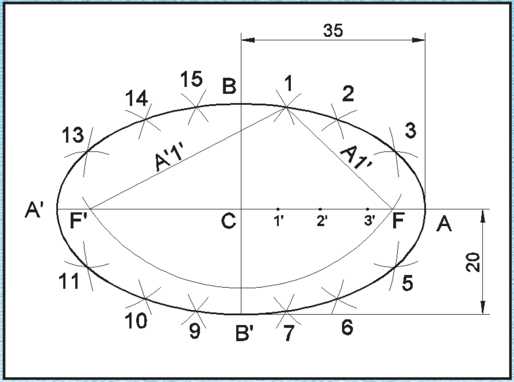


Fig. 3.3

(iii) Intersecting lines method :

Example : Draw an ellipse whose major axis = 60 mm and the minor axis = 40 mm by intersecting lines method.

Solution : Refer Fig. 3.4 : (i) Draw a rectangle (60 × 40) such that AA′ is the major axis and BB′ is the minor axis which are obtained by joining the mid-points of opposite sides of the rectangle. Mark centre as C. (ii) Now divide both the semi-major axes into four equal parts and name the points 1, 2 and 3 (iii) Similarly divide both the sides of rectangle parallel to semi minor axes in four parts, naming them 1′, 2′ and 3′ (iv) Join these points on sides with B and B′ as shown. Further Join1, 2 and 3 with B and B′ as shown (v) Extend these lines to

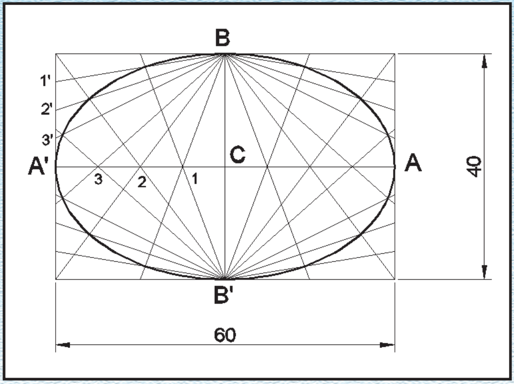


Fig. 3.4

obtain the points of intersections as shown. These points of intersection lie on ellipse. (vi) Similarly join the other points as well in the remaining three quarters (vii) Through all these points draw a smooth curve, preferably by free hand or by French curve.

3.3 PARABOLA

You must have seen the reflectors of headlights of the automobiles and the antennas of the rador and satellite transmission or reception. Can you gueses the shape of these? Yes your guess should be a "Parabola". We shall now be understanding the various parameters of the parabola. Try to fillin the blanks from the following options. (Axis, A, F, LR, ZZ', YY') Refer Fig. 3.7

1. The line about which the parabola is symeterial is XX' and is called........
2. The vertical conjugate axis is ....
3. The point....... of intersection with the axis is called .... of the parabola.
4. The line through focus is .... and is called Latus Rectum.
5. The Focus is point ....
6. The directrix is the line left to the conjugate axis is .... in the given figure.

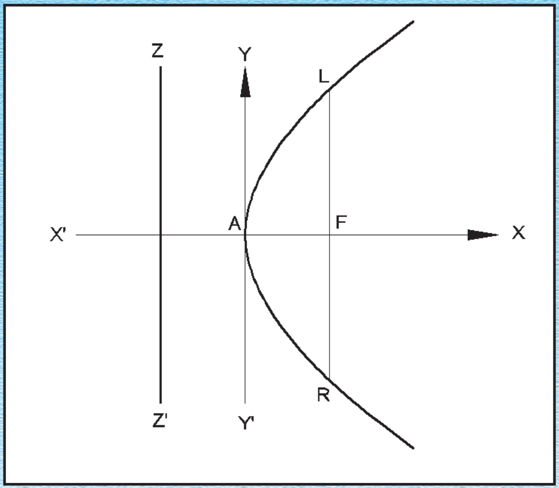


Fig. 3.7

Let us learn the various methods of drawing a parabola.

Construction of Parabola

(a) By Intersecting Lines : Draw the parabola whose width is 70 mm and the depth (height) is 30 mm.

Solution : Refer Fig. 3.5 : (i) Draw a rectangle whose length = 70 mm and the height is 30 mm (ii) Draw the central line VC perpendicular to AB at point C – the centre of AB (iii) Divide the line segments DV, VE, AD and BE each into four equal parts (iv) Name the points on the horizonal lines as 1, 2, 3 and 1', 2', 3' on vertical lines (VE and EB) (v) Join 1', 2' and 3' with V as shown on both sides (vi) From 1, 2 and 3 draw the vertical lines to intersect the lines drawn earlier (v) Match the corresponding points as shown. Mark them as fine dots (vi) Through these points draw a smooth curve. This is the parabola required.

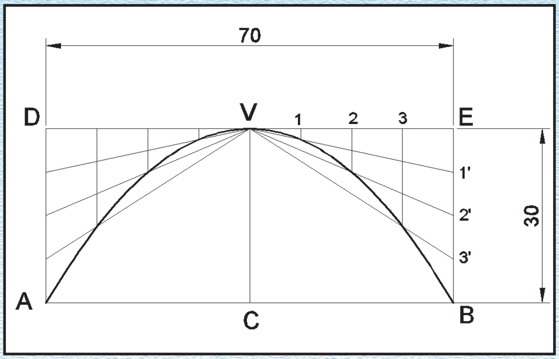


Fig. 3.5

(b) By Intersecting arcs : Draw the parabola when distance between a fixed line (called directrix) and the focus F is given = 25 mm.

Solution : Refer Fig. 3.6 : (i) Draw any vertical line (ZZ′) at any point A (preferebly in middle). This is known as directrix. (ii) On point A draw a perpendicular line AB. (iii) Cut-off AF = 25 mm and bisect it to get point V. (V is called the vertex and F is known as Focus). (iv) Take 1, 2, 3, 4 and 5 points at random on AB, preferably at increasing distances from V (v) Draw vertical lines, above and below of AB through 1, 2, F, 3, 4 and 5 points. (vi) Now take distances A1, A2, AF, A3, A4 and A5 as radii for arcs and "F as centre" and cut arcs on above and below the vertical lines drawn through 1, 2, F, 3, 4, and 5 points as shown to get pair of points (1′1′, 2′2′, 3′3′, 4′4′, 5′5′ and LR) (vii) Draw a smooth curve passing through all these points. This is Parabola.

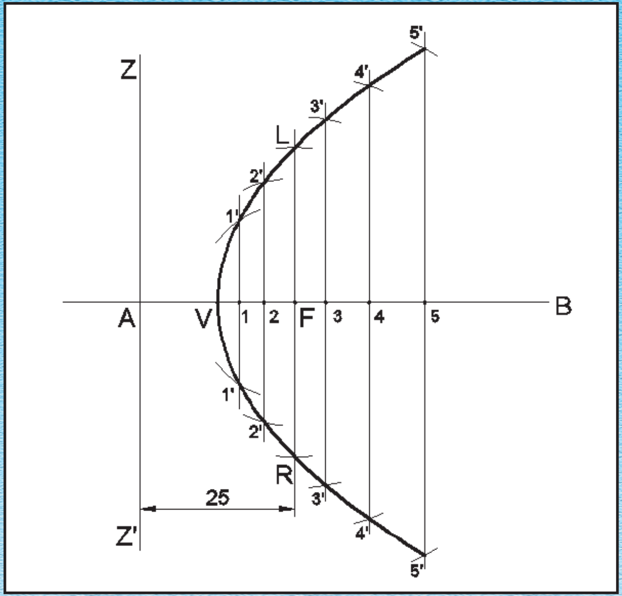


Fig. 3.6

3.4 INVOLUTE

Involute of a circle : You know that the straight line is the shortest distance between two points. So the line can be considered as the movement of the point under some conditions. In the same way if a wheel is taken and is wound tight with a non-elastic string or wire and given "One complete round". Let one end of the string or wire be "stuck" to the wheel while "the loose" end is wrapped round to meet the fixed end. Can you tell how much should be the length of the string? Now unwind the string/wire while the wheel is fixed, keeping also the loose end always tight. The loose (free) end will now trace a curve, very typical and used in Engineering in the teeth of the gears. We call this as Involute of a circle. Let us learn how to draw it ?

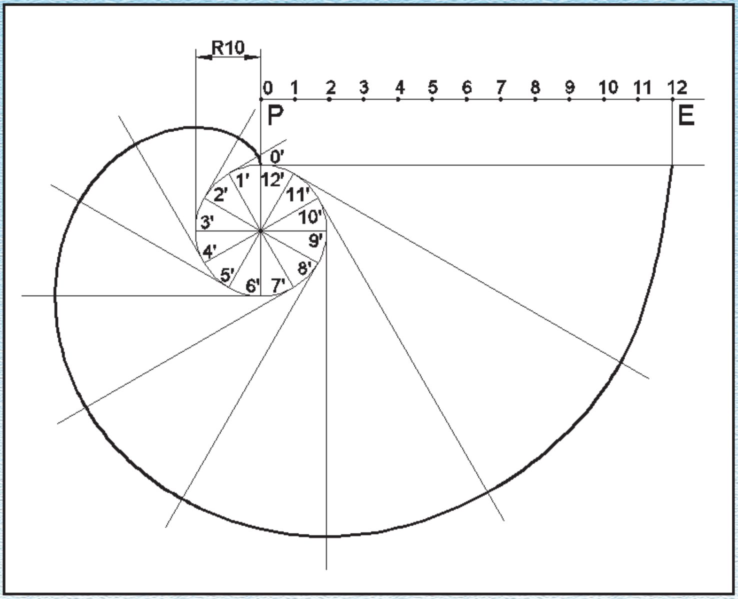


Fig. 3.8

3.4.1 DRAWING THE INVOLUTE OF A CIRCLE

Example : Draw the Involute of a circle whose diameter is 20 mm.

Solution : Refer Fig. 3.8 (i) Draw the circle of dia. 20 mm and divide it into twelve equal parts. This is easily done either constructing 30° and 60° angles by compass or by set square|protractor after drawing horizontal and vertical diameters. (ii)Name these points as 1′, 2′, 3′, 4′ ....12′ as shown in the Fig. (iii) Now on each point 1′, 2′, 3′, ... 12′ construct tangents (iv) On PE parallel to the last tangent line on 12′ mark off arcs of 1/12 of the perimeter (1′–2′ distance or between any two successive points on the circumsference). (v) Name these points 1, 2, 3, 4 .... 12 on PE parallel to the tangent at 12′. You will find the total length = PE, which is the circumference of the circle. (vi) On each of the tangents at 1′, 2′ .... 12′ cut – off arcs of increasing length (01, 02, 03, 04 ....011, 012) (vii) Draw by free hand a smooth curve to pass through these points of intersection of the tangents with the arc length cut off as (01, 02, 03 .... 011, 012). ..... This curve is the Involute of the circle.

3.5 CYCLOID : We are using wheels for means of transport on road. Let us consider a wheel rotating about its centre "without slip" on a plane straight road. If a feather of a bird get, stuck to the wheel on a certain point and remain stuck for some time. If we consider one complete rotation of such a wheel the feather will trace the typical curve called as cycloid. This curve is used in the teeth of the gears, especially straight gear called as rack in engineering.

3.5.1 CONSTRUCTION OF CYCLOID : Let us learn how to draw it.

Let us draw the cycloid of the circle whose diameter = 30 mm.

Refer Fig. 3.9 (i) Draw the circle of diameter = 30 mm and divide it into six equal parts by the compass method as explained in the construction of the involute (ii) Through the point 0′, 1′, 2′, 3′ ....6′ marked on the circle draw horizontal lines parallel to each other (iii) on the horizontal line through 0′, mark 12 points (0, 1, 2, 3....... 12) each of 1/12 of circumference (0′1′) (iv) Through these points (1, 2, 3......11) draw vertical lines (v) Find the "corresponding points of intersection" of the horizontal and vertical lines (vi) Through these points draw a smooth free hand curve known as Cycloid.

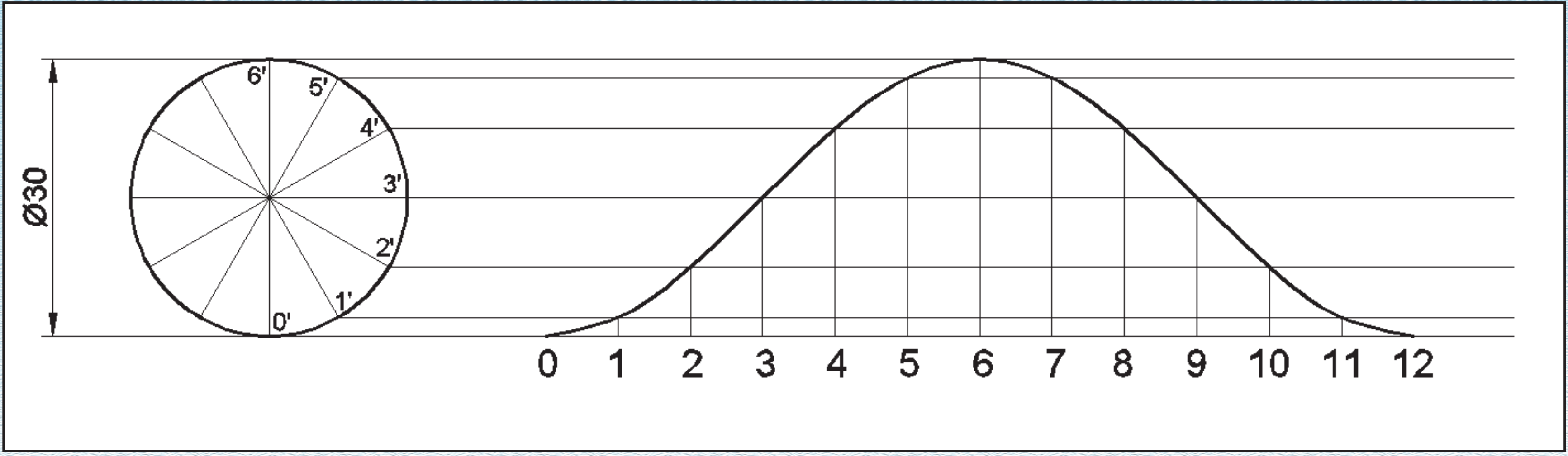


Fig. 3.9

3.6 THE HELIX : You must have heard about Screws, Nuts and Bolts. Many of you must have used them in the making of some of the models of cranes, cart, car etc. of Mechano sets. They are used to join two parts, temporarily. Did you ever study the spring like features of these parts, especially the one winding its way on the length? Some of you may be able to name it also. These are commonly known as "threads".

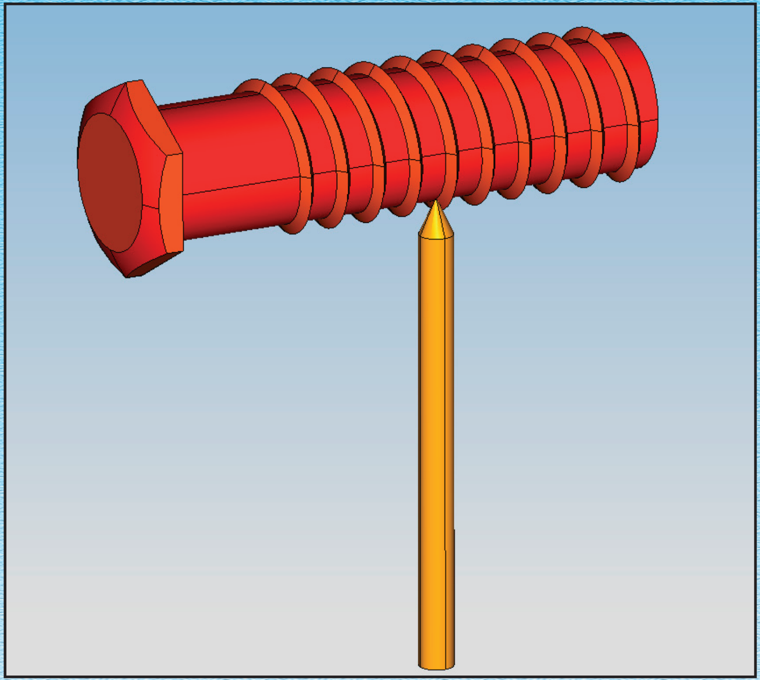


Fig. 3.10

ACTIVITY : Take a screw or a bolt insert the tip of your pencil in its groove in the centre of the length of screw/bolt. Now hold the pencil and turn the screw/bolt in either direction (i.e. clock wise/anticlockwise. Give a few complete turns. Observe what happens to the pencil. You will notice that it will move either in the forward/backward direction. This is possible due to these typical grooves known as "threads". The shape of these threads is helical. The curve that is drawn in this way is known as helix.

In Engineering we are required to join two parts. This can be done in many ways. One of the way is a pair of Nut-bolt or a screw depending on the requirement/situation. Thus they are very common in Engineering.

3.6.1 CONSTRUCTION OF HELIX : Let us study the construction of helix in detail (Refer Fig. 3.11)

(i) Draw the circle of given radius say 20 mm and divide it into six equal parts (actually twelve, but the division points on the left and right are symmertical so one side will suffice) (ii) Through these points marked (0, 1, 2, 3, ...6) draw the horizontal lines as shown (iii) Now mark the distance "pitch" = 45 mm (it is also given) and divide it into twelve equal parts as shown and match the corresponding points as shown. Note that the points are symmetrical about the vertical line through 6'. (iv) Join these points by free hand. Such a curve is called helix. This is repeated all along the length of the threaded portion of the bolt/screw.

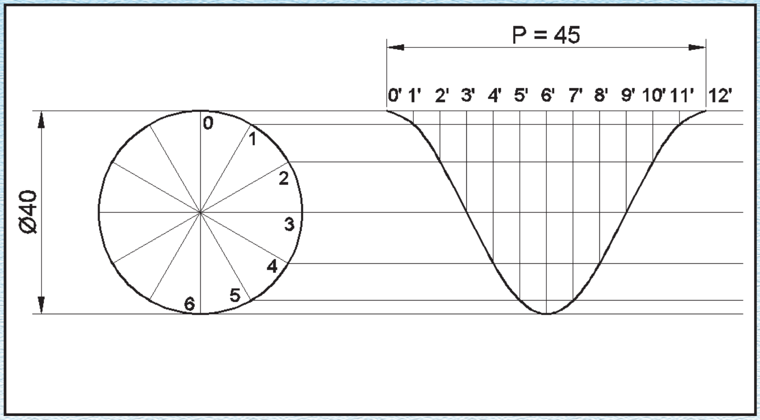


Fig. 3.11

3.7 SINE CURVE : Under the study of trigonometry you have studied the trigonometrical ratios. Let us recall the sin θ. In a right angled triangle as shown write the ratio in terms of its sides.

$$\text{sine } \theta = \frac{\text{Perpendicular}}{\text{....................}} = \frac{\quad}{AC}$$

Let us consider θ to vary from 0° to 360° and find the values of AB, and take AC as 1 unit say 10 mm.

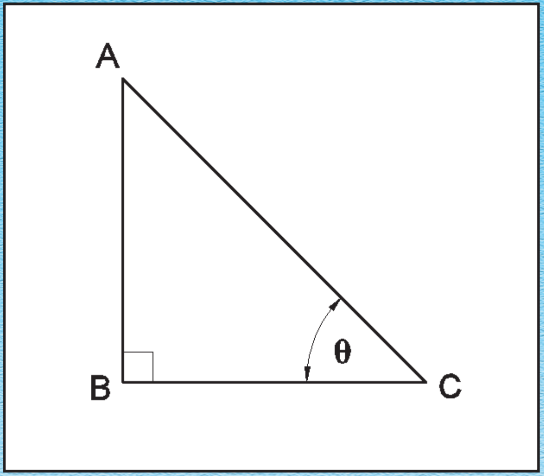


Fig. 3.12

3.7.1 CONSTRUCTION OF SINE CURVE : Refer Fig. 3.13 (i) Take a circle of given radius (10 mm) and divide it into twelve equal parts. (for simplicity only right side parts are shown) (ii) Assume a suitable scale to mark angles division (0°, 30°, 60°, 90° ....360°) on the (x-Axis) central horizontal line (iii) Match the corresponding points. Join a smooth centre through them as shown. The corresponding lengths on the y-axis shows values of sine θ. Such a curve is called the sine curve.

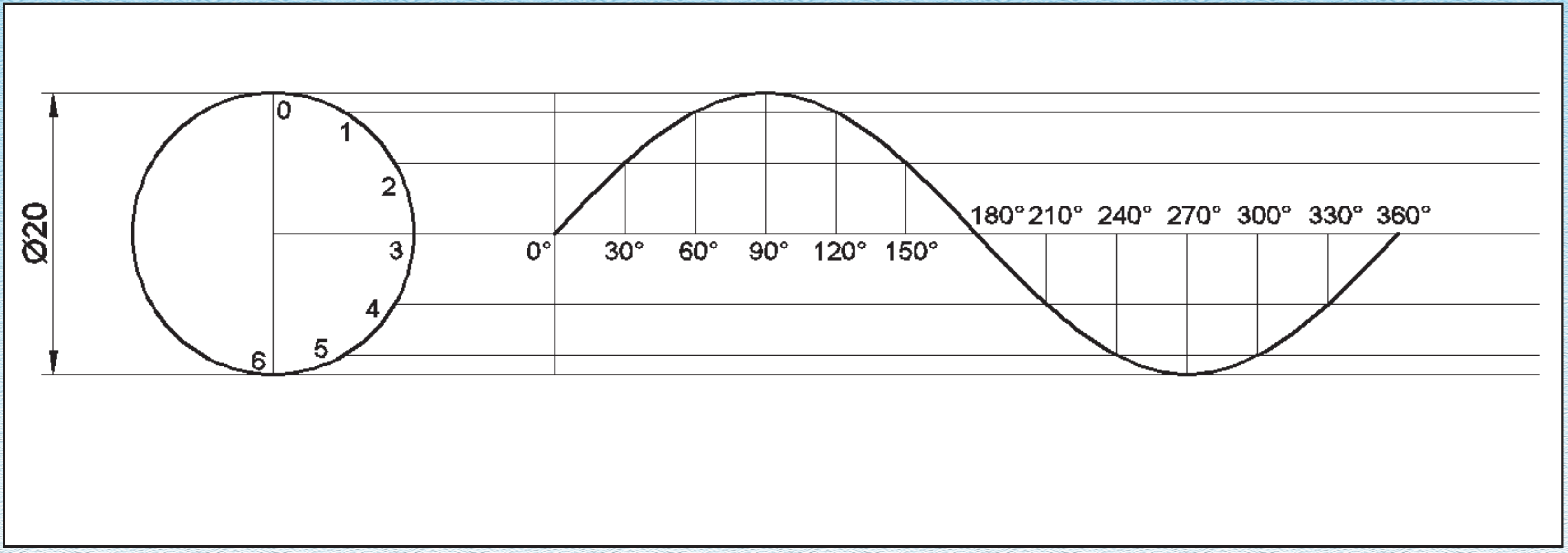


Fig. 3.13

You must have come across similar waves in the study of sound. Actually this is a continuous wave whose only one complete segment, called cycle, is shown. Such a wave in electronics / electricity is known as sinusoidal wave. Many radio waves also resemble this shape.

ASSIGNMENT

Q1. Construct the ellipse whose major axis = 70 mm and the minor axis = 40 mm by concentric circle method.

Q2. Draw an ellipse by intersecting arcs method, given the semi-major axis 40 mm and the semi-minor axis 25 mm.

Q3. Given the major-axis = 60 mm and the minor-axis = 40 mm. Draw the ellipse by intersecting lines method.

Q4. A parabola has a width = 60 mm and the depth = 25 mm. Draw this parabola by intersecting lines method.

Q5. Draw the parabola, given the distance between the directrix and the focus = 20 mm.

Q6. Draw an involute of a circle whose radius is 15 mm.

Q7. A circle is given whose radius = 20 mm. Draw the cycloid of this circle.

Q8. Draw a helix of a circle whose diameter = 40 mm and the pitch = 36 mm.

Q9. Given a circle with ϕ = 40 mm. Draw a sine - curve for it, assuming a suitable scale for degree divisions on the x-axis.

Q10. When a cone is cut in a particular way we may obtain a circle or an ellipse or a parabola as a cut surface. Fill in the blanks with a suitable alternatives given below :

(Cut parallel to base, cut at an angle to the height, cut parallel to the slant height, cut parallel to the height, cut along the height)

(a) To get a circular surface ....

(b) To obtain an elliptical surface ....

(c) To get a triangular surface ....

(d) To obtain a parabola ....

Q11. Name three machine parts used in Engineering which are (i) Circular (ii) Elliptical (iii) Parabolic.

Q12. Find out from the library /Internet where the following curves find their application in

Engineering : (i) Involute (ii) Cycloid (iii) Helix (iv) Sine - curve.

Chapter 4

ORTHOGRAPHIC PROJECTION

4.1 INTRODUCTION

We, the human beings are gifted with power to think. The thoughts are to be shared. You will appreciate that different ways and means are available to us. Can you name some? We communicate by signs/gestures/body language/talking/singing and dancing etc. In order to explain our ideas/thoughts both the listener and speaker must understand the language spoken. All our ideas originate in our mind, some are creative/innovative.

What is being imagined in our mind is to be given a reality. In Engineering, we notice that all the objects around us are three dimensional solids. This is to be explained in two dimensions i.e. on the paper/a drawing sheet. We employ a unique method to achieve this. This is called as orthographic method of projection.

This method has certain rules which are universal. This method employs the drawing consisting of straight lines, rectilinear figures, arcs and circles. Such a skill can be easily acquired. This is essential, as the Engineering Graphics is for masses.

An object is represented by drawing the boundaries of all the surfaces of the object. The boundary of a surface may be made up of straight lines or curved lines or both. As each curved or straight line is made up of a number of points, the theory of orthographic projection is logically started with the projection of points. Then we study about projection of lines, planes and solids.

In this unit, we aim to introduce some basic concepts of solid geometry. To begin the solid geometry, let us first understand the solids in detail.

4.1.1 INTRODUCTION TO SOLIDS

Whenever we look around, we see many objects which are three dimensional like cube (dice), cuboid (match box, lunch box, note-book etc.), prism (packaging box), cylinders (water bottle, gas cylinder etc.), cone (softy, tent etc.) sphere (ball). Let us now study about these solids and its projections.

4.1.1.1 SOLIDS

A solid is a three dimensional object, i.e. it has three dimensions, viz; length, breadth and height or thickness. It is bounded by plane or curved surfaces. Atleast 2 orthographic views are required to represent a solid on a flat surface. Sometimes, additional views become necessary to describe a solid completely.

The solids under study can be divided into 2 main groups viz;

1. **POLYHEDRA** – solids bounded by plane surfaces such as prisms, pyramids Fig. 4.1, 4.2

2. **SOLIDS OF REVOLUTION –** solids formed by revolution of linear figures such as cylinder, cone and sphere Fig. 4.5.

NOTE : In our study, only right regular solids are discussed. Such solids have their axis perpendicular to their base.

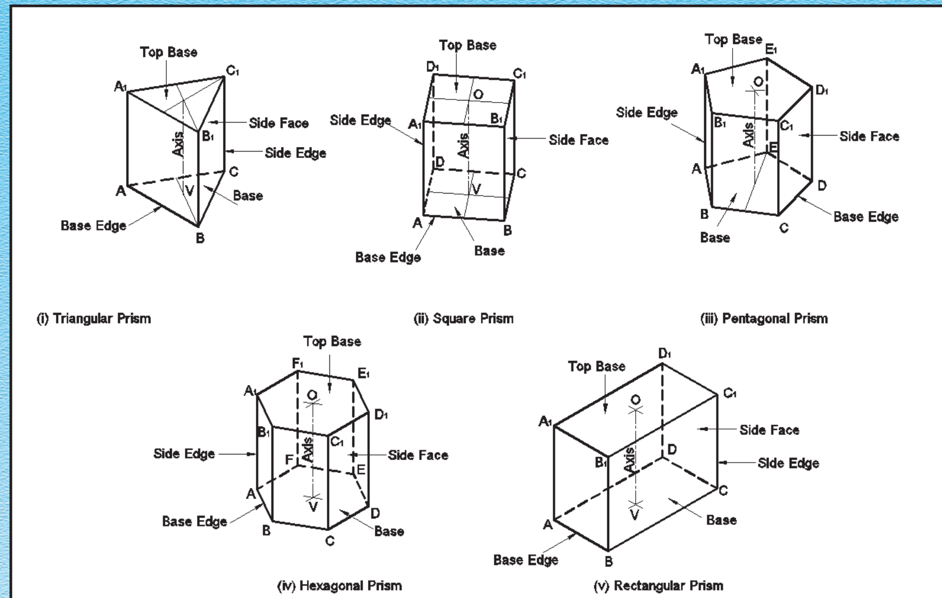


Fig. 4.1 PRISMS

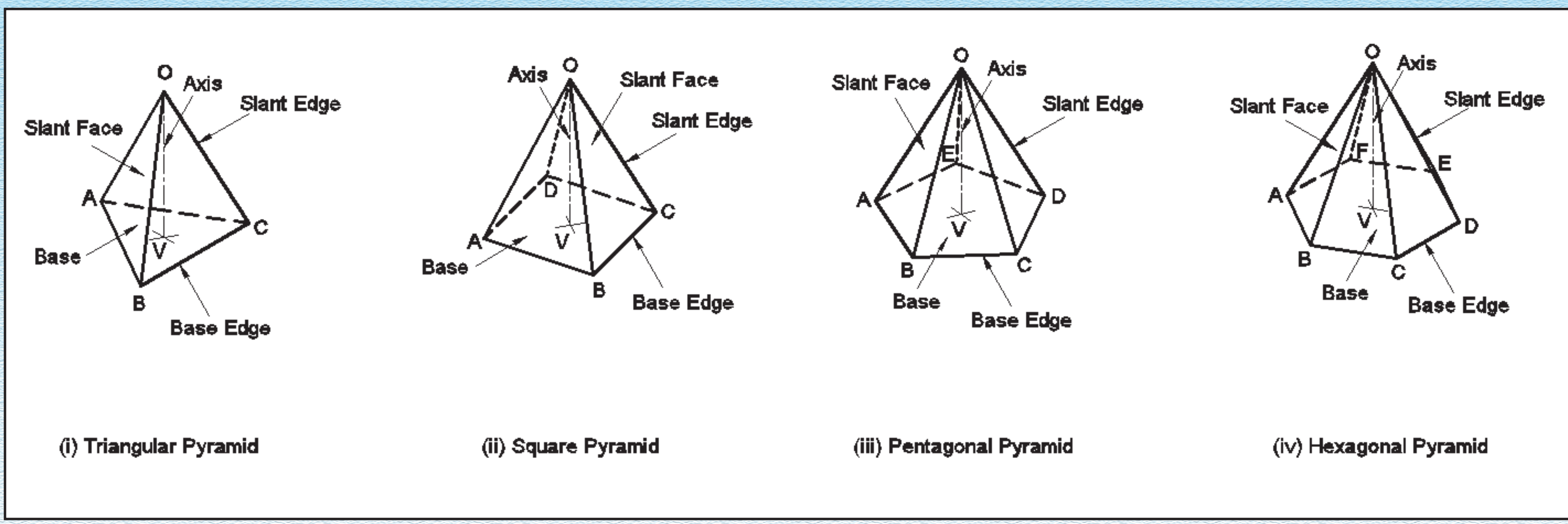


Fig. 4.2 PYRAMIDS

4.1.1.2 PRISMS & PYRAMIDS

Fig. 4.1 shows a triangular prism, a square prism, a pentagonal prism, a hexagonal prism and a rectangular prism at i, ii, iii, iv and v respectively. Fig. 4.2 shows a triangular pyramid, a square pyramid, a pentagonal pyramid and a hexagonal pyramid at i, ii, iii, and iv respectively.

We observe that a prism is bounded by rectangular surfaces on the sides, which join end surfaces that are polygons. Similary, a pyramid is bound by triangular surfaces on the sides, which meet at a point known as the apex at one end and at a polygon at the other end. The polygonal end surfaces are known as the bases of these solids.

The imaginary line joining the centre points of the end surfaces (i.e., bases) of a prism is known as the axis of the prism. Similarly, such a line joining the centre point of the base to the apex of the pyramid is known as the axis of the pyramid.

4.1.1.3 CUBE OR HEXAHEDRON

A cube has six equal faces, each a square Fig. 4.3

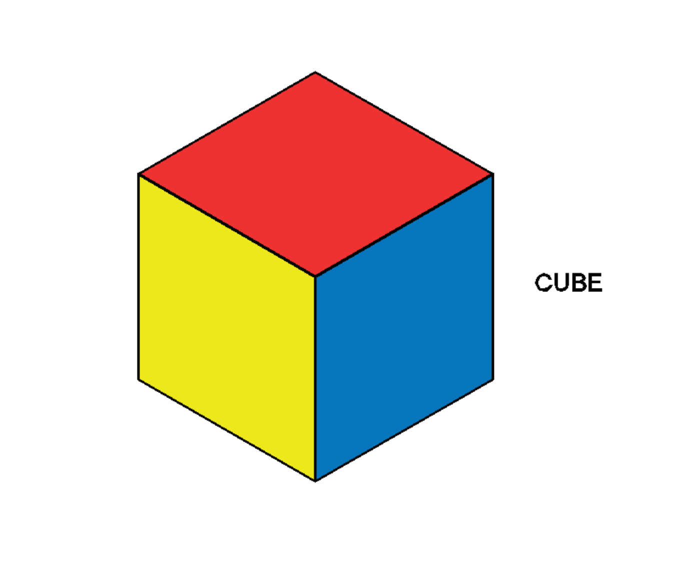


Fig. 4.3

DO YOU KNOW ?

TETRAHEDRON

Tetrahedron is a kind of polyhedron. A tetrahedron has four equal faces and each face is an equilateral triangle see Fig. 4.4.

We can say that a tetrahedron is a triangular pyramid having its base and all the faces as equilateral triangles - for example, in chemistry the structure of methane is given in the shape of tetrahedron.

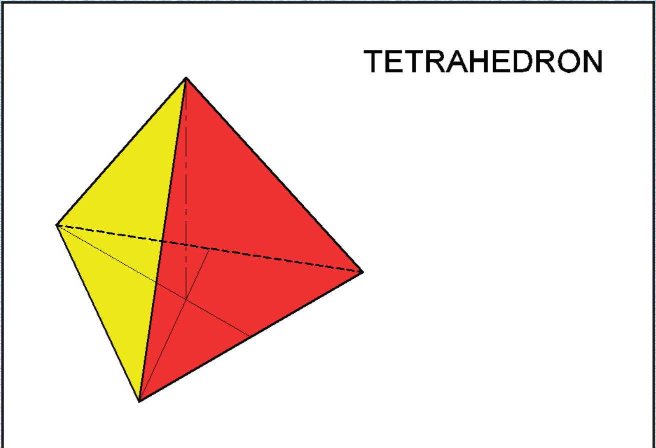


Fig. 4.4

4.1.1.4 CYLINDER, CONE & SPHERE

Fig. 4.5 shows a cylinder (i), a cone (ii) and a sphere (iii). If a straight line rotates about another fixed straight line parallel to it and the distance between the two is kept constant, the rotating line generates a cylindrical surface.

- If a straight line rotates about another fixed straight line, keeping the angle between the two lines constant, the rotating line generates a conical surface.
- If a semi circle rotates about its diameter, keeping the diameter fixed, a spherical surface is generated.
- In the above all cases, the fixed line is known as the axis while the rotating one as the generator of the solid.

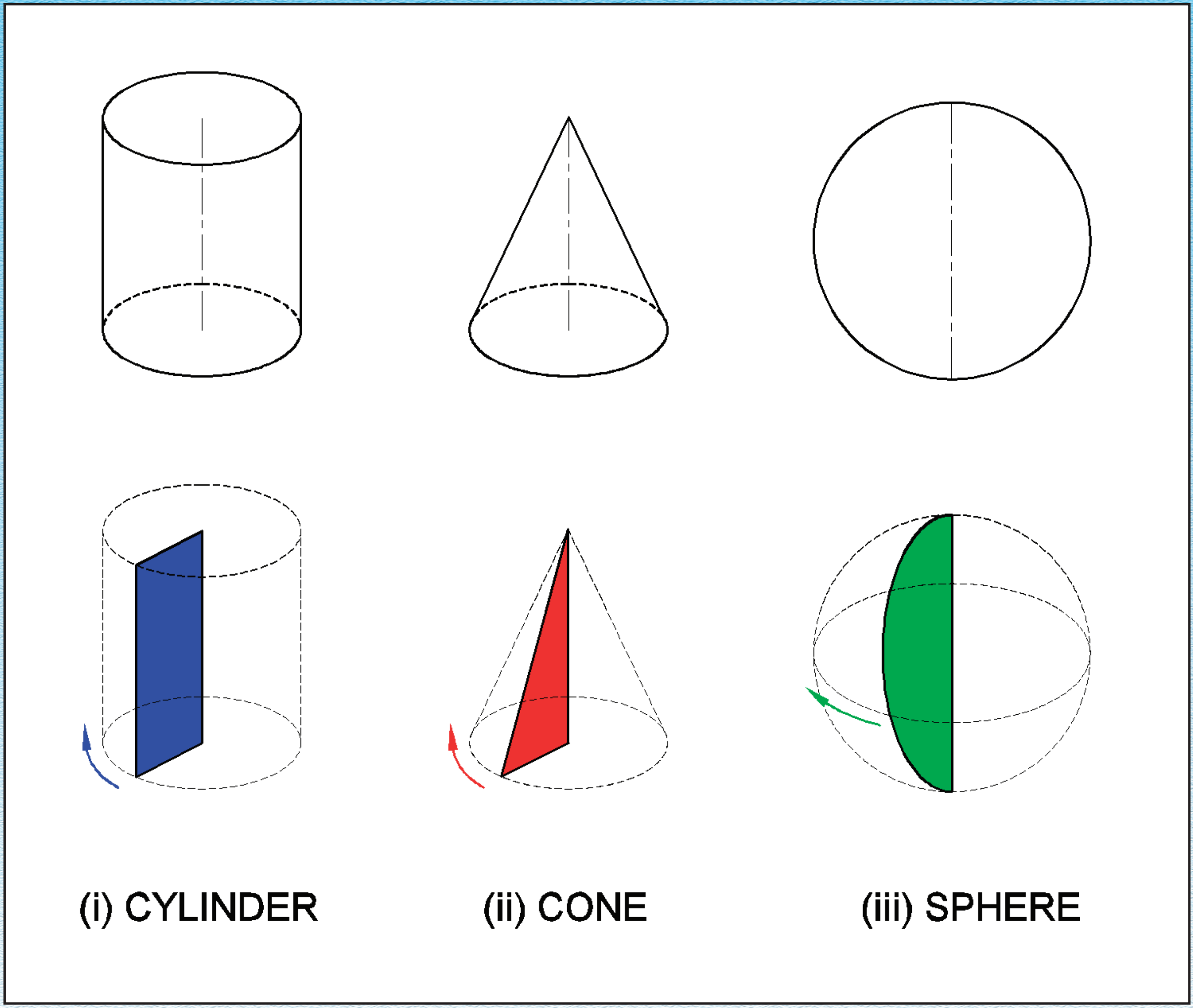


Fig. 4.5

4.1.1.5 FRUSTUMS

When a part of a cone or a pyramid nearer to the apex is removed by cutting the solid by a plane parallel to its base, the remaining portion is known as its frustum. Fig. 4.6 shows frustum of a square pyramid (i) and that of a cone (ii)

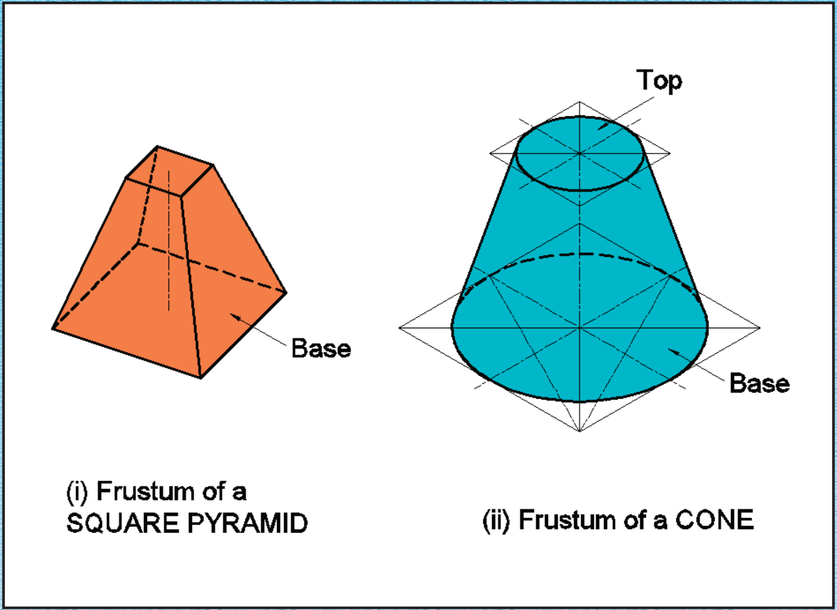


Fig. 4.6

MORE TO KNOW

Against right regular solids, there are other kind of solids such as oblique solids. Solids which have their axis inclined to bases are called oblique solids. Oblique prism, cylinder, pyramid and cone are shown below.

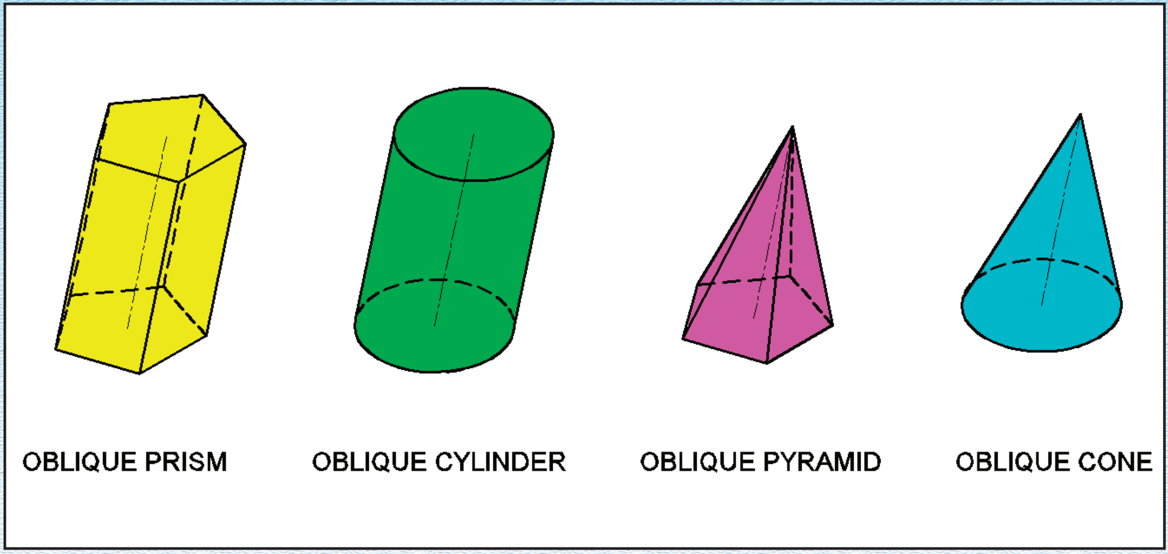


Fig. 4.7

4.2 PROJECTIONS

Suppose an object, a cube, as shown in Fig. 4.8 is placed in front of a screen and light is thrown on it (assuming the light rays which are coming from infinite source to be parallel to each other and perpendicular to the screen), then a true shadow of the object is obtained on the screen. This shadow is the projection of the object on the plane of screen, showing the contour lines or edges of the object.

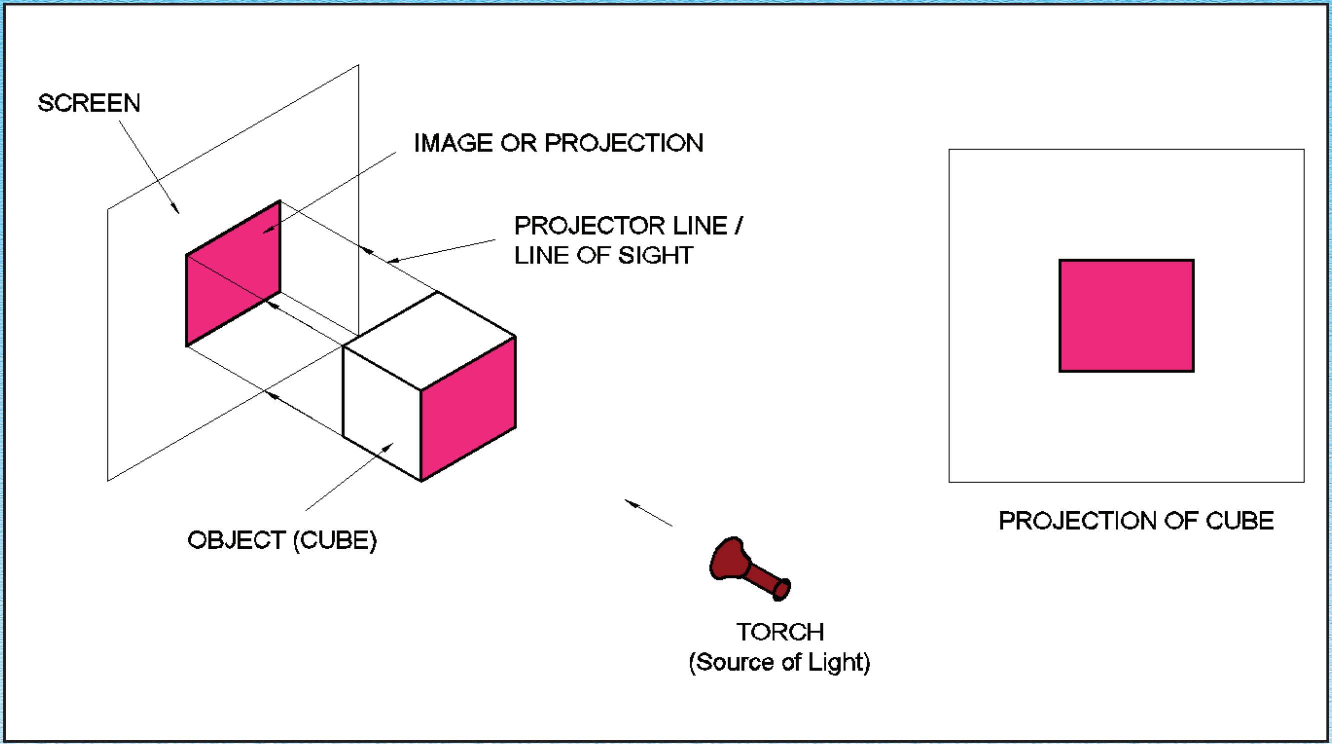


Fig. 4.8

Thus a view of an object is technically known as projection. Every drawing of an object will have four imaginary things viz.

1. "Object", 2. "Projectors", 3. "Plane of projection" and 4. "Observer's eye or station point"

4.2.1 PROJECTION - TERMS

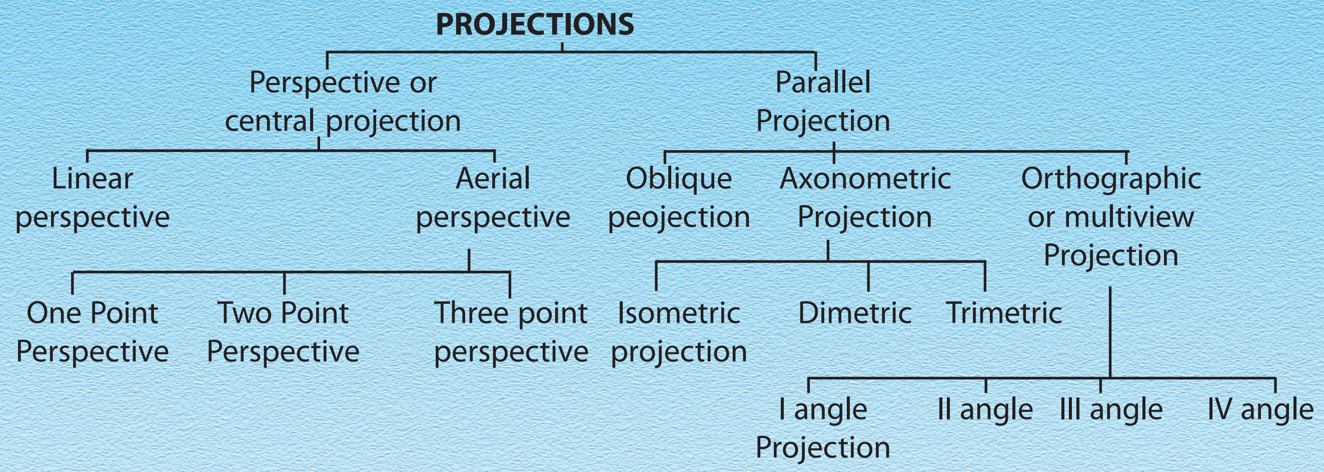
* Projection - view of an object
* Plane of projection or picture plane - The plane on which the projection is taken like Vertical Plane, Horizontal Plane etc.
* Station point or centre of projection - The point from which the observer is assumed to view the object.
* Reference/Ground Line - The line of intersection of the vertical plane and the horizontal plane is called the reference/ground line (XY)

4.2.2 CLASSIFICATION OF PROJECTIONS

The projection or drawing upon a plane, is produced by piercing the points of projections in the plane of projection.

The projections are classified according to the method of taking the projections on the plane.

A classification of projection is shown below as a flowchart.



DO YOU KNOW ?

PERSPECTIVE PROJECTION

A perspective projection is a drawing of an object as it appears to the human eye. It is similar to the photograph of an object.

4.3 ORTHOGRAPHIC PROJECTION

We have studied the meaning of the word projection in the earlier topic. We now study the orthographic projection in detail.

Orthographic projection is the method of representing the exact shape of an object in two or more views, on planes always "at right angles to each other" by extending perpendiculars from the object to the planes. Orthographic projection is universally used in engineering drawing. The word orthographic means to draw at right angles.

4.3.1 ORTHOGRAPHIC VIEWS

Different views of an object are obtained to describe it clearly with all dimensions in orthographic projection. Two planes are required to obtain the views in this projection (i) the vertical plane (V.P.) (ii) the horizontal plane (H.P.) at right angles to each other (Fig. 4.9). These planes are called Principal planes or reference planes or co-ordinate planes of projection. They make four quadrants or dihedral angles.

The position of an object can be fixed by these quadrants (dihedral angles) as follows :

1. In first quadrant - above H.P. and in front of V.P.
2. In second quadrant - above H.P. and behind V.P.
3. In third quadrant - below H.P. and behind V.P.
4. If fourth quadrant - below H.P. and in front of V.P.

The line on which the two planes meet each other is called reference line (XY) or axis of the planes. The H.P. is turned/ rotated in clockwise direction to bring it in vertical plane. We call this process of making 3D space into 2D as rabatment. The views of an object when it is placed in I quadrant can be assumed now in one plane (2D) and can be drawn on the sheet. Two views of an object are obtained on these two planes viz H.P. and V.P. A third view can also be obtained by a side plane/an auxiliary vertical plane, A.V.P.

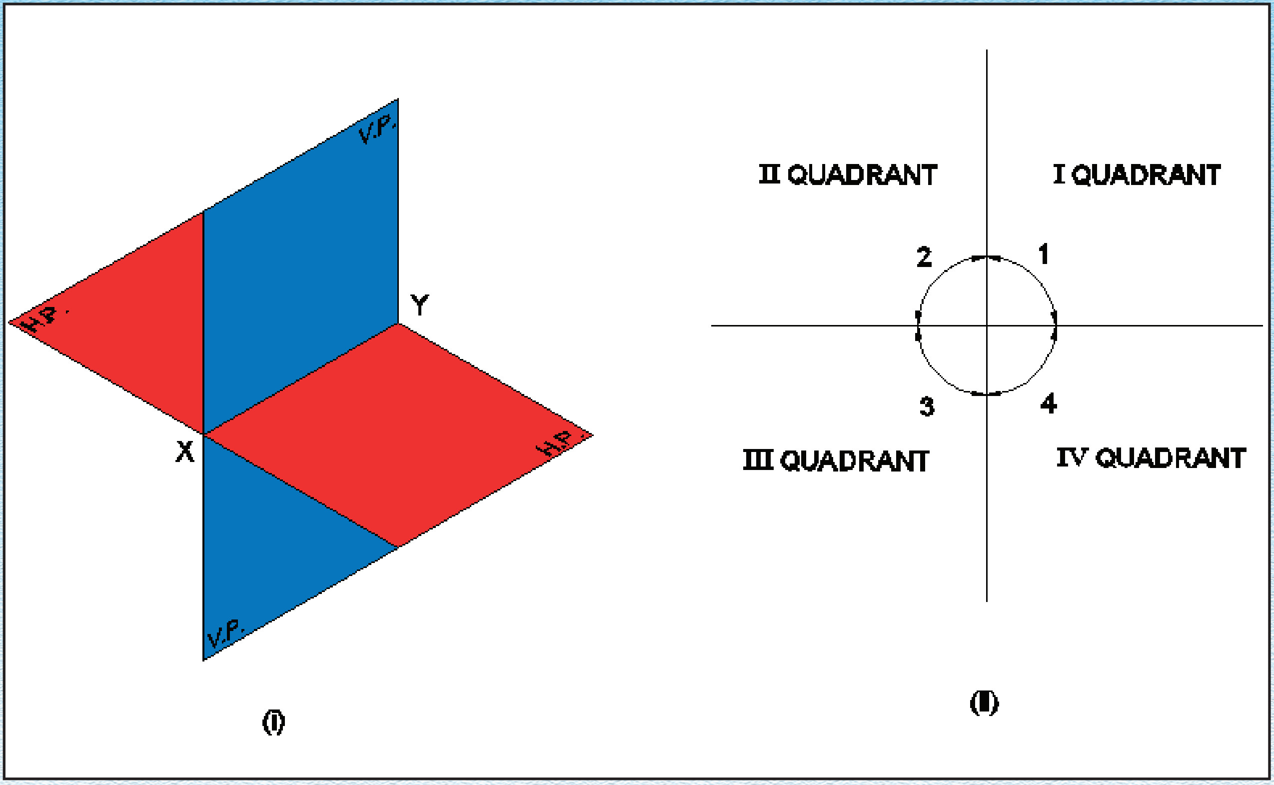


Fig. 4.9

DO YOU KNOW ?

PICTORIAL DRAWING

Orthographic projection can only be understood by technical persons, but pictorial drawings are easily understandable. It appears like a photograph of an object. It shows the appearance of the object by one view only. The following Fig. 4.10 shows the three important pictorial projections.

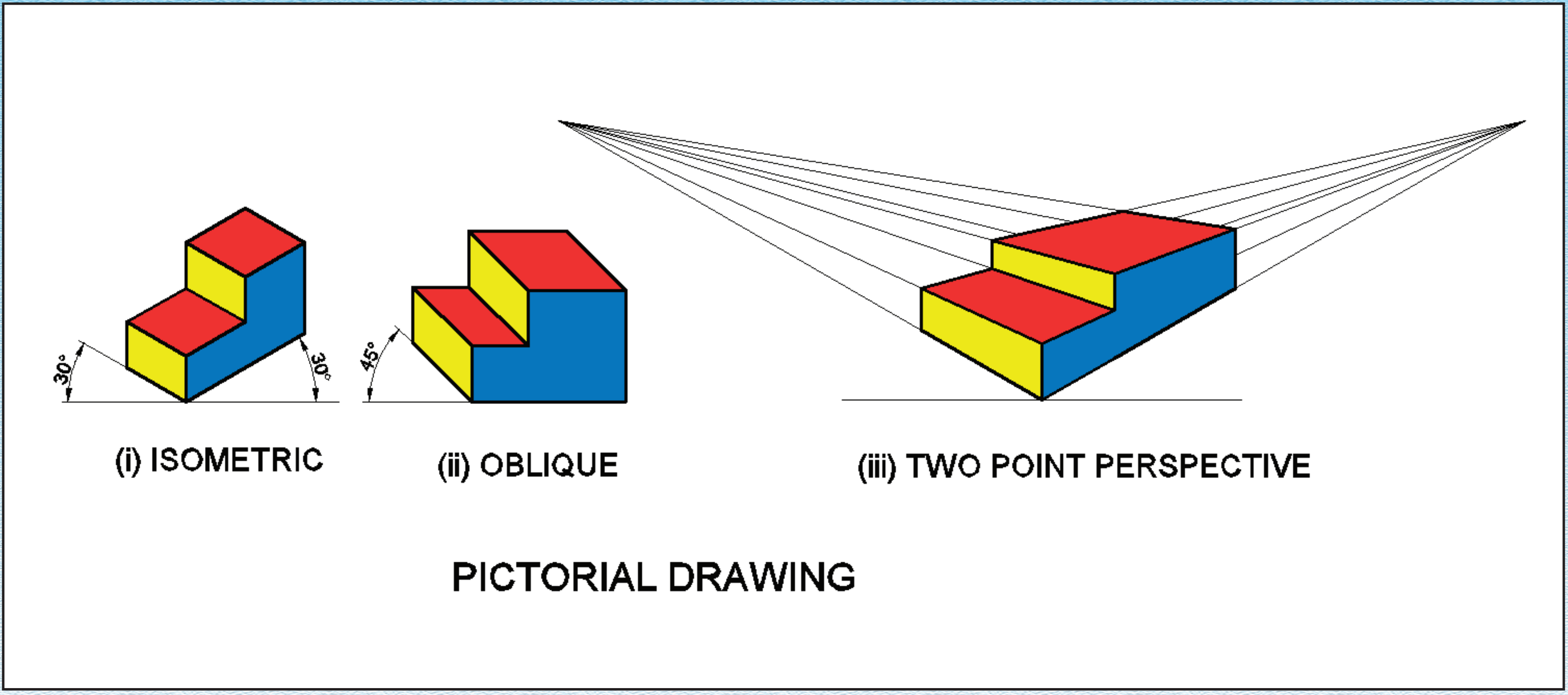


Fig. 4.10 Pictorial Drawing

DO YOU KNOW ?

When three co-ordinate planes V.P., H.P and P.P. (profile plane) or side plane are kept perpendicular to each other, Octant is formed as shown below :

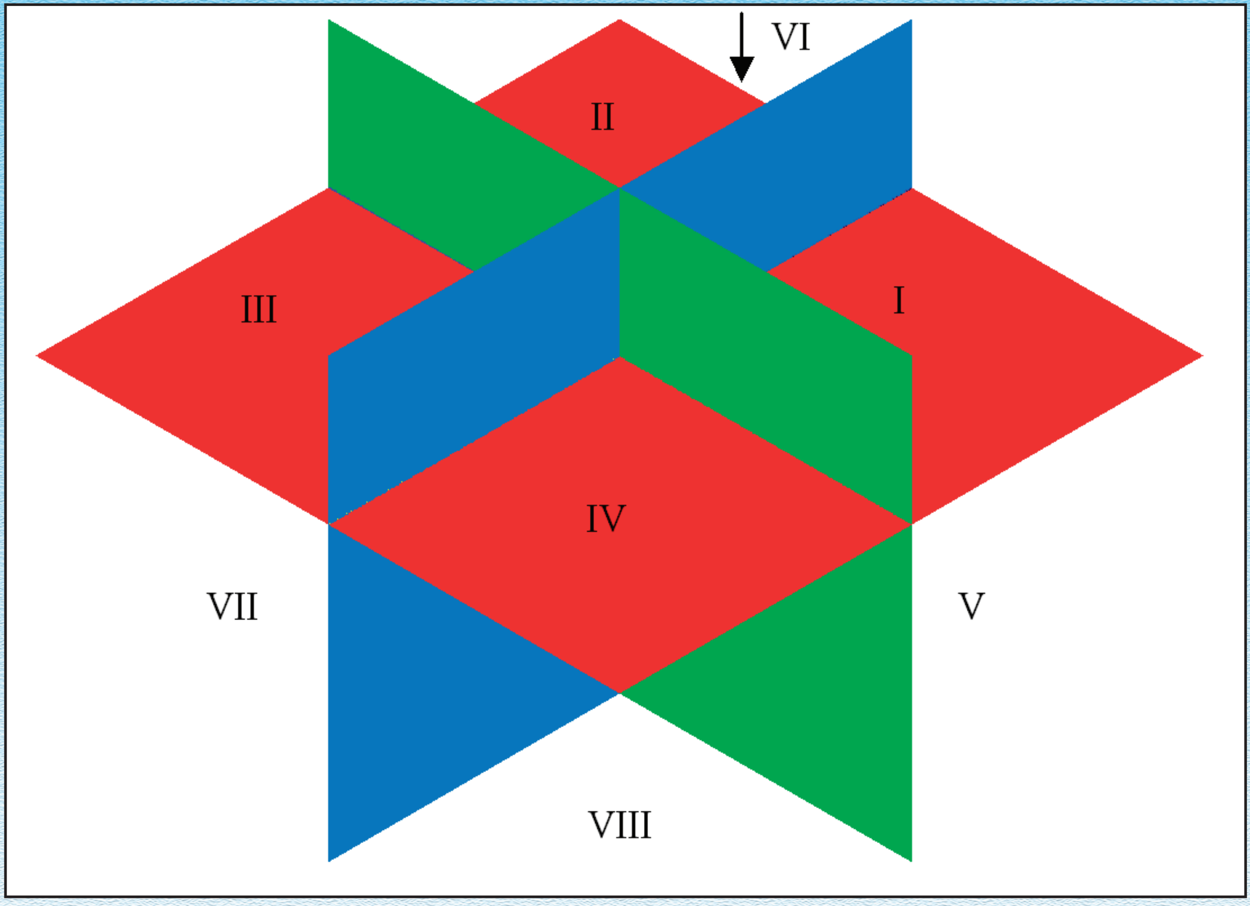


Fig. 4.11

The principle of projection in an Octant is same as the principle of projection in a quadrant.

4.3.2 THE DESIGNATION OF ORTHOGRAPHIC VIEWS

Let us now study the different views by considering the following object.

In the above fig. 4.12, view in direction F that is, view from the front is known as Front View, front elevation or elevation.

– View in direction T, that is the view from above is known as top view, top plan or plan.

– View in direction S_1 that is, view from the left, is known as left side view or left end view or left side elevation or left end elevation.

– View in direction S_2, that is view from right is known as right side view or right end view or right side elevation or right end elevation.

In the light of the above visualisation, we can again say that,

* The projection of an object, viewing from the front side, on the V.P. is called Front View/Front elevation.

* The projection of an object, viewing from the top side, on the H.P. is called Top View/plan.

* The projection of an object, viewing from the side, on A.V.P. is called side view/side elevation, end view/end elevation.

  (In common practice, while drawing, only two views From front side and top side are drawn.)

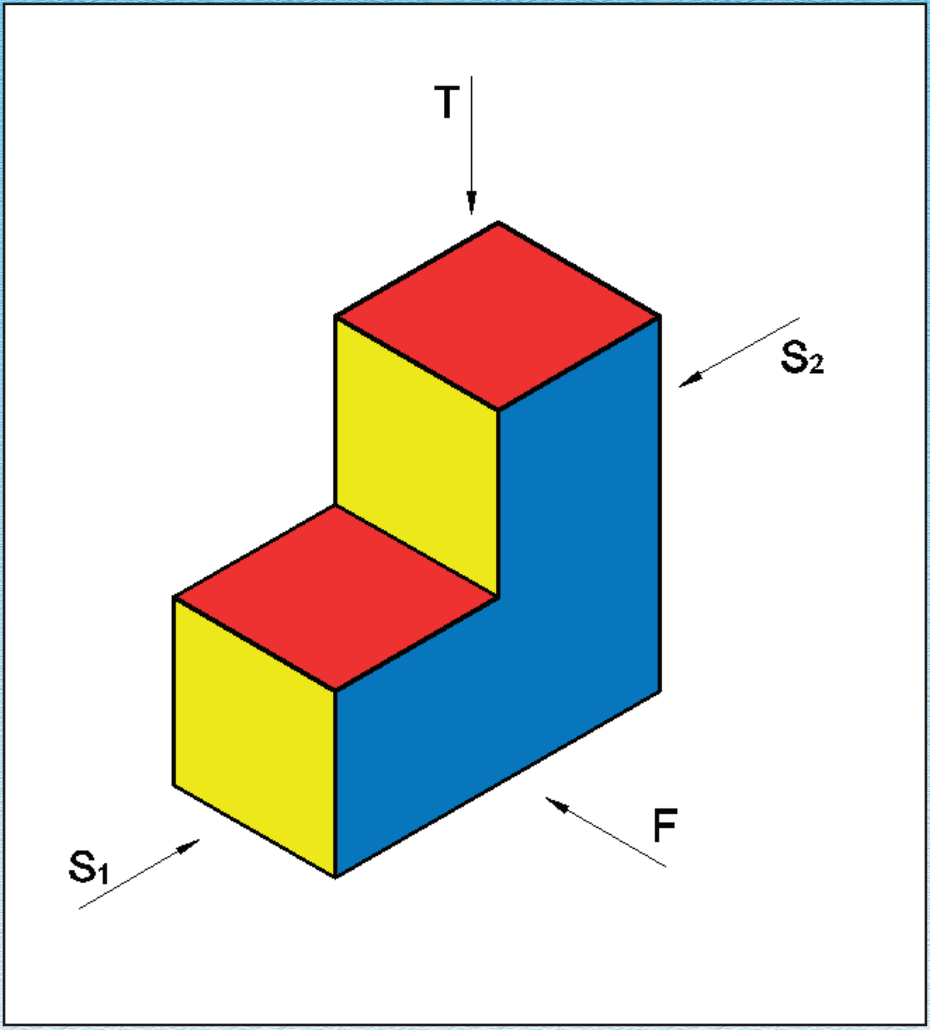


Fig. 4.12 : An Object with Direction of Views

NOTE :

Orthographic projection is classified into 4 categories according to the orientation of the object. But only I angle and III angle projection are used in Engineering Drawing.

4.3.3 FIRST ANGLE PROJECTION

In this topic, the knowledge of quadrants formed by the principal planes of projection is recalled and extended particularly to the I quadrant.

As we discussed earlier, the space above the H.P. and in front of V.P. is known as I quadrant.

To get the first angle projection, the object is assumed to be kept in the I quadrant. To understand more about first angle projection, Let us consider the following example (fig. 4.13)

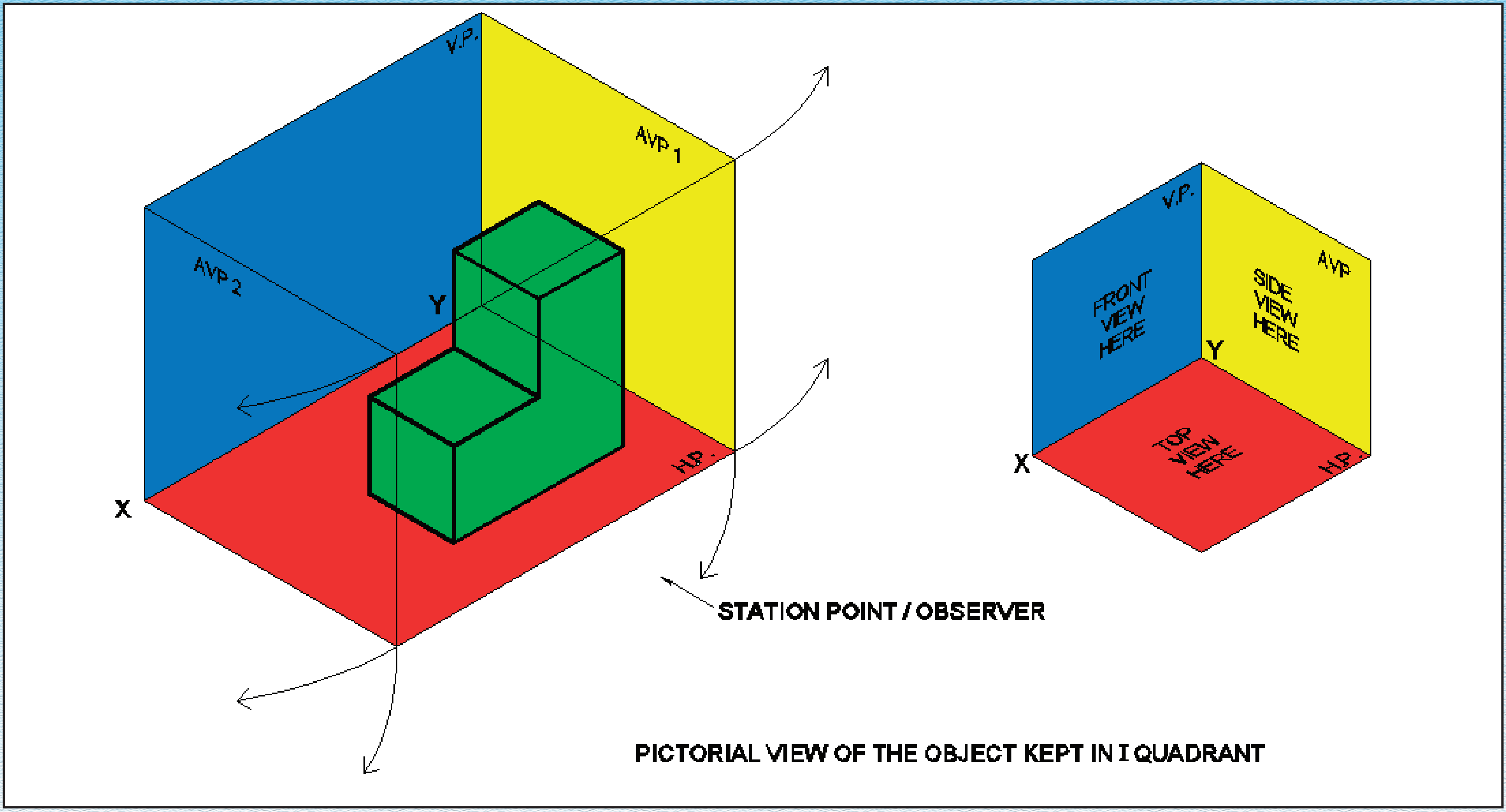


Fig. 4.13 : Pictorial view of the object kept in I quadrant

Here the object A, is kept inside a box arrangement depicting the I quadrant. That is "the object is kept between the observer and the plane of projection".

To draw the view on the 2D drawing sheet, this 3D box set up is converted into 2D planes by opening the box. We understand from the arrows given in the fig. 4.13, the H.P. is rotated down and AVP 1 is opened on the right side, AVP 2 is opened on the left side. V.P. is fixed as such. Now, the box will appear like this as shown in Fig. 4.14.

We now list some important conclusions about I angle projection.

(a) Front View is drawn above XY line

(b) Top View is drawn below XY line

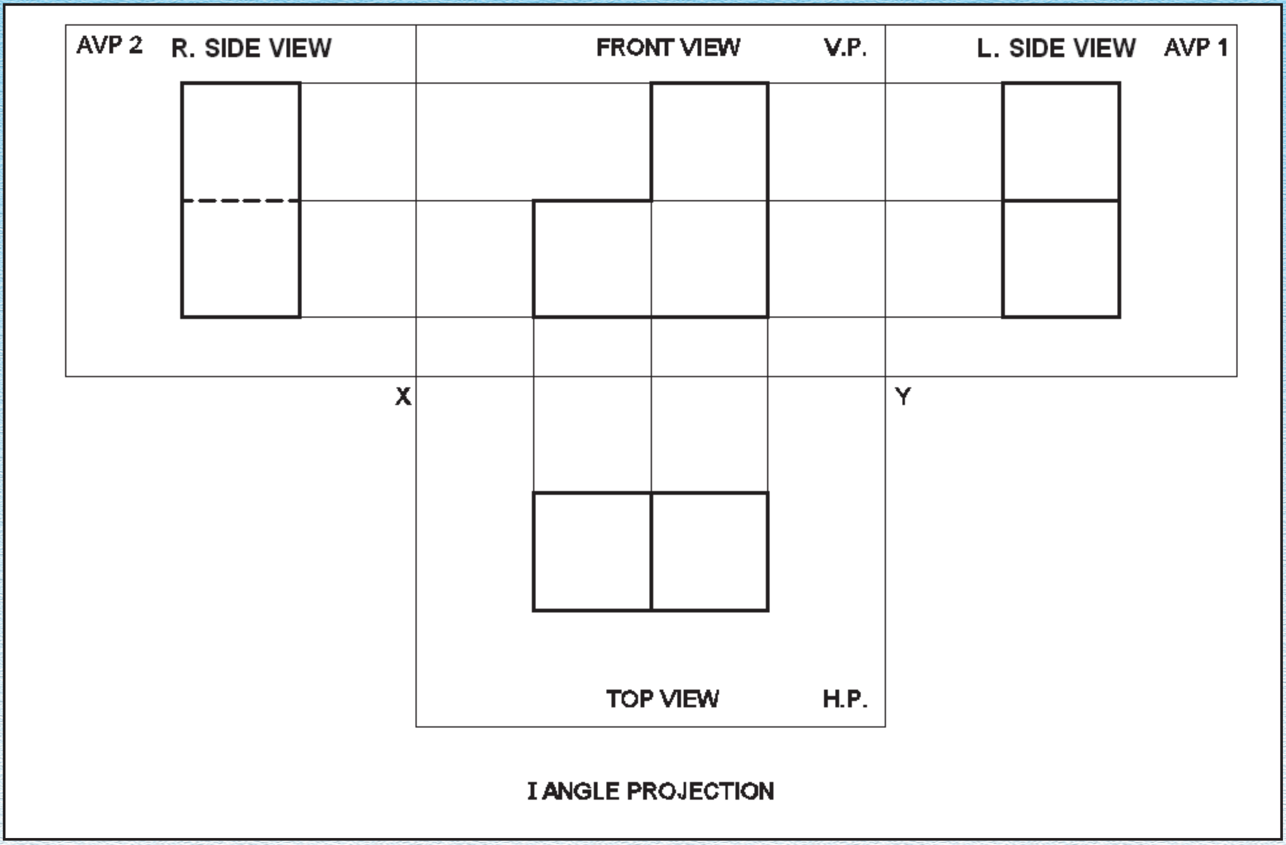


Fig. 4.14 : First Angle Projection

(c) Right side view is drawn on the left side of Front View.

(d) Left side view is drawn on the right side of Front View.

The identifying graphical symbol of I angle method of projection is shown is Fig. 4.15

NOTE : Dimensions shown are for only drawing the symbol. These dimensions need not be shown.

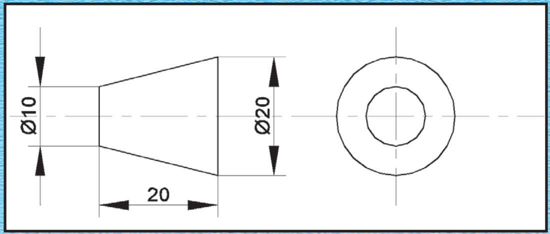


Fig. 4.15 : First Angle Projection Symbol

TRY THESE : The pictorial view of different types of objects are shown in Fig. 4.16. Sketch looking from the direction of arrow Front View, Top View and side view using I angle method of projection.

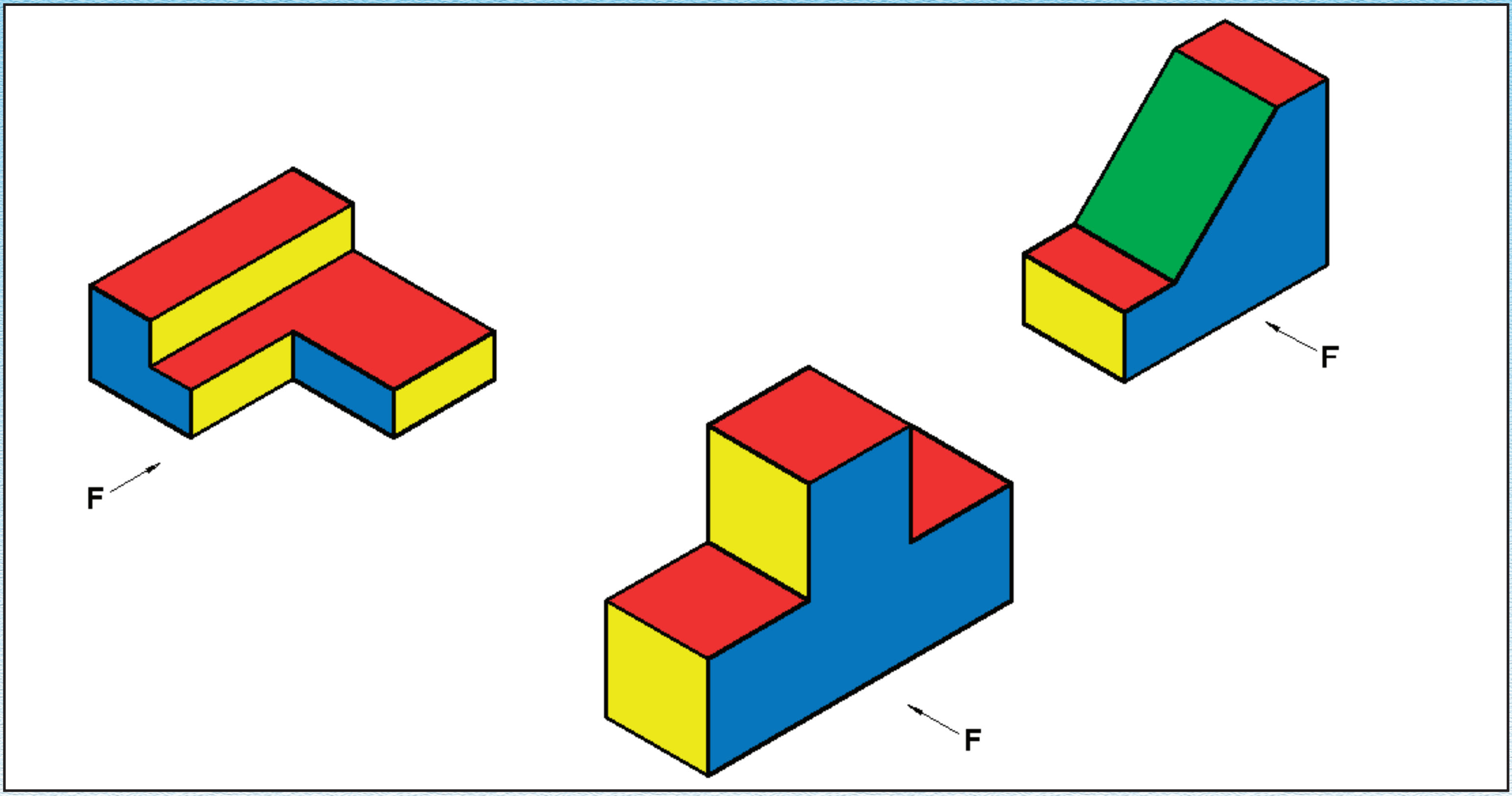


Fig. 4.16

4.3.4 THIRD ANGLE PROJECTION

Let us now study about the third angle projection using the same method of box arrangement. Fig. 4.17 shows a transparent glass box with object kept in the III quadrant. Here the observer looks through the plane of projection to project the view on the respective plane of projection.

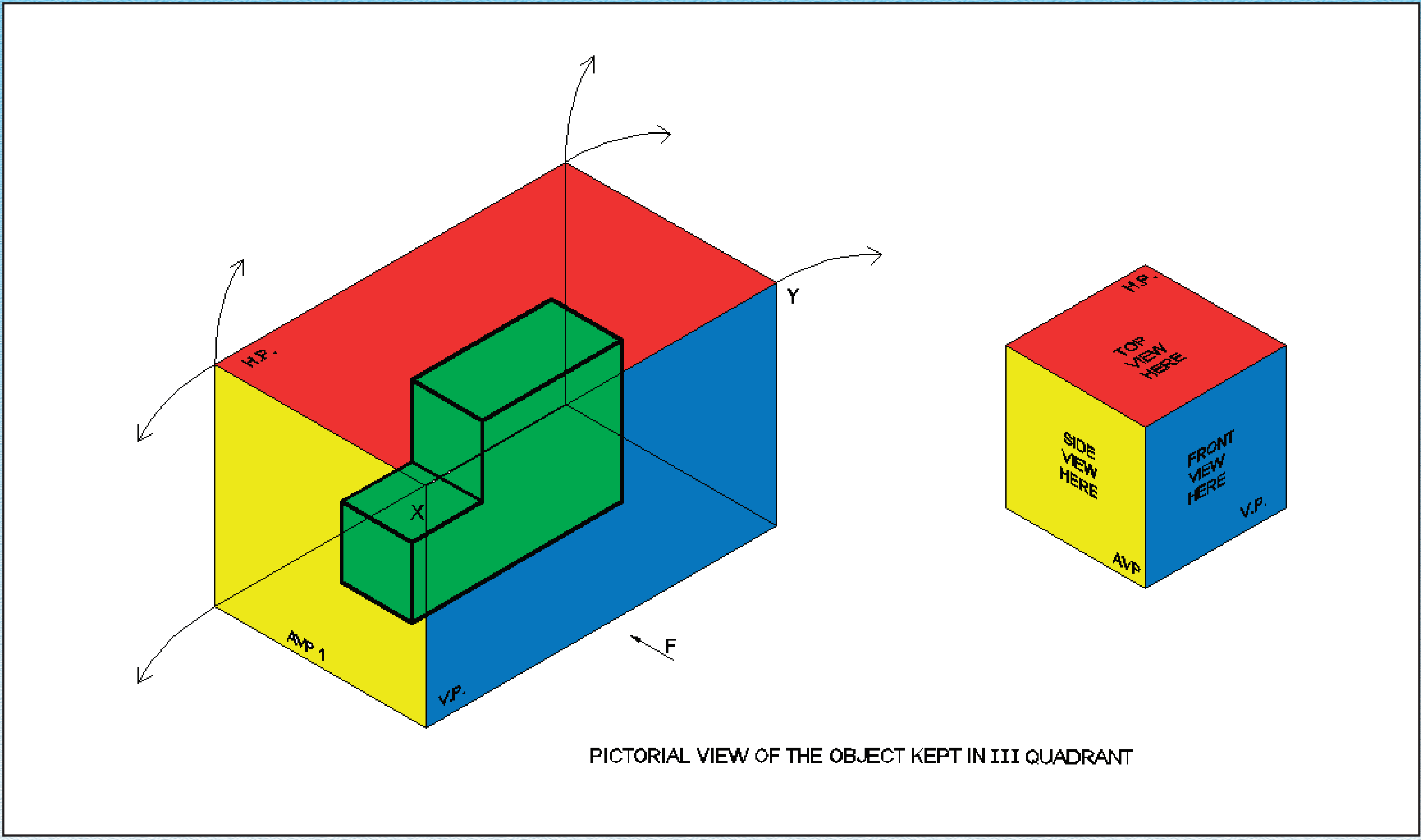


Fig. 4.17

In the third angle projection, the object is assumed to be placed in III quadrant. Here the plane of projection lies between the observer and the object.

To draw the 2D views turning/rotation is being done as shown by the arrow given in Fig. 4.17. After opening the box, it appears as shown below in Fig. 4.18

We now list some important conclusions about the III angle projection.

(a) Frontview is “below” XY line

(b) Top View is “above” XY line

(c) “Right side view” is on the “right side of Front View”

(d) “Left side view” is on the “Left side of Front View”

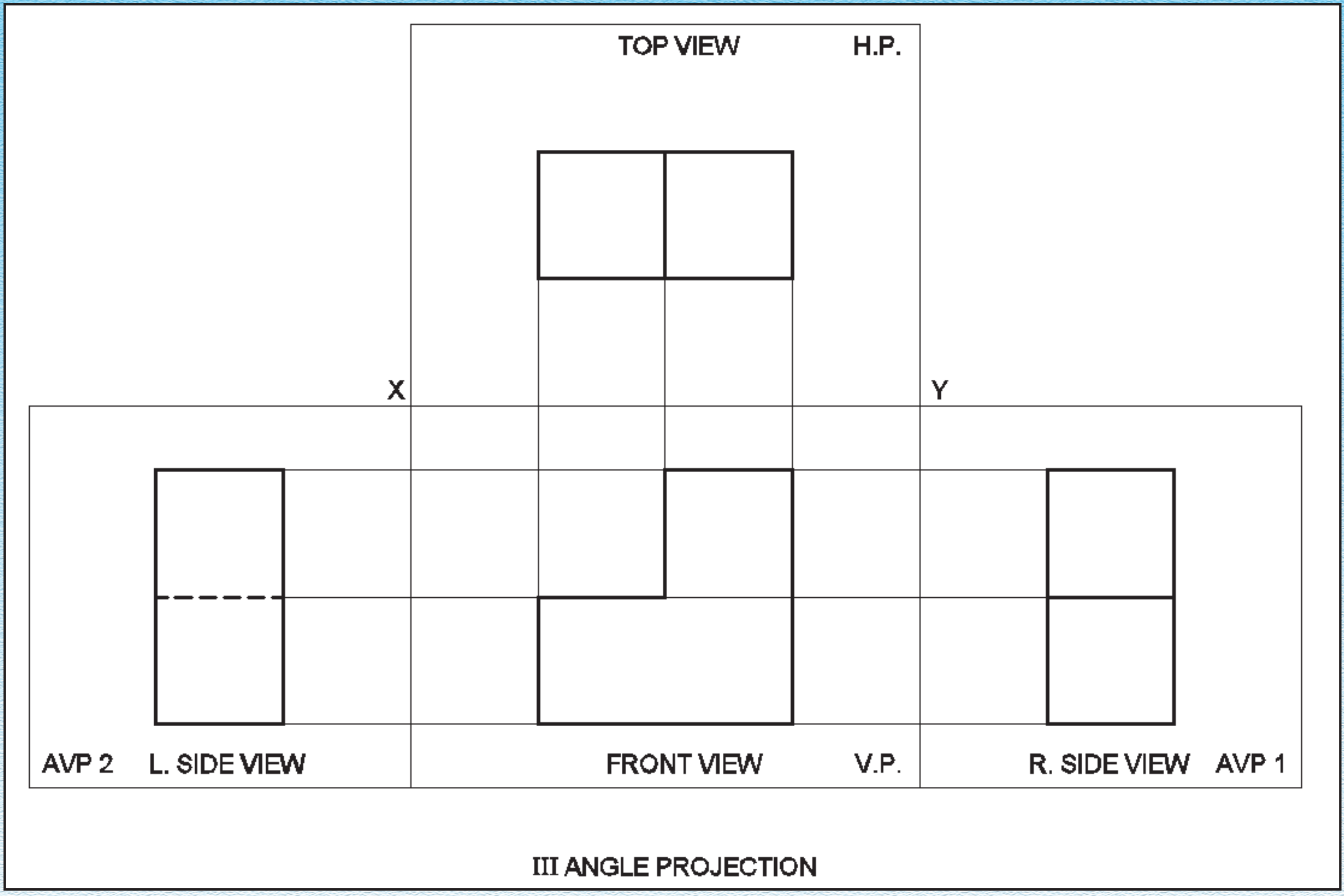


Fig. 4.18

The identifying graphical symbol of III angle projection is shown in fig. 4.19

NOTE : (i) Dimensions shown are for only drawing the symbol. These dimensions need not be shown.

(ii) Orthographic projection with I angle method of projection is used throughout this book, as recommended by B.I.S. SP : 46 : 2003 codes (revision of SP : 48 - 1988 codes).

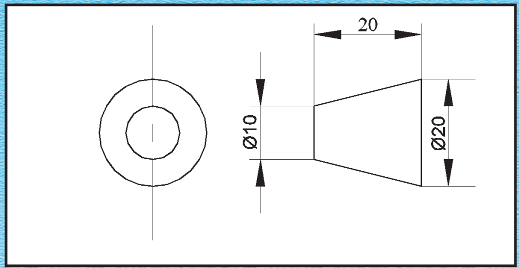


Fig. 4.19 : Third Angle Projection Symbol

We conclude this section with a few remarks on the difference between I angle and III angle projection. See table 4.1

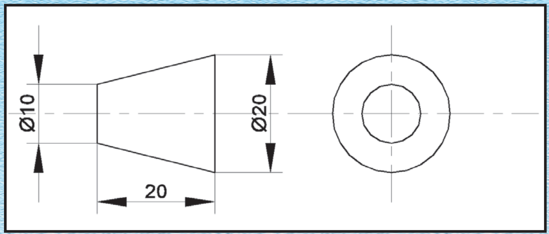
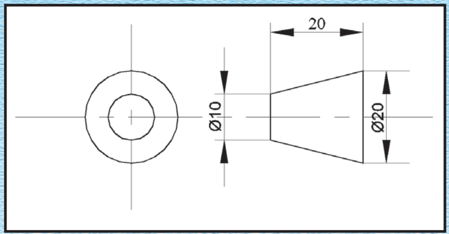
First Angle Projection Method	**Third Angle Projection Method**
(i) The identifying graphical symbol is  First Angle Projection Symbol	(i) The identifying graphical symbol is  Third Angle Projection Symbol
(ii) The object is assumed to be placed in the I quadrant	(ii) The object is assumed to be placed in the III quadrant
(iii) The object is placed in between the observer and the projection plane.	(iii) Here the projection plane is in between the observer and the object.
(iv) The projection plane is opaque.	(iv) The projection plane is transparent.
(v) In this method, the topview/plan is placed below the XY line, and the Front View/front elevation is placed above the XY line and the right side view is drawn on the left side of the Front View, the left side view is drawn on the right side view of the Front View/front elevation.	(v) In this method, the Top View or plan is placed above the XY line, Front View or front elevation is placed below the XY line and the right side view is drawn on the right side of the Front View/elevation, the left side view is drawn on the left side of the Front View/ front elevation.

Table 4.1 : Difference between First angle projection method and Third angle projection method.

THINK, DISCUSS AND WRITE

Keep the same object in II quadrant and IV quadrant in the glass box arrangement. Turn/Rotate the H.P. in clockwise direction and open up the box. Then project the views. Discuss your observation with your partner. What do you find out ?

Assignment 4.1

1. Fill in the blanks
   (i) In .... projection, the .... are perpendicular to the plane of projection.
   (ii) In I angle projection, the .... comes between the .... and ....
   (iii) In III angle projection, the .... comes between the .... and ....
2. Explain briefly how the reference line represents both the principal planes of projection.
3. Sketch neatly the symbols used for indicating the method of projection adopted in a drawing.
4.* Why second and fourth quadrants are not used in practice ?
   *(Not to be asked in the exam)

4.4 PROJECTION OF POINTS

So far, you have understood the principles of orthographic projection. Now, let us study about the projections of points in different possible positions.

Recall that there are two major reference planes viz. V.P. and H.P. in the principles of orthographic projection. With respect to these two reference planes, the position of a point would be described. A point may be situated in

(i) any one of the four quadrants

(ii) any one of the two planes

(iii) both the planes (i.e.) on the XY-line.

4.4.1 CONVENTIONS EMPLOYED

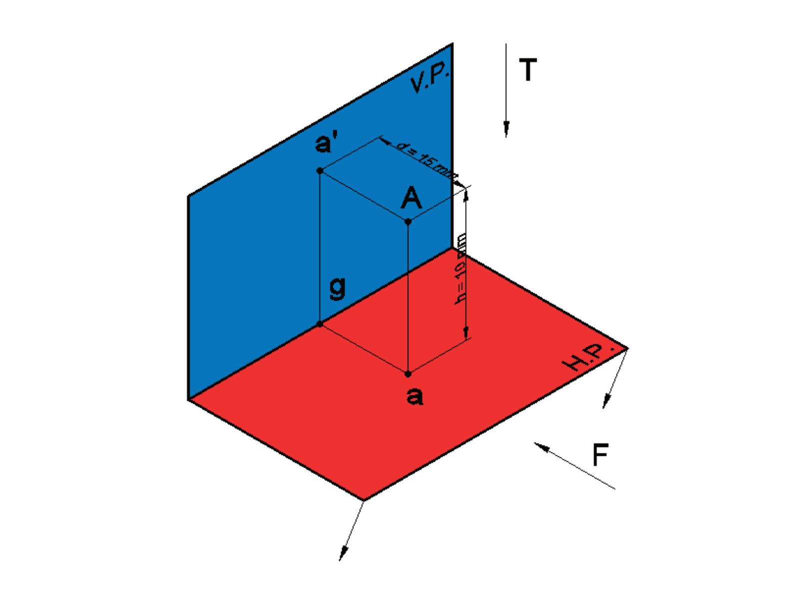
In this book, we follow the conventions recommended by the SP : 46- 2003 codes (revision of SP : 46-1988 codes)

According to this code of practice, actual points, ends of lines, corners of plane surfaces, corners of solids etc. in space are denoted by capital letters A, B, C, etc. Their Top Views are marked by corresponding small letters a, b, c, etc. and the Front Views by small letter with dashes a', b', c' etc.. We draw projectors and construction lines with continuous thin lines.

4.4.2 PROJECTION OF A POINT SITUATED IN I-QUADRANT

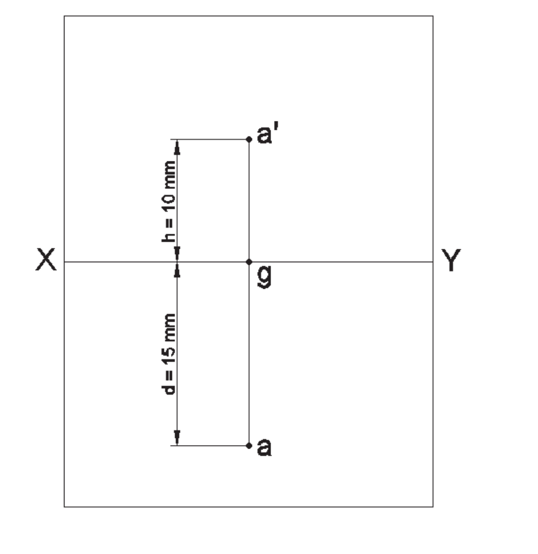
Recall that, the space above H.P. and in front of V.P. is called first quadrant.

Let us consider a point A, situated in I quadrant as shown in Fig. 4.20



PICTORIAL VIEW OF POINT 'A' IN I QUADRANT

Fig. 4.20 : Pictorial view of point in I quadrant



PROJECTION OF POINT 'A'

Fig. 4.21 Projection of Point A

Suppose the distance of point A from H.P. is 'h', say h=10 mm and distance away from V.P. is 'd', say 15 mm the orthographic projection of point A is obtained as follows (Fig. 4.21)

Here, the line (which is also called a projector) intersects XY at right angles at a point g.

You can understand from the pictorial view that, a'g = Aa

So, distance of Front View from XY = distance of the point from H.P.

Similarly ag = Aa'

So, distance of Top View from XY = distance of the point from V.P. We always denote the distance of point from H.P. as 'h' and from V.P. as 'd'.

In the light of the discussions above and visualisations, we can again say that

For I angle projection Front View lies above XY line and Top View lies below XY line. And distance from H.P. comes for Front View and the distance from V.P. comes for Top View.

Example 4.1 : A point P is 30 mm above H.P. and 20 mm in front of V.P. Draw its projections.

Solution :

We know that the space above H.P. and in front of V.P. denotes the I quadrant. From our earlier conclusion, we also know that according to I angle projection, the Front View is placed above XY and Top View below XY. See fig. 4.22

Step 1 : Draw a line XY.
Step 2 : Through any point g in it, draw a perpendicular
Step 3 : On the perpendicular, mark the point p′ above XY such that p′g = 30 mm. Similarly mark a point p below XY on the perpendicular such that pg = 20 mm

p′ and p are required projections of the point P.

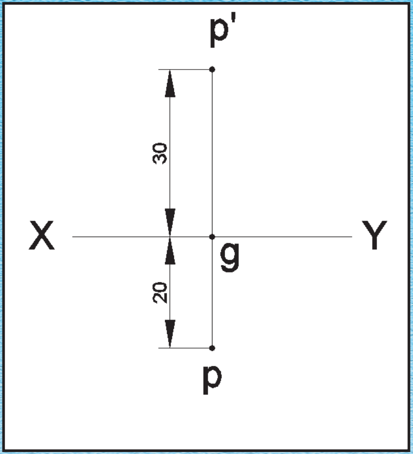


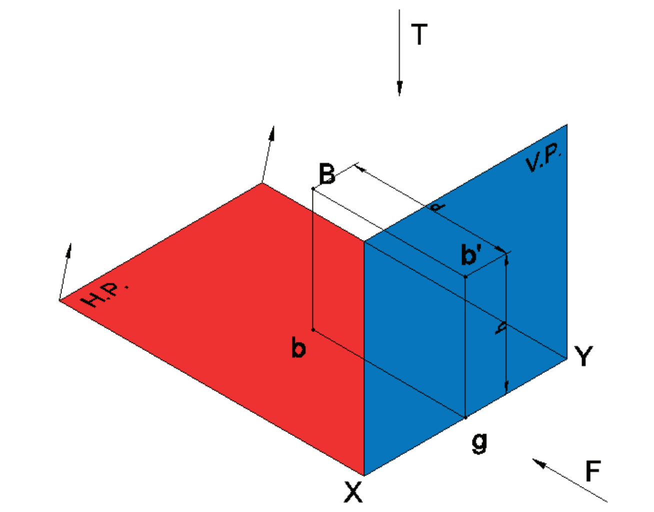
Fig. 4.22

4.4.3 PROJECTION OF POINT SITUATED IN SECOND QUADRANT

You have now studied, how to obtain the projection of point in I quadrant, in the earlier section.

In a similar way, we are going to do all the other positions of points one by one.

Consider a point B, situated in II quadrant as shown in Fig. 4.23



PICTORIAL VIEW OF POINT 'B'
IN II QUADRANT

Fig. 4.23

Suppose the distance of point B from H.P. is 'h' 15 mm and the distance from V.P. is 'd' = 20 mm after rotating/turning the H.P. in clockwise direction, we get the projection of point B, as given in Fig. 4.24

From the above illustration, now you know the fact that, when the point is situated in second quadrant, both the Front View and Top View lie above the XY line.

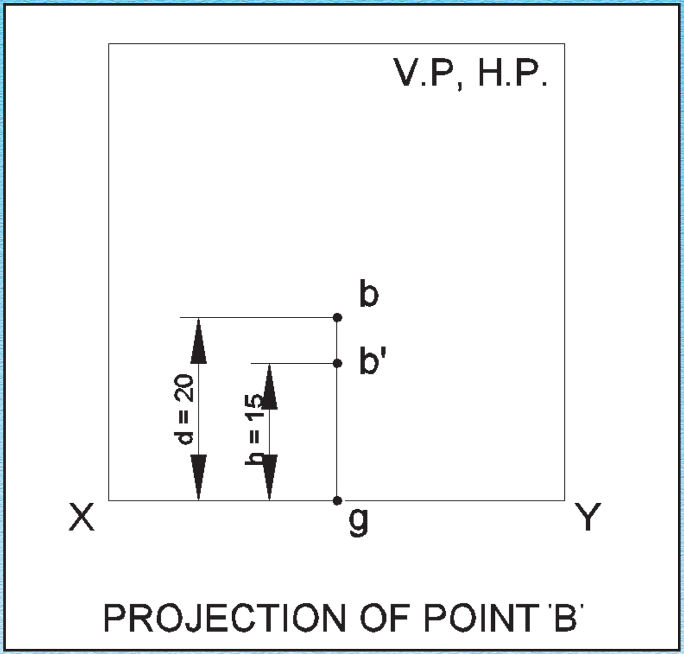


Fig. 4.24

Example 4.2 : A point Q is 25 mm above H.P. and 30 mm behind V.P. Draw its projections.

Solution : With our earlier knowledge of quadrants, we come to know that space above H.P. and behind V.P. is II quadrant.

Step 1 : Draw a XY line see fig. 4.25

Step 2 : Through any point g in it, draw a perpendicular.

Step 3 : On the perpendicular mark a point q' above XY such that gq' = 25 mm. Similarly mark a point q above XY on the same perpendicular such that gq = 30 mm. q' and q are the required projections of the point Q.

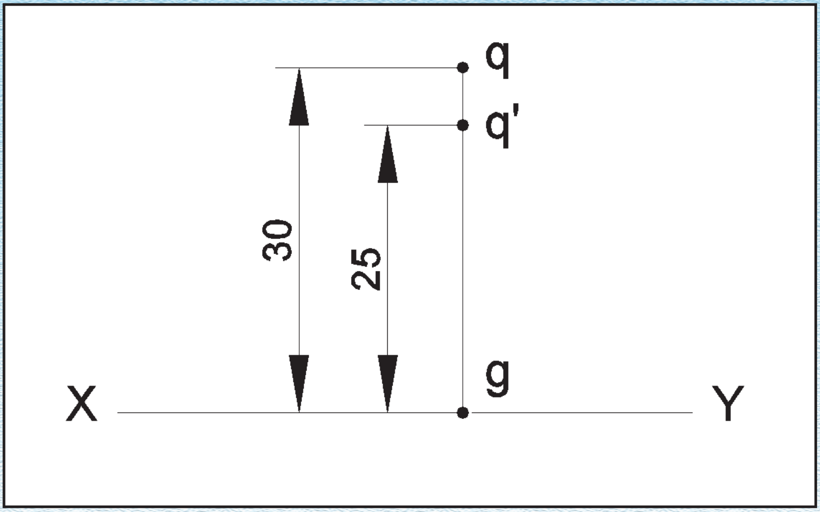


Fig. 4.25

4.4.4 PROJECTION OF A POINT SITUATED IN THIRD QUADRANT

Consider a point C, situated in III quadrant as shown in Fig. 4.26

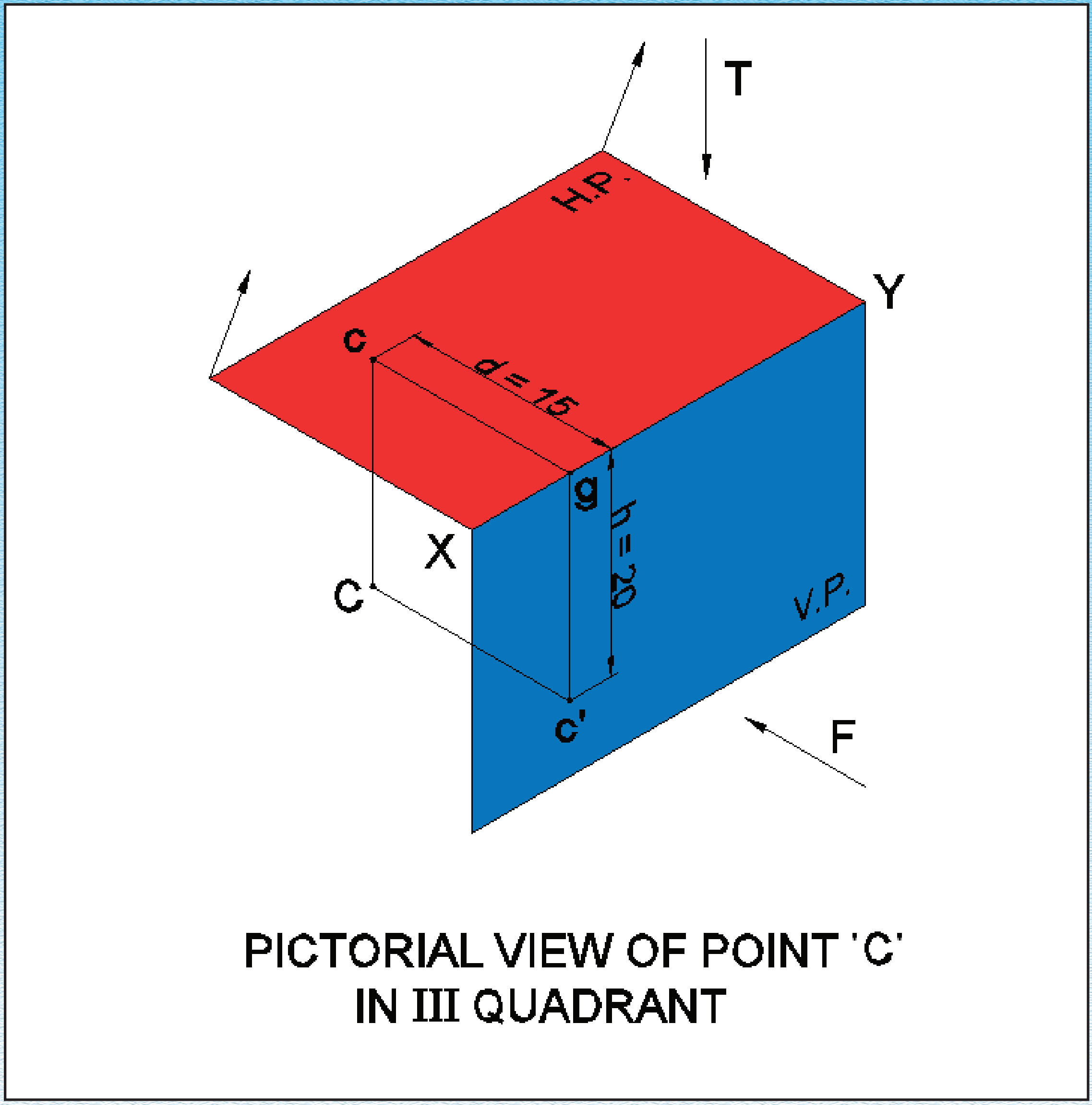


Fig. 4.26

Suppose the distance of point from H.P. is 'h' = 20and distance of point from V.P. is 'd' = 15, after rotating the H.P. in clockwise direction, we get the projection of point C on the drawing sheet as given in Fig. 4.27

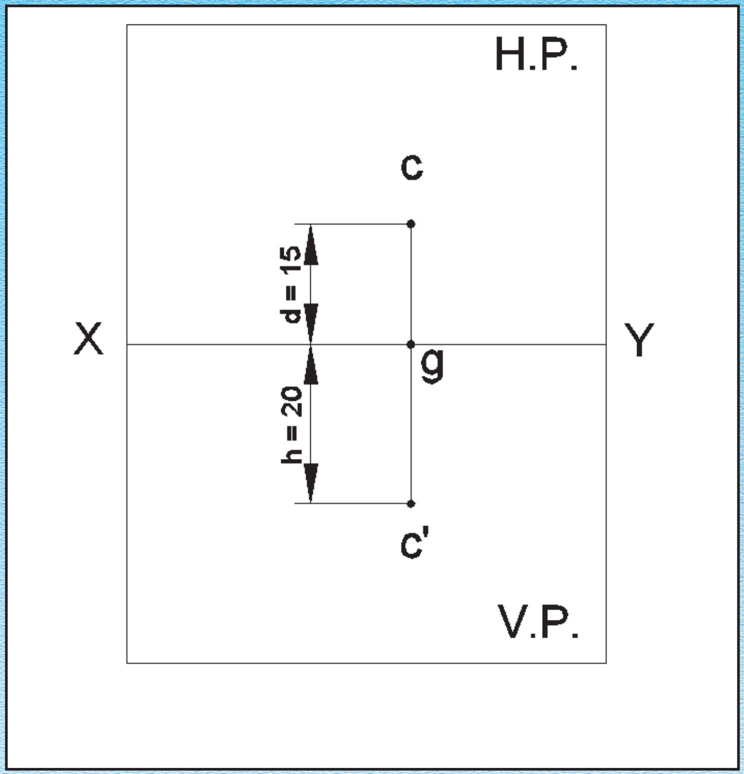


Fig. 4.27 Projection of point C

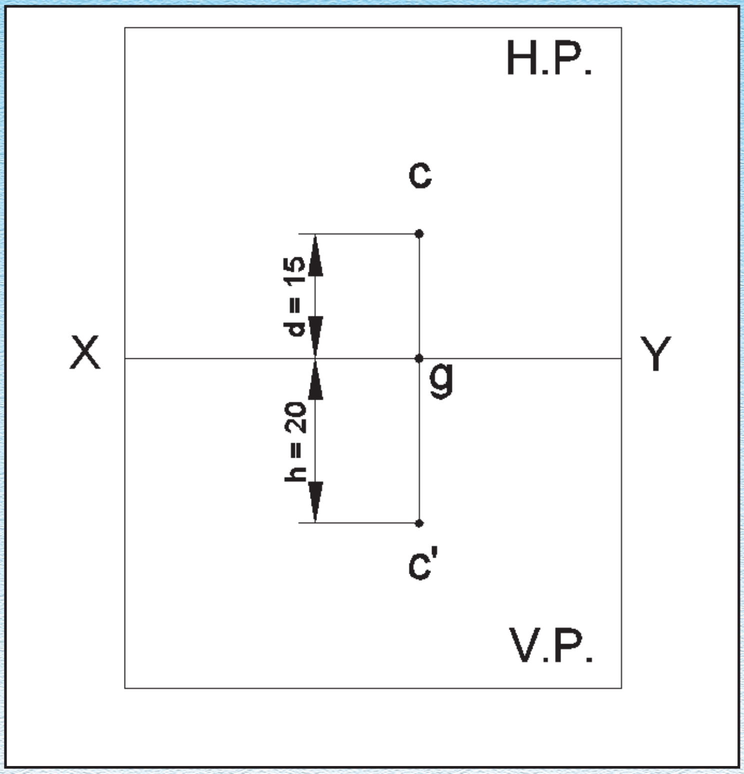


Fig. 4.28

Now, you have understood the fact that, when a point is situated in III quadrant, Top View plan is above XY and Front View is below XY.

Example 4.3 : A point R is 15 mm below H.P. and 20 mm behind V.P. Draw its projections.

Solution : Let us first study, which quadrant is mentioned in the question. The distance below H.P. and behind V.P. implies that the point R is situated in III quad. Refer Fig. 4.28, which is self explanatory.

4.4.5 PROJECTION OF POINT SITUATED IN IV QUADRANT

Consider a point E, situated in IV quadrant as shown in fig. 4.29

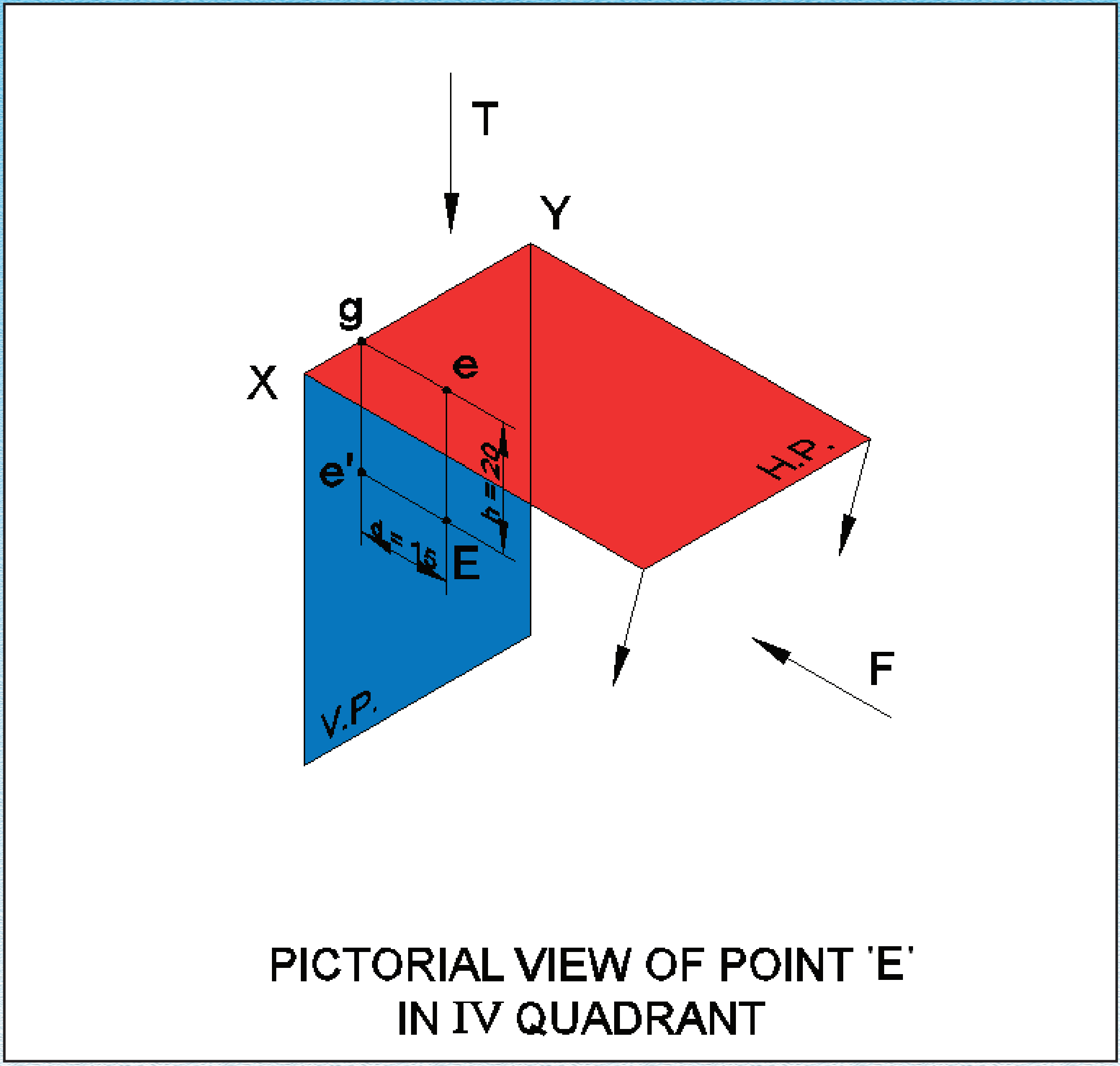


Fig. 4.29

After rabatting/rotating/turning the H.P. in clockwise direction, we will be able to draw the projections on the 2D drawing sheet, as shown in the Fig. 4.30

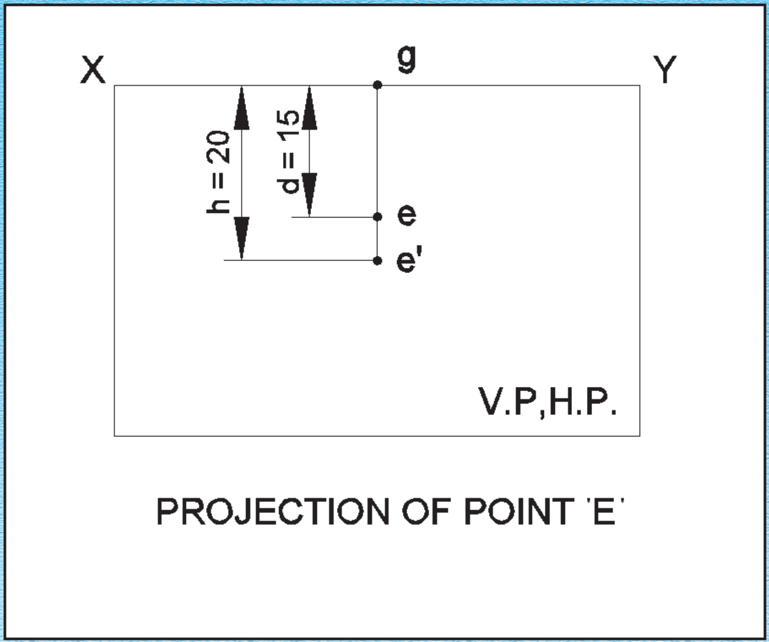


Fig. 4.30 Projection of point E

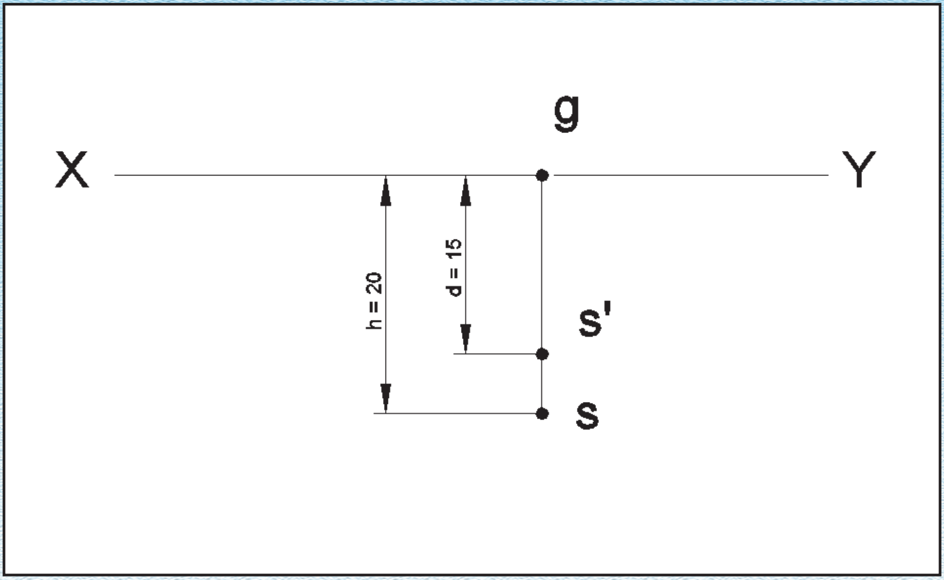


Fig. 4.31

Example 4.4 : A point S is 15 mm below H.P. and 20 mm in front of V.P. Draw its projections.

Solution : The point S here is situated in IV quadrant. Both the Front View and Top View will be placed below XY as shown in Fig. 4.31

Positions of a point and its projections in different quadrants are given in table 4.2

Dihedral Angle or Quadrant	Position of the given point	Position in Front View	Position in Top View
First	Above H.P., in front of V.P.	“Above XY”	“Below XY”
Second	Above H.P., in behind of V.P.	“Above XY”	“Above XY”
Third	Below H.P., in behind of V.P.	“Below XY”	“Above XY”
Fourth	Below H.P., in front of V.P.	“Below XY”	“Below XY”

Table 4.2 Positions of a point and its projections

THINK, DISCUSS AND WRITE

Can you guess what is the similarity between the I and III angle projections & II and IV angle projections ?

TRY THESE

State the quadrants in which the following points are situated.

(i) A point, its Top View is 40 mm above XY, Front View is 20 mm below the Top View.

(ii) A point Q, its projections coincide with each other 40 mm below XY.

4.4.6 PROJECTION OF POINT LIES ON H.P.

Consider a point M, which lies on H.P. (i.e.) distance away from H.P. becomes zero,
so h=0 in this case (Fig. 4.32)

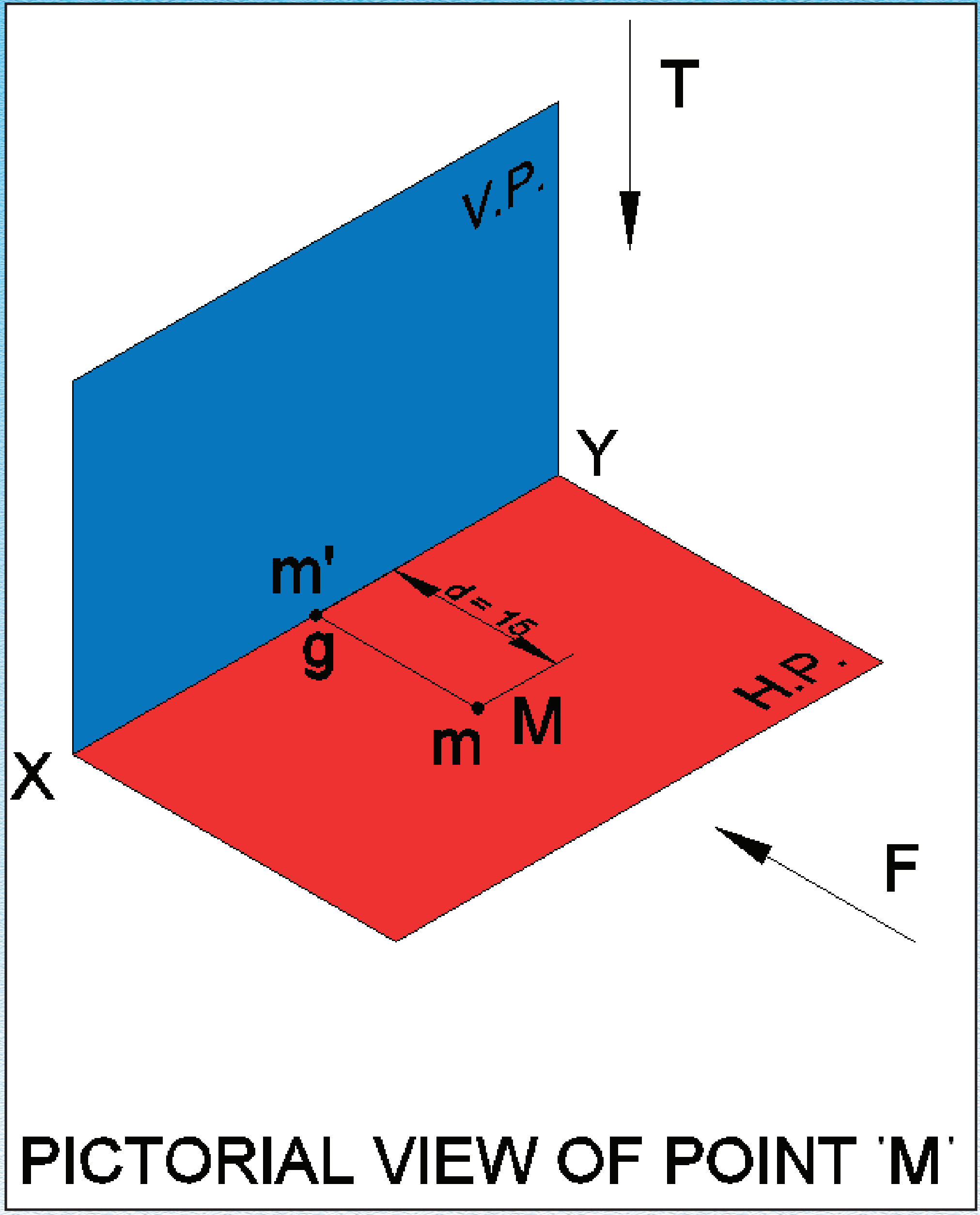


Fig. 4.32

After rotating the H.P., we can get the projection of point M as given below Fig. 4.33

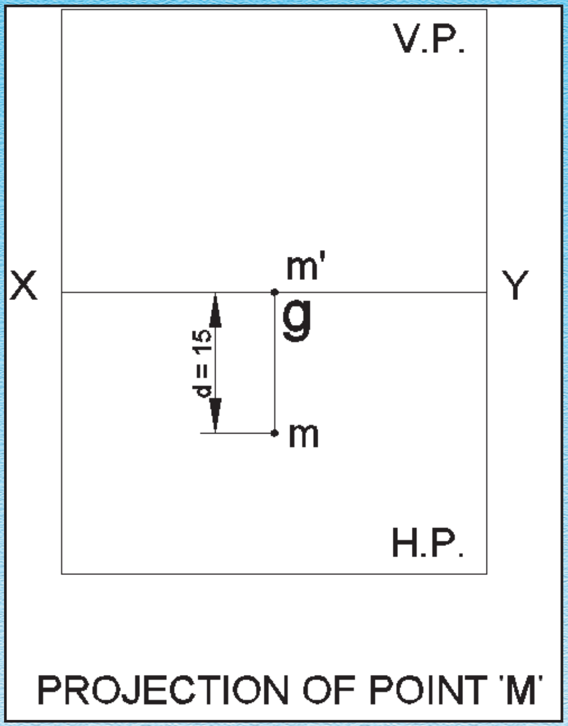


Fig. 4.33 Projection of point M

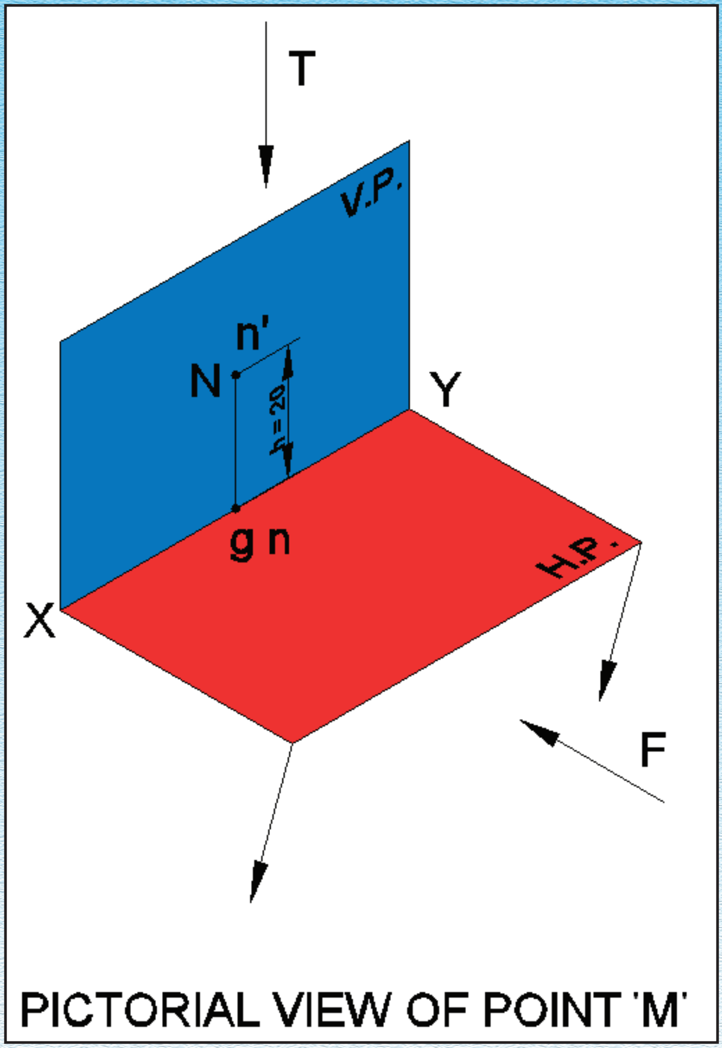


Fig. 4.34 Pictorial View

4.4.7 PROJECTION OF POINT LIES ON V.P.

Consider a point N, which lies on V.P. (i-e) d=0 in this case, Fig. 4.34

The projection obtained is shown in Fig. 4.35

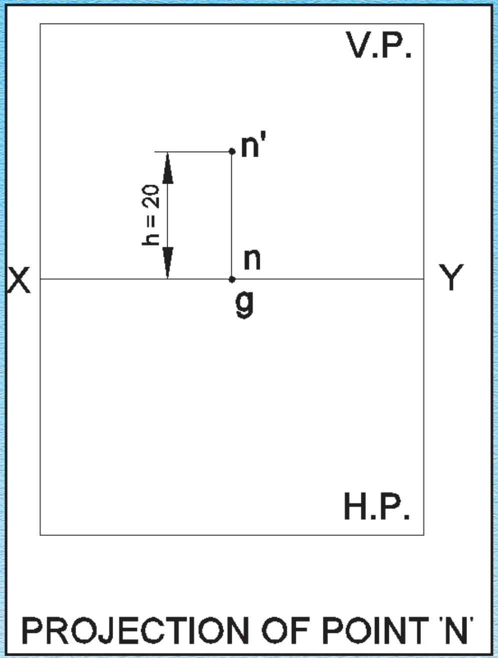


Fig. 4.35 Projection of point N

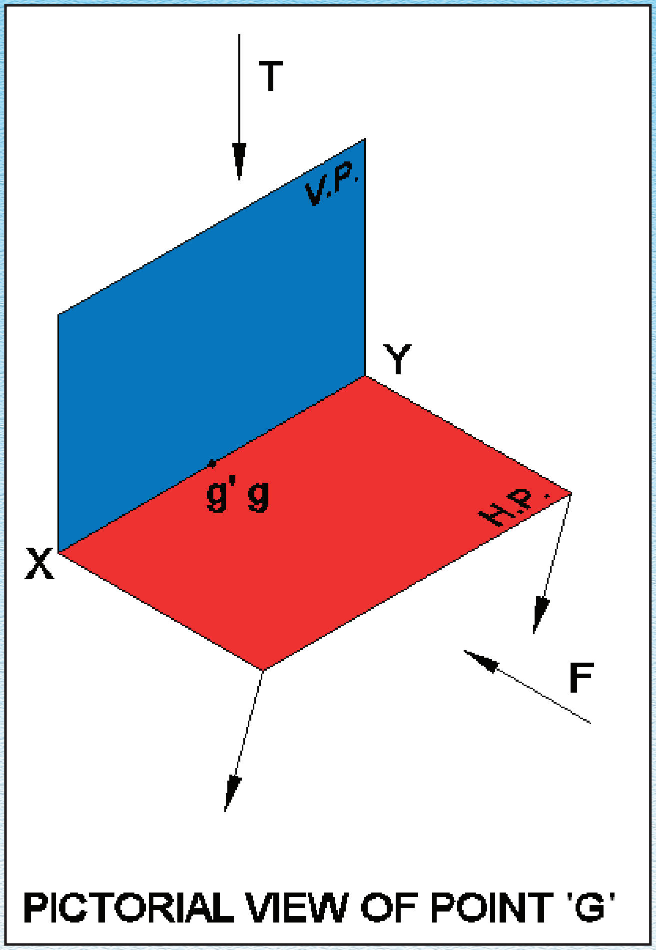


Fig. 4.36

4.4.8 PROJECTION OF POINT SITUATED IN BOTH THE PLANES

Let us consider a point G, which is situated in both the planes, Fig. 4.36

Here, the point 'G' lies on H.P., so h=0 and it lies on V.P. So, d=0 Hence both the Front View and Top View lie on XY as in Fig. 4.37

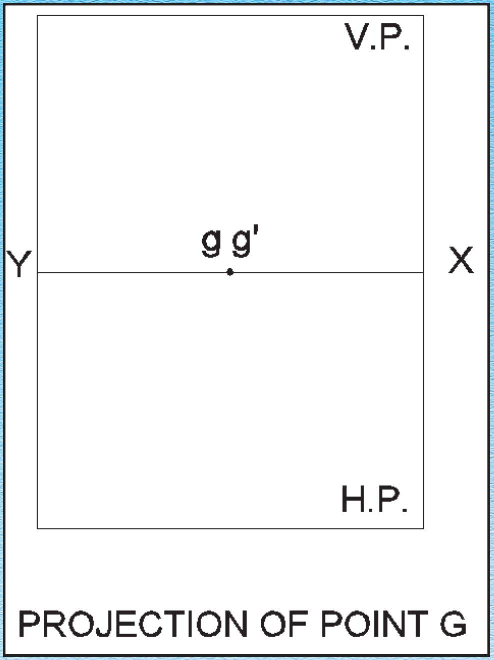


Fig. 4.37

ACTIVITY

- Take a card board and hold it horizontally.
- Take another card board and hold it vertically.
- Mark a point on H.P. and note down its projections.
- Similarly, mark a point on V.P. and study its projections.

In the same way, 3 card boards can be placed at right angles to each other to form an Octant. Study the projections of points in all the possible positions.

WHAT WE HAVE LEARNT

1. The line joining the Front View and the Top View of a point is always perpendicular to XY line and is called a projector.
2. Distance of a point from H.P. is for Front View seen in V.P., and the distance from V.P. is for Top View, seen in H.P.
3. When a point lies in "I quadrant, Front View is above XY, Top View below XY."
4. When a point lies in II quadrant, both Front View & Top View are above XY.
5. When a point lies in "III quad, Front View is below XY and Top View is above XY."
6. When a point lies in IV quad, both Front View and Top View lie below XY.
7. When a point lies on H.P. , Front View is on XY.
8. When a point lies on V.P., Top View is on XY.
9. When a point lies on both V.P. and H.P., both views are on XY.

Example 4.5 : Draw the projections of the following points on the same reference line,

(i) A, in the H.P. and 20 mm in front the V.P.

(ii) C, in the V.P. and 30 mm above H.P.

(iii) B, in both V.P and H.P.

Solution : refer fig. 4.38

Step 1 : Draw a XY line.

Step 2 : Through any point a' in it, draw a perpendicular.

Step 3 : Since the point lies in H.P. and in front of V.P., the Front View lies on XY and Top View below XY. So mark a point a' at XY, mark another point 'a' such that a'a = 20 mm

a' and a are required projections of A

Part (ii) and (iii) are self explanatory

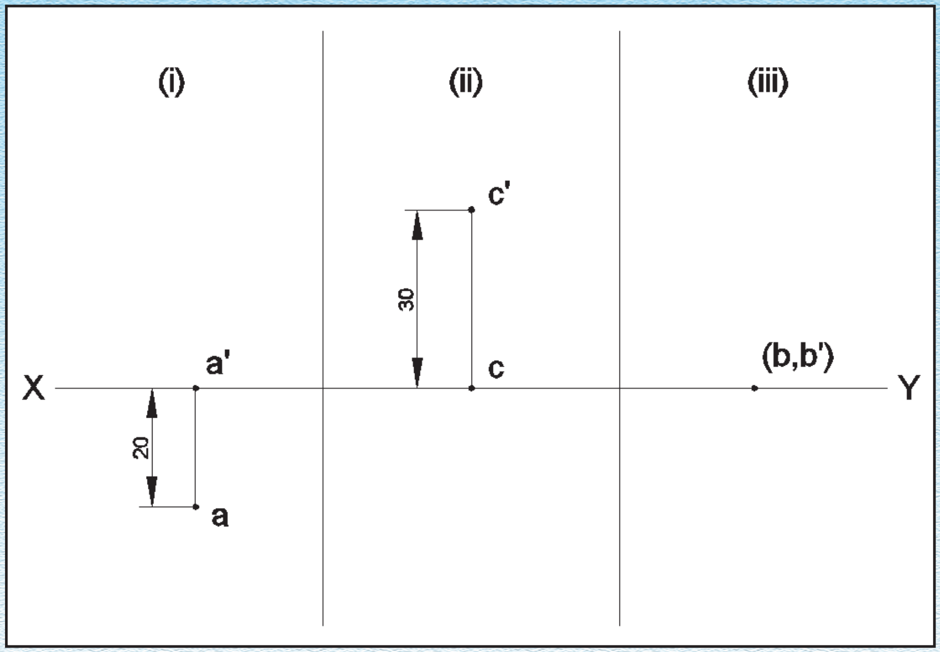


Fig. 4.38

ASSIGNMENT

1. A point D is 25 mm from H.P. and 30 mm from V.P. Draw its projections considering it in first and third quadrants.

2. A point P is 15 mm above the H.P. and 20 mm is front of the V.P. Another point Q is 25 mm behind the V.P. and 40 mm below the H.P. Draw the projections.

3. Draw the projections of the following points on the same XY,

   B, 20 mm above H.P. and 25 mm in front of V.P.

   D, 25 mm below the H.P. and 15 mm behind the V.P.

   E, 15 mm above the H.P. and 10 mm behind the V.P.

   F, 20 mm below the H.P. and 25 mm in front of V.P.

4.5 PROJECTION OF LINES

You are already familiar with the concept of straight line from class VI. Let us just recall it. A straight line is the shortest distance between two points. In solid Geometry, the projections of lines play a vital role.

The projections of a straight line are nothing but the straight lines by joining the projections of end points. In this section, we are going to study about the various positions and its respective projections of a straight line with respect to two reference planes.

4.5.1 PROJECTION OF STRAIGHT LINE PARALLEL TO BOTH THE PLANES

Consider a line PQ which is parallel to V.P. and H.P. as shown in Fig. 4.39. Its Top View and Front View (pq & p′q′) are equal to the line PQ and parallel to XY line. (Fig. 4.40)

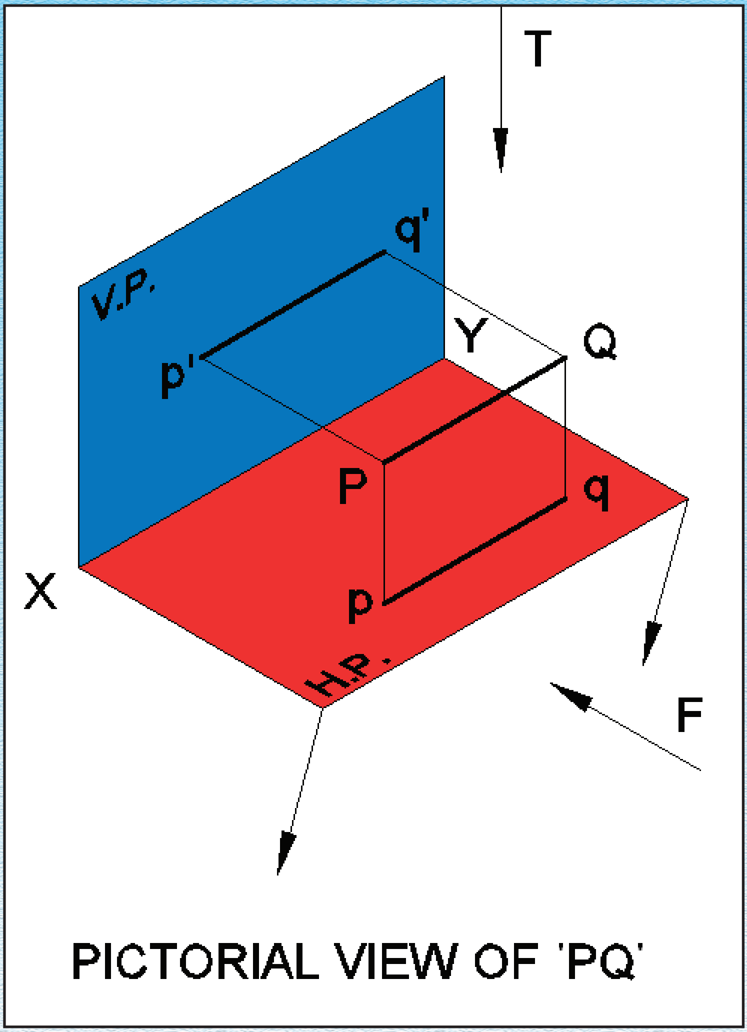


Fig. 4.39 Pictorial view of PQ

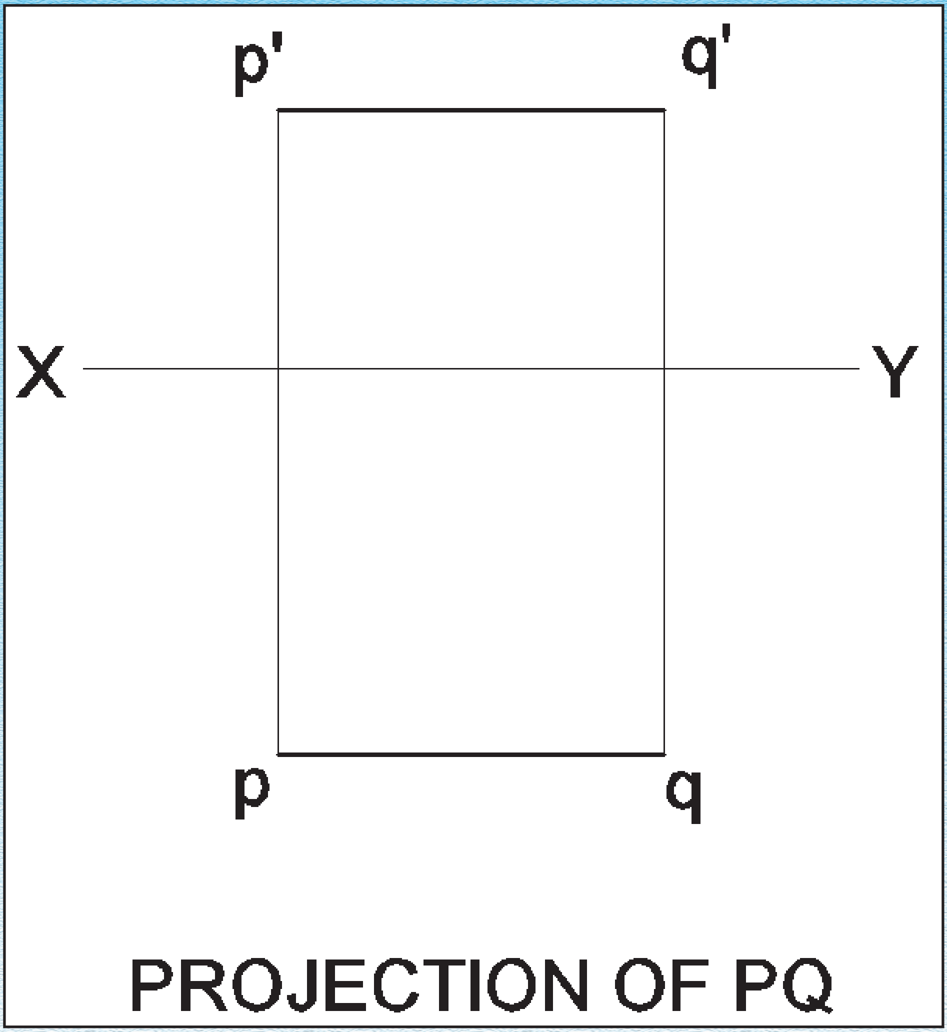


Fig. 4.40 Projection of PQ

4.5.2 PROJECTION OF STRAIGHT LINE PERPENDICULAR TO ONE PLANE AND PARALLEL TO THE OTHER

Case (i) Line perpendicular to H.P. and parallel (||) to V.P.

Suppose line MN is ⊥ to H.P. and || to V.P. as shown in Fig. 4.41. Its Front View m'n' will be equal to length of the line MN and Top View will be a point. (Fig. 4.42)

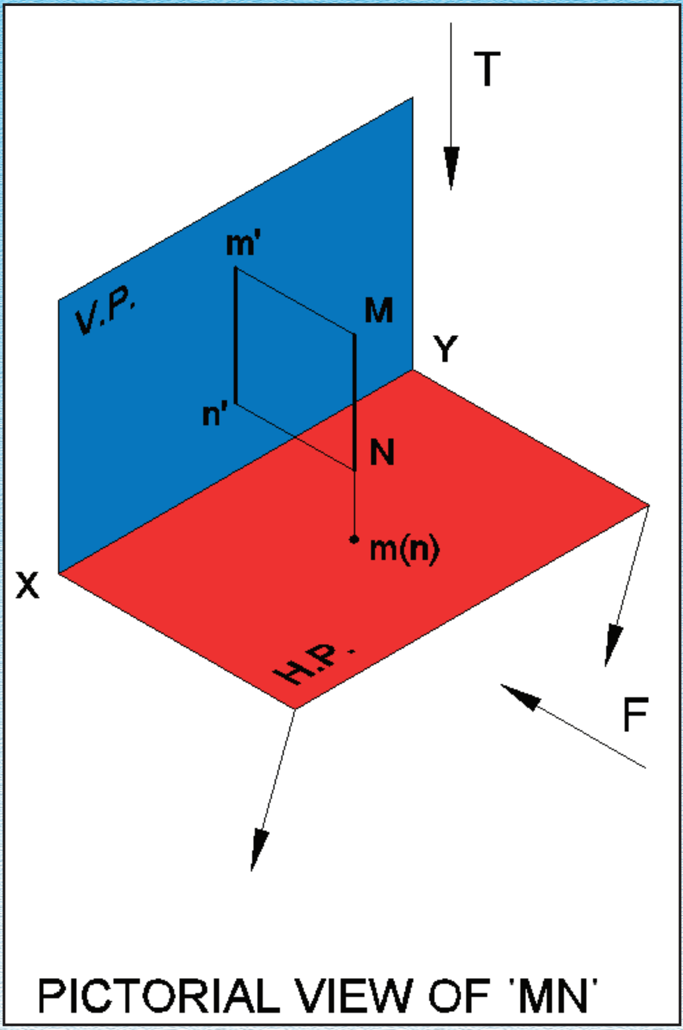


Fig. 4.41 Pictorial view of MN

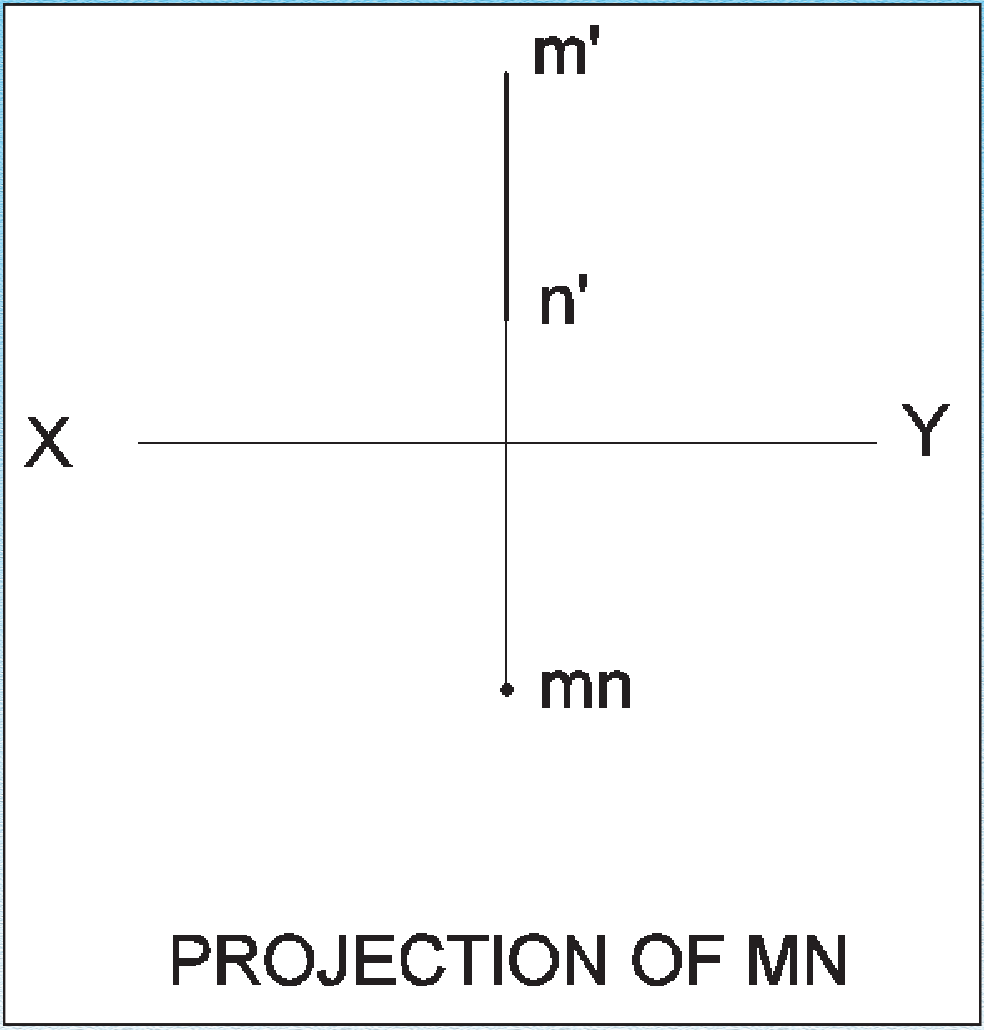


Fig. 4.42 Projection of MN

Case (ii) Line perpendicular to V.P. and parallel to H.P.

Suppose line AB is ⊥ to VP and || to H.P. as shown in Fig. 4.43 Its Top View ab will be equal to length of line AB and Front View will be a point a'b'. (Fig. 4.44)

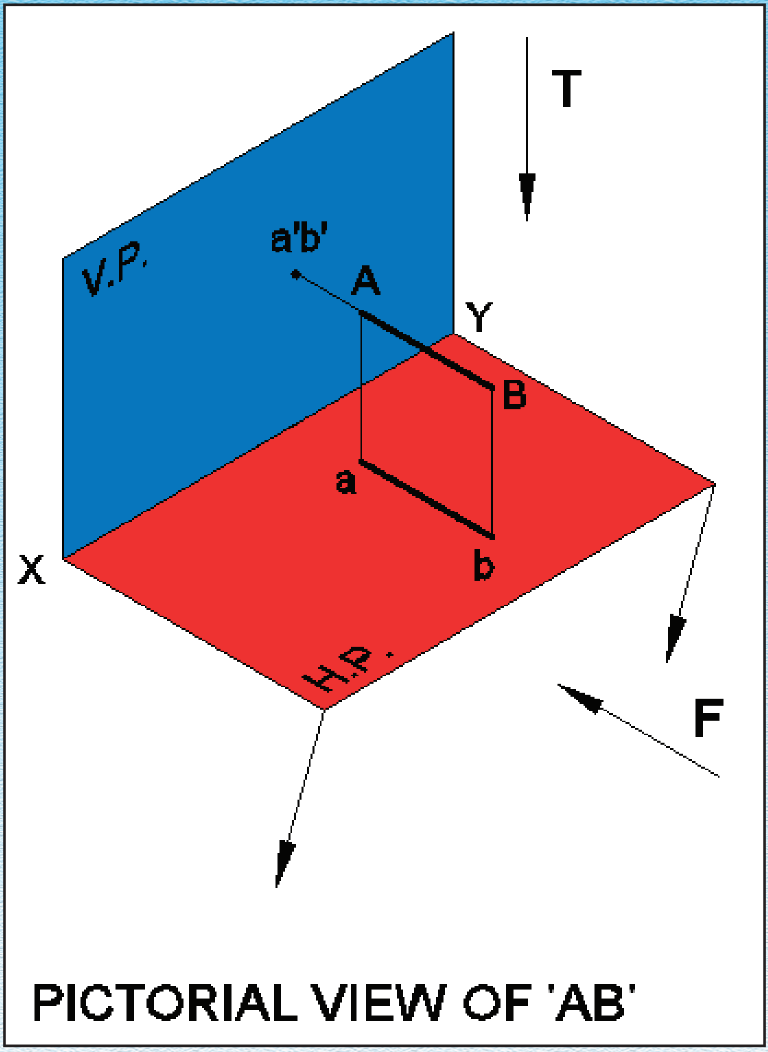


Fig. 4.43 Pictorial view of AB

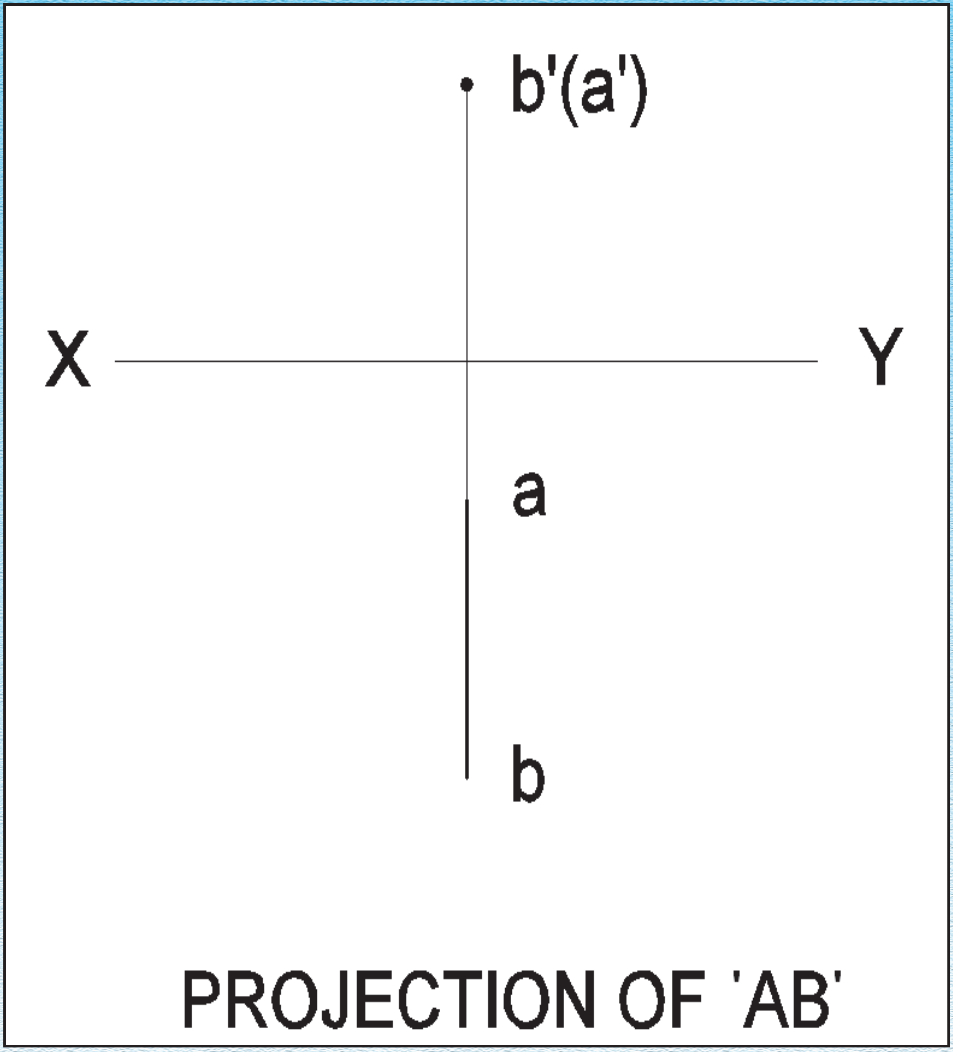


Fig. 4.44 Projection of AB

4.5.3 PROJECTION OF STRAIGHT LINE INCLINED TO ONE PLANE AND PARALLEL TO THE OTHER

Case (i) Line inclined to V.P. and || to H.P.

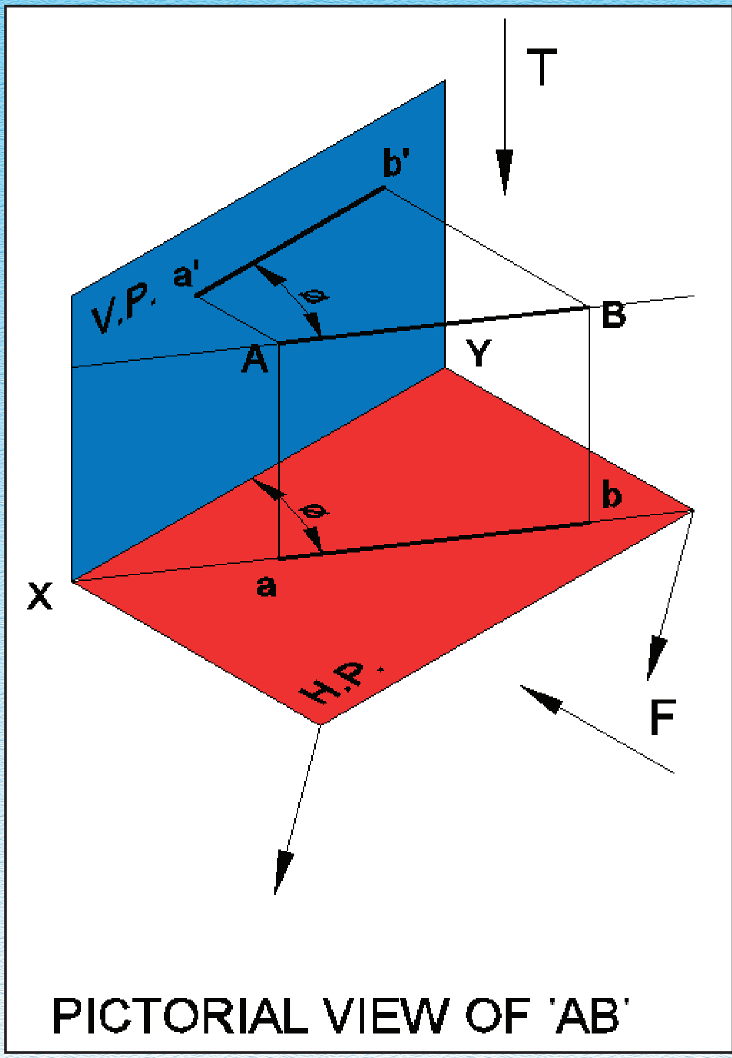


Fig. 4.45 Pictorial view

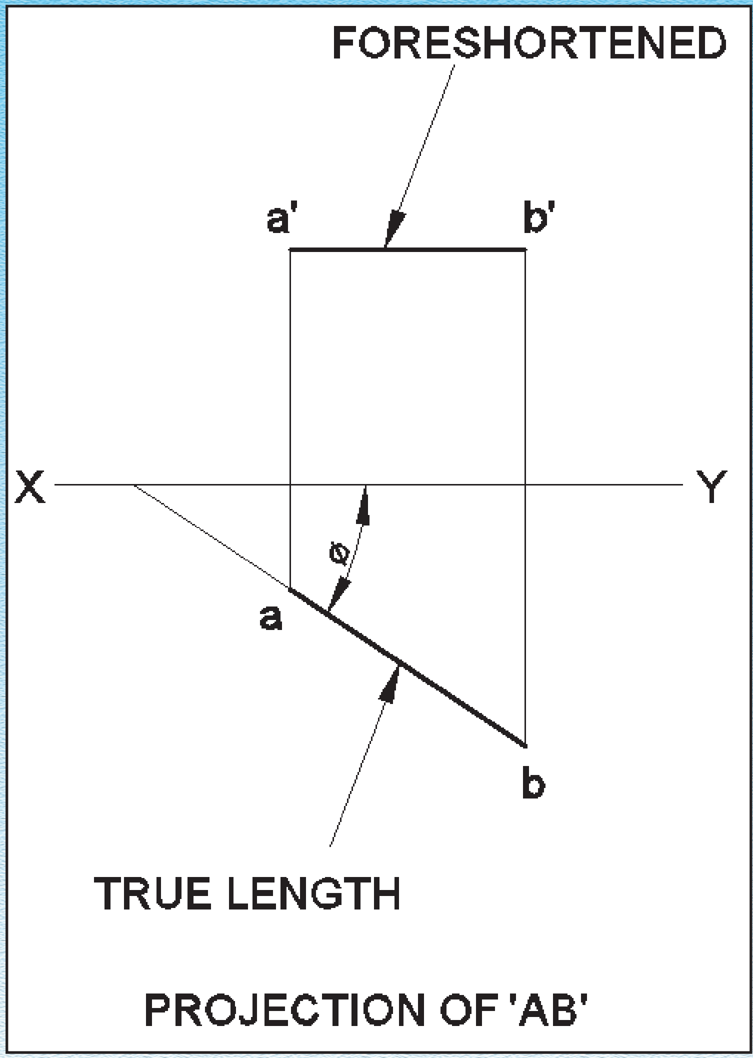


Fig. 4.46 Projection of AB

Suppose line AB (see fig. 4.45) is inclined to V.P. with an angle ϕ, its projections are shown in Fig. 4.46.

Its Top View ab gives true magnitude equal to the length of line AB, Front View is shorter than true length and || to XY.

Case (ii) Line Inclined to H.P. and parallel to V.P.

Suppose a line AB is inclined to H.P. and || to V.P. (Fig. 4.47) with an angle θ, its projections are as shown in Fig. 4.48

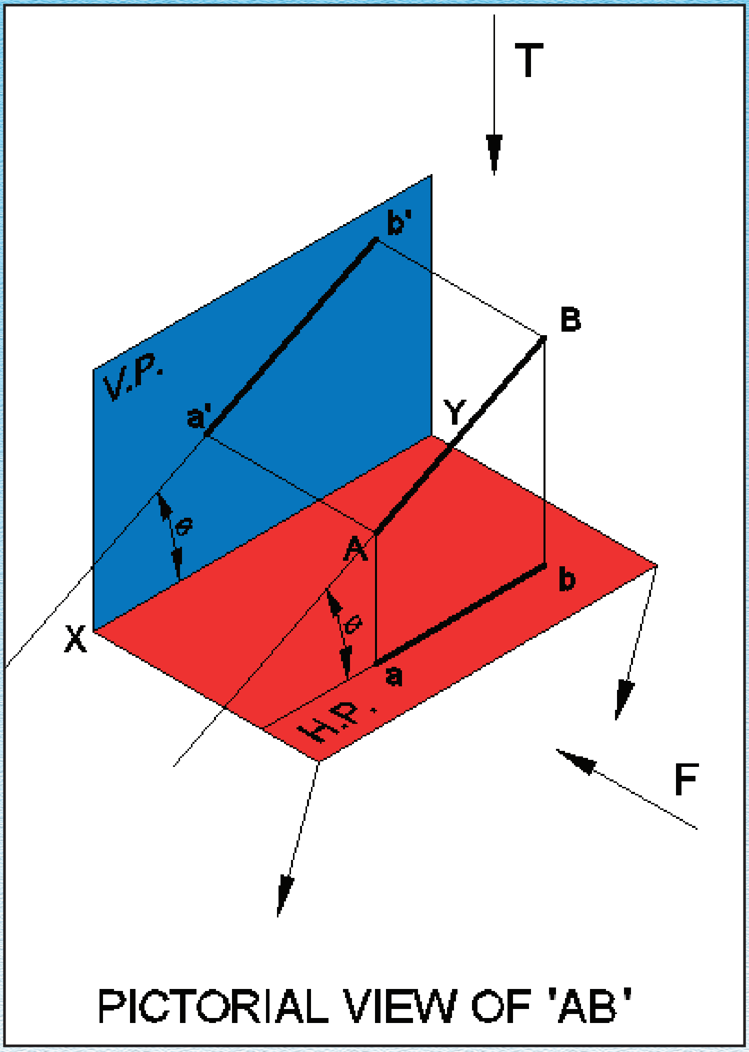


Fig. 4.47 Pictorial view of AB

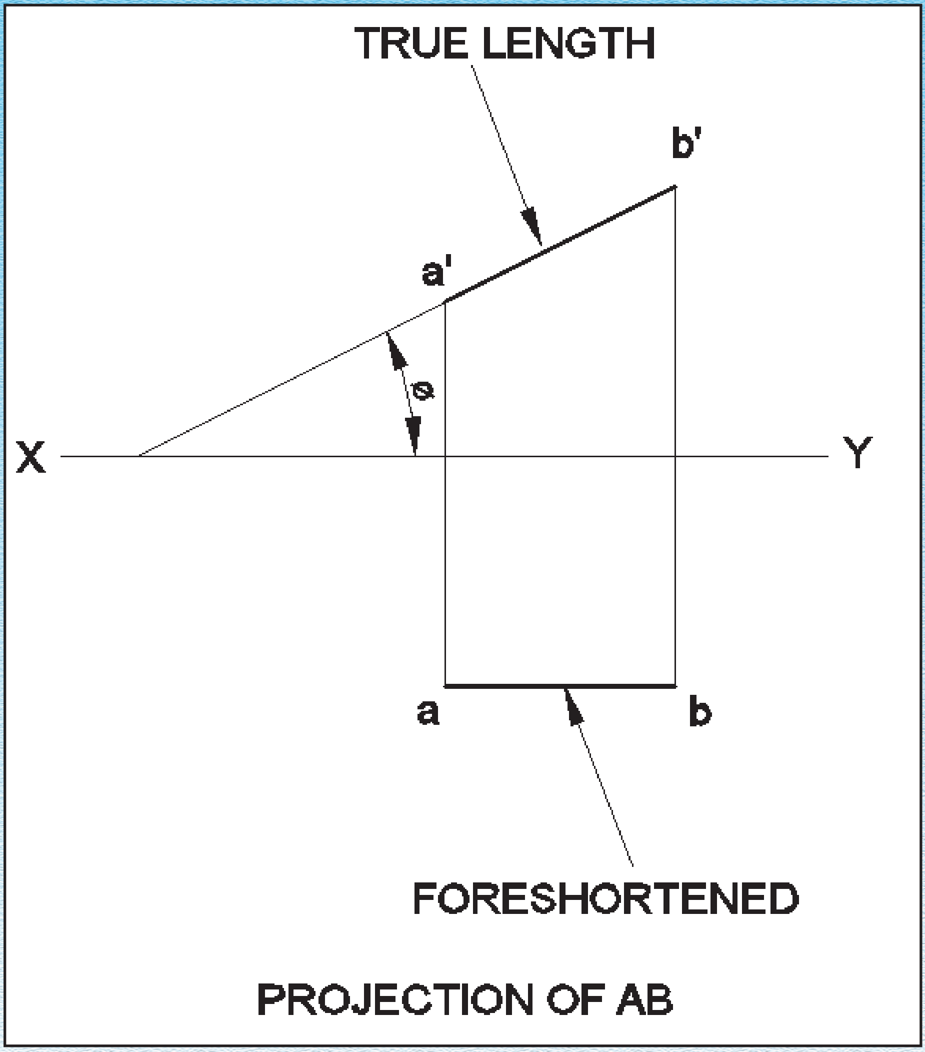


Fig. 4.48 Projection of AB

Its frontview shows its true length and is inclined to XY, at its true inclination with H.P. and Top View is shorter than the true length (i-e) "foreshortened" (apparent reduction in length)

NOTE :

(i) When a line is contained by a plane, its projection on that plane is equal to its true length, while its projection on the other plane is on reference line. (XY)

For example line CD is in the V.P. (see fig 4.49). Its Front View c'd' is equal to CD, its Top View, cd is in XY (fig. 4.50)

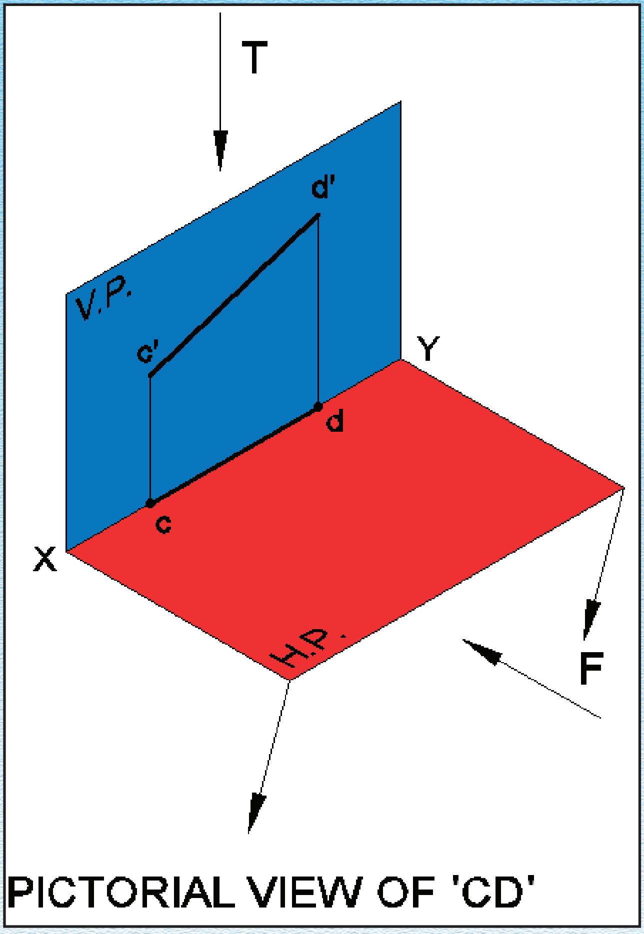


Fig. 4.49 Pictorial view of CD

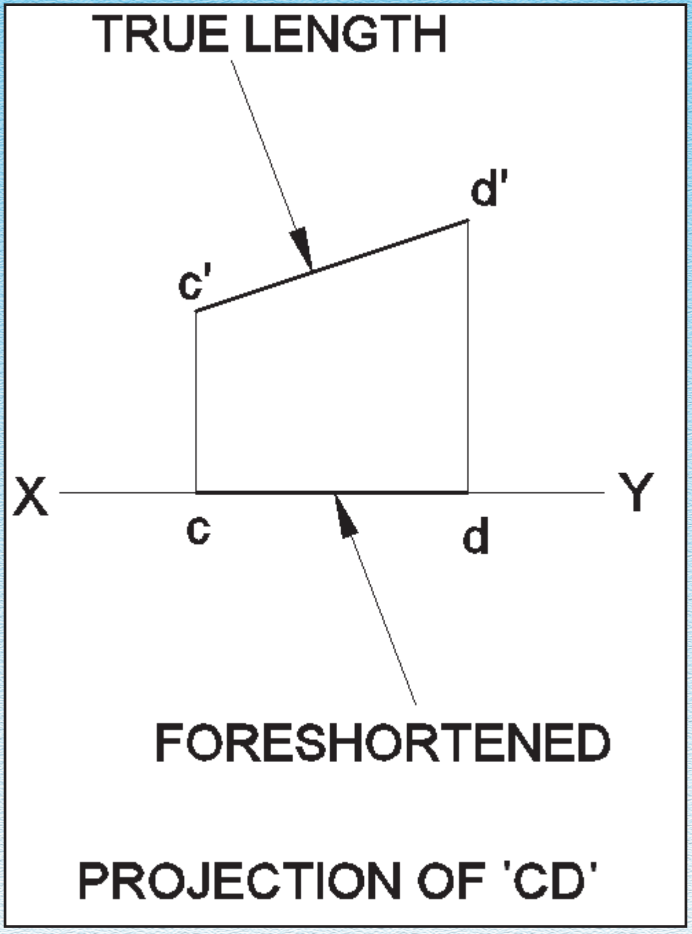


Fig. 4.50 Projection of CD

(ii) When a line is contained by both the planes, its projections lie on XY.

We understand this fact by considering an example. A line EF is contained by both V.P. and H.P. (Fig. 4.51). Its Front View and Top View both lie on XY. Fig. 4.52)

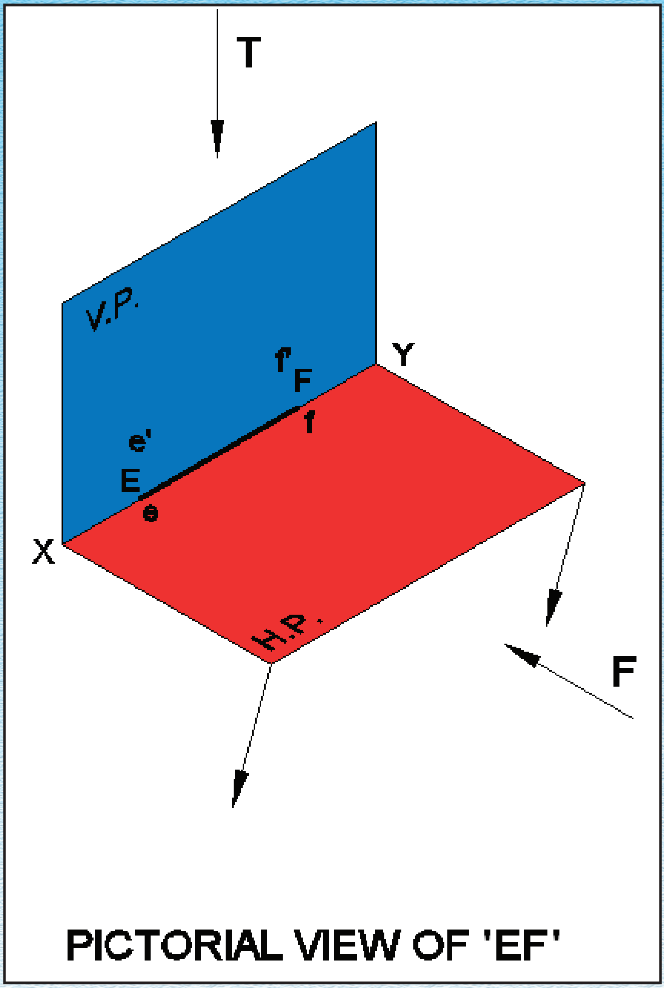


Fig. 4.51 Pictorial view of EF

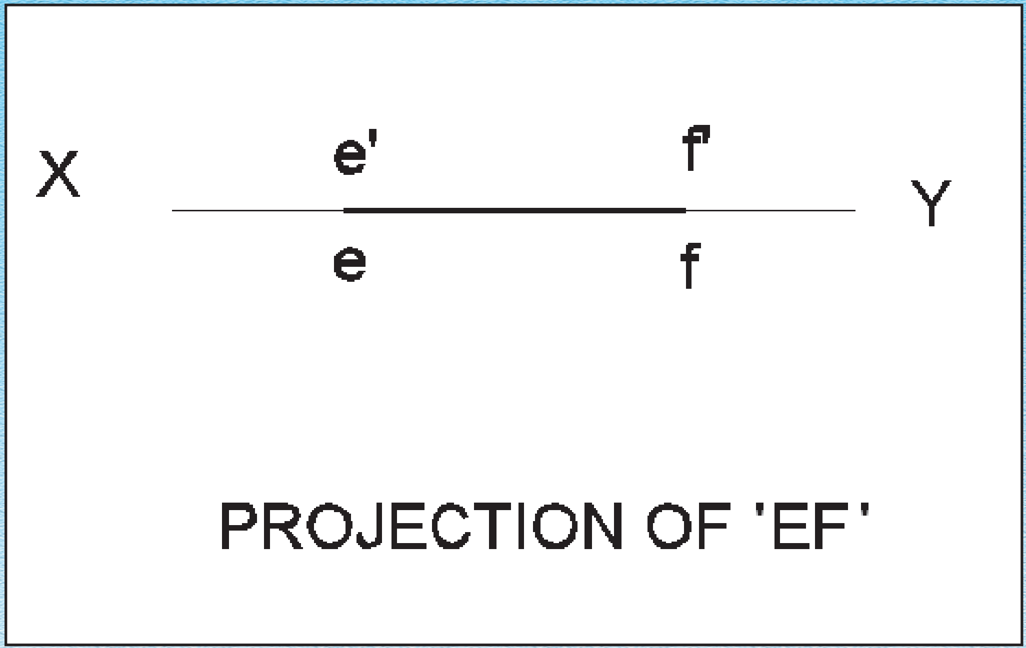


Fig. 4.52 Projection of EF

Note : Front View and topview overlap each other

4.5.4 PROJECTION OF LINE INCLINED TO BOTH THE PLANES

Consider a line AB (see fig. 4.53) inclined to both the planes. Let the angle of inclination with H.P. be θ and with V.P. be ϕ.

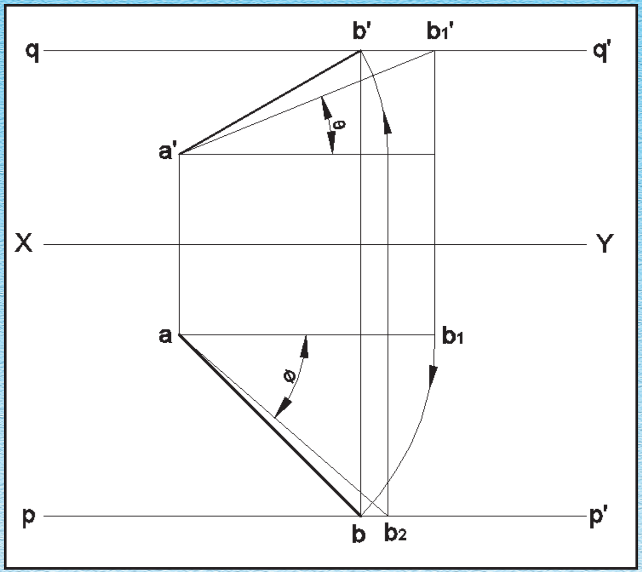
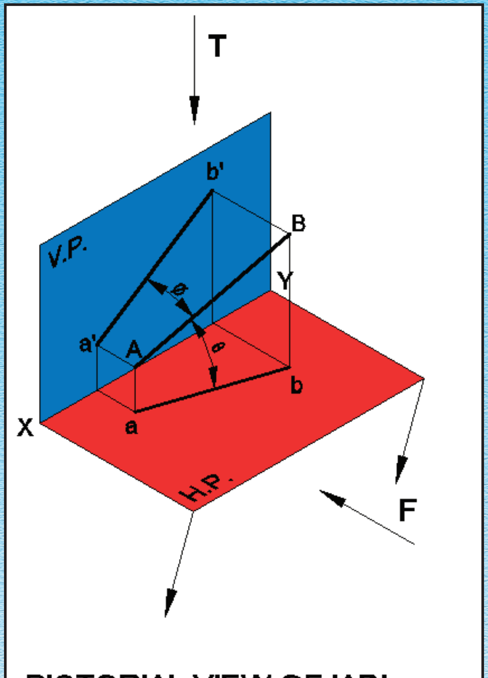


Fig. 4.54

Its projections are drawn as follows (Fig. 4.54)

Step 1 : First assume that the line is inclined to H.P. at θ and || to V.P., draw its projections as learnt in section 4.5.3



PICTORIAL VIEW OF 'AB'

Fig. 4.53

Step 2 : Now assume that the end A is not changed (i.e) without changing the inclination to H.P., change the end B, such that it is inclined to V.P. So change the Top View ab, to ab, with angle ϕ.

Step 3 : Project its corresponding Front View a'b'. a'b' and ab are the required Front View and Top View.

IMPORTANT

From this illustration, we observe that when a line is inclined to both the reference planes, its true length and true inclinations can neither be shown in Top View nor in Front View. Both Front View and Top View are inclined lines.

A brief summary of projection of lines in different positions is listed in the following table 4.3

S.No.	Position of Line	Front View	Top View
1.	Line parallel to both VP & H.P.	Horizontal line parallel to XY	Horizontal line parallel to XY
2.	Line perpendicular to H.P. and parallel to V.P.	Vertical line	Point
3.	Line perpendicular to V.P. and parallel to H.P.	Point	Vertical Line
4.	Line parallel to H.P. and inclined to V.P. at ϕ	Line parallel to XY with foreshortened length	Inclined line with true length
5.	Line parallel to the V.P. and inclined to H.P. at θ	Inclined line with true length	Line parallel to XY with foreshortened length

Table 4.3

Let us now solve some examples

Example 4.6 : Draw the projection of a line PQ, 25 mm long, in the following positions.

(i) Perpendicular to the H.P., 20 mm in front of V.P. and its one end 15 mm above the H.P.

(ii) Perpendicular to the V.P., 25 mm above the H.P. and its end in the V.P.

Solution :

(i) We understand that the given line lies in the I quadrant and perpendicular to the H.P.

As the line is perpendicular to H.P., its Front View is a line perpendicular to XY and Top View is a point. (see Fig. 4.55)

Step 1 : Draw a line XY.

Step 2 : Draw the end p', 15 mm above XY and complete the line p'q' such that p'q' = 25 and perpendicular to XY.

Step 3 : Project the Front View down to get a point. This is the required Top View pq.

p'q' and pq are the required Front View and Top View respectively.

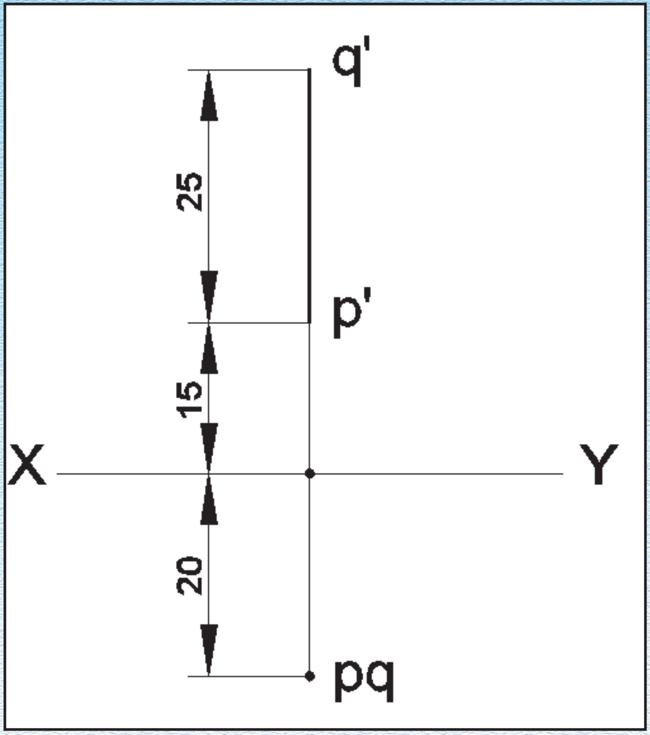


Fig. 4.55

(ii) This question belongs to the case of a line perpendicular to V.P. we know the fact that when a line is perpendicular to V.P., its Front View is a point and Top View is a line perpendicular to XY and of true length. refer Fig. 4.56

Step 1 : Draw a line XY.

Step 2 : Draw the end p on XY and draw a line pq = 25 and pependicular to XY.

Step 3 : Project the Top View above XY to get Front View, a point p'q' at a distance of 25 from XY.

p'q' and pq are the required Front View and Top View respectively.

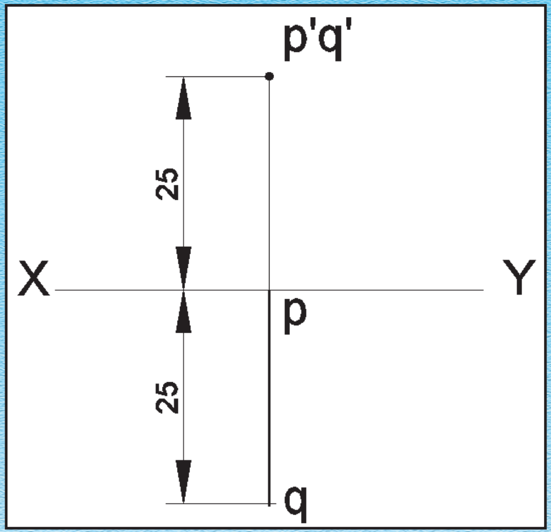


Fig. 4.56

Example 4.7 : Draw the projection of a 30 mm long AB, Straight line in the following positions.

(i) Parallel to both H.P. and V.P. and 25 mm above H.P. and 20 mm in front of V.P.

(ii) Parallel to and 30 mm above H.P. and in the V.P.

Solution :

(i) From the earlier section 4.5.2 we learnt the fact that when a line is parallel to both the planes, its Front View and Top View are lines parallel to XY and of true length

Step 1 : Draw a XY line.

Step 2 : Mark a point a', 25 mm above XY Draw a line a'b' of 20 mm parallel to XY.

Step 3 : Project down the ends a' and b' below XY to get a and b respectively.

Step 4 : Join a with b to get a line parallel to XY. a'b' and ab are the required projections.

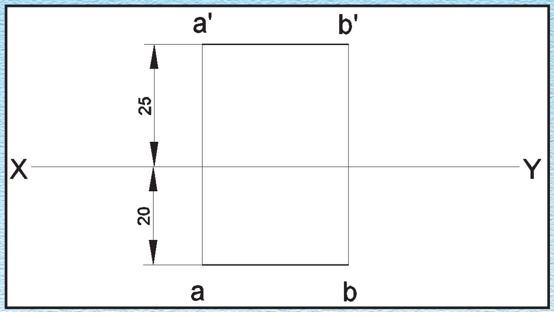


Fig. 4.57

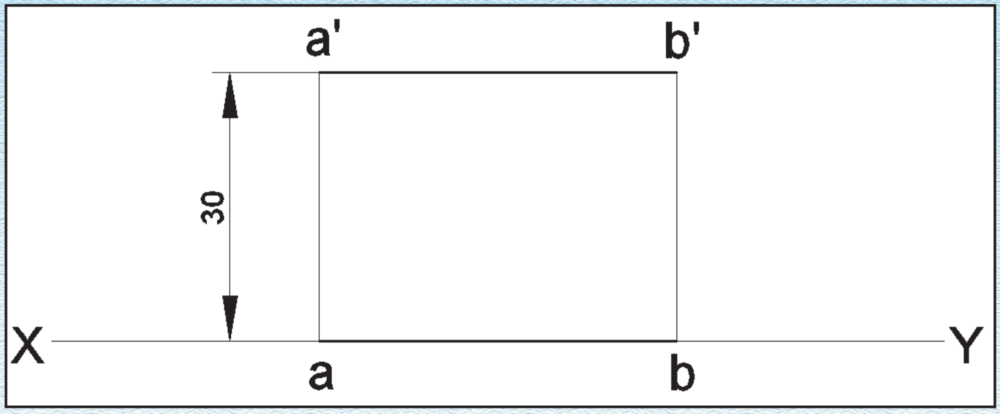


Fig. 4.58

(ii) Since the line is parallel to H.P. and in the V.P., the Front View lies above XY and parallel to it, the Top View lies on XY. Fig.

Follow the steps as shown in the previous part of the question.

Example 4.8 : A straight line AB of 40 mm length is parallel to the H.P. and inclined at 30° to the V.P. Its end point A is 10 mm from the H.P. and 15 mm from the V.P. Draw the projection of the line AB asssuming it to be located in all the four quadrants by turn.

Solution : refer Fig. 4.59 to 4.62

As the given line is || to H.P. and inclined to V.P., we know that the Top View of the line will be of true length is 40 mm and will be inclined to XY at an angle ϕ = 30°, while its Front View will remain parallel to the XY line.

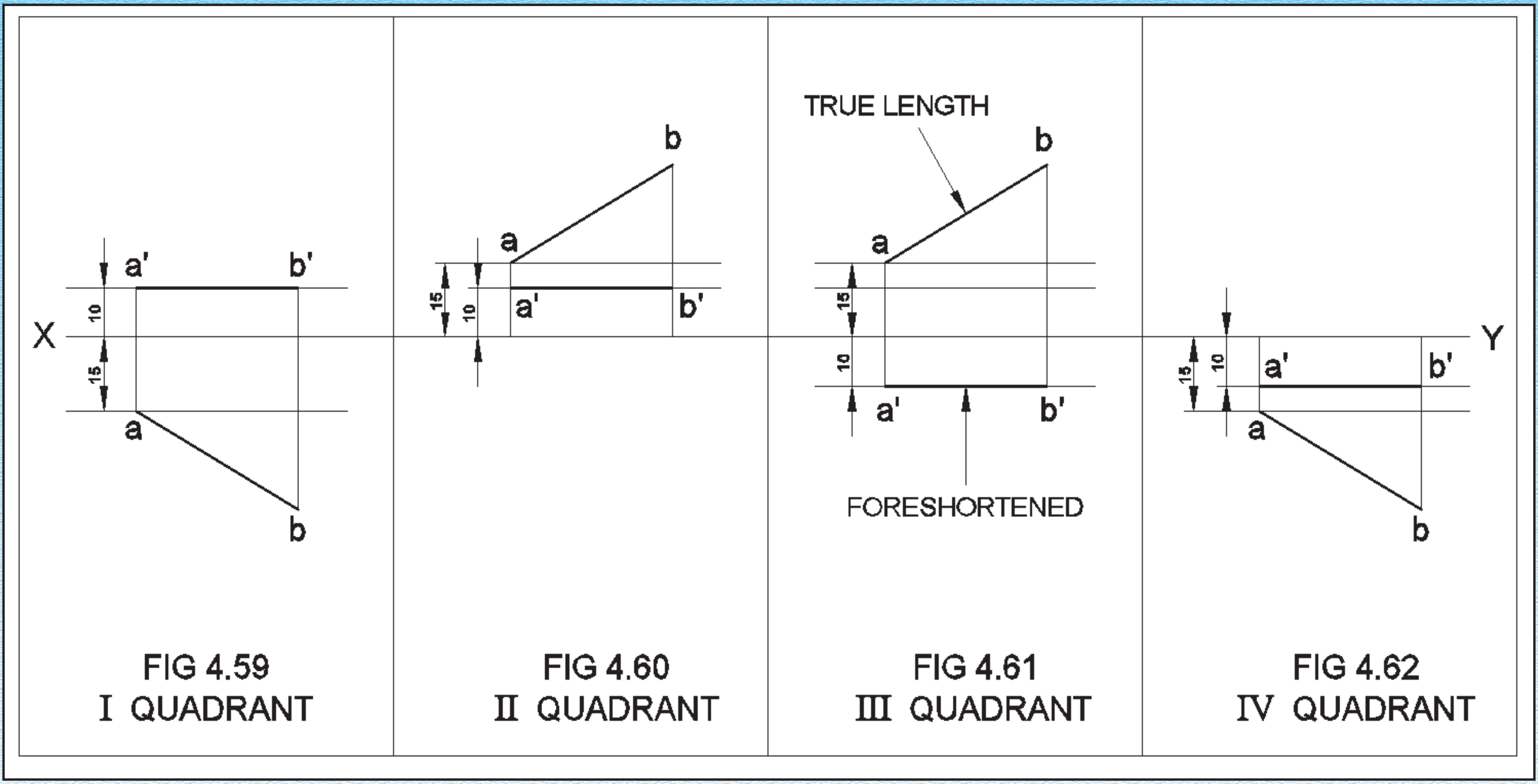


Fig. 4.59 Fig. 4.60 Fig. 4.61 Fig. 4.62

Example 4.9 : A straight line PQ of 30 mm length has its one end P 10 mm from the H.P. and 15 mm from the V.P. Draw the projections of the line if it is parallel to the V.P. and inclined at 30° to the H.P. Assume the line to be located in each of the four quadrants by turn.

Solution : Fig. 4.63 to 4.66

As the given line PQ is || to the V.P. – as shown in table 4.3 – we conclude that the Front View will be true length, 30 mm and inclined to XY at θ, i.e, the angle at which the given line is inclined to H.P., θ = 30° in this case. The Top View will remain parallel to XY line.

Position of point P is given, hence depending upon the quadrant, p′ and p can be fixed and Front View can then be drawn. The Top View is then projected as a line || to XY line.

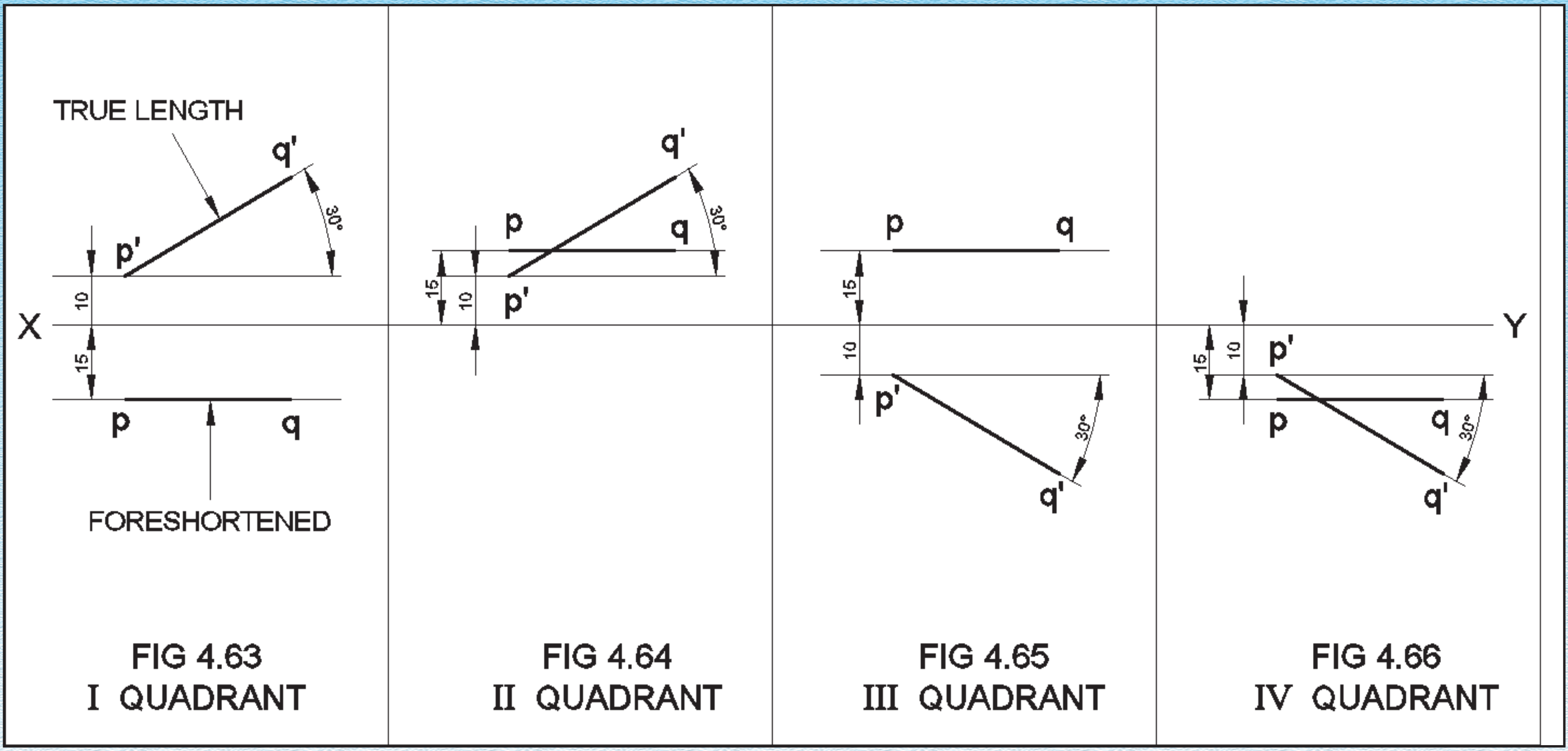


Fig. 4.63 Fig. 4.64 Fig. 4.65 Fig. 4.66

ASSIGNMENT

Draw the projections of the lines in the following positions, assuming each one to be of 40 mm length.

(a) Line CD is in V.P., || to H.P and end C is 30 mm above the H.P.

(b) Line EF is || to and 25 mm in front of V.P. and is in the H.P.

(c) Line GH is in both H.P. and V.P.

(d) Line JK is ⊥ to H.P. and 20 mm in front of V.P. The nearest point from the H.P. is J, which is 15 mm above H.P.

(f) Line UV is ⊥ to the VP, with the farthest end V from VP at 65 mm in front of VP and 20 mm above H.P.

ADDITIONAL ASSIGNMENT

*(a) Line AB || to the H.P. as well as the V.P, 25 mm behind VP and 30 mm below H.P.

*(b) Line LM is 30 mm behind VP and ⊥ to H.P. the nearest point from the H.P. is L, which is 10 mm above the H.P.

*(c) Line NP is 30 mm below the H.P. and ⊥ to V.P. the nearest point from the V. P. is P, which is 10 mm is front of V.P.

*(d) Line QR is 10 mm below the H.P. and ⊥ to V.P. the farthest point from V.P. is Q, 65 mm behind the V.P.

*(e) Line ST is ⊥ to the H.P. and behind the V.P. The nearest point from H.P. is S, which is 20 mm from V.P. & 15 mm below H.P.

* Question not to be asked in the exam.

4.6 PROJECTION OF PLANE FIGURES

Right from the earlier classes, you have been solving problems related to the plane figures (2D figures) like square, rectangle, triangle, circle, semi circle, quadrilaterals etc. We may recall that construction of these plane figures has also been done. In this section, we will introduce you to the projections of regular plane figures.

4.6.1 TYPES OF PLANES

Plane can be divided into two main categories viz (i) perpendicular planes (ii) Oblique planes

4.6.2 PERPENDICULAR PLANES

Planes which are perpendicular to one of the principal planes of projection and inclined or parallel to the other are called perpendicular planes. We are going to study the following positions and its projections.

(a) Planes perpendicular to V.P. and || to H.P.

(b) Planes perpendicular to H.P. and || to V.P.

(c) Planes perpendicular to both V.P. and H.P.

(d) Planes perpendicular to V.P. and inclined to H.P.

(e) Planes perpendicular to H.P. and inclined to V.P.

4.6.3 PROJECTIONS OF PERPENDICULAR PLANES

Similar to the sutdy of projections of points and lines in the earlier section, we are now going to study about the projection of plane figures in different positions.

Let us now see in detail the projections one by one.

4.6.3.1 PLANE PERPENDICULAR TO V.P. AND PARALLEL TO H.P.

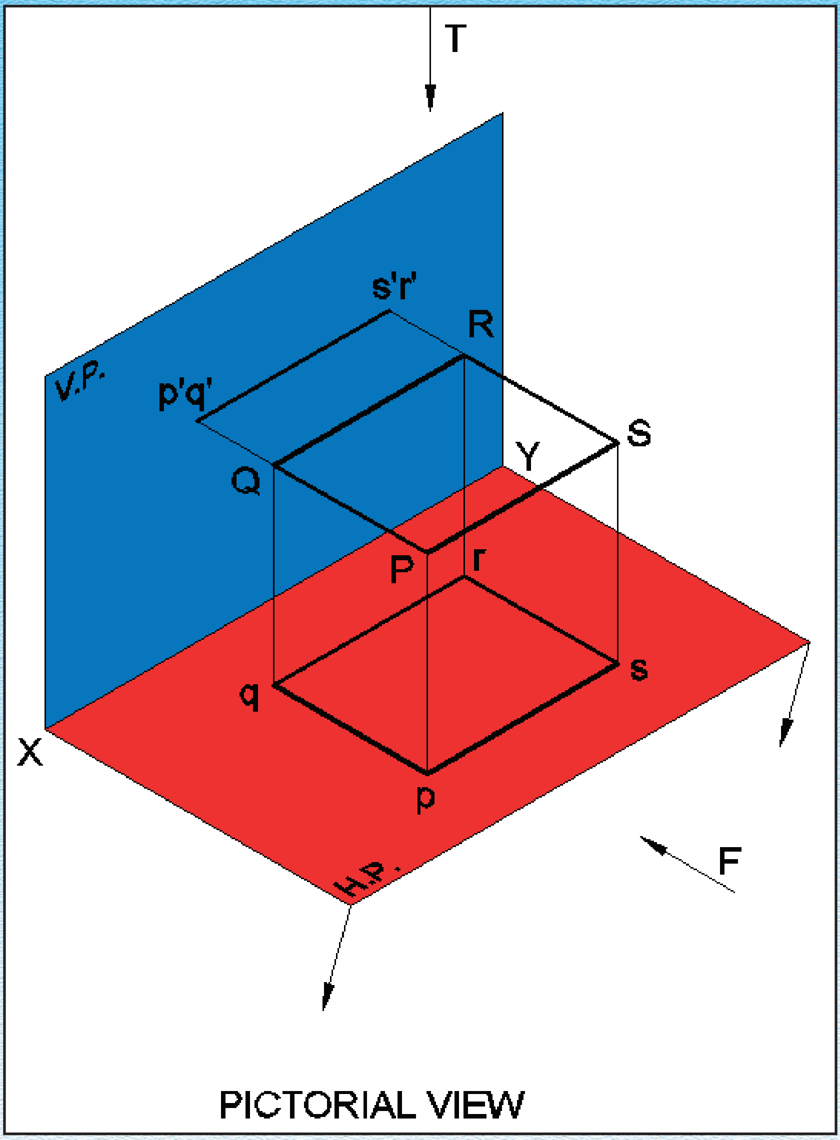


Fig. 4.67 Pictorial view

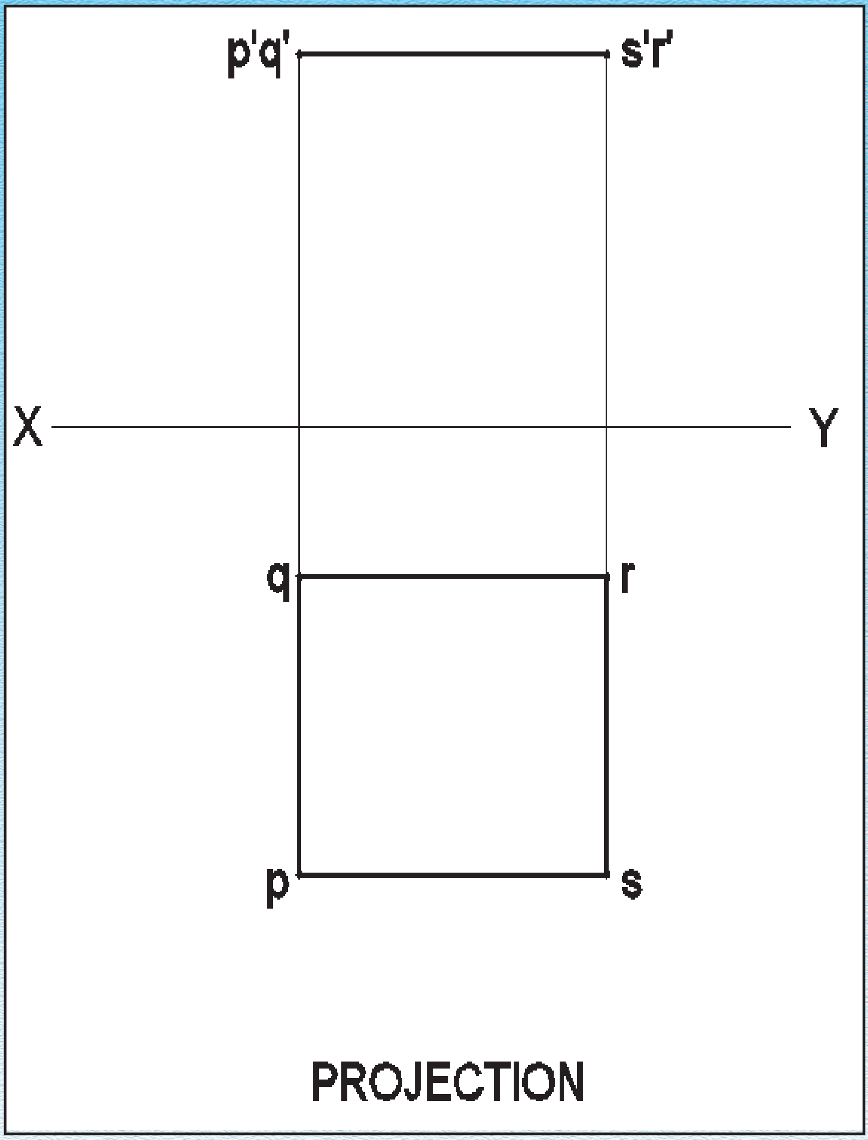


Fig. 4.68 Projection

The above given fig. 4.67, shows a plane PQRS in space, ⊥ to V.P. and is parallel to H.P.

- Its frontview p'q'r's' is a line || to XY line (see Fig. 4.68)
- Its Top View pqrs shows the actual size and shape of the plane.

Example 4.10 : An equilateral triangle ABC of 50 mm side has its plane parallel to H.P. and side AB parallel to V.P. Draw its projections when the corner C is 15 mm from H.P. and 45 mm from the V.P.

Solution : refer fig. 4.69

Step 1 : Draw a XY line.

Step 2 : Since the plane surface is parallel to H.P., Top View gives more detail of the object. So start with the Top View Place the Top View below XY such that side ab parallel to V.P. (i-e) parallel XY line.

Step 3 : Project the Top View above XY, to get the Front View, which is a line parallel to V.P. i-e parallel to XY.

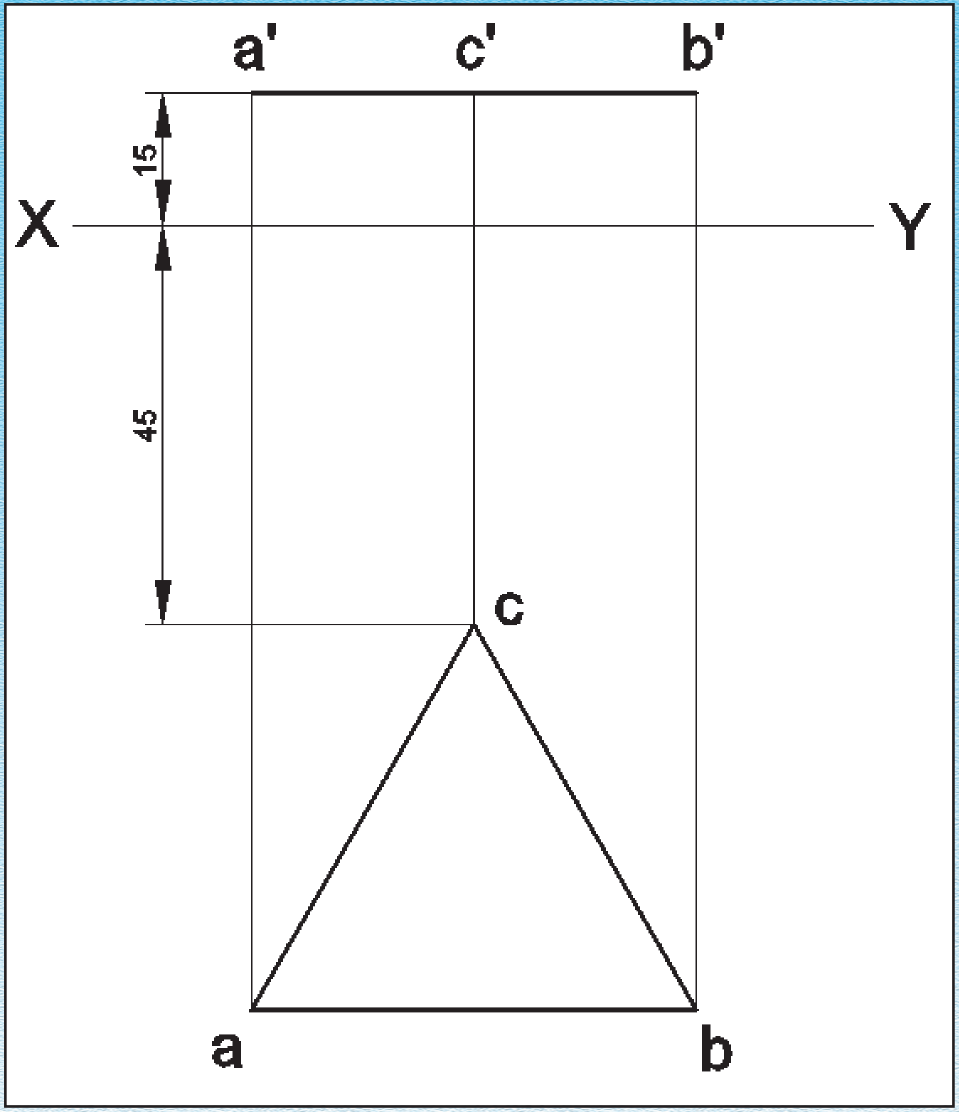


Fig. 4.69

4.6.3.2 PROJECTION OF PLANE PERPENDICULAR TO H.P. AND PARALLEL TO V.P.

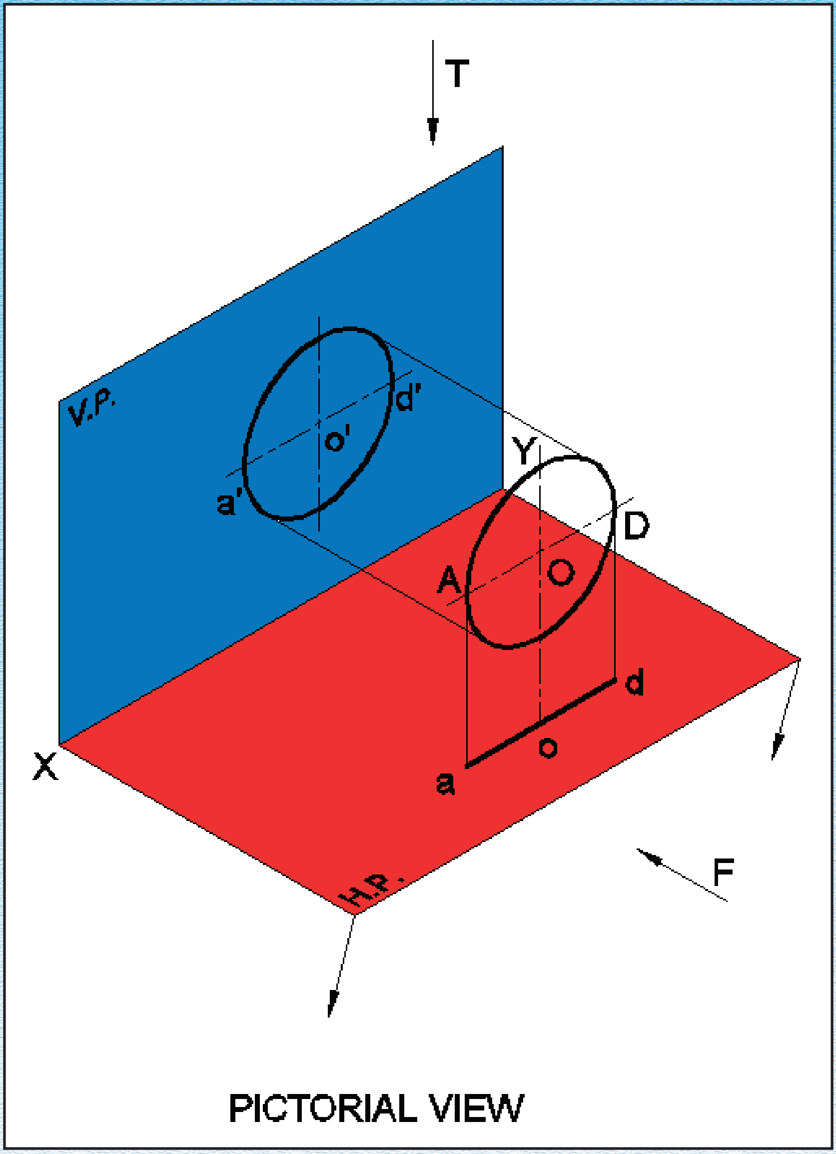


Fig. 4.70 Pictorial view

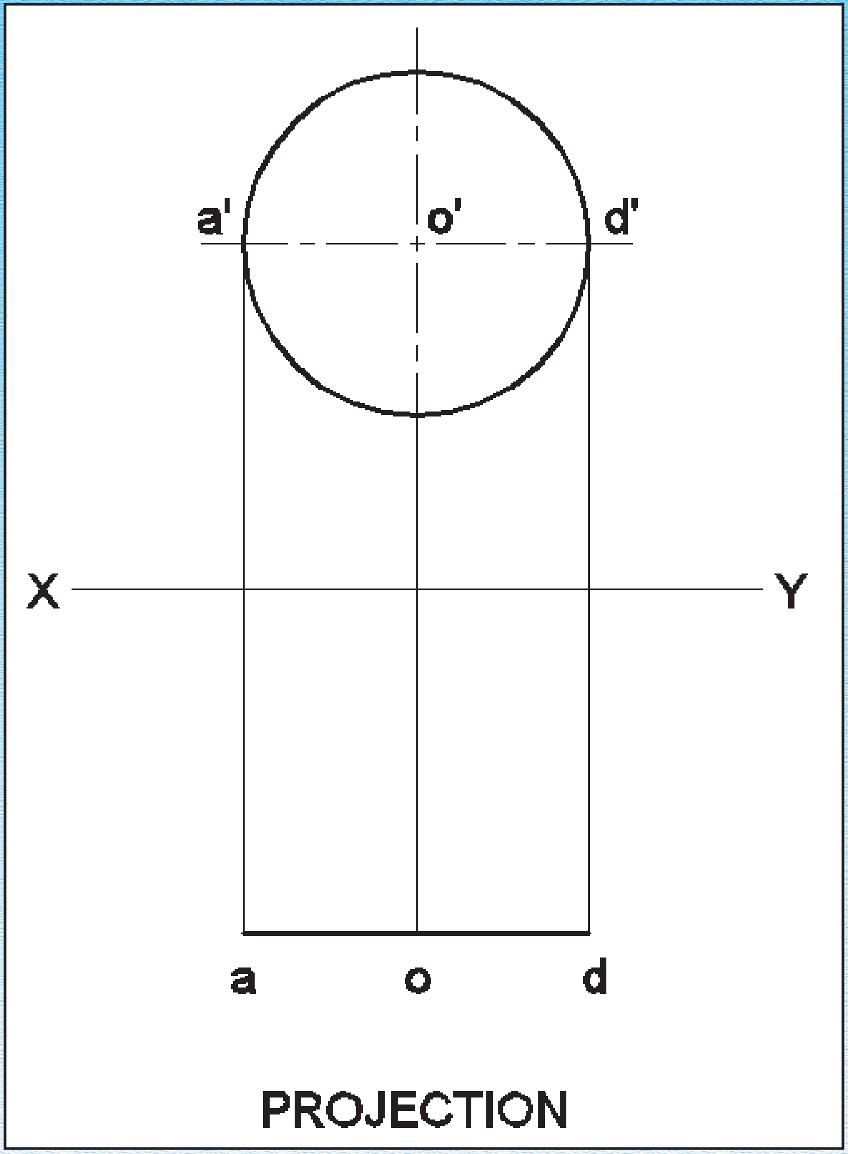


Fig. 4.71 Projection

Fig. 4.61 shows a plane figure, circle of diameter AD, in space, perpendicular to H.P. and parallel to V.P.

– Its Frontview shows the actual size and shape of the plane.
– Its Top View is a line parallel to XY line. Fig. 4.71

Example 4.11 : An equilateral triangle ABC of 50 mm side is parallel to and 15 mm in front of V.P. Its base AB is || to and 75 mm above H.P. Draw the projections of the Δ when the corner c is near the H.P.

Solution : refer fig. 4.72

Step 1 : Draw a XY line.

Step 2 : We understand from the given question that the surface is parallel to V.P. Hence start with the Front View which gives true shape and size of the object. Point C′ is near the H.P., So complete the Δ with C′ near the XY.

Step 3 : Project down the Top View from the Front View, which is a line parallel to XY line.

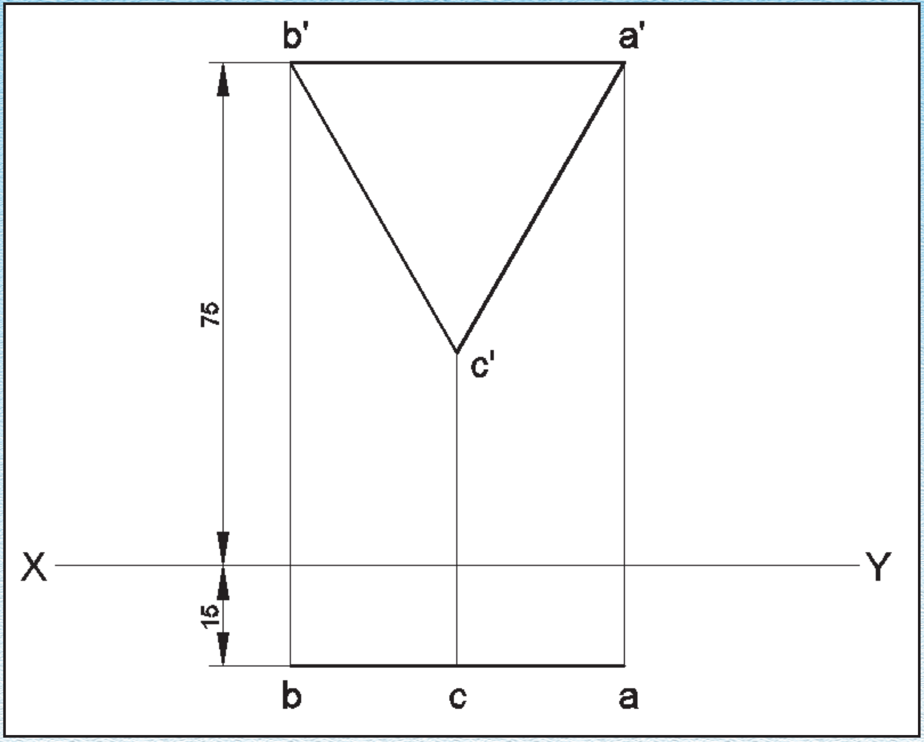


Fig. 4.72

4.6.3.3 PROJECTION OF PLANE PERPENDICULAR TO BOTH H.P. AND V.P.

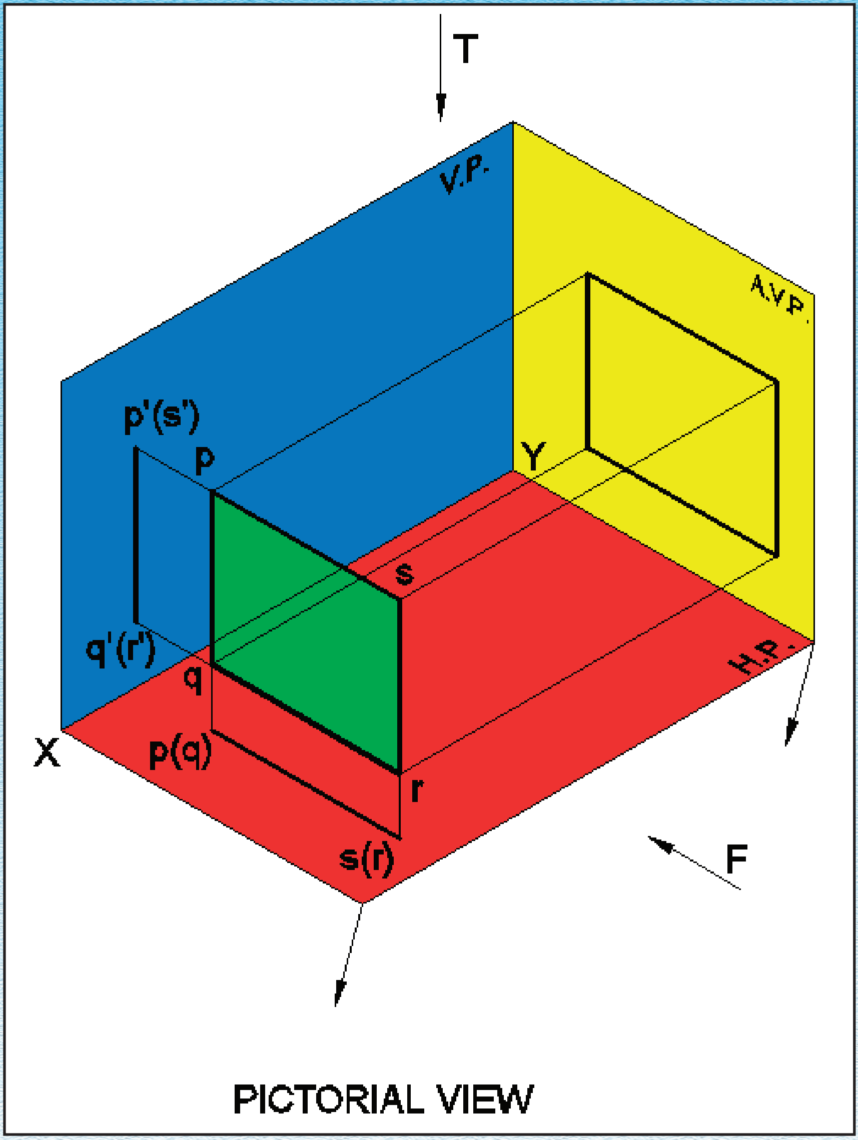


Fig. 4.73 Pictorial view

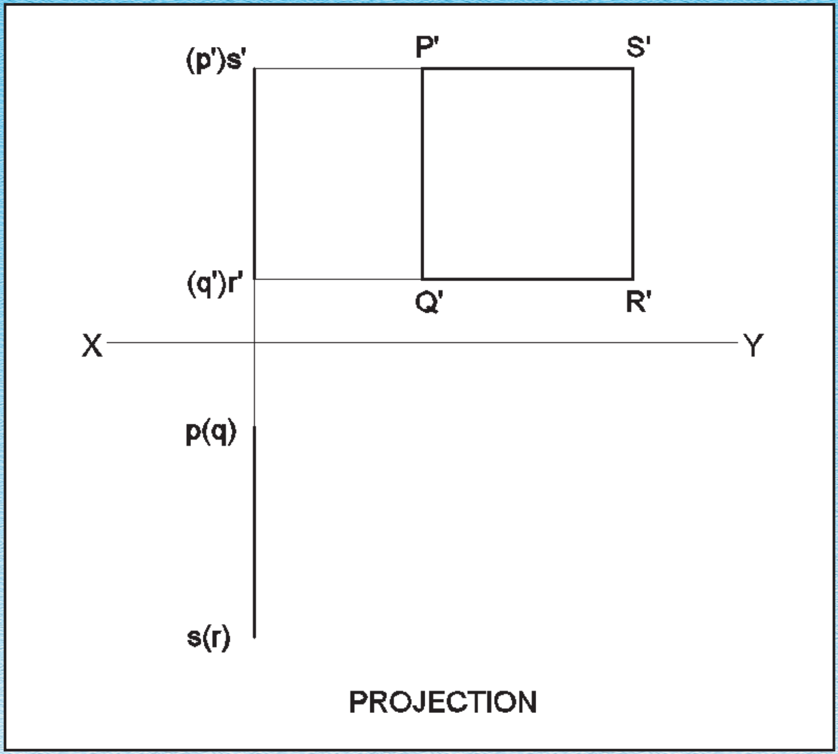


Fig. 4.74 Projection

Fig. 4.64 shows a plane figure, square PQRS in space perpendicular to both V.P. and H.P.

– Its Front View and Top View do not reveal the entire detail of the object. So a helping view/side view which shows more detail should be drawn first.

– The helping view is a square and is projected to frontview and Top View. Both Front View and Top View are line ⊥ to XY, and their length equal to the length of the side of square.

Example 4.12 : A semicircle of diameter, CD = 50 is kept in the I quadrant such that its diameter is perpendicular to V.P. and H.P. Draw its peojections, when the diameter is near V.P. Distance of diameter from H.P. is 15 mm and from V.P. is 20.

Solution : refer fig. 4.75 & 4.76

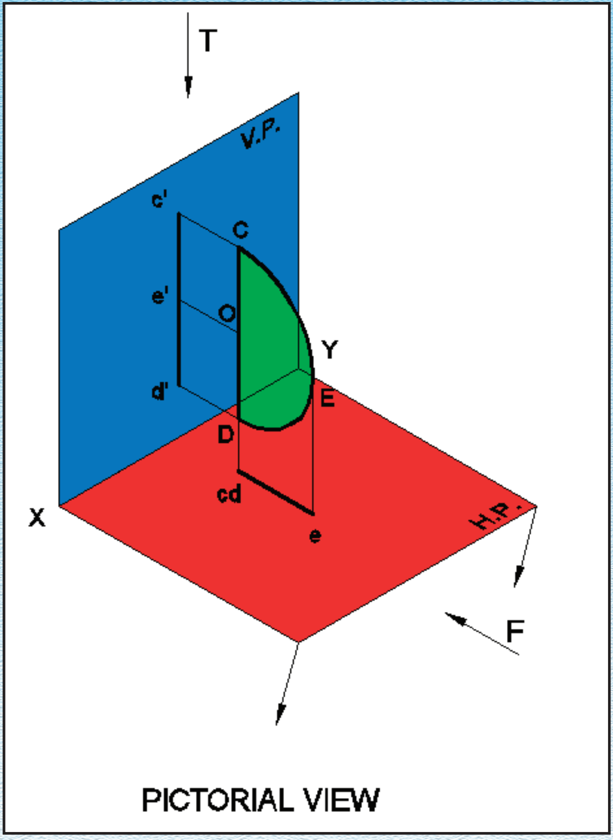


Fig. 4.75 Pictorial view

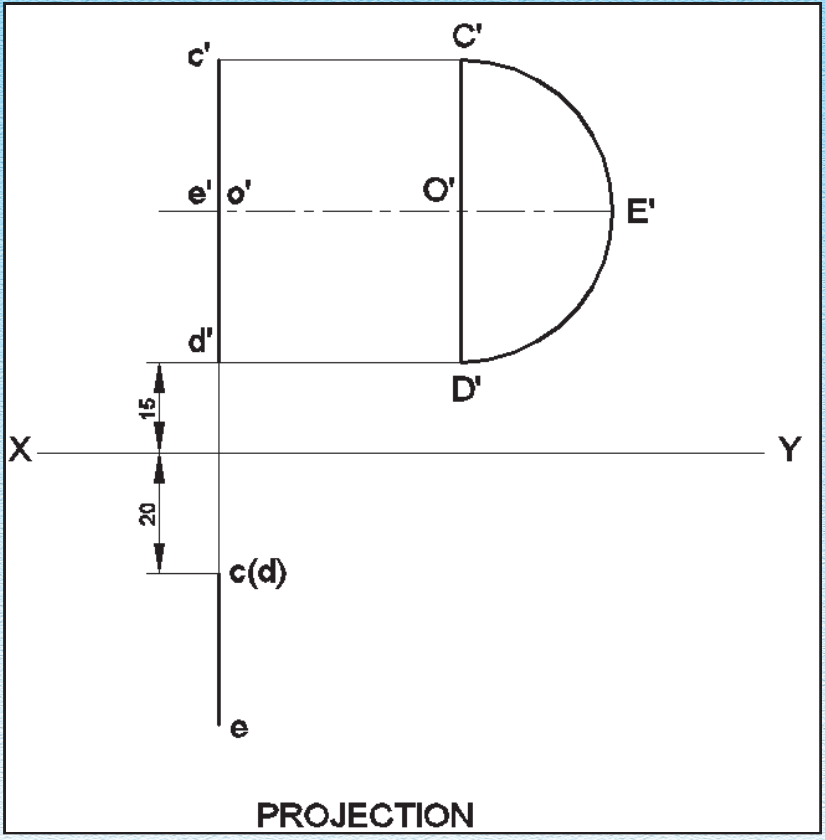


Fig. 4.76 Projection

Fig. 4.75 shows the pictorial view of the semicircle. Fig. 4.76 shows its projections.

- Its Front View is a line perpendicular to XY and is equal to the length of diameter.
- Its Top View is also a line perpendicular to XY and is equal to the radius of the semicircle.

DO THIS

Take a drawing sheet from your sketch book can you guess the shape of this lamina? Now keep the drawing sheet on the table such that the table acts as H.P and the wall acts as V.P. Then study the projections of the drawing sheet in the following positions, as shown below.

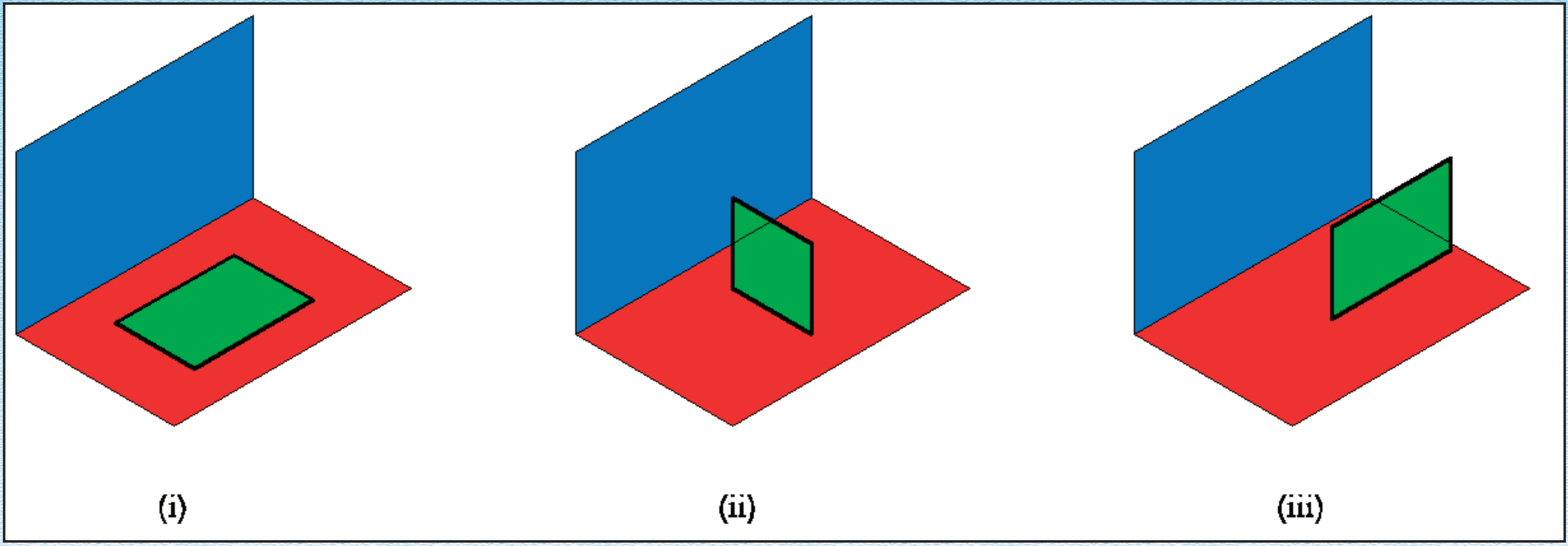


Fig. 4.77

Record your observations in the following table

S.No.	Position	Front View	Top View
(i)	Surface parallel to H.P.	a line parallel to XY	lamina of true size
(ii)	....	....	....
(iii)	....	....	....

4.6.3.4 PROJECTION OF PLANE PERPENDICULAR TO V.P. AND INCLINED TO H.P.

Fig. 4.78 shows the pictorial view of a square lamina (plane figure) which is inclined to H.P. at an angle θ and $\perp$ to V.P.

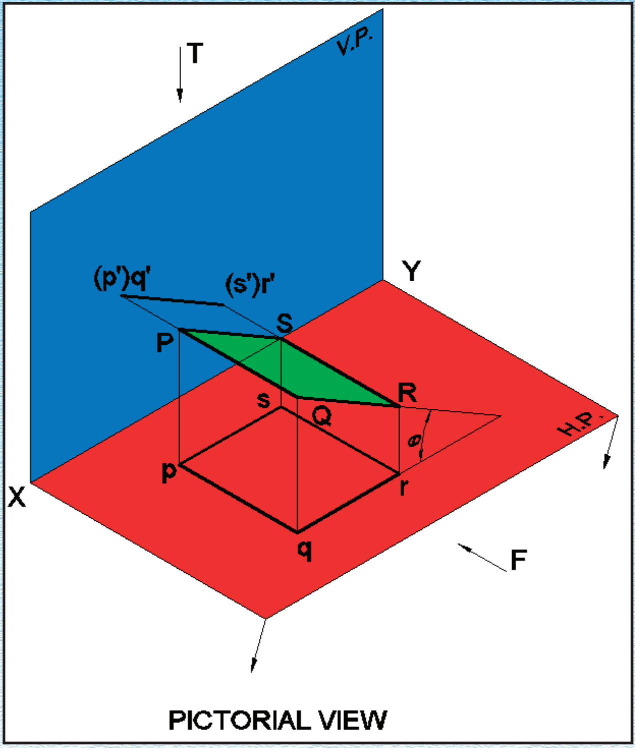


Fig. 4.78

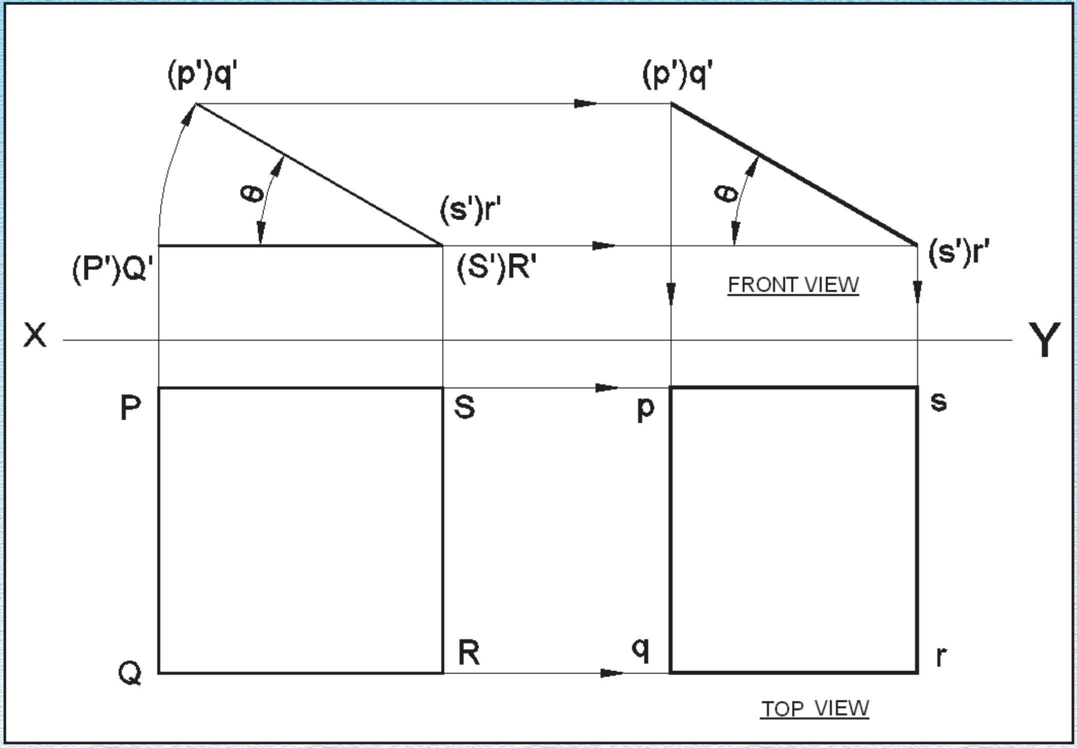


Fig. 4.79

Fig. 4.78 Shows the pictorial view of a square lamina, which is inclined to H.P. at an angle θ, and ⊥ to V.P.

The projection in this case is done in two stages. First, assume that the surface is || to H.P. and draw the Top View which is a square of true size, then project its corresponding Front View which is a line || to XY line.

Secondly, change the Front View to the required inclined line at an angle θ with XY line. Then project down its Top View which is a rectangle.

Example 4.13 : A thin horizontal plate of 15 mm sides is inclined at 45° to the H.P. and ⊥ to V.P. two of its parallel edges is parallel to V.P. the plate is 10 mm above H.P. and 15 mm in front of V.P. Draw the projections of the plate.

Solution : refer fig. 4.80

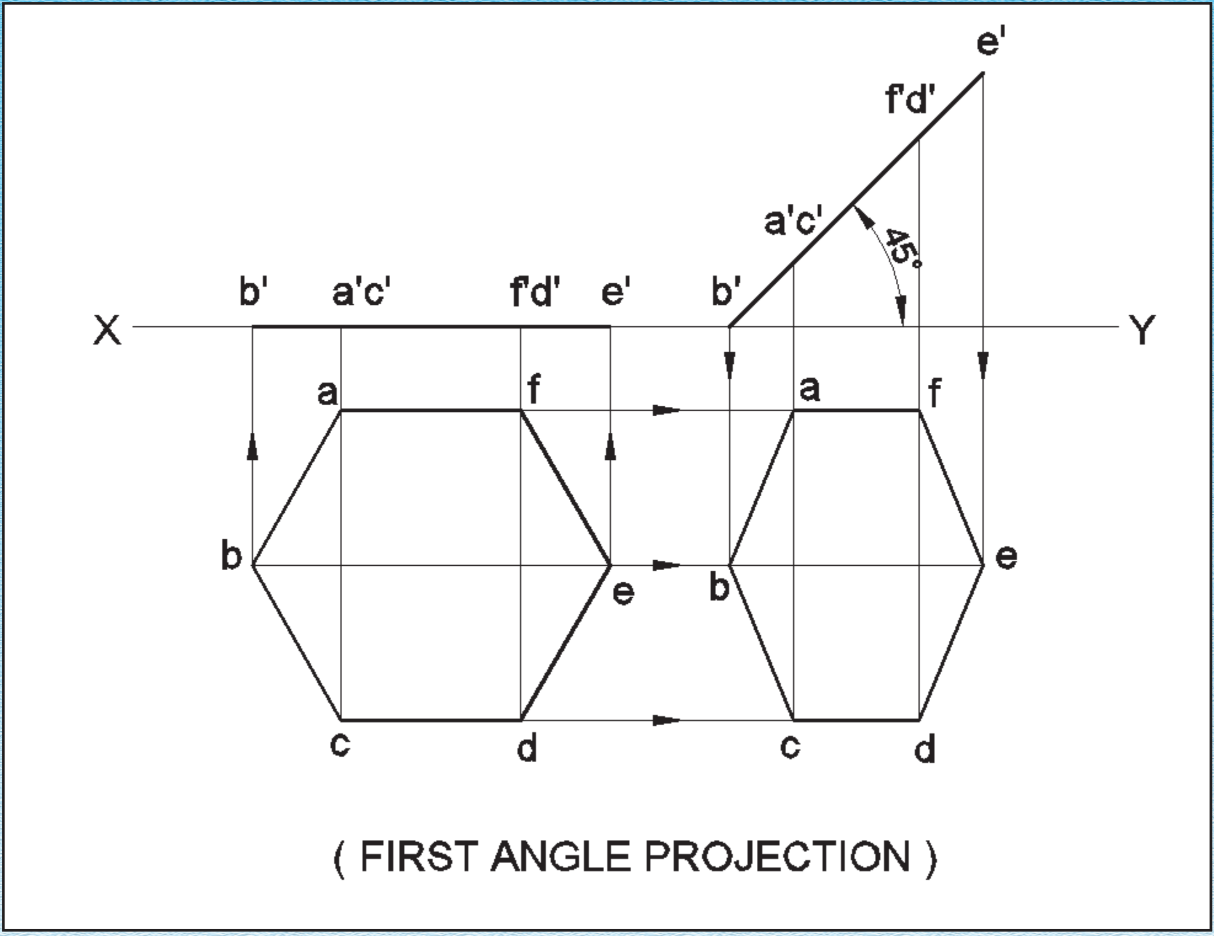


Fig. 4.80

Step 1 : Draw a XY line.

Step 2 : Assume that the plate is || to H.P., then draw its Top View which is a true hexagon.

Step 3 : Project the topview to get the Front View which is a line || to XY.

Step 4 : Change the Front View now to the angle 45° with XY. This view is an inclined line with true length.

Step 5 : Project the required Top View from the previous views. This Top View is compressed hexagon.

4.6.3.5 PROJECTION OF PLANE PERPENDICULAR TO H.P. AND INCLINED TO V.P.

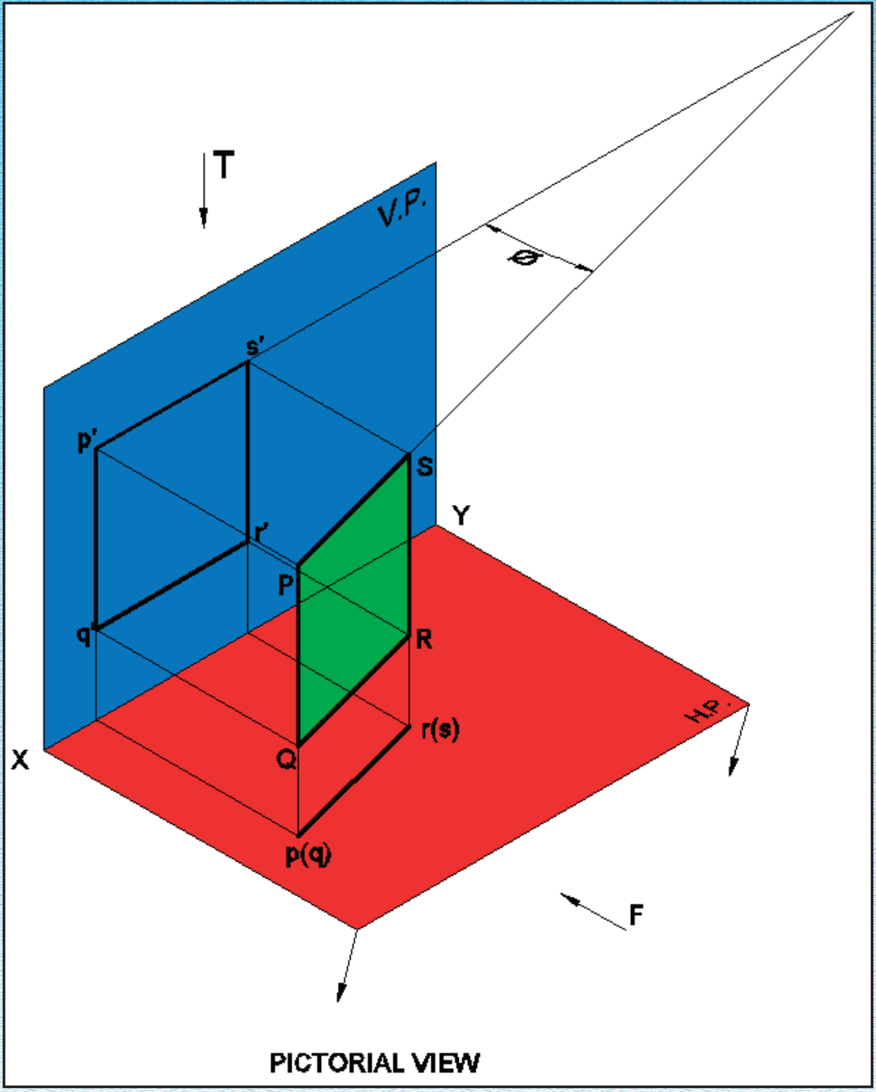


Fig. 4.81

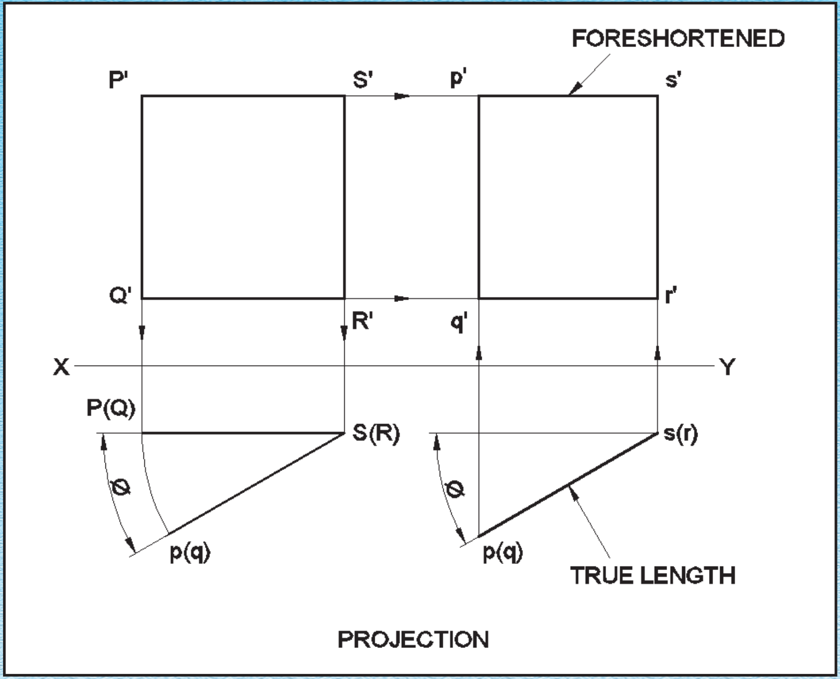


Fig. 4.82

The projection in this case (Fig. 4.81) is done in two stages.

- First assume that the surface is parallel to V.P. and start with its frontview. It is a square with true size. Then project down its Top View which is a line parallel to XY.
- Then tilt the Top View to the required inclination in angle ϕ with XY. Project the Front View from the topview. Front View is a rectangle.

Example 4.14 : Draw the projections of a circular lamina of 30 mm dia. The lamina is inclined at an angle of 45° to V.P.

Solution : refer fig. 4.83

Step 1 : Draw a XY line.
Step 2 : Assume that the lamina is parallel to V.P., So, start with its Front View, which is a circle of true size.
Step 3 : Project the Front View down to get Top View which is a line parallel to XY.
Step 4 : Tilt this Top View to the given inclination, $\phi = 45°$
Step 5 : Project the Front View from this Top View. Front View is a foreshortened circle.

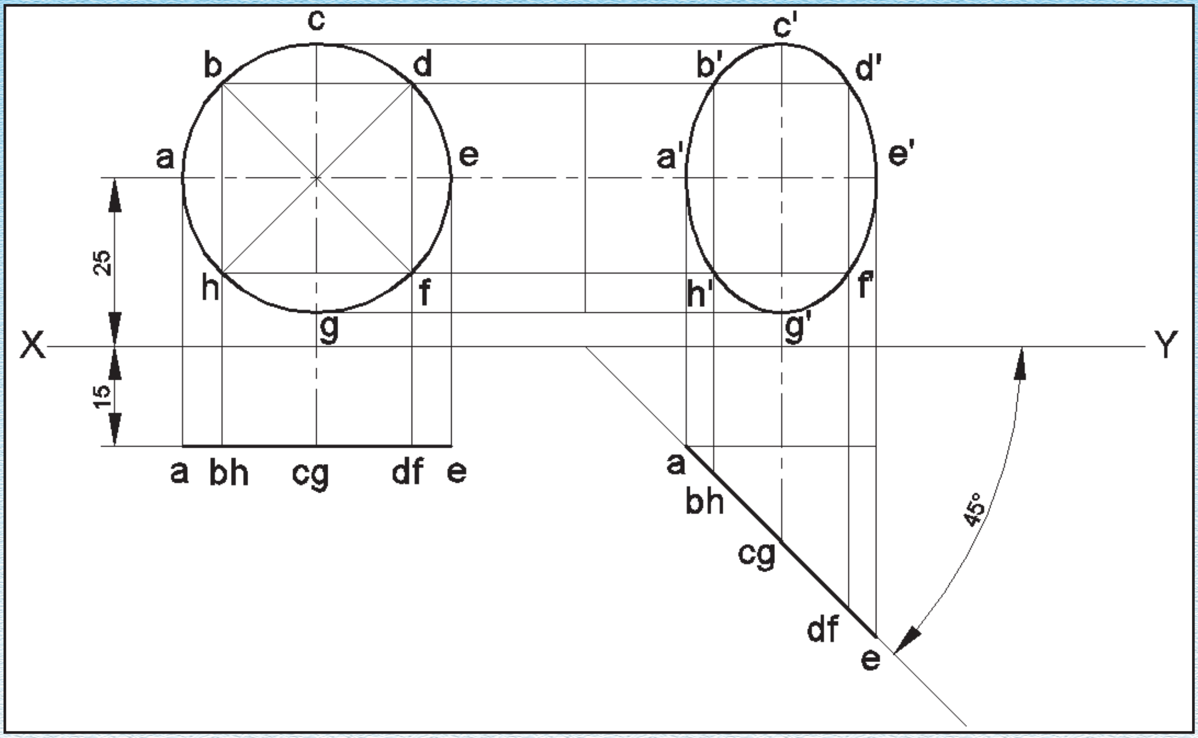


Fig. 4.83

WHAT WE HAVE DISCUSSED

– In this section, we have studied about the projections of plane figures in different positions.

PROJECTION OF PLANES PARALLEL TO ONE OF THE REFERENCE PLANES

The plane will show its true shape on the reference plane "to which it is parallel". The true shape of the plane in that reference plane to which it is parallel is drawn first" and the other view which will be a line is projected from it.

PROJECTION OF PLANES INCLINED TO ONE REFERENCE PLANE AND PERPENDICULAR TO THE OTHER

Projection of such plane is carried out in two stages. In first stage, "the plane is assumed to be parallel to that reference plane to which it is inclined". In the second stage the " Plane is tilted to the required inclination to that reference plane"

DO YOU KNOW?

PROJECTIONS OF OBLIQUE PLANES

When the plane is inclined to both the ref. planes, its projections are drawn in three stages.

– In the first stage, the plane is assumed to be || to H.P.

– In the II stage, it is titled so as to make the required angle with the H.P. Its Front View in this position will be a line while its topview will be smaller in size. (compressed)

– In the III stage the plane is turned to the required inclination with the V.P., only the position of the Top View will alter. Its shape and size will not be affected.

The projections are then completed and the corresponding distances of all the corners from XY will remain the same as in the Front View.

Let's solve one example to understand it clearly.

Draw the projections of a regular hexagon of 20 mm side, having one of its sides in the H.P. and inclined at 45° to the V.P.; and its surface making an angle of 30° with the H.P.

Solution : refer Fig. 4.84

I Stage : Draw the proj of a regular hexagon of 20 mm side in the Top View with one side ⊥ to XY. Project the Front View d'f' in XY.

II Stage : Now draw d'f' inclined at 30° to XY keeping d' in XY and project the Top View.

III Stage : Reproduce the Top View of 2nd stage by making c_1d_1 inclined at 45° to XY. From this project Front View, as shown in the Fig. 4.84.

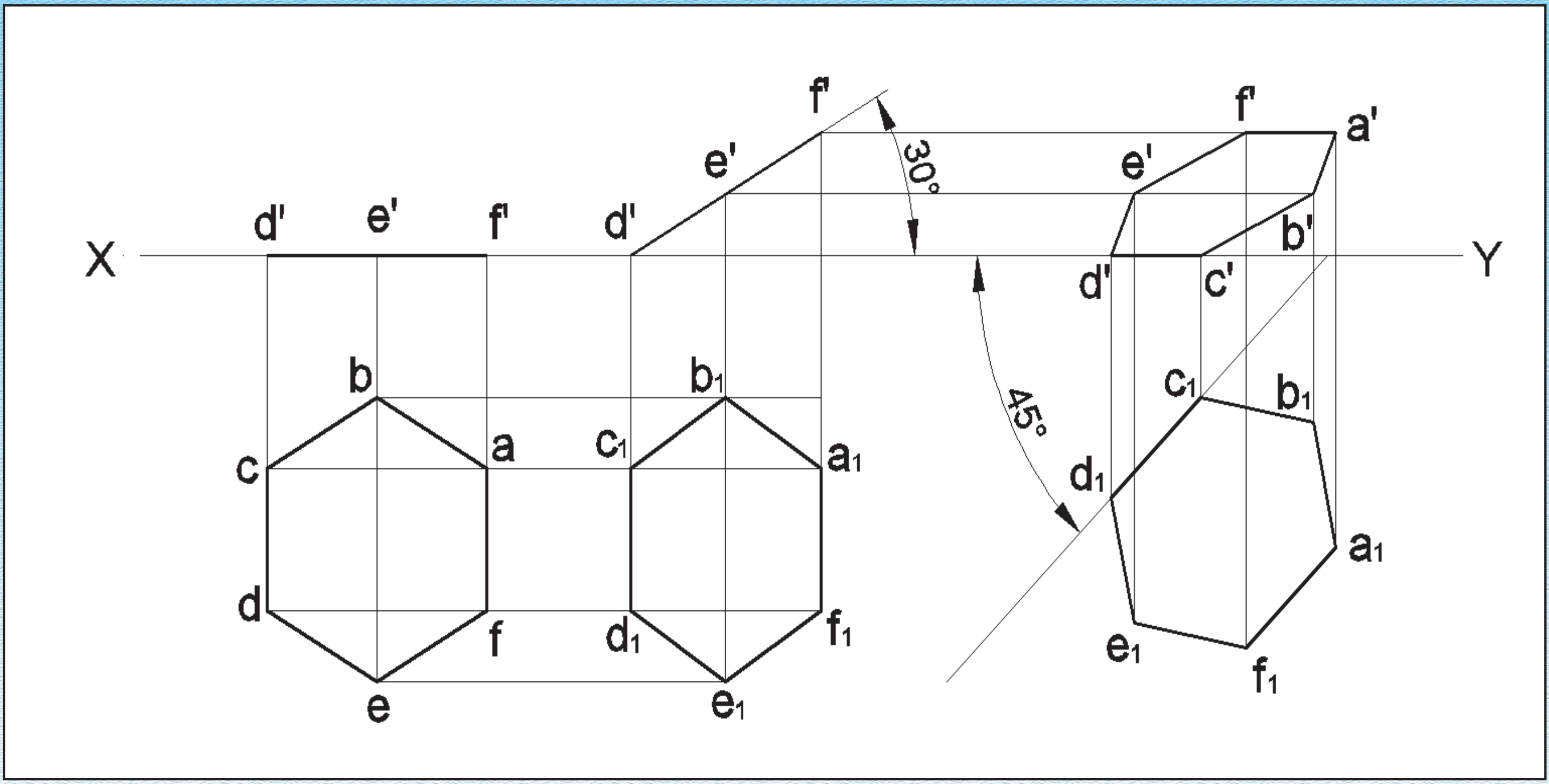


Fig. 4.84

WHAT WE HAVE LEARNT

S.No.	Position of Plane Surface	Number of Steps
1.	Parallel to the V.P., perpendicular to the H.P. Parallel to the H.P., perpendicular to the V.P.	One
2.	Perpendicular to the H.P., inclined to the V.P. Perpendicular to the V.P., inclined to the H.P.	Two
3.	Inclined to the H.P., inclined to the V.P.	Three

ASSIGNMENT

Q1. A thin pentagonal plate of 35 mm sides is inclined at 30° to the HP and perpendicular to the V.P. One of the edges of the plate is $\perp$ to V.P. 20 mm above the H.P. and its one end, which is nearer to the V.P., is 30 mm in front of the later. Draw the projections of the plate.

Q2. Draw the projections of a triangular lamina of 30 mm sides, having one of its sides AB in the VP and with its surface inclined at 60° to the V.P.

Q3. A square plate with 35 mm sides is inclined at 45° to the V.P. and $\perp$ to the H.P. Draw the projections of the plate if one of its corners is in the V.P. and the two sides containing that corner are equally inclined to the V.P.

Q4. A hexagonal plate of 30 mm sides is resting on the ground on one of its sides which is parallel to the V.P. and surface of the lamina is inclined at 45 degrees to H.P. Draw its projections.

Q5. A rectangular lamina measuring 25 mm $\times$ 20 mm is parallel to and 15 mm above H.P. Draw the projections of the lamina when one of its longer edges makes an angle of 30° to V.P.

Q6. Draw the projections of a circle of 30 mm diameter, having its plane vertical and inclined at 30° to the V.P. Its centre is 25 mm above the H.P. and 20 mm in front of V.P.

4.7 PROJECTION OF SOLIDS

After having the study of projections of points, lines and planes, we can now proceed to the projection of solids. Solids are kept in different positions and its projections are done in the following topics.

4.7.1 PROJECTION OF SOLIDS WHEN ITS AXIS PERPENDICULAR TO ONE REF. PLANE AND II TO THE OTHER

Case (i) Axis perpendicualr to the H.P. & Parallel to the V.P.

Suppose a cone rests on H.P. with its base (Fig. 4.85) and axis perpendicular to H.P., the projections are done as shown in Fig. 4.86

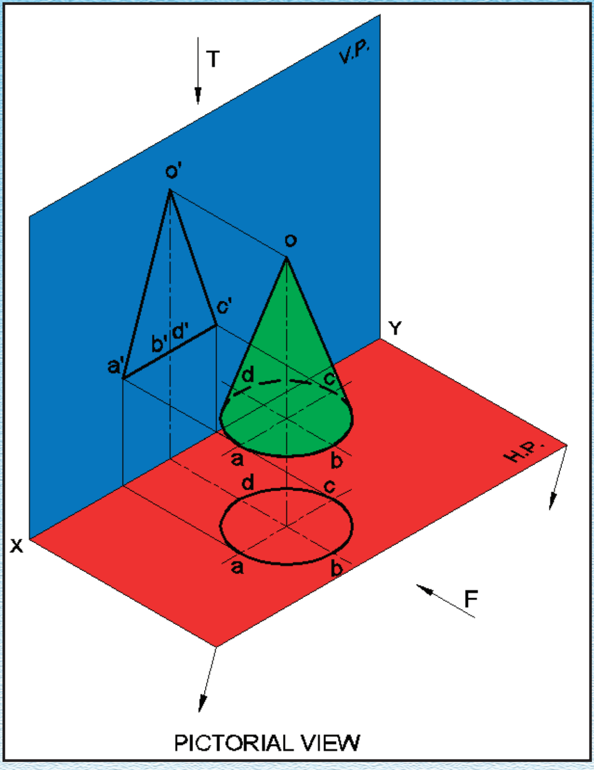


Fig. 4.85

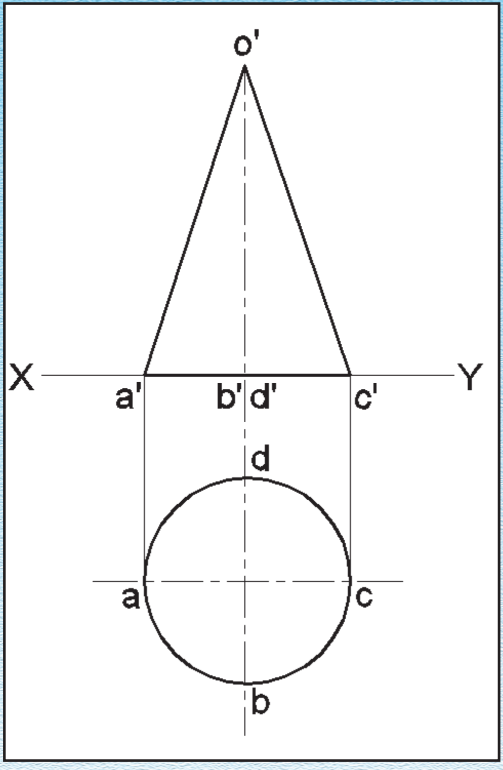


Fig. 4.86

Since the Top View shows more detail of the object, the Top View should be drawn first and then the Front View is to be projected from it.

DO YOU KNOW ?

In third angle projections, the solid can not rest easily but it will fall down as it has got no support. In order to place the solid in correct position, a third plane || to H.P. is considered and is known as Auxiliary Horizontal plane (A.H.P.) is also known as ground plane.

Example 4.15 : Project the frontview and topview of a hexagonal prism of 25 mm base edges and 50 mm height, having two of its vertical rectangular faces parallel to V.P. and its base resting on H.P.

Solution : refer fig. 4.87

Steps Involved :

Here the base of the solid rests on H.P., So its axis is ⊥ to H.P.

(i) Start with the Top View, which is a hexagon of side 25 mm

(ii) Project the Front View from the Top View, which comprises three rectangles.

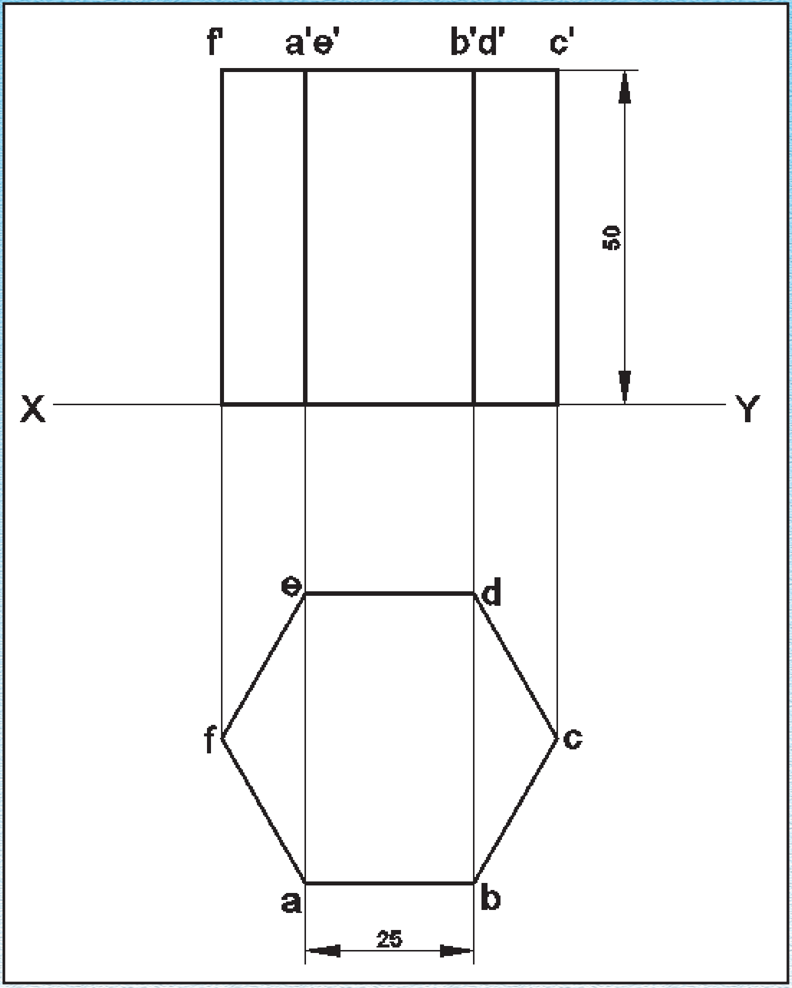


Fig. 4.87

Example 4.16 : A cube of 40 mm long edge rests on H.P. and its vertical faces are equally inclined to V.P. Draw the projections of the solid.

Solution : refer fig. 4.88

Steps (i) Start with the Top View

Construct a square on a line 'ad' 40 mm long and inclined at 45° to XY line.

(ii) Project the Top View above XY to get the Front View which comprises 2 rectangles.

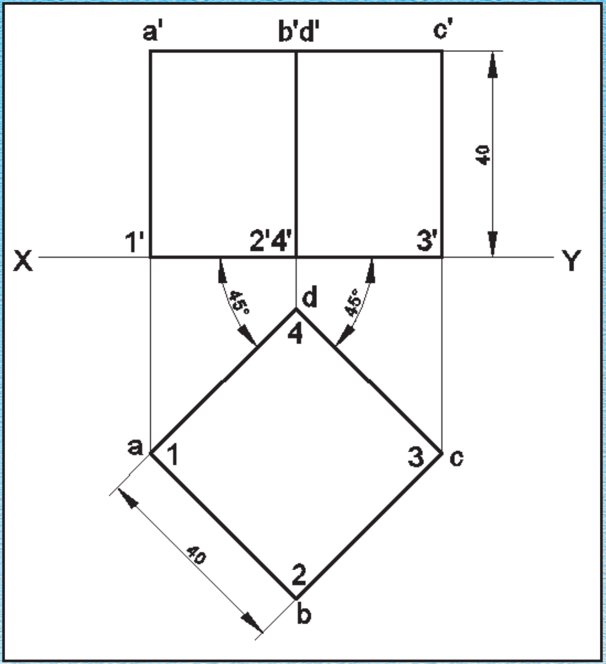


Fig. 4.88

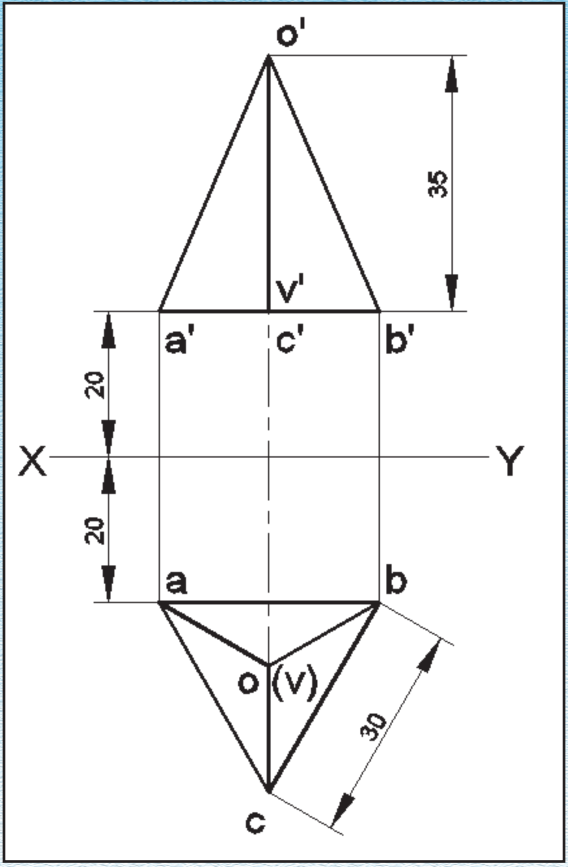


Fig. 4.89

Example 4.17 : A triangular pyramid with 30 mm edge at its base and 35 mm long axis resting on its base with an edge of the base near the VP, parallel to and 20 mm from the V.P. Draw the projections of the pyramid, if the base is 20 mm above the H.P.

Solution :

Given Data

– Triangular pyramid, 30 × 35 mm

– Base on ground, ∴ axis perpendicular to HP and base || to the HP. We recall the fact that, the projections of vertical solids to be started with the Top View.

Steps

(i) Draw an equilateral triangle.

(ii) Name its corners and mark its centre O.

(iii) Complete the Top View by drawing lines joining the Centre with the corners.

(iv) Now, project the Front View as shown in the fig. 4.89

Example 4.18 : Project the Front View and Top View of a sphere of 50 mm diameter, resting on the H.P.

Solution : see fig. 4.90

We should remember the fact that the projection of a sphere in any position, on any plane is always a circle whose diameter is equal to the diameter of the sphere.

∴ Draw a circle each for Front View and Top View which are the required projections.

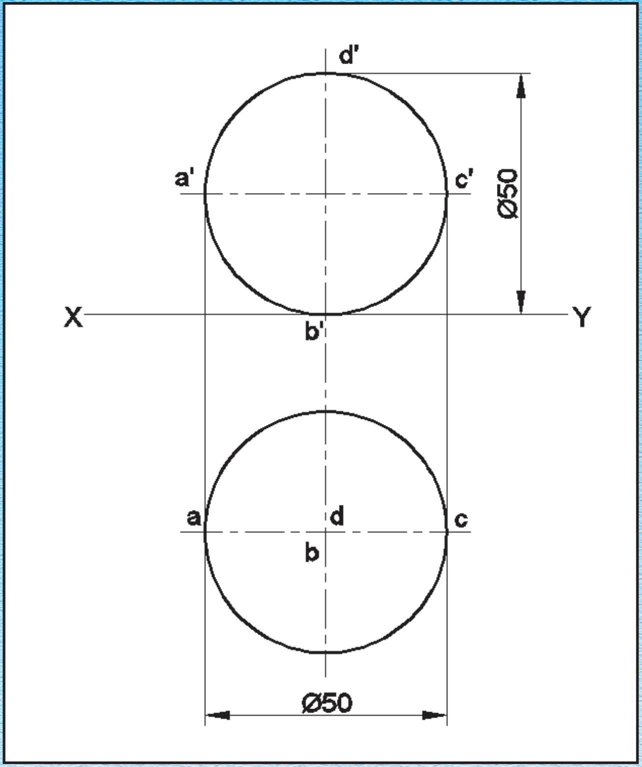


Fig. 4.90

Example 4.19 : The frustom of a cone with base dia = 50 mm, top face diameter = 25 mm and vertical axis = 30 mm is resting on its base on H.P. Project its Front View and Top View.

Solution : see fig. 4.91

Given Data

– Frustum of a cone.

– Resting on H.P., so axis ⊥ to H.P.

(i) Start with the Top View Draw two concentric circles of ϕ 25 and ϕ 50.

(ii) Project the Top View above to get the Front View, which is a trapezium.

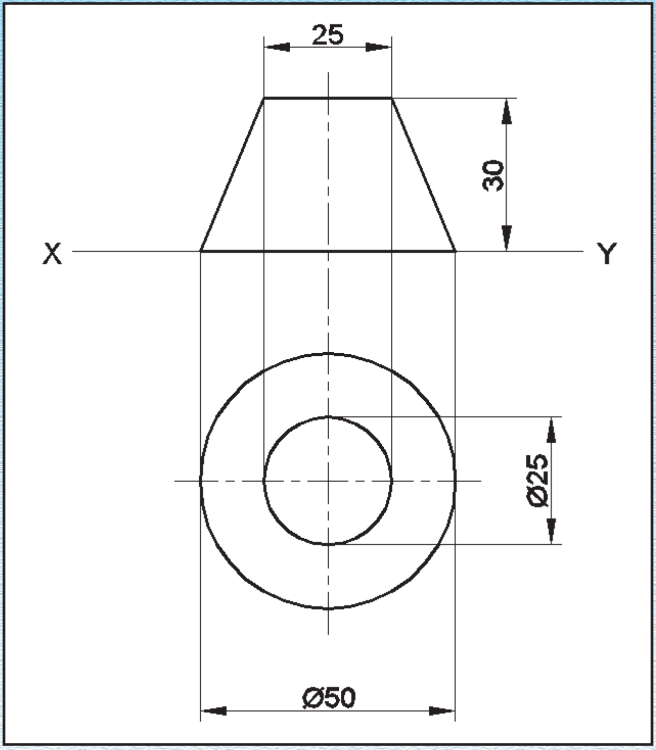


Fig. 4.91

ASSIGNMENT

1. Project the Front View and Top View of a square prism of 35 mm base edges and 50 mm vertical height, rests on H.P., with two of its vertical rectangular faces parallel to V.P.

2. A triangular prism of 40 mm base edges and 60 mm height, standing on its on H.P. with one of its vertical rectangular faces on the rear, || to V.P. Draw its projections.

3. Draw the projections of a cylinder, which rests on H.P. on its base, with 30 mm base dia and 40 mm long axis.

4. Project the Front View and Top View of a hemisphere which rests on H.P. with its circular face on Top. (ϕ = 60 mm)

5. Project the Front View and Top View of the frustum of a hexagonal pyramid, of 25 mm base edges and 70 mm height, cut at mid-height, parallel to its base.

Case (ii) Axis perpendicular to the V.P. & parallel to the H.P.

Suppose a cylinder is kept in I quadrant in such a way that, the axis is ⊥ to V.P. (Fig. 4.92), its projections are done as shown in Fig. 4.93

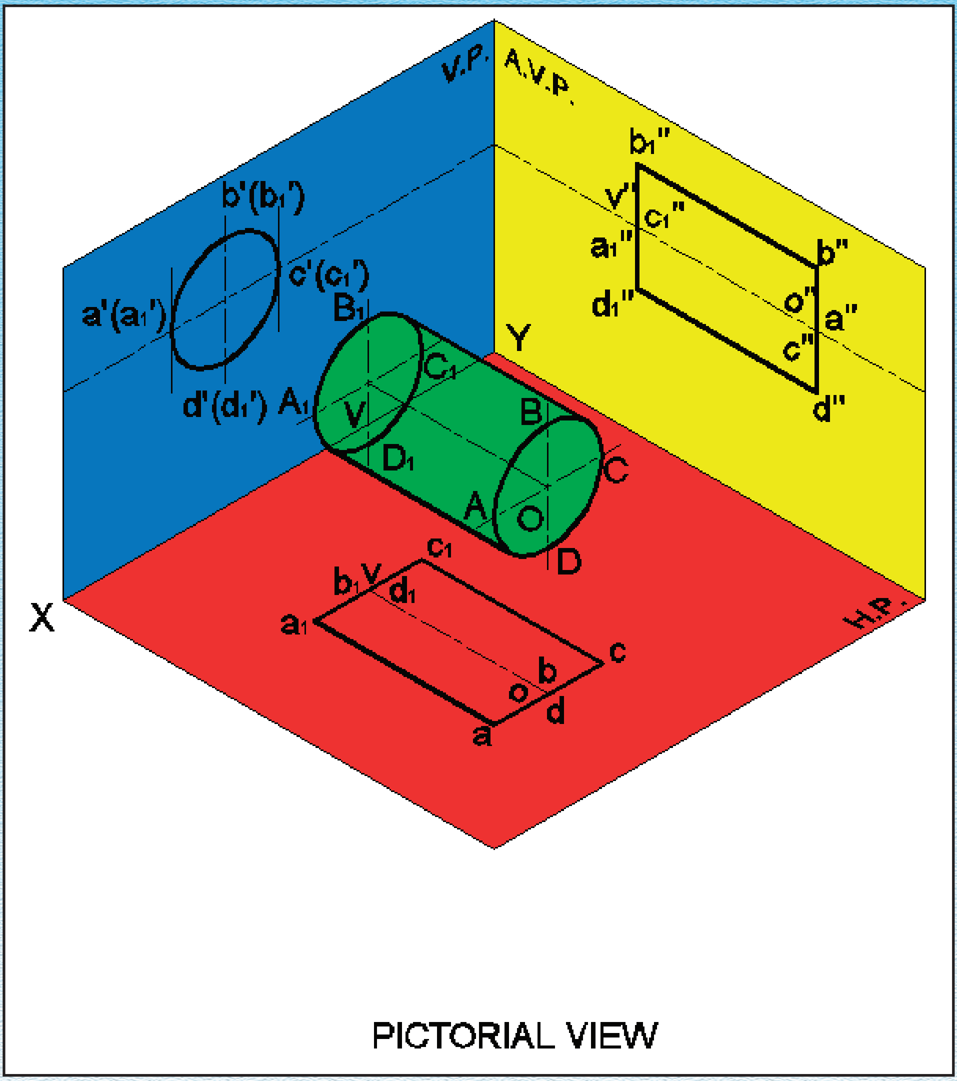


Fig. 4.92

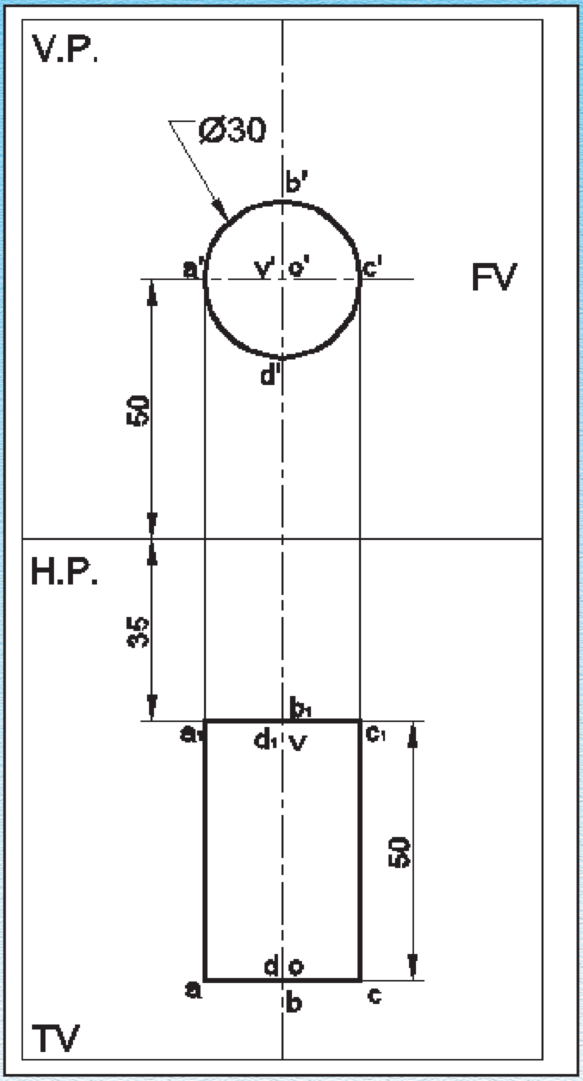


Fig. 4.93

Here Front View shows more details of the object, so the Front View should be drawn first and then the Top View is to be projected from it.

Example 4.20 : Draw the frontview and topview of a square pyramid of base edge 40 mm and axis 50 mm long, which is perpendicular to V.P., and the vertex is in front.

Solution refer Fig. 4.94

GIVEN DATA

- Square pyramid
- axis ⊥ to V.P.
- Vertex in front

(i) Since axis perpendicular to V.P., start with the Front View, which is a square with four triangular faces, in it.

(ii) Project down the Front View to get the Top View. Top View is a triangle showing one of the triangular face of the pyramid.

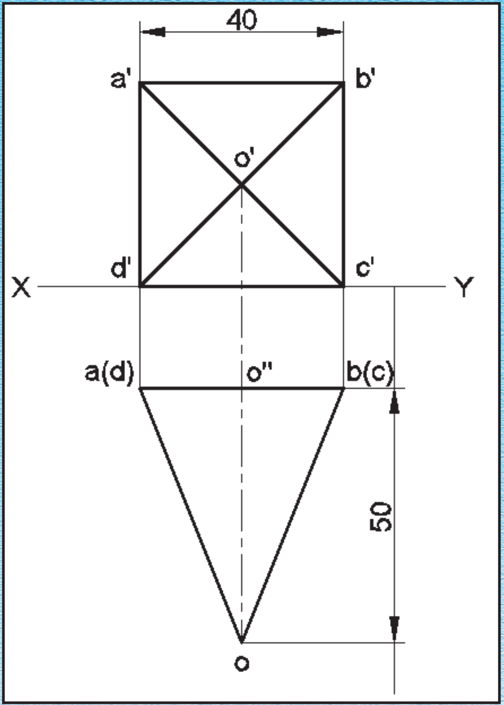


Fig. 4.94

Example 4.21 : A hexagonal prism, base 20 mm side and axis 40 mm long is lying on one of its rectangular faces. Its axis is perpendicular to V.P. and 25 mm above the ground. The nearer end is 20 mm in front of V.P. Draw its projections.

Solution refer Fig. 4.95

GIVEN DATA

- hexagonal prism
- axis ⊥ to V.P.

Since the axis is perpendicular to V.P., Front View to be drawn first.

(i) Front View is a hexagon

(ii) Front View is projected down to get the Top View which comprises 3 rectangles.

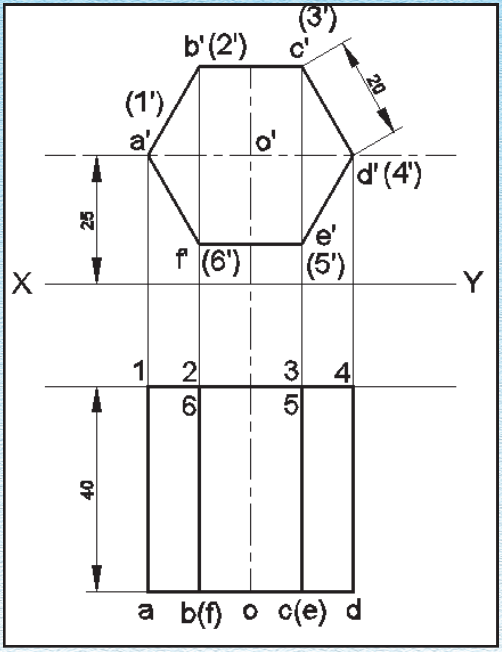


Fig. 4.95

Example 4.22 : The frustum of a cone of 40 mm base diameter and 20 mm cut face diameter, rests on H.P. with its 40 mm long axis parallel to H.P. and at right angles to V.P. the cut face is in front. Project its Front View and Top View.

Solution refer Fig. 4.96

GIVEN DATA

- Frustum of a cone
- axis ⊥ to V.P.
- cut face is in front

(i) Draw a XY line

(ii) Draw 2 concentric circles of diameter 20 and 40 above XY which is the required Front View

(iii) Project down the Top View which is in the shape of a trapezium.

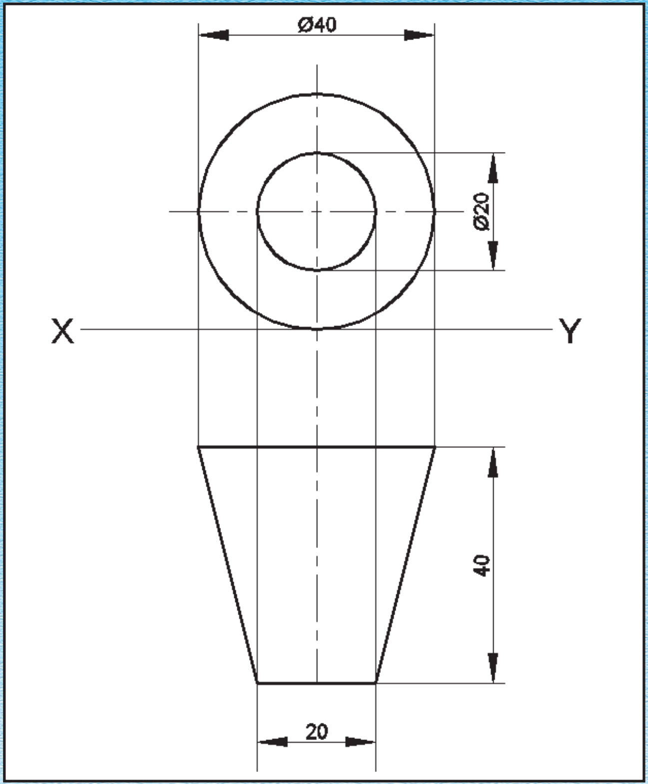


Fig. 4.96

ASSIGNMENT

Q1. Project the Front View and topview of a hollow cylinder (Pipe) having outer diameter = 50 mm, inner diameter = 40 mm and length = 50 mm, resting on the H.P., with its axis ⊥ to V.P.

Q2. A triangular pyramid, of 50 mm base and 50 mm axis, is resting on its base corner on the H.P., so that the upper edge, of the base is horizontal. The base of the pyramid is on the rear and || toV.P. Draw its projections.

Q3. Project the frontview and topview of a pentagonal prism of 30 mm base edges and 60 mm long edges which are ⊥ to V.P., and its rectangular face on top is parallel to H.P.

Q4. The frustum of a square pyramid of 40 mm base edges and 20 mm cut face (top) edges is resting on H.P. on a base edge with its 50 mm long axis horizontal and at right angles to V.P. the cut face is in front. Draw its projections.

Q5. A hexagonal prism, of 25mm base and 60 mm axis, is resting on one of the its base edges on the H.P. and its axis is perpendicular to V.P. Project its Front View and Top View.

Q6. Project the frontview and Top View of a cylinder, with base diameter = 50 mm and height = 70 mm, resting on H.P., with its axis perpendicular to V.P.

Q7. Draw the Front View and topview of a cone of base diameter = 30 mm and axis = 65 mm, with its axis perpendicular to V.P., keeping the vertex in front.

Q8. A square prism, base 40 mm side and axis 70 mm long is lying on one of its rectangular faces. Its axis is perpendicular to V.P. Draw its Front View and Top View.

Q9. The frustum of a triangular pyramid of 50 m base edge and 20 mm top edge, rests on H.P. With its base edge on it and the 60 mm long axis parallel to H.P. and at right angles to V.P. The cut face is in front. Project its frontview and topview.

Q10. A right regular pentagonal pyramid of base edge = 25 mm and height = 60 mm, having its axis perpendicular to V.P., with its base parallel to V.P. Draw its projections.

4.7.2 PROJECTION OF SOLIDS WHEN ITS AXIS IS PARALLEL TO BOTH THE REFERENCE PLANES

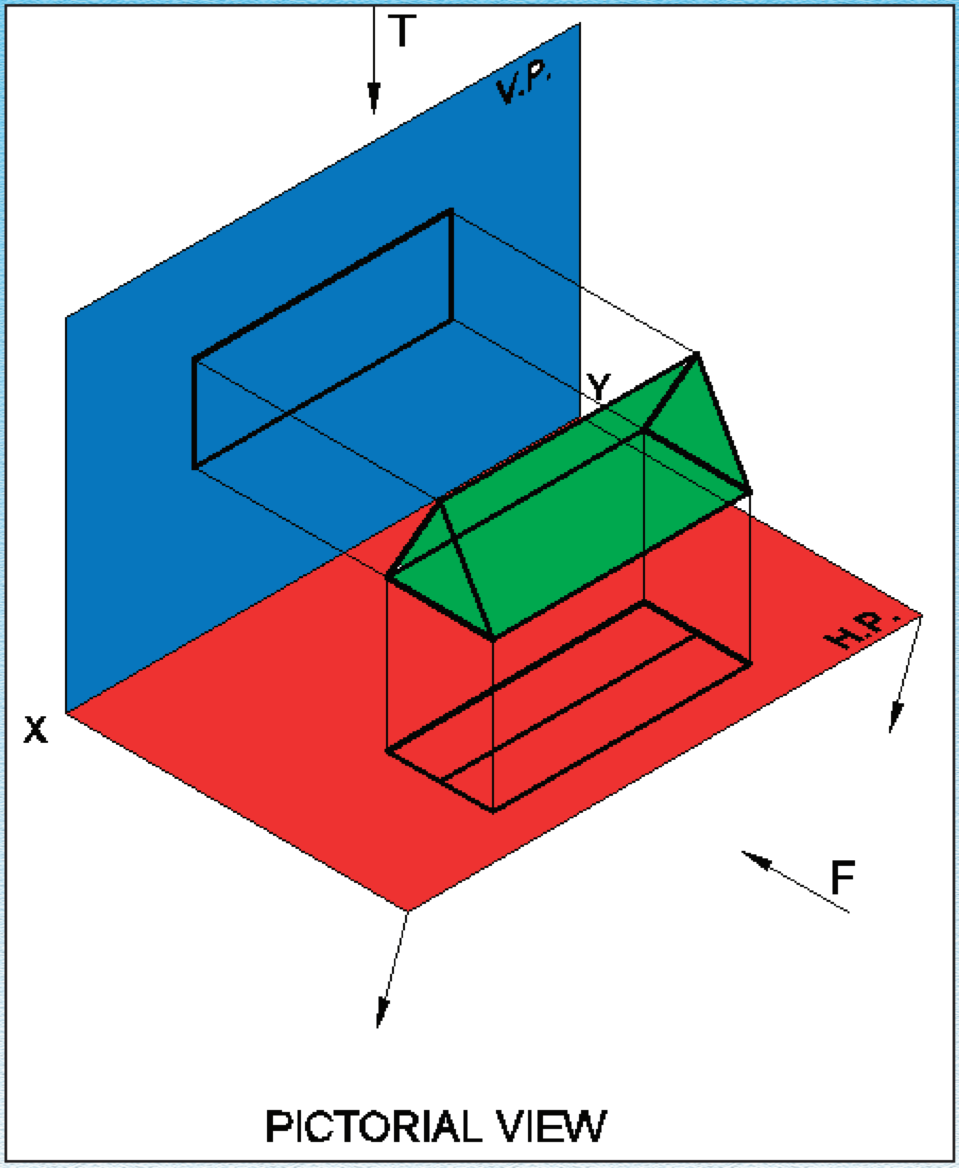


Fig. 4.97

Suppose, a triangular prism is placed in I quadrant, in such a way that the axis is parallel to both V.P. and H.P. (Fig. 4.90) its projections are done as shown in Fig. 4.98

In this position of the solid, the Front View does not reveal about the base of the solid, even Top View does not show it. We have to take the side view projected on A.V.P. So, side view must be drawn first, then Front View and Top View are projected from it.

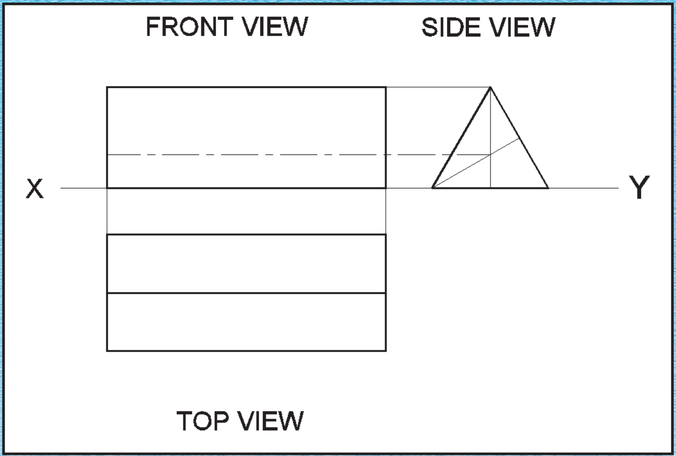


Fig. 4.98

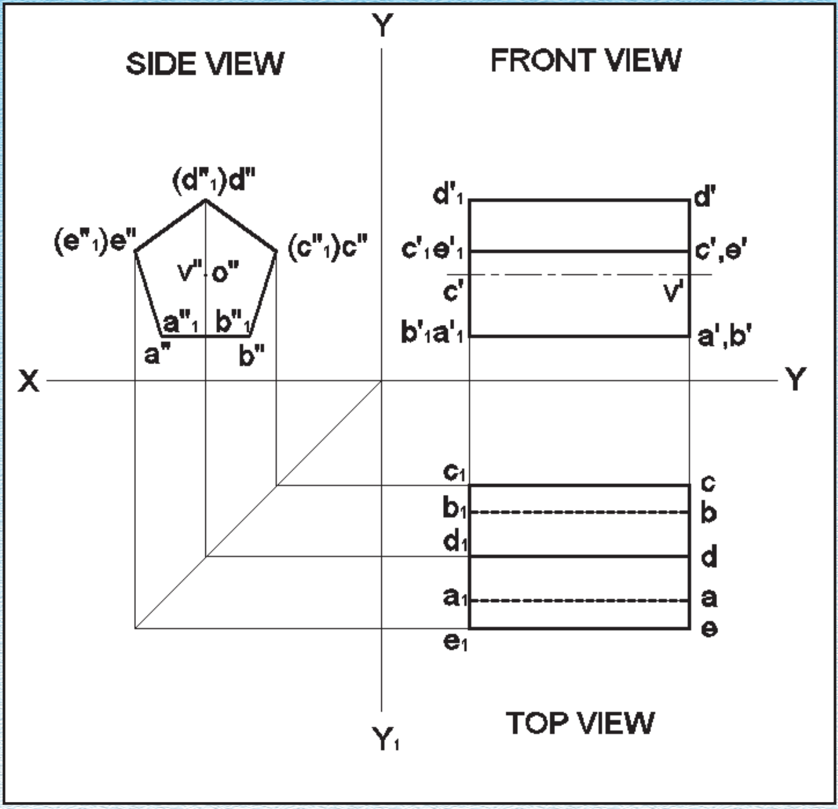


Fig. 4.99

Example 4.23 : A pentagonal prism having a 20 mm edge of its base and an axis of 50 mm length is resting on one of its rectengular faces with the axis perpendicular to the side plane. Draw the projections of the prism.

Solution refer Fig. 4.99

GIVEN DATA

- pentagonal prism
- axis perpendicular profile planed side plane
- rectangular face parallel to V.P.

Steps :

(i) Draw a XY line

(ii) Here, Axis perpendicular to P.P/side plane means the axis is parallel to both V.P. & H.P.

So start with the side view which is a triangle with true shape and size.

(iii) Then, project the corrosponding Front View and Top View, which are rectangles.

Example 4.24 : Project the Front View and Top View of a pentagonal pyramid of 30 mm base edges and 70 mm long horizontal axis, parallel to V.P., when it is resting on one corner of its base with one edge of its base on top, || to H.P.

Solution refer Fig. 4.100

GIVEN DATA

– pentagonal pyramid
– Axis parallel to both V.P. & H.P.
– Standing on its corner

Steps :

(i) Draw a XY line

(ii) Since axis parallel to VP & HP helping view side view is drawn first, which is a pentagon with the edge || to HP on the top side.

(iii) Then, using the projectors, get the Front View and Top View.

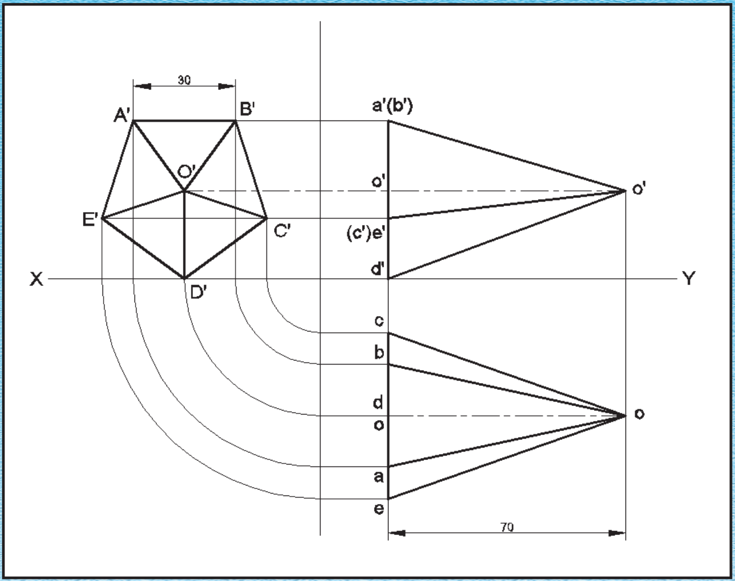


Fig. 4.100

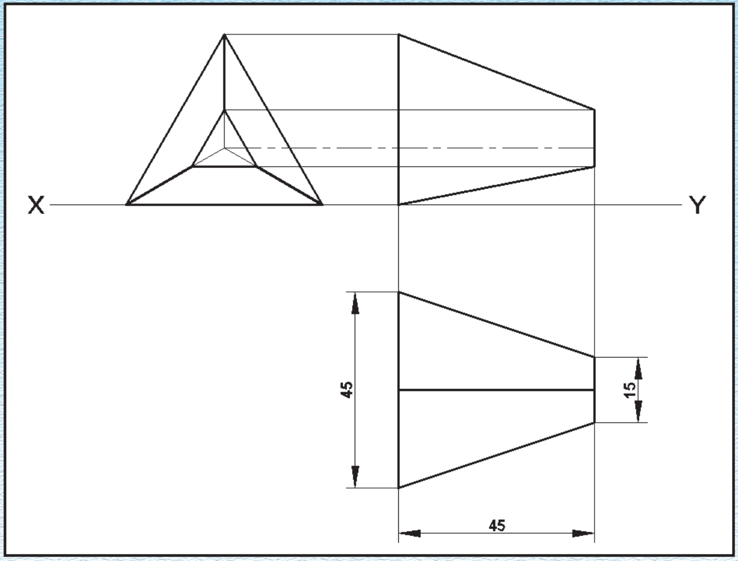


Fig. 4.101

Example 4.25 : The frustum of a triangular pyramid of 45 mm base edges and 15 mm cut face to edges , is standing on one of its base edges, which is at right angles to VP. The axis is || to both V.P. and H.P. Draw its projections.

Solution refer Fig. 4.101

GIVEN DATA

Helping view, side view must be drawn first. Then project it to get the Front View and Top View.

ASSIGNMENT

1. A hexagonal prism, base 25 mm side, axis 60 mm long, is lying on the ground on one of its faces with the axis parallel to both V.P. and H.P. Draw its projections.
2. A triangular pyramid, base 25 mm side axis 50 mm long, is resting on the ground on one of its edges of the base. Its axis is || to both the planes. Draw its projections.
3. A cylinder, base 40 mm diameter, axis 60 mm long, is lying on the ground on its generators with the axis || to both V.P. and H.P. Draw its projections.
4. The frustum of a hexagonal pyramid of 20 mm base edges and 10 mm cut face top edges is resting on H.P. on a base edge with its 50 mm long axis horizontal and parallel to V.P. The cut top face is in front. Draw its projections.

4.7.3 PROJECTION OF SOLIDS WHEN ITS AXIS PARALLEL TO REFERENCE PLANE & INCLINED TO THE OTHER CASE (I) WHEN THE AXIS INCLINED TO H.P. & PARALLEL TO V.P.

Fig. 4.102 shows pictorially a square pyramid with its axis $\perp$ to the H.P. and || to the V.P. in the first step and having its axis inclined at θ to the H.P.

This kind of two steps are required, when the axis of a solid inclined to any one of the reference principal plane.

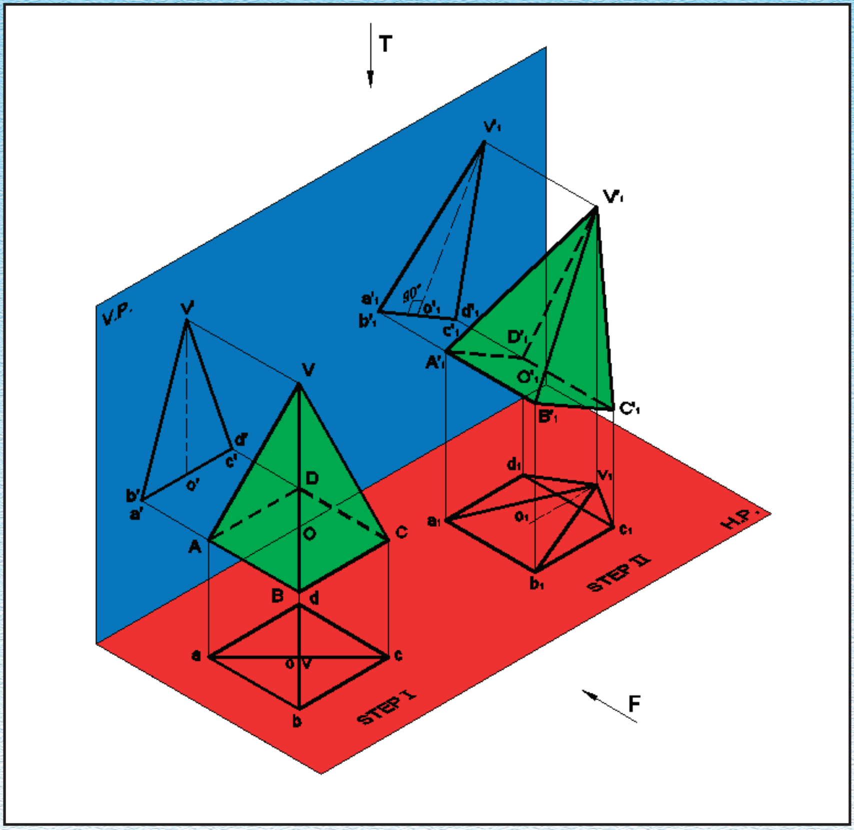


Fig. 4.102

Its projections are done as follows. Fig. 4.103

(i) Initially, the solid is assumed to have its axis perpendicular to H.P. Then views are drawn for this simple position.

(ii) Then in the second step, the solid is tilted to the given inclination with H.P. Then redraw to Front View in the previous step to the required inclination.

(iii) Required Top View will be projected from the Front View.

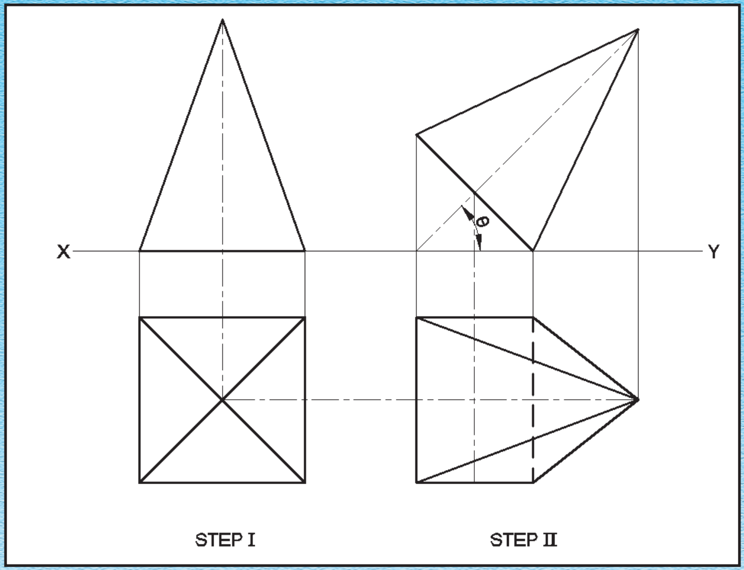


Fig. 4.103

Example 4.26 : A pentagonal prism having 20 mm edges at its base and axis of 70 mm length is resting on one of the edges of its base with its axis parallel to the V.P. and inclined at 30° to the H.P.

GIVEN DATA

– Pentagonal prism 20 mm × 70 mm

– axis || to VP and inclined to H.P. at 30°

Steps 1 : Assume, the axis is perpendicular to H.P. start drawing with the Top View, which is a pentagon i.e., true shape of the base Fig. 4.104

Steps 2 : Project the Front View above XY

Steps 3 : Then redraw this Front View with axis inclined at 30° to the XY line.

Steps 4 : Draw vertical projectors from each of the redrawn points in the Front View and horizontal lines from corosponding points in the topview drawn in step I.

Steps 5 : Note the corrosponding points of intersection and join them to obtain projections of all the surface boundaries.

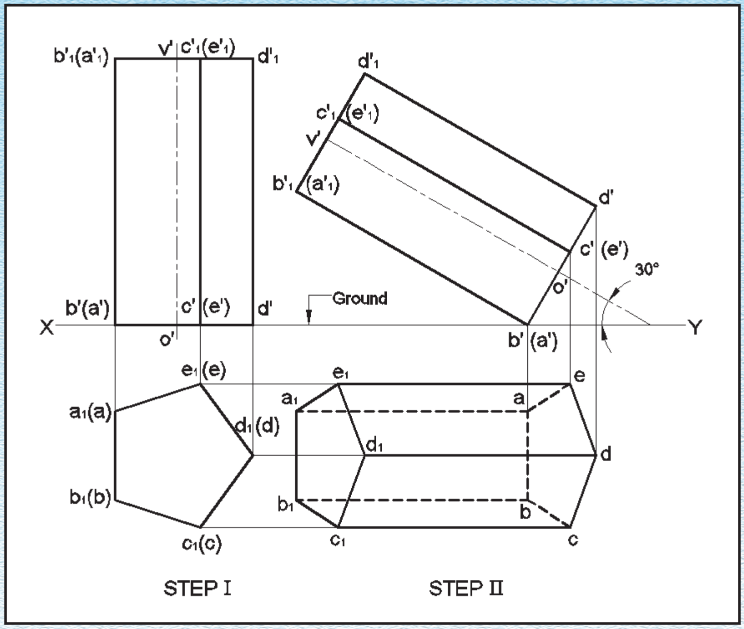


Fig. 4.104

Example 4.27 : Draw the projections of a hexagonal pyramid, base 20 mm side and axis 45 mm long, has an edge of its base on the ground. Its axis is inclined at 60° to the ground and parallel to the V.P.

Solution see Fig. 4.105

(i) Assuming the axis to be ⊥ to the ground, draw the Top View abcdef below XY.

(ii) Project the Front View as shown in Fig. 4.105

(iii) Now tilt the pyramid about the edge. On tilting, the axis will become inclined to the ground but will remain || to V.P. The axis makes 30° angle with XY.

(iv) Now from this Front View project all the points downwards and draw horizontal lines from first Top View.

(v) Reproduce the new Top View by joining the apex with the corners of the base and also draw lines for the edges of the base as shown in the fig. 4.105.

Hidden portion of the pyramid is shown by dashed (dotted) lines.

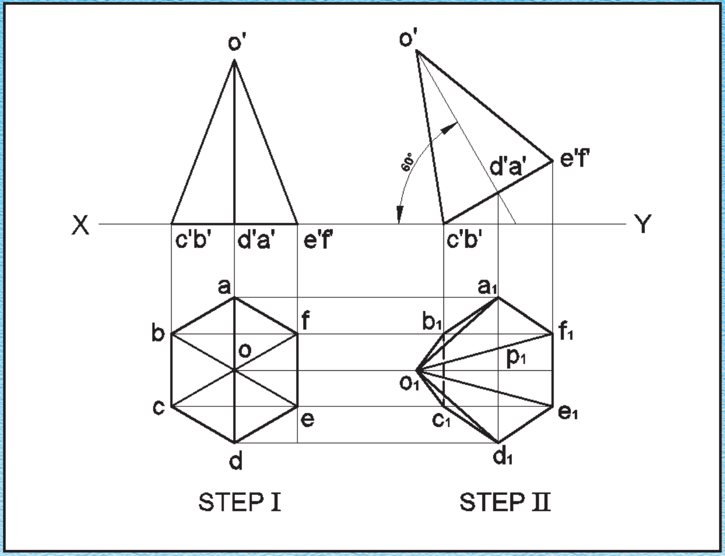


Fig. 4.105

Example 4.28 : The frustum of a cone of 45 mm base dia, 25 mm cut face diameter and 50 mm axis, rests on H.P. so that its axis is || to V.P. and inclined at 30° towards the right. Draw its projections, when the cut-face is one top.

Solution Fig. 4.106

Steps I : (i) The frustum is assumed to be in the simple position is axis ⊥ to H.P. So Draw its Top View first which are concentric circle ϕ 25 and ϕ 45

(ii) Project the Top View above XY to get the Front View.

Steps II : (iii) Tilt the Front View to the required inclination is axis makes 30° with XY line.

(iv) Project down this Front View and project horizontally from the previous Top View, to draw the required Top View, matching the corrosponding points.

Note : The titled circular ends are seen as ellipses in the topview, i.e. compressed (foreshortened) circle is ellipse.

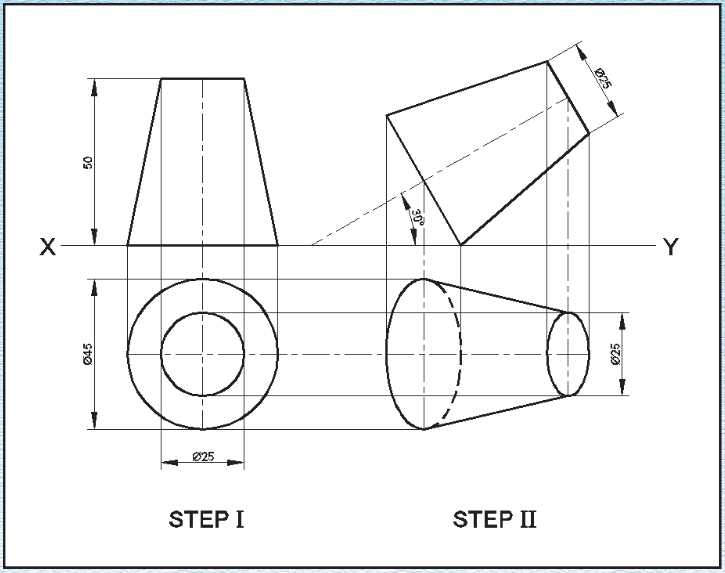


Fig. 4.106

ASSIGNMENT

1. A triangular prism with 25 mm edges at its base and the axis 60 mm long is resting on one of the edges of its base with axis || to V.P. and inclined at 30° to the H.P. Draw the projections of the prism.

2. A pentagonal pyramid of 25 mm edges of its base and axis 50 mm, has its axis perpendicular to the V.P. and 50 mm above the H.P. Draw the projections of the pyramid if one edge of its base is inclined at 30° to the H.P.

3. A frustum of square pyramid of 20 mm edges at the top, 40 mm edges at the bottom and 50 mm length of the axis has its side surface (face) inclined at 45° to the H.P. with axis || to V.P. Draw the projections of the frustum.

4. The frustum of a cone, which is 90 mm base diameter and 30 mm top diameter. Draw the projections of the cone frustum when its axis is parallel to the V.P. and inclined at (i) 30° to H.P. (ii) 60° to the H.P.

ACTIVITY

You will be studying about the development of surfaces in the later unit of this book. Using the knowledge of development of surfaces, develop different types of solids like prisms, pyramids, cones etc. and study their projections in different possible positions. Make sphere out of plasticine or clay. Cut the sphere into 2 halves to get himisphere.

Case (ii) When the axis inclined to V.P. & parallel to H.P.

The above given figure Fig. 4.107 shows pictorially a square pyramid with its axis perpendicular to V.P. and parallel to H.P. in the first step and having its axis inclined to V.P. at ϕ and parallel to H.P. in the second step.

Such problems are solved in two steps as shown in Fig. 4.108

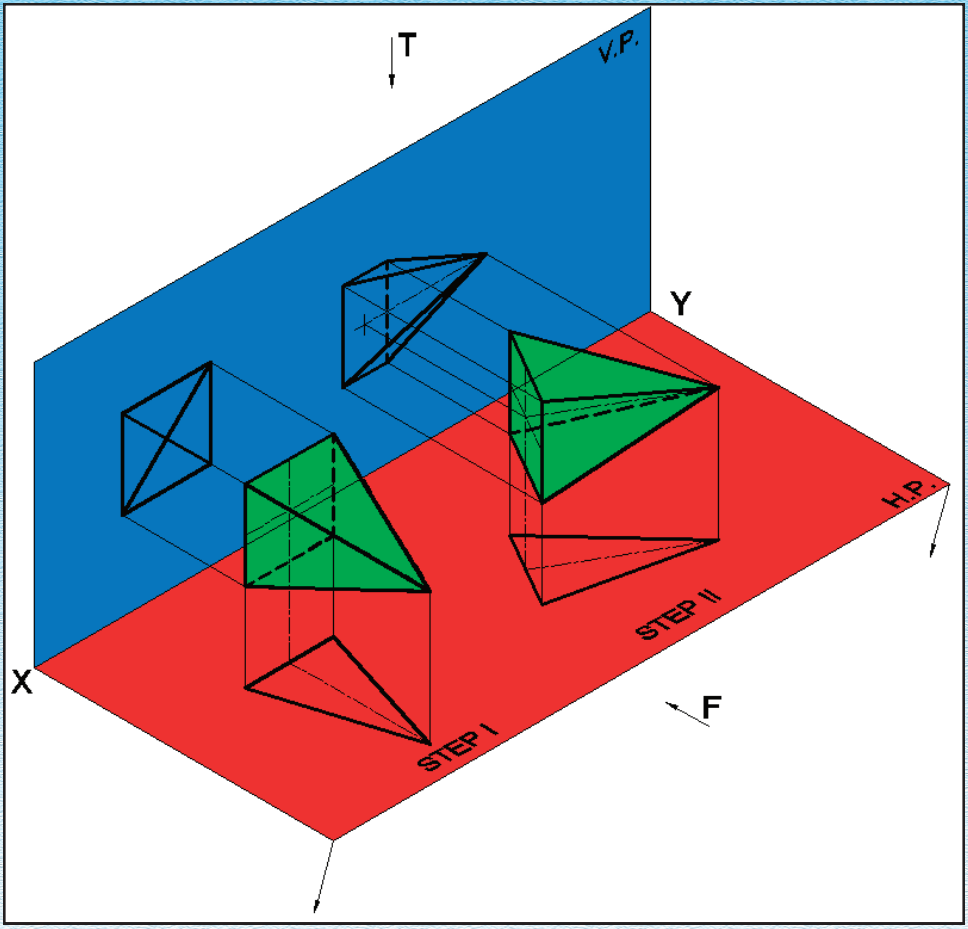


Fig. 4.107

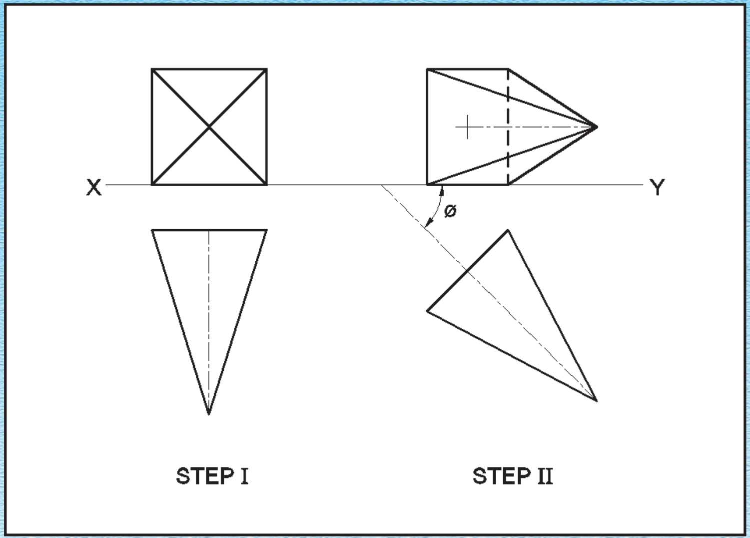


Fig. 4.108

PROCEDURE FOR DRAWING PROJECTIONS OF SOLIDS HAVING AXIS PARALLEL TO THE H.P. & INCLINED AT ϕ TO THE VP

(i) When the axis is inclined to V.P., assume it to be perpendicular to V.P. and draw, the true shape of the base in Front View and project the Top View from it.

(ii) Using proper conventional lines, redraw the Top View so that the axis is inclined at the given angle ϕ to XY line.

(iii) Draw vertical projectors from various points of redrawn Top View and horizontal lines from the Front View in the I step. The correspoinding points of intersection of these horizontal and vertical lines locate the positions of the concerned points in the Front View, in the II step.

(iv) Complete the Front View of the solid by drawing all the surface boundaries using outlines or short dashed (dotted) lines, depending upon their visibility.

Example 4.29 : A hexagonal pyramid having 20 mm sides at its base and an axis 70 mm long has one of the corners of its base in the V.P. and its axis inclined at 45° to the V.P. and parallel to the H.P.

Solution see Fig. 4.109

(i) First assume the axis to be perpendicular to V.P. and draw the true shape of the base, is hexagon in Front View locate the axis and join it to the corners of the hexagon.

(ii) To view in this simple position is drawn by projecting from the Front View.

(iii) Then redraw the Top View in the I step, so that the axis is inclined at 45° to XY line.

(iv) Draw vertical projectors from this Top View and horizontal projectors from the Front View of Step I.

(v) Complete the Front View of the solid by drawing all the surface boundaries.

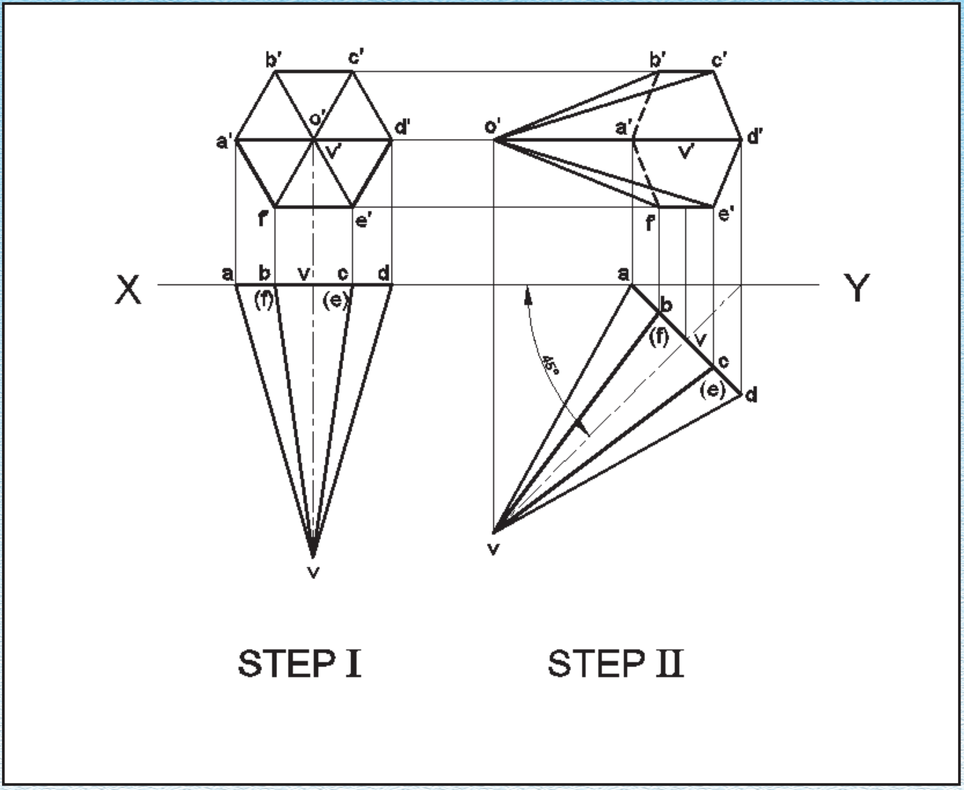


Fig. 4.109

Example 4.30 : Draw the projections of a cylinder 30 mm dia, and axis 50 mm long has its axis parallel to H.P and inclined at 45° to the V.P.

Solution see Fig. 4.110

(i) Assume the axis perpendicular to the V.P. and draw the Front View which is a circle.

(ii) Project the Top View, which is a rectangle

(iii) Redraw the Top View, such that the axis is inclined at 45° to XY line

(iv) Project this Top View and the previous Front View to get the required Front View.

(v) Circular ends are shown by drawing ellipses.

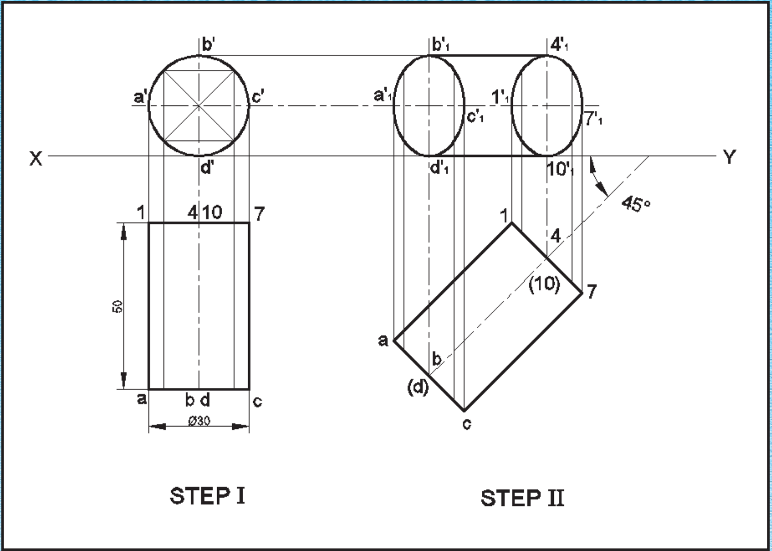


Fig. 4.110

Example 4.31 : The frustum of a square pyramid with the base edge of 40 mm and top edge of 20 mm with axis 50 mm, kept in such a way that its axis is parallel to H.P. and inclined to V.P. at 30°. The cut face is in front.

Solution see Fig. 4.111

(i) In Step I Assume the axis perpendicular to V.P. and draw the Front View which shows two square ends.

(ii) Draw the corrosponding Top View by projection.

(iii) In step (ii), redraw the previous Top View such that the axis is inclined at 30°

(iv) Projectors should be drawn from this redrawn Top View and the previous Front View to get the required Front View.

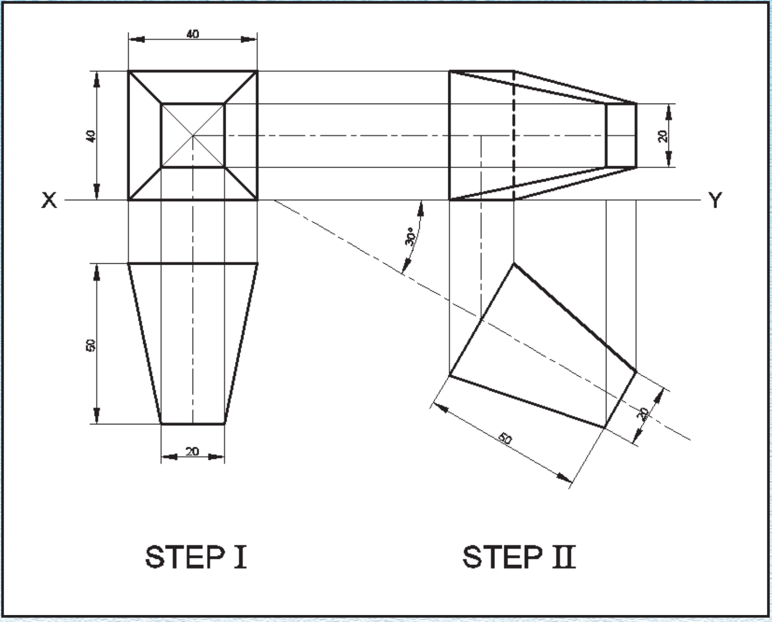


Fig. 4.111

WHAT WE HAVE LEARNT

We now list some of the important conclusions for the projections of solid in the form of a table given below :

S.No.	Position of Solid	Hints for Drawing the Proj	Number of Steps
1.	When the axis perpendicular to H.P.	Start with the Top View	one
2.	When the axis perpendicular to V.P.	Start with the Front View	one
3.	When the axis perpendicular to P.P. is axis parallel to both V.P. & H.P	Start with the side view	one
4.	Axis parallel to V.P. and inclined to H.P. at θ	(i) Assume the axis is $\perp$ to H.P. (ii) Redraw the Front View as the inclined view	Two
5.	Axis parallel to H.P. and inclined to V.P. at ϕ	(i) Assume the axis is $\perp$ to V.P. (ii) Redraw the Top View as the inclined view	Two

Table 4.5 : Steps involved in projections of solids

ASSIGNMENT

Q1. Draw the projections of a pentagonal prism having 25 mm edge of its base and the axis 50 mm long when it is resting on its base with an edge of its base inclined at 30° to the V.P.

Q2. A triangular pyramid of 50 mm edges of the base and axis 60 mm long has one of its corners of the base touching V.P. with axis parallel to H.P. and inclined at 45° to the V.P. Draw the projections of the pyramid.

Q3. The frustum of a cone of 40 mm base diameter and 20 mm cutface diameter, rests on H.P., with its axis 50 mm long, parallel to H.P. and inclined to V.P. at 30° towards right. Project the topview and Front View.

Q4. A square duct is in the form of a frustum of a square pyramid. The sides of top and bottom are 90 mm and 60 mm respectively, and the length is 110 mm. It is situated in such a way that its axis is parallel to H.P. and inclined at 60° to V.P. Draw the projections of the duct, assuming the thickness of the duct sheet to be negligible.

Q5. Draw the projections of a square prism having 30 mm edge of its base and the axis 55 mm long when it is resting on its base with its axis inclined at 30° to V.P.

Q6. Draw the projections of a hexagonal prism having 20 mm edge of its base and the axis 50 mm long when it is resting on its base, with its axis parallel to H.P. and inclined at 40° to the V.P.

Q7. A triangular prism of 50 mm base edges of the base and axis 60 mm long, resting on its base and its axis inclined at 45° to the V.P. Draw the projections of the prism.

Q8. A hexagonal pyramid of 25 mm edges of the base and 60 mm long axis, resting on its base, has its axis inclined to V.P. at 30°. Draw its projections.

Chapter 5
SECTIONS OF SOLIDS

5.1 INTRODUCTION

We have studied about the orthographic projections in which a 3 dimensional object is detailed in 2-dimension. These objects are simple.

In engineering most of the machines are extremely complicated. They have various parts inside. And we have to show the details of inside, so the engineers adopt a technique called 'sectioning'. The objects/ machines are "imagined to be cut" in a particular manner and the interior becomes visible and is shown by a sectional view.

Let us take the machine block as shown in Fig. 5.1 Examine the orthographic views of this block. They have many hidden lines (showing invisible surfaces/edges) but don't give a clear idea about the inside details.

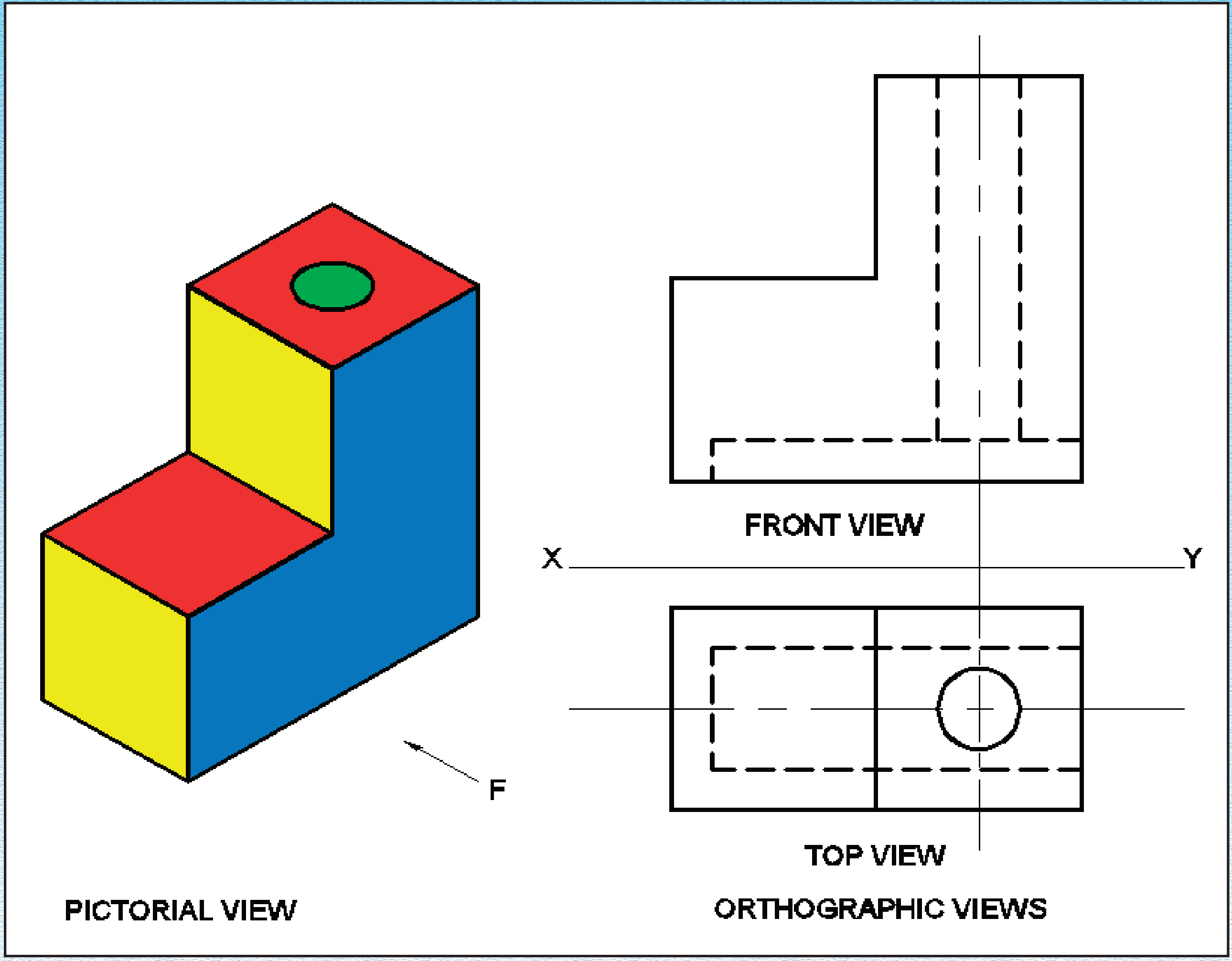


Fig. 5.1 Views of a Machine Block

So a portion/part of the object nearer to the observer is imagined to be cut and is removed away from the cutting plane, known as the 'section plane', to show the interior (inside) details more clearly. As can be seen in Fig. 5.2

The view (projection) of the remaining cut portion of the object is known as the **sectional view.** Refer to 5.2 (a) The cut/exposed surface, known as the **section** is represented by thin equidistant inclined lines (**section lines)** known as **hatching.** (Fig. 5.2 (a) & (b)).

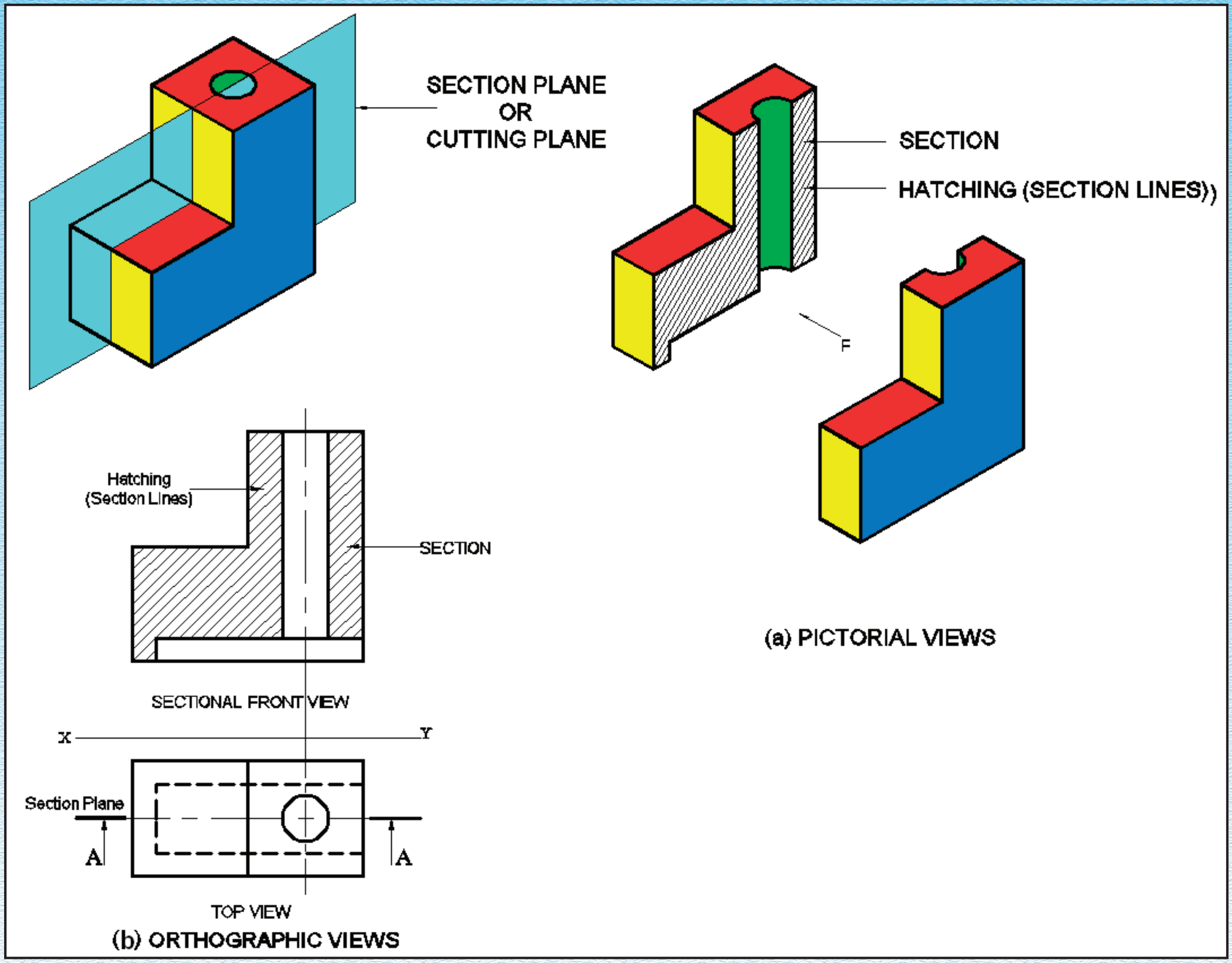


Fig. 5.2

5.1.1 Uses of Sections

We have come to know why sections are needed. Let us know some more details which are as follows :

– Sectioning helps the engineers/technicians considerably in clarifying the interior details (solid, hollow, etc.) These details are otherwise quite complicated to be shown & dimensioned by outside views & hidden lines.

– It may also be used to show a small cross section (perpendicular to axis) of a machine part as shown in Fig. 5.3

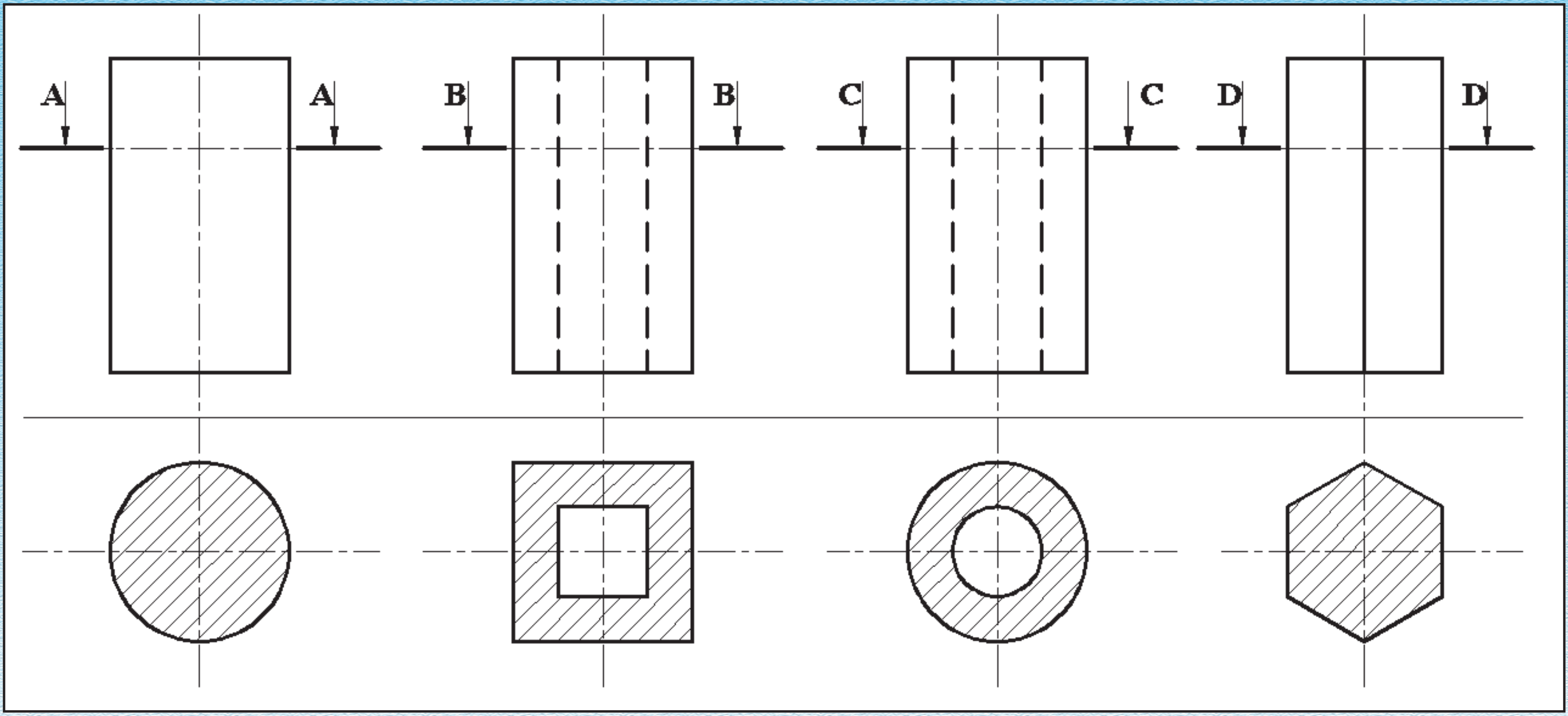


Fig. 5.3 Cross-section of Simple Solids

– It helps in understanding and interpreting the drawings for manufacture of machine parts.

In this chapter, we are going to deal with sections of simple solids which is important to understand the interpenetration of surfaces (where combination of different solids are used to make a machine part).

DO YOU KNOW ?

Various sectioning symbols are used for different materials, as shown (Fig. 5.4) :

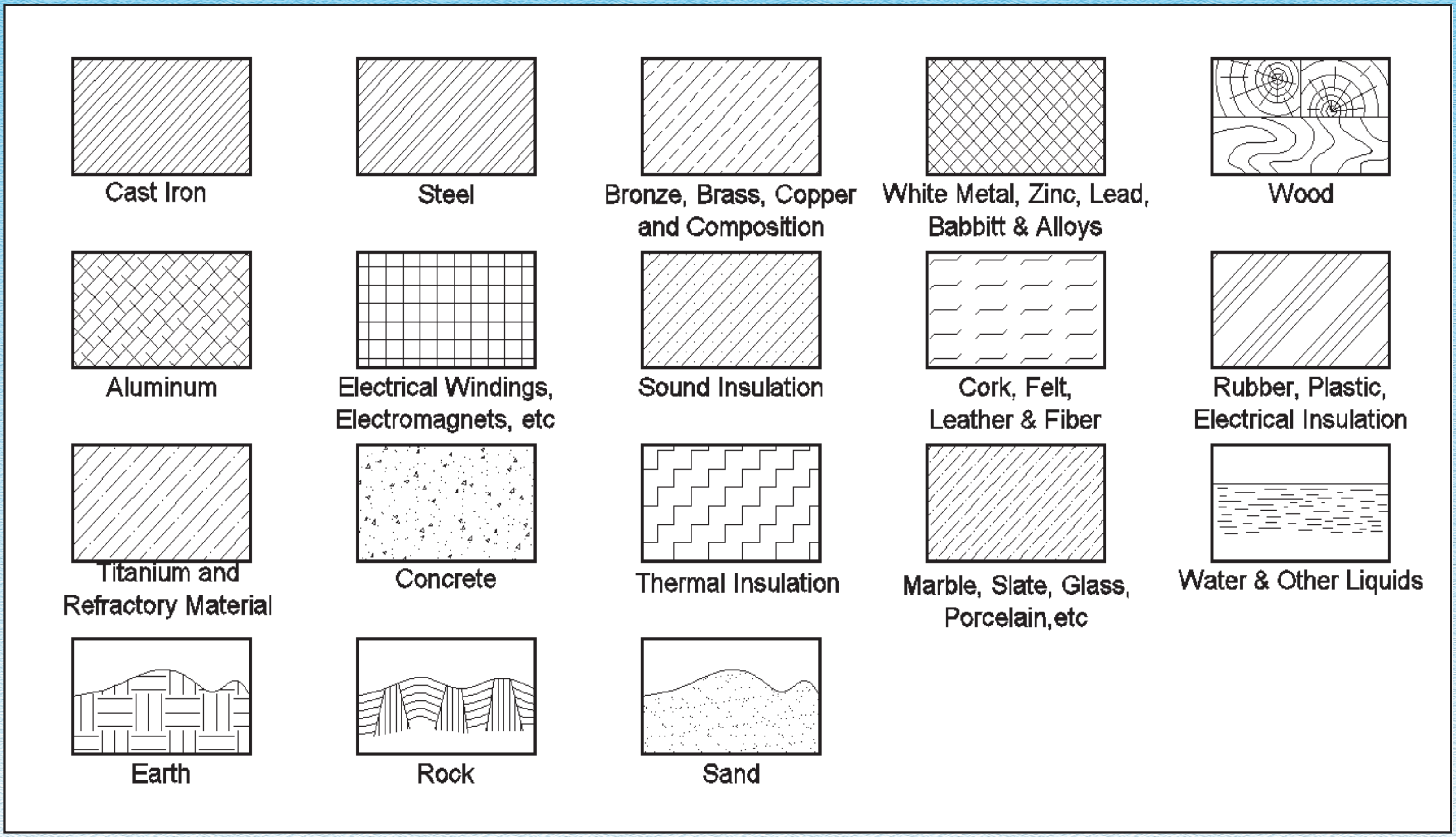


Fig. 5.4

Activity 5.1

Take some vegetables like onion/apple, cucumber/lotus stem, carrot etc. Cut them at different angles and arrange them together to get some of the following shapes (Fig. 5.5)

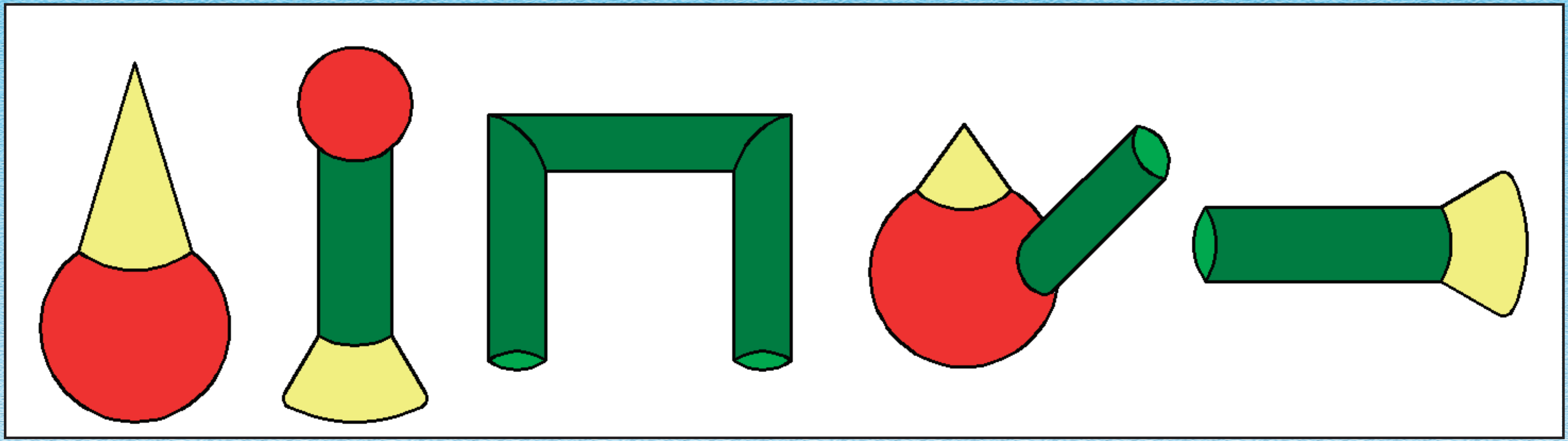


Fig. 5.5

Look around, can you identify some objects which look like a combination of simple cut-solids.

5.2 TERMINOLOGIES AND CONVENTIONS

Now, let us learn more about the terms commonly used while sectioning and the conventions to be followed as per BIS specifications SP–46 : 2003 (Revised)

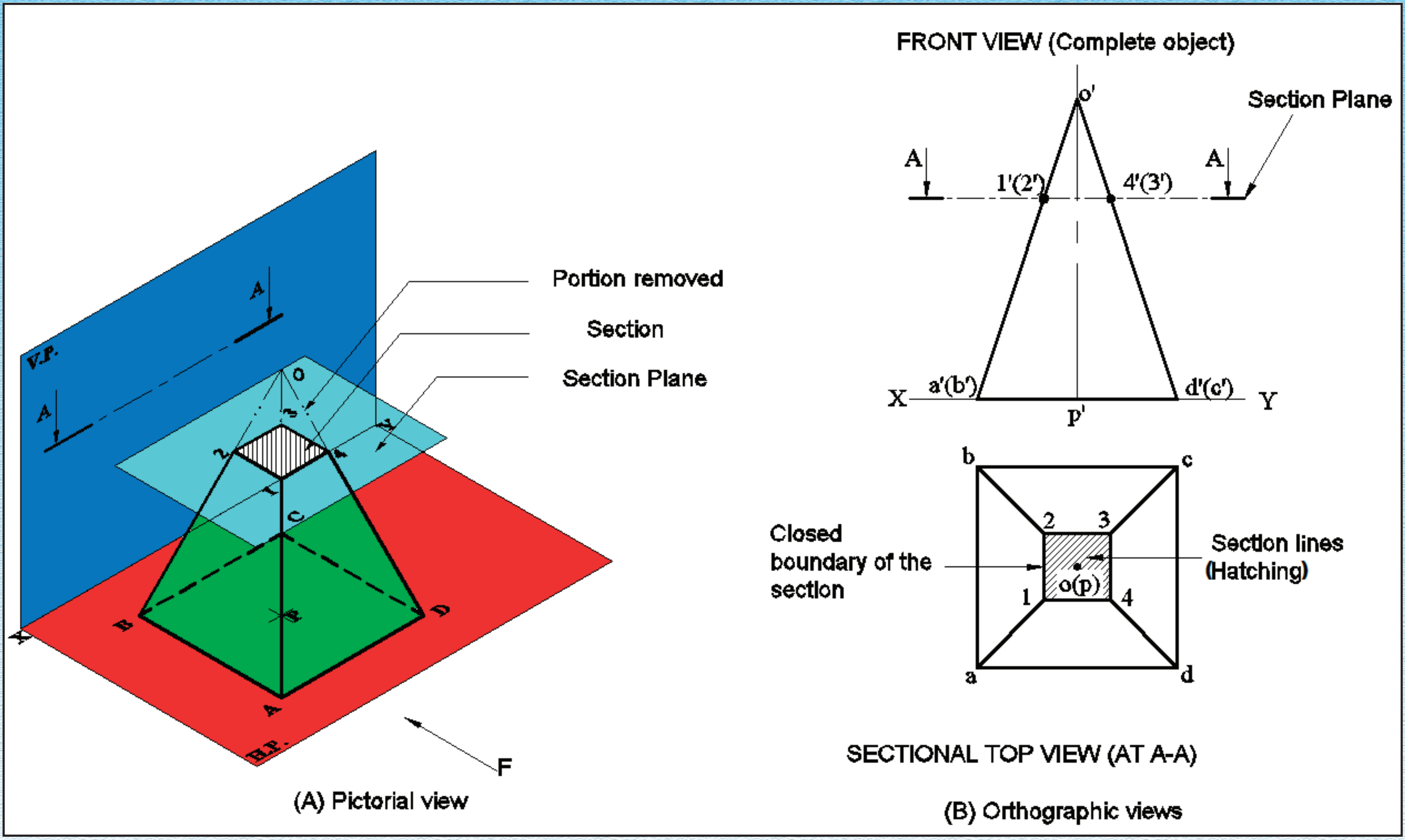


Fig. 5.6

5.2.1 Section Plane/Cutting Plane

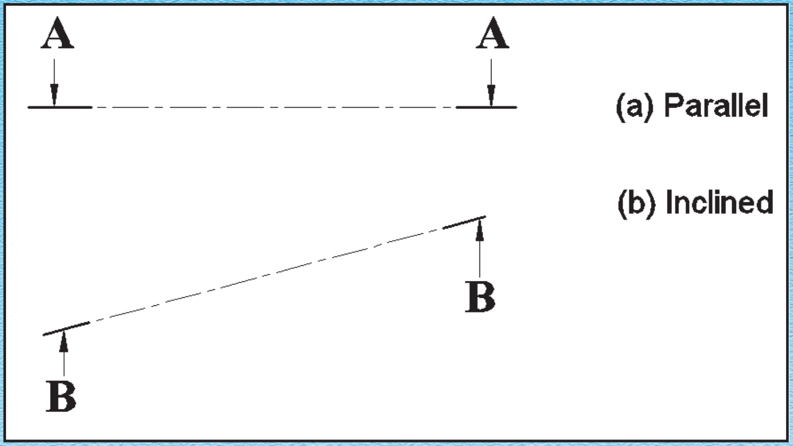


Fig. 5.7

As mentioned earlier, this plane indicates where the imaginary cutting takes place, or the path of cutting an object to make a section.

It can also be understood as the path, your knife takes to cut through the apple.

The cutting plane is shown in the orthographic view in Fig. 5.6 (B) where it appears as an edge. This edge is represented as a combination of "Chain Thin" lines as shown clearly in the Fig. 5.7.

The edges of the cutting plane line are terminated by "thick lines" with arrowheads to indicate the direction of viewing the section. It is more completely identified with reference (capital) letters (A-A, B-B etc.) at the beginning and end of the plane. This becomes useful when the object is cut by more than one section plane (Combination of more than one section plane, though rare, is used sometimes to know the details at different positions in a single sectional view).

Note : Section planes are not shown on sectional views.

5.2.2 Sectional view & Section

As mentioned earlier, this orthographic view shows the surface which has been imaginarily cut or exposed, i.e. the section and also shows the remaining portion of the object. It can be identified with the pulp of the apple alongwith its seeds which is visible after it is cut. Fig. 5.6 shows the pictorial as well as the sectional Top (orthographic) view of a square pyramid.

A sectional view generally replaces one of the regular views of the object. To make the cut surface/section seen clearly in the sectional view, it is represented by thin parallel lines (section lines) which will be dealt with later (5.2.3). While drawing sectional views, the following points should be **noted** :

1. The outline of the section is **"continous thick line"** and **"never represented as hidden lines"**
2. By and large **continuous thick line is not shown** within the section.
3. **Hidden lines are not shown** in the section unless they are needed to describe the object.
4. If a portion of the solid is removed by cutting, then it is represented by **"dashed and double dotted lines"** as shown below (Fig. 5.8).
5. The portion is assumed to be removed only in the sectional view, so other views are full and complete.


Fig. 5.8

DO YOU KNOW ?

Several types of sections are available for use in explaining the material of the inside parts (fig. 5.9)

The engineer/technician may select from among them, that best describes the shape

(a) Full section

(b) Half section

(c) Revolved / Rotated section

(d) Removed section

(e) Local / Partial section

(f) Offset section, etc.

Some of them will be learnt in the next higher class (XII).

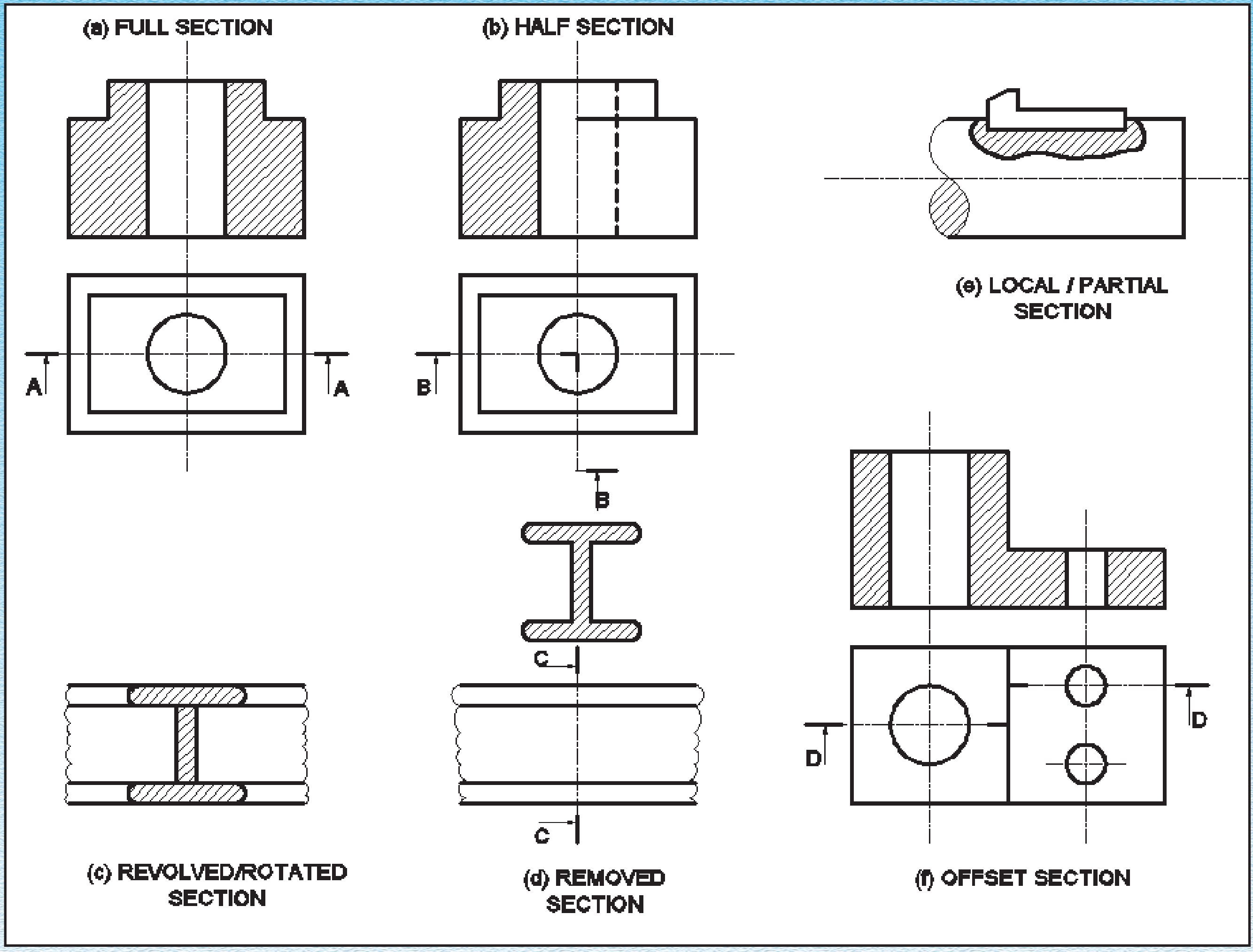


Fig. 5.9

5.2.3 Section Lines

As mentioned previously in (5.2.2), the sectional surfaces are 'hatched', i.e. continous thin parallel lines are drawn with equal spacing, (say 1-3 mm), minimum being 0.7 mm as per BIS SP : 46 – 2003 (Revised) specification. These lines are called as **"section lines"**. They are drawn at 45° to the **"principal outlines"** or "lines of symmetry of the sections", as shown in the Fig. 5.10

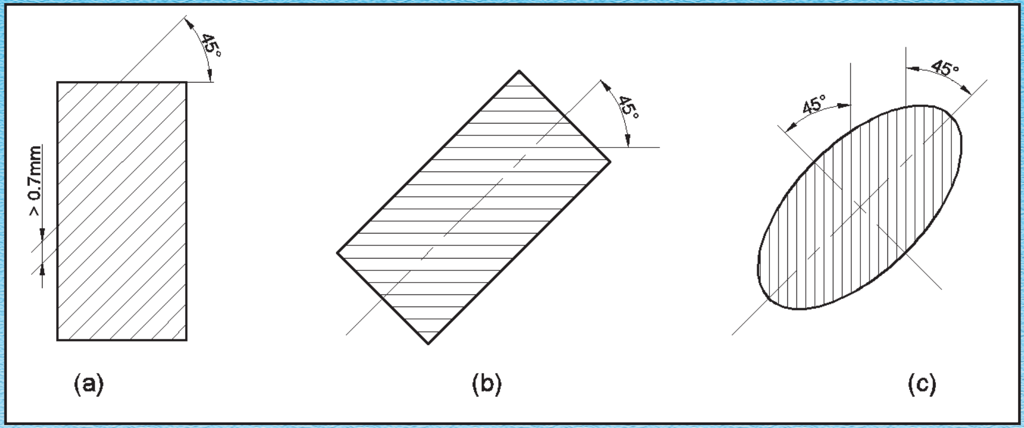


Fig. 5.10

While hatching the **following points** should be taken care of :

1. Hatching shall be interrupted when it is not possible to place inscriptions (i.e. dimensions or text), outside the hatched areas as shown in the Fig. 5.11 below:

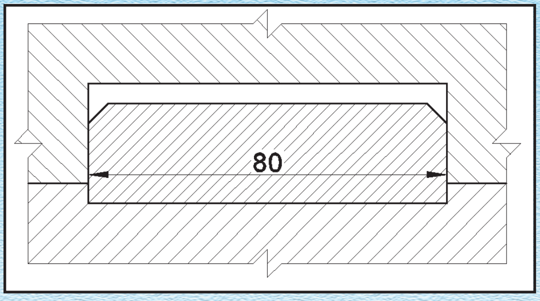


Fig. 5.11 No Hatching over text/dimensions

2. Separate areas of a section of the same component shall be hatched in an identical manner. Various ways of hatching are shown in Fig. 5.12. Adopt the correct method for a neat, precise and clear drawing.

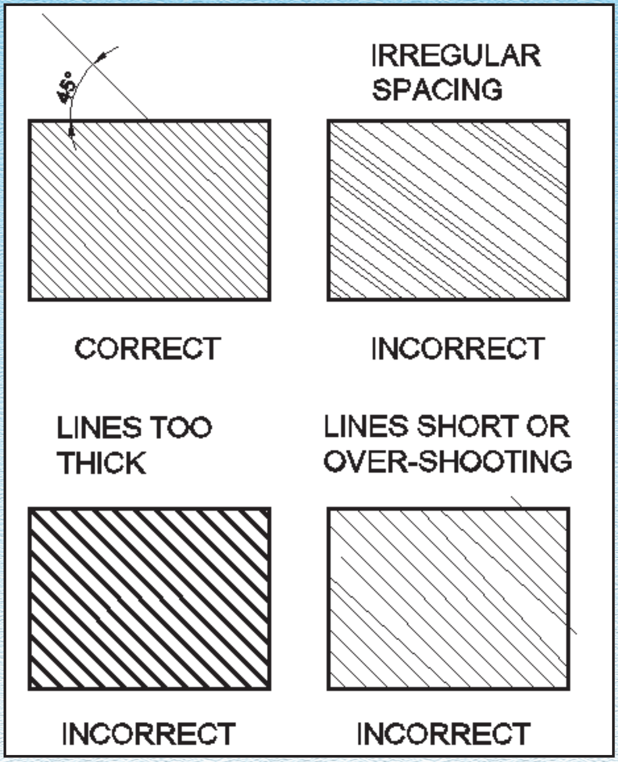


Fig. 5.12 Correct & Incorrect Methods of Hatching

ACTIVITY 5.2

Make clay/plasticine models (out of soap cakes) of simple solids (prisms, pyramids, cylinder etc.) as learnt in previons chapter. Paint them from outside.

Cut them horizontally or vertically or at some angle. The section surface will be visible clearly. Try to sketch these sections.

(These models can be used to understand the examples which will be explained later in this chapter).

TRY THESE

I. What is sectioning ?

II. Give two examples, where sectioning is used.

III. Fill in the blanks, from these alternatives (45°, 60°, sectional, cutting)

(a) The .... plane is shown as

(b) In .... view, the portion of the object between section plane and the observer is assumed, to be removed.

(c) The Hatching lines are generally drawn inclined to the horizontal at an angle of ....

Having learnt the basic concepts & techniques let us take up the drawing/construction of sectional views. In this chapter, we are going to deal with sections of simple solids, (the ones studied in the previous chapter)

5.3 DRAWING TECHNIQUES FOR SECTIONAL VIEWS

Drawing of these views is an extension of projection of solids. Hence, the procedure explained in the previous chapter is followed here also. To understand the basic technique, let us consider the example of a square pyramid which is cut by a horizontal section plane as shown in Fig. 5.6.

Steps of Construction : Refer to Fig. 5.13

1. Refer to Fig. 5.13 (1) Draw the projections of the complete solid in the required position using thin lines (as learnt in the previous chapter). Name the base and points of the axis. In this case, square base a-b-c-d- and axis points o-p. Project these points in the other view (here, Front View)

2. Refer to Fig. 5.13 (2) Mark the given section plane in the appropriate view (i.e. Front View in this case) as a line. Name the points of intersection (POIs) of this plane with the edges (base, rectangular/slant) drawn in the view. So, we have points 1′,2′, and 3′, 4′ cutting the slant edges o′-d, o′-a′ & o′c′, o′b′ respectively in Front View.

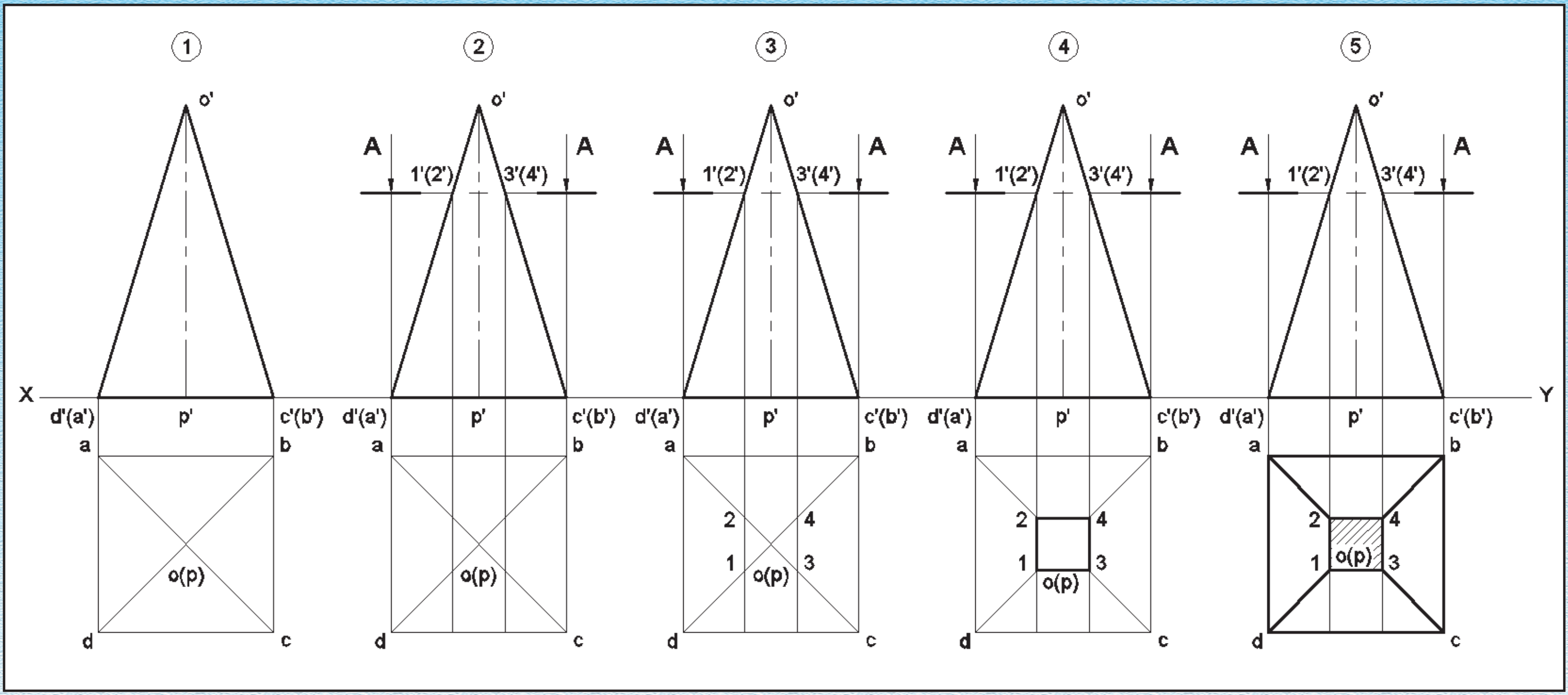


Fig. 5.13 Step wise Drawing Procedure

3. Refer to Fig. 5.13 (3) Project these points of intersection, (POIs) on the other view (here Top View) by identifying the corresponding edges they cut. So point 1 cuts o-d, pt. 2 cuts o-a and so on in the Top View.

4. Refer to Fig. 5.13 (4) Join the projected points to form the boundary of the sectioned surface with continuous thick lines.

   (**Note :** A flat surface cut by a plane, gives a straight boundary, while a curved surface cut by a plane, gives a curved boundary in the sectional view).

5. Refer to Fig. 5.13 (5) Complete the drawing of the remaining portion with continuous thick lines.

   (Note : In case a portion of the solid is removed and it lies outside the section, then it is represented by "dashed and double dotted line")

5.3.1 Types of Sectional Views

The sectional views so obtained can be either of two types :

1. Sectional Front View
2. Sectional Top View

5.3.1.1 Sectional Front View

As the name suggests, the section is seen in the Front View. This is possible when the **section plane is vertical/inclined to the vertical** i.e. perpendicular to HP and parallel to VP or it is inclined to the vertical plane (VP) as shown in Fig. 5.14.

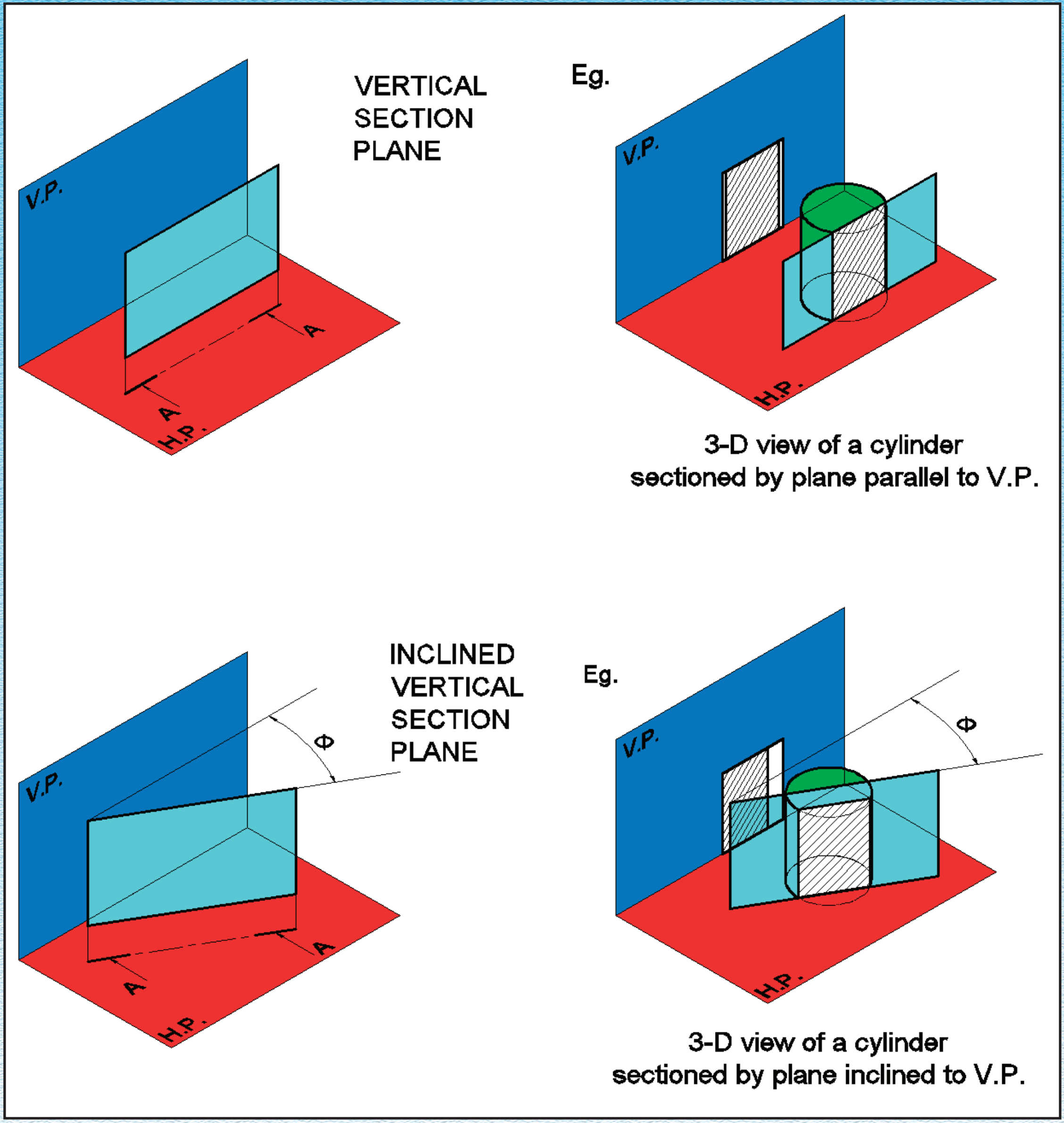


Fig. 5.14

5.3.1.2 Sectional Top View

Similarly, here, the section is seen in the Top View. That is, the section plane is horizontal/ inclined to the horizontal i.e. perpendicular to VP and parallel to HP or it is inclined to the horizontal plane (HP) as shown in Fig. 5.15.

5.3.2 : Examples

Let us consider some examples to understand construction of sectional views, as well as differences in developing them according to different cases.

5.3.2.1 Section Plane Parallel to HP & Perpendicular to VP.

As suggested in (5.3.1.2), the section plane is represented as a line in the "Front View" and the sectional view is obtained in the Top View.

Example 5.1 : A cube of 40 mm side is cut by a horizontal section plane, parallel to HP at a distance of 15 mm from the top end. Draw the sectional Top View and the Front View.

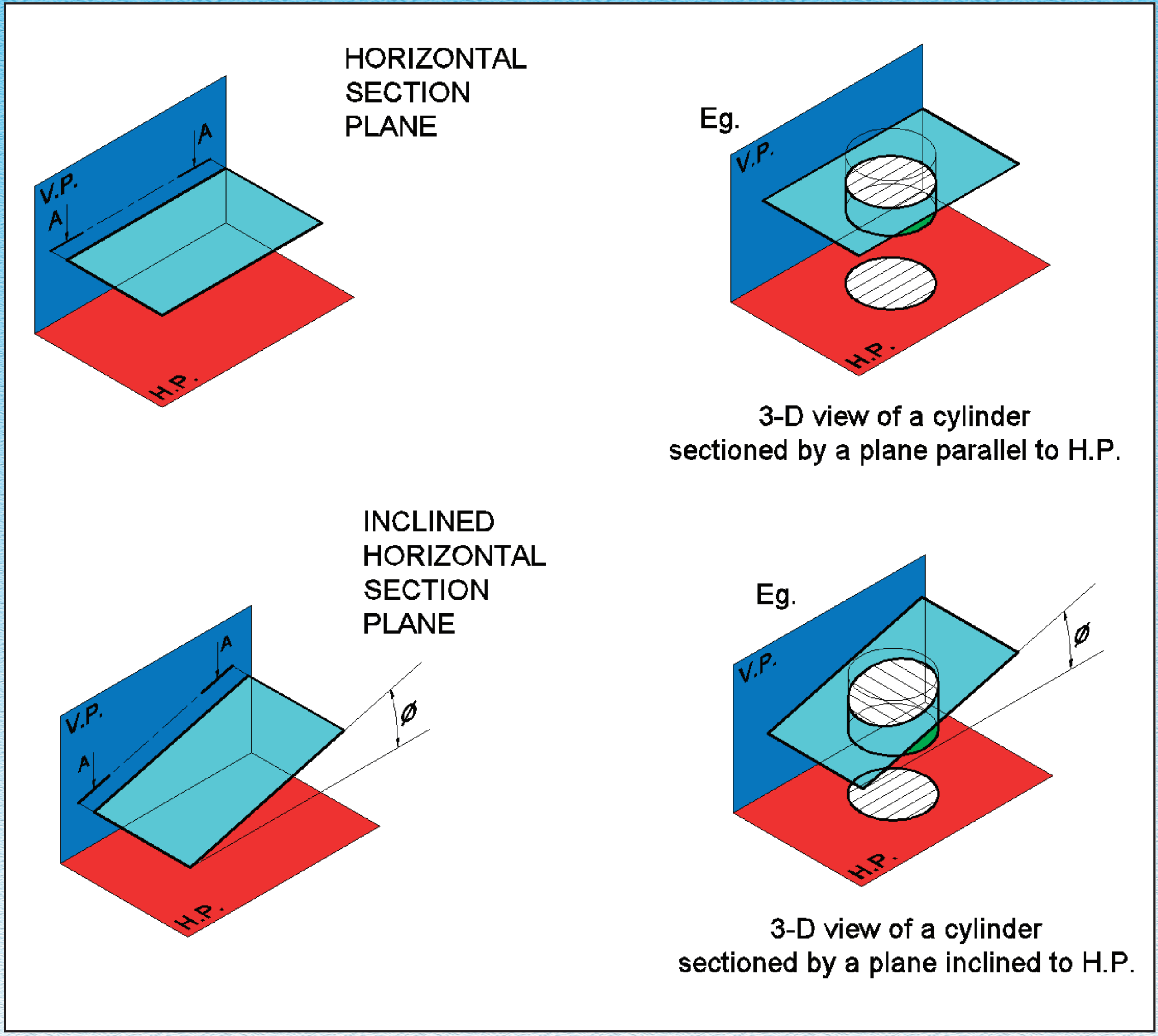


Fig. 5.15

Solution : Refer to fig. 5.16 (a)

1. Draw the Top View and Front View as shown.
2. In the Front View, draw the section plane parallel to X - Y line (HP) at a distance of 15 mm from the top edge a1′–d1′.
3. Locate points of intersection (POIs), pts. 1′, 2′ , 4′ & 3′ cutting edges a′a1′, b′b1′, c′c1′ and d′d1′ as shown pictorially in Fig. 5.16(b)
4. Project these pts. on their corresponding edges in the Front View. (Here they are the corners of the square itself.)
5. The pts. 1, 2, 3, 4 are already joined. Now hatch the area.

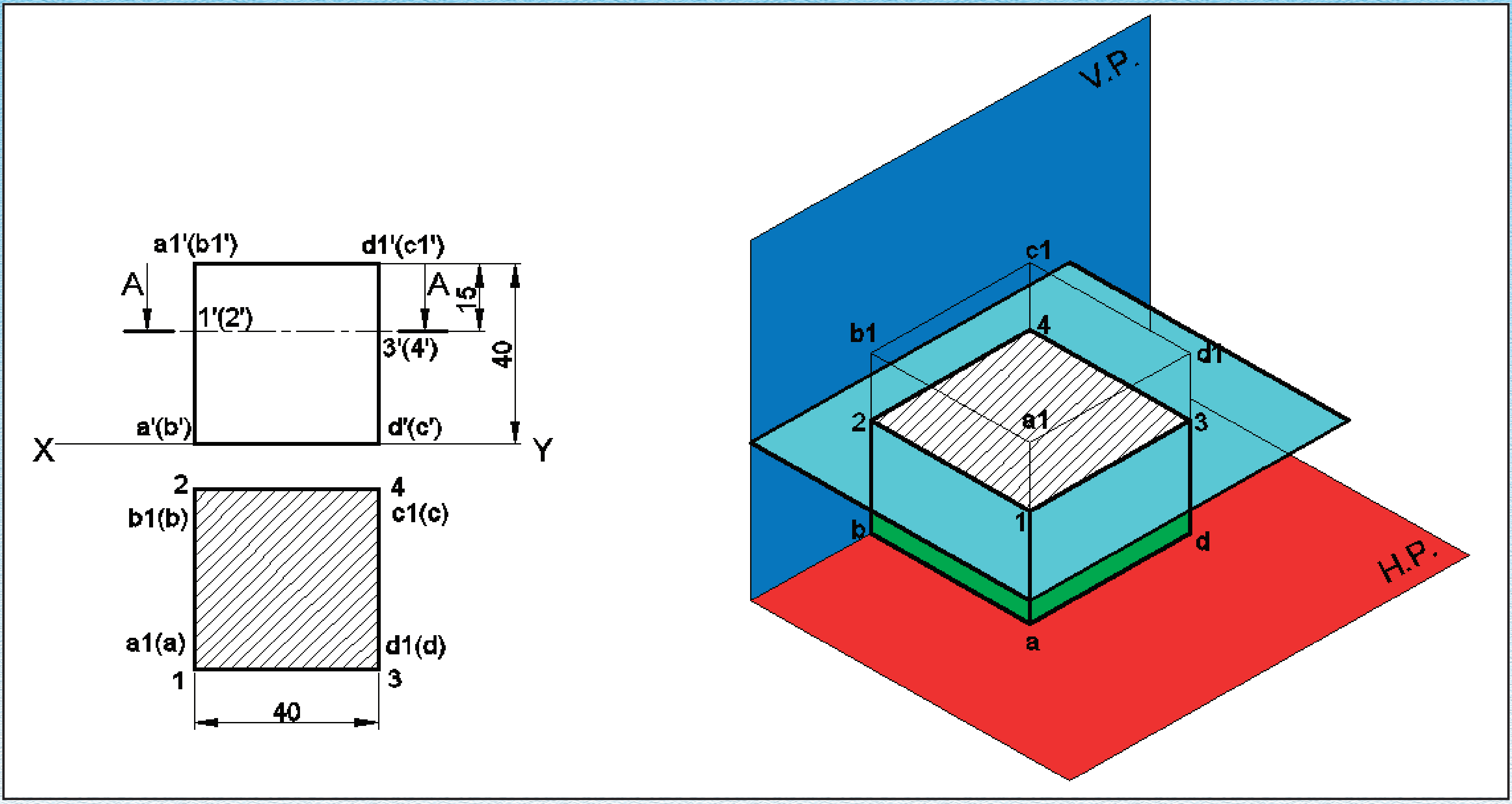


Fig. 5.16

Example 5.2 : A triangular prism with base side 40 mm and length of axis = 65 mm is resting on its rectangular face on HP with axis perpendicular to V.P. The prism is cut by a horizontal section plane, 20 mm distance above the ground. Draw the Front View and sectional Top View.

Solution : Refer to fig. 5.17 (a)

1. Draw the Front View and Top View as shown in the given position.
2. In the Front View, draw the section plane B-B at a distance of 20 mm from X-Y line and parallel to it.
3. Locate the POIs pt. 1′ cutting front edges a′b′ and the edges of the triangular face at the back at 2′. Similarly 3′ and 4′.
4. Project these pts. on their corresponding edges in the Top View. as shown in Fig. 5.17 (a)
5. Join the pts. 1, 2, 4, & 3 and hatch the area.

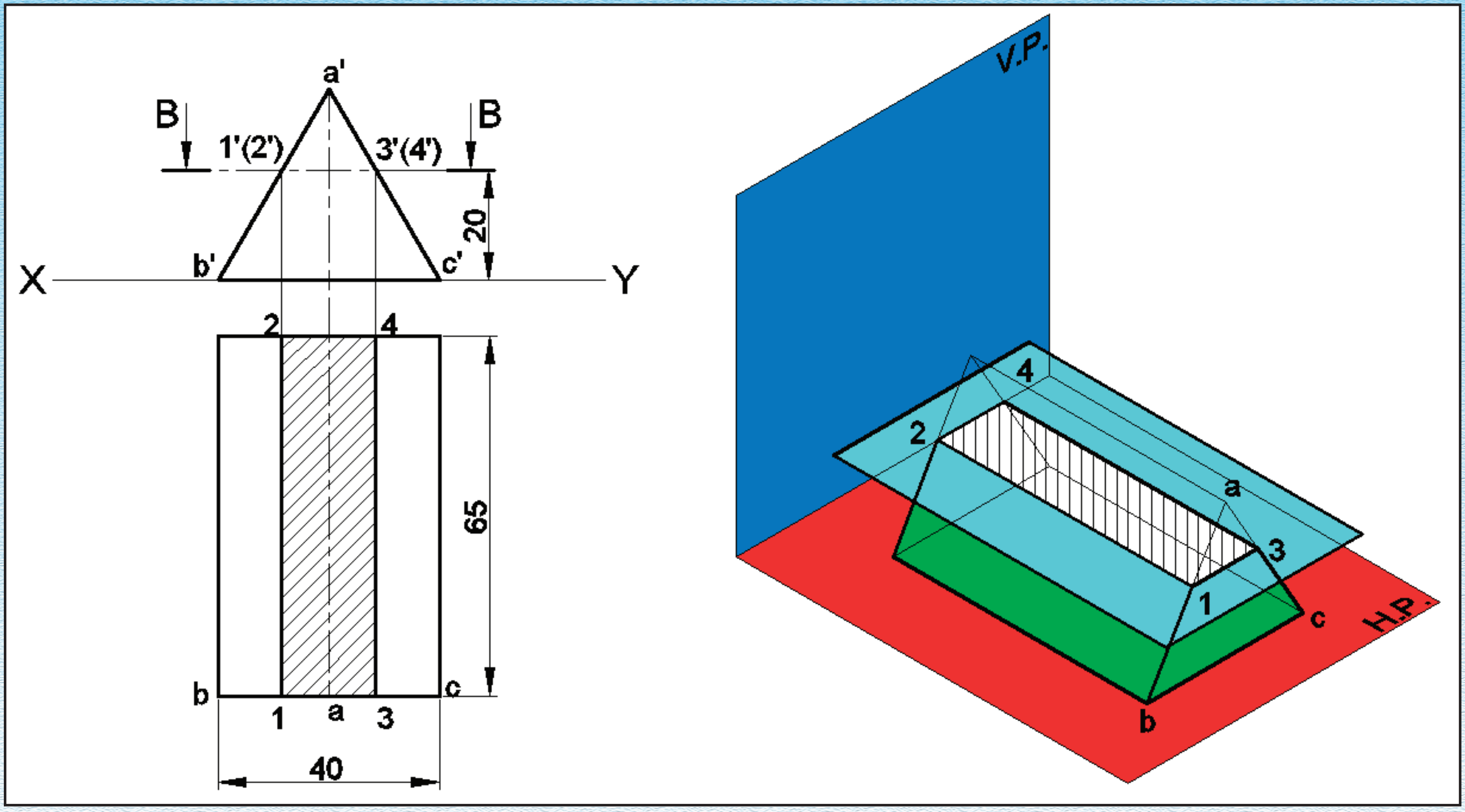


Fig. 5.17

Example 5.3 : A hexagonal pyramid is resting on its base on the ground with two of its base edges of length 30 mm, parallel to HP. A horizontal section plane, bisects the 80 mm long axis. The axis is perpendicular to H.P. Draw the Front View and sectional Top View.

Solution : Refer to Fig. 5.18

1. Draw the Front View and Top View as shown in the given position.
2. In the Front View, draw the section plane B-B passing through the mid-point of the axis 0′ 01′ as shown.
3. Locate the POIs 1′, 2′-3′, 4′-5′, 6′ cutting the edges o′a′, o′b′, o′f′, o′c′, o′e′ & o′d′ respectively.
4. Project these pts. on their corresponding edges in the Top View.
5. Join the pts. 1,3, 5,6, 4, 2 to form the outline of the section and hatch the area.

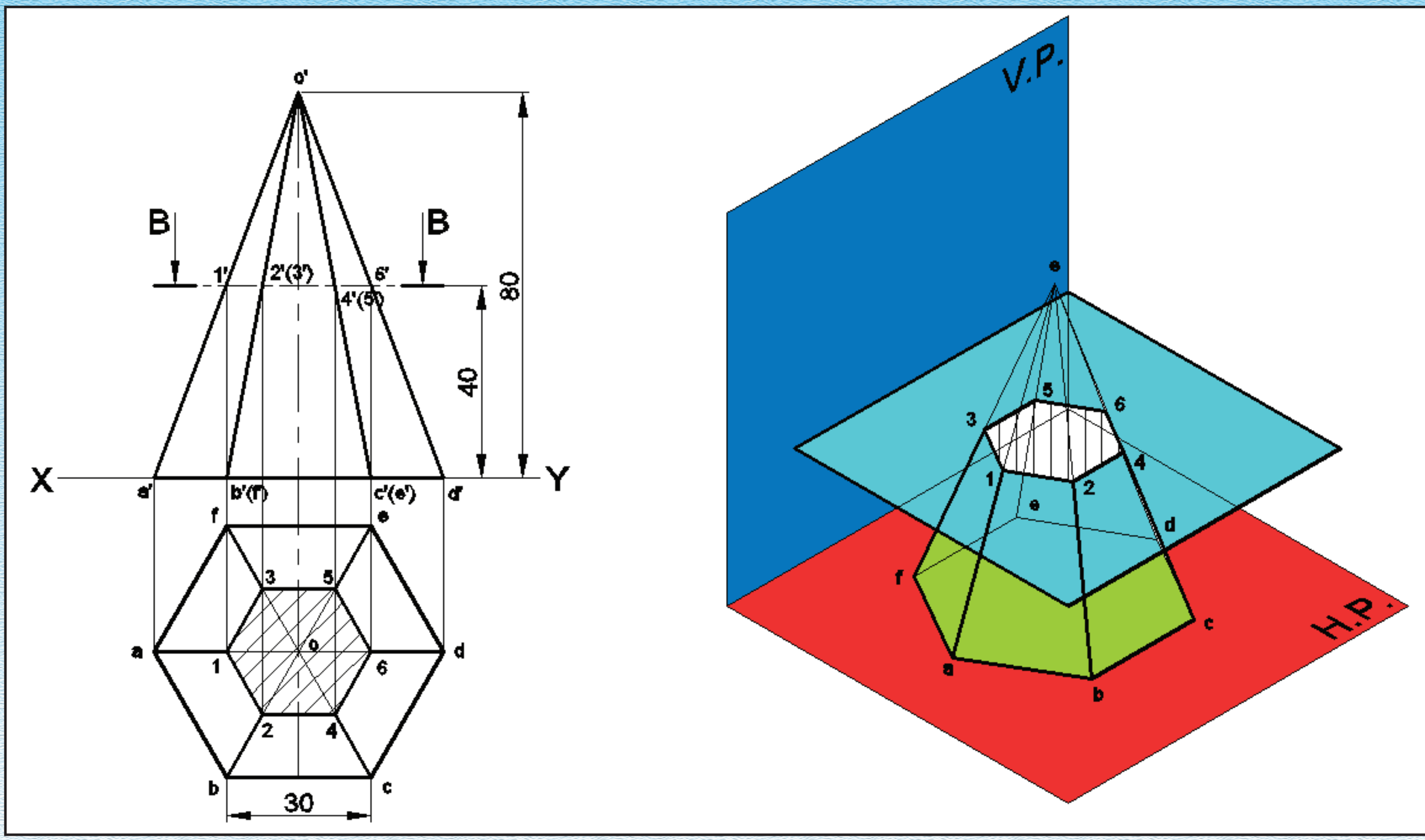


Fig. 5.18

5.3.2.2 Section Plane Inclined to HP and ⊥ to V.P.

Example 5.4 : A square prism of base side 50 mm and height of axis 80 mm has its base on HP. It is cut by a section plane perpendicular to V.P. and inclined to HP such that it passes through the two opposite corners of the rectangular face in front. Draw the sectional Top View and Front View. Find the angle of inclination of the section plane.

Solution : Refer to fig. 5.19

1. Draw the Front View and Top View as shown
2. As section plane is inclined to HP, draw line E-E in Front View meeting corners e′ and d′ making an angle θ with X-Y line (HP). Find angle θ
3. Locate the POIs 1′ - 2′, 3′ - 4′ cutting edges/corners e′, f′, d′ & c′ respectively.
4. Project these pts. in the Top View.
5. Join these pts. to form the outline and hatch the area.

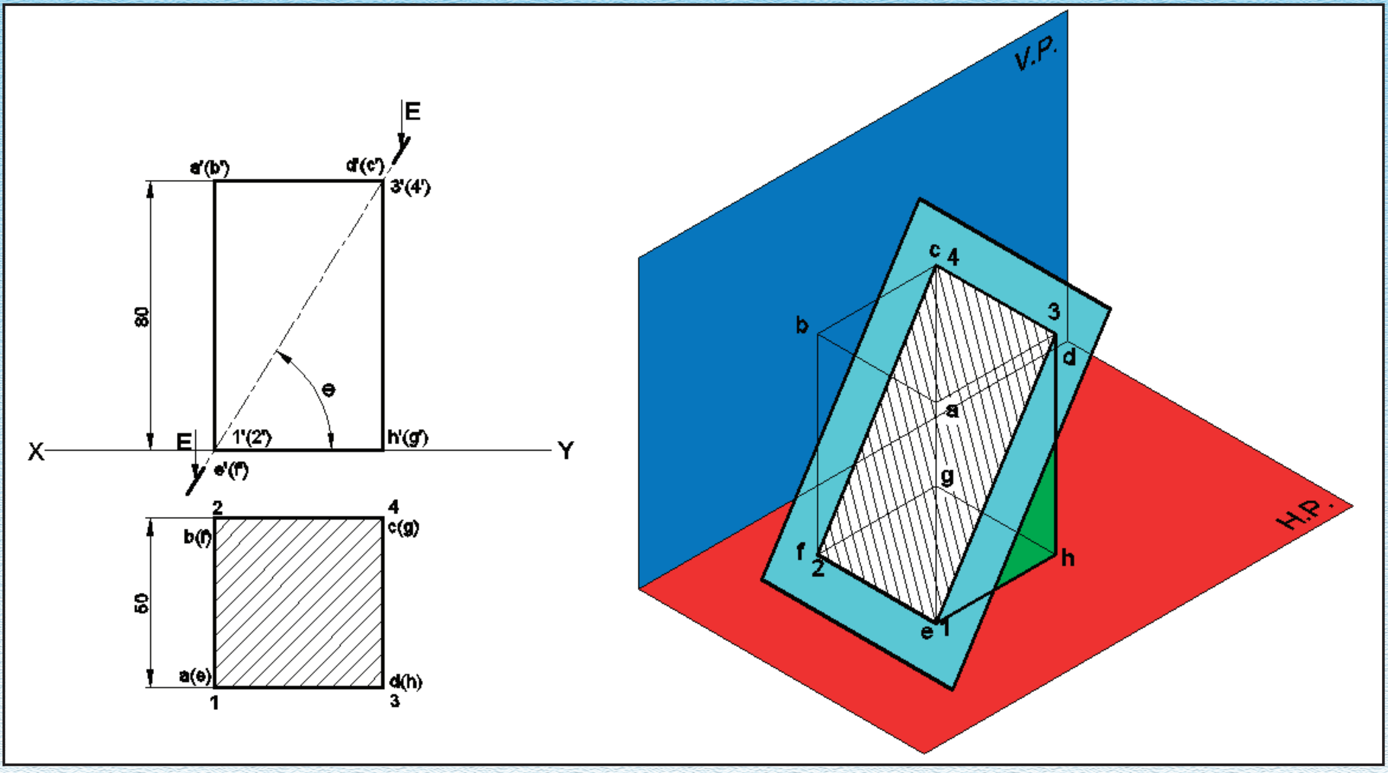


Fig. 5.19

Example 5.5 : A cylinder of base diameter 50 mm and height 70 mm is resting on its curved surface on HP such that the axis is normal to VP. A section plane inclined to HP at an angle of 60°, passes through the axis and cuts the solid into two halves. Draw the Front View and sectional Top View.

Solution : Refer to fig. 5.20

1. Draw the projections of the solid as shown.
2. In the Front View, draw the section plane F-F making an angle of 60° with X-Y line and passing through the centre.
3. Locate the POIs 1′, 2′, 3′,4′ in Front View cutting the circular faces as shown pictorially in Fig. 5.20 (b).
4. Project these pts. on their corresponding edges in the Top View.
5. Join these points 1′-2′-4′-3′ and hatch the area.
6. Draw the remaining portion. In this case, some portion of the solid is removed and lies outside the section, so it is represented by "dashed and double dotted lines."

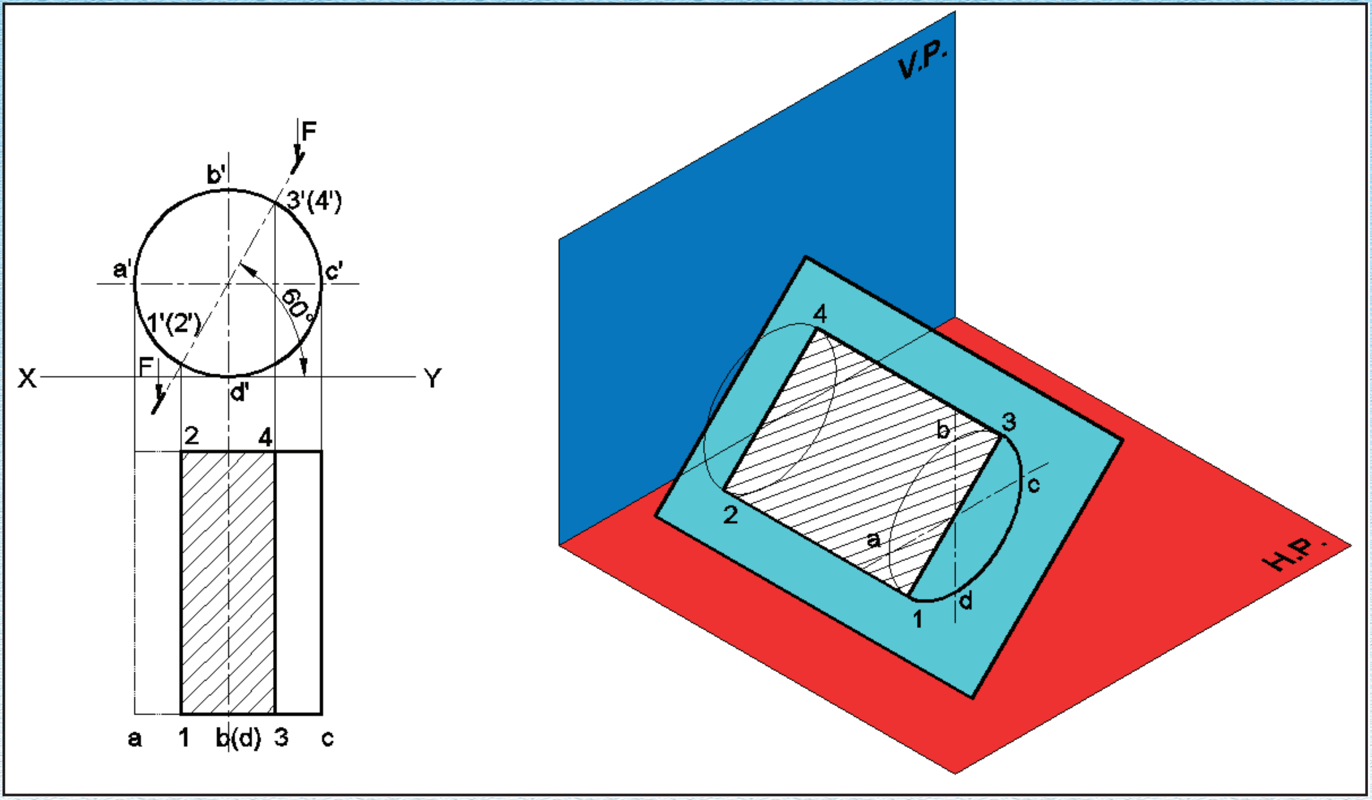


Fig. 5.20

Example 5.6 : A triangular pyramid is resting on one of its base corners on the ground, such that its 30 mm base side on top is parallel to HP. Its 65 mm long axis is ⊥ to V.P. It is cut by a section plane perpendicular to V.P. and inclined to HP at 60° such that it bisects the top base edge. Draw the Front View and sectional Top View

Solution : Refer to fig. 5.21

1. Draw the Front View and Top View in the given position as shown.
2. Draw line G-G in the Front View meeting the midpoint of edge 'a-b' and inclined at 60° to HP.
3. Locate the POIs 1' 2', 3' cutting edges a'-c', o'-a' & a'-b' respectively.
4. Project these pts. on their corresponding edges in the Top View.
5. Join pts. 1, 2, 3 and hatch the area.
6. Draw the remaining portion as mentioned in the earlier e.g. to get the sectional view.

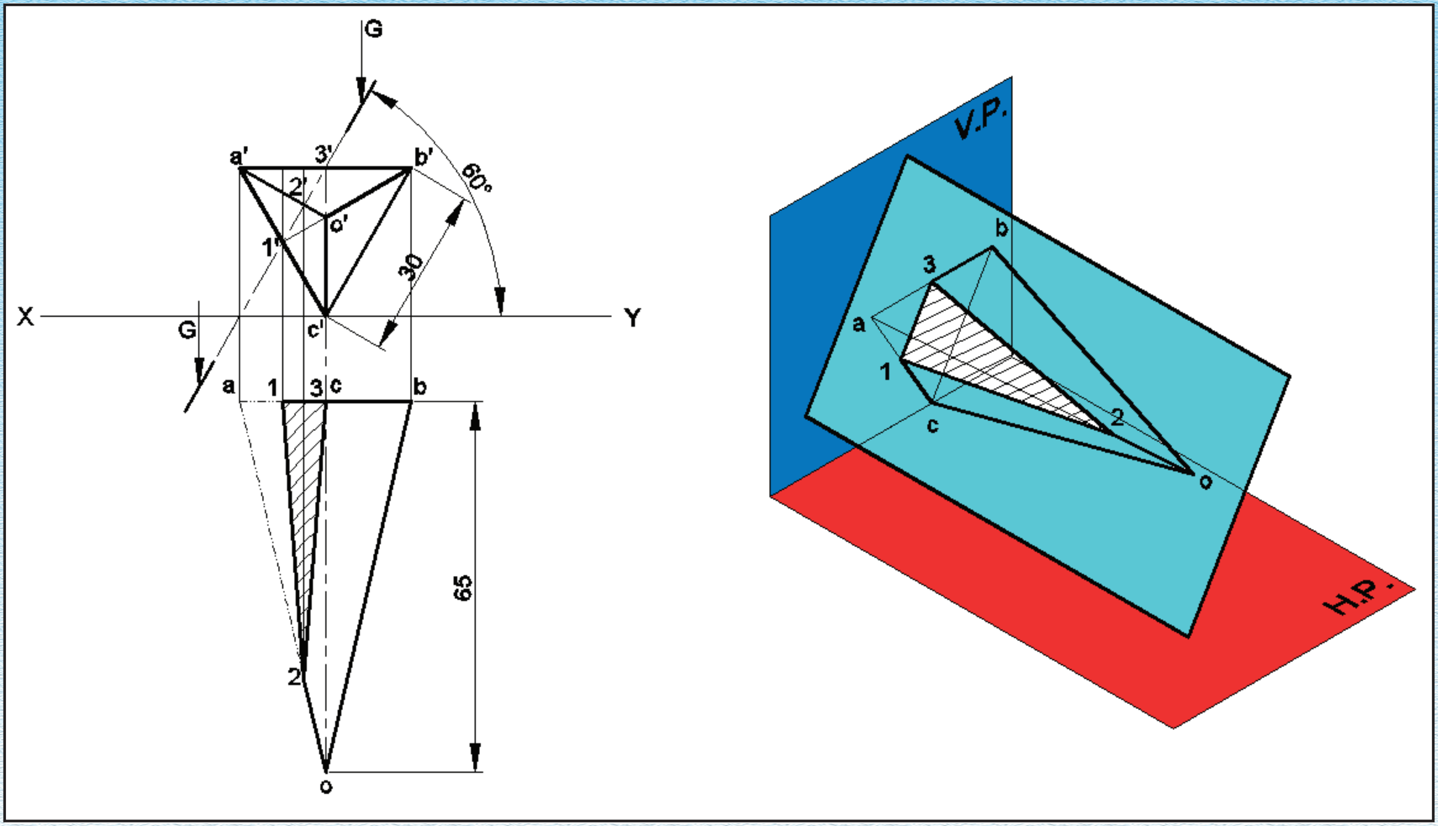


Fig. 5.21

Example 5.7 : A vertical pentagonal pyramid is lying on its base on HP with one of its 45 mm long base edge at the rear parallel to V.P. It is cut by a section plane inclined at 60° to HP and bisects the axis. The axis measures 80 mm. Draw the Front View and sectional Top View.

Solution : Refer to fig. 5.22

1. Draw the Front View and Top View in the given position as shown.
2. Draw section plane F-F inclined at 60° to X-Y and meeting axis line o'e' at a distance of 40 mm (midway) from X-Y line.
3. Locate the POIs 1' , 2', 3', 4' 5' & 6' cutting the base edges a'e' & a'b', the slant edges o'b', o'e', o'c' & o'd' respectively.
4. Project these pts. on their corresponding edges in the Top View. (But it can be seen that point 4' can't be projected vertically on the edge o'e')
5. So we have an extra step, i.e. draw a line parallel to the base from pt 4' in the Front View, meeting one of the other slant edges at pt. 7'. Then project pt. 7' in the Top View on the edge od. From pt. 7 in the Top View, draw a line parallel to the base meeting the edge oe at the desired pt. 4.
6. Join the pts. 1, 2, 3, 5, 6, 4 and hatch the area.
7. Draw the remaining portion and complete the view.

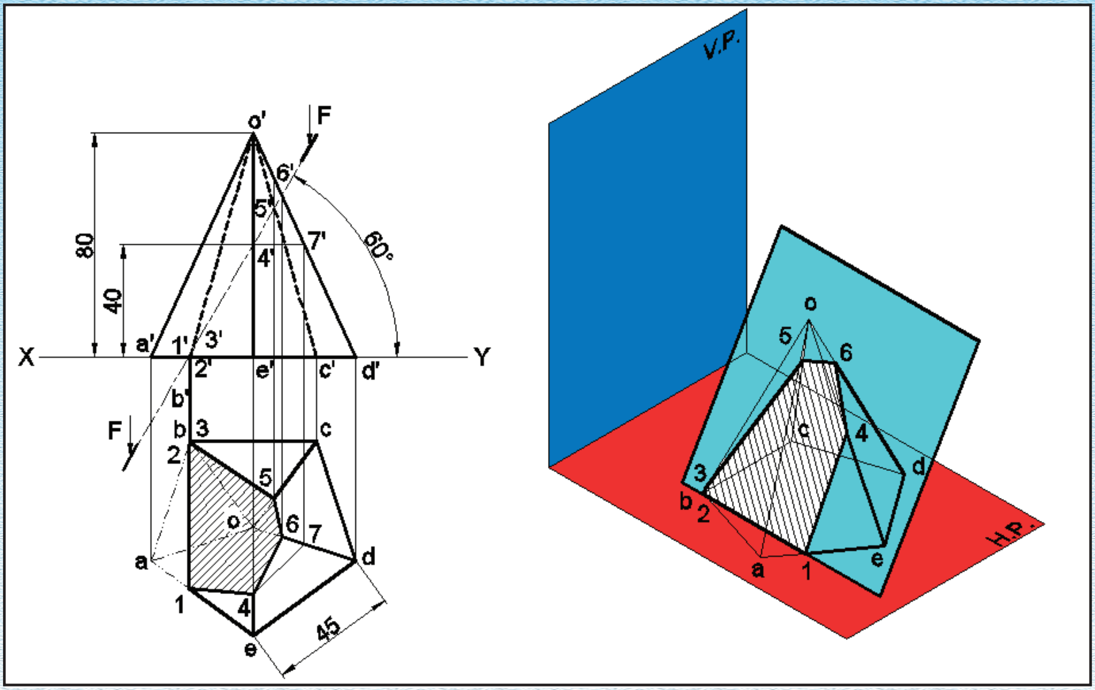


Fig. 5.22

Example 5.8 : A cone of ϕ 60 mm base and axis of length = 80 mm is resting on its circular face on H.P. It is cut by a section plane inclined at 60° to HP and meets the axis at a point 30 mm below its apex. Draw the sectional Front View and Top View.

Solution : Refer to fig. 5.23

1. Draw the Top View and Front View as shown.
2. Mark a point, 30 mm below apex o' in the Front View and draw a 60° inclined section plane D-D passing through it.
3. Locate POIs 1' & 2', meeting generators o'a' & o'b', in Front View and project them in the Top View on diameter a-o-b. (It can be seen that they don't have edges & more points need to be located to get the shape of the section)
4. Hence, divide the section plane into equal parts say 4 pt. and draw lines parallel to the base passing through these points These lines represent Circle A, B & C and their respective POIs with section plane are 3'-4', 5'-6' & 7'-8'.
5. Find the width of the lines draw in the earlier step and taking them as diameters, draw circles A, B & C in the Top View.
6. Project the POIs in the Top View, meeting the circles A, B & C at points 4, 3; 6,5 & 8, 7 respectively.
7. Join pts. 1, 4, 6, 8, 2, 7, 5, 3 as a curve. (As in this case, the section plane is cutting a curved surface.) Section the area.

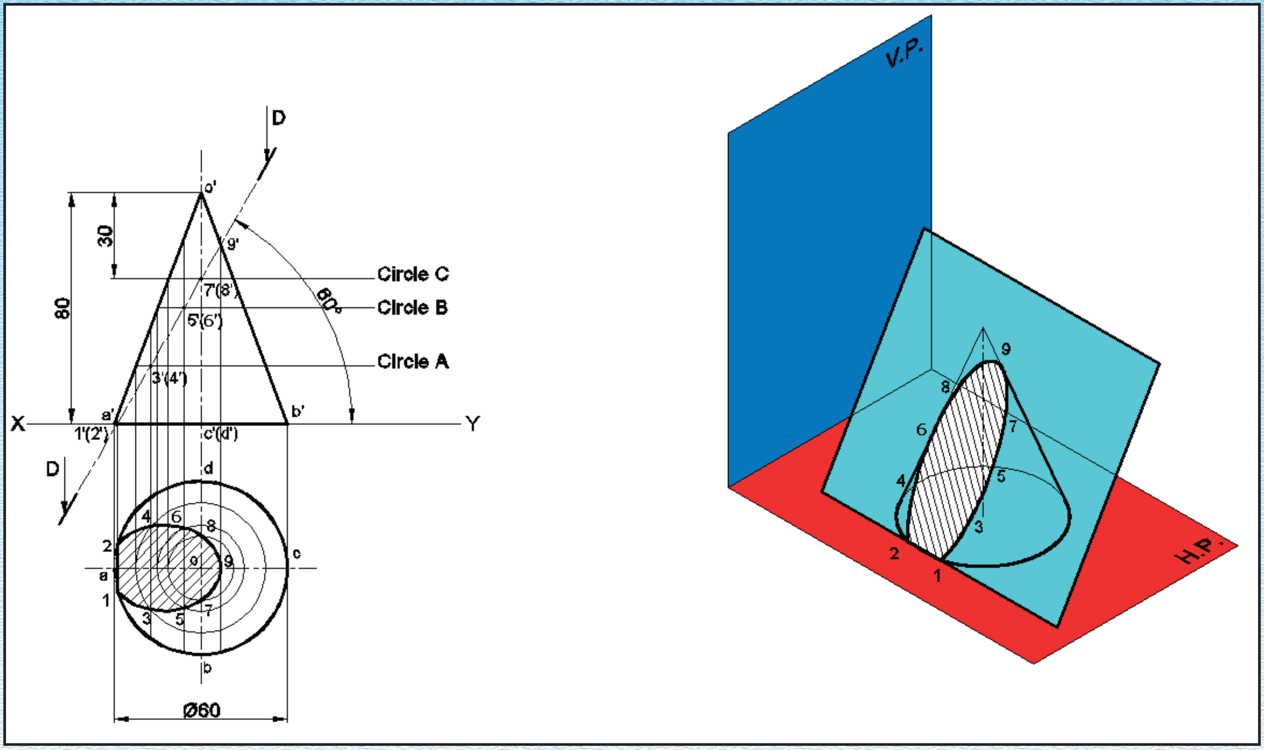


Fig. 5.23

Example 5.9 : A sphere of 32 mm diameter is cut by a horizontal section plane inclined at 45° to the HP and at a distance of 8 mm from O the centre. Draw the Front View & sectional Top View.

Solution : Refer to Fig. 5.24

1. Draw the projections of the given sphere.
2. Draw the inclined section plane A-A in the Front View which is tangential to a circle A′ of 8 mm radius.
3. Locate Pts. 1′ & 2′ meeting the outer circle as shown and project them in the Top View on the line 0-01 which represents the outer circle (circle D). It can be seen that some more points need to be located to get the shape of the section. Hence draw circles of any radii between the inner-most (circle A′) and outermost (Circle D′), at suitable distance i.e. circle B′ & C′ respectively. Project these circles as lines in the other view as shown.
4. Locate POIs on these constructed circles in the Front View, i.e. 3′,4′, 5′,6′, 7′,8′, 9′,10′, 11′,12′ meeting circles C′, B′ and A′ in Top View.
5. Project these POIs on the respective lines representing these circles in the Top View i.e. Pts. 1, 2 on circle D, pts. 3, 11, 4 & 12 on circle C and so on Join these pts. as a curve as a curved surface is cut a section plane and draw section lines.
6. Draw the remaining portion of the solid.

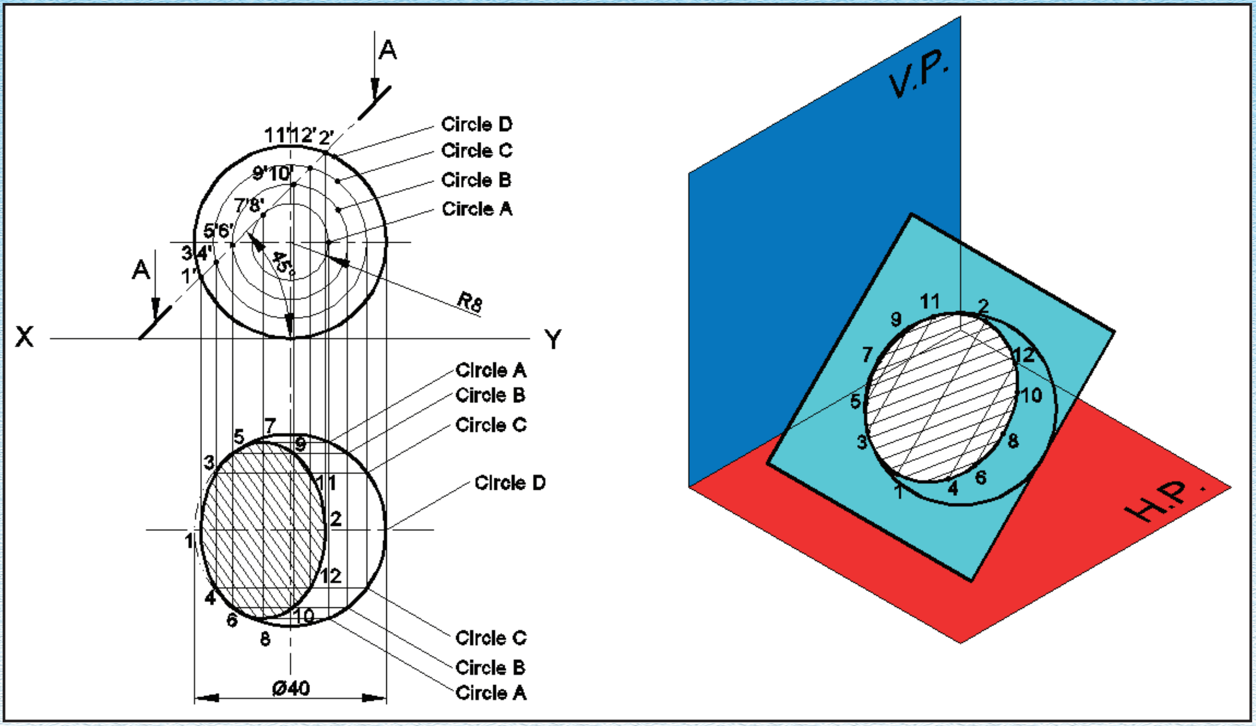


Fig. 5.24

TRY THESE

1. A Front View of a regular hexagonal pyramid is cut centrally by a section plane A-A. Complete the Top View and draw the section Fig. 5.25(a).

2. A Top View and an incomplete Front View of a square prism are shown in Fig. 5.25(b). The prism is cut by a 45° inclined section plane at a distance of 20 mm from one of the corners. Draw the given Front View, complete the Top View and add the section.

3. A pentagonal prism of length 60 mm is shown resting on HP in Fig. 5.25 (c) which is cut by section plane C-C parallel to HP at distance of 10 mm from top most long edge. Draw the given Front View, and add the sectional Top View.

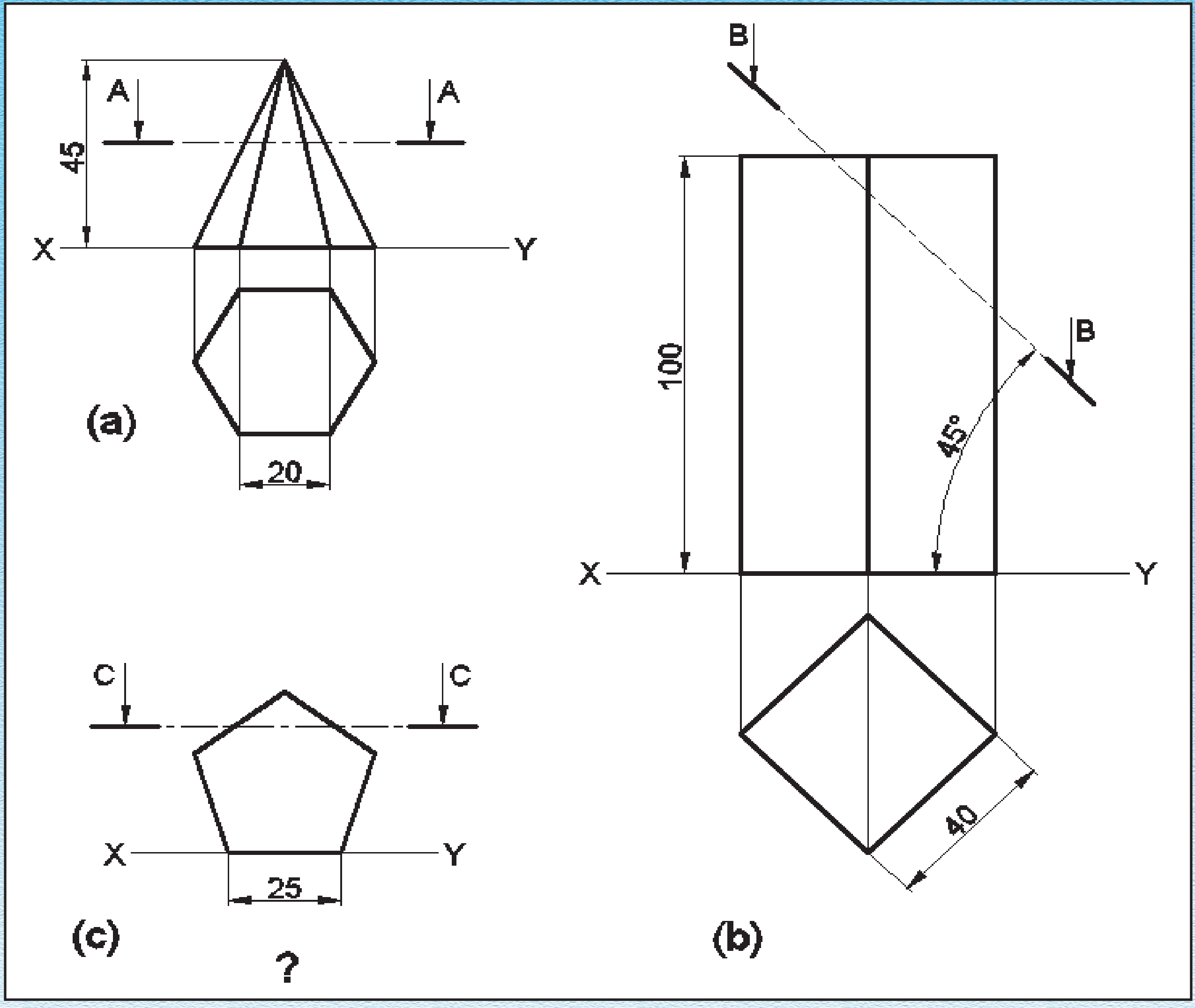


Fig. 5.25

5.3.2.3 Section Plane Parallel to VP & Perpendicular to HP

Similarly, here the section plane is represented as a line in the "Top View" and the sectional view is obtained in the Front View.

Example 5.10 : A sphere of 40 mm dia is cut by a vertical section plane, which passes through it at a distance of 10 mm from its centre. Draw the sectional Front View & Top View.

Solution : Refer to Fig. 5.26

1. Draw the projections.
2. Draw the section plane A-A at a distance of 10 mm from the centre o in the Top View as shown.
3. Locate the POIs 1, 2 in the Top View intersecting the circle. As only two points are not enough in case of section of curved surface. Hence locate two more POIs 3 & 4 meeting the axis line.
4. Project these POIs in the Front View and draw a circle with centre o' and dia 1' - 2' equal to section line 1-2 in the Top View.
5. Draw section lines to get the sectional Front View.

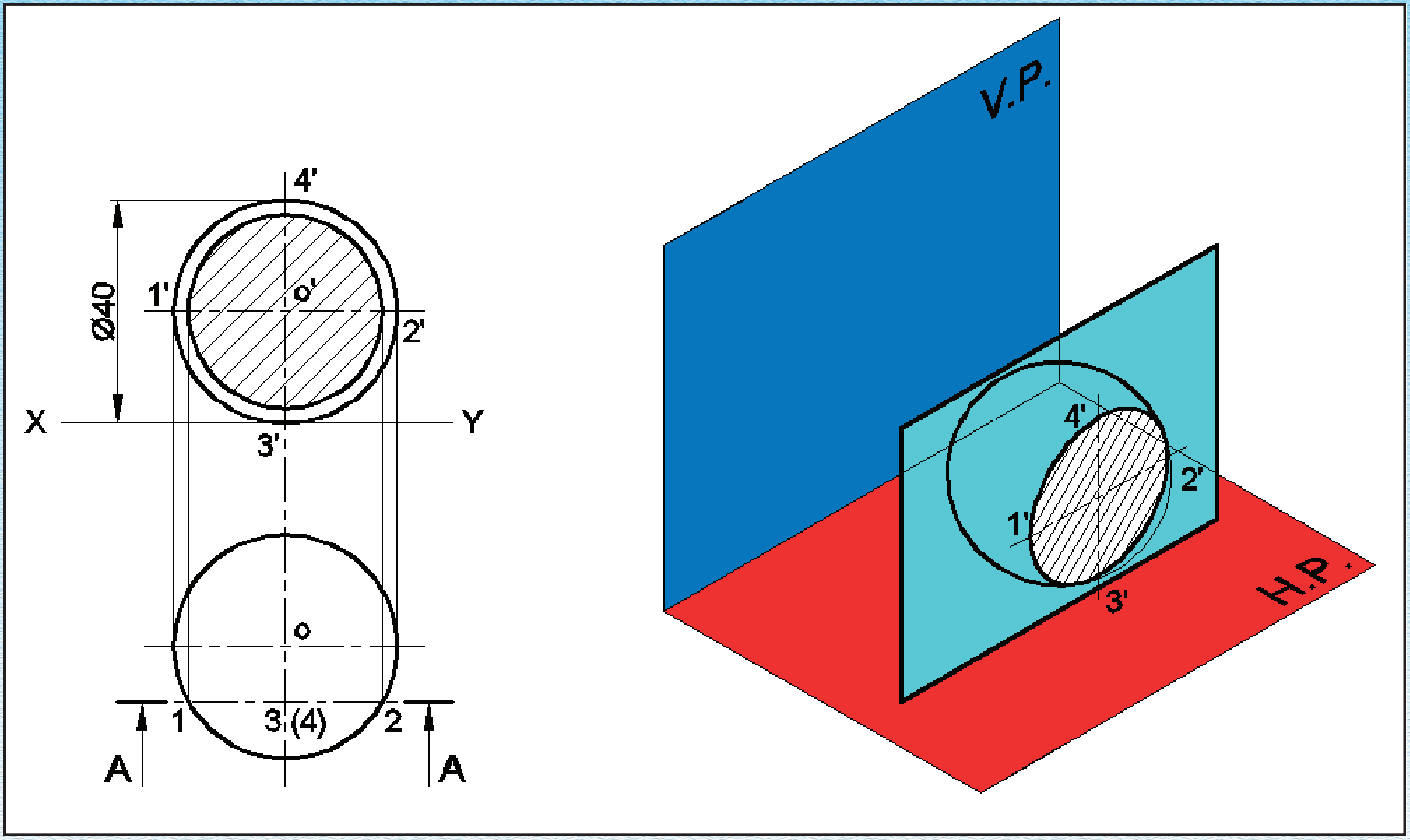


Fig. 5.26

Example 5.11 : A square prism with 30 mm base side and length of axis = 80 mm is resting on its base on HP such that all the vertical faces are equally inclined to VP. A section plane parallel to VP and perpendicular to HP, and 10 mm away from the axis, cuts the prism. Draw Top View and sectional Front View.

Solution : Refer to Fig. 5.27

1. Draw Top View and Front View of the prism as shown.
2. In the Top View, draw the section plane D-D parallel to X-Y line and at a distance of 10 mm away from the centre o.
3. Locate POIs 1, 2, & 3, 4 in Top View intersecting edges, a-b, a1-b1, b-c & b1-c1
4. Project these POIs on their corresponding edges in Front View.
5. Join 1′-2′-4′ & 3′ and section the area.

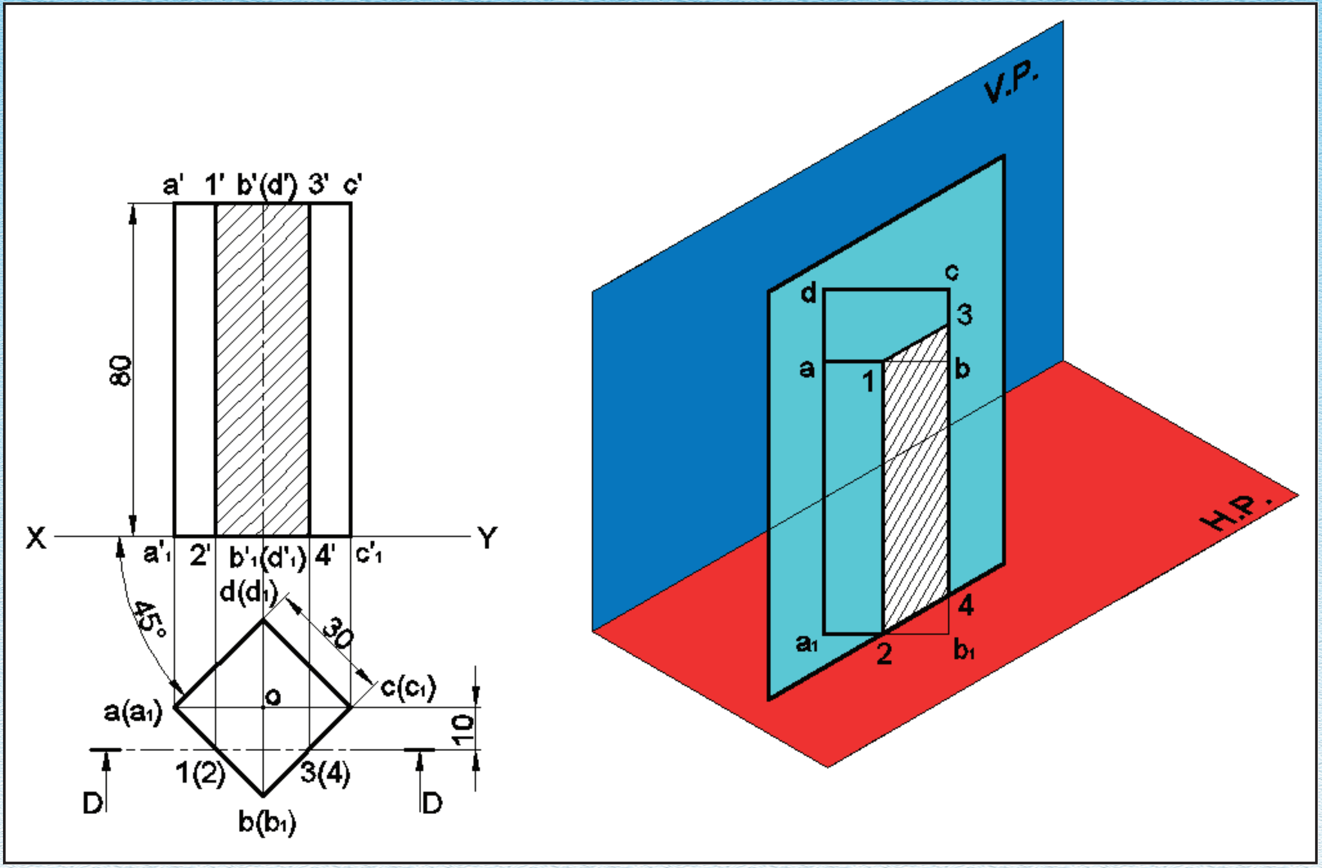


Fig. 5.27

Example 5.12 : A cone of base dia 40 mm is resting on HP and its 50 mm long axis ⊥ to HP. It is cut by a section plane ⊥ to HP and parallel to VP, at a distance of 10 mm from the front. Draw the Top View and sectional Front View.

Solution : Refer to Fig. 5.28

1. Draw the Front View and Top View as shown.
2. Draw the section plane A-A, parallel to X-Y line and 10 mm from point C.
3. Locate the POIs 1, 2 intersecting the circular base. (We can see again. as in case of Egs. 5.8 & Eg. 5.9, i.e. curved surfaces, we need to obtain more POIs)
4. So draw some concentric circles, Circle A (innermost) such that section plane is tangential to it, and another Circle B and project these circles as lines in Front View.
5. Locate points 3, 4 and 5 cutting the circles A & B and project all the POIs in the Top View.
6. Join all the points 1', 3', 4', 5' and 2' as a curve and section the area.

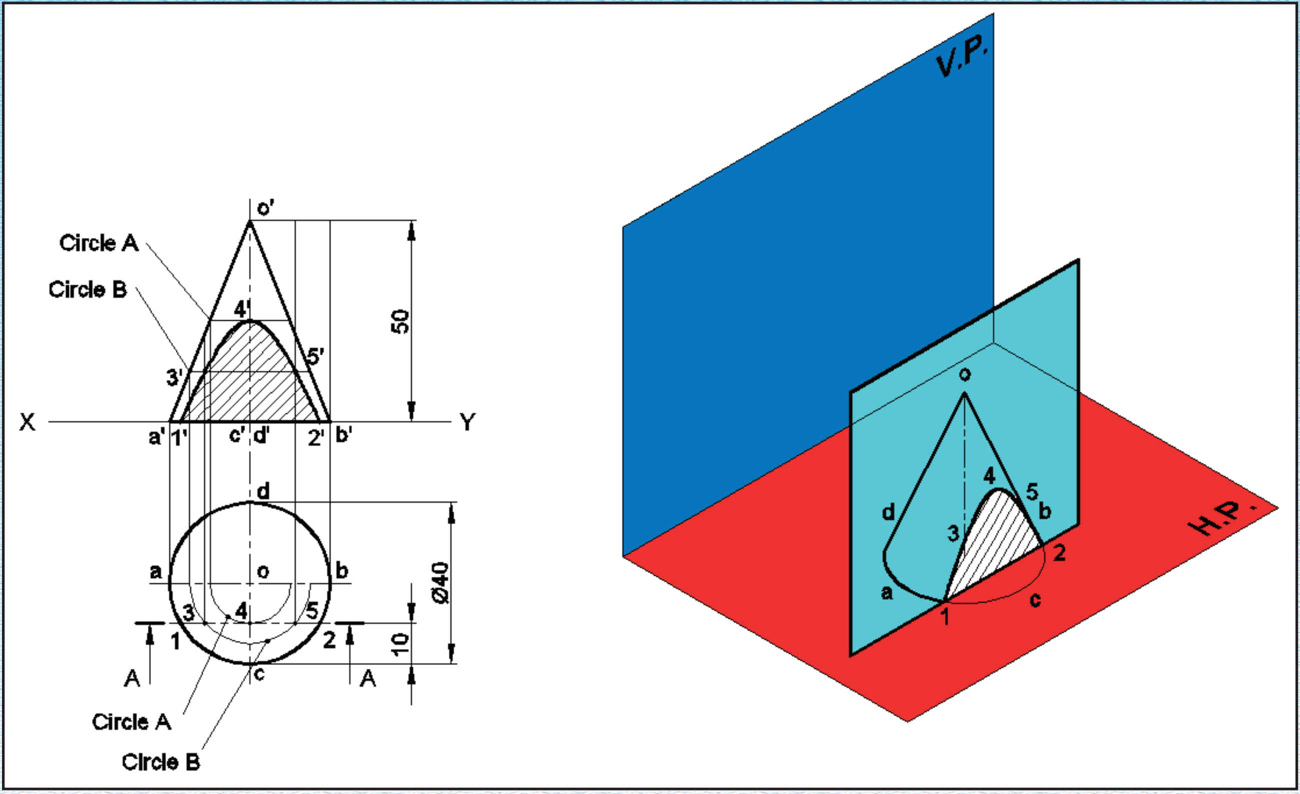


Fig. 5.28

5.3.2.4 : Section Plane Perpendicular to HP & Inclined to V.P.

Example 5.13 : A square prism of base side 40 mm and height 70 mm is resting on its rectangular face on the ground such that its axis is parallel to HP & VP. It is cut by a section plane perpendicular to HP & inclined to VP at an angle of 45° and passing through a point 10 mm from one of its ends. Draw the sectional Front View and Top View.

Solution : Refer to Fig. 5.29

1. Draw the Front View, Top View as helping side view as shown.
2. Draw line B-B inclined at 45° and 10 mm from end 'a'.
3. Locate POIs 1, 2, 3 and 4 intersecting the long edges.
4. Project these POIs in Front View and join the pts.
5. Hatch the area, and draw the remaining portion.

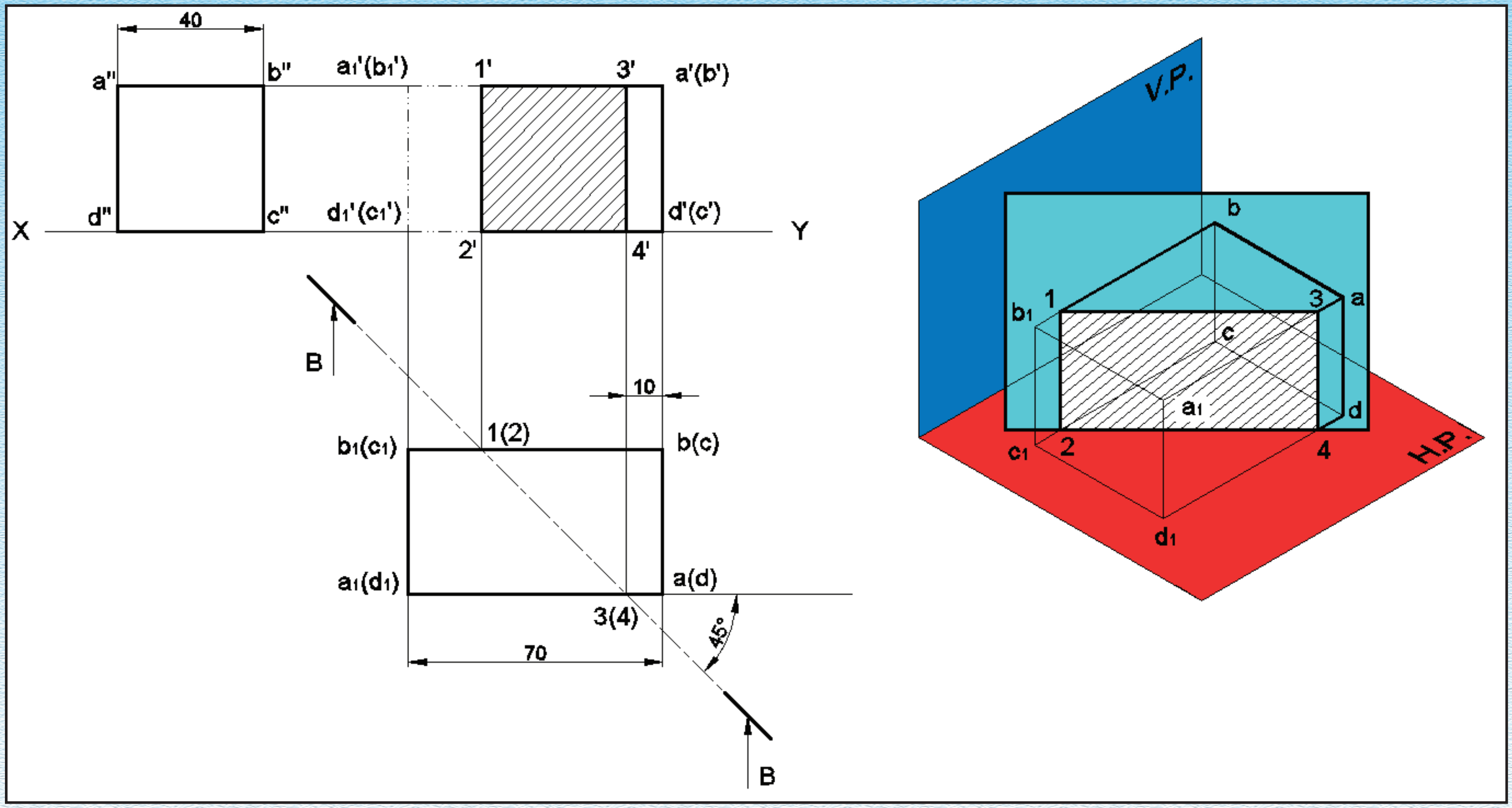


Fig. 5.29

Example 5.14 : A triangular pyramid is resting on its base on HP, such that one of its base edges at the rear is parallel to VP. Its base edge measures 35 mm and height 50 mm. A section plane inclined to VP at 45° and perpendicular to HP cuts the slant edge of the pyramid in front, at a distance of 5 mm from the axis. Draw the sectional Front View and Top View.

Solution : Refer to Fig. 5.30

1. Draw the Top View and Front View as shown.
2. In Top View, draw the section plane, inclined at 45° to VP at a distance of 5 mm from the axis pt. 'o(p)'
3. Locate POIs, 1, 2, 3 and 4 cutting the edges ac, oa, ob and be respectively.
4. Project these pts. on the corresponding edges in the Front View. [But it can be seen that pt. 3 can't be projected vertically on the edge o'b' as similar to Example 5.7]
5. Similarly, we have an extra step, i.e. draw a line parallel to base from pt. 3 in Top View such that it meets one of the slant edges 'oa' at point 5. Then project pt. 5 in the Front View on the edge o'a' and then from pt 5', draw a line parallel to base meeting the edge o'b' at point 3'.
6. Join the pts 1'-2'-3'-4' and hatch the area.
7. Join the remaining portion. (Here also, some portion of the solid is removed & lies outside the section, so it is represented by dashed double dotted lines.)

Example 5.15 : A cone, base diameter 30 mm and axis 60 mm is resting on HP such that the axis is parallel to HP and perpendicular to VP. The apex is nearer to the observer. A section plane perpendicular to HP and inclined at 60° to VP bisects the axis. Draw its sectional Front View and Top View.

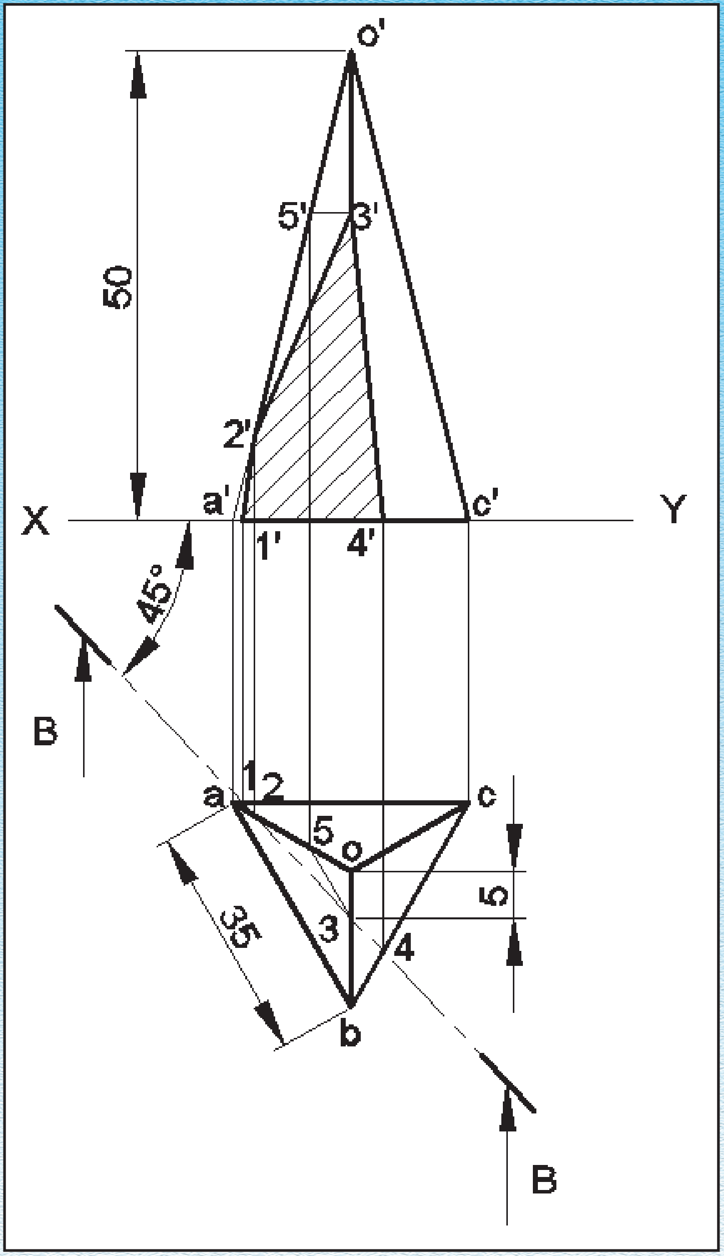


Fig. 5.30

Solution : Refer to Fig. 5.31

1. Draw the Front View and Top View as shown in the given position.

2. In Top View, draw the section plane B-B. passing through the mid point of the axis 0-01 and making an angle of 60° with VP as shown.

3. Locate the POIs 1, 2 & 3 cutting generator oa & base ac at two points. In this case, we can see they don't have edges as learnt in the previous chapter, so we divide the circle into equal parts (atleast 8 parts) and project these pts. in the other view as end points of generators.

4. We locate POIs 4, 5, 6 and 7 cutting generators " ob, oh, od" and "of" respectively.

5. Project all the POIs to pts 1′, 2′, 3′, 4′, 5′, 6′ and 7′ on the corresponding generators in Front View.

6. Join 1′-4′-6′-2′-3′-7′-5′ as a curve, since here also, the section plane is cutting a curved surface. Section the area.

7. Draw the remaining portion.

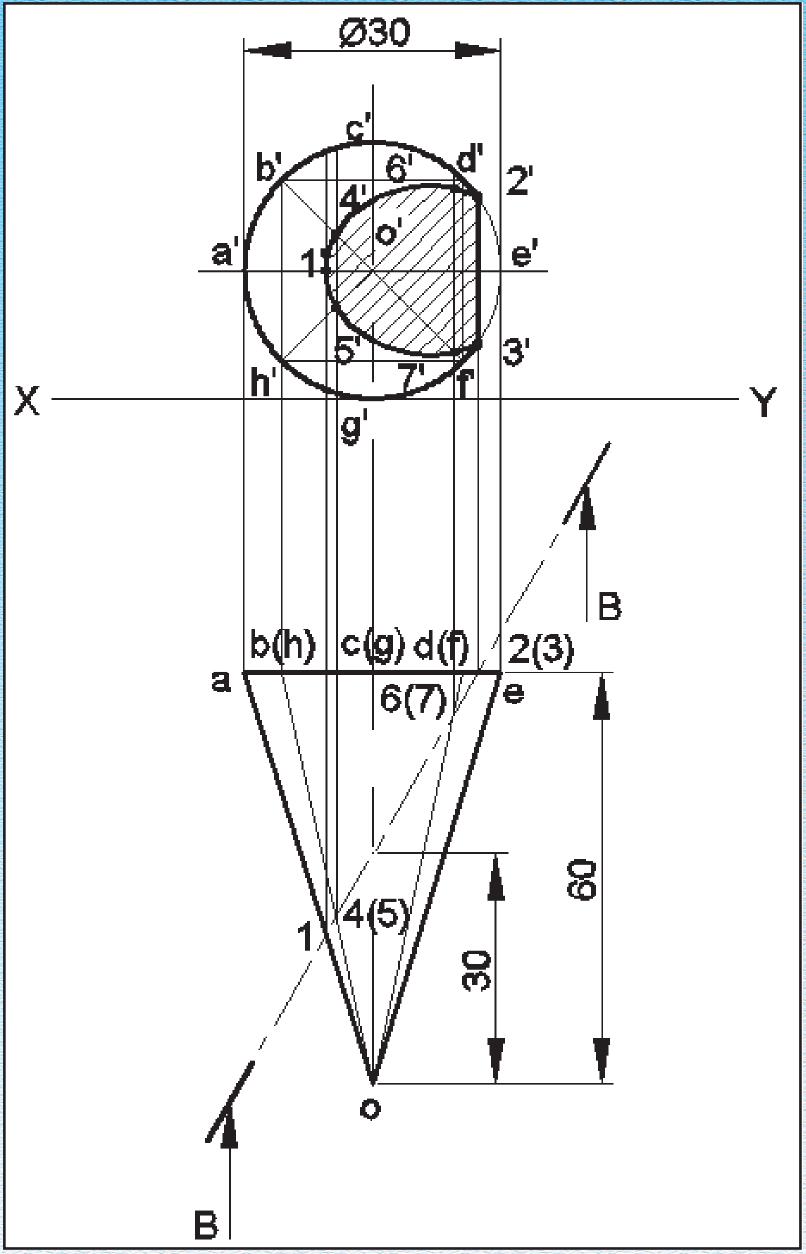


Fig. 5.31

ADDITIONAL QUESTIONS

Example 5.16 : A pentagonal prism of base side 20 mm is resting on its 35 mm long rectangular edge on the ground such that the axis is parallel to HP and VP. A section plane inclined at 60° to HP and perpendicular to VP bisects the axis. Draw its projections and the sectional view.

Solution : Refer to Fig. 5.32

1. Draw the orthographic views Front View and Top View alongwith the helping view (side view)
2. In the Front View, draw the section plane B-B which bisects the axis and is inclined at 60° to HP.
3. Locate POIs 1',2',3',4' & 5' in Front View at the intersections of the cutting plane with edges a'-a1', b'-b1', e'-e1', c'-c1', d'-d1', as shown.
4. Project these POIs in the Top View on the corresponding edges (can take help of the side view/end view to identify the edges).
5. Join pts. 1, 2, 3, 4 and 5 and section the area.
6. Draw the remaining portion of the object to get the sectional view.

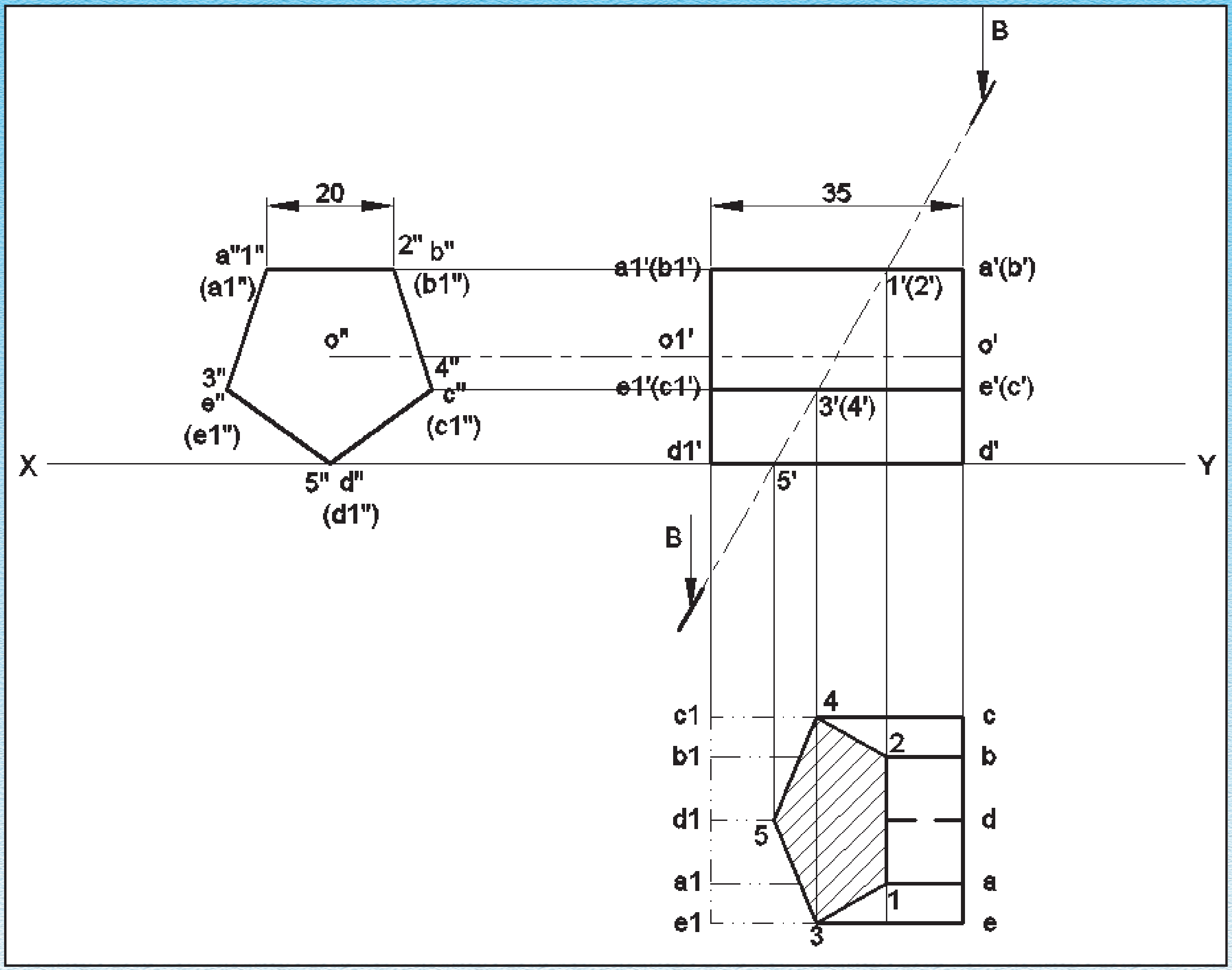


Fig. 5.32

Example 5.17 : A hexagonal pyramid of base edge 20 mm and height 40 mm is resting on one of its base edges on the ground, such that the axis is inclined at 30° to HP. A section plane parallel to HP and perpendicular to VP passing through the top-most corner of the base cuts the solid. Draw the Front View and sectional view.

Solution : Refer to Fig. 5.33

1. Draw the orthographic projections of the inclined solid as learnt inthe previous chapter.
2. Draw the section plane A-A, meeting (corners) pts. b', a' and parallel to HP (X-Y line).
3. Locate the POIs 1', 2', 3' , 4', 5', 6' meeting the edges o'b', o'a', o'c', o'f', o'd' & o'e' respectively.
4. Project these pts. in the other view (Top View) on the corresponding edges. Join 1, 2, 4, 6, 5 and 3 and draw section lines.
5. Draw the remaining portion of the solid in Top View.

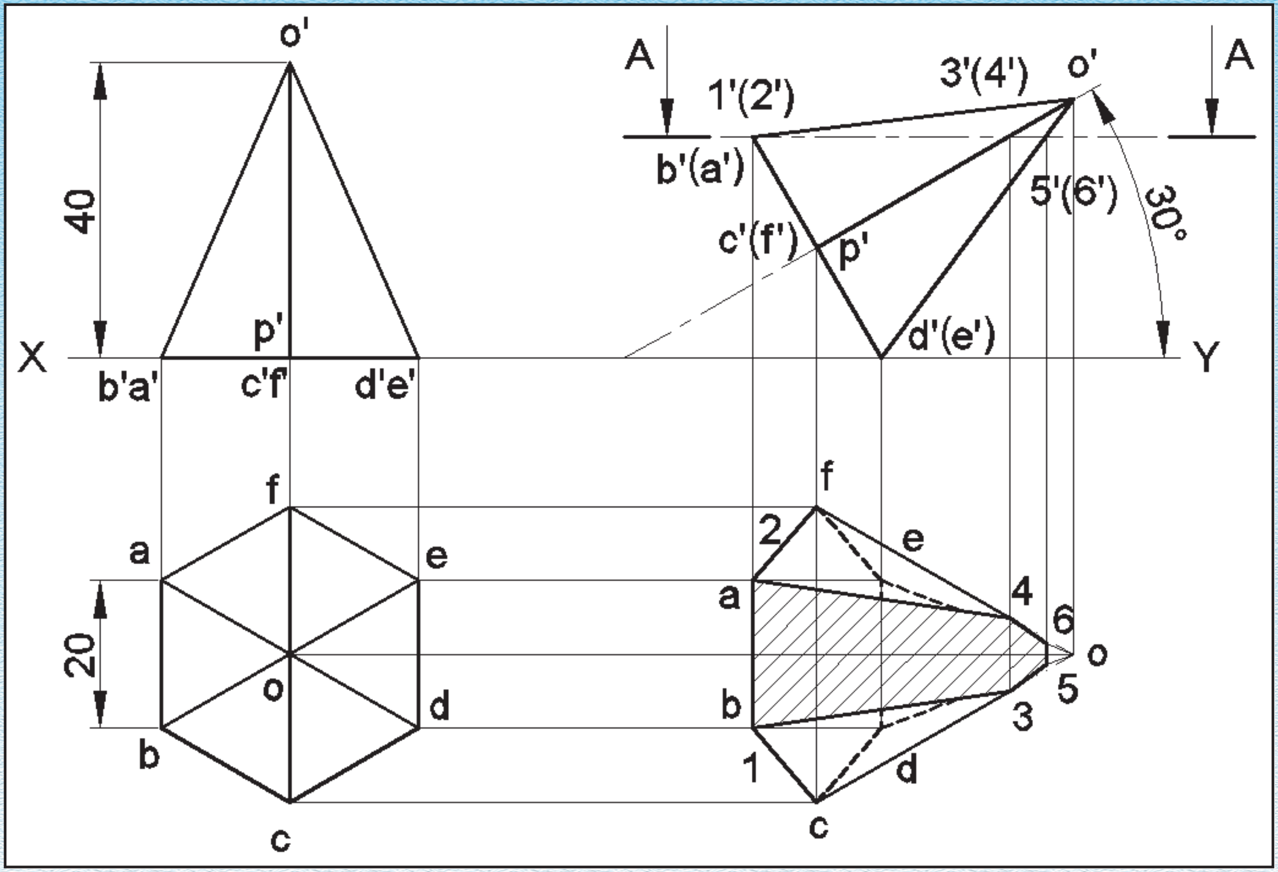


Fig. 5.33

To sum up, different section planes cut a square pyramid placed in various positions to obtain respective sectional views as shown in Fig. 5.34 (a), (b), (c) & (d).

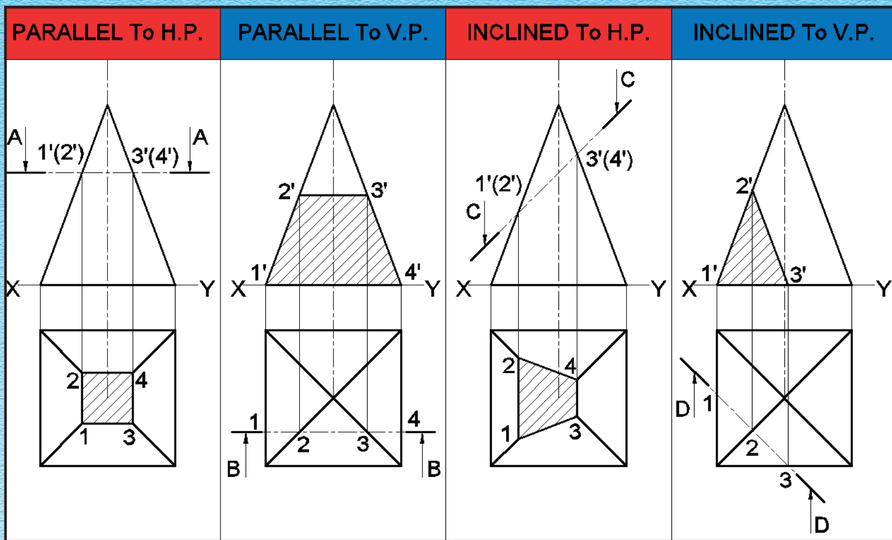


Fig. 5.34a

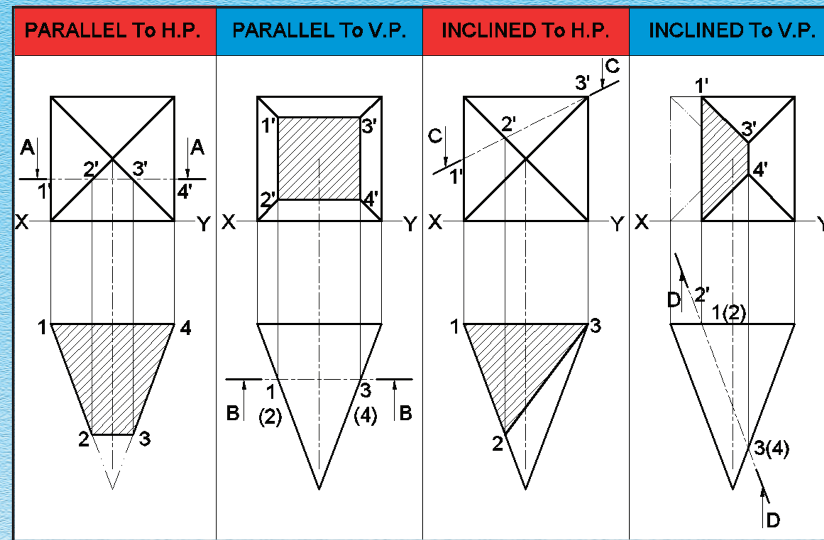


Fig. 5.34b

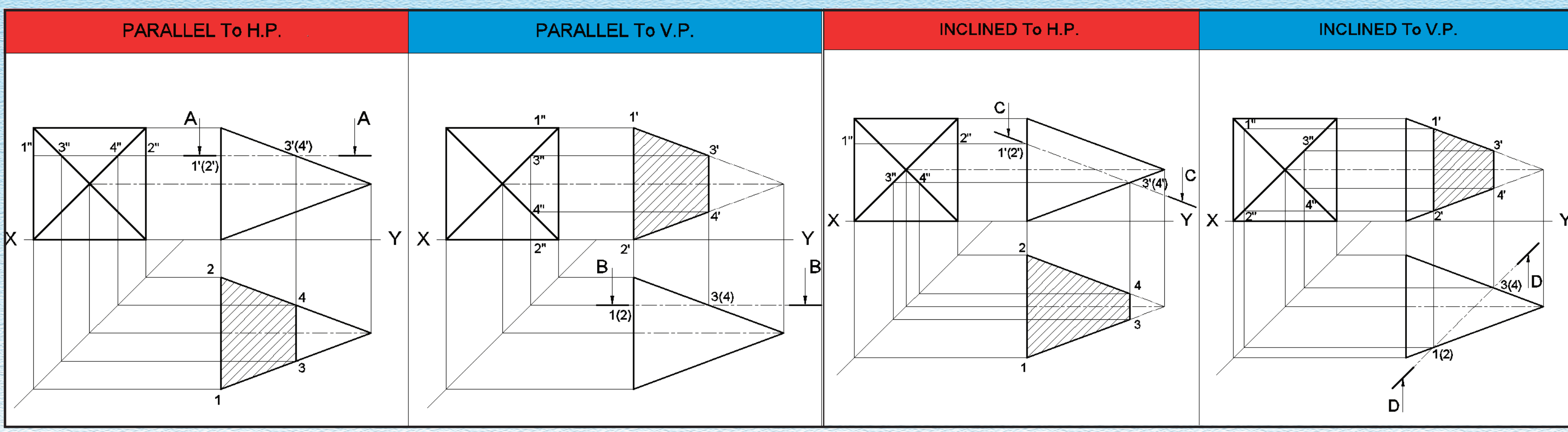


Fig. 5.34c

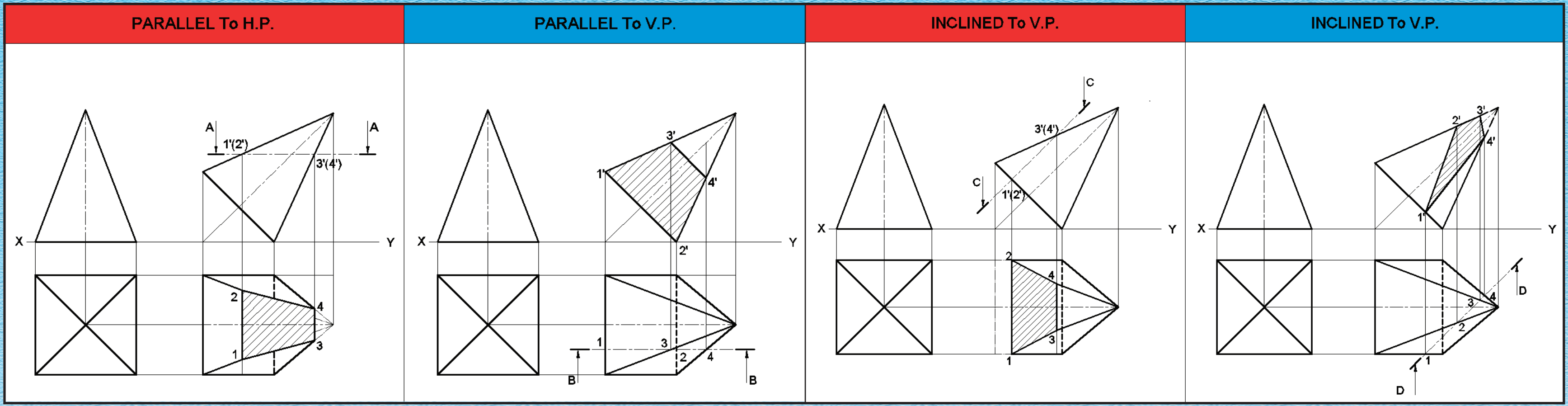


Fig. 5.34d

It can be seen in Fig. 5.34 (c) we may take help of the end (side) view (as in case of orthographic projection), to obtain the sectional/ view.

Note : It is not necessary when Front View and Top View can be obtained directly.

In Figs. 5.34(a), (b) & (d) the basic concept to draw sectional views remain same but only the orthographic projections of the solid vary according to given conditions. Similarly in case of inclined solids (with axis inclined to VP/HP), the same procedure applies.

TRY THESE

1. In Fig. 5.35 (a) & (b), some solids are projected orthographically. Section planes A-A and B-B cut them respectively. Draw their respective sectional views.
2. A cylinder with 60 mm base diameter and 60 mm long axis, rests on its base on HP. It is cut by a section plane parallel to and 40 mm above HP. Draw its Front View and sectional Top View.
3. A pentagonal pyramid, side of base 30 mm and height 60 mm, rests on HP, with its axis vertical and an edge of base normal to VP. A horizontal cutting plane cuts the solid at height of 20 mm from the base. Draw front and sectional Top View of the pyramid.
4. A cube of 55 mm side has an edge on HP and axis inclined at 60° to HP. A vertical section plane parallel to VP and perpendicular to HP cuts the axis into two halves. Draw the projections and sectional view.

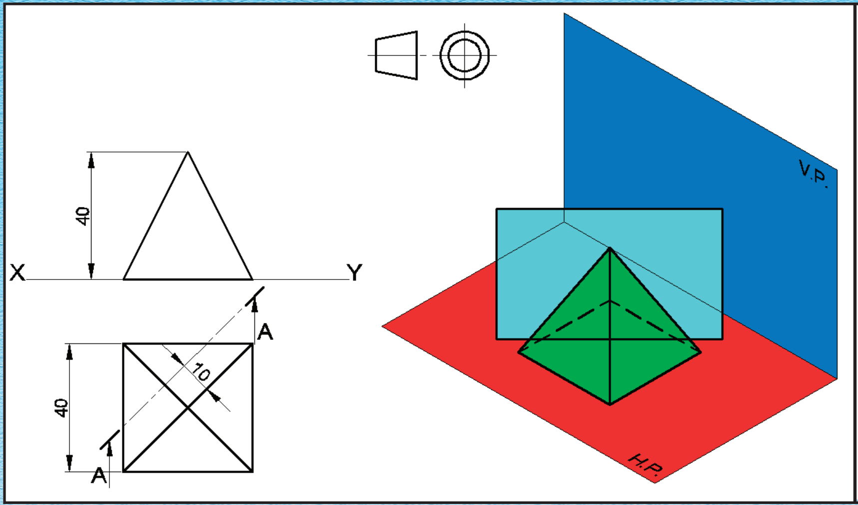


Fig. 5.35a

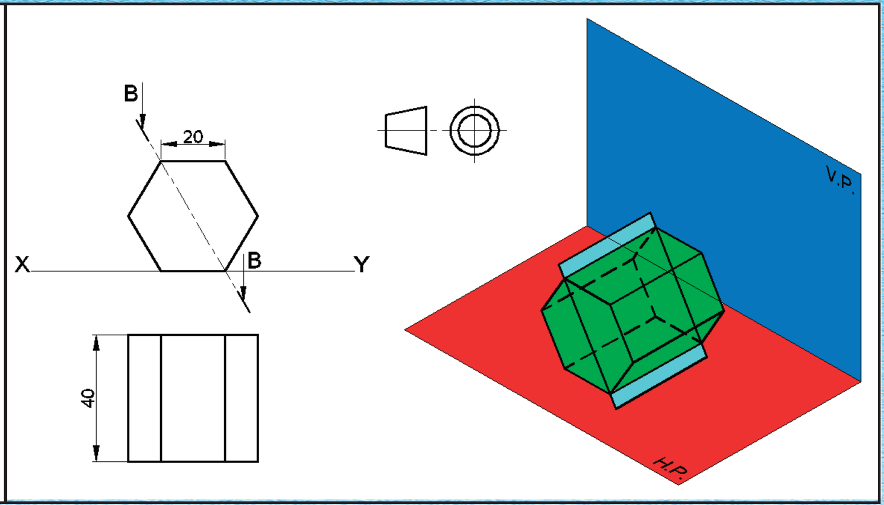


Fig. 5.35b

5.4 TRUE SHAPE OF A SECTION

Similar, to what we have learnt about true length in the previous chapter, here also we talk about true shape when we cut/section the object at some angle, i.e. the "section plane/cutting plane is inclined to HP or VP. Thus the sectional view of cut surface obtained is not the actual shape and is called as **"apparent section"**. To obtain the true shape of the section, we project it on another reference plane (auxiliary plane) parallel to the section plane as shown in the Fig. 5.36.

The true shape of the section can be obtained thus by viewing the object normal to the cut surface and projecting it on that "reference plane parallel to the section plane."

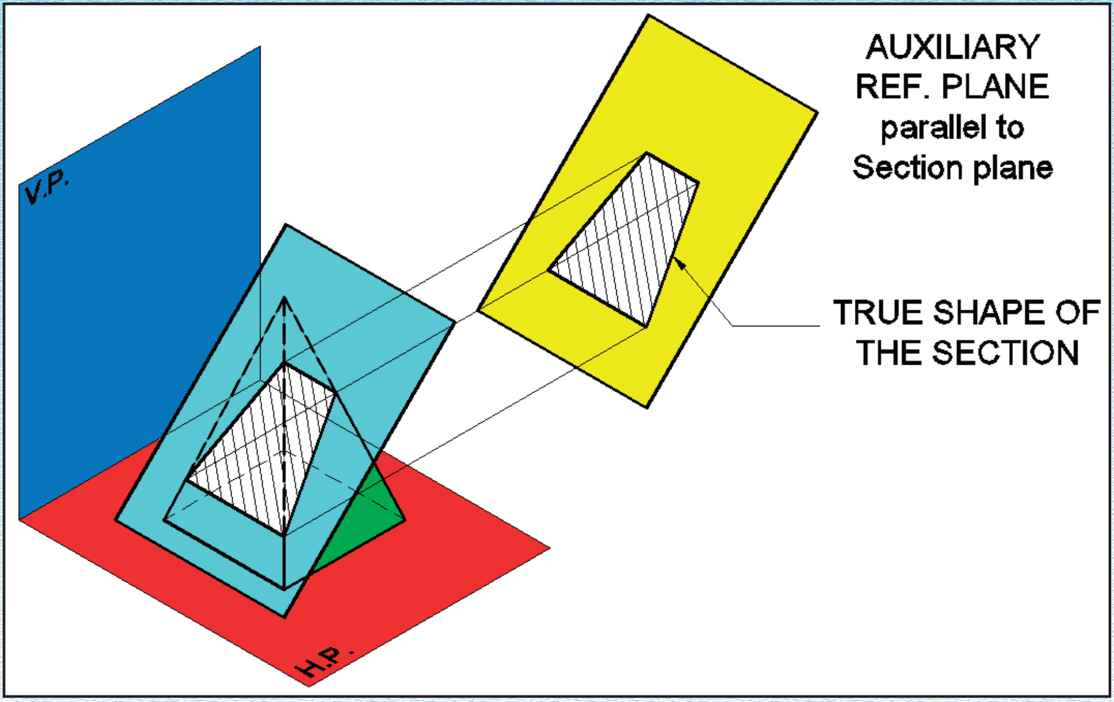


Fig. 5.36 Pictorial view of obtaining true shape of section

Note : If the section plane is parallel to HP/VP, then the True shape of the section will be visible in their respective sectional views itself.

ACTIVITY 5.3

1. Take a potato, bottle gourd or soap cakes and cut them at different angles, as shown in the Fig. 5.37

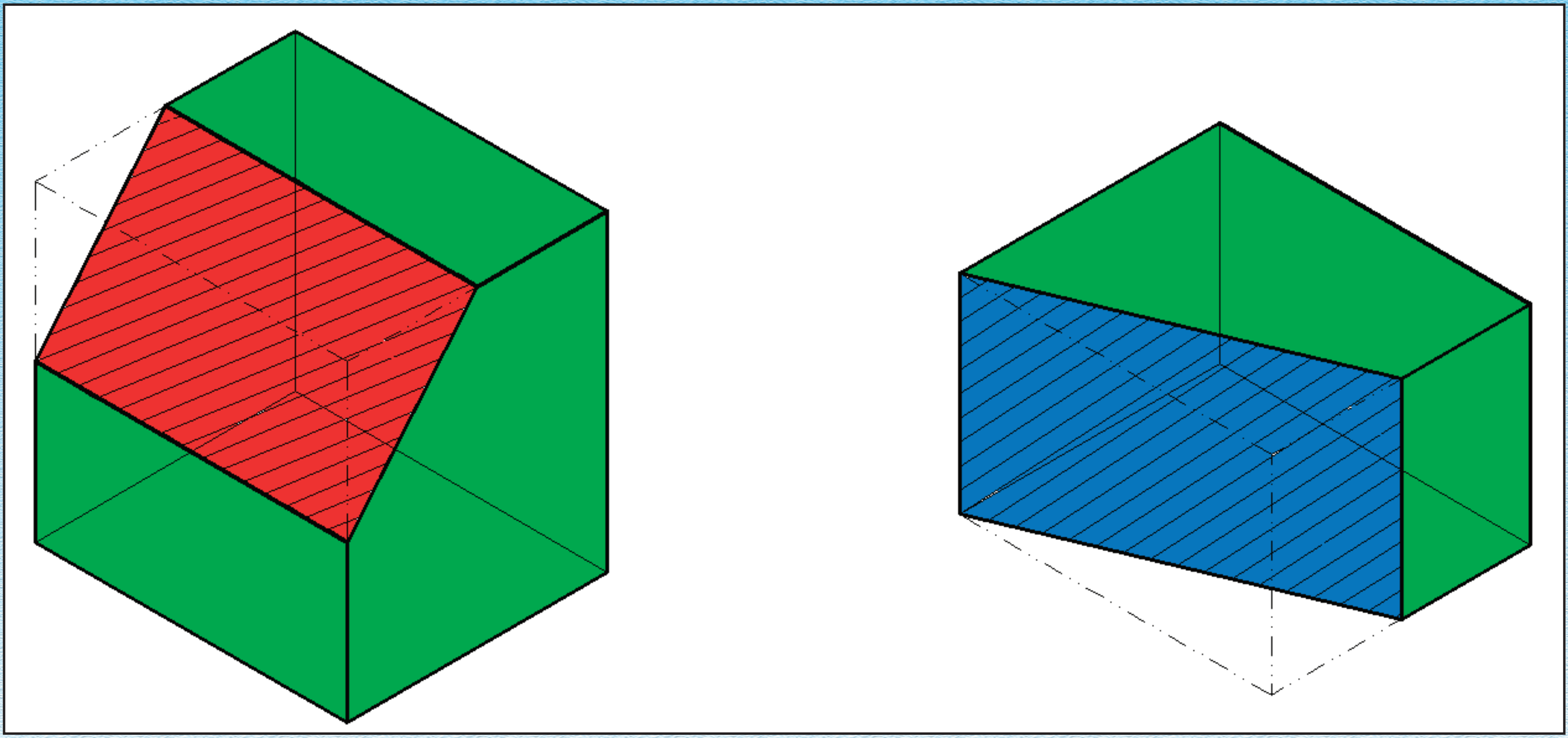


Fig. 5.37 Cut portions of different objects

2. Paint the cut surface visible/exposed to you.
3. Get some prints on a sheet of paper, by placing the painted surface firmly on the sheet. These prints will show the true shapes of the cut surfaces.

Similarly, you can get true shape prints of the cut surfaces of soap cake models of solids made in the Activity 5.2

5.4.1 Drawing Procedure for True Shape

Let us see how we can obtain (draw) the true shape of the section from the sectional view. Here also, we have to follow the procedure learnt earlier to draw the sectional view and then proceed further.

Let us consider the example of a vertical square pyramid which is cut by a section plane inclined to the ground (H.P.). It is pictorially shown in the Fig. 5.36

Steps of construction : Refer to Fig. 5.38

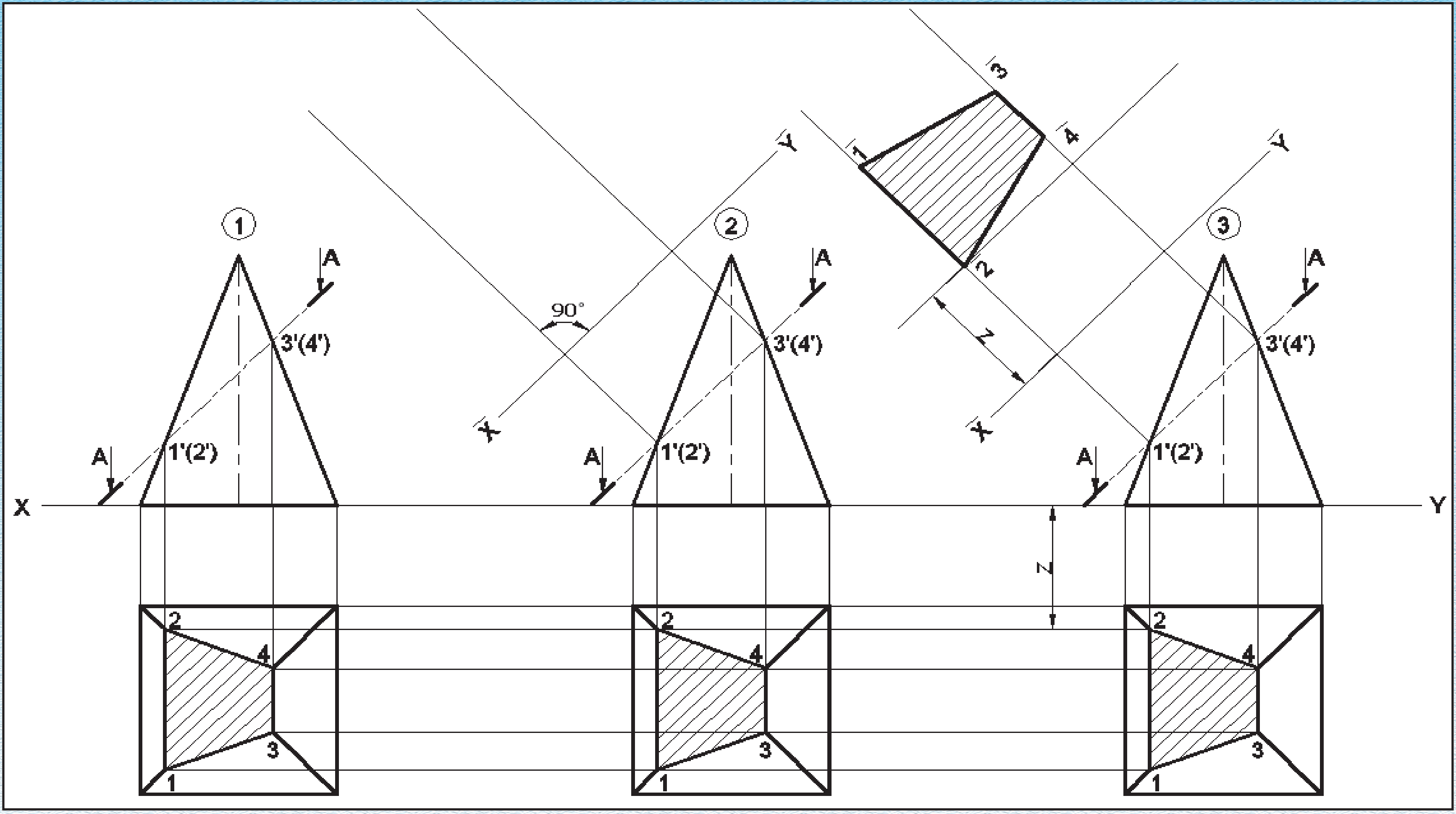


Fig. 5.38

1. Refer to Fig. 5.38 (1) Draw the projections of the solid including the sectional view as learnt earlier in (5.3)
2. Refer to Fig. 5.38(2) Draw a thin line $\bar{X}$- $\bar{Y}$, which represents the auxiliary plane, parallel to the section plane (here, A-A) at a convenient distance. Then draw projectors (thin lines perpendicular) to $\bar{X}$- $\bar{Y}$ from the POIs (here pts 1',2',3' & 4') intersecting the cutting plane.
3. Refer Fig. 5.38(3) Measure the distances of all these projected POIs in the sectional view with respect to X-Y line and mark them on their respective projectors from $\bar{X}$- $\bar{Y}$. Here distance 'z' of pt. 2 in the Top View is marked on the projector (⊥ line) with respect to $\bar{X}$- $\bar{Y}$. And so on for other POIs.
4. Join all the projected POIs wrt $\bar{X}$- $\bar{Y}$ with continuous thick lines. (Here, they are $\bar{1}$, $\bar{2}$, $\bar{3}$, & $\bar{4}$). Section the area. This is the true shape of the section.

   [Fig. 5.38 Step-wise Procedure to obtain true shape of a section]

   Let us consider some other examples to understand the drawing technique of true shape better.

5.4.2 Examples

Let us refer to the previous examples where the section plane is inclined and obtain the true shape of these sections.

Example 5.18 : A square prism of base side 50 mm and height of axis 80 mm has its base on HP. It is cut by a section plane perpendicular to VP and inclined to HP such that it passes through the two opposite corners of the rectangular face in front. Draw the sectional Top View and Front View and true shape of the section.

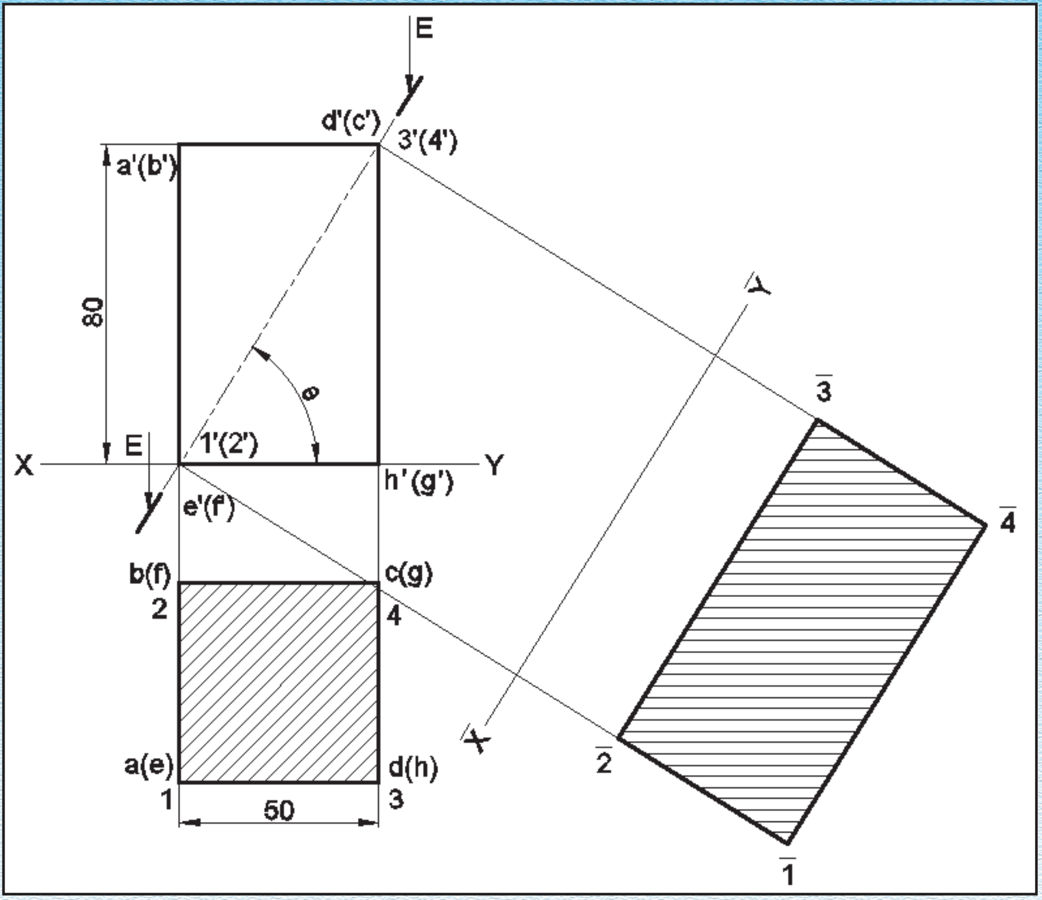


Fig. 5.39

Sol. : Refer to Fig. 5.39

1. Draw the Front View with the section plane and the sectional Top View, as learnt in example 5.4 previously.
2. Draw the reference (auxiliary) plane $\bar{X}-\bar{Y}$, parallel to the section plane E-E as shown in the Fig.
3. From the POIs in Front View i.e. 1′, 2′, & 3′, 4′, draw projectors perpendicular to the $\bar{X}-\bar{Y}$ line.
4. Measure the perpendicular distances of the pts 1, 2, 3, 4 in Top View wrt X - Y and mark then on their corresponding projectors wrt $\bar{X}-\bar{Y}$.
5. Join the projected POIs $\bar{1}, \bar{2}, \bar{4}$ & $\bar{3}$ with continous thick lines and hatch the area to obtain true shape of the section.

Example 5.19 : A cylinder of base diameter 50 mm and height 70 mm is resting on its curved surface on HP such that the axis is normal to VP. A section plane inclined to HP at an angle of 60°, passes through the axis and cuts the solid into two halves. Draw the Front View, sectional Top View and true shape of the section.

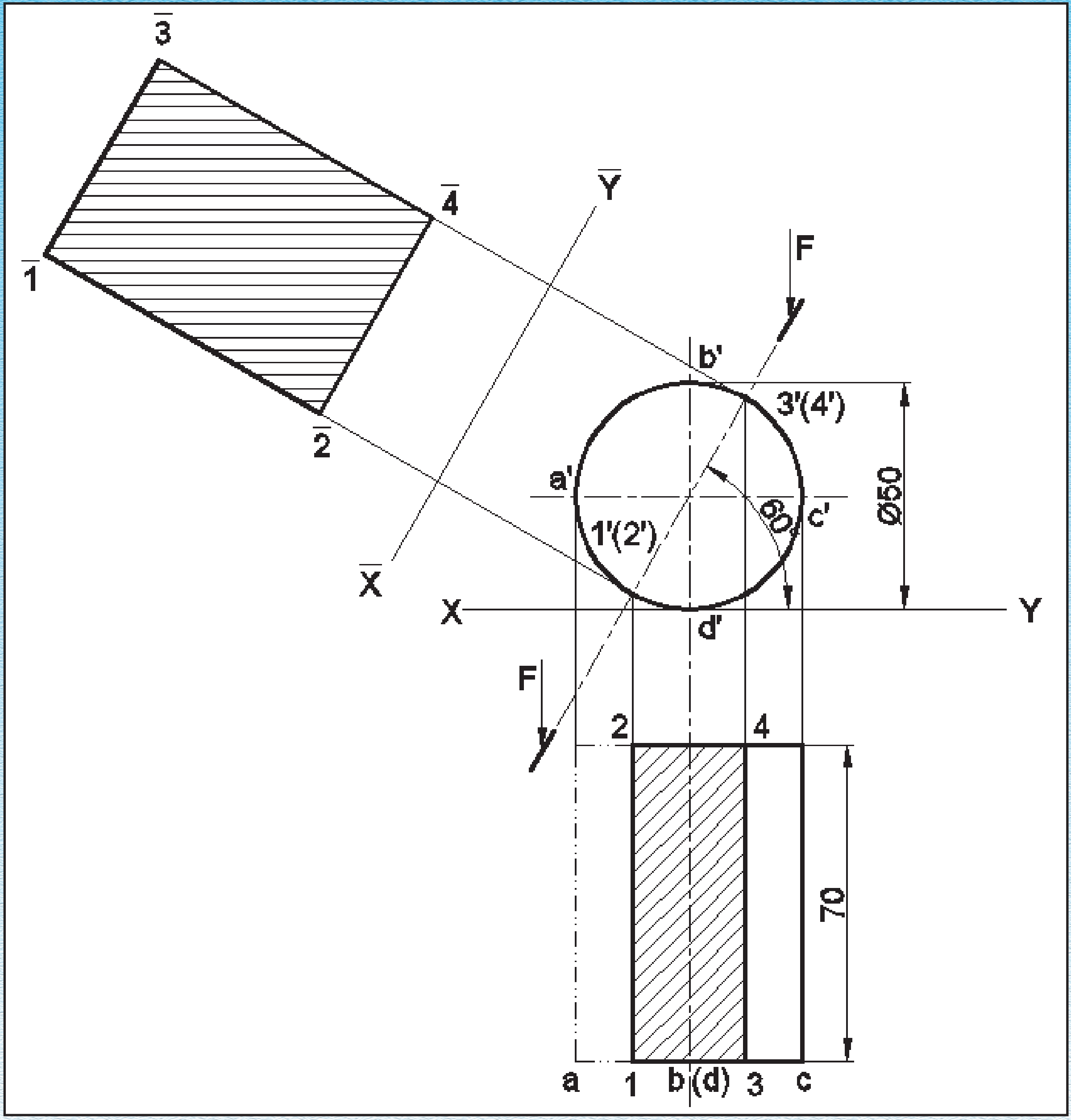


Fig. 5.40

Sol. : Refer to Fig. 5.40

1. Refer to example 5.5 and draw the orthographic projections with the sectional Top View as shown.
2. Draw the reference plane $\bar{X}$-$\bar{Y}$, parallel to the section plane F-F. From the POIs in the Front View, i.e. 1′2′ & 3′4′, draw projectors perpendicular to the $\bar{X}$-$\bar{Y}$ line.
3. Measure the perpendicular distances of these pts. 1, 2, 3 & 4 in the Top View wrt X - Y and mark the same on their corresponding projectors wrt $\bar{X}$-$\bar{Y}$.
4. Join the projected POIs $\bar{1}$, $\bar{2}$, $\bar{4}$ & $\bar{3}$ and hatch the area. This is the true shape of the section.

Example 5.20 : A triangular pyramid is resting on one of its base corners on the ground, such that its 30 mm base side on top is parallel to HP. Its 65 mm long axis is ⊥ to V.P. It is cut by a section plane perpendicular to V.P. and inclined to HP at 60° such that it bisects the top base edge. Draw its Front View and sectional Top View and obtain true shape of the section.

Sol. : Refer to Fig. 5.41

1. Draw the Front View and sectional Top View, as suggested in the Example 5.6.

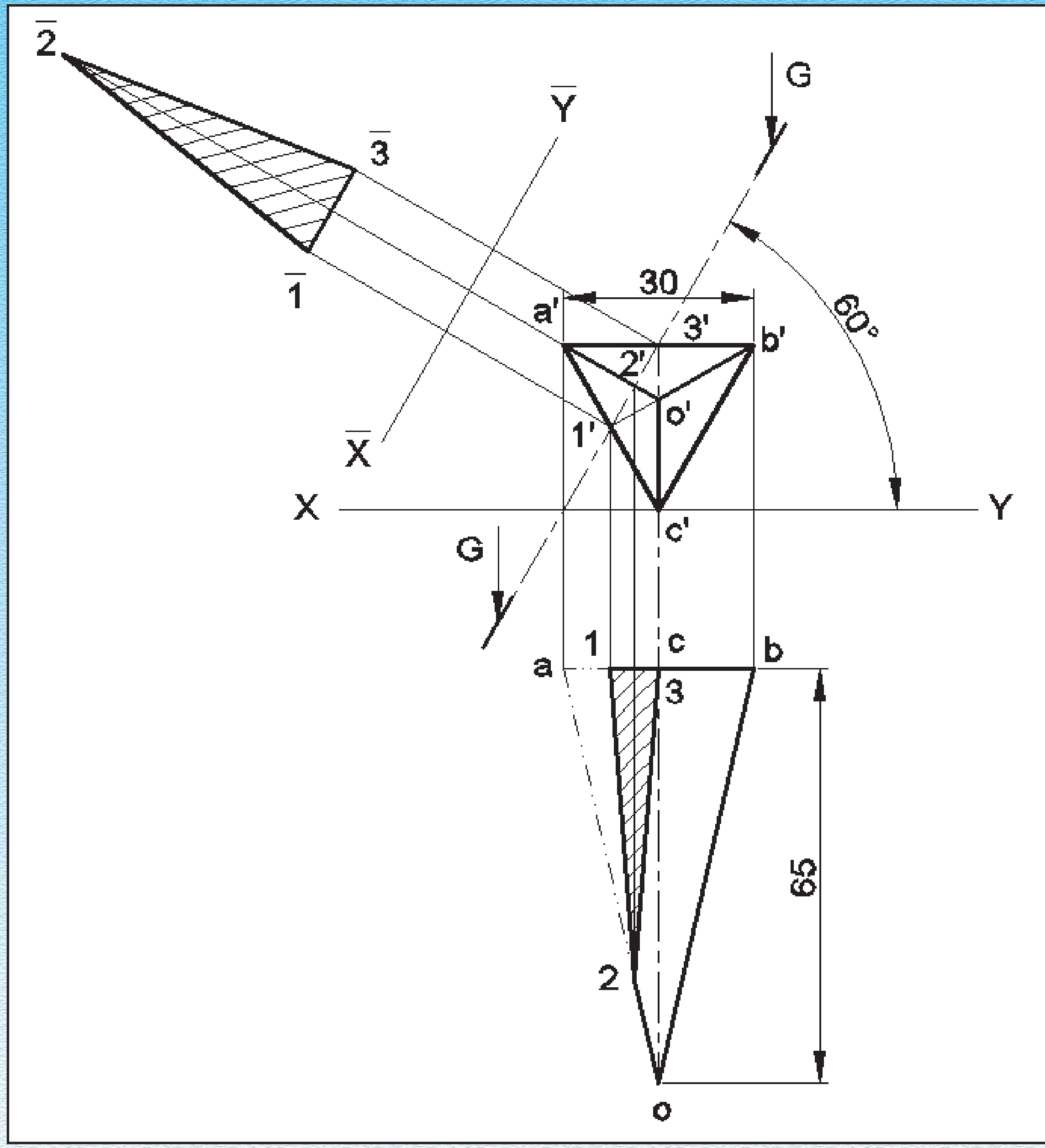


Fig. 5.41

2. Draw the auxiliary plane $\bar{X}$-$\bar{Y}$, parallel to section plane and from the POIs 1′, 2′, & 3′ in the Front View, draw projectors perpendicular to the $\bar{X}$-$\bar{Y}$ line.

3. Measure the perpendicular distances of pts 1, 2, 3 in the Top View wrt X - Y and mark the same on their corresponding projectors wrt $\bar{X}$-$\bar{Y}$.

4. Join the projected POIs, $\bar{1}$, $\bar{2}$ & $\bar{3}$ and draw section lines, to obtain the true shape of the section.

Example 5.21 : A vertical pentagonal pyramid is lying on its base on HP with one of its 45 mm long base edge at the rear parallel to V.P. It is cut by a section plane inclined at 60° to HP and bisects the axis. The axis measures 80 mm. Draw the Front View and sectional Top View and draw the true shape of the section.

Sol. : Refer to Fig. 5.42

1. Draw the Front View and sectional Top View as shown. (Refer to example 5.7)

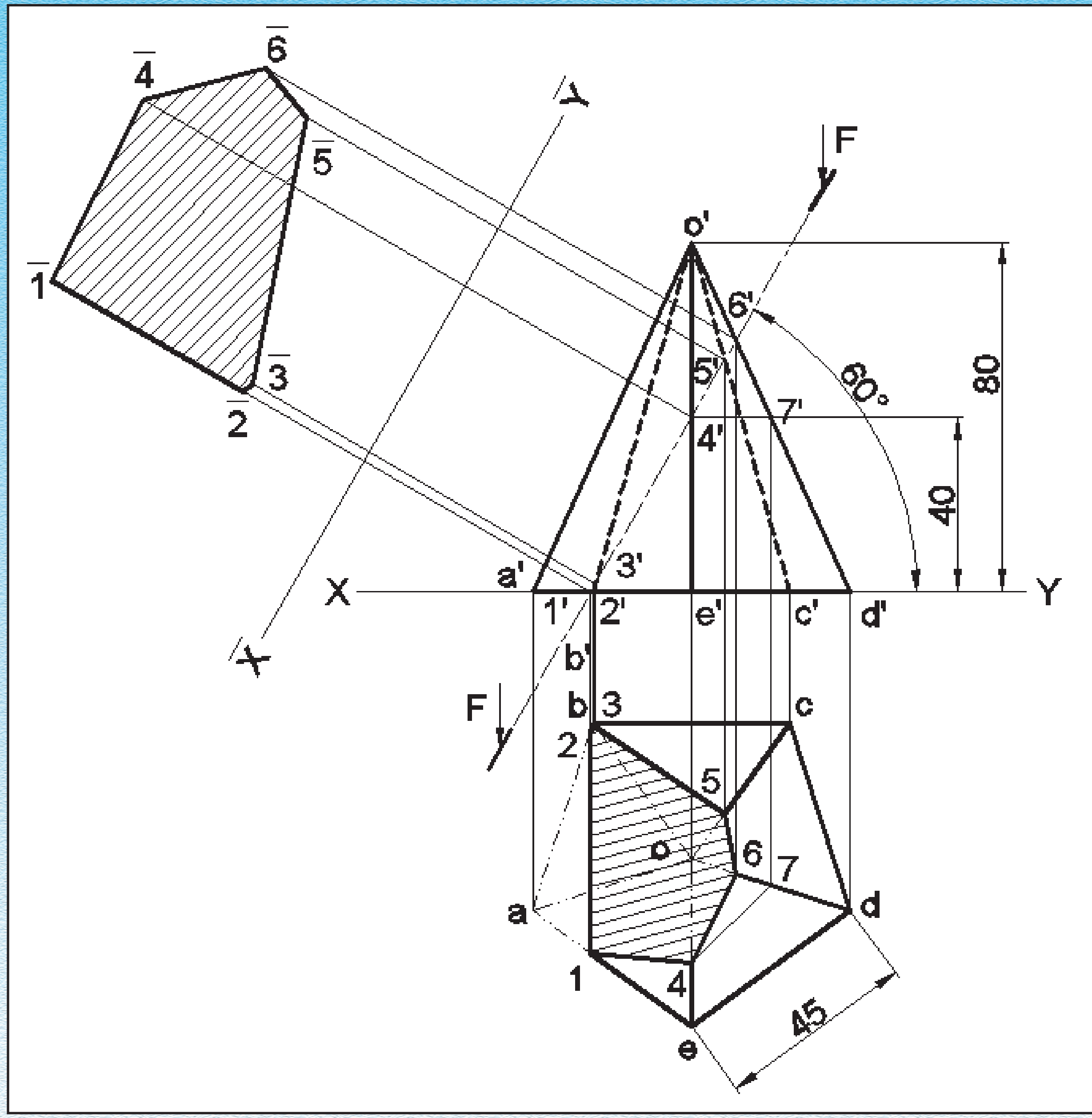


Fig. 5.42

2. Draw reference plane, $\bar{X}$- $\bar{Y}$ line parallel to section plane F-F and draw perpendicular lines (projectors) from the POIs 1′, 2′, 3′, 4′, 5′ & 6′ in the Front View
3. Measure the perpendicular distance of their respective POIs 1, 2, 3, 4, 5 & 6 in the Top View and mark the same on the corresponding projectors wrt $\bar{X}$- $\bar{Y}$ line.
4. Join the pts. $\bar{1}$, $\bar{2}$, $\bar{3}$, $\bar{5}$, $\bar{6}$ & $\bar{4}$ and hatch the area to obtain true shape of the section.

Example 5.22 : A cone of ϕ 60 mm base and axis of length = 80 mm is resting on its circular face on H.P. It is cut by a section plane inclined at 60° to HP and meets the axis at a point 30 mm below its apex. Draw the sectional Front View and Top View. Draw the true shape of the section.

Sol. : Refer to Fig. 5.43

1. Draw the Front View and sectional Top View as shown in the figure (Refer to example 5.8)
2. Draw the reference plane

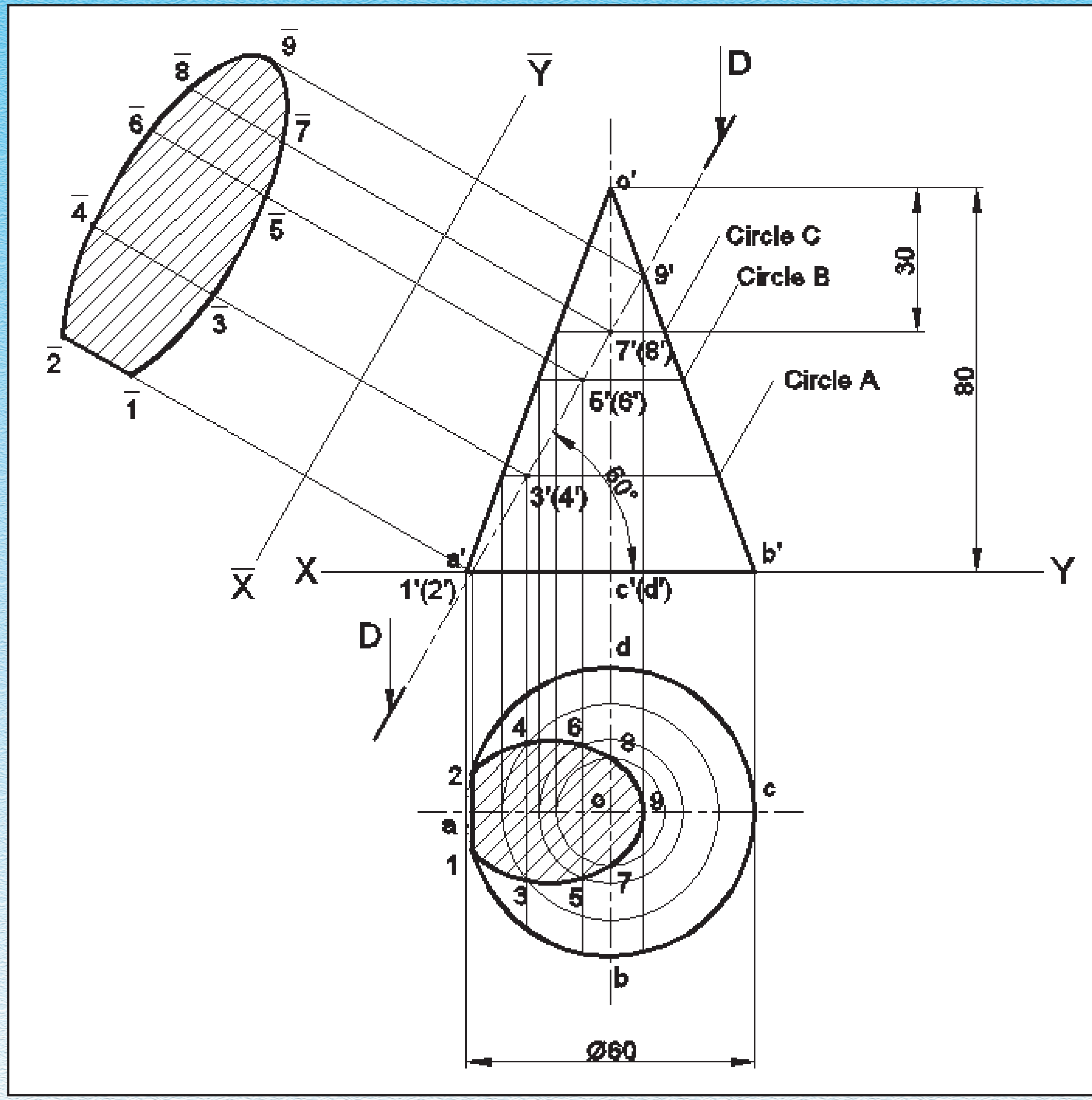


Fig. 5.43

$\bar{X}$- $\bar{Y}$, parallel to the section plane D - D From the POIs in the Front View, i.e. 1′ & 3′4′, 5′6′, 7′8′ & 2′ draw projectors perpendicular to the $\bar{X}$- $\bar{Y}$ line.

3. Measure the perpendicular distances of pts. 1, 3, 4, 5, 6, 7, 8 & 2 in the Top View from X - Y line and mark the same on their corresponding projectors wrt $\bar{X}$- $\bar{Y}$.

4. Join the projected POIs $\bar{1}, \bar{3}, \bar{5}$ & $\bar{8}, \bar{2}, \bar{7}, \bar{6}$ & $\bar{4}$ as a curve and hatch the area. This is the true shape of the section. (As it is curved surface, so the pts are joined as a curve, both in section as well as true shape)

Example 5.23 : A sphere of 32 mm diameter is cut by a horizontal section plane inclined at 45° to the HP and at a distance of 8 mm from O the centre. Draw the Front View & sectional Top View, and true shape of the section.

Sol. : Refer to Fig. 5.44

1. Draw the Front View and sectional Top View as shown (Refer to Example 5.9)

2. Draw $\bar{X}$- $\bar{Y}$ parallel to the section plane A-A at a suitable distance, and project perpendicular lines from the POIs in the Front View (1′, 3′ & 4′, 5′ & 6′, 7′ & 8′, 9′ & 10′, 11′ & 12′ and 2′) to the $\bar{X}$- $\bar{Y}$ reference line.

3. Mark their respective distances from X - Y line wrt Top View, on their corresponding projectors wrt $\bar{X}$- $\bar{Y}$.

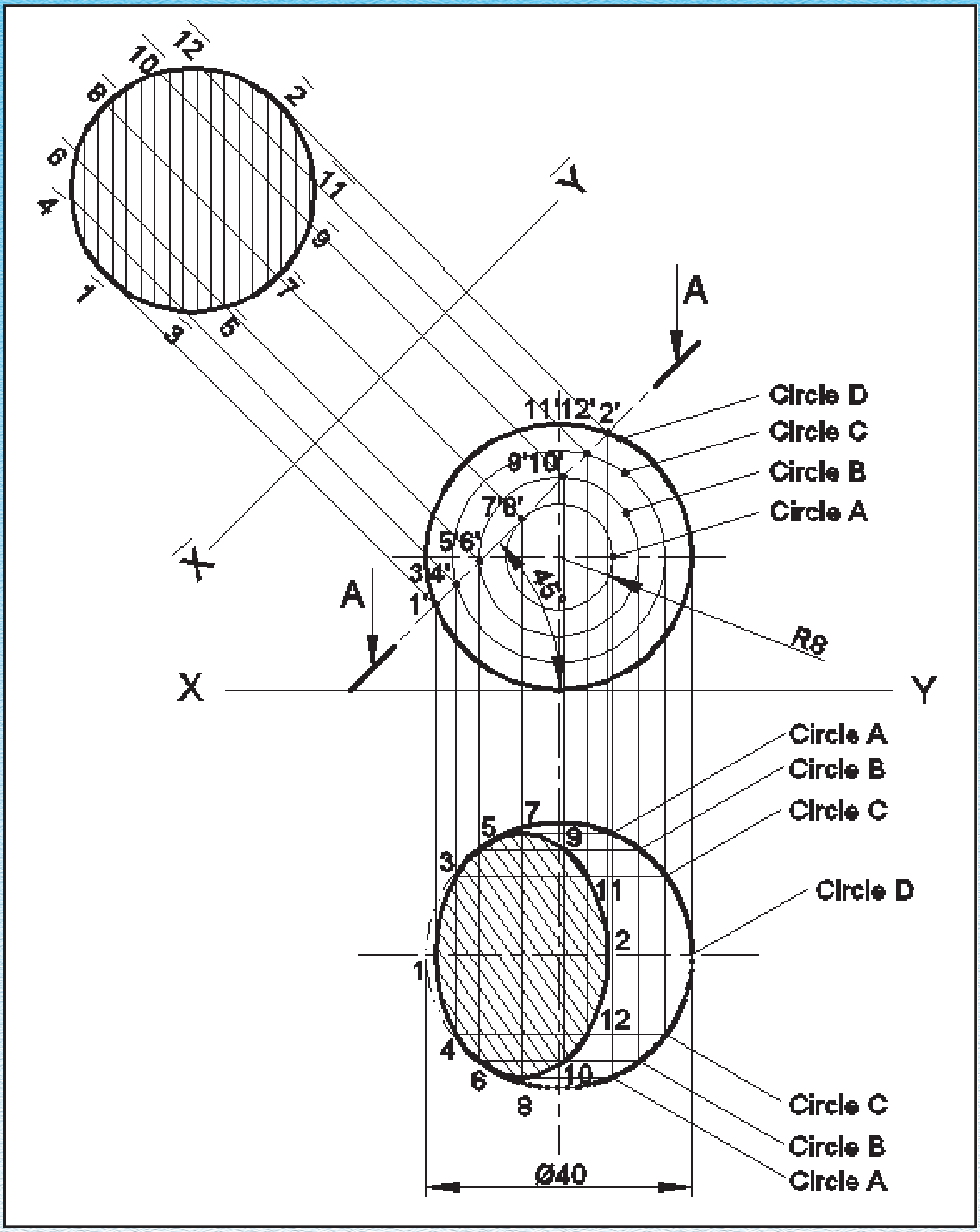


Fig. 5.44

4. Join points $\overline{1}, \overline{4}, \overline{6}, \overline{8}, \overline{10}, \overline{12}, \overline{2}, \overline{11}, \overline{9},$ as a curve, and hatch the area.

It can be seen that the true shape is a circle

[**Note :** True shape of any inclined section plane cutting a sphere is always a 'circle']

Example 5.24 : A square prism of base side 40 mm and height 70 mm is resting on its rectangular face on the ground such that its axis is parallel to HP & VP. It is cut by a section plane perpendicular to HP & inclined to VP at an angle of 45° and passing through a point 10 mm from one of its ends. Draw the sectional Front View and Top View. Also draw true shape of the section.

Sol. : Refer to Fig. 5.45

1. Draw the Top View and sectional Front View as shown (Refer to Example 5.13)

2. Draw Reference plane

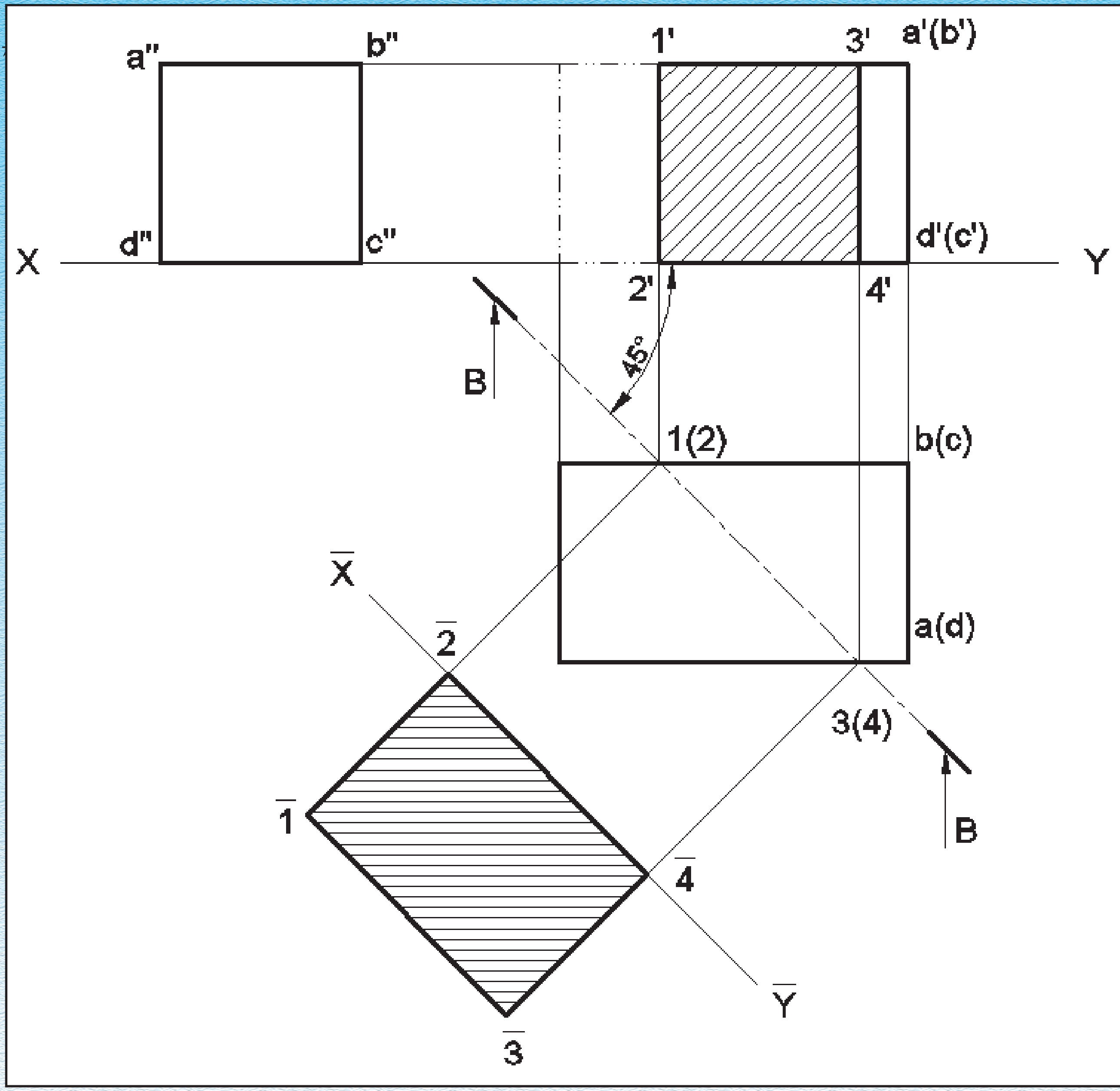


Fig. 5.45

$\overline{X}$- $\overline{Y}$ at a suitable distance parallel to the section plane B-B. Draw perpendicular projectors to the $\overline{X}$- $\overline{Y}$ line from the POIs (1, 2 & 3, 4) in the Top View.

3. Measure perpendicular distance of projected POIs in Front View (pts 1′, 2′, 4′ & 3′) wrt X - Y line and mark them on their corresponding projectors wrt $\overline{X}$- $\overline{Y}$.

4. Join the pts. $\overline{1}$, $\overline{2}$, $\overline{4}$ & $\overline{3}$ and hatch the area. This is the true shape of the section.

Example 5.25 : A triangular pyramid is resting on its base on HP, such that one of its base edges at the rear is parallel to VP. Its base edge measures 25 mm and height 50 mm. A section plane inclined to VP at 45° and perpendicular to HP cuts the slant edge of the pyramid in front, at a distance of 5 mm from the axis. Draw the sectional Front View and Top View. Obtain the true shape of the section.

Sol. : Refer to Fig. 5.46

1. Draw the Top View and sectional Front View as shown.

2. Draw the $\overline{X}$- $\overline{Y}$ line parallel to section plane B-B, and draw projectors (perpendicular lines) to it from the POIs (1, 2, 3 & 4)

3. Measure the distances of the projected POIs in Front View (1′, 2′, 3′ & 4′) from X - Y and mark these distances on the corresponding projectors wrt $\overline{X}$- $\overline{Y}$ line.

4. Join the pts. ($\overline{1}$, $\overline{4}$, $\overline{3}$ & $\overline{2}$) and section the area. This is the true shape of the section.

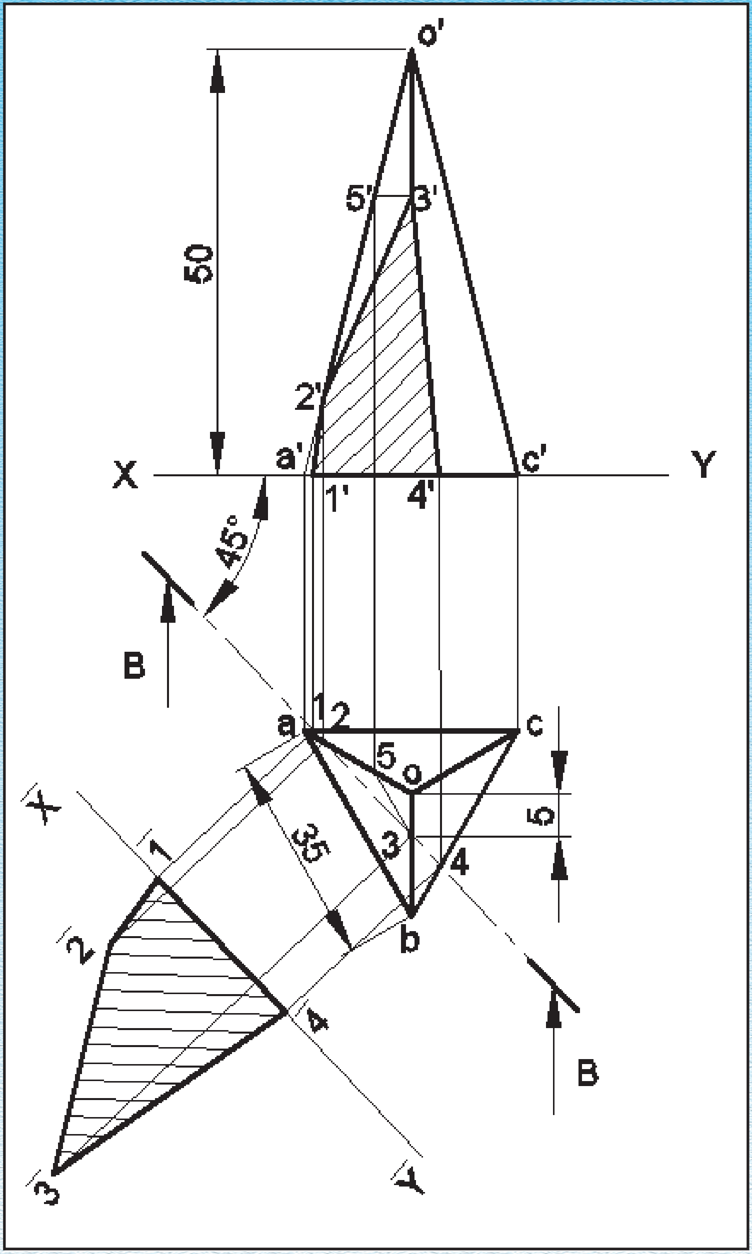


Fig. 5.46

Example 5.26 : A cone, base diameter 30 mm and axis 60 mm is resting on HP such that the axis is parallel to HP and perpendicular to VP. The apex is nearer to the observer. A section plane perpendicular to HP and inclined at 60° to VP bisects the axis. Draw its sectional Front View and Top View. Draw the true shape of the section.

Sol. : Refer Fig. 5.47

1. Draw the sectional Front View and Top View as shown (Refer to example 5.15).

2. Draw line $\overline{X}$-$\overline{Y}$ and draw projectors to it from POIs in the Top View (pts. 1, 4 & 5, 6 & 7, 2 & 3).

3. Measure their distances wrt X - Y line from their projected pts in the Front View (1', 4', 5', 6', 7', 2' & 3') and mark these distances on the corresponding projectors wrt $\overline{X}$-$\overline{Y}$.

4. Join the marked pts. $\overline{1}$, $\overline{5}$, $\overline{7}$, $\overline{3}$, $\overline{2}$, $\overline{6}$ & $\overline{4}$ as a curve and section the area.

This is the desired true shape of the section.

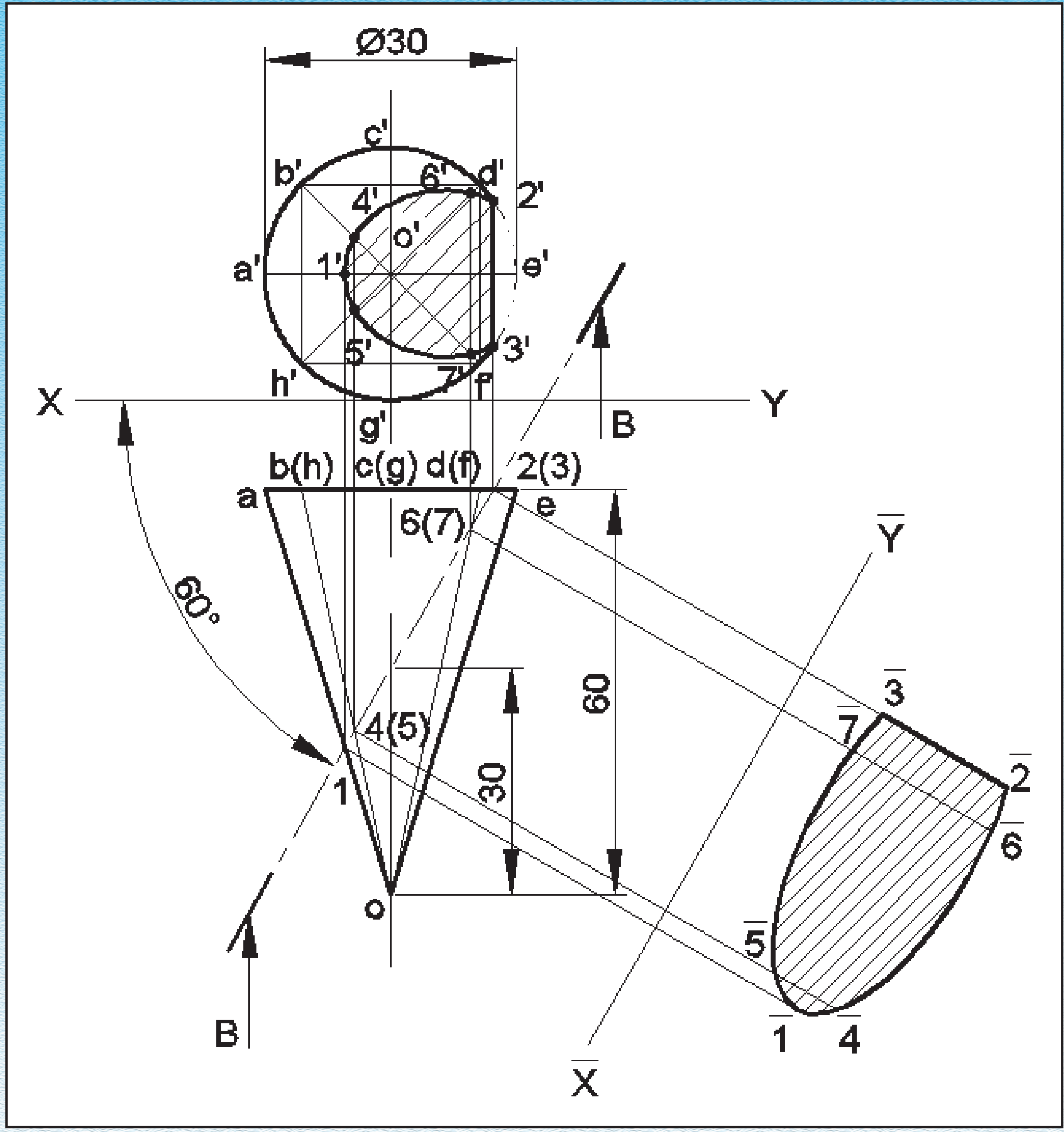


Fig. 5.47

Example 5.27 : A vertical cylinder of 30 mm dia and 40 mm height rests on its base on the ground. A section plane inclined at 45° to HP and perpendicular to VP cuts the axis, 10 mm away from the top face. Draw the projections & the sectional view. Draw the true shape of the section.

Solution : Refer to Fig. 5.48

1. Draw the Front View with the section plane and the sectional Top View of the vertical cylinder as shown.
2. Draw the reference plane $\bar{X}$- $\bar{Y}$ parallel to section plane A-A. From the POIs in Front View, i.e. 1′, 2′, 3′, 4′, 5′ & 6′, 7′, draw projectors perpendicular to the $\bar{X}$- $\bar{Y}$ line.
3. Measure the perpendicular distances of pts 1, 2, 3, 4, 5, 6, & 7 in the Top View wrt X-Y and mark the same on the corresponding projectors wrt $\bar{X}$- $\bar{Y}$.

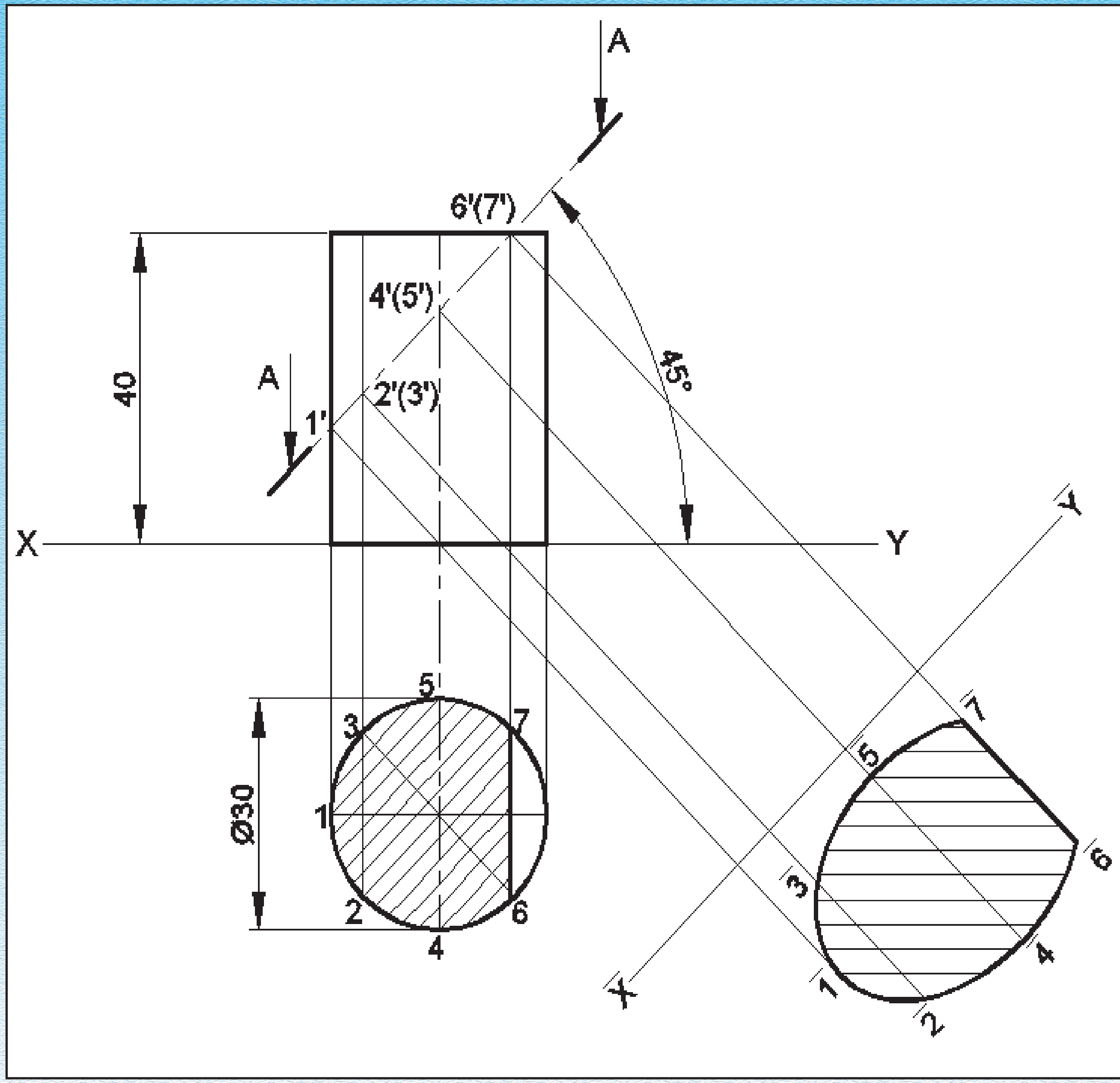


Fig. 5.48

4. Join the projected POIs $\bar{1}, \bar{3}, \bar{5}, \bar{7}, \bar{6}, \bar{4}, \bar{2}$ with continuous thick lines and hatch the area to obtain the true shape of the section. (As it is a curved surface, hence the section as well as the true shape is joined as a curve except $\bar{6}$ - $\bar{7}$ which is a straight edge)

Example 5.28 : A pentagonal pyramid is resting on one of its 20 mm long base edge on HP. Its 45 mm long axis is perpendicular to VP. A section plane inclined at 30° to VP cuts the axis, 20 mm away from the base. The apex is in front. Draw the Top View, the sectional Front View and its true -shape.

Solution : Refer to Fig. 5.49

1. Draw the projections and the sectional view as shown in the figure. (It can be noticed, pt. 3 could not be projected directly, so a line parallel to base meeting the slant edge at pt. 6 was constructed. Then from the projected pt. 6′, a line parallel to base was drawn to obtain pt. 3′ in the Front View.
2. Draw the line $\bar{X}$- $\bar{Y}$ parallel to the section plane B-B and draw projectors to $\bar{X}$- $\bar{Y}$ from pts. 1, 2, 3, 4 & 5 in the Top View.
3. Measure distances of the projected POIs $\bar{1}$ - $\bar{2}$ - $\bar{3}$ - $\bar{4}$ - $\bar{5}$ wrt X-Y and mark them on their corresponding projectors, taking the same respective distances wrt $\bar{X}$- $\bar{Y}$.
4. Join pts. $\bar{1}$ - $\bar{2}$ - $\bar{4}$ - $\bar{5}$ - $\bar{3}$, and draw section lines. This is the true shape of the sectioned surface.

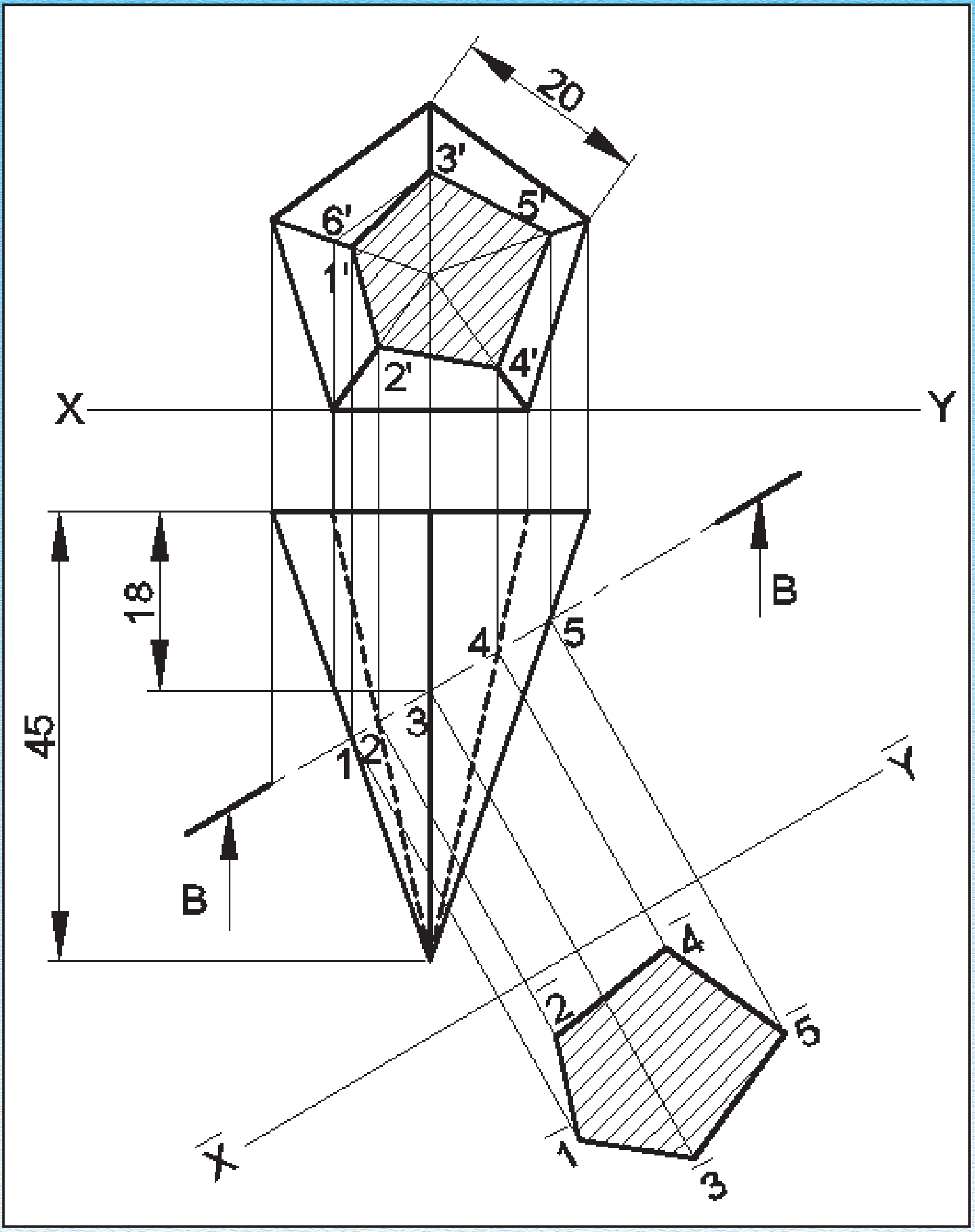


Fig. 5.49

ADDITIONAL QUESTIONS

Example 5.29 : A cone, base 30 mm dia, axis 40 mm long is resting on HP such that the axis is parallel to HP & VP. It is cut by a section plane perpendicular to VP and parallel to one of the generators and passing through a point on the axis at a distance of 15mm from the apex. Draw the sectional Top View, Front View and true shape of the section.

Solution : Refer to Fig. 5.50

1. Draw the Front View with the section plane and corresponding sectional Top View with the helping end/side view as shown.

   (It can be noticed pts 6′ & 7′ can't be projected directly. So they were projected on the end view as 6″ & 7″ on the circle (i.e. base) From the side view it was then projected on the Top View as 6 & 7).

2. Draw the line $\overline{X}$- $\overline{Y}$ parallel to the section plane C-C and draw projectors (perpendicular lines) to it from the POIs 1′, 2′, 3′, 4′, 5′, 6′ & 7′ in the Front View.

3. Mark the distances of the projected POIs, i.e. $\overline{1}, \overline{2}, \overline{3}, \overline{4}, \overline{5}, \overline{6}, \& \overline{7}$ from

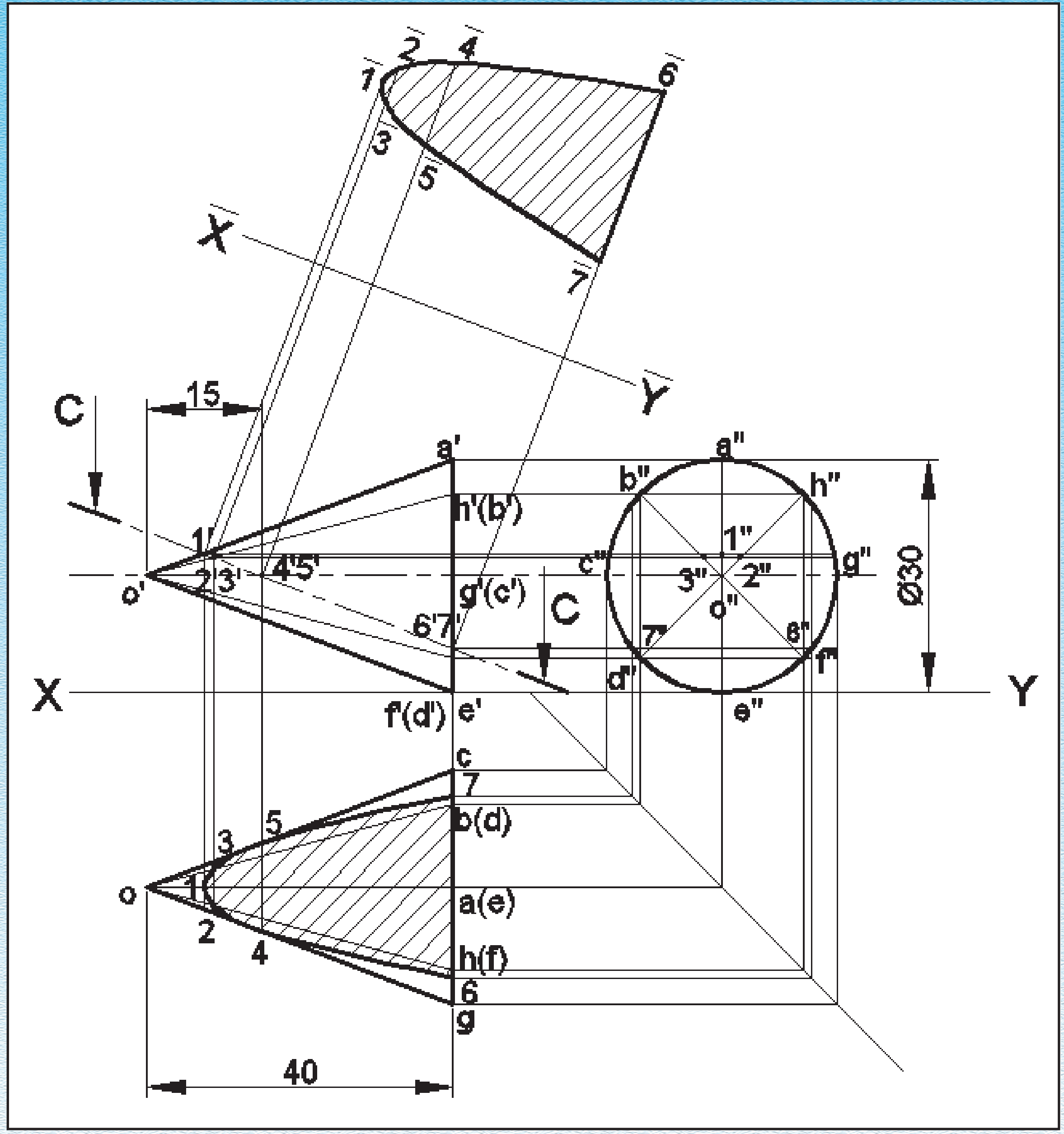


Fig. 5.50

$\bar{X}$- $\bar{Y}$ equal to the corresponding distances of the points 1, 2, 3, 4, 5, 6 & 7 from X-Y in the Top View.

4. Complete the figure in the shape of a parabola and draw section lines in it. This gives the required true shape of the section.

Example 5.30 : A hollow square prism (25 mm base side and 55 mm long axis and thickness 5 mm) rests on its base on HP with the base sides equally inclined to VP. A section plane perpendicular to HP and inclined to VP cuts the prism into two halves. Draw Top View, sectional Front View and true shape of the section.

Solution : Refer to Fig. 5.51

1. Draw the orthographic projections of the solid in the given position along with its sectional

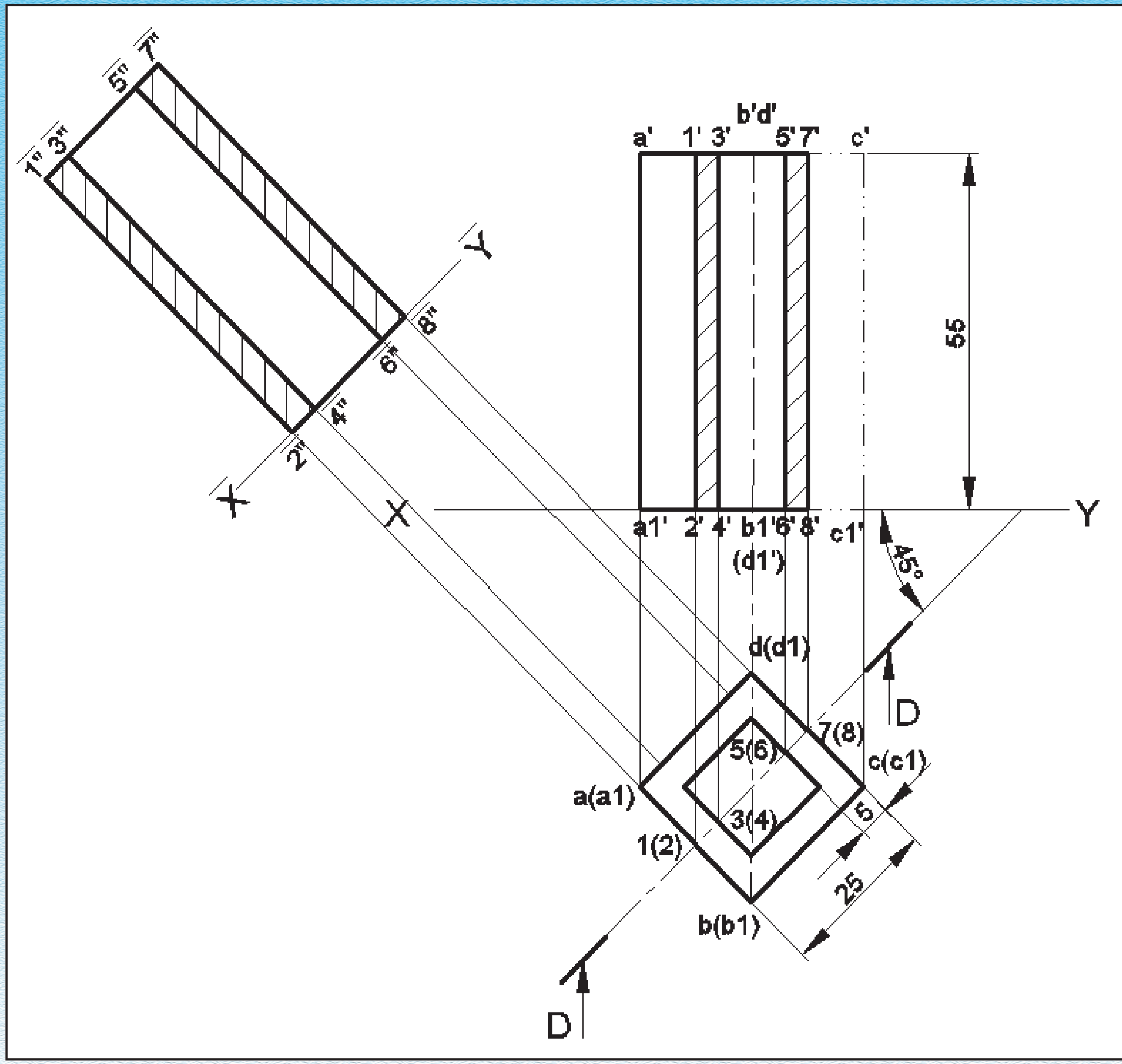


Fig. 5.51

view as shown (As it is hollow, only that part of the solid, which is cut is sectioned)

2. Draw the reference plane (auxiliary plane) $\overline{X}$- $\overline{Y}$ parallel to the section plane D-D and draw projectors to it from pts. 1, 2, 3 & 4, 5, 6, 7 & 8 in the Top View.

3. Mark the distances from $\overline{X}$- $\overline{Y}$ equal to the corresponding distances of the points 1′, 2′, 3′ & 4′, 5′, 6′, 7′ & 8′ from X-Y line in the Front View.

4. Join the pts. $\overline{1}, \overline{2}, \overline{3}$ & $\overline{4}$ and $\overline{5}, \overline{6}, \overline{7}, \overline{8}$, Section the required area to obtain the true shape of the section. (Remember spaces are not hatched, only the cut portion of the solid is hatched and hatching should also be identical for the same solid.

Example 5.31 : A hexagonal frustum (top base side 20 mm, bottom base side = 30 mm and height = 70 mm) rests on one of its base corners such that the bottom hexagonal face makes an angle of 30° with HP. A sectional plane, inclined at 60° to VP and perpendicular to HP, bisects the axis. Draw the sectional Top View, Front View and true shape of the section.

Solution : Refer to Fig. 5.52

1. Draw the projections of the frustum of the horizontal pyramid in the given position as learnt in the previous chapter. Draw the section plane and the respective sectional view in Front View as shown.

2. Draw the line $\overline{X}$- $\overline{Y}$ parallel to the section plane E-E and draw projectors.

3. Mark the distances from $\overline{X}$- $\overline{Y}$ equal to the corresponding distances of points 1, 2, 3, 4, 5 & 6 from X-Y in the Top View.

4. Join pts. $\overline{1}, \overline{2}, \overline{3}, \overline{4}, \overline{5}, \overline{6}$ and draw section lines in it. This is the true shape.

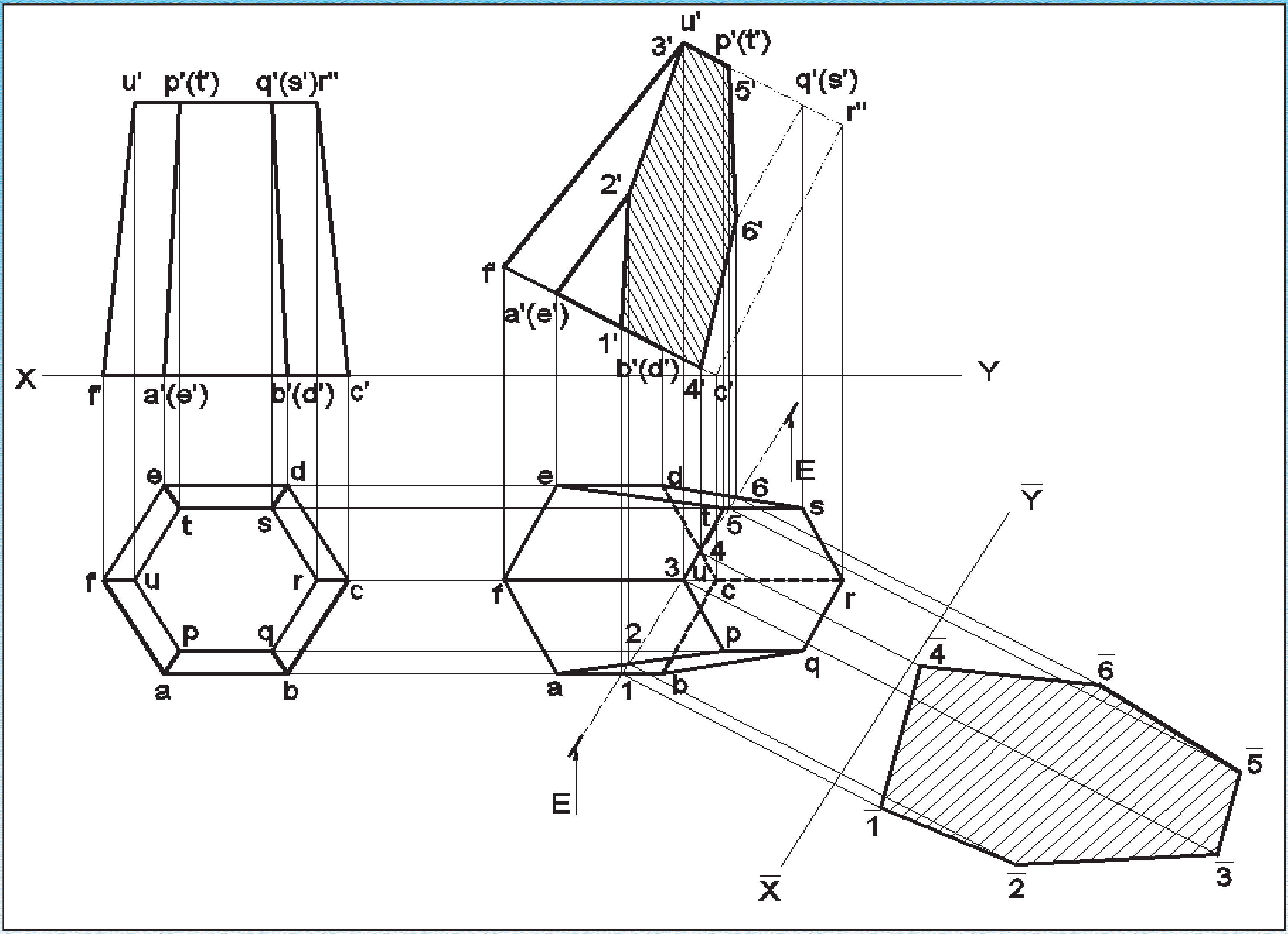
TRY THESE

I. Fill in the blanks

(a) True shape can be obtained on a plane _________________ to the section plane

(b) The true shape of a section of a sphere which is cut by an inclined section plane at some distance from the axis is __________

(c) When a vertical pentagonal pyramid is cut by a horizontal section plane, the true shape will be ___________ .


u'
p'(t')
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X
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u
c
f
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p
q
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1
b
E
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4
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3

Fig. 5.52

II. A Front View and incomplete Top View of a pentagonal pyramid is shown in Fig. 5.53 (a) The pyramid is cut by a section plane A-A inclined at 30° to HP . Draw the Front View, complete the Top View and add sectional view and true shape of the section.

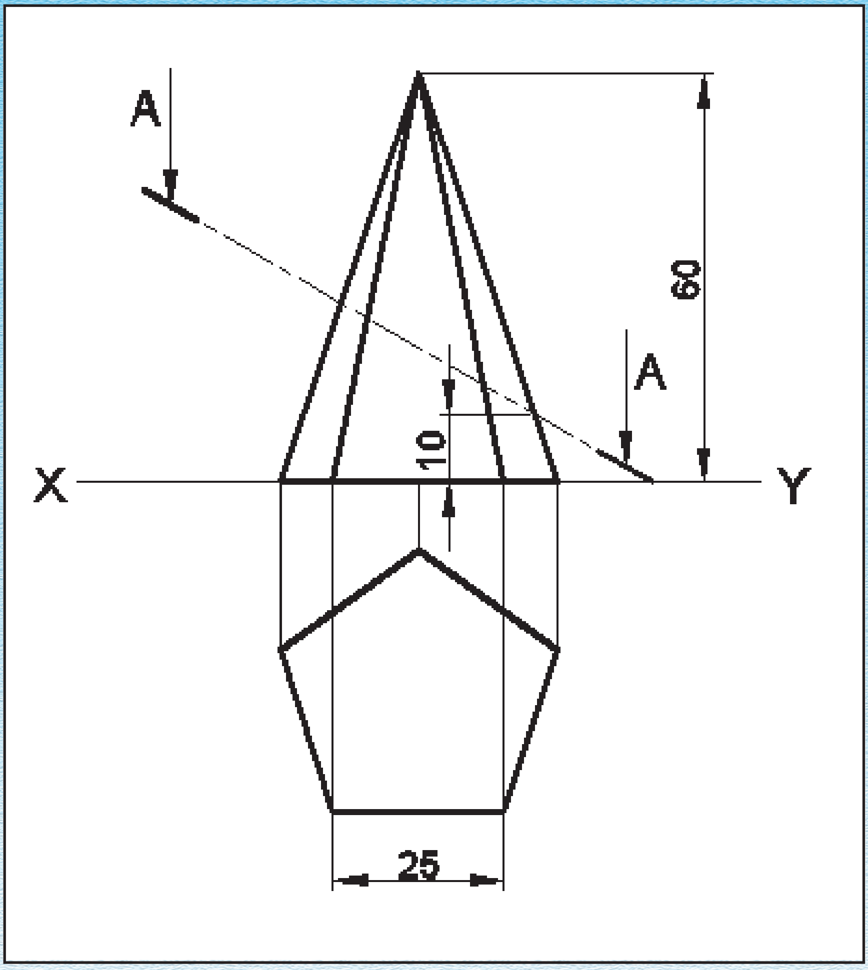


Fig. 5.53a

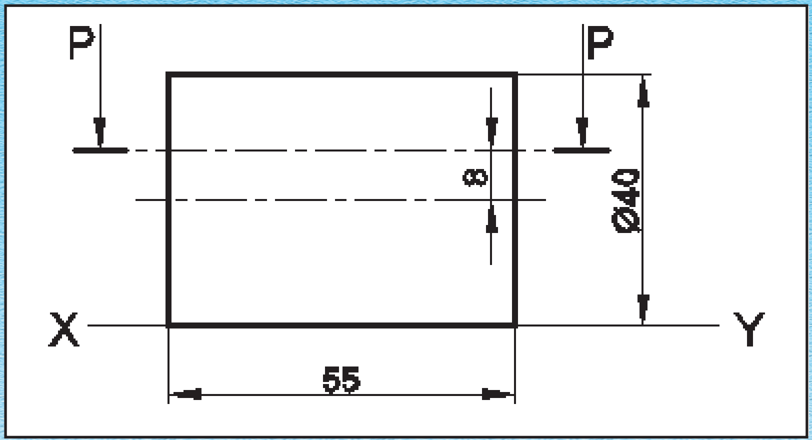


Fig. 5.53b

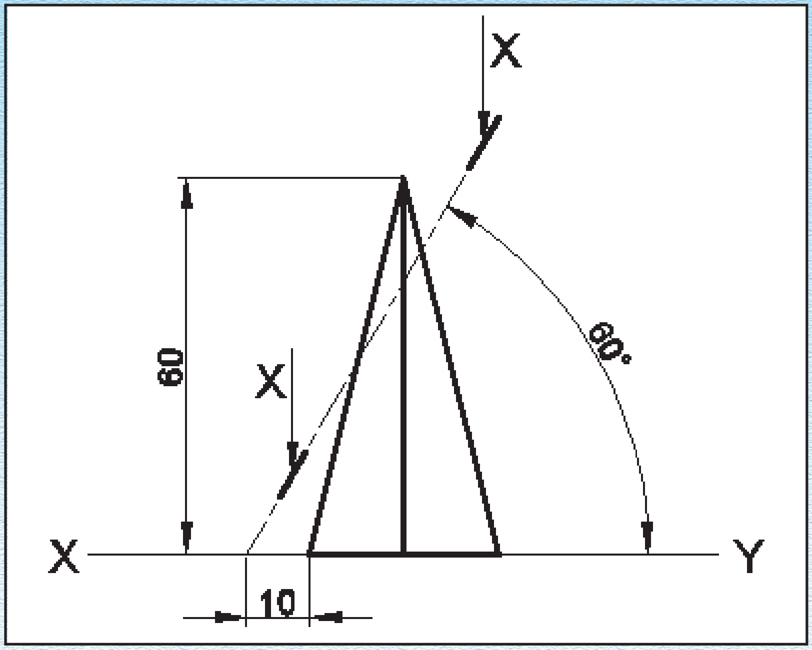


Fig. 5.53c

III. A Front View of a regular hexagonal pyramid of base edge length 20 mm is cut by a section plane X-X as shown in Fig. 5.53 (b). Draw the Front View, Top View with section and its true shape.

IV. A cylinder is shown resting on HP and cut by a section plane P-P, in Fig. 5.53 (c) Draw the given Front View, and the sectional Top View. Obtain the true shape of the section.

WHAT WE HAVE LEARNT

1. To show interior complicated details (spaces, materials etc.) and help in understanding, intrepretation of drawings, the method of sectioning is adopted.

2. The solid is imagined to be cut (sectioned) by a plane called the section plane (cutting plane).

   The arrowheads indicate the direction of viewing.

3. The surface obtained by cutting the object is called section. And it is represented by thin equidistant lines (section lines) usually drawn (hatched) at 45°.

4. The portion of the solid which lies between the cutting plane and the observer is assumed to be removed as is represented as ____________..____________..____________..____________ lines.

5. The sectional views are extension of the orthographic projections and contain the section.

6. When section plane is parallel/inclined to HP

   Sectional Top View is obtained.

   When section plane is parallel/inclined to VP.

   Sectional Front View is obtained.

7. **Procedure to draw sectional views :**
   (i) Draw the projections of the solid in the required position.
   (ii) Mark cutting plane as specified and obtain points of intersection (POIs) with the edges.
   (iii) Project these points on the corresponding edges in the other view.
   (iv) Join these points and hatch the surface.
   (v) Draw the remaining projection.

8. **In sectional views :**
   (i) No section plane is shown
   (ii) No hidden outline
   (iii) Hidden lines if necessary
   (iv) No visible lines inside the section

9. When section plane is inclined to HP/VP, the section obtained is "apparent"

10. **True shape of a section** is obtained by projecting the section on an auxiliary reference plane parallel to cutting/section plane.

11. Procedure to draw true shape :
    (i) Draw the projections alongwith the sectional view.
    (ii) Draw (an auxilary reference plane) line parallel to section plane.
    (iii) Draw projectors to this plane from POIs & (mark) transfer their respective distances from X-Y on these projectors wrt X"-Y".
    (iv) Join the pts and hatch the surface.

12. If section plane is parallel to HP/VP, then their sectional views show the true shape.

8.5 A flat surface cut by a section plane gives straight boundary and a curved surface cut by a plane, gives a curved boundary.

ASSIGNMENTS

I. Choose the correct option :

(a) The projection of a cut portion of the solid on HP is called sectional.
    (i) Top View (ii) Front View (iii) Left side view (iv) Right side view

(b) A vertical cone is cut by a horizontal section plane, the resulting cut solid is
    (i) cone (ii) cylinder (iii) frustum (iv) hemisphere.

(c) Under what conditions, the 'sectional Top View' and true shape of the section will be idential.
    (i) When the cutting plane is parallel to HP & perpendicular to VP
    (ii) When the cutting plane is perpendicular to HP & parallel to VP
    (iii) When the cutting plane is parallel to both HP & VP
    (iv) When the cutting plane is perpendicular to both HP & VP

(d) A cylinder of height equal to its base radius, is cut by a plane parallel to its axis and passing through the axis, the section surface will be

(i) Circle (ii) Ellipse (iii) Square (iv) Rectangle.

(e) Which of the following object gives a circular section, when it is cut completely by a section plane (irrespective of the angle of section plane)

(i) Cylinder (ii) Sphere (iii) Cone (iv) Circular Lamina

(f) Shape of the section obtained when a cone is cut by a plane passing through the apex and center of the base of the cone is

(i) Parabola (ii) Circle (iii) Ellipse (iv) Triangle

(g) When a regular hexagonal prism is cut by a plane parallel to the axis at some distance from it, the shape of the section is

(i) Regular hexagon (ii) Irregular hexagon (iii) Octagon (iv) Rectangle

(i) A hexagonal pyramid of 30 mm side and length of axis = 50 mm rests on HP, with one of its base edges parallel to V.P. A cutting plane parallel to VP cuts the solid 10 mm in front of the vertical axis. Draw the sectional Front View and Top View of the pyramid.

(ii) A right regular square pyramid, side of base 55 mm and height 70 mm, lies on one of its triangular faces upon ground, such that it axis is parallel to VP. A section plane parallel to HP cuts the axis at its midpoint. Draw its Front View and sectional Top View.

(iii) A pentagonal pyramid, side of base 30 mm and height 50 mm is resting on HP, keeping the axis vertical and a base edge perpendicular to VP. A horizontal cutting plane cuts the solid at a height of 25 mm from the base. Draw Front View and sectional Top View of the pyramid.

(iv) A pentagonal prism with a 25 mm base side and 65 mm height is resting on its base on HP with a side of base inclined at 30° to VP. A section plane inclined at 60° to HP and passing through the midpoint of the axis cuts the prism. Draw Front View, sectional Top View and true shape of the section.

(v) A hexagonal prism with a base side of 24 mm and an axis of 55 mm, in resting on an edge of the base on HP with the axis inclined at 60° to HP and parallel to VP. A section plane inclined at 45° to VP and passing through a point on the axis at a distance of 25 mm from the top end cuts the prism. Draw the sectional Top View, Front View and true shape of the section.

(vi) A cone, base 50 mm diameter and axis 60 mm long has its axis parallel to VP and inclined at 45° to HP. It is cut by a horizontal section plane passing through the mid-point of the axis. Draw Front View, sectional Top View and true shape of the section.

(vii) A cylinder is resting on its base on HP. It is cut by a plane inclined at 60° to HP, cutting the axis at a point 20 mm from the top. If the diameter of the cylinder = 40 mm and length 65 mm, draw their projections (Front View and sectional plan) and true shape of section.

(viii) A sphere of ϕ 50 mm rests on HP. A section plane perpendicular to HP, inclined at 45° to VP and at a distance of 10 mm from its centre cuts the sphere. Draw the Top View, sectional Front View and true shape of the section.

(ix) A triangular pyramid with 45 mm base side and 70 mm stant height, hs its base on HP and a side of base perpendicular to VP. It is cut by a section plane inclined at 60° to VP and intersecting the axis at 35 mm from its base. Draw Front View, sectional Top View and the true shape of the section.

(x) A cone of base dia 42 mm and axis 54 mm long is resting on its base on HP. It is cut by a vertical section plane, inclined at an angle of 60° with the X-Y line and is 10 mm away from the Top View of the axis. Draw Top View, sectional Front View and true-shape of the section.

ANSWERS

5.2. Pg. 4 III(a) ; (b) sectional; (c) 45°

5.3 Pg. 19 1(a) parallel, (b) Circle; (c) Pentagon

ASSIGNMENTS Pg. 21 i (a) ii (b) iii (c) (d) iii (e) ii (f) iv (g) i

Chapter 6

ORTHOGRAPHIC PROJECTIONS OF SIMPLE MACHINE BLOCKS

6.1 INTRODUCTION

We have already made you aware of many simple geometrical shapes (laminae), projected on such planes (vertical plane, horizontal plane and other auxiliary planes) while projecting the various views of simple regular geometrical solids. Similarly, it is necessary to understand any machine block as combination of the geometrical solids by adding solids together or removing geometrical solids out of a single solid. For example, a hexagonal nut is formed out of a hexagonal prism by removing a small cylinder and cutting internal helical groove (internal threads). Reverse of it is square bolt in which square prism and small cylinder is one integral solid with external helical groove (external threads) cut on it.

In figure 6.1 a cube of 15 mm is removed out from a single solid i.e. a rectangular prism.

An orthographic projection is one position drawing. It takes several drawings to show and understand all the machine block form. The views are placed relative to each other according to either of two schemes. FIRST ANGLE PROJECTION METHOD OR THIRD ANGLE PROJECTION METHOD.

Note : However we are following only first angle method of projection in all the exercises (According to CBSE prescribed syllabus)

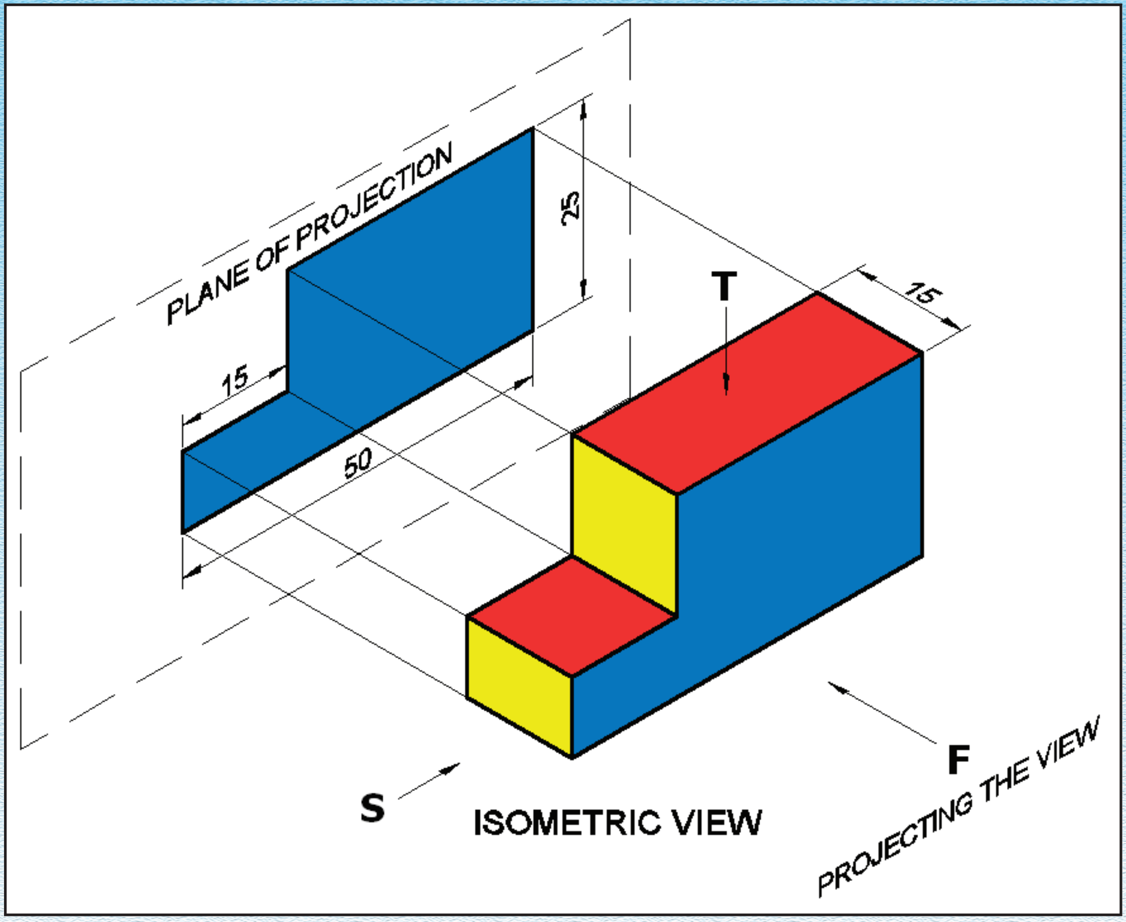
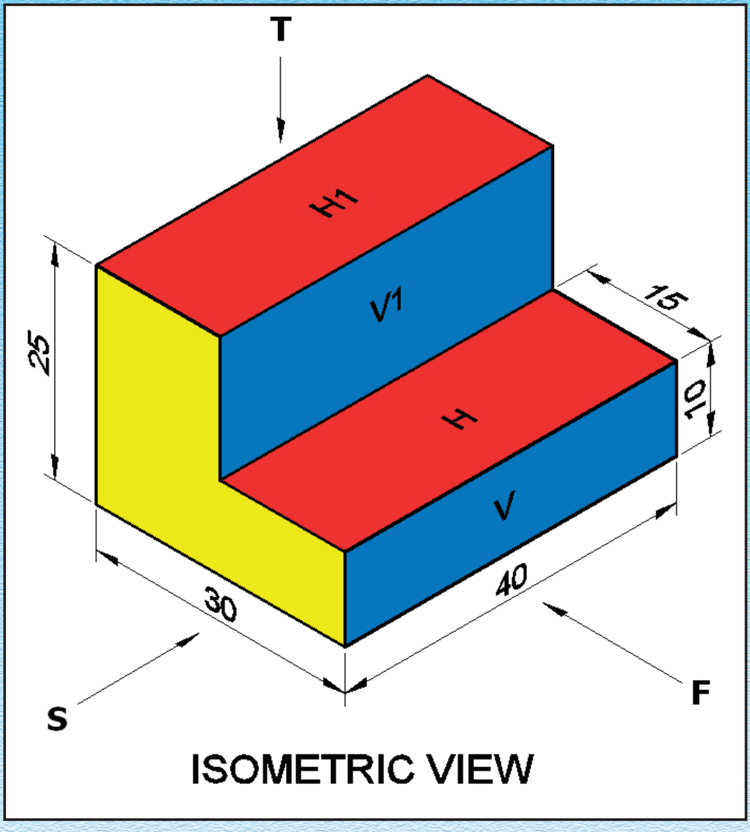


Fig. 6.1

6.2 UNDERSTANDING : SIMPLE MACHINE BLOCKS



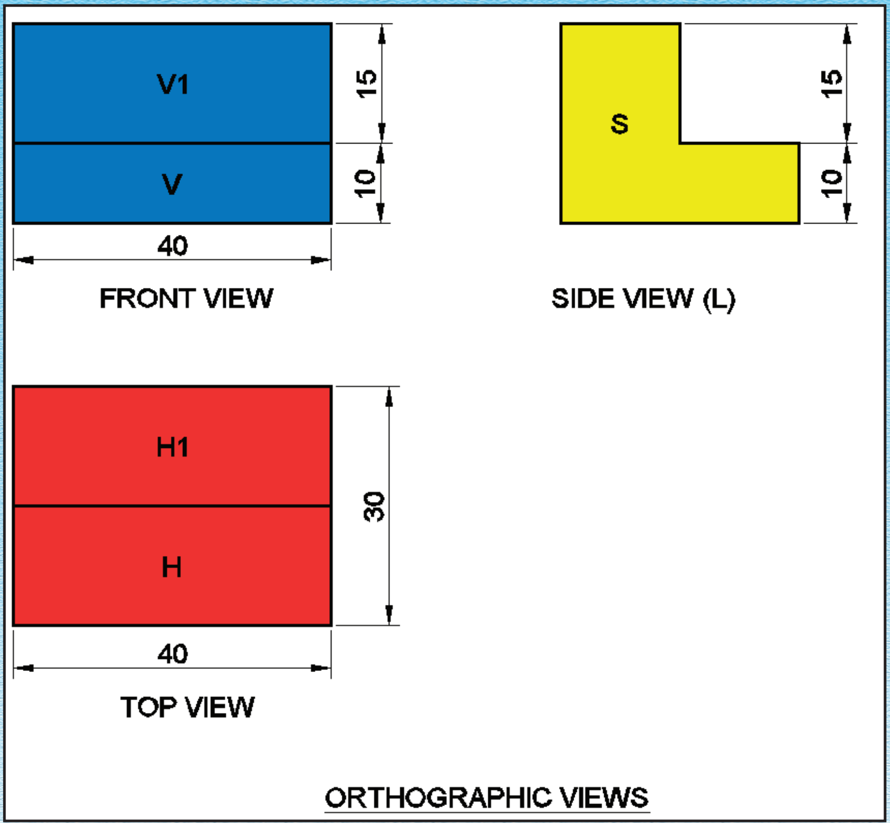


FIG. 6.2 DO IT YOURSELF

(i) No. of Vertical Faces..............

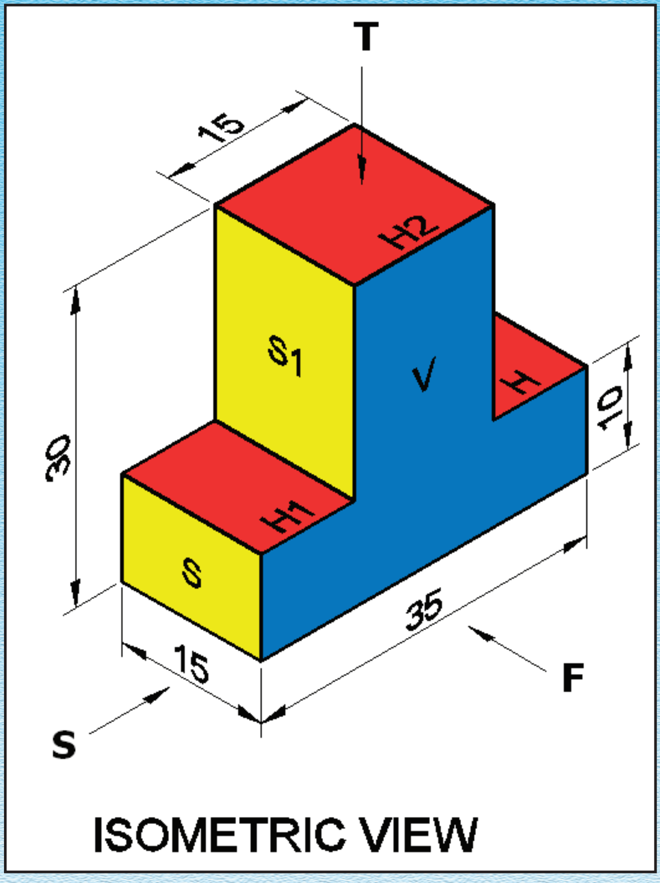
(ii) No. of Horizontal Faces...........

(iii) Give the dimension of Face 'H1' ....

(iv) Give the dimension of Face 'V_1' ....

(v) No. of side Faces ....

V = Vertical Face, H = Horizontal Face, I = Inclined Face, F = Front, S = Side and T = Top



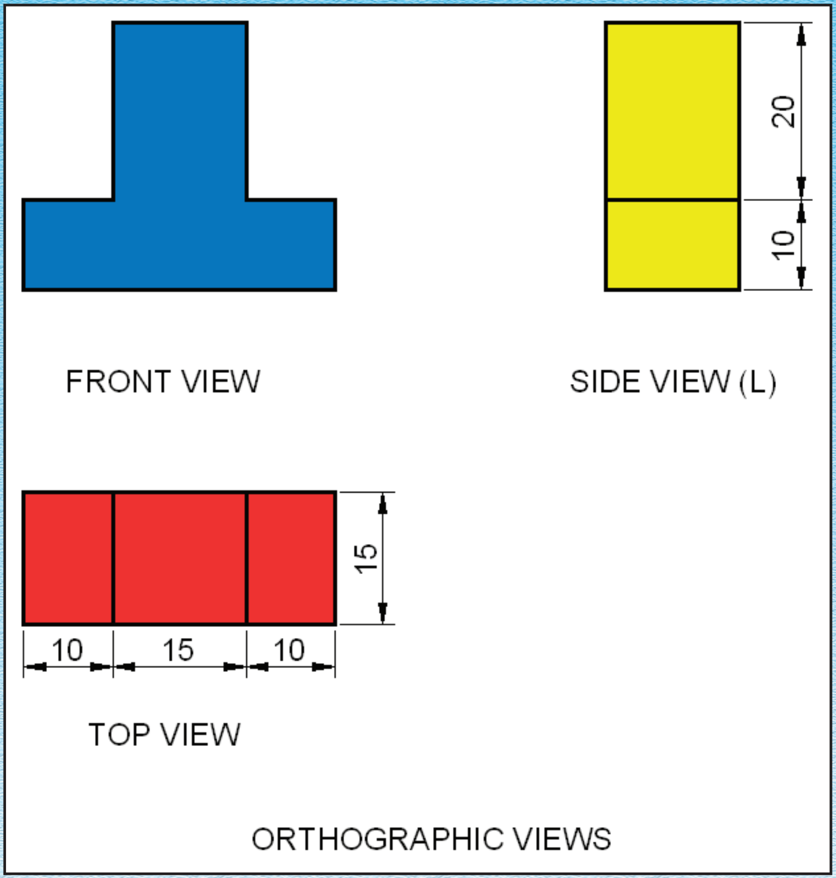


FIG. 6.3 DO IT YOURSELF

(i) No. of Vertical faces.............

(ii) No. of Horizontal faces..........

(iii) Give the dimension of face 'V_1' ....

(iv) Give the dimension of face 'H_1' ....

(v) No. of side faces ....

V = Vertical Face, H = Horizontal Face, I = Inclined Face, F = Front, S = Side and T = Top

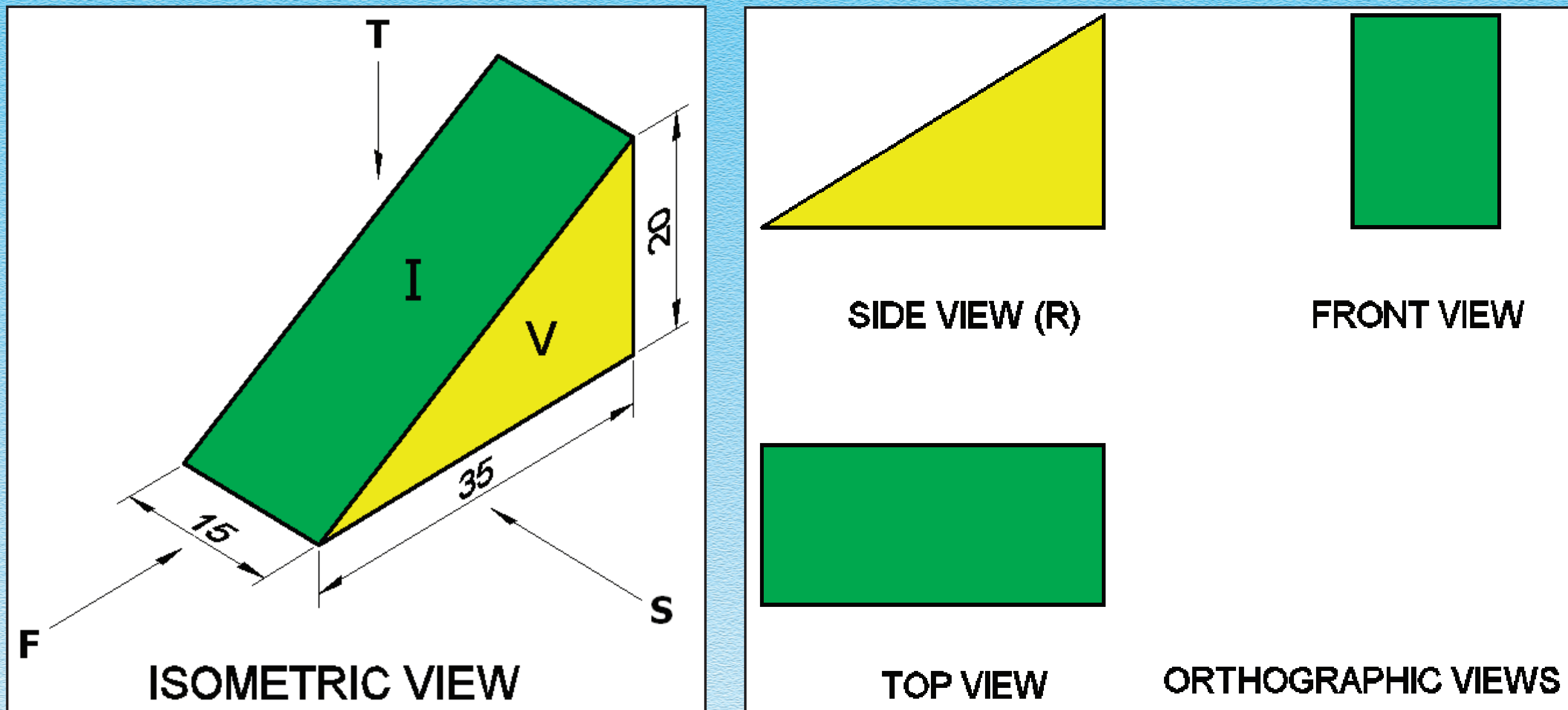


FIG. 6.4 DO IT YOURSELF

(i) No. of Vertical faces..............

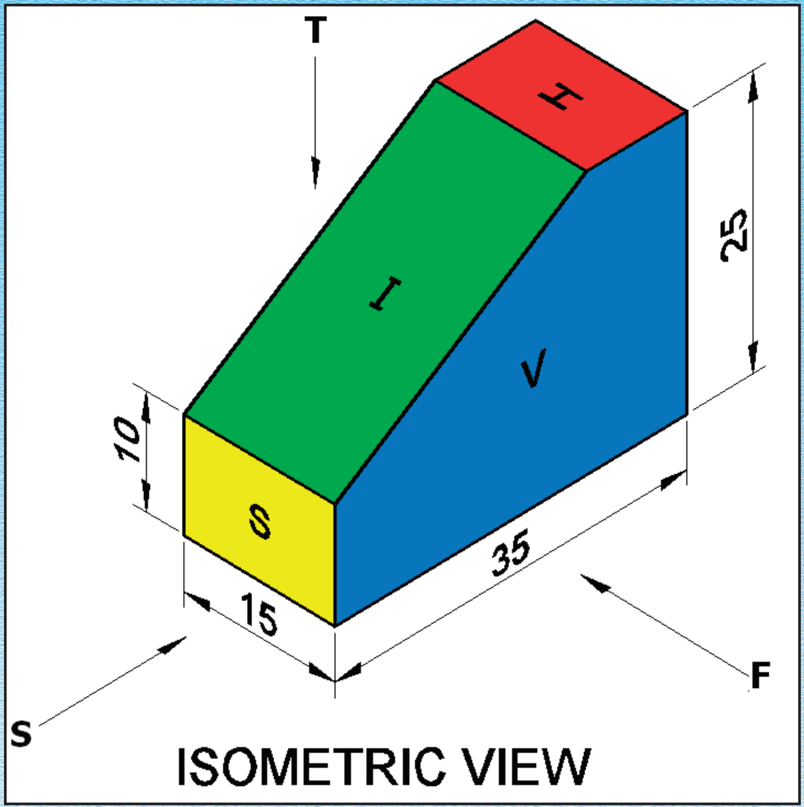
(ii) No. of Horizontal faces...........

(iii) No. of Inclined faces.............

(iv) Give the dimension of face I in Top View ....

Note : This inclined face is seen in Top View and in Front View

V = Vertical Face, H = Horizontal Face, I = Inclined Face, F = Front, S = Side and T = Top



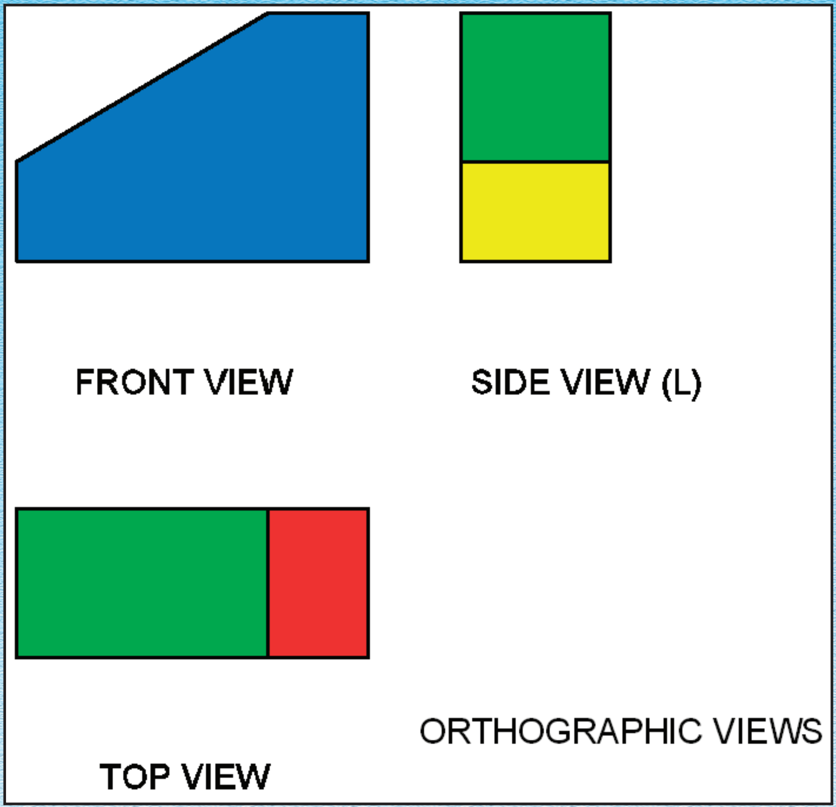


FIG. 6.5 DO IT YOURSELF

(i) No. of Vertical faces.............

(ii) No. of Horizontal faces...........

(iii) No. of Inclined faces............

(iv) Give the dimension of face I in Side View ....

Note : This inclined face is seen in Top View and in Front View

V = Vertical Face, H = Horizontal Face, I = Inclined Face, F = Front, S = Side and T = Top

IMPORTANT OBSERVATIONS :

If the surface/face of an object is either parallel to the vertical plane or horizontal plane (Principal Planes) they appear to be in TRUE SHAPE in one of the three views and appear as a "line only" in other two views (as these faces are perpendicular to the plane of projection).

When a surface/face is inclined or making an angle with two planes at the same time, that surface/face is not seen in its TRUE SHAPE in the plane to which it is inclined. It is seen in the plane to which it is inclined as a plane of reduced size due to foreshortening.

6.3 LET US FIND

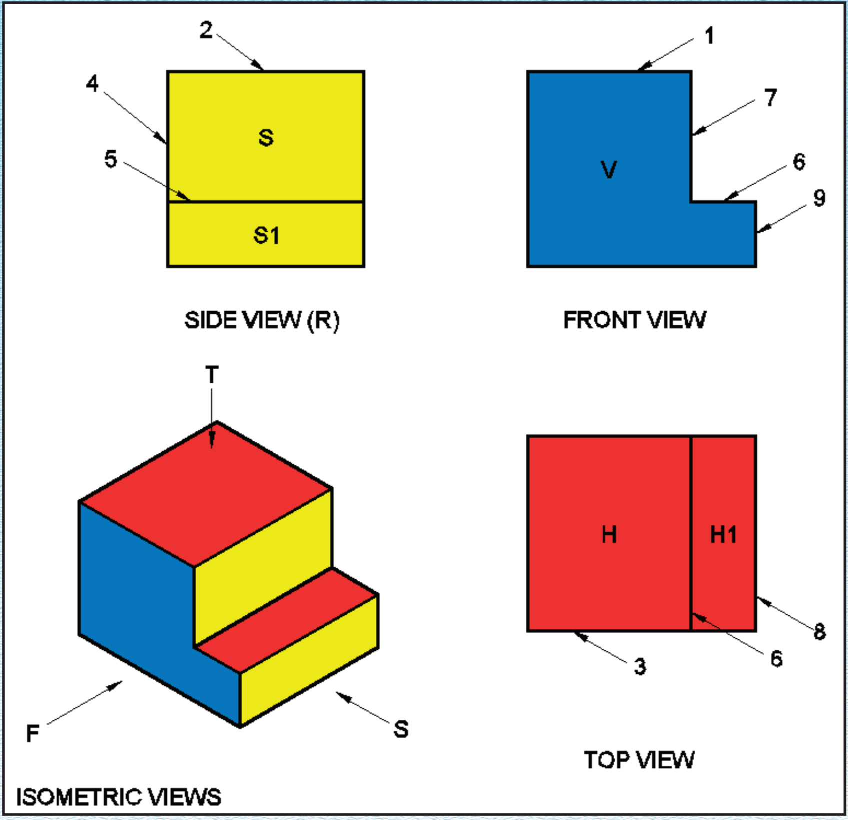


Fig. 6.6

Fill in the blanks by the corresponding line (as indicated)/True shape by observing the following views.

Pictorial View	Orthographic View		
Surfaces	Indicated As		
	Front View	Top View	Side View
(I) H	1	True Shape	2
(ii) H_1	______	______	______
(iii) V	______	______	______
(iv) S	______	______	______
(v) S_1	______	______	______

6.4 MACHINE BLOCKS WITH (HORIZONTAL AND VERTICAL FACES)

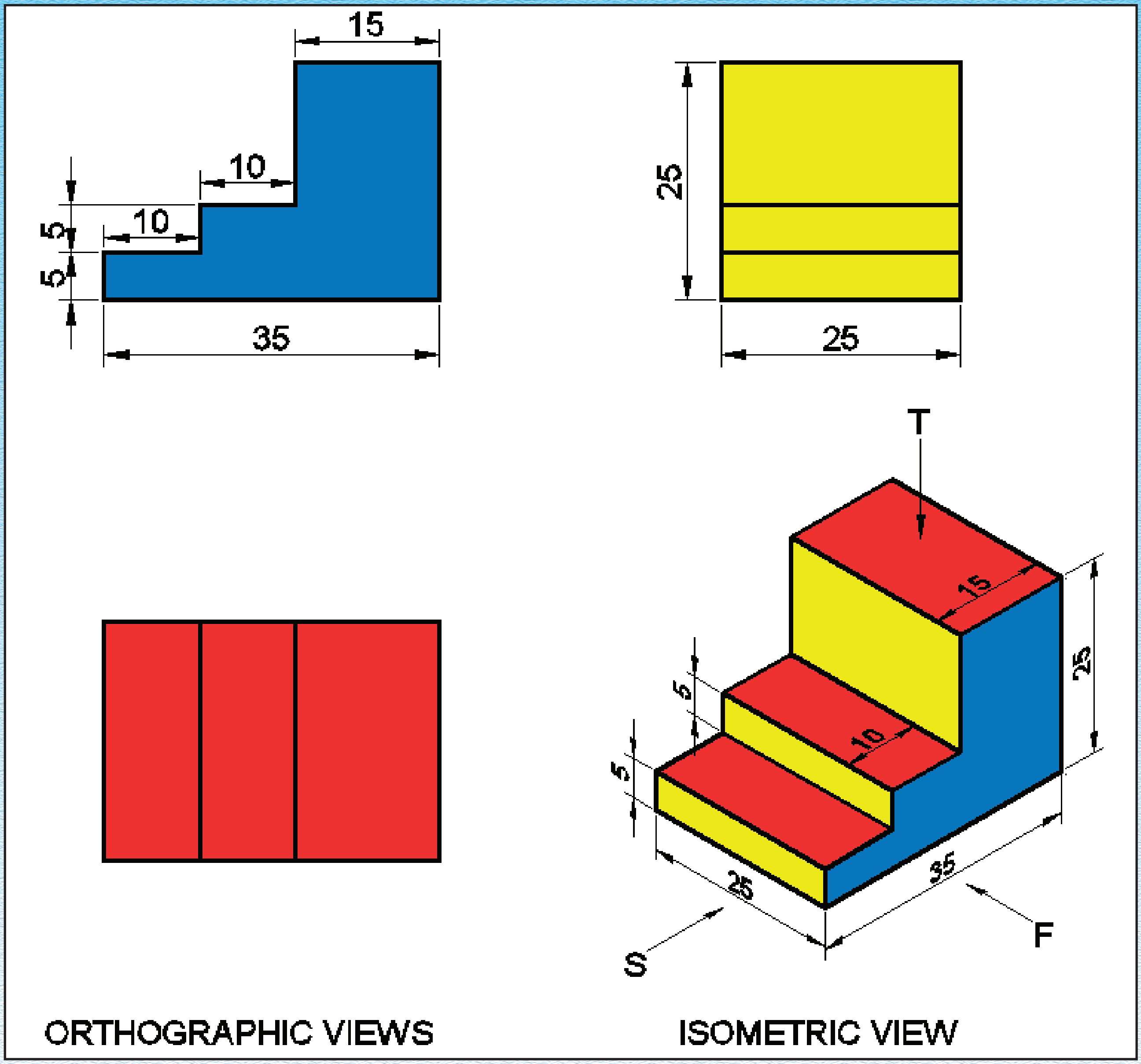
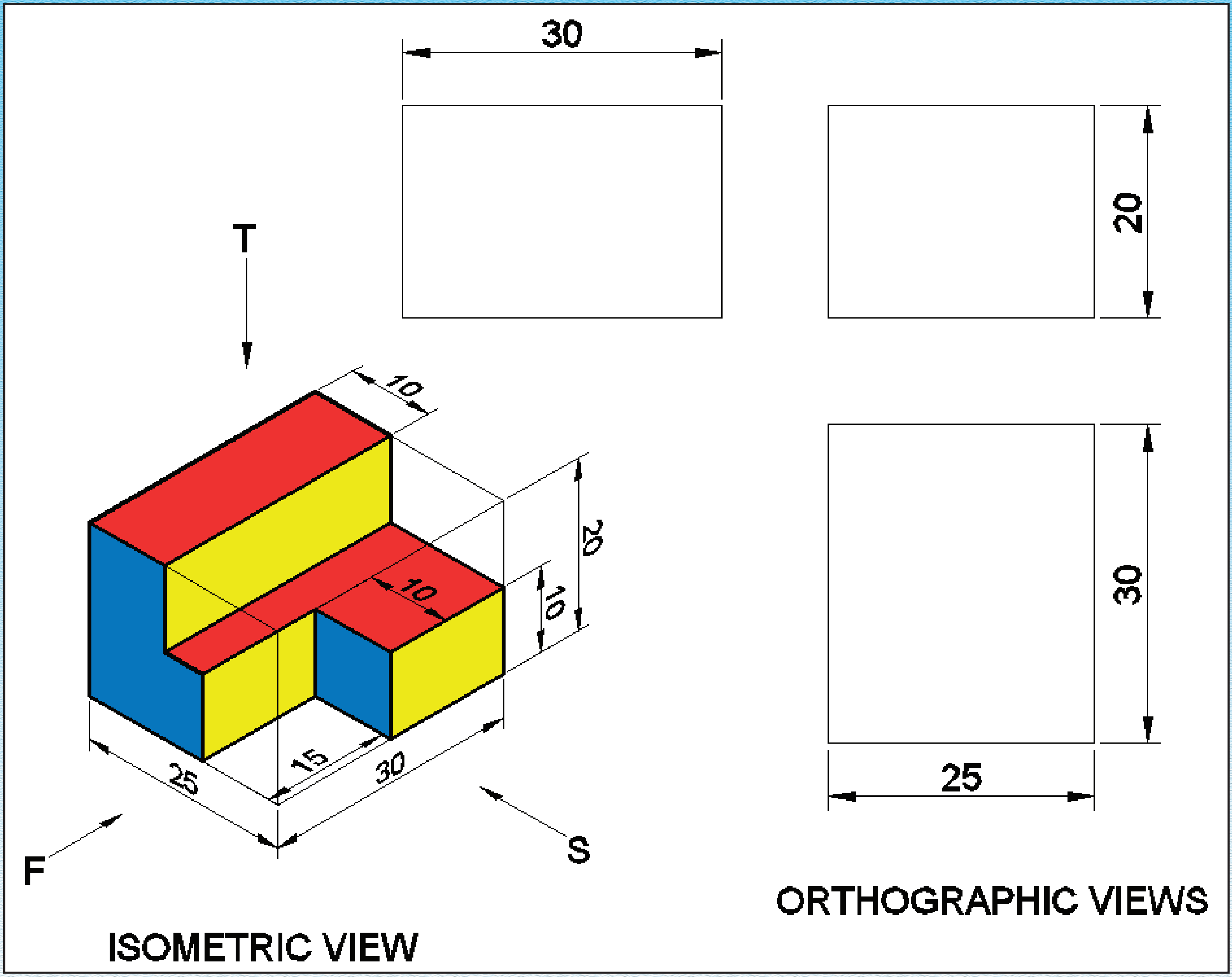


Fig. 6.7


30
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T
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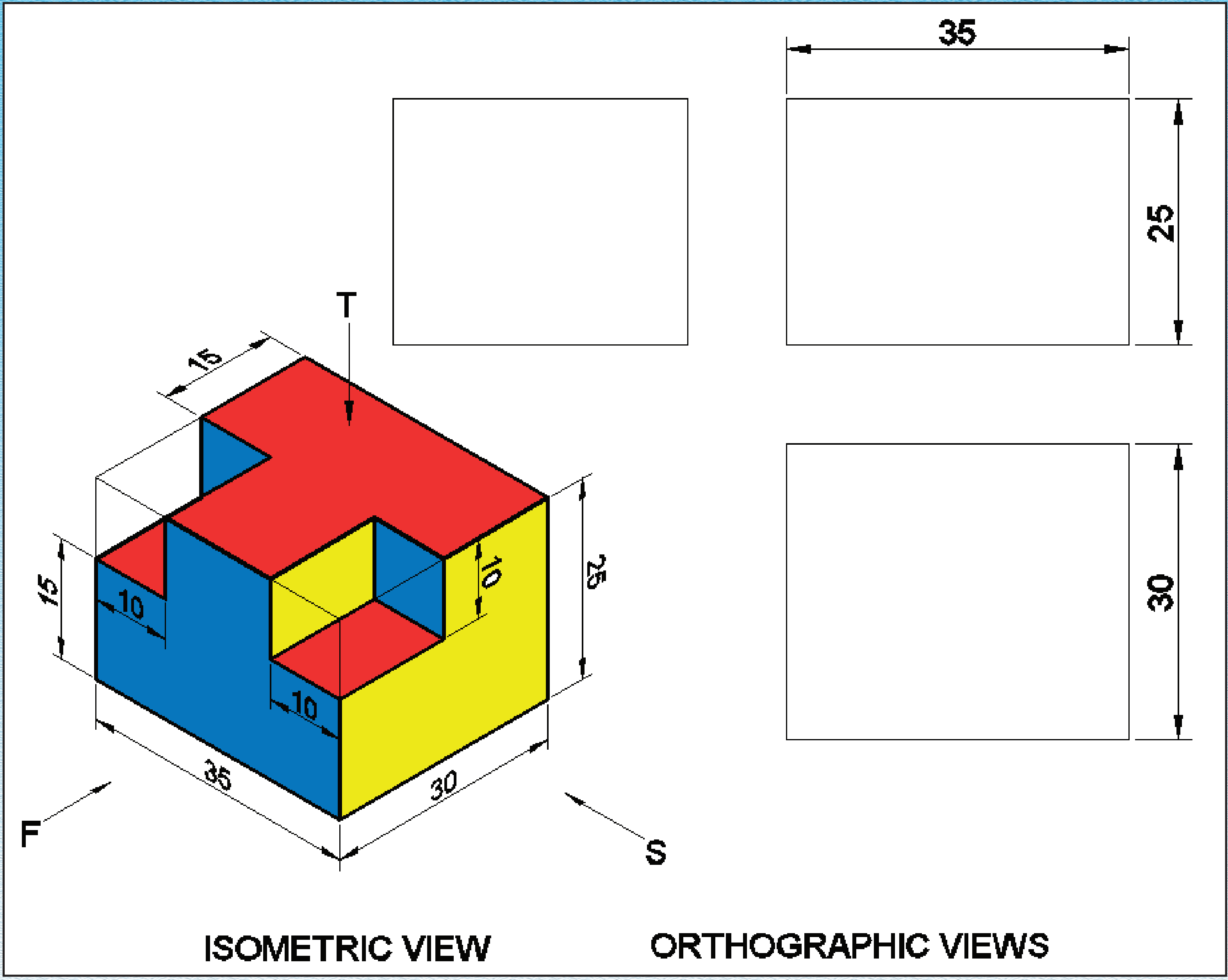
25
F
S
ORTHOGRAPHIC VIEWS
ISOMETRIC VIEW

Fig. 6.8


T
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F
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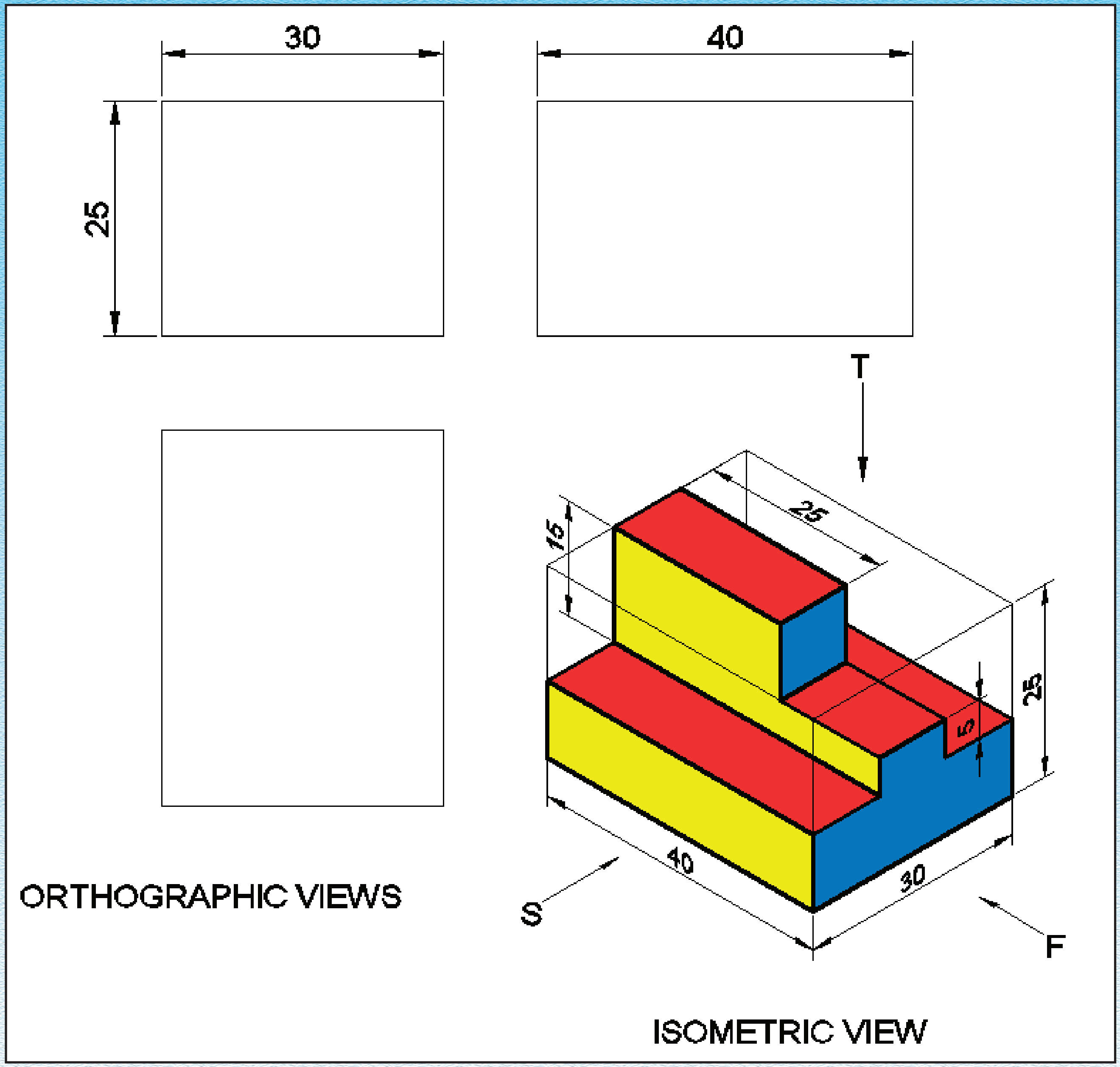
30
ISOMETRIC VIEW
ORTHOGRAPHIC VIEWS

Fig. 6.9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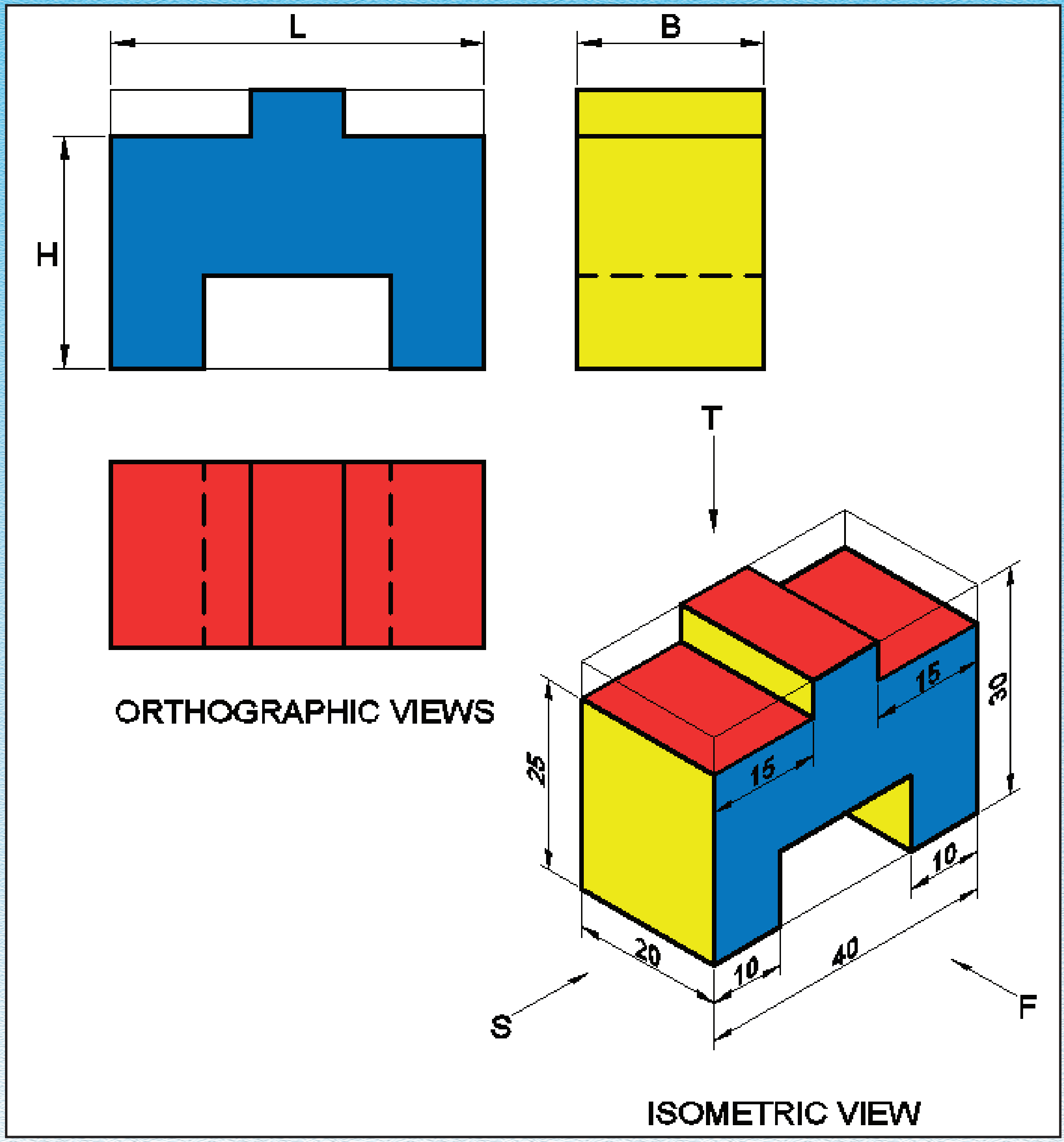
S
F
ORTHOGRAPHIC VIEWS
ISOMETRIC VIEW

Fig. 6.10


L
B
H
T
ORTHOGRAPHIC VIEWS
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40
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F
ISOMETRIC VIEW

Fig. 6.11

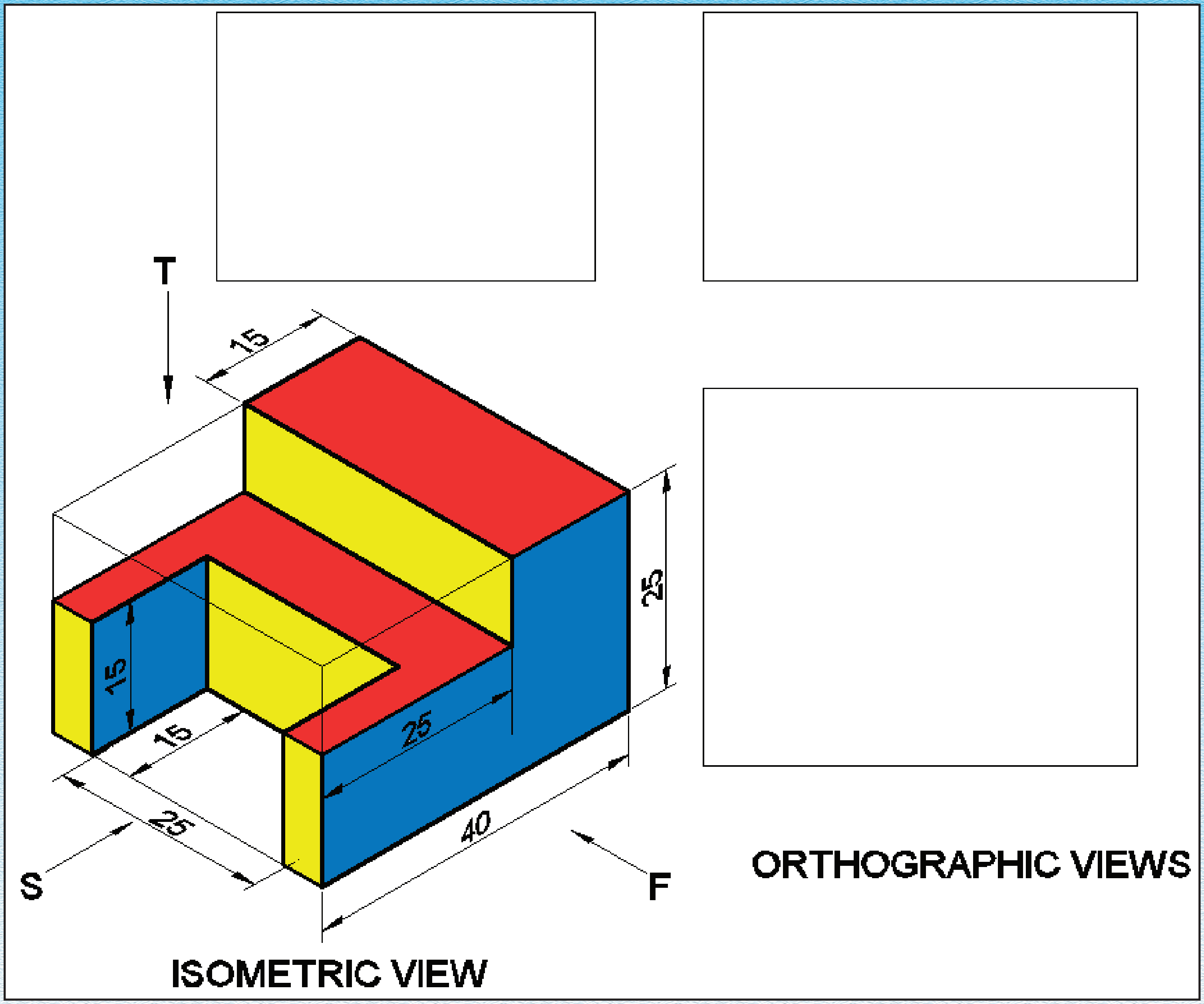


Fig. 6.12

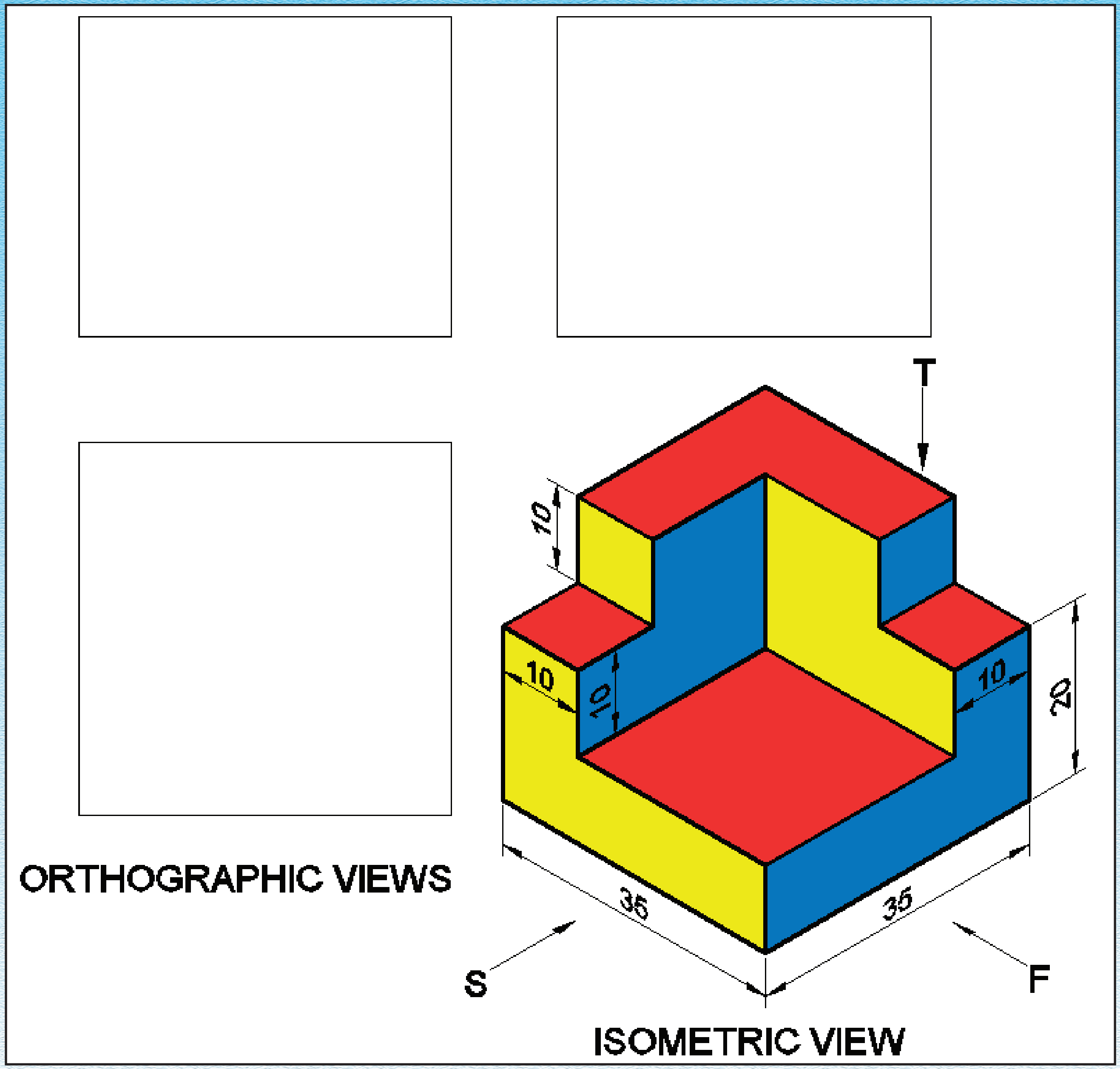


Fig. 6.13

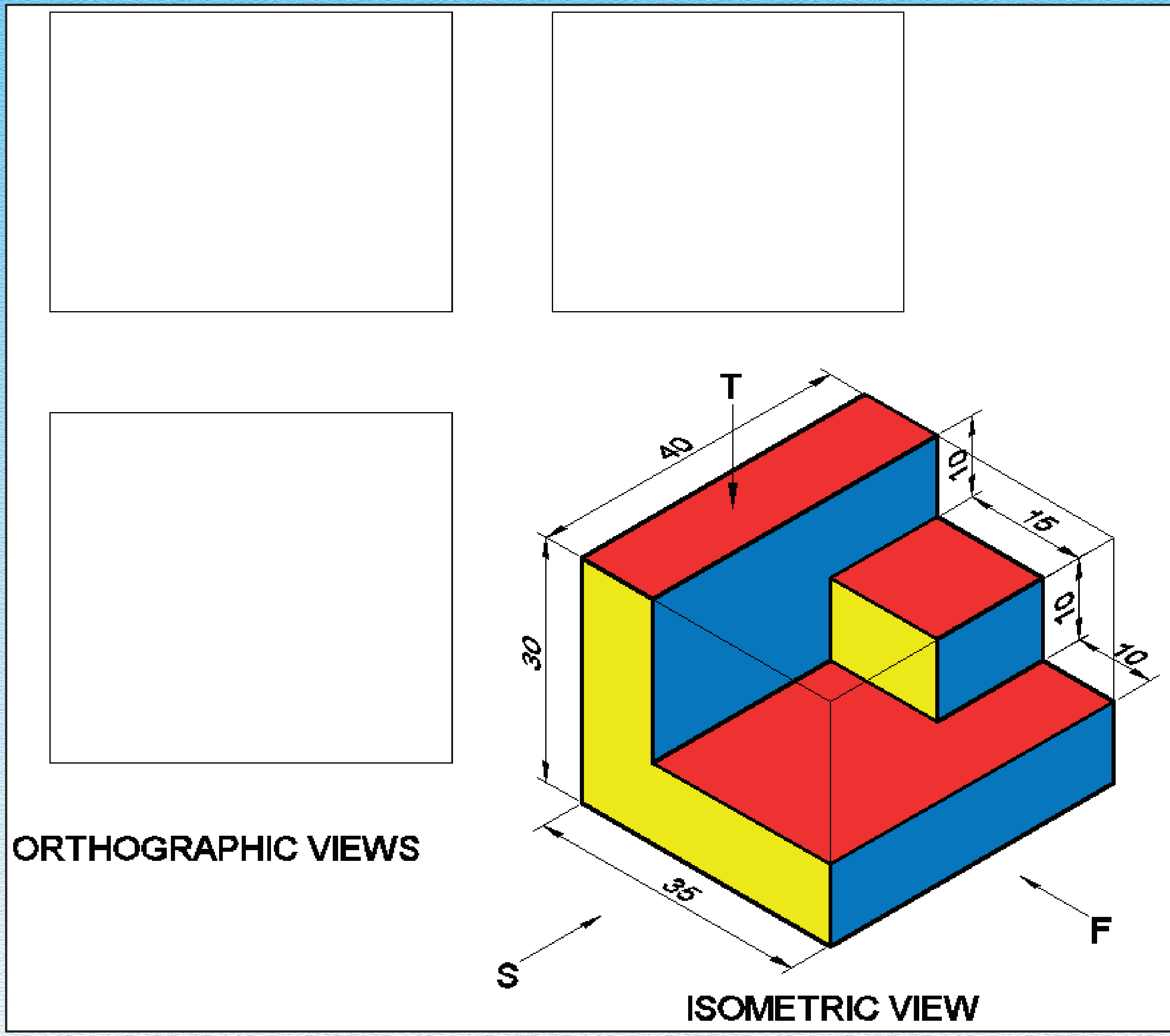


Fig. 6.14

6.5 MACHINE BLOCKS WITH (HORIZONTAL, VERTICAL AND INCLINED FACES)

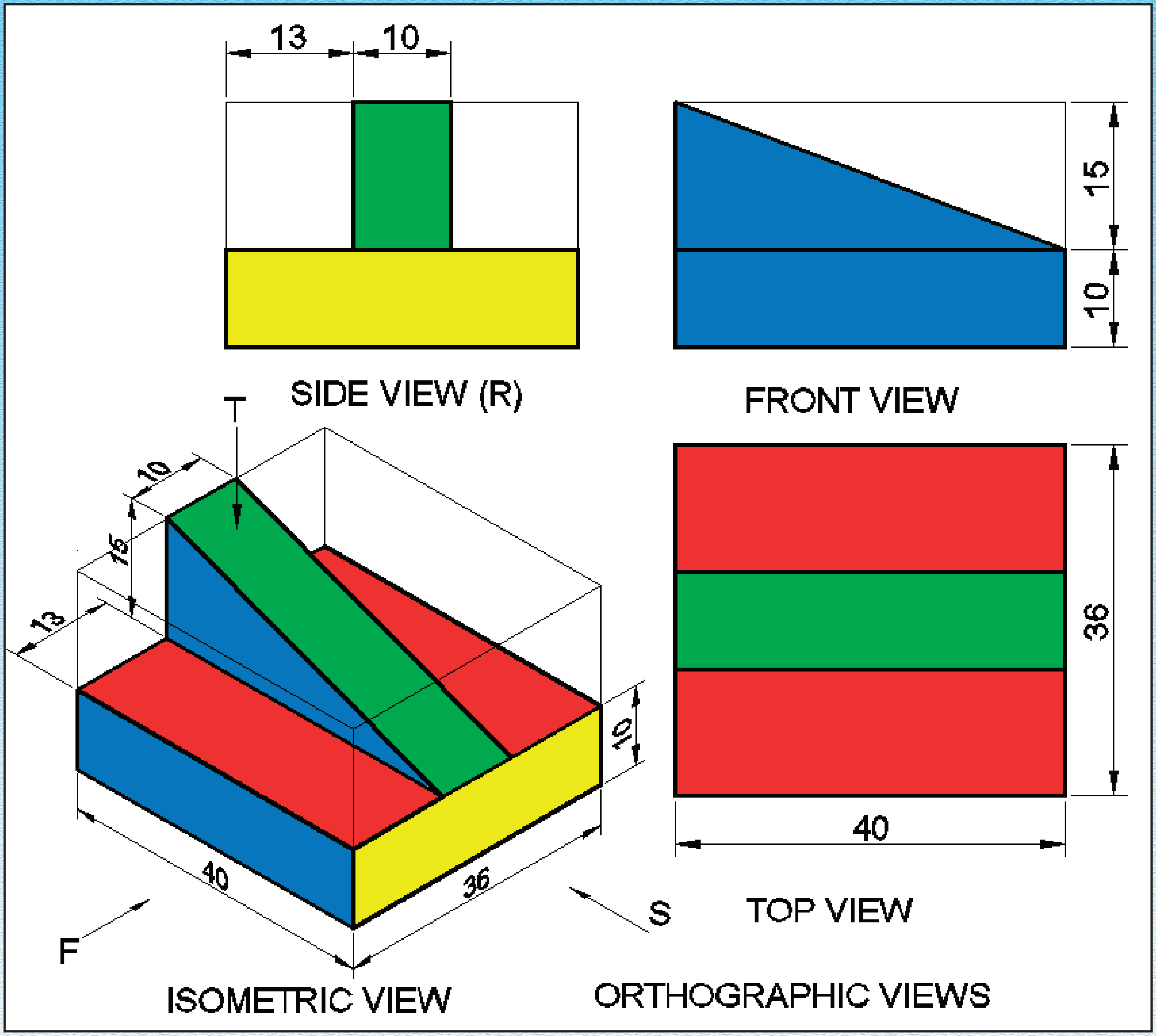
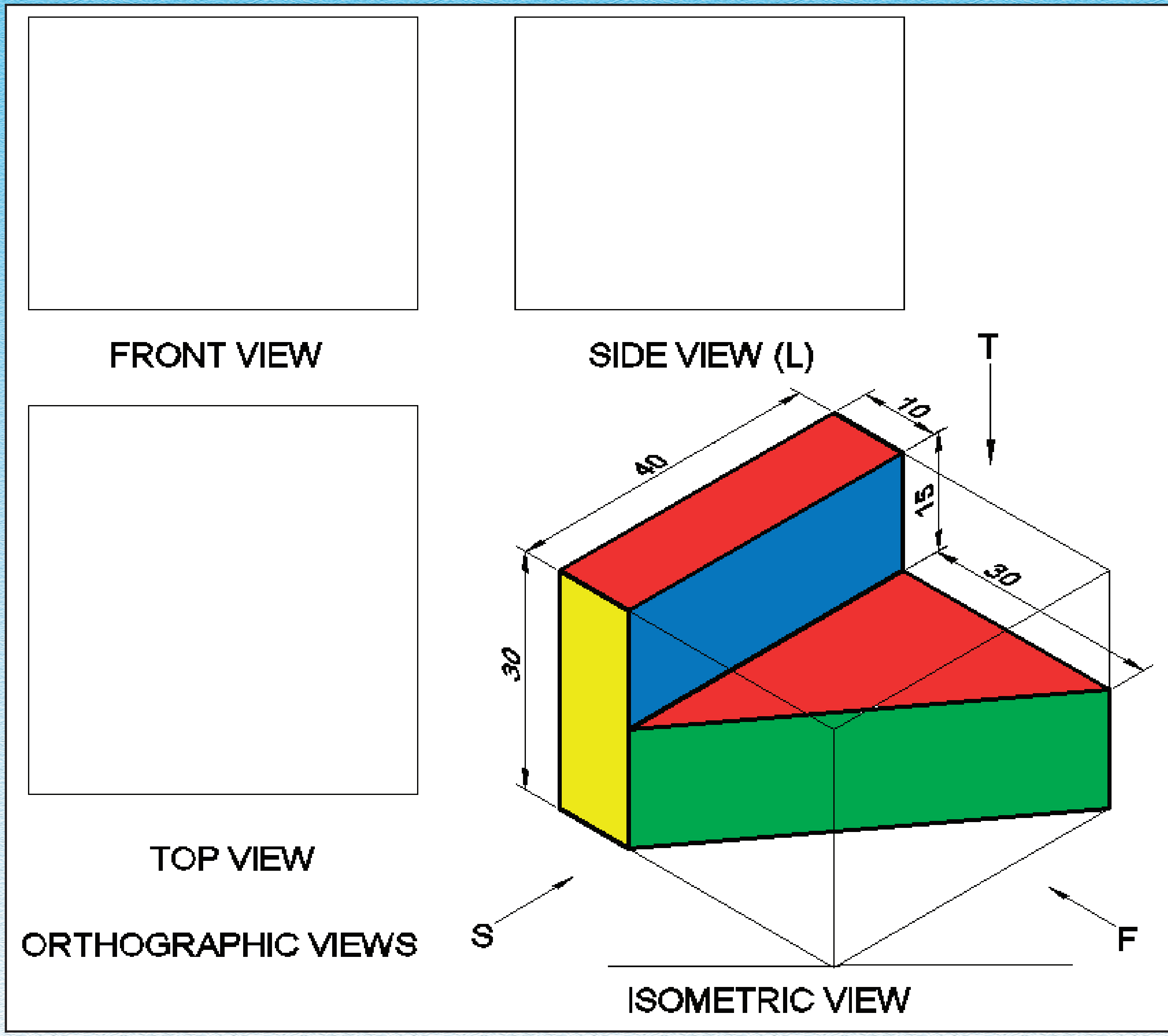


Fig. 6.15


FRONT VIEW
SIDE VIEW (L)
TOP VIEW
ORTHOGRAPHIC VIEWS
T
40
10
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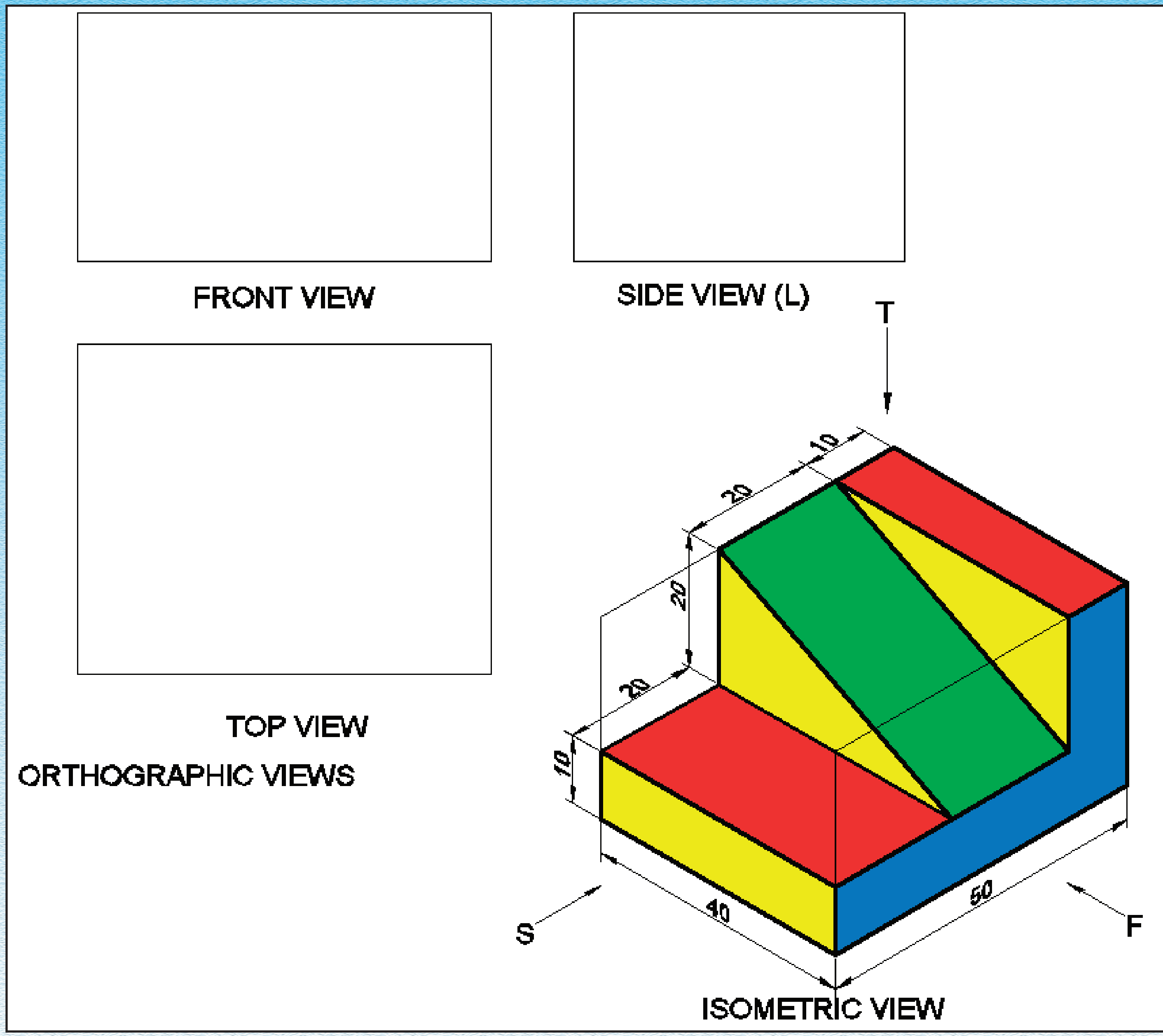
F
ISOMETRIC VIEW

Fig. 6.16


FRONT VIEW
SIDE VIEW (L)
TOP VIEW
ORTHOGRAPHIC VIEWS
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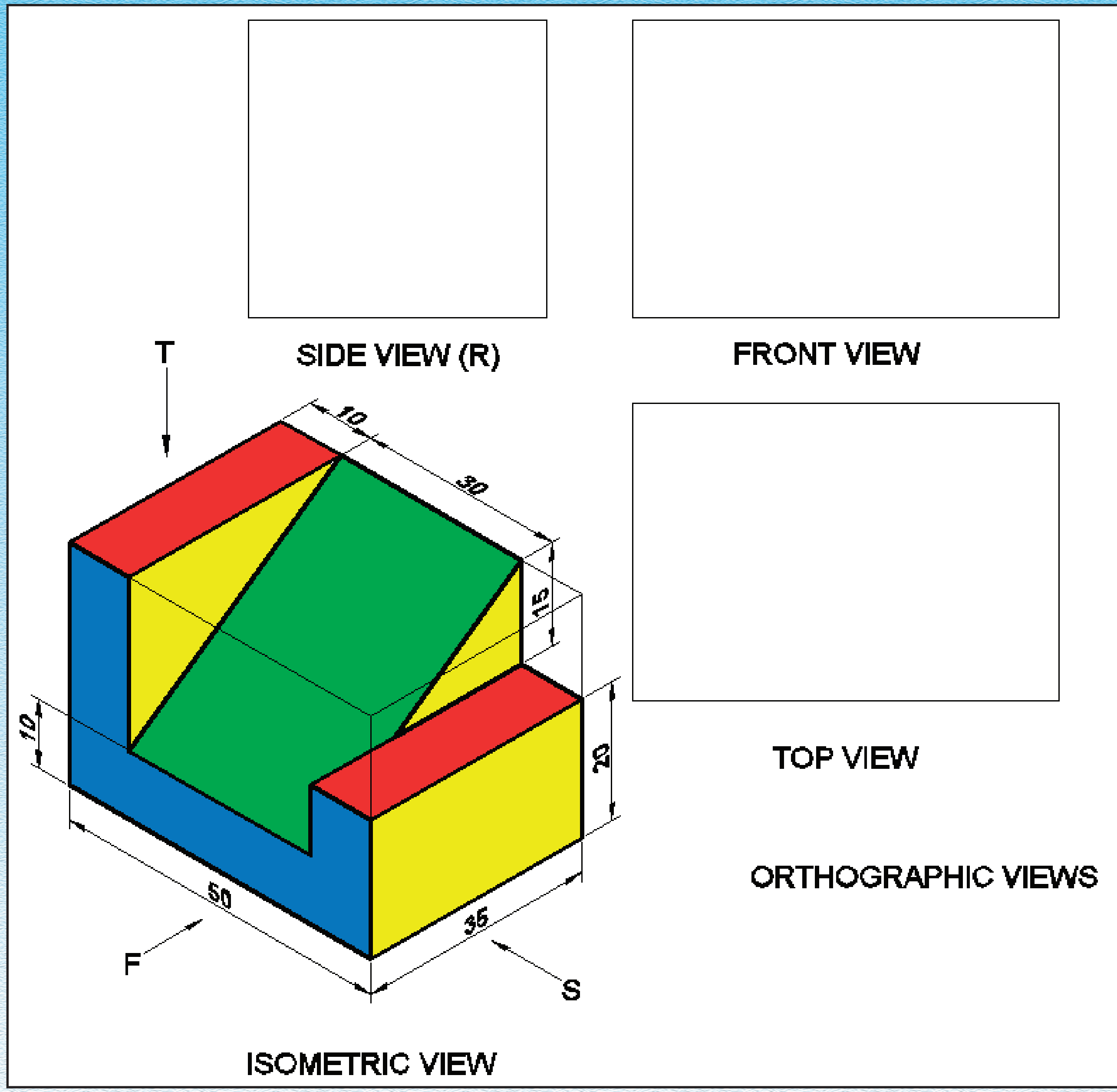
F
ISOMETRIC VIEW

Fig. 6.17


SIDE VIEW (R)
FRONT VIEW
TOP VIEW
ORTHOGRAPHIC VIEWS
T
10
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S
ISOMETRIC VIEW

Fig. 6.18

6.6 MACHINE BLOCKS : (HORIZONTAL, VERTICAL AND CURVED FACES)

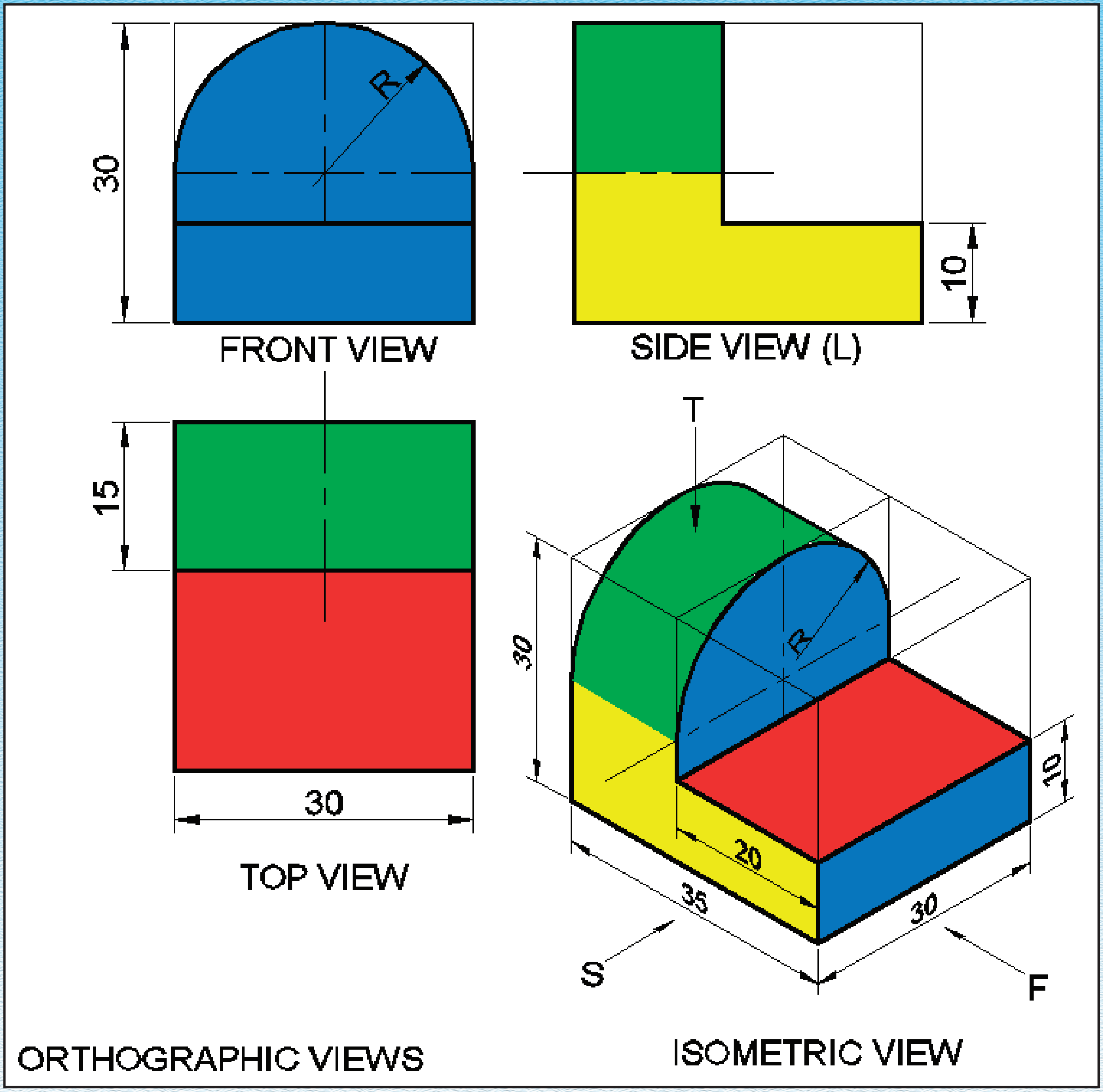
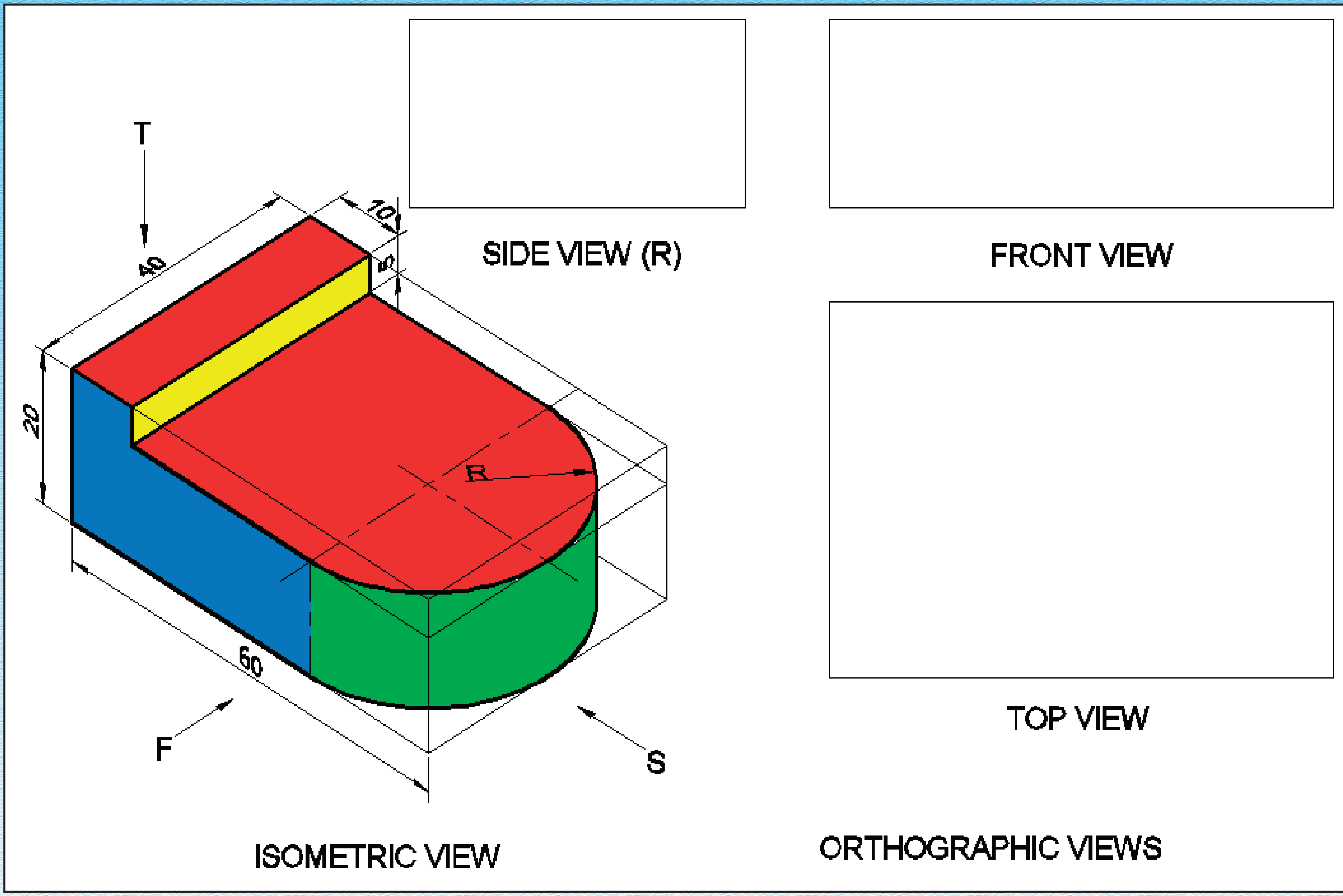


Fig. 6.19


T
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5
20
R
60
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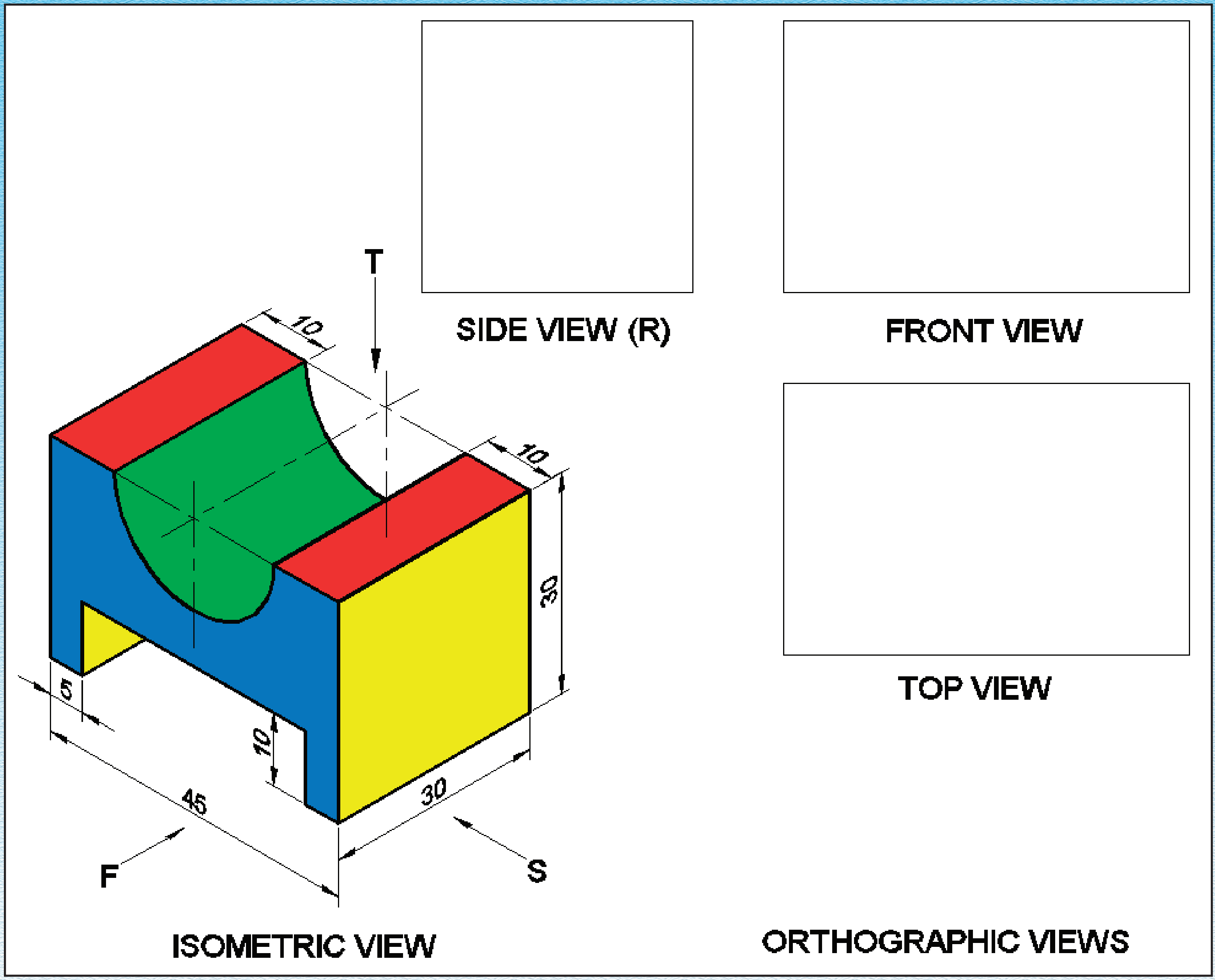
S
SIDE VIEW (R)
FRONT VIEW
TOP VIEW
ISOMETRIC VIEW
ORTHOGRAPHIC VIEWS

Fig. 6.20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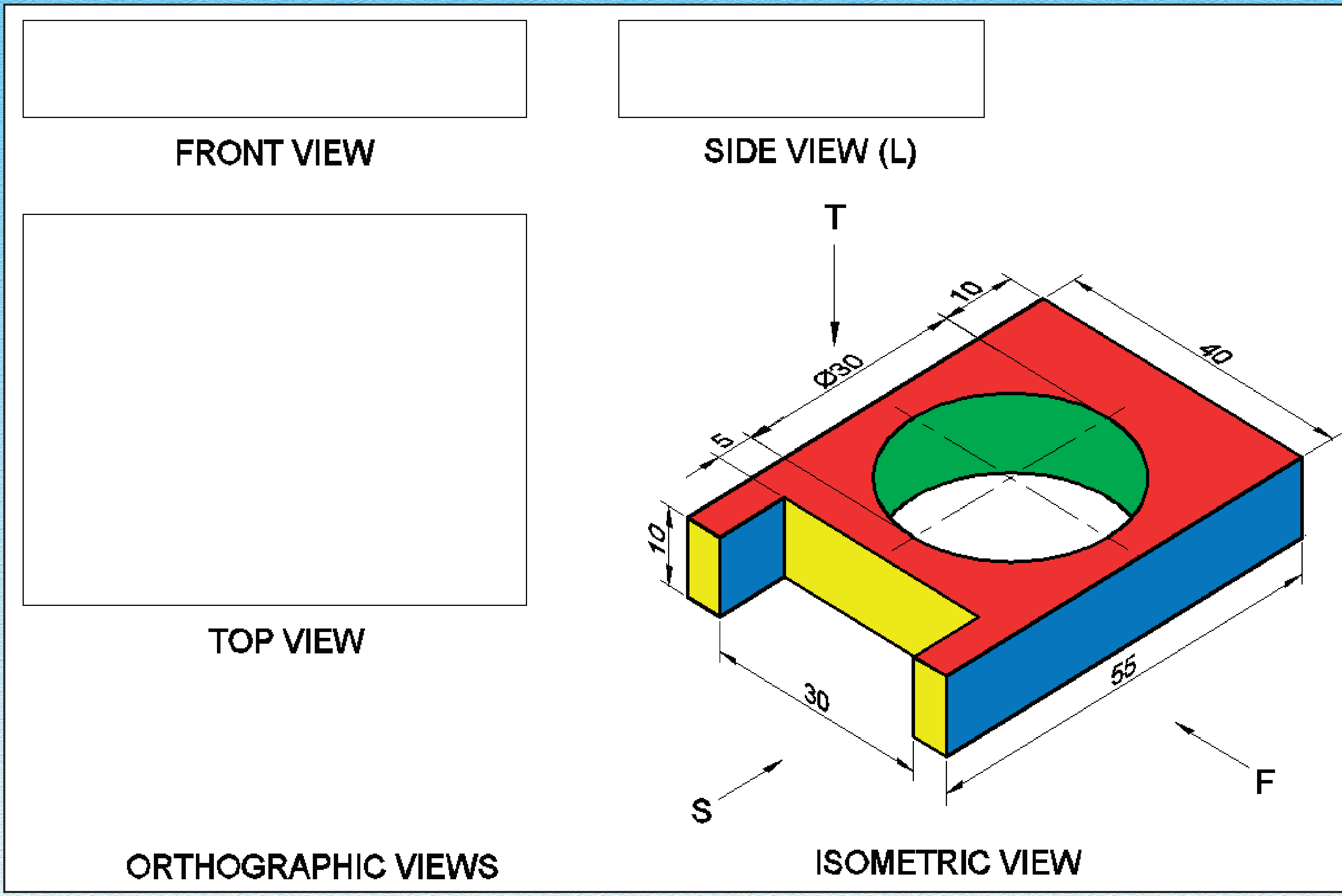
S
ISOMETRIC VIEW
SIDE VIEW (R)
FRONT VIEW
TOP VIEW
ORTHOGRAPHIC VIEWS

Fig. 6.21


FRONT VIEW
SIDE VIEW (L)
TOP VIEW
T
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Ø30
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S
F
ORTHOGRAPHIC VIEWS
ISOMETRIC VIEW

Fig. 6.22

6.7 MACHINE BLOCKS : (HORIZONTAL, VERTICAL, CURVED AND INCLINED FACES)

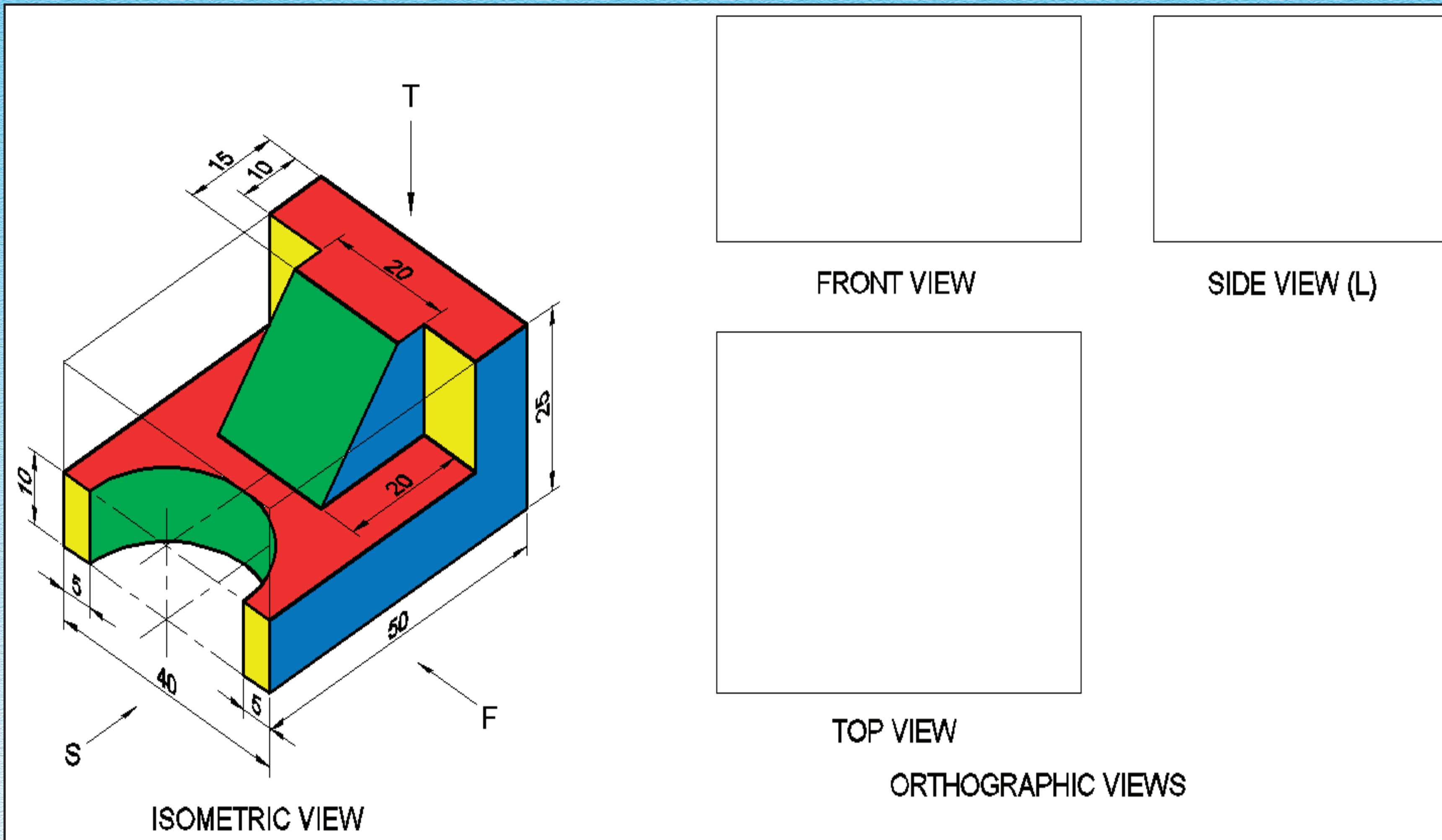
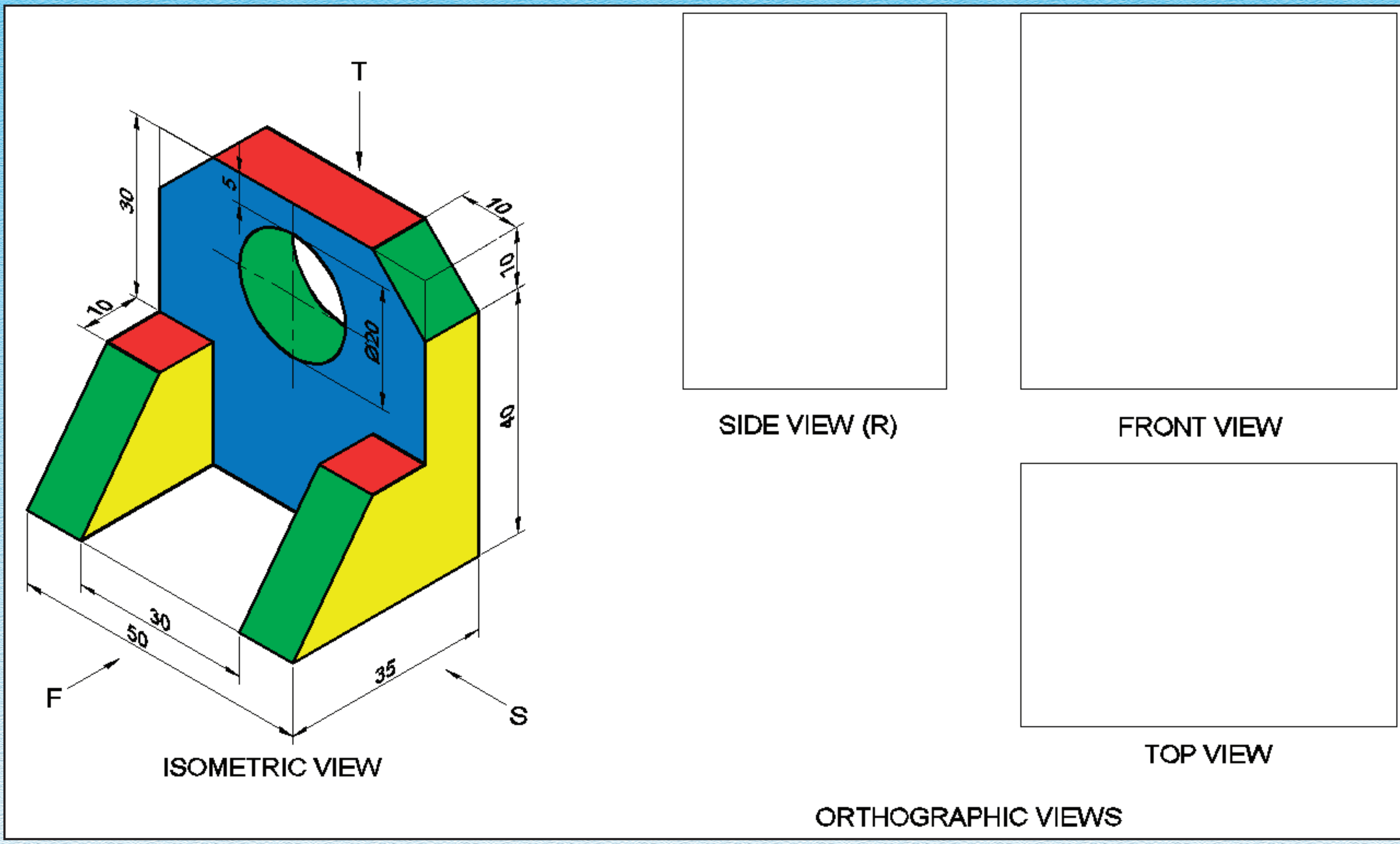


Fig. 6.23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S
ISOMETRIC VIEW
SIDE VIEW (R)
FRONT VIEW
TOP VIEW
ORTHOGRAPHIC VIEWS

Fig. 6.24

6.8 MISCELLANEOUS EXERCISES

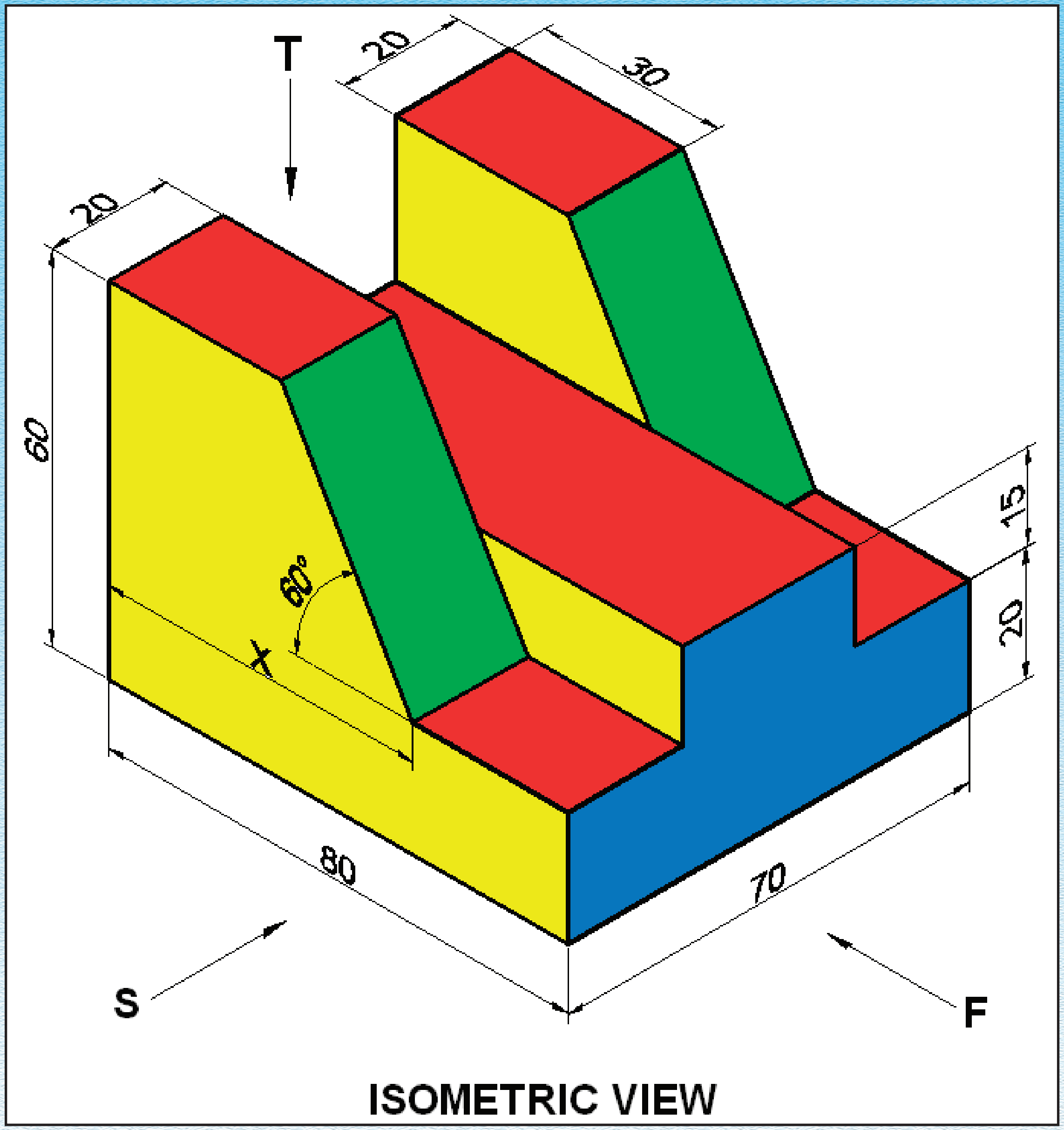


Fig. 6.25

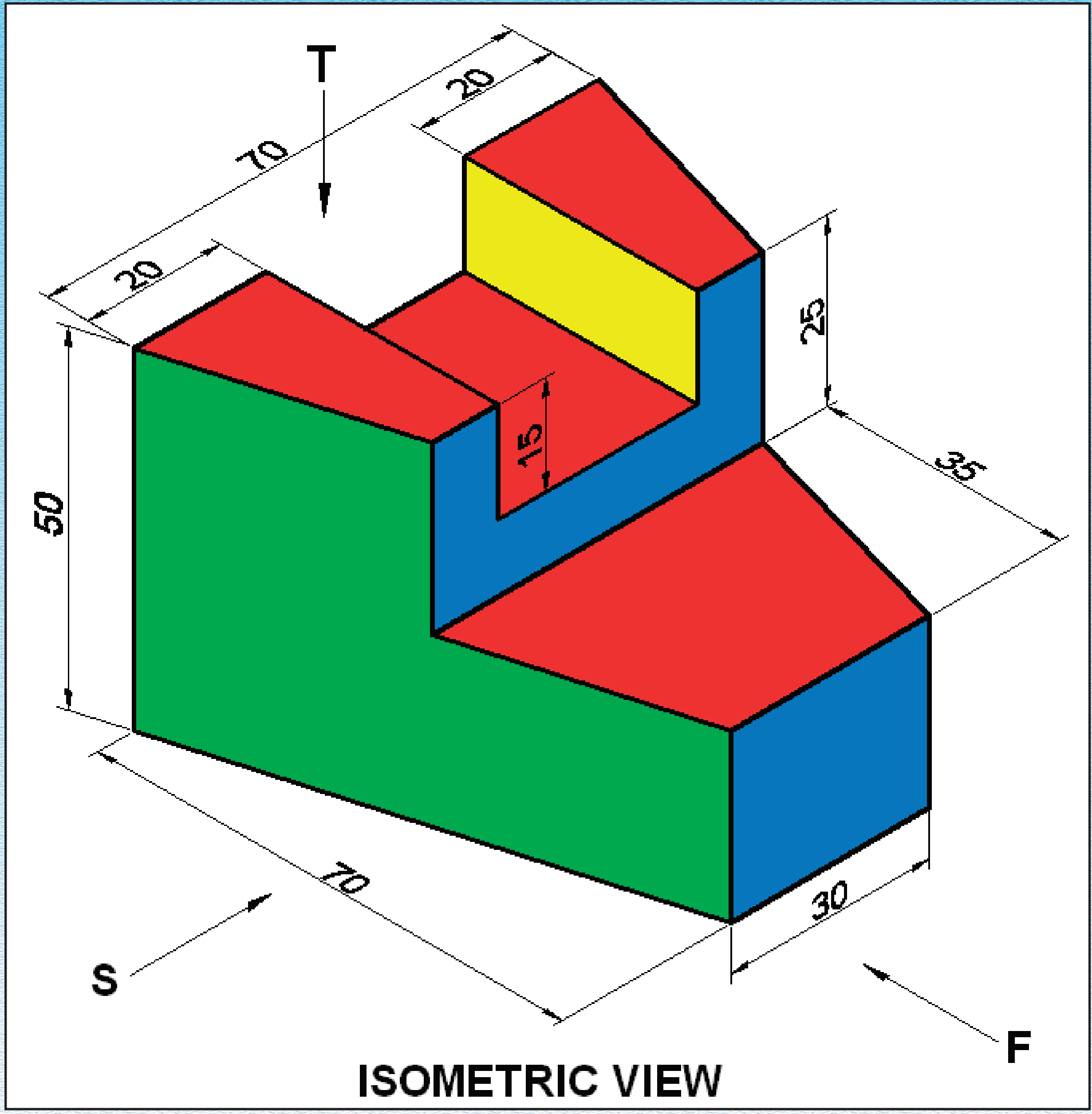


Fig. 6.26

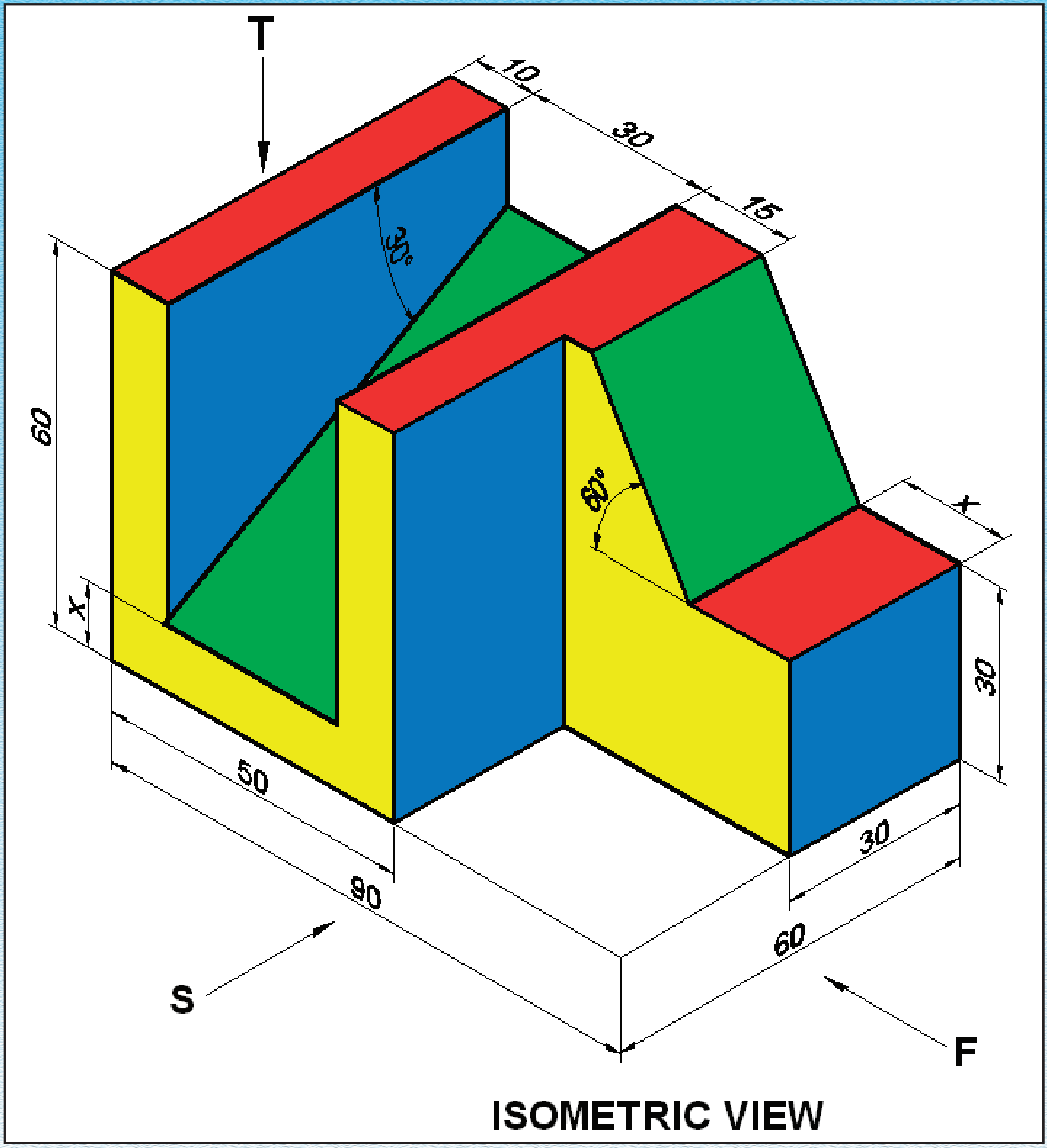


Fig. 6.27

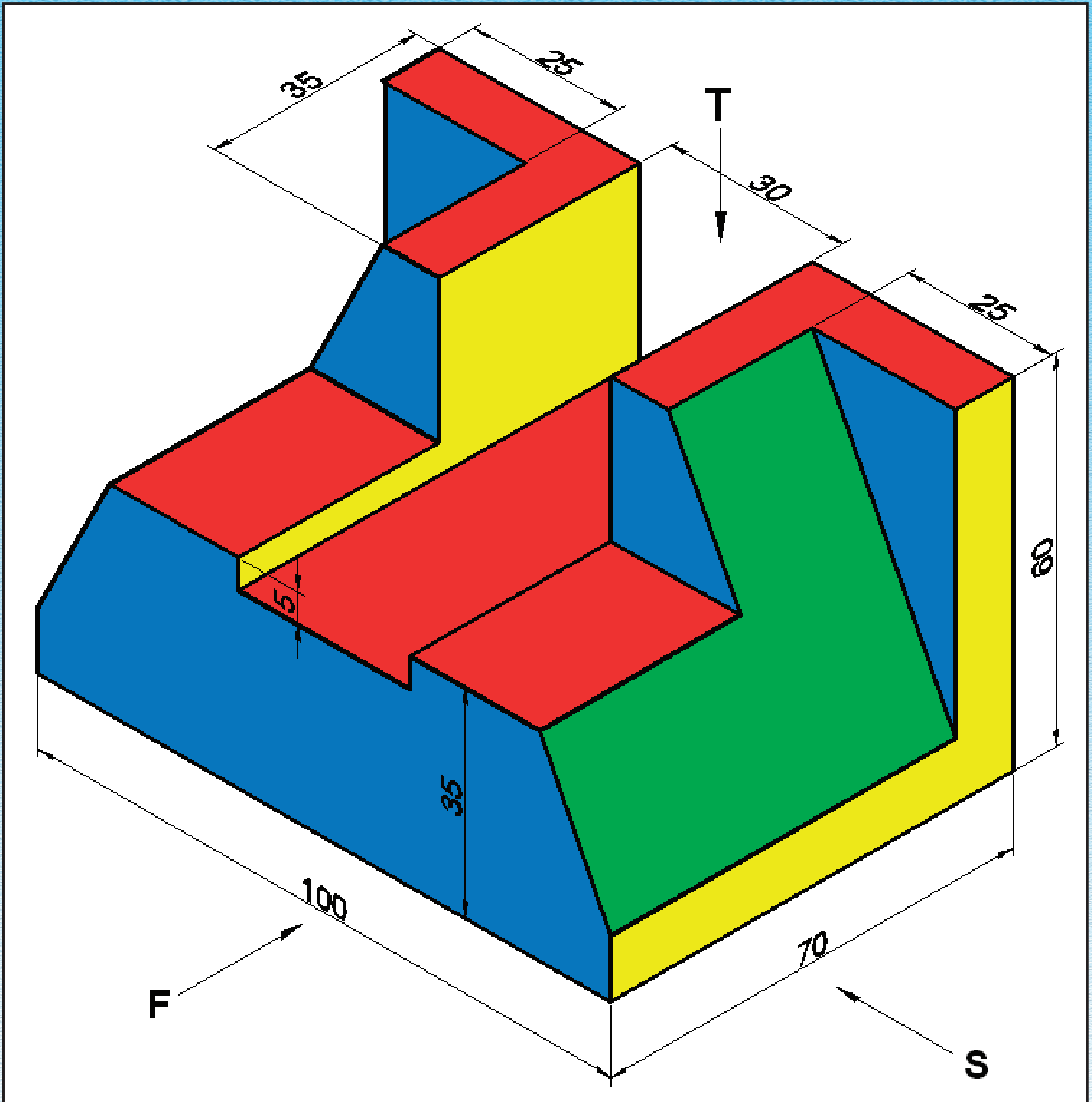


Fig. 6.28

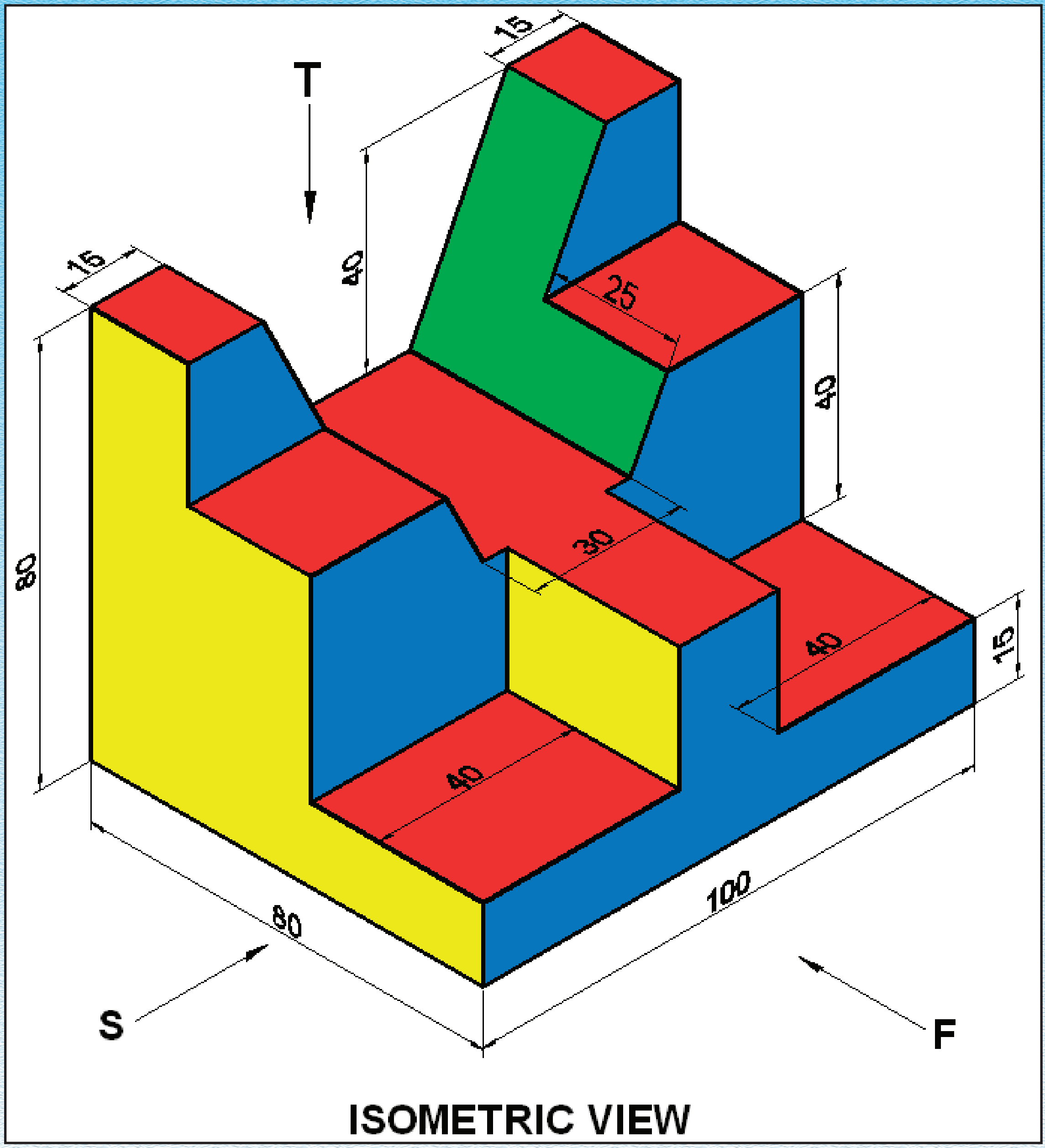


Fig. 6.29

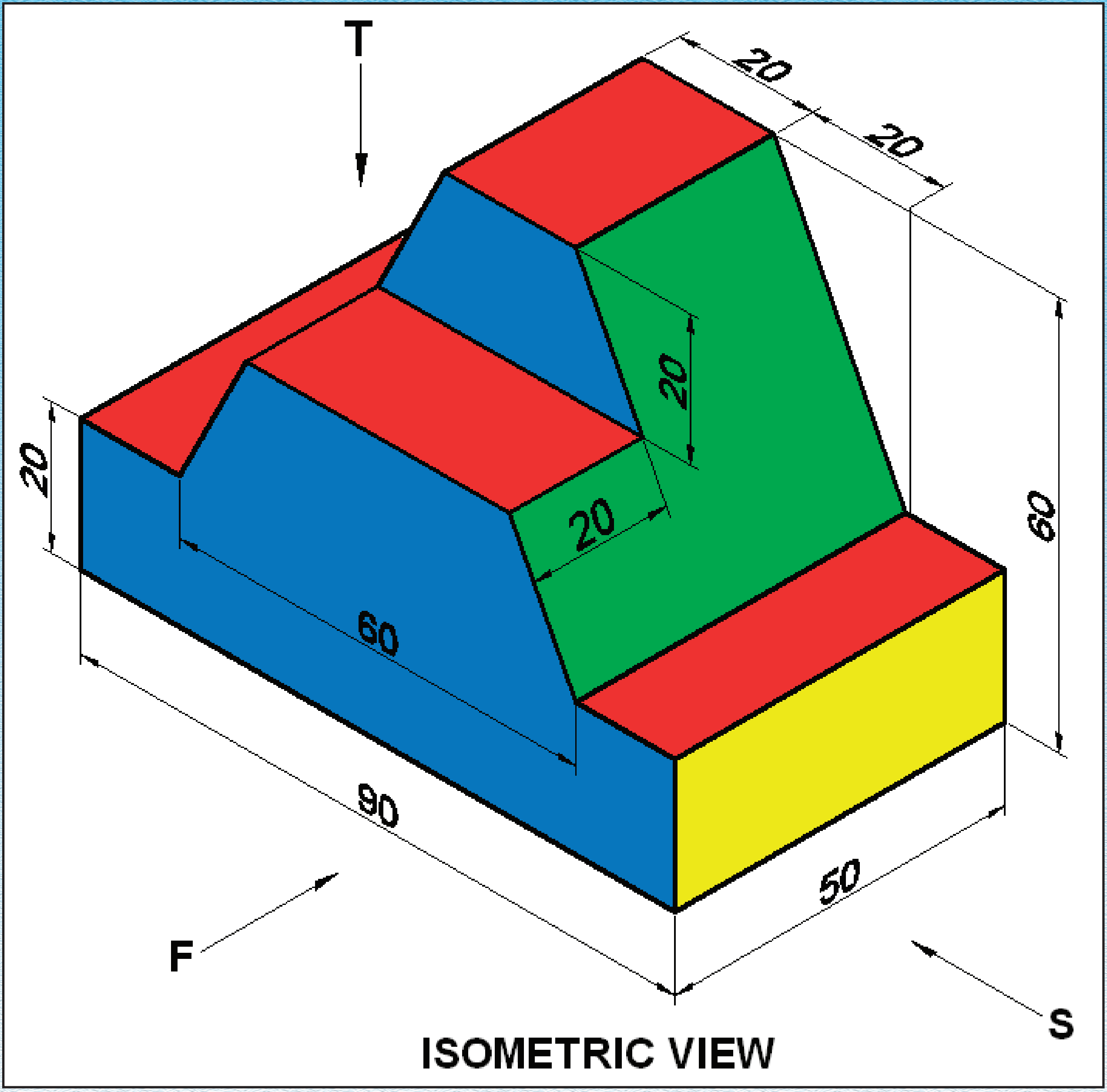
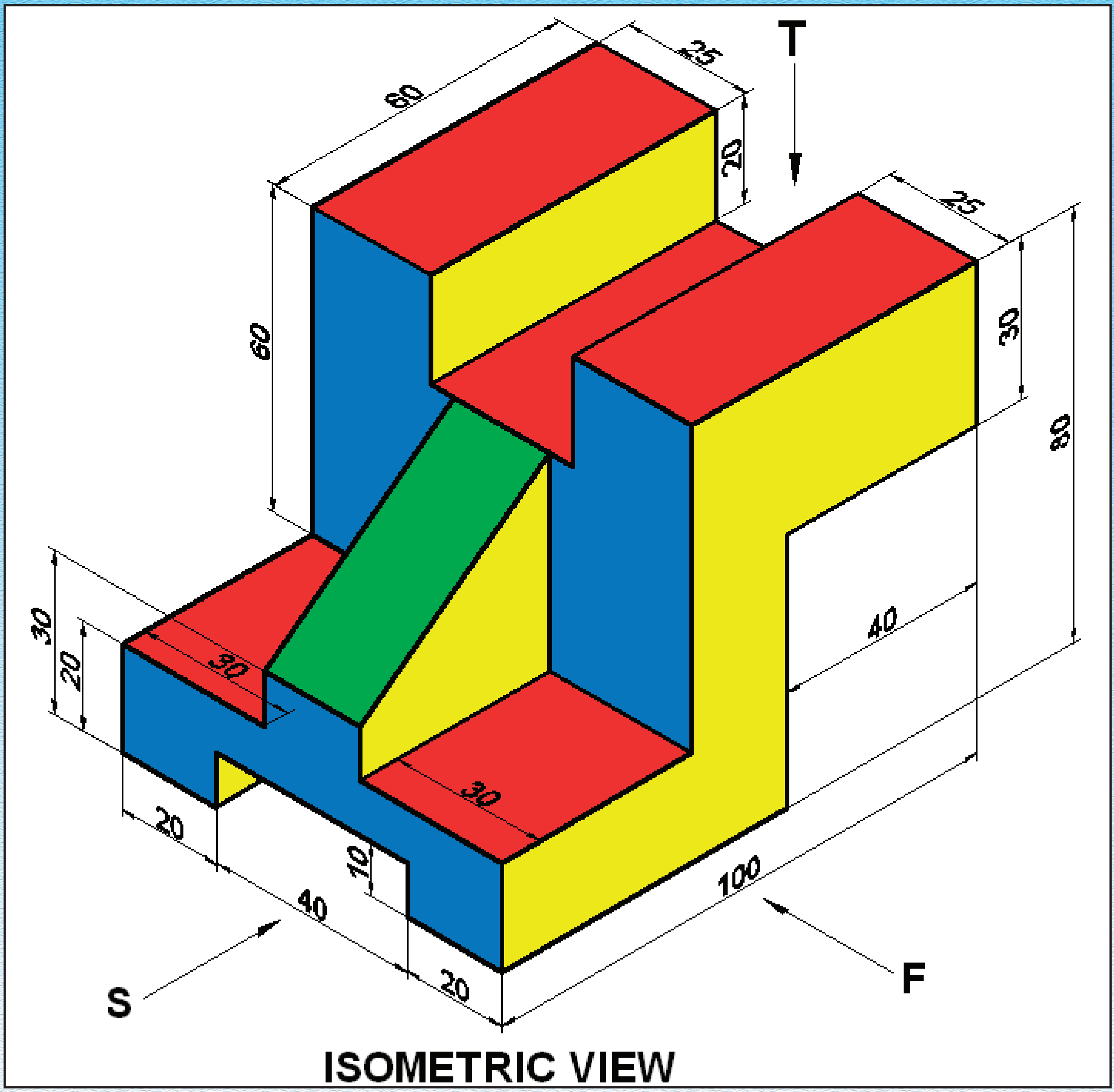


Fig. 6.30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S
F
ISOMETRIC VIEW

Fig. 6.31

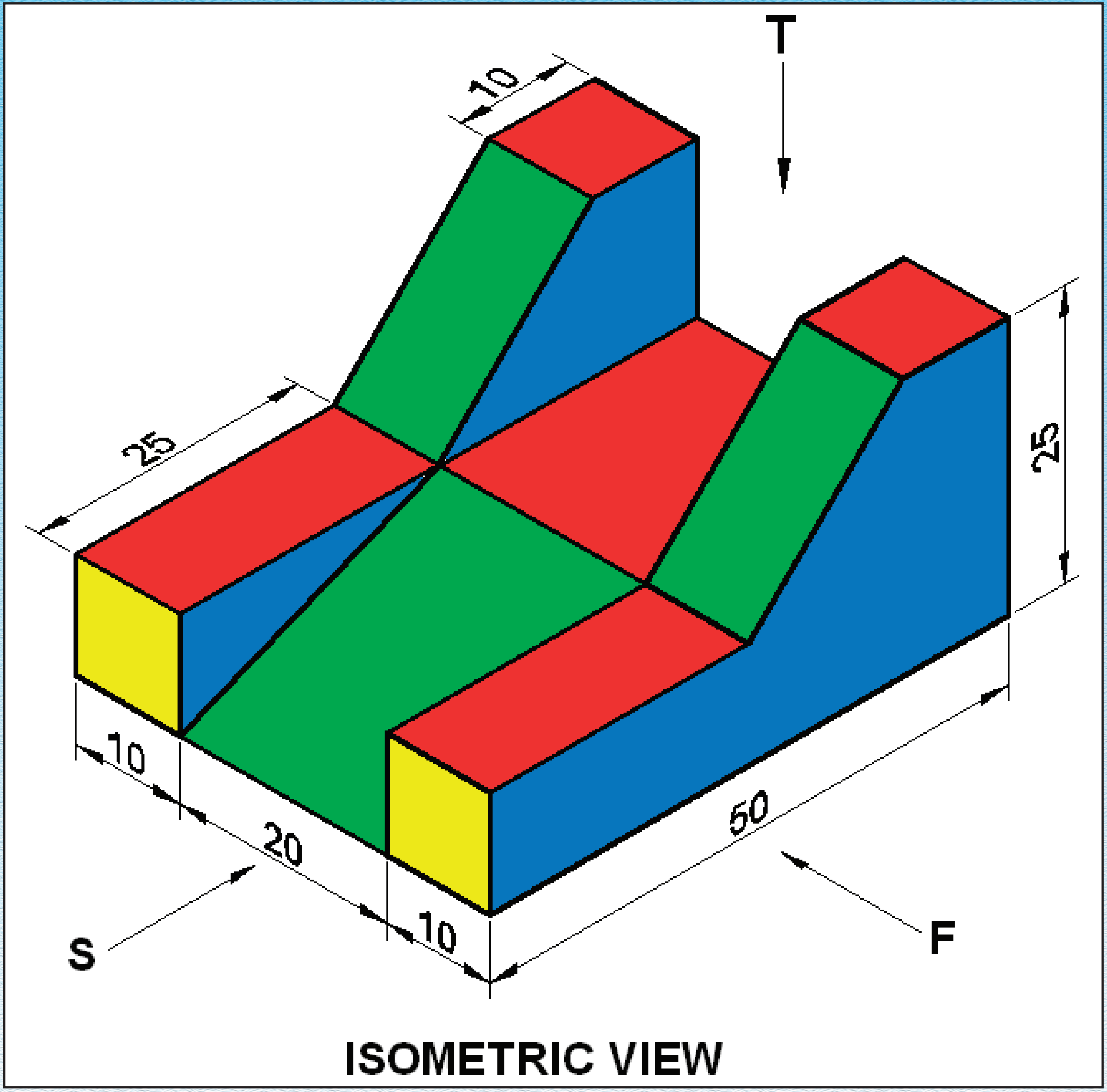


Fig. 6.32

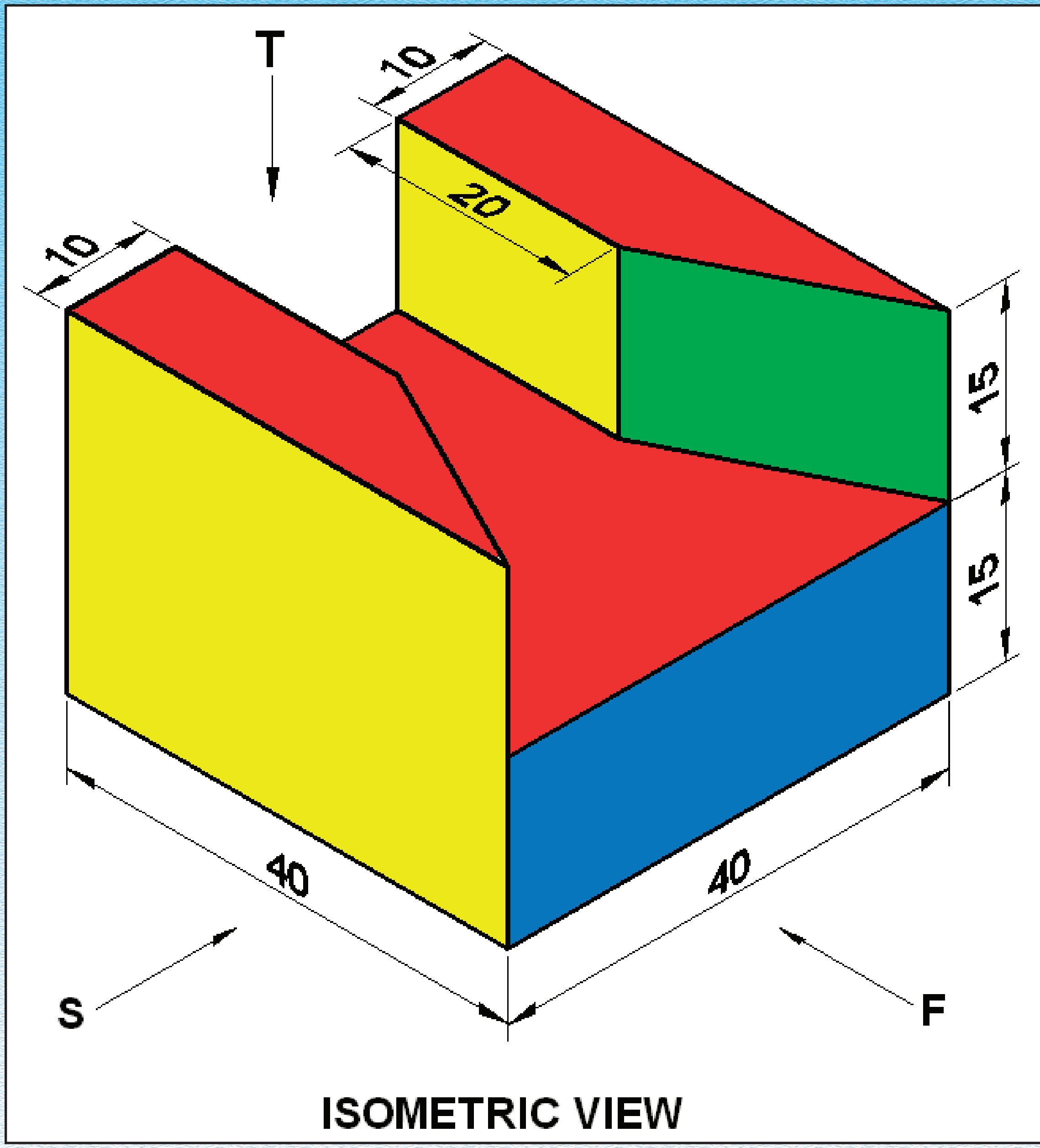


Fig. 6.33

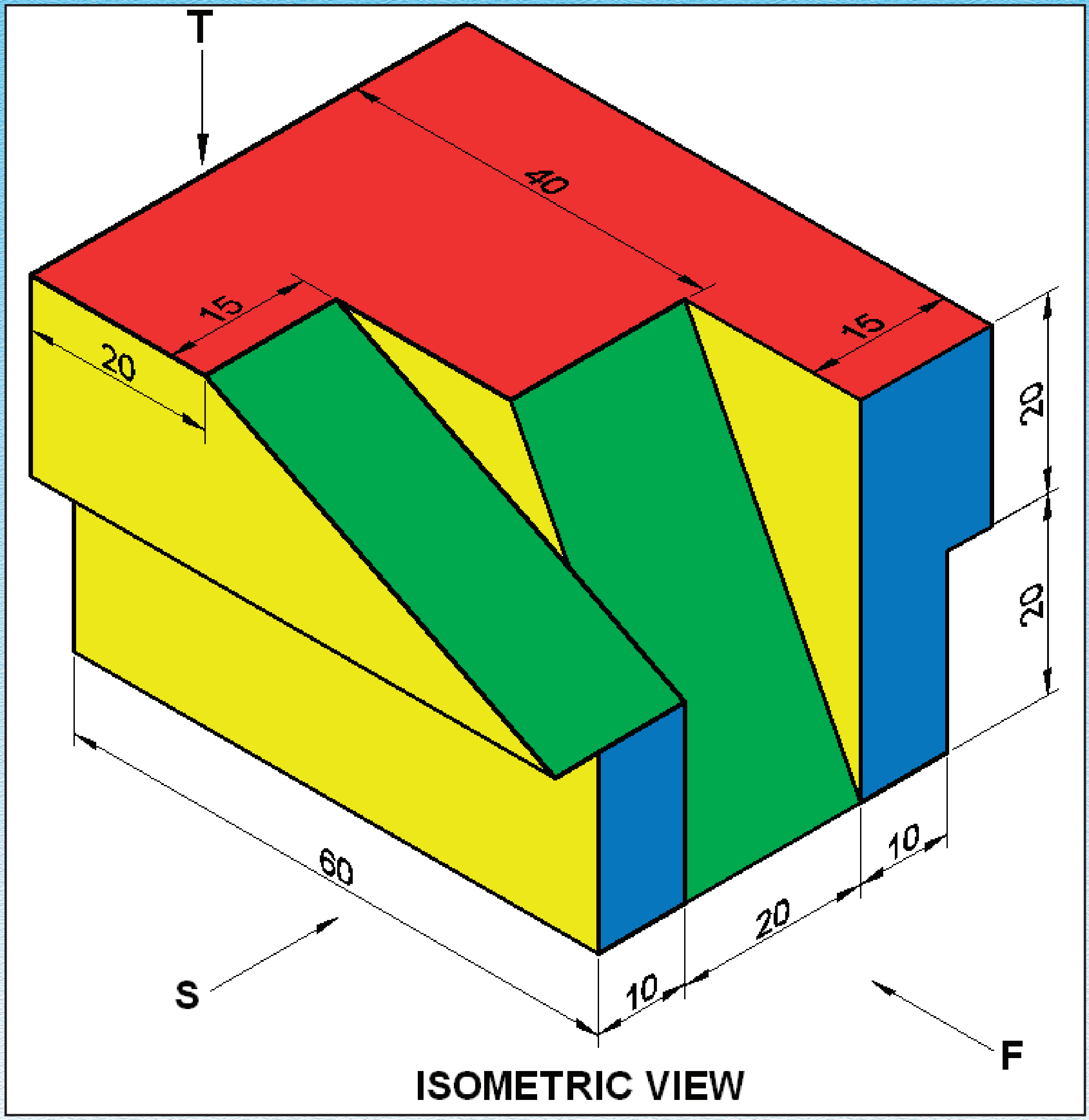


Fig. 6.34

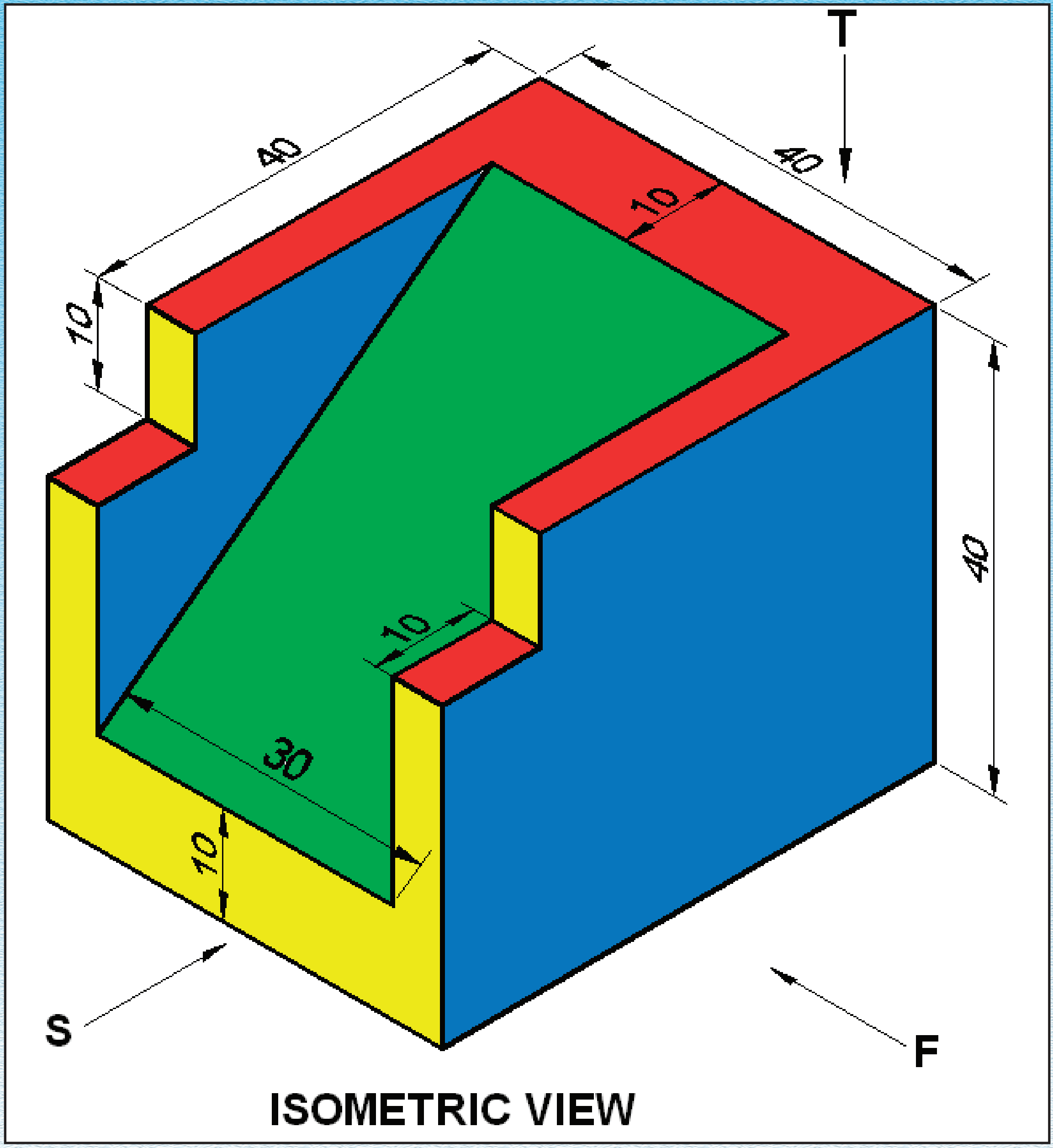
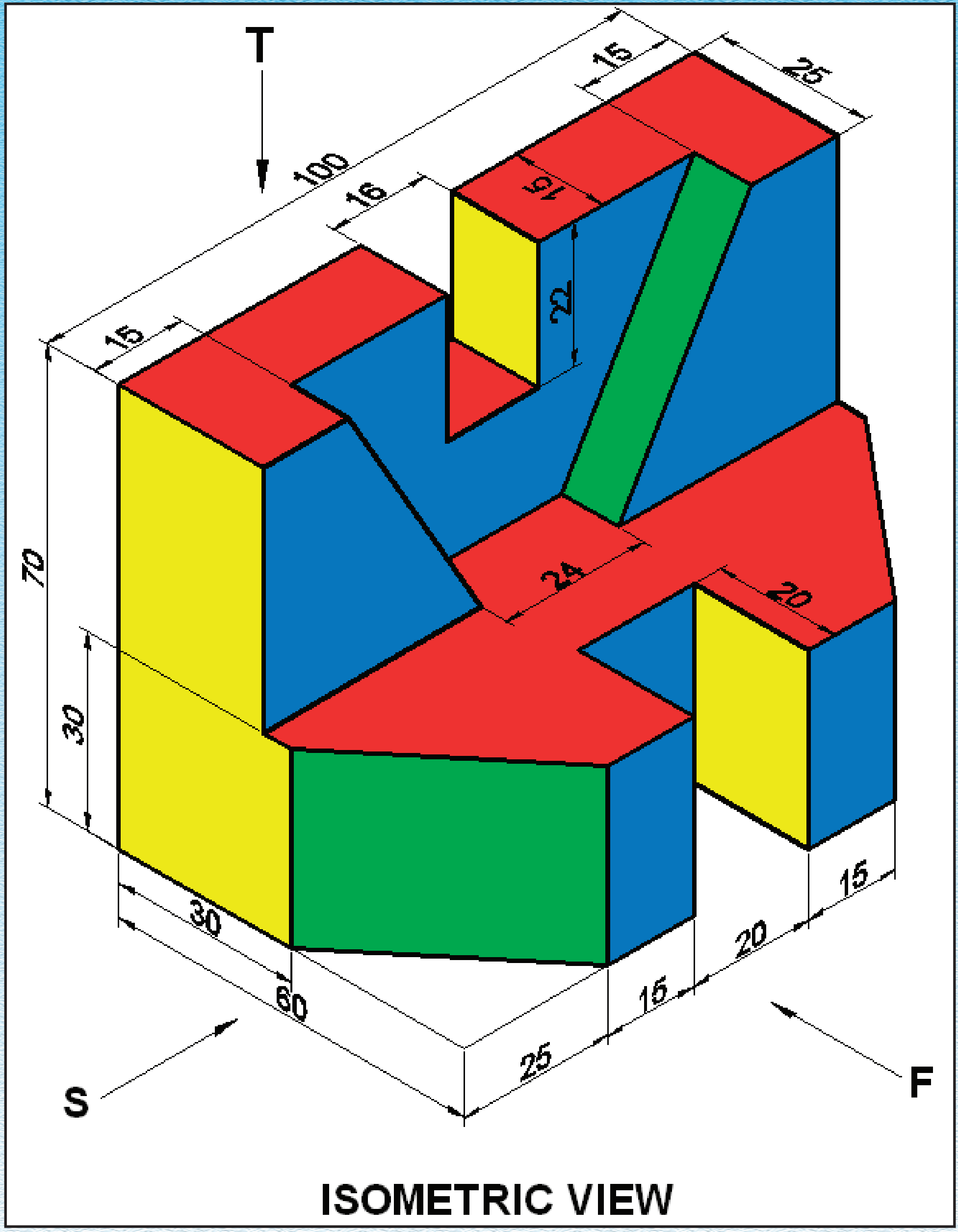


Fig. 6.35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ISOMETRIC VIEW

Fig. 6.36

Chapter 7
ISOMETRIC PROJECTION

7.1 INTRODUCTION

Have you ever noticed that every corner of the class room, bed room, drawing room has three mutually perpendicular lines. These three lines give us the feeling of solid (3 dimensions).

Let us take the example of small boxes e.g. Chalk box, which are kept in front of us. If we keep the box in such a manner that its two vertical faces and one horizontal base will be visible to us in the equiangular position at one corner then it give us feeling of solid.

So we can say that if a solid is placed in such a position that its three edges are equally inclined at an angle of 120°, then the solid is placed, said to, in isometric position and this view is called ISOMETRIC PROJECTION.

Let us recall that the Orthographic Projection as one of the best way, to represent the details of any object, i.e. by principal planes of projection (HP & VP) held mutually at right angles to each other. We know that a simple machine block in standard views like Front view, Top view and Side view will look like as shown in Fig. 7.2(a).

But these views can be interpreted only by experienced persons with technical knowledge. So in an easier way, any object can be represented by a single view/drawing that shows all the faces of the object, as they appear to the observer and give us feeling of 3-D view. The solid considered above will look like Fig. 7.2(b) in single plane method.

Thus ISOMETRIC PROJECTION is yet another method to represent the details of any object in simplest way. Let us find out ! How?

Fig. 7.1

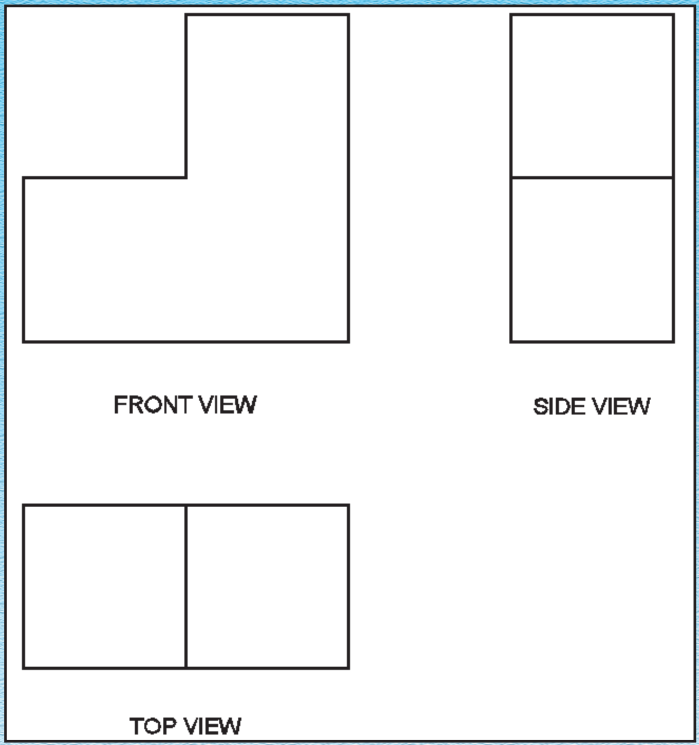

Fig. 7.2(a)

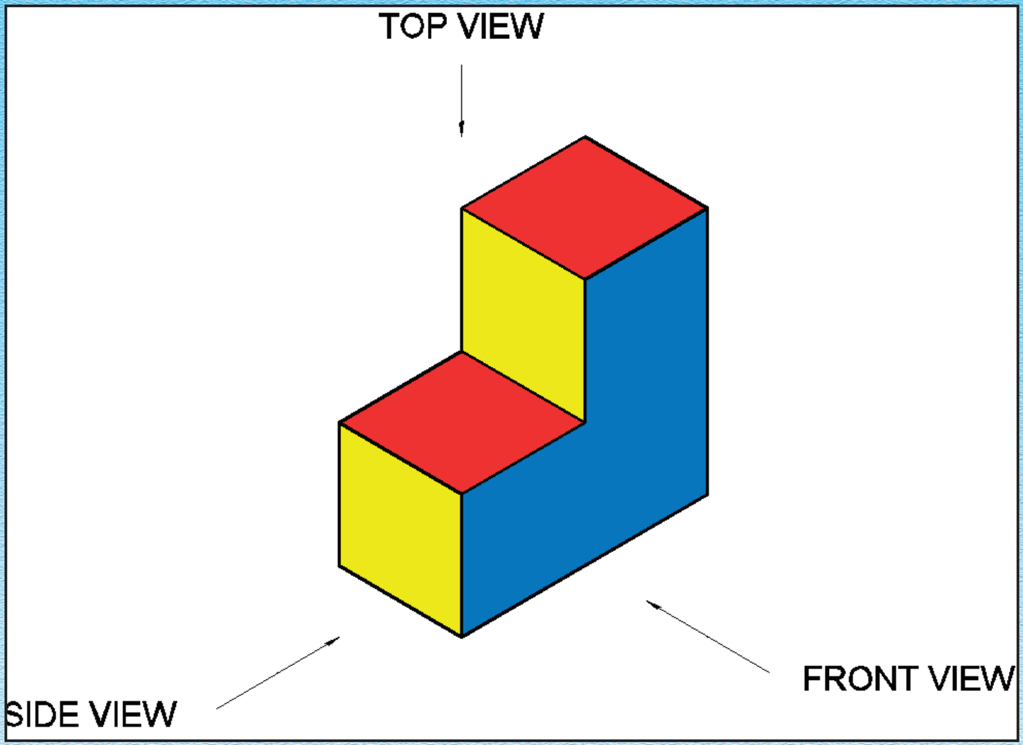

Fig. 7.2(b)

7.2 ISOMETRIC PROJECTION

The isometric projection of an object is a typical pictorial projection, drawn, with the object, So placed with respect to the planes of projection that all the three axes of the object are equally inclined to each other. Let us consider a cube [Fig 7.3(a)], for example, and draw its orthographic projections as in Fig. 7.3(b).

Now turn the cube so that all the faces are equally inclined i.e. 45° to V.P. and draw its views as shown in Fig. 7.4. Here are the Front View and Side View, both show two surfaces of the cube, parallel to the plane of projection. We can see the "Body Diagonal" in its Side View, which is the longest straight line that can be drawn in a cube.

Now raise the cube up, from rear base corner of the cube, upto that level, where the Body Diagonal becomes horizontal. Let us draw its views. Here again we find two surfaces of cube in its Side View, while Front View shows all the three faces with all the three principal axes eaually inclined to the plane of projection. So the Front View of Fig. 7.5 is the desired view, which is easy to understand as well as shows all the three dimensions in a single view. This Front View is popularly known as ISOMETRIC PROJECTION.

Direction of viewing for the object will be marked as shown and it has importance to verify the position of the observer with respect to V.P. and H.P.

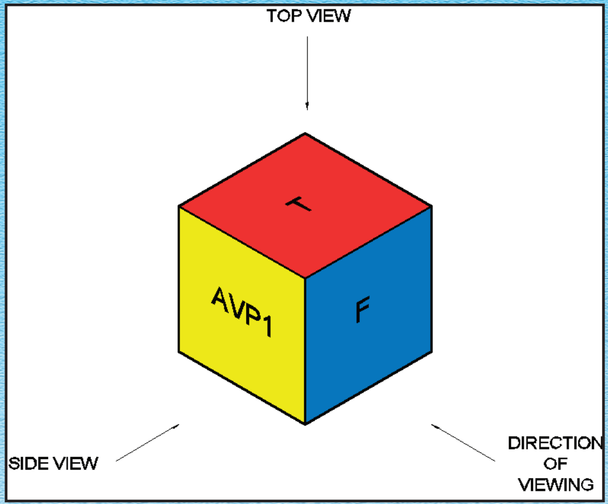

Fig. 7.3(a)

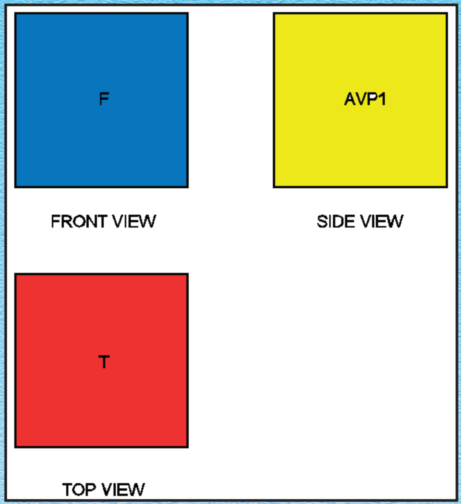

Fig. 7.3(b)

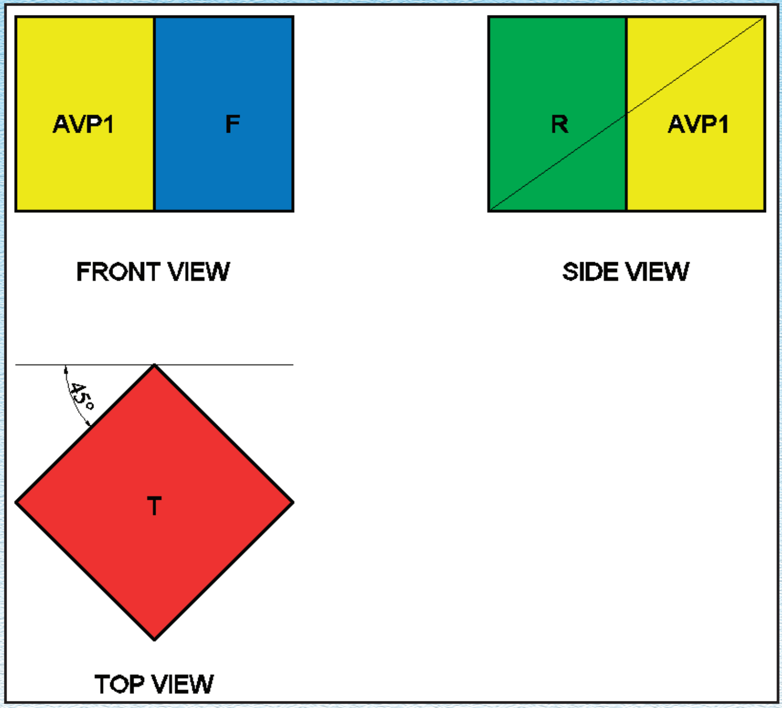

Fig. 7.4

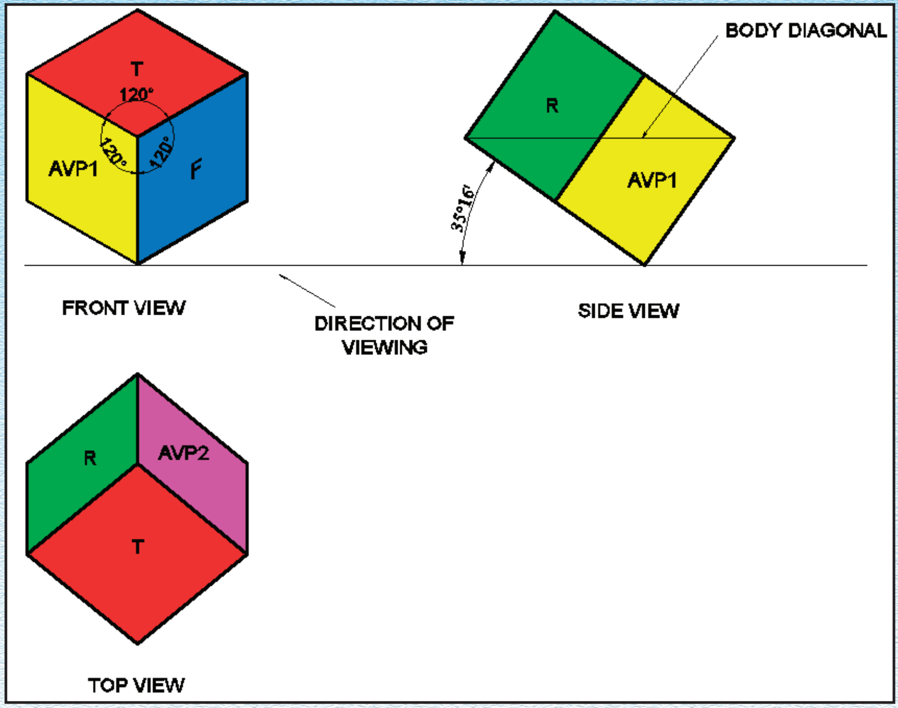

Fig. 7.5 (a & b)

DO YOU KNOW?

The cube is first turned at 45° from V.P. and in second stage it is rotated exactly at 35° 16′ with H.P to get the Isometric Projection.

7.3 ISOMETRIC SCALE

In section 7.2, we observed that isometric projection is drawn after keeping the object at specified angle to V.P. & H.P. and when the object is inclined to both the planes then the edges drawn in the isometric projection will be foreshortened with refrence to true length. As in isometric projection the three principal axes form equal angles of 120° to each other, so only one scale is needed for measurement along each of the axes. The scale used to measure isometric length is called ISOMETRIC SCALE. To find out the ratio of foreshortening, Let us consider the Front View (Isometric Projection) in Fig. 7.5(a),

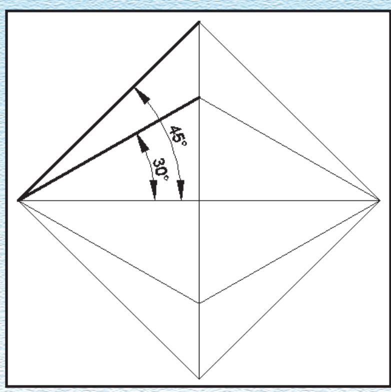

Fig. 7.6(a)

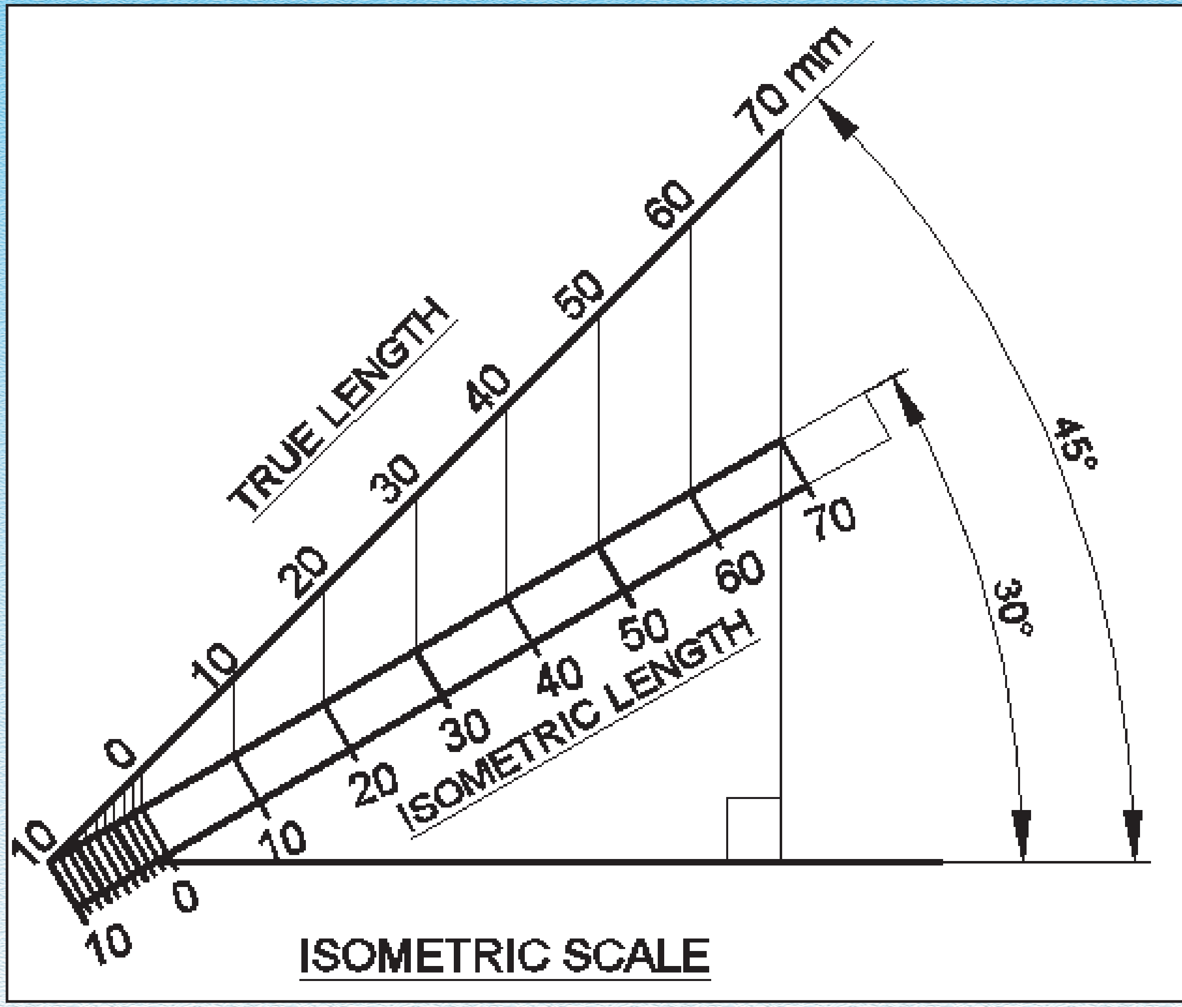

Fig. 7.6(b)

where the top (T) of the cube appears as a rhombus while in Fig. 7.4 the true shape of top (T) is square. These two shapes reveal that all the four edges of the Top (T) are foreshortened in isometric projection. If we draw both the (T) top relatively one with the, other, we can conclude that rhombus edge is the isometric length of the square edge as shown in Fig. 7.6(a).

Geometrically isometric scale can be drawn as follows:

Steps of Construction :

(i) Draw a horizontal line.
(ii) From any point on horizontal line draw two lines inclined at 30° and 45° respectively.
(iii) Mark the divisions on 45° line of one mm upto first 10 mm from starting point and then mark divisions after every 10 mm of required length, say 70 mm.
(iv) These divisions are transferred by vertical lines (i.e. at 90° to the horizontal line) upto the 30° inclined line.
(v) The scale projected on 30° line will give the isometric length.

Fig. 7.6 (b) shows the isometric scale.

DO YOU KNOW?

The value of isometric length can also be calculated mathematically w.r.t. true length. Copy the 1/4 part of the Fig. 7.6(a)

Consider the right angle ΔABC, $\frac{AB}{AC} = \cos 30° = \frac{\sqrt{3}}{2}$

Consider the right angle ΔABD, $\frac{AB}{AD} = \cos 45° = \frac{1}{\sqrt{2}}$

Or, $\frac{AB/AD}{AB/AC} = \frac{\cos 45°}{\cos 30°} = \frac{1/\sqrt{2}}{\sqrt{3}/2}$

Or, $\frac{AC}{AD} = \frac{2}{\sqrt{2} \times \sqrt{3}} = \frac{\sqrt{2}}{\sqrt{3}} = 0.8$

Or, Isometric Length $\cong 0.8 \times$ True Length

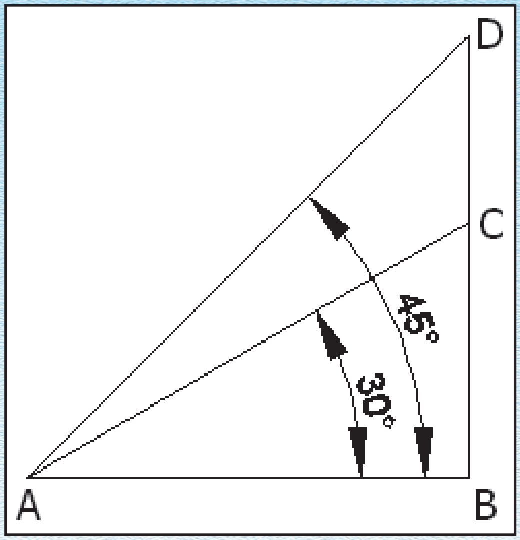

Fig. 7.6(c)

7.4 ISOMETRIC LINES

All those lines which are parallel to any of the three principal axes are called isometric lines. These can be taken directly for the value in isometric drawing (see Fig. 7.7).

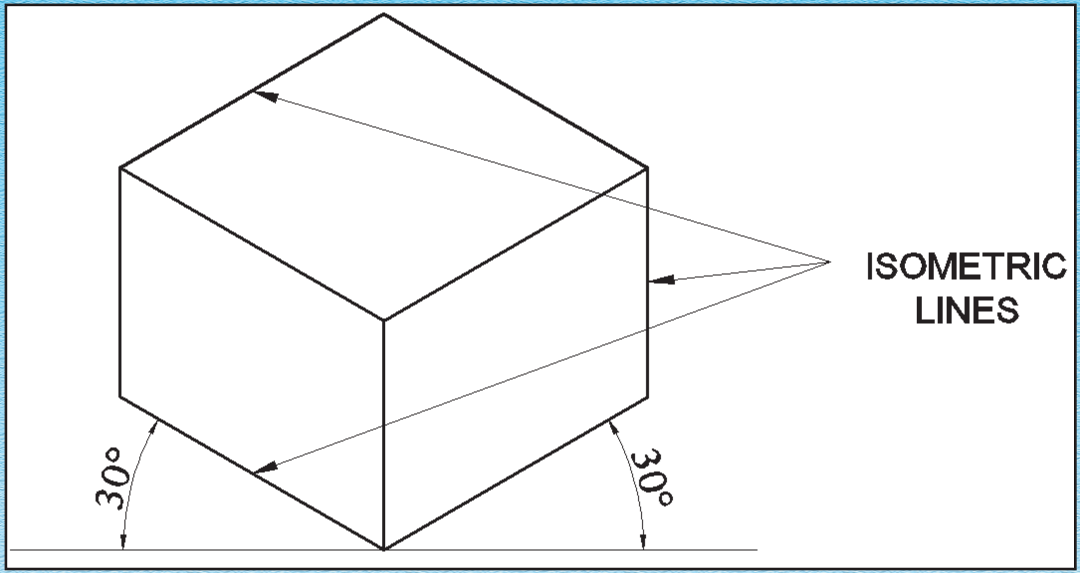

Fig. 7.7

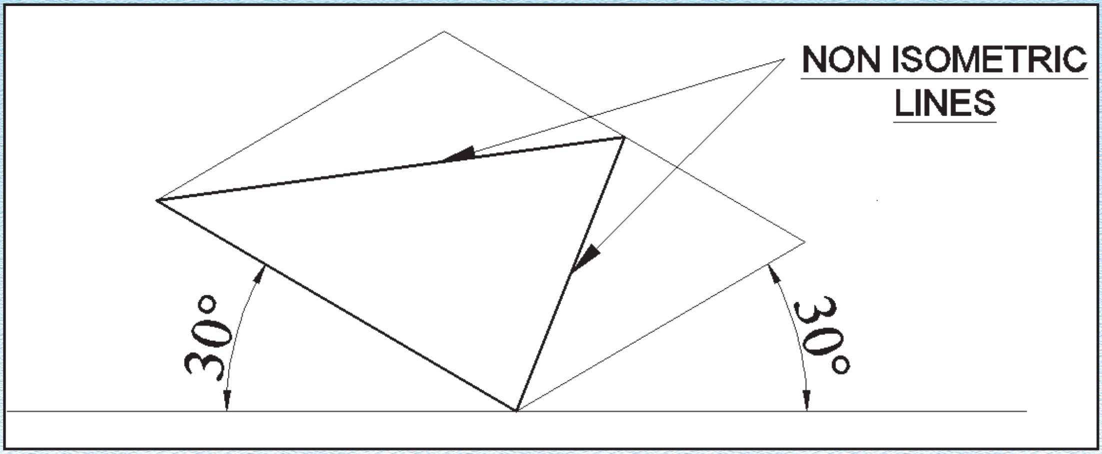

Fig. 7.8

7.5 NON ISOMETRIC LINES

All those lines which are not parallel to any of the principal axes are called non isometric lines. "These are drawn by finding the location of their two ends along principal axes and then by joining them. Non isometric lines and the angles between them do not show in their true values so can not be measured directly in isometric drawing." (see Fig. 7.8)

7.6 DRAWING TECHNIQUES FOR ISOMETRIC PROJECTION OF LAMINAE

As the isometric projection is the single plane projection as discussed in section 7.2, Do we have to turn every object in the same way? No, instead of turning, we can draw the object with respect to the three principal lines. The position of the principal lines in the isometric projection is discussed in Table 7.1.

PRINCIPAL LINE	ISOMETRIC PROJECTION	
	POSITION OF LINE	LENGTH
Perpendicular to H.P.	Vertical (90° line)	
Perpendicular to V.P.	Inclined (30° line)	Isometric Length
Perpendicular to P.P.	Inclined (30° line in other direction)	

Table 7.1 Isometric Projections of Principal Lines

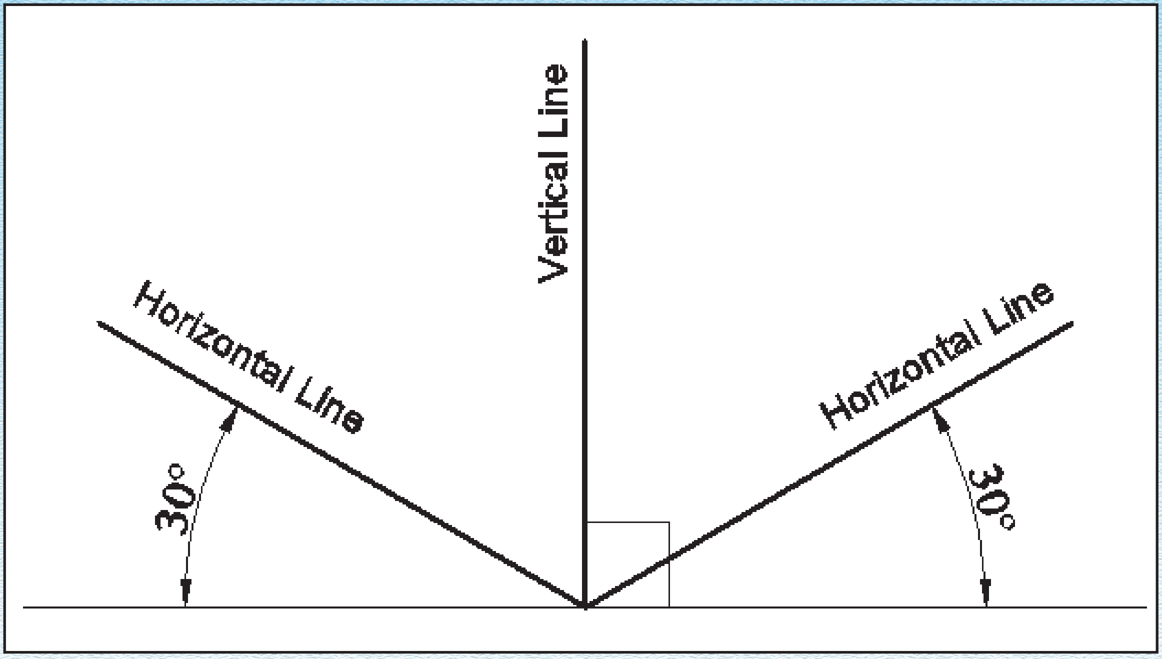

Fig. 7.9

If we consider two principal axes, at one time, they will represent H.P. & V.P. as follows.

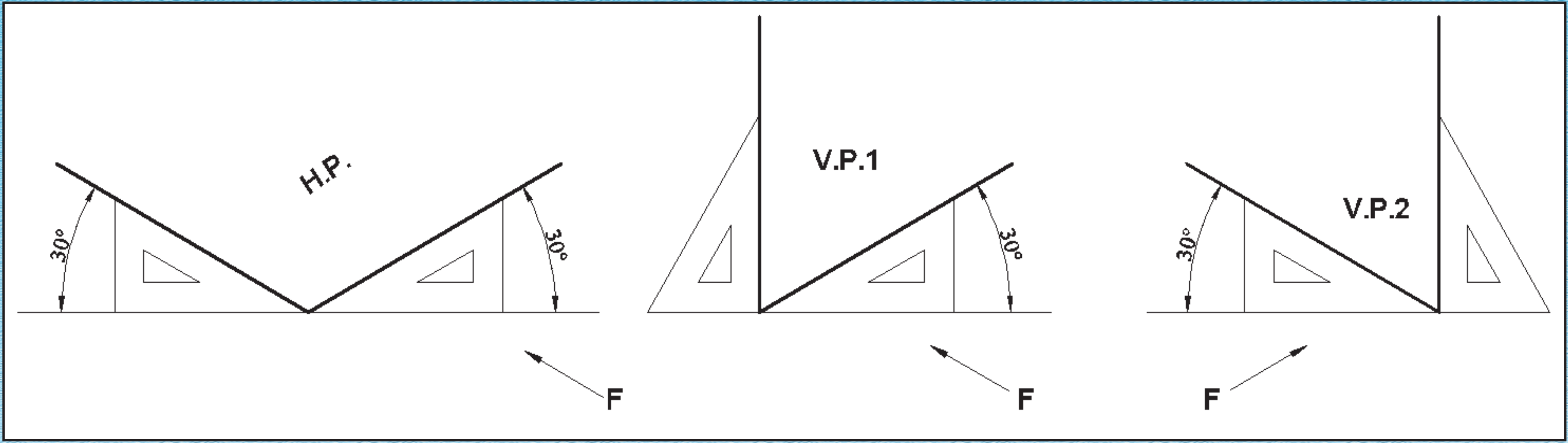

Fig. 7.10

The choice of V.P.$_1$ & V.P.$_2$ depends on the direction of viewing.

7.6.1 STEPS TO DRAW ISOMETRIC PROJECTION

(i) Draw the lamina, (Helping Fig.) by using isometric length.

(ii) Draw the centre of lamina.

(iii) Enclose the Fig. in a box, just to fit in, by thin horizontal and vertical lines.

(iv) Transfer all the points of lamina and centre onto the box lines.

(v) Draw two principal axes, as desired, V.P. or H.P.

(vi) Copy the dimensions of box to the principal axes.

(vii) Complete the isometric projection box, by parallel lines.

(viii) Copy all the points of lamina (helping Fig.) to the isometric box (called crate).

(ix) Finish the isometric projection of lamina with visible lines, dimensioning and direction of viewing (F).

7.6.2 DIMENSIONING

Dimensioning in isometric projection is done as follows (Fig. 7.11).

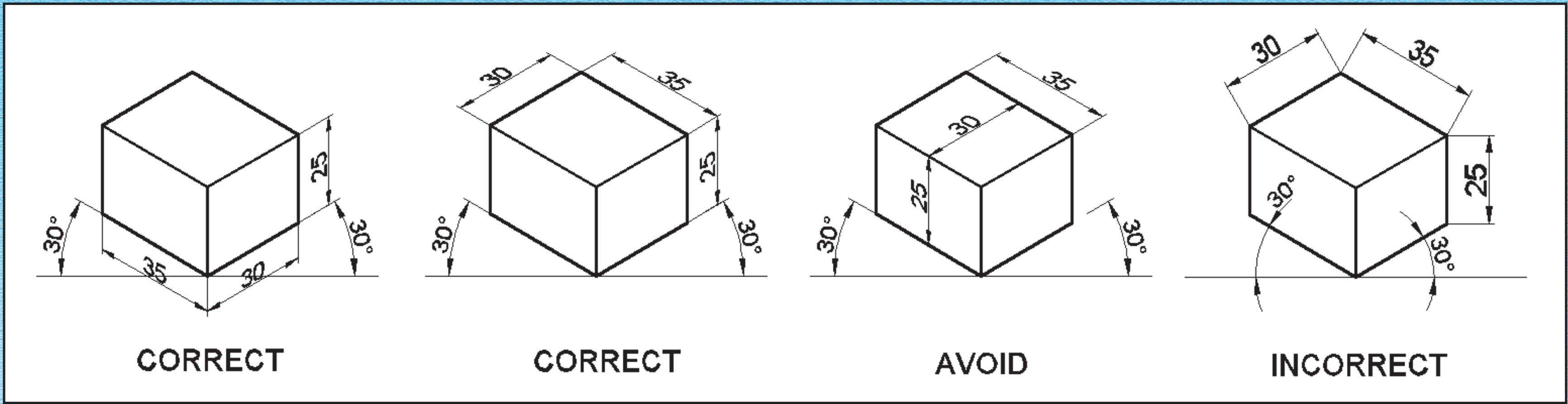

Fig. 7.11

Example 7.1 : Draw the isometric projection of an equilateral triangle of base side 60 mm in H.P.

Solution : Refer to Fig. 7.12

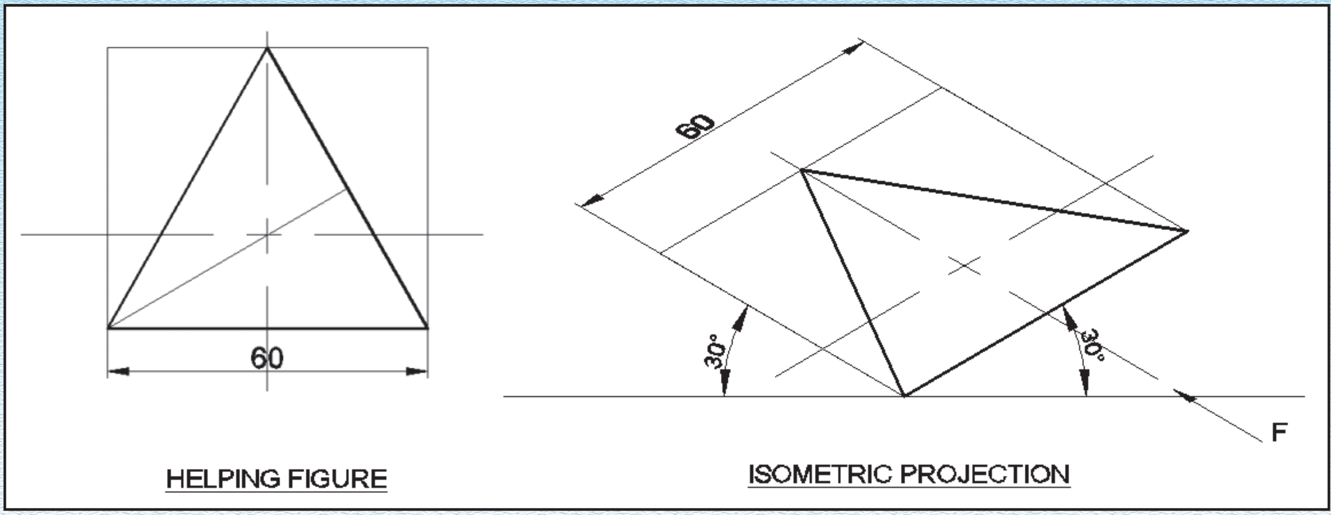

Fig. 7.12

Steps :

(i) Draw a regular triangle of 60 mm isometric length and mark its centre.

(ii) Enclose it in a box and transfer points onto the box lines to complete the helping Fig..

(iii) Draw two principal axes along 30° and 30° lines as horizontal lines, in H.P.

(iv) Copy the dimensions of box on isometric projection and complete it.

(v) Copy all the points of helping Fig. box on to the isometric box.

(vi) Draw the visible lines, dimensioning and direction of viewing (F).

Example 7.2 : Draw the isometric projection of an equilateral triangle of side 60 mm in V.P.

Solution : Refer to Fig. 7.13

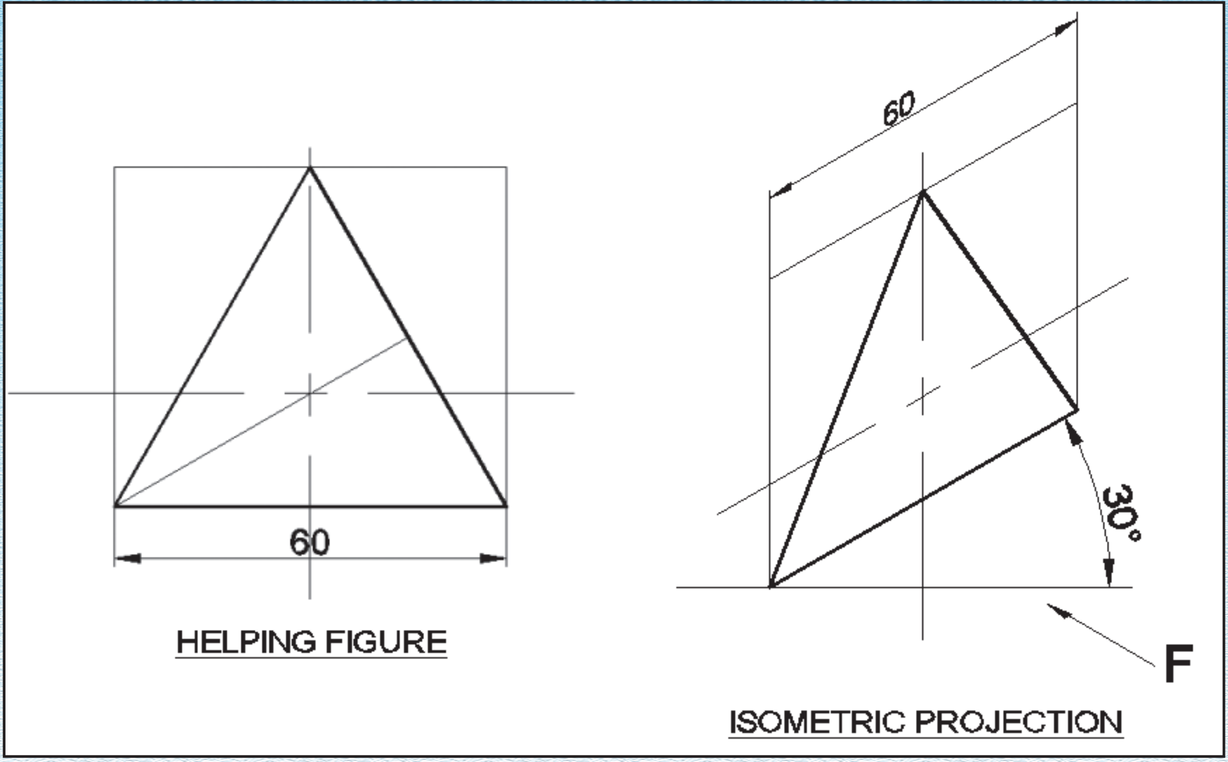

Fig. 7.13

Steps :

(i) Draw a regular triangle of 60 mm isometric length and mark its centre.

(ii) Enclose it in a box and transfer points onto the box lines to complete the helping Fig..

(iii) Draw two principal axes along 30° and 90° lines in V.P.

(iv) Copy the dimensions of box on isometric projection and complete it.

(v) Copy all the points of helping fig box on to the isometric box.

(vi) Draw the visible lines, dimensioning and Direction of viewing (F).

Example 7.3 : Draw the isometric projection of a square lamina having side 50 mm and its surface parallel to H.P.

Solution : Refer to Fig. 7.14

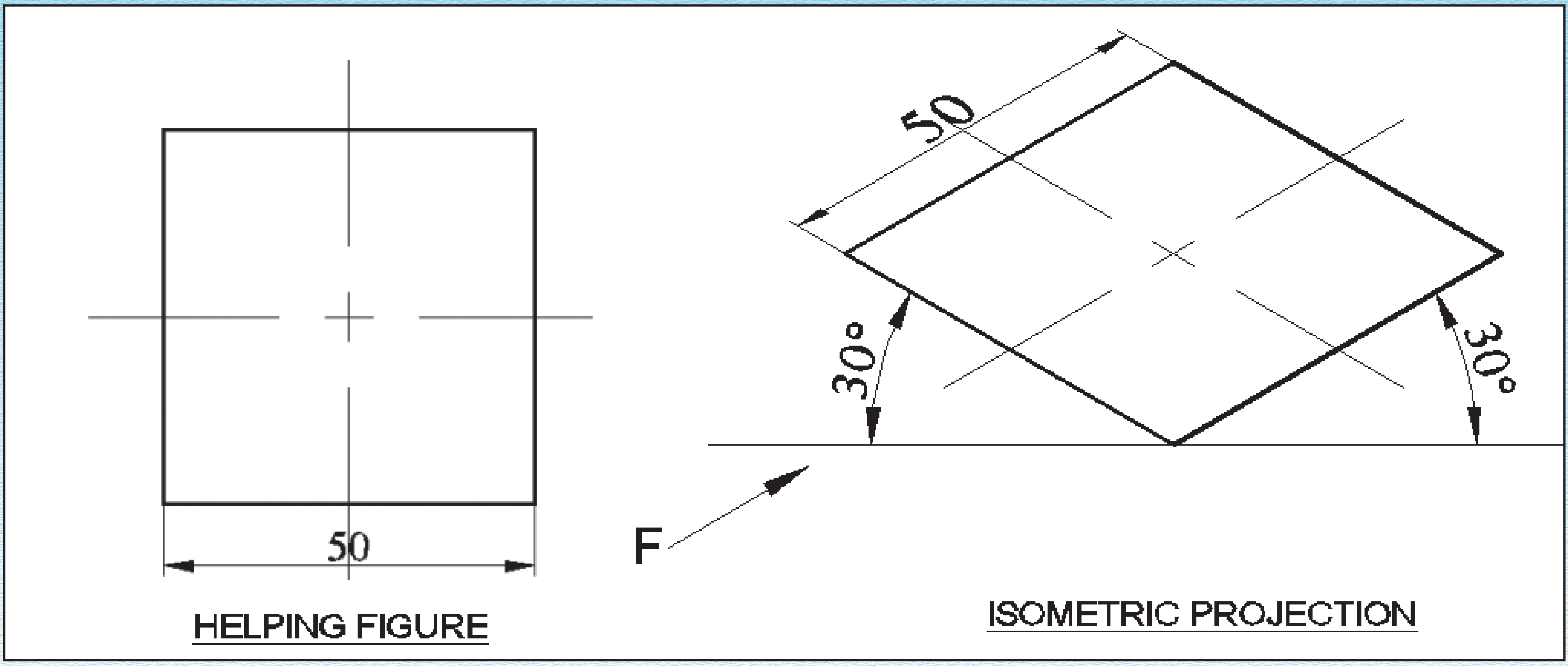

Fig. 7.14

Steps :

(i) Draw the helping Fig. and its centre with isometric length.

(ii) Transfer the points to the principal axes along 30° to 30° to keep it in H.P. and complete it.

Example 7.4 : Draw the isometric projection of a square laminae having side 40 mm and kept in V.P.

Solution : Refer to Fig. 7.15

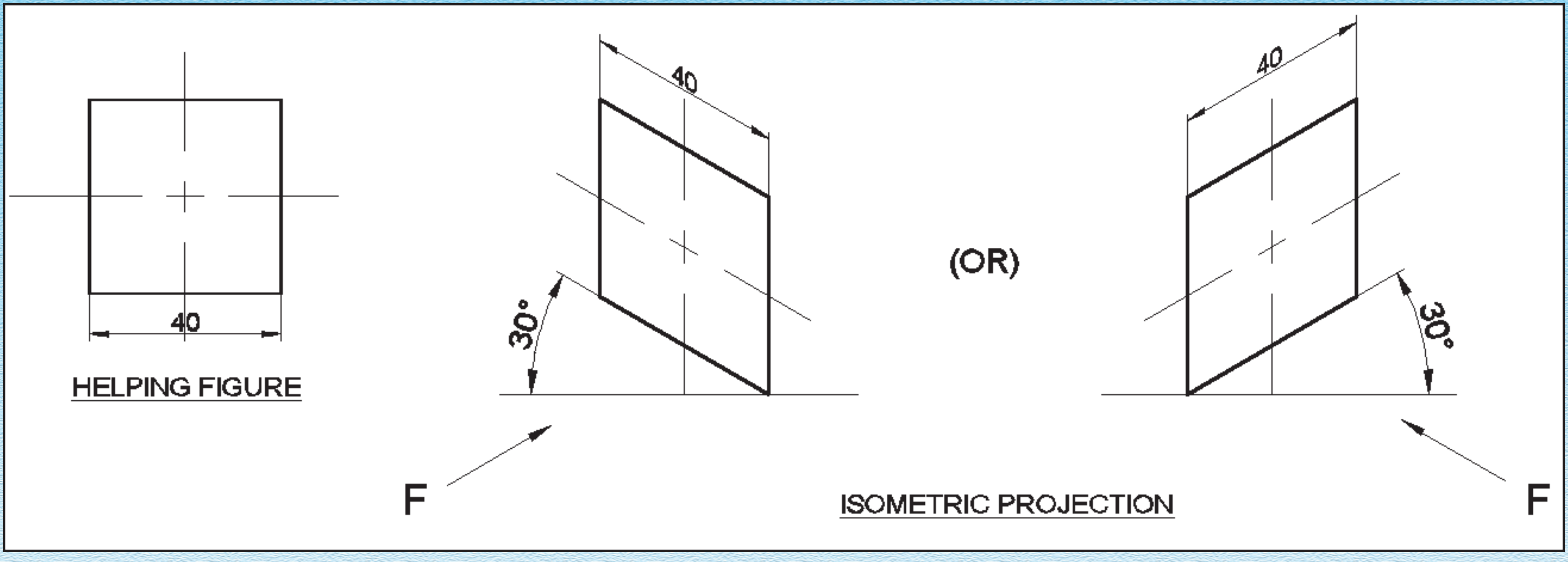

Fig. 7.15

Steps :

(i) Draw the helping Fig. and its centre by isometric scale.

(ii) Transfer the points to the principal axes along 30° to 90° to keep it in V.P. and complete it.

Example 7.5 : Draw the isometric projection of a regular pentagon of base side 40 mm in V.P.

Solution : Refer to Fig. 7.16

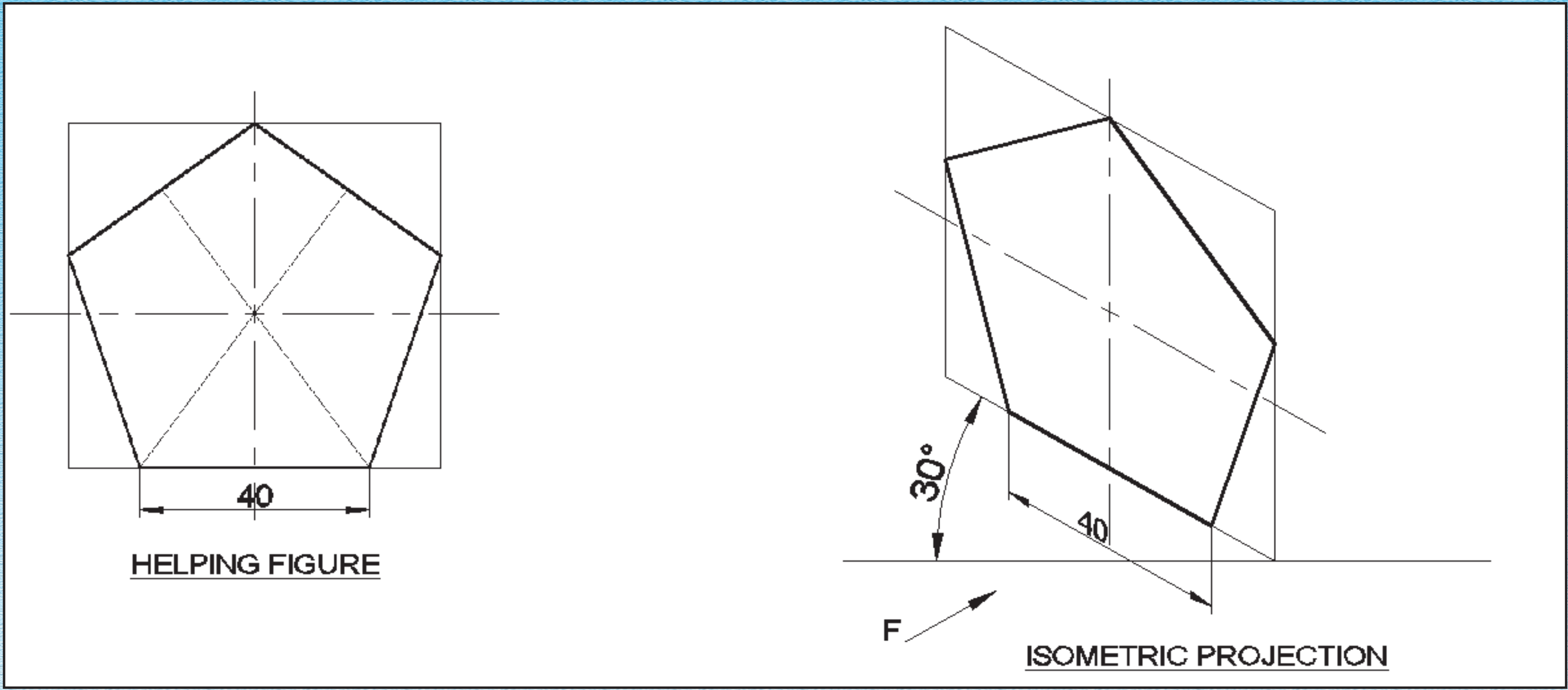

Fig. 7.16

Steps :

(i) Draw a regular pentagon of 40 mm isometric length and mark its centre.

(ii) Enclose it in a box and transfer points onto the box lines to complete the helping Fig..

(iii) Draw two principal axes along 30° and 90° lines.

(iv) Copy the dimensions of box and transfer all the points.

(v) Draw the visible lines, dimensioning and Direction of viewing (F).

Example 7.6 : Draw the isometric projection of a regular pentagon of base side 40 mm in H.P.

Solution : Refer to Fig. 7.17

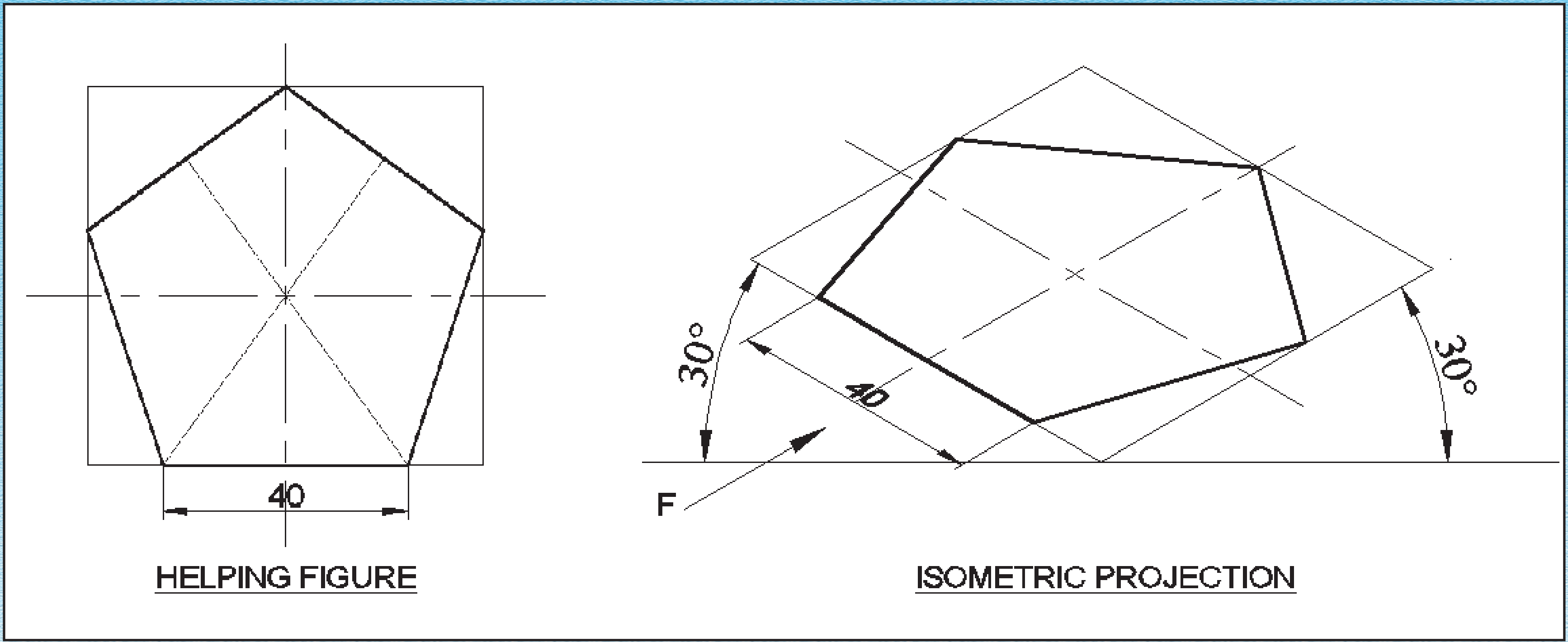

Fig. 7.17

Steps :

(i) Draw a regular pentagon of 40 mm isometric length and mark its centre.

(ii) Enclose it in a box and transfer points onto the box lines to complete the helping Fig..

(iii) Draw two principal axes along 30° and 30° lines.

(iv) Copy the dimensions of box and transfer all the points.

(v) Draw the visible lines, dimensioning and Direction of viewing (F).

Example 7.7 : Draw the isometric projection of a regular hexagon of base side 30 mm in V.P. keeping two of its bases parallel to H.P.

Solution : Refer to Fig. 7.18

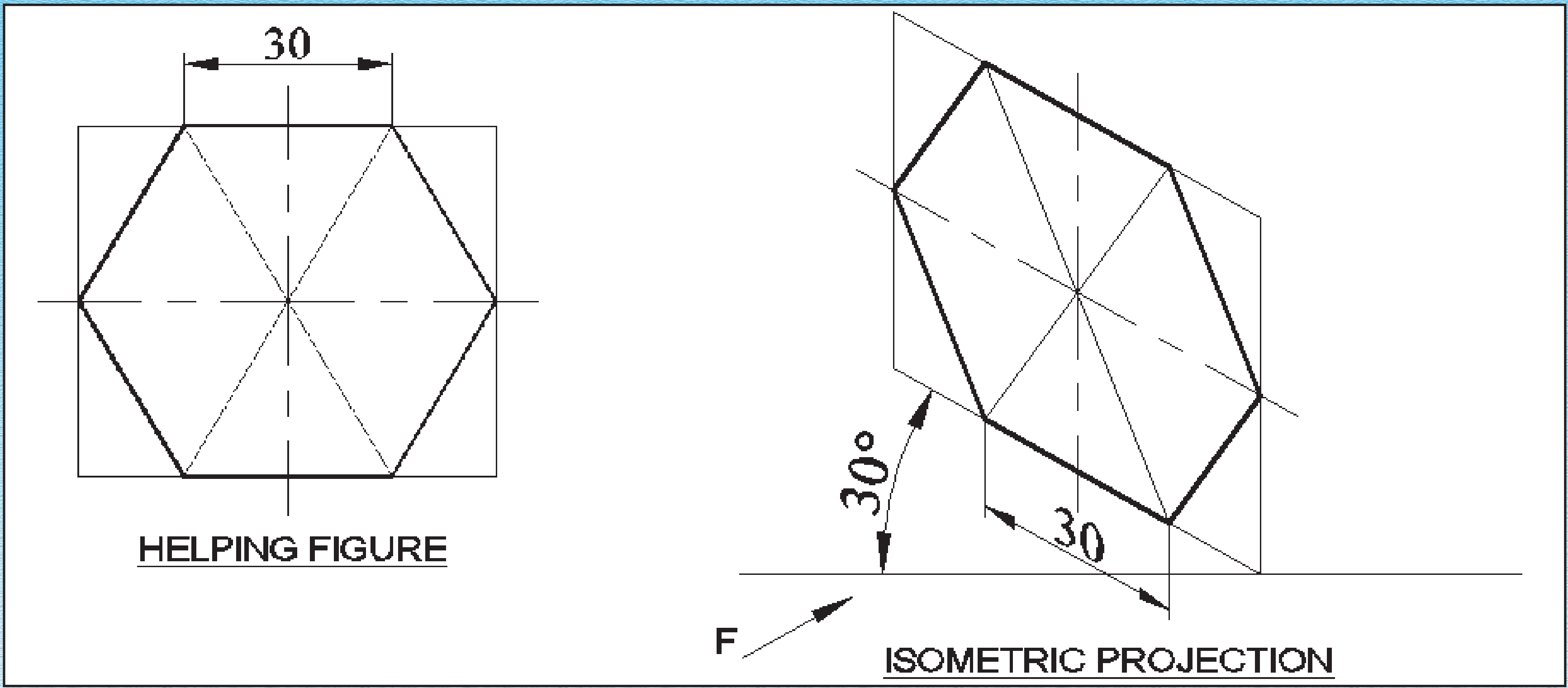

Fig. 7.18

Steps :

(i) Draw a regular hexagon of 30 mm isometric length and mark its centre.

(ii) Enclose it in a box and transfer points onto the box lines to complete the helping Fig..

(iii) Draw two principal axes along 30° and 90° lines.

(iv) Copy the dimensions of box keeping box dimension of one base line along 30° line and transfer all the points.

(v) Draw the visible lines, dimensioning and Direction of viewing (F).

Example 7.8 : Draw the isometric projection of a regular hexagon of base side 25 mm in H.P. keeping two of its bases perpendicular to the V.P.

Solution : Refer to Fig. 7.19

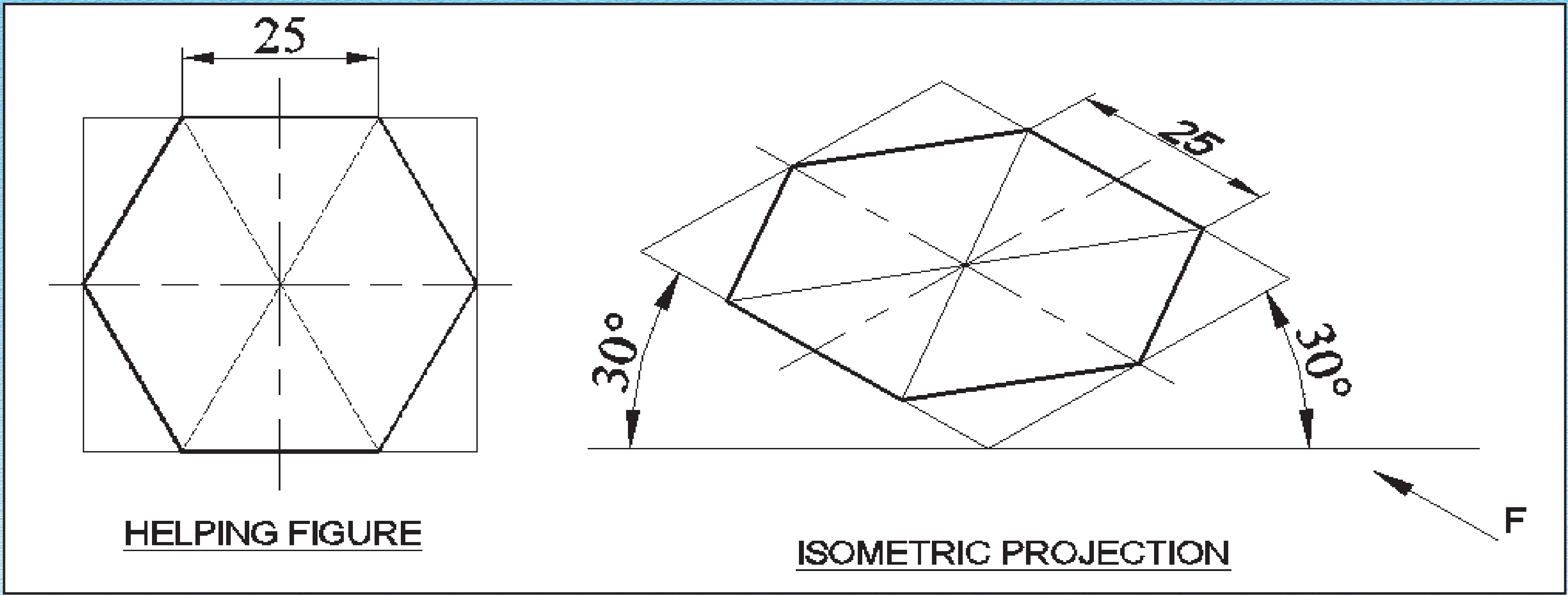

Fig. 7.19

Steps :

(i) Draw a regular hexagon of 25 mm isometric length and mark its centre.

(ii) Enclose it in a box and transfer points onto the box lines to complete the helping Fig..

(iii) Draw two principal axes along 30° and 30° lines.

(iv) Copy the dimensions of box, keeping box dimension of one base line along 30° line, which is perpendicular to the direction of viewing and transfer all the points.

(v) Draw the visible lines, dimensioning and direction of viewing (F).

Example 7.9 : Draw the isometric projection of a circle of dia 40 mm in V.P.

Solution : We know that circle does not have any corner point and for the reference we always use centre lines with it. So circle is drawn in three different methods in isometric projection as follows :

Method A : Refer to Fig. 7.20

The true projection of circle is drawn by this method. It is called **offset method**.

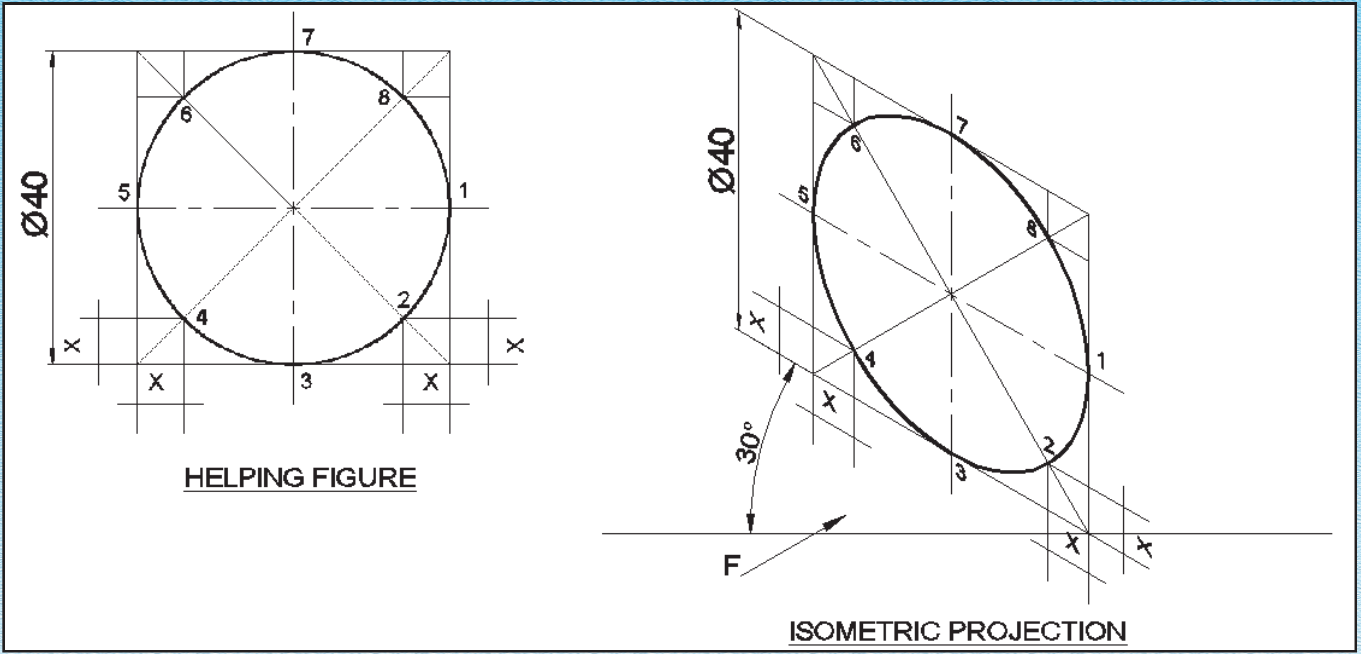

Fig. 7.20

Steps :

(i) Draw a circle of 40 mm dia isometric length and mark its centre.

(ii) Enclose it in a box, as the circle has dia, so is square.

(iii) Draw the diagonals of square.

(iv) Mark all the intercepts of circle with centre lines and diagonals as 1 to 8.

(v) Draw two principal axes along 30° and 90° lines.

(vi) Transfer all the offsets and dimensions of helping Fig. box to these principal axes.

(vii) Join all the points 1 to 8 by a smooth curve.

(viii) Complete the dimensioning and Direction of viewing (F).

Method B : Refer to Fig. 7.21

In this method, we divide the circle in 12 equal parts. It is called **coordinate construction method**.

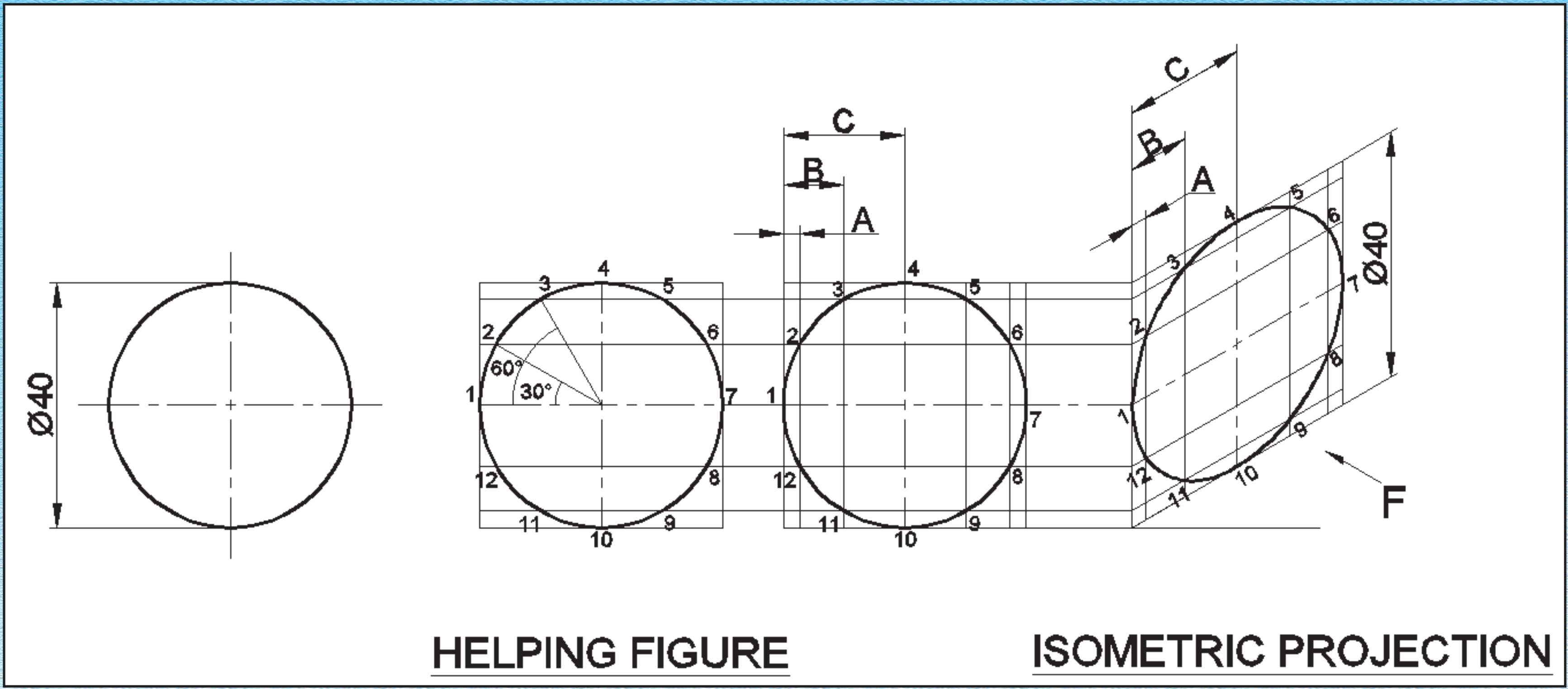

Fig. 7.21

Steps :

(i) Draw a circle of 40 mm dia isometric length and mark its centre.

(ii) Enclose it in a box. Draw the intercepts at 30° & 60° and mark all the intercepts as 1 to 12.

(iii) Draw two principal axes along 30° and 90° lines.

(iv) Transfer the coordinates of 1 to 12 points and then join all the points marked at principal axes by a smooth curve.

(v) Complete the dimensioning and direction of viewing (F).

Method C : Refer to Fig. 7.22

The true projection of circle is time consuming. So we can use **Four centre method** for Drawing an approximate projection of circle. This method is frequently used.

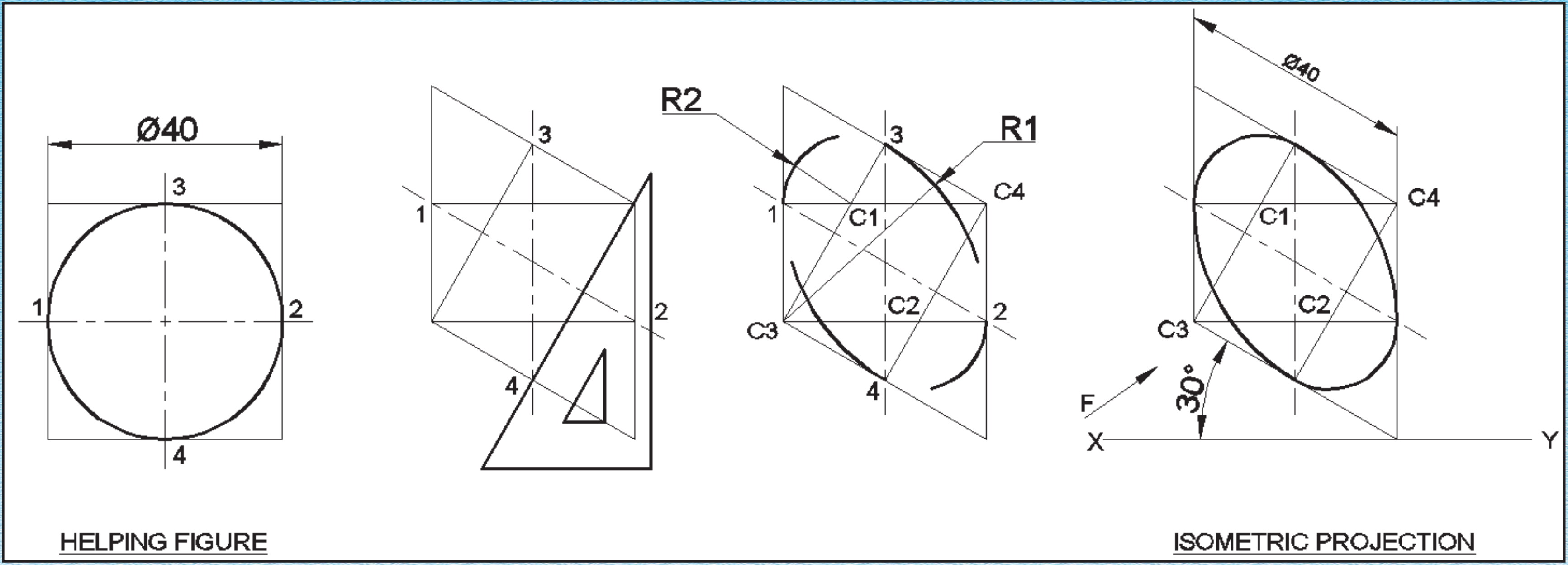

Fig. 7.22

Steps :

(i) Draw a circle of 40 mm dia isometric length and mark its centre.

(ii) Enclose it in a box, as the circle has dia, so box is square i.e. helping Fig..

(iii) Draw two principle axes along 30° and 90° lines.

(iv) Copy the dimensions of helping Fig. to isometric box.

(v) Use a 30°–60° set square to locate points 1, 2, 3 and 4 (or) join the ends of smaller diagonals to the midpoints of opposite sides.

(vi) Take C_1, C_2 as centres and a radius equal to $C_1$1, draw arcs as shown.

(vii) Take C_3, C_4 as centres and a radius equal to $C_3$3. draw arcs as shown.

(viii) Complete the dimensioning and direction of viewing (F).

Example 7.10 : Draw the isometric projection of a circle of dia 40 mm in H.P.

Solution : Refer to Fig. 7.23

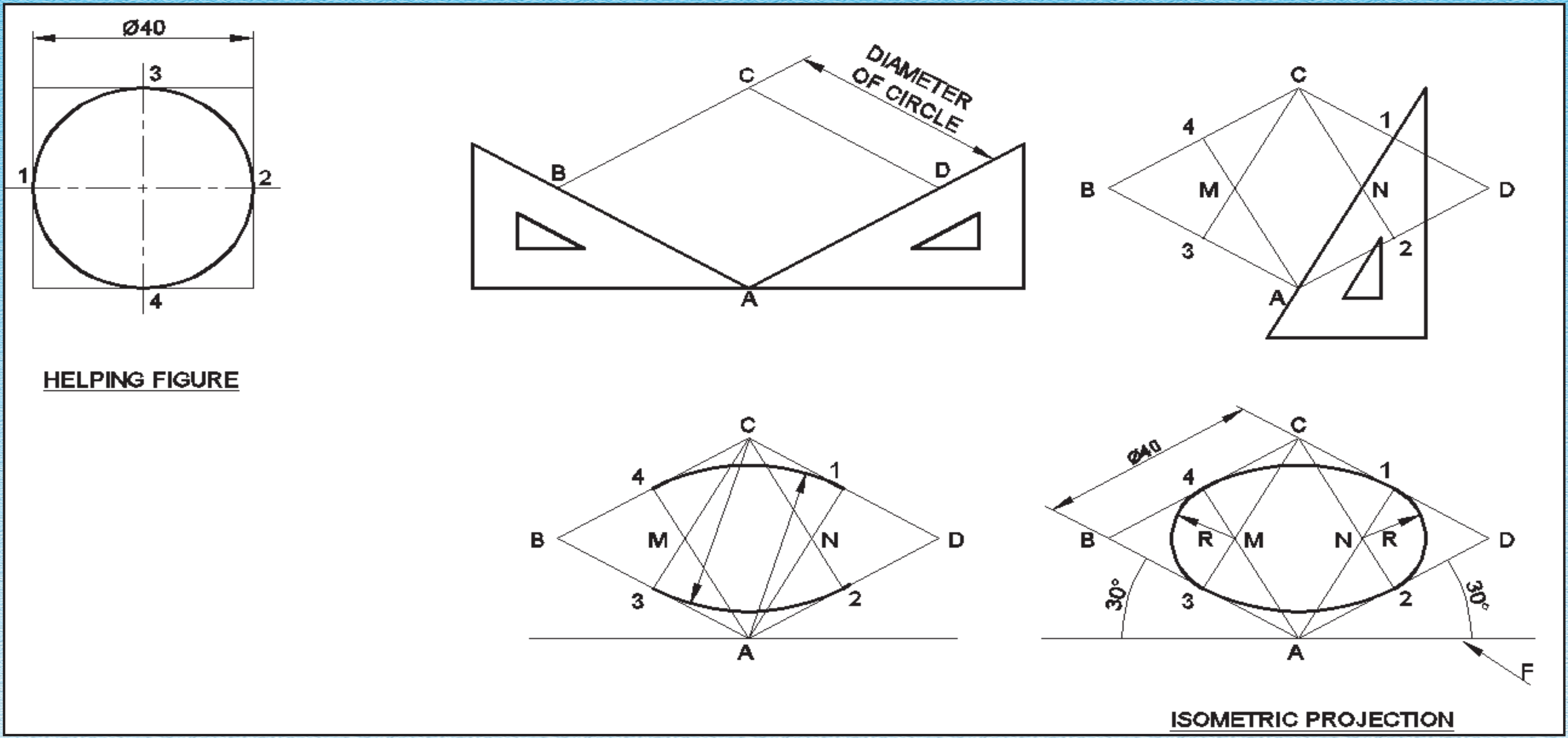

Fig. 7.23

Steps :

(i) Draw a circle of dia 40 mm isometric length and mark its centre.

(ii) Enclose it in a box, as the circle has dia, so box is a square, helping Fig..

(iii) Draw two principle axes along 30° and 30° lines with the help of 30° - 60° set square.

(iv) Complete the rhombus and name it.

(v) Use a 30° – 60° set square to locate points M and N from points A and C.

(vi) Take A and C as centres and radius equal to A1 draw arcs as shown.

(vii) Take M and N as centres and radius equal to M4, draw arcs as shown.

(viii) Complete the dimensioning and direction of viewing (F)

Example 7.11 : Draw the isometric projection of a semicircle of dia 50 mm in V.P. (a) resting on its curved edge. (b) resting on its diameter.

(a) Solution : Refer to Fig. 7.24

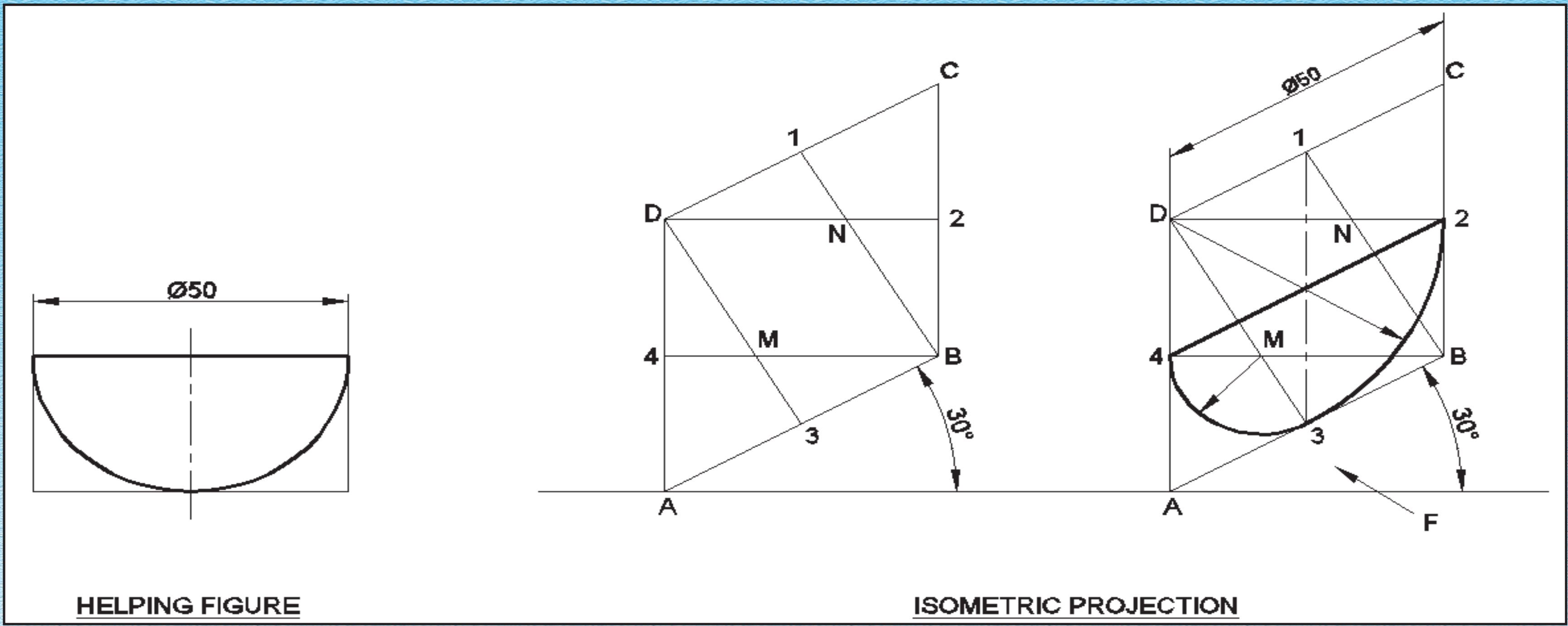

Fig. 7.24

Steps :

(i) Draw a semi circle of dia 50 mm isometric length and mark its centre.

(ii) Enclose it in a box, as the circle has dia, so box is a square i.e. helping Fig..

(iii) Draw two principle axes along 30° and 90° lines with the help of set square.

(iv) Complete the rhombus and name it.

(v) Use a 30° – 60° set square to locate points M and N from points B and D.

(vi) Take M as centre and M 3 as radius, draw arc as shown.

(vii) Take D as centre and D3 as radius, draw arc as shown.

(viii) Join 2 to 4 to complete the semi-circle.

(ix) Complete the dimensioning and direction of viewing (F).

(b) Solution : Refer to Fig. 7.25

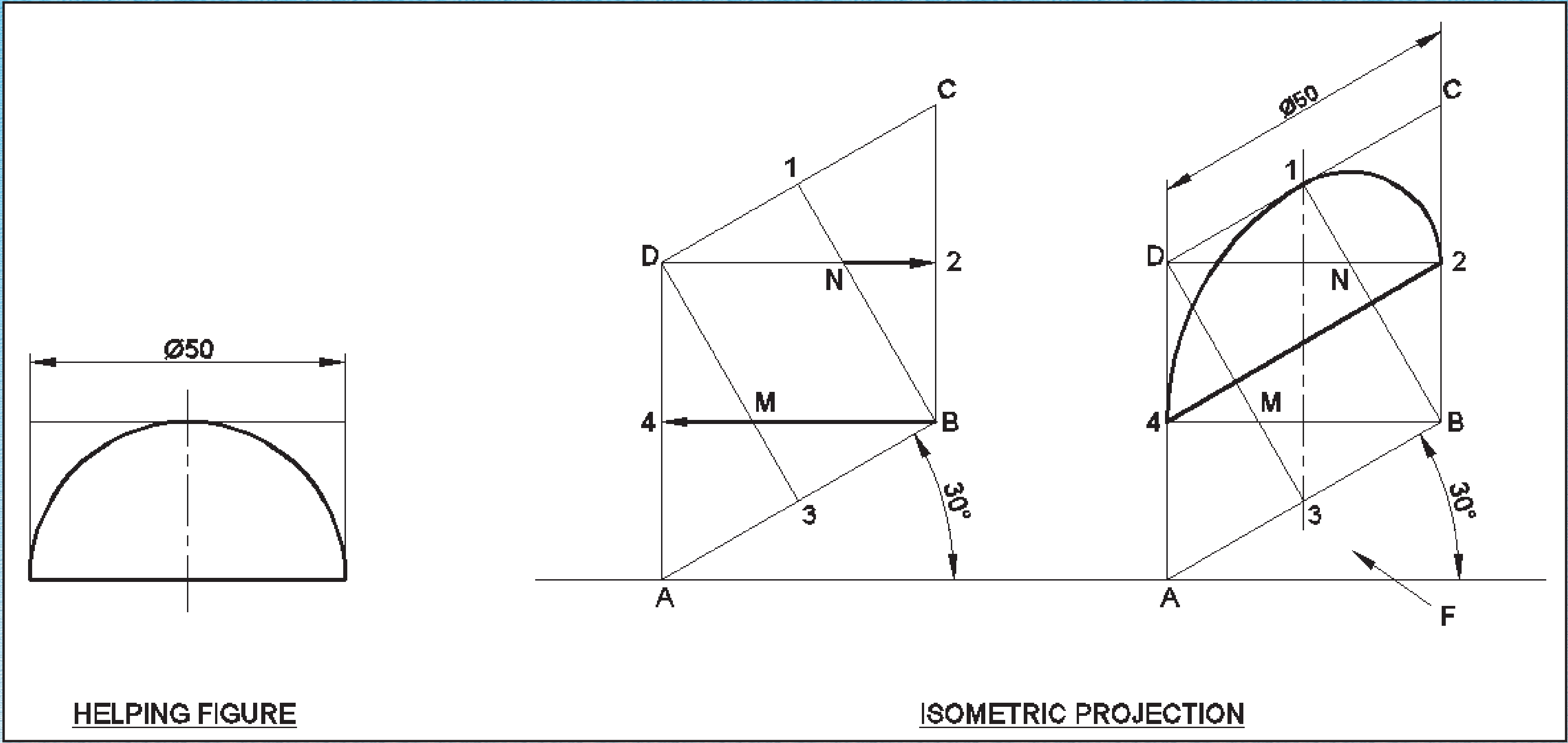

Fig. 7.25

Steps :

(i) to (v) are same as discussed in (a)

(vi) Take N as centre and N 2 as radius, draw arc as shown.

(vii) Take B as center and B4 as radius, draw arc as shown.

(viii) Join 2 to 4 to complete the semi-circle in isometric projection.

(ix) Complete the dimensioning and direction of viewing (F).

DO YOU KNOW ?

ISOMETRIC DRAWING (Isometric View)

As the name implies, in isometric drawing, all object edges are drawn with true length scale instead of foreshortened, isometric length scale. Due to the true length isometric drawing is slightly larger (22.5%) than the isometric projection. It is customary to draw isometric drawing rather than isometric projection, because it is much easier to draw, satisfactory to understand and a layman can directly measures the dimensions from the three principal axes of the drawing itself.

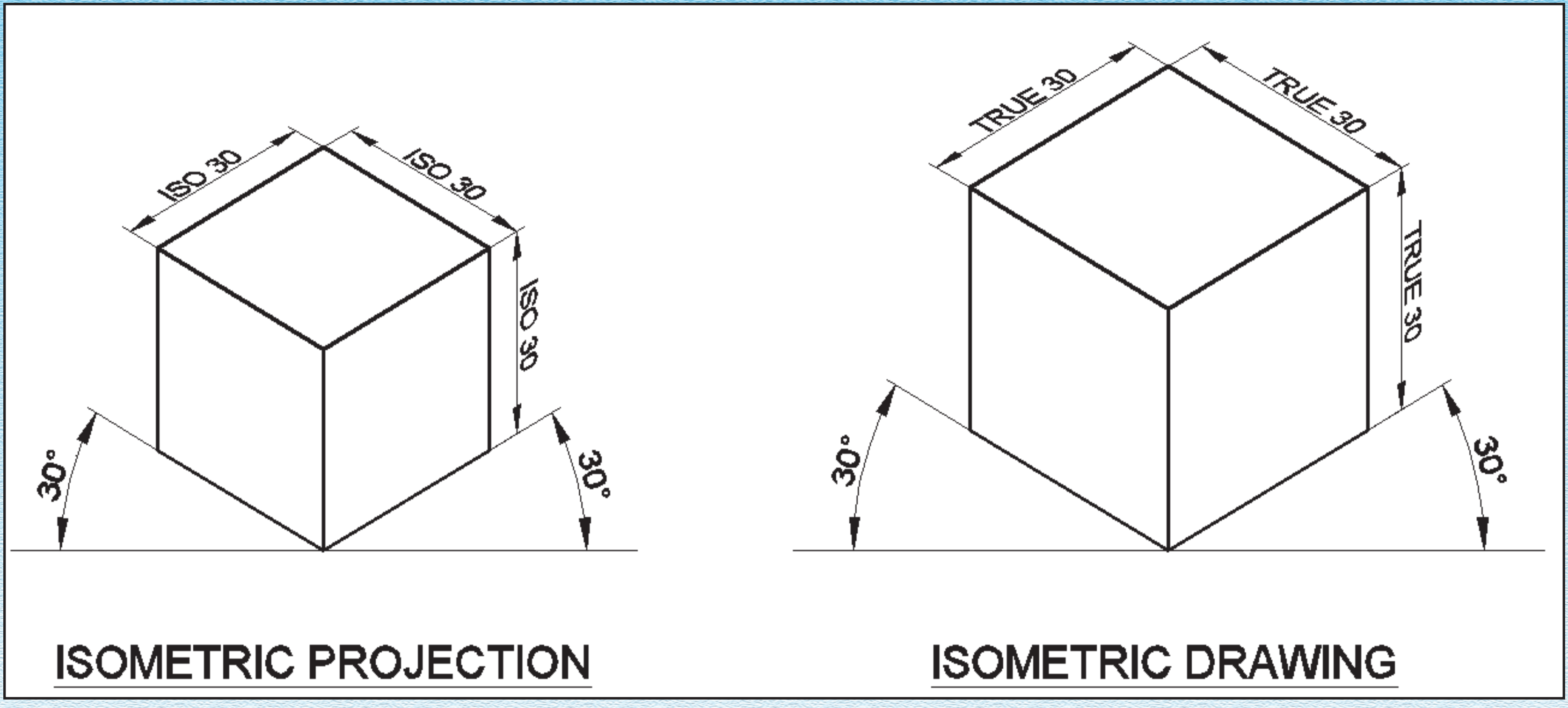

Fig. 7.26

WHAT WE HAVE LEARNT

We have learnt to show the details of an object in an easy and understandable way. Isometric projection gives the most perfect idea of the object. Layman can also copy the dimensions of object from its isometric drawing.

ASSIGNMENT

1. Draw the isometric projection of an equilateral triangle of base side 50 mm in V.P.
2. Draw the isometric projection of a square lamina having side 55 mm in H.P.
3. Draw the isometric projection of a regular pentagon of base side 35 mm in V.P.
4. Draw the isometric projection of a regular hexagon of base side 30 mm in H.P.
5. Draw the isometric projection of a circle of dia 50 mm in H.P.
6. Draw the isometric projection of a semi-circle of radius 30 mm in H.P.

Chapter 8

DEVELOPMENT OF SURFACES

8.1 INTRODUCTION

We brush our teeth daily but have you ever noticed the shape of packing box of tooth paste. Is it similar to a square prism? Let us open the box from its joints and lay down it on a plane surface. What do you observe? It is a piece of hard paper, having a rectangular shape with crease/folds on all bends. This shape is known as TRUE SHAPE of object/box and the process of unfolding of surfaces of a solid is called **Development of Surfaces.**

Can we take more examples? Yes, every packing box, birthday cap etc. can be opened up in the same way. Steel almirahs, buckets, storage vessels etc are bulky and complicated but these are also made up of sheet metal or plates from the **TRUE SHAPE** of objects.

In this chapter, we are going to study about the development of surfaces to find out the true shape of objects required to produce the three dimensional object. The knowledge of development of surfaces not only gives us the model of the object but also helps in the estimation of costing and process of manufacturing i.e. blanking, stamping, pressing, welding, riveting etc.

8.2 DEVELOPMENT OF SURFACES

If the surface of a solid is opened out and laid on a plane surface. The true shape of the surface area of the solid is obtained. It is known as the development of that solid.

The technique used in making a development from the orthographic views of a given object, is to find out the true shape of the surfaces and correct placement of one surface with respect to another adjacent element. "A development is a plane surface, which represents the unfolded surface of the object" Figure 8.1 explains the unfolding process of a cube to get its development.

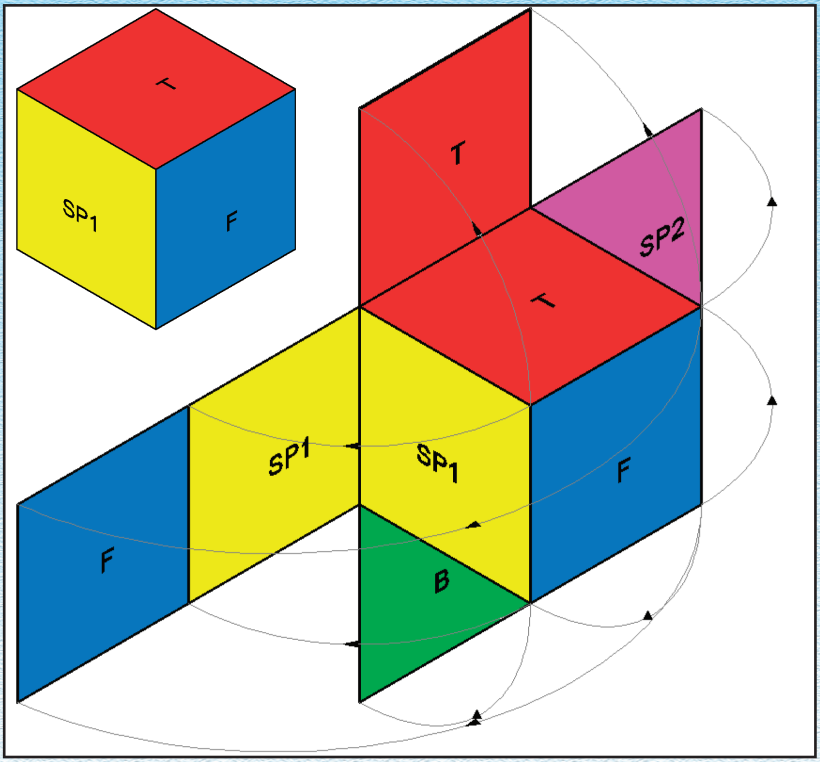

Fig. 8.1

8.3 METHODS TO DRAW DEVELOPMENT OF SURFACES

The group of developments, classified according to the type of surface involved to construct the development are as follows :-

1. Parallel line developments
2. Radial line developments

8.3.1 PARALLEL LINE (RECTANGULAR) METHOD

In this method development of surfaces of prisms and cylinders is drawn with the help of parallel lines. In this method the lateral surfaces of a solid are divided into a number of convenient rectangles. The true length of each of the side of the rectangles is found out from the orthographic views of the solid. Using these true lengths the rectangles are drawn, sequentially, one besides the other. Usually, as the height of the Front View and development is the same, the development is drawn in horizontal alignment with the Front View. The addition of two end surfaces to the lateral surface gives the complete development of the solid.

Development of the cylinder is obtained by dividing the cylindrical surface into "equal" parts with the help of generators.

8.3.1.1 CUBE

The development of the surface of a cube consists of six equal squares of side equal to the edge of the cube.

Example 8.1 : Draw the development of surface of a cube of side 40 mm.

Solution : Refer to fig. 8.2

Steps :

1. Draw the Front View and Top View of the cube.
2. Draw the base line in horizontal alignment to the Front View and on it draw four faces (i.e. squares) of the cube.
3. Draw two faces (squares) of the cube on the first and last face.

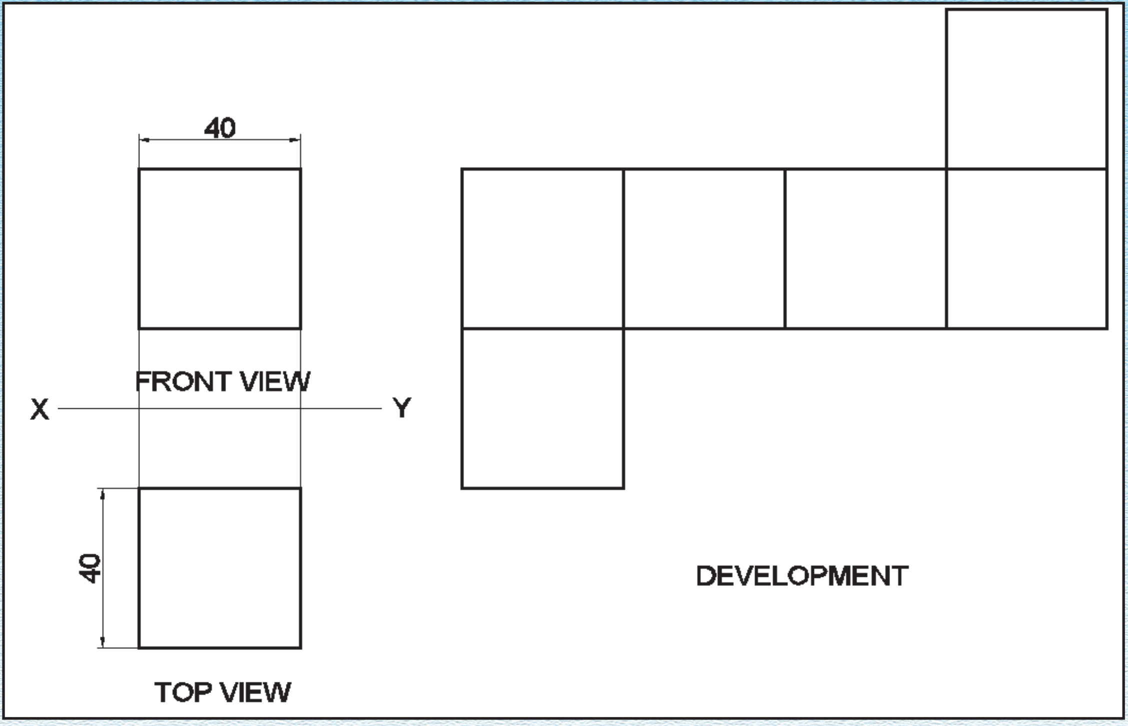

Fig. 8.2

8.3.1.2 CUBOID

The development of cuboid consists of six rectangles. Two rectangles have height (length) and width (breadth) as sides, while two rectangles have height (length) and thickness as sides. Two rectangles are drawn above and below on the first and third rectangle having width and thickness as sides. So there are three sets of two rectangles each.

Example 8.2 : Draw the complete development of a cuboid of sides 70 mm, 40 mm and 30 mm (l × b × t)

Solution : Refer to fig. 8.3

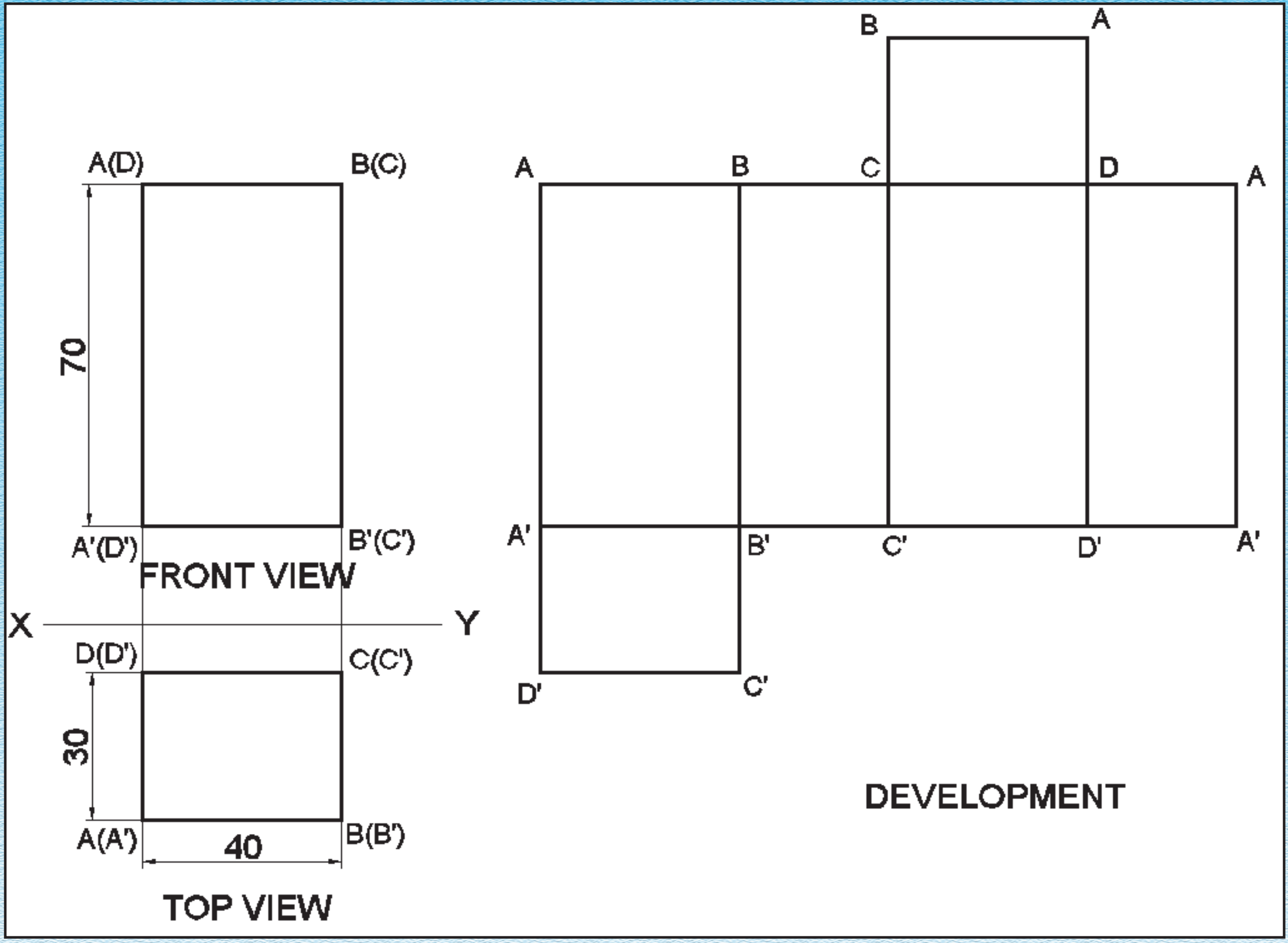

Fig. 8.3

Steps :

1. Draw the Front View and Top View of the cuboid.
2. Draw a base line in horizontal alignment to the Front View and mark line segments equal to A'B', B'C', C'D' and D'A' on it.
3. Draw the vertical line on point A equal to the length AA' (70 mm) in Front View now draw parallel lines from B', C', D' A' and complete the rectangle AA'A'A (140 × 70).
4. Complete the bases of the cuboid around two of its breadths.

8.3.1.3 PRISMS

Development of the prism consists of the same number of rectangles (faces) in sequence the number of the sides of the base of the prism. One side of the rectangle is equal to the length of the axis and another side equal to the base side. Two bases are added above and below the rectangle, on any base side. Let us draw some examples.

Example 8.3 : Draw the complete development of a triangular prism of 40 mm base edge and 60 mm long height.

Solution : Refer to fig. 8.4

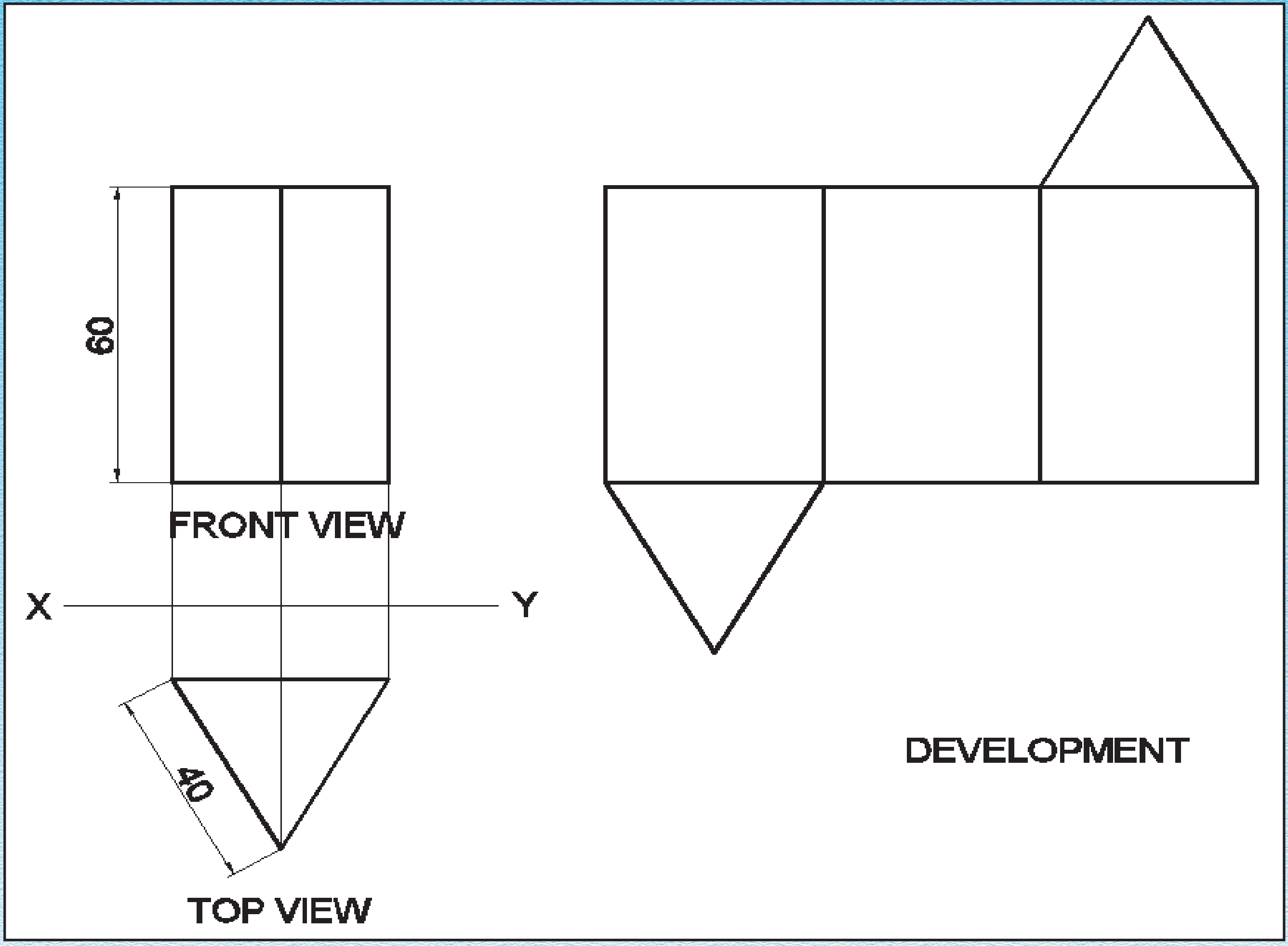

Fig. 8.4

Steps :

1. Draw the Front View and Top View.
2. Draw a base line parallel to XY and mark three line segments each equal to 40 mm.
3. Draw the projections from the Front View. Now draw the parallel lines and complete three rectangles of 60×40.
4. Complete the bases of the triangular prism on the first and last rectangles already drawn.

Example 8.4 : Draw the complete development of a square prism of base side 35 mm and height of 60 mm.

Solution : Refer to fig. 8.5

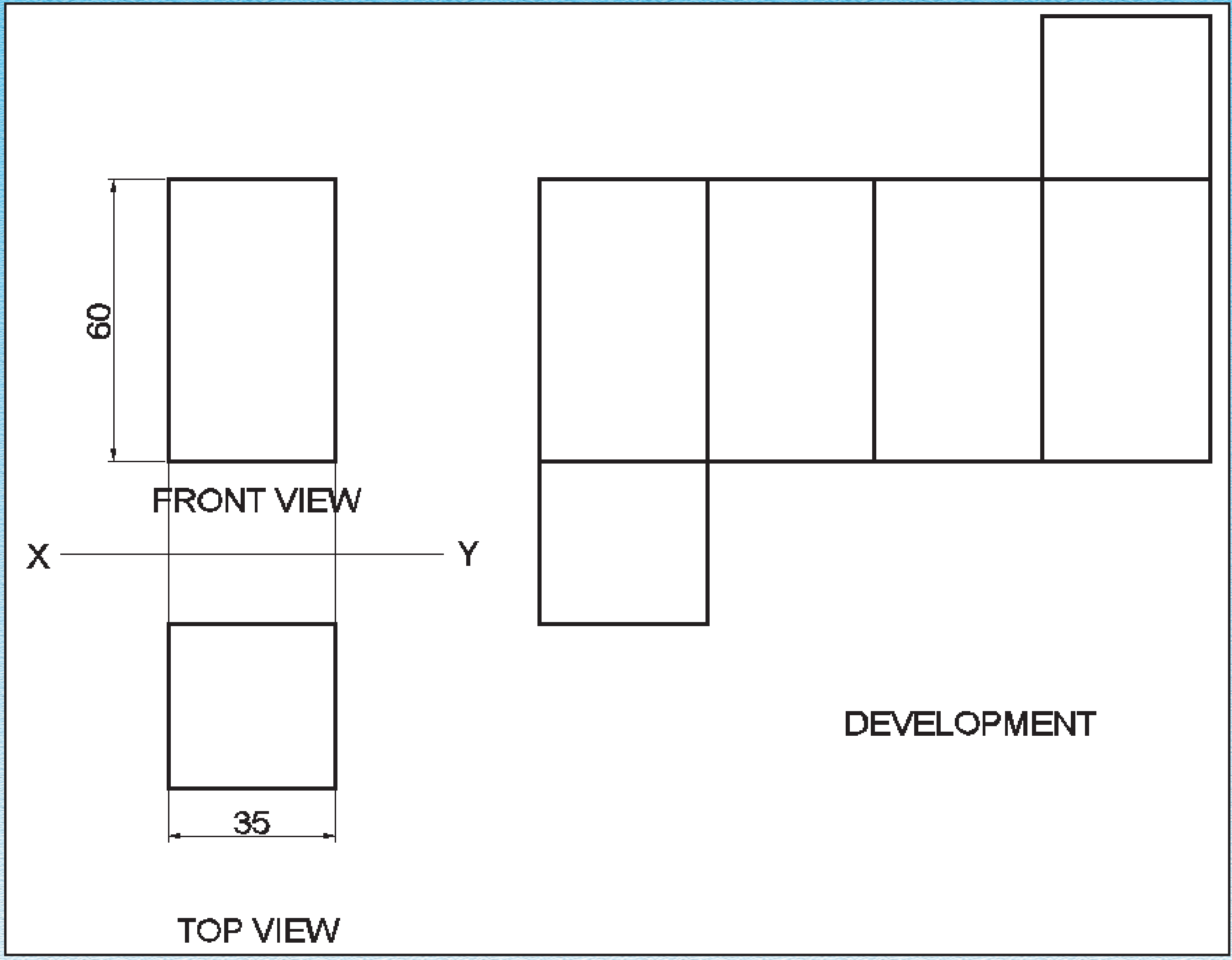

Fig. 8.5

Steps :

1. Draw the Front View and Top View of the square prism as shown in Fig. 8.5 (a)
2. Draw a base line parallel to XY and mark four line segments on it equal to the base side (35 mm).
3. Project the height from Front View of the prism, and complete the rectangle by drawing other parallel lines. (35×60 , 140×60)
4. Draw the bases of the prism i.e. squares on the first and last rectangles already drawn.

Example 8.5 : Draw the complete development of a pentagonal prism of 30 mm base edge and 50 mm long axis.

Solution : Refer to fig. 8.6

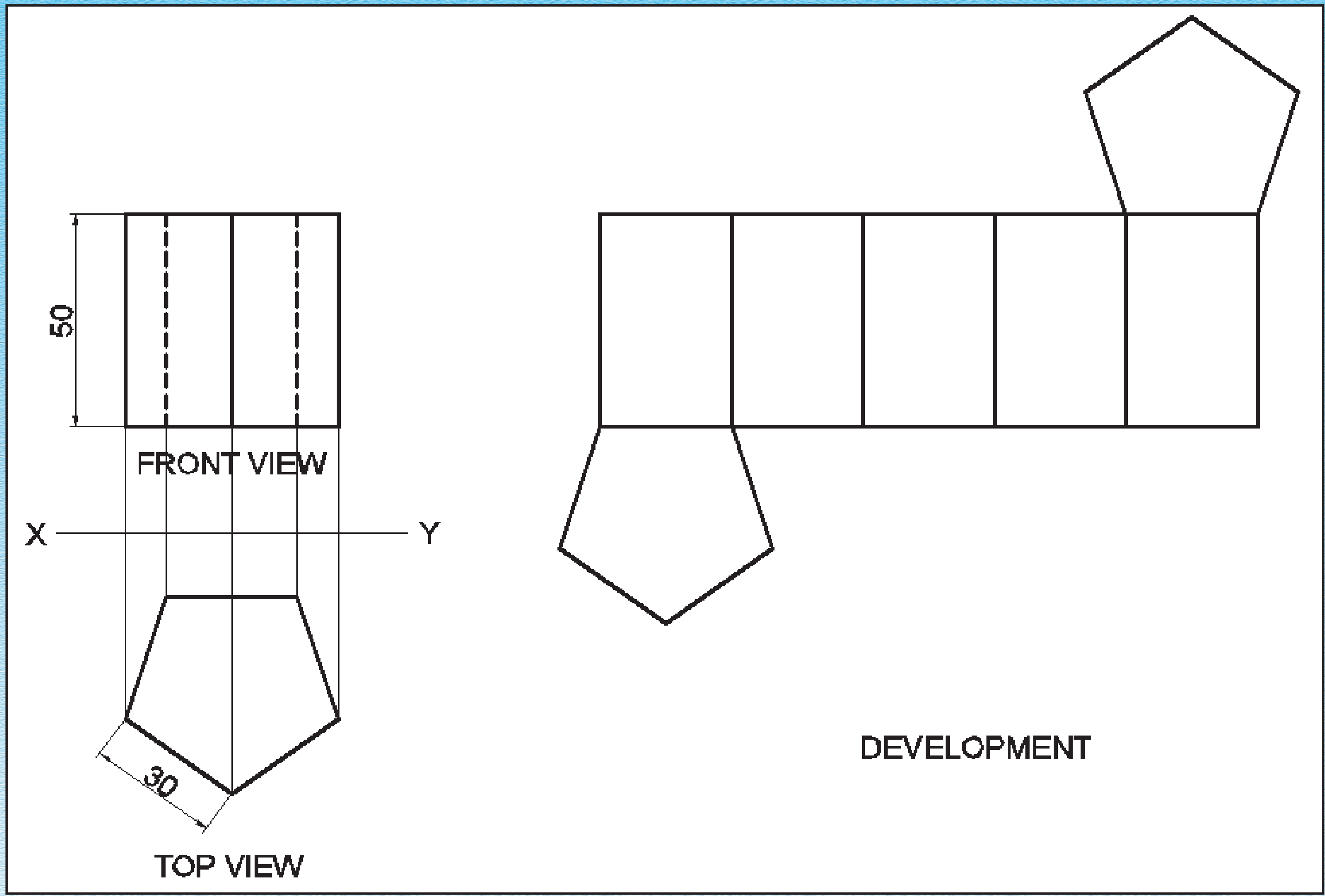

Fig. 8.6

Steps :

1. Draw the Front View and Top View of the prism.
2. Draw a base line in horizontal alignment to the Front View and mark five line segments equal to the base edge on it each = 30 mm.
3. Project the height from Front View equal to 50 mm and complete the rectangle. (150 × 50).
4. Draw the bases of the prism on the first and the last rectangles and complete the development.

Example 8.6 : Draw the development of a hexagonal prism of base edge 25 mm and axis 60 mm long.

Solution : Refer to fig. 8.7

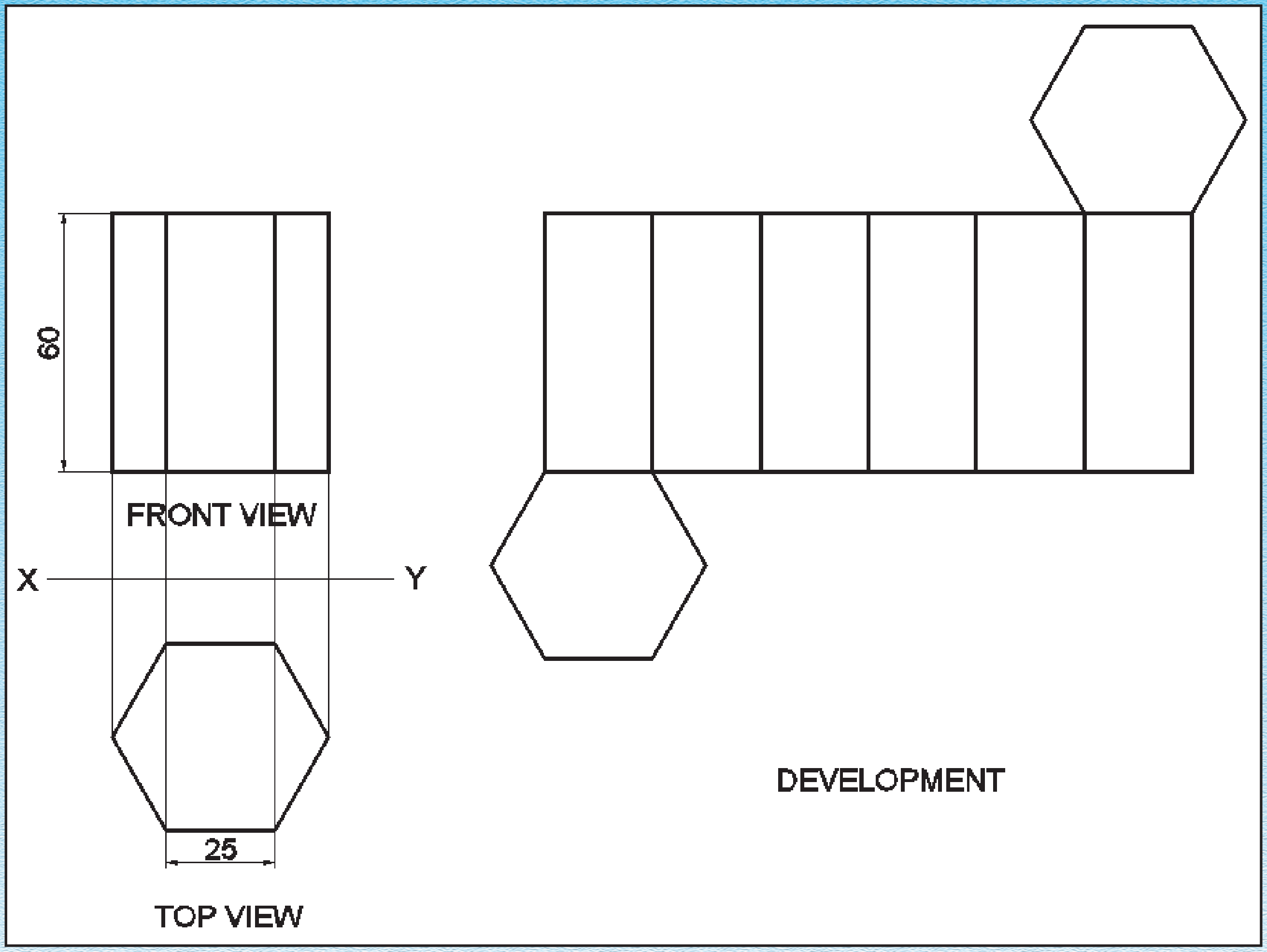

Fig. 8.7

Steps :

1. Draw the Front View and Top View.
2. Draw a base line in horizontal alignment to the Front View and mark six line segments equal to the base edge on it, each = 25 mm.
3. Project the height from Front View equal to 60 mm and complete the rectangle (150 × 60 mm)
4. Draw the bases on the first and the last rectangle and complete the development.

8.3.1.4 CYLINDER

Cylinder does not have any face edge so the development of cylinder is drawn by dividing the cylindrical (curved) surface into no. of equal rectangles (approximately) through generators. The most appropriate no. of equal rectangles are twelve.

Example 8.7 : Draw the development of a cylinder of 40 mm diameter and 60 mm high.

Solution : Refer to fig. 8.8

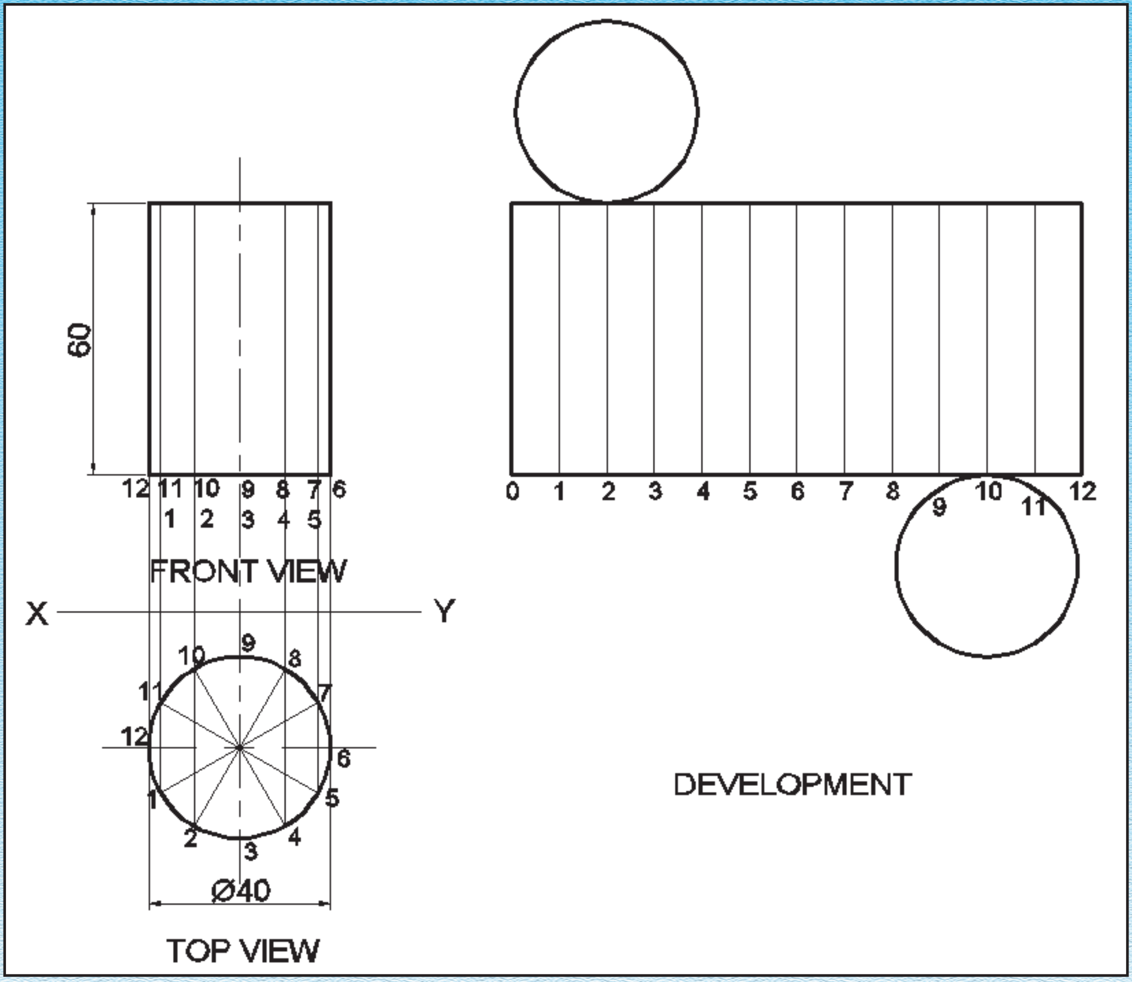

Fig. 8.8

Steps :

1. Draw the Front View and Top View of the cylinder.
2. Divide the circle in Top View into twelve equal parts at 30° and 60°. Project these points to the Front View to locate and draw the generators.
3. Draw the development in horizontal alignment of the Front View along with the generators. The distance between generators is taken equal to the chord length (1–2).
4. Draw two circles above and below on any two generators, Touching the rectangle as shown.

8.3.2 RADIAL LINE (TRIANGULATION) METHOD

Development of surfaces of pyramids is drawn by this method. According to this method, the surface is developed with the help of isosceles triangles, whose isosceles sides are equal to true length of slant edge and the third side is equal to base side. To draw the isosceles sides of all these triangles adacent to each other we take the arc of radius equal to the true length of slant edge. The centre of that arc becomes the vertex of triangle. The base edges are marked on the arc. The base of triangle is drawn on any one of the base edge. The true lengths of base edge and slant edge are taken from the Front View and Top View of that solid.

8.3.2.1 PYRAMIDS---SLANT (FACE) EDGE PARALLEL TO V.P.

When solid is kept in such a position that one of the slant edge is drawn parallel to the V.P. Then slant edge drawn in Front View will be its true length. Let us draw some examples.

Example 8.8 : Draw the development of a Triangular pyramid of base edge 35 mm and 65 mm high.

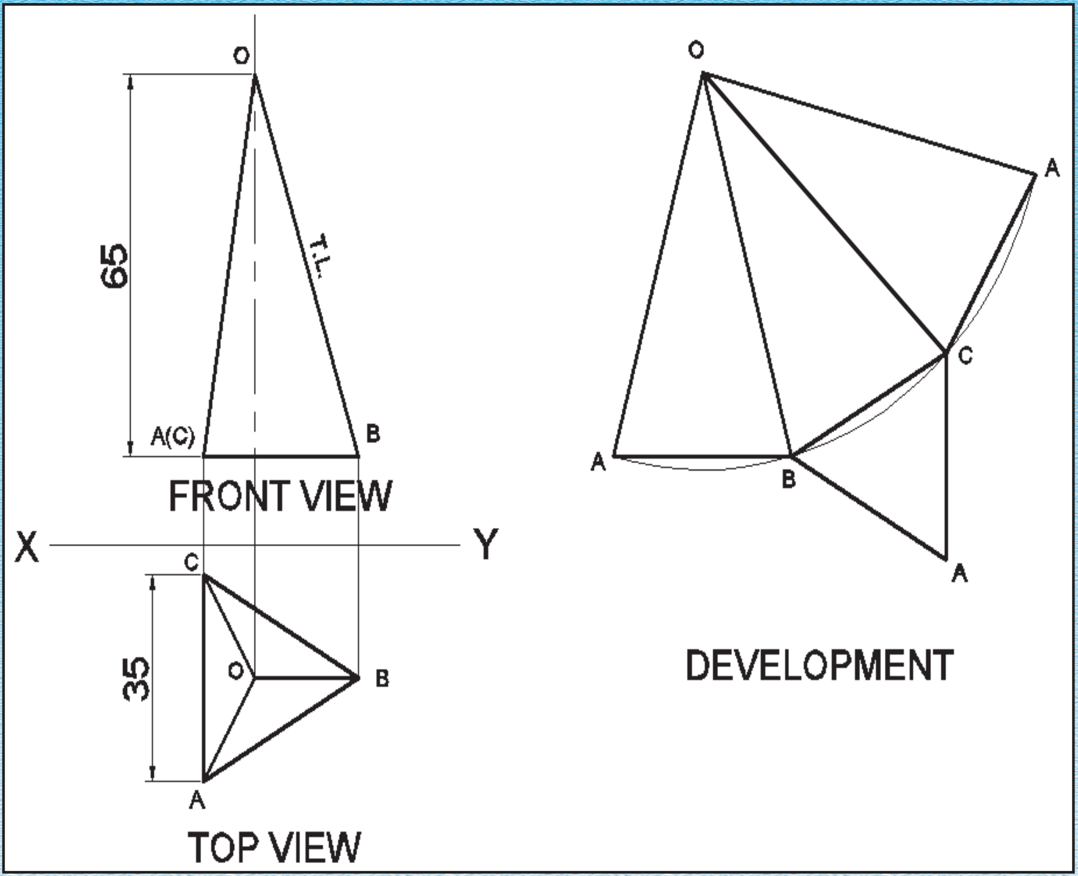

Fig. 8.9

Solution : Refer to fig. 8.9

Steps :

1. Draw the Front View and Top View of the given pyramid, keeping one of slant edge parallel to V.P. (O-B)
2. Take the length of the slant edge (O-B), from Front View, which is parallel to V.P. as radius and draw an arc.
3. Cut this arc at three points with a radius equal to base edge of the pyramid.
4. Join all these points with O as well as every point on arc with its adjacent point on arc.
5. Draw the equilateral triangle on any one of the base edge drawn on the arc adding the base.

Example 8.9 : Draw the development of a square pyramid of base side 30 mm and axes of 50 mm high.

Solution : Refer to fig. 8.10

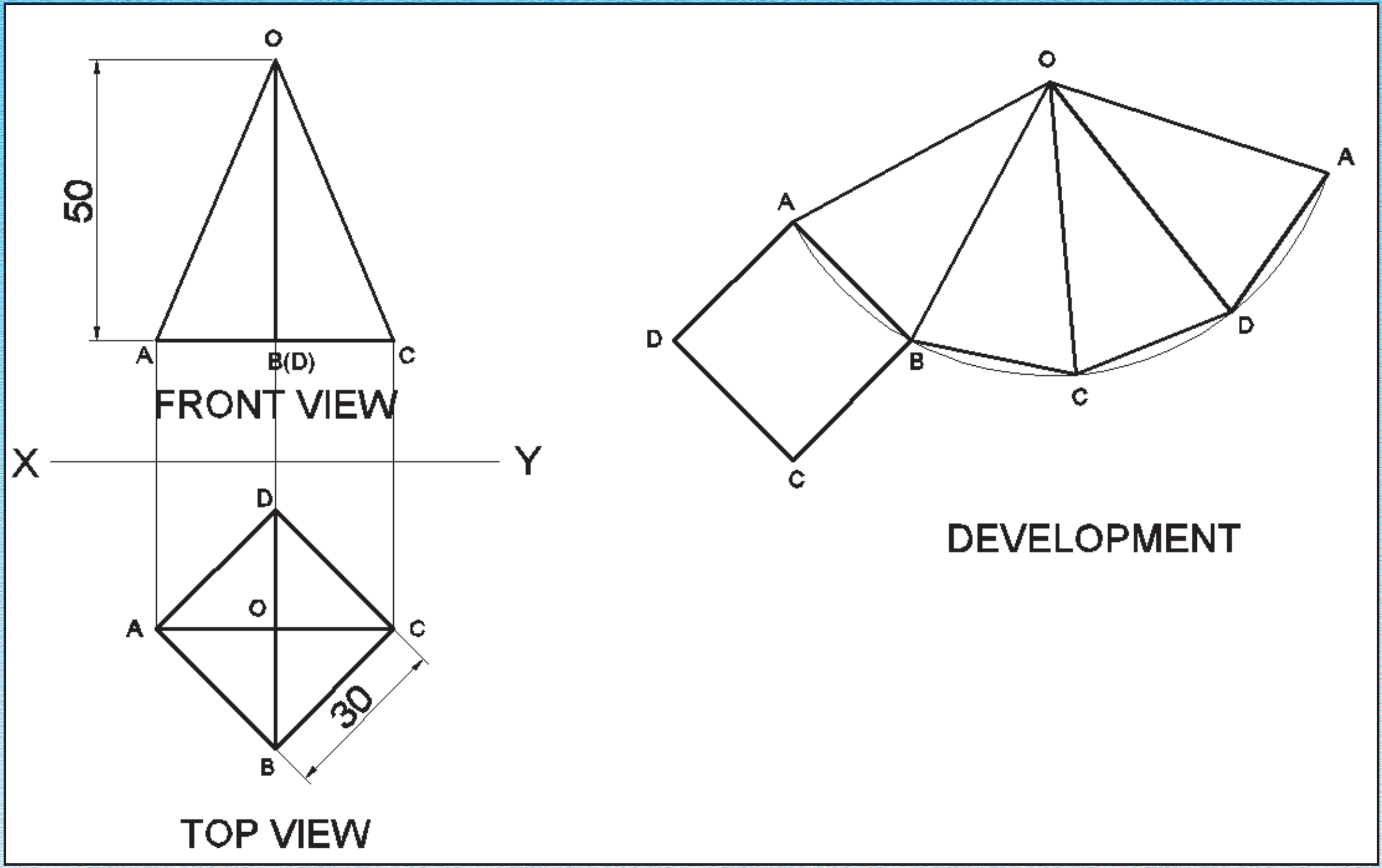

Fig. 8.10

Steps :

1. Draw the Front View and Top View of the given pyramid, keeping one slant edge parallel to V.P. (O-C)
2. Take the length of the slant edge (O-C), from the Front View, which is parallel to V.P. as radius and draw an arc.
3. Cut this arc at four points with a radius equal to base edge of the pyramid.
4. Join all these points with O and all the points on arc with its adjacent point on the arc.
5. Draw the square on any one of the base edge drawn on the arc adding the base.

Example 8.10 : Draw the development of a Pentagonal pyramid of base edge 25 mm and 75 mm high.

Solution : Refer to fig. 8.11

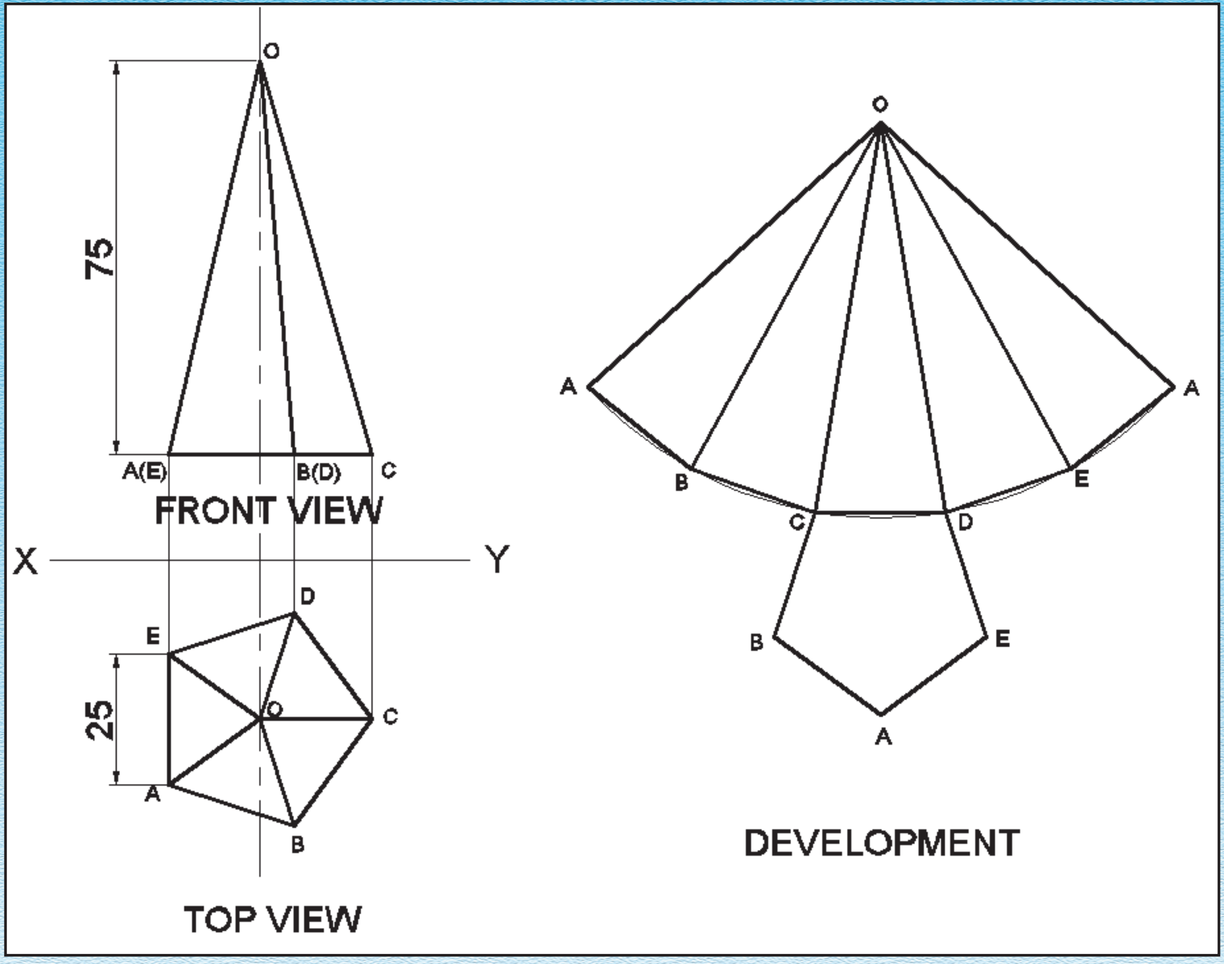

Fig. 8.11

Steps :

1. Draw the Front View and Top View of the given pyramid, keeping one of slant edge parallel to V.P. (O-C)
2. Take the length of the slant height (O-C), which is parallel to V.P. as radius and draw an arc.
3. Cut this arc at five points with a radius equal to the base edge of the pyramid.
4. Join all these points with O and each point on arc with its adjacent point on arc.
5. Draw a regular pentagon on any one of the base edge drawn on the arc, adding the base.

Example 8.11 : Draw the development of a hexagonal pyramid of base edge 25 mm and 50 mm long axes.

Solution : Refer to fig. 8.12

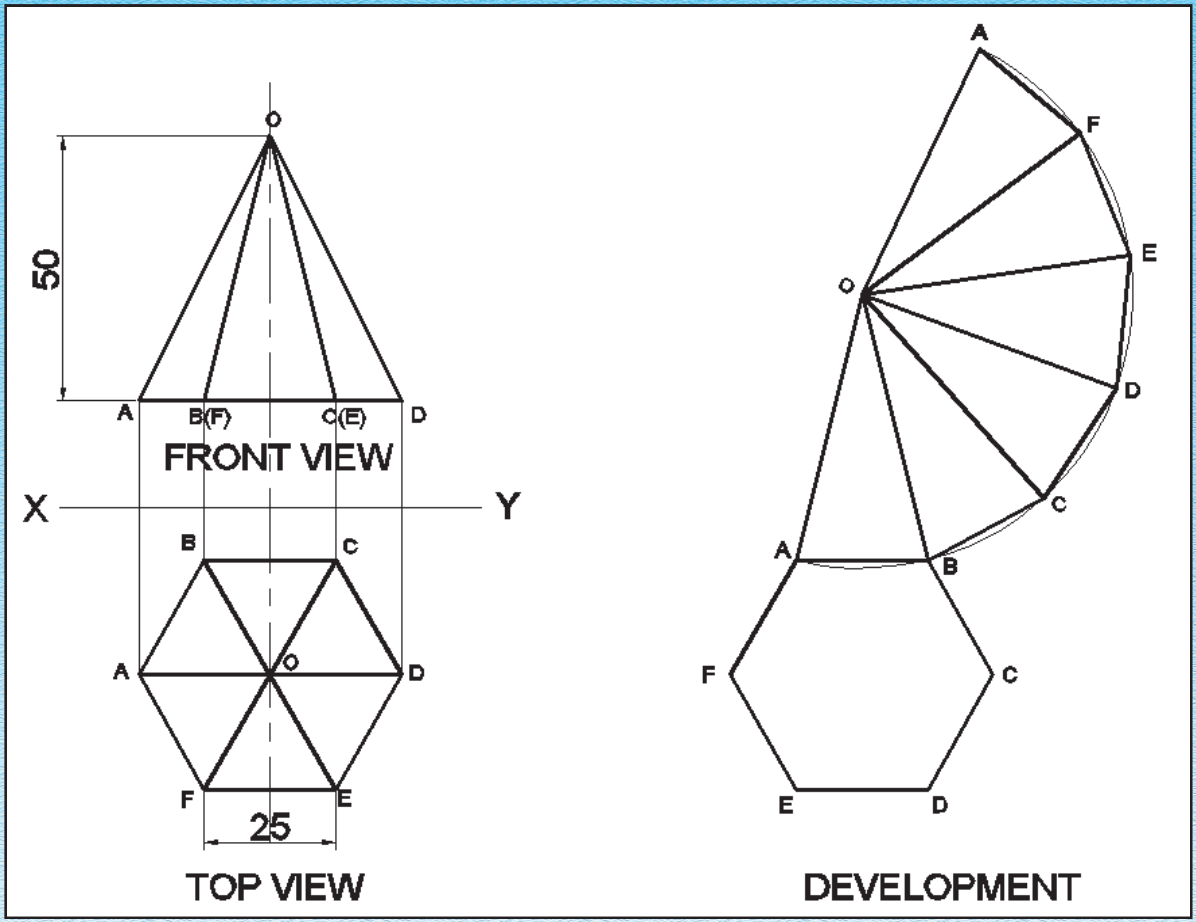

Fig. 8.12

Steps :

1. Draw the Front View and Top View of given pyramid, keeping one slant edge parallel to V.P. (O-D)
2. Take the length of the slant height (O-D), which is parallel to V.P. as radius and draw an arc.
3. Cut this arc at six points with a radius equal to the base edge of the pyramid.
4. Join all these points with O and each point on arc with its adjacent point on arc.
5. Draw a regular hexagon on any one of the base edge drawn on the arc, i.e. adding the base.

8.3.2.2 PYRAMIDS---SLANT (FACE) EDGE IS NOT PARALLEL TO V.P.

When solid is kept in a position that none of the slant edge is parallel to the V.P. Then true length of the slant edge is not shown in Front View. To find out its true length we turn the slant (face) edge in the Top View, parallel to the V.P. or XY and then project it in the Front View. Let us draw some examples :-

Example 8.12 : Draw the development of a triangular pyramid of base edge 30 mm and height of 60 mm.

Solution : Refer to fig. 8.13

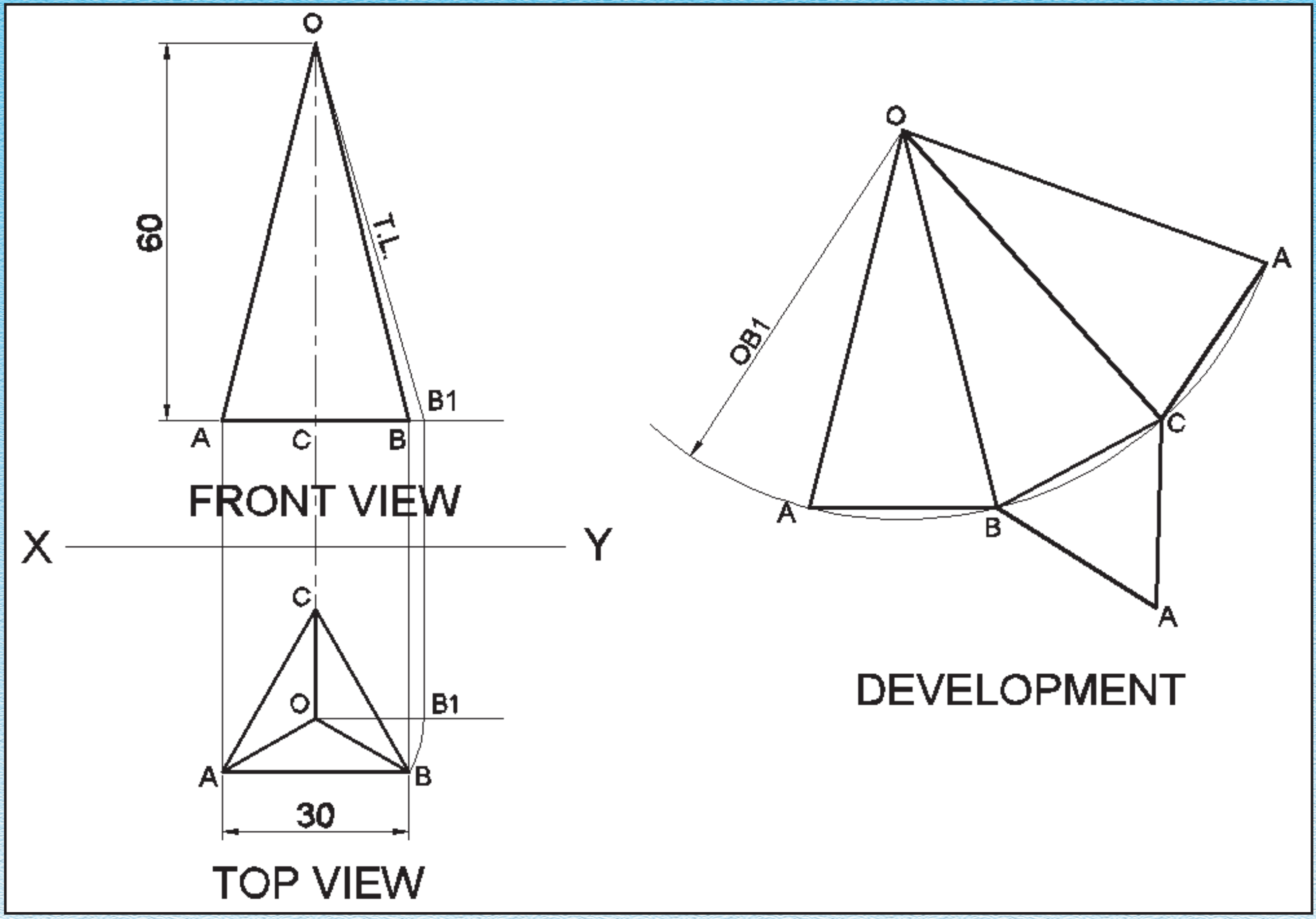

Fig. 8.13

Steps :

1. Draw the Front View and Top View of given pyramid.
2. Turn the slant (face) edge of Top View O-B parallel to the V.P. or XY, by taking radius equal to OB and O as center.
3. Project the point B_1 to the Front View and join OB_1, OB_1 is the true length of slant edge.
4. Take the length of the slant edge OB, from Front View as radius and draw an arc.
5. Cut this arc at three points with a distance equal to base edge of the pyramid.
6. Join all these points with O; and every point on arc with its adjacent point on arc.
7. Draw an equilateral triangle on any one of the base edge drawn on the arc, i.e. adding the base.

Example 8.13 : Draw the development of a square pyramid of base edge 40 mm and 65 mm height.

Solution : Refer to fig. 8.14

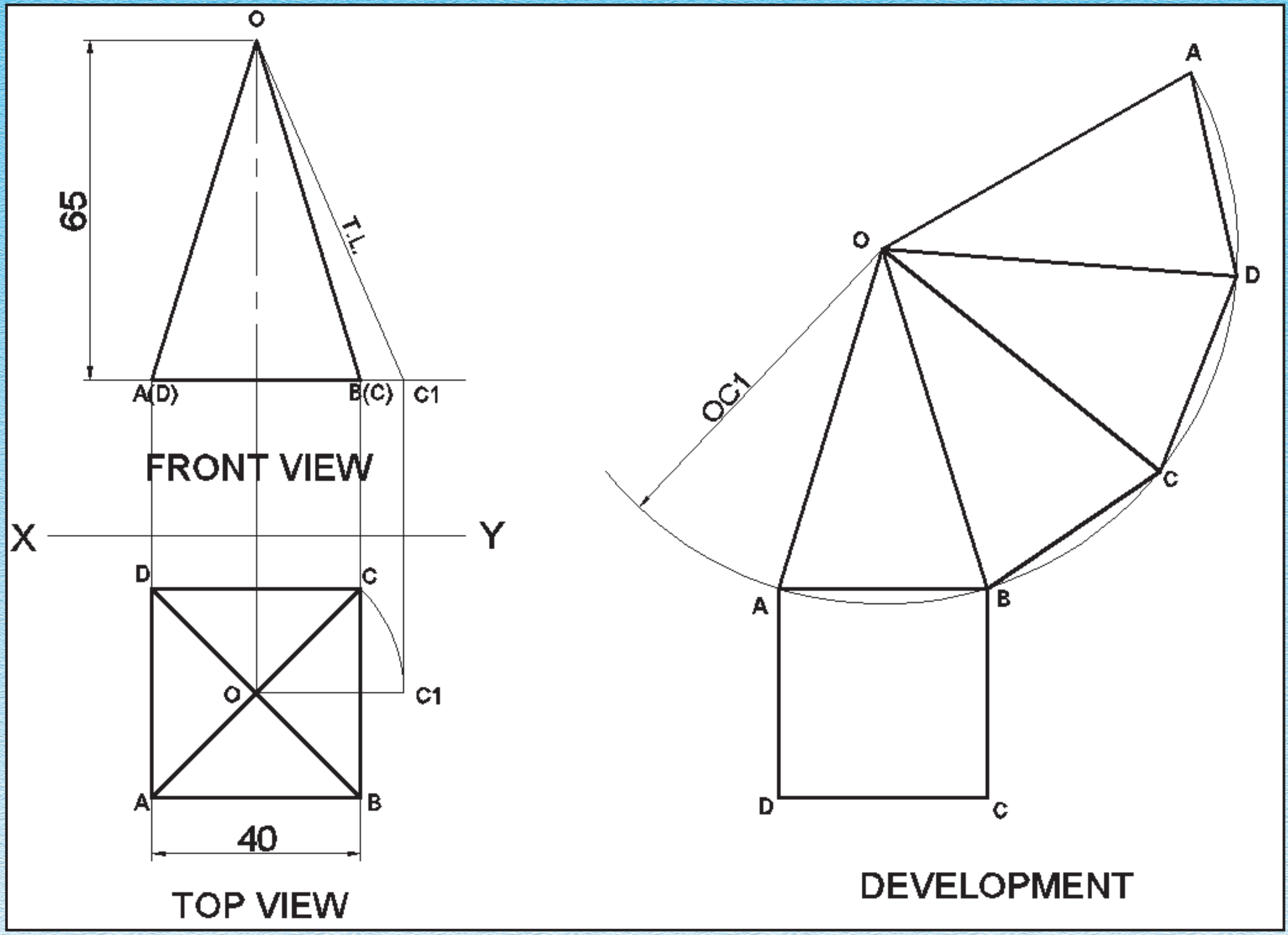

Fig. 8.14

Steps :

1. Draw the Front View and Top View of the given pyramid.
2. Transfer the corner of Top View C, parallel to the V.P. or XY, by taking radius equal to OC and O as center.
3. Project the point C_1 to the Front View and join OC_1, OC_1 is the true length of slant edge.
4. Take OC_1, as radius and draw an arc.
5. Cut this arc at four points with a distance equal to base edge of pyramid.
6. Join all these points with O; and every point on arc with its adjacent point on arc.
7. Draw the square on any one of the base edge drawn on the arc, i.e. adding the base to the development.

8.3.2.3 CONE

Cones are also having curved surface as in cylinders so the development of cone is also drawn by dividing the curved surface into no. of equal triangles (approximately) through generators. The most appropriate no. of equal triangles are twelve.

Example 8.14 : Draw the development of a cone of diameter 40 mm and height of the 60 mm.

Solution : Refer to fig. 8.15

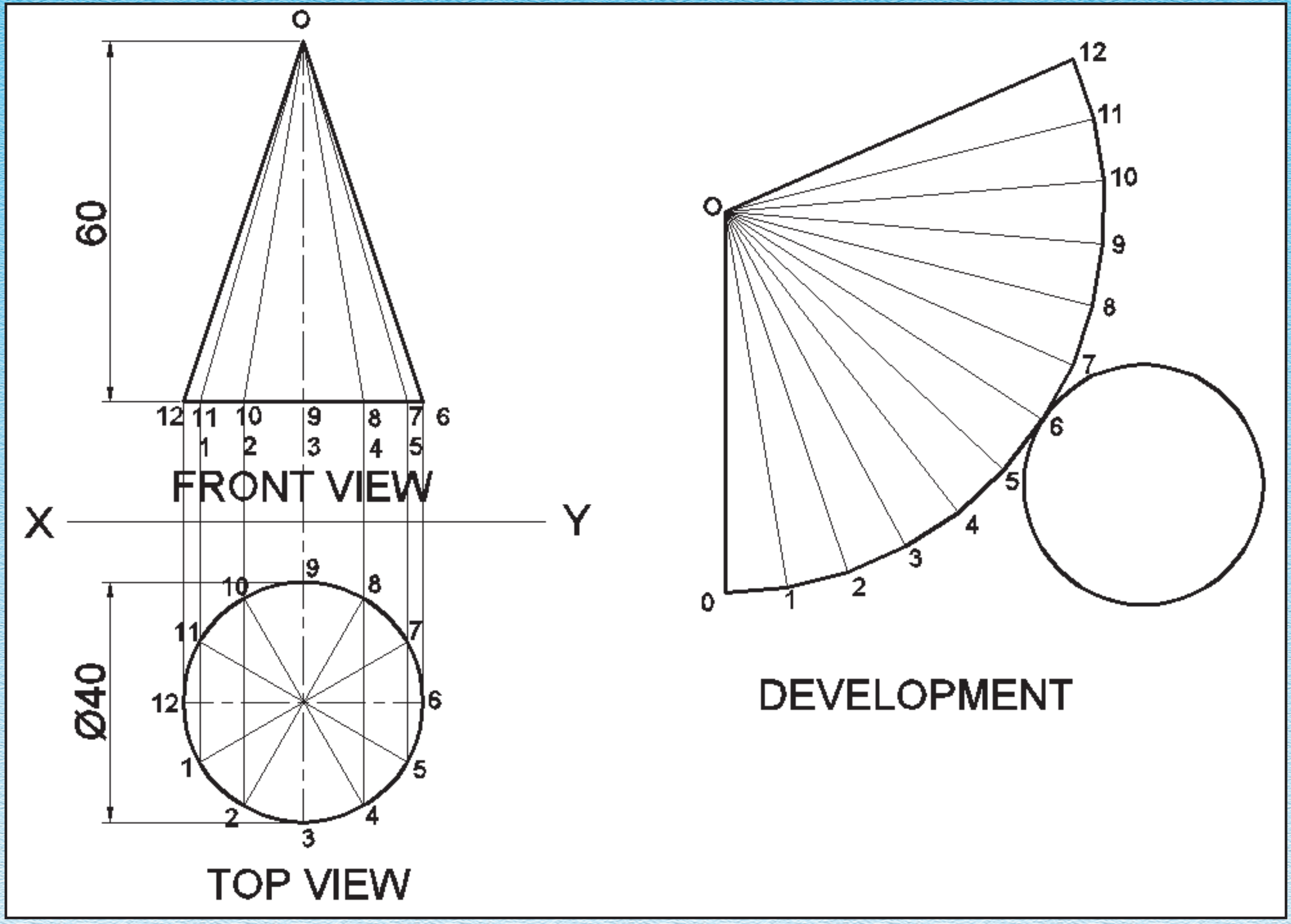

Fig. 8.15

Steps :

1. Draw the Front View and Top View of Cone.
2. Divide the circle in Top View into twelve equal parts at 30° and 60°. Project these points to the Front View to locate and draw the generators.
3. Take the slant height as radius and draw an arc.
4. Cut this arc in twelve points with the distance equal to the chord length 1-2 (from Top View).
5. Join the starting (O) and ending (12) point of the arc with O, and then draw the generators with thin lines.
6. Draw one circle on any one of the generator touching the arc. i.e. adding the base (dia = 40 mm).

WHAT WE HAVE LEARNT

We have learnt that every object is made up of surfaces and by the method of development of surfaces we can find out the true shape of the plane surface required to make, manufacture the object, which helps in to decide the steps involved, costing and estimation etc. of the object.

SHORT QUESTIONS

1. In drawing the development of objects, true lengths are used. (True/False)
2. True length of slant edge need not be known to draw a radial development. (True/False)
3. Every line on a development must be equal to the true length of that line on the actual surface (True/False)
4. Name the methods of development of right solids.
5. To develop the surfaces of pyramids, it is necessary to find _________ of the slant edges when they are not parallel to reference plane.

ASSIGNMENTS

1. Draw the development of a cube of side 50 mm.
2. Draw the development of a Triangular pyramid of base edge 30 mm and height of 60 mm.
3. Draw the development of a square prism of base side 35 mm and axes of 50 mm long.
4. A hexagonal prism of base side 30 mm and height of 60 mm is resting on its base with its axis perpendicular to the H.P. Develop its surface.
5. A cylinder having diameter of 40 mm and 65 mm high is kept on its base. Develop its surface.
6. Draw the development of a pentagonal prism of base side 30 mm and height of 55 mm.
7. Draw the development of a triangular pyramid of base side 35 mm and axis of 60 mm.
8. A pentagonal pyramid of base side 25 mm and height of 50 mm is kept on its base. Develop its surface.
9. Draw the development of a pentagonal pyramid of base edge 30 mm and 60 mm height.
10. Develop the surface of a cone of base diameter 50 mm and 60 mm axis.

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