LAB MANUAL

Engineering Drawing Sessional (IPE 1210)

Experiment 1: Study of basic tools and requirements of engineering drawing.

1. **Class Decorum**

- Enter class 10 minutes before the schedule
- Arrange the drawing table properly
- Set your drawing paper to the drawing table properly
- Drawing paper should be prepared properly before coming into the class
- Bring all the necessary drawing instruments
- Listen to the instructions properly
- Do your class work by your own effort
- Ask for help from teachers if necessary
- You must submit your drawing within given time

N.B.: No student will be allowed to attend the class with incomplete drawing instruments and Any kind of unfair means during class performance may cause severe punishment.

2. Necessary Instruments

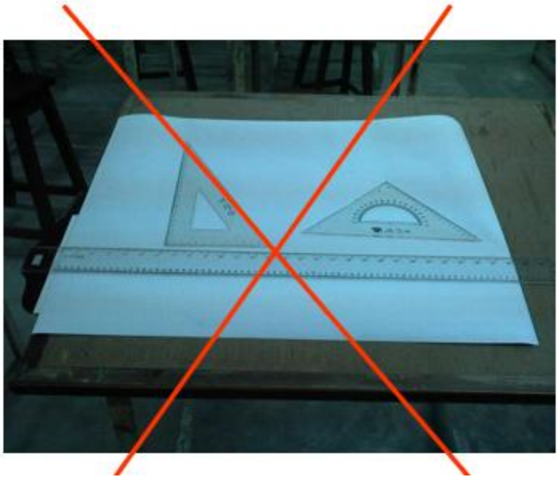
- Drawing sheet
- Drafting tape
- T-square
- Set square
- Compass and divider
- Pencil
- Eraser

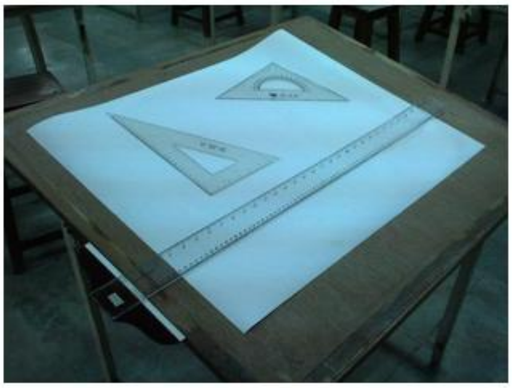
T-square/ T-scale

Set-square

Compass

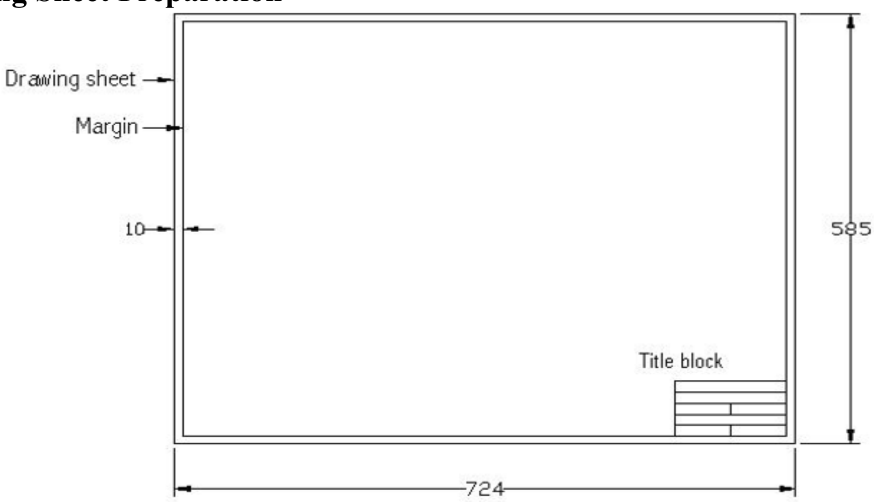
3. Drawing Table Preparation



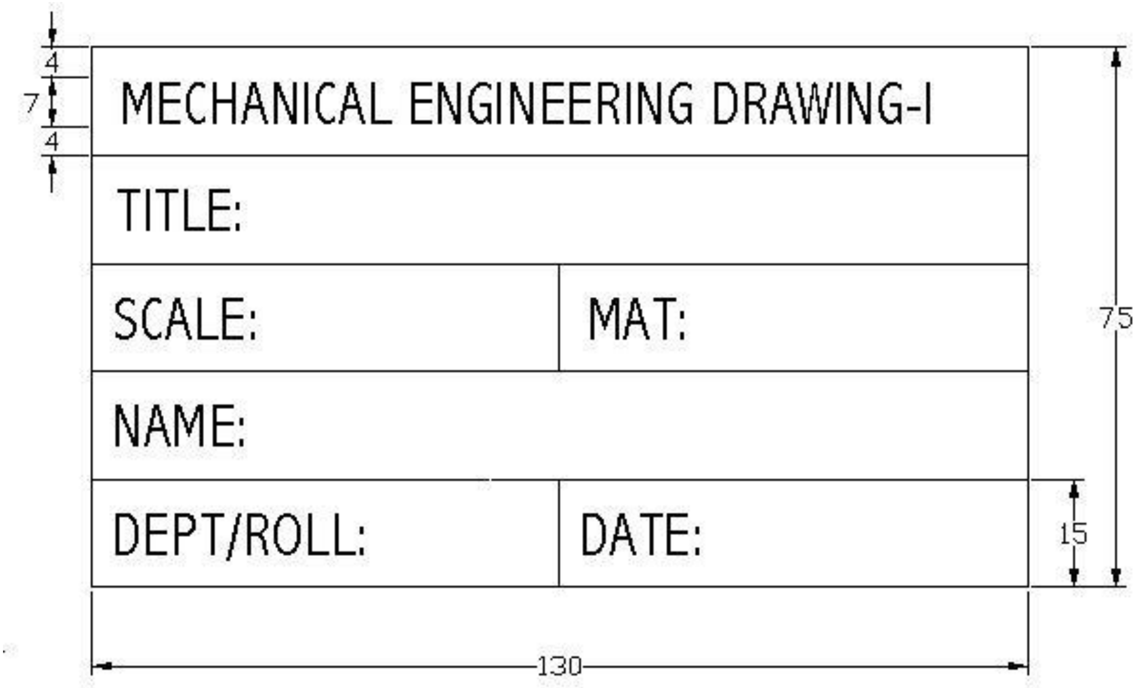


- **Try to set your drawing sheet at the middle of the table using T-scale.**
- **Affix the drawing paper with the help of drafting tape.**

4. Drawing Sheet Preparation



All the dimensions are in mm



All dimensions in mm

5. **Lettering**
    - Required for figure description, figure dimensions, notes on materials, title etc.
    - Done in single stroke either vertically or in inclined manner.
    - Only one style of lettering should be used throughout the drawing.

Experiment 2: Study and Demonstration of Lines and Dimensions of different drawings.

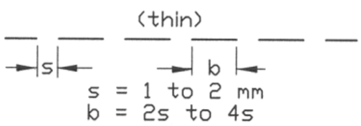
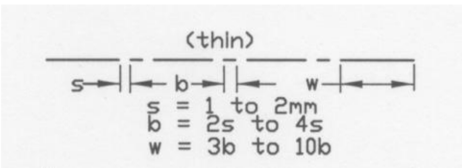
Objective

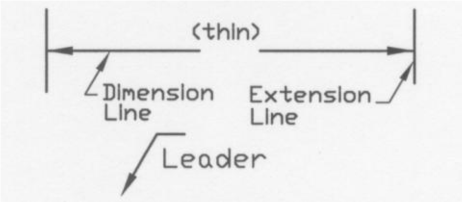
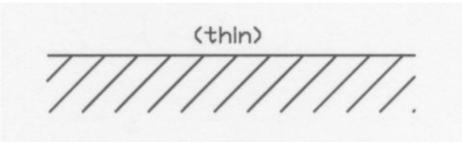
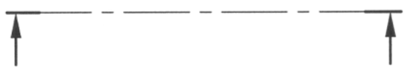
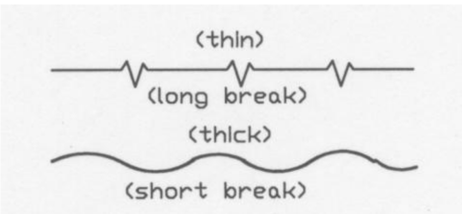
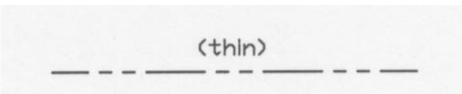
- Understand the importance of different types of lines in engineering drawing.
- Learn dimensioning techniques used in technical drawings.

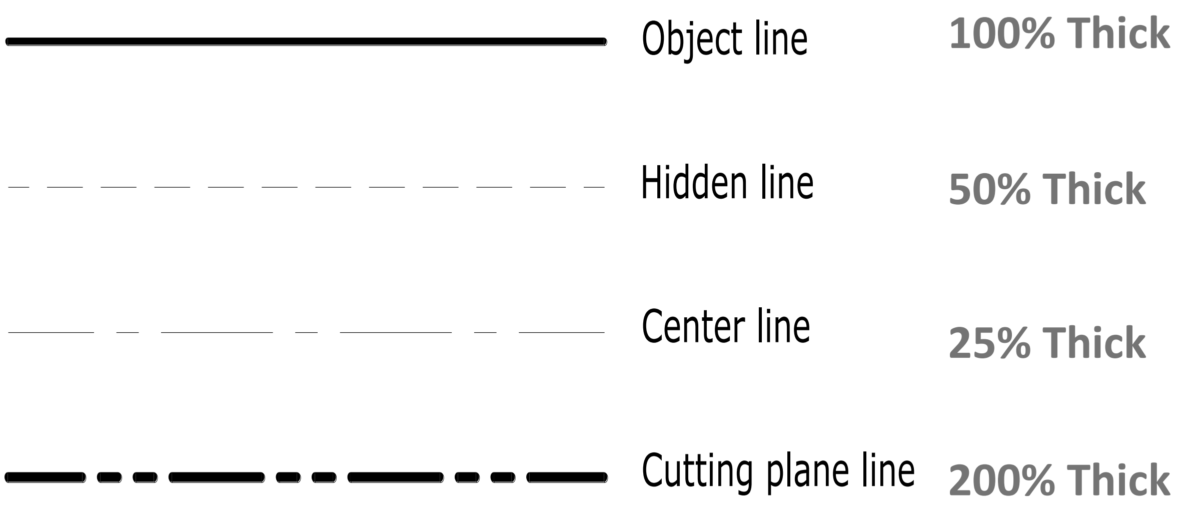
Lines in Engineering Drawing:

1. **Visible lines** – Represent the edges and outlines.
2. **Hidden lines** – Show the edges not visible in a particular view.
3. **Center lines** – Represent symmetry and centers of circles/arcs.
4. **Dimension lines** – Indicate the sizes of features.
5. **Extension lines** – Extend from features to indicate dimensions.
6. **Leader lines** – Used for annotations.

Types of lines with their usages

Sl No.	Types of Line	Usage
1	Visible line / object line  	to indicate all visible outlines of an object. It shows the shape of an object.
2	Hidden line / dashed line  	to represent the hidden edge of an object. It must begin and end with a dash touching the visible lines. Dashes that show hidden lines usually touch each other at intersection.
3	Center line  	to show the center line of holes, pitch line.

Sl No.	Types of Line	Usage
4	Extension line, dimension line and Leaders 	to show dimension of an object extension line, dimension line and leaders are used.
5	Section line 	to indicate the cut portion of an object.
6	Cutting plane line 	to show the imaginary cutting of an object
7	ISO Cutting Plane Line 	
8	Break line 	to show a break on the object. It shortens the view of a long part.
9	Phantom line/repeat line 	to show the alternate position of an object or the position of an adjacent part.



Dimensioning

It is the method of defining the geometric characteristics of the drawn object such as, lengths, diameters, angles, locations etc. using different lines and notations. Engineering drawing without dimensioning is meaningless.

Dimensioning is done basically by using-

- Arrowhead
- Extension line
- Dimension line
- Leader

Arrowheads

The important part of the dimensioning is the arrowhead. The arrowhead may be drawn in accordance with Figure 1.1. Arrowheads are usually drawn freehand. However, all arrowheads must be identical in shape and size throughout the drawing unless it becomes essential. Sometimes it becomes necessary to shorten them due to space limitation. The length of the arrowhead may vary depending on the size of the drawing. The approximate length of the arrowhead may be 3 mm. However, for the larger drawing it may be a little bit larger in size. The approximate ratio of the length to width of the arrowhead is 3:1 as shown in the figure. The arrowhead must touch the line. It must not be either away from the line or cross the line.

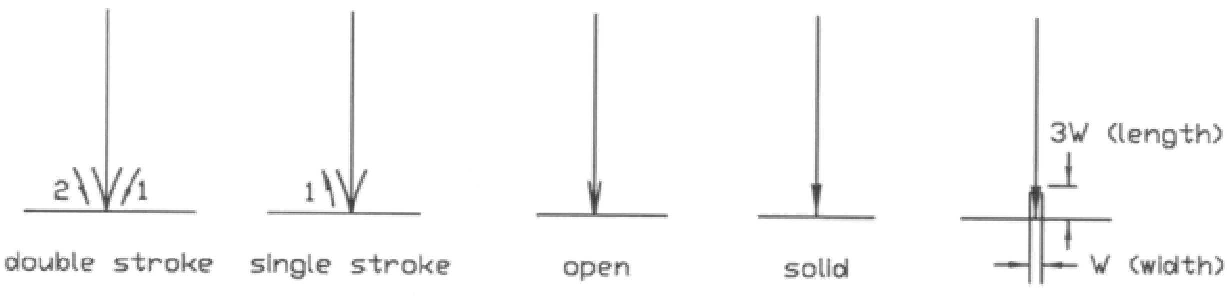
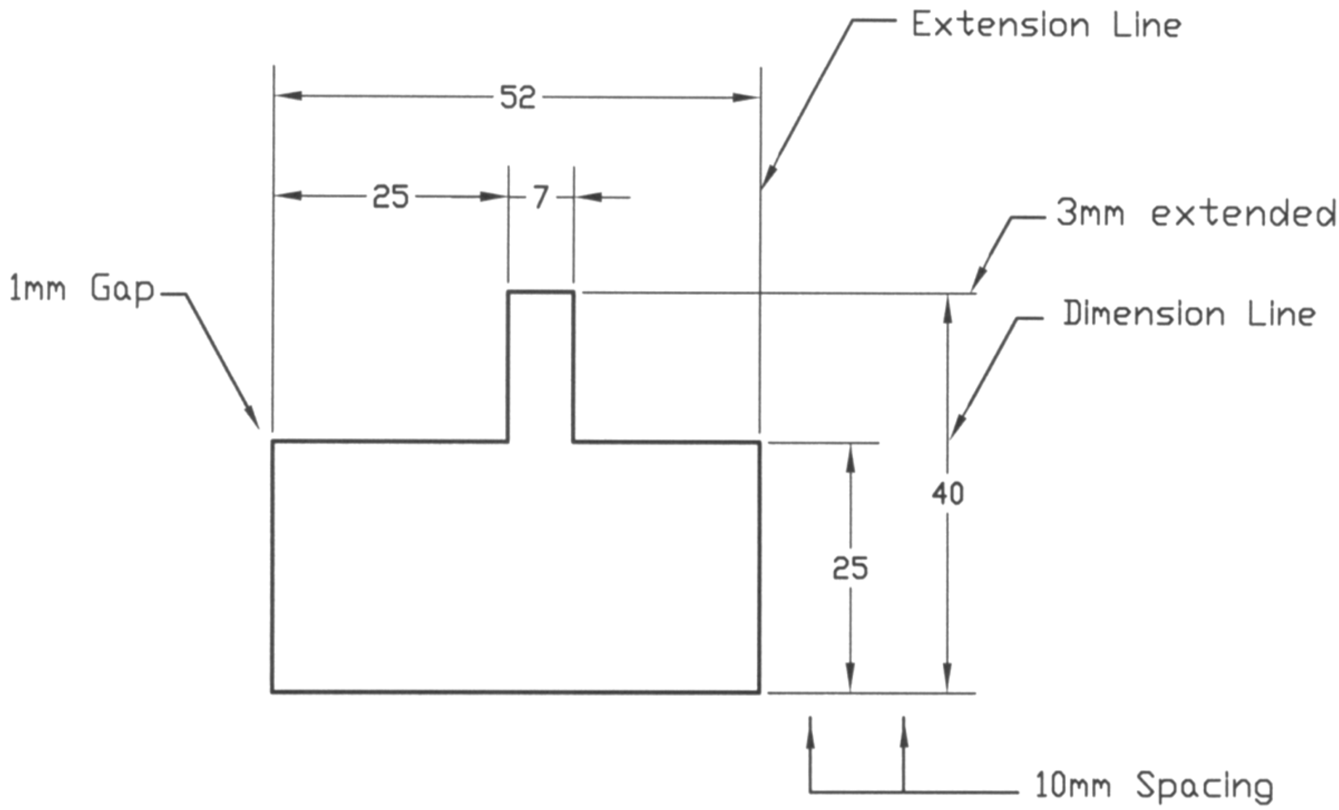
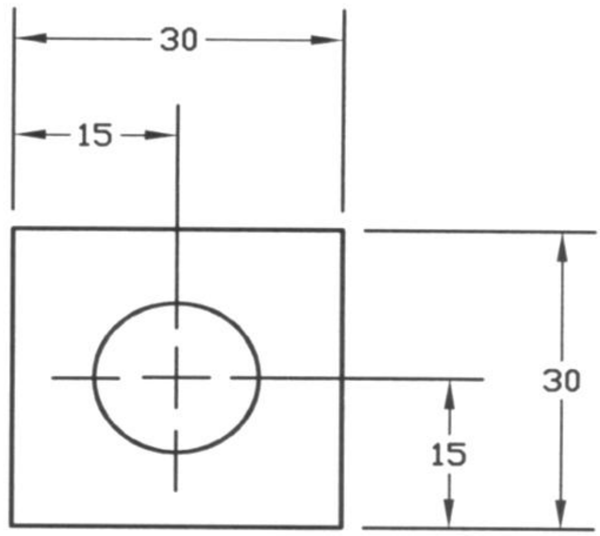


Figure 1.1: Arrowheads

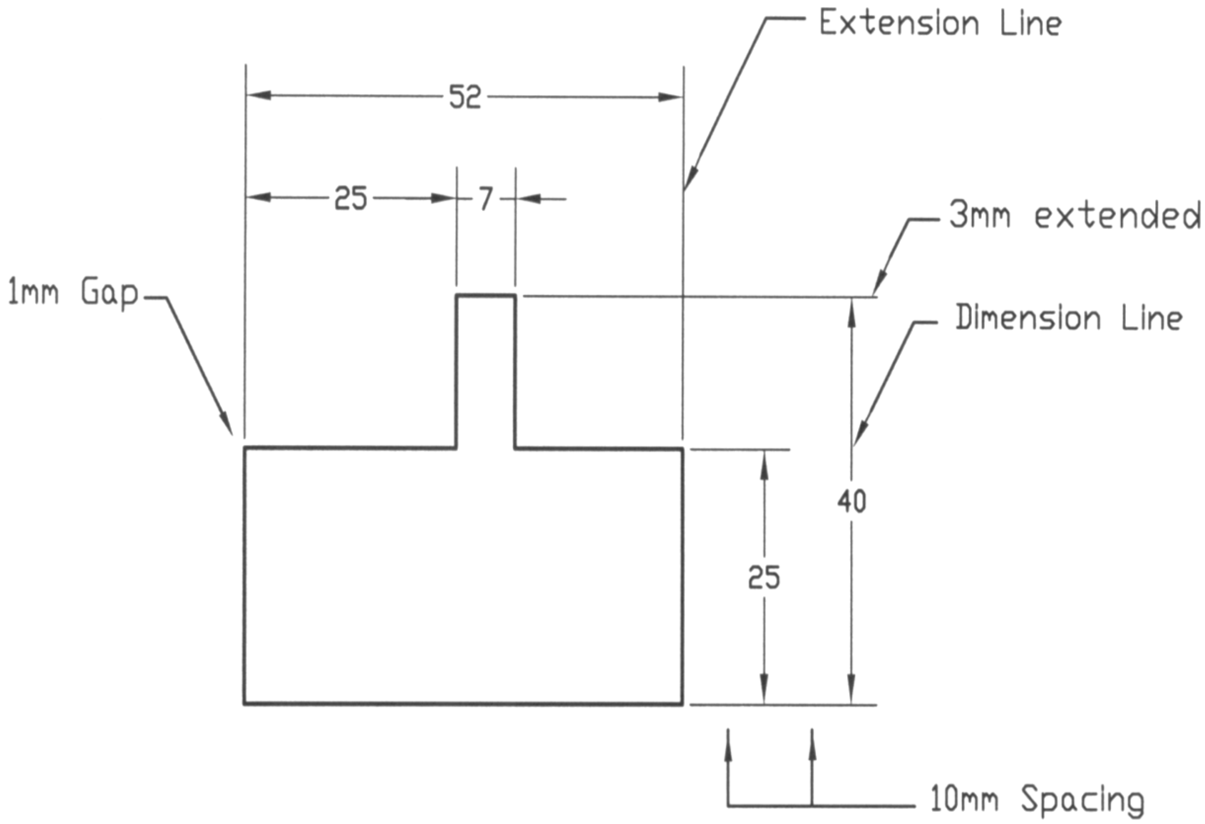
Extension line (25% thick line)





- A gap of 1 mm must be kept between the extension line and the visible line.
- An extension line should extend about 3 mm from the outermost dimension line.
- Extension lines may cross each other without a break.
- Centerlines may be used as extension lines.
- Extension lines are usually drawn perpendicular to dimension lines.

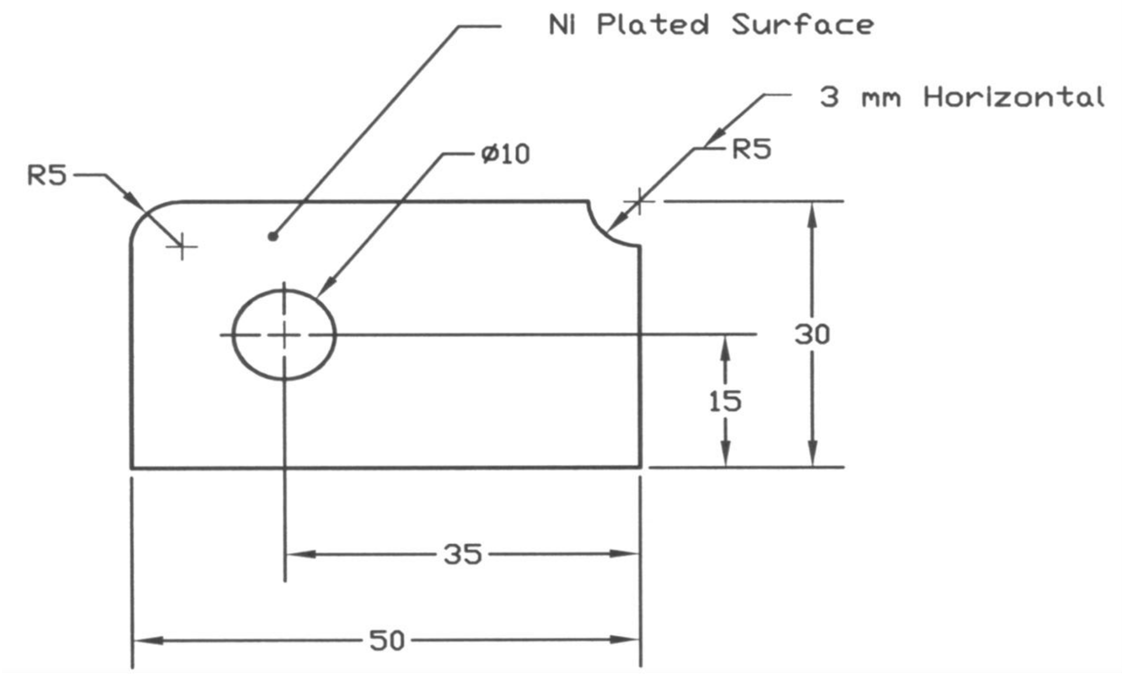
Dimension line (25% thick line)



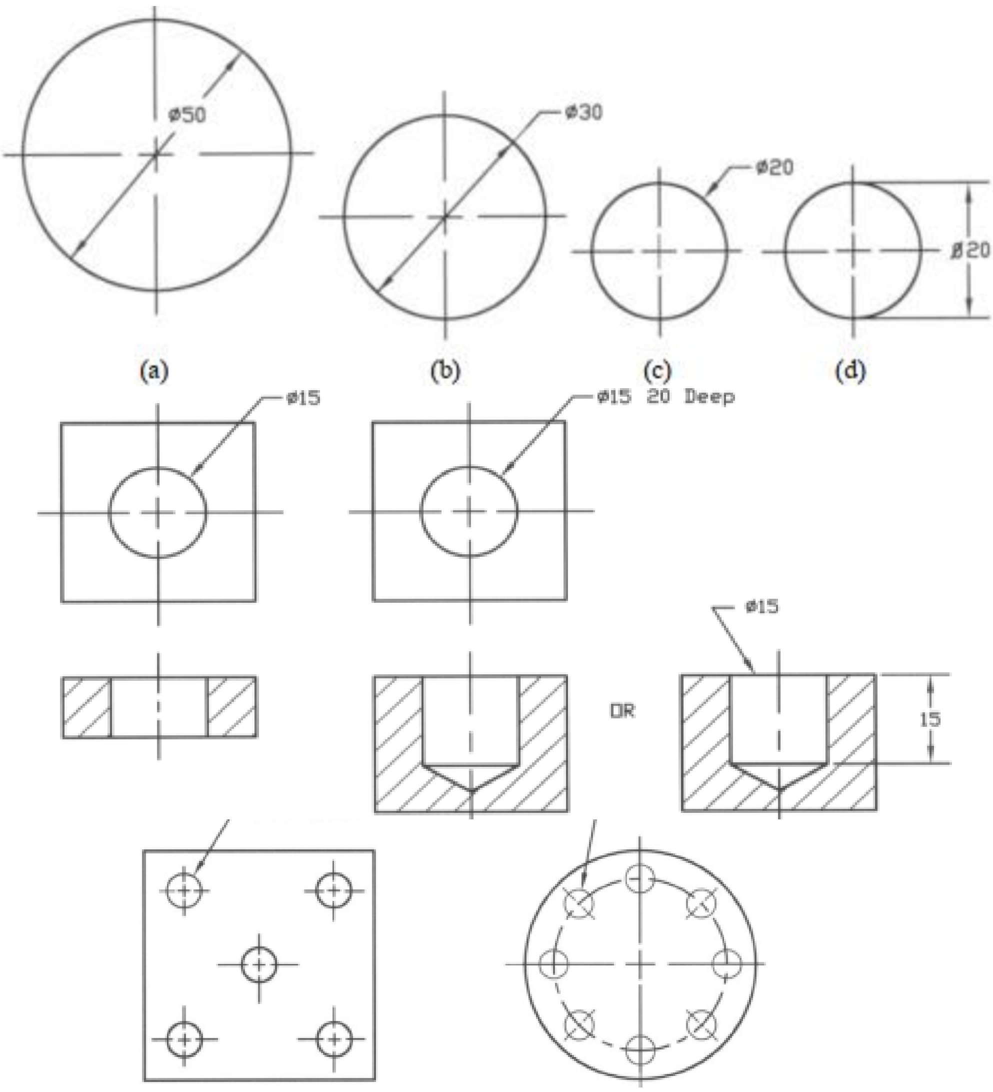
- Dimension line should be approximately 10 mm away from the visible line.
- The spacing between the consecutive parallel dimension lines may also be considered as 10 mm.
- Dimension lines should usually be placed outside the view unless it becomes necessary.
- When the space in between the extension lines is too small to insert dimension line completed with arrowhead, it may be provided outside the extension line.

Leaders

- Should always be inclined at an angle of 60^0 preferably and 45^0 occasionally with a 3 mm horizontal bar.
- Is either terminated by an arrowhead on a line or a small dot.
- Should not cross each other.
- To direct a circle or an arc the leader should be so drawn, if it is imagined to extend it must pass through the center of the circle or the arc.
- All notes and dimensions in a leader have to be provided in the horizontal direction.



Dimensioning of Circle



Experiment 3: Study and drawing of orthographic projections

3.1 Introduction

The purpose of mechanical engineering drawing is to indicate the shape and size of an object or a machine part. All objects have three dimensions such as length, breadth and height. The exact shape of an object may be produced with the help of projection. **Projection** is the process in which the rays of sight taken in a particular direction from an object to form an image on a plane called **plane of projection** or picture plane. The image on the plane is called the view of the object. There are various types of projections, such as orthographic, oblique and perspective depending on the direction of the rays of sight.

3.2 *Orthographic Projection*

When the rays of sight are made in a perpendicular direction to the plane of projection, it is called **orthographic projection**. The word orthographic is obtained from the Greek words: orthos, meaning straight, correct, at right angles to; and graphikus, meaning to write or describe by drawing lines. In the orthographic projection the observer stands in the infinite distance so that the rays of the sight appear to be parallel with each other theoretically (Figure 3.1). The perpendiculars, which are used to draw the view in the orthographic projection, are called the **projectors**. When a view is generated using perpendiculars from all the points of the object to the picture plane, it is called **orthographic view**.

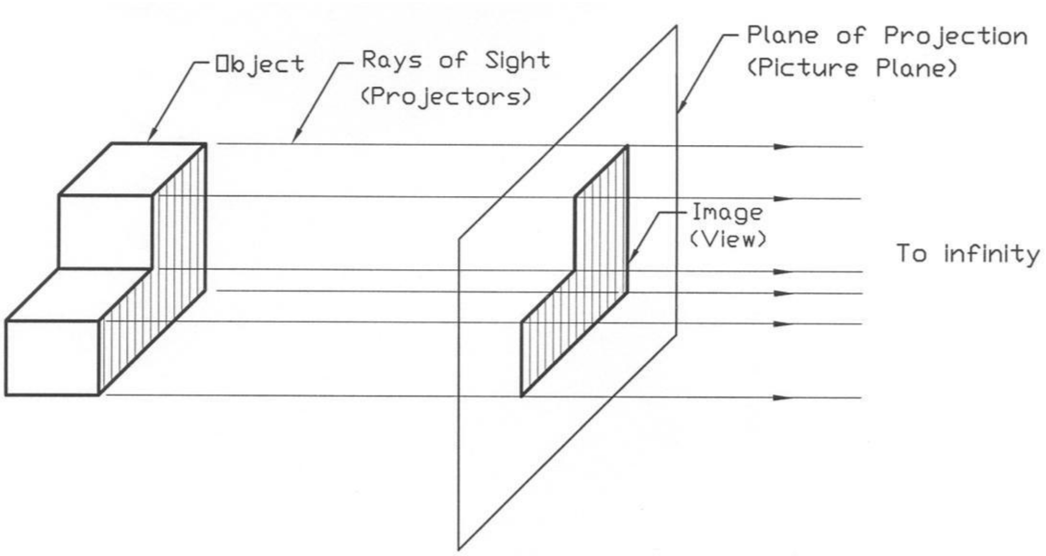


Figure 3.1: Orthographic Projection

In the oblique projection the rays of sight are parallel with each other but they are at an angle (not perpendicular) to the plane of projection. While in the perspective projection the rays of sight occur at an angle to the plane of projection but they are not parallel with each other, rather they converge to a point (Figure 3.2); as if an observer sees the image of the object on the plane of projection from his eye located at that point.

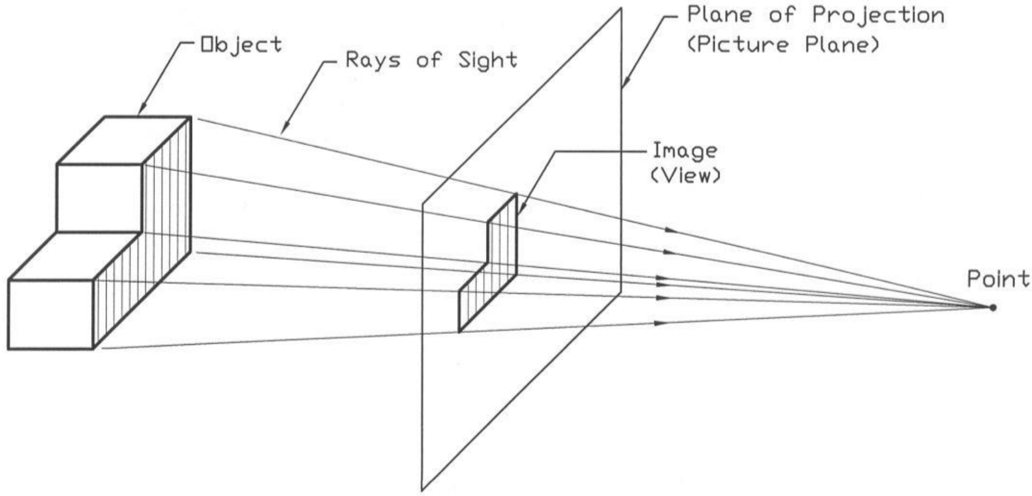


Figure 3.2: Perspective Projection

More than one plane may be required to represent the object completely. In that case the planes are positioned horizontally and vertically at right angles to each other. Total six possible views may be obtained such as, front, back, top, bottom, left and right sides. However, six views are rarely required. The number of views should be just sufficient to represent the shape of the object completely. For most of the objects, those adjacent views are necessary of which front view is the common one. Two views and sometimes one view may be good enough to represent an object completely.

3.3 *Types of Projections*

Orthographic projection can be produced in four different angles (known as dihedral angles), which are formed by horizontal, and vertical planes. The angles are shown in Figure 3.3. The first and the third angles are used only for the projection. First angle is used for the First angle projection while third angle is used for the Third angle projection. In Figure 3.4 the difference of first and third angle projections has been illustrated showing the relative positions of the observer, object and the picture plane. The object is positioned in the first quadrant for the first angle projection and in the third quadrant for the third angle projection. In order to eliminate the clumsiness, only one image for each projection has been taken into consideration in this figure.

The observer is located at infinity so that the rays of sight become parallel and fall in perpendicular direction to the picture plane. In the Third angle projection the picture plane is placed in between the object and the observer. On the other hand in the First angle projection the object is placed in between the observer and the picture plane. In Bangladesh usually the Third angle projection is used. They are used in U.S.A., Canada and many other countries. On the other hand First angle projection is used in many European and other countries. However, only the Third angle projection will be taken into consideration throughout this book.

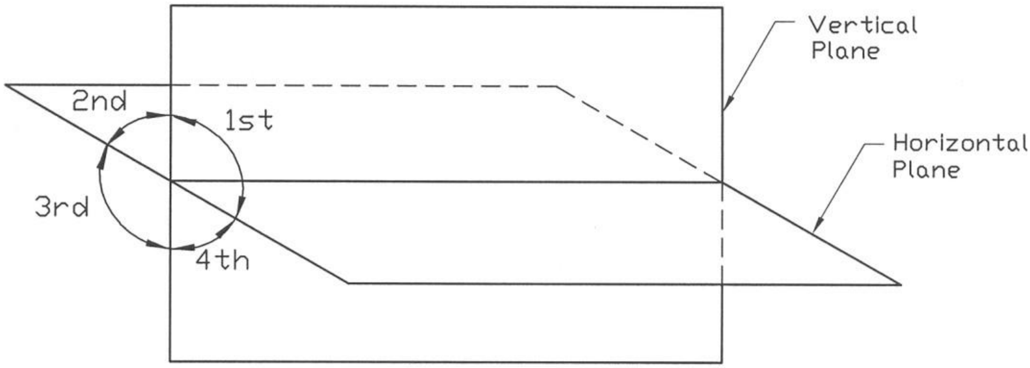


Figure 3.3: Four Different Angles

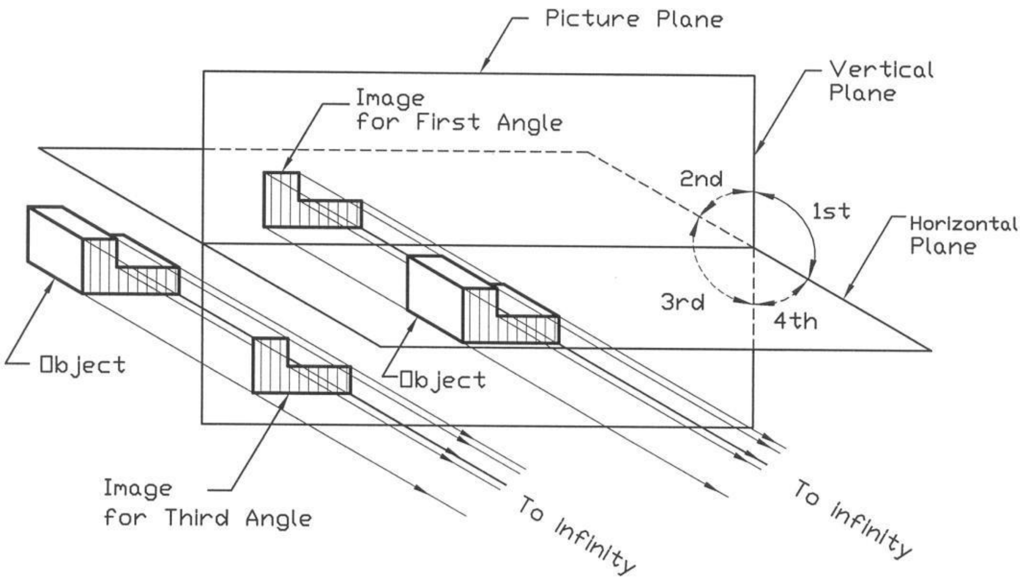


Figure 3.4: Difference Between First and Third Angle Projections

3.4 *Third Angle Projection*

The development of the Third angle projection has been illustrated in Figures 3.5 to 3.8. In Figure 3.5, a six-sided transparent box in the third angle projection has been shown. This transparent box with an object showing views on the various planes has been presented in Figure 3.6. There are six sides but here only four sides are considered to represent the object. The two other sides rear and bottom, have been omitted. The projection plane upon which the front view is projected is called the frontal plane (a-b-c-d is the frontal plane) and that upon which the top view is projected is called the horizontal plane (d-c-g-h is the horizontal plane) as shown in the figure. While the projection plane upon which the side view is projected is called the profile plane (a-d-h-e is the profile plane).

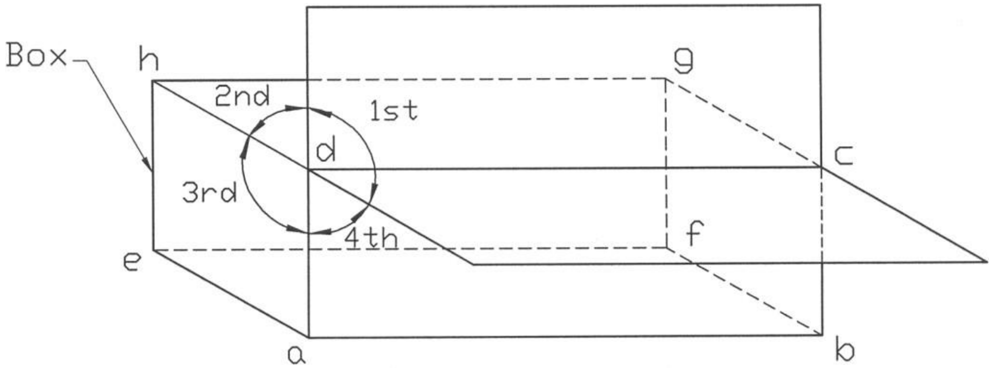


Figure 3.5: Six-Sided Transparent Box in Third Angle Projection

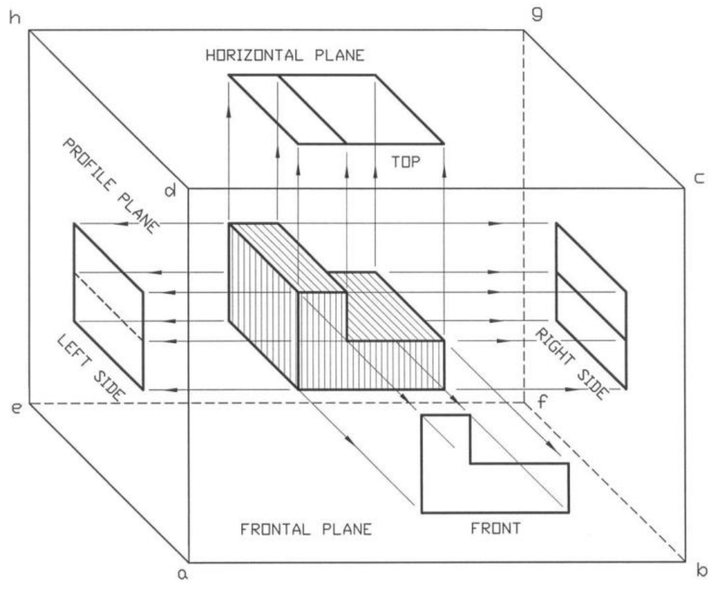


Figure 3.6: Views in Third Angle Projection

The process of unfolding the box has been shown in Figure 3.7. The views on the sides are also given here. In Figure 3.8 the relative positions of the views on the sides of the unfolding box have been provided.

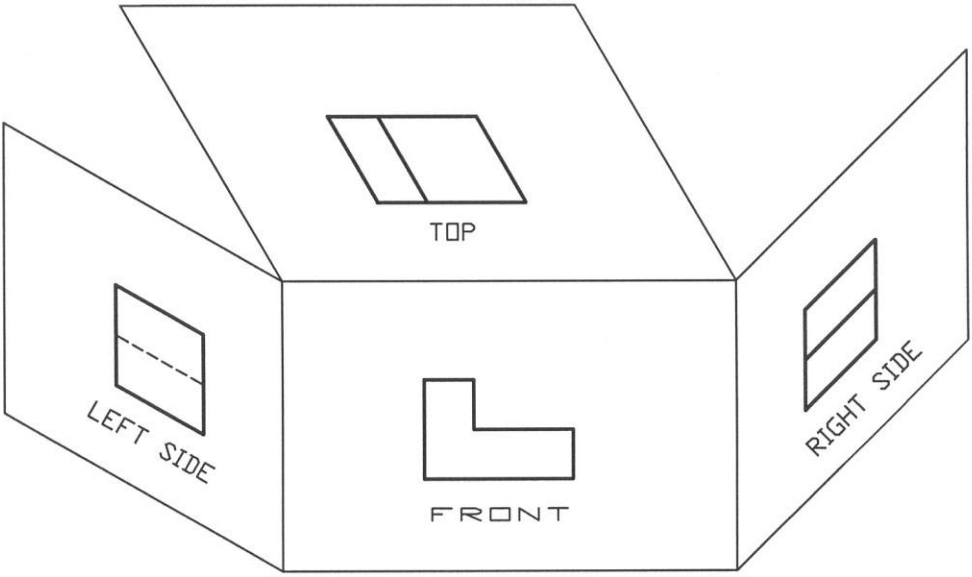


Figure 3.7: Views on Sides of Unfolding Box in Third Angle Projection

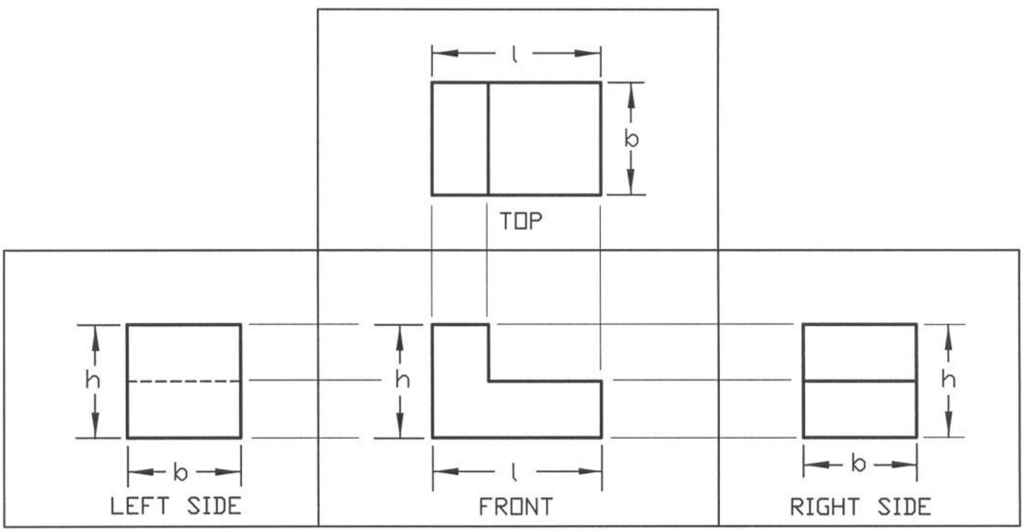
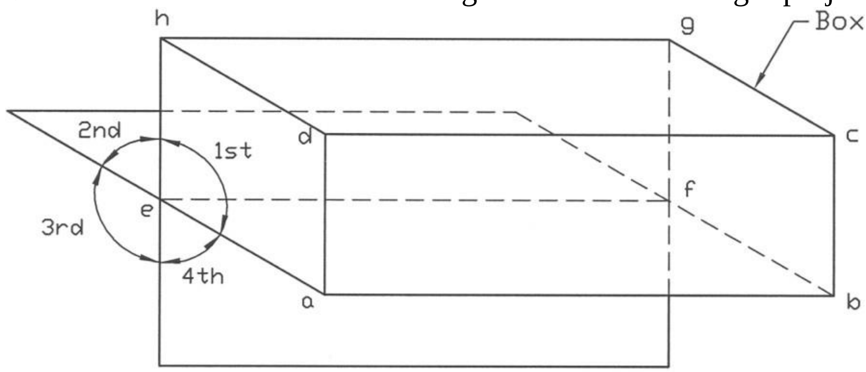


Figure 3.8: Relative Positions of Views on Sides of Unfolding Box in Third Angle Projection

3.1 *First Angle Projection*

The development of the First angle projection has been illustrated in Figures 3.9 to 3.12. The six- sided transparent box for the First angle projection has been shown in Figure 3.9. While an object showing the four views on the sides of the transparent box has been presented in Figure 3.10. In this figure front view is shown in the frontal plane (e-f-g-h is the frontal plane), top view in the horizontal plane (a-b-f-e is the horizontal plane) and side view on the profile plane (a-d-h-e is the profile plane). Views on the sides of the unfolding box in the First angle projection are



given in Figure 3.11. On the other hand the relative positions of the views on the sides of the unfolding box have been shown in Figure 3.12.

Figure 3.9: Six-Sided Transparent Box in First Angle Projection

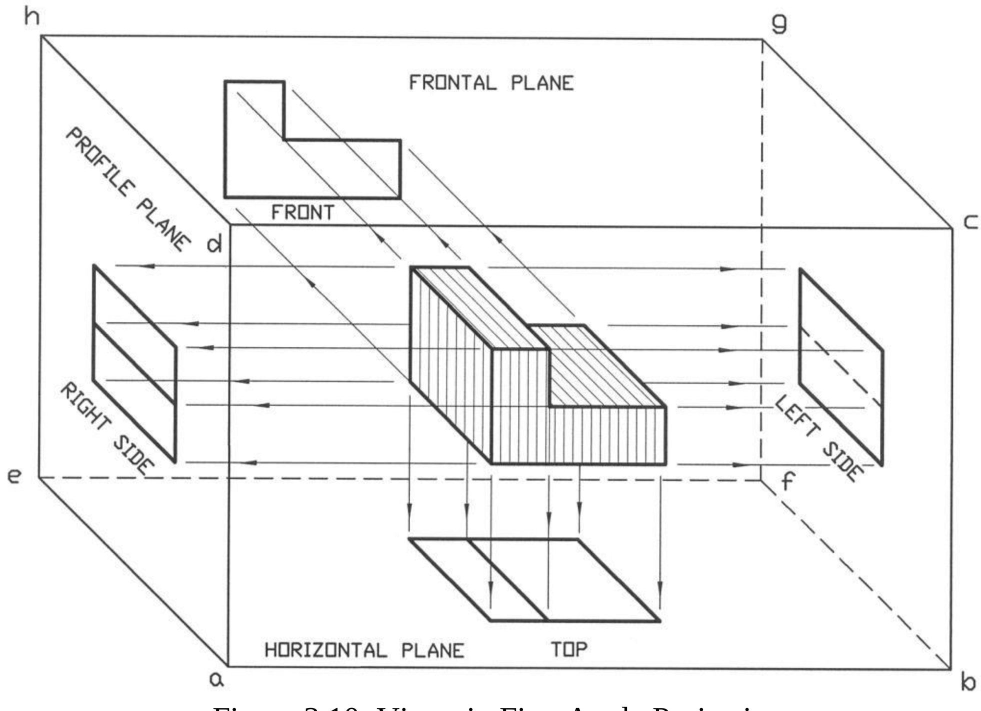


Figure 3.10: Views in First Angle Projection

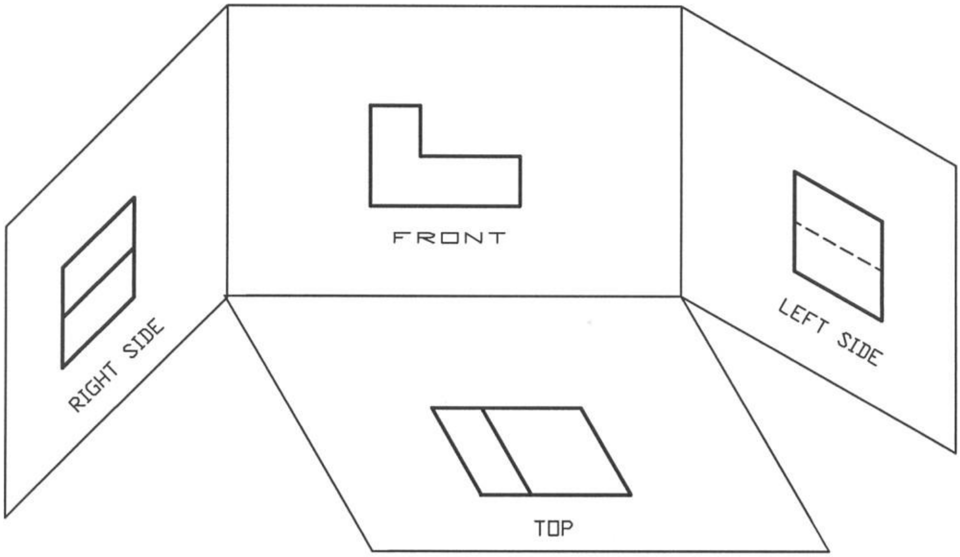


Figure 3.11: Views on Sides of Unfolding Box in First Angle Projection

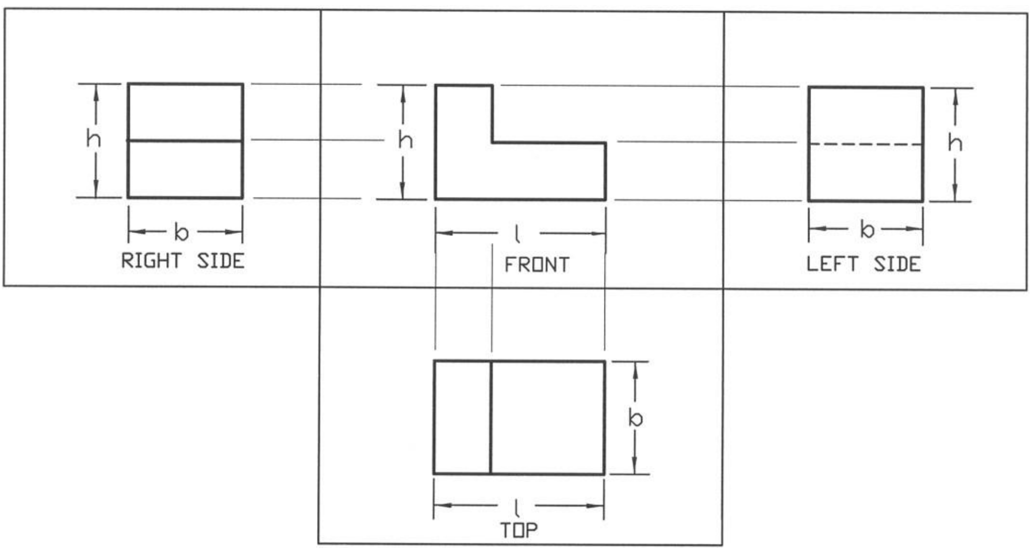


Figure 3.12: Relative Positions of Views on Sides of Unfolding Box
in First Angle Projection

3.2*Method of Projecting Views*

There are several methods of projecting views in the orthographic projection, which are shown in Figures 3.13a to 3.13d. In the projection there is a relationship of the different views. It is usual practice to draw the front view first, then the top and side views are drawn in reference to the front view with the help of the vertical and horizontal projection lines. This can be done using T-square, triangles and compasses when drawing is performed manually. In making projection lines as shown in Figure 3.13b it requires to use the compass in addition to T-square and triangles. The projection lines between the different views have been shown in Figure 3.13.

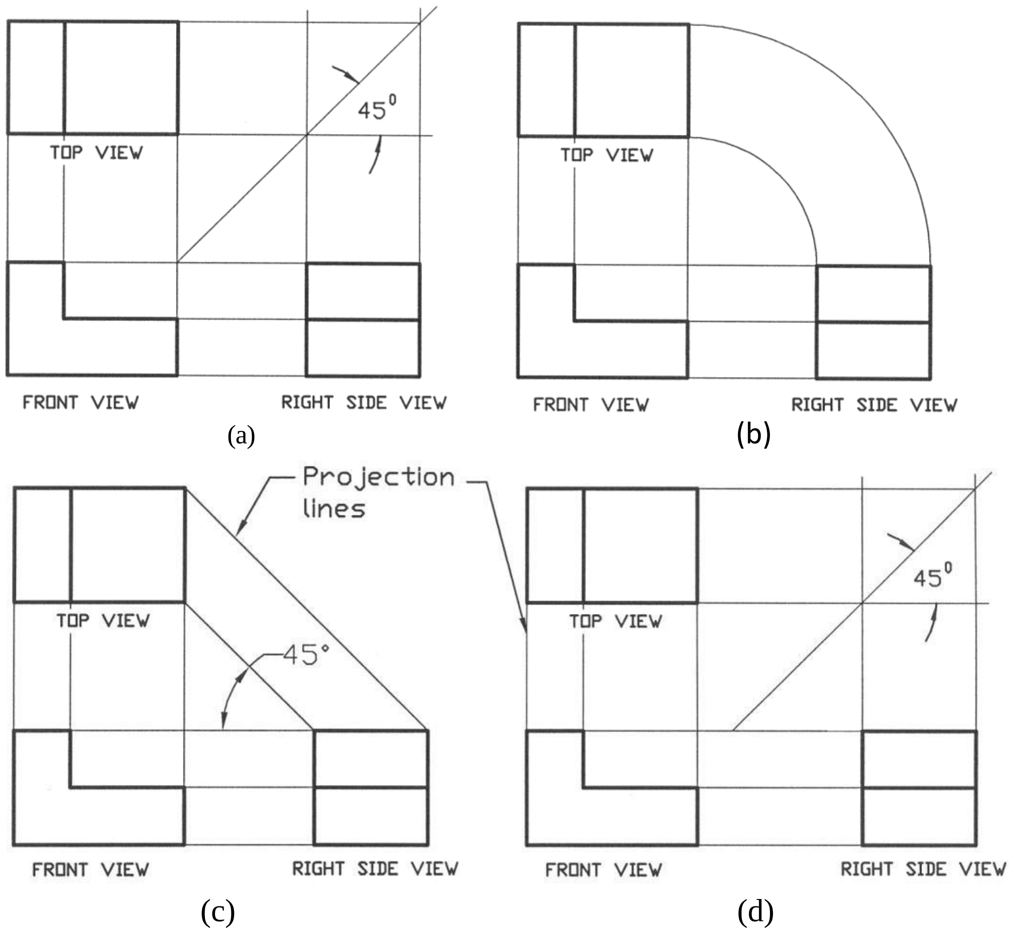


Figure 3.13: Different Methods of Projecting Views

The spacing between the views has to be determined beforehand. It will depend on many factors such as, space required for the dimensions, space required for writing views and space required for writing essential notes. The space should be sufficient in order to give the dimensions avoiding any crowding. However, the excessive space should be avoided. The beginners may choose the space in between the views as 30 to 40 mm. In Figures 3.13a to 3.13c the interspacing between the views has been made as equal. However, if it is necessary different spacing may be used as well; an example of that is shown in Figure 3.13d. Any method of projecting views as described in Figure 3.13 may be used. However, the projection as described in Figure 3.13a is mostly used. In Figure 3.14, the orthographic projection of an object has been provided as a further example.

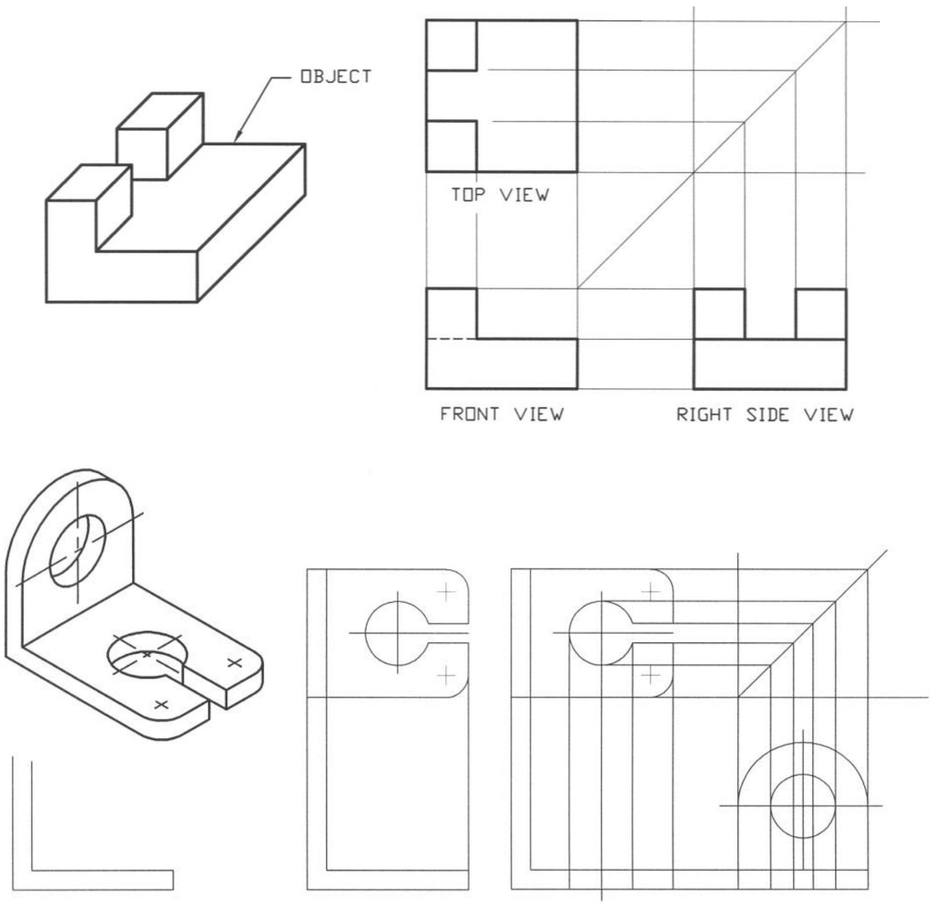
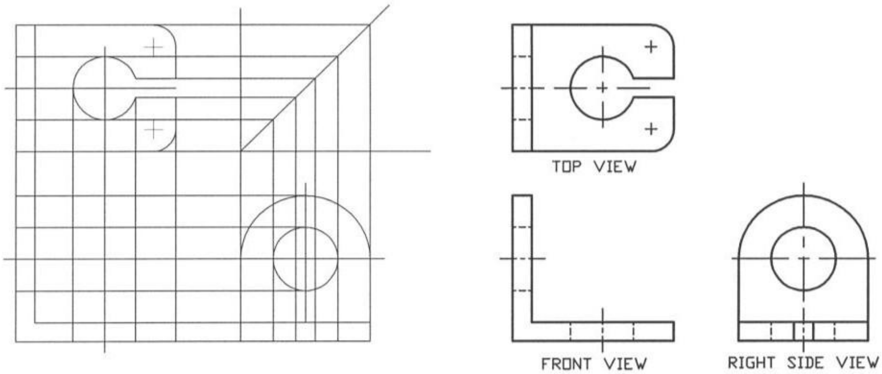


Figure 3.14: Orthographic Projection

Step-1 Step-2 Step-3



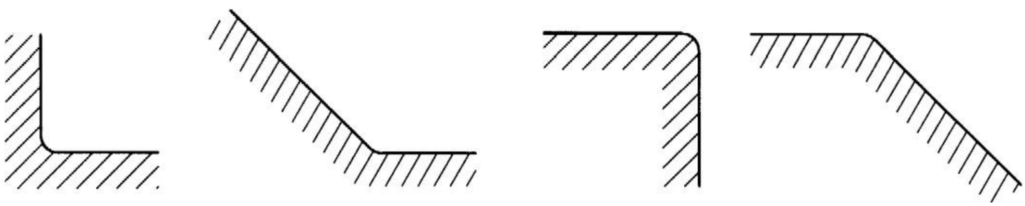
Step-4 Step-5

Figure 3.15: Typical Steps in Drawing a Part

has been started from the front view but before completion of the front view, other views have been projected in parallel. It is observed that the front view is also projected in reference to the top and sides views. It can be noted here that the thin lines have been used in projecting the preliminary views. When the views are projected completely, the projection lines are erased out and the views are completed using the lines of appropriate thickness as shown in the figure.

Fillets and Rounds

The sharp internal corners are made rounded in a casting in order to avoid the possibility of stress crack. These rounded internal corners are called fillets. On the other hand the external sharp corners are made rounded for safety and appearance. These rounded external corners are called rounds. In Figure 3.17 fillets and rounds are shown.



Fillets Rounds

Figure 3.17: Fillets and Rounds

3.1 *Projection Symbol*

Projection symbols according to ISO 128 – 1982(E) for Third Angle and First Angle are shown respectively in Figure 3.18a and Figure 3.18b. It is usual practice to locate the ISO projection

shown in Figure 3.18c. From the symbol one can easily identify the type of projection (First Angle or Third Angle) used to perform the drawing.

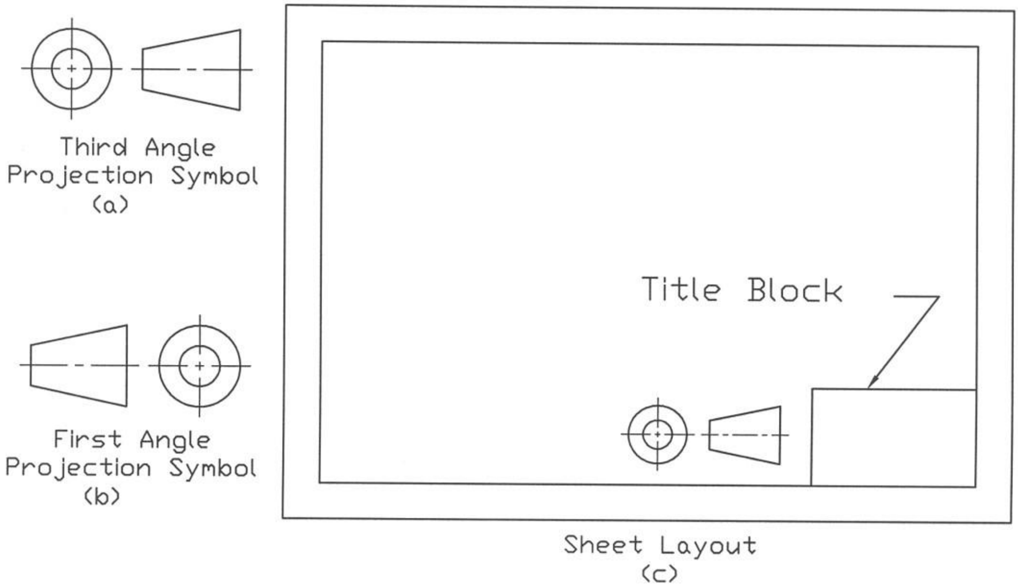
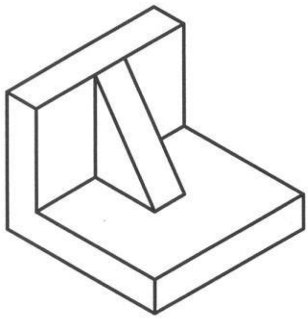
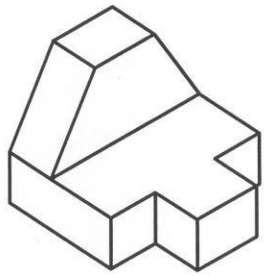


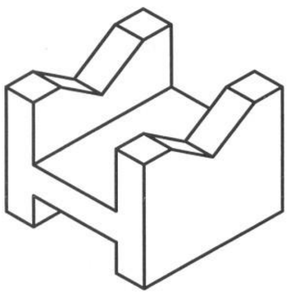
Figure 3.18: Projection Symbol

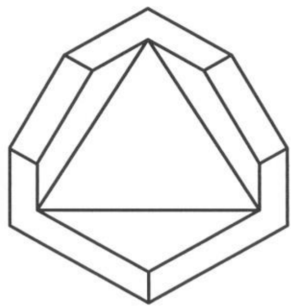
Example Problems

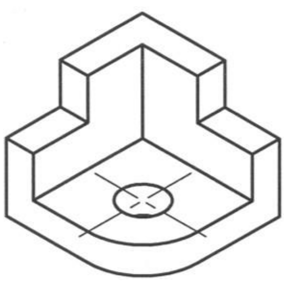
Draw the necessary orthographic views of each of the objects (Fig. P3.1 – P3.24) to best represent them on the squared or plain papers. Free hand drawings may be done

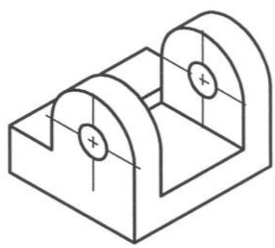


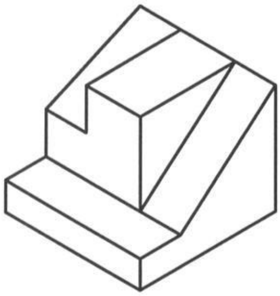


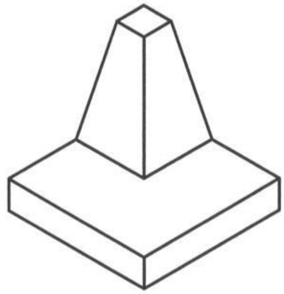


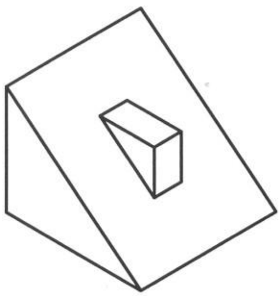


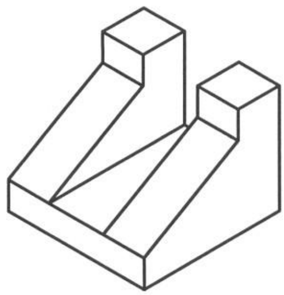


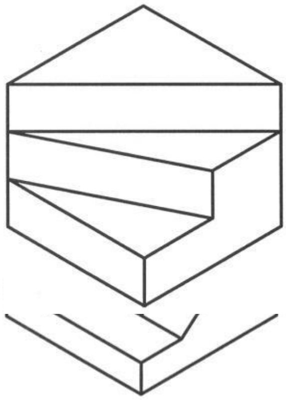


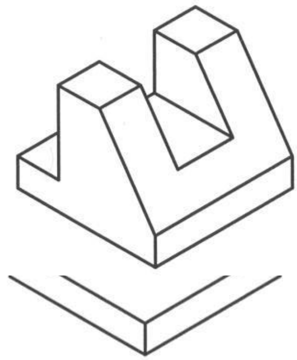


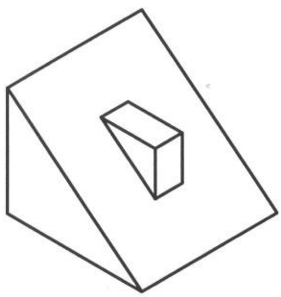


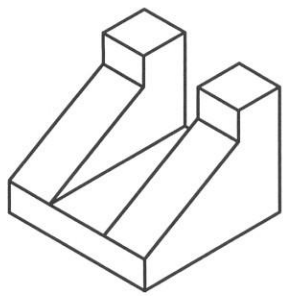












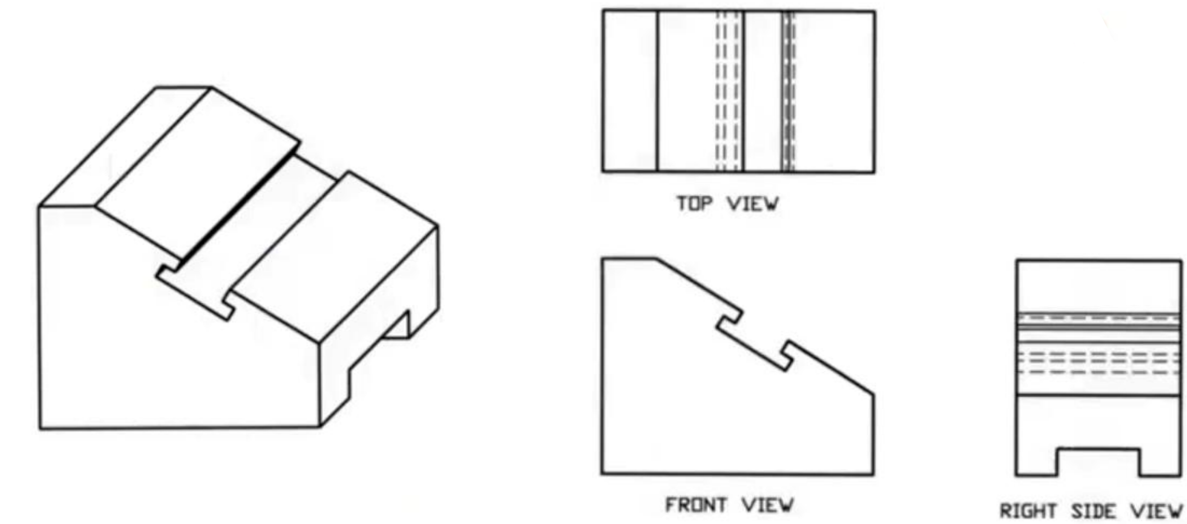
Experiment 4 : Auxiliary View

Objective

- To understand the concept and necessity of auxiliary views in engineering drawing.
- To learn the procedure for constructing different types of auxiliary views.
- To apply auxiliary views to visualize true shapes of inclined and oblique surfaces.

Introduction

In orthographic projection, when a surface is inclined to the principal planes, its true shape is not visible in standard views. Instead, it appears distorted. **Auxiliary views** are used to overcome this problem by projecting the surface onto a plane that is parallel to it.



Regular orthographic view

Why Use Auxiliary Views?

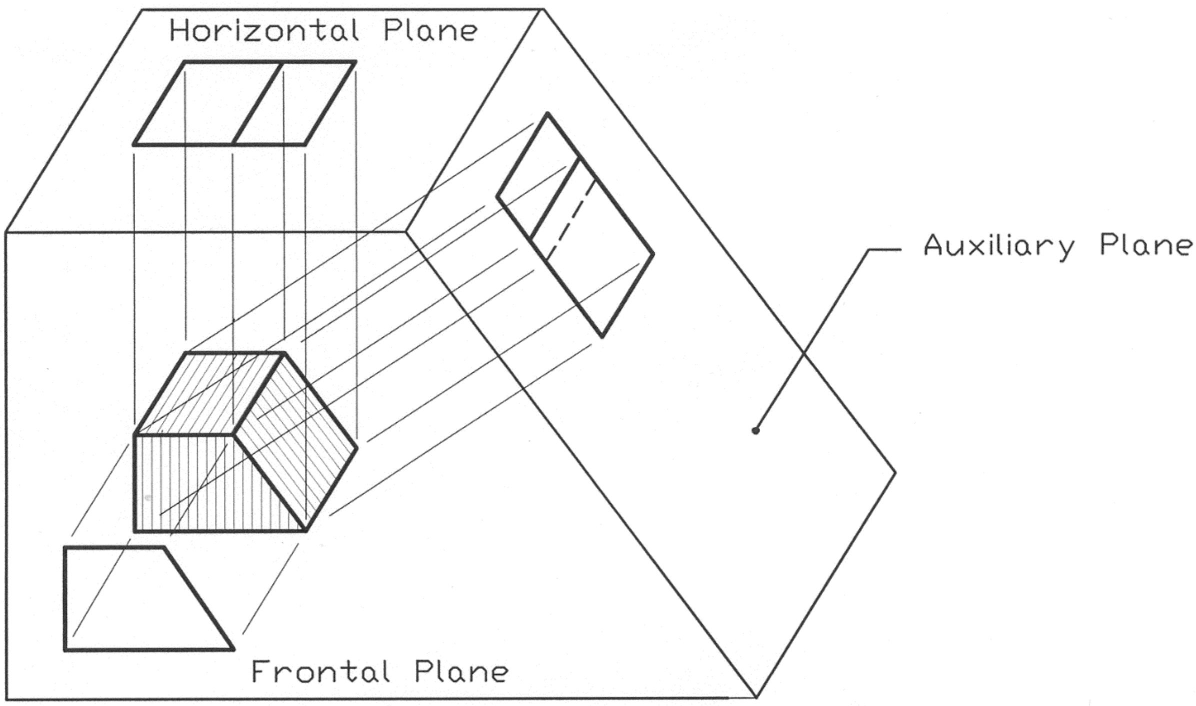
- To obtain the **true shape and size** of an inclined or oblique surface.
- To simplify the drawing by **reducing hidden lines** and distortions.
- To accurately represent **circular features and complex geometries**.

Types of Auxiliary Views

1. **Primary Auxiliary View** – Obtained by projecting onto a plane perpendicular to one of the principal planes.
2. **Secondary Auxiliary View** – A second projection taken from a primary auxiliary view for more complex shapes.
3. **Partial Auxiliary View** – Shows only the inclined surface instead of the entire object.

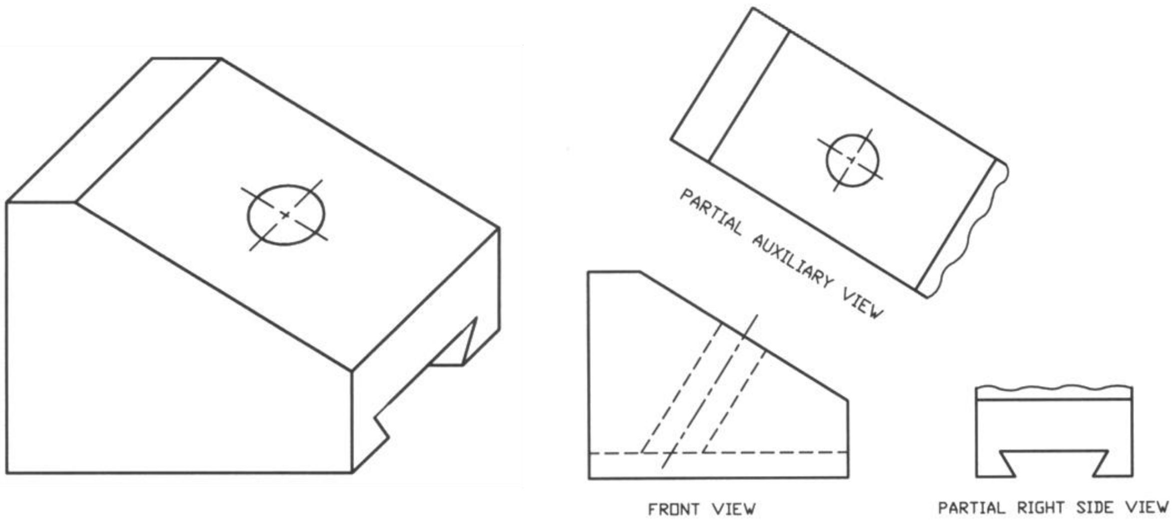
Procedure to Draw an Auxiliary View

1. **Identify the Inclined Surface**: Determine which part of the object is not showing its true shape in regular orthographic views.
2. **Select the Auxiliary Plane**: Choose a projection plane parallel to the inclined surface.
3. **Project Key Points**: Extend perpendicular projection lines from the existing views onto the auxiliary plane.
4. **Connect the Points**: Outline the shape of the surface in the auxiliary view.
5. **Add Dimensions and Annotations**: Label the features clearly to complete the drawing.



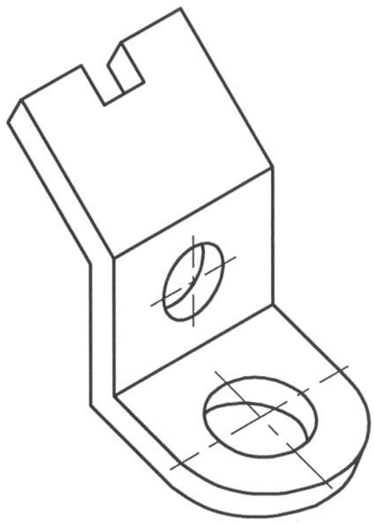
Example: Auxiliary View with a Circular Feature

When a **circular hole** is inclined in the principal views, it appears as an ellipse. The auxiliary view helps to restore its **true circular shape**.



Class Activity

- Draw an **auxiliary view of an inclined rectangular plane**.
- Construct an **auxiliary view of a cylinder with an inclined circular hole**.



Assignment

1. Draw the **auxiliary view of an object with a slanted surface**, given its front and top views.
2. Construct a **multiple auxiliary view** for an object with two inclined planes.

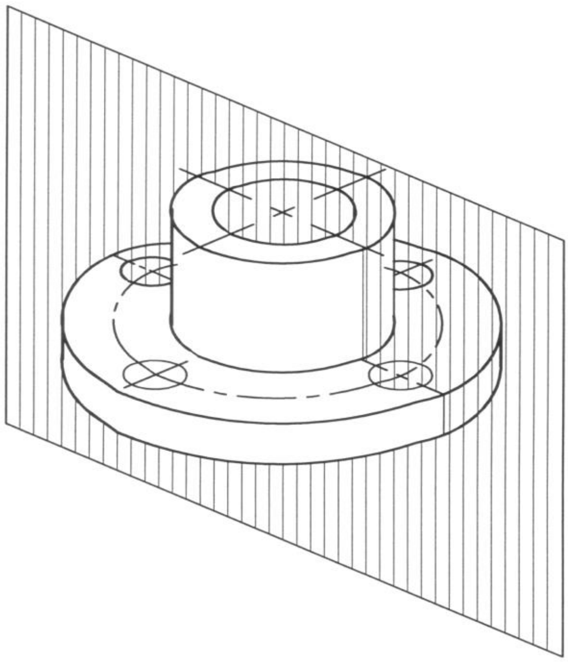
Experiment 5: Sectional View

Objective

- To understand the concept and necessity of sectional views in engineering drawing.
- To learn how to create sectional views using appropriate conventions.
- To apply sectional views to improve clarity in technical drawings.

Introduction

A **sectional view** is a drawing representation that shows the internal features of an object by assuming it has been cut along an **imaginary cutting plane**. This helps in visualizing complex components without excessive use of hidden lines.



Why Use Sectional Views?

- Hidden details can make drawings **complex and difficult to interpret**.
- Sectional views provide **clearer visualization** of internal structures.
- Essential for **dimensioning and fabrication** of components.

Types of Sectional Views

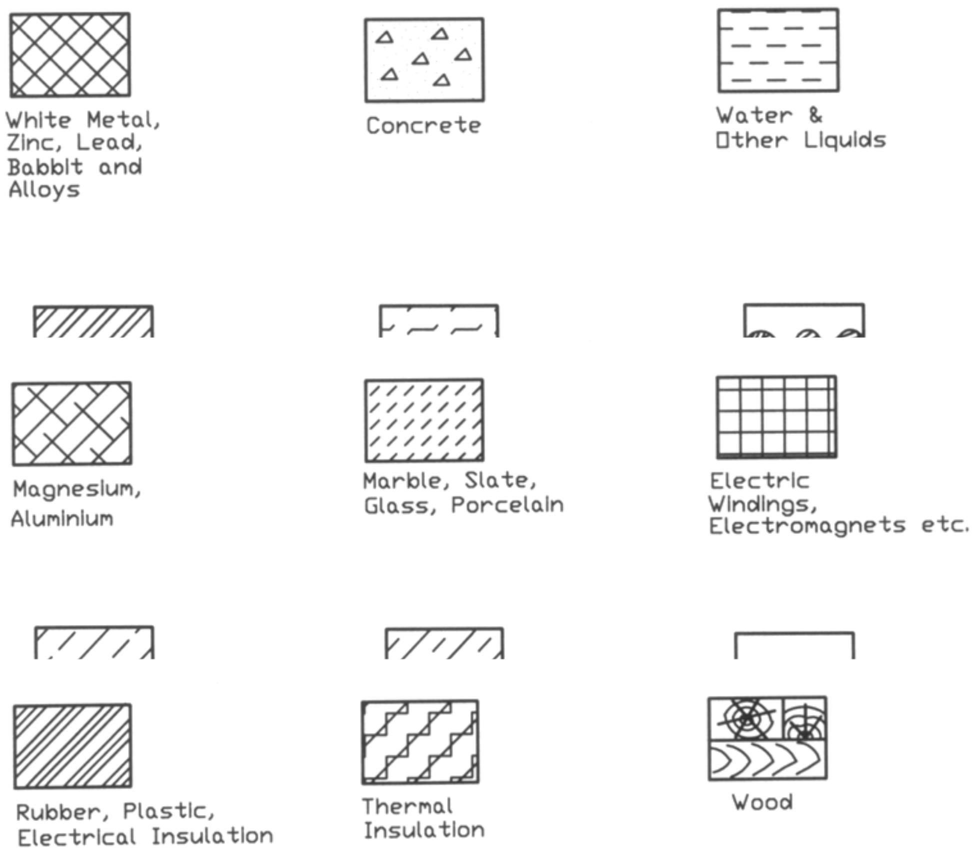
1. **Full Section** – The object is cut completely along a single plane.
2. **Half Section** – Used for symmetric objects, cutting only one-half of the part.
3. **Offset Section** – The cutting plane is bent to pass through multiple key features.
4. **Broken-Out Section** – Only a small portion is cut to reveal internal details.
5. **Revolved Section** – A cross-section is rotated into the same view.
6. **Removed Section** – A section is drawn separately from the main object.

Generating a Sectional View

1. **Select the Cutting Plane**: Choose a plane that reveals the maximum number of internal details.
2. **Draw the Cutting Plane Line**: Represent it using thick lines with arrows showing the viewing direction.
3. **Apply Section Lining (Cross-Hatching)**: Use **thin lines at 45°** to indicate the cut material.
4. **Omit Hidden Lines**: Only include hidden lines if necessary for clarity.

Section Lining (Cross-Hatching)

- Used to **differentiate materials** in sectional views.
- **Spacing should be uniform (1-3 mm)** for a clean appearance.
- **Ribs & Webs**: When sectioning through a rib **longitudinally**, section lining is omitted to prevent misinterpretation.

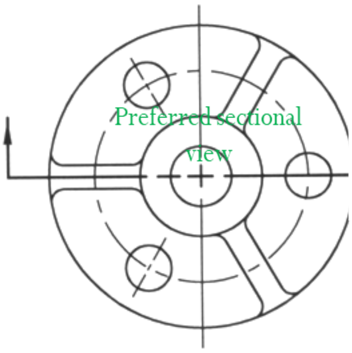


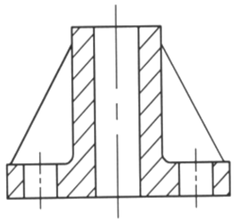
Preferred vs. True Sectional View

- When a part has **odd internal holes or ribs**, the **true sectional view** may not represent it clearly.

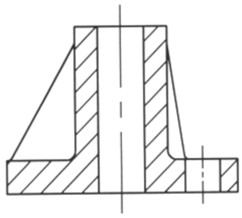
- In such cases, a **preferred sectional view** is used, where features are rotated for **better symmetry and clarity**.

View with cutting plane line



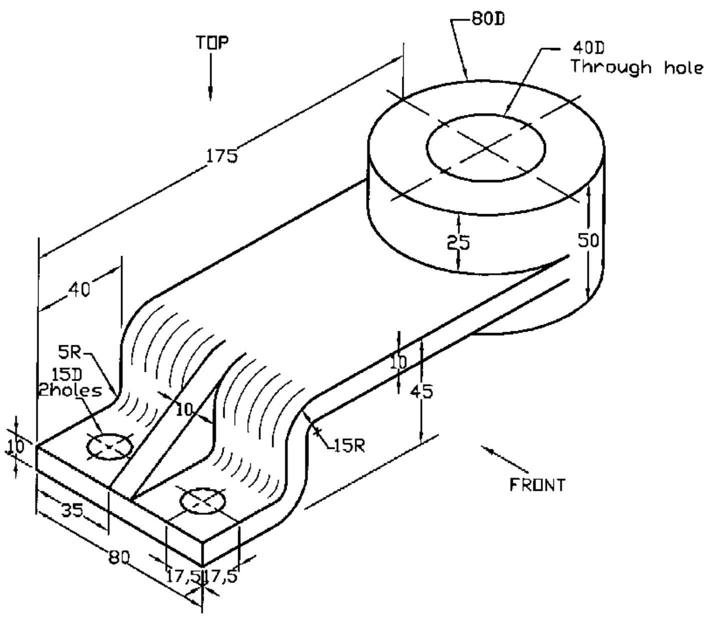


True sectional view



Class Activity

- **Draw a full sectional view** of a mechanical part with multiple internal features.
- **Create a half-section drawing** for a symmetric component.



Assignment

1. Draw a **full section** of an object with at least three internal holes and a rib.
2. Construct an **offset sectional view** for an asymmetric mechanical component.

Experiment 6 & 7: Isometric View I and Isometric View II

Objectives

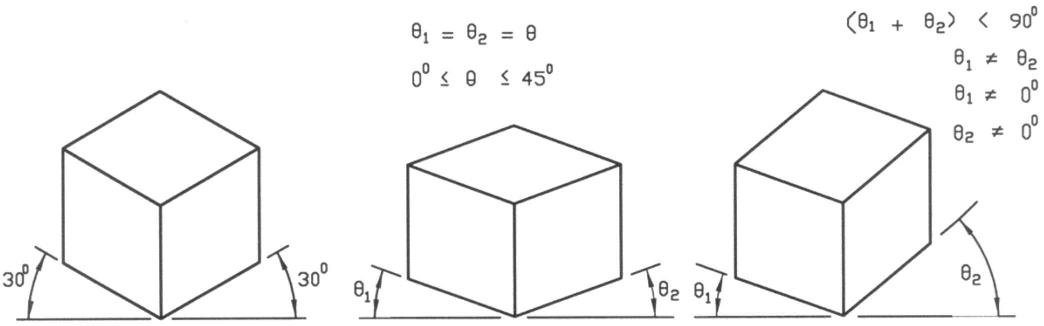
- To understand the principles of isometric projection.
- To develop skills in drawing isometric views from given orthographic projections.
- To learn about isometric scales and their applications.
- To enhance spatial visualization skills for better interpretation of 3D objects.

Introduction

A pictorial view is a three-dimensional one which is used to visualize an object in one view. On the other hand, the orthographic views such as top view, front view, side view, etc., which are separated from each other, provide necessary information about dimensions, material, surface finish, etc. to manufacture the object. With the help of a pictorial view, complicated engineering drawings can easily be communicated to people who do not have sufficient training in understanding the orthographic views. A pictorial view provides the main dimensions of the object only. It cannot be used as a working drawing. It is used only to visualize the object. Pictorial drawing is classified as:

1. Axonometric:
    - Isometric
    - Dimetric
    - Trimetric

In dimetric projection, the two angles (θ_1, θ_2), as shown in the Figure, are kept equal and may be any angle between 0^0 and 45^0 except 30^0. While in the trimetric projection, the angles (θ_1, θ_2) are not equal; the sum of them is less than $90^{0,}$ but neither angle is 0^0. The comparisons of the isometric, dimetric and trimetric projections have been shown.



(a) Isometric Projection (b) Dimetric Projection (c) Trimetric Projection

Figure: Types of Axonometric Projection

2. Oblique:

In generating an isometric projection, one looks in a perpendicular direction through the projection plane at an object, which is positioned in a rotating condition concerning the projection plane (rotated about a vertical axis and tilted). But in producing an oblique projection, the opposite phenomenon occurs. The object is positioned with its major face parallel to the projection plane. Now, an observer looks at the object through the projection plane at an oblique angle, unlike in the case of isometric projection.

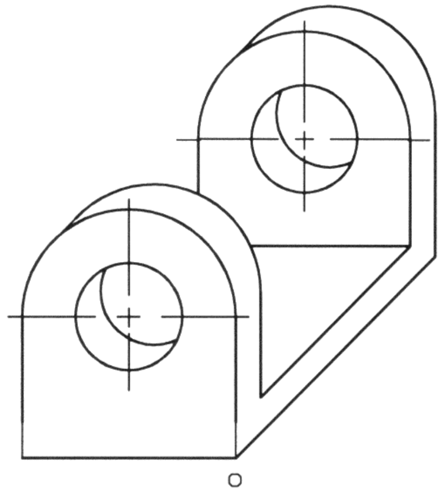


Figure: Oblique View with circular Feature

3. Perspective

Perspective drawing is relatively complicated to produce and is used mainly by architects. A perspective projection is not suitable for working drawing. An example of a perspective drawing has been shown in Figure 6.1. Perspective drawing is the view drawn looking at an object with normal vision. When an object goes away from the observer, it appears smaller and ultimately vanishes at a point. However, the engineers use only the oblique and axonometric drawing.

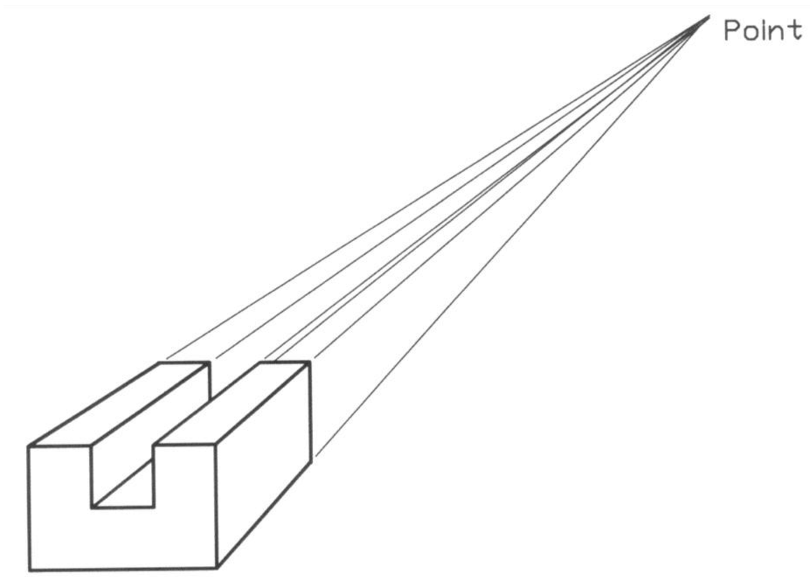


Figure: One-Point Perspective View

Making Isometric View

A simplified procedure is provided below to draw an isometric view from the orthographic projection. In Figure 6.11, the orthographic projection of an object is given from where an isometric view will be drawn. The steps mentioned below are to be followed to make the isometric view.

(1) An isometric parallelepiped is drawn (Figure 6.12) in such a way that the length (l), breadth (b) and height (h) of the parallelepiped are respectively equal to those of the orthographic projection (Figure 6.11). The lines will be very thin so that they can be erased easily when required.
(2) Now the views are drawn on the respective side of the isometric parallelepiped keeping appropriate relationship with each other (Figure 6.13). In drawing views the unnecessary lines may be avoided otherwise, the drawing will be clumsy. The horizontal lines of the view will be parallel to the isometric axes OB and OC while the vertical lines will be parallel to the isometric axis OA. Each line will be thin.
(3) Next shifting of the necessary surfaces is made keeping conformity with the views. Surface a-b-c-d has been shifted to the new position a'-b'-c'-d' and surface p-q-r-s has been shifted to the new position p'-q'-r'-s' (Figure 6.14).
(4) The unnecessary lines are now erased and the isometric view is completed making the lines thick (Figure 6.15).
(5) Finally from the generated isometric view the orthographic projection may be verified to confirm the drawing whether it has been done properly.

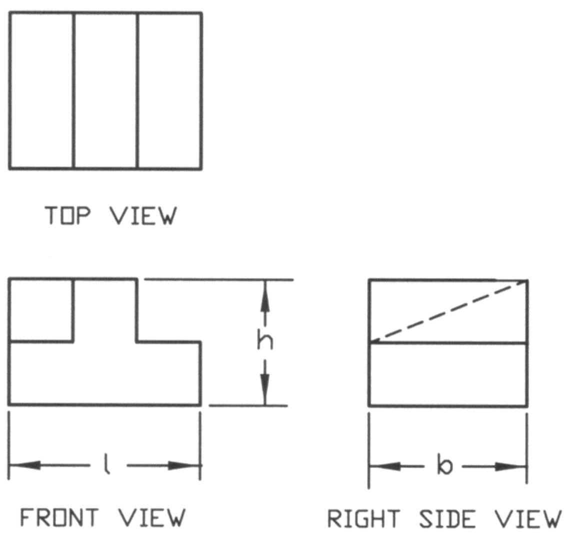
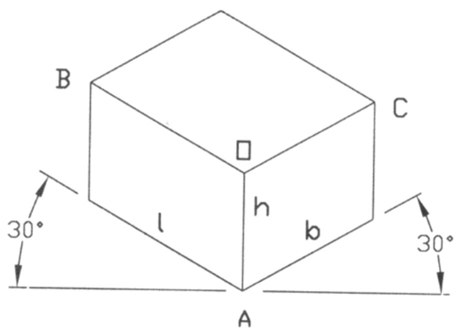


Figure 6.11: Orthogonal Projection



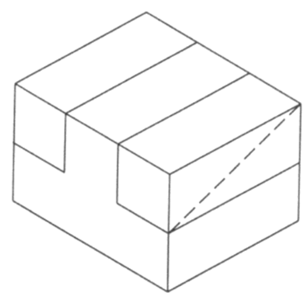


Figure 6.12: Isometric Parallelepiped Figure 6.13: Views on Each Side

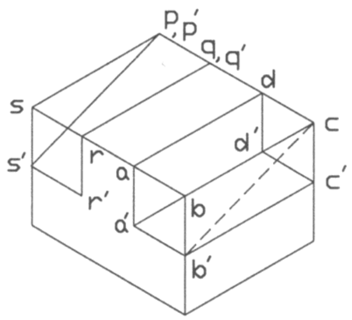


Figure 6.14: Shifting of Surfaces

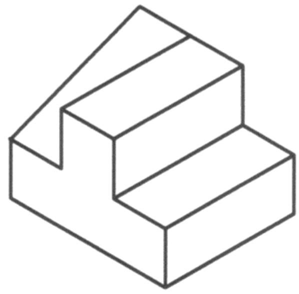


Figure 6.15: Isometric View

Making Isometric View with Circular Features

A circle in the orthographic projection is transformed into the shape of an ellipse. In Figure 6.16, the orthographic projection of an object with the circular feature is provided. To make the isometric view, the steps mentioned below are followed.

(1) A square touching the circle is drawn with sides equal to the diameter of the circle on the orthographic projection (Figure 6.17).

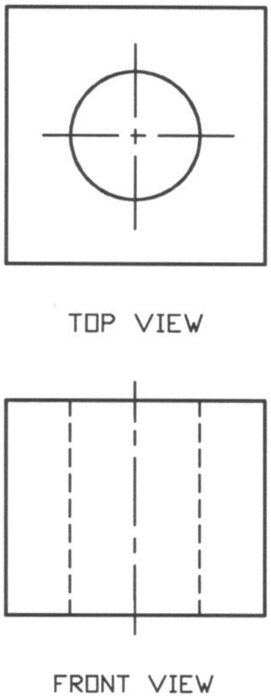
(2) Now the isometric parallelepiped (Figure 6.18) is drawn as done earlier.

(3) Next, the views on the surfaces of the parallelepiped (Figure 6.19) are drawn with the square of the circle omitting the circle itself. The square is turned into the shape of a rhombus. The unnecessary lines may be avoided.

(4) Now the lines on the rhombus are drawn as shown in Figure 6.20. Then, the four centers c_1, c_2, c_3, and c_4 are located.

(5) The two arcs are drawn with radii c_1b and c_2a with respect to the centers c_1 and c_2 respectively. The next two other arcs are drawn with radii c_3a and c_4b to the centers c_3 and c_4, respectively (Figure 6.21).

(6) Now the unnecessary lines are erased, and the isometric view is completed, making the lines thick (Figure 6.22).



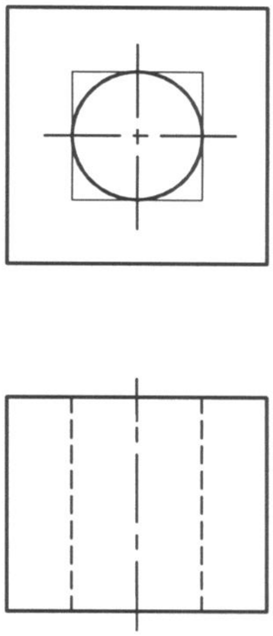


Figure 6.16: Orthographic Projection

Figure 6.17: Square Touching

Circle

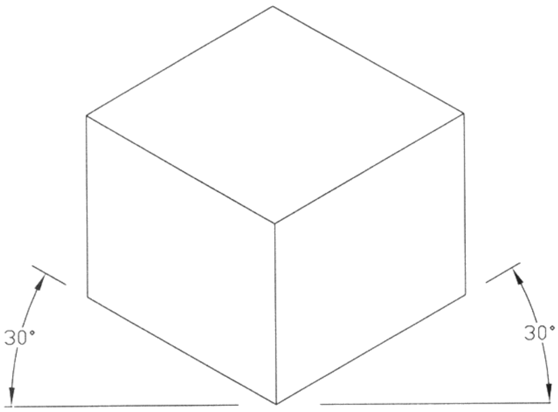


Figure 6.18: Isometric Parallelepiped

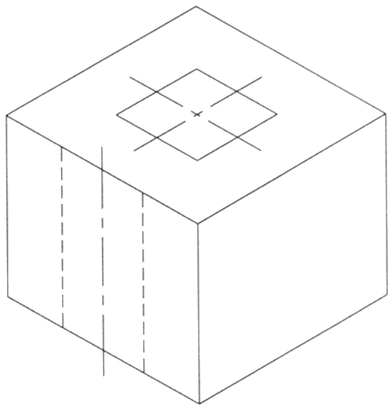
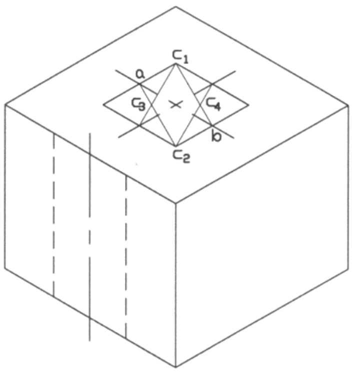


Figure 6.19: Views on Faces of Parallelepiped



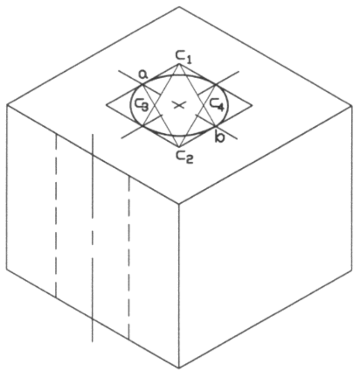


Figure 6.20: Location of Centers Figure 6.21: Drawing Arcs

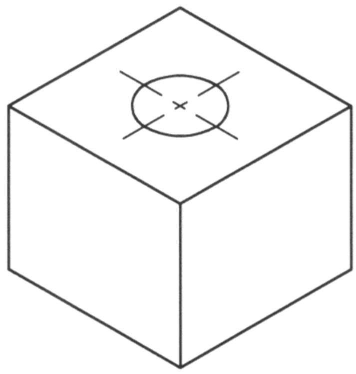


Figure 6.22: Isometric Circle

The orthographic projection of an object incorporating the circular feature is shown in Figure 6.23. The various steps are represented graphically in Figures 6.24 to 6.31 in order to generate an isometric view. This is provided as a further example.

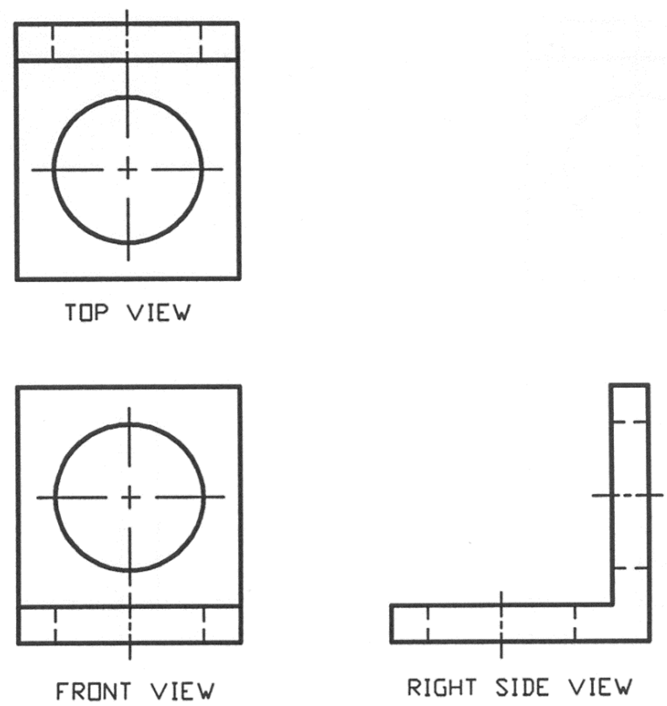


Figure 6.23: Orthographic Projection

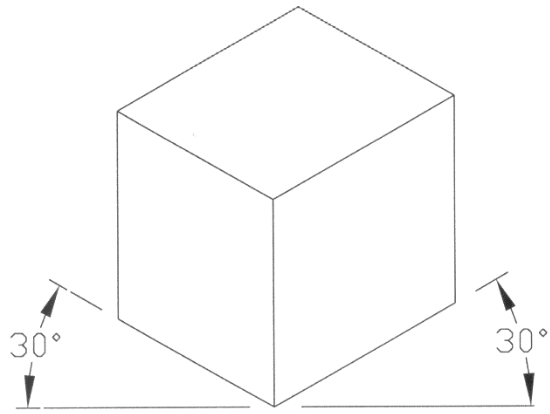


Figure 6.24: Making Parallelepiped

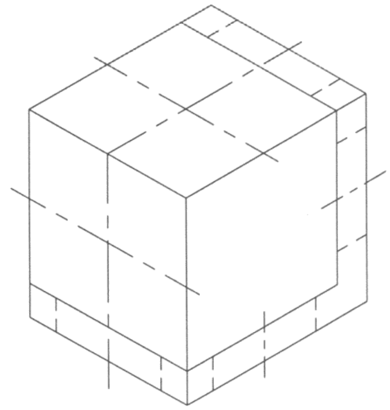


Figure 6.25: Views on Faces

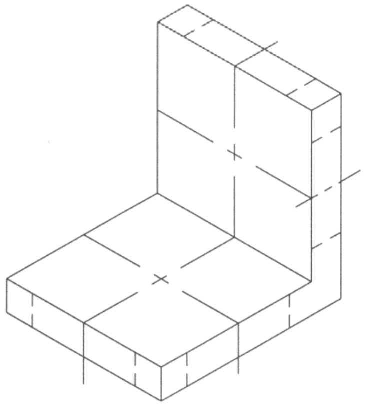


Figure 6.26: Shifting Faces

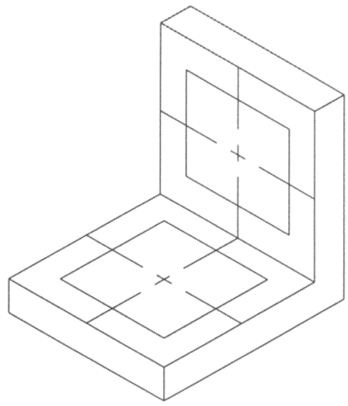


Figure 6.27: Rhombuses for Circles

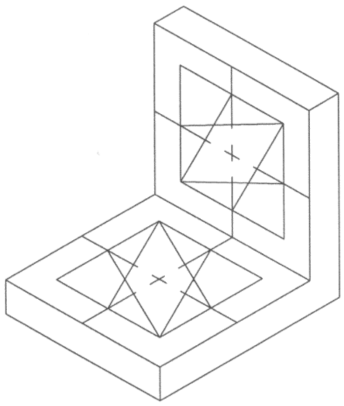


Figure 6.28: Locating Centers

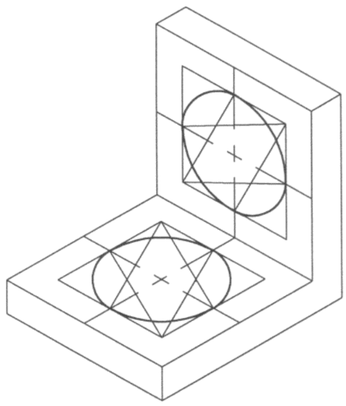


Figure 6.29: Making Ellipses

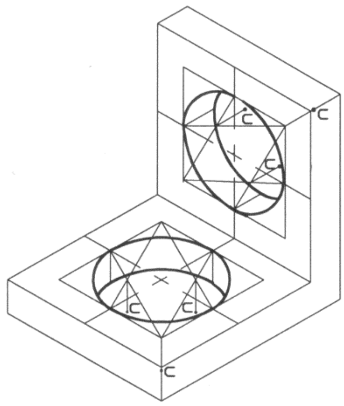


Figure 6.30: Ellipses on Other Faces

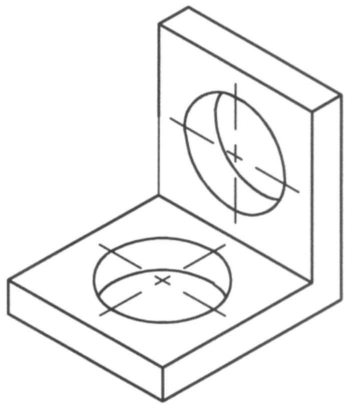
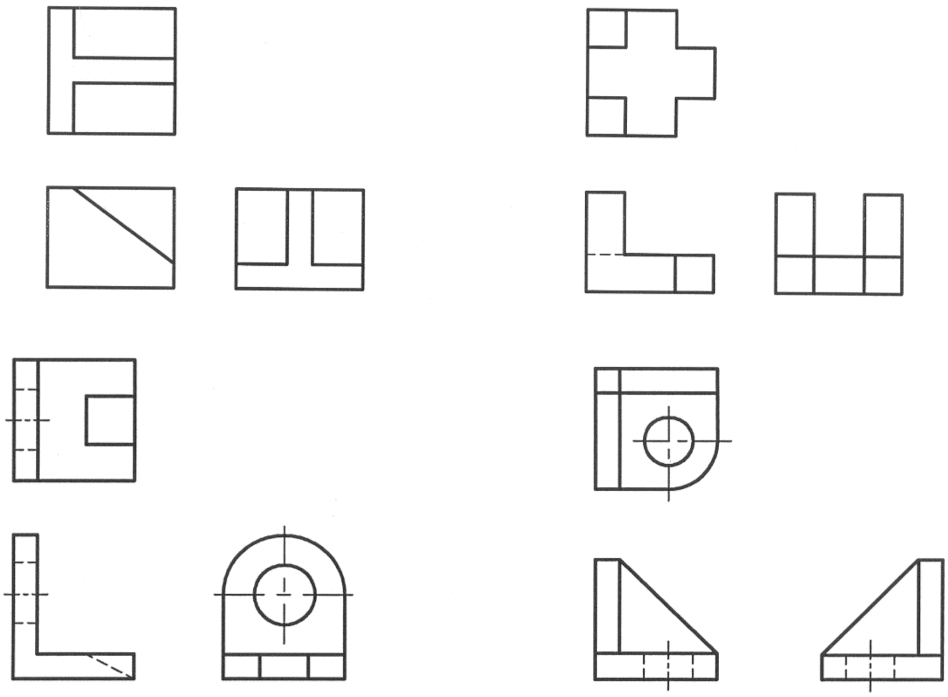


Figure 6.31: Complete Isometric View

Practice Problem: Draw the isometric sketches of the objects from the following views



Experiment 8: Thread and Bolt Drawing

Lab Title: Thread and Bolt Drawing Techniques

Objective:

1. Understand the fundamentals of screw threads and bolts.
2. Learn thread terminology and representation methods.
3. Develop skills in drawing threaded fasteners using different techniques.
4. Apply engineering standards to bolt and thread design.

Introduction: A screw is a temporary fastener used to hold parts together. Threads can be categorized into internal and external threads. Understanding thread applications and terminologies is essential for precise engineering drawings.

Thread Applications:

- Holding parts together
- Moving parts relative to each other

Thread Terminology:

- **External Thread:** A thread cut on the outside of a cylindrical body.
- **Internal Thread:** A thread cut on the inside of a cylindrical body.
- **Crest:** The peak edge of a thread.
- **Root:** The bottom of the thread cut.
- **Thread Angle:** The angle between thread faces.
- **Major Diameter:** The largest diameter of the thread.
- **Minor Diameter:** The smallest diameter of the thread.
- **Pitch:** The distance between adjacent crests or roots of threads.
- **Lead:** The distance a screw moves forward in one full rotation.
- **Thread Form:** The profile shape of the thread (e.g., knuckle thread form).

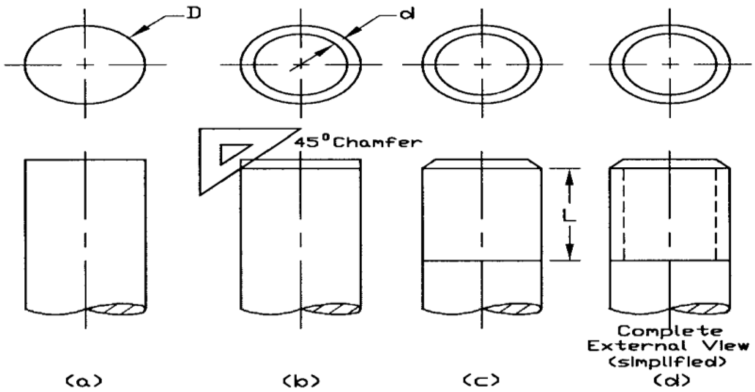
Thread Representation Techniques: Threads can be represented in engineering drawings using three methods:

1. **Simplified Representation:**
   - External thread: Thick continuous lines for the crest, thin lines for the root.
   - Internal thread: Thin continuous lines for the crest, thick for the root.

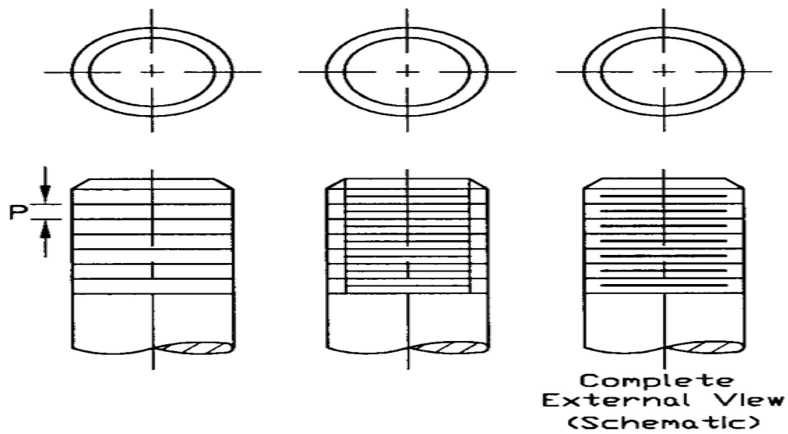
2. **Schematic Representation:**
    - Uses alternate long and short lines are used for crests and roots.
3. **Detailed Representation:**
    - Uses slanting lines to show thread profiles with sharp Vs.

Steps for Drawing Threads:

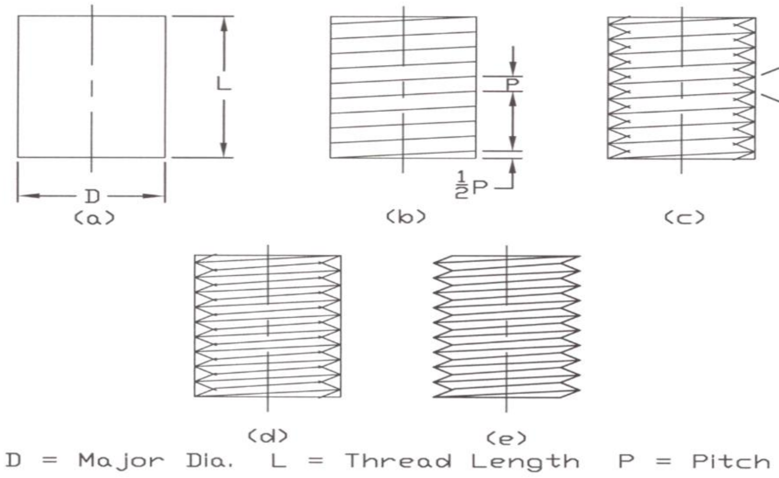
- **Simplified Method**



- **Schematic Method**

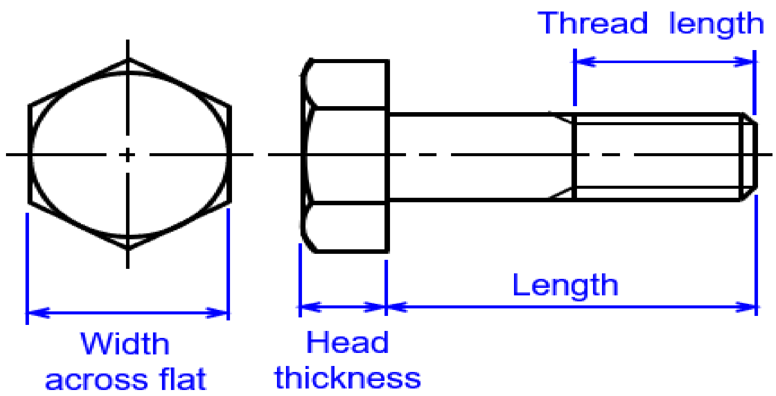


- **Detailed Method**



Bolt Terminology: A bolt is a threaded cylinder with a head. Key parameters include:

- **Head thickness**
- **Thread length**
- **Overall length**
- **Width across flats**



Example: M 42 x 4 Bolt:

- Total length: 116 mm
- Thread length: 56 mm
- Head diameter: 63 mm
- Head thickness: 25 mm

Questions for Students:

1. Explain the difference between internal and external threads.
2. What is the significance of pitch and lead in thread design?
3. Compare and contrast simplified, schematic, and detailed thread representations.
4. How does bolt head thickness impact fastening strength?

Experiment 9: Gears and Keys

Objective:

- To understand the fundamental concepts of gears and keys.
- To learn how to draw different types of gears and keys using engineering drawing techniques.
- To familiarize with gear terminologies and key design considerations.

Introduction

A **gear** is a power transmission device that transmits motion and torque between two rotating shafts with an exact velocity ratio, without slipping. Gears are widely used in mechanical systems due to their efficiency, reliability, and ability to transmit large amounts of power. Most of the machines cannot be imagined without gears. Advantages of gear:

1. It transmits exact velocity ratio.
2. Used to transmit large power.
3. High efficiency.
4. Reliable service.
5. Compact layout.

A **key** is a small mechanical component used to connect rotating machine elements, such as gears or pulleys, to shafts. It prevents relative motion between the shaft and the attached component by fitting into keyways on both. To insert the key a groove is made in the shaft, called key seat while a groove is made in the hub of the wheel, gear, pulley, sprocket etc., called the key way. A portion of the key lies in the key seat of the shaft and the rest portion fits into the key way in the hub, thus fastening them together so that there occurs no relative motion between the shaft and the hub.

Types of Gears

Common types of gears include:

- **Spur Gear** – Straight teeth, parallel to shaft axis, used in simple mechanical systems.
- **Helical Gear** – Angled teeth, offering smoother and quieter operation.
- **Herringbone Gear** – Double-helical structure, eliminating axial thrust.
- **Bevel Gear** – Conical gears used to transmit motion between intersecting shafts.
- **Internal Gear** – A gear with teeth on the inner surface of a cylindrical shape.
- **Rack and Pinion** – Converts rotational motion into linear motion.
- **Worm Gear** – Used for high torque and low-speed applications.

Spur Gear

Helical Gear

Herringbone Gear

Fig 10.1: Types of Gears

Gear Terminologies

1. **Pitch Circle:**It is an imaginary circle which by pure rolling action, would give the same motion as the actual gear. It is an imaginary circle that passes through the contact points between two meshing gears.
2. **Pitch Point:** The contact point between two meshing gears.
3. **Pressure Angle:** The angle between the line of action and the common tangent at the pitch point.
4. **Addendum:** Radial distance of a tooth from the pitch circle to the top of the tooth.Circle drawn through the top of the teeth and concentric to the pitch circle is addendum circle.
5. **Dedendum:** Radial distance of a tooth from the pitch circle to the bottom of the tooth.Circle drawn through the bottom of the teeth and concentric to the pitch circle is called root circle.
6. **Circular Pitch (Pc):** The distance from one tooth to the next along the pitch circle.

   $P_c = \pi D/T$; Here,D = pitch circle diameter T = number of teeth

7. **Diametral Pitch (Pd):** Number of teeth per unit of pitch diameter.

   $P_d = T/D$

   Tooth thickness:

- Width of the gear tooth measured along the pitch circle.

   Face of the tooth:

- It is thesurface of the gear tooth above the pitch surface.

   Flank of the tooth:

- It is the surface of the gear tooth below the pitch surface.

   Face width:

- Width of the tooth parallel to its axis.

Profile:

- It is the curve formed by face and flank of the tooth.

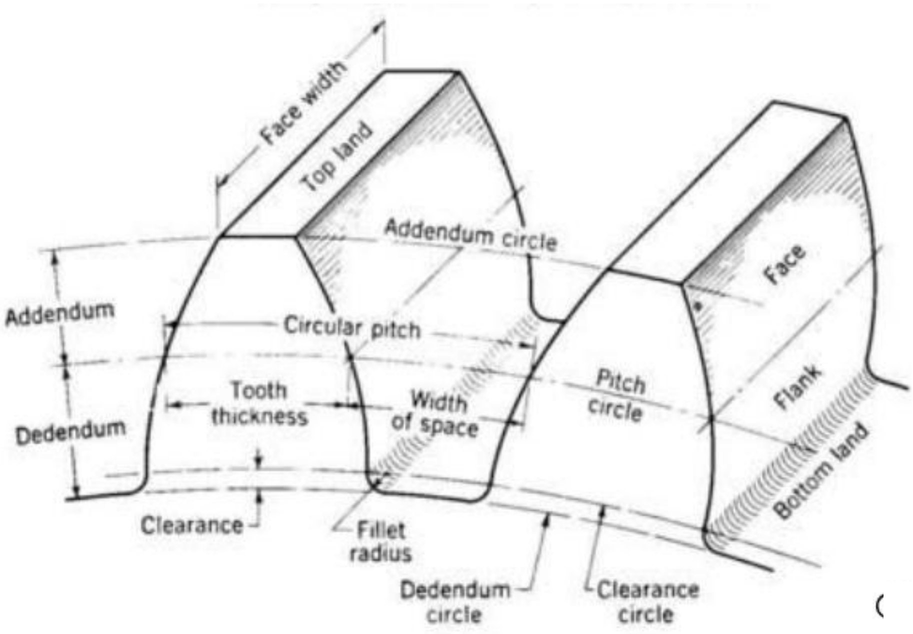


Fig 10.2: Gear Teeth Profile

Steps to Draw Gear Teeth:

1. **Draw the Base Circle.**
2. **Draw the Pitch Circle** Radius = D/2
3. **Draw an Involute Curve** intersecting the pitch circle (Radius = D/8).
4. **Find the Thickness of the Gear Tooth** using:
    - $w = 0.5 \times P_C$, where Where, $P_C = \pi D/T$
5. **Draw Addendum and Dedendum Circles:**

    $R_a = D/2+1/P_d$ and $R_d = D/2-1.25/P_d$ Where, $P_d = T/D$

6. **Repeat Previous Steps to Complete the Gear**

Types of Keys

Keys ensure the secure attachment of gears to shafts. The common types include:

1. **Square Key** – A key with a uniform square cross-section.
2. **Flat Key** – A rectangular key used for general applications.
3. **Gib-Head Key** – A tapered key with a raised end for easy removal.
4. **Pratt & Whitney Key** – A rectangular key with rounded ends, commonly used in aerospace applications.
5. **Woodruff Key** – A semi-circular key used for shafts with curved keyways.

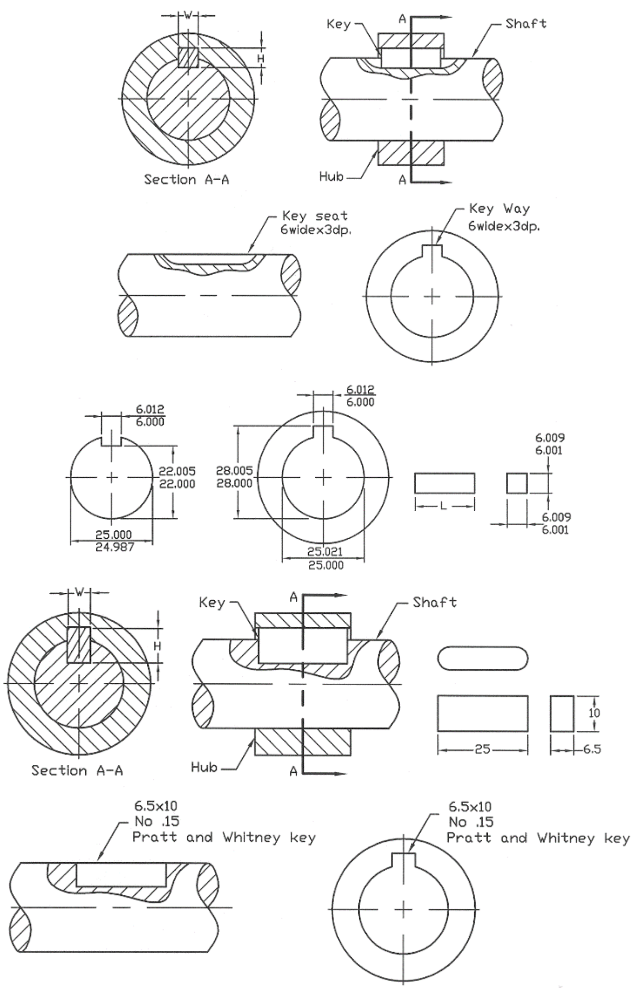


Fig 10.3: Square Key and Pratt - Whitney key

Drawing a Square Key

- Draw the **keyway** on both the shaft and the gear.
- Ensure the **key fits properly** without excessive clearance.
- Indicate **dimensions based on the standard key design table** in mechanical drawing references.

In this experiment, we learned the fundamental concepts of gears and keys, their types, terminology, and the steps to draw them accurately. Understanding these components is essential for designing efficient power transmission systems in mechanical engineering applications.

Assignment:

1. Draw a **Helical gear** with the following specifications:

- PRESSURE ANGLE, $\varphi = 20^0$
- NUMBER OF TEETH, T = 24
- PITCH CIRCLE DIAMETER, D = 8 inch

There's a keyway with 1 inch height and width. Length of the key is 10.5 inch

Experiment 10: Fasteners and Springs

Objective: To understand the types, functions, and mechanical drawings of fasteners and springs, and to practice drawing them using engineering conventions.

Introduction:

Fasteners are mechanical components used to join two or more objects together. They are commonly used in construction, manufacturing, and repairs. Most fasteners create **non-permanent joints**, meaning they can be disassembled without damaging the components. Fasteners are of two types: one is permanent and the other is removable. Rivets and welds are permanent fasteners. On the other hand bolts and nuts, keys and pins are removable fasteners.

A spring is a machine element, which stores energy when deflected. Springs may be classified as helical spring and flat spring mainly. Again helical springs may be classified as compression spring, extension spring and torsion spring. A compression spring offers resistance to the compressive force; an extension spring offers resistance to the tensile force while the torsion spring offers resistance to the twisting force.

The compression helical springs have different types of ens.They are plain end, squared or closed end, plain and ground end and squared and ground end. The helical compression spring with squared and ground end is mostly used.

Types of Fasteners

1. **Bolts** – Externally threaded fasteners designed to be used with a **nut**.
2. **Nuts** – Internally threaded fasteners that mate with bolts.
3. **Screws** – Externally threaded fasteners that do not require a nut.
4. **Washers –** Used to distribute the load of a fastener and prevent damage to surfaces.

Types of Springs

Helical Spring

- **Compression Spring** – Resists compressive force.
- **Extension Spring –** Resists tensile force.
- **Torsion Spring** – Resists twisting force and stores mechanical energy.

Flat Spring – Made from flat wire and wound in a spiral.

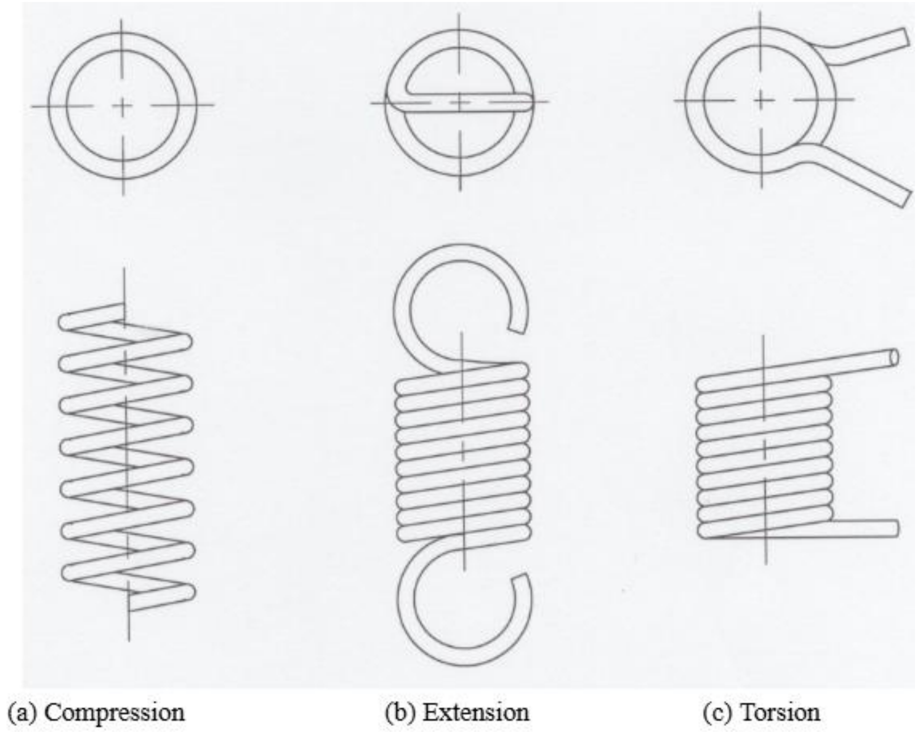


Fig 11.1: Types of Springs

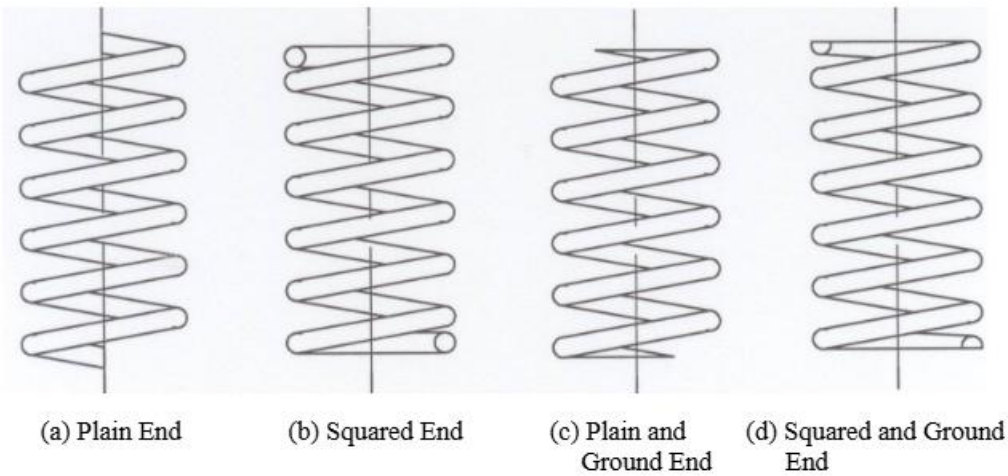


Fig 11.2: Compression Helical Springs with Different End Conditions

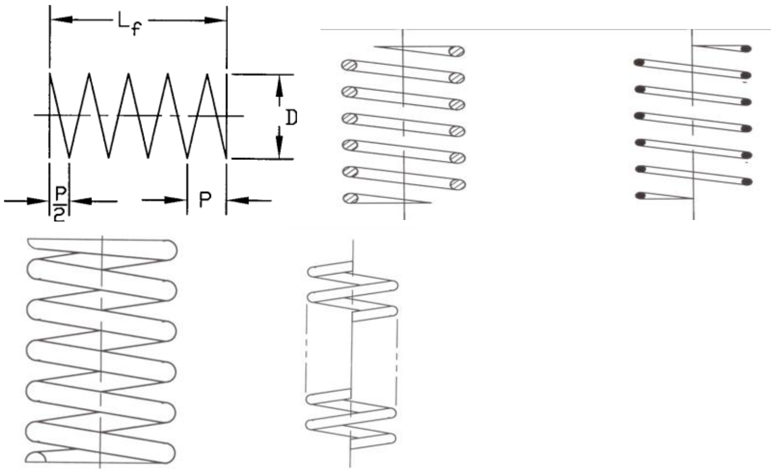
Functions of Springs

- Store energy.
- Return a component to its original position.
- Reduce shock or impact.

Engineering Drawings of Springs

- **Schematic Representation** – Used to save time when space is limited.
- **Detailed Drawing** – Shows the exact shape and dimensions.

- **True Projection** – Drawn with precise curvature and dimensions.



Spring Terminologies:

Mean Diameter (D) – mean of the inner diameter (ID) and outer diameter (OD).

Free Length (Lf): Overall length of the spring in unloaded position

Pitch (p): Center to center distance of the wire in adjacent active coils.

Active coils: Those which are free to deflect under load

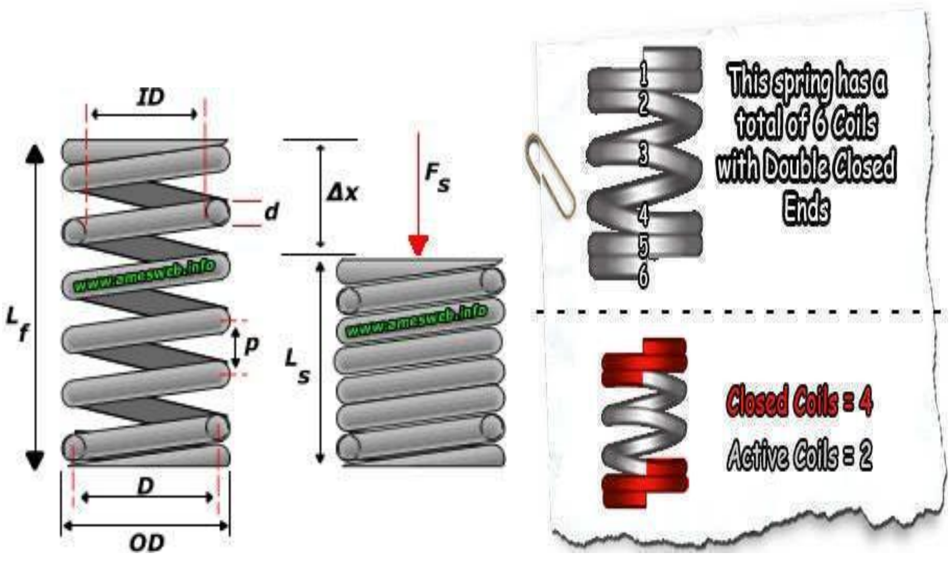
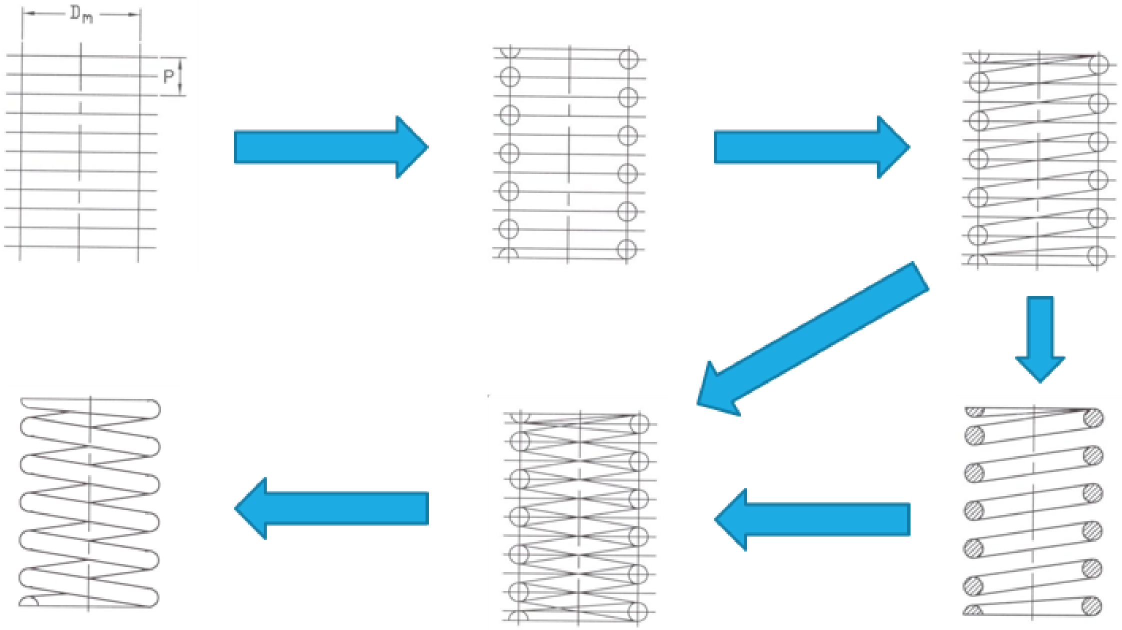


Fig 11.3: Spring Terminologies

Spring Drawing Steps:



Assignment:

1. Draw a helical compression spring with the following parameters:

- Mean Diameter: 15 cm
- Wire Diameter: 3 cm
- Pitch: 6 cm
- Number of Active Coils: 5
- End Condition: Squared and Ground Ends

2. Illustrate different types of spring end conditions.
3. Provide sectional and schematic views of a spring assembly.