

**MINISTRY OF EDUCATION
TECHNICAL TEACHERS
ASSOCIATION OF GHANA**



Design and Communication Technology

for Senior High Schools

Year 2



**Justice Akonsah Blay
Deborah Naa Ayele Okine
Emmanuel Oppong
Sappor Peter Narh**

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Ghana Education
Service (GES)





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FOREWORD

Ghana's new Senior High School Curriculum aims to ensure that all learners achieve their potential by equipping them with 21st Century skills, knowledge, character qualities and shared Ghanaian values. This will prepare learners to live a responsible adult life, progress to further studies and enter the world of work. This is the first time that Ghana has developed a Senior High School Curriculum which focuses on national values, attempting to educate a generation of Ghanaian youth who are proud of our country and can contribute effectively to its development.

The Ministry of Education is proud to have overseen the production of these Learner Materials which can be used in class and for self-study and revision. These materials have been developed through a partnership between the Ghana Education Service, teacher unions (Ghana National Association of Teachers- GNAT, National Association of Graduate Teacher -NAGRAT and the Coalition of Concerned Teachers- CCT) and National Subject Associations. These materials are informative and of high quality because they have been written by teachers for teachers with the expert backing of each subject association.

I believe that, if used appropriately, these materials will go a long way to transforming our Senior High Schools and developing Ghana so that we become a proud, prosperous and values-driven nation where our people are our greatest national asset.

Haruna Iddrisu MP

Minister for Education

SECTION

1

CONCEPTUAL DRAWING



UNIT 1: CONCEPT SKETCHES

CONCEPTUAL DRAWING

Concept Sketches

INTRODUCTION

In this unit, you will employ your knowledge in rendering techniques, proportions and perspectives to create complex object forms in perspectives, using freehand drawing and examine various basic shapes and rendering techniques used to create complex object forms in freehand drawing.

The unit will also aid in your experiments with freehand sketches to create designs in 2 point perspective with emphasis on proportions using basic shapes and rendering techniques. Again, you will use your idea of concept sketches to create complex designs with graphite pencil and coloured pencil sketches in freehand drawing.

KEY IDEAS

- Basic shapes are the building blocks of all geometrical forms in art and design
- Rendering techniques means using lines (marks) of different weights, spaces and textures to add realism to drawings.
- Freehand sketches mean drawings made without using tools like rulers or compasses. They are done by hand, quickly and loosely, to show ideas or concepts.
- Two-point perspective is a way to draw objects to look 3-Dimensional. It uses two points on the horizon where lines meet, making things look smaller as they go farther back.
- Complex designs involve using simple shapes such as circles, squares, and triangles to create more intricate and sophisticated shapes or designs.

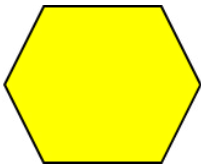
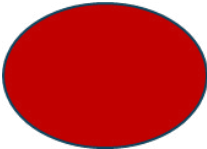
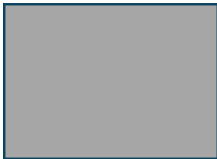
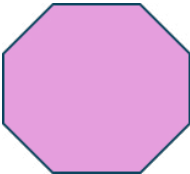
BASIC SHAPES AND RENDERING TECHNIQUES

One challenging aspect of sketching or drawing is when complex forms are involved. However, this challenge can be overcome when one understands that the complex forms are made up of simple basic units of the already known basic shapes such as circles, squares and rectangles, which are combined in various ways.

These basic shapes which are the building blocks of all geometrical forms can be combined with different rendering techniques to create intricate forms and textures that add depth and values to our designs.

Basic Shapes

Table 1.1.1: Basic shapes used for designing

SHAPE	DESCRIPTION	SHAPE	DESCRIPTION
	Square Four equal sides, Four right angles Sum of inside angles equals 360°		Hexagon Six sides and six angles The opposite sides of a regular hexagon are parallel
	Circle Closed curve with a set of points in one plane and same distance from a centre point		Trapezoid Four sides Two parallel sides
	Triangle Three sides and three angles Sum of inside angles equals 180°		Oval Closed curve flattened on one pair of opposite sides
	Pentagon Five sides and five angles Sum of inside angles equals 540°		Rhombus Four equal sides Opposite angles are equal, and less or more than 90°
	Rectangle Four sides, Four right angles Two opposite sides longer than the other two		Octagon Eight sides Eight angles Sum of the inside angles equals 1080°

Rendering Techniques

When doing freehand sketches, rendering techniques using lines (marks) of different weights, spaces and textures add realism to drawings. Such techniques can be enhanced in so many ways to create complex forms. Examples are the following:

1. Smudging and Blending

This involves using the finger or any other soft material to blend two or more media together to create smooth transitions between shades in a drawing/sketch.

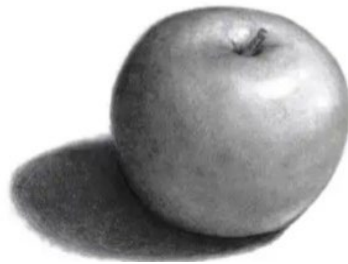


Figure 1.1.1: Smudging and blending

2. Contour Shading

A technique used to create illusion of depth and volume by shading with different line thickness and shades along the contours or edges of the object.

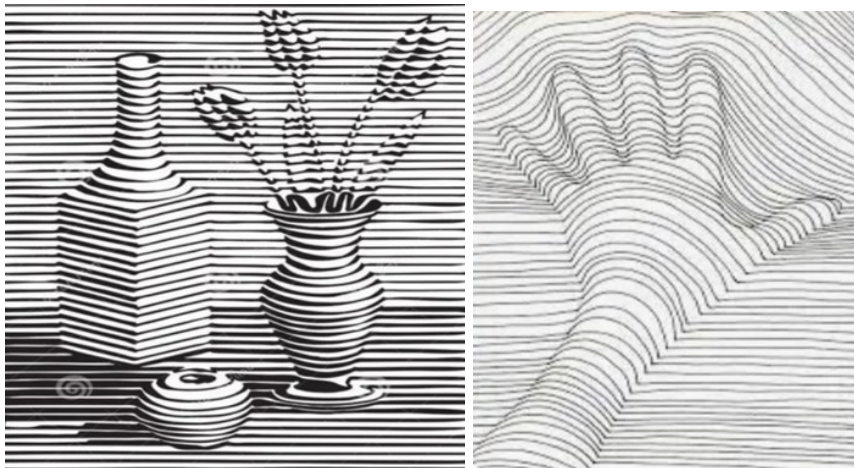


Figure 1.1.2: Contour shading

3. Negative Space Drawing

This technique is where the focus is on drawing the empty spaces around and between the objects instead of drawing the objects themselves.



Figure 1.1.3: Negative space drawing

4. Layering

The focus lies on building up layers of shading, texture or other elements to create depth and complexity.



Figure 1.1.4: Layering

5. Highlighting

This is the process of creating the illusion of depth and volume to make 2-D artwork appear more 3-D, by varying the pressure in the shading.

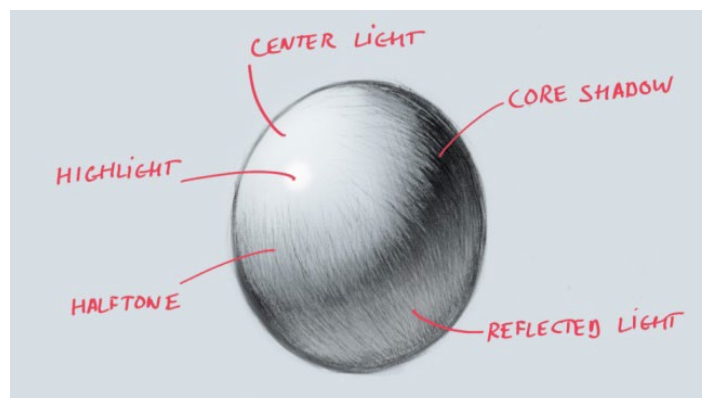


Figure 1.1.5: Highlighting

6. Erase and Lift-off

This is used to correct mistakes or create highlights in the drawing. Shape the eraser to fit into areas you want to remove or create the highlights to achieve subtle transitions in the drawing.



Figure 1.1.6: Lifting off

7. Multi-point Perspective

Creating a scene with multiple vanishing points to create a sense of depth and complexity.

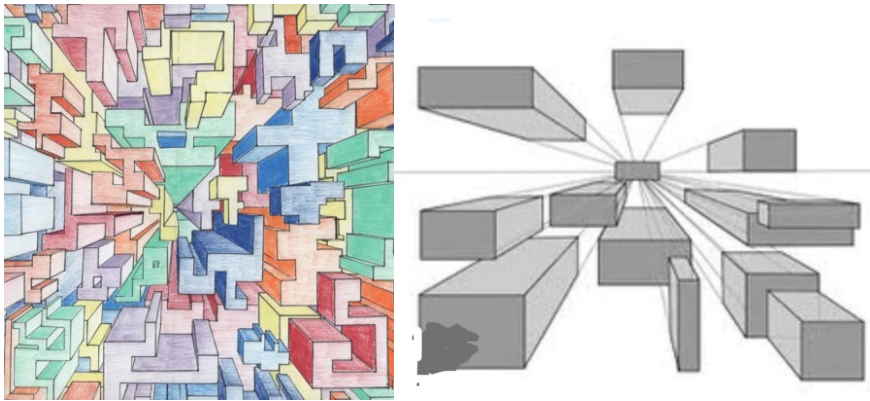


Figure 1.1.7: Multi-point perspectives

8. Using Different Pencils and Tools

This involves using variety of pencils and other tools with varying line weights, textures, and shading to create depth, value and interest in drawing.

Other shading techniques that can be used to make simple sketches look complex include Rim Lighting, Contour Highlight, Cast Shadows and Duotone Shading.

These techniques can be combined and adjusted to suit the subject matter and style of the sketches, whether drawing still life, landscapes, or portraits. Practice and experimentation will help develop unique rendering style.

With the introduction of Artificial Intelligence (AI) and neural rendering, more accurate rendering processes can be created. These techniques are used in architecture, game design, and 3D animation, bringing virtual concepts to life with stunning clarity.

Common mistakes in rendering

You may encounter mistakes that affect the overall visual appeal and realism of an artwork while rendering. This should not make you lose hope since mistakes are part of life. Realising your mistake and sharing thoughts with others can help overcome them or minimise them.

Recognising and addressing these common mistakes can go a long way to help you refine your rendering skills to create artworks that can captivate and inspire viewers. Below are some common mistakes which need attention:

1. Lack of Texture and Detail

The absence of surface detail and texture in a scene makes it appear flat or unrealistic. An example is a wooden table without any grain texture on the surface.

2. Incorrect Perspective

This refers to the use of perspective that is not accurate or logical within a scene. Example: A scene with a long building that appears to converge at the other end, the lines are not straight.

3. Inconsistent Lighting

Failing to maintain consistent lighting throughout the artwork, leading to unrealistic shadows and highlights.



Figure 1.1.8: 'Inconsistent Lighting' shading

4. Poor Colour Choices

This is where colours selected do not work well together, hence disrupting the artwork's mood and atmosphere.



Figure 1.1.9: 'Poor Colour Choices' rendering

5. Insufficient Shading

Shading that does not show depth and dimension in a scene. A typical example is a flat, uniform colour for a dress showing no folds, worn by a sitting person.

6. Overcrowding the Scene

This is where too many elements are used, making the scene look too cluttered and difficult to focus on the main theme.

7. Unrealistic Placement of Elements

Not considering the reality of things and placing objects in impossible positions, such as objects floating instead of being stable.

8. Poor Lighting

Improper use of lighting can make the work look unrealistic. Real scenes may look too light or too dark, making details of the work missing.



Figure 1.1.10: 'Poor Lighting'

9. Excessive Use of Colours

Too many bright colours creating insufficient contrast or harmony overwhelm the viewer. Correct colour choices must be adapted for realistic effect.



Figure 1.1.11: Excessive use of colour

10. Ignoring the Impact of Scale

Consider how objects and characters relate to each other in terms of size and proportion, such as objects that are too large or too small, so as not to create a sense of disorientation in the drawing.

Recognising and understanding these common mistakes, serves as a guide to improving overall quality and realism of artworks, as well as developing skills and techniques more efficiently. Mistakes can be overcome or minimised. This calls for constant practice and patience which is the key to mastering the art of rendering.

Activity 1.1.1 Food Package for a Cafeteria

In groups of no more than five, you will discuss the characteristics of basic shapes and rendering techniques used to create complex forms. Use photographs, videos, drawings, real objects and other items to guide your discussions.

Once you have finished the discussion read the following scenario and complete the exercises using what you learned.

Scenario

Your school is organising a grand Opening Ceremony for a cafeteria put up by the 2000 Year Group. It will render services to both the school and community members.

Your class has been tasked with designing the exterior casing for the food package. The package should not exceed 180mm by 150mm by 80mm.

1. Using basic shapes and rendering techniques, design the exterior of the food package showing a 3-D effect.
2. Make a brief write-up on your design indicating the choice of shapes, colours and materials used. Give a description of the shapes used, reasons for the colour choice, and the rendering technique(s) in a table or chart form.

CREATING DESIGNS IN TWO-POINT PERSPECTIVE

Perspective

Perspective is a way of drawing that makes objects look smaller as they get farther from the viewer, creating depth. The horizon line represents the viewer's eye level, and the vanishing point is where parallel lines seem to meet in the distance. This helps create a realistic sense of space and distance in drawings.

Principles of two-point perspective

In two-point perspective, there are two vanishing points, one on each side of the drawing. Vertical lines stay straight, while other lines angle toward these vanishing points. For example, the vertical edges of a building stay upright, and lines like those of the sidewalk lead to the vanishing points.



Procedures

You are going to be taken through the general procedures used to draw objects in two-point perspective.

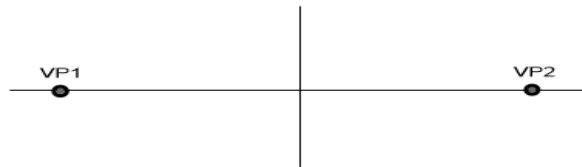
1. Draw a horizontal line to represent the horizon or the eye level, this could be at eye level, above eye level or below eye level



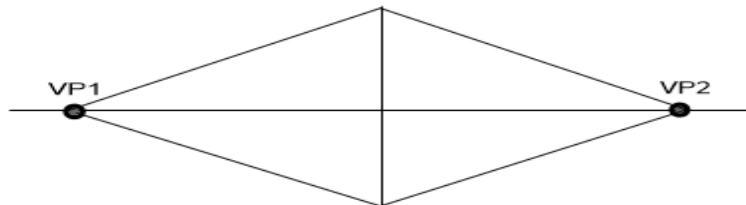
2. Mark two vanishing points on the horizon, one on the left and one on the right.



3. Draw a vertical line to represent the corner of the object you want to sketch.



4. Draw perspective lines from each vanishing point to create a grid.



5. Draw parallel vertical lines to indicate where the object ends.

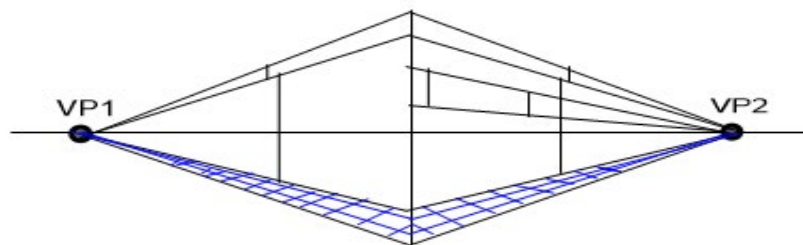


Figure 1.1.12: Stages involved in creating two-point perspective

Sketching in two-point perspective

1. Create a Grid

To create a grid is a highly effective technique that enhances perspective in realistic drawing. This tool helps you keep proportions accurate, especially when working on complex scenes or objects, ensuring consistency and depth in your perspective.

2. Measure Proportions

Mastering proportion is key to making your drawings look realistic. Accurate measurements help your artwork appear balanced and real.

3. Use Shading and Shadow

Apply shading and shadows are vital for creating depth and dimension in your drawings, making them look more realistic and lifelike.

4. Practice Regularly

After learning some key techniques for improving perspective in realism, regular practice is equally important. Like any skill, the more you draw, the more your abilities will improve.

Examples of Two-Point Perspective Designs



Figure 1.1.13: Two-point perspective design

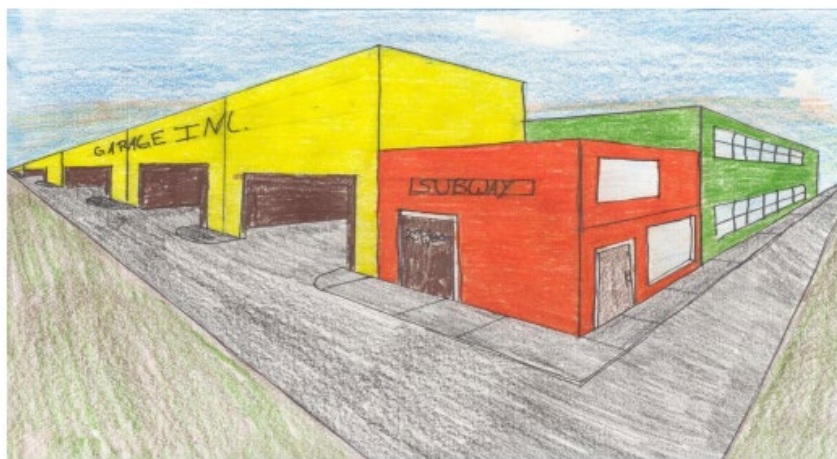


Figure 1.1.14: Two-point perspective design

Activity 1.1.2 Drawing in two-point perspective

In groups of 5, draw your School Library, the pathways and trees around it in Two-Point Perspective. (Follow the steps below to perform your work).

1. Move outside to your school library and the surrounding pathways. Walk around, taking note of the lines and angles of the library building and how the pathways recede into the distance.
2. Identify the horizon line and think about where the vanishing points would be if you sketch the scene in two-point perspective.
3. Once you have chosen a spot to sit or stand and draw, establish your horizon line and place two vanishing points on either side.
4. Note that vertical lines in two-point perspective stay vertical, but the horizontal lines will converge at the vanishing points.
5. Begin by lightly sketch the main structure of the library using two-point perspective. Focus on the walls and roof lines receding toward the vanishing points.
6. Next, add the pathways, trees, benches. Ensure that these elements also follow the rules of two-point perspective.
7. Go back to the classroom with your sketches, display them and discuss with others work.

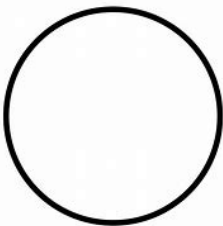
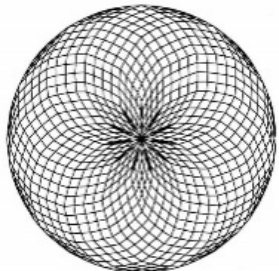
COMPLEX DESIGNS

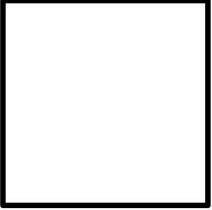
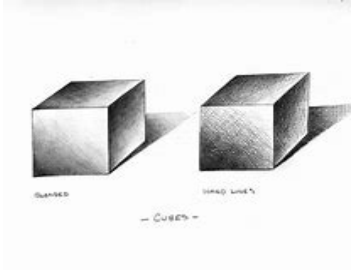
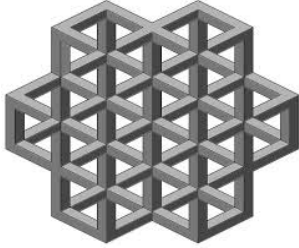
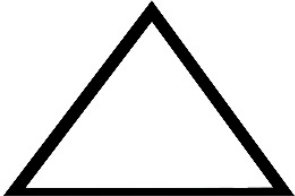
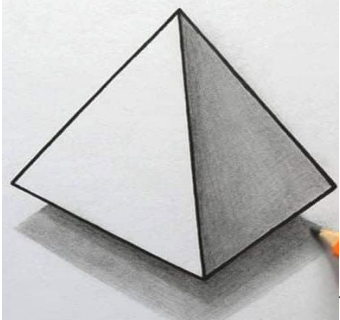
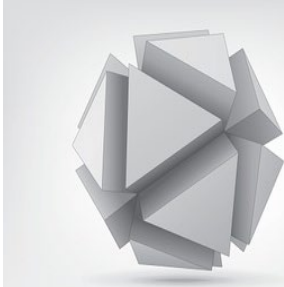
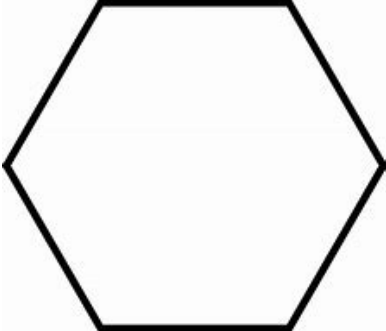
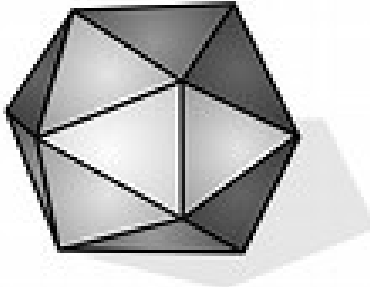
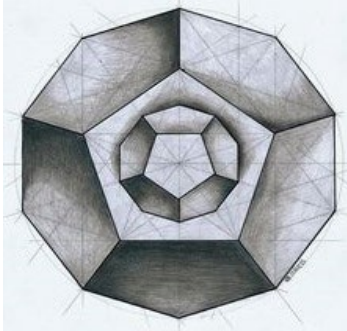
Designs usually begin with simple shapes like circles, squares, and triangles. When combined creatively, these shapes become more detailed and interesting, called Complex Designs.

Complex designs involve using simple shapes such as circles, squares, and triangles to create more intricate and sophisticated shapes or designs. The complex designs are rendered to make them more realistic and beautiful.

Examples of complex designs

Table 1.1.2: Complex shapes

Basic shape	Simple form	Complex form
 Circle		

 Square		
 Triangle		
 Hexagon		

Guidelines for creating complex design

The following guidelines will help you master the fundamental use of simple shapes and rendering techniques to create beautiful realistic complex designs:

1. Select the required basic forms

Before creating complex forms, it is important to select basic geometric shapes such as cubes, spheres, cylinders, and cones. These simple forms are the basic components or blocks for more complex structures.

2. Combination of the selected basic shapes to build the complex shapes

The selected basic shapes are put together in various ways to form the overall complex shapes.

3. Sketch the overall complex shapes using perspective and rendering techniques.

The designer will have to maintain the correct proportion and depth, interplay with light and shadow to make the sketches look more realistic.

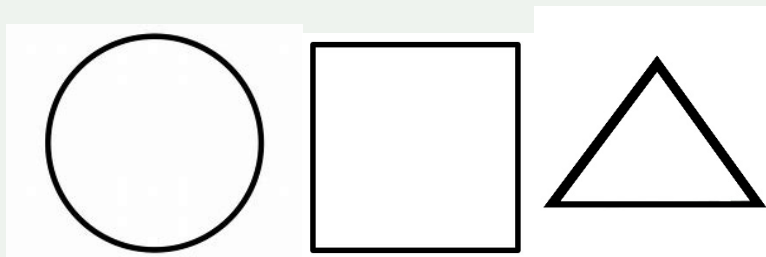
Activity 1.1.3 Tools and materials for complex design

Research and identity 4 tools and materials for complex design. Fill out the template below.

Tools (Manual)		Uses
1		
2		
Tools (Digital)		Uses
1		
2		

Activity 1.1.4 Complex design

In groups of 5, select one of the following basic geometric shapes: circles, squares, triangles.



- Follow the guidelines for creating complex designs and create a complex design using concepts in the classroom.
- Draw your final work on an A4 sheet and submit it to class for discussion.

EXTENDED READING

- Acquaye, E. A., (2010), Technical Drawing, Accra, Yetoda Publishing. Page 92 and 94.
- Watch video at YouTube on how to draw in two-point perspective.

UNIT 2: OBJECT MANIPULATION

CONCEPTUAL DRAWING

Object Manipulation in Drawing

INTRODUCTION

In your daily activities, whether eating, walking, talking, or otherwise—you engage in some form of manipulation, combining small actions to create a greater effect. The same concept applies to the designer's world. As an artist, you transform simple geometric shapes like circles and squares into complex forms by gradually adding depth, texture, and other elements. Freehand drawing techniques are the foundational skills you need to make these modifications and bring your creations to life. This process blends creativity, keen observation, and constant, patient practice.

Over time, your skills improve as you break down complex transformations into manageable steps. This section will introduce freehand drawing techniques for modifying simple geometric shapes, along with examples, illustrations, and practical tips to help you master these essential skills.

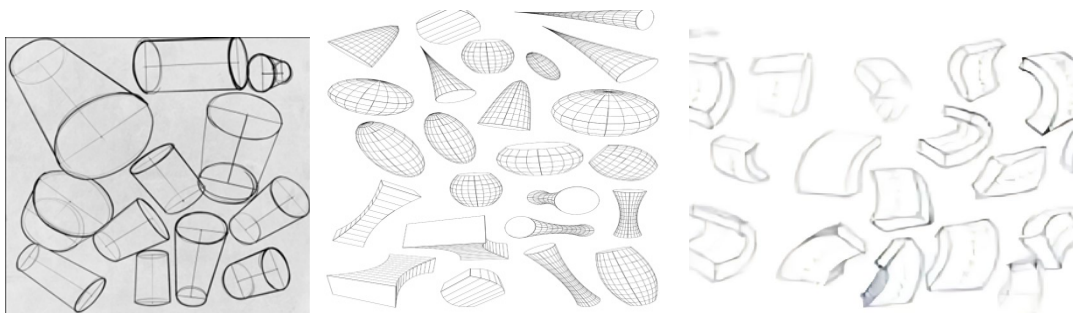
KEY IDEAS

- Shape manipulation is altering basic shapes to create new forms, such as scaling, combining, fragmentation, rotation and displacing.
- Creative freedom: Freehand drawing techniques offer flexibility to experiment and make changes spontaneously, allowing for unexpected and innovative results.
- Artistic Expression: Modifying simple shapes enables to convey their personal style, mood, and message through their work.
- Design applications: These techniques are essential in various fields, such as graphic design, product design, and architecture, to create visually appealing and functional designs.
- Skill development: Mastering freehand drawing techniques for modifying simple shapes enhances creativity, problem-solving skills, observation, and rendering techniques.
- Communication: Effective modification of simple shapes enables clear and concise communication of ideas, concepts, and designs.

MODIFYING TWO-DIMENSIONAL SHAPES USING FREEHAND DRAWING TECHNIQUES

Designing in freehand sketches usually begin with basic shapes, such as circles and squares, which are transformed into intricate, lifelike designs. Through diligent practice and careful observation, designers add texture and depth, bringing the life to subjects. This methodical approach enables them to build their skills over time, resulting in an artwork that is both expressive and captivating

SHAPES OF OBJECTS THAT CAN BE MODIFIED



Cylinders

Stretched and squeezed forms

Bent cuboids

Figure 1.2.1: Shapes of objects that can be modified

The following are some methods and tips to help you modify your drawings effectively

1. **Methods Altering Shapes and Proportions:** Altering shapes and proportions involves modifying the size, scale, and proportions of a shape or object. This can be done by enlarging or reducing part or all of the shape. It makes the original shape distorted, resulting in an entirely new form but having traces of the original shape and form.

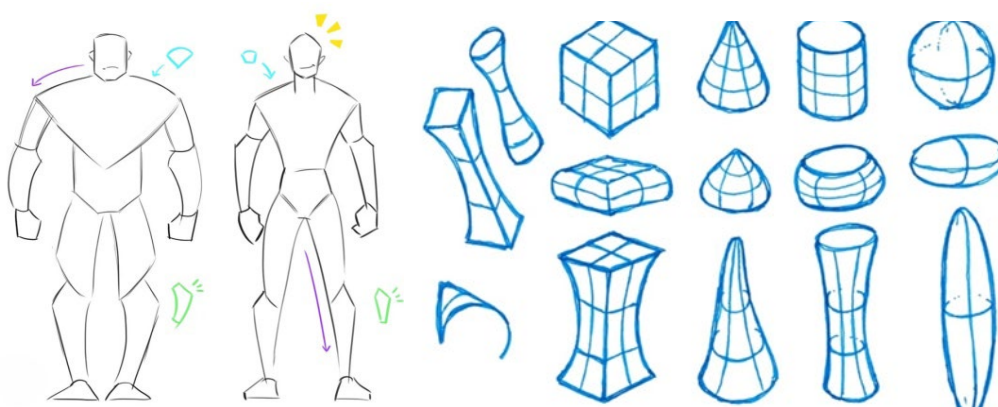


Figure 1.2.2: Altering shapes to create a new form

2. **Combining Shapes or forms:** Joining two or more shapes or forms to create a new form can be achieved by layering shapes or forms or combining those that share a common edge or boundary.

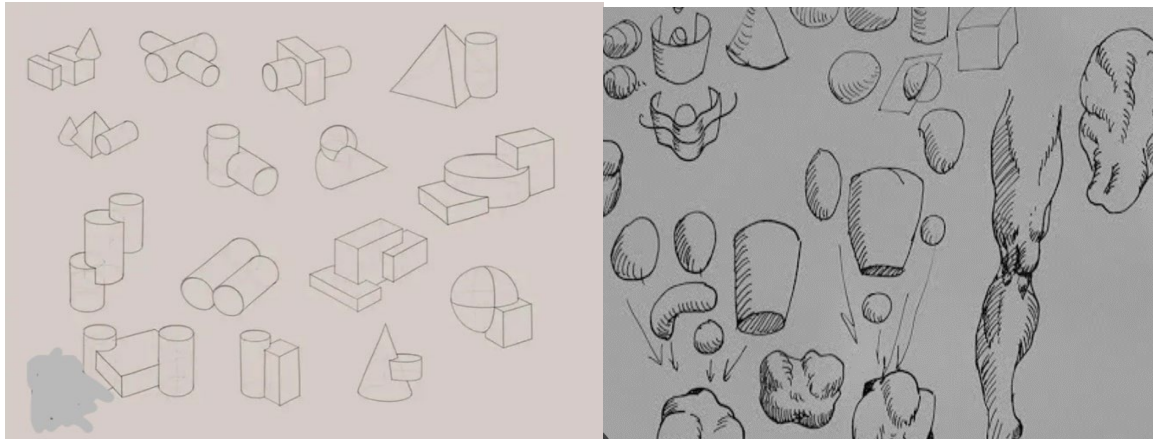


Figure 1.2.3: Forms combined to create a new form

Changing Perspective

Changing perspective involves modifying the viewpoint or orientation of a shape or object.

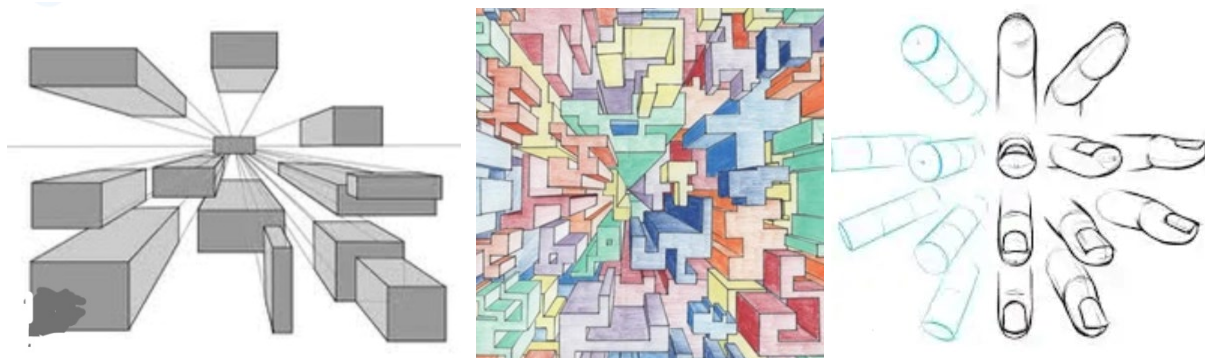


Figure 1.2.4: Changed perspectives

3. **Translating:** In this method, the shape is moved from one position to another to create a new or modified composition. This creates a sense of movement or energy. Other techniques used in modifying freehand drawings are Reflecting, Repeating, Transmuting, Disassembling and Converting.

Tips:

1. Start simple: Begin with basic shapes and gradually add complexity.
2. Use tracing paper: Trace your drawing to create a new version, making modifications as you go.
3. Experiment and take risks: Try new things and don't be afraid to make mistakes.
4. Pay attention to details: Focus on small details that can make a big impact on the overall drawing.
5. Take breaks: Step away from your drawing to clear your mind and approach it with fresh eyes.

6. Practice, practice, practice: Regularly practice modifying drawings to develop your skills.
7. Collaborate: Work with others to get feedback and new perspectives on your drawings.

Activity 1.2.1 Modification of two-dimensional shapes

The Fun Club in your area wants to go another level up. Among their plans is a grand Inaugural Ceremony, where they need a logo for some souvenirs. Their core values are Commitment to Environmental Sustainability and Community Protection.

Task: In groups of not more than five, choose only one simple shape and manipulate it to create a unique and meaningful logo. The logo should be visually appealing, incorporating elements that depicts their core values, and should be versatile for use on their various platforms (e.g., business card, billboard, T-shirt, etc.).

1. Create a pictorial table/chart that identifies five different modification techniques. The table/chart should highlight the description of the techniques and how the techniques can lead to the creation of new forms.
2. Generate another table/chart of five tools/materials that can be used to manipulate objects into freehand drawing

The logo should be presented on any durable material.

EXPERIMENTING WITH FREE-HAND DRAWING TO MODIFY 2- DIMENSIONAL SHAPES TO ACHIEVE NEW FORMS

Designs to Achieve New Forms

Using freehand drawing techniques, artists and designers can transform two-dimensional designs by creatively modifying shapes and forms. This approach allows designers to explore unconventional shapes, sizes, and perspectives that are often constrained in traditional 2D design processes. By sketching freely and without restrictions, designers have the flexibility to experiment with fluid and dynamic forms, opening up possibilities beyond the initial 2D concept.

This creative freedom enables designers to refine and expand upon original ideas, resulting in innovative designs that surpass initial boundaries.

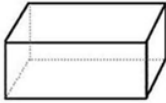
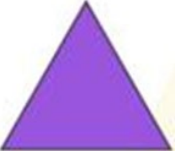
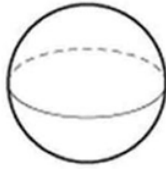
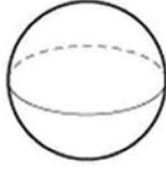
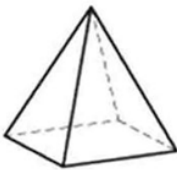
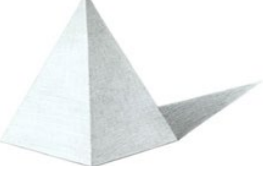
Freehand drawing offers a range of methods, from simple adjustments to more complex transformations, for modifying 2D designs. It's important to note that the tools and materials used in freehand sketching are also applied in modifying basic 2D objects, making the process accessible yet powerful for enhancing design possibilities.

Choosing a Design

To start, choose a base design simple, specific 2D or 3D shape or form that you want to modify. This could be a sketch, blueprint, or any existing drawing. Begin by visualising the selected design as a basic form, then expand upon it by applying freehand drawing techniques to manipulate and transform its shape.

Here are some examples of shapes and forms.

Table 1.2.1: Shapes to be manipulated

2-Dimensional	3-Dimensional	Shaded figures
		
		
		
		
		
		

The base design of simple but specific 2 or 3D shape

Understand the Shape and Form

Carefully observe the details of the shapes and forms you have chosen. This will help you understand the nature of the key components and structure, such as the type of line (straight, curved, diagonal, or parallel), the space (wide, closed, narrowing, etc.), and the proportions and perspective.

Selecting the Technique to Use for the Modification. Choose a Technique for Modification

There are various methods you can use to transform a shape or form to create something new. Techniques include pulling, squashing, twisting, coiling, bending, subtracting, or adding other shapes.

Create Modifications

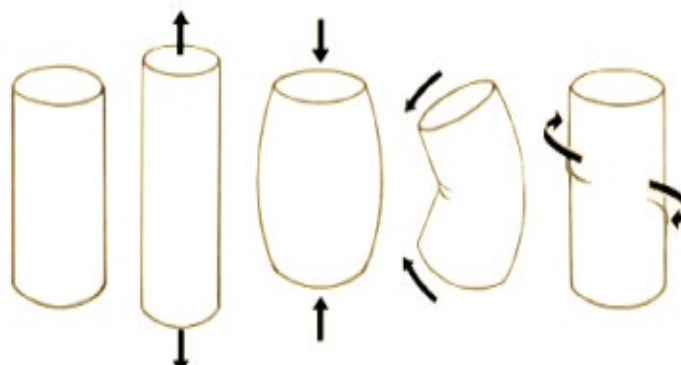
When modifying a form or shape, imagine it as a flexible, elastic object that can be manipulated in any direction. This mindset will help you apply any of the techniques mentioned above. Approach the process playfully—start with a light sketch of the original shape or form as a reference, then experiment freely. Try adjusting proportions, adding or removing elements, and reshaping the form using one or more techniques.

Explore Variations

For effective experimentation in modifying shapes and forms, it's helpful to create multiple variations. Draw several versions of the shape you've chosen, each with a different twist. Explore various approaches and ideas to see how each modification transforms the original form.

Finalise your Drawing

To complete your drawing, refine the lines and tidy up any rough areas. If it suits the design, consider adding colour or texture to enhance the visual impact.



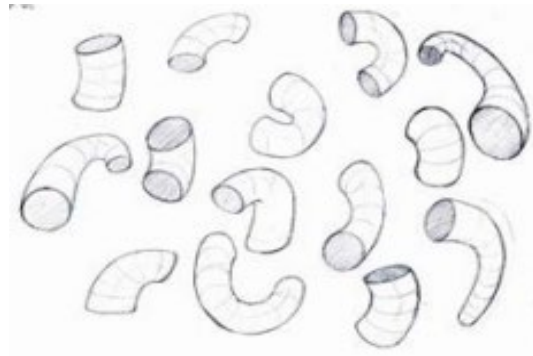


Figure 1.2.5: Modified cylinders

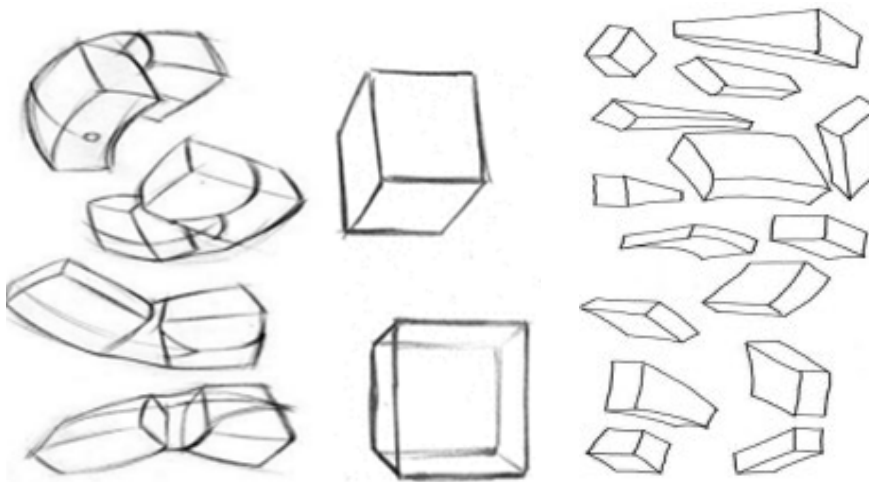


Figure 1.2.6: Cubes and rectangles

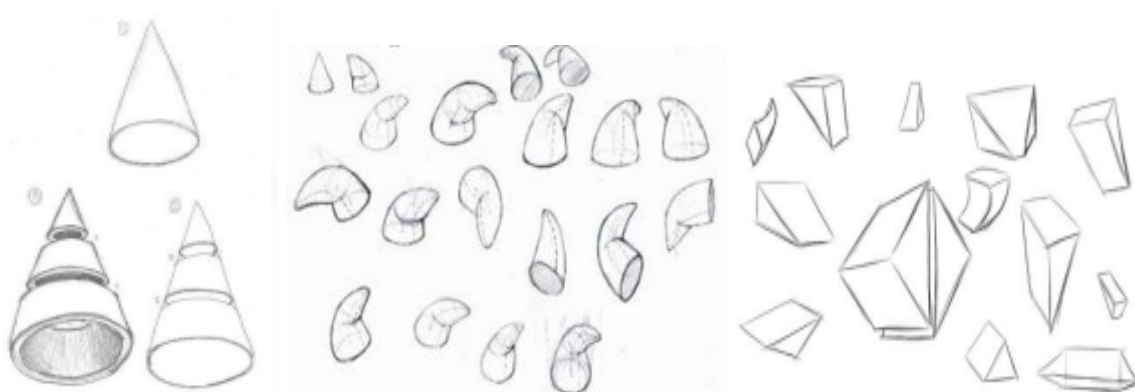


Figure 1.2.7: Triangles and cones

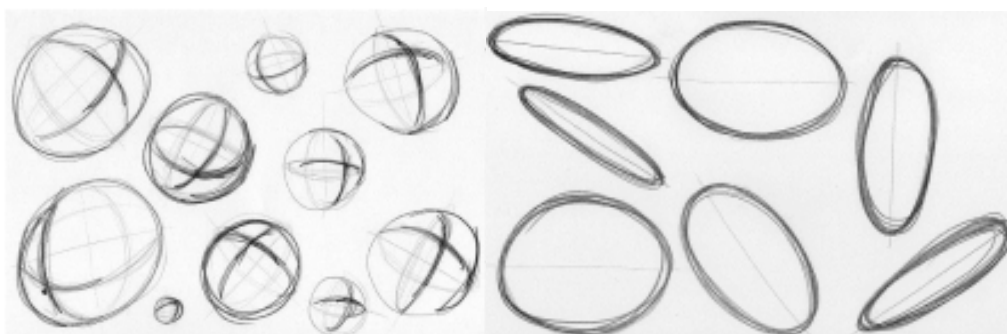


Figure 1.2.8: Circles and spheres

Activity 1.2.2 Modification of shapes and forms

1. Techniques for Modifying Shapes and Forms

In groups of 5, discuss and record ways to change shapes and forms using freehand drawing.

2. Try these

- a. Choose a few simple and complex shapes (like triangles, rectangles, or pyramids).
- b. List at least five techniques for modifying shapes (e.g., stretching, compressing, mirroring, or rotating).
- c. For each technique, make quick sketches showing how it changes the shapes.
- d. Which techniques were easiest or hardest to use?
- e. How did each technique change the look and feel of the shapes?
- f. Create a page of sketches and a short summary showing what you learned from each technique.
- g. Discuss in the group your sketches and how interpretation can vary between individuals

3. Transforming Shapes with Freehand Drawing

In groups of 5, experiment with changing simple and complex shapes into new forms using freehand drawing.

Perform these tasks as your experiment.

- a. Select a few simple shapes (like squares and circles) and some complex ones (like stars and cubes).
- b. Use freehand drawing to modify these shapes into new forms by stretching, overlapping, rotating, or distorting them.
- c. Start with a light sketch of each shape.
- d. Create several versions of each shape by trying different modifications.
- e. Combine two or more shapes and adjust their sizes and details to create new forms.
- f. Which changes produced the most interesting results?
- g. How did combining shapes affect your designs?
- h. Discuss your findings in the group and how interpretation can vary between individuals.

GENERATING SIMPLE OBJECTS IN LINE WITH THE CONCEPTS AND NARRATIVES ASSOCIATED WITH OBJECTS AND DESIGNS

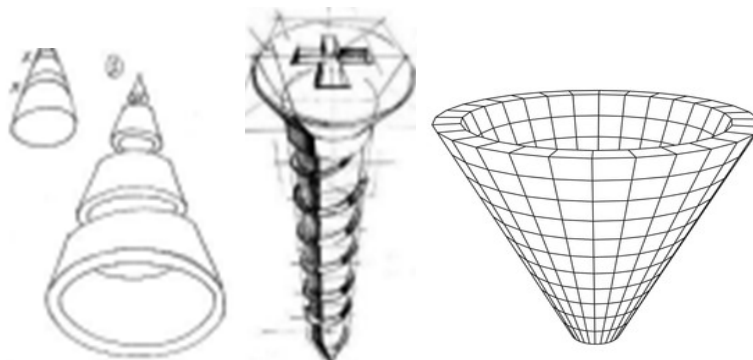
In our earlier lessons, we learned that freehand drawing is a creative method that encourages trying new ideas and helps designers express their thoughts with lively lines. This hands-on approach allows for quick changes and better understanding of space. Overall, freehand drawing combines art with design, leading to interesting and well-made objects. In year one, we talked about how shapes have different meanings in different cultures, and designers use these shapes to create useful objects, from simple to complex.

Simple Objects and Design

In your environment, objects around you come in a variety of simple and complex shapes and forms. Below are some examples provided for you to observe closely.



Figure 1.2.9: Circles



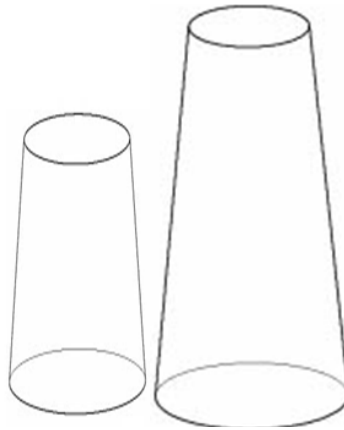


Figure 1.2.10: Triangles



Figure 1.2.11: Square/Rectangle



Figure 1.2.12: Cylinder



Figure 1.2.13: Circle and sphere



Figure 1.2.14: Designed objects

Activity 1.2.3 Generating Simple Objects Using Free-Hand Drawing

In groups of five, follow the steps outlined for generating simple objects using Free-Hand Drawing. Start with a short discussion about what the activity is asking and then produce the sketches required. Once all group members have finished compare and discuss the sketches.

Use this step-by-step explanation, along with descriptions of sketches for each stage:

Step 1: Define the Concept or Narrative

1. **Objective:** Identify what you want the object to represent.
2. **Example:** Suppose we want to sketch a cup of coffee as our object. The concept is a warm, inviting, and calming object.
3. **Keywords:** Coffee, warmth, relaxation, steam, cup, handle.

Step 2: Sketch Loose Shapes

1. **Objective:** Draw the basic shape of the object.
2. **Example:** Start with simple shapes to represent the object — for the coffee cup, sketch an oval for the top opening, a cylindrical shape for the body, and a curved line for the handle.
3. **Sketch:** An oval at the top with vertical lines forming the body of the cup, and a curved "C" shape for the handle.

Step 3: Add Gestural Lines

1. **Objective:** Use loose lines to bring movement and texture to the object.
2. **Example:** Add curvy, flowing lines to represent steam coming from the cup. Use smoother, sweeping lines to outline the cup's body and handle.
3. **Sketch:** Add wavy lines above the cup to show rising steam, and smooth curves for the cup's structure.

Step 4: Simplify and Refine

1. **Objective:** Remove unnecessary details and focus on the essential shapes.
2. **Example:** Clean up the loose shapes by defining the cup's main body, handle, and steam more clearly.
3. **Sketch:** Streamline the body and handle of the cup, simplifying the steam to a few wavy lines.

Step 5: Add Minimal Details

1. **Objective:** Add only key details that emphasize the concept.
2. **Example:** Draw a simple rim for the top of the cup and a few lines on the body to indicate depth or shading.
3. **Sketch:** Add a thicker line for the cup's rim, a few horizontal lines on the body to suggest shading or a light source.

Step 6: Refine Lines and Proportions

1. **Objective:** Adjust proportions and finalize the drawing.
2. **Example:** Make sure the handle is proportionate to the cup, and the steam feels light and natural.
3. **Sketch:** Twist the shape of the cup and handle, making the proportions more balanced, and refine the steam.

Additional Tips

1. As a beginner, experiment with different line thicknesses for emphasis.
2. Try sketching different views or styles (e.g., cartoonish or realistic) to find what best expresses your concept.

Each stage helps transition from loose ideas to a structured, clear drawing while maintaining simplicity.

Activity 1.2.4 Generating Simple Objects Using Free-Hand Drawing

In groups of five, follow the steps outlined for generating simple objects using Free-Hand Drawing. Start with a short discussion about what the activity is asking and then produce the drawings. Once all group members have finished compare and discuss the drawings.

Remember to show the sequence of each drawing's development.

Square-Based Objects

- Draw a square to represent a TV or computer screen.
- Sketch a crumpled square-based box to represent a package or container, with uneven lines to capture the folds and texture.

Cylindrical Objects

- Draw a cylinder to depict a water bottle or vase, showing the curves as they connect the top and bottom.
- Sketch a cylinder-based body as the main structure for a simple robot or animal.
- Draw a slightly flattened cylinder to represent a pencil or pen holder, focusing on the subtle taper at the edges.

Triangle-Based Objects

- Draw a distorted triangle to represent a kitchen knife holder, emphasizing the shape's unique angles.
- Create a triangle-based shape for a cloth hanger, with a slightly warped form.
- Draw a triangular doorknob with a distorted shape for added character.

Circular Objects

- Draw a simple circle for an item of outdoor furniture, such as a round stool or table.
- Sketch a twisted elliptical shape to represent a milk container with a curved form.
- Draw a coiled circle shape for a flower holder, with spiral lines for added detail.

UNIT 3: PATTERN DESIGN

CONCEPTUAL DRAWING

Pattern Design

INTRODUCTION

In this section you will learn how to use appropriate drawing materials and tools to create 2-dimensional free hand-drawn templates and patterns

This will involve a structured hand-drawing process taken into consideration complex geometric shapes and thematic ideas to generate multiple sketches. Also, you will learn how to determine dimensions and proportions, and plan your drawing process, and create detailed templates and patterns.

KEY IDEAS

- Complex geometrical shapes and forms are an advanced form of the basic shapes and forms.
- A polygon can be combined with itself or with other complex geometric shapes or forms to create a complex geometric form or shape.
- Both freehand drawings and instrumental drawings can be used to create complex geometric forms and shapes.
- Negative space is the empty area around and between main elements in a design. It helps create balance, draws attention to the main subject, and makes the design easier to look at.
- Positive space refers to the part of a design that includes the main elements, like objects and shapes. It's the area that stands out and draws attention, in contrast to the empty space around it.
- Align means to arrange elements in a straight line or in relation to each other. Good alignment makes a design look organised, improves readability, and creates a cohesive appearance.

ADVANCED FREEHAND DRAWING TECHNIQUES FOR 2-DIMENSIONAL TEMPLATES AND PATTERNS

Freehand drawing is an art form that requires skill, creativity, and precision. Advanced freehand drawing techniques enable artists, designers, and craftsmen to create intricate 2-dimensional templates and patterns with ease and accuracy. This comprehensive guide explores the refined methods and expert strategies for mastering complex freehand drawings, elevating your artistic expression and technical skills. The objective here is to develop expertise in advanced freehand drawing techniques, understand principles of proportion, perspective, and symmetry, and to learn to create intricate templates and patterns. In addition, it is to enhance artistic expression and creativity, as well as to improve precision and accuracy in drawing. The key concepts it covers include geometric patterns, symmetry and tessellations, and perspective and proportion, and it will consider the use of advanced techniques such as pattern repeat and freehand typography, using the basic drawing instruments, and paper, and other surfaces and digital tools where applicable.

Complex Geometric Shapes and Forms

Complex geometric shapes and forms are structures that exhibit intriguing and non-intuitive properties, often with multiple dimensions, symmetries, and relationships. These shapes and forms appear in various aspects of nature, art, and design, and for that matter they are used in fields like engineering, architecture, mathematics, science, art and designs, and other related fields. They possess unique properties and characteristics which are shown in the table below.

Table 1.3.1 Complex geometric shapes and forms

Shape/Form	Description
Self-Similarity	The shape exhibits the same pattern and structure at different scales, like fractals
Non-Convexity	The shape has indentations or curved sections, making it non-convex.
Curvature	The shape has continuous or discrete curvature, like circles or polygons.
Symmetry	The shape exhibits line, rotational, or reflection symmetry
Tessellations	The shape can be divided into smaller, repeating patterns
Fractality	The shape exhibits fractal properties, like self-similarity and scaling
Irregularity	The shape lacks regularity or predictability
Dimensionality	The shape exists in multiple dimensions, like 2-D or 3-D.

Modularity	The shape is composed of smaller, repeating modules
Scaling	The shape exhibits scaling properties, like fractals
Branching	The shape exhibits branching or tree-like structures
Voronoi	The shape is divided into regions based on proximity to points.
Apollonian	The shape is composed of many tangent circles
Mandelbrot	The shape exhibits intricate boundaries and self-similarity
Hyperbolic	The shape exists in hyperbolic space, with constant negative curvature

These properties and characteristics define and describe the unique features of complex geometric shapes and forms, enabling us to understand and work with them in various fields. Complex geometric forms by their nature inspire creativity, innovation, and problem-solving, which results in works which are structurally sound and aesthetically appealing. An example is its application in the design of the innovative structure like The Sydney Opera House, in Australia.



Figure 1.3.1: Sydney Opera House (1973), Sydney, Australia

In engineering, these principles are used to ensure the stability and efficiency of bridges, buildings, and other constructions, such as geodesic domes and the Lotus Temple in New Delhi, India.



Figure 1.3.2 (a): The Montreal Biosphere



Figure 1.3.2 (b): The Adomi Bridge, Ghana



Figure 1.3.3: The Lotus Temple, India

The Montreal Biosphere, formerly the American Pavilion of Expo 67, by R. Buckminster Fuller, on Île Sainte-Hélène, Montreal, Quebec, Canada. https://en.wikipedia.org/wiki/Geodesic_dome#/media/File:Mtl._Biosphere_in_Sept._2004.jpg

Adomi Bridge (1957), Ghana. https://en.wikipedia.org/wiki/Adomi_Bridge#/media/File:Adome_Bridge,_River_Volta,_Ghana.jpg

The Lotus Temple, <http://www.bahaindia.org/temple/> was designed by Fariborz Sahba, an architect from Iran.

In art, geometric shapes inspire compositions, patterns, and visual interest, allowing artists to explore abstract concepts and ideas. An example is M.C. Escher creating intricate tessellations.

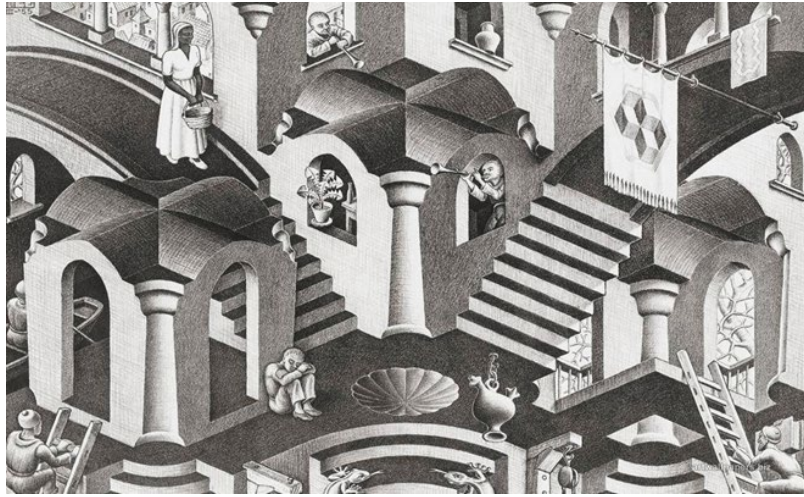


Figure 1.3.4: Maurits Cornelius. Escher |1,937 Artworks at Auction

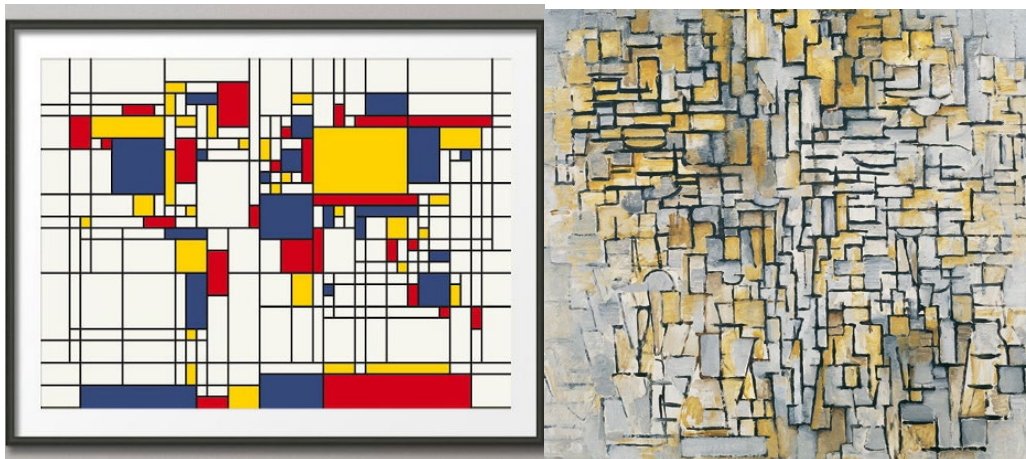
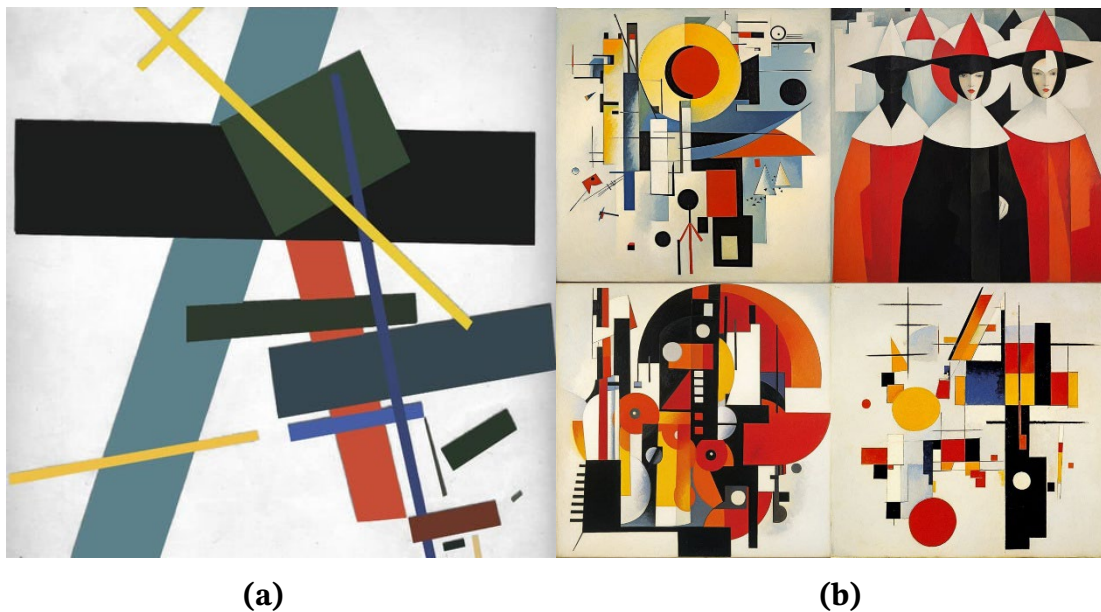


Figure 1.3.5: Abstract World Map in the style of Piet Mondrian Art Print by Michael Tompsett and Piet Mondrian's The Guggenheim Museum



(a)

(b)

Figure 1.3.6 (a): Kazimir Malevich – Suprematism, 1916 – Canvas Prints;

Figure 1.3.6 (b): Kazimir Malevich AI Art Style – Abstract Geometric;

Kazimir Malevich focused on the investigation of pure geometric forms such as squares, triangles and circles, as well as their relationships to each other within the pictorial frame.



(a)



(b)



(c)

Figure 1.3.7 (a): Bauhaus Design: A Guide to Modern Minimalism – Deft

Figure 1.3.7 (b): Bauhaus Brilliance: Illustrated Posters of Modernist

Figure 1.3.7 (c): Bauhaus-Inspired Masterpieces: Architecture Poster



Figure 1.3.8: Josef Hartwig Bauhaus Chess Sets

Josef Hartwig Chess Sets shows typical use of geometric shapes and forms such as cubes/cuboids, cylinders and spheres to form the pieces.

Freehand Drawing of Complex Geometric Shapes and Forms

Freehand drawing of complex geometric shapes and forms is an intricate art form requiring skill, consistent practice, and creativity. By understanding the principles of basic geometry and being familiar with shapes, and practicing basic freehand drawing techniques, you can master the freehand drawing of complex geometric shapes and forms.

The following are a few considerations when working on complex geometric shapes and forms:

1. Use materials and tools, like drawing paper, grid paper, or a sketchbook, and other drawing media such as pencils, pens, and markers suitable for your skill level. Don't forget to include the use of rulers, pair of compasses, and protractors.
2. Begin drawing with basic drawing techniques with straight lines, curves and shading to build good memory.
3. Understand basic geometry and practice repeatedly freehand drawing of basic shapes like circles, triangles, squares, and other polygons focusing on proportion, measurement and scaling.
4. Develop hand-eye coordination through gesture drawing and contour drawing, and master the various line weights, by drawing regularly for improvement.
5. Start drawing with light, rough sketches to map out basic structures, and gradually refine the lines to make them darker and more pleasing.
6. Use isometric and one-point perspective as a guide to practice depth and perspective views. Also break down complex shapes into simpler components.

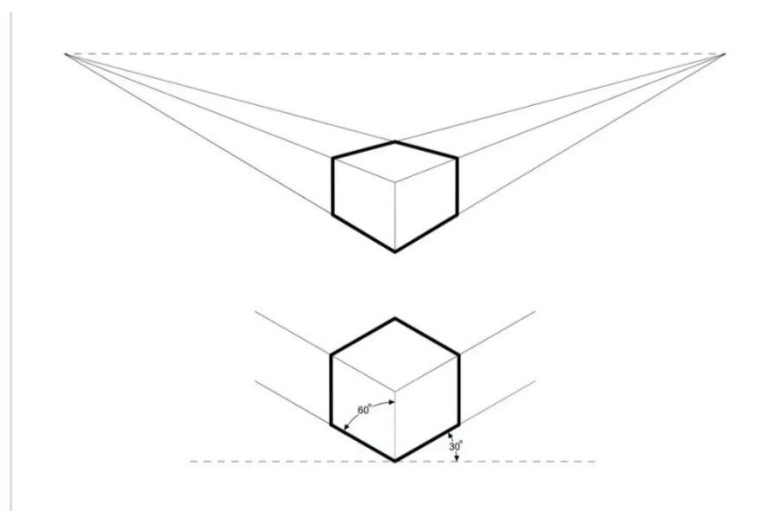


Figure 1.3.9: Isometric and one-point perspective drawing

7. Make your own grid on paper or use a grid paper to ensure alignment and proportions, using it as a guide to maintain balance and symmetry.

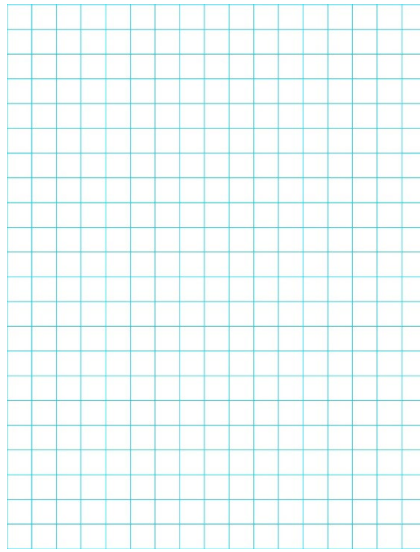


Figure 1.3.10: Square grid paper

8. Make use of symmetry and rotation to create balance and combine basic shapes to get complex designs, through overlapping shapes and new intersections.



Figure 1.3.11: Combined geometric shapes/patterns on grid paper

9. Analyse geometric patterns in nature (flowers, crystals, and honeycomb) and use them as guide to drawing complex geometric shapes and forms.



Figure 1.3.12: Honeycomb and pineapple

10. Keep your practice work in a file or use a sketchbook solely for geometrical drawings.
11. Learn from errors and experiments by discussing works with peers for constructive feedback.
12. Explore artistic styles by looking at the works by artists, architects and designers known for geometric designs, like Bridget Riley, Maurits C. Escher, Sol Lewitt, Paa Joe, Malangatana Ngwenya to imitate their techniques to expand our skills.

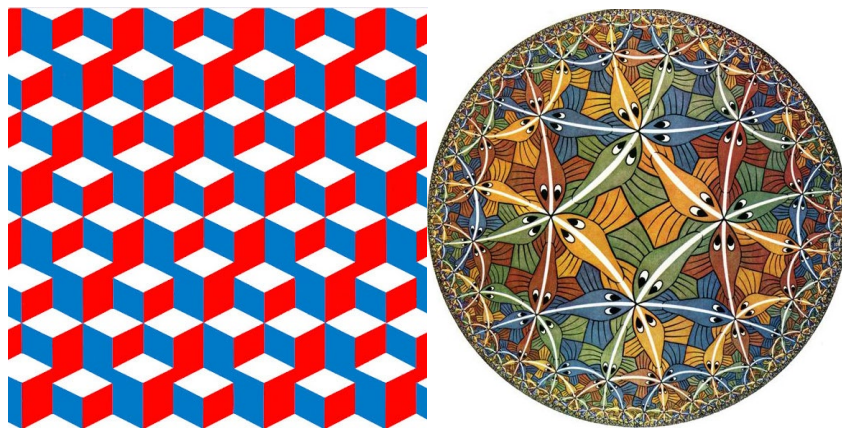


Figure 1.3.13: Bridget Riley –Op-art; Circle Limit III, 1959 – M.C. Escher



Figure 1.3.14: Stunning Building Architecture with Geometric Shape Design – Freshouz Home &Architecture Décor



Figure 1.3.15: The Smithsonian's Black-History Museum, Washington DC

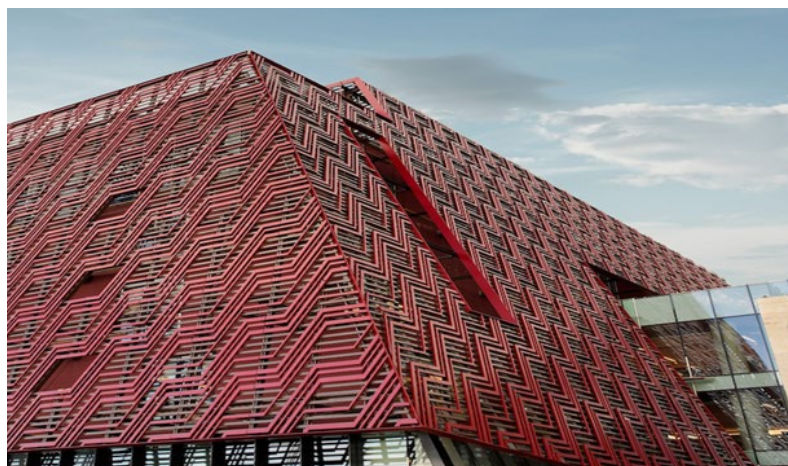


Figure 1.3.16: Garage Museum of Contemporary art in Moscow ...world –renowned architect Sir David Adjaye's work



Figure 1.3.17: African tribal art tradition/Traditional African Fabric Patterns



Figure 1.3.18: Mud House / Modern African Architecture ideas in 2024

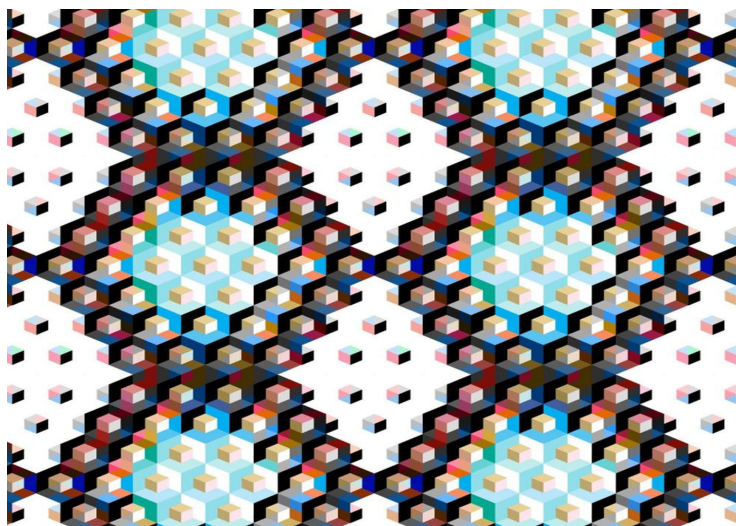


Figure 1.3.19: Complex Isometric Cube Pattern

Creating Templates and Patterns with Complex Geometric Shapes and Forms

Creating stencils and patterns with complex geometric shapes and forms requires some skill and practice when using freehand. Familiarise yourself with various geometric shapes, such as polygons, and spirals, as well as exploring repetitions in tessellations and fractal. Following are some steps to get you started:

1. Select your materials and tools like paper, cardboard, or acetate for creating the stencils, and a drawing tool like a pencil, marker, or pen.
2. Use grid systems to sketch the geometric shape or form freehand, refining it as needed until the desired level of complexity is achieved.

3. Add details and patterns, such as lines, curves, or smaller shapes to enhance the design.
4. Use a craft knife or scissors to cut out the stencil from your chosen material. Test the stencil by tracing or painting through it. Refine the stencil as needed to achieve crisp, clean lines.
5. Use the stencil to create repeating patterns on paper, fabric, or other surfaces. Use reference images or real-life observations to inspire the geometric shapes and forms.
6. Challenge complex geometric freehand skills with increasingly complex designs.
7. Apply complex geometric patterns to art, crafts, such as painting, interior design, or design projects.

FREEHAND DRAWING OF POLYHEDRONS AND COMPLEX GEOMETRICAL PATTERNS IN FRACTALS AND TESSELLATIONS

Freehand drawing of polyhedrons and complex geometric patterns in fractals requires patience, and attention to detail, and practice. By understanding and mastering various geometric patterns, and the principles underlining their making, intricate and visually appealing designs can be created. The following steps illustrate how to approach similar work:

1. Experiment with Polyhedrons

- a. **Study Basic Polyhedrons:** become familiar with the five basic platonic solids, that are tetrahedrons, cubes, octahedrons, dodecahedrons, and icosahedrons, which are the building blocks of polyhedrons.

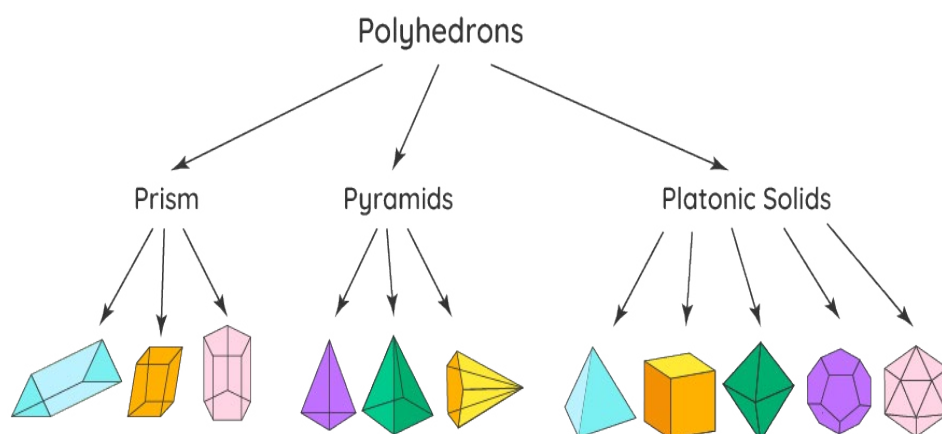


Figure 1.3.20: Basic Polyhedrons

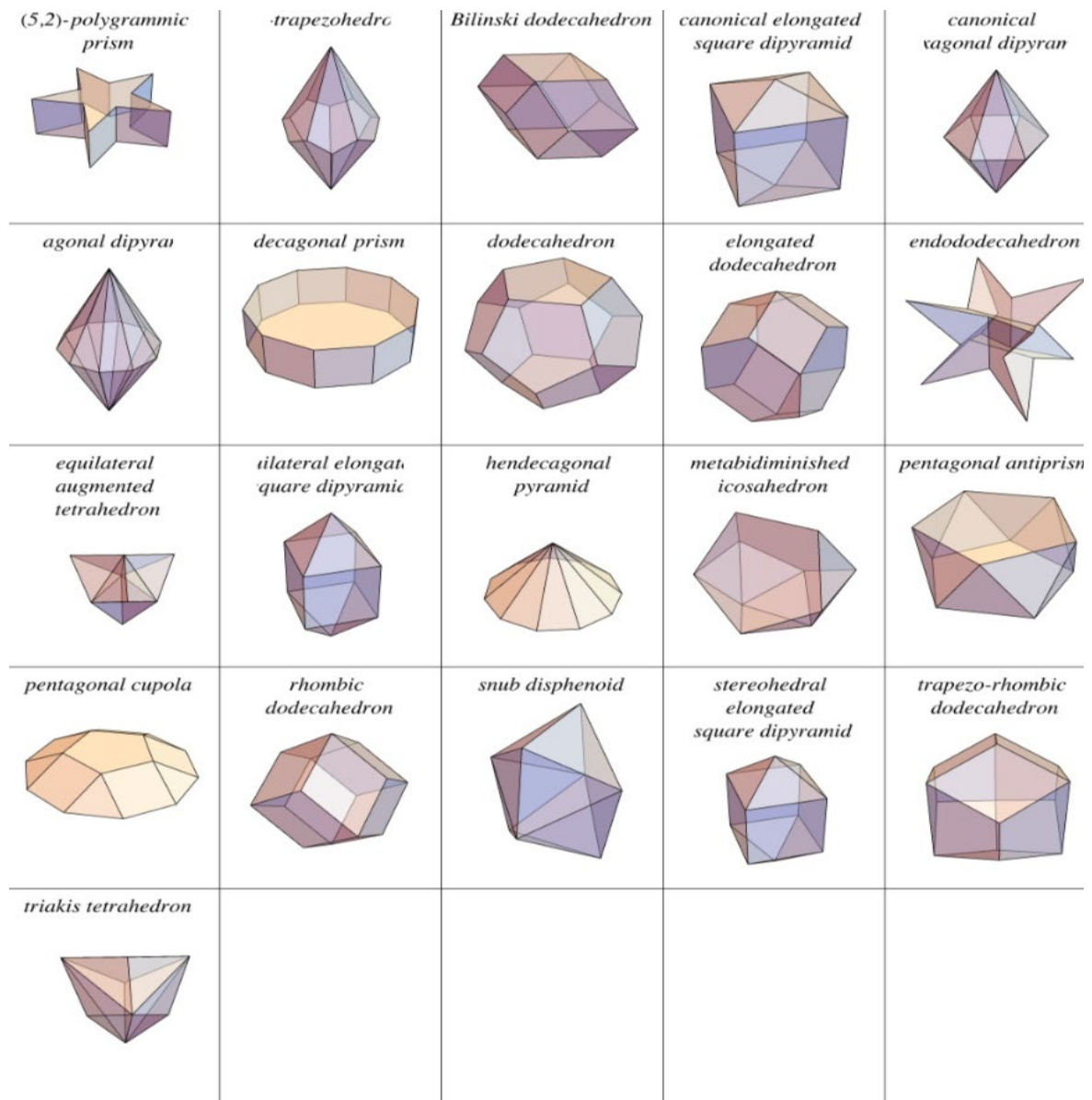


Figure 1.3.21: Dodecahedrons

- b. **Deconstruct Structures:** Break down the polyhedrons into their individual components, such as the number of faces, edges, and vertices, and how they are connected.
- c. **Combine Shapes:** Combine their components to form the whole and complete polyhedron.

2. Explore Fractals with Polyhedrons

- a. **Understand Fractal Patterns:** Study the basic properties of fractals such as self-similarity and scaling and understand how they can be used to create complex patterns.

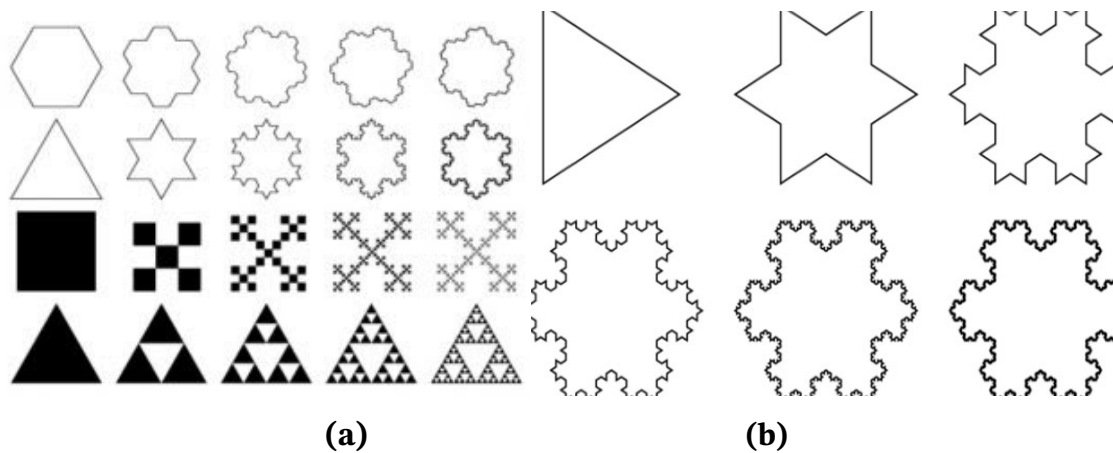


Figure 1.3.22 (a): Fractal Leaf Art <https://lh4.googleusercontent.com/proxy>

Figure 1.3.22 (b): Analysis of Fractals <https://dt5vp8kor0orz.cloudfront.net>

- b. **Draw Simple Fractals:** Start by drawing simple fractals, (e.g., repeating a triangle to form a Sierpinski triangle), or using a polyhedron as the base shape and adding smaller copies of the same shape to create a fractal pattern.

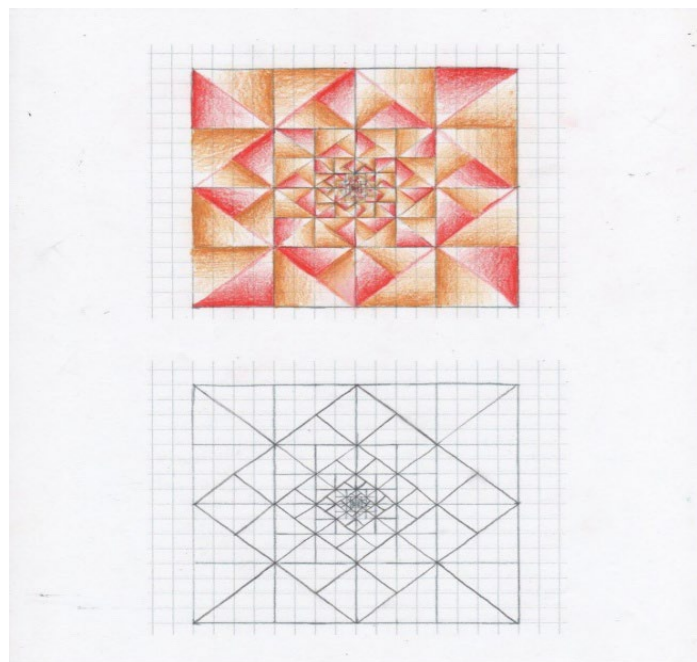


Figure 1.3.23: Fractal Art Design <https://i.pinimg.com/originals/da/59/>

- c. **Increase Complexity:** Add more layers to the fractal pattern, experimenting with different polyhedrons and shapes as the base shape, combining multiple fractal patterns, and exploring different techniques such as rotation, reflection, and scaling, to add more complexity to the fractals.

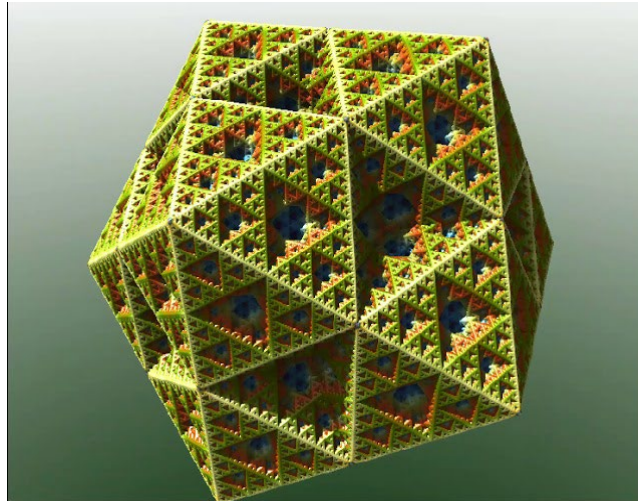


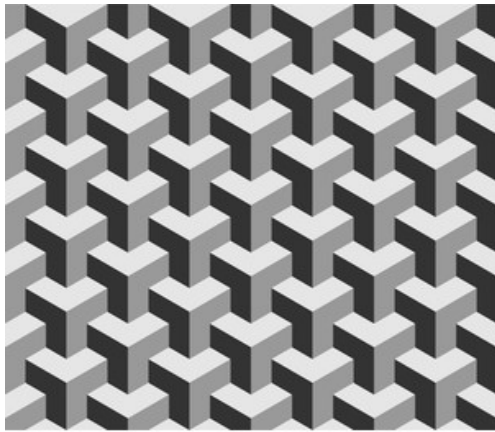
Figure 1.3.24: Sierpinski Icosahedron Fractal



Figure 1.3.25: Fractal Polyhedra

3. Create Polyhedron Tessellations

- a. **Learn Tessellation Basics:** Understand the concept of regular and irregular tessellations, types of tessellations such as periodic and non-periodic, and properties such as symmetry and repetition.
- b. **Experiment with Shapes:** Experiment with different polyhedron shapes to create tessellations by combining regular polyhedrons, irregular polyhedrons, and different shapes to create unique tessellations.



(a)



(b)

Figure 1.3.26 (a): Tessellated Royalty

Figure 1.3.26 (b): Roman Geometric Mosaic

- c. **Combine Shapes and Forms:** Explore more complex tessellations by combining multiple polyhedrons to create larger tessellations, experimenting with mixing 2D and 3D shapes, and creating hybrid tessellations by combining different types of polyhedrons.

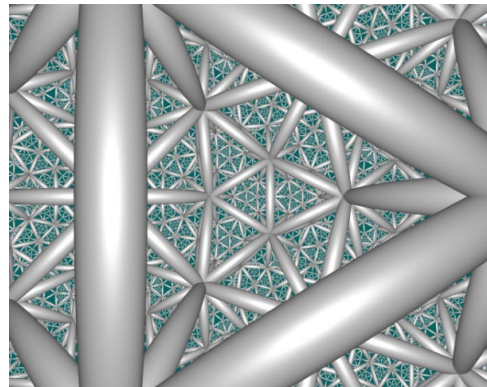
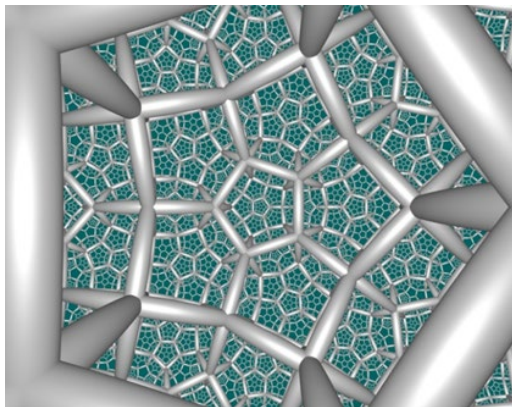


Figure 1.3.27: Icosahedral honeycomb & Dodecahedral honeycomb



Figure 1.3.28: Islamic Geometric Patterns

4. Use Precise Measurements and Angles

- a. **Tools:** Use a ruler to measure lengths, protractor to measure angles, and pair of compasses to draw arcs and circles.
- b. **Angles and sides:** Understand the properties of different geometric shapes, and be familiar the angle types, and recognise their side relationships, to maintain accuracy in the design.

5. Construct Complex Patterns with Freehand Drawing

- a. **Light Sketches:** Start with loose, gentle sketches to visualise the overall pattern.
- b. **Refine and Detail:** Gradually refine the sketch by adding details, paying attention to line quality and shape.

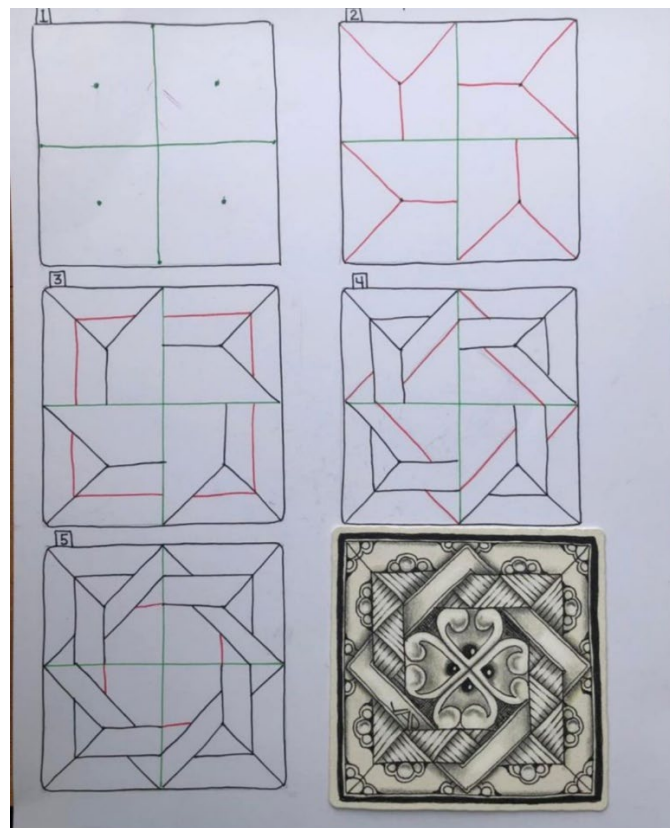


Figure 1.3.29: How to construct a geometric pattern

- c. **Symmetry and Proportions:** Adjust and fine-tune the design to achieve a harmonious balance of symmetry and proportions.

6. Inspiration and Practice

- a. **Study Examples for Practice:** Research and collect examples of patterns of polyhedrons, fractals, and tessellations in art, in manmade and natural objects in the environment for inspiration, and challenge practice.



Figure 1.3.30: Islamic mosaic ceramic tiles

Pattern Morphing and Transformation

Pattern morphing and transformation refer to the process of changing a pattern into a new form while maintaining its essence. This can be achieved through various techniques, including, scaling, rotation, reflection, and translation, which gives rise to dynamic and visually appealing design. This concept is widely used in architecture, fashion, product design, and art and design, and digital art. Understanding and applying these concepts and techniques create innovative and visually stunning designs that push the boundaries of traditional patterns.

Basic Concepts in Pattern Morphing and Transformation

1. **Morphing:** It is a technique used in art, design, and animation to create a smooth transition between two or more different shapes, forms, or images. It involves gradually changing one shape into another, often through a series of intermediate stages, to create a dynamic and fluid visual effect. An example is “Morphic Resonance” by Android Jones (2018) – A digital art piece that morphs different shapes and patterns.

Art & Zentangle • EniOken.com



Figure 1.3.31: Morphing tangles – Eni Oken

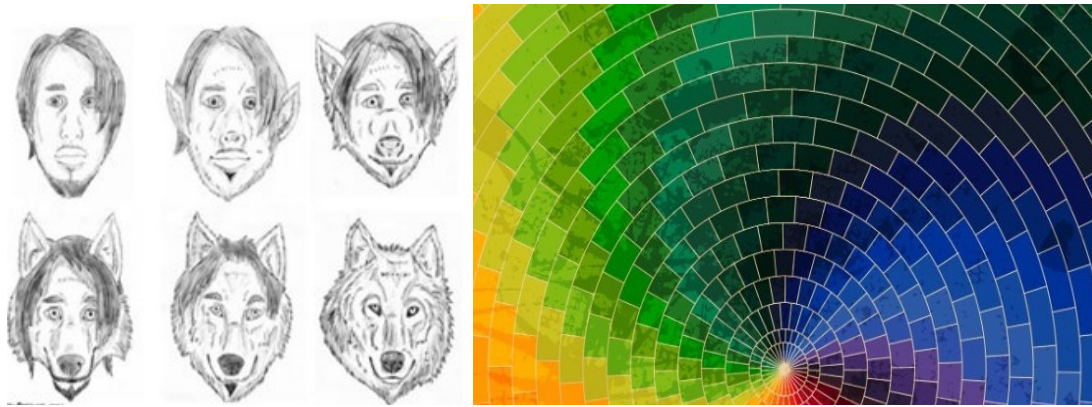


Figure 1.3.32: The notion of morphing

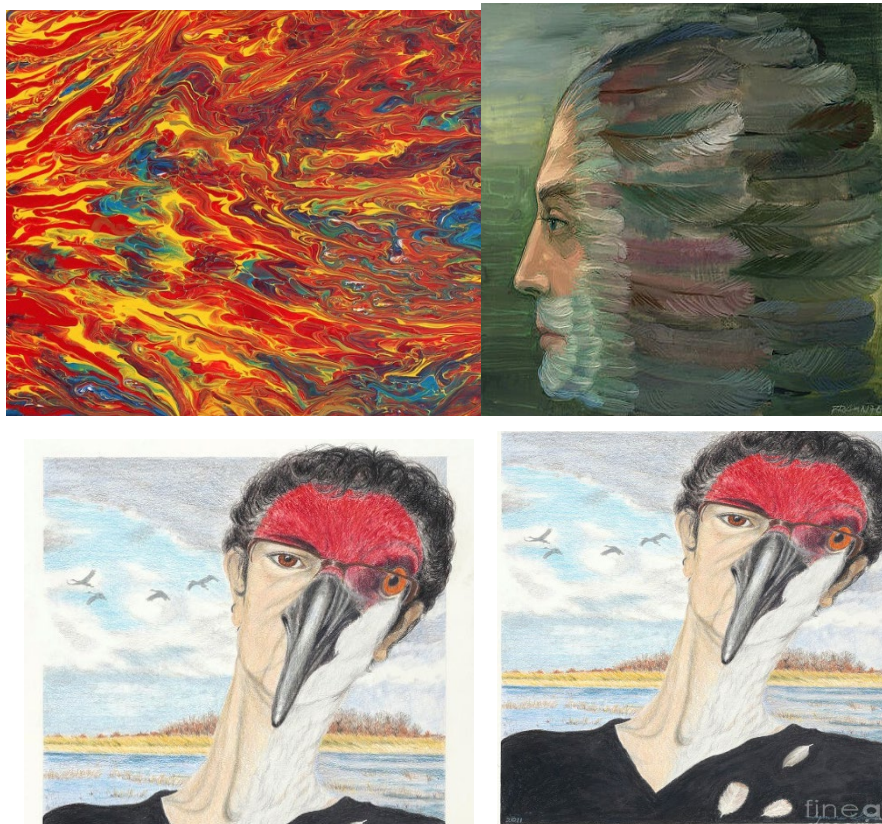


Figure 1.3.33: Morphing paintings

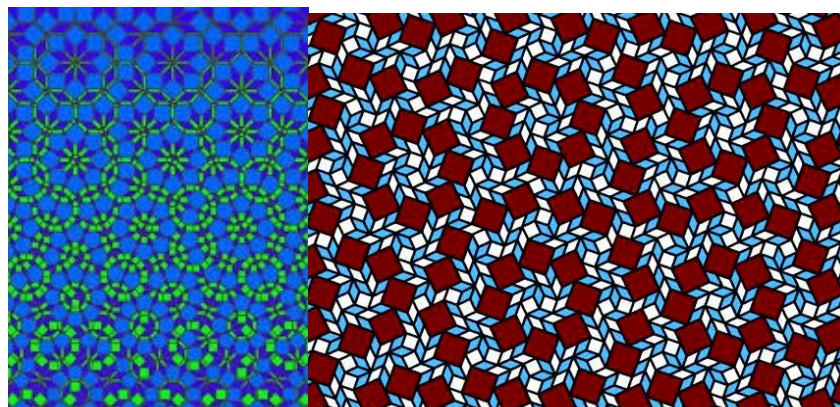


Figure 1.3.34: Morphing the tiling of octagons and squares

2. **Transformation:** In pattern making, transformation refers to the process of changing a pattern or shape into a new form, while maintaining its essential characteristics. This can be done through various techniques, such as scaling, reflection, rotation, distortion, combination and translation.

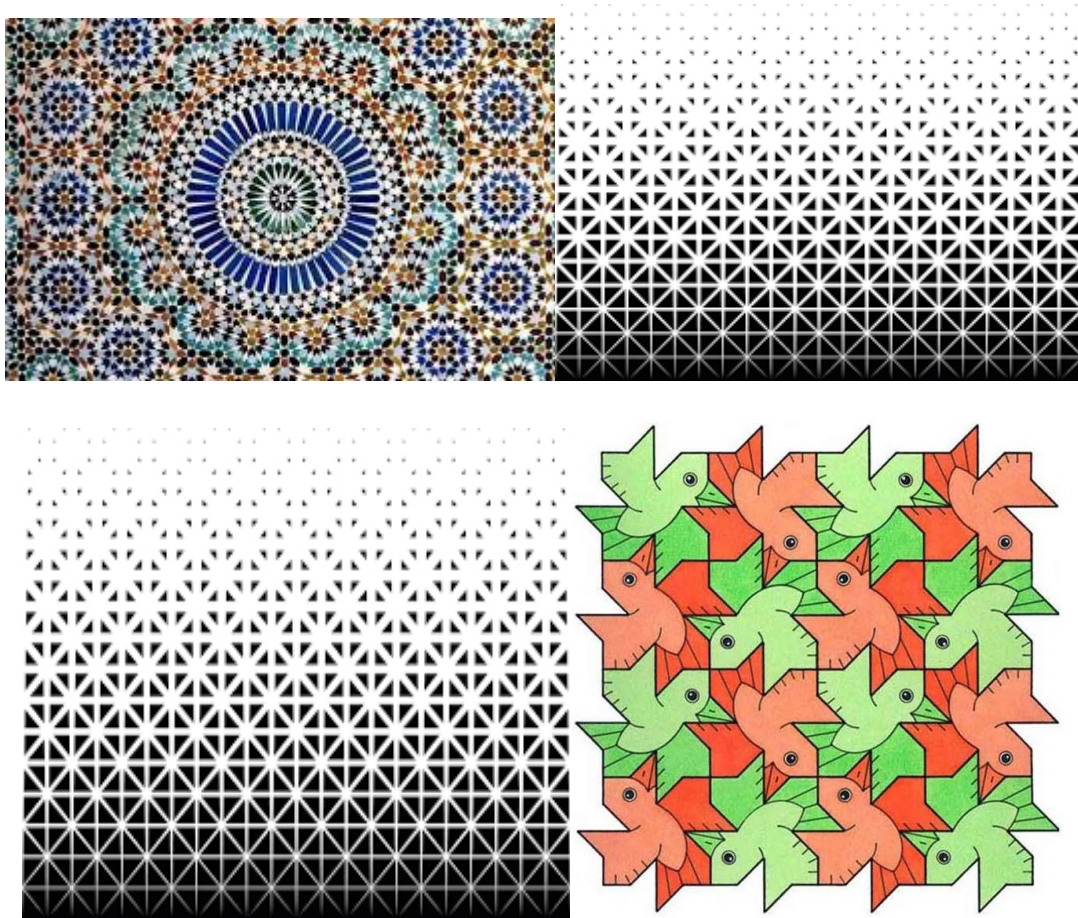


Figure 1.3.35: Transformation artwork

Tools and Techniques

1. **Manual techniques** for pattern transformation include hand drawing and sketching, paper folding and cutting, and tracing and repeating.
2. **Digital techniques** make use of graphic design software such as Adobe Illustrator, Photoshop, Computer-aided design (CAD), or CorelDraw for 2D transformations, while Autodesk Maya, Tinkercad, Blender, SketchUp, or 3ds Max can be used for 3D patterns.
3. **Practical techniques** for gradual transformation include breaking down the process into smaller steps and using techniques such as image scaling and resizing, image rotation and flipping, and image warping and flipping to create intermediate steps between two patterns.
4. **Algorithmic design** refers to the use of well-defined procedure for transforming patterns and involves using code, scripts, or other programming languages to create and manipulate designs.

5. **Dynamic systems** involve the use of kinetic art and responsive design, which create patterns that change with movement or interaction and react to environmental factors like light, sound, or user input.

Applications and Examples

1. Architecture involves transforming façade designs to change appearance, and in interior design, walls can be transformed to change colour, pattern, or texture to create dynamic spaces.



Figure 1.3.36: Dynamic D*Haus turns inside out according to the seasons in eight different configurations.



Figure 1.3.37: Architecture of the Solomon R. Guggenheim Museum

2. Fashion and textiles involve creating fabric designs that change texture, colour, or pattern across the surface and designing wearables with transforming patterns that change with movement or lighting.
3. Digital art and animation involve shape-shifting where objects or creatures are transformed into different forms, while interactive art involves developing digital installations that change based on viewer interaction.
4. Islamic geometric patterns apply geometric transformation such as rotation, reflection, and scaling to create intricate patterns, and mosaic art, where small morphing shapes are used to create larger, intricate patterns.

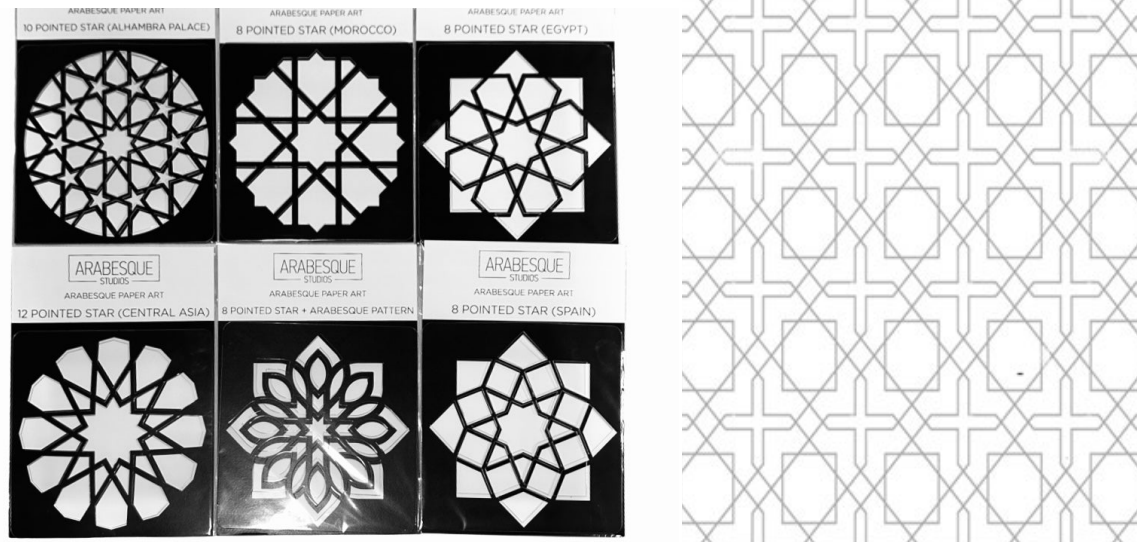
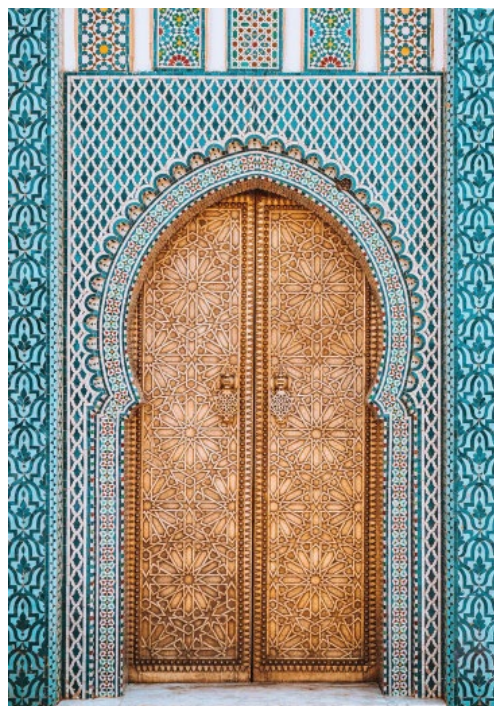


Figure 1.3.38: Islamic geometric patterns



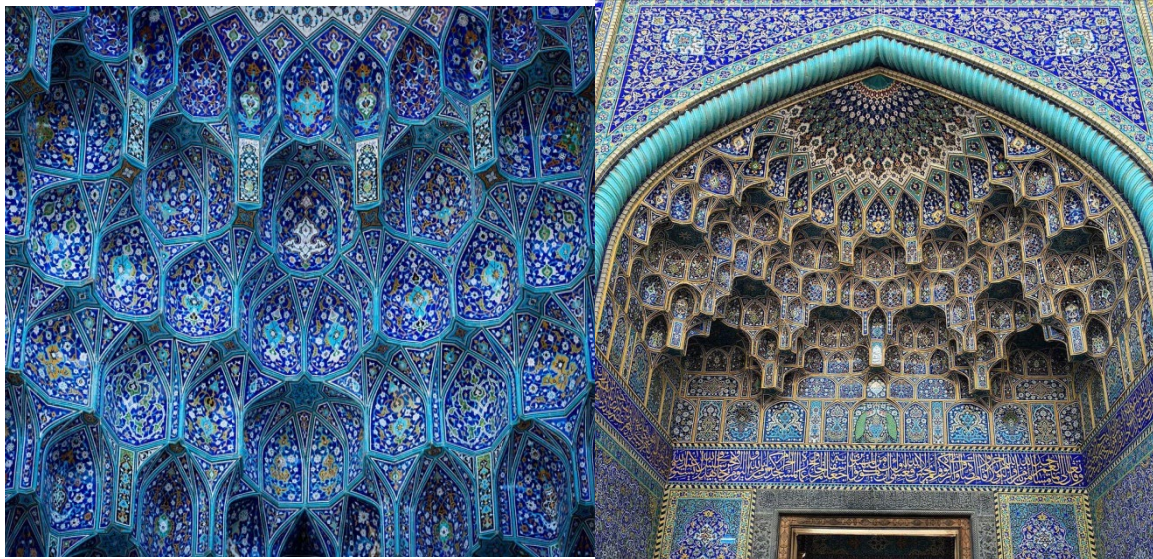
(a)



(b)

Figure 1.3.39 (a): Iron gate with 10-point stars and kite at Al-Rifa'i Mosque, Cairo (1869-1912)

Figure 1.3.39 (b): Mosque gate door entrance



(a)

(b)

Figure 1.3.40 (a): The Stunning Beauty of Islamic Geometry,

Figure 1.3.40 (b): Blue Islamic Architecture

5. Contemporary architecture: Architects like Zaha Hadid and Frank Gehry incorporate complex geometric transformations in their designs.



(a)

(b)

Figure 1.3.41 (a): Nanjing International Youth Cultural Centre by Zaha Hadid

Figure 1.3.41 (b): Boko Masterplan by Zaha Hadid Architects



Figure 1.3.42: Frank Gehry-most influential architects of the 20th century: Frank Gehry

6. Interior decoration involves shape-memory materials which incorporates materials that can change shape in response to temperature or light.
7. Digital art installations employ morphing and transformation.

Activity 1.3.1 Design a Secret Garden

Organise yourselves into groups of 5. In your group discuss points 1 to 5 below Identify which tools and materials you will need and then start working on the series of drawings. Agree in your group which sketches came out best and why.

Scenario

You are a young artist tasked with creating a series of 2-dimensional free hand-drawn geometric templates and patterns for a new stationery collection inspired by a secret garden. The collection should feature hidden pathways, mystical creatures, and attractive flowers.

Consider the following:

1. Set up a workspace with various materials and tools.
2. Spend 10-15 minutes experimenting with different small freehand drawing ideas, exploring various materials and tools.
3. Create a series of small sketches, each featuring a different element of the secret garden (e.g., a hidden pathway, a mystical creature, an attractive flower).
4. Evaluate your sketches, considering which materials and tools worked best for each element.
5. Select the most promising materials and tools to develop your 2-dimensional freehand-drawn geometric templates and patterns.

APPROPRIATE DIMENSIONS FOR FREEHAND DRAWING TECHNIQUES FOR 2-DIMENSIONAL TEMPLATES AND PATTERNS

This section focuses on developing 2-dimensional freehand-drawn templates and patterns. It encourages collaborative and problem-based learning. You will tackle complex geometric shapes and themes, selecting appropriate materials and tools, establishing a drawing framework, and producing intricate designs. The structured process includes brainstorming for creative shapes and themes, sketching multiple drafts, setting dimensions and proportions, planning each step, and crafting detailed templates and patterns.

Negative Space in Complex Geometric Template and Pattern Design

Negative space refers to the empty areas surrounding an object, which helps define its meaning and purpose. This space surrounds and separates subjects in an image, outlining the positive space. Artists like M.C. Escher demonstrate the effective use of negative space, making it a vital part of their designs. To successfully incorporate negative space in hand-drawn templates and complex geometric patterns, careful planning, precise measurements, and diligent execution are crucial for achieving balance in your artwork. By thoughtfully organizing your approach, you can create intricate and harmonious hand-drawn geometric designs that are visually compelling and innovative.

The design process often starts with rough ideas to explore how negative space interacts with geometric shapes. The goal is to balance positive and negative space for visual stability and to identify key areas that contribute to harmony and balance in the overall design.

Appropriate Dimensions for Freehand Drawing Techniques for 2-Dimensional Templates and Patterns

Understanding the right dimensions for freehand drawing techniques is crucial for creating effective 2-dimensional templates and patterns. This knowledge helps artists manage proportions, scale, and space, allowing them to create visually appealing designs. By mastering these dimensions, artists can boost their creativity and ensure their work connects with viewers. This guide will offer insights and techniques to help develop striking and well-structured 2-dimensional compositions.

Examples

1. **Traditional African Patterns:** Look at traditional African geometric patterns, which often use negative space to create rhythm and balance, e.g. Kente, and Ndebele Geometric wall designs.





Figure 1.3.43: Asante Kente cloth, 20th century, silk and cotton



Figure 1.3.44: Esther Mahlangu releases her second one-of-a-kind Ndebele-inspired design for BMW

2. **Sophie Taeuber-Arp:** A Dada artist known for her abstract and geometric designs, Taeuber-Arp skilfully used negative space to create balanced and harmonious compositions.

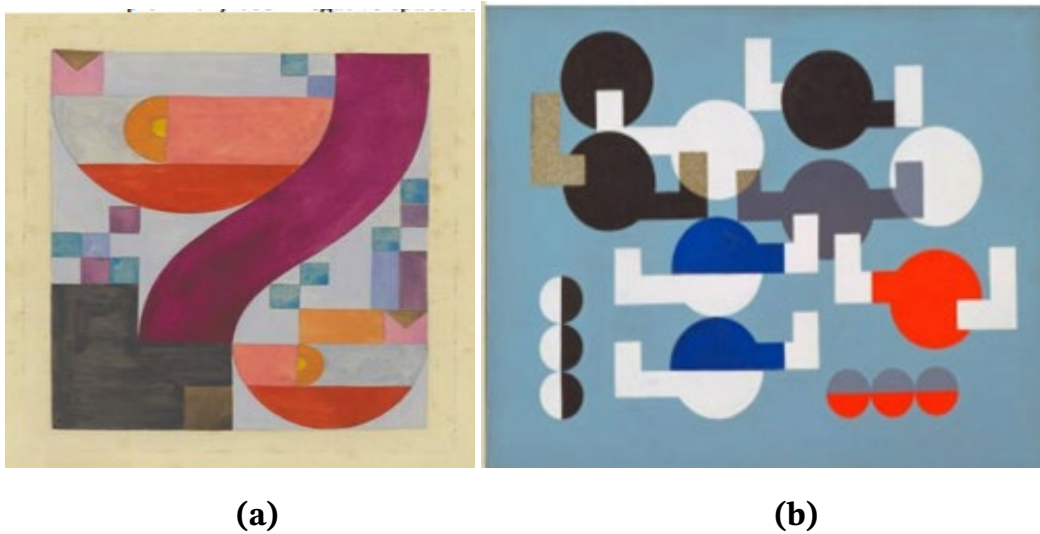


Figure 1.3.45 (a): Various elements in vertical-horizontal composition, 1918

Figure 1.3.46 (b): Composition of Circles and Overlapping Angles, 1930

3. **Bridget Riley:** A key figure in Op Art, Riley used negative space in her black-and-white and colourful geometric patterns to create a sense of movement and depth.

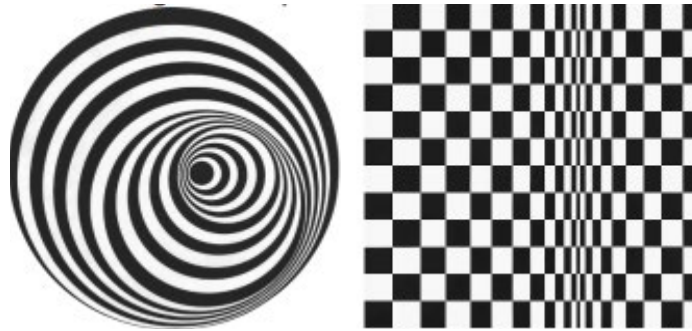


Figure 1.3.47 (a): Uneasy Centre, 1963

Figure 1.3.47(b): Bridget Riley, Movement in Squares, 1961

4. **Josef Albers:** Known for his series "Homage to the Square," Albers explored the interaction of colours and geometric shapes, often using negative space to enhance the visual impact of his work.



Figure 1.3.48: Josef Albers, Homage to Squares

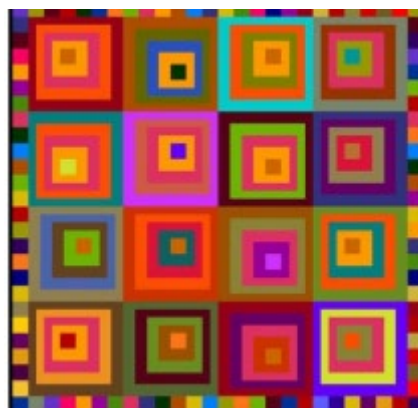


Figure 1.3.49: Quilt-Addicts, Pre-cut Quilt Kit

Activity 1.3.2

Your teacher will place you in groups of 5. The following guidance provides steps on how to employ negative spaces in template and pattern design effectively. Discuss the activity first and then continue to work with and support each other to create the finished products.

Step 1: Planning

1. Conceptualise Design:

- a. Brainstorm about the theme and purpose of the design (to create templates and patterns with complex geometric shapes and forms) and how negative space can be used to harmonise the composition.
- b. Sketch rough design ideas to explore various ways of incorporating negative spaces between and around the geometric shapes.

2. Positive and Negative Spaces:

- a. Decide and define which areas and parts of the design will be positive space (the complex geometric shapes) and which will be negative space (the background or empty areas between and around the shapes).
- b. Create a balance between positive and negative space, knowing that the negative space (around and between) is as important as the positive space (shapes or objects).

3. Measuring Tools:

- a. Use grid paper or create a grid to help measure and accurately align your geometric shapes.
- b. Tools needed include rulers, pairs of compasses, protractors, and pencils for precise measurements and good registration.

4. Determine Proportions:

- a. Scale, Size and Proportion: Decide on the scale and size of the work and the proportions of the shapes with the overall design.
- b. Measure Distances: Use a grid to measure the distances between shapes and consistency in spacing. Where plain paper is used, rulers and protractors could be used.

Step 2: Using Negative Space

1. Draw the Outline

- a. Shapes: Draw the outlines of your geometric shapes, considering the negative space.
- b. Adjustments: Adjust the positions and sizes of the shapes to optimise negative spaces.

2. Create Patterns

- a. Pattern Integration: Use negative space to create patterns that complement the shapes and design.

- b. **Symmetry and Repetition:** Align the shapes and negative spaces to incorporate symmetry and repetition to create a cohesive design.

Step 3

Execution

1. Detailed Drawing

- a. **Add Details:** Ensure that details are added to both positive and negative spaces after assembling the basic shapes.
- b. **Refine Edges:** Create clean and precise edges for the shapes.

2. Balance and Contrast

- a. **Contrast:** Use different shading techniques, colours, or line weights to create contrast between positive and negative spaces.
- b. **Balance Elements:** Ensure that negative spaces balance well with positive spaces and also guide viewers through the design.

Step 4: Final Steps

1. Review and Refine

- a. **Review:** Take a step back and look at the design from a distance to see how the negative and positive spaces interact in real-time.
- b. **Make Adjustments:** Refine the design by making necessary changes where appropriate to improve balance and harmony.

2. Finalise the Design

- a. **Ink or Shade:** Use ink or selected shading techniques to complete the design by creating a distinction between positive and negative spaces.
- b. **Clean Up:** Erase all unnecessary pencil marks and smudges and clean up the edges to ensure a clean final work.

Note these

- **Symmetry and Asymmetry:** Experiment with both symmetrical and asymmetrical designs to see how negative space can create different visual effects in the same project.
- **Layering:** Consider layering shapes and forms to create depth and complexity, using negative space to separate the layers.
- **Textures:** Use different textures in the negative space to add contrast and dimension to the design.

APPROPRIATE FREEHAND DRAWN 2-DIMENSIONAL TEMPLATES AND PATTERNS

Pattern Layering and Interplay

Pattern Layering and **Interplay** are powerful design techniques widely used across fields like technical drawing, graphic design, textiles, and architecture. Here is how each one contributes to design:

Pattern Layering: This technique involves stacking or arranging multiple patterns on top of each other. Each layer brings added depth, complexity, and visual interest to a design. In technical drawing, pattern layering can distinguish materials or object parts by applying unique textures to each layer. This builds a rich, layered visual that helps communicate the object's structure and intended appearance.

Pattern Interplay: This is about how different patterns interact or relate within a design. Interplay can enhance contrast, create harmony, or introduce rhythm in the visual composition. In technical drawing, interplay helps show the relationships between components, surfaces, or textures, aiding viewers in understanding how different parts fit together or function.



Figure 1.3.50

Here is an illustration that captures the concept of pattern layering and interplay, using geometric shapes and intricate patterns to showcase depth, contrast, and balance. The image integrates tools and techniques that reflect the design process in a visually complex and balanced layout.

Free hand-drawn pattern layering and interplay of complex geometric shapes and forms

Freehand drawing allows for the creation of intricate and dynamic designs by combining and overlapping patterns and shapes without using any guiding tools. Mastering the necessary concepts and techniques enables you to develop unique, complex geometric forms and shapes, resulting in visually engaging and detailed designs. This approach fosters creativity and builds confidence in drawing skills.

Concepts in pattern layering and interplay include:

1. Foundation Shapes:

- a. Base Geometry: Begin with fundamental geometric shapes like circles, triangles, squares, and hexagons.
- b. Accuracy: Ensure precision in drawing these shapes to maintain consistency and harmony.

2. Layering Patterns:

- a. Basic Patterns: Employ simple patterns like lines, dots, and grids.
- b. Complex Motifs: Use complex patterns such as waves, spirals, and tessellations over the base shapes.

3. Interplay of Shapes:

- a. Overlapping: Play around with overlapping shapes to create new forms and intersections.
- b. Negative Space: Use negative space to define and highlight the interplay between shapes and patterns.

4. Symmetry and Balance:

- a. Symmetrical Designs: Use radial, bilateral, or rotational symmetry to organise elements.
- b. Balanced Composition: Ensure the distribution of shapes and patterns is balanced to create a cohesive design.

5. Contrast and Texture:

- a. Contrasting Elements: Use contrasting colours, patterns, and textures to create visual interest.
- b. Texture Variations: Use different shading techniques and line weights to add depth and dimension.

Examples:

1. **M.C. Escher:** M.C. Escher, renowned for his mathematically inspired artworks, employed complex geometric shapes and negative spaces to create interesting visual effects. His "Metamorphosis" series shows interlocking forms, demonstrating his mathematical precision and ability to create complex visual interplays.



Figure 1.3.51: Escher, 1/14 Day and Night, 1938

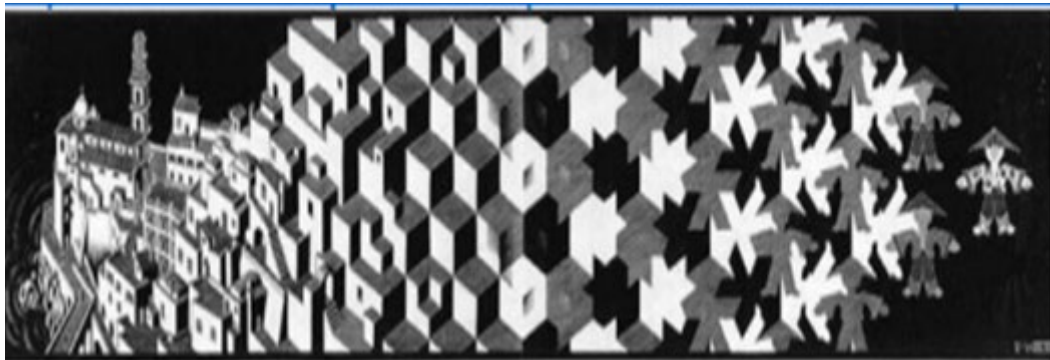


Figure 1.3.52: Escher, Metamorphosis I



Figure 1.3.53: Escher, Metamorphosis II

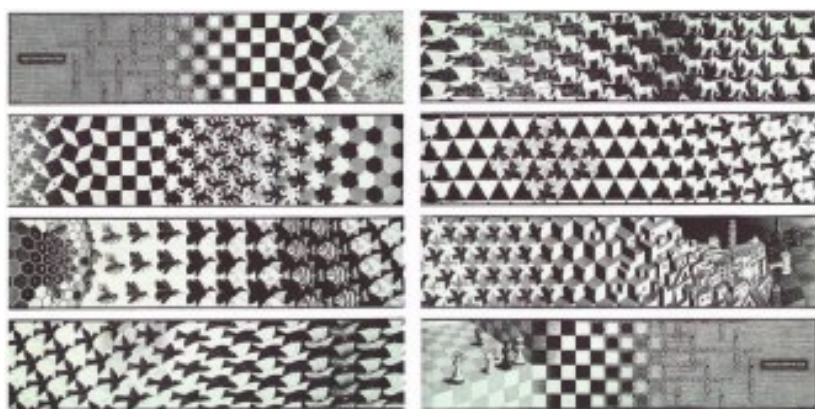


Figure 1.3.54: Escher, Metamorphosis III (1967-1968)

2. **Islamic Art:** Islamic art often features intricate geometric patterns, layered with intricate tilework and calligraphy. Examples include Alhambra's tilework, which features elaborate geometric designs layered with symmetrical patterns, showcasing the complex interplay of shapes and negative space in Islamic art.



Figure 1.3.55: Alhambra-tilework

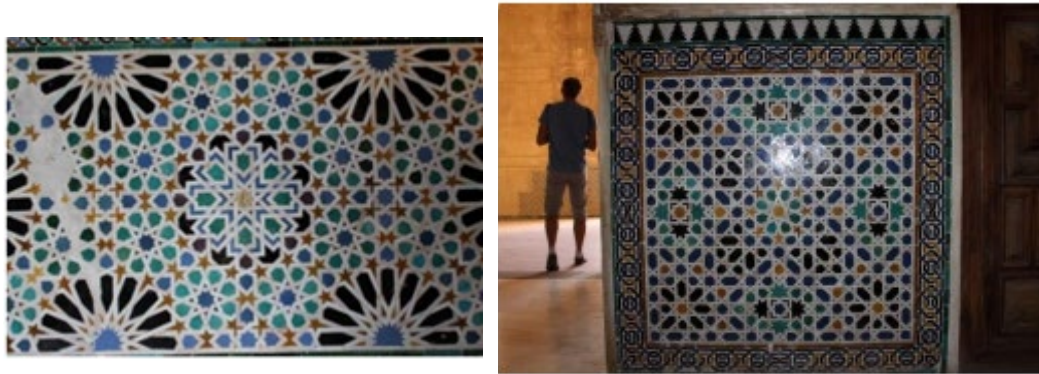


Figure 1.3.56: Detail 1&2

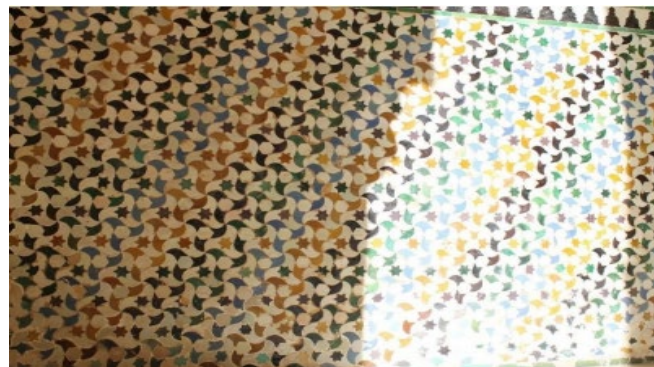


Figure 1.3.57: Detail 3

3. **Op Art:** Artists like Bridget Riley and Victor Vasarely employ geometric shapes and patterns to create optical illusions, highlighting the interplay between foreground and background. Riley's work, like "Movement in Squares," demonstrates the use of repetitive patterns and geometric shapes to create dynamic visual effects.

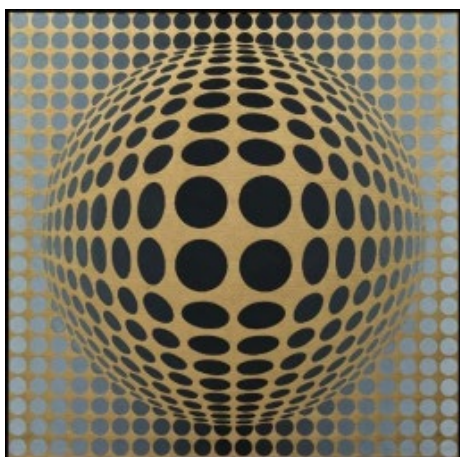


Figure 1.3.58: Victor Vasarely. Vega-Or, 1969

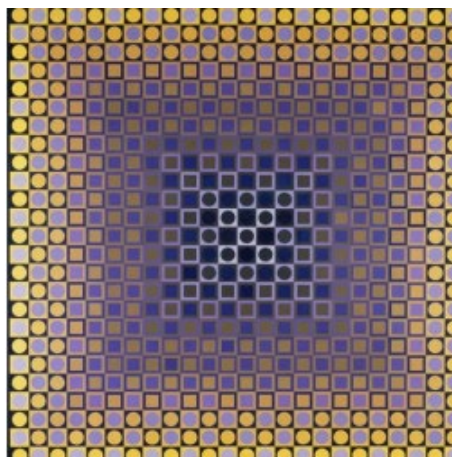


Figure 1.3.59: Victor Vasarely. Vega-Or, 1969

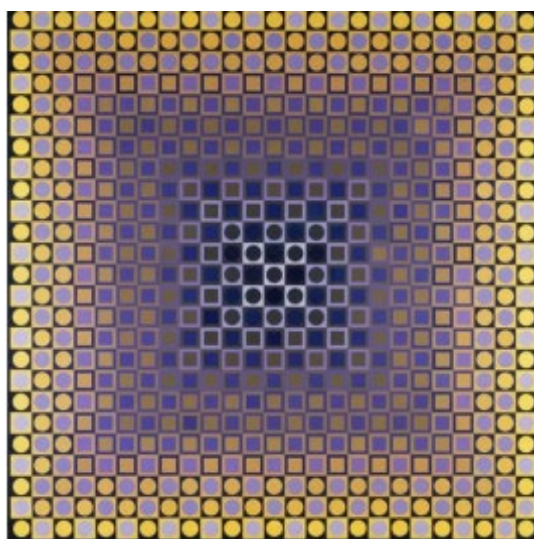


Figure 1.3.60: Victor Vasarely, Dream, 1966

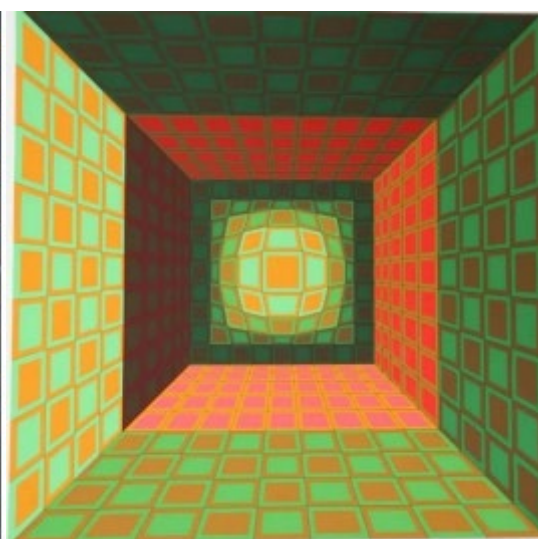


Figure 1.3.61: Green and orange composition, 1980

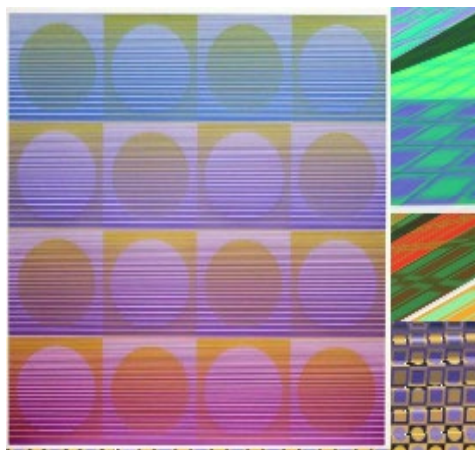


Figure 1.3.62: Carlo Crus Dees, Psychichromie 508, 1970

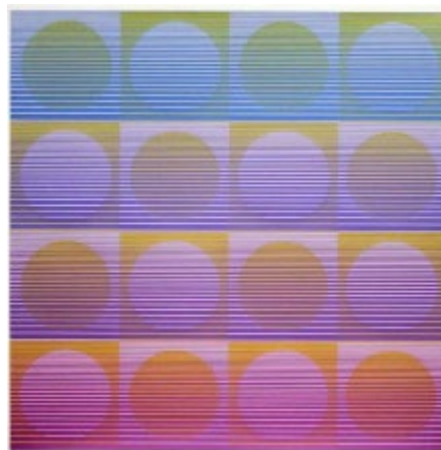


Figure 1.3.63: Julian Stanchak, Antenna, 1971

TEMPLATES AND PATTERNS OVERLAYS, TRANSPARENCIES AND OPACITIES WITH COMPLEX GEOMETRIC SHAPES AND FORMS

Overlaying complex motifs with varying opacities and textures involves combining design elements in steps to create complex, visually engaging designs that use intricate motifs, varying opacities, and textures to produce dynamic and compelling visual interplay.



Figure 1.3.64: Pattern



Figure 1.3.65: Clothing Pattern

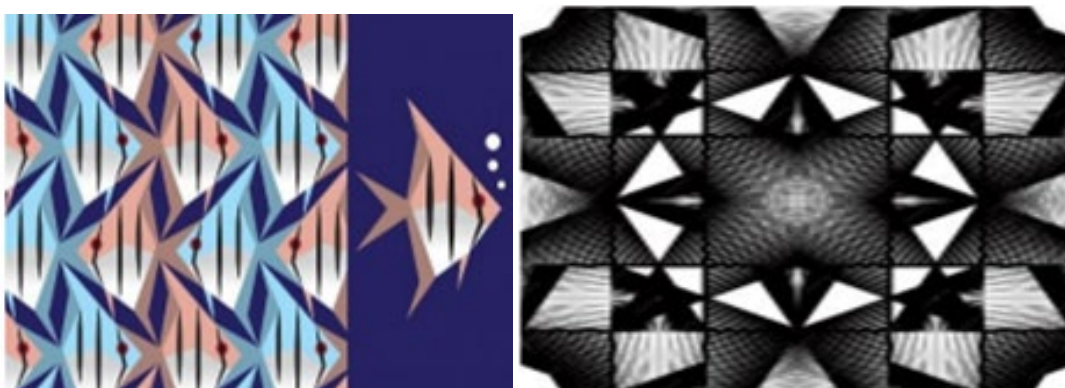


Figure 1.3.66: Angelfish

Activity 1.3.4

Your teacher will place you in groups of 5. You will discuss and produce a geometric design using pattern layering, refinement, and various tools effectively. As a group you will present your work to class for other's comments.

Use the following steps

Step 1: Planning and Sketching

1. **Initial Sketches:** Start with quick, rough sketches to plan your design and decide where each shape will go.
2. **Refine:** Gradually improve your sketch by adding layers of patterns and adjusting sizes to achieve the look you want.

Step 2: Layering Techniques

1. **Layer Patterns:** Add patterns in layers, one at a time, ensuring each new layer complements the last.
2. **Overlap Carefully:** Overlap shapes and patterns selectively to keep the design interesting without making it too busy.

Step 3: Using Tools

1. **Manual Tools:** Use rulers, compasses, and protractors for accurate measurements, and try different pens and pencils for unique textures and colours.
2. **Digital Tools:** Experiment with digital software if available for easy adjustments and precise pattern placement.

Step 4: Analyse and Improve

1. **Check Regularly:** Step back often to check if your design looks balanced and makes sense.
2. **Repeat and Adjust:** Adjust as needed, refining your design with each pass to create a polished final piece.

Note these

- **Use Grids:** Always start with a grid layout to ensure accuracy and alignment in your geometric shapes and patterns.
- **Explore Different Tools:** Experiment with various drawing tools like pens, pencils, and markers to achieve different textures and line qualities.
- **Digital Tools:** Utilise digital tools and software for more complex and precise pattern layering to create layers and interplays of complex geometric shapes and forms for study and inspiration.
- **Study Existing Designs:** Analyse existing artworks that employ pattern layering and geometric forms to understand their structure and techniques.

Activity 1.3.5

Remaining in your groups, discuss and use the guidelines below to create a layered effect and ensure that each layer aligns and contributes to the overall structure.

1. **Gather Materials:** Get tracing paper, pencils, paints, sponges, scissors, glue, and a base paper or canvas.
2. **Create Motifs:** Draw or choose simple shapes and patterns you like.
3. **Prepare Your Base:** Set up your base paper or canvas for your design.
4. **Add Layers with Opacity:** Use tracing paper to layer motifs on your base, varying the opacity by using lighter shades or diluted paints.
5. **Add Texture:** Try sponges, textured paper, or different strokes to create depth.
6. **Use Transparent Layers:** Layer with tracing paper or sheer fabric or use light washes of colour.
7. **Overlap Elements:** Place motifs over each other, letting some areas show through.
8. **Create Moiré Effects:** Overlay patterned materials at angles to create interesting visual effects.
9. **Fine-Tune:** Adjust the layers, textures, and opacity until you're happy with the result.

Note these

- **Experimentation:** Try different combinations of motifs, textures, transparency, and opacities.
- **Balance:** Maintain a balance between complexity and clarity to ensure acceptable design.
- **Consistency:** Ensure that the motifs and textures have a cohesive style or theme.

EXTENDED READING

- Oberlin, C., (2017), Geometric Patterns and Designs, Thames & Hudson
- Ruziicka, J.H., (2014), The Art of Geometric Patterns, Dover Publications
- Stevens, P.S., (2017), Geometric patterns in Nature, Cambridge University Press
- Wade, D., (2019), The Art of Islamic Pattern, Laurence King Publishing

UNIT 4: DESIGN AND REALISATION

CONCEPTUAL DRAWING

Design and Realisation

INTRODUCTION

In this unit, you will study the principles of design, focusing on creating comprehensive solutions. You will examine and produce exploded views of your final design, which illustrate how individual components fit together. This is particularly useful, as many machines and objects are disassembled for ease of transport and assembly.

Additionally, you will create precise and detailed working drawings that provide clear instructions on constructing your project. Emphasis will be placed on accuracy in measurements and the correct use of drawing instruments to ensure a professional standard of work.

KEY IDEAS

- An exploded view, also called an exploded display or diagram, visually represents an object or system in a disassembled state.
- A working drawing is a detailed and precise technical drawing that conveys all necessary information for constructing, fabricating, assembling, or manufacturing a product or structure

EXPLODED VIEW

Creating exploded views of the final design is an important part of Design Technology and documentation, especially in fields like engineering, architecture, product design, and manufacturing. An exploded view, also called an exploded display or diagram, visually represents an object or system in a disassembled state. It displays each component separately but in relation to the whole, helping viewers understand how parts fit together within the overall structure.

Purpose of Exploded Views

An exploded view is designed to clearly show how parts of an object come together. By arranging the components separately but logically, it lets viewers see how each piece contributes to and interacts within the whole structure. This approach is especially useful for visualising complex mechanisms like engines, machinery, or electronics.

Principles of Exploded Drawing

1. **Documentation:** Exploded views are often included in technical drawings and design documentation to complement other views like orthographic projections and detailed views, offering a complete representation of the design.
2. **Clarity and Understanding:** An exploded view separates components to show how each part relates to the whole assembly, providing clarity on how parts contribute and interact. This helps designers, engineers, and manufacturers better understand the assembly process.
3. **Assembly Instructions:** An exploded view guides assembly technicians and manufacturers by clearly showing the order, orientation, and steps for assembly and disassembly. This minimises errors and ensures the final product is assembled accurately.
4. **Communication Tool:** Exploded views are powerful communication tools that bridge the gap between designers, engineers, clients, and stakeholders. They enhance discussions around design decisions, modifications, and improvements by visually representing the assembly in a clear and accessible way.

Benefits of Exploded Views

Exploded views are useful tools that clearly show how parts fit together in complex systems. They enhance understanding and communication. Here are some key benefits of using exploded views.

1. **Clarity and Visualisation:** Exploded diagrams provide a clear visual representation of components and their arrangement within a complex system or product. This clarity helps engineers, technicians, and users understand the structure and function of the system, making it easier to identify and locate specific parts.
2. **Guidance for Assembly and Disassembly:** These diagrams facilitate the assembly and disassembly processes by offering a step-by-step breakdown of components. They serve as a reliable guide for technicians and users, ensuring accurate and efficient assembly or disassembly of the product.
3. **Enhanced Communication and Collaboration:** Exploded diagrams improve communication and collaboration among different teams or departments. They act as a common language that enables engineers, designers, and manufacturers to effectively share ideas and requirements.
4. **Educational and Training Tools:** In the field of education and training, exploded diagrams are valuable teaching tools that explain the inner workings of a system or product. They help grasp complex concepts and enhance their practical skills.

Steps for producing Effective Exploded Drawing

1. **Initial Assembly Drawing:** Begin with a comprehensive assembly drawing that displays all components in their assembled state. This drawing serves as the foundation for creating the exploded view.
2. **Component Separation:** Identify each part within the assembly and analyse how they are interconnected.



3. **Exploded Representation:** Following standard drafting practices, create separate drawings or layers where each component is positioned away from the others. Use dashed lines or arrows to indicate the direction in which parts are moved and the sequence of assembly.
4. **Annotation and Detailing:** Clearly label each part with its corresponding part number or description. Include any necessary annotations to clarify assembly steps, fasteners, or other critical details.

Examples of Exploded Views

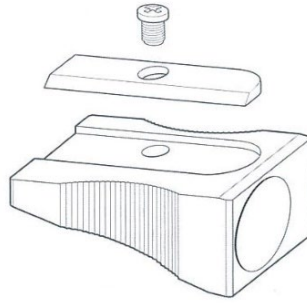


Figure 1.4.1: Exploded view of a pencil sharpener

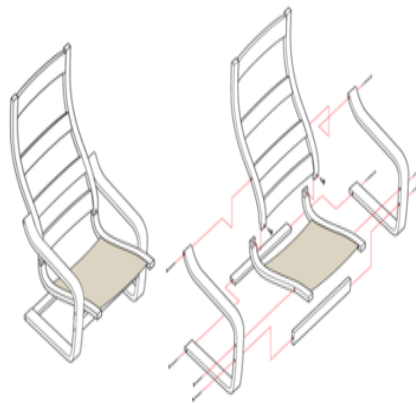


Figure 1.4.2: Exploded view of a chair

1. FINE LINE FELT PEN

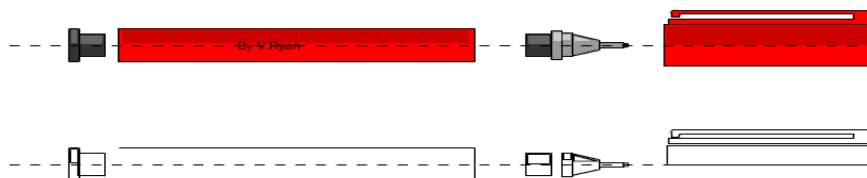


Figure 1.4.3: Exploded view of a felt pen

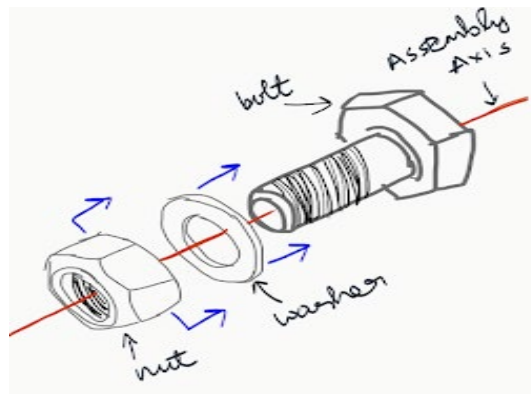
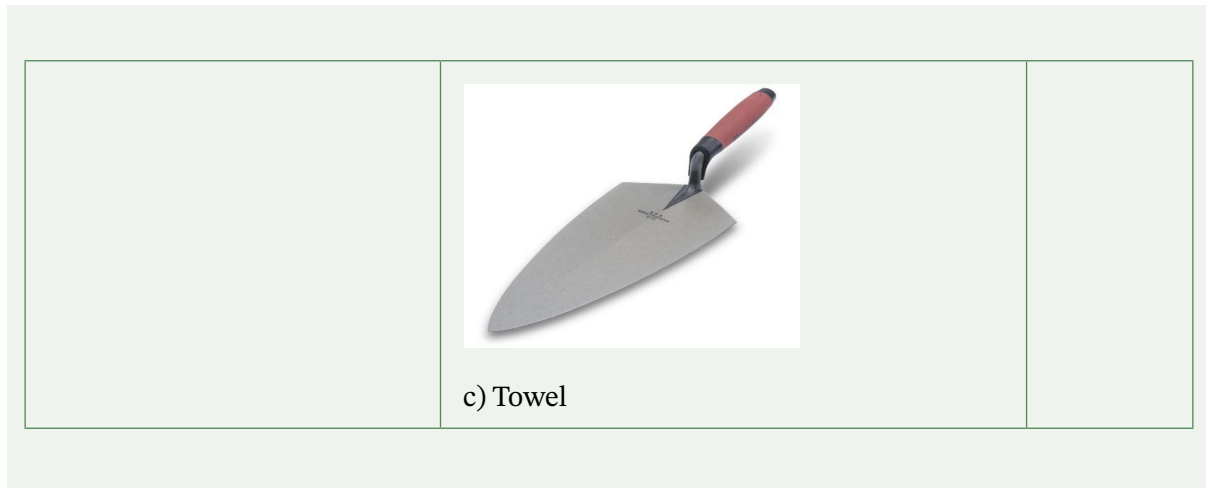


Figure 1.4.4: Exploded view of bolt, nut and washer

Activity 1.4.1 Exploring Exploded Views

Your teacher will place you into groups of 5. In your group discuss, agree and record in the table below, responses to the following.

Each group should then present their responses in front of the entire class for discussion and feedback.	Activity	Response
1	Describe what is meant by the exploded view of an object.	
2	Explain three principles used to draw the exploded view of an object	
3	Draw the exploded views for these final solution artefacts. a) Serving tray b) Steel Shoe rac	



WORKING DRAWING

A working drawing is a detailed and precise technical drawing that conveys all necessary information for constructing, fabricating, assembling, or manufacturing a product or structure. It includes multiple elements that work together to create an accurate representation of the final product, guiding technicians on exactly how to build or assemble it.

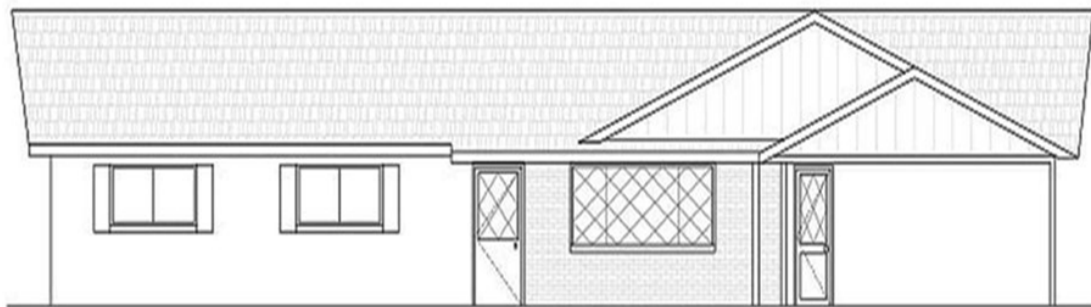
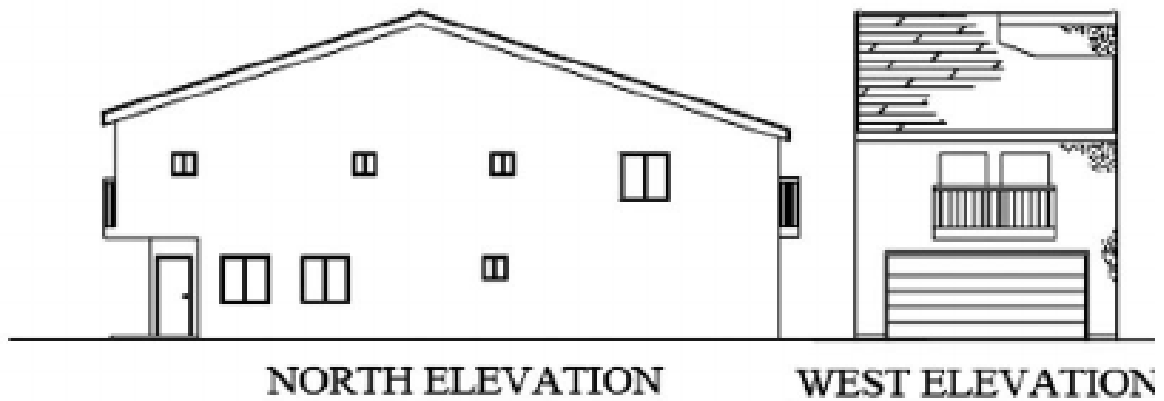
Importance of Working Drawing

1. Working drawings serve as legal documents for contractual agreements.
2. They are essential for quality control
3. Helps to ensure that the final product compliance with regulations
4. Helps to ensure the safety of the final product or structure
5. Helps to ensure functionality of the final product or structure.

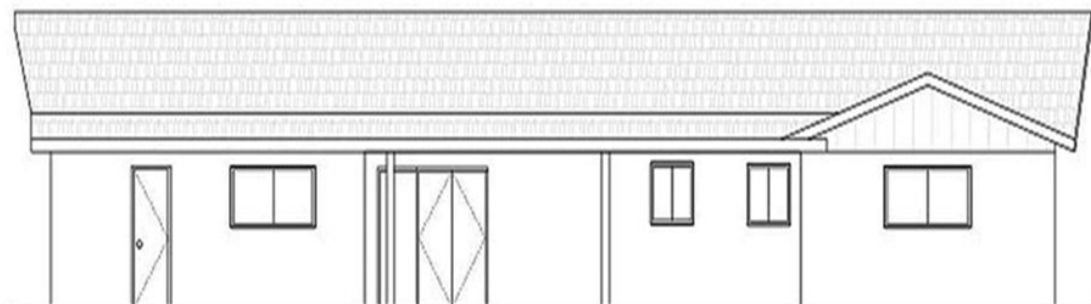
Types of working drawing

1. Elevations

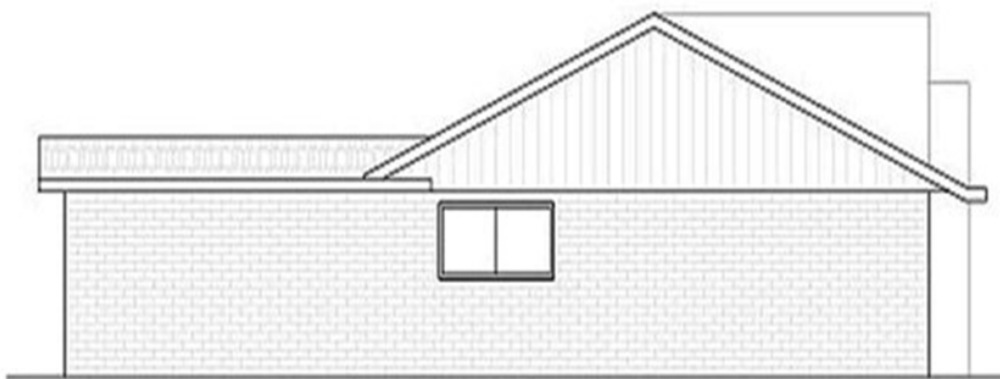
An elevation is a view of the front, back, or sides of an artifact. Typically, elevations are drawn to scale, displaying the height, width, and depth of the object. For buildings, elevations show the locations of doors, windows, and other important features that need to be represented. See the examples below:



NORTH ELEVATION (FRONT)
SCALE: 1/4"=1'-0"



SOUTH ELEVATION (REAR)
SCALE: 1/4"=1'-0"

**WEST ELEVATION (RIGHT SIDE)****EAST ELEVATION (LEFT SIDE)****Figure 1.4.5:** Building elevations**Figure 1.4.6:** Front elevation of a block

2. Plans

A plan is a top-down view that represents the internal layout of a building or object, drawn to scale. For buildings, a plan view reveals the arrangement of spaces and key features like walls, doors, and windows. In engineering, the plan view similarly captures the layout of an object from above, giving a clear perspective of its design and spatial relationships.

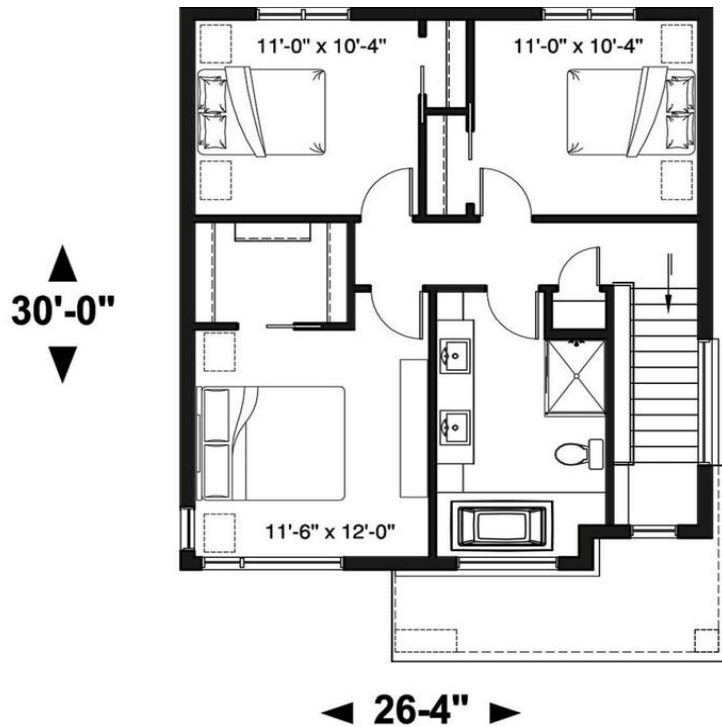


Figure 1.4.7: Plan of a building

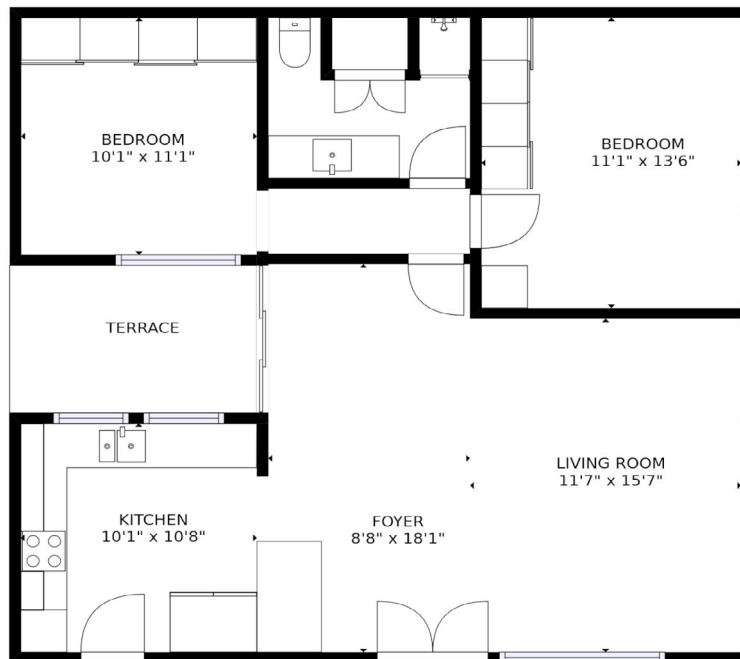


Figure 1.4.8: Plan of a block

3. Sections

A section is a scaled view that reveals a vertical cut through a building, displaying how it is organised across different floors or levels. This perspective highlights the height, width, and arrangement of key features, offering insight into the building's internal structure and spatial relationships.

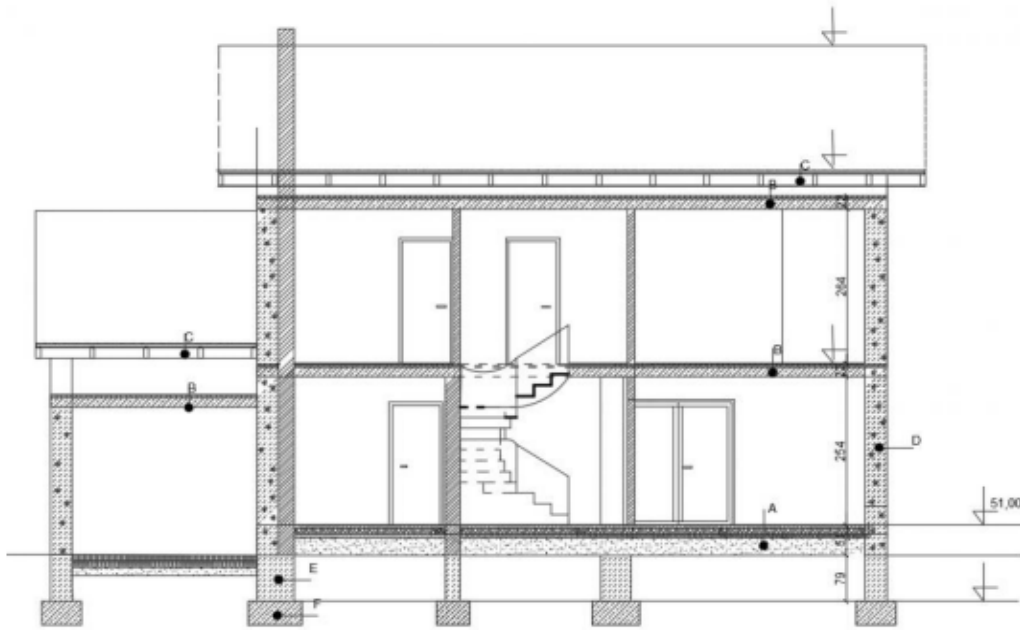


Figure 1.4.9: Section through a building

4. Structural Drawings

Structural drawings highlight the load-bearing elements essential to a building's stability. These drawings are signed and stamped by a structural engineer to certify compliance with safety standards. Contractors use both the structural drawings and the designer's plans to guide the construction process accurately.

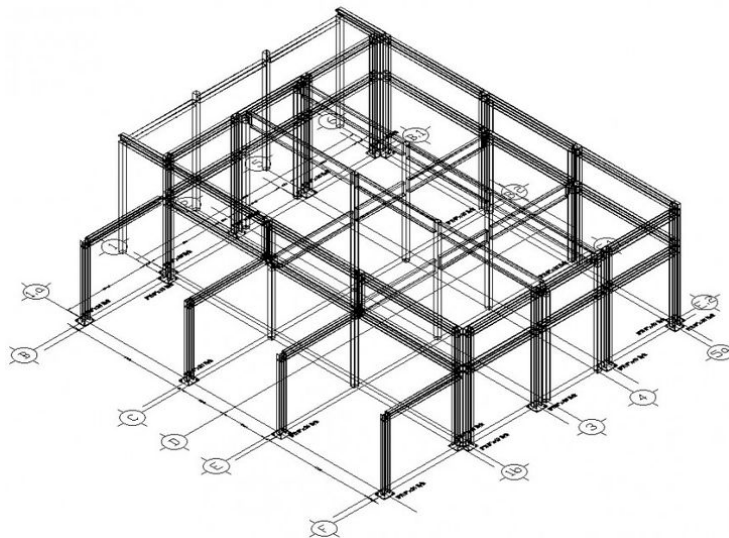


Figure 1.4.10: Structural drawing of a building

5. Electrical Drawings

Electrical drawings are specialised technical illustrations that detail the lighting, communication, and power distribution systems in commercial construction projects.

These drawings typically feature schematic diagrams that depict the wiring and connections between various components and external electrical grids within the building. Standard symbols used in electrical drawings represent circuit breakers, transformers, capacitor banks, conductors, and other critical elements, facilitating a clear understanding of the electrical system's configuration and operation.

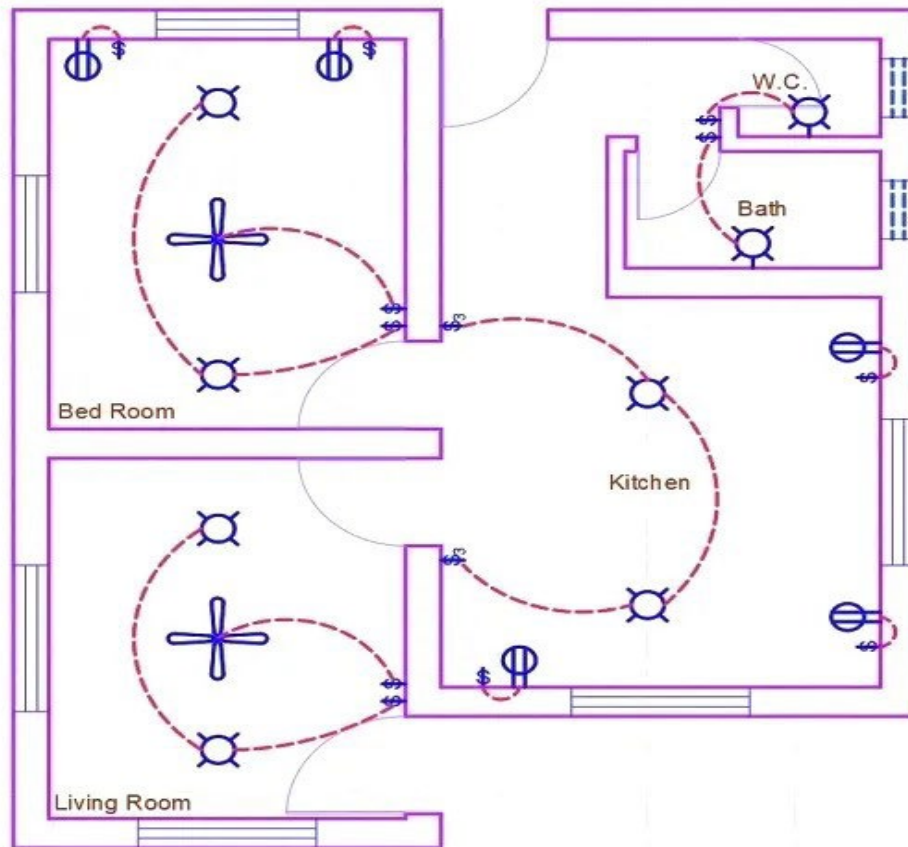


Figure 1.4.11: Electrical drawing

6. Plumbing and Sanitation Drawings

These technical drawings depict the plumbing system used for water circulation in residential or commercial buildings. They detail the layout of equipment, pipes, pumps, and drainage systems. The plumbing design drawings also indicate the locations of sanitary pipes for water supply and fixtures, as well as the connection methods for various accessories. Typically crafted by a plumbing designer, these drawings provide essential information on how water is pumped throughout the structure.

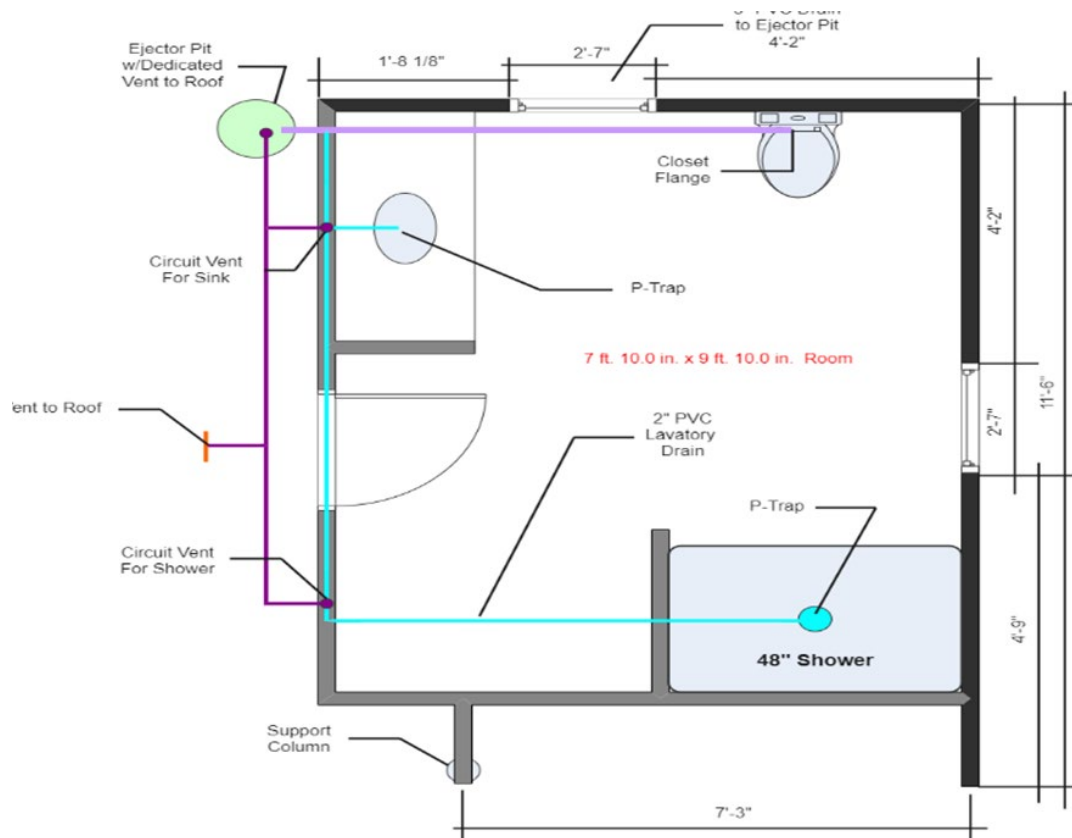


Figure 1.4.12: Plumbing and Sanitation Drawings

7. Mechanical Drawings

Mechanical drawings provide a visual representation of the mechanical systems in a building. These drawings typically include components such as pumps, compressors, and fans used in both commercial and residential projects. They also detail the piping systems for hot and cold water, along with other liquids essential for the operation of these machines.

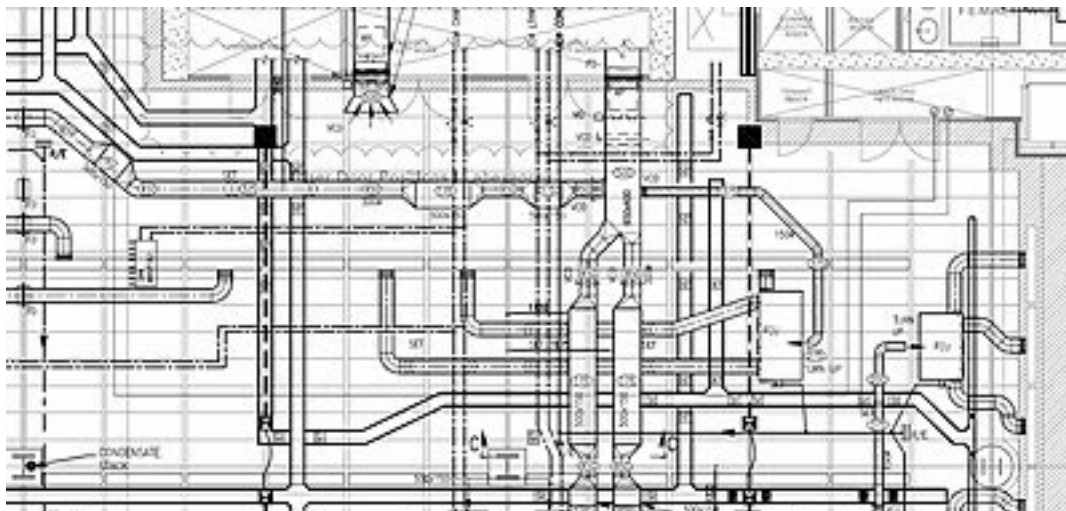


Figure 1.4.13: Mechanical Drawings



8. Roof Drawings

The roof is a vital element of any structure and should be designed with great attention to detail and precision. Engineers specializing in roofing can quickly produce blueprints, resulting in significant savings in both time and costs for the designer.

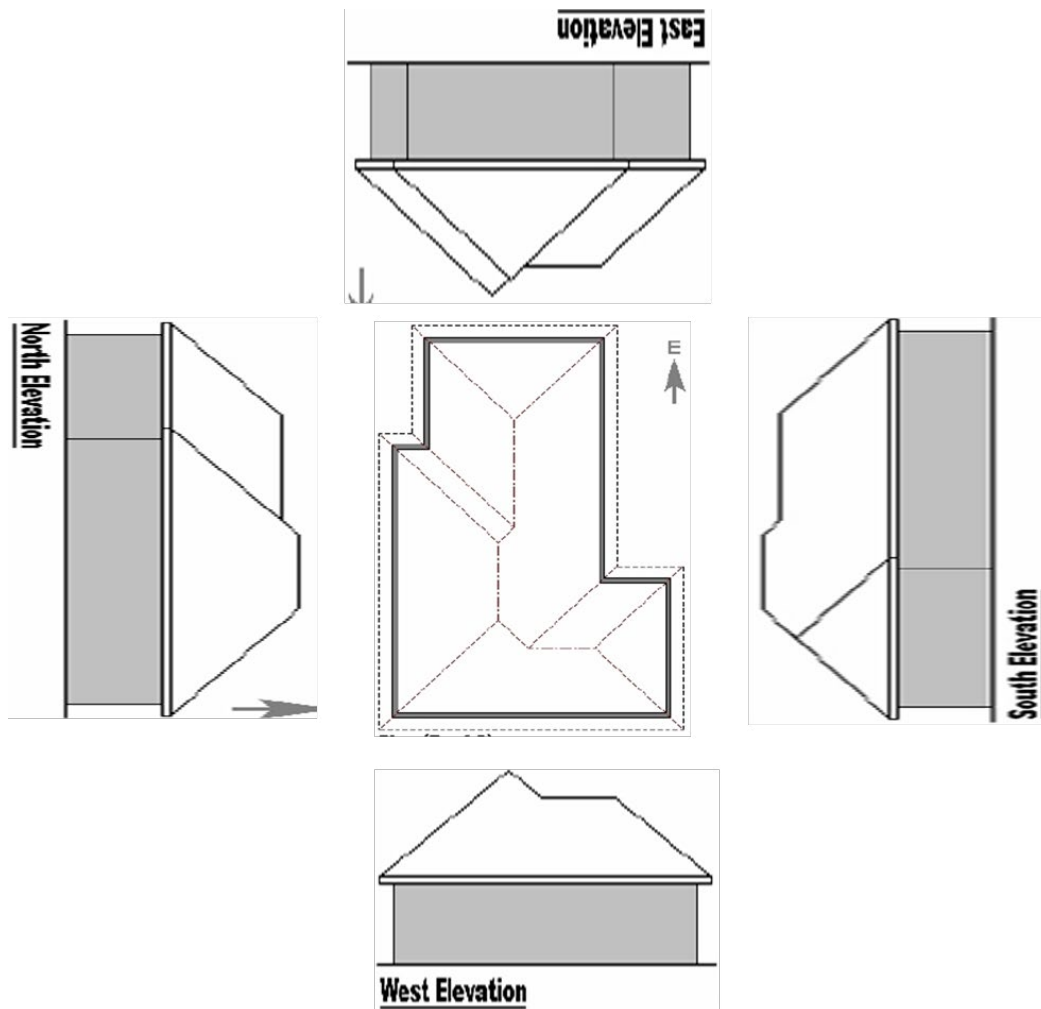


Figure 1.4.14: Roof Drawing

Key components and characteristics of a working drawing

1. **Orthographic Projections:** Working drawings usually feature multiple views of the object or structure presented in orthographic projection. These views typically include the front, plan, side, and sometimes rear perspectives, allowing for a thorough description of the design's geometry and dimensions.
2. **Dimensions and Tolerances:** Precise dimensions are vital in working drawings, detailing the size, shape, and placement of features such as holes, slots, and edges. Tolerances define permissible variations in dimensions, ensuring proper fit and functionality.

3. **Annotations and Notes:** Annotations provide additional information to enhance the clarity of the drawing. This may include specifications for materials, surface finishes, assembly instructions, part numbers, and any special notes or considerations for construction.
4. **Section Views and Detail Views:** Section views display the internal details of complex parts or assemblies by slicing through the object. Detail views zoom in on specific areas, offering a clearer depiction of intricate features or critical dimensions.
5. **Symbols and Conventions:** Working drawings incorporate standardised symbols and conventions to illustrate features such as welds, threads, fasteners, and surface textures. These symbols promote consistency and clarity in interpretation across various disciplines and industries.
6. **Scale and Units:** Drawings are typically produced at a specific scale (e.g., 1:10, 1:50) to ensure that dimensions accurately represent the actual size of the object or structure. Additionally, the units of measurement (e.g., millimeters, inches) are clearly specified.

Activity 1.4.2 Creating a neat working drawing

Select an artefact and create a working drawing of it independently, making sure to include all essential views and dimensions. Use the following steps as a guide:

Steps:

1. **Select an Artefact:** Choose a simple object (e.g., mug, box, or small tool) to draw, using any convenient dimension.
2. **Plan the Views:** Decide on the main views (e.g., front, top, side) that best show the artefact's shape and features.
3. **Sketch Roughly First:** Make a quick sketch to identify important dimensions and details.
4. **Draw the Final Version Neatly**
 - a. Use drawing tools or CAD software.
 - b. Draw each view to scale with clear lines.
5. **Add Dimensions and Labels:** Label measurements and key parts (like holes or slots). Make sure all features are included.
6. **Show competency**
 - a. **Neatness:** Clean lines and organized layout.
 - b. **Completeness:** All views and dimensions are included.
 - c. **Accuracy:** Dimensions and proportions match the artefact.

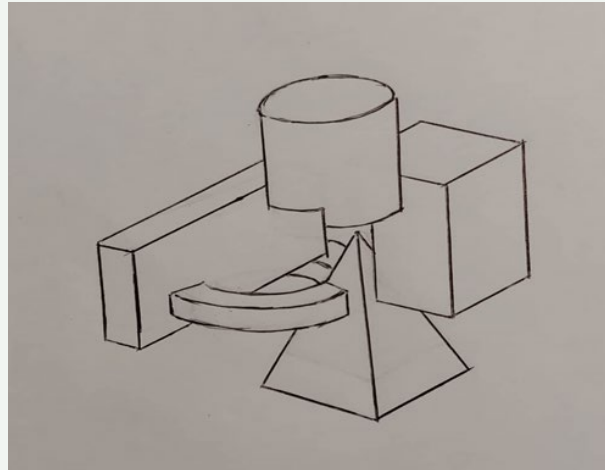
Share your work with your peers for feedback and discussion.

EXTENDED READING

Tufnell, R. (1988), *Introducing Design and Communication*, London, Century Hutchinson Ltd. (Page 48)

REVIEW QUESTIONS 1.1

1. The image below shows a design made by a student. Use it to answer the questions that follow



- Identify and describe three different basic shapes used in creating the design.
- List three different rendering techniques that can be used to depict depth and volume in the design.
- Draw and label any three basic shapes used in creating the design.
- How can a sense of depth be created on the image?
- Use freehand to create a complex form using any two of the basic shapes drawn in 2(a) above.
- Select any three of the basic shapes used in creating the complex image above and render each with different techniques. Which techniques did you use?



From the above sketch:

- Outline 3 (three) characteristics of the sketch.
- Describe the outlined characteristics and how they were used to create complex forms.

- c. Compare the characteristics of complex forms created using 2-point perspectives.
 - d. Use freehand to sketch the picture above with emphasis on proportions.
- 2.** As an interior designer you are to create a complex design idea of a bookshelves to be used at the staff common room. Using a hexagonal shape create your design and write a report. Your report should include the following:
- a. Create a series of sketches of the hexagonal bookshelves
 - b. List four relevant tools and four materials used for creating and rendering complex design
 - c. Explain how the two tools and two relevant materials for creating and rendering complex design.

REVIEW QUESTIONS 1.2

1. The following are statements based on the techniques used in modifying simple shapes in freehand drawing. Answer **true or false** to each statement:
 - a. Converting involves changing a shape from one form to another.
 - b. Translating means duplicating a shape in a pattern or sequence.
 - c. Altering shapes and proportion can create a more complex composition.
 - d. Shape manipulation can be used to create a sense of depth or perspective in a composition.
 - e. Converting a shape from one form to another always changes its proportions.
2. Create and fill in the table below, either by hand or digitally, highlighting five different tools, techniques, processes, and examples utilised for object manipulation in freehand drawing.

Tools (any 5)	Techniques (any 5)	Processes (any 5)	Example (any 5)
1.	1.	1.	1.
2.	2.	2.	2.
3.	3.	3.	3.
4.	4.	4.	4.
5.	5.	5.	5.

3. Here's an illustration of an art studio filled with diverse objects where you observe the forms, textures, and designs while reflecting on the concepts, symbolism, and narratives each object could represent.



- a. What 3 potential concepts, symbolism, and narratives can you connect to various forms and objects displayed?

- b. Describe how to use the available tools and free-hand drawing techniques to imitate the object you have selected by generating a sequence of simple line drawings into finished drawings of objects.
- c. Use available tools and techniques to imitate a selected object using the available tools and freehand drawing techniques and object manipulating techniques such as twisting, coiling, stretching, squashing and bending.

REVIEW QUESTIONS 1.3

1. What are some common themes used in 2-dimensional template and pattern design?
2. State three properties or characteristics of complex geometric shapes and forms.
3. You are to lead a group of your peers to create free hand-drawn 2-dimensional templates and pattern designs that are both visually appealing and functional.
 - a. Describe the plans or ideas to consider.
 - b. Develop a detailed chart that and justifies the selection of materials and tools needed for creating effective 2-dimensional hand-drawn templates and patterns in one selected area of application.
4. A popular home décor brand has approached you to create a collection of freehand-drawn 2-dimensional templates and patterns for their new product line. The templates and patterns will be used on various products such as fabrics, wallpapers, and ceramics.

Design a comprehensive portfolio of innovative 2-dimensional templates and patterns that showcase your artistic range and technical skills. Include:

- a. A minimum of five unique templates and patterns, each with:
 - A sketch or visual representation
 - A detailed description of the design elements, artistic choices, and inspiration
 - An explanation of the intended application or industry (e.g., fashion, graphic, interior design)
 - b. A brief reflective essay that:
 - Discusses your design philosophy and approach
 - Analyses the artistic choices made in each template and pattern
 - Evaluates how these designs could be applied in various real-world contexts
 - Explores potential collaborations or client relationships
5. Describe 5 processes involved in determining appropriate dimensions in free-hand drawn templates and patterns.
 6. Produce a geometric pattern for a tile design. Use 2-dimensional free hand-drawn circles templates and patterns with appropriate dimensions, proportions, and steps.

Hint

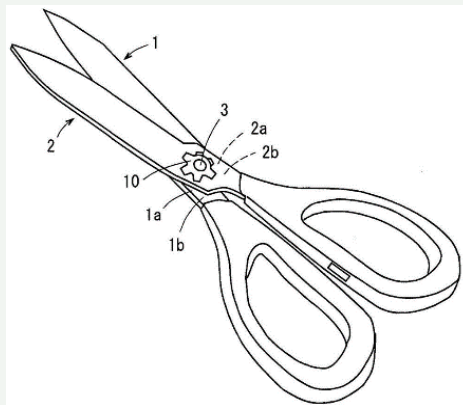
- A 10 cm x 10 cm square with a grid divide it into 4 sections (2x2 grid).
- Four circles, each 5 cm in diameter, drawn in each section, evenly spaced.



7. Explain the importance of 2-dimensional templates in pattern design.
8. Describe the steps involved in creating a template for a simple geometric shape, such as a cube or a pyramid.
9. What two factors must be considered when developing a 2D pattern to ensure accuracy and functionality in the final 3D form?

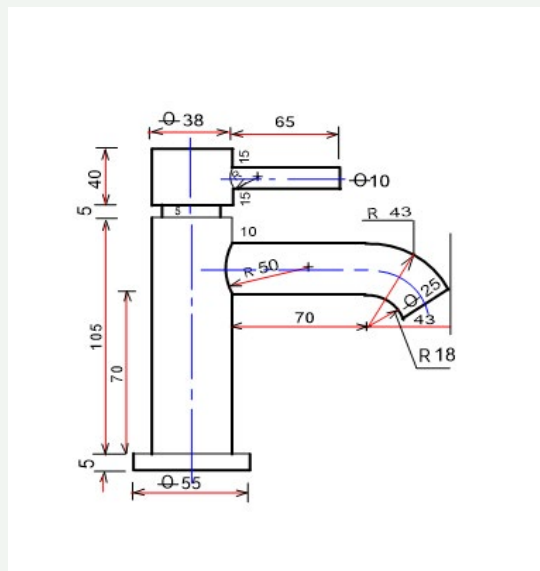
REVIEW QUESTIONS 1.4

1. Explain the term exploded view of an object.
2. Identify three key principles used in creating an exploded view of an object and explain any two of them.
3. Create an exploded view drawing of the provided three-dimensional "final design" of the scissors below.



A pair of scissors

4. Draw a clear and accurate working drawing showing the front elevation and plan view of the pipe tap given below.

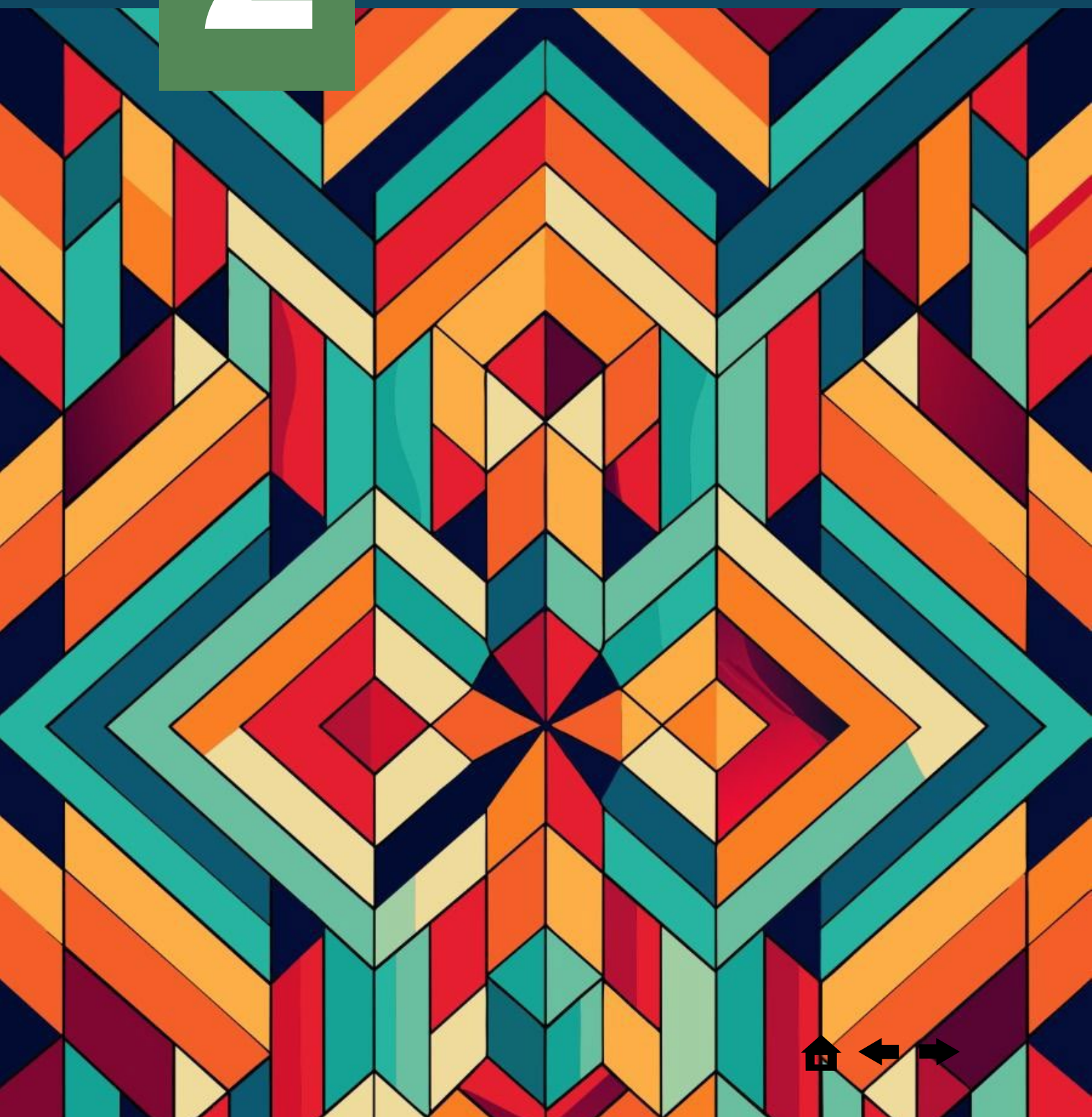


A pipe tap

SECTION

2

GEOMETRY



UNIT 1: PLANE GEOMETRY

GEOMETRY

Plane Geometry

INTRODUCTION

This unit focuses on two key concepts: Orthographic Projections and Loci, both of which are fundamental in the world of design, engineering, and geometry.

The unit explores orthographic projection a method of representing three-dimensional objects in two dimensions ensuring accuracy in size, shape, and dimensions during construction.

It will also cover the concept of loci, the plural of locus. In geometry, a locus is a set of points that satisfy specific rules or properties. For example, a circle represents the locus of points equidistant from a fixed point. Using appropriate drawing instruments, you will apply these principles to construct shapes and figures, and design artefacts based on the working principles of loci.

KEY IDEAS

- The Vertical Plane (V.P.) is also known as the front reference plane, is positioned vertically.
- The Horizontal Plane (H.P.) also refers to the horizontal reference plane, is positioned horizontally and is perpendicular to the V.P.
- The Profile Plane is the plane perpendicular to both the V.P. and H.P. The one on the right side is the right profile plane, while the one on the left side is the left profile plane.

ORTHOGRAPHIC PROJECTION

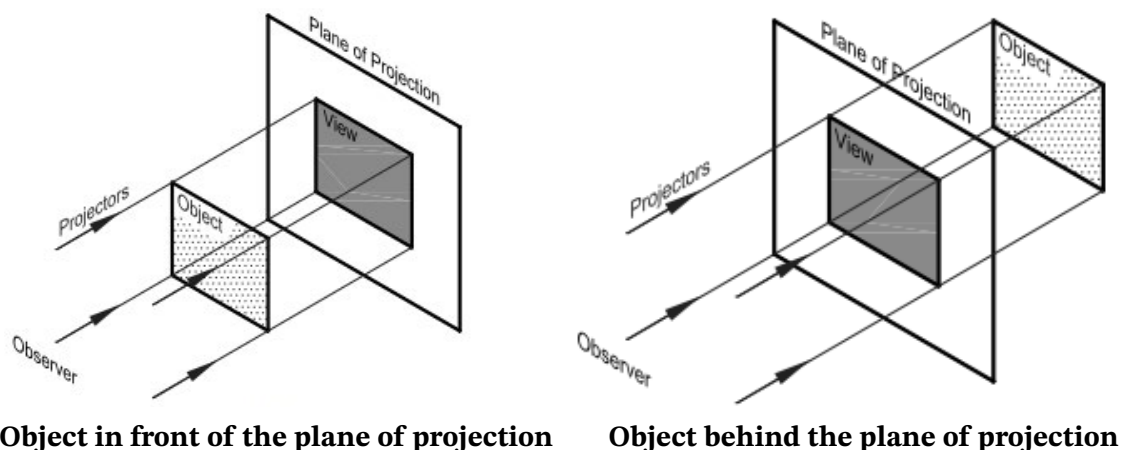


Figure 2.1.1: Orthographic projection

ORTHOGRAPHIC PLANES

Principal Planes: In orthographic projection, the object is projected onto three principal planes:

1. **Vertical Plane (VP):** Represents the front view of the object.
2. **Horizontal Plane (HP):** Represents the top view of the object.
3. **Side Vertical Plane (SVP):** Represents the side view of the object.

Projection Lines: Lines drawn from points on the object perpendicular to the projection planes determine the projected views.

The Orthographic Quadrants

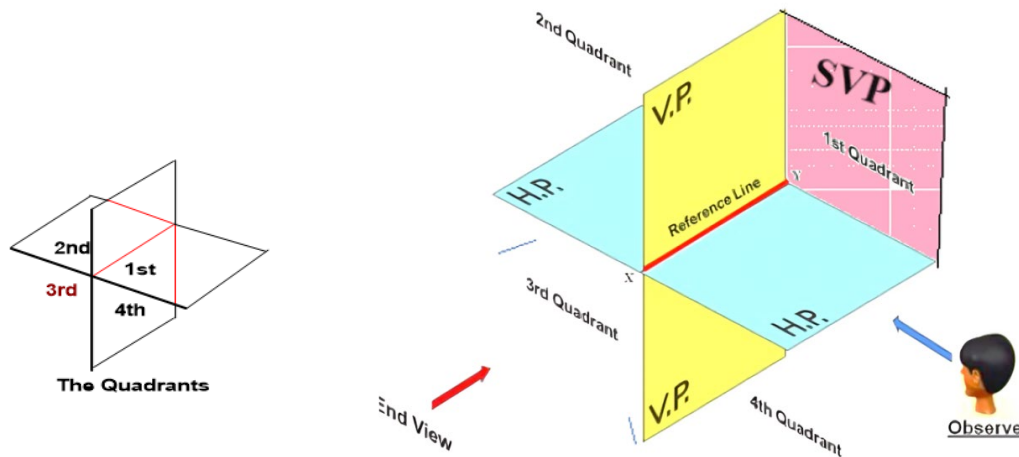
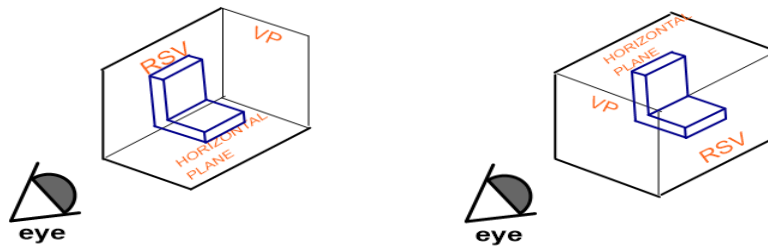


Figure 2.1.2: The orthographic quadrants

Basic Conventions

The unit has looked at using orthographic projection to create multi-view drawings of an object. The choice between the first angle and third angle projection methods depends on the position of the object relative to the horizontal plane (HP) and the vertical plane (VP). First angle projection is used when the object is above the HP and in front of the VP, while third angle projection applies when the object is below the HP and behind the VP.

For example, think of an object placed inside a transparent glass box with six sides acting as projection planes (see, figure 2.1.3 below).

**First angle projection.****Third angle projection****Figure 2.1.3:** First and Third angle orthographic projections**Table 2.1.1:** Types of orthographic projections and their symbols

Projection	symbols
First angle	
Third angle	

Table 2.1.2: Characteristics of first and third angle orthographic projections.

First angle	Third angle
The object is imagined to be in the first quadrant The Quadrants	The object is imagined to be in the third quadrant The Quadrants

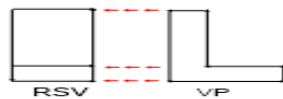
The front (VP) and top view (HP) are always in line vertically (with the front view on top of the top view)



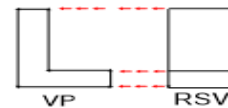
The front (VP) and top view (HP) are always in line vertically (with the front view below the top view)



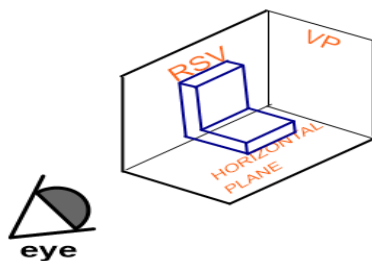
The front and side view are in line horizontally (the side views are directly next to the front view)



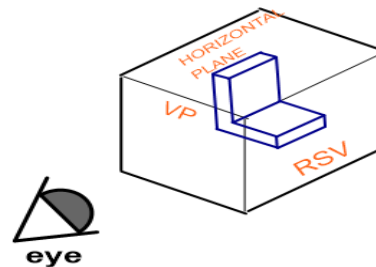
The front and side view are always in line horizontally



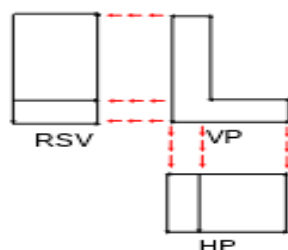
The object lies between the observer and plane of projection



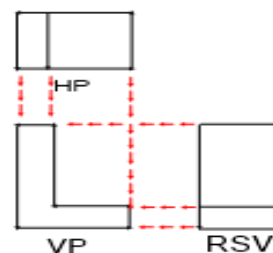
The plane of projection is assumed to be transparent



When views are drawn in their relative positions top view comes below front view, right view side view is drawn to the left side of the elevation



When views are drawn in their relative positions top view comes above front view, right view side view is drawn to the right side of the elevation



It is usually a European method

It is usually an American method

Examples of First angle and Third angle orthographic projections

Given an isometric block (figure 2.1.4), draw the block in:

1. First angle projection and
2. Third angle projection.

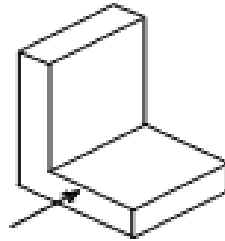


Figure 2.1.4: Isometric block

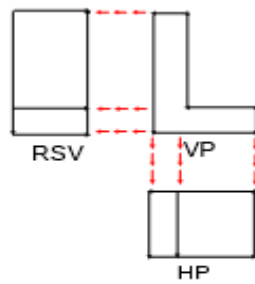


Figure 2.1.5: First angle projection

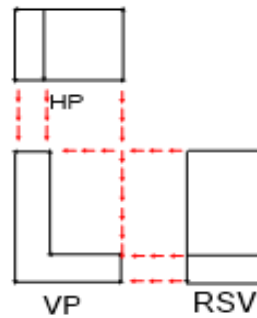


Figure 2.1.6: Third angle projection

Applications of Orthographic Projections

There are several ways that orthographic projections are used. These includes:

1. **Engineering Drawings:** Crucial for precise representation of objects in fields like architecture, mechanical engineering, and other technical domains.
2. **Manufacturing:** Serves as a blueprint for production, detailing dimensions, shapes, and assembly instructions.
3. **Design and Visualisation:** Enables designers and engineers to conceptualise, refine, and communicate ideas with clarity.

Activity 2.1.1 Identification of surfaces in First Angle

Identify the surfaces of the block shown in Figure 2.1.7 using First Angle Projection, based on the view from the direction indicated by the arrow.

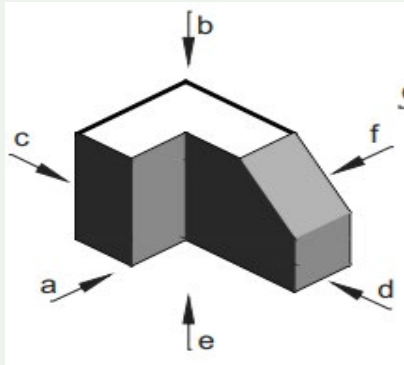


Figure 2.1.7: A block

1. Copy and complete the table.
2. Use a pencil and ruler to draw the surfaces arrowed a, b, c, d and f of the block in the table provided. Label each view appropriately.
3. Write **five (5)** short paragraphs explaining the principle of orthographic projection based on your observations and drawings.

Arrow	Draw Surface	Name of View
a		
b		
c		
d		
f		

Activity 2.1.2 Drawing of Surfaces in Third Angle

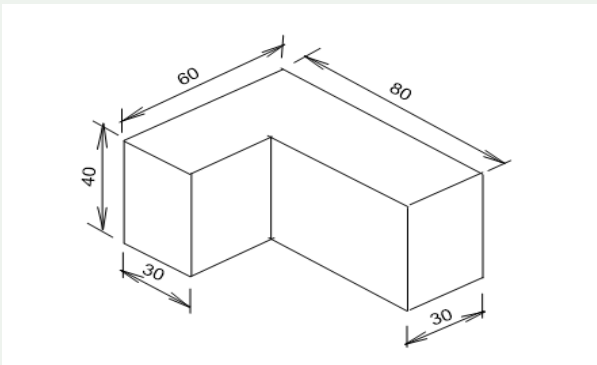


Figure 2.1.8: A Corner block

Figure 2.1.8 shows a pictorial view of a block.

Using third angle projection, Draw its:

1. Front view,
2. Top view and
3. Side view.

Activity 2.1.3 Drawing an artefact in 1st or 3rd angle projection

You will be provided with artefact such as a box, a table, a kitchen stool or other similar object. Produce a 1st or 3rd angle projection drawing of the item using the knowledge gained from the principles of drawing orthographic views.

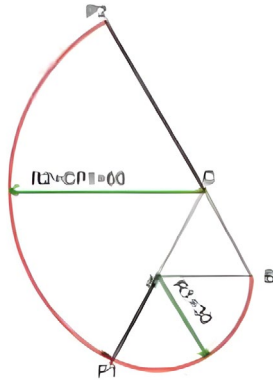
LOCI

Loci are a set of moving points in a plane in a specified direction, which make up a shape, line, or curve. The shape created satisfies a set of given rules. Many engineering curves are considered as loci (plural of locus).

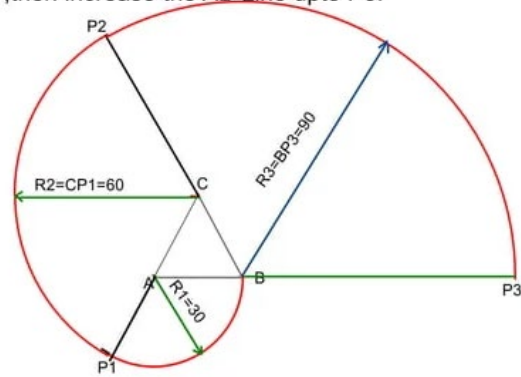
Examples of loci include:

1. Circle
2. Ellipse
3. Helix
4. Involute
5. Parabola
6. Hyperbola
7. Cycloid
8. Trochoid
9. Epicycloid
10. Cardioid
11. Link mechanism

C as the center CP1 as the radius draw the arc ,then increase the BC Line upto P2.



B as the center BP2 as the radius draw the arc ,then increase the AB Line upto P3.



B as the center BP2 as the radius draw the arc ,then increase the AB Line upto P3.

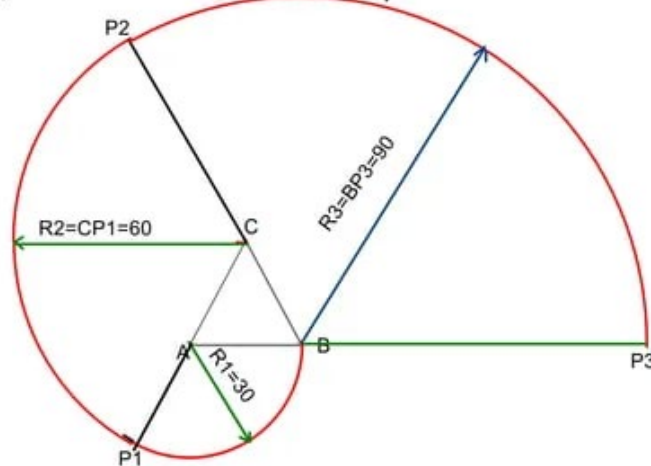


Figure 2.1.10: Involute of a Triangle

The resulting curve is the involute of the given triangle. Try different types of triangles.

To Draw the Involute of a Square

Procedure:

1. Draw the given square ABCD
2. With centre A and radius AD, draw an arc to intersect BA produced in 1
3. With centre B and radius B1 draw an arc to intersect CB produced in 2
4. With centre C and radius C2 draw an arc to intersect DC produced in 3
5. With centre D and radius D3 draw an arc to intersect AD produced in 4

The resulting curve is the involute of the given square.

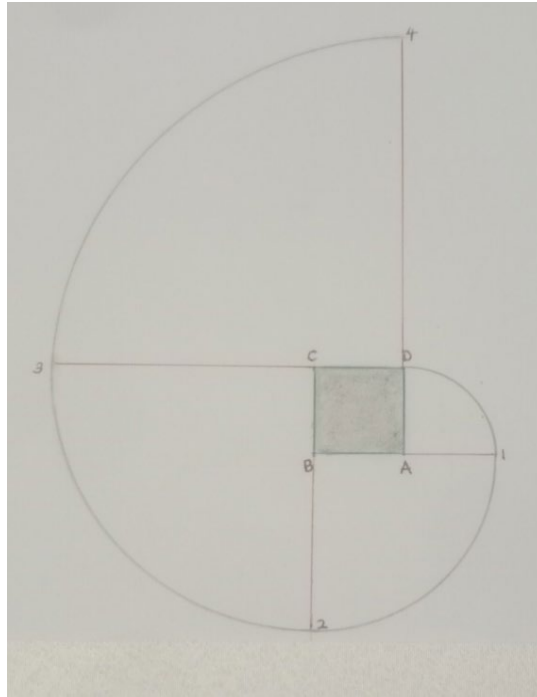


Figure 2.1.11: Involute of a given square

Follow the same procedure to draw the involute of a rectangle or other quadrilaterals

To draw the Involute of a Pentagon

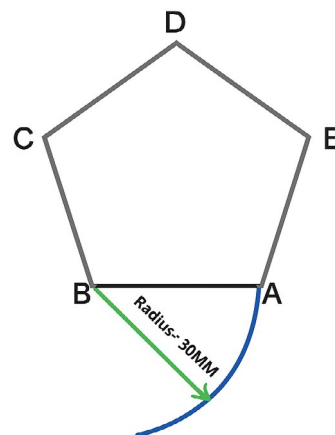
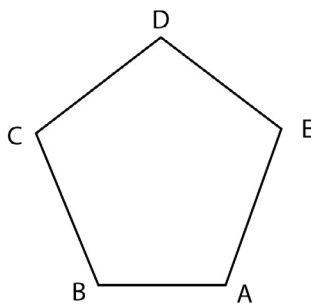
Procedure:

Follow the diagram below to draw the involute of a pentagon

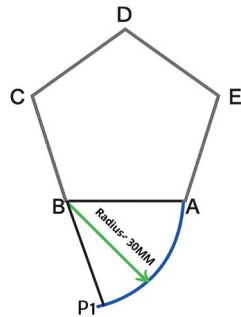
Draw the involute of the pentagon of side
AB is 30mm

Draw the arc B as the center AB as the radius
AB=30MM

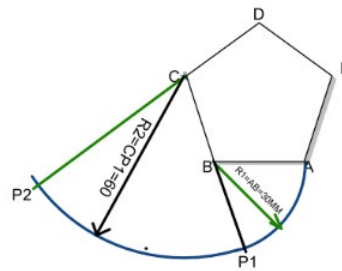
Draw the pentagon by using any one of the
method AB=30MM



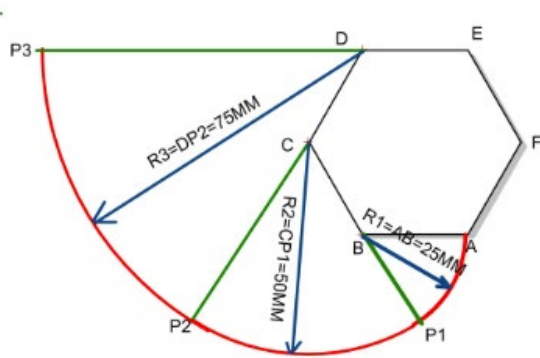
Now increase the line bc upto p1



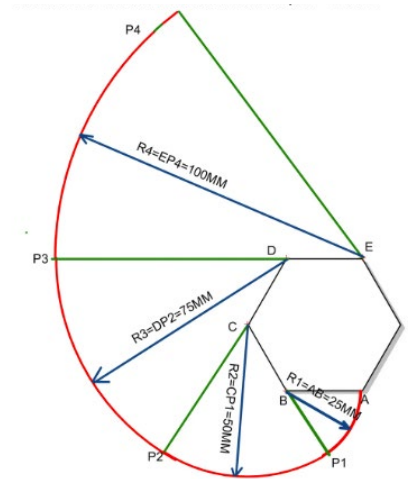
C as the center p1 as the radius draw the arc



D as the Center DP2 as the Radius Draw the arc Up to PZ=152MM

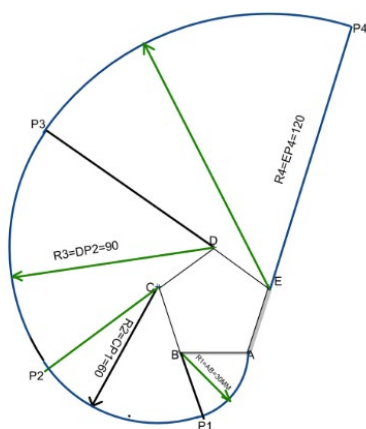


E as the center EP3 as the radius Draw the arc Upto P4=100MM

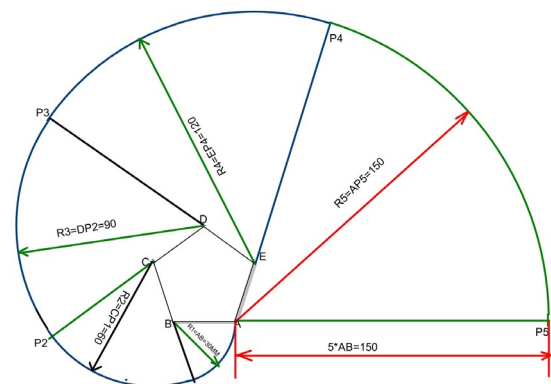


E as the EP3 as the Radius Draw the arc upto P4

A as the center AP4 as the Radius Draw the arc upto P5



E as the center EP3 as the Radius Draw the arc upto P4



A as the center AP4 as the Radius Draw the arc upto P5

Figure 2.1.12: Involute of a pentagon

To Draw the Involute of a Circle

Procedure

1. Draw the given circle, diameter D
2. Divide the circle into 8 or 12 equal parts and number the points
3. Draw a line $AB = \pi D$, the base of the circle
4. Draw tangents to each point as shown on the circle
5. With centre 1 and radius O_1 , draw an arc to cut the tangent 1 in P_1
6. With centre 2 and radius $2P_1$, draw an arc to cut the tangent 2 in P_2
7. Repeat the previous step for all the other points on the circle, i.e. centre 3, radius $3P_1$... to the last point
8. The arc through the points $P_1, P_2, P_3, \dots, P_8$ or P_{12} is the involute of the circle

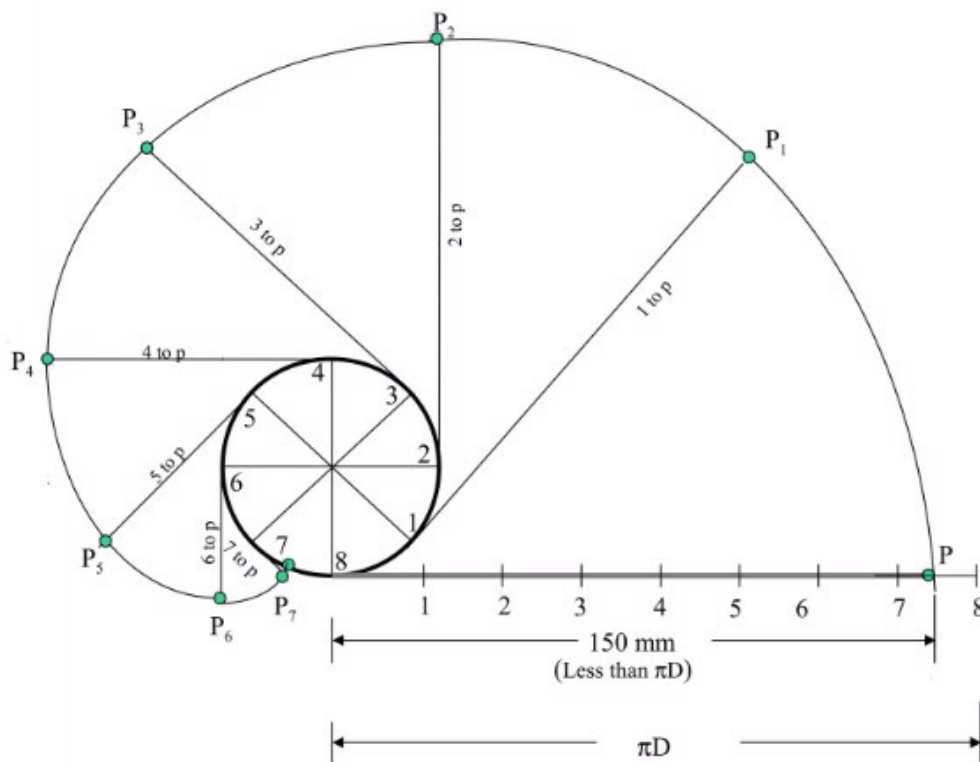


Figure 2.1.13: Involute of a circle

Activity 2.1.3: Practice Involute

1. Draw the involute of a rectangle ABCD with $AB = CD, 35\text{mm}$ and $AD = BC, 20\text{mm}$.

2. Draw the involute of a circle with base radius 20mm.

Helix

A helix is a three-dimensional spiral that is open at both ends. The base and top can be equal values, like a coil or spring, or they can be different values, similar to a cone.

A helix is a three-dimensional geometric shape that twists around a central axis, resembling a spiral staircase. It is a type of curve that combines rotation and translation. The axial movement during one revolution is called the helix or lead (pitch). Helices (plural of helix) can be left- or right-handed.

Key Properties of a Helix

1. **Pitch:** Vertical distance between consecutive turns.
2. **Radius:** Distance from axis to helix surface.
3. **Turns:** number of complete rotations.
4. **Twist:** Direct (right/left-handed).
5. **Axis:** Central line around which the helix twists.

Construction of Helix

1. Draw the plan and elevation of the cylinder
2. Divide the plan (circle) and height (pitch) of the cylinder into same number of parts e.g. 12
3. Number the points on both the plan and elevation
4. Draw horizontal lines through the points on the pitch (lead)
5. Project the points in the plan to their corresponding numbers in the elevation
6. Draw a smooth curve through the points of intersection to get the required helix

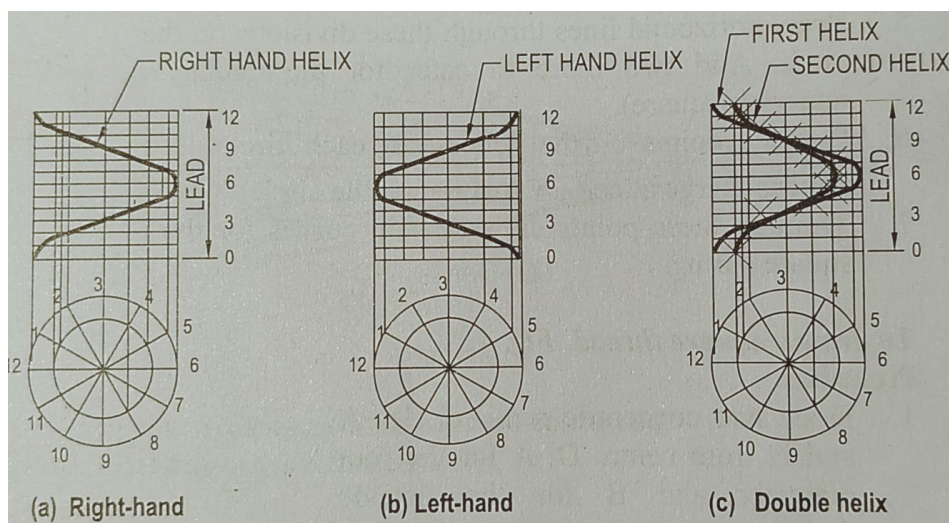


Figure 2.1.14: Construction of the helix

Practical Application of Helix

The principles of helix are used for the construction of artefacts which include

1. Drill bits
2. Screw threads
3. Car jack
4. Gears
5. Springs
6. Staircases
7. Spiral escalators



TYPES OF GEARS



Dimensions.com | Spiral Stairs - Open Risers

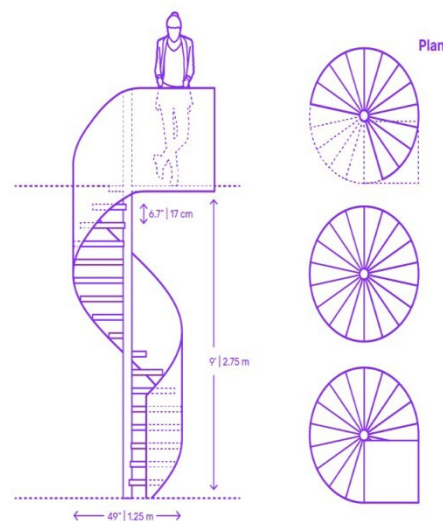




Figure 2.1.15: Practical applications of a helix – screw, bolts, springs, gears, spiral staircase

Self-Assessment

Construct the following

1. A helix with a radius of 20mm, pitch of 40mm.
2. A helix with a radius of 15mm, pitch of 20mm.

Activity 2.1.4 A helical staircase with an involute handrail

Design and construct a helical staircase with an involute handrail for an event centre in your locality. Utilize the principles of helix and involute to create a structurally sound and aesthetically pleasing staircase.

Take radius = 1200mm, pitch = 2000mm, turns = 3

Drawing Scale: 1:20 or 1:50

Note: These dimensions can be adjusted.

1. Use the information given to draw the front elevation (helix) and the plan (involute) of the staircase.
2. Analyse the implication of your design choices on the functionality of these shapes in a real-world application and evaluate the effectiveness of your construction process.
3. Provide a detailed report that includes your methodology, challenges faced, and potential improvements for future constructions.

DESIGNING BASED ON THE WORKING PRINCIPLES OF LOCI

The principles of the helix are applied in the construction of square springs, screw thread, coil springs, drill flutes, and car jacks. This will help you apply helix principles when designing a car jack.

Examples of Automobile Jack

There are several types of car jacks, from the basic scissor-type that is found in most vehicles, to heavy-duty models designed to lift large vehicles.



Figure 2.1.16: Types of Car Jacks

Types of Car Jacks

There are two main types of car jacks:

1. **Mechanical jacks**
2. **Hydraulic jacks**

Each is designed to lift a vehicle safely, however they do so very differently.

Mechanical Car Jack

A mechanical jack is the most common. They require an operator to manually crank a lever which turns a threaded screw to ratchet a system upwards or downwards.

Car jacks that work on the principles of a helix typically fall under the category of **mechanical jacks**, specifically **scissor jacks**.

Automobile jacks that use the principles of a helix, which typically refers to the use of a helical screw or thread to lift the load:

1. Scissor Jack

A scissor jack is a common type of car jack that uses a set of crisscrossing arms in the shape of a "scissors" mechanism. The lifting mechanism involves a screw that turns, often in a helical pattern, to raise the arms and lift the car. The screw, when turned, forces the arms to extend outward, which results in the car being raised. This is based on the principle of a helical screw thread.

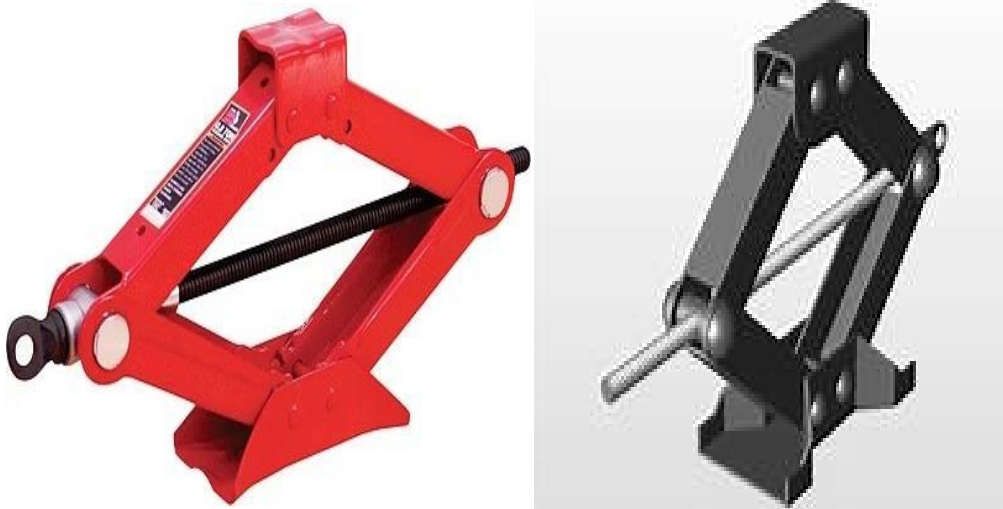


Figure 2.1.17: A scissor jack

- a. **Mechanism:** Scissor jacks use a screw mechanism to lift the car. The screw runs through the centre of a scissor-like structure. When you turn the screw, it opens or closes the scissor mechanism, raising or lowering the car.
- b. **Operation:** By rotating the screw, the helix (threaded screw) converts rotational motion into linear motion, effectively lifting the vehicle.

2. High-Lift Jacks

is a mechanical jack usually owned by farmers, off-road enthusiasts, or anyone who owns a larger-than-average vehicle.



Figure 2.1.18: High-Lift Jacks

- a. **Mechanism:** These jacks also use a screw mechanism but are designed for larger vehicles or off-road use. They can lift vehicles much higher than standard scissor jacks.
- b. **Operation:** Similar to scissor jacks, they use a threaded screw to lift the vehicle, but they are built to handle more weight and provide greater lift height

Both types of jacks are essential tools for vehicle maintenance and repairs, offering a reliable and straightforward way to lift a car using the principles of a helix.

Types of Hydraulic Jacks

1. Bottle Jacks



Figure 2.1.19: Bottle Jack

The bottle jack is vertically mounted, hence its name. They force weight in an upward direction.

A bottle jack often combines a hydraulic lift with a screw mechanism. The screw part works in a helical pattern to control the height adjustment. As the handle is rotated, the helical thread lifts or lowers the platform, and the hydraulic system does the actual lifting

2. Floor Jacks



Figure 2.1.20: Floor Jack

Floor jacks are long, horizontal jacks that have a low centre of gravity. They lift weight directly parallel to the power source.

Design Car Jack using Helix Principles

The position of the automobile jack shown is controlled by a screw ABC that is single threaded at each end (right-handed thread at A, left-handed thread at C), using this preamble and sketch, design a car jack to be used by the school driver.

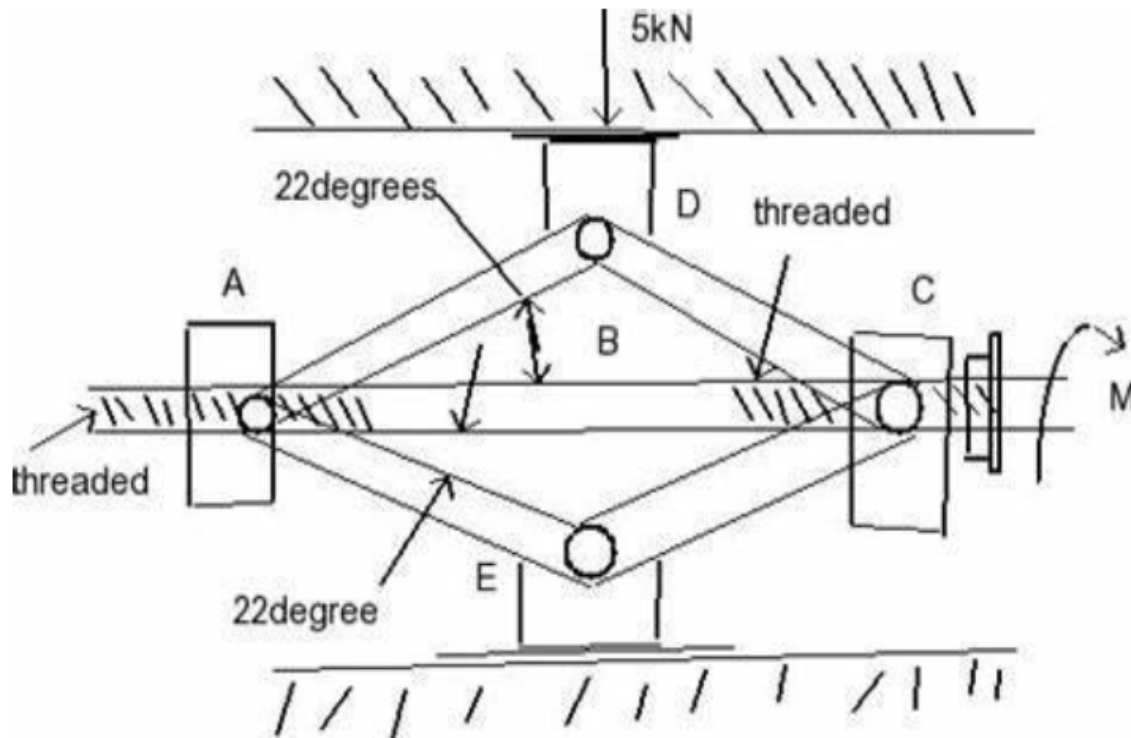


Figure 2.1.21: Designing car jack

Activity 2.1.5 Design Car Jack using Helix Principles

Organise yourselves into groups of 3 and follow the guidelines below to design a car jack that incorporates the principles of the helix, ensuring it meets specific performance criteria such as load capacity, stability, and ease of use.

1. Research and identify the various car jacks working on the principles of a helix. In your groups, discuss how these car jacks.
2. Make notes of your findings and share this with the class for an initial discussion. Design a car jack that incorporates the principles of the helix, ensuring it meets specific performance criteria such as load capacity, stability, and ease of use.
3. Create a **comprehensive design** for your car jack, showing how the helix principle is used.
 - a. Include a **detailed engineering drawings** that show the dimensions, materials, and key components.

- b. annotate your drawings to explain how the helix contributes to load capacity, stability, and ease of use.
4. Plan a prototype for your car jack, listing the materials and tools needed for construction.
 - a. Include **calculations** to show how your design meets the required load capacity (e.g., calculations for the torque required to lift the weight).
 - b. Evaluate your design for potential weaknesses, such as material choice, weight, or safety.
5. Prepare a **5-minute presentation** for your class, demonstrating how your car jack works and why it is an improvement over traditional design.

EXTENDED READING

1. Agrawal, B and Agrawal, C. M. (2015). ENGINEERING DRAWING, New Delhi, McGraw Hill Education Limited. Page 220 -222
2. French, T. E. A., (1911), A Manual of Engineering Drawing for Students and Draftsmen, New York, NY, McGraw - Hill

UNIT 2: SOLID GEOMETRY

GEOMETRY

Solid Geometry

INTRODUCTION

The best way to communicate one's ideas is through the drawings, this is especially true for the engineer, architect, designer etc; This section looks at how to apply solid geometrical figures in the construction of development of pyramids, drawing the curve of intersections of objects meeting at right angles, designing an artefact using the concept of solid geometry and the use of computer aided design (CAD) programmes that are used across a wide range of businesses such as architecture, engineering, construction, product design, graphic design and manufacturing.

KEY IDEAS

- Apply rules of surface development, such as: Triangles remain triangles, angles remain the same, edges remain straight, and shapes fit together without overlap.
- Assemble the unfolded triangular faces into a 2D net, ensuring that edges align, and shapes fit together correctly.
- Curve of intersection is the continuous boundary line formed where the surfaces of two solids intersect or overlap.
- Line of intersection is created where two solids interpenetrate or meet
- CAD is an acronym which means Computer-Aided Design, Computer-Assisted Design, Computer-Aided Drafting, or Computer-Assisted Drafting.
- CAD is specialised software used to create, modify, and optimise designs. It is widely employed in engineering, architecture, and product development, replacing manual drafting with precise digital drawings.

SURFACE DEVELOPMENT OF PYRAMIDS

Drawing the surface development of pyramids involves creating a 2D representation of the pyramid's surface, showcasing its individual faces and edges. This technique is essential in various fields like architecture, engineering, and design. To achieve an accurate surface development, certain principles such as understanding the pyramid's structure and shape, connecting the apex to each vertex, and unfolding triangular faces into 2D are followed.

By applying these principles, one can create a precise and detailed 2D representation of a pyramid's surface, revealing its intricate geometry and structure. This skill is valuable for

visualising and working with pyramids in various contexts. How to construct the surface development of some pyramids and their underlying principles is what this section addresses.

Pyramids

In graphic communication, a pyramid refers to a solid, i.e. a 3D geometric shape which has a regular base with a number of triangular faces to match, forming a common apex or vertex. The pyramid is named after the shape of the base.

Examples in real life are the Ancient Egyptian Pyramids, known as the Great Pyramid of Giza, which happens to be one of the largest and oldest pyramids existing today. Other examples are Pyramidal Roof (various) – buildings with pyramid-shaped roofs, like the Luxor Hotel (Las Vegas), and Sudanese Pyramids (Meroe, Sudan) – a numerous pyramids built for royal burials.

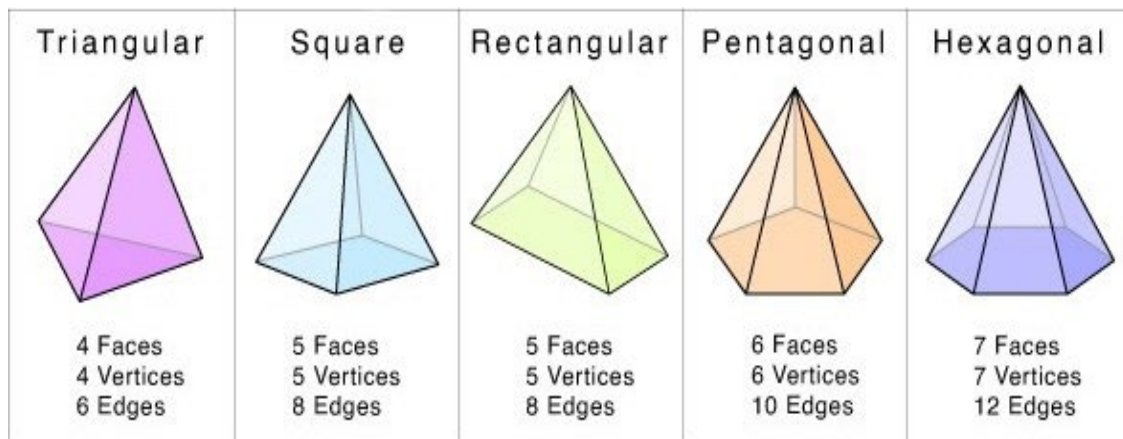


Figure 2.2.1: Examples of pyramids

Properties of Pyramids

1. **Apex:** The topmost part of a pyramid.
2. **Base:** The polygonal shape that forms the foundation of a pyramid.
3. **Lateral edges (sides):** The edges that connect the base to the apex.
4. **Lateral face:** A face that is not the base, but a triangular face that connects the base to the apex.
5. **Altitude (height):** The perpendicular distance from the base to the apex.
6. **Faces:** The flat surfaces that make up the pyramid, including the base and lateral faces.
7. **Vertex:** The corners or points where the edges meet.

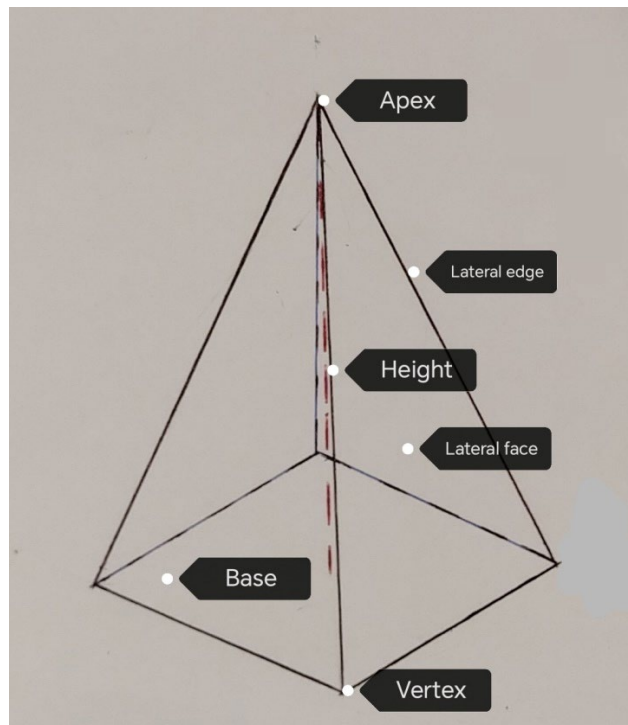


Figure 2.2.2: Parts of a pyramid

Surface development of pyramids

When a pyramid is cut open along the edges and spread out, the visible shape formed is known as the surface development of the pyramid, also known as the net of the pyramid.

Surface development of a square pyramid

Procedure used to draw the surface development of a square pyramid:

1. Draw the plan and front view of the pyramid.
2. Number the side of the square to correspond with the front view.
3. With centre P and radius P1, draw an arc to cut the centre line.
4. Project this to the front view to cut the base in P1.
5. PP1 is the true length of the side of the pyramid.
6. With centre P1 and radius PP1, draw an arc at a convenient position for the development.
7. With 41 as side, mark 4 equal spaces on the arc.
8. Join these to P1.
9. Firm in all the outlines and draw chain lines at the folds to complete the development (base open).

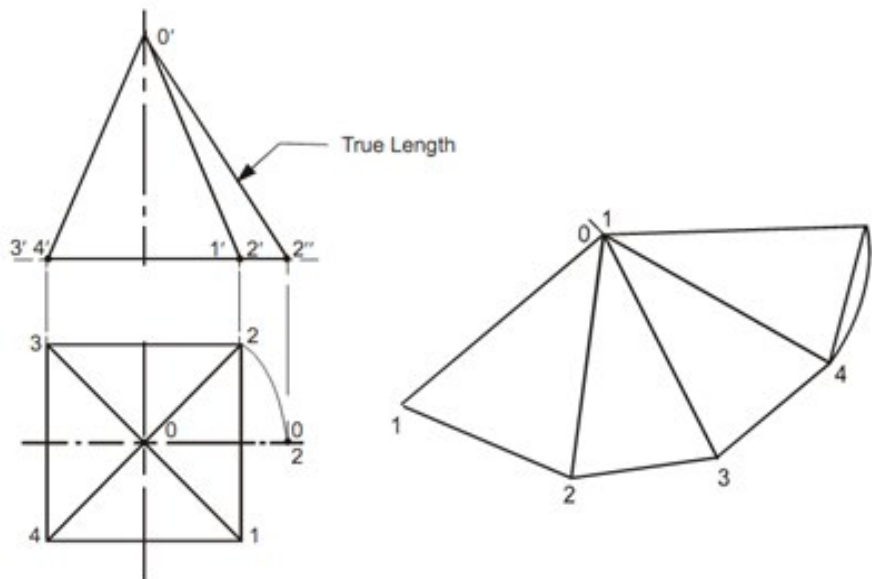


Figure 2.2.3: Surface development of a square pyramid

Surface development of a triangular pyramid

Procedure used to draw the surface development of a triangular pyramid:

1. Draw the plan and front view of the pyramid.
2. Number the sides of the triangle to correspond with the front view.
3. Draw a perpendicular bisector at X on the plan.
4. With centre X and radius X1 on the plan, draw an arc to cut the centre line at Y.
5. Project this to the front view to cut the base at B.
6. BX is the true length of the side of the pyramid.
7. With centre X and radius XB, draw an arc at a convenient position for the development.
8. With 12 as side, mark 3 equal spaces on the arc.
9. Join these to X.
10. With 12 as radius and centre 2, draw an arc.
11. With 23 as radius and centre 3, draw an arc to intersect the previous arc.
12. Firm in all the outlines to complete the development (bottom closed).

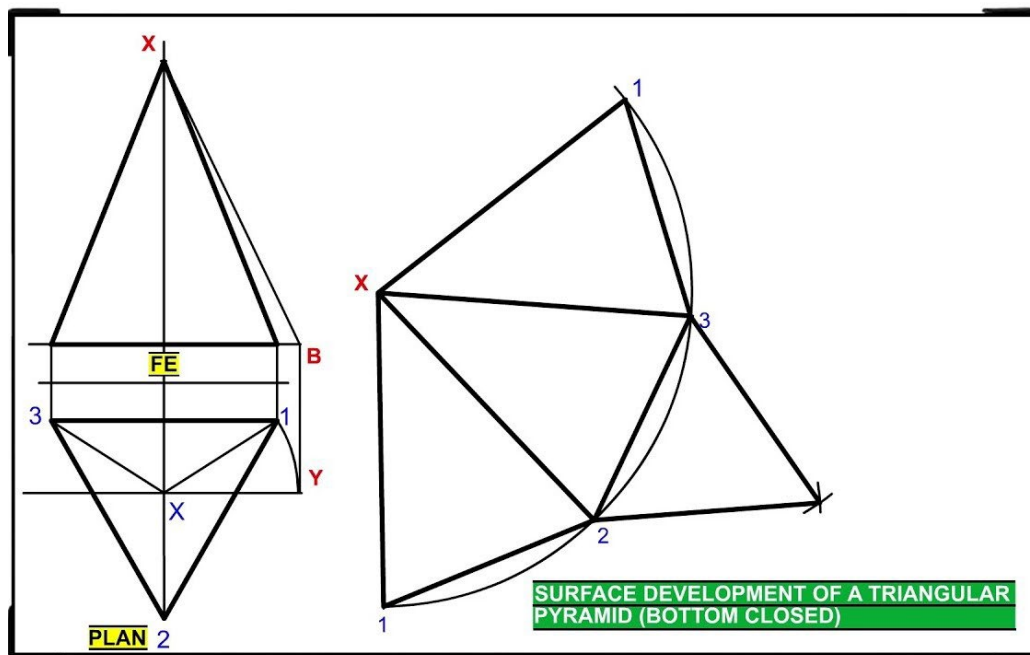


Figure 2.2.4: Surface development of a triangular pyramid

Surface development of a pentagonal pyramid (e.g. side = 30mm, height = 100mm):

Procedure used to draw the surface development of a pentagonal pyramid

1. Draw the plan and front view of the pyramid. (One diagonal on the plan should be parallel to the base of the front elevation).
2. Number the sides of the pentagon to correspond with the front view.
3. Draw the diagonals to get the centre at O on the plan.
4. Project point 1 on the plan to the base of the front elevation at 1.
5. O1 on the front elevation is the true length of the side of the pyramid.
6. With centre O and radius O1, draw an arc.
7. With 12, 23, etc. from the plan, mark 5 equal spaces on the arc.
8. Join these to O to get the development of the pyramid (bottom open).

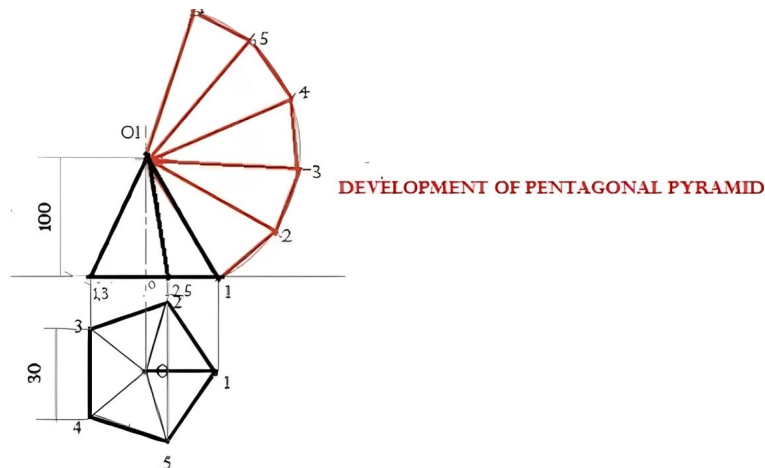


Figure 2.2.5: Surface development of a pentagonal pyramid

Procedure used to draw the surface development of a hexagonal pyramid

1. Draw the plan and front view of the pyramid.
2. Number the sides of the hexagon to correspond with the front view.
3. With centre X and radius $X1$ on the plan, draw an arc to cut the centre line at Y.
4. Project 4 on the plan to meet its corresponding point on the front view.
5. $O1$ or $O4$ is the true length of the side of the pyramid.
6. With centre O and radius $O1$ or $O4$ from the front view, draw an arc at a convenient position for the development.
7. Transfer the sides, 12, 23, etc. from the plan along the arc.
8. Join the points 1, 2, etc. to O on the development.
9. Firm in all the outlines to complete the development of the hexagonal pyramid (bottom closed).

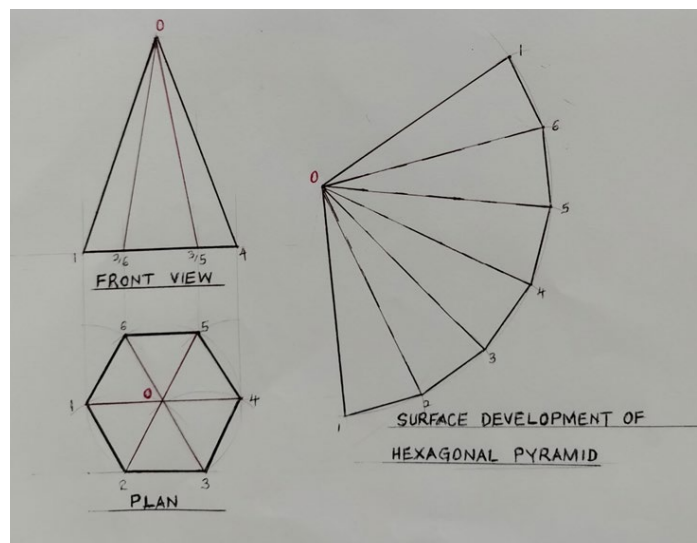


Figure 2.2.6 Surface development of a hexagonal pyramid

Application of surface development of pyramids

Surface development of pyramids has various applications in:

1. Designing buildings, roofs, and structures in architecture.
2. Developing packaging, containers, and products.
3. Designing patterns and fabrics in textile design.
4. Creating visual representations, sculptures, and installations in art and design.
5. Creating nets and patterns for manufacturing, construction, and assemblage in engineering
6. Sheet metal fabrication, metalworking, and welding
7. Paper crafts

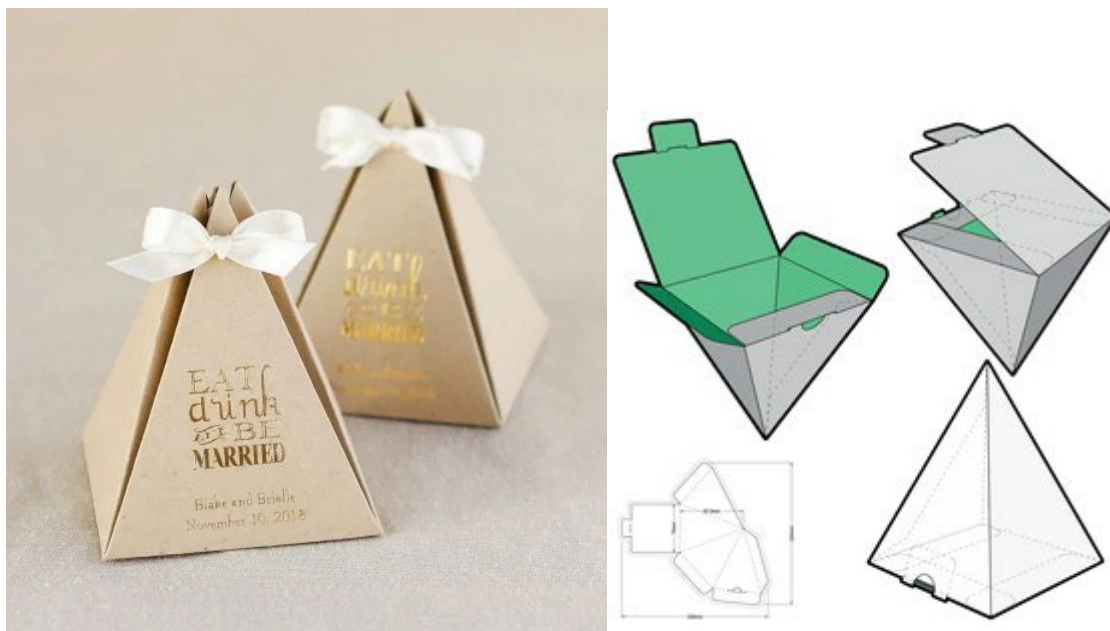
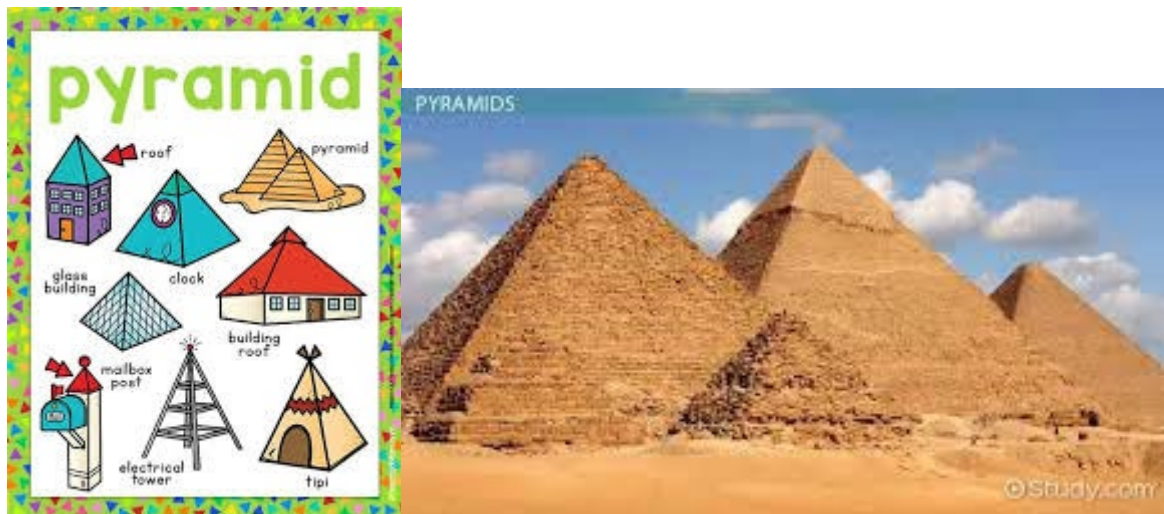


Figure 2.2.7: Real life applications of pyramids

Activity 2.2.1 Design a creative packaging solution

Organise yourselves into groups of no more than 5 and complete the following using the points listed as a guide. You can use the internet to search for videos and pictures to help. You are a product designer for a company that produces decorative candles. The marketing team wants to introduce a new, eco-friendly packaging solution that showcases the candle's unique shape while minimising material usage.

The candle's dimensions are:

Height = 100mm;

Base diameter/side=70mm;

Top diameter/side=50mm.

Choose between a triangular, square, pentagonal, and hexagonal base.

Begin by brainstorming the principles used to draw the surface development of pyramids in your groups. Share your initial insights with the class for a brief discussion.

Next, using the principles of surface development, design a pyramidal packaging solution that:

1. Encloses the candle snugly
2. Uses minimal material
3. Allows for easy assembly and disassembly
4. Showcase the candle's shape

Provide a clear and labelled diagram of your design, including:

1. The developed surface of the pyramid
2. The dimensions of each face
3. The location of any folds, creases, or seams
4. Any additional features (e.g., tabs, slots, or inserts)

Present your design to the class for discussion and feedback.

DRAWING CURVES OF INTERSECTION

When the surface of one solid meet that of another, the line(s) along which the two surfaces meet is known as the curve(s) of intersection of the surfaces of the two solids.

Many components in engineering are formed by joining various geometrical shapes

Examples of objects that exist on the principles of curves of intersection



Figure 2.2.8: Interconnected pipes

The construction of two objects joined at a right angle is guided by specific principles.

Principle one: To construct curves of intersection of two square prisms meeting at 90° but are not of the same sizes (see figure 9 below)

1. Draw the plan of the given prisms, the front and end views, in this case, the right end view.
2. Number the plan and the front view of the smaller square prism as shown.
3. Project like numbers from the plan to meet like numbers on the front view.
4. Join these points by straight lines to obtain the curve of intersection.

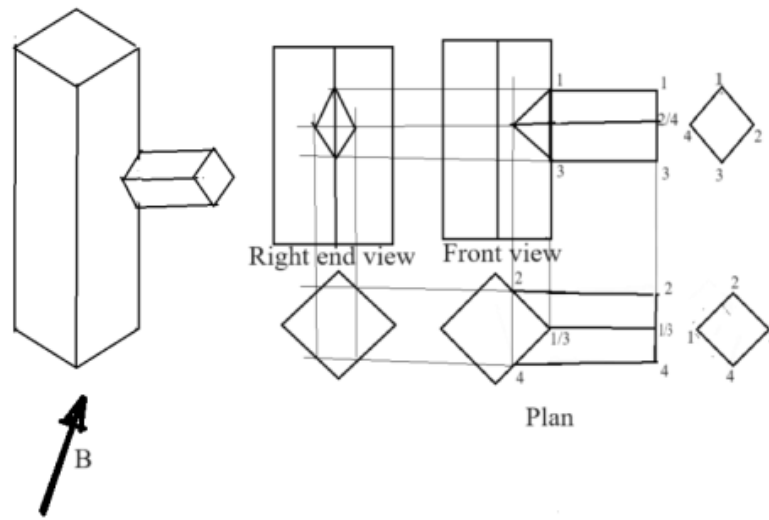


Figure 2.2.9: Curves of intersection of two square prisms meeting at 90° but are not of the same sizes

Principle two: To construct curves of intersection of two square prisms meeting at 90° and are of the same sizes.

1. Draw the plan of the given prisms, the front and end views, in this case, the right end view
2. Number the plan and the front view of the square prism as shown
3. Project like numbers from the plan to meet like numbers on the front view
4. Join these points by straight lines to obtain the curve of intersection.

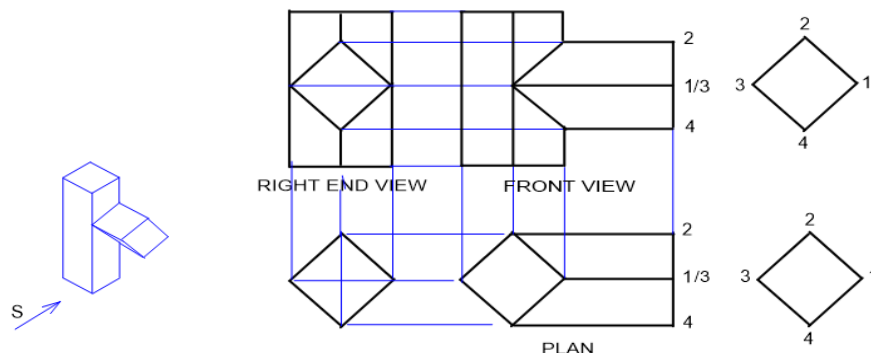


Figure 2.2.10: Curves of intersection of two square prisms meeting at 90° and are of the same sizes

Principle three: To construct curves of intersection of two similar cylinders meeting at 90° (see Figure 11).

1. Draw the plan and the partial front view of the cylinders
2. Draw semi-circle on the joining cylinder in plan and in elevation
3. Divide the semi-circles into a number of equal parts i.e. 6
4. Project horizontal lines from the plan to meet the circle
5. Number them to correspond in both views
6. Project vertical lines from the points on the circle to meet like horizontal lines in the front view
7. Mark these points.
8. Draw a smooth curve through these points to obtain the curve of intersection

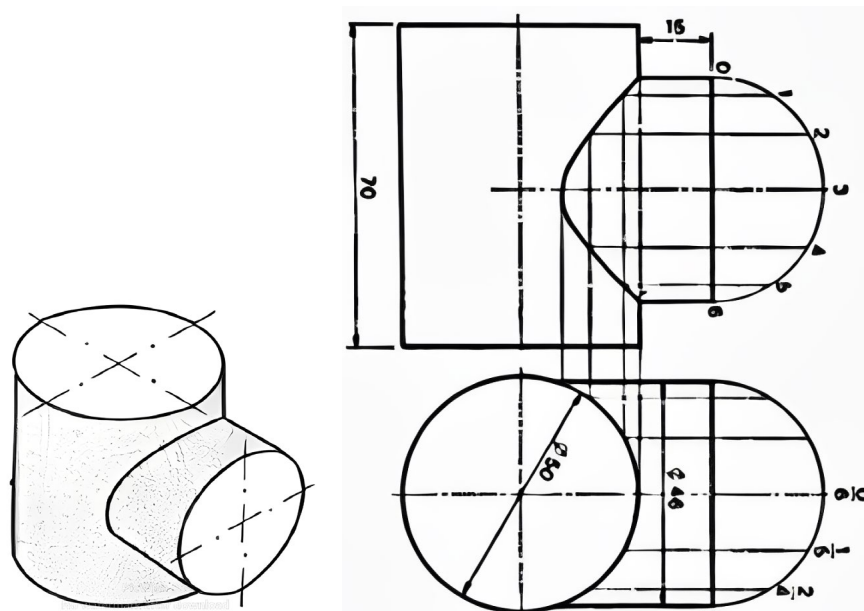


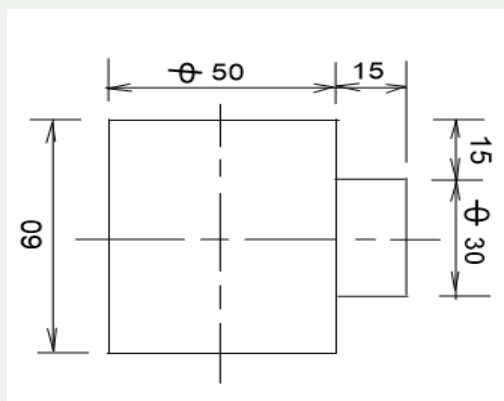
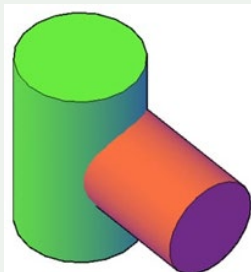
Figure 2.2.11: Curves of intersection of two similar cylinders meeting at 90°

Activity 2.2.2 Concept of drawing the curve of intersections

Organise yourselves into groups of no more than five. In your groups:

1. Brainstorm the principles of intersections
2. Discuss the concept of drawing the curve of intersections of two solid geometrical objects meeting at right angles.
3. You may use the internet to research and find pictures to supplement your understanding.
4. Present your insights and findings to the class for discussion and feedback.

Activity 2.2.3 Intersection of cylinders



a) Final joined object. b) Line diagram of joined object

Figure 2.2.12

A vertical cylinder of 50 mm diameter height 60 mm is penetrated by another cylinder of size. The axis of the penetrating cylinder is parallel to both H.P and V.P and 15 mm away from the axis of the vertical cylinder and nearer to the viewer (see figure 12). Draw to illustrate the **curve of intersection** between these two cylinders.

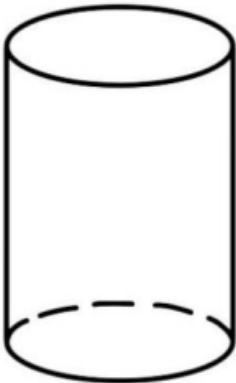
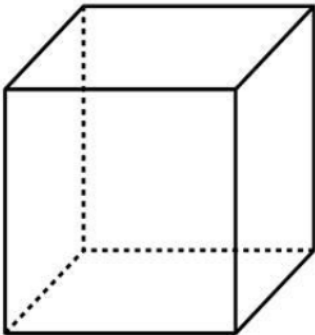
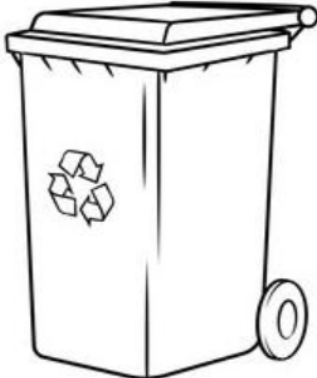
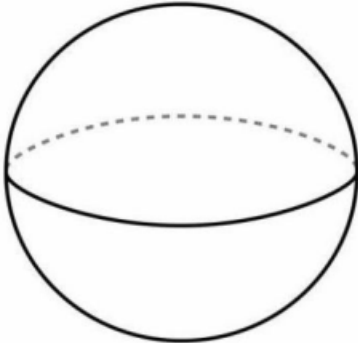
Follow these steps:

1. Sketch a circle with a diameter of 50 mm to represent the plan of a vertical cylinder.
2. Extend the horizontal diameter of the circle vertically upward to represent the true shape of the vertical cylinder. Ensure the cylinder has a height of 60 mm measured from a horizontal datum line.
3. Divide the circle into 12 equal segments and number them sequentially.
4. Project a horizontal centreline 15 mm below the plan.
5. Draw a semi-circle with a diameter of 30 mm to the right side of the plan along the centreline.
6. Extend projection lines from each divisional point on the plan to the corresponding positions on the semi-circle to represent a horizontal cylinder.
7. Draw another horizontal cylinder with a diameter of 15 mm, positioned 15 mm away from the top of the vertical cylinder.
8. Project the divisions from the plan to the front view of the horizontal cylinder.
9. Generate the point of intersection of the vertical cylinder.
10. Join points with smooth curve to obtain your curve of intersection in the front view.
11. Provide a clear explanation of the concept of drawing the curve of intersections of two solid "geometrical objects meeting at right angles.

DESIGNING WITH SOLID GEOMETRY

Solid geometry serves as a foundational tool for exploring form, structure, and designs, enabling innovative and creative solutions across various industries and applications. A lot of designed products or structures exist on the principles of solid geometry examples include water bottles, dustbins, packaging boxes, bowls etc.

Table 2.2.1: Design items based on solid geometry

Solid geometrical figures	Designed items
 Cylinder	 Cylinder Cylindrical bucket
 Cube	 Dustbin
 Sphere	 Basketball

Activity 2.2.4 Design artefacts using solid geometry

Organise yourselves into groups of no more than 5 to complete this activity. Use the following geometrical shapes to create artefacts that can be used in the home.

Name of the solid geometrical figure	Sketch	Designed items in the home
Cube		
Cylinder		
Sphere		
Pyramid		
Cone		
Prism		

Principles used to design solid geometrical artefacts: Designing artefacts with solid geometry involves applying the principles of three-dimensional shapes and their properties to create functional and aesthetically pleasing objects. Here are some key principles and considerations in designing artefacts using solid geometry.

Understanding solid geometry: Familiarisation with basic geometric shapes such as cubes, spheres, cylinders, cones, and pyramids. Understand their dimensions, proportions, and how they can be combined or modified to create complex forms.

Sketching and Conceptualisation: Begin the design process by sketching ideas and concepts that incorporate solid geometric shapes. Explore different arrangements, compositions, and variations to determine the form and structure of the artefact.

Utilising Geometric Principles: Apply geometric principles such as symmetry, balance, proportion, and spatial relationships in designs. Use these principles to create harmonious and visually appealing compositions.

Structural Integrity and Functionality: Ensure that the artefact's design considers structural integrity and functional requirements. Geometric shapes can influence the stability, strength, and usability of the artefact.

Aesthetic Considerations: Explore how solid geometry can enhance the artefact's aesthetics. Consider aspects such as texture, pattern, surface treatments, and colour schemes that complement the geometric forms and enhance the overall design.

Computer Aided Design (CAD) Modelling: Transition sketches into detailed three-dimensional models using Computer-Aided Design (CAD) software. CAD tools allow you to precisely manipulate and visualise geometric shapes, explore variations, and refine designs.

By integrating solid geometry principles into the design process, you can create artifacts that not only exhibit geometric elegance but also achieve practical functionality and aesthetic appeal.

BASIC CONCEPTS IN COMPUTER AIDED DESIGNS (CAD)

Introduction to Auto CAD

CAD is an acronym which means Computer-Aided Design, Computer-Assisted Design, Computer-Aided Drafting, or Computer-Assisted Drafting. CAD is specialised software used to create, modify, and optimise designs. It is widely employed in engineering, architecture, and product development, replacing manual drafting with precise digital drawings.

There are other related terms in the system because of their functions, and these are Computer-Aided Design and Drafting (CADD) and Computer Aided Mapping and Computer-Aided Cartography.

Why use Auto CAD?

A fascinating highly efficient and accurate software programme that has a very high level of precision for either architecture, engineering, mechanical drawings, woodwork, fashion design, or electrical and electronic components. CAD is an indispensable tool, enhancing precision, efficiency, and collaboration in modern design.

Importance of CAD in Drawing

1. **Precision:** CAD ensures high accuracy; minimising errors compared to manual drafting.
2. **Efficiency:** Tasks like modifying or replicating designs are faster and more streamlined.
3. **Versatility:** CAD supports both 2D drafting and 3D modelling for comprehensive visualisation.
4. **Flexibility:** Designs can be easily updated without redrawing.
5. **Collaboration:** Digital files enable seamless sharing and teamwork.
6. **Professionalism:** CAD produces clean and detailed presentations.
7. **Integration:** It connects with systems like Computer-Aided Manufacturing (CAM) for smooth workflows.
8. **Storage:** Digital files are easily stored and retrieved, eliminating the need for physical archives.

There are different kinds of CAD systems in use today. Among them are:

1. **Auto CAD:** This is a software generally used by Engineers for Mechanical, Furniture, Automobile or architectural drawings, etc.
2. **Auto CAD Architectural desktop:** particularly for Architectural drawings.
3. **Optitex PDF CAD/Patten design:** is for fashion design and drawing.

The following should be known before beginning actual drawing with CAD:

1. **Launching Auto CAD.**
2. **Exploring the Auto CAD interface.** These include:
 - a. **World coordinate system**
 - b. **Crosshair cursor**
 - c. **Start tap:** Setting of sheets (e.g. acad, acadiso, architecture etc.)
 - d. **Draw/ Graphic area**
 - e. **Ribbon:** consisting of various command/tools for modelling artefact (e.g. layers, draw, modify, modelling, solid editing, mesh, views, etc.)
 - f. **Command window/line**
 - g. **Status bar:** numerous settings which consist of grid mode, snap mode, orthomode, polar tracking, object snapping, workspace switching, line weight etc.
 - h. **Menu bar:** consist of home, solid, surface, mesh, visualise, parametric, insert, view, manage, etc.

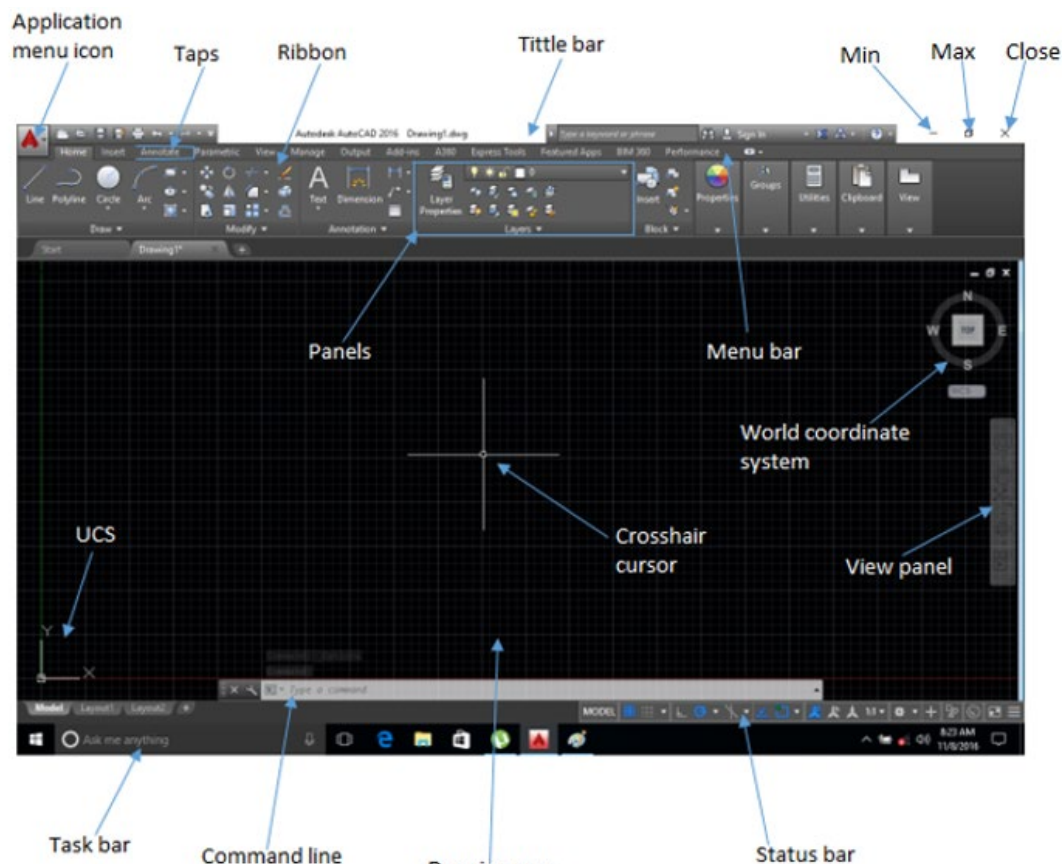


Figure 2.2.13: CAD interface

To begin AutoCAD drawing

1. **Set up the interface:** To set up means to create a new drawing/sheet that will meet your specification and convenience.
2. **Cultivate the habit of saving:** As you draw, you should develop the habit of saving the drawing periodically (about every 15 or 20 minutes) using the save icon or using the short cut keys Ctrl+S. Save stores the drawing in its most current state to the drive.
3. **The World Coordinate System:** Everything you draw in AutoCAD is created in an infinitely large drawing space and can be located by the x and y coordinates. The default coordinate system in AutoCAD is called the World Coordinate System, or WCS. The WCS can be change to a user-defined coordinate system (UCS), but it can be done if necessary.

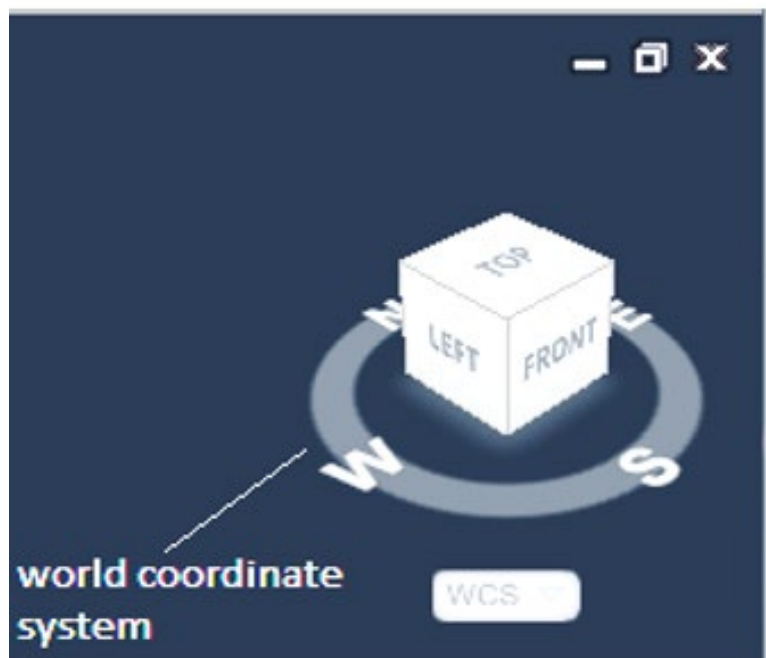


Figure 2.2.14: WCS

The steps to control the UCS icon's display:

Step 1: Choose View ⇄ UCS Icon.

Step 2: Select On to turn the display of the icon off and on.

Step 3: Select Origin to move the icon to 0, 0, 0 in the drawing, or to the lower left corner of the drawing area

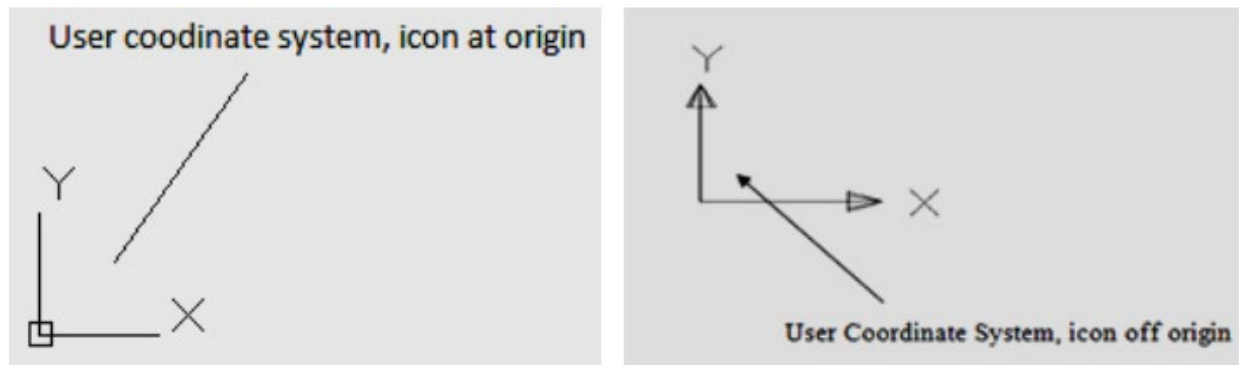


Figure 2.2.15: UCS (User Coordinate Systems)

Coordinate System

Before you start drawing, you will need to employ a coordinate system to specify points in 2D space. AutoCAD 2016 makes available five different coordinate systems for specification of points. The five different coordinate systems are:

1. Interactive coordinate system
2. Relative coordinate system
3. Absolute coordinate system
4. Polar coordinate system
5. Direct distance entry method which is easier and more efficient to use compared with the other four systems.

Direct distance entry method

The direct distance entry method is a more realistic approach where dimensions are considered very important. To specify a line length quickly, without entering coordinate values, you can specify a point by moving the cursor to indicate a direction and then enter the distance from the first point.

Example:

Draw the lines below with the line command. Respond to the common prompts as follows:

STEP	PROCEDURE
1	On the Command: - Type line. Or click on the line icon on the draw toolbar
2	Specify first point: - Click anywhere within the drawing area to pick your first point.
3	To Specify the next point, move the cursor towards the direction of the line and type in the length of the line (e.g. 100)
4	Hit the enter key to accept the dimension.
5	Specify next point by moving the cursor to the top of the draw and at an angle of 90 degrees and type the length of the second line. Example 80.

6	Hit the enter key twice to break the rubber band
7	Note that the line band is not broken the first time you hit the enter key. To break it, press the Enter key a second time. Also, you can press the escape key to end.

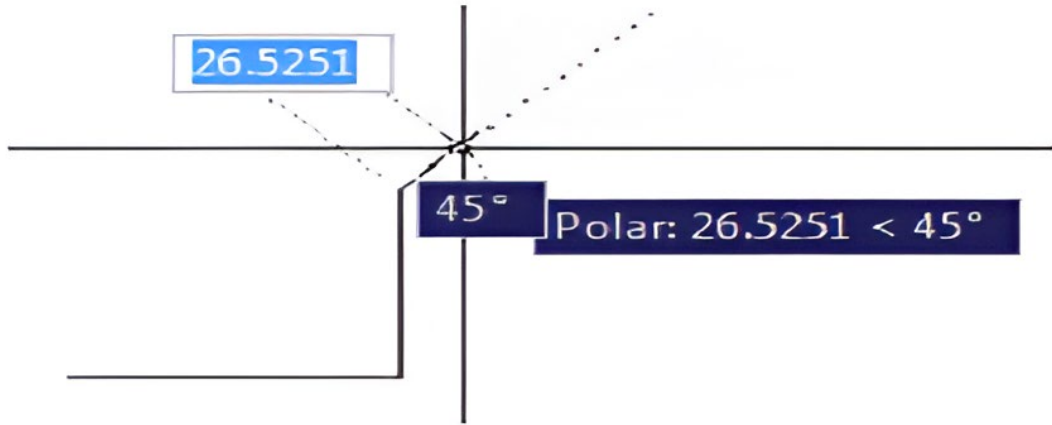


Figure 2.2.16: Direct entry Line

Object properties panel

The object property panel is a very useful feature that is used to separate different types of objects in the same space. It becomes more relevant when the objects are many and complex and need to be isolated for analyses, editing or identification.

Two ways of chosen a Layer

1. On the Home menu, choose layer properties

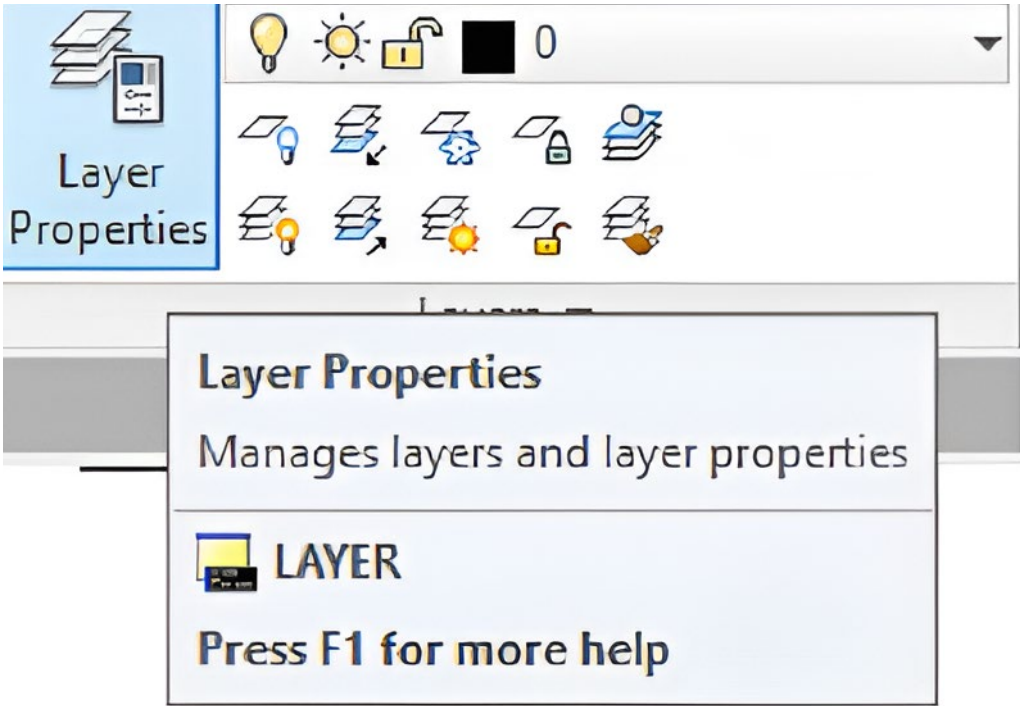


Figure 2.2.17: Layer

2. On the command line, type layer (or LA)

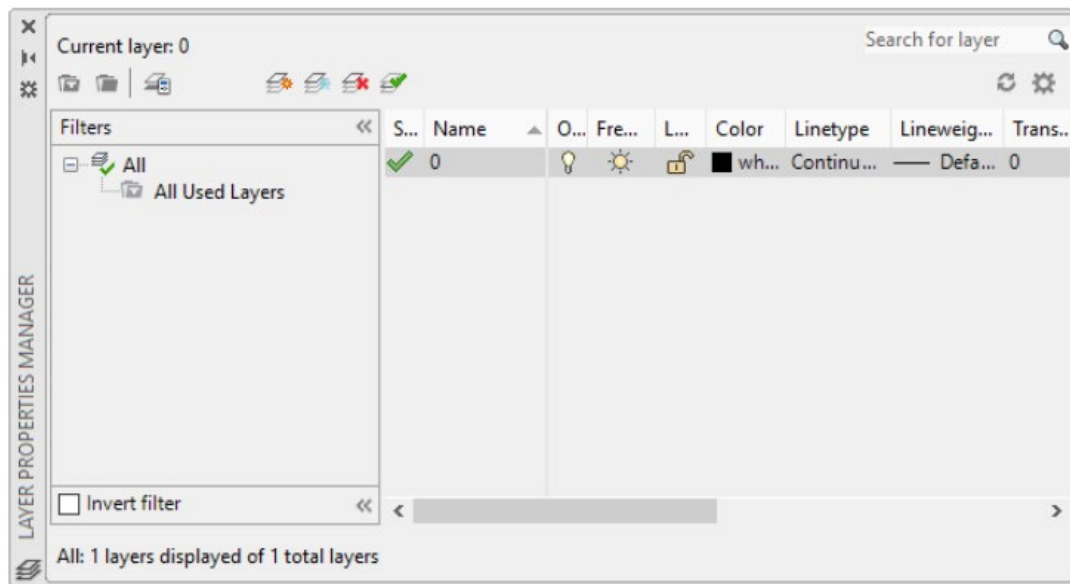


Figure 2.2.18: Layer Property Manager

Draw command

Draw commands are commands that create or add new entities to your drawing. To locate the draw command, the following two-command entry methods can be used depending on your computer setup.

1. **Draw panel:** select the command or dialogue box by picking a tool (icon button) from a draw panel on the ribbon.
2. **Keyboard entry:** type the command name, command alias, or accelerator key at the key - board.

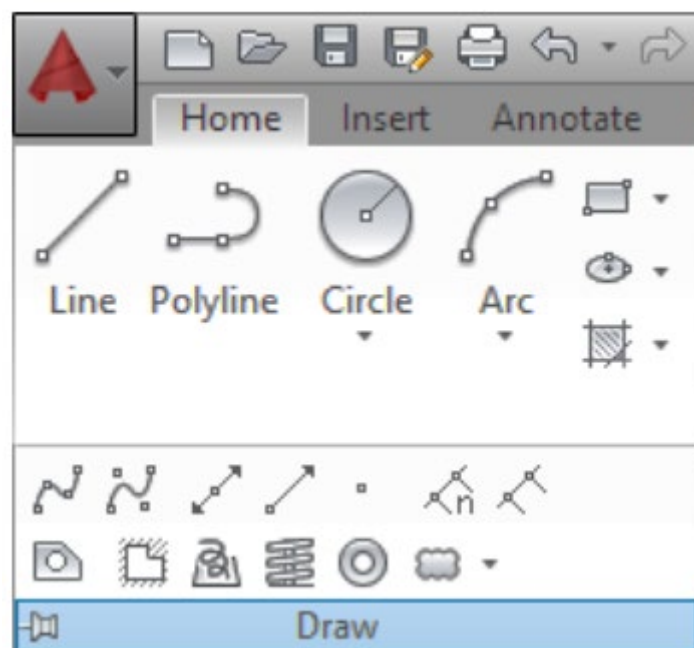


Figure 2.2.19: Draw panel

Line

The line symbol is used to draw lines. A line can be one segment or a series of connected segments, but each segment is a separate line object. Use lines if you want to edit individual segments. That is to say that if you want to edit a triangle, use lines to draw the three sides, each side representing a segment so you can edit each of the three sides.

How to draw a line 80mm

1. Click on the line icon on the draw panel or type Line at the command line.
2. Specify the start point: click to pick the start point
3. Specify the endpoint: type value (80)
4. Press ENTER to complete the line.

How to draw two perpendicular lines line AB 80mm, line BC 40

1. Click on the line icon on the draw panel or type Line at the command line.
2. Specify the start point: click to pick start point
3. Specify the endpoint: type value (80)
4. Specify the endpoints of the next segments directed upwards and at 90 degrees to the first line.
5. Specify the endpoint: type value (40)
6. Press ENTER to complete the line.

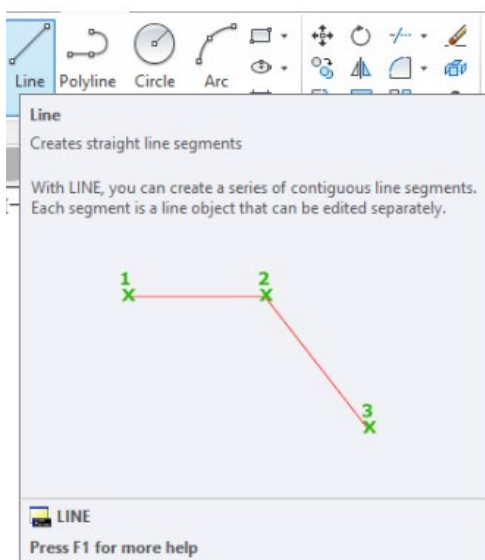


Figure 2.2.20: Line

Arcs

You can create arcs in many ways. The default method is to specify three points. That is, a start point, a second point on the arc, and an endpoint. You can also specify the included angle, radius, direction, and chord length of arcs. The chord of an arc is a straight line between the endpoints.

How to draw a continuous arc

1. Click on the Arc icon from the draw panel or type Arc at the command line.
2. Specify the first point of the arc: click to pick the first point.
3. Specify the next point of the arc: click to pick the next point.
4. Specify the next point of the arc: click to pick the next point.
5. Continue until you get the required shape

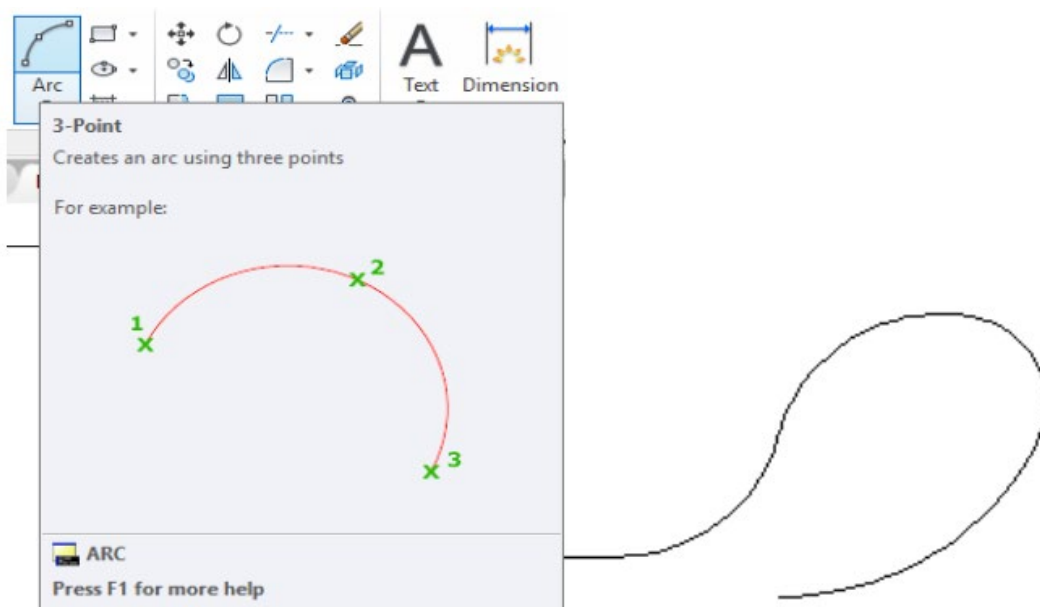


Figure 2.2.21: Arc

How to draw an arc by specifying three points

Steps

1. From the Draw panel, choose Arc
2. From the flow-out box choose Start, Centre, End.
3. Specify the start point: click to pick the start point
4. Specify the second point: click to pick the second point
5. Specify the endpoint of the arc: click to pick the endpoint

Circle

The method for creating a circle depends on the specifications given.

How to draw a circle by specifying a centre point and radius

Steps

1. Click on the circle icon or from the Draw panel, choose Circle-Centre, Radius
2. Specify the centre point: click to pick the centre point
3. Specify the radius of the circle: type the value (e.g. 80).

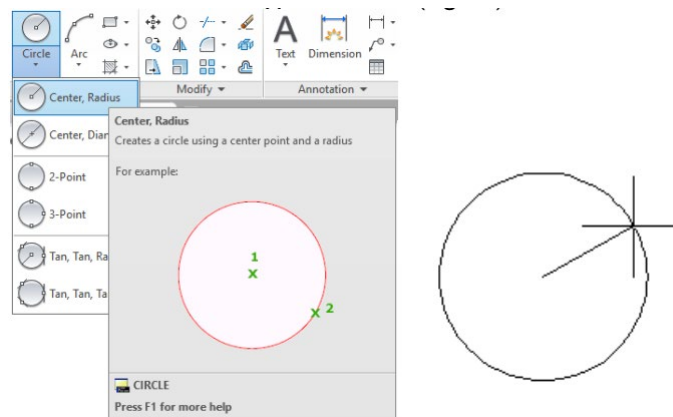


Figure 2.2.22: Circle

How to create a circle tangent to existing objects

Steps

1. From the Draw panel, choose Circle Tan, Tan, Radius
2. You are now in Tangent snap mode.
3. Select the first object to draw the circle tangent to.
4. Select the second object to draw the circle tangent to.
5. Specify the radius of the circle: enter the value.
6. Hit the enter key.

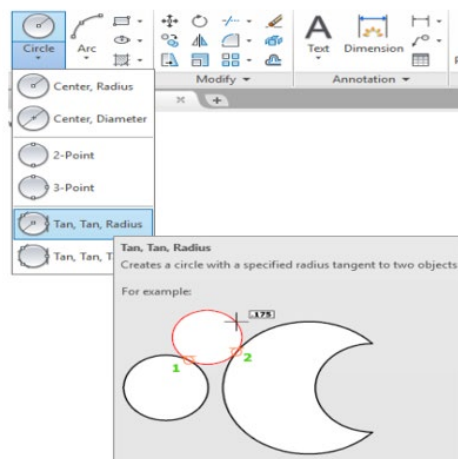


Figure 2.2.23: Circle tangent

Rectangle

How to draw a rectangle

Steps

1. Click on the rectangle icon on the draw panel.
2. Specify the first corner point: pick (move the cursor to any desired length and
3. Specify the other corner point: pick

Activity 2.2.4 Use AutoCAD to draw a rectangle

Use AutoCAD to draw a rectangle using the following steps.

Example of using measurements, (150mm and 90mm)

Steps

1. From the draw panel, choose rectangle, **or** type rectangle at the command line.
2. Specify the first point or (chamfer/fillet/thick width): click and drag
3. Specify the other corner point or (Dimensions): type D

(**Note:** type 'D' and press enter key to choose the dimension option.)

1. Specify the length for the rectangles. <0.000>: 150
2. Specify the width for the rectangle. <0.000>: 90
3. Click to end the command.
4. Discuss your results with the class for feedback.

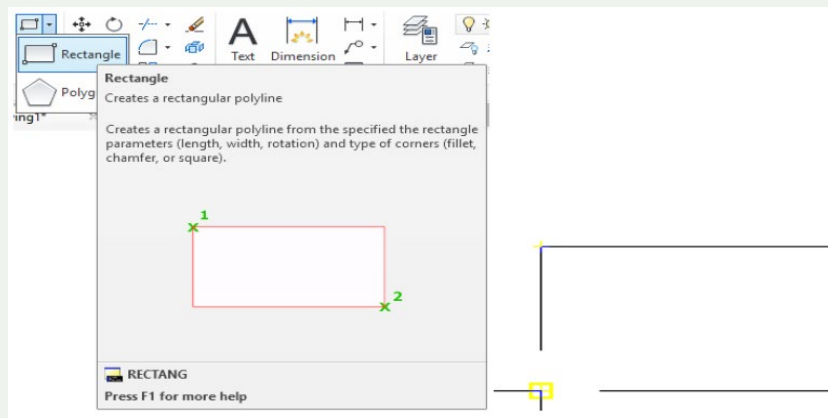


Figure 2.2.24: Rectangle

Polygon

The polygon command centres on regular polygons. It uses Line to create a polygon. The command sequence for this default method is as follows:

Steps

1. From the draw panel, choose polygon, **or** type polygon at the command line.
2. Enter the number of sides <4>: 6
3. Specify the centre of the polygon or (edge): click to pick the centre
4. Enter an option (Inscribed in circle / Circumscribed about circle) <1>: I or C
5. Specify the radius of the circle: enter value (60)
6. Command: enter

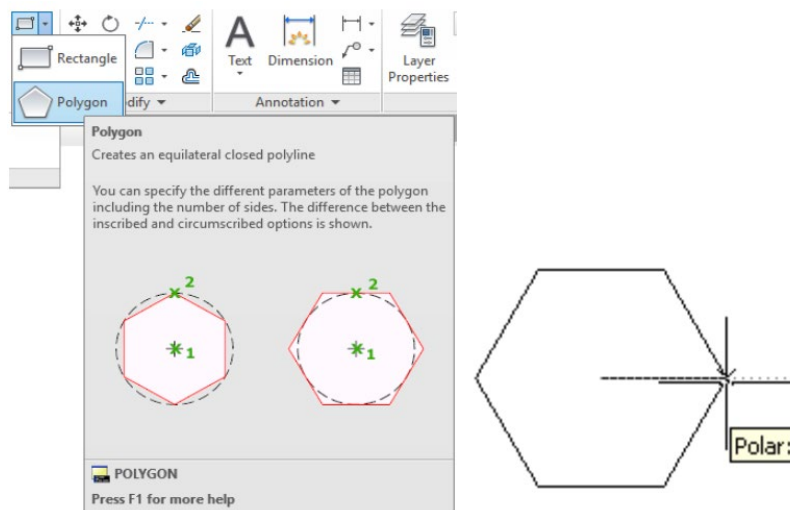


Figure 2.2.25: Polygon

Ellipse

To create full ellipses or elliptical arcs, the default method is to specify the endpoints of the first axis and the distance, which is half the length of the second axis.

How to draw a true ellipse using endpoints and distance

1. From the draw panel, choose ellipse, **or** type ellipse at the command line.
2. Specify the first endpoint of the first axis: click
3. Drag the pointing device away from the midpoint of the first axis
4. Specify the other endpoint of the first axis: enter the minor axis value (330)
5. Specify distance to the other axis or [rotation]: enter major axis value (600)

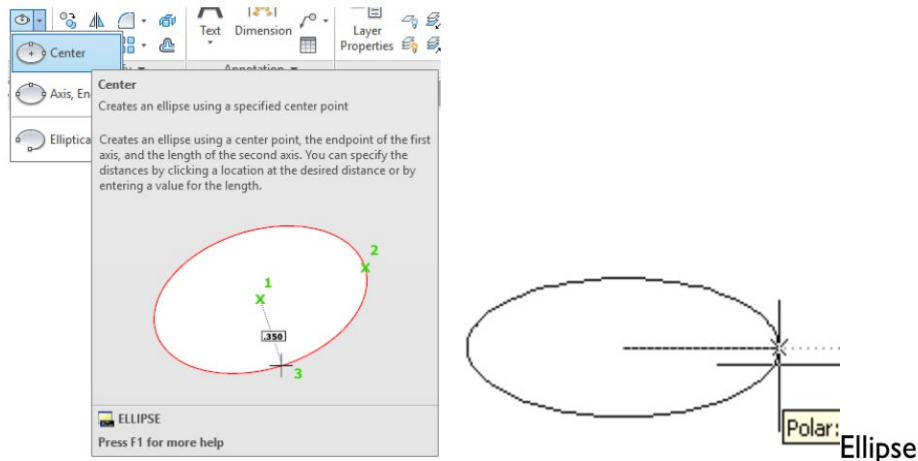


Figure 2.2.26: Ellipse

Hatch

A hatch is to create a pattern within a space provided either to enclose the space or provide some sort of beautification. The hatched space must be identified in the hatch dialogue box to take effect. Hatch is available on the command line, the draw toolbar and the screen menu.

How to hatch an enclosed area

1. Draw the object to be hatched
2. From the draw panel, choose hatch, **or** Type hatch at the command line.
3. From the ribbon, choose a different hatch from the default one.
4. Within the Boundaries panel, click on the select button.
5. Specify a point in your drawing inside each area you want to hatch.
If you make a mistake, you can right-click and choose “Clear All” or “Undo Last”.
6. Select/Pick from the shortcut menu. Press Enter to apply the hatch.

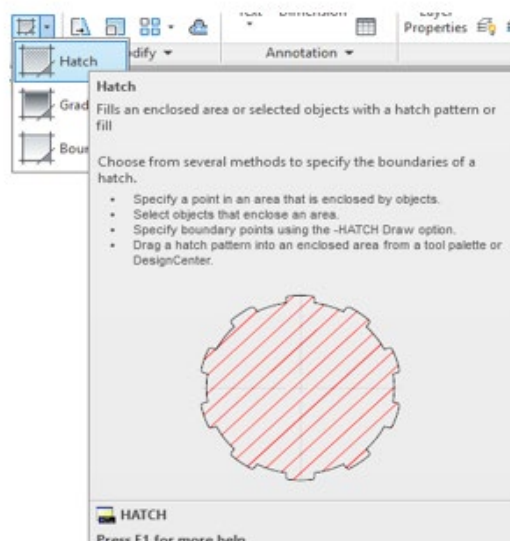


Figure 2.2.27: Hatch and Gradient

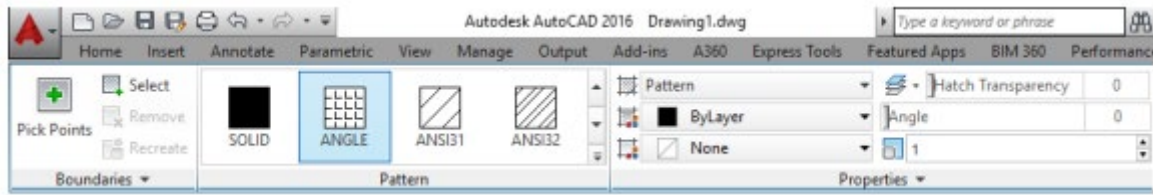


Figure 2.2.28: Hatch creation ribbon

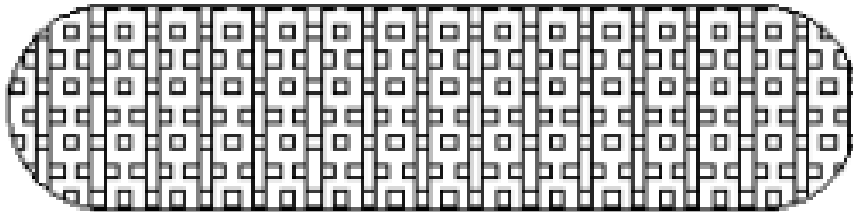


Figure 2.2.29: Select Object Hatch

Multiline Text

1. From the Annotation panel, Choose Multiline Text **or** Type MTEXT at the command line
2. Type one of the following options: Height/Justify/Rotation/Style/Width:
Or
3. Pick 2Points to define the text window.
4. Type the text and click to end the command

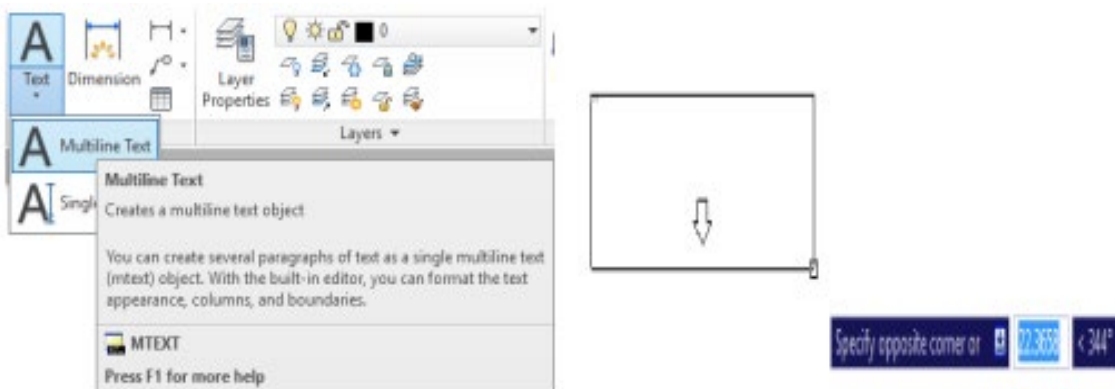


Figure 2.2.30: Multiline Text Editor

The Modify Command

Modifying commands are used to edit or change the properties of entities in your drawing. These commands can be found in the Modify panel. The following modify commands can be explored: Spline, polyline, constructional line, divide, donut, ray, revcloud, point, etc.

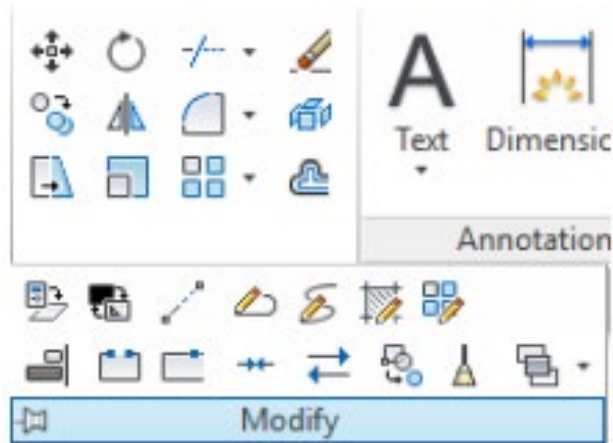


Figure 2.2.31: Modify tool bar

Erase

This command deletes objects you select from the drawing.

How to erase a selection set

Steps

1. click on the Erase icon.
2. Using window selection, select the objects to erase.
3. Press ENTER to close the command.

Mirror

This command allows you to mirror objects around a mirror line, which you define with two points, as shown in the following illustration. You can delete or retain the original objects.

To mirror objects

Steps

1. From the modify panel, click on mirror, or type mirror at the command line.
2. Select the objects to mirror with a window.
3. Specify the first point of the mirror line - Pick.
4. Specify the second point - Pick.
5. Press ENTER to retain the original objects.

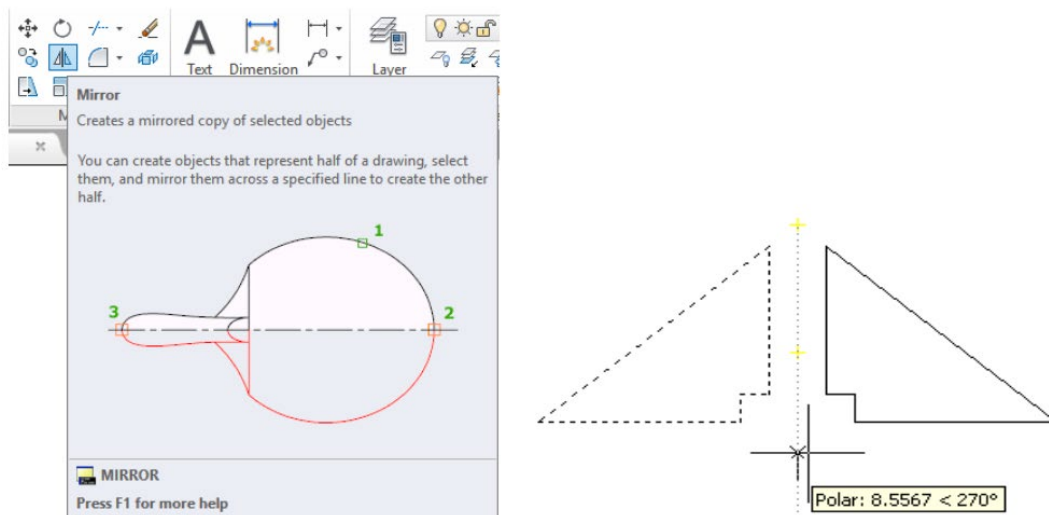


Figure 2.2.32: Mirror

Offset

Offsetting creates a new object that is similar to a selected object but at a specified distance. You can offset lines, arcs, and circles.

To offset an object by specifying a distance

Steps

1. From the modify panel, click on offset, **or** type offset at the command line.
2. Use the pointing device to specify the offset distance or enter a value.
3. Select the object of offset.
4. Specify which side to offset - Pick.
5. Select another object to offset, or press ENTER to end the command.

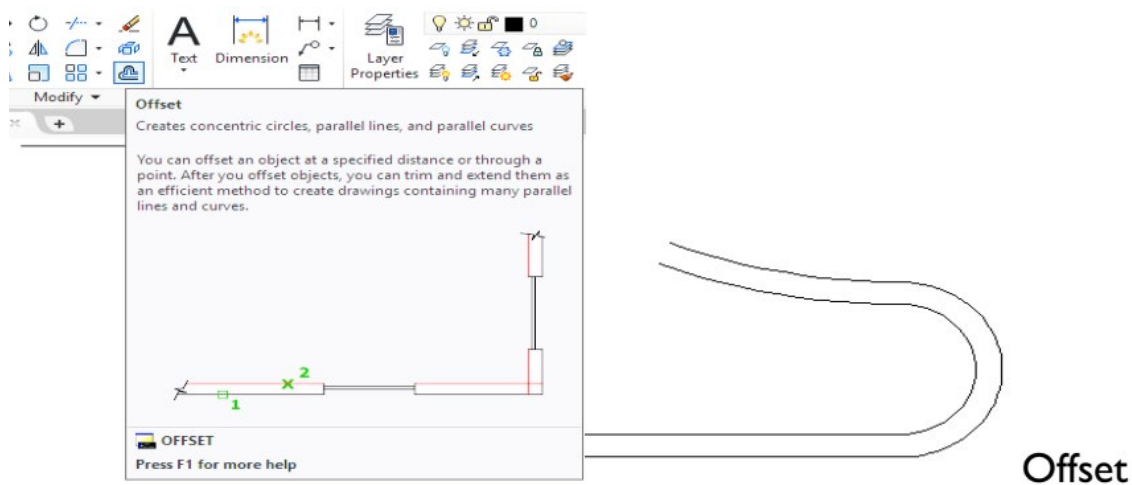


Figure 2.2.33: Offset object

Move

Move allows you to relocate one or more objects from the existing position in the drawing to any other position you specify. When you move objects, you can rotate or align them or move them without changing orientation or size.

To move an object

Steps

1. From the modify panel, click on Move, **or** type Move at the command line
2. Select the object to move.
3. Specify the base point for the move: click
4. Specify the second point of displacement: click **or** type the value

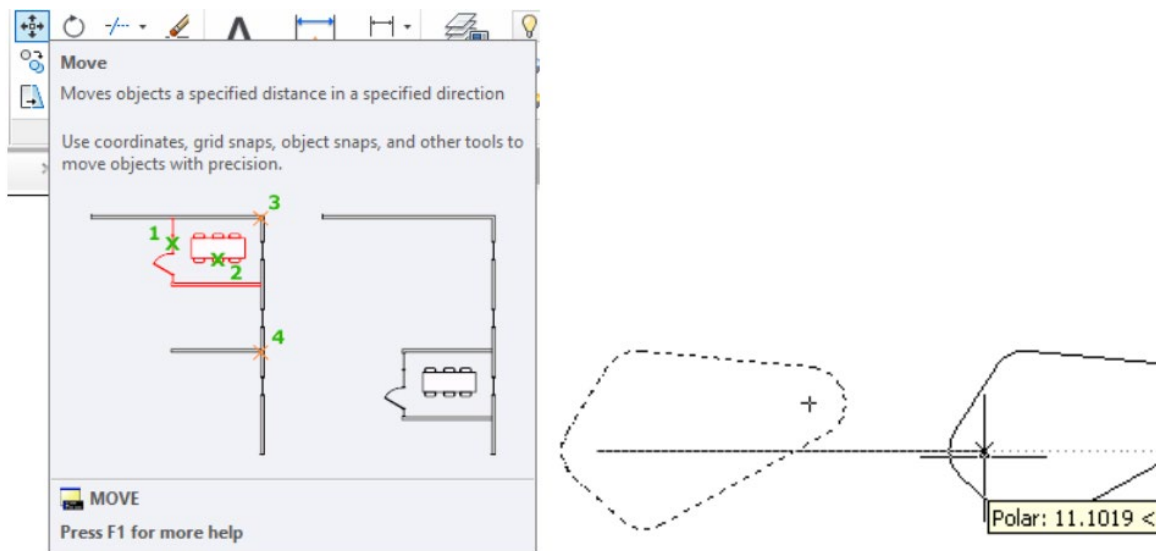


Figure 2.2.34: Move object

Copy

You can copy single or multiple objects within the current drawing, and you can copy between drawings or applications.

How to Copy a selection set once

Steps

1. From the modify panel, click on copy, or type copy at the command line
2. Select the objects to copy and press ENTER.
3. Specify the base point, (by picking a point).
4. Specify the second point of displacement: click to copy

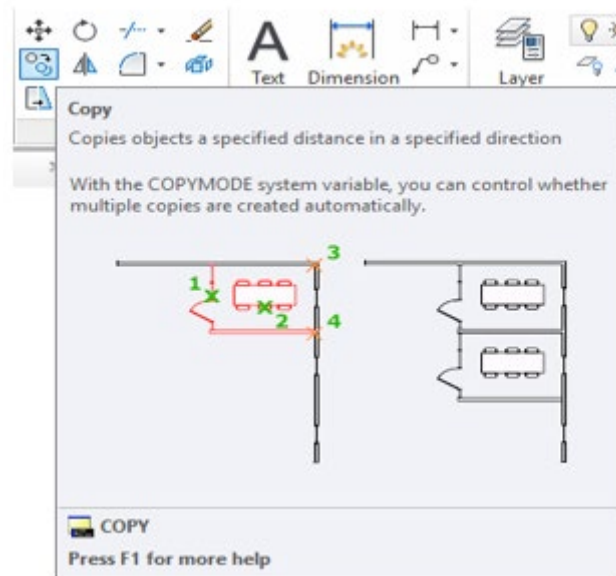


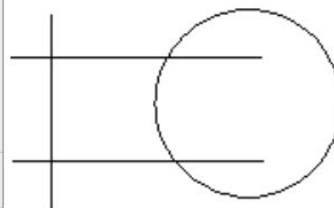
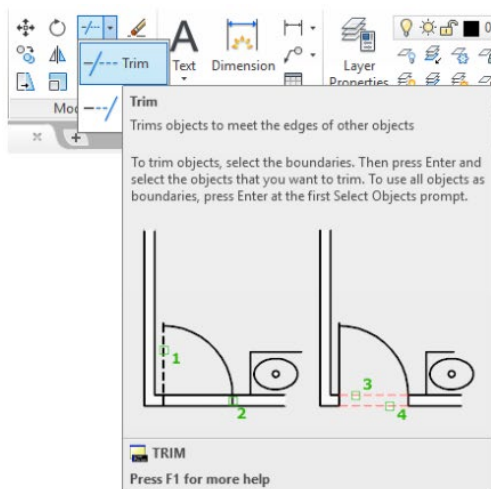
Figure 2.2.35: Copy

Trim

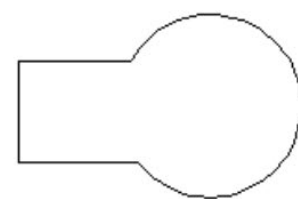
The trim command allows you to trim (shorten) the end of an object back to the intersection of another object. The middle section of an object can also be trimmed between two intersecting objects.

Steps

1. From the modify panel, choose Trim, **or** type Trim at the command line.
2. Select cutting edges: Enter
3. Select object or <select all>: Enter
4. Select object: Pick



Before trim



After trim

Figure 2.2.36: Trim

Note: the following modify command can be explored: Extend, stretch, Scale, Fillet, Chamfer, Explode, Break, Rotate, Array etc.

Advance creation techniques

AutoCAD provides you with some other drawing tools, which enable you to draw 3D objects.

1. Extrude

With EXTRUDE you can create solids by extruding (adding thickness to) selected objects. You can extrude an object along a path, or you specify a height value and a tapered angle. You can also extrude planer faces along a path, or you can specify a height value and a tapered angle.

Extruding 2D shapes

With the extrude command; you can create solids by adding thickness to 2D objects. If you create a profile using lines or arcs, use the join option of PEDIT to convert them to a single Polyline object or make them into a region before you use **extrude**.

Example: Draw a circle with radius 50mm and extrude to a height 70.

Steps:

- From the modelling panel, select Extrude, **or** type Extrude at the command line.
- Select objects: click to select the object
- Specify height of extrusion or [path]: (e.g. 70)
- Specify angle of taper for extrusion <0>: Enter.

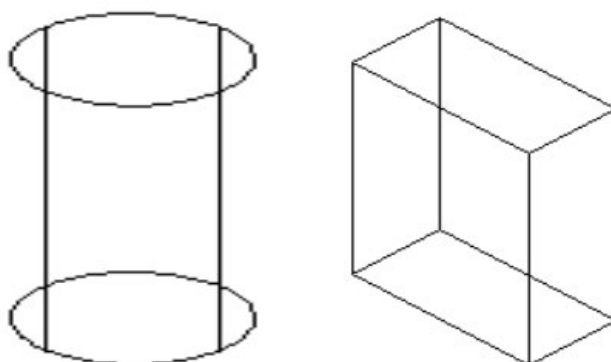
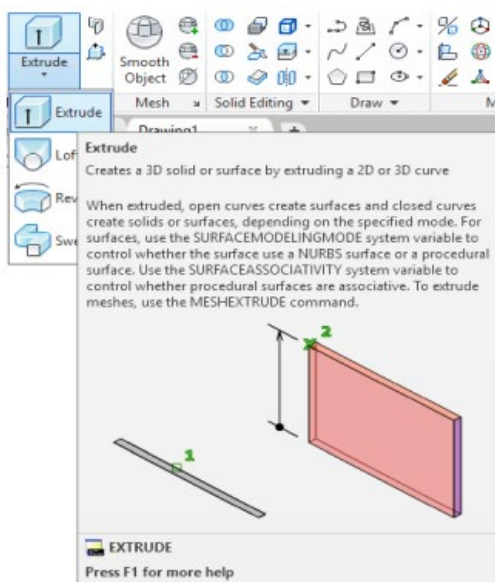


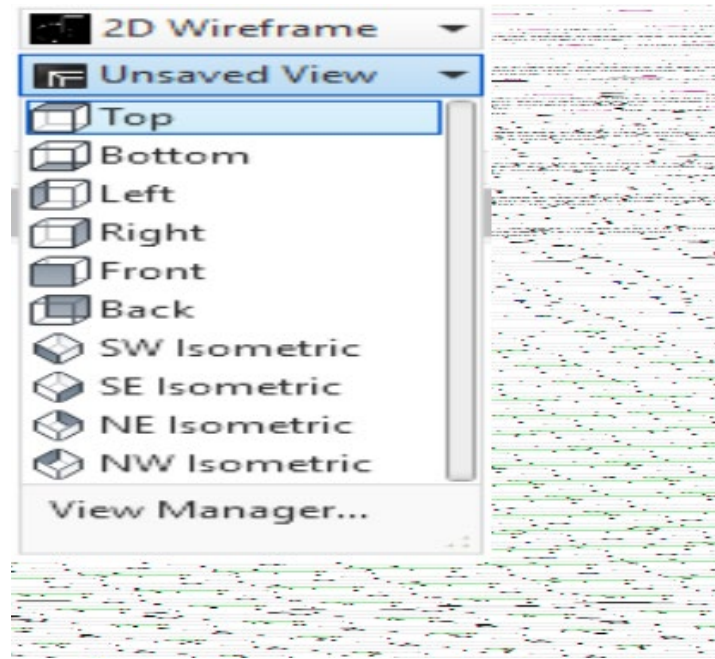
Figure 2.2.37: Extrude

2. Presspull

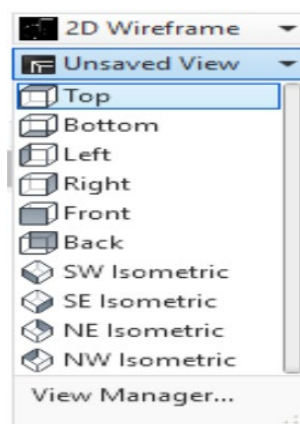
You can press or pull bounded areas by pressing and holding CTRL + ALT, or by clicking the Presspull button on the dashboard and then picking the bounded area. The area must be bounded by coplanar lines or edges.

Steps:

- From the modelling panel, select Presspull, **or** type Presspull at the command line.
- Select the object or bounded area: Click and drag to a new location.
- Presspull specify extrusion height or [multiple]: Enter the value (e.g. 90)
- Select object or bounded area: Enter

**Figure 2.2.38: 3D Views****3D view commands**

The “view pull” commands shown in the view pull-down menu below are used to change the direction from which you view a 3D model. You can access view from the view panel.

**Figure 2.2.39: 3D Views**

3. Primitive solids

Primitive solids (often called primitives) are basic geometric shapes that create 3D models. The primitives with straight edges, primitives with curves edges, and polysolid. A Polysolid is the 3D solid version of a Polyline. Polysolids are made up of both straight and curved segments. AutoCAD allows you to create eight different 3D solid primitives.

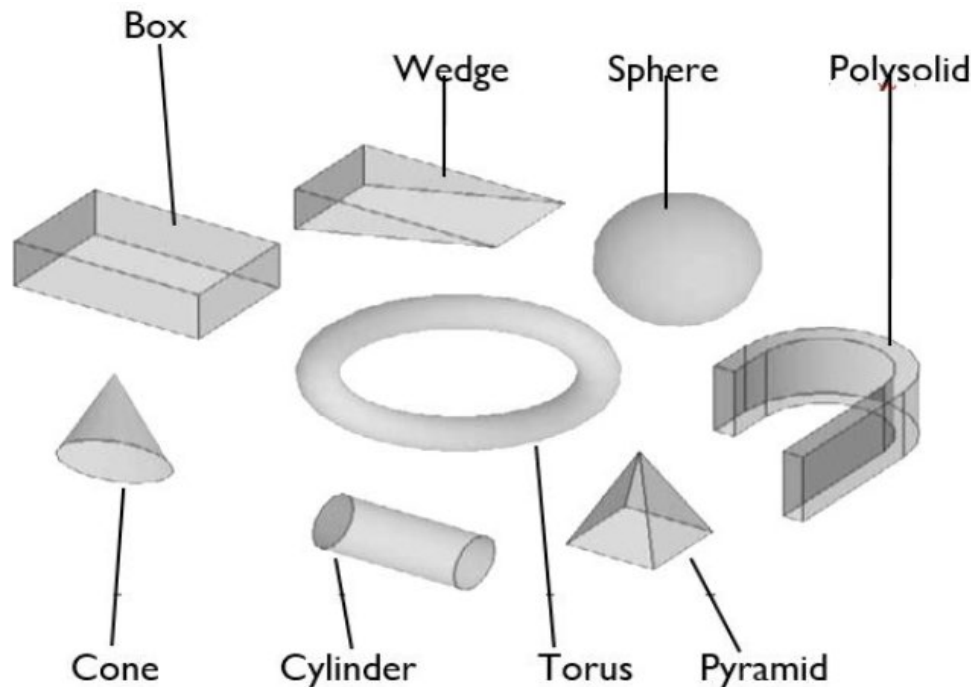


Figure 2.2.40: Primitive solids

Activity 2.2.5 Importance of CAD in drawing

1. Organise yourselves into groups of no more than five.
2. In your groups, use the internet or any other resource to research on the importance of CAD and it's use in drawing. Include examples where possible.
3. Make notes on your research and share your findings with the class for discussion and feedback.

Activity 2.2.6 Interface and pallets of CAD software

1. Organise yourselves into groups of no more than five.
2. In your groups, use the internet or any other resource to research on the Interface and pallets of CAD software. Use the following as a guide:
Interfaces.
a. Graphical User Interface

b. 3D Viewports

CAD Software Pallets:

- a. Tool Pallets
- b. Object Pallets
- c. Material Pallets
- d. Layer Pallets

Include examples where possible.

Make notes on your research and share your findings with the class for discussion and feedback.

DRAWING WITH COMPUTER AIDED DESIGNS (CAD)

Application of AutoCAD in Mechanical Drawings

AutoCAD is used to design and document engineering drawings. This involves creating orthographic projections, sections, detail and 3D modelling all within a coordinated set of drawings.

Example: Follow the steps below to draw the figure below in AutoCAD.

Steps

1. Use line to locate any point in 2D space. (See draw commands for the steps of line).
2. Use by layer properties to change line to centre lines.
3. Use offset command to offset lines (See modify command for the steps of offset).
4. Use circle command to draw circles at centres. (See draw commands for the steps of circles).
5. Use lines to form tangents to the circles.
6. Use fillet command to form arcs to the circles (See modify command for the steps of offset).
7. Use polygon (circumscribe) to obtain the octagon at the centre with radius 120mm (See draw commands for the steps of polygon).
8. Use hatch command to hatch the portions in the drawing.

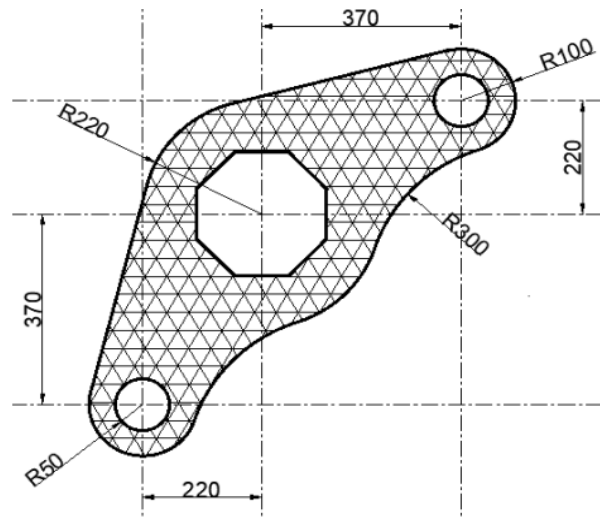


Figure 2.2.41

Activity 2.2.7 AUTOCAD in Mechanical Drawing

In pairs, draw the figure below in AUTOCAD. Save the drawing on the desktop with your family name.

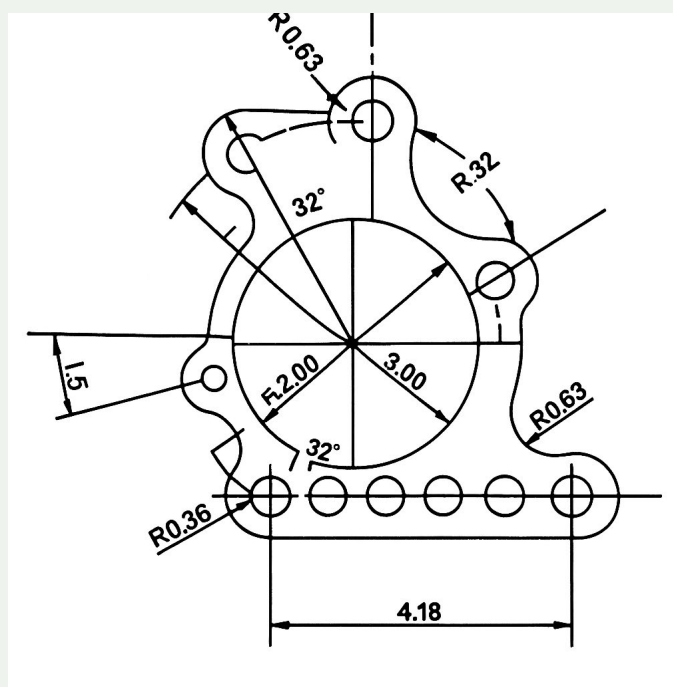


Figure 2.2.42

Application AutoCAD in Building drawing (Architecture Desktop)

AutoCAD Architecture desktop is used to design and document building drawings this includes creating a presentation plan, a floor plan layout, door and window schedules, a section, and a detail, all within a coordinated set of drawings.

Activity 2.2.8 AutoCAD in Building Drawing

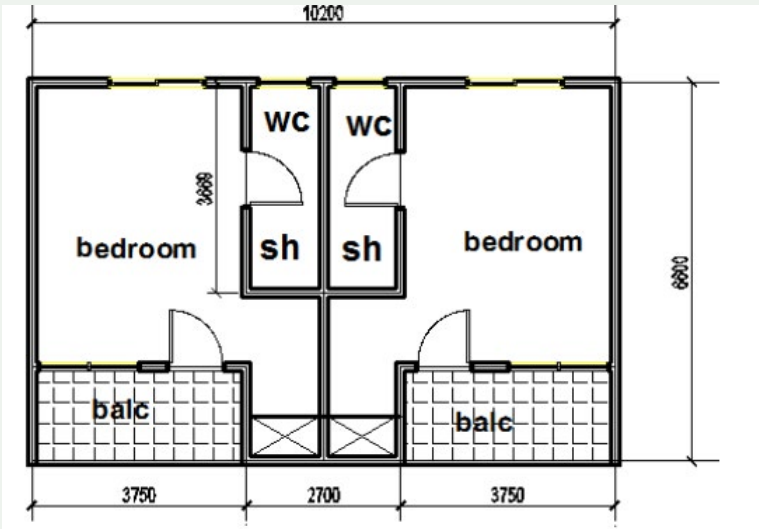
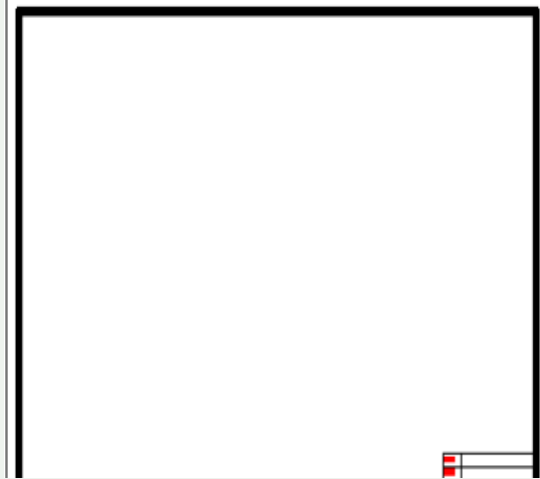


Figure 2.2.43: Floor Plan

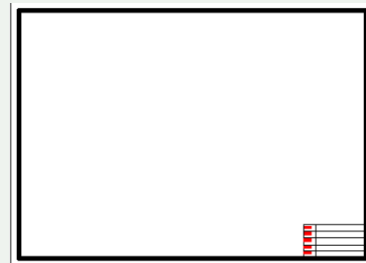
In pairs, use the instruction or techniques in the table to draw the floor plan shown above using the architecture desktop

Steps	Drawing
Set the sheet by using MVSETUP: MVSETUP →Enter Enable paper space [NO/YES] <Y>: NO Enter unit type [Scientific/Decimal/ Engineering/Architectural/Metric]: M Enter the scale factor: 1 Enter the paper width: 420 (A3) Enter the paper height: 297 (A3) OR Use a customise sheet set.	The drawing shows a rectangular frame representing the sheet. In the center, there is a crosshair with a small square at its intersection. On the left side of the rectangle, there is a vertical line with a triangle pointing upwards. On the bottom side, there is a horizontal line with a triangle pointing to the right and an 'X' mark.

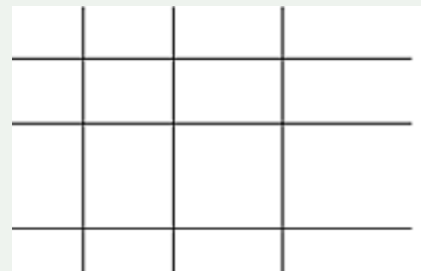
Set new layers and choose different colours, line type and line weight before starting to draw the actual objects.



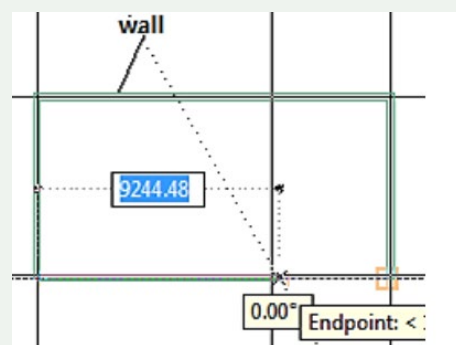
Use line command and offset command to draw title block lines in 2D space. (see Draw commands for the steps of line and modify commands for the steps of offset).



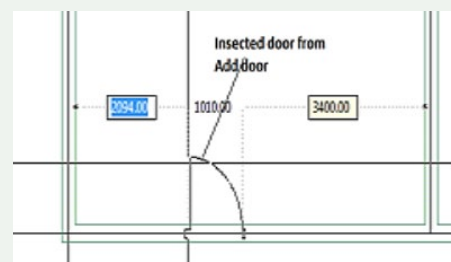
1. Use line command and offset command to draw grid lines in 2D space. (see Draw commands for the steps of line and modify commands for the steps of line offset). OR
2. Use the column grid command.

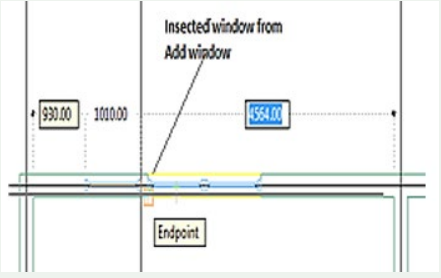
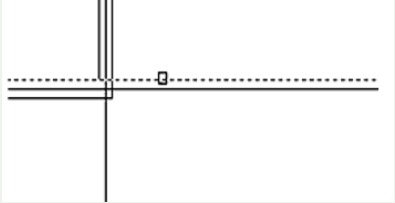
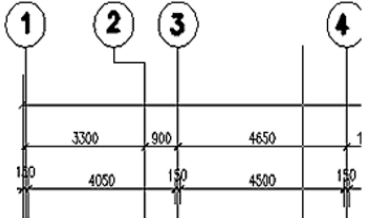
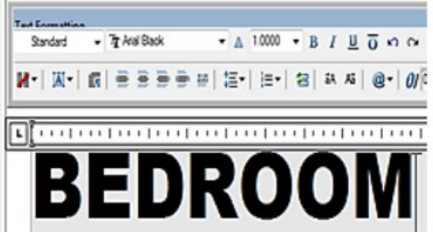


Use the Add Wall command to offset the grid lines to obtain wall thickness.



Insert door from design centre or tool palettes. Or use the command Add door.



Insect windows from design centre or tool palettes. Or use the command Add window	
Use the erase command to erase unwanted parts of object (see modify command for the steps of erase). Use the trim command to trim unwanted parts of object (see modify command for the steps of trim).	
Use the dimension commands (e.g. Linear) to dimension the object.	
Use multiline text to write text in AutoCAD. (See Draw command for the steps of multiline text).	

Elevations: Before you start the elevation drawing, you will need a floor plan. You will need to establish the overall size of the building and placement of windows, doors and other features. To draw the elevation, you must be familiar with Orthographic projection. The concepts are very similar. To create an elevation, you will project down from the plan to create a new view.

Front Elevation: Use the floor and roof plans as a guide to obtain all horizontal locations. If a roof plan has not been drawn, draw the outline of the roof shape on the print of the floor plan. For this drawing it will be assumed that (600mm) overhangs and a (300mm) gable end wall overhang will be used. Turn off any layers that you need from the drawn floor plan.

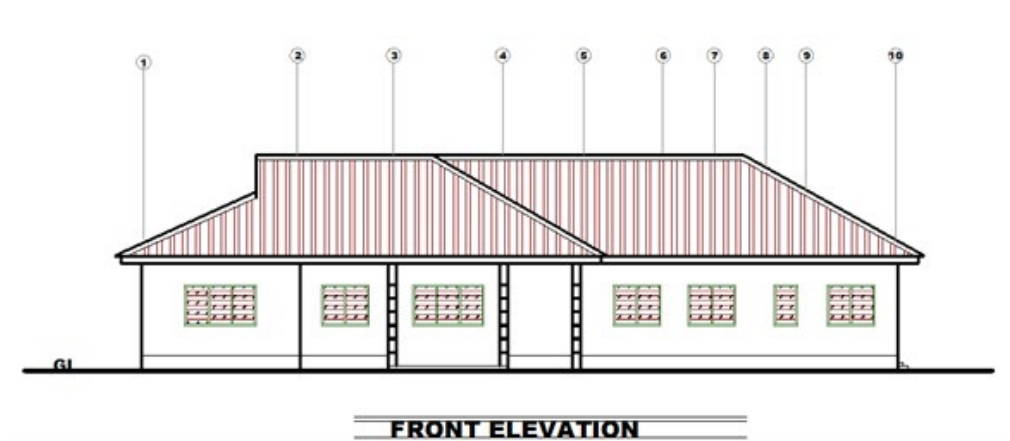


Figure 2.2.44: Front elevation

Side Elevation: Use the floor and roof plans as a guide to obtain all horizontal locations. If a roof plan has not been drawn, draw the outline of the roof shape on the print of the floor plan. For this drawing it will be assumed that (600mm) overhangs and a (300mm) gable end wall overhang will be used. Turn off any layers that you need from the drawn floor plan.

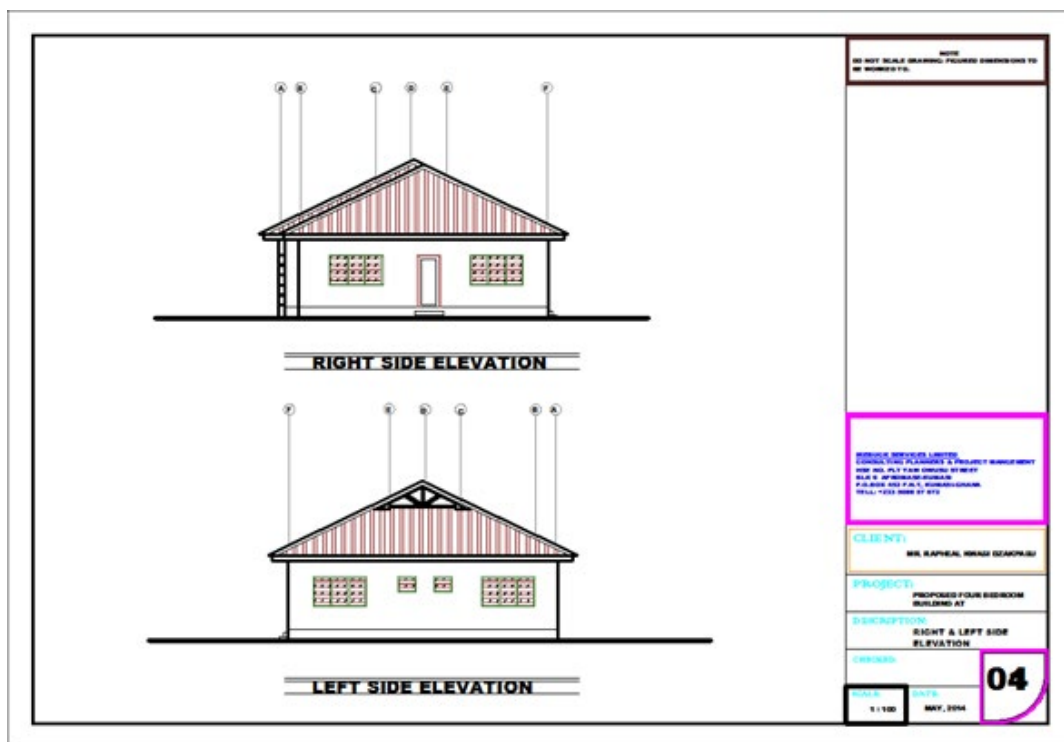


Figure 2.2.45: Side elevation

Sectional Elevation: Architects frequently prepare drawings that show a building cut in half. Their purpose is to show how the building is constructed. These drawing are known as longitudinal or transverse sections. Longitudinal means lengthwise. A longitudinal section is one showing lengthwise cut through the house. Transverse means across. A transverse section is one showing a cut across the building. The cutting plane is an imaginary plane that passes through the building.

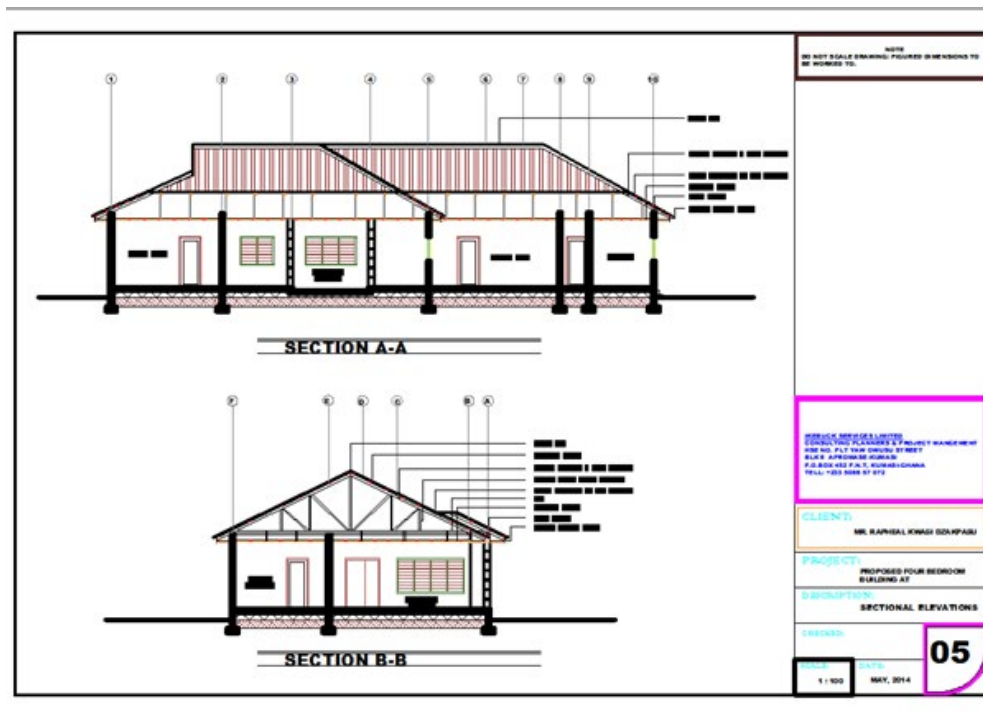


Figure 2.2.46: Sectional elevation

Application of AutoCAD/Clo 3D Standalone (Garment design)

AutoCAD/ **Clo 3D Standalone** is used to design and document pattern design drawings. This includes, sketching, creating patterns, sewing and fitting of garment, adjustment 3D modelling all within a coordinated set of drawings. This is used by fashion designers.

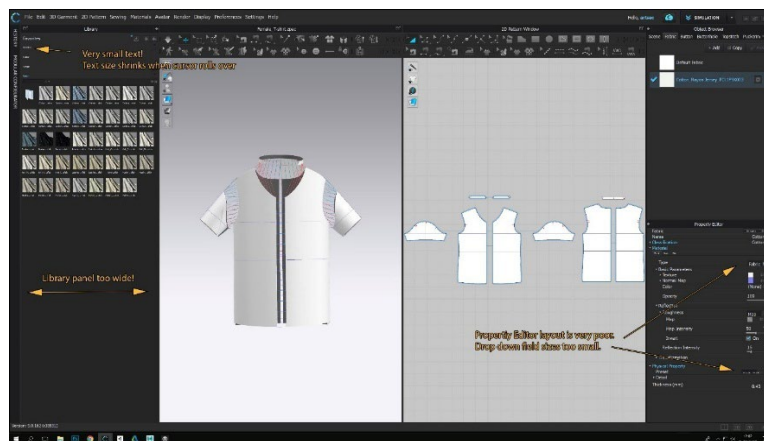


Figure 2.2.47: Clo interface

Example

Drawing clothes using AUTOCAD

Draw the detail drawing the blouse to the correct dimension with AutoCAD.

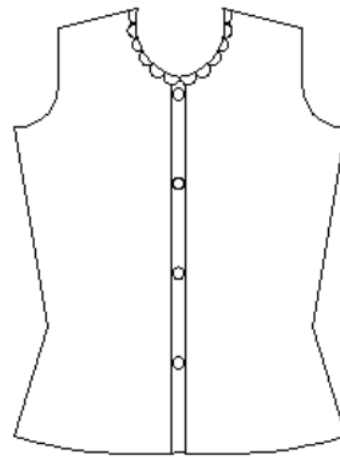
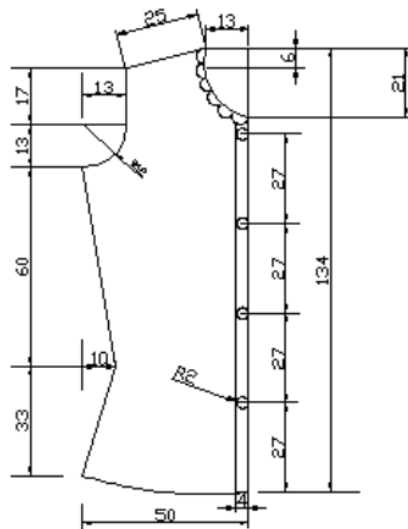


Figure 2.2.48: Blouse

Steps	Drawing
Step 1 => Line: Click on the line or type line at the command prompt to draw a rectangular guide of 50mm by 134mm. Step 2 => Offset: Click on offset or type offset at the command prompt to offset the top line of a distance 6mm inward and the sides of a distance 13mm inside the rectangle. Step 3 => Line: Click on the line or type line at the command prompt to draw a diagonal line for the shoulder at the top of the object. Step 4 => Offset: Click on offset or type offset at the command prompt to offset the top line of a distance 19mm inside the rectangle to obtain the neck. Step 5 => Arc: Click on Arc or type Arc at the command prompt to draw an Arc inside the object for the neck, by using (Centre, Start, End). Step 6 => Offset the top line downward. Step 7 => Arc: Click on Arc or type Arc at the command prompt to draw an Arc inside the object for the arm, by using (Centre, Start, End) Step 9 => Line: Use line to draw a diagonal line from the tip of the arm through the intersect offset line to the bottom left corner of the object Step 10 => Trim and erase: unwanted lines.	

Step 11 => Circle: Click on circle icon or type circle at the command prompt to draw a small circle to represent button.

Step 12 => Mirror: Click on Mirror or type Mirror at the command prompt to obtain the other side of the dress

Step 13 => Hatch the object with a collar material (see draw panel above for steps of hatch)



Step 14 => Render the object with a material



Activity 2.2.9 AutoCAD in Garment Design

In pairs, draw the skirt below to the correct dimension with AutoCAD.

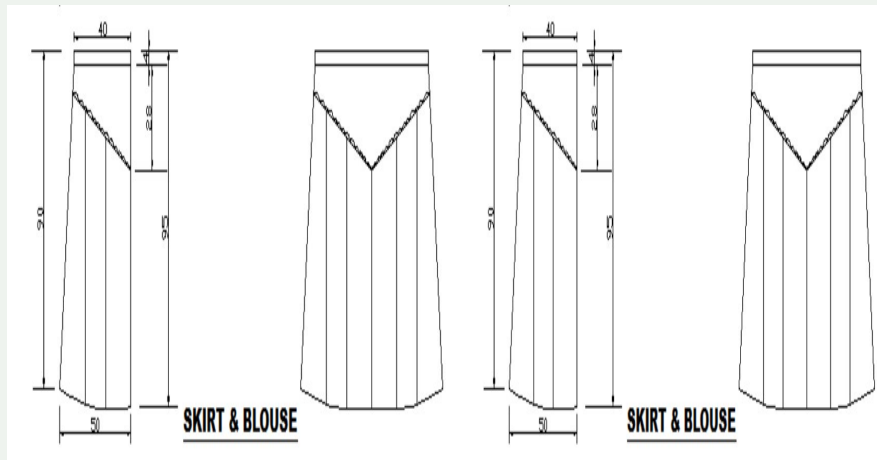


Figure 2.2.49: Skirt

EXTENDED READING

- Freebury, H. A. (1980), Geometrical and Technical Drawing, London, Macmillan Publishing Co. Inc. (Page 61 to 65)
- Morling, K. (2021), Geometric and Engineering Drawing (4TH Edition), Edward Arnold, London. Chapter 3. (Pages 39 – 50)
- Nyame, G, & Co. (2010). ICT for SHS. Kumasi-Ghana. Approaches' Ghana Ltd. (Page 441 – 443)
- Paricio, J. (2015). Perspective Sketching: Freehand and Digital Drawing Techniques for Artists & Designers. USA. Rockport Publishers. (Page 40 -42)
- Watch videos on curve of intersection from YouTube.

UNIT 3: FRACTAL GEOMETRY

GEOMETRY

Fractal Geometry

INTRODUCTION

Fractal Geometry is a fascinating part of mathematics that focuses on shapes and patterns that repeat themselves over and over. These repeating patterns are called fractals. Unlike regular shapes such as squares and circles, fractals often have irregular, jagged, or curved edges, and they look similar no matter how much you zoom in or out.

Fractals are all around us in nature. You can see them in trees, coastlines, snowflakes, mountain shapes, clouds, and lightning. Each small part of a fractal looks like a mini version of the whole.

Fractal Geometry helps us understand and describe complex shapes and natural patterns that cannot be explained using traditional geometry. It is also used in art, computer graphics, science, and architecture to create realistic designs and models.

In this unit, you will explore how fractals are created and why they are important in both nature and technology.

KEY IDEAS

- **Colour Experimentation:** Use colours to enhance the visual effect of your fractal designs.
- **Fractal Patterns:** Explore different fractal patterns like the Sierpinski triangle, Mandelbrot set, or Julia set.
- **Geometric Shape Combinations:** Combine different geometric shapes to create unique fractal designs.
- **Iteration:** The process of repeating a set of instructions to generate a fractal.
- **Polygons:** Regular or irregular polygons can be used to create intricate patterns and shapes.
- **Self-similarity:** Repeat shapes or patterns at different scales to create a sense of self-similarity.
- **Self-Similarity:** Repeat shapes or patterns at different scales to create self-similarity.
- **Shape Iteration:** Repeat shapes or patterns in a sequence to create intricate fractal designs.
- **Spirals:** Used to create fractals with a sense of movement, spirals can be based on various shapes, such as circles or squares.
- **Stars:** Used to create intricate patterns, stars can be based on various shapes, such as triangles or polygons.

- **Symmetry Operations:** Use symmetry operations like rotation, reflection, and scaling to create fractal patterns.
- The unique properties of the shapes such as triangles, allows them to be used as building blocks for fractals.
- **Triangles:** Equilateral, isosceles, or scalene triangles can be used to create complex fractals.

GEOMETRIC SHAPES USED TO CREATE COMPLEX FRACTAL DESIGNS

Geometric shapes like triangles, circles, and polygons are used to create complex fractal designs, which are by intricate patterns and self-similarity. By harnessing the unique properties of various shapes, including triangles, circles, and polygons, strikingly beautiful fractal designs can be made. These shapes can be manipulated through scaling, symmetry, translation, and other techniques to produce a wide range of such complex fractal designs.

Examples of geometric figures

1. Square/cube
2. Circle/sphere
3. Triangles/tetrahedrons
4. Other quadrilaterals
5. Other polygons

Characteristics of geometric shapes and forms used to create fractal designs

Square

1. It has four sides of equal length, and four angles of equal measure.
2. It has four right angles, which means each angle measures 90 degrees.
3. It has two diagonals which bisect each other at 90 degrees.
4. It has a rotational symmetry and reflection symmetry.
5. The area of a square is found by squaring the length of one side.

Triangles

1. A triangle has three sides and three angles.
2. The sum of the interior angles is always 180 degrees.
3. Triangles can have rotational symmetry, reflection symmetry, or both.
4. Triangles can be classified based on their angles and sides.



Based on sides

1. **Equilateral triangle:** All the three sides and three angles are equal.
2. **Isosceles triangle:** Two sides and two angles are equal.
3. **Scalene triangle:** None of the three sides and angles is equal.

Based on angles

1. **Acute angle triangle:** All angles are less than 90 degrees.
2. **Right angle triangle:** One angle is exactly 90 degrees (a right angle).
3. **Obtuse angle triangle:** One angle is greater than 90 degrees.

Circle

1. Has a central point, called the centre, which is equidistant from all points on the circle.
2. The radius is the distance from the centre to any point on the circle.
3. It has rotational symmetry and reflection symmetry.
4. The perpendicular bisector of a chord passes through the centre, and the radius drawn perpendicular to the chord bisects the chord.
5. A circle can circumscribe a triangle, quadrilaterals, and other polygons when creating fractal designs.
6. All circles are similar, and two circles are congruent if they have the same radius.

Polygons

Apart from the triangle and quadrilaterals, polygons are named according to the number of sides. They can be regular or irregular. They have rotational symmetry, reflection symmetry, or both. Examples are:

1. **Pentagon:** A polygon with five sides and five angles, sum of interior angles is 540 degrees.
2. **Hexagon:** A polygon with six sides and six angles, sum of interior angles is 720 degrees.
3. **Heptagon (Septagon):** A polygon with seven sides and seven angles, sum of interior angle is 900 degrees.
4. **Octagon:** A polygon with eight sides and eight angles, sum of interior angles is 1080 degrees.
5. **Nonagon (Enneagon):** A polygon with nine sides and nine angles, sum of interior angles is 1260 degrees.
6. **Decagon:** A polygon with ten sides and ten angles, sum of interior angles is 1440 degrees.

Polygons can be divided into triangles to create complex fractal designs.

Cube

A cube is a three-dimensional geometric shape having six faces, eight vertices, and 12 edges.

1. All the faces are squares.
2. All the faces and sides are equal in size.
3. Each of the faces meets four other faces.
4. The interior angles of the cube are right angles.
5. Each of the vertices meets three faces and three edges.
6. The edges opposite each other are parallel.

Sphere

A sphere is a three-dimensional object that is perfectly round and symmetrical.

1. Similar to circles in two-dimensional drawings.
2. Has a defined centre point called the centre.
3. All points on the surface are equidistant from the centre.
4. Have no edges or vertices.
5. The surface area of a sphere is four times the area of a circle with the same radius.

Examples of complex fractal designs

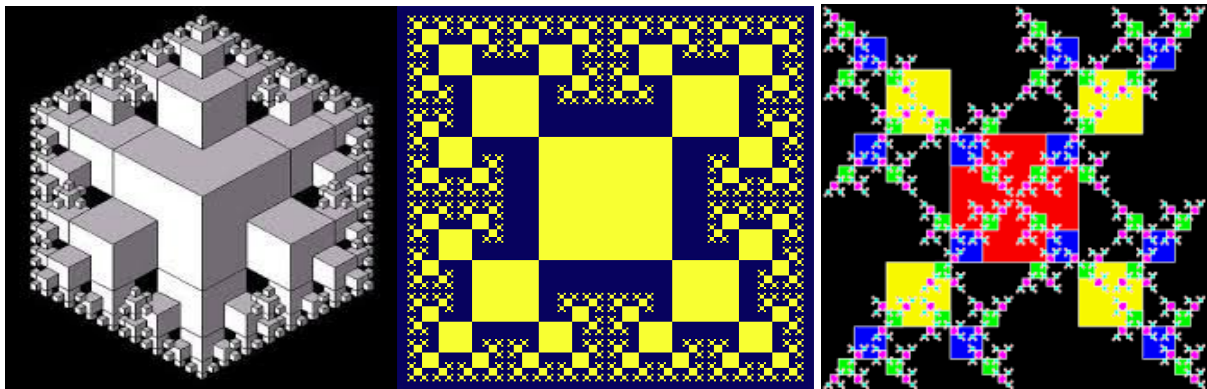


Figure 2.3.1: Complex Square/Cube fractals

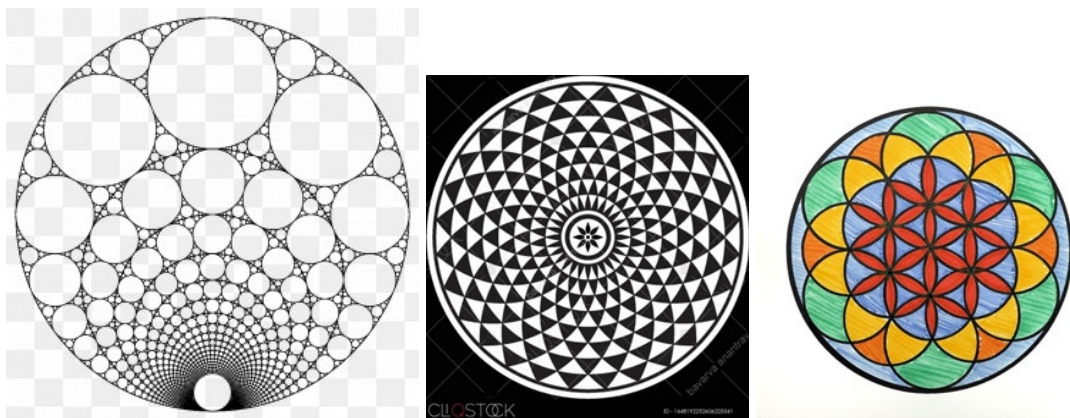


Figure 2.3.2: Complex Circle/Sphere fractals

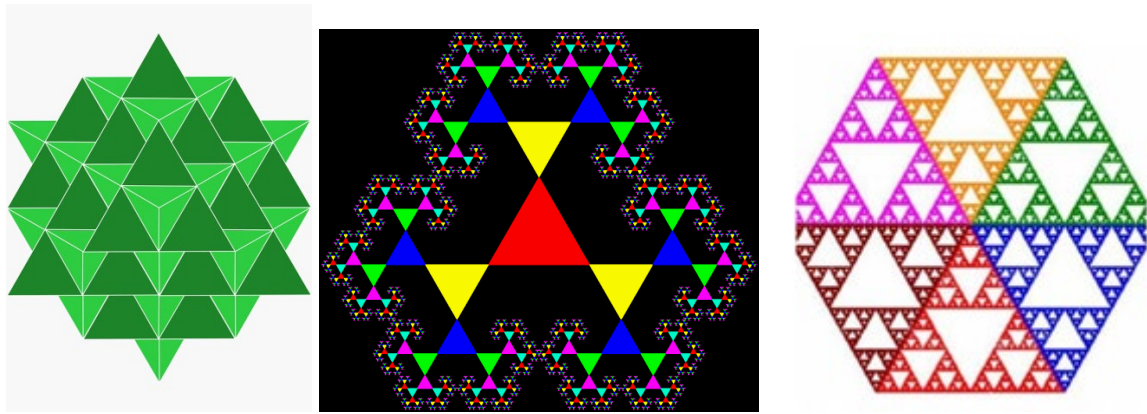


Figure 2.2.3: Complex Triangle/Tetrahedron fractals

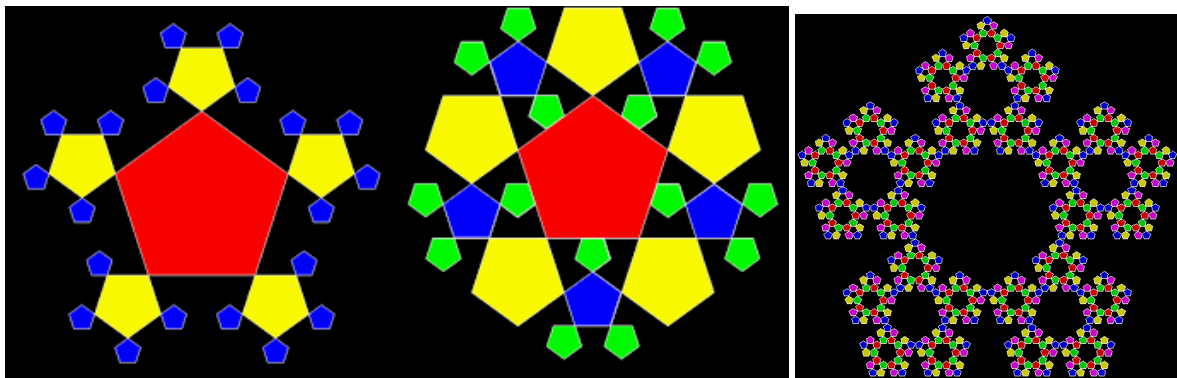


Figure 2.3.4: Complex Pentagonal fractals

Activity 2.3.1 Fractal Shape Exploration

Organise yourselves into groups of no more than 5 and complete the following activity

You are a graphic designer specialising in fractal designs. A client wants a unique fractal design for their company logo to be incorporated into their anniversary cloth. Your task is to provide them with an album of the most suitable geometrical shapes to choose from. They want each shape in three different sizes to help make a good choice.

In your team,

1. Research and discuss four distinct geometric shapes used in fractal designs.
2. Make a cut out of three different sizes of each shape such that each cut-out shape will be half or twice the previous one.
3. Create a chart or album with the cut-outs.
4. Indicate their properties and fractal design potential i.e., why the selected geometric shapes can be used for fractal designs.
5. Include with a written recommendation for the client.

Procedure

Chart creation: Create a chart with columns for;

- Shape name and cut-outs
- Shape properties (symmetry, scalability, etc.)
- Fractal design potential (high, medium, low)

Fill in the chart with your findings.

Analysis and reflection: As a group, analyse your chart and look for patterns or connections between shapes. Reflect on which shapes are most suitable for fractal designs and why. See the example below on how to word the reflection.

Example: Based on the research and analysis, I recommend using the triangle, circle, and hexagon shapes for your company logo. These shapes have high fractal design potential and exhibit properties that will create a unique and memorable logo. The triangle and hexagon have symmetry and scalability, while the circle has self-similarity, making them ideal for fractal design. These shapes will provide a strong foundation for your brand identity.

CREATING COMPLEX FRACTAL DESIGNS

Creating complex fractal designs is an art form that combines mathematics, technology, and creativity to generate intricate and visually stunning patterns. Fractals are self-similar shapes that repeat at different scales, and by using various techniques and algorithms, artists and designers can create complex and beautiful fractal designs. This process involves experimenting with different shapes, colours, and patterns to produce unique and intricate designs that can be used in various fields such as art, graphic design, and even science. Whether you're an artist, designer, or simply a math enthusiast, creating complex fractal designs offers a fascinating creative outlet that can lead to breath-taking results.

Generating complex fractal designs

Select various Plane/Solid Geometrical Figures: First thing to do is to select various geometric figures, such as triangles, squares, circles, or polygons that can be used as the basis for the fractal design.

Choose a Fractal Type: Choose a fractal type you want to design. There are several types of fractals including self-similar fractals, Mandelbrot sets, Koch snowflake, Julia set, Sierpinski triangle, and others. (covered in year one)

Experiment with Parameters: Experiment with parameters such as scaling factors, rotation, translation, and gradient effects. Using these parameters allows designers to create unique and complex fractal patterns.

Explore Colour and Visual Aesthetics: Enhance the visual appearance of a fractal design by experimenting with different colour schemes, textures, and visual effects to create a unique and captivating fractal design.

Consider 3D and Animated Fractals: Fractals can be extended into three dimensions, creating intricate and complex structures. Animated fractals can also be created to add another layer of complexity and dynamic visual storytelling to your fractal designs.

Apply Fractals in Art and Design: Fractals have numerous applications in art, design, and architecture. This involves using fractals to create visually striking patterns, textures, and structures that can be used in various design contexts.

Computer aided designs (CAD): Computer aided design (CAD) software and programming languages such as Matplotlib, Python, Fractint, Ultra Fractal, can be used to create and manipulate fractals. This allows designers to explore and create fractal patterns with precision and accuracy.

Designing complex fractal is a creative and exploratory process that merges mathematics, art, and digital technology. By experimenting with fractal generation techniques and visual aesthetics, you can create mesmerising and intellectually stimulating designs that showcase the beauty and complexity of fractal geometry.

Drawing your own complex fractals: All you need to design and draw your own fractals is a simple rule which can be repeated. You can start with any regular polygon or symmetric shape, and you can remove (colour in) shapes, add a shape to a side, or add a shape to the middle, or add a shape to a vertex. Here are some examples:

Example

1. Draw a square
2. Divide it into 9 equal parts
3. Shade/colour the centre square
4. Except for the centre square, divide the other squares into 9 equal parts
5. Shade/colour all the centre squares
6. Continue repeating steps 4-5 until you reach the desired level of complexity

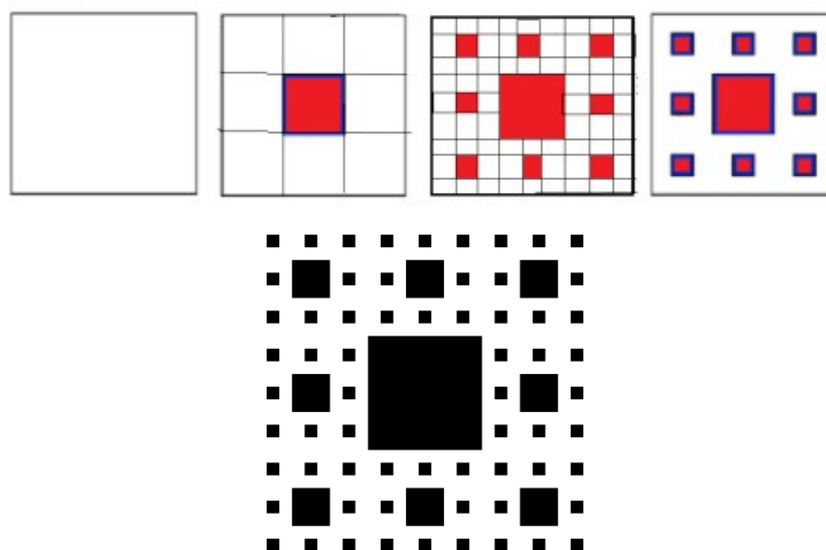


Figure 2.3.5: Drawing complex square fractals

Here is a step-by-step guide to creating a different square fractal:

Step 1: Draw a square.

Step 2: Draw a smaller square inside the larger square, making sure that it is centred and has half the side length of the larger square.

Step 3: Draw four even smaller squares, one in each corner of the larger square, making sure that they are centred and have half the side length of the smaller square.

Step 4: Repeat steps 2-3 with the smaller squares, drawing even smaller squares inside each one.

Step 5: Continue repeating steps 2-4 until you reach the desired level of complexity.

Step 6: Refine the edges of the square by drawing a smooth curve or line around the edges.

Step 7: Add colour and texture to the fractal by shading, layering, or using other artistic techniques.

The result is a fractal design with a repeating pattern of squares known as the ‘Mosaic Fractal’.

Example

1. Draw a square. This will be the starting shape of the fractal.
2. Draw two smaller squares on top of the larger square, one on each side of the centre, making sure that they are centred and have half the side length of the larger square.
3. Draw two even smaller squares on top of each of the smaller squares, making sure that they are centred and have half the side length of the smaller squares.
4. Repeat steps 2-3 with the smaller squares on top of each one.
5. Continue repeating steps 2-4 until you reach the desired level of complexity.
6. Refine the edges of the squares and add colour and texture to desired appeal.

What is the scale factor for the areas of the squares?

What is the scale factor for the lengths of the squares?

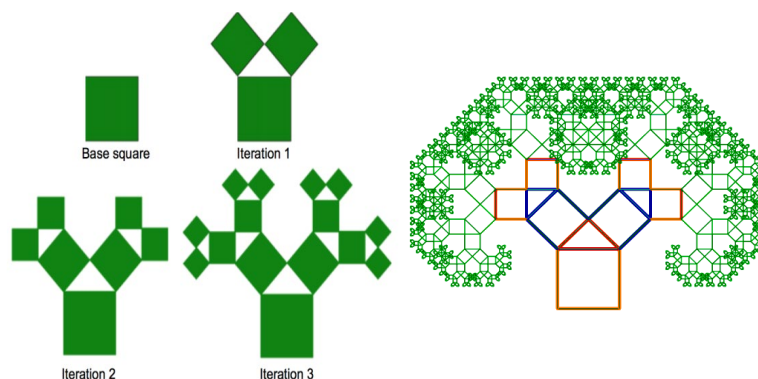


Figure 2.3.6: Drawing the Pythagorean Tree fractal design

Example

Step 1: Draw a regular hexagon with six equal sides.

Step 2: Draw lines connecting the centre of the hexagon to each of its vertices, dividing the hexagon into six equilateral triangles.

Step 3: Draw a smaller regular hexagon in each of the six equilateral triangles, making sure that the smaller hexagons are centred and have a side length that is $\frac{1}{3}$ of the original hexagon.

Step 4: Repeat steps 2-3 with each smaller hexagons, drawing even smaller hexagons in each of the six equilateral triangles.

The resulting fractal is a 2nd step hexagonal fractal, with a repeating pattern of hexagons and triangles.

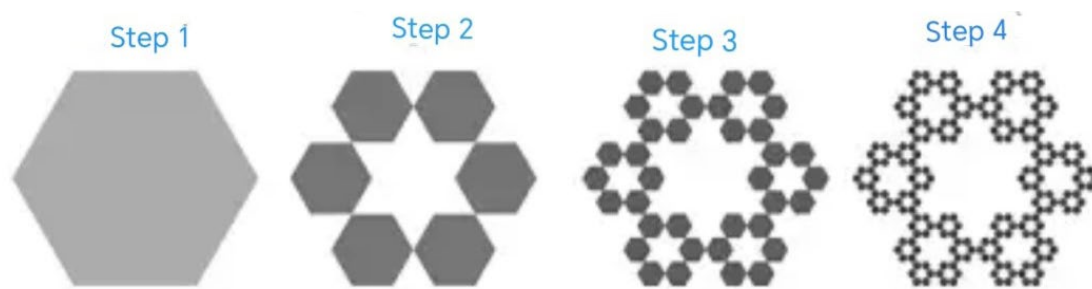


Figure 2.3.7: 2nd step hexagonal fractal

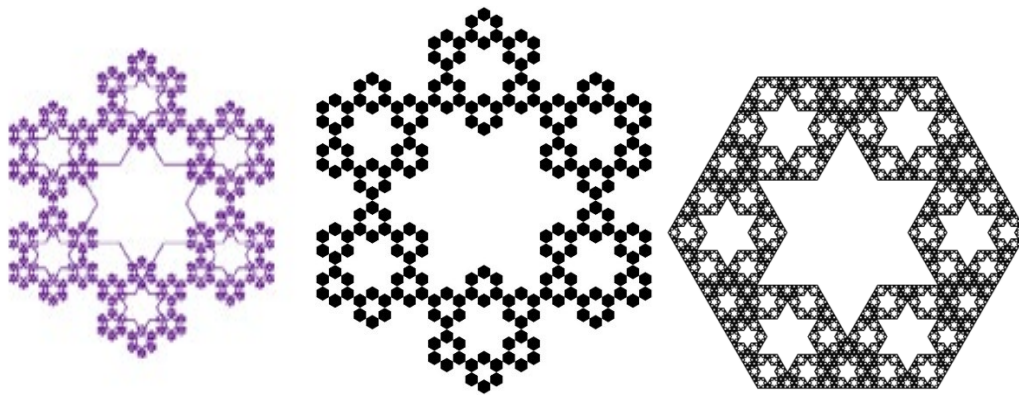


Figure 2.3.8: Drawing of star fractals



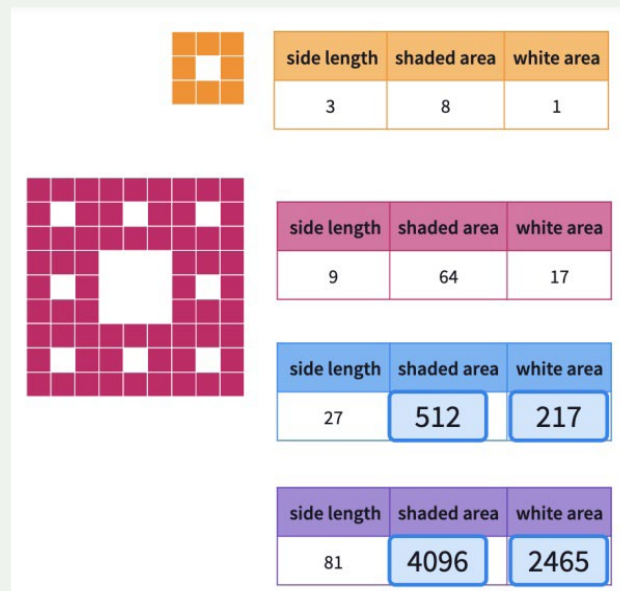
Figure 2.3.9: 5-point and 6-point fractal design on t-shirts

Note

- Start with a regular polygon. e.g., a square, equilateral triangle, or a regular hexagon, or another simple symmetrical shape.
- Decide on a simple rule.
- Draw the stages of your fractal in separate diagrams – it will help you keep track of what you are doing.

Activity 2.3.2 Fractal Frenzy: Exploring Self-Similarity

Study the diagram below to determine the relationship between the side length, shaded area, and white area of the fractal design below. Use it as a guide to answer the activity questions given.



1. A fractal design is created by repeating a pattern of triangles. If the original triangle has a side length of 6 units, and each subsequent triangle has a side length that is $\frac{1}{2}$ of the previous one, what is the side length of the 4th triangle in the pattern?
2. A self-similar fractal is created by dividing a square into 9 smaller squares, then removing the middle square. If this process is repeated 5 times, how many squares will be left in the design?
3. A branching tree fractal. is created by starting with a tree trunk and then adding two branches that split off at a 30-degree angle. If each branch is $\frac{1}{2}$ the length of the trunk and this process is repeated 4 times, how many squares will be left in the design?
4. A Sierpinski triangle is created by removing the triangles from a larger triangle. If the original triangle has a side length of 12 units, and each subsequent triangle has a side length that is $\frac{1}{2}$ of the previous one, what is the total area of the triangles removed after 3 iterations?

5. A fractal design is created by repeating a pattern of hexagons. If the original hexagon has a side length of 8 units, and each subsequent hexagon has a side length that is $\frac{2}{3}$ of the previous one, what is the side length of the 5th hexagon in the pattern?

Answers

1. The side length of the 4th triangle in the pattern is 0.75 units.
2. After 5 iterations, there will be 32,768 squares remaining in the design.
3. After repeating the process 4 times, the total number of branches in the fractal tree design is 31
4. The total area of the triangles removed after 3 iterations is $999 \sqrt[3]{\quad} \div 16$ (cube root of 999 divided by 16) square units.
5. The side length of the 5th hexagon is approximately 1.05 units.

Activity 2.3.3

Using the techniques covered above create your own self similar geometric shaped fractal design.

Use the following suggestions to support your work:

1. Use squared paper for square-based fractals, isometric paper for triangular- or hexagonal-based fractals.
2. Start with a regular polygon, eg. a square, equilateral triangle or regular hexagon, or another simple symmetric shape.
3. Decide on a simple rule.
4. Experiment with parameters such as scaling factors, rotation, translation, and gradient effects
5. Draw the stages of your fractal in separate diagrams – it will help you to keep track of what you are doing.
6. Think about using colour to differentiate the design

EXTENDED READING

- Bendsøe, M.P., Gravesen, J.M., Fractal Design and Shape Optimization, (Springer, 2015)
- Mandelbrot, B., The Fractal Geometry of Nature, (W.H. Freeman and company), 1975

ADDITIONAL READING MATERIALS

1. Fractals: An Interdisciplinary Journal of Fractal Geometry and Applications (World Scientific Publishing, 1993-present)
2. International Journal of Fractal Geometry and Applications (IGI Global, 2018-present)
3. Journal of Geometry and Physics (Elsevier, 1984-present)

REVIEW QUESTION 2.1

1. Describe three differences between 1st angle projection and 3rd angle projection.
- 2.

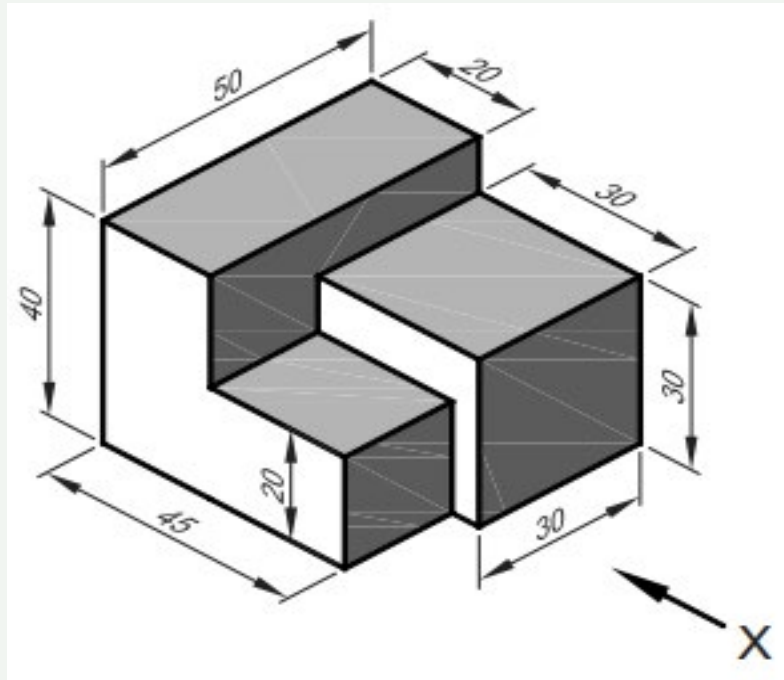


Figure 2.1.22

Pictorial view of an object is shown in Figure 2.1.22. Using first angle projection, draw its

- a. Front view from the X-direction,
- b. Top view and
- c. Left-hand side view.

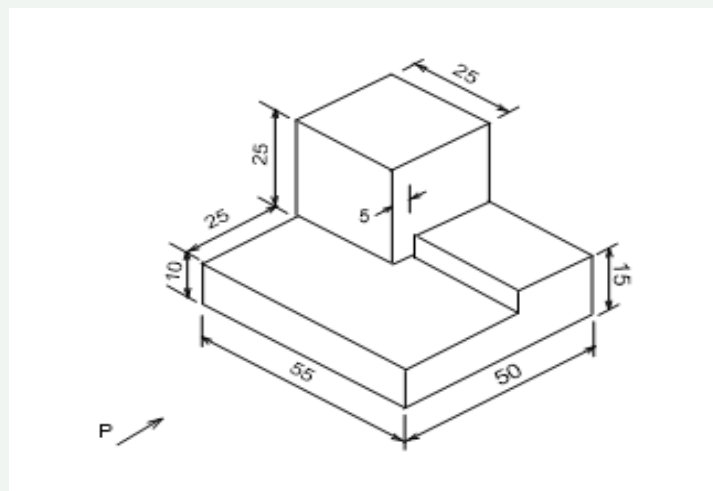


Figure 2.1.23

The pictorial view of an object is shown in Figure 2.1.23. Using third angle projection, draw its

- a. Front view from the P-direction,
- b. Top view and
- c. Right-hand side view.

3. The steps given are to draw an involute of a given square ABCD.

- a. Arrange the steps in order.
 - i. With B as centre and radius BP1 (BA+AD) draw an arc to cut the line CB produced at P2.
 - ii. The curve thus obtained is the involute of the square.
 - iii. With centre A and radius AD, draw an arc to cut the line BA produced at the point P1.
 - iv. Similarly, with centres C and D and radii CP2 and DP3 respectively, draw arcs to cut DC produced at P3 and AD produced at P3 and AD produced at P4.
- b. Explain your answer.

4. You are a team of young engineers tasked with designing an innovative car jack that enhances safety, efficiency, and ease of use in vehicle maintenance. The design must incorporate helix principles and meet the following criteria:

Load Capacity: Safely lift to 1,500 kg.

Stability: Maintain stability on flat surfaces, minimising the risk of tipping.

Operation: Enable operation by a single user with minimal effort.

REVIEW QUESTIONS 2.2

1. Complete the following with the appropriate answer from the given list: edges, vertices, identify, truthful representation, surface area.
 - a. The first step in drawing the surface development of a pyramid is to ----- the base and lateral edges of the pyramid.
 - b. The surface development of a pyramid can be unfolded along its ----- to create a 2D representation.
 - c. When drawing the surface development of a pyramid, it is essential to apply the principle of ----- to ensure accuracy.
 - d. The lateral faces of a pyramid are triangular, and their ----- are connected to the apex.
 - e. The surface development of a pyramid can be used to calculate its ----- and volume.
2. Describe five processes of drawing the curve formed by the intersection of two solid geometrical objects that meet at right angles.
3. Your parent is connecting a pipe from the mains to your residence, if the diameter of parent's pipe is 30 cm and the mains is 50 cm, construct the curve of intersection of the two pipes taking the length of the main pipe to be 60 and that of his to 15 and intersecting at 90° . Use third angle projection.
4. Explain CAD and state its importance in drawing.
5. Identify the 4 interface and 3 palettes of CAD software and state/demonstrate the use of each.

REVIEW QUESTIONS 2.3

Part A

1. What property of triangles makes them a popular choice for fractal designs like the Sierpinski triangle?
 - A. Symmetry
 - B. Scalability
 - C. Angularity
 - D. Curvature
2. Which geometric shape is often used in fractal designs to create intricate patterns and tessellations?
 - A. Pentagon
 - B. Hexagon
 - C. Octagon
 - D. Nonagon
3. Why can triangles be used to create fractal designs like the Sierpinski triangle?
4. Why are hexagons useful for creating fractal designs like the honeycomb?

Part B

Fill in the following with the appropriate word from the list: self-similar, polygonal, geometric, equilateral triangle, hexagon.

1. The _____ shape is a popular choice for fractal designs due to its ability to be easily scaled and rotated.
2. Fractal designs often employ the use of _____ shapes, which can be repeated at different scales to create intricate patterns.
3. The _____ shape is commonly used in fractal designs to create tessellations and other intricate patterns.
4. By applying _____ transformations to pictorial shapes, designers can create a wide range of fractal designs.
5. The use of _____ shapes in fractal designs allows for the creation of complex patterns and structures that exhibit self-similarity at different scales.

PART C

1. Select one of the geometric shapes used in the activities above and use it to answer the following questions:
 - a. Provide a clear and concise description of the fractal design, including its key characteristics.
 - b. Explain how the scaling factor affects the overall pattern.
 - c. List the tools and techniques you would use to create the fractal design and justify your choices.
 - d. Make a visual representation of your fractal design. (e.g., a drawing or a digital image).

SECTION

3

EXTENDED DRAWING



UNIT 1: BUILDING DRAWING

INTRODUCTION

This section covers the relationship between building plans and elevations. Building plans and elevations are fundamental to architectural design, offering distinct yet complementary views of a structure. Plans provide a top-down perspective of layouts, while elevations reveal the vertical features and exterior details.

Understanding their connection is key to accurate visualisation and construction.

Freehand sketches of building elevations enable the creative and technical representation of simple domestic structures. Using drawing instruments ensures precision in formal elevation drawings. Additionally, differentiating between electrical and electronic circuits is crucial for technical understanding. Electrical circuits deal with power distribution, while electronic circuits handle signal processing. By using standardisation symbols, you can create clear and accurate circuit diagrams. Mastering these skills is essential for integrating architectural and technical drawing into practical applications.

KEY IDEAS

- **Link between Plans and Elevations** explain how plans show the layout from above, and elevations show the exterior view from the side.
- **Freehand Elevation Sketches** are the practice of sketching simple building elevations by hand, focusing on proportion and alignment.
- **Precise Elevation Drawings refers to the** use of tools like rules and set squares to draw accurate elevations based on building plans.
- **Electrical and Electronic Circuits show that** Electrical circuits carry power, while electronic circuits handle signals; each serves a different purpose.
- **Symbols in Circuits provide knowledge** and the use of standard symbols (e.g., for switches, resistors) to simplify circuit diagrams.
- **Drawing Circuit Diagrams refers to applying** clear practical drawing of simple circuit diagrams using the correct symbols and layout.

BUILDING ELEVATIONS

Building elevations are essential elements of architectural drawings, offering a detailed view of a building's exterior or interior from a single side. They depict the vertical layout and design details, presented in orthographic projection. Typically drawn to scale, elevations accurately represent the size and proportions of the building's features.

Types of Elevations

1. Front Elevation (Main Elevation)

Description: The front view typically depicts the side of the building that faces the main approach or street.

Details include:

- a. Main entrance
- b. Roof designs
- c. Decorative elements
- d. Windows and doors
- e. Balustrades
- f. Overall front view design



Figure 3.1.1: Front view of a domestic building

Uses:

- a. Provides a clear view of the building's primary appearance.
- b. Used for visualising the main entrance and key design elements.
- c. Essential for understanding the building's first impression and architectural style.

2. Rear/end Elevation

Description: Displays the view of the building's backside or rear façade, positioned opposite the front elevation.

Details include:

- a. Secondary entrances or exits
- b. Roof design
- c. Rear windows
- d. Any rear-facing architectural features or extensions

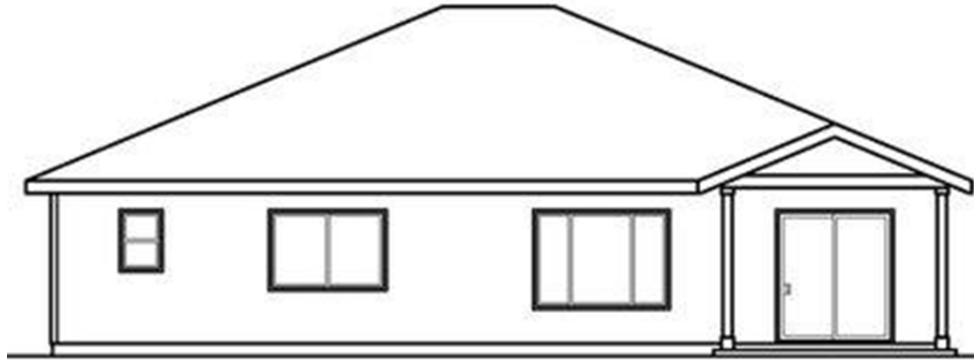


Figure 3.1.2: Rear view of a domestic building

Uses:

- a. Useful for understanding the back view of the building, which may include emergency entries or exits.
- b. Important for evaluating how the building fits into its site, particularly in residential and commercial areas.

3. Side Elevations (Left and Right Elevations)

Description: The side elevation shows the sides of the building, typically the left and right views.

Details include:

- a. Side windows and doors
- b. Projecting or recessed elements
- c. Side design features
- d. Rooflines



Figure 3.1.3: Right side view



Figure 3.1.4: Left side view

Uses:

- a. Provides a view of the building’s depth and the side aspects of its design.
- b. Helps to visualise how the building extends beyond the main facade.
- c. Essential for understanding side details and architectural continuity.

Activity 3.1.1 Element of a Building Plan

Analyse the building plan shown in Figure 3.1.5 and use it to fill in the table. List the elements present in each elevation within the table.

Then, engage in a class discussion to explain what you understand about the concept of elevations.

Elevation	Number of doors	Number of windows
Front		
Right side		
Rear		
Left side		

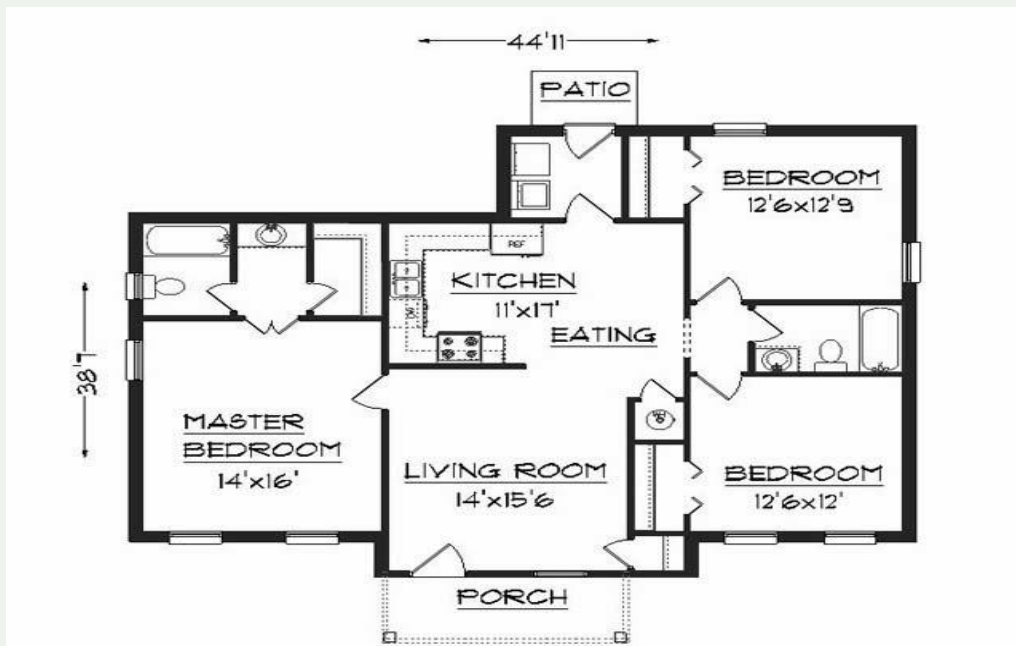


Figure 3.1.5: Building Plan

FREEHAND SKETCHES OF ELEVATIONS

Freehand sketches of building elevations are a key skill for aspiring architects, designers, and engineers. They help you quickly capture a building's design, structure, and appearance. By focusing on proportions, lines, and details, these sketches convey the building's style and form. Freehand sketching boosts creativity, improves spatial understanding, and is a valuable tool for visualising and sharing design ideas at any project stage.

Techniques for Sketching Building Elevations

1. **Study References:** Observe real buildings or photos to understand how different elevations appear from various perspectives.
2. **Start with Simple Forms:** Use basic shapes to outline the primary structure of the building as a foundation.
3. **Highlight Key Features:** Identify and sketch essential architectural elements such as windows, doors, and rooflines. Ensure these features are proportionate and aligned with your design concept.
4. **Add Details:** Enhance the sketch with textures, patterns, and ornamental details to bring the elevation to life.

Sketching techniques

1. Sketch lightly first, then refine lines.
2. Experiment with pencil grades for varying line weights.





Figure 3.1.6: Sketch of front elevation of a building

Activity 3.1.2 Sketching building elevation from floor plan

Develop skills in sketching building elevations from a floor plan.

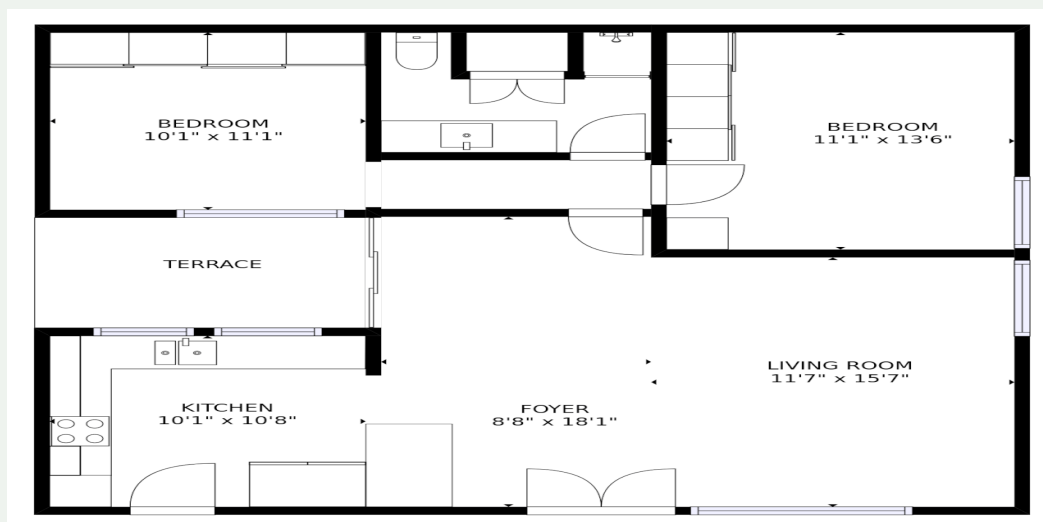


Figure 3.1.7: Floor Plan

Instructions

Materials Needed: Pencil, eraser, rule, and paper

1. **Study the Floor Plan** in Figure 3.1.7

Carefully examine the two-bedroom floor plan to understand the layout and features.

2. **Visualise the Elevations**

Imagine how the walls, doors, windows, and roof will appear from each side of the building (**front, back, and sides**).

3. Start Sketching

- Begin with the **front elevation**, outlining the overall structure using simple shapes.
- Add details such as doors, windows, and rooflines.
- Ensure the features match their placement in the floor plan.

4. Add Details

Include textures, patterns, or ornamental features where appropriate, such as brickwork or roof tiles.

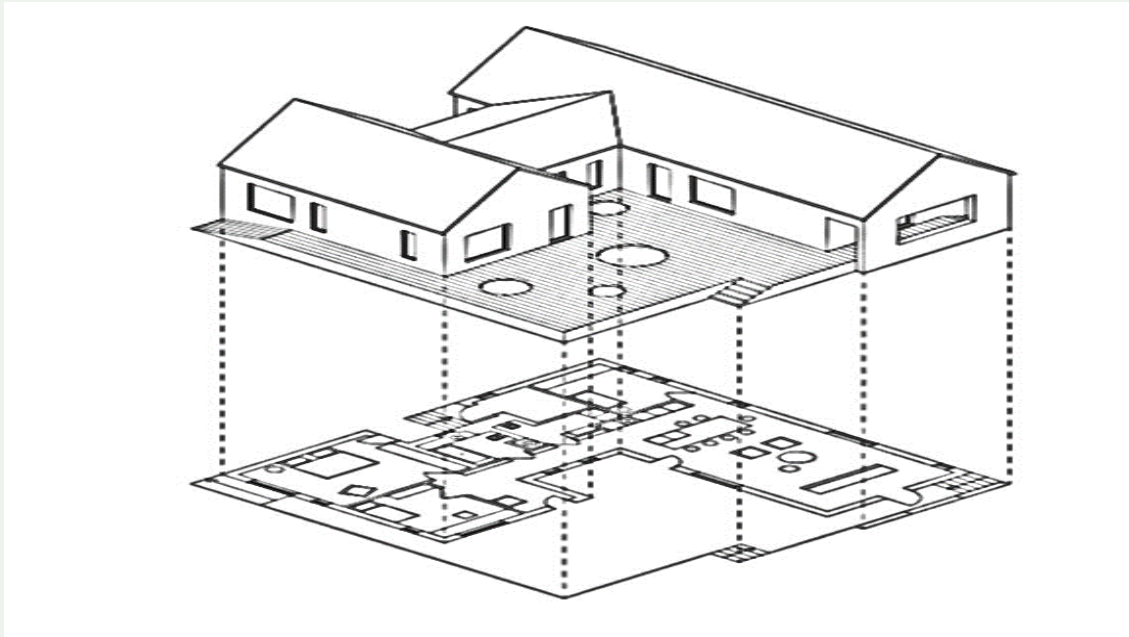


Figure 3.1.8: Building Drawing

- Repeat for other elevations, keeping them proportionate and aligned with the plan.

Activity 3.1.3 Freehand Sketching of Building Elevations

- Study the** building drawing in Figure 3.1.8 and sketch the following elevations:
 - The front
 - Right side
 - Left side
 - Rear based on the plan.

Ensure accuracy, proportions and alignment of features.

- After completion, share your drawings with the class for discussion and feedback.

DRAWING BUILDING ELEVATIONS WITH INSTRUMENTS

Before beginning any technical drawing, it is essential to gather the right tools and materials. Using the appropriate instruments ensures precision and clarity in your work, allowing for accurate representation of designs. Traditional instruments like compasses, rulers, and protractors are essential for precise manual drafting.

Today, Computer-Aided Design (CAD) software is also widely used to create detailed, scalable, and accurate architectural drawings. CAD enhances the presentation of designs, allowing for easy visualisation and precise measurements.

Below is a list of the basic equipment, materials and procedures required for effective and efficient drawing:

1. Drawing Instruments and Materials needed

- a. **T-Square** is used on drawing boards to draw straight, horizontal lines and guide other drawing instruments.
- b. **Drawing sheets** serve as the base for creating technical drawings
- c. **Set Squares (45° and 30/60°)** are used for accurate vertical line creation.
- d. **Scale Ruler** ensures precise measurement and scaling.
- e. **Protractor** is essential for drawing precise angles.
- f. **Dividers** provide deal for transferring measurements accurately.
- g. **Drawing Board** provides a stable and level working surface.
- h. **Pencils are of different grades** and used for varied line thicknesses.
- i. **Eraser** helps for making corrections as needed.
- j. **Clips** are used to hold drawing sheets or blueprints in place on a drawing board or table.

2. Setting up your Workspace

- a. **Workspace Setup:** Choose a comfortable, well-lit area and secure your drawing board.
- b. **Align the T-Square:** Place the T-square along the edge of the board, ensuring proper alignment with the drawing sheets.

3. Drawing the Elevations

- a. **Transferring Lines:** Begin by transferring straight lines from the floor plan, including details like wall thickness, doors, windows, and arches. This forms the foundation of your elevation.
- b. **Adding Dimensions:** Use the scale ruler to draw dimension lines that show the height, width, and depth of elements. Indicate exact measurements in millimetres.
- c. **Textures and Patterns:** Apply different pencil grades or fine liners to create textures (e.g., for brickwork or other surfaces).

4. Final Presentation

- High-Quality Paper:** For presentation or submission, use high-quality paper.
- Line Clarity:** Ensure all lines are clean, sharp, and well-defined.
- Title Block:** Include a title block with essential details such as the project name, date, and scale for a professional finish.

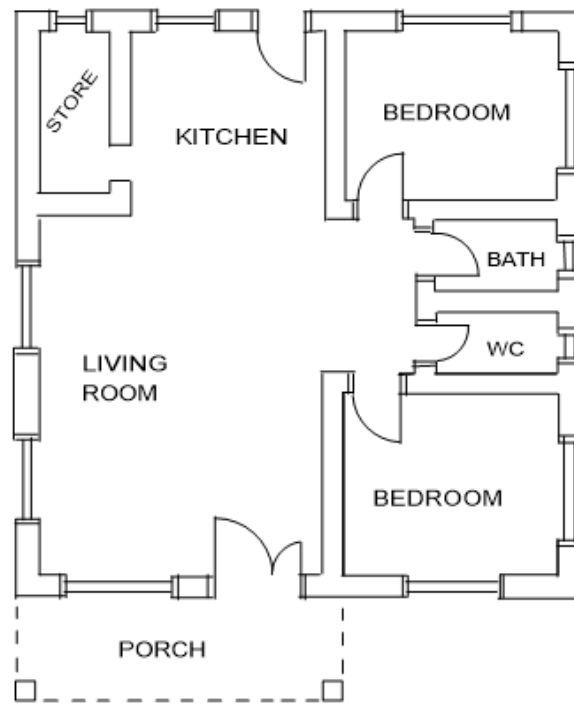


Figure 3.1.9: Floor Plan



(a) Front Elevation

(b) Back Elevation



(c) Right End/Side Elevation



(d) Left End/Side Elevation

Figure 3.1.10 (a) – (d): Drawing elevations from a given floor plan

Activity 3.1.4

Figure 3.1.10 below is a floor plan of a single bedroom residence. Study the specifications and draw accurate elevation views (south, north, east, and west).

Specifications

1. **Walls:** All walls are 150mm solid sandcrete blocks with 20mm rendering on both sides
2. **Windows:** All windows are glass louvre
W-900mm x 2100mm (Single-bay short)
WW1 – 1800mm x 1200mm
3. **Doors:** All doors are hard wood panel in wooden frame and side hang
D – 900mm x 2100mm
DD – 1200mm x 2100mm
4. **Roof:** Simple Gable roof
Main pitch – 2400mm
Porch pitch – 1050mm.

Follow these steps to develop skills to interpret a floor plan and draw accurate elevation views (south, north, east, and west) to scale.

Materials Needed:

- A provided floor plan (to scale) (Figure 3.1.9)
- Drawing sheets
- Pencil, eraser, and sharpener
- T-Square and set squares (45° and $30^\circ/60^\circ$)
- Scale rule
- Compass (optional)
- Drawing board

Steps

1. **Review the Floor Plan** (Figure 3.1.9)
 - a. Study the provided floor plan carefully.
 - b. Identify key features such as walls, doors, windows, and rooflines.
 - c. Note any measurements indicated.
2. **Understand Elevations**
 - a. **South Elevation:** The view from the south-facing side.
 - b. **North Elevation:** The view from the north-facing side.
 - c. **East Elevation:** The view from the east-facing side.
 - d. **West Elevation:** The view from the west-facing side.
3. **Set Up Your Drawing**
 - a. Tape your drawing sheet to the drafting board.
 - b. Use the scale ruler to determine the scale for your elevations (e.g., 1:100).
4. **Draw the South Elevation**
 - a. Start by projecting lines from the floor plan to the south side.
 - b. Add features like doors, windows, and wall heights as seen from the south perspective.
 - c. Ensure all elements are proportional to the scale.
5. **Draw the Remaining Elevations**
 - a. Repeat the same process for the north, east, and west elevations.
 - b. Be consistent with proportions and alignment of features.
6. **Add Details**
 - a. Include dimensions, annotations, and labels for clarity.
 - b. Ensure proper line weights to distinguish elements (e.g., outlines, window frames)

7. Finalise Your Drawing

- Review your elevations for accuracy and neatness.
- Use an eraser to clean up construction lines.

Note

- Accuracy of proportions and scale.
- Consistency across elevations.
- Neatness and clarity of the drawing.
- Proper use of annotations and dimensions.

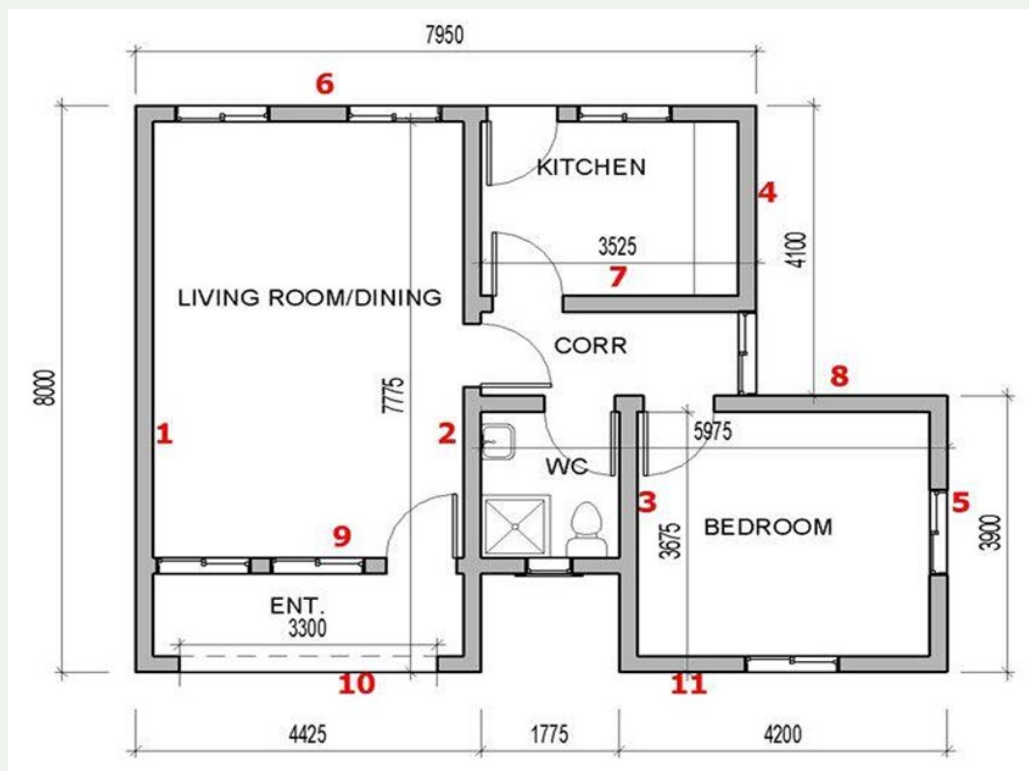


Figure 3.1.11: Floor Plan

ELECTRICAL AND ELECTRONIC CIRCUITS

Electrical Circuits

An electrical circuit is a path through which electric current flows. It includes components such as batteries that provide energy to charged particles, devices that use current (lamps or electric motors), and connecting wires or transmission lines.

Basic Components of an Electric Circuit

- Power Source:** Battery: A common source of direct current (DC) that provides the flow of electricity (electrical current).
- Conductors:** wires: typically, copper or aluminium, these provide a path for current to flow between components.

3. **Load: Resistor:** A component that limits current flow and can convert electrical energy into heat. **Bulb:** A device that emits light when current passes through it. **Motor:** Converts electrical energy into mechanical motion.
4. **Switch:** Opens or closes the circuit to control the flow of current.
5. **Other Components:**
 - a. Capacitor: Stores and releases electrical energy.
 - b. Inductor: Stores energy in a magnetic field when current passes through it.
 - c. Diode: Allows current to flow in one direction only.

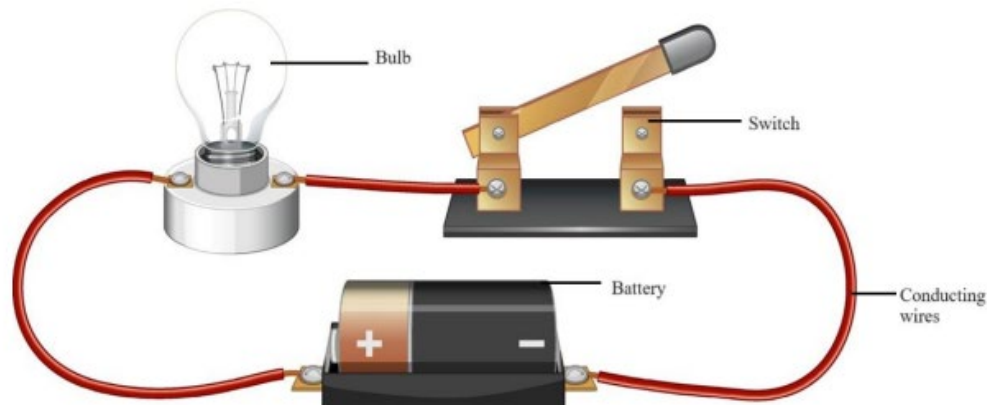


Figure 3.1.12: Simple electrical circuit

Electronic Circuits

Electronic circuits are a specialised form of electrical circuits that use electronic components to regulate the flow of electric current and perform specific functions. They are essential to modern technology, powering everything found in many modern items from everyday gadgets to advanced systems.

Basic Electronic Components

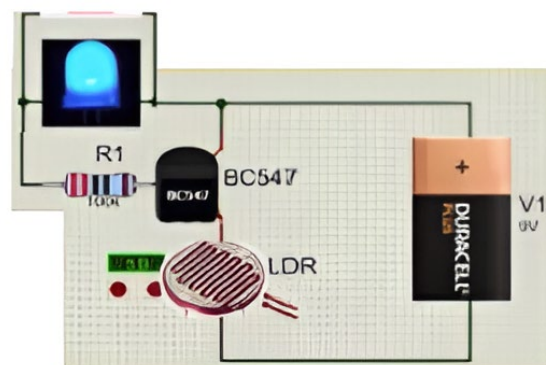
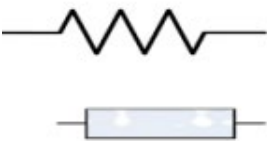
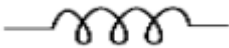
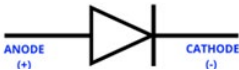
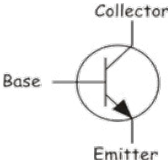
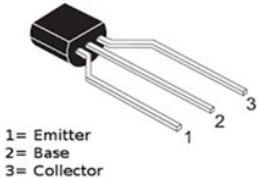


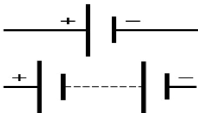
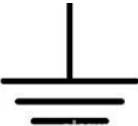
Figure 3.1.13: Simple electronic circuit

ELECTRICAL AND ELECTRONIC SYMBOLS IN CIRCUITS

Electrical and electronic symbols are standardised graphical representations of components, devices, and connections in circuits. These universally recognized symbols enable engineers, technicians, and electricians to communicate circuit designs and connections clearly and effectively.

Table 3.1.1: Electrical and electronic symbols in circuit

Name/description	Symbol	Picture
Resistor: It is a passive component that limits or controls the flow of electric current in a circuit.		
Capacitor: It is often used for filtering, energy storage, and timing applications.		
Inductor: It stores energy in a magnetic field and resists changes in current. Inductors are commonly used in applications such as filters, oscillators, and power supplies.		
Diode: It allows current to flow in one direction while blocking it in the opposite direction. Diodes are widely used in rectifiers, switches, and voltage clamping circuits.		
Transistors: It is a semiconductor device that amplifies or switches electronic signals and forms a fundamental building block in many electronic circuits.		

Battery: It is a source of electrical energy that can supply power to a circuit.		
Switch: It controls the flow of current in a circuit by either allowing or interrupting the path of electricity.		
Earth rod: It represents the reference point in a circuit or the connection to Earth, providing a zero-voltage reference.		

Activity 3.1.5 Distinguishing Between Electrical and Electronic Circuits

Setup and Materials

Organise yourselves into groups of no more than 5 and complete the following using the points listed as a guide. Your teacher will provide real objects, models and board illustrations to help.

1. Physical Components

- A simple electrical circuit kit (battery, wires, bulb, and switch).
- An electronic circuit kit (breadboard, resistor, LED, transistor, capacitor).

2. Digital Tools: Access to simulation software (e.g., Tinker cad, Circuit Lab).

3. Printed Cards

- Cards with names/pictures of components (e.g., bulb, transistor, resistor).
- Cards with examples of circuits (e.g., lighting system, amplifier)

Steps

1. Observe the displayed devices

Pictures on circuits/devices (e.g., lamp, radio, smartphone) and classify them as electrical or electronic.

2. In your groups use the devices to

- Build a simple circuit to power a bulb.
- Assemble a basic circuit with a transistor and LED.

3. Observe and record

- a. What your circuit do?
- b. What components you used?
- c. How is energy you used in your circuit?

4. Using simulation software

- a. Recreate the circuits digitally.
- b. Add variations, such as replacing the bulb with an LED or introducing a transistor.
- c. Discuss how simulations reflect real-world behaviours.

5. Reflect on these questions

- a. What are the main differences between electrical and electronic circuits?
- b. How do the two circuit components and functions differ?
- c. Where do you see these circuits in daily life?

CIRCUIT DIAGRAMS

Circuit diagrams, also known as schematic diagrams, are graphical representations of electrical and electronic circuits which show the components and interconnections of the circuit using standardised symbolic representations. These diagrams are essential for designing, analysing, and troubleshooting circuits.

Drawing simple electrical and electronic circuit diagrams

Drawing circuit diagrams involves creating a visual representation of an electrical circuit using standardised symbols to represent components and their connections.

Steps to consider

1. Understand and Use Standard Symbols

Familiarise yourself with the common symbols used in circuit diagrams

2. Tools and Materials

- a. Graph Paper for maintaining alignment and proportion.
- b. Pencils and Erasers helps in sketching and making corrections.
- c. Rules are for drawing straight lines and standard symbols.

3. Sketch the Basic Layout

- a. List all the components required for your circuit
- b. Identify their function and how they will be connected, lightly sketch the arrangement of components on graph paper.

- c. Place components logically to minimise crossing lines and ensure clarity.
4. **Connect the components**
 - a. Use a rule to draw straight lines between component symbols
 - b. Use dots to indicate junctions where wires meet
5. **Label Each Component**
Write the component value or part number next to each symbol
6. **Specify values**
Include values for resistors, capacitors, and other components as part of the label (e.g., $10\text{k}\Omega$ for a resistor).
7. **Finalise the diagram**
Ensure that all components are correctly represented and that connections match the intended design.

Example: Draw a Simple Circuit Diagram with the following components:

1. A battery (power source)
2. A resistor
3. An LED (light-emitting diode)
4. A switch

Procedures:

1. **Place the Battery:** Draw the battery symbol
2. **Add the Resistor:** Draw the resistor symbol.
3. **Place the LED:** Draw the LED symbol
4. **Connect Components:** Draw lines to connect the battery to the resistor, the resistor to the LED, and include a switch in the circuit to control the flow.
5. **Label Components:** Add labels for the battery (e.g., “9V”), resistor (e.g., “ 470Ω ”), and LED.

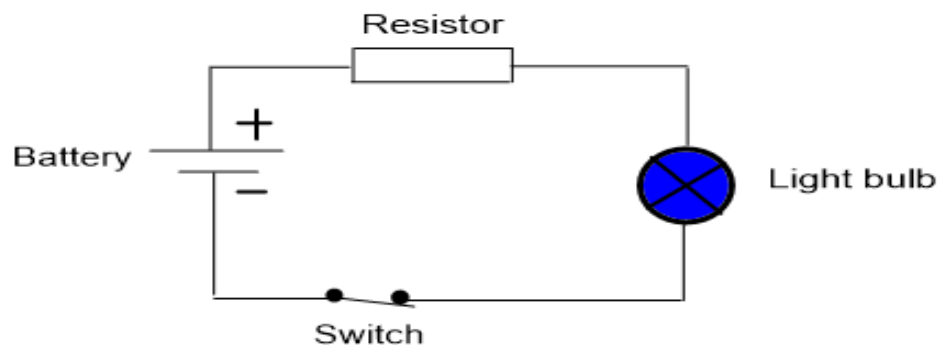


Figure 3.1.14: Circuit diagram

Activity 3.1.6 Designing and Drawing Simple Electrical Circuits

1. You need to produce 2 simple circuit diagrams complete with components
2. **Materials Needed:**
 - a. Paper and pencil/pen for sketching.
 - b. Ruler and eraser.
 - c. Reference materials (symbols and diagrams of electrical components).
 - d. Circuit simulation software (optional)
3. **Instructions:**

Review the purpose and functions of the following components:

 - a. **Switch:** Controls the flow of current in the circuit.
 - b. **Fuse:** Provides overcurrent protection.
 - c. **Circuit Breaker:** Protects the circuit from damage due to overload or short circuit.
 - d. Understand the standard symbols used to represent these components in circuit diagrams.
4. Identify the basic elements of the circuits:
 - a. **Power Source:** Choose a suitable DC or AC source.
 - b. **Load:** Determine a simple load (e.g., a bulb or a motor).
 - c. **Protective Components:** Include a fuse and circuit breaker in the design.
 - d. **Control Component:** Add a switch to control the circuit.
 - a. Arrange these components in a logical sequence, ensuring the circuit can function safely and effectively.
5. **Draft the Circuit Diagrams**
 - a. Begin by drawing a rough sketch of the circuits using the standard electrical symbols.
 - b. Ensure the arrangement is clear, with proper labelling of components (e.g., fuse, switch, load, etc.).
 - c. Refine the sketches into neat and scaled diagrams using a ruler for straight lines.

EXTENDED READING

- AutoCAD Simple Floor Plan Tutorial for Beginners – 1 of 5. Youtube.com
- Kilmer, W. O. (2003). Construction Drawing and Details for Interiors: Basic skills, Wiley & Sons Ltd. (Pages 91 – 115).
- Schexnayder, C.J. and Fiori, C.M. (2021), Handbook for Building Construction, New Delhi, MacGraw Hill Ltd. (Pages 103 – 152).

UNIT 2: MECHANICAL DRAWING

INTRODUCTION

Sectional drawing is a key technique in engineering and design, helping to show the internal structure of machine parts and components by slicing through them. This method allows you to visualise complex shapes and hidden details. Learning to sketch sectional views freehand enables quick and effective representation, while using drawing instruments ensures precision and accuracy. Additionally, understanding the difference between electrical and electronic circuits is essential—electrical circuits focus on power distribution, while electronic circuits handle signal processing. By using standardised symbols, you can accurately represent both types of circuits in clear, simple diagrams. These skills are fundamental for creating detailed technical drawings and circuit designs.

KEY IDEAS

- **Principles of Sectional Drawing:** How sectional views cut through a part to reveal its internal structure, providing clear insights into its design. How sectional drawings help in understanding complex shapes and internal details of machine parts.
- **Freehand Sketching of Sectional Views:** How to sketch sectional views by hand, focusing on accuracy, proportion, and clarity of internal features of machine components.
- **Using Drawing Instruments for Sectional Views:** How to use tools like rulers, compasses, and protractors to create precise sectional views, ensuring correct scale and detail.
- **Difference between Electrical and Electronic Circuits:** Electrical circuits are systems that carry electrical power, while electronic circuits process signals for tasks like communication or control.
- **Understanding Circuit Symbols:** Standard symbols used in both electrical and electronic circuit diagrams, such as for resistors, capacitors, switches, and diodes.
- **Drawing Simple Circuit Diagrams:** Drawing basic electrical and electronic circuit diagrams using the correct symbols and layout for clarity and functionality.

PRINCIPLES OF SECTIONING

Sectional drawings are multi-view technical drawings that contain special views of a part or parts, views that reveal interior features. Sectional drawings are used to improve clarity and reveal interior features of complicated assembled parts. Sectioning involves showing the interior of an object by imagining a cut through the object. It is used as a drawing to show internal features or views of components that cannot be clearly seen from outside. An imaginary line known as a cutting plane is used to cut through the view to show the hidden details. The cutting plane shows where the object was cut to obtain the sectioned view. The cutting planes are normally indicated as A – A, B – B, C – C, X – X, Y – Y, Z – Z etc.

The primary reason for creating a section view is the elimination of hidden lines, so that a drawing can be more easily understood or visualised.

Cutting Plane

The cutting plane is an imaginary line that cuts the object to reveal the internal features. The outside view is cut away by the cutting plane to show the internal view. The line has arrowheads. Cutting plane lines are thick (0.7 mm) dashed lines, that extend past the edge of the object 6 mm and have line segments at each end drawn at 90 degrees and terminated with arrows.

The cutting plane is controlled by the designer and can go:

1. completely through the object (full section);
2. half-way through the object (half section);
3. bent to go through features that are not aligned (offset section); or
4. through part of the object (broken-out section).

A cutting plane is represented on a drawing by a cutting plane line. This is a heavy long-short-short-long kind of line terminated with arrows. The arrows show the direction of view.

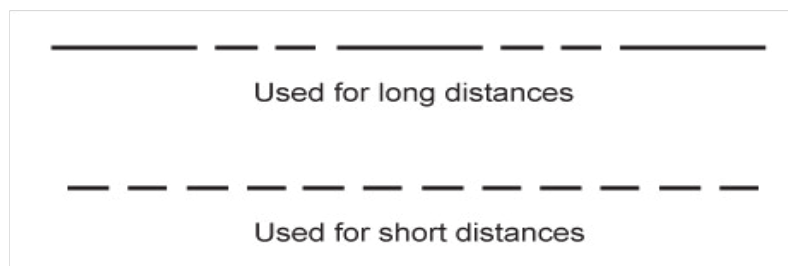


Figure 3.2.1: Cutting plane lines

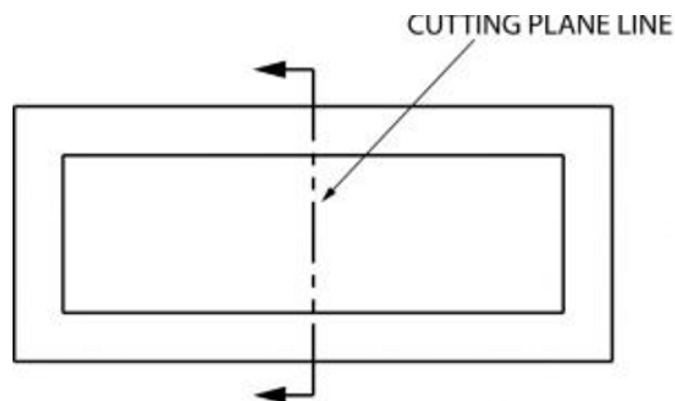
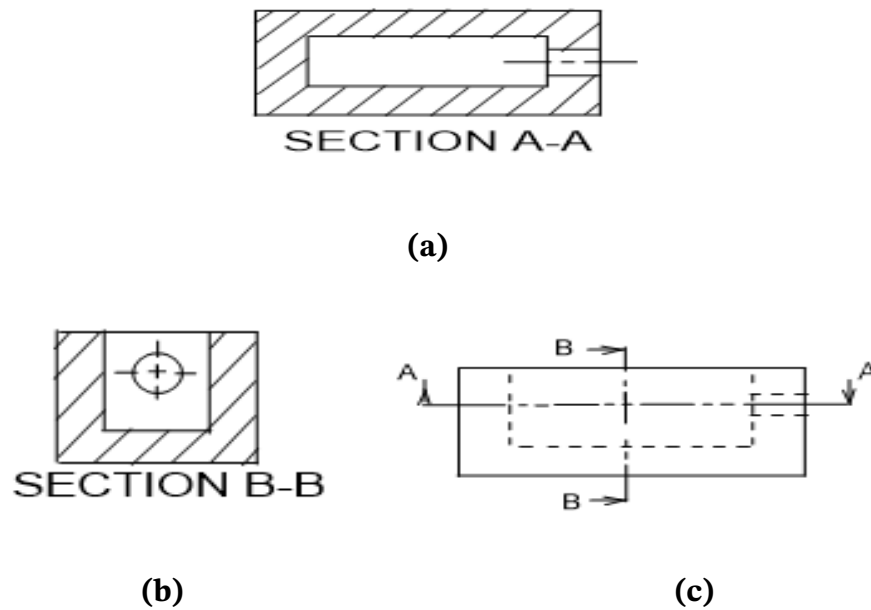


Figure 3.3.2: Cutting Plane through a rectangular block



Figures 3.2.3 a, b & c: Section of a rectangular object

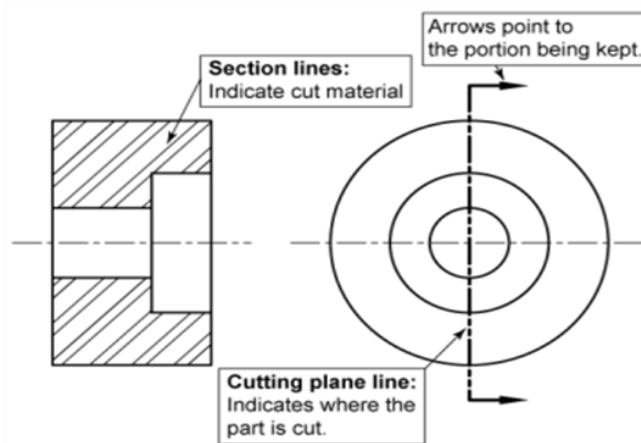


Figure 3.2.4: Cutting plane through a block

Section Lining

Section lines, also known as cross-hatch lines, are used in technical drawings to represent the surfaces exposed by a cutting plane. They help identify the type of material the object is made of by employing different symbols for various materials. This variety in section line symbols simplifies material identification, especially when an object comprises multiple materials. Section lines are typically drawn at a 45-degree angle to the horizontal, though the angle may be adjusted for adjacent parts within the same section. The spacing between these lines must remain uniform for consistency. Material specifications are usually indicated in the title block, parts list, or as a note on the drawing.

Section-lining Symbols

Section-lining symbols may be used to indicate specific materials. These symbols represent general material types only. Such as cast, iron, brass and steel.

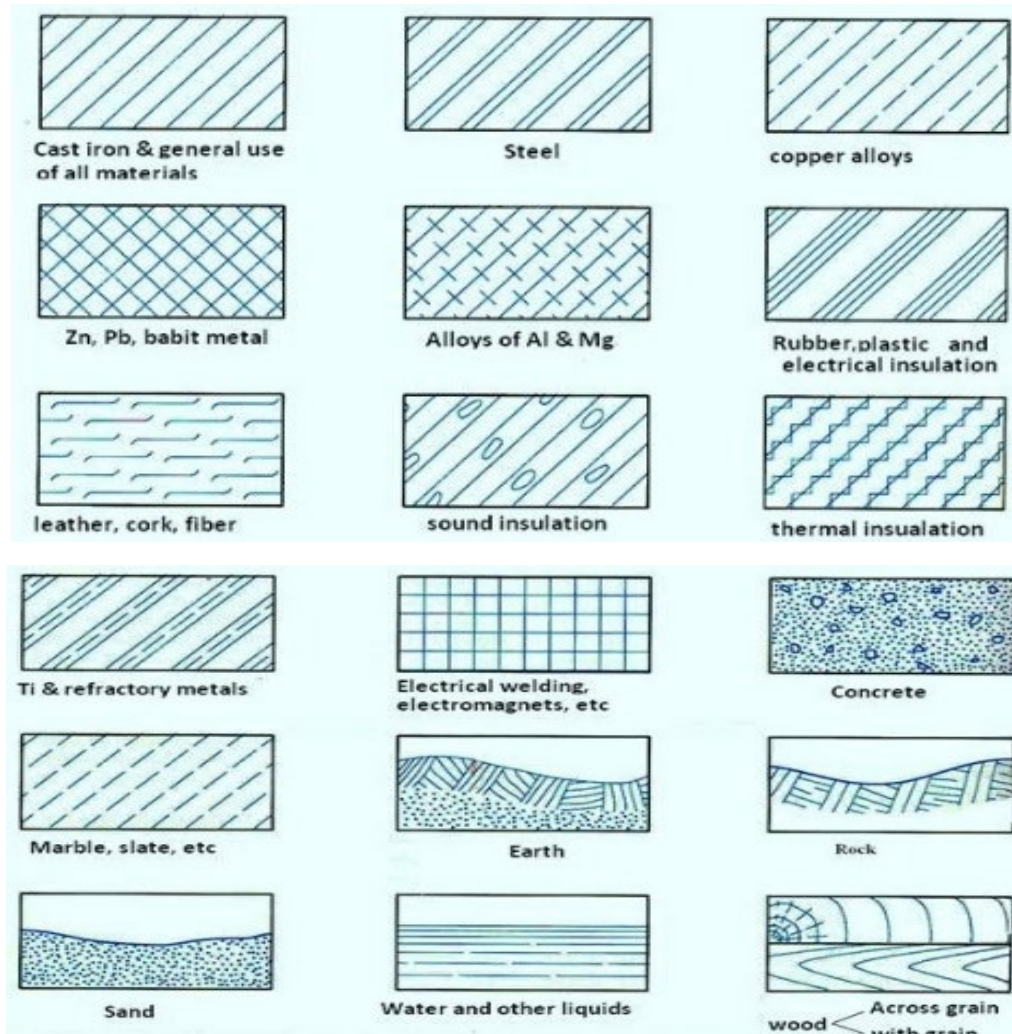
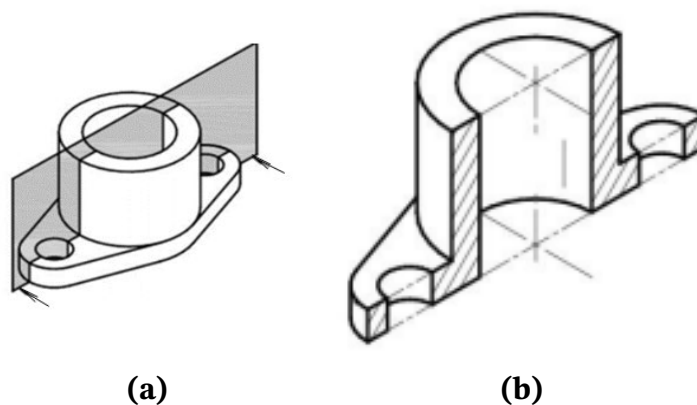


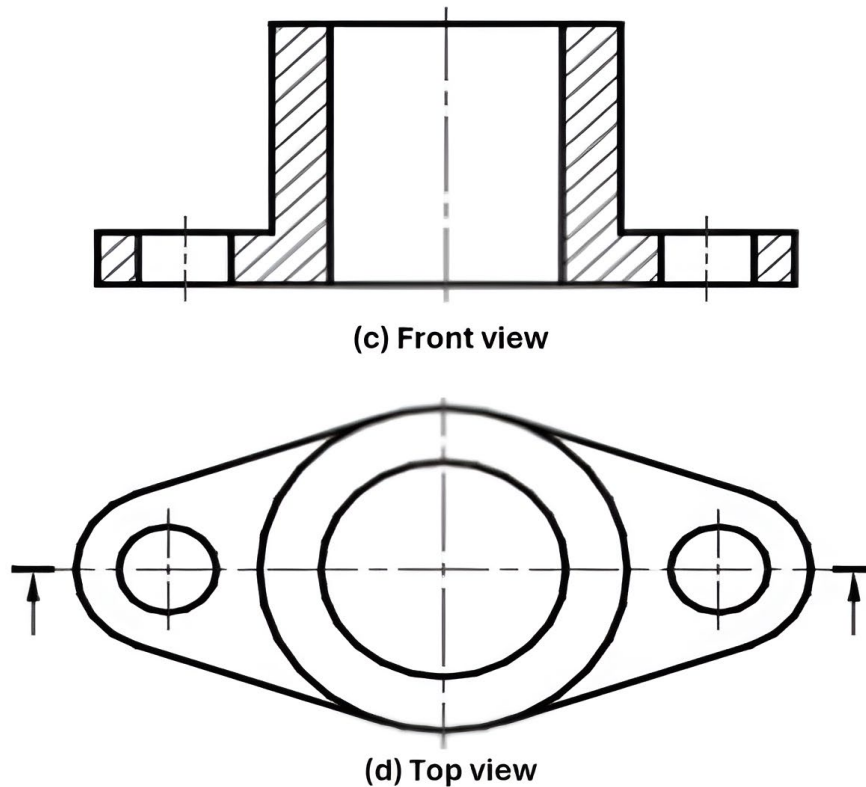
Figure 3.2.5: Sectioning symbols

Types of Sectioning

1. Full section

In a full section view, the cutting plane cuts across the entire object. When a cutting plane line passes entirely through an object, the resulting section is called a full section. The figure below illustrates a full section. The cutting plane line passes through the object in a straight line. Full section is suitable for detail assembly drawings.



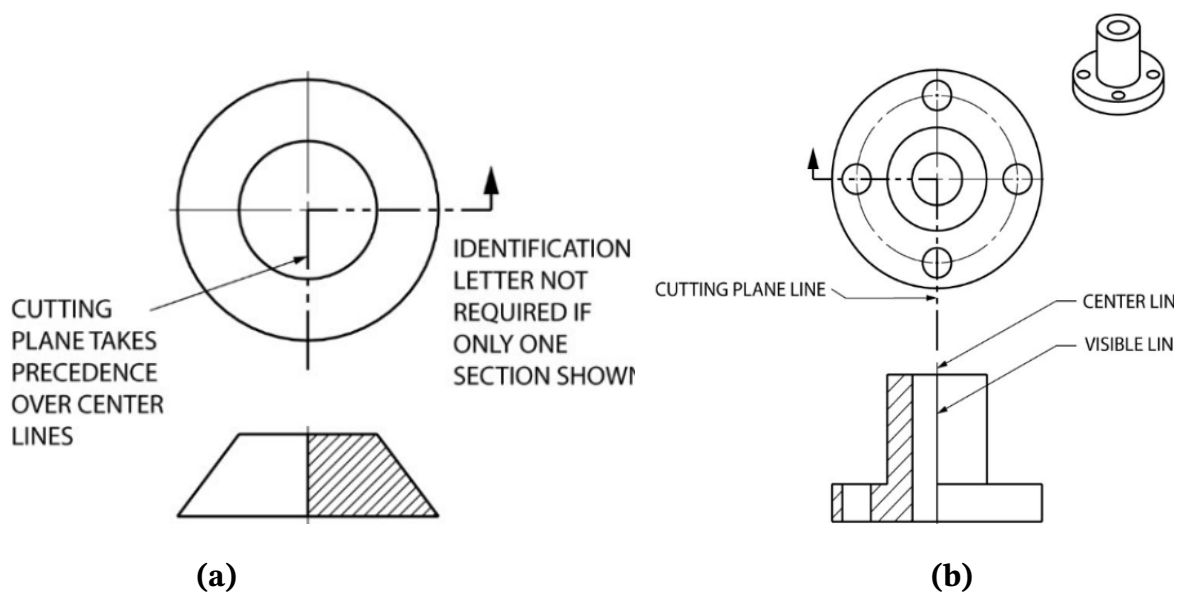


Figures 3.2.6 c-d: Full Sectioning

2. Half Section

A hidden lines are typically omitted from the unsectioned half unless they are essential for clarity or dimensioning. As with all sectional views, the cutting plane line takes precedence over the centreline in the drawing.

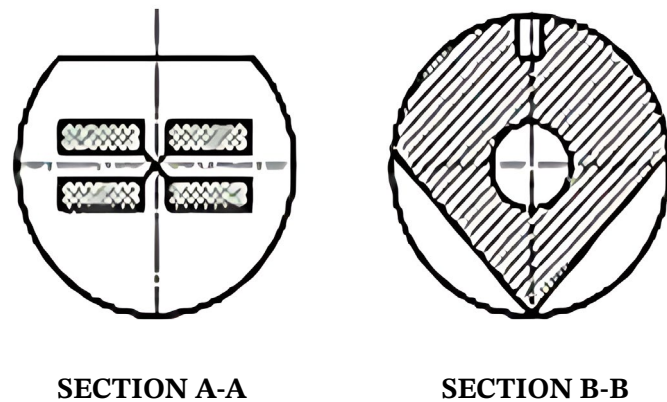
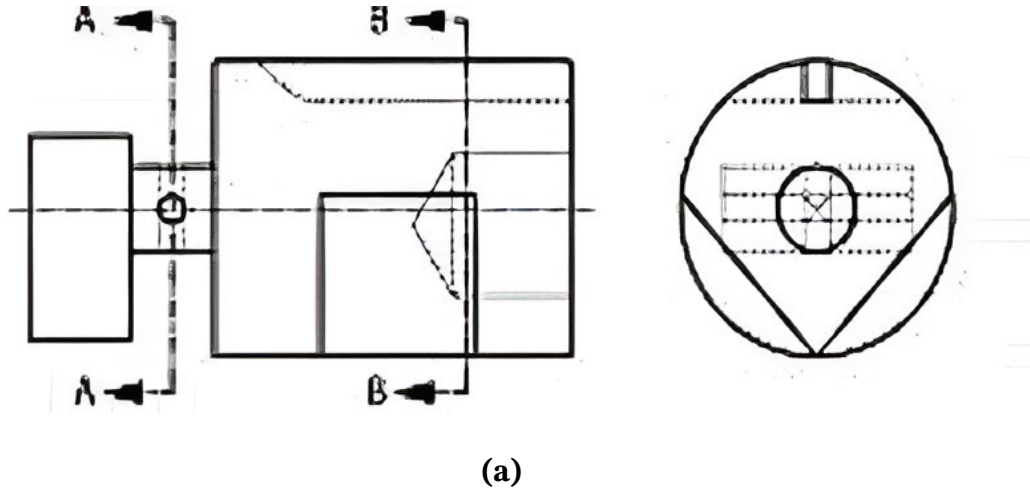
Half sections cut halfway through an object, showing one half in section and the other half as a regular view. –



Figures 3.2.7 a & b: Half sectioning

3. Removed section

A section removed from its normal projected position in the standard arrangement of views is called a “removed” section. With a removed section, the cross-section is drawn outside the given view of the artefact. It is drawn to an open area of the drawing paper. Removed sections may be partial sections and are often drawn to a different scale.



(b)

Figures 3.2.8 a & b: Removed section

4. Revolved section

A **revolved** section illustrates the shape of an object by rotating a section 90 degrees toward the viewer. In Figure 3.2.9, the three revolved sections of the box and flat spanner (spear-like object) demonstrate the changes in its shape along different points.

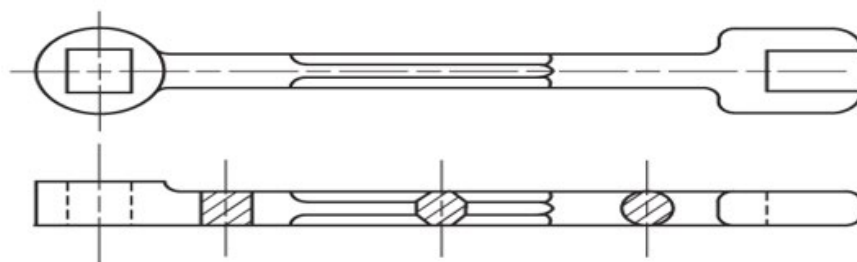


Figure 3.2.9: Revolve section

Rules of Sectioning

Rule 1: A section lined area is always completely bounded by a visible outline.

Rule 2: The section lines in all areas should be parallel. Section lines shown in opposite directions indicate a different part.

Rule 3: All the visible edges behind the cutting plane should be shown.

Rule 4: Hidden features should be omitted in all areas of a section view. Exceptions include threads and broken out sections.

Activities

Organise yourselves into groups of no more than 5 and complete the following using the points listed as a guide. You can use models, internet surfing, pictures, videos and charts to help.

Activity 3.2.1 Principles of sectional drawing

Discuss the following:

1. What is a sectional drawing?
2. Why are sectional drawings used in technical and engineering drawings?
3. Discuss common terms such as cutting plane, section plane, and hatching.

Engage in a whole class discussion to share your insights and gain feedback from your peers.

Sketch to explain examples of sectional drawings

1. Full section
2. Half section
3. Offset section
4. Revolved section

Activity 3.2.2 Drawing a Sectional View

Part A

Analysing a 3D Object

1. Each group should pick a small 3D object
2. Observe the object and imagine how it would look if cut along a specific plane.
3. Identify the most effective cutting plane to reveal internal features.

Choose a cutting plane

Decide on the orientation of the cutting plane (e.g., horizontal, vertical, or angled).

Sketch the object

1. Lightly draw the external view of the object.
2. Mark the cutting plane clearly on the sketch.

Draw the sectional view

1. Show the internal features as they would appear along the cutting plane.
2. Use hatching to represent the areas that are solid.
3. Add dimensions and labels where necessary.
4. Check for accuracy and clarity

Part B

Figure 3.2.10 shows an engine component drawn in first angle projection. Prepare a Freehand Sketch of the:

1. sectional front views (TT)
2. sectional right end view (SS) and
3. plan.

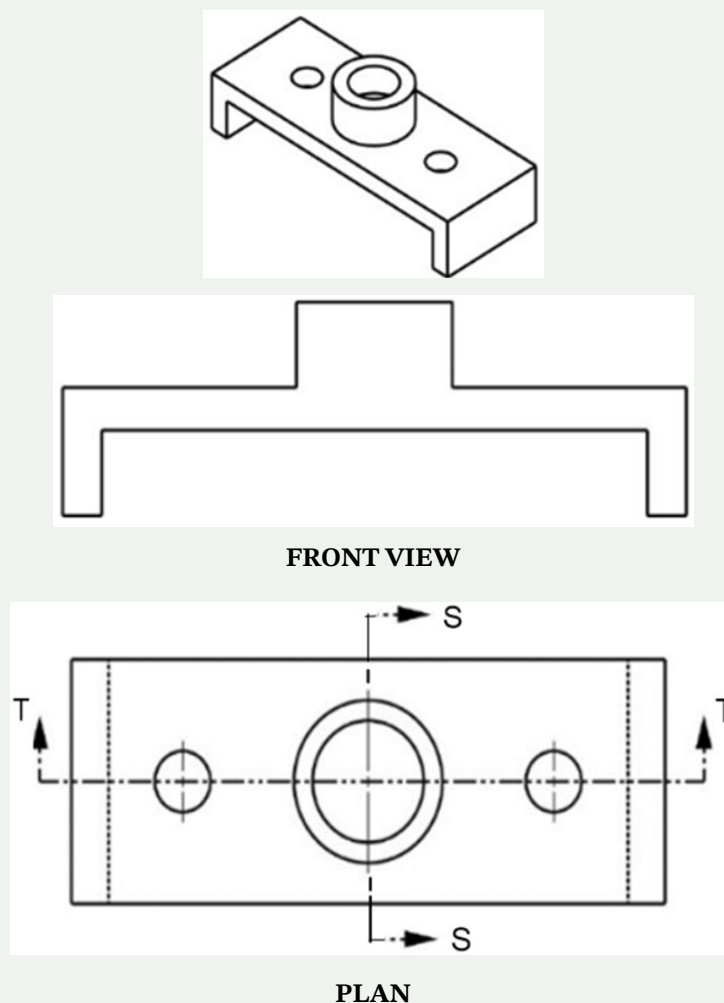


Figure 3.2.10: An Engine Component

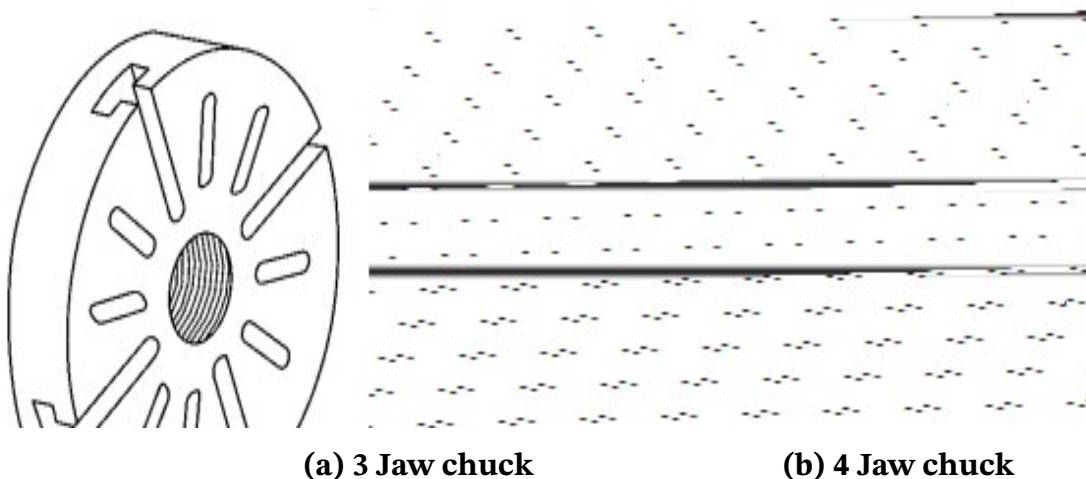
SKETCHING MACHINE PARTS

Sketching machine parts involves creating detailed drawings that represent the design and dimensions of various components used in machinery. These sketches can range from simple hand-drawn diagrams to more complex, precise CAD (Computer-Aided Design) drawings.

Here are some tips and key elements to consider when sketching machine parts:

1. Understanding the function or purpose of the part within the machine and the material the part will be made from, as it can affect the design.
2. Tools and Equipment to use - Pencil and Paper for initial sketches, ruler and a pair of compasses for accurate measurements, CAD Software for precise and scalable designs (e.g., AutoCAD, SolidWorks).
3. Drawing Standards - Using standard views such as front, top, side, and isometric to provide a complete understanding of the part. Clearly indicating all necessary dimensions, including tolerances and including labels for important features, materials and finishes.

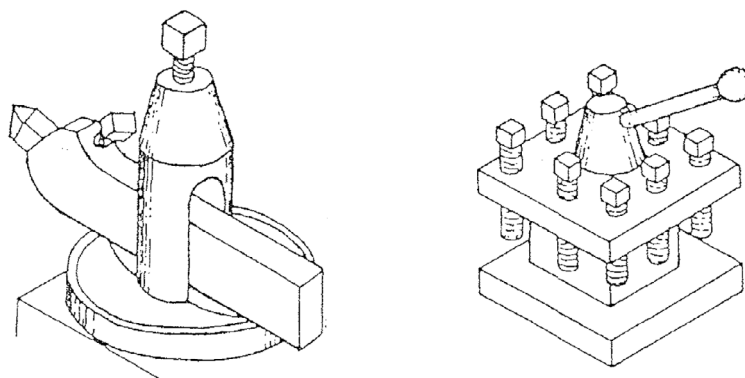
Lathe Machine Parts



(a) 3 Jaw chuck

(b) 4 Jaw chuck

Figure 3.2.11 a & b: Lathe machine parts



(a) Standard Tool Post

(b) Square Tool Post

Figure 3.2.12 a & b: Tool posts

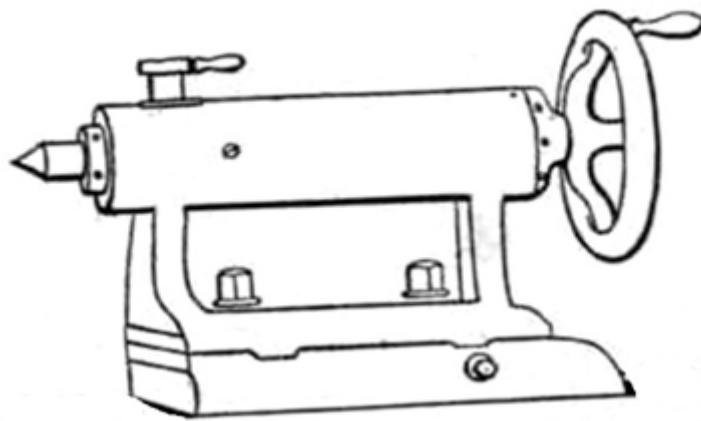


Figure 3.2.13: Tail stock

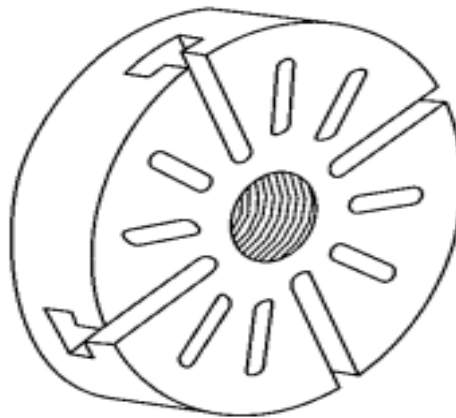
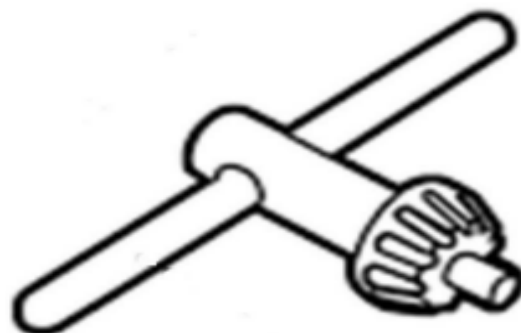


Figure 3.2.14: Face plate

Drilling Machine Parts



(a) Drill chuck



(b) Chuck key

Figure 3.2.15 a & b: Drilling machine parts

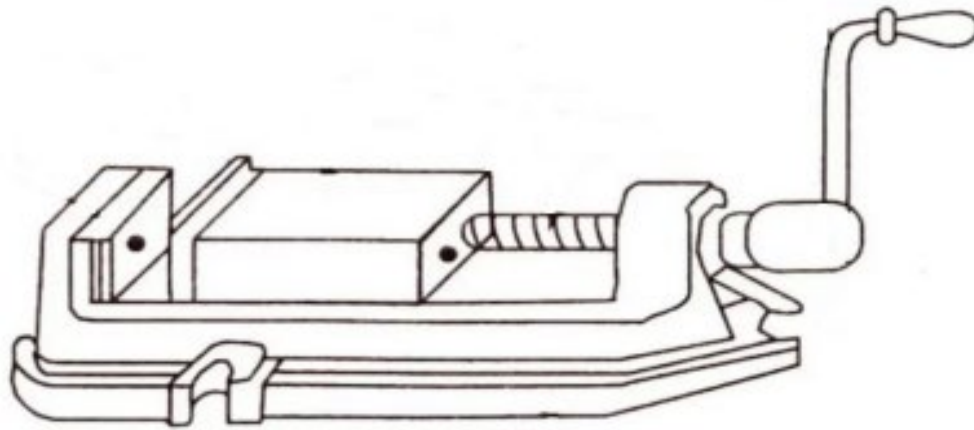
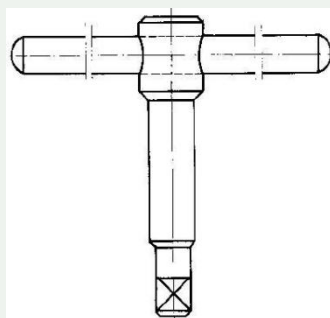


Figure 3.2.16 : Machine vice

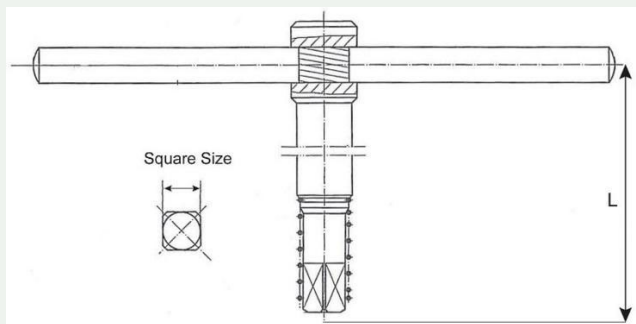
Activity 3.2.3 Freehand sketch sectional views: Lathe Chuck



(a)



(b)



(c)

Figures 3.2.17 a, b & c: Lathe chuck

Procedures:

1. Study the key's shape, dimensions, and internal details to understand what needs to be shown in the sectional view.
2. Choose an appropriate cutting plane that will reveal important internal features.
3. Sketch the overall outline of the chuck key lightly, keeping the cutting plane in mind.

4. Show the part that has been cut by drawing the internal details, such as holes or grooves.
5. Use thin, evenly spaced lines to indicate the material of the cut surfaces.
6. Label the important features (e.g., cutting plane, sectional area) for clarity.
7. Check for accuracy, darken the lines where necessary, and ensure the sketch looks neat.
8. Compare your sketch with the original object to confirm all key details are included.
9. Present your sketch to the class for discussion and feedback.

DRAWING SECTIONAL VIEWS

Sectional Views of Machine Parts and Components

Creating accurate sectional views of machine parts and components demands a strong grasp of technical drawing conventions and proficiency in using various drawing instruments. While traditional drawing instruments can be employed, sectional views are typically created using orthographic projections, specifically first-angle and third-angle projections.

Orthographic projections are mainly obtained on two principal planes namely, Vertical plane (VP) and Horizontal plane (HP). These principal planes are perpendicular to each other, and they divide the space into four quadrants (figure 3.2.18). They are called angles and are classified as:

1. First angle projection – The object lies in the first angle, i.e., above HP, in front VP
2. Second angle projection - The object lies in the second angle, i.e. above HP, behind VP
3. Third angle projection – The object lies in the third angle, i.e. below HP, behind VP
4. Fourth angle projection - The object lies in the fourth angle, i.e. below HP, in front VP

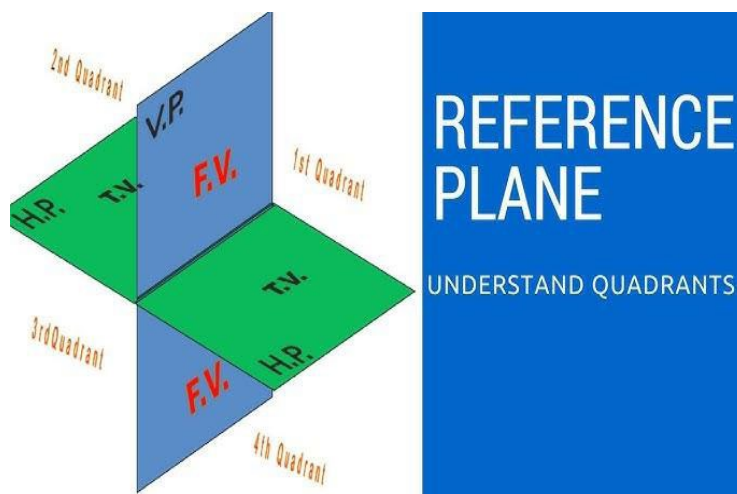


Figure 3.2.18: Plane of projection

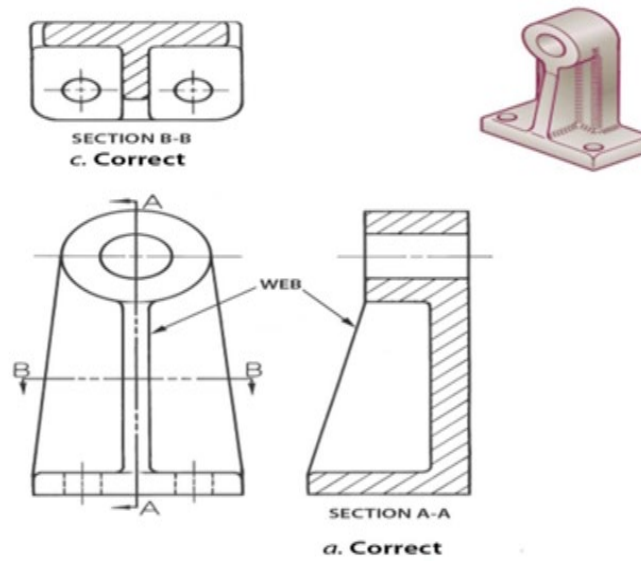


Figure 3.2.19: Part of a machine

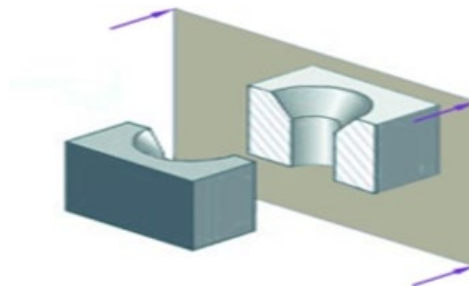
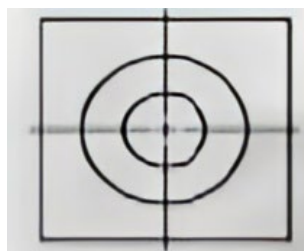
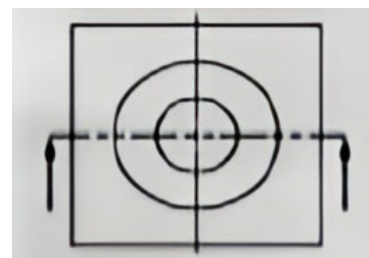


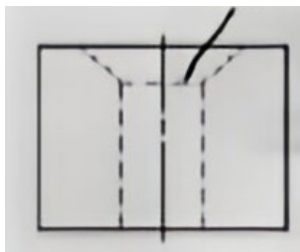
Figure 3.2.20: Part of a machine



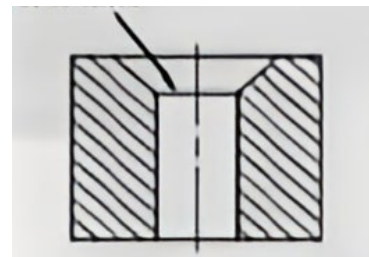
hidden line of intersection of surfaces



Visible line of intersection of surfaces



standard multiview



section view

(a)

(b)

Figure 3.2.21 a & b: Section views

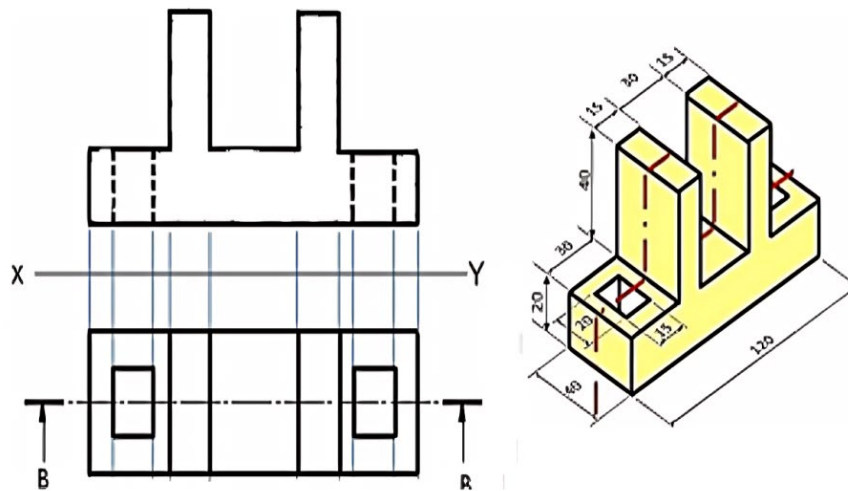


Figure 3.2.22: Part of a machine

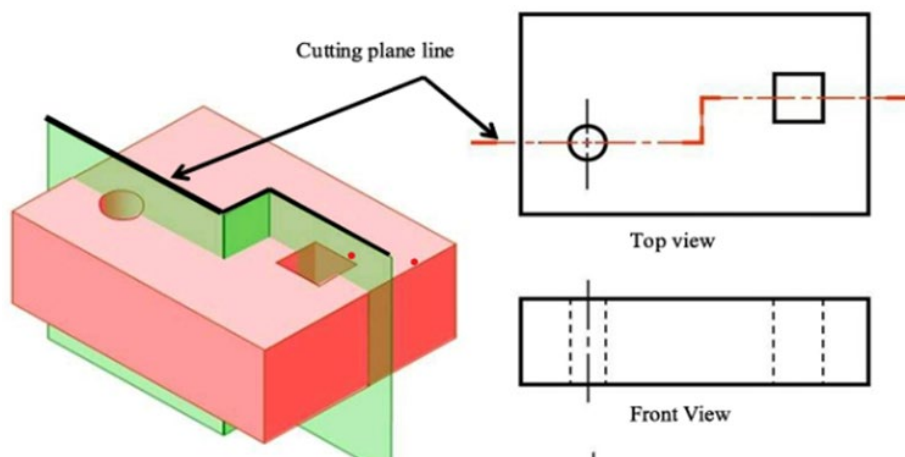
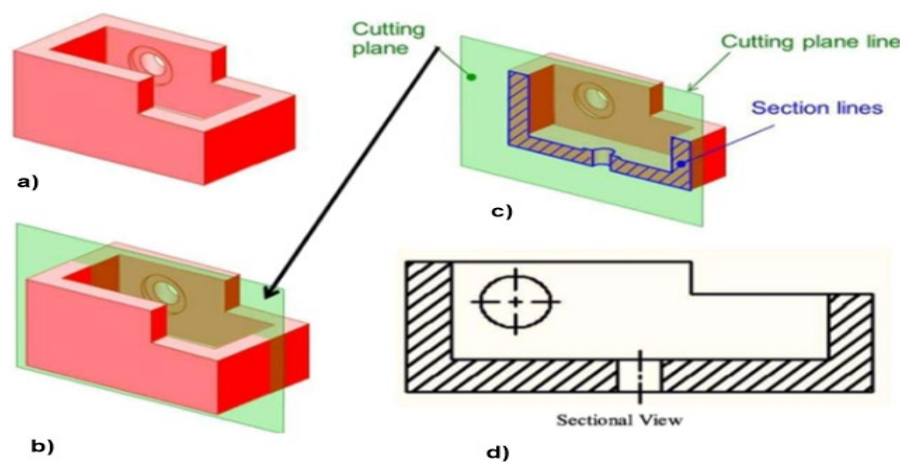


Figure 3.2.23: Cutting plane line through a machine part

Cutting plane lines are seen as actually slicing the part into two. The exposed surface is shown in the section view.



Cutting plane lines are seen as actually slicing the part into two. The exposed surface is shown in the section view.

Figure 3.2.24 : Sectioning

Activity 3.2.4 Drawing Sectional Views of Machine

Draw the sectional views of the component below in first angle and third angle projections.

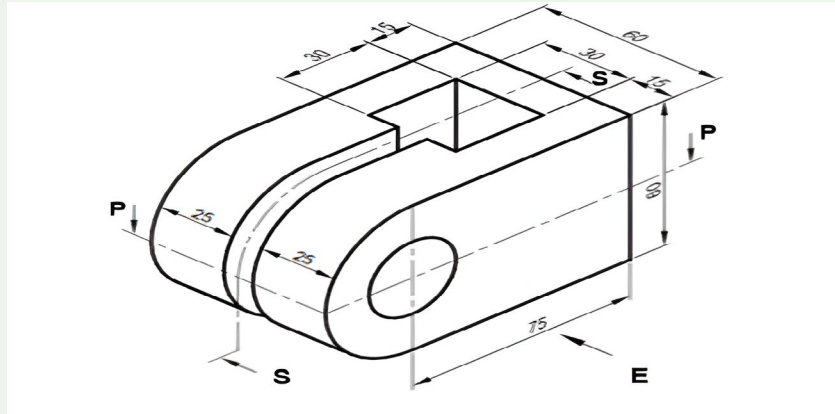


Figure 3.3.25: An engine component

Solution

1. First angle projection

Procedures:

1. Sectional Front view SS

- Draw 2 horizontal lines of 75 mm each
- draw an arc of radius 30 mm.
- draw a circle of radius 15 mm.
- draw 3 vertical lines of 60 mm.
- hatch the cut section (rectangle)
- label the view.

2. Sectional Plan PP

- project vertical lines from SS
- draw 6 horizontal lines
- draw 10 vertical lines.
- hatch the 3 cut sections
- label the view

3. Side View

- project from SS
- draw 2 horizontal lines.
- draw 4 vertical lines.

- d. draw 4 horizontal hidden lines
- e. draw 2 vertical hidden lines
- f. label the view.

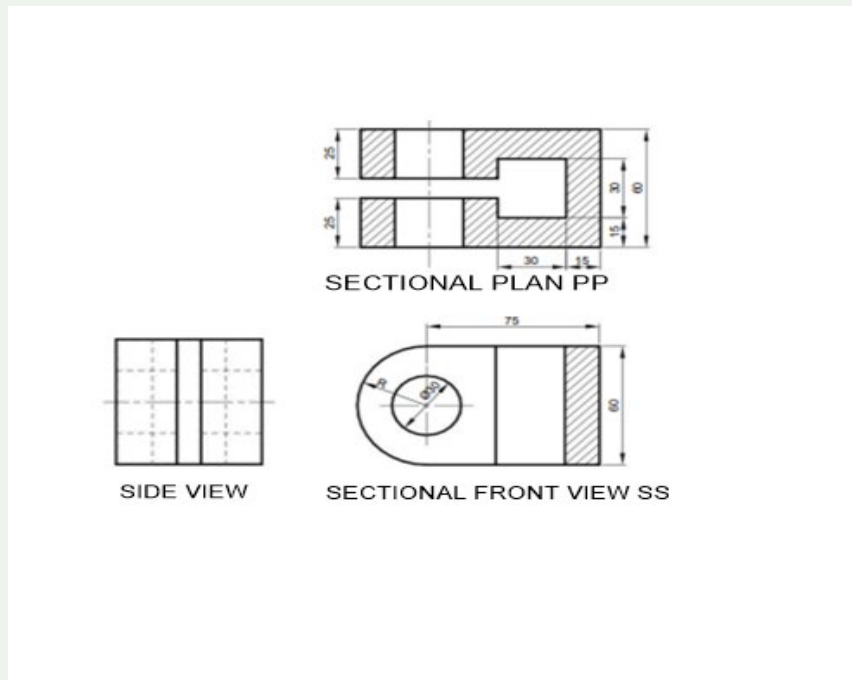


Figure 3.2.26: First Angle Projection

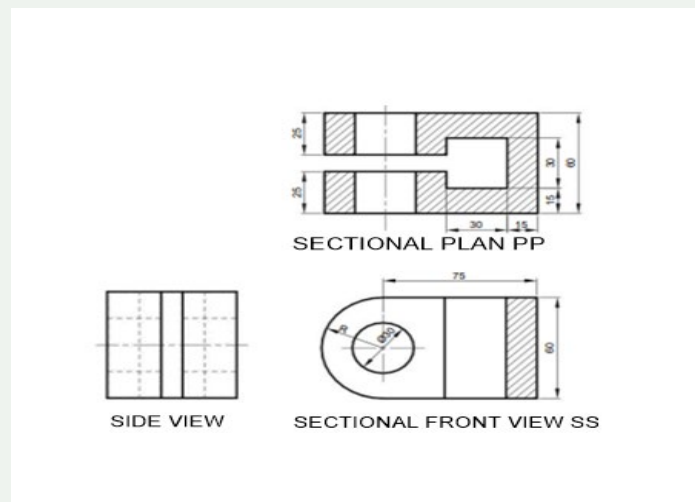


Figure 3.2.27: Third angle projection

ELECTRICAL AND ELECTRONIC CIRCUIT

Electrical Circuits

An electrical circuit is a path through which electric current flows. It includes components such as batteries that provide energy to charged particles, devices that use current (lamps or electric motors), and connecting wires or transmission lines.

Basic Components of an Electric Circuit

1. **Power Source: Battery:** A common source of direct current (DC) that provides the flow of electricity (electrical current).
2. **Conductors:** wires: typically, copper or aluminium, these provide a path for current to flow between components.
3. **Load: Resistor:** A component that limits current flow and can convert electrical energy into heat. **Bulb:** A device that emits light when current passes through it. **Motor:** Converts electrical energy into mechanical motion.
4. **Switch:** Opens or closes the circuit to control the flow of current.
5. **Other Components:**
 - a. Capacitor: Stores and releases electrical energy.
 - b. Inductor: Stores energy in a magnetic field when current passes through it.
 - c. Diode: Allows current to flow in one direction only.

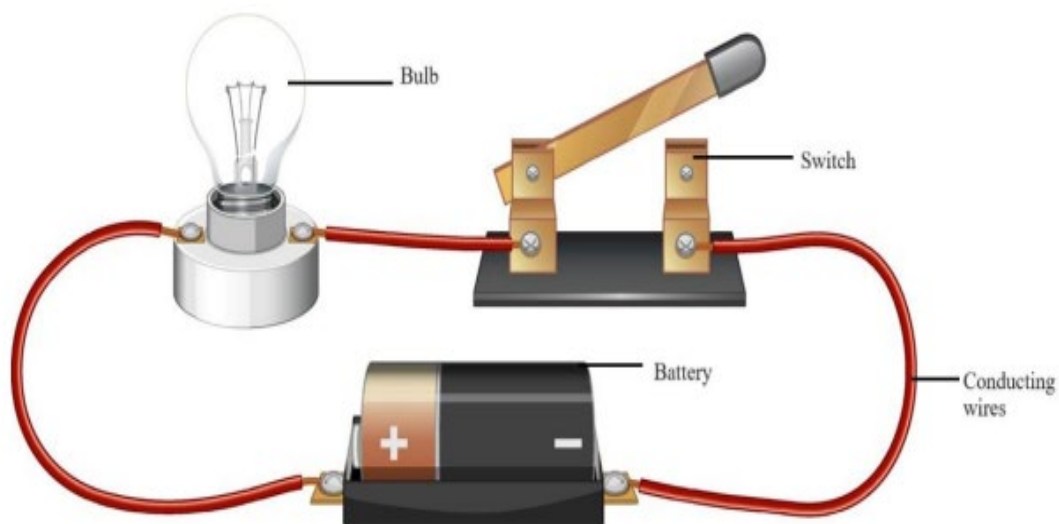


Figure 3.2.28: Simple electrical circuit

Electronic Circuits

Electronic circuits are a specialised form of electrical circuits that use electronic components to regulate the flow of electric current and perform specific functions. They are essential to modern technology, powering everything found in many modern items from everyday gadgets to advanced systems.

Basic Electronic Components

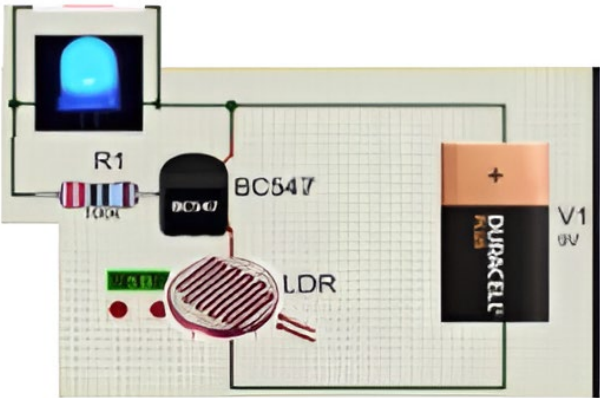


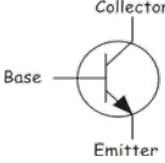
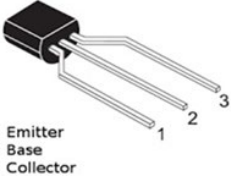
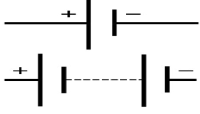
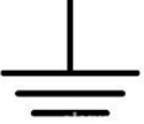
Figure 3.2.29: Simple electronic circuit

Electrical and Electronic Symbols in Circuits

Electrical and electronic symbols are standardised graphical representations of components, devices, and connections in circuits. These universally recognised symbols enable engineers, technicians, and electricians to communicate circuit designs and connections clearly and effectively.

Table 3.2.1: Electrical and electronic symbols in circuit

Name/description	Symbol	Picture
Resistor: It is a passive component that limits or controls the flow of electric current in a circuit.		
Capacitor: It is often used for filtering, energy storage, and timing applications.		
Inductor: It stores energy in a magnetic field and resists changes in current. Inductors are commonly used in applications such as filters, oscillators, and power supplies.		

Diode: It allows current to flow in one direction while blocking it in the opposite direction. Diodes are widely used in rectifiers, switches, and voltage clamping circuits.		
Transistors: It is a semiconductor device that amplifies or switches electronic signals and forms a fundamental building block in many electronic circuits.		
Battery: It is a source of electrical energy that can supply power to a circuit.		
Switch: It controls the flow of current in a circuit by either allowing or interrupting the path of electricity.		
Earth rod: It represents the reference point in a circuit or the connection to Earth, providing a zero-voltage reference.		

Activity 3.2.5 Distinguishing Between Electrical and Electronic Circuits

Organise yourselves into groups of no more than five for this activity.

Setup and Materials

1. Physical Components:

- A simple electrical circuit kit (battery, wires, bulb, and switch).
- An electronic circuit kit (breadboard, resistor, LED, transistor, capacitor).

2. Digital Tools: Access to simulation software (e.g., Tinker cad, Circuit Lab).

3. Printed Cards:

- Cards with names/pictures of components (e.g., bulb, transistor, resistor).
- Cards with examples of circuits (e.g., lighting system, amplifier)

Steps

1. **Observe the displayed devices:** Observe the pictures on circuits/devices (e.g., lamp, radio, smartphone) and classify them as electrical or electronic.
2. **In your groups use the devices to**
 - a. Build a simple circuit to power a bulb.
 - b. Assemble a basic circuit with a transistor and LED.
3. **Observe and record**
 - a. What does your circuit do?
 - b. What components did you use?
 - c. How is energy you used in your circuit?
4. **Using simulation software**
 - a. Recreate the circuits digitally.
 - b. Add variations, such as replacing the bulb with an LED or introducing a transistor.
 - c. Discuss how simulations reflect real-world behaviours.
5. **Reflect on these questions**
 - a. What are the main differences between electrical and electronic circuits?
 - b. How do the two circuit components and functions differ?
 - c. Where do you see these circuits in daily life?

CIRCUIT DIAGRAMS

Circuit diagrams, also known as schematic diagrams, are graphical representations of electrical and electronic circuits which show the components and interconnections of the circuit using standardised symbolic representations. These diagrams are essential for designing, analysing, and troubleshooting circuits.

Drawing Simple Electrical and Electronic Circuit Diagrams

Drawing circuit diagrams involves creating a visual representation of an electrical circuit using standardised symbols to represent components and their connections.

Steps to Consider

1. **Understand and Use Standard Symbols:** Familiarise yourself with the common symbols used in circuit diagrams.
2. **Tools and Materials**
 - a. Graph Paper for maintaining alignment and proportion.
 - b. Pencils and Erasers helps in sketching and making corrections.
 - c. Rules are for drawing straight lines and standard symbols.

3. Sketch the Basic Layout

- a. List all the components required for your circuit.
 - b. Identify their function and how they will be connected, lightly sketch the arrangement of components on graph paper.
 - c. Place components logically to minimise crossing lines and ensure clarity.
4. **Connect the Components:** Use a ruler to draw straight lines between component symbols, use dots to indicate junctions where wires meet.
 5. **Label Each Component:** Write the component value or part number next to each symbol.
 6. **Specify values:** Include values for resistors, capacitors, and other components as part of the label (e.g., $10\text{k}\Omega$ for a resistor).
 7. **Finalise the diagram:** Ensure that all components are correctly represented and that connections match the intended design.

Example: Draw a Simple Circuit Diagram with the following components:

- a. A battery (power source)
- b. A resistor
- c. An LED (light-emitting diode)
- d. A switch

Procedures:

1. **Place the Battery:** Draw the battery symbol.
2. **Add the Resistor:** Draw the resistor symbol.
3. **Place the LED:** Draw the LED symbol.
4. **Connect Components:** Draw lines to connect the battery to the resistor, the resistor to the LED, and include a switch in the circuit to control the flow.
5. **Label Components:** Add labels for the battery (e.g., “9V”), resistor (e.g., “ 470Ω ”), and LED.

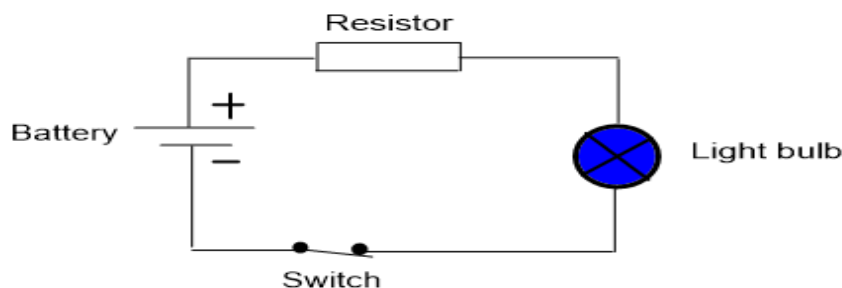


Figure 3.2.30: Circuit diagram

Activity 3.2.6 Designing and Drawing Simple Electrical Circuits

You will be required to design and draw two simple electrical circuits.

Materials Needed

1. Paper and pencil/pen for sketching.
2. Ruler and eraser.
3. Reference materials (symbols and diagrams of electrical components).
4. Circuit simulation software (optional)

Instructions

1. Review the purpose and functions of the following components:
 - a. **Switch:** Controls the flow of current in the circuit.
 - b. **Fuse:** Provides overcurrent protection.
 - c. **Circuit Breaker:** Protects the circuit from damage due to overload or short circuit.
 - d. Understand the standard symbols used to represent these components in circuit diagrams.
2. **Identify the basic elements of the circuits:**
 - a. **Power Source:** Choose a suitable DC or AC source.
 - b. **Load:** Determine a simple load (e.g., a bulb or a motor).
 - c. **Protective Components:** Include a fuse and circuit breaker in the design.
 - d. **Control Component:** Add a switch to control the circuit.
 - e. Arrange these components in a logical sequence, ensuring the circuit can function safely and effectively.
3. **Draft the Circuit Diagrams**
 - a. Begin by drawing a rough sketch of the circuits using the standard electrical symbols.
 - b. Ensure the arrangement for each circuit is clear, with proper labelling of components (e.g., fuse, switch, load, etc.).
 - c. Refine the sketches into neat and scaled diagrams using a ruler for straight lines.

EXTENDED READING

1. Agrawal, B and Agrawal, C. M. (2015), Engineering Drawing, McGraw Hill Education (India) Private Limited, New Delhi. (Page 7.29 – 7.39)
2. Morling, K. and Danjou, S (2022), Routledge Taylor & Francis Group Publishing, New York (Page 250 – 259)

UNIT 3: GARMENT DESIGN TECHNOLOGY

INTRODUCTION

Garment design technology is a multifaceted process that involves creativity, technical skills, and attention to detail. The fundamental skills are the ability to assess and utilise various tools, take accurate body measurements, and draft basic pattern blocks.

By understanding the applications and limitations of various manual and digital tools, such as pencils, rulers, scissors, and computer-aided design (CAD) software, designers can efficiently create their designs.

Applying the basic principles of measurement-taking, designers can obtain precise body measurements, which serve as the basis for drafting pattern blocks.

Drafting basic pattern blocks for bodice and sleeve is another critical step in garment design, as it enables designers to create a blueprint for their designs.

This Unit addresses the world of garment design, exploring the tools, techniques, and principles that underpin this creative and technical field, which will enable you to gain the fundamental skills required to succeed in garment design.

KEY IDEAS

- Identify and evaluate manual and digital tools used in garment design, such as pencils, rulers, scissors, and CAD software.
- Apply basic principles to take accurate body measurements, including understanding measurement points, using correct measuring techniques, and recording measurements accurately.
- Master various measurement techniques, such as taking circumference, length, and width measurements, and using these measurements to create a fitting garment.
- Understand the basics of drafting basic pattern blocks for bodice and sleeve, including identifying key measurement points, using pattern making techniques, and creating a basic block.
- Learn to draft basic pattern blocks for bodice and sleeve, including understanding the relationships between measurements, pattern pieces, and garment fit.
- Apply and integrate knowledge of tool assessment, body measurement principles, and pattern block fundamentals to create a well-fitting garment.

THE MEANING OF GARMENT IN THE COMMUNITY

Garments play a significant role in every community, extending beyond their basic function of covering the body. Clothing communicates identity, values, and cultural heritage, serving as a visual representation of an individual's belonging and affiliation. The following show some of the importance of garments in relation to the community:

1. **Cultural Identity and Expression:** Garments play a significant role in expressing and preserving cultural identity within a community. Traditional clothing and textiles often reflect a community's history, customs, and values. By wearing traditional garments, community members can connect with their cultural roots and express their identity.

This cultural identity is shaped by various factors, including traditional clothing where unique designs, patterns, and fabrics that are specific to a community; cultural symbolism, which feature symbolic motifs, colours, or patterns that hold cultural significance; and community values, where the garments reflect a community's values, such as modesty, spirituality, or creativity.

2. **Social Signifiers:** Garments can serve as social signifiers, conveying information about an individual's social status, occupation, or affiliation. Social signifiers can be intentional or unintentional, and they can influence how individuals perceive and interact with each other.

Members of various subcultures and communities of interest, such as status symbols, occupational uniforms, business attires, sports organisations, uniforms in schools, and affiliation markers such as logos, insignia, or colours associated with particular groups, can also be shown by one's clothing choices.

3. **Economic and Production Contexts:** The production and distribution of garments can have significant economic and social impacts on a community. The garment industry can provide employment opportunities, stimulate local economies, and promote cultural exchange.

These can be seen in areas like the small-scale textile industries that produce traditional fabrics, which are then converted into different garments to be distributed by retailers, wholesalers, or consumers, often involving marketing and advertising strategies.

4. **Adaptation and Evolution:** Garments can adapt and evolve over time, reflecting changes in cultural, social, and economic contexts. This adaptation and evolution can be driven by various factors, including technological advancements, cultural exchange, and environmental concerns.

The exchange of cultural practices with advances in textile production can lead to the creation of new garment designs, styles, and trends that shows different cultural practices, ideas, and values.

5. **Symbolism and Ritual:** Garments can hold symbolic meanings and play significant roles in rituals and ceremonies. Symbolism and ritual can be used to convey cultural values, mark important life events, and provide spiritual significance.

On occasions such as weddings, births, or funerals, the garments worn form an integral part. The garments that have symbolic motifs, colours, or patterns may be worn to represent spiritual beliefs or signify momentous life changes.

Tools Used in Garment Design and Their Applications

Garment design technology relies heavily on various tools to facilitate the design process. The tools enable designers to create, develop and produce high-quality garments if used effectively. Among these tools, drawing and drafting tools play a crucial role in bringing designs to life. These tools enable designers to sketch, draw, and draft garment designs with precision. They have been categorised into drawing, measuring, marking, and cutting tools.

Drawing tools which include pencils, pens, markers, coloured pencils and drawing boards are used for creating sketches, illustrations, and technical drawings. Drafting tools, consisting of measuring, marking, and cutting tools include tailor's chalk, tracing wheels, tape measure, rulers, curves, protractors, French curves, pattern making rulers, scissors, and rotary cutter. Papers used in garment design include sketchbook/drawing book, tracing paper, dress maker's carbon paper, and other miscellaneous papers like tissue paper and interfacing paper.

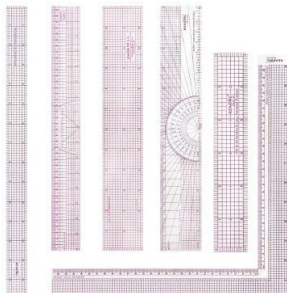
Tools/papers Used in Garment Design, Image and Their Applications

Table 3.3.1 Drawing tools for designing

Tool	Image	Application
Pencils		Used for sketching and drawing designs.
Pens		Used for creating final drawings, drawing patterns, and writing notes.

Coloured pencils		Used for adding colour and detail to designs.
Sketchbook/drawing books		Used for recording ideas, sketching designs, and developing concepts.
Computer Aided Design (CAD)		Used for creating and editing 2D designs, patterns, and sketches.

Table 3.3.2 Measuring tools

Tool	Image	Application
Tape measure		Used to measure and draw straight seam and cutting lines, taking body measurements, drafting patterns, and measuring fabrics. Also aids in connecting lines.
Rulers		There are different types. Used for measuring small distances for tucks, hems, facings, and also for taking measurements in drafting.

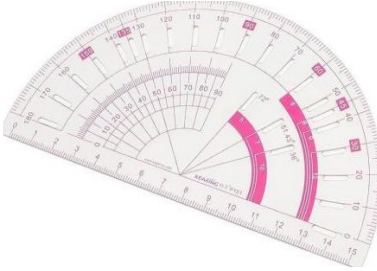
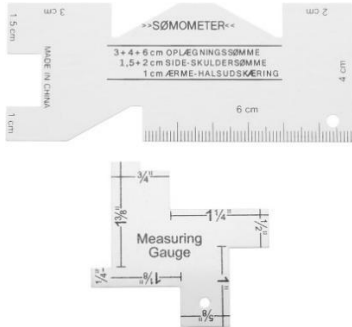
		French curve/curve is used in manual drafting to draw smooth curves of varying radii for armhole, hip, etc. The curve is placed on the drawing material, and a pencil or other implement is traced round its curve to produce the desired result.
Protractor		Used to measure and mark angles in patterns, to rotate patterns in designs, and fabrics, for accurate fit and shaping.
Gauges		Used to measure short distances at hem lines, buttonholes and areas where other small measurements require checking, such as pleats and tucks.
Square		Square is used for finding and aligning the grain of fabric and also for making perpendicular lines in pattern drafting.
Yardstick		Used for marking hemlines and checking grain lines when laying out the pattern.

Table 3.3.3 Marking tools

Tool	Image	Application
Pens and pencils		Used for marking the outlines of shapes in pattern drafting.
Tracing wheel		Used with dress maker's carbon to transfer pattern markings to cloth/fabric.
Tailor's chalk		Made of wax or stone chalk. Used to transfer seam lines and other pattern details to fabric.
Dressmaker's carbon		A wax-coated paper on one side and is available in different colours. Used with the tracing wheel or pencil to transfer pattern markings.

Tracing paper and drafting paper		Tracing paper is used to create copies of designs and patterns, and also for transferring designs from one surface to another. Drafting paper is used to create patterns, and to make adjustment and changes to patterns.
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Table 3.3.4 Cutting tools for drafting

Tool	Image	Application
Scissors		There are different types. The Shears also known as dressmaking shears is used for precise cutting and trimming of fabrics, opening seams, and clipping threads. The pinking shears has saw-toothed blade which leaves a zigzag pattern. It is used to cut seams, edges, and curves, and prevents fraying and unravelling of fabrics.
Rotary cutter		Used or cutting fabrics quickly and accurately, especially for large quantities.

Activity 3.3.1

Organise yourselves into groups of no more than five.

In your groups, brainstorm and reflect on the following questions:

1. What is meant by the term garment and how is it used in your community?
2. What is the importance of those garments in your community?
3. What tools do you think are used to design those garments?

Present your findings to the class for feedback and discussion. You can be creative and can use pictures, charts or a digital presentation to share your findings.

TAKING BODY MEASUREMENTS ACCURATELY

The Meaning of Body Measurement in Garment Design

Body measurements refer to measurements of a real person (or individuals) who will wear a garment.

Body measurements play a crucial role in the design of garments since they influence fit, comfort, and overall success of the piece. By taking accurate measurements, garment designers can make sure their creations fit well and satisfy the wearer's functional and aesthetic needs.

Body measurements are important in garment design since they guarantee that, the garment fits properly and accentuates the wearer's natural curves.

Key Body Measurements in Garment Design

The parts of the body to be measured are dependent on the kind or type of garment to be constructed. However, there are key measurements for garment design peculiar to all sex types (male or female garments).

These include:

1. Bust/Chest: Measurement around the fullest part of the bust or chest.
2. Waist: Measurement around the natural waistline, typically above the belly button.
3. Hips: Measurement around the fullest part of the hips.
4. Inseam: Measurement from the crotch to the bottom of the ankle.
5. Sleeve Length: Measurement from the shoulder to the desired sleeve length.
6. Shoulder Width: Measurement from one shoulder seam to the other.

Importance of body measurements in garment design

The following are some importance of body measurements in garment design:

1. **Promotes good fit and comfort:** Accurate measurements help create garments that fit the body properly, enhancing both comfort and appearance. It also helps in maintaining correct proportions, so the garment doesn't appear too loose or too tight.
2. **Makes pattern drafting easy:** Body measurements are used by designers to create patterns that will result in clothes that fit properly. Every measurement helps to accurately shape the pattern. Once more, knowing body dimensions aids in creating custom or standard sizes that fit a variety of body shapes.

3. **Ensures good style and aesthetical appeal:** Measurements guarantee that design features (such as hems, darts, and seams) suitably follow the natural contours of the body. Well-fitting clothing improves its visual attractiveness by giving the design a polished, deliberate appearance.
4. **Aids alterations and customisation:** Precise measurements for bespoke clothing enable modifications to be made so that the finished item fits precisely in accordance with personal preferences. It helps tailors to make the required post-production changes to ensure the garment fits the wearer well and is well-fitting.
5. **Ensures consistency in production:** Precise body measurements facilitate the production of clothing in uniform sizes for various batches and clients. They provide the foundation for quality control, ensuring that clothing fits according to the necessary criteria.
6. **Guaranteed consumer satisfaction** For ready-to-wear clothing, providing accurate size guides based on body measurements helps consumers select the right size, leading to greater satisfaction. This also means proper sizing reduces the likelihood of returns due to fit issues, improving overall customer experience.

Principles of body measurement

The principles of body measurement in garment designing ensure that clothing fits well, complements the wearer's body shape, and aligns with the intended design.

Importance of principles for taking body measurements

Designers can make clothes that fit properly and improve the comfort and style of the wearer by following the principles or guidelines. Measurement must be precise and accurate in order to produce apparel that fits nicely.

1. **Accuracy:** To make sure the clothing fits properly, measurements must be taken precisely. The fit and general look might be impacted by even minor differences. To prevent measurement differences, always the same technique and appropriate measuring tools (tape measure). Proper Posture: To guarantee that the garment fits comfortably, the wearer should stand in a relaxed, natural posture while having their measurements taken. The measuring tape should be snug without constricting the body, neither too tight nor too loose.
2. **Proper Measuring Tools:** For precise measures, use a flexible, non-stretchable measuring tape. Make sure the body is measured on a flat level surface for some measurements (such as the waist).
3. **Adjustments for Design:** Based on body measurements, include ease (more space for comfort and movement) and seam allowances (more fabric for sewing) in the design. Adjust the garment's pattern to suit individual body types and style preferences; for example, add pleats or darts where needed.

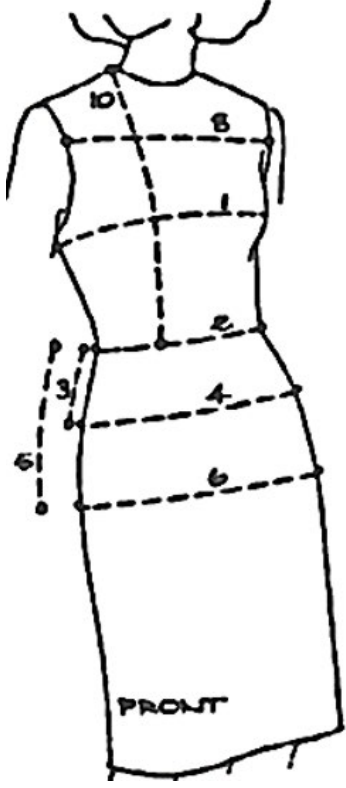
4. **Taking Body Shape into Account:** Recognise the various body types and how they impact clothes fit. It is necessary to modify measurements to account for different body shapes and sizes. Modify patterns to balance or accentuate body proportions based on personal measurements.
5. **Standardisation vs. Customisation:** Use size charts and standardised measurements for mass-produced clothing. Make sure a range of body shapes and sizes are represented in these criteria. Take precise measurements of each person when ordering bespoke or made-to-measure clothing to ensure a great fit that fits the wearer's unique body type.
6. **Measurement repetition and appropriate documentation or recording:** To guarantee precision and consistency, take several measurements. Measuring twice makes it easier to spot inconsistencies. Measurements should be meticulously recorded or documented, particularly for custom designs, to guarantee that any future adjustments or clothing are made using correct measurements.
7. **Client Communication:** To make sure your clients' demands are satisfied, talk to them about their preferences, body issues, and fit requirements. Gather and evaluate fitter input to hone measurements and enhance subsequent designs.

Measuring Techniques

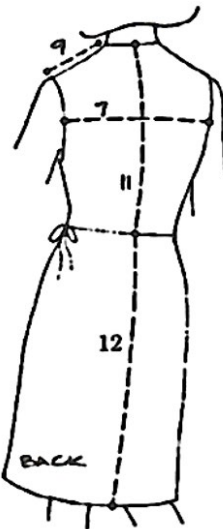
1. Verify the accuracy of your tape measure with the rulers you plan to use.
2. Take measurements over unadorned, well-fitting, simple clothing. There should be regular shoes and undergarments. The subject of the measurement should stand up straight and naturally
3. Tie a piece of string or thin tape around the natural waist to begin. Use this to get accurate direction for vertical measures, when every centimetre counts.
4. Measure every inch around the figure firmly but loosely. Always measure up to the nearest even centimetre or inch when measuring the breast or chest.
5. Marking the armhole and base of the neck with pins or chalk may be useful for cross measures (back, chest, shoulder).
6. If the measurement is based on standard charts, make sure it is current by measuring both summer and winter garments over suitable undergarments. Do not forget to annotate charts with names and dates.
7. Additional inspections may be necessary for a specific design, such as the depth of the neckline or the placement of the yoke. Record each of these specific design metrics in a notepad.

Table 3.3.5 Body Measurement for Women's Bodice and Skirts

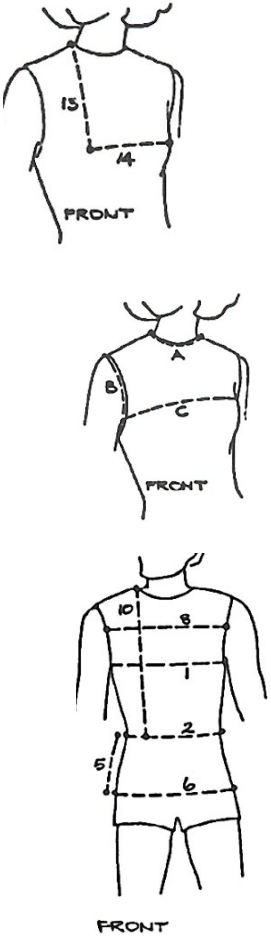
1	Bust	Around the figure & over the fullest part of the bust
2	Waist	Around the natural waistline
3	Waist to hipbone	Length taken at side
4	Hips	Around figure, over hip bones
5	Waist to Seat	From side to the widest part
6	Seat	Around widest part (Tape not to pull-in under abdomen)
7	Back Width	Across the shoulder blades from armhole to armhole
8	Front Chest	Across from armhole to armhole. Below the base of the throat
9	Shoulder line	The length from base of neck to top of armhole position
10	Neck to Waist front	Length, from shoulder at base of neck, over bust, to waist
11	Neck to waist back	Length, from the bone at the top of the spine to the waist
12	Full length of garment	At centre back from neck, in at waist & on to required length



For	Women's	Patterns
1	Shoulder to bust point	Length from the shoulder at base of neck to the bust point
2	Distance	between bust point
Check for measurements bodice patterns		
A	Neck	Around the base of the neck
B	Armhole	Around the armhole as for a set-in sleeve
C	High Bust	Around the chest. Under arms and above bust



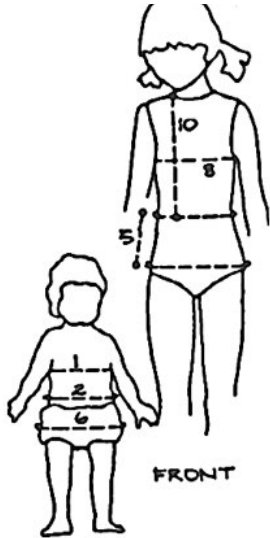
Measurement for men's Casual Wear

1	Chest	Around the figure and over the fullest part of the chest	
2	Waist	Around the natural waistline	
5	Waist to Hip/ Seat area	Taken from the side to the widest part	
6	Hip/ Seat	Around widest part	
7	Back width	Across the shoulder blades from armhole to armhole	
8	Front Chest	Across from armhole to armhole. Below the base of the throat	
9	Shoulder line	The length from base of neck to top of armhole position	
10	Neck to Waist front	Length, from shoulder at base of neck, to waist	
11	Neck to Waist back	Length, from the bone at the top of the spine to the waist	
12	Full length of garment	At centre back from neck, in at waist & on to required length	

Check	Measurements for	Bodice patterns
A	Neck	Around the base of the neck
B	Armhole	Around the armhole as for a set- in sleeve

Table 3.3.7 Body Measurement for Children

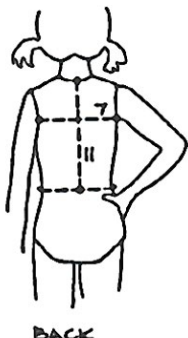
1	Chest	Around the figure & over the fullest part of the chest
2	Waist	Around the natural waistline
5	Waist to hip/ Seat area	Length taken at side
6	Hip/ Seat	Around figure, over hip bones
7	Back width	From side to the widest part from side to the widest part
8	Front Chest	Around widest part (Tape not to pull -in under abdomen)
9	Shoulder line	The length from base of neck to top of armhole position
10	Neck to Waist front	Length, from shoulder at base of neck, over bust, to waist
11	Neck to waist back	Length, from the bone at the top of the spine to the waist
12	Full length of garment	At centre back from neck, in at waist & on to required length



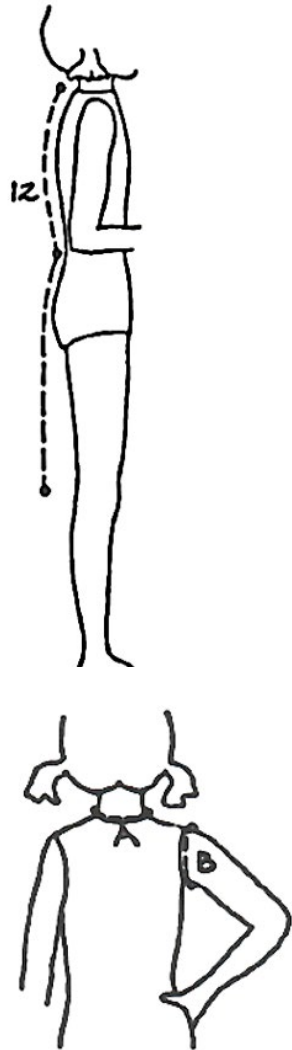
FRONT



BACK



BACK

Check	Measurement	For Bodice patterns	
A	Neck	Around the base of the neck	
B	Armhole	Around the armhole as for a set-in sleeve	

Activity 3.3.2 Practicing Body Measurement for Garment Design

Organise yourselves into groups of no more than 5 and complete the following.

Materials Needed:

1. Measuring tapes
2. Mannequins or diagrams of the human body
3. Worksheets to record measurements
4. Pencils/pens

Steps:

1. Discussion of Principles

In your groups, brainstorm the principles of body measurement. Ensure the following principles are covered:

- a. Use a snug but not tight tape measure.
- b. Measure on a flat surface.
- c. Maintain consistent posture (e.g., standing straight).
- d. Wear light or fitted clothing during measurement.
- e. Start from fixed reference points (e.g., shoulder, waist).

2. **Body Part Identification**

- a. Use a mannequin, diagram, or volunteer to identify key parts of the body that need to be measured, including:
 - i. Chest/Bust
 - ii. Waist
 - iii. Hip
 - iv. Shoulder width
 - v. Arm length
 - vi. Back length
 - vii. Sleeve length

3. **Practical Measurement Activity**

- a. Measure your partner or mannequin, recording the measurements accurately
- b. What is the importance of teamwork and accuracy?

4. **Application for Bodice and Sleeve Blocks**

- a. Select specific measurements needed for:
 - i. **Bodice block:** Bust, waist, shoulder, back length
 - ii. **Sleeve block:** Arm length, bicep circumference, sleeve length
- b. Record the measurements in a table format.

5. **Reflection and Sharing**

- a. Share your group's experience, challenges, and results.
- b. Discuss how accurate measurements affect the final garment.

DRAFTING BASIC PATTERN BLOCKS FOR BODICE AND SLEEVE

In garment making, there are a number of ways to make patterns which will translate into final garment products. These include making patterns by drafting, draping or flat method. The focus for this unit will be on pattern making through drafting. Other methods of pattern making will be focused as we progress in garment manufacturing processes.

The ability to draw patterns is a fundamental activity in garment design that connects the idea to the final product. It entails making intricate templates that serve as a guide for cutting and assembling cloth into a wearable item. The fit, finish, and general success of the finished garment are directly impacted by the precision and calibre of pattern drafting. In addition to guaranteeing accuracy and consistency, pattern drafting gives designers the freedom to experiment with new ideas and expedite the manufacturing process.

Meaning of Pattern Drafting

Pattern Drafting is the process of making intricate garment patterns or templates. These patterns, which often include all the parts needed to make the garment—such as sleeves, bodices, skirt panels, and collars can be created either manually or digitally.

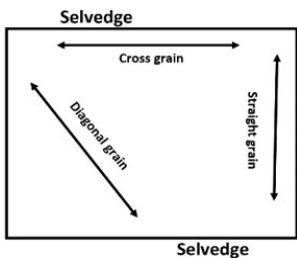
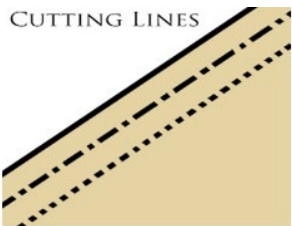
Importance of Pattern Drafting

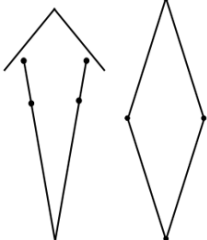
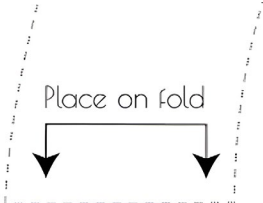
1. **Consistency:** Patterns guarantee uniformity between several outfits in commercial production. Large-scale and high-quality manufacturing depend on the uniform fit and style of every piece made from the same pattern.
2. **Design Flexibility:** Designers can try out various fits, styles, and cuts by using drafting patterns. Designers have the creative flexibility to create new designs by altering pre-existing patterns.
3. **Cost Efficiency:** Accurate designs eliminate fabric waste and the necessity for trial-and-error fittings. Efficient pattern drawing leads to cost savings in fabric and labour.
4. **Precision and Fit:** Pattern drafting ensures that garments fit well and align with the designer's vision. Accurate patterns lead to better fitting garments and reduce the need for extensive alterations.
5. **Speed:** A pattern can be utilised again and again once it is established. This expedites the process of design and production, freeing up designers to concentrate on originality and creativity.
6. **Technical Communication:** Patterns give designers, pattern makers, and manufacturers a common language. They make sure that the design specifications are understood by all parties engaged in the garment production process.
7. **Principles of drafting garment patterns:** Drafting garment patterns involves applying a set of principles to create accurate and functional templates for garment construction. These principles ensure that patterns result in well-fitting,

aesthetically pleasing garments. Here's an overview of the core principles involved in pattern drafting.

8. **Ensure measurement accuracy:** Having precise measurements is essential to designing patterns that fit nicely. They guarantee that the garment won't require a lot of alterations down the road to fit the specified body or dress shape. Measure important body parts such the bust, waist, hips, shoulder width, and inseam precisely. Make sure the individual being measured is standing in a relaxed, natural posture and use a flexible measuring tape.
9. **Understanding Body Shapes:** Distinctive body forms and dimensions necessitate distinct adaptations. Drafting patterns that account for variances in body shape are made easier with an understanding of body kinds. You must acquaint yourself with typical body types and dimensions. Adapt patterns to individual proportions, considering adjustments for ease of wear and stylistic choices.
10. **Comfort Allowance:** The extra room that is added to a pattern to allow for comfort and movement is called ease. A well-fitting and wearable outfit is crucial. Include two different kinds of ease: For mobility and comfort on a daily basis. Both are usually included in every area of clothing. Extra room for aesthetic elements like gathers or pleats is known as design ease.
11. **Allowances for seams:** Extra fabric is added to pattern edges to allow for stitching, which is known as a seam allowance. They guarantee correct fit and assembly. Give all pattern piece edges seam allowances. Typical allowances vary from 1/4 inch (6.5mm) to 5/8 inch (16mm), contingent upon the article of clothing and the stitching methods employed.

Table 3.3.8 Pattern making symbols in pattern drafting

Symbol Name	Image	Purpose
1. Grainlines		Grain lines indicate the direction in which the pattern piece should be placed in relation to the fabric's grain. ensures that the apparel will hang and fit correctly
2. Cutting Line		Cutting lines serves as the fabric's cutting line. Seam allowances are included in the cutting line if they are not shown separately.

3. Notches		Little triangles or diamonds pointing outward from the cutting line are used to align the pattern pieces correctly when sewing.
4. Darts		symbols in the shape of triangles or diamonds that show where the cloth should be stitched to form the garment to fit the wearer's body. Usually, they have a line that extends from the triangle's tip, either straight or curved.
5. Pleats		Symbols that indicate the proper placement for folding and stitching fabric to produce a pleated look. They frequently take the form of lines with numerous arrows or brackets.
6. Button and Buttonhole Marks		The locations of buttons and buttonholes are indicated by squares or circles. These symbols frequently have placement related measurements.
7. Cut or place on Fold		On fold is a remark (often a line with a folded arrow) telling the seam-free cutter to cut the pattern piece as one continuous piece on the fold of the fabric
8. Zip		It is positioned at the edge of a pattern piece—the centre back, side seam, or any other opening in the garment—where the zipper is going to be sewed.
9 Adjustment line		A guide or notation on a pattern piece that shows where modifications can be made to change the garment's fit, size, or shape is known as an adjustment line in clothing patterns.

Women's Basic Bodice Drafting

The shaping for the women's basic bodice block is based on two rectangles which represent half of the back and half of the front. The size of these rectangles or blocks is determined by the bust measurement and the shaping within these blocks by the figure measurements.

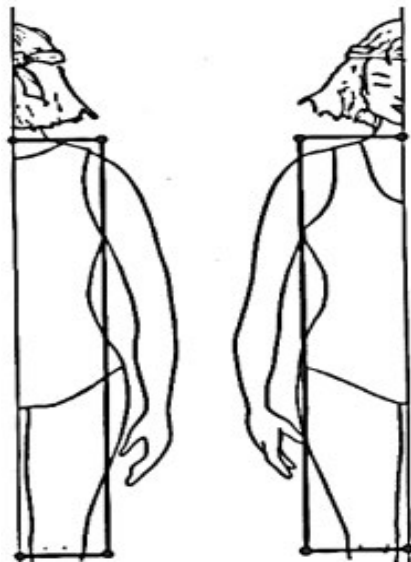


Figure 3.3.1: The body foundation in rectangles

The Body Foundation Pattern Method with the underarm dart drafting processes

Step 1 Rectangular Block

First draw two rectangles to represent half of the back and half of the front, spacing them 15cm/ 6inches. Apart with the back to the left-hand side.

Table 3.3.9

Back Foundation Block	Width = $\frac{1}{4}$ of the bust measurement
	Length = as required
Front Foundation Block	Width = $\frac{1}{4}$ of the bust measurement + 3cm/ 6inches for tolerance over the diaphragm Length = as required

The front pattern is wider than the back pattern for its full length. This places the side seam correctly. If the neck to waist front measurement is longer than the neck to waist back measurement, then the extra is added on to the front block length at the hem.

IMPORTANT – Name both blocks. The side seams face each other at the middle Centre Back to the far left and the Centre Front to the far right.

Step 2 Horizontal Guide – lines

The next step is to rule lines across the block to give for the shaping of the pattern. Some are drawn according to the Guide Chart given and others are taken from the Personal Measurements Chart.

The shoulder guide line, bust guide line and waist line are all measured down from the top of the blocks. Hip and seat lines are measured down from the waist line. Name each line until they are well positioned.

Table 3.3.9

Shoulder Guide-line	Back & Front are the same
Bust Guide-line	
Waistline	Back taken from Measurement Front taken from Measurement
Hip line	Back and Front taken from Measurement
Seat Line	Back and Front taken from Measurement

Step 3

Draft on a large sheet of plain paper. Use metric rulers, a good set square, a 2B pencil and the required measurement needed for the pattern.

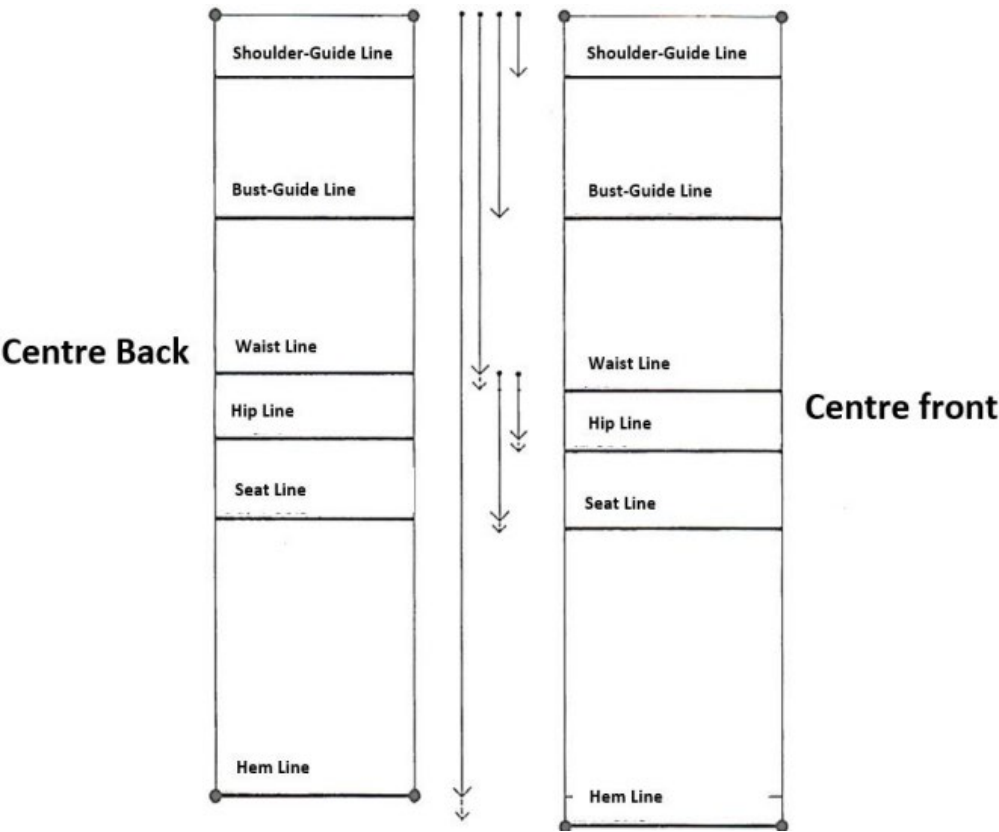


Figure 3.3.2: Body foundation block

Step 4 Vertical Guide- lines

Now rule in the vertical guide- line for the armhole and neck shaping. These lines run from the top of each block at a distance in from the Centre back and Centre front.

Table 3.3.10 Vertical guide lines

Neck Guide- line	Back and Front taken from the Guide Chart. Rule down to just below the Shoulder Guide- line
	Back = $\frac{1}{2}$ back width in from centre back
Armhole Guide- line	Front = $\frac{1}{2}$ chest in from Centre front
	Rule both back and front down to the Bust Guide line

Step 5 Shaping the Bodice

The foundation is ready for shaping.

1. **Back Neck:** Draw a curved line from the top of the neck guide- line to a point 1.5 cm / 5/8 inch, below the top of the block at the Centre back
2. **Front Neck:** Draw a curved line from the top of the neck guide-line to a point 1.5 cm. below the shoulder guide line at the Centre front. As these two curves are to fit around the base of the neck column, shape them accordingly.
3. **Shoulder Lines:** The back and front are ruled from the top of the neck shaping to a point 1.5cm. up from the shoulder guide-lines for average positioning. Make these lines shoulder length.
4. **Armhole:** For back and front, rule the first part of the armhole from the outer point of the shoulder-line to touch the armhole guide-line about half-way down. From there, curve down and around until you reach the bust guide- line on the side seam edge. Keep the curve diagonally out from the corner by approximately 2.5cm on the front armhole and 1.5cm on the back armhole. (Less for very small sizes). The armhole may be reshaped later to curve out any sharp angles.

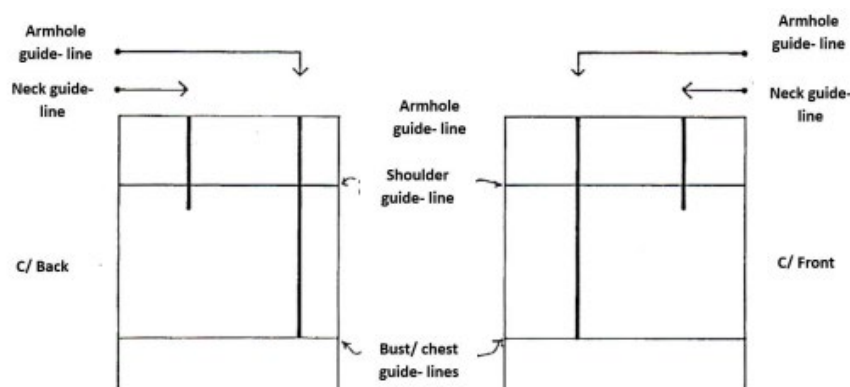


Figure 3.3.3: Shaping the armhole

Step 6 Shaping the Side seams

It will be easy to simply go along the waistlines for $\frac{1}{4}$ of the waist measurement, but as the blocks are of different widths this will make the side seams (which have to be joined together) run at different angles. By this method the sides seams match and the greater overall width of the front pattern is maintained.

1. **Waist shaping Back and Front:** Halve the waist measurement ($M/2$) and subtract the answer from the sum of two block widths. This is for half the figure so divide by two and come in this amount from the side seam at the waist line on both blocks.
2. **Hip and Seat Shaping Back and Front:** Work out these two measurements separately in the same way as for the waist shaping. However, if the $\frac{1}{2}$ hip answer or the $\frac{1}{2}$ seat answer is greater than the sum of the two blocks, the point for shaping will fall outside the blocks; If the answer to your sum is less, the point is inside. If it is the same, you go exactly to the inside lines of the blocks.
3. **Hemline Back and Front:** After joining up all the points on the side as far as the seat, go down to the hem, bringing the line out by a suitable amount. This could be from 3cm. For a short block to 7cm. For a floor length block. These side seams are ruled in the first instance. They will later be softly curved, but only after all shaping for a particular pattern is completed.

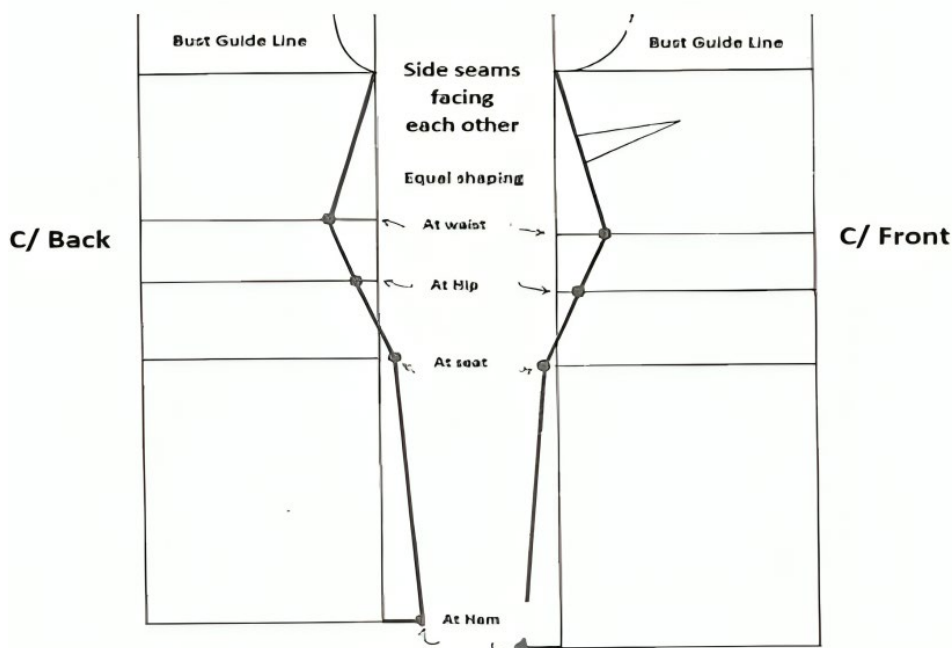


Figure 3.3.4: Shaping the side seams

Step 7 Dart

Darts give shape and form to an otherwise flat pattern. Some darts are essential while others are optional. In a later lesson we will learn how to shift darts to new positions, but for the initial foundation they should be placed as follows:

1. **Front Underarm Dart:** For bust shaping in women's pattern. This is the most important dart in a women's pattern as it gives the shaping for the bust and brings the side seam to the same length.
 - a. First establish the bust point as measured $M/13$ down from the neck / shoulder point and half of measurement $M/14$ in from the centre front.

See Table 3.3.5

- b. Then from the bust guide line. Go down the side seam by approximately 9cm. Rule a line from there to the bust point. This is the centre line of your dart. The width of this dart is the difference between $M/10$ and $M/11$. The dart length should stop several cm short of the bust point. Adjust the side seams to allow for the stitching of the dart. This can be done by folding in.

This dart is not necessary for all figures and designs but can be useful.

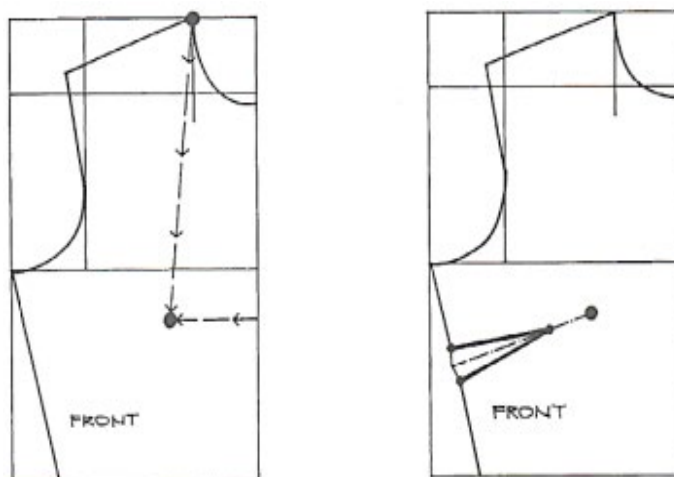
Go down the shoulder-line 6cm and rule to the bust point. This is the centre line of your dart. Rule in the dart 2.5cm. wide and the full length of the centre line. This width (2.5cm) must be added on to the shoulder line, being careful not to drop its end below the established point.

This is used to correct the length of the back shoulder-line and can be placed in the most suitable position for the figure and style involved

Its length should be from 6cm to 8cm. its direction should be towards a point 8cm. in from the centre back on the bust guide line. This will then line up with any vertical darts.

2. **Vertical Waist- Shaping Darts**

These can be placed in the foundation pattern, particularly those running from back waist to the hip/ seat area. As they vary so much from style to style, they are best left to each individual pattern.



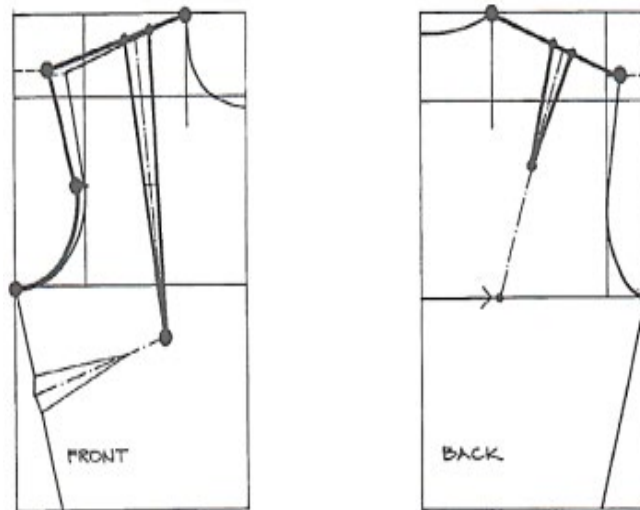


Figure 3.3.5: Connecting and transferring darts

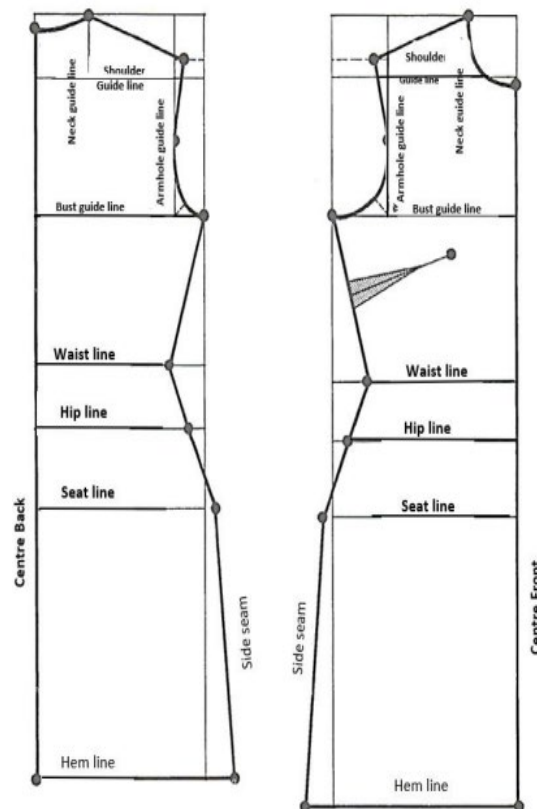


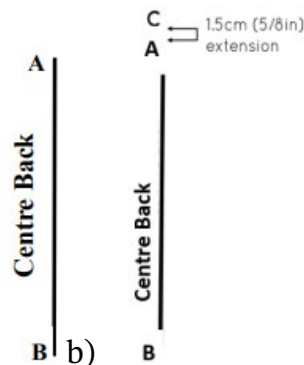
Figure 3.3.6: Completed front and back bodice block

Note: Dart positioned to any referred section of the block depending on the individual style preference and adaptation. Then Pattern marking symbols can now be added.

Body Foundation with Waist dart drafting processes

Step 1: Construct the Centre Back

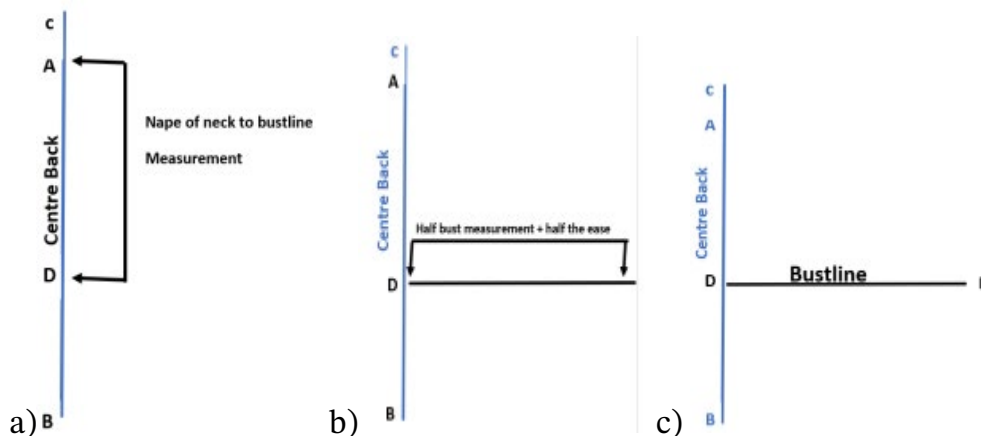
1. With a large piece of pattern paper mark a point **A** close to the top left corner (always leave some space around the starting point when drafting patterns). From this point, draw a vertical line down the left-hand side of the paper that is the length of the nape of neck to waist measurement. Mark the end point as **B**. This line will become the CENTRE BACK of the block and the grainline of the back pattern piece.



2. Extend line **AB** by 1.5cm (1/2") from **A**, and label new endpoint as **C**. This extra 1.5cm (1/2") allows for back neck shaping. Label AB as CENTRE BACK (**CB**).

Step 2: Construct the Bustline

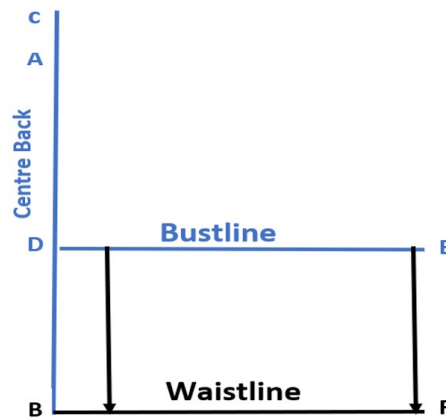
1. Next, indicate BUST LINE (the horizontal line that runs through both the front and back of the pattern at bust level). Take the nape of neck to bustline measurement. Then, measuring from point **A**, mark this length as point **D** online **AB**



2. Square out from point **D** with a line that is half of your bust measurement (only half bust is required as the pattern is on a half – i.e. the front will be cut on the fold, and a pair of the back will be cut) plus ease. For the example if you decide to add 5cm (2") ease to the bust. Remember to halve the amount of ease, before adding it to your half-bust measurement,
3. Label end point of this line as **E**. Mark this line as BUST LINE.

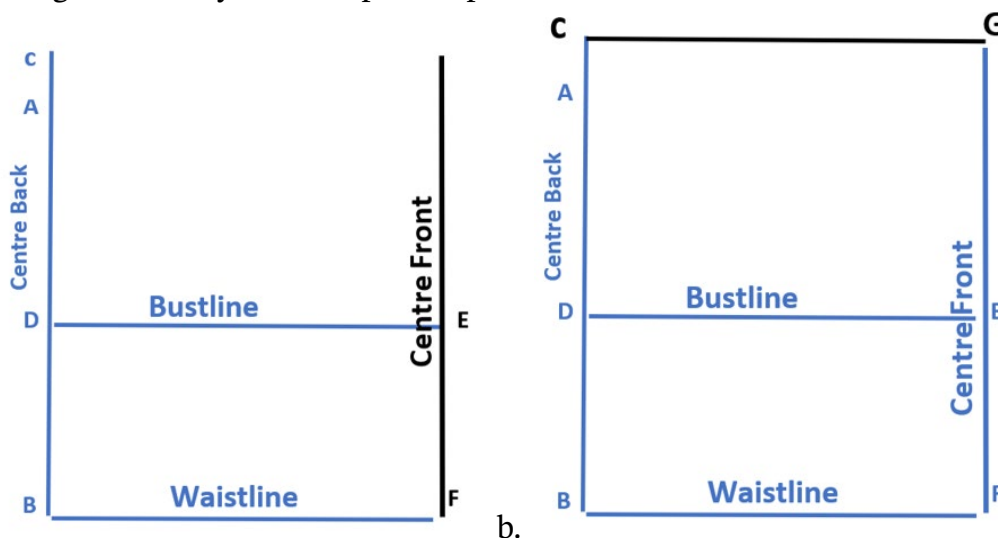
Step 3: Construct the Waistline

Square out from point **B**, drawing a line the same length as your bust line. Mark endpoint as **F**. Label this line **WAIST LINE**.



Step 4: Construct the Centrefront

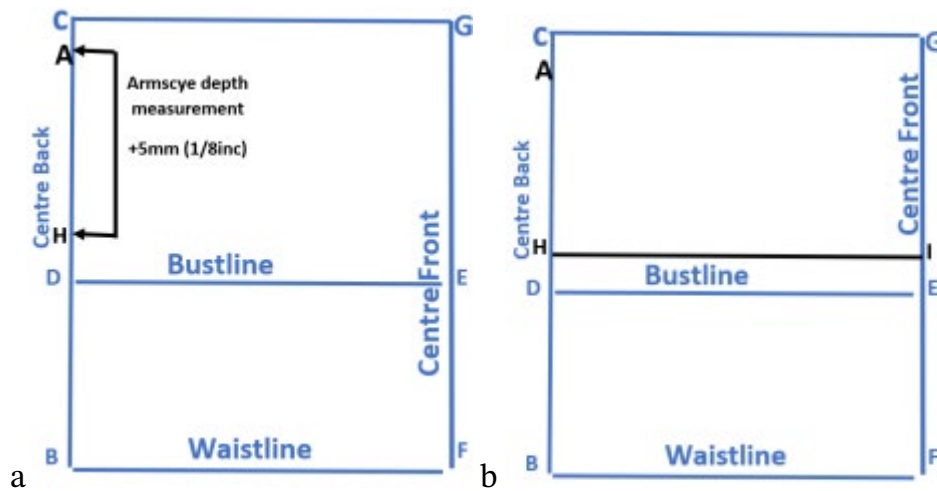
Square up from **F** (passing through **E**), the length of the **CENTRE BACK** (including the extension), and mark the end point as **G**. Label **FG** as the **CENTRE FRONT (CF)**. This will also be the grainline of your front pattern piece.



Join **G** to **C** with a straight line.

Step 5: Mark the Armscye

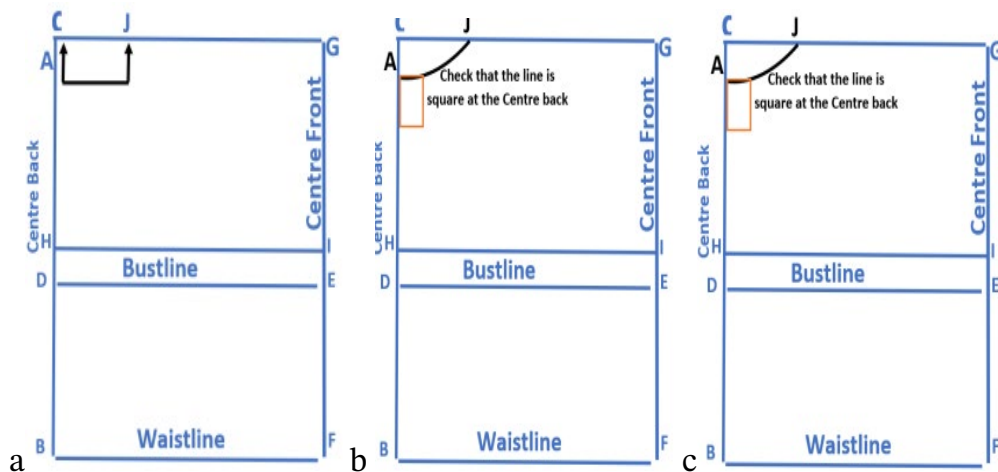
1. Take the armscye depth measurement and add 0.5cm (1/4"). Measuring from point **A** down towards point **B**, mark this distance on **CENTRE BACK**. Label this point as **H**.



2. Square out from **H** and extend the line until it intersects the CENTRE FRONT line. Mark the intersection points as **I**.

Step 6: Construct the Back Neckline

1. Take your neck measurement and divide it by 5. Measuring from point **C**, mark this measurement on line **CJ**. Label this point as point **J**.

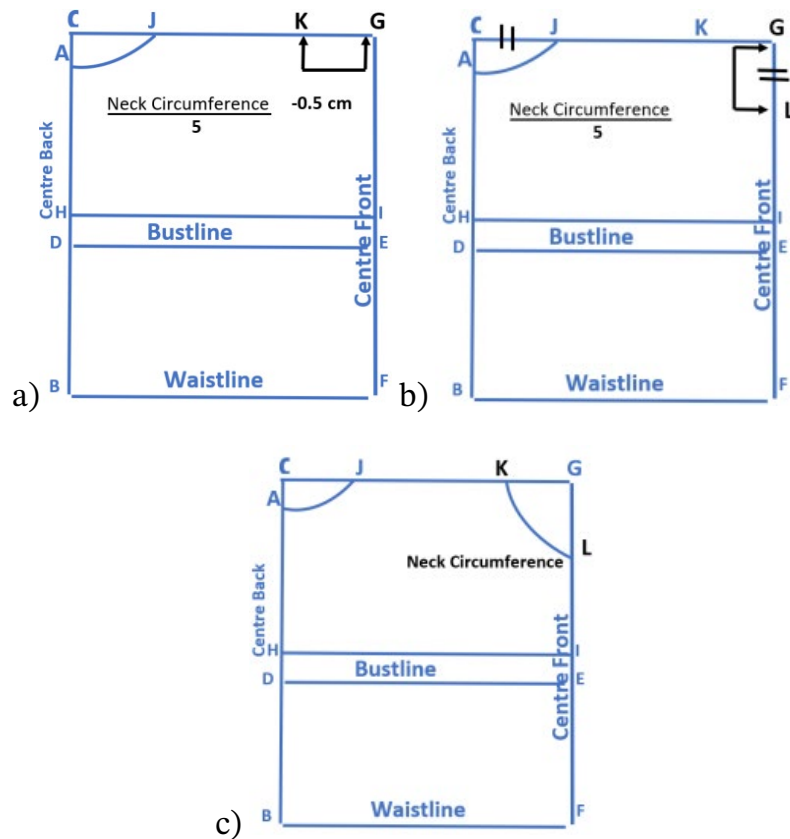


Join points **A** and **J** with a shallow curve – this curve is the back neckline.

2. When working with curved lines, always check that they come to a right angle when they meet a straight seam (for example, the centre front, centre back or side seam). By doing this, you ensure that you will get a nice smooth curve when you cut a pair of a particular piece or cut it on the fold.

Step 7: Construct the Front Neckline

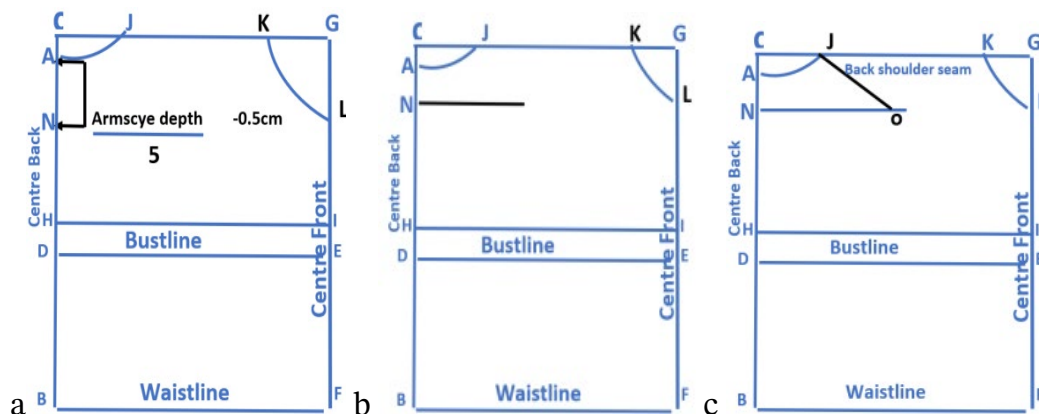
1. Take the neck measurement, divide it by 5 and then subtract 0.5cm (1/4"). Mark this measurement on line **GC** (measuring from point **G**) as point **K**.



2. On the CENTRE FRONT (GF) mark a point the same length as CJ down from point G (neck circumference divided by 5). Mark the point as L.
3. Join K to L with a deep curve – this is the front neckline. As we did with the back neckline, check that the curve of the neckline meets the centre front at a right angle (so that you will get a nice smooth neckline when you cut the piece on the fold).

Step 8: Drafting the Back Shoulder Seam

1. Take the armscye depth measurement and divide it by 5 and then subtract 0.5cm (1/4"). Mark this distance, measuring down from A on the CENTRE BACK as point N.

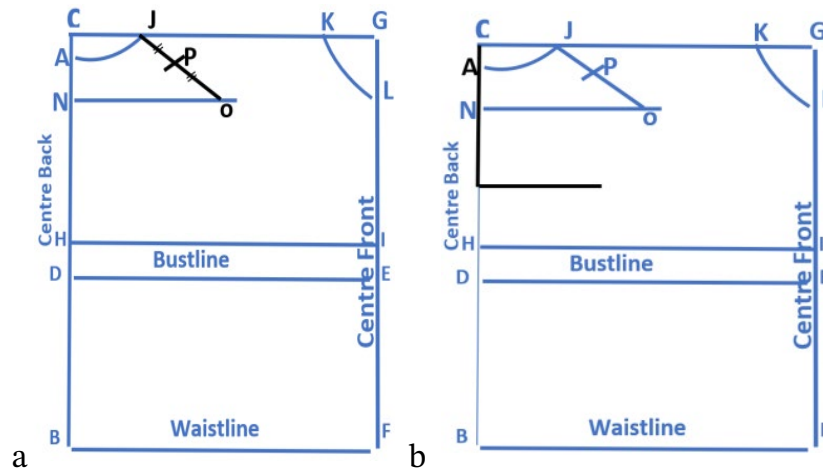


2. Square out from point N. This is just a guideline, so does not have to be a specific length.

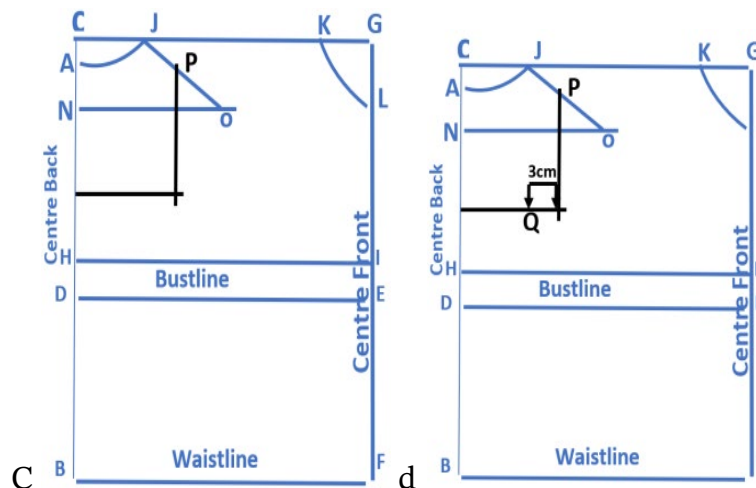
- Take the shoulder length measurement and add 1.5cm (1/2") (this is the allowance for the shoulder dart). With this length in mind (or written down if you have a bad memory like me), use a ruler to pivot from point **J** until your measurement passes through the perpendicular line drawn from **N**. Draw a straight line to create your shoulder line. Label the endpoint as **O**.

Step 9: Drafting the Back Shoulder Dart

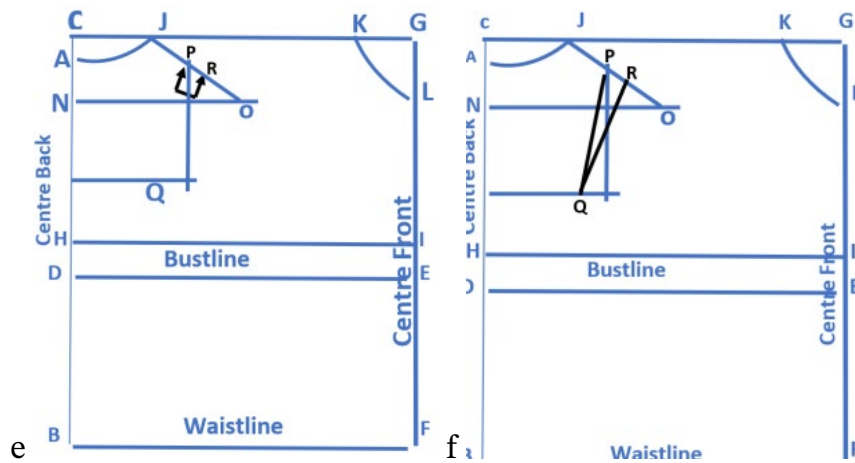
- Mark the midpoint of the back shoulder seam (line **JO**) (i.e. the distance halfway between **J** and **O**) as point **P**.



- Mark a point 15cm (6") down from point **A**, on the CENTRE BACK line, and square out from this point. Once again, this is only a guideline, so does not need to be a specific length.



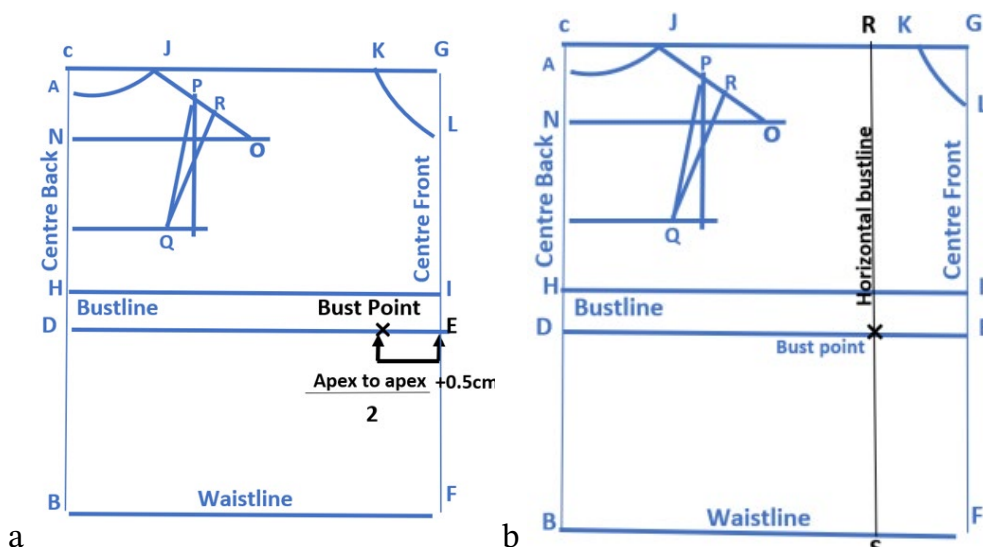
- From point **P**, draw a guideline parallel to CENTRE BACK, extending down until it passes through the perpendicular line that you marked in the previous step.
- From where these lines intersect, mark a point 3cm (1 1/4") towards the CENTRE BACK and label as point **Q**. **Q** will become the point of the back shoulder dart.



5. Mark a point 1.5cm (1/2") from **P** on the back shoulder seam (line **JO**), towards **O**. Label this point as point **R**
6. Join **P** to **Q** to create the first dart arm and point **R** to **Q** to create the second dart arm.

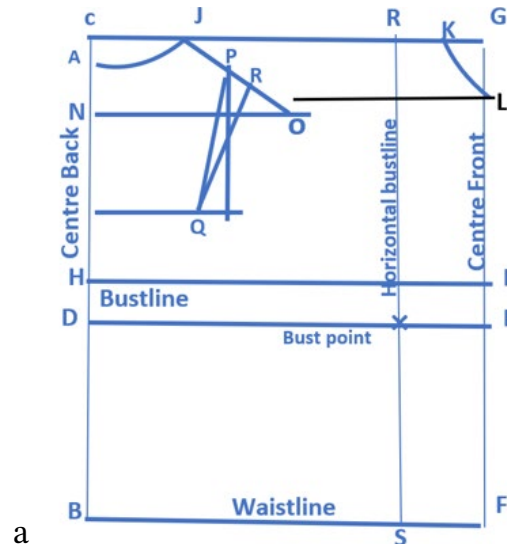
Step 10: Mark the Bust Point

1. Move your attention to you **BUSTLINE** (line **ED**). Take the bust point to point measurement and divide it by 2 (as we are working on the half) and add 0.5cm (1/4") (allocated ease). Take note of this measurement. From point **E**, on the bustline, mark a point, the distance you just found from point **E**. Mark this point as your **BUST POINT**.
2. Draw a vertical line, parallel to the centre front and centre back, passing through the bust point, intersecting all your horizontal guidelines. This line is the **VERTICAL BUST LINE**. Where it intersects **CG** label as point **R** and point **S** where it intersects the **WAISTLINE** (**BF**)

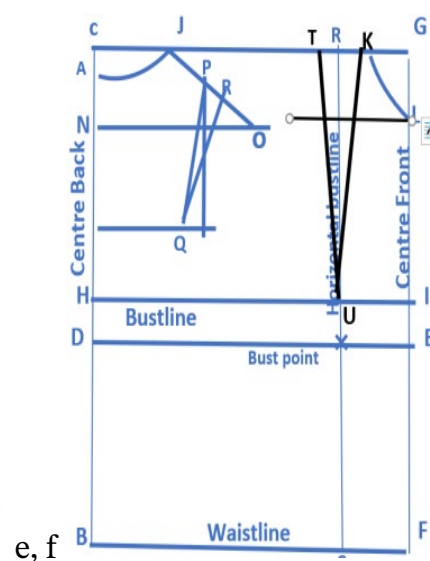
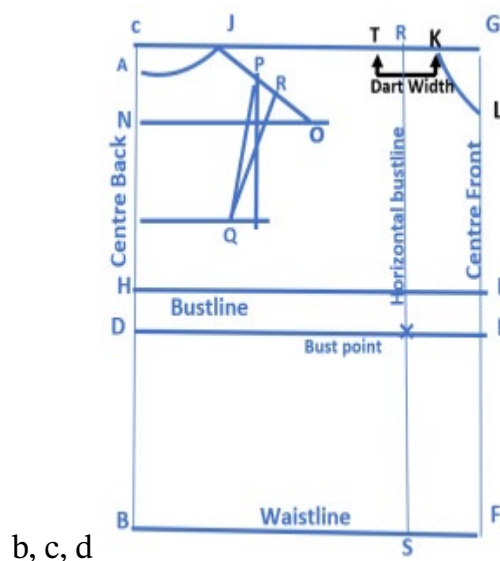


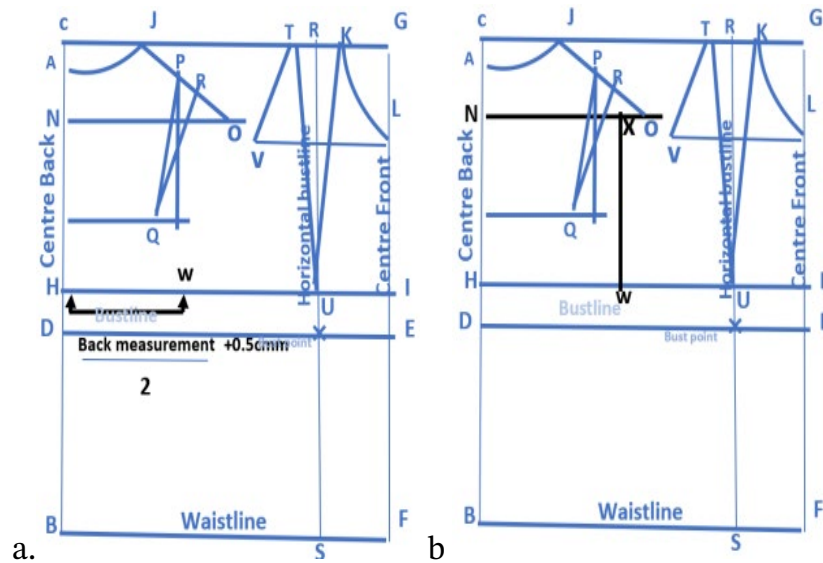
Step 11: Draft the Front Shoulder Dart

1. Mark a point 0.5cm (1/4") up from **L** on the CENTRE FRONT (line **GF**) and square out from this point. Again, this is just a guideline, so it doesn't have to be a specific length.

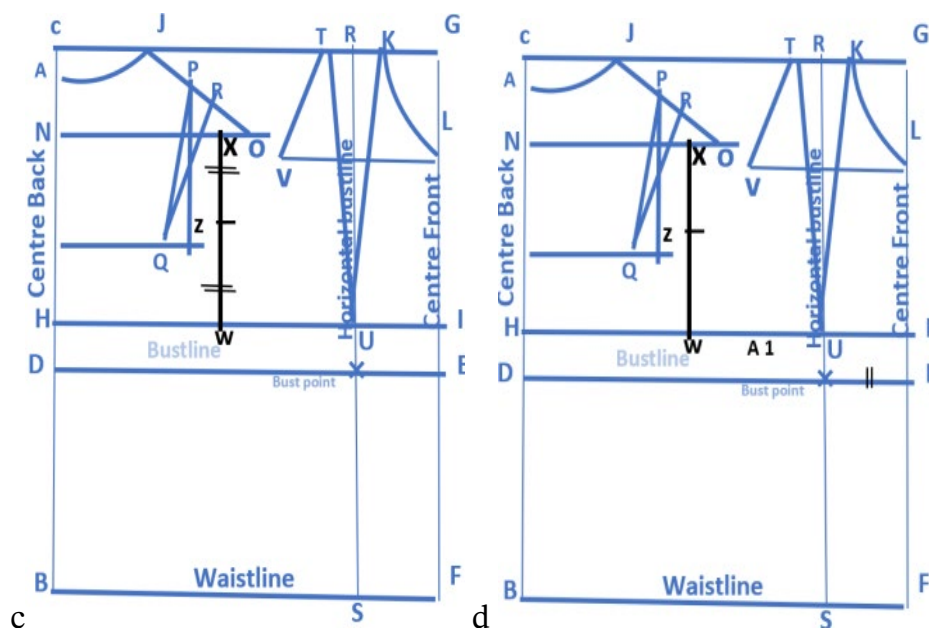


2. Add or subtract 0.6 cm (1/4") to 7cm (2 3/4") for each 4cm (1 1/2") bust increment above or below 88cm (34 1/2"). For bigger busts you will need a larger dart (add to 7cm), and for a smaller bust you will need a small dart (therefore subtract from 7cm).
3. For example, a bust measurement of 84cm (33"), which is 4cm (1 1/2") below 88cm (34 1/2"), therefore I need to subtract 0.6cm (1/4") from 7cm (2 3/4"), leaving a dart width of 6.4cm (2 1/2").
4. Take dart width measurement and mark this distance from **K** as point **T**.

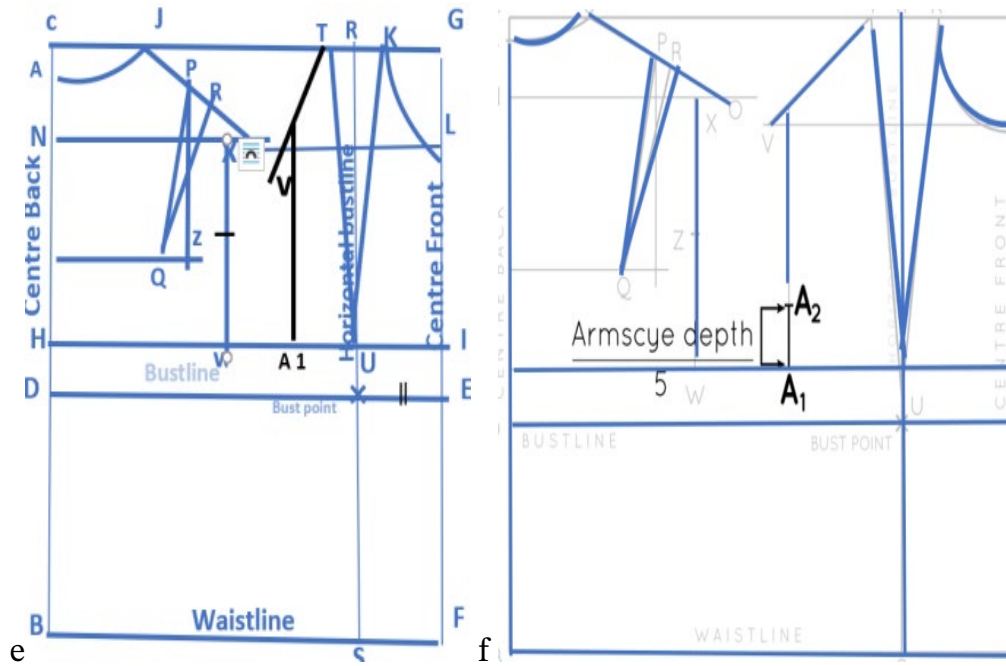




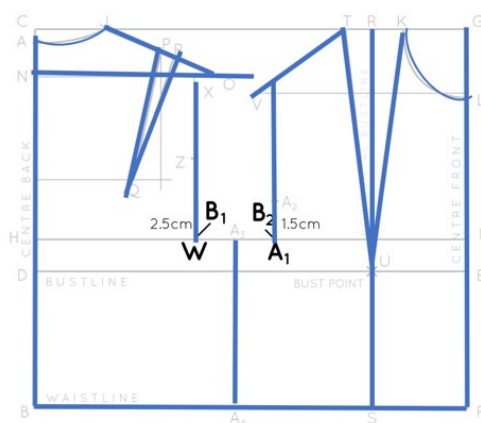
3. Find the midpoint of line XW. Mark as point **Z**.
4. Take the distance from the CENTRE FRONT to BUST POINT (i.e length from **E** to **BP** or half bust apex to apex measurement plus 0.5cm) and mark this distance on line **HI**, measuring from the dart arm closest to CENTRE back. Mark point as **A1**.



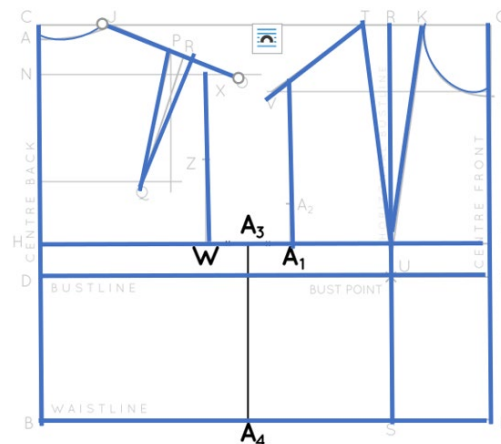
5. Square up from point **A1** so that the line intersects the front shoulder seam (line **VT**).
6. Take the armscye depth measurement and divide it by five. Mark this length on the line just drawn from **A1**, as point **A2**.



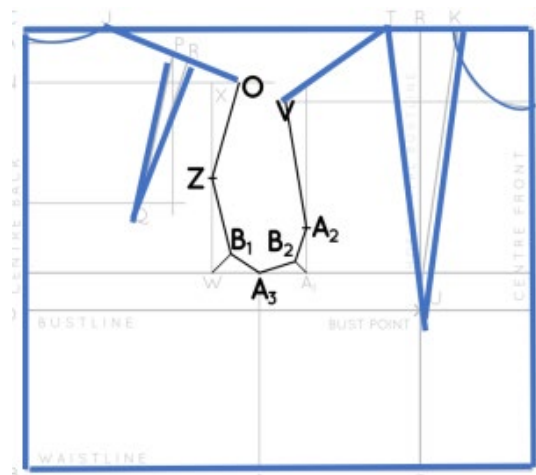
7. Find the midpoint of the line between **W** and **A1** and mark as **A3**. Square down from this point so that the line intersects waistline (line **BF**). Mark intersection point as **A4**.
8. Draw diagonal lines (lines drawn at a 45-degree angle) inwards from points **W** and **A1**. From **W** the line needs to be 2.5cm long (1") (mark endpoint as **B1**), and from **A1** 1.5cm long (1/2") (mark endpoint as **B2**). These diagonal lines will help in the next step, when we are at the stage of drawing in the curve of the armhole.
9. Join **O** to **Z** to **B1** to **A3** to **B2** to **A2** to **T** with straight lines.



g)



h)

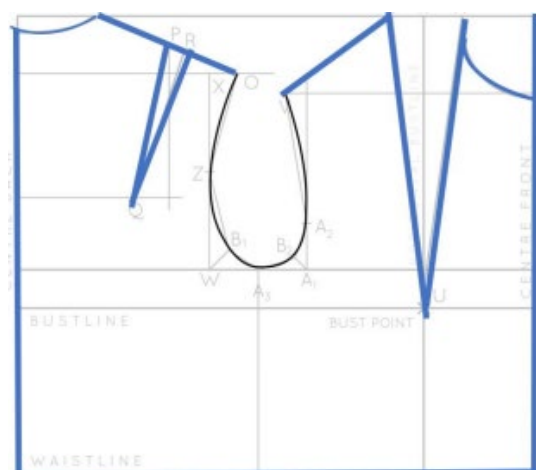


Step 14: Creating Darts

At this point, the waist measurement is the same as the bust measurement. For a lot of us, our bust measurement is larger than our waist measurement. To remove this excess width from the waist and to create a well-fitting block you will add waist darts (one in the back waist and one in the front waist – remember this is on the half so when you make your block there will be two in the back, and two in the front. We will also slightly taper the side seam, which we will also treat as a dart at this stage).

To work out how much width you will need to remove with your darts, take your waist measurement and add 2cm (7/8”) ease. Subtract this measurement from your bust measurement and divide your answer by 2.

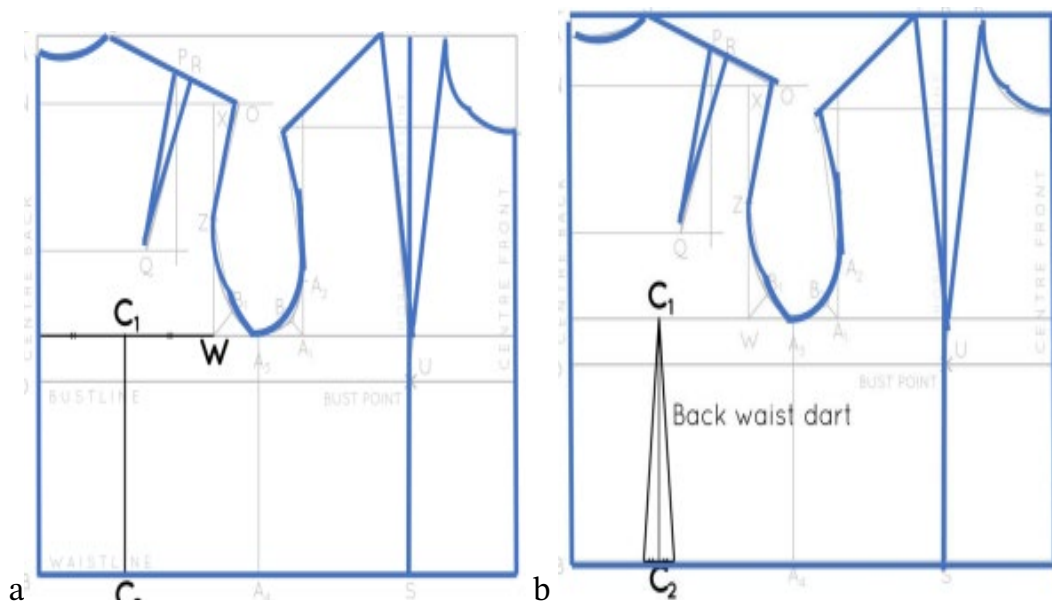
Divide this number by three, so that it can be distributed evenly throughout back dart, front dart and side seam.



Step 15: Draft the Back Waist Dart

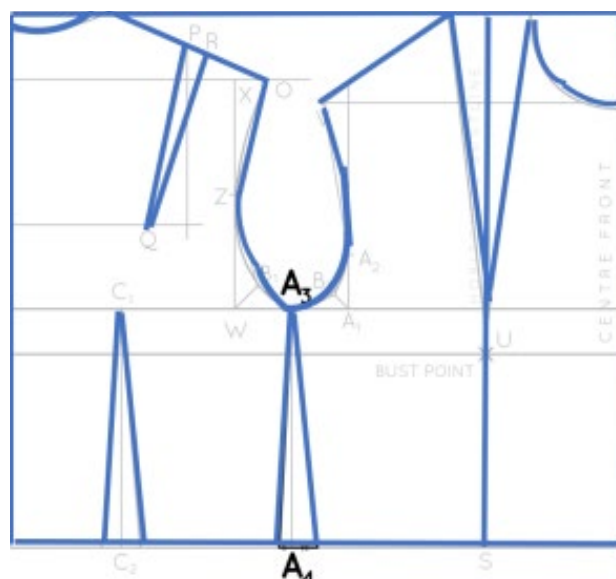
To mark the placement of the back waist dart, find the midpoint of line **HV** and label as **C1**. Square down from this point so that line intersects the **WAIST LINE (BF)**. Mark the point of intersection as point **C2**. This will become the centre of your back dart.

Distribute the dart width evenly either side of **C2** and join endpoints to **C1** to create dart arms.



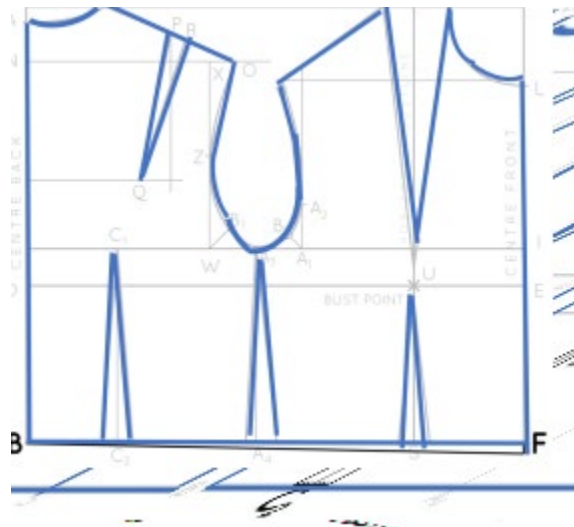
Step 16: Draft the Side Seam

For simplicity, at this stage, treat the side seam (line **A3-A4**) as a dart at this point. Distribute one third of the dart width to the back of the bodice and two-thirds to front of the bodice, either side of **A2**. Join the endpoints to **A3** to create the front and back side seams.



Step 17: Draft the Front Waist Dart

Distribute dart width evenly either side of **S** and join the endpoints to a point 1cm (3/8") down from **BP** to create dart arms.

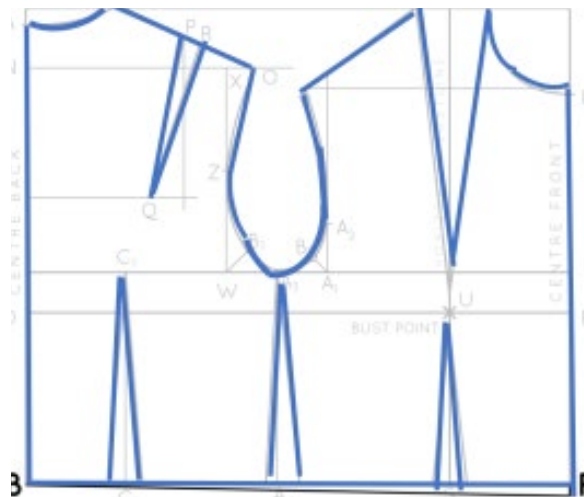


Step 18: Balance the Waistline

At this point the waistline of the pattern is straight. But as the front of our bodice must pass over the fullest part of our chest (our bust), we need to add a little extra length to our CENTRE FRONT, to prevent this part of the waistline from riding up when the bodice is made.

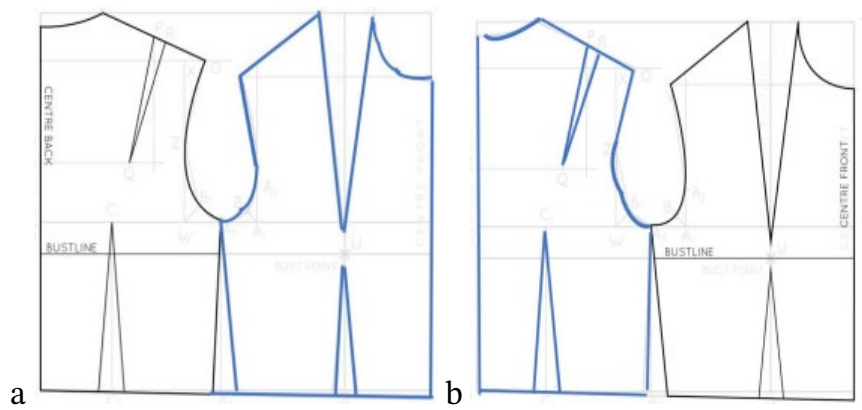
Mark a point 0.5cm (1/4") to 1.5cm (1/2") down from point **F** as point **C1**. (0.5cm (1/4") for small bust / 1cm (3/8") for medium bust / 1.5cm (1/2") for large bust)

Join point **B** to point **C1**.



Step 19: Trace the Pattern

1. With a second piece of pattern paper, trace off the back pattern piece – being sure to include all important details (i.e., bust line and darts).
2. Leaving a space between the pieces, trace the front pattern piece.



To finish, add shaping to the darts and then add seam allowance to the pattern. As it is a bodice block, it is handy to have it available without seam allowance (as when you are making alterations or adjusting a pattern it is far easier to do so without seam allowance), but as you will need to make a toile to see how it fits, add seam allowance to the seams that will be sewn - the side seams, centre back and shoulder seams. The other seams - the neckline, armholes and waistline - can be left without seam allowance so that you can get a true indication of what it will look like without having to finish these seams or add a facing etc.

ADD PATTERN MARKINGS AND CUTTING INSTRUCTIONS

Drafting of Sleeve Block

Table 3.3.11 Arm Measurements for Sleeve Patterns

15. Front length	With the arm straight, take on the inside from armhole to wrist	
16. Outside Length	With the arm bent, from shoulder, over elbow to the wrist bone	

17. Elbow to wrist	Length taken on the inside of the arm	
18. Thickest part of the arm	With the arm bent measure around the muscle	
19. Forearm	Around the arm at the thickest part below elbow	
20. Wrist	Around the wrist over the wrist bone	
D. Sleeve head depth	Tie a piece of string around the arm as high up as possible. Measure from the shoulder point to the string	
E. Hand	Around the hand and over the knuckles with thumb in palm	

The Sleeve Foundation Pattern

One Piece, Set- in Sleeve Foundation

Rule up a rectangle on a plain sheet of paper. This will be known as the Sleeve Block. The back is to be on the left-hand side.

Sleeve Block Size	Width = Thickest part of arm (M/ 18) + 5cm
	Length = Outside arm length (M/ 16)

Divide this block in half-length ways

Now rule two guidelines across the block to help shape the sleeve head

Line AB is one third of the block width down from the top. Around this up to the nearest centimetre. Line “CD” is half the depth of “AB” plus 1cm. down from the top. This makes the top section 2cm. deeper than the second section.

Divide the two top sections into four equal parts length ways, making eight top sections in all.

The elbow line is ruled across at measurement M/17, up from the base or wrist, “EF”

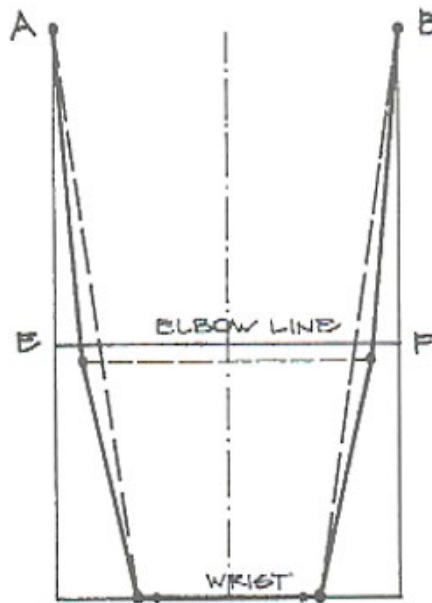


Figure 3.3.8: Adjustment for wide forearm

Activity 3.3.3 Drafting Basic Blocks

1. In groups of no more than 5 pick one type of block each (bodice, skirt, sleeve, pants).
2. Use pre-measured body data (for women, men, or children) to draft your block. You can also use your own body measurements as well as those provided as these will be individual to you.
3. Use the following materials for your work: Graph paper, pencils, rulers, French curves, erasers, measuring tapes.
4. Make a neat sketch to show a chart of common pattern symbols (e.g., grainline, notches, darts, cutting line, stitching line).
5. Ensure proper proportions based on measurements and necessary pattern symbols like notches, darts, and grainlines.
6. Each group should present their blocks and explain their process.
7. All groups should come together and combine your blocks to create a complete pattern for a simple garment.
8. Ensure accuracy in aligning different blocks.

Activity 3.3.4 Garment Construction Workshop

In groups of no more than five, assume the following scenario and answer the following questions.

You are a pattern designer tasked with creating a workshop for aspiring fashion designers. The workshop aims to teach students about the various tools used in garment design and pattern making, and how they are applied in garment construction.

Task: Create a manual or digital chart that illustrates the following:

1. The meaning of pattern drafting and how it applies to garment design,
2. The different types of garment design and pattern making tools (e.g., rulers, curves, scissors, etc.)
3. The specific uses or applications of each tool in garment construction (e.g., cutting, drafting, etc.)
4. The step-by-step process of how each tool is used in garment construction.

NB: Use manila card of large piece of paper for the manual chart or create a digital chart using presentation software (e.g., PowerPoint or any other software).

Activity 3.3.5 Designing for the Community Festival

The local community is organising a cultural festival, and they need a traditional garment designed for the occasion. As a garment designer, you have been tasked with designing a garment that represents the community's cultural heritage. You need also to give an address on the occasion concerning the impact of garments on community identity and culture by identifying four key roles they play. Support your analysis with specific examples from four different communities, discussing how these roles contribute to social, economic, and environmental aspects. In your groups:

1. Explain how you will get information on your garment design task.
2. Write the address for the occasion. [NB: Share the areas among your group members to research into and bring their findings for collation and presentation).

EXTENDED READING

- Arnold, R., *Fashion: A Very Short Introduction*, (Oxford University Press, 2017)
- <https://www.universityoffashion.com/tools/>
- *The Fashion Book*, by Phaidon editors, (Phaidon Press, 2014)

ADDITIONAL READING MATERIALS

1. **Magazines:** Vogue Business Fashionist
2. **Online Resources**
 - a. Fashion Design Online Courses – Skillshare, Coursera, and Udemy
 - b. Pattern Making Tutorials _ YouTube, Craftsyt, and Creativebug

REVIEW QUESTIONS 3.1

Figure 3.1.15 is a sketch of a two-bedroom residence. Study the features and answer these questions.

1. Draw the following:
 - a. Front elevation
 - b. Rear elevation
 - c. Right side elevation and
 - d. Left side elevation

Ensure precision, accuracy and neatness.

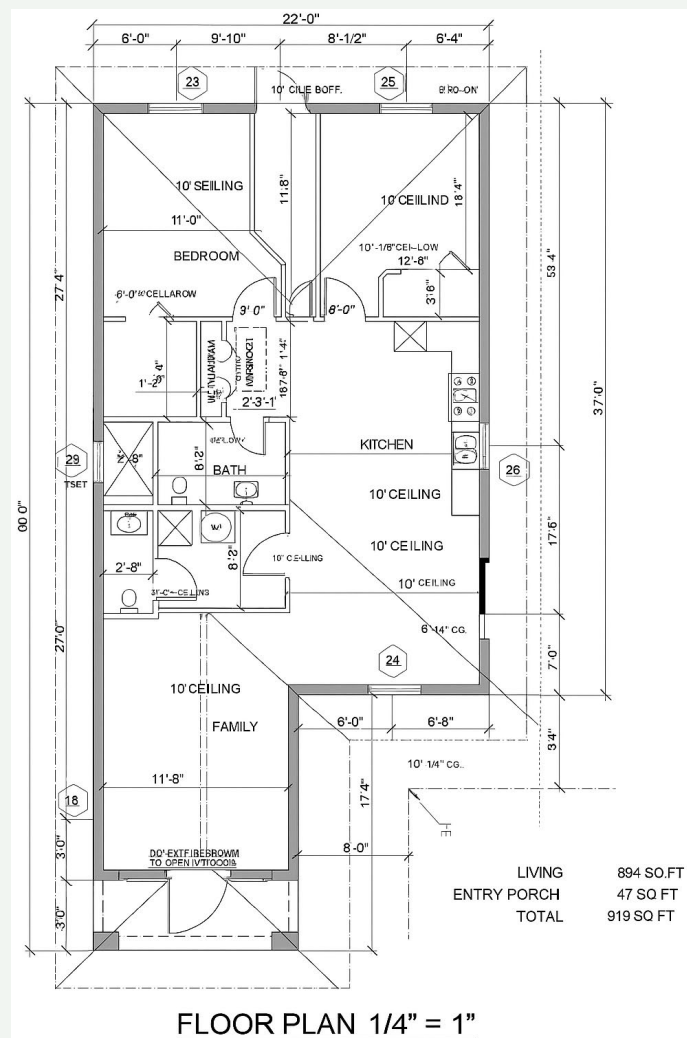


Figure 3.1.15

- 2.** Your SRC “2001 Year Group” is embarking upon a project of putting up a visitor’s bungalow for the school. As a student designer, interpret the floor plan below and draw accurate views to show the south, north, east, and west elevations.



Use the scale of 1:10

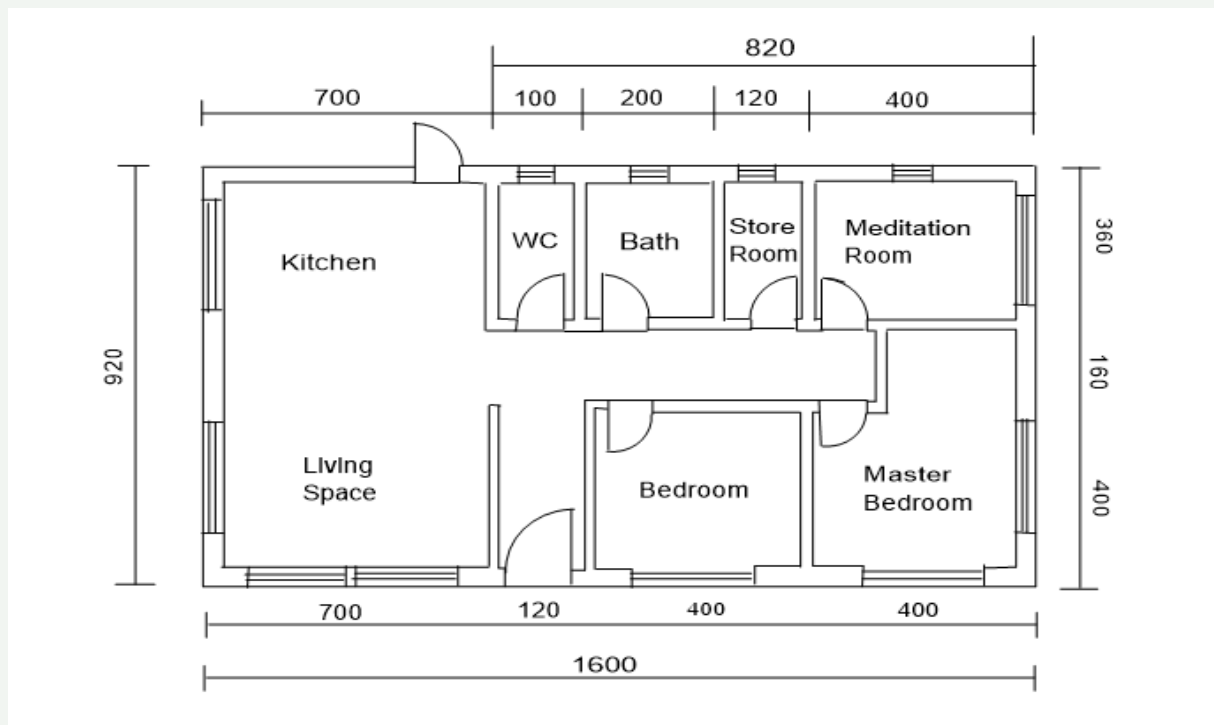


Figure 3.1.16: A Floor Plan

Section A

Choose the correct answer for the following questions.

1. Which of the following is a characteristic of an electrical circuit?
 - A. Uses transistors and diodes
 - B. Processes signals and data
 - C. Operates primarily with low power
 - D. Focuses on power transmission and distribution
2. What do electronic circuits primarily do?
 - A. Generate mechanical motion
 - B. Operate with analogue and digital signals
 - C. Transmit high-voltage electricity
 - D. None of the above
3. Which of the following is an example of a simple electrical circuit?
 - A. A light switch controlling a bulb
 - B. A television
 - C. A computer motherboard

- D. A smartphone processor
4. Which of these components is commonly found in electronic circuits but not in basic electrical circuits?
- A. Resistor
- B. Switch
- C. Microcontroller
- D. Light bulb
5. What do electrical circuits generally use?
- A. Alternating current (AC) or direct current (DC) for high-power devices
- B. Low-voltage signals for data processing
- C. Microchips to process information
- D. None of the above

Section B

1. Define an electrical circuit and provide two examples of its applications.
2. Define an electronic circuit and provide two examples of its applications.
3. List two key differences between electrical and electronic circuits in terms of components and functionality.
4. Why are semiconductors important in electronic circuits?

Section C

1. Copy the table and compare electrical circuits and electronic circuits under the following headings:

Feature	Electrical Circuit	Electronic Circuit
1. Definition		
2. Primary purpose		
3. Typical components		
4. Power level used		
5. Examples		

2. Discuss how advances in electronic circuit design have impacted modern technology. Include examples such as smartphones, medical devices, or renewable energy systems.
3. Explain the differences between electrical and electronic circuits with examples and discuss how these differences impact their use in real life.

REVIEW QUESTIONS 3.2

1. Sketch the following machine parts in free hand sketches
 - a. Bolt
 - b. Nut
2. Compare and contrast the design features and functional roles of a bolt and a nut by creating detailed freehand sketches. Include annotations to explain how each part contributes to their overall functionality in a mechanical assembly

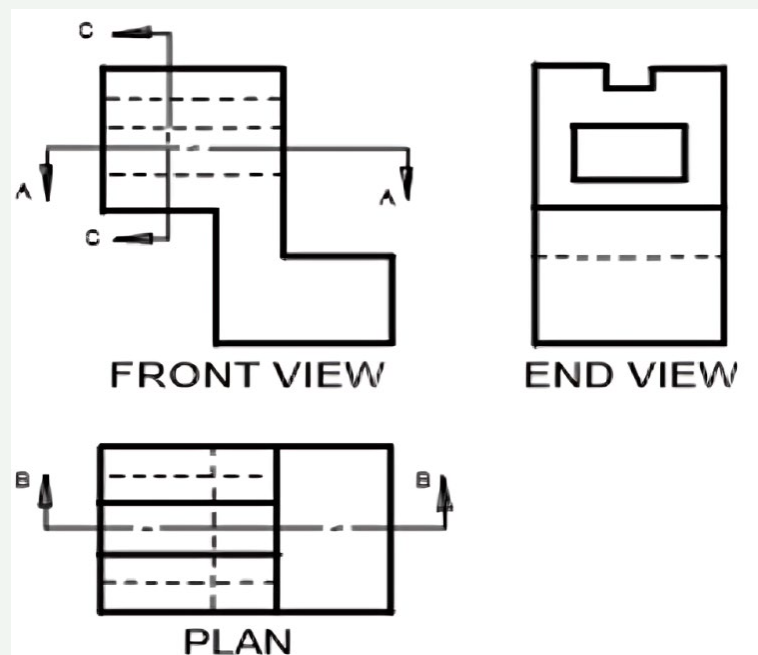


Figure 3.2.30: Sections view

3. Figure 3.2.31 is an engine component. Draw in first angle projection the following views:
 - a. Sectional front view MM
 - b. Sectional side view RR
 - c. Sectional Plan HH

All dimensions are in millimetres.

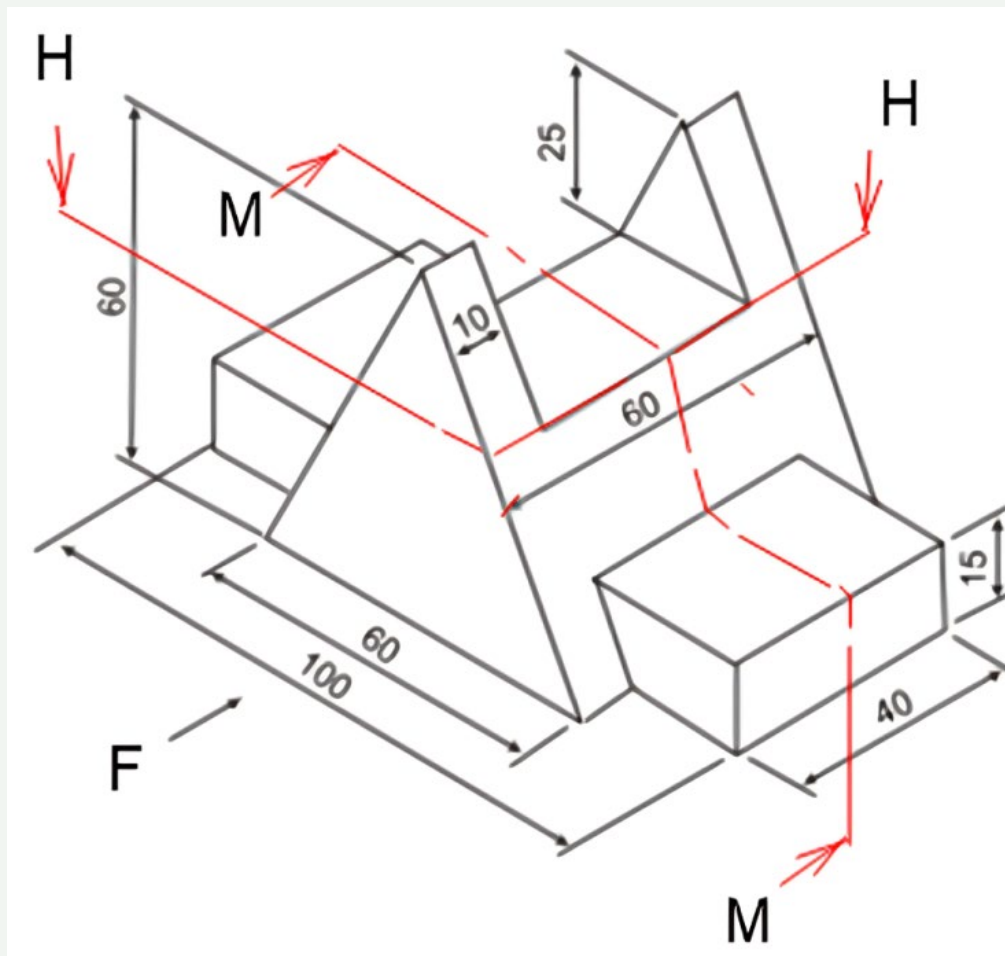


Figure 3.2.31: An engine component

4. Examine the figure below and construct a detailed sectional view using the third-angle projection method. In your drawing, describe the importance of this projection technique and discuss how it affects the understanding of the object's dimensions and features.

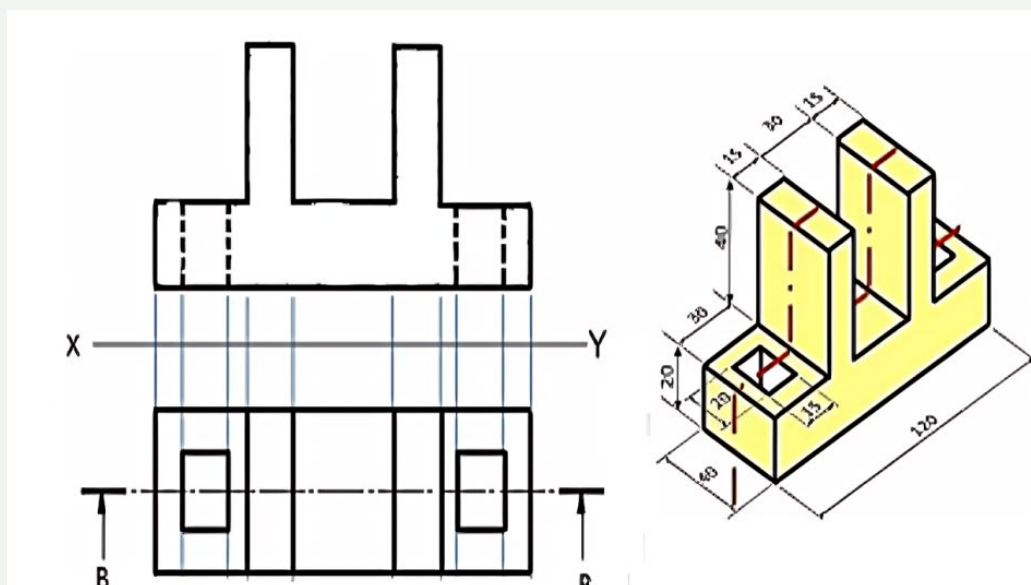


Figure 3.2.32: Sectional view of a block

REVIEW QUESTIONS 3.3

1. With reference to the extension activity above, answer the following questions:
 - a. As you start planning to create the pattern for the garment, you remembered that you need to use the definition of a garment to help you with your design. Explain what a garment is, highlighting on its characteristics, and give some examples.
 - b. To cut the fabric accurately and efficiently, which tool would you use? Name and describe the use of at least 4 more tools used in garment making.
 - c. You need to create a prototype of the garment, and you require two types of papers for the process. What are these papers, and what are their uses?
2. Define body measurement in the context of garment design.
3. Describe three key principles of body measurement in garment design.
4. Create manual or digital pictorial charts showing:
 - a. Different body measurements taken for various individuals.
 - b. Highlight specific measurements needed for bodice and sleeve blocks.
 - c. Label and organise the charts clearly.
5.
 - a. Identify four critical principles for taking body measurements.
 - b. Analyse the significance of body measurement in garment design by:
 - i. Providing real-world examples (e.g., tailoring for athletes,)
 - ii. Discussing how accurate measurements contribute to the success of garments in terms of fit, functionality, and aesthetics.
6. Write a short essay (150–200 words) discussing the impact of pattern marking symbols on the effectiveness of pattern drafting in the fashion industry. Focus on how these symbols improve accuracy and efficiency during garment production.
7. Provide a list of five key pattern marking symbols. For each symbol, explain its purpose and importance for designers and manufacturers.

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GLOSSARY

2-D	Two-dimensional, referring to a design that exists only in two dimensions (length and width).
A circuit	shows the electrical pathways and connections in a building, illustrating how electrical components are linked and how electricity flows through the system.
A concept	is an idea or understanding of something. It is the main thought behind a project or plan and helps guide its development.
A projection	is an image, or a drawing of an object made on a plane.
A transformer	is represented by a specific symbol or diagram that illustrates its function and connections within an electrical system.
Assemble	is about the process of putting together individual components or parts to form a complete product or system. This process is essential for creating functional and cohesive designs.
Base Circle	The circular reference surface from which a helix or involute curve originates.
CAD	Computer-aided design, a technology used for designing and pattern making.
Circuit Breaker	Protects the circuit from damage due to overload or short circuit.
Circumscribe	To draw a shape around another shape, so that the second shape is completely enclosed by the first shape.
Conductors	are wires typically, copper or aluminium, these provide a path for current to flow between components.

Congruent	Refers to two or more shapes that have the same size and shape.
Contrast	means the difference between two or more elements in a design or image, like colour, shape, size, or texture that makes them stand out from each other. High contrast can draw attention to specific parts of a design, while low contrast can make elements blend together. Using contrast helps create focus, balance, and visual interest.
Cutting Plane	An imaginary flat surface used to "cut" through an object to reveal its internal features, shown as a thick dashed line with arrows.
Dart:	A fold or tuck in fabric used to shape a garment.
Designs	refer to plans or drawings that show how something should look or work. They help create things like objects, buildings, and artwork.
Digital	The screen area in CAD software where you draw and design, with tools and menus.
Diode	allows current to flow in one direction while blocking it in the opposite direction.
Disassemble	refers to the process of taking apart a product or system into its individual components or parts.
Distortion	refers to altering proportions to create unique perspectives.
Electrical Circuits	Use basic components like resistors, switches, and power sources. <i>Example:</i> connect switches to light bulbs.
Electronic Circuits	Incorporate advanced components such as transistors, microcontrollers, and integrated circuits. <i>Example:</i> data processing and signal handling.
Elevations	are side views of a building or structure. They display the height, size, and outside look of the building, including details like windows, doors, and materials.
Fabric	A material made from fibres, yarns, or threads.
Fabrication	refers to the process of manufacturing components and structures from raw materials through various methods such as cutting, forming, joining and finishing. It involves several key stages and techniques.
Foreshortening	shortening lines or shapes to show depth and create a sense of 3D.
Freehand	Drawn or created without the use of digital tools or software.

Front View (F.V. or Elevation)	The view of an object as seen from the front and drawn on the V.P.
Full Section	A view showing all internal features of an object when it is fully cut into two equal parts.
Fuse	Provides overcurrent protection.
Garment	a piece of clothing, such as a dress, shirt, or pants.
Geometric	Relating to shapes and forms based on mathematical principles.
Half Section	A view showing one-half of an object's interior while the other half remains as an external view, often used for symmetrical objects.
Harmonise	means to arrange elements like colours, shapes, and textures so they work well together in a balanced, pleasing way.
Hatching	Thin, evenly spaced lines on cut surfaces to indicate the material that was cut.
Helix Angle	The angle between the helix axis and the tangent line to the base circle.
Integrate	emphasises the relationship between individual components and the final design outcome, ensuring they work together effectively.
Interconnection	shows how different parts are linked or joined together in a design. It helps illustrate how the parts fit or work together
Interplay	refers to how different elements work together and affect each other. It is about the interaction between things, like colours, shapes, or textures, and how they combine to create interesting effects or balance
Interpreting	means understanding building plans and drawings to know what they show and mean.
Intersection	refers to the line or curve where the surfaces of two objects meet or overlap, showing how they connect in space.
Intricate	refers to something that is highly detailed and complex, featuring many interconnected parts that contribute to its overall beauty and craftsmanship.
Iteration	Repeating a set of rules or transformations to generate the fractal design.
Layering	is a design technique where different materials, colours, textures, or elements are placed on top of each other that adds depth and makes the design more interesting and detailed.

Layout	is the way spaces, rooms, or elements are arranged in the drawing.
Lead Angle	The angle between the helix axis and a tangent line to the base circle.
Narratives	mean stories about events or experiences. They can be true or fictional and help share ideas or entertain. Narratives usually include characters, a plot, and a setting.
Offset Section	A sectional view created by bending the cutting plane to include features that are not in a straight line.
Overlapping	refers to putting one element on top of another to create a layered look. This adds visual interest, depth, and complexity to the design.
Pattern	A repeating design or motif used to create a cohesive look.
Pitch	The axial distance between consecutive turns of a helix.
Plan	is a top-down view of a building or structure. It shows how the spaces are laid out and arranged inside the building.
Plumbing	refers to the layout and details of the piping systems used for water supply, drainage, and waste disposal within a building.
Principal Planes	Another name for the reference planes, (First and Third Angle Projections)
Reference Line (XY Line)	The intersection line between the principal planes, commonly referred to as the xy line .
Reference Planes	The V.P., H.P., and profile planes, all mutually perpendicular to each other, are collectively called reference planes.
Refine	means to improve something by making small changes or removing unwanted parts.
Resistor	is an electronic component that reduces or controls the flow of electric current in a circuit. It is measured in ohms (Ω)
Revolved Section	A cross-sectional view rotated 90 degrees and drawn directly on the object's main view.
Rotation	means drawing objects as they would appear when turned in space.
Rotational symmetry	Refers to the property of a shape that looks the same after a certain amount of rotation around a central point.

Scale	refers to the ratio that compares the size of a drawing to the actual size of the object or structure. It is important in technical drawings for keeping measurements and proportions accurate.
Sectioning	is an imaginary cut made through an object to expose the interior or to reveal the shape of a portion.
Self-similarity	The property of a fractal being made up of smaller copies of itself.
Side View (End View)	The view of an object as seen from either the left or right side, drawn on the profile plane.
Stretching	means changing the size or shape of an object to achieve a specific look or to make it fit in a certain space.
Switch	Controls the flow of current in the circuit. Example: connect switches to light bulbs.
Symmetrical	means both sides look the same when divided down the middle, like a mirror image. This creates a balanced and pleasing look, making the design feel orderly and stable.
Template	A pre-designed format or structure used as a starting point for creating a design.
Top View (T.V. or Plan)	The view of an object as seen from above and drawn on the H.P.
Transformation	is changing an object's form, such as stretching or compressing it.
Translating	is turning design ideas or sketches into detailed drawings or changing 2D plans into 3D views and vice versa.
Turns	Number of complete rotations.
Visualising	refers to Imagining how the building or its parts will look based on the drawings.
Workspace	is the area where building drawings are created. It could be a physical drawing table or workstation with tools like rules and T-squares.
Yarn	A length of fibres or threads used to make fabrics.

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This book is intended to be used for the Year Two Design and Communication Technology Senior High School (SHS) Curriculum. It contains information and activities to support teachers to deliver the curriculum in the classroom as well as additional exercises to support learners' self-study and revision. Learners can use the review questions to assess their understanding and explore concepts and additional content in their own time using the extended reading list provided.

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