# ABES ENGINEERING COLLEGE, GHAZIABAD

## DEPARTMENT OF MECHANICAL ENGINEERING

## LAB FILE

## Engineering Graphics and Design Lab (BCE151/BCE251)

**(Engineering Graphics and Design Lab, Ramanujan Block, 1st Floor)**

## B.Tech. 1st Year (I Semester/ II Semester)


**Mr. Chetan Rajoria** | **Dr. R.S. Raman**

**(Lab Coordinator)** | **(HOD-ME)**


## DR. A.P.J. ABDUL KALAM TECHNICAL UNIVERSITY, LUCKNOW

## About the Lab

The engineering graphics and design lab (BCE151/ BCE251) is a crucial introductory course in the first year of B.Tech. programs offered by AKTU, Lucknow irrespective of the engineering specialization. This is vital because engineers often need to communicate their ideas visually to colleagues, clients, and contractors. This lab is designed to provide students with hands-on experience in graphical communication and technical drawing. Various Drawing sheets are prepared by the students for different topics and in the last they also learn to use AutoCAD software on an introductory level in a computer lab.

It aims to develop their skills in creating and interpreting engineering drawings, diagrams, and visual representations of objects. Its significance lies in its role as a centre of engineering design, communication and problem-solving skills, which are essential for success in the diverse and dynamic fields of engineering.

## OBJECTIVE:

The objective of an engineering graphics Lab in the first year of engineering is to impart foundational skills and knowledge related to graphical representation, visualization and technical communication in the context of engineering. Students are provided exposure of techniques, skills and modern engineering tools necessary for engineering practice. They are familiarized with orthographic projection and other techniques used to represent objects in multiple views. This knowledge is essential for understanding and creating engineering drawings. Some other objectives of the lab are to develop the drawing skills, and to enhance the spatial visualization of the students besides this, another objective is to promote Computer-Aided Design (CAD) Proficiency in the students.

## List of Experiments

# ABES ENGINEERING COLLEGE, GHAZIABAD

## DEPARTMENT OF MECHANICAL ENGINEERING

## Engineering Graphics and Design Lab (BCE151 / BCE251)

| S. No. | Name of Experiments | Outcomes |
|---|---|---|
| 1 | To demonstrate the methods of dimensioning and lettering and to understand the applications of various types of lines in an engineering drawing. | CO1 |
| 2 | To understand the concepts of Orthographic projection, and to demonstrate the method of projection of points located in any of the four quadrants. | CO1 |
| 3 | To understand the fundamentals of orthographic projection of straight lines and to demonstrate the method of projection of lines located in 1st quadrant only. | CO1 |
| 4 | To understand the fundamentals of orthographic projection of 2D surfaces and to demonstrate the method of projection of planes. | CO2 |
| 5 | To understand the fundamentals of orthographic projection of regular 3D objects and to demonstrate the method of projection of Solids. | CO2 |
| 6 | To understand the fundamentals of isometric scale and projection, and to draw isometric projection of plane surfaces as well as standard and compound solids. | CO3 |
| 7 | To demonstrate the application of AutoCAD software for design and creation of basic drawings. | CO4 |

## Beyond Lab Curriculum:

| S. No. | List of Experiments | Outcomes |
|---|---|---|
| 1 | To learn various ways of drawing a regular polygon and to learn some basic geometrical construction work. | CO1 |
| 2 | To draw various engineering curves like epicycloid, hypocycloid and involute curves. | CO1 |

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# ABES ENGINEERING COLLEGE, GHAZIABAD

## DEPARTMENT OF MECHANICAL ENGINEERING

## Engineering Graphics and Design Lab (BCE151 / BCE251)

**COURSE OUTCOMES:**

Upon the completion of this course, the student will be able to:

| Course Outcome No. | Statement | Knowledge Level, KL |
|---|---|---|
| **CO1** | Draw orthographic projection of basic identities such as points and lines. | K3 |
| **CO2** | Draw orthographic projections of plane surfaces and simple regular solids | K3 |
| **CO3** | Draw Isometric Projections of compound geometrical solids. | K3 |
| **CO4** | Apply AutoCAD software for creation of engineering drawing and models | K3 |

**CO-PO Mapping:**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 2 | | | | | | 2 | 1 | | 2 |
| **CO2** | 3 | 2 | 2 | | | | | | 2 | 1 | | 2 |
| **CO3** | 3 | 2 | 2 | | | | | | 2 | 1 | | 2 |
| **CO4** | 3 | 1 | 2 | | 3 | | | | 2 | 1 | | 2 |
| **Course** | **3** | **1.75** | **2** | | **3** | | | | **2** | **1** | | **2** |

**Signature of Lab Coordinator** **Signature of HOD (ME)**

# ABES Engineering College, Ghaziabad

## Department of Mechanical Engineering

**ENGINEERING GRAPHICS AND DESIGN LAB (BCE 151/BCE251)**

**SHEET No-01 (DIMENSIONING, LETTERING AND TYPES OF LINES)**

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**1.1 Objective** **1.2 Instruments to be used** **1.3 Theory** **1.4 Lettering**

**1.5 Procedure** **1.6 Precautions** **1.7 Viva Questions**

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### 1.1 OBJECTIVE:

To demonstrate the methods of dimensioning and lettering and to understand the applications of various types of lines in an engineering drawing.

### 1.2 INSTRUMENTS TO BE USED:

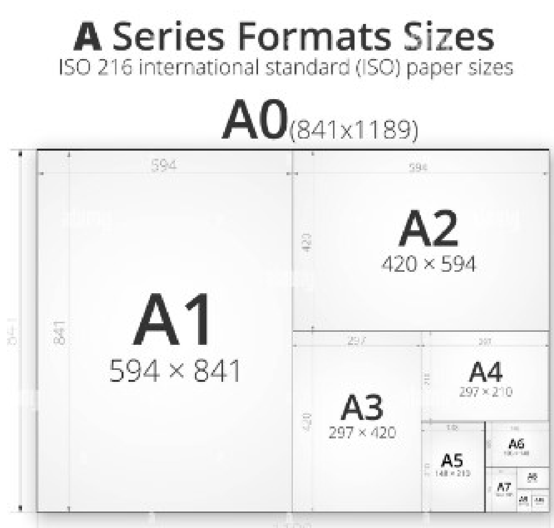
Drawing board , Mini drafter, Geometrical Instrument box (including a protractor, set of rulers, Pencils - H, 2H, eraser, sharpener, compass and divider), Drawing sheet clips (preferably) or cello tape, a Drawing sheet – A2 size, sheet cover.

### 1.3 THEORY:

**1.3.1 Introduction and sizes of the sheet:** 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 of engineers from which a trained person can visualize objects without any need of oral communication. As per various requirements, various standard sizes of sheets are in use, e.g. A0, A1, A2, A3, A4, A5, etc. As per ISO standard, the sizes of some of them are mentioned below-

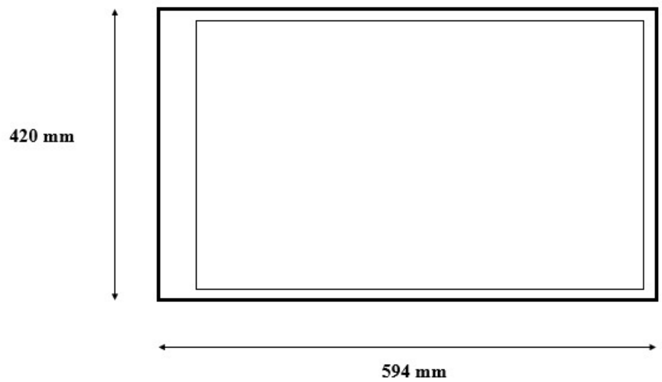
- 210 mm x 297 mm (A4)
- 297 mm x 420 mm (A3)
- 420 mm x 594 mm (A2)
- 594 mm x 841 mm (A1)
- 841 mm x 1189 mm (A0)

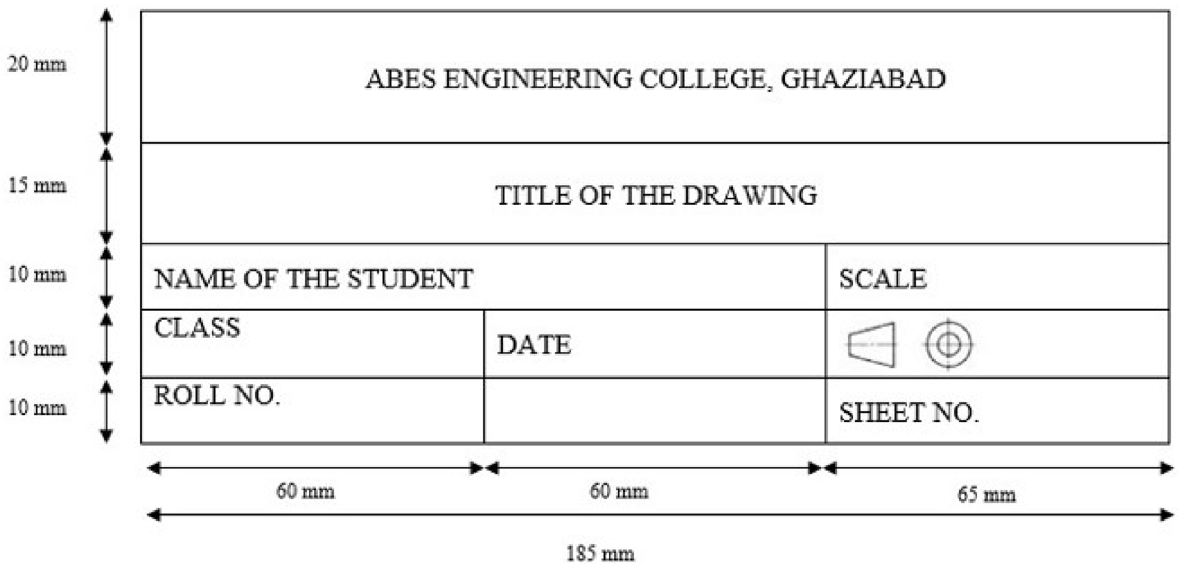
We will use A2 Sheet for drawing in the lab.




**1.3.2 Border of the sheets :** Before using the sheets For engineering drawing, a border line is to be drawn As per the following information : *5 mm from each side Right , top & Bottom and 20 mm from left side* (keeping the sheet in landscape layout).

**1.3.3 Title block :** A title block is to be prepared by the owner of the sheet with all the required details as shown in the diagram below : In every sheet, this title block is to be prepared in the bottom right corner of the sheet, after the border. The name of the student and his/her roll number is to be mentioned using Black pen, and rest all other entries are to be filled using H pencil.



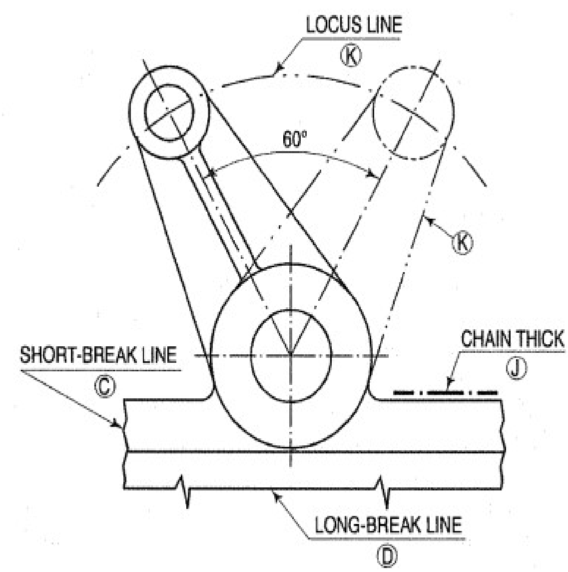



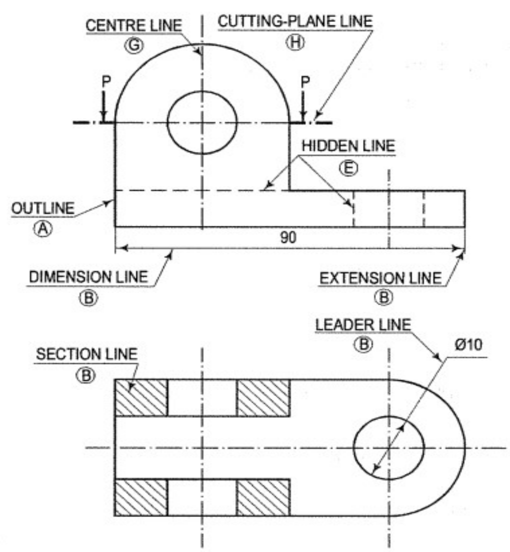

**1.3.4. Types of lines:**

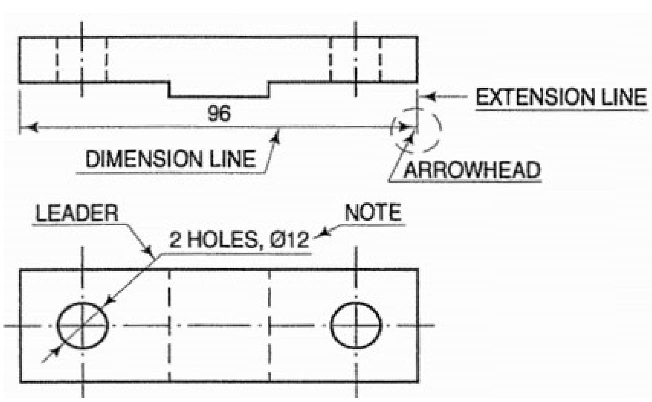
| Line | | Description | General Application |
|---|---|---|---|
| A | | Continuous thick | A1 Visible outlines.<br>A2 Visible edges. |
| B | | Continuous thin (straight or curved) | B1 Imaginary lines of intersection.<br>B2 Dimension lines.<br>B3 Projection lines.<br>B4 Leader lines.<br>B5 Hatching lines.<br>B6 Outlines of revolved sections in place.<br>B7 Short centre lines |
| C | | Continuous thin free hand | C1 Limits of partial or interrupted views and sections, If the limit is not a chain thin. |
| D | | Continuous thin (straight) with zigzags | D1 Long break line |
| E | | Dashed thick | E1 Hidden outlines.<br>E2 Hidden edges. |

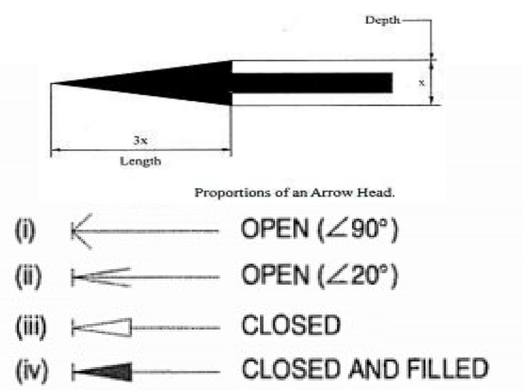
| | | | |
|---|---|---|---|
| F | | Dashed thin | F1 Hidden outlines.<br>F2 Hidden edges. |
| G | | Chain thin | G1 Center lines.<br>G2 Lines of symmetry.<br>G3 Trajectories |
| H | | Chain thin, thick at ends and changes of direction | H1 Cutting planes. |
| J | | Chain thick | J1 Indication of lines or surfaces to which a special requirement applies |
| K | | Chain thin double dashed | K1 Outlines of adjacent parts.<br>K1 Alternative or extreme position of movable parts.<br>K3 Centroidal lines.<br>K4 Initial outlines prior to forming<br>K5 Parts situated in front of the cutting plane |

The use of various types of lines (mentioned in the table above) is shown in the following engineering drawings-




Proportions of an Arrow Head.

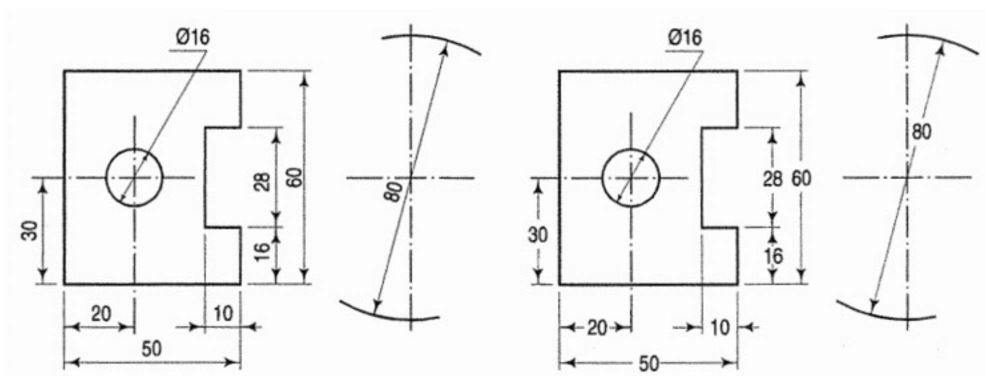
**1.3.5 Arrow head dimensions:** An arrow is an integral part of engineering drawing. Specially for dimension representation, arrow heads are used in dimension lines as well as in leader lines. The size of an arrow head is to be kept small, and its *width and length should be in the ratio of 1:3*. There are various types of arrow heads which can be used in the drawings, but “Closed and filled” is most popularly used.

**1.3.6 DIMENSIONING:** Drawing of a component, in addition to providing complete shape description, must also furnish Information regarding the size description. These are provided through the distances between the Surfaces, location of holes, nature of surface finish, type of material, etc. The expression of these features on a drawing, using lines, symbols, figures and notes is called dimensioning.

Methods of indicating dimensions: i) Aligned System, ii) Unidirectional Method

i) **Aligned system:** Dimensions should be placed parallel to and above their dimension lines and preferably at the middle, and clear of the line. Dimensions may be written so that they can be read from the bottom or from the right side of the drawing.

ii) **Unidirectional system:** Dimensions should be indicated so that they can be read from the bottom of the drawing only. Non-horizontal dimension lines are interrupted, preferably in the middle for insertion of the dimension.




Aligned system Unidirectional system

All dimension will be in mm until unless specified otherwise.

**General Principles of dimensioning: -**

- All dimensions should be mentioned on drawing.
- No single dimension should be repeated where unavoidable.
- Mark the dimensions outside the drawing as far as possible.
- Avoid dimensions to hidden lines wherever possible.
- The longer dimensions should be placed outside all intermediate dimensions, so that dimension line cannot cross extension lines.

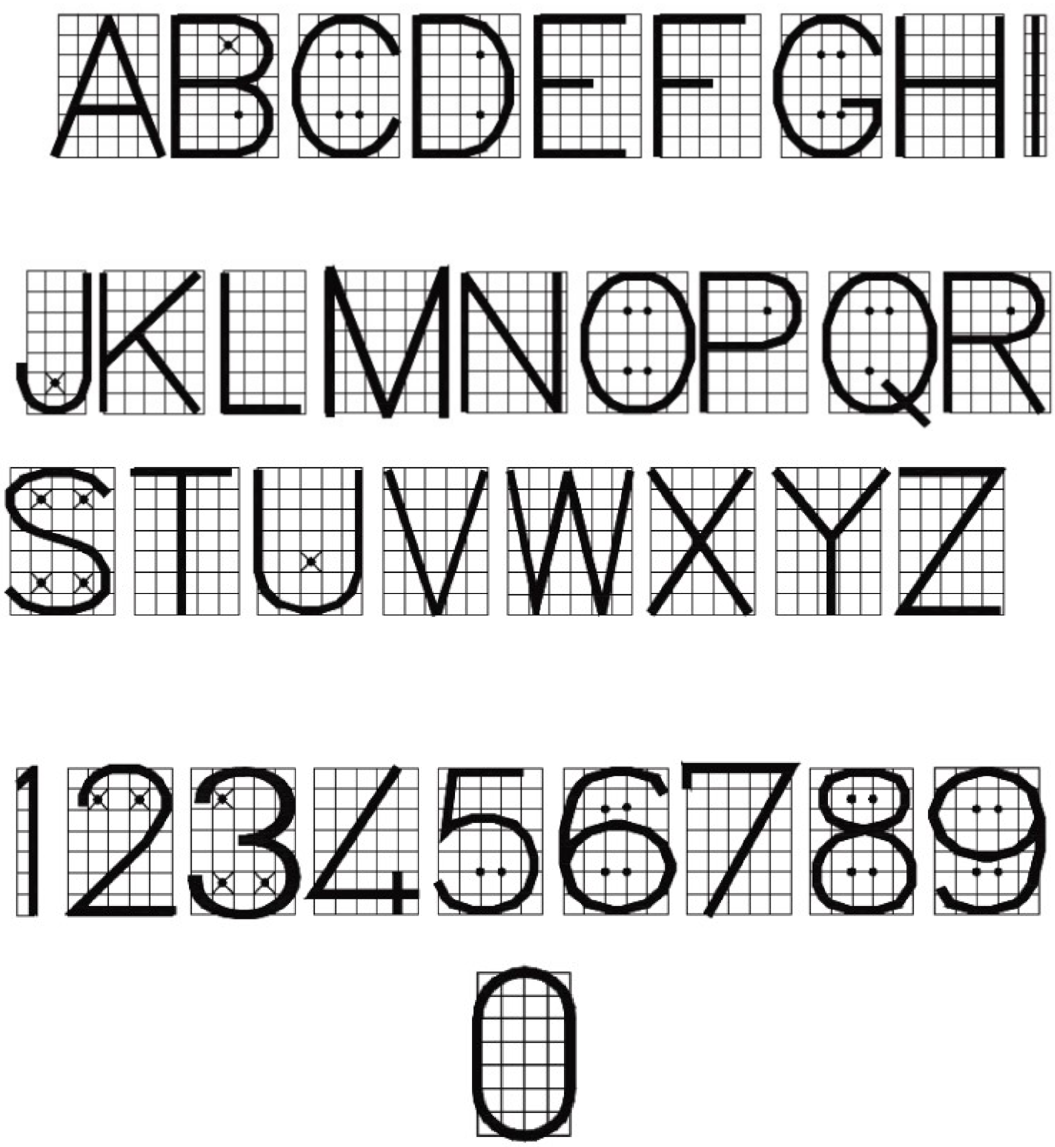
**1.4 LETTERING**

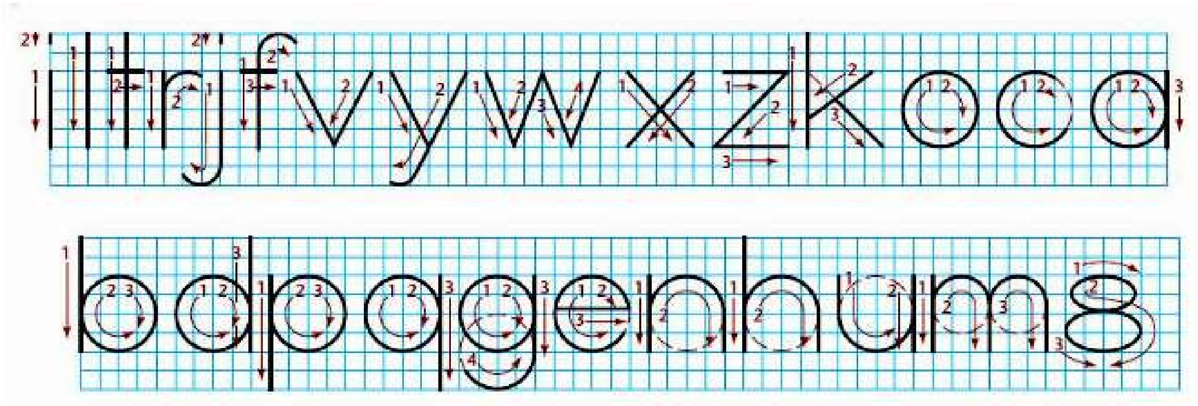
In engineering drawing, whatever is written on the drawing sheet must be written in a particular fashion so that it is legible, uniform in appearance, and ready for quick reading. The writing explains those details of the object which cannot be shown through lines. Apart from this, there are other writings such as titles, sub titles and recording details about the drawing which are written on the prepared drawing. The poor lettering and numbering not only kills the beauty of the drawing but sometimes convey incorrect information also, resulting in wastage of time and labour. The process of writing details on the drawing sheet is called *lettering*.

Following types of lettering system is used in the drawing sheets:

- Single stroke capital letters also known as capital uppercase letters.
- Single stroke capital inclined (*italic*) letters.
- Double stroke capital letters.
- Double stroke inclined (*italic*) capital letters.
- Small vertical lowercase letters.
- Small inclined (*italic*) lowercase letters.

Here in the lab, we will practice to draw only these two types- single stroke capital letters, and single stroke small vertical lowercase letters.





**1.5 PROCEDURE**

- For CAPITAL letters, guide-lines (or grid) are prepared using **eight** parallel horizontal lines, each 3 mm apart, and numerous perpendicular lines with the same gaps in between. A uniform grid pattern of small equal sized squares (*3mm X 3mm*) is obtained, with **seven** squares in each column. 2H pencil is used for preparing this grid.

- As shown in the figures above, most of the letters are drawn in the size ratio of:

  **height : width** = 7:5
- These letters and numerals are *exceptions* for this size:

  **I** (7:1), **J** (7:3), **L** (7:4), **M** (7:6), **W** (7:6), **1** (7:1), **0** (zero) (7:4).
- A gap of one blank column is to be left between every consecutive letter or numeral.

- For small letters, guide-lines (or grid) are prepared using **nine** parallel horizontal lines, each 3 mm apart, and numerous perpendicular lines with the same gaps in between. A uniform grid pattern of small equally sized squares is obtained, with **eight** squares in each column. 2H pencil is used for preparing this grid.
- The letters are mainly drawn in the central **four** rows as shown in the figures, with the extension of specific letters up to the top row or the bottom row, as required. The size ratio of each letter is also shown in the figure.

**1.6 PRECAUTIONS:**

1. The drawing board must not wobble and all four legs of the drawing board must be properly stable on the ground.

2. The drafter must be of good built quality and it must be rigidly fixed on the top left corner of the drawing board to make sure that perfect parallel/perpendicular lines are obtained on the drawing.

3. The pencils should be properly sharpened to attain required accuracy in drawing.

4. Hands should be clean and surroundings should be free from any dirt.

5. The sheet should not displace during the whole duration of drawing, and its edges should be perfectly horizontal and vertical with respect to the board edges.

6. The light and dark lines (i.e. thin and thick lines) must be clearly distinguishable.

7. Use of eraser should be as less as possible, to avoid any chances of previous imprints on the sheet.

8. A sufficient gap should be maintained with the drawing boards of other nearby students.

**1.7 VIVA QUESTIONS:**

**1)** What are the standard sheet sizes for engineering drawing? Which size we use in Engineering Graphics and Design lab?
**2)** How much gap is maintained for the border lines on all the four sides on a sheet?
**3)** What are the dimensions of the title block?
**4)** What are different types of lines?
**5)** What dimensional ratio is to be maintained for drawing an arrow head?
**6)** What are various methods of dimensioning?
**7)** Explain the applications of- a) Hidden lines, b) Extension lines, c) Projector lines, d) Leader lines, e) Continuous thick lines, f) Continuous thin lines.
**8)** What is the purpose of 'Lettering' on engineering drawing?

# ABES Engineering College, Ghaziabad

## Department of Mechanical Engineering

**ENGINEERING GRAPHICS AND DESIGN LAB (BCE 151/BCE251)**

**SHEET No-02 (FUNDAMENTALS OF ORTHOGRAPHIC PROJECTION, AND PROJECTION OF POINTS)**



### 2.1 OBJECTIVE:

To understand the concepts of Orthographic projection, and to demonstrate the method of projection of points located in any of the four quadrants.

### 2.2 INSTRUMENTS TO BE USED:

Drawing board, Mini drafter, Geometrical Instrument box (including a protractor, set of rulers, Pencils - H, 2H, eraser, sharpener, compass and divider), Drawing sheet clips (preferably) or cello tape, a Drawing sheet – A2 size, sheet cover.

### 2.3 THEORY:

#### 2.3.1 SOME IMPORTANT TERMS

**i) Projection:** It is basically the representation of a 3D object on a 2D surface. If straight lines are drawn from various points on the contour of an object to meet a plane, object is said to be projected at that plane. The figure formed on that plane by joining all the dropped points in correct sequence in which the lines meet the plane is called a projection of the object.

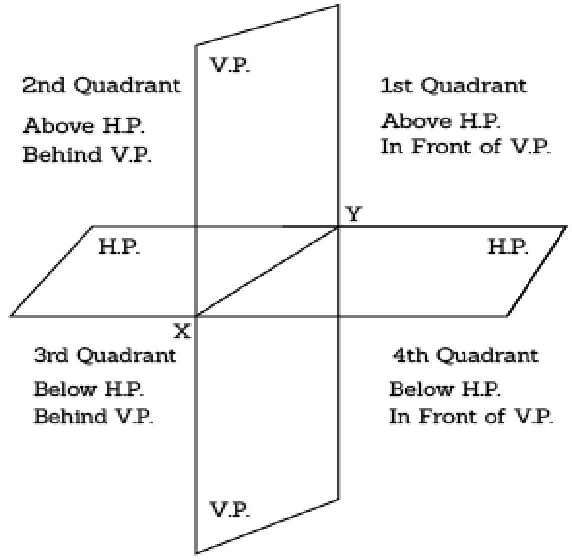
**ii) Projector lines or Projectors:** The lines from the object to the plane of projection are called as the projectors or projector lines.

**iii) Plane of projection:** The plane on which the projectors meet is known as the plane of projection.

**iv) Orthographic projection:** When the projectors are parallel to each other and also perpendicular to the projection plane, the projection is called orthographic projection. A plane parallel to the floor is known as **horizontal plane (HP)**. Orthographic projection of an object on horizontal plane is known as **top view (plan)**. One plane conveniently selected out of the planes perpendicular to horizontal plane is known as **vertical plane (VP)**. When the projection is taken on that plane, it is known as **front view (elevation).** A plane perpendicular to horizontal plane and vertical plane both is known as auxiliary vertical plane or **profile plane (PP)**. Orthographic projection on auxiliary plane is known as end view or

**side view**.

**v) Quadrants:** Whole of the 3D space is divided in to 4 quadrants, named as 1st, 2nd, 3rd and 4th quadrants. Object can be placed in any of the four quadrants, and its location is defined in terms of HP and VP as shown in the figure.

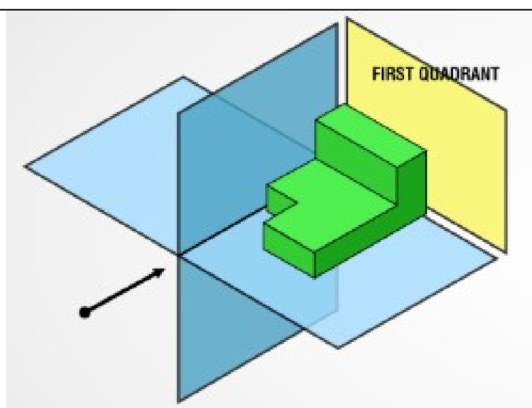
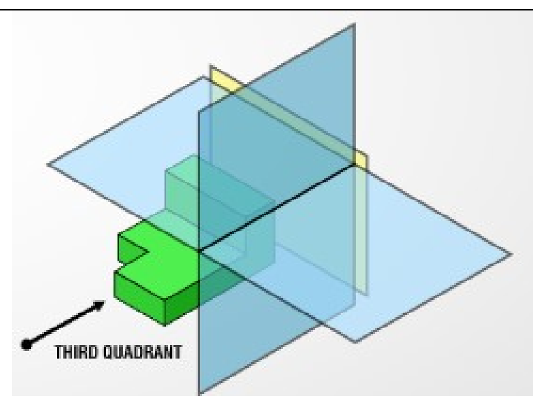



**vi) Reference Line:** The line of intersection of both the principle planes is called as reference line or XY line. All measurements are done with respect to this line.

**vii) Fixed and rotating planes:** As mentioned earlier, the plan and elevation are obtained on two mutually perpendicular planes, HP and VP respectively. To represent both of these projections on a single 2D plane, it is assumed that VP is fixed and HP can rotate in clockwise (i.e. downward) direction with an angle of 90°.

### 2.3.2 FIRST ANGLE AND THIRD ANGLE PROJECTION

For obtaining the projections (front, top or side views) of an object, it is placed either in the first quadrant or in the third quadrant. Accordingly, the projection systems are called as '1st Angle Projection' or '3rd Angle Projection'. The detailed difference between these two types of projection system is mentioned below-

| 1st Angle Projection System | 3rd Angle Projection System |
|---|---|
| Object is placed in the first quadrant | Object is placed in the third quadrant |
| The planes are considered as opaque. | The planes are considered as transparent. |
| Right side view is obtained to the left of elevation, and left side view is obtained to the right of elevation. | Right side view is obtained to the right of elevation, and left side view is obtained to the left of elevation. |
| Plan is obtained below and elevation is obtained above the XY line | Plan is obtained above and elevation is obtained below the XY line |
|   |   |

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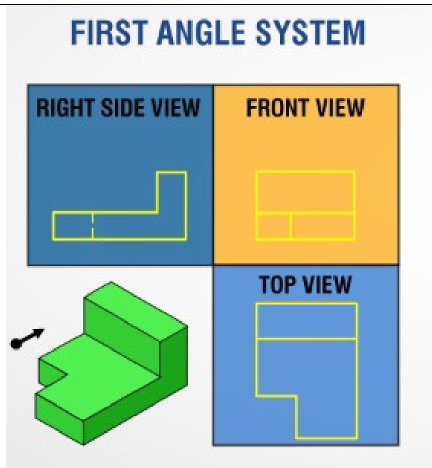
<td>
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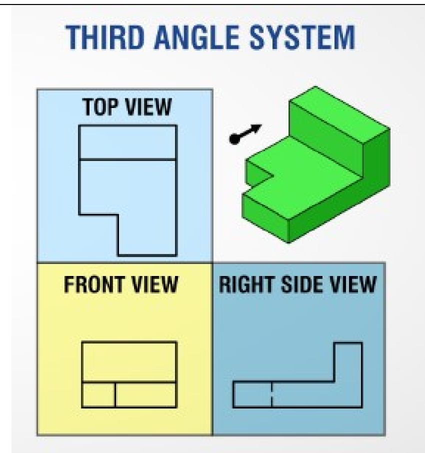
<td>
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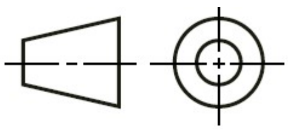
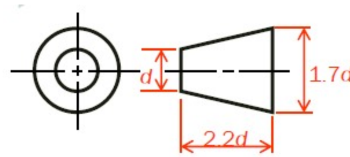
<td>Symbol:<br></td>
<td>Symbol:<br>
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**Why 2nd and 4th angle projection is not used :** As per the declared rule of projection, when the horizontal plane is rotated 90° in a clockwise direction, the top and front views will overlap. And these overlapping projection views create confusion in the drawing. Therefore, the <u>second and fourth angle projection systems are not used.</u>

## 2.4 PROJECTION OF POINTS

A point is an element or entity which has no dimensions.

**Conventional Representation:**

- Actual Position of a point designated by capitals i.e. A, B, C, D …
- Front view of a point is designated by small letters with dashes i.e. a’, b’, c’, d’….
- Top view of a point is designated by only small letters i.e. a, b, c, d ….
- Side view of a point is designated by small letters with double dashes i.e. a”, b”, c”, d”...

A point can be situated in the following positions with respect to principal planes of projection-

1. Point situated above H.P and in front of V.P. (in 1st quadrant)
2. Point situated above H.P and behind V.P (in 2nd quadrant)
3. Point situated below H.P and behind V.P. (in 3rd quadrant)
4. Point situated below H.P and in front of V.P. (in 4th quadrant)
5. Point situated on H.P and in front of V.P. (on HP, between 4th and 1st quadrant)
6. Point situated above H.P and on V.P. (on VP, between 1st and 2nd quadrant)
7. Point situated on H.P and behind V.P. (on HP, between 2nd and 3rd quadrant)
8. Point situated below H.P and on V.P. (on VP, between 3rd and 4th quadrant)
9. Point situated on both H.P and V.P. (on XY line)

## 2.5 PROCEDURE

**For any case, Front View is obtained on the VP and distances above/below HP are marked on it. Similarly, Top View is obtained on the HP and distances in front of/behind VP are marked on it.**

### 2.5.1 When the point is lying in the $1^{st}$ quadrant; or between $4^{th}$ and $1^{st}$ quadrants; or between $2^{nd}$ and $1^{st}$ quadrants (cases no. 1, 5 and 6 above):

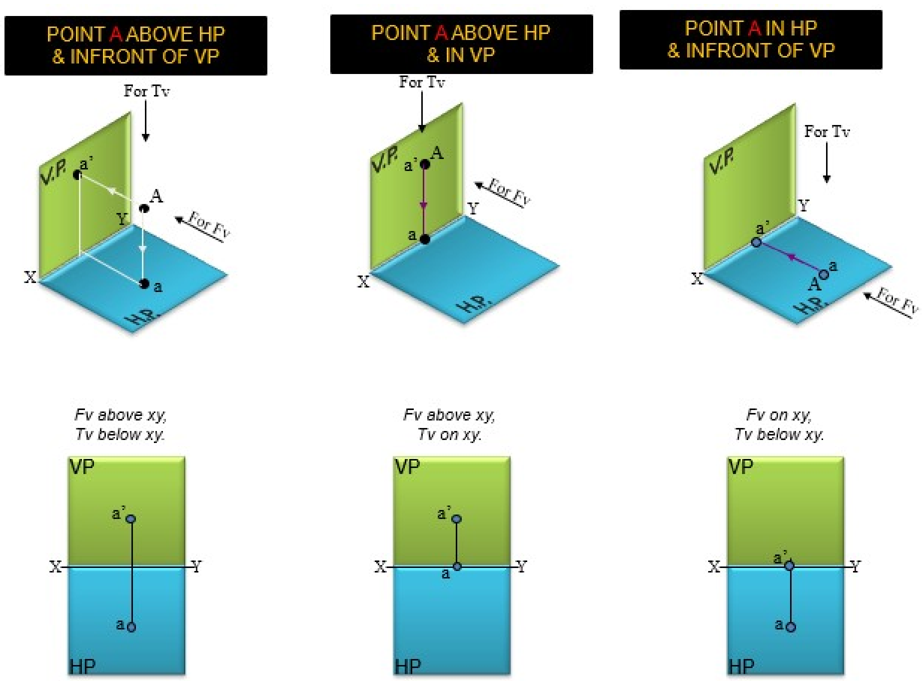
Let, a point is K mm above HP and L mm in front of VP.

i) Draw the XY line

ii) Front view is obtained above the reference line, at a distance of K mm from it.

iii) Top view is obtained below reference line, at a distance of L mm from it.

iv) If a point is on HP, then K = 0. If a point is on VP, then L = 0. Mark front view or top view accordingly.




### 2.5.2 When the point is lying in the $2^{nd}$ quadrant, or between $2^{nd}$ and $3^{rd}$ quadrants (cases no. 2 and 7 above):

Let, a point is K mm above HP and L mm behind VP.

i) Draw the XY line

ii) Front view is obtained above the reference line, at a distance of K mm from it.

iii) Top view is also obtained above the reference line, at a distance of L mm from it.

iv) If a point is on HP, then K = 0. Mark the front view accordingly.

### 2.5.3 When the point is lying in the $3^{rd}$ quadrant, or between $3^{rd}$ and $4^{th}$ quadrants (cases no. 3 and 8 above):

Let, a point is K mm below HP and L mm behind VP.

i) Draw the XY line

ii) Front view is obtained below the reference line, at a distance of K mm from it.

iii) Top view is obtained above the reference line, at a distance of L mm from it.

iv) If a point is on VP, then L = 0. Mark the top view accordingly.

**2.5.4 When the point is lying in the 4th quadrant (cases no. 4):**

i) ) Draw the XY line

ii) Front view is obtained below the reference line, at a distance of K mm from it.

iii) Top view is also obtained below the reference line, at a distance of L mm from it.

**2.5.5 When the point is lying on both, HP and VP (cases no. 9):**

i) ) Draw the XY line

ii) Front view and Top view, both the views are obtained as a single point on the reference line, because K = 0 as well as L = 0

**2.6 PROBLEMS FOR PRACTICE**

**Q.1) Draw the orthographic projections of the following points, keeping the projectors 20 mm apart-**

(a.) Point P is 30 mm. above H.P and 40 mm. in front of VP

(b.) Point Q is 25 mm. above H.P and 35 mm. behind VP

(c.) Point R is 32 mm. below H.P and 45 mm behind VP

(d.) Point Sis 35 mm. below H.P and 42 mm in front of VP

(e.) Point T is in H.P and 30 mm behind VP

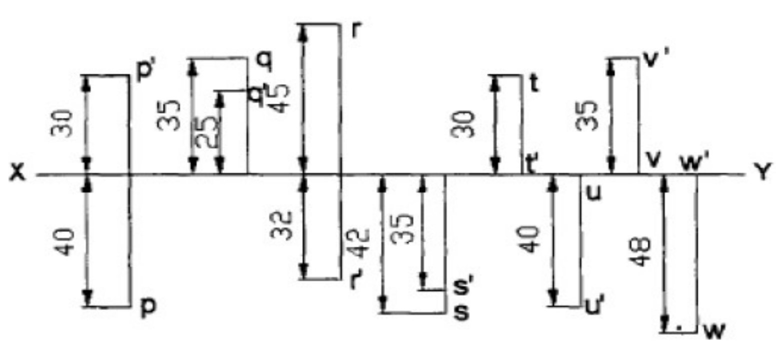
(f.) Point U is in V.P and 40 mm. below HP

(g.) Point V is in V.P and 35 mm. above H.P

(h.) Point W is in H.P and 48 mm. in front of VP

**Solution**

The Front/Top views of all the above-mentioned points can be drawn by following the general procedure points.




**Q.2) The two points A and B are in the H.P. The point A is 30 mm in front of the V.P., while B is behind the V.P. The distance between their projectors is 75 mm and the line joining their top views makes an angle of $45^0$ with xy. Find the distance of the point B from the V.P.**

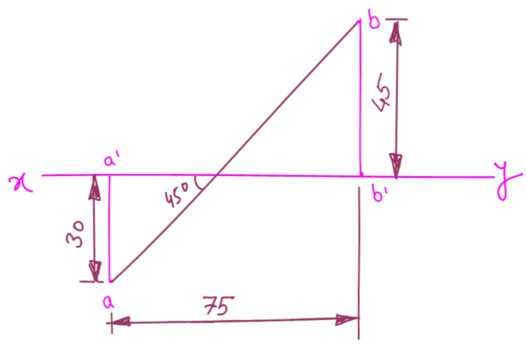
**Solution:** The steps are given below-

i) Draw the XY line

ii) The projections of point A can be exactly marked, because its distances from both the planes, HP and VP is given. Marked the points **a'** (front view) and **a** (top view) respectively.

iii) Marked the front view of point B as **b'** at a distance of 75 mm along XY line, and drawn a perpendicular line above it.

iv) Drawn a line at **a**, at an angle of 45° with XY line, which met the previously drawn perpendicular at point **b**. This the required top view of the point B.




**Q.3) Projections of various points are given in fig. State the position of each point with respect to the planes of projection, given distances are in millimeters.**

**Solution:**

**A** : 20 mm below HP, 30 mm behind VP.

**B** : 25 mm above HP, 30 mm in front of VP

**C** : 45 mm below HP, 15 mm in front of VP

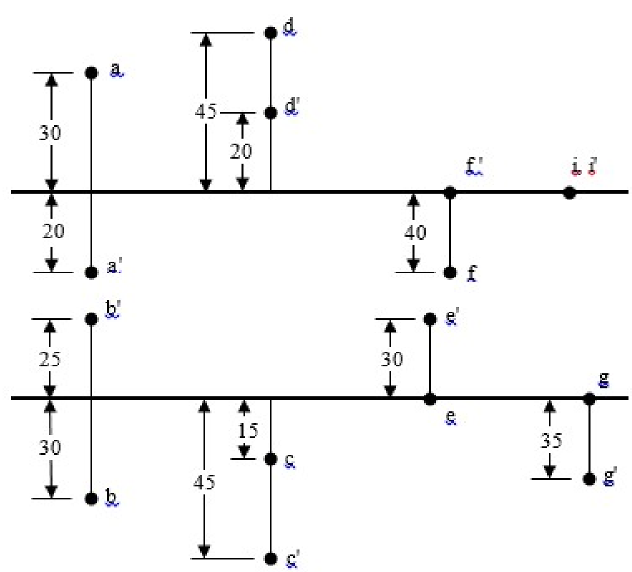
**D** : 20 mm above HP, 45 mm behind VP

**E** : 30 mm above HP and in the VP

**F** : In the HP and 40 mm in front of VP

**G** : 35 mm below HP and in VP

**I** : in both, HP and VP.



## 2.7 PRECAUTIONS:

1. The drawing board must not wobble and all four legs of the drawing board must be properly stable on the ground.

2. The drafter must be of good built quality and it must be rigidly fixed on the top left corner of the drawing board to make sure that perfect parallel/perpendicular lines are obtained on the drawing.

3. The pencils should be properly sharpened to attain required accuracy in drawing.

4. Hands should be clean and surroundings should be free from any dirt.

5. The sheet should not displace during the whole duration of drawing, and its edges should be perfectly horizontal and vertical with respect to the board edges.

6. The light and dark lines (i.e. thin and thick lines) must be clearly distinguishable.

7. Use of eraser should be as less as possible, to avoid any chances of previous imprints on the sheet.

8. A sufficient gap should be maintained with the drawing boards of other nearby students.

## 2.8 VIVA QUESTIONS

**1)** What do you understand by Projection?

**2)** What is the purpose of Projection Lines?

**3)** What are fundamental planes of projection? What is a ‘profile plane’?

**4)** What do you understand by Orthographic Projection’?

**5)** What are various quadrants?

**6)** What is the definition of reference line (or XY-line)?

**7)** What is the difference between 1$^{st}$ angle and 3$^{rd}$ angle projection systems?

**8)** Draw the symbols of 1$^{st}$ angle and 3$^{rd}$ angle projection.

**9)** Why we do not use 2$^{nd}$ angle or 4$^{th}$ angle projection system?

**10)** A point is behind VP and below HP. In which quadrant it is lying?

**11)** A point is in the 2$^{nd}$ quadrant. How can be describe its location in terms of reference planes HP and VP?

**12)** The FV and TV of a point are below XY-line. In which quadrant the point is lying?

# ABES Engineering College, Ghaziabad

## Department of Mechanical Engineering

**ENGINEERING GRAPHICS AND DESIGN LAB (BCE 151/BCE251)**

**SHEET No-03 (PROJECTION OF LINES)**

| | | |
|---|---|---|
| **3.1 Objective** | **3.2 Instruments to be used** | **3.3 Theory** |
| **3.4 Problems for Practice with Procedure** | **3.5 Precautions** | **3.6 Viva Questions** |

### 3.1 OBJECTIVE:

To understand the fundamentals of orthographic projection of straight lines and to demonstrate the method of projection of lines located in $1^{st}$ quadrant only.

### 3.2 INSTRUMENTS TO BE USED:

Drawing board, Mini drafter, Geometrical Instrument box (including a protractor, set of rulers, Pencils - H, 2H, eraser, sharpener, compass and divider), Drawing sheet clips (preferably) or cello tape, a Drawing sheet – A2 size, sheet cover.

### 3.3 THEORY:

#### 3.3.1 Fundamentals

A straight line is the shortest route to join any two given points. It is a one-dimensional object having only length (l). The projection of straight line is obtained by joining the top and front views of the respective end points of the line. We will discuss the cases of Orthographic Projections of Line, when the line is placed in the first quadrant only, i.e., $1^{st}$ Angle Projection only. The actual or real length of the straight line is known as *true length* (**TL**). Sometimes when a line is observed from an angle other than 90°, its true length is not visible, but a shorter length is visible.

#### 3.3.2 Trace of a Line

1) The point of intersection or meeting of a line with the reference plane, extended if necessary, is known as the trace of a line.
2) The point of intersection of a line with the HP is known as the horizontal trace, represented by **HT** and that with the VP is known as the vertical trace, represented by **VT**.
3) No trace is obtained on a reference plane when a line is kept parallel to that plane.
4) If the line is given parallel to VP and inclined to HP, only HT will be obtained and no VT, and vice versa.
5) If the line is given parallel to both the planes, neither HT nor VT will be obtained.

### 3.3.3 Different Positions of a Line with respect to Principle Planes

1. Parallel to both the planes (HP and VP)
2. Parallel to one plane and perpendicular to the other
3. Parallel to one plane and inclined to the other
4. Situated completely in one plane and inclined to other
5. Inclined to both the planes

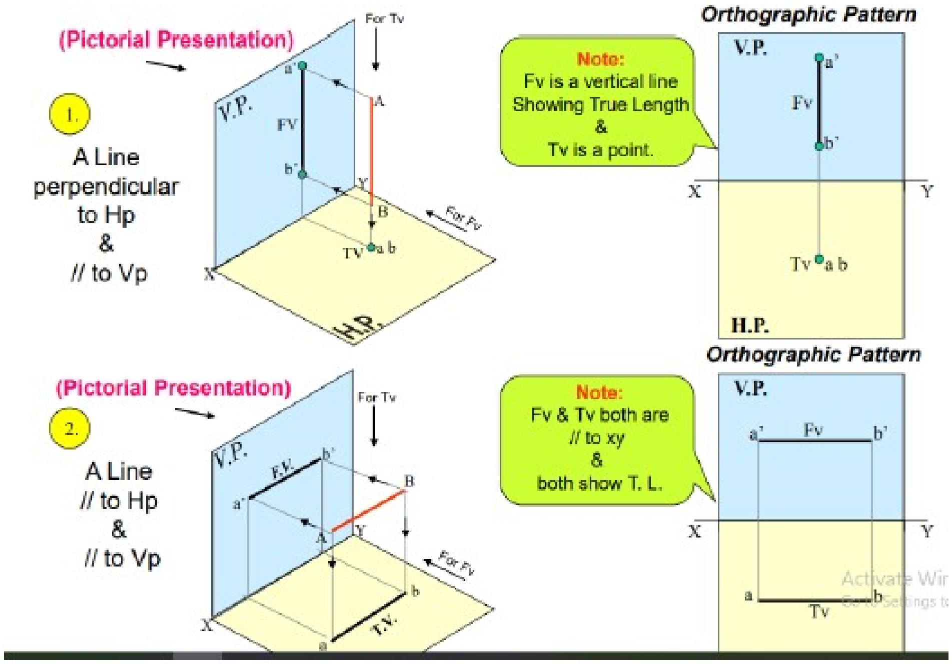



*Fig 1(a) and 1(b)*

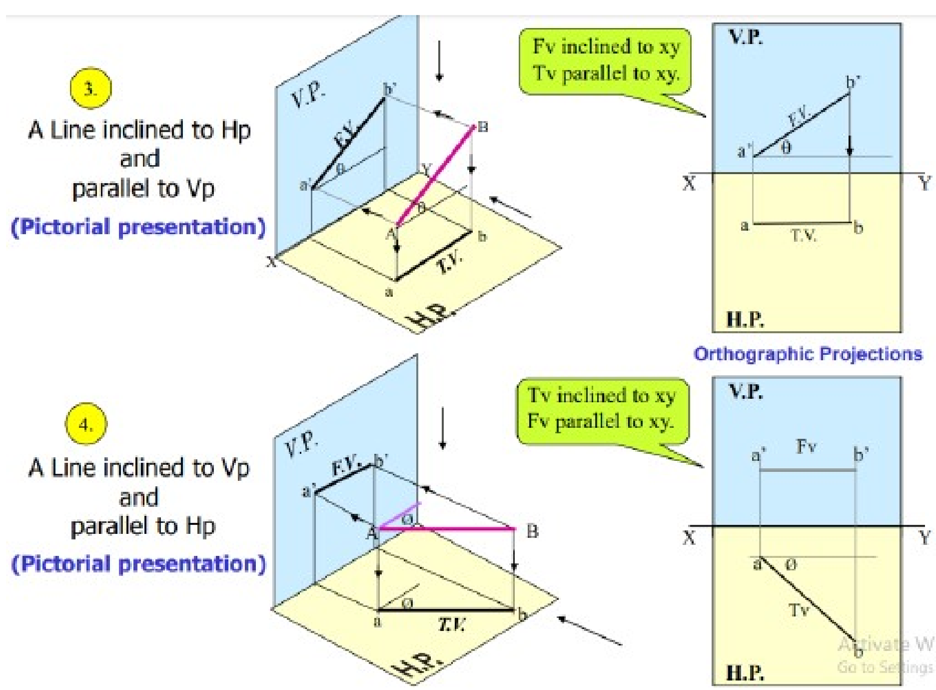



*Fig 2(a) and 2(b)*

Here, Figure 1 indicates two positions-

- **1(a)**: *When the line is parallel to VP and perpendicular to HP*. In such case, True Length (TL) will be observed in the Front view (FV) and only a point will be observed in the Top View (TV). Opposite will happen when the line is parallel to HP and perpendicular to VP.
- **1(b):** *When the line is parallel to both the planes (HP and VP)*. In such case, TL can be observed in both the views, FV and TV and both of them are obtained parallel to the XY line.

Figure 2 indicates two positions-

- **2(a):** *The line is parallel to VP and inclined to HP*. In such case, TL will be observed in the FV, and a shortened length will be obtained in the TV. FV is drawn first above the XY line, and then projections are dropped down from both of its ends to the other side of XY line up to the desired distance, to get the TV.

  **NOTE**: True inclination of the line with HP can be observed in the FV.

- **2(b):** *The line is parallel to HP and inclined to VP*. In such case, TL will be observed in the TV, and a shortened length will be obtained in the FV. TV is drawn first below the XY line, and then projections are drawn upward from both of its ends to the other side of XY line up to the desired distance, to get the FV.

  **NOTE**: True inclination of the line with VP can be observed in the TV.

- *When the line is completely in a plane and inclined to the other plane*. Let, the line is in HP and inclined with VP. The projections of such case can be drawn just like **2(b)**, and the only difference is that the shortened length will be obtained on the XY line itself, because the distance is *zero*.
- Now let, the line is in VP and inclined with HP. The projections of such case can be drawn just like **2(a)**, and the only difference is that the shortened length will be obtained on the XY line itself, because the distance is *zero*.
- *When the line is inclined to both the planes*, such problems are solved in three steps. Firstly, it is assumed that the line is parallel to first plane and inclined to the second one. Projections are drawn for it. Then it is assumed that the line is parallel to the second plane and is inclined to the first one. Projections are drawn once again. In the last step, these two projections are merged in to a single projection. TL of the line is not observed in any of the two views.

  **NOTE**: True inclination of the line with VP and HP are *NOT* observed in the final FV and TV respectively. Only apparent angles are observed.

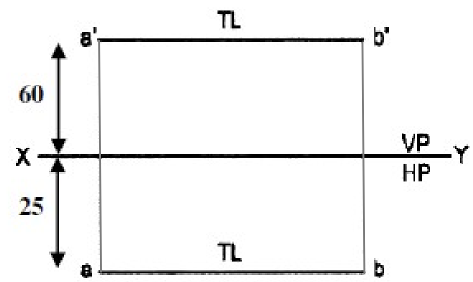
**NOTE- In the cases when TL is observed only in one view: that view is drawn first in which TL is observed. Then, parallel projections are drawn to the other side of XY line to get the other view of shortened length.**

### 3.4 PROBLEMS FOR PRACTICE WITH PROCEDURE

**Q.1) A 50 mm long line AB is parallel to both H.P and V.P. The line is 25 mm in front of V.P and 60 mm above H.P, draw the projections of the line.**

**Solution:**

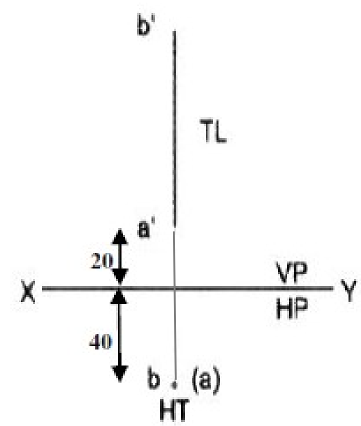
1. Draw XY line
2. Mark FV of point A as **a'** at 60 mm above XY line. Draw its TL parallel to XY line. Mark other end as **b'**
3. Mark TV of point A as **a** at 25 mm below XY line. Draw its TL parallel to XY line. Mark other end as **b**.
4. Join **b** and **b'** with a thin projection line.




**Q.2) A 60 mm long line AB has its end A at a distance of 20mm above the H.P. The line is perpendicular to the H.P and 40 mm in front of V.P, draw the projections of the line.**

**Solution:**

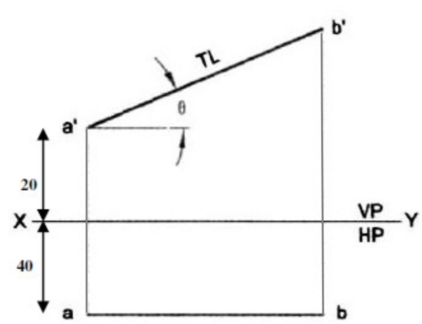
1. Draw XY line
2. Mark FV of point A as **a'** at a distance of 20 mm above XY. Draw TL of line perpendicular to XY and thus locate point **b'**.
3. Draw a thin and light projection line to the other side of XY and mark superimposed points **b(a)** to locate to TV of this line.
4. Point **b(a)** will also be the HT of the given line. There will be no VT, as the line is parallel to VP.




**Q.3) A 80mm long line AB has the end A at a distance of 20 mm above HP and 40 mm in front of V.P. The line is inclined at 30° to H.P and parallel to V.P, draw the projection of the line.**

**Solution:**

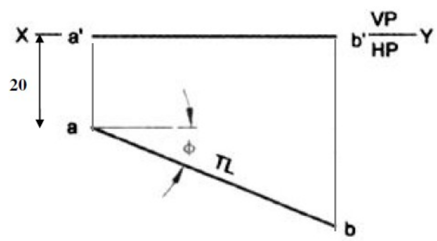
1. Draw XY line.
2. As TL will be observed in the FV, locate the point **a'** at 20 mm above XY.
3. From **a'** draw the TL of the line inclined at 30° with XY and mark the other end **b'**
4. Drop projection lines from both of these ends and draw TV of this line at a distance of 40 mm below XY, and parallel to it. Mark its ends as **a** and **b**.



**Q.4) A line AB 60 mm long is situated in H.P and inclined to V.P at 30°. The end A is 20 mm in front of V.P, draw the projection of line.**

Solution:

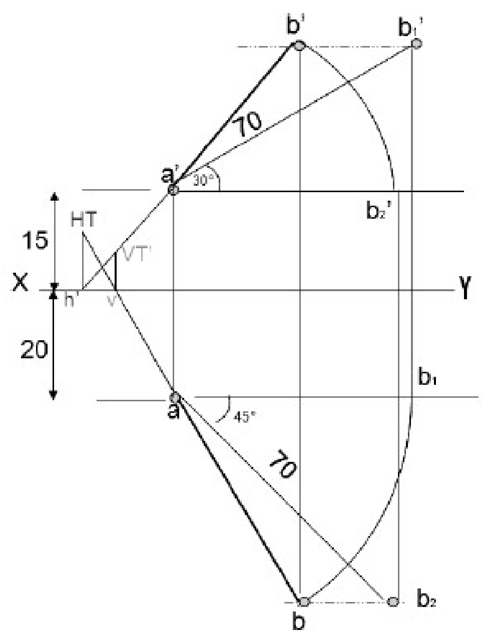
1. Draw XY line.
2. Mark the TV of point A as **a** 20 mm below XY.
3. Draw TL of the line below XY from point **a** at an angle of 30° with XY and thus mark the other end **b**
4. Draw the thin and light projectors from both of these ends **a** and **b** up to the XY line and mark the FV of this line as **a'b'**. The FV will be obtained on XY line itself.




**Q.5) A line AB, 70 mm long, has its end A 15 mm above HP and 20 mm in front of VP. It is inclined at 30° to HP and 45° to VP. Draw its projections.**

**Solution:**

1. Draw XY line.
2. Locate the FV of the point A as **a'** 15 mm above XY and its TV as **a** 20 mm below XY**.**
3. Firstly, *assume that this line is parallel to VP and is inclined 30° to HP*. Draw its TL from point **a'** with 30° inclination and mark it as **a'b₁'**.
4. Draw vertical projectors from point **b₁'** to the other side of XY line and locate point **b₁** horizontally along point **a**.
5. Secondly, *assume that this line is parallel to HP and is inclined 45° to VP*. Draw its TL from point **a** with 45° inclination and mark it as **ab₂**.
6. Draw vertical projectors from point **b₂** to the other side of XY line and locate point **b₂'** horizontally along point **a'**.
7. From points **b₂** and **b₁'** draw horizontal *locus lines* (chain dashed), indicating the locus of these points when true lengths **ab₂** and **a'b₁'** are rotated about the vertical.
8. Take **a'b₂'** as radius and **a'** as centre, and create an *arc* from **b₂'** to meet the locus line of **b₁'** at point **b'**. Point **b'** is the true FV of the point B.
9. From Point **b'** drop a vertical projector downward to meet the locus line of point **b₂** at point **b**. This point **b** is the true TV of the point B. The point **b** can also be located by creating an *arc* from point **b₁** taking **ab₁** as radius and point **a** as centre.
10. Join point **a** and **b** to get the desired final top view **ab**. Also join **a'** and **b'** to get the desired final front view **a'b'.**



**3.5 PRECAUTIONS:**

1. The drawing board must not wobble and all four legs of the drawing board must be properly stable on the ground.

2. The drafter must be of good built quality and it must be rigidly fixed on the top left corner of the drawing board to make sure that perfect parallel/perpendicular lines are obtained on the drawing.

3. The pencils should be properly sharpened to attain required accuracy in drawing.

4. Hands should be clean and surroundings should be free from any dirt.

5. The sheet should not displace during the whole duration of drawing, and its edges should be perfectly horizontal and vertical with respect to the board edges.

6. The light and dark lines (i.e. thin and thick lines) must be clearly distinguishable.

7. Use of eraser should be as less as possible, to avoid any chances of previous imprints on the sheet.

8. A sufficient gap should be maintained with the drawing boards of other nearby students.

**3.6 VIVA QUESTIONS**

1. How can you define a line?
2. What is 'True Length (TL)' of a line?
3. In what cases TL of a line is observed? In what cases it is not observed?
4. What do you understand by 'trace of a line'?
5. A line is perpendicular to VP. How will you describe its TV and FV?
6. The FV and TV of a line are 'TL' and a 'point' respectively. How will you describe its orientation with reference to HP and VP?
7. The FV and TV of a line are 'shorter length' and a 'TL' respectively. How will you describe its orientation with reference to HP and VP?
8. In what case, TL of a line can be observed in both, FV and TV?
9. A line is parallel to HP. Will it be parallel to VP too? In what case it is possible?
10. A line is parallel to VP and inclined at some angle with HP. How can you describe its FV and TV?
11. A line is in HP and inclined at some angle with VP. How can you describe its FV and TV?

# ABES Engineering College, Ghaziabad

## Department of Mechanical Engineering

**ENGINEERING GRAPHICS AND DESIGN LAB (BCE 151/BCE251)**

**SHEET No-04 (PROJECTION OF PLANES)**

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**4.1 Objective** | **4.2 Instruments to be used** | **4.3 Theory**

**4.4 Problems for Practice with Procedure** | **4.5 Precautions** | **4.6 Viva Questions**

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### 4.1 OBJECTIVE:

To understand the fundamentals of orthographic projection of 2D surfaces and to demonstrate the method of projection of planes.

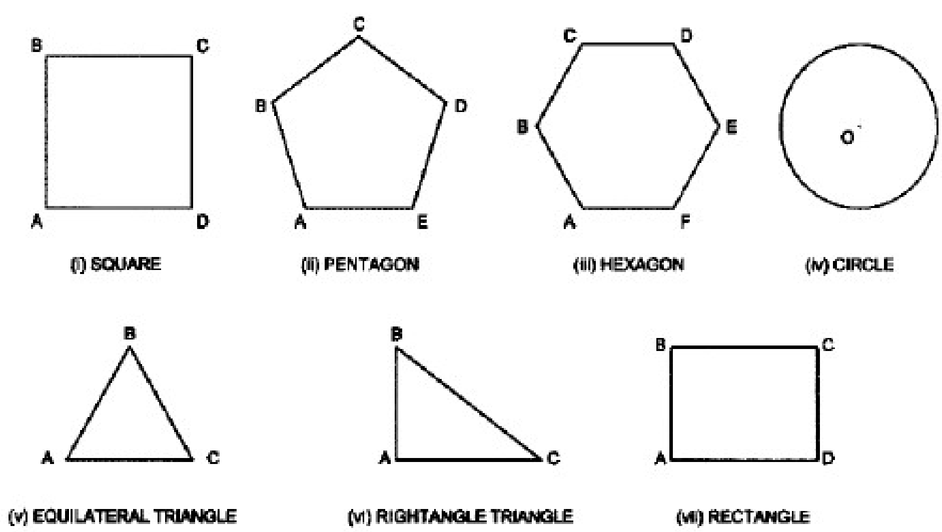
### 4.2 INSTRUMENTS TO BE USED:

Drawing board, Mini drafter, Geometrical Instrument box (including a protractor, set of rulers, Pencils - H, 2H, eraser, sharpener, compass and divider), Drawing sheet clips (preferably) or cello tape, a Drawing sheet – A2 size, sheet cover.

### 4.3 THEORY:

#### 4.3.1 Fundamentals

A plane is a two-dimensional object having length and breadth only. Its thickness is always neglected; various shapes of plane figures are considered such as triangle, square, rectangle, circle, pentagon, hexagon, etc.



**4.3.2 Trace of Plane:**

The trace of a plane is the line of intersection or meeting of the plane surface with the reference plane; if necessary the plane surface is extended to intersect the reference plane. The intersection line of the plane surface with HP is called the Horizontal Trace (HT) and that of VP is called the Vertical Trace (VT).

**4.3.3 Some Points to Remember:**

- When a plane is seen from orthogonal position (i.e. from perpendicular position), its *True Shape (TS)* can be observed. But when it is seen from some angular position, its true shape cannot be observed, but somewhat distorted or shortened shape can be observed.
- When a plane is seen along its surface, it is observed like a straight line. The two extreme opposite points on the plane become the end-points of that line.
- In any way, a plane surface cannot be observed as a point only.

**4.3.4 Possible orientations of a plane surface with reference to the reference planes (HP and VP):**

A plane figure is positioned with reference to the reference planes (HP and VP) by referring its surface in the following possible positions *(only 1st Angle Projection System)-*

**1.** Parallel to one plane and perpendicular to the other plane

a) Parallel to VP and Perpendicular to HP

b) Perpendicular to VP and Parallel to HP

**2.** Perpendicular to both VP and HP

**3.** Perpendicular to one plane and Inclined to the other plane

a) Perpendicular to VP and Inclined to HP

b) Inclined to VP and Perpendicular to HP

**4.** Planes Inclined to both VP and HP

**Case 1 (a):** The true shape of such plane can be seen from the Front. Hence, FV is drawn first and projectors are drawn from its extremities (corners) to get the TV below XY line. Since the plane is parallel to VP, the TV will be obtained as a straight line parallel to the XY line.

**Case 1 (b):** The true shape of such plane can be seen from the Top. Hence, TV is drawn first and projectors are drawn up from its extremities (corners) to get the FV above XY line. Since the plane is parallel to HP, the FV will be obtained as a straight line parallel to the XY line.

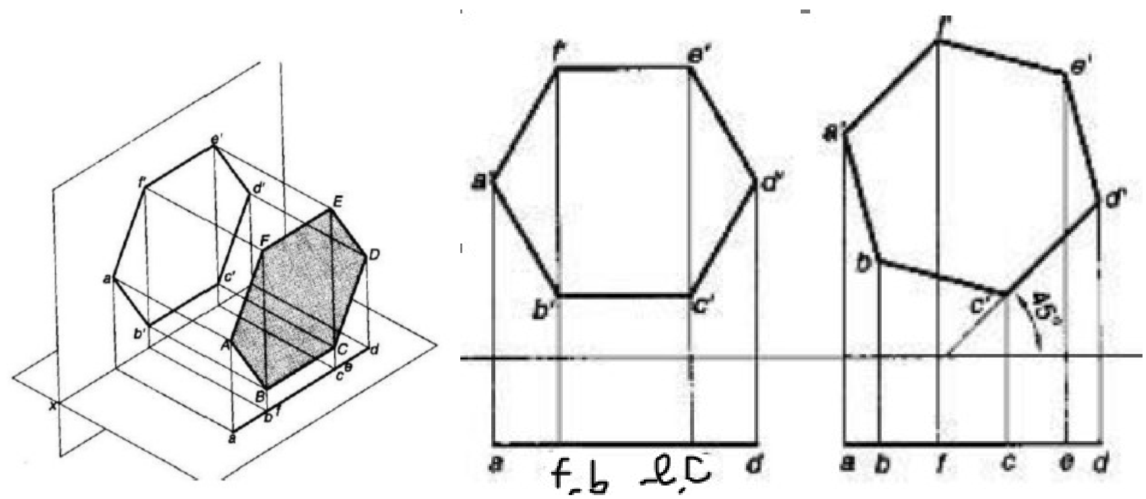
**Case 2:** In such case, the plane will be parallel to the *Profile Plane (PP)*. Hence in both the views, only straight lines will be observed perpendicular to XY line. In the FV, the length of the line will be the height of the surface (i.e., the dimension parallel to VP). In the TV, the length of the line will be the width of the surface (i.e., the dimension parallel to HP).

**Case 3 (a) and 3(b):** In such cases, the projections are drawn in TWO steps. Firstly, it is assumed that the given plane is NOT inclined to a reference plane, but is parallel to it. Its projections are drawn as mentioned in case 1(a) or 1(b). So, one of its views will be a *straight-line*. In the second step, its straight-line view is drawn again by the given angle and horizontal and vertical projectors are used to create the apparent shape of the plane in the other view. This method is known as 'Change of Position' method. In any of the final FV or TV the true shape of the plane will not be visible.

### 4.4 PROBLEMS FOR PRACTICE WITH PROCEDURE

**Q.1) A Hexagonal plane with a 30 mm side has its surface parallel to and 20 mm in front of the VP. Draw its Projections, when (i) an edge is parallel to the HP, (b) an edge is inclined at 45° to the HP**

**Solution:**




**For (i)**

1) Draw XY line
2) Draw the FV first and create a regular Hexagon of 30 mm edge, having one of its edge parallel to XY line, at some arbitrary distance above it (distance is not given).
3) Draw projectors from each corner of the Hexagon to the other side of XY line, and create the desired TV in form of a straight line parallel to the XY line and 20 mm below it.
4) Label all the corners on FV and corresponding points on TV as per rules. In case of super-imposed points in TV, the point is labelled first which is observed first from the top.

**For (ii)**

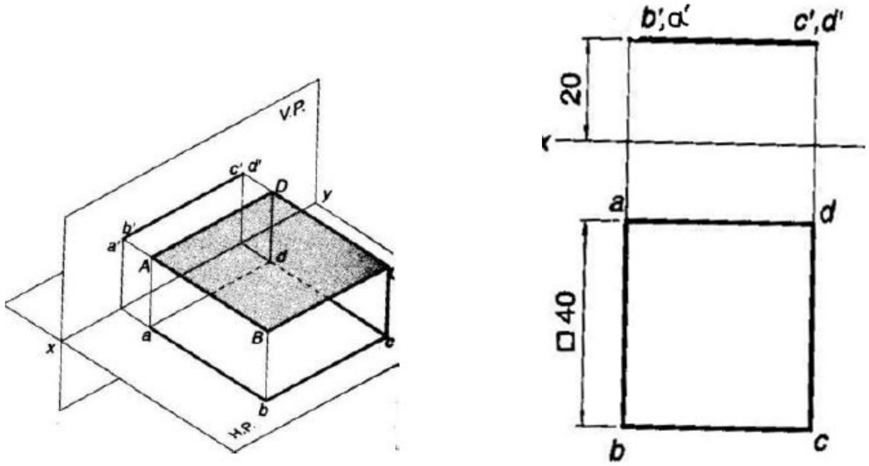
1) Draw XY line
2) Draw the FV first and create a regular Hexagon of 30 mm edge, having one of its edge inclined at 45° to XY line, at some arbitrary distance above it (distance is not given).
3) Draw projectors from each corner of the Hexagon to the other side of XY line, and create the desired TV in form of a straight line parallel to the XY line and 20 mm below it.
4) Label all the corners on FV and corresponding points on TV as per rules.

**Q.2) A Square plane with a 40 mm side has its surface parallel to and 20 mm above the HP. Draw its Projections, when a side is parallel to VP.**

**Solution:**

1) Draw XY line

2) Draw the TV first and create a square of 40 mm sides, keeping one of its side parallel to the XY line, at some arbitrary distance below it (distance is not given).

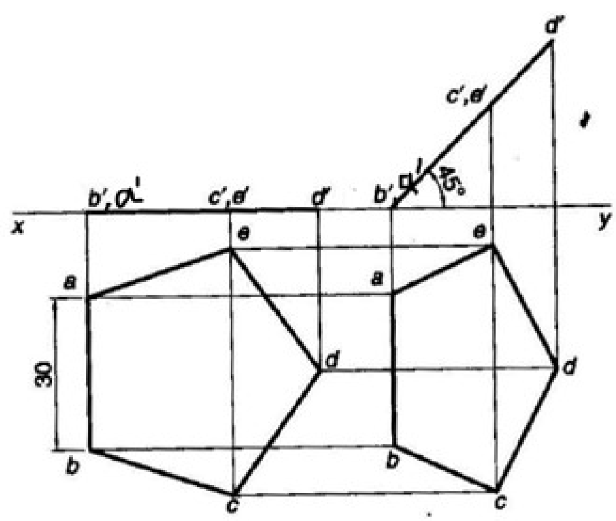



3) Draw the projectors from all its four corners to the other side of XY line, to get the FV in form of a straight line parallel to the XY line and 20 mm above it.
4) Label all the corners of the TV and corresponding points in the FV as per rules. In case of super-imposed points in FV, the point is written first which is observed first from the front.

**Q.3) A Pentagonal plane with a 30 mm side has an edge on the HP, the surface of the Plane is inclined at 45° to the HP. Draw its Projections.**

**Solution:**

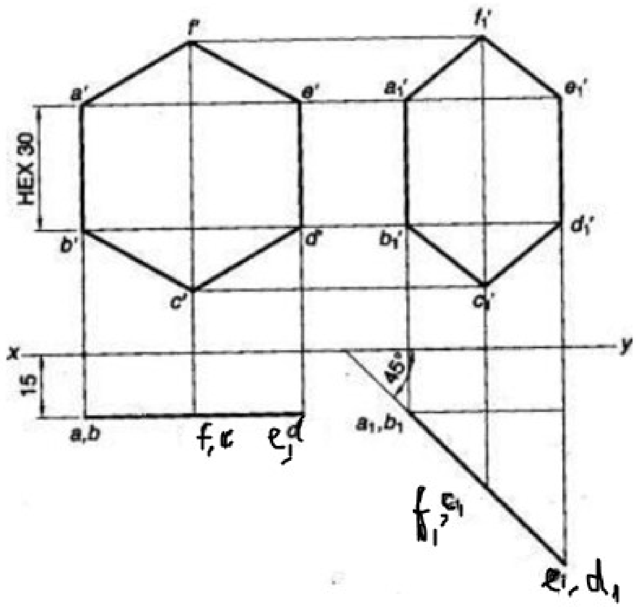
1) Draw a reference line (XY line).
2) Firstly, assume that the given Pentagon is not inclined to HP, but is completely on HP. Choose some suitable distance from VP and create a regular Pentagon (true shape) with 30 mm side below XY, keeping one of the sides perpendicular to XY line. Draw corresponding FV too (its FV will be a line on XY).
3) Following 'Change of Position' method, draw the same FV again to the right side with 45° inclination with HP. Use divider (or compass) for transferring the distances. Provide same labelling of the points too.
4) Draw vertical projectors from the newly drawn FV and horizontal projectors from the previously drawn TV. Mark the points of meeting of vertical and horizontal projectors of the same points. Join them in the correct sequence to get the final shape of the TV. Darken the desired lines.



**Q.4) A Hexagonal plate with a 30 mm side and negligible thickness has its surface perpendicular to the HP and inclined at 45° to the VP. Draw its Projections. When one of its sides of the Plane is Parallel to and 15 mm in front of the VP.**

**Solution:**

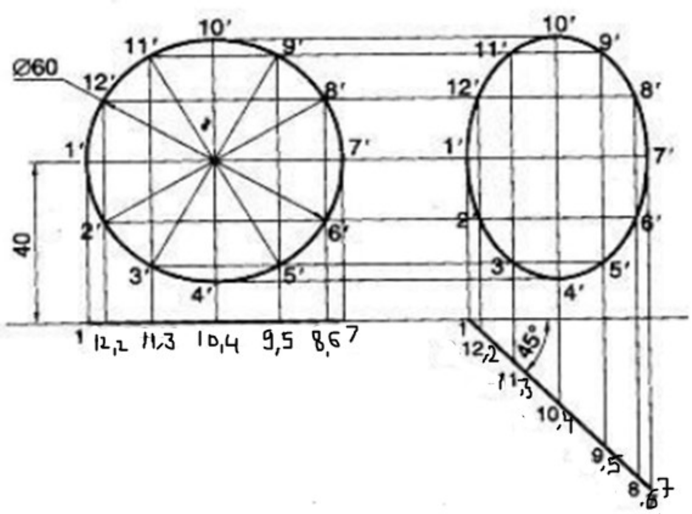
1) Draw a reference line (XY line).
2) Firstly, assume that the given plate is not inclined to VP, but is parallel to it and 15 mm in front of it. Draw its FV (true shape) and TV. FV will be drawn first and then TV will be created using projectors.
3) Now, use the 'Change of Position' method and draw its new TV with the inclined position (at 45°) using divider or compass.
4) Draw vertical projectors from the new TV and horizontal projectors from the previously drawn FV. Mark the points of meeting of vertical and horizontal projectors of the same points. Join them in the correct sequence to get the final shape of the FV. Darken the desired lines.




**Q.5) A Circular plane with a 60 mm diameter is resting on a point on its circumference on VP. The centre is 40 mm above HP, and its surface is inclined at 45° to the VP and perpendicular to the HP. Draw Its Projections.**

**Solutions:**

1) Draw a reference line (XY line).
2) Firstly, assume that the given plate is not inclined to VP, but is completely into it. As per the given information, locate the centre of the circular plate 40 mm above HP. Draw a circle of radius 30 mm around its centre (true shape) above XY line and draw corresponding TV in the XY line.




3) As circle has no corners, we need to create some reference points on its circumference. Divide the whole circumference into 12 equal parts using basic geometry and mark them (1' – 12'). Locate corresponding points in the TV as well (1-12).

4) Use change of position method and draw final shape of the TV with 45° inclination using divider or compass. Marks all 1-12 points on it too.

5) Draw vertical projectors from all (1-12) points of the newly drawn TV and horizontal projectors from all (1'-12') points of the previously drawn FV. Mark the points of meeting of vertical and horizontal projectors of the same points. Join them freehand in the correct sequence to get the final shape of the FV, which will be an *ellipse*. Darken the desired lines.

**4.5 PRECAUTIONS:**

1. The drawing board must not wobble and all four legs of the drawing board must be properly stable on the ground.

2. The drafter must be of good built quality and it must be rigidly fixed on the top left corner of the drawing board to make sure that perfect parallel/perpendicular lines are obtained on the drawing.

3. The pencils should be properly sharpened to attain required accuracy in drawing.

4. Hands should be clean and surroundings should be free from any dirt.

5. The sheet should not displace during the whole duration of drawing, and its edges should be perfectly horizontal and vertical with respect to the board edges.

6. The light and dark lines (i.e. thin and thick lines) must be clearly distinguishable.

7. Use of eraser should be as less as possible, to avoid any chances of previous imprints on the sheet.

8. A sufficient gap should be maintained with the drawing boards of other nearby students.

**4.6 VIVA QUESTIONS**

1. How can you describe a plane?
2. What do you understand by 'True Shape' of a plane?
3. What are the possible cases when true shape of a plane can be observed?
4. In what cases a plane can be observed like a line only?
5. The FV and TV of a plane are lines. Is it possible? How?
6. The true shape of a plane is observed in its FV and only a line is observed in its TV. How can you describe its orientation with respect to the fundamental planes of projection (HP and VP)?
7. A plane is completely in HP. How will be its FV and TV?

# ABES Engineering College, Ghaziabad

## Department of Mechanical Engineering

**ENGINEERING GRAPHICS AND DESIGN LAB (BCE 151/BCE251)**

**SHEET No-05 (PROJECTION OF SOLIDS)**

| | | |
|---|---|---|
| **5.1 Objective** | **5.2 Instruments to be used** | **5.3 Theory** |
| **5.4 Problems for Practice with Procedure** | **5.5 Precautions** | **5.6 Viva Questions** |

**5.1 OBJECTIVE:**

To understand the fundamentals of orthographic projection of regular 3D objects and to demonstrate the method of projection of Solids.

**5.2 INSTRUMENTS TO BE USED:**

Drawing board, Mini drafter, Geometrical Instrument box (including a protractor, set of rulers, Pencils - H, 2H, eraser, sharpener, compass and divider), Drawing sheet clips (preferably) or cello tape, a Drawing sheet – A2 size, sheet cover.

**5.3 THEORY:**

**5.3.1 Fundamentals**

A solid has three dimensions, viz. length, breadth and thickness. It has definite shape and volume. A solid may be represented by orthographic views, the number of views depends on the type of solid and its orientation with respect to the planes of projection.

**5.3.2 Detailed Classification of Solids : Prisms and Pyramids**

Solids are classified into two major groups. **(i) Polyhedron,** and **(ii) Solids of revolution**

**(i)** A **polyhedron** is defined as a solid bounded by only plane surfaces (called faces). They are mainly of these types: (a)Regular polyhedrons (b) Prisms and (c) Pyramids, (d) Frustums, (e) Truncated Solids

a) **Regular Polyhedron:** These are the polyhedrons in which all the faces are of same shape and size, i.e. exactly identical. Some examples are *Tetrahedron* (4 equal equilateral triangular faces), *Cube* or *Hexahedron* (6 equal square faces), *Octahedron* (8 equal equilateral triangular faces), *Dodecahedron* (12 equal regular pentagonal faces).
b) **Prisms:** This is a polyhedron having two equal and similar faces called its ends or bases, parallel to each other and joined by other faces, which are parallelograms. The imaginary line joining the centres of the bases is called the *axis*. A ***right regular prism*** has its axis perpendicular to the bases and all its side-faces are equal sized rectangles.

c) **Pyramids:** This is a polyhedron having a plane figure as a base and a number of triangular faces meeting at a point called the vertex or apex. The imaginary line joining the apex with the centre of the base is its *axis*. A ***right regular pyramid*** has its axis perpendicular to the base, which is a regular plane figure. Its faces are all equal isosceles triangles.

d) **Frustum:** When a pyramid or a cone is cut by a plane parallel to its base, thus removing the top portion, the remaining portion is called its frustum.

e) **Truncated Solids:** When a solid is cut by a plane inclined to base it is said to be truncated.

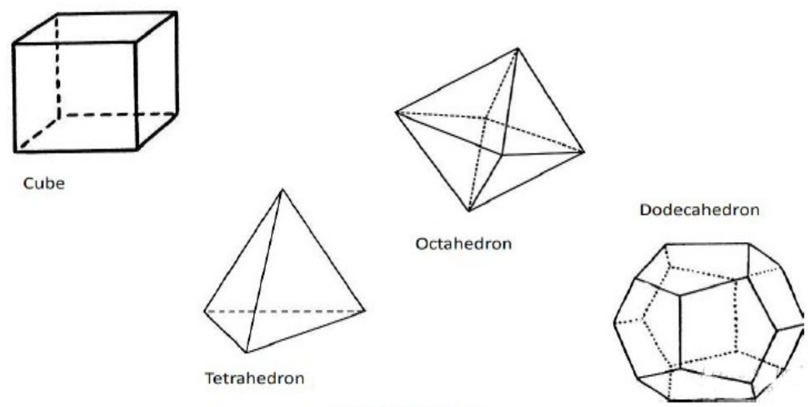
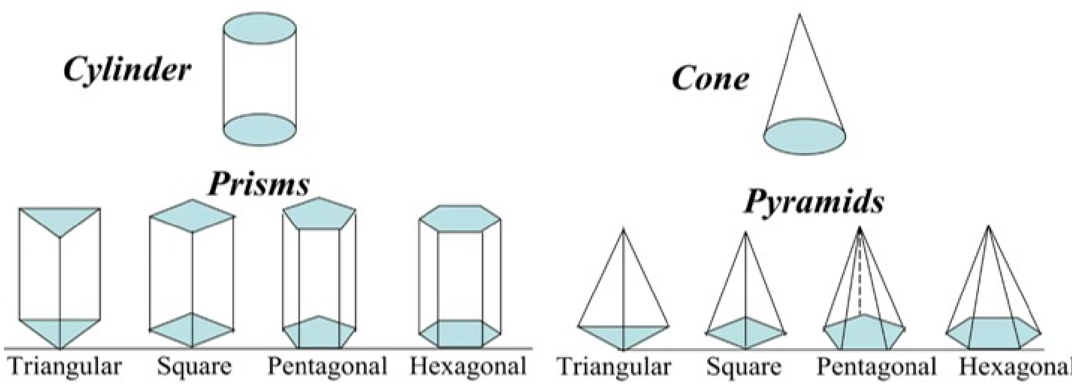
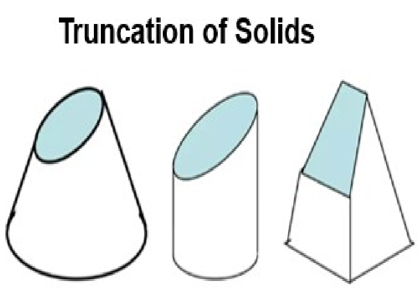
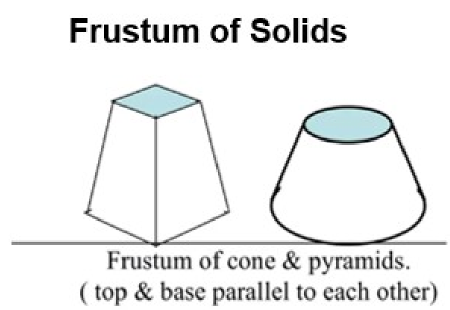


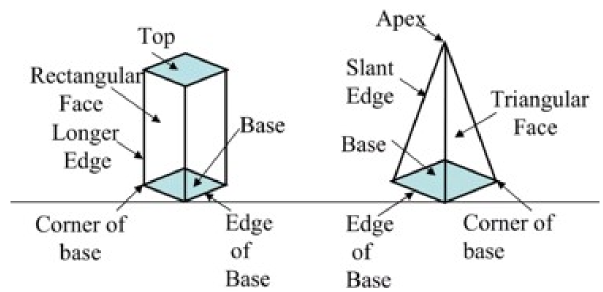
Fig: Tetrahedron




Some terminologies related to the Prisms and Pyramids are shown in the figure to the right. In a prism, two equal faces are observed (top and base) connected through longer edges. In a Pyramid, a number of equal slant edges develop equal sized triangular faces. There is only one face (base) of Pyramids with an Apex.



**(ii) Solids of Revolution:** If a plane surface is revolved about one of its edges, the solid generated is called a solid of revolution. The examples are (i) Cylinder (created using a rectangular plate), (ii) Cone (created using a right-angled triangular plate), (iii) Sphere (created using a semi-circle).

**5.3.3 Some points to remember:**

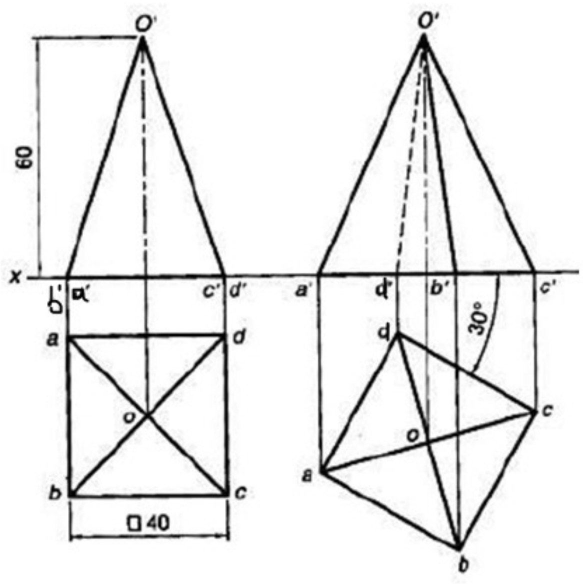
- A solid is positioned with respect to the reference planes (HP and VP) by referring its axis, one of the base edges, one of the side edges, any corner, faces, side faces, etc.
- In case of inclined axis cases, 'Change of Position' method is used to get the desired final projections.
- Axis of solids are shown using 'chain lines'.
- In front/top views, some parts of the solid will not be visible. The edges of such hidden parts are shown using dashed (dotted - - - - -) lines.

**5.4 PROBLEMS FOR PRACTICE WITH PROCEDURE**

**Q.1) A Square Pyramid, having base with a 40 mm side and 60 mm axis is resting on its base on the HP. Draw its Projections when (a) a side of the base is parallel to the VP. (b) A side of the base is inclined at 30° to the VP.**

**Solution:**

**Case (a):**




**1)** Draw XY line

**2)** Draw a square of 40 mm side keeping one of the sides parallel to XY line (and below it) and also show its diagonals, indicating the slant edges of the Pyramid.

**3)** Draw projectors from the TV to the other side of XY and draw its FV in form of an isosceles triangle with 60 mm height and 40 mm base. Mark all the relevant points in TV and FV. Also show the axis, using chain line.

**Case (b):**

Follow similar steps as discussed in the case (a), the only difference is that in TV, the square will be having one of the edges inclined at 30°. Hence, whole TV will be turned by 30°. In the FV, show three applicable slant edges as visible (thick and dark) and one edge as hidden (dashed). Axis will be shown using chain line.

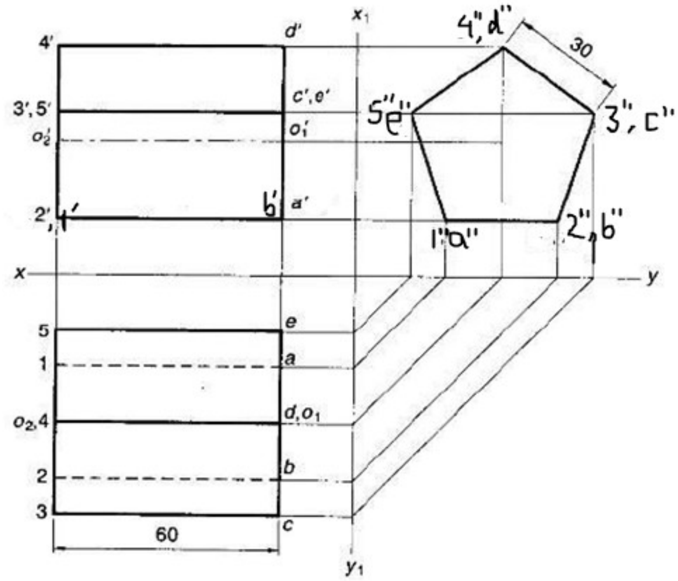
**Q.2) A pentagonal Prism having a base with a 30 mm side and 60 mm long axis, is having one of its rectangular faces parallel to and 15 mm above HP, and axis parallel to the VP. Draw its projections.**

**Solution:**

1) Draw XY line

2) True shape of the pentagonal face will not be visible in any of the views – FV or TV. For it, draw a side view (here LHSV) to the right of $X_1Y_1$ (vertical) reference line. Keep its base edge 15 mm above XY.

3) Draw horizontal and vertical projectors from every five points and from the centre of the pentagon. From XY line, turn the vertical projectors into horizontal below XY. You can use arcs or 45° lines for it.




4) Using the projector lines, draw rectangular faces as applicable in the FV and TV and mark the axis length 60 mm in any one of them.

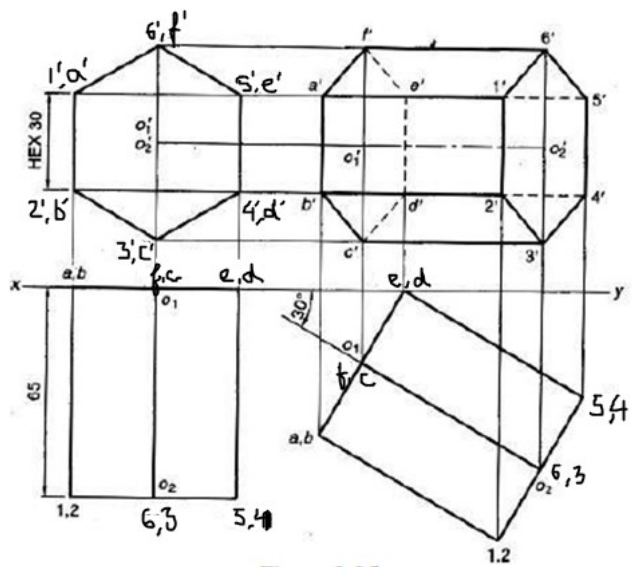
**Q.3) A hexagonal prism having a base edge 30 mm and axis 65 mm long, is kept between HP and VP in such a way that one of its base edge is in VP and perpendicular to HP. Its axis is inclined at 30° with VP and parallel to HP. Draw its projections.**

**Solution:**

1) Draw the reference line (XY line).

2) Firstly, assume that the axis is perpendicular to VP and the whole face is in the VP. Keeping one of the edges perpendicular to XY, create a *Hexagonal* FV above XY and corresponding TV of the given prism below XY.

3) Carefully using your drafter, draw the final TV with axis inclined at 30° keeping one of the edges (DE) in VP. Use divider or compass for transferring the distances (*change of position method*).



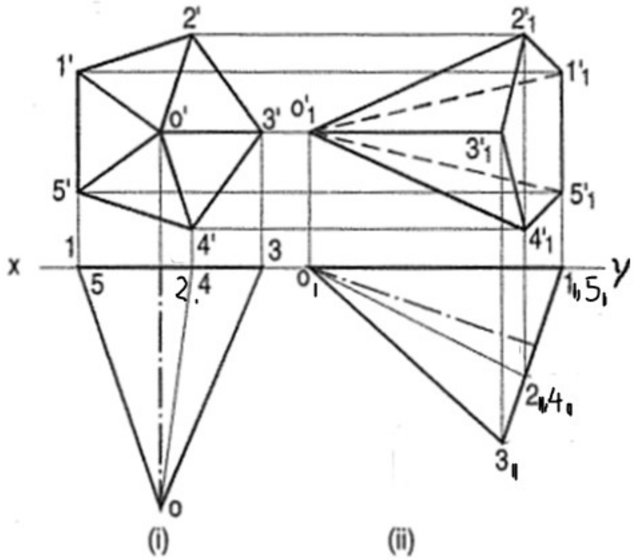

4) Draw vertical projector lines from the final TV and horizontal projector lines from FV. Mark the points of intersection of horizontal and vertical projector lines for every corner.

5) Darken all the visible lines and draw dashed lines for all the hidden edges in the Final FV. Also show the axis using a chain line in the final FV.

**Q.4) A pentagonal Pyramid is having base edge 30 mm and height 60 mm. One of its triangular faces is in VP and the axis is parallel to HP. Draw its FV and TV.**

**Solution:**

1) Draw the reference line (XY line).
2) Firstly, assume that the base is in VP. Draw a regular *Pentagon* above XY keeping one of its side (1-5) perpendicular to XY line. Also show its slant edges.
3) Draw the corresponding TV below the XY line.
4) Following '*change of position*' method, Draw the final TV with one of the triangular slant faces (O-1-5) in VP (i.e. in XY line). Use divider or compass for transferring the distances.

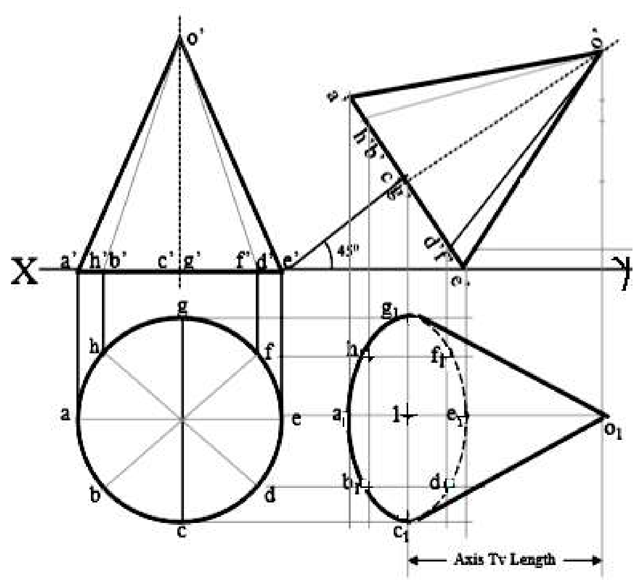



5) Draw vertical projector lines from the final TV and horizontal projector lines from the FV. Mark the points of intersection of these projector lines and join these points in the correct order to get the final FV of the given *Pyramid*. Darken the desired visible outer edges and draw hidden lines for the edges not visible. Also show the axis of the *pyramid* using a chain line.

**Q.5) A cone is resting on one of the point on the circumference of its base on HP. Its axis is parallel to VP and 45° inclined to HP. Draw its FV and TV.**

**Solution:**

1) Draw the XY line.
2) Firstly, assume that the cone is resting on its base on HP and its axis is perpendicular to it. Draw its projections.
3) Since the base of the cone has no corners, mark equally spaced 8 to 12 points on its circumference in the TV. Here, 8 parts are done: **a** to **f**. Mark corresponding points **a'** to **f'** in the FV too.
4) Following '*change of position*' method, re-draw the final FV with the axis inclined at 45° with XY line (i.e. with HP).



5) Draw vertical projector lines from the final FV and horizontal projector lines from the TV. Mark the points of intersection of horizontal and vertical projections of a same point. Join the points in the correct order to obtain the desired final TV.

6) **Darken** all the visible edges. In the TV, the lower arc must be drawn dashed, as this part of the base is not visible from the top. So, $\mathbf{c_1}$ to $\mathbf{g_1}$ is dashed. Also measure and mark the final TV axis length.

**5.5 PRECAUTIONS:**

1. The drawing board must not wobble and all four legs of the drawing board must be properly stable on the ground.

2. The drafter must be of good built quality and it must be rigidly fixed on the top left corner of the drawing board to make sure that perfect parallel/perpendicular lines are obtained on the drawing.

3. The pencils should be properly sharpened to attain required accuracy in drawing.

4. Hands should be clean and surroundings should be free from any dirt.

5. The sheet should not displace during the whole duration of drawing, and its edges should be perfectly horizontal and vertical with respect to the board edges.

6. The light and dark lines (i.e. thin and thick lines) must be clearly distinguishable.

7. Use of eraser should be as less as possible, to avoid any chances of previous imprints on the sheet.

8. A sufficient gap should be maintained with the drawing boards of other nearby students.

**5.6 VIVA QUESTIONS**

1. How can you describe a 'Solid'?
2. Tell a brief classification of solids.
3. What is a 'Polyhedron'
4. What is a 'Tetrahedron'?
5. What are 'Prisms'?
6. What are 'Pyramids'?
7. What are 'Frustum of solids'?
8. What are 'Truncated solids'?
9. What is a 'Solid of revolution'?
10. Generally, in what case we need another (side) view of a solid in addition to TV and FV?
11. In what cases we can observe the true shape of the base of a Pyramid?
12. The FV and TV of a solid are in shape of an isosceles triangle and a square respectively. What type of solid is it?
13. The FV and TV of a solid are in shape of a rectangle and an equilateral triangle respectively. What type of solid is it?

# ABES Engineering College, Ghaziabad

## Department of Mechanical Engineering

**ENGINEERING GRAPHICS AND DESIGN LAB (BCE 151/BCE251)**

**SHEET No-06 (SECTIONING OF SOLIDS)**

**6.1 Objective** **6.2 Instruments to be used** **6.3 Theory**

**6.4 Problems for Practice with Procedure** **6.5 Precautions** **6.6 Viva Questions**

### 6.1 OBJECTIVE:

To demonstrate the methodology of orthographic projection of section of solids and to obtain the true sectional view.

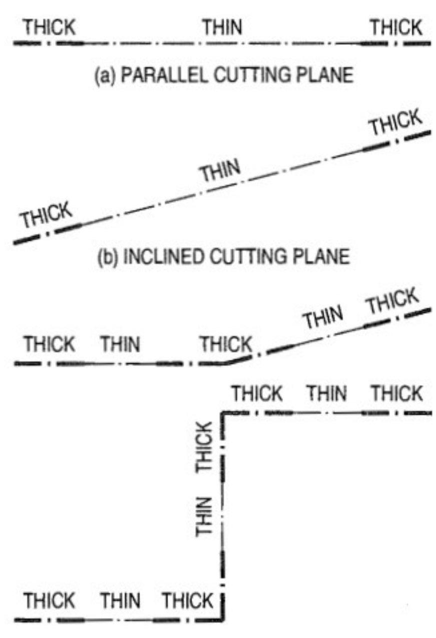
### 6.2 INSTRUMENTS TO BE USED:

Drawing board, Mini drafter, Geometrical Instrument box (including a protractor, set of rulers, Pencils - H, 2H, eraser, sharpener, compass and divider), Drawing sheet clips (preferably) or cello tape, a Drawing sheet – A2 size, sheet cover.

### 6.3 THEORY:

#### 6.3.1 Meaning of Sectioning of Solids

Invisible features of an object are shown by dotted lines in their projected views. But when such features are too many, these lines make the views more complicated and difficult to interpret. In such cases, it is customary to imagine the object as being cut through or *sectioned* by planes. The part of the object between the cutting plane and the observer is assumed to be removed and the view is then shown *in section.*



(a) PARALLEL CUTTING PLANE

(b) INCLINED CUTTING PLANE

(c) CUTTING PLANE AT CHANGING POSITION

#### 6.3.2 Cutting Plane and Sectional View

The imaginary plane which cuts the solid is called a section *plane* or a *cutting plane.* The surface produced by cutting the object by the section plane is called the *section.* It is indicated by thin section lines (*Hatching*) uniformly spaced and inclined at 45°. The projection of the section along with the remaining portion of the object is called a *sectional view.*

### 6.3.3 Section Plane

Section planes are generally perpendicular planes. They may be perpendicular to one of the reference planes and either perpendicular, parallel or inclined to the other plane. As per latest 8.1.S. convention (SP: 46-2003), the cutting-plane line should be drawn as shown in fig.

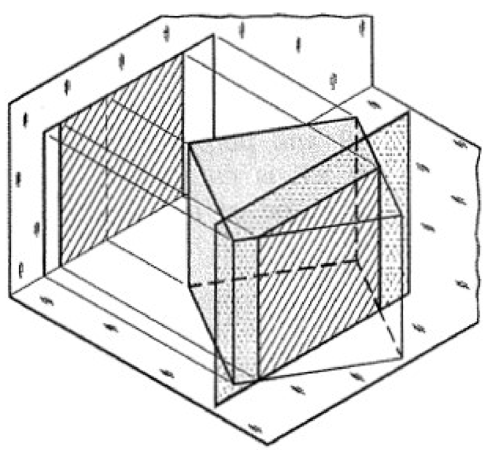
### 6.3.4 True shape of a section

The projection of the section on a plane parallel to the section plane will show the true shape of the section. Thus, when the section plane is parallel to the H.P. or the ground, the true shape of the section will be seen in *sectional top view.* When it is parallel to the V.P., the true shape will be visible in the *sectional front view.* But when the section plane is inclined, the section has to be projected on an auxiliary plane parallel to the section plane, to obtain its true shape. When the section plane is perpendicular to both the reference planes, the sectional side view will show the true shape of the section.

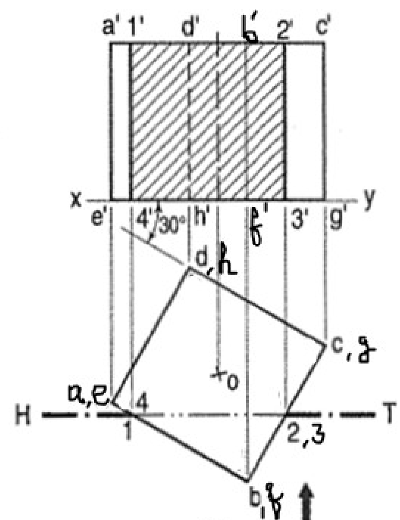
## 6.4 PROBLEMS FOR PRACTICE WITH PROCEDURE

**Q.1) A cube of 35 mm long edges is resting on the H.P. on one of its faces with a vertical face inclined at 30° to the V.P. It is cut by a section plane parallel to the V.P. and 9 mm away from the central axis and further away from the V.P. Draw its sectional front view and the top view.**

**Solution:**



(i)

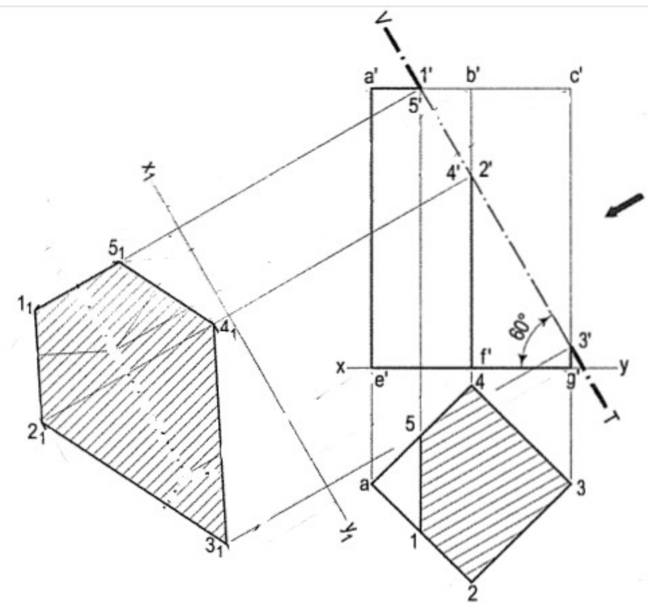



(ii)

1) Draw the XY line and draw the projections of the whole cube in the required position.
2) Draw a line H.T. in the top view (to represent the section plane) parallel to XY and 9 mm from **o**.
3) Name the points at which the edges are cut, viz. **ab** at **1**, **be** at **2**, **gf** at **3** and **fe** at **4**.
4) Project these points on the corresponding edges in the front view and join them in proper order. As the section plane is parallel to the VP, figure **1' 2' 3' 4'** in the front view, shows the true shape of the section.
5) Show the views by dark but thin lines, leaving the lines for the cut-portion fainter. Draw section lines in the rectangle for the section.

**Q.2) A square prism, base 40 mm side, axis 80 mm long, has its base on the H.P. and its faces equally inclined to the V.P. It is cut by a plane, perpendicular to the V.P., inclined at 60° to the H.P. and passing through a point on the axis, 55 mm above the H.P. Draw its front view, top view and the true shape of the cut-section.**

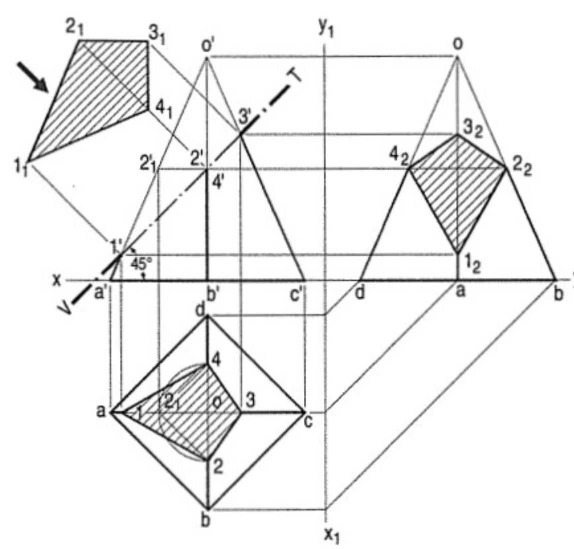
**Solution:**



1) Draw the XY line and Draw the FV and TV of the given prism in the required position.
2) Mark various points on the views viz., **a, a', b', c'**,…etc.
3) On the central line (axis) in the FV, mark a point 55 mm above XY (named as **2'** or **4'**) and draw the cutting-plane line VT inclined at 60°. This cutting-plane line intercects with the top surface at points **1'**, **5'** and with the side vertical edge **c'g'** at point **3'**.
4) Mark correcponding points **1** to **5** in the TV and draw section lines (hatching) in that portion.
5) From the points **1'** to **5'** draw projectors perpendicular to the cutting-plane line VT and draw another auxilliary reference line $X_1Y_1$ at some suitable distance.
6) Using divider or compass, take the distance between XY line and **5**, and mark it from the line $X_1Y_1$ to locate point $\mathbf{5_1}$. Similarly, locate rest other points $\mathbf{1_1}$, $\mathbf{4_1}$, $\mathbf{2_1}$ and $\mathbf{3_1}$ too. Join in the correct order to get the desired true shape of the section.

**Q.3) A square pyramid, base 40 mm side and axis 65 mm long, has its base on the H.P. and all the edges of the base equally inclined to the V.P. It is cut by a section plane, perpendicular to the V.P., inclined at 45° to the H.P. and bisecting the axis. Draw its sectional top view, sectional side view and true shape of the section.**

**Solution:**



1) Draw the XY line and then draw the projections of the pyramid in the required position.
2) The section plane will be seen as a line in the FV. Hence, draw a line V.T. through the mid-point of the axis and inclined at 45° to XY. Name in correct sequence the points at which the four edges are cut and project them in the top view.
3) Here, points **2'** and **4'** cannot be projected

directly. Hence, assume a horizontal section through **2'** and draw a line parallel to the base, cutting **o'a'** at **$2_1$'**. Project **$2_1$'** to **$2_1$** on ***oa*** in the TV. From **$2_1$** draw a line parallel to **ab** and cutting **ob** at a point **2**. Or, with **o** as centre and radius **o$2_1$**, draw an arc cutting **ob** at **2** and **od** at **4**. Complete the section **1 2 3 4** by joining the points and draw section lines in it.

**4)** Assuming the V.T. to be the new (auxiliary) reference line, draw the true shape of the section in a similar way as discussed in the previous question.

**5)** Project the side view from the two views. The removed portion of the pyramid may be shown by thin and faint lines.

## 6.5 PRECAUTIONS:

1. The drawing board must not wobble and all four legs of the drawing board must be properly stable on the ground.

2. The drafter must be of good built quality and it must be rigidly fixed on the top left corner of the drawing board to make sure that perfect parallel/perpendicular lines are obtained on the drawing.

3. The pencils should be properly sharpened to attain required accuracy in drawing.

4. Hands should be clean and surroundings should be free from any dirt.

5. The sheet should not displace during the whole duration of drawing, and its edges should be perfectly horizontal and vertical with respect to the board edges.

6. The light and dark lines (i.e. thin and thick lines) must be clearly distinguishable.

7. Use of eraser should be as less as possible, to avoid any chances of previous imprints on the sheet.

8. A sufficient gap should be maintained with the drawing boards of other nearby students.

## 6.6 VIVA QUESTIONS

1. What do you understand by sectioning of solid?
2. Define sectioning line.
3. How to denote the cutting planes on front view or top view of an object?
4. What is ‘sectional view’?
5. What do you understand by ‘true shape’ of a section?
6. In what case the true shape of a section of solid can be observed in its front or top view itself, without any need of a separate sectional view?
7. What can be the possible true shapes (polygon) of a section of a square prism?

# ABES Engineering College, Ghaziabad

## Department of Mechanical Engineering

**ENGINEERING GRAPHICS AND DESIGN LAB (BCE 151/BCE251)**

**SHEET No-07 (ISOMETRIC SCALE AND ISOMETRIC PROJECTIONS)**

| | | |
|---|---|---|
| **7.1 Objective** | **7.2 Instruments to be used** | **7.3 Theory** |
| **7.4 Problems for Practice with Procedure** | **7.5 Precautions** | **7.6 Viva Questions** |

### 7.1 OBJECTIVE:

To understand the fundamentals of isometric scale and projection, and to draw isometric projection of plane surfaces as well as standard and compound solids.

### 7.2 INSTRUMENTS TO BE USED:

Drawing board, Mini drafter, Geometrical Instrument box (including a protractor, set of rulers, Pencils - H, 2H, eraser, sharpener, compass and divider), Drawing sheet clips (preferably) or cello tape, a Drawing sheet – A2 size, sheet cover.

### 7.3 THEORY:

#### 7.3.1 Principles of Isometric Projections

It is a pictorial orthographic projection of an object in which a transparent cube containing the object is tilted until one of the solid diagonals (the largest diagonal joining two farthest corners) of the cube becomes perpendicular to the vertical plane and the three axes are equally inclined to this vertical plane. The Pictorial drawing shows several faces of an object in one view, approximately as it appears to the eye. Isometric projection of a cube in steps is shown in figure (1) below. Here, ABCDEFGH is the isometric projection of the cube.

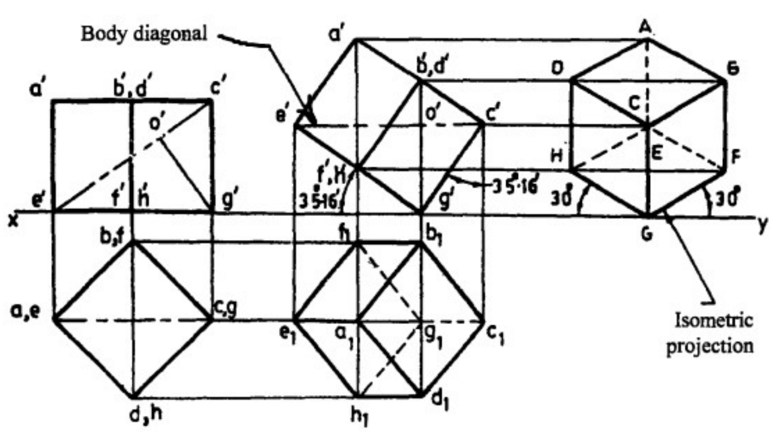
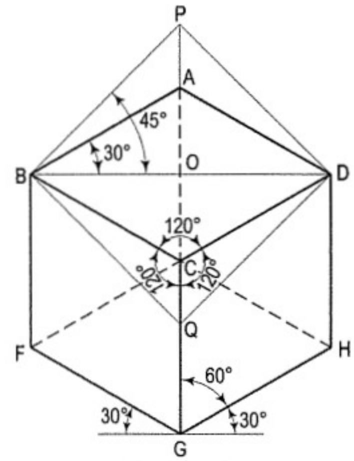


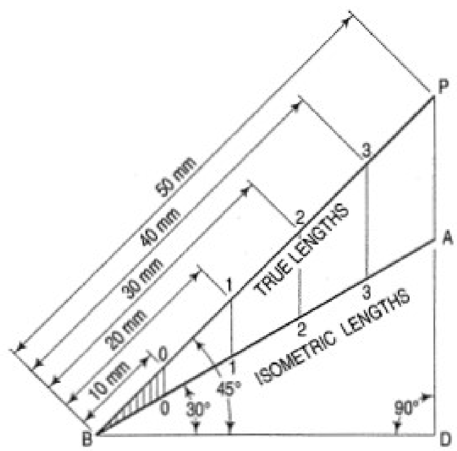

Fig (1)




The front view of the cube, resting on one of its corners (G) is the isometric projection of the cube. The isometric projection of the cube is reproduced in Fig (2). In the isometric projection of the cube, 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. The diagonal BD of the top face is parallel to the V.P. and hence, retains its true length.

**7.3.2 Isometric Axes, Isometric Lines, Isometric Planes:** The three lines *CB, CD* and CG (Fig. (2)) meeting at the point C and making 120° angles with each other are termed *isometric axes.* The lines parallel to these axes are called *isometric lines.* The planes representing the faces of the cube as well as other planes parallel to these planes are called *isometric planes*

**7.3.3 Isometric Scale:** As all the edges of the cube are equally fore-shortened, the square faces are seen as rhombuses. The rhombus *ABCD* (Fig (2)) shows the isometric projection of the top square face of the cube in which *BD* is the true length of the diagonal. Construct a square *BQDP* around *BD* as a diagonal. Then *BP* shows the true length of *BA*.




In triangle ABO,

$BA/BO = \sec 30° = 2/\sqrt{3}$

In triangle PBO,

$BP/BO = \sec 45° = \sqrt{2}$

Therefore,

$BA/BP = (2/\sqrt{3})/(\sqrt{2}) = \sqrt{2} / \sqrt{3} = \mathbf{0.816}$

Thus, the isometric projection is reduced in the ratio $\sqrt{2}:\sqrt{3}$ , i.e. the isometric lengths are 0.816 of the true lengths. Therefore, while drawing an *isometric projection,* it is necessary to convert true lengths into isometric lengths for measuring and marking the sizes. This is conveniently done by constructing and making use of an isometric scale as shown in Fig.(3).

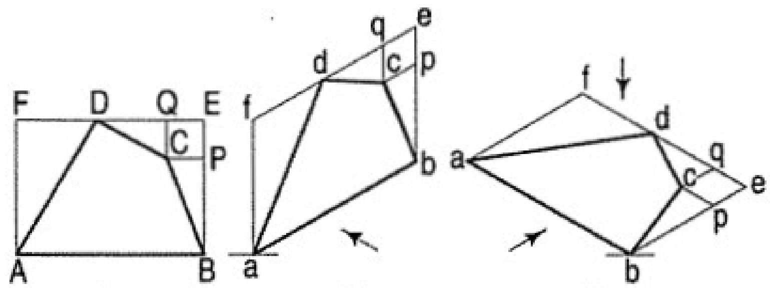
**NOTE**: Generally, just for simplicity and convenience, dimensions are not reduced and an isometric view is drawn with the true dimensions (this is not applicable if the given solid is a compound solid with some spherical parts). This is advantageous because the true dimensions can be read from the drawing directly. In such cases, the isometric drawing will be somewhat larger (22%) than the true isometric projection.

**7.4 PROBLEMS FOR PRACTICE WITH PROCEDURE**

**Q.1) The front view of a quadrilateral whose surface is parallel to VP is shown in the figure. Construct its isometric drawing. AB = 50 mm, AD = 40 mm, DC = 20 mm, CB = 30 mm, angle DAB = 60°.**

**Solution:**

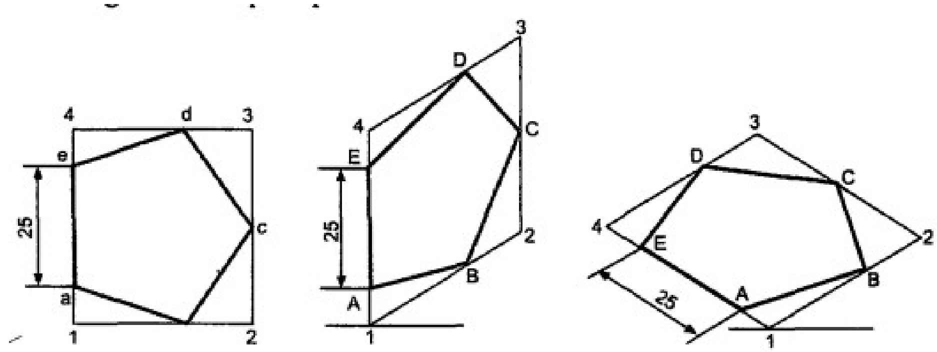
1) Enclose the quadrilateral in a rectangle ABEF.
2) Draw lines CP and CQ parallel to the sides FE and BE respectively.
3) Draw the isometric view of the rectangle and obtain the point **d** in **fe**. Draw the isometric view **cpeq** of the rectangle CPEQ.
4) Draw the quadrilateral **abcd** which is the required isometric view.




**Q.2) Figure shows the projection of a pentagonal plane with side 25 mm each. Draw the isometric drawing of the plane when the surface is (i) parallel to VP and (ii) parallel to HP**

**Solution:**

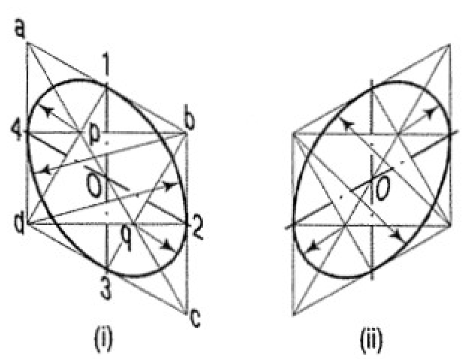
1) Enclose the given pentagon **abcde** in a rectangle **1234**.
2) Make the isometric drawing of the rectangle **1234** by using true lengths.
3) Locate the points A and B such that 1a = 1A and 1b = 1B.
4) Similarly locate point C, D and E such that 2c =2C, 3d =3D and e4 =E4.
5) ABCDE is the isometric drawing of the pentagon.
6) Following the above principle of construction, parallel to HP case can be drawn.




**Q.3) A circular surface having diameter 60 mm is parallel to the VP. Draw the isometric view of the circle using *four-centre method (arc method).***

**Solution:**

1) Draw the rhombuses with faint lines in both the possible isometric planes with sides equal to the diameter of the circle. One of those rhombus is **abcd** with sides **ab**, **bc**, **cd** and **da**.
2) Mark the mid-points of each side as **1, 2, 3** and **4** respectively.
3) Construct **d1** and **b4**. these two intersect at a point **p**. Similarly, construct **b3** and **d2** which intersect at point **q**.
4) Using **p** as centre and **p4** or **p1** as radius, construct an arc **41**. Similarly, using **q** as centre and **q3** or **q2** as radius, construct another arc **23**.



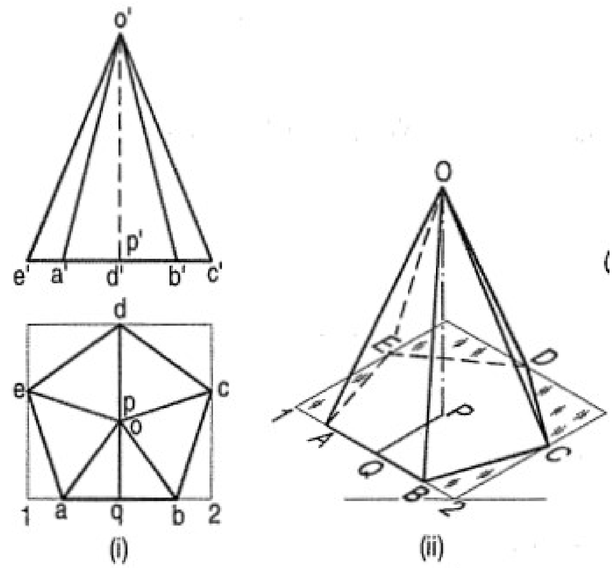
5) Using **d** as centre and **d1** or **d2** as radius, construct an arc **12**. Similarly, using **b** as centre and **b4** or **b3** as radius, construct another arc **34**. Darken the whole shape (ellipse) **1234** which is the desired approximate isometric drawing of the given circle.

**NOTE**: The ellipse obtained by the *four-centre method* is not a true ellipse and differs considerably in size and shape from the true ellipse. But owing to the ease in construction and to avoid the labour of drawing freehand neat curves, this method is generally employed.

**Q.4) Draw the isometric view of the pentagonal pyramid, the projections of which are given in fig. Each side of the given pentagon is 25 mm in length, and its height is 50 mm.**

**Solution:**

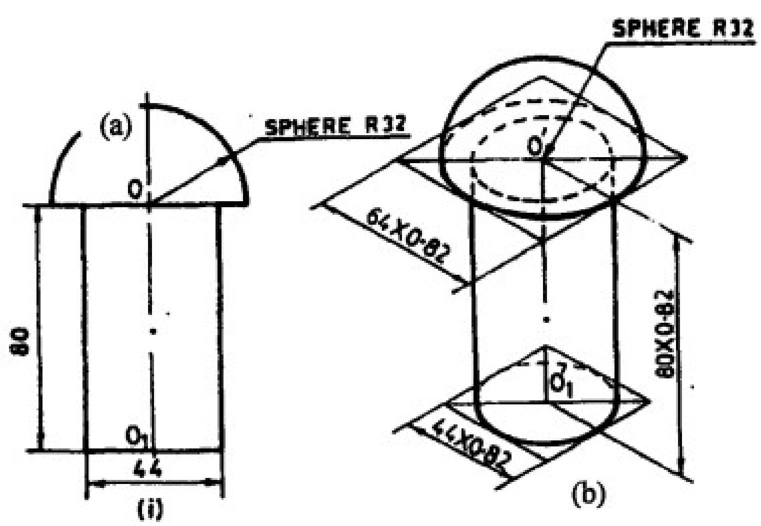
1) Enclose the base (in the top view) in a rectangle.
2) Draw an offset ***oq*** (i.e. ***pq)*** on the line ***ab***.
3) Draw the isometric view of the rectangle in shape of a rhombus and locate the corners of the base in it as **A, B, C, D** and **E**.
4) Mark a point **Q** on the line ***AB*** such that ***AQ*** = ***aq***. From **Q**, draw a line ***QP*** equal to ***qp*** and parallel to **2C**. At ***P,*** draw a vertical ***OP*** equal to ***o'p'*** (from FV) using chain line.




5) Join **O** with the corners of the base, thus completing the isometric view of the pyramid (fig (ii)). Edges **OE**, **AE** and **ED** will not be visible in this view, and hence to be drawn with hidden lines.

**Q.5) A rivet is shown in the figure, with various dimensions mentioned in its front view. Draw its isometric projection.**

**Solution:**




**NOTE:** For the solids involving spheres or a part of a sphere, isometric scale must be used because in isometric view or any other oblique view, a sphere is always observed with true dimensions, and not reduced dimensions. To construct exactly the same shape of such compound solids, it is mandatory to use isometric scale. Following are the steps:

1) Construct the base rhombus with isometric dimensions (= 44 x 0.816 mm).
2) Create the base ellipse using four-centres method. Mark its centre $\mathbf{O_1'}$.
3) At point $\mathbf{O_1'}$ draw a vertical chain line and mark the isometric height of the given rivet (= 80 x 0.816 mm), locate the point **O'.** This point **O'** is the centre of the top hemisphere.
4) Construct another rhombus around the centre **O'** using isometric dimension of the diameter of top hemisphere (= 64 x 0.816 mm).
5) Around the bottom side of **O'** create half-ellipse using four-centre method, or by free-hand. On its upper side construct a semi-circle with diameter equal to the major axis of the half-ellipse drawn earlier.
6) Darken all the visible dimensions and use hidden lines for showing invisible edges.

## 7.5 PRECAUTIONS:

1. The drawing board must not wobble and all four legs of the drawing board must be properly stable on the ground.

2. The drafter must be of good built quality and it must be rigidly fixed on the top left corner of the drawing board to make sure that perfect parallel/perpendicular lines are obtained on the drawing.

3. The pencils should be properly sharpened to attain required accuracy in drawing.

4. Hands should be clean and surroundings should be free from any dirt.

5. The sheet should not displace during the whole duration of drawing, and its edges should be perfectly horizontal and vertical with respect to the board edges.

6. The light and dark lines (i.e. thin and thick lines) must be clearly distinguishable.

7. Use of eraser should be as less as possible, to avoid any chances of previous imprints on the sheet.

8. A sufficient gap should be maintained with the drawing boards of other nearby students.

## 7.6 VIVA QUESTIONS

1. What is isometric projection?
2. Define: (1) Isometric axes, (2) Isometric lines, (3) Isometric planes.
3. What is the significance of a pictorial view?
4. What is the advantage of an isometric view?
5. What is isometric scale?
6. What is the factor of reduction in dimensions in case of an isometric view?
7. Why isometric scale is not applicable in case of spheres or a hemisphere?

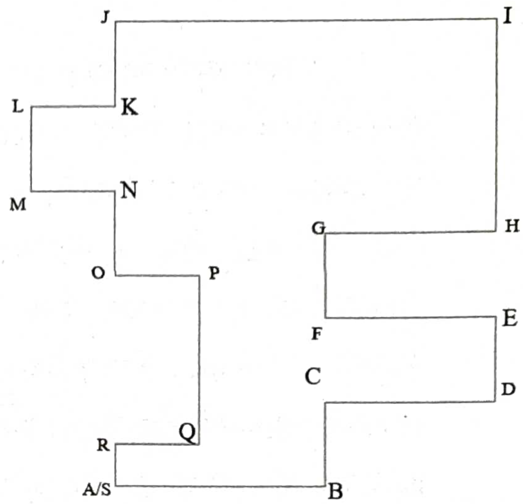
# AUTOCAD EXERCISES FOR FIRST YEAR STUDENTS

Engineering Graphics and Design LAB (BCE151/BCE251) Session:2023-24

**Exercise 1/4:-** CARTESIAN COORDINATE SYSTEM

Coordinates:

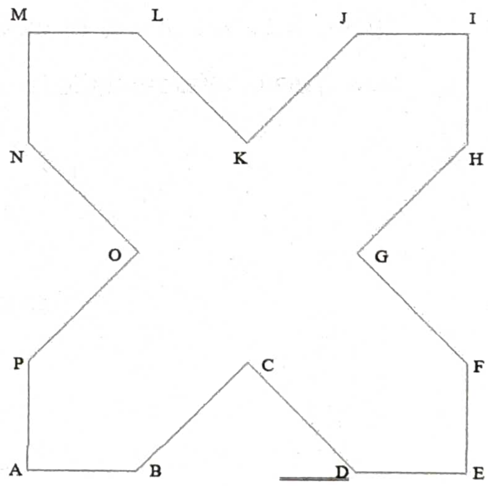
A=(100,100), B=(105,100), C=(105,102), D=(109,102),E=(109,104), F=(105,104), G=(105,106), H=(109,106), I=(109,111), J=(100,111), k=(100,109), L=(98,109), M=(98,107), N=(100,107), O=(100,105), P=(102,105), Q=(102,101), R=(100,101), S=(C)



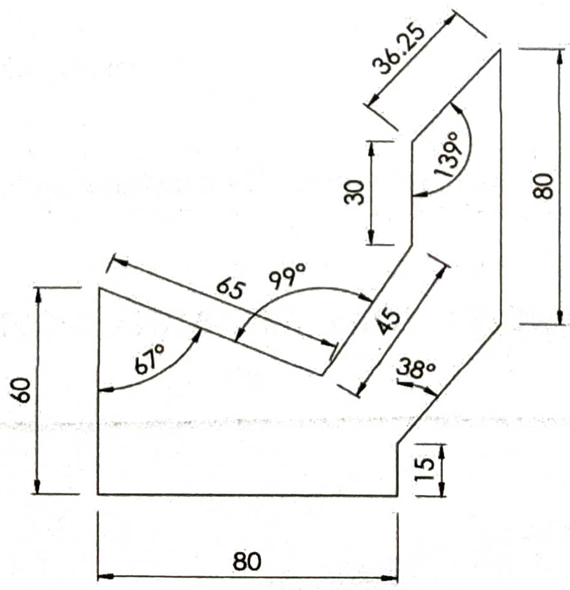

**Exercise 2/4:-** CARTESIAN COORDINATE SYSTEM

Coordinates:

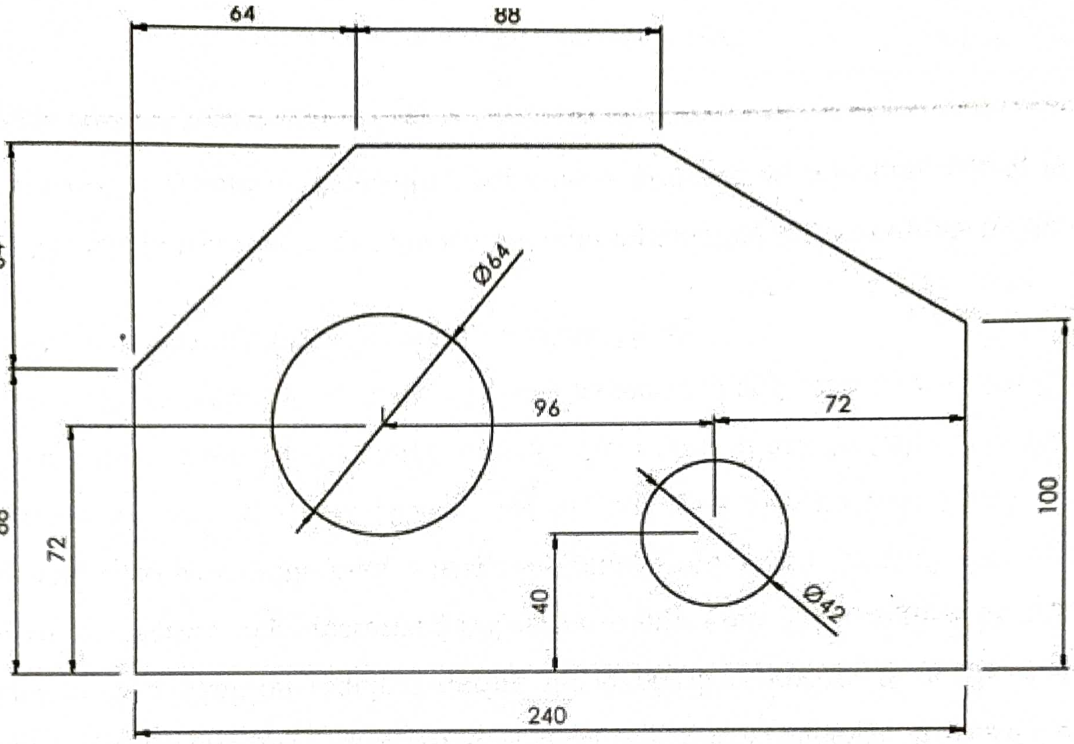
A=(290,100), B=(340,100), C=(390,150), D=(440,100),E=(490,100), F=(490,150), G=(440,200), H=(490,250), I=(490,300), J=(440,300), k=(390,250), L=(340,300), M=(290,300), N=(290,250), O=(340,200), P=(290,150).




**Exercise 3/4:-** POLAR COORDINATES SYSTEM



**Exercise 4/4:**




30/01/2023
Sign. Lab Coordinator

30/10/23
Sign. HOD