Techno India NJR Institute of Technology

Lab Manual

Computer Aided Engineering Graphics

(1FY3-28/ 2FY3-28)

Bharat Kr. Suthar

Department of Civil Engineering

For Techno India NJR Institute of Technology

पंकज पोरवाल

Dr. Pankaj Kumar Porwal

(Principal)

I & II Semester
Common to all branches of UG Engineering & Technology

1FY3-28/ 2FY3-28: Computer Aided Engineering Graphics

Credit: 1.5   **Max. Marks: 75 (IA:45, ETE:30)**
0L+0T+3P

Introduction: Principles of drawing, lines, type of lines, usage of Drawing instruments, lettering, Conic sections including parabola, hyperbola, Rectangular Hyperbola (General method only); Scales-Plain, Diagonal and Vernier Scales.

Projections of Point & Lines: Position of Point, Notation System, Systematic Approach for projections of points, front view & Top view of point, Position of straight lines, line parallel to Both the RPs, Line perpendicular to either of the RPs, Line inclined to one RP and parallel to the other, Line inclined to Both the RPs, Traces of a line (One drawing sheet, one assignment in sketch book).

Projection of Planes: Positions of planes, Terms used in projections of planes, plane parallel to RP, plane inclined to one RP and perpendicular to the other RP, plane perpendicular to Both the RPs, plane Inclined to Both the RPs, True shape of the plane, Distance of a point from plane, Angle between two planes.

Projections of Regular Solids: frustum and truncated solids, those inclined to both the Planes-Auxiliary Views.

Section of Solids: Theory of sectioning, section of prisms and cubes, section of pyramids and Tetrahedron section of Cylinders, section of cones, section of spheres (One drawing sheet, one assignment in sketch book)

Overview of Computer Graphics : Covering theory of CAD software [such as: The menu System, Toolbars (standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Crosshairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), Command Line (where applicable), The Status Bar, Different methods of zoom as used in CAD, Select and erase objects.: Isometric Views of lines, Planes, Simple and compound Solids.

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Course Overview :

Student will Learn and understand the basic principles of engineering drawing and the concepts of orthographic and isometric projections.

Course Outcomes:

CO.NO.	Cognitive Level	Course Outcome
1	Comprehension	To expose the students to standards and conventions followed in preparation of engineering drawings.
2	Application	To make them understand the concepts of orthographic and isometric projections.
3	Analysis	Draw and explain orthographic projection of points, lines, and planes.
4	Synthesis	Explain various commands and create drawing in AutoCAD.
5	Evaluation	To make them understand the relevance of engineering drawing to different engineering domains.

Course Outcome Mapping with Program Outcome:

Computer Aided Engineering Graphics Year of Study: 2020-21 Program Outcomes (PO's)												
Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3											
CO2	3	3										
CO3		3	3	3								3
CO4		2								2		
CO5									2	2		2
1: Slight (Low) , 2: Moderate (Medium), 3: Substantial (High)												

CO-PO Justification:

CO	PO	CL	Justification
CO1	PO1	3	To understand Basic knowledge about drawing and its methods.
CO2	PO1	3	To interpret engineering drawing problems with technical mathematics.
	PO2	3	To solve by correlating mathematical drawing with problem analysis.
CO3	PO2	3	To locate object and its orientation with multiple practice problems of projections.
	PO3	3	To design the intermediate geometry problems with development of solutions.
	PO4	3	Theory of projection will help the students to investigate complex problems.
	PO12	3	Theory of projection help students through out their life.
CO4	PO3	2	Visualization skill helps the students in design & develop solutions.
	PO10	2	Visualization skill helps students to convey their idea easily.
CO5	PO9	2	By doing team work students will improve their technical communication skill.
	PO10	2	To express their ideas to another technical person by communicative drawing.
	PO12	2	To help students to prepare, read and interpret product drawings during life.

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MODULE - I
Introduction to Engineering Drawing

1.1 Introduction

Drawing instruments and accessories - Engineering drawing is a two dimensional representation of three dimensional objects. In general, it provides necessary information about the shape, size, surface quality, material, manufacturing process, etc., of the object. It is the graphic language from which a trained person can visualize objects. Drawings prepared in one country may be utilized in any other country irrespective of the language spoken. Hence, engineering drawing is called the universal language of engineers. Any language to be communicative should follow certain rules so that it conveys the same meaning to everyone. Similarly, drawing practice must follow certain rules, if it is to serve as a means of communication. For this purpose, Bureau of Indian Standards (BIS) adapted the International Standards on code of practice for drawing. The other foreign standards are: DIN of Germany, BS of Britain and ANSI of America.

1.2 Role of Engineering Drawing:

The ability to read drawing is the most important requirement of all technical people in any profession. As compared to verbal or written description, this method is brief and clear. Some of the applications are: building drawing for civil engineers, machine drawing for mechanical engineers, circuit diagrams for electrical and electronics engineers, computer graphics for one and all.

1.3 Lettering and Dimensioning Practices (As per BIS : SP : 46 : 2003)

Introduction: Engineering drawings are prepared on standard size drawing sheets. The correct shape and size of the object can be visualized from the understanding of not only its views but also from the various types of lines used, dimensions, notes, scale etc. For uniformity, the drawings must be drawn as per certain standard practice. This chapter deals with the drawing practices as recommended by Bureau of Indian Standards (BIS) SP: 46:2003. These are adapted from what is followed by International Standards Organization (ISO).

1.4 Title Block:

The title block should lie within the drawing space at the bottom right hand corner of the sheet. The title block can have a maximum length of 170 mm providing the following information. 1. Title of the drawing. 2. Drawing number. 3. Scale. 4. Symbol denoting the method of projection. 5. Name of the firm, and 6. Initials of staff, who have designed, checked and approved. The title block used on shop floor and one suggested for students class-work is shown in fig;
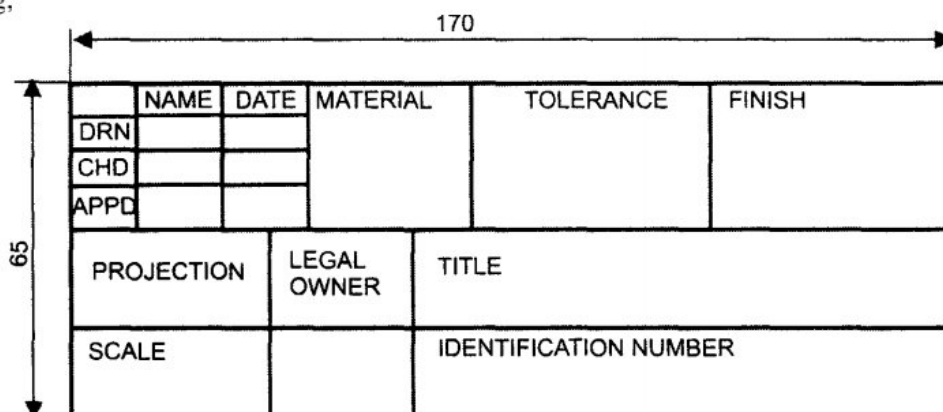
1.5 Lines (IS 10714 (part 20): 2001 and SP 46: 2003):

Just as in English textbook the correct words are used for making correct sentences; in Engineering Graphics, the details of various objects are drawn by different types of lines. Each line has a definite meaning and sense to convey. IS 10714 (Pint 20): 2001 (General principles of presentation on technical drawings) and SP 46:2003 specify the following types of lines and their applications:

1.6 Lettering practice

ABCDEFGHIJKLMNOP
QRSTUVWXYZ
aobcdefghijklmnopq
rstuvwxyz
[(!?:"-=+x: √°%&)]∅
0123456789 IVX
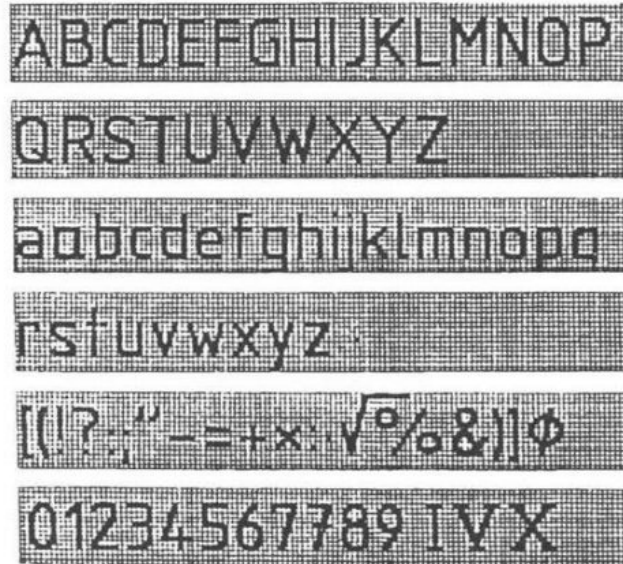
The following are some of the guide lines for lettering

1. Drawing numbers, title block and letters denoting cutting planes, sections are written in 10 mm size.
2. Drawing title is written in 7 mm size.
3. Hatching, sub-titles, materials, dimensions, notes, etc., are written in 3.5 mm size.
4. Space between lines = ~ h.
5. Space between words may be equal to the width of alphabet M or 3/5 h.
6. Space between letters should be approximately equal to $1/5$ h. Poor spacing will affect the visual effect.
7. The spacing between two characters may be reduced by half if h is given a better visual effect, as for example LA, TV; over lapped in case of say LT, TA etc, and the space is increased for letters with adjoining stems.
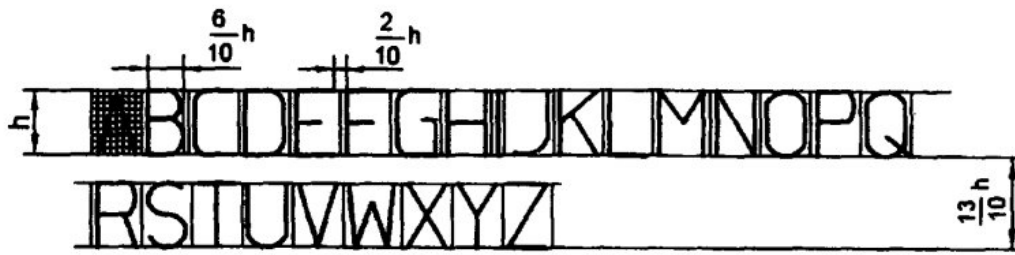
CAPITAL Letters

- Ratio of height to width for most of the CAPITAL letters is approximately = 10:6
- However, for M and W, the ratio = 10:8 for I the ratio = 10:2

Lower-case Letters

- Height of lower-case letters *with* stem *I* tail (b, d, f, g, h, j, k, I, p, q, t, y) = $Cz = c3 = h$
- Ratio of height to width for lower-case letters *with* stem or tail = 10:5
- Height of lower-case letters *without* stem or tail c1 is approximately = *(7/10)* h
- Ratio of height to width for most lower-case letters *without* stem or tail = 7: 5
- However, for m and w, the ratio = 7: 7. For I and I, the ratio = 10:2

ⁿ A B C D E F G H J K L M N O P Q
R S T U V W X Y Z

a b c d e f g h i j k l m n o p q r
s t u v w x y z

0 1 2 3 4 5 6 7 8 9 $\frac{2}{3}$

ENGINEERING GRAPHICS IS THE LANGUAGE
OF ENGINEERS
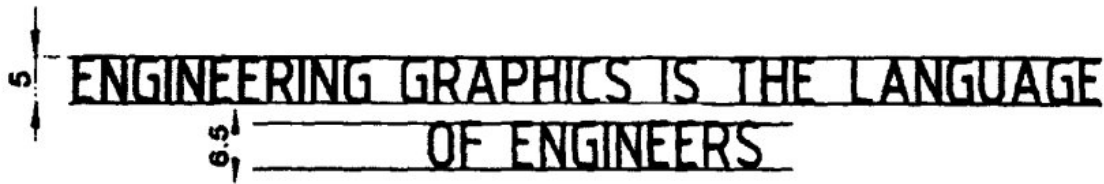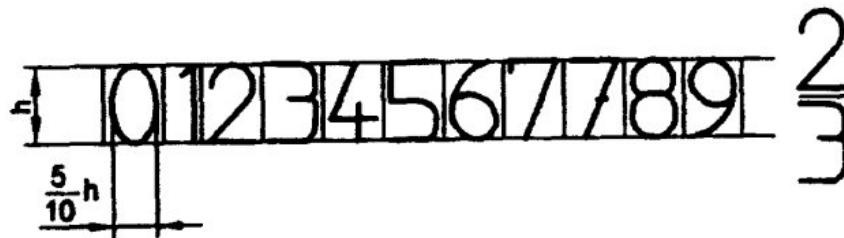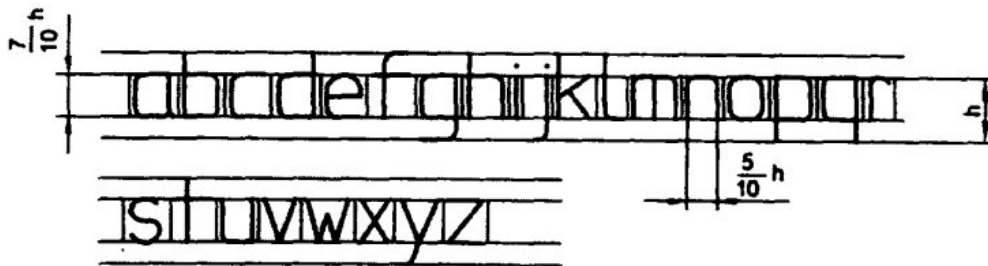
Principles of Dimensioning:

Some of the basic principles of dimensioning are given below.

1. All dimensional information necessary to describe a component clearly and completely shall be written directly on a drawing.
2. Each feature shall be dimensioned once only on a drawing, i.e., dimension marked in one view need not be repeated in another view.
3. Dimension should be placed on the view where the shape is best seen.
4. As far as possible, dimensions should be expressed in one unit only preferably in millimeters, without showing the unit symbol (mm).
5. As far as possible dimensions should be placed outside the view.
6. Dimensions should be taken from visible outlines rather than from hidden lines .

1.7 Scales

Introduction

It is not possible always to make drawings of an object to its actual size. If the actual linear dimensions of an object are shown in its drawing, the scale used is said to be a **full** size scale. Wherever possible it is desirable to make drawings to full size.

Reducing and enlarging scales

Objects which are very big in size cannot be represented in drawing to full size. In such cases the object is represented in reduced size by making use of reducing scales. Reducing scales are used to represent objects such as large machine parts, buildings, town plans etc. A reducing scale, say 1: 10 means that 10 units length on the object is represented by 1 unit length on the drawing. Similarly, for drawing small objects such as watch parts, instrument components etc., use of full scale may not be useful to represent the object clearly. In those cases enlarging scales are used. An enlarging scale, say 10: 1 means one unit length on the object is represented by 10 units on the drawing.

The designation of a scale consists of the word Scale, followed by the indication of its ratio as follows.

Scale 1: 1 for full size scale
Scale 1: x for reducing scales (x = 10, 20 ...... etc.,)
Scale x: 1 for enlarging scales.
Note: For all drawings the scale has to be mentioned without fail

Representative Fraction

The ratio of the dimension of the object shown on the drawing to its actual size is called the Representative Fraction (RF).

For example, if an actual length of 3 meters of an object is represented by a line of 15mm length on the drawing

$$RF = 1:200$$

If the desired scale is not available in the set of scales it may be constructed and then used.
Metric Measurements
10 millimeters (mm) = 1 centimeter (cm)
10 centimeters (cm) = 1 decimeter (dm)
10 decimeter (dm) = 1 meter (m)
10 meters (m) = 1 decameter (dam)
10 decameters (D m) = 1 hectometer (h m)
10 hectometers (h m) = 1 kilometer (km)
1 hectare = 10,000 m.^{2}

Types of Scales

The types of scales normally used are:
1. Plain scales.
2. Diagonal Scales.
3. Vernier Scales.

Plain Scales

A plain scale is simply a line which is divided into a suitable number of equal parts, the first of which is further sub-divided into small parts. It is used to represent either two units or a unit and its fraction such as km and h m, m and dm, cm and mm etc.

Diagonal Scales

Plain scales are used to read lengths in two units such as meters and decimeters, centimeters and millimeters etc., or to read to the accuracy correct to first decimal. Diagonal scales are used to represent either three units of measurements such as meters,

Vernier Scales

The vernier scale is a short auxiliary scale constructed along the plain or main scale, which can read up to two decimal places. (n -1) Thus, 1 vsd = -n-msd or 1- msd When 1 vsd < 1 it is called forward or direct vernier. The vernier divisions are numbered in the same direction as those on the main scale. When 1 vsd> 1, it is called backward or retrograde vernier. The vernier divisions are numbered in the opposite direction compared to those on the main scale. The least count (LC) is the smallest dimension correct to which a measurement can be made with a vernier. For forward vernier, L C = (1 msd - 1 vsd). For backward viermier, LC = (1 vsd - 1 msd)

1.9 Conic Sections

Cone is formed when a right angled triangle with an apex and angle θ is rotated about its altitude as the axis. The length or height of the cone is equal to the altitude of the triangle and the radius of the base of the cone is equal to the base of the triangle. The apex angle of the cone is 2θ.

When a cone is cut by a plane, the curve formed along the section is known as a conic. For this purpose, the cone may be cut by different section planes and the conic sections obtained are shown, d, and e.

c- Ellipse   d- Parabola

e- Hyperbola
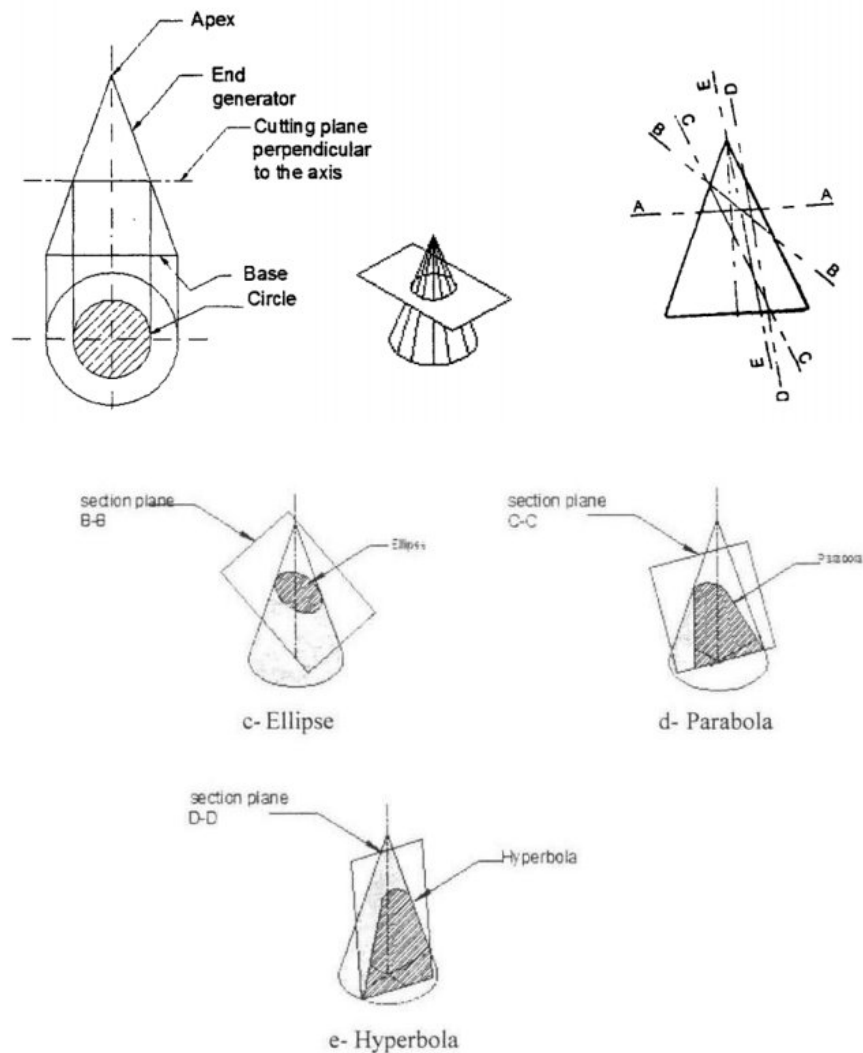
Circle

When a cone is cut by a section plane A-A making an angle α = 90° with the axis, the section obtained is a circle.

Ellipse

When a cone is cut by a section plane B-B at an angle α, more than half of the apex angle i.e., θ and less than 90°, the curve of the section is an ellipse. Its size depends on the angle α and the distance of the section plane from the apex of the cone.

Parabola

If the angle α is equal to θ i.e., when the section plane C-C is parallel to the slant side of the cone, the curve at the section is a parabola. This is not a closed figure like circle or ellipse. The size of the parabola depends upon the distance of the section plane from the slant side of the cone.

Hyperbola

If the angle α is less than θ (section plane D-D), the curve at the section is hyperbola. The curve of intersection is hyperbola, even if α = θ, provided the section plane is not passing through the apex of the cone. However if the section plane passes through the apex, the section produced is an isosceles triangle.

Special Curves

Cycloidal Curves

Cycloidal curves are generated by a fixed point in the circumference of a circle when it rolls without slipping along a fixed straight line or circular path. The rolling circle is called the generating circle, the fixed straight line, the directing line and the fixed circle, the directing circle.

Cycloid
A cycloid is a curve generated by a fixed point on the circumference of a circle, when it rolls without slipping along a straight line.
Eg:
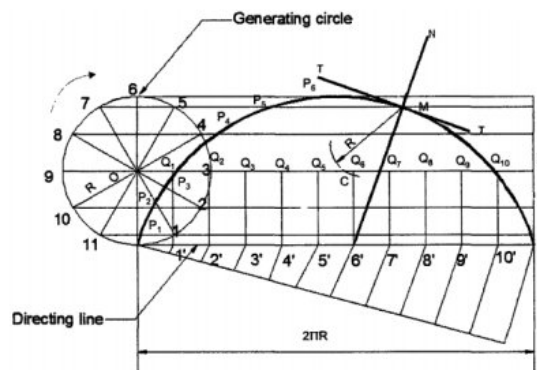
Involutes
An involute is a curve traced by a point on a perfectly flexible string, while unwinding from around a circle or polygon the string being kept taut (tight). It is also a curve traced by a point on a straight line while the line is rolling around a circle or polygon without slipping.
eg: To draw an involute of a given square of side a.
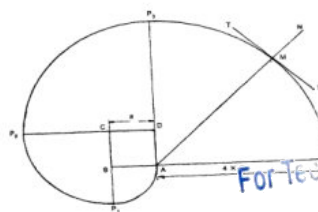
EXERCISES

1. A 4 cm long line on a map represents a 1.5 m length. Determine the RF and draw a scale long enough to measure up to 6m. Show a distance of 4.6 m on it.

2. Construct a scale of 1:54 to show yards and feet and long enough to measure 9 yards. Mark a distance of 5 yards 2 feet on it.

3. Old road map of Bombay city was drawn with 10 cm, on the map representing 25 miles. Construct a plain scale to read miles on this map and long enough to measure distance between gateway of India and Borivalli which is 40 miles.

4. Construct a scale to measure up to 50 m if 1cm represents 4 m, finds its RF and mark a distance 37 m on it.

5. A 4 cm long line on map represents 1.5 meter length. Determine the RF and draw a scale long enough to measure up to 6 meters. Show a distance of 4.6 meters on it.

6. A Stone is thrown from a 4 m high building and at its highest flight; the stone just crosses the top of a 10 m high tree from the ground. Trace the path of the projectile, if the horizontal distance between the building and the tree is 5m. Find the distance of the point from the building where the stone falls on the ground.

7. A circus man rides on a motor cycle inside a globe having a 100mm radius. The motor cycle wheel is 60mm diameter. Draw the locus of a point lying on the circumference of the wheel of the motor cycle for one complete revolution.

8. Construct an ellipse when the distance of the focus from the directrix is equal to 60 mm and eccentricity 2/3. Also, draw a normal and a tangent to the curve at a point 35 mm from the focus.

9. Draw a straight line AB of any length. Make a point F, 80 mm from AB. Trace the paths of a point P moving in such a way that the ratio of its distance from the point F, to its distance from AB is (a) 3:2 (b) 1 Plot at least 10 points. Name each curve. Draw a normal and a tangent to each curve at a point on it 45mm from F.

10. Draw the major axis of an ellipse is 110 mm long and the foci are at a distance of 15 mm from its ends. Draw the ellipse, One-half of it by concentric circles method and the other half by rectangle method.

11. A circle of 50 mm diameter, rolls on a horizontal line for half a revolution clock wise and then on a line inclined at 60^0 to the horizontal for another half clockwise. Draw the curve traced by a point P on the circumference of the circle, taking the top most point on the rolling circle as the initial position of the generating point.

12. Draw a cycloid for one complete revolution of a cycle having a 30 mm radius. Taking the top most point on the rolling circle as the initial position of the generating point. Draw a tangent and a normal to the curve at a point distant 40 mm above the base line.

13. The foci of an ellipse are 100 mm apart and the minor axis is 70 mm long. Determine the length of the minor axis and draw half the ellipse by concentric circles method and the other half by Oblong method. Draw a curve parallel to the ellipse and 25 mm away from it.

14. Construct a hypocycloid, rolling circle 60 mm diameter and directing circle 120 mm diameter.

MODULE - II

Overview of computer graphics, customization & CAD drawing, annotations, layering & other functions, demonstration of a simple team design project

Introduction

In previous chapters we dealt with traditional drawings in which we use essentially drawing board tools such as paper, pencils, drafter, compasses, eraser, scale etc., which will take more time and tough in complex drawings. The drawback with traditional drawing is information SHARING i.e. if an engineer is drawing design of machine component and suddenly the manufacturer modifies dimension of innermost part of the component; in such situations one cannot modify the drawing already drawn, he should redraw the component. CADD is an electronic tool that enables us to make quick and accurate drawings with the use of a computer. Drawings created with CADD have a number of advantages over drawings created on a drawing board. CADD drawings are neat, clean and highly presentable. Electronic drawings can be modified quite easily and can be presented in a variety of formats. There are hundreds of CADD programs available in the CADD industry today. Some are intended for general drawing work while others are focused on specific engineering applications. There are programs that enable you to do 2D drawings, 3D drawings, renderings, shadings, engineering calculations, space planning, structural design, piping layouts, plant design, project management, etc.

Examples of CAD software

Auto-CAD, PRO-Engineer, IDEAS, UNIGRAPHICS, CATIA, Solid Works, etc.

History of CAD

In 1883 Charles Barbage developed idea for computer. First CAD demonstration is given by Ivan Sutherland (1963). A year later Rum produced the first commercial CAD system. Many changes have taken place since then, with the advancement of powerful computers, it is now possible to do all the designs using CAD including two-dimensional drawings, solid modeling, complex engineering analysis, production and manufacturing. New technologies are constantly invented which make this process quicker, more versatile and more powerful.

Advantages of CAD

(i) Detail drawings may be created more quickly and making changes is easy than correcting drawings drawn manually.
(ii) It allows different views of the same object and 3D pictorial view, which gives better visualization of drawings and symbols which can be stored for easy recall and reuse.
(iii) By using the computer, the drawing can be produced with more accuracy.
(iv) Drawings can be more conveniently filed, retrieved and transmitted on disks and tape.
(v) Quick Design Analysis, Simulation and Testing is possible.
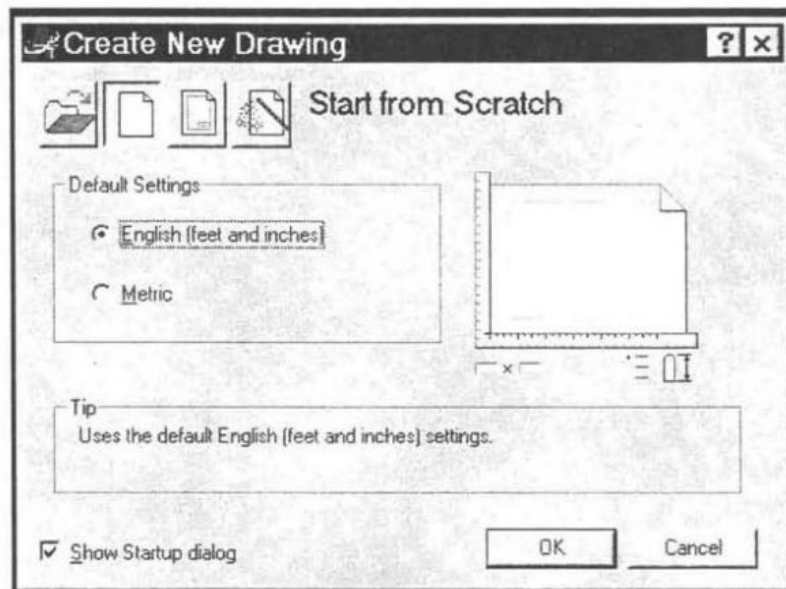
Auto CAD Main Window
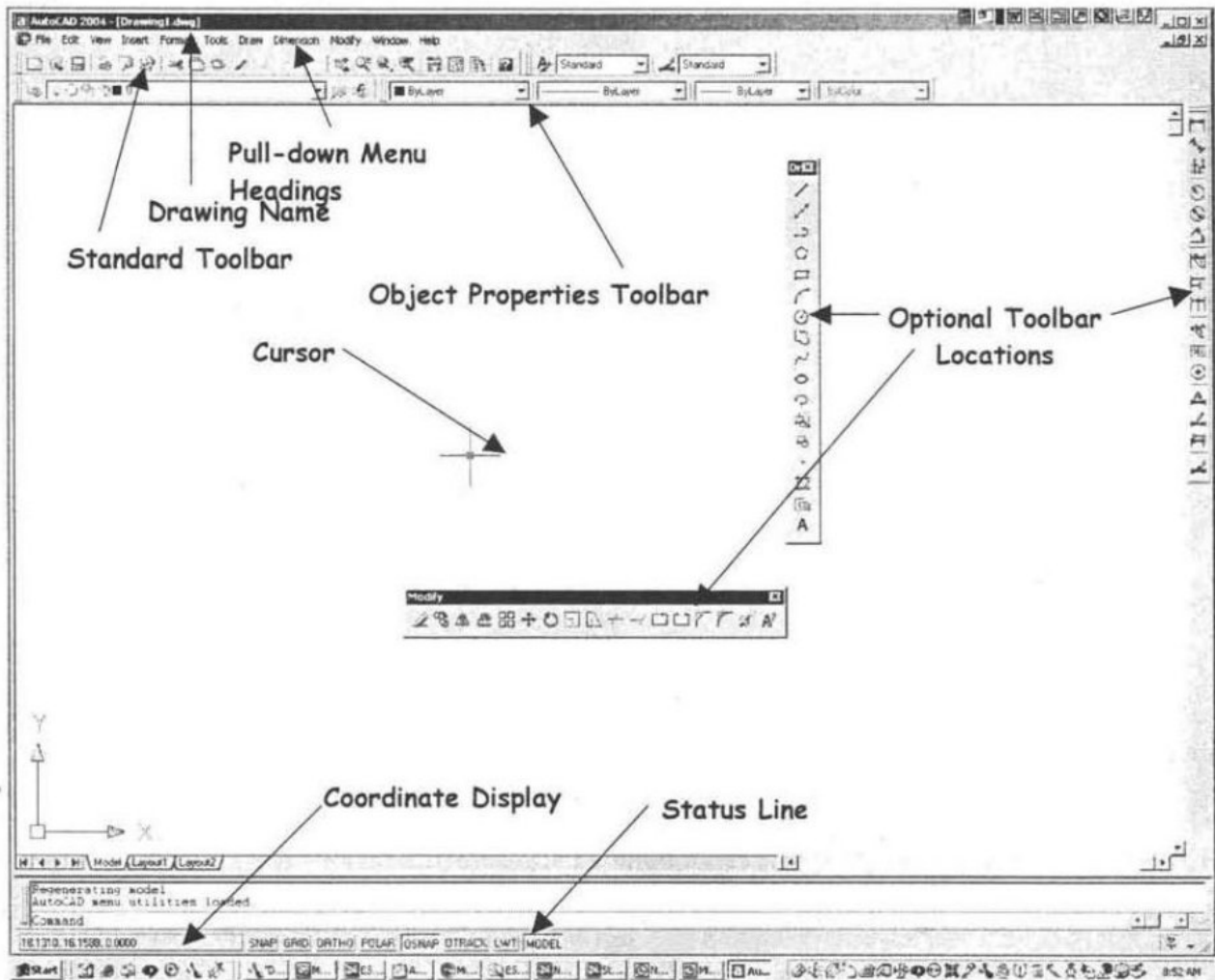
Starting a new drawing

Select A New file from pull-down or toolbar
File>New

- Startup dialog box will be opened, with four Options
- Open an existing drawing
- Start from scratch
- Use a template
- Use a Wizard

Select Start from Scratch, Click on Metric (millimeters).

Setting drawing limits:

It is normal when using AutoCAD to draw objects full size, so it's usually necessary to reset the drawing limits to (about) the size of the object being drawn. Move the cursor to the bottom left of the screen, you can notice Command box. We can fix required paper size like AO, AI, A2, A3, A4 etc. from the Command box.

```
Command:
Command: '_limits
Reset Model space limits:
Specify lower left corner or [ON/OFF] <0.0000,0.0000>:
Specify upper right corner <420.0000,297.0000>: 297,210
Command:
```

Erasing objects

Removes objects from the drawing. Activate from Modify pull-down
Prompt will appear to.... select objects
Cursor changes to selection box

Ways to select objects for erasure
Pick with selection box
Create a window to select multiple objects
Type ALL to select everything visible on screen

Saving a drawing file

Save
Saves drawing to current name (Quick save)
Allows user to input name if drawing has never been saved

Save as
Allows input of a drawing name or location every time
Provides the ability to change file saving version

The coordinate system

The coordinate system is another method of locating points in the drawing area. It enables us to locate points by specifying distances from a fixed reference point. One can locate a point by giving its distance in the horizontal direction, vertical direction, measuring along an angle, etc. The coordinate system is available when a function requires data input in the form of point locations. You may use it while drawing, editing or any time you need to locate a point. The most common coordinate systems are as follows:
- Cartesian coordinates
- Polar coordinates

Cartesian coordinates

Cartesian coordinates is a rectangular system of measurement that enables you to locate points with the help of horizontal and vertical coordinates. The horizontal values, called X-coordinates, are measured along the X-axis. The vertical values, called Y-coordinates, are measured along the Y-axis. The intersection of the X- and Y-axes is called the origin point, which represents the (0, 0) location of the coordinate system.

The positive X values are measured to the right and the positive Y values are measured above the origin point. The negative X and Y values are measured to the left and below. To enter a coordinate, you need to enter both the X and Y values separated by a comma (X, Y).
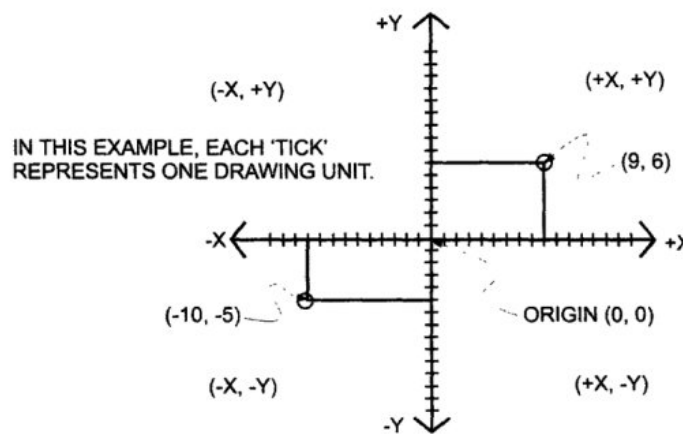
Polar coordinates

Polar coordinates allow you to define a point by specifying the distance and the direction from a given point. This mode of measurement is quite helpful in working with angles. To draw a line at an angle, you need to specify how long a line you want to draw and specify the angle. Write down the Auto CAD commands to complete the above exercise.

The formats to enter coordinates

Cartesian or polar coordinate values can be entered in two formats:
- Absolute
- Relative

Absolute format is a way of measuring distances from a fixed reference location (origin point), which is the (0, 0) location of the co-ordinate system. Consider this point to be stationary at all times. In some CADD programs this point remains visible at the left bottom corner of the drawing area, while in others it is invisible. You can use this point as a reference to measure any distance in the drawing. Absolute coordinates are primarily used to adjust the alignment of diagrams in a drawing, to align one drawing with another or to make plotting adjustments.

Relative format is a way of measuring distances from the last point entered. All measurements are taken the same way as the absolute coordinates, with the only difference being that the relative coordinates are measured from the last point entered instead of the origin point. When a point is entered, it becomes the reference for entering the next point and so on. This mode of measurement is frequently used for drawing because it is always convenient to place the drawing components relative to each other rather than a fixed reference point.

Examples:

Cartesian Coordinates

Sounds like math, and it is exactly the same as in math
Input as either Absolute or Relative Coordinates
- Absolute X; Y
- Relative @K, Y

Polar Coordinates (Vector Coordinates)

Used to input a distance and the direction angle
Format: @Distance<Angle

User-defined coordinate system

CADD allows you to create a user-defined coordinate system that can help simplify drawing. When you need to work with a complex drawing that has many odd angles this mode of measurement is very useful.

Let's say you need to draw or modify an odd-shaped diagram, it is very difficult to use Cartesian or polar coordinates because they would involve extensive calculations. In this case, you can create a custom coordinate system that aligns with the odd angles in the diagram. To define a new coordinate system, you need to specify where you want the origin point and the direction of the X and Y-axis. The computer keeps working according to this customized coordinate system unless you set it back to normal.

Function Keys

F I - AutoCAD Help Screens
F2 - Toggle Text/Graphics Screen
F3 - OSNAP On/Off
F4 - Toggle Tablet Modes On/Off
F5 - Toggle iso-planes Modes On/Off
F6 - Toggle Coordinates Modes On/Off
- Coordinates has 2 modes when in a drawing command
- X. Y coordinates
- Polar coordinates (Distance<Angle)
F7 - Toggle Grid Modes On/Off
F8 - Toggle Ortho Modes On/Off
F9 - Toggle Snap Modes On/Off
FIO - Toggle Polar Modes On/Off
F11 - Toggle Object Snap Tracking Modes On/Off
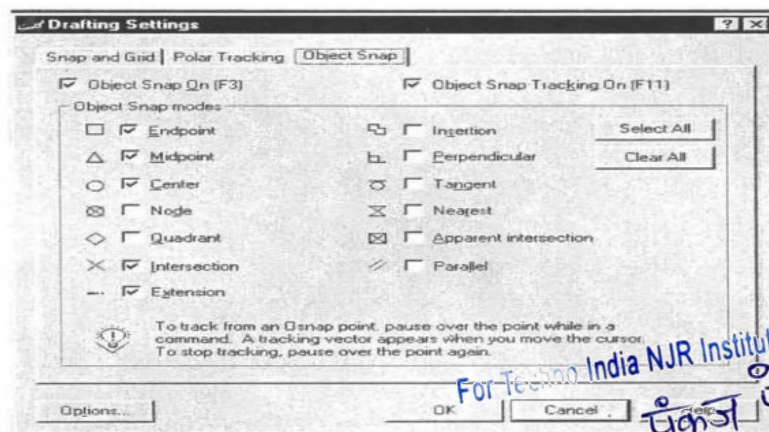
Poly line command

Creates a multisided closed shape
- Located by the center and radius or
- Located by edges of polygon
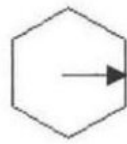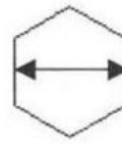
Center - radius   Edge points

Polygon may be inscribed or circumscribed about a circle (Remember inscribed is inside!)
(a) Circumscribed Polygon is outside like a bolt head radius is to the middle of segment
(b) Inscribed Polygon is inside radius is to the corner
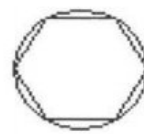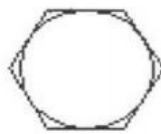
Rectangle command

- Creates a rectangular object based on 2 opposite corner points
- Use relative coordinates: @ distance < angle or @ X,Y for second point
- Rectangle options
- Fillet - fillets the corners based on input radius
- Chamfer - chamfers the ends based on chamfer distances
- Width - changes width of lines

Using line types

There are a number of line types available in CADD that can be used to enhance drawings. There are continuous lines, dotted lines, center lines, construction lines, etc. CADD enables you to follow both geometrical and engineering drawing standards. You can use line types to represent different annotations in a drawing. For example, an engineer can use line types to differentiate between engineering services in a building plan. One line type can be used to show power supply lines, while the others to show telephone lines, water supply lines and plumbing lines.

CADD is preset to draw continuous lines. When you enter the line command and indicate a starting point and end point, a continuous line is drawn. If you want to draw with another line type, you need to set that line type as the current line type. Thereafter, all the lines are drawn with the newly selected line type.

Drawing Flexible Curves

CADD allows you to draw flexible curves (often called splines) that can be used to draw almost any shape. They can be used to create the smooth curves of a sculpture, contours of a landscape plan or roads and boundaries of a map. To draw a flexible curve, you need to indicate the points through which the curve will pass. A uniform curve is drawn passing through the indicated points. The sharpness of the curve, the roughness of the lines and the thickness can be controlled through the use of related commands.

Drawing arcs and circles

CADD provides many ways to draw arcs and circles. There are a number of advanced techniques available for drawing arcs and circles, which can simplify many geometrical drawing problems. You can draw an arc by specifying circumference and radius, radius and rotation angle, chord length and radius, etc. Arcs are drawn so accurately that a number of engineering problems can be solved graphically rather than mathematically. Suppose you need to measure the circumference of an arc, just select that arc and the exact value is displayed. The following are basic methods for drawing arcs and circles: (These are essentially the same methods you learn in a geometry class. However, when drawing with CADD the approach is a little different.)

Center point and radius
- points
- Angle and radius
- points
- 2 tangents and a point
- tangents

Basic Commands

- The "draw" toolbar
- Lines
- Polylines
- Circles
- Arcs
*The "modify" toolbar
- Erase
- Copy
- Move
- Offset
- Fillet
- Array
- Trim
- Extend

Drawing Lines

Either type "line" on the command line or click on the line icon in the draw toolbar.
- Lines can be drawn by point and click.

Can keep an eye on the coordinates display to make sure that you get what you want.
- Lines can be specified by their end point coordinates.

Type in the coordinates on the command line
- Lines can be specified by their first point coordinates, then by a distance and angle.

Select starting point, type in "@distance<angle"

Example: @5<45 would go 5 units at a 45 degree angle:

- Click the line icon (or enter "line" on the command line)
- Draw a horizontal line whose left end coordinate is 0,.5 and is 5 mm long.
- Continue the line so that the second segment is starts at the end of the first line and goes vertically up 1.5 mm

The Copy Command

- The copy command is used to make a single duplicate of an entity or group of entities.
- Click on copy icon in the modify menu and follow the instructions on the command line
- Note that copy offsets may be independent of the actual line

Selecting Objects

- AutoCAD has several ways to select objects.
  - Click on each object that you want to select.
  - Make a window that encloses all the objects that you want to select.
- Click on the lower or upper left corner of desired window area
- Click on the opposite corner of the window area
  - Make a boundary that selects everything that is within the boundary and that crosses the boundary.
- Click on the lower or upper right corner of desired window area
- Click on the opposite corner of the window area

EXERCISES

1. Write down the Auto CAD commands to complete the exercise.
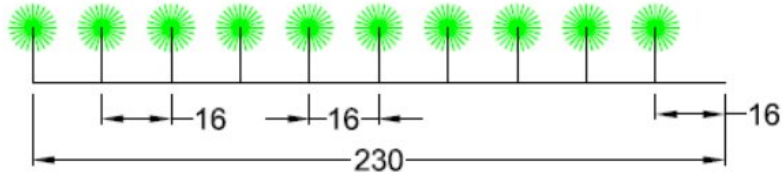
You Have 10 trees. Plant the trees on the above line. Use Divide command
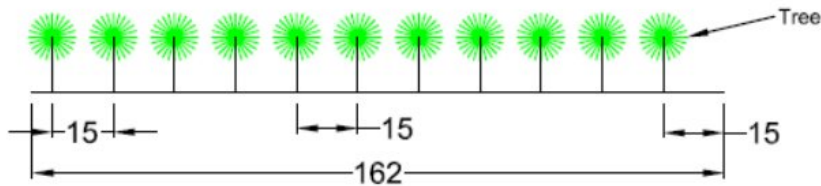
Fig.1

You have to plant the tree at every 15 unit. Use Measure command.

2. Write down the Auto CAD commands to complete exercise.

S3/D1

HEXAGON

DIVISION OF A LINE
IN TO EQUAL PARTS
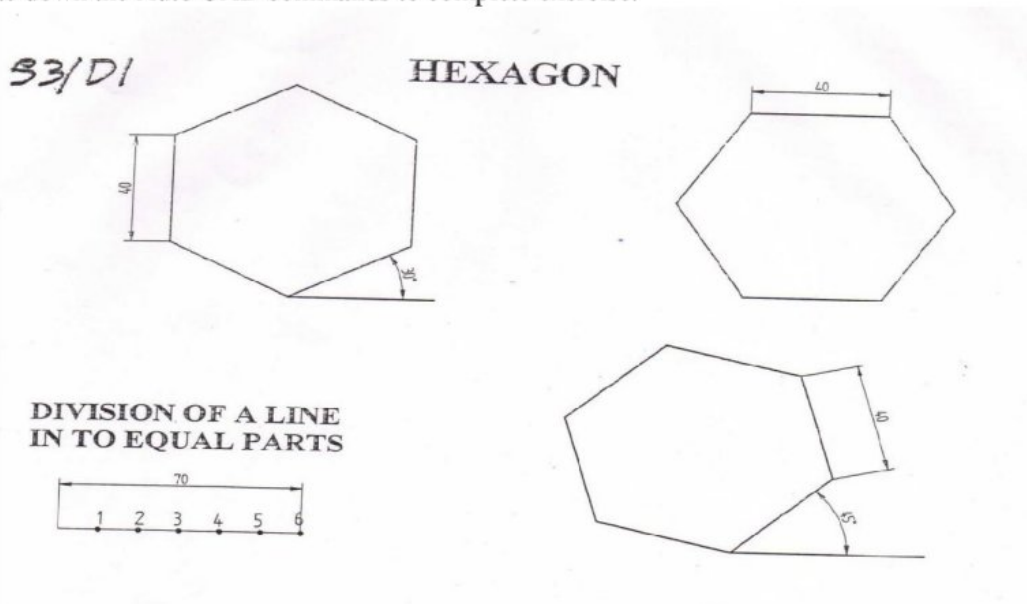
For Techno India NJR Institute of Technology

पंकज पोरवाल

Dr. Pankaj Kumar Porwal

(Principal)

3. Write down the Auto CAD commands to complete exercise.

S2/D1

RECTANGLES
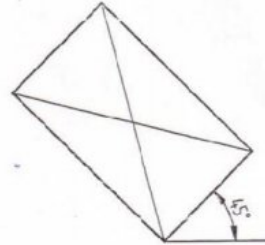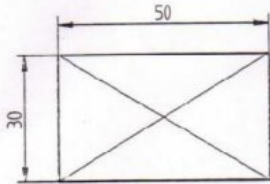
PENTAGON
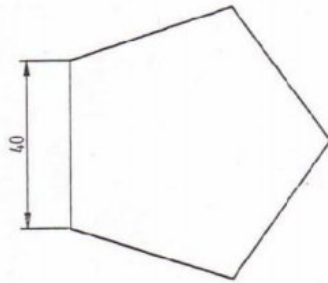
PENTAGON
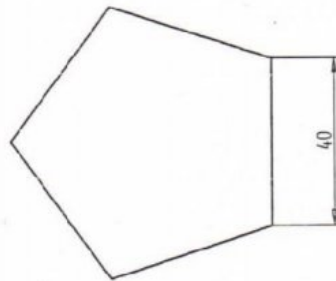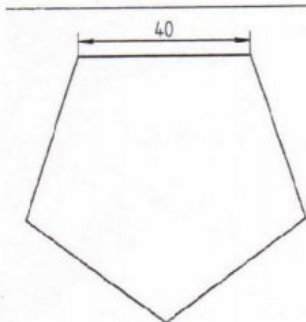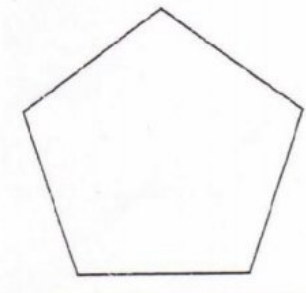
MIRROR IMAGE
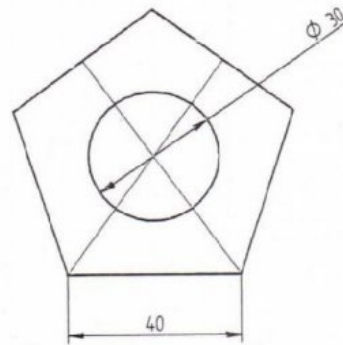
PENTAGON WITH A CIRCULAR HOLE

MIRROR IMAGE

4. Write down the Auto CAD commands to complete the exercise.

Ø10
Ø25
Ø50

(135,105)

45

33

10

WIDTH = 3

Red
Blue
Yellow
+0.7
-0.8

100

Ø50
Ø24

100
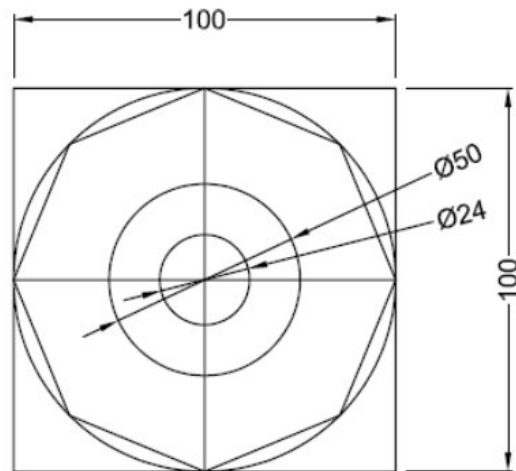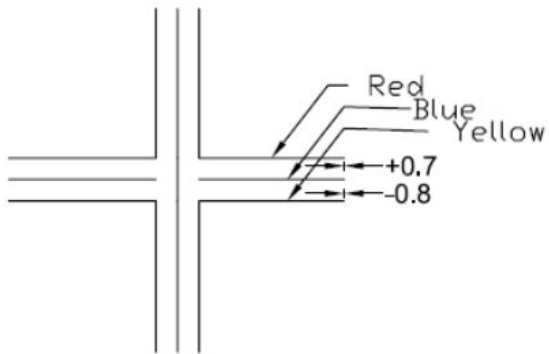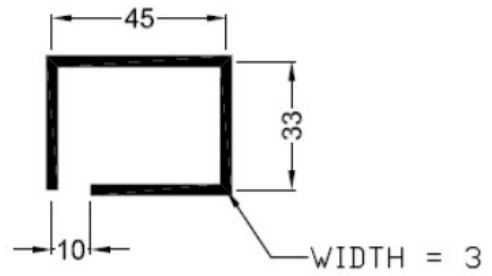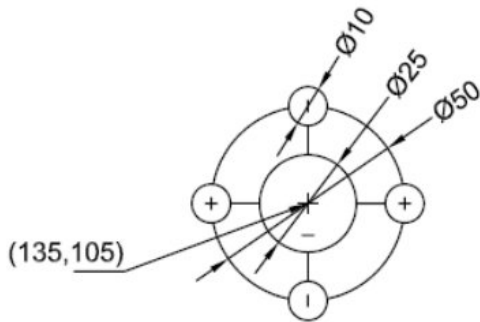
Orthographic projections

Introduction

Engineering drawing, particularly solid geometry is the graphic language used in the industry to record the ideas and information necessary in the form of blue prints to make machines, buildings, structures etc., by engineers and technicians who design, develop, manufacture and market the products.

Projection

As per the optical physics, an object is seen when the light rays called visual rays coming from the object strike the observer's eye. The size of the image formed in the retina depends on the distance of the observer from the object.

If an imaginary transparent plane is introduced such that the object is in between the observer and the plane, the image obtained on the screen is as shown in Fig.5.1. This is called perspective view of the object. Here, straight lines (rays) are drawn from various points on the contour of the object to meet the transparent plane, thus the object is said to be projected on that plane.

Terms Used

VP and H.P are called as principal planes of projection or reference planes. They are always transparent and at right angles to each other. The projection on VP is designated as Front view and the projection on H.P as Top view.
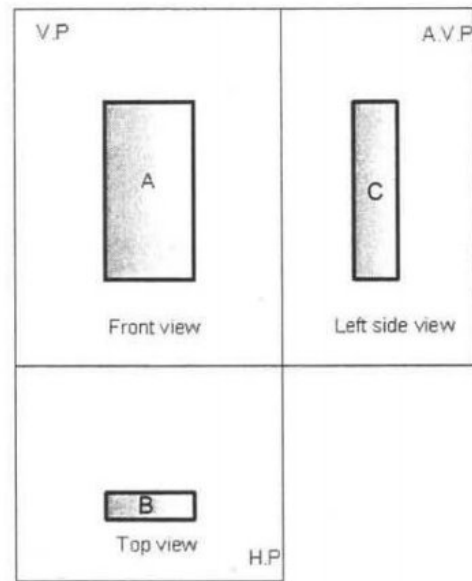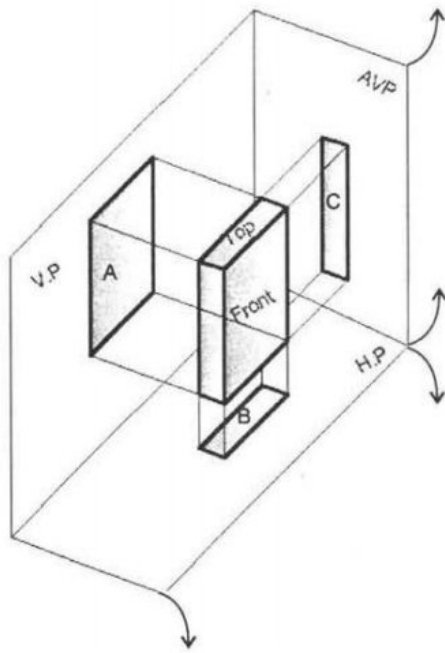
Four Quadrants

When the planes of projections are extended beyond their line of intersection, they form Four Quadrants. These quadrants are numbered as I, II, III and IV in clockwise direction when rotated about reference line xy.
Four Quadrants:
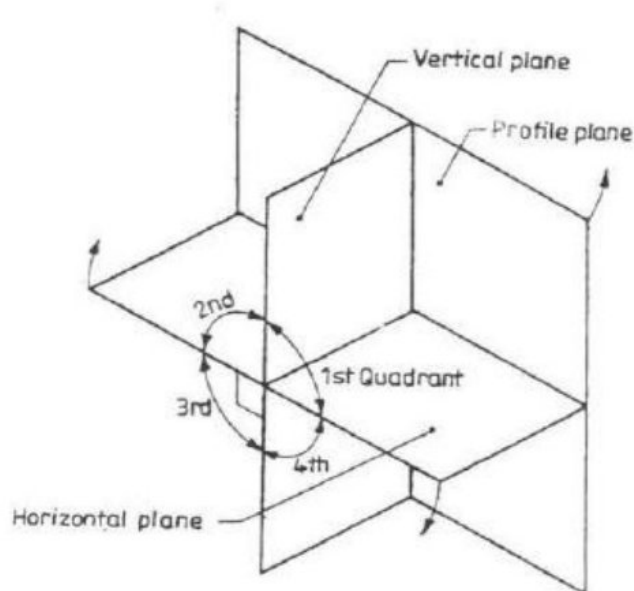
First angle projection

When the object is situated in first quadrant, that is, in front of V.P and above H.P, the projections obtained on these planes are called First angle projection.

(i) The object lies in between the observer and the plane of projection.

(ii) The front view is drawn above the x y line and the top view below x y.
   (above x y line is V.P and below x y line is H.P).

(iii) In the front view, H.P coincides with x y line and in top view V.P coincides with x y line.

(iv) Front view shows the length (L) and height (H) of the object and Top view shows the length(L) and breadth(B) or width(W) or thickness (T) of it.
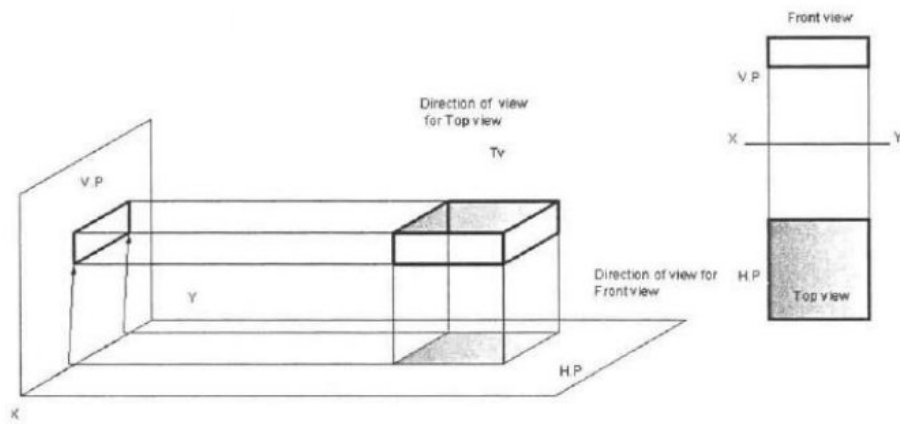
Third Angle Projection

In this, the object is situated in Third Quadrant. The Planes of projection lie between the object and the observer. The front view comes below the x y line and the top view about it.

Method of obtaining front view:
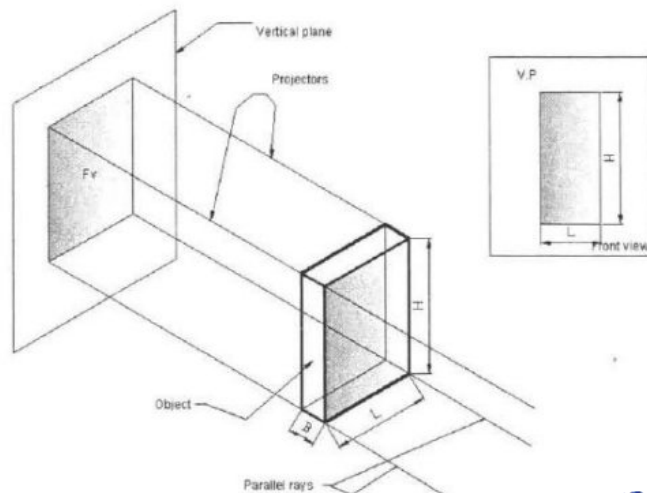
Method of obtaining top view:

EXERCISES

1. Draw the front view, top view and side view of the object whose isometric view is shown in the figure below (All dimensions are in mm).
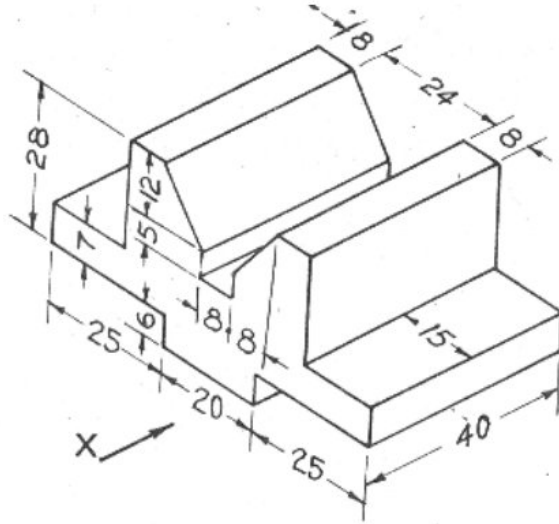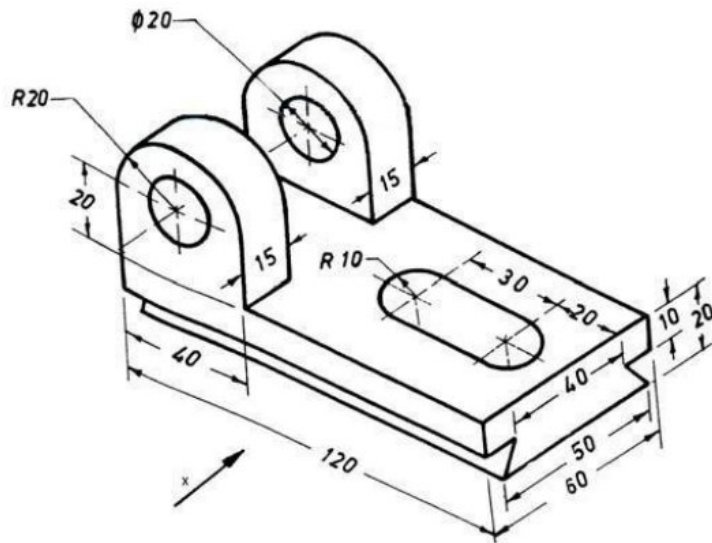

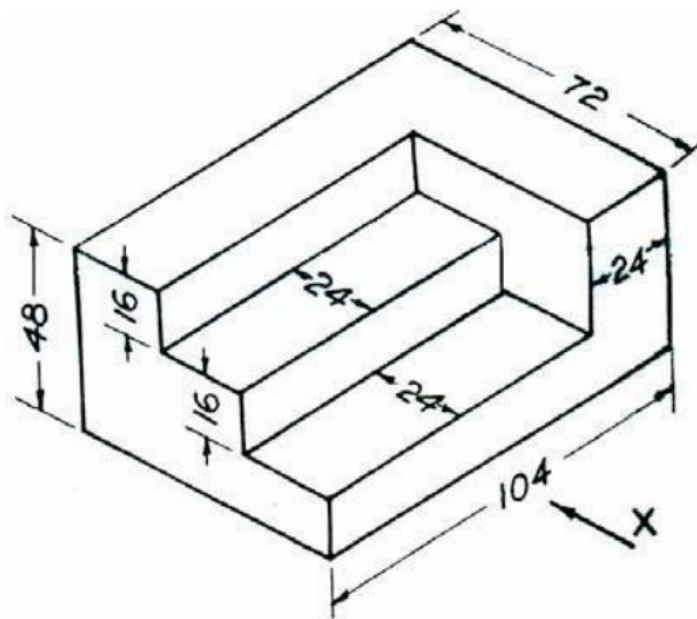2. Draw front view, top view and side view of the model shown below:
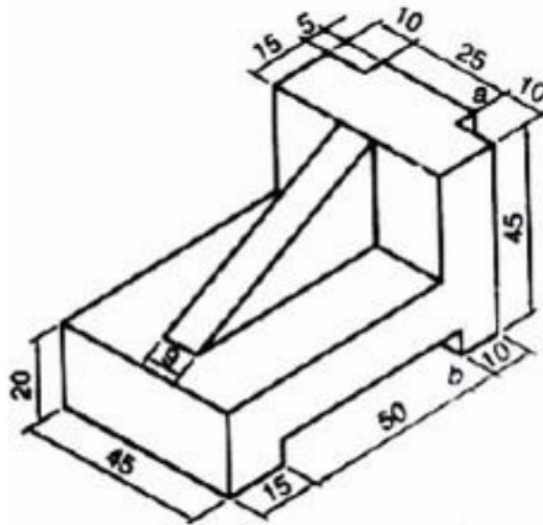
3. Draw the necessary Orthographic views for the Isometric view of the object shown below:

4. Draw front view, top view and side view of the model shown below:

5. Draw the Orthographic views of the Isometric view shown in the following figure:
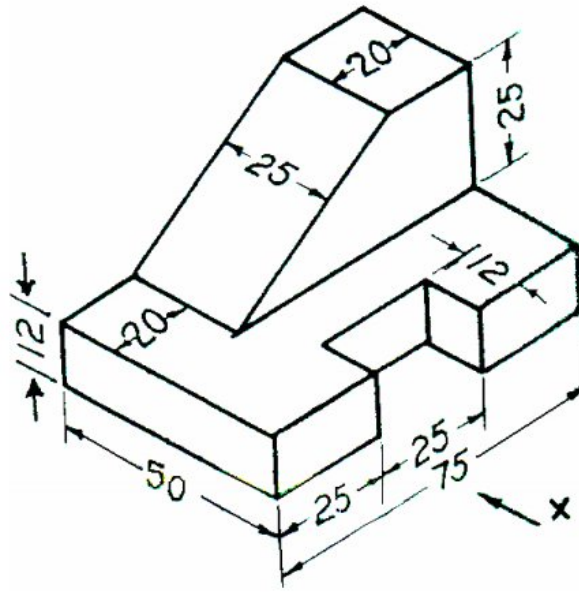
MODULE - IV

Projections of regular solids, sections and sectional views of right regular solids

Introduction

A solid has three dimensions, the length, breadth and thickness or height. A solid may be represented by orthographic views, the number of which depends on the type of solid and its orientation with respect to the planes of projection. Solids are classified into two major groups.
(i) Polyhedron, and (ii) Solids of revolution

Polyhedron

A polyhedron is defined as a solid bounded by plane surfaces called faces.
They are:
(i) Regular polyhedron (ii) Prisms and (iii) Pyramids.

Regular Polyhedron

A polyhedron is said to be regular if its surfaces are regular polygons. The following are some of regular polyhedrons.

(a) Tetrahedron   (b) Hexahedron(cube)   (c) Octahedron   (d) Dodecahedron   (e) Icosahedron
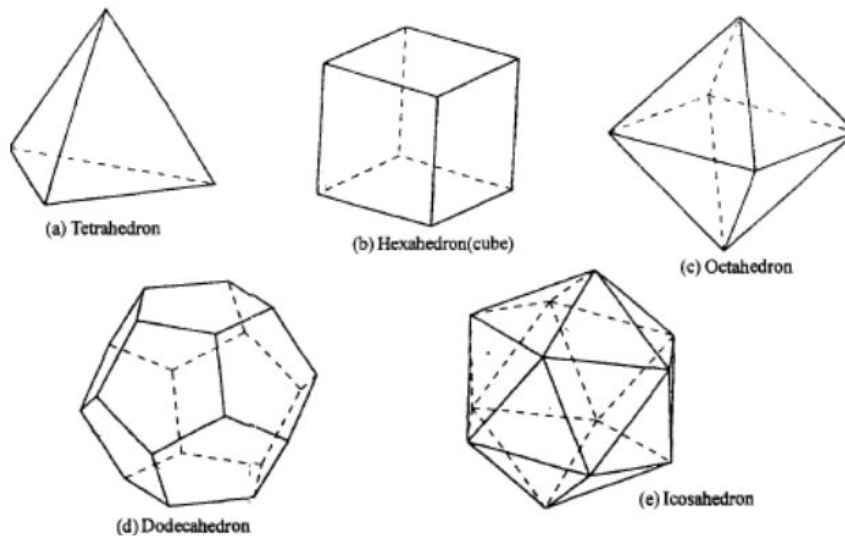
(a) Tetrahedron: It consists of four equal faces, each one being a equilateral triangle.
(b) Hexahedron (cube): It consists of six equal faces, each a square.
(c) Octahedron: It has eight equal faces, each an equilateral triangle.
(d) Dodecahedron: It has twelve regular and equal pentagonal faces.
(e) Icosahedron: It has twenty equal, equilateral triangular faces.

Prisms

A prism is a polyhedron having two equal ends called the bases parallel to each other. The two bases are joined by faces, which are rectangular in shape. The imaginary line passing through the centers of the bases is called the axis of the prism.
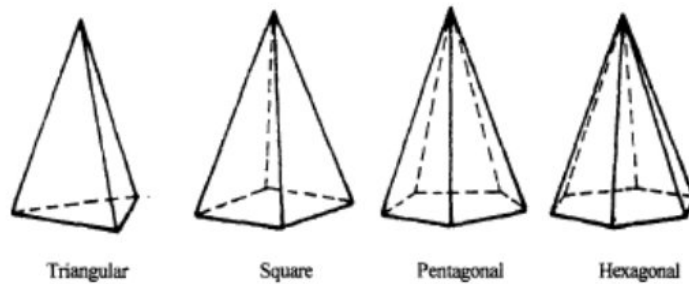A prism is named after the shape of its base. For example, a prism with square base is called a square prism; the one with a pentagonal base is called a pentagonal prism, and so on.

Cube   Right prism   Right rectangulr prism   Right pentagonal prism   Hexagonal prism
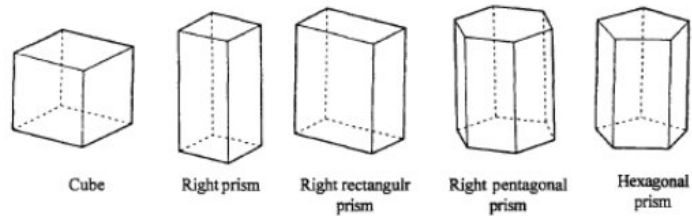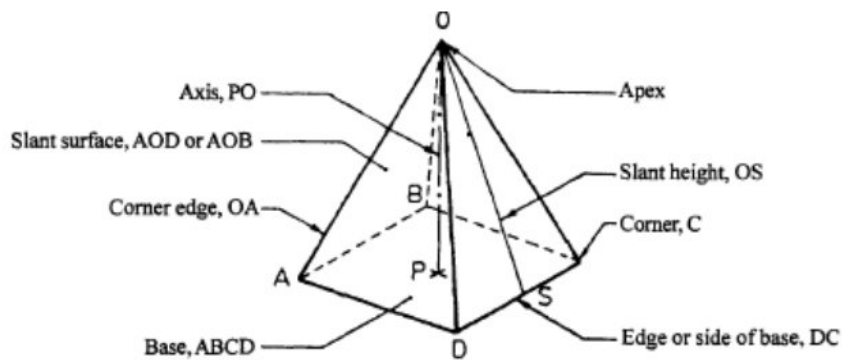
Pyramids

A pyramid is a polyhedron having one base, with a number of isosceles triangular faces, meeting at a point called the apex. The imaginary line passing through the centre of the base and the apex is called the axis of the pyramid. The pyramid is named after the shape of the base. Thus, a square pyramid has a square base and pentagonal pyramid has pentagonal base and so on.

Triangular   Square   Pentagonal   Hexagonal

The nomenclature of a pyramid is shown in figure:

Axis, PO —   — Apex
Slant surface, AOD or AOB —
Corner edge, OA —   — Slant height, OS
 — Corner, C
Base, ABCD —   — Edge or side of base, DC

EXERCISES

1. A square pyramid base 40 mm side and axis 75 mm long is placed on the ground on one of its slant edges so that the vertical plane passing through that edge and axis makes and angle of 30^0 with the V.P. Draw its three views.

2. A pentagonal pyramid having a base with a 30 mm side and a 60 mm long axis rests on an edge of its base on the ground, so that the highest point of the base is 20 mm above the ground. Draw its projections if the vertical plane containing the axis is inclined at 30^0 to the V.P.

3. Draw the projection of a cone, base 75 mm diameter and axis 100 mm long, lying on H.P. on one of its generators with axis parallel to the V.P.

4. A pentagonal prism is resting on corner of its base on the ground with a large edge containing that corner is inclined at 45° to the HP and the vertical plane containing that edge and the axis inclined at 30° to the VP. Draw its projections of its base side 40 mm and height 65 mm.

5. A square prism, side of base 30 mm and axis 50 mm long , has its axis inclined at 60^0 to H.P. its has an edge of its base in the H.P and inclined at 45^0 to V.P. Draw the projections.

6. A cone of base diameter 60 mm and altitude 75 mm lies on the H.P. on one of its generators. The plan of the axis is inclined at 45^0 to the V.P. draw its projections.

7. A square prism base 40 mm side and height 65 mm has its axis inclined at 45° to HP and has an edge of its base on the HP and inclined at 30° to VP. Draw its projections.

8. A square pyramid having a base with a 40 mm side and a 75 mm long axis has a corner of its base on the V.P. A slant edge contained by that corner is inclined at 45^0 to the V.P and the plane containing the slant edge and the axis is inclined at 60^0 to the H.P. Draw its projections.

9. Draw the projection of a rectangular pyramid of height 60 mm and base edge 30 mm resting on a corner with the slanting edge containing the above corner at 60^0 with H.P.

10. A pentagonal pyramid, base 25 mm side and axis 50 mm long has one of triangular faces in the V.P. and the edge of the base contained by that face makes an angle of 30 degrees with the H.P. Draw its projections.

11. One of the body diagonals of a cube of 45 mm edge is parallel to the H.P. and inclined at 45 degrees to the V.P. Draw the front view and top view of the cube.

12. A cone of base diameter 40 mm and axis height 60 mm rests on the ground on a point of its base circle such that the axis of the cone is inclined at 40^0 to the H.P and 30° to the V.P, Draw its front and top view.

13. A square prism, side of base 30mm and axis 50 mm long, has its axis inclined at 60° to HP. It has an edge of its base in the HP and inclined at 45° to VP. Draw its projections.

14. A square pyramid of base edge 30 mm and altitude 40 mm has one of its slant faces in the V.P and the edge of the base contained by that face is inclined at 45° to the H.P. Draw the projections of the pyramid when the vertex is in the H.P.

15. A pentagonal prism side of base 25 mm and axis 65 mm long rests with one of edges of its, base on

H.P Its axis is inclined at 30°, to H.P and parallel to V.P. Draw its projections.

16. A square prism, base 40 mm side and height 65 mm has its axis inclined at 45^0 to the HP and has an edge of its base, on the H.P and inclined at 30° to the V.P. Draw its projections.

17. Draw the projections of a cone, base 30 mm diameter and axis 50 mm long, resting on H.P on a point of its base circle with the axis making an angle of 45° with H.P and 30° with V.P.

18. Draw the projection of a square pyramid of base 40 mm side and axis 70 mm long, when the solid lies with one of its slant edges on HP and the vertical plane passing through that slant edge and axis makes 30^0 with V.P.

19. A pentagonal pyramid, with base 35 mm side and height 70 mm rests on one edge of its base on HP so that the highest point on the base is 25 mm above HP. Draw its projection, when the axis is parallel to VP. Draw another front view, on a reference line inclined at 45^0 to the edge on which it is resting so that the base is visible.

20. A frustum of a cone diameter of base 60 mm, diameter of top surface 30 mm and axis 45mm long is lying on HP on one of its generators. The plane containing the axis and the generator makes an angle of 45^0 to VP. Draw its front and top views.

MODULE - V
Development of surfaces and isometric projections

Introduction

A layout of the complete surface of a three dimensional object on a plane is called the development of the surface or flat pattern of the object. The development of surfaces is very important in the fabrication of articles made of sheet metal. The objects such as containers, boxes, boilers, hoppers, vessels, funnels, trays etc, are made of sheet metal by using the principle of development of surfaces.

In making the development of a surface, an opening of the surface should be determined fIrst. Every line used in making the development must represent the true length of the line (edge) on the object.

The steps to be followed for making objects, using sheet metal are given below:

5. Draw the orthographic views of the object to full size.
6. Draw the development on a sheet of paper.
7. Transfer the development to the sheet metal.
8. Cut the development from the sheet.
9. Form the shape of the object by bending.
10. Join the closing edges.

Methods of Development

The method to be followed for making the development of a solid depends upon the nature of its Lateral surfaces. Based on the classification of solids, the following are the methods of development.

1. Parallel-line Development

It is used for developing prisms and single curved surfaces like cylinders in which all the edges / Generators of lateral surfaces are parallel to each other.

2. Radial-line Development

It is employed for pyramids and single curved surfaces like cones in which the apex is taken as Centre and the slant edge or generator (which are the true lengths) as radius for its development.

Eg: To draw the development of a square prism of side of base 30mm and height 5Omm.
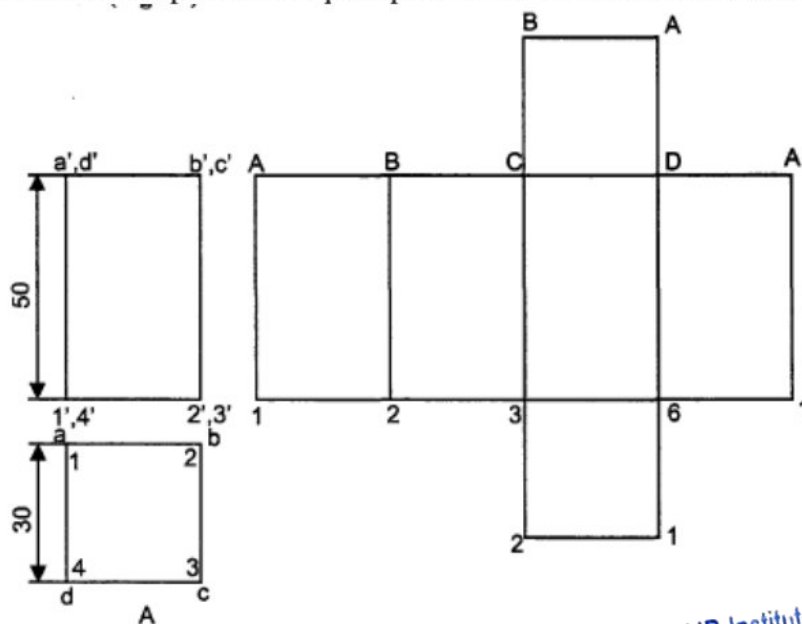
EXERCISES

1. A Hexagonal pyramid of base 50 mm and axis 100 mm long is resting on its base with two of its side parallel to VP. It is cut by a sectional plane perpendicular to VP and inclined at 45^0 to HP. Sectional plane is passing through the midpoint of axis .Draw the development for the top part of the pyramid.

2. Draw the development of a cylinder of 50 mm diameter and 75 mm height, containing a square hole of 25 mm side. The sides of the hole are equally inclined to the base and the axis of the hole bisects the axis of the cylinder.

3. A cylinder, base 65 mm diameter and 90 mm long, and the base lying on the ground. It is cut by a horizontal section plane inclined 30^0 to the H.P and cutting the axis at a point 40 mm above the ground. Draw the development of lateral surface of cylinder.

4. A pentagonal prism, base 30 mm side and axis 60 mm long, and the base lying on the ground. It is cut by a horizontal section plane inclined 30^0 to the H.P and cutting the axis at a point 25 mm above the ground. Draw the development of lateral surface of cylinder.

5. A pentagonal prism having a base with 30 mm side and 70 mm long axis is resting on its base on HP. Such that one of the rectangular faces is parallel to VP. It is cut by an auxiliary inclined plane whose VT is inclined at 45^0 with the reference line and passes through midpoint of the axis, draw the development of the lateral surface of the prism.

6. A cube of 40 mm edge stands on one of its faces on H.P. with a vertical face making 45^0 to the V.P. a horizontal hole of 30 mm diameter is drilled centrally through the cube such that the hole passes through the opposite vertical edges of the cube. Obtain the development of the lateral surface of the cube with the hole.

7. A right cone with 50 mm base diameter and 60 mm axis is resting on its base in the HP, its cut by an auxiliary inclined lane parallel to and 8 mm away from the extreme generator, draw the development of the lateral surface of the remaining solid.

8. A cone, base 50 mm diameter and 70 mm long, and the base lying on the ground. It is cut by a horizontal section plane inclined 45^0 to the H.P and cutting the axis at a point 40 mm above the ground. Draw the development of lateral surface of cone.

9. A square pyramid with side of base 30 mm axis 50 mm long is resting on its base on H.P with on edge of the base parallel to V.P .it is cut by a sectional plane, perpendicular to V.P and inclined at 45^0 to H.P the sectional plane is passing through the midpoint of the axis. Draw the development of the surface cut pyramid.

ISOMETRIC PROJECTIONS

Introduction

Pictorial projections are used for presenting ideas which may be easily understood by persons even without technical training and knowledge of multi-view drawing. The pictorial drawing shows several faces of an object in one view, approximately as it appears to the eye.

Isometric scale

In the isometric projection of a cube shown in Fig, the top face ABCD is sloping away from the observer and hence the edges of the top face will appear fore-shortened. The true shape of the triangle DAB is represented by the triangle DPB.
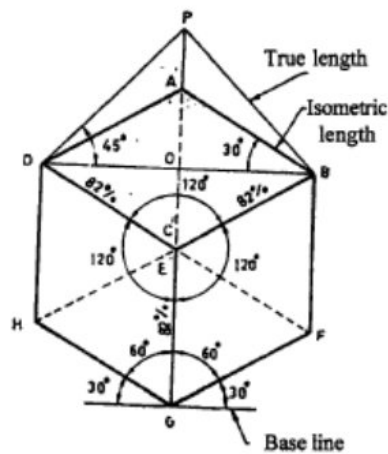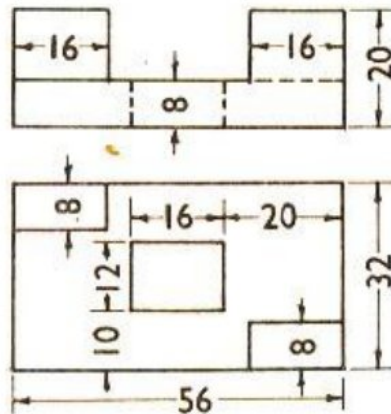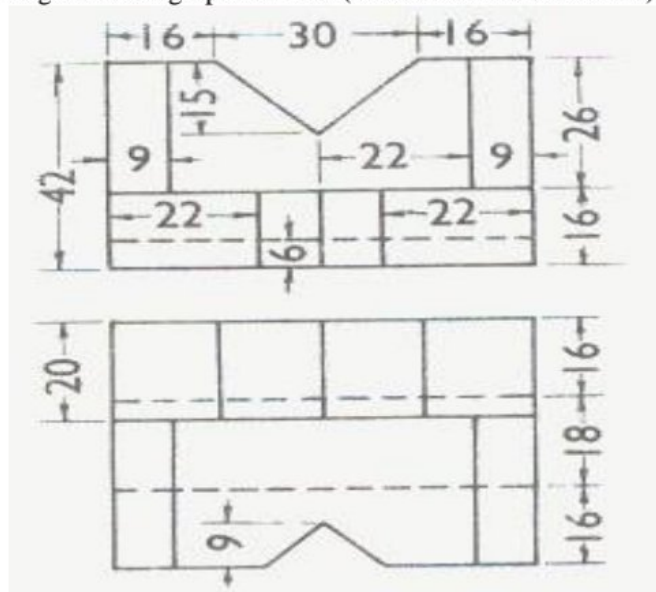

Isometric Scale:
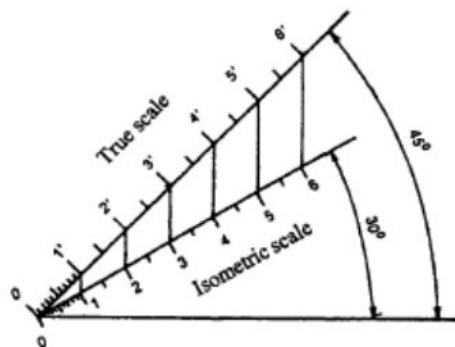
EXERCISES

1. Draw an isometric view of given figure below. (All dimensions are in mm).
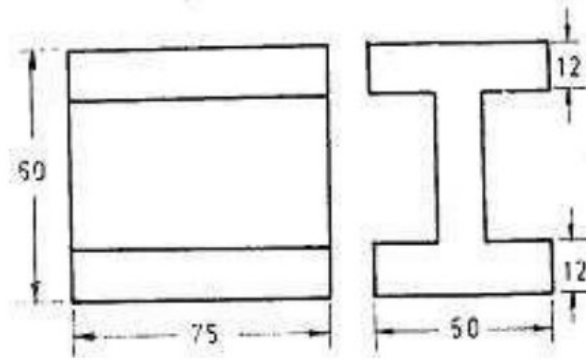

2. Draw the isometric view of given orthographic views. (All dimensions are in mm)

3. Draw the isometric projection of a frustum of hexagonal pyramid, side of base 30 mm the side of top base 15 mm of height 50 mm.

4. Draw the isometric view of a cone 40 mm diameter and axis 55 mm long when its axis is horizontal.

5. The outside dimensions of a box made of 5 mm thick wooden planks are 80 x 60 x 50 mm. The depth of the lid on outside is 10 mm. Draw the isometric view of the box with the lid open.

6. A cylinder of base diameter 30 mm axis 60 mm is resting centrally on a slab of 60 mm square and thickness 20 mm. Draw the isometric projection of the combination of the solids.

7. A paperweight consists of a frustum of a square pyramid, side of base 70 mm at the bottom, 40 mm at the top and 20 mm height. It is surmounted by a cylinder of 30 mm diameter with spherical knob of 40 mm diameter at the top such that the center of the sphere is at a height of 25 mm from the top of the frustum. Draw the isometric projection of the assembly.

8. Draw the isometric view of the object whose orthographic projections are given in fig. All dimensions are in mm.