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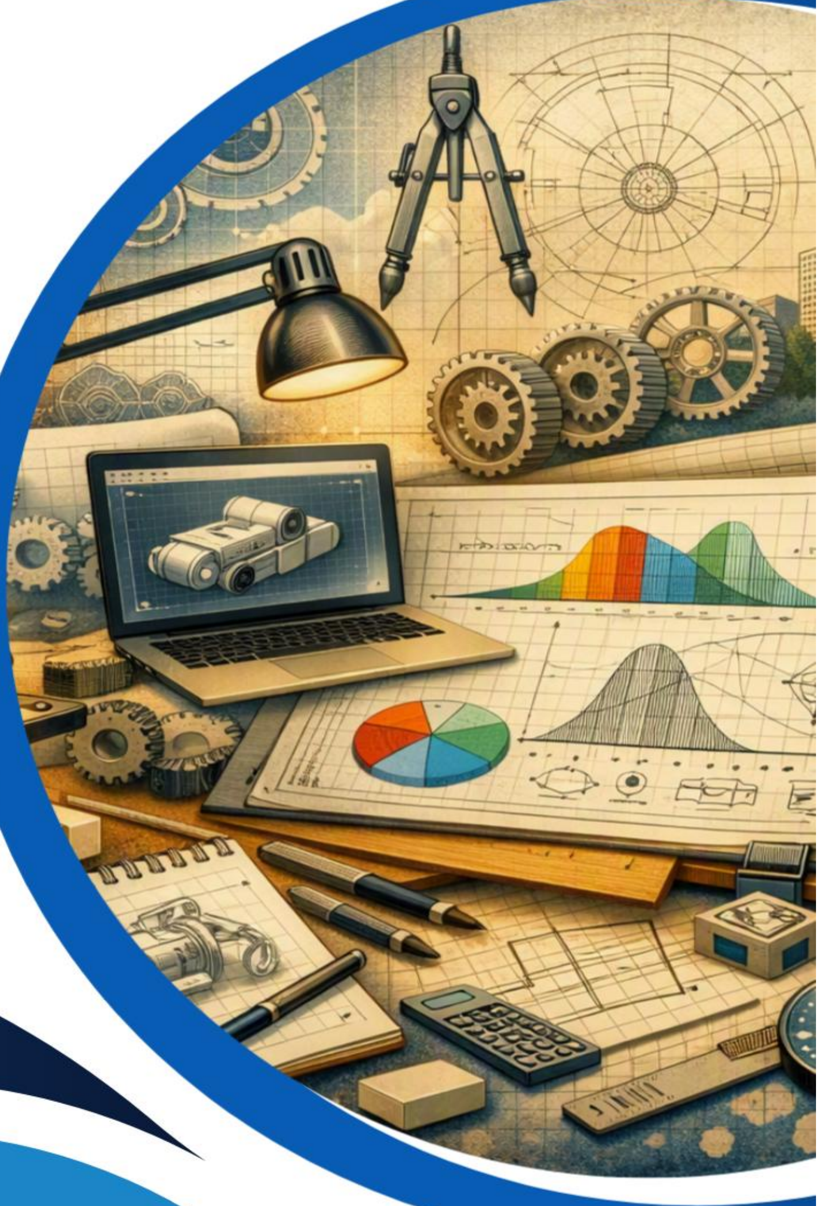
EHS218

INTRODUCTION TO ENGINEERING DRAWING & DESIGN



COURSE CODE: EHS 218

COURSE TITLE : Introduction to Engineering Drawing & Design

COURSE UNIT LOAD: (2 Units C: LH 30)

SERIES LIST

1. **Foundations of Engineering Drawing**
2. **Line Types, Formats, and Instruments**
3. **Projection Theory and Multi-View Representation**
4. **Isometric, Oblique, and Auxiliary Drawings**
5. **Dimensioning, Sections, and Conventional Representations**

Series 1 Foundations of Engineering Drawing

Main Parts and Sub-Parts

1.1 Concept of Engineering Drawing

- 1.1.1 Definition and importance
- 1.1.2 Role in engineering communication

1.2 Paper Formats in Engineering Drawing

- 1.2.1 Standard sizes (A0–A4)
- 1.2.2 Application and layout conventions

1.3 Drawing Instruments and Their Uses

- 1.3.1 Basic instruments (compass, ruler, protractor, T-square)
- 1.3.2 Handling and maintenance of instruments

Introduction

Engineering drawing is the language through which engineers communicate ideas, designs, and specifications with clarity and precision. Imagine a scenario where a team of engineers is working on a new machine: without a common graphical language, misunderstandings would arise, leading to costly errors. This Series sets the foundation for your journey into engineering drawing, helping you appreciate its role as the backbone of technical communication in design and manufacturing.

The aim of this Series is to introduce you to the fundamental principles of engineering drawing, guide you in applying standard paper formats, and equip you with the skills to handle essential drawing instruments effectively.

We shall commence this Series by examining the concept of engineering drawing, focusing on its definition, importance, and role in engineering communication. Next, we will explore paper formats, considering standard sizes and layout conventions that ensure uniformity in technical drawings. Finally, we will wrap up by studying drawing instruments, looking at their types, uses, and proper handling to achieve accuracy and neatness in your work.

Series learning outcomes

By the end of **Series 1: Foundations of Engineering Drawing**, you should be able to:

- **SLO 1.1:** Define the concept of engineering drawing and explain its importance as a universal language of engineers.
- **SLO 1.2:** Analyse the role of engineering drawing in effective communication within design and manufacturing processes.
- **SLO 1.3:** Apply standard paper formats correctly in technical drawings, ensuring clarity and uniformity.
- **SLO 1.4:** Identify and evaluate the functions of basic drawing instruments such as compasses, rulers, protractors, T-squares, and set squares.
- **SLO 1.5:** Demonstrate proper handling and maintenance of drawing instruments to achieve accuracy and neatness in engineering drawings.

1.1 Concept of Engineering Drawing

Engineering drawing is the **graphical representation** of objects, systems, or structures, created according to established conventions. It is often described as the universal language of engineers because it allows ideas to be communicated clearly and without ambiguity. Unlike artistic sketches, engineering drawings are precise, standardised, and governed by rules that ensure consistency across different users and contexts.

For example, when designing a bridge, engineers in different locations can collaborate effectively because the drawing conveys exact dimensions, shapes, and specifications. Fill-in-the-blank ITQ: Engineering drawing is the _________ language of engineers.

Figure 1.1: Placeholder for illustration showing an engineer using a drawing board.
Caption: An engineer preparing a technical drawing using standard instruments.

1.1.1 Definition and Importance

An engineering drawing is a **technical document** that conveys information about the shape, size, and features of an object. Its importance lies in its ability to eliminate guesswork, reduce errors, and provide a reliable reference for manufacturing and construction.

Fill-in-the-blank ITQ: An engineering drawing conveys information about the __________, __________, and __________ of an object.

1.1.2 Role in Engineering Communication

The role of engineering drawing in communication is critical. It ensures that designers, manufacturers, and technicians interpret the same information. Without this shared language, projects would suffer from misinterpretation and inefficiency.

Fill-in-the-blank ITQ: Engineering drawing ensures that __________, __________, and __________ interpret the same information.

Pilot questions 1.1

1. Engineering drawing is primarily a form of: a) Artistic expression b) Universal engineering language c) Freehand sketching d) Informal communication
2. Which of the following best describes engineering drawing? a) A casual sketch b) A precise graphical representation c) A painting d) A decorative art

3. Engineering drawing conveys information about: a) Colour and texture b) Shape, size, and features c) Artistic style d) Personal creativity

1.2 Paper Formats in Engineering Drawing

A **paper format** refers to the standardised size and layout of drawing sheets used in engineering. These formats are internationally recognised, ensuring that drawings produced in one location can be understood and reproduced accurately elsewhere. The most common formats are A0, A1, A2, A3, and A4, each defined by the ISO 216 standard. Correct application of paper formats guarantees uniformity, clarity, and ease of interpretation.

Fill-in-the-blank ITQ: The largest paper format used in engineering drawing is size __________.

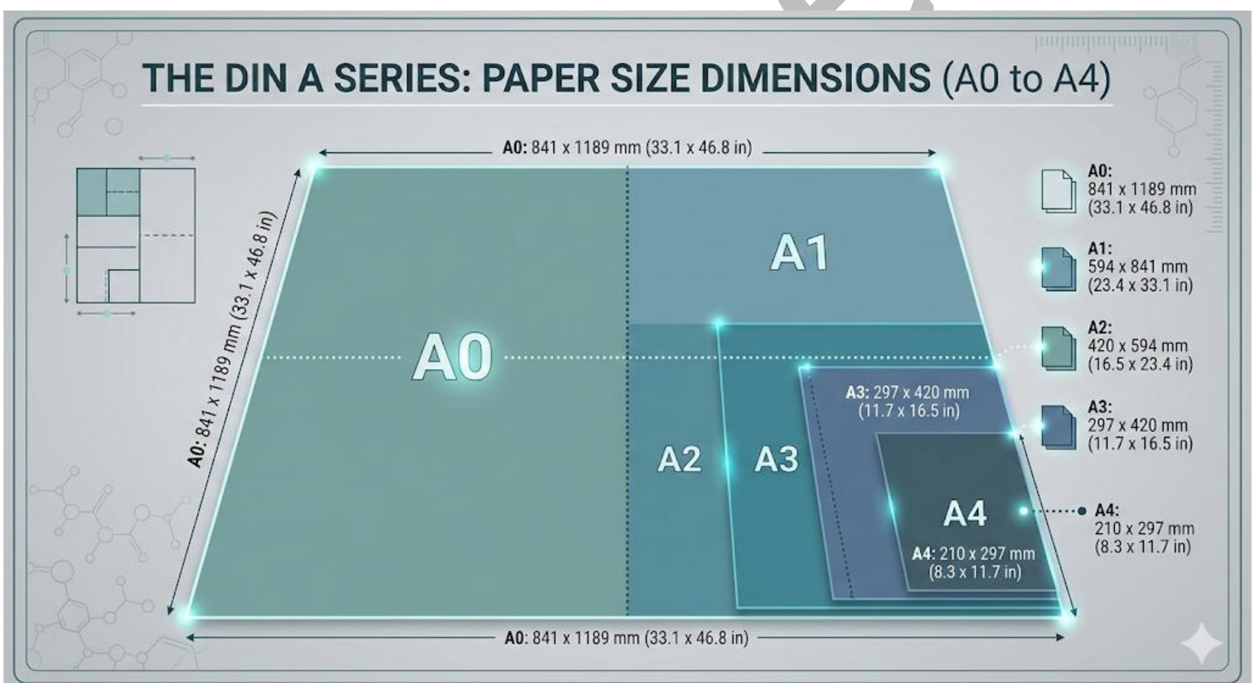


Figure 1.2: Placeholder for illustration showing standard paper formats arranged from A0 to A4. *Caption: Standard paper formats used in engineering drawing.*

1.2.1 Standard Sizes (A0–A4)

The **A-series paper sizes** are based on a consistent ratio, where each size is half the area of the previous one. For example, A1 is half the size of A0, and A2 is half the size of A1. This system allows drawings to be scaled up or down without distortion.

Fill-in-the-blank ITQ: The A-series paper sizes are based on a consistent __________ ratio.

1.2.2 Application and Layout Conventions

Paper formats are not only about size but also about layout. Each sheet includes a **title block**, which contains essential information such as the drawing title, author, date, and scale. Margins and borders are also standardised to ensure neatness and readability.

Fill-in-the-blank ITQ: The _________ block on a drawing sheet contains information such as title, author, and scale.

Pilot questions 1.2

1. Which paper format is the largest? a) A4 b) A3 c) A1 d) A0
2. Why are paper formats standardised? a) To reduce costs b) To ensure uniformity and clarity c) To allow artistic freedom d) To simplify printing
3. The title block on a drawing sheet usually contains: a) Colour and shading details b) Author, date, and scale c) Artistic notes d) Decorative patterns

1.3 Drawing Instruments and Their Uses

Drawing instruments are specialised tools used to produce accurate and neat engineering drawings. They are designed to ensure precision, consistency, and efficiency in technical communication. Unlike freehand sketches, which may vary from person to person, the use of instruments guarantees that drawings conform to established standards.

Fill-in-the-blank ITQ: A _________ is used to draw circles and arcs in engineering drawing.

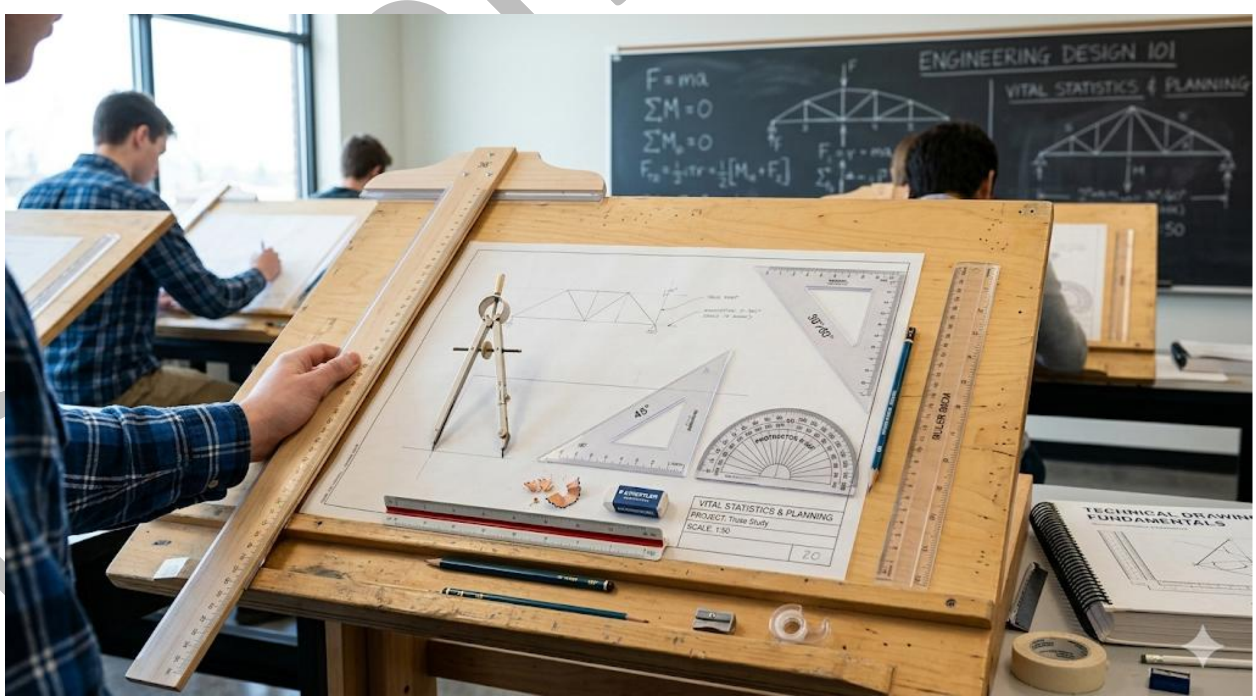


Figure 1.3: Placeholder for illustration showing a set of drawing instruments (compass,

ruler, protractor, T-square, set squares). *Caption: Common drawing instruments used in engineering drawing.*

1.3.1 Basic Instruments

The most common instruments include:

- **Compass:** Used to draw circles and arcs.
- **Ruler/Scale:** Used to measure and draw straight lines to scale.
- **Protractor:** Used to measure and construct angles.
- **T-square:** Used to draw horizontal lines and guide set squares.
- **Set squares:** Used to draw vertical and inclined lines at fixed angles.

Fill-in-the-blank ITQ: A _________ is used together with a T-square to draw vertical and inclined lines.

1.3.2 Handling and Maintenance of Instruments

Proper handling of instruments is essential to achieve accuracy. Instruments should be kept clean, stored properly, and used with care to avoid damage. For example, compasses should be tightened securely to prevent slipping, and rulers should be checked regularly to ensure they are not bent or worn. Maintenance ensures longevity and reliability of the instruments.

Fill-in-the-blank ITQ: Instruments should be kept _________ and stored properly to ensure accuracy and longevity.

Pilot questions 1.3

1. Which instrument is used for drawing parallel lines? a) Compass b) T-square c) Protractor d) Divider
2. Which instrument is essential for measuring angles? a) Compass b) Protractor c) Set square d) Scale
3. Which instrument is used to draw circles and arcs? a) Compass b) Ruler c) T-square d) Divider

Series summary

This Series has provided you with the essential foundations of engineering drawing, emphasising its role as the universal language of engineers. We began by exploring the concept of engineering drawing, focusing on its definition, importance, and role in communication. Then we examined paper formats, considering standard sizes and layout conventions that ensure clarity and uniformity. Finally, we studied drawing instruments, identifying their functions and highlighting the importance of proper handling and maintenance.

By working through these Parts, you should now be able to define engineering drawing and explain its relevance (SLO 1.1 and SLO 1.2), apply standard paper formats correctly (SLO 1.3), identify and evaluate the functions of basic drawing instruments (SLO 1.4), and demonstrate appropriate handling and maintenance practices (SLO 1.5). These outcomes form a strong foundation for progressing into more advanced aspects of engineering drawing in subsequent Series.

Glossary of terms

- **Compass:** An instrument used to draw circles and arcs accurately.
- **Drawing instruments:** Tools used to produce precise and neat drawings, such as compasses, rulers, protractors, T-squares, and set squares.
- **Engineering drawing:** A technical graphical representation of objects or systems, serving as the universal language of engineers.
- **Paper format:** Standardised sheet sizes used in engineering drawing, such as A0 to A4, defined by international standards.
- **Protractor:** An instrument used to measure and construct angles.
- **Ruler/Scale:** A straight-edged instrument used to measure and draw lines to scale.
- **Set square:** A triangular instrument used with a T-square to draw vertical and inclined lines at fixed angles.
- **Title block:** A section of a drawing sheet containing essential information such as title, author, date, and scale.
- **T-square:** An instrument used to draw horizontal lines and guide set squares for vertical and inclined lines.

Concept check questions 1

Objective questions

1. (Linked to SLO 1.1) Engineering drawing is best described as: a) A decorative art b) A universal language of engineers c) A casual sketch d) An informal communication
2. (Linked to SLO 1.3) Which paper format is the largest in the A-series? a) A4 b) A3 c) A1 d) A0
3. (Linked to SLO 1.4) Which instrument is primarily used to measure angles? a) Compass b) Protractor c) T-square d) Divider

Short-answer questions

4. (Linked to SLO 1.2) Explain why engineering drawing is considered the universal language of engineers.

5. (Linked to SLO 1.3) State two reasons why standardised paper formats are important in engineering drawing.

6. (Linked to SLO 1.5) Mention two practices that ensure proper maintenance of drawing instruments.

Long-answer questions

7. (Linked to SLO 1.1 and SLO 1.2) Define engineering drawing and analyse its role in effective communication within design and manufacturing processes.

8. (Linked to SLO 1.4 and SLO 1.5) Identify five basic drawing instruments and evaluate their functions. Discuss how proper handling and maintenance contribute to accuracy and neatness in engineering drawings.

Answers to Concept check questions 1

Objective questions

1. b) A universal language of engineers
2. d) A0
3. b) Protractor

Short-answer questions

4. Engineering drawing is considered the universal language of engineers because it provides a precise and standardised way of communicating ideas, designs, and specifications without ambiguity.

5. Standardised paper formats are important because they ensure uniformity across drawings and allow scaling without distortion.

6. Instruments should be kept clean and stored properly, and they should be checked regularly to avoid damage or wear.

Long-answer questions

7. **Basic response:** Engineering drawing is a technical graphical representation of objects or systems. It plays a vital role in communication by ensuring that designers, manufacturers, and technicians interpret the same information accurately. **Value-added response:** Beyond its basic role, engineering drawing also supports collaboration across international teams, reduces errors in production, and provides a legal and professional record of design specifications.

8. **Basic response:** The five basic instruments are compass, ruler, protractor, T-square, and set square. Each has a specific function, such as drawing circles, measuring

angles, or guiding lines. Proper handling ensures accuracy, while maintenance prevents wear and prolongs usability. **Value-added response:** In addition to their basic functions, these instruments form the foundation of modern computer-aided design tools. By mastering their use, learners develop precision skills that transfer to digital platforms, enhancing adaptability in both manual and computer-based drawing environments.

Answers to Pilot Questions 1

Pilot questions 1.1

1. b) Universal engineering language
2. b) A precise graphical representation
3. b) Shape, size, and features

Pilot questions 1.2

1. d) A0
2. b) To ensure uniformity and clarity
3. b) Author, date, and scale

Pilot questions 1.3

1. b) T-square
2. b) Protractor
3. a) Compass

References and Attributions 1

- Course document: *EHS 218: Introduction to Engineering Drawing & Design* (University course material).
- ISO 216 Standard: Paper sizes (A-series formats).

Figures

- **Figure 1.1**: Placeholder illustration of an engineer using a drawing board. *AI prompt suggestion: "Generate a realistic illustration of an engineer using a drawing board with T-square and compass, classroom setting, professional style."*
- **Figure 1.2**: Placeholder diagram showing paper sizes A0 to A4 arranged in descending order. *AI prompt suggestion: "Generate a clear diagram showing paper sizes A0 to A4 arranged in descending order, labelled with dimensions, professional style."*

- **Figure 1.3**: Placeholder illustration of a set of drawing instruments. *AI prompt suggestion: "Generate a realistic illustration of a set of drawing instruments including compass, ruler, protractor, T-square, and set squares, arranged neatly on a drawing board."*

Series 2 Line Types, Formats, and Instruments

Main Parts and Sub-Parts

2.1 Types of Lines in Engineering Drawing

- 2.1.1 Classification of lines (continuous, dashed, chain, etc.)
- 2.1.2 Uses of different line types in technical drawings

2.2 Drawing Formats and Their Applications

- 2.2.1 Standard drawing formats and conventions
- 2.2.2 Methods of format construction

2.3 Instruments for Line Work and Format Handling

- 2.3.1 Instruments used for specific line types
- 2.3.2 Techniques for accuracy and neatness in format application

Introduction

In the last Series, we explored the foundations of engineering drawing, focusing on its definition, the importance of paper formats, and the use of basic drawing instruments. Building on that knowledge, this Series will guide you into the conventions of line types, the application of drawing formats, and the instruments used to achieve accuracy in technical drawings. These elements are essential because they provide the structure and clarity that make engineering drawings universally interpretable.

The aim of this Series is to equip you with the skills to classify and apply different line types, construct and manage drawing formats, and employ instruments effectively for line work and format handling.

We shall commence this Series by examining the types of lines used in engineering drawing, considering their classification and specific uses. Next, we will explore drawing formats, focusing on standard conventions and methods of construction. Finally, we will wrap up by studying the instruments used for line work and format handling, highlighting techniques that ensure accuracy and neatness.

Series Learning Outcomes 2

By the end of **Series 2: Line Types, Formats, and Instruments**, you should be able to:

- **SLO 2.1:** Classify different types of lines used in engineering drawing and explain their specific applications.
- **SLO 2.2:** Apply standard drawing formats and conventions correctly in technical drawings.
- **SLO 2.3:** Construct drawing formats using appropriate methods to ensure clarity and uniformity.
- **SLO 2.4:** Identify instruments used for line work and format handling, and evaluate their functions.
- **SLO 2.5:** Demonstrate techniques for accuracy and neatness when using instruments to produce line types and formats

2.1 Types of Lines in Engineering Drawing

Lines are the most fundamental elements of engineering drawing. They are not drawn arbitrarily but follow specific conventions that give meaning to the drawing. Each line type conveys particular information, such as visible edges, hidden features, or centre lines. By learning to classify and apply line types correctly, you ensure that your drawings are clear, standardised, and easily understood by others.

Fill-in-the-blank ITQ: A _________ line is used to represent visible edges of an object.

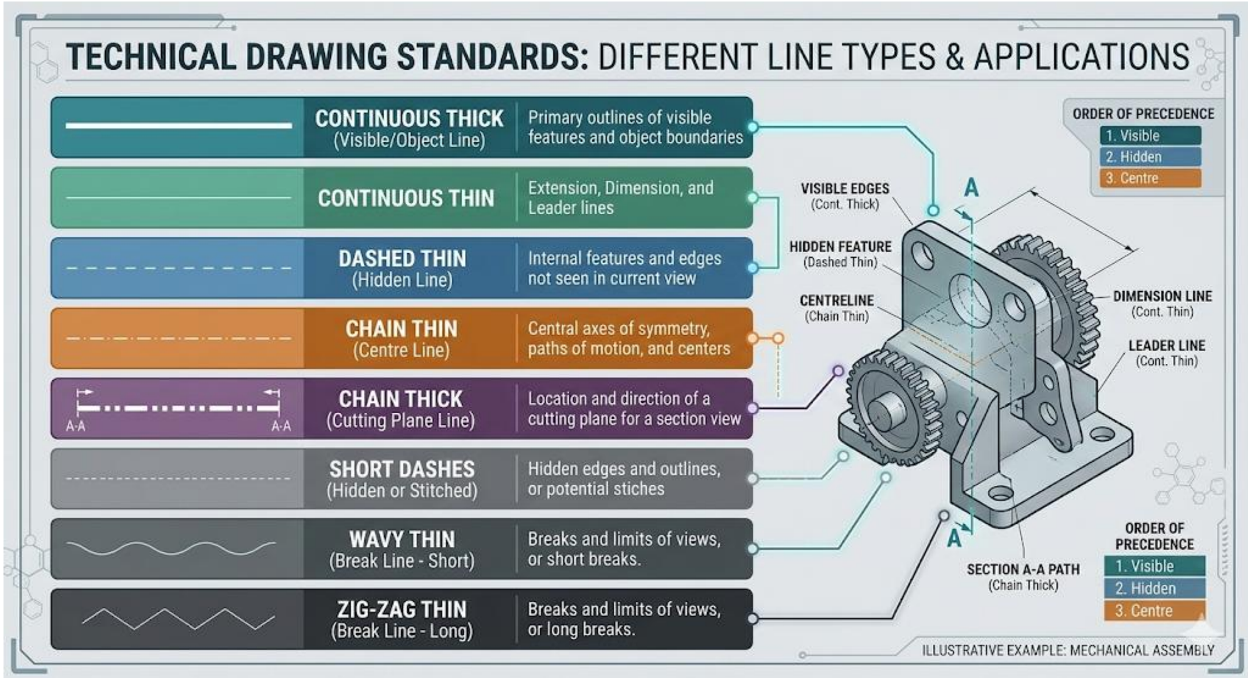


Figure 2.1: Placeholder for illustration showing different line types (continuous thick, dashed, chain, centre line). *Caption: Common line types used in engineering drawing.*

2.1.1 Classification of Lines

Lines are classified according to their appearance and purpose. Common types include:

- **Continuous thick line:** Represents visible outlines and edges.
- **Dashed line:** Represents hidden features not visible in the current view.
- **Chain line:** Indicates special features such as surfaces to be treated.
- **Centre line:** Represents axes of symmetry or centres of circles.

Fill-in-the-blank ITQ: A __________ line is used to represent hidden features in a drawing.

2.1.2 Uses of Different Line Types

Each line type has a specific use that eliminates ambiguity. For example, a continuous thick line shows what is directly visible, while a dashed line reveals hidden parts. Centre lines are essential for symmetrical objects, and chain lines highlight surfaces requiring special attention. Correct use of line types ensures that the drawing communicates all necessary details without confusion.

Fill-in-the-blank ITQ: A __________ line is used to represent axes of symmetry.

Pilot questions 2.1

1. Which line type is used to represent visible outlines? a) Dashed line b) Continuous thick line c) Chain line d) Centre line

2. Which line type is used to represent hidden features? a) Continuous thick line b) Dashed line c) Chain line d) Centre line
3. Which line type is used to represent axes of symmetry? a) Continuous thick line b) Dashed line c) Chain line d) Centre line

2.2 Drawing Formats and Their Applications

Drawing formats provide the structured framework within which engineering drawings are prepared. They ensure that every drawing follows a consistent layout, making it easier to interpret and reproduce across different contexts. Formats include standardised sheet divisions, margins, borders, and title blocks, all of which contribute to clarity and professionalism in technical communication.

Fill-in-the-blank ITQ: The _________ block on a drawing sheet contains information such as title, author, date, and scale.

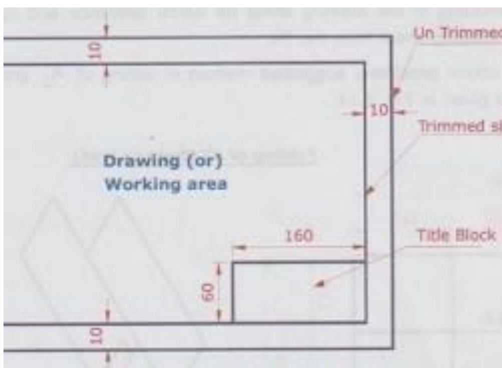


Fig. 2.12. Layout of Drawing sheet

Figure 2.2: Placeholder for illustration showing a standard drawing format with margins, borders, and a title block. *Caption: Standard drawing format with layout conventions*.

2.2.1 Standard Drawing Formats and Conventions

Standard drawing formats are based on internationally recognised paper sizes (A-series) and include specific layout conventions. Margins are typically uniform, borders frame the drawing neatly, and the title block provides essential information. These conventions ensure that drawings are not only accurate but also easy to read and share.

Fill-in-the-blank ITQ: Margins and _________ frame the drawing neatly and ensure clarity.

2.2.2 Methods of Format Construction

Constructing a drawing format involves setting up the sheet with correct margins, borders, and title block placement before beginning the actual drawing. This preparation stage is crucial because it establishes order and prevents confusion later. A well-constructed format reflects professionalism and enhances the credibility of the drawing.

Fill-in-the-blank ITQ: Constructing a drawing format involves setting up margins, borders, and __________ placement.

Pilot questions 2.2

1. What is the purpose of a title block in a drawing format? a) To decorate the sheet b) To provide essential information such as title, author, and scale c) To add colour and shading d) To show hidden features
2. Which of the following is NOT part of a standard drawing format? a) Margins b) Borders c) Title block d) Freehand sketches
3. Why is format construction important in engineering drawing? a) It adds artistic value b) It ensures order, clarity, and professionalism c) It allows creativity without rules d) It reduces the need for instruments

2.3 Instruments for Line Work and Format Handling

Instruments play a crucial role in producing accurate line types and constructing drawing formats. While you were introduced to basic instruments in Series 1, this Part focuses on their specific applications for line work and format handling. By mastering these tools, you will be able to produce drawings that are both precise and professional.

Fill-in-the-blank ITQ: A __________ is used with a T-square to draw vertical and inclined lines accurately.

Figure 2.3: Placeholder for illustration showing instruments applied to line work (T-square with set square, compass for arcs, protractor for angles). *Caption: Instruments applied to line types and format construction.*

2.3.1 Instruments Used for Specific Line Types

Different instruments are suited to different line types. For example:

- **T-square and set squares:** Used together to draw horizontal, vertical, and inclined lines.
- **Compass:** Used for arcs and circles.
- **Protractor:** Used for constructing angles.
- **Scale/ruler:** Used for measuring and drawing straight lines to scale.

Fill-in-the-blank ITQ: A __________ is used to measure and construct angles in engineering drawing.

2.3.2 Techniques for Accuracy and Neatness

Accuracy and neatness depend on how instruments are handled. For instance, the T-square should be pressed firmly against the edge of the drawing board to prevent slippage, while compasses must be tightened to avoid uneven arcs. Neatness is achieved by maintaining sharp pencil points and consistent line thickness. Proper technique ensures that the drawing communicates clearly and looks professional.

Fill-in-the-blank ITQ: Accuracy and neatness in drawing depend on proper __________ of instruments.

Pilot questions 2.3

1. Which instrument is used with a T-square to draw vertical lines? a) Compass b) Set square c) Protractor d) Divider
2. Which instrument is essential for constructing angles? a) Compass b) Protractor c) T-square d) Scale
3. Which practice helps ensure neatness in engineering drawing? a) Using blunt pencils b) Maintaining sharp pencil points and consistent line thickness c) Pressing instruments lightly without control d) Avoiding margins and borders

Series summary

This Series has focused on the conventions that give engineering drawings clarity and meaning. We began by examining the types of lines, learning how continuous, dashed, chain, and centre lines are classified and applied to represent visible edges, hidden features, and axes of symmetry. We then explored drawing formats, considering standard layout conventions such as margins, borders, and title blocks, and how these contribute to order and professionalism. Finally, we studied instruments for line work and format handling, identifying their specific applications and techniques that ensure accuracy and neatness.

By completing this Series, you should now be able to classify and apply line types correctly (SLO 2.1), use standard drawing formats and conventions (SLO 2.2), construct formats with clarity and uniformity (SLO 2.3), identify instruments for line work and evaluate their functions (SLO 2.4), and demonstrate techniques for accuracy and neatness in drawing (SLO 2.5). These outcomes strengthen your ability to produce professional engineering drawings and prepare you for more advanced topics in subsequent Series.

Glossary of terms

- **Centre line:** A line used to represent axes of symmetry or centres of circles.
- **Chain line:** A line used to indicate special features such as surfaces requiring treatment.
- **Continuous thick line:** A line used to represent visible outlines and edges of an object.
- **Dashed line:** A line used to represent hidden features not visible in the current view.
- **Drawing format:** The structured layout of a drawing sheet, including margins, borders, and title block.
- **Margins:** The uniform spaces around the edges of a drawing sheet that frame the content.
- **Protractor:** An instrument used to measure and construct angles.
- **Set square:** A triangular instrument used with a T-square to draw vertical and inclined lines.
- **Title block:** A section of a drawing sheet containing essential information such as title, author, date, and scale.
- **T-square:** An instrument used to draw horizontal lines and guide set squares for vertical and inclined lines.

Concept check questions 2

Objective questions

1. (Linked to SLO 2.1) Which line type is used to represent visible outlines? a) Dashed line b) Continuous thick line c) Chain line d) Centre line

2. (Linked to SLO 2.2) Which element is NOT part of a standard drawing format? a) Margins b) Borders c) Title block d) Freehand sketches
3. (Linked to SLO 2.4) Which instrument is used with a T-square to draw vertical lines? a) Compass b) Set square c) Protractor d) Divider

Short-answer questions

4. (Linked to SLO 2.1) Explain why different line types are necessary in engineering drawing.

5. (Linked to SLO 2.2) State two reasons why drawing formats are important in technical communication.

6. (Linked to SLO 2.5) Mention two practices that help ensure neatness when using drawing instruments.

Long-answer questions

7. (Linked to SLO 2.1 and SLO 2.2) Define line types and analyse their role in ensuring clarity and accuracy in engineering drawings.

8. (Linked to SLO 2.4 and SLO 2.5) Identify four instruments used for line work and format handling. Evaluate their functions and discuss techniques that ensure accuracy and neatness.

Answers to Concept check questions 2

Objective questions

1. b) Continuous thick line
2. d) Freehand sketches
3. b) Set square

Short-answer questions

4. Different line types are necessary because they convey specific information, such as visible edges, hidden features, or symmetry, ensuring clarity and preventing misinterpretation.

5. Drawing formats are important because they provide a structured layout that ensures uniformity and professionalism, and they make drawings easier to interpret and reproduce.

6. Practices include maintaining sharp pencil points and consistent line thickness, and ensuring instruments are handled firmly and correctly to avoid slippage.

Long-answer questions

7. **Basic response:** Line types are conventions in engineering drawing that represent different features, such as visible outlines, hidden parts, or axes of symmetry. They ensure clarity by distinguishing between what is seen and what is hidden. **Value-added response:** Beyond clarity, line types also standardise communication across industries and countries, reduce errors in manufacturing, and support collaboration by providing universally recognised symbols.

8. **Basic response:** Instruments include the T-square, set square, compass, and protractor. Each serves a specific function, such as drawing straight lines, vertical lines, arcs, or angles. Accuracy and neatness are achieved by handling instruments properly and maintaining sharp pencils. **Value-added response:** In addition to their basic functions, these instruments train learners in precision and discipline, skills that transfer to digital drawing tools. Proper technique also enhances efficiency, reduces rework, and ensures professional-quality outputs.

List of references 2.

1. **ISO 128: Technical Drawings, General Principles of Presentation.**
   International Organisation for Standardisation.
   A standard that outlines the rules for line types, line widths, and general conventions used in engineering drawing.
2. **ISO 5457: Sizes and Layout of Drawing Sheets.**
   International Organisation for Standardisation.
   This standard specifies the A-series drawing sheet sizes, margins, borders, and title block requirements.
3. **ISO 7200: Technical Product Documentation, Data Fields in Title Blocks.**
   International Organisation for Standardisation.
   Provides guidance on mandatory and optional fields to include in title blocks and revision tables.
4. **Giesecke, F. E., Mitchell, A., Spencer, H., Hill, I., Dygdon, J., Novak, J., and Loving, R. (Technical Drawing with Engineering Graphics).**
   Pearson Education.
   A widely used engineering graphics textbook that illustrates line conventions, lettering, sheet layouts, and basic instrument use.
5. **French, T. E., Veilleux, J. C., and Foster, C. J. (Engineering Drawing and Graphic Technology).**
   McGraw-Hill.
   Covers traditional drawing instruments, sheet organisation, and projection principles with examples.
6. **Bertoline, G., and Wiebe, E. (Fundamentals of Graphics Communication).**
   McGraw-Hill.

Provides foundational concepts in both manual and digital drawing, including CAD interfaces.

7. **Department of Mechanical or Civil Engineering Drawing Manual (Institution-Specific).**
   Kwara State University or relevant faculty drawing guide.
   Institutional manuals typically outline title block formats, borders, acceptable sheet styles, and unique departmental standards.
8. **Autodesk AutoCAD User Guide.**
   Autodesk Corporation.
   Provides digital drawing standards, tools, and recommended practices for CAD environments.
9. **Technical Drafting Handbook (Author/Year Placeholder).**
   Generic or local drafting references that define line types, tools, and sheet preparation techniques used in Nigerian engineering schools.
10. **Projection Theory and Multi-View Representation**

Part 3.1 Fundamentals of Projection Theory

Sub-Parts

- **3.1.1 Concept of Projection and Lines of Sight**
- **3.1.2 Types of Projection Systems**
  (orthographic, oblique, perspective)
- **3.1.3 Planes of Projection**
  (horizontal plane, vertical plane, profile plane)

Part 3.2 Orthographic Projection Principles

Sub-Parts

- **3.2.1 First-Angle and Third-Angle Projection Methods**
- **3.2.2 Projection of Points, Lines, and Planes**
- **3.2.3 Roles of Reference Planes in 2D Projection**

Part 3.3 Multi-View Representation of Objects

Sub-Parts

- **3.3.1 Standard Orthographic Views**
  (front, top, right-side, left-side, auxiliary views)
- **3.3.2 Alignment and Spacing of Views**
- **3.3.3 Representation of Hidden and Centre Features**

Part 3.4 Interpreting and Constructing Multi-View Drawings

Sub-Parts

- **3.4.1 Converting 3D Solids to Multi-View Drawings**
- **3.4.2 Reading and Visualising Multi-View Representations**
- **3.4.3 Common Errors and Good Practice in Multi-View Drawing**

Introduction.

In the previous Series, we examined the use of line types, drawing formats, and instruments, which are essential for producing neat and standardised technical drawings. Building on that foundation, this Series introduces you to the principles that enable engineers to convert three-dimensional objects into clear two-dimensional representations. Understanding projection theory is fundamental at this stage, because it forms the bridge between basic drawing conventions and the more advanced drawing techniques you will encounter later in the course.

The aim of this Series is to familiarise you with the theory and application of projection systems and to equip you with the skills required to construct and interpret multi-view drawings accurately.

We shall commence this Series by exploring the fundamentals of projection theory, including the concept of projectors and the different projection systems. Moving on to the second Part, we will examine the principles of orthographic projection and the roles of reference planes. Subsequently, we will study how objects are represented using standard multi-view drawings, with attention to alignment, spacing, and the use of hidden or centre features. Finally, the Series will be rounded off with a focus on interpreting and constructing multi-view drawings, allowing you to identify common errors and apply good practice in engineering communication

Series learning outcomes.

Upon completing this Series, you should be able to:

SLO 3.1 define the key concepts and principles that underpin projection theory,

SLO 3.2 explain the major projection systems used in engineering drawing,

SLO 3.3 distinguish between first-angle and third-angle orthographic projection methods,

SLO 3.4 construct orthographic projections of points, lines, and planes using reference planes,

SLO 3.5 produce standard multi-view drawings of objects with correct alignment and spacing,

SLO 3.6 apply appropriate line types to represent hidden and centre features in multi-view drawings, and

SLO 3.7 interpret multi-view representations to identify object geometry and detect common errors.

3.1 Fundamentals of Projection Theory

3.1.1 Concept of projection and lines of sight

Projection plays an essential role in engineering drawing because it allows us to convert real objects into accurate graphical representations that can be communicated, interpreted, and manufactured. In this context, **projection** refers to the systematic method of transferring the features of a three-dimensional object onto a two-dimensional plane using imaginary straight lines. These imaginary straight lines are called **projectors**, defined as the straight lines drawn from every point on the object towards the projection plane to create its image. When you understand how projectors behave, it becomes easier to visualise how the front, top, and side views of objects are produced in technical drawings.

A simple diagram showing an object, projectors, and a projection plane
Figure 3.1: Illustration of an object being projected onto a plane using straight projectors

When we view an object, our eyes create imaginary observation lines that travel directly towards the object. These imaginary viewing paths are called **lines of sight**, which are straight lines drawn from the observer's eyes to the object being viewed. In engineering drawing, these lines of sight are assumed to be straight and parallel so that the resulting image does not distort the true shape or size of the object. This is particularly important in orthographic projection, where accurate dimensions are required for manufacturing and design.

To visualise this better, imagine that you are standing directly in front of a classroom table. Your lines of sight allow you to see the table's front shape without distortion. If you step to the right, your lines of sight give you a new shape that corresponds to the right-hand side of the table. Each change of viewpoint creates a new representation, and engineering drawing uses this principle to create all the principal views required for interpreting an object.

Fill in the blank: In technical drawing, the imaginary straight lines drawn from the observer toward an object are known as _________.

Illustration of an observer standing in different positions and projecting lines of sight towards a block
Figure 3.2: Lines of sight from different viewing directions around a 3D object
Suggested AI prompt: “Generate an educational diagram showing an observer, multiple viewing directions, and lines of sight projected towards a simple object.”
Search string: *lines of sight observer viewing directions engineering graphics OER*

It is helpful to think of projection and lines of sight as tools that simplify complex shapes. When many projectors are drawn from an object to a projection plane, the resulting two-dimensional image becomes a faithful representation of the object's geometry. This is why projection theory is the foundation of all forms of engineering drawing, including multi-view, auxiliary, isometric, and sectional representations. Without understanding projection, it becomes difficult to interpret engineering drawings confidently.

Fill in the blank: When projectors are drawn perpendicular to a projection plane, the resulting projection is referred to as _________ projection.

Pilot questions 3.1

1. What term is used to describe the imaginary straight lines used to transfer an object’s features to a projection plane?
2. What name is given to the straight imaginary viewing lines drawn from the observer?
3. Why are lines of sight assumed to be parallel in orthographic projection?
4. What happens when the observer changes position around an object?
5. What is the purpose of projection in engineering drawing?

3.1 Fundamentals of Projection Theory

3.1.2 Types of projection systems

Engineering drawings rely on different projection systems to represent objects accurately for communication and manufacturing. A **projection system** is a structured method that determines how projectors meet the projection plane to create a view of an object. Each system produces a different form of representation, and understanding the distinctions will help you choose the correct method for a given drawing task.

There are three major projection systems in engineering graphics. These are **orthographic projection**, **oblique projection**, and **perspective projection**. Each system uses a different arrangement of projectors, and this arrangement determines whether the final view is realistic, distorted, or dimensionally accurate.

Simple labelled comparison of orthographic, oblique, and perspective projection on three separate planes

Figure 3.3: Comparison of the three major projection systems
Suggested Search string: *orthographic oblique perspective projection comparison engineering drawing OER*

Orthographic projection is the most widely used in engineering drawing. **Orthographic projection** is a projection system where projectors are parallel to one another and perpendicular to the projection plane, producing accurate, undistorted views. This accuracy makes orthographic drawings suitable for manufacturing, because every measurement shown corresponds exactly to the true size of the object.

In contrast, **oblique projection** is a system where projectors are parallel but inclined at an angle to the projection plane. This creates a pictorial view that shows the front face in true shape while the receding sides are shown at an angle. Although oblique drawings provide a more descriptive appearance, they do not preserve true dimensions on the angled faces.

Perspective projection uses converging projectors. **Perspective projection** is a projection system in which all projectors converge at a single point known as the station point. This system creates images that resemble human vision, making the object appear realistic. However, perspective drawings distort sizes and are therefore not used for manufacturing or machining.

Fill in the blank: A projection system that preserves true dimensions by using projectors perpendicular to the projection plane is known as __________ projection.

Diagram showing how projectors behave differently in the three systems
Figure 3.4: Direction of projectors in orthographic, oblique, and perspective projection
Suggested

The choice of projection system depends on the purpose of the drawing. Orthographic projection is used when accuracy and manufacturing detail are required. Oblique projection is commonly used for quick sketches or illustrations where the front view must remain undistorted. Perspective projection is best for presentations and visual appreciation rather than technical production. As you work through later Parts of this Series, you will see that multi-view representation depends entirely on orthographic projection, since it provides the precision needed for engineering communication.

Fill in the blank: The projection method that best represents how the human eye naturally views objects is called __________ projection.

Pilot questions 3.1.2

1. What is a projection system in engineering drawing?
2. Which projection system uses parallel projectors that are perpendicular to the plane?
3. In which projection system are projectors parallel but inclined?

4. Which system uses a station point?
5. Why is orthographic projection preferred for manufacturing?

3.1 Fundamentals of Projection Theory

3.1.3 Planes of projection

In engineering drawing, the concept of projection becomes meaningful only when we consider the surfaces onto which objects are projected. These surfaces are called **projection planes**, defined as imaginary flat surfaces used to receive the projected image of an object. Projection planes help us organise different views so that we can interpret the height, width, and depth of an object accurately. Without them, the front, top, and side views that make up multi-view drawings would not have a logical structure.

The three principal projection planes used in orthographic drawing are the **horizontal plane**, the **vertical plane**, and the **profile plane**. The **horizontal plane (HP)** is the imaginary surface onto which the top view of an object is projected. The **vertical plane (VP)** receives the front view, while the **profile plane (PP)** receives the side view. These three planes meet at right angles, forming what is known as the principal planes of projection used in engineering graphics.

Diagram showing HP, VP, and PP intersecting at right angles
Figure 3.5: Orientation of the horizontal, vertical, and profile projection planes

The arrangement of these planes determines how views relate to one another. For example, the HP lies flat like a floor, and the VP stands upright like a wall. When projectors from an object meet the VP, the resulting front view shows the shape and height of the object. When projectors meet the HP, the resulting top view shows width and depth. The PP, placed to the side, gives the right-side or left-side view. Understanding this layout helps you visualise why views are placed in particular positions on a drawing sheet.

Fill in the blank: The projection plane that receives the front view of an object is called the __________ plane.

When producing actual engineering drawings, we imagine folding these planes outward to form a flat drawing sheet. This creates a familiar arrangement where the front view is placed centrally, the top view is placed above or below it depending on the projection method, and the side view is placed appropriately to the left or right. Learning how these planes unfold helps you avoid common layout mistakes and improves your accuracy when constructing multi-view drawings.

Illustration of projection planes being unfolded to produce orthographic views
Figure 3.6: Unfolding the projection planes to form a 2D drawing sheet

Fill in the blank: The plane used to project the top view of an object is the _________ plane.

Pilot questions 3.1.3

1. What is a projection plane in engineering drawing?
2. Which projection plane receives the top view of an object?
3. What view is obtained on the vertical plane?
4. Which projection plane is used for obtaining the side view?
5. Why do we mentally unfold the projection planes when constructing multi-view drawings?

3.2 Orthographic Projection Principles

3.2.1 First-angle and third-angle projection methods

Orthographic projection uses a structured approach to represent an object on different planes. Two globally recognised methods are used for placing and interpreting the views that result from this projection. These are the **first-angle projection method**, defined as the method in which the object is imagined to be placed between the observer and the projection plane, and the **third-angle projection method**, defined as the method in which the projection plane is imagined to be placed between the observer and the object. These two systems follow the same principles of projection but differ in the arrangement of the resulting views.

In the first-angle method, commonly used in Europe, Asia, and many Commonwealth countries, the object lies in the first quadrant. This means the observer looks at the object, and the object casts its projection onto the plane behind it. Therefore, the views appear opposite to their physical position. For example, the right-hand side of the object is drawn on the left-hand side of the front view. This reversal does not affect accuracy because the linework is guided by projection rules.

Diagram comparing the placement of views in first-angle projection
Figure 3.7: View arrangement in first-angle projection

In the third-angle method, which is widely used in North America, the planes are positioned differently. Here, the projection plane is imagined to be between the observer and the object. As a result, the views appear in the same direction as their physical locations. For example, the right-hand side of the object is drawn on the right-hand side of the front view. This arrangement often feels more intuitive for beginners because it aligns with natural expectations about direction.

Diagram comparing the placement of views in third-angle projection
Figure 3.8: View arrangement in third-angle projection

The choice between first-angle and third-angle projection depends largely on regional or institutional standards. Many industries in Europe and Asia prefer first-angle projection, while industries in the United States and Canada use third-angle projection. Regardless of the choice, both systems rely on the same principle of projecting features onto the horizontal, vertical, and profile planes, and both produce accurate engineering drawings suitable for manufacturing.

Fill in the blank: In the third-angle method, the projection plane is placed between the __________ and the object.

To avoid confusion when reading or producing drawings, projection symbols are used. These symbols act as a quick reference that tells you whether a drawing follows first-angle or third-angle standards. Engineers and designers must check these symbols before interpreting any view to ensure that they follow the correct arrangement pattern.

Projection symbols for first-angle and third-angle projection
Figure 3.9: Standard projection method symbols

Fill in the blank: The symbol shown on a drawing that indicates the projection method is called the __________ symbol.

Pilot questions 3.2.1

1. What is the main difference between first-angle and third-angle projection?
2. In which projection method is the object placed between the observer and the plane?
3. Which projection method is commonly used in North America?
4. Why is it important to check the projection symbol on a technical drawing?
5. Where is the right-hand side view placed in first-angle projection?

3.2 Orthographic Projection Principles

3.2.2 Projection of points, lines, and planes

Orthographic projection becomes clearer when we begin with simple geometric elements. A complex object is nothing more than an arrangement of points, lines, and surfaces. By learning how these basic elements behave when projected onto the horizontal and vertical planes, you will be able to construct accurate views of more complicated shapes later in the Series.

The simplest element is the **point**, which is defined as a position with no length, width, or thickness. In orthographic projection, a point is represented by its projection on the **vertical plane (VP)** and the **horizontal plane (HP)**. These are called the **front view** and **top view** of the point respectively. The relative vertical or horizontal distance of these two projections from the XY line shows whether the point is above, below, in front of, or behind the projection planes.

Diagram showing a point located above the HP and in front of the VP, with its projections on both planes
Figure 3.10: Projection of a point onto the horizontal and vertical planes

The next geometric element is the **line**, defined as a straight path connecting two points. In projection, the appearance of a line depends entirely on its orientation relative to the projection planes. A line parallel to a plane appears in **true length**, while a line inclined to a plane appears **foreshortened**, meaning it looks shorter than its actual length. A line perpendicular to a plane appears as a point on that plane because its projectors meet the plane at a single location. Understanding these variations helps you predict how edges of an object will appear in different views.

Fill in the blank: A line that appears shorter than its actual length in projection is said to be __________.

Diagram showing a line parallel to HP, inclined to VP, and perpendicular to HP
Figure 3.11: Different appearances of a line depending on its orientation

The third element is the **plane**, defined as a flat two-dimensional surface extending in length and width. A plane can also be projected onto HP and VP. A plane that is perpendicular to one of the projection planes will appear as a line on that plane. A plane parallel to a projection plane will appear as a true shape, while a plane inclined to a projection plane will appear distorted. These principles help you understand why surfaces of objects sometimes appear as edges or irregular shapes in orthographic drawings.

Fill in the blank: A plane appears in its true shape only when it is _________ to the projection plane.

Diagram showing a plane parallel to VP and inclined to HP
Figure 3.12: Appearance of a plane when parallel and when inclined

A strong grasp of how points, lines, and planes are projected will make multi-view drawing easier. When you can predict how each component behaves, you can more confidently construct front, top, and side views of real objects.

Pilot questions 3.2.2

1. What is the front view of a point called?
2. When does a line appear in true length in projection?
3. What term describes the shortened appearance of an inclined line?
4. How does a plane appear when it is perpendicular to a projection plane?
5. When does a plane appear in its true shape?

3.2 Orthographic Projection Principles

3.2.3 Roles of reference planes in 2D projection

Orthographic projection depends on a clear relationship between the imaginary surfaces used for projection. These surfaces are known as **reference planes**, defined as the principal planes used to organise, align, and separate orthographic views. The two most important reference planes are the **horizontal plane (HP)** and the **vertical plane (VP)**. A third plane, known as the **profile plane (PP)**, is also used to obtain side views. Together, these reference planes provide a systematic framework that ensures views are placed correctly and interpreted accurately.

The key feature that establishes order within orthographic projection is the **XY reference line**, defined as the straight line that represents the intersection between the HP and VP. This line acts as a hinge around which the planes are imagined to rotate when unfolding the views onto a flat drawing sheet. When the HP is rotated downward to lie in the same plane as the VP, the XY line ensures that the front view and top view stay perfectly aligned.

Diagram showing HP, VP, XY line, and unfolding movement
Figure 3.13: How reference planes rotate to form a flat 2D projection layout

These reference planes determine how each view relates to the others. The VP receives the front view, showing height and width. The HP receives the top view, showing width and depth. When the HP is rotated downward, the top view appears directly below the front view. This consistent placement allows engineers to read the geometry of an object without confusion. Similarly, the PP receives the side view, and when unfolded, it aligns horizontally with the front view. The PP helps to show depth in relation to height and is especially important when objects have complex side features.

Fill in the blank: The intersection between the horizontal and vertical planes is represented by the __________ reference line.

Illustration showing front, top, and side views aligned using reference planes
Figure 3.14: Alignment of orthographic views using HP, VP, and PP

Reference planes also prevent misinterpretation. Since all views originate from the same system of projection, the alignment ensures that features such as edges, holes, and curves match across views. For example, if a hole appears in the front view, its projection must align vertically or horizontally with its corresponding appearance in the top and side views. Without reference planes, these alignments would become inconsistent, and the drawing could be misleading.

Fill in the blank: When reference planes are unfolded, the top view appears directly __________ the front view in orthographic projection.

Understanding the role of reference planes ensures that orthographic drawings remain clear, logical, and easy to interpret. As you progress to multi-view representation in later Parts, you will see how these planes guide the placement, spacing, and alignment of all views on the drawing sheet.

Pilot questions 3.2.3

1. What is the purpose of reference planes in orthographic projection?
2. Which reference plane receives the front view?
3. What is the function of the XY line?
4. Why is the profile plane important in orthographic drawing?
5. Where is the top view placed after the horizontal plane is unfolded?

3.3 Multi-View Representation of Objects

3.3.1 Standard orthographic views

In engineering drawing, one of the most important skills you must develop is the ability to represent a three-dimensional object using several two-dimensional views. These views are known as **orthographic views**, defined as accurate two-dimensional representations of an object obtained by projecting its features perpendicularly onto reference planes. Orthographic views allow you to show all the essential dimensions of an object without distortion, which is why they form the backbone of working drawings used in design and manufacturing.

The three principal orthographic views are the **front view**, the **top view**, and the **side view**. The **front view**, also called the elevation, is the most descriptive and typically shows the object's characteristic shape. The **top view**, also called the plan, is obtained by projecting the object onto the horizontal plane and shows the width and depth. The **side view** is projected onto the profile plane and shows the height and depth. These three views work together to reveal all three dimensions of the object in a structured format.

Diagram showing a simple block with its front, top, and right-side views
Figure 3.15: The three principal orthographic views of a simple object

When creating these views, each one must be aligned carefully. In standard orthographic drawing, the top view is placed directly above the front view so that the width lines line up exactly. The side view is placed to the right or left of the front view depending on whether first-angle or third-angle projection is used. This alignment ensures that the features correspond correctly between views, making it easier to identify hidden holes, slots, or other features.

Fill in the blank: The top view must always be placed directly __________ the front view in standard orthographic drawing.

Another important feature of orthographic views is that they use consistent projection lines to show relationships between features. For example, corners and edges that appear in the front view must align perfectly with the corresponding edges in the top or side views. This is why construction lines, drawn lightly and neatly, play a vital role during the drafting process. These lines guide you as you transfer measurements from one view to another to maintain accuracy.

Diagram showing alignment of views using projection (construction) lines
Figure 3.16: Alignment of orthographic views using construction lines

Orthographic views also rely on the correct use of line types to ensure clarity. Visible edges are drawn with continuous thick lines, hidden features are represented with dashed lines, and symmetrical features are shown with chain lines. Applying these line types consistently helps readers interpret the drawing accurately, especially when objects have internal cavities or symmetrical shapes that may not be evident from a single view.

Fill in the blank: Hidden features in an orthographic view are represented using __________ lines.

As you continue through this Series, you will learn how these standard views combine to form complete multi-view drawings. Mastering the basic arrangement and interpretation of orthographic views now will make the later tasks of reading and constructing detailed technical drawings easier and more intuitive.

Pilot questions 3.3.1

1. What is meant by an orthographic view?
2. Which orthographic view shows the most descriptive shape of an object?
3. What two dimensions does the top view display?
4. Why is alignment important when placing orthographic views?
5. What type of line is used to represent hidden features?

3.3 Multi-View Representation of Objects

3.3.2 Alignment and spacing of views

When creating multi-view drawings, it is essential to place each view in a position that clearly reflects the geometry of the object. This process is known as **alignment**, defined as the correct positioning of orthographic views so that corresponding features lie on the same vertical or horizontal projection lines. Good alignment ensures that anyone reading the drawing can easily relate features across the front, top, and side views without confusion. Alignment is not optional in engineering drawing. It is a fundamental requirement for clarity, accuracy, and professional presentation.

In standard orthographic drawing, the front view acts as the reference point for all other views. The top view must be placed directly above the front view, ensuring that the widths of the two views align. The side view must be placed directly to the right or left of the front view, depending on whether the drawing uses first-angle or third-angle projection. This horizontal or vertical relationship allows the drafter to transfer measurements easily and accurately between views, reducing the risk of errors.

Diagram showing the correct alignment of front, top, and side views using projection lines
Figure 3.17: Alignment of views using vertical and horizontal projection lines

Equally important is **spacing**, defined as the deliberate and proportional distance maintained between orthographic views. Proper spacing prevents crowding of details and ensures that projection lines do not overlap with object features. If the views are placed too close together, there is a risk that dimensioning, hidden features, or centre lines will become difficult to read. When views are spaced too widely, the drawing becomes unnecessarily large and may look disorganised. Maintaining moderate spacing helps produce a neat, balanced layout that is easy to interpret.

Fill in the blank: When the top view is placed directly above the front view, their __________ must be aligned.

Spacing also affects the visual flow of the drawing. A well-spaced drawing allows the drafter or reader to scan from one view to another smoothly. The gaps between views should remain consistent across the drawing sheet. In practice, projection (or construction) lines are drawn lightly to guide the placement and spacing of each view. Once the views are in position, these projection lines are cleaned or faded so that they do not appear in the final presentation.

Illustration showing good spacing versus poor (crowded and widely spaced) placement of views
Figure 3.18: Comparison of proper and improper spacing in multi-view drawings

Another benefit of proper alignment and spacing is the reduction of interpretation errors. When views are aligned correctly, edges, corners, and hidden features match perfectly across all views. This prevents mistakes in visualising the object and supports accurate manufacturing. Misaligned views, on the other hand, may cause features to appear shifted or distorted, leading to design misunderstandings or production mistakes. This is why experienced drafters take care to construct layout lines before committing to final linework.

Fill in the blank: The distance between orthographic views that ensures clarity and neatness is known as __________.

Understanding alignment and spacing is essential as you move deeper into multi-view representation. These skills not only improve your drawing quality but also prepare you for advanced topics such as auxiliary views, sectional drawings, and dimensioning standards.

Pilot questions 3.3.2

1. What is meant by alignment in multi-view drawing?
2. Where should the top view be placed in relation to the front view?
3. Why is proper spacing important in orthographic drawings?
4. What might happen if views are placed too close together?

5. How do projection (construction) lines assist in view alignment?

3.3 Multi-View Representation of Objects

3.3.3 Representation of hidden and centre features

When creating orthographic views, not all features of an object are visible from a single direction. Some surfaces may lie behind others, and some features, such as holes or symmetrical elements, may not appear clearly in one view. To communicate these important but unseen details, engineering drawing uses two special types of lines. These are **hidden lines**, defined as thin dashed lines used to represent features that are not visible from the viewing direction, and **centre lines**, defined as thin chain lines used to indicate symmetrical axes or the centres of circular features.

Hidden lines play a crucial role in multi-view representation because they reveal internal features that cannot be seen in a particular view. For example, if an object contains a drilled hole that passes through its body, this hole may not appear in the front view except as a circular outline. In the top and side views, however, the hole will be represented using dashed hidden lines to show its position inside the object. The use of hidden lines allows engineers and technicians to understand internal geometry without needing a sectional drawing.

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Illustration showing an object with a through-hole and the hidden lines appearing in different views
Figure 3.19: Representation of hidden features in orthographic views

Centre lines are equally important because they indicate symmetry and the centres of circles, arcs, slots, and cylindrical features. A centre line consists of a long dash and a short dash repeated in a regular pattern. When you draw the front and top views of a cylindrical object, the centre lines help identify its axis. This is important for interpreting the geometry of rotating parts such as shafts, pulleys, and bushings. Centre lines also help when placing dimensions, ensuring that measurements are taken from the correct reference points.

Fill in the blank: A line made of alternating long and short dashes is used to indicate a feature's __________.

Diagram showing centre lines applied to circular and symmetrical features
Figure 3.20: Use of centre lines to indicate symmetry and circular centres

Poor use of hidden or centre lines can lead to misinterpretation. If hidden lines are omitted where they are needed, important internal details may be missed, which can result in manufacturing errors. If centre lines are drawn incorrectly or inconsistently, it becomes difficult to interpret circular or symmetrical features. Because of this, learners are encouraged to draw lightly at first, then darken the correct line types once they are confident in their placement.

Fill in the blank: Features that are not visible from a particular direction are shown using __________ lines.

Mastering hidden and centre lines enhances your ability to read and create accurate technical drawings. As you progress to converting 3D objects into multi-view drawings, you will rely heavily on these line types to represent both visible and invisible geometry clearly.

Pilot questions 3.3.3

1. What type of line is used to show features that cannot be seen in a given view?
2. What does a centre line represent in an orthographic drawing?
3. How are centre lines typically drawn?
4. Why are hidden lines important in multi-view drawings?
5. What might happen if hidden lines are omitted in a technical drawing?

3.4 Interpreting and Constructing Multi-View Drawings

3.4.1 Converting 3D solids to multi-view drawings

Being able to convert a three-dimensional object into a set of two-dimensional views is one of the most important skills in engineering drawing. The process begins by examining the **3D solid**, defined as a physical or imagined object with height, width, and depth. To create its orthographic views, you must imagine the object placed within the projection planes and then determine what each plane would receive when projectors strike it at right angles.

A helpful way to begin is to identify the three principal dimensions of the object: **height**, **width**, and **depth**. These dimensions appear across the front, top, and side views. The front view shows height and width. The top view shows width and depth. The side view shows height and depth. Thinking about the object in this structured way prevents confusion and helps you predict how each feature transfers to each projection plane.

Diagram showing a simple 3D block with labelled height, width, and depth
Figure 3.21: Identifying the principal dimensions of a 3D object

Search string: *3D block height width depth diagram OER*

Once the principal dimensions are understood, the next step is **view selection**, defined as the process of choosing which view best describes the object's shape. The front view is usually selected first because it normally shows the most characteristic shape of the object. After selecting the front view, the top and side views naturally follow based on the arrangement of projection planes. As you draw, light construction lines help you align features across the views to maintain accuracy.

Fill in the blank: The view that typically shows the most descriptive shape of an object is the __________ view.

The process of converting a 3D object into its views requires careful mental rotation. You must imagine looking at the object from the front, above, and the side. Each direction reveals different surfaces and features. These features appear as edges, curves, or hidden lines depending on the viewing angle. For instance, a circular hole may appear as a true circle in the front view but appear as hidden lines in the top or side views. Recognising these transformations takes practice but becomes easier as you work with more objects.

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Illustration showing a 3D solid and its corresponding three orthographic views
Figure 3.22: Converting a simple 3D object into its front, top, and side views

During the conversion process, each geometric feature must be translated accurately. Visible edges appear as continuous thick lines. Hidden features such as internal holes or recesses appear as dashed lines. Centre lines appear where circular or symmetrical features exist. By following these projection and linework rules, you ensure that your multi-view drawing communicates the true shape and structure of the object.

Fill in the blank: Features inside the object that cannot be seen from a particular direction are represented using __________ lines.

To complete the conversion, all three views are laid out in a neat, aligned, and well-spaced arrangement. The views together should provide a complete description of the object so that a manufacturer could recreate it exactly. As your confidence grows, you will be able to convert more complex solids such as prisms, cylinders, pyramids, and composite forms.

Pilot questions 3.4.1

1. What are the three principal dimensions of a 3D object?
2. What is the first step in converting a 3D object into multi-view drawings?
3. Why is the front view usually selected first?
4. What type of lines are used to represent features that cannot be seen from a particular view?
5. Why are construction lines important when creating multi-view drawings?

3.4 Interpreting and Constructing Multi-View Drawings

3.4.2 Reading and visualising multi-view representations

One of the most important skills in engineering drawing is the ability to **read** and **visualise** objects from their orthographic views. **Reading a multi-view drawing** means interpreting the information contained in the front, top, and side views to understand the real three-dimensional shape of the object. **Visualising**, in this context, refers to mentally constructing the 3D form based on the arrangement of features across these views. This skill is essential because engineering drawings rarely present objects in 3D form, yet technicians, engineers, and builders must be able to imagine the object accurately.

When reading multi-view drawings, you must first examine the front view, since it contains the most descriptive shape. From this, you can determine the basic outline and key edges. Next, you compare the front view with the top view. The two views must align through projection lines, allowing you to confirm width and depth relationships. You then compare the front view with the side view to understand height and depth. By matching corresponding edges and corners across all three views, you can reconstruct the object's true geometry.

Illustration showing how edges correspond across front, top, and side views
Figure 3.23: Matching features across orthographic views to interpret a 3D object

Hidden lines are particularly important when visualising an object. They show features that are concealed in one view but visible or partially visible in another. For example, a rectangular cut-out may appear in the top view but not in the front view, where its presence is revealed only by hidden lines. **Hidden features** are therefore essential clues that help you reconstruct the complete shape of the object. Similarly, **centre lines**, which indicate axes of symmetry or circular features, help identify holes, cylindrical shapes, or symmetrical recesses.

Fill in the blank: Hidden lines help you identify features that are __________ in a particular view.

Reading multi-view drawings also requires careful attention to the shape of edges. A line in one view may represent a flat surface, a curved edge, or even the boundary of a hole in another view. For example, a circle in the front view often appears as a rectangle with hidden lines in the top or side views. A sloping surface may appear as an edge in one view and a full surface in another. Recognising these variations improves your confidence when interpreting more complex components.

Diagram showing how a circular hole appears differently in the three orthographic views
Figure 3.24: Visualising circular features across front, top, and side views

To improve your visualisation skills, you can practise by sketching simple solids and then attempting to predict their orthographic views before checking the actual results. Over time, this mental conversion becomes faster and more intuitive. It also prepares you for advanced reading tasks such as interpreting auxiliary views, sectional views, and dimensioned drawings, which rely on the same fundamental principles.

Fill in the blank: A circle seen in the front view may appear as a pair of _________ lines in the top or side views.

Pilot questions 3.4.2

1. What does it mean to read a multi-view drawing?
2. Why is the front view usually examined first when interpreting multi-view drawings?
3. How do hidden lines assist in visualising an object?
4. What might a circular hole look like in the top or side view?
5. Why is it important to match edges across all orthographic views?

3.4 Interpreting and Constructing Multi-View Drawings

3.4.3 Common errors and good practice in multi-view drawing

As you begin constructing multi-view drawings, it is natural to make mistakes, especially when learning to visualise objects and maintain alignment across views. Recognising these mistakes early improves your accuracy and confidence. One of the most frequent errors encountered is **misalignment**, defined as the incorrect horizontal or vertical placement of orthographic views so that corresponding features do not line up. Misaligned drawings make it difficult to interpret edges and surfaces correctly and may lead to incorrect manufacture of parts.

Another common error is the **incorrect use of line types**, defined as using the wrong graphical representation for visible, hidden, or symmetrical features. For instance, drawing a hidden edge with a continuous line or using a chain line instead of a dashed line can confuse the reader. Improper use of line weights also reduces clarity. These mistakes occur when projection lines are ignored or when the drafter fails to examine how features appear in each view.

Illustration comparing a correctly drawn set of views and a misaligned or incorrectly lined version
Figure 3.25: Examples of common errors in multi-view drawing

A third source of error is **inconsistent spacing**, defined as placing views too close together or too far apart. Crowded views can cause projection lines, hidden lines, or dimensions to overlap, making the drawing difficult to read. On the other hand, excessive spacing wastes drawing space and creates a disorganised layout. Balanced spacing ensures that each view is readable and aesthetically arranged.

Fill in the blank: When views are placed too close together, important details may become _________.

Another frequent mistake is **failure to include hidden lines** where necessary. Leaving out hidden details creates incomplete drawings and may give the false impression that the object is solid where it is not. Similarly, some learners draw hidden lines in the wrong places, often because they have not fully visualised the 3D geometry. This stresses the importance of practising mental rotation and checking each view before finalising the linework.

Feature	Correct Practice	Incorrect Practice
Intersections	Dash should touch the visible line at a "T" junction.	Leaving a gap between the dash and the visible edge.
Corners	Dashes should meet at a solid corner.	Leaving a gap at the corner or crossing lines haphazardly.
Clarity	Dashes are shorter than those used for center lines.	Making dashes too long (looks like a phantom line).
Consistency	Uniform length and spacing throughout the drawing.	Varying dash lengths, which creates visual "noise."

Illustration showing correct and incorrect representation of hidden features
Figure 3.26: Proper versus improper use of hidden lines

A final common error is **omitting centre lines**, which are essential when dealing with holes, cylindrical parts, or symmetrical objects. A missing centre line can make features difficult to interpret, especially in manufacturing contexts where precision and alignment are critical. Good practice requires that centre lines be drawn lightly at first and then darkened once the drafter is satisfied with the layout.

Fill in the blank: Missing centre lines can make it difficult to identify the _________ of circular features.

To achieve good practice in multi-view drawing, you should always begin with light construction lines to establish alignment and spacing. Examine each view carefully to ensure that corners, edges, and hidden features match across all views. Use standard line types consistently and revise your drawing before applying final line weights. With time, these habits will help you produce professional and accurate engineering drawings.

Pilot questions 3.4.3

1. What is meant by misalignment in multi-view drawing?
2. Why is incorrect use of line types a common source of confusion?
3. How does inconsistent spacing affect drawing clarity?
4. Why must hidden lines be included where necessary?
5. What role do centre lines play when representing circular features?

Series summary.

This Series introduced you to the essential principles that make projection possible in engineering drawing. We began by examining the concept of projection and the behaviour of lines of sight, which helped you understand how three-dimensional objects are represented on two-dimensional planes. Then, we explored the major projection systems and the role of reference planes in organising views and maintaining consistent alignments.

Following that, we considered how objects are represented using standard orthographic views and how careful alignment and spacing contribute to neat and accurate drawings. You also learnt how hidden and centre features are expressed using correct line types. In the final Part, we focused on the practical skills involved in interpreting and constructing multi-view drawings, including the conversion of 3D solids into views, visualising objects from multiple directions, and avoiding common errors that occur during drafting.

Overall, this Series has equipped you with a strong foundation in projection theory and multi-view representation, preparing you for more advanced drawing tasks such as isometric drawing, auxiliary views, sectional drawing, and detailed dimensioning in the subsequent Series.

Glossary of terms.

Centre line: A thin chain line used to indicate symmetry, circular centres, or axes of rotation in a drawing.

Depth: One of the three principal dimensions of an object, representing the distance from front to back.

Front view: The orthographic view that shows the most descriptive shape of an object, projected onto the vertical plane.

Hidden line: A thin dashed line used to represent features that cannot be seen from a particular viewing direction.

Horizontal plane (HP): The reference plane onto which the top view of an object is projected.

Line of sight: An imaginary straight line drawn from the observer toward the object when viewing or projecting it.

Orthographic view: A two-dimensional representation of an object obtained by projecting its features perpendicularly onto a reference plane.

Plane: A flat two-dimensional surface that can be projected onto HP, VP, or PP depending on orientation.

Profile plane (PP): The reference plane used to obtain side views of an object.

Projection: The method of transferring the shape of a 3D object onto a flat 2D plane using imaginary projectors.

Projector: A straight imaginary line drawn from an object to a projection plane to create its image.

Reference plane: Any of the main projection planes, such as HP, VP, or PP, used to organise and align orthographic views.

Side view: An orthographic view that shows the height and depth of an object, projected onto the profile plane.

Top view: An orthographic view that shows the width and depth of an object, projected onto the horizontal plane.

Vertical plane (VP): The reference plane onto which the front view of an object is projected.

Visualisation: The mental process of imagining a 3D object from its 2D views.

Concept check questions 3

Linked to SLO 3.1 and SLO 3.2

1. **Objective:** Which of the following correctly describes a projector in projection theory?
   a. A device used to scale a drawing
   b. An imaginary straight line drawn from an object to a projection plane

c. A physical instrument for producing angled lines
d. A line used only in pictorial drawing

2. **Short answer:** Explain the difference between central projection and parallel projection.

3. **Objective:** In first-angle projection, where is the top view placed relative to the front view?
a. Directly above
b. Directly below
c. To the right
d. To the left

Linked to SLO 3.3

1. **Long answer:** Describe the procedure for constructing the three standard orthographic views of a simple 3D object. Your answer should refer to view selection, use of projection planes, and alignment.

2. **Objective:** Which view displays an object's height and width?
a. Top view
b. Side view
c. Front view
d. Auxiliary view

Linked to SLO 3.4

1. **Short answer:** Why are hidden lines essential when reading multi-view drawings?

2. **Objective:** A circular hole appears as two dashed lines in which type of orthographic view?
a. Front view
b. Top or side view
c. Isometric view
d. Pictorial view

3. **Long answer:** Identify and discuss any four common errors that may occur when constructing multi-view drawings. Explain how each error affects the readability or accuracy of the drawing.

These answers correspond to all Pilot Question sets in:

- **Part 3.1.1**
- **Part 3.1.2**
- **Part 3.1.3**

- **Part 3.2.1**
- **Part 3.2.2**
- **Part 3.2.3**
- **Part 3.3.1**
- **Part 3.3.2**
- **Part 3.3.3**
- **Part 3.4.1**
- **Part 3.4.2**
- **Part 3.4.3**

As required, all answers are placed **after the last learning unit of the Series**, written in clear British English, concise, and aligned with the content.

Answers to pilot questions 3.

Pilot questions 3.1.1

1. Projectors
2. Lines of sight
3. Projectors are assumed to be parallel
4. Lines of sight are the straight lines from the observer
5. Orthographic

Pilot questions 3.1.2

1. A structured method used to project objects onto planes
2. Orthographic projection
3. Oblique projection
4. Perspective projection
5. Because it provides accurate, undistorted measurements

Pilot questions 3.1.3

1. A flat imaginary surface used for projection
2. Horizontal plane
3. Front view

4. Profile plane
5. Directly below

Pilot questions 3.2.1

1. The placement of views differs
2. First-angle projection
3. Third-angle projection
4. To identify the projection method quickly
5. On the left side of the front view

Pilot questions 3.2.2

1. The front view of a point is its projection on the VP
2. When the line is parallel to the projection plane
3. Foreshortening
4. As a line
5. When the plane is parallel to the projection plane

Pilot questions 3.2.3

1. To organise and align orthographic views
2. Vertical plane
3. It acts as the intersection between HP and VP
4. It provides the side view
5. Directly below the front view

Pilot questions 3.3.1

1. A 2D representation obtained through perpendicular projection
2. The front view
3. Width and depth
4. To ensure matching features
5. Dashed lines

Pilot questions 3.3.2

1. Correct positioning of views

2. Directly above
3. It prevents crowding and maintains clarity
4. Important features may overlap
5. They guide placement and alignment

Pilot questions 3.3.3

1. Hidden lines
2. The axes or centres of features
3. Long and short dashes
4. They reveal internal details
5. Important unseen features may be misinterpreted

Pilot questions 3.4.1

1. Height, width, and depth
2. Identifying principal dimensions
3. Because it shows the most descriptive shape
4. Hidden lines
5. They ensure accurate alignment of features

Pilot questions 3.4.2

1. Interpreting views to understand a 3D object
2. It is the most descriptive
3. They show unseen features
4. As two dashed lines
5. To reconstruct geometry accurately

Pilot questions 3.4.3

1. Incorrect positioning of views
2. Because they misrepresent visible and hidden features
3. It causes crowding or disorder
4. They provide essential internal information
5. They identify the centres of circular features

List of references 3.

1. **Giesecke, F. E., Mitchell, A., Spencer, H. C., Dygdon, J. T., Novak, J. E., and Lockhart, S. (Technical Drawing with Engineering Graphics).** Pearson Education.
   A comprehensive text covering projection theory, orthographic views, and the principles of engineering graphics.
2. **French, T. E., Veilleux, J. C., and Foster, C. J. (Engineering Drawing and Graphic Technology).** McGraw-Hill.
   A widely used reference explaining projection systems, multi-view representation, and technical drawing standards.
3. **Bertoline, G. R., Wiebe, E. N., Hartman, N. W., and Ross, W. A. (Fundamentals of Graphics Communication).** McGraw-Hill.
   Provides detailed illustrations and explanations on orthographic projection, visualisation, and the interpretation of engineering drawings.
4. **ISO 128: Technical Drawings, General Principles of Presentation.** International Organisation for Standardisation.
   The international standard that defines line types, view conventions, and rules used in engineering projection.
5. **ISO 5456: Projection Methods.** International Organisation for Standardisation.
   Provides detailed guidance on first-angle and third-angle projection, along with rules governing projection practices.
6. **Engineering Drawing Laboratory Manual, Department of Engineering, Kwara State University.**
   An institutional reference that outlines practical drawing exercises, projection procedures, and standard departmental formats.
7. **NADIA Technical Drawing Handbook (Local Edition).**
   A supplementary text commonly used in Nigerian institutions to reinforce concepts in projection, multi-view drawing, and technical communication.

Proposed Outline for Series 5: Dimensioning, Sections, and Conventional Representations

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Part 5.1 Fundamentals of Dimensioning

Sub-Parts

- **5.1.1 Meaning and purpose of dimensioning**
- **5.1.2 Components of a dimension (dimension lines, extension lines, arrows, figures)**
- **5.1.3 Rules and standards of dimensioning (placement, spacing, orientation)**

Part 5.2 Sectional Views and Their Applications

Sub-Parts

- **5.2.1 Meaning and purpose of sectional views**
- **5.2.2 Types of sectional views (full, half, offset, broken-out)**
- **5.2.3 Sectional conventions and hatching rules**
- **5.2.4 When and why sections are preferred over hidden lines**

Part 5.3 Conventional Representations in Engineering Drawing

Sub-Parts

- **5.3.1 Standard symbols used in mechanical and civil drafting**
- **5.3.2 Conventional representations of materials (steel, wood, concrete, etc.)**
- **5.3.3 Conventions for threads, fasteners, gears, springs, and machine elements**

Part 5.4 Applying Dimensioning and Sectioning to Composite Objects

Sub-Parts

- **5.4.1 Dimensioning best practice on sectional views**
- **5.4.2 Reading and interpreting dimensioned sectional drawings**
- **5.4.3 Producing a combined dimensioned and sectioned multi-view drawing**

Introduction.

In the previous Series, you learnt how to construct and interpret isometric, oblique, and auxiliary views, all of which help you visualise and communicate the form of objects in three dimensions. Building on that foundation, this Series focuses on the conventions used to describe sizes, shapes, internal features, and standard engineering symbols. These conventions are essential because even the clearest drawing becomes incomplete without accurate dimensions, sectional views, and standardised representations.

The aim of this Series is to equip you with the knowledge and skills required to apply correct dimensioning techniques, construct sectional views, and use conventional engineering symbols confidently and accurately.

We shall commence this Series by exploring the fundamentals of dimensioning, including the purpose of dimensioning and the rules that guide the placement of dimension lines, extension lines, arrows, and figures. Next, we will examine sectional views, studying different section types and the hatching rules that help reveal internal features clearly. Following that, we will consider conventional representations used in engineering drawings, covering standard symbols and material conventions. Finally, the Series will be rounded off with the application of dimensioning and sectioning techniques to composite objects, allowing you to interpret and produce fully detailed engineering drawings with confidence.

Series learning outcomes.

Upon completing this Series, you should be able to:

SLO 5.1 define key dimensioning components and explain their purpose in engineering drawings,

SLO 5.2 apply standard rules and conventions to place dimensions accurately on orthographic and sectional views,

SLO 5.3 distinguish between different types of sectional views and explain when each type is appropriate,

SLO 5.4 construct sectional views that reveal internal features clearly and correctly,

SLO 5.5 identify and use standard engineering symbols and conventional representations for materials and mechanical features,

SLO 5.6 interpret dimensioned and sectioned drawings to determine object geometry and internal details, and

SLO 5.7 produce a complete multi-view drawing that integrates accurate dimensions, sectional features, and conventional symbols.

5.1 Fundamentals of Dimensioning

5.1.1 Meaning and purpose of dimensioning

Dimensioning is one of the most essential practices in engineering drawing because it transforms a visual representation into a complete technical communication tool. **Dimensioning** is defined as the process of indicating the sizes, locations, and critical details of features on a drawing so that a component can be manufactured, inspected, and assembled correctly. Without proper dimensioning, even a clearly drawn object cannot be produced with accuracy, since the drawing does not provide the necessary numerical information.

Dimensioning ensures that every important measurement is communicated in a precise and standardised way. These measurements include lengths, diameters, angles, hole positions, thicknesses, and spacing. A well-dimensioned drawing removes the need for guesswork and allows technicians, machinists, and fabricators to interpret and reproduce the object exactly as intended. This is why dimensioning is considered a universal technical language within engineering and design disciplines.

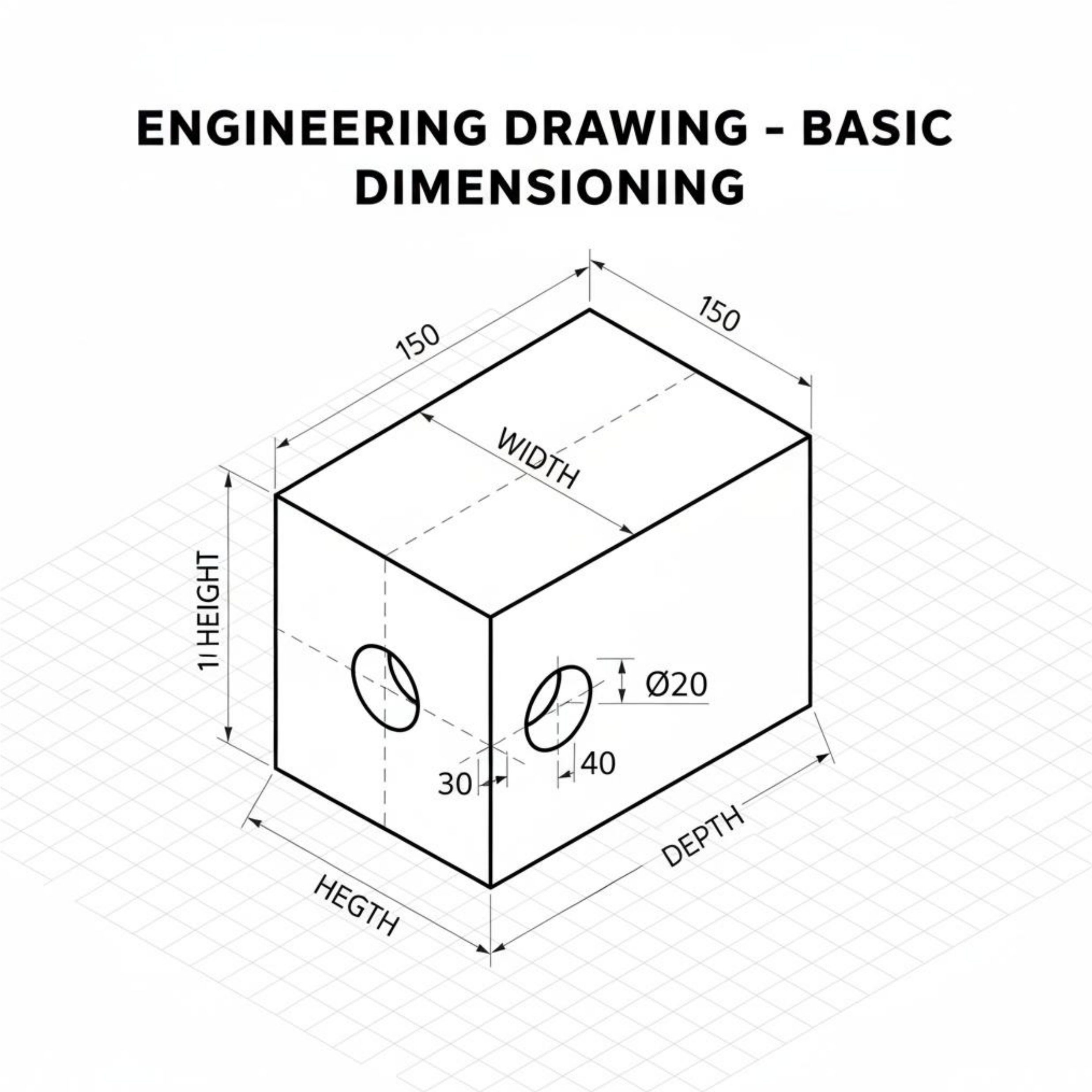


Illustration showing an object with labelled dimensions on key features
Figure 5.1: Example of a simple object with essential dimensions indicated

One of the key purposes of dimensioning is **clarity**, defined as the ability of a drawing to communicate all necessary measurements without confusion. Clear dimensioning eliminates ambiguity about how long an edge is, how far apart two features are, or where a hole is positioned. Another purpose is **accuracy**, defined as the exactness required to produce a component that fits and functions correctly. Accurate dimensions ensure that parts will assemble properly, especially when they must fit into other components or form part of a larger system.

Fill in the blank: Dimensioning provides the __________ information needed to manufacture a component correctly.

Dimensioning also serves the purpose of **standardisation**, ensuring that all drawings follow the same rules regardless of who creates or reads them. International standards, such as ISO conventions, specify how to place dimension lines, extension lines, arrows, and numeric figures. These rules help engineers communicate effectively across different industries, regions, or companies. When everyone follows the same standards, drawings become easier to read and errors are reduced.

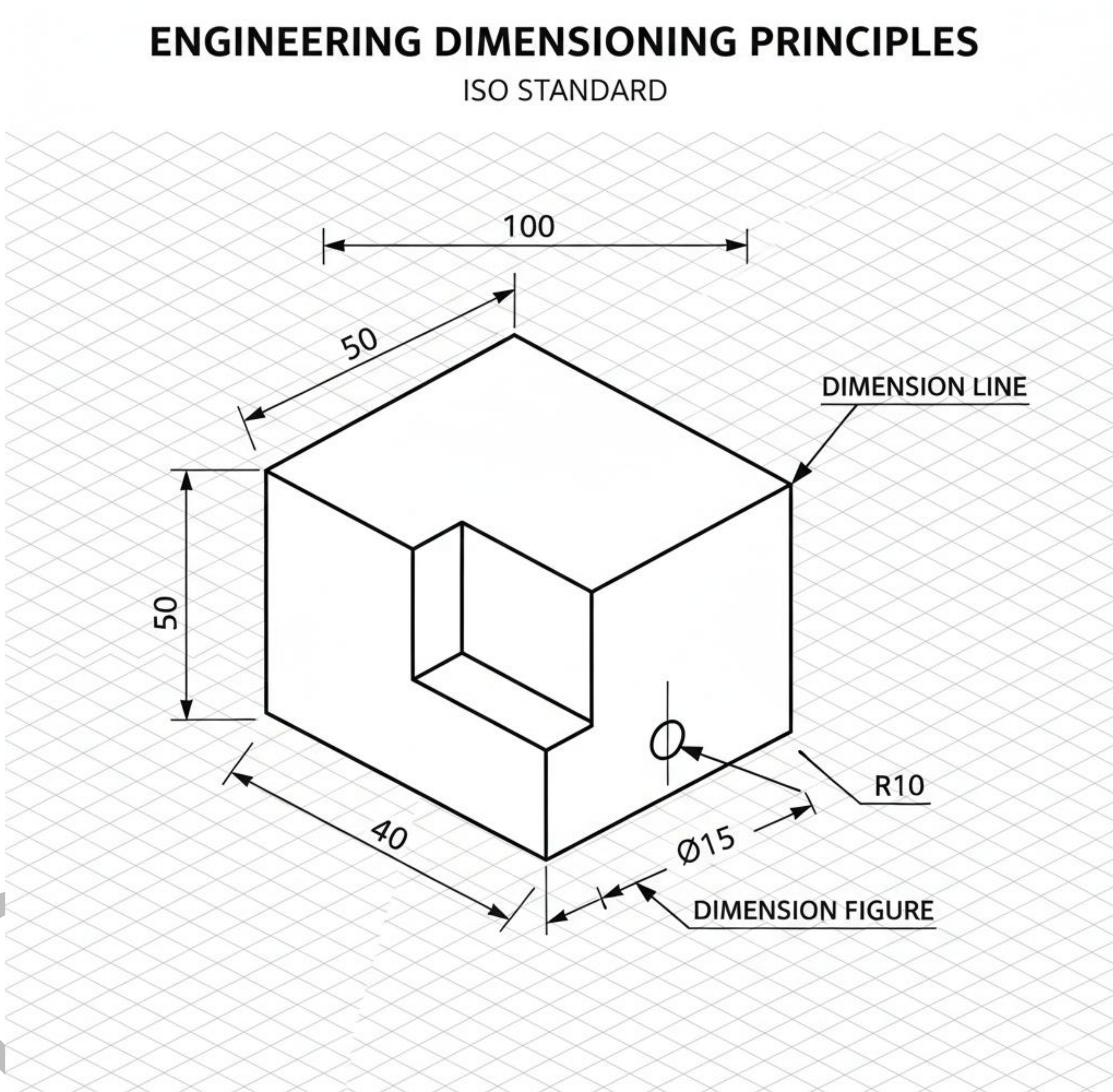


Illustration showing dimension lines, extension lines, and figures labelled correctly
Figure 5.2: Standard dimensioning elements used in engineering drawings

Finally, dimensioning enables **functional communication**, meaning it helps readers understand not just the object's size but how it will operate or fit within a system. The arrangement of dimensions often hints at manufacturing priorities, design intent, or important functional relationships. A well-dimensioned drawing tells the full story of the part, from its basic size to its most critical features.

Fill in the blank: Standardised dimensioning ensures that drawings can be read consistently across different __________ and industries.

Pilot questions 5.1.1

1. What is dimensioning in engineering drawing?
2. Why can a drawing not be manufactured correctly without dimensions?
3. What two key purposes does dimensioning serve when communicating measurements?
4. What is the benefit of using standardised dimensioning rules?
5. Which elements of a drawing commonly require numerical dimensions?

5.1 Fundamentals of Dimensioning

5.1.2 Components of a dimension (dimension lines, extension lines, arrows, figures)

To apply dimensioning correctly, it is important to understand the essential elements that make up a complete dimension. Each component plays a specific role in communicating measurements clearly and accurately. A **dimension** is made up of four main components: the **dimension line**, the **extension line**, the **arrowhead**, and the **dimension figure**. These elements work together to show the size and location of features on an engineering drawing.

The **dimension line** is a thin line drawn parallel to the feature being measured. It is defined as the line that carries the numerical value of the dimension and is usually placed slightly away from the object to avoid clutter. The dimension line indicates the direction in which the measurement applies. Dimension lines should never touch the edges of the object itself; instead, they remain separate to maintain clarity.

The **extension line** is a thin line used to indicate the exact points on the object where the dimension begins and ends. An extension line starts slightly away from the edge of the feature and extends beyond the dimension line. This prevents the drawing from appearing cramped and makes it easier to interpret the measurement. Extension lines should always be perpendicular to the dimension line for maximum clarity.

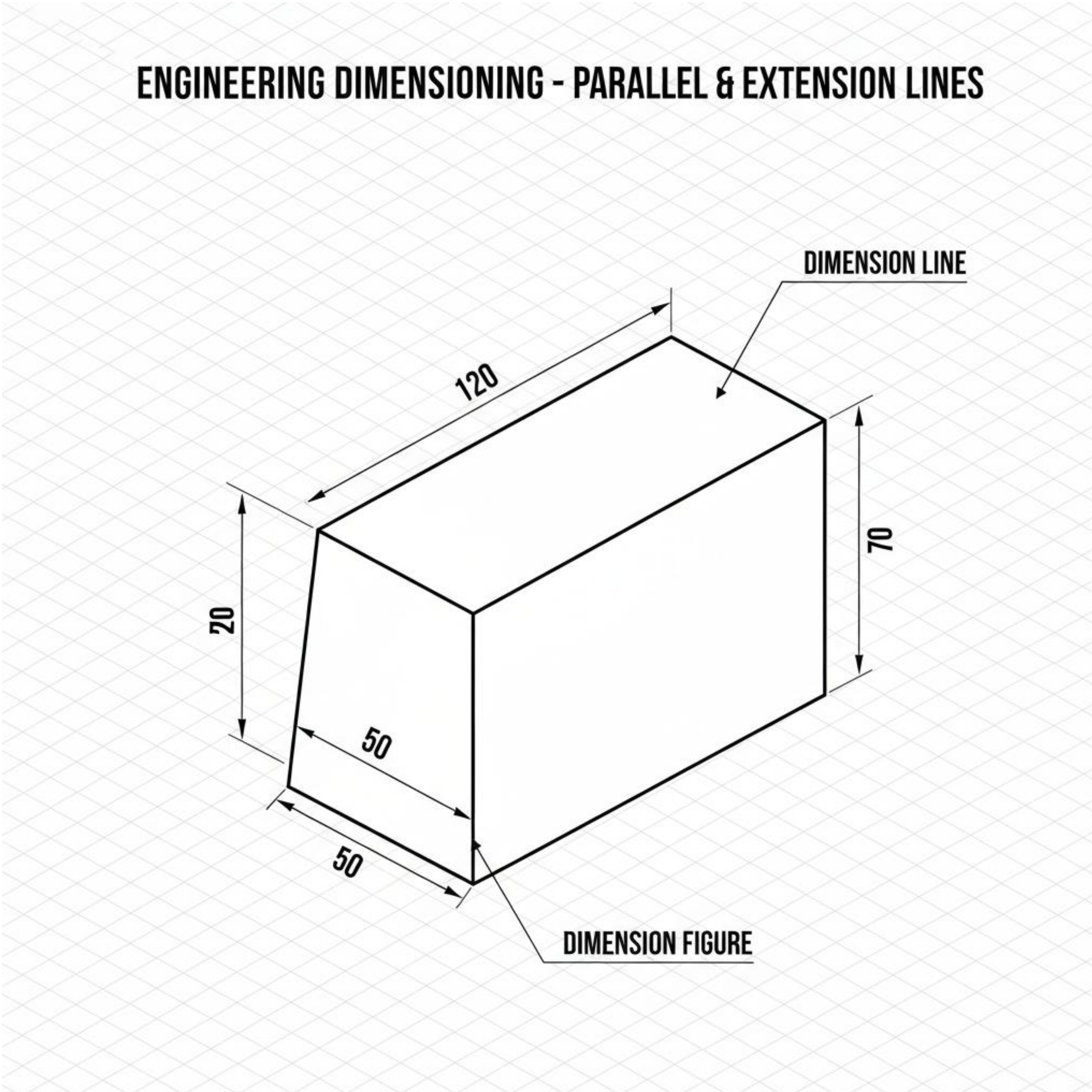


Diagram showing dimension lines and extension lines applied to a rectangular block
Figure 5.3: Placement of dimension and extension lines for accurate measurement

The **arrowhead**, also called the arrow, is a small triangular marking placed at the ends of a dimension line. Arrowheads indicate exactly where the measurement begins and ends. They are drawn neatly and consistently, usually filled in, and pointed toward the extension lines. Correctly shaped arrowheads improve readability and make the drawing look professional. Some standards allow ticks instead of arrows, but arrowheads remain the most widely accepted option.

Fill in the blank: Arrowheads are placed at the ends of the __________ line to indicate the limits of a measurement.

The final component is the **dimension figure**, defined as the numerical value showing the actual size of the feature. The figure is typically placed above the dimension line or in a small break within the line, depending on institutional practice. The dimension figure should be centred, clear, and written so that it can be read from the bottom or right-hand side of the drawing sheet. Consistent lettering style and sizing are essential for maintaining overall clarity.

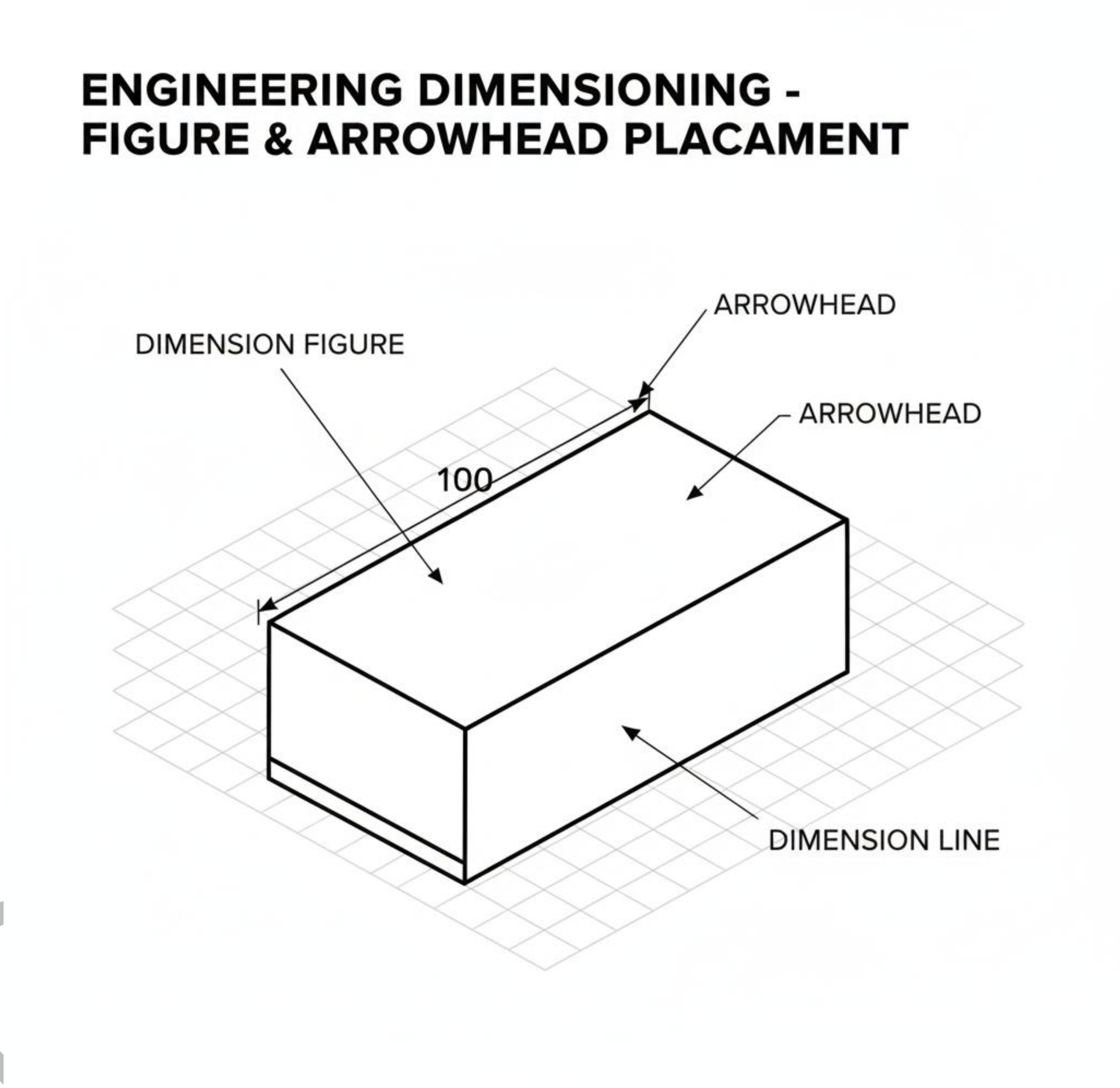


Diagram illustrating arrowheads and correctly positioned dimension figures
Figure 5.4: Example showing arrowheads and dimension figures on a dimension line

When these components are combined correctly, they form clear and reliable dimensions that can be interpreted without confusion. Poorly arranged dimension components lead to misinterpretation and can result in manufacturing errors. Mastering these components is an important step toward producing professional engineering drawings.

Fill in the blank: The numerical value placed on a dimension line is known as the __________ figure.

Pilot questions 5.1.2

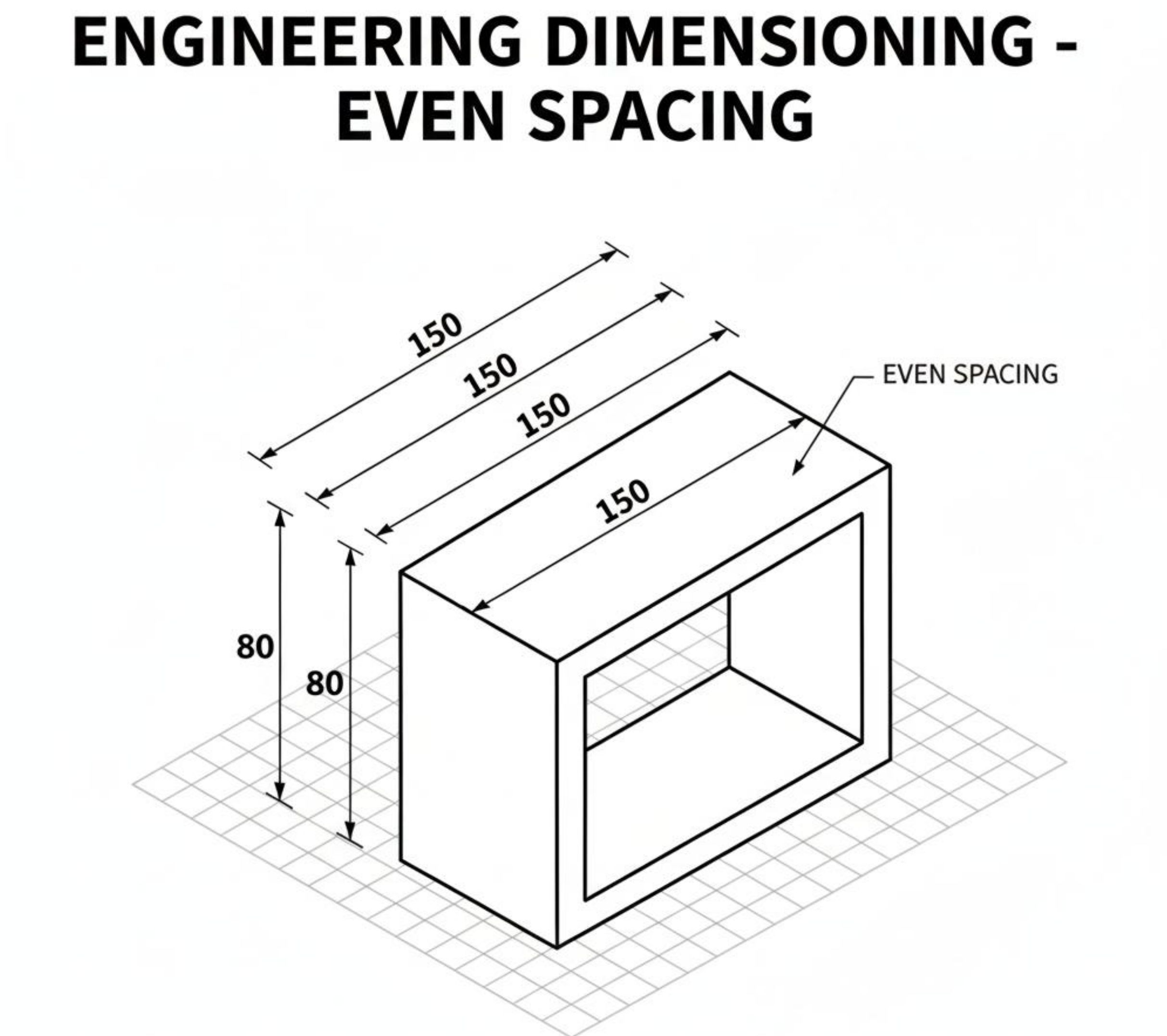
1. What is the function of a dimension line?
2. Why should extension lines start slightly away from the object?
3. What do arrowheads indicate on a dimension line?
4. Where should dimension figures be placed for best readability?
5. What might happen if dimension components are arranged poorly?

5.1 Fundamentals of Dimensioning

5.1.3 Rules and standards of dimensioning (placement, spacing, orientation)

Effective dimensioning relies on a set of standard rules that ensure clarity and uniformity across engineering drawings. **Dimensioning rules** are the accepted guidelines that determine how, where, and in what order dimensions should be placed. These rules help prevent overcrowding and ensure that measurements are easy to read. One basic rule is that dimension lines must be placed outside the outlines of the object whenever possible so that the drawing remains neat and uncluttered.

Another important guideline relates to spacing. **Spacing** refers to the distance between consecutive dimension lines. Good practice requires even spacing so that the eye can follow each measurement without confusion. Dimensions should also be arranged in a logical sequence, usually from the smallest details to the overall size of the object. This helps the viewer interpret the drawing quickly.



Simple dimensioning layout showing correct placement and spacing
Figure 5.5: Standard placement and spacing of dimension lines

Orientation is also important. **Orientation** means ensuring that dimensions are readable from the bottom or right-hand side of the drawing sheet. This standard reduces rotation of the sheet and improves readability. Angled features must be dimensioned using clear extension lines, and dimensions should never be duplicated on different views unless necessary for clarity.

Fill in the blank: Dimensions should be placed in a way that makes them easy to read from the __________ or right-hand side of the sheet.

Following these rules helps ensure that drawings remain tidy, consistent, and acceptable for technical communication, manufacturing, and inspection.

Pilot questions 5.1.3

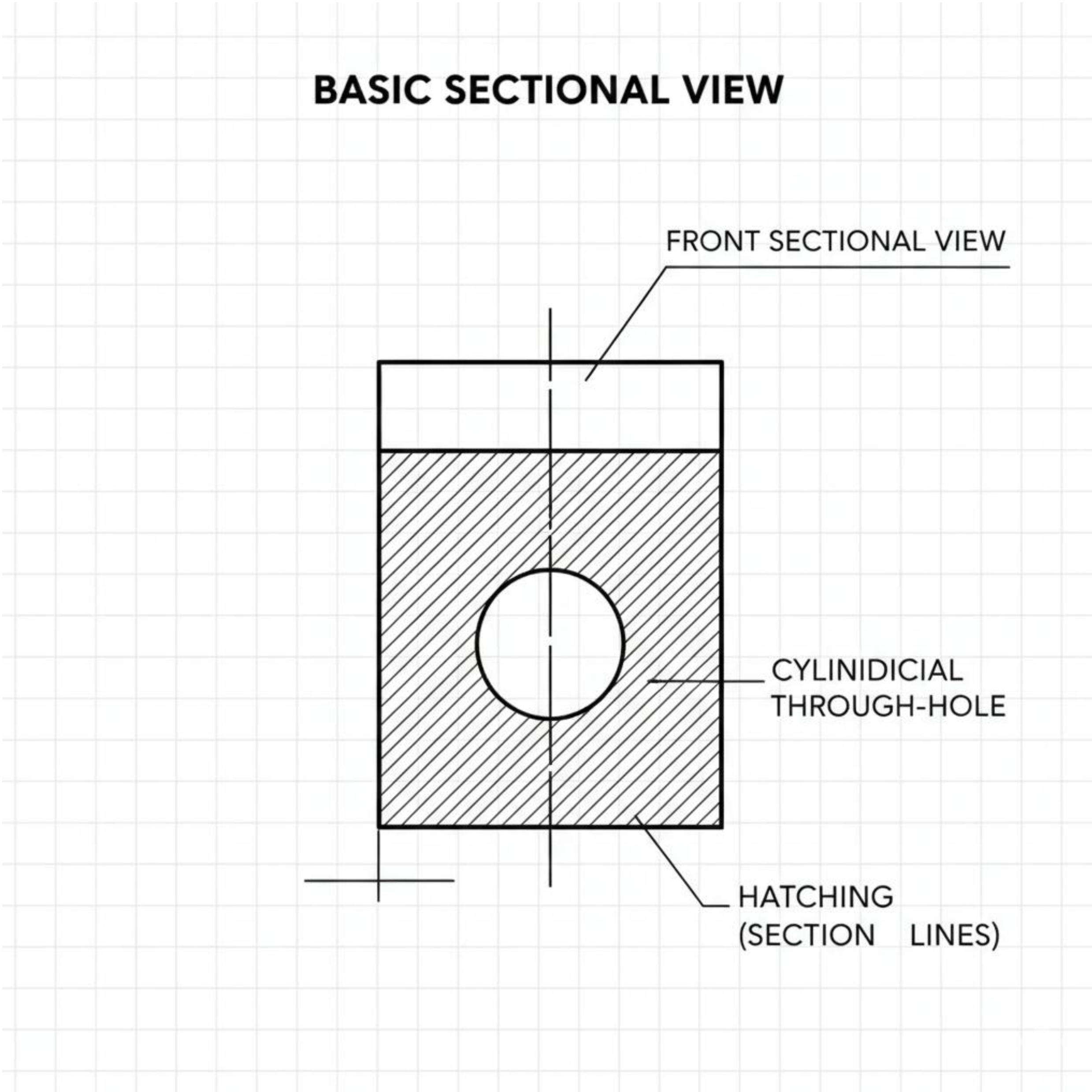
1. Why should dimension lines be placed outside the object when possible?
2. What is meant by spacing in dimensioning?
3. Why is orientation important when placing dimension figures?
4. Which direction should dimensions be readable from?
5. What might happen if dimension spacing is uneven?

5.2 Sectional Views and Their Applications

5.2.1 Meaning and purpose of sectional views

In engineering drawing, some internal features cannot be shown clearly using ordinary orthographic views alone. A **sectional view** is a drawing that shows the inside of an object as if a part of it has been cut away. This method reveals internal shapes such as holes, cavities, ribs, and recesses in a clear and understandable way. Sectional views make drawings easier to read by reducing the number of hidden lines needed.

The main purpose of sectional views is **clarity**, defined as the ability to present internal details without relying heavily on dashed hidden lines. Another purpose is **accuracy**, because seeing the true shape of internal features helps prevent misinterpretation. Sectional views are especially useful when designing, manufacturing, or inspecting parts with complex internal geometry.



Simple block cut in half to reveal internal hole
Figure 5.6: Basic sectional view showing an internal feature

Sectional views also support better **dimensioning**, because it is easier to place dimensions on a clear cut surface than on cluttered hidden lines. This improves the quality and readability of the drawing and ensures that internal measurements can be communicated precisely.

Fill in the blank: A sectional view shows the object as if part of it has been __________ away.

Pilot questions 5.2.1

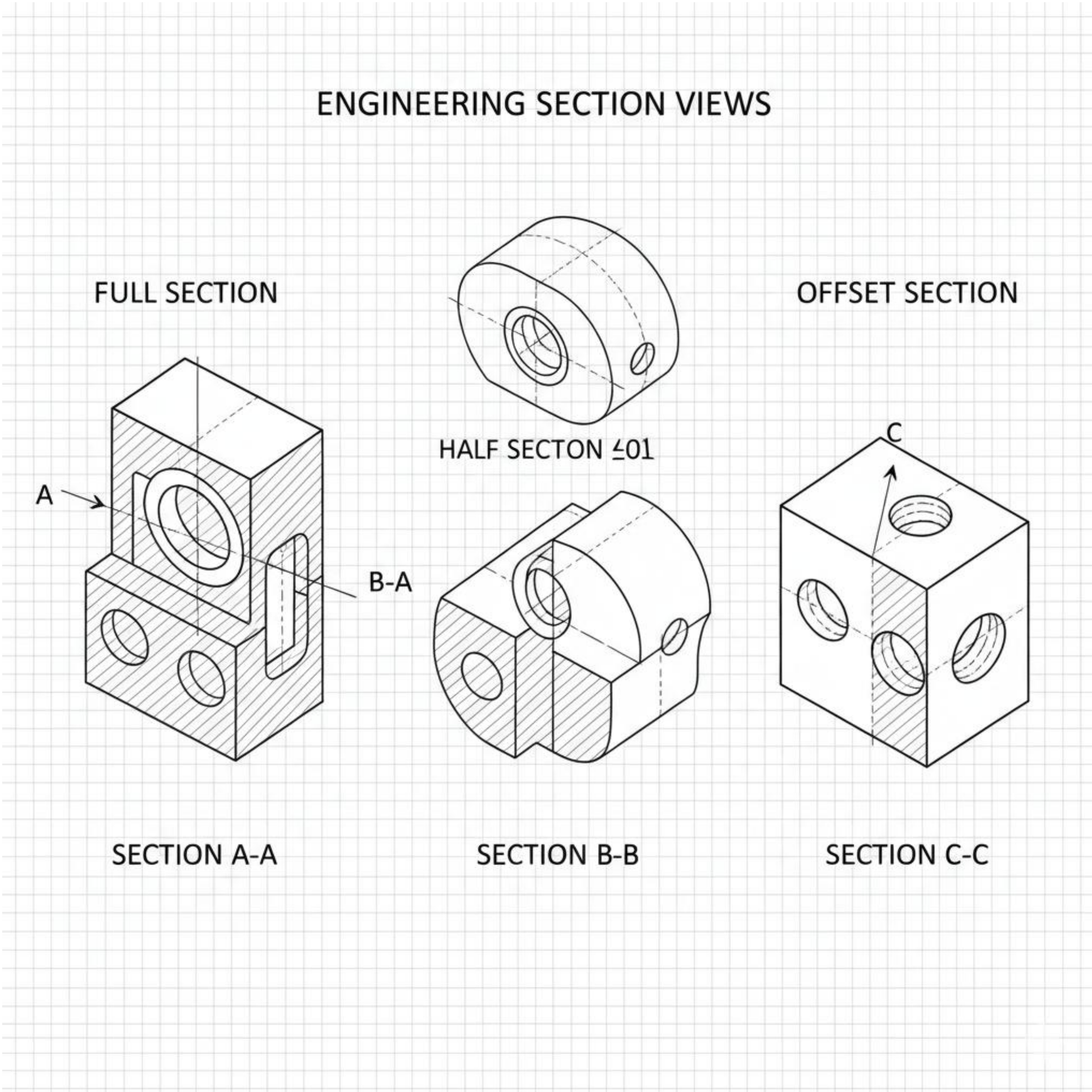
1. What is a sectional view?
2. Why are sectional views useful for showing internal features?
3. What drafting problem do sectional views help reduce?
4. Why are sectional views preferred for dimensioning internal details?
5. Which type of features benefit most from sectional representation?

5.2 Sectional Views and Their Applications

5.2.2 Types of sectional views (full, half, offset, broken-out)

Different engineering situations require different ways of cutting an object to reveal its internal details. A **sectional view** can be created in several forms depending on which features need to be shown. The **full section** is created when a cutting plane passes completely through the object, dividing it into two equal parts. This type is useful when most of the internal structure needs to be shown clearly.

A **half section** removes only one quarter of the object, allowing both internal and external features to be seen in the same view. This is especially useful for symmetrical objects such as cylinders and housings. An **offset section** uses a stepped cutting plane, defined as a plane that bends or changes direction to pass through several important features that do not lie in a straight line. This type helps reveal multiple internal elements at once.



Three simple objects showing full, half, and offset sectional examples
Figure 5.7: Examples of common sectional types

A **broken-out section** removes a small, irregular portion of the view to expose a limited internal area without cutting the entire object. This method is useful when only one internal feature needs to be highlighted.

Fill in the blank: A cutting plane that bends to pass through several features is called an __________ section.

Pilot questions 5.2.2

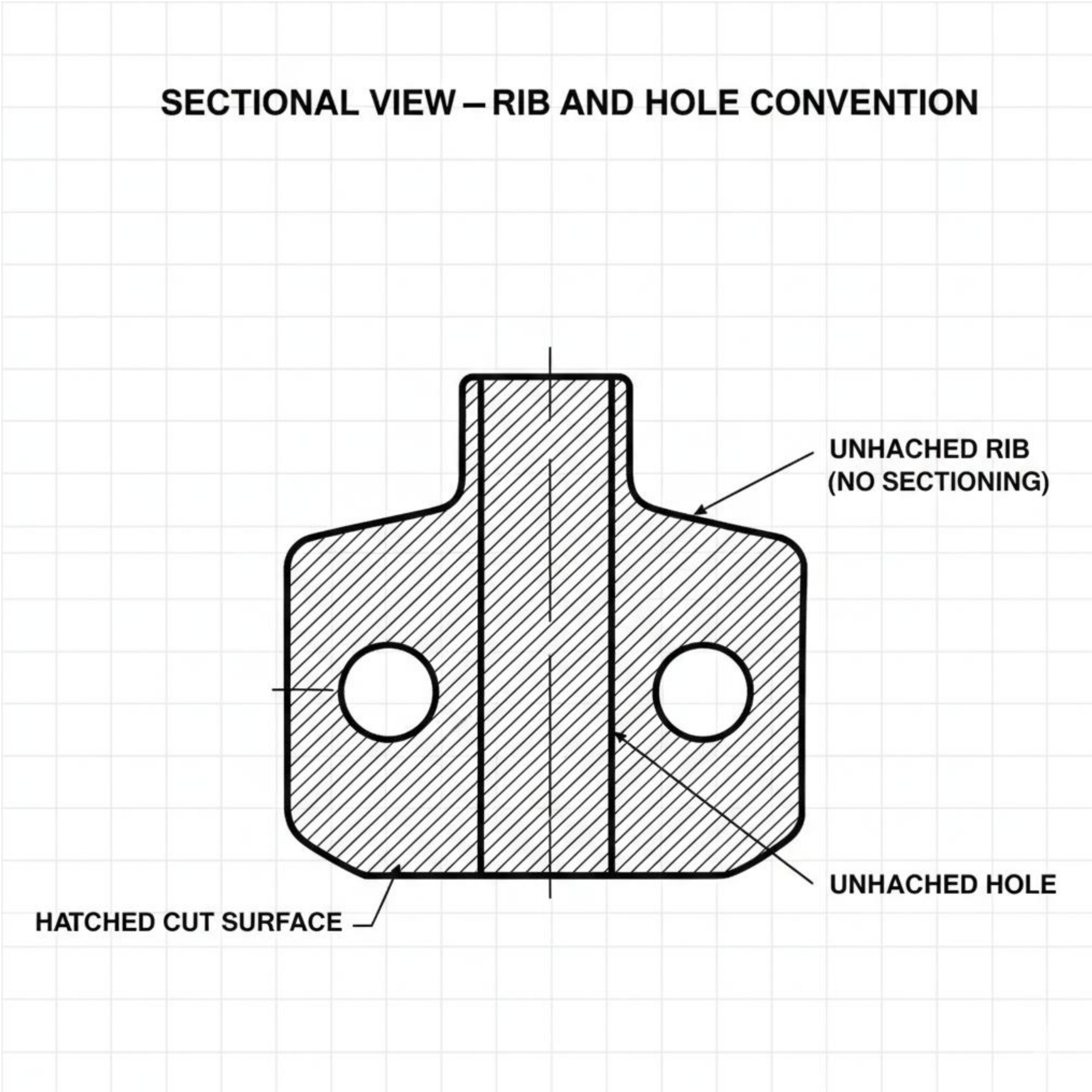
1. What is a full sectional view used for?
2. Why is a half section useful for symmetrical objects?
3. What makes an offset section different from a full section?
4. When should a broken-out section be used?
5. Which sectional type uses a stepped cutting plane?

5.2 Sectional Views and Their Applications

5.2.3 Sectional conventions and hatching rules

When an object is cut to produce a sectional view, the cut surfaces must be shown using **hatching**, defined as thin, evenly spaced lines used to indicate the areas where material has been sliced. Hatching makes it easy to distinguish between solid material and empty spaces. These lines are usually drawn at a 45-degree angle and kept uniformly spaced to maintain a neat appearance.

Sectional conventions ensure that all drawings follow the same rules. For example, **rib conventions** state that ribs, webs, and thin features are not hatched when the cutting plane passes lengthwise through them. This prevents the drawing from looking too dense. Similarly, **holes and voids** should not be hatched, since they represent empty space. These conventions help readers understand what is solid and what is hollow.



Example showing hatching on a cut surface and unhatched ribs and holes
Figure 5.8: Standard hatching application in a sectional view

Hatching may vary when two adjacent parts appear in the same section. In such cases, the hatching direction or spacing is changed slightly to show that the parts are different. This is helpful in assemblies where multiple materials touch each other. The drafter must always keep hatching consistent across a single part.

Fill in the blank: The thin lines used to show cut material in a sectional view are called __________ lines.

Pilot questions 5.2.3

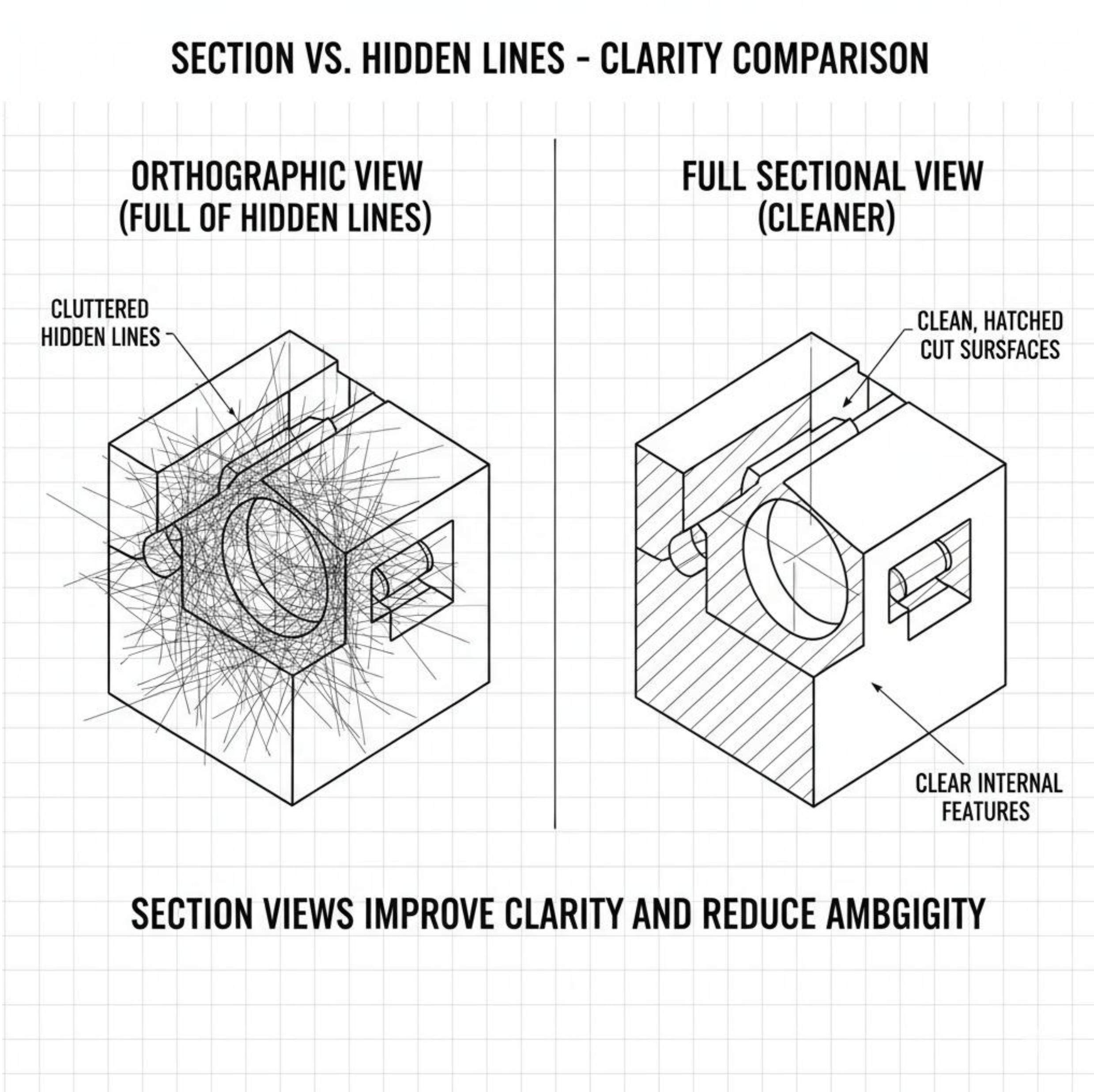
1. What is the purpose of hatching in a sectional view?
2. Why are ribs not hatched when cut lengthwise?
3. Which features should never be hatched?
4. How can you distinguish adjacent parts in a sectional drawing?
5. What angle is commonly used for standard hatching?

5.2 Sectional Views and Their Applications

5.2.4 When and why sections are preferred over hidden lines

Hidden lines can show the presence of internal features, but when there are many of them, the drawing can become crowded and difficult to read. A **section** is preferred when the internal structure is complex, when several hidden features overlap, or when clear communication is required. A sectional view replaces multiple hidden lines with a clean and uncluttered representation, making it easier to understand the shape and position of internal details.

Sections are also preferred for **dimensioning**, defined as the placement of numerical information on a drawing. It is often clearer to place dimensions on a sectioned surface than on a view filled with hidden lines. This improves accuracy and reduces the risk of mistakes. In addition, sections allow the drafter to show the true shape of internal features, which hidden lines cannot provide.



Comparison of a drawing with many hidden lines versus a cleaner sectional view
Figure 5.9: Using sections to improve clarity over hidden lines

Fill in the blank: A sectional view is preferred when hidden lines make a drawing appear too ________.

Pilot questions 5.2.4

1. Why can relying only on hidden lines reduce clarity?
2. When is a sectional view more suitable than hidden lines?

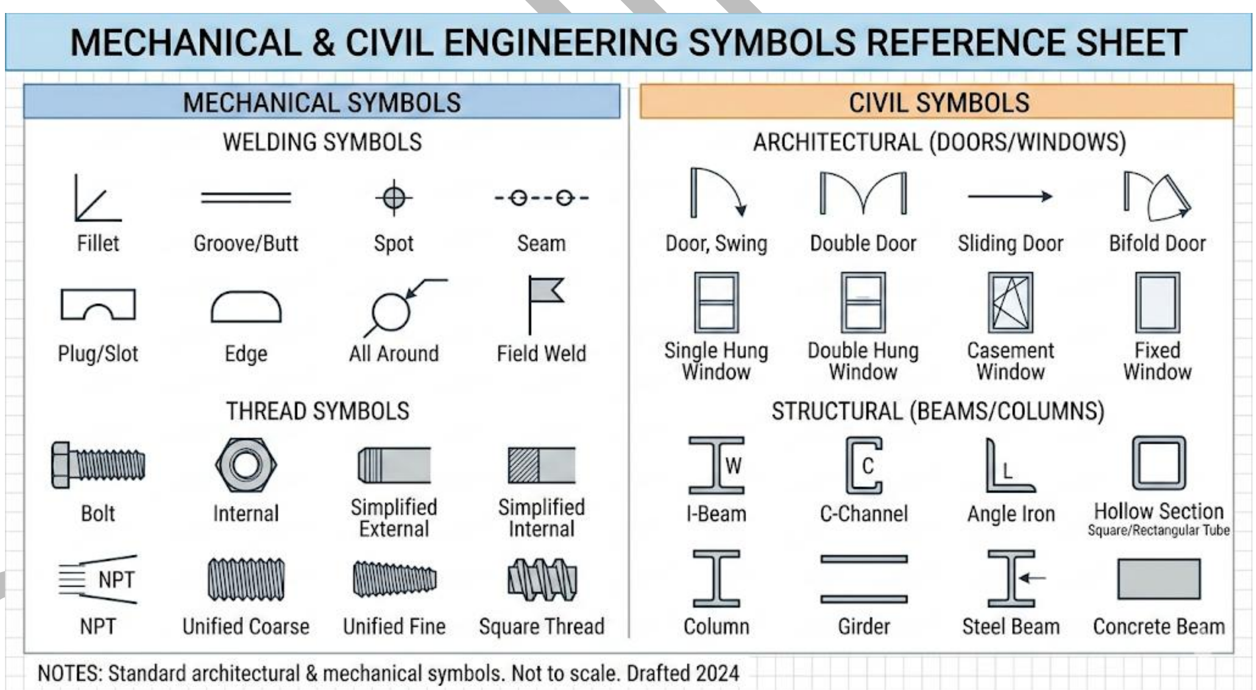
3. Why are sections useful for dimensioning internal features?
4. What advantage does a section have over hidden lines when showing true shape?
5. What problem do sectional views help avoid in busy drawings?

5.3 Conventional Representations in Engineering Drawing

5.3.1 Standard symbols used in mechanical and civil drafting

Engineering drawings use **standard symbols**, defined as simplified graphic signs representing common features, materials, and components. These symbols help drafters communicate complex information quickly without needing to draw every detail. By using recognised symbols, drawings remain clear, consistent, and easy to interpret across different industries and professions.

In mechanical drafting, common symbols include those for **welds**, **threads**, **bearings**, **springs**, and **surface finishes**. These symbols save time and reduce clutter, since they show essential information in a compact form. In civil drafting, symbols are used for **doors**, **windows**, **electrical fittings**, **plumbing fixtures**, and **structural elements** such as beams and columns. Using the correct symbols ensures that everyone involved in construction or manufacturing understands the same meaning.



A collection of basic mechanical and civil drafting symbols
Figure 5.10: Examples of standard symbols used across engineering drawings

Standard symbols must follow accepted drafting conventions so that drawings remain universal. Using wrong or improvised symbols can cause confusion or errors in fabrication or construction. For this reason, drafters must be familiar with the symbols most relevant to their discipline.

Fill in the blank: Standard symbols help reduce drawing clutter by replacing detailed shapes with simple __________.

Pilot questions 5.3.1

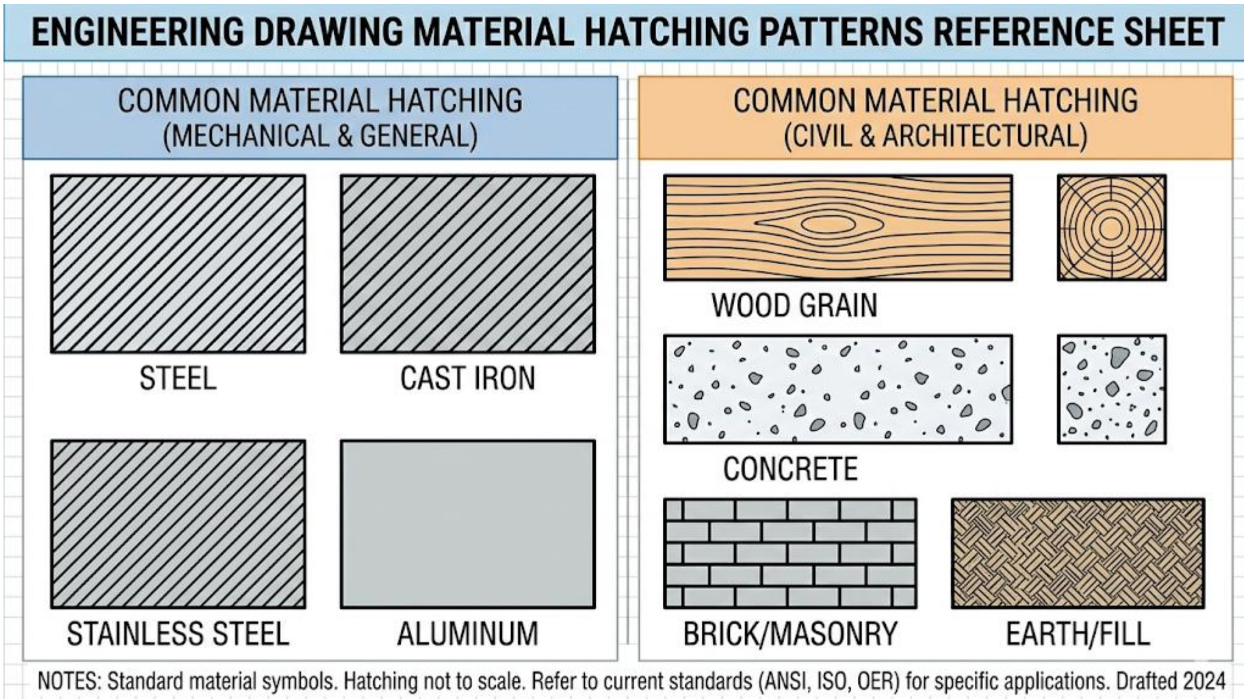
1. What is the purpose of using standard symbols in engineering drawings?
2. Name two symbols commonly used in mechanical drafting.
3. Name two symbols commonly used in civil drafting.
4. Why is it important to use recognised symbols instead of improvised ones?
5. How do symbols help keep drawings clear and readable?

5.3 Conventional Representations in Engineering Drawing

5.3.2 Conventional representations of materials (steel, wood, concrete, etc.)

Engineering drawings often show different materials using **conventional representations**, defined as standard hatching patterns or textures used to indicate the type of material in a part or structure. These conventions ensure that anyone reading the drawing can easily identify what the object is made of without needing lengthy notes.

Common materials each have a recognised pattern. **Steel** is represented using evenly spaced diagonal lines. **Cast iron** uses diagonal lines combined with short breaks. **Wood** is shown with curved grain-like lines to suggest natural texture. **Concrete** is represented by a combination of small stones and speckles. These patterns help distinguish one material from another, especially in sectional views.



Examples of simple material hatching for steel, wood, and concrete
Figure 5.11: Standard hatching patterns for common materials

These material representations are helpful in both mechanical and civil drawings. For example, in a mechanical part, identifying steel versus cast iron may be important for machining. In a civil drawing, distinguishing wood framing from concrete elements helps builders understand load-bearing roles. Consistency is key, as using the wrong pattern can lead to misinterpretation.

Fill in the blank: Wood is typically shown with curved lines to represent natural __________ patterns.

Pilot questions 5.3.2

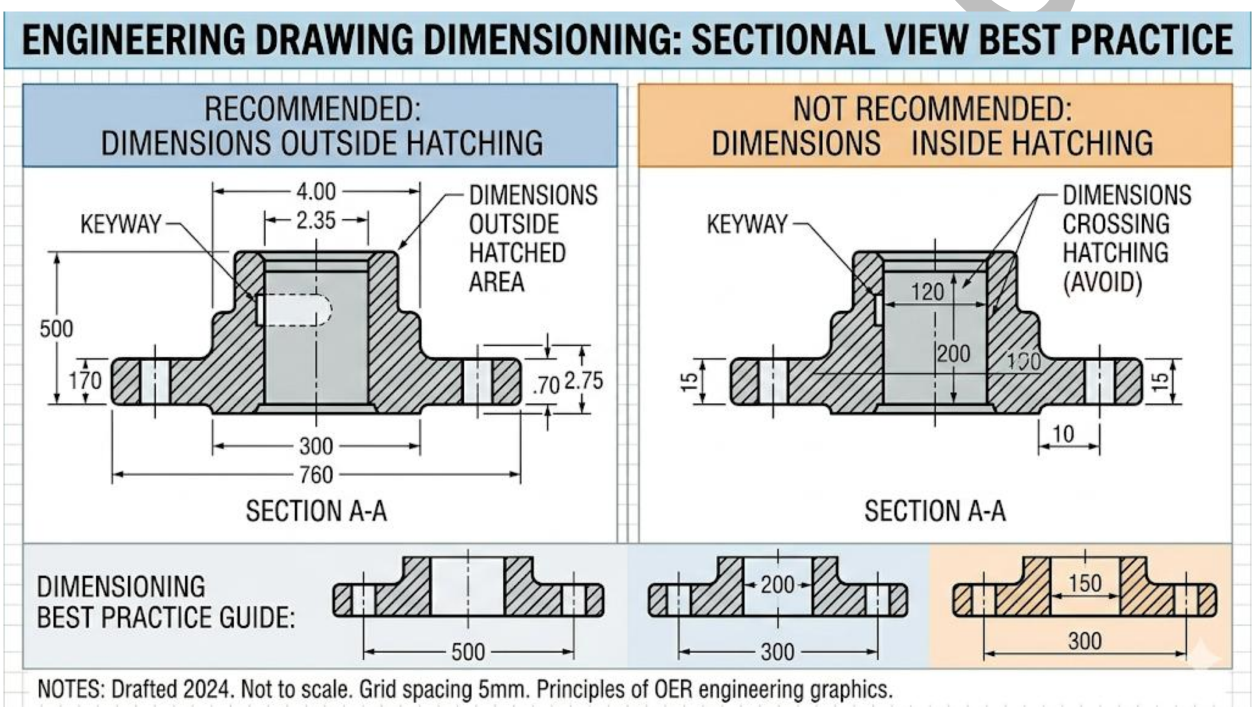
1. What is the purpose of using material conventions in drawings?
2. How is steel usually represented in sectional views?
3. Why is it important to show different materials using different hatching?
4. What pattern is used to show the natural texture of wood?
5. Give one example of where material conventions are useful in civil or mechanical work.

5.4 Applying Dimensioning and Sectioning to Composite Objects

5.4.1 Dimensioning best practice on sectional views

Sectional views often provide the clearest place to add measurements because they show internal details without the clutter of hidden lines. **Sectional dimensioning** refers to the practice of placing dimensions directly on the cut surface of a sectional view to improve clarity and accuracy. This ensures that the true shape and size of internal features can be communicated without confusion.

When dimensioning a sectional view, dimensions must be placed on **visible edges**, defined as edges that appear clearly after the object has been cut. Hidden edges should not be dimensioned unless absolutely necessary. It is also good practice to keep dimensions outside the hatched areas whenever possible, since placing figures over hatching can reduce readability. Extension lines should project from clean edges to avoid interfering with the hatch pattern.



Sectional view showing correct placement of dimensions outside hatched regions
Figure 5.12: Good practice for adding dimensions to sectional views

Sectional views also help in dimensioning **internal features**, such as hole diameters, slot widths, and cavity depths. These dimensions should be added in the section where the feature appears in true shape. Adding them in a non-sectional view can lead to mistakes because internal features may appear shortened or hidden. This is why sectional views are often the preferred location for critical internal measurements.

Fill in the blank: Dimensions on sectional views should be placed on clean, visible __________ to maintain clarity.

Pilot questions 5.4.1

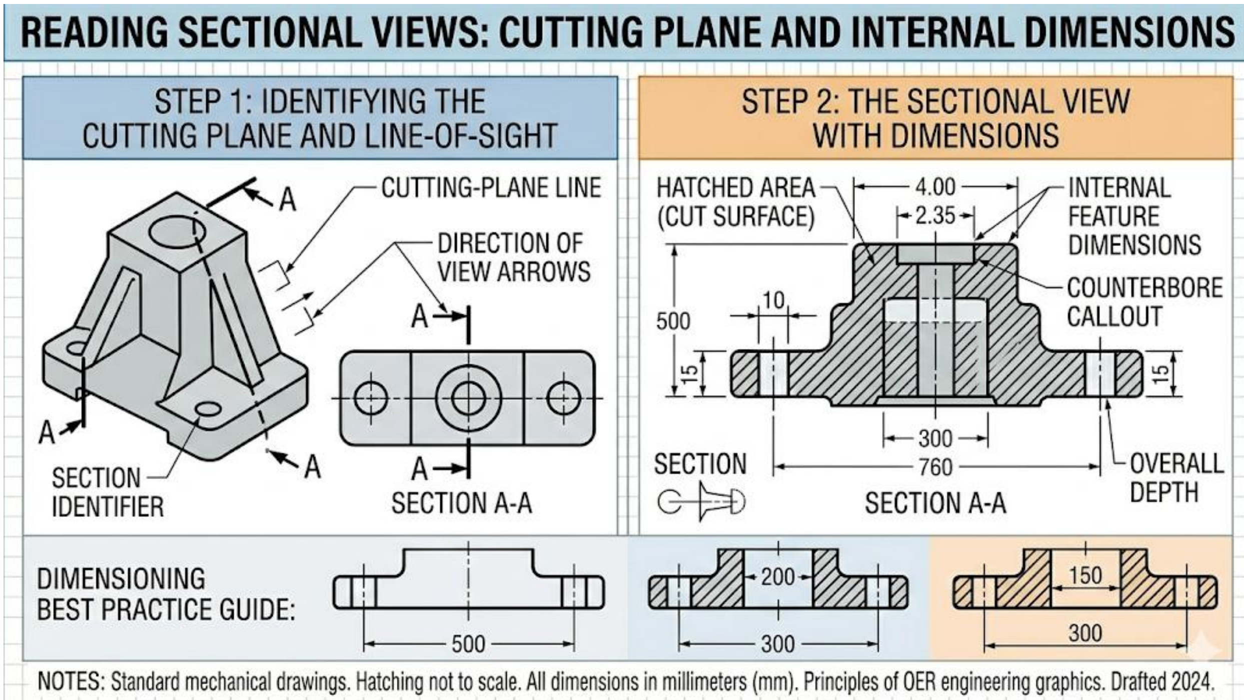
1. Why are sectional views helpful for placing internal dimensions?
2. Where should dimensions be placed to avoid interfering with hatching?
3. Which features benefit most from dimensioning on sectional views?
4. Why should hidden edges rarely be dimensioned?
5. What part of the sectional view should extension lines project from?

5.4 Applying Dimensioning and Sectioning to Composite Objects

5.4.2 Reading and interpreting dimensioned sectional drawings

Reading a sectional drawing requires you to understand both the cut surfaces and the dimensions placed on those surfaces. A **dimensioned sectional drawing** is a sectional view that shows internal features along with the measurements needed for manufacturing. Because the cut surface reveals the true shape of hidden details, interpreting these drawings is usually clearer than reading multiple hidden lines in a normal orthographic view.

To read a dimensioned sectional drawing, begin by identifying the **cutting plane**, defined as the imaginary plane that slices through the object. This determines which surfaces are hatched and which remain unchanged. Next, look for **visible edges**, since these represent the boundaries of the cut shape. Dimensions placed on these edges indicate actual sizes, such as the diameter of holes or the depth of recesses.



Sectional view with labelled cut surfaces and dimensions
Figure 5.13: Interpreting dimensions on a sectional view

Sectional drawings also help you understand the relationships between internal features. For example, a hole that appears as an ellipse in a top view will appear as a true shape circle in the sectional view if the cutting plane passes through it. Always follow the dimension lines and extension lines carefully, as they guide your interpretation of size and placement.

Fill in the blank: The imaginary surface that slices through the object to create a section is called the __________ plane.

Reading sectional drawings becomes easier with practice, especially when you compare the sectional view to the corresponding orthographic views. Together, they give a complete picture of both external and internal geometry.

Pilot questions 5.4.2

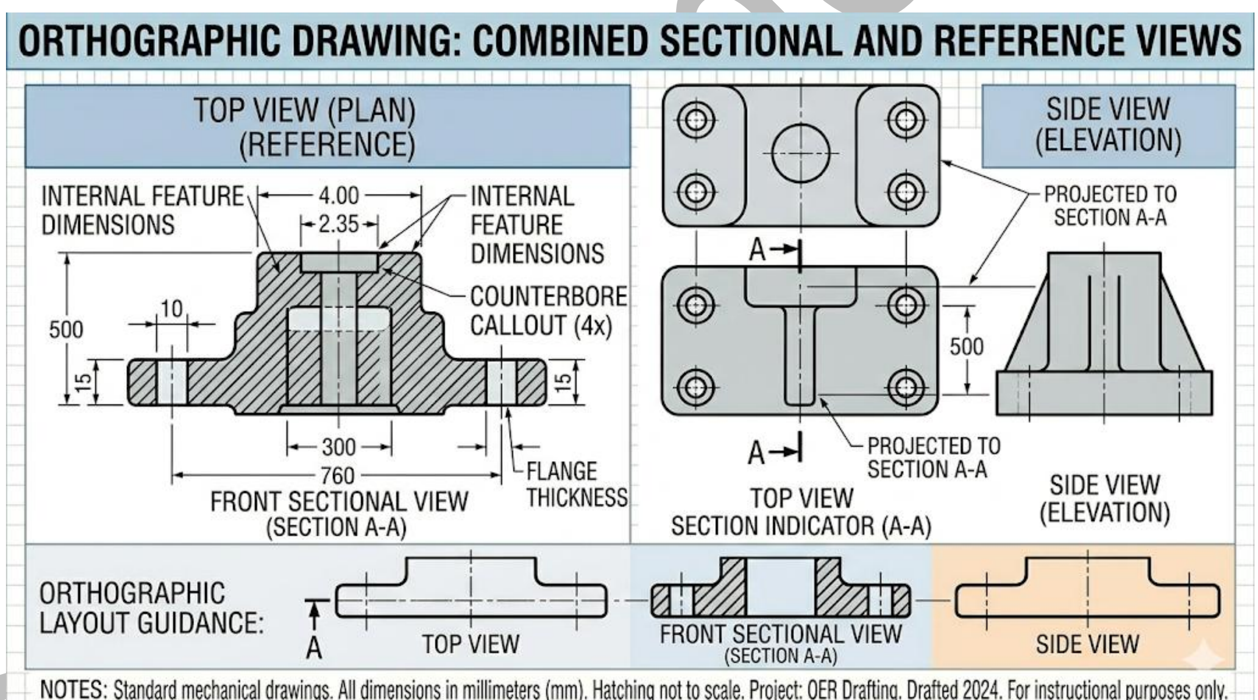
1. What is the first feature you should identify when reading a sectional drawing?
2. Why are sectional drawings clearer than views with many hidden lines?
3. What do visible edges represent in a sectional drawing?
4. How does a sectional view show the true shape of internal openings?
5. What information do dimension lines provide in a sectional view?

5.4 Applying Dimensioning and Sectioning to Composite Objects

5.4.3 Producing a combined dimensioned and sectioned multi-view drawing

A combined drawing that includes both sectional and dimensioned views provides the most complete understanding of an object's internal and external features. A **combined multi-view drawing** is a technical drawing that shows sectional views alongside standard orthographic views, with clear and accurate dimensions applied to each feature. This type of drawing is essential when a component contains both visible and hidden details that must be manufactured accurately.

To produce a combined drawing, begin with the standard front, top, and side views. Next, select the view that will benefit most from a section. A sectional front view is often chosen because it reveals the internal details clearly. Once the sectional view is created, dimensions should be added to the **true-shape surfaces**, defined as surfaces shown without distortion in the sectional view. Dimensions for internal features such as hole diameters, groove widths, or cavity depths should be placed on the sectional view rather than on external views.



Combined orthographic drawing with one sectional view and dimensions
Figure 5.14: Example of a combined dimensioned and sectioned multi-view drawing

The remaining views help support interpretation. For example, the top view may show the shape of openings, while the side view may show height relationships. All dimensions must follow standard placement, spacing, and orientation rules to keep the drawing tidy and readable. Hidden lines should be used only where necessary, since the section already provides clarity.

Fill in the blank: Internal dimensions such as hole sizes should be placed on the view where the feature appears in its __________ shape.

A combined dimensioned and sectioned drawing gives engineers, machinists, and inspectors a complete picture of the part, reducing errors and improving communication across the design and manufacturing process.

Pilot questions 5.4.3

1. What does a combined multi-view drawing show?
2. Why are sectional views helpful when dimensioning internal features?
3. Which view is commonly chosen for sectioning?
4. Where should dimensions for internal details be placed?
5. Why should hidden lines be used sparingly in combined drawings?

Series summary.

This Series introduced you to the essential conventions needed to communicate size, internal detail, and material information clearly in engineering drawings. We began by studying the purpose of dimensioning and the key components required to present measurements accurately. You learnt the rules for placing, spacing, and orienting dimensions so that drawings remain clear, standardised, and easy to interpret.

Next, we explored sectional views and how they reveal internal features more clearly than hidden lines. You examined different types of sectional views and learnt the conventions for hatching and representing cut surfaces. You also saw when sectional views should be used instead of hidden lines to improve clarity and support accurate dimensioning.

Following that, we considered conventional representations, including standard symbols and material patterns used in mechanical and civil drafting. These conventions help simplify complex information and ensure consistency across industries. The Series concluded with the application of dimensioning and sectioning principles to composite objects. You learnt how to read, interpret, and produce combined multi-view drawings that include sectional and dimensioned views for both internal and external features.

Together, these skills form an essential foundation for professional engineering communication and prepare you for more advanced drafting practices beyond this course.

Glossary of terms.

Broken-out section: A sectional view that removes a small, irregular area of the drawing to show one localised internal feature.

Cutting plane: An imaginary plane used to slice through an object to reveal internal features in a sectional view.

Dimension figure: The numerical value placed on a dimension line to indicate an actual measurement.

Dimension line: A thin line that shows the direction and extent of a measurement and typically carries the dimension figure.

Dimensioning rules: Accepted guidelines that determine how dimensions should be placed, spaced, and oriented for clarity.

Extension line: A thin line that extends from a feature to show the exact limits of a dimension.

Full section: A sectional view created when the cutting plane passes entirely through the object.

Half section: A sectional view showing one half of the object sectioned and the other half left uncut, useful for symmetrical shapes.

Hatching: A set of thin, evenly spaced lines used to show the material cut by the cutting plane.

Hidden line: A dashed line used to represent features that are not visible from a particular viewpoint.

Material conventions: Standard hatching or texture patterns used to indicate different materials such as steel, wood, or concrete.

Offset section: A sectional view created using a stepped cutting plane that bends to pass through multiple important features.

Sectional view: A drawing that shows the internal features of an object as if part of it has been cut away.

Sectional dimensioning: The practice of adding measurements directly to sectional views to improve clarity of internal features.

Standard symbols: Simplified graphic signs used to represent mechanical or civil elements, such as welds, threads, doors, and beams.

True-shape surface: Any surface shown without distortion, typically visible only in sectional or auxiliary views.

Concept check questions 5

Linked to SLO 5.1

1. **Objective:** Which of the following best describes a dimension?
   a. A decorative marking
   b. A numerical value showing size or location
   c. A type of hidden line
   d. A hatching pattern
2. **Short answer:** Why is dimensioning important in engineering drawings?

Linked to SLO 5.2

1. **Objective:** Dimension figures should be
   a. Placed inside the object
   b. Placed above or within the dimension line
   c. Placed on hidden lines
   d. Written diagonally
2. **Short answer:** State one rule that helps ensure dimension lines remain clear and readable.

Linked to SLO 5.3 and SLO 5.4

1. **Objective:** Which sectional type uses a stepped cutting plane?
   a. Full section
   b. Half section
   c. Offset section
   d. Broken-out section
2. **Short answer:** Why are sectional views preferred over hidden lines for complex internal details?
3. **Long answer:** Describe how a full section is created and explain why it is useful for interpreting internal geometry.

Linked to SLO 5.5

1. **Objective:** Which of the following is a standard engineering symbol?
   a. Hidden texture
   b. Weld symbol
   c. Shadow line
   d. Offset point
2. **Short answer:** Why must standard symbols be used instead of creating new ones?

Linked to SLO 5.6

1. **Objective:** Which material is typically represented using evenly spaced diagonal lines?
   a. Wood
   b. Concrete
   c. Steel
   d. Plastic

2. **Short answer:** What information can you gain from reading a dimensioned sectional drawing?

Linked to SLO 5.7

1. **Long answer:** Explain the steps involved in producing a combined dimensioned and sectioned multi-view drawing. Your answer should refer to creating the views, choosing where to apply a section, and placing dimensions on true-shape surfaces.

Answers to pilot questions 5.

Pilot questions 5.1.1

1. It is the process of adding sizes and locations to a drawing.
2. Because the object cannot be manufactured correctly without numerical information.
3. Clarity and accuracy.
4. They ensure uniform communication across drawings.
5. Edges, holes, recesses, angles, and internal features.

Pilot questions 5.1.2

1. To show the direction and extent of a measurement.
2. To prevent the drawing from appearing cramped.
3. The limits of a measurement.
4. Above or within the dimension line.
5. It may cause confusion or misinterpretation.

Pilot questions 5.1.3

1. To keep the drawing neat and readable.
2. The even distance between dimension lines.
3. It ensures that dimensions can be read quickly.

4. From the bottom or right-hand side.
5. Confusion or difficulty reading the drawing.

Pilot questions 5.2.1

1. A drawing that shows the inside of an object as if cut.
2. Because they reveal internal details clearly.
3. Excessive use of hidden lines.
4. Because sections show features in true shape.
5. Holes, cavities, recesses, ribs, and other internal features.

Pilot questions 5.2.2

1. To show the whole internal structure.
2. Because it shows both internal and external details together.
3. It uses a stepped cutting plane.
4. When only a small internal area needs to be shown.
5. Offset section.

Pilot questions 5.2.3

1. To show cut material clearly.
2. Because they would appear too dense if hatched.
3. Holes and empty spaces.
4. By changing the hatch direction or spacing.
5. Forty-five degrees.

Pilot questions 5.2.4

1. They can make the drawing confusing.
2. When the internal structure is complex.
3. They show internal features clearly for measurement.
4. It shows the true shape.
5. Crowding from excessive hidden lines.

Pilot questions 5.3.1

1. To communicate features and components quickly using simple signs.

2. Weld symbols and thread symbols.
3. Door symbols and beam symbols.
4. To avoid errors and ensure standard interpretation.
5. By simplifying complex features.

Pilot questions 5.3.2

1. To identify materials clearly.
2. With diagonal lines.
3. To avoid confusing one material with another.
4. Grain-like curved lines.
5. In civil plans showing structural elements or in mechanical parts showing material types.

Pilot questions 5.4.1

1. Because internal features appear clearly in section.
2. Outside the hatched regions.
3. Hole diameters, slot widths, cavity depths.
4. Because they are not truly visible.
5. Clean visible edges.

Pilot questions 5.4.2

1. The cutting plane.
2. Because they remove clutter from hidden lines.
3. The boundaries of the cut shape.
4. By showing the surface in true shape.
5. Sizes and positions of internal features.

Pilot questions 5.4.3

1. Sectioned and unsectioned views with dimensions.
2. Because they reveal internal shapes clearly.
3. The front view.
4. On the true-shape sectional surface.
5. Because the section already provides clarity.

List of references 5.

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2. **French, T. E., Veilleux, J. C., and Foster, C. J. (Engineering Drawing and Graphic Technology).** McGraw-Hill.
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3. **Bertoline, G. R., Wiebe, E. N., Hartman, N. W., and Ross, W. A. (Fundamentals of Graphics Communication).** McGraw-Hill.
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   Defines the international standards for dimensioning elements, sectional conventions, and general drafting practice.
5. **ISO 129: Technical Product Documentation, Dimensioning.** International Organisation for Standardisation.
   Provides detailed rules for dimensioning methods, placement, and practices used in engineering drawings.
6. **ISO 406: Technical Drawings, Tolerances of Linear and Angular Dimensions.** International Organisation for Standardisation.
   Supports advanced dimensioning requirements by explaining tolerances and measurement precision.
7. **Engineering Drawing Laboratory Manual, Department of Engineering, Kwara State University.**
   An institutional guide used for practical training on dimensioning, sectional views, and material conventions.
8. **NADIA Technical Drawing Handbook (Local Edition).**
   A commonly referenced resource in Nigerian institutions for basic and intermediate drafting standards