GENERAL MACHINIST

PAPER - I

ENGINEERING DRAWING

VOCATIONAL EDUCATION

HIGHER SECONDARY - FIRST YEAR

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Untouchability is a sin

Untouchability is a crime

Untouchability is inhuman

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1. INTRODUCTION TO ENGINEERING DRAWING

1.1 Introduction

The oldest form of communication among human beings is sharing of ideas through some sort of graphical language. They might have put into use a peculiar equipment to make out images. We can even imagine that ancient men used a stick to scratch messages on sand. Early Egyptians used paint and brushes to make pictures to be used as a form of communication. In the field of Engineering drawing, some special equipments (or) tools are required to make images. At present we use pencils, sketch pad and even computer controlled plotting devices for making drawings.

1.2 Engineering drawing

Engineering drawing is an effective method of communication between engineers belonging to various disciplines of engineering. All the necessary features of an object are mentioned on the drawing with proper dimensioning and important remarks. The entire community of engineers can analyse the object for its correctness, accuracy of the object's design and modifications. As all the production related remarks and instructions are graphically expressed in the drawing, it is easy for the production process to be carried out.

Engineering drawing is the language of engineers. This language is spoken, read and written in its own way. It is used as a means of communicating ideas, concepts and designs to all the others involved in the process of production. Engineering drawing is drawn by an engineer having engineering knowledge for engineering purposes. Engineering drawing is the starting point for all engineering disciplines – Mechanical, Automobile, Production, Civil, Architectural, Computer Science, Communication, Instrumentation, Aeronautical , Marine, Agricultural, Mining, Chemical, Textiles etc.

The views of an object are drawn initially on a tracing paper and this drawing is known as **original drawing.** Additional copies of the original drawings are taken according to the need and they are are called as **Blue prints** or **Ferro prints**.

1.3 Importance of Engineering drawing

It is not possible to explain all the details of objects orally irrespective of the size of the object (very small to large). Some of the details may be left out, misrepresented or misunderstood.

There may be some difficulty in understanding oral communications because of the languages spoken by the individuals. Considering such difficulties, drawings are used to communicate with people from different levels in the field of engineering (from engineers to workers). They can understand the drawing and help manufacture new components. Another distinct advantage of drawing is that the details are protected for further reference.

As there is a definite grammar for a language and rules and regulations for games and sports, there is definition for a drawing. Each and every symbol, line, letter and numbers has its unique meaning. Drawings should be made with these definitions in mind. Same methods are to be followed in making drawings for them to be accepted and understood all over the world.

1.4 Geometrical drawing

Geometrical drawing is the foundation for all engineering drawings. It is the art of representing geometrical objects like square, rectangle, circle, cylinder, cone , sphere etc., on a drawing sheet. Geometrical drawing can be classified as

1. Plane geometrical drawing
2. Solid geometrical drawing

When objects having two dimensions (i.e. length and breadth) like square, rectangle and quadrilateral are drawn a drawing sheet, it is known as plane geometrical drawing.

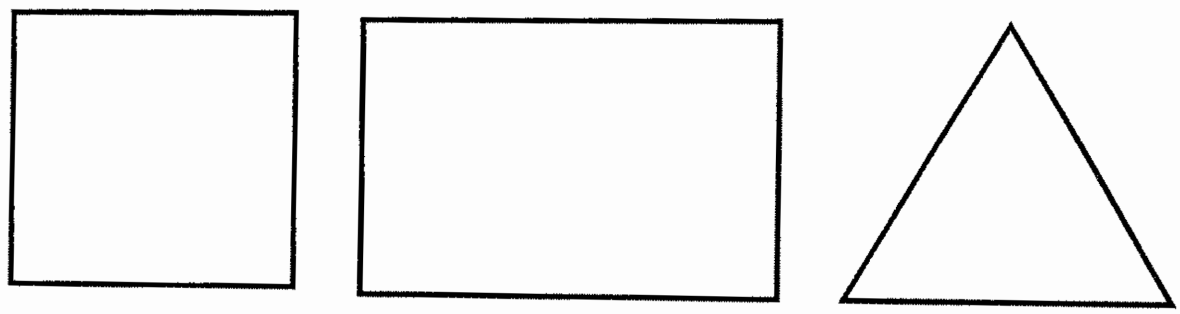


Fig 1.1 Plane geometrical drawing

Solid geometrical drawing is the method of drawing objects having three dimensions (i.e. length, breadth and height) like cube, cylinder, sphere etc on a drawing sheet.

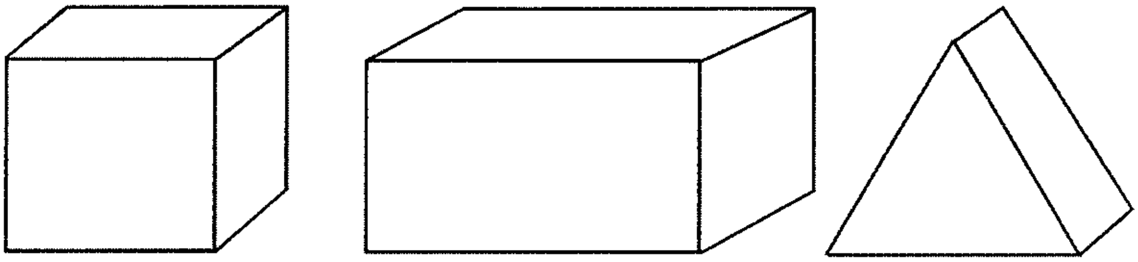


Fig 1.2 Solid geometrical drawing

1.5 Computer graphics

The usage of computer is increasing in all the walks of our life. The engineering profession is greatly benefited by the advent of computers and computer graphics. Complex problems are solved at a faster rate by computers. Computers help us to a greater extent in modifying older designs and thereby planning and constructing more sophisticated engineering systems, machines and structures than in the past.

Computers and associated equipments such as plotters are available at a reasonable cost now. Drawing and designing software application packages like Auto CAD, Pro-e can be utilized to make computer graphics. Hence, the computer graphics can be seen as an advanced method of traditional constructing methods.

In the following chapters , some basic ideas are given to make simple drawings involving both plane and solid geometrical constructions,. Some primitive ideas regarding making of simple constructions using AutoCAD are also given. Every aspiring engineer needs this knowledge to represent his concept of ideas graphically.

QUESTIONS

I A. Choose the correct option

1. Drawing different views of an object on a tracing sheet is
   - a. Drawing
   - b. Original drawing
   - c. Grammer of a drawing
   - d. Blue print
2. The drawings that are understood all over the World are made according to
   - a. the definition of a drawing
   - b. computer graphics
   - c. manual drawings
   - d. tracing paper
3. The basic drawing for all engineering drawings is
   - a. computer graphics
   - b. original drawing
   - c. geometrical drawing
   - d. manual drawing
4. Cartoon movies are made using
   - a. computer graphics
   - b. plane geometrical drawing
   - c. original drawing
   - d. manual drawing

I B. Answer the following questions in one or two words

1. What is the name of copies taken from the original drawings?
2. Mention any two branches of engineering.
3. What are the types of geometrical drawings ?
4. Mentiion any one use of computer graphics.
5. Mention the names of software used to make computer aided drawings?

II. Answer the following questions in one or two sentences

1. What is a drawing?
2. Mention the importance of engineering drawings.
3. What do you mean by geometrical drawing?
4. What is plane geometrical drawing?
5. What is solid geometrical drawing?

III. Answer the following question in about a page

1. What is the importance of engineering drawing ? Explain.

2. DRAWING INSTRUMENTS

2.1 Introduction

The necessity of proper equipments and instruments for making drawings was discussed in the previous lesson. Good quality of drawing instruments is needed to make accurate drawings. However, these instruments should be handled correctly and accurately. Following are the instruments required for preparing drawings.

1. Drawing board
2. Tee – square
3. Drafter
4. Pencils and pencil leads
5. Scales
6. Set squares
7. Protractors
8. French curves
9. Instrument box
   a. Compass
   b. Divider
   c. Inking pen
   d. Lengthening bar
10. Drawing sheets

2.2 Drawing board

A drawing board is made of four or five strips of soft wood with approximate thickness of 20mm. The wood should be well-seasoned and soft and made of pine, oak or fir. The strips are cleated at the back by battens with screws to prevent them from warping.

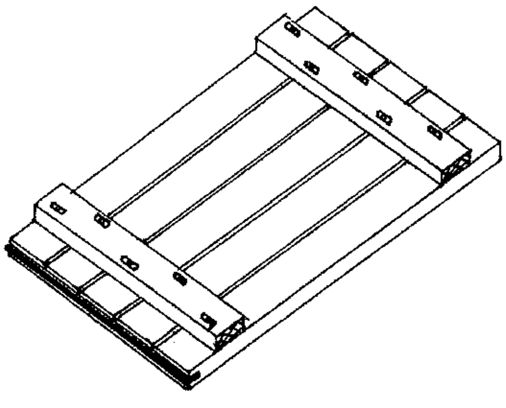


Fig. 2.1 Drawing board

A straight ebony strip is fitted on the left edge of the board. This enables the movements of tee-square on the board. *The drawing board is illustrated in Fig, 2.1*

The top surface of the drawing board should be flat and smooth and the thickness uniform. B.I.S (Bureau of Indian Standards) has standardized the sizes of drawing board as follows

Sl. No.	Designation	Size in mm L x W x T	Size of sheet
1	D_0	1500 x 1000 x 25	A_0
2	D_1	1000 x 700 x 25	A_1
3	D_2	700 x 500 x 15	A_2
4	D_3	500 x 350 x 15	A_3

2.3 Tee-square

Tee-square is made of hard quality of wood like teak or mahogany. There are two parts of a Tee-square namely - stock and blade. The working edge is formed by an ebony piece attached to the blade. The stock slides along the ebony piece attached to the drawing board. These two parts are connected at right angles to each other by means of screws or dowel pins. The working length of the Tee-square is approximately equal to the length of the drawing board. *Tee square is illustrated in Fig, 2.2*

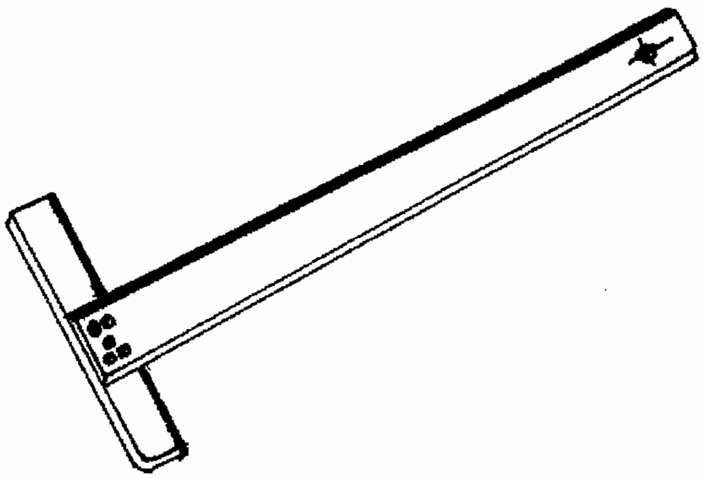


Fig. 2.2 Tee-square

Standard sizes of Tee-square according to B.I.S are

Sl. No.	Designation	Length of the working edge of the blade in mm
1	T_0	1500 ± 10
2	T_1	1000 ± 10
3	T_2	700 ± 5
4	T_3	500 ± 5

Tee-squares are used to draw horizontal lines parallel to each other. When used along with set-square, it is used as a base to draw various angles.

2.4 Drafter

It comprises of a pair of steel strips hinged at the centre. At one end, a clamp is provided. This clamp is useful in clamping the drafter at the left side top corner of the drawing board. The other end is known as working end which consists of two perpendicular scales and a circular base. The perpendicular scales are graduated in millimeters whereas circular scale is graduated in degrees up to 360^0. The working end can be oriented to any angle and fixed at the position with help of a knob.

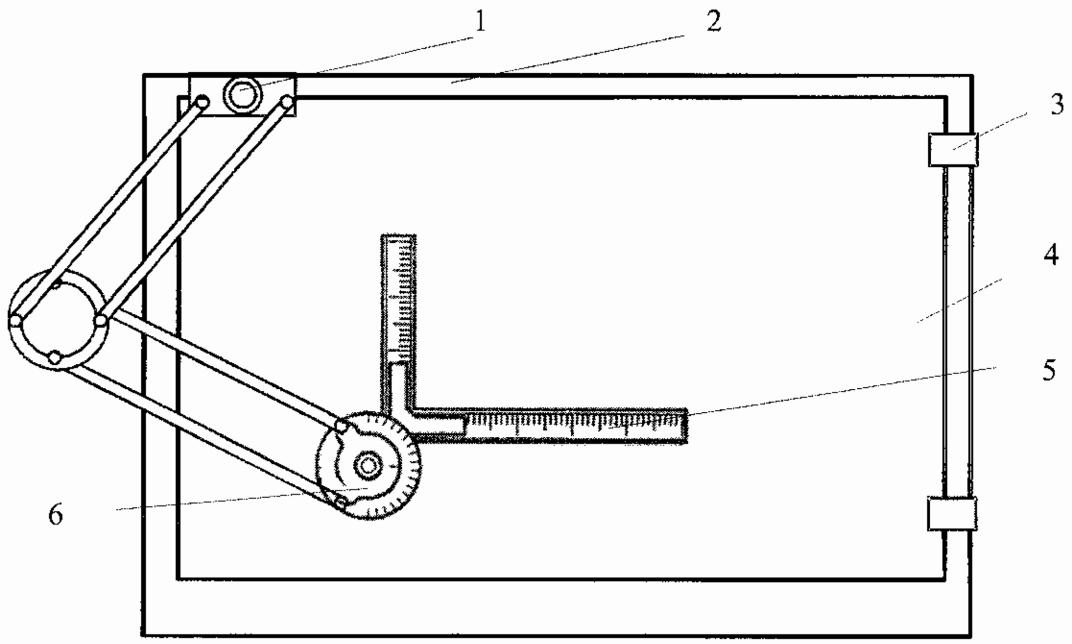


Fig. 2.3 Drafter

1. Clamp 2. Drawing board 3. Clip 4. Drawing sheet

5. Perpendicular scales 6. Circular scale

When the clamping end is fitted to the drawing board, the working end can be made to slide over the board. After the perpendicular scales are set at the desired angle, parallel or perpendicular lines can be drawn. Taking reference from the circular scale, lines at any desired angle can also be drawn. *Fig. 2.3 illustrates a Drafter.*

2.5 Pencils

Pencils are used for making drawings on drawing sheets. The quality of the pencil determines the accuracy and appearance of the drawing. The grades of pencils are designated by markings made on each of them. The grade of the pencil describes the hardness of the graphite lead used. The grades of pencils range from 9H to 7B where 9H is the hardest and 7B is the softest. Hard pencils such as 2H,H are used for making engineering drawing and for lettering and dimensioning, softer pencils like HB are used. HB pencils are also used for making freehand sketches. The grades of the pencils may be categorised as

1. Soft	7B to 2B
2. Medium	B to 3H
3. Hard	4H to 9H

2.6 Scales

The proportion of dimensions between the drawing of an object and the object itself is the scale of the drawing. Different proportions are represented on a set of scales to make drawings of objects having different range of dimensions. The set of scales are designated as M_1, M_2, M_3 ....M_8 and on each scale, two different proportions are marked. For example, on scale M_1, Full size (1:1) and Half size (1:2) are marked .

M_2	1:2.5	&	1:5
M_3	1:10	&	1:20
M_4	1:50	&	1:100
M_5	1:200	&	1:500
M_6	1:300	&	1:600
M_7	1:400	&	1:800
M_8	1:1000	&	1:2000

The scales are flat or triangular and are made of celluloid, cardboard, wood or metal. The concept of scales is explained in detail later in Chapter 6.

2.7 Set-square

Set-squares are useful in drawing perpendicular lines and lines at 30^0, 45^0, 60^0 and 90^0 to the horizontal lines drawn with Tee-square. By the combined use of two set-squares, we can also draw lines at 15^0, 75^0 and 105^0 to the horizontal line.

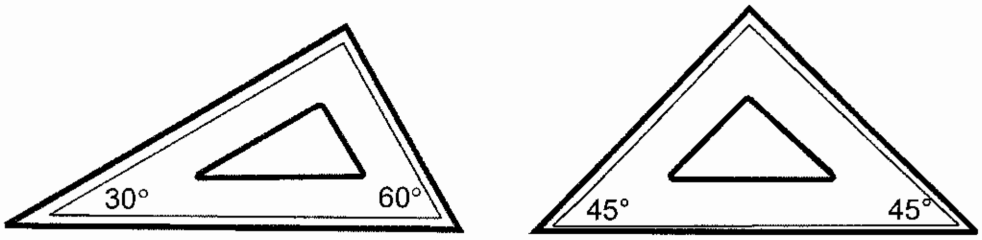


Fig. 2.4 Set-squares

There are two types of set-square

1. Thirty – Sixty (30^0-60^0)
2. Forty five (45^0)

30^0-60^0 set-square has edges having 30 degrees and 60 degrees apart from an edge which is right angled. The 45^0 set-square also has a right angled edge besides two edges having 45^0 and is in the form of an isosceles triangle. They are made of transparent celluloid to enable us to see the lines underneath them. *Fig. 2.4 illustrates set squares.*

2.8 Protractor

Protractors are used to measure or construct angles which cannot be done by set-square. The shape of the protractor may be circular or semi-circular. They are made of celluloid, wood or ivory. *Fig. 2.5 illustrates a Protractor.*

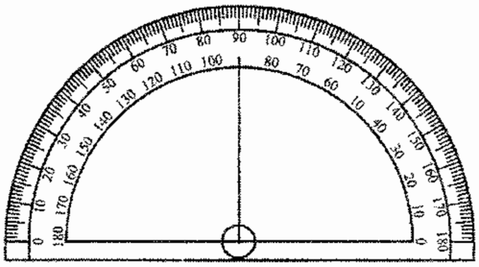


Fig. 2.5 Protractor

2.9 French curves

French curves are the templates made of plastic or celluloid sheet. Profiles and contours of different shapes and sizes are cut on the edges of French curves. Curved lines and circular arcs which cannot be drawn with a compass can quickly be drawn with French curves. *Fig. 2.5 illustrates French Curves.*

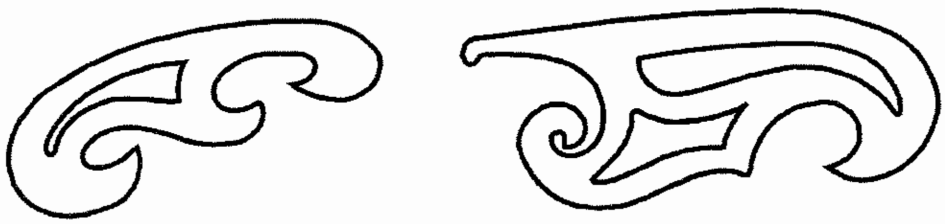


Fig. 2.6 French curves

2.10 Instrument box

The instrument box contains different drawing instruments for drawing different types of drawings. The instruments are

1. Large size compass
2. Small bow compass
3. Small ink bow compass
4. Large size divider
5. Small bow divider
6. Lengthening bar
7. Inking pen
8. Pin point
9. Ink point
10. Lead case

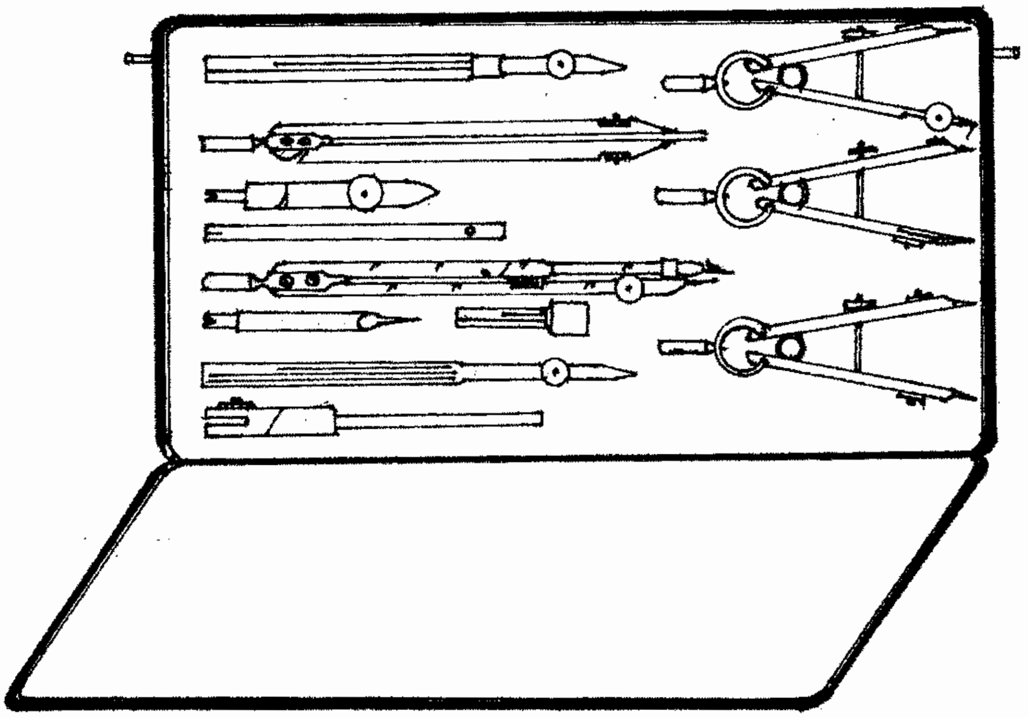
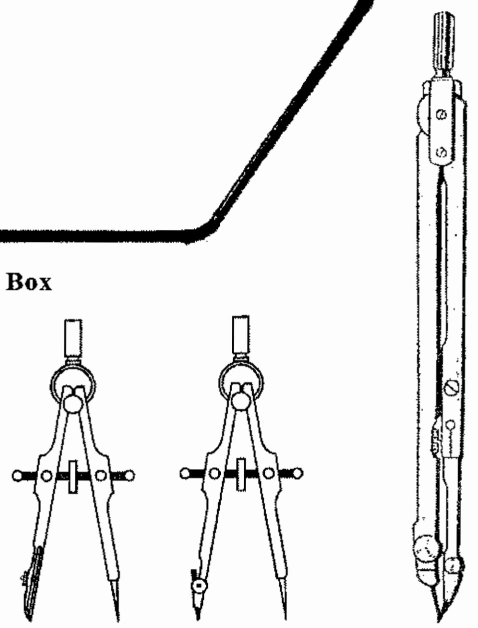


Fig. 2.7 Instruments Box

2.10.1 Compass

Compasses are used for drawing circles and acrs of required sizes. It has two metal legs joined at the top with the help of a knee joint. One of the two legs is fitted with a adjustable needle. The other leg has an attachment which can hold an inking device (or) a pencil lead tip.



A B C

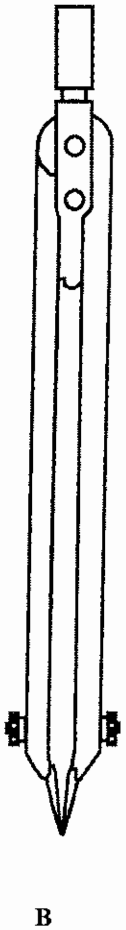
Fig. 2.8 Types of compasses
A - Bow compass B - Ink Bow compass
C - Large size compass

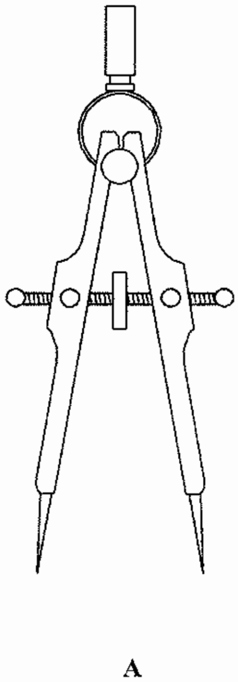
The **large size compass** is approximately 150 mm long and the **small size compasses** are 95 mm long. **Small bow compass** can hold pencil leads and an ink bow is attached to one of the legs of the **small ink bow compass.** Circles and acrs of very large radius are drawn with a lengthening bar attached to the second leg.

2.10.2 Divider

Straight lines or curved lines are divided into required number of equal parts with the help of dividers. (Divider is also useful in transferring dimensions from a part to another part in the drawing and to set off given distances from the scale to the drawing) It is very similar in construction to a compass but for the fact that both the legs of the divider are provided with steel points.

Inking pen is used to draw straight lines and curved lines in ink. It consists of a metal nib fitted to an ivory or metal holder. **Pin point** and **ink point** are used as attachment to a large compass. Lead case is useful in holding lead sticks of different grades.





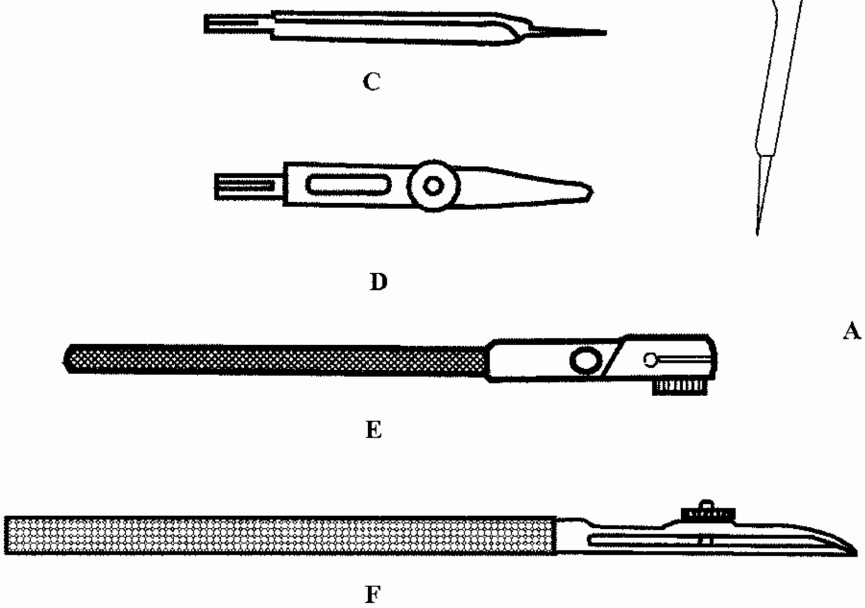


Fig. 2.9 Drawing instruments
A Small size divider B. Large size divider C. Pin point D. Ink point E. Lengthening bar F. Inking pen

2.11 Drawing Sheets

Different qualities of drawing sheets are used for making drawings. The quality of the sheet depends upon the nature of drawing. It should be tough, strong and of uniform thickness. The effect of erasing should not be felt and ink should not spread out. The smooth side of the sheet should always be used for drawing.

The standard sizes of trimmed drawing sheets recommended by ISO (International Organization for Standardiaztion) and adopted by BIS (Bureau of Indian Standards) – BIS : 10711 -1983 are as follows.

Sl .No	Designation	Size	
		Length	Width
1	A0	1189	841
2	A1	841	594
3	A2	594	420
4	A3	420	297
5	A4	297	210

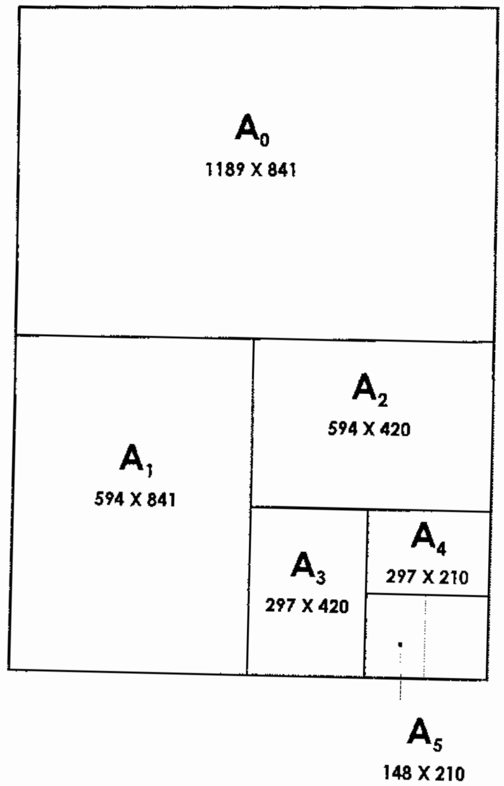


Fig. 2.10
Different sizes of drawing sheets

QUESTIONS

I A. Choose the correct option

1. Drawing boards with dimensions of 1000 x 700 x 25 is designated as

   a. D_0 b. D_1 c. D_2 d. D_3

2. Drawing sheets with dimensions of 297 x 210 is designated as

   a. A_0 b. A_1 c. A_2 d. A_4

3. Horizontal parallel lines are drawn with

   a. Tee square b. Protractor
   c. French curves d. Drawing board

4. Freehand sketches are made with

   a. 2B pencils b. 4B pencils
   c. HB pencils d. 2H pencils

5. Angular lines are drawn and measured with

   a. divider b. protractor
   c. compasses d. Tee square

6. Straight and curved lines may be divided equally with

   a. divider b. protractor
   c. compasses d. inking pen

I B. Answer the following questions in one or two words

1. What are the two parts of a Tee-square?
2. Mention the two types of set-square.
3. What are the grades of drawing pencils ?
4. What are the scales made of ?

II. Answer the following questions in one or two sentences

1. What is the use of french curves ?
2. Mention the use of inking pen.
3. What are the instruments found in the instrument box ?

III. Answer the following question in about a page

1. Draw and explain the construction and uses of a drafter.
2. Write short notes on

   a. Protractor b. French curves c. Compass d. Divider

3. BUREAU OF INDIAN STANDARDS

3.1. Introduction

The filed of engineering and Technology is fast evolving day by day to set newer trends in the world community. The arrival of foreign technologies, technical tie – ups between different countries, and exchange of new technologies have made it mandatory to set specific international standards in the field. This need is most felt in preparing and understanding of engineering drawing. **Indian Standards Institution (ISI)** establizhed in the year 1947, formulated the code of practice for general engineering drawing in the year 1955. ISI was taken over and renamed as **Bureau of Indian Standards (B.I.S.)** in the year 1987 by an Act in the Indian Parliament.

In the year 1987, B.I.S. has adopted the standards of **I.S.O. (International Organization for Standardization)** in full. The following are the topics adopted by B.I.S. in the field of Engineering drawing (latest version)

Sl. No.	Standard	Indian Status	Corresponding ISO standard
1.	Drawing sheet (Sizes, layout etc.)	IS : 10711 – 2001	ISO : 5457 - 1999
2.	General principles of presentation of Technical Drawing (Lines etc.)	IS : 10714 – 2001	ISO : 128 - 1996
3.	Lettering on Technical Drawing	IS : 9609 – 2001	ISO : 3098-1997
4.	Methods of Dimensioning	IS : 10718 - 1993	ISO : 3040 – 1990

(Note : In the standards mentioned above, either the whole topic or certain part(s) of the topic may have been withdrawn and new standards introduced)

3.2. Lay out of drawing sheet

The layout of any drawing sheet should make it easy for the readers to locate all important references of the drawing . For this a standard arrangement should be followed in which all the informations are included. The **lay out of a drawing** sheet should have the following features

1. Margin
2. Title block
3. Parts list
4. Revision panel
5. Zone system
6. Folding marks

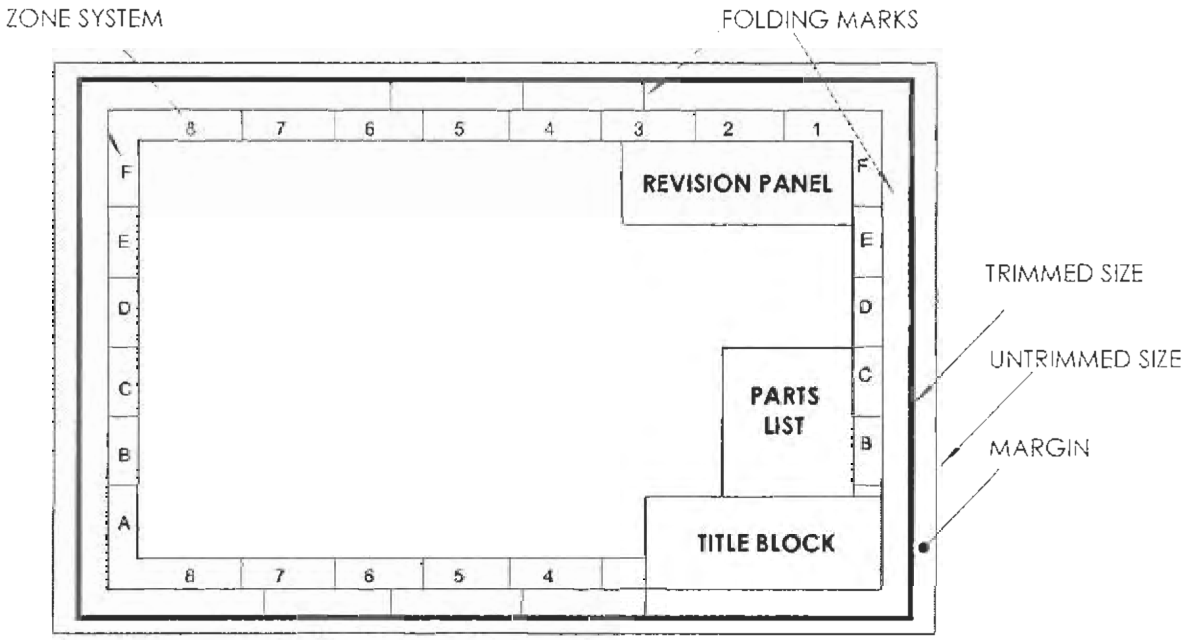


Fig. 3.1 Lay out of a drawing sheet

Lay out of a drawing sheet is illustrated in Fig 3.1

3.2.1. Margin

Margin is provided in a drawing sheet to enable it to be trimmed. After trimming, the sizes of the standard drawing sheets should be equal to the sizes of trimmed sheets recommended by B.I.S. (It is already given in section 2.11. *Fig. 3.1 shows the provision of margin in a drawing sheet.*

Apart from margins, border lines are drawn to get a complete working space. Drawing of border lines should also facilitate easy filing or binding.

3.2.2 Title Block

Provision of title block in a drawing is necessary as it gives all informations regarding the drawing. It is placed at the bottom right hand corner of the drawing sheet. B.I.S. has recommended the size of the title block to be 185 mm X 65 mm. The size is the same for all designated sizes of the sheet (ie. from A0 to A5). The title block should contain the following informations

1. Title of drawing
2. Name of the Organization (or) firm
3. Drawing number – a unique identifier for filing
4. Scale
5. Symbol representing the method of projection (either first or third angle)
6. Initials of the staff - (Designed, drawn, checked & issued) with date

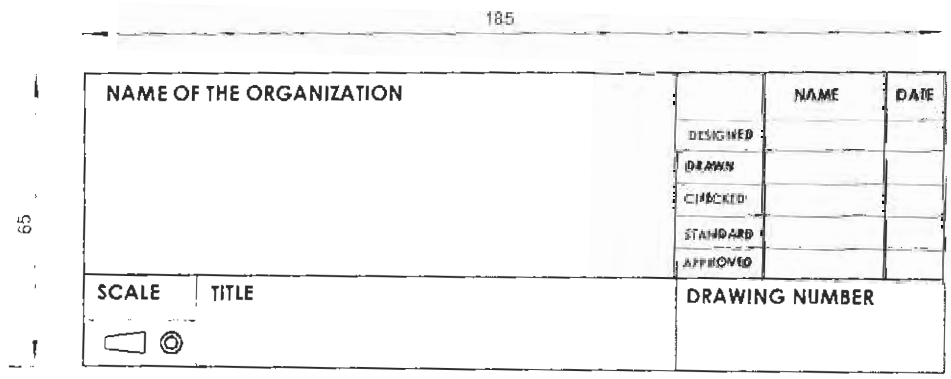


Fig. 3.2 Title block of a drawing sheet

A sample title block is illustrated in Fig. 3.2

3.2.3. Parts List

Parts list is a table to show the names of parts drawn in the sheet and their related details. Parts of large machinies may be grouped as assemblies and drawn on different sheets. The details of the parts in these assemblies are shown in respective sheets. The parts list is located at the right side bottom just above the title block of the drawing. The parts list should contain the following details in it.

1. part number
2. name of the parts (or) description
3. quantity required
4. cross references to other drawings
5. material specification

When the parts list is very large, a seprate sheet may be used for parts list alone.

3.2.4. Revision panel

Revision panel is a table to record all alterations and revisions made in a drawing from time to time. Details such as the revision number, date, zone, brief record and dated initials of the approving authority are recorded in it. It may be located at right side top corner of the drawing or in the title block itself.

3.2.5. Zone system

Zone system is a feature used as reference to identify the location where the revision is actually made. For this, the working space of the sheet (A2, A1, & A0) is divided into equal zones. The zones are referenced by the column and the row they belong to. The columns are designated by numarals both at the top and bottom, and the rows are designated by letters both at right side and left side of the sheet.

3.2.6. Folding marks

Folding marks are made on the drawing sheet to enable them to be folded for proper filing or binding. Folding is done by two different methods to serve two purposse. One method of folding is done for easy filing or binding. This method allows the drawing sheets to be unfolded and refolded when attached with other papers, without the necersity of removal from the file. The other method is used for the sheet to be stored in filing cabinets. In both methods, the folding is done in such a menner that the title block is visible on the folded sheets.

QUESTIONS

I A.Choose the correct option

1. BIS refers to

a. Bharath Industrial Society
b. Bureau of Indian Standards
c. British Institute of Standards
d. Bureau of International Standards.

2. ISI was taken over and renamed as BIS in the year

a. 1947 b. 1983 c. 1987 d. 1999.

I B. Answer the following questions in one or two words

1. When was B.I.S established ?
2. What does ISO refer to ?

II. Answer the following questions in one or two sentences

1. What is a title block ?
2. What is a revision panel ?

III. Answer the following question in about a page

1. What are the informations to be furnished in a title block ?
2. Draw a sample lay-out of a drawing sheet and explain its features.

4. LETTERING & DIMENSIONING

4.1 Introduction

Lettering is a important feature in Engineering drawings. Writing of titles and subtitles of drawings, dimensioning the parts of the objects drawn, writing the scale and other details is called **dimensioning.** As the use of instruments for lettering will consume more time, It is very essential to do lettering free hand with speed, neatness, and beauty of form.

The requirements of lettering, namely types and sizes of letters and techniques of letterings are specified in IS 9609-1983 (Lettering for Technical Drawings)

4.2 Importance of lettering

Neatness, legibility, uniformity, suitability for microfilming and photocopying are the main features of lettering. Poor lettering will spoil the appearance of a drawing and lead to wrong results. Lettering is the talk of the drawing and so it is very important that it is done correctly to finish the drawing completely.

4.3 Proportions of lettering

There is no specified proportions for each letter of alphabets while lettering. Considering uniformity, a proportion between the height and the width his to be followed. There are three proportions by which lettering can be done best. They are

1. Normal lettering — NORMAL LETTERING
2. Condensed lettering — CONDENSED LETTERING
3. Extended lettering — EXTENDED LETTERING

Normal lettering will have normal height and width and finds application in general use. Condensed lettering has shortened width with respect to its height and is used where space available is limited. Extended lettering will have more width and normal height.

4.4. Spacing of letters

The distance left between two adjacent letters while lettering is known as spacing of letters. Equal spaces have to be left between letters for better appearance. Spacing is judged by observation and done by practice.

A distance equal to the 3/5th of the height of the letter has to be left between two successive words. The space between two lines should be equal to 1½ times the height of the letters.

4.5 Size of letters

The size of letters in engineering drawing is the height of the letters. B.I.S recommends standard sizes of lettering for various features and they are listed below

Sl .No	Feature	Size (Hieght in mm)
1	Drawing Numbers, Letters indicating cutting plane section	10, 12
2	Title of the drawing	6, 8
3	Sub-titles and headings	3, 4, 5 & 6
4	Material List, Dimensioning, Schedules, Notes	3, 4 & 5
5	Tolerances Alteration entries	2 & 3

4.6 Types of letters

The lettering in which the alphabets are written with uniform thickness is known as Gothic lettering. Gothic lettering may be done on single stroke and double stroke. Double stroke letters are thicker than single stroke letters.

Types of letters

1. Vertical letters
    a) Upper case letters (Capital)
    b) Lower case letters

2. Inclined letters
    a) Upper case letters (Capital)
    b) Lower case letters

4.6.1 Vertical letters

If the direction of alphabets and numerals is vertical, the letters are known as vertical letters. Both upper case and lower case letters are written in this fashion.

4.6.2 Inclined letters

When the letters are written inclined to the horizontal line, they are called inclined letters. The angle of inclination is approximately 75° from right to left.

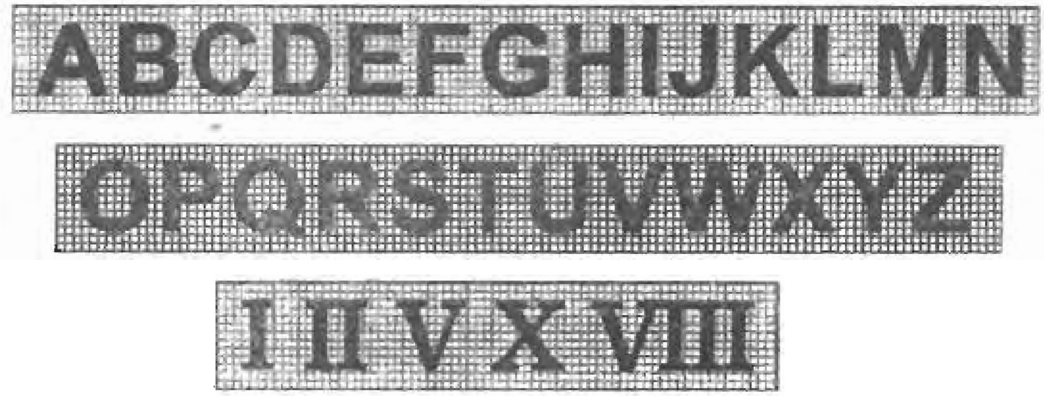


Fig. 4.1 Vertieal upper case letters

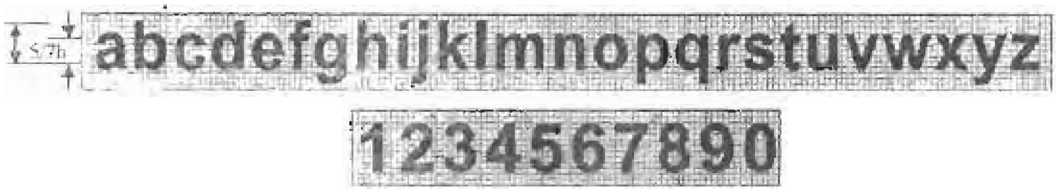


Fig. 4.2 Vertical lower case letters

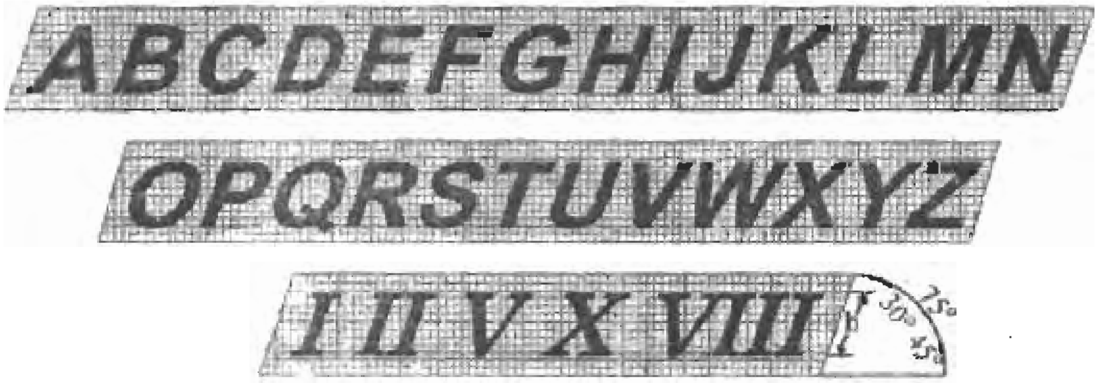


Fig. 4.3 Inclined upper case letters

Fig. 4.4 Inclined lower case letters

4.7 Dimensioning

Drawings are made to represent the actual shape and size of the object to be produced. So, it is necessary to place proper dimensions and related informations regarding different parts of the object. In case the dimensioning is not done properly, there will be a great loss in materials, labour and time.

Dimensioning is known as the method of writing various sizes (or) measurements of an object and other important informations such as tolerances on a finished drawing. It should be done with great care that no information is left out in describing the object completely.

4.8 Types of dimensions

It should be noted that any object is made up of different shapes in the form of a cube, cylinder, cone, sphere etc., Hence it is easy to place dimensions of these geometrical forms separately and to locate each from the other. So the dimensions used in engineering drawing may be classified as

1. Size dimensions   2. Locating dimensions

4.8.1 Size dimensions

Size dimensions are used to indicate various sizes of an object such as length, breadth, height, radius and diameter. In the diagram shown below size dimensions are represented by the letter 'S'

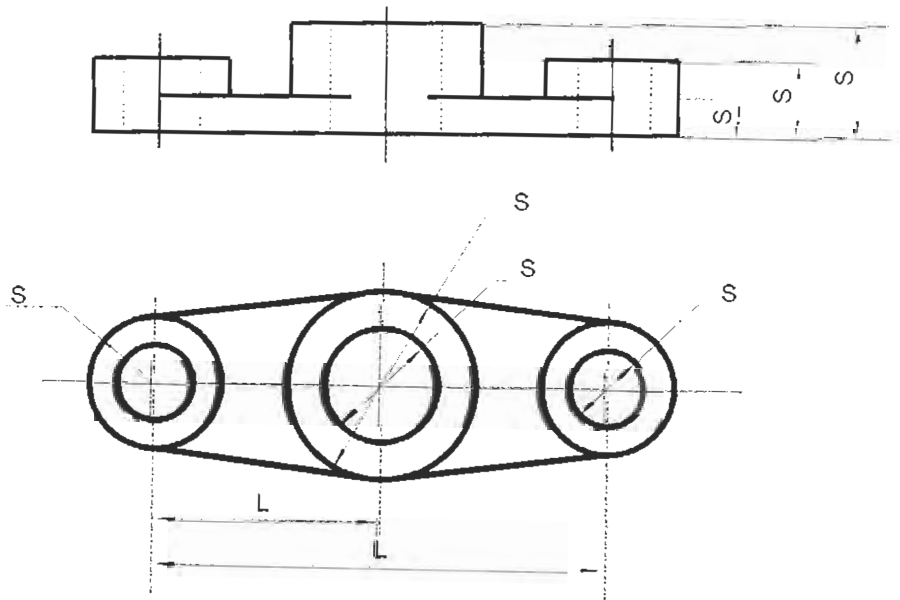


Fig. 4.5 Size and locating dimensions
S - Size dimensions L - Locating dimension

4.8.2 Locating dimensions

Locating dimensions are used to locate the position of a feature of the object with relation to another feature. Distances between the centers of two holes and the distance between the centre of a hole to an edge of the object are some examples for locating dimensions. The letter 'L' represents locating dimensions in the diagram.

4.9 Systems of dimensioning

According to B.I.S., there are two systems of placing dimensions on drawings and they are

1. Aligned system
2. Unidirectional system

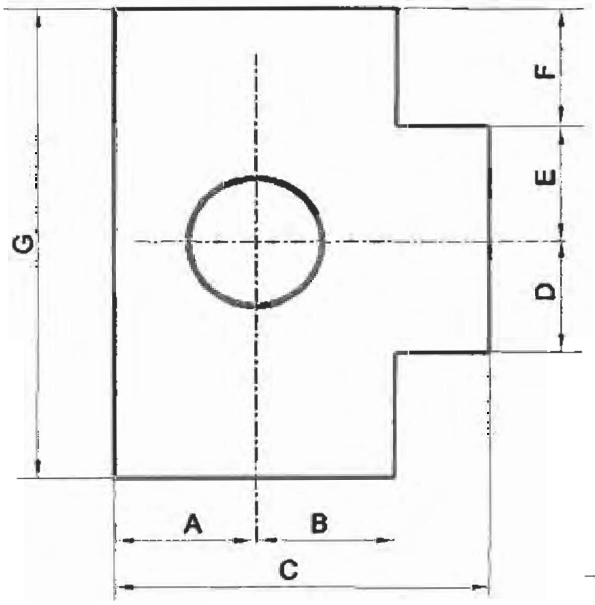


Fig. 4.6 Aligned system of dimensioning

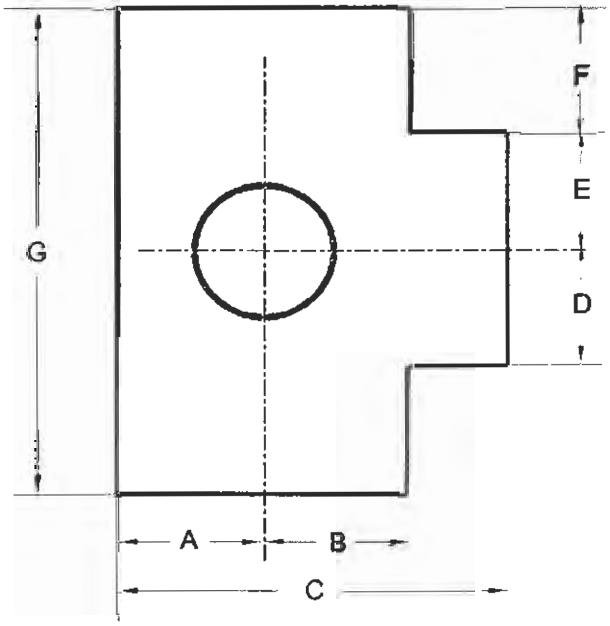


Fig. 4.7 Unidirectional system of dimensioning

4.9.1 Aligned system

In this system, the dimensions are placed in a manner to read them from the bottom or from the right side of the drawing. All the dimensions are placed above the dimensions lines. Aligned system of dimensioning is commonly used in engineering drawing.

4.9.2 Unidirectional system

In this system, the dimensions are placed so that they may be read from the bottom of the drawing only. The dimensions are placed approximately at the middle of the dimension line by breaking it. There is no restriction in controlling the direction of dimension lines.

4.10 Notation of dimensioning

The dimension lines, extension lines, leader lines, arrow heads, dimension figures, notes and symbols make up the notation of dimensioning.

4.10.1 Dimension line

Dimension lines are used to indicate the measurement in numbers at a space above them or at a space created by breaking them approximately at their centre. Dimension line is drawn as thin continuous line.

4.10.2 Extension line

It is the line that extends from the outline of the object on a drawing. It is a continuous thin line extending atleast about 2mm beyond the dimension line.

4.10.3 Leader line

When some notes are to be made regarding a specific feature of a drawing, leader lines are used. They extend from where the notes have to be applied to a point where the notes are actually written. Leader line has an arrow at one end which touches the particular feature. It is drawn at any convenient angle between 30° to 60°.

4.10.4 Arrow head

Arrow heads are placed at both ends of a dimension line. They touch the extension lines drawn from the outline of the part and indicates the extent of a dimension. The length and width of the arrow should be in the ratio 3:1.

4.10.5 Dimension figure

The size of a specific feature is indicated by the dimension figure either as a numeral or as symbols like Ø, R followed by numerals.

4.11 Types of lines

Engineering drawing is made by the combination of different types of lines. Each line shown in the drawing is meant to represent a seprate meaning. So it is necessary to understand the types of lines and their meaning to make or read a drawing successfully.

4.11.1 Continuous thick line

A continuous thick line in a drawing represents a visible edge or outline. It is drawn with a **H** or **HB** grade pencil.

4.11.2 Continuous thin line

Continuous thin lines are used for construction of a drawing. These lines are also used for drawing dimension lines, extension lines, leader lines, and sectional lines (hatching lines). When used as construction lines, they do not appear on the finished drawing. But in geomentrical drawings, they are not removed. Continuous thin lines are drawn with **2H** pencils.

4.11.3 Short dashes

Short dashes represent hidden features or outlines in a drawing. The dashes should be of uniform length and the spacing equal. They are drawn with **H** pencils.

4.11.4 Long chain (thin)

Long chain lines are drawn as an alternative combination of a long dash and a short dash. The lengths of both long dashes and short dashes are to be maintained uniform and they are equispaced. They represent centre lines, extreme positions of movable parts and pitch circles in drawings. This type of line is drawn with a **2H** pencil.

4.11.5 Long chain (thick at ends)

It is very similar to a long chain line except that the terminal long dashes are drawn thick. Cutting plane lines are represented by this type of line. The terminal dashes are drawn with **H** pencil and others with **2H** pencils.

4.11.6 Long chain (Thick)

A long chain line is drawn thick completely for this type of line. The surfaces which are to receive additional treatment are represented by a long chain (thick) line. It is drawn with a **HB** pencil.

4.11.7 Continuous thin (Wavy)

Irregular boundary lines and short break lines are drawn as wavy continuous thin lines. They are drawn with **2H** pencils.

4.11.8 Ruled line and short zigzag (thin)

These lines indicate long break lines. When a long structure of uniform shape is to be shown on a drawing, its view is intercepted by this line and it is drawn with **2H** pencil.

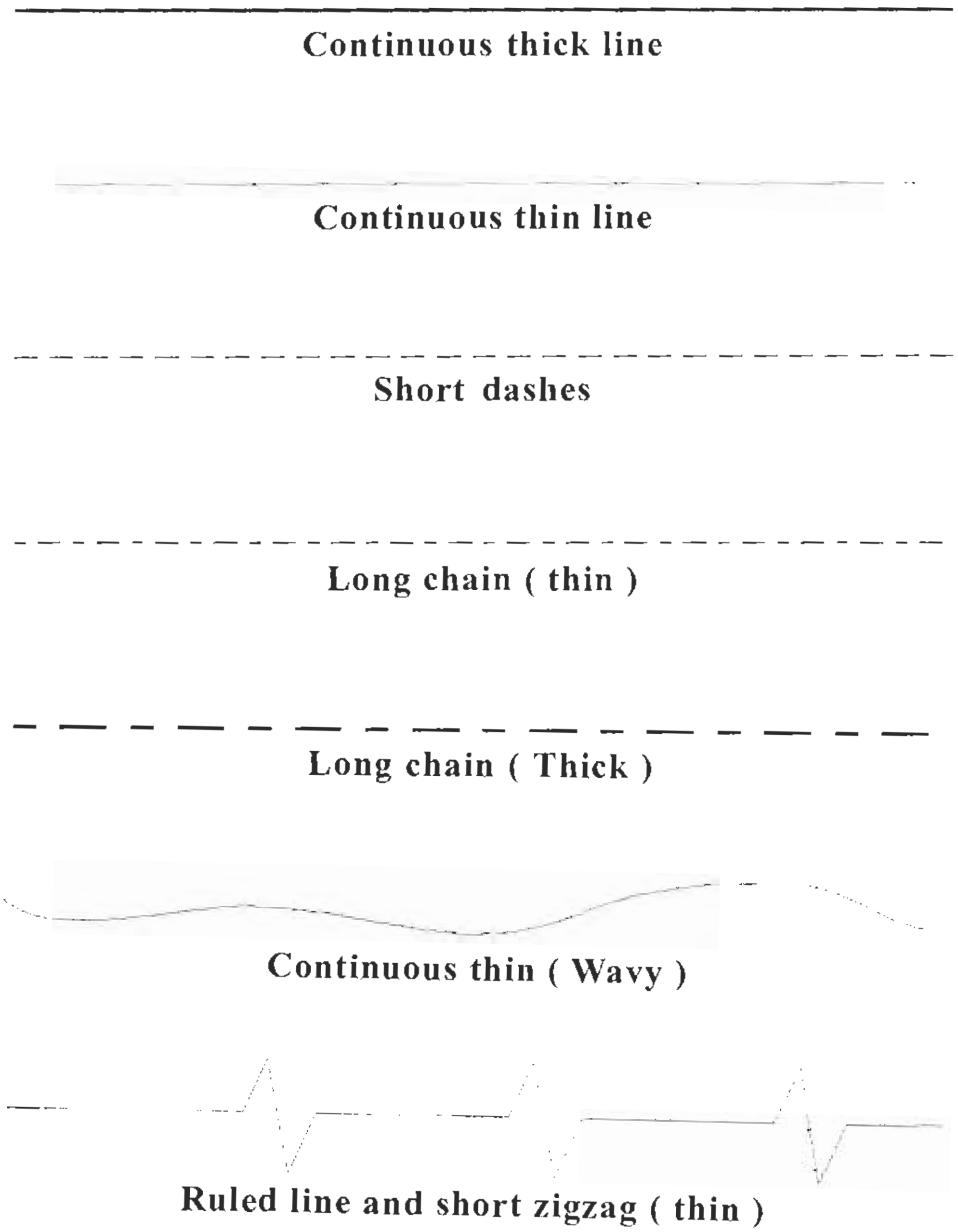


Fig. 4.8 Types of lines

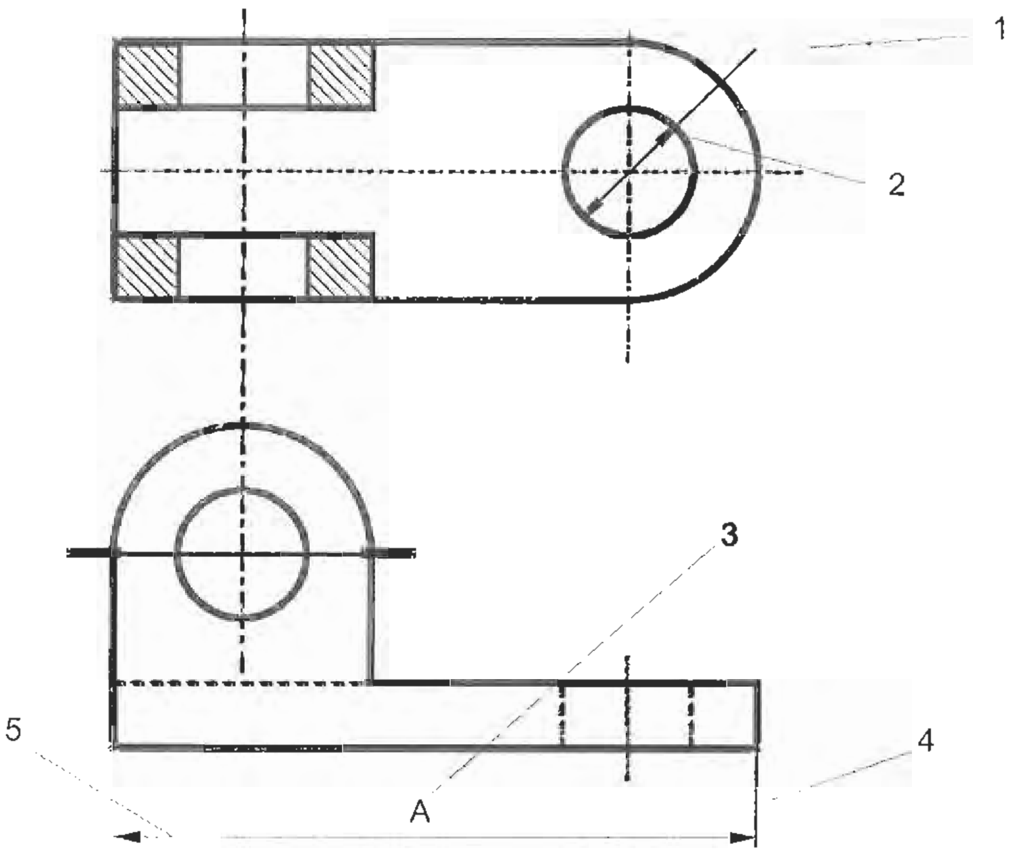


Fig. 4.9 Notation of dimensioning
1. Leader line 2. Arrow head 3. Dimension figure 4. Extension line 5. Dimension line

4.12 General rules for dimensioning

1. Dimensions should be placed outside the view as far as possible.
2. Dimension lines should not intersect each other.
3. Dimension lines should not be placed cutting an extension line.
4. Dimension should be given on the view which shows the relevant features most clearly.
5. Dimensions should never be crowded. If the space is not sufficient, arrow heads may be replaced by dots or inclined lines.

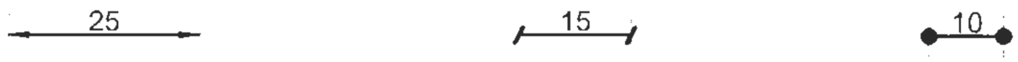


Fig. 4.10 Dimensioning methods

6. The distance between the outline of the object and the first dimension line should be at least 10mm.
7. A distance of atleast 8mm should be kept between two adjacent dimension lines.
8. The extension line should not project beyond 2mm from the dimension line.
9. Leader lines should be constructed at an angle to the horizontal (30^0, 45^0 and 60^0).
10. Centre lines should not be used as dimension line.
11. Dimensions with smaller sizes should be placed near the drawing than those with bigger sizes.
12. Dimensions marked in one view need not be repeated in other views.
13. While dimensioning angles, their values are placed outside the view.
14. Remarks, instructions and foot notes should be written horizontally.
15. Dimensions of parts which are not drawn to scale should be underlined. If the whole drawing is not drawn to scale, a note should be made in the drawing as 'NOT TO SCALE'.
16. When all the dimensions are in same unit, there is no need to mention the unit. Instead a foot note should be written as 'ALL DIMENSIONS ARE IN mm.'
17. The size of the datum plane should be written within brackets.
18. While dimensioning external threads, the type, size and length should be marked.
19. The size of a circle should be indicated by its diameter.

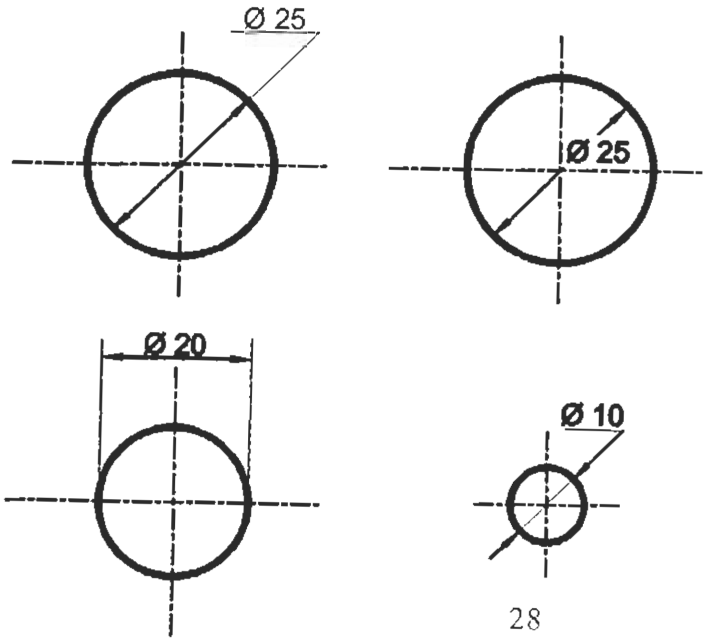


Fig. 4.11 Different methods of dimensioning circles

20. The size of the arcs should be indicated by its radius.

21. While marking the dimension of an arc, the dimension should be preceeded by a mark 'R'.

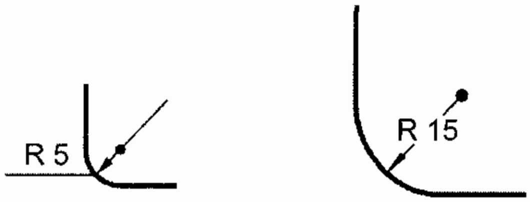


Fig. 4.12 Methods of dimensioning arcs

22. The dimension of spheres is done as shown below

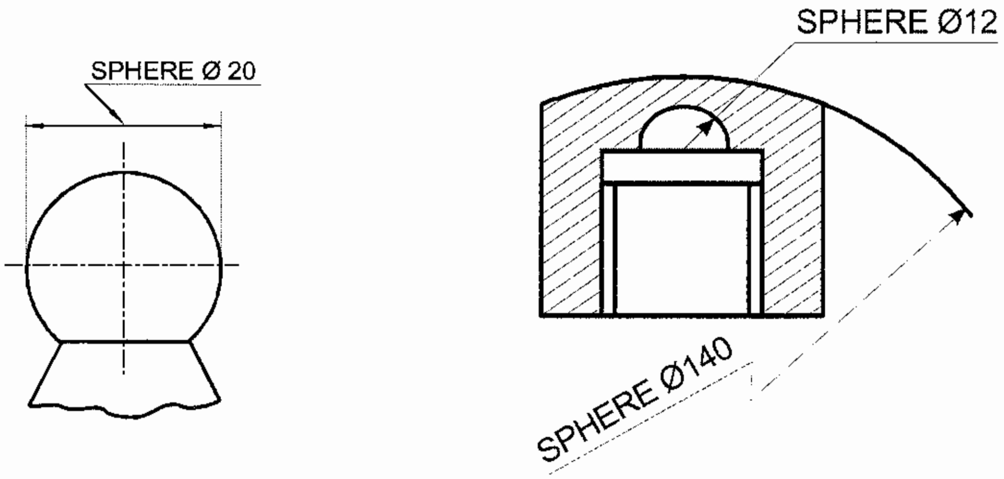
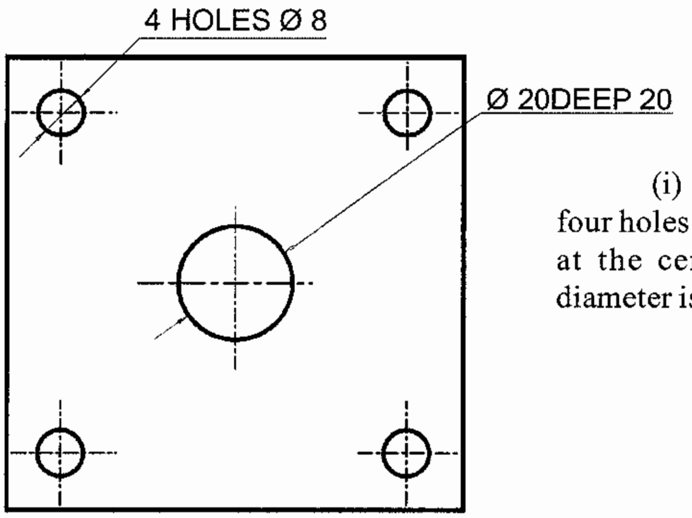


Fig. 4.13 Dimensioning spheres

23. The dimensions of holes may be made in the following methods



(i) It should be understood that the four holes are of 8mm diameter. The hole at the centre is 20mm deep and the diameter is 20mm.

Fig. 4.14
Dimensioning of holes

(ii) The hole on the left is 50mm deep and is of diameter 12mm. The other hole is a through hole of diameter 20mm.

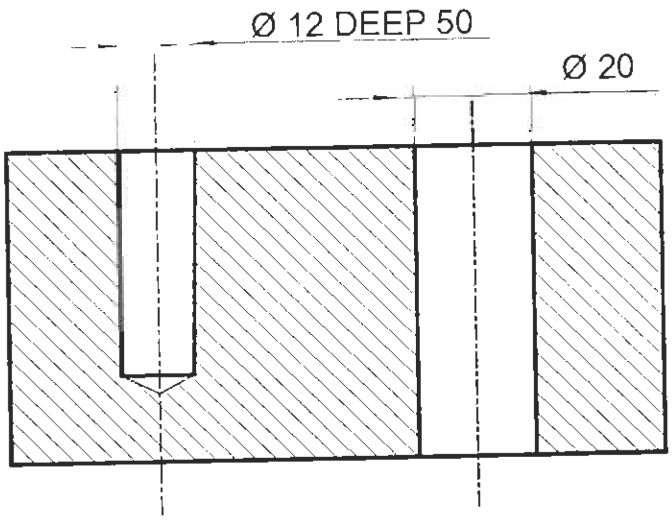


Fig. 4.15 Dimensioning of holes

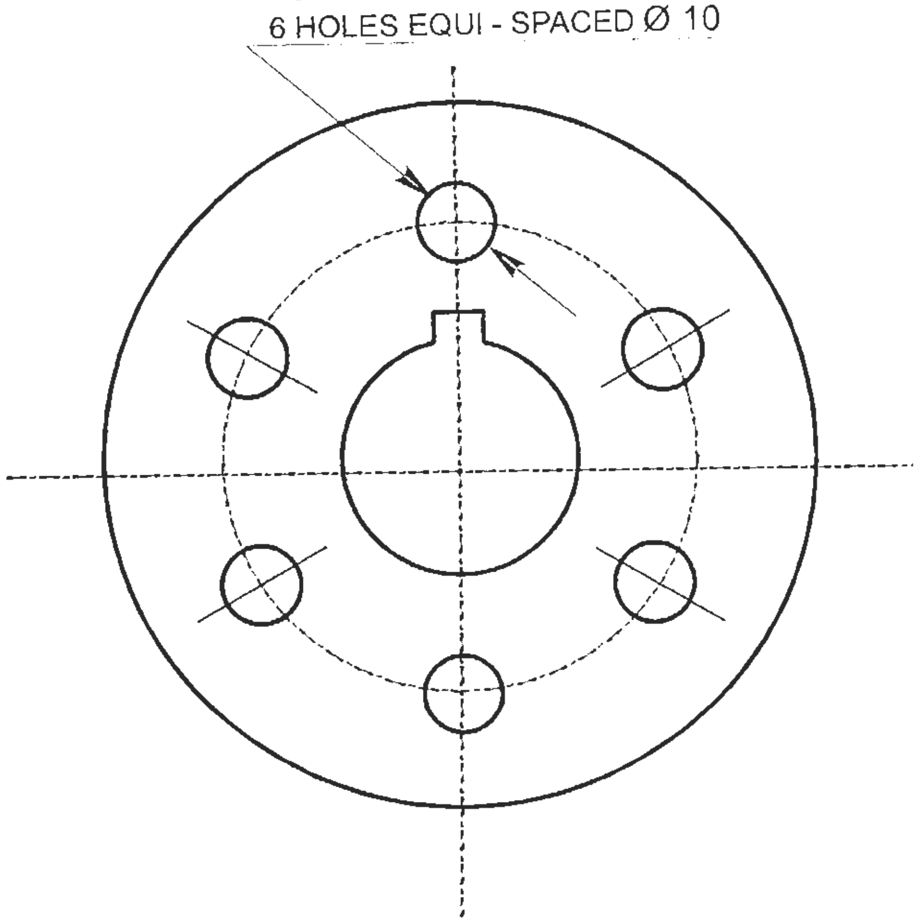


Fig. 4.16 Dimensioning of holes

(iii) The holes of equal size arranged on a circle at equidistance are dimensioned as shown above.

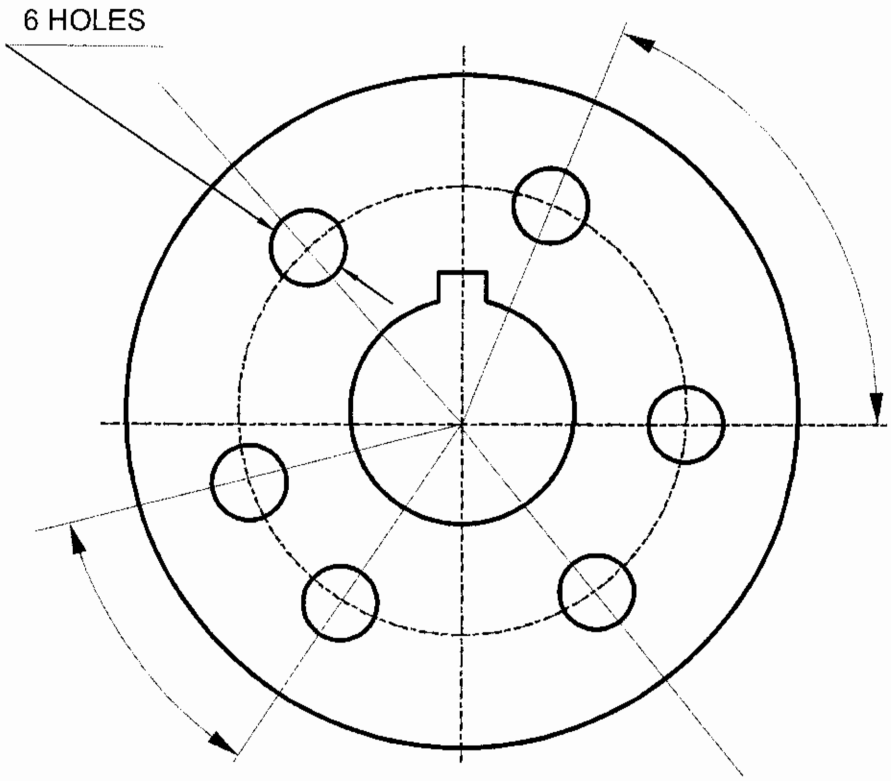


Fig. 4. 17 Dimensioning of holes

(iv) The holes of equal size arranged on a circle at unequal distances from each other are dimensioned as shown above.

24. Countersinking is the enlargement of the top of the hole conically. Countersinking is dimensioned as shown in the following diagrams.

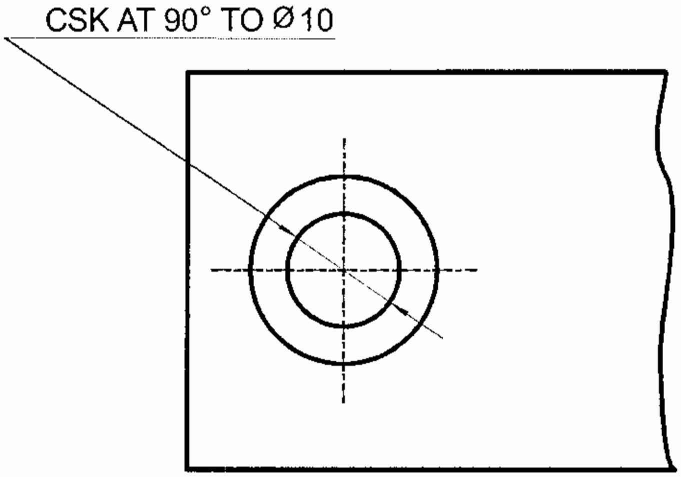


Fig. 4.18 Dimensioning a countersunk hole

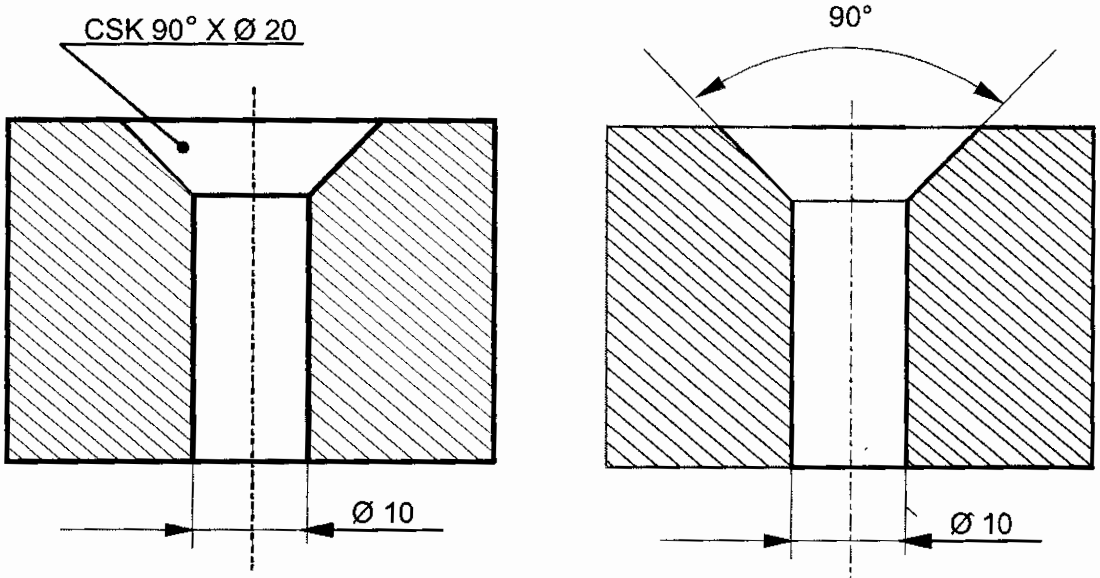


Fig. 4.19 Dimensioning a countersunk hole

25. Counterboring is the enlargement of the top of the hole cylindrically. Counterboring is dimensioned as shown in the following diagrams.

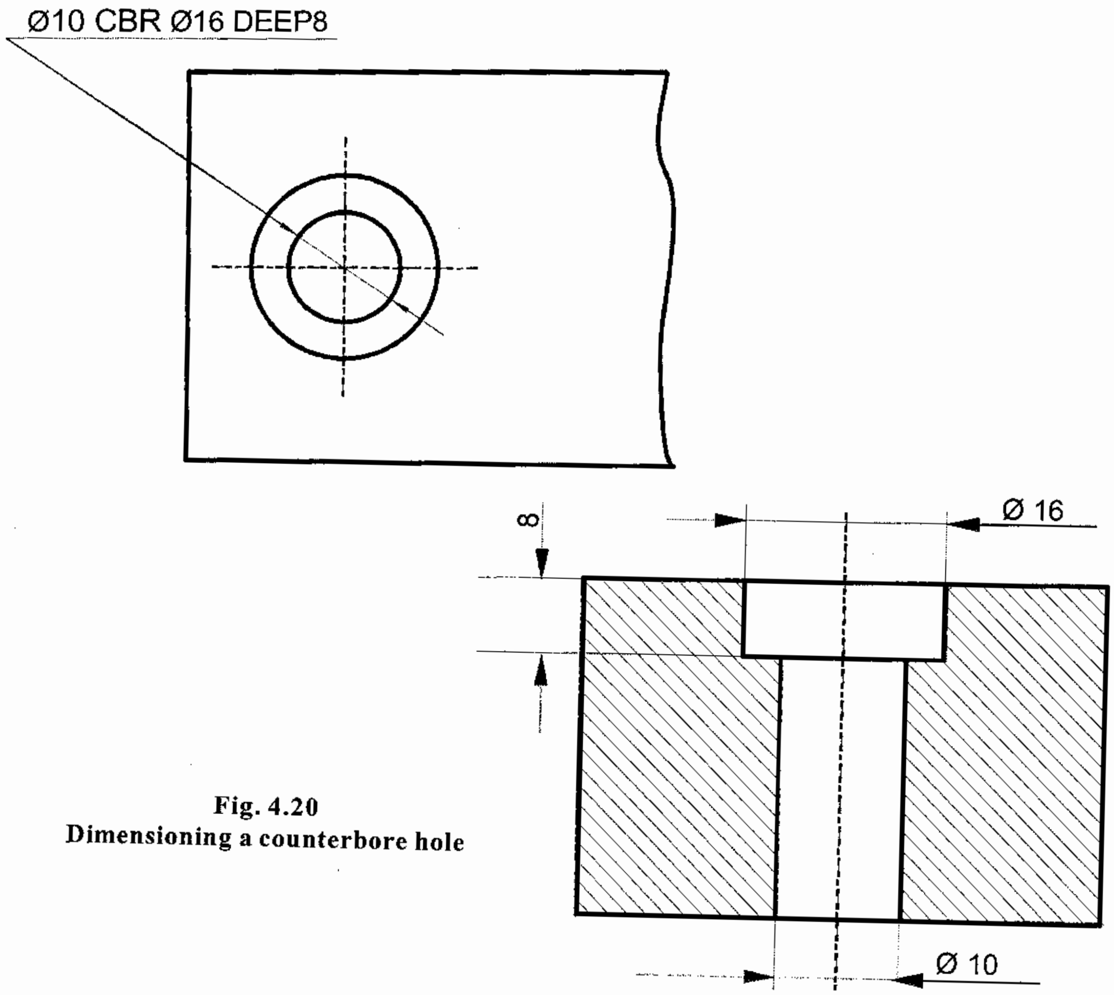


Fig. 4.20
Dimensioning a counterbore hole

26. Chamfering is done at the ends of cylindrical parts and parts having cylindrical holes. Chamfering is dimensioned as shown in the following diagrams.

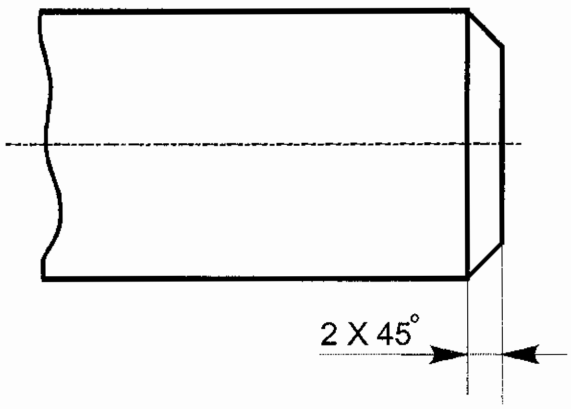


Fig. 4.21 Dimensioning a external chamfer

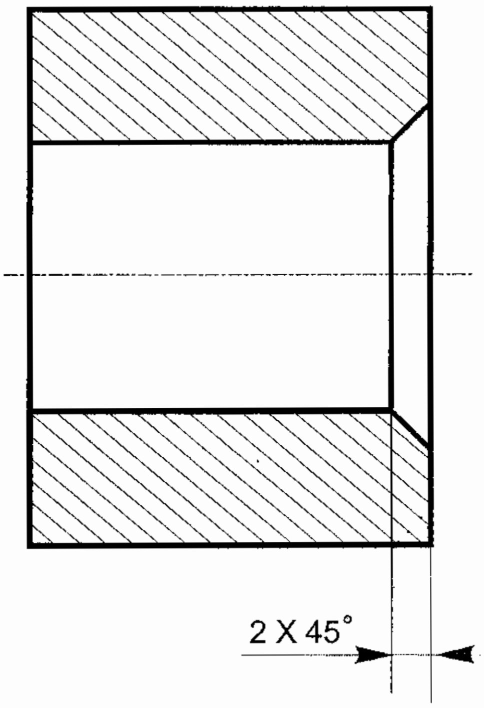


Fig. 4.22 Dimensioning a internal chamfer

27. Square and hexagonal profiles are dimensioned as shown in the diagrams below

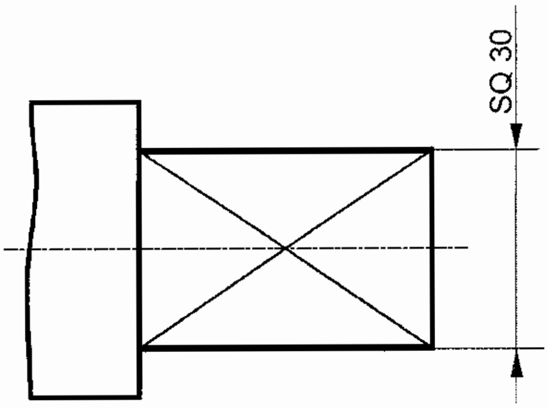


Fig. 4.23 Dimensioning a square profile

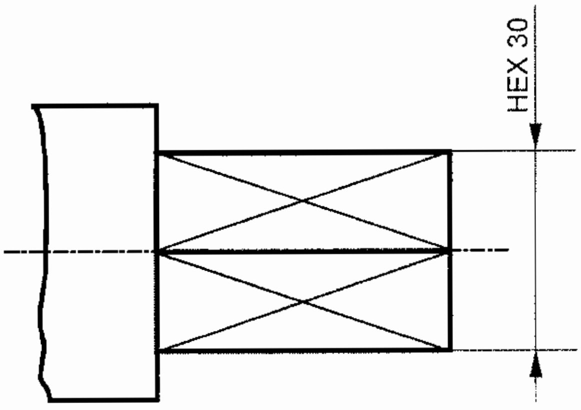


Fig. 4. 24 Dimensioning a hexagonal profile

28. Tapered profiles are dimensioned as shown in the diagram

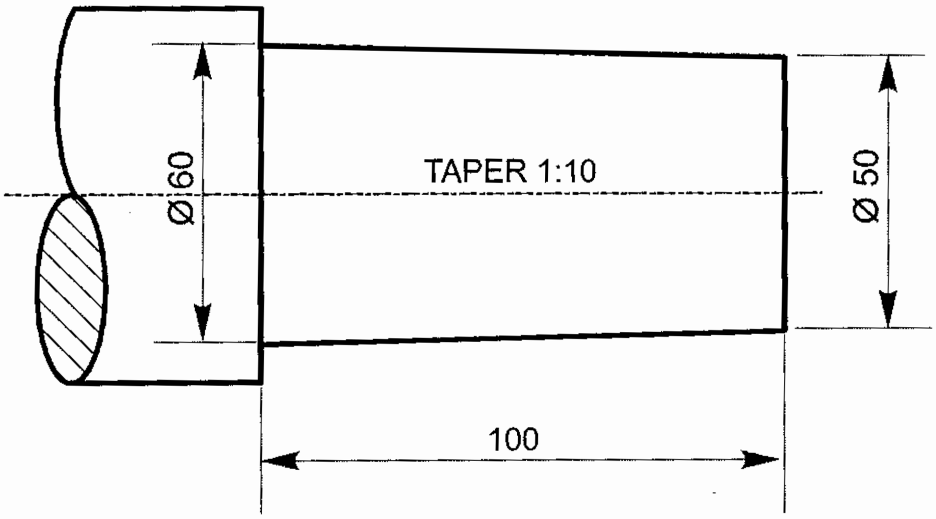


Fig. 4.25 Dimensioning a tapered profile

4.13 Incorrect and correct methods of dimensioning

In the previous section, guidelines are given regarding proper dimensioning of some important profiles. However, there are chances that dimensions may not be repressented in a correct way. Some examples are given in the next few pages to highlight the situations where dimensions are misrepresented frequently and to correct them.

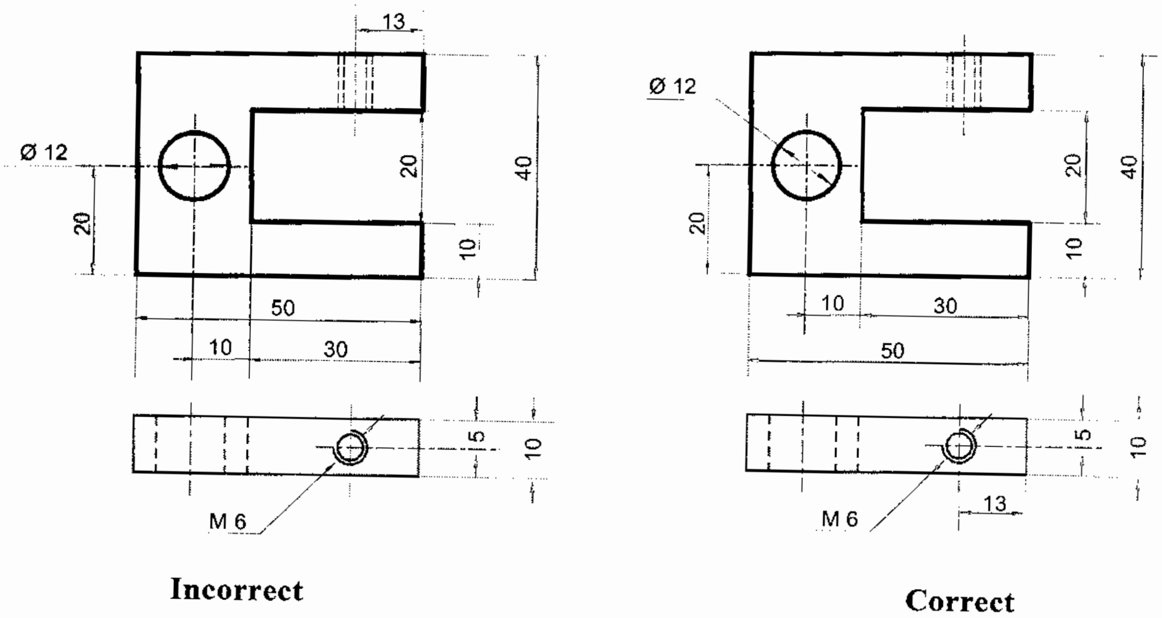
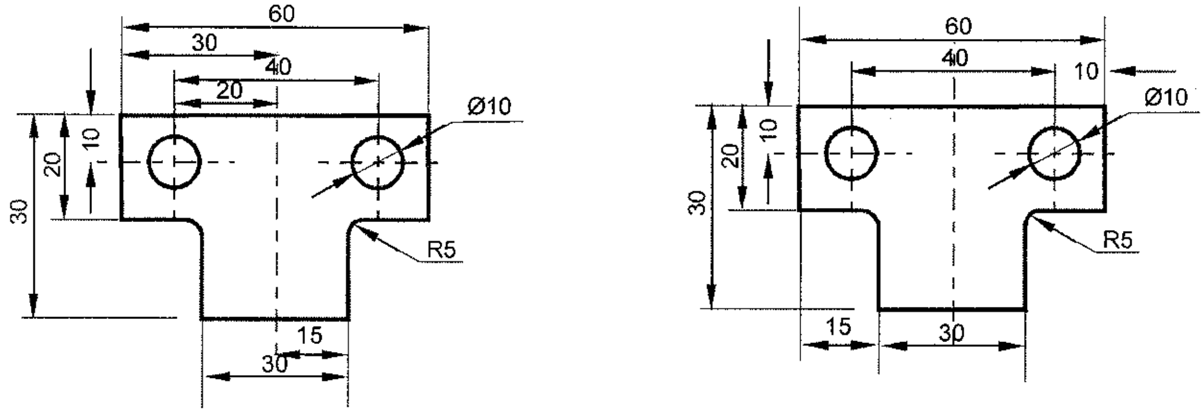
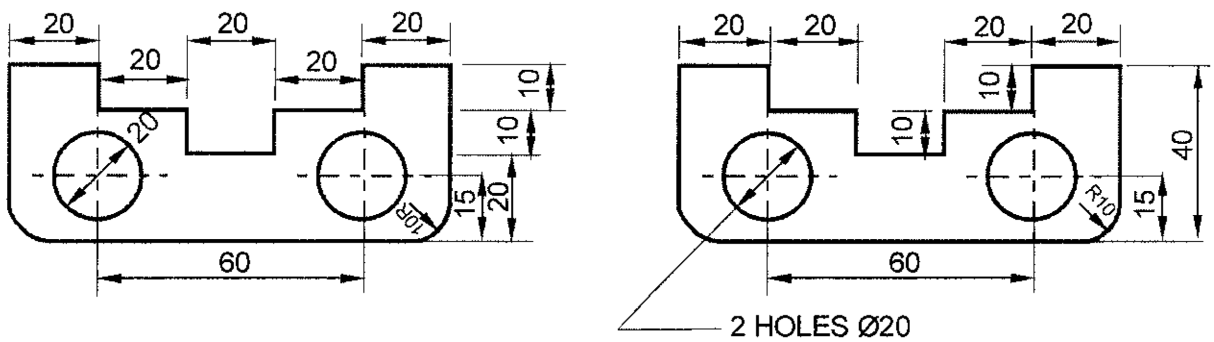


Fig. 4. 26



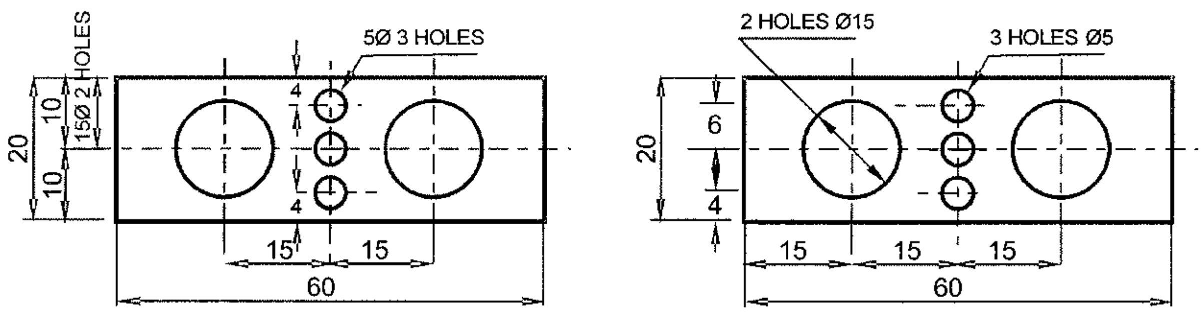
Incorrect Correct

Fig. 4.27



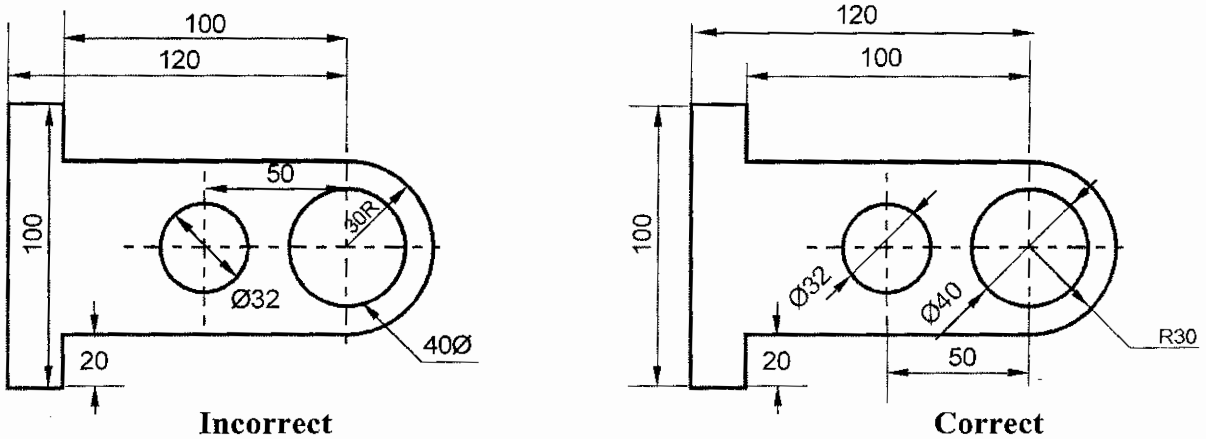
Incorrect Correct

Fig. 4.28



Incorrect Correct

Fig. 4.29



Incorrect **Correct**

Fig. 4.30

Exercise

Some exercises are given to correct the misrepresented dimensioning

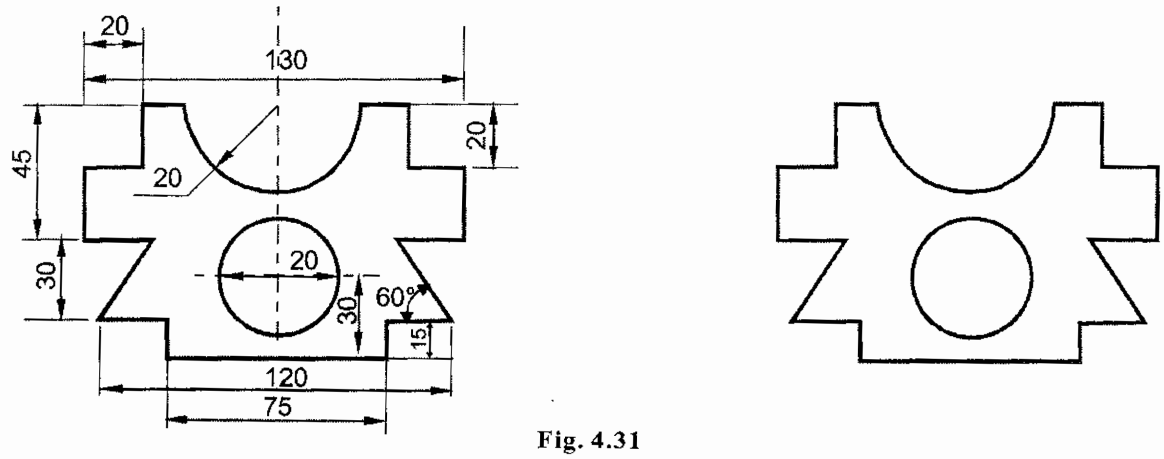


Fig. 4.31

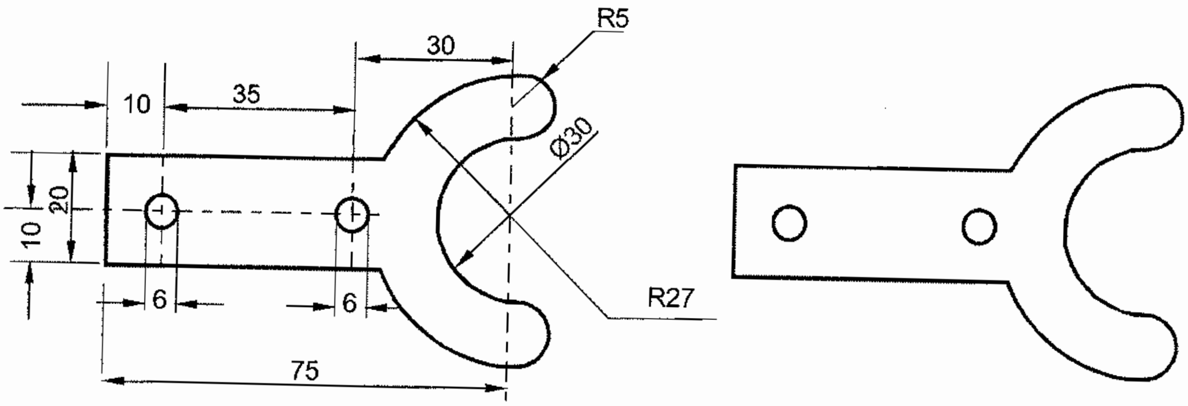


Fig. 4.32

Correct the misrepresented dimensioning

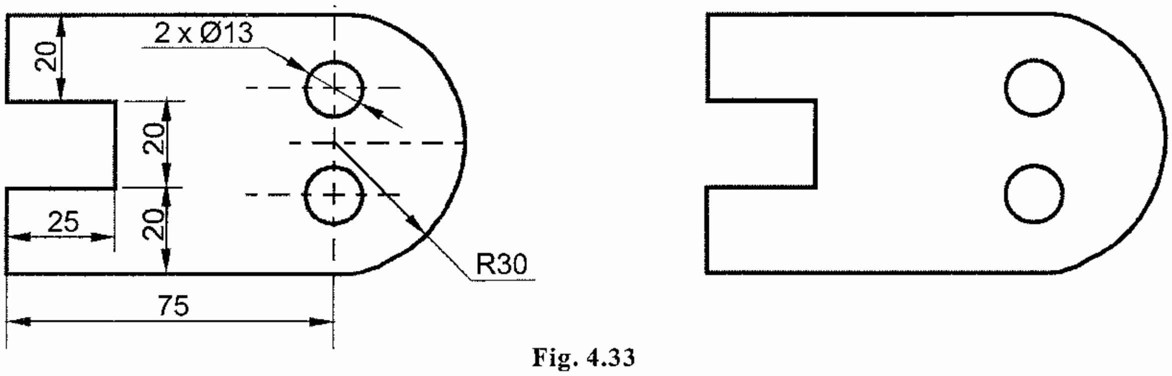


Fig. 4.33

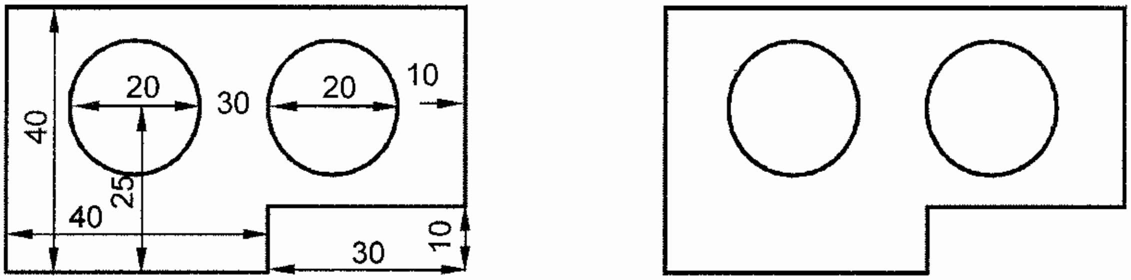


Fig. 4.34

QUESTIONS

I . Choose the correct option

1. The size of letters in the title of the drawing is

   a. 10mm b. 6mm c. 3mm d. 2mm

2. Gothic lettering

   a. is done by writing alphabets with uniform thickness

   b. is done with calligraphic nibs

   c. has shortened width with respect to its height

   d. has more width and normal height

3. The method of placing dimensions parallel and above the dimension lines is

   a. aligned system b. leader line method

   c. extension line method d. unidirectional system

4. The length and width of the arrow head should be in the ratio

   a. 2:1 b. 1:2 c. 3:1 d. 5:2

II. Answer the following questions in one or two sentences

1. What are the main features of lettering ?
2. What are the types of letters ?
3. What do you mean by inclined letters ?
4. What is dimensioning ?
5. What is size dimension ?
6. What is locating dimension ?
7. What is aligned system of dimensioning ?
8. Draw the methods of dimensioning circles.

III. Answer the following questions in about a page

1. What do you mean by size of letters? Explain.
2. Draw different types of lines and specify their applications.
3. Briefly discuss the instructions for correct dimensioning.

5. GEOMETRICAL CURVES

5.1 Introduction

In engineering drawing, it is very important know to how to construct plane curves and special curves as these profiles are useful in representing shapes of various components. They are also useful in the study of some engineering parameters. These geometrical curves can be learnt under two headings.

1) Conics (or) Conical Sections

2) Special Curves

5.2 Conical sections

The sections obtained by the intersection of a right circular cone by a cutting plane at different position to the axis of the cone are called conical sections. They can also be called as conics.

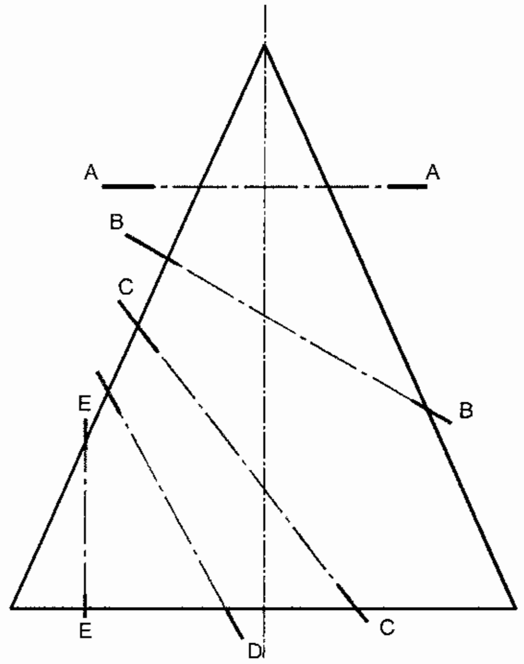


Fig. 5.1 Cutting planes at different angles to the axis of a right circular cone
AA - Circle BB - Ellipse CC - Parabola DD - Hyperbola EE - Rectangular hyperbola

5.2.1 Right circular cone

If the base of a cone is perpendicular to its axis then the cone is called right circular cone. The top most point of the cone is called apex. The axis of the cone is an imaginary line joining the apex and the centre of the base circle. The lines joining the apex and the circumference of the base circle are known as generators.

5.2.2 Circle

When the cutting plane is perpendicular to the axis and cuts all the generators, the obtained section is a circle.

5.2.3. Ellipse

If a section is obtained by allowing the cutting plane at an angle to the axis of the cone cutting all generators, the section is an ellipse.

5.2.4 Parabola

If the cutting plane is inclined to the axis of the cone and parallel to one of the generators, the resultant section is a parabola.

5.2.5 Hyperbola

When the cutting plane cuts the cone such that its angle of inclination with the axis of the cone is smaller than the angle made by the generator of the cone, the obtained section is hyperbola

5.2.6 Rectangular Hypabola

When the cutting plane is parallel to the axis of the cone, the resultant section is a rectangular hyperbola.

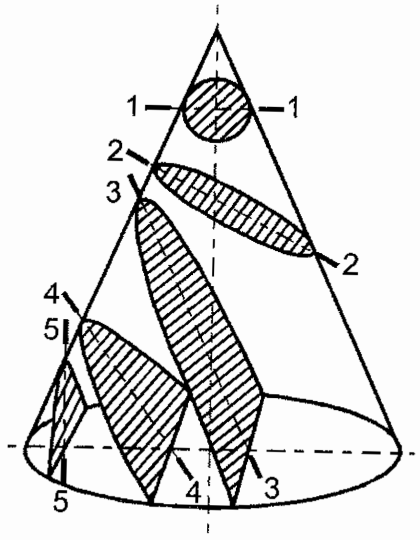


Fig. 5.2 Curves obtained by cutting a right circular cone at different angles

1-1 Circle
2-2 Ellipse
3-3 Parabola
4-4 Hyperbola
5-5 Rectangular hyperbola

5.3. Mathematical definitions of conical sections

5.3.1 Conic

Conic can be defined as the locus of a moving point in a plane such that the ratio between its distance from a fixed point and a fixed straight line is a constant. This ratio is known as eccentricity.

5.3.2 Focus

The fixed point with respect to each of the conics is known as focus (F)

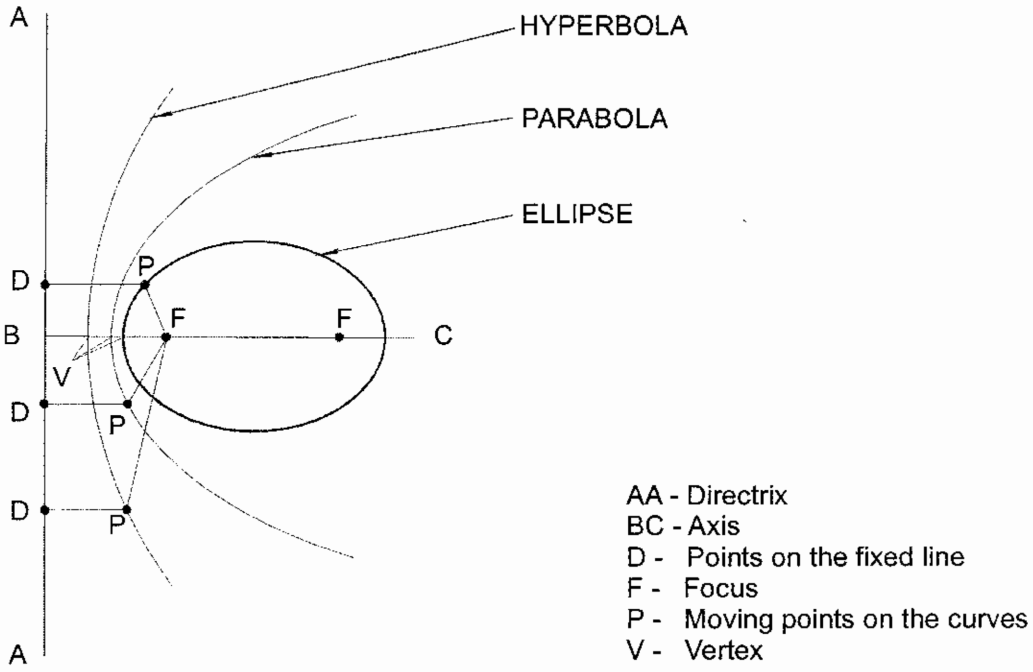


Fig. 5.3 Mathematical representation of conical sections

5.3.3 Directrix

The fixed straight line regarding all these conics is known as directrix.

5.3.4 Eccentricity

$$\text{Eccentricity} = \frac{\text{Distance of the moving point from the focus}}{\text{Distance of the moving point from the directrix}}$$

5.3.5 Axis

The line passing through the focus and perpendicular to directrix is called axis.

5.3.6 Vertex

The point at which the conic cuts the axis in known as vertex.

5.3.7 Ellipse

Ellipse is the curve generated by a point moving in such a way the ratio of the distance from the fixed point (Focus) to its distance from the fixed straight line is a constant. The ratio is always is less than 1 (directrix).

5.3.8 Parabola

Parabola is the curve generated by a point moving in a plane in such a way that the ratio of its distance from the fixed point to its distance from the fixed straight line is a constant and is always equal to 1.

5.3.9 Hyperbola

Hyperbola is a curve generated by a point moving in such a way that the ratio between the distance from the fixed point and its distance from the fixed straight line is a constant and is greater than l.

5.4 Construction of Ellipse

The methods of constructing ellipse are

1) Concentric circles methods

2) Rectangle method

3) Parallelogram method

4) Eccentricity method

4) Pin and string method

6) Trammel method

5.4.1 Concentric circle method

For constructing an ellipse by concentric circles method, only the major axis and the minor axis dimensions are given.

Two perpendicular lines AB and CD are drawn representing the dimensions of major axis and minor axis generally by keeping the major axis in horizontal position. With the point of intersection of these lines as centre (O), two concentric circles are drawn with major axis and minor axis as their diameters.

The circumference of these circles are divided into 12 or 16 equal parts and radial lines are drawn though these points. The radial lines interact the two circles at 1, 2, 3, - - - - - - - 12 and 1', 2', 3', - - - - - - - - - 12'.

Vertical lines are constructed through the points 1, 2, 3, - - - - - - — - - 12 and horizontal lines are drawn through 1', 2', 3', - - - - - - - - 12'. These pairs of lines intersect to get points P_1, P_2, P_3, - - - - - - - - - P_{12} though which a smooth curve of ellipse is drawn.

Constructing an ellipse with major axis 100mm and minor axis 60mm.

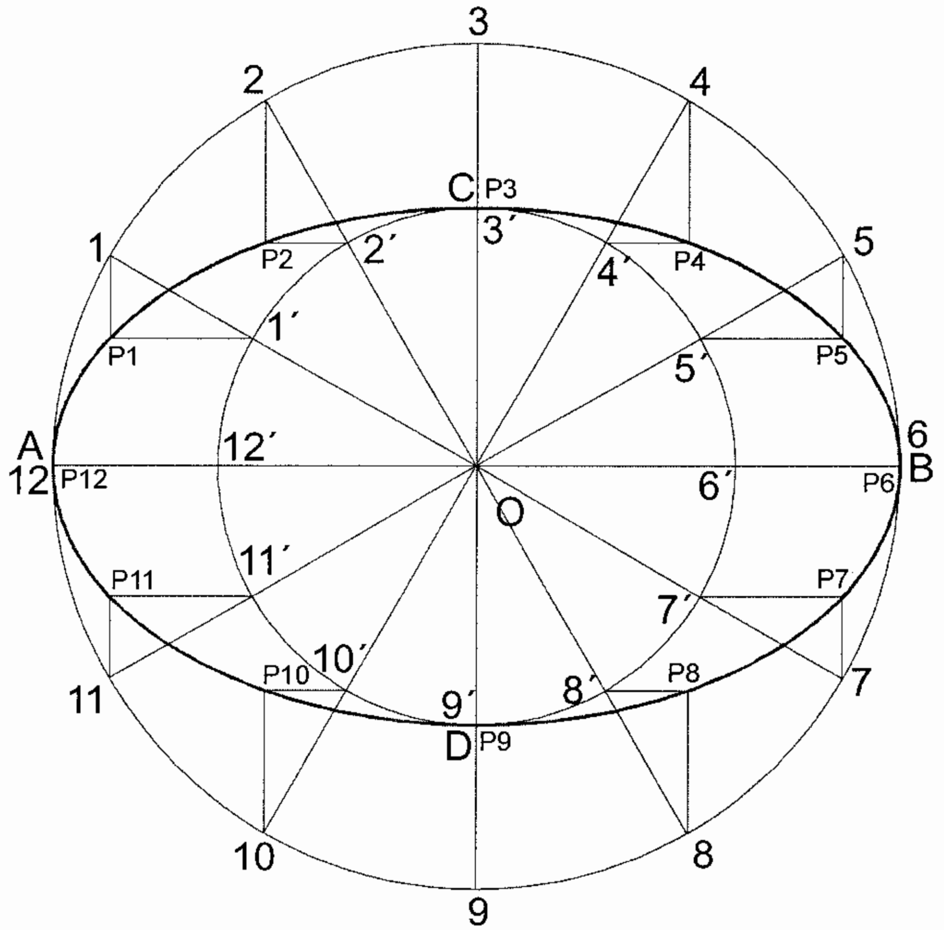


Fig 5.4 Construction of ellipse by concentric circles method

5.4.2. Rectangle Method

Constructing an ellipse by rectangle method involves the dimensions of major and minor axis.

Two perpendicular lines (AB & CD) are drawn measuring major axis and minor axis so that they bisect each other at a point O. Through the terminal points of the major axis (A & B) two lines parallel to CD (PQ & RS) are drawn. Another pair of lines parallel to AB (QR & PS) are drawn through the terminal points of the minor axis (C & D). A rectangle PQRS is obtained.

AB = PS = QR and CD = QP = RS. AQ is divided into 4 equal parts and named as 1, 2, 3. AO is also divided into same number of equal parts (4) & named as 1_1, 2_1, 3_1. Lines are drawn from D connecting the points 1, 2, & 3. C 1_1 is drawn and extended to meet D1 at P_1. Similarly C$2_1$and C3_1 are drawn and extended to get points P_2 and P_3. A smooth curve is drawn through the points A, P_1, P_2, P_3 and D.

The same procedure is followed on all the three other quarter of the rectangle PQRS and the ellipse of given dimensions is obtained.

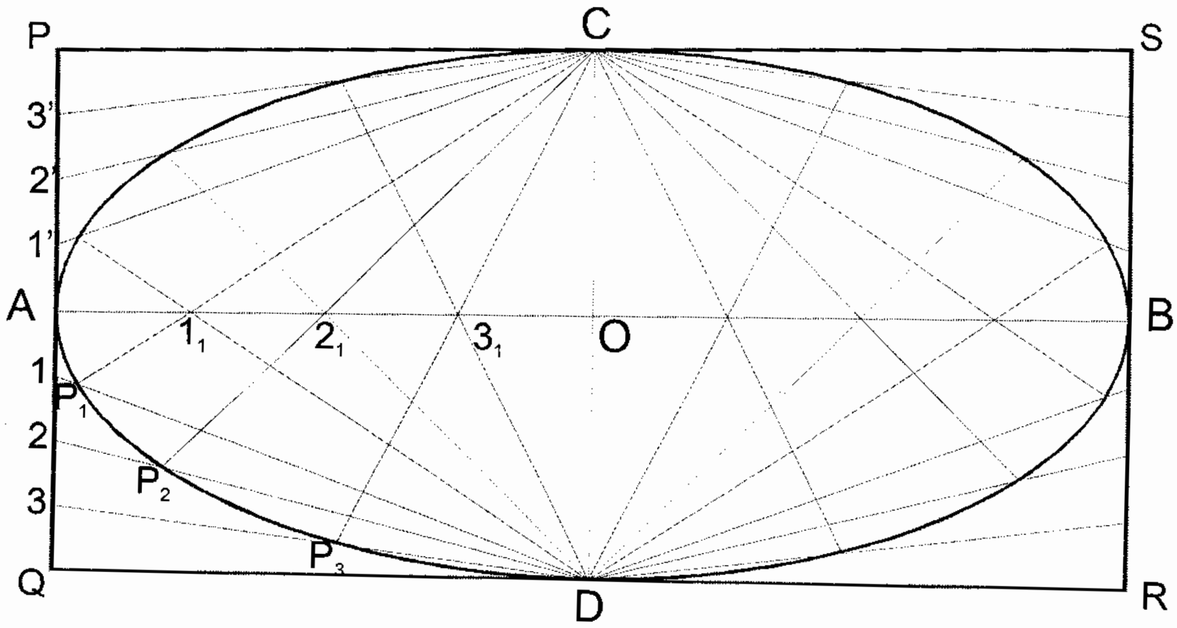


Fig 5.5 Construction of ellipse by rectangle method

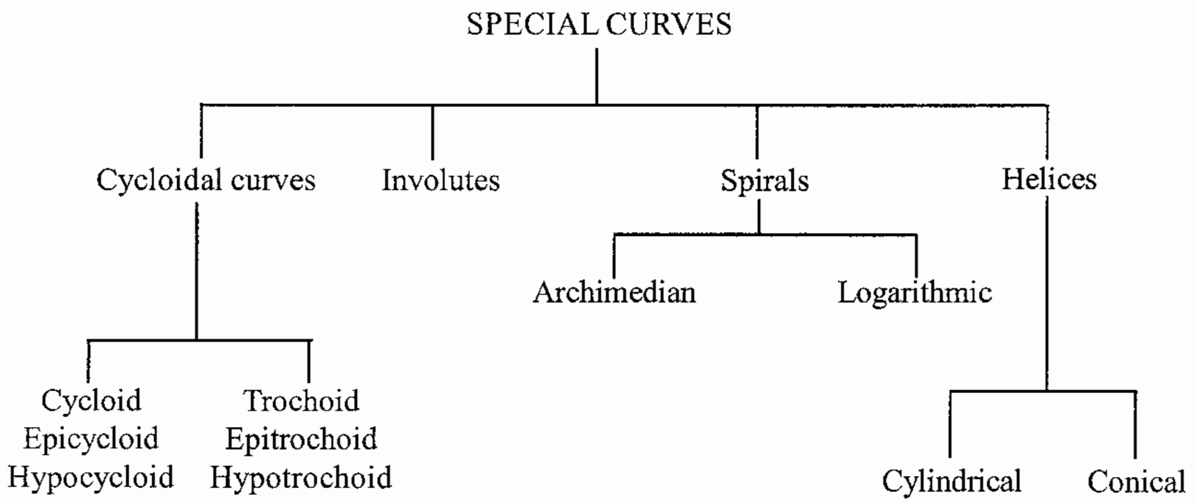
5.4.3 Engineering applications of ellipse

The curve of ellipse can be used for

- Concrete arches
- Stone bridges
- Glands
- Stuffing boxes
- Reflectors used in automobiles

5.5 Special curves

Apart from practising to construct conical sections, an aspiring engineer at this level needs to know about some special curves. Cycloids, Trochoids, Involutes and Spirals are some curves which find engineering application.



Classifications of special curves

5.5.1 Cycloidal curves

Cycloidal curve is made by a fixed point on the circumference of a circle when rolled along a fixed straight line or a circle without slipping.

Cycloidal curves are : 1) Cycloid 2) Epicycloid 3) Hypocycloid

When a circle is rolled without slipping on a straight line, the curve generated by a point on the circle is known as **cycloid**.

When a circle (generating circle) is rolled without slipping on another circle (directing circle), the curve generated by a point on the generating circle is called **epicycloid**.

When a circle (generating circle) is rolled without slipping on the inside of another circle (directing circle), the curve generated by a point on the generating circle is known as **hypocycloid**.

5.5.2 Involute

Involute is a curve generated by a point on a piece of thread when it is unwound from a geometrical shape. The thread (or) string is kept tight when it is unwound. The gemotrical shape may be a circle, a triangle or a polygon. The involute of a circle is known as evolute.

5.5.3 Spirals

Spiral is a curve generated by a point which moves around a centre called pole while moving towards or away from the centre.

5.5.4 Helix

Helix is a curve generated by a point moving around and along the surface of a right circuular cone with a uniform angular velocity about the axis and with a uniform linear velocity in the direction of the axis.

5.6 Surfaces

An object may have a combination of surfaces of different types. They may be simple as flat surfaces or complicated like the surface of an asbestas roofing sheet. The different types of surfaces are

I. Flat surface

a. Horizontal surface   b. Vertical surface   c. Inclined surface

II. Spherical surface

a. Concave surface   b. Convex surface

5.6.1. Flat surface

A flat surface is free from any irregularities. A flat surface may be horizontal, vertical or inclined.

Example : Surfaces of walls, floorings in the house and surfaces of the slides that children play

Horizontal surface :

A flat surface which is horizontal is known as horizontal surface. The top surface of the table and floors of buildings are some examples of horizontal surface.

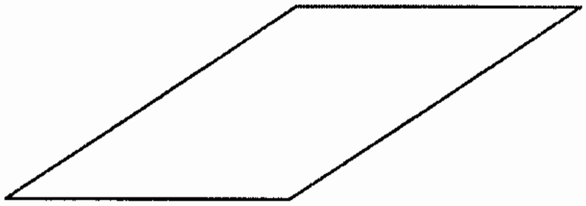


Fig. 5.6 Horizontal surface

Vertical surface :

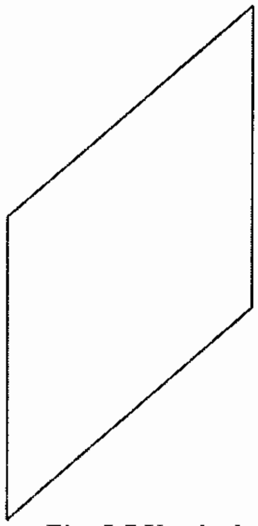


Fig. 5.7 Vertical surface

A flat surface which is perpendicular to the horizontal surface is called vertical surface. The walls of rooms and the sides of doors are some examples for vertical surfaces.

Inclined surface :

A surface which is neither horizontal nor vertical and inclined at any angle between them is known as inclined surface. The surface of the play slides is a vertical surface.

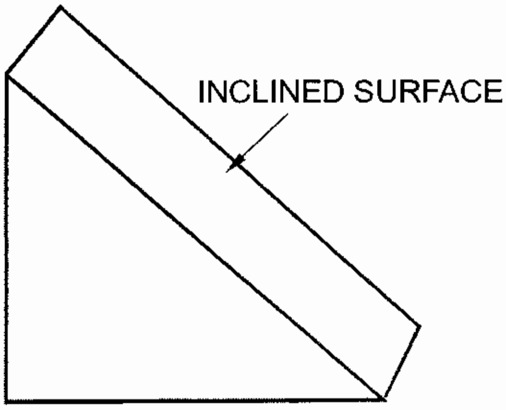


Fig. 5.8 Inclined surface

5.6.2 Spherical surface

Both concave and convex surfaces are categorised as spherical surfaces.

Concave surface

The surface which is curved inside spherically is known as concave surface. The inner surfaces of the decorative arches are examples of concave surface.

A B

Fig. 5.9 Spherical surface

A - Concave surface B - Convex surface

Convex surface

The surface which is curved outside spherically is known as concave surface. The outer surface of a rubber ball is an example of convex surface.

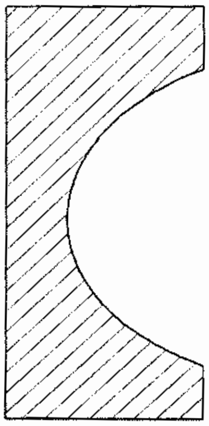


Fig. 5.10 Parabolic surface

5.6.3 Parabolic surface

A parabola is a curve obtained when a cutting plane inclined to the axis of the cone and parallel to one of the generators cuts a right circular cone. A surface resembling a parabola is known as parabolic surface. The reflectors of automobiles is an example of parabolic surface.

QUESTIONS

I A. Choose the correct option

1. The surface of a wall is

a. irreglar surface	b. vertical surface
c. horizontal surface	d. inclined surface

2. The surface of the sectioned rubber ball will be

a. irreglar surface	b. concave surface
c. convex surface	d. flat surface

I B. Answer the following questions in one or two words

1. What is the name of the surface at right angles to the horizontal surface?
2. What is the name of the surface of the reflector of automobiles?

II . Answer the following questions in one or two sentences

1. What do you mean by conics ?
2. What is an ellipse ?
3. Mention the types of flat surfaces.
4. What are the types of spherical surfaces ?
5. What do you mean by corrugated surface ?

III. Answer the following questions in about a page

1. Explain the curves obtained by sectioning a right circular cone by cutting planes at different angles to its axis.
2. Explain - Flat surface, Horizontal surface, Vertical surface and Inclined surface

6. SCALE OF A DRAWING

6.1 Introduction

It is now our knowledge that drawings are made to show all the details of objects clearly. But, it is not always possible to show the objects on a drawing sheets in actual sizes. For example, large machine parts cannot be represented on a drawing sheet in its original size. Hence, it is necessary to reduce the size of the object in a fixed proportion to show it in a drawing. At the same time, it is necessary to increase the size of the object in some cases to give a clear description of the object.

In both cases, a proportion is used either to reduce or increase the dimensions of the object. So the proposition by which the actual size of the object is reduced or increased on a drawing is known as **scale of a drawing.**

Scales are usually made of celluloid, card board, wood or metal. They are actually rulers on which different propositions are represented to make drawings of objects having different range of dimensions. As far as possible, standard scales are adopted in making drawings. The standard scales are designated as M1, M2, M3 - - - - - - - - - M8 as explained in chapter 2 (2.6). When standard scales are not suitable for making a particular drawing, scales in required proposition can be constructed.

6.2 Uses of Scales

The important uses of scales are

1) Scales are useful in making reduced size and enlarged size drawings.
2) Dimensions are set off on drawings when the scale used is indicated in the title block of the drawing.
3) The dimensions of various parts can be measured directly.

6.3 Types of Scales

There are three types of scales according to the proportions made on them.

1) Full size scale

2) Reducing scale

3) Enlarging scale

6.3.1 Full size scale

When the measurements of objects are shown on a drawing in its actual sizes, the scale used in the drawing is full size scale. *Full size scale is indicated as 1: 1*

6.3.2 Reducing scale

When the size of the object is too large to be accommodated on a drawing sheet, the dimensions of the object are reduced in a particular proportion and represented in the drawing. This scale is known as reducing scale. *Eg:- 1 : 2, 1: 5 & 1 : 10*

6.3.3 Enlarging scale

When the size of the object to be shown on the drawing sheet is very small to give clear description about the object, the dimensions of the object are enlarged in a particular proportion. This scale is called enlarging scale. *Eg:- 2 : 1, 5 : 1, 10 : 1.*

6.4 Units used in measuring dimensions

In this context it is important to know the units which are in use to measure dimensions in metric system.

6.4.1 Units for measuring linear dimensions

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

6.4.2 Units for measuring area

100 Square Millimeters (mm^2)	= 1 Square Centimeter (cm^2)
100 Square Centimeters	= 1 Square Decimeter (dm^2)
100 Square Decimeters	= 1 Square Meter (m^2)

6.4.3 Units for measuring volume

1000 Cubic Millimeters (mm^3)	= 1 Cubic Centimeter (cm^3)
1000 Cubic Centimeter	= 1 Cubic Decimeter (dm^3)
1000 Cubic Decimeter	= 1 Cubic Meter (m^3)

6.5 Representative Fraction (R. F)

Representative Fraction is the ratio of the distance of the object on the drawing to the corresponding actual dimension of the object in same units.

$$\text{R. F} = \frac{\text{Distance on the drawing of an object}}{\text{Corresponding actual dimension of the object}}$$

To calculate Representative Fraction of a drawing when 1 centimeter on the drawing represents 1 meter in actual size.

$$\text{R. F} = \frac{\text{Distance on the drawing of and object}}{\text{Corresponding actual dimension of the object}}$$

$$= \frac{1}{1 \text{ X } 10 \text{ X } 10} = \frac{1}{100} = 1 : 100$$

In constructing scales calculating the Representative Fraction (R. F) is very important.

6.6 Necessary informations required for constructing scales

As explained in section 6.1, when the required scale is not found in the standard set of scales, the same has to be constructed. While doing so, the following informations are necessary.

1) Representative Fraction (R. F)

2) Maximum length of the scale

3) Units to be represented in the scale

The maximum length of the scale is determined in such way that it is slightly longer than the maximum dimension that is going to be represented in the drawing.

Dimensions may be measured in same units all through the drawings. Some times, they are measured in two or three units. (like centimeters, decimeters and meters). In some other cases, it may be unit and a fraction of the same unit.

6.7 Classification of scales

Depending on the requirement of size and units that are to be represented, different types of scales are used. They are classified as

1. Plain scale
2. Diagonal scale
3. Comparative scale
4. Vernier scale
5. Scale of chords

6.7.1 Plain scale

Plain scale is a line which is divided into suitable number of equal parts or units, the first part of which is further divided into small parts or sub-units of main unit. Plain scales are used to represent two units or one unit and its fraction. For example

i) kilometers and hectometers

ii) meters and decimeters

iii) centimeter and millimeter

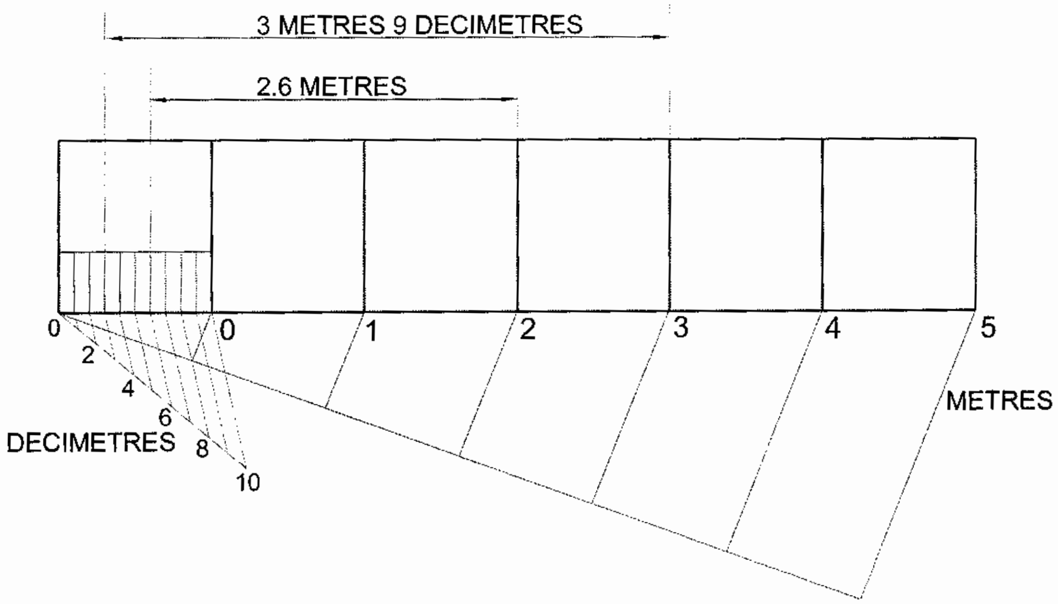


Fig 6.1 A sample plain scale

In the sample scale shown above, an actual distance of 40 units is representated as 1 unit in the scale. The units of decimeters and meters are shown.

6.7.2 Diagonal Scale

Diagonal scale is similar to a plain scale except that the first part which is divided into small part is further divided to represent a third small unit or the decimal of the second unit. Diagonal scales are used to represent three units of dimensions like meter, decimeter and centimeters. They can also be used to represent two units and a fraction of the second unit.

6.7.3 Scale of chords

It is used to make out or to measure angles of any measurement

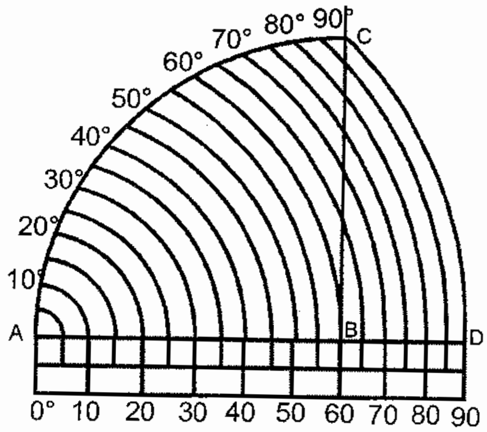


Fig 6.2 Scale of chords

QUESTIONS

I. Answer the following questions in one or two words

1. What is the name of the scale when the measurements of an object are shown on a drawing in its actual sizes?
2. What do you mean by plain scale?
3. Mention any one type of a scale.
4. What is the ratio of the scale when the distance on a drawing is twice that of the actual size?

II. Answer the following questions in one or two lines

1. What is scale of a drawing ?
2. What are the important uses of scales ?
3. What are the types of scales ?
4. How are scales classified ?
5. What is Respresentative Fraction (R.F.) ?

III. Answer the following questions in about a page

1. Explain the types of scales.
2. How are scales classified ? Explain.

7. THEORY OF PROJECTION

7.1 Introduction

In the introductory chapter, it was explained that the need of the drawing is to communicate the ideas and informations regarding an object between a number of engineers and operators in the fields of designing, developing, manufacturing and marketing. As regards to solid geometric drawing, there is the necessity of presenting the informations about a three dimensional object on a two dimensional plane of paper. In overcoming this difficulty, the views of the objects are represented pictorially. Apart from pictorial drawings, the information about the object can be represented in more than one view arranged in a specified order. In general, obtaining the views of the object on a drawing sheet is known as **projection** and procedures and rules involved in the process are known as **theory of projection.**

7.2 Theory of projection

In engineering drawing, the exact shape and size of an object should be shown on a two dimensional plane of paper. For doing so, the object is imagined to be located between the observer and the plane on which the view is going to be obtained. Straight lines are drawn from different points on the contour of the object to meet the plane of paper. The points obtained on the sheet of paper are joined in proper sequence to form the image or view of the object.

7.2.1 Projectors

The imaginary lines drawn from the contour of an object to meet the plane of paper are called **projectors.**

7.2.2 Projection

The image or view obtained on the plane of paper is known as **projection.** The image is formed by joining the points obtained on the plane in proper sequence.

7.2.3 Plane of projection

The plane on which the image or view is obtained is called **the plane of projection.**

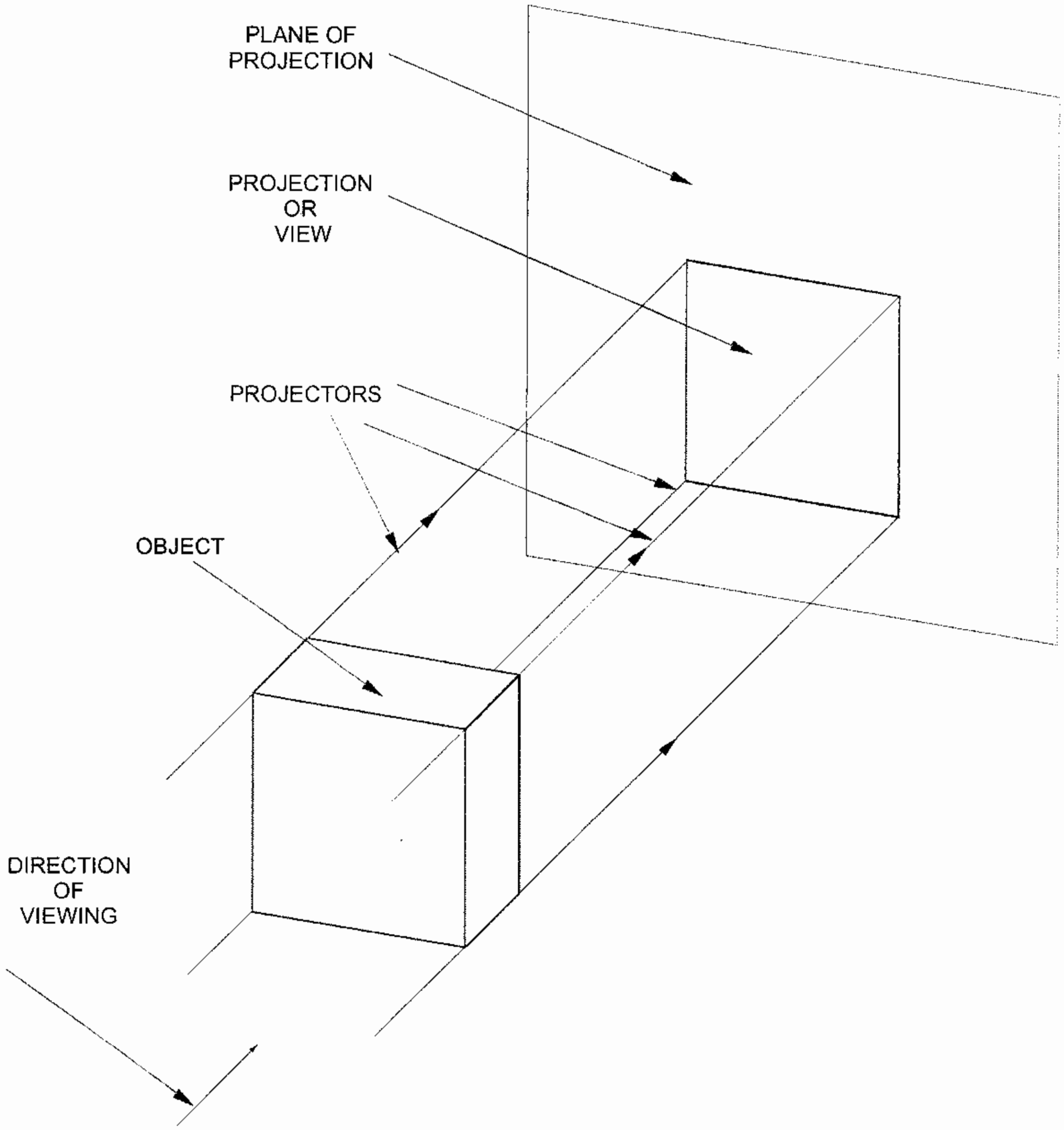


Fig 7.1 Elements of projection

7.3 Types of projection

Projection can be classified based on the following factors

i) Position of planes of projection

ii) The angle of inclination the projectors make with the plane

iii) The point of viewing

iv) The angle between the projectors

The different types of projections are :

I. Pictorial projection (single view projection)

a) Axonometric projection

i) Isometric projection

ii) Dimetric projection

iii) Trimetric projection

b) Oblique projection

i) Cavalier projection

ii) Cabinet projection

iii) Clinographic projection

c) Perspective projection

II. Orthographic projection (multi view projection)

a) First angle projection

b) Third angle projection

7.4 Pictorial projection

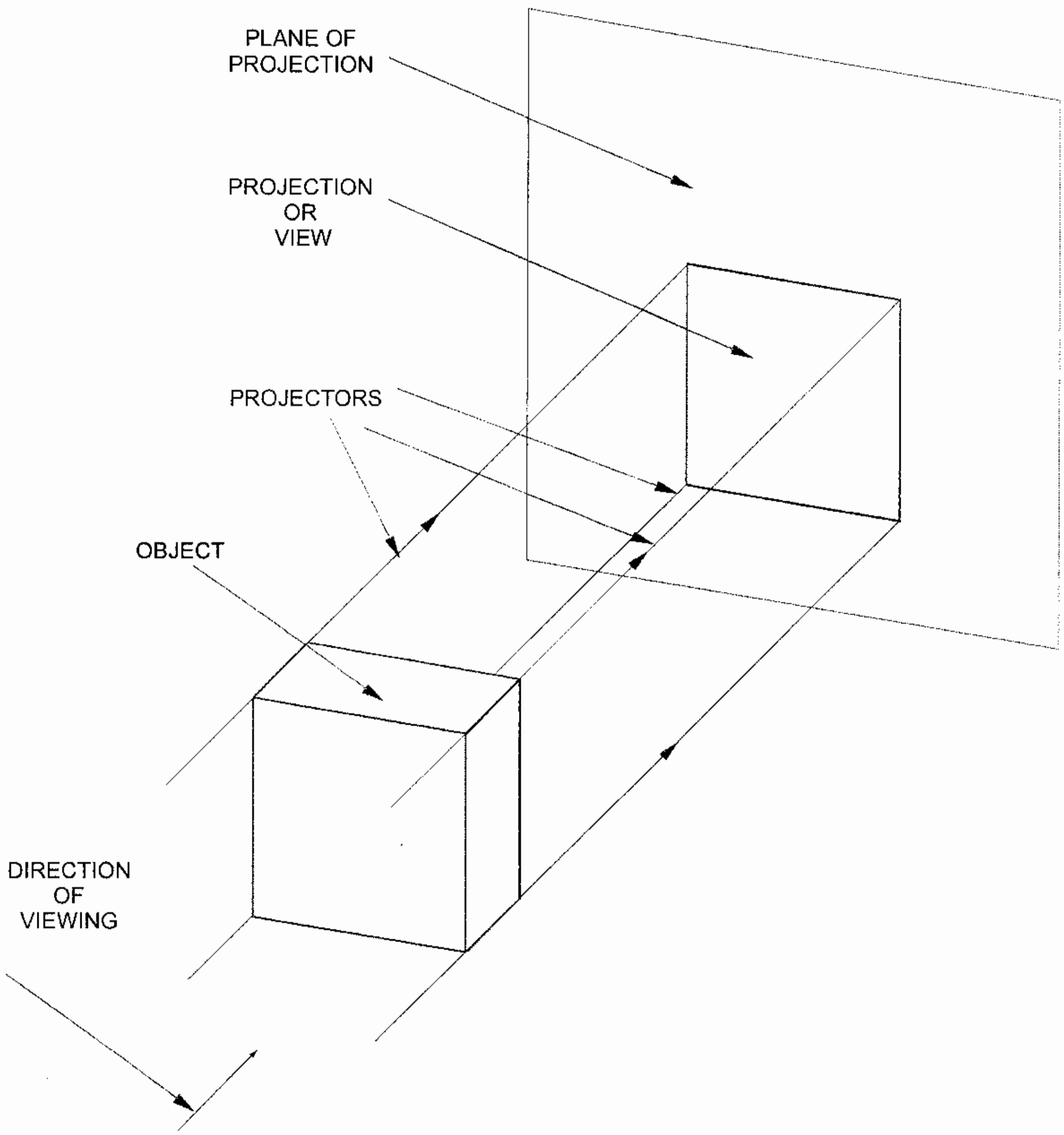
Pictorial projection is a projection in which the description of the object is presented completely in one view. These projections give an immediate impression of the general shape and details of the object. But the exect size of the object is not exhibited.

7.4.1 Isometric projection

It is one type of pictorial projection obtained on a plane when the object is so placed that all its three axes stand at equal angles to the plane of projection.

7.4.2 Oblique projection

It is the projection of an object on a plane when one face of the object is kept parallel to the plane and the other adjacent face is inclined at 45° to the plane, i.e. the projectors make an angle of 45° with the plane of projection. Here two axes are perpendicular to each other. But the third axis is drawn either at 30° or at 45° to the horizontal. The main types of oblique drawings are i) Cavalier drawing and ii) Cabinet drawing.



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Cavalier drawing :

In this type of drawing, two axes are drawn perpendicular to each other and the third is inclined at 45°. It is made to the exact dimensions of the object. However, in many instances, this projections makes the view appear distorted.

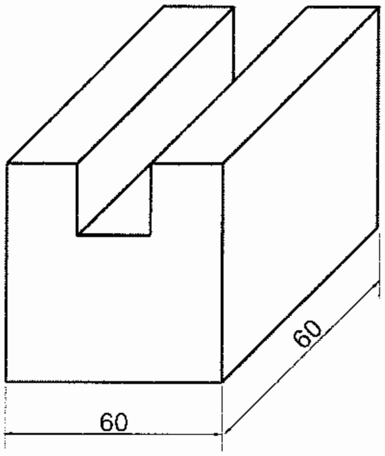


Fig 7.2 Cavalier drawing

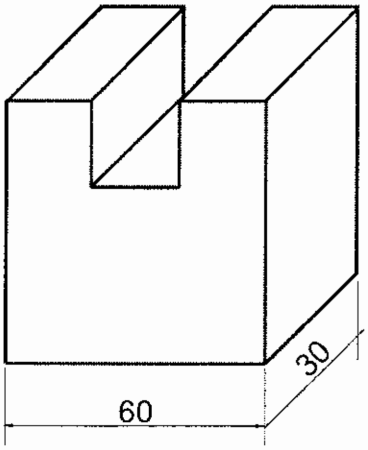


Fig 7.3 Cabinet drawing

Cabinet drawing :

To reduce distortion, the dimensions of the object along the receding axis is drawn to half scale. The resulting view is called cabinet drawing.

7.4.3 Perspective projection

It is the projection of an object obtained on a plane when the projectors converge to a point. This projection does not represent the actual size of the object.

7.5 Orthographic projection

It is the projection in which different views of an object are obtained on planes of projection when the projectors are parallel to each other and perpendicular to the plane on which the view is projected.

There are some assumptions to be made for obtaining orthographic projection :

1. The observer looks at the object from an infinite distance.

2. The lines drawn from various points on the contour of the object (projectors) are parallel to each other.

3. On projection from the object, these lines meet the plane (of projection) at right angles (the projectors are perpendicular to the plane of projection)

4. The plane of projection is transparent.

In *Fig. 7.1,* the observer looks at the object from an infinite distance. As such, the projectors are parallel to each other as shown in the figure. These projectors meet the plane of projection which is transparent at right angles to it. The points made by the projectors on the plane are joined in proper sequence and the projection (or) view is obtained.

The view so obtained is not sufficient for the complete description of the object as it shows only two dimensions. In order to provide complete description of the object, one or more views on different planes should be obtained in a similar manner changing only the position of viewing the object.

7.5.1 Principal planes of projection

Generally, two planes are used to obtain views in orthographic projection. Vertical plane (V.P) and Horizontal Plane (H.P) are known as **principal planes of projection.** They are also called as **reference planes** and are perpendicular to each other and transparent.

Vertical Plane (V.P) : The plane which is vertical is known as vertical plane. Front view of the object is obtained on the plane.

Horizontal Plane (H.P) : The plane which is horizontal and perpendicular to the vertical plane is known as horizontal plane. The top view of the object is obtained on this plane.

Profile Plane (P.P) : The plane which is perpendicular to both vertical plane and horizontal plane is known as profile plane. It is also called a **Auxiliary Vertical Plane** (A.V.P)

Auxiliary Plane: The plane which is placed at any angle to the two principal planes is known as auxiliary plane.

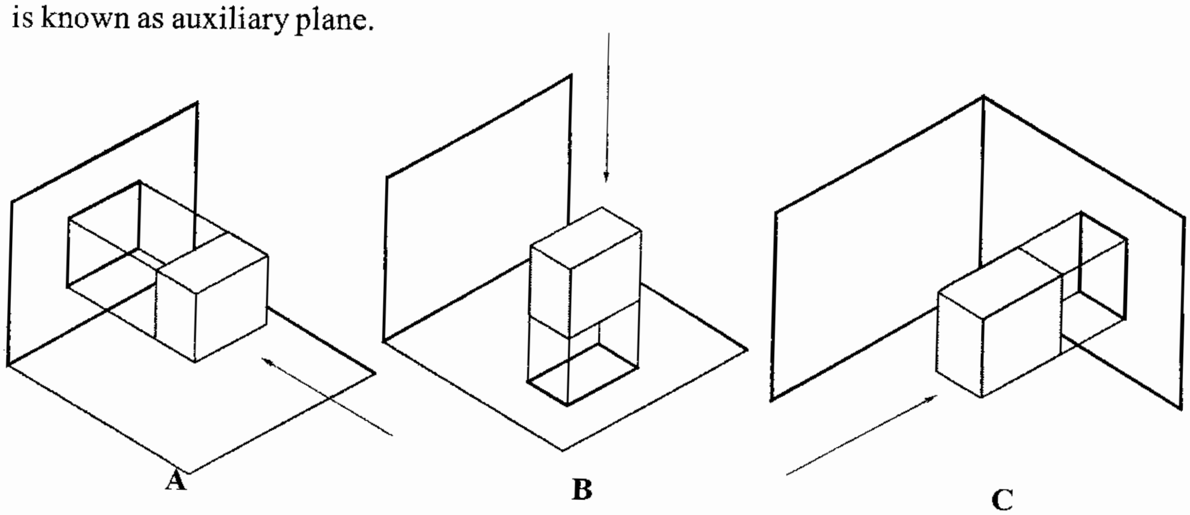


Fig 7.4 Principle planes of projection

A. Front view on verticle plane B. Top view on horizontal plane C. Side view on Profile Plane

7.5.2 Views obtained in orthographic projection

Different views are obtained on different planes in orthographic projection. They are

1. Front view (or) Elevation
2. Top view (or) Plan
3. Side view (or) Side elevation
4. Auxiliary view

Front View : When the object is viewed from its front, the projection (or) view of the object obtained on the vertical plane, is known as front view. It is also known as **Elevation.** The details of length and height are found in this view.

Top View : When the object is viewed from its top, the projection (or) view of the object obtained on the horizontal plane is known as top view. It is also called as **Plan.** Length and width details of the object are found in this view.

Side View : When the object is viewed from its side, the projection (or) view of the object obtained on the auxiliary vertical plane is known as side view. It can also be called as **side elevation.**

Auxiliary View : When the object is viewed from a direction which is not parallel to any of the three major axes, the projection (or) view obtained on a auxiliary plane is known as auxiliary view. When a specific detail which cannot be shown in any of the above three views is necessary to be shown, it is done so on an auxiliary view.

Apart from the above four views, other views like view from the rear, view from below and sectional views can also be drawn for an object according to the need.

7.6 Types of orthographic projection

The object can be placed in any of the four quadrants to obtain the projections (or) views. In convention, the practice of getting the views by placing the object either in the first or in the third quadrant is followed. So, the types of orthographic projections are

1. First angle projection
2. Third angle projection

7.6.1 First Angle Projection

When the object is placed in the first quadrant in front of the vertical plane and above the horizontal plane, the method of obtaining the projections on these planes is called **First Angle Projection.**

In this method of projection, the object lies between the observer and the planes of projection. The front view is obtained above the ground line (or) reference line and the top view is obtained below the ground line. When the horizontal plane and auxiliary vertical plane are rotated after obtaining the projections, the views will be arranged as follows:

1. The top view is placed below the front view
2. The left side view is placed at the right side of the front view
3. The right side view is positional at the left side of the front view

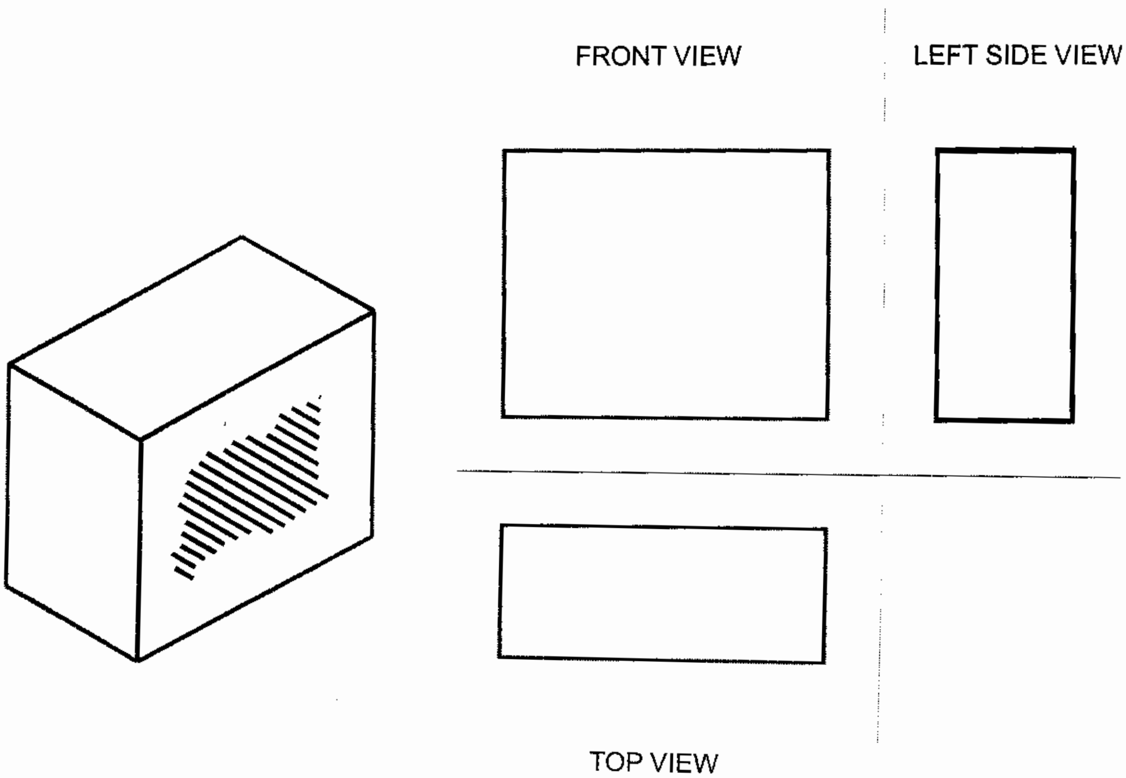


Fig. 7.5. Arrangements of views in first angle projection

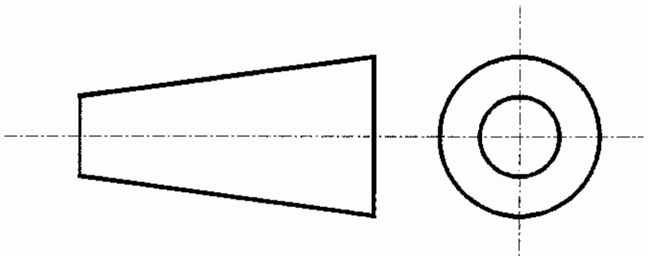


Fig. 7.6 Symbol of first angle projection

7.6.2 Third Angle Projection

The method of obtaining projections on vertical and horizontal planes by placing the object in the third quadrant is known as **Third angle projection.** Here, the object is placed behind the vertical plane and below the horizontal plane.

In the method of projection, the planes of projection lie between the observer and the object. The front view is obtained below the ground line and the top view is obtained above the ground line.

When the horizontal plane and the auxiliary vertical plane are rotated after obtaining the projections, the views will be arranged as follows:

1. The top view is placed above the front view
2. The left side view is placed at the left side of the front view
3. The right side view is placed at the right side of the front view

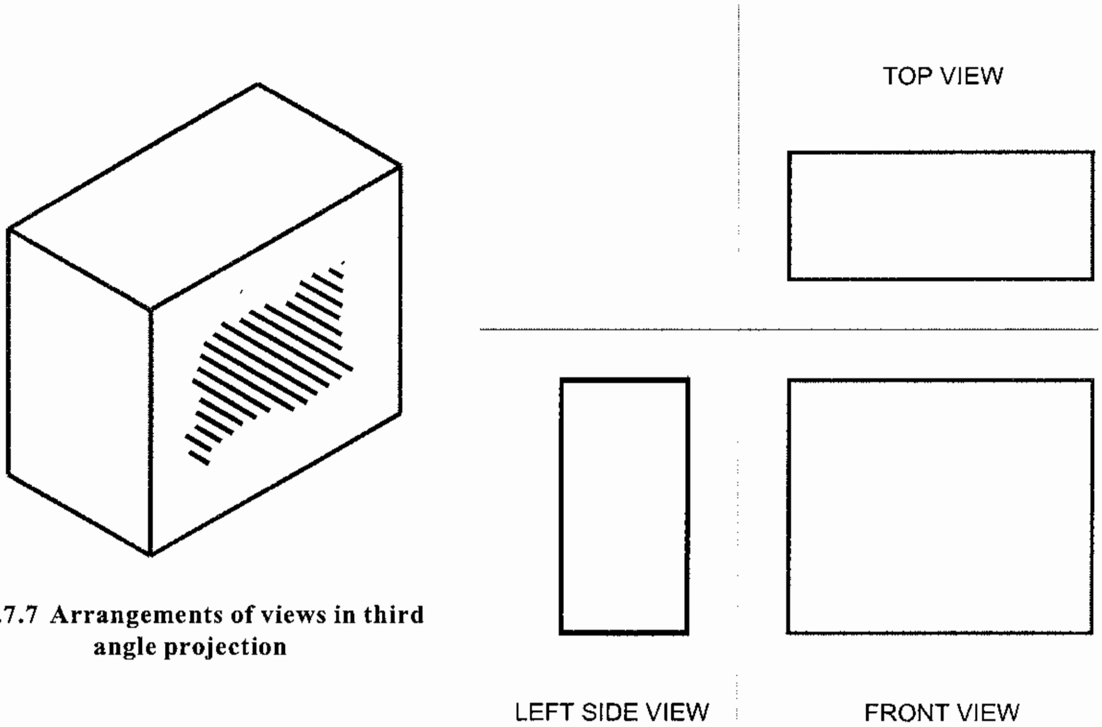


Fig.7.7 Arrangements of views in third angle projection

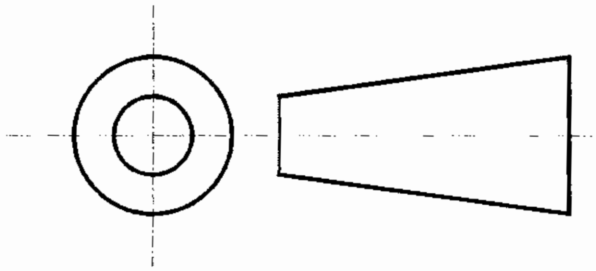


Fig. 7.8 Symbol of third angle projection

Though both first angle and third angle projections are in practice world over, B.I.S., has recommended the use of first angle projections for engineering drawing in line with the specification of ISO.

7.7 Making orthographic projection from isometric view

The isometric view helps us in understanding the shape of the object but does not give the dimensional and inner details of the object. But these details are necessary for designing and manufacturing purposes. So, the need of orthographic projection becomes essential.

The object is viewed from the direction of arrow to obtain the front view. If the arrow is not given, the most prominent view is taken as front view. The other views are obtained by viewing the object in direction that are perpendicular to the one utilised for front view.

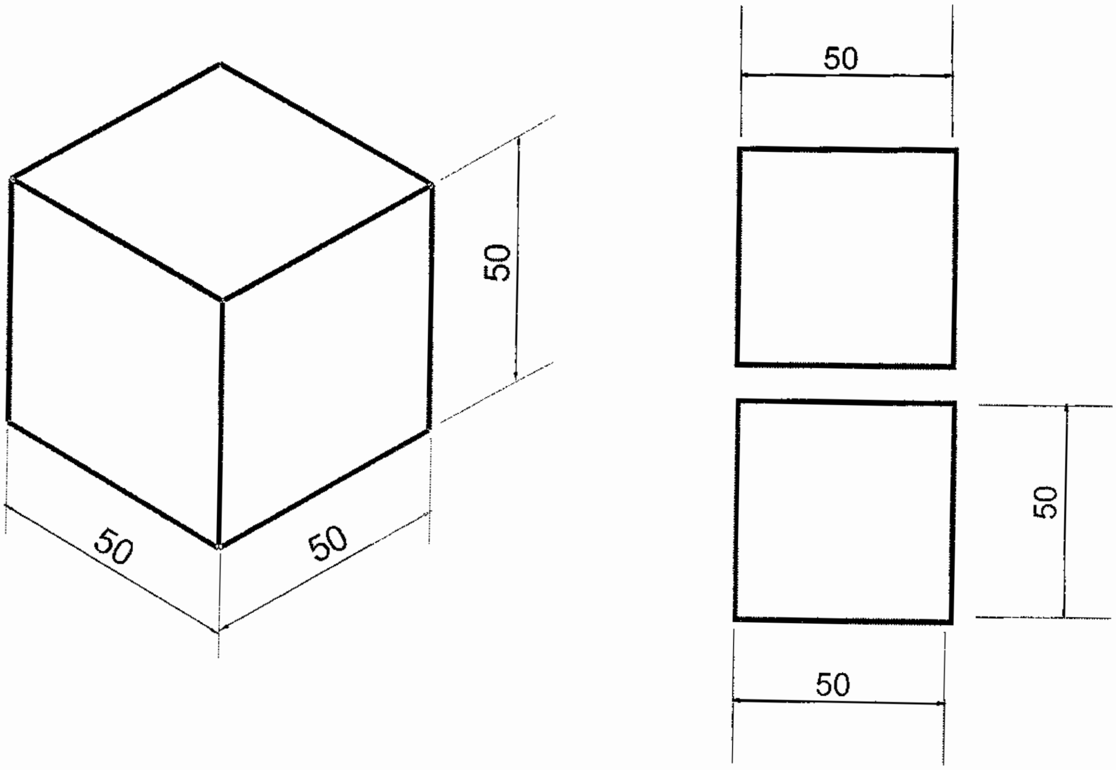


Fig. 7.9 Making orthographic projection

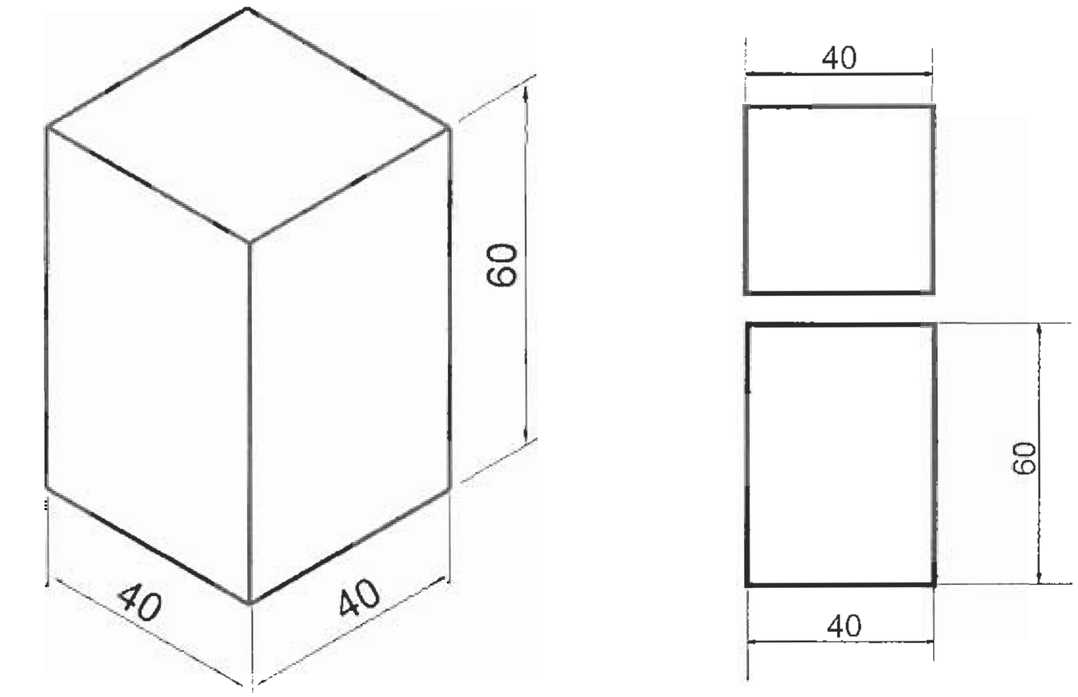


Fig. 7.10 Making orthographic projection

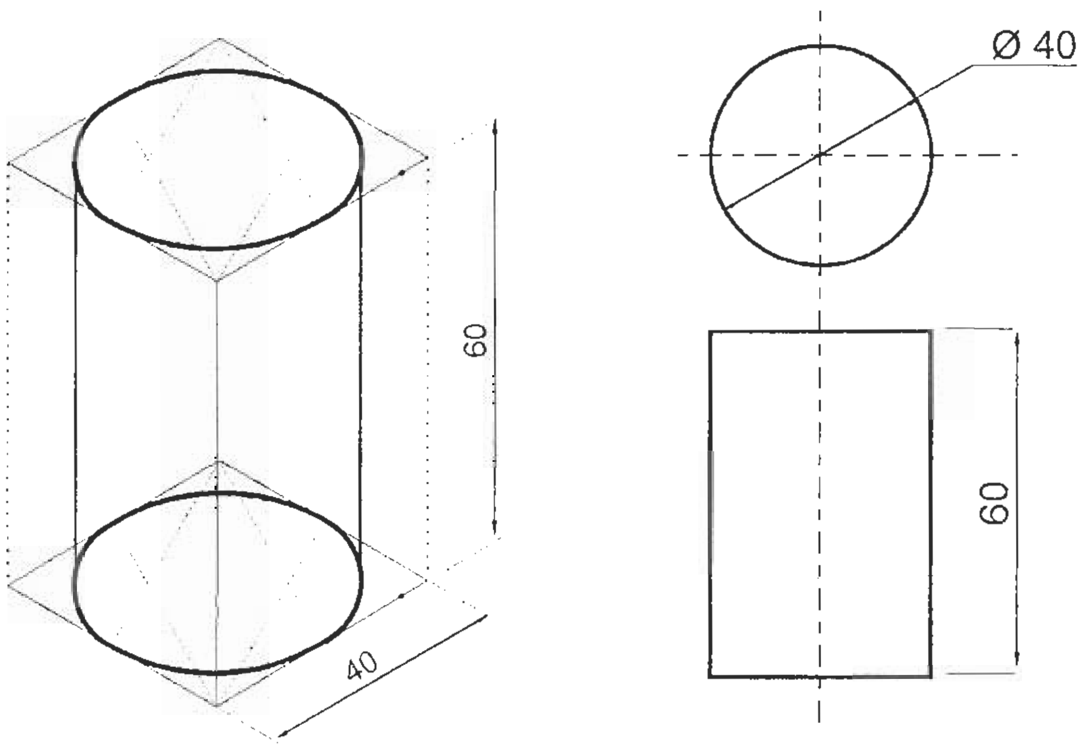
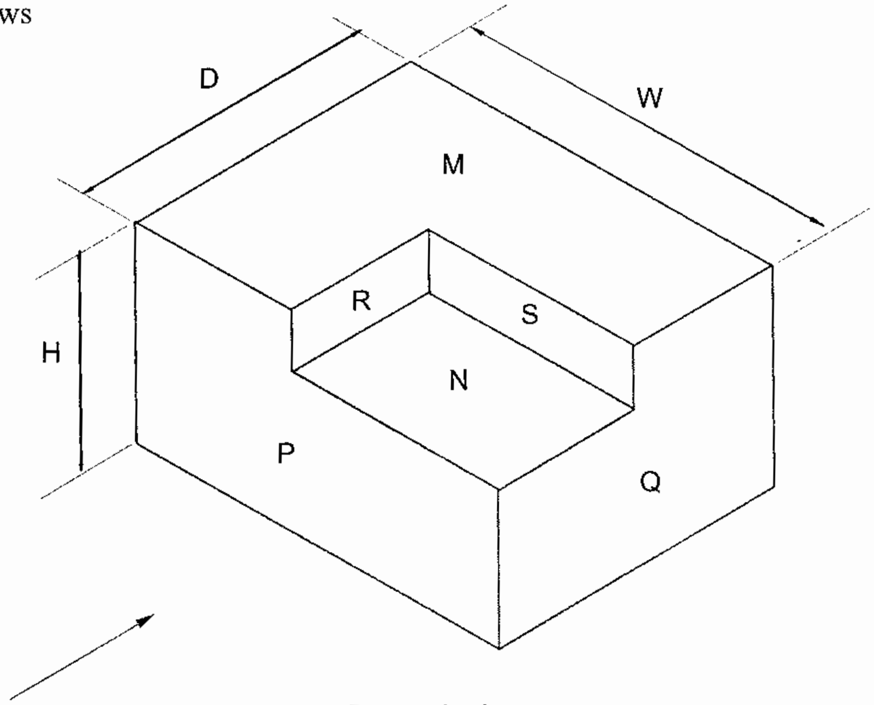


Fig. 7.11 Making orthographic projection

The following illustrations are given to make orthographic projections from the given isometric views



Isometric view

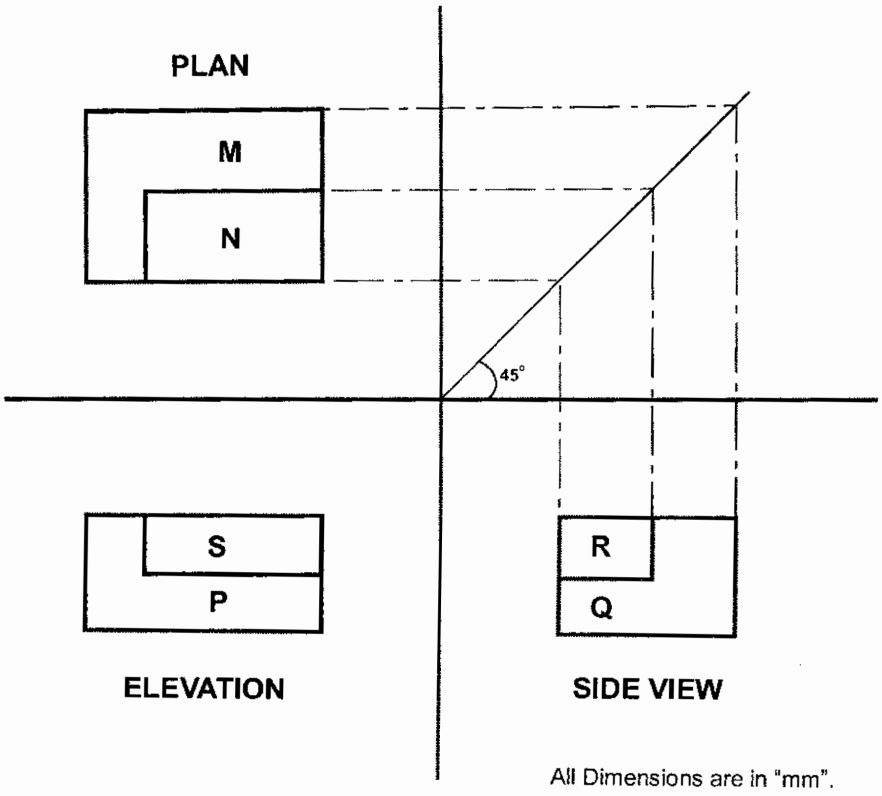
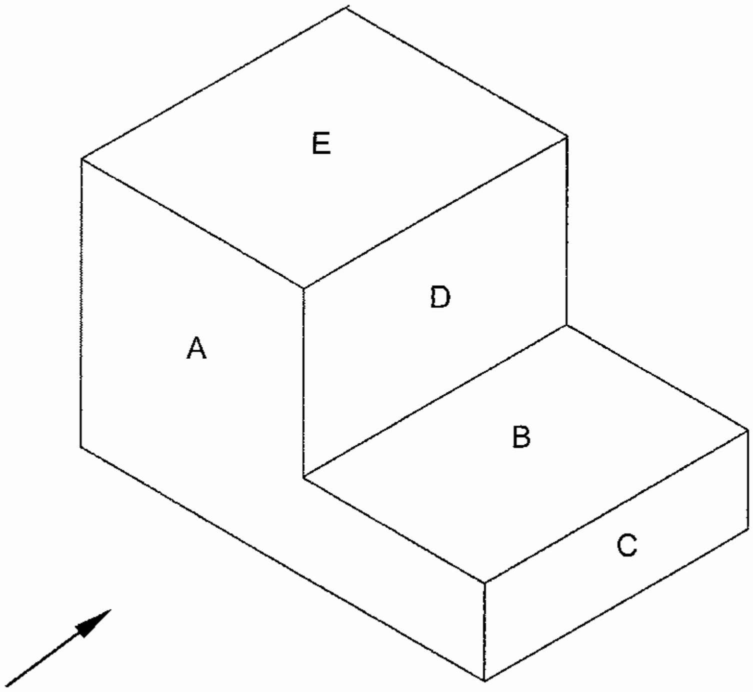


Fig. 7.12 Orthographic projection



Isometric view

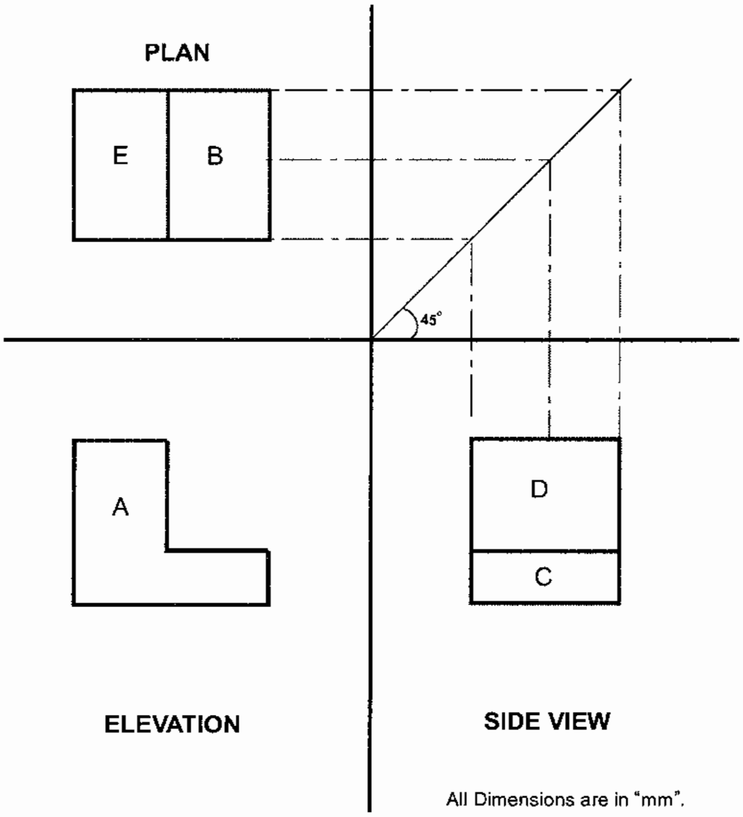
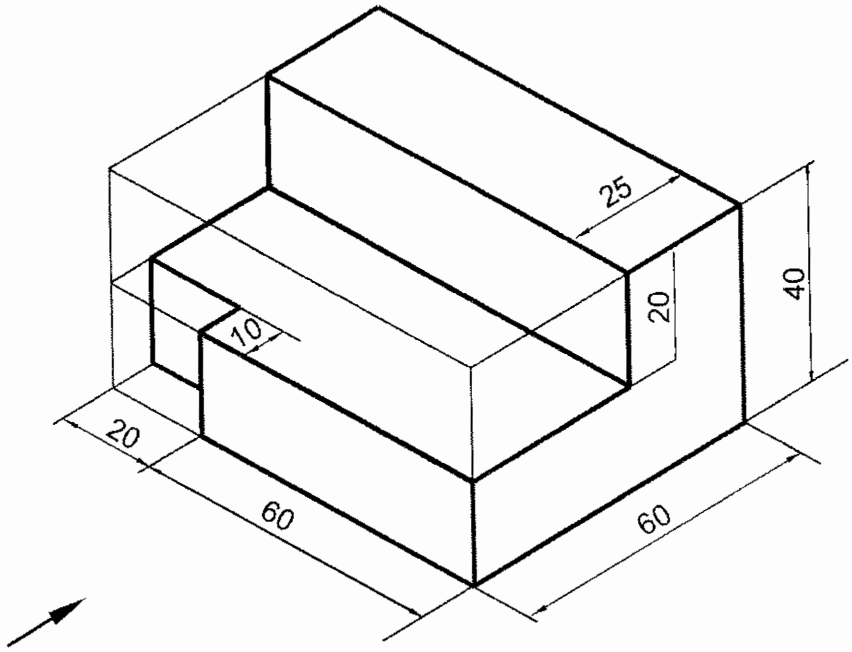
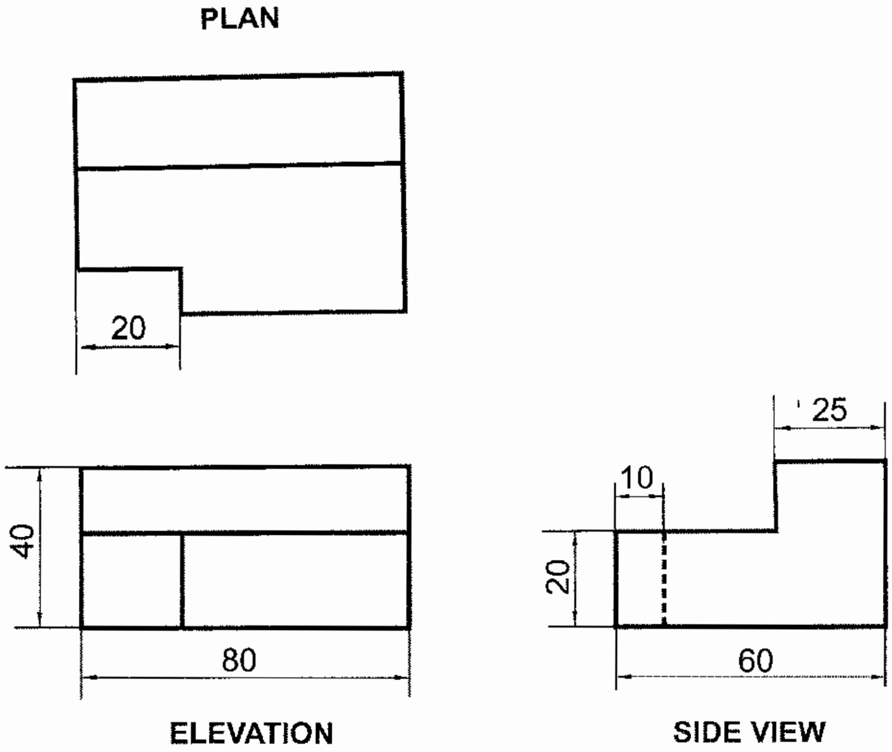


Fig. 7.13 Orthographic projection

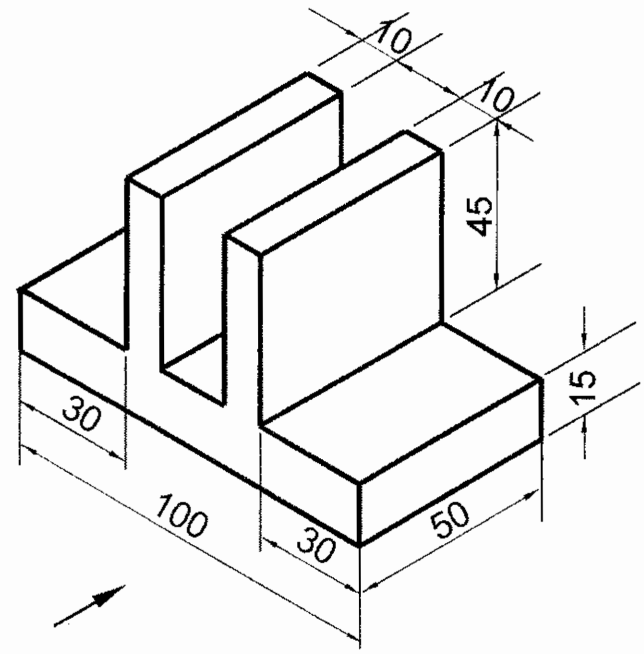


Isometric view



ALL DIMENSIONS ARE IN mm.

Fig. 7.14 Orthographic projection



Isometric view

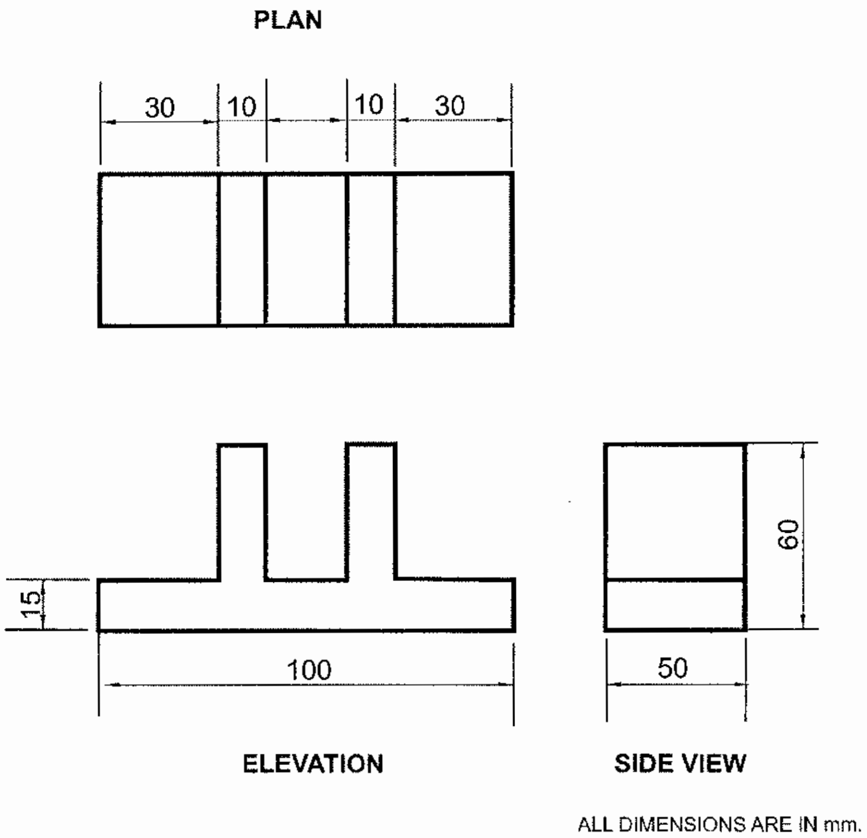
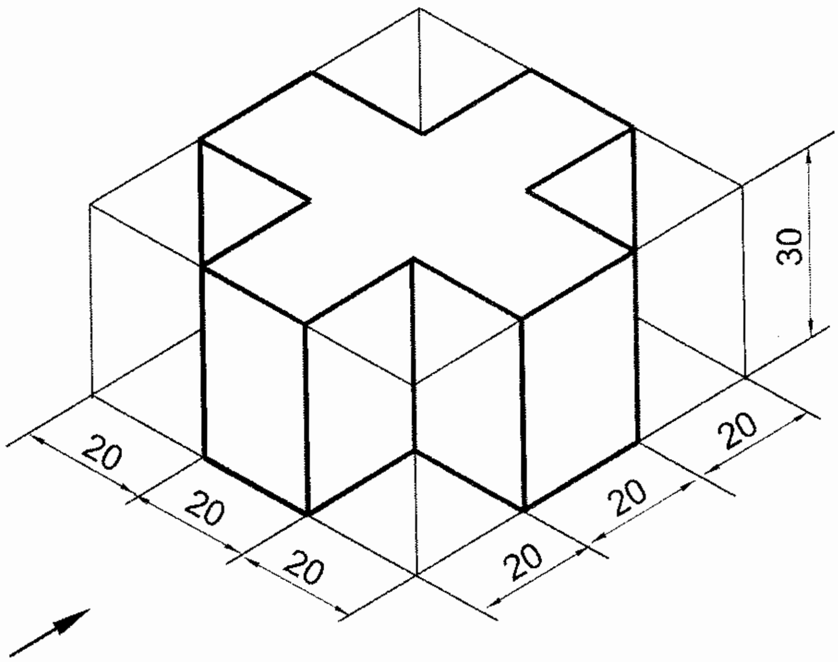
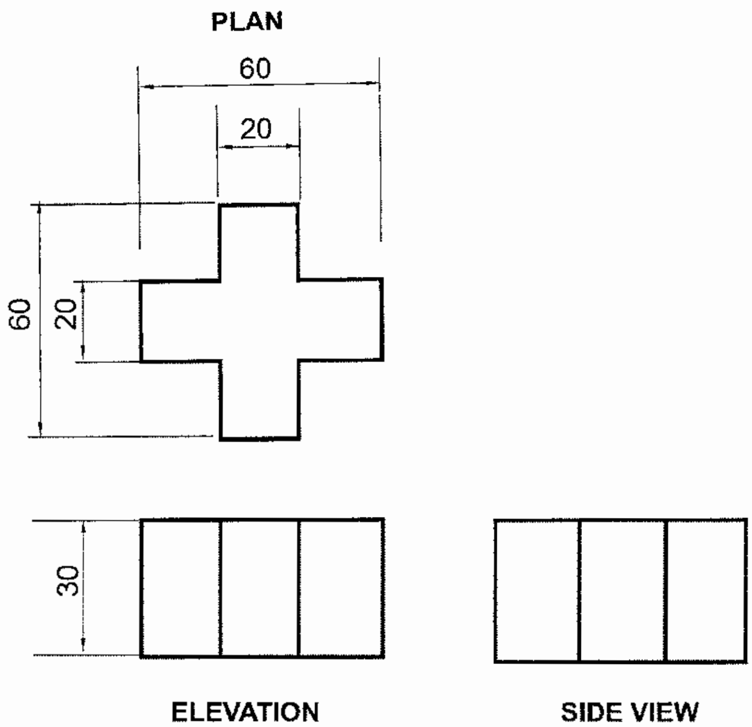


Fig. 7.15 Orthographic projection

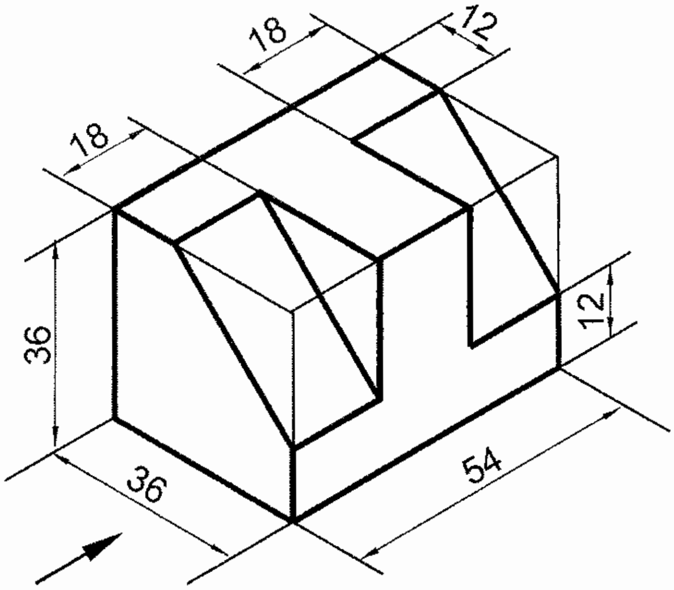


Isometric view



ALL DIMENSIONS ARE IN mm.

Fig. 7.16 Orthographic projection



Isometric view

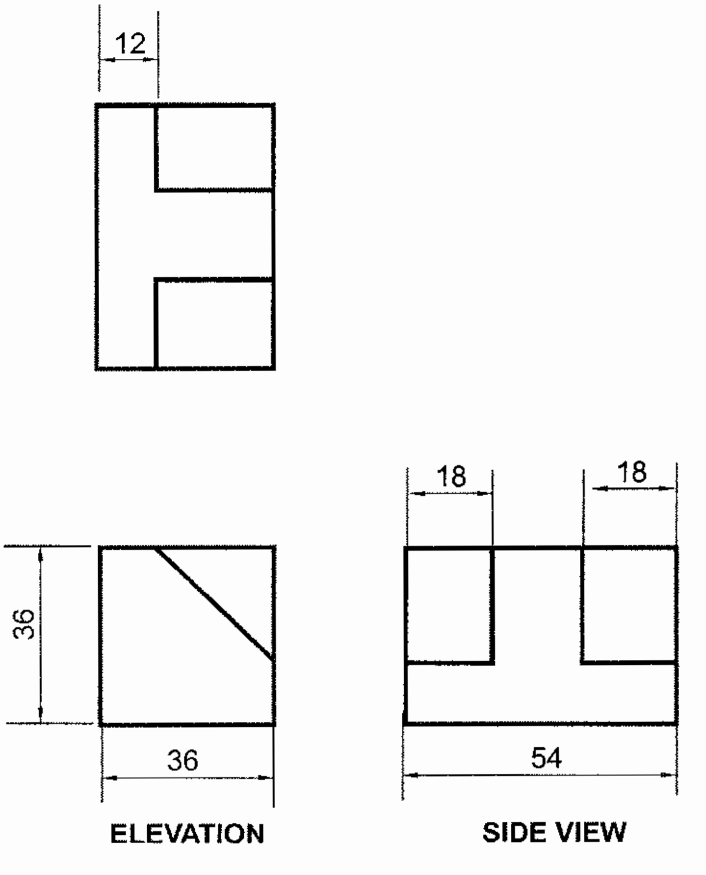


Fig. 7.17 Orthographic projection

The following drawings are given to make practice in obtaining orthographic projection in first angle projection from each of them. The direction of arrow is considered as the direction of viewing.

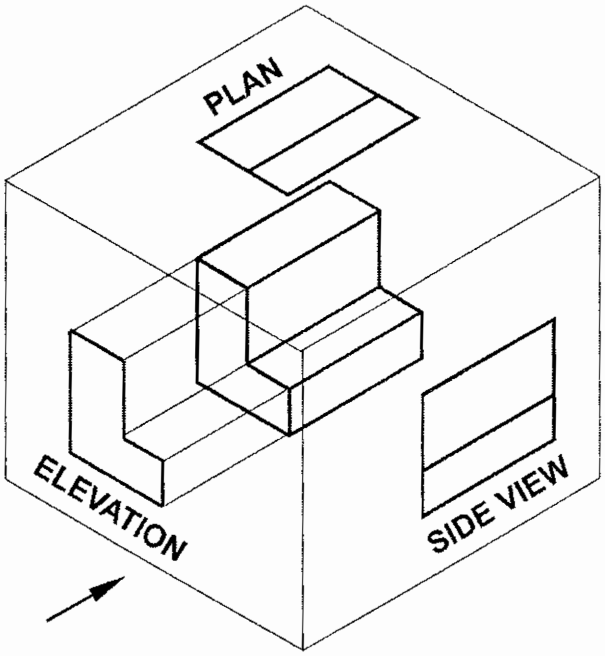


Fig. 7.18

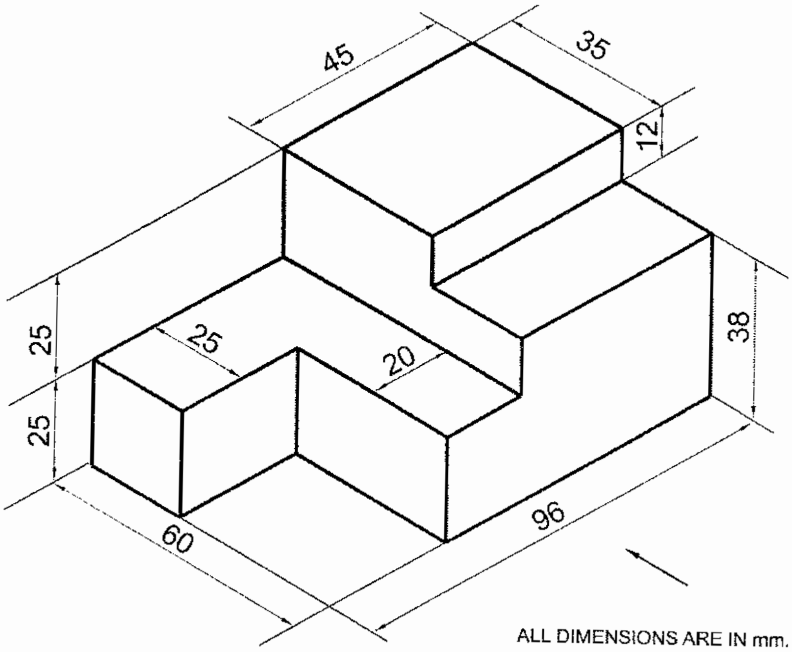


Fig. 7.19

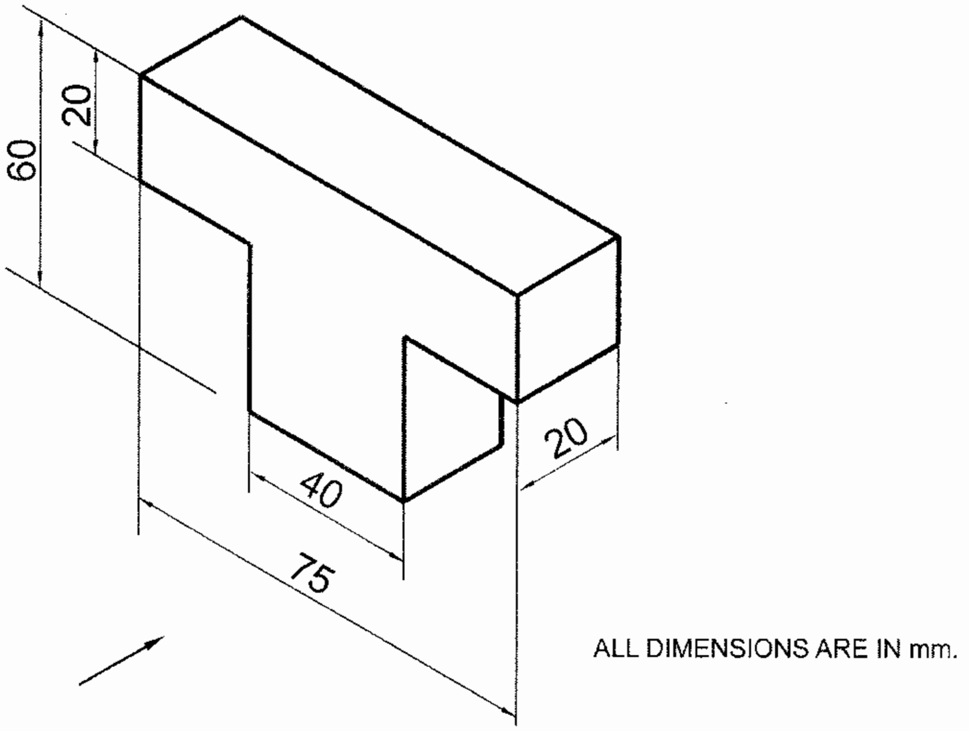


Fig. 7.20

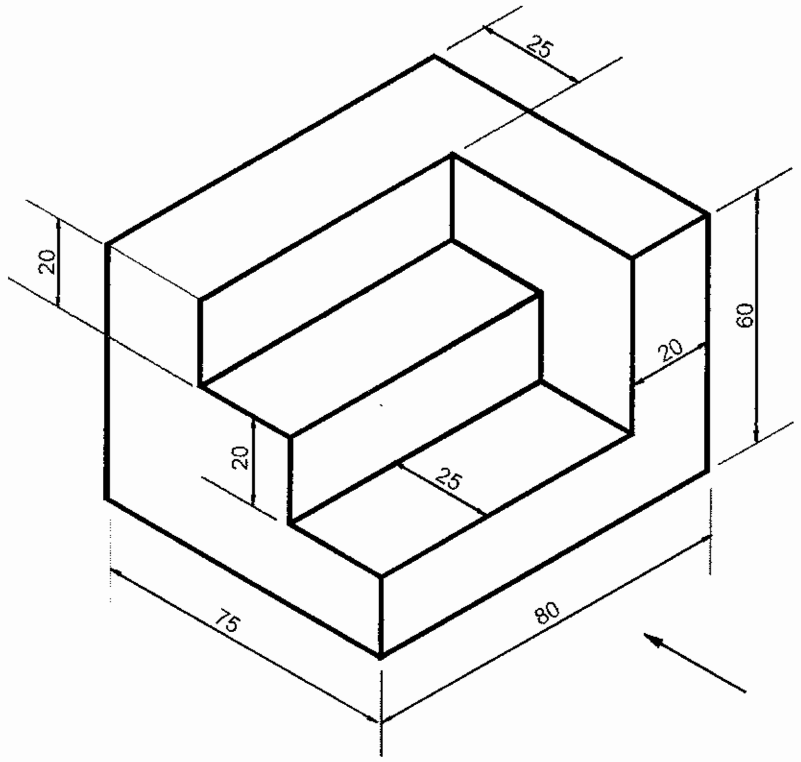


Fig. 7.21

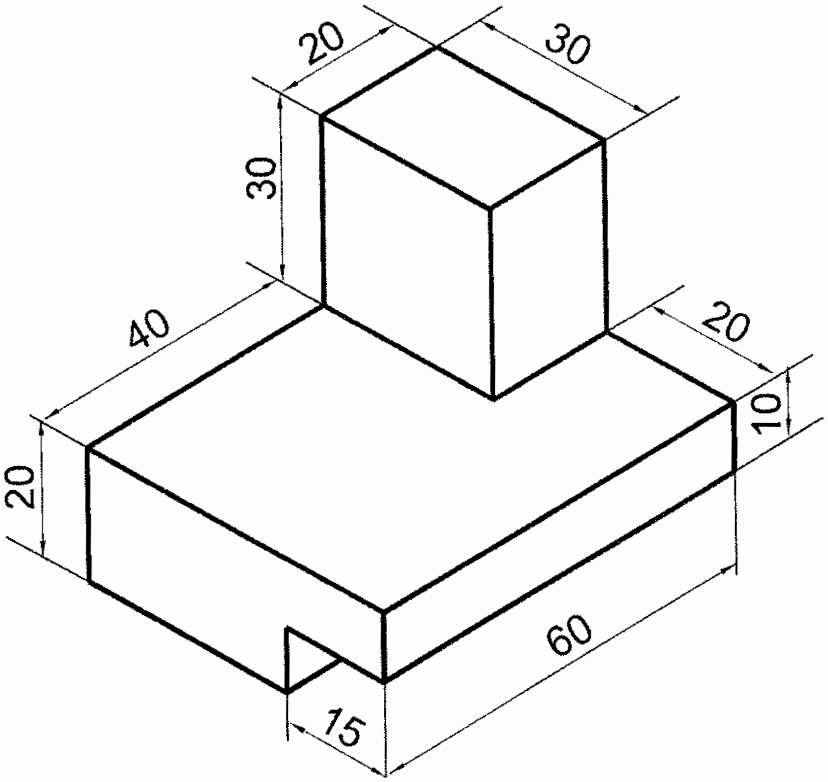


Fig. 7.22

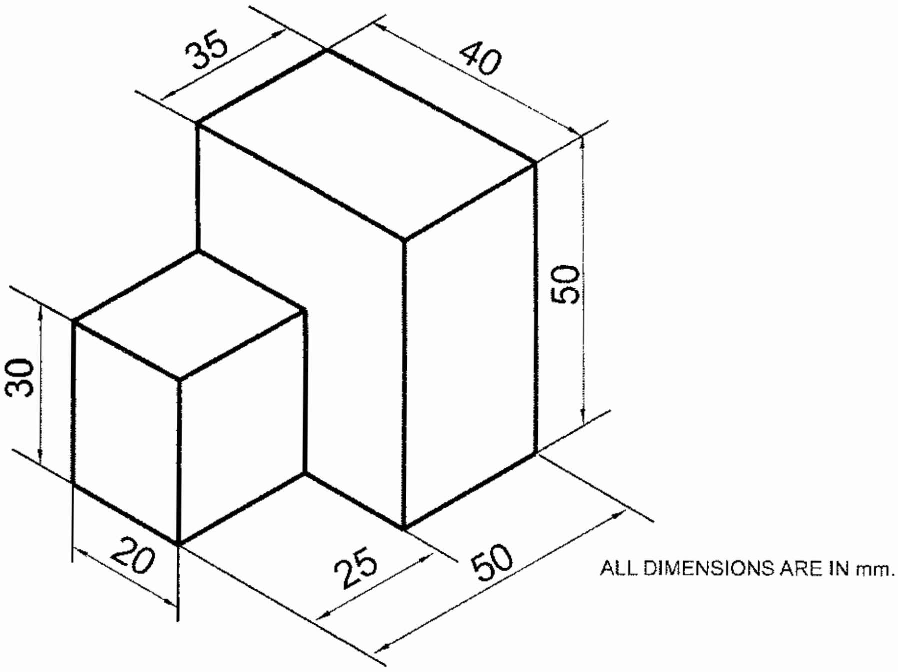


Fig. 7.23

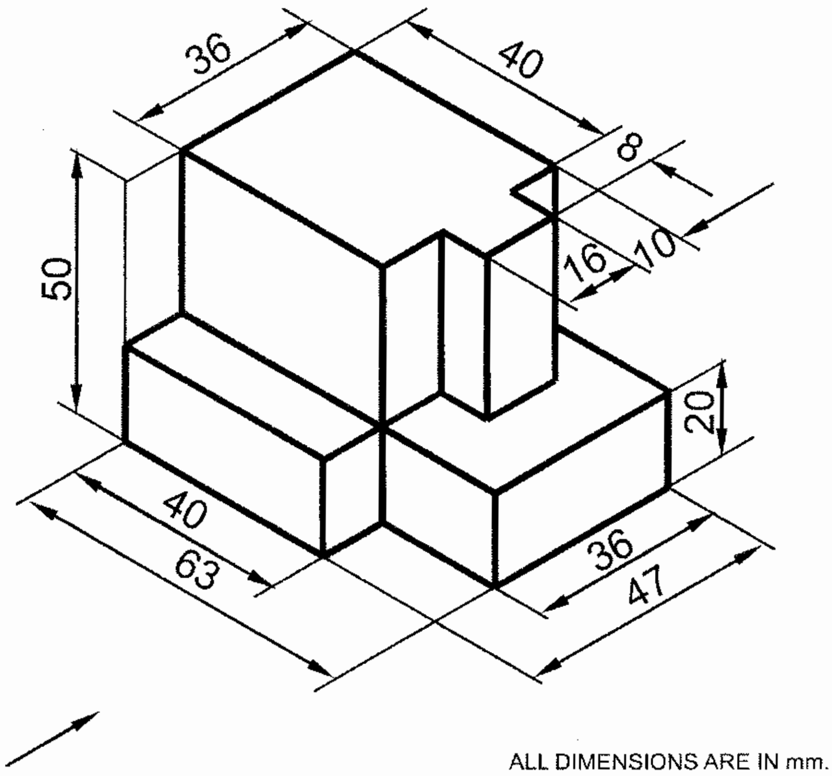


Fig. 7.24

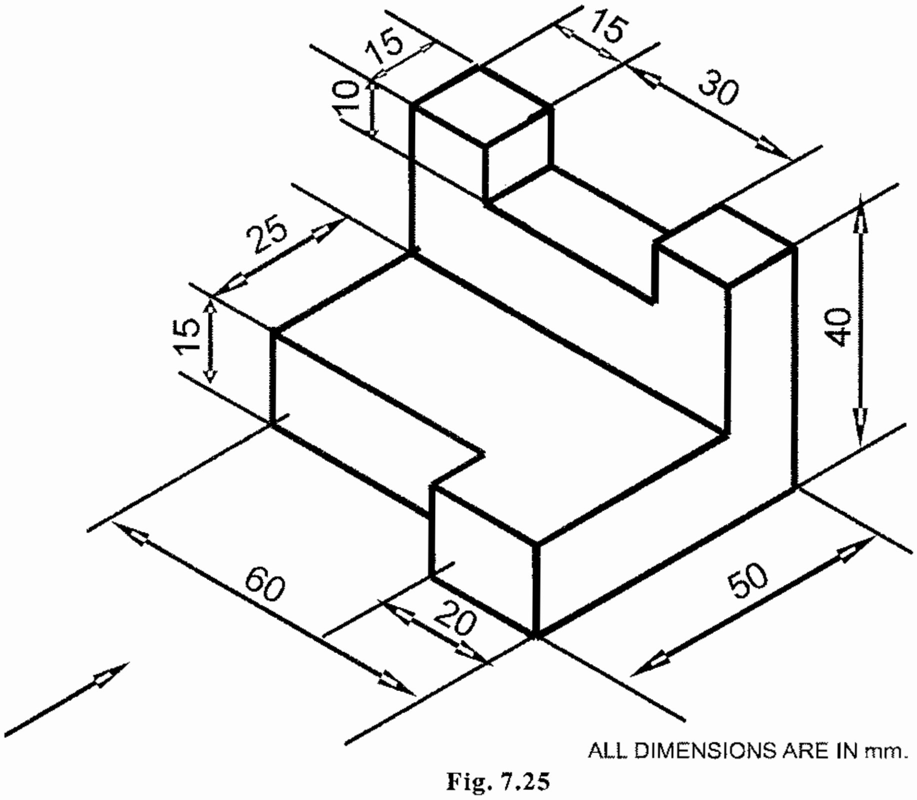


Fig. 7.25

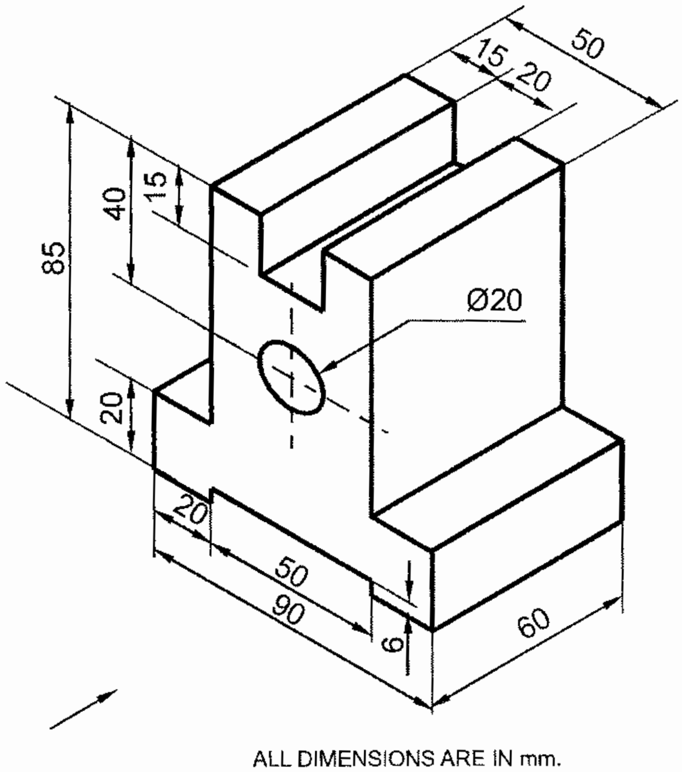


Fig. 7.26

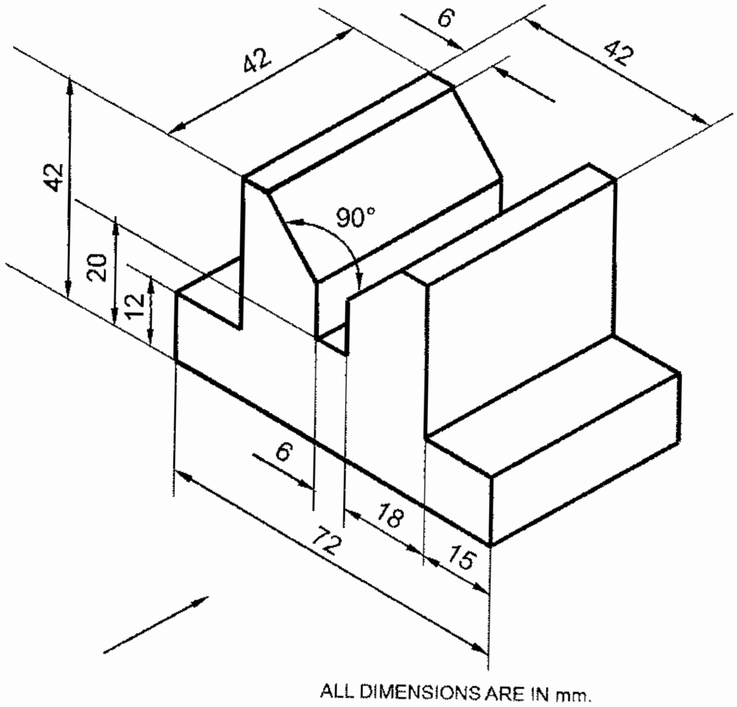


Fig. 7.27

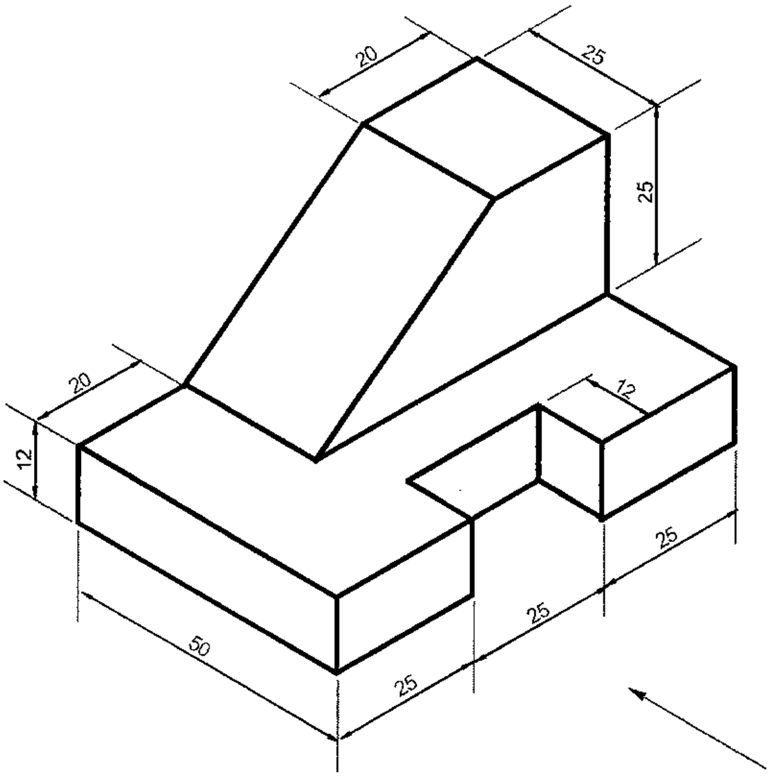


Fig. 7.28

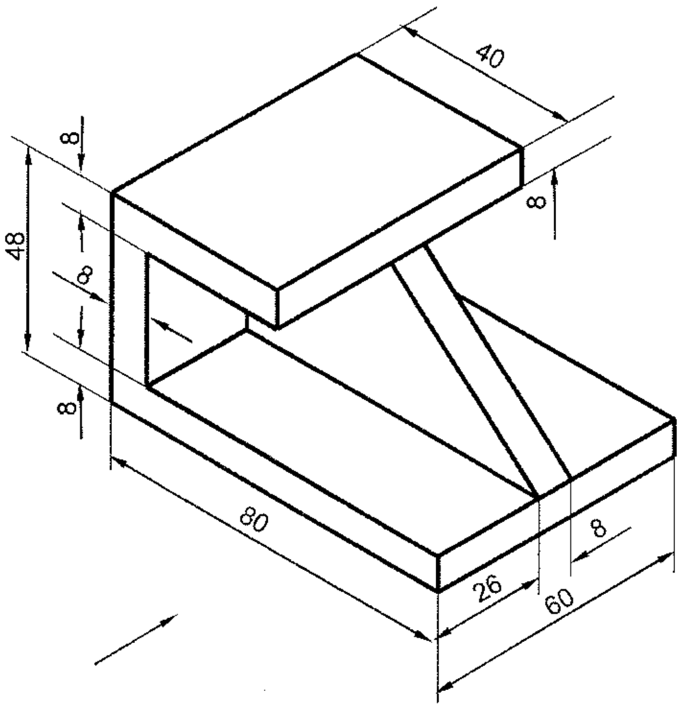


Fig. 7.29

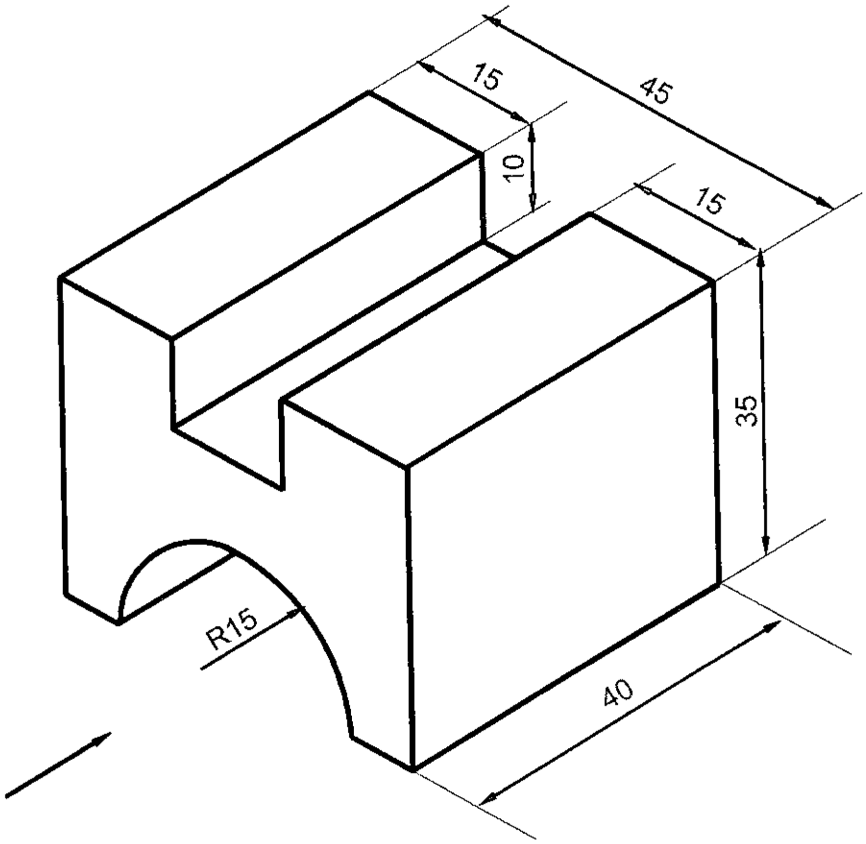


Fig. 7.30

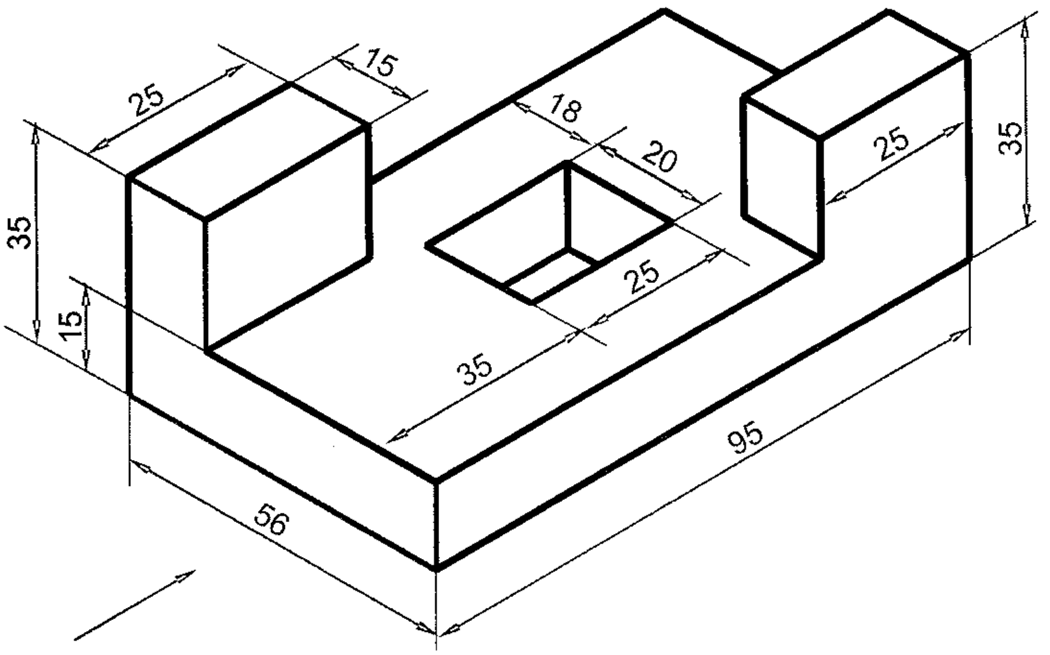


Fig. 7.31

7.8 Making isometric view from orthographic projection

Isometric projection is the representation of an object in pictorial form. In isometric projection, there are three principal axes namely X, Y and Z which are 120^0 apart. The length, breadth and height of the object are drawn on these axes.

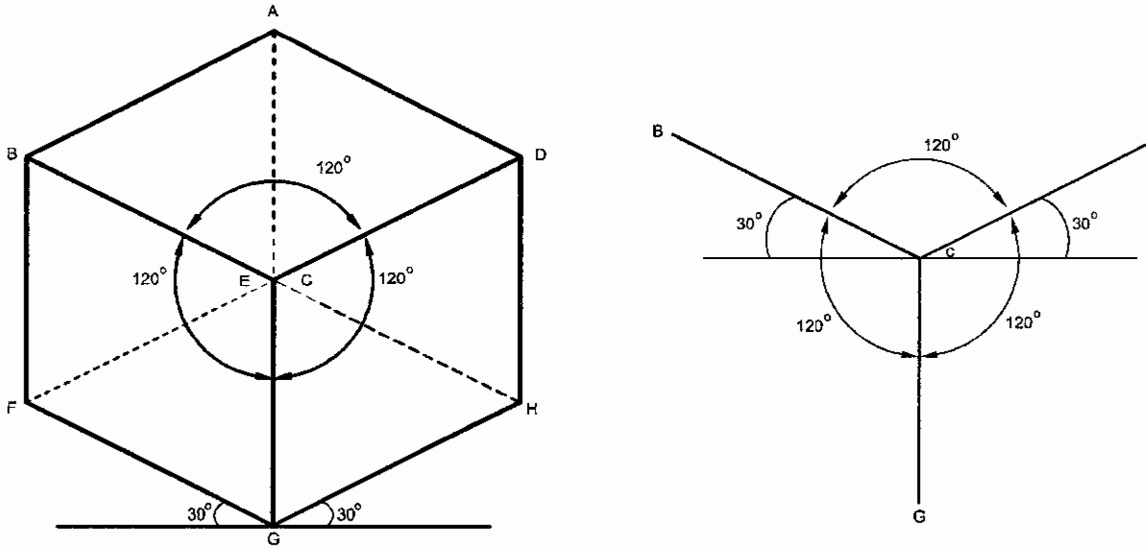


Fig. 7.32 Three axes of isometric view

The following exercises are given as practice to draw isometric views from orthographic projections.

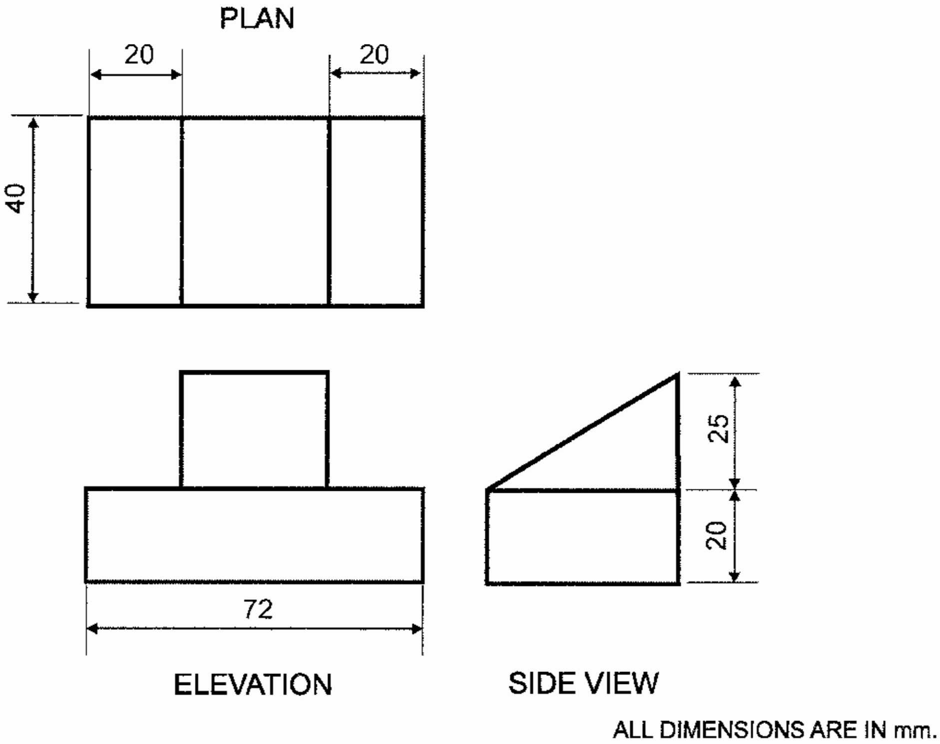


Fig. 7.33

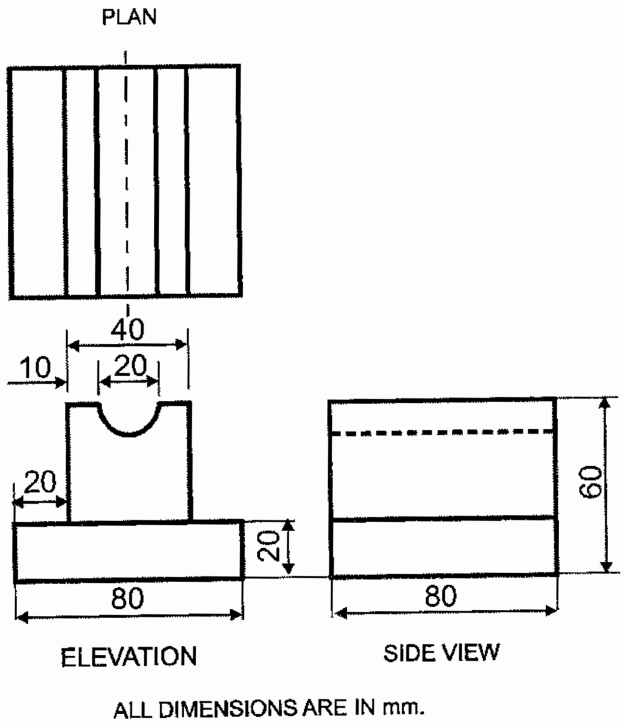


Fig. 7.34

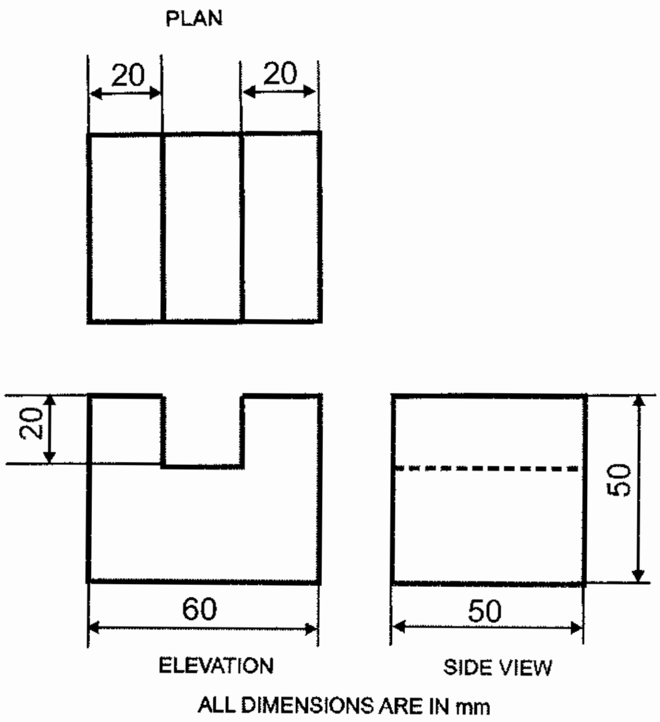
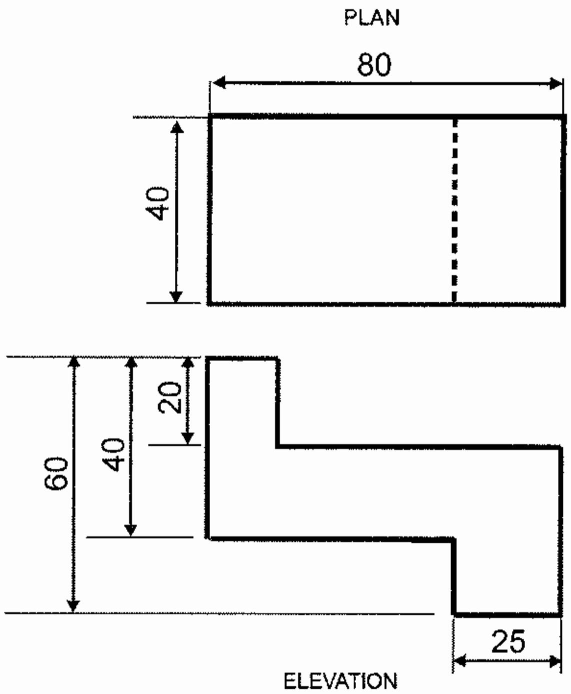
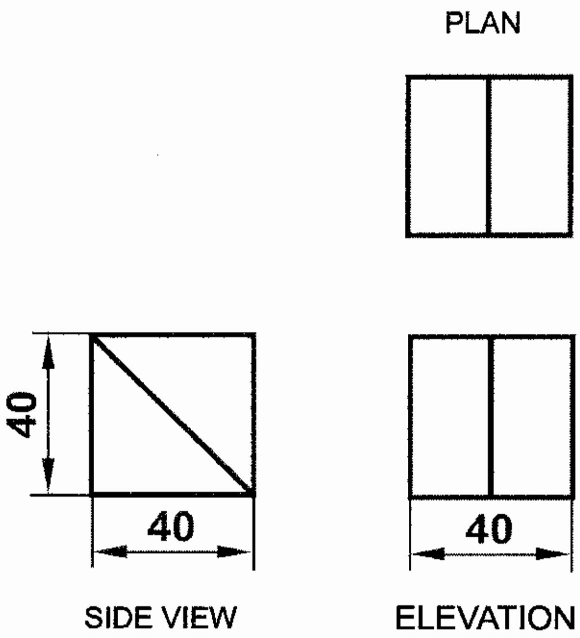


Fig. 7.35



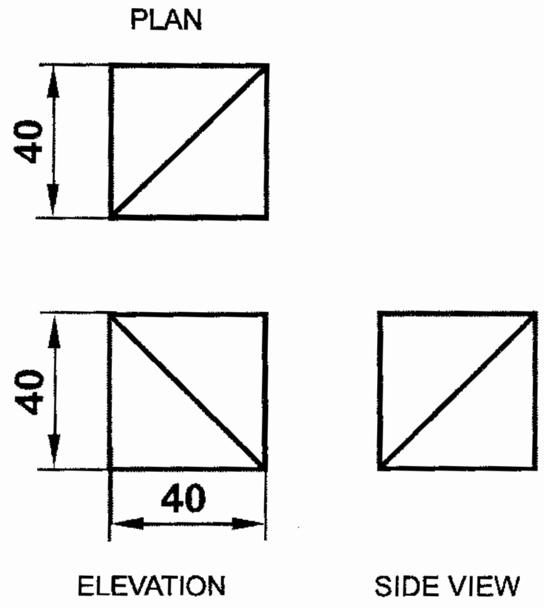
ALL DIMENSIONS ARE IN mm

Fig. 7.36



ALL DIMENSIONS ARE IN mm.

Fig. 7.37



ALL DIMENSIONS ARE IN mm.

Fig. 7.38

QUESTIONS

I. Choose the correct option

1. The method of drawing length, breadth and height of an object on planes 120° apart is known as

   a. orthographic projection   b.isometric projection

   c. first angle projection   d. third angle projection

2. The lines drawn from the contour of an object to the plane of projection are called

   a. imaginary lines   b. straight lines   c. projectors   d. projection

3. Top view is obtained on

   a. vertical plane   b.horizontal plane   c. profile plane

   d. auxiliary plane

4. In first angle projection, the top view is placed

   a. above the front view   b. left side of the front view

   c. right side of the front view   d. below the front view

I. B. Answer the following questions in one or two words

1. What are the types projections ?
2. What are the types of orthographic projection ?

II. Answer the following questions in one or two lines

1. What is isometric projection ?
2. What is orthographic projection ?
3. What is third angle projection ?
4. What are the views obtained in orthographic projection ?
5. Draw the symbol of first angle projection.
6. Draw the symbol of third angle projection.

III. Answer the following questions in about a page

1.Explain the views obtained in orthographic projection.

IV. Answer the following questions in detail

1. Draw the front view, top view and the side view of the given isometric view in first angle projection.

2.Draw the isometric view of the object whose views are given in orthographic projection.

(Use the exercises given in earlier pages for these questions)

8. SECTIONAL VIEWS

8.1 Introduction

In orthographic projection, the interior details of an object are represented by dotted lines. When such details are limited, there are only a few dotted lines in the drawing. Too many dotted lines drawn in a drawing to represent a complicated interior of an object make it difficult and confusing for the reader. To overcome this difficulty, these objects are imagined to be cut through completely or partially by a plane known as cutting plane. The portion of the object lying between this imaginary cutting plane and the observer is assumed to be removed to show the inner details of the object clearly. The view obtained from the cut object is drawn as a **sectional view** or simply **a section.**

The objectives of a sectional view

1. To show the inner details of the object
2. To dimension the hidden features correctly
3. To provide additional informations about the object

8.2 Elements of a sectional view

In understanding the sectional views, the following elements are essential

1. Cutting plane
2. Direction of viewing
3. Sectional view
4. Sectional lines

8.2.1 Cutting plane

An imaginary plane by which the object is assumed to be cut is called **cutting plane.** It is assumed to be thin and transparent. A cutting plane is perpendicular to any one of the reference planes (Vertical Plane or Horizontal Plane). At the same time, it is either parallel or inclined or perpendicular to the other reference plane.

A cutting plane is represented by a long chain line thick at ends. This cutting plane line is shown in a view adjacent to the sectional view. This line may be straight or it may change direction at some points to show every internal detail in a same sectional view.

8.2.2 Direction of viewing

The direction of viewing the sectioned object is represented by showing arrows at the ends of the cutting plane line. The direction indicated by the arrows helps in identifying the portion of the object imagined to be removed after section.

8.2.3 Sectional view

The view obtained by cutting the object by a cutting plane to show the inner details is known as **sectional view.** The sectional view shows all visible edges behind the cutting plane.

If the cutting plane is parallel to horizontal plane, the sectional view is shown in the top view. This view is known as **sectional top view.** The cutting plane in indicated in the front view.

When the cutting plane is parallel to the vertical plane, the sectional view is shown in the Front view and the view is known as **sectional front view.** The cutting plane is shown in the top view.

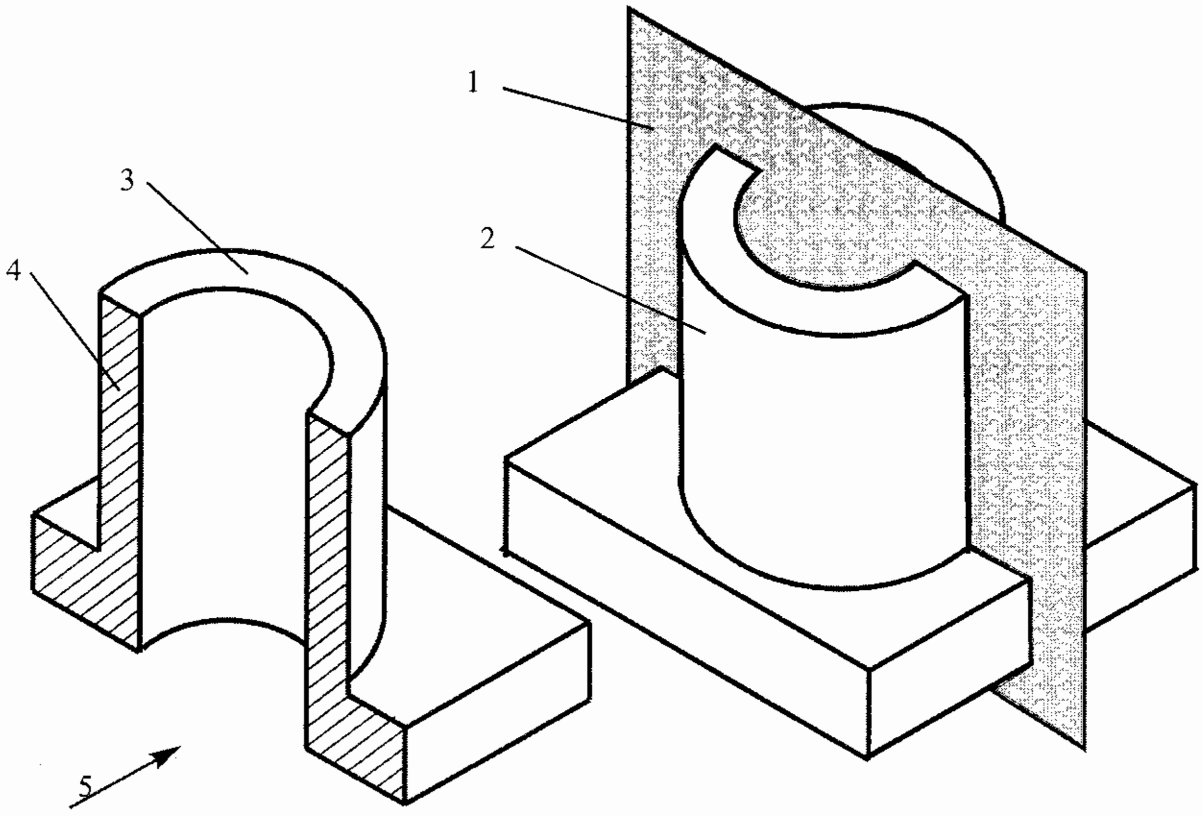


Fig 8.1 Elements of a sectional view

1. Cutting plane 2. Portion of the part to be removed 3. Sectioned part 4. Sectional lines 5. Direction of viewing

8.2.4 Sectional lines

The lines used to show the surfaces sectioned by the cutting plane are known as **section lines.** They are thin, equispaced and parallel. They are drawn inclined at 45° to the horizontal line or the axis of the object. They differentiate the sectioned portion of the object from the un - sectioned portion. The process of drawing sectional lines on sectional views is called **hatching.**

8.3 Guidelines to draw hatching lines in sectional views

The following guidelines are to be followed in the process of hatching.

1) Sectional lines should be drawn at 45° to the axis of the object or main outline of the section. They should not be drawn parallel to any of the main outlines.

2) The space between the sectional lines should be equal and approximately equal to 1.5 to 3 mm. The spacing however depends upon the overall size of the section being hatched. Uniformity in spacing is judged by the eye and attained by practice.

3) Adjacent parts in section are hatched in opposite direction or by varying the space between the sectional lines. When another part adjacent to the first two parts needs sectioning, the lines should drawn at 30° or at 60° to the horizontal line.

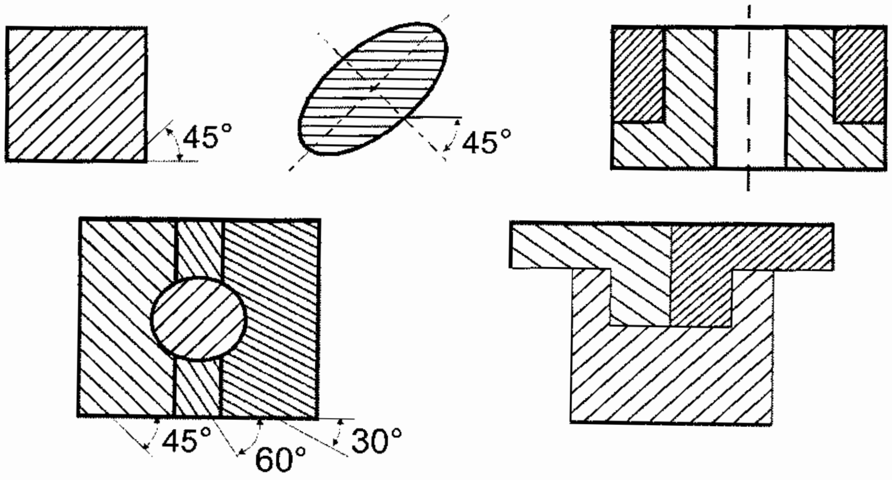
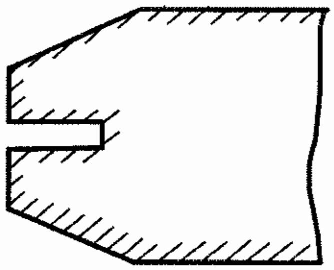


Fig 8.2 Different methods of placing sectional lines

4) When larger areas are to be sectioned, the hatching is limited to a small portion. This will avoid confusion and clumsy look of the drawing.

5) If a dimension is to be shown in a sectioned area, the dimension is made first. The section lines are then drawn leaving the area in which the dimension is made.



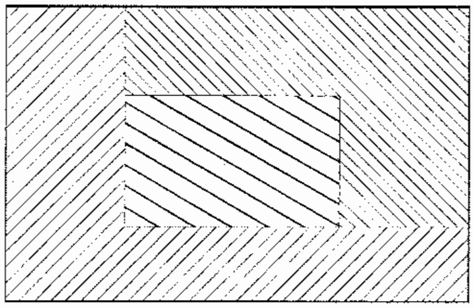


Fig 8.3 Sectioning methods

A - Sectioning a large area B - Adjacent parts in section

8.4 Types of sectional views

In order to show the inner details of the object, several, methods of sectioning are in practice in engineering drawing. The choice of the method depends upon the shape characteristics of the object to be sectioned. Some of the methods of sectioning are listed as the types of sectional views. They are

1) Full section
2) Half section
3) Off set section
4) Revolved section
5) Removed section
6) Partial section
7) Thin section

8.4.1 Full section

When an object is assumed to be cut completely through its centre line, the front half portion of the object is imaged to be removed. The remaining portion of the object is viewed and the view obtained is known as full **sectional view.**

In *Fig 8.4,* the cutting plane is allowed to pass completely throught the centre line of the object. The half portion lying between the cutting plane and the observer is imagined to be removed. The observer views the object in the direction indicated by the arrows and the view is obtained. This method is known as full section and the resultant view is called full sectional view.

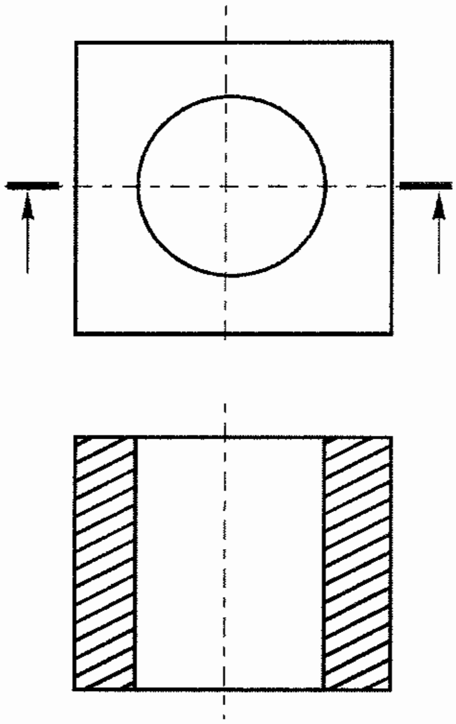


Fig 8.4 Full section

8.4.2. Half section

When the front quarter portion of the object is assumed to be removed after allowing two cutting planes at right angles, the resultant view obtained is known as **half sectional view.**

Half sectional view may be left or right when obtained in front view projected on a vertical plane. It may be top half or bottom half when obtained in a top view projected on a horizontal plane.

Half sectional view is generally obtained for symmetrical objects. The main feature of half section is that it shows both internal and external construction of the object in the same view. This feature is very useful in assembly drawings.

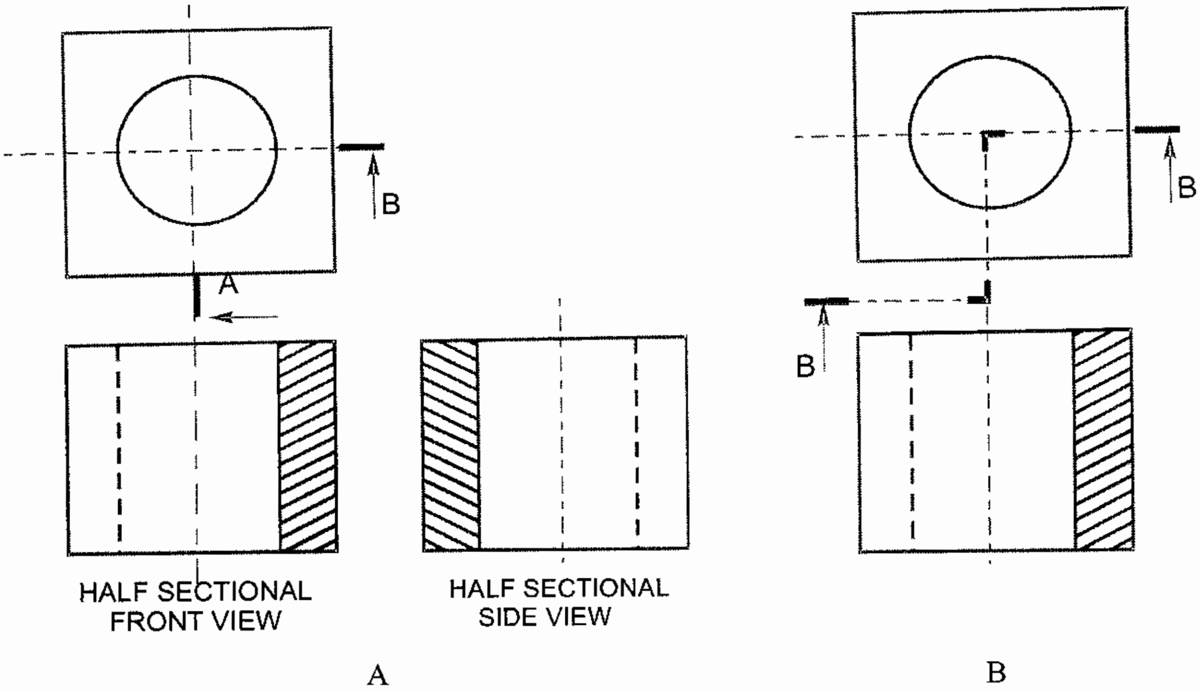


Fig 8.5 Half section

Fig. 8.5. shows half sectional views of an object under section by different types of cutting planes.

The cutting planes pass through both the centre lines of the object. The left front quarter portion of the object is imagined to be removed. The half sectional view is obtained in the front view. The cutting plane line and the direction of viewing are shown in the adjacent view.

8.4.3 Offset section

In full section, the cutting plane is straight and passes through the centre of the object. In some objects, this cutting plane does not expose all the required details. So, the cutting plane is offset to change its direction and allowed to pass through the required details of the object. The view obtained is called **offset section.** The offset in the cutting plane should be at 90°.

Fig 8.6 shows the offset section and the resultant sectional view. Note that the cutting plane is allowed to bend at 90° to pass through the required details.

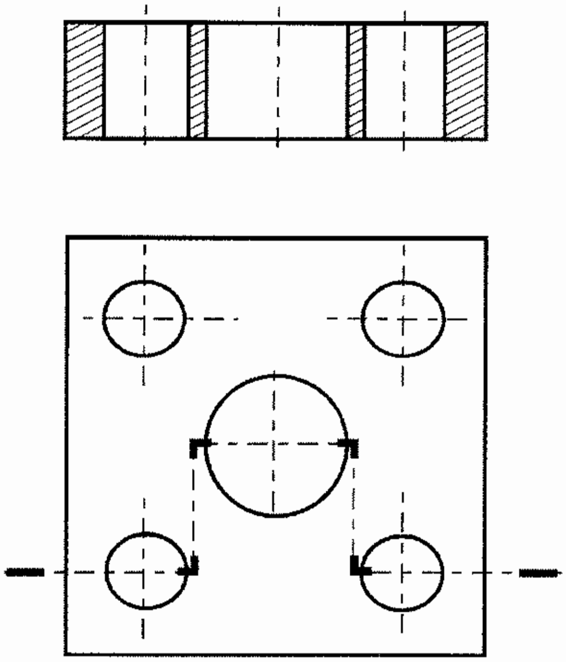


Fig 8.6 Off-set section

8.4.4 Revolved section

In some cases, a drawing may have several long structural parts of different cross–sections. It will be very difficult to identify the cross-section of such parts. In such cases, the section of each member is obtained by passing the cutting plane perpendicular to the axis or centre line. The obtained section is revolved by 90° through the axis to show the view perpendicular to the cutting plane. Revolved sections are used to show the section of elongated objects like connecting rods, long bars of different cross-section and ribs of pulleys.

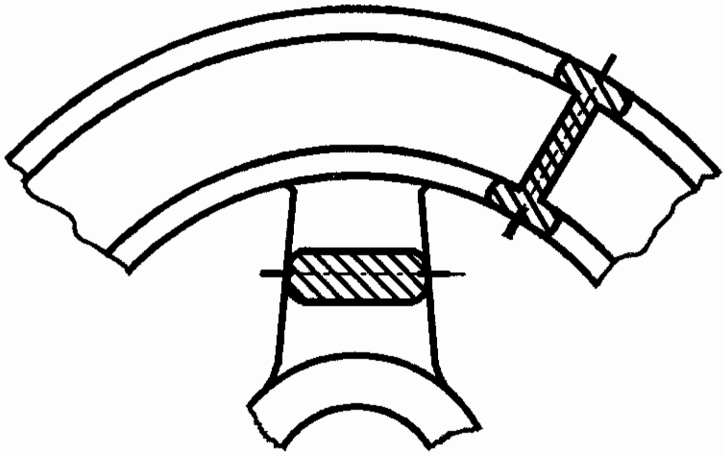


Fig 8.7 Revolved section

In *Fig 8.7*, it is shown how to allow the cutting plane. It also shows the sectional view revolved by 90°.

8.4.5 Removed Section

Removed section is obtained in a similar manner as revolved section. The cutting plane passes perpendicular to the centre line or axis of the object. The obtained section is revolved by 90° about its centre. The view which is perpendicular to the cutting plane is shown in a adjacent place on the drawing. The location of the section is indicated by a cutting plane line with reference letters.

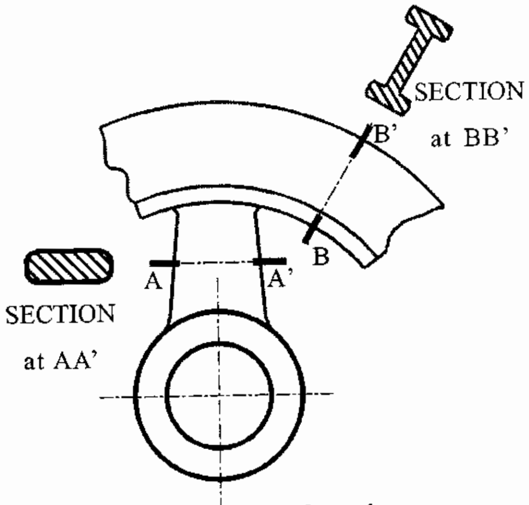


Fig 8.8 Removed section

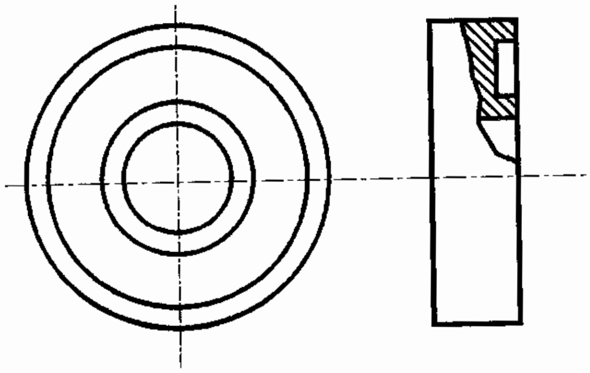


Fig 8.9 Partial section

8.4.6 Partial Section

When a small hidden detail of an object is to be shown in section, it is not necessary to draw full or half sectional view. In such cases, only a partial section is enough. The object is assumed to be broken at the required location to show the inner details. The section is bounded by a short irregular break line. It is also called **broken out section.**

8.4.7 Thin Section

When parts such as steel structural shapes, sheet metal, packings and gaskets are sectioned, the sectioned area is very small. In such cases, sectional lines can not be drawn. They are shown as blackened in sections and a thin white space is left between adjeacent parts in section.

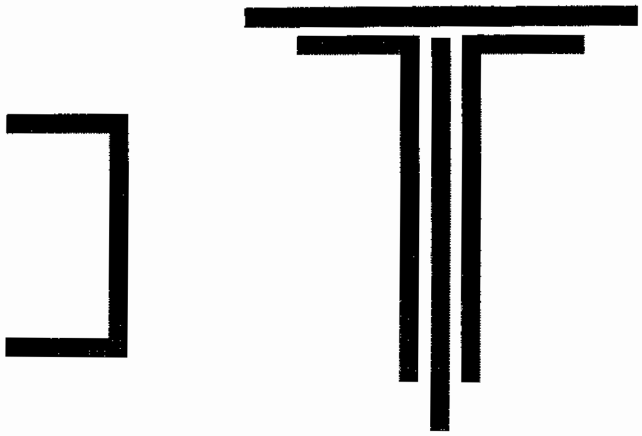
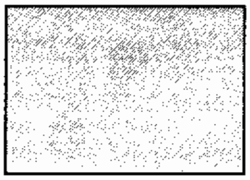
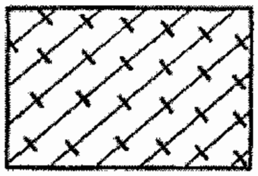
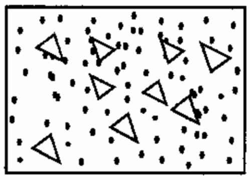
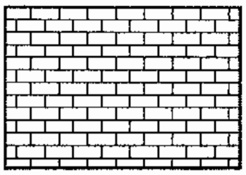
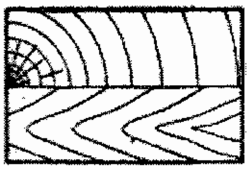
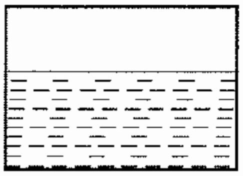
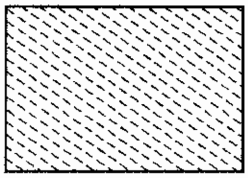
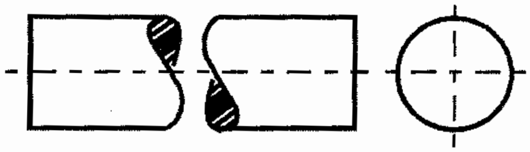
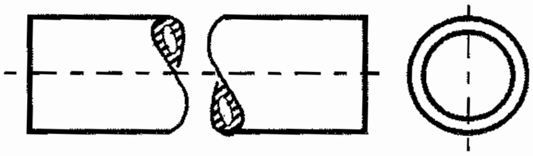
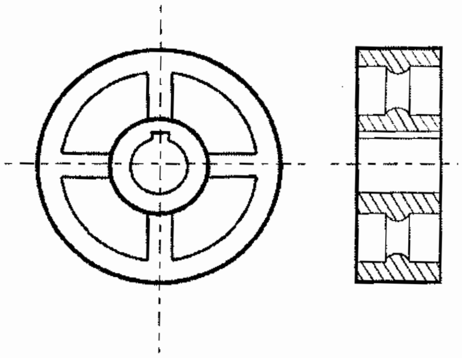
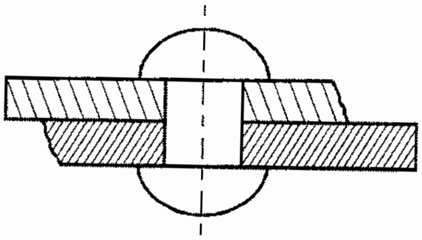
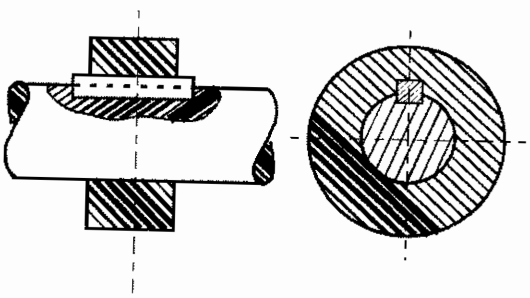


Fig 8.10 Thin section

8.5 Conventional representation of various materials in section

Sl. No	Material	Conventional representation
1.		Cast Iron Steel Brass
2.		Lead Aluminium
3.		Concrete
4.		Brick work
5.		Wood
6.		Glass
7.		Liquids
8.		Fiber

8.6 Conventional representation of various parts in section

Sl. No	Parts	Conventional representation
1.	Shafts	
2.	Pipes	
3.	Bars	
4.	Arms of pulley	
5.	Rivets	
6.	Keys & Cotters of shafts	

QUESTIONS

I A. Choose the correct option

1. The lines used to show the hidden details of a drawing are known as
   a. centre lines　　b. sectional lines
   c. dotted lines　　d. hatching
2. The sectioned portion of the object is indicated by
   a. dimension lines　　b. hatching
   c. hidden lines　　d. centre lines
3. The cutting plane angle of full sectioon is
   a. 180^0　　b. 90^0　　c. 60^0　　d. 45^0
4. The section of a connecting rod is generally shown in
   a. half section　　b. revolved section
   c.local section　　d. off-set section
5. The method showing the section of an object adjacent to its view is
   a. half section　　b. revolved section
   c.local section　　d. removed section

I B. Answer the following questions in one or two words

1. What is the process of drawing sectional lines known as ?
2. How is the direction of viewing of a sectioned object represented in a drawing ?
3. How is a cutting plane indicated in a drawing ?

II. Answer the following questions in one or two lines

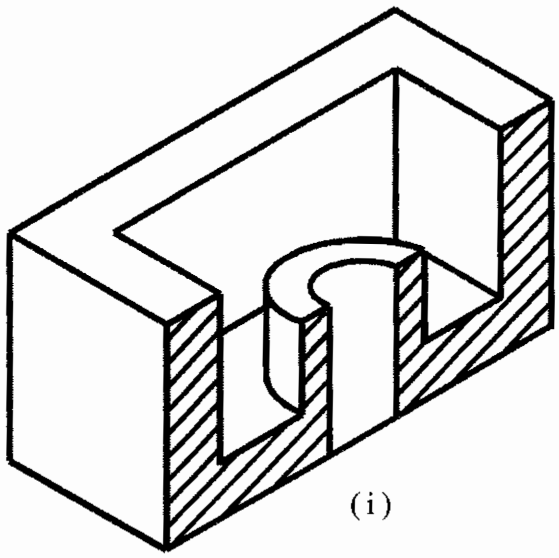
1. What are the objectives of a sectional view ?
2. What is a cutting plane ?
3. What is a sectional view ?
4. Write short notes on sectional lines.
6. What are the types of half sectional views ?
7. What is off-set section ?
8. What is thin section ?
9. Draw the conventional representation of a. Lead B. Aluminium c. Wood

III. Answer the following questions in about a page

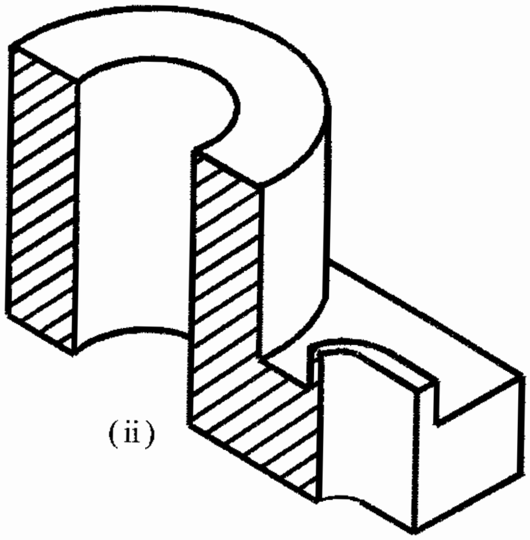
1. List the guidelines to be followed in drawing sectional lines ?
2. What are the types of sectional views ?

IV. Answer the following questions in about a page

1. Explain full section with an illustration.
2. Explain half section with an illustration.
3. Explain off-set section with an illustration.
4. Draw the orthographic views of the sectional views given below with approximate dimensions.



(i)



(ii)

9. FASTENERS

9.1. Introduction

A fastener may be defined as a machine element used for holding (or) joining two (or) more parts of a machine or a structure. The process of joining the parts is known as fastening. There are two types of fasteners namely

1. Temporary fasteners
2. Permanent fasteners

Temporary fasteners are useful in joining the parts temporarily. The parts can be separated when required without any damage. It is commonly used where the parts are assembled and disassembled repeatedly. The strength of the temporary fasteners is limited.

Screws, bolts, nuts, studs, keys, cotter pins and couplings are some examples of temporary fasteners.

The permanent fasteners are utilised when the parts are necessary to be joined permanently. It is impossible to separate the parts without any damage to them. But the strength of joint is more.

Welded and riveted joints are some examples of permanent fasteners.

9.2. Threads

Threads are first developed by Sir Joseph Whitworth of England in the year 1841.The form developed by him is known as British Standard Whitworth.

Threads are one of the several methods of fastening two or more components temporarily. A thread is a helical groove cut on the cylindrical surface of a round rod or a hole.

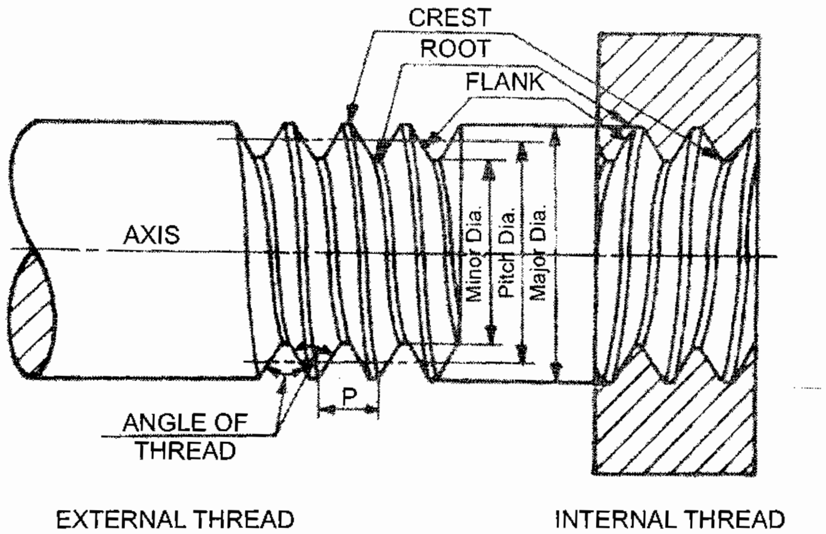


Fig 9.1 Nomenclature of thread

9.2.1. Nomenclature of threads

Major Diameter

This is the largest diameter of a screw thread, touching the crests of an external thread or the roots of an internal thread.

Minor Diameter

This is the smallest diameter of a screw thread, touching the roots or core of an external thread (or) the crests of an internal thread.

Pitch Diameter

This is the diameter of an imaginary cylinder passing through the threads at the points where the thread width is equal to the space between the threads.

Pitch

Pitch is the distance measured parallel to the axis, between corresponding points on adjacent screw threads.

Lead

Lead is the distance a screw advances axially on one full revolution.

Flank

Flank is the straight portion of the surface, on either side of the screw thread.

Crest

It is the peak edge of the screw thread that connects both the flanks of a thread at the top.

Root

It is the bottom edge of the thread that connects the adjacent flanks at the bottom.

Angle of thread

This is the angle included between the flanks of the thread, measured is an axial plane.

9.2.2. Right hand thread, Left hand thread

Right hand thread

When the axis of the screw is horizontal, if the slope of the thread lines are towards the right hand side, then the thread is called right hand thread. A right hand thread advances into a threaded hole when turned clockwise.

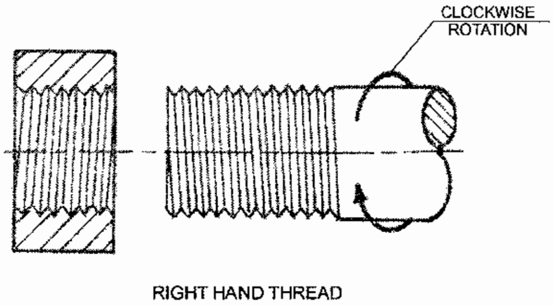


Fig 9.2 Right hand thread

Left hand thread

When the axis of the screw is horizontal, if the slope of the thread lines are towards the left hand side, then the thread is called left hand thread. A left hand thread advances into the nut when turned is a counter clockwise direction.

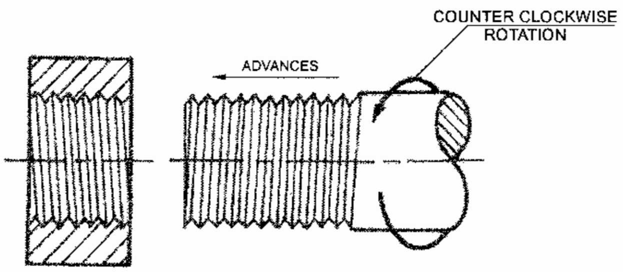


Fig 9.3 Left hand thread

9.2.3. Single start thread, Multiple start thread

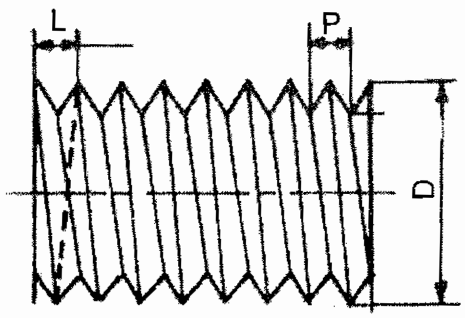
Single start thread

When only one helix forming the threads, run on a surface, it is called a single start thread. It is called single start thread also because only one starting point is seen on the beginning of the threaded portion. In a single start thread, the pitch is equal to the lead. Threads are always single start unless or otherwise specified.

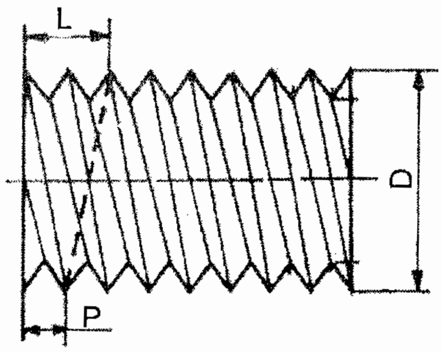
Multiple start thread

When two or more helices forming the threads run side by side on the cylindrical surface, it is called multiple start threads. It is called as a multiple start thread also because two or more than two starting points are seen at the beginning of the threaded portion. In double start threads, the lead is twice the pitch, in triple start threads, the lead is three times the pitch and so on.

Lead = number of starts x pitch



SINGLE START THREAD



DOUBLE START THREAD

P - PITCH L - LEAD
D - MAJOR DIAMETER

9.4 Single start and double start thread

Uses of multiple threads

Multiple threads are used wherever quick motion is required and application of great force is not allowed. Example: on fountain pens, bottles, tooth paste caps, valves, power press screws and vice screws, etc to impart quick action in opening and closing.

9.3. Forms of thread

British Standard Whitworth thread (BSW)

This form of thread is used as a standard thread in Britain. It is the modified form of "V" thread having angle of 55^0.

The theoretical depth of BSW thread is 0.96 P (P - Pitch of the thread). $1/6^{th}$ of the theoretical depth is rounded of both at the top and bottom of the thread.

British Standard Fine (BSF) and British Standard Pipe (BSP) threads have the same profile of the BSW threads. But they have finer pitch values and smaller depths. BSF threads find application in automobile and aircraft industry. BSP threads are used on pipes meant for gas, steam and water.

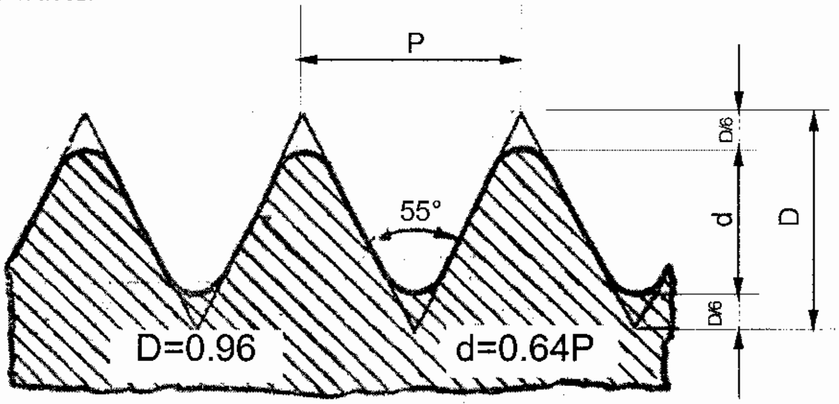


Fig 9.5 BSW thread

British Association thread (BA)

The angle of BA thread is $47½^0$. The theoretical depth of this form of thread is 1.136P. The actual depth of the thread becomes 0.6P after 0.236 of the theoretical depth is rounded of both at the top and bottom. This form of thread is generally used for small instrument screws having diameters less than ¼".

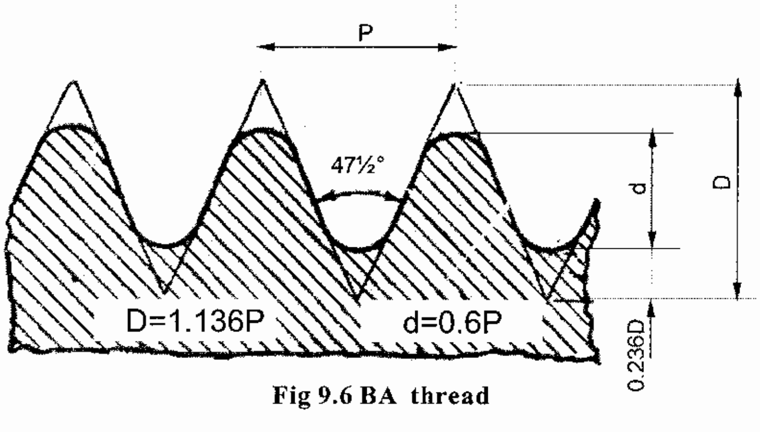


Fig 9.6 BA thread

Metric thread

The angle of metric thread is 60^0. The actual form of unified thread recommended by ISO is adopted as metric thread.

The theoretical depth of both external and internal threads of this form is 0.866P. The crests of the thread are cut parallel to the axis of the screw and roots rounded off to obtain the actual depth. Metric thread is designated by its major diameter and its pitch value. It is the most used form of thread in the industry.

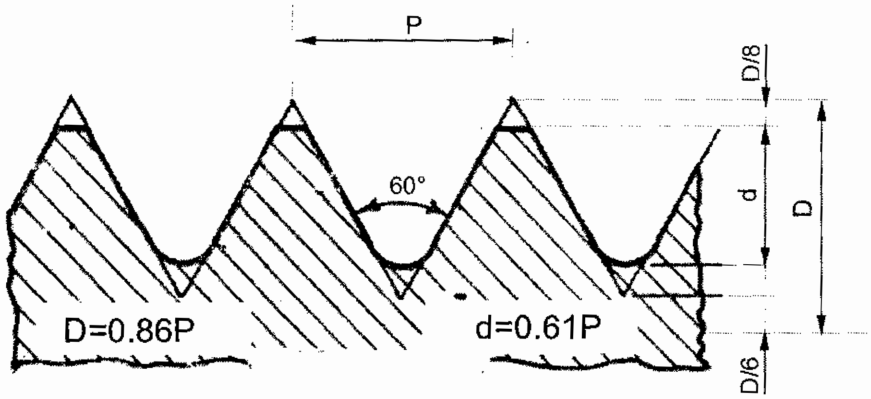


Fig 9.7 Metric thread

Square thread

The angle of thread is 90^0. The flanks and sides of the thread are at right angles to the axis of the thread. The depth and thickness of the thread are equal to half the value of its pitch. It is generally used for transmission of power and for obtaining large axial movement of the nut.

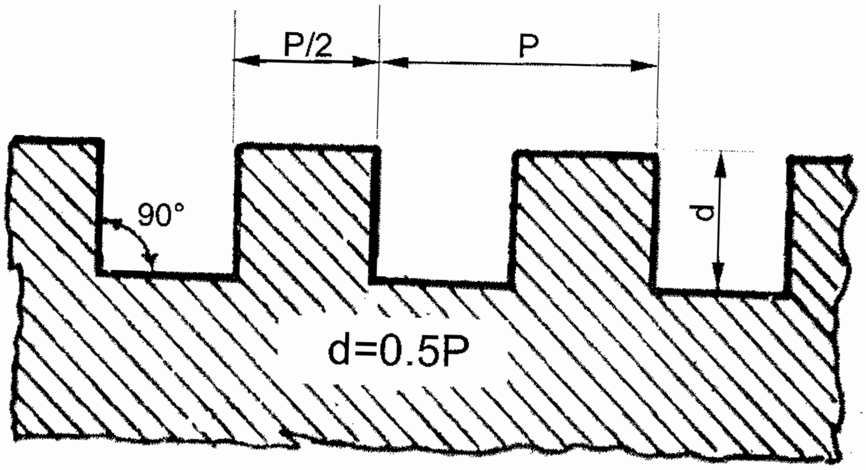


Fig 9.8 Square thread

Acme thread

The angle of the thread is 29^0. It is a modification of square thread. It is stronger than square thread as its root is wider and is easy to cut. The shape of this thread enables easy engagement of spilt nuts and is therefore used in lathe leadscrews, radial drilling machine etc.,

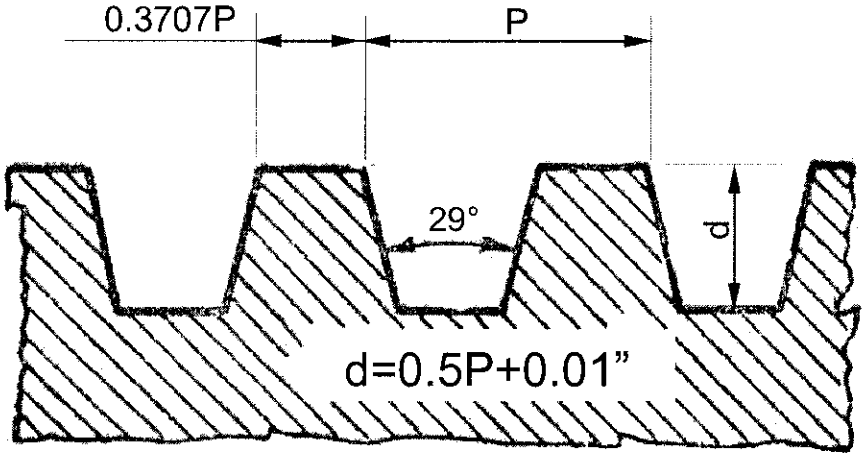


Fig 9.9 Acme thread

Knuckle thread

This thread is also a modification of square threads. It is formed by rounding off the corners of square thread so that it has a complete rounded profile. The section of the knuckle thread shows semicircles of radius, R = 0.25P. The depth of the thread is 0.5P. It can withstand heavy wear and rough usage.

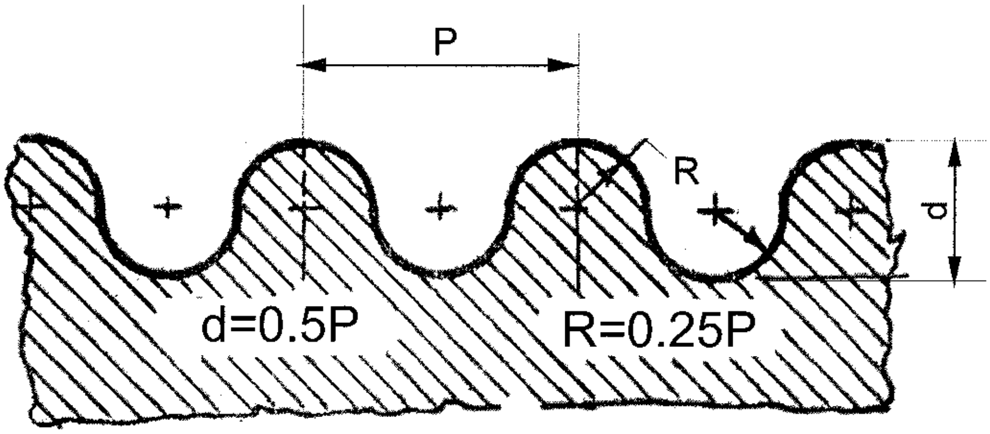


Fig 9.10 Knuckle thread

Buttress Thread

Buttress thread is a combination of square and V thread. One flank of the thread is at right angles to the axis. The angle between the two flanks is 45^0. The theoretical depth is equal to its pitch value. 1/8th of the theoretical depth is cut off parallel to the axis at both crest and root. Because of its shape, It is useful in transmitting power in one direction.

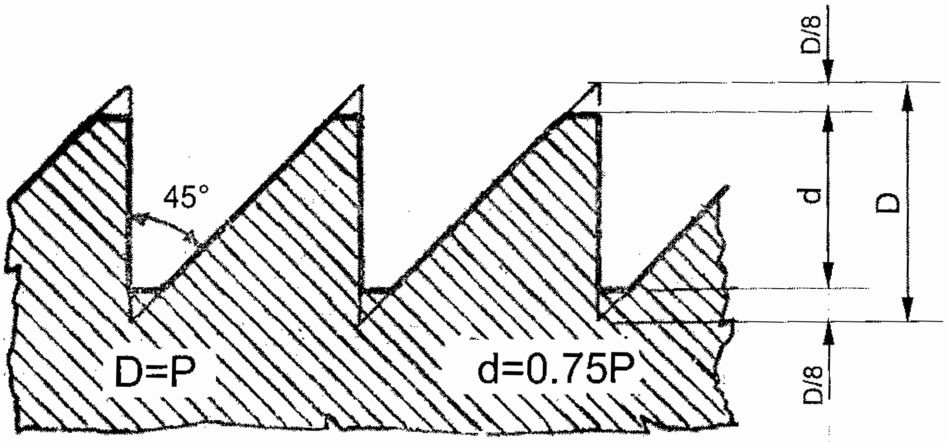


Fig 9.11 Buttress thread

9.4. Bolts, nuts and washers

A screw pair consists of a nut and a bolt. This pair is useful in fastening parts or components used in engineering construction.

9.4.1 Bolts

A bolt is a threaded shaft which comprises of two parts known as a shank and a head. The shank is cylindrical and is threaded at the tail end for sufficient length. The shape of the head differs with the purpose of the bolts.

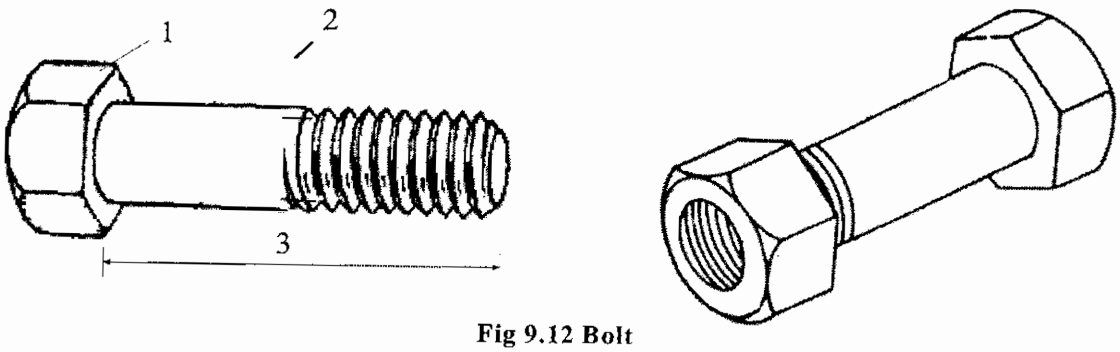


Fig 9.12 Bolt

1. Head 2. Shank 3. Length of the bolt

Some important types of bolts are

i) Through bolt
ii) Tap bolt
iii) Stud bolt

Through bolt :

Through bolts are used to connect two parts which have unthreaded holes on them. The bolt is inserted into the holes and the other end is tightened with a nut.

Tap bolt :

This type of bolt is used when one of the connected parts have a threaded hole.

Stud bolt :

Bolts that do not have an head is called as stud bolt. The neck of the bolt may have a collar or a square section. Stud bolts are useful in connecting two parts of which one has a hole and the other has a threaded hole. Stud bolt is tightened into the threaded hole with a spanner operating on the square neck of the bolt. The other part is inserted and the joint is effected by tightening the nut.

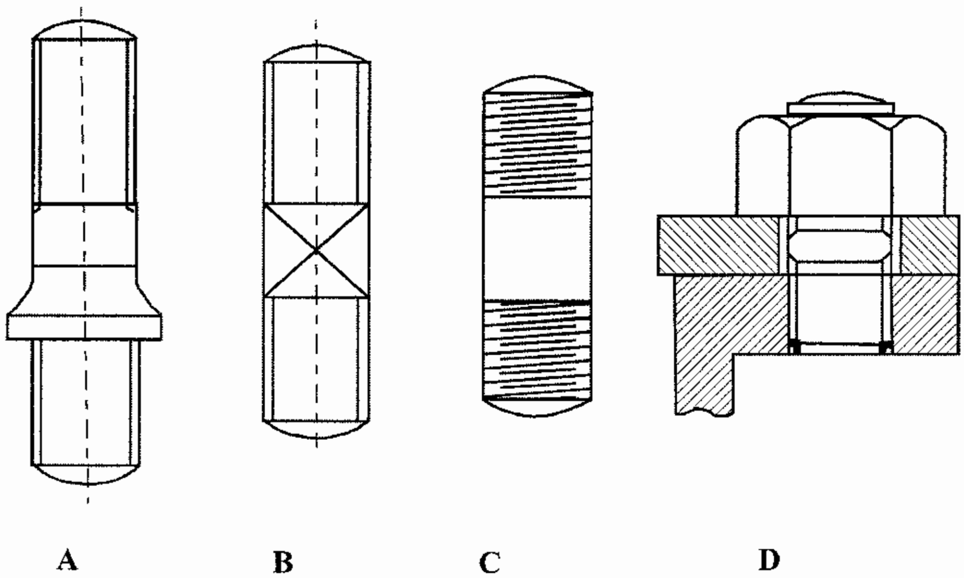


Fig 9.13 Stud bolt

A, B & C - Types of stud bolt D - Stud bolt in assembly

9.4.2 Nuts

A device used with a bolt or a stud to join two or more parts together temporarily is known as a nut. Nut is a square or hexagonal shaft having a through hole which is threaded.

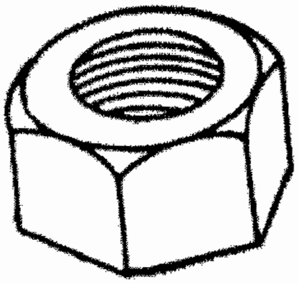


Fig 9.14 Hexagonal nut

In order to ensure proper joint of the connection, a split pin is inserted into a hole made across the bolt diametrically. In slotted nut and castle nut a slot is made to accommodate the split pin.

9.4.3 Washers

A circular disc of metal having a central hole for inserting a bolt or a stud is known as a washer. It is placed below a nut to provide a perfect seating for the nut. The force taken by it is evenly distributed over a large surface area. It helps in screwing the nut more tightly. Different types of washers like plain washers, chamfered washers and spring washers are in general use.

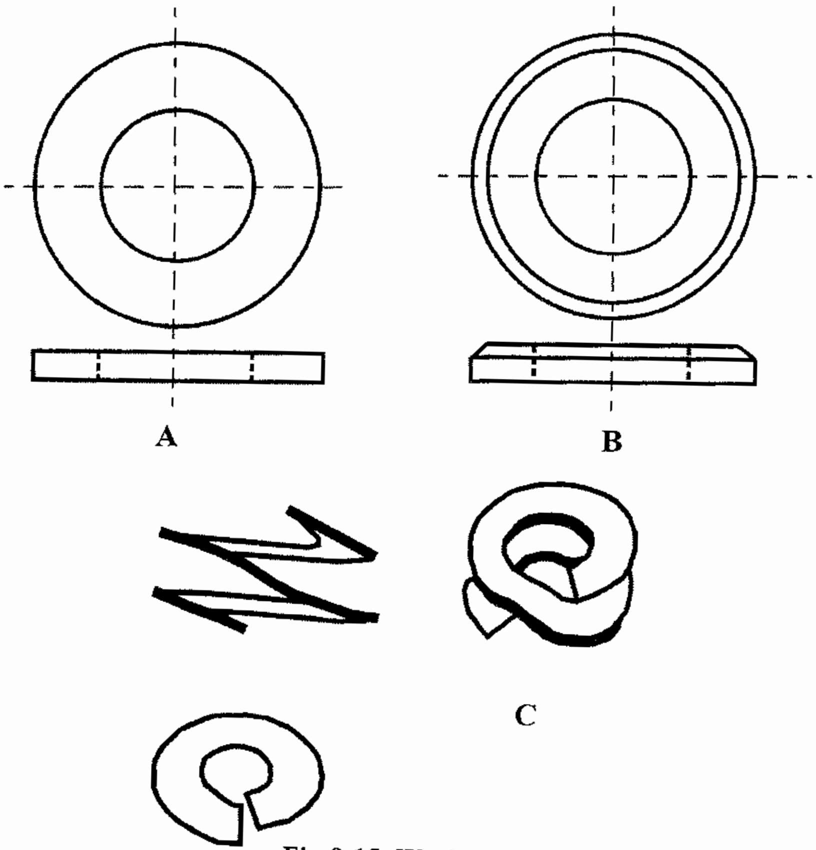


Fig 9.15 Washers

A- Plain washer B- Chamfered washer C- Spring washer

9.5 Methods of representing threads in drawings

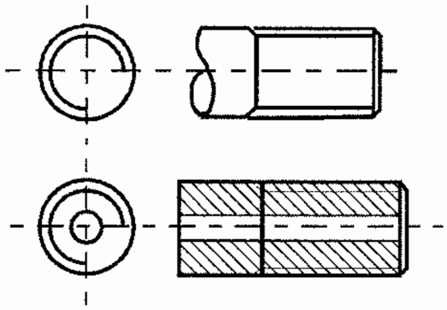
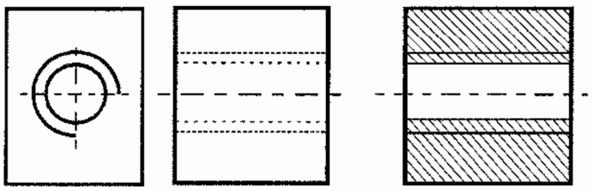
THREADS	BIS CONVENSION
External V-Thread, Single Start right hand	
Internal V-Thread	

Fig 9.16 Methods of representing threads in drawings

9.6. Keys

Keys are machine elements used to connect a shaft and the parts mounted on it such as pulleys, gears, wheels, couplings etc., and prevent relative rotational movement between them. It is subjected to shearing and torsion stresses and hence, it is always made of steel. It is inserted in the axial direction between the shaft and the hub or boss of the mating piece. The groove cut on the shaft as well as in the hub, to accommodate the key, is called a key way.

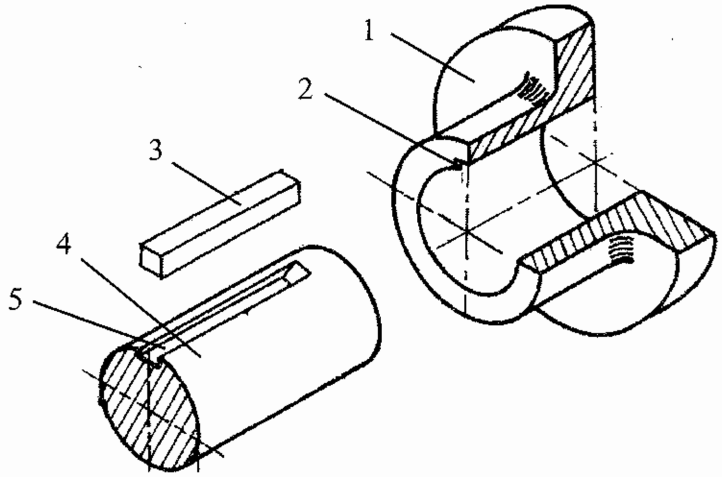


Fig 9.17 Key and keyway (Parallel sunk key)

1. Hub 2. Keyway in the hub 3. Key 4. Shaft 5. Keyway in the shaft

9.6.1 Classification of keys

1. Sunk keys
2. Saddle keys
3. Round keys

9.6.2. Sunk keys

This is a standard form of key and may be either of rectangular or square cross-section. The end may be squared or rounded. Generally, half the thickness of the key fits into the shaft keyway and the remaining half in the hub keyways.

Types of sunk keys

a. Parallel key b. Taper key
c. Gib headed key d. Feather key
e. Wood – ruff key

Parallel key

A parallel key is rectangular or square in cross – section and uniform in width and thickness throughout its length. These keys are generally used where pulleys, gears or other similar parts are secured to the shafts permitting relative axial movement. To achieve this, a clearance fit must exist between the key and the keyway in which it slides.

Taper key

A taper key is uniform in width but tapered in thickness. The bottom surface of the key is straight and the top surface is tapered. When inserted in its position, it prevents relative rotational as well as axial movement between the parts. The magnitude of the taper is 1 :100.

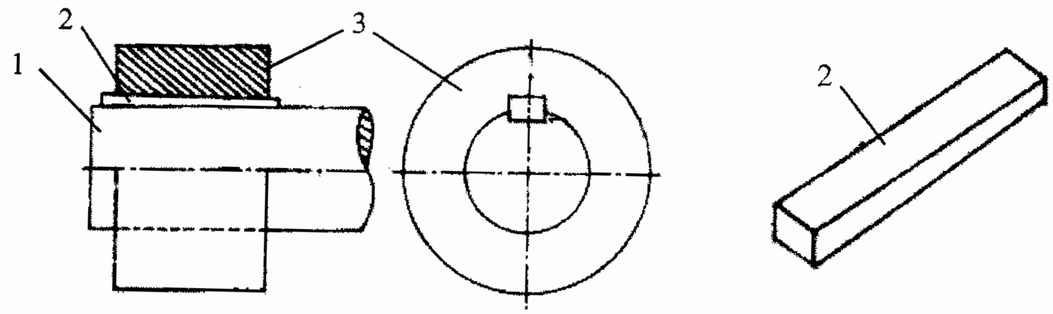


Fig 9.18 Taper sunk key

1. Shaft 2. Taper sunk key 3. Hub

Gib headed key

A taper key is removed by hammering at its thinner end. When that end is inaccessible, the key is usually provided with a head, called a gib – head to facilitate its removal. This type of key is used when the connected parts are to be separated occasionally for the purpose of repair or maintenance.

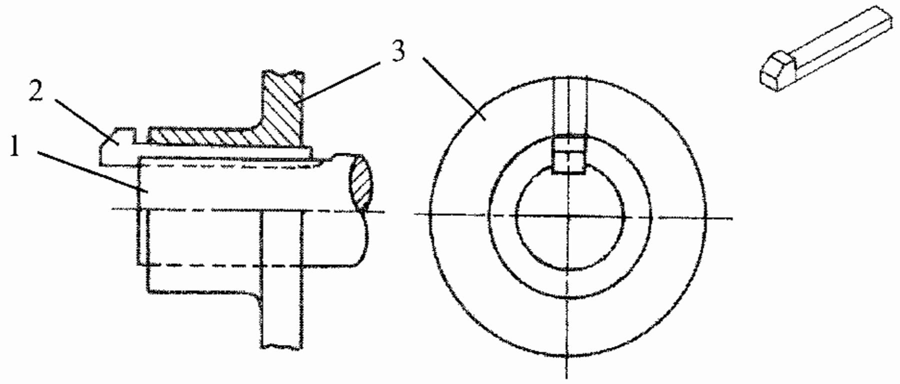


Fig 9.19 Gib headed key

1. Shaft 2. Gib headed key 3. Hub

Feather Key

A feather key is attached to one member of the pair, screwed to the shaft. Feather keys are parallel keys and permit relative axial movement of the pair. It may be rectangular, square, dove tail (or) rounded in cross section.

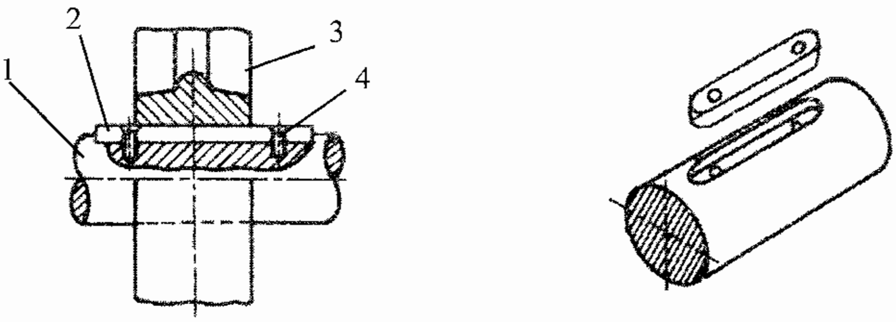


Fig 9.20 Feather key

1. Shaft 2. Feather key 3. Hub 4. Screw

Wood ruff key

This key is in the form of a segment of a circular disc of uniform thickness. It fits into a slot of corresponding shape cut in the hub of the wheel. The key and the slot in the shaft are of same radius so that the key can be adjusted to any taper. It is mainly used on tapered shafts of machine tools and automobiles.

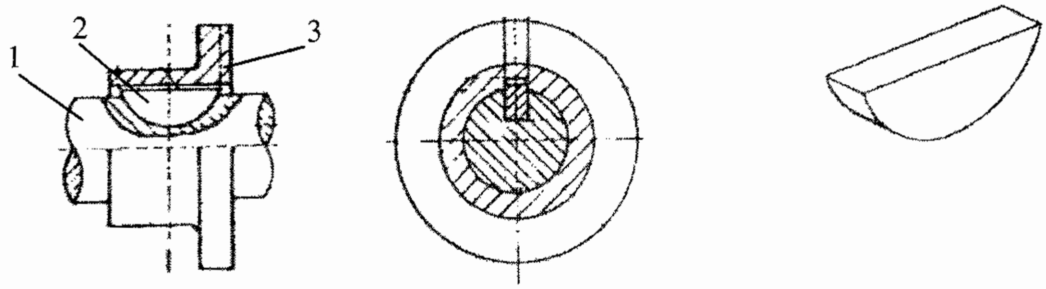


Fig 9.21 Woodruff key

1. Shaft 2. Woodruff key 3. Hub

9.6.2. Saddle Keys

It is a key with uniform width but tapering in thickness on the upperside. The magnitude of the taper provided is 1:100. Saddle keys are used for low power transmission.

These are made in two forms,

1. Hallow saddle keys
2. Flat saddle keys

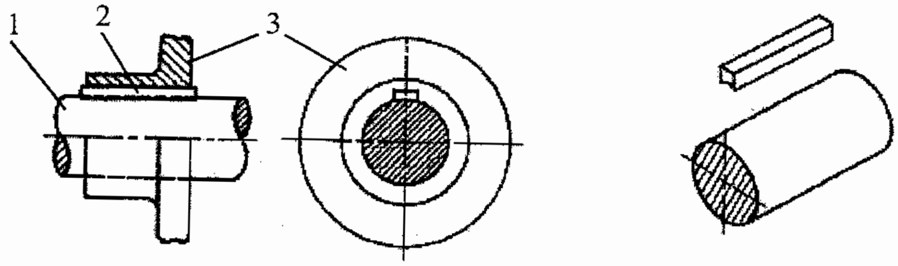


Fig 9.22 Hollow saddle key

1. Shaft 2. Hollow saddle key 3. Hub

Hollow saddle key

A hollow saddle key has a concave shaped bottom to suit the curved surface of the shaft, on which it is used. The keyway is only cut in the hub of the wheel. The relative rotation is prevented by the friction between the key and the shaft.

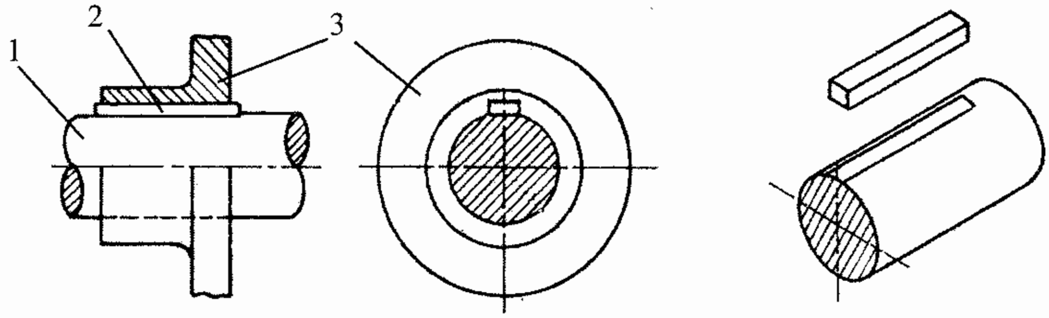


Fig 9.23 Flat saddle key

1. Shaft 2. Flat saddle key 3. Hub

Flat saddle key

It is similar to the hollow saddle key except that the bottom surface of it is flat. It fits on the flat surface provided on the shaft. It gives more secured fastening than a hollow saddle key.

9.6.4. Round Key

Keys of circular cross – section are called round keys, usually tapered (1:50) along the length. A round key fits in the hole drilled partly in the shaft and partly in the hub. The ends of the round keys may be curved or chamfered. The mean diameter of the pin may be taken as 0.25D. Where D is shaft diameter. It is generally used for light duty, where the loads are not considerable.

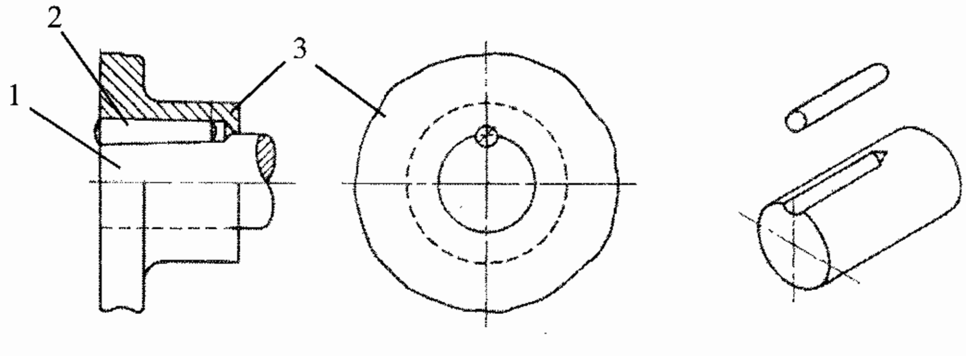


Fig 9.24 Round key

1. Shaft 2. Round key 3. Hub

9.7. Proportion of keys

Parallel key

Given d – diameter of the shaft

w – width of the key = d/4 = 0.25 d

t - Thickness of the key = 0.66w or d/6

l – length of the key = 1.5 d (minimum)

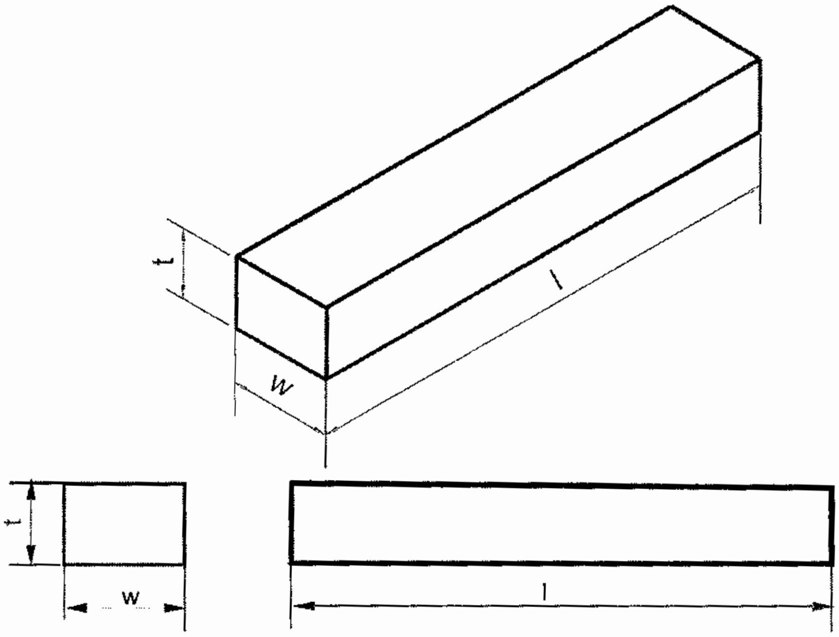


Fig 9.25 Proportion of parallel key

Gib headed key

Given d – diameter of the shaft

w – width of the key = d/4 = 0.25 d

t - Thickness of the key = 0.66w or d/6

h - height of the key = 1.75 t

b = breadth of the gib = 1.5 t

Angle of chamfer = 45^0

Standard taper = 1 : 100

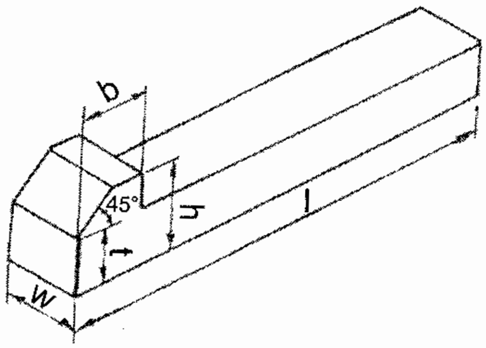


Fig 9.26 Proportion of Gib headed key

QUESTIONS

I . A. Choose the correct option

1. An example for permanent fastener is

   a. Welded joint b. Screwed joint c. Keyed joint d. Couplings

2. .... is a temporary fastener

   a. Welded joint b. Riveted joint c. Screwed joint d. Forging

3. Pitch of a screw is measured

   a. parallel to its axis b. perpendicular to its axis

   c. from the crest to the root d. from the root to the crest

4. The diameter of a screw touching the roots of the external thead is known as

   a. pitch diameter b. major diameter

   c. Minor diameter d. lead of the thread

5. The angle of the BSW thread is

   a. 29^0 b. 55^0 c. $47½^0$ d. 90^0

6. BSP and BSF threads have the same profile as

   a. BA thread b. Acme thread

   c. Buttress thread d. BSW thread

7. The angle of metric thread is

   a. 29^0 b. 55^0 c. $47½^0$ d. 60^0

8. Keys are used to

   a. prevent relative movement between shaft and pulleys

   b. actuate relative movement between shaft and pulleys

   c. prevent rotation

   d. to join pulleys and gears

I. B. Answer the following questions in one or two words

1. Who developed threads first?
2. What are the types of threads?
3. Give examples for temporary fasteners.
4. Give examples for permenant fasteners.
5. Lead= pitch x ....
6. Mention the types of washers.
7. What are keys made of ?
8. What are the types of saddle keys ?

II. Answer the following questions in one or two sentenses

1. What is meant by temporary fastener ?
2. Define 'pitch' of a thread.
3. What is a bolt?
4. What is a keyway ?
5. Mention the types of sunk keys.

III. Answer the following questions in about a page

1. Explain briefly about fasteners.
2. Draw and explain the nomenclature of a thread.
3. Explain 'Right hand thread' and 'left hand thread' with diagrams.
4. Explain the types of sunk keys.
5. Write the proportions of a Parallel key and Gib-headed key.

IV. Answer the following questions in detail

1. Explain the different forms of threads with suitable diagrams.
2. Explain the types of keys with suitable diagrams.

10. ASSEMBLY DRAWING

10.1. Introduction

A machine or mechanism may have a large number of simple to complex components. The shape and sizes of these components are decided by the designer. The designer's ideas are generally expressed by means of free hand drawings. Based on these drawings, detail and assembly drawings are made. The relation between various parts of the machine or mechanisms should clearly be understood for the purpose of the final design and production.

10.2. Assembly drawing

An assembly drawing may be defined as a drawing which shows all the parts of the machine assembled in their relative functional positions.

A detail drawing is a drawing which shows complete informations about the production of a part or a mechanism.

10.2.1. Informations to be furnished in assembly drawings

1. One main view to show the best assembly
2. Selected overall dimensions and important centre to centre distance
3. Identification of different parts on assembly drawing
4. Necessary sections
5. Parts list, notes, title block etc.

10.3. Classifications of assembly drawings

1. Design assembly drawing
2. Working assembly drawing
3. Sub assembly drawing
4. Installation assembly drawing

10.3.1 Design assembly drawing

An assembly drawing made at the designing stage while developing a machine is known as design assembly drawing. These are made to a larger scale so that the required changes or modifications may be thought of by the designer, keeping in view their functional requirements and appearance.

10.3.2 Working assembly drawing

These drawings are normally made for simple machines, comprising small number of parts. Each part is completely dimensioned to facilitate easy fabrication.

10.3.3 Sub assembly drawing

It is a assembly drawing of a group of related parts which form a part of a complicated machine. It is difficult to give the complete working assembly drawings of a entire machine but working parts or sub assembly drawings are necessary for each unit.

10.3.4 Installation assembly drawing

The drawing which shows how to install or erect a machine or structure is known as installation assembly drawing.

10.4 Procedure for making assembly drawing from details

In order to make assembly drawings from details, the following points are to be noted.

1. The relative positions of various parts are studied based on their function, shape and size.
2. Both the external and internal features of each part is studied.
3. Overall dimensions of assembly are calculated and a suitable scale is selected.
4. While making the front view, the main central part of the assembly is drawn first and the remaining parts are drawn in the sequence of assembly.
5. Other views are drawn making projections from front view.
6. Sections are shown in any of the views, if necessary.
7. Overall dimensions are marked and part numbers noted.
8. Parts list, title block are completed with necessary information.

QUESTIONS

I. Choose the correct option

1. The shape and size of a component are decided by
   - a. the worker
   - b. the supervisor
   - c. the designer
   - d. the manager

2. Detail and assembly drawings are made based on
   - a. freehand sketches
   - b. discussions
   - c. sectional views
   - d. orthographic views

II. Answer the following questions in one or two lines

1. What is an assembly drawing ?
2. What is a detail drawing ?
3. What are the informations to be furnished in an assembly drawing ?
4. How are assembly drawings classified ?

III. Answer the following questions in about a page

1. Write down the procedure for making assembly drawings from detail drawings.

Sample assembly drawings

The drawings in the next pages are given for the students to understand the method of making assembly drawing. They can also understand how the assembly drawings will look like.

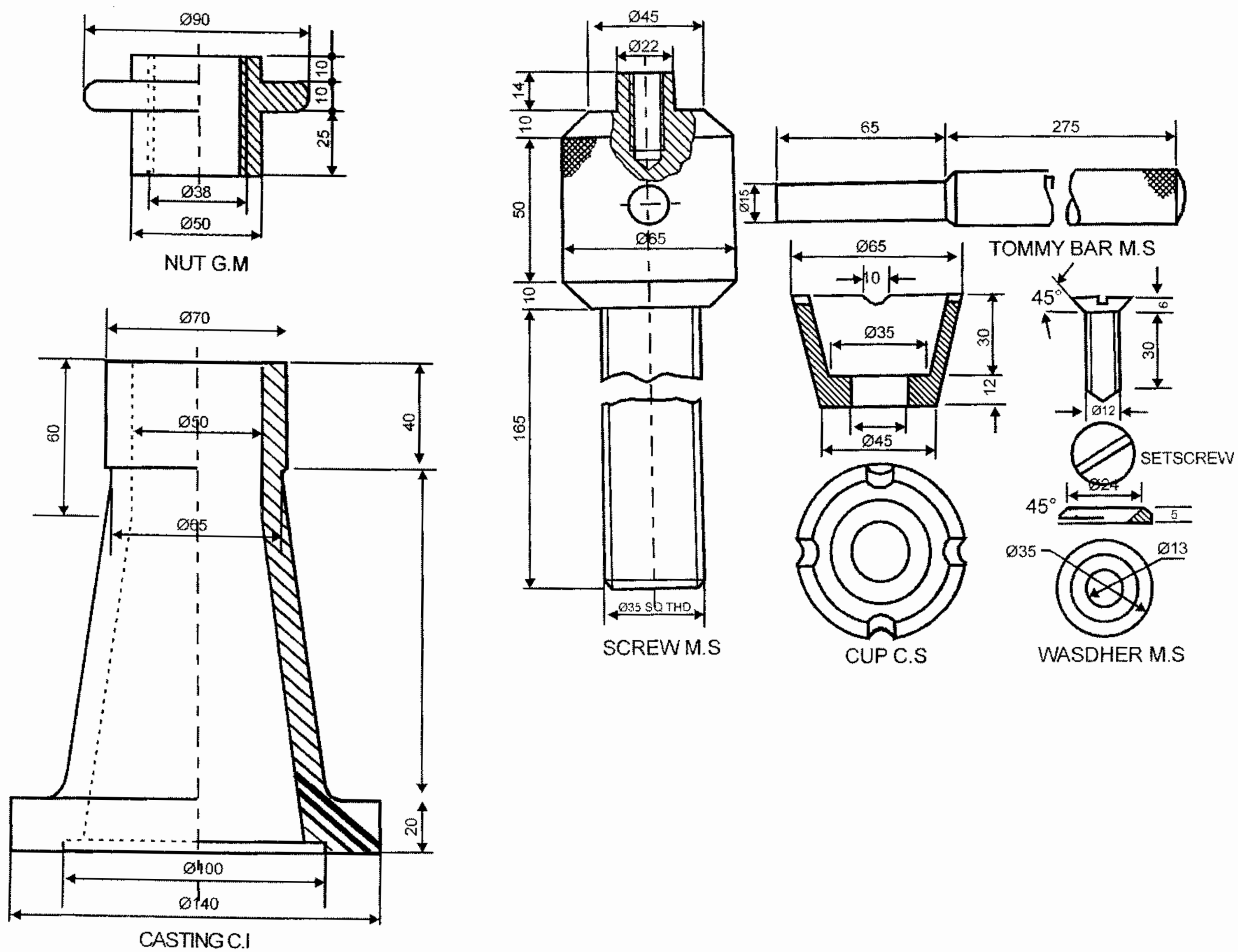


Fig. 10.1. Details of a screw jack

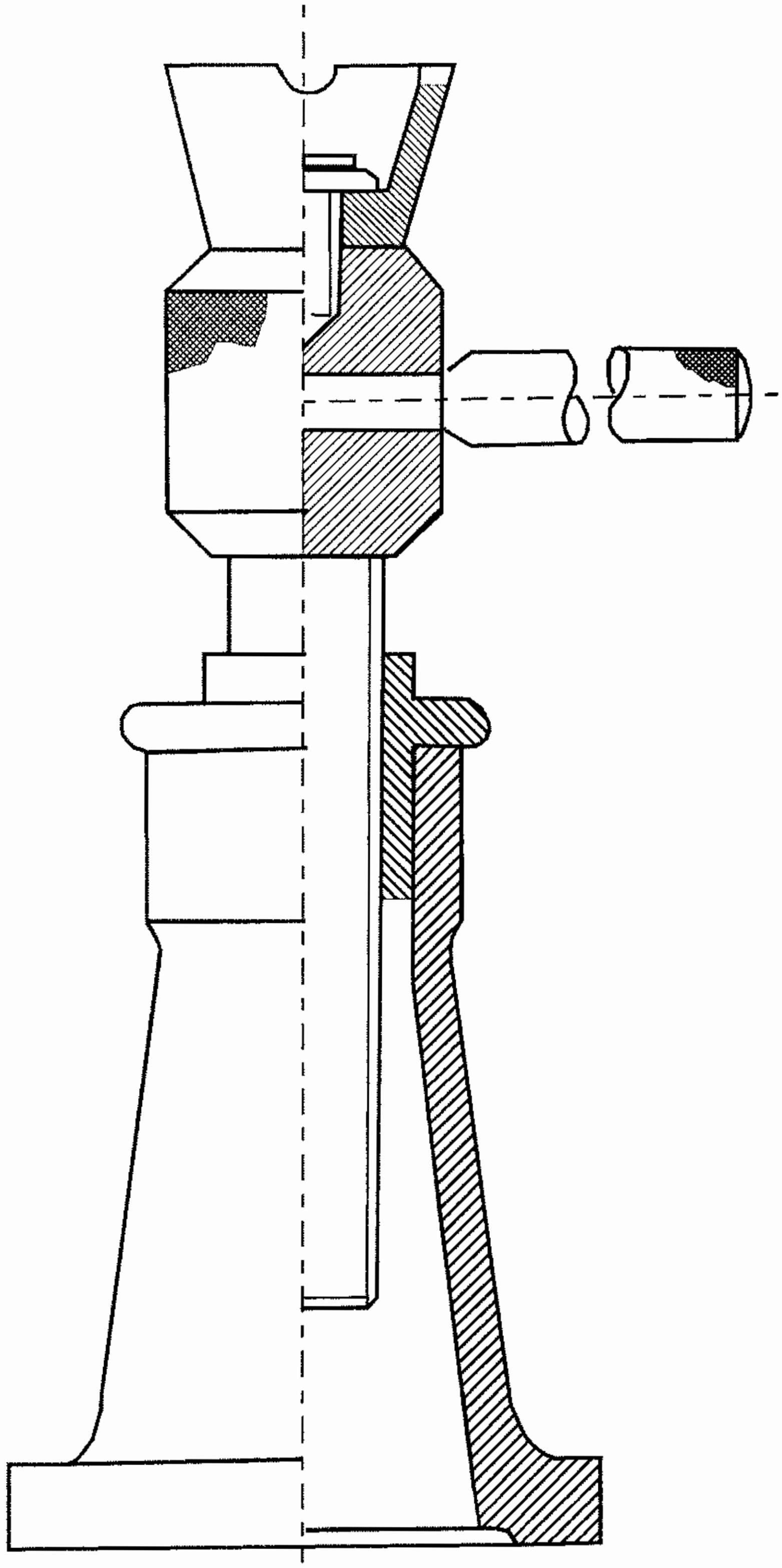


Fig. 10. 2 Assembly of parts of a screw jack

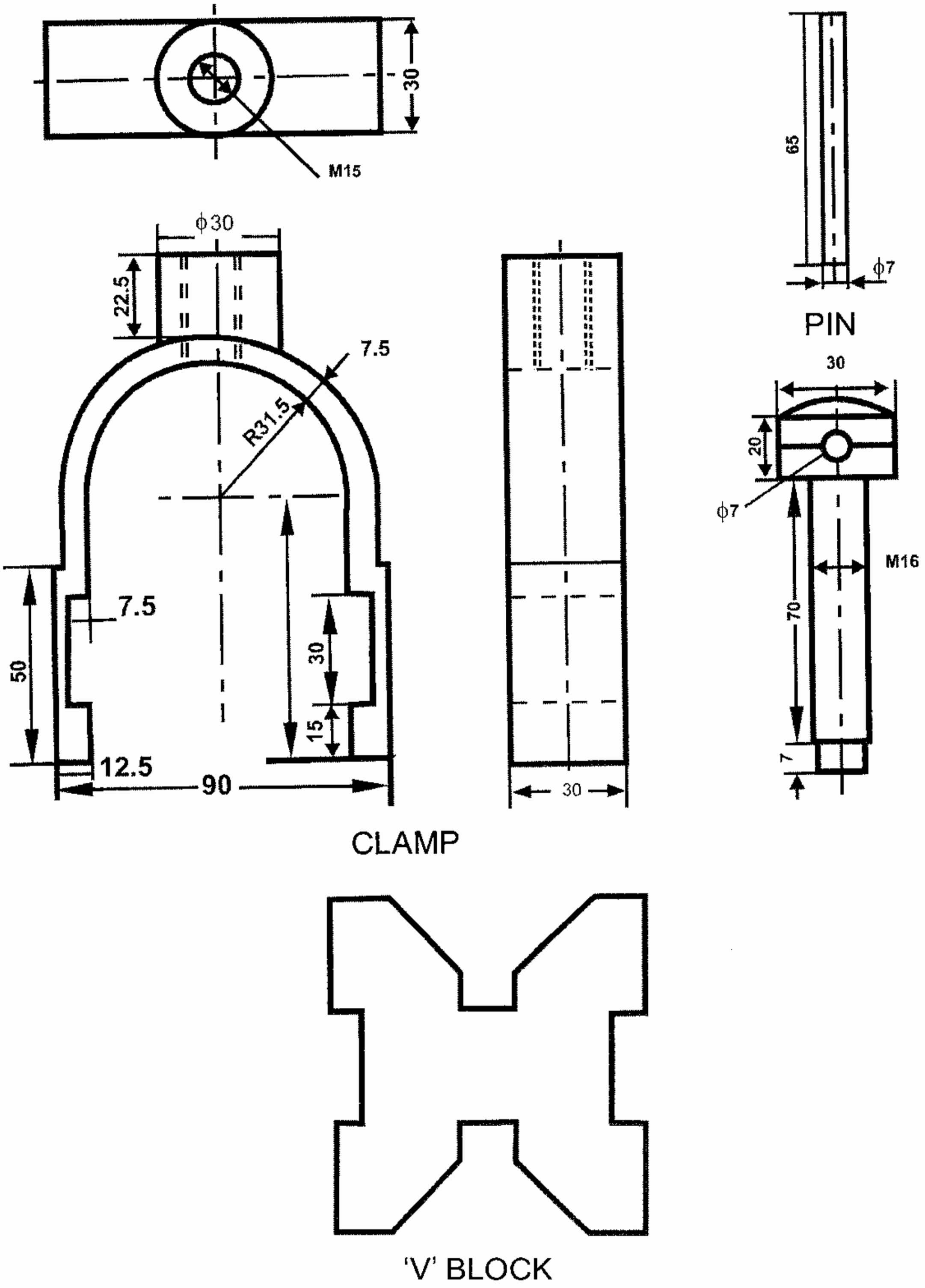


Fig. 10. 3. Details of a " V " block

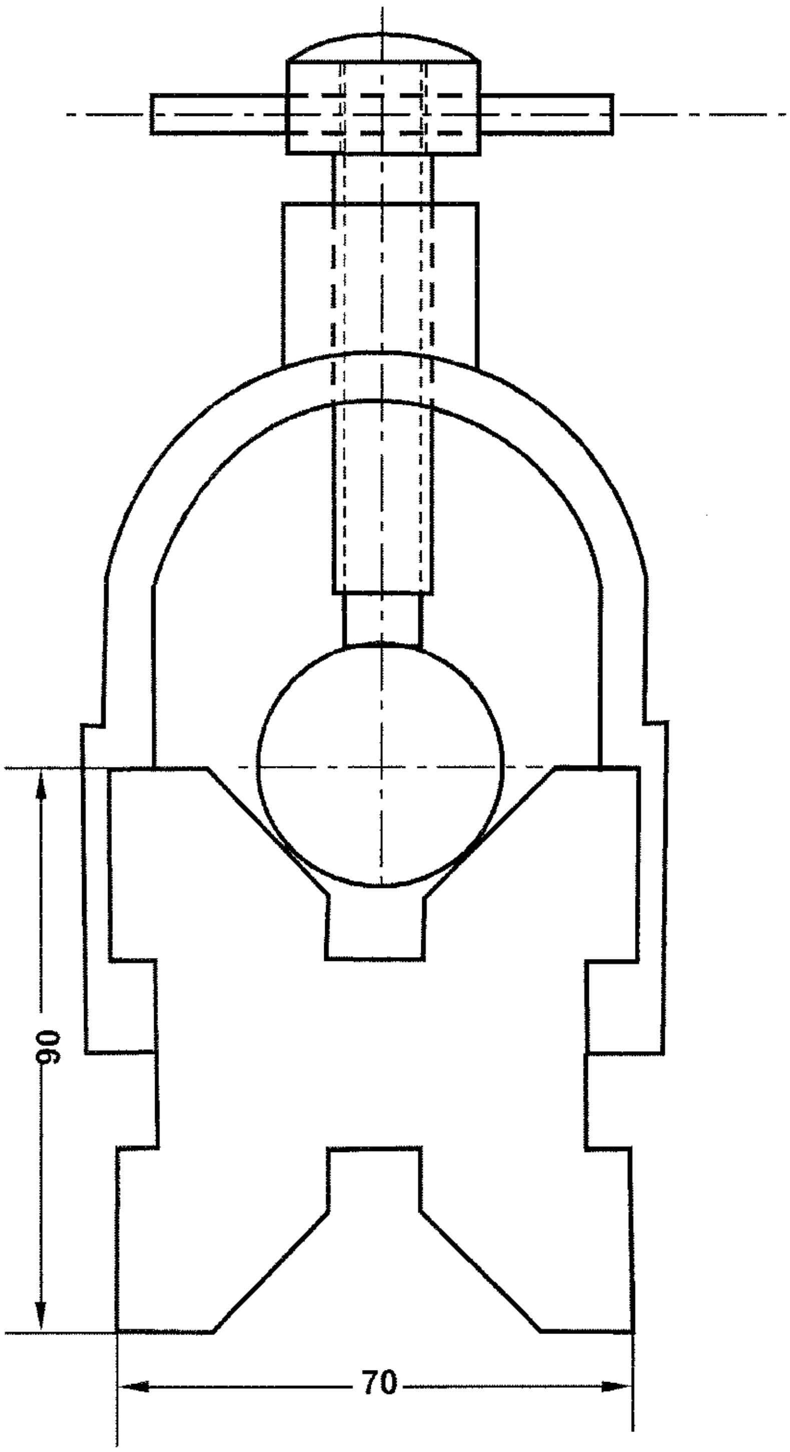


Fig. 10. 4. Assembly of a " V " block

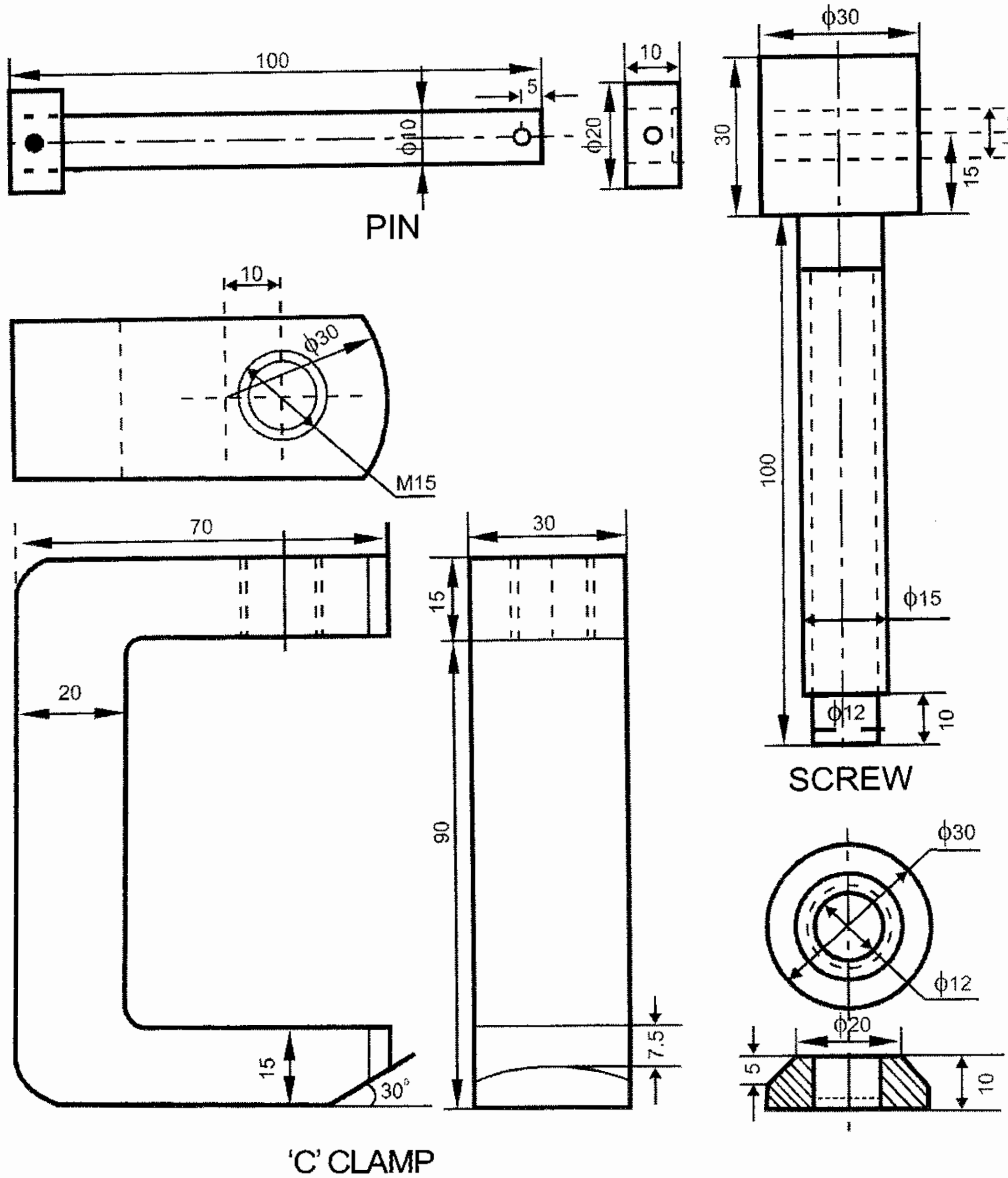


Fig. 10. 5 Details of a " C " clamp

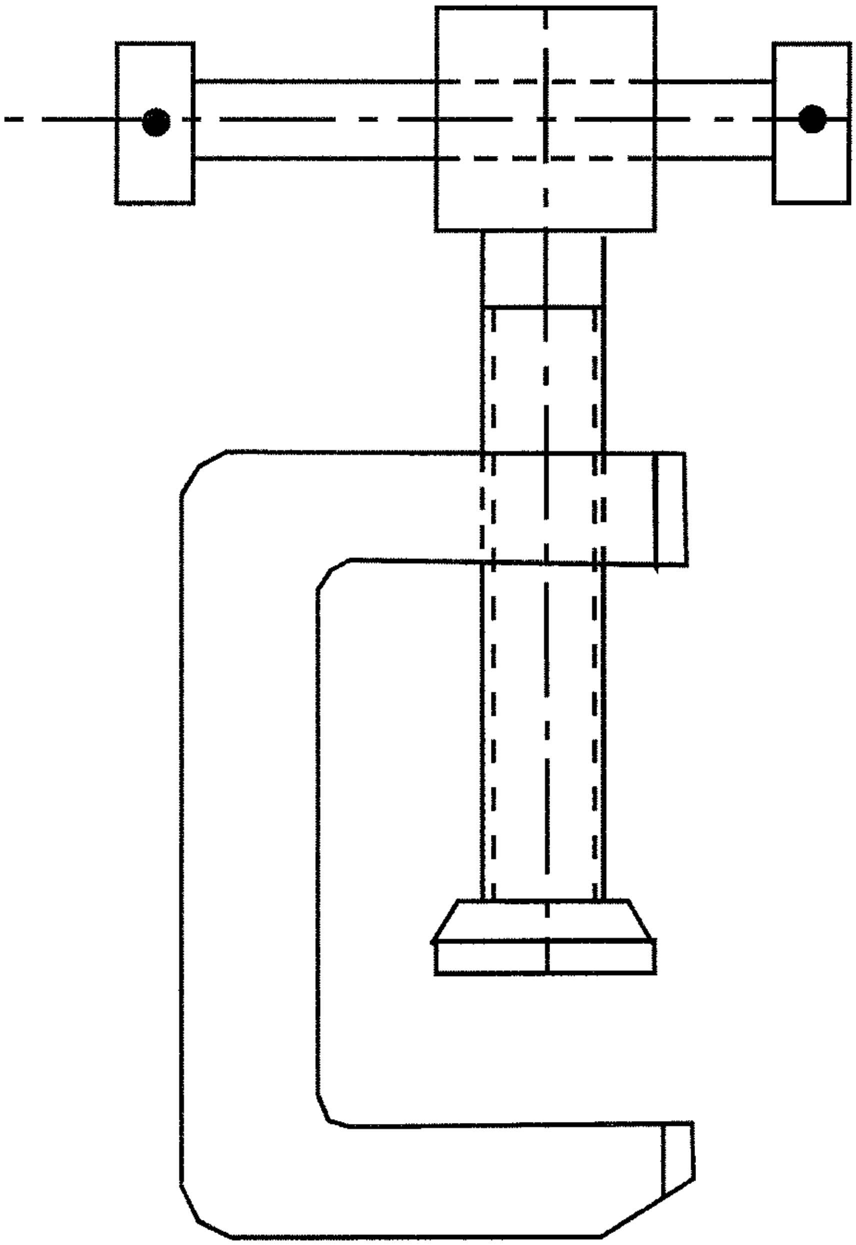


Fig. 10. 6 Assembly of a " C " clamp

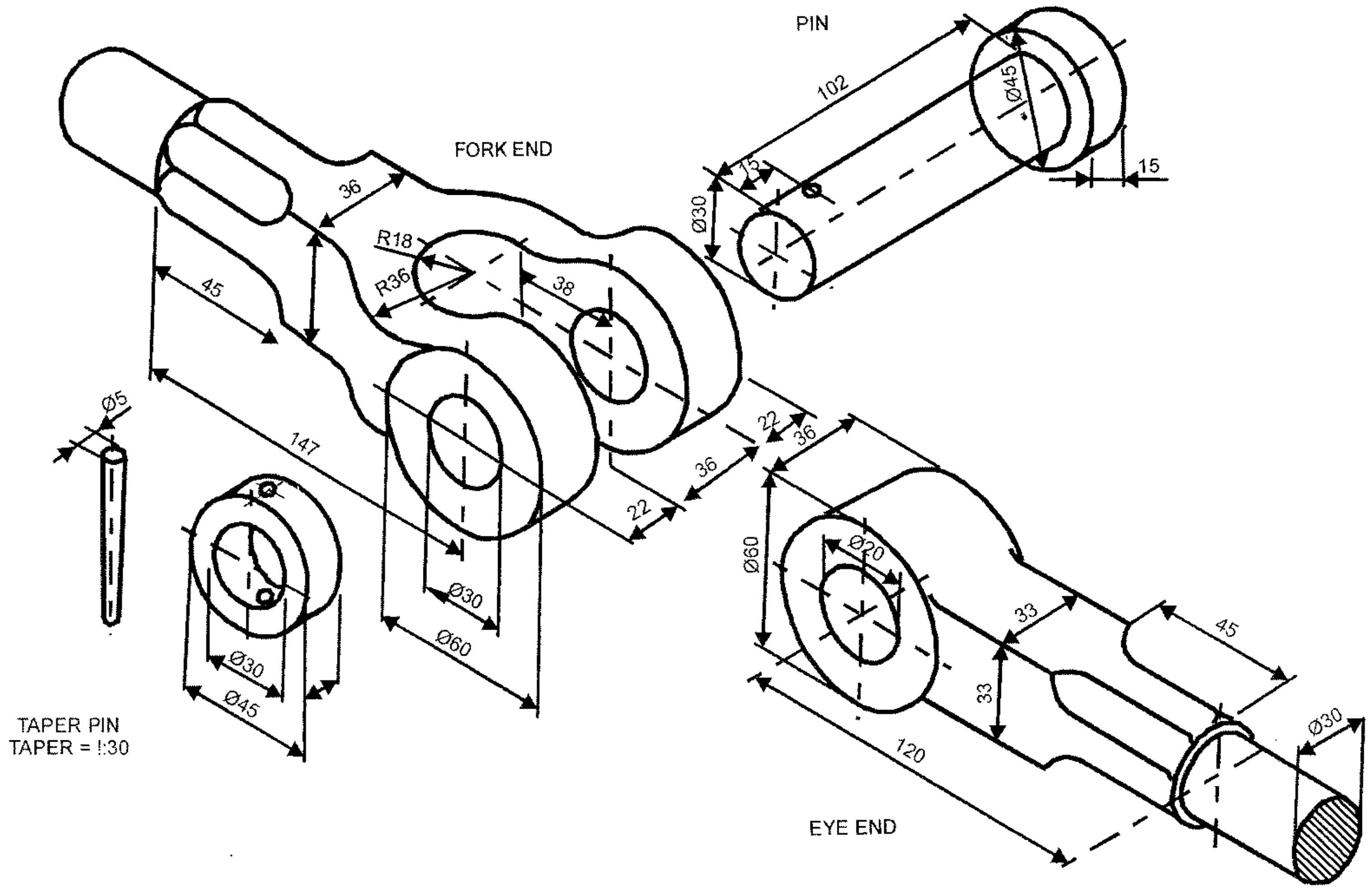


Fig. 10. 7 Details of a kuuckle joint

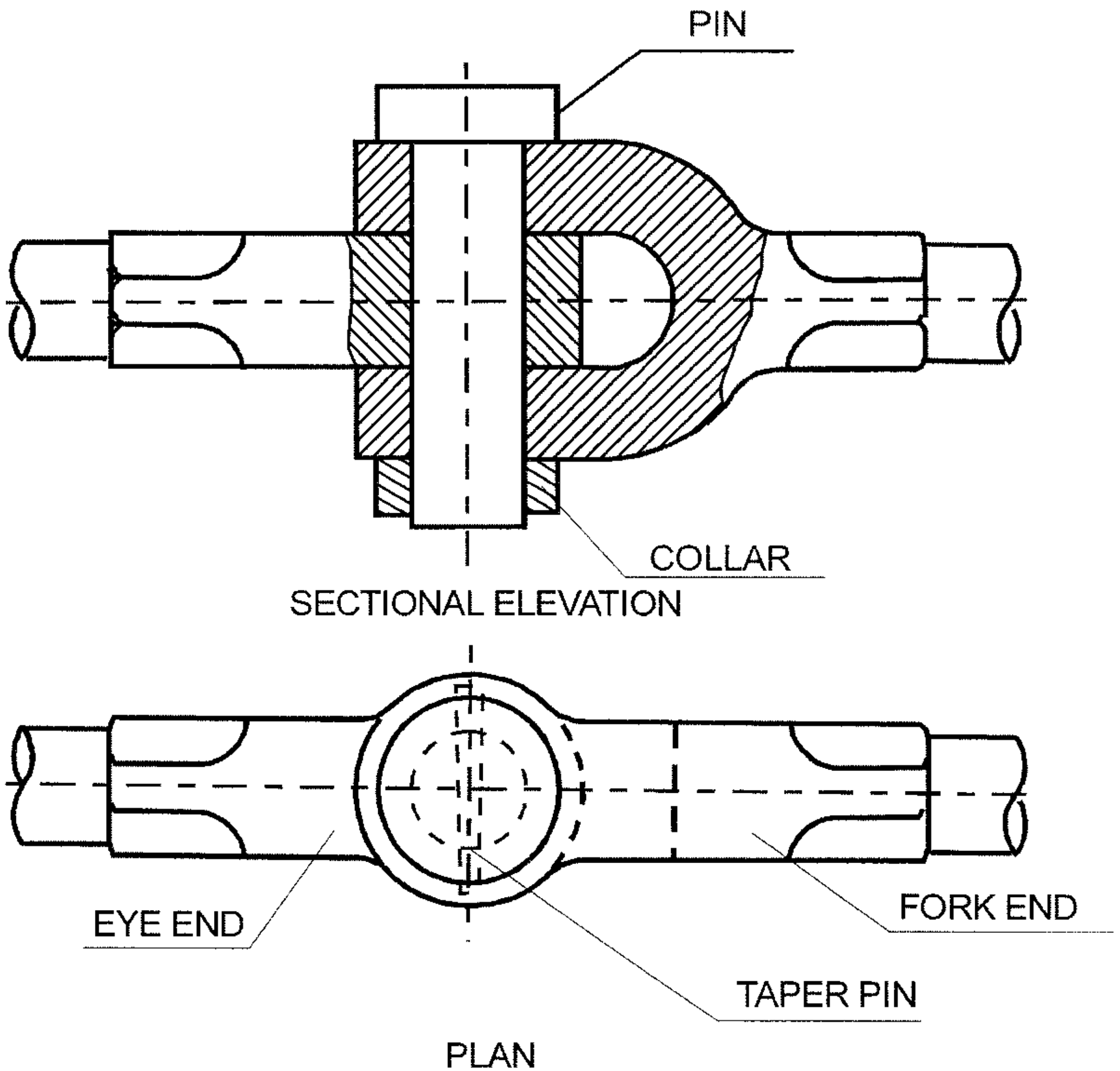


Fig. 10. 8 Assembled views of a kuuckle joint

11. DRAWINGS SYMBOLS AND BLUE PRINT READING

11.1 Introduction

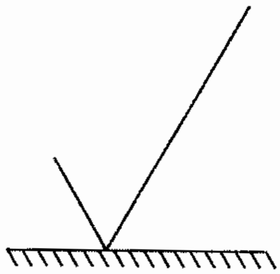
So far we have discussed on different methods of construction of simple plane geometrical drawings and solid geometrical drawing. All along we have learnt about the drawing instruments, standard conventions about drawing sheets and the types of lines used in constructing drawings, lettering and dimensioning, constructing basic geometrical curves, scales used in drawings, the theory of projection - orthographic and isometric, sectional views and assembly drawings. It is also very important for an aspiring engineer to understand and read various drawings. A drawing may have different types of symbols and abbreviations in describing the components and production processes. An effort is made here to make the student aware of some simple and important symbols used in a drawing and the systematic study about reading drawings.

11.2 Machining symbols

Symbols used for indication of surface roughness

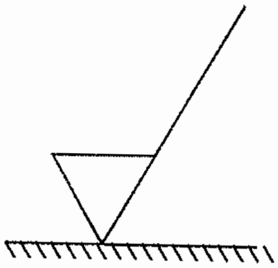
11.2.1 The basic symbol

Basic symbol consists of two legs of unequal length inclined at 60^0 to the line representing the surface under consideration.



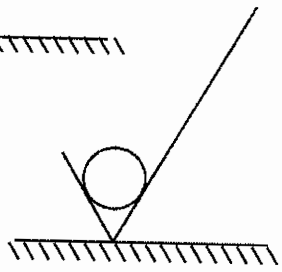
11.2.2 A bar added to the basic Symbol

A bar is added to the basic symbol, if the removal of material from the surface is required.



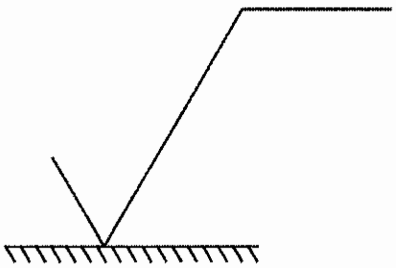
11.2.3 A circle added to the basic symbol

The removal of material from the surface is not permitted when circle is added to the basic symbol. This symbol also means that the surface is to be left in the state resulting from a preceding manufacturing process.

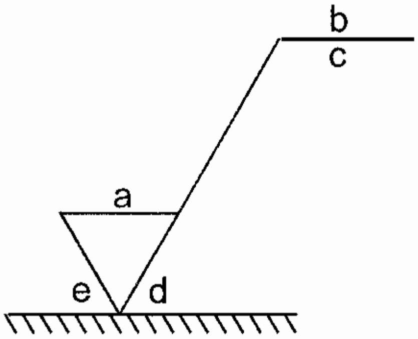


11.2.4 A horizontal line added to the basic symbol

A horizontal line is added to the basic symbol when some special surface characteristics have to be indicated. Mostly the production method is indicated above the horizontal line.



11.2.5 Positions of various specifications in the symbol



a. Roughness value – it is indicated either by any of the roughness grade symbols (N1, N2, ...N 12) or their respective roughness values in .... μm.

b. Machining process - the process of manufacturing is noted here (MILLED, DRILLED, etc.

c. Sampling length – the length of the surface being considered for determining the surface roughness value (0.25 to 2.5 mm)

d. Direction of lay – it is the primary direction of the surface pattern made by tool marks

Parallel

Perpendicular

Crossed

Multidirectional

Circular

e. Machining allowance – it is the machining allowance expressed in mm

11.2.6 Roughness symbols and values

Roughness Grade number	Roughness value in μm	Roughness symbol
N12	50	∼
N11 N10	25 12.5	▽
N9 N8 N7	6.3 3.2 1.6	▽▽
N6 N5 N4	0.8 0.4 0.2	▽▽▽
N3 N2 N1	0.1 0.05 0.025	▽▽▽▽

11.3 Abbreviations for materials

11.3.1 Ferrous materials

Sl. No.	Ferrous material	Abbreviation
1	Cast Iron	CI
2	Cast Steel	CS
3	Forged Steel	FS
4	Mild Steel	MS
5	Spring Steel	Sp.S

11.3.2 Non-ferrous materials

Sl. No.	Non-ferrous Material	Abbreviation
1	Aluminium	Al
2	Brass	Br.
3	Bronze	Bronze
4	Copper	Cpr
5	Gun Metal	GM
6	White Metal	WM
7	Zinc	Zn

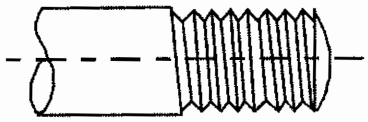
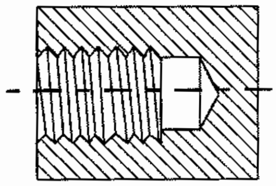
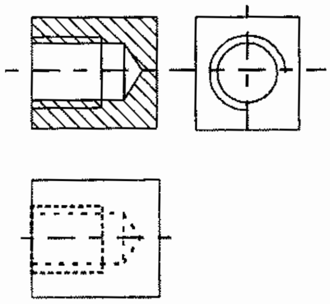
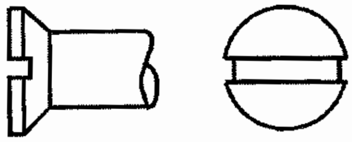
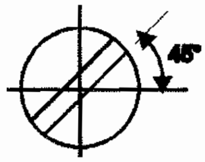
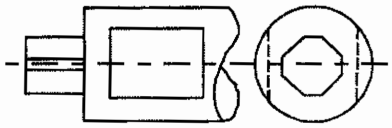
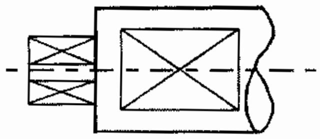
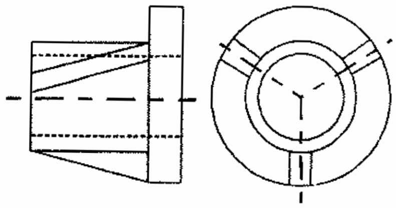
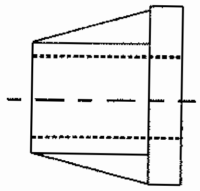
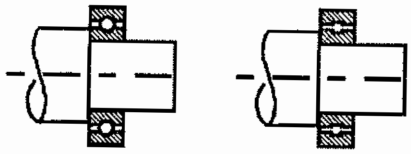
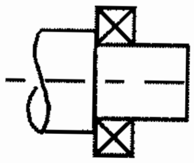
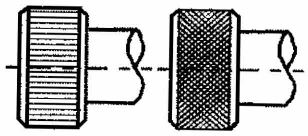
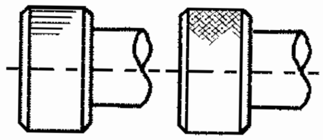
11.4 Drawing abbreviations

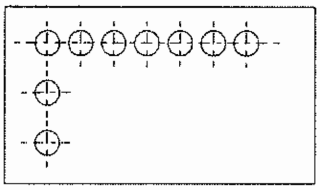
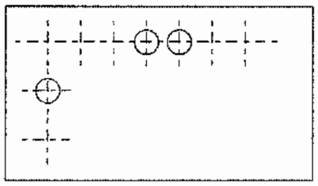
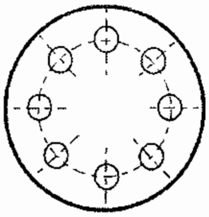
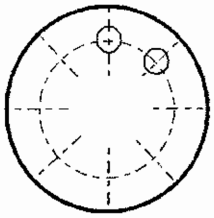
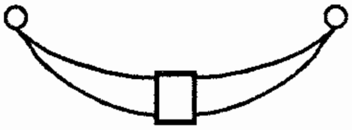
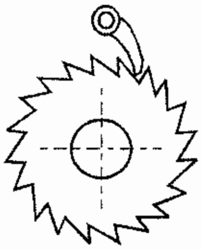
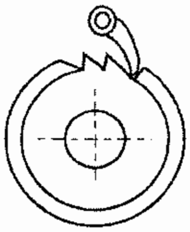
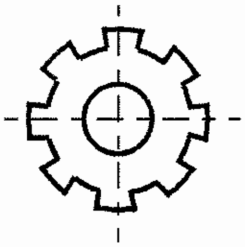
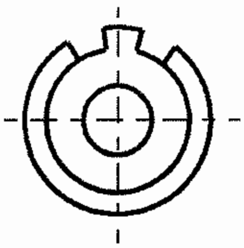
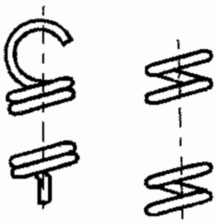
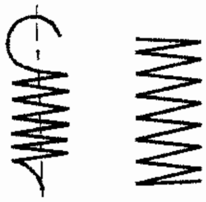
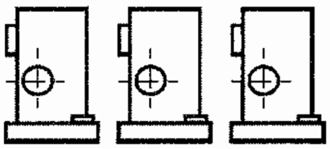
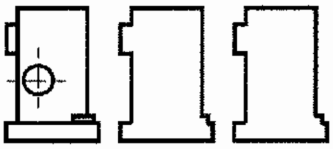
Sl.No.	Term	Abbreviation
1	Across corners	A/C
2	Across flats	A / F
3	Alteration	Alt
4	Approved	APPD
5	Approximate	AAPROX
6	Assembly	Assy.
7	Auxiliary	AUX
8	Centimeter	cm
9	Centres	CRS
10	Centre line	CL

Sl.No.	Term	Abbreviation
11	Centre to centre	C / C
12	Checked	CHD
13	Circular pitch	CP
14	Connected	CONN
15	Continued	CONTD
16	Counterbore	C'BR
17	Countersink	CSK
18	Cylindrical	CYL
19	Diameter	DIA
20	Diametral pitch	DP
21	Dimension	DIM
22	Drawing	DRG
23	External	EXT
24	Figure	FIG
25	Ground level	GL
26	Hexagon	HEX
27	Horizontal	HORZ
28	Inspected	INSP
29	Inside diameter	ID
30	Internal	INT
31	Kilogram	kg
32	Kilometre	km
33	Left hand	LH
34	Machine	M / C
35	Manufacturing	MFG
36	Maximum	MAX
37	metres per second	m / s
38	Mechanical	MECH
39	Millimetre	mm
40	Minimum	MIN

Sl.No.	Term	Abbreviation
41	Miscellaneous	MISC
42	Module	m
43	Nominal	NOM
44	Not to scale	NTS
45	Number	No.
46	Opposite	OPP
47	Outside diameter	OD
48	Pitch circle diameter	PCD
49	Pitch circle	PC
50	Quantity	QTY
51	Radian	rad
52	Radius	R
53	Reference	REF
54	Required	REQ
55	Right hand	RH
56	Serial Number	SL.NO.
57	Specification	SPEC
58	Spherical	SPHERE
59	Spot face	SF
60	Square	SQ
61	Symmetrical	SYM

11.5 Representation of various features in drawings

Title	Actual Projection/Section	Convention
External Threads		
Internal Threads		
Slotted Head		
Square End and Flat		
Radial Ribs		
Bearing		
Knurling		

Title	Actual Projection/Section	Convention
Holes on Linear Pitch		
Holes on Circular Pitch		
Leaf Spring		
Ratchet and Pawl		
Splined Shaft		
Springs		
Repeated Parts		

Sl. No.	Description	Symbol	Specified dimensions	
01.	Round section	Ø	d	
02.	Tube	◎	d x t	
03.	Square section	□	s	
04.	Triangular section	△	a	
05.	Hexagonal section	⬡	s	
06.	Half round section	◠		
07.	Rectangular section	▬	w x t	
08.	Angle section	L	A xB	
		L	A xB	
09.	T Section	T	h x b	
			h x b	
10.	I - beam section	I	h	
11.	Channel section	[	h	
12.	Z section	Z		
13.	Rail section			
14.	Bulb Angle section		h	
15.	Bulb plate section		h	

11.6 Blue print reading

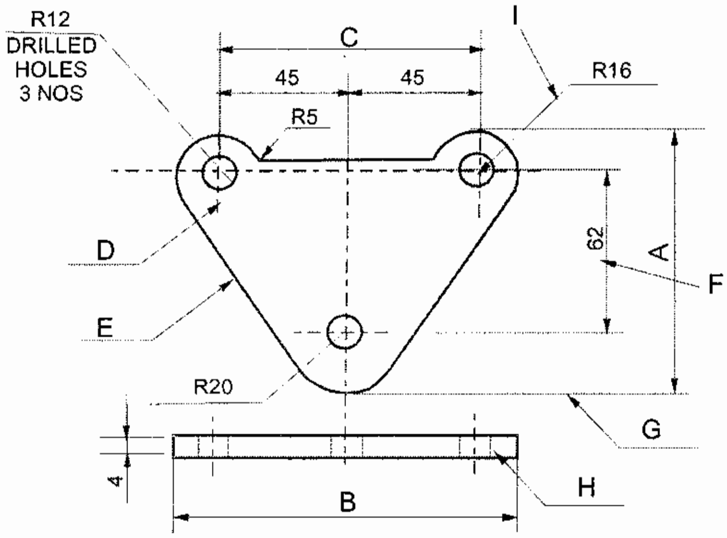
Blue print is the common name given to the copies taken from an original drawing. The name has nothing to do with the colour of the paper or the colour of the drawing lines.

Blue print reading is an essential skill for any technical persons to perform his job in industry satisfactorily for manufacturing a component accurately and correctly. Proper interpretation of the drawing is essential. Blue print reading involves the following aspects.

1. Visualization of the object from the given orthographic views
2. Interpretation of the dimensions, notes and symbols.

For blue print reading, one must have a thorough knowledge of principles of drawing and orthographic projections & also various manufacturing processes.

Some drawings are given as exercises to read them correctly and answer the questions given below each of them.

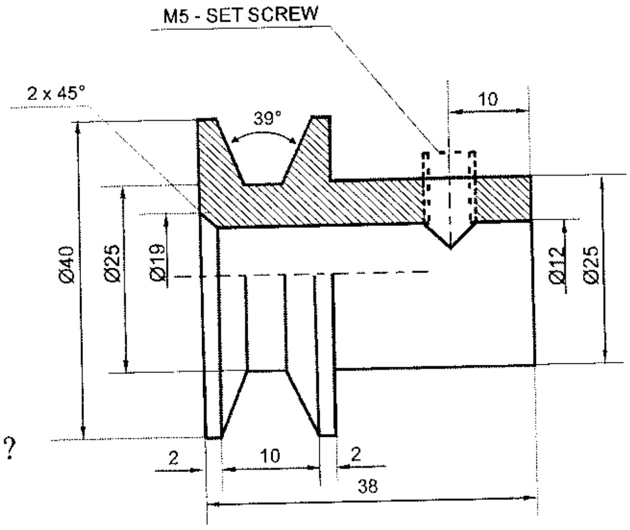


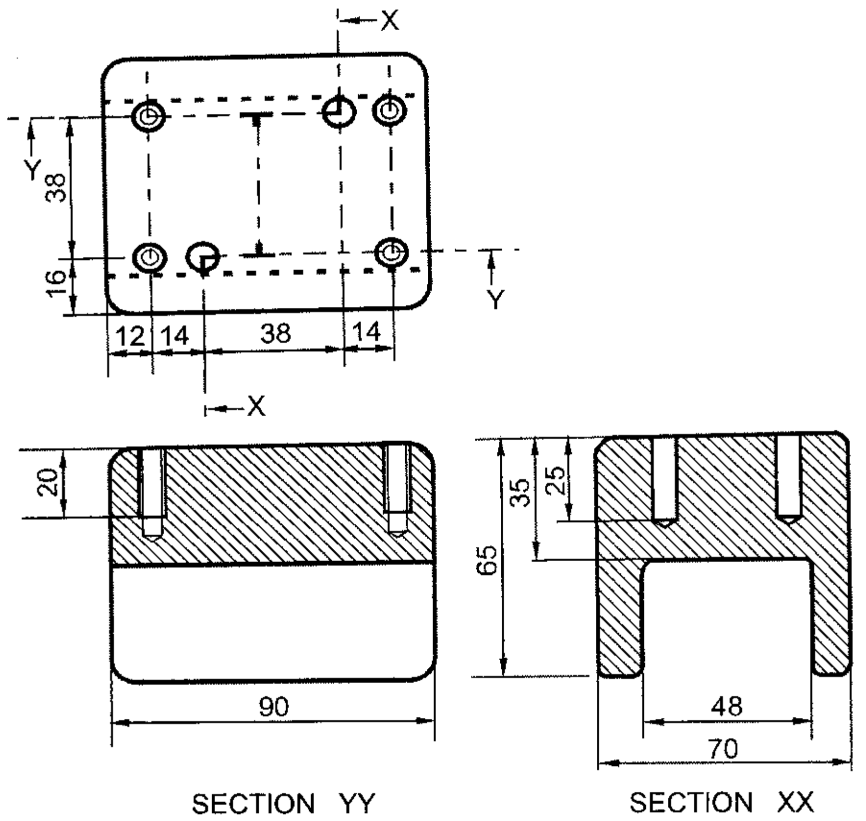
Answer the questions given below with reference to the above diagram

1. What are the two views drawn in the diagram ?
2. What are the types of lines indicated by the letters D E, F, G, H,& I ?
3. What is the total width of the part (B) ?
4. How many holes are there in the part ?
5. What is the thickness of the plate ?
6. What are the diameters of the holes ?
7. What is the radius of the arc in the top of the object ?
8. What is the distance between the top two holes (C) ?
9. What is the dimension representing " A "

Answer the given questions with reference to the diagram

1. What is the name of the part ?
2. Mention the use of the part.
3. What is the outer diameter of the part ?
4. What is the length of the part ?
5. What is the size of the thread ?
6. What is the angle of the V - groove ?
7. What is the diameter of the central hole ?
8. What is the depth of the V - groove ?



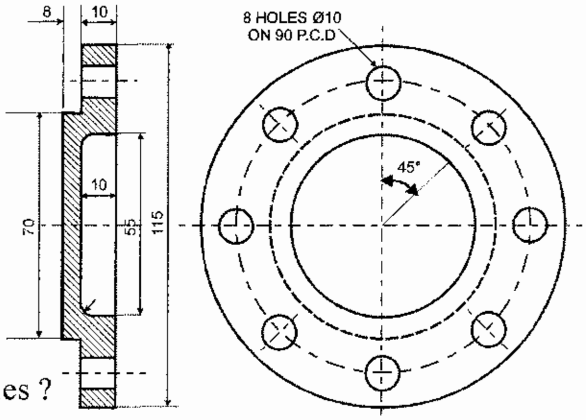


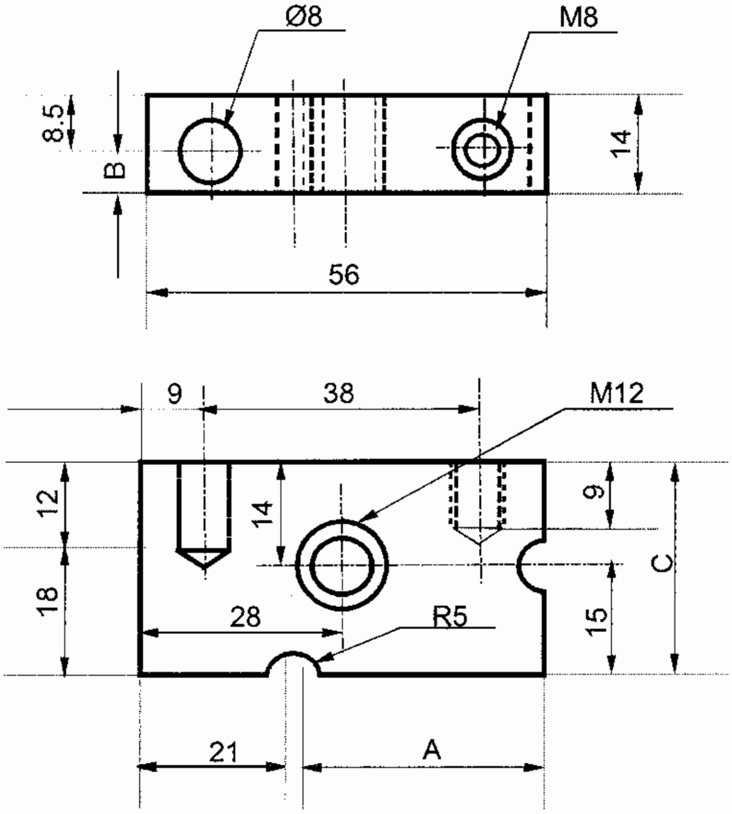
Answer the questions given below with reference to the above diagram

1. What is the length, breadth and height of the part ?
2. How many tapped holes are there in the part ?
3. What is the depth of untapped holes ?
4. What is the depth of tapped holes ?
5. What is the width and height of the hollow portion of the part ?

Answer the given questions with reference to the diagram

1. What is the name of the part ?
2. What is the pitch circle diameter ?
3. How many holes are there in the part ?
4. What is the outer diameter of the part ?
5. What is the thickness of the part ?
6. What is the angle between two adjacent holes ?

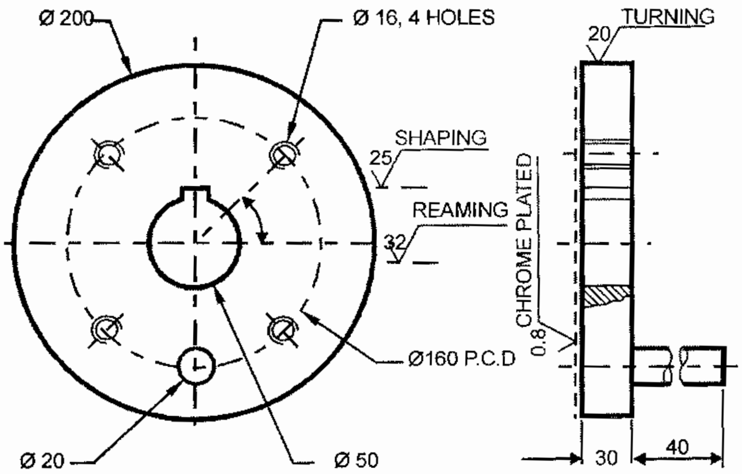




FILLER PLATE

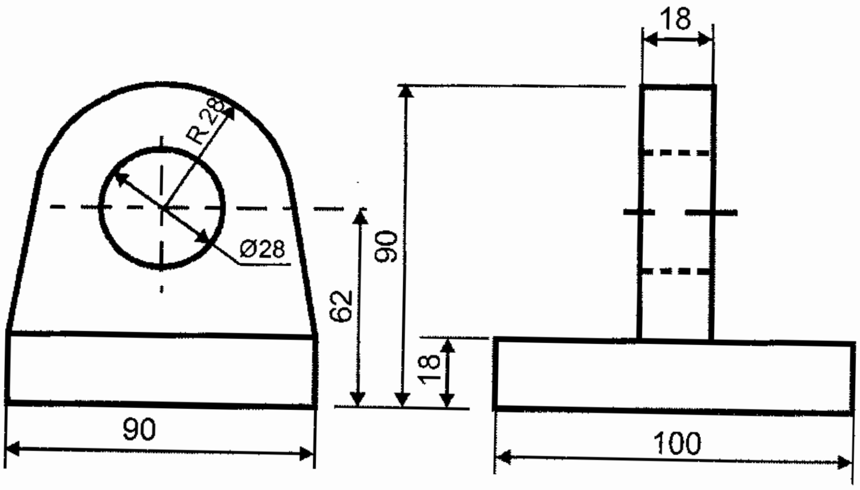
Answer the questions given below with reference to the above diagram

1. What is the name of the part ?
2. How many holes are tapped ?
3. What is the radius of the groove ?
4. What is the height, length and width of the part ?
5. What is the tap size and length of the tapped portion of the smaller tapped hole ?
6. What are the dimensions represented by A, B & C ?



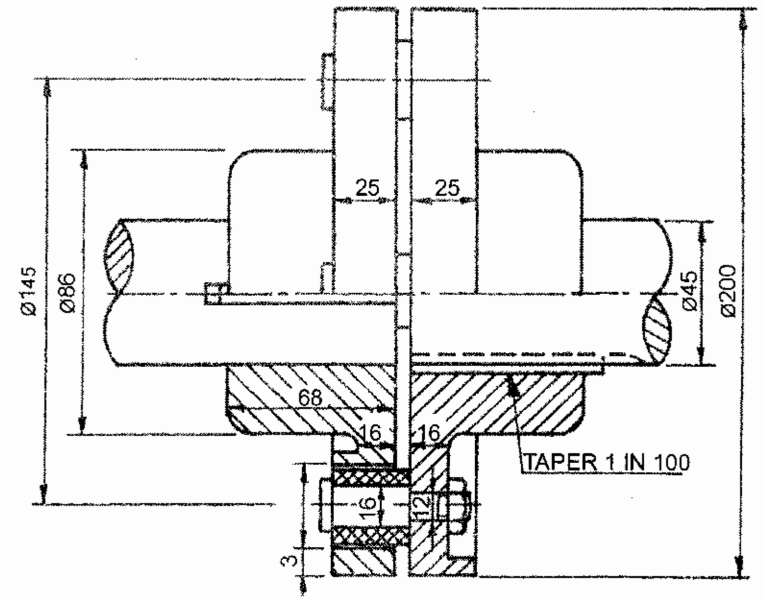
Answer the questions given below with reference to the above diagram

1. How many threaded holes are there in the part ?
2. What is the size of the pin ?
3. What is the overall diameter of the flange ?
4. What is the operation involved in machining the outer diameter ?
5. What is the intended finishing process for the face of the flange ?
6. What is the diameter of the central hole ?
7. What is the process by which the keyway is to be machined ?
8. What is the roughness of the reamed hole ?



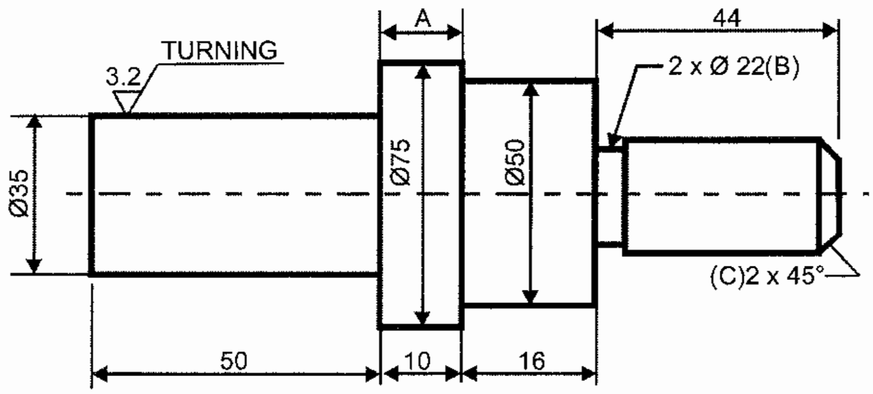
Answer the questions given below with reference to the above diagram

1. What are the overall dimensions of the bracket shown ?
2. What is the shape and size of the base of the bracket ?
3. What is the size of the hole in the bracket ?
4. What is the radius of the curved top ?



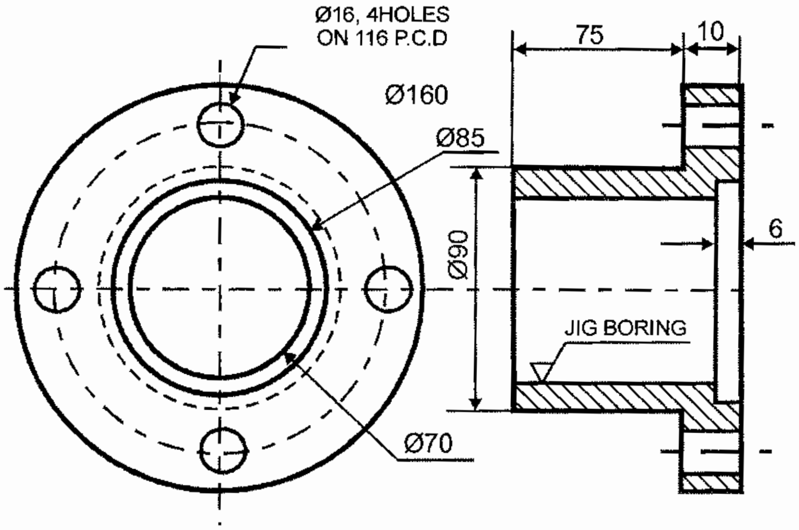
Answer the questions given below with reference to the above diagram

1. What is the diameter of the shafts to be joined ?
2. What is the type of key used in the coupling ?
3. What is the outer diameter of the flange ?
4. How many bolts are used in the coupling ?



Answer the questions given below with reference to the above diagram

1. What is the diameter of the portion indicated by A ?
2. What is the overall length of the part ?
3. What is the dimension B indicate ?
4. What is the dimension C indicate ?
5. What is the meaning of the machining symbol placed on the portion of the part of Ø35 mm ?



Answer the questions given below with reference to the above diagram

1. What is the overall diameter of the flange ?
2. What does the machining symbol indicate ?
3. What is the diameter and thickness of the flange ?
4. What is the distance between the centres of Ø16mm opposite holes ?
5. What does the circle in dotted line of the front view represent ?
6. What is the length and thickness of the pipe ?

12. AutoCAD

12.1 Introduction

AUTOCAD was developed by an American company Autodesk Inc., and term 'CAD' refers to Computer Aided Design (or) Drafting.

Computer Aided Drafting – CAD is defined as a process of producing drawings in which computer, software and related hardware are used. The software stored in the disks provides the program and the drafter gives the commands and data to the computer to perform the drawing task.

Manual drawings are made using various drawing instruments. It is the foundation of engineering communication and Computer Aided Drafting (CAD) is developed on the fundamentals of manual drawing.

The beginning of computer graphics is assumed to have happened in 1950. The " Whirlwind computer " were installed at Massachusetts Institute of Technology (MIT) and drawing of simple figures was done in that year. When the International Business Machine Corp. (IBM) started making computers suitable for graphics in 1964, CAD became commercially available. A tremendous advance in hardware as well as software was made in 1980's. After a slow start, the computer graphics grew dramatically to a popular system for drafting by the beginning of 1990's.

Other than AutoCAD, several CAD packages such as Solid Works, Unigraphics and Pro - Engineer are also available in modern Computer Aided Drafting (CAD).

12.2 Applications of AutoCAD

Mechanical Engineering	:	In designing of Machine elements, Assemblies, Automobile Components.
Civil Engineering	:	In designing of Architectural landscapes, buildings and dams.
Electrical Engineering	:	In designing of Electrical wiring circuits and making PCBs (Printed circuit boards)
Film Industry	:	For creation of 3D graphical models.

12.3 Advantages of AutoCAD

> Drawings can be made easily and quickly

> Accuracy of the drawings is high

> Editing and modifying the existing drawings are possible

> Storing and retrieving the drawings are very easy

> Dimensioning of drawings is done easily

> Drawings can be accessed and shared by people at different places of the world simultaneously

> It is possible to customize AutoCAD to suit our needs.

12.4 Hardware and software

Computer is an electronic device which controls raw data into meaningful information. It is a machine that accepts data as the input, processes it and produces the desired results as output.

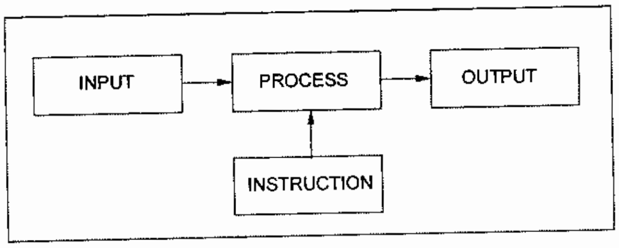


Fig. 12.1 Units of computer systems

12.4.1. Hardware

Hardware of a computer includes all the physical equipments or devices associated with it. Input devices, output devices, Central Processing Unit (CPU), Memory storage are some important elements of hardware.

Input devices

Input device is a mechanism used to enter data or information into the processing unit Keyboard, mouse, scanners are some of the input devices.

Output devices

After the input data are processed inside CPU, the results are stored in the memory. When these results are to be retrieved and converted as printed drawings, we need output devices. Some of the output devices are printers, (Dot matrix, Laser Jet, Ink Jet) and electro mechanical pen plotters.

Central Processing Unit (CPU)

CPU is the most important part of a computer hardware. It serves as the brain for all the processes done in the computer. The processing is executed with the help of the micro processor of different clock speeds.

Memory Storage

The memory storage devices of a computer are of two types.

1. Primary Storage
2. Secondary Storage

The primary Storage is useful when the control unit receives or retrieves data for execution. RAM (Random Access Memory) and ROM (Read Only Memory) are primary storage.

Secondary Storage in the form of hard disks, floppy disks and CDs are useful only in storing data.

12.4.2 Software

Software is a set of chain like statements, commands and procedures used by a computer to perform a task. Generally software are classified as

1. System software
2. Application Software

System software includes operating systems like Windows 98, Linux etc., and compilers.

Application software includes major packages like Microsoft Office, Adobe Page Maker, Photo Shop etc.,

12.5 AutoCAD – getting started

When the computer is switched on, the windows (95 or 98 or xp) operating system is loaded in the main memory (RAM).

AutoCAD can be started by

Click the start button and Program > AutoCAD > AutoCAD

AutoCAD icon in the window Desktop is double clicked to select AutoCAD program.

When the AutoCAD is started, the program displays a typical AutoCAD screen as shown in *Fig. 12.2*

12.6 Important Features of AutoCAD

12.6.1 Title bar

This is at the top of the window showing the name of the program and the name of the current drawing.

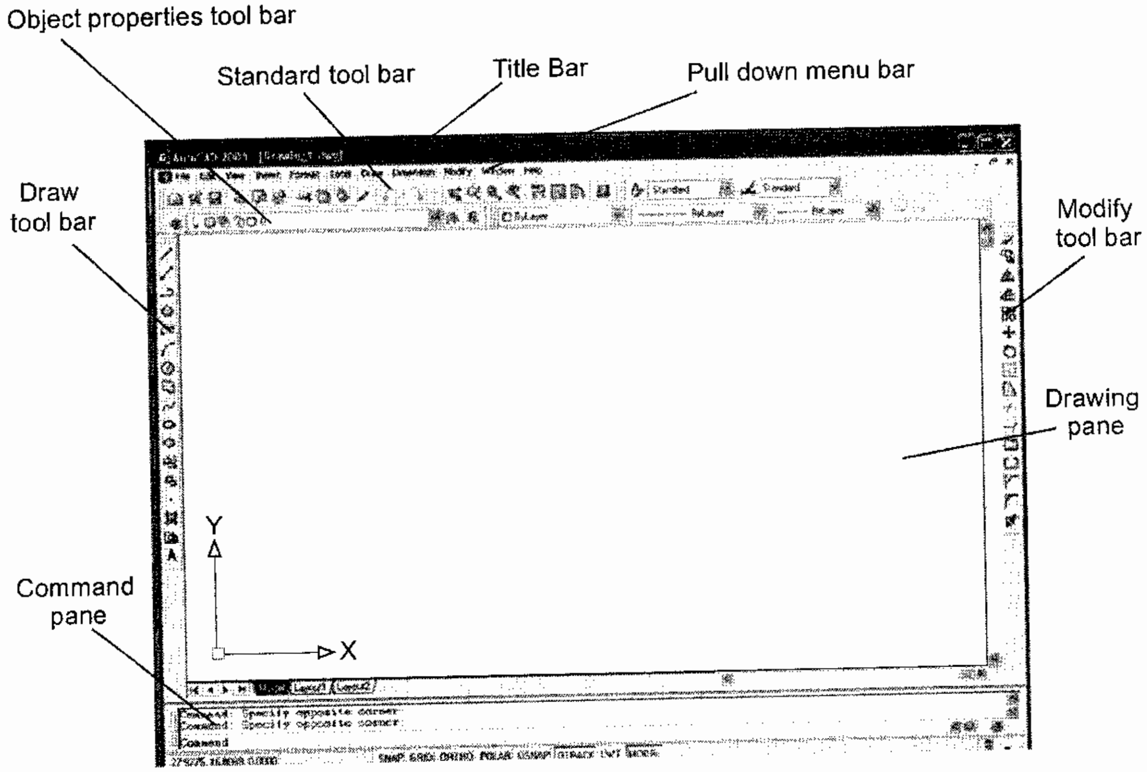


Fig. 12.2 AutoCAD window

12.6.2. Pull down menu bar

It is located just below the title bar providing pull down menus. From pull down menu bar, we can choose many commands - each of them categorized under a main menu. When the pointer is brought to each menu, a list of sub menu can be opened for selection.

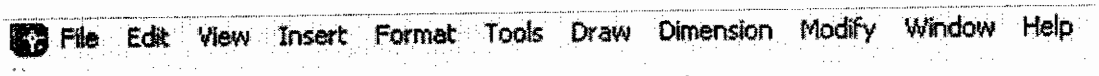


Fig. 12.3 Pulldown menu bar

The "File" menu	gives sub menu for managing the files like New, Open, Close, Save, Save as, Export, Page setup, Print and Exit.
The "Edit" menu	covers the file editing operations like Undo, Redo, Cut, Copy, Paste, Select All, Clear and Find.
The "View" menu	covers about the view of the drawing on the screen like Redraw, Zoom, 3D views, Shade, Render, Display and Toolbars.
The "Insert" menu	covers Block, Layout and Hyperlink.
The "Format" menu	contains sub menus like Layer, Colour, Line type, Line weight, Text style, Dimension style, Unit and Drawing Limits.
The "Tools" menu	covers Spelling, Display order, Properties, Auto LISP etc.

The "Draw" menu provides all drawing commands such as Line, Ray, Multiline, Polyline, 3D Polyline, Polygon, Rectangle, Arc, Circle, Spline, Ellipse, Block, Hatch etc.

The "Dimension" menu covers the commands like Quick Dimension, Linear, Aligned, Radius, Diameter, Angular, Baseline, Leader, etc.

The "Modify" menu gives modification commands like Erase, Copy, Mirror, Offset, Array, Move, Rotate, Stretch, Trim etc,.

The "Window" menu makes the screen to be viewed in cascade, horizontally, vertically.

The "Help" menu provides details about the software program and help topics under different categories.

12.6.3 Tool bars

When the AutoCAD is started different tool bars are displayed.

The displayed toolbars are

1. Standard toolbar
2. Object properties tool bar
3. Draw tool bar
4. Modify tool bar

Standard toolbar

It is displayed just under the pull down menu bar. It consists of icons like New, Open, Save, Plot, Plot Preview, Publish, Cut to clipboard, Copy to clipboard, Paste from Clipboard, Match properties, Undo, Redo, Pan Real time, Zoom Real time, Zoom window, Zoom previous, Properties, Design centre, Tool Palettes and Help. It also has text style control and dimension style control icons.

Object Properties toolbar

It is found below the standard toolbar. It facilitates immediate selection of layers, Line types and Change of properties commands. It contains Layer properties manager, Lock or unlock layer, Layer previous, Colour control, Line type control and Line weight control icons.

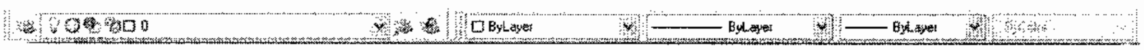


Fig. 12.4 Object properties tool bar

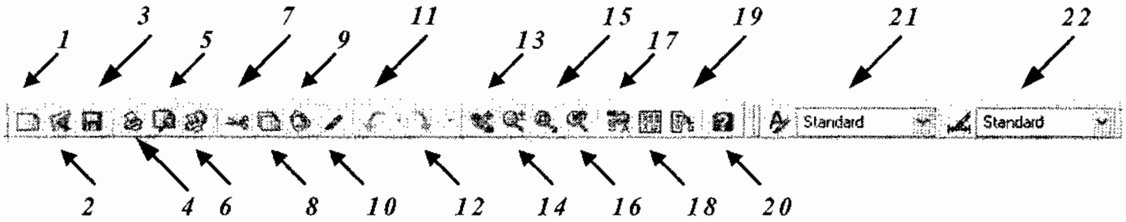


Fig. 12.5 Standard tool bar

1. Q New 2. Open 3. Save 4. Plot 5. Plot preview 6. Publish 7. Cut to clipboard 8. Copy to clipboard 9. Paste from clipboard 10. Match properties 11. Undo 12. Redo 13. Pan Realtime 14. Zoom Realtime 15. Zoom window 16. Zoom previous 17. Properties 18. Design centre 19. Tool palettes 20. Help 21. Text style control 22. Dimension style control

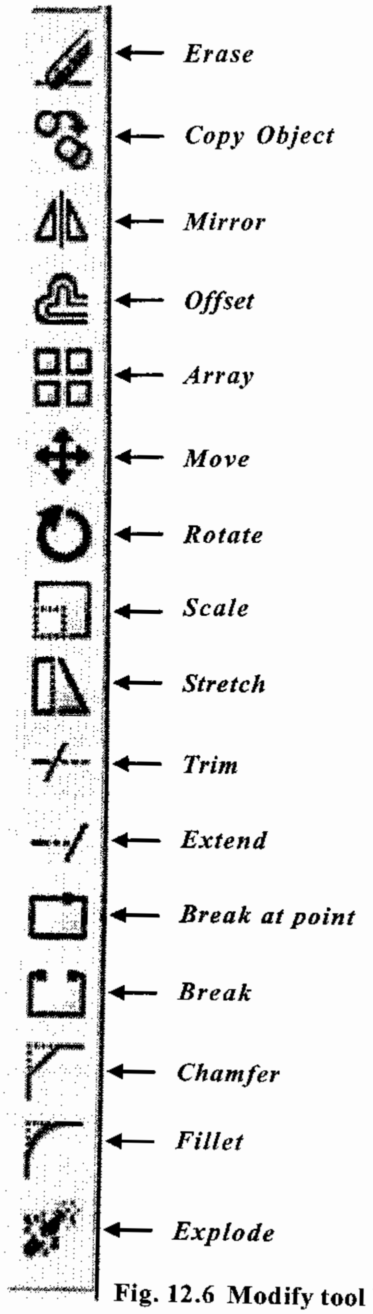


Fig. 12.6 Modify tool bar

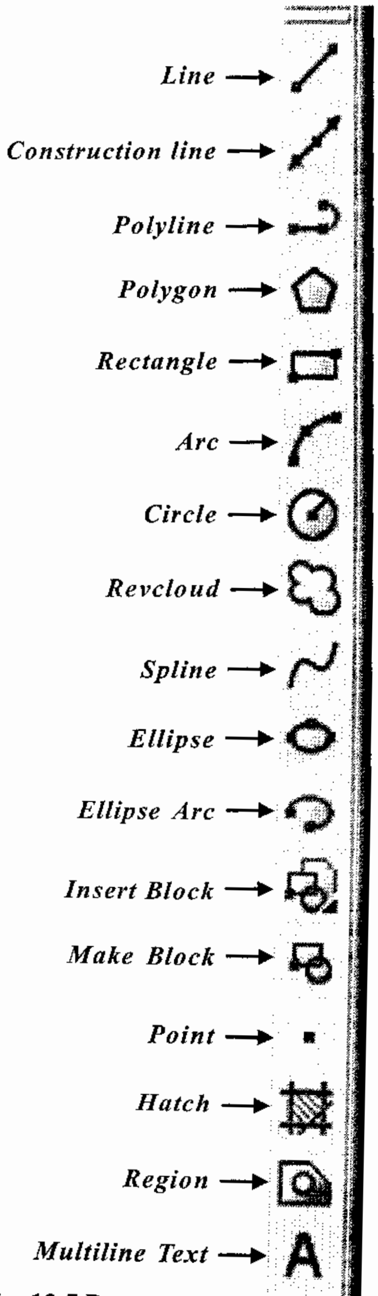


Fig. 12.7 Draw tool bar

Draw tool bar

It is placed at left of the drawing pane. It contains tools needed to create new objects. It contains icons such as Lines, Construction line, Polyline, Polygon, Rectangle, Arc, Circle, Rev cloud, Spline, Ellipse, Ellipse Arc, Insert block, Make block, Point, Hatch, Region & Multi line Text.

Modify Toolbar

It is found at the right side of the drawing pane. It contains icons which modify the existing objects in a drawing. Erase, Copy object, Mirror, Offset, Array, Move, Rotate, Scale, Stretch, Trim, Extend, Break at point, Break, Chamfer, Fillet, and Explode are the icons found in a modify toolbar.

12.6.4 Command window

AutoCAD commands, view prompts and program messages can be typed in a command window. It is found just below the drawing pane.

The command window initially displays the three most recent lines of prompts, but you can change the number of lines displayed. Scroll bars on the right side of this window let you scroll back to see previous prompts.

Fig. 12.8 Comman window

12.6.5 Status bar

The status bar is a horizontal area found at the bottom of the document below the command window. It provides information about the current status of what is viewed in the window.

12.7 AutoCAD commands

Different AutoCAD commands are entered in the command window to execute or make a particular drawing. These commands can be grouped under different categories and are shown in the next page.

Sl.No.	CATEGORY	AUTOCAD Commands
1.	Drawing commands	Arc, circle, dount, ellipse, line, mline, pline, point polygon, ray, rectang, sketch, spline, trace, xlin.
2.	Editing Commands	Array, break, bhamfer, bcanges, chprop, copy, ddedit, dist, divided, erase extened, fillet, insertobj, length, match prop, measure, mirror, meledit, move, offset, oops, pedit, purge, rotate, scale, splinedit, stretch, trim.
3.	Text Commands	Mtext, text
4.	Display Commands	3dorbit, 3dzoom, camera, ddtype, ddvpoint, dview, edge, hide, light, mview, pan, plan, qtext, redraw, redrawall, regen, regenall, regenauto, scene, view, viewers, vpoint.
5.	Dimensioning Commands	Dim & dim1, dimaligned, dimangular, dimbaseline, dimcenter, dimcontinue, dimdiameter, dimedit, dimlinear, dimordinate, dimradius, dimstyle, dimedit, leader.
6.	Setting Commands	Base, Color, elev, fill, isplane, layer, limits, linetype, itscale, lweight, mlstyle, multiple, options, ortho, osnap, snap, style, ucsicon, ucuman, ucs
7	Hatching Commands	Bhatch, boundary, hatch, hatchedit, region
8	3D surface Commands	Edgesurf, pface, rulesurf, tabsurf
9	3D drawing / Solid commands	3d face, 3dmesh, 3dpoly, box, cone, cylinder, interfere, intersect, revolve, sphere, torus, union, wedge.
10	Block commands	Block, explode, insert, minsert, wblock, xplode
11	System Variables	Aperture, blipmode, celtscale, cmddia, cords cvport, dispsilh, dragmode, edgemode, explmode filletrad, fontalt, gridmode, gridunit, gripsize, highlight, hpang, hpname, hpbound, hpmame, isavebak, limcheck, limmax, limmin, itscale, lunits, measurement mirrtext, mtexted, offsetdist, orthomode, osmode, pellipse, pickbox, plinewid, plotrotmode, polysides qtextmode, savetime, shadeedge, shapstly, splinetype, surftab1, surftab2, trimmode, ucsfollow ucsion

12.8 Command entry

Typically, there are three ways of giving a command in AutoCAD. They are listed below

1. Giving commands using keyboard

When a new document is opened, the command pane is ready to accept commands. The required command is typed in the command pane and the enter key is pressed.

2. Giving commands using toolbars

The toolbar is an array of icons. Clicking the appropriate icon activates the relevant command.

3. Giving command using dropdown menus

All commands are also available in dropdown menus. Similar types of commands are categorized and are kept in relevant dropdown menus. Required command is clicked from the dropdown menu titles to activate the relevant command.

12.9 File management in AutoCAD

The file management involves creating a new document, opening a existing document, saving and closing the current document and finally quitting AutoCAD.

12.9.1 Creating a new document

To create a new drawing file, any one of the following procedures is adopted.

1. In the AutoCAD pull down menu bar click – file ⟶ New
2. In the standard toolbar, click the icon Q new
3. In the command entry pane, Type NEW ↵
4. In the keyboard, press Ctrl + N

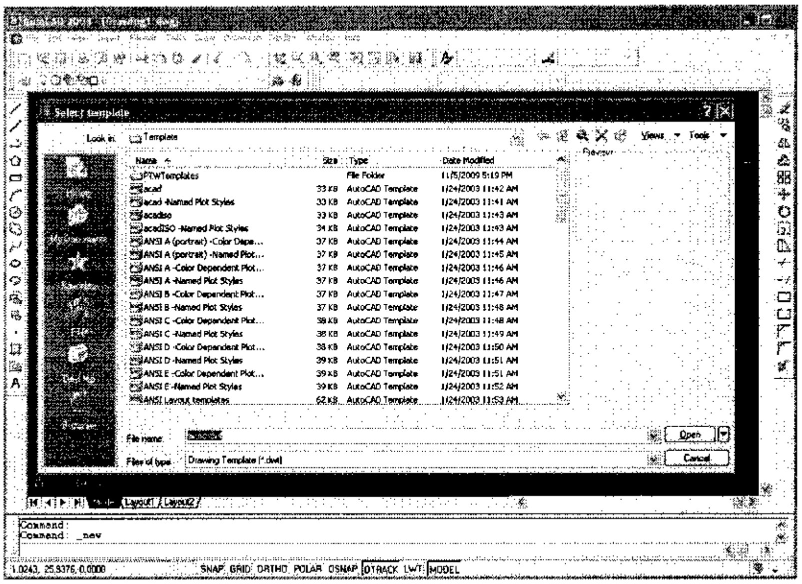


Fig. 12.9
AutoCAD creating a new document

By performing any one of the above procedures, a window as shown in *Fig. 12.9* is opened.

12.9.2. Opening an existing document

To open an existing file, the following procedure is adopted.

1. In the AutoCAD pull down menu bar, Click – file ⟶ open
2. In the standard toolbar, click the icon Open
3. In the command entry pane, type OPEN ↵
4. In the keyboard, press Ctrl + O

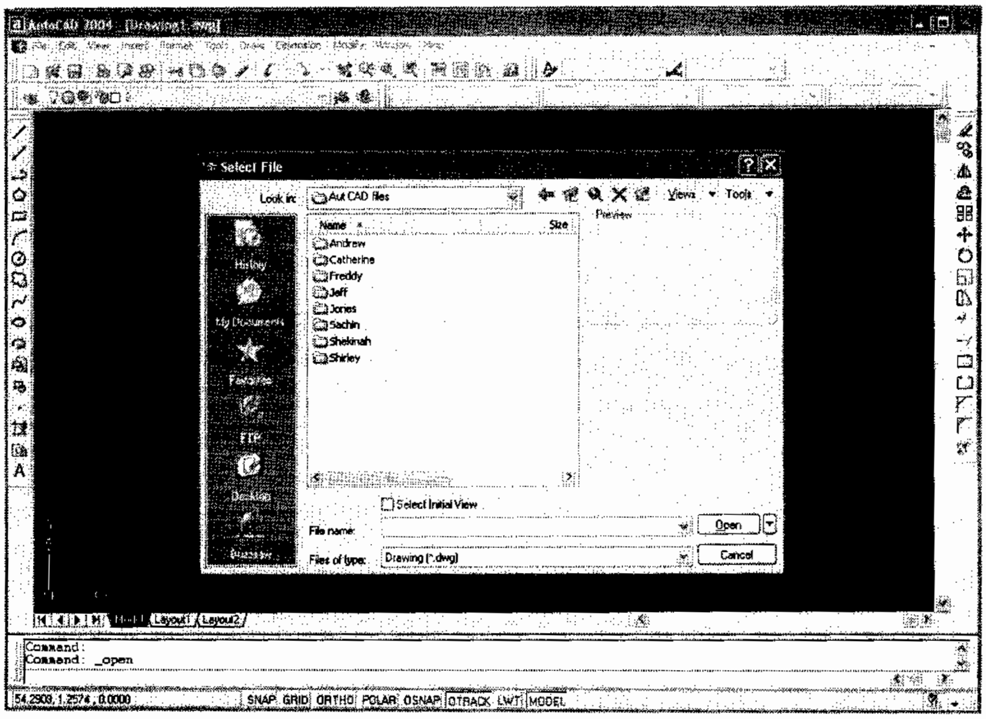


Fig. 12.10 Open dialog box

By performing any one of the above procedures, a window as shown in *Fig. 12.10*is opened.

12.9.3. Saving the current document

To save the current drawing, the following procedure is adopted.

1. In the AutoCAD, pull down menu bar, Click – file⟶ Save or File ⟶ Save as
2. In the standard toolbar, click the icon Save
3. In the command entry pane, type Q Save ↵
4. In the keyboard, press Ctrl + S

By performing any one of the above procedures, a window as shown in *Fig. 12.11* is opened.

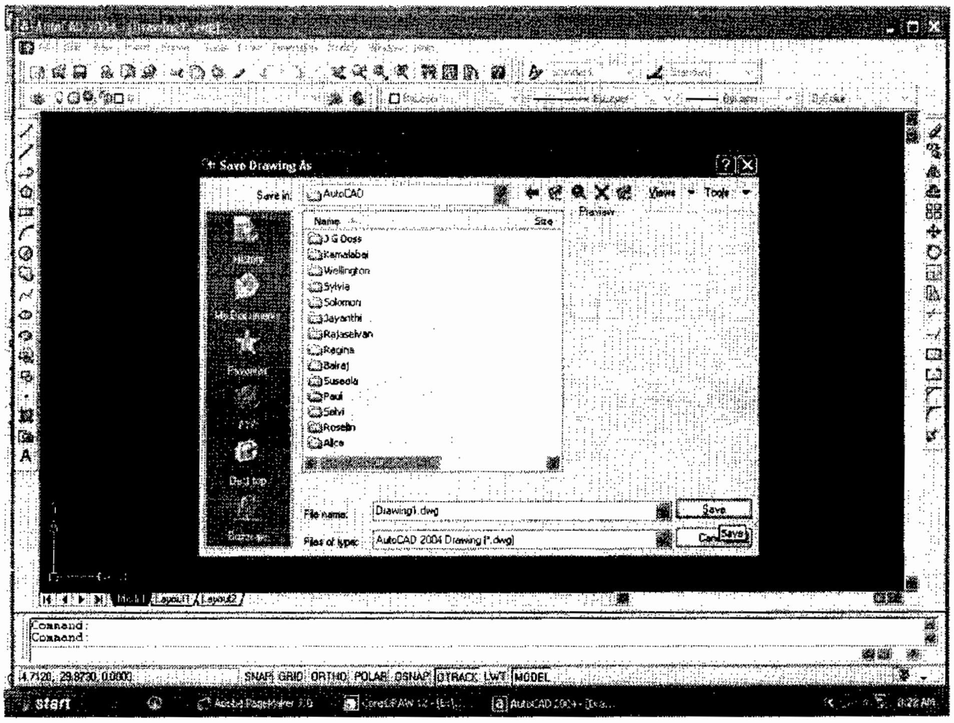


Fig. 12.11 Save As dialog box

12.9.4 Closing the current document

To close the current drawing the following procedure is adopted

1. In the pull down menu bar, click – file ⟶ Close
2. In the command entry pane, type "CLOSE" ↵

When any one of the above procedures is executed, a dialog box as shown in *Fig. 12.12* is displayed.

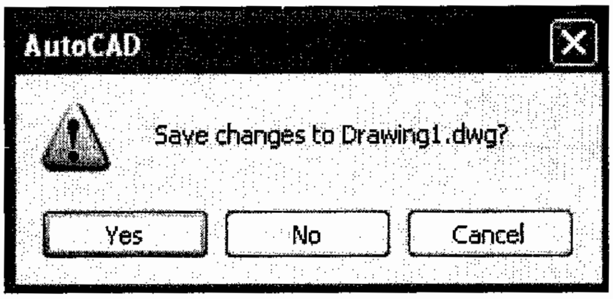


Fig. 12.12 Closing the correct document

In the above dialog box, the yes button is clicked to close the file.

12.9.5 Quitting AutoCAD

To quit AutoCAD window, any one of the following actions is done.

1. In the pull down menu bar, click – File ⟶ Exit
2. In the command entry pane, type "EXIT" ↵

12.10 Draw command

Some primary Draw commands are explained in the following pages

12.10.1 LINE command

This command is used to construct a line from one point to another. It is specified by its two endpoints.

To draw a line,

1. Click on the icon named **line** in the draw toolbar
2. In the pull down menu bar, click Draw → Line
3. In the command entry pane, type LINE ↵

By performing any one of the above tasks, AutoCAD prompts "Specify first point" A point on the drawing pane is clicked using cursor.

AutoCAD prompts "Specify next point" or (Undo)	Another point on the drawing ↵ pane is clicked using cursor.

On completion of the above tasks, a straight line appears on the drawing pane.

In AutoCAD, coordinate system is followed to locate the points. 2D drafting is done by considering the drawing pane as X , Y plane. The location of a point is specified by its X and Y coordinates. The left hand bottom corner on the screen is considered as origin (0,0). Generally there are three coordinates systems used in AutoCAD.

1. Absolute coordinate system
2. Relative coordinate system
3. Polar coordinate system

In absolute coordinate system, the points are located with respect to the origin (0,0) to draw a line. To mark a point, the value is given in pairs as (X Coordinate value, Y coordinate value)

Draw a line by Absolute coordinate System

Command	: Line ↵
Specify first point	: 0 , 0 ↵
Specify next point or (undo)	: 80, 0 ↵
Specify next point or (undo)	: 80, 80 ↵
Specify next point or (close/undo)	: 0, 80 ↵
Specify next point or (close/undo)	: 0,0 (or) C ↵

In the relative coordinate system, the points are located with reference to previous point to draw a line. The symbol @ should prefix any relative entry.

Draw a line by relative coordinate system.

Command	: Line ↵
Specify first point	: 0 , 0 ↵
Specify next point or (undo)	: @ 40, 0 ↵
Specify next point or (undo)	: @ 0, 40 ↵
Specify next point or (close/undo)	: @ -40, 0 ↵
Specify next point or (close/undo)	: @ 0,-40 (or) ↵

In the polar coordinate system, the points are located by defining the distance of the point from the current position and the angle made to that line from the positive X – axis. The symbol @ should prefix any relative entry similar to relative coordinate system. In addition, the symbol< should be placed between the distance and the angle.

Draw a line by Polar Coordinate system.

Command	: Line ↵
Specify First point	: 50 , 50 ↵
Specify next point or (undo)	: @ 40 < 0 ↵
Specify next point or (undo)	: @40 < 90 ↵
Specify next point or (close/undo)	: @ 40 < 180 ↵
Specify next point or (close/undo)	: @ 40 < 270 (or) C ↵

12.10.2 CIRCLE command

This command is used to draw a circle by several options. To draw a circle

1. Click on the icon named circle in the Draw tool bar.
2. In the pull down menu bar, click draw → circle.
3. In the command entry pane, type CIRCLE ↵

By performing any one the above tasks, AutoCAD prompts " specify centre point for circle or [3P/2P/Tty (tan tan radius)] "

Though there are several methods to draw circles, only two methods are described here.

1. Centre radius method
2. Centre diameter method

Centre radius method

Command : CIRCLE ↵

Specify centre point or [3P/2P/Ttr (tan tan radius)] : 25, 25 ↵

Specify radius of circle or [Diameter] : 10 ↵

Centre diameter method

Command : Circle

Specify centre point or [3P/2P/Ttr (tan tan radius)] : 20, 20 ↵

Specify radius of circle or [Diameter] : D ↵

Specify Diameter of circle : 15 ↵

12.10.3 ARC command

This command is used to draw arcs in many options. To draw an arc

1. Click on the icon Arc in the draw tool bar.
2. In the pull down menu bar, click draw ⟶ Arc.
3. In the command entry pane, type ARC ↵

By performing any of the above tasks, AutoCAD prompts "specify start of the arc or [Centre]"

Though there are several methods to draw arcs in AutoCAD, only three points methods is described here.

Command : ARC ↵

Specify Start point or arc [center] : 0, 0 ↵

Specify Second point of arc [center / End] : 20, 20 ↵

Specify end point of arc : 40,0 ↵

12.10.4 ELLIPSE command

This command is used to draw an ellipse in many options. To draw an ellipse,

1. Click on the icon Ellipse in the draw tool bar.
2. In the pull down menu bar, click draw ⟶ Ellipse
3. In the command entry pane, type ELLIPSE ↵

By performing any of the above tasks, AutoCAD prompts " specify Axis end point of Ellipse or [Arc / Center] "

Though there are several methods to draw Ellipse in AutoCAD, only Axis, End points method is described.

Command : ELLIPSE ↵

Specify Axis end point of ellipse or [arc / center] : 0, 0 ↵

Specify Other end point of axis : 40, 0 ↵

Specify distance to other axis or [Rotation] : 25 ↵

12.10.5 POLYGON command

This command is used to draw a Polygon.

To draw a polygon,

1. Click on the icon Polygon in the draw tool bar.
2. In the pull down menu bar, click draw → Polygon.
3. In the command entry pane, type POLYGON ↵

By performing any of the above tasks, AutoCAD prompts " enter number of sides "

Command : POLYGON ↵

Enter number of sides : 6 ↵

Specify Centre at polygon or (edge) : E ↵

Specify first end point of edge : 4, 4 ↵

Specify Second end point of edge : 12, 4 ↵

12.10.6. RECTANGLE command

This command is used to draw a rectangle.

To draw rectangle.

1. Click on the icon Rectangle in the draw tool bar.
2. In the pull down menu bar, click draw → Rectangle.
3. In the command entry pane, type RECTANG ↵

By performing any of the above tasks, AutoCAD prompts " specify first corner point "

Command : RECTANG ↵

Specify first corner point or (Chamfer / Elevation / Fillet / Thickness / width) : 5, 5 ↵

Specify other corner point or (Dimension) : 15,10 ↵

12.10.7 HATCH Command

This command is used to draw hatching lines in a closed boundary region. There are several standard hatch patterns available in AutoCAD

Command : BHATCH ↵

The boundary hatch dialog box as shown in *Fig 12.13* appears

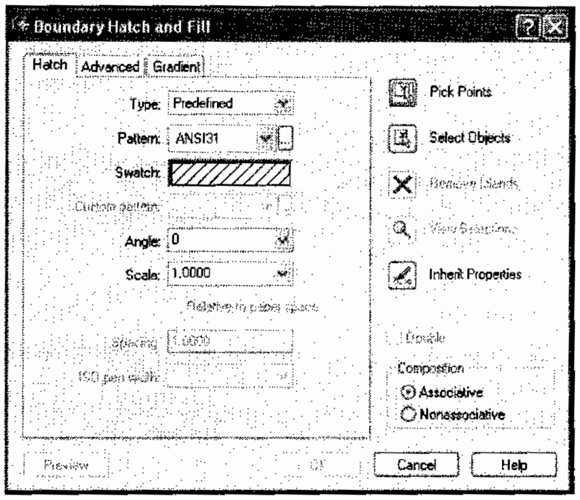


Fig. 12.13 HATCH Command dialog box

1. Click on pick points button in the dialog box
2. Select a point inside a closed object ↵
3. Click OK in the dialog box.

12.10.8. MULTILINE TEXT Command

This command enables text written on the drawing pane. The area in which the text is to be written should be located first on the screen / using cursor.

Command : M TEXT ↵

Specify first corner : 10,10 ↵

Specify opposite corner or [Height/Justify/Line spacing/Rotation/Style/Width] : 20,20 ↵

Multi line text editor appears on the screen

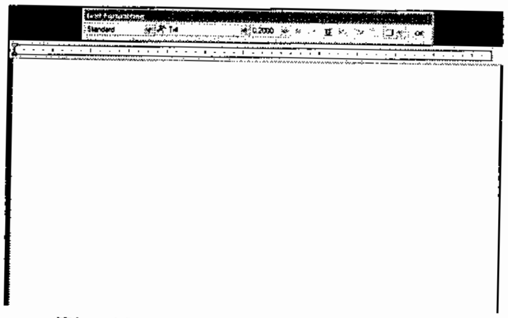


Fig. 12.14 MULTING TEXT editor

Required text is typed in the text editor. Here the font, size of letter etc., can be modified as required.

QUESTIONS

I . A. Choose the correct option

1. CAD stands for

   a. Computer and Design	b. Computer and Drafting

   c. Computer Accounting Designing	d. Computer Aided Drafting

2. Key board and mouse are

   a. Processing devices	b. Output devices

   c. Input device	d. Executing devices

3. Floppy drive is a

   a. Primary storage device	b. Secondary storage device

   c. Input device	d. Output device

4. Title bar is situated

   a. at the top of the window	b. at the bottom of the window

   c. in the drawing pane	d. in the tool bar

5. CIRCLE is

   a. a display command	b. a text command

   c. a editing command	d. a drawing command

6. Mtext is a

   a. drawing command	b. text command

   c. display command	d. editing command

I. B. Answer the following questions in one or two words

1. AutoCAD was developed by..........
2. Name some CAD packages other than AutoCAD.
3. What is the application of AutoCAD in film industry ?
4. What is the role of AutoCAD in electrical engineering ?
5. Where is pull down menu bar situated ?
6. Where is command window located ?

II. Answer the following questions in one or two sentenses

1. What are the application of AutoCAD ?
2. What is a computer?
3. What is an hardware?
4. Define - input device ?
5. What is an output device ?

6. What is a CPU ?
7. What are the types of memory stroage ?
8. Define - software.
9. How are software classiffied ?
10. How is AutoCAD started ?
11. What are the important features of a AutoCAD window ?
12. What are the types of AutoCAD tool bar ?
13. What are the icons present in the draw tool bar ?
14. What is a modify tool bar ?
15. What is the use of command window ?
16. What is status bar ?
17. What are the different categories of AutoCAD commands ?
18. Name some drawing commands.
19. Mention some diamension commands.
20. What are the methods of entering a commend in AutoCAD ?
21. What is known as file management in AutoCAD ?
22. How will you create a new drawing file ?
23. Write the method of opening an exiting document ?
24. How are files saved AutoCAD ?
25. How are points located in AutoCAD ?
26. What are the types of coordinate system in AutoCAD ?

III. Answer the following questions in about a page

1. What are the advantages of AutoCAD ?
2. Explain the menu found in pulldown menu bar ?
3. Explain the tool bar of AutoCAD ?
4. Explain command window ?
5. Explain command entry in AuotoCAD ?
6. How is an arc drawn in AutoCAD ?
7. Explain the command ' ELLIPSE ' ?
8. How is Hatching done in AutoCAD ?
9. Explain ' Multi line text ' command.

III. Answer the following questions in detail

1. Explain the hardware and software of a computer.
2. Explain file management in AutoCAD.
3. Explain how lines are drawn by different methods in AutoCAD.
4. How is a circle drawn in AutoCAD ?

QUESTION PAPER BLUE PRINT

Sl. No.	CHAPTER	Questions allotment				Remarks
		Part - A	Part - B	Part - C	Part - D	
		1 mark	4 marks	10 marks	80 marks	
1.	Introduction to Engineering drawing	3	1	-	-	
2.	Drawing instruments	3	1	1	-	
3.	Bureau of Indian standards	1	-	-	-	
4.	Lettering & Dimensioning	1	2	1	-	
5.	Geometrical curves	1	1	1	-	
6.	Scale of a drawing	1	1	-	-	
7.	Theory of projection	2	1	-	1	
8.	Sectional views	4	2	1	-	
9.	Fasteners	6	1	1	-	
10.	Assembly drawings	-	1	-	-	
11.	Drawing symbols & Blue print reading	2	-	-	-	
12.	AutoCAD	6	4	2	&	
	Total questions	30	15	7	1	

MODEL QUESTION PAPER

GENERAL MACHINIST PAPER - I

ENGINEERING DRAWING

Time : 3 hours Marks : 200

PART - I

A. Choose the correct answer **30 x 1 =30**

1. The basic drawing for all engineering drawings is
   a. computer graphics b. original drawing
   c. geometrical drawing d. manual drawing

2. Drawing boards with dimensions of 1000 x 700 x 25 is designated as
   a. D_0 b. D_1 c. D_2 d. D_3

3. Freehand sketches are made with
   a. 2B pencils b.4B pencils c. HB pencils d.2H pencils

4. The length and width of the arrow head should be in the ratio
   a. 2:1 b. 1:2 c. 3:1 d. 5:2

5. The surface of a wall is
   a. an irreglar surface b. a vertical surface
   c. a horizontal surface d. an inclined surface

6. In first angle projection, the top view is placed
   a. above the front view b. left side of the front view
   c. right side of the front view d. below the front view

7. The lines used to show the hidden details of a drawing are known as
   a. centre lines b. sectional lines
   c. dotted lines d. hatching

8. The section of a connecting rod is generally shown in
   a. half section b. revolved section
   c.local section d. off-set section

9. The method of showing the section of an object adjacent to its view is
   a. half section b. revolved section
   c.local section d. removed section

10. Pitch of a screw is measured
    a. parallel to its axis b. perpendicular to its axis
    c. from the crest to the root d. from the root to the crest

11. .... is a temporary fastener

a. Welded joint		b. Riveted joint

c. Screwed joint		d. Forging

12. The angle of metric thread is

a. 29^0		b. 55^0		c. $47½^0$		d. 60^0

13. CAD stands for

a. Computer and Design		b. Computer and Drafting

c. Computer Accounting Designing		d. Computer Aided Drafting

14. Floppy drive is a

a. Primary storage device		b. Secondary storage device

c. Input device		d. Out put device

15. Mtext is a

a. drawing command		b. text command

c. display command		d. editing command

B. Answer the following questions in one or two words

16. What is the name of copies taken from the original drawings?

17. What are the types of geometrical drawings ?

18. What are the grades of drawing pencils ?

19. When was B.I.S established ?

20. What are the types projections ?

21. What is isometric projection ?

22. Mention any one type of a scale.

23. What is the process of drawing sectional lines known as ?

24. Draw the conventional representation of glass in section.

25. Who developed threads first?

26. What is lead of a thread?

27. What are keys made of ?

28. Who developed AutoCAD?

29. What is the role of AutoCAD is electrical engineering ?

30. Where is commanded windiow located ?

PART - II

Answer any ten questions in one or two sentences **10 x 4 = 40**

31. What is a drawing?
32. Mention the uses of a French curve.
33. What are the types of letters used in a drawing ?
34. What is aligned system of dimensioning?
35. Define - Ellipse.
36. What are the important uses of scales ?
37. What is third angle projection ?
38. What are the objectives of a sectional view ?
39. What is a sectional view ?
40. What is a keyway ?
41. What is a detail drawing ?
42. What is a CPU ?
43. Define software.
44. Mention some dimension commands.
45. What is known as file management in AutoCAD ?

PART - III

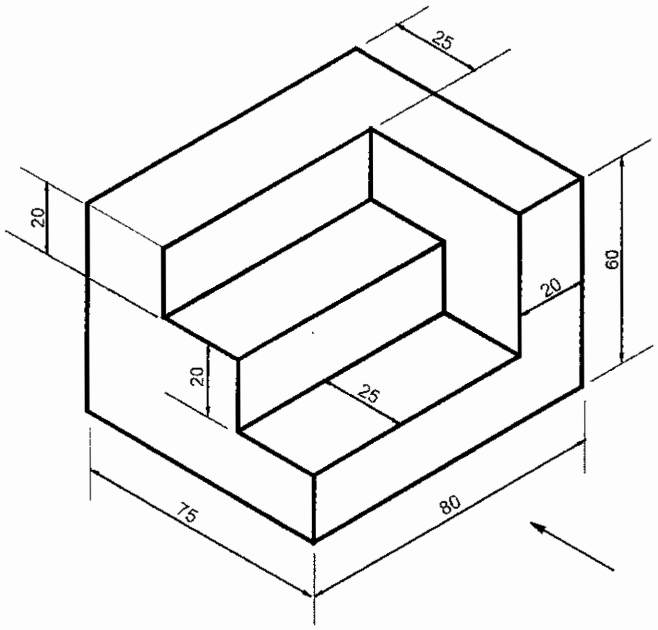
Answer the following questions in about a page **5 x 10 = 50**

46. Draw and explain the construction and uses of a drafter.
47. Draw different types of lines and specify their applications.
48. Mention different types of geometrical curves and explain.
49. What are the types of sectional views ?
50. Explain the different forms of threads with suitable diagrams.
51. Explain the tool bar of AutoCAD ?
52. Explain ' Multi line text ' command.

PART - IV

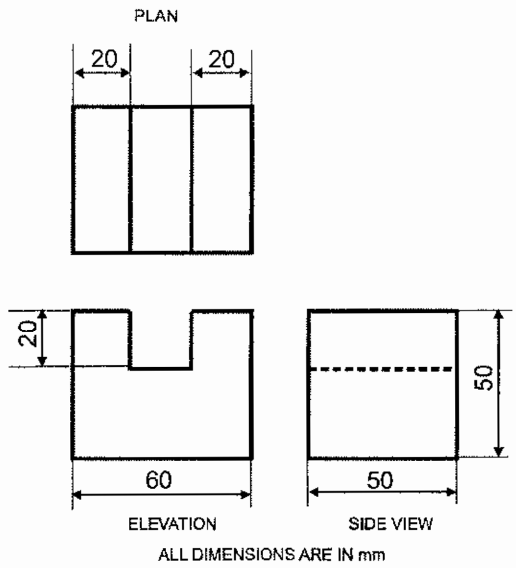
Answer the following questions in detail **80 marks**

53. Draw the views in orthographic projection of the part shown in isometric view.



(or)

Draw the isometric view from the views shown in orthographic projection.



GENERAL MACHINIST

PAPER - II

WORKSHOP ENGINEERING

VOCATIONAL EDUCATION

HIGHER SECONDARY - FIRST YEAR

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Untouchability is a sin

Untouchability is a crime

Untouchability is inhuman

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GENERAL MACHINIST

HIGHER SECONDARY FIRST YEAR

PAPER - II
WORKSHOP ENGINEERING

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- Accidents
- Safety
- First aid

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- Tap
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- Case hardening
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- Heat treatment furnaces

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- Quality Control
- Management
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- Cost of the material
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- Wages paid to the workers
- Cost for making accessories like jigs and fixtures
- Administrative expenditure
- Profit and tax

CONTENTS

1. WORKSHOP ENGINEERING – SAFETY PRECAUTIONS

1.1 Introduction

In this era of technological revolution, modern machineries and industries show dramatic development. New techniques lead to new machines. In order to cater to the needs of our daily life, new machines are developed and find places in our house, office, commercial plazas, industry etc., Machines became a part of our life. We can see our daily life begins and ends with machines - from water-heater, grinder, refrigerator etc, Giant machines in the factories also fit the bill.

In order to satisfy the rising demands of the mankind, such machines are manufactured in large number. Machinists involve themselves in the process of mass production and avert any shortfall in the demand. Special trainings need to be given to machinists to make them aware of modern manufacturing techniques and special skill developing abilities.

A machine tool is a machine which is used in manufacturing process. An industry or a factory may have many machine tools such as lathes, drilling machines, shaping machines, milling machines and grinding machines. It may also have several types of hand tools and cutting tools involved in the production process.

Industries can be classified as small scale industry, medium scale industry and large scale industry according to the range of investments and production. All such industries need specially skilled machinists in achieving their target in production.

1.2 Machinist

A machinist can be defined as a person who has a complete knowledge of operating various machine tools and handling different hand tools. In the process of doing so, he makes components or machine parts of required size and shape from various materials.

1.2.1. Duties of a machinist

1. A machinist should have a complete and thorough knowledge of operating different machine tools.

2. He should know how to handle various hand tools and instruments.

3. He should have a complete knowledge of reading production drawings. He should understand the various notes given in the drawing and different symbols marked on the drawing. He will then analyse about the size and shape of the component or assembly, the material(s) used for manufacturing them and the method of production.

4. He should operate the machine tools in a proper manner providing periodical maintenance.

5. He should be able to provide appropriate cutting speed, feed and depth of cut according to the rigidity of the machine, nature of the material used for manufacturing and the type of cutting tool used.

6. He should provide wholesome support to the overall development of the industry he works in.

1.2.2. The role of a machinist in the growth of a country

1. The industrial growth depends solely on the capacity of qualitative and quantitative production. A machinist should keep this in mind and dedicate himself in achieving this.

2. A machinist performs his duties to meet his own ends. If the economical status of a worker or a machinist is better, the overall economical growth of the industry and the country are bound to be better.

3. The growth of industry increases the employment opportunities.

4. Any commodity when produced in lesser numbers, costs high. Increased production reduces the cost of the item. Reduced costs increase the number of consumers. Increased number of consumers is the index of growth of a country on real terms.

So, it is evident that the growth of industry or a workshop depends on the efficient and skilled machinists.

1.3. Accidents

Accidents can be called as an undesired event which takes place suddenly causing damages to human lives and materialistic loss. Accidents occur everywhere in factories, workplace, on roads and at home. The main reasons of accidents can be attributed to lack of carefulness and not correcting some minor faults or deficiencies.

1.3.1. Causes for accidents

In industries, accidents can be averted by placing proper attention on the activities that take place there. Some important causes for accidents are

1. Not possessing adequate experience in the task to be done
2. Showing sense of urgency in the work
3. Desire of making quick time money
4. Working with poor health
5. Lack of adequate rest or sleep
6. Improper handling of hand tools
7. Inadequate facilities in the workplace
8. Improper environment
9. Wearing improper attire
10. Incorrect holding of work pieces and tools in machines
11. Lack of focus, indolence
12. Unnecessary conversations and lack of attention on the work

1.4. Safety

Safety can be defined as an attitude to keep away damages or accidents from happening in a workshop by strictly following the precautions and conducting the activities in a careful manner.

The advent of new gadgets and machines are welcome to cater our needs. But at the same time, they bring dangers and potential of accidents along with them. Accidents take place at a regular basis in industries. Every human life is essential and invaluable. In order to prevent the loss of human lives, safety should be enforced at all costs. Safety is an attitude and working safely is a state of mind. A machinist should accept that safe working habits are important in keeping himself and others working alongside him away from accidents.

Safety in a workshop can be categorized under four headings. They are

1. General workshop safety precautions
2. Safety precautions regarding hand tools
3. Safety precautions regarding machine tools
4. Safety regarding operators

1.4.1. General Workshop safety precautions

1. The layout of machines in the workshop should be suitably done considering proper lighting and ventilation.

2. First- aid box containing proper medicine and instruments should be kept always ready in a workshop.

3. Inflammable materials should be kept in safe places with proper precautions.

4. Round and cylindrical objects, sharp articles and tools should not be found in pathways for it may cause injuries to the workers.

5. Oil and grease should not be found spilled inside the workshop.

6. Hot objects should be kept separately wherein messages like “HOT”, “DO NOT TOUCH” are displayed.

1.4.2 Safety precautions regarding hand tools

1. Files, hammers and screw drivers with proper handles alone should be put into use.

2. When hammers, chisels and punches are put into use, care should be taken that any oil, grease or metal chips present on their heads are cleaned completely.

3. Measuring instruments should be handled properly to increase their durability.

4. After use, measuring instruments should be kept safely in their respective covers.

5. Sharp tools and accessories should be kept in their covers or boxes safely.

6. The hand tools should be used for the specific purpose for which they are intended. They should not be substituted for some other tools, when proper tools are not available.

7. Hand tools should not be placed near machine tool when their usage is not necessary.

8. Marking and measuring should not be done on rotating and moving parts.

9. Tools having cutting edges like files, chisels and scarpers should not be grouped with other hand tools when storing.

10. Tools like file, try square and hacksaw frames should not be used as an hammer or a screw driver.

11. Hacksaw blades should not be given undue tightening when fitted on hacksaw frames.

12. The hand tools should not be placed on electrical equipments.

1.4.3. Safety precautions regarding machine tools

1. Proper packing pieces should be used while lifting or shifting machine tools.

2. Operators should work on machines which they are familiar with. When they choose to work on unfamiliar machines, accidents may take place.

3. The amount of parameters like feed, cutting speed and depth of cut should be selected according to the strength and rigidity of the machine tools.

4. Sharp tools should not be placed on machine tools.

5. Sudden failures and defects in the machines should not be corrected or attended by the operator himself. Proper technicians should be called for repair works.

6. The machines should be stopped immediately if any abnormal sound comes from them.

7. Placards showing the message “THE MACHINE IS OUT OF ORDER” should be placed near the machines which are breakdown or under repair.

8. The operator should not change the speed or lubricate when the machine is still functioning.

9. While erecting new machine tools, their weight, efficiency and speed are assessed and foundation bolts of sufficient strength should be installed.

10. The machine tools should be maintained properly. It should be monitored regularly for scheduled maintenance and periodical lubrication.

1.4.4 Safety precautions regarding operators

1. Operators should wear tight clothings. They should avoid wearing loose dresses.

2. Operator should not wear ties and bows while working.

3. The dress code of the operator does not allow him to wear small towel or clothes around his neck or on shoulders.

4. Operator should wear only leather footwear.

5. While performing operations like grinding, welding and chiseling, the operator should wear safety goggles.

6. Metal chips should not be cleaned with bare hands but with proper brushes.

7. Safety plates and equipments should be installed before the machine is set on for operation.

8. The operator should wear gloves while handling hot and sharp articles.

9. The operator should resist himself from changing the speed, marking or lubricating on functioning machines.

10. The operator should seek the help of others while handling heavy and fragile materials.

11. Strict code of discipline should be followed in the workshop. Running, playing and chatting with others are to be avoided in the workshop.

12. The operator should not rest his body on the machines at any time, when working on them.

13. The operator should prefer working on machines which are familiar to him.

14. The operator should not touch unsafe and un -insulated electrical wires.

1.5 First aid

So far, we have discussed about various factors to enforce safety and avoid accidents. At some times, the focus on safety may be missing due to some reason or other. In such circumstances, accidents may happen causing liabilities to the industry as well as to the operator.

Accidents may happen at anytime in a workshop. The affected or injured person should be provided with immediate medical attention before he is taken to a hospital. This treatment which is given on the spot is known as first aid.

Every factory or a workshop should be equipped with a doctor or a first aid assistant. Apart from this, all the operators should be given proper training in first aid. These measures will avoid heavy losses of lives.

Every workshop should have a first aid box always ready with proper medicine and instruments.

1.5.1 Materials to be found in a first aid box

1. Tincture iodine	2. Tincture Benzene
3. Dettol	4. Burnol
5. Boric powder	6. Meshed cloth
7. Cotton	8. Plaster
9. Small scissors	10. Knife
11. Small stirrer	12. Small wooden strips
13. Basin for washing eyes	14. Broad based beaker for mixing medicine

A wheel chair and a stretcher are also necessary for transferring the injured or affected person to a hospital.

QUESTIONS

I. A. Choose the correct option

1. The person who manufactures different parts is
   a. Supervisor b. Machinist c. Manager d. Foreman

2. First aid is
   a. a manufacturing process b. safety regarding operators
   c. immediate treatment given at the spot of accidents
   d. breakdown of machines

I. B. Answer the following questions in one or two words

1. How are industries classified ?
2. Mention any two duties of a machinist.

II. Answer the following questions in one or two sentences

1. Who is a machinist?
2. What is an accident?
3. What is safety?
4. What is known as first aid?
5. What are the medicines found in a first aid box?

III. Answer the following question in about a page.

1. What are the duties of a machinist?
2. Discuss the role of a machinist in the growth of a country?
3. What are the main causes for accidents?
4. List out the safety precautions regarding hand tools?
5. What are the safety precautions regarding machine tools?
6. What are the safety precautions regarding operators?

2. HAND TOOLS

2.1. Introduction

Different types of tools are used in fabricating various components of a machine or a machine tool. Tools are also useful in assembling or dissembling machine elements. Some other tools are used to measure dimensions, marking sizes and dimensions and cutting off undesired portions of materials. All these tools are known as hand tools. These hand tools serve as the nerve centre of workshops. Hand tools are very much necessary even in a modern workshop which has very accurate and precise machines.

Some of the hand tools are

1. Vise	2. File
3. Hacksaw frame	4. Try square
5. Scriber	6. Punch
7. Hammer	8. Surface plate
9. V block	10. Angle plate
11. Surface gauge	12. Parallel clamp
13. C Clamp	14. Spanner and wrench
15. Bearing puller	16. Tap set
17. Die and die holder	18. Scraper

The above tools can be broadly classified under following categories

1. Measuring tools
2. Marking tools
3. Cutting tools
4. Assembling and dismantling tools

2.2 Vise

Vise is generally used to hold workpieces when operations like drilling, filing, chiseling and hacksaw cutting are performed on them. Vise is a essential hand tool in a workshop. A workshop is complete only when it has different types of vises. There are several types of vises used according to the type of work to be performed, the shape & size of the work and the method of holding.

The types of vises are

1. Bench vise
2. Hand vise
3. Leg vise
4. Pipe vise
5. Pin vise
6. Tool maker's vise
7. Machine vise
8. Swivel vise
9. Universal vise

2.2.1. Bench vise

Bench vise is a tool which finds application in all workshops. It is useful in holding workpieces while doing works like filing, chiseling and hacksaw cutting. It is mounted on a bench by means of bolts and nuts. There are two jaws in a vise and they are 1. Fixed jaw and 2. movable jaw. Jaw plates are screwed on the faces of these two jaws. The gripping surfaces of the jaw plates are knurled for proper gripping of the work. The body of the vise is made of cast iron, and the jaws are made of tool steel. The handle is made of mild steel.

There is a screw arrangement to make the movable jaw move upto a desired point. When the handle is rotated, the screw which passes through a nut in the fixed jaw makes the movable jaw move. The movement is suitably adjusted according to the size of the work to be held. The size of the vise is specified by the maximum distance between the fixed and movable jaw.

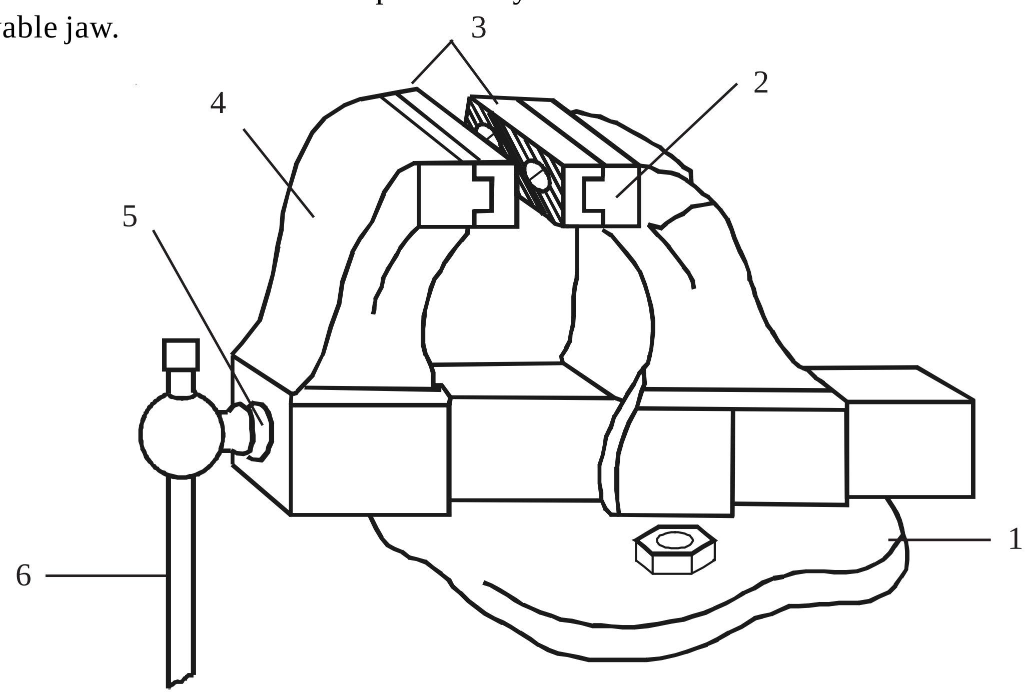


Fig 2.1. Bench vise

1. Base, 2. Fixed jaw, 3. Jaw plates, 4. Movable jaw, 5. Screw, 6. Handle

2.2.2. Hand vise

Small objects like screws, rivets, keys and drills are held with the help of a hand vise. When the force which needs to be applied is more, hand vises are fitted on benches.

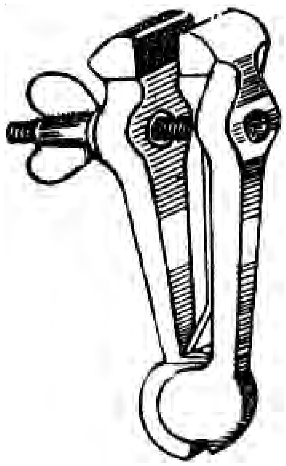


Fig 2.2 Hand vise

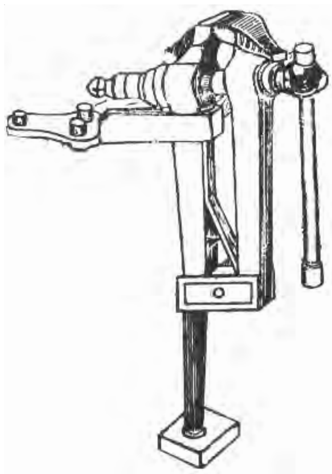


Fig 2.3 Leg vise

2.2.3. Leg vise

Leg vises are generally used in a blacksmith's shop or in a foundry. They are useful in holding work pieces when doing works like striking, chiseling and cutting. The body of the leg vise is made of Nought iron and so it holds on to sudden and heavy blows made on it.

2.2.4. Pipe vise

Pipe vise consists of a base and a column fitted on it. A 'V' shaped jaw is fitted on the base. The column is provided with another 'V' shaped movable jaw. Work is done on pipes or round rods fitted between these two jaws.

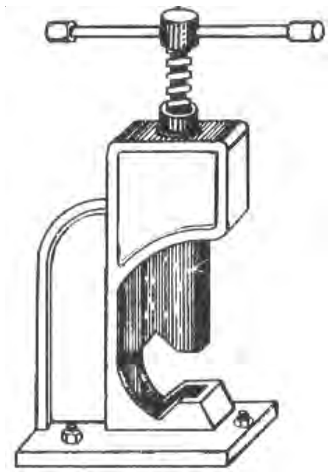


Fig 2.4 Pipe vise

2.2.5. Pin vise

The pin vise has three jaws which open or close by equal amount on turning a sleeve surrounding the jaws. This movement enables the vise to hold small round objects. Strings and wires of small diameters can be held with a pin vise.

The other types of vises are used in big workshops and machine shops.

Fig 2.5 Pin vise

2.2.6. Maintenance of vise

1. Vises should be maintained properly. Care should be taken that the screw of the vise is free from dirt or metal burrs.

2. The screw of the vise should be lubricated with grease for proper sliding of the movable jaws.

3. The top of the vise should not be used as an anvil.

2.3. Clamps

2.3.1. Parallel clamp

Parallel clamp can also be known as tool makers clamp. Two iron frames are connected to a screw. It is useful in holding small parts made of non ferrous metals.

2.3.2. C – Clamp

It resembles the English alphabet ‘C’ and hence named so. It consists of a frame in the shape of the letter ‘C’, a screw and an handle. It is made of low carbon steel. One side of the frame is flat and the other end is bored and threaded. The screw which has a flat end passes through the threaded hole in the frame. The other side of the screw has an handle attached to it. The work is held between the flat ends of the frame and the screw.

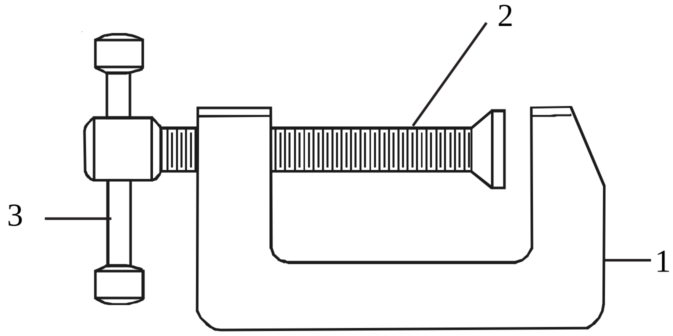


Fig 2.6 ‘C’ clamp
1. Frame
2. Screw 3. Handle

2.4. Files

A file is a hardened steel tool having slanted and parallel rows of cutting edges or teeth on its surfaces. It is used to cut, smooth or fit metal parts. It is also used on wooden and plastic parts. It cuts all materials except hardened steel. Small quantities of unrequired metal can be removed with files. Metal burrs leftout after chiseling and hacksaw cutting are removed with the help of files. It is also used to sharpen the cutting edges of sharp tools like saws.

The tang is a pointed part which fits into the handle. The point is the end opposite to the tang. The heel is next to the tang. The face of the file has a slanting rows of cutting edges.

Files are classified according to the following factors.

1. Effective length
2. Sectional form
3. Cut of teeth
4. Grade

2.4.1. Length

The length of the file is its size. It is measured from the point to the heel excluding tang. Generally files are available in sizes ranging from 100mm to 200 mm. Files upto the length of 500 mm are also available to be used for heavy duty work.

2.4.2. Sectional form

The shape of the file is its cross section. Files are made in different forms of shape. Most commen types of forms are

1. Hand file
2. Flat file
3. Square file
4. Round file
5. Half round file
6. Triangular file
7. Knife edge file

Hand file

It is similar to a flat file but its only difference is that it has uniform width. It is useful in filing internal square edges.

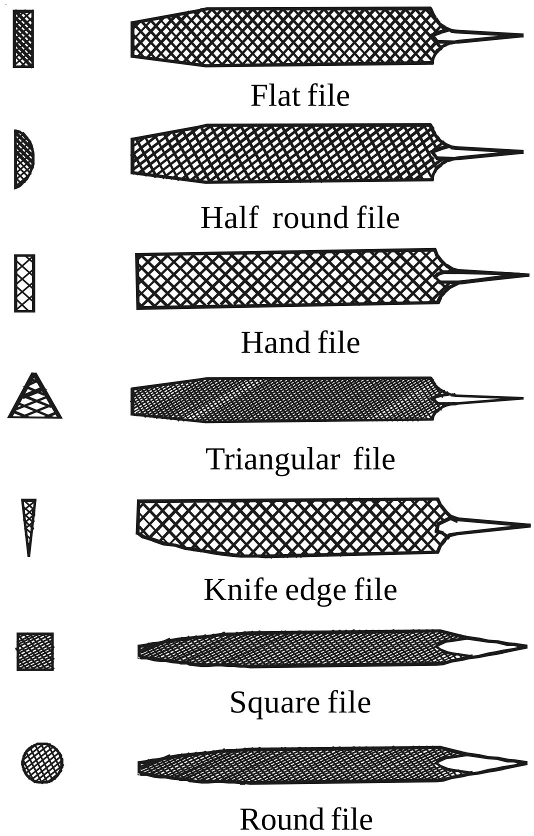


Fig 2.7 Types of files

Flat file

It is rectangular in cross section and is the most common form of file. It is always double cut on the faces and single cut on the edges. It is tapered in width towards point. It is used for general work and can be adopted for speed work.

Square file

It is square in cross section. It is tapered towards the point. It has double cut teeth on all the four faces. It is used for filing square corners, enlarging square and rectangular openings.

Round file

Round file is circular in cross section. The diameter of the file is uniform for about two thirds of its length. From there it is tapered towards point. It carries single cut teeth all around its surface. It is used for filing curved surfaces and enlarging round holes.

Half round file

The cross section of a half round file is not a half circle but around 1/3 rd of the circle. The width of the file is tapered towards point. It may have single cut teeth on the curved surface and double cut teeth on the flat surface. It is used to file concave and convex surfaces as well as other curved surfaces.

Triangular file

It is also called as three square file and its cross section is a triangle. Each side is inclined at 60^0 to its adjacent side. It is tapered towards point and has single cut or double cut teeth on all its sides. It is used for filing grooves and sharp corners of edges more than 60^0.

Knife edge file

The cross section of this file is tapered and looks like that of a knife. It carries double cut teeth on both its faces and single cut teeth on the edge. It is used to file sharp corners and edges of keyways.

Maintenance of files

During filing, the metallic burns coming out of the filed parts occupies the clearance spaces between the teeth. It prevents efficient cutting. These burns should be removed with brushes having thin metallic wires.

2.4.3. Cut of teeth

Cut of teeth of a file refers to the type of teeth on the faces. Files can be classified according to cut of teeth as

1. Single cut file
2. Double cut file
3. Rasp cut file

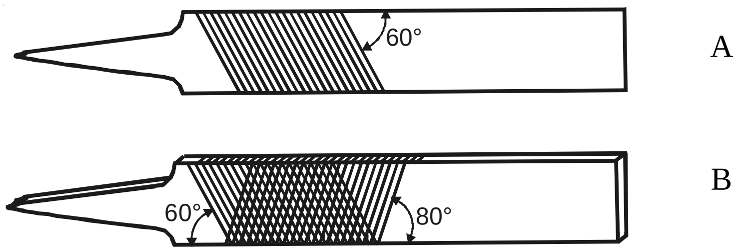


Fig 2.8 Single cut and Double cut file
A. Single cut B. Double cut

Single cut file

In single cut file, the teeth are cut in parallel rows on the faces normally inclined at an angle of 60^0 with the centre line of the face.

Double cut file

In double cut file, there are two sets of teeth one similar to those of a single cut file and another set running diagonally across the first set at an angle of about 80^0 from the other side. Harder materials are cut with double cut files.

Rasp cut file

The cross section of this file is half round. The teeth of the file are triangular in shape and project from the face surfaces. Rasp cut files are used to file soft materials like wood, plastic and hard rubbers.

2.4.4. Grade

The grade of a file refers to the coarseness or the spacing between the rows of the teeth. It is designated by the number of rows of teeth per inch.

There are five types of files according to its grade. They are

1. Rough file (R) – 20 to 25 teeth / inch
2. Bastard file (B) – 25 to 30 teeth / inch
3. Second cut file (SC) – 35 to 40 teeth / inch
4. Smooth file (S) – 40 to 60 teeth / inch
5. Deed smooth file (DS) – 80 to 100 teeth / inch

2.5. Hacksaw frame

Hacksaw frame consists of a frame, a wooden handle, prongs, tightening screw and a wing nut. It is used for sawing all metals except hardened steel. Tightening screw with the help of a wing nut is used to stretch the blade as desired.

There are two types of hacksaw namely

1. Standard or solid hacksaw
2. Adjustable hacksaw

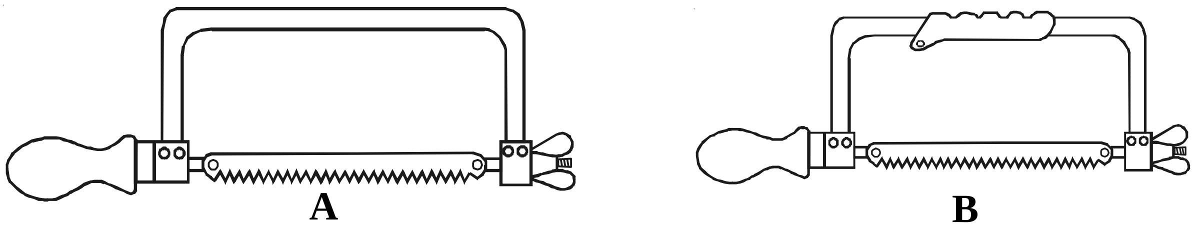


Fig 2.9 Types of hacksaw frames
A. Solid type B. Adjustable type

Standard hacksaw

In this type, the distance between the prongs cannot be altered. So it is suitable for a particular length of hacksaw blades only.

Adjustable hacksaw

In this type, the distance between the prongs can be adjusted to hold hacksaw blades of different lengths say from 200 mm to 300 mm.

2.5.1. Hacksaw blades

Hacksaw blades are made of high carbon steel, Tungston steel, low alloy steel or high speed steel. They are then hardenered and tempered. They are made as thin sheet with cutting edges present on one side or on both sides. The size of the blade is specified by the distance between the holes on either sides along the length.

According to the distance between two successive teeth on the blade (pitch), they are classified as coarse, medium, and fine pitch blades. Soft materials like plastics are cut by coarse pitch blades. Medium pitch blades are employed to cut tool steel, hard light alloys, thick sections and tubes. Materials of small thickness are cut accurately by fine pitch blades.

2.5.2. Reasons for the breakage of hacksaw blades

1. The cutting action may not be of uniform speed and thrust
2. Improper fitting of blades (undue tightness or looseness)
3. Putting into use new blades in old cuts
4. Not selecting blades of suitable pitch
5. Poor workmanship

2.5.3. Reasons for the blunting of hacksaw blades

1. The material being cut is harder than the blades
2. Improper selection of blades
3. Application of high thrust and speed
4. Applying thrust during return stroke also
5. Not applying a coolant

2.6. Scraper

Scrapers are used for shaving off or parting off thin slices or flakes of metal to make a fine, smooth surface. The material used for making scrapers is a good quality forged steel and the cutting edge is very hard. Scraping is a process of obtaining a true flat surface which is superior in quality than that can be produced by machining are filing. The top of the surface plate is coated with a thin film of Prussian blue. The surface to be scraped is laid on the surface plate and moved back and forth. The high spots on the work will be marked with Prussian blue. The high spots are scraped down by giving the scraper a small circular motion. There are three different types of scrapers according to its shape. They are

1. Flat scraper
2. Half-round scraper
3. Triangular scraper

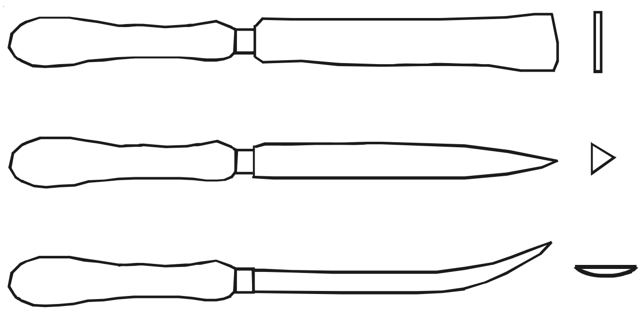


Fig 2.10 Scrapers

Flat scraper :

The flat scraper is the most common type and has the cutting edge at the end. It is used to produce a perfect flat surface. It is available in different lengths ranging from 200 to 250 mm.

Half-round scraper

The shape of half-round scraper is like a half-round file. They are used to scrape round or curved surfaces.

Triangular scraper

The triangular scraper has three cutting edges. Its is used to scrape round or curved surfaces and to finish sharp corners free from burrs.

Maintenance of scrapers

1. The cutting edges of the scraper should always be kept sharp.
2. It should be kept in a special case or wrapped in a piece of cloth when not in use.
3. It should be used for no other purposes other than scraping.

2.7. Marking tools

In addition to the measuring instruments, some tools are used to make marking on the workpieces and to scribe lines on them. They are known as marking tools.

Scribing is a very important action in making a component. Lines are to be drawn on the workpiece according to the design. These lines are drawn with reference the contours of the work preferably at right angles or with reference to a certain datum line. The position of these edges or the position of the datum line may be determined from the drawing which is necessary for each job.

Effects of poor marking

1. Waste of job material
2. Wastage of time
3. Leads to loss because of the production of inaccurate products
4. Consequent transporting expenditure
5. Earning bad name in the industry

Guidelines for good marking

1. Drawing should be correctly understood
2. Marking tools should be kept ready
3. Proper marking tools should be used
4. Scribed lines are checked for correctness before punching
5. Selection of punches should be done properly

Types of marking tools

1. Steel rule	2. Jenny caliper
3. Divider	4. Trammel
5. Punches	6. Try square
7. Scriber	8. Surface plate
9. Marking table	10. Surface gauge
11. V – block	12. Angle plate

2.7.1 Steel rule

Steel rule is used generally for measuring all kinds of objects. It is also adapted for marking and scribing straight lines. It is made of thin steel sheet and hence named so.

2.7.2 Jenny caliper

Jenny caliper has two legs – one straight and sharp and the other slightly bent at the bottom. The top of the legs are connected by a rivet or a spring. It is made of mild steel and case hardened. It is also called as odd leg caliper and hermoprodite. There are two types of jenny calipers namely fixed point odd leg caliper and adjustable point odd leg caliper. Jenny calipers are used to find the centre of the round rod and to draw parallel lines at regular intervals on workpieces

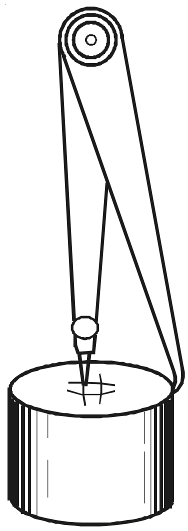


Fig 2.11 Jenny caliper

2.7.3 Divider

Divider has got two legs having sharpened ends. The two legs are connected at the top by a rivet or by a spring.

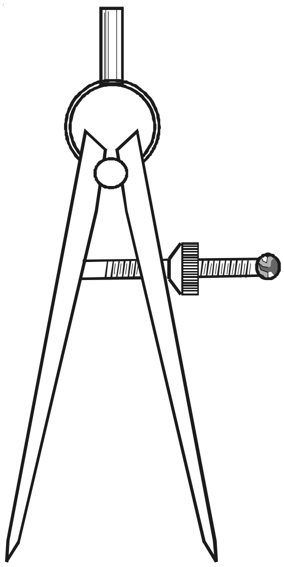


Fig 2.12 Divider

It is made of high carbon steel and hardened.

Uses of divider

1. To scribe arcs and parallel lines on workpieces
2. To divide straight lines and curved lines into equal parts
3. To find and check the centre of a round rod
4. To mark correct dimensions taken from the steel rule on workpieces

2.7.4 Trammel

Trammel can be used as a divider and as well as an inside and outside caliper. It consists of a solid beam known as trammel bar into which two trams are attached. These trams have a chuck attached to each of them which will hold pointed edges to be used as the tools mentioned above. The position of the trams can be locked at a desired point.

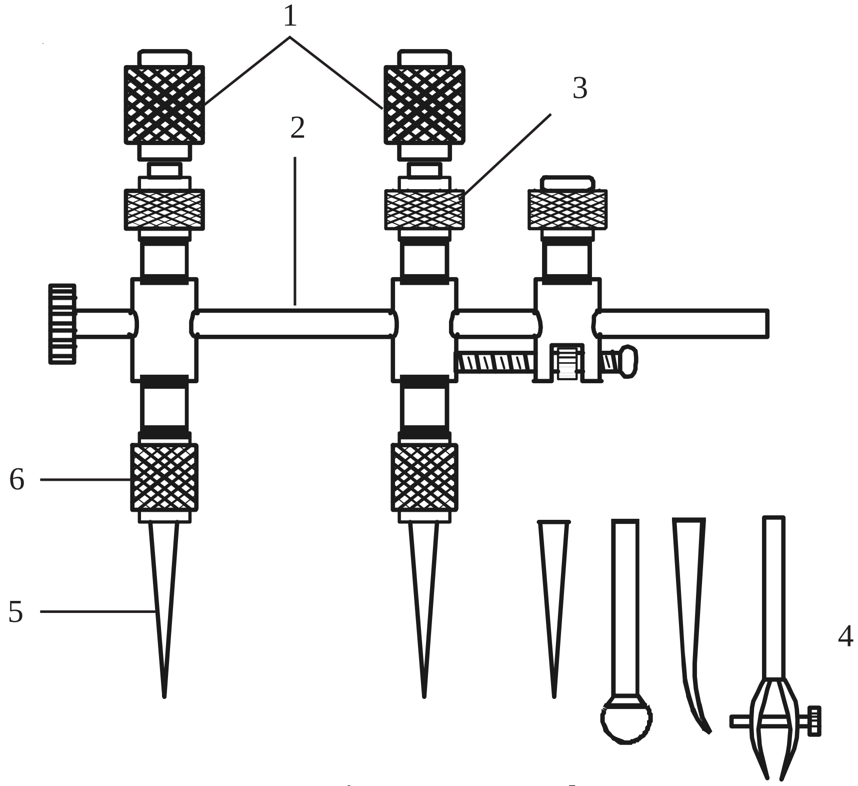


Fig 2.13 Trammel

1. Clamping screws 2. Horizontal beam 3. Tram
4. Types of legs 5. Driver leg 6. Chuck

2.7.5 Punches

Punches are used to make permanent marks on the lines already scribed on the workpieces. The punch marks make the line appear clearly. Punches are also used to make marks on exact locations on the workpieces where drilling is to be performed.

Punches are made of steel alloys. The punching ends are ground to a required angle. The body of the punch is knurled to provide gripness.

Types of punches

1. Prick punch	2. Dot punch
3. Centre punch	4. Hollow punch
5. Bell punch	6. Pin punch

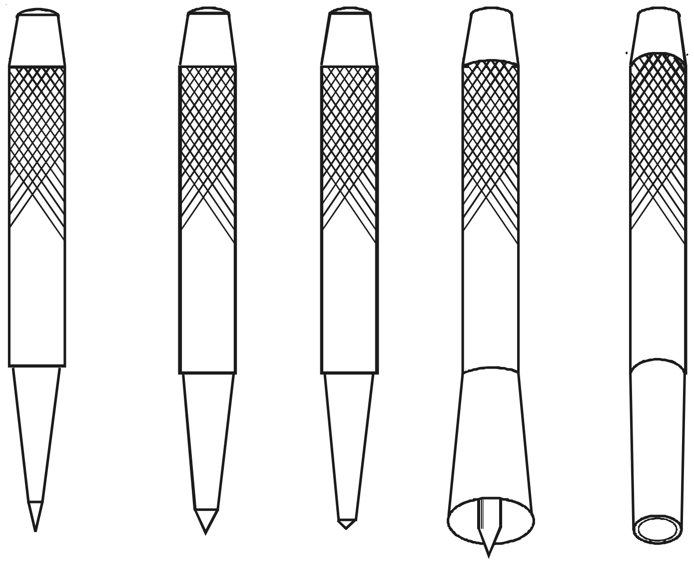


Fig 2.14 Types of punches

A. Prick punch B. Dot punch C. Centre punch

D. Bell punch E. Hollow punch

Prick punch

Prick punches are used in some precision works and on softer materials. The end of the punch carry an angle of 30 degrees.

Dot punch

Dot punches are used to make marks on the workpieces and to make scribed lines appear clearly. The end of the dot punch is ground to have an angle of 60 degrees. Punch marks are made at regular intervals on the lines (interval may be 6mm for straight lines and 3mm for curved lines).

Centre punch

The angle of the centre punch is 90 degrees. It is used to make marks on locations where drilling operation is going to be performed. The marks made by the punches will allow the drill to get seated and rotated at the exact location.

Hollow punch

The end of the hollow punch is concave inside. It is used to make holes on sheet materials like leather, rubber and cardboard sheets.

Bell punch

It is useful in marking centres on the faces of round rods.

Pin punch

Pin punch is used to make small holes on thin sheet materials. It is also used to insert or remove small pins into or out of holes.

2.7.6 Try square

Try square is used to check the perpendicularity of surfaces (both external and internal) It is also useful in scribing parallel lines perpendicular to a particular surface and to check flatness of surfaces.

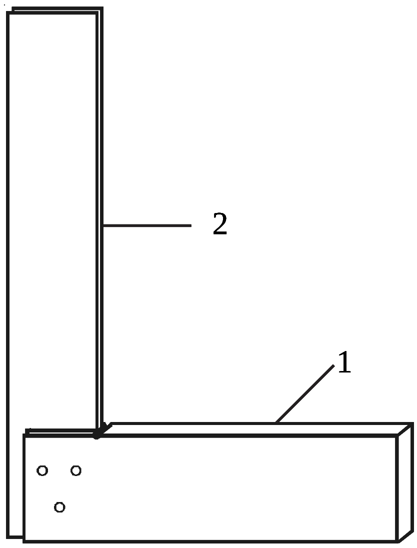


Fig 2.15 Try square
1. Stock, 2. Blade

Try square consists of two parts namely stock and blade. Stock is made of cast iron or cast steel and blade is made of high carbon steel or stainless steel. All sides of the stock are machined accurately and perpendicular to the adjacent sides. The blade is rivetted to the stock such that both of them are absolutely perpendicular to each other. There will be an undercut on the stock nearer to the bottom of the blade. It will accomodate burrs on the workpiece if any. The blade of the try square may be graduated.

Try square should be maintained properly. The blade of the try square should not be used as a screw driver and stock as hammer. It should be oiled properly for avoiding rust formation on its surfaces

2.7.7 Scriber

A scriber is used to scribe lines on the workpieces. It is made of high carbon steel which is hardened and tempered. The end of the scriber is ground sharp to have an angle of 12^0 to 15^0. The body of the scriber is knurled to provide gripness. It is available in different lengths - 150mm, 200mm & 250mm.

There are different types of scribers available. They are :

1. Straight ended scriber
2. Bent ended scriber
3. Adjustable scriber
4. Offset scriber
5. Knife-edge scriber

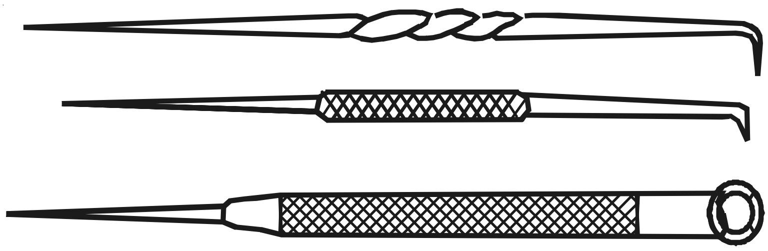


Fig 2.16 Scibers

2.7.8 Surface plate

The flatness of a surface of a work can be tested with the help of a surface plate. It is also used for marking-out work.

Fig 2.17 Surface plate

Surface plates are made of grey cast iron. The top surface of the surface plate is very accurately machined and scraped for further accuracy. It should be mounted on a bench or on a special stand at an height of about 800mm. They are made in two grades of accuracy - A grade & Bgrade. A grade suface plates are with 0.005mm flatness and B grade with 0.2mm flatness. It is available in sizes of 150 x 100mm and 1000 x 750mm.

Care of surface plate :

1. The surface plate should be covered when not in use.
2. The top surface should be kept free from rust and dirt.
3. It should be wiped with a clean cloth and smeared with grease or oil after use.
4. Parts having burrs on them should not be rubbed on the top surface of the plate.

2.7.9 Marking table

Marking table accommodates surface plates to be mounted on it. It helps in marking and inspection. It is made of mild steel and the top is made of cast iron. It is available in sizes of 900 x 900 x 825 mm.

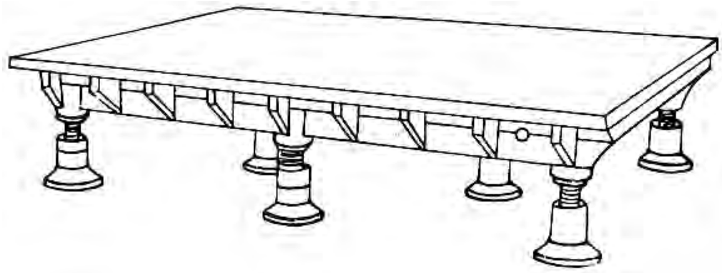


Fig 2.18 Marking table

2.7.10 Surface gauge

Surface gauge is also a marking tool. It can also be called as marking block. This instrument is used to scribe straight lines on work surfaces and it can also be used to check the correctness of surface level. In combination with a dial indicator, it is used to lineup cutting tool or workpieces for inspection.

The base of the surface gauge is accurately machined and a pillar stands vertically on it. A scriber is attached to the pillar by means of a clip. The scriber can be positioned practically in any position.

There are two types of surface gauges namely

1. Vertical pillar surface gauge
2. Universal surface gauge

Vertical pillar surface gauge

This is a simple form of surface gauge in which a pillar is fitted into a heavy base vertically. A scriber is attached to the pillar by means of a clip. It is adjusted by means of a knurled nut. It is not suitable for precision work.

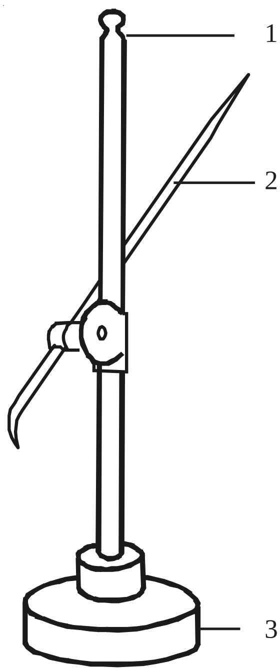
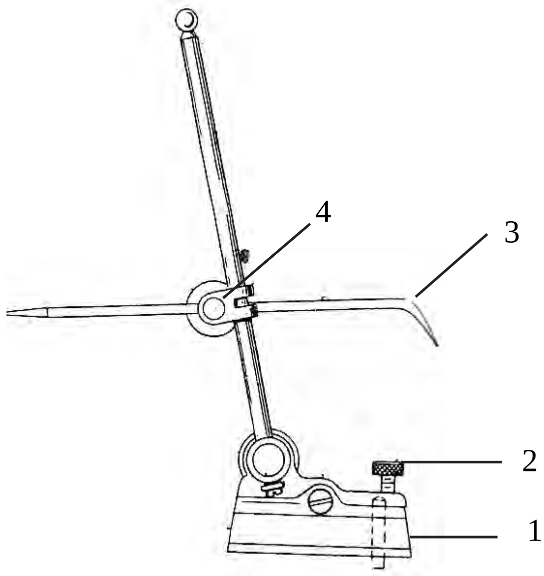


Fig 2.19 Vertical pillar Surface gauges

1. Base 2. Scriber 3. Pillar



Before setting the instrument for scribing and checking, the surface plate, the angle plate and the work are cleaned neatly. For measuring purposes, the steel rule of the combination set is selected. Angle plate is placed on the surface plate. The steel rule and the work are placed closely on one side of the angle plate. The tip of the sciber is set and adjusted by sliding the clip suitably. The required straight line may be drawn by moving the surface gauge along the work upon the surface plate.

Fig 2.20 Universal Surface gauges
1. Base 2. Adjusting screw 3. Scriber 4. Clip

Universal surface gauge :

It has a base having 'V' groove, a spindle and a scriber. The scriber is adjusted by means of a knurled nut. The advantage in comparison with pillar type is that fine adjustments can be made by means of an adjusting screw. Pins provided on the base can be pushed down to act as a guide against the top of the surface plate. 'V' groove on the base enable it to be placed on round rods.

Uses of surface gauges

1. To find centres of round rods and square rods
2. To set workpieces aligned to the axis of the lathe while held by chucks
3. Can be used as a vernier height gauge to draw horizontal lines on workpieces
4. To check parallelism of opposite sides on machined parts
5. The scriber of the surface gauge is replaced by a dial indicator and used for alignment of machine tools.

2.7.11 V- block

V' blocks have a 'V' shaped groove and rectangle grooves on it. The angle of the V groove is either 90^0 or 120^0.The face of the 'V' block is square or rectangular in section. It is used to hold cylindrical workpieces when these workpieces are be machined in a drilling machine, shaping machine and milling machine. It is also used to hold round rods when some markings are to be done on it.

The usual sizes of a V block are 50 mm to 250 mm in length and 50 mm to 100 mm in width and height.

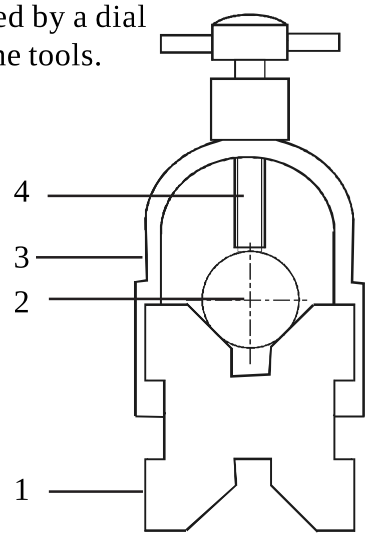


Fig 2.21 'V' block
1. V block 2. Cylindrical work
3. U Clamp 4. Screw

2.7.12 Angle plate

It resembles the English alphabet ‘L’. It has got two sides absolutely perpendicular to each other.Usually it is made of cast iron. The sides of the angle plate has got slots and holes on it. It is used to hold workpieces on machine tools like lathe, drilling machine and milling machine. It is also used to check the perpendicularity of surfaes either internally or externally. It is also used for marking on workpieces when used along with other marking tools like surface gauge. It is specified by its length, width and height.

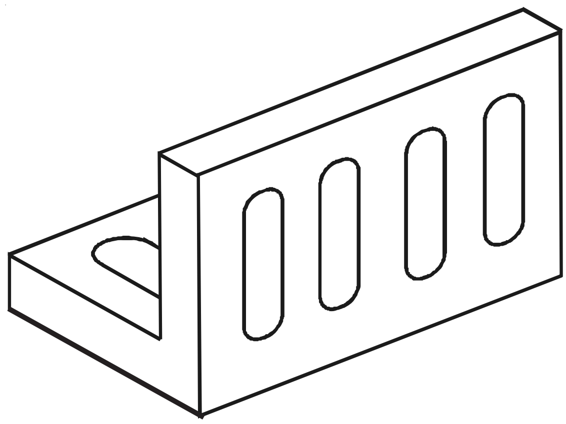


Fig 2.22 Angle plate

2.8 Hammer

Hammer is a striking tool. It is used to strike metal parts to straighten or bend them and bring them to the required shape. It is also used to drive nails and rivets. It finds place in a blacksmith’s shop also.

The types of hammers are

1. Hand hammer 2. Sledge hammer
3. Claw hammer 4. Soft hammer

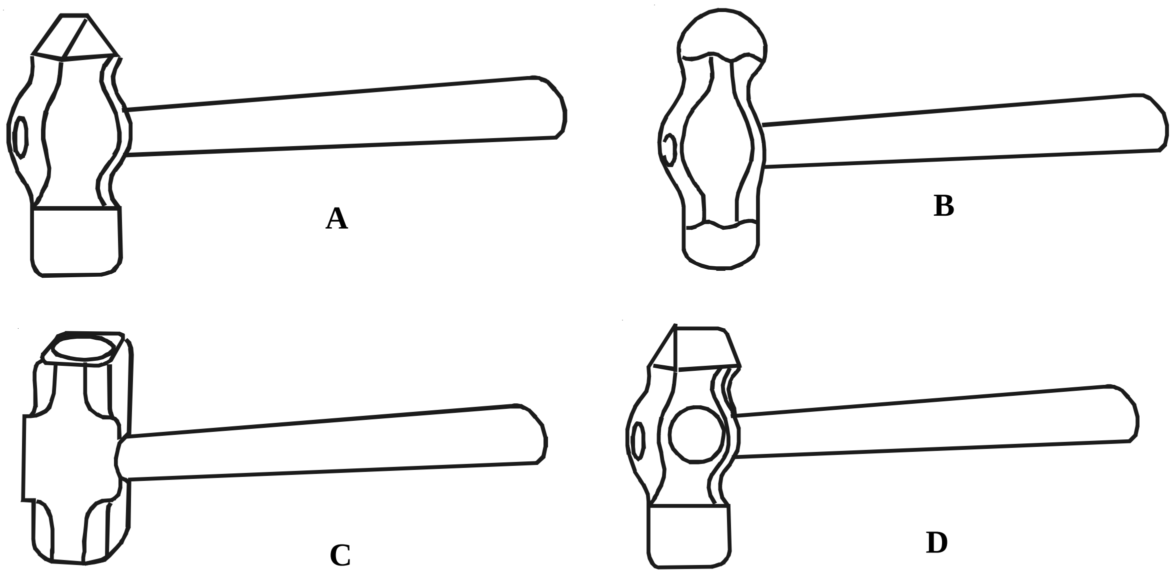


Fig 2.23 Types of hammers

A - Cross peen hammer B - Ball peen hammer

C - Sledge hammer D - Straight peen hammer

Hand hammers are of different types and they are

1. Ball peen hammer
2. Cross peen hammer
3. Straight peen hammer
4. Double face hammer

2.8.1 Hand hammers

They are made of cast steel or carbon steel. The peen and the face are hardened. The body of the hammer has a through slot. An handle made of wood is inserted into the slot with suitable wedges.

2.8.2 Sledge hammer

Sledge hammers are generally used in blacksmith's shop. They are useful in bending and straightening cylindrical and square rods. It is very similar in shape to a double face hammer but of larger size. As the weight of sledge hammer is very high, it is used on heavier workpieces.

2.8.3 Claw hammer

Claw hammer is special type of hammer. The face of the claw hammer is cylindrical in shape and the peen is slightly bent towards the handle. The peen has a central opening which facilitates in the removal of nails.

2.8.4 Soft hammer

Soft hammers are used for gentle blows on metal parts. It is adapted where the blow marks are not desired. It is also used on softer materials. It is made of materials like wood, plastic, brass and aluminium. It is also known as mallet.

2.9 Spanners and wrenches

These tools are generally used to drive in or drive out bolts and nuts into or out from sleeves or collars. There are different types of spanners according to shape and utility. Their sizes correspond to the sizes of the bolts and nuts on which they are used.

2.9.1 Double ended spanner

It is made of high carbon steel and mostly made by forging method. Slots are provided on both the ends of the spanner. These slots are inclined at about 30^0. There may be some slipping when operating with this spanner.

Fig 2.24 Double ended spanner

2.9.2 Box spanner

Box spanner looks like a sleeve. It is designed to be used on nuts requiring great leverge. There won't be any sliping during handling. It is made in a variety of shapes such as square, hexagon and octagon.

2.9.3 Ring spanner

It is designed with 12 notches or points inside a closed end. The points of a nut may be gripped by any one of the 12 notches of the spanner which permits the turning of a nut where only a short pull of the spanner is possible.

Fig 2.25 Ring spanner

2.9.4 Adjustable spanner

Adjustable spanneror wrench has a movable jaw which makes it adjustable to various sizes of nuts. When using this wrench, the jaws should be pointed in the direction of the force applied.

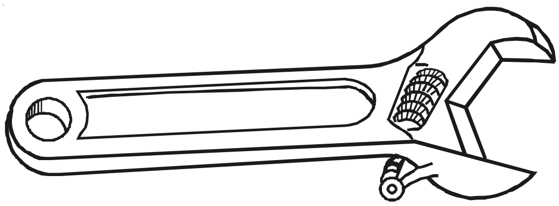


Fig 2.26 Adjustable spanner

2.9.5 Allen key

It is made of square or hexagon shaped stock to fit the holes in the heads of safety set screws or socket head screws. They are available in differet sizes.

2.9.6. Screw driver

A screw driver is a hand tool that is designed to turn screws. The blade is made of steel, attached to one end of which is a wooden or plastic handle. The other end is flattened to fit in to the slots in the heads of screw or bolts. Screw drivers are made in many sizes.

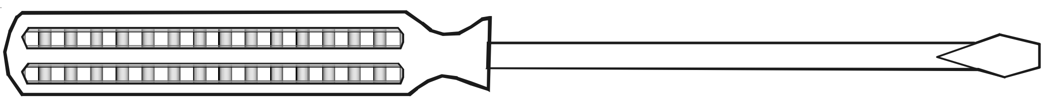


Fig 2.27 Screw driver

2.9.7. Philips Screw driver

A Philips screw driver is specialy designed to fit the heads of Philips screws. It differs from other screw drivers in that the end of the blade is fluted instead of being flat. It is made in several sizes.

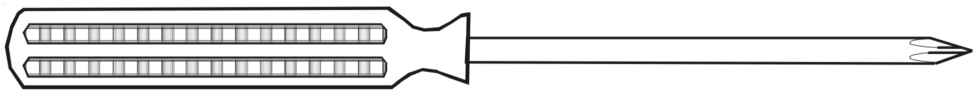


Fig 2.28 Philips screw driver

2.9.8. Pliers

Pliers are made in many styles and are used to perform as many different operations. They are used for holding and gripping small articles in situatuins where it may be inconvenient or unsafe to use hands.It is not a good practice to use pliers in place of a wrench.

Side cutting pliers

Side - cutting pliers are made with cutting blades on one side of the jaws. They are used mostly for gripping and cutting wires.

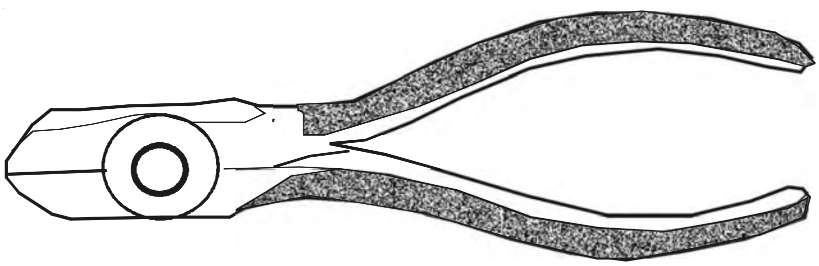


Fig 2.29 Side cutting pliers

Nose pliers

Nose pliers are made with a thin nose or jaws.This tool can be used for placing and removing small items in narrow spaces. It is also preferred for electrical and radio repair work.

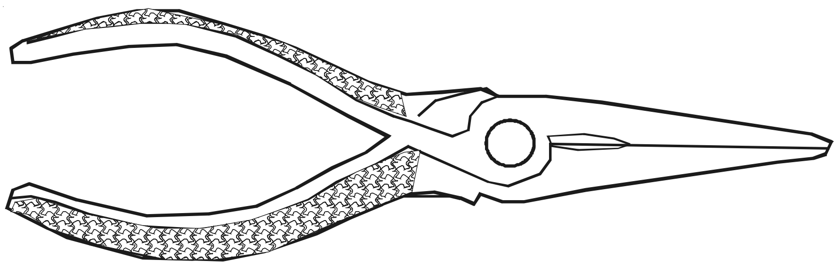


Fig 2.30 Nose pliers

2.10 Bearing puller

This is a device to remove the bearing from the shaft. It works in the principle of bench - vice. The legs of the puller is widened to hold the bearing and the bottom of the screws of the puller should touch the face of the shaft, then turned clockwise as shown in the figure. Due to the movement of the screw rod of the puller the bearing is easily pulled out from the shaft. Arbor press is used to fix the bearing in the shafts.

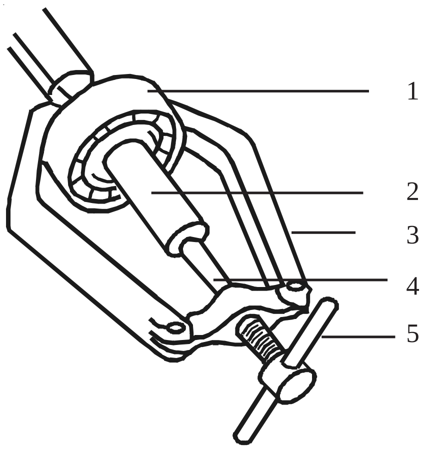


Fig 2.31 Bearing puller

1. Bearing 2. Shaft 3. Leg 4. Screw 5. Handle

2.11 Tap

A tap is a screw like tool which has threads like a bolt and three or four flutes cut across the thread. It is used to cut threads on inside of a hole as in a nut. The tap is used along with the wrench which holds the tap with it. The cutting edges are formed by the flutes on the thread. The lower end of the tap is somewhat tapered so that it can dig into the walls of the hole. The top of the tap has a square shank which helps it to be held by the wrench. Taps are made of either high speed steel or high carbon steel and hardened and tempered.

Taps are made in sets of three - 1. Taper tap
2. Second tap
3. Bottoming tap

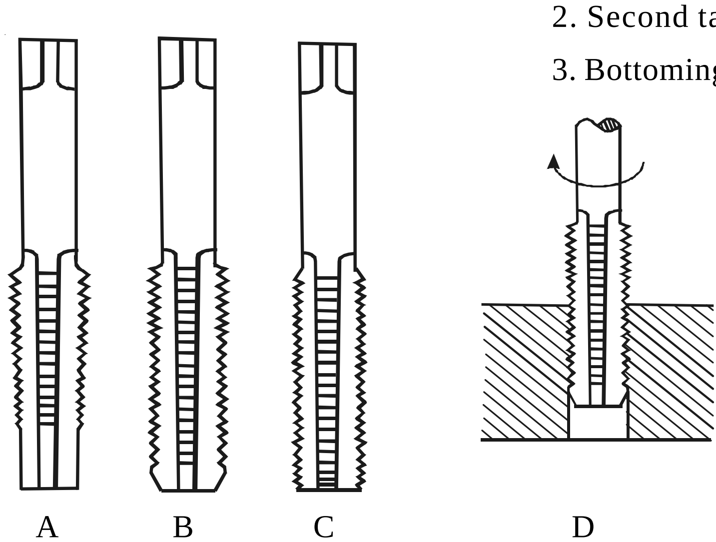


Fig 2.32 Tap set

A. Taper tap B. Second tap
C. Bottoming tap
D. Tapping operation

Taper tap

The taper tap has about six threads tapered. It allows the tap to dig into the hole easily to form threads gradually as the tap is turned into the hole. The wrench holding the tap is moved clockwise and anti - clockwise while tapping. Oil is applied into the hole as the tap is screwed.

Second tap

It is tapered back from the edge about three or four threads. This is used after the taper tap has been used to cut the thread as far as possible.

Bottoming tap

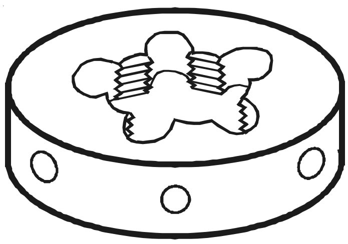
It has threads for the whole of its length. It is used to finish the work prepared by the other two taps.

Hints to be observed while tapping :

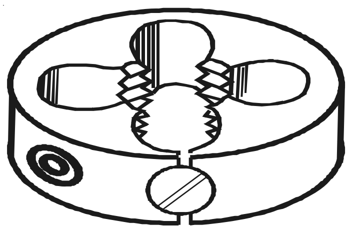
1. Taps should be used in order i.e from taper tap to bottoming tap through the second tap.
2. It should be ensured whether the tap enters into the hole properly.
3. Burrs are removed by turning the tap back and forth.
4. High pressure should not be applied on the taps.
5. Proper wrenches should be used to operate the taps.
6. Cooling agents should be used while tapping.

2.12 Dies

Dies are used to cut threads on a round bar of metal, such as the threads on bolt. It is a round or square block of hardened steel with a hole containing threads and flutes which form cutting edges.



A



B

Fig 2.33 Dies

A. Solid die B. Adhustable die

There are mainly two types of dies in common use

1. Solid die 2. Adjustable die

Solid die

A solid die is one which has fixed dimension and cannot be adjusted for larger or smaller diameter. Adjustable means that it can be set to cut on larger or smaller diameter.

Adjustable die

A circular adjustable split die shown in the figure is very common. The die is split through one side and a slight adjustment is made by means of the set - screw . If this screw is tightened up the die is opened up slightly, whilst unscrewing will cause the die to spring in. Another common type is the two - piece rectungular die. In this type the dies are fitted into a special stock and they are closed by means of the adjusting screw. The size of the die is specified by the outer diameter of the thread to be made.

The tool for holding and turning the threading die is called a die - stock.

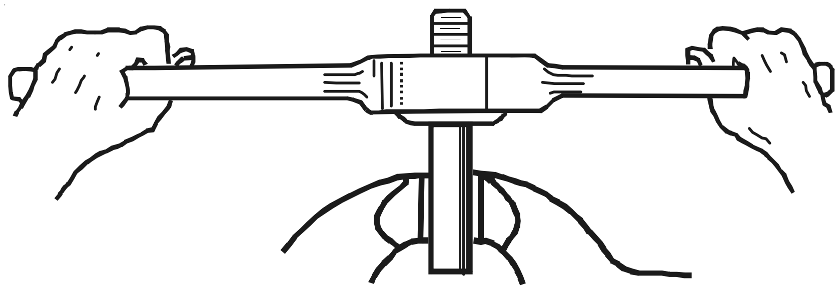


Fig 2.34 Threading by a die

1. Work 2. Die stock 3. Vise

QUESTIONS

I. A. Choose the correct option

1. The vise with ‘V’ shaped jaws is

   a. leg vise b. hand vise c. pipe vise d. pin vise

2. Convex and concave surfaces can be filed with a

   a. flat file b. square file c. triangular file d. half round file

3. Grade of a file with 40 to 60 teeth per inch is

   a. rough file b. second cut file c. smooth file d. dead smooth file

4. An hammer made of wood, plastic or rubber is known as

   a. hard hammer b. soft hammer

   c. straight hammer d.double face hammer

5. The tool used to hold and cut sheets and wires is a

   a. screw driver b. pliers c. allen key d. ring spanner

6. Centre of a round rod can be found with a

   a. steel rule b. jenny caliper c. trammel d. punch

7. Punch with an angle of $30^0$is known as

   a. centre punch b. dot punch c. pin punch d. prick punch

8. The tool used for finding centre of a work held in a lathe is

   a. Marking table b. universal surface gauge c. V block d. angle plate

I. B. Answer the following questions in one or two words

1. Name two types of vises.
2. State the use of a round file.
3. What are the two types of hacksaw frames?
4. What is the use of an adjustable spanner?
5. What is the use of a divider?
6. What is the use of a scriber?
7. Mention the use of angle plate.

II. Answer the following questions in one or two sentences

1. What is a vise?
2. What is a C - Clamp?
3. Name four types of files.
4. What are the types of hammer?
5. What is a nose plier?
6. What is a scraper?
7. What is a tap?
8. What is a die?
9. What is a centre punch?
10. What is an angle plate?

III. Answer the following questions in about a page.

1. What are the reasons for the breakage and blunting of hacksaw blades?
2. Explain the process of tapping with a diagram.
3. Draw and explain the construction and uses of a jenny caliper.
4. Explain the construction of try square with a diagram.
5. Explain a pillar type surface gauge with a diagram.

IV. Answer the following questions in detail.

1. Explain the types of files with suitable diagrams.
2. Draw and explain a bearing puller.

3. MEASURING INSTRUMENTS

3.1 Introduction

Measuring instruments are useful in checking the sizes and grades of an object. The grade of a product depends upon its shape, correct size and the quality of the surface finish. To measure these features, different types of measuring instruments are used.

Some of the instruments are used to measure the sizes to a high degree of accuracy. Some other instruments are useful in checking whether the sizes of the products are within the desired limits. We can compare the actual sizes of the products with correct sizes with the help of some instruments.

3.2 Different categories of measuring instruments

1. Linear measuring instruments
   eg. - Steel rule, vernier calipers, depth gauge
2. Angular measuring instruments
   eg. - Bevel protractor, sine bar, combination set
3. Plane surface measurements
   eg. - Surface plate, dial indicator

3.2.1. Types of measuring Instruments

a. Standard measuring instruments
   Standard measuring instruments include steel rule etc.

b. Adjustable measuring instruments
   These instruments include calipers, vernier caliper, micrometer, dial test indicator, vernier height guage, bevel protractor etc.

3.2.2 Methods of measuring

1. Direct method - with instruments like steel rule, micrometer, vernier calipers, vernier height gauge, bevel protractor,dial indicator etc.,

2. Indirect method - with instruments like calipers, divider, surface gauge, sine bar etc.,

3. Inspection method - with gauges

3.2.3. Grades of measuring instruments

a. Precision measuring instruments

b. Semi – precision measuring instruments

c. Non- precision measuring instruments

3.3. Linear measuring instruments

There are several measuring instruments available to measure linear dimensions with different accuracies. The accuracy of an instrument depends upon the least count of the particular device. The least count of steel rule in 0.5 mm whereas dimensions to an accuracy of 0.01 mm can be measured with micrometers. With some instruments, reading of dimensions can be done directly as in the case of steel rule, micrometer, vernier caliper etc., In some other instruments like calipers, readings have to be arrived with reference to some other instruments like steel rule. Some linear measuring instruments are explained in this section.

3.3.1. Steel rule

It is one of the most useful tools in a workshop for taking linear measurements and scribing straight lines. It is usually made of materials like hardened steel, stainless steel and spring steel.

Lline graduations are etched or engraved at intervals of fractions of a standard unit of length. Measurements are marked both in English and Metric scales. In English scale, the markings are in inches whereas they are in millimetres in Metric scale. The accuracy of the steel rule is 0.5 mm in Metric scale and 1/64'' in English scale.

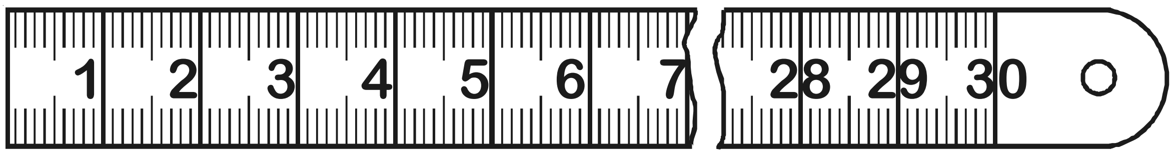


Fig 3.1 Steel rule

Steel rules are available in different lengths, breadths and thickness. Steel rules are in lengths of 100, 300, 500, and 1000mm. The width and thickness of the rules vary with their length. For example- For a rule of 500mm length, the width wiil be 18 to 22 mm and the thickness will be 0.4 to 0.6 mm.

There are different types of steel rules and they are:

1. Standard rule
2. Flexible rule
3. Narrow rule
4. Hook rule
5. Folding rule
6. Steel tape
7. Spring rule

Standard rule:

Standard rules have standardised measurements marked on it and are accepted the World over. They are useful in measuring, scribing llines and checking measurements. They are available in lengths of 150mm to 300 mm (6 to 12 inches).

Flexible rule:

This type of steel rule is flexible in nature and so it is useful in taking measurements on irregular and cylindrical sufaces.

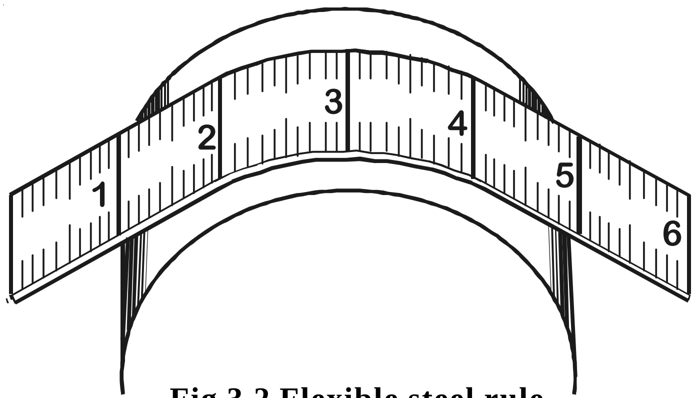


Fig 3.2 Flexible steel rule

Narrow rule:

The width of this type of rule is small. So it is used for measuring depths of narrow holes, lengths and widths of narrow slots. Measurements of any one of the scales - either Metric or English may be marked on them.

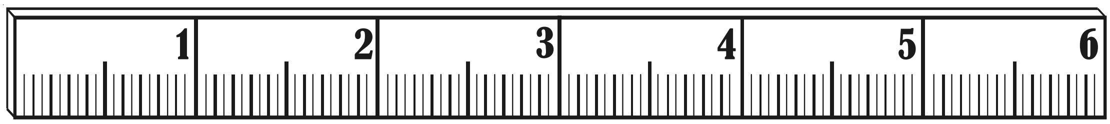


Fig 3.3 Narrow rule

Hook rule:

It has a hook attached to one of its ends. Hook rules are used to measure from broken or bevelled ends. It is also useful in measuring narrow and deep slots. When measurements are to be taken from the centre of chamfered centre holes of gears, hook rules are utilised.

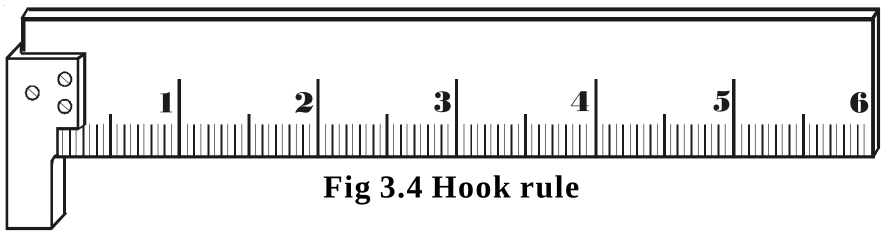


Fig 3.4 Hook rule

Folding rule

Folding rules are designed to be able to be folded or unfolded according to the need.

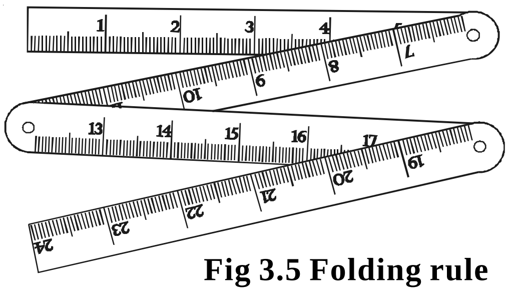


Fig 3.5 Folding rule

Steel tape

The steel tapes are made of thin steel sheet. They are available in different lengths of 1m, 3m and 5m. The tape is wound inside a closed case and can be pulled out when necessary to the required length.

Spring steel rule

These types of rules are useful where castings are made. Metallic components will expand at the influence of heat and shrink on cooling. Moulds are made considering this fact. Rules used in this context are known as spring rules.

Miantenance of steel rules

1. It should not be used on rough surfaces.
2. It should not be used as a wedge or as a screw-driver.
3. Heavy objects should not be placed on it.

3.3.2 Calipers

Calipers are used to measure diameters of round rods and to measure the internal and external dimensions of square or rectangular objects. Measurements can not be taken directly as in a steel rule but along with steel rule.

According to construction, there are two diffrent types of calipers. They are:

1. Solid joint calipers
2. Spring calipers

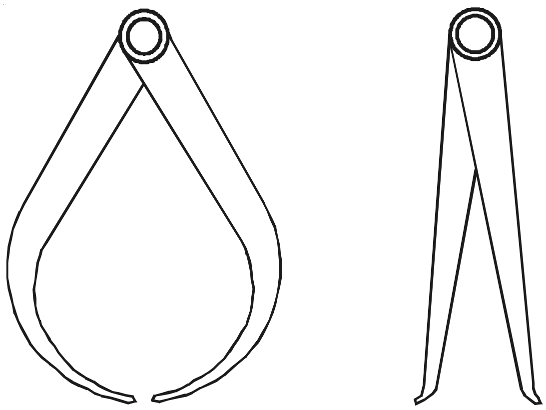


Fig 3.6 Calipers
A. Outside caliper B. Inside caliper

Solid joint calipers

The legs of this type of calipers will be connected by rivets at the top. It is slightly difficult to adjust the distance between the two legs of the solid joint calipers. It can be handled by a skilled operator only. *Different types of solid joint calipers are shown in Fig. 3.6ii*

Spring caliper

The top portions of the legs of this type of caliper are connected by a spring. There is a screw and a nut to adjust the distance between the legs. The nut is rotated in suitable direction to open or close the distance between the legs.

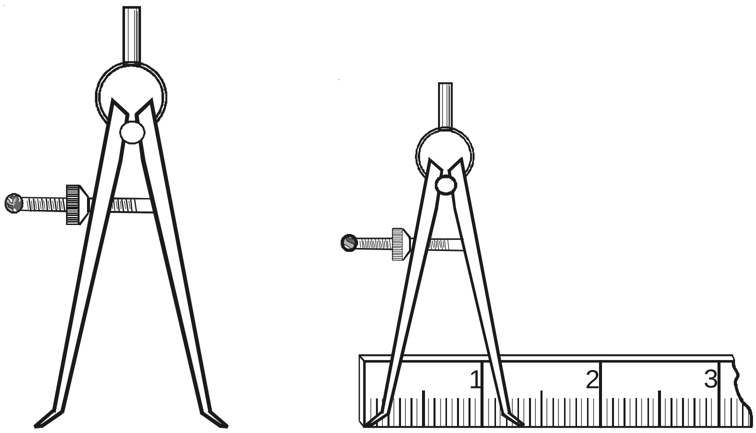


Fig 3.7
Method of measuring with inside caliper

Types of calipers

1. Inside caliper
2. Outside caliper
3. Jenny caliper

Inside caliper

This type of caliper is used to measure the internal dimensions of holes and slots.

Outside caliper

This type of caliper is used to measure external dimensions like length and breadth of various objects and diameters of round rods etc.,

Jenny caliper:

Jenny calipers are used to find the centres of round rods and to draw parallel lines at regular intervals on workpieces. One of the legs of this type of caliper is straight and the other is bent. It can also be called as odd leg caliper or hermoprodite.

Maintenance of calipers

1. It should not be used on hot and rotating parts.
2. It should be kept on flat surfaces.
3. Heavy objects should not be placed on it.

3.3.3. Vernier caliper

Vernier caliper is a precision measuring instrument. The least count of vernier caliper is usually 0.02 mm. Vernier caliper was developed by a French scientist known as Pere Vernier in the year 1830 and the instrument is called after his name.

Vernier calipers are useful in measuring outer dimensions, inner dimensions and depths of holes and slots. Graduation in millimeters are marked on a scale known as main scale. A fixed jaw is attached to the mainscale. There is another jaw known as movable jaw attached with a vernier head. It is also graduated and this scale in known as vernier scale. A screw is attached to the movable jaw to lock the movable jaw afer sliding it to the required distance. The inner sides of both the jaws are parallel.

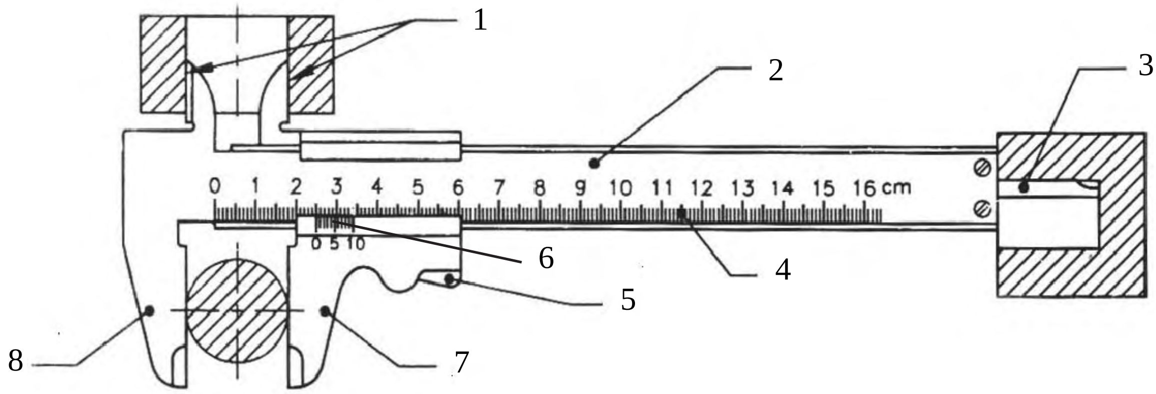


Fig 3.8 Vernier caliper

1. Jaws for measuring inner dimensions 2. Main scale 3. Narrow plate for measuring deprh 4. Main scale graduations 5. Locking screw 6. Vernier scale 7. Movable jaw 8. Fixed jaw

The object to be measured is held between the fixed jaw and the movable jaw and the movable jaw is adjusted to have contact on the side of the object. Fine adjustment screw is then adjusted for accurate contact and correct measurement. The reading on both the main scale and the vernier scale are then noted.

A narrow slot is provided on the back of the main scale to accommodate a narrow plate. This plate is made to move along with the vernier scale to measure depths of holes and slots. Two separate jaws are provided on the top side for measuring inner dimensions.

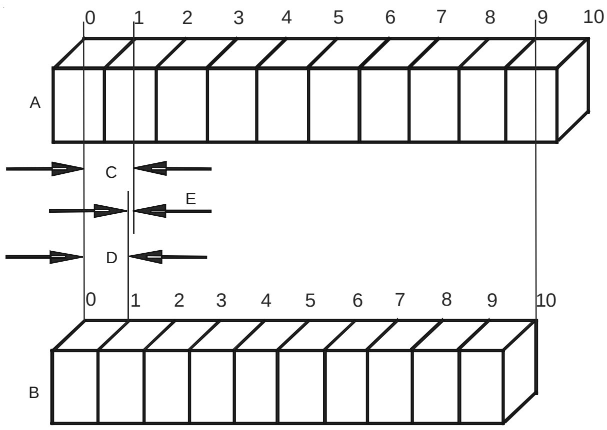


Fig 3.9 Visualisation of least count

A. Main scale dividions B. Vernier scale dividions C. One main scale dividions D. One vernier scale dividions E. Least count

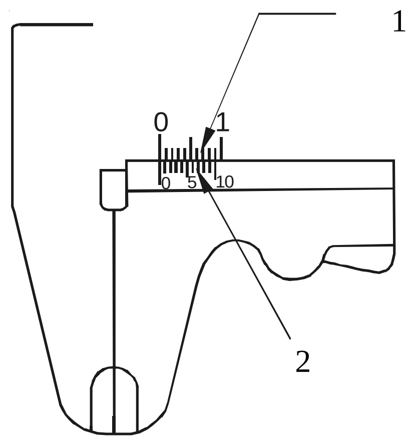


Fig 3.10 Main scale and vernier scale

1. Main scale division
2. Vernier scale division

Method of measuring:

One division of the main scale is 1mm. The vernier scale has 10 divisions which is equal to 9 mm.

$$\begin{aligned} 10 \text{ vernier division} &= 9 \text{ mm} \\ 1 \text{ vernier division} &= 9 / 10 \text{ mm} \\ &= 0.9 \text{ mm} \end{aligned}$$

Least count of a vernier caliper is the difference between one main scale division and one vernier scale division.

$$\begin{aligned} &= 1.00 - 0.9 \\ &= 0.01 \text{ mm} \end{aligned}$$

In some other types of vernier calipers, one main scale division is 0.5mm and the vernier scale has 25 divisons.

$$\begin{aligned} 25 \text{ vernier divisios} &= 12\text{mm} \\ 1 \text{ vernier division} &= 12 / 25 \text{ mm} \\ &= 0.48 \text{ mm} \end{aligned}$$

Least count of a vernier caliper is the difference between one main scale division and one vernier scale division.

$$\begin{aligned} &= 0.5 - 0.48 \\ &= 0.02 \text{ mm} \end{aligned}$$

$$\text{Reading} = \left.\begin{matrix}\text{No. of main scale} \\ \text{divisions}\end{matrix}\right\} + \left(\begin{matrix}\text{Least} \\ \text{count}\end{matrix}\right) \text{X} \begin{matrix}\text{No. of vernier} \\ \text{divisions}\end{matrix}$$

3.3.4 Vernier height gauge

Vernier height gauge is used to measure the height of objects and for precision layout work. Measurements are made by placing the instrument on the surface plate. Measurements can be done to an accuracy of 0.02mm.

The base of the height gauge is made of steel. A graduated beam is mounted vertically on the base. It is graduated in millimeters. A movable jaw called slider is fitted on the graduated beam. It can be adjusted up and down to enable it measure objects of diffrent heights. A scriber is attached to the slider for layout purposes. The slider has a graduated scale called vernier scale. There is a fine adjustment screw fitted on the slider which is useful in adjusting the jaw accurately. A clamping screw is fitted on the slider to lock the jaw at the required position.

To take measurement , the instrument and the object are placed on the surface plate. The measuring jaw is placed on the top of the object and fine adjustment is made with the screw meant for it. The jaw is locked in this particular position with the help of slider clamping screw. The main scale division and the vernier scale division are taken note of.

$$\text{Reading} = \left.\begin{matrix}\text{No. of main scale}\\ \text{divisions}\end{matrix}\right\} + \begin{pmatrix}\text{Least}\\ \text{count}\end{pmatrix} \times \begin{matrix}\text{No. of vernier}\\ \text{divisions}\end{matrix}$$

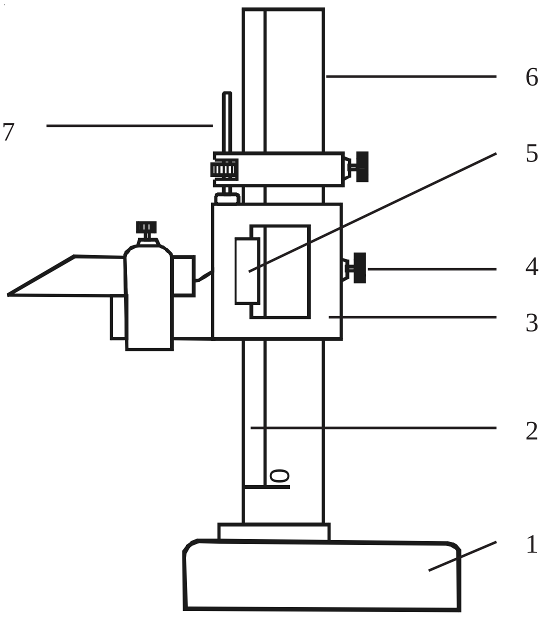


Fig 3.11 Vernier height gauge

1. Base
2. Main scale
3. Slider
4. Clamping screw
5. Vernier scale
6. Graduated beam
7. Scriber

3.3.5. Micrometer

Micrometer is an instrument to measure length, width and thickness of small and medium sized objects to an accuracy of 0.01mm in Metric scale and 0.001inches in English scale. The working principle of this instrument is based on a screw. It is also known as screw gauge.

The frame is 'U' shaped and it is made of cast steel or light alloys. The anvil is hardened and is attached to one end of the frame. The graduated barrel is attached to the other end of the frame. It has the dactum line and fixed graduations. The spindle is attached to the thimble and the rotation of the thimble will make the spindle to move forward or backward. The spindle does the actual measuring and has threads of 0.5mm pitch.

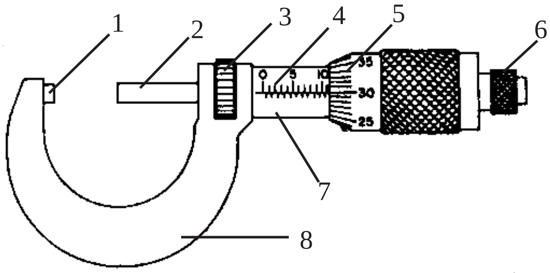


Fig 3.12 Micrometer

1. Anvil 2. Spindle 3. Locking nut 4. Main scale division 5. Thimble 6. Ratchat 7. Barred 8. Frame

Thimble is a tubular cover attached to the spindle. The bevelled edge of the thimble is divided into 50 equal divisions and every fifth division is numbered. Ratchet is a small extension of the thimble. It slips when the pressure on the screw reaches a certain amount. This produces uniform readings.

Method of measuring

One division of the main scale (barrel) is equal to 0.5mm. The micrometer screw is of 0.5mm pitch while the thimble is divided into 50 equal divisions. So one full revolution of the thimble will make the spindle to move forward or backward by a distance of 0.5mm.

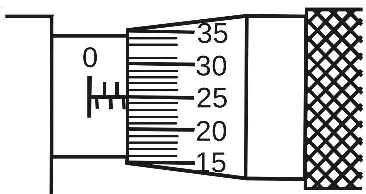
50 thimble divisions = 0.5mm

1 thimble division = 0.5 / 50 mm

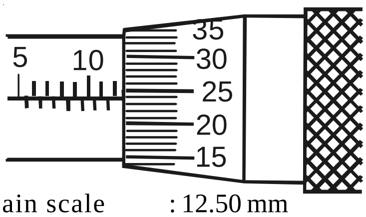
= 0.01 mm

This measurement is called the least count of the instrument. The part to be measured is held between the end of the spindle and the anvil. The reading on the main scale and the thimble divisions are taken and the reading is

Reading = No. of main scale divisions + (Least count) X No. of thimble divisions ± Zero error

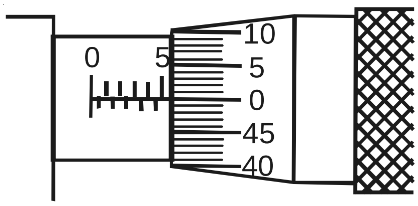


Main scale	: 2.50 mm
Thimble scale	: 0.25 mm
	: 2.75 mm

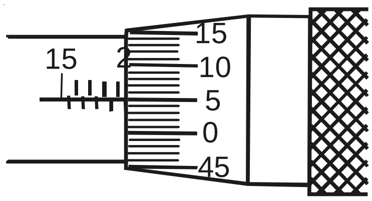


Main scale	: 12.50 mm
Thimble scale	: 00.24 mm
	: 12.74 mm

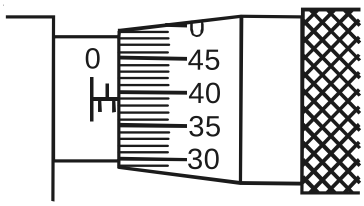
Fig 3.13 Different reading of micrometer



Main scale	: 5.50 mm
Thimble scale	: 0.00 mm
	: 5.50 mm



Main scale	: 19.50 mm
Thimble scale	: 00.05 mm
	: 19.55 mm



Main scale	: 1.50 mm
Thimble scale	: 0.39 mm
	: 1.89 mm

British micrometer

The screw used in a British micrometer has 40 T.P.I. It is understood that the pitch value is 1/40". The thimble has 25 equal divisions on it. When the thimble is rotated for one full revolution, the spindle moves a distance of 1/40". When the thimble is rotated for one of its own divisions, the spindle moves a distance of 1/40" X 1/25 = 1/1000" = 0.001". This is the least count of British micrometer.

Errors in a micrometer

When the micrometer is closed, the end of the spindle and the anvil come into contact. The zero of the thimble should coincide with the datum line on the barrel. If these two do not coincide, some error is said to be in the micrometer. This error is known as zero error and it should be corrected. There are two types of errors found in a micrometer.

They are

1. Positive error

2. Negative error

Positive error

When the micrometer is closed, if the zero of the thimble is found below the datum line, the error is said to be positive. The amount of error should be deducted from the reading. The number of thimble divisions between the zero of the thimble and the datum line is the reading necessary for calculating the amount of error.

Positive error = thimble divisions as obtained above x least count

The error calculated as above should be corrected whenever measurements are taken using the instrument.

$$\left.\begin{array}{l}\text{Reading}\\ \text{after correction}\end{array}\right\} = \left.\begin{array}{l}\text{No. of main scale}\\ \text{divisions}\end{array}\right\} + \left(\begin{array}{l}\text{Least}\\ \text{count}\end{array}\right) \text{X} \begin{array}{c}\text{No. of thimble}\\ \text{divisions}\end{array} - \begin{array}{l}\text{positive}\\ \text{error}\end{array}$$

Negative error

When the micrometer is closed, if the zero of the thimble is found above the datum line, the error is said to be negative. The amount of error should be added to the reading. The number of thimble divisions between the zero of the thimble and the datum line is the reading necessary for calculating the amount of error.

Negative error = thimble divisions as obtained above x least count

The error calculated as above should be corrected whenever measurements are taken using the instrument.

$$\left.\begin{array}{l}\text{Reading}\\ \text{after correction}\end{array}\right\} = \left.\begin{array}{l}\text{No. of main scale}\\ \text{divisions}\end{array}\right\} + \left(\begin{array}{l}\text{Least}\\ \text{count}\end{array}\right) \text{X} \begin{array}{c}\text{No. of thimble}\\ \text{divisions}\end{array} + \begin{array}{l}\text{Negative}\\ \text{error}\end{array}$$

3.3.6 Inside micrometer

The inside micrometer is useful in taking internal measurements to an accuracy of 0.01 mm and 0.001". The principle of inside micrometer is very similar to that of the external micrometer. Holes with diameters over 50 mm are measured with inside miocrometer.

The inside micrometer has the following parts - measuring unit, extension rod and an handle. The distance between the measuring faces wiil vary from 50 to 63 mm when the thimble is rotated. Extension rods may be attached to the unit for measuring holes with diameter over 63 mm. Extension rods are available in the following sizes - 13 mm, 25mm, 50 mm, 100 mm, 150 mm, 200 mm and 600 mm.

The pitch value of the inside micrometer is 0.5 mm. The main scale on the barrel is graduated for 13mm. The circumference of the thimble is divided into 50m equal divisions. One full revolution of the thimble will make the measuring end to move a distance of 0.5 mm. One division of the thimble is equivalent to a measurement of 0.01 mm.

3.3.7 Depth micrometer

Depth micrometer is useful in measuring the depth of holes, slots and keyways. The method of measuring is very similar to that of an external micrometer.The accuracy of this instrument is 0.01 mm. There should be proper seating for the instrument head to measure accurately. The depth micrometer consists of an head, spindle, barrel, thimble, locking ring and a ratchet stop. Head is the part of the instrument which is placed on top of the hole. The bottom of the head is perfectly flat to ensure correct seating of the instrument. The spindle does the actual measuring. The amount of protrusion of the spindle from the bottom of the head is the actual measurement. The barrel has got the datum line and fixed graduations which are numbered. The thimble is connected with the spindle at its outer end and moves with the spindle. The locking ring is used to lock the instrument at the desired setting.

The depth micrometer is provided with three interchangeable spindles with measuring ranges of 25 to 50 mm, 50 to 75 mm, and 75 to 100 mm.

3.3.8 Differences between a vernier caliper and a micrometer

VERNIER CALIPER	MICROMETER
1. Available in various accuracies	1. Accuracy is mostly 0.01mm or 0.001''
2. External, internal and depth measurements can be measured with a single instrument of vernier caliper.	2. External, internal and depth measurements should be taken with different types of micrometers.
3. The measuring range is more (can measure upto 200mm)	3. The measuring range is less (can measure upto 25mm only at the most.)
4. Measuring is done with sliding arrangement	4. It has thread arrangement for measuring
5. Measuring is done quickly.	5. Slow measuring process
6. Contact area is more.	6. Less contact area .

3.3.9 Vernier micrometer

Vernier micrometer is an instrument in which a vernier scale is attached to the conventional external micrometer. It is used in the same manneras that of an ordinary micrometer. Measurements are taken using three scales namely - main scale (on the barrel), thimble scale and vernier scale. The vernier scale has 10 spaces running parallel to the dactum line on the barrel. These 10 divisions are equal to 9 divisions of the thimble.

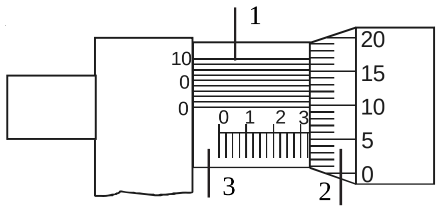


Fig 3.14 Vernier Micrometer
1. Vernier scale 2. Thimble division
3. Barrel (Main scale)

3.4. Angular measuring instruments

Like linear measuring instruments, angular measuring instruments are available in different accuracies. Combination set, vernier bevel protractor and sine bar have different accuracies.

3.4.1 Combination set

Combination set consists of a blade (steel rule), a square head, a protractor head and a centre head. The rule is made of tempered steel with a groove cut along the lentgh on which all the other parts may slide. Each part is provided with a knurled nut for locking it into position.

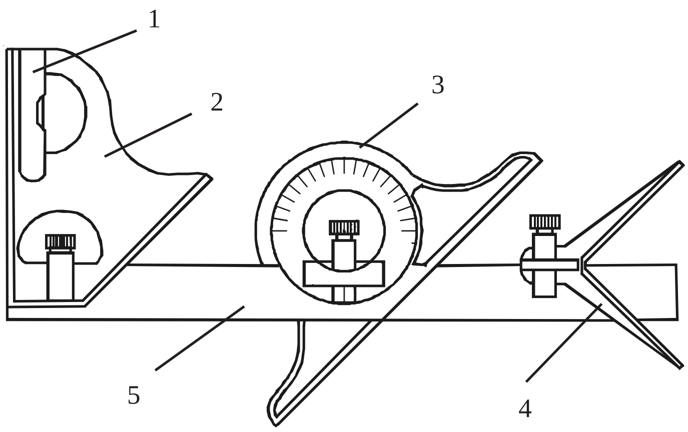


Fig 3.15 Combination set

1. Sprit level 2. Square head 3. Protractor head 4. Centre head 5. Steel rule

Steel rule

Steel rule is graduated on both the ends. The size of a combination set is specified by the length of the steel rule.

Square head

It is a small part which has one of its sides at 90^0 and other side at 45^0 to the base surface. It has got a spirit level which can be used to check the levels of surfaces (horizontality). Square head can be used to scribe and check angle. When used along with steel rule, it serves as depth gauge. It is useful in checking the perpendicularity of surface internally.

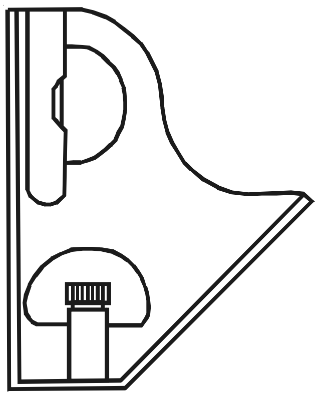


Fig 3.16 Square head

Centre head

It has two legs at right angles to each other. So it is 'V' shaped with an angle of 90^0.When it is attached to steel rule, the angle is bisected. This construction helps in finding the centre of round rods. It is also useful in checking perpendicularity of surfaces externally.

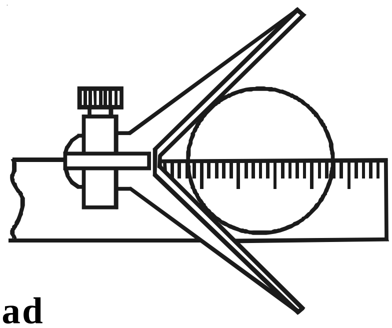


Fig 3.17 Square head

Protractor head

It has a protractor attached to a frame. Angular graduations are marked on the protractor from 0^0 to 180^0. There is a '0' mark on the frame. When the '0' on the frame coincides with '0' of the protractor it is understood that the line is horizontal. When used along with steel rule, straight lines can be scribed on the workpieces at a requried angle to the external surface. It is also useful in checking the levels of angular surfaces. As a spirit level is attached to the protractor it is easy to operate it.

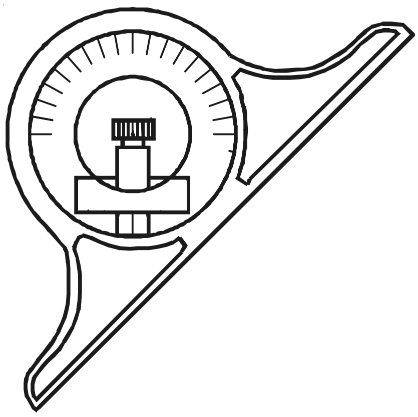


Fig 3.18 Protractor head

3.4.2 Vernier bevel protractor

Bevel protractor is an instrument used for measuring and testing angles. It is adopted where angles are to be laid out or measured within the limits of 5 min.

The bevel protractor consists of a stock integal with a disc which is fitted with a pivot at the centre. On this point, the graduated dial is allowed to rotate when clamping nut is released. Another clamp clamps the blade rigidly to the dial. The blade can be moved lengthwise or replaced by another blade of differrent length. A vernier scale is fitted to the disc to take vernier readings and for accurate measurements. To set the instrument, it is necessary to release the clamping nut and turned to the required position.

The dial is graduated in degrees over an arc of 180 degrees reading from each end of the arc. The vernier scale has 12 divisions which is equal to 23^0 in the main scale.

12 vernier divisions	=	23^0
‘	=	23 X 60 min
1 vernier division	=	$\frac{23 \times 60}{12}$
	=	115 Min

One vernier division is 5 minutes short of 2 degrees. The instrument can be utilised to measure angles to the accuracy of 5 minutes.

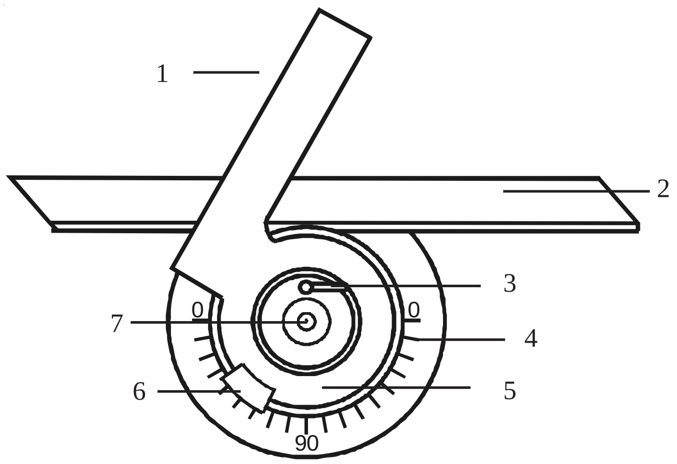


Fig 3.19 Vernier bevel protractor

1. Stock 2. Movable blade, 3. Clamp of blade 4. Main Scale 5. Disc
6. Vernier Scale 7. Locking screw

In order to take reading from the bevel protractor, the reading on the main scale is directly taken to the number of whole degrees between ‘0’ of the main scale and ‘0’ of the vernier scale. The number of spaces from ‘0’ of the vernier scale to a line which coincides with a line on the main scale is also taken note of. This number is multiplied by ‘5’ to be added as a reading in minutes.

Fig 3.20 Reading with vernior bevel protractor

3.4.3 Sine bar

Sine bar is used to measure angles accurately. Measurements of angles using bevel protractor is direct whereas sine bar makes indirect mesurements. Sine bar is used in conjuction with slip guages for setting of angles and of tapers from a horizontal surface. The accuracy attained with this instrument is very high.

Sine bar consists of an accurately lapped steel bar which is stepped at its ends with a roller secured into each step by a screw. The screw holds the roller in contact with both faces of the step. A sine bar is specified by the distannce between the centres of two rollers (100 mm or 250 mm)

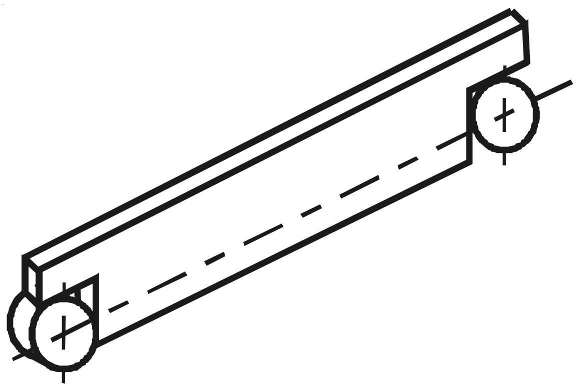


Fig 3.21 Sine bar

For accurate measurements, the following points are important

1. The rollers of must be of same diameter.

2. The distance between their centres must be absolutely correct.

3. The line joining the centre of the rollers must be absolutely parallel with the bottom and top surfaces of the bar.

H = 100mm

Sin A = a / H

< A = Sin-1 (a / 100)

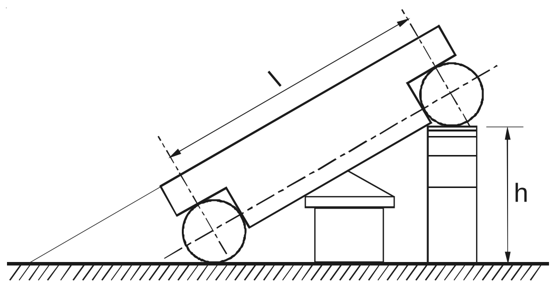


Fig 3.22 Measuring with Sine bar

Where 'a' is the difference in total heights of slip gauges at both ends of the sine bar. The corresponding angle can be obtained from trignometre tables.

3.5 Gauges

Gauges are the tools which are used to check the size, shape and relative positions of various parts. They are not provided with graduated parts. They are manufactured for a particular size. Different gauges are designed for different sizes and shapes. They are made of alloy steel, heat treated and ground accurately to the required size.

3.5.1 Advantages of gauges

1. The measurements are checked quickly and easily.
2. The cost of gauges is less when compared with precision measuring instruments.
3. A semi-skilled operator can handle gauges.
4. No supervision is required.
5. The production is increased.

3.5.2 Grades of gauges

Gauges are made of alloy steel preferrably high speed steel. They are hardened and tempered and made in three different grades.

1. Workshop gauge
2. Inspection gauge
3. Master gauge

Workshop gauge

This grade of gauges are used in workshops to check the dimensional accuracy of the products manufactured in the shop. The accuracy of workshop gauge is 0.025mm or 0.0001".

Inspection gauge

Inspection gauges are designed to be handled by skilled operators for inspection purposes. It is made with an accuracy of 0.0001" or 0.0025mm.

Master gauge

Master gauges are useful in checking the workshop gauges and inspection gauges. It is also used to check very accurate tools and are made with an accuracy of 0.00001" or 0.00025mm.

3.5.3 Classification of gauges

Gauges can be classified as standard gauges and limit gauges.

Standard gauges

They are made to the nominal size of the part to be tested.

Limit gauges

Limit gauges are made to the limit sizes of the work to be measured. One of the sides or ends of the gauge is made to the maximum permissible size and the other side or end is made to the minimum permissible size. The use of a limit gauge is to decided if the actual dimensions of the part are within the specified limits.

3.5.4 Types of gauges

Gauges are classified according to accuracy, shape and the elements to be checked. Some of them are mentioned below.

1. Plug gauge
2. Ring gauge
3. Taper gauge
4. Snap gauge
5. Thread gauge
6. Screw pitch gauge
7. Template gauge
8. Radius and fillet gauge
9. Wire gauge
10. Plate gauge
11. Feeler gauge
12. Telescopic gauge
13. Slip gauge

Plug guage

Plug gauges are used for checking the bores of many different shapes and sizes. There are plug gauges dor straight cylindrical holes, tapered holes and splined holes.

Stanndard plug gauges are used to check the nominal size of a cylindrical hole. The progressive limit plug gauges has got ‘go’ end and ‘ no go ’end on the same side of the gauge. It is used to check the limits of sizes. The double ended limit plug gauges are used to test the limit of sizes. At one end it has a plug of minimum limit size - ‘go’ end at the other end a plug of maximum limits sizes ‘no go’ end.

Fig 3.23 Plug gauge

A - Double ended plug gauge B - Progressive plug gauge

Ring gauges

Ring gauges are used to test external diameters. They allow shafts to be checked more accurately since they embrace whole of their surfaces. Ring gauges are expensive to manufacture and therrefore find limitted usage.

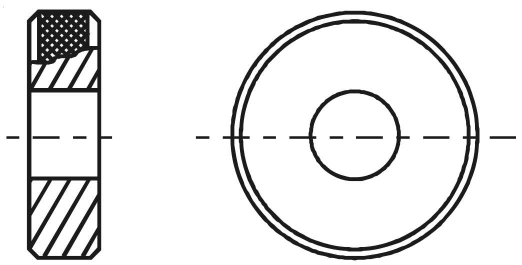


Fig 3.24 Ring gauge

Taper gauge

The best method of testing taper is to use taper gauges. They are also used to gauge the diameter of taper at some point. The gauges are made in both the plug and ring style.

The taper diameter is checked by noting how far the gauge enters the tapered hoe. A mark is made at some point on the gauge to show the right diameter for the large end of the taper.

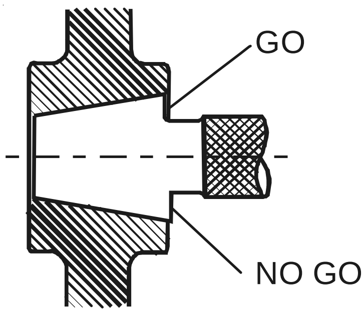


Fig 3.25 Taper plug gauge

Snap gauges

Snap gauges are used for checking external dimensions. There are different types of snap gauges namely

1) Caliper snap gauge

2) Adjustable snap gauge

3)Double ended solid snap gauge

Caliper gauge

The caliper gauge with ‘go’ and ‘no go’ end is used for medium sizes.

Adjustable snap gauge

Adjustable snap gauges are used for larger sizes. This is made with two fixed anvils and two adjustable anvis. One set of anvils is for the ‘go’ end and the another set of anvils is for ‘no go’ end. These gauges have two recesses to receive the adjustable anvils with screws. The anvils are set for a specified sizes with adjustable range of 3 to 8 mm.

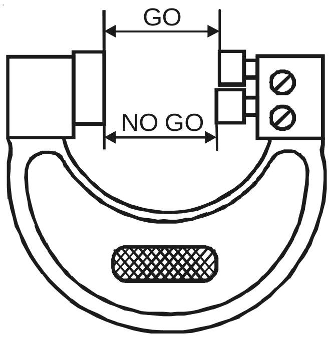


Fig 3.26 Adjustable snap gauge

Double ended solid snap gauge

Double ended solid snap gauges are used for smaller sizes.

Thread gauges

Threads (pitch diameter of threads) are checked with thread gauges. For checking internal threads, plug threads gauges are used, while for checking external threads (Screws and bolts) ring gauges are used.

Screw pitch gauge

Screw pitch gauges are useful in picking out a required screw and for checking pitch of screw threads. They consist of a number of flat blades which are cut out to a given pitch and pivoted in a holder. Each blade is stamped with the pitch or number of threads.

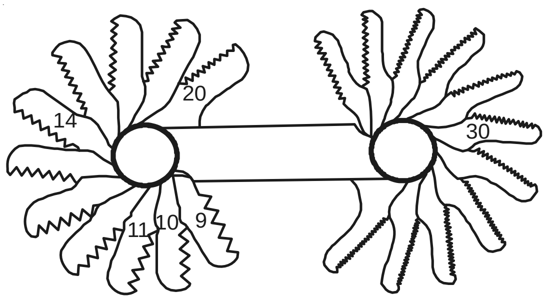


Fig 3.27 Screw pitch gauge

Template gauges

Template gauges are made from sheet steel. A template profile gauge may contain two outlines that represent the limits within which a profile must lie.

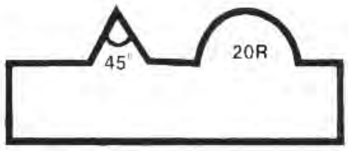


Fig 3.28 Template

Radius gauge

The function of a radius gauge is to check the radii of curvature of convex surfaces over a range of 10 to 25 mm. The gauges are made in sets of thin plates curved to different radii at the ends. Each set consists of 16 convex and 16 concave blades.

Fillet gauge

The function of these gauges is to check the radii for curvature of concave surfaces

Plate and wire gauges

The thickness of sheet metal is checked by means of plate gauges and wire diameters by means of wire gauges. The plate gauge is used to check the thickness of plates from 0.23 to 3 mm and the wire gauge is used to check the wire diameters from 0.1 to 10 mm.

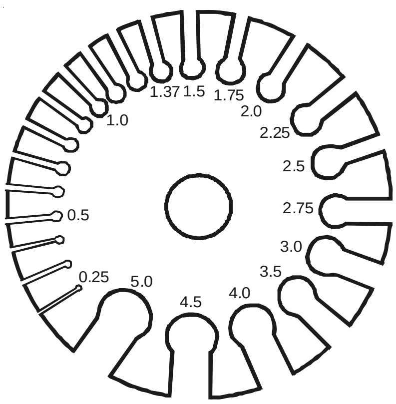


Fig 3.29 Plate and wire gauge

Feeler gauges

Feeler gauges are useful in checking small gaps between mating surfaces. They are made as precision machined blades with different thickness. The thickness ranges from 0.03 to 1.0 mm. All the blades are placed in a holder and have indications of their thickness marked on them.

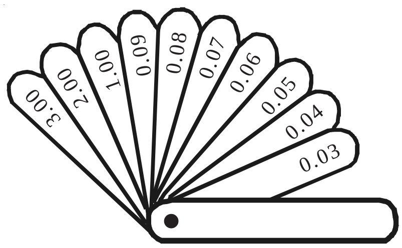


Fig 3.30 Feeler gauge

Telescopic gauge

Telescopic gauge is used for measuring inner dimensions of holes and slots. It consists of a handle and two plungers. The two plungers are telescopic into each other with spring tension. The plungers are compressed and inserted into the hole or slot. It is allowed to expand and touch the opposite surfaces. The plungers are locked in position and taken out to know the measurement. The measurement can be done with a micrometer.

Slip gauge

Slip gauges are also known as gauge blocks. They are made of high speed steel and alloy steel. They are made as rectangular hardened blocks machined accurately and finished to a very high accuracy.

They are made in different sizes as blocks and arranged in a case exclusively meant for that. They are used for verifying measuring tools such as micrometers and comparators. Slip gauges are made both in Metric method (mm) and in English method (inches). After use, the blocks should be placed back safely in the case.

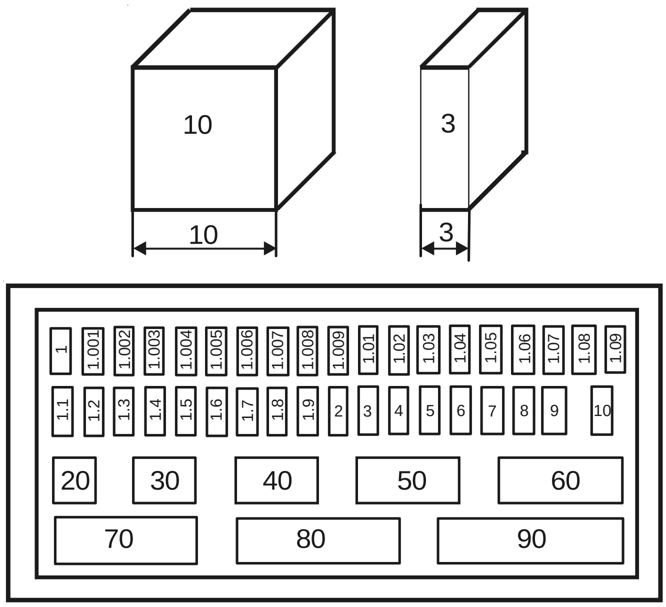


Fig 3.31 Slip gauge

3.7 Differences between gauges and templates

Gauges	Templates
1. Mostly made of high speed steel	1. Made of thin steel sheets
2. Accuracy is very high	2. They are not very accurate
3. Costly	3. The cost is less
4. Used to cheek sizes and shapes	4. Used only to cheek the shape of particular object
5. Not used on hot articles	5. Can be used on all parts

QUESTIONS

I. A. Choose the correct option

1. ________ is a direct measuring instrument
   a. Caliper b. Gauge c. Vernier caliper d. Divider

2. Surface gauge is a
   a. direct measuring instrument b. indirect measuring instrument
   c. inspecting instrument d. plane surface measuring instrument

3. Measurements on cylindrical surfaces are done with
   a. narrow rule b. hook rule c. folding rule d. flexible rule

4. The length and outside diameter of an object can be measured with
   a. jenny caliper b. combination set
   c. vernier height gauge d. outside caliper

5. The least count of a vernier is
   a. 0.01mm b. 0.02 mm c. 0.001 mm d. 0.1mm

6. Zero errors are generally found in
   a. micrometer b. combination set c. sine bar d. vernier caliper

7. Angular measurements are done to an accuracy of 5 minutes with
   a. Sine bar b. vernier bevel protractor
   c. combination set d. inside micrometer

I.B. Answer the following questions in one or two words

1. Give an example for inspecting instrument.
2. Mention one use of jenny caliper.
3. What is the accuracy of a master gauge?
4. What is the use of feeler gauge?
5. Mention the use of a telescopic gauge.

II. Answer the following questions in one or two sentences

1. What are the different categories of measuring instruments?
2. What is a steel rule?
3. What is a caliper?
4. What are the types of calipers?
5. What is a micrometer?
6. What is sine bar?
7. What is the use of vernier bevel protractor?
8. What are gauges?
9. What is a depth gauge?
10. The reading obtained in a micrometer with a positive error of 0.08mm is 25mm. Find the reading after correction.
11. The reading obtained in a micrometer with a negative error of 0.07mm in 20mm. Find the reading after correction.

III. Answer the following questions in about a page

1. Explain different methods of measuring.
2. Explain the types of steel rule.
3. Explain the errors found in a micrometer.
4. List different types of gauges.
5. Explain plate gauge with a diagram.
6. Draw and explain a screw pitch gauge.
7. Explain a template.
8. Explain – Ring gauge and plug gauge
9. Differentiate a template from a gauge.

IV. Answer the following questions in detail

1. Draw and explain a vernier caliper.
2. Explain a vernier height gauge with a diagram.
3. Draw a neat diagram of a micrometer and explain how measurements are taken using it.
4. Differentiate a vernier caliper from a micrometer.
5. Draw and explain a sine bar.
6. Explain slip gauges with a diagram.

4 ENGINEERING MATERIALS

4.1 Introduction

A material can be defined as the one which occupies space. It may be a solid, a liquid or a gas. We need materials of different kinds for food, clothing, housing, medicine, energy, telecommunication, transportation etc. The materials are either natural or artificial. The natural materials in need include air, water, oil, minerals, cereals, metals, wood, rubber etc., The artificial materials are made from primary materials which occur naturally. The latest trend is to make or synthesize special materials for specific applications. The synthetic materials include vitamins, medicines, textiles, petrol, fuels, refrigerants, textiles, dyes, soaps, detergents, chemicals, paper, glass, polymers like plastics, cement, steel, non ferrous alloys etc. Though we need the materials found in the list for our daily life, only a few of them are useful in engineering industry.

4.2 Engineering materials

Engineering is all about making or constructing something. New technologies pave way for the engineers in various fields to design, develop and manufacture several machines, fabrication vehicles, and electronic gadgates and build structures. We find by observing the products, that all of them are made of materials with specific characteristics. With the evolution of new materials, the technology gets further boost by developing more efficient products.

For example, it is everybody's knowledge that very little current is consumed when a computer executes its operation. But this current is converted as heat which has to be conducted by some packing material. The complex situation in this aspect is the speed of execution needs to be multifold and the size of the computer should be reduced. This will take the heat generated into greater heights. If a computer of said capacity should become a reality, a proper packing material is needed. Nowadays very compact size computers are available with the advent of new matrix composite materials which conducts away the high quantum of heat. In deciding the characteristics of various materials, the structure is an important factor.

4.3 Structure of materials

When we work with various materials in our daily life not all of them have similar characters or properties. Some of them are soft and some other hard. Some material withstands high temperatures but others do not withstand. We observe some metals are shaped into different shapes whereas it is not possible for some other metals.

Water is stored in metal jars. But acids are stored in glass bottles only and not in metal jars. The differences in the structure of various materials are the reason for their different characters and properties. So, it becomes necessary to know about the structures and their influence upon the general properties of different materials.

4.3.1 Structure of metals

When molten metals attain solid shapes, the atoms are arranged in a specific position to form a shape known as crystals. The centers of atoms in a crystal are connected by lines to form a three dimensional geometrical shape known as **lattice.** The smallest basic shape representing the relative position of atoms is known as a unit cell. Many unit cells make a crystal when they are arranged in a proper order. The unit cells of majority of the metals are of cubic and hexagonal shape.

The common crystal lattice structures are

1. Simple cubic crystal
2. Body centered cubic crystal
3. Face centered cubic crystal
4. Hexagonal closely packed crystal

Simple cubic crystal (SCC)

In this structure, the atoms are present at the corners of the cube only.

Body centered cubic crystal (BCC)

The unit cell of this structure consists of atoms present at each corner of a cube and another atom at the centre of the cube. Metals like Iron, Sodium ,Vanadium and Molybdenum belong to this category. An important character of BCC metals is that their tendency to deform plastically.

Face centered cubic crystal (FCC)

Atoms are present on all the corners of the cube. In this structure, apart from this one atom each is present on all the faces of the cube. Examples of FCC structure are Copper, Gold, Nickel, Aluminium and their alloys. FCC metals are ductile and have high electrical conductivity.

Hexagonal closely packed crystal (HCP)

The unit cell of HCP crystal is hexagonal in shape. Atoms are present on all the corners of the hexagonal prism, one atom each at the centre of both top and bottom faces and three atoms in a mid plane. Zinc, Cadmium, Cobalt and Titanium are some examples of HCP crystal structure. They are very ductile and can easily be deformed.

There are some materials which don't have their atoms arranges in a lattice and they are known as amorphous. Rubber, thermostat plastics and metallic glasses are amorphous. The atomic structures of materials are identified by X-ray diffraction technique.

4.4 Properties of materials

Now, we know different types of internal structure are responsible for the varied behavior of different materials. These behavior or properties are classified as

Physical properties

Mechanical properties

Chemical properties

Electrical properties

Thermal properties

Density, melting point and specific heat of a material are known as its physical properties. Properties such as oxidation, corrosion and solubility are classified as chemical properties. Electrical properties of a material are resistivity, conductivity and dielectric strength. Thermal conductivity and thermal expansion are known as thermal properties.

Mechanical properties of a material

Mechanical properties of a material are defined as the behavior of a material when external mechanical forces are applied on them. These behaviors are very essential during designing and manufacturing processes. They are

1. Strain	6. Stiffness
2. Stress	7. Elasticity
3. Strength	8. Ductility
4. Hardness	9. Malleability
5. Toughness	10. Resilience

External mechanical forces can act on an object in different ways. If the load is acting on the object as two equal and opposite forces to pull it, the object tends to elongate and the load is known as **tensile load**.

The load is **compressive** when two equal and opposite forces act on object to push or compress it. The object will tend to shorten on compressive load.

When an object is subjected to two equal and opposite forces acting on the cross section of the object to make it shear, the load is known as **shear load**.

Strain

When an external force acts upon an object, it deforms the object and brings about changes in its dimensions. Strain can be defined as the ratio of change in dimension to the original dimension of the object on which the forces act. As it is the ratio between dimensions equal unit, strain has no unit.

Stress

When an object is subjected to external forces, some resisting forces are set-up within the object. Stress in an object can be defined as the force that resists the deformation caused by external forces per unit area. It is expressed in Newton/m^2. When an object is subjected to tensile load, it is under tension. The stress developed within the body is known as tensile stress. When compression forces act upon an object, it is under compression. The stress developed to resist compression is called compressive stress. Shear stress is a force developed within an object to resist shear force which tends to shear in cross section.

Strength

When an object is subjected to external forces, the ability of the material of the object to withstand such forces is known as strength.

A material has different strengths to withstand different forces. The ability of the material to withstand stretching is its tensile strength. Objects which are designed to carry heavy loads should have high tensile strength.

Compressive strength of a material is its ability to withstand compression. Concrete and bricks have high compression strength.

The ability of a material to resist shearing forces is called shear strength. Bolts, screws, rivets and welded joints should have higher shear strength as they are subjected to shear forces to fracture them across their cross section.

Hardness

Hardness of a material is defined as its strength to oppose penetration or indentation, wear, tear and scratching. Hardness is a property considered primary when selecting materials for producing cutting tools and machine tool structures. Diamond is the hardest material. High carbon steel and high speed steels have higher hardness.

Toughness

Toughness is the ability of a material to withstand sudden external forces. It is the amount of energy absorbed by the material before it develops fracture. Materials which do not withstand sudden forces are called brittle. Milling cutters and gears are subjected to sudden impacts. Tough materials like alloy steels are used for manufacturing such components.

Stiffness

Stiffness of a material is its ability to resist deformation. It is also referred as Youngs's modules of electricity.

Young's modulus of elasticity = Stress/Strain

Elasticity

The ability of a material to regain its original size and shape on removal of the applied forces is known as elasticity. It is the ratio of strain and stress.

Elasticity = Strain/Stress

Ductility

Ductility is defined as the ability of a material to sustain plastic deformation before breaking. Ductile materials undergo considerable permanent deformation before breaking. Gold and Copper are highly ductile. Ductile materials are easily bent or formed to required shapes.

Malleability

Malleability of a material is the ability to get deformed under compression. A malleable material can be flattened into thin sheets without breaking. Ductility is a tensile property whereas malleability is a compressive property. Not all malleable materials are ductile. Lead is malleable but not ductile. But it can be said all ductile materials are malleable. Apart from Lead, Tin, Copper, Aluminuim and Silver are malleable.

Resilience

The ability of a material to absorb energy when elastically deformed and to give it off when unloaded is known as resilience.

4.5 Classification of materials

The variety and number of engineering materials are growing at a faster rate. A proper material for manufacturing a particular component has to be selected considering various properties of the material. Materials intended for engineering purposes are broadly classified as

1. Metals

2. Ceramics

3. Polymers

4. Composites

4.5.1 Metals

The main characters of metals are their luster, high thermal and electrical conductivity, strength, ability to be easily shaped and moderate to higher strength and density. But they are less corrosion resistant and their properties change vastly at higher temperatures.

Metals are extracted from their ores and purified. But pure metals don't have all the properties to be used as engineering materials. In order to get the desired properties and to use them in industry, two or more metals are combined and the resultant material is known as alloy.

Alloys are classified as ferrous alloys and non-ferrous alloys.

Ferrous alloys have iron as their main constituent.

I. Iron alloys

- a. Pig iron (95% Iron, rest-Carbon, Sulphur, Silicon, Phosphorus)
- b. Cast iron (Iron, 2-4.5% - Carbon, 3.5%-Silicon)
    - i. White cast iron
    - ii. Grey cast iron
    - iii. Malleable cast iron
    - iv. Alloy cast iron
- c. Wrought iron

II. Steel

- a. Carbon steel
    - i. Low carbon steel or mild steel
    - ii. Medium carbon steel
    - iii. High carbon steel
- b. Alloy steels (Metals alloyed with steel include Nickel, Chromium, Cobalt, Manganese, Tungsten, Molybdenum and Vanadium)

Non – Ferrous alloys

Non- Ferrous alloys have elements other than Iron as their main constituent. Non-ferrous alloys include alloys of Aluminium, Copper, Tin, Zinc, Lead.

4.5.2 Ceramics

Ceramics are otherwise known as a non metallic, inorganic material. The general characteristics of ceramics are

1. Hardness
2. Very high strength even at high temperatures
3. Resistant to oxidation and corrosion
4. Good thermal and electrical insulation
5. Wear resistant
6. Highly brittle

They are made from powdered materials by fabrication through the application of heat. They include oxides, silicates, borides, nitrides and carbides.

The application of ceramics

Constructional products	-	Brick, sewage pipes, roof tiles & wall tiles
White ware	-	Dinnerware, electrical porcelain
Refractory	-	Bricks and monolithic products used in different industries
Glasses	-	Flat glasses for windows, container vessels, pressed and blown Glass.
Abrasives	-	Natural (diamond) Synthetic (Silicon Carbide & Aluminium Oxide) - used for grinding , polishing & lapping
Cement	-	Buildings, bridges & dams.
Electrical	-	Insulators, capacitors, magnets & super conductors.

4.5.3 Polymers

A polymer has a repeating structure based on Carbon. The repeated structure gives a chain like molecules bonded together to form solids.

The main characteristics of polymers are

1. Easy to fabricate
2. Resist corrosion of all forms
3. Good electrical insulation
4. Lighter and less dense than metals and ceramics
5. Low strength
6. High toughness
7. Poor resistance to higher temperature.

Important industrial polymers are plastics and rubber. Plastics are a large group of synthetic materials manufactured by forming or by moulding methods. Plastics can be broadly divided into two classes namely

Thermo plastic polymers   Thermosetting polymers

Thermo plastic polymers include polystyrene, polyvinylchloride (PVC), polyethylene and polypropylene. They melt on heating and can be processed by a number of moulding and extrusion methods. Thermosetting polymers cannot be melted.

Rubber is a natural polymer and a variety of rubbers are known as elastomers.

Here are some selected polymers and their applications:

Nylon

It is a thermoplastic polymer and has high tensile strength. Nylon is used in textile industry to manufacture clothes, bags and ropes. They are also useful in manufacturing gears, pulleys, belts, electrical cables etc. In domestic front, sieves, brushes, mosquito nets and cutlery are manufactured with nylon.

PVC (Poly vinyl chloride)

It is used to manufacture frames for doors and windows, furniture, bottles, lids, pipes and plumbing fittings. In automobile field, door panels, arm rests and dash boards are made with PVC. In medical field, I.V bottles and respiratory masks are made with PVC.

Polycarbonates

Their very high strength, scratch and corrosion resisting character and ability to withstand high temperature make them find applications in making eye lenses, spectacles, helmets, bullet-proof jackets, windows of aeroplane and space vehicles.

Teflon

Teflon finds applications in non-stick cookware and electric irons.

4.5.4 Composites

A composite can be defined as a combination of two or more distinct materials to form a new material. The new material will have properties that cannot be achieved by any one of the constituent material. But they will retain their original properties. A wide range of engineering materials are composites.

Composites generally have two phases namely matrix phase and reinforcing phase. The matrix material and the reinforcing material may be a metal, a ceramic or a polymer. Generally the matrix material is ductile and tough and reinforcing materials are strong and have low densities.

Common classifications of composites are

1. Reinforced plastics
2. Metal-matrix composites
3. Ceramic-matrix composites
4. Concrete
5. Sandwich structure

4.6. Common engineering materials

An engineering material which satisfies all the requirements of the produce has to be found out in order to obtain the complete advantage of the technology. A good material needs to satisfy functional requirements, fabrication requirements and economic requirements. Some of the common engineering materials are listed below

1. Cast iron
2. Steel
3. Aluminium
4. Copper
5. Lead
6. Zinc
7. Tin
8. Chromium

All these metals and their alloys

4.6.1. Cast iron

The different types of cast iron are alloys of Iron, Carbon and other elements like Silicon, Manganese, Phosphorus and Sulphur. The amount of Carbon present in cast iron ranges from 2% to 4.5%

Characteristics of cast iron

1. Hard and brittle
2. Cannot be forged, magnetized or tempered
3. High compressive strength
4. Low tensile strength
5. Melting point about 1100^0c
6. Better machinability (Grey cast iron)
7. Higher absorption of vibrations and deflections
8. Wear resistant

Because of these characters, cast iron is useful in manufacturing machine beds, columns, frames and housings, pipes and cylinders of automobile engines.

Alloy cast iron is obtained by alloying cast iron with other metallic elements like Nickel, Chromium, Cobalt, Copper, Tungsten, Molybdenum and Vanadium. Cast iron is brittle and cannot withstand shocks. Besides, it has a low tensile strength. By alloying the above metals with cast iron, these shortcomings can be improved greatly.

4.6.2 Steel

Both Cast iron and Steel are alloys of Iron and Carbon. If the Carbon content goes beyond 2%, it is present in free state in the alloy and the alloy is known as cast iron. When the content of carbon is within 2%, carbon is found in the combined state only.

There are two distinct categories of steel

1. Carbon steels
2. Alloy steels

Carbon steels

Carbon steels are further classified on the basis of percentage of carbon as

1. Low carbon steel
2. Medium carbon steel
3. High carbon steel

Low carbon steel

It contains 0.05% to 0.3% of Carbon. It is soft, ductile and has low tensile strength but is tough. Screws, nuts, bolts, boiler plates, structural sections, chains are made with low carbon steels. It is also known as mild steel.

Medium carbon steel

0.3% to 0.6% Carbon is present in medium carbon steels. It has high tensile strength and high machinability. It is less ductile when compared with low carbon steel. It is used to manufacture products like agricultural tools, wheel axles, wires, ropes, hammers, springs dies and crankshafts.

High carbon steel

The amount of carbon present in high carbon steel ranges from 0.6% to 1.7%. It is very hard and has high tensile strength and high wear resistance. But the ductility is very low. High carbon steel is used to make wrenches, chisels, punches, files, drills and carpentry tools.

Alloy steel

Steels having one or more elements other than Iron and Carbon are termed as alloy steels. According to American Iron & Steel Institute, the other elements present in the alloy steel also influence the properties of steel. The alloying elements with steel are Chromium, Nickel, Manganese, Silicon, Vanadium, Molybdenum, Tungsten, Phosphorous, Copper, Titanium, Cobalt, and Aluminium.

The presence of various elements makes up different types of steel. They are utilized for some specific purposes only. Some important alloy steels are

1. Stainless steel
2. Tool steel
3. Special alloy steel

Stainless steel:

Stainless steel is obtained by adding 4% to 6% of Chromium and 4% to 8% of Nickel with low carbon steel. Along with these elements, 0.8% of Silicon and 0.5% of Molybdenum are also added. A little further quantity of Chromium is added to reduce the possibility of rusting.

Tool steel:

Different types of tools used in various machine tools and majority of hand tools are made with tool steel. Though there are different types of tool steels available, High Speed Steel (HSS) is very important.

High speed steel is used in making drills, single point cutting tools and milling cutters. Because of the presence of HSS, the tools can be used for high speed machining. Tungsten HSS, Molybdenum HSS, Cobalt HSS and Vanadium HSS are different types of HSS. Of all these steels, Tungsten HSS is most widely used in making cutting tools. It contains 18% of Tungsten, 4% of Chromium 1% of Vanadium and 0.7% of Carbon. It has high wear resistance and high heat resistance.

4.6.3 Non-ferrous metals

A metal other than Iron is known as non-ferrous metal. The melting points of these metals are low when compared with that of Iron. Non-ferrous metals include Aluminium, Copper, Tin, Lead, Zinc, Nickel, Chromium, Gold etc., These metals can be mixed in desired proportions to obtain various alloys like brass, bronze and bell metal.

Aluminium and its alloys

Aluminium is bluish-white or light grey in colour. It is light weight, ductile, malleable, highly corrosion resistant and good electrical and thermal conductor. Initially, it was extracted from Aluminium Chloride. Generally it is extracted from its main ore bauxite by electrolysis method. As pure Aluminium is soft, some other elements are added to make it stronger. These alloys can be moulded, forged and turned on lathes. The melting point is 658^0 C. Utensils and reflectors are some of its main applications. Duralumin and Y – alloy are some important alloys of Aluminium.

Lead and its alloys

Lead is probably the heaviest common metal. It is grey in colour. It is soft, ductile and non-corrosive. It is extracted from the ore of Galena. It has a low melting point of 327^0 C.

Copper and its alloys

Copper can be distinguished from other metals with its reddish-brown colour. It is generally extracted from an ore called pyrites. The impurities are filtered in various stages to obtain pure Copper. It is soft, ductile, and malleable and conducts heat & electricity. The melting point of Copper is 1083^0 C. It is used in making electrical wires, pressure vessels and utensils. Brass and Bronze are important alloys of Copper.

Tin

It is white in colour, soft, ductile and malleable. Because of its non-corrosive property, it is used for coating on Copper and other steel parts. The melting point of Tin is 232^0 C.

Zinc

It is a white coloured metal. Zinc sulphite and Zinc carbonate are its ores. It is purified in several stages to obtain its pure form. The melting point of Zinc is 419^0 C. Zinc is used for coating a protective layer on Iron and Steel parts. This process of coating is known as Galvanizing.

Chromium:

It is a grey coloured metal. The melting point of Chromium is 2930^0 C. It is used as an additive to steel to form alloy steels.

QUESTIONS

I. A. Choose the correct option

1. Oxidation is a

   a. physical property   b. electrical property
   c. thermal property   d. chemical property

2. The property of changing the shape of a metal part is a

   a. thermal property   b. electrical property
   c. physical property   d. chemical property

3. Metal with 18% of Tungsten, 4% of Chromium 1% of Vanadium and 0.7% of Carbon is

   a. High Speed Steel   b. Carbon steel
   c. Bronze   d. Tungsten HSS

B. Answer the following questions in one or two words

1. State two major divisions of metals.
2. Mention any two types of Cast Iron.
3. What are the two types of Steel?
4. Mention any two types of alloy steels.
5. Expand – HSS.
6. What do you mean by ‘ceramics’?

II. Answer the following questions in one or two sentences

1. What are the important properties of metals?
2. What is hardness?
3. What is ductility?
4. What is the use of Zinc?

III. Answer the following questions in about a page

1. Explain the mechanical properties of a material.

5. HEAT TREATMENT

5.1 Introduction

Every metal has its unique characteristics and properties. The properties of these metals can be altered to suit our needs by heating them in their solid state and then cooling them. Heat treatment is a process which includes heating a metal or an alloy to a particular temperature, soaking the metal at the temperature for a particular period of time and cooling the metal at a particular rate to attain certain desired qualities.

When steel is heated, changes are found in their internal structure. The amount of Carbon changes because of the heat. The structure and the properties are subjected to changes during cooling process after heating.

The amount of change in internal structure of Steel will vary according to the amount of heat it is subjected to, the method and the speed of cooling.

5.2 Objectives of heat treatment

A metal or an alloy may be heat-treated to accomplish one or more of the following purposes.

1. To restructure the physical properties like hardness, ductility and toughness of the metal.
2. To improve the characters of wear resistance, corrosion resistance and heat resistance
3. To soften the metal for machining
4. To harden the outer surface of the metals
5. To alter the grain size of metals
6. To create homogenous internal structure
7. To relieve internal stress of the metal that is developed while going through machining processes
8. To make changes in electrical and magnetic properties
9. To improve machinability.

While heating metals, their internal structure starts to transform at a particular temperature. This temperature is known as **Lower critical temperature** of the metal. On further heating, the whole internal structure is transformed at a particular temperature. This temperature is called **Upper critical temperature**.

5.3 Methods of heat treatment

1. Annealing
2. Normalising
3. Hardening
4. Tempering
5. Case - hardening
    a) Carburising
    b) Nitriding
    c) Cyaniding
    d) Induction hardening
    e) Flame hardening

5.4 Annealing

Annealing consists of

1. Heating the steel slightly above the critical temperature
2. Holding it as this temperature for a considerable period of time
3. Slowly cooling it

The annealing temperature is 30^0 C to 50^0 C above the higher critical temperature. Generally, oil fired furnace, gas fired furnace or sintering (electrical) furnaces are used for heating. The temperatures are monitored by barometers. The holding at the annealing temperature is 3 to 4 minutes for each millimeter of section of the largest piece being heated. The metal is slowly cooled by burying in a conducting material such as sand, lime or ashes.

The critical temperature of the metal varies with the amount of carbon present in it.

The purpose of annealing are

1. Soften the steel
2. Improve machinability
3. Increase or restore ductility and toughness
4. Relieve internal stresses
5. Refine grain size
6. Prepare steel for subsequent heat treatment
7. Make structural homogeneity

5.5 Normalising

The process of normalising consists of heating the metal to temperatures within the normalising range (Usually 40^0 C to 50^0 C above higher critical temperature) and holding it at the temperature for a short time (about 15 min) and cooling in air.

Normalising is done usually on forged, rolled and cast parts. The internal structure of these parts will be in total disarray after the said processes. Normalizing is done to correct these defects.

The purposes of normalising are

1. To eliminate coarse grained structure
2. To remove internal stresses
3. To improve mechanical properties of steel
4. To create homogenous internal structure
5. To increase the strength

5.6. Hardening

The process of hardening consists of heating the steel to a temperature above critical point (from 750^0C to 850^0C), holding it at the temperature for a considerable period of time and rapidly cooling it by quenching it in water, oil or salt bath.

The purposes of hardening are

1. To develop hardness
2. To resist wear and enable it to cut other metals
3. To improve strength, elasticity, toughness and ductility

5.7 Tempering

It is observed that the hardened steel is very hard and brittle. This structure is not suitable for engineering work. So hardening should always be followed by tempering.

The process of tempering involves reheating the steel after hardening to temperatures below lower critical temperature, holding it for a considerable time and slow cooling.

The purposes of tempering

1. To decrease the brittleness of hardened steel
2. To stabilise the structure of metal
3. To reduce some of the hardness produced during hardening
4. To increase the toughness of steel
5. To improve ductility

5.8 Case hardening

At times it is necessary that only the outer skin of a part should be hard and wear resistant. The inner core may be soft and tough. The case hardening process involves a chemical change in the outer surface of the work and so differs from other methods of heat treatment. Its is a process of forming a high carbon surface on a low carbon steel part and the objective is to produce a part with tough, ductile core and a hard outer surface.
The different processes of case hardening are

1) Carburising   2) Nitriding
3) Cyaniding   4) Induction hardening
5) Flame hardening

5.8.1 Carburising

The process of carburising involves heating iron or steel to red heat (from 900^0C to950^0C)in contact with some carbonaceous materials such as wood (or) leather, charcoal, crushed bones with compounds such as carbonates of barium, calcium or sodium. Iron at temperatures close to its critical temperature has an affinity of carbon. The carbon enters the metal to form an outer surface of high carbon steel.

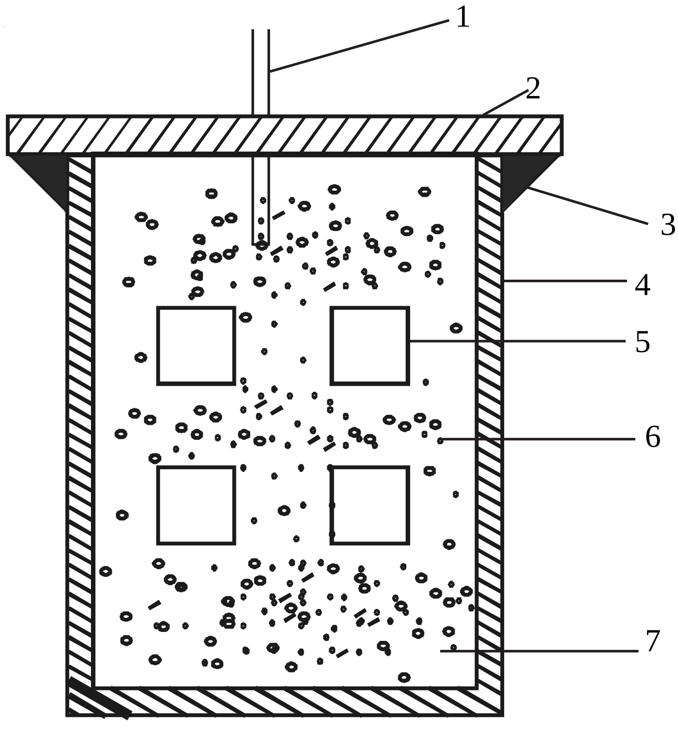


Fig 5.1 Carburising

1. Test bar
2. Lid
3. Fireclay
4. Steel case
5. Metal parts
6. Carburising powder
7. Rammed powder

Disadvantages of carburizing are

1. Not suitable for mass production
2. Time involved is more (for packing, heating, cooling and unpacking)
3. The amount of hardening cannot be controlled easily

5.8.2 Cyaniding

Cyaniding is the process of producing hard surfaces on low carbon or medium carbon steel by immersing steel in molten salt bath containing cyanide at 800^0 to 900^0 C for about 15 minutes and then quenching the steel in water or oil. The hardness produced by this treatment is due to the presence of compounds of Nitrogen and Carbon in the surface layer. A bath containing 1/3 (one third) each of Sodium chloride, Sodium carbonate and Sodium cyanide is used for cyaniding treatment. The surface is hardened to a thickness of 0.125mm.

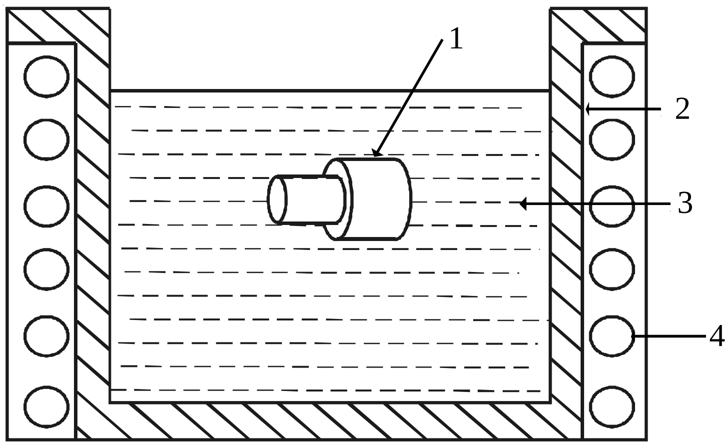


Fig 5.2 Cyaniding

1. Metal part 2. Container 3. Salt bath 4. Heating coil

Advantages of Cyaniding

1. It is a rapid process
2. The exterior will have high lustre
3. Uniform hardening
4. The ductility is increased

5.8.3 Nitriding

Nitriding is the process of producing hard surface layer on alloy steels only. Nitriding consists of heating the steel in the atmosphere of Ammonia gas at temperatures of 500^0 C to 600^0 C. The ammonia is dissociated as Nitrogen and Hydrogen and the Nitrogen combined with elements in the steel to form nitrides. These nitrides give extreme hardness to the surface.

Advantages of Nitriding

1. The obtained hardness is very high
2. Wear resistance and corrosion resistance is increased
3. No scaling because of rapid cooling
4. Suitable even for complicated structures

5.8.4 Induction hardening

It is a method of hardening the outer surface of the parts by heating them with a high frequency current. It can be done very quickly. It has proved satisfactory for many surface hardening operations required in crankshafts, camshafts, axle shafts and similar surfaces. It can be differentiated from other case hardening processes in the sense that the analysis of the surface steel is not changed. It is accomplished by very rapid heating and quenching of the surface.

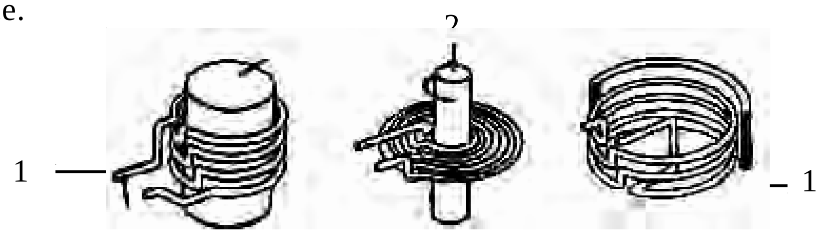


Fig 5.3 Induction hardening
1. Heating coil 2. Metal part

Advantages

1. The process is very quick
2. High rate of change of properties
3. The exterior surface can be made of high quality
4. The internal hardening can be controlled

Disadvantages :

1. The cost of the equipment is very high
2. Low carbon steel can not be hardened
3. Maintenance cost of the equipment is more

5.8.5 Flame hardening

Flame hardening is a process of hardening the steel by heating it with the flame of an oxy-acetylene torch. The flame is directed to the desired part without heating the other parts. The part to be hardened is fitted on the rotating shaft of a motor and the flame is directed to the part. After heating, the part is subjected to rapid quenching in water.

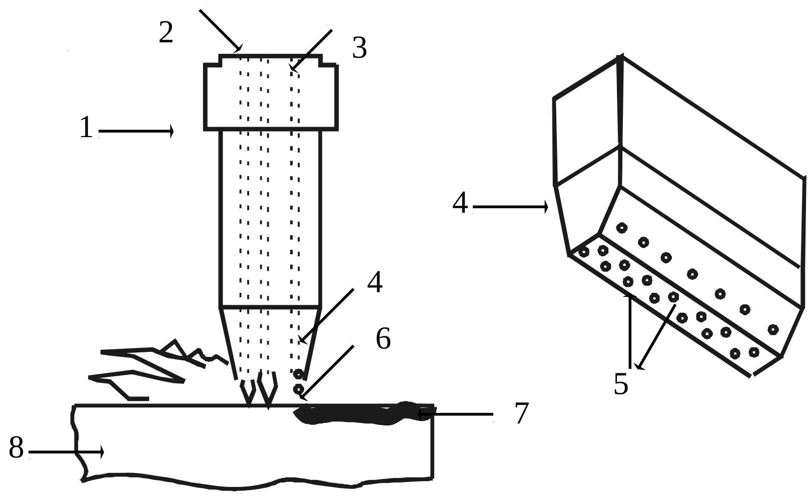


Fig 5.4 Flame hardening
1. Direction of torch movement
2. Oxy acctylene inlet
3. Water inlet
4. Water nozzle
5. Flame nozzle
6. Quenching by awater
7. Hardend portion of the part
8. Metal part

Advantages

1. It is simple and cost effective
2. It is possible to harden a part which is too large or inconvenient to be placed in a furnace
3. The time required for heating is less than in a furnace

5.9 Quenching

Quenching is done as a cooling process after the metal is heated and soaked in the same temperature for a certain period of time. It is done with water, oil or high pressure air.

The materials used for quenching are

1. Sodium solution
2. Cool water
3. Salt baths
4. Grades of oil
5. Air

5.10 Heat treatment furnaces

Some common types of heat treatment furnaces are mentioned below

1. Sintering furnace
2. Gas fired furnace
3. Oil fired furnace
4. Salt bath furnace

5.10.1 Sintering furnace

It is also known as electrical furnace. There are three layers in this type of furnace. The parts to be heated are arranged in a tray and sent into the furnace by means of conveyors.

The amount of heat inside the furnace is controlled by thermocouples and resistors. The temperature required for the heating process is set in this instrument. The parts are kept in the same temperature for a required time in the soaking zone. Afterwards the parts are cooled by a proper method to complete the hardening process. There are separate control devices to operate the conveyors at different speeds.

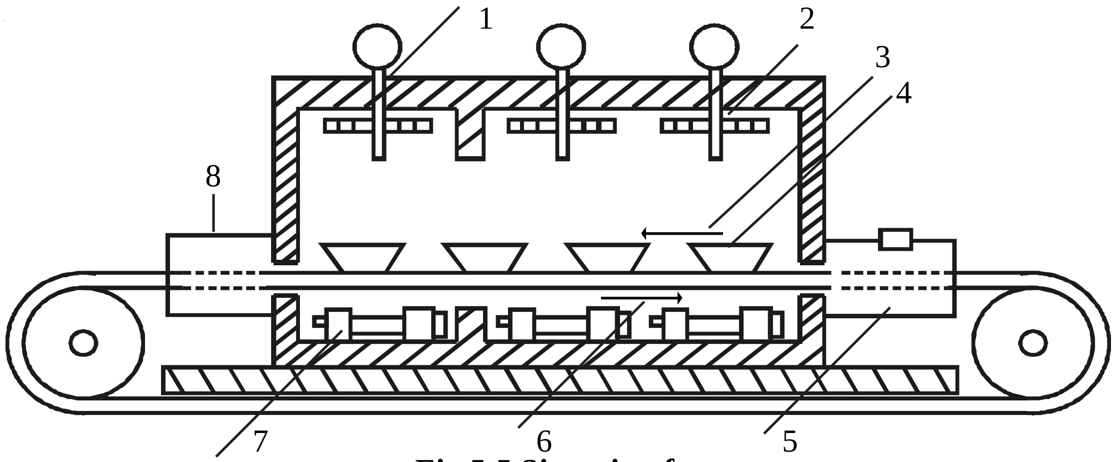


Fig 5.5 Sintering furnace

1. Thermo couple 2. Resistors 3. Gas 4. Workpiece 5. Quaking zone 6. Divection of belt movement 7. Resistors 8. Heating zone

QUESTIONS

I.A Choose the correct option

1. The method of heat treatment done to increase the wear resistance quality is
   a. annealing b. hardening c. tempering d. normalising

2. ……………………. is a method of case-hardening
   a. Tempering b. Annealing c. Nitriding d. Hardening

3. The media used for rapid quenching is
   a. Cyaniding b. Tempering c. Sodium salt bath d. Oil

4. The furnace with three layers is
   a. Gas fired furnace b. Salt bath furnace
   c. Sintering furnace d. Oil fired furnace

I. B Answer the following questions in one or two words

1. What change can be obtained by heat treating steels and alloys?
2. Mention one case-hardening process.

II. Answer the following questions in one or two sentences

1. Define ‘Heat treatment’.
2. What are the methods of heat treatment?
3. What is lower critical temperature and upper critical temperature?
4. What is annealing?
5. What are the types of furnaces?
6. What is quenching?

III. Answer the following questions in about a paragraph

1. What is case-hardening? Mention the case-hardening methods.
2. Explain “ Hardening”.
3. Carburising, Cyaniding – Explain
4. Nitriding, Induction hardening – Explain.
5. Normalising, Tempering – Explain.

IV. Answer the following questions in detail.

1. Explain the objectives of heat treatment.
2. Draw and explain - Sintering furnace
3. Induction hardening, flame hardening – Explain with diagrams

6. JIGS AND FIXTURES

6.1 Introduction

Jigs and fixtures are used to hold the workpieces firmly, locate the work and to guide the tool accurately. They are useful where large quantities of identical workpieces are to be manufactured with accurate measurement and precise quality. They replace the conventional work holding devices and are meant exclusively for a particular pattern of work. The processes of marking dimensions, and setting of workpieces are totally eliminated.

6.2 Advantages of jigs and fixtures

1. The production is increased as jigs and fixtures are adapted for quantity production of identical workpieces.

2. The cost of production is minimised.

3. The total machining time is reduced as it is not necessary to make marking on every individual workpiece.

4. The mounting time for the workpiece is considerably reduced.

5. The work is located accurately and so the accuracy of the product is more.

6. As the size and tolerance on dimensions are within specified limits, there is scope for interchangeability.

7. The cost incurred on quality control becomes less.

8. Machining can be performed even by a semi-skilled operator.

9. Machining can be performed at a quick rate by providing more cutting speed, feed and depth of cut.

10. As the machining process is safer, accidents are avoided.

6.3 Jigs

Jigs are special devices used to hold the workpieces and to guide and control the tools used in the machining process. Steel sleeves attached to the jig will guide the tool. The jigs are easy to handle as they are of very less weight. Jigs are classified according to the type of operation performed on the work.

6.4 Fixtures

Fixtures are devices which hold and locate the work during inspection or in a production process. It does not guide the tool. Vise, V block, angle plate, step block and T bolts can be seen as simple fixtures. Fixtures can hold irregular and unsymmetrical workpieces also.

6.5 Differences between a jig and a fixture

Jigs	Fixtures
1. A jig holds and locales the work as well as guides the tool.	1. A fixture holds and locates the work but does not guide the tool.
2. Jigs are made lighter for quick handling.	2. Fixtures are generally heavier.
3. Clamping with the table is mostly unnecessary	3. Fixtures are bolted rigidly on the machine table.
4. Jigs are used for drilling, reaming and tapping operations	4. Fixtures are used in milling, grinding, planing and turning operations

6.6 Elements of jigs and fixtures

The main aim of a jig or fixture is to hold the work properly in a particular position relative to the position of the tool. This aim is met by special provisions built within a jig or fixture. The basic elements of a jig or a fixture are

1. Body or frame
2. Locating elements
3. Clamping elements
4. Tool guiding elements
5. Indexing elements

6.6.1 Body or frame

This is an important part of jigs and fixtures. It gives support to the other elements of the jig. Projecting lugs are provided on the bottom of the jig body to attach it to the table of the machine. Holes are drilled in the base of the fixture body to clamp it to the machine table.

6.6.2 Locating elements

The locating elements are responsible for proper positioning and supporting of the work inside a jig of fixture. They ensure that the relative positions of the tool and the work is not disturbed due to clamping or cutting forces of the tool. They should resist bending, shearing and twisting of the parts supported by jigs or fixtures. Correct location of the work influences the accuracy of the finished product. Stop pins, rest buttons, jack pins, V block parallels are some locating elements.

6.6.3 Clamping elements

The clamping elements ensure stable position of the work located in a jig or a fixture. The work gets loose in a fixture because of either cutting forces or of the work's own weight. So, adequate number of clamping devices of proper type should be provided in a jig or fixture for its effective operation. The clamping devices should also ensure easy clamping and as well as easy releasing of the work after machining processes. Some common clamping devices are: Edge clamp, Strap clamp, Screw clamp, Latch clamp and Hinge clamp.

6.6.4 Tool guiding elements

Tool guiding elements are useful in mounting the tool with respect to the location of the work and guiding the tool during machining process. For example, the accuracy of drilling operation will depend on the tool guide that guides the drill. This guiding element known as sleeve or bush will be subjected to wear and tear because of the rotating tool. So the bushes should be made of wear resisting materials.

6.6.5. Indexing elements

Indexing elements are useful only when it is required to machine at different positions on a work. They rotate the work through a required angle and hold it firmly in correct position for the next part of the machining. This may be compared to the indexing head mechanism in a milling machine.

6.7 Location

Location helps to provide the required relationship between the workpiece and the jig or fixture. Correct location ensures high accuracy in the finished products. Jigs and fixtures are designed to restrict all possible movements of workpiece.

6.7.1. Principle of location

The rectangular block is free to move along the three axes. The body can also rotate about the axes and thus the total degree of freedom of a body along which it can move is six. In order to locate the block correctly within a jig, all these six movements must be restrained by arranging suitable locating points and then clamping the block in position.

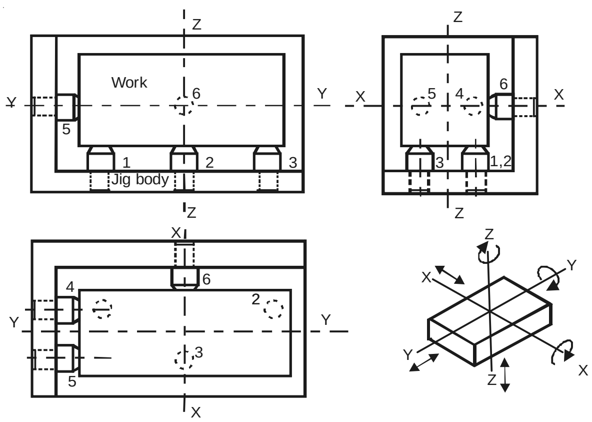


Fig. 6.1 3-2-1 Location

6.7.2 Six point location (3 - 2 - 1 location)

This is also called six points location of a rectangular block. It is assumed that the block shown in the figure is made to rest on several points on the jig body. The bottom of the block is supported against three points, the rear face of the block bears against two points and the side of the block rests against a single point, all projections from the jig body. It will be now clear that the downward movement of the block is restrained by three supporting points, which have the capability of supporting even a rough casting. The movements along other axis are restrained by the double and the single points respectively.

The rotary movements of the block about the three axes are also restrained by the bottom, back and side pins. The axes points thus serve to locate a block correctly while restraining all its movements. The locating points for an uneven object can be determined by different arrangements, but the guiding principle remains the same.

6.8 Types of jigs

1. Plate jig	6. Leaf jig
2. Angle plate jig	7. Vise jig
3. Channel jig	8. Ring jig
4. Box jig	9. Indexing jig
5. Diameter jig	10. Jig bushing

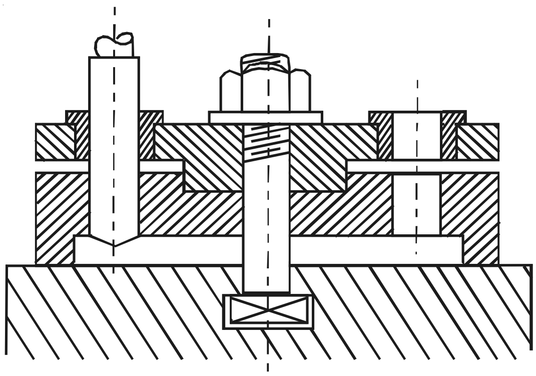


Fig. 6.2 Drill jig

Plate jig

Plate jigs are used when many numbers of holes are to be drilled on a workpiece. A plate having the required number of bushings fitted on it is held over the work. The plate and the work are held together by bolts. Holes at the required locations are then made by feeding the drills into the bushings.

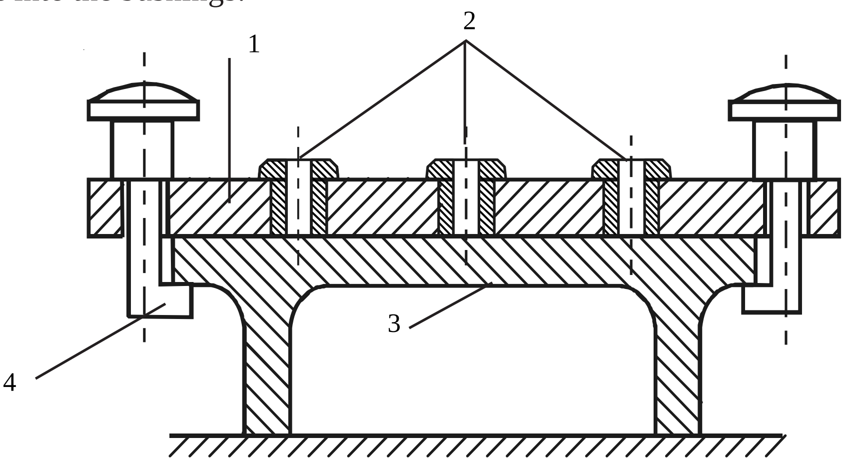


Fig. 6.3 Plate jig

1. Plate 2. Drill bushes 3. Work 4. Bolt

Channel jig

A channel jig is made of a channel section. The work is mounted in the channel and held firmly. It has clamping devices and the usual bushings at the required locations. Holes at the required locations are then made by feeding the drills into the bushings.

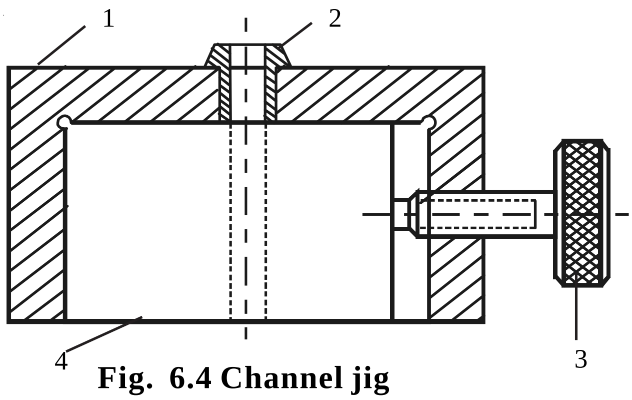


Fig. 6.4 Channel jig

1. Channel 2. Bush 3. Threaded knob 4. Work

Angle plate jig

It resembles an angle plate. One side of the jig is fitted on the machine table. On top of the other side, a plate with required drill bushes is attached to guide the drills. The work is held and clamped on the vertical side of the angle plate by means of a stud bolt. It is used for drilling holes in pulleys and gears.

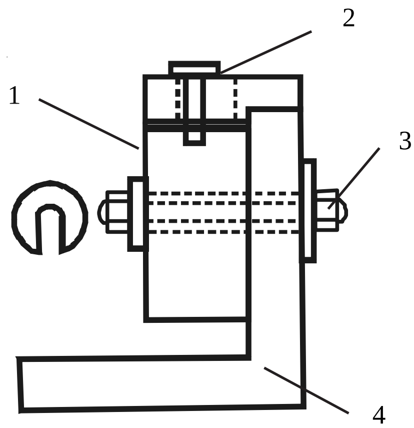


Fig. 6.5 Angle plate jig

1. Work 2. Bush 3. Stud bold 4. Angle plate

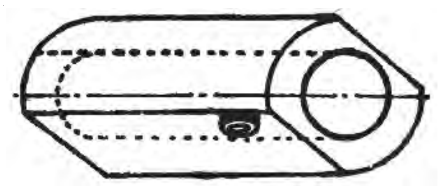


Fig. 6.6 Diameter jig

Diameter jig

This type of jig is used to drill holes on cylindrical pieces of work.

Box jig

It looks like closed box. The work is completely enclosed inside the jig. The top of the box is present with drill bushings at the required locations. Holes are then made by feeding the drills into the bushings.

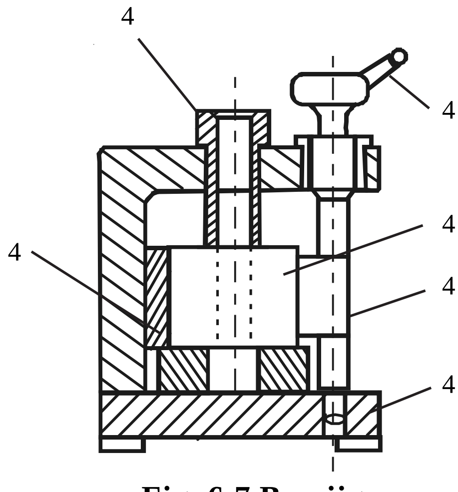


Fig. 6.7 Box jig

1. Pad 2. Bush 3. Handle 4. Work 5. Cam 6. Base

6.9 Types of fixtures

There are different types of fixtures used on the machine tables of different machine tools. Some important fixtures are listed below

1. Milling fixture with vise jaws
2. Plain milling fixture
3. Milling fixture with keyways
4. Spring milling fixtures

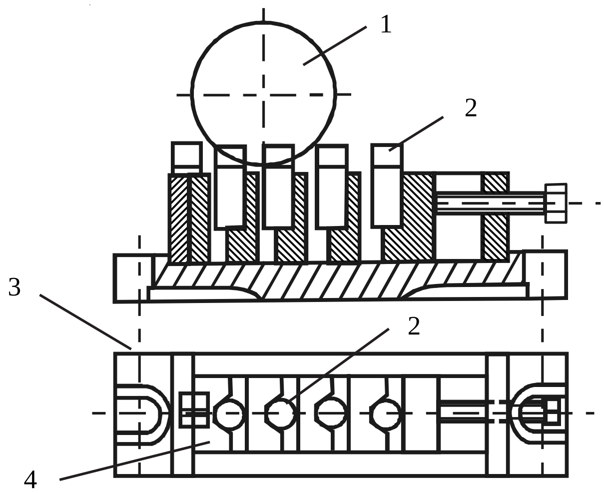


Fig. 6.8 Plain milling fixture

1. Slot milling cutter 2. Work pieces 3. Base 4. V - block

Plain milling fixture

The example shown in the diagram is useful in machining slots on the top of cylindrical workpieces. The diagram shows four V blocks holding four cylindrical pieces by straps. A setting block present in the fixture sets the path for the cutter's feed movement. The table is moved vertically for the depth of cut to finish the operation.

6.10 Points to be considered for designing a jig or a fixture

1. A thorough study of the workpiece is necessary. Details such as accuracy, weight, number of pieces to be machined, the type of material and the type of operation are to be considered.

2. The type, capacity and accuracy of the machine tool are to be taken note of.

3. Methods of mounting workpieces, loading and unloading methods, clamping methods, locating methods, the recess between the work and the jig, tool setting and guiding methods are to be considered.

4. Fool proofing arrangements for proper loading of work and swarf (chips) removal arrangement

5. Safety

QUESTIONS

I.A Choose the correct option

1. The jig meant to hold cylindrical workpieces
   a. Box jig   b. Diameter jig   c. Channel jig   d. Angle jig

2. The fixture meant to hold cylindrical workpieces
   a. Milling fixture with vise jaws   b. Plain milling fixture
   c. Milling fixture with keyways   d. Spring milling fixtures

I. B Answer the following questions in one or two words

1. Are the tools guided in jigs?
2. Name any two clamps used in a jig.

II. Answer the following questions in one or two sentences

1. What is a jig?
2. What is a fixture?
3. What do you mean by location?
4. What are the types of jigs?
5. What are the types of fixtures?

III. Answer the following questions in about a paragraph

1. What are the differences between jig and fixtures?
2. Explain 'Plate jig' with a diagram.
3. Explain 'Channel jig' with a diagram.
4. Draw and explain Ring jig and Box jig.

IV. Answer the following questions in detail.

1. List out the advantages of jigs and fixtures.
2. Explain various elements in a jig.
3. Explain 3-2-1 location with a diagram.

7. STANDARDISATION

7.1 Introduction

In order to manufacture a machine, we require thousands of small components. For this, various materials are used. Several parts are machined in various machines. In engineering, these materials and components are classified according to their qualities. This should be followed and the components should be manufactured accordingly. The aim of all modern manufacturing is to produce parts of absolute accuracy. The accuracy of the product depends upon the precision of the parts & accessories of the machine and keenness of the cutting tools used in the machine tool. But it is not always possible to keep exact measurements in mass production. If sufficient time is given, any operator would work and maintain the sizes within a close degree of accuracy. Still there would be some size variations. Some standards regarding a few parts are set by competent organizations by allowing size variations within restricted limits.

For example, bolts, nuts, threads, keys, studs, washers, tapers, gears, bearings and different sizes of plates and wires are available in standard sizes very easily. The production is also increased by reducing the cost. Then only the components are easily available and sold everywhere. Trading from one country to other is also increased.

7.2 Standardization

If any component is broken or to be changed due to wear and tear, it can be easily replaced by a new component by purchasing it from the market. These parts are manufactured by following the quality, the accuracy of size and other standards strictly prescribed by the following organizations like ISO and BIS. This is called standardization.

7.3 Interchangeability

In making mating parts in mass production, it is not always possible to maintain the dimensional accuracy of the parts. There are some variations in dimensions in few of the many number of products. If the variations of sizes are within certain limits, all parts of equivalent sizes will be fit for operating in machines and mechanisms. Certain deviations are allowed to ensure interchangeability of mating parts.

7.3.1 Advantages of interchangeability

1. As the parts are manufactured within desired limits, all parts of equivalent sizes will fit for operation.

2. The rate of production is increased in shorter period of time. The cost is reduced.
3. As standard parts are available easily, the time taken for replacement is very limited.
4. The rate of waste in mass production becomes less.

7.4 Basic terminology in interchangeable system

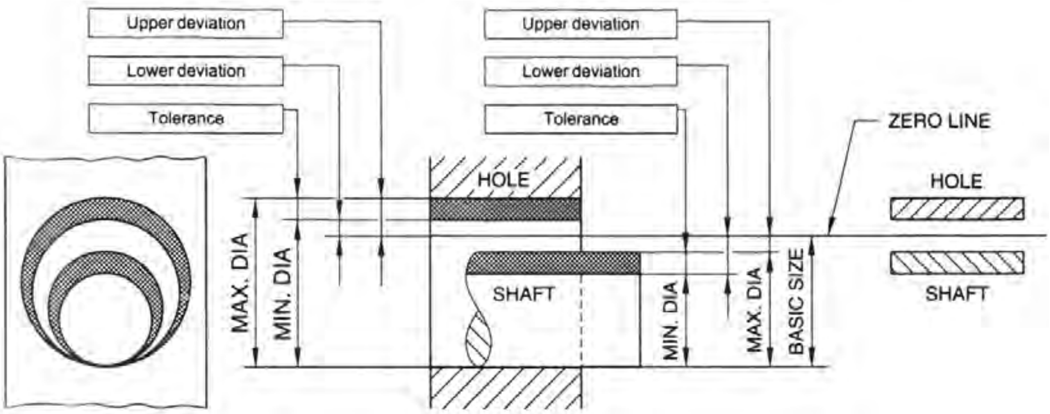


Fig 7.1 Interchangeable system

7.4.1 Shaft

The shaft indicates the outer diameter of a cylindrical profile.

7.4.2 Hole

The hole indicates the inner diameter of a cylindrical hole of a part.

7.4.3 Basic Size

Basic size of a dimension is the size in relation to which all limits of variation are determined. This is fixed up by designer considering its functional aspects without indicating any tolerance.

7.4.4 Actual size

The actual size of a component is its measured size. The actual size of a finished part will always deviate from the basic size or nominal size. But the difference between the basic size and actual size must not exceed a certain limit.

7.4.5 Limits of sizes

Limits of a size are two extreme permissible sizes between which the actual size is contained. The maximum limit of a size is the largest permissible size while the smallest permissible size is known as minimum limit of a size.

7.4.6 Deviation

The algebraic difference between the actual size and its corresponding basic size is called deviation.

Upper deviation

It is the algebraic difference between the maximum limit of a size and its corresponding basic size.

Lower deviation

It is the algebraic difference between the minimum limit of a size and its corresponding basic size.

7.4.7 Zero line

The zero line is the line of zero deviation and it represents the basic size. When the zero line is drawn horizontally positive deviations are shown above it and the negative deviations are shown below it. The sign + is added with positive deviations and the sign – is added with negative deviations.

7.4.8 Tolerance

Tolerance on a dimension is the difference between the maximum limit of size and minimum limit of size. It is the variation in size tolerated to cover reasonable imperfections in workmanship and varies with different grades of work.

However, tolerance is equal to the algebraic difference between the upper and the lower deviations.

There are two basic ways of specifying to tolerance

1) Unilateral tolerance

2) Bilateral tolerance

Unilateral tolerance

Unilateral tolerance is used where it is important for the dimension to vary in only one direction. Parts manufactured will fall close to the desired dimension but can vary in only one direction. An example is a drilled hole. As the drill is made close to the basic hole size, it is not possible to drill hole under size.

Example

Basic size is 40.00

Maximum limit is 40.02 (+0.02) and Minimum limit is 40.00(-0.00)

Here the tolerance is 0.02 and it is covered in the positive side only.

or

Basic size is 40.00

Maximum limit is 40.00 (+0.00) and Minimum limit is 39.98(-0.02)

Here the tolerance is 0.02 and it is covered in the negative side only.

Bilateral tolerance

Bilateral tolerance is used where the parts may vary in either direction from the basic size. If the tolerance is divided some being allowed on either side of the zero line (basic size), the system is called bilateral. It is not necessary that the variation should be equal.

Basic size is 40.00

Maximum limit is 40.04 (+0.04) and Minimum limit is 39.98(-0.02)

Here the tolerance is 0.06 and it is covered on both sides of the zero

7.5 Fits

The relation between two parts where one is inserted into the other with a certain degree of tightness or looseness is known as fit.

Types of fits

Depending upon actual limits of the hole and the shaft, fits can be divided into three classes

1. Clearance fit
2. Interference fit
3. Transition fit

7.5.1 Clearance fit

In a clearance fit, there is a positive difference between the largest possible shaft and the smallest possible hole. In this type of fit, the minimum clearance is always greater than zero. Such fits give loose joining and there will be some amount of freedom between the shaft and the hole. Bush bearings and channel bearings are fitted with clearance fit.

7.5.2 Interference fit

In an interference fit, there is a negative allowance between the largest hole and the smallest shaft, the shaft being larger than the hole. Ball bearings require interfere fits.

There are three grades of interference fits namely

1. Shrink fit
2. Heavy driving fit
3. Light driving fit

The parts with holes are heated to expand. In this condition, the shaft is inserted into the hole and the joint is rapidly cooled to have a strong fit. This is known as shrink fit.

In heavy driving fit, a good amount of force is given to drive the shaft into the hole.

Light diving fit involves a light force employed to drive the shaft into the hole.

7.5.3 Transition fit

They cover cases between first two classes of fits. The use of transition fit does not guarantee either interference or a clearance. Any pair of parts mating with transition fit may fit with interference while another pair with same fit may have a clearance fit. There are four different grades of transition fits and they are

1. Force fit
2. Tight fit
3. Wringing fit
4. Push fit

7.6 Hole basis and shaft basis

In a general limit system, it is necessary to decide on what basis the limits are to be found to give the desired fit. There are two distinct systems for varying the sizes of parts known as: hole basis and shaft basis.

7.6.1 Hole basis

A limit system is said to be on a hole basis when the hole is the constant member and different fits are obtained by varying the size of the shaft. In this hole system the high and low limits are constant for all fits of the same accuracy grade and for the same basic size.

7.6.2 Shaft basis

A limit system is said to be on a shaft basis when the shaft is the constant member and different fits are obtained by varying the size of the hole. In this shaft system the high and low limits are constant for all fits of the same accuracy grade and for the same basic size.

7.7 Limit systems

It is very important to keep limits and fits within desired limits. It has to be standardised to be able to produce components with interchangeability. There are several organizations Worldwide to ensure standardisation. They are

1. International Organization of Standards (ISO)
2. Newall system
3. Indian Standard Institution (ISI)

7.7.1 International Organization of Standards (ISO)

This system, setout in BS 4005: 1969, allows for 27 types of fits and 18 grades of tolerance covering a size range of 0 to 3150 mm. In this system, the 27 possible holes are designated by capital letters A, B, C,...... etc. and the shafts by lower case letters a, b, c...... etc. The 18 grades of tolerance are designated by numerals T01, T0, T1, T2...... T16.

For specifying a particular hole or shaft, it is to be written as the letter followed by the numeral. For example **H7** for a hole and **f7** for a shaft.

7.7.2 Newall system

This system is a bilateral hole basis system. It provides two classes of tolerance (A and B) for holes to accommodate two grades of workmanship. Class A is for extremely accurate work and grade B for general engineering work. This system gives shaft limits for the following classes of fit.

7.7.3 Indian Standards

This system of limits and fits recommended in IS: 919-1963 comprises 18 grades of fundamental tolerances or grades of accuracy of manufacturing with designations IT 01, IT 0, IT1,.....IT16.

It also recommends 25 types of fundamental deviations indicated by letter symbols for both holes and shafts (Capital letters of A to ZC for holes and small letters of a to zc for shafts)

In order to indicate a particular fit, the basic size common for both the hole and the shaft is noted followed by tolerance and deviation.

Example : **50 H8g7**

QUESTIONS

I.A Choose the correct option

1. The system that enables parts of equivalent sizes with dimensional variation within certain limits to be fit for operating is
   a. Limits　　b. Unilateral tolerance
   c. Deviation　　d. Interchangeability

2. If the size of the shaft is smaller than the hole size, the system of fits is
   a. Interference fit　　b. Clearance fit　　c. Driving fit　　d. Push fit

3. The fit which involves the shaft being driven into the hole with light force
   a. Light driving fit　　b. Heavy driving fit
   c. Shrink fit　　d. Tight fit

4. The algebraic difference between the actual size and its corresponding basic size is called
   a. Maximum limit　　b. Deviation
   c. Tolerance　　d. Minimum limit

I. B Answer the following questions in one or two words

1. Define 'Shaft' in terms of interchangeable system.
2. What are the two basic ways of specifying tolerance?

II. Answer the following questions in one or two sentences

1. Define 'Interchangeability'.
2. What do you mean by limits of size?
3. What is fit?
4. What is 'Basic size'?
5. Write short notes on the types of deviations.
6. What are the different limit systems?

III. Answer the following questions in about a paragraph

1. What is tolerance? Explain.
2. Explain the limit systems.

IV. Answer the following questions in detail

1. Explain the terms used in interchangeability.
2. Explain the different types of fits.

8. TRANSMISSION OF POWER

8.1 Introduction

A source of power is always needed in workshop processes particularly in cutting and forming of metals. Electricty as a means of conveying power to machinery is widely adopted. The electrical energy is converted into rotational energy by means of an electric motor and the machine converts the input of rotational energy into various forms necessary for doing the job.

When power is transmitted by gears and chain, there is no slip in velocity ratio. It is called positive drive. When power is transmitted by a belt drive, there is always a possibility of some slipping between the belt and the faces of the pulleys. So the character of motion transmitted is non-positive.

8.2 Methods of transmitting power

1. Belt drive

2. Gear drive

3. Chain drive

4. Clutch drive

5. Rope drive

6. Friction drive

8.3 Belt drive

Belt drive is one of the common methods of transmitting motion and power from one shaft to another by means of a thin inextensible band running over two pulleys. In a belt drive arrangement, the shaft which transmits the rotational power is known as the driving shaft. The pulleys mounted on the driving shaft is known as driver or driving pulley. The shaft which receives the rotational power is known as driven shaft and the pulley mounted on it is known as follower or driven pulley. The transmission of power becomes possible because of the grip between the pulley and the belt. Belt drive is generally used in mills and factories. When the distance between the connected shafts is not great, belt drive to used.

8.3.1 Types of belt drive

Generally power is transmitted by belt drives in two types

1. Open belt drive
2. Crossed belt drive

Open belt drive

In this type of belt drive the belt is not crossed. The belt connects the top portions of the pulleys directly. The grip between the belt and the pulley is minimum. The driver and the follower rotate in the same direction. The portion of the belt joining the pulleys on the upper side is called slack side. The portion of the belt joining the pulley on the lower side is called the tight side.

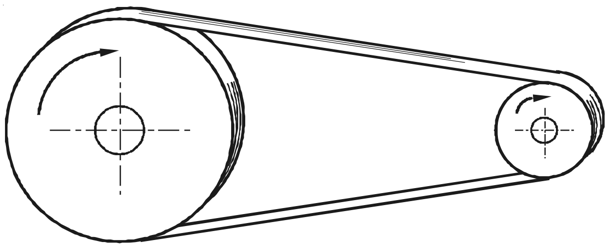


Fig. 8.1 Open belt drive

Crossed belt drive

In this type of belt drive, the belt is crossed between the pulleys. The belt connects the top portion of the driver with the lower portion of follower. The grip between the belt and pulley is greater because of the crossed nature of the belt. The pulleys connected by the cross belt arrangements rotate in the opposite directions. If the driver rotates in clockwise direction, the follower will rotate in the anticlockwise direction.

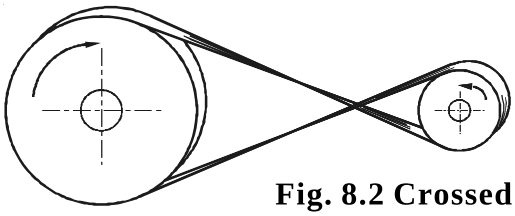


Fig. 8.2 Crossed belt drive

8.3.2 Types of belt

Belt is usually made from leather, rubber and canvas thread in a moulded form . The two ends of a belt are connected by hooks and pins. Generally two forms of belts are used

1. Flat belt
2. V – belt

The cross section of a flat belt is in the form of a rectangle. The thickness of a flat belt varies from 0.75 mm to 5 mm. The efficiency of this form of belt is approximately 98%. It is used on pulleys having flat faces.

V belt has a cross section of trapezoidal form. The thickness of the V-belt ranges from 8 mm to 19 mm. The efficiency various from 70 % to 98 %. This form of belt is used on pulleys having V grooves.

8.3.3 Velocity ratio of a belt drive

Velocity ratio of a belt drive is the ratio of number of revolutions of follower to the number of revolutions of driver in a particular time.

If D1 and D2 are the diameter of driver and follower and N1 and N2 are the number of revolutions per minute of the driver and the follower

$$\text{Velocity ratio} = \frac{N2}{N1} = \frac{D1}{D2}$$

Though the theoretical value of velocity ratio is calculated as above, it differs from it because of the thickness of the belt and belt slip. These factors should also be taken into account in calculating the actual velocity ratio.

The speed of the shaft or the pulley is expressed in RPM (Revolutions Per Minute). If we want to increase the speed of the follower with respect to the driver, the pulley on the driven shaft should be smaller in size (diameter) than the pulley on the driving shaft. If we want to decrease the speed of the follower, the pulley on the driven shaft should be larger in size.

$$D1N1 = D2N2$$

8.3.4. Solved Examples

Example -1

Pulleys of diameters 200 cm and 50 cm are connected by a belt drive. Find the velocity ratio.

Solution

Consider N1 as the speed of the driving pulley

N2 as the speed of the driven pulley

D1 as the diameter of the driving pulley = 200 cm

D2 as the diameter of the driven pulley = 50 cm

$$\text{Velocity ratio} = \frac{N2}{N1} = \frac{D1}{D2} = \frac{200}{50} = 4$$

Example -2

Two pulleys of diameters of 600 mm and 200 mm are connected by means of a open belt drive. If the smaller pulley rotates at a speed of 400 r.p.m. in clockwise direction, find the speed and direction of rotation of the larger pulley.

Solution

Consider $D1 = 600$ mm ; $D2 = 200$ mm ; $N1 = 400$ r.p.m. ; $N2 = ?$

$$D1N1 = D2N2$$

$$N2 = \frac{D1N1}{D2} = \frac{600 \times 400}{200} = 1200 \text{ r.p.m}$$

The larger pulley will rotate at the speed of 1200 r.p.m. in clock wise direction.

Example -3

Two shafts are connected by a belt drive. On one of the shafts, a pulley of 100 mm diameter is fitted and it rotates at a speed of 1500 rpm in anticlockwise direction. What should be the diameter of the driven pulley if it is to rotate at a speed of 750 rpm in clock wise direction? What should be the type of belt drive?

Consider $D1 = 100$mm ; $N1 = 1500$rpm ; $N2 = 750$ rpm; $D2 =?$

$$D1N1 = D2N2$$

$$D2 = \frac{D1N1}{N2} = \frac{100 \times 1500}{750} = 200 \text{ mm}$$

The diameter of the pulley is 200mm and the belt should be cross driven.

8.3.5 Belt slip

When power is transmitted through belt drive, the follower of the drive will not rotate at the estimated speed. It will rotate at a lower speed only. The main reason for this defect is slackness of the belt.

Belt slip is the difference between the distance covered by a point on the pulley and the distance covered by a point on the belt per minute. Belt slip is always expressed in percentage.

$$\text{Belt Slip} = \frac{\text{Estimated speed - Actual speed}}{\text{Estimated speed}} \times 100$$

If D1 and D2 are the diameters of the pulleys and N1 and N2 are their speed in rpm and S is the amount of belt slip in percentage,

$$\text{Velocity ratio} = \frac{N2}{N1} = \frac{D1}{D2} \times \frac{(100 - S)}{100}$$

Example - 4

A driving pulley of diameter 60cm rotates at a speed of 200rpm. The driven pulley of diameter 40cm connected by a belt drive rotates at speed of 291rpm. Find the percentage of belt slip.

D1 = 60 cm D2 = 40cm

N1 = 200rpm N2 (Actual)= 291rpm

$$\text{Velocity ratio} = \frac{N2}{N1} = \frac{D1}{D2}$$

$$\frac{N2}{200} = \frac{60}{40} \quad N2 = \frac{60}{40} \text{ X } 200 = 300 \text{ rpm}$$

The estimated speed of the driven pulley is 300rpm. But it rotates at 291rpm.

$$\text{Belt Slip} = \frac{\text{Estimated speed - Actual speed}}{\text{Estimated speed}} \text{ x } 100$$

$$= \frac{(300-291)}{300} \text{ x } 100 = \frac{9}{300} \text{ x } 100 = 3\ \%$$

8.4 Gears

Gears are used to transmit power between rotating parts to operate various machines. The power transmission is achieved without any slip. It is also advantageous in the sense that higher velocity ratio can be achieved in limited space. Only parallel shafts are connected by belt drive whereas non-parallel and perpendicular shafts are connected by means of gears to transmit power.

8.4.1 Forms of gears

There are different forms of gears namely

1. Spur gear
2. Helical gear
3. Bevel gear
4. Rack and pinion gear
5. Worm and Worm gear

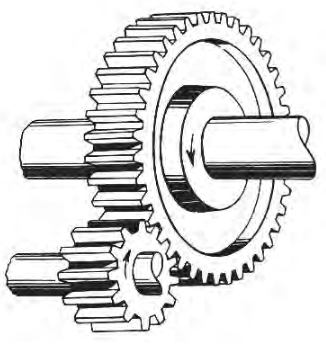


Fig. 8.3 Spur gear

Spur gear

Spur gears have their teeth elements parallel to the rotating shafts. These gears are used to transmit power between parallel shafts. A small sized gear is called pinion.

Helical gears

If the teeth elements are twisted or helical, they are known as helical gears. These gears may be used for connecting shafts that are at an angle in the same plane or in different planes. They are smooth acting because there will always be more than one tooth in contact. Depending upon helix, the helical gears are classified as right hand type or left hand type.

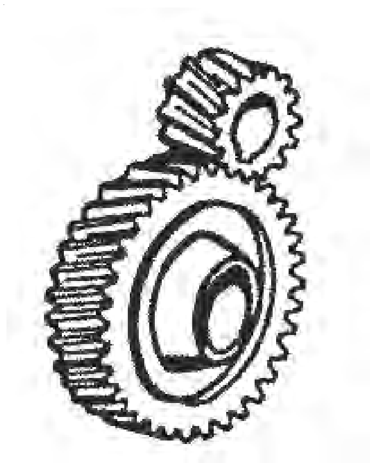


Fig. 8.4 Helical gear

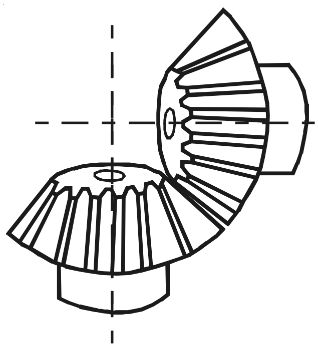


Fig. 8.5 Bevel gear

Bevel gears

The power is transmitted between two shafts which are at right angles through bevel gears. It is in the shape of a truncated cone having all the teeth elements on the conical surface. When the connected shafts are right angles and the bevel gears have same number of teeth, the gears are known as miter gears.

Rack and pinion gears

This type of gear is used to convert rotary motion into linear motion or vice versa. The rack gears are straight and flat and have no curvature. This mechanism is used in lathe and drilling machine.

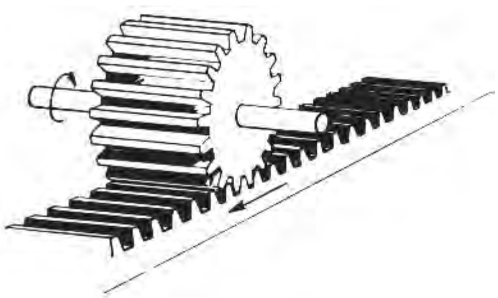


Fig. 8.6 Rack and pinion gear

Worm and worm gear

Worm and worm gear are used to transmit power between two perpendicular shafts. Worm may be single threaded or multi threaded. The worm gear resembles a spur gear. In this gearing the worm will always be the driver. This gearing is used where a large speed reduction is desired. It is useful in indexing head, lifts, rotary table and in the apron of lathe.

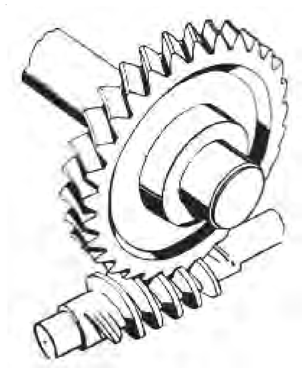


Fig. 8.7 Worm and worm gears

8.4.2 Gear drive

It is possible to drive shafts that are parallel or intersecting by the use of gearing arrangement. Gear drive is used where moderate to large amount of power is to be transmitted at constant velocity ratio. If the driving gear rotates in the clockwise direction, the follower will rotate in the anti-clockwise direction. The velocity ratio of a gear drive depends on the number of teeth present on the driving gear and the driven gear or the pitch diameter of the driving and driven gears.

8.4.3 Velocity ratio of gear drive

Velocity ratio of a gear drive is the ratio of number of revolutions of driven shaft or driven gear to the number of revolutions of driving shaft or driving gear in a particular time.

If N1 and N2 are the number of revolutions of driver and follower and T1 and T2 are the number of teeth on the driving gear and the driven gear.

$$\text{Velocity ratio} = \frac{N2}{N1} = \frac{T1}{T2}$$

Example

If a gear having 24 teeth rotates at a speed of 450 rpm. in clock-wise direction, what will be speed and direction of rotation of a gear having 36 teeth which is in mesh with the first one ?

T1 = 24 teeth   N1 = 450rpm   T2 = 36 teeth

$$\text{Velocity ratio} = \frac{T1}{T2} = \frac{N2}{N1}$$

$$\text{Velocity ratio} = \frac{24}{36} = \frac{N2}{450}$$

$$N2 \times 36 = 450 \times 24$$

$$N2 = (450 \times 24) / 36 = 300 \text{ rpm}$$

The second gear will rotate at 300 rpm in anti-clockwise direction

8.4.4 Simple gear train

If a gear train is arranged by keeping only one gear on a shaft, it is called simple gear train. The net velocity ratio of the gear drive is determined by the number of teeth present on the first and the last gears of the drive. To get higher velocity ratio simple gear train is not suitable. The intermediate gears of the drive are used only to fill the gap between the driving shaft and the driven shaft. It is also useful in changing the direction of rotation of the follower with respect to the driver.

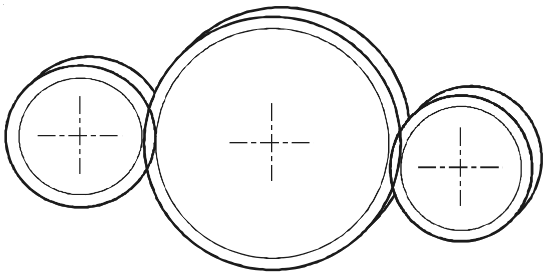


Fig. 8.8 Simple gear train

Example

Gears A,B,C and D are connected by a simple gear train. The number of teeth on them are 80,50,60 and 40. If the gear D rotates at a speed of 320rpm in clock-wise direction, what will be the speed of the gear A ?

TA = 80teeth ; TB = 50teeth ; TC = 60teeth ; TD = 40teeth ;

ND = 320rpm.

Velocity ratio = NA ÷ ND = TD ÷ TA

$$\text{Velocity ratio} = \frac{NA}{ND} = \frac{TD}{TA}$$

$$NA = (TD \div TA) \times ND$$
$$= (40 \div 80) \times 320$$
$$= 160 \text{ rpm}$$

8.4.5 Compound gear train

If the gear drive is arranged by keeping more than one gear on a shaft, it is called compound gear train. The net velocity ratio of the gear drive is influenced by the intermediate gears also. So it is possible with a compound gear train to attain a higher velocity ratio in limited space. The direction of rotation of the follower with respect to the driver is determined by a number of intermediate gears on separate shafts.

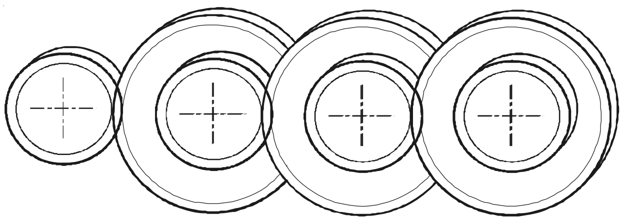


Fig. 8.9 Compound gear train

Example

A compound gear train is arranged in which the driving shaft A rotates shaft C through intermediate shaft B. The gear on shaft A has 30 teeth which rotates at 1200 r.p.m. in clock wise direction. It meshes with a gear of 90 teeth on shaft B. This shaft has another gear with 40 teeth which meshes with a gear on shaft C. What is the speed and direction of rotation of the gear on shaft C which has 60 teeth?

TA = 30 teeth ; TB1 = 90 teeth ; TB2 = 40 teeth ; TC = 60 teeth

NA = 1200 ; NB1 = ? NB2 = ? NC = ?

$$\text{Velocity ratio} = \frac{NA}{NB1} = \frac{TB1}{TA}$$

$$NB1 = \frac{TA \times NA}{TB1} = \frac{30 \times 1200}{90} = \frac{36000}{90} = 400 \text{ r.p.m.}$$

$$NB2 = NB1 = 400 \text{ r.p.m.}$$

$$NC = \frac{TB2 \times NB2}{TC} = \frac{40 \times 400}{60} = \frac{16000}{60} = 266.66 \text{ r.p.m.}$$

The driven shaft will rotate at 266.6 rpm in clockwise direction.

QUESTIONS

I. A. Choose the correct option

1. Power is transmitted between shafts at moderate distance by
   a. belt drive b. gear drive c. chain drive d. friction drive

2. The diameter of the driving pulley is 200cm. The velocity ratio of the drive is 4. The diameter of the driven pulley is
   a. 100cm b. 25cm c. 40 cm d. 50cm

3. Velocity ratio of a gear drive is
   a. N1D1 = N2D2 b. NT-NA/NTX100 c. T1/T2 = N2/N1 d. r.p.m.

B. Answer the following questions in one or two words.

1. Expand r.p.m.
2. What are the types of belt drive?
3. Mention any two forms of gears.
4. What is a idle gear?

II. Answer the following questions in one or two sentences

1. What are methods by which power can be transmitted?
2. What is belt slip?
3. What are the types of gear train?
4. What is rack and pinion?

III. Answer the following questions in about a page

1. Explain power transmission by a belt drive.
2. Explain velocity ratio.
3. Draw a simple gear train and explain.
4. Draw a compound gear and explain.

IV. Answer the following questions in detail

1. Explain open belt drive with a diagram.
2. Crossed belt drive – draw and explain.

9. HYDRAULICS

9.1 Introduction

The volume of a liquid can not be changed by applying pressure. This quality of liquids forms the base of study of Hydraulics. Hydraulics in general means the study of water but industrial hydraulics involves the projects based on different types of oils. In modern metal working plants, hydraulic pressure is being used to operate practically every type of machine tool. So the hydraulic liquid is the working medium used in hydraulic circuits. This is due to the simplicity of the method of applying power and to the smoothness of operation that can be obtained.

9.2 Properties of fluids

The following are the important properties of fluids

1. Density
2. Pressure
3. Specific weight
4. Specific volume
5. Relative density
6. Compressibility
7. Viscosity

9.2.1 Density

Density of a fluid can be defined as the mass per unit volume.

Density = Mass / Volume

The unit of density is Kg/m^3

9.2.2 Pressure

The force acting on a unit area of a plane is the pressure of the liquid.

Pressure = Force / Area

The unit of pressure is Newton / m^2 (N/m^2) or Pascal.

The pressure at a point in a static liquid depends upon the depth and the density of the liquid. The pressure increases with the depth.

9.2.3 Specific weight

Specific weight of a fluid can be defined as the weight per unit volume.

Specific weight = weight / volume

The unit of specific weight is N/m^3

9.2.4 Specific volume

Specific volume of a fluid can be defined as the volume per unit mass.

Specific volume = volume / mass

The unit of specific volume is m^3/Kg.

It can be seen as the reciprocal of density.

9.2.5 Relative density

Relative density of a liquid can be defined as the ratio of the density of the liquid and the density of water.

Relative density of the liquid = Density of the liquid / Density of water

Since it is the ratio between the densities of two liquids, this quantity has no unit.

9.2.6 Compressibility

Compressibility of a liquid can be defined as the property of changing its volume under the influence of pressure. However, the change in volume of a liquid under pressure is very small and liquids are generally incompressible fluids.

9.2.6 Viscosity

Viscosity can be defined as the resisting quality of the liquid against its flow. If the temperature increases, the viscosity of a liquid decreases.

9.3 Hydraulic system

An Hydraulic system is one in which the power is transmitted from one place to another through the medium of an incompressible fluid called oil. Various actions in industries take place with hydraulic systems by utilising hydraulic power.

9.3.1 Pneumatic system

If the medium of oil is replaced by compressed air, the system is called pneumatic system. In modern machineries, various actions of machine tools and automatic machines take place using hydraulic or pneumatic systems.

9.4 Characteristics of hydraulic liquids

1. The main requisite of the hydraulic liquid is to transmit energy.
2. It should be lubricating
3. It should have an easy flow
4. The liquid should not easily be changed in to a solid or a gas.
5. It should not be inflammable.
6. It should be easily available at low cost.
7. It should not easily be oxidized.
8. It should be non – corrosive.
9. The viscosity index of the oil should be high.

Oil having all the above characteristics is very rare. Suitable oils are prepared by mixing various chemicals for this purpose. Oils having different hydraulic properties are available in market.

9.5 Advantages of hydraulic drive over mechanical drive

1. The heat generated during power transmission in the bearings and the moving parts are carried away by the oil itself. So the system does not require any cooling arrangements.

2. Highly efficient and makes minimum noise.

3. It is more compact and eliminates the complicated linkages like gears, cams and levers.

4. It does not require any lubricating as the result of wear and tear because the moving parts are very less compared to a mechanical drive.

5. The hydraulic system components are connected by pipelines. Hence it provides flexibility in locating the components at any desired place.

6. By varying the quantity of oil flow by means of a valve, any amount of speeds can easily be obtained.

7. The oil used in the system provides cushioning effect for the shock loads and so the life of the components is increased.

8. Very large forces can easily be obtained and force multiplication is also possible with minimum loss of energy.

9. Whenever the hydraulic system is overloaded, the pressure is immediately relieved. So the system components are protected against breakages and over strains.

10. The hydraulic oil is incompressible. Hence the system is very sensitive far instantaneous operations. So back lashes experienced in mechanical system will not exist in hydraulic system.

11. The system requires very simple maintenance care.

12. The system provides quick return motion of components with simple arrangements. So the idle time of machining operations is reduced.

13. The hydraulic system provides very high degree of dependability.

14. It is advisable to have hydraulic devices where there are chances for electrical accidents.

15. As the cutting action is smooth and steady, the tools last longer.

16. The hydraulic energy can be transformed into different types of work which require rotational, linear, continuous and intermittent movements. These movements can be had at constant speed or at variable speeds.

9.5.1 Disadvantages of hydraulic drive

1. There is always a possibility of leakage of oil. This will attract dust and the shop will present an ugly outlook.

2. The hydraulic system should be maintained with maximum care. The failure to do so will lead to the breakdown of the system.

3. The pressure of the oil passing through the circuit is very high. Accidents will take place if any break of circuit takes place.

4. The leakage of the oil will lead to fire accidents at times.

9.5.2 Advantages of pneumatic drive

1. Air is available in large quantities at free of cost.

2. Pneumatic drive does not hamper the environment.

3. Pneumatic circuits are simple to establish and they are cheaper.

9.5.3 Disadvantages of pneumatic drive

1. Pneumatic drive involves air under very high pressure and so it may cause failures because of sudden change of pressure.

2. Heat is generated in machine elements

9.6 Hydraulic pipelines

The pipelines used in hydraulic circuits should be strong and the inner surface of the pipes should be smooth. It should be of sufficient diameter and be able to withstand shock loads.

9.6.1 Materials used in making hydraulic pipelines

1. Steel 2. Plastic 3. Rubber

9.7 Hydraulic safety devices

When hydraulic equipments are in operation, the pressure of the liquid will not remain constant. The change of pressure may be a uniform increase or uniform decrease. The changes may also be sudden. But at the same time the pressure of the circuit should not exceed a predetermined value. If the pressure goes beyond the desired limit, it will cause damage to the circuit and make it inactive. So, proper safety devices should be added to the circuit.

Hydraulic fuse, pressure relief valve, shock absorber, and accumulator are some of the safety devices used in a hydraulic circuit.

9.7.1 Hydraulic fuse

Hydraulic fuse is a thin sheet placed inside a chamber. It will withstand only the optimum pressure of the circuit. When the pressure exceeds the desired limits the sheet tears and the oil is made to flow back to the reservoir. In this case, a new valve has to be put in the place of a damaged one.

9.7.2 Pressure relief valve

Pressure relief valve is a device used to control the pressure in the hydraulic circuit at a desired limit to protect the circuit. Pressure relief valve is directly connected to the hydraulic circuit. It has got a globe like valve attached to a spring. The tension of the spring can be altered according to the need with the help of a screw. The globe like valve prevents the oil to pass through the bypass entry due to the pressure exerted by the spring. If the pressure in the circuit exceeds the desired limit, the valve opens to allow the oil to pass through the bye pass back to the reservoir. By this, the pressure of the circuit is brought back to the desired limit.

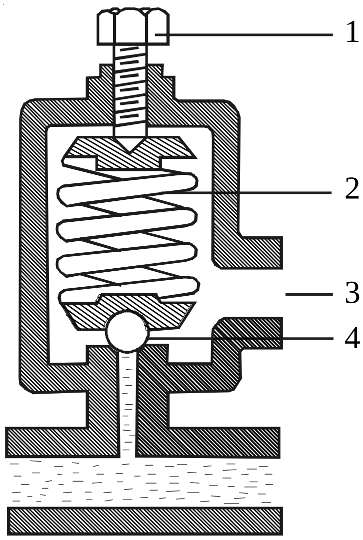


Fig 9.1 Pressure relief valve

1. Screw 2. Spring 3. Bye pass 4. Value

9.7.3 Hydraulic accumulator

The accumulator is used to preserve a good amount of hydraulic liquid in itself and to provide the flow of oil when necessary. Though it cannot be classified as a safety device, it can be utilized as a shock absorber. When the flow of oil in the circuit is required to be minimum the surplus oil is preserved in the accumulator. When additional amount of oil is needed, the accumulator provides the same to the circuit.

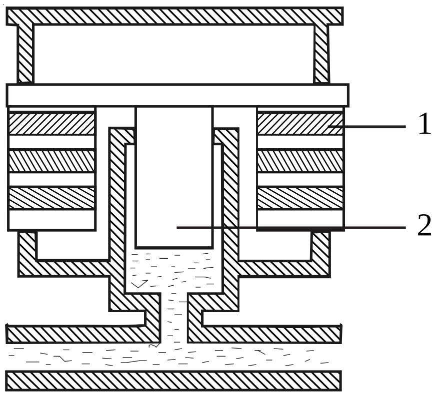


Fig 9.2 Hydraulic accumulator
1. Weight 2. Ram

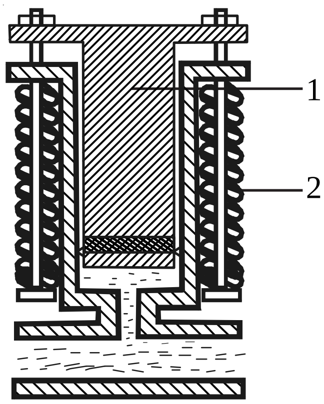


Fig 9.3 Hydraulic shock absorber
1. Ram 2. Spring

9.7.4 Hydraulic shock absorber

Pressure in a hydraulic circuit will experience a sudden surge, fall or shock due to opening and closing of valves and the change of volume of the liquid in the circuit. If the same is allowed to happen continuously, the circuit will get damaged. To adjust such pressure fluctuations and absorb the shocks, shock absorbers are connected to the circuit as shown in the diagram. It prevents the circuits from being damaged.

9.7.5 Emergency cut-off valve

When the pressure of the hydraulic liquid in the circuit goes beyond controllable limits and when, the motor, which is used to operate the hydraulic pump, consumes excessive electric current, the emergency cut off valve comes into operation to switch off the motor.

The emergency cut off valve is positioned between the hydraulic pump and the primary control valve. If the pressure relief valve in the circuit fails to function, the pressure in the circuit goes beyond limits. It will make the pipelines of the circuits to break. So it is necessary that the emergency cut off valve is positioned between the hydraulic pump and the primary control valve to switch off the motor of the hydraulic pump.

9.8 Basic hydraulic circuit

The hydraulic liquid is pumped by a hydraulic pump through the filter from the reservoir. The pressure of the liquid can be known with the help of a pressure gauge. If the pressure in the circuit is above the desirable value, a pressure relief valve connected to the circuit releases the excessive pressure. The high-pressure liquid reaches the four-way plunger valve (selector valve) through the inlet. The diagram shows the plunger in neutral position. In this position the inlet P is disconnected from the outlets A and B. So the pumped oil goes back to the reservoir.

If the plunger in the selector valve is pushed to the left position the inlet P and outlet A are connected and so are B and drain E. The high-pressure liquid pushes the piston in the forward direction. The oil present on the right side of the piston reaches the reservoir through B and E.

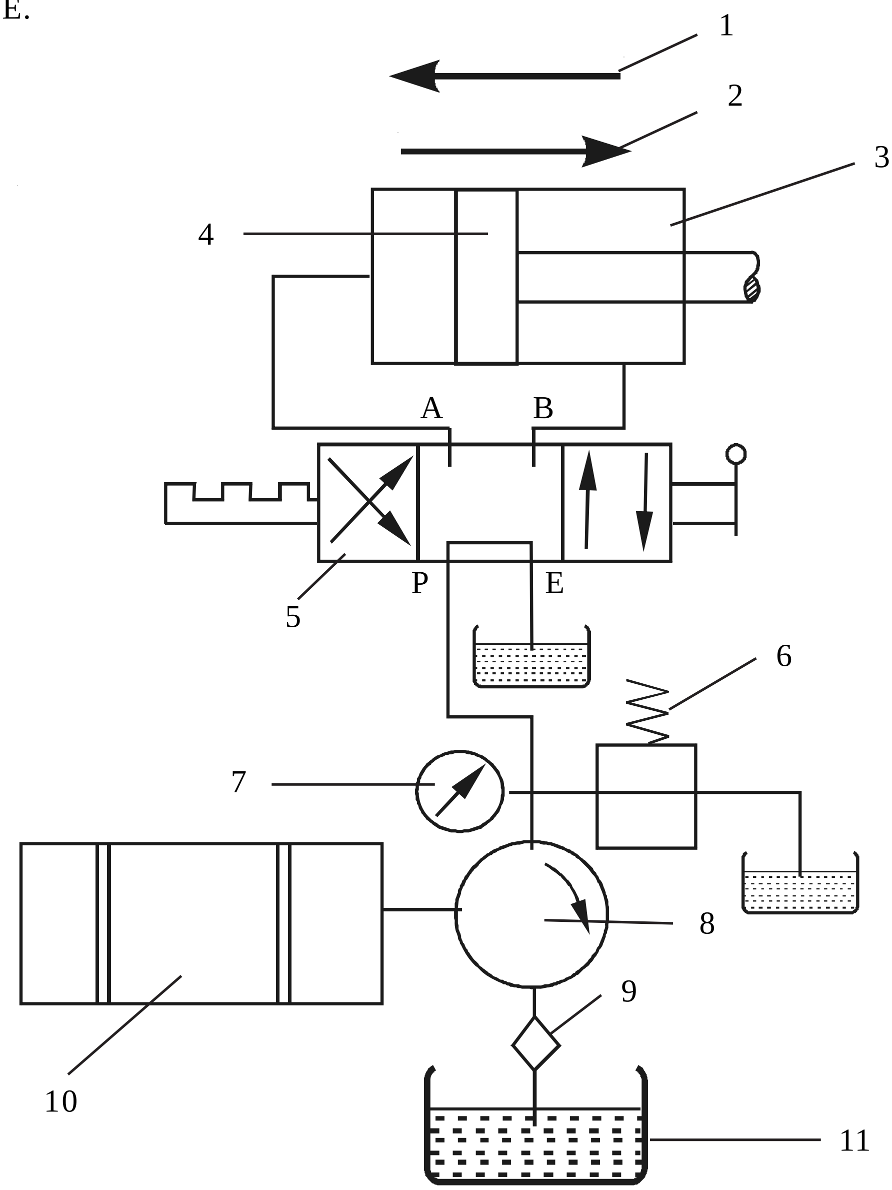


Fig 9.4 Basic hydraulic circuit

1.Forward stroke 2. Return stroke 3. Cylinder 4. Piston 5. Direction control valve 6. Pressure relief valve 7. Pressure gauge 8. Pump 9. Filter 10. Motor 11. Reservoir

If the position of the plunger is altered to the right side P and B & A and E are connected. High-pressure oil passes through B to push the piston in the opposite direction. The oil present on the other side of the piston reaches the reservoir through A and E.

QUESTIONS

I. A. Choose the correct option

1. Mass per unit volume is
   a. density b. pressure c. specific volume d. viscocity

2. The unit of pressure is
   a. m^2 b. N/m^2 c. m^3 d. None of the above

B. Answer the following questions in one or two words

1. State two characters of hydraulic liquids.
2. Mention an advantage of pneumatic circuits.
3. Mention any one material used to make hydraulic pipeline.

II. Answer the following questions in one or two sentences

1. What is hydraulics?
2. What is hydraulic fuse?
3. What is pressure relief valve?
4. What is a hydraulic shock absorber?
5. What do you mean by an hydraulic system?
6. Mention four hydraulic safety devices.

III. Answer the following questions in about a page

1. Mention various characters of hydraulic liquids.
2. Draw and explain a hydraulic accumulator.
3. Hydraulic shock absorber – Draw and explain.

IV. Answer the following questions in detail

1. Draw and explain the functioning of a pressure relief valve.
2. What are the advantages and disadvantages of hydraulic drive?
3. Draw and explain a basic hydraulic circuit.

10. ELECTRICITY

10.1 Introduction

Matters are in three states – solids, liquids and gases. All these matters are made up of minute particles known as molecules. Several atoms make up a molecule. According to electronic theory, atoms are made of positively charged particles known as protons, negatively charged particles known as electrons and uncharged particles - neutrons. Electricity is - energy made available by the flow of electric charges (electrons & protons) through a conductor.

In this modern era, this power of electricity moves and operates the world- to operate all the machines and every movements that take place in it.

10.2 Voltage, Current and Resistance

10.2.1 Voltage

The force or pressure between opposite potentials of charged atoms are called voltage or potential difference (PD). In the case of D.C., it is the potential difference between the positive and negative terminals. In A.C., it is the potential difference between the phase and neutral terminals. The unit of voltage is Volt and V denoted by the letter 'V'.

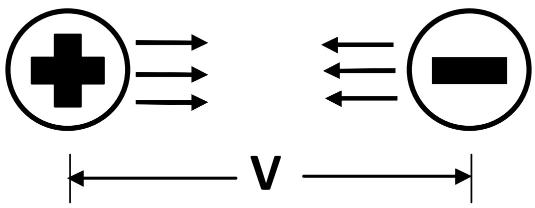


Fig 10.1 Voltage

Volt :

A volt is the amount of potential difference required to pass one Ampere of current through a conductor with a resistance of one Ohm.

10.2.2 Current

The flow of electrons across the cross section of a conductor is known as Current. The unit of current is Ampere and is denoted by the letter 'A'.

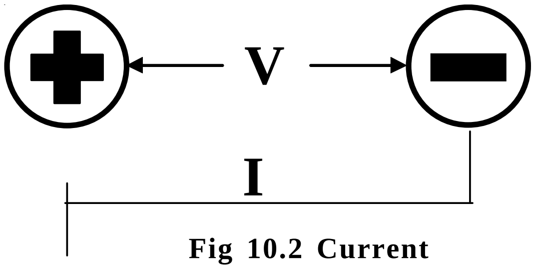


Fig 10.2 Current

Ampere

It is the amount of current passing through the cross section of a conductor if one Coulomb of electricity is allowed to pas through the conductor.

I = **Q** / t Ampere

Where I – Current in Amperes

Q – Electricity in Coulombs

t – time

10.2.3 Resistance

The property of a material to oppose the flow of electrons through it is known as Resistance. The unit of resistance is Ohm and is denoted by the letter 'R'.

R, Resistance = *l* L /A

Where

l - the specific resistivity in ohm- meter

L - length of material in meter

A - area of the material in m^2

Also the resistance is depends on the temperature of co-efficient of the material.

10.3 Ohm's law

The current passing through a conductor under constant temperature is directly proportional to the potential difference across the conductor and indirectly proportional to the resistance of the conductor.

I = V / R ; R = V / I ; V= IR

Where I - Current

V - Voltage

R - Resistance

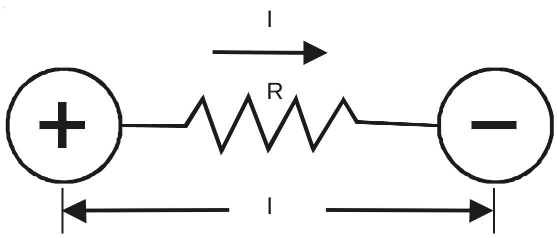


Fig 10.3 Ohm's Law

10.4 Electric circuit

It is a complete closed path which allows electricity to pass from a source through the conductors.

10.4.1 Series circuit

When a circuit is made up of two or more resistances connected in series, it is known as series circuit.

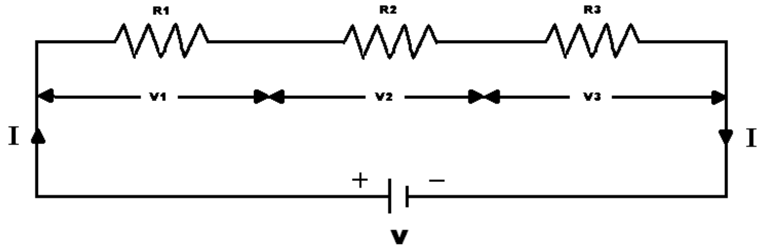


Fig 10.4 Series circuit

$V = V_1 + V_2 + V_3$ $\quad$ $R = R_1 + R_2 + R_3$ $\quad$ I = Same for all elements.

10.4.2 Parallel circuit

When two or more resistances are connected parallel to each other with same starting and end points, the circuit is known as parallel circuit.

$V = V_1 = V_2 = V_3$

$I = I_1 + I_2 + I_3$

$R = 1/R_1 + 1/R_2 + 1/R_3$

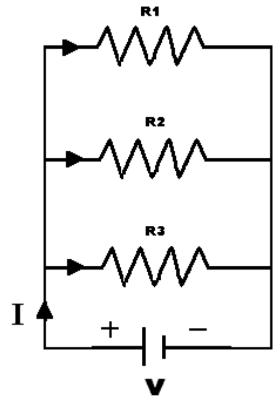


Fig 10.5 Parallel circuit

Example 1

Calculate the total resistance of a circuit with three resistances connected in series with the source of 36 V with reference to Fig 10.6

R_1 *= 4 Ohms ;* $\quad$ R_2 *= 8 Ohms ;* $\quad$ R_3 *= 12 Ohms*

$R = R_1 + R_2 + R_3$

$= 4 + 8 + 12$

$= 24$ Ohms

$I = V/R$

$= 36/24 = 1.5$ A

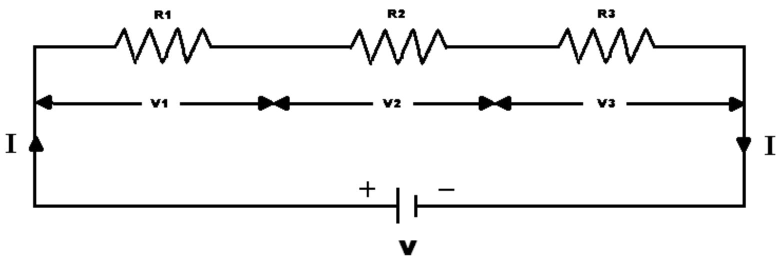


Fig 10.6

Example 2

Calculate the total resistance of the circuit connected with three resistances in parallel as in fig with the source of 36V. Also calculate the current passing through each resistances with reference to Fig 10.7

R_1 = 4 Ohms ; R_2 = 6 Ohms ; R_3 = 12 Ohms

$1/R = 1/R_1 + 1/R_2 + 1/R_3$

$= 1/4 + 1/6 + 1/12$

$= 1/2$

$R = 2$ Ohms

$I_1 = V/R_1 = 36/4 = 9A$

$I_2 = V/R_2 = 36/6 = 6A$

$I_3 = V/R_3 = 36/12 = 3A$

$I = I\text{-}_1 + I_2 + I_3$

$= 9+6+3 = 18A$

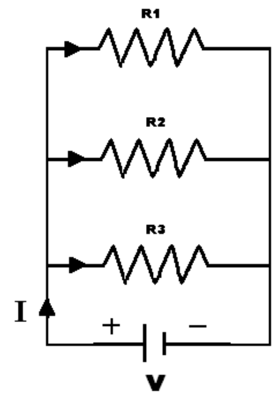


Fig 10.7

Example 3

Calculate the effective resistance of the following combination of resistances connected in series and parallel between point A and C with reference to Fig 10.8

V= 60V; R_1= 3 Ohm; R_2= 6 Ohm; R_3= 18 Ohm

R between AB (parallel)

$1/R_{AB} = 1/R_1 + 1/R_2$

$= 1/3 + 1/6$

$R_{AB} = 2$ ohm

R between AC (series)

$R_{AC} = R_{AB} + R_3$

$= 2+18$

$= 20$ ohm

Total circuit current

$I = V/R = 60/20 = 3A$

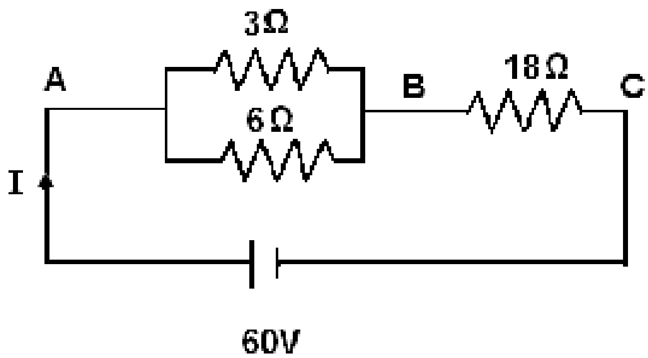


Fig 10.8

10.5 Kirchhoff's laws

Kirchhoff's laws are used in determining the equivalent resistance of a complex network and the current flowing in various conductors. There are two laws namely

1. First law or Current law
2. Second law or Voltage law

10.5.1 First law or Current law

The algebraic sum of the currents at any junction of a network is zero. In other words, the sum of the currents flowing towards a point is equal to the total current flowing away from it.

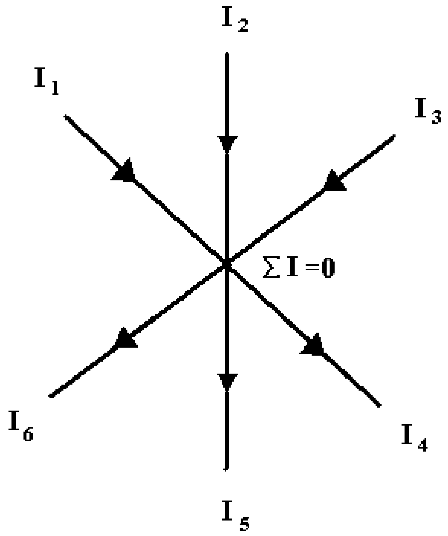


Fig 10.9 Kirchhoff's First Law

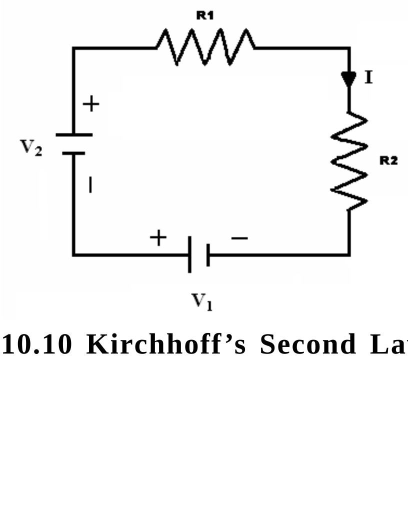
(At a junction, the incoming currents are equal to the out going currents)

$$I_1 + I_2 + I_3 = I_4 + I_5 + I_6$$

$$I_1 + I_2 + I_3 - I_4 - I_5 - I_6 = 0$$

10.5.2 Second law or Voltage law

In any closed electric circuit, the algebraic sum of potential drops is equal to the sum of impressed e.m.fs.



$$V_1 + V_2 = I R_1 + I R_2$$

$$V_1 + V_2 - IR_1 - I R_2 = 0$$

Fig 10.10 Kirchhoff's Second Law

10.6 Power and energy

10.6.1 Power

Power is the rate of doing work.

P= W/t

where P – power

W – work done

t – time

Power in an electric circuit is

P = V x I

V – voltage

I - current

The unit of power is Watt.

10.6.2 Energy

Energy may be defined as the capacity to do work. It is the power utilized for a particular time.

Electric energy = electric power x time

The unit of energy is Watthours. It may also be expressed in KiloWatthour.

One unit of energy is 1 KiloWatthour.

1 H.P = 735.5 Watts

10.7 Magnetism

Magnet is a substance having a property of attracting things made of Iron and its alloys. The magnet has two poles. When a magnet is suspended, it comes to rest by pointing North and South directions. The end pointing towards North is called North pole and the other end pointing South is known as South pole. The attraction takes place between opposite poles and the like poles repel.

10.7.1 Electromagnetism

Electromagnet is a device consisting of a laminated core and a coil which produces appreciable magnetic flux only when an electric current flows through the coil. The science which deals with the relation between electricity and magnetism is known as electromagnetism.

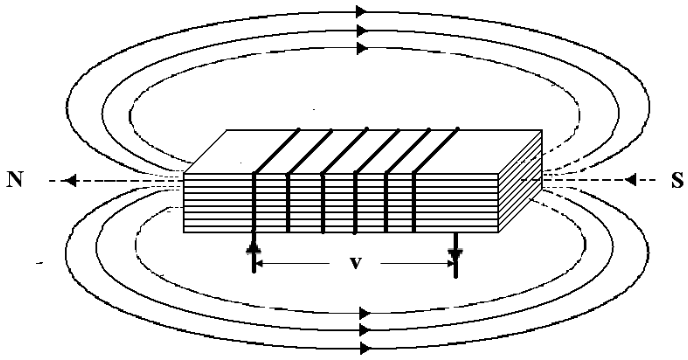


Fig 10.11 Electromagnetism

10.7.2 Magneto-Motive Force

It is the difference of magnetic potential which maintains a magnetic flux in a magnetic circuit. The unit of MMF is Gilbert. In M.K.S. System the unit is Ampere Turns (AT).

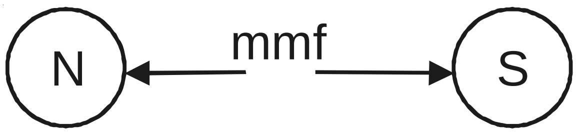


Fig 10.12 Magneto-motive force

10.7.3 Magnetic Flux

Magnetic flux is a group of lines of force crossing the space of a magnetic field. It is denoted by ϕ.

The unit of Magnetic flux is Weber in M.K.S. system and Maxwell in C.G.S. system.

10.7.4 Flux Density

Flux density is the number of lines of magnetic flux per unit area. It is denoted by the letter 'B'.

10.7.5 Magnetic Intensity

Within the magnetic field, the intensity at any point will be measured by the source felt by the N pole of one Weber placed at that point. It is denoted by H.

10.7.6 Permeability

It is the ratio of the magnetic flux produced by a given magnetic force of the material to the magnetic flux which would be produced by the same magnetic force in a perfect vacuum. There are two types of permeability namely

1. Absolute permeability
2. Relative permeability

10.7.7 Reluctance

It is the opposition offered by a magnetic path to the presence of a magnetic flux. The unit of reluctance is AT/wb.

10.8 Electromagnetic induction

A current is induced in a conductor when it is cut by a magnetic flux. It is known as electromagnetic induction. The current so induced is known as electro motive force (e.m.f). The e.m.f induced in the conductor depends upon the strength of the magnetic flux and the speed at which the conductor cuts the flux.

10.8.1 Faraday's laws of electromagnetic induction

First Law

Whenever any conductor is made to rotate in a magnetic field and hence cut the magnetic lines of force or the flux, an electro motive force (e.m.f.) will be induced in that conductor.

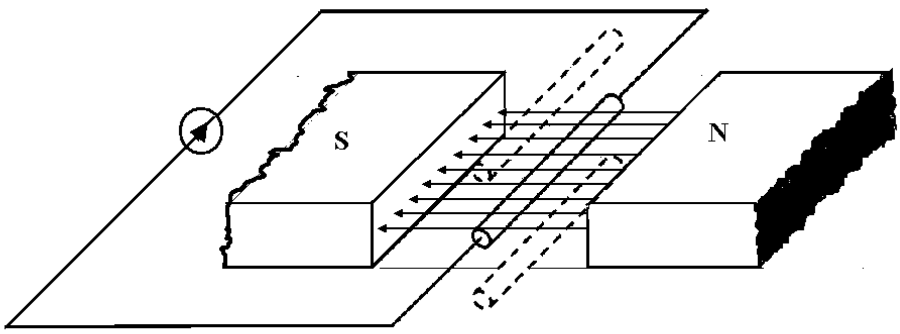


Fig 10.13 Faraday's Laws

Second Law

The magnitude of the induced e.m.f. is directly proportional to the rate of change of flux linked with the conductor.

If the conductor AB has N number of turns and the flux linked with the conductor changes from $\phi_1$wb to $\phi_2$wb in 't' secconds,

the initial linked flux = N ϕ_1 and

the final linked flux = Nϕ_2

Induced e.m.f = Nϕ_1 - Nϕ_2 / t wb / sec

10.8.2 Direction of e.m.f

The relation between the directions of the motion of conductor, the induced e.m.f and the magnetic flux can be explained by Flemming's right hand and left hand rules.

Flemming's right hand rule

If we spread the thumb, forefinger and the middle finger of the right hand mutually at right angles to each other and the thumb is placed in the direction of motion of the conductors and the fore finger in the direction of the magnetic flux, then the middle finger indicates the direction of induced e.m.f.

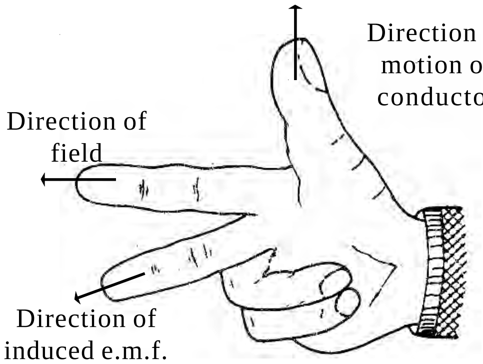


Fig 10.14 Flemming's Right hand Rule

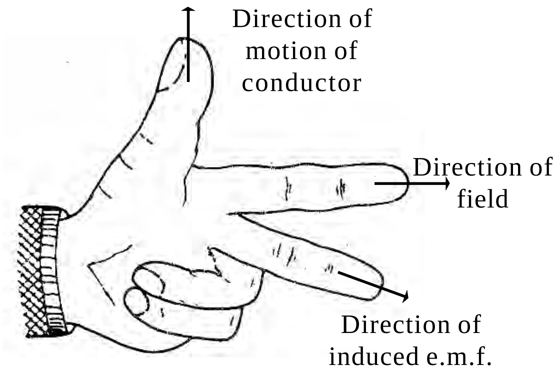


Fig 10.15 Flemming's Left hand Rule

Flemming's left hand rule (for electric motors)

If we spread the thumb, forefinger and the middle finger of the left hand mutually at right angles to each other and the fore finger is placed in the direction of the magnetic flux and the middle finger in the direction of induced e.m.f., then the thumb indicates the direction of motion of the conductors.

10.9 D C and A C fundamentals

10.9.1 D C fundamentals

D.C. means direct current and it is available from positive terminal (anode) and negative terminal (cathode). Current flows as electrons from negative potential to positive potential. D.C is generally produced by chemical processes as in batteries. D.C generators are used for generation of high capacity.

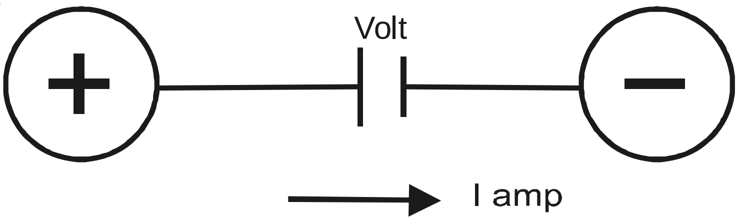


Fig 10.16 D.C current

10.9.2 AC fundamentals

A.C means alternating current. The magnitude and the direction of the current and the voltage alternates continuously.

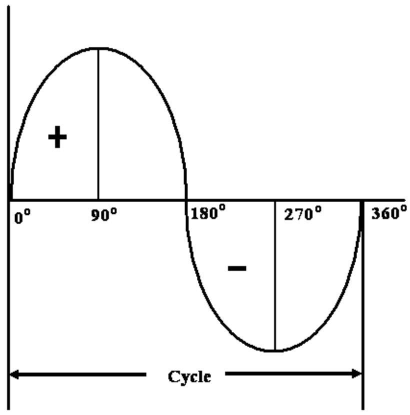


Fig 10.17 A.C current

10.9.3 Cycle

A full change in value and direction of alternating quantity is known as a cycle. The time taken for one cycle is known as period.

10.9.4 Frequency

The number of cycles per second of alternating quantity is known as frequency. It is expressed in cycles per second. Its unit is Hertz (Hz). In India, the standard value of AC system is 50 Hz.

10.10 AC 3 Phase system

The 3 phase AC system can be achieved by the rotation of 3 coils of conductors placed in a magnetic field at 120 ° apart. This system can be operated as delta(three wire) or star(four wire) connection.

Line Voltage (V_L) :

The voltage between any two phases of the system is known as Line Voltage.

$$V_L = V_{RY} = V_{YB} = V_{RB}$$

Line Current (I_L):

The current flowing between any two phases of the windings is called as Line Current.

$$I_L = I_R = I_Y = I_B$$

Phase Voltage (V_P) :

The voltage between any one of the phases and the neutral terminal is known as Phase Voltage.

Phase Current (I_P) :

The current flowing through any one of phase winding is called as Phase Current.

10.10.1 Delta System

$V_L = V_P = V_{RY} = V_{YB} = V_{RB}$

$I_P = I_R = I_Y = I_B$

And $I_P = I_L\sqrt{3}$

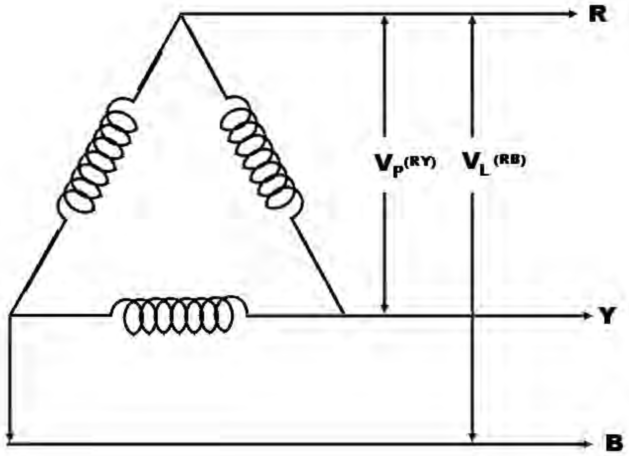
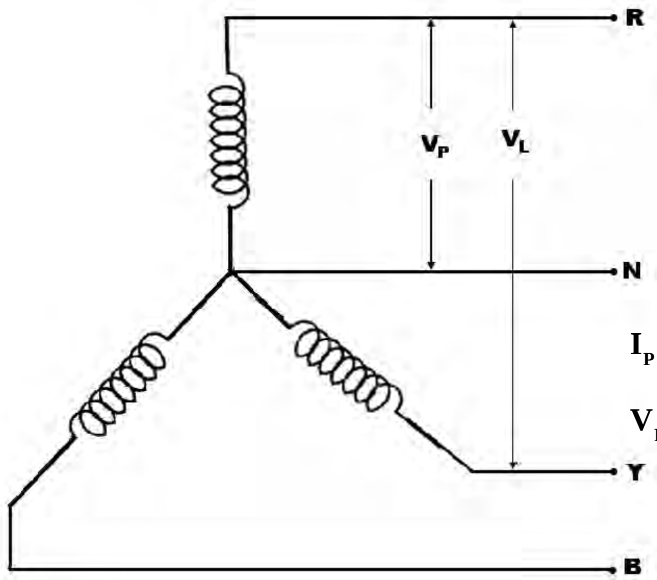


Fig 10.18 Three phase Delta system

10.10.2 Star System



$I_P = I_L = I_R = I_Y = I_B$

$V_P = V_L\sqrt{3}$ ($V_{RN} = V_{YN} = V_{BN} = V_P$)

Fig 10.18 Three phase Star system

10.10.3 Comparison of Star and Delta systems

Delta	Star
$V_L = V_P$	$V_P = V_L\sqrt{3}$
$I_P = I_L\sqrt{3}$	$I_L = I_P$

10.11 Differences between DC and AC systems

DC SYSTEM

1. 

2. The voltage increases from “ 0” to higher potential
3. It is direct current system
4. There is no frequency
5. The current will be spent only when connected to load
6. It is only one voltage system
7. It has the polarity system

AC SYSTEM

1. 

2. It has instantaneous potential refered to Vm and instant of phase angle with RMS
3. It is the alternating current system
4. It has the frequency in the system
5. It has the reactive load with resistance ,inductance and capacitance (RLC load)
6. It has multiple phase system with three phase star , three phase delta and single phase system
7. There is no polarity in the system

QUESTIONS

I. A. Choose the correct option

1. The unit of current is
   a. Volt b. Watt c. Ampere d. Ohm

2. The unit of voltage is
   a. Watt b. Weber c. Volt d. Gilbert

3. The unit of resistance is
   a. Meter b. Ohm c. Watthour d. Coulomb

4. The unit of power is

a. Volt b. Ampere c. Watt d. Ohm

5. The frequency of A.C current is

a. 50 c/s b. Volt c. Coulomb d. Meter

I. B. Answer the following questions in one or two words

1. What type of circuit has equal current in all its elememnts?
2. What type of circuit has equal voltage in all its elememnts?
3. How is Kirchhoff's first law otherwise known as?
4. How is Kirchhoff's second law otherwise known as?
5. 1 HP = ...
6. Expand - mmf.
7. Expand - emf.
8. How is D.C current generally generated?
9. Mention the two methods of connection in A.C three phase supply.
10. Differentiate 'Star' and 'Delta'.

II. Answer the following questions in one or two sentences

1. What is electric current?
2. What do you mean by Resistance?
3. State Ohm's law.
4. What is Flux density?
5. What is Permeability?
6. State Faraday's first law.
7. State Faraday's second law.

III. Answer the following questions in about a page

1. Series circuit, Parallel circuit – Explain.
2. Explain Kirchhoff's laws with illustrations.
3. Explain Flemming's laws with illustrations.
4. Explain Star and Delta connections with circuit diagrams.
5. Compare D.C with A.C.

11. INDUSTRIAL MANAGEMENT

11.1 Introduction

Over the period of years, industry has shown tremendous growth. The growth of industry has created a sense of competition and became complex. In order to overcome the challenges of modern business, new concepts and techniques of management became inevitable. The system of modern management should be scientific and at the same time it should be humanistic.

In this chapter, we will discuss a very few important aspects of industrial management.

11.2 Plant engineering

A factory or a plant is a place where all raw materials are collected and the end products are manufactured. Capital can be referred to the raw material, the man power and the machineries required.

Plant engineering is a discipline of study about shaping, establishing and enhancing the utility power of the above factors of men, machine and materials.

11.2.1 Plant location

Plant location is an important exercise of selecting a suitable site and area for establishing a new plant or for expanding a existing plant. This is very essential as it decides the operational and capital cost of the product.

11.2.2 Important factors to be considered in selecting a plant location

1. The plant should be located as near as possible to the place where the raw materials are available. This will reduce the cost involved in transportation of the raw material.

2. The location should be conveniently connected by highways and railways.

3. The availability of adequate labour is a important factor.

4. The topography of geography, area of available land, shape of the site and drainage facitlities should be suitable to the needs of the plant. The location should not be prone to floods and earthquakes.

5. Sufficient quantity of quality water should be available near the plant location. It will be useful for drinking and sanitary purpose.

6. Electrical power of adequate strength and necessary fuel should be available at the plant location.

7. The atmosphere of the plant should provide adequate lighting and ventilation facilities.

8. Location of a plant should be selected to avail maximum tax concessions, loan facilities and low power tariff.

9. Proper housing facilities for the employees, presence of hospitals, educational institutions, markets and recreational facilities should also be considered while selecting locations.

10. Presence of related industries near the location is preferable.

11.2.3 Plant Layout

The physical arrangements of buildings, machinery, equipments, workplaces and other facilities for the manufacturing process is known as plant layout. A good plant layout makes the process of production more efficient by providing easier movement of men and materials with minimum handling.

11.2.4 Advantages of a good plant layout

1. Handling of materials and transportation becomes minimum

2. The rate of production increases because of effective use of man and machines

3. Workers feel comfortable with less movement inside the plant

4. The available space is economically and efficiently used

5. Investments on equipments becomes minimum

6. Simple, easy and effective supervision is possible

11.3 Work Study

Work study is a technique to increase the productivity. It is used to find out the reasons for shortfall in the efficiency of the human work and set guidelines for improvement. By increasing production, the cost is reduced and the product reaches more people. Work study aims on the above objective.

Work study is a combination of two techniques namely (i) Method study and (ii) Work measurement.

11.3.1 Method study

Method study is a systematic recording and critical analysis of the method of doing a work. It also proposes a new method of doing the same work in a easy and effective manner to reduce costs.

11.3.2 Work Measurement

Work measurement is a technique to find out the time taken for a qualified worker to finish a specified work at a particular level of performance.

11.3.3 Production and productivity

Production can be defined as a process of manufacturing the required end product from the available raw materials.

Productivity can be defined as a ratio between the output in quantum of wealth and the input of resources of production

$$\text{Productivity} = \frac{\text{Production output}}{\text{input of resources.}}$$

11.3.4 Productivity based on different resources

a. Productivity of land

Let us assume an agriculturist spends Rs. 5000.00 to plant casuarina saplings in his land of 1 acre and earns yields worth Rs. 10000.00

$$\text{Productivity} = \frac{\text{Production output}}{\text{input of resources.}} = \frac{10000}{5000} \times 100 = 200\%$$

We consider another case where the same agriculturist spends Rs. 1000 more for better saplings and better methods of cultivation in the same area and earns yields worth Rs. 15000.00

$$\text{Productivity} = \frac{\text{Production output}}{\text{input of resources.}} = \frac{15000}{6000} \times 100 = 250\%$$

In this case the productivity is increased by 50%

b. Productivity of men

We consider a case of a machinist who works on a milling machine and makes 40 gears a day. By improved methods of work, the same machinist is able to machine 50 gears in a day. The increase in productivity can be calculated as

$$\frac{50 - 40}{40} \times 100 = 25\%$$

Increase in productivity = 25%

c. Productivity of machine

Let us consider a case where an operator works on a drilling machine for 8 hours to make drills on 100 identical workpieces. With the same machine, the operator is able to make drills on 140 workpieces by using jigs and drills with high cutting speeds.

$$\text{The increase in productivity} = \frac{140-100}{100} \times 100 = 40\%$$

11.3.5 Means of increasing productivity

Some important means of increasing the productivity are given below

1. By improving the working conditions
2. By improving the process involved in production
3. By reducing the non- productivity time by work measurement
4. By providing suitable incentives to the workers
5. By proposing better plant maintenance programmes
6. Old and worn out machines should be corrected to make them function as before
7. Men (Workers), Machine and materials should be maintained at the required quantum
8. By providing the operators with new and proper training
9. Layout of the plant and equipments should be improved

11.4 Production Planning and Control (PPC)

Production planning is a process of scheming the production procedures to get the finished products of required quality from the raw mqterials within a prescribed time frame economically.

Production control is a process of making specific arrangements to carry out the procedures outlined by production planning. It should also oversee corrective measures in case of failures in the production process.

11.4.1. Functions of PPC

1. Preplanning : It involves the decisions of the preparatory functions in the production process.

2. Route plan : It is the plan of arranging various activities that take place from the stage of raw material to the finished product.

3. Scheduling : Scheduling is the preparation of a time table to show the time of starting and the time of completing of operations involved in production of each component.

4. Despatching : It is the process of ordering different departments to carry out production process as per the route plan and scheduling.

5. Controlling : It is the process of getting reports from all departments regarding production and taking correcting actions (if necessary).

11.4.2 Importance of PPC

No action will take place in a plant on its own. A worker cannot go on with production process without specific instructions. This important task of arranging specific instructions to the workers to carry out specific tasks at specific time frame with specific materials at specific quantity and quality on specific machines. It is the main duty of the Department of PPC. It is not exaggeration if it is said that PPC is the nerve centre of an industry. PPC ensures the name and reputation of an industry in the society.

11.5 Quality Control

The quality of a product is the fitness of the product regarding its intended purpose. In production process, it is not always possible to maintain the quality for all the number of products. The quality may vary with each piece of the product. It depends on the machine on which it is produced, the tools used, the methods holding tools and workpieces etc., This variation in quality is unavoidable. However, the variations should be within desired limits.

By ensuring quality control, we can look forward to quality productions in future. It can be said that the quality control cannot do anything with the past production. So the action plan deviced to control the quality of the product before the production process is known as quality control.

11.6 Management

With the industrial growth in the twentieth century, new machines, mechanism and production methods have evolved. The field of production has shown a remarkable development. Increased production led to competitions in business. Competition and confusion were the results of new methods of trade. The bosses of the industries were not able to face the competitions and resolve problems arising out of it. In order to resolve these issues, a new set up in governing was found necessary. Separate personal have been appointed to supervise and control the activities of the industries. They are known as managers.

Management can be defined as a system of extracting work from men with full satisfaction of the employer, employee and the common man. It is a process of achieving the objectives of an organisation by directing and controlling the various activities of the involved manpower.

11.6.1 Frederick W. Taylor

Frederick W. Taylor is regarded as the father of 'Scientific management movement.' He laid foundation for modern scientific management between 1880 and 1890. He started his career as a labourer in the Midvale steel company, U.S.A. in the year 1878. He held different positions in the company and later became the Chief Engineer in 1884. He was instrumental in developing new principles of management and wrote a book titled 'The principles of scientific management'

According to F.W. Taylor, scientific management involves the following procedures,

1. Observation	2. Measurement
3. Experimental comparison	4. Formulation of procedure

11.6.2 Henri Fayol

Henri Fayol was a French industrialist. He was a graduate in Mining engineering. He joined as an Engineer in a coal mining company in the year 1860. Later, he became the Managing Director of the company. He retrieved the company from near bankruptcy to set it as a leading coal mining company in France.

Based on his hard work and a successful managing experience, he wrote a book titled "General and Industrial Management". It contained his general management principles. He categorized all the activities of industrial undertakings into six groups. They are

1. Technical activities (Production related)
2. Financial activities (Capital related)
3. Commercial activities (buying material and selling products)
4. Security activities (Protection of properties)
5. Accounting activities (Statistics and stock taking)
6. Managerial activities (plan and control)

11.7 Organisation

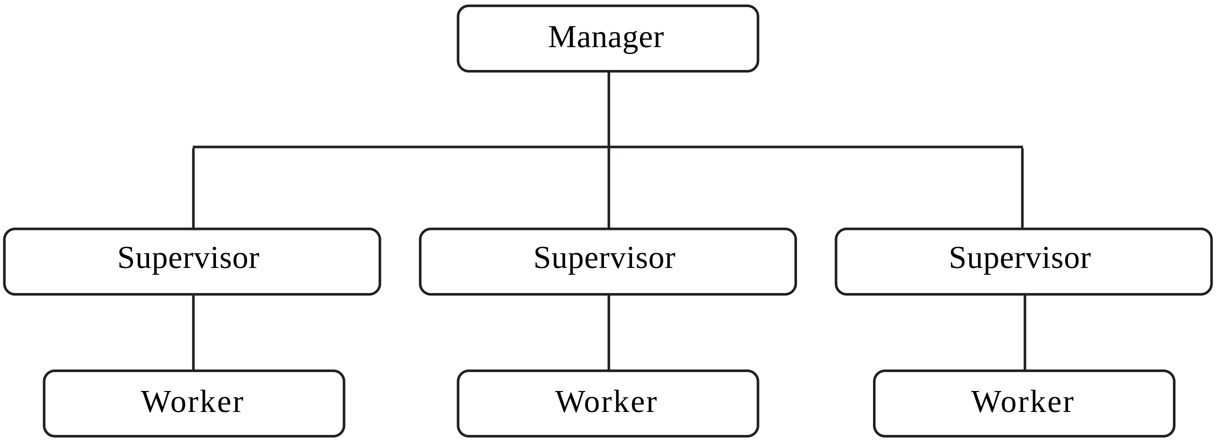
The process of organizing in a industry involves the identification and establishment of its objectives and coordination of the capital, raw material, machines and people to reach out the set objectives. The institution which involves in the process is known as an organisation.

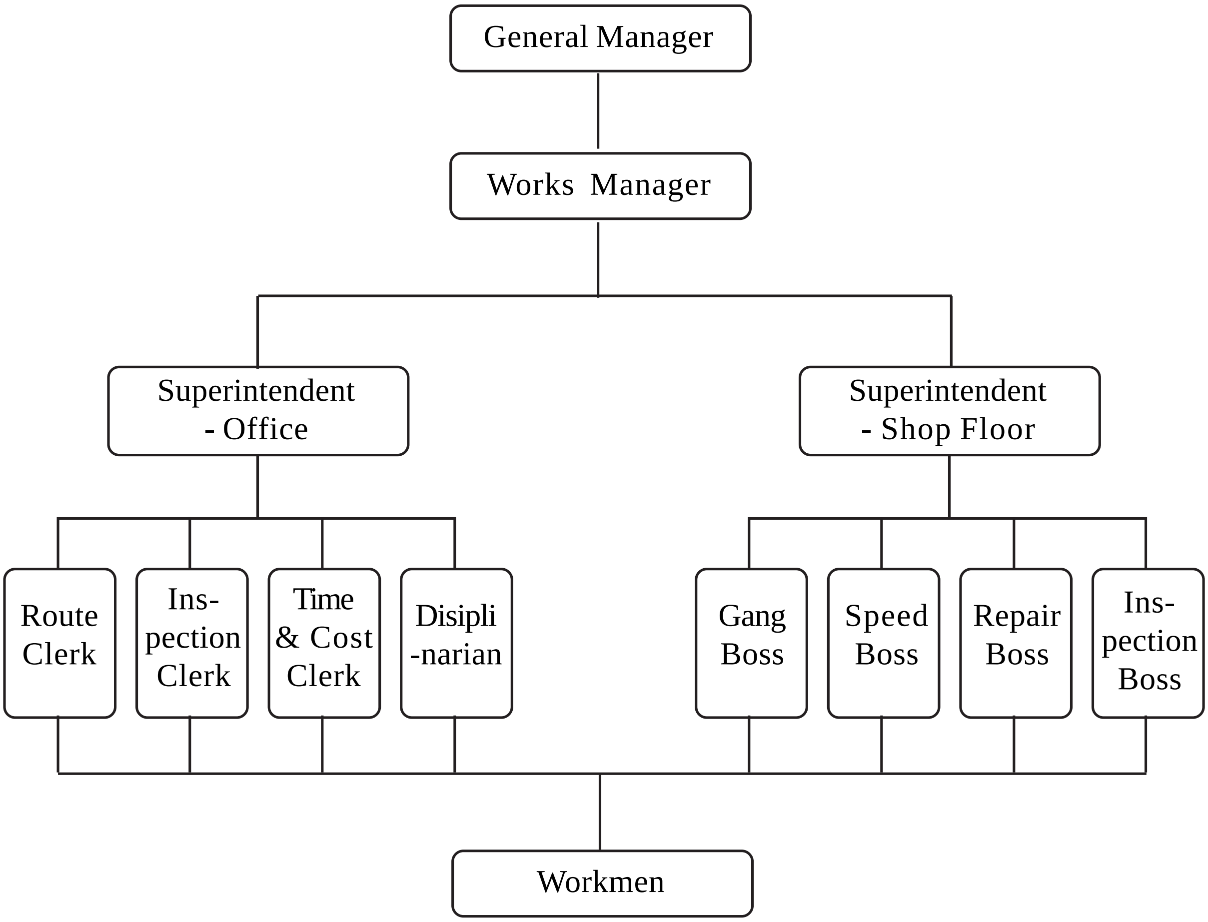
11.7.1 Types of organisation

1. Line Organisation	2. Taylor's functional organisation
3. Line and staff organisation	4. Line and functional staff organisation
5. Committee organisation	

11.7.2. Organisation chart

Organisation chart is a graphical representation of various steps of organisational structure.





QUESTIONS

I. A. Choose the correct option

1. Work study is
   a. a technique of increasing production   b. method of plant layout
   c. method study   d. work measurement

2. Production planning is
   a. Productivity of men   b. Productivity of machine
   c. Scheming of productivity procedures   d. Quality control

3. Father of 'Scientific management movement' is
   a. Henri Fayol   b. Vernier   c. F.W. Taylor   d. James Nasmith

I. B. Answer the following questions in one or two words

1. What is method study?
2. Mention any one method of increasing productivity.
3. Mention any one type of organisation.
4. Who is a manager?

II. Answer the following questions in one or two sentences

1. What is plant engineering?
2. What is plant location?
3. Define – Work study.
4. What is management?
5. What is an organisation?

III. Answer the following questions in about a page

1. Production, Planning and Control – Explain.
2. Explain 'Quality control'.
3. List out the types of organisation.
4. What are the advantages of a good plant location.

IV. Answer the following questions in detail

1. What are the factors to be considered in selecting a plant location?
2. Explain the methods of increasing productivity.
3. Draw a sample organisation chart.

12. COST ESTIMATION

12.1 Introduction

Cost estimation can be defined as the estimation of expenditure incurred for the entire manufacturing process in producing an object.

Cost estimation should be done by taking into account the following points.

1. Cost of the raw material

   It is calculated by considering the size of the work and the expected wastage of the material during production.

2. Wages paid to the workers
3. Machining charges
4. Cost for making accessories like jigs and fixtures
5. Administrative expenditure
6. Profit

12.2 Cost of the material

The cost of the raw material includes the price of the material required, taxes, labour paid for loading and unloading, and transportation charges.

Miscellaneous expenditures like the cost of the soap, oil, blades, cotton waste, grease and chalkpieces should also be included in this head. These items add up as indirect cost of the material.

Raw materials are of two types

1. Standard raw material purchased according to the size
2. Cast material

12.3 Machining charges

A part or component is obtained only after it is subjected to several operations performed on different machine tools. The machining charges are calculated by considering the duration of machining on each of these machine tools involved in manufacturing the particular component. The machining charges differ for different type of machine tools.

Following is the table prepared approximately for calculating the machining charges. The charges mentioned may vary according to the capacity and the accuracy of the machine tool.

Machine	Duration	Rate per hour
Drilling machine	1 hour	Rs. 100.00
Lathe	1 hour	Rs. 150.00
Shaping machine	1 hour	Rs. 200.00
Milling machine	1 hour	Rs. 250.00
Grinding machine	1 hour	Rs. 300.00

12.4 Wages paid to the workers

This includes the amount of wages paid to the workers employed for operating the machine tools and the expenditure for miscellaneous operations performed on the workpieces. Charges for hacksaw cutting, marking and indexing, polishing, fitting and assembling are counted under this head.

12.5 Cost for making accessories like jigs and fixtures

If the production process involves the usage of jigs and fixtures, the cost incurred for manufacturing or purchasing the same should be taken into account.

12.6 Administrative expenditure

It can also be called as overhead charges. It includes

1. Depreciation (Wear and tear on machine tools and other tools)
2. Repairs and maintenance of the machine tools
3. Expenditure on fuels and electricity
4. Rent and maintenance for the building of the manufacturing unit
5. Salary paid to the administrative staff
6. Salary paid to the supervisors, storekeepers and watchman
7. Expenditure on advertising, travel and postage.
8. Welfare of the workers, contribution to the employee’s fund
9. Interest on capital

The overhead charges may vary from a factory to factory. It may range from 130% to 300%.

12.7 Profit and tax

Profit is calculated 10% of all the expenditure mentioned above. Sales tax and packing charges should also be included in this account.

Example

100 No's of spur gears are required with the following specifications.

No. of teeth	=	60
Module	=	3
Width of the gear	=	30mm
Diameter of the stock	=	40mm

Find out the total cost of estimation and the cost of a single gear if the cost of the cast material is Rs.35 per Kg and the approximate weight of a gear is 1Kg.

I. Cost of the raw material

As the gears are to be cast, the cast material should be ordered.

Weight of a single gear	=	1Kg
Weight of 100 gears	=	100 Kg
Cost of 1Kg of Cast material	=	Rs. 35
Cost of 100Kg of material	=	100x35
	=	Rs. 3500
Loading and unloading charges	=	Rs.50
Transportation (Freight)	=	Rs. 50
Cost of the raw material	=	3500 + 50 + 50
	=	Rs. 3600

II. Machining charges

Name of the Machine	Operation	Total time for 100 gears		Rate per hour	Total
		In minutes	In hours		
Lathe	24 minutes are required for turning both the sides of the cast gear blank (for 1 gear)	2400	40	150	6000
Slotting Machine	24 minutes are required for slotting (for 1 gear)	2400	40	200	8000
Milling Machine	48 minutes are required for milling (for 1 gear)	4800	80	250	20,000
Total machining charges			160		34,000

III. Wages paid to the workers

Total machining time = 160 Hours

Working hours (8 Hours per day) 160 / 8

= 20

Labour(Rs.200 per day) = 20 x 200

= 4000

IV. Overhead charges

= Rs. 500

V. Profit

Profit	=	(Cost of raw material + Machining charges + Wages + Overhead charges) x 10%
	=	(3600 + 34000 + 4000 + 500) x 10%
	=	42100 x 10%
	=	4210
Cost of 100 gears	=	42100 + 4210
	=	Rs. 46310
Cost of a single gear	=	46310 / 100
	=	463.10

QUESTIONS

I. A. Choose the correct option

1. The expenditure on the maintenance of the machine tools is

a. Administrative expenditure b. Salary to the staff

C. Cost of raw materials d. Tax

I.B. Answer the following questions in one or two words

1. What is the name of the expenditure incurred for making work holding devices?

II. Answer the following questions in one or two sentences

1. What is cost estimation?
2. What do you mean by the wages paid to the workers?

III. Answer the following questions in about a page

1. What are the important factors to be considered in cost estimation ?
2. Administrative expenditure – Explain.
3. Explain ‘Cost of raw materials’.

IV. Answer the following questions in detail

1. Explain ‘machining charges’.

MODEL QUESTION PAPER

GENERAL MACHINIST PAPER - II

WORKSHOP ENGINEERING

Time : 3 hours Marks : 200

PART - I

A. Choose the correct answer **30 x 1 =30**

1. The person who manufactures different parts is

   a. Supervisor b. Machinist c. Manager d. Foreman

2. First aid is

   a. a manufacturing process b. safety regarding operators
   c. immediate treatment given at the spot of accidents
   d. breakdown of machines

3. The vise with 'V' shaped jaws is

   a. Leg vise b. Hand vise c. Pipe vise d. Pin vise

4. The tool used to hold and cut sheets and wires is a

   a. screw driver b. pliers c. allen key d. ring spanner

5. Centre of a round rod can be found with a

   a. steel rule b. jenny caliper c. trammel d. punch

6. _______ is a direct measuring instrument

   a. Caliper b. Gauge c. Vernier caliper d. Divider

7. Measurements on cylindrical surfaces are done with

   a. narrow rule b. hook rule c. folding rule d. flexible rule

8. The property of changing the shape of a metal part is a

   a. thermal property b. electrical property
   c. physical property d. chemical property

9. The method of heat treatment done to increase the wear resistance quality is

   a. Annealing b. Hardening c. Tempering d. Normalising

10. The media used for rapid quenching is

    a. Cyaniding b. Tempering c. Sodium salt bath d. Oil

11. The system that enables parts of equivalent sizes with dimensional variation within certain limits to be fit for operating is

    a. Limits b. Unilateral tolerance
    c. Deviation d. Interchangeability

12. If the size of the saft is smaller than the hole size, the system of is

a. Interference fit b. Clearance fit c. Driving fit d. Push fit

13. The fit which involves the shaft being driven into the hole with light force

a. Light driving fit b. Heavy driving fit

c. Shrink fit d. Tight fit

14. Power is transmitted between shafts at moderate distance by

a. belt drive b. gear drive c. chain drive d. friction drive

15. The unit of pressure is

a. m^2 b. N/m^2 c. m^3 d. None of the above

B. Answer the following questions in one or two words

16. Mention the use of a round file.
17. What is the use of adjustable spanner?
18. What is rhe use of a scriber?
19. Mention one use of a jenny caliper.
20. Mention one use of a feeler gauge.
21. Expand HSS.
22. Are the tools guided in jigs?
23. Expand RPM.
24. What is the use of bevel gears?
25. Mention one use of a pneumatic circuit.
26. How is Kirchhoff's first rule otherwise known as?
27. Mention any one material used to make hydraulic pipeline.
28. Mention the unit of electric current.
29. What is the unit of Resistance?
30. Who is the father of 'Scientific management movement?

PART - II

Answer any ten questions in one or two sentences 10 x 4 = 40

31. What is 'First aid'?
32. Mention any four types of files.
33. What is a centre punch?
34. What is a caliper?
35. What are gauges?
36. What is annealing?
37. Define - Hardness.
38. What is a jig?
39. What is basic size?
40. What are the methods poer transmission?

41. What is a pressure relief valve?
42. What is current?
43. What is resistance?
44. What is management?
45. What is cost estimation?

PART - III

Answer the following questions in about a page **5 x 10 = 50**

46. What are the safety precautions regarding an operator?
47. State the reasons for the breaking and blunting of hacksaw blades.
48. Draw and explain a jenny caliper.
49. Explain different methods of measuring.
50. Ring gauge, Plug gauge - Explain.
51. Explain the process of Hardening.
52. Draw and explain - Series circuit and Parallel circuit.

PART - IV

Answer the following questions in detail **4 x 20 = 80**

53. Explain a bearing puller with a diagram.

(or)

Vernier caliper - Draw and explain.

54. Explain the differences between gauges and templates.

(or)

Explain sintering furnace with a diagram.

55. Explain 3 - 2 - 1 location with a diagram.

(or)

Explain the interchangeable system

56. Draw a basic hydraulic circuit and explain.

(or)

What are the important factors to be considered in selecting a plant location?

QUESTION PAPER BLUE PRINT

Sl. No.	CHAPTER	Questions allotment				Remarks
		Part - A	Part - B	Part - C	Part - D	
		1 mark	4 marks	10 marks	20 marks	
1.	Workshop Engineering & Safety Precautions	2	1	1 O	-	
2.	Hand Tools	6	2	2	1	
3.	Measuring Instruments	4	2	2	2	
4.	Engineering Materials	2	1	-	-	
5.	Heat Treatment	2	1	1 B	1	
6.	Jigs and Fixtures	1	1	1 B	1	
7.	Standardisation	3	1	-	1	
8.	Transmission of Power	3	1	1 O	-	
9.	Hydraulics	3	1	1 A	1	
10.	Electricity	3	2	1 A	-	
11.	Industrial Management	1	1	-	1	
12.	Cost Estimation	&	1	&	&	
	Total questions	30	15	10	8	

Note : Any one of the O, A & B marked questions

GENERAL MACHINIST

PRACTICAL

VOCATIONAL EDUCATION

HIGHER SECONDARY - FIRST YEAR

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Untouchability is a sin

Untouchability is a crime

Untouchability is inhuman

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GENERAL MACHINIST PRACTICAL

HIGHER SECONDARY - FIRST YEAR

Sl.No.	Date	Exercise	Page No.	Signature of the teacher
1		Filing, marking & punching		
2		Hacksaw cutting		
3		‘L’ cutting		
4		‘V’ cutting		
5		‘T’ cutting		
6		‘Z’ cutting		
7		‘⊔’ cutting		
8		Step cutting		
9		Triangular cutting		
10		Dovetail cutting		

1. FILING, MARKING & PUNCHING

Aim :

To perform the operations of filing, marking and punching

Tools required :

1. Bench vise
2. Try square
3. Hacksaw frame
4. Scriber
5. Steel rule
6. Punches
7. Flat file - rough
8. Flat file - medium
9. Flat file - smooth
10. Triangular file
11. Hammer
12. Divider
13. Chalk paste
14. Vernier caliper
15. Surface plate

Procedure:

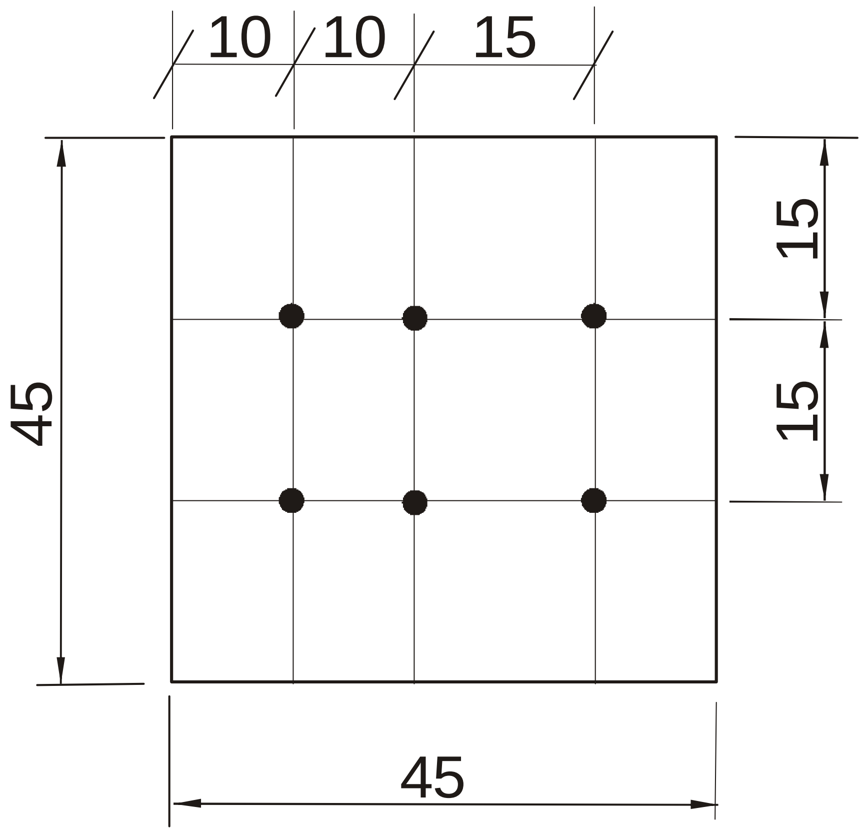
1. The design of the given model is studied completely to understand the features like its size and shape.

2. The given piece of metal is checked for sizes whether it is sufficient for the design.

3. Hand tools and measuring instruments are selected suitably to perform the required operations.

4. The piece of metal (mild steel) is held in the bench vise and two adjacent sides are filed for squareness using a flat file. These two sides are considered prime sides.

GIVEN DESIGN OF THE JOB



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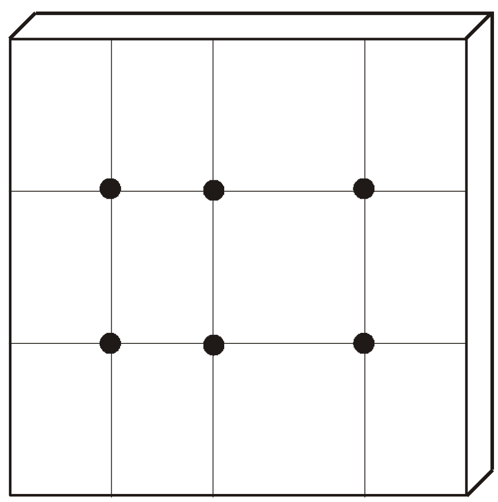


5. The remaining two sides are also filed for squareness (The angle between adjacent sides = 90 degrees). The same is checked with the help of a try-square.

6. The piece of work is checked for 90^0 on all four sides.

7. A thin layer of chalk paste is applied on the flat surface of the metal piece.

8. Chalk is allowed to dry.

9. The given design is scribed on the chalked surface using steel rule, divider and scriber.

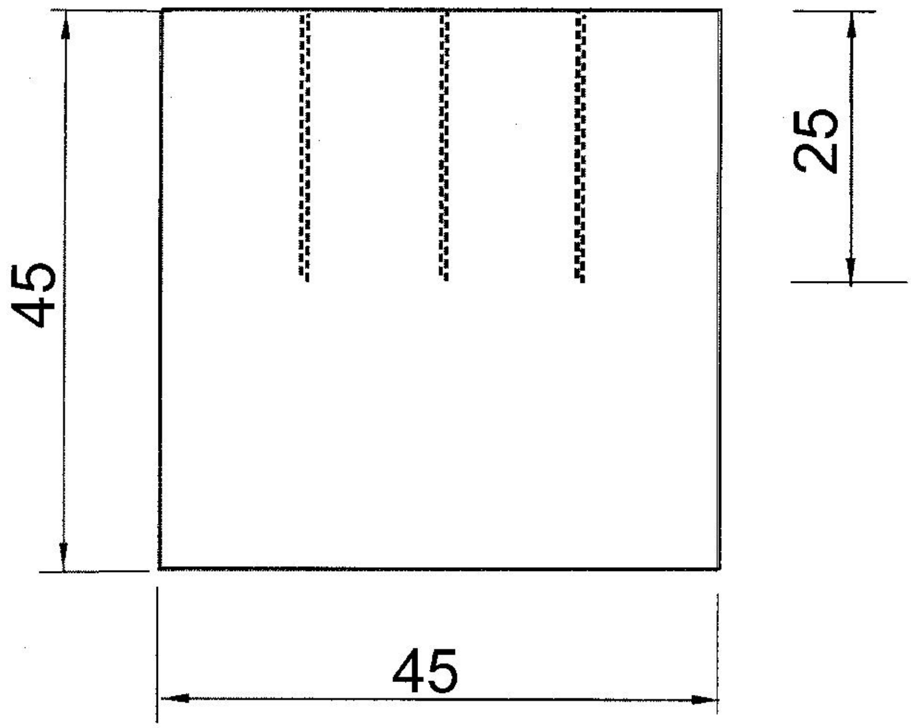
10. Punch marks are made at required points on the surface using a dot punch and a hammer.

11. Punch marks are made by keeping the punch inclined at 60^0 so that they are filed off later.

Conclusion :

The operations of square filing, marking and punching are performed according to the given design on the given M.S plate.

GIVEN DESIGN OF THE JOB



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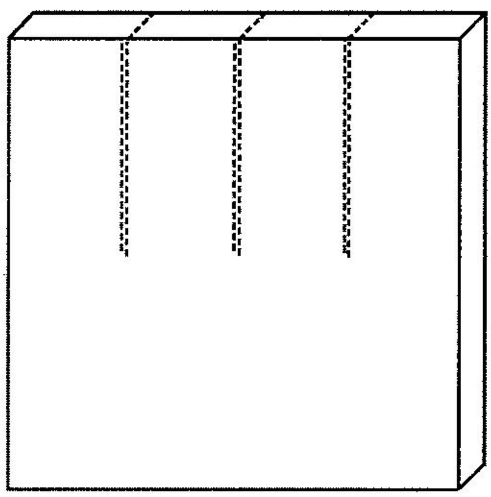


2. HACKSAW CUTTING

Aim :

To perform hacksaw cutting on the gi ven M.S. plate according to the given design

Tools required:

1. Bench vise
2. Try square
3. Hacksaw frame
4. Scriber
5. Steel rule
6. Punches
7. Flat file - rough
8. Flat file - medium
9. Flat file - smooth
10. Triangular file
11. Hammer
12. Divider
13. Chalk paste
14. Vernier caliper
15. Surface plate

Procedure :

1. The design of the given model is studied completely to understand the features like its size and shape.

2. The given piece of metal is checked for sizes whether it is sufficient for the design.

3. Hand tools and measuring instruments are selected suitably to perform the required operations.

4. The piece of metal (mild steel) is held in the bench vise and two adjacent sides are filed for squareness using a flat file. These two sides are considered prime sides.

5. The remaining two sides are also filed for squareness (The angle between adjacent sides = 90 degrees). The same is checked with the help of a try-square.

6. The piece of work is checked for 90^0 on all four sides.

7. A thin layer of chalk paste is applied on the flat surface of the metal piece.

8. Chalk is allowed to dry.

9. Lines are scribed on the chalked surface using steel rule, divider and scriber.

10. Punch marks are made at required points on the surface using a dot punch and a hammer.

11. Punch marks are made by keeping the punch inclined at 60^0 so that they are filed off later.

12. The spacing between adjacent punch marks should be at least 6mm.

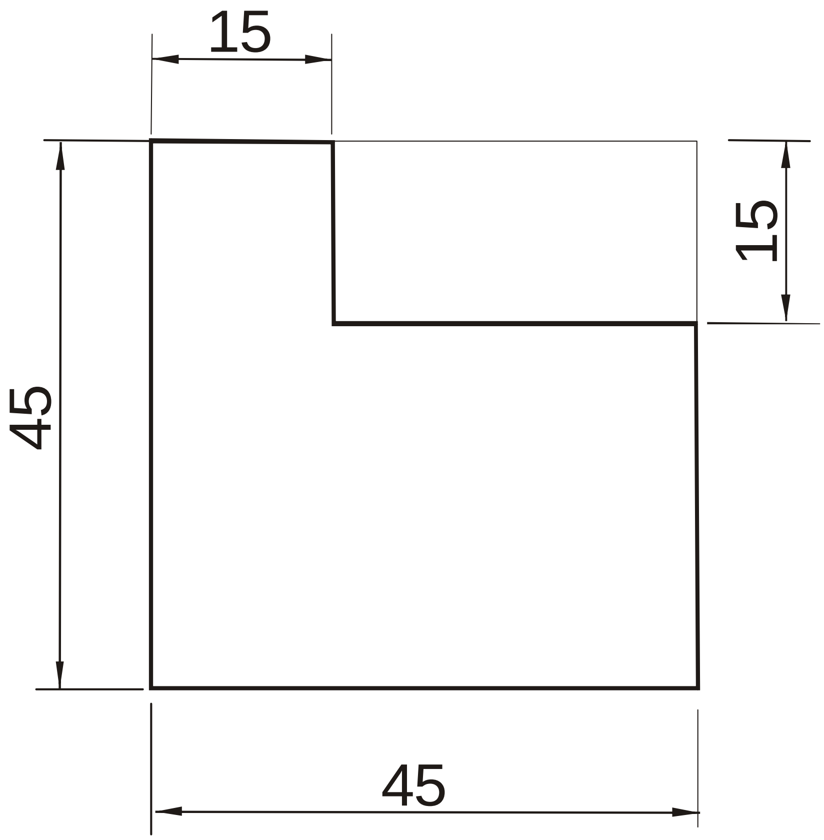
13. Hack cuts are made on the metal piece at marked locations.

14. The cuts should be made by making the hacksaw frame stroke for the full length at a medium pace.

Conclusion :

The operations of square filing, marking, punching and hacksaw cutting are performed according to the given design on the given M.S plate.

GIVEN DESIGN OF THE JOB



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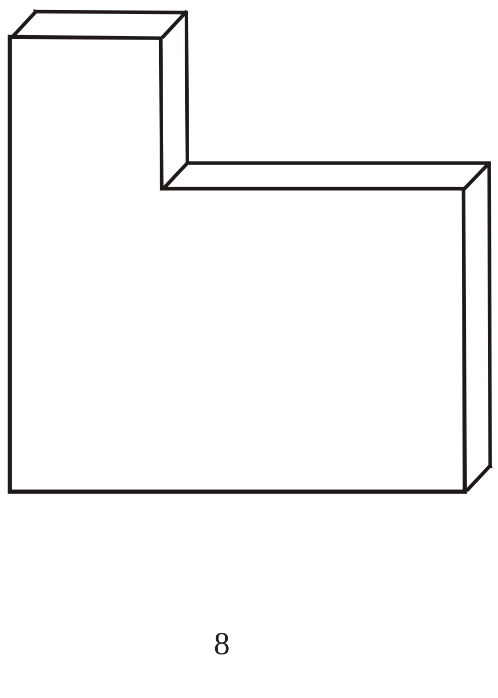


3. ‘L’ CUTTING

Aim :

To perform ‘L’ cutting on the given M.S. plate according to the given design

Tools required :

1. Bench vise
2. Try square
3. Hacksaw frame
4. Scriber
5. Steel rule
6. Punches
7. Flat file - rough
8. Flat file - medium
9. Flat file - smooth
10. Triangular file
11. Hammer
12. Divider
13. Chalk paste
14. Vernier caliper
15. Surface plate

Procedure :

1. The design of the given model is studied completely to understand the features like its size and shape.

2. The given piece of metal is checked for sizes whether it is sufficient for the design.

3. Hand tools and measuring instruments are selected suitably to perform the required operations.

4. The piece of metal (mild steel) is held in the bench vise and two adjacent sides are filed for squareness using a flat file. These two sides are considered prime sides.

5. The remaining two sides are also filed for squareness (The angle between adjacent sides = 90 degrees). The same is checked with the help of a try-square.

6. The piece of work is checked for 90^0 on all four sides.

7. A thin layer of chalk paste is applied on the flat surface of the metal piece.

8. Chalk is allowed to dry.

9. The design for 'L' shape is clearly scribed on the flat chalked surface with the help of steel rule, divider, try square and scriber as per the given dimensions.

10. Punch marks are made at required points on the surface using a dot punch and a hammer.

11. Punch marks are made by keeping the punch inclined at 60^0 so that they are filed off later.

12. The spacing between adjacent punch marks should be at least 6mm.

13. Thin auxiliary lines are made at a distance of 1.5mm from the punched line.

14. Hack cuts are made on these auxiliary lines. The unwanted portion of the metal piece is removed.

15. The remaining portion of the metal piece is fitted on the bench vise. The rough surface resulting from hacksaw cutting is filed with the help of flat files (rough, medium and smooth)

16. When filing, care is taken that half of the punch mark is retained on the workpiece.

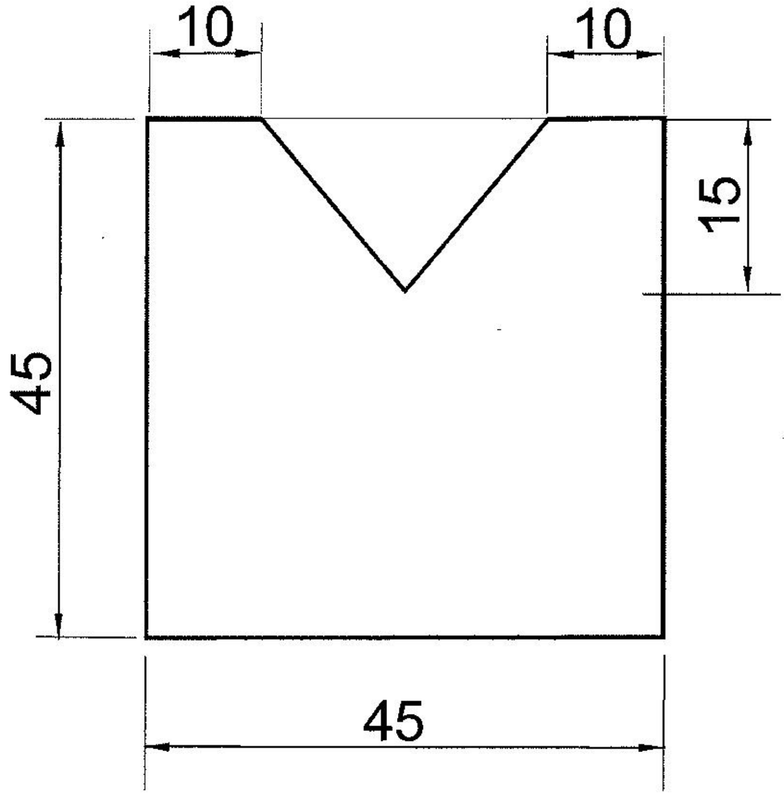
17. The sharp corner of the 'L' shape is finish filed with the help of triangular file.

18. The edge surfaces of the workpiece are checked frequently for perpendicularity and parallelism with the help of a try-square.

Conclusion :

The operations of square filing, marking, punching hacksaw cutting and finish filing (for 'L' shape) are performed according to the given design on the given M.S plate.

GIVEN DESIGN OF THE JOB



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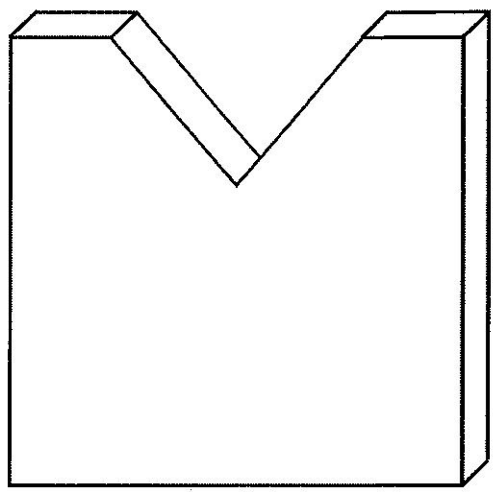


4. ‘V’ CUTTING

Aim :

To perform ‘V’ cutting on the given M.S. plate according to the given design

Tools required :

1. Bench vise
2. Try square
3. Hacksaw frame
4. Scriber
5. Steel rule
6. Punches
7. Flat file - rough
8. Flat file - medium
9. Flat file - smooth
10. Triangular file
11. Hammer
12. Divider
13. Chalk paste
14. Vernier caliper
15. Surface plate
16. Combination set

Procedure :

1. The design of the given model is studied completely to understand the features like its size and shape.

2. The given piece of metal is checked for sizes whether it is sufficient for the design.

3. Hand tools and measuring instruments are selected suitably to perform the required operations.

4. The piece of metal (mild steel) is held in the bench vise and two adjacent sides are filed for squareness using a flat file. These two sides are considered prime sides.

5. The remaining two sides are also filed for squareness (The angle between adjacent sides = 90 degrees). The same is checked with the help of a try-square.

6. The piece of work is checked for 90^0 on all four sides.

7. A thin layer of chalk paste is applied on the flat surface of the metal piece.

8. Chalk is allowed to dry.

9. The design for ‘V’ shape is clearly scribed on the flat chalked surface with the help of steel rule, divider, try square and scriber as per the given dimensions. The angular lines are scribed with the help of the protractor head of a combination set.

10. Punch marks are made at required points on the surface using a dot punch and a hammer.

11. Punch marks are made by keeping the punch inclined at 60^0 so that they are filed off later.

12. The spacing between adjacent punch marks should be at least 6mm.

13. Thin auxiliary lines are made at a distance of 1.5mm from the punched line.

14. Hack cuts are made on these auxiliary lines. The unwanted portion of the metal piece is removed.

15. The remaining portion of the metal piece is fitted on the bench vise. The rough surface resulting from hacksaw cutting is filed with the help of flat files (rough, medium and smooth)

16. When filing, care is taken that half of the punch mark is retained on the workpiece.

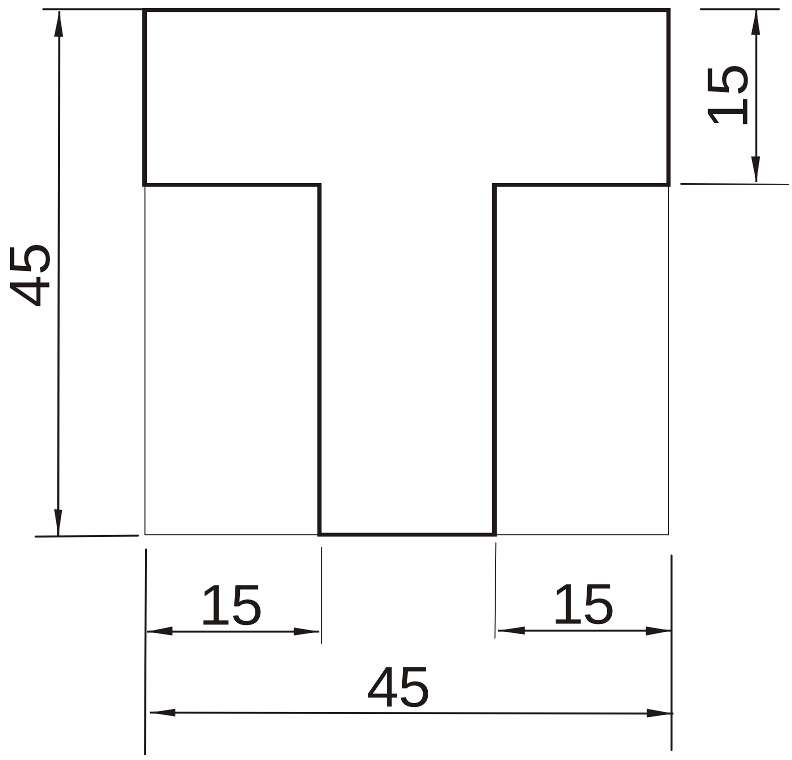
17. The sharp corner of the ‘V’ shape is finish filed with the help of triangular file.

18. The edge surfaces of the workpiece are checked frequently for perpendicularity and parallelism with the help of a try-square.

Conclusion :

The operations of square filing, marking, punching hacksaw cutting and finish filing (for ‘V’ shape) are performed according to the given design on the given M.S plate.

GIVEN DESIGN OF THE JOB



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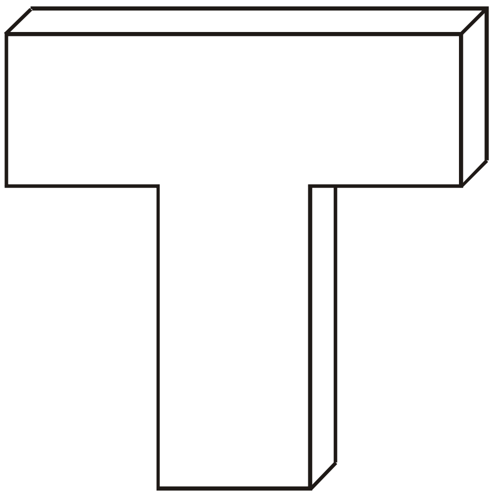


5. ‘T’ CUTTING

Aim :

To perform ‘T’ cutting on the given M.S. plate according to the given design

Tools required :

1. Bench vise
2. Try square
3. Hacksaw frame
4. Scriber
5. Steel rule
6. Punches
7. Flat file - rough
8. Flat file - medium
9. Flat file - smooth
10. Triangular file
11. Hammer
12. Divider
13. Chalk paste
14. Vernier caliper
15. Surface plate

Procedure :

1. The design of the given model is studied completely to understand the features like its size and shape.

2. The given piece of metal is checked for sizes whether it is sufficient for the design.

3. Hand tools and measuring instruments are selected suitably to perform the required operations.

4. The piece of metal (mild steel) is held in the bench vise and two adjacent sides are filed for squareness using a flat file. These two sides are considered prime sides.

5. The remaining two sides are also filed for squareness (The angle between adjacent sides = 90 degrees). The same is checked with the help of a try-square.

6. The piece of work is checked for 90^0 on all four sides.

7. A thin layer of chalk paste is applied on the flat surface of the metal piece.

8. Chalk is allowed to dry.

9. The design for ‘T’ shape is clearly scribed on the flat chalked surface with the help of steel rule, divider, try square and scriber as per the given dimensions.

10. Punch marks are made at required points on the surface using a dot punch and a hammer.

11. Punch marks are made by keeping the punch inclined at 60^0 so that they are filed off later.

12. The spacing between adjacent punch marks should be at least 6mm.

13. Thin auxiliary lines are made at a distance of 1.5mm from the punched line.

14. Hack cuts are made on these auxiliary lines. The unwanted portion of the metal piece is removed.

15. The remaining portion of the metal piece is fitted on the bench vise. The rough surface resulting from hacksaw cutting is filed with the help of flat files (rough, medium and smooth)

16. When filing, care is taken that half of the punch mark is retained on the workpiece.

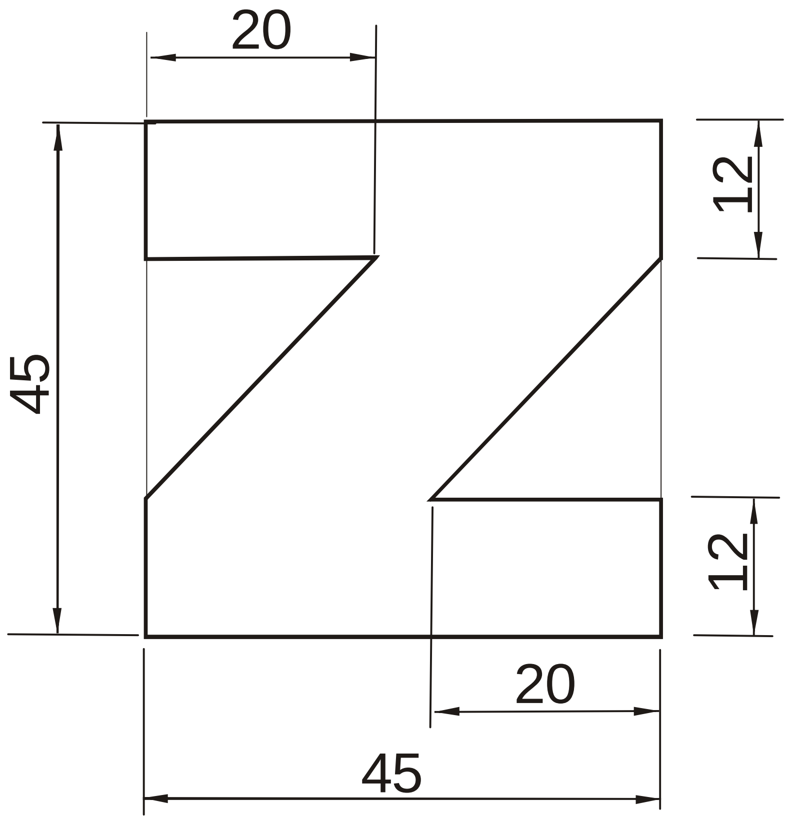
17. The sharp corner of the ‘T’ shape is finish filed with the help of triangular file.

18. The edge surfaces of the workpiece are checked frequently for perpendicularity and parallelism with the help of a try-square.

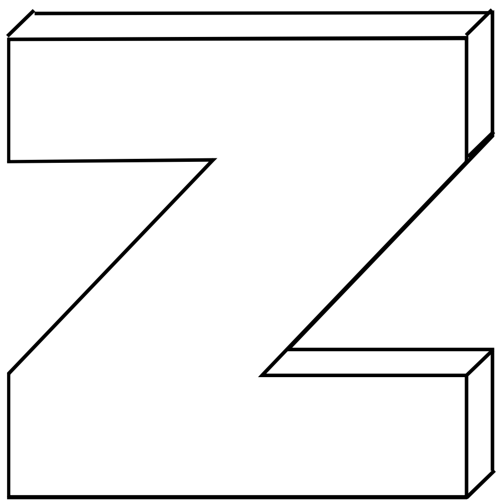
Conclusion :

The operations of square filing, marking, punching hacksaw cutting and finish filing (for ‘T’ shape) are performed according to the given design on the given M.S plate.

GIVEN DESIGN OF THE JOB



FINISHED WORKPIECE



6. ‘Z’ CUTTING

Aim :

To perform ‘Z’ cutting on the given M.S. plate according to the given design

Tools required :

1. Bench vise
2. Try square
3. Hacksaw frame
4. Scriber
5. Steel rule
6. Punches
7. Flat file - rough
8. Flat file - medium
9. Flat file - smooth
10. Triangular file
11. Hammer
12. Divider
13. Chalk paste
14. Vernier caliper
15. Surface plate
16. Protractor
17. Combination set

Procedure :

1. The design of the given model is studied completely to understand the features like its size and shape.

2. The given piece of metal is checked for sizes whether it is sufficient for the design.

3. Hand tools and measuring instruments are selected suitably to perform the required operations.

4. The piece of metal (mild steel) is held in the bench vise and two adjacent sides are filed for squareness using a flat file. These two sides are considered prime sides.

5. The remaining two sides are also filed for squareness (The angle between adjacent sides = 90 degrees). The same is checked with the help of a try-square.

6. The piece of work is checked for 90^0 on all four sides.

7. A thin layer of chalk paste is applied on the flat surface of the metal piece.

8. Chalk is allowed to dry.

9. The design for ‘V’ shape is clearly scribed on the flat chalked surface with the help of steel rule, divider, try square and scriber as per the given dimensions. The angular lines are scribed with the help of a protractor or the protractor head of a combination set.

10. Punch marks are made at required points on the surface using a dot punch and a hammer.

11. Punch marks are made by keeping the punch inclined at 60^0 so that they are filed off later.

12. The spacing between adjacent punch marks should be at least 6mm.

13. Thin auxiliary lines are made at a distance of 1.5mm from the punched line.

14. Hack cuts are made on these auxiliary lines. The unwanted portion of the metal piece is removed.

15. The remaining portion of the metal piece is fitted on the bench vise. The rough surface resulting from hacksaw cutting is filed with the help of flat files (rough, medium and smooth)

16. When filing, care is taken that half of the punch mark is retained on the workpiece.

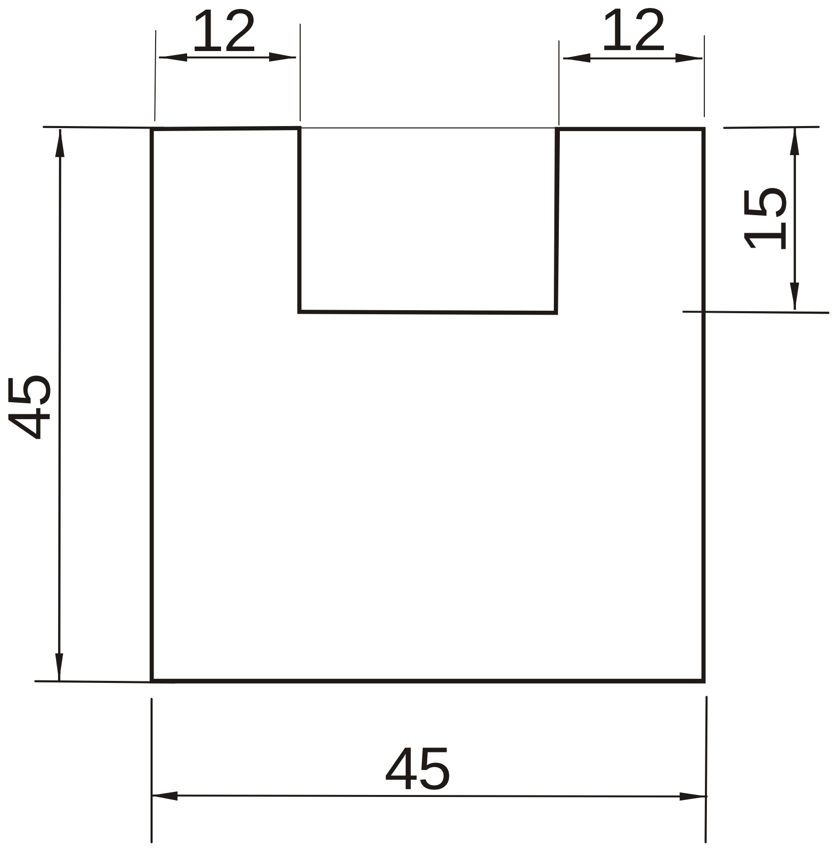
17. The sharp corner of the ‘Z’ shape is finish filed with the help of triangular file.

18. The edge surfaces of the workpiece are checked frequently for perpendicularity and parallelism with the help of a try-square.

Conclusion :

The operations of square filing, marking, punching hacksaw cutting and finish filing (for ‘Z’ shape) are performed according to the given design on the given M.S plate.

GIVEN DESIGN OF THE JOB



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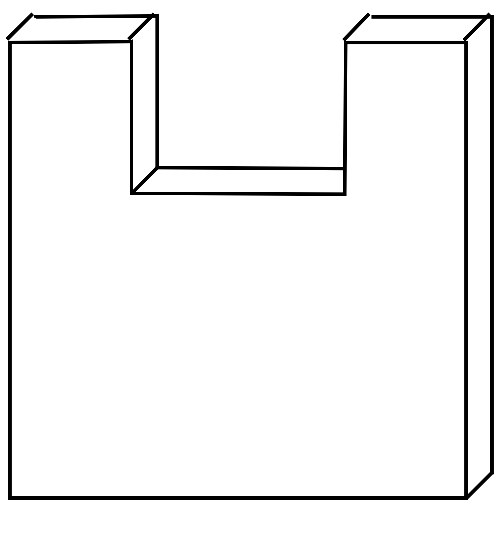


7. '⊔' CUTTING

Aim :

To perform '⊔' cutting on the given M.S. plate according to the given design

Tools required :

1. Bench vise
2. Try square
3. Hacksaw frame
4. Scriber
5. Steel rule
6. Punches
7. Flat file - rough
8. Flat file - medium
9. Flat file - smooth
10. Triangular file
11. Hammer
12. Divider
13. Chalk paste
14. Vernier caliper
15. Surface plate

Procedure :

1. The design of the given model is studied completely to understand the features like its size and shape.

2. The given piece of metal is checked for sizes whether it is sufficient for the design.

3. Hand tools and measuring instruments are selected suitably to perform the required operations.

4. The piece of metal (mild steel) is held in the bench vise and two adjacent sides are filed for squareness using a flat file. These two sides are considered prime sides.

5. The remaining two sides are also filed for squareness (The angle between adjacent sides = 90 degrees). The same is checked with the help of a try-square.

6. The piece of work is checked for 90^0 on all four sides.

7. A thin layer of chalk paste is applied on the flat surface of the metal piece.

8. Chalk is allowed to dry.

9. The design for '⊔' shape is clearly scribed on the flat chalked surface with the help of steel rule, divider, try square and scriber as per the given dimensions.

10. Punch marks are made at required points on the surface using a dot punch and a hammer.

11. Punch marks are made by keeping the punch inclined at 60^0 so that they are filed off later.

12. The spacing between adjacent punch marks should be at least 6mm.

13. Thin auxiliary lines are made at a distance of 1.5mm on both the vertical sides of the shape '⊔'.

14. Hack cuts are made on these two auxiliary lines.

15. One more hacksaw cut is made starting from the top of one of the vertical cuts, moving diagonally to meet another vertical cut at the bottom.

16. Another diagonal cut is made to remove almost all the unwanted portion of the metal piece.

17. The remaining portion of the metal piece is fitted on the bench vise. The rough surface resulting from hacksaw cutting is filed with the help of flat files (rough, medium and smooth)

18. When filing, care is taken that half of the punch mark is retained on the workpiece.

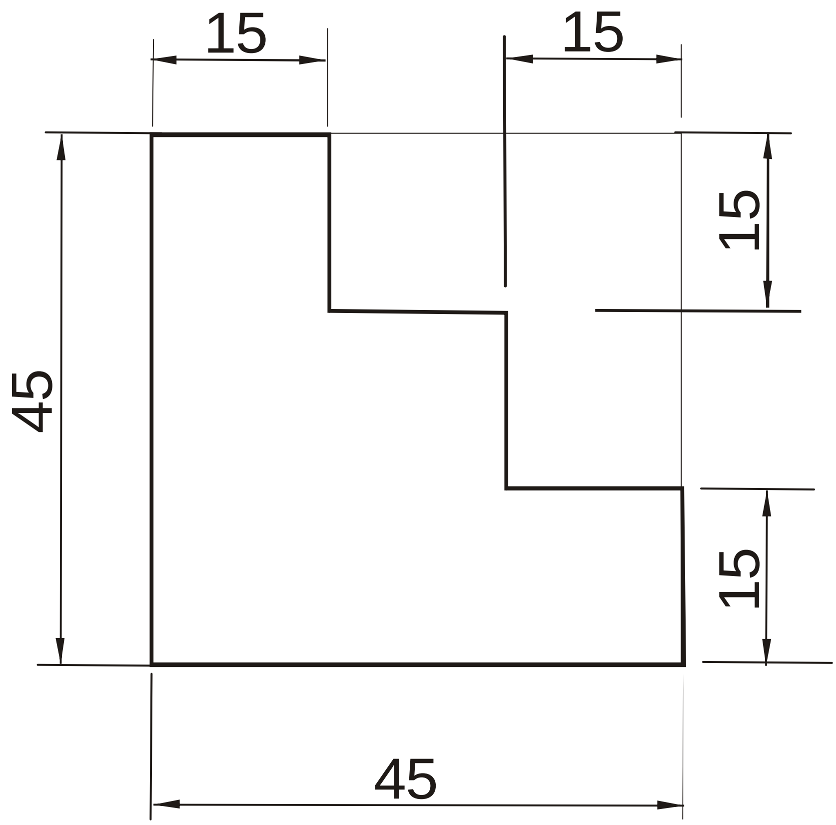
19. The sharp corner of the '⊔' shape is finish filed with the help of triangular file.

20. The edge surfaces of the workpiece are checked frequently for perpendicularity and parallelism with the help of a try-square.

Conclusion :

The operations of square filing, marking, punching hacksaw cutting and finish filing (for '⊔' shape) are performed according to the given design on the given M.S plate.

GIVEN DESIGN OF THE JOB



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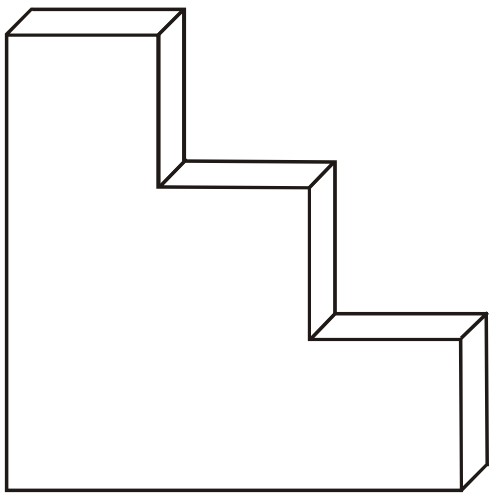


8. STEP CUTTING

Aim :

To perform step cutting on the given M.S. plate according to the given design

Tools required :

1. Bench vise
2. Try square
3. Hacksaw frame
4. Scriber
5. Steel rule
6. Punches
7. Flat file - rough
8. Flat file - medium
9. Flat file - smooth
10. Triangular file
11. Hammer
12. Divider
13. Chalk paste
14. Vernier caliper
15. Surface plate

Procedure :

1. The design of the given model is studied completely to understand the features like its size and shape.

2. The given piece of metal is checked for sizes whether it is sufficient for the design.

3. Hand tools and measuring instruments are selected suitably to perform the required operations.

4. The piece of metal (mild steel) is held in the bench vise and two adjacent sides are filed for squareness using a flat file. These two sides are considered prime sides.

5. The remaining two sides are also filed for squareness (The angle between adjacent sides = 90 degrees). The same is checked with the help of a try-square.

6. The piece of work is checked for 90^0 on all four sides.

7. A thin layer of chalk paste is applied on the flat surface of the metal piece.

8. Chalk is allowed to dry.

9. The give design in the form of steps is clearly scribed on the flat chalked surface with the help of steel rule, divider, try square and scriber as per the given dimensions.

10. Punch marks are made at required points on the surface using a dot punch and a hammer.

11. Punch marks are made by keeping the punch inclined at 60^0 so that they are filed off later.

12. The spacing between adjacent punch marks should be at least 6mm.

13. Thin auxiliary lines are made at a distance of 1.5mm from the punched line.

14. Hack cuts are made on these auxiliary lines. The unwanted portion of the metal piece is removed.

15. The remaining portion of the metal piece is fitted on the bench vise. The rough surface resulting from hacksaw cutting is filed with the help of flat files (rough, medium and smooth)

16. When filing, care is taken that half of the punch mark is retained on the workpiece.

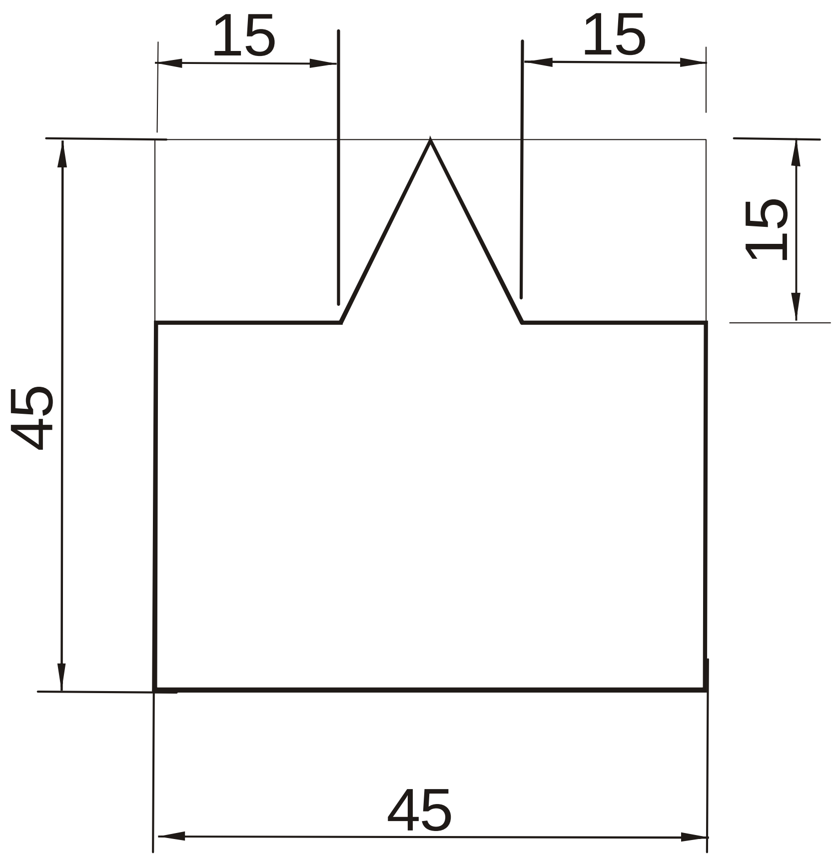
17. The sharp corners of the steps are finish filed with the help of triangular file.

18. The edge surfaces of the workpiece are checked frequently for perpendicularity and parallelism with the help of a try-square.

Conclusion :

The operations of square filing, marking, punching hacksaw cutting and finish filing (for step cutting) are performed according to the given design on the given M.S plate.

GIVEN DESIGN OF THE JOB



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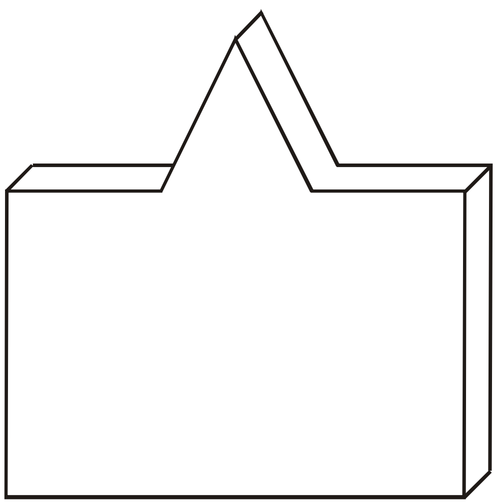


9. TRIANGULAR CUTTING

Aim :

To perform triangular cutting on the given M.S. plate according to the given design

Tools required :

1. Bench vise
2. Try square
3. Hacksaw frame
4. Scriber
5. Steel rule
6. Punches
7. Flat file - rough
8. Flat file - medium
9. Flat file - smooth
10. Triangular file
11. Hammer
12. Divider
13. Chalk paste
14. Vernier caliper
15. Surface plate
16. Protractor
17. Combination set

Procedure :

1. The design of the given model is studied completely to understand the features like its size and shape.

2. The given piece of metal is checked for sizes whether it is sufficient for the design.

3. Hand tools and measuring instruments are selected suitably to perform the required operations.

4. The piece of metal (mild steel) is held in the bench vise and two adjacent sides are filed for squareness using a flat file. These two sides are considered prime sides.

5. The remaining two sides are also filed for squareness (The angle between adjacent sides = 90 degrees). The same is checked with the help of a try-square.

6. The piece of work is checked for 90^0 on all four sides.

7. A thin layer of chalk paste is applied on the flat surface of the metal piece.

8. Chalk is allowed to dry.

9. The design of triangular form is clearly scribed on the flat chalked surface with the help of steel rule, divider, try square and scriber as per the given dimensions. The angular lines are scribed with the help of a protractor or the protractor head of a combination set.

10. Punch marks are made at required points on the surface using a dot punch and a hammer.

11. Punch marks are made by keeping the punch inclined at 60^0 so that they are filed off later.

12. The spacing between adjacent punch marks should be at least 6mm.

13. Thin auxiliary lines are made at a distance of 1.5mm from the punched line.

14. Hack cuts are made on these auxiliary lines. The unwanted portion of the metal piece is removed.

15. The remaining portion of the metal piece is fitted on the bench vise. The rough surface resulting from hacksaw cutting is filed with the help of flat files (rough, medium and smooth)

16. When filing, care is taken that half of the punch mark is retained on the workpiece.

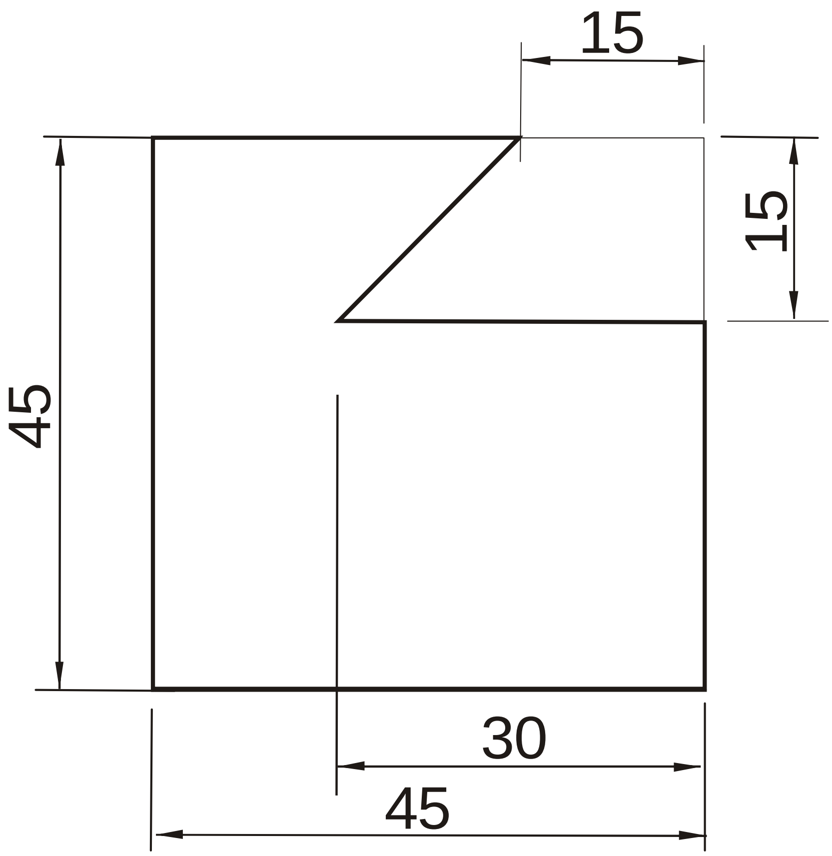
17. The sharp corners of the triangular shape are finish filed with the help of triangular file.

18. The edge surfaces of the workpiece are checked frequently for perpendicularity and parallelism with the help of a try-square.

Conclusion :

The operations of square filing, marking, punching hacksaw cutting and finish filing (for triangular rcutting) are performed according to the given design on the given M.S plate.

GIVEN DESIGN OF THE JOB



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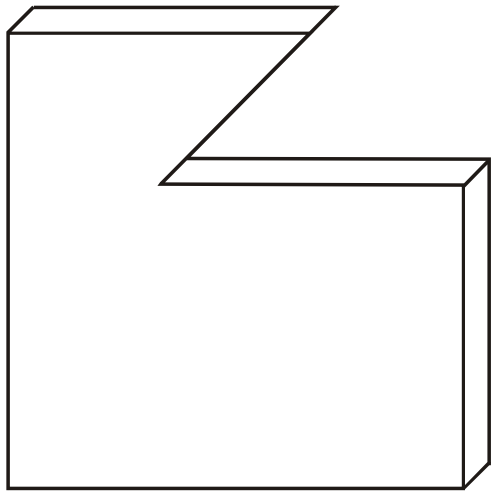


10. DOVETAIL CUTTING (Single side)

Aim :

To perform dovetail cutting (single side) on the given M.S. plate according to the given design

Tools required :

1. Bench vise
2. Try square
3. Hacksaw frame
4. Scriber
5. Steel rule
6. Punches
7. Flat file - rough
8. Flat file - medium
9. Flat file - smooth
10. Triangular file
11. Hammer
12. Divider
13. Chalk paste
14. Vernier caliper
15. Surface plate
16. Protractor
17. Combination set

Procedure :

1. The design of the given model is studied completely to understand the features like its size and shape.

2. The given piece of metal is checked for sizes whether it is sufficient for the design.

3. Hand tools and measuring instruments are selected suitably to perform the required operations.

4. The piece of metal (mild steel) is held in the bench vise and two adjacent sides are filed for squareness using a flat file. These two sides are considered prime sides.

5. The remaining two sides are also filed for squareness (The angle between adjacent sides = 90 degrees). The same is checked with the help of a try-square.

6. The piece of work is checked for 90^0 on all four sides.

7. A thin layer of chalk paste is applied on the flat surface of the metal piece.

8. Chalk is allowed to dry.

9. The design of dovetail cutting (single side) is clearly scribed on the flat chalked surface with the help of steel rule, divider, try square and scriber as per the given dimensions. The angular lines are scribed with the help of a protractor or the protractor head of a combination set.

10. Punch marks are made at required points on the surface using a dot punch and a hammer.

11. Punch marks are made by keeping the punch inclined at 60^0 so that they are filed off later.

12. The spacing between adjacent punch marks should be at least 6mm.

13. Thin auxiliary lines are made at a distance of 1.5mm from the punched line.

14. Hack cuts are made on these auxiliary lines. The unwanted portion of the metal piece is removed.

15. The remaining portion of the metal piece is fitted on the bench vise. The rough surface resulting from hacksaw cutting is filed with the help of flat files (rough, medium and smooth)

16. When filing, care is taken that half of the punch mark is retained on the workpiece.

17. The sharp corner of the dovetail cutting (single side) is finish filed with the help of triangular file.

18. The edge surfaces of the workpiece are checked frequently for perpendicularity and parallelism with the help of a try-square.

Conclusion :

The operations of square filing, marking, punching hacksaw cutting and finish filing (for dovetail cutting - single side) are performed according to the given design on the given M.S plate.

General guidelines for fitting work

In this modern era, automatic machines are used for manufacturing in small, medium and heavy industries. But fitting and bench work finds an important place in completing and finishing a job to the desired accuracy. Some components that come out after machining processess require some minor operations to be performed by hand tools. Fitting work is an important method in doing this. Fitting is the assembling of parts together and removing them for necessary fit. Both these types of work require many number of hand tools, devices and equipments.

Fitting of parts are made with different kinds of fits. It may be arranged where the fit is tight, loose or very loose. The parts may be arranged to move together with no relative movement or rotational and sliding relative movement. The tools used in a fitting workshop are dealt in the later section.

Observation exercise for students :

We happen to see various machine tools in engineering shops. We see the sliding and rotating parts are made to fit into each other by Dovetail joints, T - joints, L - joints triangular joints and as holes and shafts. These joints should be closely watched to understand their nature and their respective uses.

For example, in a lathe - the parts of the assembly of carriage - saddle, cross-slide and compound slide. Observe these joints for their shape and purpose.

Obsrve the top o fthe table of a shaping machine - What is the shape of the slots made on it? What is its purpose?

Again in the shaping machine, the ram reciprocates on the column. Observe the joint between the top of the column and bottom of the ram for their shape and purpose.

Observe the method of joining of the parts column, knee, saddle and table of a milling machine. These parts are joined by different methods of joining and for different purposes.

Likewise different parts of different machine tools are joined by different methods for obtaining different utilities.

We can also observe some house-hold articles are also joined by different methods.

1. The cap and the body of the bottles that we use daily. How are they joined ?

2. The tiffin-carrier. How are the set of dishes held together ?

3. Hot-cases. How is the lid joined with the base ?

4. The base vessel and the lid of the pressure cooker. What are methods by which they are joined ? Why ?

5. The regulator of the L.P.G cylinder. How is it fitted with the cylinder ?

6. The frames and the doors of the windows. How are they fitted ?

7. Day-to-day usages of waist belts, pen caps, cell phone panels and wrist watch straps. Observe how they are fastened ?

8. Observe the domestic water line taps. How are they opened and closed ?

9. The water pipelines made out in our localities for distribution. How are they connected ?

10. The drums and the tyres of automobiles. How are they fitted ?

By observation we find that different parts are connected or fitted or joined by different methods. Taking these examples in mind we should realise that the manufacturing processess involve joining of various components to accomplish different purposes.

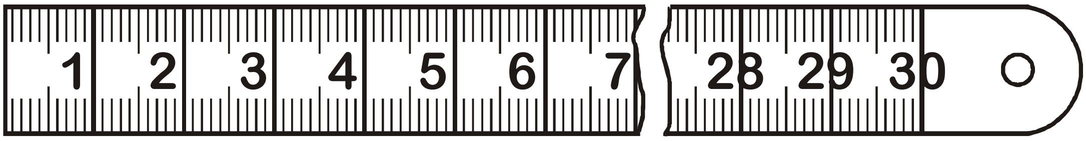
Tools used in fitting workshop :

There are different types of tools used in fitting shop and they are classified as

1. Marking tools - Steel rule, protractor, divider, trammel, punches, try square, surface gauge etc.,
2. Measuring devices and instruments- Different types of gauges, vernier calipers, micrometers, combination set, slip gauges etc.,
3. Holding and supporting tools - Different types of vices, V block, marking table, surface plate etc.,
4. Striking tools - Different types of hammers
5. Cutting tools - Files, Scrapers, Chisels and hacksaw blades
6. Tightening tools - Pliers, spanners and wrenches

Some of the tools used in the fitting shop are illustrated here :

1. Steel rule



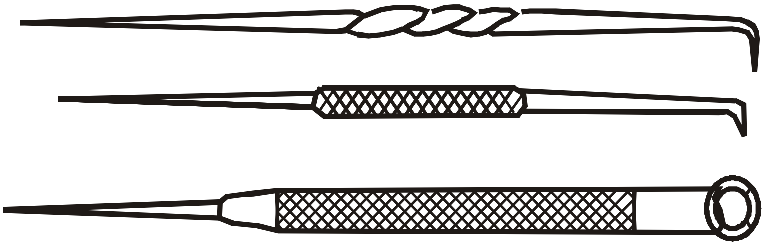
It is one of the most useful tools in a workshop for taking linear measurements and scribing straight lines.

2. Surface plate

The flatness of a surface of a work can be tested with the help of a surface plate. It is also used for marking-out work.

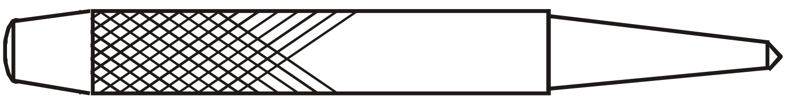
3. Scribers

Scribers are used to mark dimensions and to scribe lines on the workpieces.



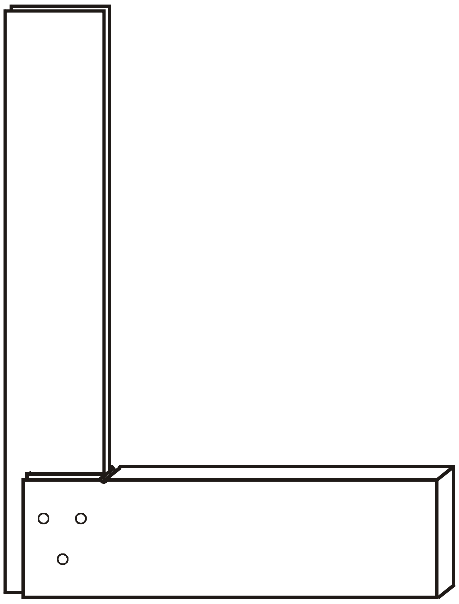
4. Punches

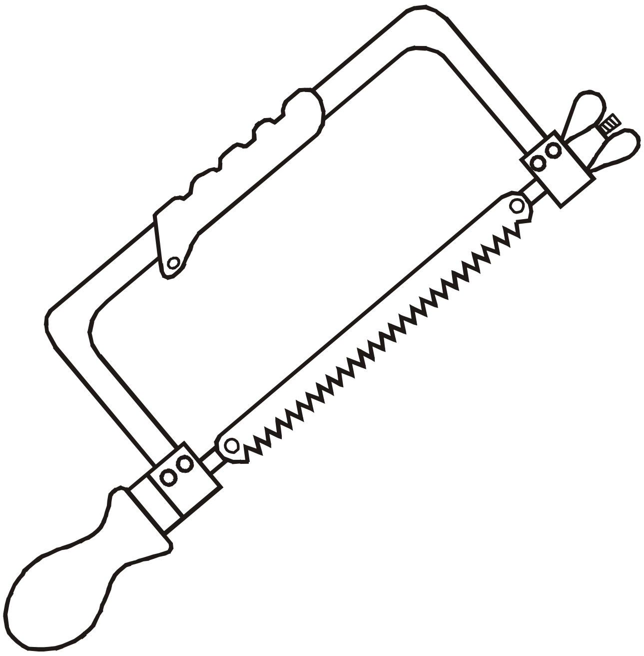
Punches are used to make permanent marks on the lines already scribed on the workpieces. The punch marks make the line appear clearly. Punches are also used to make marks on exact locations on the workpieces where drilling is to be performed. Punch marks are made at regular intervals on the lines (interval may be 6mm for straight lines and 3mm for curved lines).



5. Try square

Try square is used to check the perpendicularity of surfaces (both external and internal) It is also useful in scribing parallel lines perpendicular to a particular surface and to check flatness of surfaces.



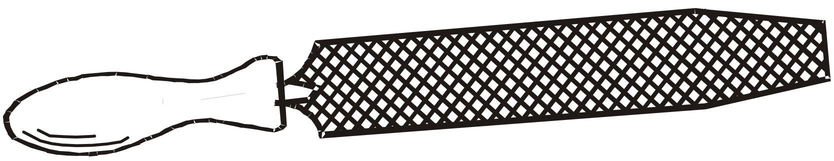


6. Hacksaw

It is used for sawing all metals except hardened steel. It consists of a frame and a blade.

7. Fles

A file is a hardened steel tool having slanted and parallel rows of cutting edges or teeth on its surfaces. It is used to cut, smooth or fit metal parts. It cuts all materials except hardened steel. Small quantities of unrequired metal can be removed with files. Metal burrs leftout after chiseling and hacksaw cutting are removed with the help of files.



8. Vice

Vise is generally used to hold workpieces when operations like drilling, filing, chiseling and hacksaw cutting are performed on them.

The different types of vises used in a shop are Bench vise, Hand vise, Leg vise, Pipe vise, Pin vise, Tool maker's vise, Machine vise, Swivel vise, Universal vise.

General Workshop safety precautions

1. The layout of machines in the workshop should be suitably done considering proper lighting and ventilation.

2. First- aid box containing proper medicine and instruments should be kept always ready in a workshop.

3. Inflammable materials should be kept in safe places with proper precautions.

4. Round and cylindrical objects, sharp articles and tools should not be found in pathways for it may cause injuries to the workers.

5. Oil and grease should not be found spilled inside the workshop.

6. Hot objects should be kept separately wherein messages like "HOT", "DO NOT TOUCH" are displayed.

Safety precautions regarding operators

1. Operators should wear tight clothings. They should avoid wearing loose dresses.

2. Operator should not wear ties and bows while working.

3. The dress code of the operator does not allow him to wear small towel or clothes around his neck or on shoulders.

4. Operator should wear only leather footwear.

5. While performing operations like grinding, welding and chiseling, the operator should wear safety goggles.

6. Metal chips should not be cleaned with bare hands but with proper brushes.

7. Safety plates and equipments should be installed before the machine is set on for operation.

8. The operator should wear gloves while handling hot and sharp articles.

9. The operator should resist himself from changing the speed, marking or lubricating on functioning machines.

10. The operator should seek the help of others while handling heavy and fragile materials.

11. Strict code of discipline should be followed in the workshop. Running, playing and chatting with others are to be avoided in the workshop.

12. The operator should not rest his body on the machines at any time, when working on them.

13. The operator should prefer working on machines which are familiar to him.

14. The operator should not touch unsafe and un -insulated electrical wires.