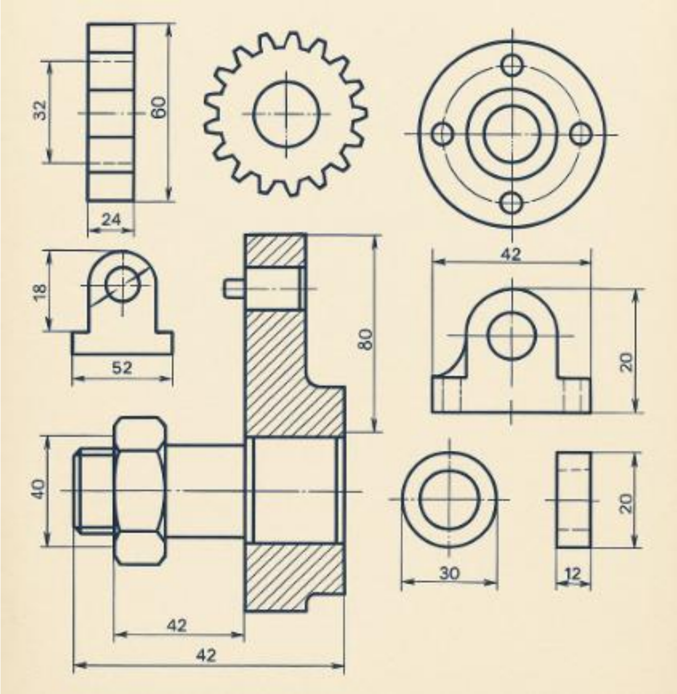
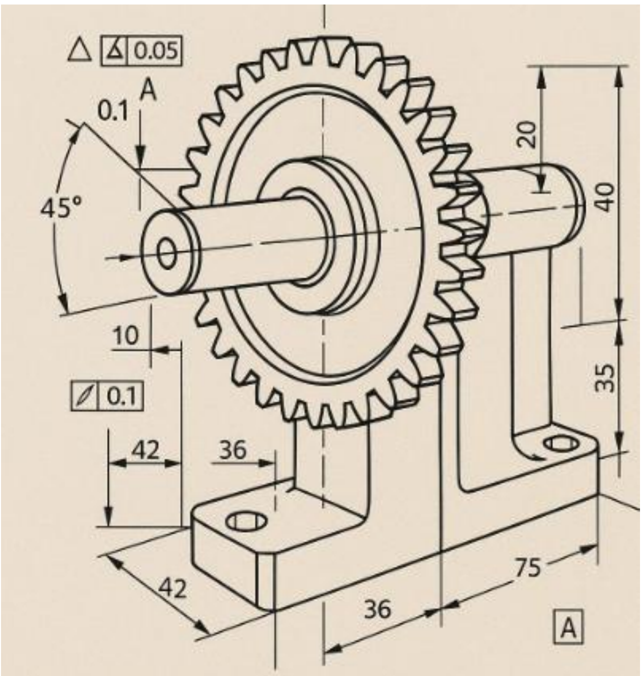
Draft Study Material





DRAUGHTSMAN MECHANICAL

(Qualification Pack: Ref. Id. CSC/Q0402)

Sector: Capital Goods

(Grade XI)

PSS CENTRAL INSTITUTE OF VOCATIONAL EDUCATION
(a constituent unit of NCERT, under Ministry of Education, Government of India)
Shyamla Hills, Bhopal- 462 002, M.P., India
http://www.psscive.ac.in

DRAUGHTSMAN MECHANICAL
(Job Role)

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Preface

Vocational Education is a dynamic and evolving field, and ensuring that every student has access to quality learning materials is of paramount importance. The journey of the PSS Central Institute of Vocational Education (PSSCIVE) toward producing comprehensive and inclusive study material is rigorous and time-consuming, requiring thorough research, expert consultation, and publication by the National Council of Educational Research and Training (NCERT). However, the absence of finalized study material should not impede the educational progress of our students. In response to this necessity, we present the draft study material, a provisional yet comprehensive guide, designed to bridge the gap between teaching and learning, until the official version of the study material is made available by the NCERT. The draft study material provides a structured and accessible set of materials for teachers and students to utilize in the interim period. The content is aligned with the prescribed curriculum to ensure that students remain on track with their learning objectives.

The contents of the modules are curated to provide continuity in education and maintain the momentum of teaching-learning in vocational education. It encompasses essential concepts and skills aligned with the curriculum and educational standards. We extend our gratitude to the academicians, vocational educators, subject matter experts, industry experts, academic consultants, and all other people who contributed their expertise and insights to the creation of the draft study material.

Teachers are encouraged to use the draft modules of the study material as a guide and supplement their teaching with additional resources and activities that cater to their students' unique learning styles and needs. Collaboration and feedback are vital; therefore, we welcome suggestions for improvement, especially by the teachers, in improving upon the content of the study material.

Deepak Paliwal
(Joint Director)
PSSCIVE, Bhopal

Date: 18th Aug 2025

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Module Overview

This module lays the groundwork for understanding and applying the essential principles of engineering drawing. Trainees are introduced to standard drawing formats, industry conventions, and the proper use of drafting tools. Key topics include various line types, lettering styles, and methods for constructing scales. The module emphasizes precision, clarity, and correct instrument handling to produce accurate mechanical drawings. Its primary goal is to equip learners with the foundational skills needed to convey engineering concepts and dimensions effectively through standardized technical illustrations.

Learning Outcomes

Upon completing this module, you will be able to:

- Confidently and correctly use essential engineering drawing tools.
- Apply standard drafting conventions, line types, and lettering methods in technical illustrations.
- Construct plain and diagonal scales to represent dimensions accurately.
- Produce clean, precise mechanical drawings in accordance with recognized drafting standards.

Module Structure

Session 1: Engineering Drawing and Drawing Sheet
Session 2: Working with Drawing Instruments
Session 3: Types of Lines and Methods of Drawing Letters and Numbers
Session 4: Plain Scale and Diagonal Scale

Session 1: Engineering Drawing and Drawing Sheet

1. Introduction to Engineering Drawing

Engineering drawing is a clear and standard way of showing how something is designed and how it works. It helps engineers and designers share their ideas correctly through diagrams. These drawings are very important in making, building, and putting things together, as they give a complete and exact picture of the object.

Core elements of engineering drawing include:

- **Lines –** Show the edges, surfaces, and outlines of objects.
- **Dimensions –** Give information about the size, shape, and scale of parts**.**
- **Symbols –** Use simple signs to show materials, actions, or components.
- **Views –** Use different drawing methods like front, side, and top views (orthographic), 3D-like views (isometric), and cut-through views (sectional) to show objects on flat paper.2. Classification of Drawings

Engineering drawings are categorized based on their application and the discipline in which they are used. Each type serves a specific purpose and adheres to standards suited to its field.

The main classifications include:

a) Engineering Drawings

These are technical drawings used across various engineering domains to convey design intent and manufacturing details.

- **General Purpose Drawings –** Show the overall design used in making or building something.
- **Detailed Drawings –** Give exact details about each part, like size, limits, and special notes.
- **Assembly Drawings –** Show how different parts come together to make the final product or machine.

b) Geometrical Drawings

These drawings focus on basic shapes like lines, angles, curves, and solids. They help in understanding geometry, which is the foundation of technical drawing in engineering

c) Machine Drawings

These drawings show machine parts and how they fit together. They include important details like size, limits, materials, and how to assemble them, which are needed for making mechanical systems.

d) Architectural Drawings

Mostly used in architecture and civil engineering, these drawings show plans for buildings, roads, and other structures. They focus on layout, size, materials, and how spaces are arranged in a project.

e) Electrical Drawings

These drawings show electrical circuits and systems, like wiring diagrams and layout plans. They are important for explaining how electrical setups are designed and installed.

2. Drawing Sheet and Its Specifications

A drawing sheet is the base where engineering drawings are made. It gives space to show designs clearly. To keep everything uniform and easy to use, these sheets follow standard sizes and formats set by rules like ISO or ANSI.

Common sheet sizes are:

- A0: 841 x 1189 mm (Fig. 1.1)
- A1: 594 x 841 mm
- A2: 420 x 594 mm
- A3: 297 x 420 mm
- A4: 210 x 297 mm

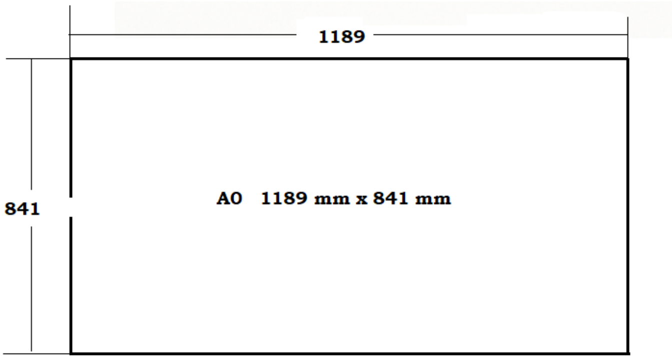


Fig. 1.1: Sheet Size A0

Specifications

- **Paper Type** – Good quality, smooth paper is used so lines are neat and long-lasting.
- **Margins and Borderlines –** These mark the area where the drawing should be made, keeping everything inside clear limits.

- **Title Block –** This part gives key details like the drawing name, scale, date, drafter's name, and any changes made, helping to identify the drawing easily.

3. Numbering the Sheet, Fixing the Sheet on the Drawing Board, and Preparation of Drawing

a) Numbering the Sheet

- A uniform numbering system helps categorize and reference drawings, crucial for handling numerous documents in large-scale projects.
- Drawing numbers are usually included in the title block, making it easier to monitor revisions and versions.

b) Fixing the Sheet on the Drawing Board

- The drawing sheet is positioned on a drawing board- a flat, stable surface that keeps the paper steady during the drawing process.
- It is secured in place using pins or clips at the corners to prevent any movement while working.

c) Preparation of Drawing

- Prior to starting, choose the correct scale, units, and projection method (like orthographic or isometric).

- Light pencil sketches are drawn first to accurately capture dimensions and angles, before finalizing with ink.

4. Description of Margin, Borderline, Title Block, and Orientation Marks

a) Margin

The margin is the empty border around the drawing area that keeps the artwork away from the paper's edges, protecting it from damage, trimming, or hiding during handling and storage.

b) Borderline

The borderline is a bold, continuous line marking the outer edge of the drawing area, framing the artwork and separating it from the margin.

c) Title Block

- Usually found in the bottom right corner, the title block contains key details like:

- The drawing's title (object or component name)
- Identification number
- Scale applied
- Drafter's name
- Date of creation or revision
- Company or organization information

- The size and layout of the title block follow standardized guidelines to ensure consistency (Fig.1.2).

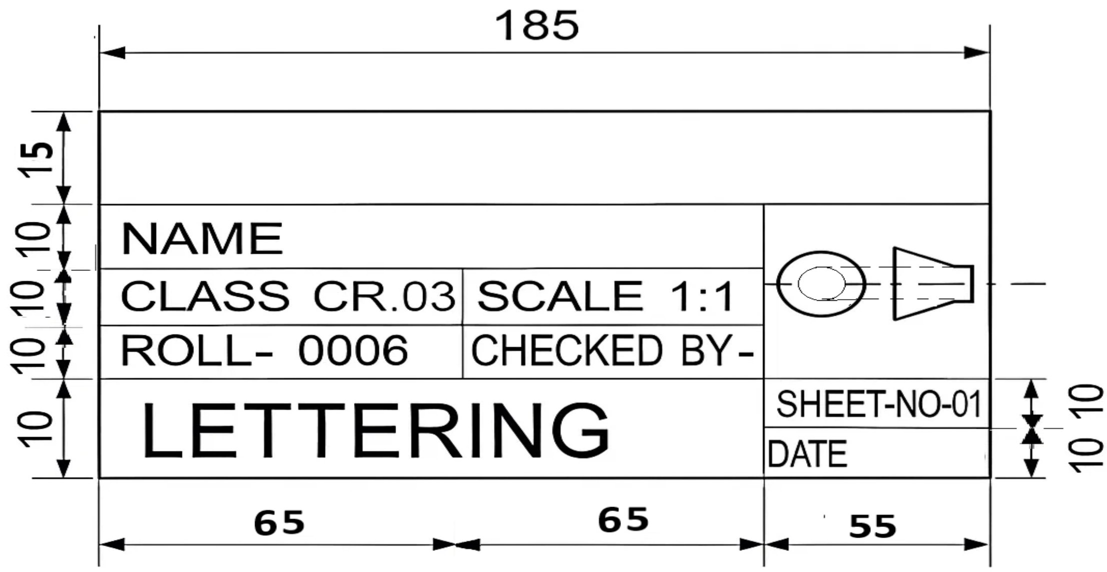


Fig. 1.2: Example of Title Block

d) Orientation Marks

- Orientation marks, also called fold lines or diagonal indicators, show the proper positioning of the drawing.
- They help maintain correct alignment when the sheet is folded or viewed from various angles, especially during printing or presentation.

5. Folding of Prints for Filing Cabinets or Binding

- Proper folding is crucial when storing engineering drawings to preserve their condition:
- Fold neatly along specified lines to avoid damage and maintain order.
- Techniques like quarter or Z folds are used, depending on drawing size and filing systems.
- Avoid creasing important areas like dimensions, notes, or annotations to keep key details visible and intact.

PRACTICAL EXERCISE

Activity: Preparation of Drawing Sheet for Mechanical Drafting

Objective: To accurately prepare a drawing sheet for technical drafting by securing it on a drawing board, numbering it, and adding essential layout elements.

Materials Required:

- Standard drawing sheet (as per BIS or ISO specifications)
- Drawing board
- Drawing clips or masking tape
- T-square
- Set squares
- Pencil (preferably H or 2H for construction lines)
- Eraser
- Scale or ruler
- Compass (if needed)

Procedure:

1. Fixing the Sheet:

- Place the drawing sheet flat on the drawing board.
- Align the sheet edges parallel to the board's edges.
- Secure the sheet at the corners using drawing clips or masking tape to prevent movement during drawing.

2. Numbering the Sheet:

- Clearly write the sheet number at the top right corner or according to the institution's standard format.
- Ensure the numbering is neat and legible.

3. Drawing Margins:

- Use a pencil and scale to draw margins on all four sides of the sheet.
- Standard margin widths are:
    - Left margin: 25 mm
    - Right, top, and bottom margins: 10 mm (unless otherwise specified)

4. Drawing the Borderline:

- Draw a continuous, straight line just inside the margins to form the border.
- Use a 0.5 mm pencil or technical pen for uniform line thickness.

5. Drawing the Title Block:

- Sketch the title block at the bottom right corner of the sheet.
- Follow BIS/ISO standards for the size and layout of the title block.
- Include essential details such as:
    - ➢ Drafter's name
    - ➢ Drawing title
    - ➢ Drawing number
    - ➢ Scale
    - ➢ Date
    - ➢ Names of checker and approvers (if applicable)

6. Orientation Marks:

- Add orientation symbols, such as a north or direction arrow.
- Position these marks according to standard conventions used in mechanical drawings.

CHECK YOUR PROGRESS

A. Answer the following questions

1. How would you define engineering drawing?
2. Name any two essential elements of an engineering drawing.
3. What is the purpose of lines in an engineering drawing?
4. Why are dimensions important in a drawing?
5. What do symbols typically indicate in engineering drawings?

B. Multiple Choice Questions

1. Which drawing type illustrates how separate components come together to form a complete assembly?
   a) Detailed Drawing
   b) Assembly Drawing
   c) Electrical Drawing
   d) Geometrical Drawing

2. What is the primary function of a General-Purpose Drawing?
   a) To depict electrical circuits
   b) To study geometric shapes
   c) To convey design details for manufacturing
   d) To show how machine parts fit together
3. Geometrical Drawing mainly focuses on:
   a) Machine assemblies
   b) Building layouts
   c) Electrical circuits
   d) Shapes, angles, and three-dimensional solids
4. Which type of drawing serves as the foundation for engineering graphics?
   a) Architectural Drawing
   b) Machine Drawing
   c) Geometrical Drawing
   d) Assembly Drawing
5. Machine Drawing typically includes:
   a) Spatial planning for buildings
   b) Creating geometric figures
   c) Electrical wiring diagrams
   d) Detailed specifications such as materials and tolerances

C. Fill in the blanks

1. Electrical drawings represent electrical _________, systems, and wiring layouts.
2. Electrical drawings are used to communicate _________ engineering designs and layouts.
3. The drawing sheet serves as the _________ for representing the object being designed.
4. Drawing sheets are standardized according to _________ or ANSI norms.
5. The _________ defines the area where the drawing will be made.

D. True or False

1. Drawings must be folded carefully along designated folding lines.
2. Depending on the sheet size and filing method, drawings are usually folded using quarter folds or Z folds.
3. It is acceptable to fold over dimension lines or annotations if it saves space.
4. Using correct folding methods is important to prevent damage to the drawings.
5. Orientation marks indicate the correct positioning of the drawing.

Session 2: Working with Drawing Instruments

1. Different Drawing Instruments

Precision and accuracy are crucial in engineering drawing, which requires the use of various specialized instruments to produce clear and detailed work. There are following drawing instruments which are commonly used in technical drafting

a) Drawing Board

- A drawing board is a flat, smooth, and rigid surface that securely holds the drawing sheet (Fig. 1.3). It offers a stable base to prevent paper distortion during drafting and is typically made from wood or durable composite materials.
- **Size:** Drawing boards are available in multiple dimensions corresponding to standard paper sizes like A0, A1, A2, etc. The board should be sufficiently large to hold the entire drawing sheet securely and provide ample working space.

Fig. 1.3: Drawing Board

b) Drawing Pencils

Pencils are vital for precise drawing and come in different grades to indicate lead hardness (Fig. 1.4).

- Hard pencils (H, 2H) produce fine, light lines suited for detailed and accurate work.
- Soft pencils (B, 2B, 3B) create darker, bolder lines, useful for shading and highlighting.
- Recommended practice: Use both hard and soft pencils to achieve a good balance between detail and emphasis in technical drawings.

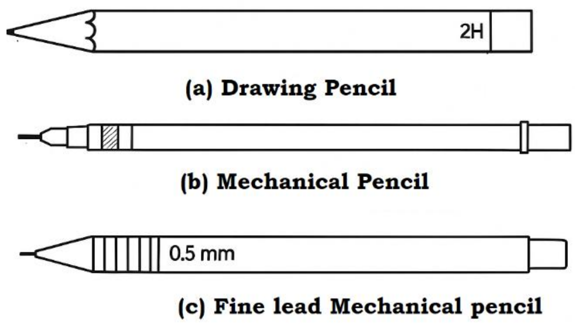


Fig. 1.4: Drawing Pencils

c) Pencil Sharpener

Pencil sharpeners help maintain a fine, sharp point on pencils, which is essential for producing clean and precise lines. They come in various types, including handheld models and rotary sharpeners.

d) Eraser

Erasers are used to remove unwanted pencil marks from the drawing. Rubber erasers are common for general use, while kneaded erasers are preferred for delicate corrections as they can lift graphite gently without harming the paper surface.

e) Erasing Shield

An erasing shield is a thin sheet made of metal or plastic with various shaped cutouts. It protects specific areas of the drawing during erasing, allowing for precise removal of pencil marks in detailed regions without affecting the surrounding work.

f) Scales

Scales are tools for measuring distances and drawing straight lines at set angles. They come in different types, including:

- **Architectural Scale:** Designed for architectural drawings with specialized ratio markings.
- **Engineer's Scale:** Used mainly in mechanical and civil engineering for accurate measurement.
- **Ruler:** A simple instrument used to draw straight lines and measure lengths on drawings.

g) Roller Scales

Roller scales, also known as rolling rulers, are designed to measure long distances on larger drawings (Fig. 1.5). Equipped with a rolling mechanism, these scales glide smoothly across the drawing surface, making it easier to measure extended or irregular shapes accurately.

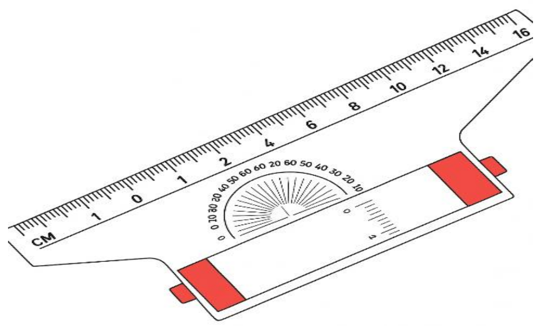


Fig. 1.5: Roller Scale

h) Set Squares

Set squares are triangular drafting tools featuring right-angled edges (Fig. 1.6) used to draw perpendicular and angled lines accurately. They are commonly available in two types based on their angle measurements:

- **45° Set Square:** Used to draw lines at a 45-degree angle.
- **30°/60° Set Square:** Designed for creating lines at 30°, 60°, and 90-degree angles.

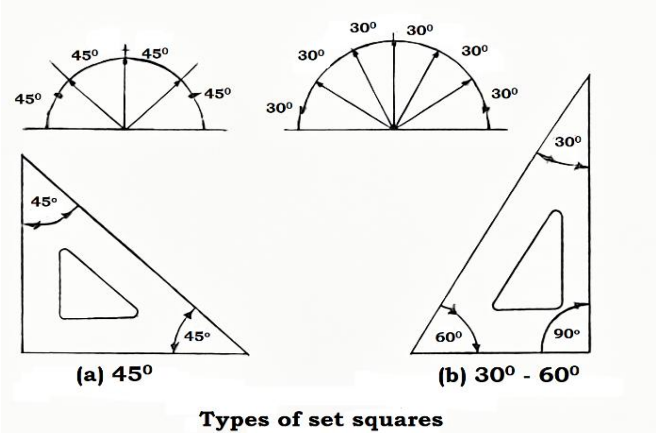


Fig. 1.6: Set Squares

i) Small Bow Compass

A bow compass is a tool used to draw accurate circles and arcs. It consists of two hinged armsone with a pencil and the other with a pointed needle that serves as the center point (Fig. 1.7).

Fig. 1.7: Small Bow Compass

j) Small Size Divider

Dividers, similar in appearance to a compass, have two pointed legs and are mainly used to measure distances, transfer dimensions, or evenly divide lines on a drawing.

.

k) Protractor

A protractor is a tool used to measure and draw angles (Fig. 1.8). It has a degree-marked scale that enables accurate angle measurement, which is crucial in technical drafting.

Dividers are drafting tools with two pointed legs, similar to a compass in appearance. They are mainly used for measuring distances, transferring dimensions, and dividing lines into equal parts on a drawing.

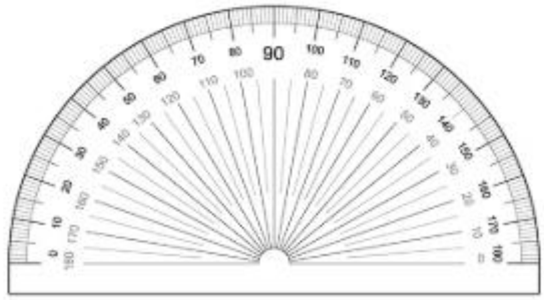


Fig. 1.8: Protractor

2. Drafting Machine (Mini Drafter)

The drafting machine, also known as a mini drafter (Fig.1.9), is a versatile tool that integrates the functions of a drawing board and set square. It enables users to draw straight lines at various angles quickly and accurately, making it ideal for detailed and precise technical drawings.

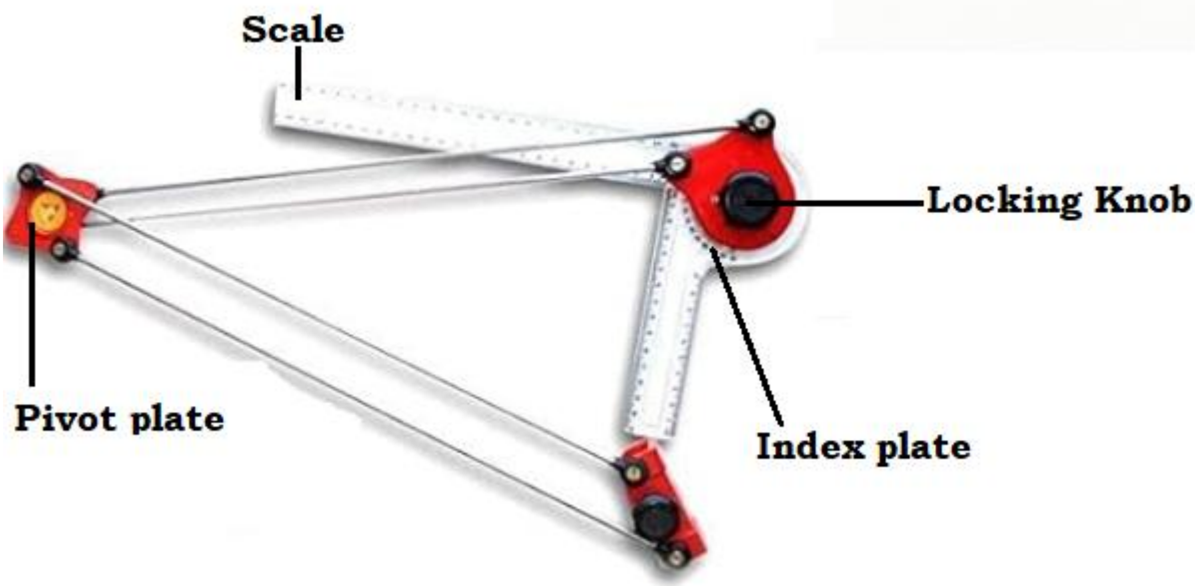


Fig. 1.9: Mini Drafter

Fixing the Mini Drafter on the Drawing Board:

1. **Positioning:** The drafting machine is typically installed either at the top or bottom edge of the drawing board.
2. **Attachment:** It is firmly secured using adjustable clamps or screws to maintain stability during use.
3. **Adjustments:** Once fixed, the arms and head of the drafting machine are adjusted to the desired angles and positions before starting the drawing process.

3. Use of Drawing Pins, Cello Tape, Duster, and Sandpaper Block

a) Drawing Pins

Drawing pins, also known as thumbtacks (Fig.1.10), are used to fasten the drawing sheet securely to the drawing board. They help keep the paper steady, preventing any movement while drafting.

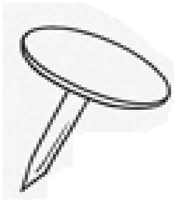


Fig. 1.10: Drawing Pins

b) Cello Tape

Cello tape, also called transparent adhesive tape (Fig. 1.11), is commonly used to temporarily secure a drawing sheet or to attach small items to the drawing board. It can also be used to stick papers onto walls or other surfaces for display or easy reference.

Fig. 1.11: Cello Tape

c) Duster

A duster (Fig. 1.12) is used to clean the drawing surface and remove dust or debris from the drawing sheet. Keeping the workspace clean helps prevent smudges and ensures the drawing remains neat and clear.

Fig. 1.12: Duster

d) Sandpaper Block

A sandpaper block (Fig.1.13) is coated with fine abrasive material and is used to gently clean or smooth the edges of drawings or paper. It is particularly effective for removing smudges or graphite residue, but care must be taken to avoid harming the drawing surface.

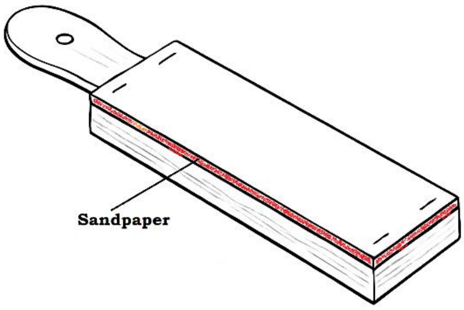


Fig. 1.13: Sandpaper Block

PRACTICAL EXERCISE

Activity: Use of Drawing Instruments for Constructing Basic Lines and Angles

Objective: To recognize and properly use different drawing instruments and pencils to accurately create simple lines and angles on a drawing sheet, following mechanical drafting standards.

Materials Needed:

- Drawing sheet
- Drawing board
- Drawing clips or masking tape
- T-square
- Set squares (45° and 30°–60°)
- Roller scale or drafting machine (if available)
- Compass
- Divider
- Protractor
- Pencils of various grades (H, 2H, HB)
- Eraser
- Ruler/scale

Procedure:

1. **Familiarize with Drawing Instruments (Fig. 1.14):**
    - Examine the available drawing tools.
    - Learn the purpose of each instrument:

- T-square: For drawing horizontal lines.
- Set squares: For vertical, inclined, and perpendicular lines.
- Compass: For drawing arcs and circles.
- Protractor: For measuring and constructing angles.
- Roller scale: For drawing parallel lines.
- Pencils: Use H or 2H pencils for light construction lines, HB for final outlines.

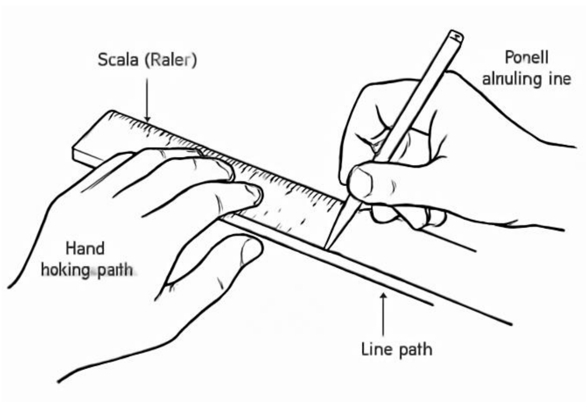


Fig. 1.14: Straight Lines with Scale

2. **Securing the Drawing Sheet:**
   - Attach the drawing sheet firmly onto the drawing board using clips or masking tape.
   - Make sure the sheet is properly aligned and oriented.
3. **Drawing Straight Lines Using the Scale:**
   - With the help of a ruler or T-square, draw straight lines of specified lengths (e.g., 50 mm, 100 mm).
   - Clearly label each line with its length measurement.

4. Drawing Parallel Lines with a Roller Scale:

- Start by drawing baseline using the T-square.
- Then, using a roller scale (Fig. 1.15) or drafting machine, draw multiple parallel lines evenly spaced above and below the baseline (for example, 10 mm apart).

Fig. 1.15: Parallel Lines Using Roller Scale

5. Drawing Parallel and Perpendicular Lines Using Set Squares (Fig. 1.16):

1. Place the T-square firmly along the edge of the drawing board to draw a horizontal base line.

2. Align a 45° or 30°–60° set square against the T-square to draw vertical (perpendicular) lines from the base line.
3. Slide the set square along the T-square to draw additional parallel lines as needed
4. Label each line clearly according to its orientation.

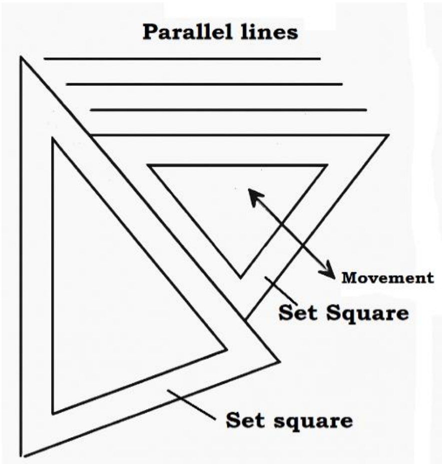


Fig. 1.16: Draw Parallel Lines

HOW TO DRAW PERPENDICULAR LINES

Drawing Perpendicular Lines Using a Compass:

- Select a point on a given line.
- With a compass, draw arcs that intersect the line on both sides of the point.
- Use these intersections to draw a perpendicular by connecting them through the original point (Fig. 1.17 (a)).

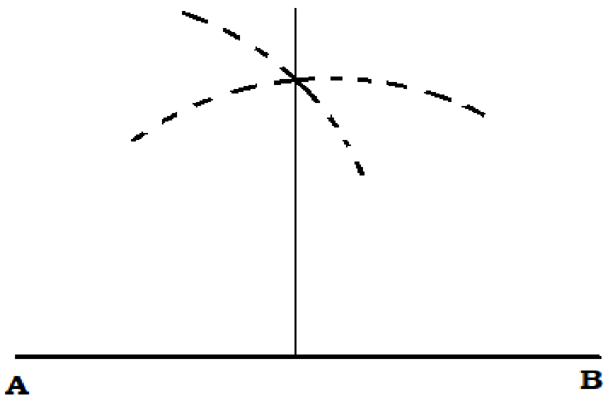


Fig. 1.17(a): Draw Perpendicular Lines Using a Compass

5. **Constructing Various Angles Using Set Squares:**

- Use set squares to mark and draw angles of different measures, such as 30°, 45°, 60°, 90°, and 120° (Fig.1.17(b)).
- Ensure each angle is neatly labeled with its corresponding degree.

Fig. 1.17(b): Draw Perpendicular Using Set Squares

Construction of angle 60 degrees (60°)

60 degrees is one of the most basic constructions, which facilitates constructing angles of several other measures (Fig. 1.18). The steps are:

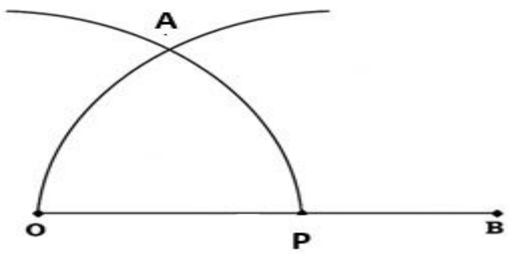


Fig. 1.18: 60° Angle

Step 1: Draw a line segment. Mark the left end as point O and the right end as point B (Fig. 1.19).

Fig. 1.19: Construction of Angle (Step 1)

Step 2: Take the compass and open it up to a convenient radius. Place its pointer at O and with the pencil head make an arc which meets the line OB at say, P (Fig. 1.20).

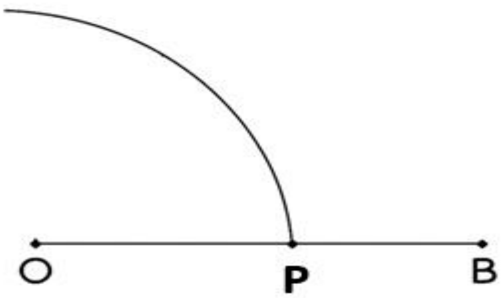


Fig. 1.20: Construction of Angle (Step 2)

Step 3: Place the compass pointer at P and mark an arc that passes through O and intersects the previous arc at a point, say A (Fig. 1.21).

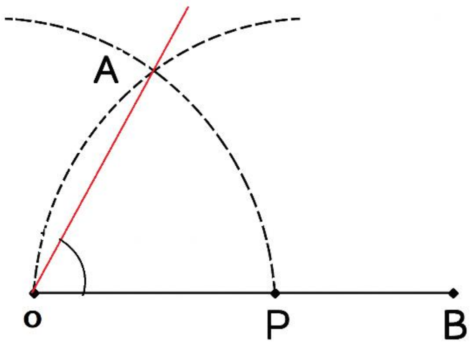


Fig. 1.21: Construction of Angle (Step 3)

Step 4: Draw a line from O through P. We get the required angle i.e. ∠AOB = 60-degree.

CHECK YOUR PROGRESS

A. Short Answer Questions

1. What is the primary function of a drawing board in technical drawing?
2. What materials are commonly used to make drawing boards?
3. Name any two standard sizes of drawing boards.
4. What does the "H" grade in pencils indicate?
5. What is the typical use of "B" grade pencils in drafting?

B. Multiple Choice Questions

1. What is the primary function of a pencil sharpener in drafting?
   a) To color the drawing
   b) To maintain a fine and sharp pencil point
   c) To break the pencil in half
   d) To clean the drawing surface
2. Which type of eraser is best suited for detailed and gentle corrections?
   a) Rubber eraser
   b) Electric eraser
   c) Kneaded eraser
   d) Ink eraser
3. What is the purpose of an erasing shield?
   a) To secure the sheet to the board
   b) To sharpen drawing tools
   c) To erase small, specific areas without disturbing the rest of the drawing
   d) To clean the board
4. Which instrument is commonly used to draw straight lines and take measurements?
   a) Compass
   b) Scale
   c) Divider
   d) Eraser
5. Which type of scale is mainly used in mechanical and civil engineering drawings?
   a) Rolling scale
   b) Standard ruler
   c) Architect's scale
   d) Engineer's scale

C. Fill in the blanks

1. Set squares are _____ tools used to draw perpendicular or angular lines.
2. A bow compass is used for drawing _____ or arcs.
3. The bow compass has one arm with a pencil and the other with a _____ for pivoting.
4. Dividers are used to measure or _____ distances on a drawing.
5. Unlike a compass, both arms of a divider have _____ tips.

D. True or False

1. Thumbtacks (drawing pins) are used to hold the drawing sheet firmly on the board.
2. Transparent adhesive tape is meant solely for permanently fixing sheets.

3. Sandpaper blocks can be used to gently remove graphite marks or smudges from the paper.
4. Using drawing pins helps keep the sheet stable during drafting.
5. A sandpaper block should be applied with pressure to erase pencil marks quickly.

Session 3: Types of Lines and Methods of Drawing Letters and Numbers

1. Types of Lines and Their Uses in Engineering Drawing

Lines are essential in technical drawing, serving to convey the form, size, and hidden or visible features of objects. Each line type follows standard conventions and has a specific function (Table 1.1). Some of the commonly used lines in engineering graphics are discussed in following section:

a) Continuous Thick Line

- **Purpose:** Depicts the visible edges and outlines of an object.
- **Example:** The clearly visible perimeter of a mechanical part.

b) Continuous Thin Line

- **Purpose:** Used for dimensioning, projection, extension, and leader lines.
- **Example:** Measurement indicators between two points on a drawing.

c) Dashed Line (Thin Short Dashes)

- **Purpose:** Represents features not visible from the current viewpoint.
- **Example:** Hidden holes or recesses behind solid surfaces.

d) Chain Thin Line (Centerline)

- **Purpose:** Indicates axes of symmetry, centerlines of circles, or paths of rotation.
- **Example:** The center axis of a cylindrical shaft or hole.

e) Break Line

- **Purpose:** Used to shorten the representation of long components by showing only a part.
- **Example:** A long rod shown with a section removed to fit on the sheet.

f) Chain Line (Dash-Dot Line)

- **Purpose:** Represents movement paths, alternate positions, or functional directions.
- **Example:** The arc traced by a swinging lever or robotic arm.

g) Thin Chain Line with Thick Ends

- **Purpose:** Indicates surfaces that require machining or specific surface finishes.
- **Example:** Machined surfaces marked for grinding or polishing.

h) Long Dash Line (Cutting Plane Line)

- **Purpose:** Used to define where an object is cut to show internal features in section views.
- **Example:** Section lines in an exploded or internal part view.

Table 1.1: Types of lines used in Engineering Drawings

S. No.	Type of line	Image of line	Application
1	Continuous thick line		Used for outlines
2	Continuous thin line		Used as leader lines, dimension lines, construction lines etc.
3	Continuous thin line-wavy		Used to show irregular lines boundary lines, short break lines etc.
4	Short Dashes Medium line		Used for hidden outlines and edges
5	Long chain thin line		Used for locus lines, centre lines etc.
6	Long chain line thick at ends and thin elsewhere		Used for cutting plane lines
7	Long chain thick line		Used to indicate surfaces requiring additional treatments
8	Ruled line and short zig-zag thin		Used for long break lines

2. Introduction to Lettering in Technical Drawing

Lettering in engineering drawings involves writing text in a precise and readable manner. It plays an essential role in conveying important information such as dimensions, notes, labels, and titles. For effective communication, the lettering must be clear, uniform, and easy to read.

- **Purpose:** Ensures that all textual information on the drawing is easily interpreted by engineers, machinists, and other professionals.
- **Standards:** Standardized lettering styles, such as those specified by **ISO 3098** or **ANSI**, are followed to maintain consistency across all technical documents.
- **Tools Used:**

Lettering can be done using:

- Pencils (for initial layout or temporary notes)
- Mechanical pens or fine-tip ink pens (for final, permanent lettering)

3. Lettering: Structure, Spacing, Size, and Guidelines

Proper lettering is essential in engineering drawings to maintain clarity and professionalism. The form, spacing, and size of letters follow specific guidelines to ensure uniformity and readability.

a) Structure and Style of Letters

- **Design:** Letters used in technical drawings are generally simple and without decorative strokes commonly sans serif to improve clarity.
- **Uniformity:** Each letter should maintain consistent proportions in height, width, and thickness, promoting a clean and professional appearance.

b) Spacing Between Letters and Words

- **Letter Spacing (Kerning):** Even spacing between letters is important to avoid overlapping or crowding, which can make the text hard to read.
- **Word Spacing:** The space between words should typically equal the width of a capital letter to maintain a balanced appearance across the drawing.

c) Letter Size Standards

- **Large Format Drawings (e.g., A0, A1):** Letter heights are usually around **5 to 7 mm**, making them clearly visible from a distance.
- **Smaller Format Drawings (e.g., A3, A4):** Letters may be reduced to **2 to 3 mm** to suit the limited space while remaining legible.
- **Scaling Consideration:** Letter size should be adjusted in proportion to the drawing scale to ensure readability regardless of sheet size.

4. Introduction to Dimensioning

Dimensioning involves adding precise measurements to a drawing to clearly define the size, shape, and location of an object's features. This includes indicating lengths, widths, heights, angles, radii, and other geometric details that are critical for accurately producing the part.

- **Purpose:** Dimensioning provides all the necessary numerical information needed to manufacture or construct the component correctly. It ensures that everyone involved in the production process understands the exact size, proportions, and allowable tolerances of the design.

- **Standards:** To maintain consistency and clarity, dimensioning is carried out following established guidelines such as ISO or ANSI standards. These standards help standardize the way measurements are represented across different drawings and industries.

5. Notation Concepts, Dimension Placement Methods, Units, and Dimensioning Guidelines in Mechanical Drafting

a) Notation Concepts

Notation involves using standardized symbols and abbreviations in drawings to represent various dimensions and features such as radii, angles, and geometric characteristics.

- Common symbols include:
  - **R:** Denotes radius, for example, *R10* means a radius of 10 mm.
  - **Ø:** Represents diameter, such as *Ø20* indicating a 20 mm diameter hole.
  - **±:** Shows tolerance, for instance, *±0.1 mm* means the measurement can vary by 0.1 mm above or below the specified size.

b) Dimension Placement Methods

- **Linear Dimensioning:** Measures distances between two points along straight lines, often used to show length, width, or height on horizontal or vertical axes.
- **Radial and Angular Dimensioning:** Used to specify circular features like radii and diameters, or the angles between lines or surfaces. For example, *R15* for a curve's radius or *45°* for an angle.
- **Coordinate Dimensioning:** Defines points in terms of X, Y (and sometimes Z) coordinates, commonly used for complex components and assemblies. Coordinates might be noted as *(50, 100)* on a 2D plane.
- **Ordinate Dimensioning:** Places measurements relative to a fixed reference point or origin, which simplifies readings and minimizes errors in manufacturing. For example, distances are measured from the left edge of a part.

c) Units of Measurement

- **Metric System (SI Units):** Predominantly used worldwide, dimensions are typically shown in millimeters (mm) for lengths, diameters, and radii, and degrees (°) for angles.
- **Imperial System:** Mainly used in the U.S., dimensions may be in inches (in) or feet (ft).

- **Tolerances:** These specify allowable limits of variation, such as ±0.5 mm, ensuring parts fit and function correctly during assembly.

d) Dimensioning Guidelines

- **Clarity:** All dimensions must be clear and unambiguous so the feature being measured is obvious.
- **Avoid Repetition:** No single feature should be dimensioned more than once to prevent confusion.
- **Placement:** Whenever possible, dimensions should be positioned outside the main drawing area to keep the drawing neat, avoiding overlap with object lines or details.
- **Use of Arrows:** Arrows indicate the precise start and end points of a dimension, pointing directly at the feature measured.
- **Leader Lines:** These lines connect dimensions or notes to specific features to maintain clarity, especially when the dimension is offset from the object.

PRACTICAL EXERCISE

Activity: Identification of types of lines

Objective: To Identify the type of line in a given drawing.

Materials Required:

- Pencil

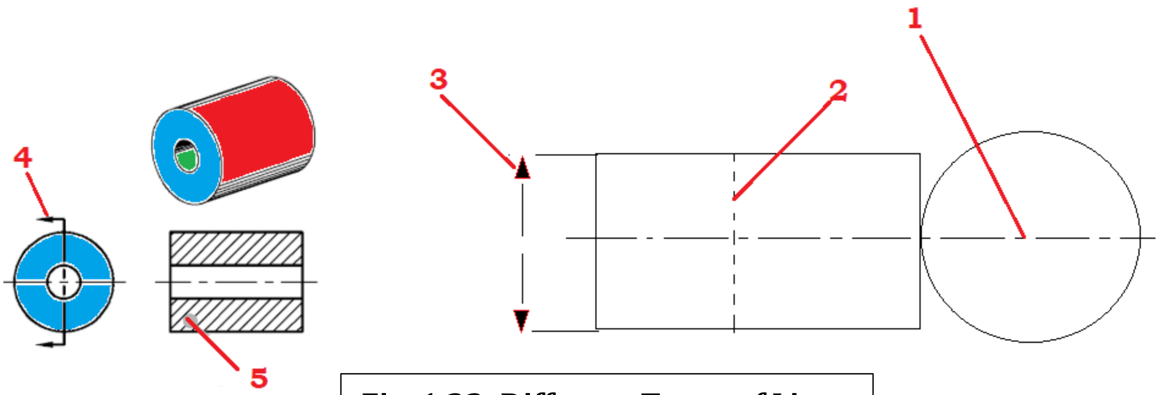


Fig. 1.22: Different Types of Lines

Task: Identify the types of lines used in the drawing (Fig. 1.22)

1. ________________________________

2.________________________________

3.________________________________

4.________________________________

5. _________________________________

CHECK YOUR PROGRESS

A. Answer the following questions

1. What does a continuous thick line represent in an engineering drawing?
2. Give an example of where a continuous thick line is used.
3. What does a dashed (or chain) line indicate in a technical drawing?
4. Provide an example of when a dashed line would be applied.
5. For what purposes is a dotted line used in technical drawings?

B. Multiple Choice Questions

1. What is the role of a break line in an engineering drawing?
   a) To represent symmetry
   b) To depict motion
   c) To show that a section of the drawing is intentionally omitted
   d) To illustrate hidden features
2. Which type of line indicates the direction of movement or mechanical action?
   a) Break line
   b) Long dash line
   c) Dash dot line
   d) Continuous thick line
3. What does a thin chain line typically denote in technical drawings?
   a) Hidden edges
   b) Surfaces to be finished or cutting planes
   c) Axis of symmetry
   d) Interrupted or broken parts
4. Which line style is commonly used to mark cutting planes in sectional views?
   a) Dash dot line
   b) Long dash line
   c) Continuous thin line
   d) Dotted line
5. When is it most appropriate to use a break line in a drawing?
   a) To mark the centerline of a hole
   b) To show hidden details
   c) To shorten a drawing by excluding repetitive sections
   d) To indicate an axis of rotation

C. Fill in the blanks

1. Lettering refers to the practice of writing or drawing _____ on an engineering drawing.
2. Letters in technical drawings are usually _____ serif for simplicity and clarity.
3. The spacing between letters is known as _____.
4. For large-scale drawings, the letter size should be between _____ mm.

5. For smaller drawings like A3 or A4, the letter height is typically _____ mm.

D. True or False

1. In dimensioning, notations such as R for radius and Ø for diameter are commonly used symbols.
2. The ± symbol represents a fixed dimension without any tolerance allowed.
3. Linear dimensioning applies only to curved features in a drawing.
4. Radial and angular dimensioning are used to specify circular and angular details.
5. Coordinate dimensioning involves locating points using X, Y, and Z coordinates on a drawing.

Session 4: Plain Scale and Diagonal Scale

1. Understanding Plain Scale and the Principle of Representative Fraction (R.F.)

Plain Scale:

A plain scale is a straightforward linear measuring tool used to depict the length or distance of an object on a drawing according to a specified ratio. It consists of evenly divided markings that enable accurate scaling of real-world measurements onto the drawing surface. This scale helps in translating actual dimensions into smaller, proportional lengths suitable for the drawing's size (Fig. 1.23).

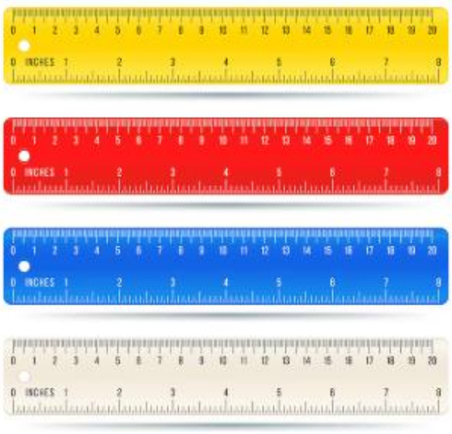


Fig. 1.23: Plain Scale

Structure of a Plain Scale:

- A plain scale is typically composed of multiple sections, each subdivided into smaller units.
- The scale is calibrated using units like meters, centimeters, or inches, with each subdivision corresponding to a precise fraction of the real measurement.
- For example, one segment of the scale may represent a single unit of length on the actual object, while other segments could correspond to 10 or 100 times that unit, depending on the required scale.

Principle of R.F. (Representative Fraction):

The Representative Fraction (R.F.) is the ratio between the dimensions of the object as drawn on the drawing sheet and the actual dimensions of the object in reality. It is a fraction expressed as 1:X**,** where 1 represents a unit length on the drawing, and X represents the corresponding unit length in real life.

Formula:

$$R.F. = \frac{Length\ of\ object\ in\ Drawing}{Actual\ length\ of\ Object}$$

Examples:

- Scale 1:10 means that 1 unit of length on the drawing is equivalent to 10 units in real life. For example, if a mechanical part is 100 mm in real life, it will be represented as 10 mm on the drawing.
- Scale 1:100 means that 1 unit of length on the drawing corresponds to 100 units of real-life measurement.

2. Diagonal Scale and Scale of Chord

Diagonal Scale:

A diagonal scale is a specialized measuring tool used to achieve higher accuracy when dealing with fractional dimensions. It helps in obtaining precise measurements by allowing readings that fall between the standard divisions on a regular scale (Fig. 1.24).

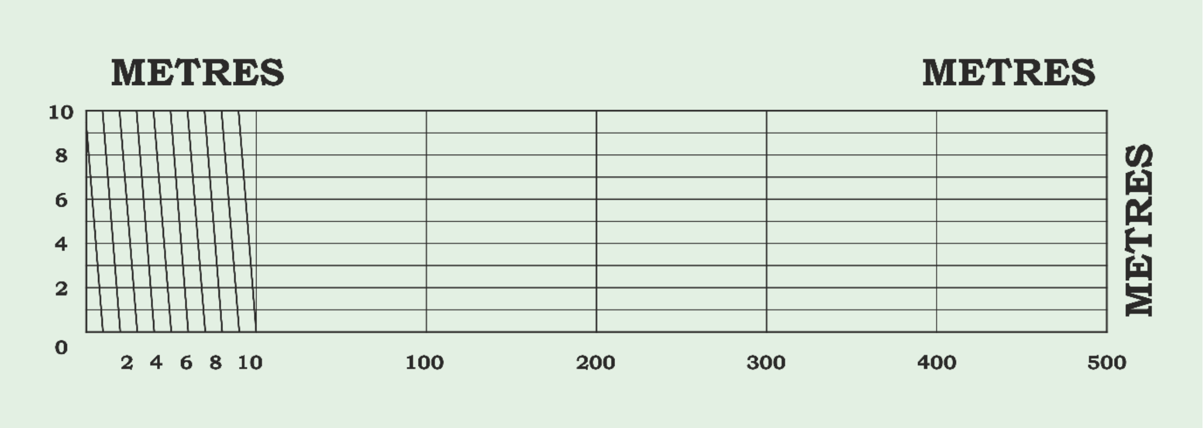


Fig. 1.24: Diagonal Scale

Structure of a Diagonal Scale:

- A diagonal scale is constructed by drawing diagonal lines over a standard linear scale.
- It consists of a main scale divided into whole units, such as meters or inches, while the diagonal lines provide subdivisions for fractional measurements.
- Each diagonal line represents a fraction of the main unit (for example, 1/10 or 1/100), enabling more precise measurement of distances, particularly for small or detailed dimensions.

Scale of Chord:

The scale of chord is designed for measuring angles on a circle or arc. It uses the chord length the straight line joining two points on an arc to represent angular measurements. This type of scale is particularly useful for accurately determining angles or arc lengths in technical drawings (Fig. 1.25).

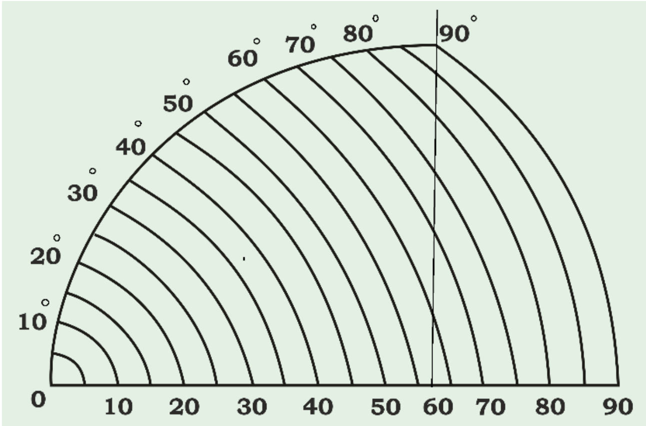


Fig. 1.25: Scale of Chord

Structure of a Scale of Chord:

- This scale translates angular measurements into linear distances measured along the chord of a circle. The chord, which is the straight line connecting two points on an arc, is divided into smaller segments.
- For instance, the scale may be marked in increments such as 1°, 2°, 3°, and so on, each representing the corresponding angle of the arc. This makes it especially useful for measuring angles or arcs that are too large or impractical to measure directly with a protractor.

PRACTICAL EXERCISE

Activity: Construction of Plain Scale, Diagonal Scale, and Scale of Chords

Objective: To construct and use plain scale, diagonal scale, and scale of chords using a given Representative Fraction (RF) for accurate measurement and representation in engineering drawings (Fig. 1.26).

Materials Required:

- Drawing sheet
- Drawing board
- Drawing clips or masking tape
- Pencils (2H for construction, H or HB for final lines)
- Scale (ruler)
- Compass
- Divider

- Protractor
- Set squares
- Eraser

Part 1: Constructing a Plain Scale

Given:

- Representative Fraction (RF): (e.g., 1:50)
- Units to represent: Metres and decimetres
- Maximum length to measure: 5.4 metres

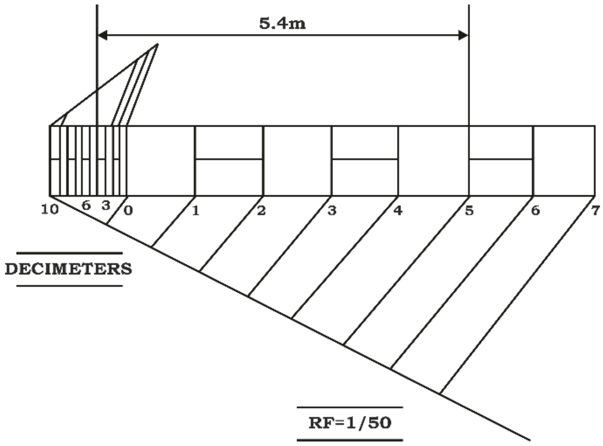


Fig. 1.26: Construction of Plain Scale

Procedure:

1. Calculate the scale length:
   The length of scale in centimetres is calculated by multiplying the Representative Factor (RF) by the maximum length to measure in centimetres.
2. Draw a horizontal line equal to the calculated length.
3. Divide the line into equal parts to represent whole units (e.g., metres).
4. Subdivide the first division into 10 parts to represent sub-units (e.g., decimetres).
5. Label the divisions clearly.

Part 2: Constructing a Diagonal Scale (Fig. 1.27)

Given:

- Representative Fraction (RF): (e.g., 1:40)
- Units to represent: Metres, decimetres, and centimetres
- Maximum length to measure: 4.76 metre.

Procedure:

1. Calculate the scale length as in the plain scale.
2. Draw a horizontal base line equal to the scale length.
3. Divide the base line into equal parts for main units (metres).
4. Divide the first main unit into 10 parts (decimetres).
5. Erect perpendiculars and construct a rectangle of suitable height.
6. Subdivide vertical lines to create diagonals for the smallest unit (centimetres).
7. Draw diagonals from top corners of the vertical divisions to bottom of the next
8. Label all parts of the scale clearly.

Scales: Diagonal Scale

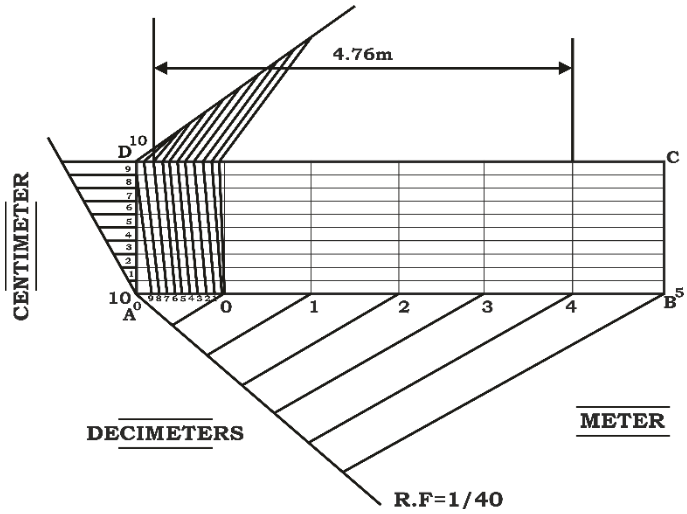


Fig. 1.27: Construction of Diagonal Scale

Part 3: Constructing a Scale of Chords (Fig. 1.28)

Procedure:

1. Draw a base horizontal line and mark a point O as the centre.
2. With O as centre, draw a circle using a compass (radius can be 5 cm or suitable).
3. Using a protractor, mark angles at 10°, 20°, 30°, ..., up to 90° along the arc.
4. Draw chords from point O to each degree mark along the circle's circumference.
5. Transfer these chord lengths to a straight horizontal base line to form the Scale of Chords.
6. Label each division with its corresponding angle (in degrees).
7. This scale can now be used to set out angles without a protractor.

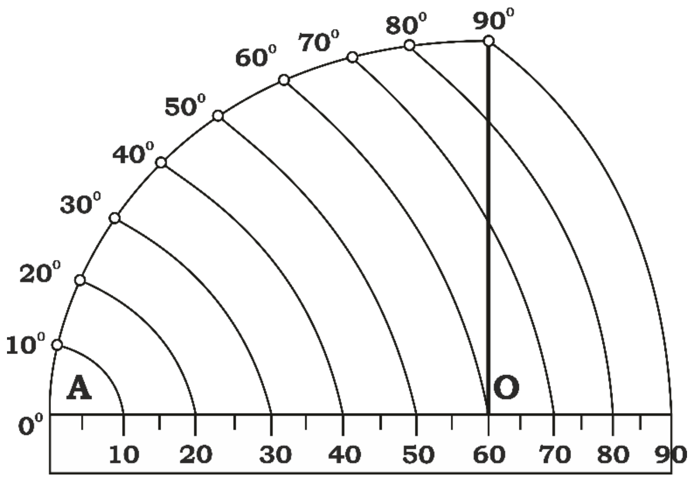


Fig. 1.28: Construction of Scale of Chords

CHECK YOUR PROGRESS

A. Answer the following questions

1. What is the purpose of a plain scale?
2. How would you classify a plain scale?
3. What conversion does a plain scale perform?
4. In what way is a plain scale usually segmented?
5. Which measurement units are commonly used on a plain scale?

B. Multiple Choice Questions

1. What does the Representative Fraction (R.F.) indicate in a technical drawing?
   a) The total drawing area

b) The thickness of the lines
c) The proportion between the drawing size and the real object size
d) The color scheme used in the drawing

2. In an R.F. of 1:50, what does the number 50 signify?
   a) 50 real-life objects
   b) 50 units on the drawing
   c) 50 units in actual size
   d) 50 scale divisions on the drawing
3. If the actual dimension of an object is 200 mm and its representation on the drawing is 20 mm, what is the Representative Fraction?
   a) 1:5
   b) 1:10
   c) 1:20
   d) 1:100
4. Which formula correctly calculates the Representative Fraction?
   a) Drawing length multiplied by actual length
   b) Actual length divided by drawing length
   c) Drawing length divided by actual length
   d) Drawing area divided by actual area
5. What is the primary benefit of using a diagonal scale?
   a) It reduces the overall size of drawings
   b) It improves color accuracy
   c) It allows for finer, more accurate measurements
   d) It simplifies the depiction of large objects

C. Fill in the blanks

1. A scale of chord is used to measure _____ dimensions in a circle or arc.
2. The scale of chord is based on the _____ length of an arc.
3. A chord is a straight line connecting two points on an _____.
4. The scale of chord is helpful for precise measurement of _____ in technical drawings.
5. The structure of a chord scale converts angular measurements into _____distances.

D. True or False

1. A diagonal scale is created by adding diagonal lines over a standard linear scale.
2. The main scale in a diagonal scale only displays fractional units.
3. The diagonal lines on the scale provide additional subdivisions representing fractions of a unit.
4. Each diagonal line corresponds to arbitrary or random measurement values.
5. Diagonal scales are useful for obtaining highly precise and fine measurement

MODULE 2	THEORY OF PROJECTION

Module Overview

This module provides essential foundational knowledge in engineering drawing, focusing on the interpretation and creation of technical representations. Students begin by constructing basic geometric shapes, emphasizing the correct and safe use of drawing tools. Key concepts such as orthographic projection is introduced, enabling learners to accurately depict three-dimensional objects in two-dimensional formats, with correct dimensioning and scaling techniques. The module explores both first-angle and third-angle projection systems that are critical standards in technical drawing. Through guided exercises, learners will also develop freehand sketching skills to improve their sense of proportion and visual accuracy.

Learning Outcomes

Upon successful completion of this module, you will be able to:

- Accurately draw fundamental geometric shapes using standard drafting tools, while adhering to proper safety practices.
- Read and produce orthographic projections of three-dimensional objects, applying correct dimensioning and scaling techniques.
- Identify the differences between first-angle and third-angle projection systems and use each method correctly based on drawing standards.
- Translate between isometric and orthographic views to effectively communicate the shape and structure of components from multiple perspectives.

Module Structure

In the Draughtsman (Mechanical) trade, precision and clarity are key parameters. The main sessions of the module are:

Session 1: Geometrical Figures Using Drawing Instruments
Session 2: Projection Planes and Principles of First and Third Angle Projections
Session 3: Principles of Orthographic Projection
Session 4: Free Hand Sketches of Simple Machine Parts with Correct Proportions
Session 5: Sectional Views of Orthographic Projections
Session 6: Conversion of Isometric views into orthographic projections and vice-versa

Session 1: Geometrical Figures Using Drawing Instruments

Before starting the session let us first understand how to use the drawing instruments safely.

1. Importance of Safety and General Precautions When Using Drawing Instruments

Drawing instruments are vital for producing accurate technical, mechanical, and engineering illustrations. To ensure both the precision of the drawings and the safety of the user, proper handling and maintenance of these tools are essential.

Why Safety Matters:

- **Avoiding Injuries:** Many drawing tools, such as compasses, dividers, cutters, and set squares, have sharp tips or edges. Mishandling these can result in cuts or puncture wounds. For instance, the pointed end of a compass must be handled cautiously.
- **Maintaining Attention:** Adequate lighting and correct sitting posture help reduce eye fatigue and physical discomfort, allowing users to stay focused during detailed work.
- **Ensuring Accuracy:** Safety practices also help maintain the condition and alignment of instruments, which directly influences the precision of measurements and drawings.

General Safety Precautions:

1. **Careful Handling of Sharp Tools:** Always handle items like compasses, cutters, and dividers with care. Keep sharp points protected when not in use and avoid pointing them toward yourself or others.
2. **Use a Stable Working Surface:** Ensure the drawing board is placed on a level, firm surface. A shifting board can compromise accuracy and lead to errors.
3. **Minimize Distractions:** Work in a quiet, organized space to maintain concentration, especially when using precise tools like rulers, protractors, and scales.
4. **Keep Instruments Clean:** Regularly clean tools to avoid buildup of dust or residue that can interfere with accurate measurements or leave unwanted marks on the sheet.
5. **Ensure Proper Lighting:** Good lighting is crucial for detailed drafting tasks. It helps reduce eye strain and enhances the visibility of fine lines.

6. **Maintain Good Posture:** Sit upright and at a comfortable height to avoid strain on the neck and back, particularly during long periods of drawing.
7. **Use Erasers and Markers Sparingly:** Excessive erasing or heavy use of markers may smudge the drawing or damage the sheet. Always erase gently and only when necessary.

2. Proper Care and Maintenance of Drawing Instruments

Drawing tools are precision instruments that can be costly. Regular maintenance and careful handling are essential to ensure they remain accurate and durable over time.

Tips for Maintaining Common Drawing Tools:

• Rulers and Scales:

- Keep them clean by wiping off dust and dirt regularly to maintain measurement accuracy.
- Use a soft brush or cloth to clean the surface.
- Store rulers and scales in protective sleeves or cases to prevent warping, bending, or scratches.

• Compasses and Dividers:

- Lightly oil the pivot joints to keep the movement smooth and rust-free.
- Always place a cap or protective cover over the pointed ends to prevent injury and tool damage.
- Tighten the adjusting screws to avoid instability or slippage during use.

• Set Squares and Protractors:

- Handle with care to avoid cracking or chipping edges and corners.
- Store flat in a safe space to avoid warping or accidental damage.

• Pencils and Erasers:

- Keep pencils sharp for clean, precise lines, preferably using a good-quality sharpener.
- Use erasers gently and only when necessary to avoid tearing or smudging the paper.

• Drawing Board:

- Regularly dust the board with a clean, dry cloth to maintain a smooth drawing surface.

- Protect it from extreme temperatures or moisture, as these can cause the board to warp or degrade over time.

3. Definition of Ellipse, Parabola, Hyperbola, Eccentricity, and General Methods of Their Construction

Conic Sections in Mechanical and Engineering Drawings

In mechanical and technical drafting, conic sections such as ellipses, parabolas, and hyperbolas play a vital role in illustrating complex component shapes and curves. A solid understanding of these curves, including their characteristics, definitions, and construction techniques, is essential for a Mechanical Draughtsman. These curves are often used in the design of gears, cams, reflectors, and aerodynamic components, where precision and accuracy are critical.

a) Ellipse:

Ellipse

An ellipse (Fig. 2.1) is a smooth, closed curve where the total distance from any point on the curve to two fixed points known as the foci remains constant.

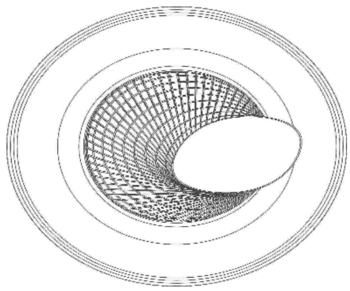


Fig. 2.1: Ellipse

- **Equation (Standard Form):**

  The Standard Equation of an Ellipse (Centered at Origin) is

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

  where,
  - a is the semi-major axis
  - b is the semi-minor axis
  - If a>b, the major axis is horizontal
  - If b>a, the major axis is vertical

Applications in Mechanical Drafting:

- Ellipses are used to represent sections of cones, gears, pulleys, and cylindrical parts in perspective.

Construction Method (Using the 'Focus' or 'String Method'):

(Refer Fig. 2.2)

- Fix two foci: Place two pins (foci) on the paper.
- Use a string: Attach a string to the pins and move a pencil along the string while keeping it taut.
- The path traced by the pencil is the ellipse.

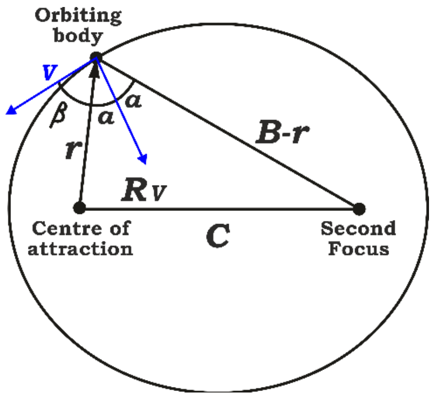


Fig. 2.2: Construction Method (Using the 'Focus' or 'String Method')

b) Parabola:

A parabola (Fig. 2.3 and Fig. 2.4) is a curve where every point is equidistant from a fixed point (focus) and a fixed line (directrix) (Refer equation from Fig. 2.4).

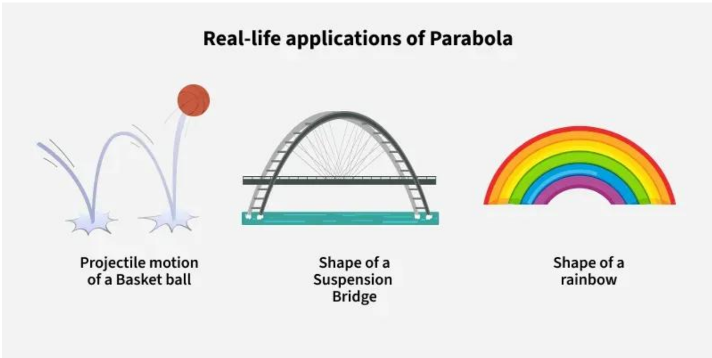


Fig. 2.3: Parabola Applications

Opening Right or Left (horizontal parabola):

$y^2 = 4ax$

Opens right if a>0, left if a<0

Vertex at (0,0)

Focus at (a,0)

Directrix x = -a

Opening Up or Down (vertical parabola)

$x^2 = 4ay$

Opens right if a>0, down if a<0

Vertex at (0,0)

Focus at (0, a)

Directrix y = -a

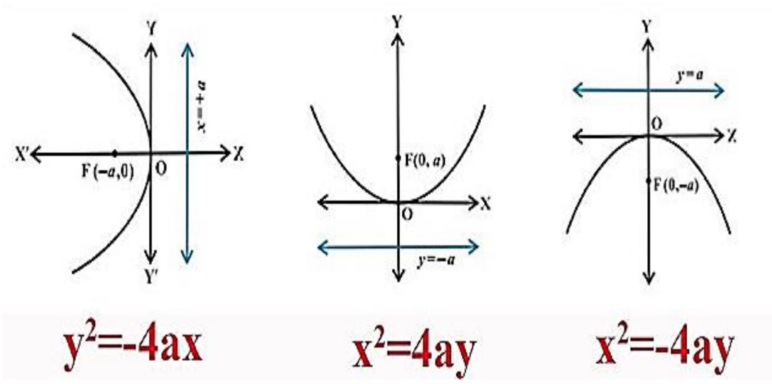


Fig. 2.4: Parabola Equations

Applications in Mechanical Drafting:

Parabolas are often used in reflecting surfaces or in parabolic gears.

Construction Method (Using the 'Directrix and Focus' Method) (Fig. 2.5):

1. Draw the directrix: A straight line parallel to the x-axis.

2. Mark the focus**:** Place a point (focus) a certain distance from the directrix.
3. Use the equidistant property**:** For every point on the curve, the distance from the focus is equal to the distance from the directrix.

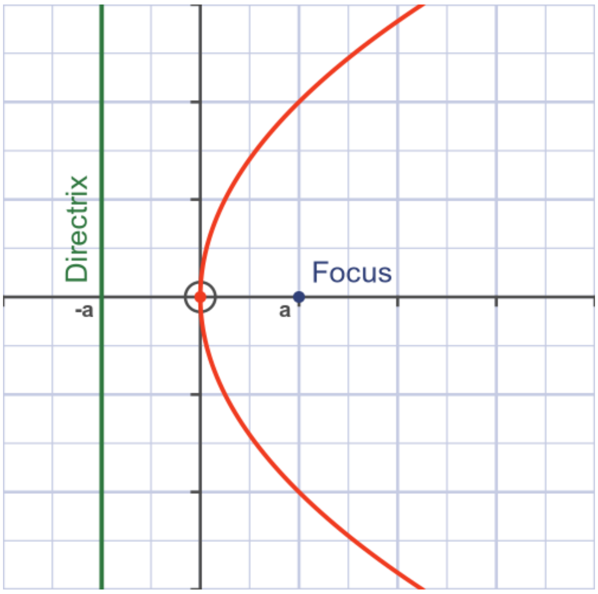


Fig. 2.5: Construction Method (Using the 'Directrix and Focus' Method)

c) Hyperbola:

A hyperbola (Fig. 2.6) is a curve where the difference in distances from any point on the curve to two fixed points (called foci) is constant.

Fig. 2.6: Practical Example of Hyperbola

Equation:

Horizontal hyperbola

$$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$$

Opens left and right

Centre at (0,0)

Transverse axis is along the x-axis

Foci at $(\pm c, 0)$, *where* $c^2 = a^2 + b^2$

Vertical hyperbola

$$\frac{y^2}{a^2} - \frac{x^2}{b^2} = 1$$

Opens up and down

Centre at (0,0)

Transverse axis is along the y-axis

Foci at $(0, \pm c)$, *where* $c^2 = a^2 + b^2$

Applications in Mechanical Drafting:

Hyperbolas are used in optics, acoustic applications, and some specialized mechanical designs involving motion paths.

Construction Method (Using the 'Foci' Method):

1. Fix two foci: Place two points (foci) on the drawing sheet (Fig. 2.7).
2. Mark constant difference: For any point on the curve, the difference in distances to the two foci is constant.
3. Trace the curve: Use a ruler to ensure that this constant difference is maintained while tracing the hyperbola.

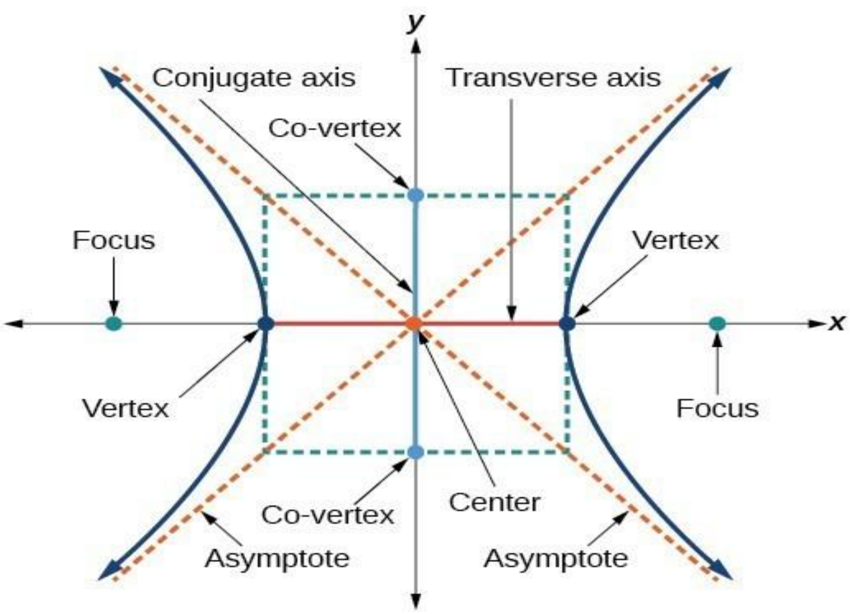


Fig. 2.7: Construction Method (Using the 'Foci' Method)

d) Eccentricity:

Eccentricity is a measure of how much a conic section deviates from being a perfect circle. It (Fig. 2.8) is defined as the ratio of the distance from the centre to the focus, divided by the distance from the centre to the vertex.

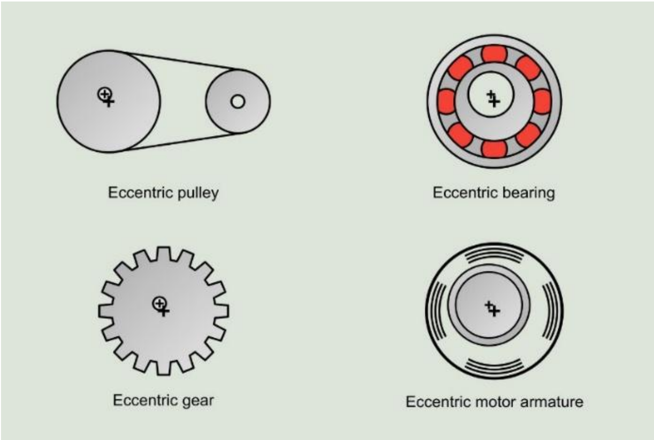


Fig. 2.8: Eccentricity

- **Formula for Eccentricity**:

  1. Ellipse

  e = $\sqrt{1 - \frac{b^2}{a^2}}$ where a > b

  0 < e < 1

  More eccentric, more stretched

  2. Hyperbola

  e = $\sqrt{1 + \frac{b^2}{a^2}}$

  e > 1

  More eccentric = wider opening

- **Applications**: Eccentricity determines the shape of the ellipse, with eccentricity = 0 representing a circle, and values approaching 1 indicating more elongated ellipses.

PRACTICAL EXERCISE

Activity: Construction of Polygons, Circles, and Line Division Using Drawing Instruments

Objective: To use standard drawing instruments for constructing regular polygons (up to 8 sides),

Materials Required:

- Drawing sheet
- Drawing board
- Drawing clips or masking tape
- Compass
- Ruler (scale)
- Divider
- Set squares
- Protractor
- T square
- Pencils (2H for construction, H or HB for final lines)
- Eraser

Part 1: Construction of Regular Polygons (Up to 8 Sides) on an Equal Base (Fig. 2.9)

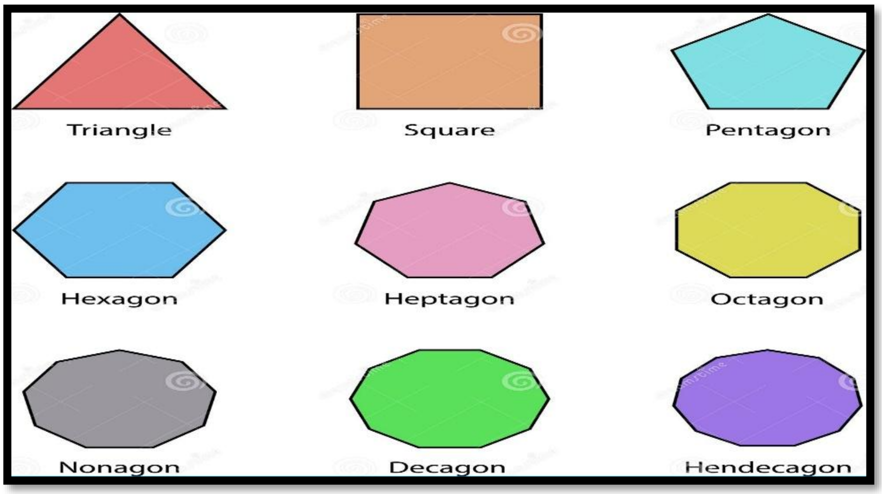


Fig. 2.9: Different Types of Polygons

Procedure:

1. Draw a base line of given length (e.g., 60 mm) using a scale.
2. Construct the following regular polygons on the same base length:
    - Triangle (Equilateral)
    - Square
    - Pentagon
    - Hexagon
    - Heptagon
    - Octagon
3. Use appropriate geometric methods:
    - Compass method for triangle and hexagon.
    - Angle method or external angle method for polygons with more than 6 sides.
4. Label each polygon clearly with its name and number of sides.

CHECK YOUR PROGRESS

A. Answer the following questions

1. Why is it essential to follow safety practices while handling drawing tools?
2. What precautions should be taken when working with sharp instruments like compasses and blades?
3. How does maintaining proper posture benefit you during long drawing sessions?
4. What is the role of adequate lighting in producing quality technical drawings?
5. What type of surface is best suited for placing a drawing board?

B. Multiple Choice Questions

1. Why is it important to maintain drawing instruments regularly?
   a) To add vibrant colors to drawings
   b) To boost artistic creativity
   c) To keep them working properly and extend their lifespan
   d) So a drawing board is no longer required
2. What is the correct method for cleaning rulers and measuring scales?
   a) Using soap and water
   b) Wiping with a soft cloth or brush

c) Scraping off dirt with sharp tools
d) Dipping them in oil

3. What should you do with compasses and dividers after using them?
a) Leave them open on the worktable
b) Store them in water to clean
c) Cover their pointed ends to avoid accidents
d) Place them near heat to dry
4. Why is it recommended to oil the pivot point of a compass or divider?
a) To add extra weight
b) Only to prevent rust
c) To allow smooth and easy movement
d) To loosen the joints completely
5. How can you ensure a compass or divider stays accurate while drawing?
a) Oil the pencil lead regularly
b) Leave the joints loose for flexibility
c) Keep the legs tightly fixed to avoid slipping
d) Sharpen the metal tips frequently

C. Fill in the blanks

1. An ellipse is a curve where the sum of the distances from any point on the curve to two fixed points called ______ is constant.
2. In the ellipse equation, 'a' represents the ______.
3. In the ellipse equation, 'b' represents the ______.
4. If a>ba > ba>b, the major axis is ______.
5. Eccentricity is a measure of how much a conic section deviates from being a ____.

D. True or False

1. A parabola is defined as a curve where each point is equally distant from a fixed point and a straight line.
2. The directrix is the name of the fixed point in a parabola.
3. Parabolic shapes are often found in components like reflective surfaces and certain gear types.
4. A hyperbola is a curve where the total distance from any point on it to two fixed points remains constant.
5. The two reference points used to draw a hyperbola are known as foci

Session 2: Projection Planes and Principles of First and Third Angle Projections

1. Concept of Quadrants (First, Second, Third, and Fourth Quadrant)

Understanding Quadrants in Engineering and Mechanical Drawing

In Mechanical and Engineering drawings, the idea of quadrants plays a crucial role in visualizing and positioning objects in space relative to the viewer. The projection system is based on a coordinate layout that is split into four distinct quadrants, each indicating a specific spatial arrangement. These quadrants help in determining how an object is projected onto a drawing plane, depending on its location in relation to the observer (Fig. 2.10).

Quadrants in Engineering Drawing

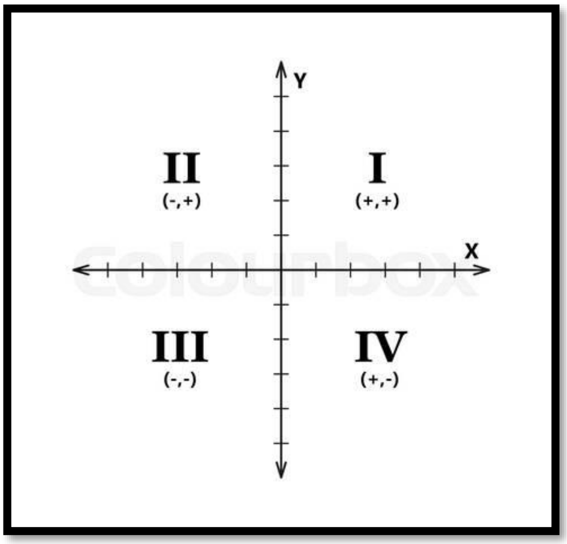


Fig. 2.10: Concept of Quadrants

1. **First Quadrant (Top-right):**
    - Both X and Y coordinates are positive in this quadrant.
    - This is the most frequently used quadrant in mechanical drawing because it represents objects located in the positive direction along both axes, making it ideal for typical component views.
2. **Second Quadrant (Top-left):**
    - Here, the X coordinate is negative while the Y coordinate remains positive.
    - Although it is less common in mechanical drafting, this quadrant can be useful in specific cases where negative X values need to be represented, such as specialized machine parts or unique design requirements.
3. **Third Quadrant (Bottom-left):**
    - Both X and Y coordinates are negative in this quadrant.
    - This area is rarely applied in standard mechanical drawings but may be relevant when depicting components or features positioned in negative regions on both axes, such as certain angular orientations.
4. **Fourth Quadrant (Bottom-right):**

- In this quadrant, X is positive and Y is negative.
- It is less commonly used but can serve specific purposes when representing objects with negative Y coordinates, useful in certain projections or custom component layouts.

2. Types of Projection Planes (Horizontal, Vertical, and Auxiliary Plane)

In technical and mechanical drawing, the choice of projection plane (Fig. 2.11) plays a crucial role in accurately representing 3D objects on a 2D surface. The projection plane helps in determining how the object is viewed and how the different views are oriented.

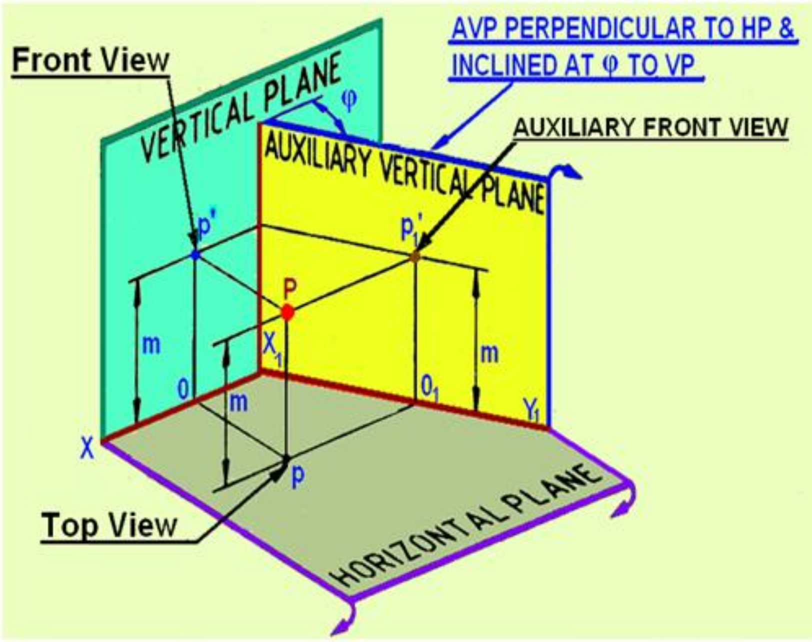


Fig. 2.11: Types of Projection Planes

Types of Projection Planes

1. **Horizontal Plane (HP):**
   - This plane lies parallel to the ground and is often called the ground plane or the XY plane.
   - In mechanical drawing, the top view of an object is projected onto this plane, offering a bird's-eye perspective of the object.
2. **Vertical Plane (VP):**
   - Positioned perpendicular to the horizontal plane, the vertical plane runs upright and is also known as the frontal plane or XZ plane.
   - The front view of an object is projected onto this plane, displaying how the object appears when viewed from the front.

3. **Auxiliary Plane:**
   - This plane is not part of the standard set and is introduced when features of an object cannot be adequately shown on the horizontal or vertical planes. It is typically angled or tilted.
   - The auxiliary view reveals details of inclined or slanted surfaces that are not fully visible in the primary top, front, or side projections.

3. Define Object, Observer, Reference Line, and Projector Rotation of Plane

When working with projections, it is essential to understand the relationship between the object, observer, and the projection plane (Fig. 2.12).

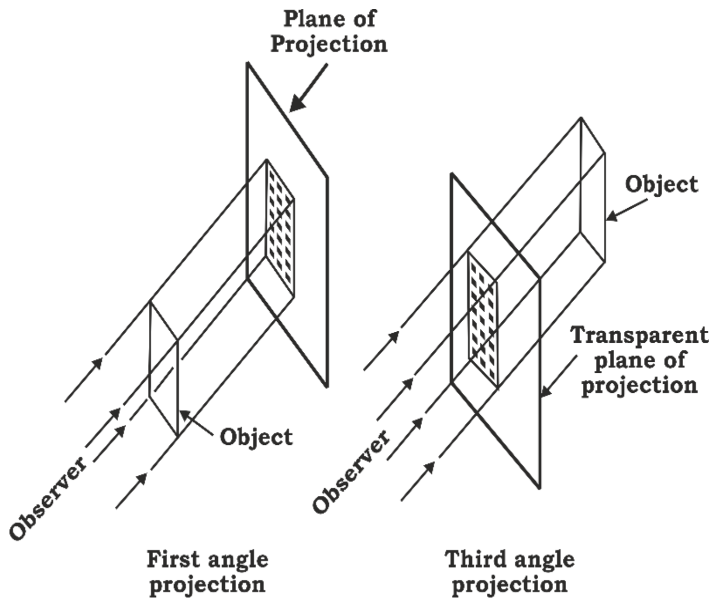


Fig. 2.12: Projections

Definitions:

1. **Object:**
   The object refers to the actual physical item or three-dimensional model being depicted in the drawing. In mechanical drafting, this can be any individual part, machine component, or complete assembly that needs to be illustrated.
2. **Observer:**
   The observer is the point of view or vantage from which the object is seen. The observer's position influences how the object is visually represented in the drawing. In orthographic projection, the observer is at an infinite distance, which results in parallel projection lines rather than converging ones.
3. **Reference Line:**

A reference line is usually a horizontal or vertical guideline used as a baseline on the drawing sheet. It helps establish the correct orientation and alignment of the various views, serving as a foundational point for laying out projections.

4. **Projectors and Rotation of Plane:**
    - **Projectors:** These are imaginary lines that show the direction in which features of the object are transferred onto the projection plane to create the drawing views.
    - **Rotation of Plane:** This refers to turning the object or the projection plane around a certain axis relative to the observer to produce different views. For example, rotating the plane can change a top view into a side view, revealing additional details of the object from multiple angles.
5. **First, Second, Third, and Fourth Angle Projections:**

   Orthographic projection in mechanical drawing involves representing a 3D object in 2D by projecting its views onto different planes. The angle projection type determines the arrangement and positioning of these views on the drawing sheet, affecting how the object's different faces are displayed relative to one another.

First Angle Projection:

- In first angle projection, the object is situated in the first quadrant, meaning the projection planes are placed between the observer and the object.
- **Arrangement on Drawing:** The front view appears at the top, the top view is placed below the front view, and the side view is shown to the right of the front view.
- **Common Regions:** This method is predominantly used in Europe, India, and Australia.

Second Angle Projection:

- The second angle projection involves placing the object in the second quadrant, but it is rarely utilized in practice.
- **Drawing Characteristics:** Although theoretically feasible, this approach often causes overlapping views and confusion, so it is generally avoided in technical drafting.
- **Practical Use:** It is not widely adopted due to its limitations.

Third Angle Projection:

- Third angle projection places the object in the third quadrant with the projection planes between the observer and the object.

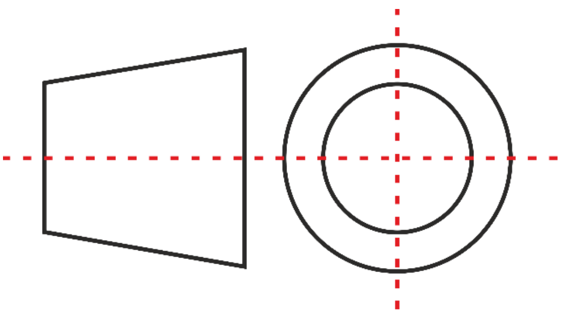
- **Layout:** The front view is located at the top, the top view is positioned above the front view, and the side view is placed to the left of the front view.
- **Regions of Use:** This projection technique is commonly followed in the United States, Canada, and Mexico.

Difference between First and Third Angle Projections (Table 2.1 and Fig. 2.13):

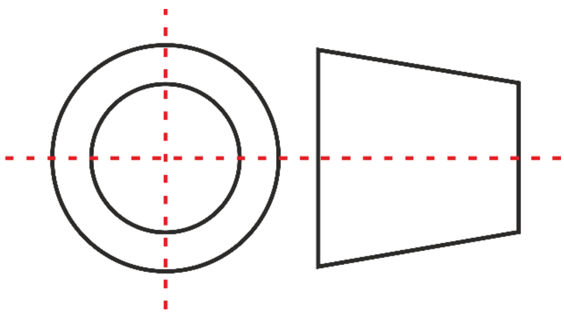
- **First Angle:** The views are arranged differently, and the top view is placed below the front view, while the side view is placed on the opposite side.
- **Third Angle:** The views are placed in a more conventional way, with the top view above the front view, and the side view to the left.

Table 2.1: First Angle Vs Third Angle Projection

First angle Projection	Third angle projection
Object is placed in First Quadrant i.e., above HP and in front of VP	Object is placed in Third Quadrant. i.e., Below HP and behind VP.
Object is in between the plane and observer	Plane is in between the object and observer
Front view is drawn above the reference line	Front view is drawn below the reference line
Top view is arranged vertically below the front view	Top view is arranged vertically above the front view.
Side view is horizontally aligned with the front view. But left side view is drawn on the right side of the front view and the right-side view is drawn on the left side of front view.	Side view is horizontally aligned with the front view. But the left side view is placed on the left side of front view and the right-side view symbol is placed on the right side of front view.



i) First Angle Projection



ii) Third Angle Projection

Fig. 2.13: First and Third Angle Projections

5. Top View, Front View, and Side View

The top view, front view, and side view are the standard views used in orthographic projection to represent a 3D object on a 2D plane. These views help to depict different aspects of the object clearly and in a standardized manner (Fig. 2.14).

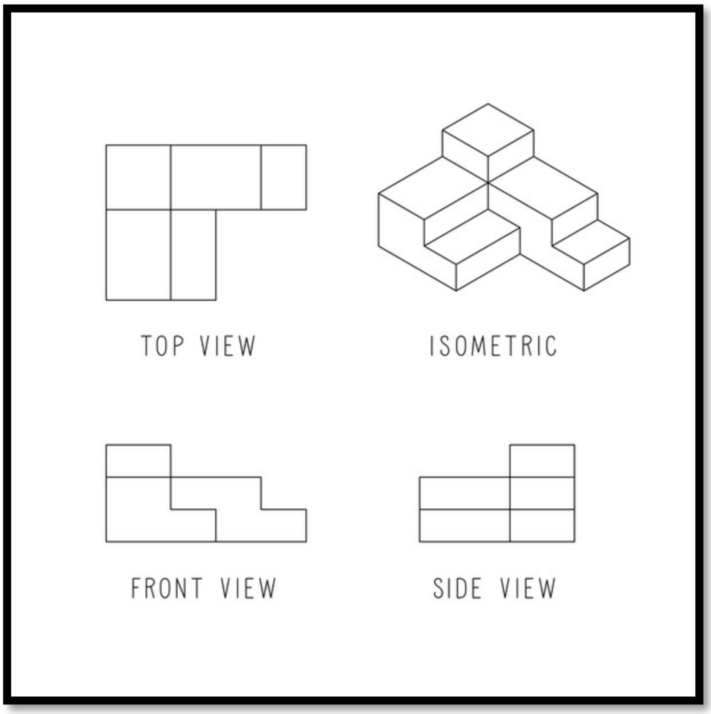


Fig. 2.14: Views (Front, top and side)

Top View:

- The top view, often called the plan, shows the object as seen from directly above, projected onto the horizontal plane (HP).
- **In Mechanical Drawings:** This perspective reveals the width and depth of the object, providing a clear layout of its overall shape. For example, mechanical parts such as gears or motors are commonly represented in this view to illustrate their footprint and dimensions.

Front View:

- The front view displays the object as observed from the front, projected onto the vertical plane (VP).
- **In Mechanical Drawings:** This is usually the primary view, showing the object's height and width. It effectively communicates the shape and key features of the component. For instance, the front view of a machine frame highlights its height and structural details.

Side View:

- The side view depicts the object as seen from either side, projected onto a plane perpendicular to both the horizontal and vertical planes.
- **In Mechanical Drawing:** This view focuses on the depth and height of the object, helping to show thickness and profiles. For example, the side view of a shaft reveals its length and features such as keyways or splines.

PRACTICAL EXERCISE

Activity: Projection of Points, Lines, and Planes in Different Quadrants with Rotation of Planes

Objective: To understand and draw the four quadrants, project points in different quadrants, perform rotation of planes, and draw projections of lines and planes in various positions within the First and Third quadrants as per orthographic projection principles.

Materials Required:

- Drawing sheet
- Drawing board
- Drawing clips or masking tape
- Pencils (2H for construction lines, H or HB for final lines)
- Eraser
- T square
- Set squares
- Compass
- Protractor
- Scale (ruler)

Part 1: Drawing Quadrants and Projection of Points

Procedure:

1. **Draw the Four Quadrants (Fig. 2.15):**
    - Draw the Reference Line (XY line) horizontally in the centre of the sheet.
    - `Divide the sheet into four quadrants around this reference line:
        - Above XY and in front of VP → First Quadrant
        - Below XY and in front of VP → Second Quadrant (used less in mechanical drawing)
        - Below XY and behind VP → Third Quadrant
        - Above XY and behind VP → Fourth Quadrant (used less in mechanical drawing)

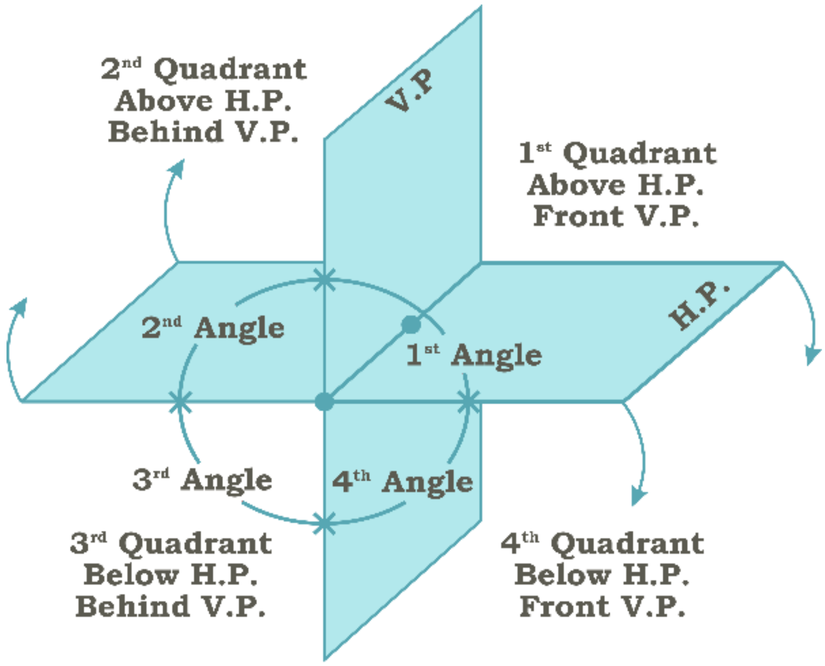


Fig. 2.15: Four Quadrants

2. **Mark and Project Points in Different Quadrants:**

   - Place points A, B, C, and D in each quadrant.
   - Project their Front View (FV) and Top View (TV) based on their relative position to HP and VP.
   - Label views properly (e.g., a', a).

A point (A) above HP and in front of VP (first quadrant)- Fig. 2.16

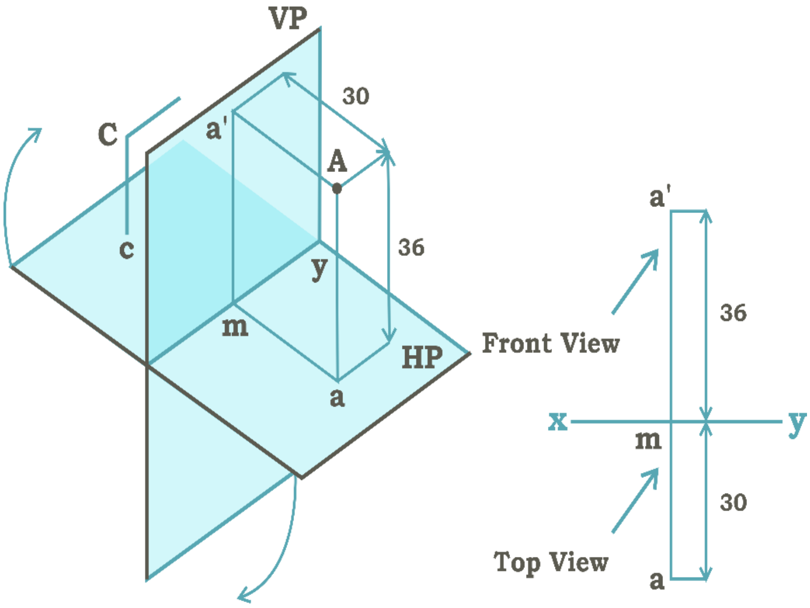


Fig. 2.16: First quadrant

A point (C) above HP and behind VP (Second quadrant)- Fig. 2.17

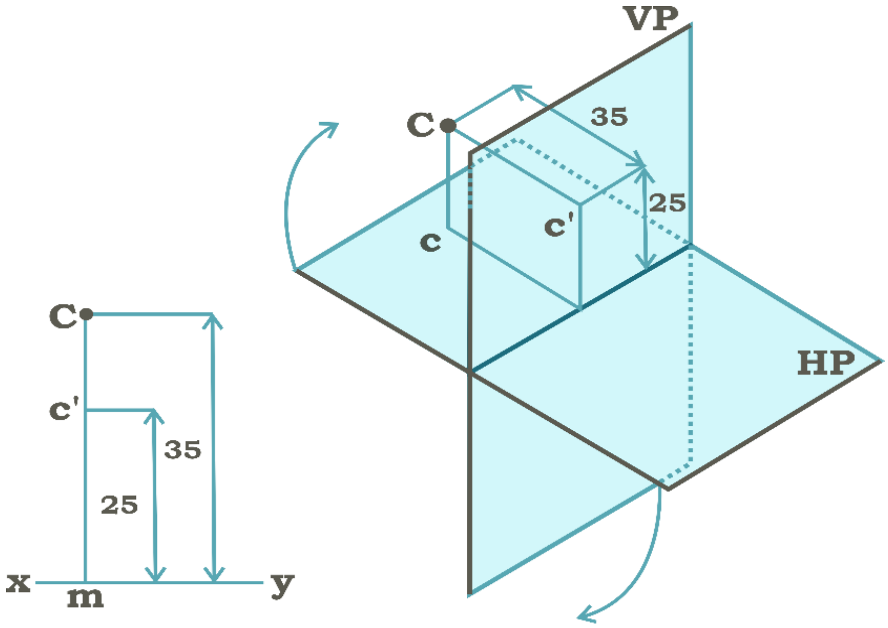


Fig. 2.17: Second quadrant

A point (C) below HP and behind VP (3rd Quadrant)- Refer Fig. 2.18:

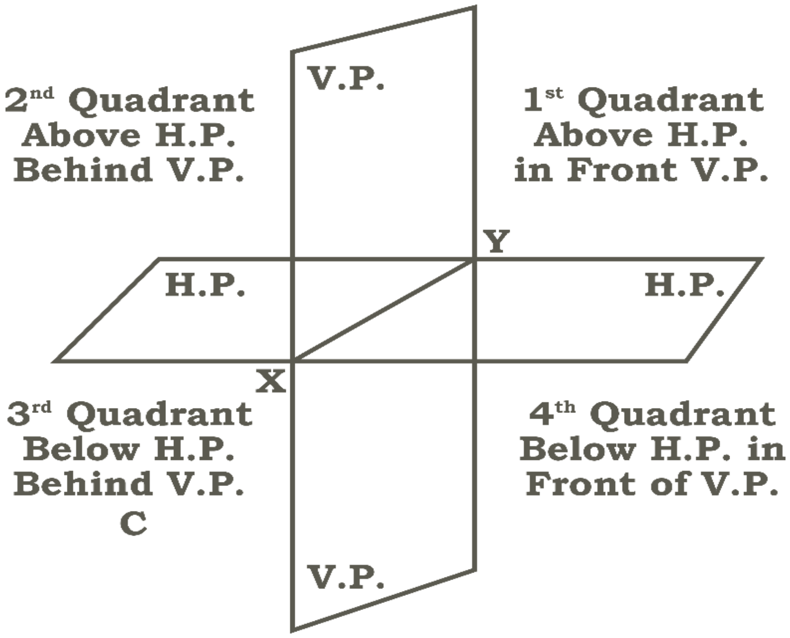


Fig. 2.18: Third Quadrant

A point (D) below HP and in front of VP (4th Quadrant)-Refer Fig. 2.19:

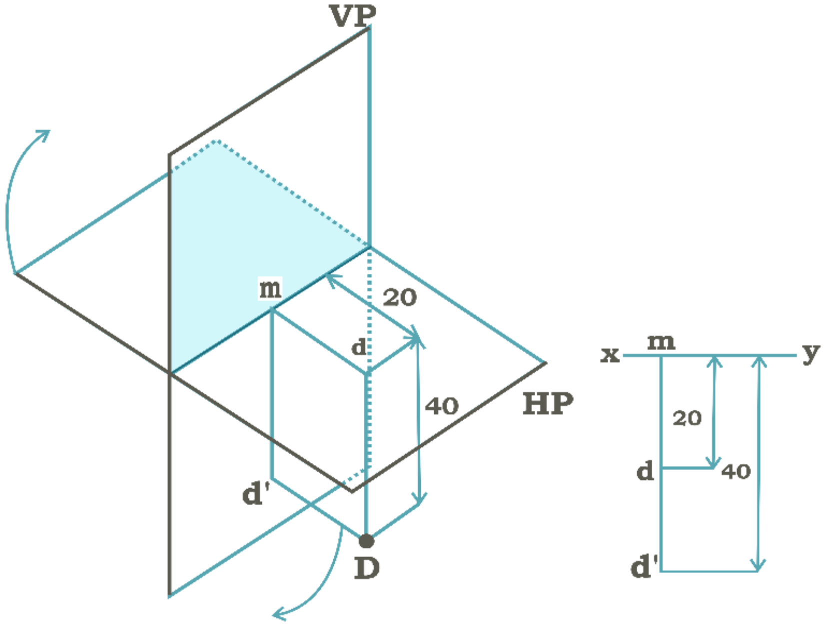


Fig. 2.19: Fourth Quadrant

CHECK YOUR PROGRESS

A. Answer the following questions

1. How many quadrants are there in the coordinate system used in engineering drawings?
2. Which quadrant has positive values for both X and Y coordinates?
3. What are the signs of the X and Y coordinates in the second quadrant?
4. Which quadrant has negative values for both X and Y coordinates?
5. What are the signs of the X and Y coordinates in the fourth quadrant?

B. Multiple Choice Questions

1. What is the primary use of the horizontal plane (HP) in mechanical drawings?
   a) Front view
   b) Side view
   c) Top view
   d) Isometric view
2. Which plane is positioned perpendicular to the horizontal plane?
   a) Auxiliary plane

b) Vertical plane
c) Diagonal plane
d) Oblique plane

3. What purpose does the auxiliary plane serve in engineering drawings?
   a) Shows the top view from the side
   b) Displays the standard front view
   c) Represents details of inclined or slanted surfaces
   d) Creates a 3D wireframe model
4. Which plane is commonly referred to as the ground or XY plane?
   a) Vertical plane
   b) Horizontal plane
   c) Auxiliary plane
   d) Oblique plane
5. The vertical plane is also called the ______.
   a) Ground plane
   b) Side plane
   c) Frontal plane
   d) Top plane

C. Fill in the blanks

1. The ______ is the physical or 3D model being represented in a drawing.
2. In mechanical drafting, the object can be a part, machine component, or ______.
3. The ______ is the viewpoint or position from which the object is observed.
4. The ______ line is a baseline used to determine the orientation and position of views.
5. Rotating the projection plane helps shift the view from a top view to a ______ view.

D. True or False

1. In First Angle Projection, the object is positioned in the first quadrant.
2. The projection planes are located behind the object in First Angle Projection.
3. Second Angle Projection is commonly used in engineering drawings.
4. The object is positioned in the second quadrant in Second Angle Projection.
5. Third Angle Projection places the object in the third quadrant.

Sessions 3: Principles of Orthographic Projection

1. Principle of Orthographic Projection

Orthographic projection is a technique used to depict three-dimensional objects on a two-dimensional plane (Fig.2.20). It is widely adopted in Engineering and Mechanical drawings because it delivers precise and clear views of an object's dimensions and details.

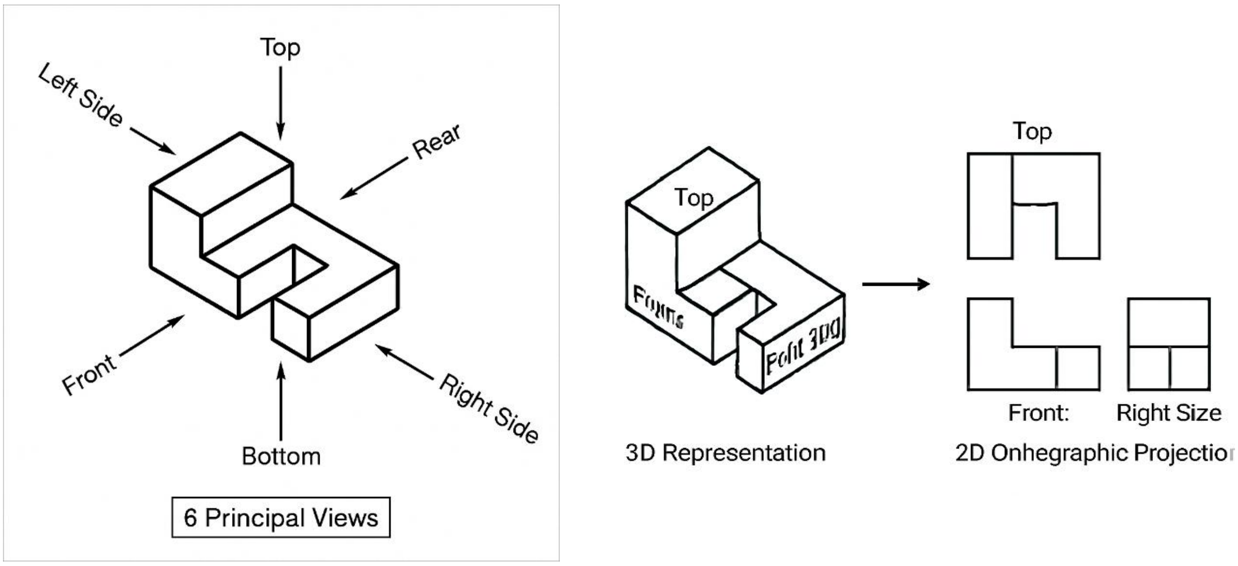


Fig. 2.20: Principle of Orthographic Projection

Basic Concept:

- Orthographic projection is the process of representing the features of a 3D object onto a flat 2D surface by projecting views from different directions, typically the front, top, and side.
- The fundamental principle involves viewing the object from these directions, with projection lines (projectors) drawn perpendicular to the plane of projection and parallel to each other.
- This approach preserves the true dimensions and shape of the object without any distortion or change in scale, which is crucial for accurate manufacturing and assembly.

Process:

- **Projection Planes:** The object is positioned either in the first quadrant (for first angle projection) or the third quadrant (for third angle projection), with the observer considered to be infinitely far from the object.
- The main views produced are:
    - **Front View:** Displays the object as seen from the front.
    - **Top View:** Displays the object as viewed from above.
    - **Side View:** Displays the object from one side.
- **Alignment of Views:** The arrangement of these views on the drawing sheet follows specific rules depending on whether the first angle or third angle projection method is used.

2. Projection of Solids (Cylinder, Prisms, Cones, Pyramids, and Their Frustums)

In mechanical drafting, the ability to represent three-dimensional solids in two-dimensional views is a fundamental skill. Projecting common solids like cylinders, prisms, cones, pyramids, and their truncated forms (frustums) enables draughtsmen to clearly illustrate complex shapes. This process ensures that engineers, manufacturers, and other professionals receive precise and comprehensible representations necessary for design and production (Fig. 2.21).

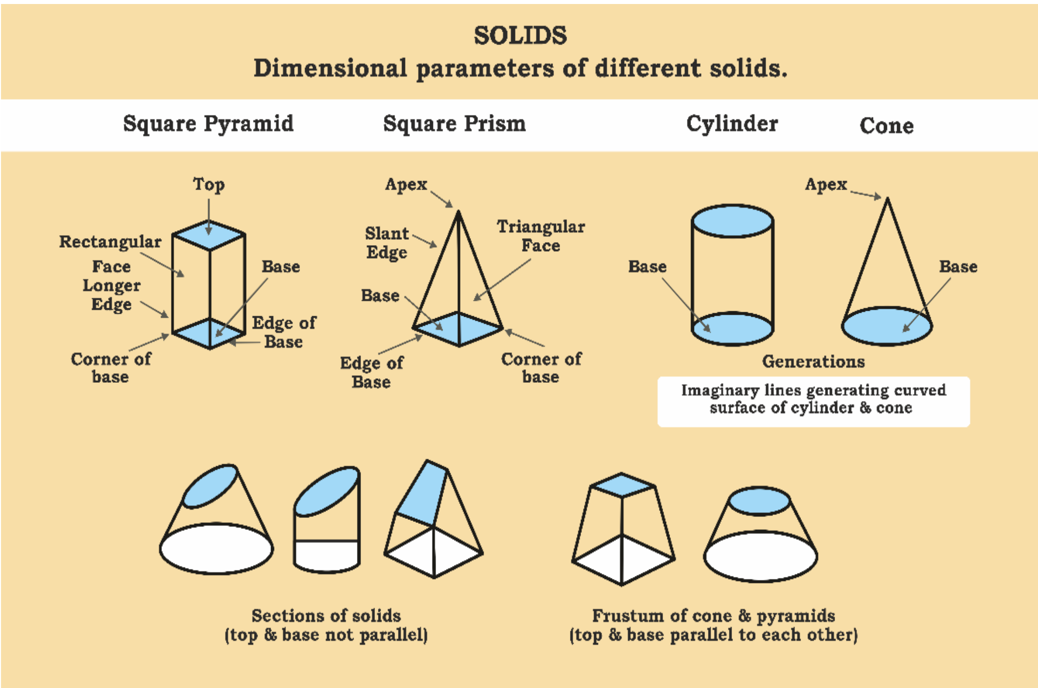


Fig. 2.21: Solids

Projection of a Cylinder:

A cylinder is a three-dimensional solid characterized by two parallel circular bases connected by straight, perpendicular sides.

- **Top View:** When viewed from above, a vertically standing cylinder is represented as a circle, showing the diameter of its circular base.
- **Front View:** The front projection of a vertical cylinder appears as a rectangle, where the height corresponds to the cylinder's height and the width matches the diameter of the base.
- **Side View:** Similar to the front view, the side view of a vertical cylinder is also a rectangle. However, if the cylinder is laid horizontally, the side view will display a circle (the base), while the top view will show a rectangular shape corresponding to the length and diameter of the cylinder.

A cylinder of diameter 30 mm and axis length 50 mm is resting on the HP on a point so that its axis is inclined at 45^0 to the HP and parallel to the VP. Draw its top and front views (Fig: 2.22).

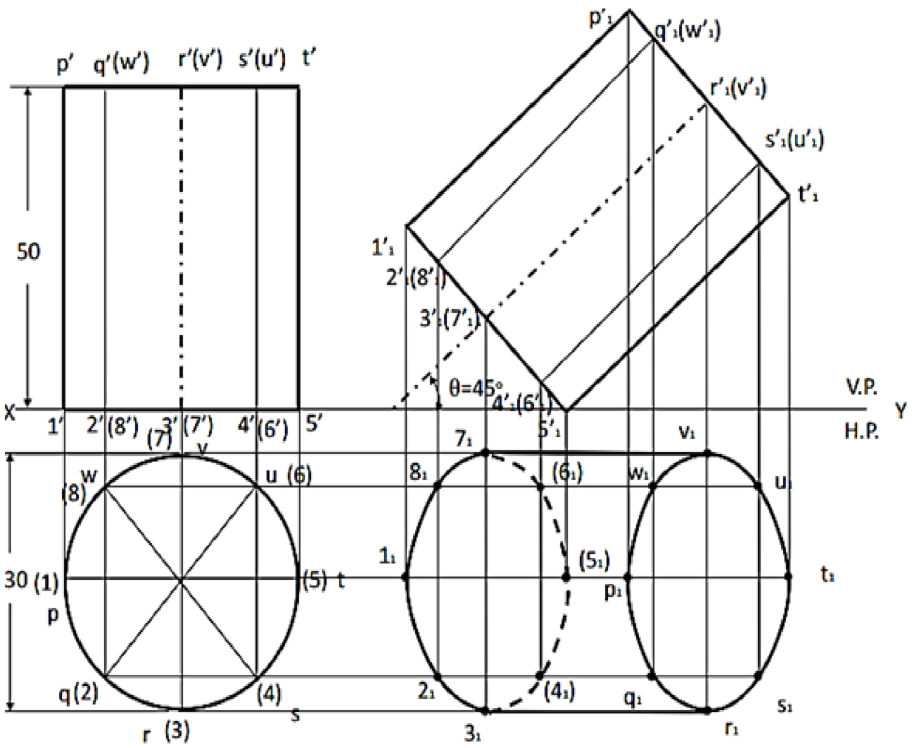


Fig. 2.22: Projection of a Cylinder

Projection of Prisms:

A prism is a solid figure characterized by two parallel, congruent polygonal bases connected by rectangular faces.

- **Top View:** The top projection displays the shape of the prism's base polygon, such as a triangle, square, or hexagon.
- **Front View:** This view shows the prism's height along with the shape of the base as seen from the front angle.
- **Side View:** Similar to the front view, the side view reveals the height and the profile of the base polygon.

For instance, a square prism (or rectangular box) appears as a square in the top view, while both the front and side views are depicted as rectangles showing the height and base dimensions.

A prism is a polyhedron having two equal and similar end faces called top face and bottom face joined by other faces which may be rectangles or parallelograms (Fig. 2.23). The imaginary line joining the centres of the faces is called the Axis.

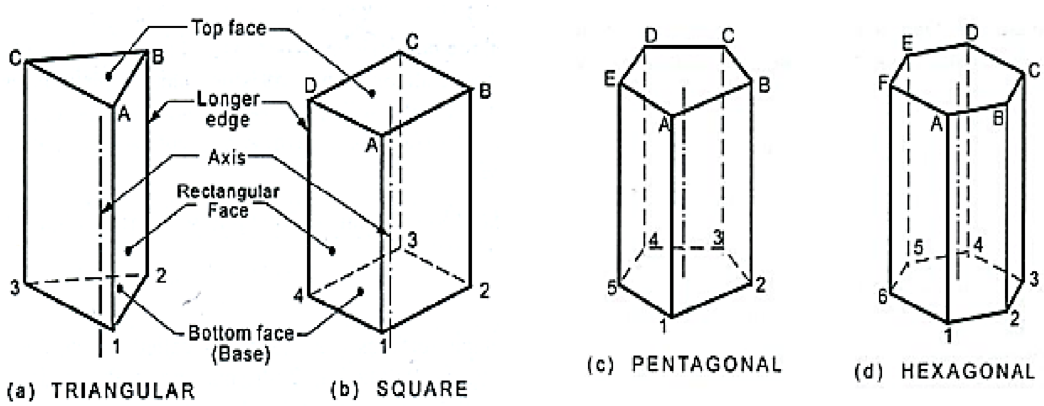


Fig. 2.23: Prisms Examples

Let us try: A square prism of base side 35 mm and axis length 60 mm rests on one of its base edges on the HP with its axis inclined at 30° to the HP and parallel to the VP. Draw its top and front views (Fig. 2.24).

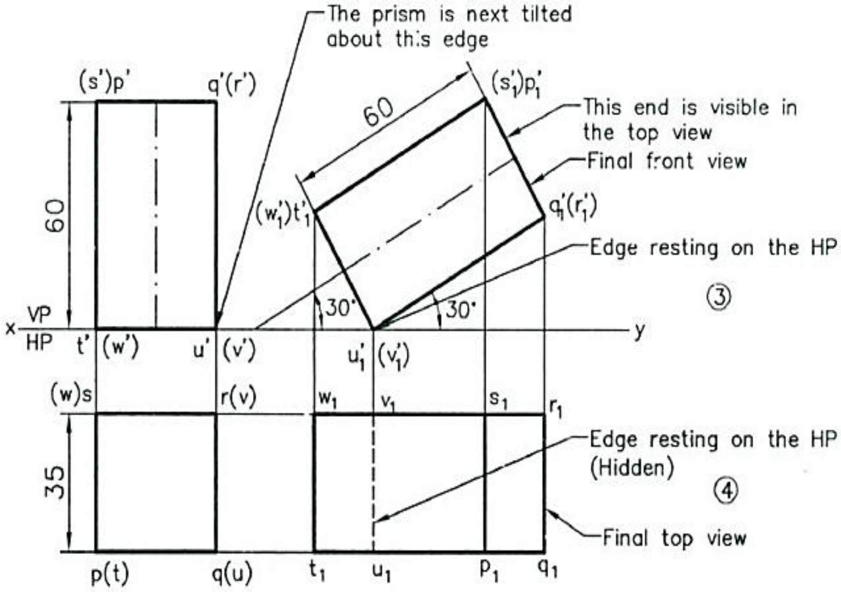


Fig. 2.24: Projection of Prisms

Projection of Cones:

A cone is a three-dimensional shape with a circular base that narrows to a single tip known as the apex.

- **Top View:** When viewed from above, the cone appears as a circle, representing its base.
- **Front View:** Viewed from the front, the cone takes the form of a triangle, with the apex at the top and the base width equal to the diameter of the circular base.
- **Side View:** The side view is similar to the front, showing a triangle of the same size.

For instance, if the cone stands upright, its top view is a circle, and the front view is a triangle. If the cone is inclined, the top view will still be circular, but the front view may look like an ellipse due to the tilt.

Projection of Pyramids:

A pyramid is a solid figure characterized by a polygon-shaped base and a single apex located directly above the center of the base.

- **Top View:** The top view displays the outline of the polygonal base.
- **Front View:** The front view appears as a triangle, with the apex positioned at the top and the base shape visible at the bottom.

- **Side View:** Similar to the front view, the side view also shows a triangular shape with the apex at the top.

For example, in the case of a square pyramid, the top view will reveal a square, while both the front and side views will present triangular shapes.

A pyramid is a polyhedron having a plane figure for its base and equal number of isosceles triangular faces meeting at a point called vertex or apex (Fig. 2.25).

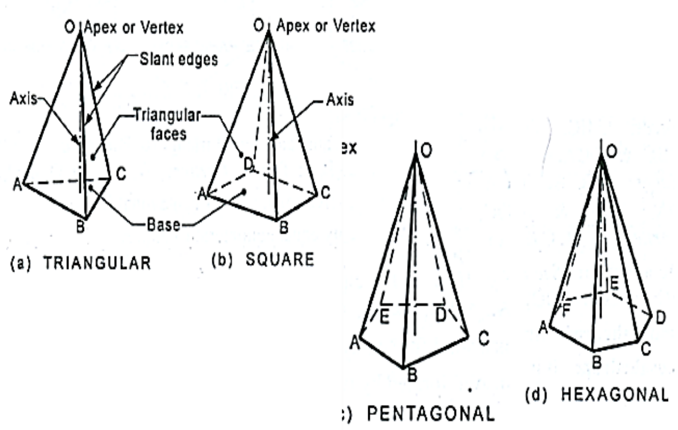


Fig. 2.25: Pyramids Examples

A square pyramid of base side 60 mm and altitude 100 mm lies on the HP on one of its triangular faces with its axis parallel to the VP. Draw its projections (Fig. 2.26).

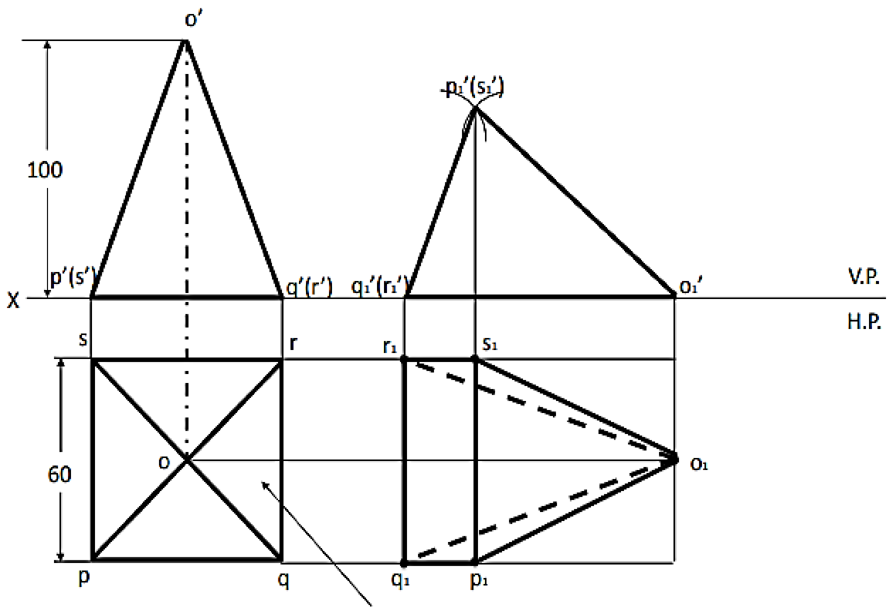


Fig. 2.26: Projection of Pyramids

Projection of Frustums:

A frustum is created by cutting the top off a pyramid or cone with a plane parallel to its base, resulting in a truncated solid.

- **Top View:** The top view shows a smaller polygon or circle, depending on whether the original solid was a pyramid or a cone.
- **Front View:** The front view displays a trapezoidal shape for a pyramid frustum or a truncated triangle for a cone frustum.
- **Side View:** Similar to the front view, the side view also presents a trapezoid for a pyramid frustum or a truncated triangle for a cone frustum.

Frustum: When a pyramid of a cone is cut by a cutting plane parallel to its base, the remaining portion thus obtained after removing the top portion is called the Frustum (Fig. 2.27):

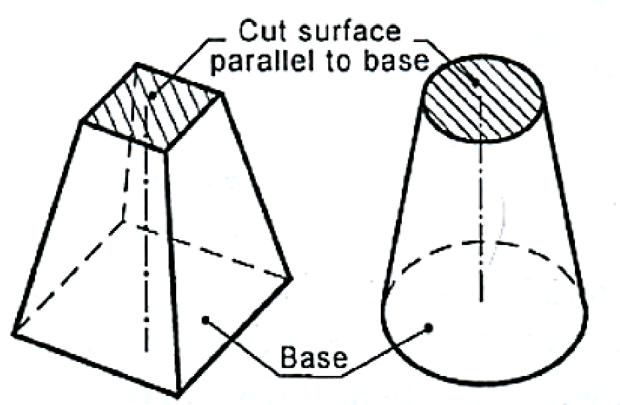


Fig. 2.27: Frustum of Pyramid and Cone

PRACTICAL EXERCISE

Activity Title: See It from All Sides – Exploring Solid Projections

Objective: Students will visualize and draw 2D projections (top, front, and side views) of 3D solids such as cylinders, cones, prisms, pyramids, and their frustums.

Materials Needed:

- Simple 3D objects (or paper models) like:
  - Toilet paper roll (cylinder)
  - Ice cream cone (cone)
  - Pencil box (rectangular prism)

  - Tent model (pyramid)
  - Paper frustum model (can be made by cutting the top off a cone/pyramid)
- Graph or plain paper
- Pencil, ruler, eraser
- Colored pens (optional)
- Printable worksheet (optional)

Activity Steps:

Part 1: Solid Observation

1. Divide students into groups and give each group one solid model.
2. Ask students to observe the object from:
   - Top View (looking straight down)
   - Front View (from the front)
   - Side View (from the side)

Part 2: Drawing Projections

3. On graph paper or worksheet:
   - Draw the Front View (what they see from the front).
   - Draw the Top View (what they see from above).
   - Draw the Side View (from the right or left side).
4. Label the views and major features (like height, radius, slant edges, etc.).

Example: Cylinder (Fig. 2.28)

- Front View: Rectangle (height and diameter)
- Top View: Circle
- Side View: Rectangle (same as front)

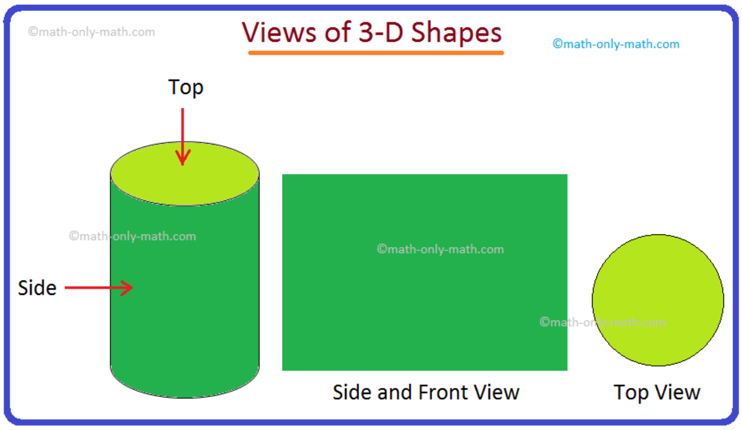


Fig. 2.28: Cylinder views

Example: Pyramid (Fig. 2.29)

- Front View: Triangle
- Top View: Square with diagonals (showing center)
- Side View: Triangle (different angle)

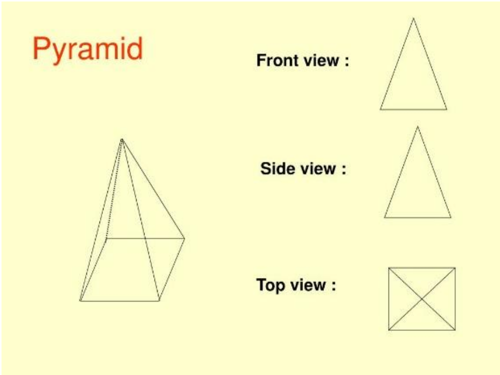


Fig. 2.29: Pyramid views

Learning Outcomes:

- Recognize how 3D objects are represented in 2D.
- Improve spatial understanding and visualization.
- Learn to differentiate between various types of projections.

CHECK YOUR PROGRESS

A. Answer the following questions

1. What is the definition of orthographic projection?
2. Why is orthographic projection commonly used in engineering drawings?
3. In orthographic projection, how are the projection lines positioned?
4. What are the three primary views represented in orthographic projection?
5. What are the two main types of orthographic projection techniques?

B. Multiple Choice Questions

1. What shape is seen in the top view of a vertical cylinder?
   a) Rectangle
   b) Triangle
   c) Circle
   d) Square

2. How does the front view of a vertical cylinder appear in an orthographic projection?
   a) Square
   b) Rectangle
   c) Circle
   d) Ellipse
3. When a cylinder is placed horizontally, what does the side view display?
   a) Triangle
   b) Circle
   c) Rectangle
   d) Ellipse
4. Which view illustrates the height of a vertical cylinder?
   a) Top View
   b) Side View
   c) Front View
   d) Isometric View
5. What characteristic do cones and pyramids share in their projections?
   a) Both have rectangular bases
   b) Both have circular top views
   c) Both taper to a single point
   d) Both display identical side views

C. Fill in the blanks

1. A prism is a solid object with two _________, identical polygonal bases.
2. The top view of a prism shows the shape of the _________ base.
3. A cone has a circular base and a single _________.
4. The top view of a cone is a _________.
5. The top view of a pyramid shows the shape of the _________ base.

D. True or False

1. A frustum is created by slicing a pyramid or cone horizontally, removing the top portion.
2. The top view of a cone frustum appears as a smaller circle compared to the base.
3. In the front view, a pyramid frustum is shown as a trapezoid.
4. The side view of a cone frustum displays a complete triangular shape.
5. Frustums are commonly depicted in technical drawings to illustrate objects with tapered ends.

Session 4: Free Hand Sketches of Simple Machine Parts with Correct Proportions

1. Techniques for Freehand Sketching of Machine Parts

Freehand sketching is a vital skill in mechanical drafting, allowing engineers, designers, and draftsmen to quickly capture ideas or rough concepts of machine components. It facilitates visualization before producing detailed technical drawings. Below are common methods employed in freehand sketching of machine parts:

Key Techniques:

1. **Isometric Sketching:**

   This method depicts a three-dimensional object on a two-dimensional plane, where the three principal axes (length, width, and height) are drawn at equal angles of 120° to each other.

   Use: It is widely used to create quick 3D visualizations of machine parts such as gears, shafts, and flanges, helping to understand their overall form.

2. **Orthographic Sketching:**

   Orthographic sketches represent an object through multiple views-usually the front, top, and side-to accurately show the shape and size from different angles.

   Use: This method is ideal for parts that require precise dimensions and clarity, such as brackets, plates, and mounts.

3. **Oblique Sketching:**

   Oblique projection displays the front face of an object in true shape, while the depth is shown at an angle, often 45°.

   Use: Useful for simpler depth visualization of components like pulleys, gears, and sprockets where a straightforward 3D effect is desired.

4. **Sectional Sketching:**

   Sectional sketches illustrate a cut-through view of an object, exposing its internal details.

Use: Applied to complex parts like valves, motors, and compressors to reveal inner features not visible from the outside.

5. **Proportional Sketching:**

   This approach emphasizes maintaining the relative sizes of different parts of a component without precise measurements.

   Use: Suitable for rough conceptual sketches or layouts where exact scale is not critical.

6. **Freehand Detailing:**

   Once rough sketches are laid out, finer elements such as holes, threads, fillets, and surface finishes are added freehand to enrich the drawing.

   Use: Important for adding realistic details to sketches, making them more useful for subsequent detailed drawings or manufacturing.

2. V Threads and Square Threads

Threads play a crucial role in mechanical systems, serving functions such as fastening, adjustment, and transmitting rotational motion between parts. The choice of thread type depends on factors like the intended application, the amount of load to be supported, and how the thread will be manufactured.

V Threads (or ISO Threads):

- V threads are the most commonly used type of threading, characterized by a V shaped profile with a 60° included angle (Fig. 2.30).

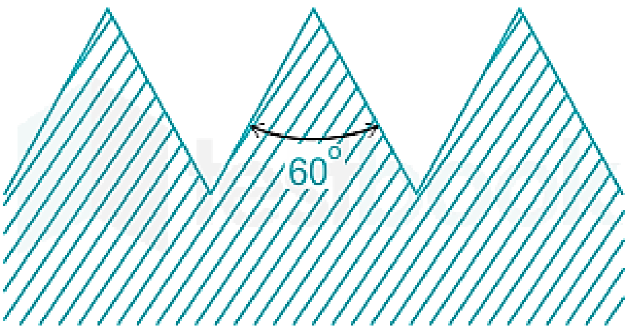


Fig. 2.30: V Threads

Application: V threads are commonly employed in bolts, nuts, and screws where high resistance to tensile and shear forces is needed. They are extensively used across industries like machinery manufacturing, construction, and automotive engineering due to their strength and reliability.

Square Threads:

- Square threads have a square shaped profile, where the sides of the thread are perpendicular to the axis of the shaft, providing a greater contact area (Fig. 2.31).

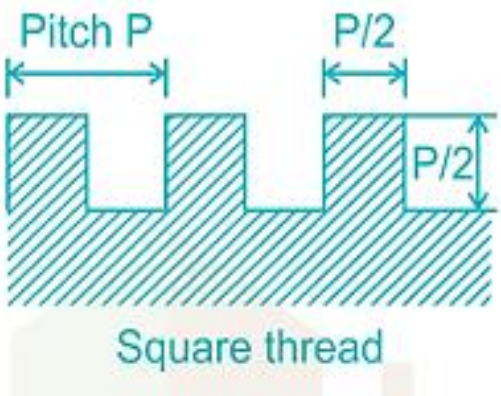


Fig. 2.31: Square Threads

Application: Square threads are primarily utilized in power transmission systems, such as lead screws in lathes, because they efficiently convert rotational motion into linear movement.

3. **Hexagonal Headed and Square Headed Bolt, Stud, Washer, and Nut Symbols of Machine Components**

   In mechanical drafting, standardized symbols are employed to depict different machine components in a clear and concise manner. These symbols play a vital role in ensuring effective communication between designers and manufacturers. Below are some of the commonly used symbols representing bolts, studs, washers, and nuts:

   Hexagonal Headed Bolt:

- A hexagonal headed bolt has a head with six flat sides. This shape allows for easy gripping with a wrench or spanner (Fig. 2.32).

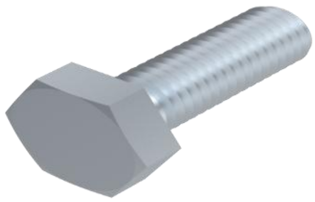


Fig. 2.32: Hexagonal Headed Bolt

Symbol: The bolt is depicted using a hexagon to symbolize its head, accompanied by a line to illustrate its shaft. Generally, the bolt's head is shown from a top or front perspective, whereas the shaft is presented in a side view.

Square Headed Bolt:

- A square headed bolt is similar to the hexagonal headed bolt, except it has a square head for use with a wrench or spanner (Fig. 2.33).

Fig. 2.33: Square Headed Bolt

Symbol: The bolt head is illustrated as a square in the drawing, while the shaft is depicted by a simple line. This representation is often used for bolts designed to handle higher torque loads.

Stud:

- A stud is a type of fastener that is similar to a bolt but has threads at both ends. It is often used in places where bolted connections are difficult to install or remove (Fig. 2.34).

Fig. 2.34: Studs

Symbol: A stud is usually depicted as a cylinder featuring threads on both ends. It is commonly paired with nuts on either side, allowing each threaded end to fasten separate components.

Washer:

- A washer is a slender, flat ring that helps spread the load of a fastener like a bolt or nut and protects the surface underneath from damage.
- **Symbol:** The washer is usually depicted as a thin circular shape with a central hole (Fig. 2.35). The specific type whether plain, spring, or lock washer is indicated by variations in the symbol.

Fig. 2.35: Washer

Nut:

- A nut is a fastening component with either a hexagonal or square shape that screws onto the threaded end of a bolt or stud to join two parts securely (Fig. 2.36).
- **Symbol:** The hexagonal nut is symbolized by a hexagon, while the square nut is depicted as a square. Additional details like size and thread specifications can be included through annotations.

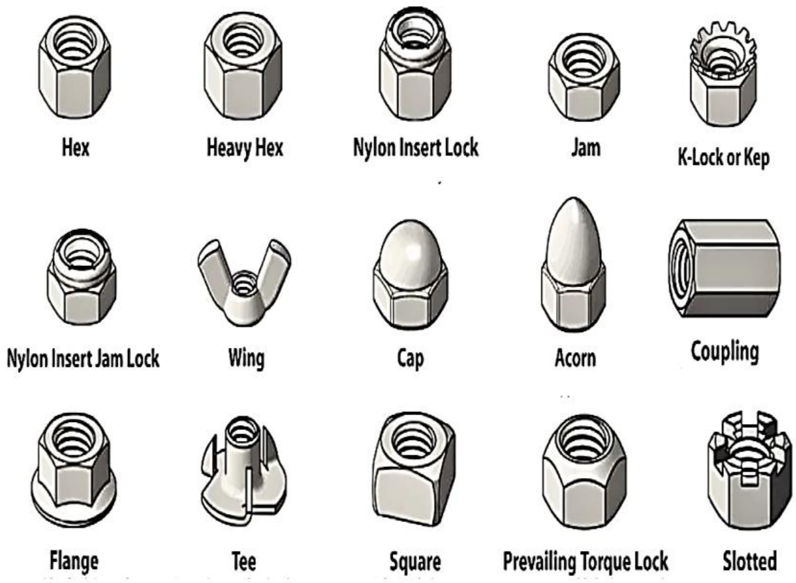


Fig. 2.36: Types of Nuts

PRACTICAL EXERCISE

Objective: To enhance the ability to create proportionate freehand sketches of various thread forms and fasteners including bolts, nuts, studs, and washers along with their standard signs, symbols, and material abbreviations as specified in SP:46:2003 (Bureau of Indian Standards).

Materials Needed:

- Sketchbook or plain drawing sheets
- HB and 2H pencils
- Eraser
- Ruler (for reference only; sketches should be freehand)
- SP: 46:2003 reference chart or material symbols guide (if available)

Part 1: Freehand Sketching of Fasteners

Draw the following fasteners in two views: front and top.

1. **Hexagonal Headed Bolt**

This is a common type of nut typically used with fasteners. It features six flat sides, forming a hexagonal shape hence its name(Fig. 2.37). The edges are chamfered or rounded at a 30° angle on one side only. This chamfering creates an arc along each vertical face, resulting in a circular outline on the nut's top surface.

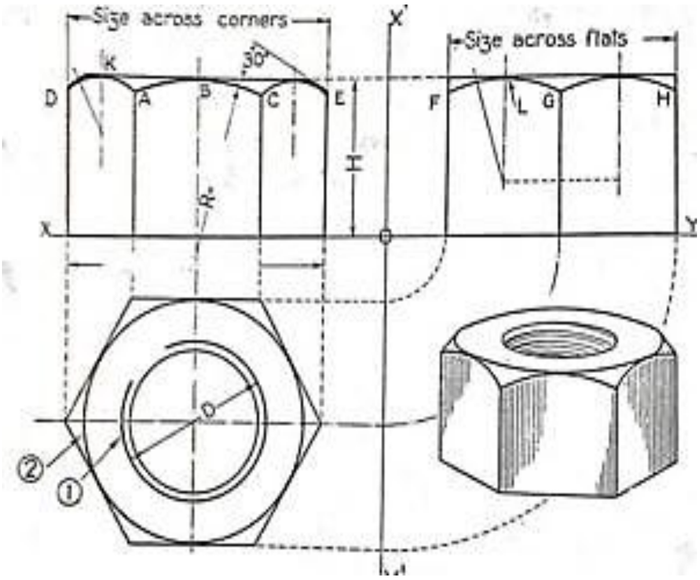


Fig. 2.37: Hexagonal Nut

Proportions of the Hexagonal nut:

- D is the nominal diameter of the bolt
- Width across flats, W = 1.5 D + 3 mm
- Thickness of nut, T = 0.9 D to D
- Distance across corners = 2D
- Angle of chamfer = 30° to base of the nut
- Radius of chamfer, R = 1.4 D

CHECK YOUR PROGRESS

A. Answer the following questions

1. What is the purpose of isometric sketching in machine drawing?
2. Which sketching method shows an object through its top, front, and side views?
3. What are the benefits of using oblique sketching?
4. Why is sectional sketching used in technical drawings?
5. Give an example where isometric sketching is especially useful.

B. Multiple Choice Questions

1. What is the included angle for ISO V-threads?
   a) 45°
   b) 90°
   c) 60°
   d) 30°
2. Which type of thread is most widely used in nuts, bolts, and screws?
   a) Square threads
   b) Acme threads
   c) V-threads
   d) Buttress threads
3. What is the main use of square threads?
   a) Fluid sealing
   b) Decorative purposes
   c) Power transmission
   d) Electrical insulation
4. Why are square threads commonly chosen for lead screws in lathes?
   a) They are simple to produce
   b) They reduce vibration
   c) They generate high friction
   d) They convert rotational motion to linear motion efficiently
5. V-threads are most commonly found in which application?
   a) Hydraulic cylinders
   b) Gear trains
   c) Automotive bolt connections
   d) Worm gears

C. Fill in the blanks

1. A ___________ headed bolt has six flat sides, making it easy to grip with a wrench or spanner.
2. A square headed bolt has a head with ___________ sides, typically used where higher torque is needed.
3. In drawings, the head of a square headed bolt is represented using a ___________ shape.
4. A ___________ is a type of fastener with threads at both ends and no head.
5. The symbol of a stud is shown as a ___________ with threads at both ends.

D. True or False

1. A washer helps to spread the load of a fastener and protects the surface from damage.
2. Washers are always manufactured in square shapes to improve load distribution.
3. In technical drawings, a washer is typically symbolized by a thin circle with a central hole.
4. A nut is an internally threaded component, usually hexagonal or square, used with bolts or studs.
5. Nuts cannot be shown using symbols in engineering drawings.

Session 5: Sectional Views of Orthographic Projections

1. Understanding Cutting Planes and Their Representation

In mechanical drawing, a cutting plane refers to an imaginary surface that slices through an object to expose its internal features in a sectional view. This method is especially useful for displaying internal details that are not visible in standard views, helping to simplify complex objects by reducing the use of hidden lines.

As designs become more complex such as in the case of an engine block it becomes necessary to show the inner structure clearly. Sectional views make this possible by illustrating the object as if it has been cut open, much like slicing a fruit to see what's inside. This technique, known as sectioning, is widely used in engineering and industrial design to reveal internal components or features.

For example, when a solid block is sectioned, it can be visually divided into parts. Just like cutting an apple shows its core, sectioning a mechanical part provides a clearer understanding of its interior in technical sketches or drawings (Fig. 2.38).

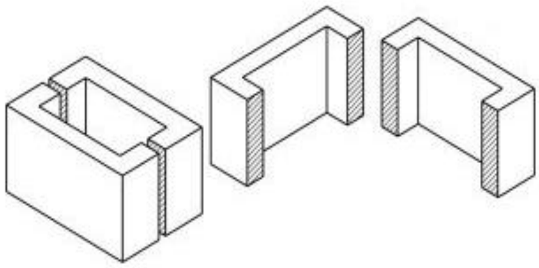


Fig. 2.38: Sectional Views

Representation of a Cutting Plane:

- A cutting plane is depicted using a thick line terminated by arrowheads on both ends, which show the direction from which the section is viewed (Fig. 2.39).
- This line is usually labeled with letters (e.g., A–A or B–B) to identify the corresponding sectional view in the drawing.
- It is generally drawn in the top view (plan view) to indicate the exact location where the object is sliced.
- The arrowheads point toward the side of the object that will be visible in the sectional view, guiding how the internal features should be interpreted.

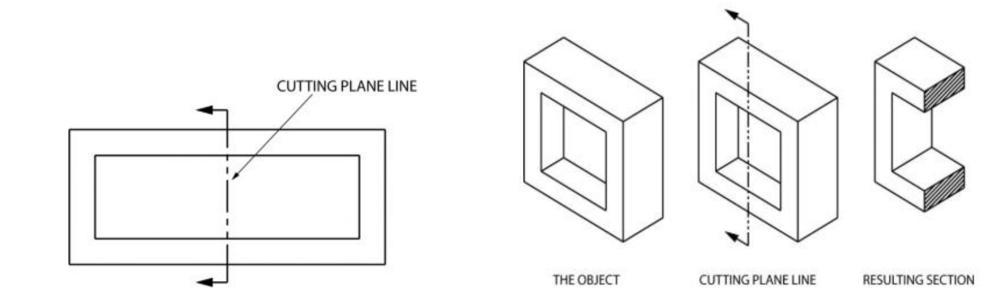


Fig. 2.39: Cutting Plane Representation

2. Solid Sections: Types of Sectional Views

In mechanical drafting, sectional views play a crucial role in displaying the internal configuration of machine components. By conceptually slicing through an object and omitting a portion of it, these views make hidden features visible, something that's often challenging with regular orthographic projections.

Among the various sectioning techniques, **Full Sections** and **Half Sections** are the two most widely used methods for clearly illustrating internal details.

Full Section:

- In a full section, the object is cut completely through the middle, and the part behind the cutting plane is removed entirely. The resulting view shows all the internal features of the part (Fig. 2.40).

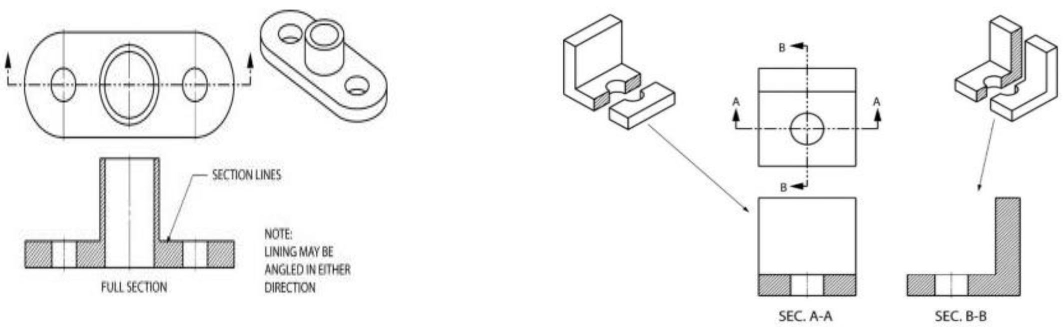


Fig. 2.40: Full Section

How It Works (Full Section):

- The object is entirely sliced along a chosen plane, and the portion behind the cutting plane is imagined as removed.
- This method is especially useful when the internal geometry is intricate and needs to be clearly illustrated for better understanding.

Half Section:
A half section involves cutting through half of the object and removing the sectioned part. The other half remains intact, providing a view of the external features (Fig. 2.41).

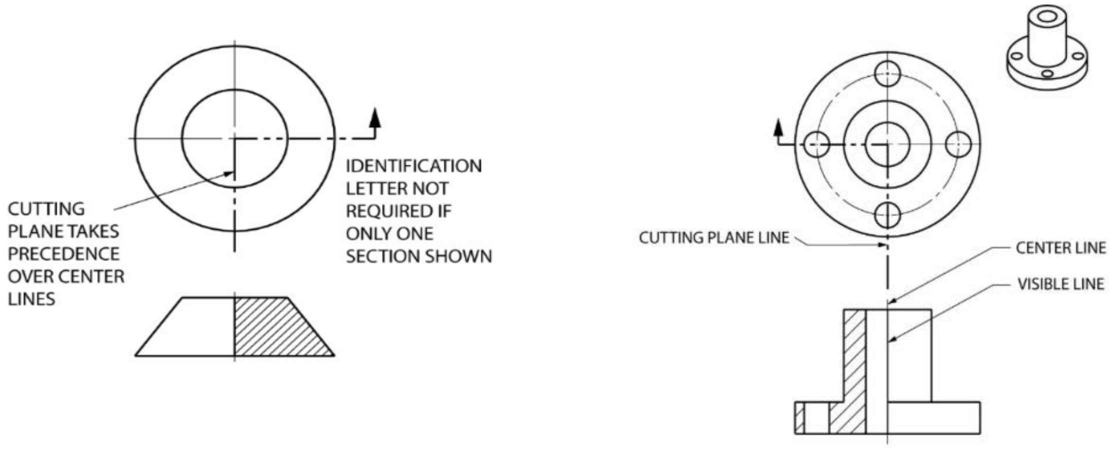


Fig. 2.41: Half Section

How It Works (Half Section):

- The object is split along a central cutting plane, with one half removed to expose internal features, while the remaining half displays the external shape.
- This approach is particularly effective for symmetrical objects, as it allows both internal and external details to be shown in a single view.

Types of Sectional Views:

- **Revolved Section**: A part of the object is rotated (revolved) 90° to show internal details (Fig. 2.42).

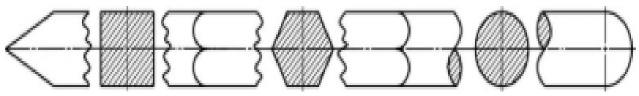


Fig. 2.42: Revolved Section

- **Removed Section**: A section is drawn separately from the main drawing for clarity (Fig. 2.43).

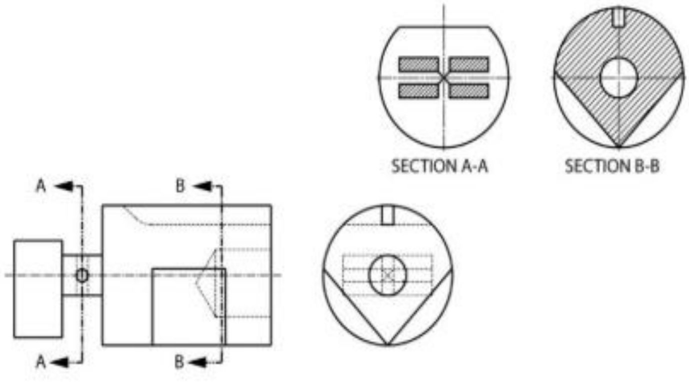


Fig. 2.43: Removed Section

- **Broken out Section**: A portion of the object is broken out to show internal features without cutting the entire part (Fig. 2.44).

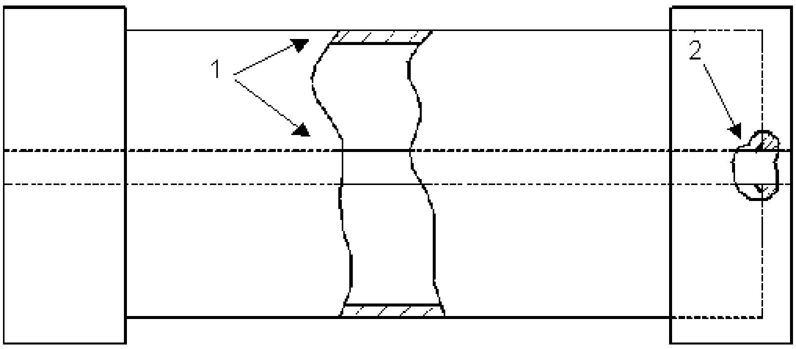


Fig. 2.44: Broken Out Section

3. Hatching for Various Materials

Hatching is a drafting technique used in sectional views to represent the type of material a component is made from. By applying distinct patterns of lines or shading, different materials can be easily identified in a drawing.

Key Principles of Hatching:

- Hatch lines are usually drawn at a 45° angle relative to the main horizontal or vertical edges.
- The lines should be evenly spaced to give a clear and consistent depiction of the solid material.

- Each material is assigned a specific, standardized hatch pattern to differentiate it from others clearly.

Hatching for Common Materials (Fig. 2.45):

1. **Steel:**
    - Represented by closely spaced parallel lines, usually about 0.5 mm apart.
    - Used to indicate steel parts such as machine frames, shafts, and gears.
2. **Cast Iron:**
    - Depicted using thick, continuous straight lines arranged in a regular pattern.
    - Commonly found in motor housings, brackets, and machine bases.
3. **Aluminum:**
    - Shown with fine, closely spaced lines that are lighter than those used for steel.
    - Often used for lightweight components like engine parts and vehicle housings.
4. **Brass:**
    - Illustrated with diagonal lines at a 45° angle, similar to steel but with lighter line weight and wider spacing.
    - Typically used in fittings, valves, and electrical hardware.
5. **Wood:**
    - Indicated by curved or jagged lines mimicking the grain pattern.
    - Rare in mechanical drawings, but may appear in items like tools, jigs, or non-metallic parts.
6. **Rubber:**
    - Represented by zigzag or densely packed lines, highlighting its elastic nature.
    - Used in gaskets, seals, and vibration dampening components.
7. **Plastic:**
    - Depicted with short, evenly spaced parallel lines.

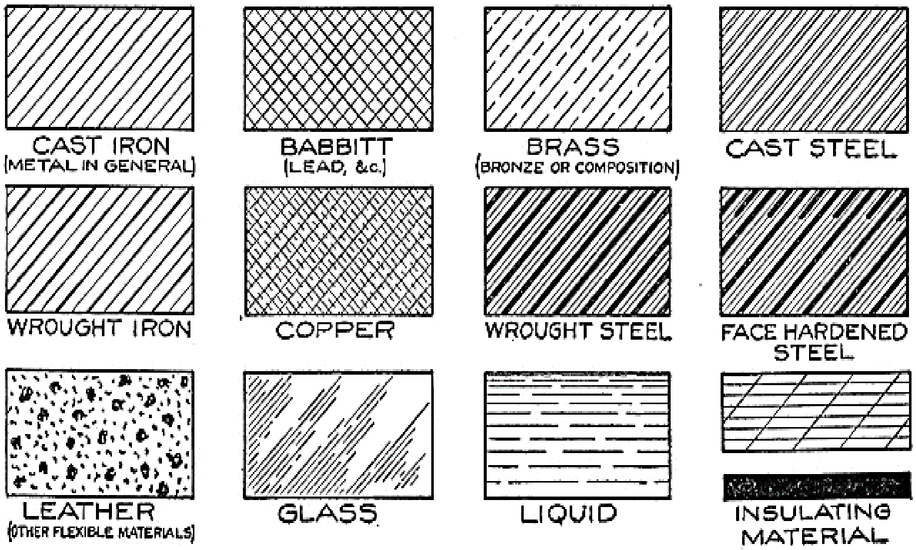


Fig. 2.45: Hatching Lines for Different Materials

PRACTICAL EXERCISE

Activity: Drawing Sectional Views of a Machine Block with Material Hatching Symbols

Objective: To draw the sectional views (Front, Top, and Side) of a given machine block, accurately represent internal features, and apply correct material hatching symbols as per BIS SP:46–2003.

Materials Required:

- Drawing sheet
- Drawing board
- Drawing clips or masking tape
- T square
- Set squares
- Compass
- Scale (ruler)
- Protractor
- Pencils (2H for construction, H or HB for final lines)
- Eraser
- SP:46–2003 standard reference for material symbols

Instructions:

Part 1: Representing Material Hatching Symbols (As per SP: 46–2003)

Procedure:

1. Identify materials used in different parts of the block (as specified or assumed).
2. Apply standard material symbols in the sectional areas, such as:

Material	Hatching Symbol Description
Cast Iron (CI)	45° lines equally spaced
Steel (St)	Same as CI or labelled as St
Bronze	Alternating long and short dashes
Copper	Double lines or close spacing
Rubber	Crossed lines or stippling
Wood	Grain pattern symbol
Glass	Zigzag line symbol or solid fill

3. Use different hatch angles or spacing if multiple materials are present adjacent to each other.
4. Clearly label each sectional view and the material types if not obvious from symbols.

Outcome:

By completing this activity, the learners will:

- Understand and draw correct sectional views of machine components
- Visualize and represent internal features using sections
- Apply BIS material hatching symbols
- Draw freehand and instrument-based drawings of mechanical components

CHECK YOUR PROGRESS

A. Answer the following questions

1. What does the term cutting plane mean in mechanical drafting?
2. Why is a cutting plane used in technical drawings?
3. What role do sectional views play in engineering drawings?
4. How is a cutting plane represented visually in a drawing?
5. Give an example of a scenario where using a cutting plane improves the drawing

B. Multiple Choice Questions

1. How is a cutting plane typically depicted in a technical drawing?
   a) Fine dotted line
   b) Thin solid line
   c) Thick line with arrowheads at both ends
   d) Zigzag line

2. What do the arrowheads on a cutting plane signify?
   a) Material type
   b) Viewing direction after the cut
   c) Location of hidden features
   d) Wall thickness
3. What is the usual labeling format for a cutting plane?
   a) 1-1, 2-2
   b) A-A, B-B
   c) X-Y, Z-Z
   d) α-α, β-β
4. In which view is the cutting plane most commonly shown?
   a) Front view
   b) Side view
   c) Bottom view
   d) Plan (top) view
5. During a full section, which portion of the object is removed?
   a) Only the exterior surface
   b) The section behind the cutting plane
   c) The section in front of the cutting plane
   d) Only internal voids

C. Fill in the blanks

1. Hatching is a technique used in _______ views to indicate the material of a part.
2. _______ is represented by thick, continuous, straight lines in a uniform pattern.
3. Each material has its own standard _______ of hatching to distinguish it from others.
4. Hatching lines should be evenly spaced to clearly represent a _______ material.
5. The material commonly used for machine frames, shafts, or gears and shown with closely spaced hatching is _______.

D. True or False

1. Brass is typically hatched with diagonal lines at a 45° angle, similar to steel but with lighter lines and wider spacing.
2. In mechanical drawings, wood is depicted using curved or jagged lines that simulate the grain pattern.
3. Rubber is represented by zigzag or densely packed hatch lines to reflect its flexible nature.
4. Plastic components are shown with short, evenly spaced parallel lines in sectional views.
5. Plastic is commonly used as a material for the bases of heavy machinery.

Session 6: Conversion of Isometric views into Orthographic Projections

1. Principle of Isometric Projection, Isometric Drawing, and Isometric Scale

In mechanical drafting, **isometric projection** is a technique used to represent three-dimensional objects on a two-dimensional plane. This method displays objects in a way that closely resembles how the human eye perceives them, by positioning the axes at specific angles to maintain proportion and efficiently utilize space (Fig. 2.46). The advantage of isometric projection is evident when comparing a 3D object to its corresponding 2D views, where a three-dimensional form is transformed into two-dimensional drawings (Fig. 2.47).

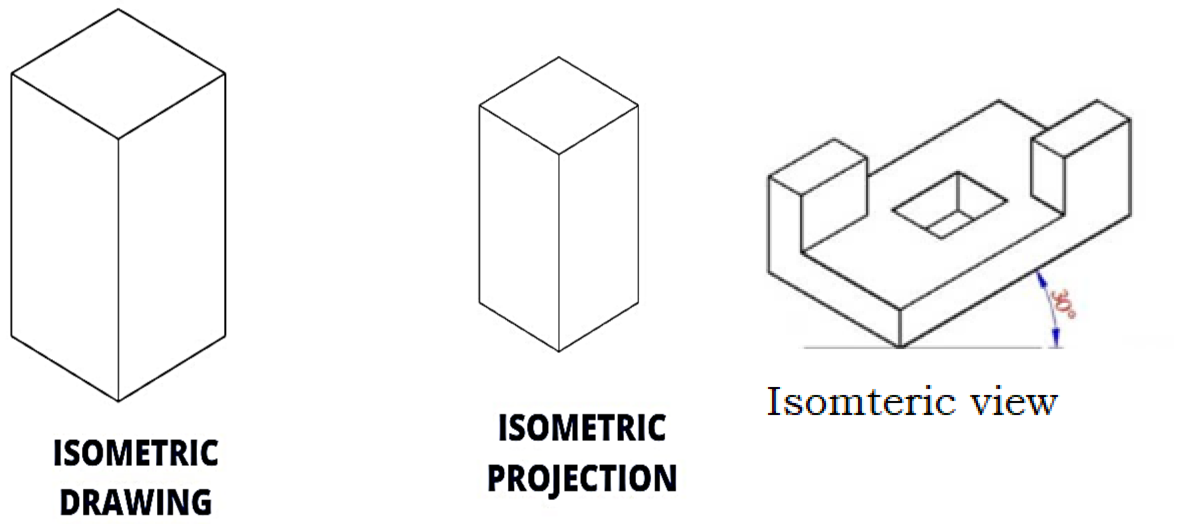


Fig. 2.46: Isometric Drawing, Isometric Projection and Isometric View

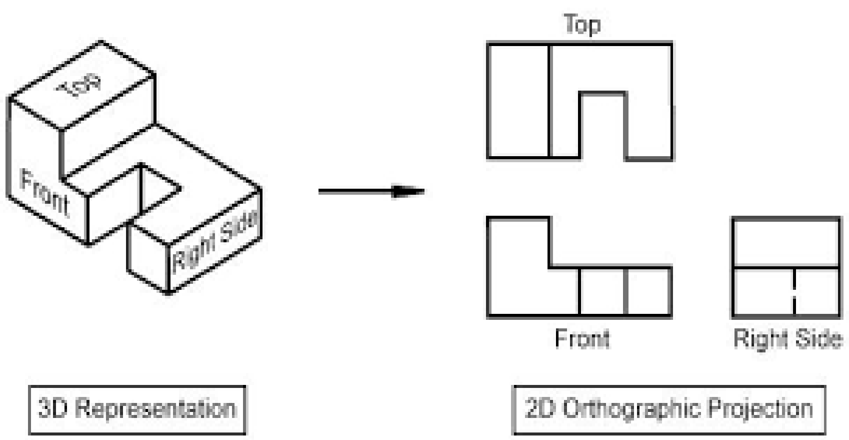


Fig. 2.47: 3-Dimensional (3D) Representation to 2-Dimensional (2D) Projection

Isometric Drawing:

- Isometric drawing is the process used to produce an isometric projection, where the three dimensions of an object i.e., length, width, and height are represented on a flat, two-dimensional surface. In this method, the axes are spaced 120° apart from each other.
- This technique is commonly employed in mechanical drafting to illustrate machine components, assemblies, and tools, providing a clear and proportionate view without the distortion of complex perspective drawings.

Principle of Isometric Projection:

- Isometric projection is a form of axial projection where the three main axes length, width, and height are equally spaced, usually at 120° angles from each other.
- The object is oriented so that all three axes are equally foreshortened, eliminating the perspective distortion found in conventional 3D views. This results in a balanced and clear depiction of the object's shape.

In summary, **isometric drawing** uses the true measurements of the object, whereas **isometric projection** applies an isometric scale, slightly reducing the dimensions to maintain proportional accuracy.

2. Isometric Scale:

- In isometric drawing, the isometric scale is used to scale the objects correctly because the isometric projection causes foreshortening. The scale compensates for this foreshortening by reducing the length of the object along the axes to maintain true proportions in the drawing (Fig. 2.48).

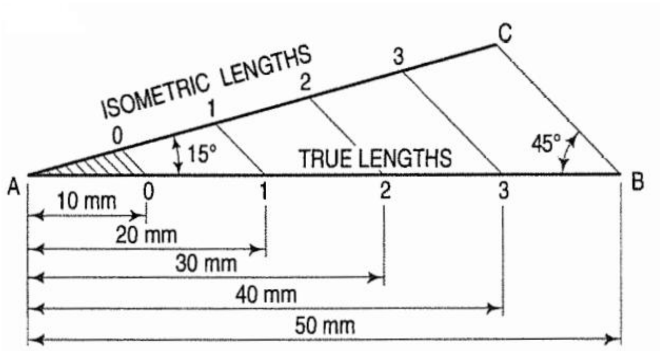


Fig. 2.48: Isometric scale

When the shortening of isometric lines in an isometric projection is ignored and actual lengths are used instead, the resulting view Fig as shown in Fig. 2.49 maintains the same shape but appears approximately 22.5% larger than the one created using an isometric scale as shown in Fig. 2.50. Because this method simplifies the drawing process, the version using true measurements is referred to as an isometric drawing or isometric view, whereas the version created using the isometric scale is termed an isometric projection. The isometric projections are reduced in the ratio of √2: √3 i.e., the isometric length is 0.815 of the true length.

Note: When creating projections, it is essential to convert true lengths into their corresponding isometric lengths for accurate measurement and representation. This is achieved by constructing and applying an isometric scale.

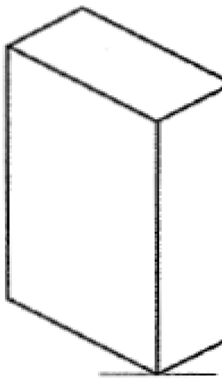


Fig. 2.49: Isometric View (with true length)

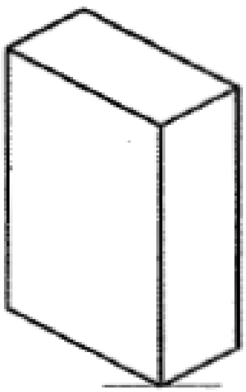


Fig. 2.50: Isometric View (with isometric scale)

Now let us differentiate precisely between isometric view and isometric projections.

Isometric View:

- An isometric view is created by looking at an object from a specific angle, typically about 45° to each axis in three-dimensional space, allowing all three dimensions height, width, and depth to be displayed in accurate proportions.

- In this view, three faces of the object are visible, with the edges along each axis spaced at 120° from one another, ensuring that none of the axes appear more distorted than the others.

Isometric Projection:

- Isometric projection is the technique used to represent a 3D object on a 2D plane, maintaining equal angles of 120° between the three principal axes.
- This is a form of axonometric projection where the object is shown without perspective distortion, and all axes are foreshortened equally to preserve proportionality.
- While isometric projection refers to the method or process, the isometric view is the resulting visual representation that displays the object clearly and without distortion.

Differences:

- The **isometric view** represents how an object appears to an observer positioned at a 45° angle to the axes (Fig. 2.51).
- The **isometric projection** is the underlying drawing technique used to produce such views, ensuring equal foreshortening along all three axes and eliminating perspective distortion (Table 2.2).

Table 2.2: Isometric view v/s isometric projection

Isometric view	Isometric projection
Drawn to actual scale	Drawn to isometric scale
When lines are drawn parallel to isometric axes, the true lengths are laid off.	When lines are drawn parallel to isometric axes, the lengths are foreshortened to 0.81 times the actual lengths.

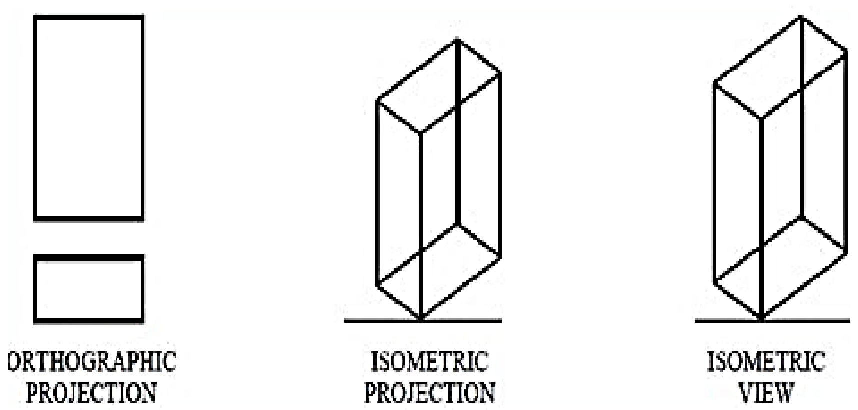


Fig. 2.51: Isometric Projection and Views

3. Methods of Isometric Projections and Dimensioning

Methods of Isometric Projection:

Several techniques are used to create an isometric projection of an object, with the most common being:

1. **Single-Point Isometric Projection:**
    - This approach begins by establishing a single reference point from which the object's three axes (X, Y, Z) are set at their isometric angles, typically 120° apart.
    - Dimensions are scaled down using the isometric scale factor (approximately 0.816), while keeping the angles between the axes consistent.
2. **Grid-Based Isometric Projection:**
    - A grid composed of lines set at 120° angles is drawn to serve as a guide for constructing the object.
    - The object is then sketched onto this framework, ensuring that all elements follow the correct isometric alignment and proportional foreshortening.
3. **Freehand Isometric Drawing:**
    - This method relies on the drafter's skill to draw the object directly on the sheet without using tools such as grids.
    - The drafter carefully maintains the 120° spacing between axes and uses experience to accurately capture the isometric proportions by hand.

Methods of Isometric Dimensioning:

Dimensioning in isometric drawings differs from standard 2D dimensioning because the axes are foreshortened. To maintain accuracy, the following approaches are typically used:

1. **Isometric Dimensions:**
    - Dimensions along the isometric axes are adjusted by applying the isometric scale factor (approximately 0.816) to reflect their true lengths.
    - These measurements are placed directly along the axes, showing the foreshortened values correctly.
2. **Horizontal and Vertical Dimensions:**
    - Horizontal dimensions are aligned parallel to the X and Y axes of the isometric drawing.
    - Vertical dimensions are aligned with the Z axis.
    - Usually, dimensions are drawn at 30° angles and scaled using the isometric factor, with occasional modifications for better readability.
3. **Offset Dimensions:**

    - When dimensions need to be shown along inclined or non-isometric surfaces, offset dimensioning is used. These dimensions are scaled appropriately to maintain accuracy despite the angle.

4. **Avoiding Perspective Distortion:**
    - Isometric dimensioning does not incorporate perspective distortion, so skewed or distorted dimensions are avoided to keep the drawing clear and precise.

PRACTICAL EXERCISE

Activity: Drawing Isometric Scales, Views, and Projections of Solids with Orthographic Conversion (Fig. 2.52).

Objective:

To construct an isometric scale, create isometric views of circles and polygons, and additionally, to convert orthographic views into isometric projections using given dimensions.

Materials Required:

- Drawing sheet
- Drawing board
- T square
- Set squares (30°–60°)
- Compass
- Protractor
- Divider
- Scale (ruler)
- Pencils (2H for construction, H or HB for final lines)
- Eraser

Part 1: Construction of Isometric Scale

Procedure:

1. Draw a horizontal line (true scale).
2. From the left end, draw a 45° line (for actual measurements) and a 30° line (for isometric measurements).
3. Mark regular divisions (e.g., 1 cm) along the 45° line.
4. Project vertical lines from these points to intersect the 30° line.
5. Transfer these intersecting points to the 30° line this line now represents your isometric scale.
6. Label it clearly as Isometric Scale.

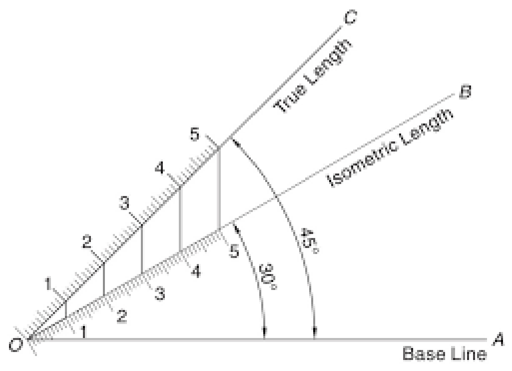


Fig. 2.52: Construction of Isometric Scale

CHECK YOUR PROGRESS

A. Answer the following questions

1. How is isometric projection defined in the context of mechanical drafting?
2. What is the primary purpose of using isometric projection in technical drawings?
3. In what ways does isometric drawing differ from other types of technical drawings?
4. What is the standard angle maintained between the axes in an isometric projection?
5. What are the main reasons for the frequent use of isometric drawings in mechanical drafting?

B. Multiple Choice Questions

1. At what angle are the three main axes drawn in an isometric projection?
   a) 90°
   b) 60°
   c) 45°
   d) 120°
2. Why does isometric projection avoid perspective distortion?
   a) Because all axes are vertical
   b) Because the axes are parallel and foreshortened equally
   c) Because it uses curved lines
   d) Because it incorporates shadows
3. How do isometric drawing and isometric projection differ regarding dimensions?
   a) The drawing exaggerates dimensions
   b) The projection uses perspective views
   c) The drawing shows true dimensions; the projection uses scaled-down

dimensions via the isometric scale
d) The projection ignores the height dimension

4. What role does the isometric scale play?
   a) It increases the thickness of lines
   b) It adjusts dimensions to compensate for foreshortening
   c) It adds color coding to drawings
   d) It converts the view to perspective projection
5. From what viewpoint is an object typically seen in an isometric view?
   a) Directly from the front
   b) At a right angle
   c) From a viewpoint that equally shows all three dimensions
   d) From underneath

C. Fill in the blanks

1. Isometric projection refers to the method of projecting a _____ object onto a __________ plane while keeping all three axes at equal angles of ___.
2. In isometric projection, the object is shown _____________ and all three ______are _______________.
3. Isometric projection is a type of ____________ where all three axes are inclined equally to the ____________.
4. ______________ focuses on the geometric process, while the ___________ is the final result of that process.
5. In an isometric view, the object is observed from a position that makes a _______ to each axis, allowing all three dimensions______ to be seen.

D. True or False

1. In isometric drawings, horizontal dimensions are aligned parallel to the X and Y axes.
2. Vertical dimensions in isometric drawings run along the Z axis.
3. The isometric scale enlarges the actual dimensions to better fit the drawing.
4. All dimensions in isometric drawings are consistently drawn at a 45° angle.
5. Offset dimensions are applied when features lie on axes that are not isometric.

MODULE 3 DRAWING OF DIFFERENT MACHINE PARTS

Module Overview

This module provides students with an overview of key fastening and joining components used in mechanical assemblies. It covers a range of devices such as locking mechanisms, screws, foundation bolts, rivets, and important parts like keys, cotters, pins, and circlips. Students will also learn how to interpret and create technical drawings for welded joints using standard symbols. By completing this module, learners will be able to recognize these components and accurately produce engineering sketches, establishing a strong foundation for tasks related to mechanical design, assembly, and repair. The focus is on hands-on practice and visualization to improve technical drawing skills, preparing students for practical roles in fitting, fabrication, and maintenance within engineering industries.

Learning Outcomes

Upon finishing this module, you will be able to:

- Recognize various mechanical fastening and joining elements, including screws, bolts, rivets, keys, and cotters.
- Understand and use standard welding symbols to accurately depict welded joints in engineering drawings.
- Describe the functions and uses of locking mechanisms, foundation bolts, and shaft securing devices within mechanical systems.
- Create detailed and accurate technical sketches of fastening and joining parts following accepted drafting standards.

Module Structure

The Draughtsman (Mechanical) curriculum emphasizes understanding mechanical fasteners and joints. The structure of module 3 is as follows:

Session 1: Introduction to Locking Devices (Lock Nuts, Spring Washers, Split Pins)
Session 2: Types of Screws (Machine Screws, Cap Screws, Set Screws)
Session 3: Foundation Bolts (Rag Bolts, Eye Bolts, and Applications)
Session 4: Representation of Welded Joints Using Standard Symbols (Butt, Lap, Fillet)
Session 5: Shaft Securing Elements (Keys, Cotter Joints, Splined Shafts, Pins, Circlips)
Session 6: Types of Rivets and Their Applications (Snap Head, Pan Head, Countersunk Rivets)

Session 1: Introduction to Locking Devices (Lock Nuts, Spring Washers, Split Pins)

1. Different Types of Locking Devices

Locking devices are employed in mechanical systems to stop nuts and bolts from loosening because of vibrations or movement. They serve as safety features that ensure components remain securely fastened. The main types of locking devices are shown in Table 3.1.

Table 3.1: Types of locking devices

Locking Device	Description	Use
Lock Nut (Double Nut)	Two nuts are tightened together on a bolt. The second nut "locks" the first one.	Used in vibrating machines or moving parts.
Castle Nut (Slotted Nut)	A nut with slots (cuts) on the top. A split pin is inserted through a hole in the bolt and these slots.	Used in vehicles, axles, and shafts.
Split Pin (Cotter Pin)	A metal pin inserted through a hole in a bolt to stop a nut from turning. Its ends are bent to hold it in place.	Commonly used with castle nuts or slotted nuts.
Spring Washer (Lock Washer)	A washer shaped like a spring. It keeps pressure on the nut so it does not loosen.	Used in engines and machines.
NY lock Nut	A nut with a nylon ring inside. The nylon grips the bolt thread to stop it from loosening.	Used in automotive vehicles and aircrafts.
Locking Plate	A metal plate with tabs that bend over the bolt or nut to lock it.	Used in gearboxes and engines.

Common Types of Locking Devices:

1. **Jam Nut (Lock Nut)**

   A thin nut tightened against another nut to prevent loosening.
2. **Castle Nut**

   A nut with slots (like a castle turret) that allows a cotter pin to secure it in place.
3. **Sawn Nut**

   A nut cut or slotted to enable locking with a pin or wire.
4. **Penn, Ring, or Grooved Nut**

   Nuts designed with grooves or rings to accommodate locking mechanisms.
5. **Pin Locking**

   Locking method where a pin is inserted through the bolt and nut to stop rotation.
6. **Plate Locking**

   A plate is used to secure nuts or bolts by physically preventing their movement.
7. **Spring Lock Washer**

   A washer with a split and twisted shape that provides tension to keep the fastener tight.

1. Jam Nut or Lock Nut

- The most common locking device is a Jam lock or Check nut (Fig. 3.1).

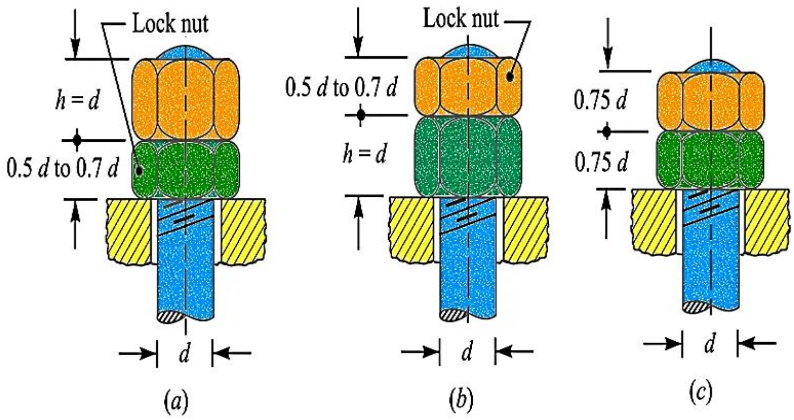


Fig. 3.1: Lock Nut or Jam Nut

Lock nuts are specially designed to resist loosening caused by vibrations or dynamic loads. They are typically thinner about half to two-thirds the height of a standard nut. One common locking method involves placing the thin nut first and tightening it normally. A regular (thicker) nut is then screwed on top (Fig. 3.1a). After securing the upper nut, the lower nut is slightly loosened so that it locks tightly against the upper one. This setup often requires a thin spanner, which may not always be available in every workshop.

To simplify the process, an alternative approach is to reverse the order placing the thin nut on top (Fig. 3.1b). However, when both nuts are properly tightened, the top nut tends to carry more of the tensile load. Therefore, placing the thicker nut on top is generally more effective.

To avoid both the spanner accessibility issue and the uneven load distribution, a practical solution is to use two nuts of the same thickness, (Fig. 3.1c).

2. Castle Nut

- A **castle nut** features a standard hexagonal base with a cylindrical extension at the top, which is slotted in line with each flat face (Fig. 3.2).
- A **split pin** is inserted through the aligned slots in the nut and a pre-drilled hole in the bolt, creating a secure mechanical lock that holds unless the pin breaks.
- This type of locking nut is commonly used in applications that experience high vibration or sudden impacts, such as in automotive assemblies, due to its reliable locking mechanism.

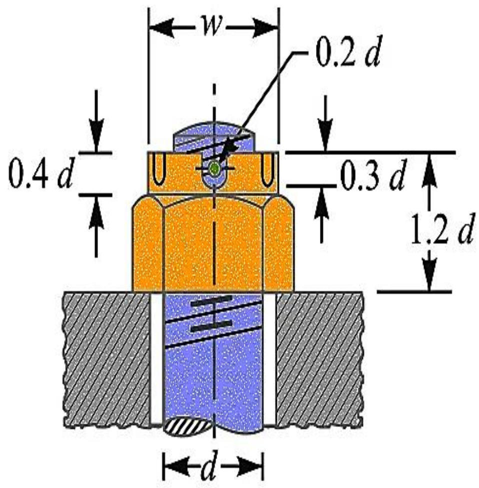


Fig. 3.2: Castle Nut

3. Sawn Nut

- A **sawn nut** is designed with a partial slot cut into it, typically extending halfway through the body.
- Once the nut is tightened onto the bolt, a small set screw inserted across the slot is tightened. This increases the friction between the nut and the bolt threads.
- The added friction from the screw helps prevent the nut from loosening under varying load conditions, making it more secure in dynamic or vibrating environments.

4. Penn, Ring or Grooved Nut

- Grooved Nut has an upper portion hexagonal and a lower part cylindrical as shown in the above figure.
- Grooved Nut is largely used where bolts pass through connected pieces reasonably near their edges such as in marine type connecting rod ends (Fig. 3.3).
- The bottom portion of the Nut is cylindrical and is recessed to receive the tip of the locking set screw.
- The bolt hole requires counter boring to receive the cylindrical portion of the nut. In order to prevent bruising of the latter by the case hardened tip of the set screw, it is recessed.

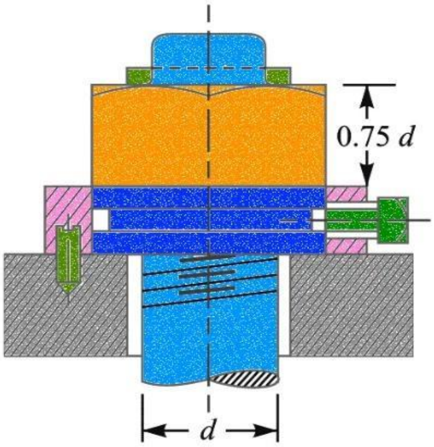


Fig. 3.3: Grooved Nut

5. Locking with Pin

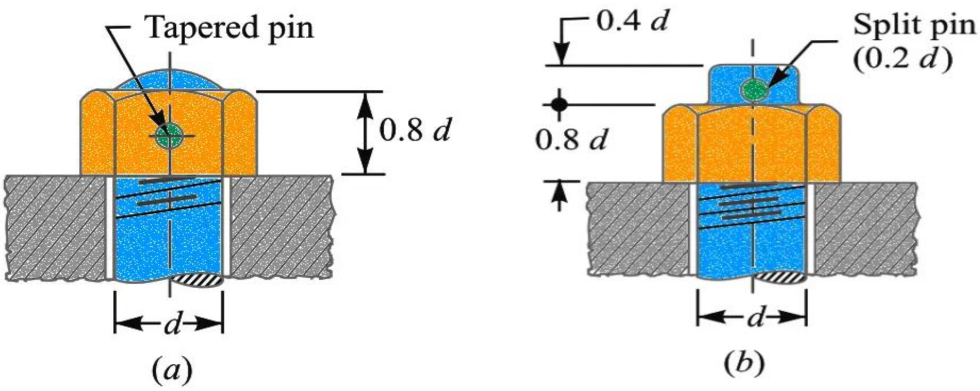


Fig. 3.4: Locking with Pin

The nuts may be locked by means of a taper pin or cotter pin passing through the middle of the nut (Fig. 3.4 (a)).

But a split pin is often driven through the bolt end after the nut is screwed on the bolt (Fig. 3.4 (b)).

6. Locking with Plate

A **locking plate** or **stop plate** is used to secure a nut in position after adjustment. These plates allow the nut to be locked at specific angular positions, typically in 30° increments. Once the nut is set in place, the plate is used to hold it securely and prevent any rotation due to vibration or movement (Fig. 3.5).

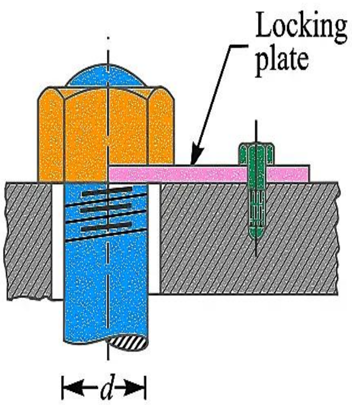


Fig. 3.5: Locking with Plate

7. Spring Lock Washer

- When the nut is tightened, the **spring lock washer** is compressed against the surface beneath it. One edge of the washer bites into that surface, creating additional friction and helping to resist loosening due to vibration or dynamic forces (Fig. 3.6).
- A variety of spring-type lock washers are available on the market, with some designs offering reliable performance in maintaining secure fastenings.

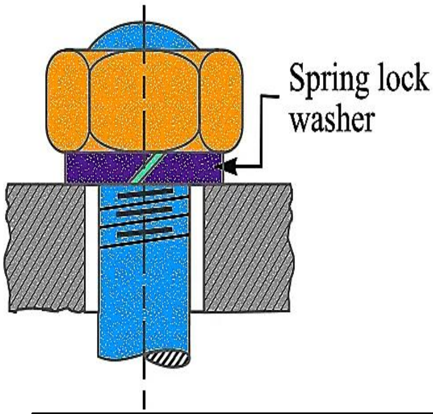


Fig. 3.6: Spring Lock Washer

2. Basic Locking Methods (Simplified Explanation)

a) Double Nut Method (Lock Nut)

How it works:

- First, tighten the main (lower) nut.
- Then, screw a second nut tightly against the first.
- The opposing force between the two nuts prevents them from loosening.

Common Uses:

- Found in machines and equipment where vibrations are frequent like engines, pumps, and rotating assemblies.

How to Draw:

- Show two nuts on the same bolt. Label as **Double Nut (Lock Nut) Method**.

b) Split Pin (Cotter Pin) Locking

How it works:

- A hole is drilled across the bolt or shaft.
- After tightening the nut (often a castle nut), insert a split pin through the hole.
- Bend both ends of the pin to prevent it from slipping out.

Common Uses:

- Used in axles, steering systems, and wheel hubs especially in automotive and transport applications.

How to Draw:

- Depict the nut with a pin passing through the bolt. Label its **Split Pin (Cotter Pin)**.

c) Spring Washer (Lock Washer)

How it works:

- Place the washer beneath the nut.
- As the nut tightens, the washer compresses slightly like a spring.
- This creates constant tension, helping to prevent the nut from coming loose.

Common Uses:

- Found in equipment exposed to vibration such as motors and machines.

How to Draw:

- Show a spring washer under the nut and label it **Spring Washer** with its conventional symbol if applicable.

d) Castle Nut Locking

How it works:

- The nut has vertical slots on its top, resembling castle turrets.
- After tightening, a hole in the bolt allows a split pin to be inserted through both the nut and the bolt.
- The pin is bent to secure the nut and stop rotation.

Common Uses:

- Widely used in steering mechanisms, brakes, and suspension parts of vehicles.

How to Draw:

- Draw the slotted nut with a split pin inserted through it and mark it as **Castle Nut with Split Pin**.

PRACTICAL EXERCISE

Activity: Drawing Locking Arrangements for Fasteners

Objective: To learn how to recognize and accurately represent various mechanical locking systems for nuts, machine screws, cap screws, and set screws through standard engineering drawing practices.

Materials Required:

- Drawing board and standard drafting tools
- A3-size engineering drawing sheets
- Pencils (grades H and HB), eraser, and ruler
- Reference samples or charts showing common fasteners
- BIS/ISO engineering drawing standard manual (if available)

Instructions / Activity Steps:
Step 1: Understand Locking Mechanisms

Study the following locking techniques and their functions:

- Double nut (lock nut method)
- Spring washer
- Castle nut with split pin
- Locking plate

- Set screw with a locking nut

Step 2: Choose and Sketch Fasteners

Select and produce drawings of the following examples:

- Hexagonal nut paired with a lock nut
- Machine screw with a spring washer
- Cap screw secured with a locking plate
- Castle nut combined with a split pin
- Set screw used with a locking nut

Step 3: Drawing Exercise

Prepare clean, clearly labeled, and dimensioned sketches using freehand or drawing instruments. Include:

- Proper use of hidden lines
- Thread depiction using standard drafting conventions
- Sectional views, where needed, for internal clarity

Step 4: Assembly Representation

Illustrate how each locking method functions when assembled (e.g., a bolt passing through a plate secured with a nut and washer).

CHECK YOUR PROGRESS

A. Answer the following questions

1. What is the purpose of using locking devices in mechanical joints?
2. Name two commonly used types of locking nuts.
3. Which locking system uses a pin to secure the nut in place?
4. Which locking method incorporates a washer as a key element?
5. What role does a sawn nut play in fastening systems?

B. Multiple Choice Questions

1. Which approach best solves both the issue of spanner availability and uneven load distribution in lock nuts?
   a) Use a single thin nut only
   b) Use two nuts of the same thickness

c) Place a thinner nut on top and a thicker one below
d) Replace with a sawn nut

2. What distinguishes a Castle Nut from other types?
a) It has a smooth, round body
b) It features a hexagonal base with a slotted cylindrical top
c) It is made entirely from plastic
d) It includes a welded washer
3. How is a Castle Nut secured to prevent loosening?
a) By welding it onto the bolt
b) Using a split pin inserted through the nut slots and bolt hole
c) With a small side screw
d) Through friction alone
4. In which applications are Castle Nuts most frequently used?
a) Furniture making
b) Electronic devices
c) Automotive and situations with shocks and vibrations
d) Decorative hardware
5. What is a defining characteristic of a Sawn Nut?
a) A slot cut halfway through the nut
b) Made primarily from brass
c) Uses a split pin for locking
d) Thinner than a regular nut

C. Fill in the blanks

1. Grooved Nut has an upper portion _____ and a lower part _______.
2. Grooved Nut is largely used where bolts pass through connected pieces reasonably near their _________, such as in marine type connecting rod ends.
3. The bottom portion of the nut is _________ and is recessed to receive the tip of the locking set screw.
4. The bolt hole requires _________ to receive the cylindrical portion of the nut.
5. To prevent bruising of the nut by the case-hardened tip of the set screw, the nut is _________.

D. True or False

1. In the Double Nut locking method, two nuts are tightened against each other to stop any movement.
2. Castle Nuts do not rely on pins or other locking devices to stay secure.
3. The Lock Nut technique involves using just one nut to fasten the bolt.
4. Spring Washers are typically used in machinery that does not experience vibrations.
5. Castle Nuts feature slots shaped like castle battlements, allowing a split pin to be inserted.

Session 2: Types of Screws (Machine Screws, Cap Screws, Set Screws)

As a Mechanical Draughtsman, it's essential to be familiar with the different kinds of machine screws, cap screws, and set screws because they are frequently used in mechanical assemblies. Each type has unique features, thread details, and uses, which must be accurately depicted in technical drawings. Below is an overview of machine screws, their applications, and how to represent them in mechanical drawings:

A. Machine Screws

Machine screws are threaded fasteners that join multiple components in machinery, typically by screwing into tapped holes or securing with nuts (Fig. 3.7). They come in a variety of sizes and materials. Compared to bolts, machine screws generally have finer threads.

Types of Machine Screws:

1. **Standard Machine Screws:**
    - Usually paired with a nut or used in a pre-tapped hole.
    - Threading runs uniformly along the shaft for smooth engagement.
    - Common head shapes include flat, pan, round, and hexagonal.
2. **Countersunk Machine Screws:**
    - Feature a conical head designed to sit flush with the surface.
    - Used in situations where a smooth surface finish is required, preventing interference or damage.
3. **Self-Tapping Machine Screws:**
    - Capable of cutting their own threads into materials such as plastic or soft metals.
    - Ideal for applications where pre-tapped holes are not available or feasible.

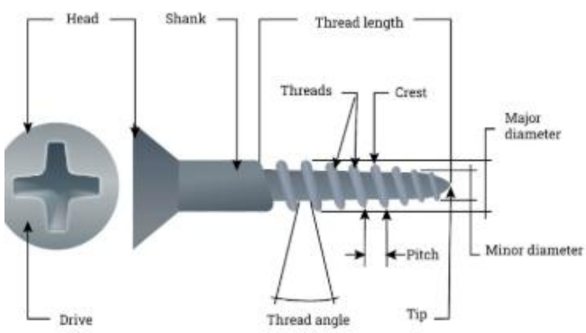


Fig. 3.7: Parts of a screw

Machine screws come in a wide range of sizes, head styles, materials (with stainless steel being especially common), and thread grades to suit different applications.

Below is a summary of some of the most frequently used types of machine screws available:

Head Types

Selecting the appropriate head type is crucial for your specific project. It's important to note that this discussion focuses on the shape of the screw head itself, rather than the type of drive or slot used to turn the screw. The head shape influences how the screw sits in or on the material and affects the overall function and appearance.

Hex Head Machine Screws

Hex head machine screws, sometimes referred to as set screws, closely resemble traditional bolts due to their solid, six-sided hexagonal head (Fig. 3.8). This familiar shape allows them to be tightened with a standard wrench or spanner, providing extra torque when needed. Additionally, some hex head machine screws feature a recessed drive socket in the head, which makes them compatible with conventional screwdrivers or hex keys for installation.

Fig. 3.8: Hex Head Machine Screws

Flat Head Machine Screws

Flathead machine screws are ideal for situations where the fastener must sit flush with the surface into which it is inserted. Their flat top combined with a countersunk underside allows the screw to create a smooth, even finish, making them perfect for joining panels and components without protruding above the surface (Fig. 3.9).

Fig. 3.9: Flat Head Machine Screws

Oval Head Machine Screws

Oval head machine screws provide a compromise between the classic pan head (round head) and flat head machine screws. Unlike pan heads, which remain prominently raised above the surface, oval heads feature a curved underside that creates a gently countersunk effect, making them less conspicuous once installed. However, they do not sit as flush as flat head screws (Fig. 3.10).

Fig. 3.10: Oval Head Machine Screws

Cheese Head Machine Screws

Cheese head screws resemble traditional round head screws when viewed from above, but their side profile reveals a flat-topped, cylindrical head with considerable depth. This design is often preferred for applications requiring additional strength and durability (Fig.3.11).

Fig. 3.11: Cheese Head Machine Screws

B. Cap Screws

Cap screws are a variety of machine screws designed to be tightened into pre-tapped holes. They feature a smooth, cylindrical head and are frequently used in machinery, engines, and various mechanical assemblies.

Types of Cap Screws:

1. **Hexagon Head Cap Screws**:
   - These have a hexagonal head that can be tightened with a wrench or socket (Fig. 3.12).

Fig. 3.12: Hexagon Head Cap Screws

- Common in heavy duty applications like construction machinery and automotive parts.

2. **Socket Head Cap Screws**:

    - These screws have a cylindrical head with an internal hexagon (Fig. 3.13).
    - They are used when high torque is needed and when the head must sit in a limited space.
    - Often used in precision machinery or aerospace.

Fig. 3.13: Socket Head Cap

3. **Flat Head Cap Screws**:

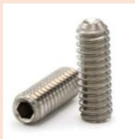
    - The head is flat and countersunk, allowing the screw to sit flush with the surface (Fig.3.14).

Fig. 3.14: Flat Head Cap Screws

C. Set Screws

Set screws are fasteners commonly used to hold one component firmly within or against another, such as securing a gear or pulley on a shaft. Unlike typical screws, set screws generally do not need a nut; they work by pressing directly against the surface to keep the parts locked in position. Different types of set screws are described in Table 3.2.

Table 3.2: Types of set screws

Types of Set Screws	Details	Image
Flat Point Set Screws:	• The end of the screw is flat and contacts the part being secured. • Ideal for light clamping and low torque applications.	
Cup Point Set Screws	• The screw has a cup shaped end that presses into the surface it is tightening against. • Provides better grip and torque resistance than flat points.	

Cone Point Set Screws	• The tip of the screw is cone shaped. • Typically used for more secure clamping in precision applications or when higher torque is required.	
Dog Point Set Screws	• The screw has a flat tip with a cylindrical section. • It fits into a hole or groove, making it ideal for high precision and load-bearing applications.	

PRACTICAL EXERCISE

Activity: Drawing Different Types of Screws and Marking Straight Lines for Panel Placement

Objective: To develop skills in accurately drawing different screw types according to engineering standards and to master precise panel marking using marking threads.

Tools and Materials Needed:

- Drawing tools (drawing board, compass, set square, protractor)
- Drawing sheets (A3 or A4 size)
- Pencils (H and HB), eraser, ruler
- Steel rule, surface plate
- Marking blue or chalk
- Marking thread (cotton thread coated with chalk)
- Scriber and punch
- Reference materials (BIS/ISO standards manuals)

Instructions / Activity Steps:

Part A: Drawing Different Screw Types

1. Examine and familiarize yourself with these screw types:
    - Machine Screws (including round head, cheese head, countersunk, etc.)
    - Cap Screws (such as hex head, socket head, slotted head)
    - Set Screws (flat point, cone point, dog point, cup point)
    - Snap Head Screws (commonly used in riveting or decorative applications)

2. Prepare detailed drawings showing:
   - Front View
   - Top View
   - Side View or Sectional View (when necessary)
3. Accurately label and dimension each drawing, ensuring correct thread representation and head detailing according to BIS/ISO standards.

CHECK YOIUR PROGRESS

A. Answer the following questions

1. How do machine screws differ from bolts?
2. What are the three main types of machine screws?
3. How are the threads of a standard machine screw usually characterized?
4. What type of head design is typical for a countersunk machine screw?
5. What are the common applications of self-tapping machine screws?

B. Multiple Choice Questions

1. What does the term "head type" of a machine screw describe?
   a) The material it is made from
   b) The shape of the screw's head
   c) The thread pattern of the screw
   d) The size of the screw
2. Which feature is typical of hex head machine screws?
   a) A flat, rounded head
   b) A six-sided hexagonal head
   c) A cross-slotted recessed head
   d) A countersunk head
3. How can hex head machine screws be installed?
   a) Only with a screwdriver
   b) Only using pliers
   c) With a standard wrench or spanner, or with a screwdriver if it has a recessed drive
   d) By hammering
4. Hex head machine screws are sometimes referred to as:
   a) Lag screws
   b) Set screws
   c) Wood screws
   d) Self-tapping screws
5. Which of these is NOT part of the definition of a screw's "head type"?
   a) The shape of the head

b) The style of the drive or slot on the head
c) Whether the head is hexagonal or flat
d) The overall shape of the screw head

C. Fill in the blanks

1. Oval head machine screws offer a middle ground between the traditional _________ head and a _________ head machine screw.
2. Oval heads have a ________ underside creating a slightly ___________ profile.
3. Oval head machine screws do not _______as neatly as flat head machine screws.
4. Cheese head screws have a ________-topped head that is _________ in profile.
5. Cheese head screws are often chosen for extra _________ and _________.

D. True or False

1. The flat point set screw features a cone-shaped tip designed to resist high torque.
2. Flat point set screws are best suited for applications requiring light clamping and low torque.
3. Cup point set screws have a concave tip that digs into the surface to enhance grip.
4. Cone point set screws have a flat tip combined with a cylindrical shaft.
5. Dog point set screws are designed to fit into holes or grooves, making them suitable for precise positioning and bearing loads.

Session 3: Foundation Bolts (Rag Bolts, Eye Bolts, and Applications)

Foundation Bolt

Anchor bolts, also known as foundation bolts, are fasteners used to secure structural components firmly to concrete foundations. These bolts play a crucial role in providing stability, strength, and durability to various structures like buildings, bridges, towers, and machinery. By anchoring the structure to its foundation, foundation bolts help maintain the integrity of the construction and prevent unwanted movement.

Types of Foundation Bolts

There are several varieties of foundation bolts, each with a distinct function and a range of applications in building. Let's examine a few of the most popular types:

L Shaped Foundation Bolts:

L-shaped foundation bolts are named for their distinctive L-shaped design (Fig. 3.15). These bolts have a threaded portion that extends beyond the concrete surface, allowing secure attachment of structural elements. They are commonly used to connect concrete foundations with various structural components such as buildings, columns, and beams.

Fig. 3.15: L Shaped Foundation Bolts

J Shaped Foundation Bolts:

Another commonly used type of foundation bolt is the J bolt (Fig. 3.16). These bolts feature a J-shaped design, with the curved end providing enhanced anchorage. J bolts are often employed to secure heavy equipment, machinery, and columns to concrete foundations.

Fig. 3.16: J Shaped Foundation Bolts

U Shaped Foundation Bolts:

U bolts have a distinctive U-shaped form with threaded ends on each side (Fig. 3.17). They are commonly used to secure objects around pipes or poles. These bolts are frequently found in the assembly of pipelines, electrical systems, and plumbing installations.

Fig. 3.17: U Shaped Foundation Bolts

Plate Bolts:

Bolts that have a flat plate attached to their threaded end, are known as plate bolts or bent bolts (Fig.3.18). The plate offers a broader surface area, making these bolts ideal for securing steel, concrete, or wooden plates to foundations by distributing the load more effectively.

Fig. 3.18: Plate Bolts

Expansion Bolts:

Wedge anchors, often called expansion bolts, are specifically designed for installation in porous or hollow substrates like brick or concrete blocks. Tightening these bolts causes them to expand inside the material, ensuring a firm and reliable grip. They are widely used in situations where strong resistance to pull-out forces is essential (Fig. 3.19).

Fig. 3.19: Expansion Bolts

PRACTICAL EXERCISE

Activity: Drawing of Eye Foundation Bolt

Objective: To learn the purpose and structure of foundation bolts and accurately sketch an Eye Foundation Bolt.

Tools and Materials Needed:

- Drawing paper (A4 or A3 size)
- Drawing board with mini drafter or T-square and set squares
- Pencils (2H for construction lines, HB for final outlines)
- Compass and ruler
- Eraser and sharpener
- Relevant IS standards for reference, such as IS: 5624 on foundation bolts (if available)

Procedure:

Part A: Sketching the Eye Foundation Bolt

1. Begin by drawing the vertical threaded shaft.
2. At the bottom of the shaft, sketch a circular loop (eye) formed by bending the shank.
3. Add details such as:

   - Thread length and pitch (either standard dimensions or symbolic representation)
   - Nut and washer positioned on the upper end

4. Clearly label each component, including the threaded section, eye, washer, and nut.

Learning Outcomes:

- Develop an understanding of how foundation bolts function and their typical design features.
- Acquire the ability to create precise mechanical drawings that conform to industry standards.
- Practice proportional drawing techniques and standard conventions related to bolts and nuts.
-

CHECK YOUR PROGRESS

A. Answer the following questions

1. What is the purpose of using foundation bolts?
2. What is another common name for foundation bolts?
3. Why are foundation bolts important in building construction?
4. What types of structures commonly use foundation bolts?

5. What is the primary function of expansion bolts?

B. Multiple Choice Questions

1. What is the shape of L-shaped foundation bolts?
   a) Straight with a hooked tip
   b) Formed in an L shape
   c) Circular
   d) Spiral-shaped
2. Which of the following is a typical application of L-shaped foundation bolts?
   a) Attaching furniture to walls
   b) Securing concrete foundations to buildings, columns, and beams
   c) Connecting metal piping
   d) Holding electrical cables in place
3. What characterizes J-shaped foundation bolts?
   a) They have a straight end
   b) They have a J-shaped bend with a curved end
   c) They feature a flat head
   d) They are used exclusively for wood structures
4. What benefit does the curved end of J bolts provide?
   a) Simplifies installation
   b) Enhances anchoring strength in concrete
   c) Offers an ornamental look
   d) Helps prevent rusting
5. J-shaped foundation bolts are primarily used to secure:
   a) Small household objects
   b) Heavy machinery, large equipment, and columns to concrete bases
   c) Electrical components
   d) Lightweight panels

C. Fill in the blanks

1. U bolts feature threaded ends on both sides and have a __________-shaped profile.
2. U bolts are frequently used to fasten things around a ________ or __________.
3. U bolts are commonly used in __________, electrical systems, and plumbing installations.
4. Plate bolts have a flat ______ affixed to the threaded end.
5. Plate bolts are ideal for fastening __________, concrete, or wooden plates to foundations.

D. True or False

1. Wedge anchors are another name for expansion bolts.
2. Expansion bolts are meant to be used exclusively in solid steel structures.

3. Tightening an expansion bolt causes it to expand within the base material, creating a strong hold.
4. Expansion bolts are often used in materials like brick or hollow concrete blocks.
5. Expansion bolts are unsuitable for situations that demand high resistance to pull-out forces.

Session 4: Representation of Welded Joints Using Standard Symbols (Butt, Lap, Fillet)

There are five primary types of welded joints commonly used in fabrication:

- Butt Joint
- Corner Joint
- Edge Joint
- Lap Joint
- T-Joint

Each joint type serves a unique purpose and has distinct structural characteristics. Gaining proficiency in welding these joints is crucial for producing durable and high-quality welds. A solid understanding of these joint configurations is key to ensuring strength and reliability in welded structures.

Butt joint

A butt joint connects two workpieces aligned in the same plane, with their edges either touching or separated by a narrow gap (Fig. 3.20). Welders commonly use this joint type when a flat, seamless weld surface is required such as in the assembly of plates, pipes, or tubing. It's often applied in automotive components like exhaust systems and door panels. When properly aligned and welded, butt joints offer strong mechanical performance.

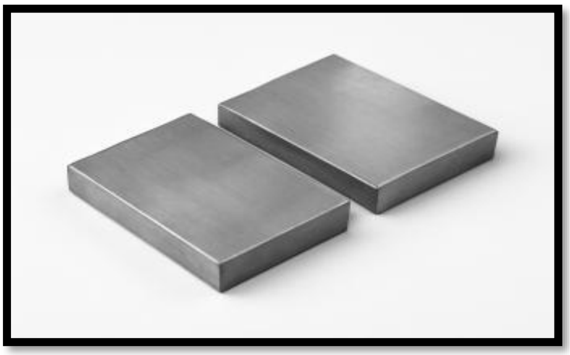


Fig. 3.20: Butt Joint

The butt joints can be designed in several ways:

Butt joints can be tailored in different ways depending on the material's thickness, the specific application, and the strength requirements of the weld. These joints may include a backing strip to support the weld (known as backed welds) or be left open at the root, referred to as open root joints. For thinner materials, minimal edge preparation is needed, and a square groove where edges are left flat is typically used. In contrast, thicker materials often require bevelled edges, either on one side (single bevel) or both sides (V-groove), to allow for deeper weld penetration. The choice between square and bevelled designs depends on the desired weld strength, ease of fabrication, and material dimensions.

Corner joint

Fig. 3.21: Corner Joint

A corner joint is formed when two workpieces meet at a 90-degree angle, creating an L-shaped connection (Fig. 3.21). These joints are simple to construct and typically need minimal or no edge preparation. They are commonly used in applications that involve square or rectangular frames such as building a welding table or similar structures.

Corner joints come in two main forms: **open corner** and **closed corner**. In a closed corner joint, one-piece rests flush against the edge of the other, while in an open corner joint, the two pieces meet at their edges, leaving a visible gap that exposes the thickness of both metals.

The choice between these two types depends largely on material thickness and the required structural strength. Open corner joints, which form a V-shaped gap, may require higher weld deposition and faster travel speeds especially when working with thin materials to avoid burn-through. Closed corner joints typically allow for a smoother finish, and the weld face can be ground down to blend seamlessly with the surrounding metal.

Proper alignment is essential when forming corner joints, especially if a precise 90-degree angle is needed. Poor fit-up or lack of support can lead to distortion during welding. To maintain accuracy and prevent movement, using a jig or fixture to hold components in place is highly recommended.

Edge joint

Fig. 3.22 Edge Joint

An edge joint is formed when the edges of two workpieces are aligned so they run parallel or nearly parallel to each other (Fig. 3.22). This type of joint is typically used in low-stress applications where the components won't be exposed to significant impact or mechanical loads. It is not recommended to use edge joints in situations where the welded parts will face high stress or sudden force.

Edge joints can vary based on how the edges are prepared before welding. They may be left square (square groove) or shaped into configurations like V-groove, J-groove, or U-groove through grinding, cutting, or machining much like in butt joint preparation. These modifications help ensure better weld penetration and coverage. For increased strength, welding can be applied along multiple sides of the joint.

Edge joints share some characteristics with corner joints. The main difference lies in placement: corner joints are usually formed at the outer edges of components, while edge joints are located on the inner sides. The decision between using an edge or corner joint often depends on factors like material thickness and the specific demands of the application.

In cases where appearance matters, edge joints might require post-weld grinding to create a smooth, flush finish with the base material.

Lap joint

A lap joint is created by overlapping two metal pieces and welding along the area where they meet (Fig.3.23). This joint type offers strong mechanical performance, particularly when both sides of the overlap are welded. Welding on both sides adds strength and improves overall joint stability.

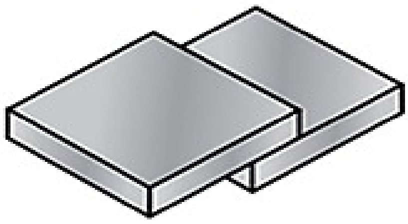


Fig. 3.23: Lap Joint

The required amount of overlap in a lap joint depends on the thickness of the materials being joined thicker materials generally need more overlap for adequate strength. Lap joints are commonly used in applications involving sheet metal or plate, such as vehicle floor repairs or patching holes.

To ensure a strong weld, the overlapping pieces must fit tightly with no gaps. When welding thin materials like sheet metal, it's important to lower the amperage and increase travel speed to prevent warping or burn-through.

When deciding between a lap joint and a butt joint, consider the application. Butt joints offer a cleaner, flush finish with the materials in the same plane, while lap joints though more visually prominent provide greater strength in high-stress areas.

Essential Tips for Welding Lap Joints:

- Weld on both sides of the overlapping sections to enhance joint strength and stability.
- For thicker materials, increase the amount of overlap to ensure adequate support.
- Ensure the two workpieces are tightly fitted with minimal gaps before welding to achieve a clean, solid weld.

T-joint

A T-joint is formed when one workpiece is positioned perpendicular to another, creating a "T" shape typically with the edge of one piece joined to the surface of the other (Fig. 3.24). These joints are known for their strong structural integrity, especially when welded on both sides. T-joints are commonly found in structural frameworks, piping systems, and equipment fabrication.

One of the advantages of T-joints is that they often require minimal edge preparation, making them relatively easy to weld when correct techniques and parameters are applied. The contacting edges may be left unaltered or shaped through cutting, grinding, or machining, depending on the demands of the application.

For optimal strength, it’s crucial to position the weld on the same side as the expected load or impact. If stress is applied from the opposite direction, there’s a higher risk of failure. Welding both sides of the joint helps to reinforce it, particularly in cases where force may be applied from multiple directions.

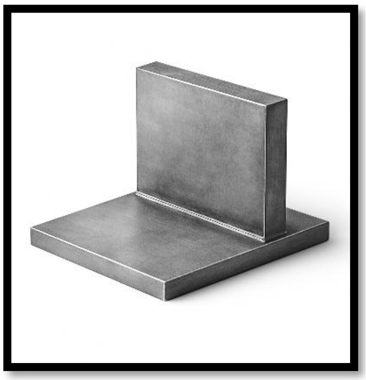


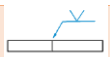
Fig. 3.24: T-Joint

T-joints are among the most versatile joint types, suitable for welding in various positions flat, vertical, horizontal, and overhead unlike some joints that are more position-sensitive. When welding a standard 90-degree T-joint, a 45-degree work angle is typically used to ensure proper fusion between both parts. In cases involving materials of different thicknesses, more weld material should be directed toward the thicker piece to maintain joint integrity.

Weld Symbol Standard Representation

Table 3.3 shows weld symbol for different types of welded joints.

Table 3.3: Weld symbols and their representation

Weld Type	Symbol	Representation Details
Fillet Weld	▲	Triangular symbol, applied at the corner of two pieces.
Butt Weld		With butt welds the welding symbol will tell you the final finish or contour,
Tee Joint Weld	T	A vertical symbol at the intersection of the two parts.

Edge Joint	_	Horizontal line indicating the joint on the edge of the material.
Corner Joint	∟	Right-angle symbol representing a corner joint.

The detailed description of welding symbols used in practical applications is given in Fig. 3.25.

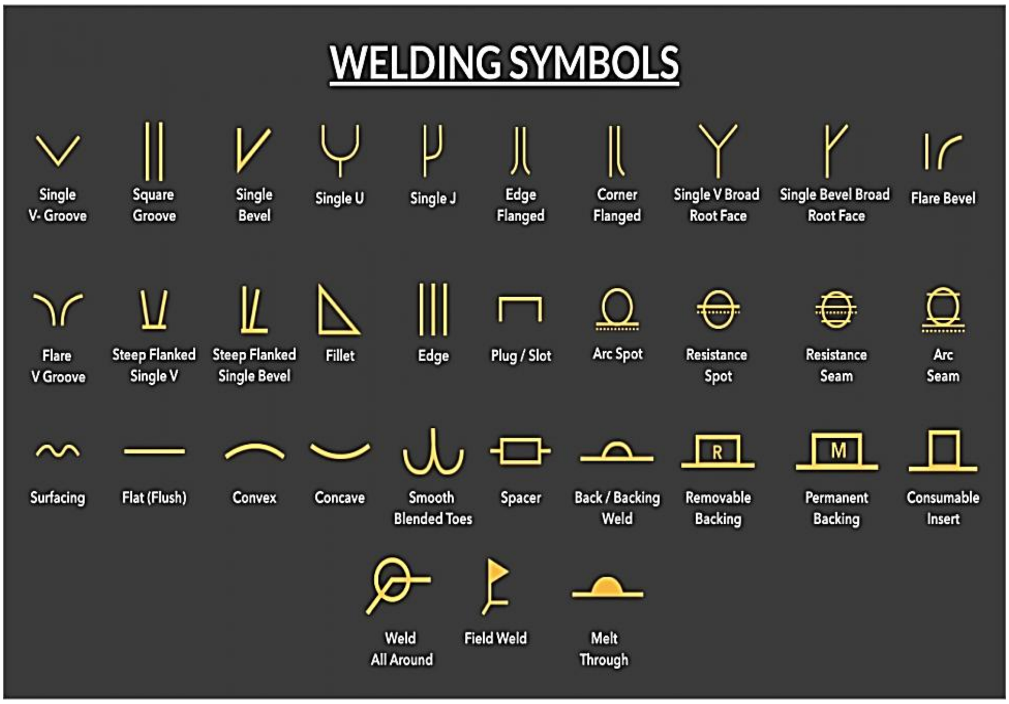


Fig. 3.25: Welding Symbols

PRACTICAL EXERCISE

Activity: Drawing Welding Symbols on Drawing Sheet as per SP:46-2003

Objective: To learn and accurately represent welding symbols on fabrication and mechanical drawings, following the guidelines of the Bureau of Indian Standards (SP:46-2003). This ensures clear, consistent communication in welding and fabrication processes.

Tools and Materials Required:

- A4 or A3 drawing sheet
- Drawing board and mini drafter (or T-square with set square)
- Pencils: 2H (for construction lines), HB (for final lines)
- Ruler and compass
- Eraser and sharpener
- SP:46-2003 Manual (Engineering Drawing for Students and Draftsmen)

Activity Steps:

Step 1: Draw the Reference Line and Arrow

1. Begin by drawing a straight horizontal reference line.
2. From one end of this line, draw an arrow pointing to the location where the weld is to be applied.
3. Optionally, add a tail on the opposite end of the reference line to include any additional notes or welding process details.

Step 2: Insert Welding Symbols

1. Select 2–3 common weld types to illustrate, such as:
    - Fillet weld
    - V-butt weld
    - Square butt weld
2. Place the weld symbol relative to the reference line:
    - **Below the line** → weld to be performed on the *arrow side*
    - **Above the line** → weld to be done on the *opposite side*
    - **Both sides** → indicate welds on both sides (e.g., double fillet weld)

Learning Outcomes:

- Develop a clear understanding of standard welding symbol conventions used in technical drawings.
- Gain hands-on experience in drafting and interpreting weld symbols according to SP:46-2003.
- Improve communication with fabricators, welders, and engineers through the use of standardized welding notations.

CHECK YOUR PROGRESS

A. Answer the following questions

1. What is an open-root butt joint?
2. What does square groove mean in butt joint terminology?
3. When are beveled edges required for butt joints?
4. What is a V-groove joint?
5. What factors influence the use of a root opening in a butt joint?

B. Multiple Choice Questions

1. What angle is typically formed between two workpieces in a corner joint?
   a) 45 degrees
   b) 60 degrees
   c) 90 degrees
   d) 120 degrees
2. Which best describes a closed corner joint?
   a) Two pieces meeting at a V-shaped angle
   b) One edge positioned flush against another
   c) A joint with a visible gap at the corner
   d) A type of T-joint used for heavy-duty applications
3. What defines an open corner joint?
   a) A joint reinforced with a backing strip
   b) Welded with filler metal on both sides
   c) A joint where the edges do not meet flush, showing the thickness of the metal
   d) Welded on both the front and back surfaces
4. Why is increasing the travel speed important when welding open corner joints on thin materials?
   a) To enhance weld penetration
   b) To prevent burn-through
   c) To minimize filler metal consumption
   d) To produce smoother weld beads

5. What is an effective method to reduce distortion during welding of corner joints?
   a) Increase welding speed
   b) Lower the welding current
   c) Use a jig or fixture to securely hold the pieces
   d) Avoid grinding the weld after completion

C. Fill in the blanks

1. An edge joint is created when the fit-up of the workpieces leaves the _____or nearly parallel to one another.
2. Edge joints are not recommended for use where parts are subject to ____or _______.
3. The edges in edge joints can be prepared using different grooves like ________________.
4. A lap joint is formed when two workpieces ________ and the weld is placed at the point where they ______.
5. Lap joints provide better strength when ________ of the overlapped pieces are _______.

D. True or False

1. Welding on both sides of a T-joint enhances its overall strength.
2. Achieving proper weld penetration in a 90-degree T-joint usually requires a 45-degree work angle.
3. When joining materials of different thicknesses in a T-joint, the majority of the weld should be applied to the thinner piece.
4. T-joints can only be welded in flat and horizontal positions.
5. The weld in a T-joint should be placed on the side opposite to where the load is expected for better durability.

Session 5: Shaft Securing Elements (Keys, Cotter Joints, Splined Shafts, Pins, Circlips)

Types of Keys in Machine Design

In machine design, keys are bar-shaped components, usually rectangular or circular, that help connect rotating elements such as shafts and gears. They may have slight variations or added features depending on their intended function. The common types of keys include:

- Sunk Keys
- Saddle Keys
    - Flat Saddle Key
    - Hollow Saddle Key
- Tangent Keys
- Round Keys
- Spindle Keys

Sunk Key

A sunk key is placed partly in a slot cut into the rotating shaft and partly in a corresponding slot in the hub or boss of the mating component. This type of key is used to provide a positive mechanical drive between the shaft and the attached part. Sunk keys come in different shapes and designs, such as rectangular, square, parallel, gib-head, feather, and Woodruff keys, each suited to specific applications.

Saddle Key:

In the case of the saddle key, which is the first type of key in Machine Design, the keys function involves resisting relative motion and transmitting torque through friction between the key and the shaft. Hence, saddle keys require a high coefficient of friction. There are two types of saddle keys:

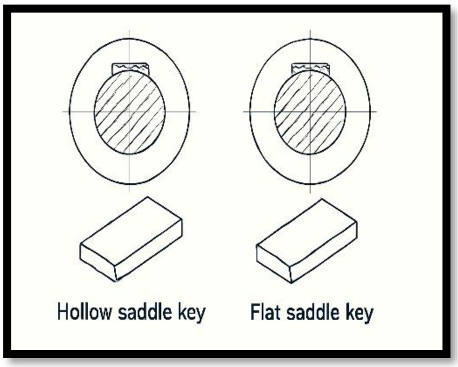


Fig. 3.26: Saddle Key

Flat Saddle Key: This tapered key fits mostly within the hub keyway and lays flat on the shaft. **Hollow Saddle Key:** Another tapered key, it fits mostly within the hub keyway, featuring a curved bottom to match the shafts contour (Fig. 3.26) .

Tangent Keys

Tangent keys fit into slots on both the rotating shaft and the hub, positioned so they align tangentially with the shaft's surface. Usually, these keys are installed in pairs, arranged at right angles to each other to effectively transmit torque (Fig. 3.27).

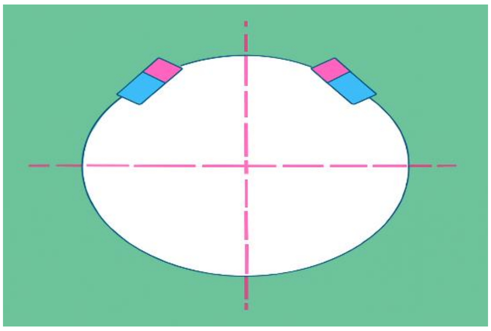


Fig. 3.27: Tangent Keys

Round Keys:

Round keys, as the name suggests, have a circular cross section and are fitted into both the rotating shaft and the hub. Circular keyways are drilled and reamed after the mating parts are assembled. These keys are well suited for low power drive applications (Fig. 3.28).

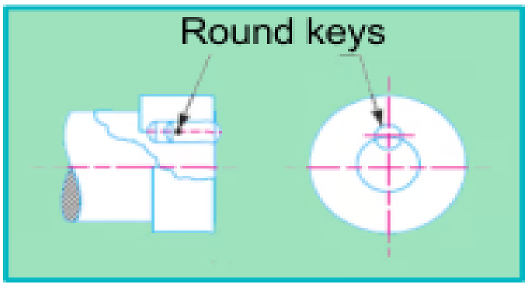


Fig. 3.28: Round Keys

Spindle Key:

Spindle Keys

Spindle keys are integral features formed directly on the shaft by milling splines, while the mating hub is machined with matching grooves using broaching. This design permits axial movement between the shaft and hub, providing a distinct functional benefit in certain mechanical applications (Fig. 3.29).

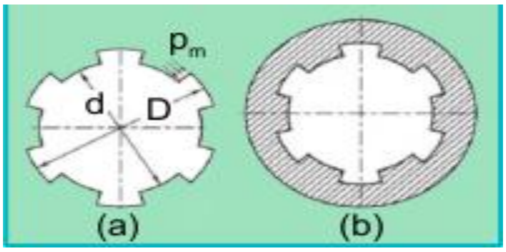


Fig. 3.29: Spindle Key

Types of Cotter Joints

Cotter joints are primarily classified into three categories based on their construction and application:

1. Socket and Spigot Cotter Joint
2. Sleeve and Cotter Joint
3. Gib and Cotter Joint

1. Socket and Spigot Cotter Joint (Fig. 3.30).

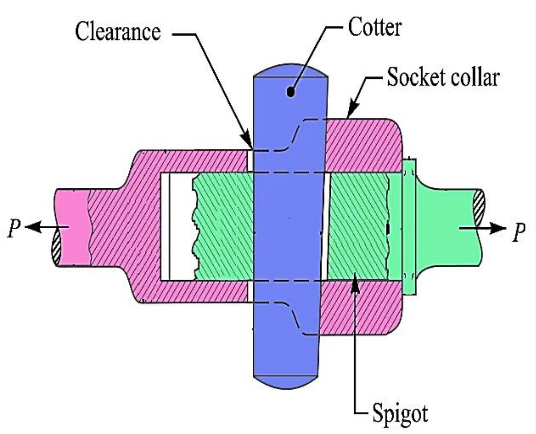


Fig. 3.30: Socket and Spigot Cotter Joint

- In the socket and spigot cotter joint, one rod end is shaped like a socket, while the other rod's end, known as the spigot, fits into this socket.
- Both the socket and the spigot have rectangular slots cut into them.
- A cotter pin is inserted tightly through these slots to securely connect the two rods temporarily.
- The joint typically experiences axial loads, which may change direction, so it must be designed to withstand both tensile and compressive forces.
- The compressive load is primarily supported by the collar on the spigot end.

2. Sleeve and Cotter Joint (Fig. 3.31)

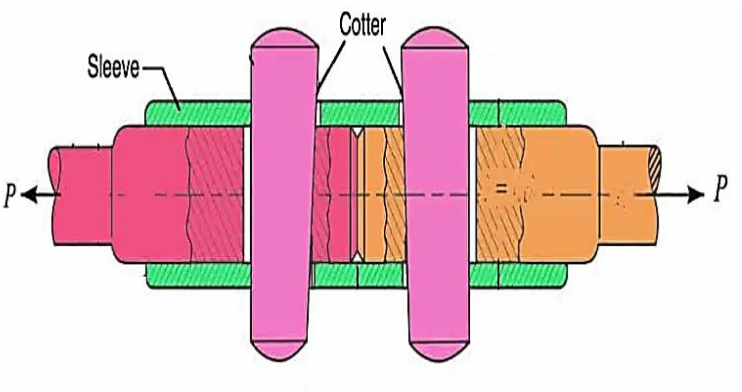


Fig. 3.31: Sleeve and Cotter Joint

The sleeve and cotter joint is commonly used to connect two round rods or bars.

- This joint employs a sleeve, also known as a muff, which fits over the ends of the two rods.
- Two cotters, one for each rod end, are inserted into matching holes in the sleeve and rods.
- Both the sleeve and cotters typically have a taper of 1 in 24. It is important that the tapered sides of the two cotters face each other, as shown in the schematic.
- The clearances are carefully designed so that when the cotters are driven in, the rods are pulled tightly together, ensuring a secure joint.

3. Gib and Cotter Joint (Fig. 3.32)

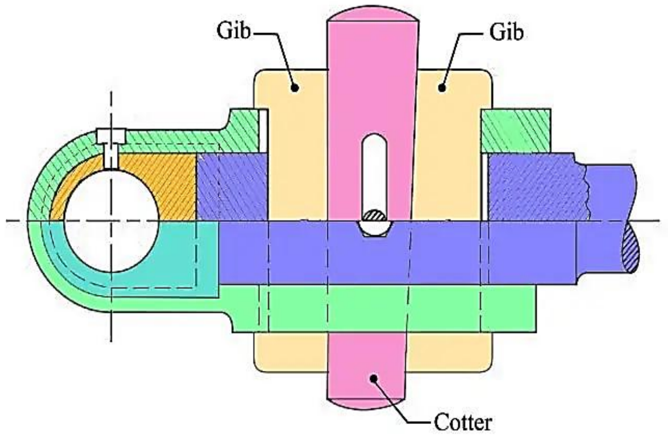


Fig. 3.32: Gib And Cotter Joint for Strap End of a Connecting Rod

For the cotter joint, we have a possibility that we do not need to use the gib. In such cases, when the cotter alone is used, the friction between its ends and the inside of the slots in the strap tends to cause the sides of the strap to spring open outwards as shown dotted in the below figure (Fig. 3.33).

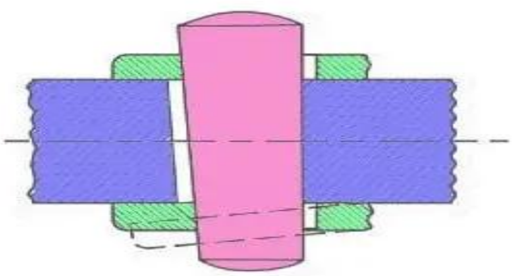


Fig. 3.33: Cotter Joint without Gib

We have to prevent this, so we have to use Gibs. So, what if we have used Gib (Fig. 3.34). Either we can use one Gib or two Gibs on both sides which hold together the ends of the strap.

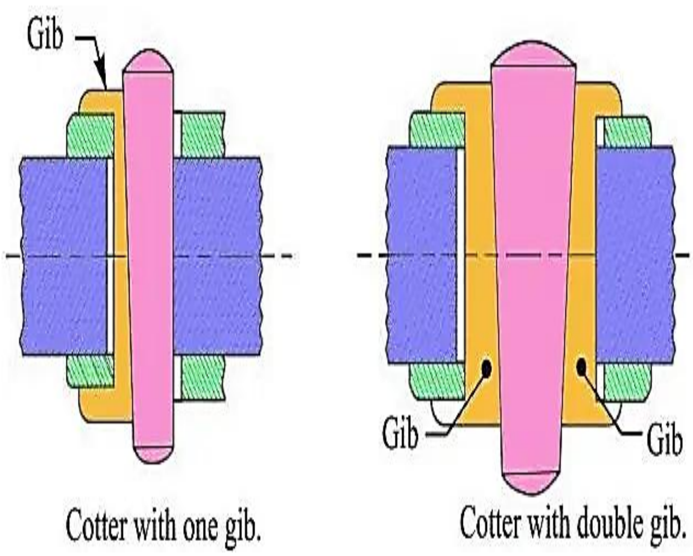


Fig. 3.34: Cotter with gib

Types of Circlips

The types of circlips include internal, external, stainless steel and E type circlips. The details of these circlips are as follows:

Internal Circlips

Internal circlips are designed to be installed inside bores or housings. Available in both metric and imperial sizes, they are versatile and suitable for a wide range of applications. Known for their durability and extended service life, internal circlips are often favored over other types. When used with enclosed equipment, they also offer good resistance to corrosion (Fig. 3.35).

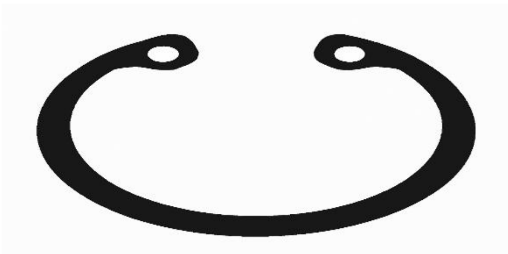


Fig. 3.35: Internal Circlip

External Circlips

External circlips are designed to fit snugly around the outside of a shaft. They serve as efficient alternatives to bulkier fastening components such as threaded sleeves, rivets, cotter pins, set collars, nuts, and machined shoulders. Like internal circlips, they are available in both metric and imperial sizes. One key advantage of external circlips is their ability to conserve space, making them ideal for compact mechanical assemblies (Fig. 3.36).

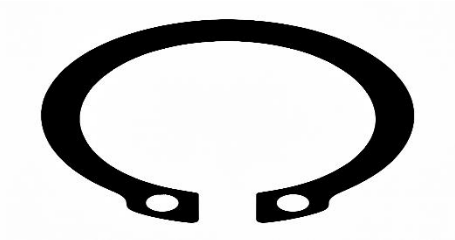


Fig. 3.36: External Circlip

Stainless Steel Circlips

Stainless steel is a widely used material for manufacturing circlips due to its strength and durability. These circlips offer long-lasting performance once installed, making them a reliable choice for various applications. Their semi-flexible design allows for easy installation and removal without causing damage to the shaft, housing, or the circlip itself (Fig. 3.37).

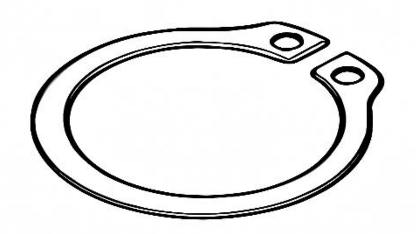


Fig. 3.37: Stainless steel Circlip

E-Type Circlips

E-type circlips are mounted radially onto shafts, rather than axially like traditional circlips. They are designed to snap into a groove on the shaft, providing secure positioning. Unlike standard circlips, E-clips do not have grip holes and therefore cannot be installed using typical circlip pliers. Instead, they are pressed into place using either a specialized tool or regular pliers (Fig. 3.38).

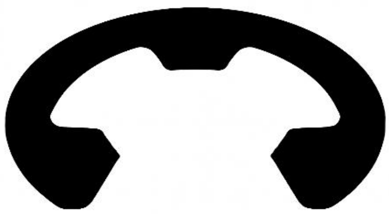


Fig. 3.38: E Type Circlips

PRACTICAL EXERCISE

Activity Title: Drawing of Different Types of Keys Flat Saddle Key

Objective: To recognize, comprehend, and accurately illustrate different types of keys such as the flat saddle key used in mechanical systems for securing rotating components to shafts.

Tools and Materials Needed:

- A4 or A3 drawing sheet
- Drawing board with mini-drafter or T-square and set squares
- Pencils: 2H for construction lines, HB for final detailing
- Compass and ruler
- Eraser and sharpener
- IS Standard Reference: IS 2292:1974 (Keys and Keyways)

Activity Instructions:

Step 1: Drawing a Flat Saddle Key

1. Begin by sketching the shaft in side view.
2. Depict a rectangular key resting on the top surface of the shaft.
3. Draw the hub placed over both the shaft and the key.
4. Clearly label all parts: **Shaft**, **Flat Saddle Key**, and **Hub**.

CHECK YOUR PROGRESS

A. Answer the following questions

1. What is a sunk key?
2. What is the purpose of a sunk key in mechanical connections?
3. What are the common types of sunk keys?
4. What is a saddle key?
5. How does a saddle key differ from a sunk key?

B. Multiple Choice Questions

1. What is a defining feature of a flat saddle key?
   a) Fully embedded in the shaft
   b) Designed with a curved base
   c) Rests on the shaft and primarily fits into the hub keyway
   d) Exclusively used in heavy torque systems
2. What makes a hollow saddle key different from a flat saddle key?
   a) It has a square profile
   b) It lacks any taper
   c) It features a curved underside to match the shaft contour
   d) It is suitable only for circular shafts
3. How are tangent keys installed in relation to the shaft and hub?
   a) Along the length of the shaft
   b) Tangent to the shaft's outer surface
   c) Positioned at 45-degree angles
   d) Inserted vertically through the hub
4. In most assemblies, how are tangent keys typically arranged?
   a) Randomly around the shaft circumference
   b) In pairs, set at 90 degrees to each other
   c) Aligned along the shaft's axis
   d) Used one at a time in each connection
5. What is the basic shape of a round key?
   a) Square
   b) Rectangular
   c) Circular
   d) Tapered

C. Fill in the Blanks

1. The _________ and cotter joints are used to connect two round rods or bars.
2. In this joint, a sleeve, also called a _________, is used over the two rods.
3. Two _________ (one on each rod end) are inserted in the holes provided in the sleeve and rods.
4. The sleeve and cotters usually have a taper of _________.
5. The _________ sides of the two cotters should face each other.

D. True or False

1. Internal circlips are specifically designed to be installed inside a bore or housing.
2. External circlips are intended for fitting within the internal surface of a housing or bore.
3. Internal circlips are manufactured exclusively in metric dimensions.
4. External circlips can serve as substitutes for components like cotter pins and threaded sleeves.
5. A key benefit of using external circlips is their ability to reduce space usage in assemblies.

Session 6: Types of Rivets and Their Applications (Snap Head, Pan Head, Countersunk Rivets)

Types of Rivets Used in Manufacturing

Rivets come in a variety of forms, each engineered to suit specific materials, strength requirements, and applications. In sheet metal fabrication, seven types of rivets are most frequently used due to their versatility and performance characteristics. Let's explore these commonly used rivets in detail.

1. Solid Rivets

Solid rivets, often referred to as round rivets, are among the most used and oldest types of fasteners. They feature a simple structure consisting of a solid shaft and a pre-formed head, typically made from materials like steel, aluminum, or copper. These rivets are known for their strength and reliability (Fig. 3.39).

Fig. 3.39: Solid Rivets

The installation process involves deforming the tail end of the rivet using a hammer or crimping tool, which secures the joint. The ease of installation, combined with their durability, makes solid rivets suitable for applications in aerospace, marine structures, electronics, machinery, and construction especially where thin structural components need to be joined.

2. Blind/Pop Rivets

Blind rivets consist of a hollow tubular body with a head and a mandrel running through the center. To install, the rivet is placed into a pre-drilled hole in the materials being joined. Using a special rivet tool, the mandrel is pulled through the rivet, causing the rivet's tube to expand and clamp the parts securely together.

Fig. 3.40: Blind/Pop Rivets

Unlike solid rivets, blind rivets can be installed from only one side of the workpiece, making them especially useful in situations where access to the back side of the joint is limited or impossible (Fig. 3.40). Due to their convenience and reliability, blind rivets are widely used in shipbuilding, electronics, aerospace, and various household applications.

3. Drive Rivets

Drive rivets also feature a mandrel running through their center, like blind rivets. However, unlike blind rivets, drive rivets do not require a special tool to pull the mandrel through. Instead, they can be installed simply by hammering the mandrel into the rivet body, often with the support of a backing block, to secure the joined parts (Fig. 3.41).

Fig. 3.41: Drive Rivets

These rivets are ideal for applications where holes do not extend completely through the material, such as fastening panels or attaching nameplates to blind holes.

Their straightforward installation method makes them a convenient option for various assembly tasks.

4. Self-Piercing Rivets

Self-piercing rivets do not require a pre-drilled hole for installation. Equipped with a chamfered tip or beveled drill, these rivets can penetrate the top layer of materials, partially piercing the lower layer (Fig. 3.42). An upsetting die then flares the rivet's tail, locking it securely into the base material and forming a low-profile button. These rivets are especially suited for high-stress applications and are highly effective for joining dissimilar materials, such as steel and aluminum, which are otherwise difficult to weld together.

Fig. 3.42: Self Piercing Rivets

5. Split Rivets

Split or bifurcated rivets are similar to self-piercing rivets and are commonly used for joining softer materials such as wood, plastic, and leather (Fig. 3.43). While they are not suited for heavy-duty or critical applications, they are ideal for light repair tasks around the home.

These rivets feature bodies that are split or sawed, often with sharp tips that allow them to pierce through

Fig. 3.43: Split Rivets

the materials easily, making them practical for quick and simple fixes.

6. Tubular Rivets

Tubular rivets consist of a solid head, a shank, and a partially hollow body (Fig. 3.44). They come in various configurations but typically feature a head on one end and a hollow tube on the other. The hollow end is inserted through the materials to be joined, and the field head is formed by deforming this end using a cold forming process.

Fig. 3.44: Tubular Rivets

Since cold forming is essential during installation, tubular rivets are generally made from soft, ductile metals with low tensile strength. These rivets are widely used in commercial products and electrical assemblies due to their ease of installation and compatibility with light-duty applications.

7. Flush Rivets

Flush rivets, also known as countersunk rivets, are specifically designed for applications where a smooth and streamlined surface is required (Fig. 3.45). These rivets feature a countersunk head that fits into a matching countersunk hole, allowing the rivet to sit flush with the surface.

Fig. 3.45: Flush Rivets

They are ideal for use on exterior surfaces where appearance and minimal drag are important, such as in aircraft skins and other aerodynamic structures. Their low-profile design makes them suitable for applications where both function and aesthetics matter.

Types of Riveted Joints

Riveted joints are mainly classified into two categories based on how the plates are connected: **lap joints** and **butt joints** (Fig. 3.46).

Lap Joint

In a lap joint, the two components being joined overlap one another. This type of joint is commonly used for connecting materials such as metal, wood, or plastic. In woodworking, lap joints are frequently used and can be of two types: full lap or half lap, depending on the depth of overlap.

Butt Joint

A butt joint is formed when the ends of two plates are placed edge-to-edge (butted together) in alignment. To secure the joint, a separate cover plate, also called a strap, is used to bridge the connection. This strap may be placed on one side or both sides of the main plates and is fastened using rivets. Butt joints are commonly used in structural and mechanical applications where alignment and strength are critical.

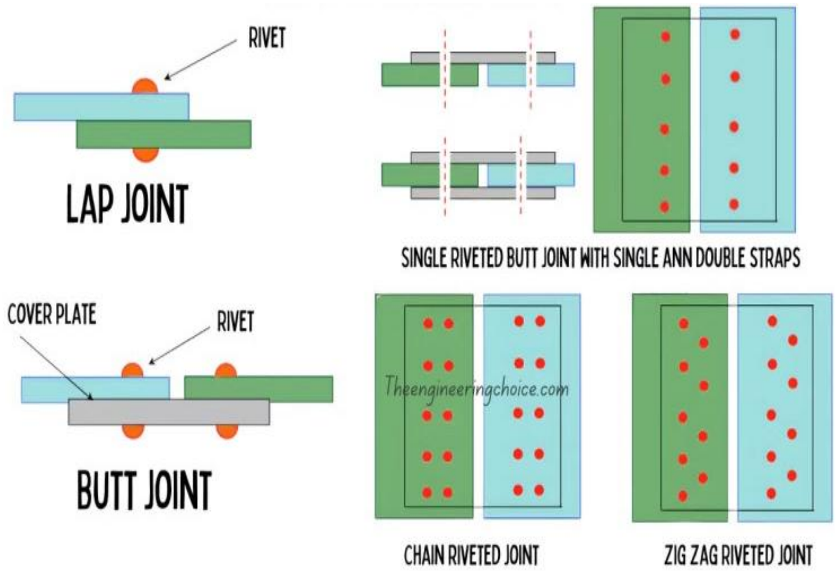


Fig. 3.46: Types of Riveted Joints

Types of Butt Joints

Butt joints can be further classified based on the number and position of cover plates used:

1. **Single Strap Butt Joint**

   In this configuration, the two main plates are placed edge-to-edge, and a single cover plate (or strap) is attached on one side. Rivets are used to fasten the cover plate to both main plates.

2. **Double Strap Butt Joint**

   Similar to the single strap joint, but with two cover plates placed on either side of the main plates. This provides greater strength and symmetry, as the rivets secure both straps across the butted plates.

Types of Riveted Joints Based on Rivet Arrangement

Depending on how the rivets are arranged, riveted joints can also be categorized into the following types:

- **Chain Riveted Joint**: In this layout, the rivets are aligned in parallel rows directly opposite each other along straight lines.
- **Zig-Zag Riveted Joint**: Unlike chain riveting, the rows of rivets in this type are staggered, forming a zig-zag pattern that offers better load distribution and resistance to shear.
- **Diamond Riveted Joint**: Commonly used in butt joints, this arrangement features rivets laid out in a diamond pattern wider near the joint and tapering toward the edges. This configuration is typically used for decorative or specialized structural applications.

Conventional Representation in Engineering Drawing

The standard drawing symbols are shown in Table 3.4.

Table 3.4: Standard Drawing Symbols

Feature	Representation
Rivet in Top View	Solid black circle
Rivet in Side View	Two parallel lines (shaft and head)
Riveted Joint	Plates shown in overlap with dotted centrelines and rivets shown
Zig-Zag Rivet Pattern	Rivets shown staggered in rows
Chain Rivet Pattern	Rivets shown aligned vertically and horizontally

Rivet Plate Thickness Relation & Rivet Arrangement Calculation

The empirical formula for determining rivet diameter (d) based on plate thickness (t) in mm is as follows:

$$d = 1.2\sqrt{t} \text{ to } 1.5\sqrt{t}$$

For example:

- If plate thickness = 10 mm
  Then rivet diameter = $1.2\sqrt{10} \approx 3.8$ mm to $1.5\sqrt{10} \approx 4.7$ mm
  (So, use 5 mm or 6 mm rivets)

PRACTICAL EXERCISE

Activity: Drawing Rivet Heads

Objective: To accurately draw various standard rivet head types using proportions based on rivet diameter, and to illustrate standard lap and butt riveted joints in both chain and zig-zag arrangements.

Tools and Materials Needed:

- Drawing board and instruments (compass, set square, ruler, protractor)
- A3 drawing sheets (recommended)
- Pencils: H-grade for construction lines, HB for final drawings
- Eraser, divider, and French curves
- Reference materials: Rivet samples or standard rivet charts
- BIS/ISO Standards Manual (optional but beneficial)

Instructions / Activity Steps:

Part A: Drawing Standard Rivet Heads

1. Study the following commonly used rivet head types according to IS specifications:
   - Snap Head (also known as Button Head)
   - Pan Head
   - Flat Head
   - Countersunk Head
   - Conical (Cone) Head
   - Mushroom Head

Drawing Guidelines:

- Choose an appropriate scale (e.g., 1:1 or 2:1), depending on the size of the rivet.
- Apply standard drawing conventions for threads and rivets as per BIS/ISO.
- Clearly label all relevant parts: rivet head, main plate, cover plate, etc.
- Add a title block and border on each drawing sheet for proper documentation.

CHECK YOUR PROGRESS

A. Answer the following questions

1. What is the common name for solid rivets?
2. Which materials are mostly used to make solid rivets?
3. What tools are typically used to shape or deform solid rivets during installation?
4. What characteristic distinguishes blind rivets from other rivet types?
5. What are the main components of a blind rivet?

B. Multiple Choice Questions

1. Which tool is commonly used to install a drive rivet?
   a) Rivet gun
   b) Crimping tool
   c) Hammer
   d) Welding torch
2. Drive rivets are typically used for which of the following purposes?
   a) Connecting heavy structural beams
   b) Securing bolts in place
   c) Attaching nameplates into blind holes
   d) Welding different types of metals
3. How do drive rivets differ from blind rivets?
   a) They need a rivet gun for installation
   b) They join materials by applying heat
   c) They don't require a special tool to pull the mandrel
   d) They cannot be used in holes without access to both sides
4. What distinguishes self-piercing rivets from other rivet types?
   a) They need pre-drilled holes before installation
   b) They join materials by welding
   c) They can pierce the upper layer without pre-drilling
   d) They are only suitable for plastic materials
5. What component helps self-piercing rivets secure into the lower sheet?
   a) Welding tip
   b) Upsetting die
   c) Screw thread
   d) Magnetic head

C. Fill in the blanks

1. The bodies of split rivets are usually ______ or split.
2. The sharp tips of split rivets help them _________ materials.
3. Tubular rivets have a head, shank, and a partially _________ tube.
4. Tubular rivets are usually joined using the _____ forming technique.
5. The field head is formed on the _______ side of a tubular rivet.

D. True or False

1. In a single strap butt joint, a single cover plate is placed on just one side of the main plates.
2. A double strap butt joint features only one cover plate positioned on one side of the plates.
3. In a chain riveted joint, rivet rows are positioned directly opposite each other in straight lines.
4. In a zig-zag riveted joint, the rivets are arranged in a straight, linear pattern.
5. A diamond riveted joint is commonly used in lap joints.

MODULE 4 INTRODUCTION TO TINKERCAD

Module Overview

Tinkercad is a free, web-based 3D modelling software accessible through any internet browser. Since its release in 2011, it has gained widespread popularity for designing models intended for 3D printing and is widely used as an introductory tool for teaching constructive solid geometry in educational settings. This module is designed for Grade XI Draughtsman–Mechanical students to explore Tinkercads 2D drafting features. Emphasizing top-view sketches, students will learn to operate the interface, manipulate basic shapes, work with exact dimensions, and create simple 2D mechanical parts. By the conclusion of the module, learners will be proficient in digitally creating, annotating, and exporting fundamental 2D technical drawings.

Learning Outcomes

After finishing this module, you will be able to:

- Recognize the key features and functions of Tinkercad as an online 2D design and drafting tool.
- Confidently create, align, and edit basic 2D shapes within the Tinkercad workspace.
- Use precise measurement and positioning methods to design simple 2D mechanical parts like plates and flanges.
- Export your finalized 2D drawings in suitable formats for presentation, printing, or documentation.

Module Structure

The sessions of this module are planned as follows:

Session 1: Basics of Tinkercad Software

Session 2: Creating and Modifying the Shapes

Session 3: Dimensioning and Exporting the Designs

Session 1: Basics of Tinkercad Software

Introduction to Tinkercad

Tinkercad is a free, browser-based tool for 3D design and modeling, widely used for both simple and advanced projects, especially in 3D printing. Its straightforward and easy-to-learn interface makes it perfect for beginners and is frequently used in educational settings. Key features include:

1. **3D Modeling:** Users create models by combining basic shapes such as cubes, cylinders, and spheres, which can be resized, rotated, and adjusted to build more detailed designs.
2. **Simple Interface:** The drag-and-drop functionality makes it easy for new users to start designing without a steep learning curve.
3. **3D Printing Compatibility:** Finished models can be exported in formats like STL or OBJ, designed with 3D printing in mind.
4. **Electronic Circuit Design:** Tinkercad also supports creating and simulating circuits, which are useful for electronics learners and hobbyists.
5. **Coding Integration:** With Code Blocks, users can generate 3D models through visual programming, combining coding concepts with design.
6. **Collaboration:** It allows sharing and collaborative editing, making group projects easier to manage.

General Steps to start working with Tinkercad

1. Scroll the website **https://www.tinkercad.com/** on your PC / Laptop.
2. Click on Sign Up and follow the steps to create your own account (Fig. 4.1)

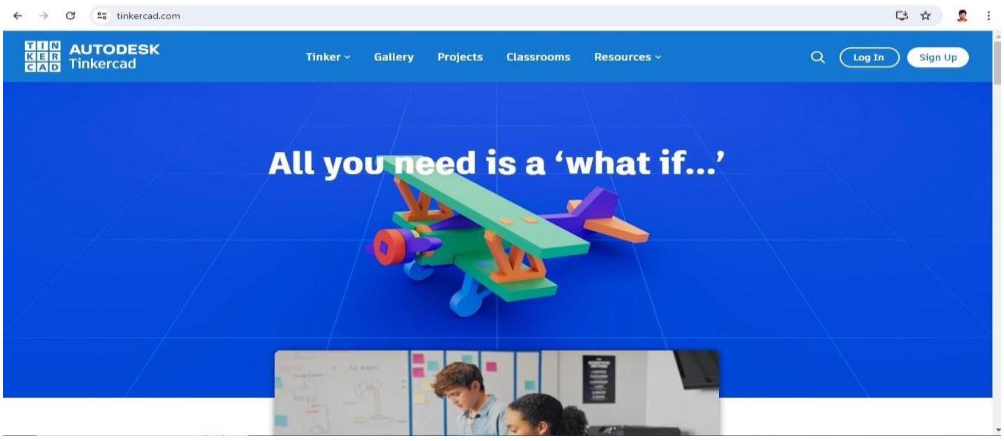


Fig. 4.1: Sign up on Tinkercad

Now, let us go through the actual workspace of Tinkercad (Fig. 4.2).

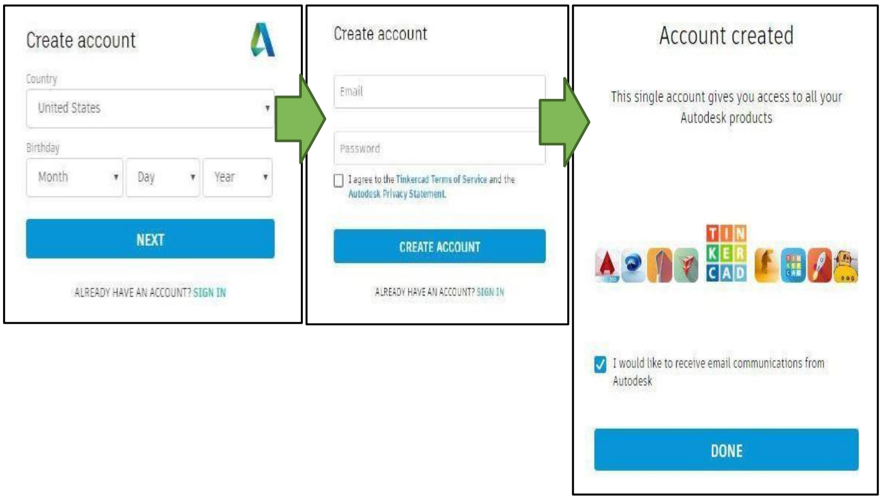


Fig. 4.2: Create account on Tinkercad

Tinkercad work space overview (Fig. 4.3).

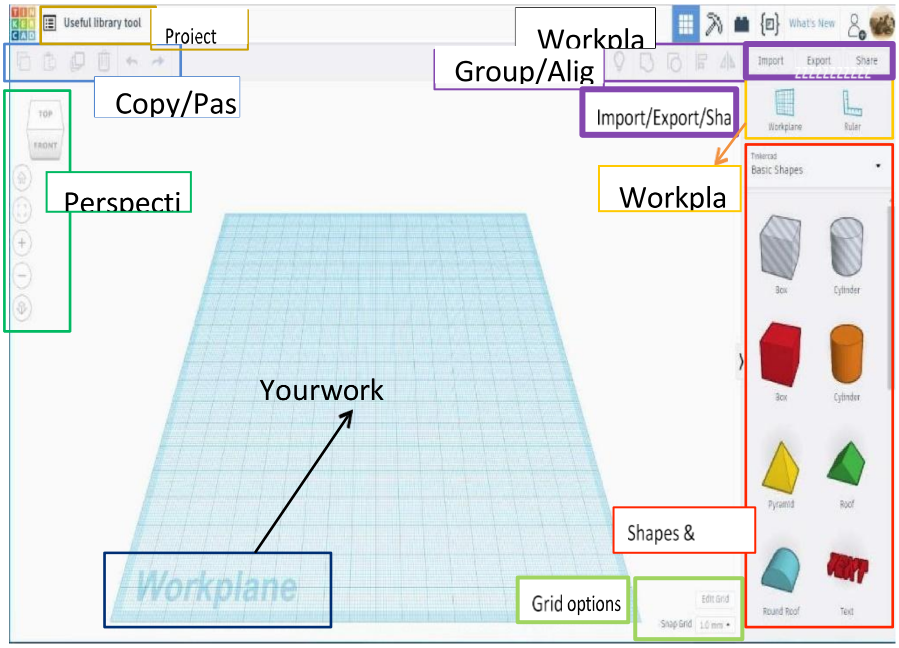


Fig. 4.3: Tinkercad Workspace

Planning some basic tasks

1. Moving a shape or symbol from the basic shapes menu to your work plane (clicking and dragging) (Fig. 4.4).

1. Select which shape you would like to add to your work plane.
2. Move your mouse over the work plane where you would like to drop your shape.
3. Left click to "drop" shape and add it to the work plane.

Note: Alternatively, you can left click and hold the shape you want, drag your mouse to where you want to put it on the Workplane and then let go of the left click button on the mouse to drop your shape.

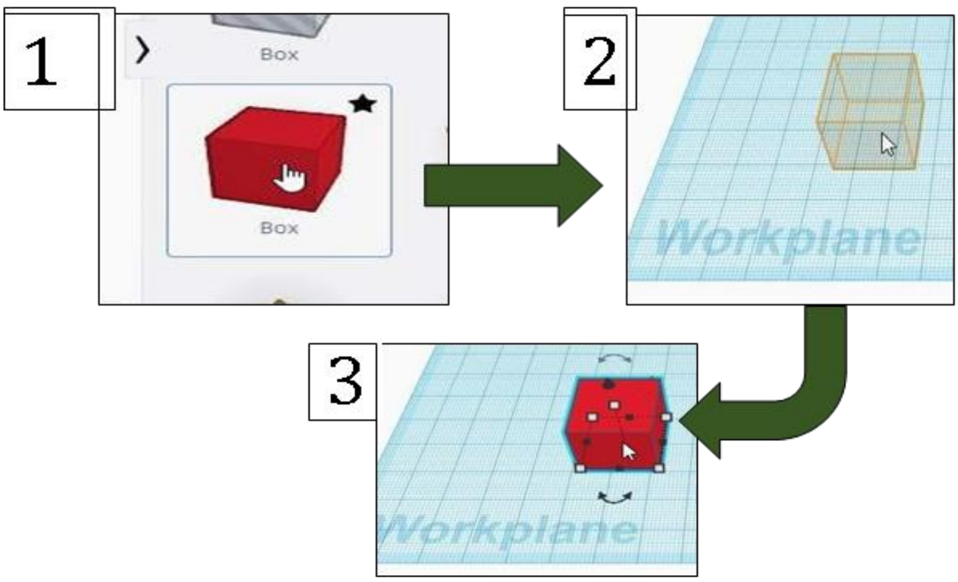
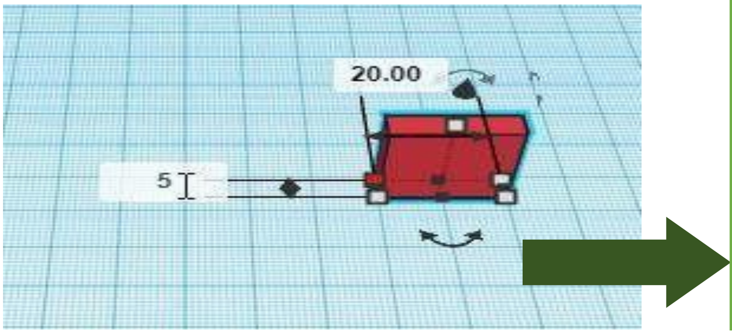


Fig. 4.4: Clicking and Dragging

I. Resizing your shape

There are many ways to edit your shape once it is on the work plane. (Fig. 4.5 and 4.6)



Once a shape is selected on the work plane, carefully click a small gray box to change a specific measurement of a shape by left clicking within the white text boxes that appear.

Note: Selected points will change colour from gray (unselected) to red (selected).

Fig. 4.5: Resizing the Shape (1)

Click and drag the small white circles when you have a shape selected to make changes.

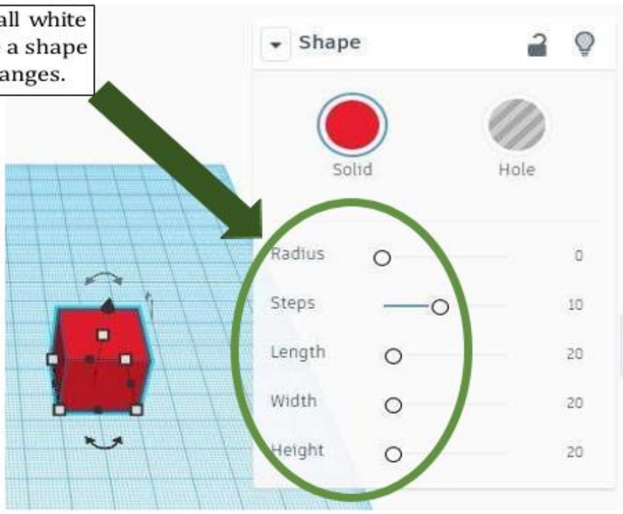


Fig. 4.6: Resizing the shape (2)

Note: Alternatively, you can click on the left and drag any of the points to change the size/shape of the object selected.

II. Moving a shape above or below the work plane (Fig. 4.7).

a. You can move a shape above the work plane by clicking and dragging the cone-shaped handle above your shape. This function allows you to stack shapes on top of each other.

b. Remember to view your shape from the front to make sure it is not floating above the Work plane. This could mess up your 3D print if the base of your project is not touching the Work plane.

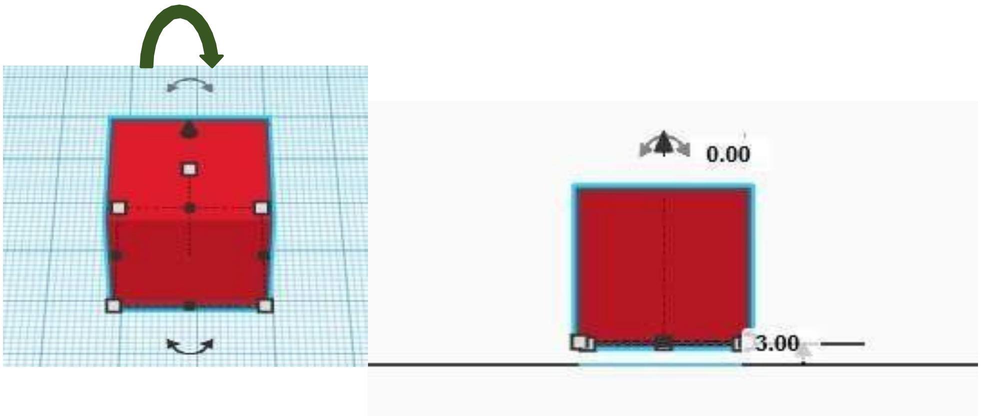


Fig. 4.7: Moving a Shape above or Below the Workplane

IV. The workplane button

If you would like to work or build on the side of a shape, you can change the Work plane to be the surface of a shape side by clicking this button and then clicking the side of a shape.

Try this

i. Choose any shape such as a cuboid
ii. Click the workplane button and select the side. The side you have so selected, the workplane will be shifted as per that.
iii. Select the prismoid and place on the selected sides (Fig 4.8).

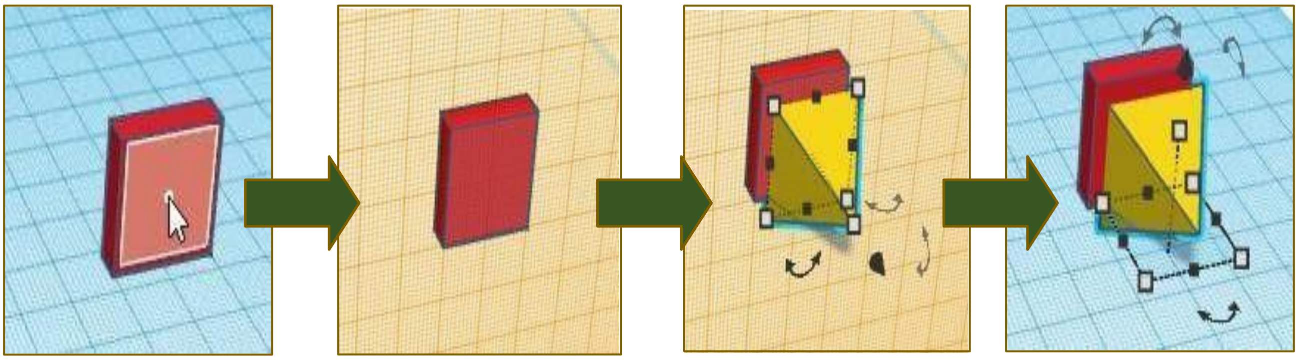
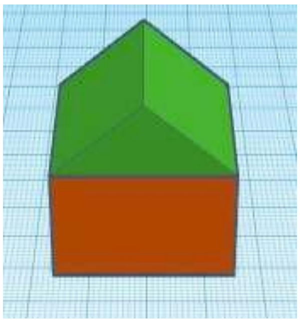


Fig. 4.8: Use of Workplace Button

PRACTICAL EXERCISE

Activity: Design a basic House (With no specific dimensions)



Requirements: Laptop or Desktop with an internet connection.

Procedure:

(Refer Fig. 4.9 with steps mentioned)

1. Open browser and open "www.tinkercad.com".
2. Login and choose to create 3D modelling.
3. Click and drag a "Box" shape from the Basic Shapes menu to your Workplane.
4. Change the size of your box to be the size of house that you prefer.
5. Change the area of your Workplane to the top of the box in order to add your roof.
6. Add a "Roof" shape on top of your box shape to make a house.
7. Change the color of your house

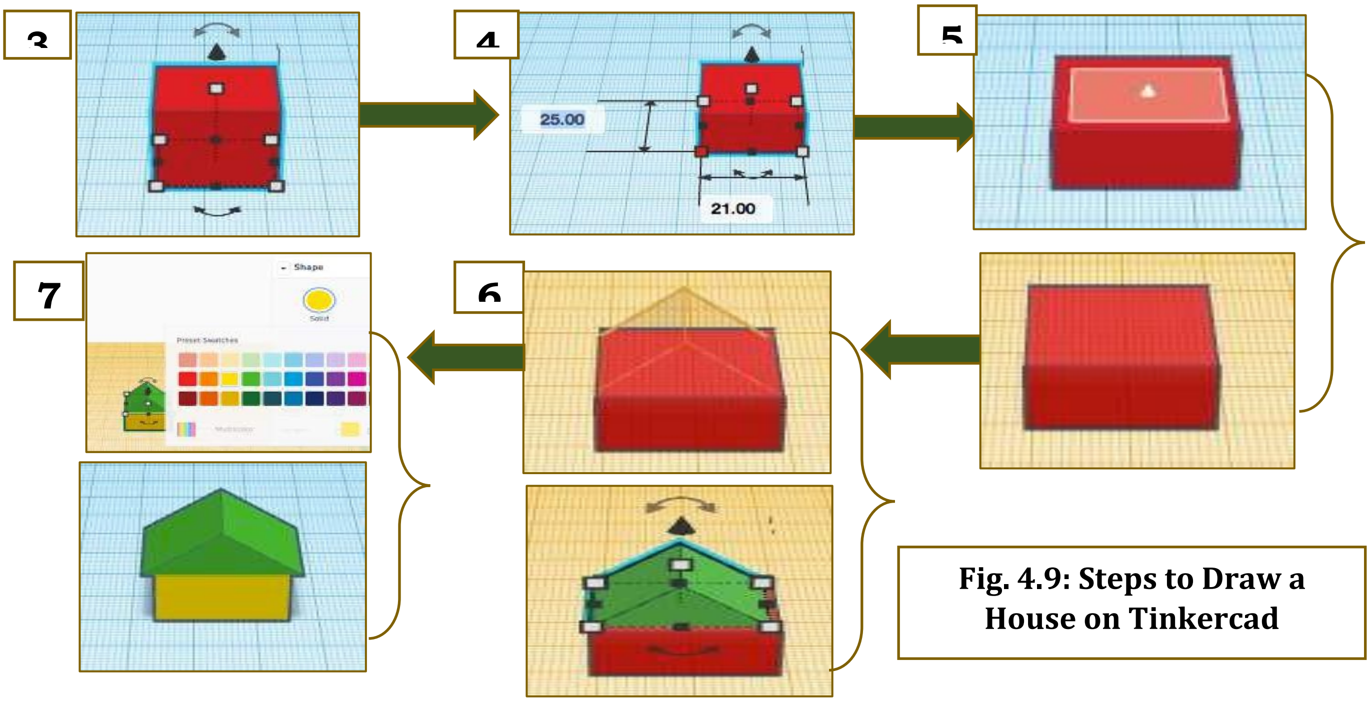


Fig. 4.9: Steps to Draw a House on Tinkercad

CHECK YOUR PROGRESS

A. Answer the following questions

1. How would you describe Tinkercad?
2. Which type of user is Tinkercad best suited for?
3. What capabilities does Tinkercad offer for 3D design?
4. What features contribute to Tinkercad's user-friendly experience?
5. Is it possible to prepare and export Tinkercad designs for 3D printing?

B. Multiple Choice Questions

1. Which feature in Tinkercad enables users to build and test electronic circuits?
   a) Code Blocks
   b) Shape Builder
   c) Circuit Design
   d) Animation Tools
2. The Circuit Design tool in Tinkercad is particularly beneficial for:
   a) Architects
   b) Students and hobbyists
   c) Graphic designers
   d) Gamers
3. What is the main function of Code Blocks within Tinkercad?
   a) Simulating electrical current
   b) Exporting files for 3D printing
   c) Creating 3D models through block-based coding
   d) Enabling real-time collaboration
4. Tinkercads Code Blocks feature is most similar to which programming style?
   a) Text-based coding
   b) Command-line scripting
   c) Block-based programming
   d) Game scripting
5. How does Tinkercad support teamwork on projects?
   a) Group chat functionality
   b) Live video editing
   c) Design sharing and collaborative editing
   d) File encryption

C. Fill in the blanks

1. In Tinkercad, you can use basic shapes like ________, cylinders, spheres to create models.
2. Tinkercad does not require installation because it runs _______ in a web browser.
3. Tinkercad supports exporting files in ________, OBJ, and other 3D printing formats.
4. Tinkercad is suitable for creating complex models by combining ________ shapes.
5. Tinkercad is popular in education because it is _______, easy to use, and helps teach 3D modeling basics.

Session 2: Creating and Modifying the Shapes

Creating and Modifying Shapes in Tinkercad

Learning to create and edit shapes in Tinkercad is essential for producing accurate 2D and 3D mechanical drawings. The process starts by choosing basic shapes such as rectangles, circles, and polygons from the shape library. These shapes can then be moved, resized, rotated, copied, and aligned using Tinkercads user-friendly tools.

One useful feature is grouping, which allows you to merge several shapes into a single object. This is helpful when designing more complex parts like flanges or plates. Tools like grid snapping and the ruler help ensure precise placement and correct dimensions. With regular practice, users can improve their spatial understanding and gain confidence in creating neat and professional mechanical designs digitally.

To get started, try a hands-on activity: design and draw a personalized keychain with your name. You will need a laptop or desktop with internet access. Simply log into Tinkercad using your email ID and follow the instructions to create the keychain (Fig. 4.10).

Fig. 4.10: Keychain Design in Tinkercad

1. Click on the Create new design button (Fig. 4.11).

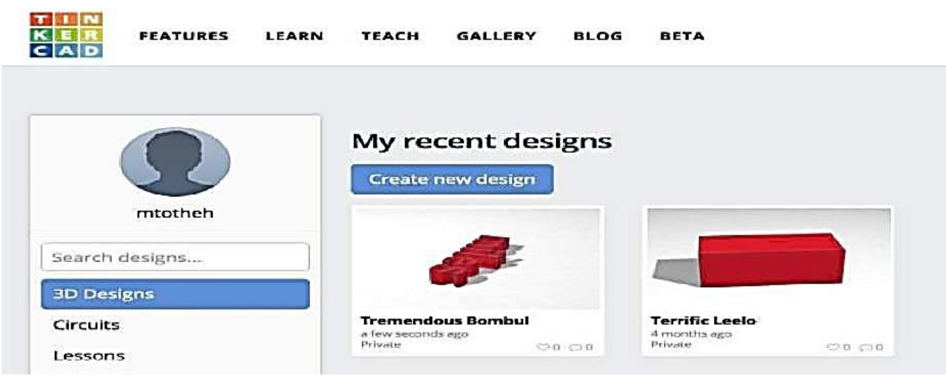


Fig. 4.11: Create New Design Button

2. Click and drag a box on to the Work plane (Fig. 4.12).

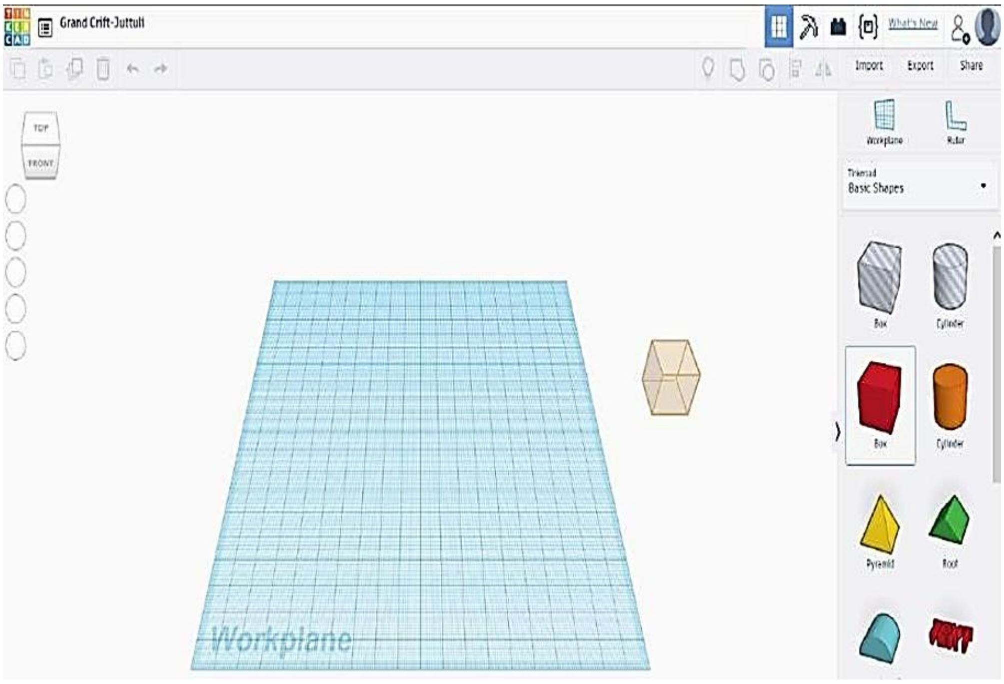


Fig. 4.12: Click and Drag a Box

3. Click and drag the box in to a rectangle, roughly 60 mm long by 22 mm wide. (Fig. 4.13 and 4.14). Grab the middle handle and reduce the height/thickness to around 2 mm.

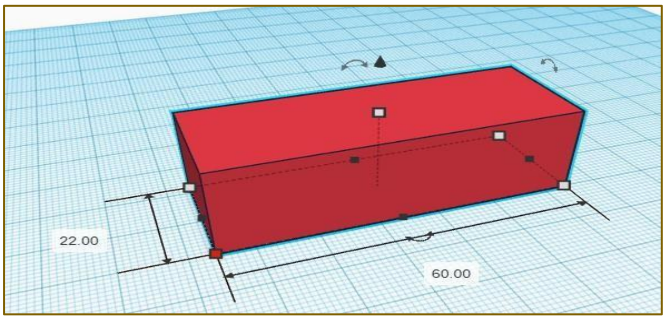


Fig. 4.13: Create Box of Mentioned Depth and Width

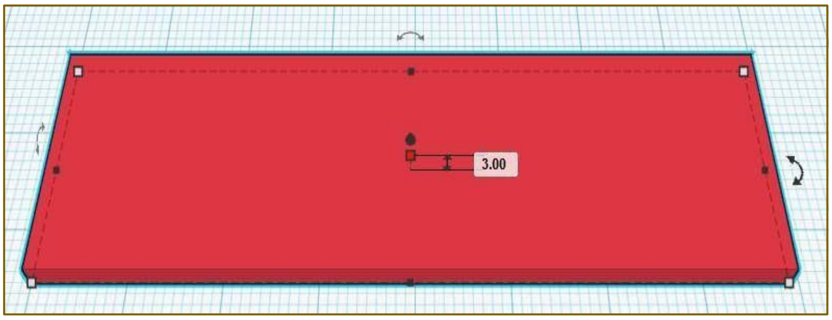


Fig. 4.14: Reducing the Height/Thickness of Box to 2 mm

4. Click and drag the Text shape on to the Work plane (Fig. 4.15).

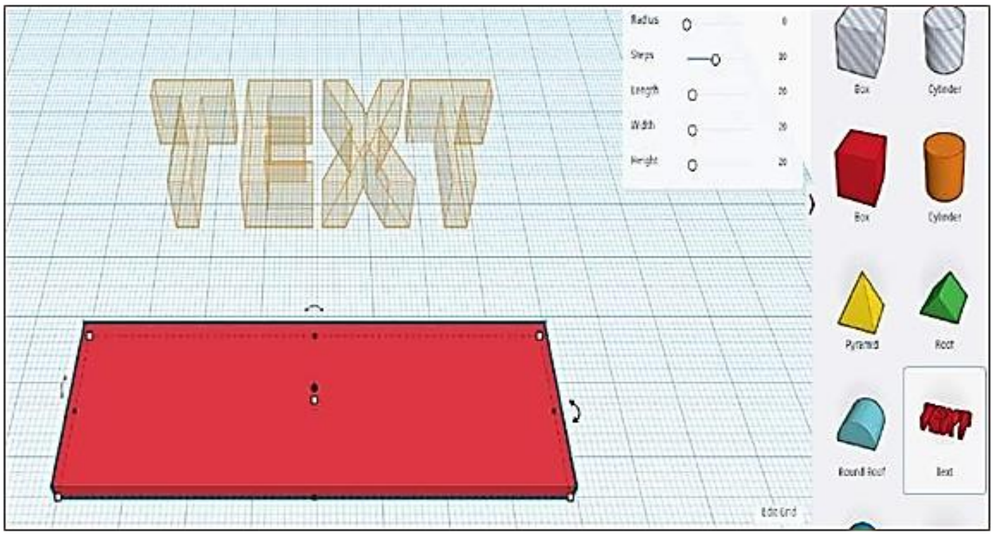


Fig. 4.15: Dragging Text into Workplane

5. Type in your first name in the text box in the shape menu appears. If your first name is long, you may need to click and drag the side of your box to make it longer (Fig. 4.16).

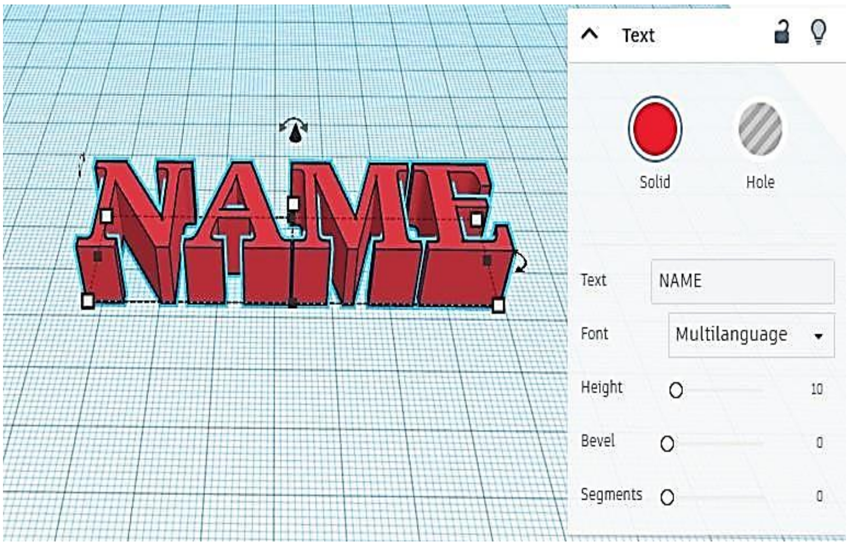


Fig. 4.16: Insert the Name

6. Once you have typed your name, drag it on top of your box. Click your middle handle and decrease the thickness of your name to around 3 mm (Fig. 4.17).

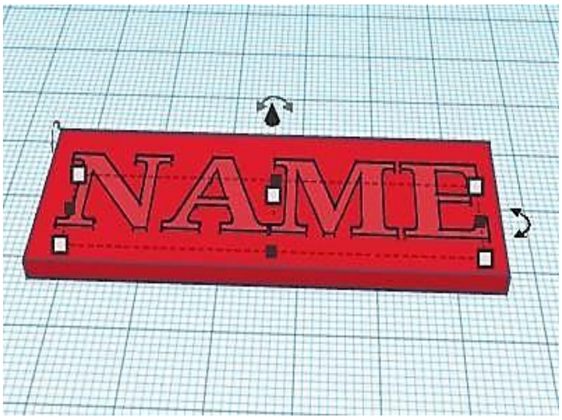


Fig. 4.17: Placing Name over the Box And Adjusting its Thickness

7. Scroll to the bottom of your Basic Shapes menu and drag a tube onto the Work plane (Fig. 4.18).

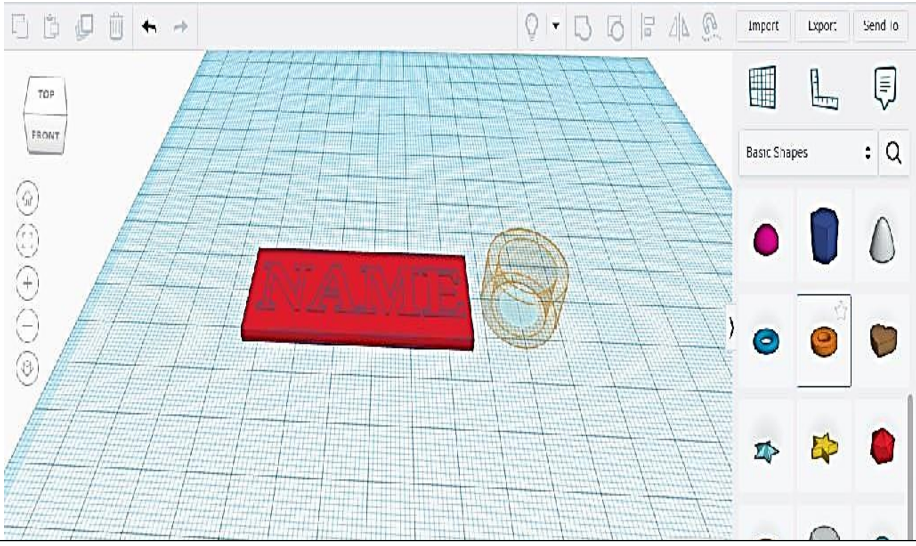


Fig. 4.18: Selection of Tube Shape from the Basic Shapes

8. Click and drag the middle handle to reduce the thickness of the tube to around 2.50 mm and radius of approx. 15 mm (Fig. 4.19).

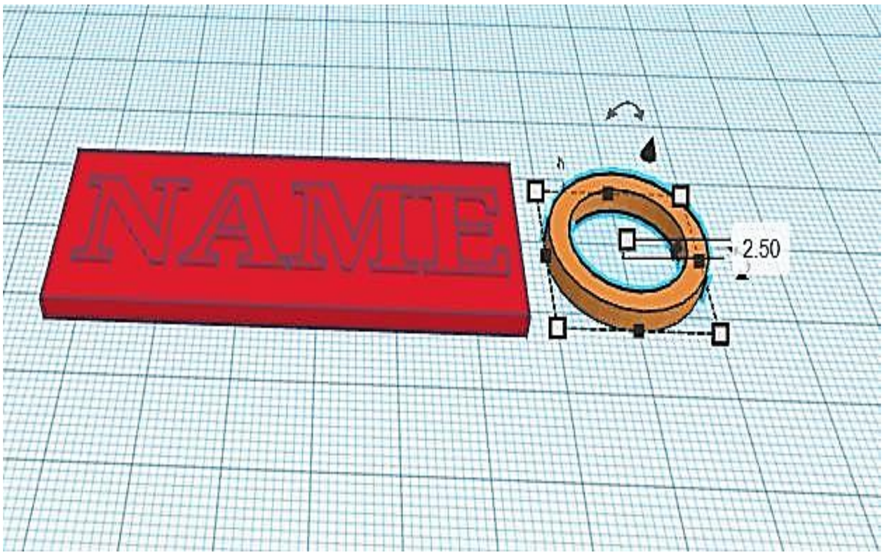


Fig. 4.19: Click and Drag on the Box

9. Drag your tube and place it so the bottom ¼ (or so) is inside your box (Fig. 4.20).

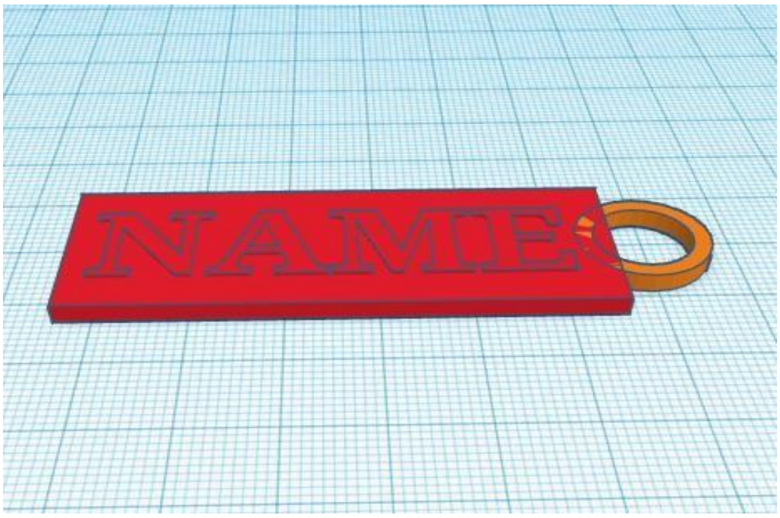


Fig. 4.20: Blending the Tube to the Box to some Extent

10. Click and drag as square around your entire design (Fig. 4.21).

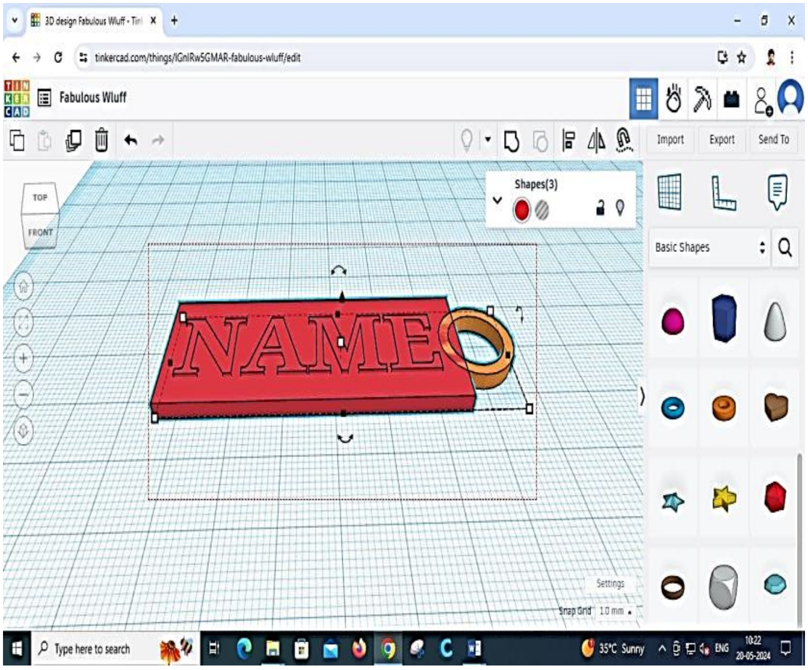


Fig. 4.21: Selecting the Overall design

11. Click on the Group button, which will connect all the pieces of your project together (Fig. 4.22).

Fig. 4.22: Finalization of the Overall design

Admire your finished key chain (Fig. 4.23).

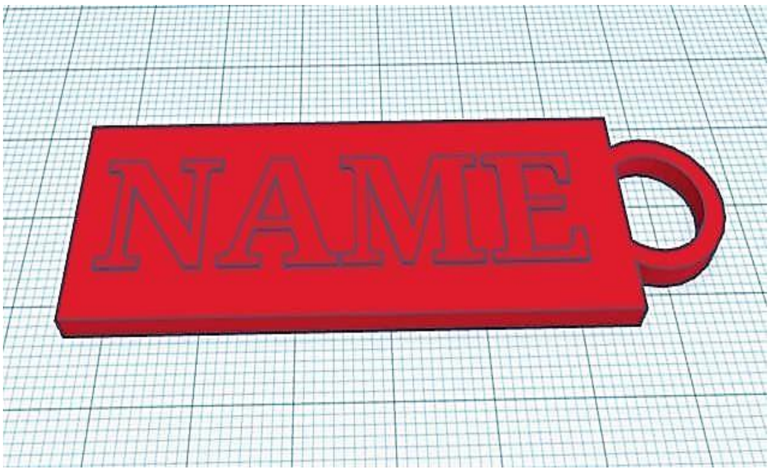


Fig. 4.23: Final Key Chain Design

12. **Renaming Your Project:**

When you start a new project in Tinkercad, it automatically gives it a default name, which is often quirky or random. To change this, simply click on the current project name located at the top left corner of the screen (Fig. 4.24). This will highlight the name, turning it into an editable text box where you can type in a new name of your choice.

Fig. 4.24: Changing the Project Name

13. **Saving Your Project:**

Tinkercad saves your work automatically, so you don't have to worry about losing progress. When you exit the project, a small green notification bar will appear at the bottom of the screen indicating that your work is being saved (Fig. 4.25). Keep in mind that until you manually download your design, it remains stored safely in the cloud on Tinkercads servers.

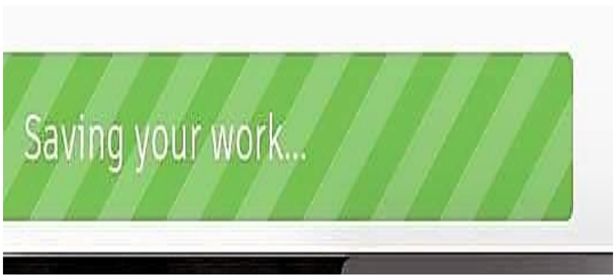


Fig. 4.25: Saving the Project

PRACTICAL EXERCISE

Activity: Drawing shapes in Tinkercad
Objective: To draw the objects in Tinkercad (Fig. 4.26).

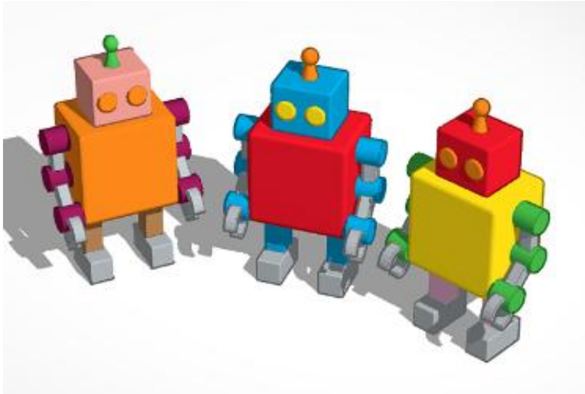


Fig. 4.26: 3D Robots

Materials required: Laptop or PC with internet connection

Procedure:
Follow the procedure as explained in session 1 and 2 of this module and draw images. Choose your own specifications. Write the step by step procedure followed by you.

Learning outcomes:
After completing this activity, the learners will be able to:
1. Identify the commands used in Tinkercad.
2. Draw 2D and 3D shapes using the commands of Tinkercad.

CHECK YOUR PROGRESS

A. Answer the following questions

1. What is the initial step when starting to build shapes in Tinkercad?
2. What kinds of modifications can you apply to shapes in the Tinkercad workspace?
3. How does the grouping tool function in Tinkercad?
4. Which types of mechanical parts can be created by grouping multiple shapes together?
5. Which features in Tinkercad assist with placing and sizing objects precisely?

B. Multiple Choice Questions

1. What type of project name does Tinkercad assign by default when you create a new design?
   a) Based on your email
   b) A randomly generated funny name
   c) Current date and time
   d) A numeric ID
2. How can you change the default project name in Tinkercad?
   a) Using the settings panel
   b) By right-clicking anywhere on the screen
   c) By clicking directly on the name in the top-left corner
   d) By downloading the project with a new name
3. What happens after clicking on the default project name in Tinkercad?
   a) An export window opens
   b) The name turns into an editable text box
   c) The project name becomes locked
   d) The name is erased automatically
4. How are your projects stored in Tinkercad?
   a) Manually by pressing a save button
   b) Saved temporarily in your browser
   c) Automatically saved to cloud storage
   d) Only saved if downloaded as a file
5. What on-screen message shows that Tinkercad is saving your progress?
   a) Saving to desktop…
   b) Download finished
   c) A green bar with the message Saving your work
   d) Unable to save changes

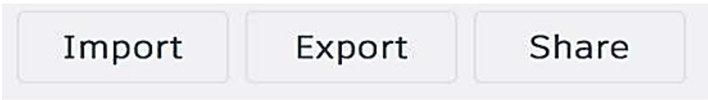
Session 3: Dimensioning and Exporting the Designs

Dimensioning in Tinkercad

Dimensioning in Tinkercad is a crucial step that turns a basic sketch into a functional engineering drawing. By enabling the **Ruler** tool, users can see real-time coordinates along the X and Y axes and input precise values for length, width, height, or spacing between design elements.

Additional features like **text labels** and **workplane annotations** allow users to mark tolerances, hole sizes, or other specifications directly on the model. Once all measurements are confirmed, the design can be exported using the **Export** menu. For documentation purposes, users can utilize **PDF printers** to capture top-view layouts, making it suitable for engineering reports or technical presentations.

Let us learn to import, export and share the designs made in Tinkercad.



Importing Files into Tinkercad

To bring external designs into your Tinkercad workspace, use the **Import** button. This feature allows you to upload either 2D or 3D files directly from your computer by dragging and dropping, or by selecting a file through your device's file browser.

You can also download pre-made models from popular 3D model repositories such as **Thingiverse** or **My Mini Factory** and then import them into Tinkercad for further customization or editing (Fig. 4.27).

Fig. 4.27: Import Menu

Exporting Your Design

After completing your project in Tinkercad, you may want to save it externally for purposes such as 3D printing or documentation. To do this, use the **Export** button.

Once clicked, a menu will appear allowing you to choose from various file formats suitable for different applications such as. STL, .OBJ, or .SVG. Select the format that matches your intended use, and the file will be downloaded to your device for future use or printing (Fig. 4.28).

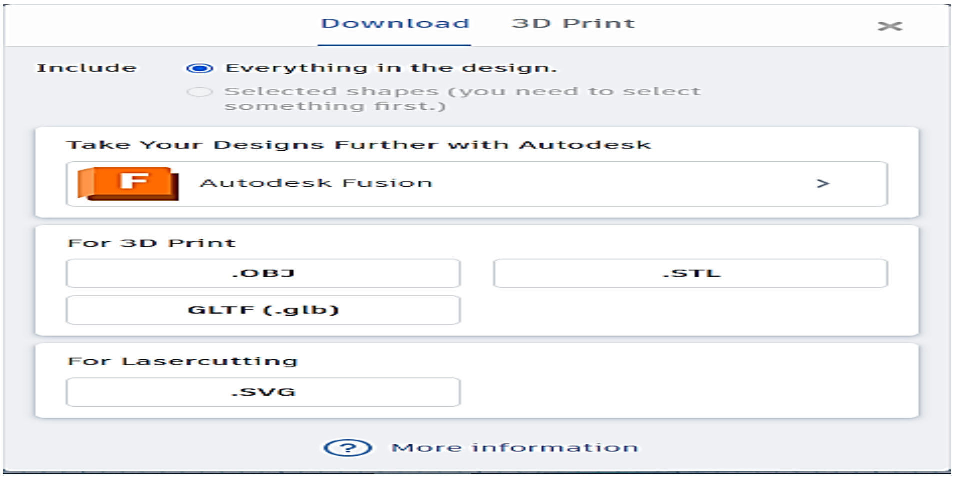


Fig. 4.28: Export the Design

Choosing the Right File Format: STL vs .OBJ

Once your 3D model is complete, you'll need to decide which file format to export, most commonly either. STL or .OBJ. Each format has its own advantages, and the choice depends on your project's requirements (Fig. 4.29).

1.. STL (Stereolithography)

The .STL file format is the most widely used for 3D printing. It's supported by nearly all CAD software and is compatible with most 3D printers.

- It works by breaking the 3D model into thin, 2D layers.
- These layers guide the printer in creating the object layer by layer.
- .STL files contain only the geometric information of the object (no color or texture data).
- Best suitable for simple, single material prints where appearance (like color) is not a concern.

2. .OBJ (Object File)

The .OBJ format is more versatile and detailed compared to. STL.

- It includes not only geometry but also information like textures, colors, and material properties.
- Ideal for models that require a more realistic appearance or are used in rendering or animation.
- Supported by many CAD tools and compatible with modern 3D printers that support color printing or advanced material handling.

Fig. 4.29: Complete 3D Print

PRACTICAL EXERCISE

Activity: Creating a drawing in Tinkercad and exporting it to 3D printer for printing

Objective: Enable students to design a 3D cube with rounded edges and patterned dots using Tinkercads shape manipulation and alignment tools, and export the final model as an STL file ready for 3D printing.

Materials Needed:

- Computer or laptop with internet connectivity
- Active Tinkercad account
- Access to **https://www.tinkercad.com**
- 3D printer (optional; available in school lab or via simulation software)

Procedure:

Refer to the instructions covered in Sessions 1 and 2 of this module to get started with designing. You may customize specifications as desired.

Step 1: Start a New Project

- Log into your Tinkercad account and select **Create New Design**

- Rename your project to “Custom Dice” or a name of your choice

Step 2: Build the Cube

- Drag a **Box** shape from the Basic Shapes panel onto the workplane
- Adjust its size to **20 mm × 20 mm × 20 mm** using the dimension input boxes
- (Optional) Soften the cube’s edges by setting the **Radius** value to around **2 mm**

Step 3: Create the Dots (Pips)

- Add a **Cylinder** shape to the workplane
- Resize it to **3 mm diameter** and **1 mm height**
- Position the cylinder on one face of the cube to represent the number “1”
- Duplicate and place cylinders on other faces to display numbers 2 through 6
- Use the **Align** and **Workplane** tools to precisely position the dots on each face

Step 4: Combine Shapes

- Select the cube and all cylinder shapes
- Click **Group** to merge them into a single object suitable for printing

Step 5: Export the Model

- Click the **Export** button in the upper right corner
- Choose the **.STL** file format for 3D printing
- Save the exported file for use with slicing software or direct 3D printing

CHECK YOUR PROGRESS

A. Answer the following questions

1. Which tool in Tinkercad allows you to measure and specify exact dimensions?
2. What type of coordinate information does the Ruler tool provide?
3. What kind of numerical values can users input when using the Ruler tool?
4. How can students annotate their designs to indicate tolerance or hole sizes?
5. After adding dimensions, what is the process for exporting the design?

B. Multiple Choice Questions

1. Which option allows you to bring external files into Tinkercad?
   a) Upload
   b) Import

c) Export
d) Add File

2. What types of files can be imported into Tinkercad?
   a) Only text files
   b) Only images
   c) Both 2D and 3D files
   d) Only projects created in Tinkercad
3. When your Tinkercad project is finished and ready for 3D printing, what should you do?
   a) Delete the project
   b) Rename the project
   c) Export the design
   d) Share it on social media
4. After clicking the "Export" button in Tinkercad, what is the next step?
   a) Change the colors
   b) Select a file format like STL or OBJ
   c) Edit the shapes
   d) Add annotations

MODULE 5 HEALTH AND SAFETY

Module Overview

This module is designed for Draughtsman (Mechanical) students to build a strong foundation in workplace safety. It emphasizes the need for keeping work areas clean, well-organized, and free from hazards. Learners will develop skills to recognize and understand various safety signs, symbols, and color codes that indicate potential dangers and necessary precautions. The course also addresses fire safety techniques, the safe use of electrical tools, and how to operate different types of fire extinguishers correctly. In the concluding section, students will learn how to create ergonomically effective workstations and provide basic first aid for minor injuries. Overall, the module encourages adopting a proactive safety approach vital in mechanical workshop settings.

Learning Outcomes

Upon completing this module, you will be capable of:

- Recognizing and practicing essential safety measures to keep mechanical work areas tidy and free from hazards.
- Understanding and correctly interpreting standard safety signs, symbols, and color indicators used to highlight dangers and safety instructions in workshops and factories.
- Applying fire safety precautions effectively, handling electrical equipment safely, and operating fire extinguishers properly.
- Setting up workstations according to ergonomic principles to promote comfort and safety, as well as providing basic first aid for minor injuries commonly encountered in mechanical settings.

Module Structure

In the Draughtsman (Mechanical) course, the structure of the module on Health and Safety is framed as follows:

Session 1. Maintaining a Safe and Organized Mechanical Workspace
Session 2. Understanding Safety Signs and Hazard Colour Codes
Session 3. Fire Prevention and Electrical Safety
Session 4. Ergonomics and Basic First Aid in the Workshop

Session 1: Maintaining a Safe and Organized Mechanical Workspace

Importance of Safety in the Lab and Workshop:

As a Mechanical Draughtsman, you will be working with sharp tools, power machinery, and precise drawing instruments. Maintaining safety is crucial to:

- Safeguard yourself and your colleagues from accidents and injuries
- Avoid damage to costly tools and materials
- Maintain the precision and efficiency of your work
- Adhere to industry regulations and legal safety standards

Important Health and Safety Guidelines for Engineering Drawing Work:

1. **Adopt Correct Sitting Posture:** Sit with your back well-supported and feet flat on the ground to prevent strain on your back and neck.
2. **Ensure Sufficient Lighting:** Use bright, evenly spread light to reduce eye fatigue and improve the clarity of your drawings.
3. **Use Adjustable Furniture:** Chairs and drawing tables that can be adjusted help maintain comfort and reduce physical tiredness.
4. **Keep the Work Area Neat:** An uncluttered workspace reduces the risk of accidents and makes it easier to access drawing tools.
5. **Store Tools Safely:** When not in use, keep sharp instruments like compasses and dividers properly secured.
6. **Take Breaks Often:** Short, regular breaks help relieve eye strain and physical tension.
7. **Avoid Overreaching:** Arrange your tools so that frequently used items are within easy reach to minimize stretching.
8. **Wear Protective Gear When Necessary:** Safety glasses should be worn when working close to cutting tools or machinery.
9. **Follow Electrical Safety Practices:** Use powered drafting equipment carefully, ensuring it is handled correctly to prevent hazards.
10. **Have First Aid Supplies Ready:** Keep a basic first aid kit nearby to manage minor injuries promptly.

Essential Safety Equipment for Workshops and CAD Computer Labs:

1. **Personal Protective Equipment (PPE) Kits (Fig.5.1):** PPE plays a crucial role in maintaining safety within mechanical workshops and preventing injuries during various tasks. Important precautions include:

- Always wear the full PPE kit along with safety glasses to shield your eyes from dust and flying debris.
- Use gloves when handling sharp edges or hot objects to avoid cuts and burns.
- Wear closed-toe footwear, ideally safety shoes, to protect your feet from heavy or sharp items.
- Use dust masks when working in environments with airborne particles or sprays to prevent inhalation of harmful substances.
- Check PPE regularly for any signs of damage or wear, and replace any compromised gear promptly to ensure continued protection.

Fig. 5.1: PPE Kit

2. Ergonomics in the Drafting Lab:

- Maintain an upright posture with feet flat on the floor and elbows bent at a 90-degree angle.
- Keep drawing tools and materials close by to avoid unnecessary stretching.

- Adjust your drafting table and chair to a comfortable height and position.
- Take regular breaks to prevent fatigue and reduce strain from sitting or drawing for long periods.

3. Safety Practices in the CAD Lab (Using Tinkercad):

- Keep your workspace tidy and free from clutter.
- Handle computers and related equipment with care and responsibility.
- Maintain good posture with properly adjusted seating.
- Manage cables safely to prevent tripping or damage.
- Ensure your hands are clean and dry before using the computer.
- Report any equipment problems right away.
- Log out of your accounts after finishing your session.
- Follow all instructions provided by your instructor.

4. Workshop Tools and Equipment Safety:

- Inspect tools for damaged cords, loose components, or signs of wear before using them.
- Operate only the tools you have been trained to use.
- Store tools in their designated places after use to avoid creating hazards.
- Never use machines without proper training or supervision.

5. Electrical and Fire Safety:

- Avoid overloading power outlets or using faulty plugs.
- Be aware of the location of the main power switch for emergency shutdowns.
- Understand how to operate a fire extinguisher using the PASS technique: Pull the pin, Aim at the base of the fire, Squeeze the handle, and Sweep side to side.
- Keep flammable materials well away from sources of heat.

6. Housekeeping and Cleanliness:

- Always tidy your workspace before and after completing tasks.
- Report any spills, broken tools, or damaged furniture immediately.
- Dispose of waste properly, paying special attention to sharp objects and hazardous chemicals.

7. Emergency Procedures:

- Familiarize yourself with the locations of:
  - First aid kits
  - Fire extinguishers
  - Emergency exits and evacuation routes

- Report all accidents or near-misses promptly to your instructor.

How Safety Measures Help Prevent Accidents

1. **Minimizes the Chance of Injury**

- Using personal protective equipment such as safety glasses, gloves, and sturdy footwear protects you from hazards like flying particles, sharp edges, and falling objects.
- Maintaining good ergonomic practices while drafting helps reduce long-term strain on your back, neck, and wrists.

2. **Protects Equipment from Damage**

- Following proper safety procedures when operating tools and machines helps prevent damage and malfunctions, which can otherwise cause accidents or work interruptions.

3. **Reduces Fire and Electrical Risks**

- Conducting routine checks on electrical cords, plugs, and powered equipment helps prevent issues such as short circuits or fires (Fig. 5.2).

Fig. 5.2: Electrical Hazards

4. **Fosters Increased Awareness**

- A safe workplace encourages attentiveness and accountability, helping everyone stay focused and avoid careless mistakes.

5. **Supports Prompt Emergency Actions**

- Being familiar with first aid, how to operate fire extinguishers, and the locations of emergency exits allows for swift and effective responses during emergencies, reducing potential harm.

Table 5.1 highlights common unsafe practices observed during workshop or lab activities and the corresponding safety measures to prevent accidents. It serves as a quick reference to promote safe behaviour and awareness among students.

Table 5.1: Unsafe practices and safety measures

Unsafe Practice	Consequences	Safety Measure
Using a cutter without gloves	Hand injury	Wear cut resistant gloves
Loose clothing near rotating machine	Entanglement, serious injury	Wear fitted clothing and secure sleeves
Skipping PPE during grinding	Eye injury from flying sparks	Use safety goggles
Ignoring a frayed extension cord	Electric shock or fire	Report and replace damaged cables
Poor posture at drafting table	Chronic back/neck pain	Use ergonomic posture aids

PRACTICAL EXERCISE

Activity: Identify Unsafe Practices in a Mechanical Drafting Workshop

Objective: Students will identify and explain 10 unsafe lab practices by analysing images (if available) or imagining real workshop scenarios.

Instructions:

- Break students into pairs or small groups.
- Show them a series of workshop images OR describe real world mechanical workshop scenarios.
- Ask them to identify unsafe practices in each case and explain the hazards.
- Then, they must recommend a safer alternative.

Refer Table 5.2 for some of the unsafe practices, their risks and safe alternatives that may be followed to ensure safety.

Table 5.2: Unsafe Lab Practices (with Explanations & Safer Alternatives)

Unsafe Practice	Explanation of Risk	Safe Alternative
No PPE (Personal Protective Equipment)	Without goggles, gloves, or safety shoes, workers risk cuts, eye injuries, and chemical burns.	Always wear goggles, gloves, shoes, and overalls in the lab.
Loose Clothing or Jewellery	Can get caught in rotating machines like lathes or drills.	Wear fitted clothing; remove jewellery before work.
Poor Housekeeping (Tools Scattered)	Tools lying around can cause trips and falls.	Return tools to tool boards after use; keep the workspace clean.
Running or Horseplay in Workshop	Can lead to collisions or spills near sharp or hot equipment.	Always walk and maintain discipline in the lab.
Using Damaged Tools	Cracked hammers or dull chisels can break or slip, injuring the user.	Inspect tools regularly; report or replace damaged ones.
Incorrect Handling of Measuring Instruments	Can lead to inaccurate measurements and wastage or part failure.	Handle instruments (like Vernier callipers) with care and store properly.
Not Clamping Work Pieces Properly	Unsecured parts can fly off when drilling or cutting.	Always clamp the job securely before machining.
Ignoring Machine Guards	Exposed moving parts can catch fingers or clothing.	Never operate machines with guards removed or open.
Improper Disposal of Waste (Metal Chips, Oil)	Slips, falls, and contamination may result.	Dispose of metal waste in bins; clean oil spills immediately.
Overcrowding Around Equipment	Leads to accidents and hinders emergency movement.	Maintain safe distances around machines; limit people in operating zones.

CHECK YOUR PROGRESS

A. Answer the following questions

1. Why is it essential to follow safety rules in a lab or workshop environment?
2. In what ways does practicing safety contribute to more precise work?
3. Why is it necessary to store sharp drawing instruments correctly?

4. What is the recommended posture to maintain while working on drawings?
5. How does proper lighting improve the drawing process?

B. Multiple Choice Questions

1. What is the primary role of PPE kits in mechanical workshops?
   a) To enhance appearance
   b) To protect against injuries during tasks
   c) To speed up work
   d) To avoid using equipment
2. Which item should be worn to shield your eyes from dust and particles?
   a) Face mask
   b) Gloves
   c) Safety goggles
   d) Earplugs
3. Why is it important to take breaks during extended drawing work?
   a) To socialize with others
   b) To reduce physical strain and fatigue
   c) To check your phone
   d) To sharpen pencils
4. Which type of footwear is safest to wear in a mechanical workshop?
   a) Open sandals
   b) Athletic shoes
   c) Closed-toe safety boots
   d) No footwear

C. Fill in the blanks

1. Do not overload _______ or use damaged plugs.
2. Always know where the main _______ switch is located.
3. Clean your _______ area before and after tasks.
4. Always report _______ or near-miss incidents to your instructor.

D. True or False

1. Using safety gear like gloves and protective eyewear helps lower the risk of getting hurt.
2. Proper body posture and ergonomic setup have no impact on reducing long-term physical stress during drafting tasks.
3. Items that fall on the workshop floor can be ignored if they appear undamaged.
4. Operating machines and tools the right way helps prevent wear and potential breakdowns.
5. Disregarding safety rules can lead to injuries and slow down the work proce

Session 2: Understanding Safety Signs and Hazard Colour Codes

In the Draughtsman - Mechanical trade, recognizing safety signs is crucial for maintaining a safe and accident-free workspace. These signs use specific colors and symbols to clearly convey warnings, required actions, restrictions, and emergency details. Being able to identify and respond to these signs accurately helps both students and professionals remain aware of possible dangers in mechanical workshop settings.

Purpose of Safety Signs:

Safety signs play a vital role in helping students and draughtsman maintain awareness and avoid accidents. They are designed to:

- Highlight possible dangers in the workspace
- Indicate required safety measures or protective actions
- Clearly state what actions or behaviors are prohibited
- Guide quick and appropriate responses in emergency situations

These signs are essential for promoting safe practices in mechanical and drafting environments.

1. Warning Signs

Appearance: Yellow triangle with a black border (Fig. 5.3)

Meaning: Used to signal the presence of a potential hazard that may lead to injury or equipment damage if not handled properly.

Examples in a Draughtsman - Mechanical Setting:

- Caution: Sharp Tools – Typically found near cutting areas or tool stations
- Warning: Hot Surface – Displayed around machinery or components that generate heat
- High Voltage – Posted near electrical panels or equipment handling live current

Purpose: These signs serve as a visual alert, reminding users to be cautious and take appropriate safety measures in hazardous areas.

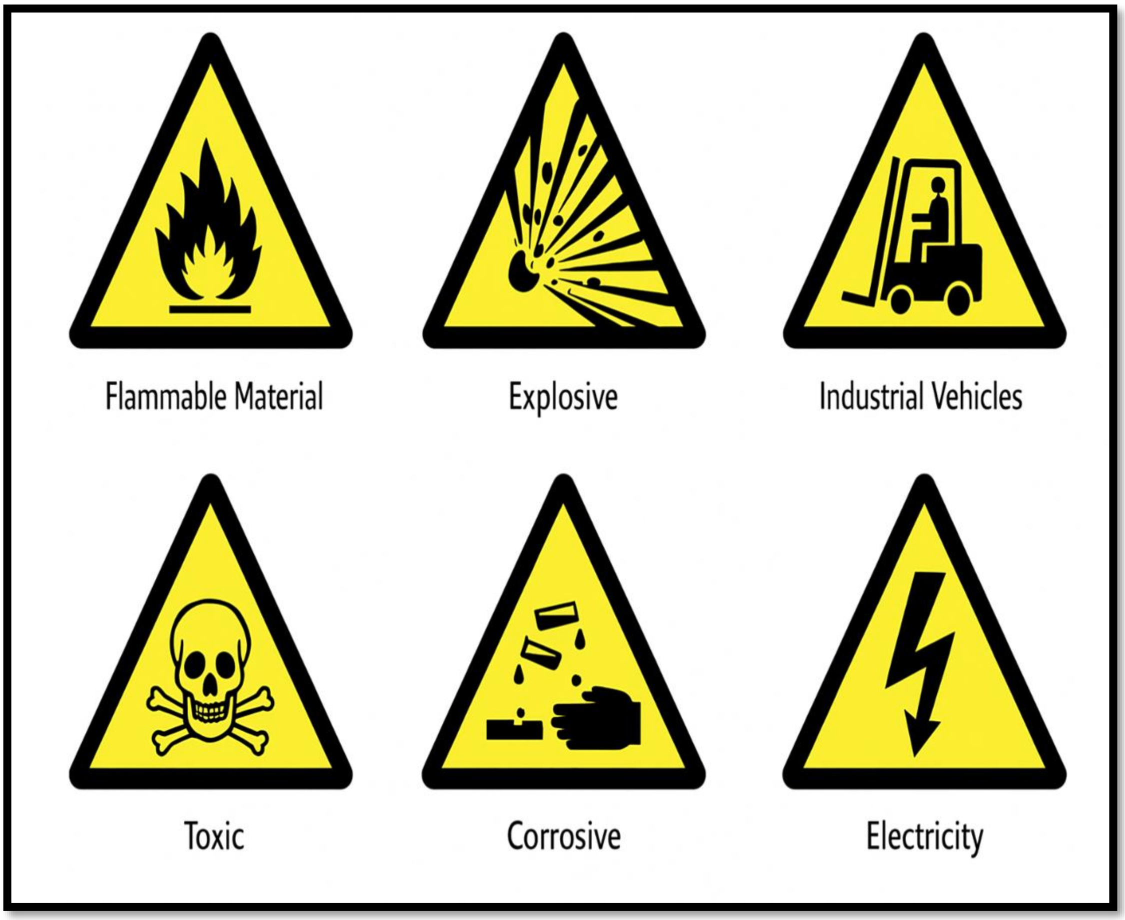


Fig. 5.3: Warning Signs

2. **Mandatory Signs**
   Appearance: Blue circle with white pictograms (Fig. 5.4)

   Meaning: These signs indicate specific actions that must be followed to ensure personal safety and prevent accidents.

   Examples in a Draughtsman - Mechanical Environment:

- Wear Safety Goggles – Required when working with grinding, cutting, or flying particles
- Use Hand Gloves – Necessary while handling sheet metal, sharp objects, or chemicals
- Wear Safety Shoes – Essential for foot protection in workshop areas with heavy tools or equipment

Purpose:
Mandatory signs are designed to promote safe behavior by clearly stating the protective measures that individuals are required to follow while working in potentially hazardous conditions.

Fig. 5.4: Mandatory Signs

3. Prohibition Signs

Visual Appearance: A red circle with a diagonal line crossing through a black symbol (Fig. 5.5)

Meaning: These signs are used to show activities or behaviors that are strictly forbidden, especially when such actions could pose safety risks or interfere with operations.

Examples in Mechanical Drafting Settings:

- No Eating or Drinking – To avoid spills, equipment damage, or contamination near machines and drawing tools

- No Entry Without Authorization – Used to restrict access to areas where only trained personnel should operate machinery
- Do Not Touch – Placed near high-voltage panels or sensitive instruments to prevent accidents or disruption

Purpose:
These signs serve to discourage unsafe actions and protect both people and equipment by clearly marking what is not allowed in specific areas.

Fig. 5.5: Prohibition Signs

4. Emergency Signs

Appearance: Green rectangle or square with white symbols (Fig. 5.6).

Meaning: These signs provide essential information related to emergency procedures or the location of safety equipment.

Examples in a Draughtsman - Mechanical Workshop:

- First Aid Station – Indicates where basic medical supplies are kept
- Emergency Exit – Marks the path to leave the building safely during a fire or other emergency
- Eye Wash Station – Located near areas where chemicals are handled, offering immediate rinsing in case of exposure

Purpose:
Emergency signs are designed to guide individuals quickly and clearly to safety equipment or exit routes, allowing for fast, effective responses during urgent situations.

Fig. 5.6: Emergency Signs

Colour Coding of Tools and Hazards

Colour Coding Important for Draughtsman – Mechanical Students

In both drafting labs and mechanical workshops, colour coding plays a key role in maintaining safety and efficiency. It helps to:

- Quickly recognize potential hazards and locate the right tools
- Reduce the chances of errors and workplace accidents
- Keep the workspace neat, organized, and easy to navigate
- Ensure compliance with established industry safety practices

1. **Tool Colour Coding**

Applying specific colours to tools helps with:

- Clearly identifying each tool's intended use
- Avoiding confusion between tools that look alike but serve different functions
- Systematically arranging tools in their proper storage areas for easy access and inventory control

Table 5.3 shows the Colour Codes for Tools in Drafting/Workshop.

Table 5.3: Colour Codes for Tools in Drafting/Workshop

Tool Type	Colour Code	Purpose
Precision Drawing Tools (e.g. compass, divider)	Blue	For clean work; keep separate from workshop tools
Cutting Tools (e.g. blades, cutters)	Red	Sharp and hazardous handle with care
Measuring Instruments (e.g. callipers, rulers)	Green	Frequently used, store accessibly
Power Tools (e.g. drills, grinders)	Yellow	Electrical hazard caution advised

Hazard Colour Coding (Based on Standard Safety Colours) is shown in Table 5.4.

Table 5.4: Colour coding to mark hazard zones, materials, and safety equipment

Colour	Meaning	Use in Draughtsman Mechanical
Red	Fire hazard or stop	Fire extinguisher location, emergency stop buttons
Yellow	Caution or physical hazard	Marking around sharp tools, rotating equipment, wet floors

Blue	Mandatory action	Wear PPE signs, required procedures
Green	Safety information	First aid kits, eye wash stations, emergency exit paths
Orange	Warning for energized equipment	Electrical panels, voltage sources
Black/White	Housekeeping or general markings	Storage zones, walkways, equipment boundaries

PRACTICAL EXERCISE

Activity: Spot the Sign! Safety Sign Identification Game

Objective: To help students recognize and classify the four main types of safety signs used in mechanical workshops.

Materials Required:

- Printed or digital images of various safety signs
- Four labelled boxes or chart paper sections (Warning - Yellow, Mandatory - Blue, Prohibition - Red, Emergency - Green)
- Scissors, glue (if printed), or digital tools (if done online)

Types of Signs to Include (Fig.5.7):

Signs and Symbols	Examples
Warning	High Voltage, Slippery Floor
Mandatory	Wear Safety Goggles, Use Ear Protection
Prohibition	No Smoking, Do Not Touch
Emergency	First Aid Kit, Emergency Exit

Fig. 5.7: Safety signs

Procedure:

1. Provide students with 12 to 16 images of various safety signs mixed together.
2. Have students sort the signs into the correct categories based on their color and meaning.
3. For each safety sign, students should write a brief sentence explaining its purpose (for example, "Wear safety goggles – Mandatory sign").

Presentation:

- Students, either individually or in groups, will select two signs from each category to present.
- They will explain why each sign is important in the context of a mechanical workshop environment.

Learning Outcomes:

Upon completing this activity, learners will be able to:

- Recognize the four main types of safety signs by their colors and symbols.
- Sort safety signs into the categories of Warning, Mandatory, Prohibition, and Emergency.
- Understand and explain the purpose of each type of safety sign as it applies to a mechanical workshop.

CHECK YOUR PROGRESS

A. Answer the following questions

1. What is the primary function of safety signs?
2. In what ways do safety signs assist during emergency situations?
3. Why is it crucial to have safety signs in mechanical and drafting workspaces?
4. What color and shape are typically used for warning signs?
5. What kind of information do warning signs convey?

B. Multiple Choice Questions

1. What is the typical shape and color of Mandatory Signs?
   a) Red square with white text
   b) Yellow triangle with black symbol
   c) Blue circle with white symbols
   d) Green rectangle with black border
2. What do Mandatory Signs communicate?
   a) Danger warnings
   b) Actions that are forbidden
   c) Required safety actions you must follow
   d) Information about emergency exits
3. What shape and color characterize Prohibition Signs?
   a) Yellow triangle with black border
   b) Blue square with white symbols
   c) Red circle with a diagonal slash
   d) Green circle with a check mark
4. What do Prohibition Signs signify?
   a) Instructions for emergencies
   b) Required safety procedures
   c) Suggested best practices
   d) Actions that are not permitted

Session 3: Fire Prevention and Electrical Safety

Role of Fire Extinguishers in Workshops and CAD Labs

In mechanical workshops and drafting areas, fires may start due to materials like paper, flammable liquids, or electrical malfunctions. Understanding the type of fire and selecting the appropriate extinguisher is essential for:

- Protecting people from harm
- Stopping the fire early to prevent it from spreading
- Minimizing damage to equipment, tools, and the workspace

Different types of fires and fire extinguishers are described in detail in Table 5.5 and Table 5.6.

Table 5.5: Types of Fire and Their Characteristics

Class	Fire Type	Common Source in Draughtsman Mechanical
Class A	Ordinary combustibles (paper, wood)	Paper sheets, cardboard, wooden drawing boards
Class B	Flammable liquids (oil, paint, fuel)	Adhesives, cleaning agents, machine oil, spray paints
Class C	Electrical fires	Short circuits, damaged cords, faulty machines

Table 5.6: Types of Fire Extinguishers and Their Use

Extinguisher Type	Use On	Do NOT Use On	Application in Draughtsman Lab
Water (Red label)	Class A fires only	Class B & C (spreads fire/shock risk)	Paper bin fire, wood pieces
Foam (Cream label)	Class A & B	Class C	Oil spill fire, flammable solvents
Dry Powder (Blue label)	Class A, B, & C	N/A (safe for all, but messy)	Electrical fire, mixed source fires
CO_2 (Black label)	Class B & C	Class A (ineffective on solids)	Electrical panel, PC, or machine fire

Wet Chemical (Yellow label)	Class F (cooking oil fires)	Not relevant	Usually not used in mechanical settings

Important Safety Tips for Fire Extinguisher Use

- Never apply water to fires involving electricity or flammable liquids.
- Always check the label on the extinguisher to confirm its suitability for the fire type.
- Follow the PASS technique to operate the extinguisher effectively:
  - **Pull** the safety pin
  - **Aim** at the base of the fire
  - **Squeeze** the handle
  - **Sweep** the nozzle from side to side

Electrical Safety is Crucial in Mechanical Drafting Labs

Electrical tools and machines are widely used for operations such as cutting, grinding, and sanding. Handling these tools safely is critical because:

- Faulty wiring can cause electric shocks that may result in serious injuries or fatalities.
- Improper use or malfunctions can damage the workspace and halt productivity.
- Damaged cords and power tools increase the risk of fire hazards.

Safe Practices for Using Electrical Tools

- **Inspect Tools Before Use:**
  - Check for visible damage like exposed wires, loose parts, or frayed cords.
  - Ensure the tool is well-maintained and lubricated if necessary.
  - Read the user manual when operating a new tool to understand proper usage.
- **Proper Handling:**
  - Hold tools firmly with both hands for better control whenever possible.
  - Avoid using electric tools in wet conditions to reduce the risk of shock.
  - Always unplug tools when not in use, especially during maintenance or when changing parts.
- **Use Tools Correctly:**
  - Only use tools for their intended functions: do not substitute tools for other tasks.
  - Make sure tools are grounded properly to prevent electrical hazards.
- **Wear Appropriate PPE:**
  - Use safety glasses to protect your eyes from flying debris.

- Wear hearing protection when tools generate loud noise.
- Use gloves for grip but avoid loose gloves that can get caught in moving parts.

Safe Handling of Electrical Wiring

- **Check Cords and Plugs:**
  - Inspect cables for damage such as cuts, frays, or exposed wiring before use.
  - Report any damaged cords immediately for repair or replacement.
  - Ensure plugs fit securely in outlets without exposed prongs.
- **Avoid Circuit Overload:**
  - Be mindful of the power ratings and avoid plugging too many devices into a single outlet.
  - Use surge protectors for sensitive electronics like computers and design software.
- **Organize Wiring:**
  - Keep cords away from walkways to prevent trips and falls.
  - Coil and store cables properly after use to avoid damage.
  - Use clips or protective sleeves to safeguard cables from wear and tear.
- **Prevent Water Exposure:**
  - Never operate electrical tools near water or in damp environments.
  - Always dry your hands thoroughly before handling electrical equipment.
- **Switch Off and Unplug:**
  - Turn off tools and unplug them when not in use or before maintenance.

Handling Faulty or Broken Tools

- Do not try to repair electrical tools unless you are trained to do so.
- Immediately report any malfunctioning equipment to your supervisor or instructor.
- Use substitute tools until repairs are completed by qualified personnel.

PRACTICAL EXERCISE

Activity: PASS the Fire- Fire Extinguisher Dry Run

Objective:

To train students on the proper use of a fire extinguisher through a hands-on demonstration, focusing on correct operation techniques and emergency preparedness in a mechanical drafting or workshop setting.

Materials Required:

- A demonstration fire extinguisher (preferably a dry chemical ABC type)
- A simulated fire setup, such as a cone decorated with red and yellow paper to mimic flames
- Personal protective equipment (PPE), including safety gloves and goggles for authenticity
- Signage indicating fire extinguisher locations within the lab or workshop
- A whiteboard or visual aid displaying the PASS method for extinguisher use

The PASS Technique (Explain to Students) (Fig. 5.8):

Step	Action
P	**Pull** the pin
A	**Aim** the nozzle at the base of the fire
S	**Squeeze** the handle
S	**Sweep** the nozzle from side to side

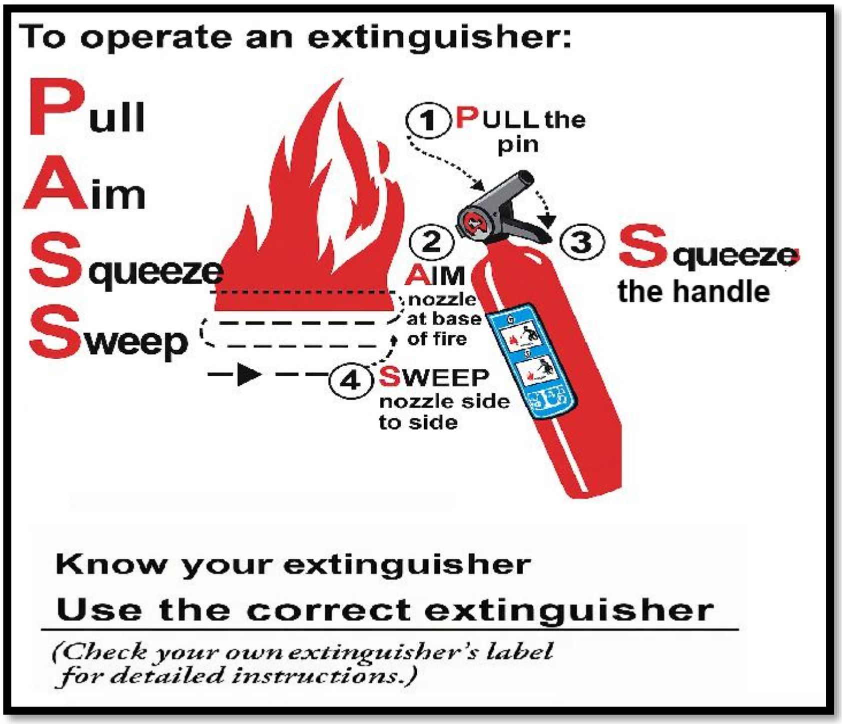


Fig. 5.8: Operating fire extinguisher

Procedure:

1. **Introduction & Discussion:**

   Begin by asking students what actions they would take if a small fire broke out near their workstation.

   Explain the following points:

   - Different types of fire extinguishers, focusing on the ABC type commonly used for general fires in labs and workshops.
   - Appropriate situations for using a fire extinguisher: only for small, manageable fires.
   - The importance of alerting others and calling for help immediately if there is a real fire.
2. **Demonstration:**
   The instructor performs a live demonstration of the PASS method using the demo fire extinguisher:
   - Approach the mock fire setup carefully.
   - Pull the safety pin.
   - Aim the nozzle at the base of the fire.
   - Squeeze the handle firmly.
   - Sweep the extinguisher side to side until the fire is out.

CHECK YOUR PROGRESS

A. Answer the following questions

1. What are typical sources of fire hazards in workshops or CAD labs?
2. What is the primary goal of using a fire extinguisher in a lab setting?
3. Which kind of fire should never be extinguished with water?
4. In the PASS technique, what does the letter "P" represent?

B. Multiple Choice Questions

1. Why is it important to follow safety practices when using electrical tools in drafting labs?
   a) To increase work speed
   b) To make the tools look better
   c) To avoid electric shocks, injuries, and fire hazards
   d) To skip wearing safety equipment
2. What are the possible consequences of ignoring faulty wiring?
   a) Tools operate faster

b) Power output increases
c) Risk of electric shock or fire increases
d) Electricity costs decrease

3. What should you do with a tool when it is not being used or is undergoing maintenance?
   a) Leave it on standby mode
   b) Cover it with a cloth
   c) Disconnect it from the power source
   d) Keep it running
4. Why is it important to use tools only for their designed purpose?
   a) To complete tasks quicker
   b) To extend tool lifespan
   c) To reduce noise levels
   d) To prevent accidents and damage to the tools
5. Which personal protective equipment (PPE) is recommended when working with electric tools?
   a) Only a lab coat
   b) Helmet and safety boots
   c) Safety goggles, ear protection, and appropriate gloves
   d) Face mask only

C. Fill in the blanks

1. Never use _______ cords; report them immediately for replacement.
2. Ensure the plug is securely inserted and that there are no exposed _______.
3. For sensitive equipment like computers, use a _____ protector.
4. Keep cords out of walkways to prevent _______ hazards.
5. Use cord management clips or ______ protectors to avoid wire damage on the floor.

D. True or False

1. Tools should always be switched off and unplugged when they are not being used.
2. It is safe to perform cleaning or maintenance on a tool while it is still connected to power.
3. Any damaged or malfunctioning tools must be reported to a supervisor or instructor immediately.

Session 4: Ergonomics and Basic First Aid in the Workshop

Maintaining good ergonomic posture means sitting upright with proper back support, keeping your feet flat on the floor, and positioning your elbows at a 90-degree angle while working on drawings. This helps reduce physical fatigue and lowers the risk of developing musculoskeletal issues over time during drafting activities.

Ergonomics is Important in Drafting

As a Mechanical Draughtsman, you'll spend extended periods seated at drafting tables, using computer-aided design (CAD) software, and handling technical tools like Tinkercad. Without attention to ergonomic principles, you may be prone to musculoskeletal problems, including back pain, neck tension, eye strain, and repetitive motion injuries.

Proper **ergonomic posture** (Fig. 5.9) helps you:

- Prevent injuries like carpal tunnel syndrome and back pain.
- Improve focus and comfort, making long drafting sessions more productive.
- Boost overall health by reducing muscle strain and tension.

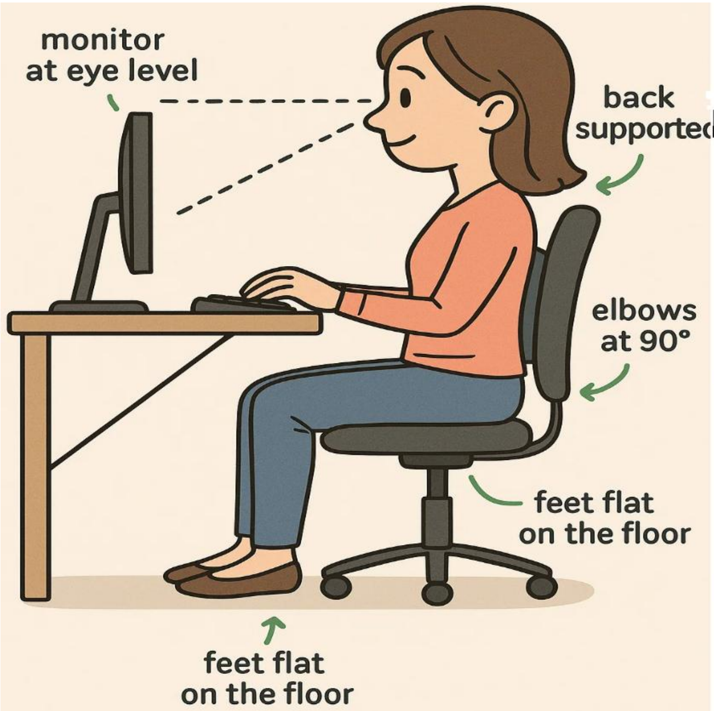


Fig. 5.9: Proper Ergonomic Posture

1. **Chair and Seating Adjustments**

Chair Height: Adjust your chair so your feet rest flat on the floor with knees bent at a 90-degree angle. This position helps reduce pressure on your lower back and legs.

Seat Depth: Maintain a gap of about 2 to 4 inches between the front edge of the chair and the back of your knees to ensure good blood flow.

Back Support: Choose a chair with lumbar support that follows the natural curve of your lower back to help prevent discomfort and maintain proper posture.

2. Desk and Workstation Setup

Work Surface Height: When seated, your elbows should be bent at a right angle with forearms parallel to the desk surface. For drafting tables, set the tilt so you can work comfortably without stretching too far: usually a slight inward angle works best.

Keyboard and Mouse Placement (for CAD users): Position the keyboard at or slightly below elbow height to keep wrists straight and avoid bending. Keep the mouse close to the keyboard to minimize reaching and reduce arm strain.

3. Monitor Position and Visual Comfort

Screen Placement: Place your monitor about 18 to 30 inches away from your eyes, with the top edge of the screen roughly at eye level to avoid neck strain. Tilt the monitor slightly upward if needed.

Lighting: Avoid glare on your screen by positioning your workstation parallel to windows. Use soft, indirect lighting to reduce eye fatigue. An anti-glare screen filter can also help minimize reflections.

4. Posture and Movement

Maintain Neutral Posture: Sit with your back straight, shoulders relaxed, and elbows close to your body. Keep your wrists straight when typing or drawing to prevent strain.

Feet and Leg Position: Keep your feet flat on the floor or use a footrest if necessary. Avoid crossing your legs to promote healthy circulation.

Regular Breaks: Follow the 20-20-20 rule every 20 minutes, look at something 20 feet away for 20 seconds to rest your eyes. Also, stand and stretch every 30 to 60 minutes to boost blood flow and ease muscle tension.

First Aid Essentials for Draughtsman Mechanical Students

Importance of First Aid in the Drafting Lab

Working with sharp tools, chemicals, and maintaining static postures for long periods can lead to injuries. Having basic first aid knowledge helps manage minor injuries like cuts, eye irritation, or muscle strains quickly, creating a safer workspace and preventing complications or long-term damage.

1. First Aid for Cuts

Common Causes:

- Handling sharp instruments such as scalpels, utility knives, and metal edges.
- Contact with metal debris or small shavings causing abrasions.

Prevention:

- Always wear cut-resistant gloves when working with sharp tools or metal pieces.
- Keep your workspace tidy to minimize the risk of accidental cuts.

2. First Aid for Eye Irritation

Common Causes:

- Exposure to dust or particles from cutting, grinding, or sanding.
- Splashes from chemicals like solvents, inks, or drafting materials.
- Eye strain caused by bright lights or screen glare.

Prevention:

- Use safety goggles when operating grinders, saws, or handling chemicals.
- Position your monitor and seating to reduce glare and ease eye fatigue.
- Maintain a clean environment to limit airborne dust.

3. First Aid for Muscle Strains

Common Causes:

- Poor posture during prolonged sitting at drafting tables or while using CAD software.
- Repetitive actions such as continuous sketching or mouse/keyboard use.

- Lifting heavy equipment or adopting awkward positions.

Prevention:

- Maintain proper ergonomic posture while sitting or working at your desk.
- Take frequent breaks to stretch your wrists, arms, neck, and back to relieve tension.
- Use adjustable desks and chairs to provide a comfortable and healthy working position.
-

PRACTICAL EXERCISE

Activity: Smart Ergonomic Drafting Workstation

Objective: To practice setting up a drafting workstation using ergonomic principles that promote comfort, correct body alignment, and help prevent injuries.

Materials Needed

- Adjustable drafting tables
- Ergonomic chairs with height adjustment and lumbar support
- Footrests or alternative supports
- Wrist rests and desk lamps (if available)
- Posters or visual guides illustrating proper posture
- Ergonomic Setup Checklist handouts
- Drafting tools such as rulers, T-squares, and drawing sheets for simulation

Procedure

1. **Introduction:**
   Start with a brief discussion to engage students:

- Why is maintaining good posture important in drafting work?

  Explain the following key points:

- Poor posture can cause strain in the neck, back, and wrists.
- Applying ergonomic principles boosts concentration and reduces the risk of long-term injuries.
- Setting up the workstation correctly is just as important as mastering drafting tools, even in manual drafting tasks.

2. **Instructor Demonstration**

   Table 5.7 shows the methods to set up a workstation for ergonomic comfort.

Table 5.7: Setting up a workstation for ergonomic comfort

Ergonomic Factor	Correct Setup
Chair height	Feet flat on the floor (or footrest), knees at 90°
Back support	Chair supports lower back/lumbar region
Drafting table angle	Slightly inclined to avoid neck bending
Drawing position	Work area within natural reach, centre of the table
Lighting	Even lighting, ideally from the left (for right-handed users)
Arm/wrist support	Forearms supported, wrists neutral when drawing

3. Student Setup Challenge

Instructions:

- Students work alone or in pairs to adjust and arrange their drafting workstations using the available materials and ergonomic aids.
- They should follow the Ergonomic Setup Checklist to ensure proper setup.

Checklist Items:

- Chair height and position correctly adjusted
- Lower back fully supported by the chair's backrest
- Feet flat on the floor or resting comfortably on a footrest
- Desk or drafting table set to an appropriate height and angle
- Drawing surface centered for easy reach and visibility
- Wrists and arms maintained in neutral, relaxed positions
- Adequate and comfortable lighting focused on the work area

CHECK YOUR PROGRESS

A. Answer the following questions

1. Why is maintaining ergonomics essential when working on drafting tasks?
2. What health issues can arise if ergonomic principles are ignored?
3. Which health problem is often linked to incorrect hand or wrist positioning during drafting?
4. In what ways does maintaining good posture improve work efficiency?
5. How does practicing proper ergonomics contribute to overall well-being?

B. Multiple Choice Questions

1. What is the recommended seat height for drafting work?
   a) Feet dangling off the floor
   b) Knees positioned higher than the hips
   c) Feet flat on the floor with knees bent at a 90-degree angle
   d) Sitting on the front edge of the chair
2. How much space should you leave between the front edge of your chair and the back of your knees?
   a) 6 to 8 inches
   b) No gap at all
   c) 2 to 4 inches
   d) About one foot
3. Which area of the back should a chair's backrest ideally support?
   a) Upper spine area
   b) Neck region
   c) Lower back (lumbar area)
   d) Shoulder blades
4. When seated at a drafting table, what is the correct elbow angle?
   a) 120 degrees
   b) 45 degrees
   c) 90 degrees
   d) 180 degrees (fully extended)
5. Where should the mouse be positioned when working on CAD tasks?
   a) Placed far away from the keyboard
   b) Positioned above the computer monitor
   c) Close to the keyboard for easy access
   d) Resting on your lap

C. Fill in the blanks

1. Always wear _______ gloves when handling sharp tools or metal parts.
2. . _______ or debris from grinding and cutting can cause eye irritation.
3. Use _______ goggles when working with chemicals or power tools.
4. Poor _______ during long sitting hours can lead to muscle strain.
5. Use a height-adjustable _______ and properly set chair to support posture.

ANSWER KEY

Module 1: INTRODUCTION TO ENGINEERING DRAWING

Session 1: Engineering Drawing and Drawing sheet

B. Multiple choice questions

1. B 2. C 3. D 4. C 5. D

C. Fill in the blanks

1. Circuits 2. Electrical 3. Base 4. ISO 5. borderline (or margin)

D. True or False

1. True 2. True 3. False 4. True 5. True

Session 2: Working with Drawing Instruments

B. Multiple choice questions

1. B 2. C 3. C 4. B 5. D

C. Fill in the blanks

1. triangular 2. Circles 3. Needle 4. Transfer 5. Pointed

D. True or False

1. True 2. False 3. True 4. True 5. False

Session 3: Types of Lines and Methods of Drawing Letters and Numbers

B. Multiple choice Questions:

1. C 2. C 3. B 4. B 5. C

C. Fill in the blanks

1. text 2. Sans 3. Kerning 4. 5 to 7 5. 2 to 3

D. True or False

1. True 2. False 3. False 4. True 5. True

Session 4: Plain Scale and Diagonal Scale

B. Multiple choice questions

1. C 2. C 3. C 4. C 5. C

C. Fill in the blanks

1. angular 2. Chord 3. Arc 4. Angles 5. linear

D. True or False

1. True 2. False 3. True 4. False 5. True

Module 2: THEORY OF PROJECTION AND ORTHOGRAPHIC PROJECTION, SECTIONAL VIEW, ISOMETRIC VIEW

Session 1: Geometrical figures using Drawing Instruments

B. Multiple choice Questions

1. C 2. B 3. C 4. C 5. C

C. Fill in the blanks

1. foci 2. semi-major axis 3. semi-minor axis 4. horizontal 5. perfect circle

D. True or False

1. True 2. False 3. True 4. False 5. True

Session 2: Projection Planes and Principles of First and Third Angle Projections

B. Multiple choice questions

1. C 2. B 3. C 4. B 5. C

C. Fill in the blanks

1. object 2. Assembly 3. Observer 4. Reference 5. side

D. True or False

1. True 2. False 3. False 4. True 5. True

Session 3: Principle of Orthographic Projection

B. Multiple choice questions

1. C 2. B 3. B 4. C 5. C

C. Fill in the blanks

1. parallel 2. Polygonal 3. apex 4. circle 5. Polygonal

D. True or False

1. False 2. True 3. True 4. False 5. True

Session 4: Free Hand Sketches of Simple Machine Parts with Correct Proportions

B. Multiple choice questions

1. C 2. C 3. C 4. D 5. C

C. Fill in the blanks

1. Hexagonal 2. Four 3. Square 4. Stud 5. Cylinder

D. True or False

1. True 2. False 3. True 4. True 5. False

Session 5: Sectional views of Orthographic Projections

B. Multiple choice questions

1. C 2. B 3. B 4. D 5. B

C. Fill in the blanks

1.sectional 2. Cast iron 3. Pattern 4. Solid 5. steel

D. True or False

1. True 2. True 3. True 4. True 5. False

Session 6: Conversion of Isometric views into Orthographic Projections

B. Multiple choice Questions

1. D 2. B 3. C 4. B 5. C

C. Fill in the blanks

1. three-dimensional, two-dimensional, 120°
2. without perspective distortion, axes, foreshortened equally
3. axonometric projection, plane of projection
4. Isometric projection, isometric view
5. 45° angle, height, width, depth

D. True or False

1. True 2. True 3. False 4. False 5. True

Module 3: DRAWING OF MACHINE PARTS

Session 1: Introduction to Locking Devices (Lock Nuts, Spring Washers, Split Pins)

B. Multiple choice Questions

1. B 2. B 3. B 4. C 5. A

C. Fill in the blanks

1. hexagonal; cylindrical 2. Edges 3. Cylindrical 4. counter boring 5. recessed

D. True or False

1. True 2. False 3. False 4. False 5. True

Session 2: Types of Screws (Machine Screws, Cap Screws, Set Screws)

B. Multiple choice Questions

1. B 2. B 3. C 4. B 5. B

C. Fill in the blanks

1. pan (round), flat 2. curved, countersunk 3. Countersink 4. flat, cylindrical 5. strength, durability

D. True or False

1. False 2. True 3. True 4. False 5. True

Session 3: Foundation Bolts (Rag Bolts, Eye Bolts, and Applications)

B. Multiple choice Questions

1. B 2. B 3. B 4. B 5. B

C. Fill in the blanks

1. U 2. pipe, pole 3. Pipelines 4. Plate 5. steel

D. True or False

1. True 2. False 3. True 4. True 5. False

Session 4: Representation of Welded Joints Using Standard Symbols (Butt, Lap, Fillet)

B. Multiple choice Questions

1. C 2. B 3. C 4. B 5. C

C. Fill in the blanks

1. edges parallel 2. impact, stress 3. square groove, V groove, J groove, U groove 4. overlap, intersect 5. sides, welded

D. True or False

1. True 2. True 3. False 4. False 5. False

Session 5: Shaft Securing Elements (Keys, Cotter Joints, Splined Shafts, Pins, Circlips)

B. Multiple choice questions

1. C 2. C 3. B 4. B 5. C

C. Fill in the blanks

1.Sleeve 2. Muff 3. Cotters 4. 1 in 24 5. Taper

D. True or False

1. True 2. False 3. False 4. True 5. True

Session 6: Types of Rivets and Their Applications (Snap Head, Pan Head, Countersunk Rivets)

B. Multiple choice questions

1. C 2. C 3. C 4. C 5. B

C. Fill in the blanks

1. Sawed 2. Pierce 3. Hollow 4. Cold 5. Hollow

D. True or False

1. True 2. False 3. True 4. False 5. False

Module 4: INTRODUCTION TO TINKERCAD

Session 1: Basics of Tinkercad Software

B. Multiple choice questions

1. C 2. B 3. C 4. C 5. C

C. Fill in the blanks

1. cubes 2. Online 3. STL 4. Simple 5. free

Session 2: Creating and Modifying the Shapes

B. Multiple choice Questions

1. B 2. C 3. B 4. C 5. C

Session 3: Dimensioning and Exporting the Designs

B. Multiple choice questions

1. B 2. C 3. C 4. B

Module 5: HEALTH AND SAFETY

Session 1: Maintaining a Safe and Organized Mechanical Workspace

B. Multiple choice questions

1. B 2. C 3. B 4. C

C. Fill in the blanks

1. sockets 2. Power 3. Work 4. accidents

D. True or False

1. True 2. False 3. False 4. True 5. True

Session 2: Understanding Safety Signs and Hazard Colour Codes

B. Multiple choice questions

1. C 2. C 3. C 4. D

Session 3: Fire Prevention and Electrical Safety

B. Multiple choice questions

1. C 2. C 3. C 4. D 5. C

C. Fill in the blanks

1. damaged 2. Prongs 3. Surge 4. Tripping 5. hose

D. True or false

1. True 2. False 3. True

Session 4: Ergonomics and Basic First Aid in the Workshop

B. Multiple choice questions

1. C 2. C 3. C 4. C 5. C

C. Fill in the blanks

1. cut resistant 2. Dust 3. Safety 4. Posture 5. Desk

GLOSSARY

Scale – The ratio of the drawing size to the actual size of the object.

Projection – A method of showing a 3D object on a 2D plane.

Orthographic Projection – A way of drawing different views (front, top, side) of an object.

Isometric Projection – A type of 3D drawing where the axes are 120° apart.

Hidden Line – A dashed line used to show edges not directly visible.

Leader Line – A thin line that connects notes or dimensions to a feature.

Hatching – Parallel lines used in a sectional view to show cut surfaces.

Assembly Drawing – A drawing that shows how different parts fit together.

Part Drawing – A detailed drawing of a single component.

Fastener – A device (screw, bolt, rivet) used to join two parts together.

Key – A small metal piece used to prevent relative motion between shaft and hub.

Washer – A thin plate used under a nut or bolt head to distribute load.

Rivet – A permanent fastening element used to join parts.

Weld Symbol – A symbol used on drawings to indicate type of weld joint.

Section Line – Lines used to represent the cut surface in sectional views.

Dimension Line – A thin line with arrows that shows the extent of a dimension.

Extension Line – A thin line that extends from the object to the dimension line.

Chamfer – A beveled or angled edge on a part.

Fillet – A rounded inside corner between two surfaces.

Radius (R) – Distance from the center of a circle to its boundary.

Diameter (Ø) – Distance across a circle through its center.

Centre Mark – A small cross used to indicate the center of a circle or arc.

Dimension – A measurement that shows the size (length, width, height) of a part.

Tolerance – The allowed variation in size that is acceptable during manufacturing.

Surface Finish – The texture or smoothness of a part's outer surface.

Material Specification – Information about the type of material to be used.

Section View – A cut-through view that shows the inside of a part.

Isometric View – A 3D-like drawing that shows how a part looks from an angle.

Front View – The main side of a part as seen from the front.

Top View – A drawing that shows the part as seen from above.

Right-Side View – A drawing that shows the part as seen from the right side.

Title Block – The box on a drawing that gives details like part name, date, scale, etc.

Centreline – A dashed line that shows the center of holes or symmetrical features.