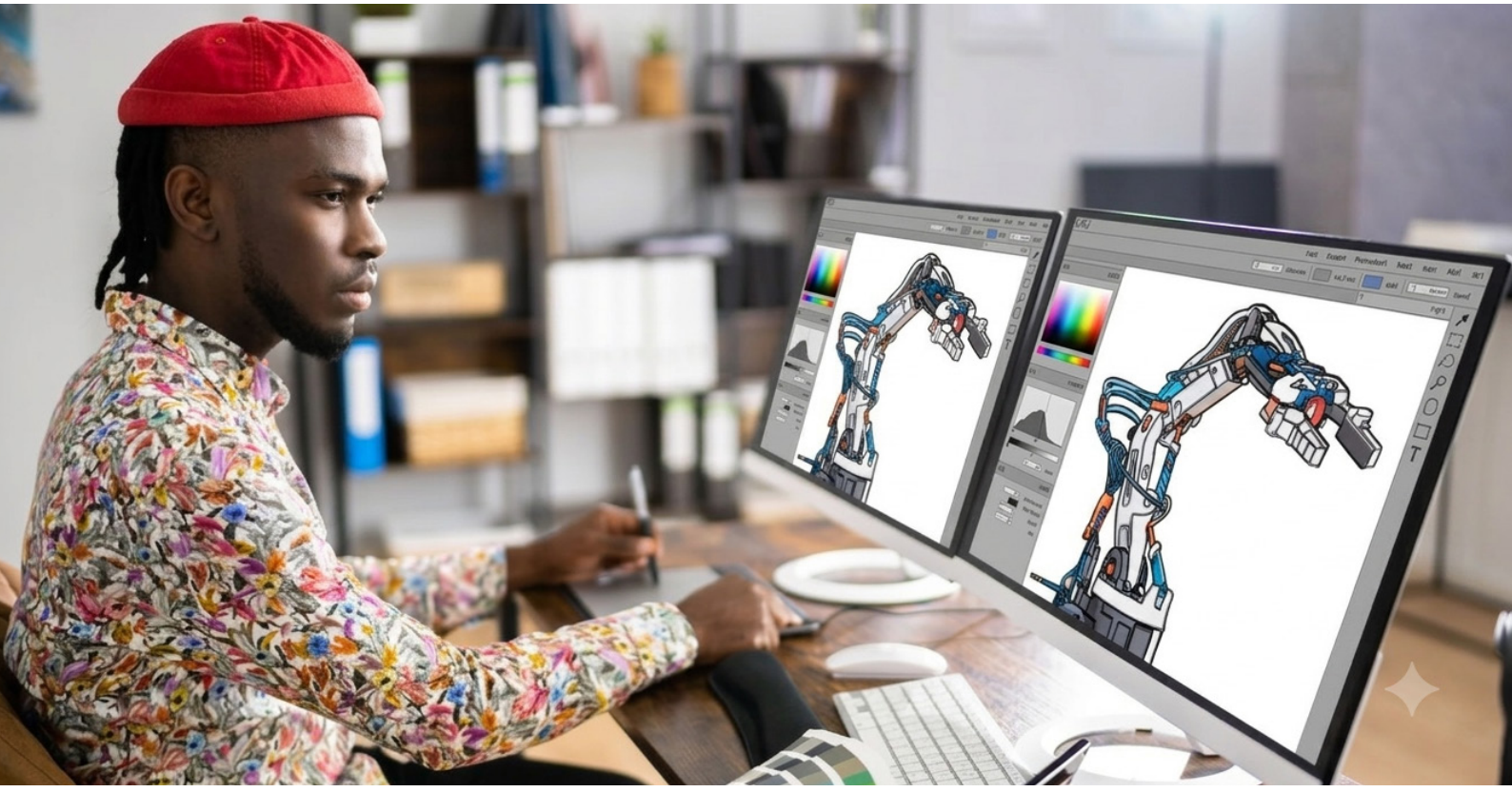
MINISTRY OF EDUCATION
TECHNICAL TEACHERS
ASSOCIATION OF GHANA

Design And Communication Technology

for Senior High Schools

Year 3



Justice Akonsah Blay
Deborah Naa Ayele Okine
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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

Introduction

In this unit, you will apply your knowledge of one-point and two-point perspective drawing to draw objects in three-point perspective. Also, you will learn the process of creating genuine, complex designs by experimenting with available techniques and tools. That is using graphite and coloured pencils.

KEY IDEAS

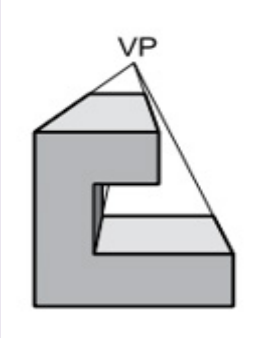
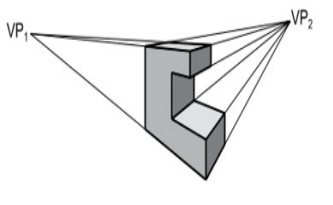
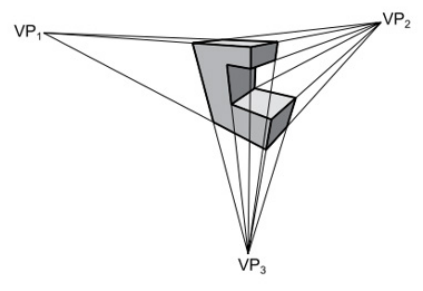
- Complex designs start from simple shapes. By using techniques like shading, layering, and adding colour, patterns, and textures, simple shapes can be turned into detailed and beautiful designs.
- Graphite and coloured pencils are used in different ways. Graphite pencils make light or dark lines depending on the grade (H, B, HB, F), while coloured pencils come in wax, oil, or water-based types for adding colour.
- How hard you press the pencil matters. Light pressure gives soft colours, and strong pressure makes darker colours that are harder to change.
- Practising freehand sketching helps you get better at three-point perspective. You can try different angles and improve without always using rulers or other tools.
- This method is often used in buildings and city drawings. It makes objects look tall, tilted, or as if you are looking up or down at them.
- Three-point perspective uses a horizon line and three vanishing points. All the lines in the drawing meet at these points to make the object look real.

CREATING DESIGNS IN 3- POINT PERSPECTIVE

Three-point perspective is a drawing method that helps us show objects in a more realistic way. Unlike one- or two-point perspective, which only show width and height, three-point perspective uses a third vanishing point to add depth and height. This makes it very useful when drawing tall buildings, aerial views, or objects seen from unusual angles. It is the same way our eyes see things when we look up at something very tall or look down from above. Learning this technique will help you create drawings that look more lifelike, dramatic, and visually interesting.

Activity 1.1.1: Understanding Perspective Drawing

Study and complete the table below

S/N	Sketch	Number of Varnishing Point	Description of the lines	Type of perspective
1				
2				
3				

Principles of 3-Point Perspective

The significant principle of three-point perspective includes the horizon line and three vanishing points; all objects in the scene must converge at these vanishing points.

To create a successful three-point perspective drawing, learners need to recap on one-point perspective, two-point perspective, parallel lines and orthogonal lines.

Description of three-point perspective drawings

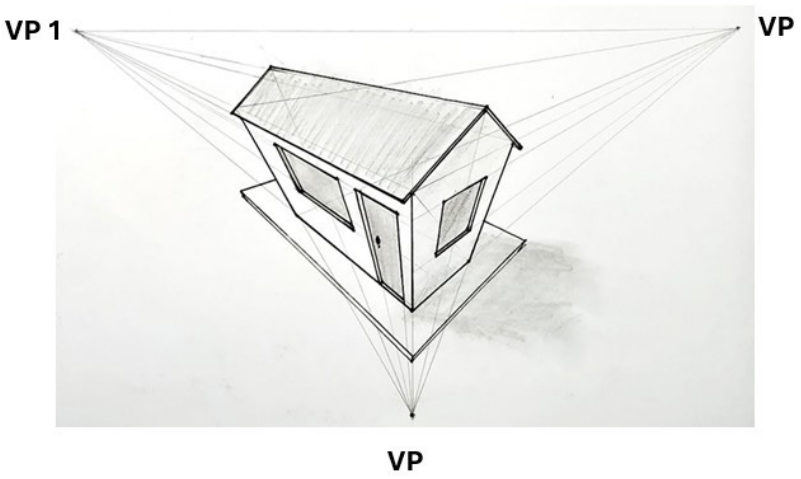


Figure 1.1.1: A house in three-point perspective

Steps for creating designs in 3-point perspective

1. Start by sketching the horizon line.

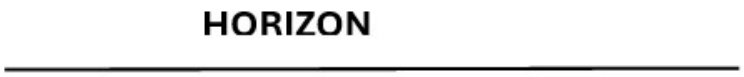


Figure 1.1. 2 a: Horizontal line

2. Place the three vanishing points. Two along the horizon and one either above or below it, depending on your viewpoint.

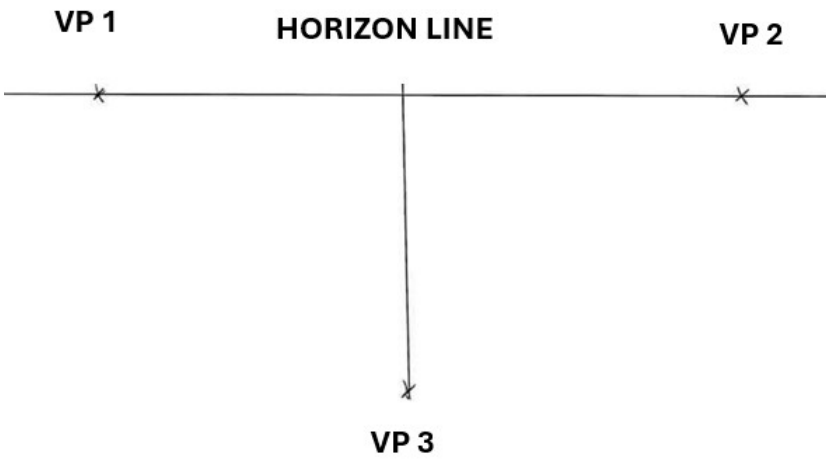


Figure 1.1. 2 b: Guide for three-point perspective

3. Draw a line from the third vanishing point to define the vertical edge of the THR building or object. From the endpoints of this line, draw lines to the other two vanishing points on the horizon. These create the sides of your object or building.

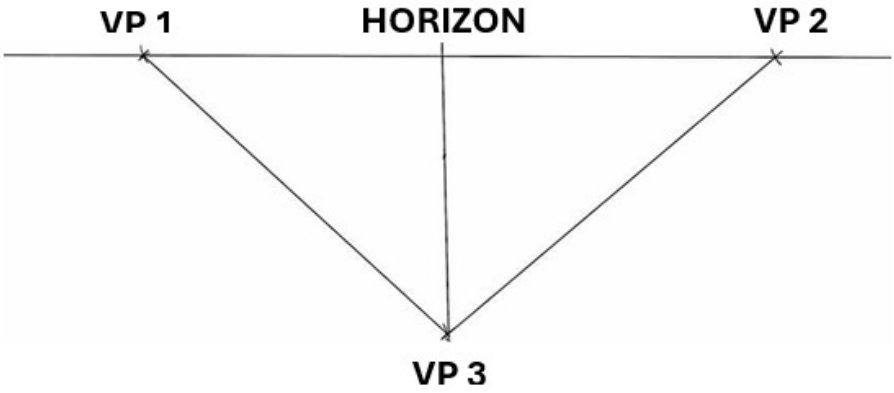


Figure 1.1. 2 c: Three-point perspective axis

4. Indicate the height of the building or object on the horizontal line

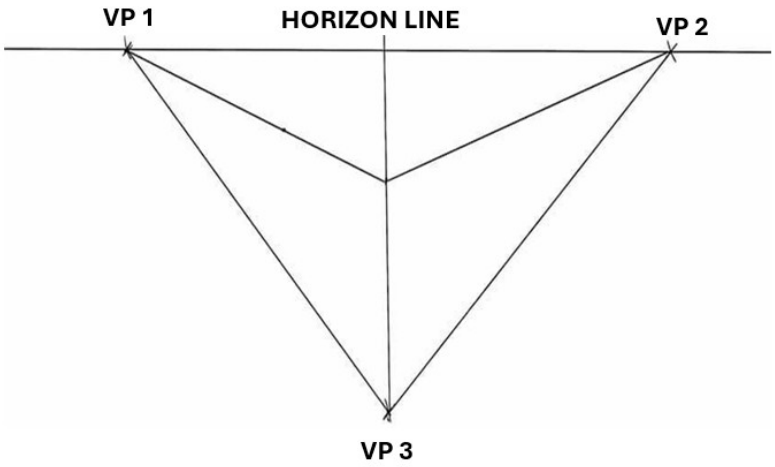


Figure 1.1. 2 d: Height of the Building or Object on the Horizontal Line

5. Indicating the thickness of the building or object

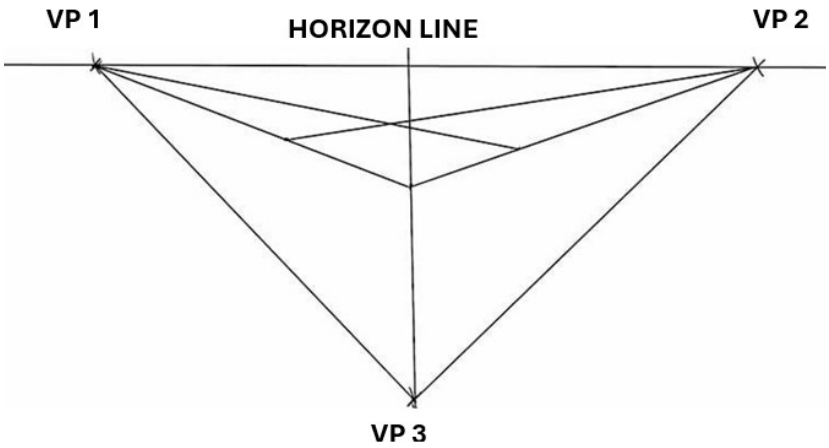


Figure 1.1. 2 e: Indicating the thickness of the building or object

6. Obtain the outline of the building or object.

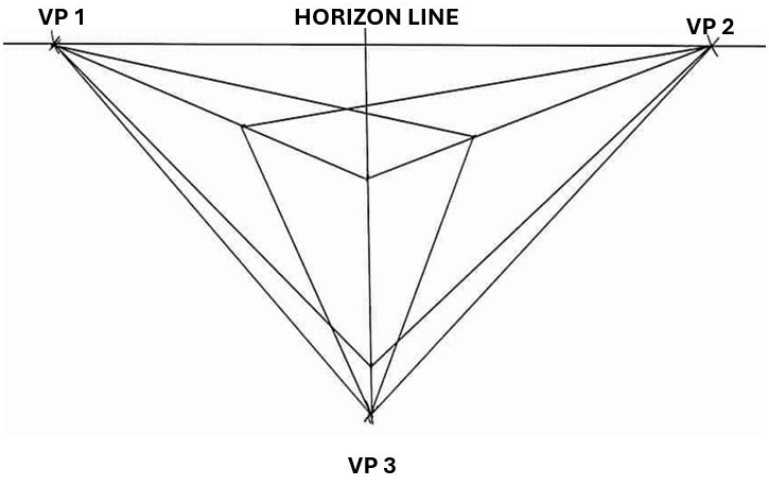


Figure 1.1. 2 f

7. Add details

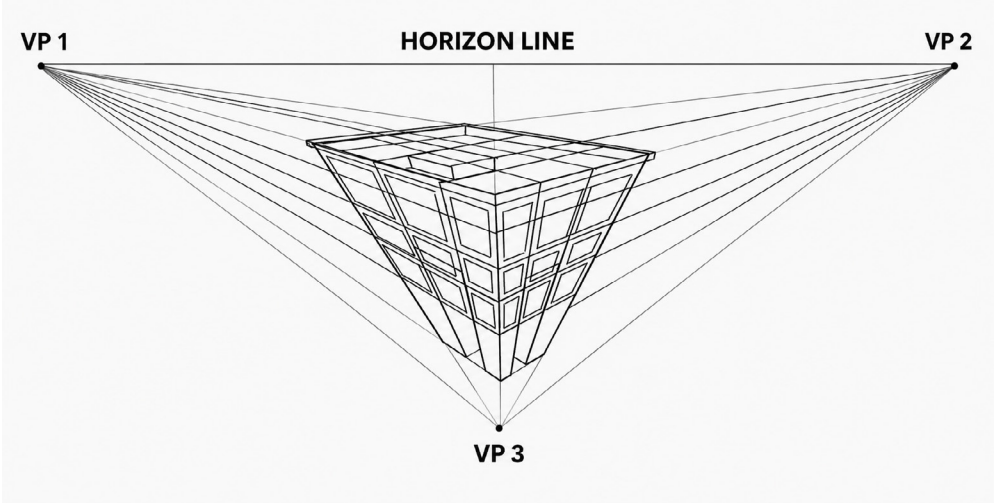


Figure 1.1. 2 g

8. Apply appropriate rendering techniques

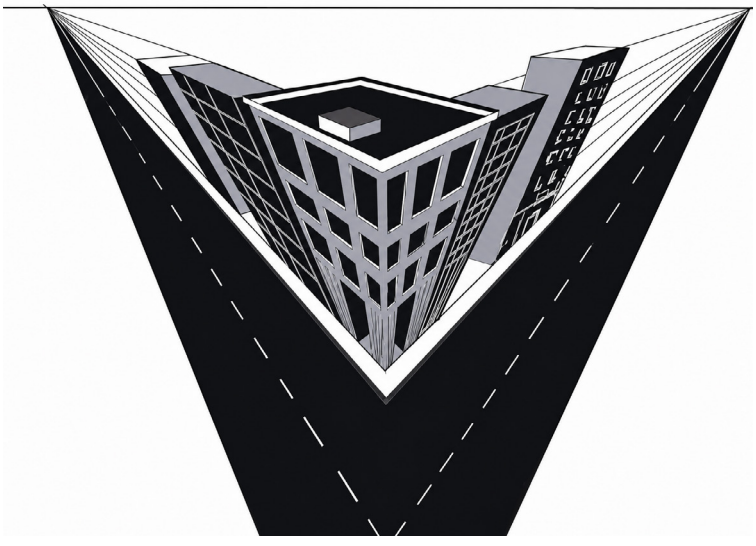


Figure 1.1. 2 h: Final drawing in three-point perspective

NOTE *It is important to remember that in three-point perspective, all lines will converge to one of the three vanishing points.*

Activity 1.1.2 Complex Building in Three-Point Perspective

A team of designers have been asked to create a complex building in three-point perspective. They are given the picture of the Villagio II building in Accra, Ghana.



Figure 1.1. 3: Villaggio II building in Accra

Study the picture carefully in groups and complete the following tasks:

1. Create a freehand sketch of this building using 3-point perspective. The drawing should:
   - **a.** Show a clear understanding of all three vanishing points
   - **b.** Demonstrate proper proportions between different elements of the building
   - **c.** Incorporate at least three different basic geometric shapes in your design
2. Apply appropriate rendering techniques to show:
   - **a.** At least two different surface textures
   - **b.** The direction of the light source and resulting shadows
   - **c.** Depth through line weight variation
3. Briefly explain three key principles you applied to maintain accurate proportions in the 3-point perspective drawing.

CREATING COMPLEX DESIGNS WITH GRAPHITE AND COLOUR PENCILS

Understanding Graphite Pencil Grades

Graphite pencils are available in various hardness and softness levels, which determine the pencil's lightness and darkness. These are indicated by letters and numbers:

1. **"H"** is hard and produces lighter marks.
2. **"B"** is soft and produces darker marks.
3. **"F"** is medium soft and produces fine marks.
4. **"HB" is** medium hard and is good for general writing and sketching.

Soft Graphite Pencils (B Range)

Grade	Characteristic	Use
9B	Very soft, dark, and dense	Deep shading, bold lines, and expressive drawings
8B	Soft and dark	Shading, creating textures, and adding depth
7B	Soft and dark	Sketching, shading, and creating bold lines
6B	Soft	Shading, creating textures, and adding depth
5B	Soft	Sketching, shading, and creating expressive lines
4B	Medium-soft	Shading, creating textures, and adding depth
3B	Medium-soft	Sketching, shading, and creating varied lines
2B	Medium	General drawing, shading, and creating subtle textures

Medium Graphite Pencils (HB and F)

Grade	Characteristic	Use
HB	Medium hardness	General writing, drawing, and sketching
F	Firm but still medium soft	Detailed work, fine lines, and subtle shading

Hard Graphite Pencils (H Range)

Grade	Characteristic	Use
H	Hard	Fine details, light shading, and creating subtle textures
2H	Harder	Detailed work, fine lines, and light shading
3H	Harder	Creating fine details, light shading, and precise lines
4H	Very hard	Creating light delicate lines, and fine details
5H	Very hard	Creating very light lines, fine details, and subtle textures
6H	Extremely hard	Creating very light, precise lines, and fine details
7H	Extremely hard	Creating very light, delicate lines, and fine details

8H	Extremely hard	Creating very light, precise lines, and fine details
9H	Extremely light	Creating very light, delicate lines, and fine details



Figure 1.1.4: Graded Pencils





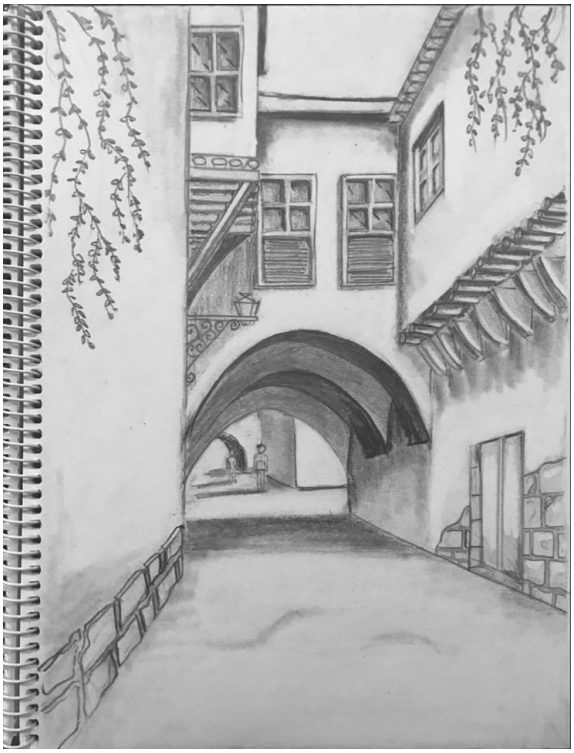






Figure 1.1.5: Graphite Images

Understanding Coloured Pencils

Coloured pencils can be in the following forms

1. Wax-based coloured pencils
2. Oil-based coloured pencil
3. Water-based pencils

Working with coloured pencils makes artworks lovely and interesting. It is much more difficult to fix darker colours than lighter colours. It is advisable to be aware of the pressure when applying colour.

The stronger the pressure, the more intense the colour will be. Because of this, you may want to start off with light pressure to avoid applying dark colours too quickly.

We can layer different colours to create unique shades and textures.

Coloured pencils can be blended to create smooth transitions between colours.

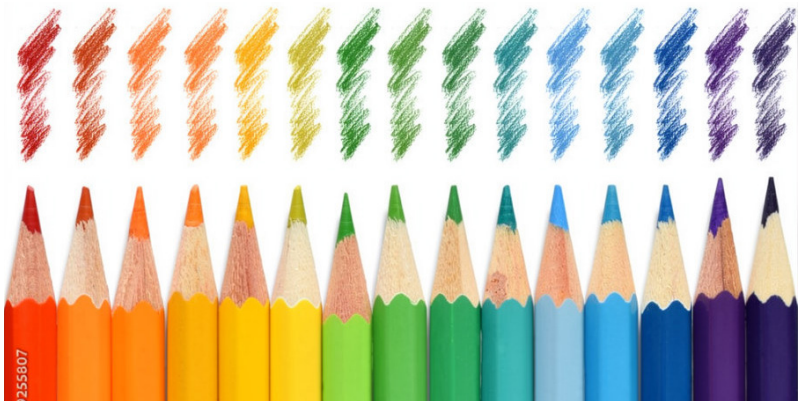


Figure 1.1.6: Coloured Pencils



Figure 1.1. 7: Coloured Pencil Images

Basic shapes, rendering techniques, complex forms and the relevant tools and materials

Basic shapes	Rendering techniques	Tools and materials
Square	Stippling	Graphite pencil

Circle	hatching	Coloured pencil
Triangle	Shading	Sketch pad

Basic shapes and rendering techniques

Shape	Graphite technique	Coloured pencil technique
Circle	Smooth hatching, gentle shading	Layering, blending, circular strokes
Square/Rectangle	Hatching, cross-hatching	Layering, texture
Triangle	Sharp lines, hatching, texture	Angular strokes, layering, contrasting colours
Oval/Ellipse	Smooth shading, gentle hatching	Soft layering, blending, curved strokes

This chart provides a starting point for exploring different rendering techniques for basic shapes. Feel free to experiment and adapt these techniques to suit your artistic interests.

3D Forms – Shape and rendering techniques

Form	Graphite technique	Coloured pencil technique
Sphere	Blending (smoothly merge values to suggest curvature)	Layering, blending, soft colours
Cube	Hatching (use parallel strokes to create even shading)	Layering, bold colours
Cylinder	Gradual hatching (use gentle transitions to suggest rounded form)	Layering, blending, smooth transition
Cone	Cross-hatching (use layered strokes to create texture and depth)	Angular strokes, bold colours
Pyramid	Linear shading (use sharp lines and subtle gradations to suggest geometric form)	Angular strokes, bold colours

These pairings can serve as a starting point for exploring different shading techniques for various shapes.







Figure 1.1.8: Examples of complex designs

How to create complex designs using graphite and coloured pencils

Guidelines to effectively use graphite pencils and coloured pencils to create complex geometric designs:

1. Understanding basic shapes to start creating complex designs, it is essential to understand the role of basic shapes in designing.
2. Using tools and techniques to turn basic shapes into complex designs.
3. Layering shapes to build complexity.
4. Adding colour and gradients to shapes.
5. Incorporating patterns and textures.

Graphite pencils

1. Select a range of pencil grades (HB, 2B, 4B, 6B) to achieve varying line weights and shading.
2. Keep your pencils sharp to achieve precise lines and details.

3. Use different line weights to create depth, dimension, and visual interest.
4. Ensure accurate proportions and measurements to maintain geometric integrity.
5. Create guidelines to help achieve precise shapes and lines.
6. Use hatching, cross-hatching, and stippling to create texture, depth, and dimension.
7. Use blending stumps or tortillons to smooth out shading and create subtle transitions.

Coloured pencils

1. Select a range of coloured pencils with hardness levels and pigment loads.
2. Develop a colour scheme that complements the geometric design.
3. Build layers of colour to achieve the desired intensity and texture.
4. Use sharp pencils to achieve precise lines and details.
5. Use different strokes and techniques to create texture and interest.
6. Use blending stumps or tortillons to merge colours and create smooth transitions.
7. Study reference images to improve your understanding of colour and geometric forms.

Additional Tips

a. Create a light sketch to establish the overall composition and proportions
b. Gradually build up layers of graphite to achieve the desired shading and texture.
c. Begin with a light layer of colour and gradually build up to achieve the desired intensity.
d. Apply colour theory principles to create harmonious and visually appealing designs.
e. Coloured pencil work can be time-consuming, so be patient and enjoy the process.

Activity 1.1.3 Sustainable Playground Design

The school administration of the community basic school has announced that the current playground needs renovation. Senior secondary school students in

the designing class have been tasked with developing the initial concept of a new, sustainable playground that meets the needs of all students.

Step 1: Research

a. Investigate examples of sustainable playgrounds

b. Identify features that make them safe, inclusive, and eco-friendly.

c. Note the different materials (e.g., recycled wood, tyres, bamboo, natural grass) needed and their benefits.

Step 2: Define the Needs of the Playground

a. Discuss what the current playground lacks and what children of different ages need.

b. Consider safety, accessibility, and activities (climbing, sliding, resting, creative play, etc.).

c. Write a short list of design requirements.

Step 3: Brainstorming Ideas

a. Come up with three creative concepts.

b. Make sketches of at least 3 possible designs.

Step 4: Develop Initial Sketches

a. Compare and select your best idea and create a larger, detailed sketch.

b. Use graphite or coloured pencils to show form, texture, and material choices.

c. Annotate (label) the drawing to explain the purpose of each feature.

Step 5: Final Design Development

a. Create a neat, finalised drawing of your playground concept.

b. Add colour and shading to make it realistic and attractive.

c. Clearly label sustainable materials, safety features, and activity zones.

Step 6: Presentation

a. Prepare a short explanation (oral or written) of your design.

b. Highlight how it meets the needs of all students and how it is sustainable.

c. Present to the class

EXTENDED READING

- https://artincontext.org/three-point-perspective-drawing

REVIEW QUESTIONS

1. Explain the principles of three-point perspective.
2. Identify three characteristics of three-point perspective drawings.
3. Create a 3-point perspective drawing of a prominent building in your school with emphasis on proportions and freehand sketches.
4. You are a senior designer at a creative agency, and you have been tasked with creating a new design project. Your team is to present your concept sketches, design process, and final product. As you work on your design project, you will need answers to the following questions as a guide.
   a. What is the first step in creating a complex design using graphite and coloured pencils?
   b. How do you use graphite pencils to create depth and dimension in a design?
   c. Give three tips for using coloured pencils to add colour and detail to a design.
   d. How do you balance composition and visual elements in a complex design?

UNIT 2: OBJECT MANIPULATION

Introduction

In this unit, you will learn how object manipulation techniques in freehand drawing can be used to create innovative solutions to societal problems. By transforming natural and manmade forms through methods like fragmentation, exaggeration, and recombination, you will progress from simple manipulations to complex designs that address real-world challenges. Along the way, you will strengthen skills in observation, analysis, and creative transformation while balancing technical drawing with conceptual thinking. Both individual and group tasks will involve creating manual and digital design solutions, supported by reflection on the design process. Beyond technical competence, you will develop a design mindset that considers the wider social impact of creative work. By the end of the unit, you will be able to apply object manipulation as a tool for generating meaningful designs that can serve as interventions for improving everyday life.

KEY IDEAS

- **Application of Manipulation:** Utilising techniques such as stretching, compressing, combining, or repeating helps to transform natural forms.
- **Creation of Simple Designs:** Producing basic sketches or models showcases how natural objects can be reimagined into functional designs.
- **Creative Transformation:** Applying object manipulation techniques (scaling, fragmenting, combining, repeating) to natural or manmade forms aids in developing innovative design solutions.
- **Design Application:** Creating sketches or models of both simple and complex designs provides practical interventions to enhance daily life and social interactions.
- **Observation of Nature:** Observing shapes, patterns, and structures in natural objects (e.g., leaves, shells, and animal limbs) inspires creative ideas.
- **Problem Identification:** Recognising societal challenges (e.g., mobility, safety, waste management) can lead to effective design solutions.

GENERATE SIMPLE DESIGNS FROM NATURAL OBJECTS USING TECHNIQUES IN OBJECT MANIPULATION AND FREEHAND DRAWING

Generate Simple Designs from Natural Objects Using Freehand Drawing

Nature has always been humanity's greatest design inspiration. From the spiral patterns in seashells to the intricate veining of leaves, natural objects offer a boundless source of design elements waiting to be discovered and transformed through the skilled hand of a designer.

This unit will help you explore the process of generating simple designs from natural objects using freehand drawing techniques.

Stages of Generating Simple Designs from Natural Objects Using Freehand Drawing Techniques

1. **Choose Your Natural Object**

   The process begins with selecting compelling natural specimens that speak to you as a designer, offering interesting shapes, textures, or patterns that can inspire unique design solutions.

2. **Observe and Analyse**

   Through careful observation, you will develop the ability to break down complex natural forms into their fundamental elements, understanding the underlying structures that make them visually appealing.

3. **Sketching the Design**

   Using freehand drawing techniques, you will translate your observations into preliminary sketches, practising essential skills in form comprehension, proportion, and perspective.

4. **Add Your Creative Touch**

   This critical stage involves manipulating and transforming the natural forms through various techniques, where you will experiment with rotation, scale, repetition, and stylisation to create an object entirely new.

5. **Reflect and Iterate**

   Design is an evolving process that requires continuous reflection and refinement. To evaluate your work critically and make improvements based on design principles.

6. **Further Exploration**

   As your skills develop, you will discover how these nature-inspired designs can be applied across various design disciplines and potentially address real-world challenges.

Design Complexity Progression

A good way to design is to start with nature-inspired templates, like the structure of a leaf or the pattern of a butterfly wing. Begin with simple line drawings to capture the basic form. Then, make the design more complex by adding layers, line variations, shading, and textures.

For advanced designs, you can use abstraction—simplifying natural forms while adding symbolic or metaphorical elements to express deeper meanings. This step-by-step process helps you build a collection that shows both technical skill and creative ideas and can even inspire solutions to real-life challenges.

This method improves your drawing and observation skills while encouraging originality and creativity, which every designer needs. By learning from nature and adding your personal style, you can create designs that are fresh, innovative, and rooted in timeless natural patterns.

Integrated Communication Design Technology (Object Manipulation)

Project 1: Bioinspired Water Harvesting Solution

In your community, water scarcity has become increasingly problematic during dry seasons. The local school has partnered with environmental engineers to develop innovative water harvesting solutions inspired by nature. Community stakeholders will evaluate designs for potential implementation as a pilot project.

Design Brief

Use object manipulation techniques to turn natural water-collecting forms (like leaves or shells) into a creative design for community water harvesting. Step by step, transform these natural shapes into a solution that can help solve real water problems. Develop your ideas through conceptual sketches, either by hand with pencils and colours or digitally with CAD software, to create clear and innovative designs. Your solution must be:

1. Low-maintenance and durable
2. Constructed from locally available materials
3. Aesthetically integrated with existing architecture
4. Capable of collecting significant water volume

Guidelines

a. Work in groups to design one unique water collection system inspired by natural forms (like leaves, shells, or cactus spines).

b. Use sketching to show how these shapes can be transformed into a practical solution for communities facing water scarcity.

c. Your sketches should clearly show how the natural idea is reimagined into an efficient water harvesting system.

Object Analysis & Concept Development

Natural Object Research Phase

1. Document selected natural water-collecting structures through detailed sketches using graphite pencils.
2. Create object analysis diagrams showing:
   - **a.** Structural properties of water-collecting natural forms through different line weights
   - **b.** How these forms capture, channel, and store water
   - **c.** Ways to transform these into human-scale systems
3. Research modern water harvesting approaches using biomimicry
4. Identify key elements to keep or transform in your conceptual sketches

Design Concept Generation (Graphite & Coloured Pencil)

1. Each group member must develop one unique water harvesting concept through detailed sketching.
2. Required conceptual drawings per concept:
   - **a.** Detailed graphite sketches showing natural water-collecting mechanisms
   - **b.** Concept sketches showing manipulation techniques with varying line weights
   - **c.** Coloured pencil renderings addressing water collection, filtration, and storage
3. Hold a group critique to select two concepts for further development.
4. Deliver Water Collection Concept Sketch Portfolio

Design Development & Presentation

Design Refinement (Manual Drawing or CAD)

Further develop two selected water harvesting concepts through:

1. Refined conceptual sketches emphasising form development and water flow
2. Detailed studies of key features using pencil techniques or CAD
3. Exploration of materials and mechanisms through colour and texture rendering

Design Application

Create comprehensive design visualisations using coloured pencil techniques or CAD showing:

a. The water harvesting system in different settings (rooftops, community spaces, etc.)
b. Key functional elements through exploded or sectional views
c. Water flow diagrams and collection capacity calculations

Design Selection & Prototype Development

1. Evaluate refined designs based on water collection efficiency and innovation
2. Select the final direction with clear design rationale
3. Develop final presentation drawings using pencil techniques or CAD
4. Create detailed documentation of your design process
5. Build a physical model demonstrating water collection principles

Final Presentation

1. Present your water harvesting solution to the class (5 minutes per group)
2. Display progression from initial natural form sketches to final design
3. Show how your system collects, channels, and stores water
4. Produce Concept Sketch Portfolio, Final Renderings & Physical Model

Project Requirements

Conceptual Sketching Requirements

1. **Start with Sketch Iterations**
   a. Draw your first idea.

   b. Refine it by creating 2–3 more versions, each time adding improvements.

2. **Play with Pencil Techniques**
   a. Use light and dark lines to show edges and depth.
   b. Add shading and perspective to make your sketches look 3D.
3. **Add Colours for Realism**
   a. Use coloured pencils to show different materials.
   b. Apply blue or transparent tones to represent water flow.
4. **Show Transformation**
   a. Create small diagrams that explain how natural water-collecting forms (like leaves or shells) inspired your design.
   b. Label Your Work
   c. Add technical notes and arrows to explain details (e.g., material, joints, or flow direction).

Visualisation Requirements

Demonstrate visualisation skills through;

1. Quality sketch renderings showing water interaction with materials
2. Detailed visualisations of water collection, channelling, and storage mechanisms
3. Professional presentation layouts of conceptual sketches
4. Innovative water harvesting element development through iterative sketching
5. Consistent representation across all sketch materials

Exhibition Requirements

The following Concept Sketch Display;

1. Progressive development sketches showing water collection concept evolution
2. Natural water-collecting object analysis sketches
3. Transformation sketches showing manipulation techniques
4. Initial ideation sketches in graphite

Process Display

1. All initial water harvesting concept drawings.
2. Design development sketches showing evolution of concepts

3. Final design visualisations in coloured pencil or CAD

Application Showcase

1. Detailed drawings of:

1. Water collection, channelling, and storage mechanisms
2. Material and construction strategy through colour rendering
3. Installation and maintenance considerations
4. Environmental considerations and water quality
5. Community impact in different settings

Design Documentation

1. Complete specification sketches and diagrams
2. Material representation through coloured pencil techniques
3. Water flow diagrams showing collection efficiency
4. Maintenance and durability information integrated with sketches

Physical Model

1. Accurate model matching of concept sketches
2. Professional display base complementing the design
3. Functional demonstration of water collection principles
4. Correct material representation
5. Accurate demonstration of object transformation techniques

INTEGRATED COMMUNICATION DESIGN TECHNOLOGY (OBJECT MANIPULATION)

Bioinspired Sustainable Waste Disposal Solution

Project 2: Bioinspired Sustainable Waste Disposal Solution

In your community, improper waste disposal has become increasingly problematic, leading to environmental degradation and health concerns. The local school has

partnered with environmental engineers to develop innovative waste management solutions inspired by nature's decomposition and filtration systems.

Design Brief

Apply object manipulation techniques to transform natural waste-processing structures into an innovative community waste disposal solution. Through systematic manipulation of natural forms, develop a design that addresses this real societal problem. Use conceptual sketching as your main tool to develop complex designs, using either CAD software or manual drawing tools such as graphite and coloured pencils.

Your solution must be:

1. Low-maintenance and durable
2. Constructed from locally available materials
3. Aesthetically integrated with existing architecture
4. Capable of processing significant waste volume sustainably

Group Structure and Dynamics

In groups, design one unique waste processing system inspired by natural processes like decomposition or filtration. Each member should create a detailed sketch showing their idea. Then, as a group, combine your ideas into a practical system that could help communities with limited waste infrastructure. Use sketching to show how natural mechanisms can be reimagined into an efficient and sustainable waste management solution.

Natural Object Research Phase

1. Select a document of natural waste-processing structures (fungi, decomposers, filter feeders) through detailed sketches using graphite pencils.
2. Create object analysis diagrams showing:
    a. Structural properties of waste-processing natural forms through different line weights
    b. How these forms break down, filter, and transform waste
    c. Ways to transform these into human-scale systems
3. Research modern sustainable waste management approaches using biomimicry
4. Identify key elements to keep or transform in your conceptual sketches

Design Concept Generation (Graphite & Coloured Pencil)

1. Each group member must develop one unique waste disposal concept through detailed sketching.
2. Give the required conceptual drawings per concept:
   a. Sketch with graphite showing detailed natural waste-processing mechanisms
   b. Show concept sketches with manipulation techniques of varying line weights
   c. Use coloured pencil renderings to address waste collection, sorting, and processing
3. Hold a group critique to select one concept for further development.
4. Begin developing the selected concept through:
   a. Refined conceptual sketches emphasising form development and waste flow
   b. Detailed studies of key features using pencil techniques or CAD
   c. Exploration of materials and mechanisms through colour and texture rendering

Design Application & Refinement

1. Create comprehensive design visualisations using coloured pencil techniques or CAD showing:
   a. The waste disposal system in different settings (homes, community spaces, etc.)
   b. Key functional elements through exploded or sectional views
   c. Waste flow diagrams and processing capacity calculations
2. Develop final presentation drawings using pencil techniques or CAD
3. Create detailed documentation of your design process
4. Build a simple physical model demonstrating waste processing principles

Final Presentation & Exhibition

1. Present your sustainable waste disposal solution to the class (5 minutes per group)
2. Display progression from initial natural form sketches to final design
3. Show how your system collects, processes, and transforms waste

4. Deliverable: Complete Concept Sketch Portfolio, Final Renderings & Physical Model

Project Requirements

Conceptual Sketching Requirements

Demonstrate good sketching skills through:

1. Progressive concept development through multiple sketch iterations
2. Effective use of line weight, shading, and perspective in graphite pencil
3. Colour application techniques using coloured pencils to show materials and waste flow
4. Detailed transformation diagrams showing manipulation of natural waste-processing forms
5. Technical labels and references integrated into sketches

Visualisation Requirements

Demonstrate visualisation skills through:

1. Quality sketch renderings showing waste interaction with materials
2. Detailed visualisations of waste collection, sorting, and processing mechanisms
3. Professional presentation layouts of conceptual sketches
4. Innovative waste management element development through iterative sketching
5. Consistent representation across all sketch materials

Exhibition Requirements

Concept Sketch Display

1. Progressive development sketches showing waste management concept evolution
2. Natural waste-processing organism analysis sketches
3. Transformation sketches showing manipulation techniques
4. Initial ideation sketches in graphite

Process Display

1. All initial waste disposal concept drawings (3-5 sets of studies)

2. Design development sketches showing the evolution of concepts
3. Final design visualisations in coloured pencil or CAD

Application Showcase

Detailed drawings of:

1. Waste collection, sorting, and processing mechanisms
2. Material and construction strategy through colour rendering
3. Installation and maintenance considerations
4. Environmental considerations and sustainability features
5. Community impact in different settings

Design Documentation

1. Complete specification sketches and diagrams
2. Material representation through coloured pencil techniques
3. Waste flow diagrams showing processing efficiency
4. Maintenance and durability information integrated with sketches

Physical Model

1. Build a small paper model that looks like a given sketch. Compare your model to the sketch.
2. Create a simple base (cardboard or paper) for your model. Test which shape makes your design look best.
3. In groups, make a mini model (using bottles, funnels, or paper) to show how waste can be recycled or separated.
4. Use shading and colours to show different materials (wood, glass, metal, fabric) in a sketch.
5. Start with a cube template. Change it into another form (pyramid, cylinder, or stool leg) by folding, cutting, or sketching.

Activity 1.2.1 Creating the Dew Bank

Your community is facing severe water scarcity during dry seasons, affecting agriculture, hygiene, and daily life. The local school has partnered with environmental engineers to develop innovative water harvesting solutions inspired by nature. As a member of the design team, you are tasked with applying

biomimicry principles to transform natural water-collecting structures into efficient and sustainable systems. Your design should address the real societal problem of water scarcity in a specific region.

Your solution must be:

1. Low-maintenance and durable
2. Constructed from locally available materials
3. Aesthetically integrated with existing architecture
4. Capable of collecting significant water volume

Activity 1.2.2 Designing a Biomimetic Waste Management System

Your community is struggling with improper waste disposal, leading to environmental degradation and health concerns. The local school has partnered with the Environmental Protection Agency (E.P.A.) engineers to develop innovative waste management solutions inspired by nature's decomposition and filtration systems. As a member of the design team, you are tasked with creating a biomimetic waste management system that efficiently processes waste, minimises environmental impact and promotes community health.

Your solution must be:

1. Low-maintenance and durable
2. Constructed from locally available materials
3. Aesthetically integrated with existing architecture
4. Capable of processing significant waste volume sustainably

MODIFYING EXISTING NATURAL/MANMADE OBJECTS TO CREATE SIMPLE AND COMPLEX DESIGNS AS INTERVENTIONS FOR SOCIETAL PROBLEMS USING FREEHAND DRAWING

Good design has the power to turn simple ideas into meaningful solutions for real-world problems. Through freehand drawing, you can reimagine natural and manmade objects to address urgent societal needs. This skill encourages creative, out-of-the-box thinking that leads to innovative and practical interventions. Designs may enhance everyday items or introduce new products tailored to specific challenges. By focusing on solutions that promote sustainability, accessibility, and social well-being, design goes beyond aesthetics—it becomes a powerful tool for positive change and a better future.

How to Modify Existing Natural/Manmade Objects to Create Designs for Societal Problems

This creative process follows a structured yet flexible approach:

1. **Identification of the Societal Problem**

   We begin by carefully examining the challenges in our communities, seeking to understand their root causes and impacts on people's daily lives.

2. **Selecting the Object**

   With the problem clearly defined, we choose existing natural or manmade objects that have potential for modification. The selected object should have properties or characteristics that could be adapted to address our identified challenge.

3. **Brainstorming Modifications**

   This stage involves creative thinking about how the chosen object might be altered, combined, or repurposed. We consider changes to form, function, scale, and material to transform it into a solution.

4. **Sketching the Design**

   Using freehand drawing techniques, we bring our ideas to life on paper. These sketches allow us to explore various possibilities quickly and develop our concepts visually.

5. **Complexity in Design**

   As our ideas mature, we progress from simple to more complex designs. We might start with basic modifications and gradually introduce more sophisticated elements that enhance functionality or aesthetic appeal.

6. **Prototype and Feedback**

   Through more detailed drawings, we create visual prototypes of our designs and gather feedback from potential users and stakeholders to refine our concepts.

7. **Communicate the Concept**

   We learn to effectively present our design interventions, explaining how they address the societal problem and demonstrating their potential impact.

8. **Reflecting and Iterating**

   Design is never truly finished. We continuously assess our work, identify areas for improvement, and refine our designs accordingly.

Through this process, freehand drawing becomes a tool for reimagining everyday objects as practical solutions to real challenges. It strengthens technical drawing skills

while shaping the mindset of a socially responsible designer—one who views problems as opportunities for creativity and positive impact.

PROJECT 1: Integrated Communication Design Technology (Object Manipulation)

Project Scenario: Nature-Inspired Mobility Aid for Elderly Community Members

Many elderly residents in your community struggle with mobility challenges, particularly when walking over uneven pavements and steep inclines in the neighbourhood. The local community centre has partnered with physiotherapists to develop innovative mobility aids inspired by natural movement systems.

Design Brief

Use object manipulation techniques to modify natural or manmade forms in order to design innovative mobility aids for the elderly. Observe how animals and plants move efficiently in challenging environments—for example, the flexibility of a cat's limbs, the stability of a mountain goat's hooves, or the adaptability of climbing plants. Apply these insights to redesign traditional walking aids. Through freehand drawing, create design concepts that can enhance mobility, independence, and dignity for elderly community members. Your solution must be:

1. Low-maintenance and durable
2. Constructed from locally available materials
3. Aesthetically pleasing and non-stigmatising
4. Capable of providing significant stability enhancement

Group Structure and Dynamics

In groups, use freehand sketching to design one unique mobility aid for the elderly. Take inspiration from natural movement systems (e.g., animal limbs, plant structures) and apply object manipulation techniques such as stretching, compressing, combining, or scaling. Show in your sketches how these natural forms can be transformed into a practical design that improves mobility, independence, and dignity.

Natural Object Research Phase

1. Select the document of natural movement structures through detailed sketches.
2. Create object analysis diagrams showing:
   a. Original structural properties of movement-enabling natural forms

   b. Potential manipulation techniques that could be applied
   c. Progressive manipulation steps to transform the natural form
3. Research existing applications of object manipulation in mobility aid design.
4. Identify which manipulation techniques are most suitable for your mobility solution

Design Concept Generation through Object Manipulation

1. Each group member must develop one unique mobility aid concept, showing clear manipulation techniques
2. Required conceptual drawings per concept:
   a. Original natural object sketches before manipulation
   b. Progressive sketches showing specific manipulation techniques applied
   c. Final concept sketches showing how manipulation transforms the object into a mobility aid solution
3. Hold a group critique to select one concept for further development
4. Begin developing the selected concept through:
   a. Advanced manipulation techniques to create more complex forms
   b. Detailed studies showing how manipulation enhances functionality
   c. Exploration of how multiple manipulated elements work together

Design Application & Refinement

1. Create comprehensive design visualisations showing:
   a. How manipulation techniques solve specific aspects of mobility challenges
   b. How simple forms become complex functional systems through manipulation
   c. Technical details showing manipulation-enabled functionality
2. Develop final presentation drawings highlighting object manipulation
3. Build a simple physical model demonstrating key manipulation principles
4. Prepare technical documentation of your solution

Final Presentation & Exhibition

1. Present your solution to the class (5 minutes per group)
2. Explicitly demonstrate how object manipulation techniques transformed simple natural forms into complex design solutions

3. Show how manipulation techniques directly address the societal problem of mobility challenges for the elderly
4. Display your process work, final visualisations, and physical model
5. Deliverable: Complete Object Manipulation Journey and Final Solution

Object Manipulation Requirements

Demonstrate mastery of manipulation techniques through:

1. Clear before/after documentation of manipulated forms
2. Multiple manipulation techniques applied to natural forms
3. Progressive complexity development through manipulation
4. Technical explanation of how manipulation enhances functionality
5. Strategic application of manipulation to solve specific design challenges

Visualisation Requirements

Demonstrate how manipulation creates complex solutions through:

1. Quality sketches showing transformation through manipulation
2. Detailed visualisations of how manipulated forms enable functionality
3. Clear connection between manipulation techniques and problem-solving
4. Innovative applications of manipulation to create complex systems
5. Physical model demonstrating manipulation principles

Prototype Construction Guide

Stage	Steps	Materials	Techniques
1. Planning	• Create scale drawings • Identify key components • Plan movement pathways • Determine connection methods	• Graph paper • Tracing paper • Ruler and compass • Templates	• Scale drawing • Component mapping • Movement diagramming
2. Base Construction	• Cut base elements to size • Mark component positions • Create mounting points • Build a supporting structure	• Plywood/ MDF/Foam board • Balsa wood • Adhesive • Cutting tools	• Measuring • Cutting • Joining • Reinforcing

3. Form Development	• Create primary forms from natural inspiration • Apply manipulation techniques • Build primary support surfaces • Form movement mechanisms	• Card stock • Clay/Plasticine • Wire mesh / Plastic sheet	• Folding • Moulding • Bending • Cutting/slicing
4. Mobility System	• Create contact points • Develop stability system • Build grip components • Install flexible elements	• Plastic tubing • Small containers • Flexible materials • Grip materials	• Drilling • Sealing • Connecting • Testing stability
5. Surface Treatment	• Apply texture to surfaces • Add colour treatments • Create surface patterns • Enhance visual elements	• Paint • Coloured paper • Textured materials • Finishes	• Painting • Collaging • Texturing • Finishing
6. Functionality Testing	• Test stability • Verify movement pathways • Check weight capacity • Assess comfort	• Weight tests • Movement simulations • Measuring tools • Stopwatch	• Controlled testing • Measurement • Documentation • Refinement

Exhibition Requirements - Use this manipulation process to display your work

1. ***Sketch It:*** Draw a simple object, then show its "after" version once it's transformed through manipulation.
2. ***Show the Steps***: In pairs, explain or sketch the steps you used to change the object (stretch, compress, combine, etc.).
3. ***Function Check:*** Discuss as a group how your changes made the object more useful.
4. ***Compare & Share:*** Display your simple and final designs side by side, then explain the difference to the class.

Design Development through Manipulation

1. ***Sketch Journey:*** Start with a simple natural form (e.g., leaf, shell, or bone). Create a series of sketches that gradually show how it becomes more complex through manipulation.

2. ***Mix & Match Manipulation:*** Apply at least two different manipulation techniques (stretch, compress, combine, repeat) to the same form, then compare results with your group.
3. ***Design Showcase:*** Present your final mobility aid design. Explain how your manipulations solved specific challenges for the elderly (stability, grip, comfort, efficiency).
4. ***Material & Function Map:*** Create a simple chart or diagram linking your design to possible materials, showing how each part functions and works together.
5. ***Mini Model Challenge:*** Build a quick paper, cardboard, or wire model of your design. Demonstrate to classmates how the manipulation turned a simple form into a functional mobility aid.

PROJECT 2: Integrated Communication Design Technology (Object Manipulation)

Nature-Inspired Road Safety Solutions for Vulnerable Road Users

Many pedestrians, cyclists, and motorcyclists in your community face significant safety challenges, particularly when travelling at night or in poor visibility conditions. The local transport authority has partnered with road safety experts to develop innovative safety solutions inspired by natural visibility and protection systems found in nature.

Design Brief

Use object manipulation techniques to transform natural or manmade forms into innovative road safety solutions for vulnerable users. Observe how animals and plants improve visibility and protection in tough environments—for example, the reflective eyes of cats, the bold patterns of insects, or the protective shells of seed pods. Apply these ideas to redesign common road safety equipment. Through freehand drawing, create concepts that can enhance visibility, protection, and overall safety on the road. Your solution must be:

1. Low-maintenance and durable
2. Constructed from locally available materials
3. Aesthetically pleasing and user-friendly
4. Capable of providing significant safety enhancement in various weather and light conditions

Community stakeholders will evaluate designs for potential implementation as a pilot project.

Group Structure and Dynamics

In your groups, sketch one unique road safety concept inspired by natural forms. Use object manipulation techniques (stretching, compressing, combining, scaling, repeating, etc.) to transform simple natural or manmade structures into functional safety designs. Focus on improving visibility and protection for vulnerable road users. At the end, share your sketches with the class and explain how your design works.

Natural Object Research Phase

1. Document selected natural visibility and protection structures through detailed sketches
2. Create object analysis diagrams showing:
   a. Original structural properties of visibility-enhancing natural forms
   b. Potential manipulation techniques that could be applied
   c. Progressive manipulation steps to transform the natural form
3. Research existing applications of object manipulation in road safety design
4. Identify which manipulation techniques are most suitable for your safety solution

Design Concept Generation through Object Manipulation

1. Each group member must develop one unique road safety concept, showing clear manipulation techniques
2. Required conceptual drawings per concept.
   a. Original natural object sketches before manipulation
   b. Progressive sketches showing specific manipulation techniques applied
   c. Final concept sketches showing how manipulation transforms the object into a road safety solution
3. Hold a group critique to select one concept for further development
4. Begin developing the selected concept through:
   a. Advanced manipulation techniques to create more complex forms
   b. Detailed studies showing how manipulation enhances functionality
   c. Exploration of how multiple manipulated elements work together

Design Application & Refinement

1. Create comprehensive design visualisations showing.
   a. How manipulation techniques solve specific aspects of road safety challenges

   b. How simple forms become complex functional systems through manipulation
   c. Technical details showing manipulation-enabled functionality
2. Develop final presentation drawings highlighting object manipulation
3. Build a simple physical model demonstrating key manipulation principles
4. Prepare technical documentation of your solution

Final Presentation & Exhibition

1. Present your solution to the class (*5 minutes per group*)
2. Explicitly demonstrate how object manipulation techniques transformed simple natural forms into complex design solutions
3. Show how manipulation techniques directly address the societal problem of road safety for vulnerable users
4. Display your process work, final visualisations, and physical model
5. ***Deliverable***: Complete Object Manipulation Journey and Final Solution

Object Manipulation Requirements

Demonstrate mastery of manipulation techniques through:

1. Clear before/after documentation of manipulated forms
2. Multiple manipulation techniques applied to natural forms
3. Progressive complexity development through manipulation
4. Technical explanation of how manipulation enhances functionality
5. Strategic application of manipulation to solve specific design challenges

Visualisation Requirements

Demonstrate how manipulation creates complex solutions through:

1. Quality sketches showing transformation through manipulation
2. Detailed visualisations of how manipulated forms enable functionality
3. Clear connection between manipulation techniques and problem-solving
4. Innovative applications of manipulation to create complex systems
5. Physical model demonstrating manipulation principles

Table 2.1: *Prototype Construction Guide*

Stage	Steps	Materials	Techniques
1. Planning	• Create scale drawings • Identify key components • Plan visibility systems • Determine connection methods	• Graph paper • Tracing paper • Ruler and compass • Templates	• Scale drawing • Component mapping • Visibility diagramming
2. Base Construction	• Cut base elements to size • Mark component positions • Create mounting points • Build a supporting structure	• Plywood/MDF/ Foam board • Balsa wood • Adhesive • Cutting tools	• Measuring • Cutting • Joining • Reinforcing
3. Form Development	• Create primary forms from natural inspiration • Apply manipulation techniques • Build primary visibility surfaces • Form protective mechanisms	• Card stock • Clay/Plasticine • Wire mesh • Plastic sheet	• Folding • Moulding • Bending • Cutting/slicing
4. Safety System	• Create reflective elements • Develop a visibility system • Build protective components • Install flexible elements	• Reflective materials • Transparent containers • Flexible materials • High-contrast materials	• Drilling • Sealing • Connecting • Testing visibility
5. Surface Treatment	• Apply texture to surfaces • Add colour treatments • Create high-visibility patterns • Enhance visual elements	• Paint • Coloured paper • Reflective material • Finishes	• Painting • Collaging • Texturing • Finishing
6. Functionality Testing	• Test visibility • Verify protection capabilities • Check durability • Assess user comfort	• Light tests • Impact simulations • Measuring tool • Stopwatch	• Controlled testing • Measurement • Documentation • Refinement

Exhibition Requirements

Manipulation Process Display

1. Before/after sketches showing transformation through manipulation
2. Step-by-step manipulation technique documentation
3. Analysis of how manipulation enhances functionality
4. Comparison of simple forms versus complex outcomes

Design Development through Manipulation

1. Progressive sketches showing increasing complexity through manipulation
2. Multiple manipulation techniques applied to the same form
3. Final complex designs emerging from simple natural forms

Application Showcase

Detailed drawings showing the following.

a. How manipulation techniques solve specific road safety challenges
b. How simple forms become complex functional systems
c. How manipulation enhances visibility and protection
d. How multiple manipulated elements work together

Technical Documentation

1. Manipulation technique specifications
2. Material applications for manipulated forms
3. Functional diagrams showing manipulation-enabled features
4. Implementation and maintenance considerations

Physical Model

1. Clear demonstration of manipulation techniques
2. Functional representation of road safety principles
3. Accurate demonstration of simple-to-complex transformation
4. Interactive elements showing how manipulation enables enhanced safety.

Activity 1.2.3 Night Sight – A Biomimetic Road Safety Solution

As a member of a design team, you have been tasked with developing biomimetic road safety solutions to improve visibility and protection for pedestrians, cyclists, and motorcyclists in your community, particularly at night or in poor visibility conditions.

Apply object manipulation techniques to modify existing natural or man-made objects and create innovative road safety solutions inspired by natural visibility and protection systems.

Your solution must be:

1. Low-maintenance and durable
2. Constructed from locally available materials
3. Aesthetically pleasing and non-stigmatising
4. Capable of providing significant stability enhancement

Activity 1.2.4 Steady Step – A Biomimetic Elderly Mobility Aid

As a member of a design team, you have been tasked with developing biomimetic mobility aids to improve mobility, independence, and dignity for elderly community members who struggle with mobility challenges inspired by natural movement systems.

Apply object manipulation techniques to modify existing natural or man-made objects and create innovative mobility aids inspired by natural movement systems.

Your solution must be:

1. Low-maintenance and durable
2. Constructed from locally available materials
3. Aesthetically pleasing and user-friendly
4. Capable of providing significant safety enhancement in various weather and light conditions

EXTENDED READING

- Morling, K. (2010), Geometric and Engineering Drawing, Third Edition, London, Elsevier Publications Ltd. Pages 122-147 (Figure 10.9 – 10.23)
- Richards, J. (2013). Freehand Drawing and discovery: Urban Sketching and concept Drawing for Designers. USA. Wiley & Sons. Pages: 50 – 70.

REVIEW QUESTIONS

1. How can object manipulation techniques, inspired by natural forms, be used to achieve innovative design solutions?
2. Outline a step-by-step process for generating a simple design from a natural object using object manipulation techniques.
3. Evaluate the benefits and limitations of using object manipulation techniques to generate designs from natural objects.
4. How can designers balance the needs of different stakeholders when creating design interventions for societal problems?
5.
    a. Describe a scenario where a designer's intervention could have unintended consequences.
    b. How might a designer mitigate these consequences?
6. What are **two** potential benefits and **two** challenges involved in the community design process for societal problems?

UNIT 3: PATTERN DESIGN (COMPLEX 3D TEMPLATES AND PATTERNS)

Templates and Patterns

Introduction

When creating three-dimensional freehand templates and patterns, you need to follow a clear process from preparation to completion. First, you must select the right drawing materials and tools—such as pencils, markers, erasers, and paper—to ensure your designs are accurate and clear. Next, you should develop appropriate frameworks like grids, guidelines, and perspective lines to establish structure and proportion.

These frameworks will help you integrate the necessary elements for shaping precise 3D forms. Finally, you will refine and complete your design by adding details, shading, outlines, and labels to produce a polished and functional template. By following these steps, you will strengthen both your technical drawing skills and creative problem-solving abilities, enabling you to transform simple ideas into accurate, visually clear, and practical three-dimensional designs.

KEY IDEAS

- **Material and Tool Selection:** Begin by identifying and selecting suitable drawing materials such as pencils, markers, and various types of paper, alongside essential tools like rulers, compasses, and erasers to ensure the creation of accurate freehand sketches.
- **Application in 3D Drawing:** Effectively use the chosen materials and tools to create three-dimensional freehand templates and patterns that showcase depth and volume.
- **Framework Development:** Construct foundational drawing structures, including grids, guidelines, and axes, to help achieve precision in three-dimensional freehand artwork.
- **Integration of Elements:** Incorporate essential features such as proportions, perspectives, and reference points to develop clear and functional 3D templates and patterns.
- **Refinement and Accuracy:** Continuously review and adjust the three-dimensional template or pattern, ensuring that proportions, details, and perspectives are accurate and well-defined.
- **Completion of Design:** Finally, enhance the design by adding finishing touches such as outlines, shading, and labelling to create a clear and polished 3D presentation.

SIMPLE TO COMPLEX 3-D FREEHAND TEMPLATES AND PATTERNS DRAWING TECHNIQUES

Complex 3-D Freehand Templates and Patterns Drawing Techniques

Complex 3D freehand templates and patterns are advanced drawing methods used by artists and designers to produce detailed three-dimensional representations by hand. Unlike simple sketches, these techniques provide accurate guides that help designers visualise complex forms and serve as foundations for constructing physical objects.

Importance of These Techniques

1. They develop crucial spatial thinking skills, helping learners understand how objects exist in three dimensions—a fundamental ability for careers in design, architecture, and engineering.

   Unlike computer-aided design, freehand techniques build a deep, intuitive understanding of form and space that transfers across all design disciplines.

2. The inherent techniques bridge the gap between imagination and reality. Learners discover how to translate abstract ideas into concrete plans that can be followed to create physical objects.

   This translation process requires advanced problem-solving skills as learners work out how complex forms can be broken down into manageable components.

3. These techniques preserve important traditional design methods that remain relevant in our digital age. Many professional designers still begin with hand-drawn concepts before resorting to digital tools.

4. Freehand techniques are accessible to most learners regardless of access to technology, making advanced design skills available in diverse educational settings while building confidence through the mastery of challenging techniques that produce tangible results.

Significance of Complex 3D Freehand Templates and Patterns

Complex 3-D freehand templates and patterns are vital skills that provide essential foundations for numerous design professions and creative practices.

1. These techniques enable designers to visualise ideas before expensive production, saving crucial resources and time.

2. They develop cognitive abilities, including spatial reasoning and problem-solving, that transfer across all design fields.
3. In an environment where technology is limited, unreliable, or unavailable, these hand skills ensure design work can continue without interruption.
4. They preserve cultural knowledge and traditional craft techniques that might otherwise be lost.

Key Techniques

The key techniques include

1. **Cross-section drawing showing internal structures**

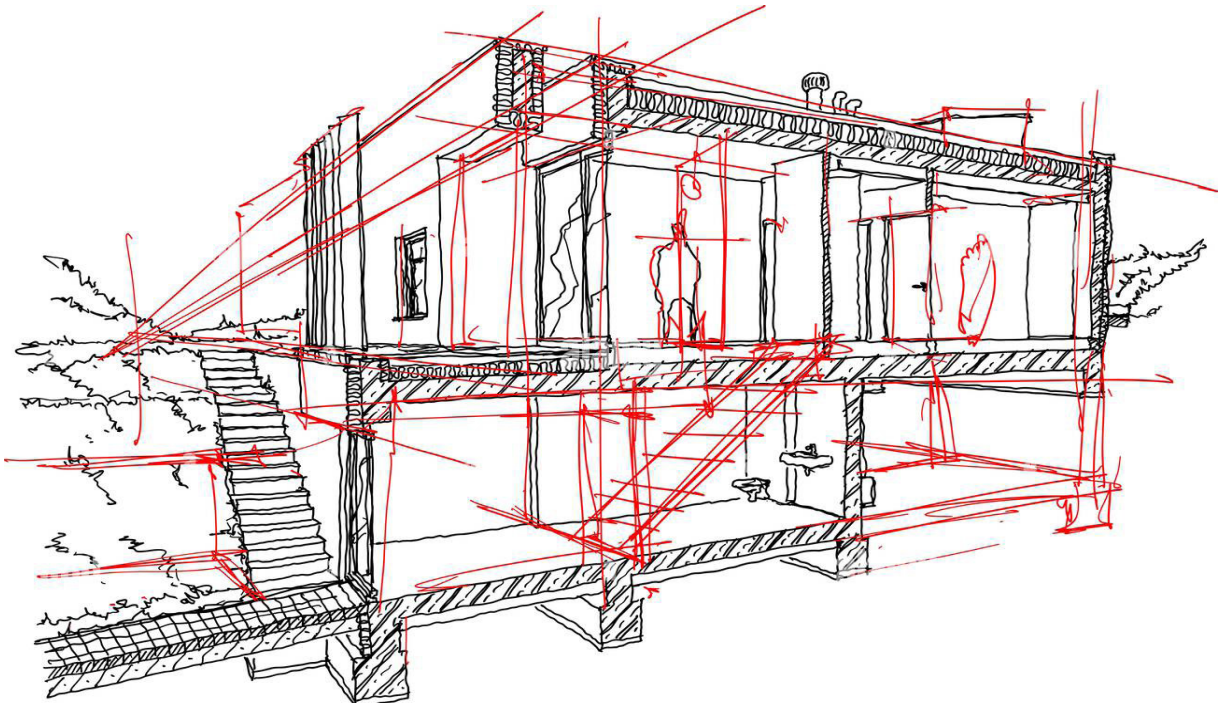


Figure 1.3.1: Architectural sketch of section of modern two-story detached house with flat roof and garden

2. **Net development (flattening 3D forms into 2D patterns that can be cut and folded)**

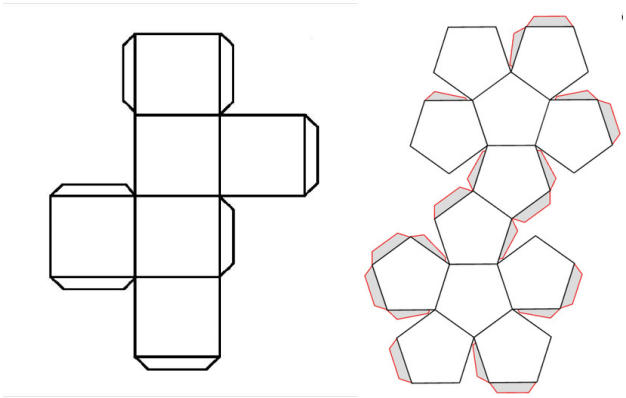


Figure 1.3.2: Archimedean Cube and Dodecahedron

3. Orthographic projection (showing multiple views of an object)

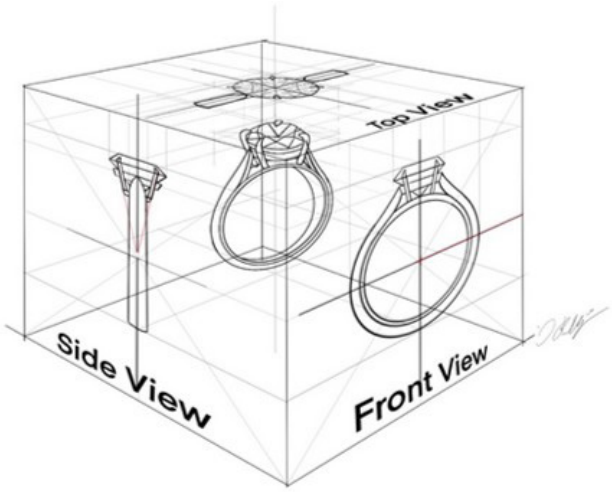


Figure 1.3.3: Orthographic Drawing to Perspective Drawing

4. Exploded views (showing assembly relationships)

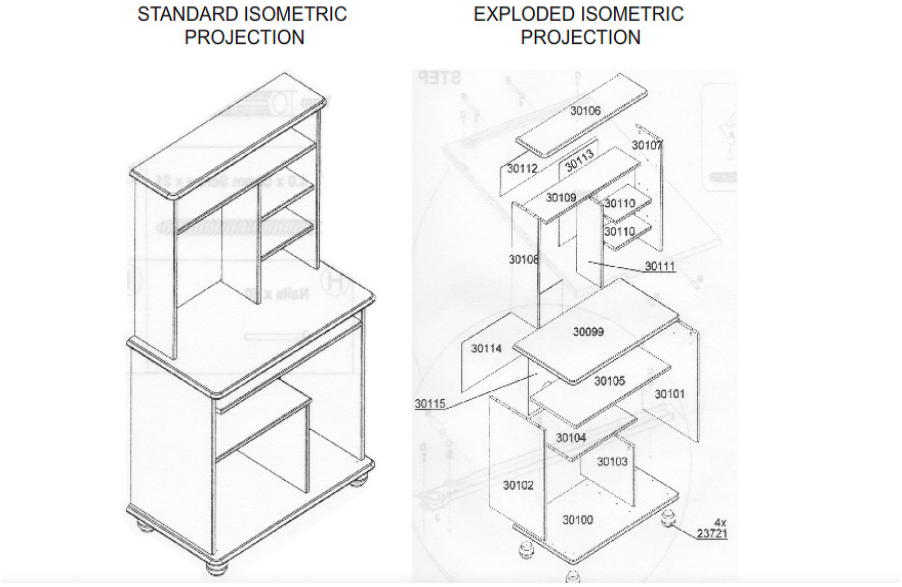


Figure 1.3.4: Isometric Drawing and Exploded Drawing

5. Vanishing point perspective (creating realistic depth).

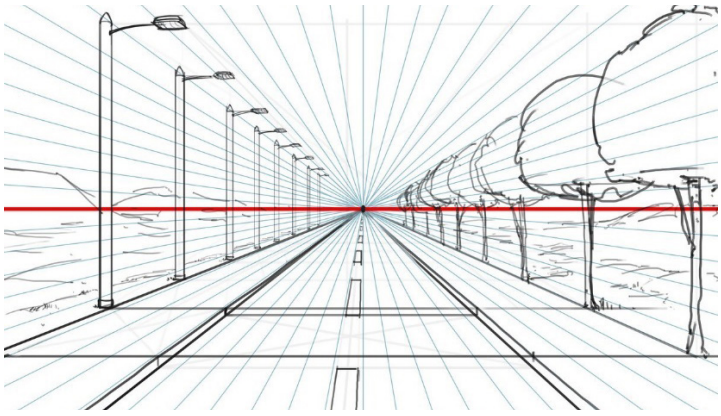


Figure 1.3.5: Perspective Drawing with vanishing point

Key Characteristics of the Technique

1. **Layered Complexity**

   The design evolves from simple frameworks to complex, multi-dimensional structures, often incorporating cultural motifs or symbolic references**.**

2. **Iterative Refinement**

   Each stage of development refines the previous, ensuring structural and aesthetic coherence.

3. **Spatial Interplay**

   Focus on the relationship between form, void, and viewer interaction, often exploring cultural narratives and local materials.

Examples and Applications

Historical Influences

1. **Gothic cathedrals** exhibit a range of complex design phenomena. The Notre-Dame de Paris, which combines structural elements like pointed arches with intricate façades, is a great example.

   These complex architectural feats, along with numerous examples from the classical world, are relevant as they established the foundation for integrating complexity into functional frameworks.



Figure 1.3.6a: Notre Dame de Paris (Exterior)

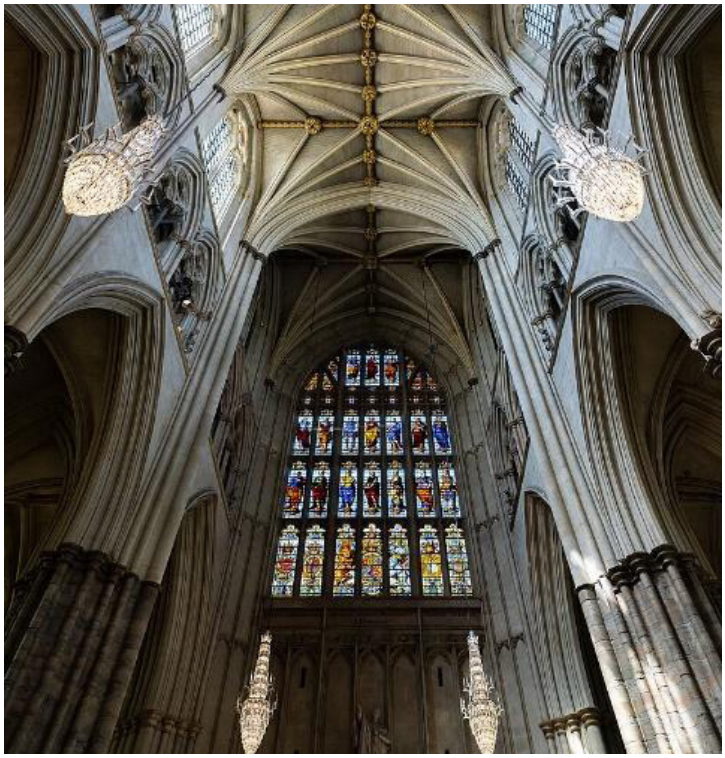


Figure 1.3.6b: Westminster Abbey (Interior - cross barrel-vault ceiling), London.

2. African Vernacular Architecture

An example is the Great Mosque of Djenné in Mali, which demonstrates a complex-to-complex approach with a mud-based skeletal structure adorned with intricate sculptural protrusions.



Figure 1.3.7a: The Aksum Obelisk, in Aksum (Tigray Region, Ethiopia)



Figure 1.3.7b: Great Mud Mosque of Djenne, Mali

Designers who rely on these skills include those discussed below.

Abrima Erwiah

Ghanaian fashion designer Abrima Erwiah of Studio One Eighty-Nine uses hand-drafted patterns to create garments that support traditional textile crafts.





Figure 1.3.8: Ebrima Erwiah of Studio 189

David Adjaye (Ghanaian British Architect)

Works at the National Museum of African American History and Culture, Washington, D.C.



Figure 1.3.8a: Complex Framework - Inspired by Yoruba crown designs.

Adjaye's work uses geometric patterns to merge cultural significance with modern structural techniques.

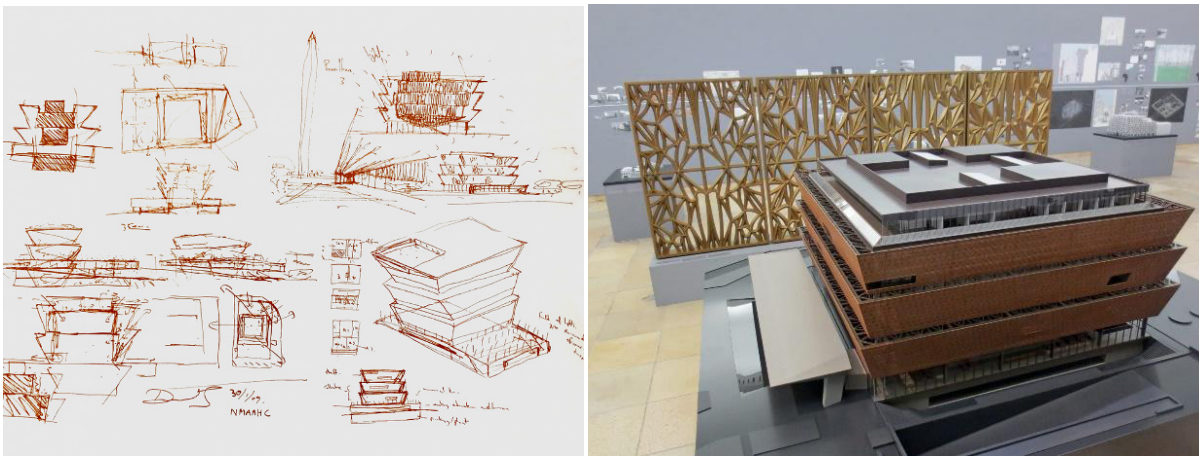


Figure 1.3.8b: Cultural Innovation.

Combines layered facade systems with bold interior spaces, creating dynamic spatial experiences.



Figure 1.3.8c: Werk 5 – New Craft



Figure 1.3.9: Abrahamic Family House, with all three spaces in view by Adjaye Associates. Photograph by Adjaye Associates

Francis Kéré (Burkina Faso)

1. Gando Primary School, Burkina Faso

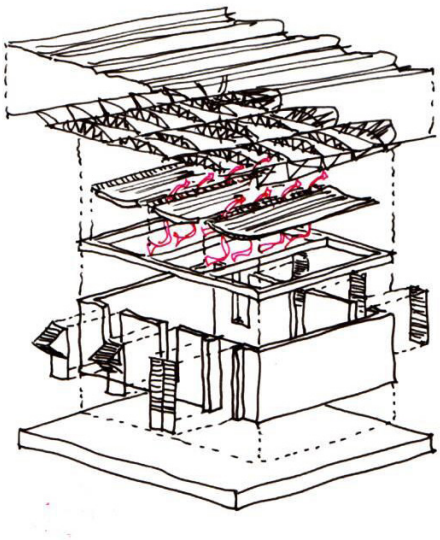


Figure 1.3.10a: Complex Framework - Uses locally sourced materials such as clay and timber to create intricate yet functional designs.



Figure 1.3.10b: Sustainability.

Incorporates natural ventilation systems and layered construction techniques that align with both cultural and environmental contexts.



Figure 1.3.10c: Dano Secondary School, Burkina Faso, Kéré Architecture. Photo by Erik-Jan Ouwerkerk.

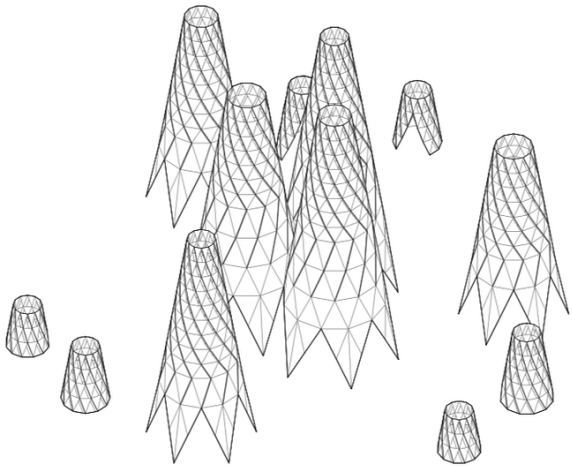


Figure 1.3.11: The Coachella Installation 2019



Figure 1.3.12: Installation drawings of Sarbalé Ke. Image © Francis Kéré



Figure 1.3.13: Sarbalé Ke by Francis Kéré at the Coachella Valley Music and Arts Festival 2019, photo by Iwan Baan.

Simphiwe Mbunyuza (South African Sculptor)



Figure 1.3.14a: Simphiwe Mbunyuza (2023)

Sculptural works combining ceramics and metal to explore African identity, exploring African cultural symbolism through functional and non-functional ceramic pots,

delving into relationships and interactions within African culture, with special focus on Xhosa people.



Figure 1.3.14 b: Complex Technique.

Starts with abstracted traditional forms, refining them into highly detailed, tactile sculptures that engage with contemporary issues.

Mariam Kamara (Nigerian Architect – f. Atelier Masōmī)



(a) **(b)**

Figure 1.3.15: Niamey Cultural Centre Complex-to-Complex Application.

Integrates traditional Hausa architectural motifs into a modern design, transitioning from geometric 2D sketches to dynamic 3D forms.

1. Atelier Masōmī, Making of an Artisan's Valley, Venice Architecture Biennale, 2021.

2. Atelier Masōmī uses colourful metal canopies to build Dandaji Market in Niger, 2018.

Global Practitioners

Antoni Gaudí

Example: Sagrada Família combines organic forms with structural innovation.



Figure 1.3.16a: Antoni Gaudí, Freehand Sketch, 1905



Figure 1.3.16b: Sagrada Familia Basílica

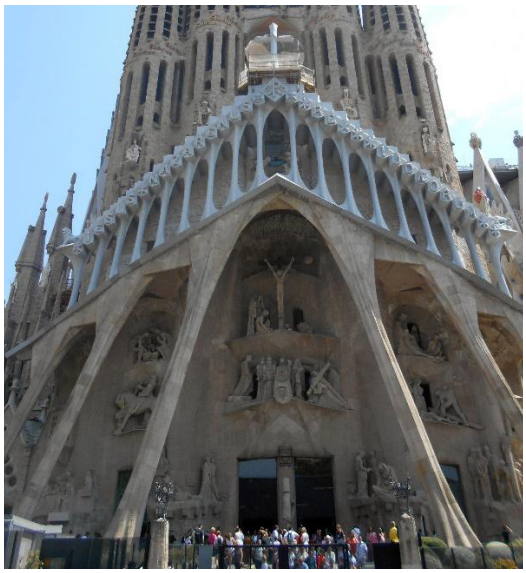


Figure 1.3.16 c: Sagrada Família, Façade, in 2018

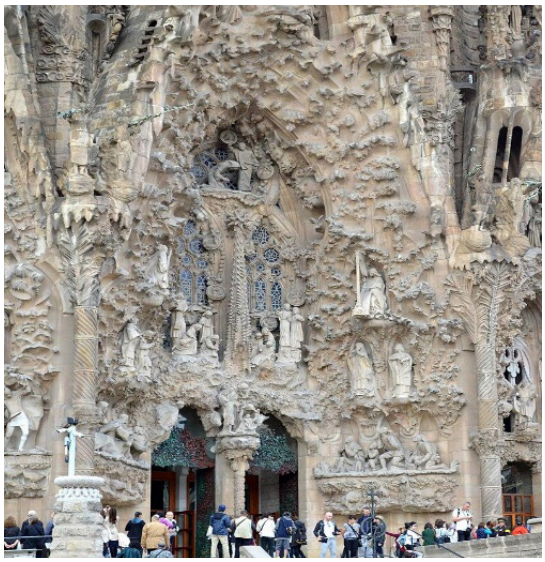


Figure 1.3.16d: Portal of Charity on the Passion Nativity Façade, created by Etsuro Sotoo

Frank Gehry Sketch, ca. 1991

Example: Guggenheim Museum Bilbao showcases flowing, dynamic forms derived from a skeletal framework.

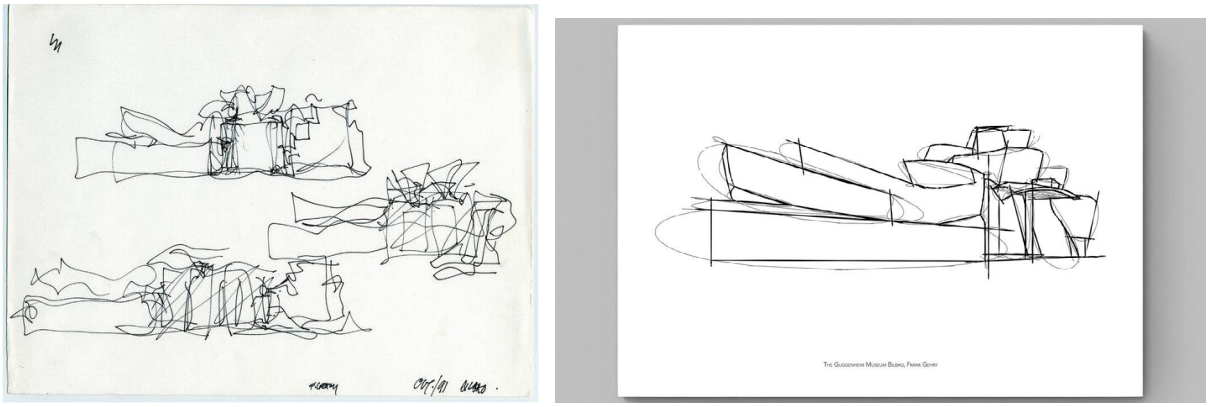


Figure 1.3.17: Guggenheim Museum Bilbao Project Sketch _026. Copyright: Frank O Gehry, 1991. Image courtesy of Gehry Partners, LLP.

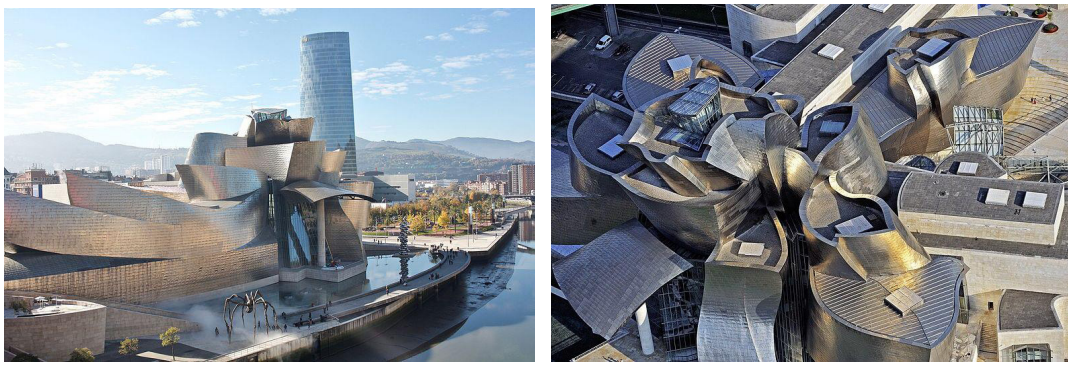


Figure 1.3.18: Guggenheim Museum, Bilbao and Aerial view of the museum

Zaha Hadid

Example

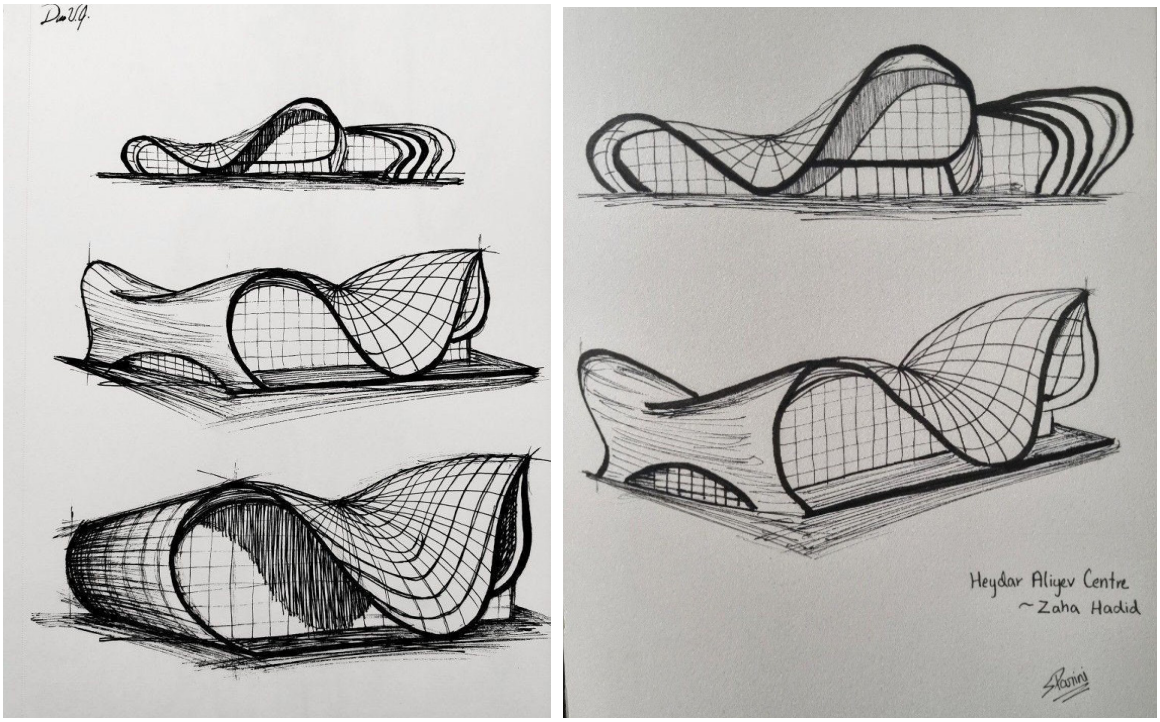


Figure 1.3.19: Hadid's designs explore fluid geometries.

Hadid's designs explore fluid geometries, evolving simple shapes into complex spatial compositions. For Hadid, painting was a design tool, and abstraction an investigative structure for imagining architecture and its relationship to the world we live in.



Figure 1.3.20a: Exteriors



Figure 1.3.20b: Exteriors and Interiors of Heydar Aliyev Cultural Centre (2012), Baku, Azerbaijan.

Alexander McQueen

The late British fashion designer was renowned for his revolutionary pattern-cutting techniques. His complex 3D templates enabled the structural garments that defined his collections. McQueen would develop complex paper patterns by hand before any fabric was cut, allowing him to create his signature sculptural silhouettes.



Figure 1.3.21: Sketchbook spread from McQueen's 'Savage Beauty' exhibition at the Met



Figure 1.3.22a: Widows of Culloden by Alexander McQueen



Figure 1.3.22b: Widows of Culloden, Fall 2006, Met Exhibition

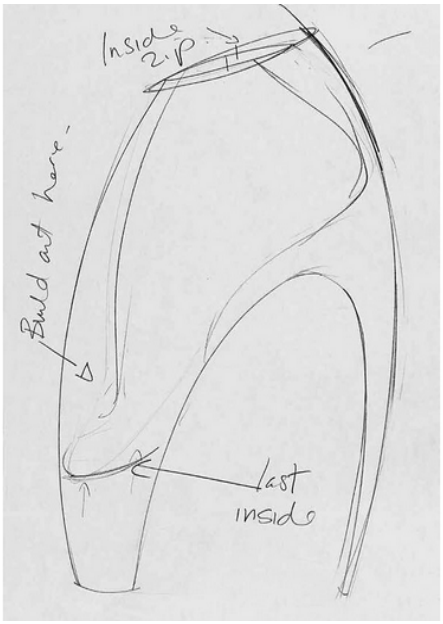


Figure 1.3.22c: The Armadillo Boot by Alexander McQueen, 2009



Figure 1.3.22d: Armadillo Shoes in a Catwalk, 2009

George Nakashima, the influential furniture designer

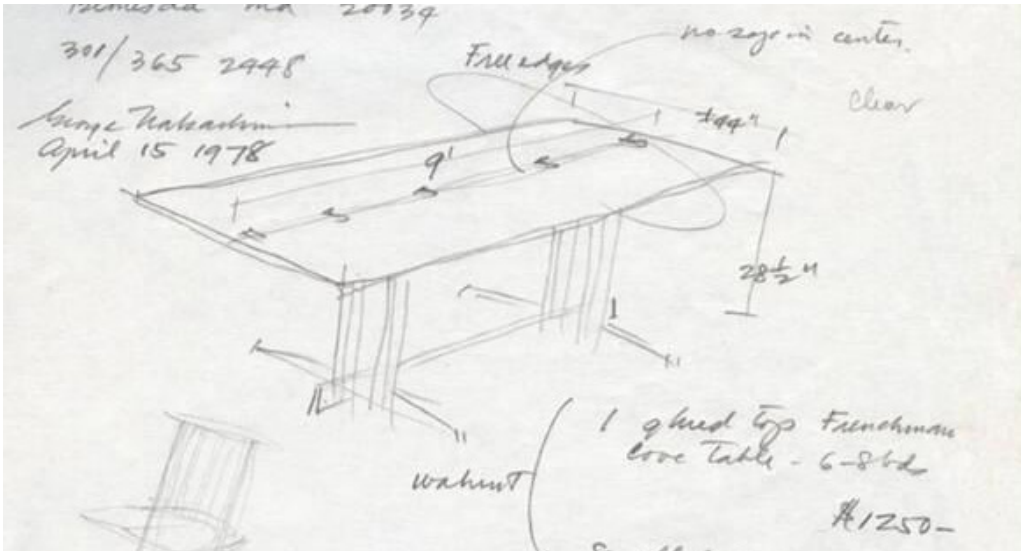


Figure 1.3.23a: The process involved creating full-scale patterns that responded to each unique piece of wood.



Figure 1.3.23b: George Nakashima, the influential furniture designer, relied exclusively on hand-drawn templates to create his signature woodwork.

His process involved creating full-scale patterns that responded to each unique piece of wood.

SIMPLE TO COMPLEX TECHNIQUES

Translating, Converting, and Permuting Simple to Complex Techniques

The Progression Pathway

The structured approach allows learners to develop spatial reasoning and technical skills to create complex 3D templates that accurately represent sophisticated designs while remaining practical construction guides. This systematic progression builds skills from simple to complex template techniques.

Basic Translation Techniques

Simple flat shapes are first translated into three-dimensional forms through fundamental techniques.

1. **Extrusion**: extending a 2D shape along a third axis (e.g., circle to cylinder)
2. **Revolution**: rotating a profile around an axis to create a form (e.g., semicircle to sphere)
3. **Stacking**: building layers to create depth and form
4. **Contour drawing:** using parallel lines to show surface curvature

Conversion Methods

Convert between different representational systems by:

1. converting orthographic views (top, front, side) into isometric drawings
2. transforming 2D nets into visualised 3D objects through folding lines
3. shifting between cross-sections to understand internal structures
4. translating measurement drawings into proportional sketches

Complex Permutations

Advanced techniques involve permutating and combining multiple approaches of

1. hybrid projection systems that mix perspective and orthographic elements
2. exploded axonometric drawings showing assembly relationships
3. compound curvature representation through grid deformation techniques
4. nested forms with transparent outer layers showing internal components

Practical Application Process

The practical process typically follows this sequence:

1. Begin with simple geometric primitives (cubes, cylinders, spheres);
2. Progress to compound forms created by joining primitives;
3. Introduce curved surfaces and organic forms;
4. Develop complex assemblies with multiple interrelated components;
5. Create templates that include internal mechanisms and moving parts.

Advancing from Complex to Hyper-Complex 3D

Evolutionary Design Processes

1. **Iterative complexity:** Taking existing complex 3D free-hand designs and systematically increasing their intricacy through multiple iterations

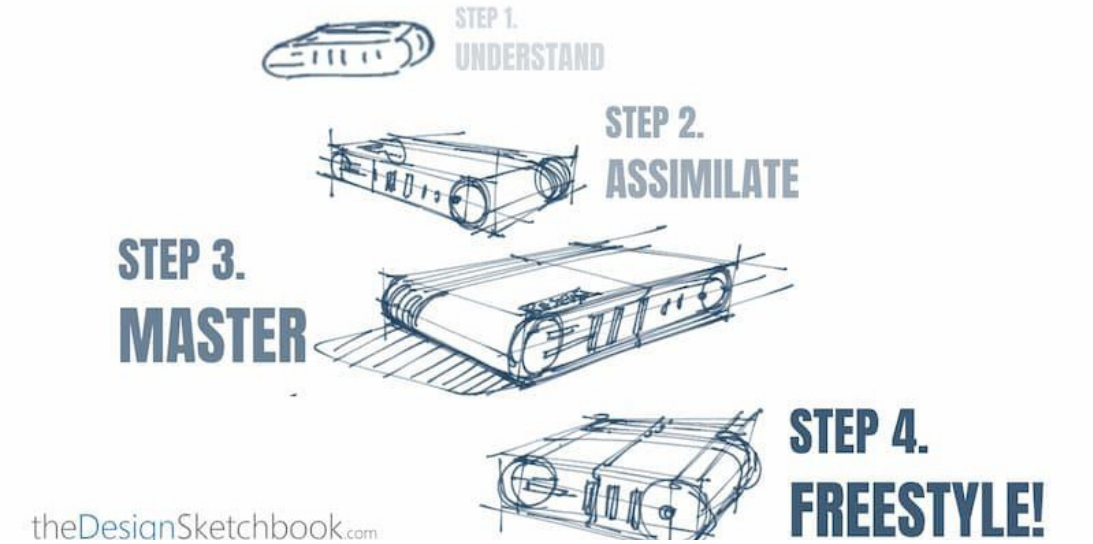
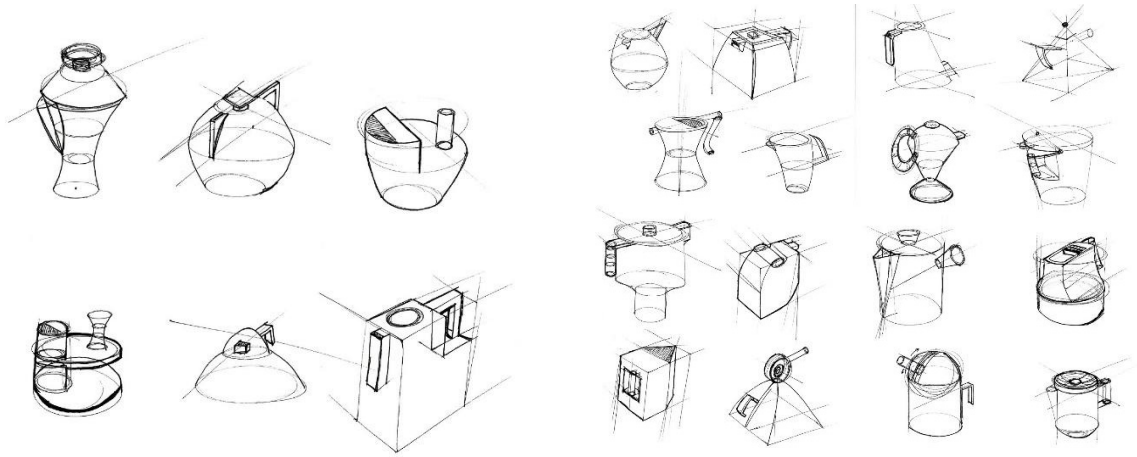


Figure 1.3.24: Draw It 4 Times

Draw it many times differently or draw the same thing differently incrementally.



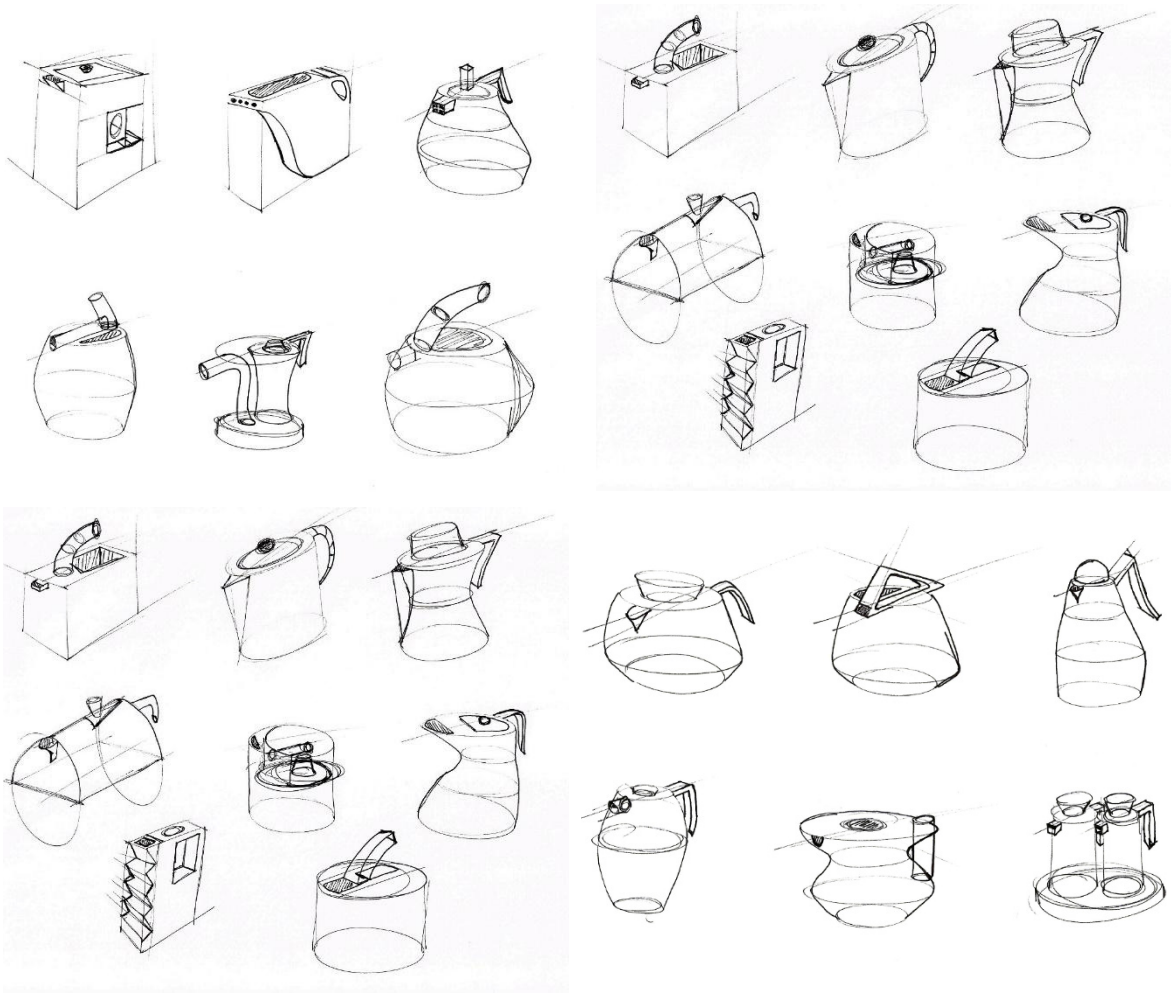


Figure 1.3.25: Kettle Iterations (Different types of iterations)

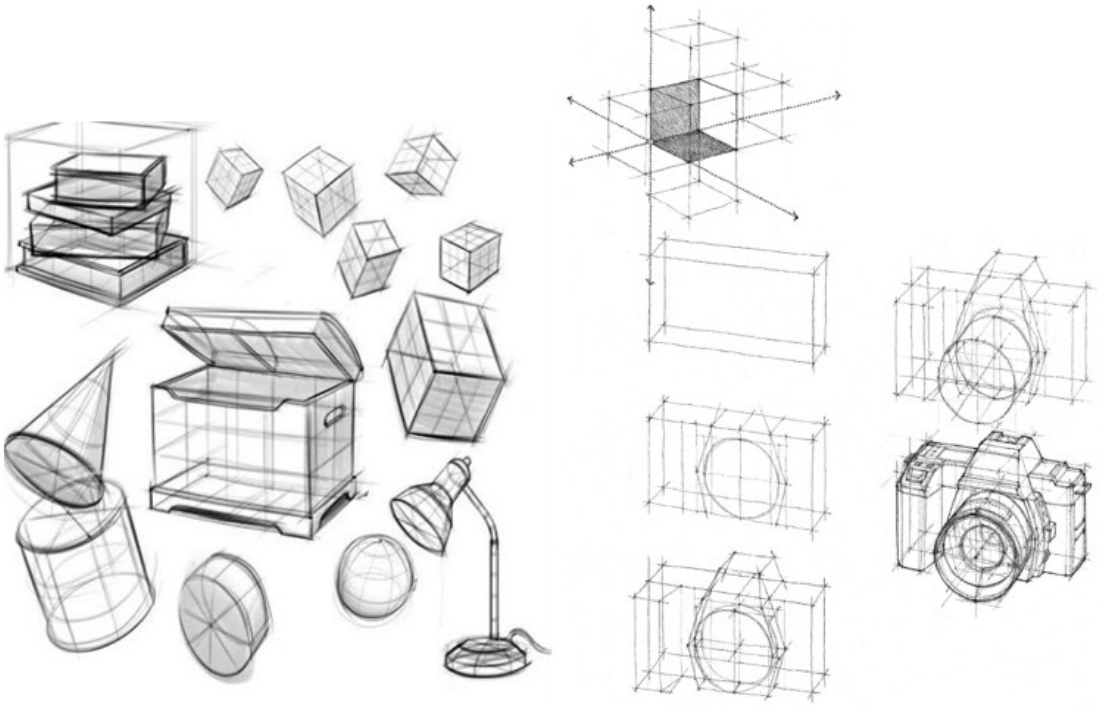


Figure 1.3.26: Drawing through the form. Thinking 3-dimensionally

2. Dimensional layering: Adding nested dimensions within an already complex 3D structure

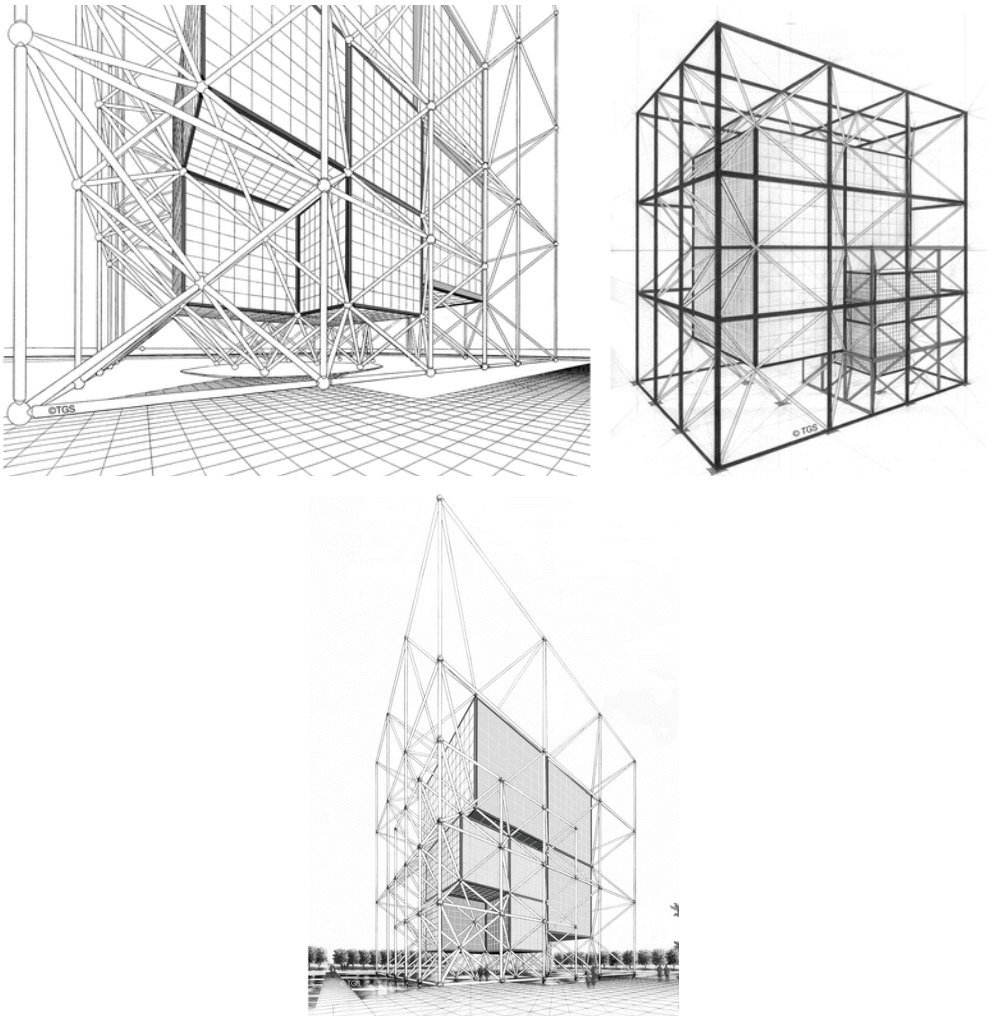


Figure 1.3.27: Fractal Hypercube-Building Fractal-inspired development.

Incorporating self-similar patterns at different scales within the same 3D framework.

Advanced Free-Hand Techniques

1. **Multi-perspective integration:** Creating drawings that simultaneously represent multiple viewpoints of a complex 3D form

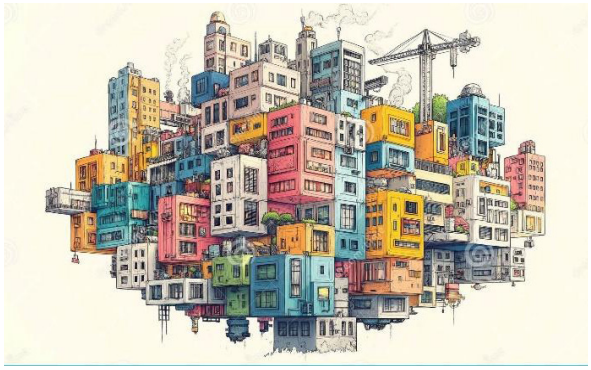


Figure 1.3.28a: Generative AI. Colourful, imaginative depiction of a floating city composed of various interconnected, stacked buildings in diverse shapes and sizes.

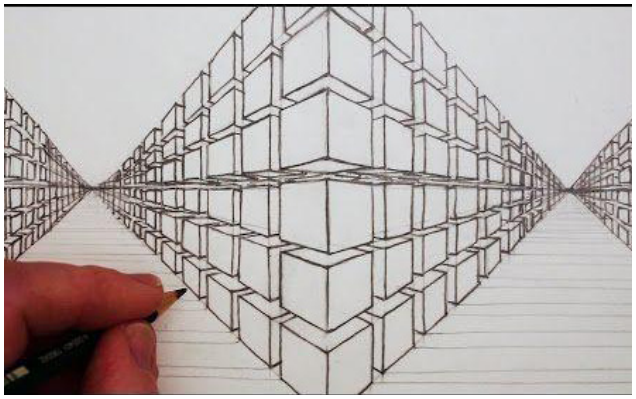


Figure 1.3.28b: Perspective

2. **Cross-sectional mapping:** Developing detailed interior structures that complement exterior complexity.



Figure 1.3.29a: Sectional diagrams.

These reveal internal structures, materials, and spatial relationships while integrating exterior factors, aesthetics and context to ensure optimal design and functionality.

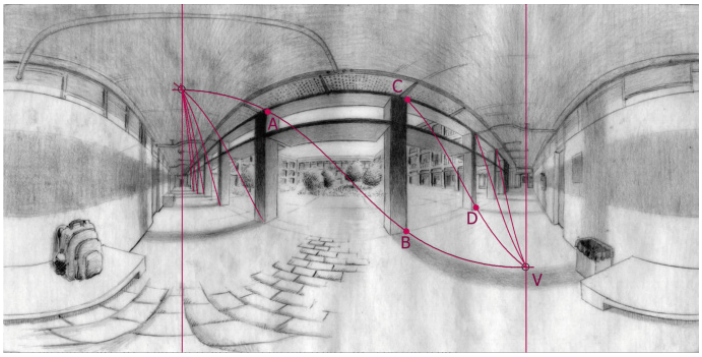


Figure 1.3.29b: Internal Spherical

A case for internal spherical perspective that combines conical anamorphisms with a compact visual sphere flattening, offering mathematical and artistic applications.

3. **Negative space articulation:** Defining complex forms through the careful rendering of spaces between structural elements.

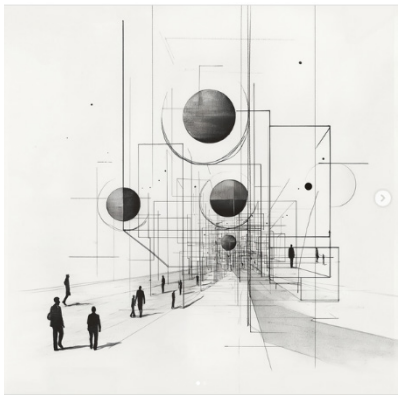


Figure 1.3.30a: Architectural diagrams

The architectural diagrams depict a futuristic floating grid of circles and squares, interconnected by thin metal structures, which blend minimalist design with a balance of structure and openness.



Figure 1.3.30b: The “Curvilinear Atrium”

This sketch envisions a vibrant shopping mall with sweeping curves, bold colours, and a dynamic design that reimagines the commercial interior as a living organism.



Figure 1.3.30c: The “Fluid Retail Loop”

This sketch reimagines a shopping mall interior as a space of dynamic movement and playful spatial interaction.

Tetrix-inspired Concepts

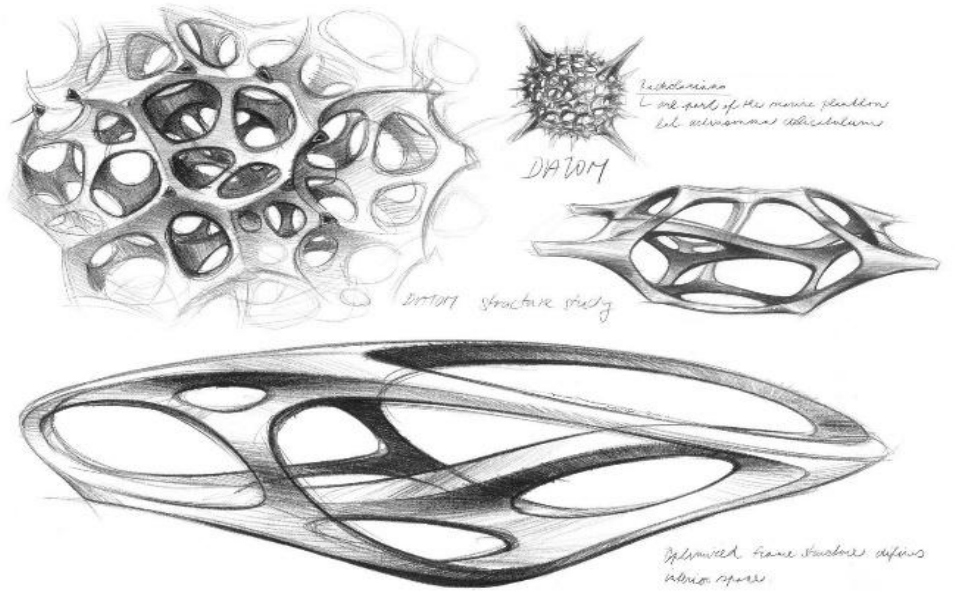


Figure 1.3.31: Mercedes-Benz Interior Space Conceptual Sculpture

Experimental Approaches

1. **Deconstructive drawing:** Breaking down complex 3D forms and reassembling them in more intricate configurations

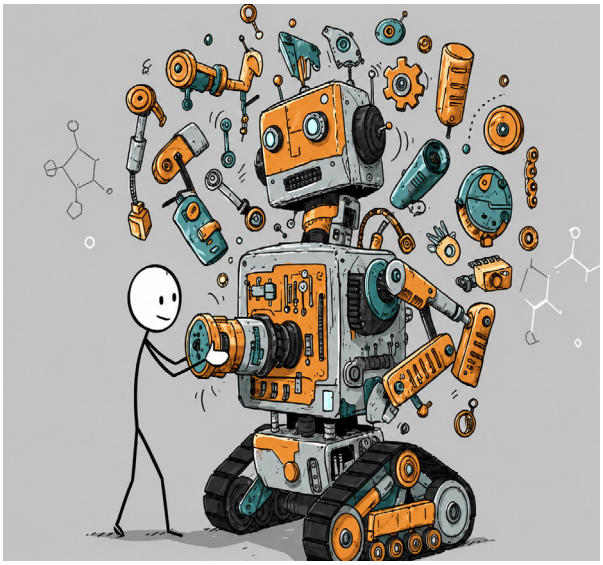


Figure 1.3.32a: Assembling a robot with floating components

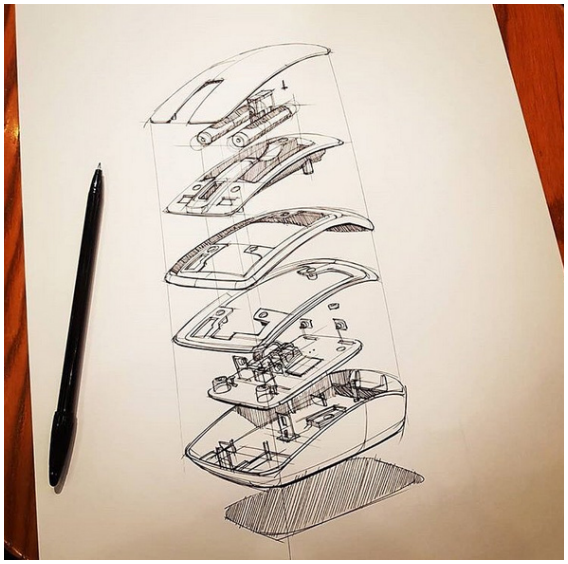


Figure 1.3.32b: Deconstructed sketch of a computer mouse by @wanku.

2. **Metamorphic progression:** Documenting the transformation of one complex 3D form into another more elaborate structure

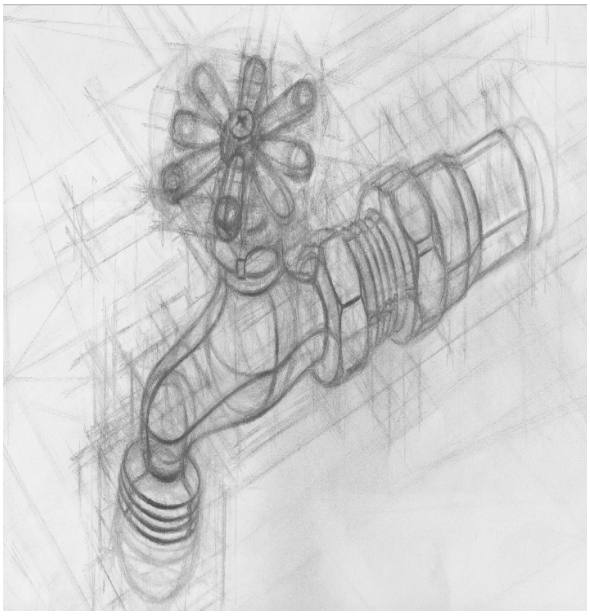


Figure 1.3.33a: Cecila Ramay Complex

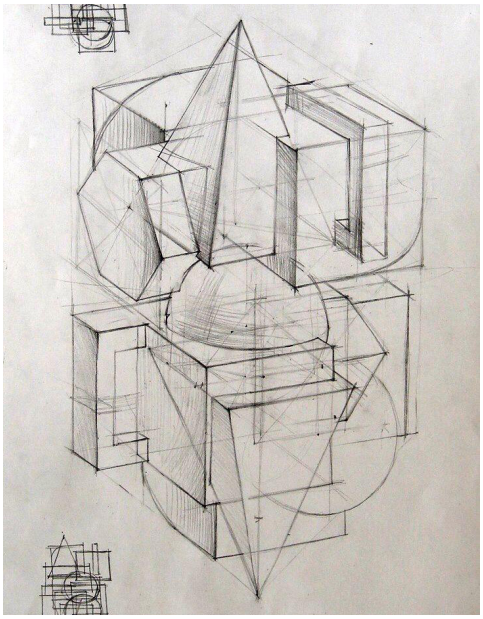
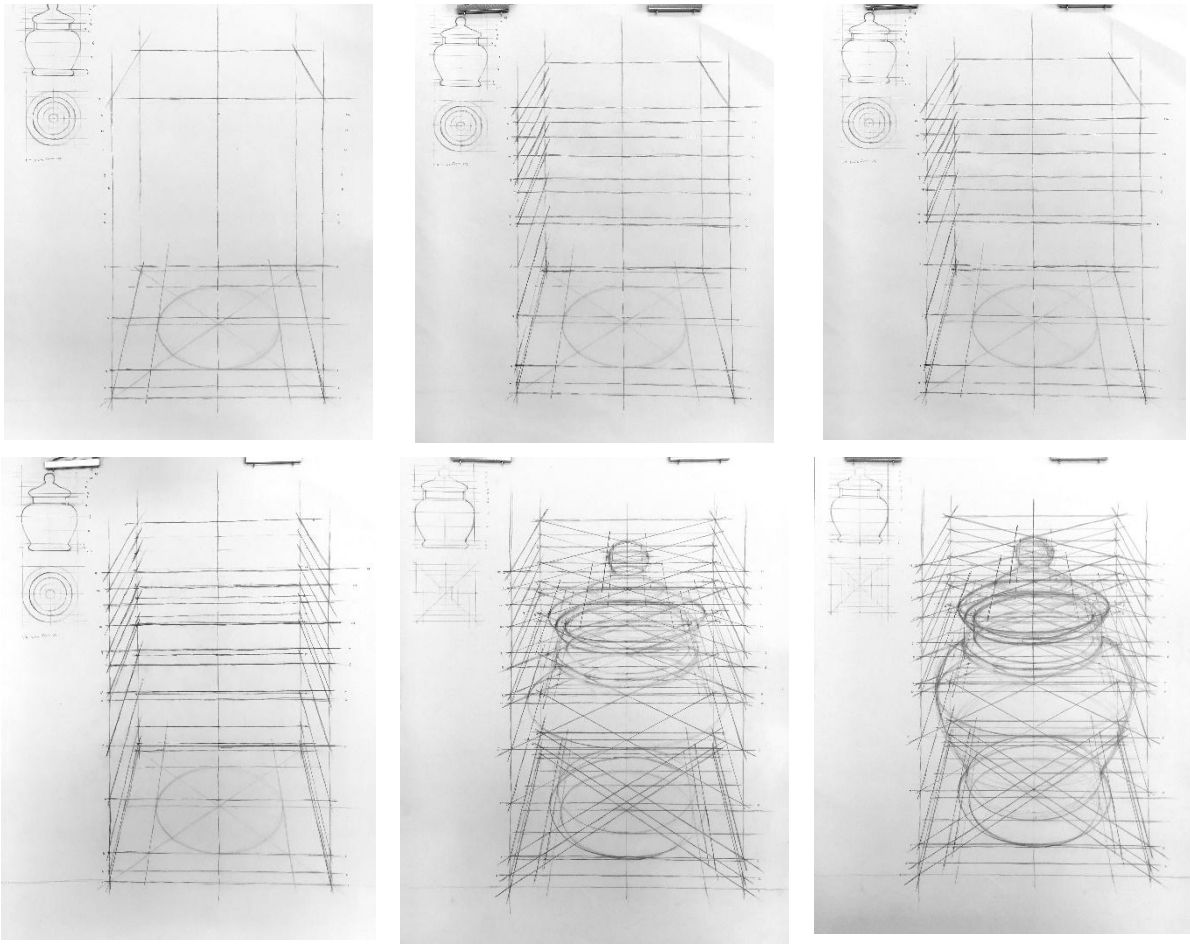


Figure 1.3.33b: Object Fusion

Object Drawing

3. **Spatial narrative development:** Creating sequences of drawings that show how complex forms evolve through space and context



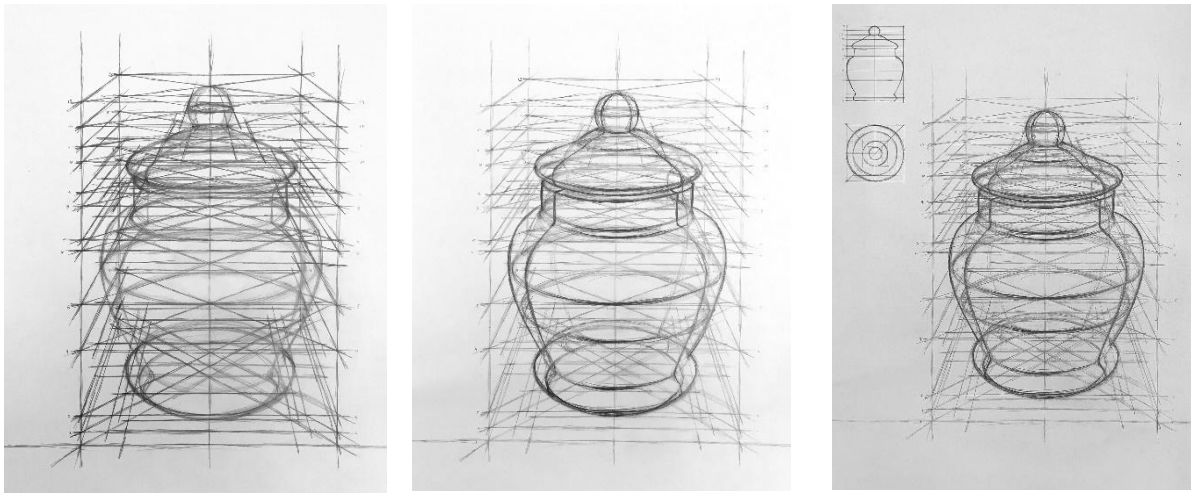


Figure 1.3.34: Keith Wash Complex to Complex Objects

Project Brief 1

You are asked to design reusable food packaging for a local bakery. The packaging should keep products fresh, reduce waste, and be easy to reuse.

1. Use freehand drawings to create and develop your design ideas.
2. Turn your sketches into 3D packaging templates that can be reproduced for testing (dummy manufacturing).
3. Include indigenous patterns, symbols, and colours to reflect local culture while also meeting modern sustainability needs.

Steps / Activity Flow

1. Selects a local food product (e.g., bread, cocoa, fruits, shea butter).
2. Research & Inspiration
   a. Identify indigenous symbols, patterns, and colours that represent local culture (e.g., Adinkra, kente, or traditional motifs).
   b. Discuss how these symbols can show values like sustainability, unity, or heritage.
3. Freehand Sketching
   a. Sketch 3 rough ideas for packaging (box, wrapper, or container).
   b. Highlight how indigenous patterns and sustainable features (reusability, eco- friendly materials) are included.
4. Selection & Refinement
   a. Choose the best sketch.
   b. Refine it into a clear freehand drawing with visible details of folds, cuts, and design elements.

5. Template & Pattern Development
   a. Convert the sketch into a flat pattern (net) for packaging.
   b. Mark cutting lines, folding lines, and decoration zones where indigenous motifs will be applied.
6. Mini-Exhibition & Feedback
   a. Present your final template and explain:
   b. How it reflects local culture
   c. How it supports sustainability

Appropriate 3-D Freehand Templates and Patterns Drawing Techniques

To create accurate three-dimensional designs, you need to apply the right freehand drawing techniques. These techniques guide you in developing clear templates and patterns that form the basis for constructing or visualising complex objects.

Elements and Principles of Complex 3D Pattern Drawing for Object Construction

Focus: Designing patterns that translate into three-dimensional forms or embellishments.

Elements

1. ***3D Geometry:*** Incorporating spheres, cubes, and other solids into patterns.
2. ***Surface Patterns:*** Applying 2D designs onto 3D surfaces, accounting for curvature and distortion.
3. ***Depth and Layering:*** Adding dimensionality by stacking or offsetting pattern elements.
4. ***Materiality:*** Patterns influence how light interacts with 3D objects (e.g., matte vs glossy).

Principles

1. ***Continuity***: Ensuring patterns flow seamlessly over 3D surfaces.
2. ***Perspective***: Adjusting design elements to account for viewer angles and object orientation.
3. ***Scale***: Balancing the pattern's size with the object's volume.

Example: Designing the façade of a building where geometric patterns create shadows and textures based on light direction.

Elements and Principles of Complex Pattern Drawing (3D)

Focus: Creating patterns that exist as standalone 3D objects or sculptural forms.

Elements

1. ***Volume***: Patterns extend into space, forming intricate structures (e.g., lattice or mesh).
2. ***Structural Strength:*** Patterns function as part of the object's framework, not just decoration.
3. ***Interaction***: The design responds to the environment (light, air, or touch).

Principles

1. ***Balance***: Ensuring the pattern maintains structural integrity in 3D.
2. ***Tessellation***: Repeating units fit seamlessly in three dimensions.
3. ***Dynamic Flow:*** Patterns guide the eye or create movement within the space.

Example: A 3D-printed pavilion featuring interlocking cellular patterns.

Elements and Principles of Complex Object Construction (3D)

Focus: Integrating patterns into the structural and aesthetic design of three-dimensional objects.

Elements

1. ***Internal Framework:*** Patterns inform the object's internal support system.
2. ***Surface Modulation:*** Textures and patterns enhance visual appeal and functionality (e.g., grip or aerodynamics).
3. ***Material Properties:*** The Choice of material dictates how patterns are expressed in 3D.

Principles

1. *Form and Function:* Patterns must serve a purpose, such as reducing weight or adding strength.
2. *Spatial Efficiency:* Patterns optimise the use of 3D space within and around the object.
3. *Interaction*: Users engage with the patterns through touch or movement.

Example: A parametric chair design where the backrest features a perforated pattern that adds flexibility and reduces weight.

Principles of Template Appropriation (3D)

Focus: Using templates to create 3D designs or objects while introducing unique adaptations.

Principles

1. ***3D Mapping:*** Adapting 2D templates for 3D forms (e.g., unfolding a 3D shape into a flat template for fabrication).
2. ***Transformation***: Using templates to guide shape transformations (e.g., scaling or morphing).
3. ***Precision***: Templates must account for material thickness and assembly tolerances. For example, a fashion designer uses a flat fabric template and reinterprets it into a 3D garment using draping techniques.

Examples

1. ***Parametric Architecture:*** A pavilion with tessellated patterns that adapt to sunlight, creating shaded spaces.



Figure 1.3.32: The Pentaura Pavilion

This is a timber umbrella made to give students and teachers at Escola Turó de Can Mates, a primary school in Sant Cugat del Vallès, Spain, a place to hang out and get shade from the sun.



Figure 1.3.33: Sculptural Design.

A 3D-printed vase with flowing patterns that change density along its surface.



Figure 1.3.34: Honeycomb Grille Compatible for Audi A3 S3 2017 2018 2019 2020

Industrial Design: Car grills featuring honeycomb patterns that combine aesthetics with aerodynamics.

When these principles are applied in 3D templates and patterns, they add a deeper level of complexity and functionality, allowing patterns to become integral to both the form and purpose of the object.

Activity 1.3.1 Template Development and Materials Sourcing

As a furniture designer, you have been tasked with creating a stool that incorporates indigenous patterns, symbols, and colours, with the outcome being production-ready templates for furniture dummies for a fashion boutique. Your design process must demonstrate how hand-drawn 3D templates evolve into reproducible production templates suitable for creating scale models and full-size mock-ups.

Designing a Stool with Indigenous Patterns

Step 1

1. Sketch indigenous **patterns, colours, and symbols** (e.g., Adinkra, kente, local carvings).
2. **Discuss**: How can these cultural elements be applied to a stool?

Step 2

Draw 2–3 quick stool sketches.

1. Show where cultural motifs and colours will appear (legs, seat, supports).
2. Focus on both functionality and aesthetic appeal.

Step 3

Share sketches within your group.

1. Vote or agree on the best stool idea to refine further.
2. Explain why this design was chosen.

Step 4

1. Refine the chosen sketch into a 3D freehand drawing.
2. Break the stool into basic parts (legs, seat, supports).
3. Draw each part as a flat template showing dimensions, fold lines, and decoration zones.

Step 5

1. Use cardboard, stiff paper, or lightweight material to cut out your templates.
2. Assemble them into a scale model (mini stool dummy).
3. Apply patterns and colours to test the cultural design.

Step 6

Each group presents their stool dummy and explains:

1. How it incorporates indigenous culture.
2. How the 3D sketches became templates.

3. How the design could be reproduced as a full-size stool mock-up.

Activity 1.3.2 Production-Ready Templates and Dummy Manufacturing

You are a fashion designer tasked with creating a contemporary fashion piece that reinterprets indigenous textile patterns, with the outcome being production-ready templates for garment dummies and toiles. The piece should be eco-friendly, stylish, and reflective of current fashion trends. Your design journey must demonstrate how traditional patterns evolve through drawing exploration into reproducible templates suitable for pattern cutting, dummy production, and sample making.

Designing a Contemporary Fashion Piece with Indigenous Patterns

Step 1

1. List indigenous textile patterns, colours, or symbols (e.g., kente, Adinkra, woven motifs).
2. Discuss how these can be reimagined in a modern garment.
3. Share 2–3 ideas with the class.

Step 2

1. Sketch 2–3 fashion ideas (dress, jacket, top, or trousers).
2. Indicate where indigenous patterns and eco-friendly materials will be applied.

Step 3

1. Compare your sketches.
2. Select one strong design that combines;
   a. Cultural inspiration
   b. Eco-friendly materials
   c. Current fashion trends

Step 4

1. Refine the chosen sketch into a clear fashion drawing.
2. Break it into flat patterns (bodice, sleeve, collar, skirt/pant parts).
3. Mark cutting lines, folds, and zones for cultural motifs.

Step 5

1. Use paper, cardboard, or scrap fabric to create a mini garment dummy.
2. Assemble the patterns to test shape and fit.
3. Add simplified versions of motifs to show cultural influence.

Step 6

Present your dummy and explain.

1. How the design reflects indigenous culture.
2. How it stays eco-friendly and stylish.
3. How sketches became templates, and templates became a dummy garment.

Appropriate Freehand Drawn 3-Dimensional Templates and Patterns

Freehand drawing techniques are essential for developing accurate 3D templates and patterns. By applying correct methods, you can transform ideas into clear visual guides that show shape, proportion, and structure. These templates and patterns not only support creative expression but also serve as practical foundations for designing and constructing real objects.

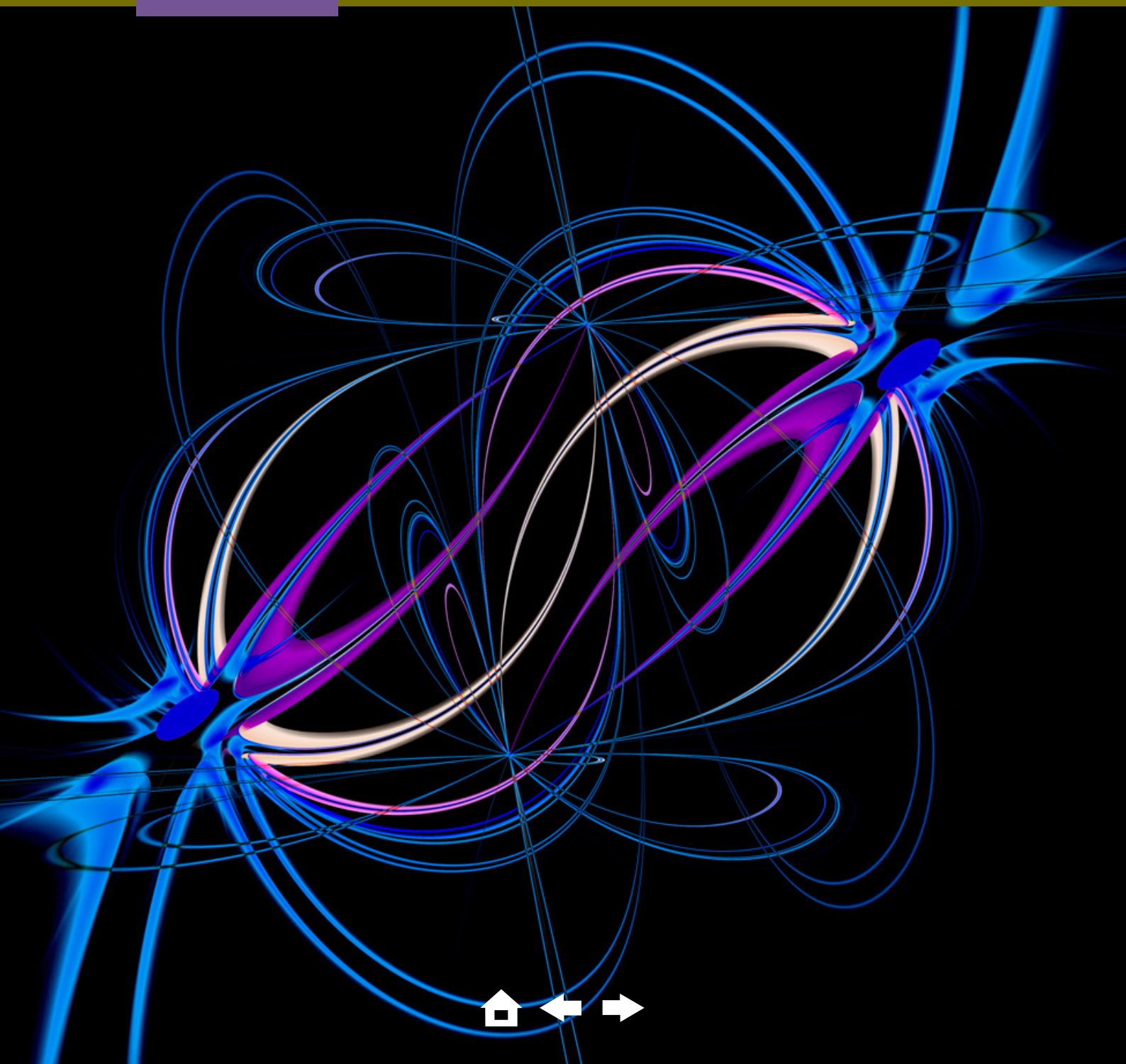
REVIEW QUESTIONS

1.
    a. Explain the purpose of creating 2D to 3D templates,
    b. Describe some techniques for developing complex 3D freehand templates and patterns, and
    c. Give an example of a contemporary designer or practitioner known for using complex 3D freehand drawing.
2. Compare and contrast the use of orthographic projection and perspective drawing in creating complex 3D templates. State which approaches you would choose for a specific design project and why.
3. Describe the process of transforming 2D designs into 3D models, highlighting the key techniques and considerations involved.
4. Explain the role of cross-sectional mapping in creating complex 3D models from 2D designs.
5.
    a. Discuss the role of iterative complexity in creating complex 3D models from 2D designs.
    b. How does this approach contribute to the final product?
6. Explain the steps and purpose involved in transforming a 2D design into a complex 3D object.
7. Outline three challenges designers face when transforming freehand drawn 2D designs into complex 3D objects, and how to overcome some of the challenges.

SECTION

2

GRAPHIC COMMUNICATION



UNIT 1: PLANE GEOMETRY

Geometry

Introduction

In this unit, you will build on what you have already learned in the previous years. You will go deeper into plane geometry and see how two-dimensional (2D) shapes play an important role in graphic communication and design.

You will learn what auxiliary projection is and how to draw auxiliary elevations and plans of objects. This will help you find the true size and shape of slanted surfaces in technical drawings. You will also explore different types of arches—how they are made, where they are used, and how they help bridge spaces.

In addition, you will look at how forces act on beams. You will learn how to calculate the reaction forces that keep beams and trusses in balance using geometry.

KEY IDEAS

- A beam represents a horizontal member that carries loads and transfers them to supports like columns or walls.
- A force demonstrates a push or pull that can move, support, or change the shape of a structure.
- A truss is a strong framework made of triangles that helps support heavy loads using tension and compression.
- An arch is a curved structure that spreads weight to its supports and is used for strength and decoration.
- Auxiliary projection helps us see the real shape and size of a slanted surface that is not represented front, top, or side views.
- Auxiliary views are created by introducing an additional reference plane - usually at an offset from one of the principal planes (front, top, or side).

AUXILIARY PROJECTIONS

Auxiliary projections are extra views used when the main orthographic views **(front, top, and side)** cannot clearly show the true shape or size of slanted or angled surfaces. They allow surfaces to be seen more accurately that are not represented on standard projections.

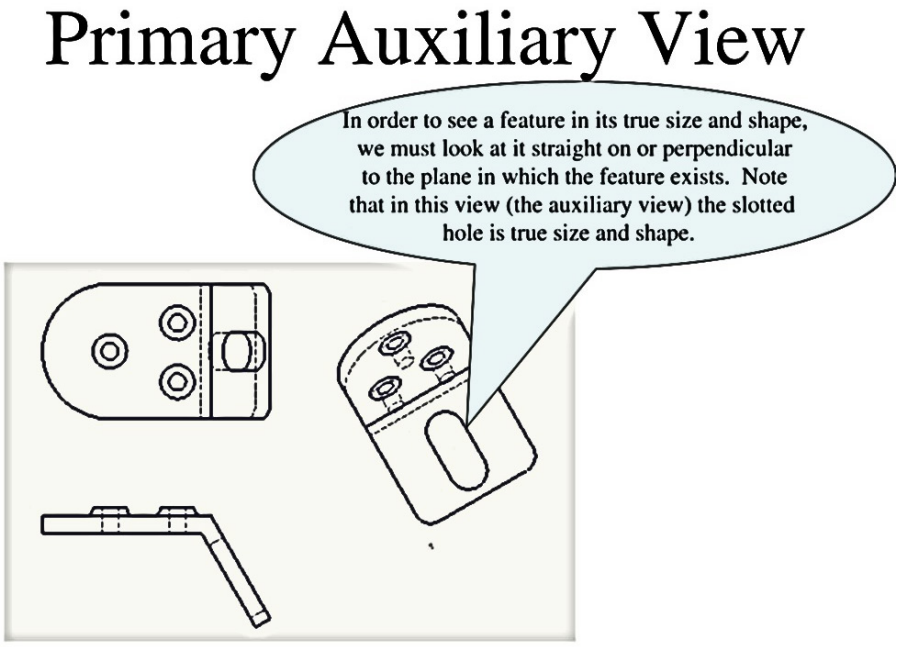


Figure 2.1:1: Auxiliary projection

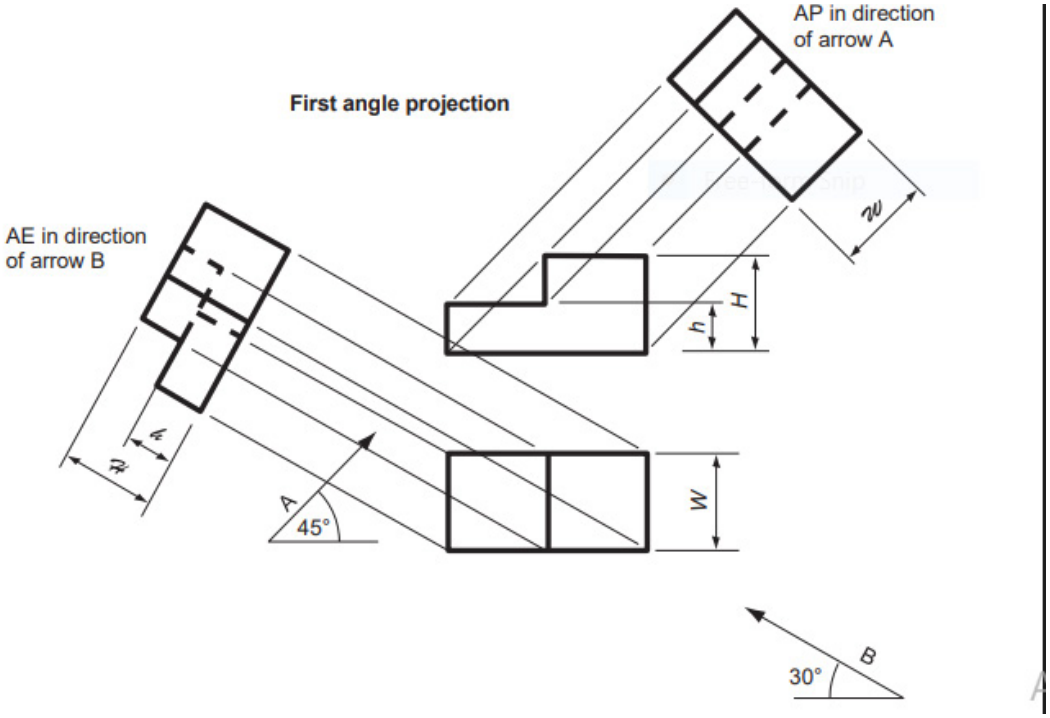


Fig. 2.1.2: Example of Auxiliary Projection

Application of Auxiliary Projections in Technical Drawing

1. They reveal the true shape of inclined surfaces
2. They show true lengths of lines that appear foreshortened in principal views

3. They are essential for accurate dimensioning and manufacturing of complex objects
4. They help in determining true angles between surfaces

Types of Auxiliary Projection

1. **Primary Auxiliary Views**

   Primary auxiliary views are drawn directly from one of the main orthographic views (Principal views - front, top, or side) to show the true shape and size of a surface that appears distorted in the standard views. ***See Figure 2.1.2***.

   a. **Auxiliary Elevation**: This view is projected from the **front view**. It is used when a surface is inclined to the vertical plane and needs to be shown in its true form.

   b. **Auxiliary Plan**: Projected from the **top view**, this helps to accurately show surfaces inclined to the horizontal plane.

   c. **Auxiliary Profile**: This is projected from the **side view** and is used to reveal the true shape of surfaces that are slanted relative to the profile plane.

2. **Secondary Auxiliary Views**

   Secondary auxiliary views are taken from an already existing **primary auxiliary view**, not directly from the principal views.

   a. They are useful when a surface is inclined in more than one direction, and a primary auxiliary view cannot accurately show its true shape.

   b. These views provide a clearer and more accurate representation of complex features, especially in detailed engineering or technical drawings.

Real-World Application of Auxiliary Projections

1. **Architectural Design and Construction**

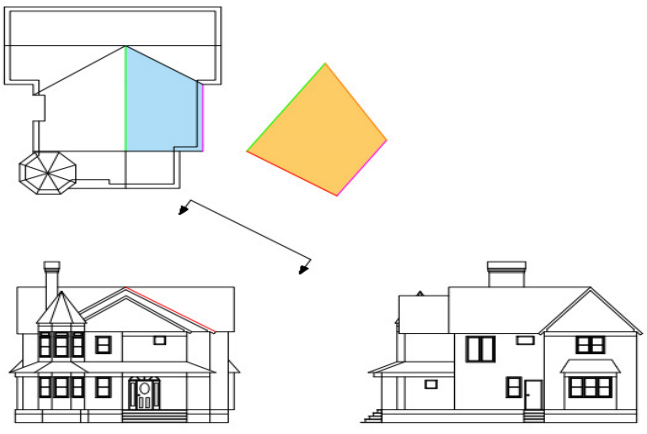


Figure 2.1.3: Building Roof

Specific Example: When designing a building with sloped roofs, auxiliary views are critical to show the true shape of roof planes, accurate roof pitch angles, and the precise intersection of different roof sections.

Impact: Ensures proper water drainage, structural integrity, and accurate material calculations for construction.

2. **Aerospace Engineering**

Specific Example: When designing an aircraft wing with its airfoil shape, auxiliary views reveal the true profile at various sections along the wingspan.

Impact: Critical for achieving proper aerodynamic performance, structural strength, and weight distribution in aircraft design.

3. **Mechanical Engineering and Manufacturing**

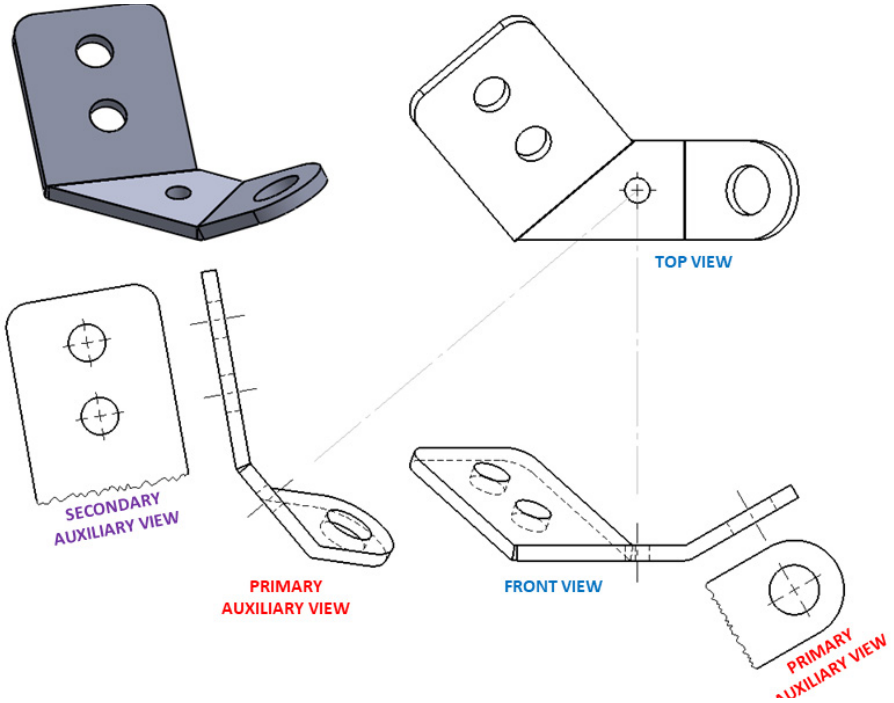


Figure 2.1.4: Engine bracket

Specific Example: When designing a mounting bracket with angled flanges, auxiliary views show the true shape of each flange and the exact hole locations for proper assembly.

Impact: Ensures components fit together correctly, function as intended, and can be manufactured with precision.

Activity 2.1.1 Importance of Auxiliary Projection

1. Form a group with 2-4 classmates and discuss the following scenario.

You are part of a design team working on a machine part that has a slanted surface. The team is struggling to measure its true shape using only front, top, and side views.

Based on this, answer the following questions.

a. Why do the standard orthographic views fail to give a clear view of the object?

b. How can an auxiliary view help in this situation?

2. Present your group report with sketches to the class for discussion.

Activity 2.1.2 Real-world application of Auxiliary Projection

1. In pairs, identify four real-world objects or fields where auxiliary projections are important. (***Example***: aircraft wings, ramps, sloped roofs, custom vehicle parts, packaging design)

For each item identified, write:

a. Where the inclined surface is.

b. Why are auxiliary views needed?

c. What would go wrong if an auxiliary view were not used?

2. Present your work for discussion; note the similarities and differences in others' presentations.

CONSTRUCTING AUXILIARY PROJECTIONS OF GIVEN OBJECTS

In this section, you will learn how to draw auxiliary views step by step to make your technical drawings clearer and more accurate.

First and Second Auxiliary Projections

A first auxiliary projection

This is made when the surface of an object is not clearly shown in the main (front, top, or side) views. This first auxiliary view helps to show the true shape of the inclined surface.

A second auxiliary projection

This is made from the first auxiliary view. It is used when the surface is still not fully visible or needs further detail. The second auxiliary view is drawn at a right angle to the first one.

For example, if the first auxiliary view is an auxiliary elevation (from the front view), then the second one could be an auxiliary plan (from the top view), or the other way around.

These second views help to show the true shape of complex or slanted surfaces more clearly in drawing objects.

Drawing Procedures

1. To construct the first auxiliary elevation of a cube

Step 1 Construct the front elevation and plan of the object
Step 2 Construct a new ground line X1 and Y1 at the required angle to the principal plane
Step 3 Construct lines perpendicular to line X1 and Y1from the sides in the plan
Step 4 Take vertical measurements from the elevation and transfer these lines to the auxiliary elevation

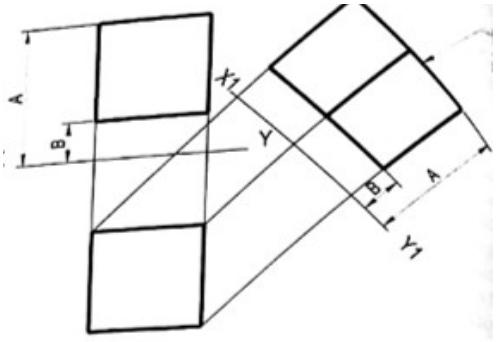


Figure 2.1.5: Auxiliary elevation

This is an auxiliary projection diagram used in technical drawing. It features three squares connected by lines, with one square positioned horizontally, another vertically, and the third at an angle.

The diagram includes lines extending from the edges of the squares, marked with letters such as A, B, X, and Y, indicating dimensions and angles.

This type of projection is used to represent three-dimensional objects on a two-dimensional plane, showing different views and angles.

2. To construct the first auxiliary plan of a cube

Step 1 Construct the front elevation and plan of the object
Step 2 Construct a new ground line X1 and Y1at the required angle
Step 3 Construct vertical lines to the lines X1 and Y1 from the edges of the elevation
Step 4 Take measurements A, B, etc. from the plan and transfer these into the auxiliary plan to show the shape of the projection

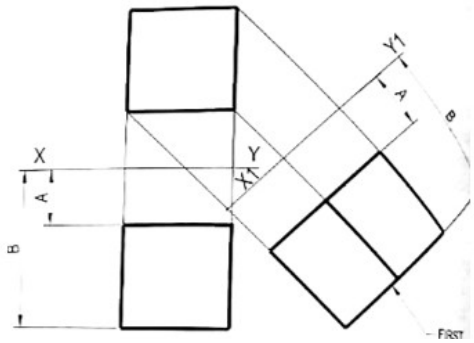


Figure 2.1.6: First Auxiliary Plan

In first-angle projection, the front elevation is positioned to the left of the auxiliary plan, showing the true shape and size of the object's front face.

The plan view is placed below the front elevation, providing a top-down perspective of the object's layout.

The auxiliary plan in the image offers an angled view to accurately represent features not parallel to the main projection planes.

3. To construct the second auxiliary projection of a cube

Step 1 Construct the front elevation and plan of the object
Step 2 Construct the first auxiliary plan on X1 and Y1
Step 3 Construct the new plan line X2 and Y2
Step 4 Construct a line perpendicular to the ground line X2 and Y2 from the corner of the first auxiliary projection into the new projection, and take the transfer measurement from the original elevation to make the second auxiliary projection
Step 5 Firm in the plan, elevation and the auxiliary projections

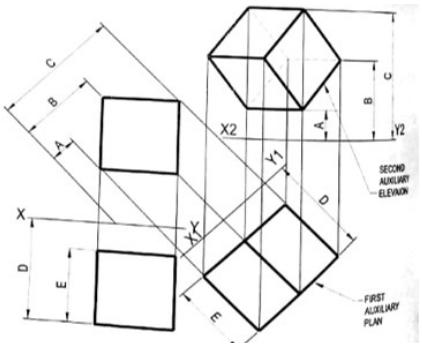


Figure 2.1.7: Second Auxiliary Projection of a cube

Figure 2.1.7 shows a technical drawing of a cube in different projections.

The image shows three views of a cube: a top view, a front view, and an isometric view.

The top view and front view are represented as squares, while the isometric view shows the cube in a three-dimensional perspective.

The drawing includes various labelled dimensions and lines, such as A, B, C, D, E, F, G, H, I, J, K, L, X, Y, X1, Y1, X2, and Y2. The terms “First Auxiliary Plan” and “Second Auxiliary Elevation” are also labelled on the drawing.

4. To construct the first auxiliary elevation of a cylinder

Step 1 Draw the given front view and plan.
Step 2 Divide the circle into several equal parts and number them.
Step 3 Draw the new ground line X1Y1 at a right angle to these projected lines and at any convenient distance from the elevation.
Step 4 From the plan, draw lines from the numbered points perpendicular to the X1Y1 line.
Step 5 Transfer distances from the elevation to the perpendicular line.
Step 6 Mark the points and draw a smooth curve through the points to give the auxiliary elevation of the cylinder.
Step 7 Complete the drawing by adding the relevant lines to give the first auxiliary elevation.

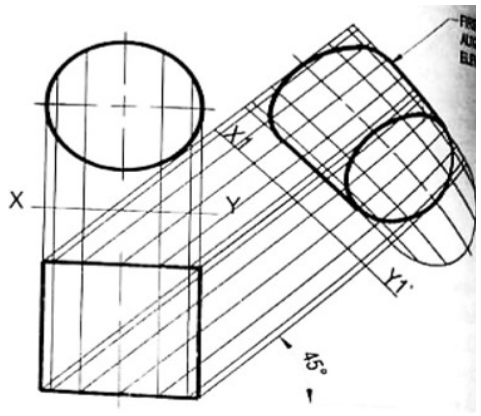


Figure 2.1.8: First Auxiliary elevation of a cylinder

Figure 2.1.8 shows a drawing of a cylinder in three different views.

The left side shows a front view with a circle, the bottom left shows a plan view with a rectangle, and the right side displays the first auxiliary elevation of the cylinder tilted at a 45-degree angle.

The drawing includes projection lines connecting the plan and the auxiliary elevation.

5. To construct the first auxiliary plan of a cone

Step 1 Construct the given elevation and plan.
Step 2 Divide the circle into 12 equal parts and number.
Step 3 Draw the new ground line X1Y1.
Step 4 Draw lines from the numbered points in the elevation into the new projection.
Step 5 Draw a line parallel to the X1Y1 a distance equal to the diameter.
Step 6 Draw a semi-circle, divide and number this semi-circle
Step 7 Transfer measurements from the plan to the new projection
Step 8 Trace like numbers and mark the points and draw a smooth Curve through them to give the first auxiliary plan.

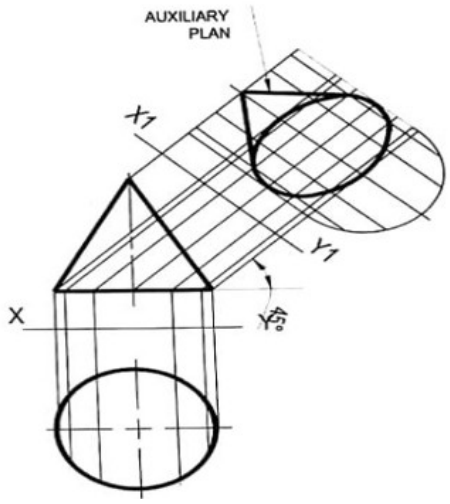


Figure 2.1.9: First auxiliary plan of a cone

Figure 2.1.9 is a drawing of a cone with the front elevation and plan drawn in first angle orthographic projection, including an auxiliary plan drawn with a projection from the front elevation generated from X_1-Y_1 axes.

Common Challenges and Solutions

When drawing auxiliary projections, you may face some challenges. Do not worry, this is normal. In this section, we will look at common problems students face and simple ways to solve them.

	CHALLENGE	SOLUTION
1	Determining which Auxiliary view to use	In this case, identify slanted surfaces that look like lines in the main views. If the surface looks like a line in the top view, draw an auxiliary elevation. If it looks like a line in the front view, draw an auxiliary plan.
2	Maintaining accurate measurements	Use dividers or compasses to transfer measurements precisely. Double-check all dimensions before finalising the drawing.
3	Complex objects with multiple inclined surfaces	Tackle one surface at a time. Label points clearly to avoid confusion when projecting to the auxiliary view.

Activity 2.1.3 Auxiliary projection of a truncated cone

You are helping to design a metal cone for an air pipe. The cone has been cut slanted at the top so it can fit against a sloped wall. You are given the front view and top view of the cone in first-angle projection. The cone is 75 mm tall and 60 mm wide at the base (***Figure 2.1.10***)

Before the designers can cut the metal sheet:

a. They need to see the true shape of the slanted top surface.

b. They need to know the true length of the slanted edge.

1. You are required to draw

a. The front and top views to full size.

b. A primary auxiliary elevation to show the true shape of the slanted surface.

c. A primary auxiliary plan to show the true length of the slanted edge.

These views are important for protecting the final piece cut to be assembled correctly.

Bottom of Form

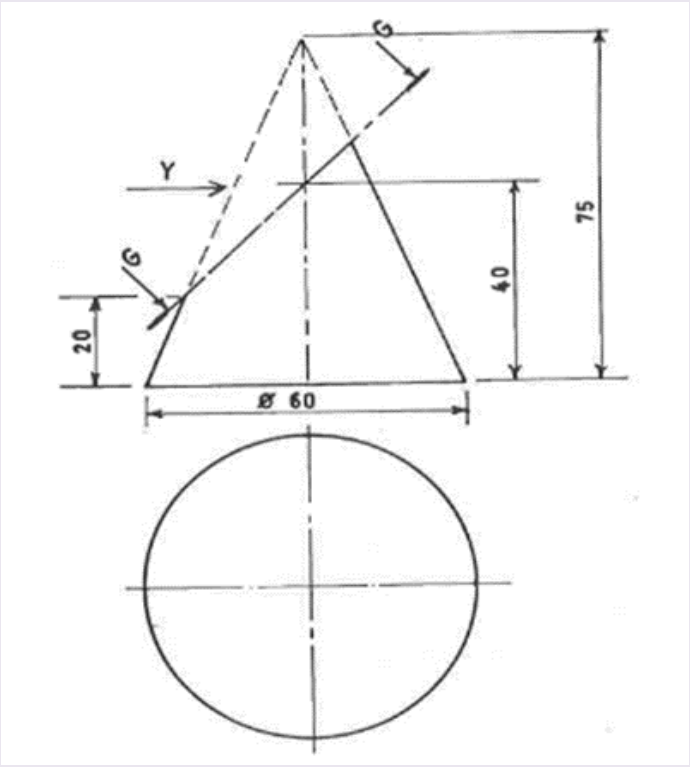


Figure 2.1.10: Front elevation and plan of a truncated cone

2. Follow the guidelines below to construct the truncated cone

Construction of the front and top views of the truncated cone

a. Draw the front elevation of the cone with height, 75 mm, and base, 60mm

b. Project the cutting plane G-G from the left, 20mm through the axis at 40mm from the base.

c. Use short dashes to indicate the cut portion of the cone.

d. Project from the front elevation to draw a circle (plan) of diameter 60mm

e. Project for the cut surface on the plan

f. Divide the circle into 12 equal parts

Construction of the auxiliary elevation of a truncated cone.

a. Project lines from the plan at an angle 450

b. Construct a perpendicular to the lines and label it X1 – X1

c. Transfer points from the front elevation to the lines projected

d. Join point to complete the auxiliary elevation

Construction of the primary auxiliary plan that shows the true length of the edge.

a. Project lines from the front elevation perpendicular to the cutting plane.

b. Construct a line perpendicular to the lines projected from the front elevation and label Y1 – Y1.

c. Transfer points from the plan to the lines projected.

d. Join points to complete the auxiliary plan.

Activity 2.1.4 Auxiliary views of a regular cylinder

Your community is experiencing sanitation problems due to widespread littering and scattered waste. You have been assigned to design a cylindrical dustbin for the community to improve environmental cleanliness.

Given base diameter, 50 mm and height (axis length), 70 mm, use first angle orthographic projection and auxiliary projection, draw the following views of the dustbin,

a. Front View

b. Top View

c. Right-Side View

d. Auxiliary View to show the true shape of the curved surface (if inclined)

1. Follow the guidelines below to draw the auxiliary views of the cylinder

First stage

1. Draw circle ***a' d' g' f'*** and divide it into 12 equal parts to represent the front view.

2. Project points from the front view to obtain ***a, 1, 7, g.*** as its top view.

Second stage

1. Reproduce the top view of the first stage, keeping ***g*** on ***x y*** and ***g, 7*** inclined at 30° to ***x y***
2. Obtain ***a, b, c, d, e, f, g, h, I, j, k, l.*** and ***1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12***. in the front view as the intersecting points of the projectors from the top view of the second stage with the corresponding locus lines from the front view of the first stage.
3. Join these points and obtain ***a' d' 4' 7' 10' j'*** as the top view.
4. Draw a line inclined at θ to the H.P. and θ to the V.P., inclined at α to ***x y***.

Third stage

1. Draw a line ***0'1***, ***0'3***, 70 mm (true length of the axis) inclined at 45° to ***x y***.
2. Draw an arc with ***0'1*** as the centre and radius equal to the front view of the axis (***0'1 0'2*** from the second stage) to meet the horizontal line from **0'3** at point **0'2**,
3. Reproduce the front view of the second stage keeping **0'1, 0'2** at α to ***x y***.
4. Obtain **a, b, c, d, e, f, g, h, I, j, k, l** and **1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12** in the top view as the intersecting points of the projectors from the front view of the third stage with the horizontal projectors drawn from the top view of the second stage.
5. Join the points and obtain the required top view.

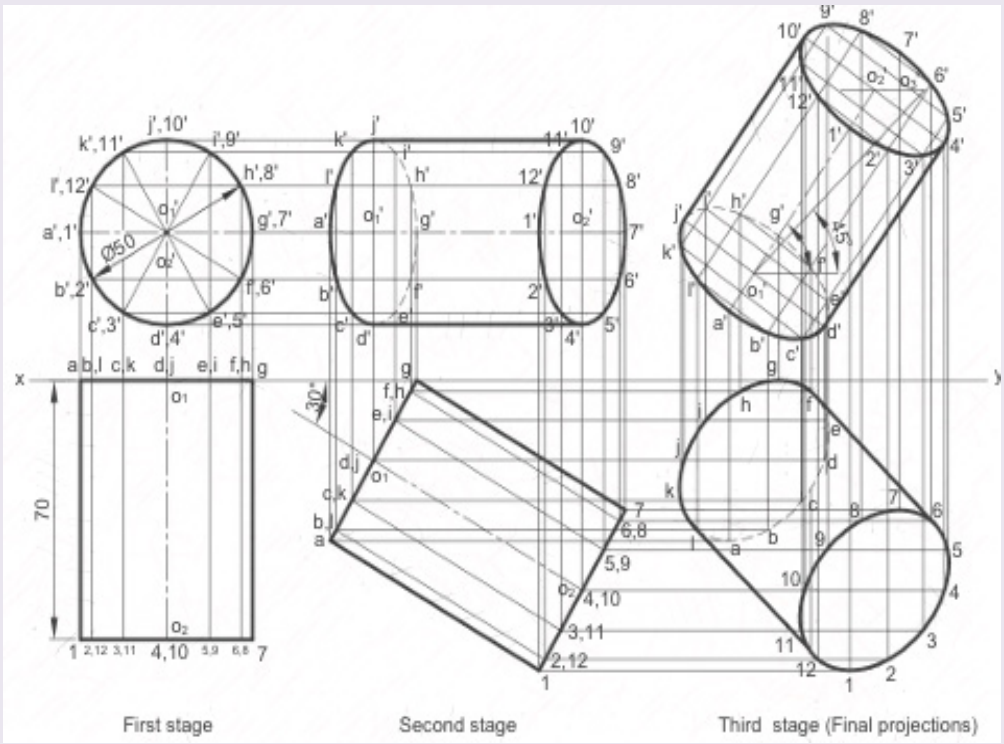


Figure 2.1.11: Auxiliary elevation and plan of the cylinder

ARCHES

In architecture, an arch is an opening in a structure that is curved on top and designed with stones, bricks or timber to distribute loads. Arches are used in structural engineering because they can support a large mass placed on top of them. You may see arches over entrances, doors and windows. They can also be used in constructing bridges.



A Balcony



A Bridge



A Main Gate



Doors and Windows

Figure 2.1.12: Pictures of Arches

Types of Arches

There are many arches designed by ancient and modern architects.

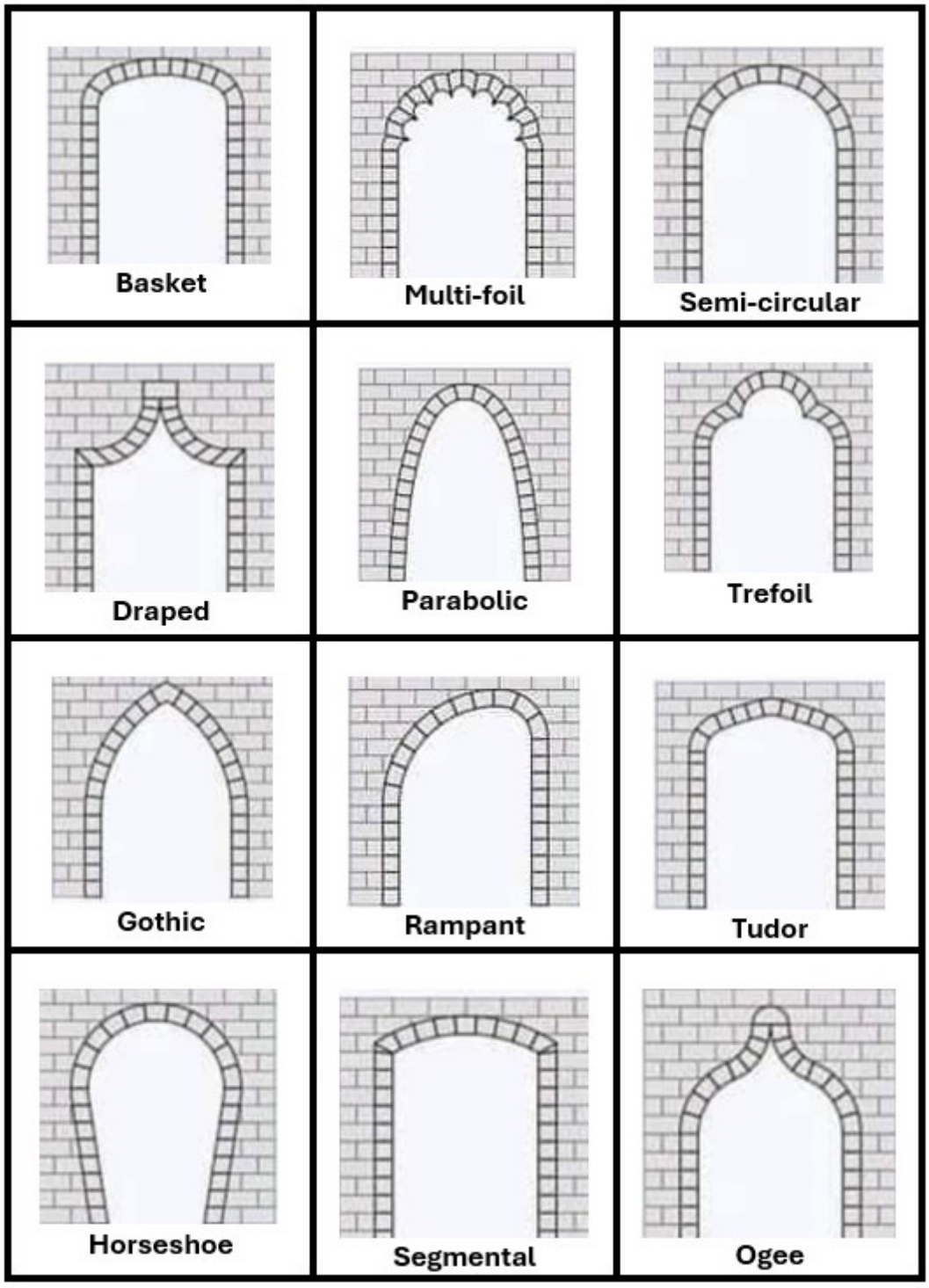


Figure 2.1.13: Types of arches

Terminologies of an arch structure

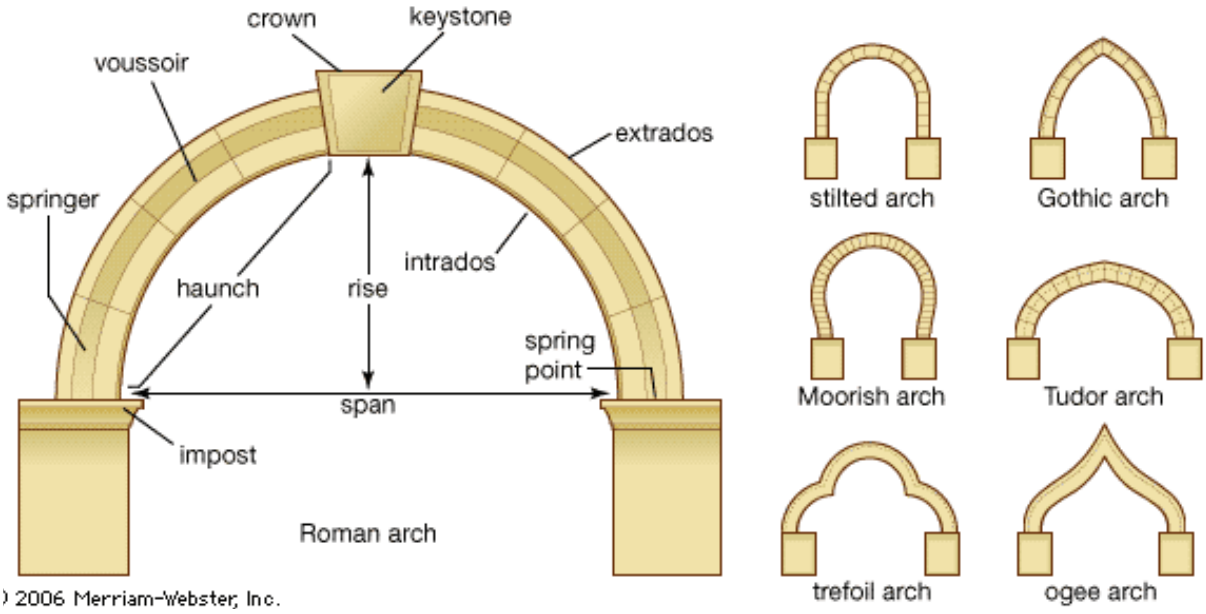


Figure 2.1.14: Terminologies of an arch structure

Activity 2.1.5 Construction of arches

Equilateral arch

In constructing equilateral arches, the span equals the radius

1. Draw the span AB
2. With centre A and B, and radius AB, draw arcs to intersect at C

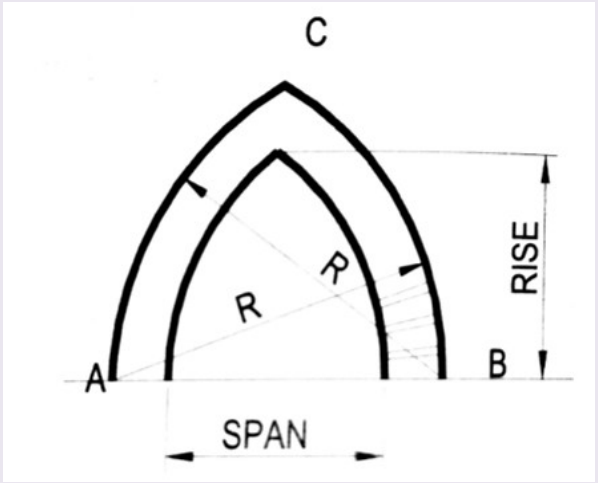


Figure 2.1.15: Equilateral Arch

Parabolic arch

To set out the pointed parabolic arch.

1. Draw the rectangle ABCD.

2. Bisect AB at E.
3. Divide AD into four equal parts and number them.
4. Divide AB into eight equal parts and number them.
5. Draw horizontal lines through the points on AD to BC.
6. From D, draw radial lines to the numbered points on AB.
7. Plot points with like numbers.
8. Draw a smooth through the points to obtain the parabolic arch.

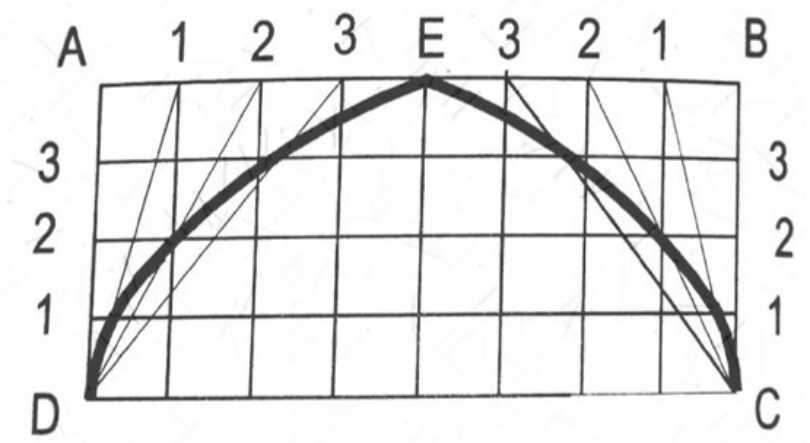


Figure 2.1.16: Parabolic arch

Semi-circular arch

To set out the semi-circular arch,

1. Draw the span AB.
2. Bisect it at C.
3. With centre C and radius AC, outline the semi-circle AB.

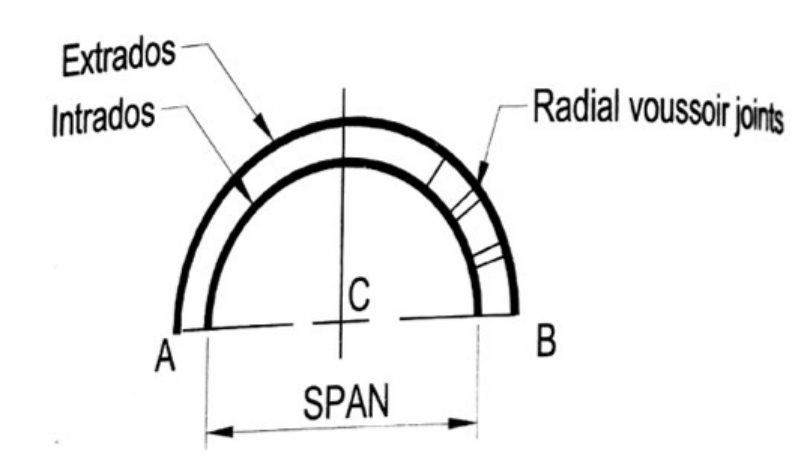


Figure 2.1.17: Semi-circular arch

Activity 2.1.6 Paper model of an arched bridge

Materials

- Two study books.
- A strip of paper (about 50 mm wide and 200 mm long)
- A small, lightweight object (e.g., a small cardboard box)

Procedure

1. Position the two books approximately 150 mm apart on a flat surface.
2. Create a simple paper bridge by laying the strip of paper across the gap between the books. You can shape the paper according to the type of arch design you want to test.
3. Gently place the small object on the centre of the paper bridge to check if the bridge can support the weight.

Real-life application of arches

1. **Architecture & Construction**: Arches are used in bridges, doors, windows, and tunnels because they spread weight evenly and make structures strong.
2. **Engineering**: Engineers use arches in tall buildings, dams, and stadiums to help carry heavy loads safely.
3. **Automotive Design**: Cars have curved shapes like arches to move more easily through air and use less fuel.
4. **Medical Science**: Your foot has a natural arch that helps you balance, walk, and run better.

FORCES ACTING ON BEAMS AND TRUSSES

Beams and trusses help support external loads, internal forces and reactions of structures. The in-depth knowledge of forces, beams and trusses is important in structural engineering.

Force: A force is a push **or** pull that can change the shape, speed, or direction of an object. Force is measured in Newtons (N).

Beams: A beam is a long, straight structural element designed to carry loads across a span

Trusses: A truss is a framework made of interconnected triangles, designed to distribute loads efficiently.

Types of forces acting on beams and trusses

1. Compression (pushing forces)
2. Tension (pulling forces)
3. Shear (sliding forces)
4. Torsion (twisting forces)
5. Bending (combination of compression and tension)

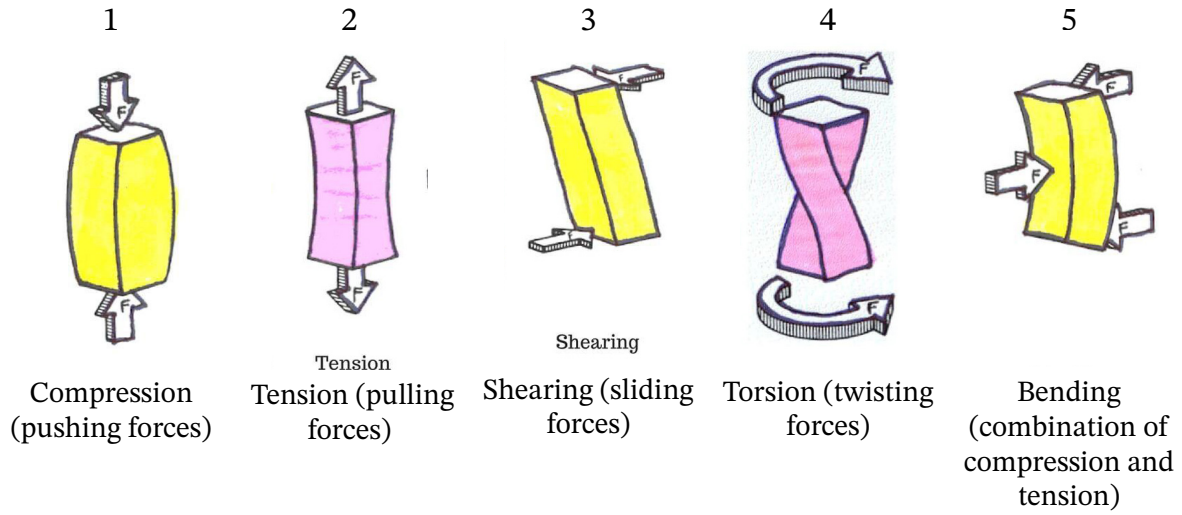
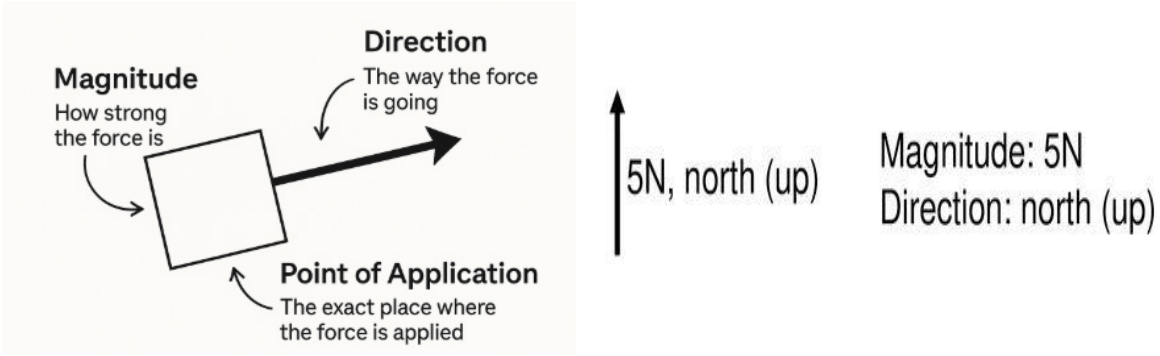


Figure 2.1.18: Forces acting on a body

Characteristics of Forces

1. **Magnitude:** The size or strength of the force. It shows how strong the push or pull is.
2. **Direction:** Where the force is acting or moving. Thus up, down, left, or right.
3. **Point of application**: The exact place where the force is applied to an object. E.g., pushing a door by the handle versus in the middle. (where the force is applied)



Diagrammatic illustration Mathematical illustration

Figure 2.1.19: Characteristics of Forces

Framed Structures

A framed structure is built by connecting strong pieces, known as members, to create a solid framework. These members are usually arranged in triangular or rectangular shapes to give the structure strength and stability.

Common Types

Here are some common types of frame structures

1. Roof trusses (triangulated frameworks)
2. Beams (horizontal load-bearing members)
3. Frames of a building (combinations of beams and columns)

Applications of Framed Structure

1. **Bridges**

   Bridges are built to handle different forces acting on them. These include dead loads (like the weight of the bridge parts—deck, girders, or trusses) and live loads (like cars, people, and other moving things). To safely carry these loads and prevent collapse, bridges need to withstand two main types of force:

   a. **Compression**: This is a force that pushes materials together. *Example:* The top part of an arch bridge is under compression.

   b. **Tension**: This is a force that pulls materials apart. *Example:* The cables of a suspension bridge experience tension.

2. **Roof systems**

   The roof covering and battens carry the weight of the roof and any extra load, like wind or people walking on the roof. This weight is passed to the purlins or rafters, which help hold and support the load.

   The load then moves to the tie beams, collar ties, or the walls of the building. The tie beams or collar ties help hold the roof together and stop it from spreading out and pushing the walls apart.

3. **Towers/Building Frames**

   In multi-storey towers or framed buildings, dead and live loads on slabs are distributed to beams (in beam-and-slab systems) or directly to columns (in flat-slab systems) and then carried as axial compression and bending in columns down to the foundations.

Equilibrium of Forces

Principle

A structure is in equilibrium when all the forces acting on it are balanced. This means:

1. The sum of all horizontal forces is zero
2. The sum of all vertical forces is zero
3. The sum of all turning forces (moments**)** around any point zero

When these conditions are met, the structure does not move or tip over.

Reaction Forces

These are the forces exerted by supports to help keep a structure in balance (equilibrium)

Types of Loading Conditions

1. **Concentrated Load:** A force applied at one specific point on a structure. *Example*: A heavy object placed on a single spot.
2. **Distributed Load:** A force spread out over a length or an area**.** *Example*: The weight of roofing sheets spread across rafters.
3. **Self-Weight:** The weight of the structure itself, caused by gravity. *Example*: The weight of beams, walls, or slabs.

Activity 2.1.7 Forces in beams and trusses

Your school is building a pavilion. The roof is to be supported by beams and trusses and must be able to support all forces acting on the pavilion.

1. In your groups of 2-4, explain how **compression, tension and shear forces** act on the beams and trusses to help the builders understand how the structure should be designed.
2. Present your report for a whole-class discussion.

Activity 2.1.8 Relationship between forces acting on beams

Follow the steps below to describe the relationship between forces acting on beams in building construction.

Step	Area	Operation	Equipment
1	**Set up a Model Beam**	Place a ruler or a stick between two supports (such as books or chairs) to form a simple beam.	Rulers or wooden sticks, string or rubber bands, chairs or boxes,
2	**Apply Load**	Gently place a weight at various parts of the beam and observe what happens. **Note:** vary the weights	Weights such as stones, books or water bottles
3	**Observe and Record**	**1.** Describe where the beam bends or flexes. **2.** Discuss which parts are **under tension** (stretched) and which are **under compression** (squeezed). **3.** Talk about what could happen if the beam breaks or cracks (**shear** force).	Pen, pencil, ruler and sketch pad
4	**Class Discussion**	**1.** How do builders use this knowledge when designing beams in buildings? **2.** Describe how materials and beam shapes are chosen to handle these forces and prevent collapse	Pen, pencil, ruler and Cardboard or manila cards

FINDING MAGNITUDE OF REACTION FORCES KEEPING BEAMS AND TRUSSES IN EQUILIBRIUM

Finding reaction forces is an important skill in structural analysis. It helps to ensure that beams and trusses stay balanced under loads. These forces provide the support that resists loads, preventing the structure from moving or collapsing. This analysis forms the foundation for all subsequent structural design decisions.

Principles of Resolution of Forces



Figure 2.1.20 A: Stable

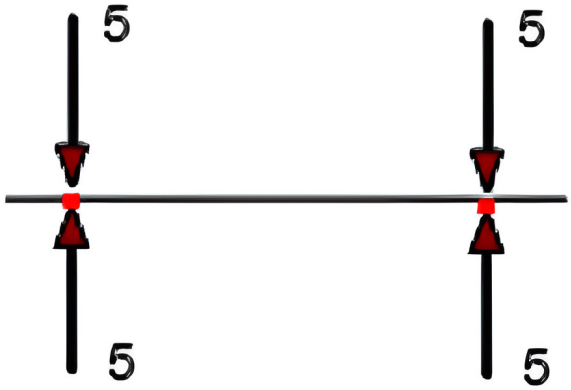


Figure 2.1.20 B: Stable

Figure 2.1.20 A and ***B*** are two forces acting on the same point in the same plane; they have the same magnitude **(size) and direction (**line of action) for equilibrium (balance) to be maintained.

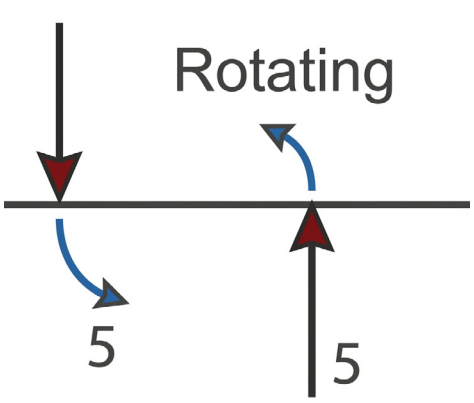


Figure 2.1.20 C: Unstable

***Figure 2.1.20 C*:** An unstable couple occurs when the forces are equal in magnitude but not directly opposite in direction. This results in rotational motion.

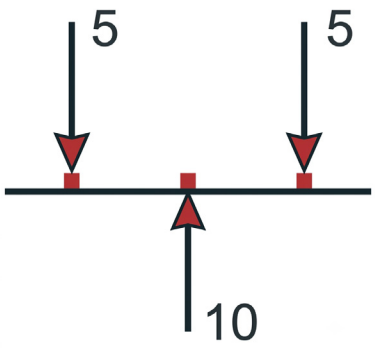


Figure 2.1.20 D: Stable

***Figure 2.1.20 D*:** shows that two parallel forces can be balanced by a single force that is equal in magnitude and parallel in direction.

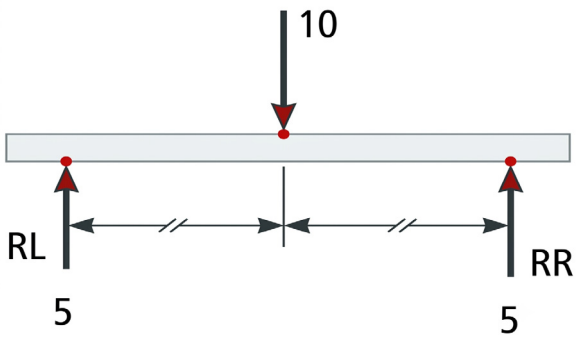


Figure 2.1.20E: Stable

A simple beam seen in ***Figure 2.1.20 E*** has a central load of 10 units supported at both ends. The load is evenly shared between the two supports, resulting in reaction forces of 5 units on the left support (RL) and 5 units on the right support (RR).

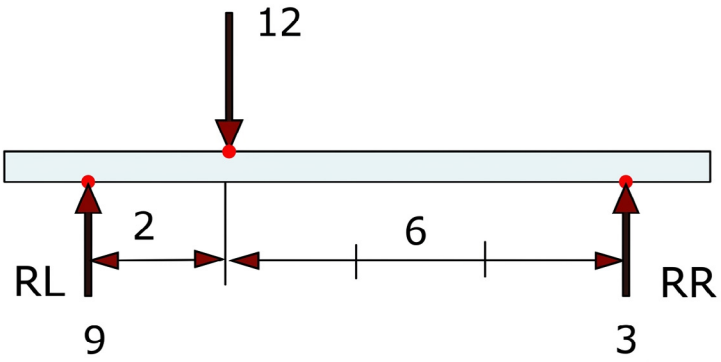


Figure 2.1.20 F: Stable

Figure 2.1.20 F is a simple beam that carries an offset load of 12 units. The reactions at the supports, RL and RR, are determined by dividing the load in the ratio 2:6, based on the relative distances between the load and the two supports, as shown in the diagram.

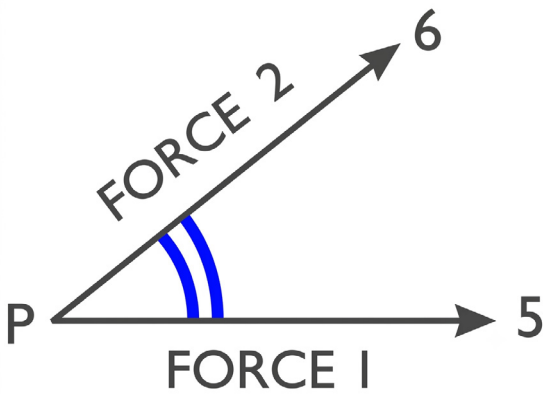


Figure 2.1.20 G: Forces

Figure 2.1.20 G shows Two Forces at a Point (P). Force 1 = 5 units, Force 2 = 6units

Resolution of Equilibrium by Vector Diagram

Scale diagram

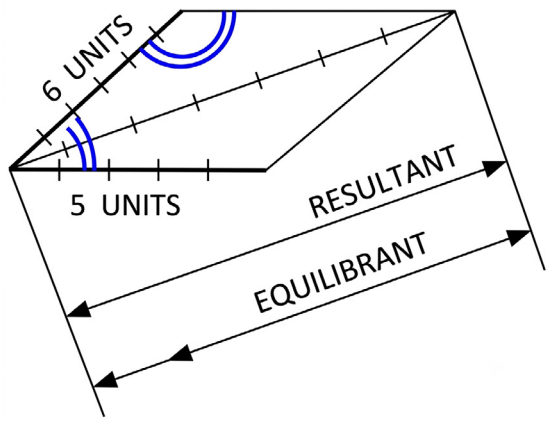


Figure 2.1.20.H: Resultant

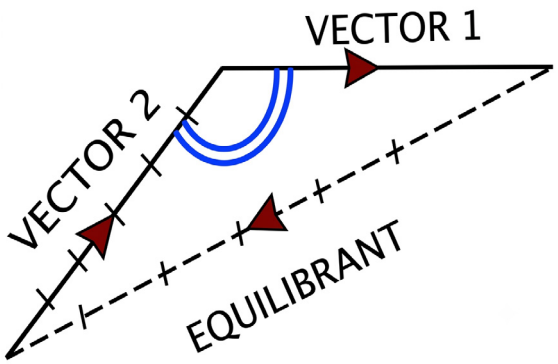


Figure 2.1.20 J: Vectors

Finding Reactions and Resultant Forces

To find the reaction forces on the left (RL) and right (RR) of a simply supported beam.

1. Draw the space diagram
2. Draw the force diagram
3. Choose any point O at 50 mm from the force diagram
4. Join O to the force points to obtain AO, BO, CO, DO, and EO.
5. Draw A line parallel to AO to intersect lines 1 and 2 at A and B
6. From B, draw a line parallel to OB to intersect line 3 at C
7. From C, draw a line parallel to line OC to intersect line 4 at D
8. From D, draw a line parallel to OD to intersect line 5 at E
9. Join the reaction line at A and E, known as the closer
10. Draw a line parallel to AE, the closer to O in the polar diagram, to cut the force line at E; this line divides the force line into two parts, AE and ED
11. The distance between AE is the left-hand reaction, and ED is the right-hand reaction. Measure AE in mm and convert to KN using the scale to obtain the reaction at RL, and measure and convert ED to obtain RR

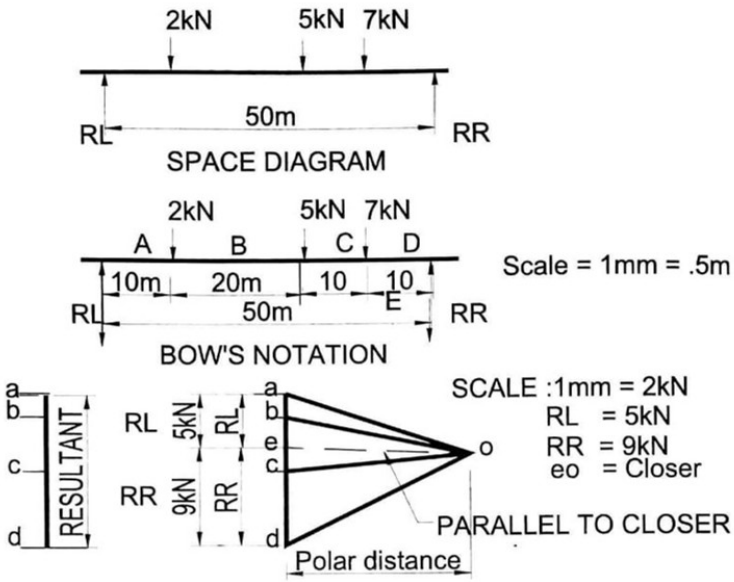


Figure 2.1.21: Supported beam with point loading

To find the resultant wind thrust on the truss, given the load acting on the roof

1. Draw the space diagram
2. Draw the force and the polar diagram
3. Use Bow's notation to letter the diagram
4. Draw the closer
5. Draw a parallel to the closer
6. At E, draw a line parallel to reaction RR to intersect F
7. Draw a vertical line from A to cut F
8. The distance AF = RL; the reaction on the left
9. The distance EF represents RR, the right end reaction

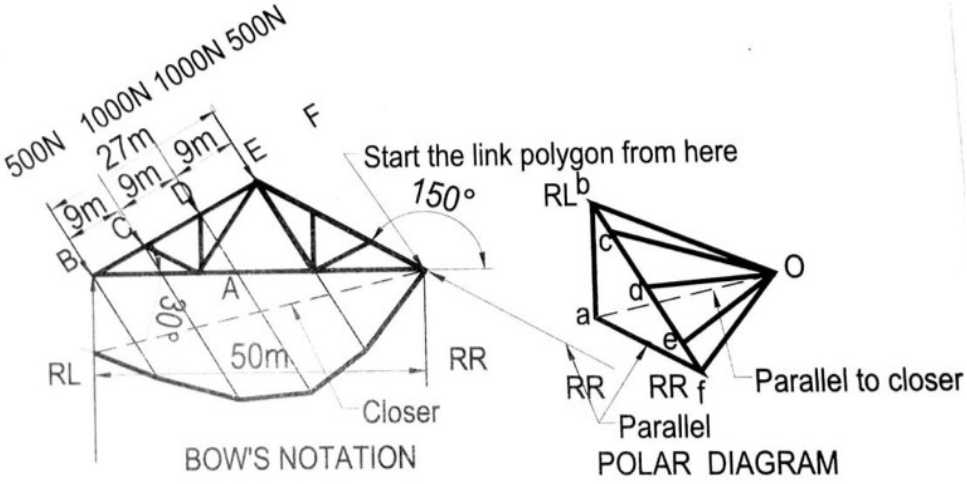


Figure 2.1.22: Trusses with wind loading

Bending moment and shear force diagram

Bending moment and shear force diagrams are graphical representations that show how internal forces vary along the length of a beam. These diagrams are essential tools in structural analysis and design, providing critical information about where a beam experiences maximum stress and helping engineers determine appropriate beam sizes and materials.

Fundamental Concepts of Bending Moment and Shear Force

Shear Force (V)

1. The internal force acting perpendicular to the beam's axis
2. Tends to cause sliding between adjacent cross-sections
3. Measured in units of force (N, kN)

Bending Moment (M)

1. The internal moment that causes the beam to bend
2. Results from the cumulative effect of loads and their distances
3. Measured in units of force x distance (Nm, kNm)

Step-by-Step Process for Drawing shear force diagrams

1. Draw the space diagram and extend the force and reaction lines vertically.
2. Draw a horizontal reference line from the force points on the polar diagram to intersect the vertical lines from the space diagram for easy reference
3. Construct the Shear Force Diagram by Starting at the Left End of the Beam
4. Account for Left Support Reaction. If there is support at the left end, plot its vertical reaction value by drawing a vertical line from the reference axis to this value
5. Progress Along the Beam by moving from left to right, addressing each load and its effect
6. For point loads, create a vertical jump in the diagram equal to the load magnitude. Upward jump for downward loads, downward jump for upward loads
7. Continue to the right end and Process all loads in sequence from left to right.
8. Complete and label the Diagram by Adding Reference Lines, adding a title and scale and including units for all values

9. Define Sign Convention: typically, positive shear forces are plotted upward, and negative shear forces are plotted downward

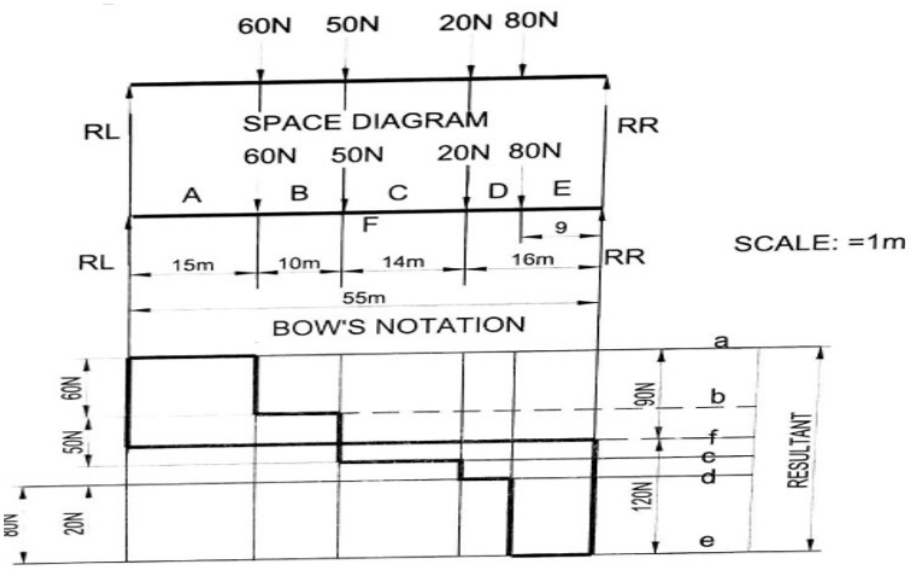


Figure 2.1.23: Shear force diagram

Drawing shear force diagrams graphically is a valuable skill that provides immediate visual insight into a beam's structural behaviour. This approach helps engineers and designers understand how forces flow through structures, identify critical design points, and communicate structural concepts effectively.

By following a systematic approach and understanding the fundamental principles that govern how loads affect shear forces, you can accurately represent the internal shear behaviour of beams under various loading conditions. This graphical understanding forms the foundation for more complex structural analysis and design decisions.

Step-by-Step Process for Drawing Bending Moment Diagrams

1. Draw the polar diagram.
2. Position the pole ***O*** to the right of the diagram.
3. Join the point ***O*** to the load point.
4. From the reaction ***RL***, draw a line parallel to ***OA*** to intersect the 5 kN load point.
5. From the point, draw a line parallel to ***OB*** to intersect the 8 kN line.
6. From this point, draw a line parallel to ***OC*** to intersect the 5 kN line.
7. From this point, draw a line parallel to ***OD*** to intersect reaction ***RR***.
8. Join the points ***RL*** and ***RR*** to obtain the closer.
9. From ***O,*** draw a line parallel to the closer to intersect the polar diagram load line.

10. Plot the vertical coordinates at the load point from the horizontal base to obtain the bending moment diagram.

11. Plot these vertical ordinates on the horizontal line.

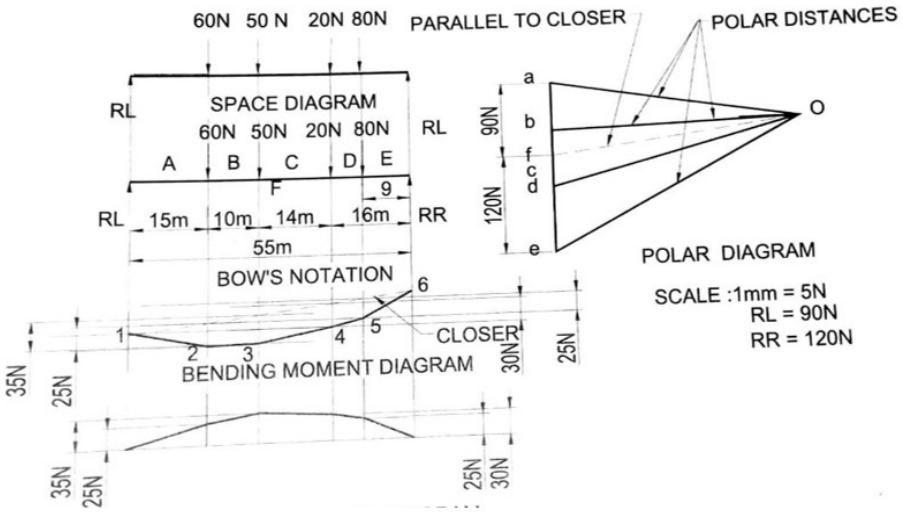


Figure 2.1.24: Forces with bending moment diagram

Activity 2.1.9 Finding the Magnitude of Reaction Forces

In your groups, follow the steps to find the magnitude of reaction forces, keeping beams and trusses in equilibrium.

Sample Materials

- A wooden or metal beam (1m–1.5m long ruler or straight stick)
- Two supports (bricks, blocks, or chairs)
- Masses or weights (stones or 0.5kg–1kg objects)
- Spring scale or bathroom scale (if available)
- Measuring tape or ruler
- Graph paper and pencil

1. Set up the Beam

a. Place the beam horizontally on two supports, one at each end (like a bridge).

b. Mark the positions of the supports (e.g., A and B) and measure the total length of the beam.

2. Apply Loads: Place known weights on the beam at specific distances from the left support (A).

For example: 2kg at 0.3m from A, and 1kg at 0.7m from A

3. Record Data

a. Note the position and weight of each load.

b. Use gravity ($g = 10\ m/s^2$) to convert mass to force:

e.g., $2kg = 2 \times 10 = 20N$

4. **Sketch the Beam:** Draw a simple Free Body Diagram (FBD) of the beam.

Show:

a. The length of the beam.

b. Position and magnitude of each load.

c. Unknown reaction forces at A (RA) and B (RB).

5. **Calculate Reaction Forces use equilibrium conditions**

a. **$\Sigma F = 0$** $\rightarrow$ RA + RB = Total downward loads.

b. **ΣM about A = 0** (Take moments about support A to find RB).

c. RB x Length of beam = $\sum$ (Load x Distance from A).

d. Solve for RB, then find RA using total vertical force balance

6. **Verify:** If using spring scales or a bathroom scale, place them under the supports to compare measured and calculated reactions.

Activity 2.1.10 Bending Moment and Shear Force Diagrams

Follow these steps to draw bending moment and shear force diagrams in your groups.

A beam 1m long is supported at both ends. It carries 20N at 0.3m from A, 10N at 0.7m from A.

1. Find RA and RB

a. Draw and label a Free Body Diagram.

b. Apply equations of equilibrium ($\Sigma F = 0$ and $\Sigma M = 0$).

c. Solve for unknown reactions correctly.

d. Reflect on possible errors if values do not match measured ones.

2. Repeat the activity with

a. A beam with three loads

b. A triangular truss model using sticks and pins (calculate support reactions only)

EXTENDED READING

- Morling, K. (2010), Geometric and Engineering Drawing, Third Edition, London, Elsevier Publications Ltd. Pages 122-147 (Figure 10.9 – 10.23)

REVIEW QUESTIONS

1. A designer drawing the views of a slanted metal bracket was advised to use auxiliary projection. Explain why auxiliary projection is important for the slanted metal bracket.
2. Use one example in a building to illustrate how auxiliary projections are used in real life.
3. The hopper of your school's corn mill is badly rusted and partially corroded. You have been asked to design a replacement for the fabricators to construct. The new hopper should have the shape of a truncated hexagonal pyramid, with the following dimensions: base side, 35mm, top side, 20 mm, and vertical height, 45mm. Draw full size, the following views of the new hopper
   a. Front and Top Views
   b. Primary Auxiliary Elevation
   c. Primary Auxiliary Plan
4. Your community plans to build a modern public washroom. You have been selected to design its front entrance and windows. With knowledge in architectural design, construction
   a. A semi-circular arch front door with a span of 70 mm.
   b. A Gothic (equilateral pointed) arch window with a span of 65 mm.
5. A modern SHS building with an entrance height of 6500 mm and a span of 4000mm needs a new segment-arch design entrance.
   a. Draw the recommended arch type to scale (1:200)
   b. Label three important parts of the arch.
6. In your own words, describe the following three types of forces that act on beams and trusses. Include simple examples to show how each force works:
   a. Compression – What happens when a force pushes parts of a structure together?
   b. Tension – What happens when a force pulls parts of a structure apart?
   c. Shear – What happens when two connected parts slide or try to move past each other?

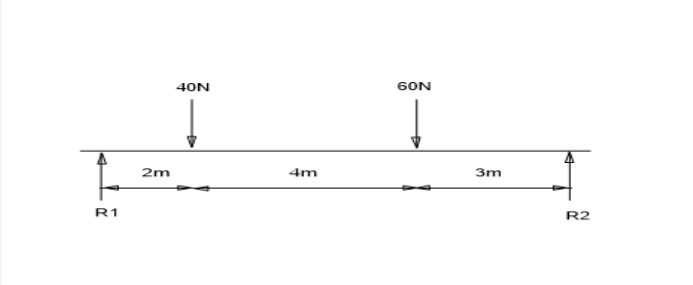


Figure 2.1.25: Simply supported beam.

7. ***Figure 2.1.25*** shows a beam of length 9m with supports at both ends, carrying loads of 40kg at 2m from the left support and 60kg at 4m from the left.

Using a scale of **1m: 10mm** and **1kN: 0.5 mm.**

a. Identify the types of reactions occurring at both supports.

b. Draw the shear force diagram of the forces.

c. Draw the bending moments of the forces.

UNIT 2: SOLID GEOMETRY

Geometry

Introduction

In this section, you will explore how solids intersect and learn how to draw and design artefacts using these principles. By studying intersections, you will develop the ability to visualise and construct accurate curves, a key skill in creating complex 3D forms. You will apply these skills to design an artefact that uses one or more curves of intersection. By the end of the section, you should be able to confidently apply intersection concepts to produce precise drawings and translate them into practical designs, combining both geometric accuracy and creativity.

KEY IDEAS

- The concept of the curve of intersection can be used to design artefacts that combine strength, smooth function, and attractive appearance.
- When solids of different sizes meet at different angles, the intersection curves become uneven or asymmetrical in shape.
- When two solids of the same size meet at different angles, their intersection forms a curve such as circles or ellipses, depending on the angle.

CURVE OF INTERSECTIONS OF THE SAME SIZE

In engineering, curves of intersection are the lines where two solids meet. They ensure accurate fitting and smooth joints. For example, in machines they guide the cutting and joining of pipes, in buildings they show how domes or roofs meet walls, and in cars or aeroplanes they shape body panels for strength and aerodynamics.

In this unit, you will learn to draw curves formed when two solids of the same size intersect at different angles. Using orthographic projection and simple geometric construction, you will plot points on each solid and connect them to reveal the intersection curve. Working with equal-sized solids makes it easier to understand how the angle affects the shape of the curve. Through practice, you will develop skills in visualising 3D intersections and producing accurate technical drawings.

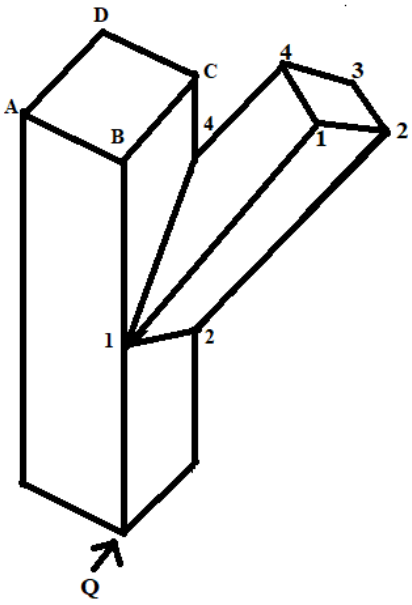


Figure 2.2.1: Two Equal Square Prisms Intersecting at an Angle

Procedure for Drawing the Curve of Intersection of Equal Square Pipes

1. Draw the front elevation and plan of the main pipe in orthographic projection (First angle or Third angle) and label the vertices **A, B, C** and **D.**

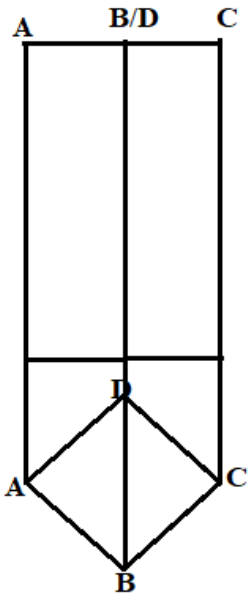


Figure 2.2.2: Front and Top Views of Base Square Prism

2. Draw the duct at a given angle to the main pipe in the front elevation and label the vertices **1,2,3** and **4.**
3. Project the duct to the plan and label **1,2,3** and **4**

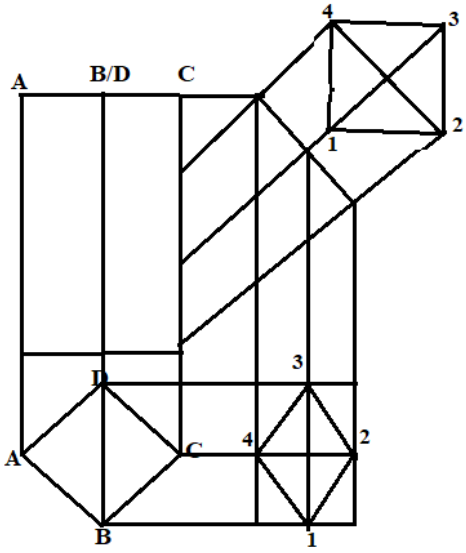


Figure 2.2.3: Front and Top View of the Intersected Two Equal Square Prism

4. Project from the plan the points of intersection of the lines from the duct with the main pipe to the front elevation.
5. Extend the lines on the duct in the front elevation to intersect with their corresponding lines from the plan.
6. Join the points according to the numbers to form the curve of intersection.

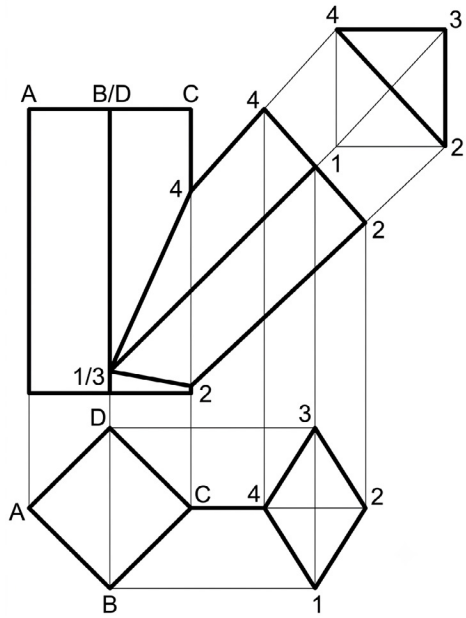


Figure 2.2.4: Final Draw of Intersectional Two Equal Square Prisms

Activity 2.2.1 Draw the Curves of Intersection

Figure 2.2.4 shows a T-pipe connection that consists of a vertical cylinder of diameter 50mm and a horizontal cylinder of the same size. The axes of the cylinders meet at right angles.

Follow the procedure below to draw the curves of intersection.

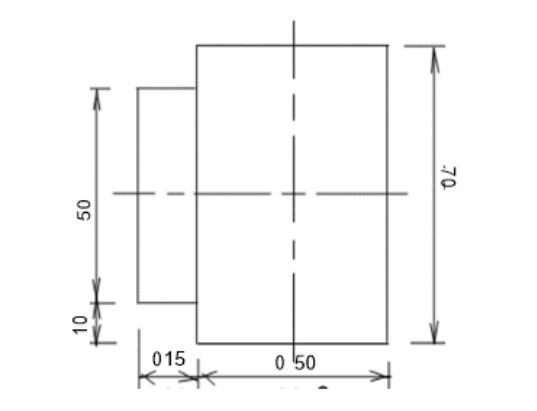


Figure 2.2.5: A Cylindrical Solid

Procedure

1. Draw the top and front views of the cylinders.
2. Divide the circle in the top view into 12 equal parts.
3. Mark point ***m***, where the generator through ***1*** in the top view meets the circle in the top view of the vertical cylinder. Similarly mark ***m*1, m*2,*** ·····, ***m11***
4. Project ***m*** to ***m*** on the generator ***II*** in the front view.
5. Project ***7*** to ***m1, m11; 8 to m2, m 10*** and 9 to ***m*3**, ***m*9**, similarly project all the point.
6. Draw a smooth curve through ***m3***, ***m2***, ***m1***, ***m***, ***m*11**, ***m*10**, ***m9***.

This curve is the intersection curve at the front. The curve at the rear through ***m4***, ***m5***---**m*8*** coincides with the corresponding visible curve at the front. Since the horizontal cylinder penetrates and comes out at the other end, a similar curve of intersection will be seen on the right also.

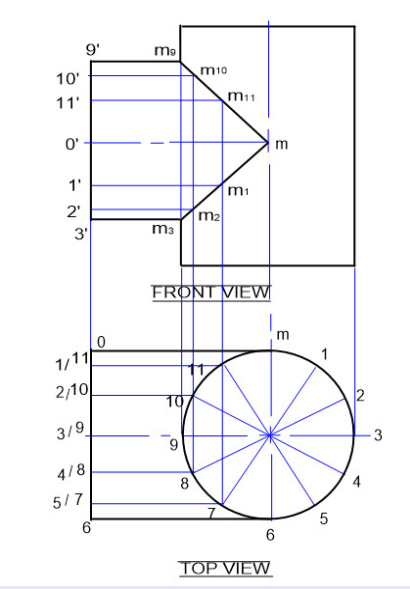


Figure 2.2.6: Final Drawing of Curve for Intersection of Two Cylindrical Prisms

CURVE OF INTERSECTIONS OF DIFFERENT SIZES

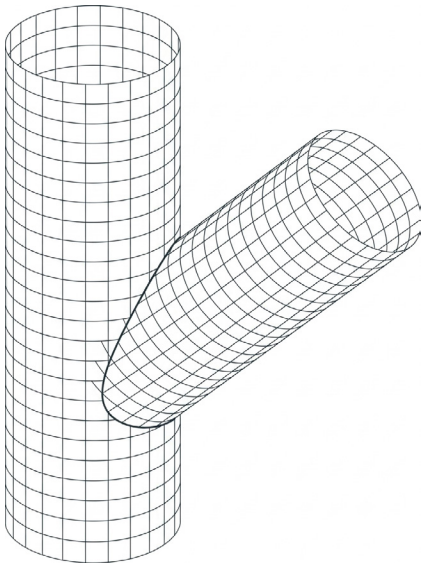


Figure 2.2.7: Curve of Intersections of Different Sizes

Procedure for Drawing the Curve of Intersection of Cylindrical Pipes of Different Sizes

STEP 1

1. Draw the front elevation and plan of the main pipe in orthographic projection (First angle or Third angle).
2. Construct a semi-circle at the end of the duct in the front elevation, with the radius of the duct
3. Divide the semi-circle into several equal parts (8 or 12) and label
4. Construct a semi-circle at the end of the duct in the plan, with the radius of the duct,
5. Divide the semi-circle into some equal parts as done in the front elevation and label
6. Project lines that are parallel to the sides of the duct from the divisions on the semi-circle into the main pipe in the front elevation.
7. Project lines that are parallel to the sides of the duct from the divisions on the semi-circle to intersect with the circumference of the main pipe in plan.

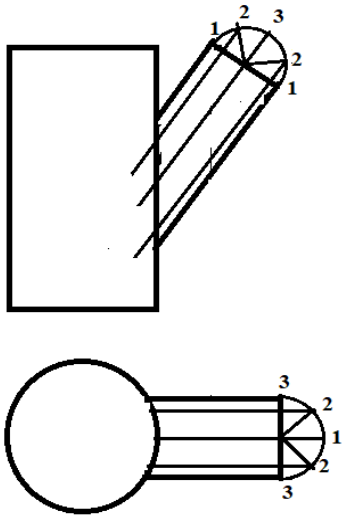


Figure 2.2.8A: Step 1

STEP 2

1. Project vertical lines from the end of the duct in the front elevation to the plan
2. Join the points of intersection of the lines from the front elevation and their corresponding lines in the plan with curves to complete the plan.
3. Project vertical lines from the point of intersection of the main pipe and the duct in plan to intersect their corresponding points in the front elevation.

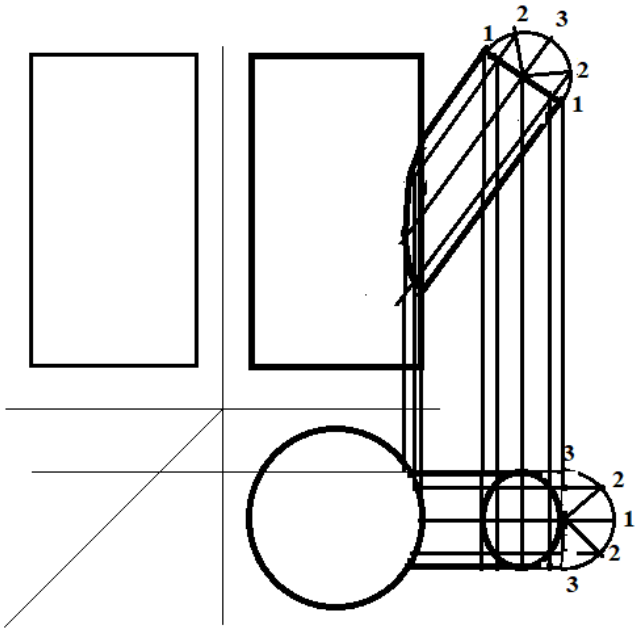


Figure 2.2.8B: Step 2

4. Join the points of intersection on the front elevation to produce the curve of intersection in the front elevation.

5. Project from the front elevation and plan to produce the end elevation as done in orthographic projection.
6. Clearly outline the work to make it complete and indicate the curve of intersection.

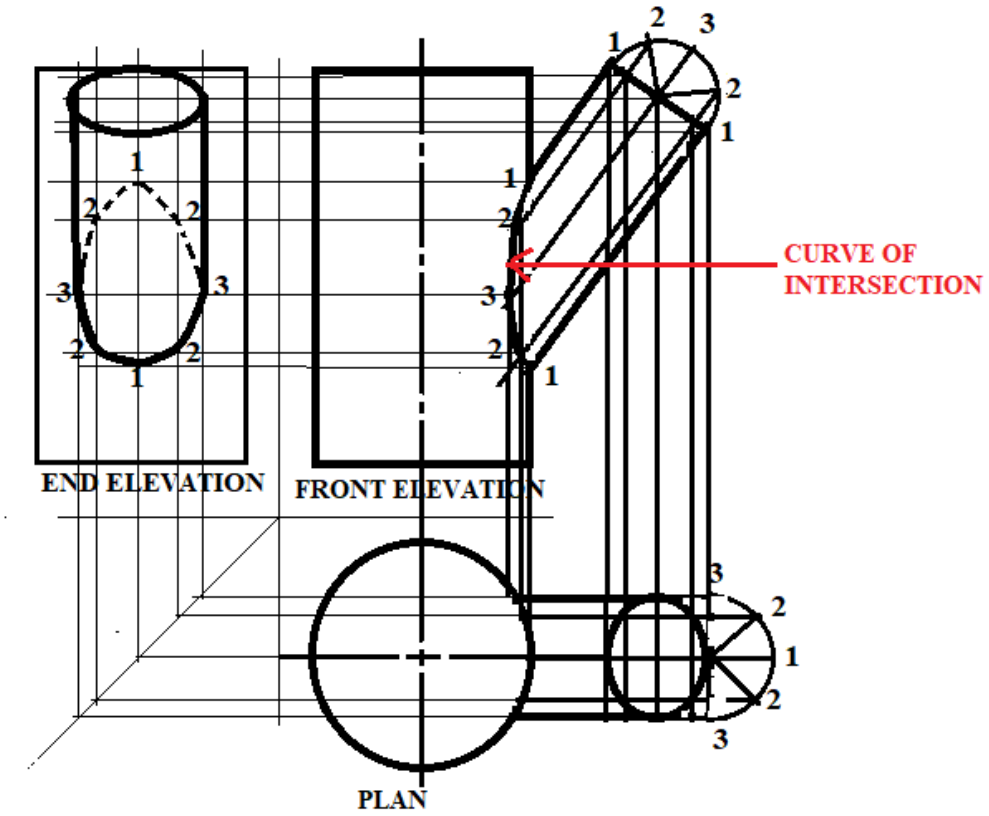


Figure 2.2.8: Curve of Intersection of Cylindrical Pipes of Different Sizes

Activity 2.2.2 Intersections of Solids of Different Sizes

A hexagonal prism of base side 40 mm and axis 100 mm is resting on its base on H.P. with a side of base parallel to V.P. It is penetrated by a cylinder of base diameter 50 mm and axis 100 mm such that their axes bisect each other at right angles.

Follow the Procedure below to draw three views of the combination and show the curves of intersection.

Procedure

1. Draw a hexagon **a, b, c, d, e, f** of side 40 mm to represent the true view **(TV)** of the prism.
2. Project its front view **(FV)** and side view **(SV)** with a 100 mm long axis and label them **a', b', c', d', e', f' and a", b", c", d", e", f"** respectively.

3. Draw the **SV** of the cylinder, which is a circle of diameter 50 mm and the centre of which bisects the axis of the prism at right angles.
4. Project this circle to get the **FV** and **TV** and label them as shown.
5. First locate the points of intersection in the **TV** of the generators **1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11** and **12** of the cylinder with the faces of the prism on left side as **p1, p2, p3, p4, p5, p6, p7, p8, p9, p10, p11, p12** and on right side as **q1, q2, q3, q4, q5, q6, q7, q8, q9, q10, q11, q12.**
6. Project points **p1, p2, p3, p4, p5, p6, p7, p8, p9, p10, p11, p12** to **FV** to meet their corresponding generators **1', 2', 3', 4', 5', 6', 7', 8', 9', 10', 11', 12'** at points **p1', p2', p3', p4', p5', p6', p7', p8', p9', p10', p11', p12'.**
7. Similarly, project **q1, q2, q3, q4, q5, q6, q7, q8, q9, q10, q11, q12** to **FV** and obtain points **q1', q2', q3', q4', q5', q6', q7', q8', q9', q10', q11', q12'.**
8. Join points **p1', p2', p3', p4', p5', p6', p7'** and **q1', q2', q3', q4', q5', q6', q7'** by continuous lines as shown.
9. These lines show the curves of intersection.

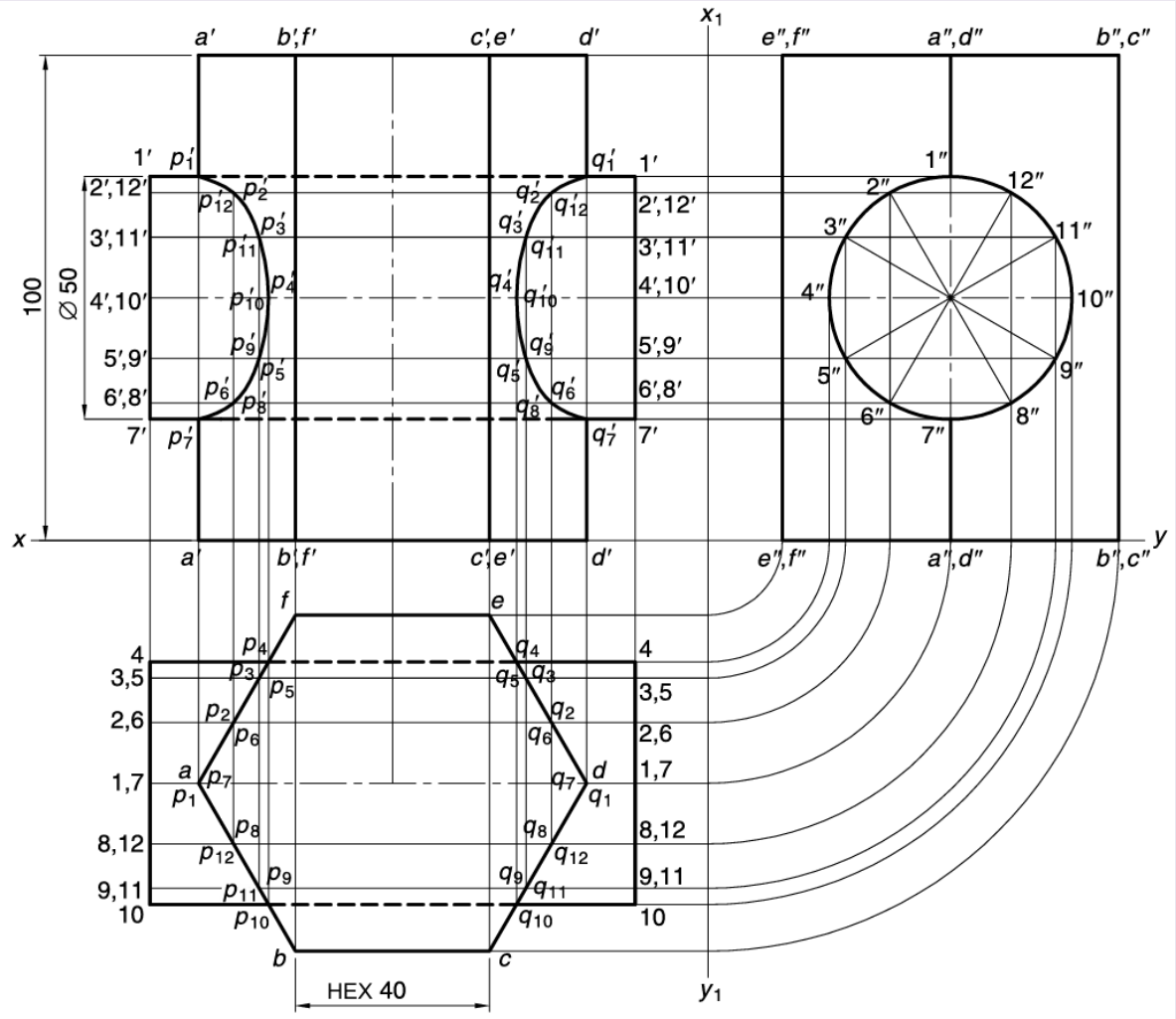


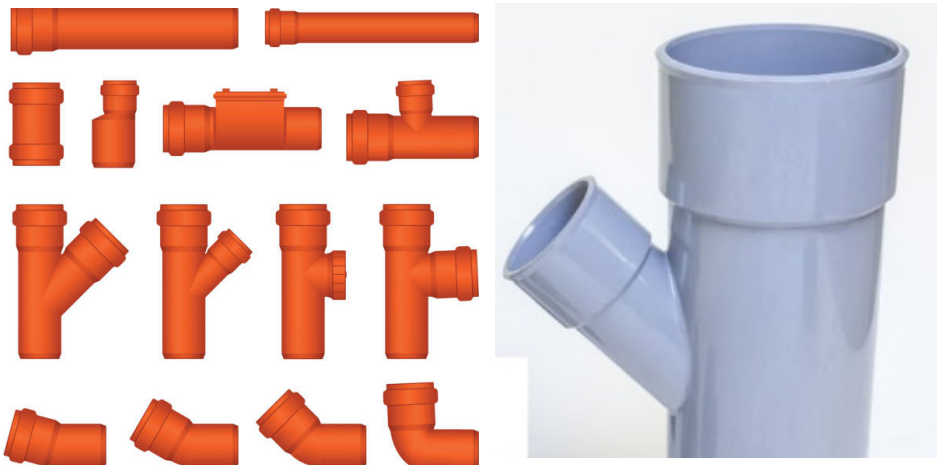
Figure 2.2.9: Three views of the combination of the curves of intersection.

DESIGNING ARTEFACTS

Introduction to Real-Life Applications

You see curves of intersection where two or more solids meet, creating shapes that are both useful and attractive. For example, you notice them at pipe junctions in plumbing for smooth fluid flow, in bicycle frame tube joints for strength and aerodynamics, and in modern furniture where intersecting curves add stability and style. By recognising these curves, you can design with both function and aesthetics in mind.

Examples of artefacts made with curves of intersections are shown below.



A: Pipe Connections and Joints



B: Design of Watering Cans



C: Furniture design



D: Playground items



E: Bicycle Frames







F: Industrial Pipe Connections and Valves

Figure 2.2.10: Examples of Artefacts Made with Curves of Intersections

Role of the Curve of Intersection in Artefacts Design

1. **Functionality:** Distribute forces or guide movement (e.g., pipe intersections reduce turbulence; bicycle frames channel loads smoothly).
2. **Structural Integrity:** Elimination of stress concentrations and improvement of stability.
3. **Aesthetics**: Creation of visual harmony, softness, and dynamic form.
4. **User Interaction**: For smooth transitions and enhancement of ergonomics and comfort (e.g., handrails, seating).
5. **Material and Manufacturing**: Influences material choice and fabrication methods.

Activity 2.2.3 Design Artefacts Using the Curve of Intersection

Follow the guidelines below to create and showcase an artefact that uses curves of intersection to combine strength and style.

1. **Draw two clear sketches of solids intersecting**
   - **a.** Label each sketch with:
     - **i.** The two solids you chose.
     - **ii.** The angle and curve formed.
   - **b.** Add a short note on how the curve adds both function (e.g., load support, smooth flow) and beauty.
2. **Model or Detailed Drawing**

Build a simple scale model or create a detailed drawing/rendering.

Clearly show:

a. The exact curves where the solids meet.

b. Overall size and shape.

c. Chosen material or finish.

3. **Short Explanation**

In 100–150 words, explain:

a. How your curve solves a specific function (e.g., strengthens structure, guides movement).

b. How it enhances the artefact's appearance.

Note: You may choose between sketching/drawing or building a simple model depending on available resources.

4. **For Sketches/Detailed Drawings**

a. Drawing sheets or plain A4 papers

b. Pencils (HB, 2B for shading)

c. Erasers and sharpeners

d. Ruler, set squares, and compass

e. Coloured pencils or markers (optional, for highlighting curves)

5. **For Scale Models (choose affordable/local options)**

a. Cardboard

b. Manila card or thick paper

c. Clay (modelling clay or local substitute)

d. Wood offcuts

e. Plastic bottles or containers

f. Scissors/craft knife

g. Adhesives (glue stick, white glue, or masking tape)

h. Paint or markers

6. Present your sketching/drawing or building a simple model to the class for exhibition.

EXTENDED READING

- Freebury, H. A. (1980). Geometrical and Technical Drawing (Part 2 & 3). London, Cassell Ltd. Pages 61 – 65.
- Morling, K. & Danjor, S. (2022). Geometric and Engineering Drawing. (Fourth Edition). New York. Routledge. (Pages 205 – 215).

REVIEW QUESTIONS

1. ***Figure 2.2.11*** shows the front elevation and plan of the water distribution lines joints to be used by Ghana Water Company. Draw
   - the front elevation and plan in first-angle orthographic projection.
   - the complete right end elevation
   - the curve of intersections of the pipes

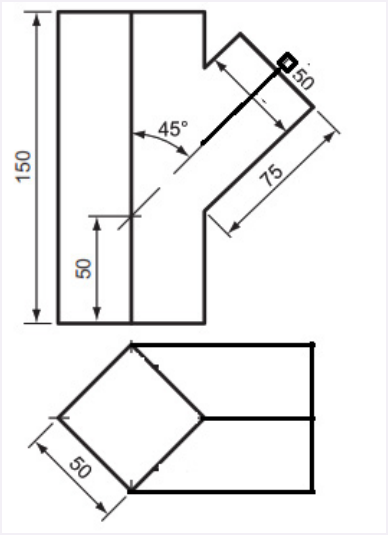


Figure 2.2.11: Front Elevation and Plan

2. ***Figure 2.2.12*** is the front elevation of pipes connected. Draw in third-angle orthographic projection.
   - The front elevation
   - Draw the complete plan
   - Right end elevation
   - The curve of intersections of the pipes

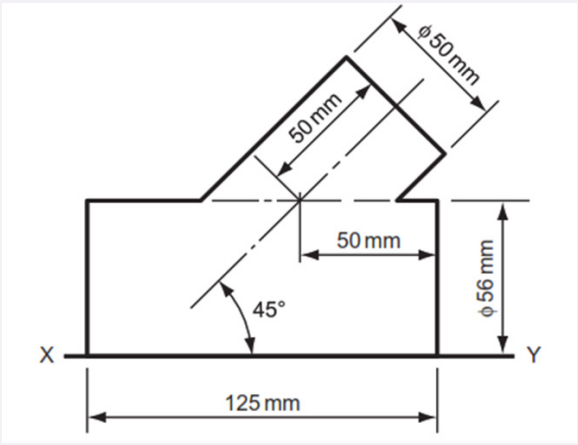


Figure 2.2.12: Front Elevation

3. Identify and name **two artefacts** that clearly show curves of intersection in your community. For each of the artefacts:
   - **a. Sketch** the artefact and highlight the curves of intersection.
   - **b. Discuss Functionality**: How do the intersection curves help the artefact work better?
   - **c. Discuss Aesthetics**: How do the curves improve its appearance?

Write your group's findings in the table below.

Artefact Name	Sketch	Functionality of Curves	Aesthetic role of Curves

UNIT 3: FRACTAL GEOMETRY

Introduction

In this section, you will build on your understanding of the basic concept of fractal geometry to create more complex fractal designs. A fractal is a never-ending pattern that is self-similar across different scales – a shape that, when split into parts, each part is approximately a reduced-size copy of the whole. The section will help you select various geometric shapes used to create complex fractal designs and use the idea of fractal geometry to create complex fractal designs.

By applying the knowledge of fractal geometry, you will be able to construct more advanced fractal patterns.

KEY IDEAS

- Fractal design techniques include iterative, boundary transformation, iterative function systems, hybridisation, and organic adaptation.
- Fractal design uses self-similarity and iteration to repeat patterns. Thus, each design looks like a smaller copy of the whole.
- Fractal transformation processes like shape blending, shape nesting, fractal iterations, and symmetry breaking add complexity and unique design.
- Geometric shapes such as triangles, squares, circles, ellipses, stars, and polygons are key building blocks that can be combined or transformed to create complex designs.
- Project development process includes research and inspiration, sketching, technical development, design enhancement, and application
- Project Development Process is the step-by-step guide to creating complex fractal designs.

FRACTAL GEOMETRY

Selecting appropriate geometric shapes like triangles, squares, and circles is the foundation for creating effective and visually compelling fractal designs. Understanding fractal properties like self-similarity and scaling is important for creating those designs. These guides explore the various geometric shapes that can be used as building blocks for complex fractal patterns, their properties, and how they can be effectively combined and transformed to create sophisticated designs.

Basic Geometric Shapes for Fractal Design

1. **Triangles**

   Triangles are a fundamental shape in fractal design, offering versatility and complexity. Different types, such as equilateral, isosceles, scalene, and right-angled triangles, can be used to create complex patterns.

Selection Considerations

a. Equilateral triangles create balanced, harmonious designs

b. Scalene triangles can create more dynamic, asymmetrical patterns

c. Right-angled triangles work well for grid-based fractal systems

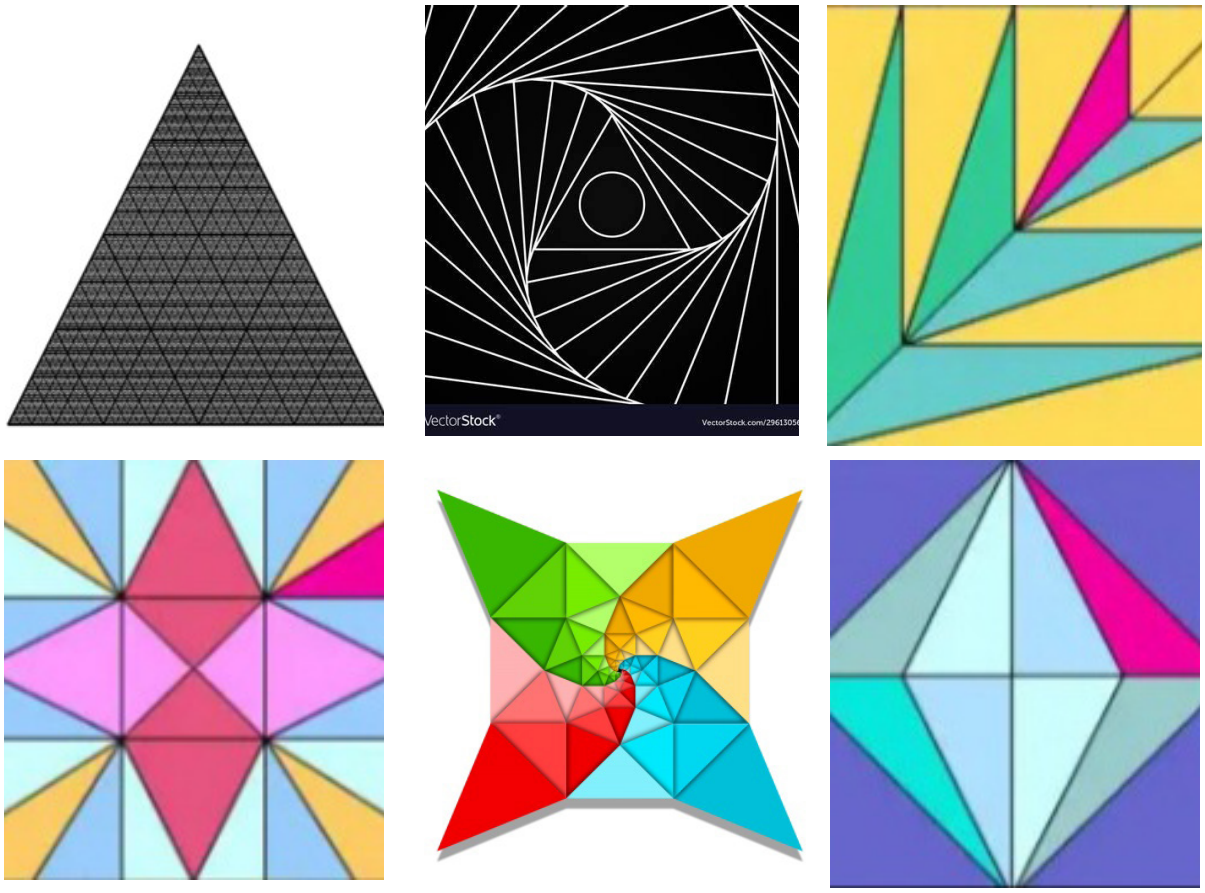


Figure 2.3.1: Triangles in Fractal Design

2. **Squares and Rectangles**

   Different types of squares and rectangles, such as varying sizes, orientations, and arrangements, can be used to generate complex fractals.

Selection Considerations

a. **Squares** create ordered, structured fractals with clear alignment

b. **Rectangles** with different proportions can add rhythm and direction

c. Both can be easily combined with other shapes in composite designs

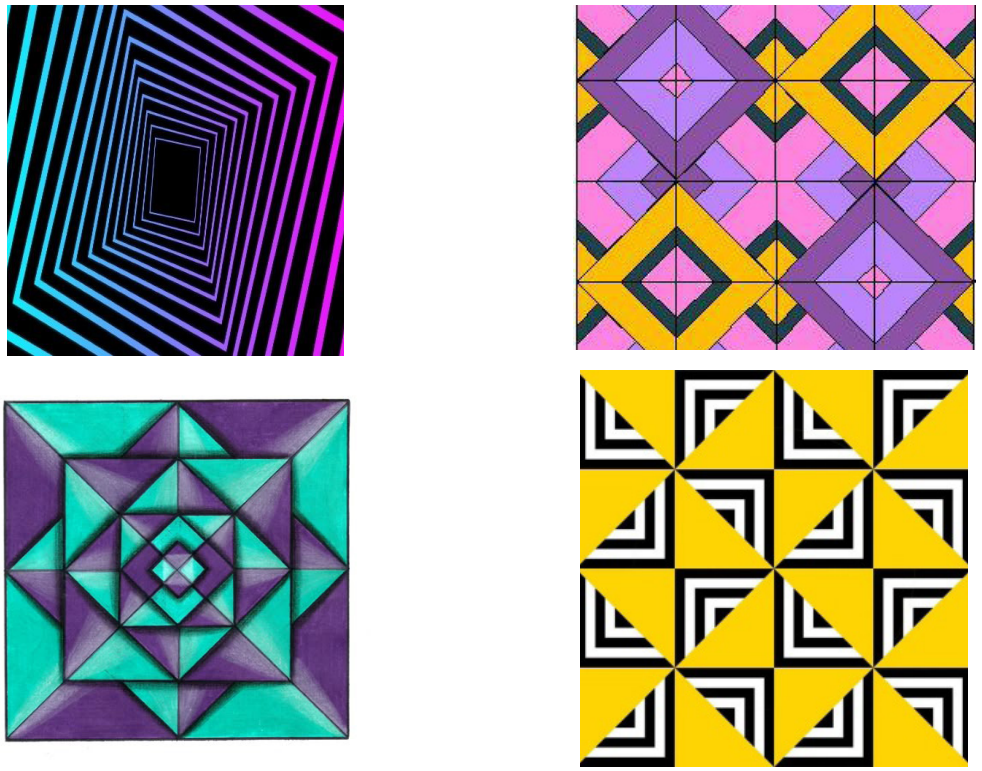


Figure 2.3.2: Squares and Rectangles in Fractal Design

3. Circles and Ellipses

Circles and ellipses have continuous, unbroken curves.

Selection Considerations

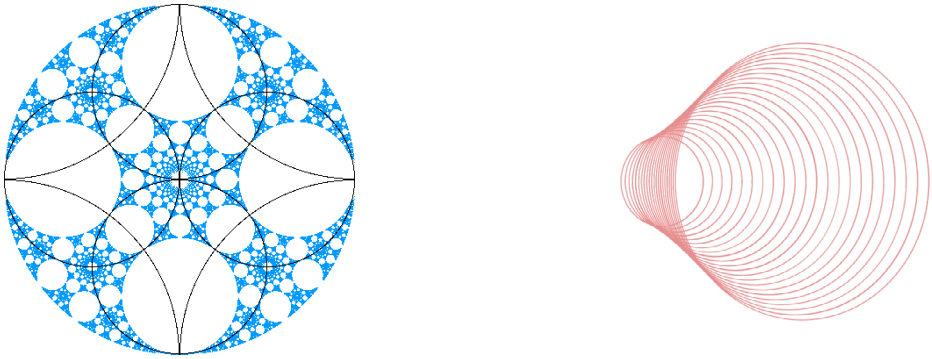
a. Circles are perfectly round, creating fractals with smooth, flowing with high aesthetics.

b. Circles are ideal for creating highly symmetrical, radial patterns.

c. Ellipses can create more dynamic, asymmetrical patterns.

d. Both can be combined with straight-edged shapes for contrast.

e. Challenging to construct precisely by hand but effective in digital designs



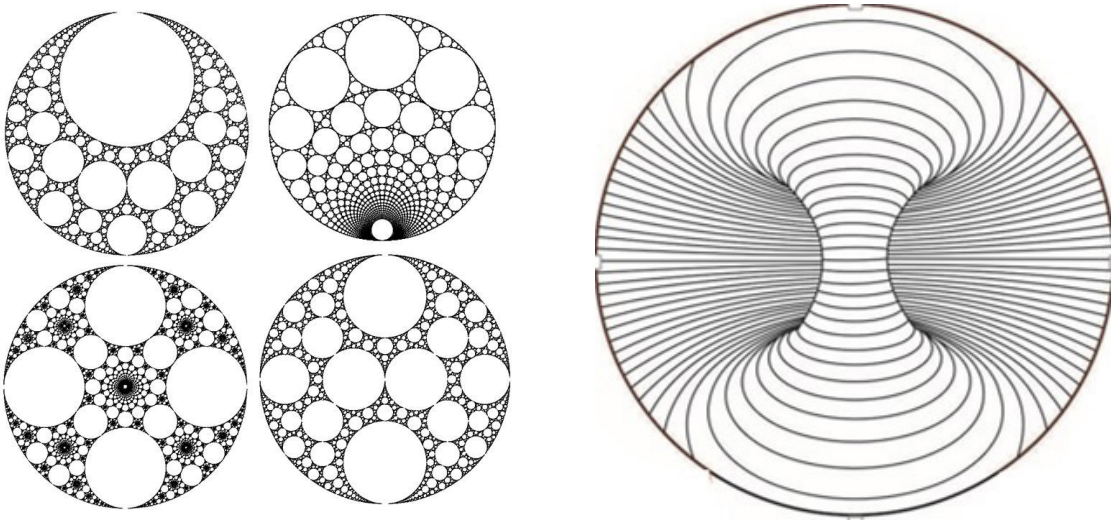


Figure 2.3.3: Circles and Ellipses in Fractal Design

4. **Stars and Polygons**

   Polygons are multi-sided shapes with a varying number of sides and angles.

   Stars are pointed shapes with symmetrical arms radiating from a central point.

Selection Considerations

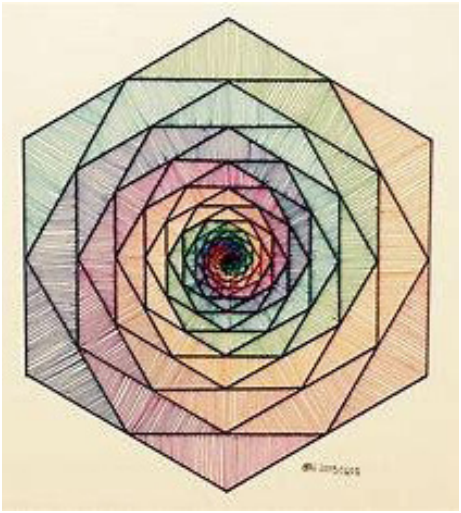
a. Stars create visually striking patterns with cultural resonances

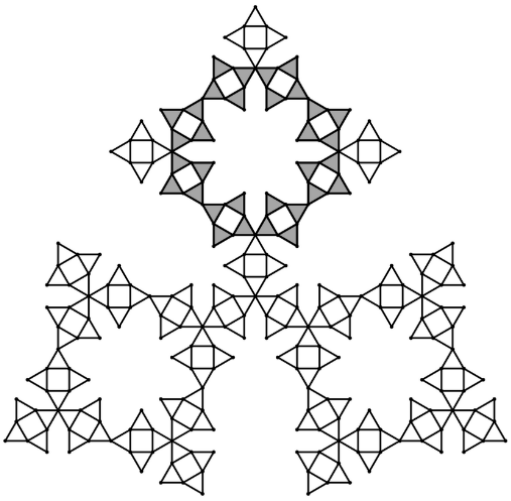
b. More complex to construct but visually rewarding

c. Effective for decorative applications

d. Polygons offer flexibility in design and are used to create complex geometric designs.

e. The pointed shape of a star adds a unique touch to fractal designs.





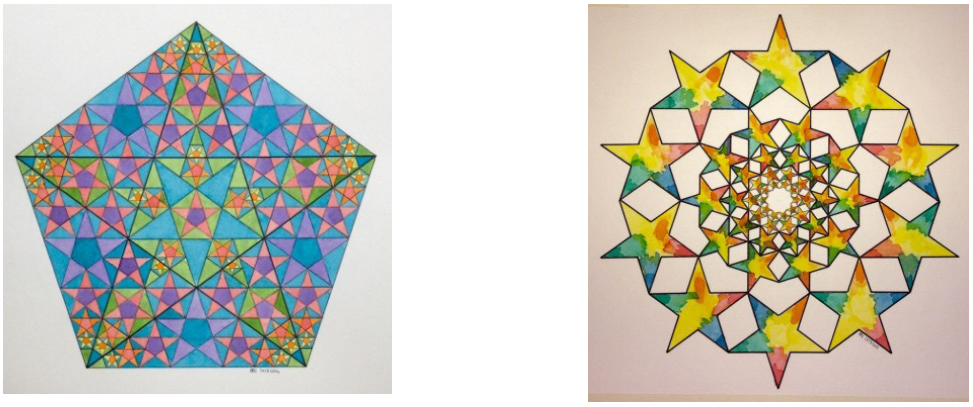


Figure 2.3.4: Stars and Polygons in Fractal Design

Combining and Transforming Shapes in Fractal Geometry

1. **Composite Shapes** are a combination of multiple shapes to create new complex forms

Design Potential

a. Allows for more unique and original fractal patterns

b. Creates more complex self-similarity relationships among designs

c. Enables greater creative expression

d. Enhance the aesthetic appeal of the design.

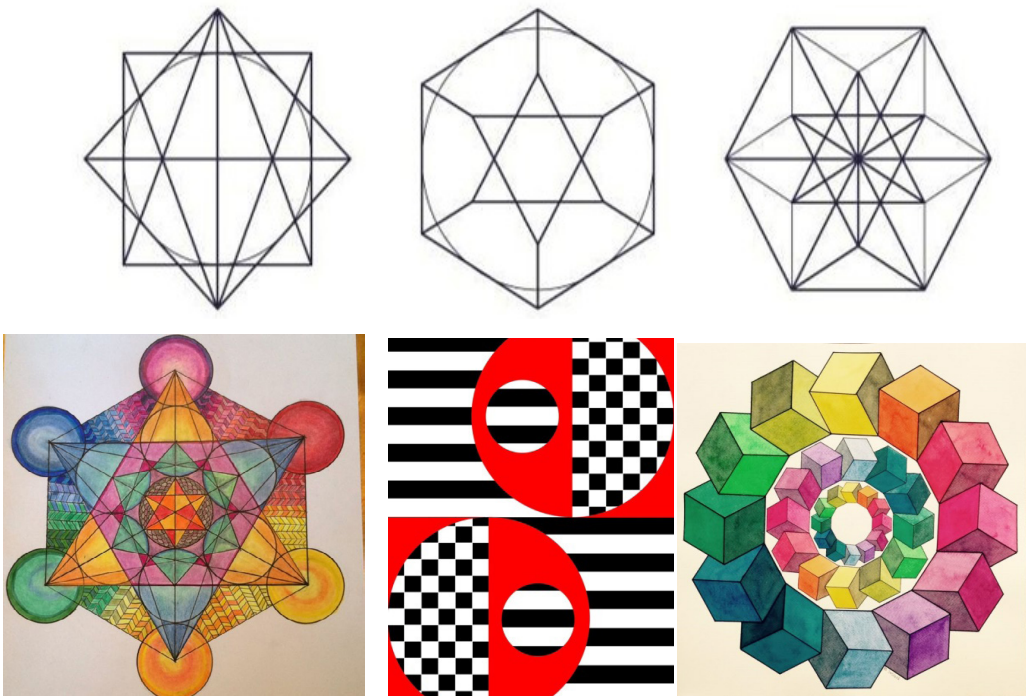


Figure 2.3.5: Composite Shapes in Fractal Designs

2. **Shape Blending** is the merging of shapes to create smooth transitions.

Design Potential

a. Shape blending produces organic patterns.

b. It creates soft, curved designs.

c. It generates natural-looking fractals that mimic real-world patterns.

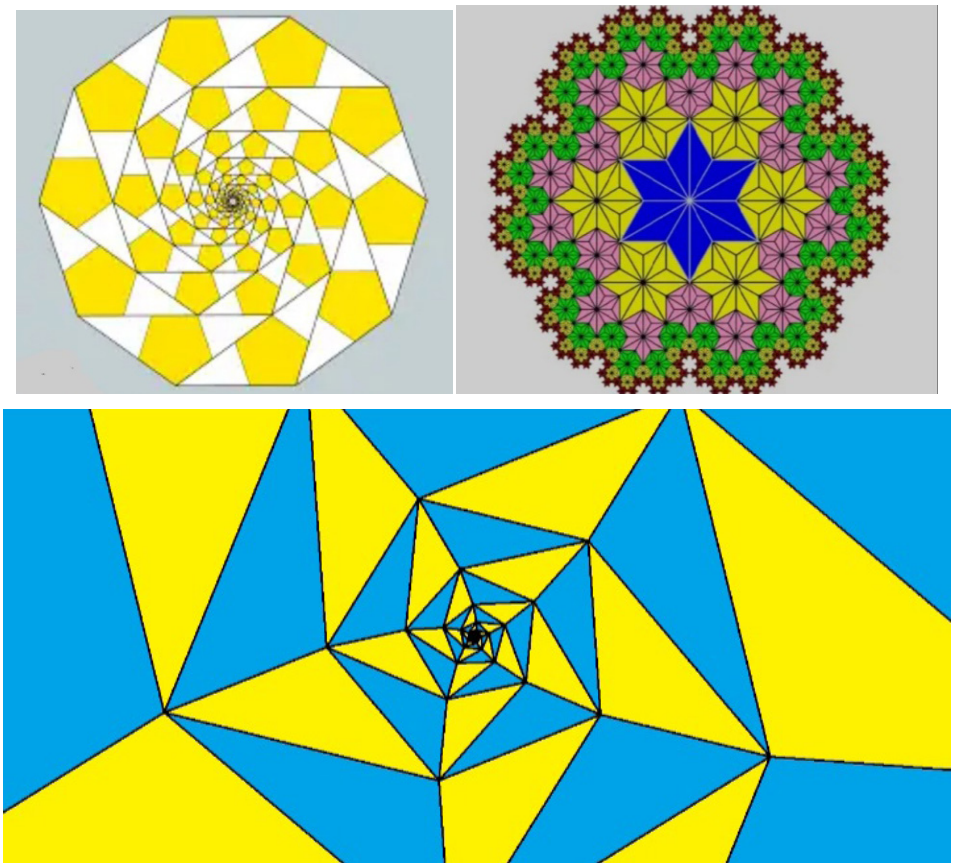
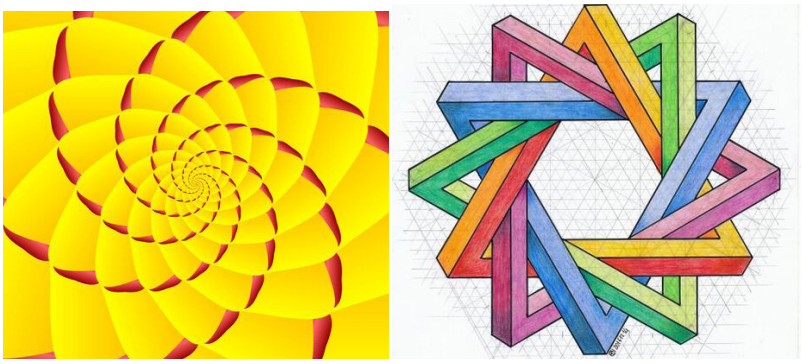


Figure 2.3.6: Shape Blending in Fractal Designs

3. **Fractal Iterations** means repeating shapes with transformations.
   a. Fractal iterations create self-similar patterns.
   b. They add intricate details to the design.
   c. They form complex, geometric designs that are highly aesthetic.



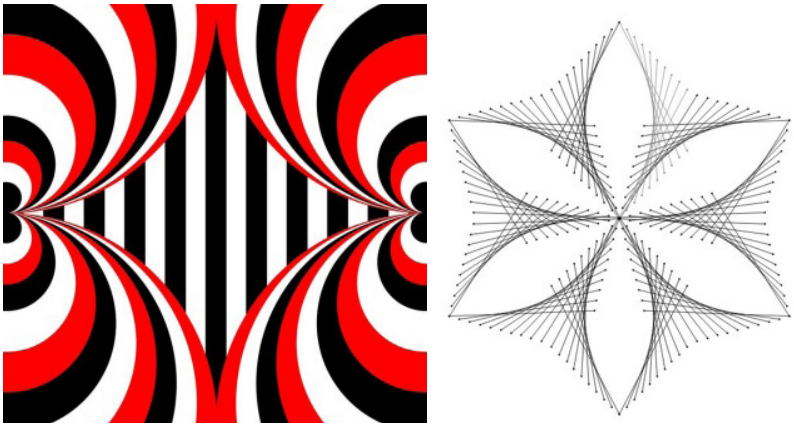


Figure 2.3.7: Fractal Iterations in Fractal Designs

4. **Symmetry Breaking** is the introduction of symmetry through transformations.

Design Potential

a. Symmetry breaking creates dynamic patterns.

b. It generates unpredictable designs that are interesting.

c. It creates visual interest by adding complexity.

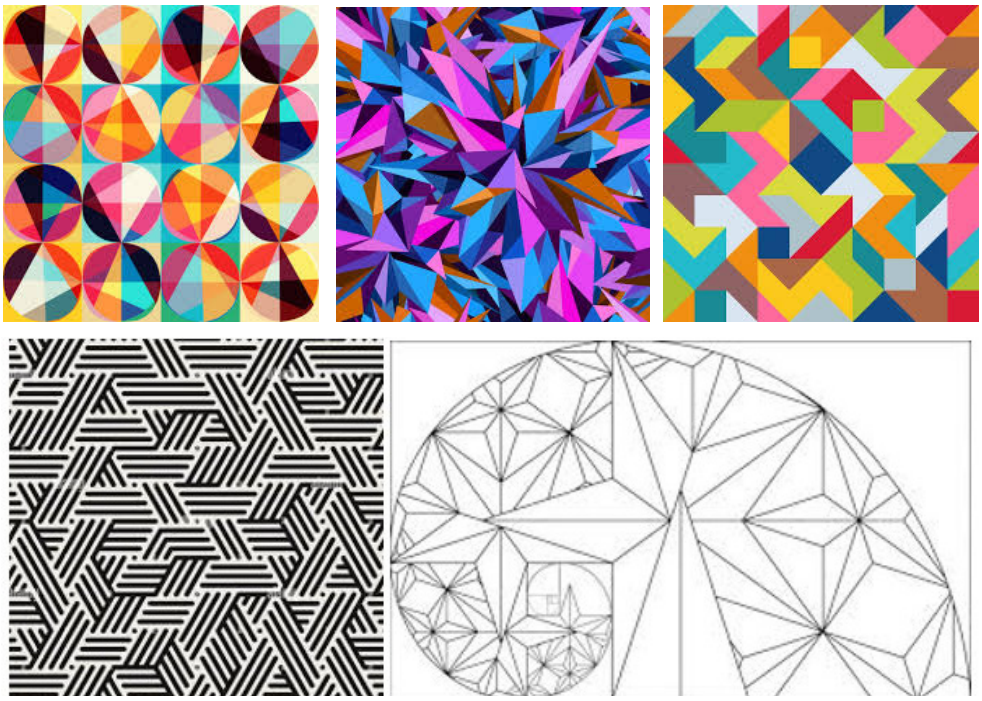


Figure 2.3.8: Symmetry Breaking in Fractal Designs

5. **Shape Nesting** is the embedding of shapes within each other.

Design Potential

a. Shape nesting creates intricate patterns.

b. It forms layered designs that add depth.

c. It generates complex, geometric forms that are visually striking.

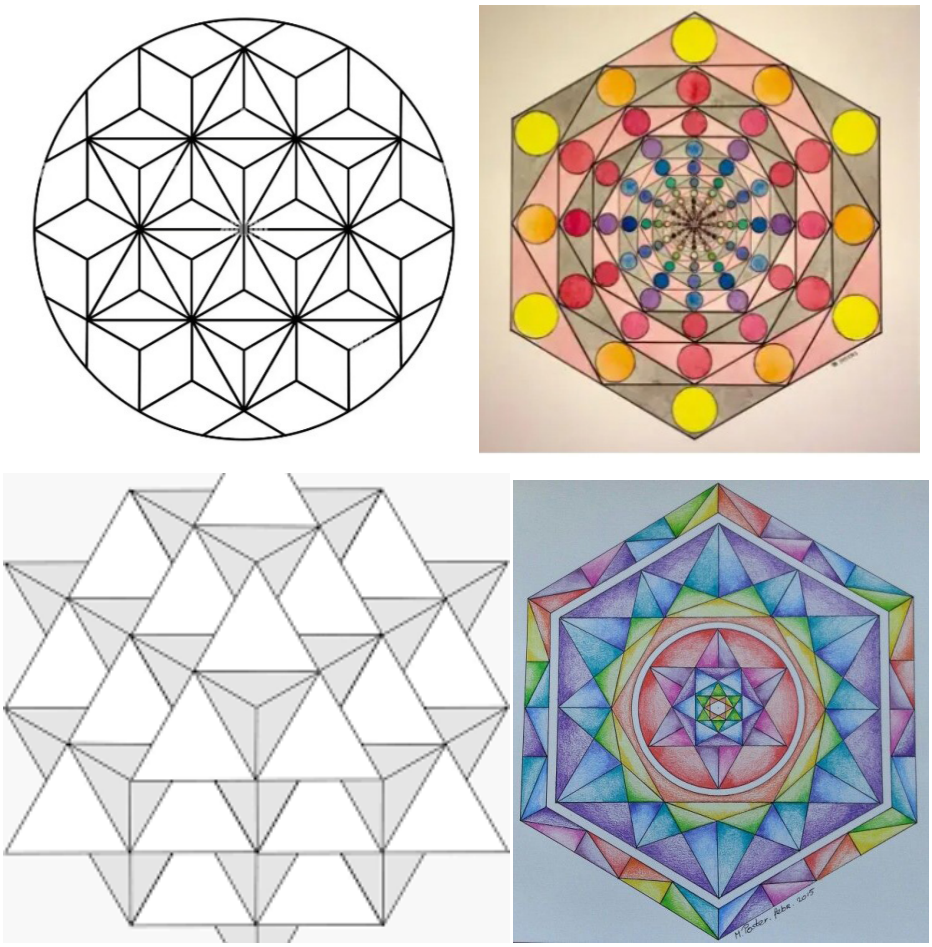


Figure 2.3.9: Shape Nesting in Fractal Designs

Steps for Selecting Geometric Shapes in Fractal Design

1. **Recognise the dual role of shape selection**
   - **a.** Understand that choosing a shape is both a **technical** and a **creative** decision.
   - **b.** Remember that this choice strongly affects the final design outcome.
2. **Study the properties of shapes**
   - **a.** Explore the characteristics of different geometric forms (e.g., symmetry, angles, edges, scalability).
   - **b.** Identify the potential each shape holds for fractal development.
3. **Make informed choices**: Use your understanding of shape properties to select forms that will lead to effective and visually engaging fractal designs.

4. **Combine shape selection with transformation rules**
   a. Apply systematic transformations such as scaling, rotation, reflection, or translation.
   b. Recognise that successful designs emerge when shapes and transformations work together.
5. **Consider both simple and complex shapes**
   a. Experiment with basic forms like triangles and squares.
   b. Progress to composite or more intricate shapes as confidence develops.
6. **Focus on iterative evolution**
   a. Predict how the initial shape will change with each iteration.
   b. Check how this evolution contributes to achieving the overall design purpose.

Activity 2.3.1 Fractal Design For Public Building

A public building requires **THREE** different fractal design applications

a. A floor pattern representing flowing water

b. A wall panel suggesting local plant life

c. A ceiling feature inspired by traditional cultural patterns

Materials/ Tools Needed

Graphite Pencils, Colours (Water/Pencil/Marker), Sheet, Cardboard, Rule/Set Square, Scissors/Cutter

Based on the following guidelines, design the three-fractal required

1. Select geometrical shapes for the design
2. Justify the selection based on properties
3. Create a preliminary sketch showing how your selected shape would be developed through three iterations
4. Choose colours for the design and provide reasons for the selection
5. Present your work to the class for discussion

CREATING COMPLEX FRACTAL DESIGNS

Fractal geometry offers a powerful framework for creating complex, visually engaging designs that exhibit self-similarity across different fields. In this section, you will explore the usage of fractal principles to create original, sophisticated designs that can

be applied to various contexts, including textiles, architecture, product design, and visual arts.

Foundational Fractal Techniques

These are the building blocks for creating complex fractal designs. They include the following.

Iterative Subdivision

Dividing geometric shapes into smaller parts, creating recursive patterns.

Process

1. Begin with a primary geometric shape (triangle, square, etc.)
2. Establish a subdivision rule (e.g., divide into smaller similar shapes)
3. Apply the rule consistently across multiple iterations
4. Maintain geometric precision at each stage.

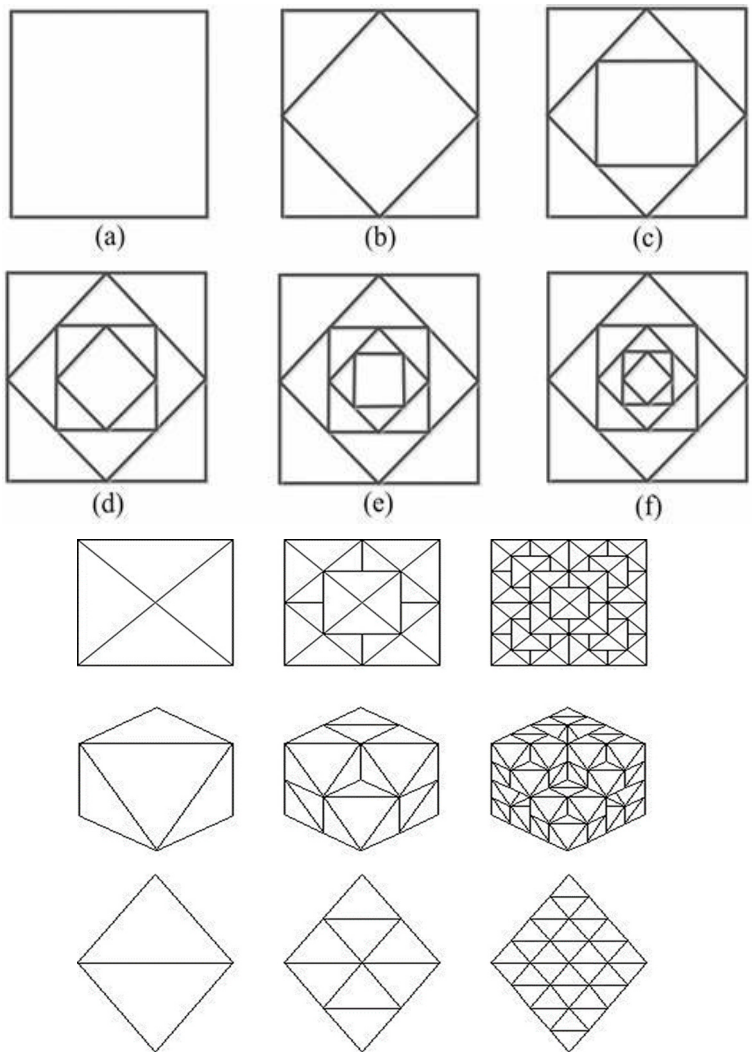


Figure 2.3.10: Iterative Subdivision

Boundary Transformation

Modifying the boundaries of shapes through consistent replacement rules

Process

1. Start with a simple boundary (straight line or simple shape)
2. Create a generator pattern to replace each segment
3. Apply the generator to each straight segment
4. Repeat for multiple iterations

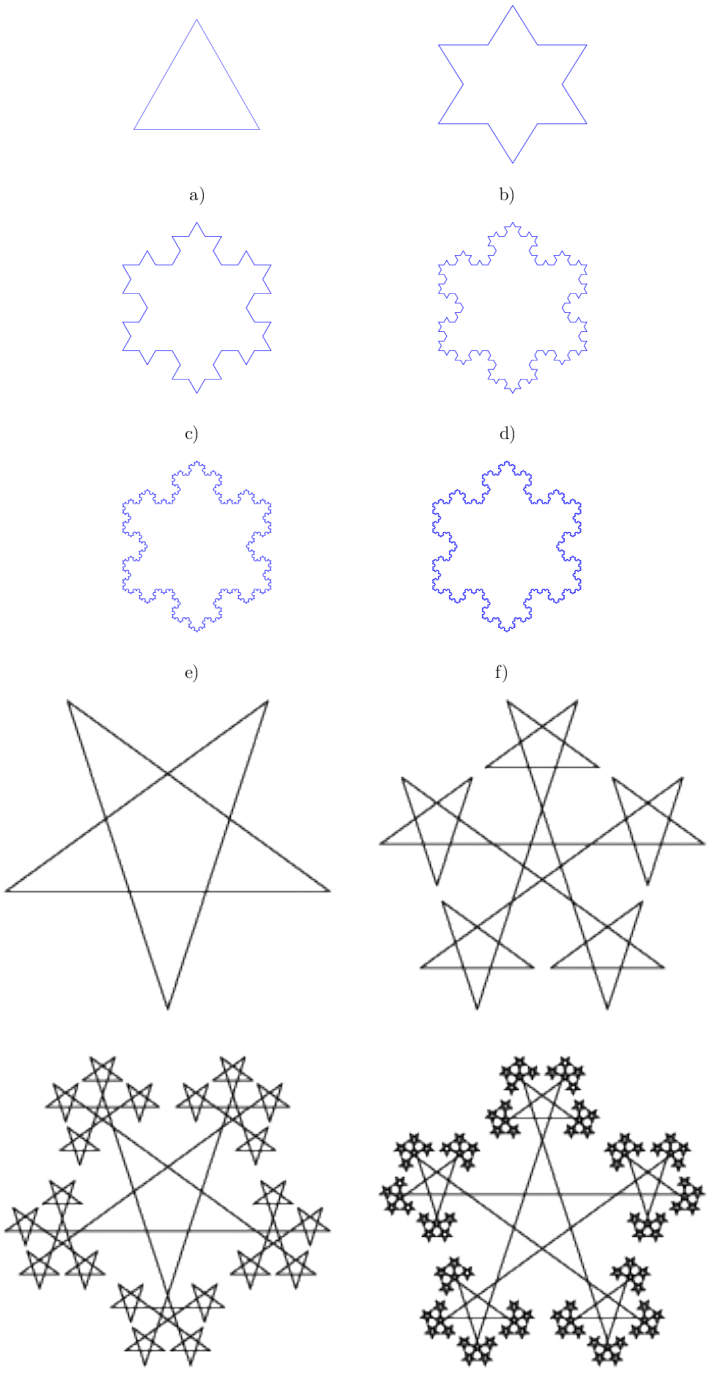


Figure 2.3.11: Boundary Transformation

Iterated Function Systems (IFS)

Using mathematical transformations to create self-similar patterns

Process

1. Select a base shape or pattern
2. Define a set of transformations such as scaling, rotations, and translations
3. Apply the transformations to the starting shape to create smaller copies
4. Repeat the transformation process, applying the same set of transformations to the new shapes
5. Combine the copies into a unified design

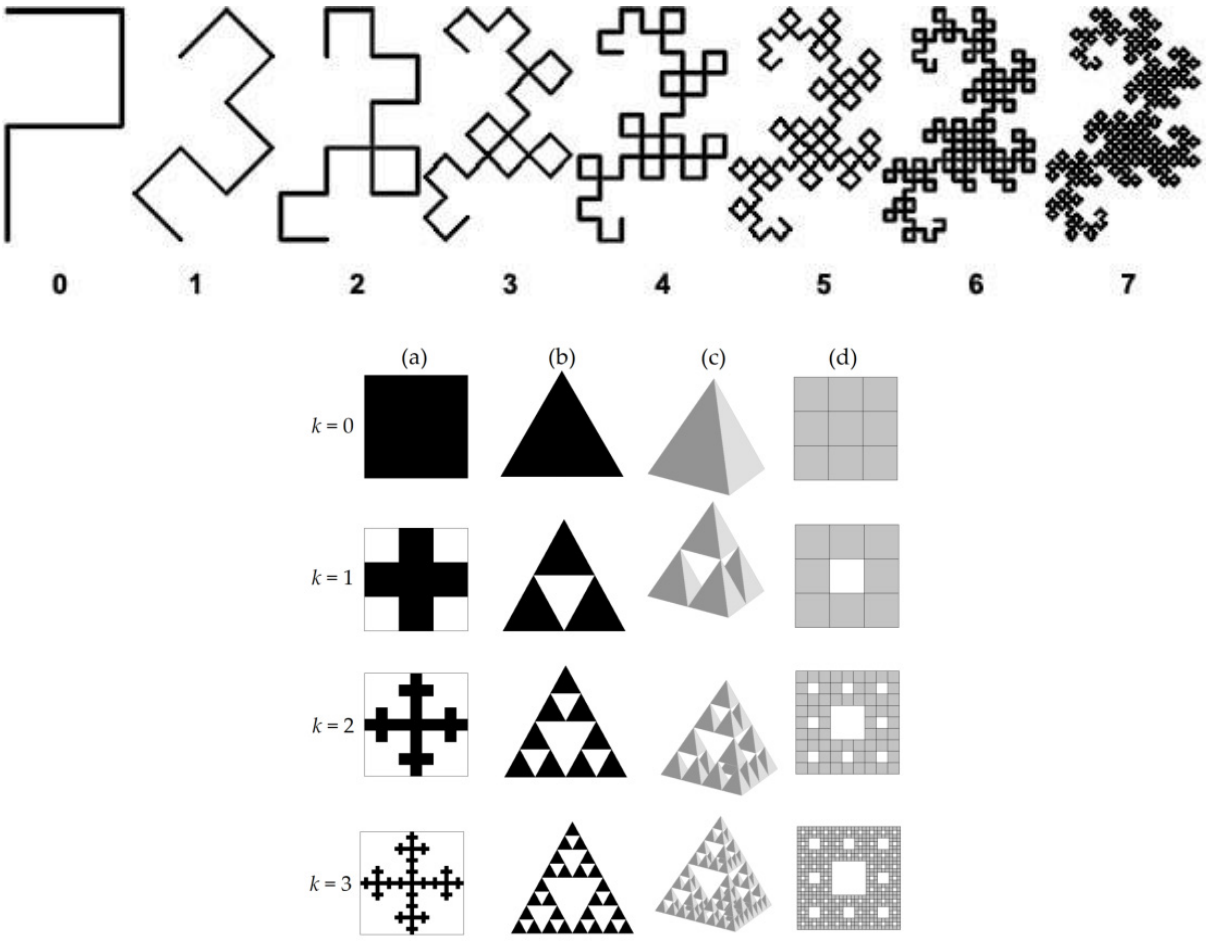


Figure 2.3.12: Iterated Function Systems (IFS)

Fractal Hybridisation

Combining different fractals to create unique patterns

Process

1. Select two or more fractals with different properties and characteristics

2. Identify integration points where patterns can merge
3. Establish transition rules between different fractal systems
4. Maintain visual cohesion across the hybrid design

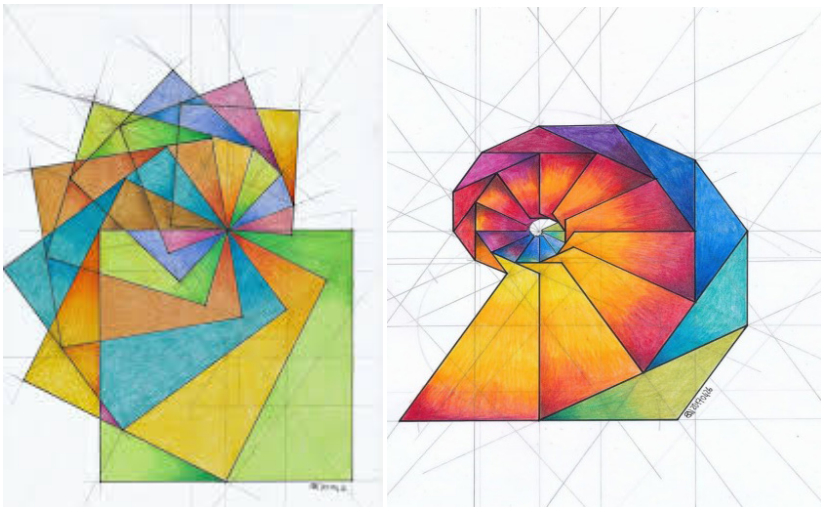


Figure 2.3.13: Fractal Hybridisation

Organic Adaptation

Modifying geometric fractals to create natural and organic forms.

Process

1. Begin with a structured geometric fractal
2. Introduce controlled irregularity to straight lines and angles
3. Vary the scaling factor slightly between iterations
4. Add natural elements like curves and asymmetry

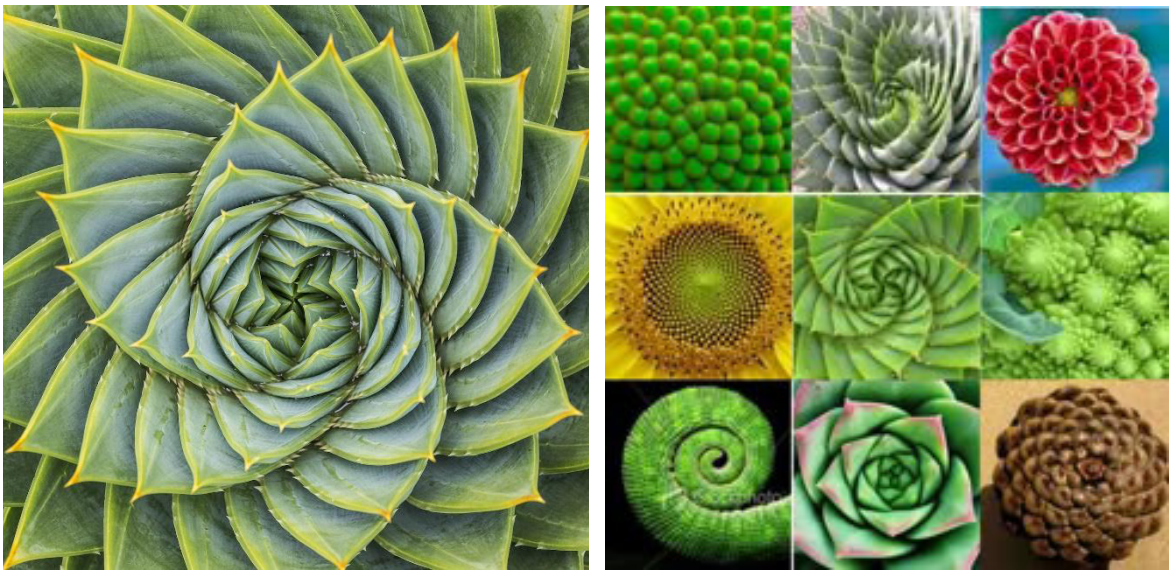


Figure 2.3.14: Organic Adaptation

Project Development Process

1. **Research and Inspiration.**
   - **a.** Gather references and inspiration from nature, art, and culture
   - **b.** Explore different types of fractals and their applications
   - **c.** Identify the theme and concept for the project (e.g., cultural oasis)
2. **Fractal Selection and Planning**.
   - **a.** Choose a specific fractal pattern or structure to work with
   - **b.** Determine the scale and complexity of the fractal design
   - **c.** Plan the composition and layout of the design
3. **Sketching Initial Ideas**.
   - **a.** Create rough sketches of the fractal design concept
   - **b.** Experiment with different shapes, patterns, and textures
   - **c.** Refine the design idea and identify potential challenges and solutions
4. **Technical Development**
   - **a.** Draw the foundation shape with precise measurements
   - **b.** Establish clear guidelines for iteration
   - **c.** Set up a coordinate system or grid if needed
   - **d.** Apply the selected fractal rule with careful attention to detail
   - **e.** Maintain geometric accuracy
   - **f.** Evaluate the visual effect and make adjustments if necessary
   - **g.** Progressively develop the design through planned iterations
   - **h.** Maintain consistency in the application of rules
   - **i.** Use appropriate tools to ensure precision
   - **j.** Add line weight variation for visual hierarchy
   - **k.** Refine intersections and connections between elements
5. **Design Enhancement**
   - **a.** Emphasise certain iterations through line weight or colour
   - **b.** Ensure the design reads well at different viewing distances
   - **c.** Develop a colour strategy that enhances the fractal structure
   - **d.** Consider using colour to differentiate iteration levels
   - **e.** Explore gradients or colour progressions that follow the fractal logic

6. **Application Development**
   - **a.** Modify the design to suit its intended application
   - **b.** Consider how the fractal will translate to the intended medium
   - **c.** Create final renderings showing the design in context

Activity 2.3.2 Create Beautiful Fractal Design For Exhibition

1. Using any foundational fractal technique, create a beautiful fractal design model for;
   - **a.** The floor pattern representing flowing water
   - **b.** The wall panel suggesting local plant life
   - **c.** The ceiling feature is inspired by traditional cultural patterns.
2. Display your work on the classroom walls for exhibition

EXTENDED READING

- Fractal Foundation – https://fractalfoundation.org

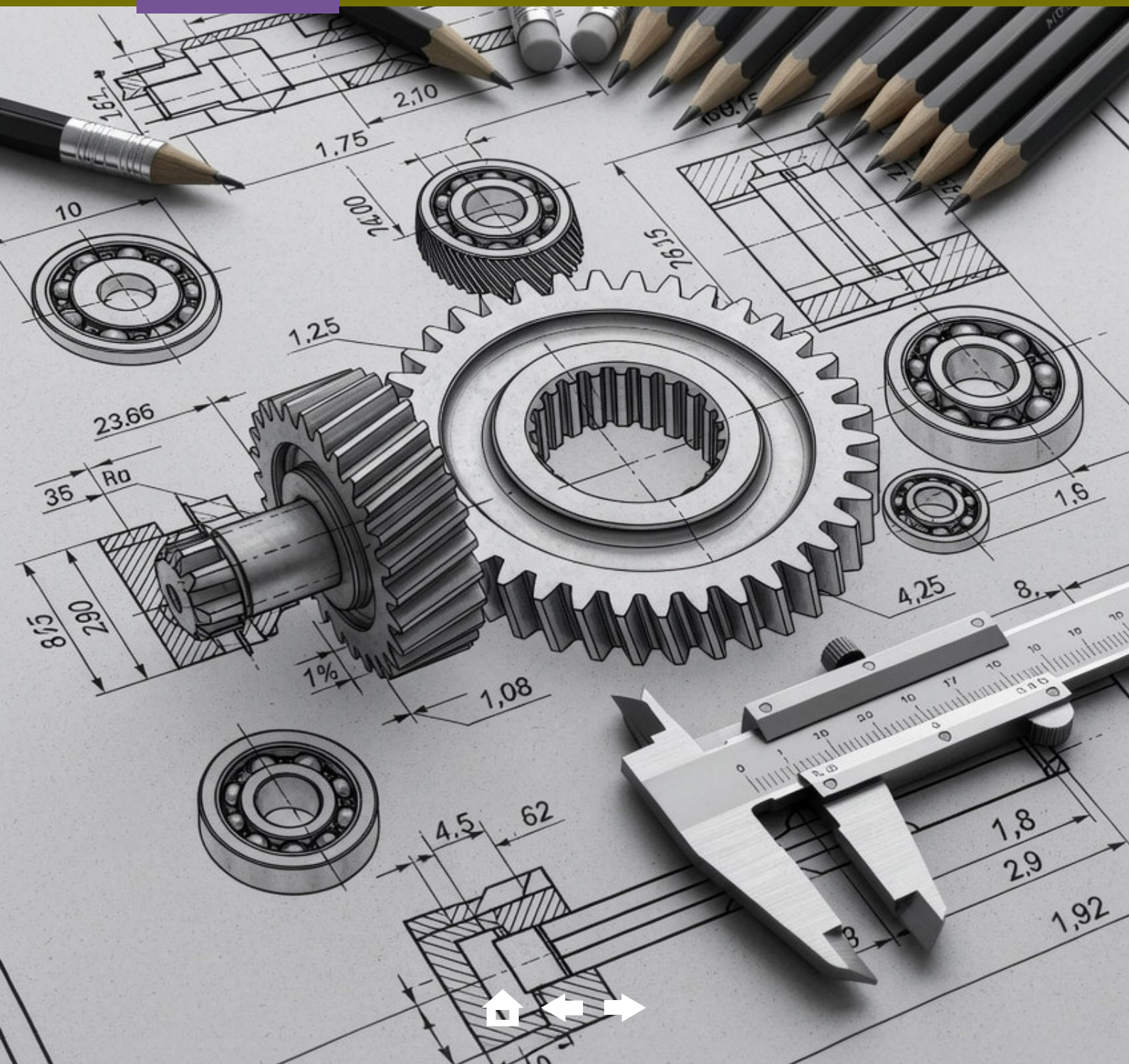
REVIEW QUESTIONS

1. Discuss three characteristics of geometric shapes used to create complex fractal designs.
2. Explain the processes involved in the boundary transformation technique and use it to create a beautiful complex fractal design for a clothing company in Ghana

SECTION

3

EXTENDED DRAWING



UNIT 1: BUILDING DRAWING

Introduction

This unit will help you understand building drawings, and you will be able to produce freehand sketches of building elevations, ground floor plans and sections of buildings.

Also, you will explore building codes and standards, which will include standard room dimensions and spatial requirements, door and window specifications, circulation and accessibility standards, basic structural requirements, and conventional representation of building elements, etc.

Learners will also produce sketches of floor plans of domestic buildings and proceed to develop them with drawing instruments or CAD, as well as the sectioning.

KEY IDEAS

- A floor plan shows the arrangement of rooms, walls, doors, and windows in a building, drawn to scale.
- Building codes and standards guide safety, accuracy, and uniformity in drawing and construction.
- Freehand sketches of floor plans help you practice proportions and layouts without instruments.
- Sectional drawings show a vertical cut of the building, revealing internal details with correct hatching and labels.
- Symbols represent building elements (doors, windows, stairs, fixtures) for easy, uniform and clear interpretation.
- Using drawing instruments or CAD ensures precision, correct scale, and neat presentation of floor plans.

BUILDING CODES, STANDARDS AND SYMBOLS

Building codes, standards, and symbols form the essential language of architectural communication and construction regulation. They create a standardised framework that ensures buildings are safe, functional, and constructed according to recognised best practices.

Building Codes

Building codes are legally enforceable regulations established by governmental authorities that set minimum requirements for the design, construction, alteration, and maintenance of buildings. These regulations primarily focus on:

1. **Public Safety**: Protecting occupants from structural failure, fire hazards, and health risks
2. **Accessibility**: Ensuring buildings can be used by people of all abilities
3. **Energy Efficiency**: Regulating thermal performance and energy consumption
4. **Sanitation**: Establishing requirements for plumbing and waste management
5. **Structural Integrity**: Setting minimum standards for structural systems

Building codes typically have the force of law and are adopted at national, regional, or local levels. In Ghana, the Ghana Building Code (GBC) provides the regulatory framework for construction practices throughout the country.

Building Standards

Building standards are documented agreements containing technical specifications or precise criteria to be used consistently as rules, guidelines, or definitions of characteristics. Standards may be:

1. **Voluntary**: Recommended practices developed by industry organisations
2. **Mandatory**: When referenced or incorporated into building codes
3. **Consensus-based**: Developed through collaboration among experts, manufacturers, and users

Standards address specific aspects of building design and construction, such as:

a. Material properties and performance

b. Testing methodologies

c. Installation procedures

d. Product specifications

e. Design methodologies

Standards are typically developed by organisations such as the Ghana Standards Authority (GSA), the International Organisation for Standardisation (ISO), or industry-specific bodies.

Building Symbols

Building symbols are graphical representations used in architectural and construction drawings to communicate design intent, spatial arrangements, and technical information. These symbols provide a universal visual language that allows drawings to be understood across language barriers and professional disciplines.

Types of Building Symbols

Architectural Symbols: Representing walls, doors, windows, stairs, and other building elements.

SYMBOL NAME	SYMBOL	SYMBOL NAME	SYMBOL
Double door		Revolving door	
By-pass door		Glider window	
Window		Casement window	
Bi-fold door		Garden window	
Double Bi-fold door		Sliding door	
Overhead door		Double sliding door	
Folding door		Sliding glass door	

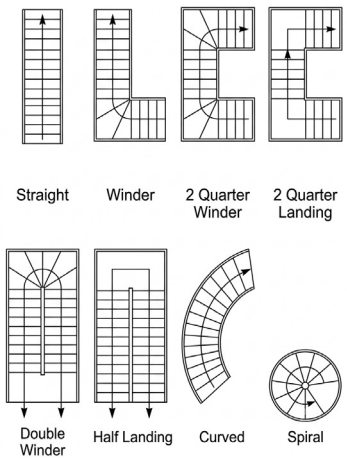


Figure 3.1.1: Architectural Symbols

1. **Material Symbols**: Indicating different construction materials

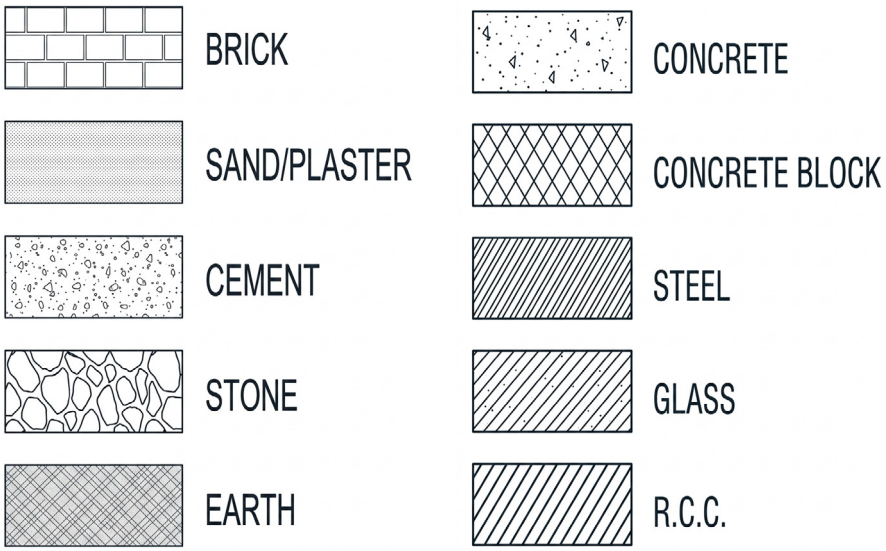


Figure 3.1.2: Material Symbols

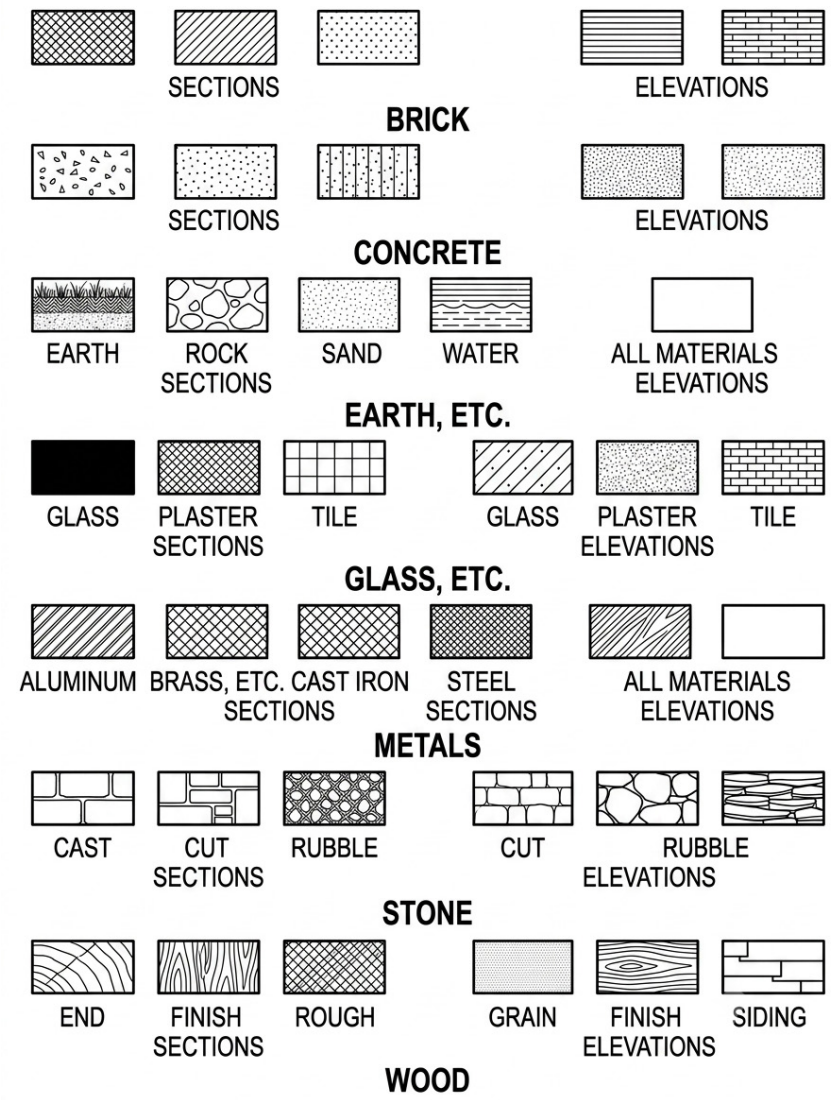


Figure 3.1.3: Material Symbols

2. **Electrical Symbols**: Showing lighting fixtures, outlets, switches, and electrical systems

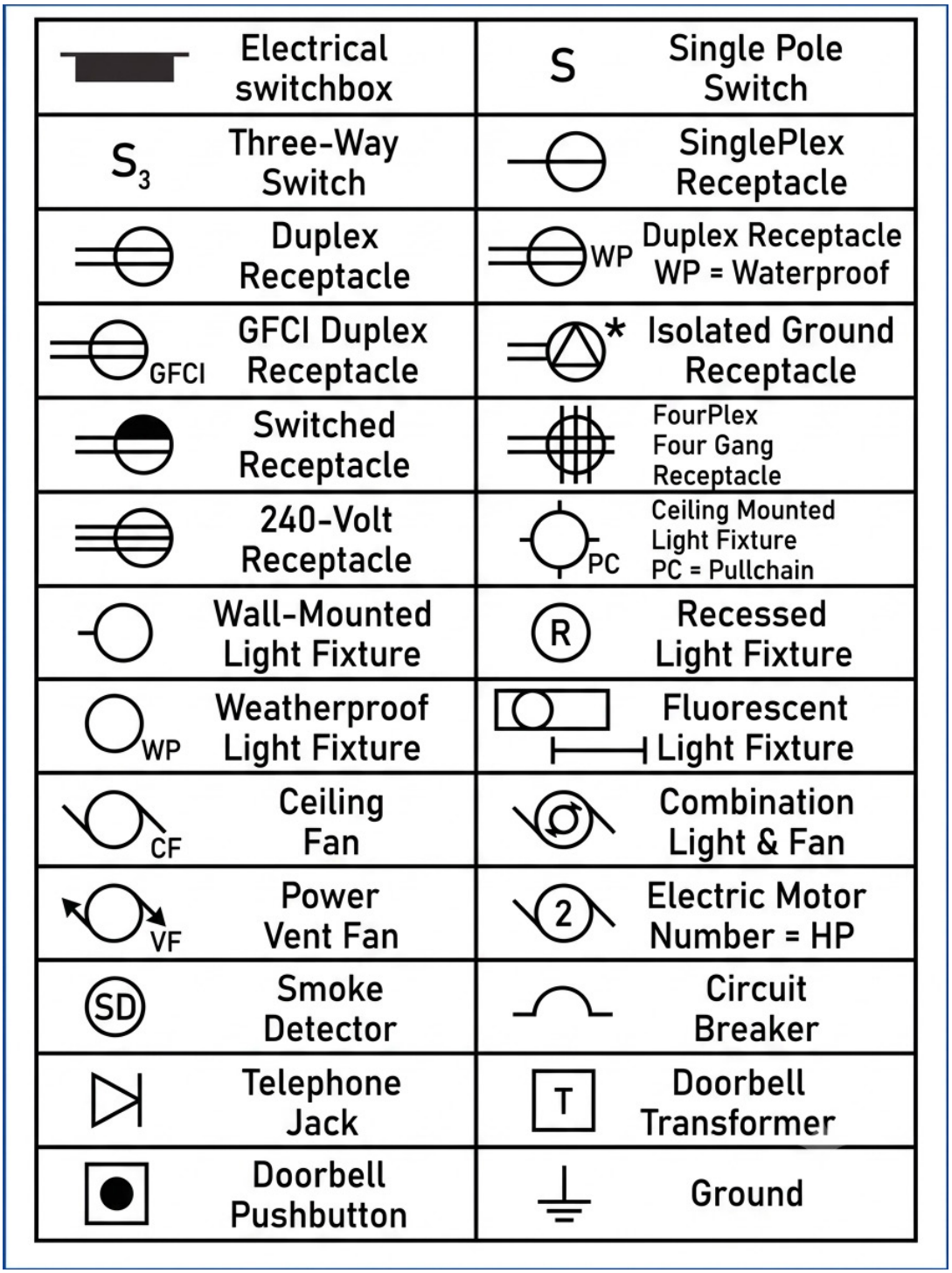


Figure 3.1.4: Electrical Symbols

3. **Plumbing Symbols**: Representing fixtures, pipes, and sanitary systems



Figure 3.1.5: Plumbing Symbols

4. **Mechanical Symbols**: Indicating HVAC components and equipment

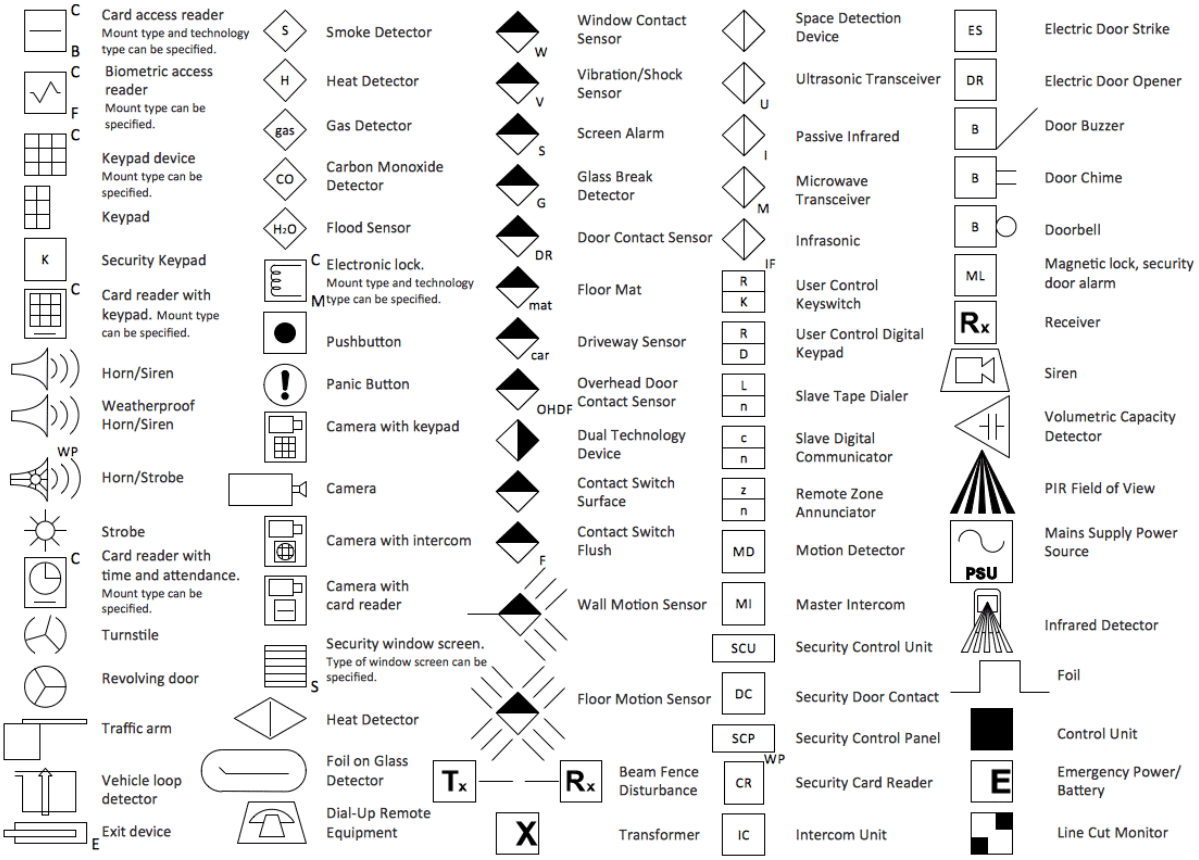


Figure 3.1.6: Mechanical Symbols

Importance of Building Codes, Standards, and Symbols

1. **Ensuring Public Safety and Welfare**

   The primary purpose of building codes and standards is to protect public health, safety, and general welfare as they relate to the construction and occupancy of buildings. They establish minimum requirements to:

   a. Prevent structural collapse

   b. Ensure adequate ventilation and air quality

   c. Prevent electrical and mechanical hazards

   d. Provide accessibility for people with disabilities

   e. Ensure sanitary conditions

2. **Facilitating Clear Communication**

   Building symbols and standardised drawing conventions enable effective communication among all stakeholders in the construction process:

   a. Architects and designers can clearly express design intent

   b. Engineers can specify technical requirements

   c. Contractors can accurately interpret construction documents

   d. Building officials can verify code compliance

   e. Clients can understand the proposed designs

3. **Promoting Consistency and Quality**

   Standardisation through codes, standards, and symbols promotes:

   a. Consistent application of best practices

   b. Predictable building performance

   c. Quality assurance in construction

   d. Efficient construction processes

   e. Reduced construction costs through standardisation

   f. Simplified maintenance and renovation

4. **Supporting Legal and Regulatory Frameworks**

   Building codes and standards provide:

   a. Legal basis for enforcement of safety requirements

   b. Clear criteria for design approval and permitting

   c. Benchmarks for inspection and quality control

   d. Framework for dispute resolution

e. Basis for building permit review

Building codes, standards, and symbols form the essential framework for architectural communication and construction regulation. They ensure that buildings are safe, functional, and constructed according to recognised best practices. Understanding these elements is fundamental for anyone involved in the design, construction, or regulation of buildings.

Activity 3.1.1 Ground Floor Plans and Construction Symbols

1. Write down three rules in your school and explain why each rule is important.
2. Write three reasons why we need rules and standards in building construction.
3. Use simple rectangles to sketch a basic floor plan.
4. Label the sketch
   - **a.** Copy the basic construction symbols below and write what each stands for.



   - **b.** Draw a small sample bathroom with symbols for toilet, shower, and bathtub.

Tools and materials needed: cardboard, pencil, ruler, colour pencils, felt pen, or marker.

   - **c.** Present your work for class discussion.

FREEHAND SKETCHES OF GROUND FLOOR PLANS

Freehand sketching of floor plans is a fundamental skill in architectural design and communication. These preliminary drawings serve as visual thinking tools that allow designers to quickly explore spatial ideas, communicate concepts, and document existing conditions without the constraints of formal drafting tools.

Mastering freehand floor plan sketching provides a valuable foundation for both design development and technical documentation.

Examples of freehand floor plan sketches

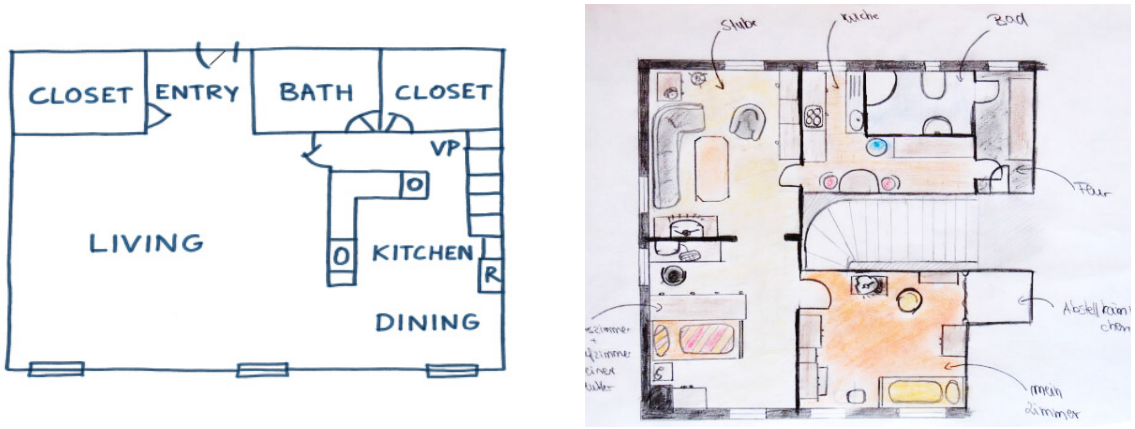


Figure 3.1.7: Freehand Floor Plan Sketches

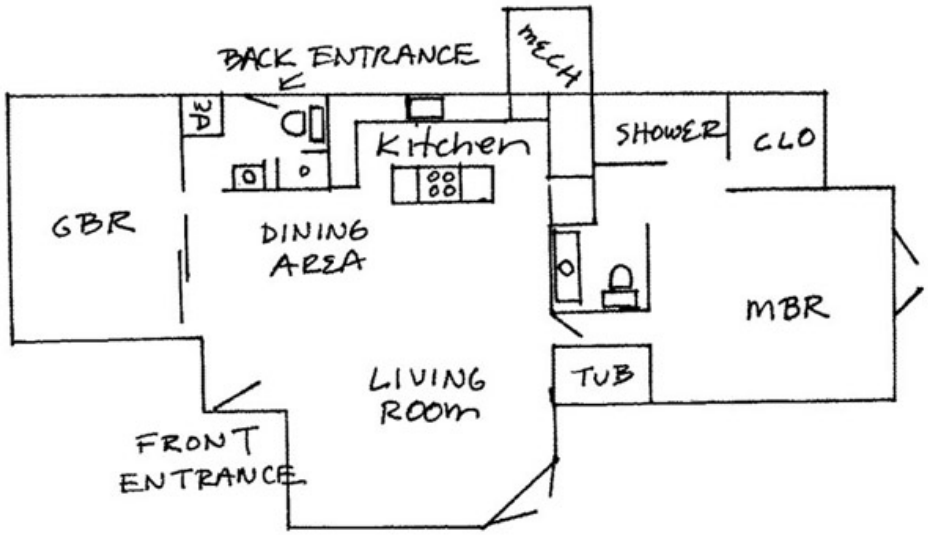


Figure 3.1.8: Freehand Floor Plan Sketches

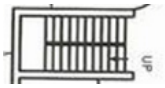
Purpose and Applications of Floor Plan Sketches

1. Quickly visualise multiple spatial arrangements
2. Testing different layouts and circulation patterns
3. Rapidly modify and refine spatial concepts
4. Conveys design ideas in an accessible format
5. Share concepts with colleagues and consultants easily and quickly.
6. Record existing conditions during field visits
7. Provides clarification during site meetings
8. Participate in collaborative design sessions

9. Creates immediate visual responses to client input
10. Establishes basic layouts before formal drafting

Fundamental techniques in sketching floor plans

1. **Establishing Scale and Proportions:** Work at a consistent scale (typically 1:50 or 1:100) and maintain relative sizes of spaces even without precise measurements. Consider using grid paper to maintain proportions (each square can represent a standard measurement)
2. **Line Hierarchy:** Bold, confident lines for main structural walls, medium-weight lines for interior partitions, lighter lines for built-in elements and dotted or very light lines for context or below elements
3. **Architectural Symbols and Conventions**

Architectural element	Description	Sketch
Wall Representation	Parallel lines with appropriate thickness.	
Door Notation	Simple arcs showing swing direction.	
Window Indication	Breaks in wall lines with sill marks.	
Stair Representation	Parallel lines with direction arrows.	
Fixture Symbols. i.e. water closet, bath, etc.	Simplified representations of standard elements.	

Annotation and Dimensioning

1. **Room Labels**: Clear text identifying space functions
2. **Key Dimensions**: Critical measurements noted directly on the sketch
3. **Notes**: Brief explanations of special features or requirements
4. **North Arrow**: Simple indication of orientation

Activity 3.1.2 Describe and Sketch Your Home Layout

Materials Needed

- Plain paper or sketchbook
- Pencil and eraser

- Ruler (optional)

Think About Your Home

1. Walk through your home in your mind or take a quick look around.
2. Identify the main areas: entry, living room, kitchen, bathroom, bedrooms, storage/closets, etc.

Describe the House Layout

1. On a sheet of paper, write a short paragraph describing your home's layout.
2. *Example:* "When you enter through the front door, the living room is on the right. The kitchen is straight ahead, with a small dining area beside it. There are two bedrooms on the left side and a bathroom at the end of the hallway."

Sketch Your House Layout

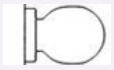
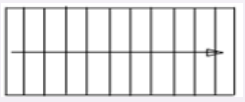
1. Using a pencil and ruler, draw a simple floor plan (top view) of your home.
2. Include major rooms and label each space clearly.
3. Indicate doors and windows with simple symbols (e.g., curved lines for doors).
4. Keep the sketch neat, but freehand drawing is allowed—focus on layout, not perfection.
5. Modify and give a reason for the change or addition.

EXTENDED READING

- Bell, J. (2006). 21st Century House. UK: Abbeville Press.
- Watch Videos on "Building codes and symbols in English" from YouTube.

REVIEW QUESTIONS

1. Explain a floor plan in relation to:
   - **a.** Use of a floor plan
   - **b.** Building codes
   - **c.** Standards and symbols
   - **d.** Relevance to the building industry
2. Identify the following building drawing symbols

Building drawing symbols	Description
	
	
	
	
	
	
	

3. Draw a freehand floor plan of a simple two-bedroom house for a client, ensuring it meets the requirements given below.

Specifications: Your floor plan must include and clearly label the following spaces.

- **a.** Living room
- **b.** Kitchen
- **c.** Dining area
- **d.** Two bedrooms
- **e.** three bathrooms

f. Entrance porch or veranda

Your sketch must show

a. Appropriate placement of doors and windows
b. Wall thicknesses (using double lines)

UNIT 2: MECHANICAL DRAWING

Introduction

In this section, you will develop a solid understanding of assembly drawing principles, starting from identifying individual component parts to creating detailed working drawings using both manual drafting tools and CAD software. Across four thematic areas, each covered in two meetings, you will learn how to interpret part geometry, apply basic and advanced assembly conventions, prepare complete assembly layouts (including bills of materials), and produce accurate, working drawings to scale. By the end, you will be able to confidently translate component details into fully dimensioned assembly and part drawings, clearly visualising and communicating mechanical designs and relationships

KEY IDEAS

- **Add dimensions and notes** to include sizes, materials, and necessary instructions to the detailed drawings
- **Choose correct views**, such as orthographic, sectional, and exploded views, where needed to show the full detail of the part or assembly.
- **Draw to scale** to keep correct proportions when using drawing instruments or CAD.
- **Identify all components** by listing each part of an object and showing how they fit together.
- **Show assembly relationships** to indicate how parts connect with centre lines, fasteners, and sectioning.
- **Use standards and title blocks** following drawing conventions (ISO/BS) when completing the title block for clarity.

INTERPRETING COMPONENT DRAWINGS FOR ASSEMBLY

In engineering and design, drawings are the common language for planning machines, tools, and structures before they are built. Component drawings show the size, shape, and features of each part that will be assembled into the final product.

In this lesson, you will learn to read two main types: orthographic views (showing an object, in 2D, from different angles) and sectional views (cutting through the object to reveal the inside). You will also identify features like holes, shafts, slots, and keyways that help parts fit and work together.

This skill is important in engineering, manufacturing, construction, and architecture to ensure accuracy and smooth assembly. By the end, you will be able to interpret a component drawing and understand its shape, function, and how it connects with other parts.

Understanding Orthographic and Sectional Views

Orthographic and Sectional views are two-dimensional (2D) representations of three-dimensional (3D) objects. It usually includes:

a. Front View

b. Top View (Plan)

c. Side View (End Elevation)

Each view displays a specific face of the component, drawn to scale and correctly aligned with the others. Orthographic projections are produced using either **first-angle** or **third- angle.** These projection methods are shown below.

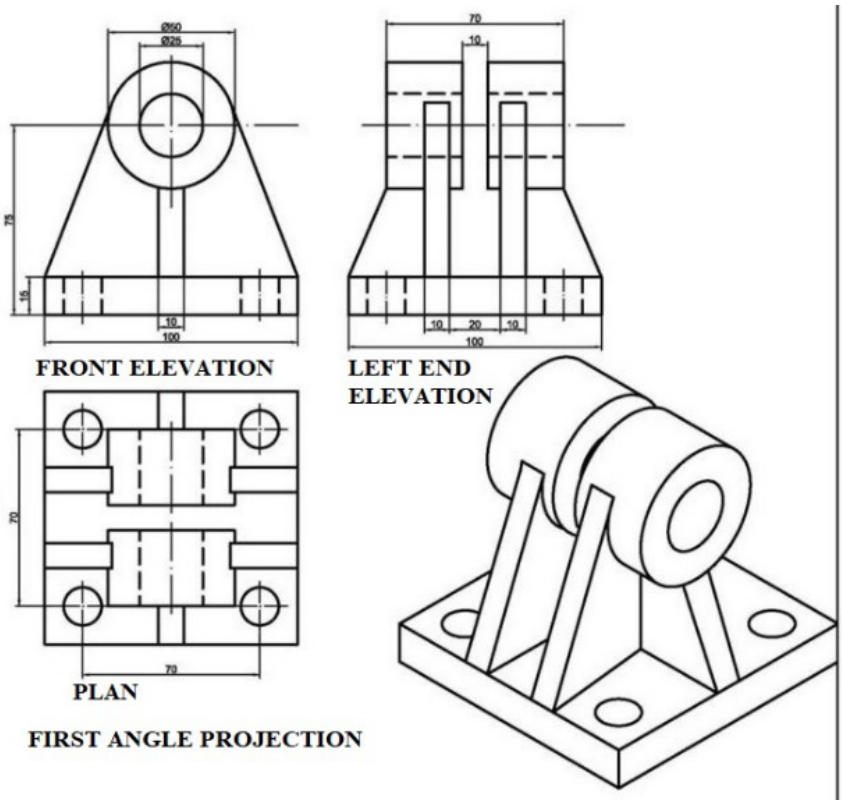


Figure 3.2.1: First Angle Orthographic

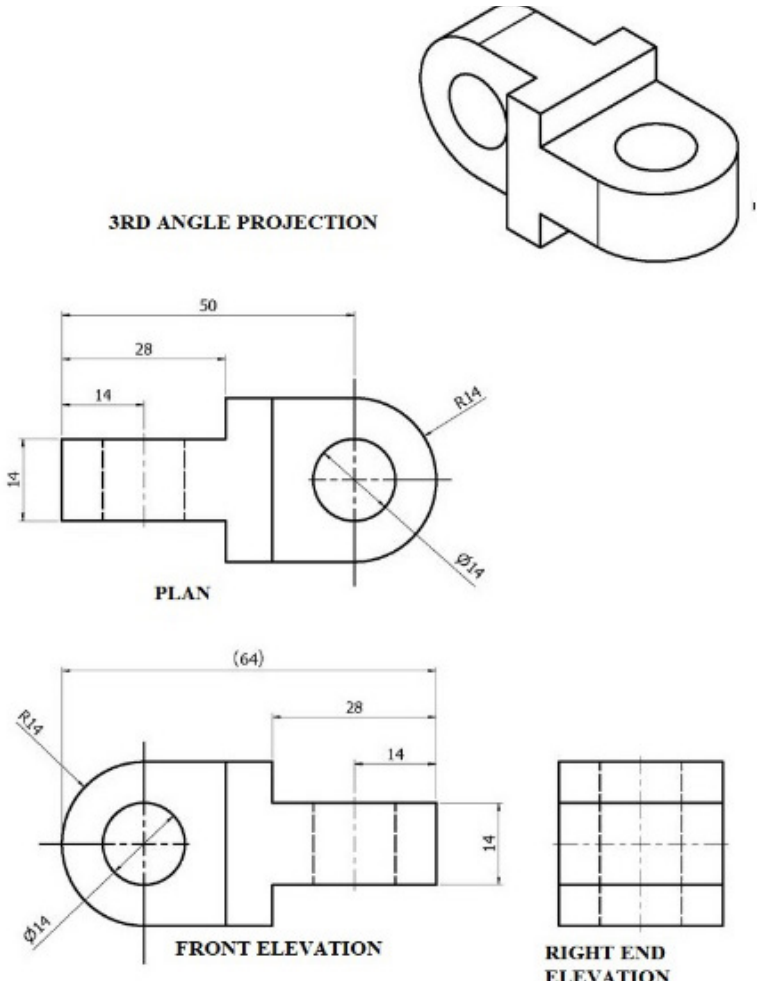


Figure 3.2.2: Third Angle Orthographic

Sectional Views

These are used to show hidden features by cutting through the object, making internal details like holes, shafts, and keyways visible.

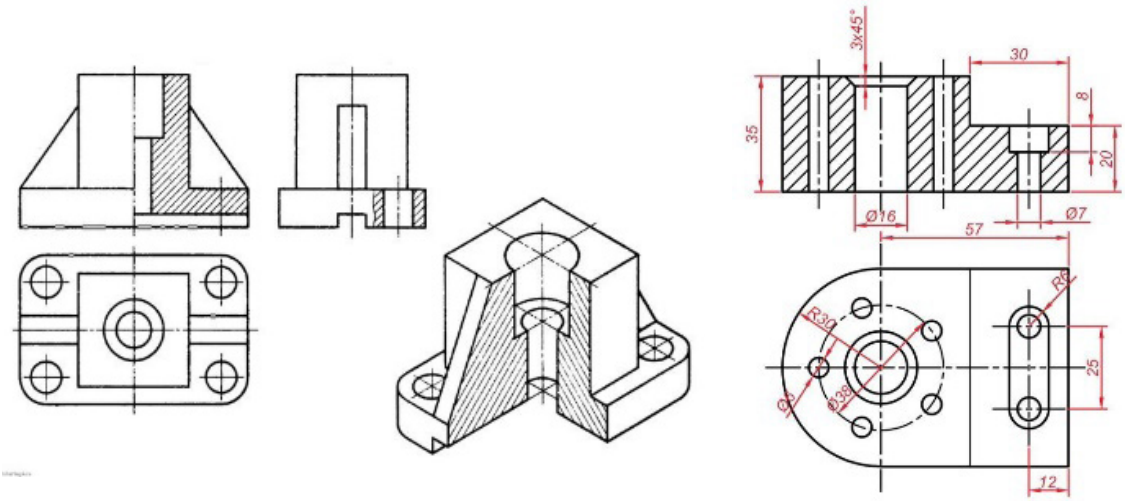


Figure 3.2.3: Sectioning components

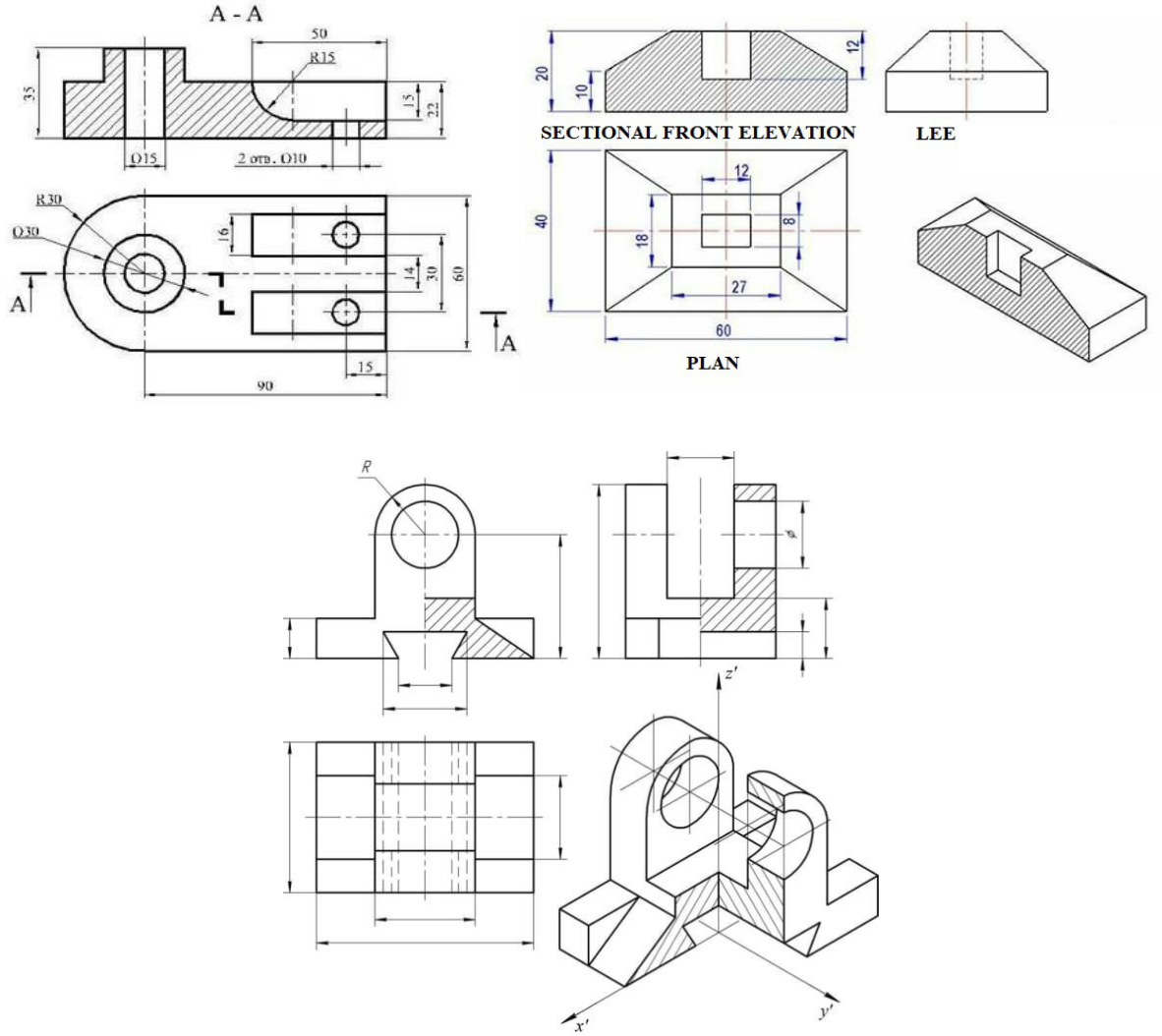
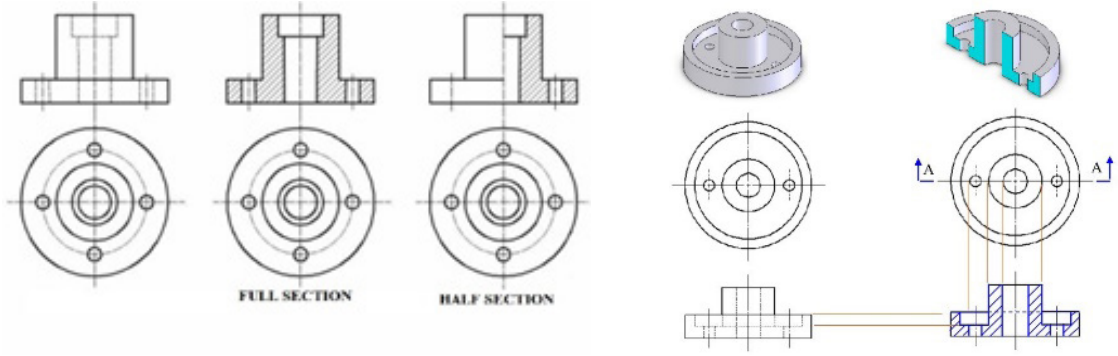


Figure 3.2.4: Sectioning components

Identifying Common Mating Features in Drawing Holes

In a sectional view, holes appear as empty circular or cylindrical spaces which are visible through the thickness.

1. These areas are left without hatch lines to indicate the absence of material.
2. Centre lines, shown as alternating long and short dashes, run through the centres of the circles to mark their axes.



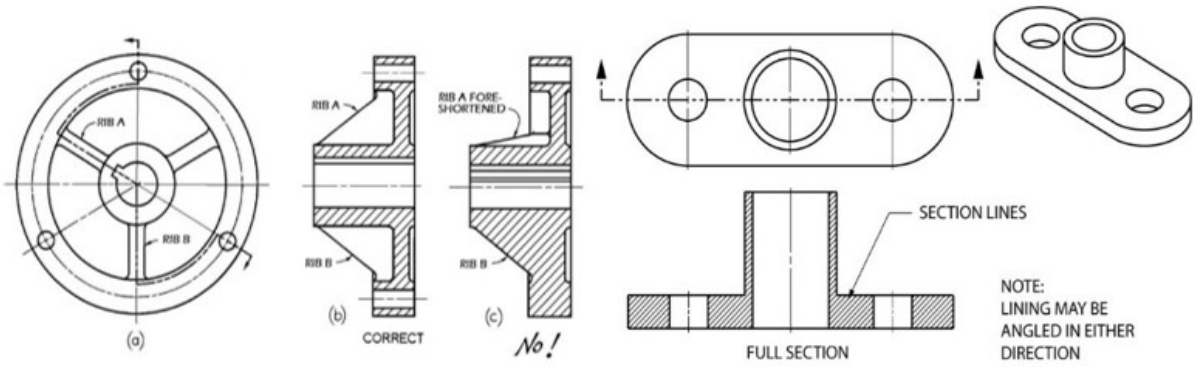


Figure 3.2.5: Common mating of holes

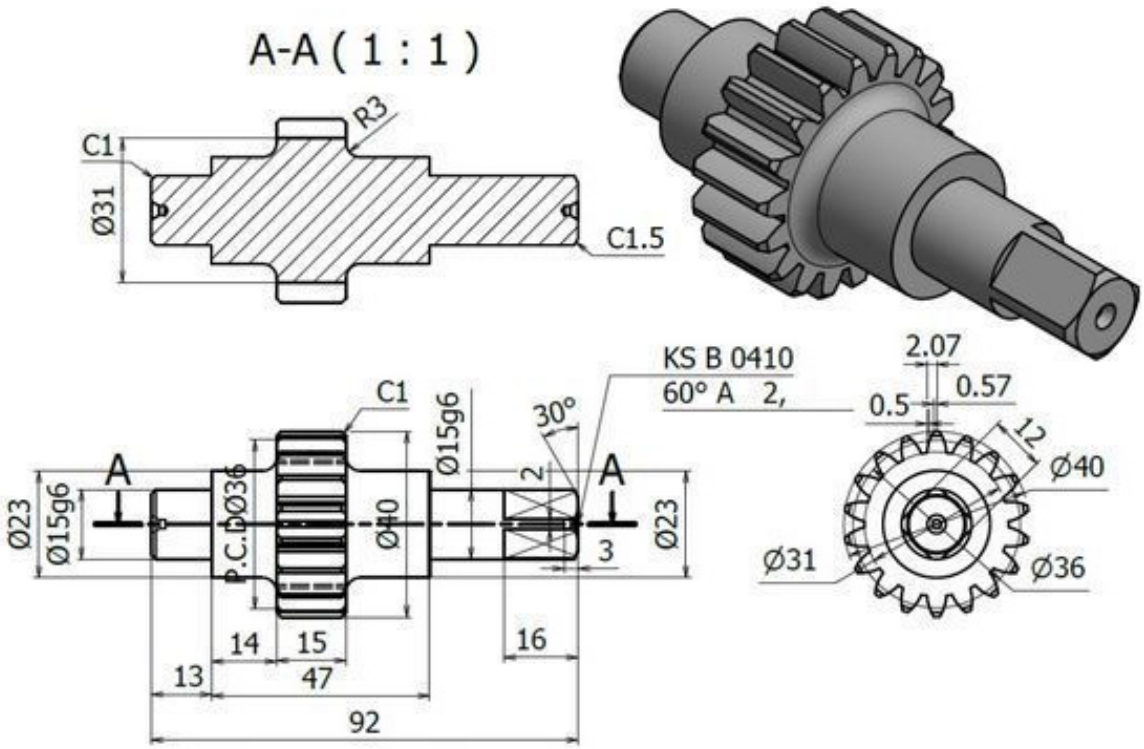
Shafts

Shafts can fit into holes with tight or loose tolerances.

When shafts get sectioned, if they are solid material, they are filled with the same hatch pattern, which shows it's solid.

If deeper detail is needed, sometimes a half-section is used where only one side of the shaft is hatched

In assembly drawings, shafts (and bolts, keys, pins) are usually not hatched, even if the section plane intersects them. This helps keep them, visually, distinct.



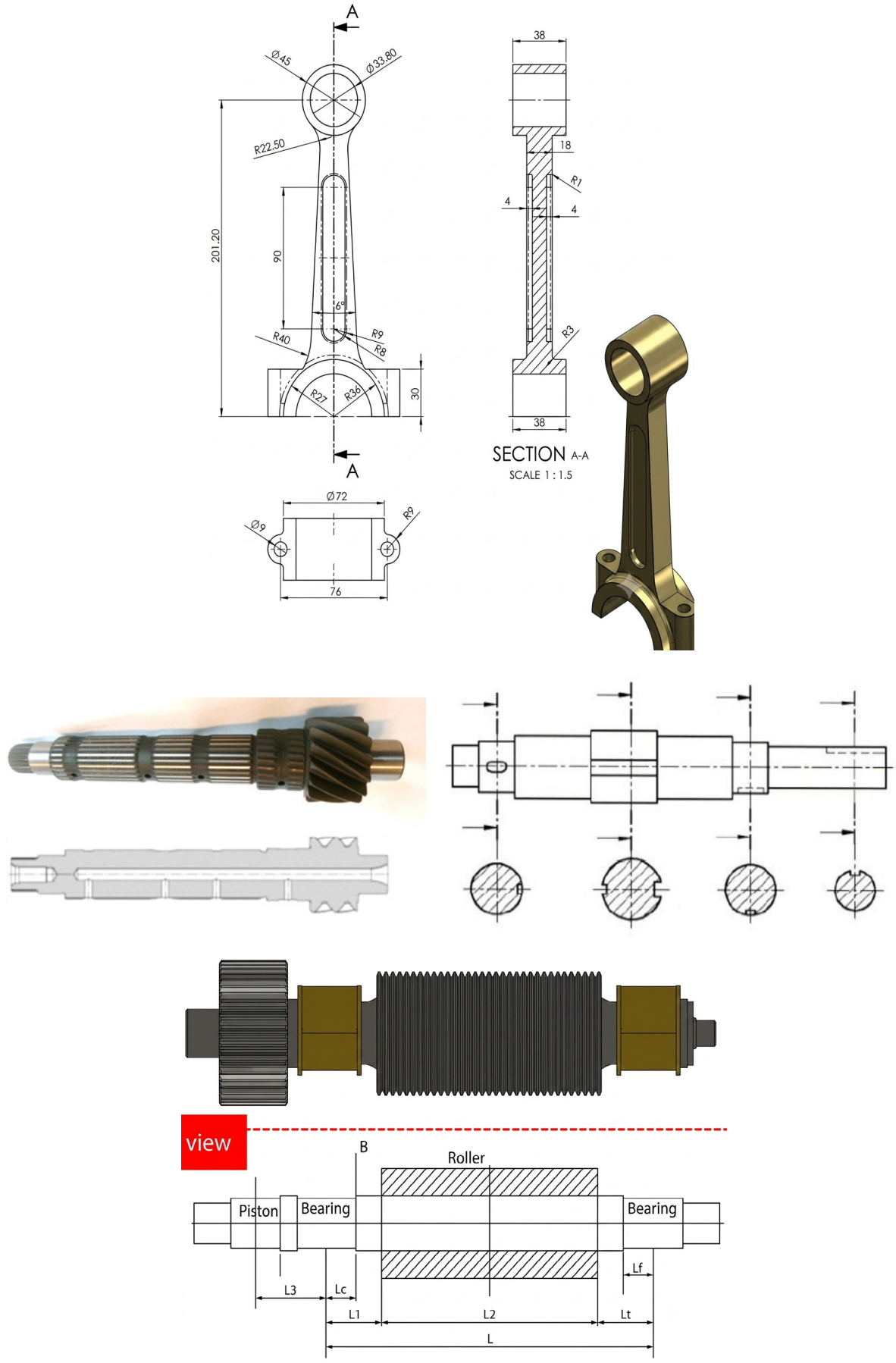
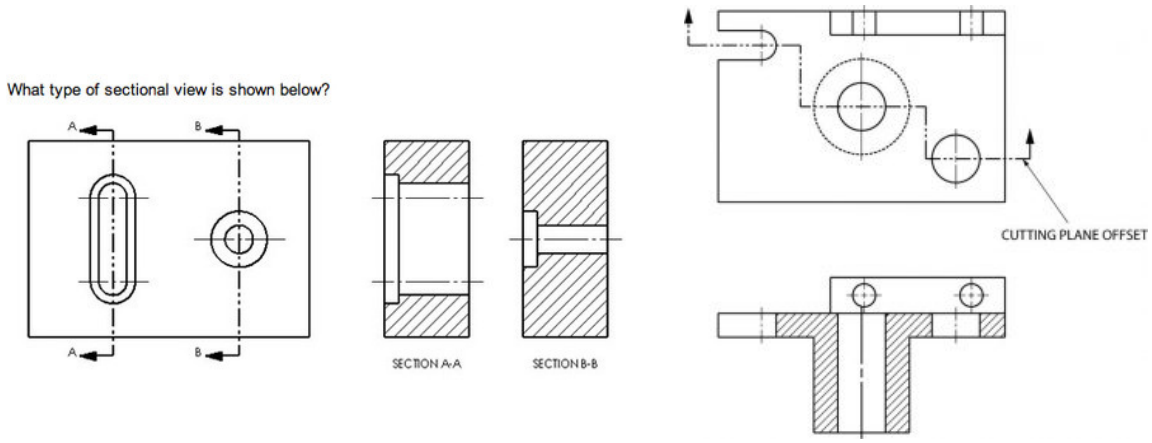
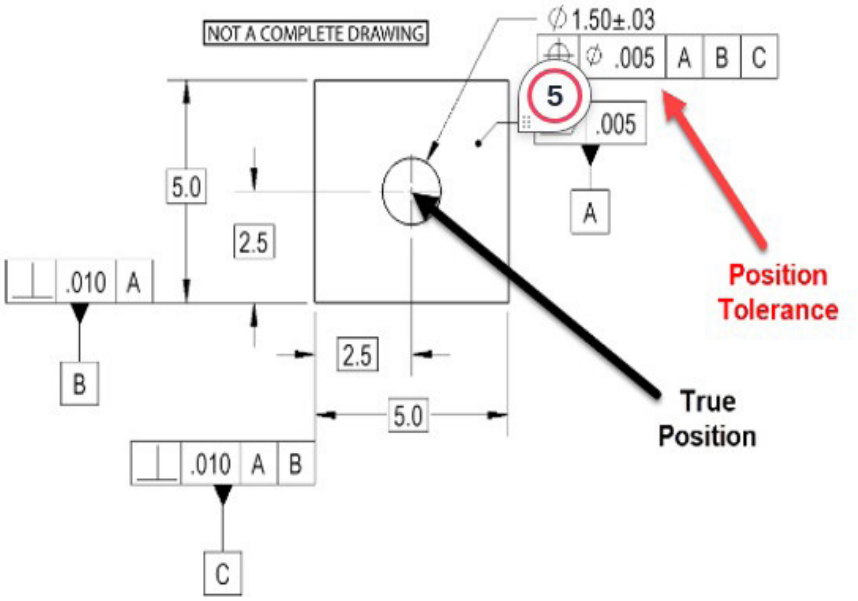


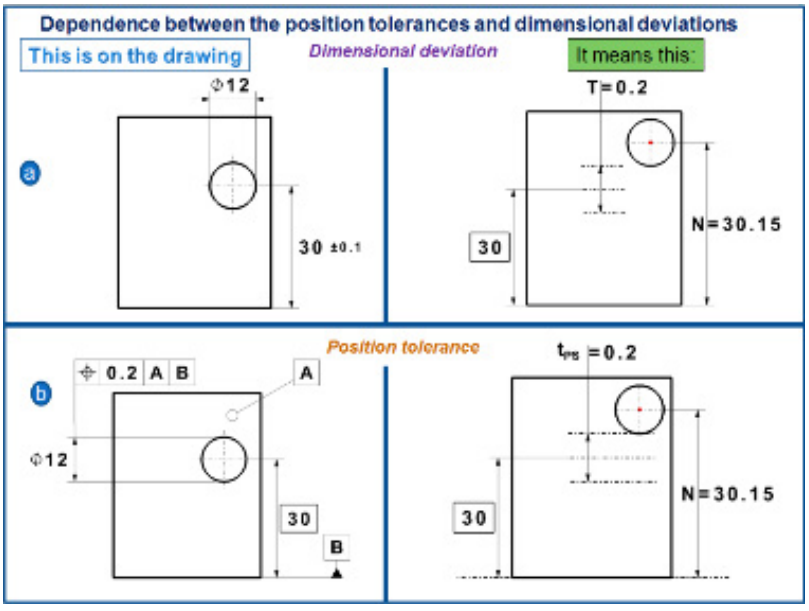
Figure 3.2.6: Sectioning Shafts

Slots

These appear to be long, narrow cuts typically used for guides, clearances, or adjustable parts.







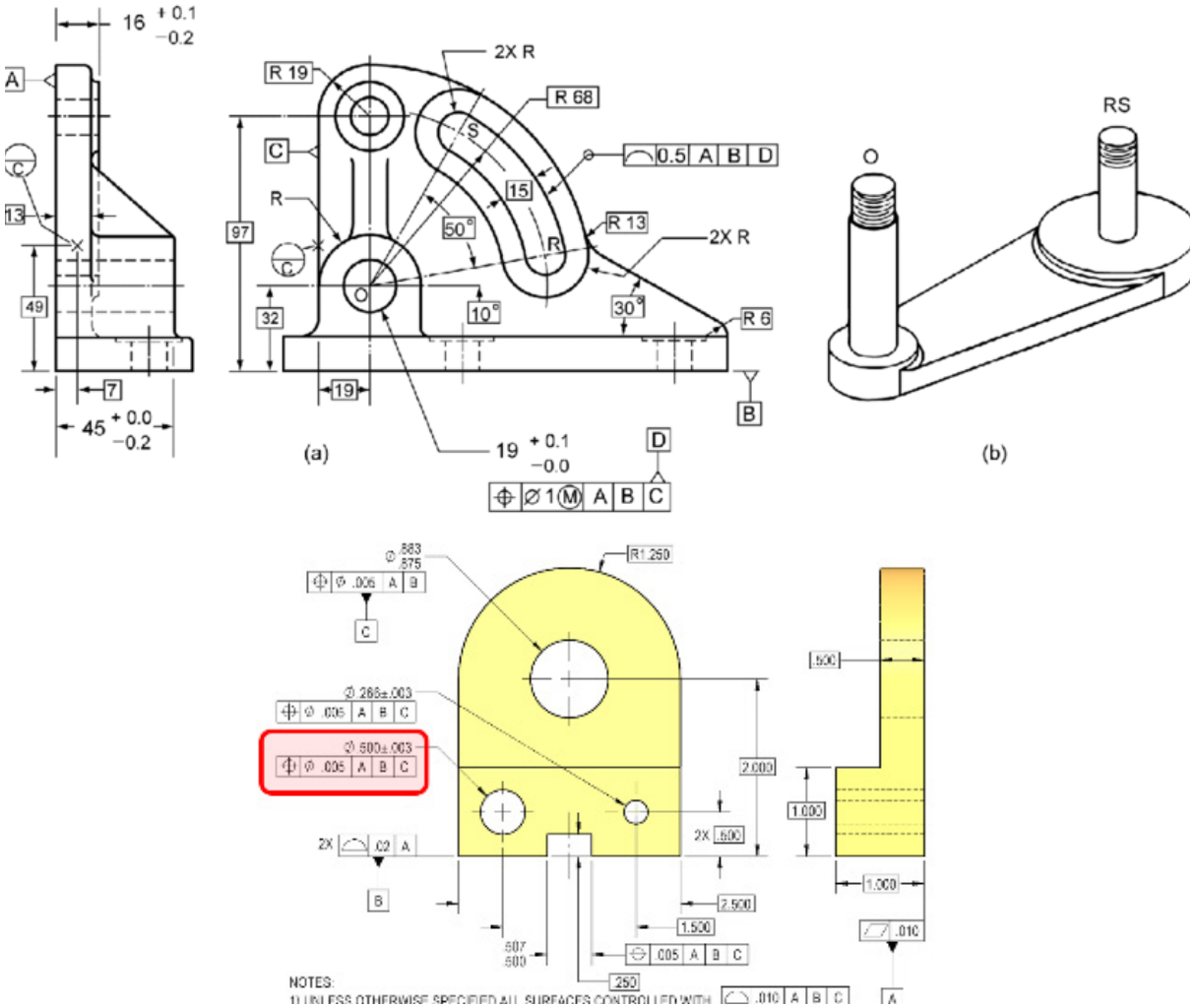


Figure 3.2.7: Sectioning slot

Keys and Keyways

These are devices used to connect rotating components like gears to shafts to prevent relative rotation.

They are **not** sectioned

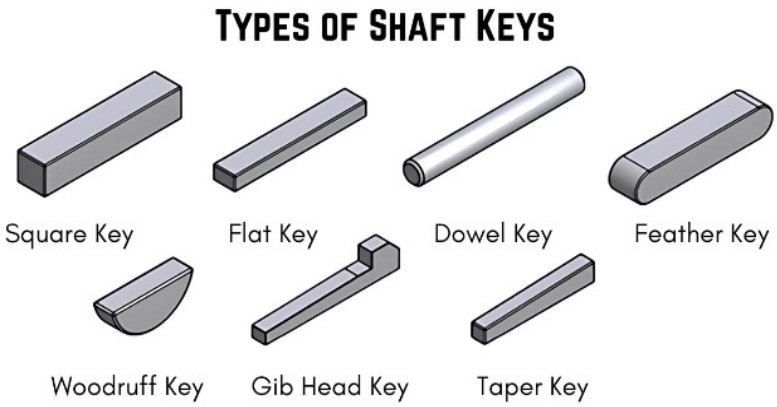


Figure 3.2.8: Type of Some Common Keys

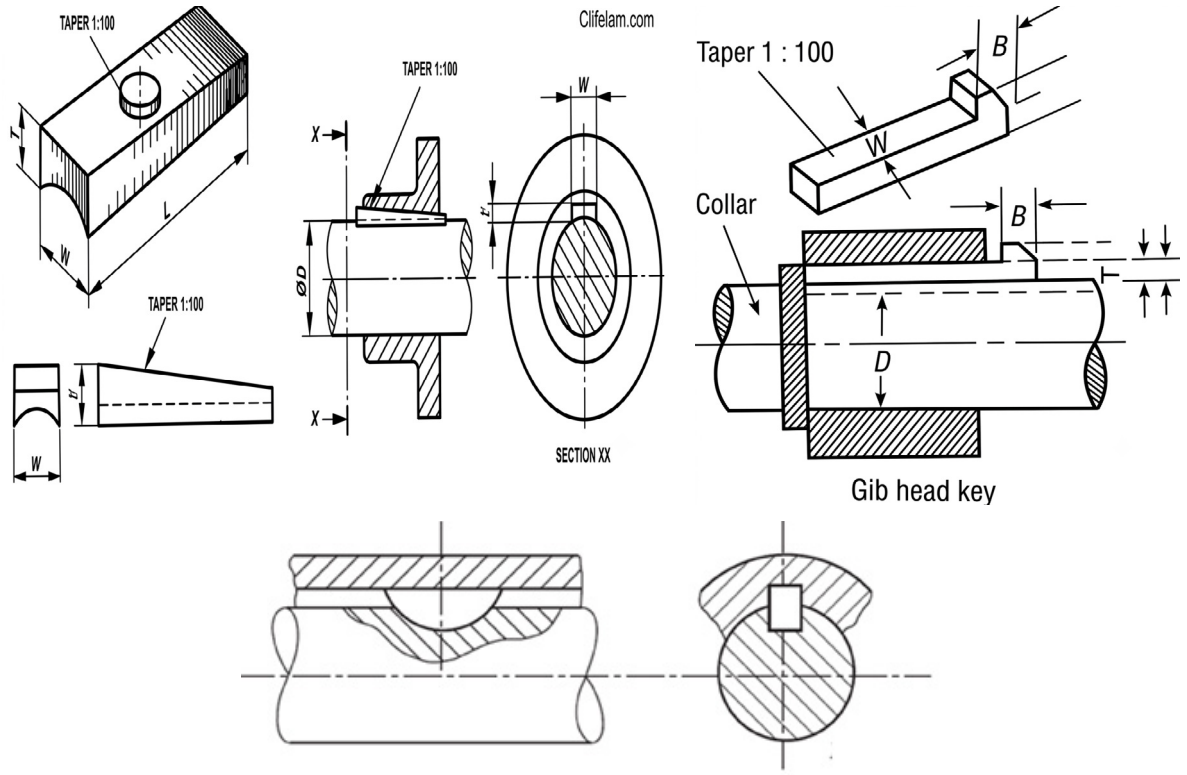


Figure 3.2.9: Use of keys

Watch the following videos

- https://www.youtube.com/watch?v=S8Qmy4fGnnE
- https://youtu.be/S8Qmy4fGnnE?si=jwfm0iOncHZFRQ09

BOLTS AND NUTS

Bolts

Bolts are externally threaded fasteners that are shown with the thread profile. In sectional views, the bolt threads are clearly depicted on the cut side and overlay the mating part's seat. Their head (e.g. hexagon, socket cap) appears in correct geometric form, often simplified to fit the drawing scale.

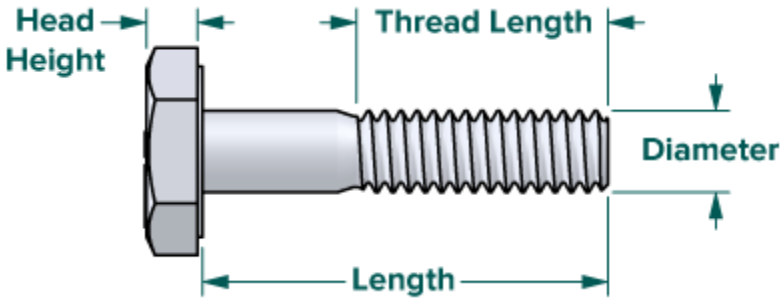


Figure 3.2.10: Parts of Bolts

Hatching Rules

In assembly drawings, even if the cutting plane passes through the bolt, it is not hatched. Instead, the surrounding material is hatched to indicate solid, while the bolt remains clear to show it is a separate component.

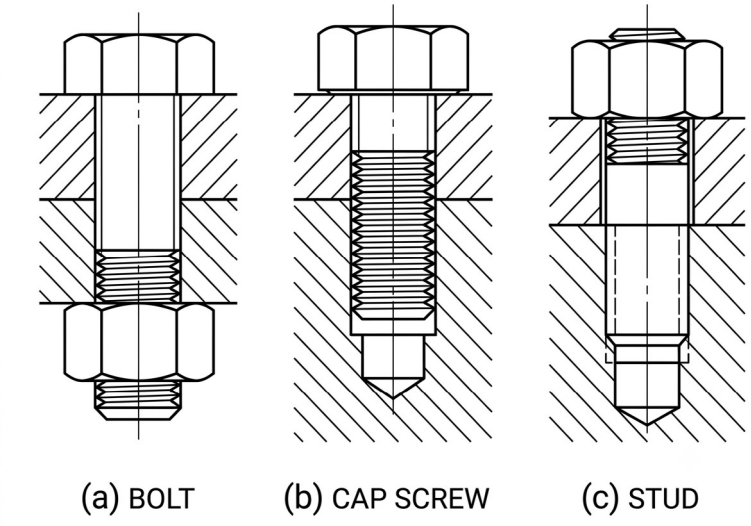


Figure 3.2.11: Sectioning assembled drawing

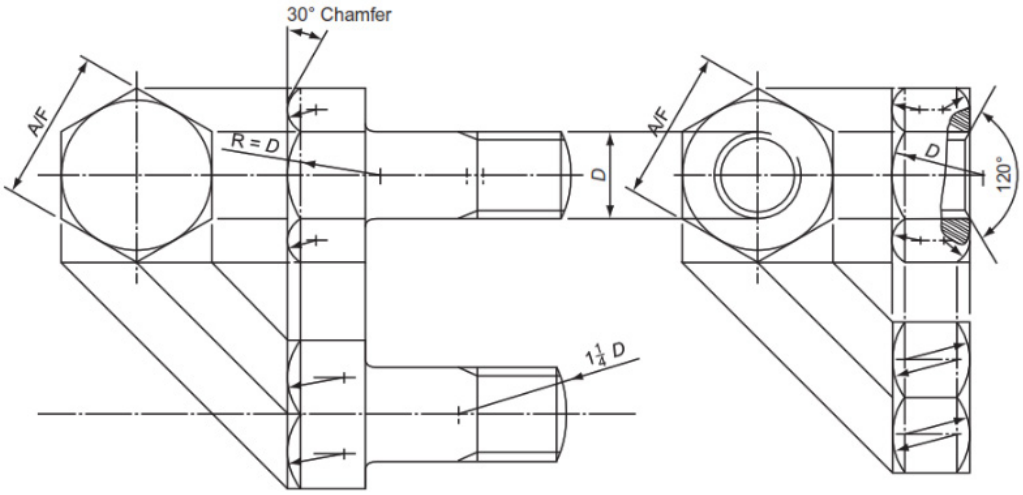
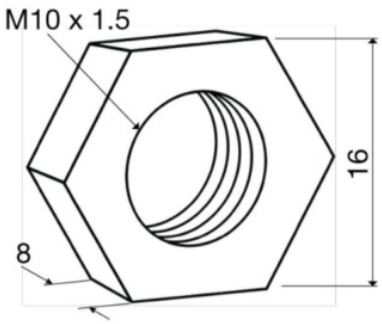


Figure 3.2.12: Drawing Bolts and Nuts

Nuts

Nut Representation

Nuts are internally threaded fasteners that are displayed in their true hexagon or square head shape. Their internal thread detail is simplified or omitted in many cases for clarity, especially when part of an assembly.



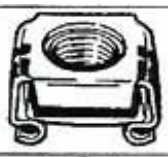
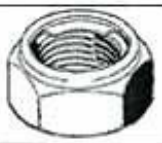
	Hexagon Nut		Cage Nut
	Flange Nut		Hexagon Weld Nut
	Nylon Insert Self Lock Nut		Square Nut
	Wing Nut		U Nut
	Kep Nut		T – Nuts For Channels
	Push Nut		Pal Nut
	Castle Nut		Cap Nut
	Coupling Nut		Jam Nut

Figure 3.2.13: Types of Nuts

Hatching

Nuts behave like bolts in drawings: when included in an assembly section, they are shown without hatching, even though they are technically inside the section. Sectional Joint Detail

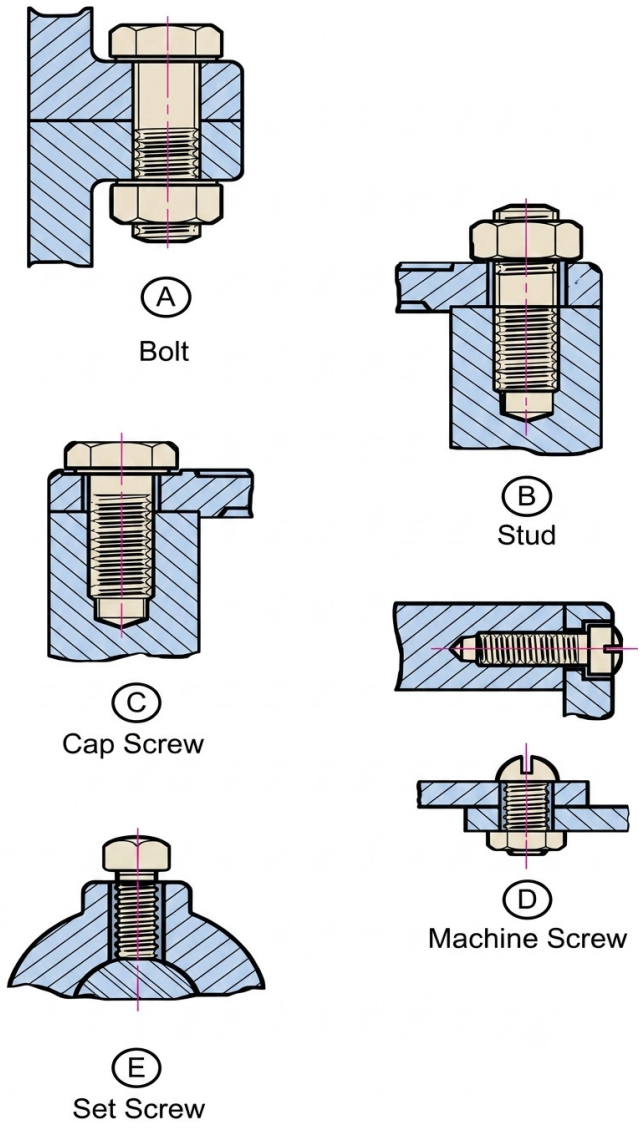


Figure 3.2.14

Thread Interaction

In a sectional view of a bolt–nut assembly, the external threads of the bolts are drawn over the mating hole, but the hole's internal threads are usually not shown.

Half-Section Illustration

A half-section is often used (as shown in the image): one half is cut (hatched background), and the bolt and nut threads are visible in detail. On the uncut half, the exterior profiles are shown

FASTENER LOCKING

Fasteners are locked to prevent loosening under vibration or stress; both sectional views and assembly drawings use clear, standard conventions. The following shows the methods of locking fasteners and their standard conventions.

1. **Locking Washers**

   Tab washers are drawn as thin washers beneath the bolt head or nut. Examples are Tab or Lock Washer**.** After tightening, one or more tabs are lifted ("bent up") against the flats of the bolt or nut, locking it in place.

   In section views, the washer is hatched like solid material, and the bent tab is shown pressing up against the bolt or nut.

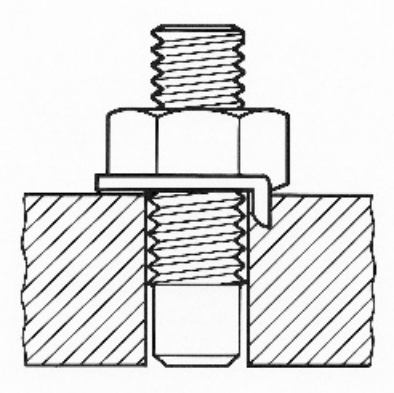


Figure 3.2.15: Fastener lock

2. **Lock Nuts and Self-Locking Nuts**

   A lock nut (e.g. nylon-insert or serrated nut) is drawn in the assembly without special hatch lines; it's shown unhatched to indicate it's a separate part.

   Internal locking features (such as a nylon ring) aren't usually detailed, only indicated by notes or callouts (e.g. "nylon insert").

3. **Castle Nuts and Split Pins (Cotter Pins)**

   Castle nuts feature radial slots and are paired with a split pin inserted through a cross-drilled bolt. In the section, the nut slots and pin are clearly drawn, with the pin hatched if it lies on the cut plane. This provides a visual lock that resists rotation.

4. **Thread-Locking Clips or Nuts with Tines**

   Some nuts use small spring tabs or tines that engage notches in the bolt threads. In assembly views, you'd see the nut plus tabs or clips, with tines embedded in bolt notches to show direction-limited rotation.

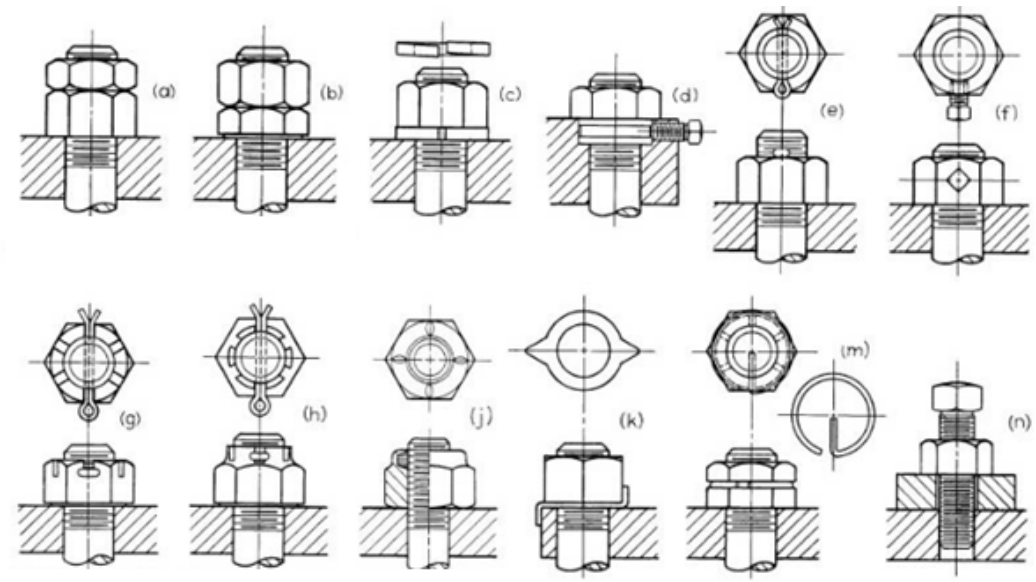


Figure 3.2.16: Lock Nut Types

a. **Regular Unfinished Jam Nut (Amer Std):** A thin nut used as a lock when jammed against a standard nut.

b. **Regular Semi-Finished Jam Nut (Amer Std):** Similar to (i) but partially machined for a finer fit.

c. **Wing Nut:** Features wings for hand tightening; self-locking when hand-tightened.

d. **Set-Screw Lock Nut:** A standard nut with an integrated set screw to lock it in place.

e. **Slotted Nut with Cotter Pin:** A hex nut with slots cut into it, secured by a cotter pin for positive locking.

f. **Lock Nut with Locking Plate:** A nut paired with a locking plate (or tab washer) bent over to prevent rotation.

g. **Finished Slotted Nut (Amer Std):** Precisely machined slotted nut secured via cotter pin

h. **Finished Castle Nut (Amer Std):** Similar to a slotted nut but with castellations; uses a cotter pin for locking.

i. **ESNA Stop Nut:** A nut with a nylon or resin insert providing prevailing torque for self-locking.

j. **Tab Nut (Press-On Lock Nut):** Incorporates tabs that engage the flats of the bolt to prevent loosening.

k. **Serrated Lock Nut:** Features serrations on the bearing surface that bite into the mating surface.

l. **Prevailing-Torque Nut (e.g., Nyloc):** Contains a deformed top section or insert that provides frictional locking.

Putting It All Together in Drawings

Locking Method	Section Drawing	Assembly Drawing
Tab Washer	Washer hatched, tab bent up	Side view with bent tab
Lock Nut	Nut unhatched, noted locking	Shows nut, distinct from material
Castle Nut + Pin	Nut slots & pin visible, pin hatched if cut	Clear depiction with a pin-through bolt
Clip/Tines	Clip shown, tines in bolt notches	Shows engagement of threads

Rivets in Assembly and Sectional Views

A rivet is a permanent fastener. It's like a metal pin that holds two or more plates together by deforming one or both ends so it can't come out. Rivet has a cylindrical rod with a head and a shank (the straight body that goes through holes)

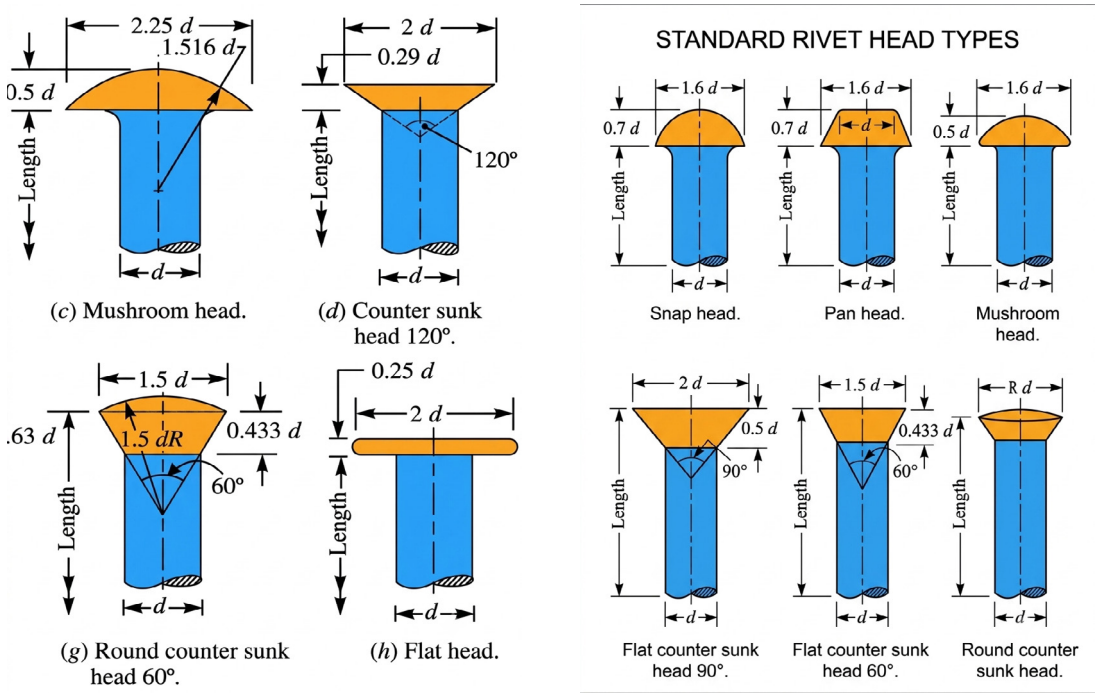


Figure 3.2.17: Types of rivets

When doing an assembly drawing, show the rivet in position, joining the parts. Visible lines are used to indicate the rivet head and shank. Hidden lines are used to show the shank inside the plates if the view doesn't cut through.

Rivet in Sectional View

Sectional views are very useful for showing how a rivet passes through parts.

In a section, show the rivet cut in half, so you can see the shank inside the plates, the formed tail end (flattened) and the head on the opposite side. Hatching is applied to the plates but not to the rivets.

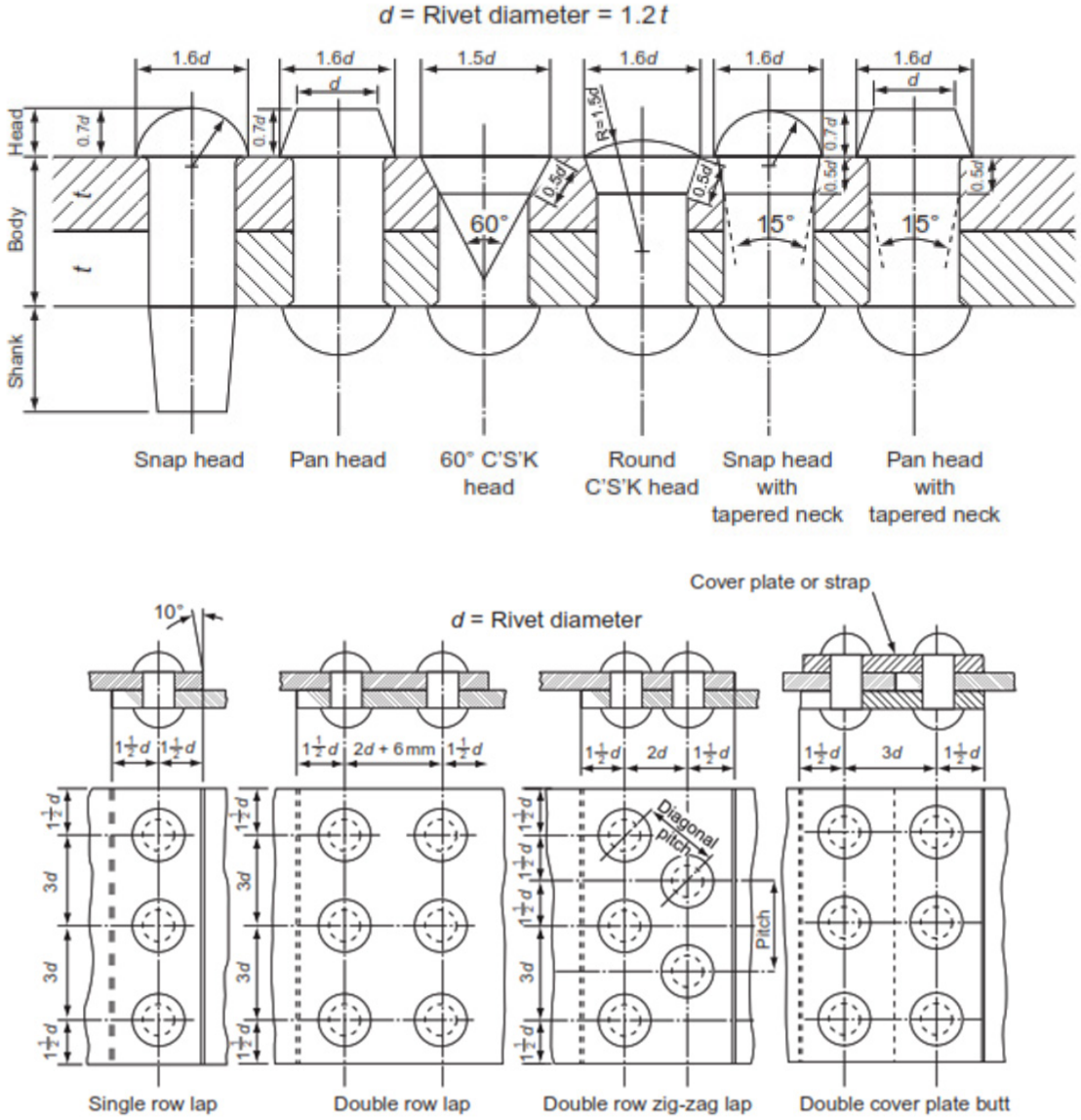


Figure 3.2.18: Rivet in Assembly Drawing

Activity 3.2.1 Interpreting Component Drawings for Assembly

Materials Needed: Pencil, eraser, ruler, and drawing instruments

Instructions

1. Identify 3–5 parts of a simple mechanical assembly in your locality. e.g., a clamp, coupling, or small gearbox
2. **Study Each Drawing** – Examine the orthographic and sectional views of each part. Identify key features such as holes, slots, shafts, and keyways.
3. **Note Dimensions** – Record critical measurements needed for assembly (e.g., hole diameters, distances between features, mating surfaces).

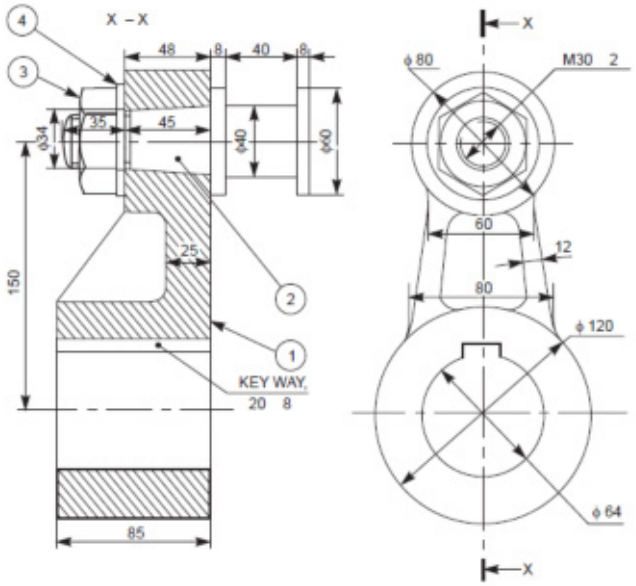
4. **Identify Matching Features** – Determine which parts fit together and how (e.g., shaft into hole, slot over tab).
5. **Sketch an Assembly Layout** – Create a freehand or CAD sketch showing how the parts connect, ensuring correct alignment and scale.
6. **Label Components** – Assign part numbers and list them in a simple Bill of Materials (BOM).
7. **Verify Fit** – Check your assembly sketch against the provided drawings to ensure accuracy.

CREATING ASSEMBLY LAYOUTS

In this section, you learn how to choose the most effective views, orthographic, exploded or sectional, to reveal assembly relationships and hidden details. Through precise sketching, they learn to orient each component correctly, label key features, and present a coherent assembly drawing that guides fabrication and inspection.

Assembly Drawing

A drawing that shows the various parts of a machine in their correct working locations in an assembly drawing.



Parts List

Part No.	Name	Material	Qty
1	Crank	Forged Steel	1
2	Crank Pin	45C	1
3	Nut	MS	1
4	Washer	MS	1

Assembly drawing.

Figure 3.2.19

Types of Assembly Drawings

Design Assembly Drawing

When a machine is designed, an assembly drawing or a design layout is first drawn to clearly visualise the performance, shape and clearances of various parts that make the machine.

Detailed Assembly Drawing

It is usually made for simple machines, comprising a relatively smaller number of simple parts. All the dimensions and information necessary for the manufacture and assembly of such parts are provided directly on the assembly drawing. Separate views of specific parts in enlargement, showing how the parts fit together, may also be drawn in addition to the regular assembly drawing.

Sub-Assembly Drawing

Many assemblies, such as an automobile, lathe, etc., are assembled with many pre-assembled components as well as individual parts. These pre-assembled units are known as sub-assemblies. A sub-assembly drawing is an assembly drawing of a group of related parts that form a part in a more complicated machine. Examples of such drawings are: lathe tail-stock, diesel engine fuel pump, carburettor, etc.

Installation Assembly Drawing

On this drawing, the location and dimensions of a few important parts and the overall dimensions of the assembled unit are indicated. This drawing provides useful information for assembling the machine, as this drawing reveals all parts of the machine in their correct working position.

Assembly Drawings for catalogues

Special assembly drawings are prepared for company catalogues. These drawings show only the pertinent details and dimensions that would interest the potential buyer.

Exploded Assembly Drawing

In some cases, exploded pictorial views are supplied to meet instruction manual requirements. These drawings generally find a place in the parts list section of a company instruction manual. In exploded views, the parts are positioned in the sequence of assembly but separated from each other.

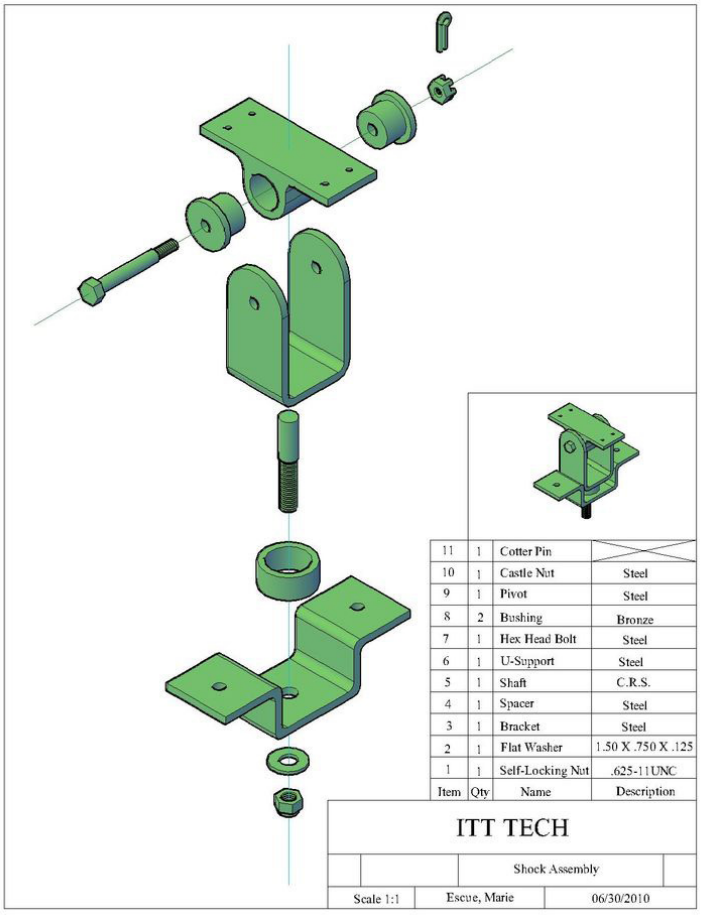


Figure 3.2.20

Assembly Drawings for Instruction Manuals

These drawings in the form of assembly drawings are to be used when a machine, shipped away in assembled condition, is broken down to check all the parts before reassembly and installation elsewhere. These drawings have each component numbered on the job.

Schematic Assembly Drawing

It is very difficult to understand the operating principles of complicated machinery merely from the assembly drawings. Schematic representation of the unit facilitates easy understanding of its operating principle. It is a simplified illustration of the machine or of a system, replacing all the elements with their respective conventional representations.

Machine Shop Drawing

Rough castings and forgings are sent to the machine shop for finishing operations. Since the machinist is not interested in the dimensions and information of the previous stages, a machine shop drawing frequently gives only the information necessary for

machining. Based on the same principle, one may have a forge shop drawing, pattern shop drawing, sheet metal drawing, etc.

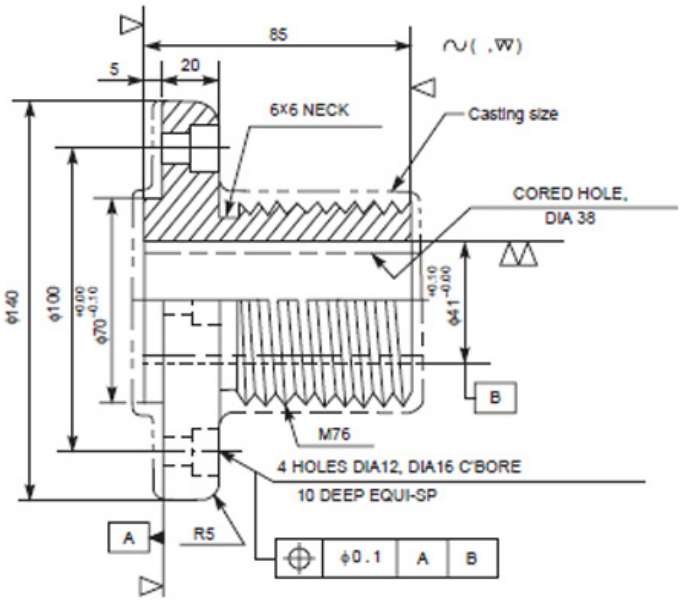


Figure 3.2.21

Patent Drawing

When new machines or devices are invented, patent drawings come into existence to illustrate and explain the invention. These are pictorial drawings and must be self-explanatory. The patent drawings must be mechanically correct and include complete illustrations of every detail of the invention. However, they are not useful for production purposes. The salient features on the drawing are numbered for identification and complete description.

Reference Planes & Datums

Reference Plane

A reference plane is an imaginary, perfectly flat surface from which measurements, orientations and views are established in an assembly drawing. It serves as a primary organising datum: all parts are aligned relative to this plane to ensure consistent positioning. In practice, you might choose a principal face or a plane through key features (e.g. the mounting face of a bracket) as your reference plane.

Datum

A datum is a defined point, line or plane on a component that acts as the origin for all dimensions and tolerances. Datums establish the part's orientation and location within an assembly.

How to establish a datum

Primary Datum: Constrains movement along three axes (X, Y, and Z) and is used to fully locate the part.

Secondary Datum: Constrains movement along two axes, orienting the part around the primary datum.

Tertiary Datum: Constrains movement along the final axis, fully fixing the component in space.

Areas to consider when selecting a datum

1. Functional surfaces.
2. Mating surfaces.
3. Readily accessible surfaces.
4. Surface of sufficient size to allow repeatable measurements.

By selecting clear reference planes and datums, you create a common framework that ensures every component is drawn and manufactured from. This will allow it to fit precisely in the assembly.

View Selection

An assembly drawing can be made in orthographic projection, exploded view, and sectional view, depending on what one is looking for.

1. Orthographic: Best for dimensioning standard features.
2. Exploded: Shows component relationships and assembly sequence.
3. Sectional: Reveals hidden interfaces and fit-up details.

Sketching Techniques

- Use light construction lines for datum axes.
- Break lines and cutting plane symbols must be clearly indicated.
- Label each component and datum feature with reference letters/numbers.

Examples of assembly drawings

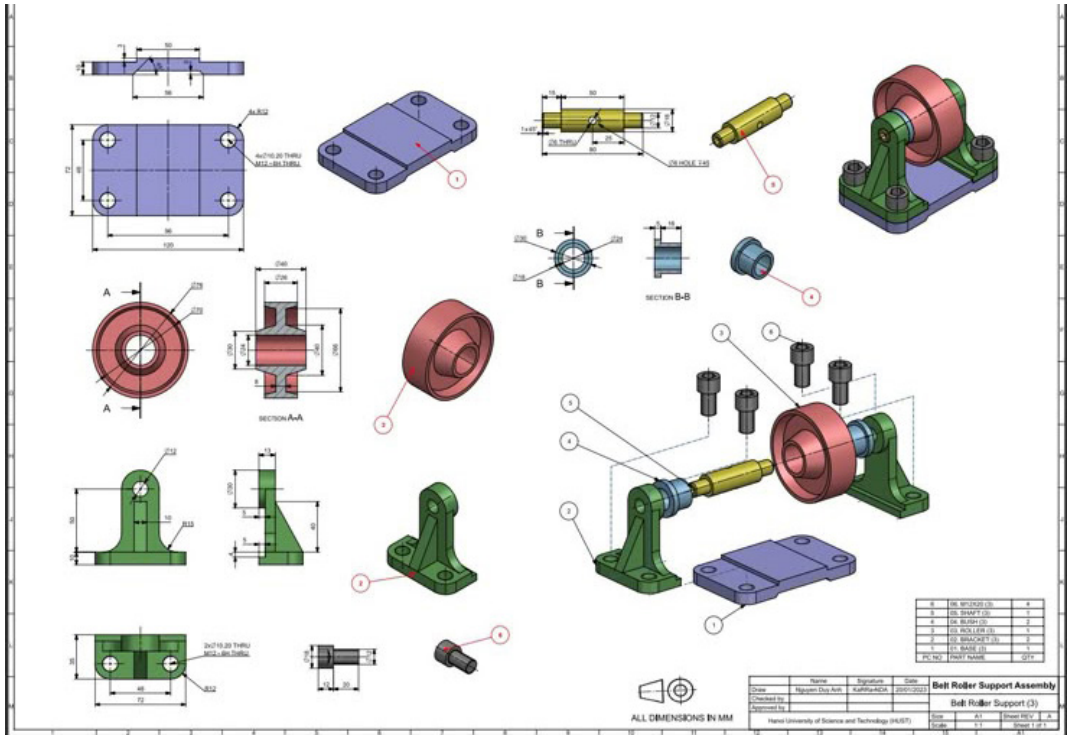


Figure 3.2.22

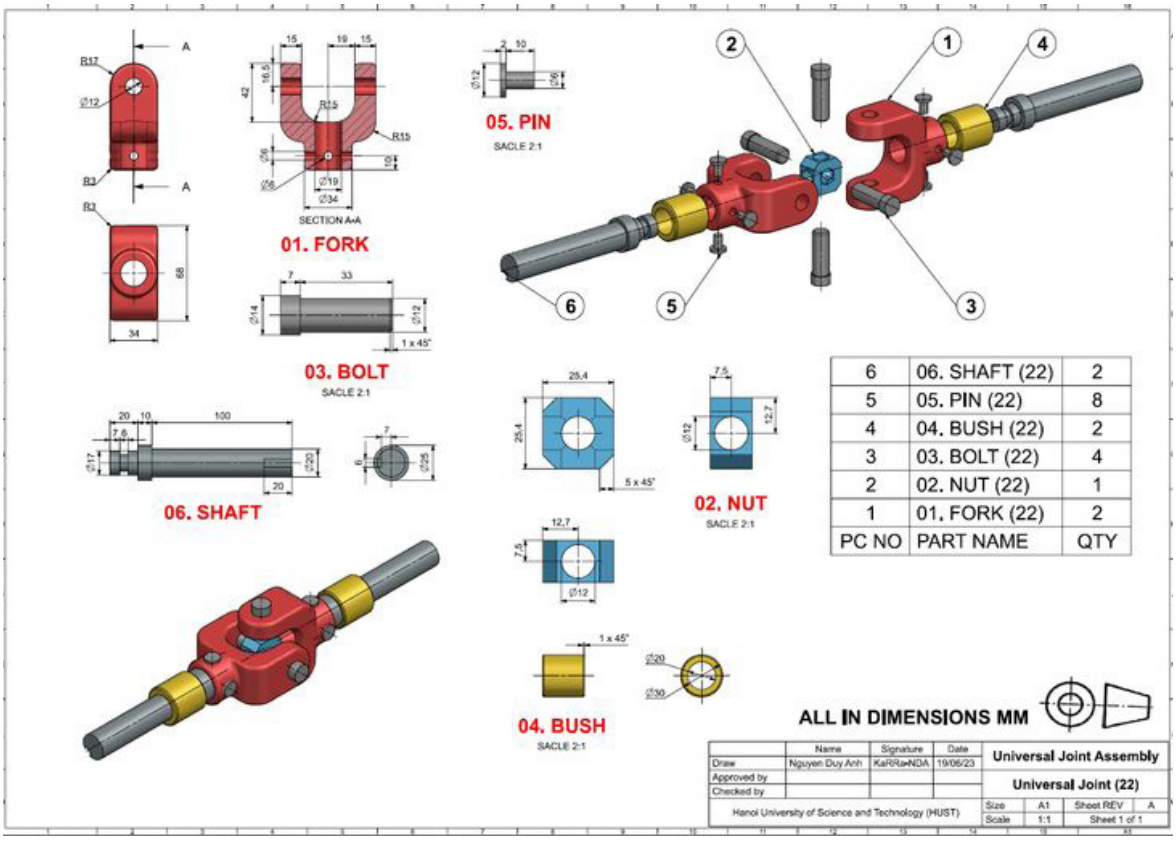


Figure 3.2.23

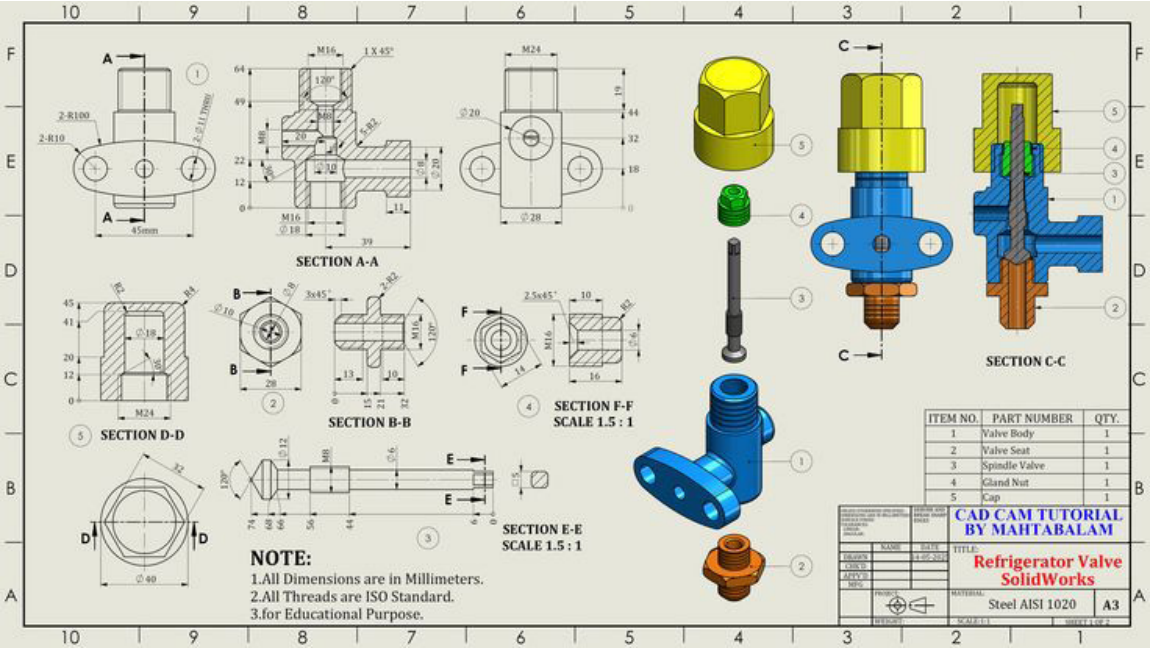


Figure 3.2.24

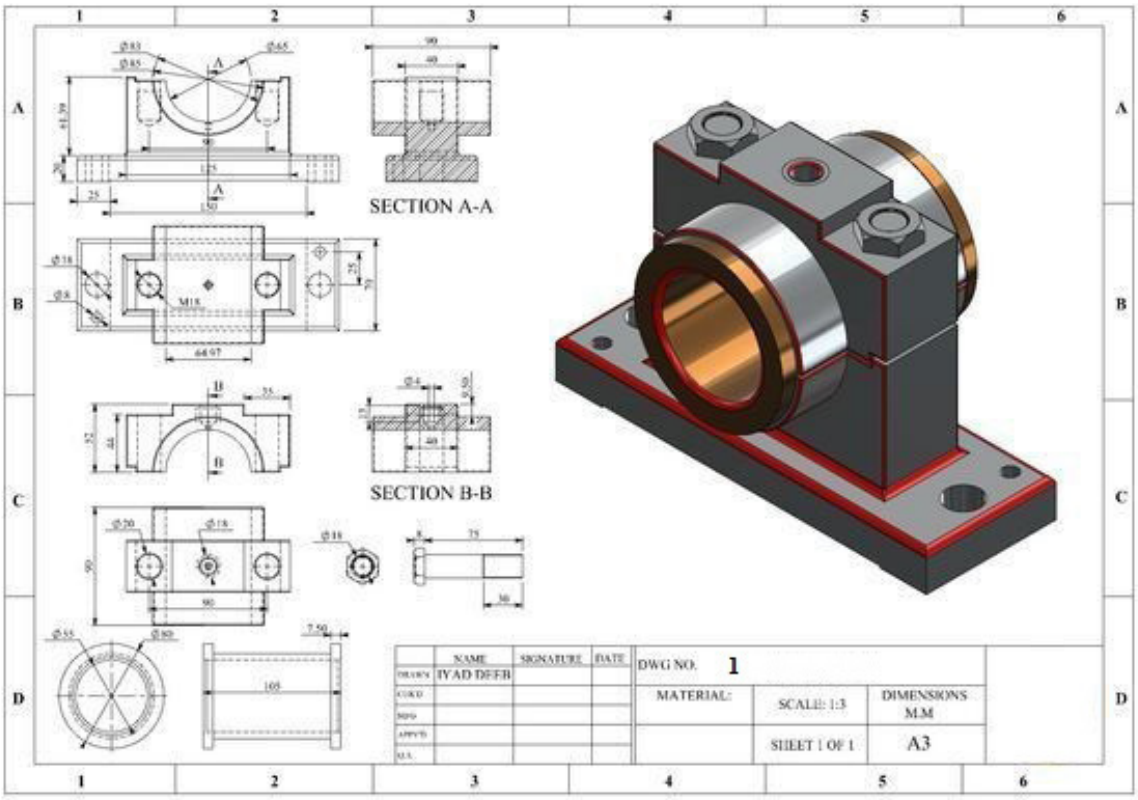


Figure 3.2.25

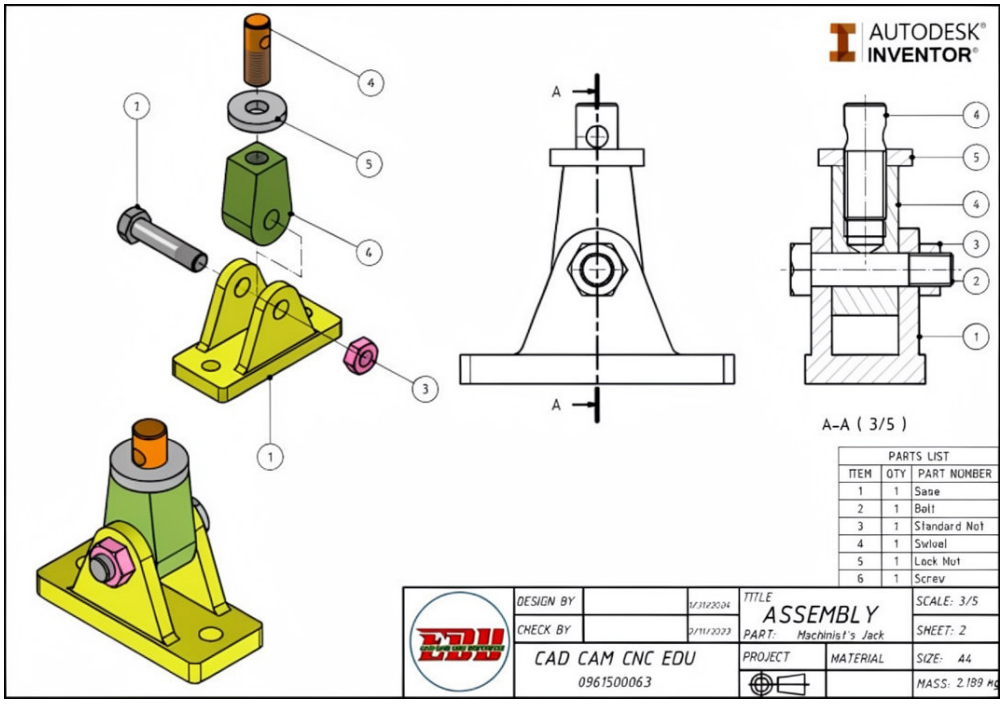


Figure 3.2.26

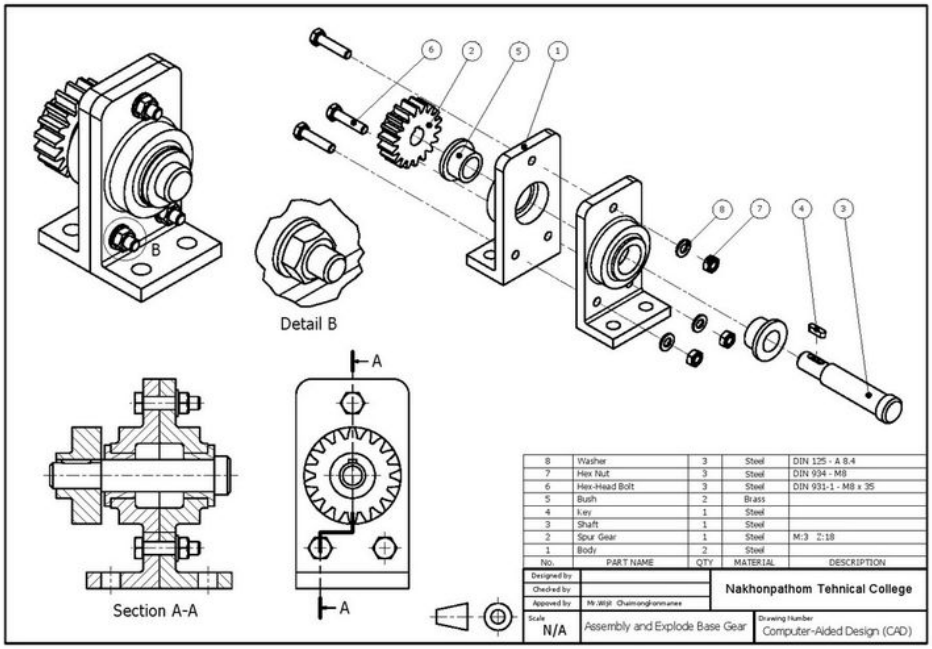


Figure 3.2.27

Activity 3.2.2 Diagnose exploded Pump Assembly Drawing

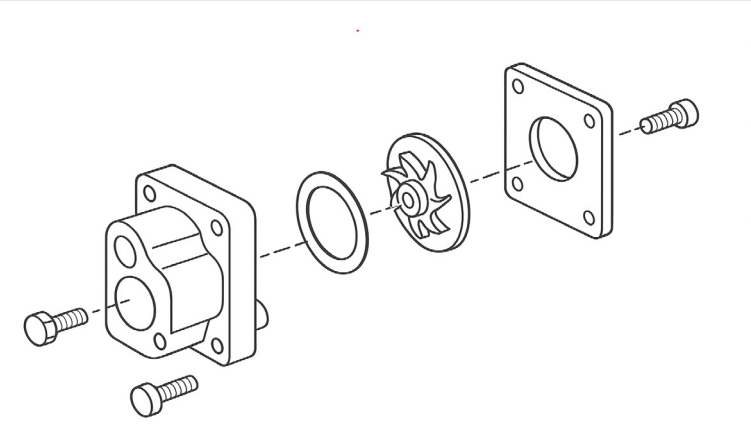


Figure 3.2.28: Exploded Pump Assembly Drawing

Materials Needed

- Printed exploded view of a simple pump assembly (with two misaligned parts and omitted fasteners)
- Pencils, erasers, rulers, and drawing instruments
- **Optional**: CAD software for digital corrections

Instructions

Step 1: Study the provided exploded drawing carefully.

Step 2: Diagnose Issues

1. Identify **what is wrong** with the assembly (e.g., misaligned parts, missing fasteners, wrong orientation).
2. Determine if **datum planes** or **reference points** are missing.
3. Evaluate if the **view choice** is clear and logical.

Step 3: Propose Corrections

1. Decide on the correct datum plane.
2. Select the most appropriate orthographic or sectional view to clarify the assembly.
3. Identify where the missing fasteners should be placed.

Step 4: Sketch the Corrected Layout

1. Draw your improved exploded view showing correct alignment, all fasteners, and proper orientation.
2. Clearly label the datum and reference planes used.

Step 5: Report Back

1. Present your corrected drawing to the class.
2. Explain how proper datum selection and view choice solved the assembly issues.

Manual Drafting of Working Drawings

At this time, you will use drawing instruments to produce scaled orthographic and sectional views, applying standard hatching, dimensions, and title blocks. Also, you will focus on precision and follow BS/ISO conventions.

Working Drawings

A working drawing, or engineering drawing, is a detailed plan for making a component, product, or structure. It gives exact details - such as dimensions, shapes, materials, tolerances, and assembly steps - so others can build it accurately. Its main purpose is to clearly show your design so machinists, fabricators, or builders can follow it.

A working drawing must be clear and precise, often showing several views (front, top, side, and sectional) to fully describe the object. You also include dimensions, surface finishes, notes, material details, and any special treatments required.

You should follow standard drawing conventions and symbols to avoid confusion - using different line types for edges, hidden parts, and centrelines, and adding symbols for welds, finishes, and tolerances. By following standards like ASME, BS or ISO, your drawing can be understood and used anywhere in the world.

Manual Drafting of Working Drawings

A Step-by-Step Guide to Producing Scaled Orthographic and Sectional Views

Introduction

Manual drafting is a fundamental skill for engineers, architects, and designers, ensuring precision and adherence to technical drawing standards (BS/ISO). This guide covers the step-by-step process of creating orthographic and sectional views with proper hatching, dimensioning, and title blocks.

Materials and Tools Required

Before starting, ensure you have the following

- Drawing board (with T-square or parallel rule)
- Drawing paper (A2/A3/A4, depending on project size)

- Pencils (H, 2H for construction lines; HB for final lines)
- Eraser & sharpener
- Set squares (30°/60° and 45°)
- Compass & dividers
- Scale ruler (for scaling drawings)
- French curves (for irregular shapes)
- Protractor (for angular measurements)
- Templates (for standard symbols and shapes)

Step 1: Setting Up the Drawing Sheet

1. Select the appropriate sheet size (A2, A3, or A4) based on the complexity of the drawing.
2. Fix the drawing sheet onto the board using drafting tape.
3. Draw the border lines (typically 10- 20 mm from the edge).
4. Add the title block (bottom-right corner) with:

a. Drawing title

b. Scale used

c. Drafter's name & date

d. Company/project name

e. Revision number (if applicable)

Step 2: Selecting and Applying the Scale

Choose a suitable scale (e.g., 1:1, 1:2, 1:5, 1:10, 1:20, 1:50, or 1:100) based on the object size.

BS/ISO standards require a clear indication of the scale in the title block.

Step 3: Drawing Orthographic Views

Orthographic projections (front, top, side views) must follow Third Angle Projection (BS 8888:2020) or First Angle Projection (ISO 5456-2) as per requirements.

Procedure

1. Lightly sketch construction lines (using 2H pencil) to define the main outlines.
2. Project lines from one view to another to maintain alignment.

3. Draw visible outlines (using HB pencil) with consistent line weights:
   a. Thick continuous lines (0.5mm–0.7mm) for visible edges.
   b. Thin continuous lines (0.2mm–0.3mm) for construction/extension lines.
4. Add hidden details (dashed lines, 2mm dash, and 1mm gap) for obscured features.
5. Check accuracy using the 45° mitre line method for depth consistency.

Step 4: Creating Sectional Views

Sectional views reveal internal features by "cutting" the object.

Procedure

1. Choose the cutting plane (indicate with a thick dashed line and arrows showing the viewing direction).
2. Sketch the sectioned area, removing the front part.
3. Apply standard hatching (BS EN ISO 128-50:2001):
4. Hatching lines at 45° (thin, evenly spaced).
   a. Different materials may have unique patterns (e.g., concrete, metal).

b. Draw visible edges behind the cutting plane.

5. Label the section (e.g., "SECTION A-A").

Step 5: Dimensioning the Drawing

Follow BS 8888:2020 or ISO 129-1:2018 for dimensioning rules.

Key Guidelines

1. Place dimensions outside the view where possible.
2. Use aligned or unidirectional dimensioning (consistent throughout).
3. Avoid over-dimensioning (only critical measurements).
4. Arrowheads should be slim and filled (1:3 ratio).
5. Leader lines point clearly to features.

Step 6: Finalising the Drawing

1. Review for errors (missing lines, missing/incorrect dimensions).
2. Darken final lines (HB pencil or technical pen).
3. Erase construction lines carefully.

4. Add notes & annotations (e.g., surface finishes, tolerances).
5. Sign and date the title block.

Conclusion

Manual drafting requires patience and precision. By following BS/ISO standards, learners can produce professional-quality working drawings with correct orthographic projections, sectional views, and dimensioning.

Additional Tips

1. Keep tools clean to avoid smudging.
2. Practice line consistency for clarity.
3. Refer to BS 8888 or ISO 128 for detailed conventions.

Activity 3.2.3 Drafting stages of a mechanical bracket

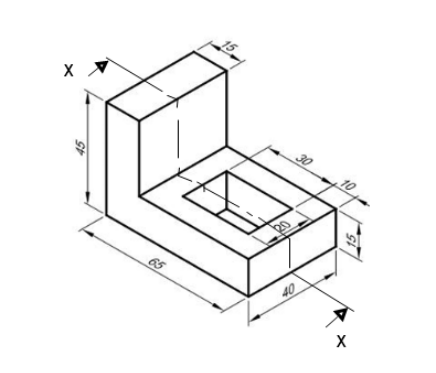


Figure 3.2.29: An engine component

1. ***Figure 3.2.29*** is a simple mechanical bracket. Follow the drafting in stages:
2. Sketch construction lines to full scale using an appropriate drawing instrument.
3. Refine into final orthographic views.
4. Add a sectional view X-X with hatching.
5. Apply major dimensions.
6. Present your work for class discussion.

CAD MODELLING AND PLOTTING OF WORKING DRAWINGS

Using CAD Software to Generate Accurate 2D Drawings from 3D Models

Step 1- Import a 3D Model

Procedure

1. Open your CAD software (AutoCAD).
2. Import an existing 3D model file (e.g., `.STEP`, `.IGES`).

Example

a. File

b. Open

c. Select a 3D model.

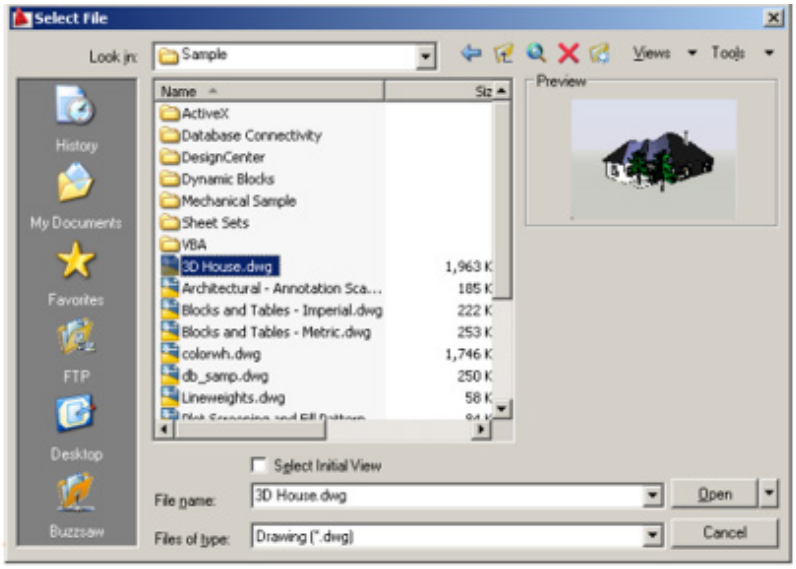


Figure 3.2.30: CAD software (1)

Step 2 – Orient and Create 2D Views

Procedure

1. Generate the required orthographic views (front, top, right side) and any sectional views.
2. Align views properly.
3. Add an isometric view for clarity if needed.

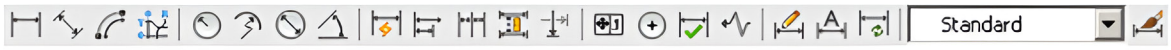
Step 3 – Add Dimensions and Annotations

Procedure

1. Apply linear, angular, and diameter dimensions, as needed.
2. Use notes, symbols, and tolerances where necessary.
3. Ensure dimension styles are consistent.

Example

Use `DIMLINEAR`, `DIMDIAMETER`, and `TEXT` commands.



Aligned



Radius or diameter



Angular dimension



Continue or Baseline dimension



Leader dimension



Apply Correct Units, Layers, Line Types, and Export for Printing/Plotting

Step 1 – Set Drawing Units

Procedure

1. Confirm that the drawing uses millimetres.
2. Adjust units accordingly.

Example: UNITS` command set to `millimetres

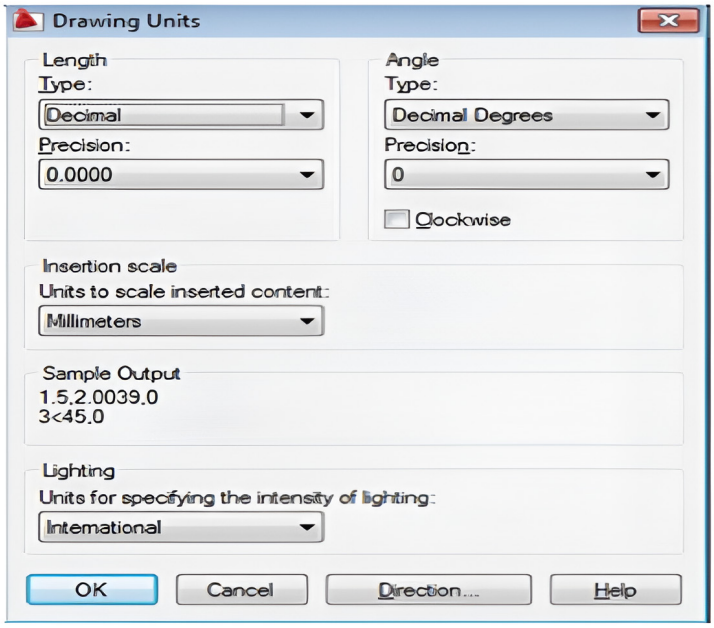


Figure 3.2.31: CAD software (2)

Step 2 – Organise Layers

Procedure

1. Create and assign layers for:
   - **a.** Visible edges
   - **b.** Hidden lines
   - **c.** Centre lines
   - **d.** Dimensions
   - **e.** Annotations
2. Set appropriate colours and line types.

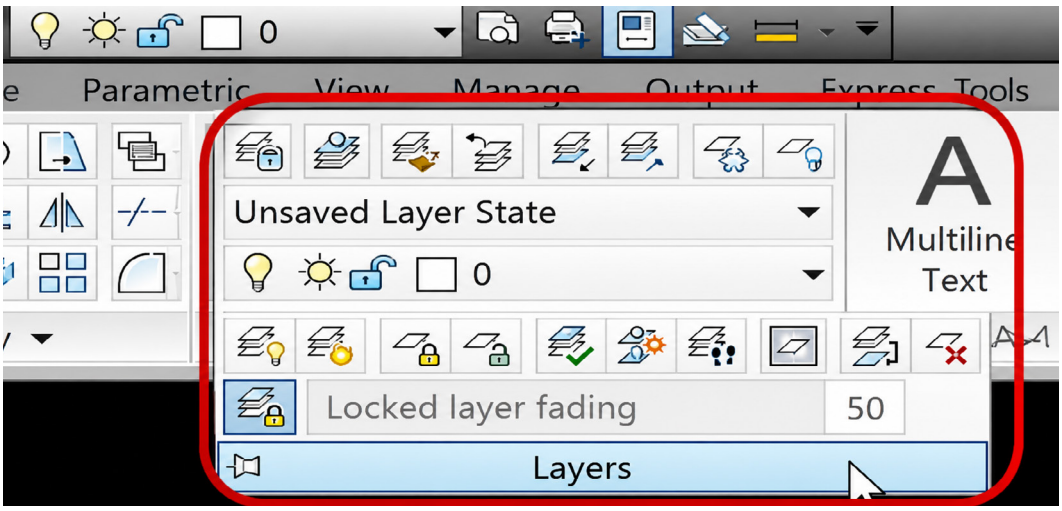


Figure 3.2.32: CAD software (3)

Example: Layer Properties Manager. Create layers;

- 0 - Visible` (continuous line)
- 1 - Hidden` (dashed line)
- 2 - Centre` (centre line)
- 3 - Dimensions` (continuous line)

Assign colours (e.g., blue for hidden, green for centre lines).

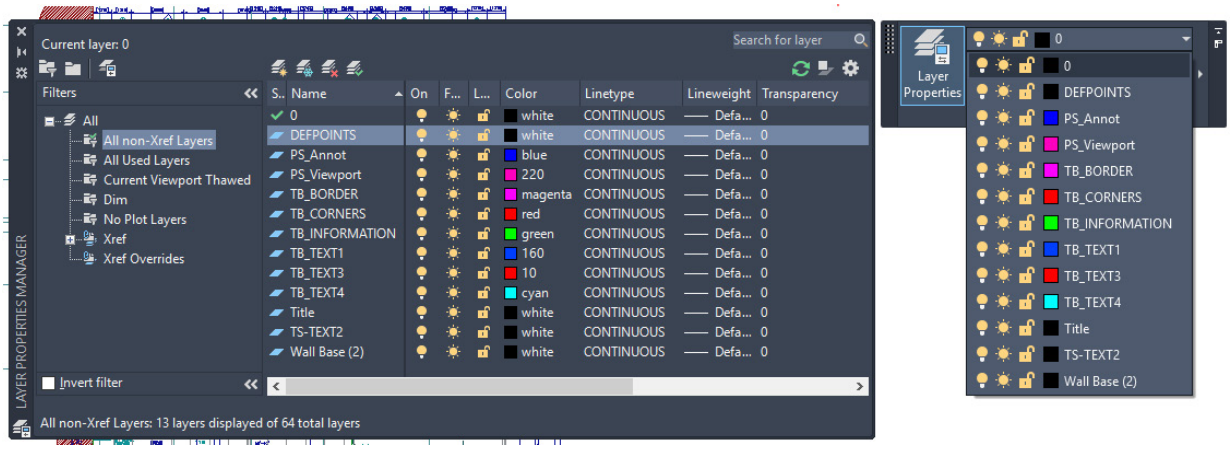


Figure 3.2.33: CAD software (4)

Step 3 – Apply Line Types and Weights

Procedure

Assign line types to each layer.

1. Visible – Continuous
2. Hidden – Dashed
3. Centre – Centre line

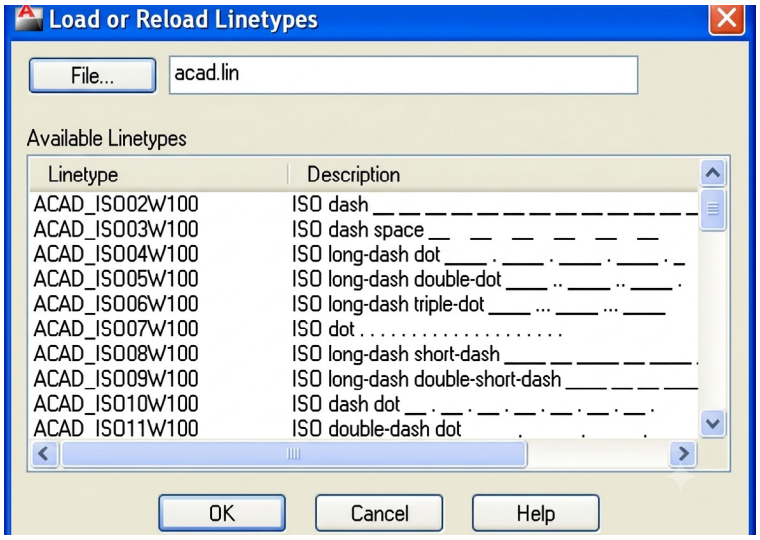


Figure 3.2.34: CAD software (5)

Set line weights (thickness). E.g., Visible lines = 0.5 mm, Hidden lines = 0.3 mm.

Example: Properties palette to set line weights.

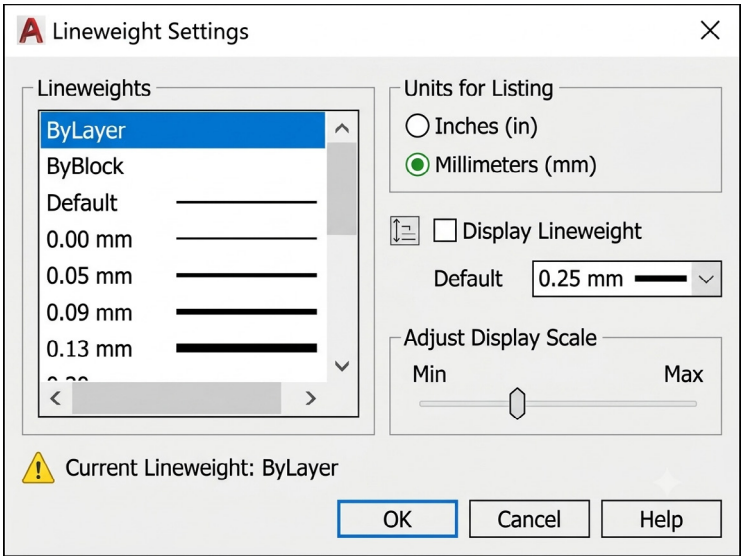


Figure 3.2.35: CAD software (6)

Step 4 - Export Drawing for Plotting

Procedure

1. Save the drawing in a suitable format (`DWG`, `DXF`, `PDF`).
2. Prepare the file for printing or digital sharing.

Example

1. `PLOT` command > choose printer/plotter > select paper size.
2. Export as PDF: `EXPORTPDF`.

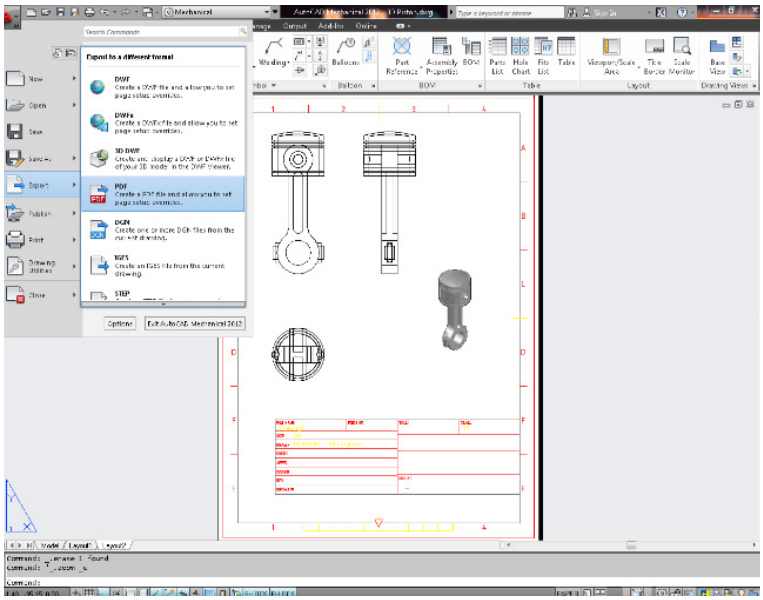


Figure 3.2.36: CAD software (7)

Set up Sheet Sizes, Viewports, and Line Weights

Step 1 – Define Sheet Size

Procedure

1. Choose an appropriate paper size (A3, A2, A1).
2. Set margins and title block.

Example:

`Layout` tab > `Page Setup Manager` > Modify > choose A3.

https://youtu.be/tOHGb8Ay_Ls?si=W8VyyQ4_6BRBw1Ss

Step 2 – Create Viewports

Procedure

Insert viewports in the paper space to display different views.

Example: Layout` tab > `Layout Viewports` > `Rectangular` > draw viewport.

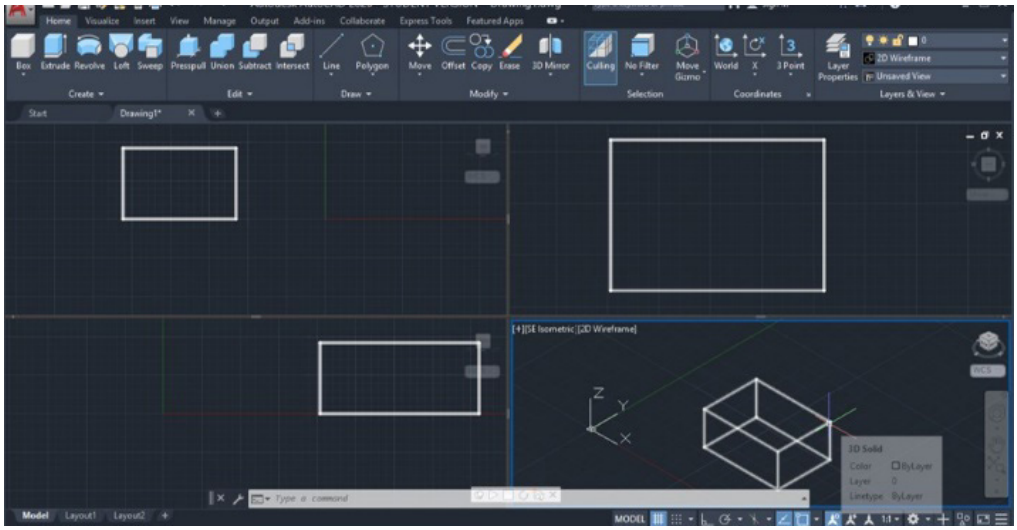


Figure 3.2.37: CAD software (8)

Step 3 – Assign View Scales

Procedure

Set scales for each viewport, e.g., 1:1, 1:2, 1:5, depending on the component size.

Example: Select viewport > Properties > Standard Scale > select 1:2.

Step 4 – Check and Adjust Line Weights

Procedure

1. Preview how line weights will look when plotted.
2. Adjust if necessary.

Example:

   a. `Plot` > `Preview` to see line weight representation.

   b. Practical Example: Create and Plot a Bracket Drawing

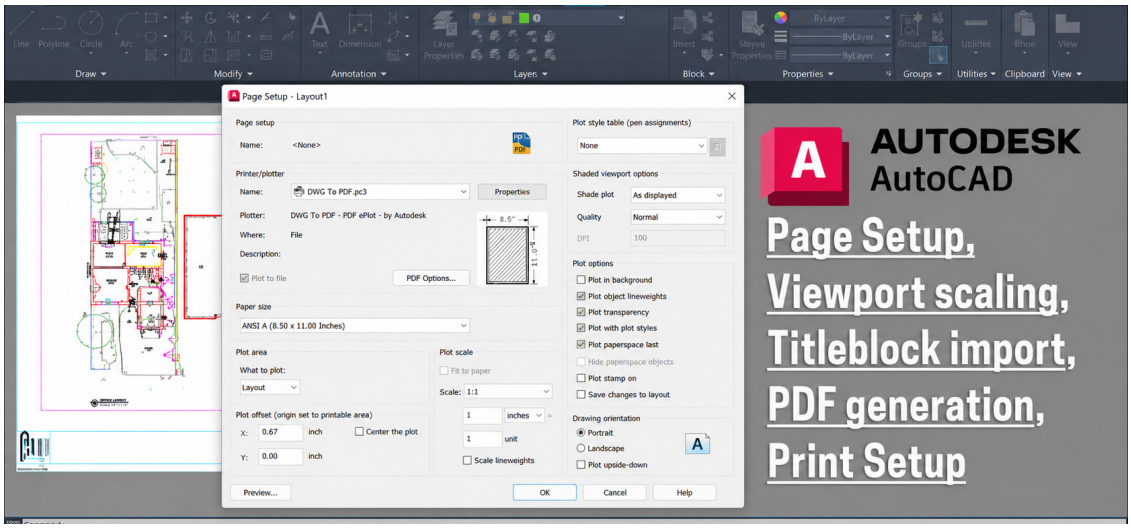


Figure 3.2.38: CAD software (9)

Activity 3.2.4 CAD Software to Generate 2D Drawings

Follow the steps below: use CAD software to generate accurate 2D drawings from 3D models, apply correct units, layers, line types, and export for printing/ plotting

Steps

1. **Set Up the CAD Environment**
   - **a.** Open the CAD software and configure the workspace.
   - **b.** Select the correct drawing units (e.g., millimetres or inches).
   - **c.** Create and name layers for different elements (e.g., outlines, centrelines, dimensions, hatching).
   - **d.** Assign appropriate line types and line weights to each layer.
2. **Import or Create the 3D Model**
   - **a.** Open the existing 3D model or construct it within the CAD software.
   - **b.** Verify that the model is complete and accurate.

c. Check orientation and scale of the 3D model.

3. **Generate 2D Views from the 3D Model**
   - **a.** Use the "view base" or equivalent command to project 2D views (front, top, side, isometric).
   - **b.** Align orthographic views properly.
   - **c.** Add sectional views if needed to reveal internal details.
4. **Refine the 2D Drawing**
   - **a.** Apply correct line types (thick for visible edges, dashed for hidden, chain for centrelines).
   - **b.** Use hatching patterns for sectional areas.
   - **c.** Insert dimensions, labels, and annotations.
   - **d.** Check alignment and clarity of drawings.
5. **Prepare for Output**
   - **a.** Set up the drawing layout or paper space.
   - **b.** Insert a title block with project details, scale, and drawing number.
   - **c.** Adjust scale factors for different views.
   - **d.** Ensure correct plotting style (pen assignments, line weights, and colours).
6. **Export and Print/Plot**
   - **a.** Preview the drawing before printing.
   - **b.** Export as PDF/DWG/DXF depending on requirements.
   - **c.** Print/plot using the correct paper size (A4, A3, etc.) and orientation.
   - **d.** Verify that the final output matches professional drafting standards.

EXTENDED READING

- https://youtu.be/tOHGb8Ay_Ls?si=W8VyyQ4_6BRBw1Ss
- Rhodes, L. B and Cooks, R. S. (1982). Engineering Geometrical Drawing, Pitman Publishers. Pages 66 – 72
- Venkata, R, K, (2008). Textbook of engineering drawing. BS Publications. Page 41 - 49

REVIEW QUESTIONS

Look carefully at the sectional drawing provided below.

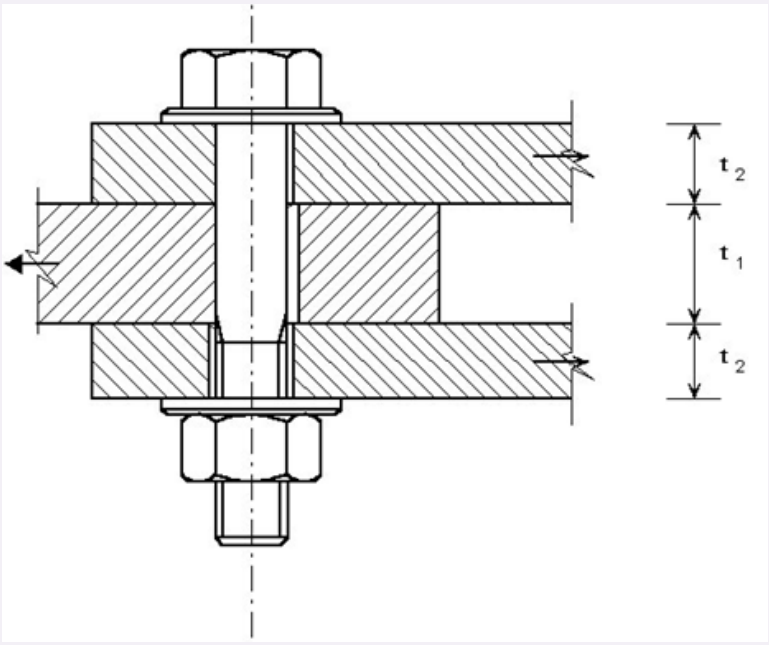


Figure 3.2.39

1. Analyse the drawing and answer these questions
   - **a.** Describe step by step how you know which parts are solid material and which are fasteners.
   - **b.** Explain why the bolt, nut, and washer are drawn without hatching,
   - **c.** What is the role of fasteners in the assembly?
2. Explain the following:
   - **a.** Definition and importance of exploded views
   - **b.** Definition and importance of sectional views
   - **c.** Define primary datum and secondary datum with an example drawing.
   - **d.** Sketch an exploded view of a simple object (e.g., a bolt and nut assembly) and label parts according to conventions.
   - **e.** Draw a sectional view of a simple block with a hole, applying correct hatching and symbols.

3.

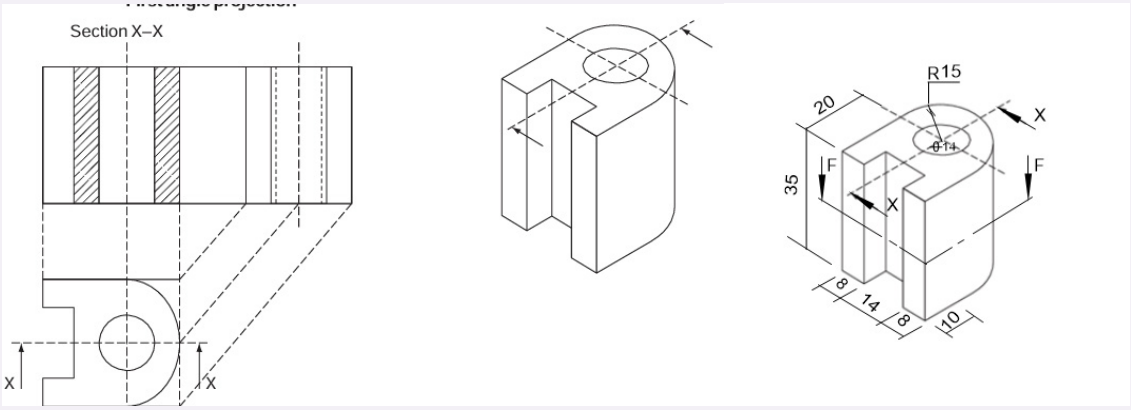


Figure 3.2.40: An engine component

a. Analyse the orthographic views of Figure 3.2.40, identify errors or missing elements and correct them. Consider;

- Scale, line types, sectional view with hatching.
- Dimensioning and labelling standards.
- Title block information.

b. Compare your manual drawings to CAD versions for discussion on pros/cons

4.

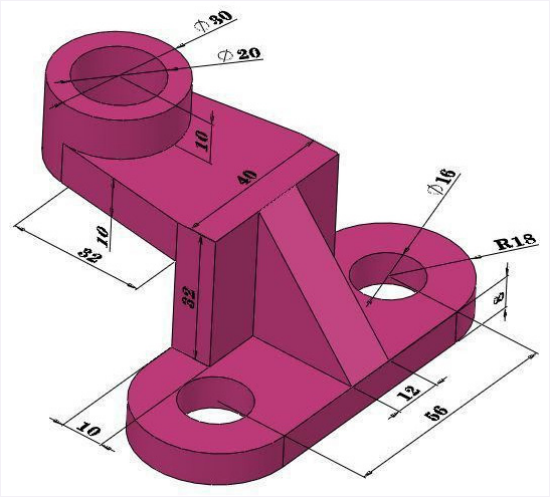


Figure 3.2.41: A machine bracket

Figure 3.2.41 provided is a 3D model of a mounting bracket assembly consisting of:

a. Main bracket body with mounting holes

b. Reinforcement ribs

c. Countersunk holes for fasteners

d. Curved support surface

Explain how you will use CAD to draw the bracket.

UNIT 3: GARMENT DESIGN TECHNOLOGY

Introduction

Pattern grading is an important process in garment design. By applying key principles, pattern graders can maintain the design's integrity and proportion, resulting in garments that fit a wide range of customers.

In your previous lessons, you learned how to use basic principles, such as using a flexible tape measure to take accurate body measurements, and draft basic pattern blocks for the bodice and sleeves.

In this section, you will learn how garment patterns work in the design and production process and the tools needed to adapt and change garment patterns to fit a variety of body sizes and design requirements.

Also, you will be able to analyse garment designs to determine and dissect them into their parts, work with pre-existing patterns to modify, grade patterns according to size, produce new designs, and make precise adjustments and alterations to guarantee proper fit and style.

KEY IDEAS

- **Fit and Proportion:** The ultimate goal of pattern grading is to maintain the fit and proportion of the original design across different sizes, ensuring that the garment looks and feels good on various body types.
- **Grade Rules:** Grade rules are used to specify the amount of increase or decrease in measurements between sizes, taking into account factors like fabric stretch and fit preferences.
- **Measurement Charts:** Pattern graders use measurement charts and size tables to determine the incremental changes in measurements between sizes, ensuring accuracy and consistency.
- **Pattern Piece Manipulation:** Pattern graders may need to manipulate individual pattern pieces to accommodate different sizes, ensuring that seams, grain lines, and other design elements remain consistent.
- **Proportion Scaling:** Grading involves proportionally scaling up or down a base pattern piece to create different sizes, maintaining the designer's integrity and proportions.
- **Size Range Development:** Pattern grading involves creating a size range for a garment design, ensuring a good fit for different body types and sizes.

PATTERN GRADING IN GARMENT DESIGN

Pattern grading is a process in garment design that involves creating a range of sizes for a single garment design, ensuring a consistent and flattering fit and proportion across different body types and sizes. By applying key principles like proportional scaling, measurement charts, and grade rules, pattern graders can maintain the design's integrity and proportion, resulting in garments that look and feel good on various customers.

The primary goal of pattern grading in garment design is to create a range of sizes, such as S, M, L, XL, XXL, or 8, 10, and 12, that fit different body types and sizes while maintaining the original designs.

1. **Fit**: Ensuring the garment fits comfortably and accurately across various sizes.
2. **Proportion**: Preserving the design's aesthetic appeal and balance in each size.
3. **Integrity**: Maintaining the design's intended shape, style, and functionality.

This can be done using manual tools like rulers and measuring guides to scale up or down the pattern piece, or using computer-aided design (CAD) software to grade patterns. This is best for mass production, commercial fashion design, and high-accuracy needs.

Purpose of Pattern Grading

The primary purpose of pattern grading is to ensure that a garment design fits well and looks great on various customers regardless of their size or body type. By creating a range of sizes, pattern grading enables garment manufacturers to cater for a wider range of customers, reduce returns and exchanges, and improve customer satisfaction.

Importance of Pattern Grading

Creation of Size Ranges

Pattern grading enables a fashion designer to create size ranges (e.g., sizes 6 to 18) for garment designs, ensuring that a single design can fit various body types and sizes. This involves scaling up or down a base pattern piece while maintaining the design's integrity.

Production Efficiency

Pattern grading streamlines production by allowing manufacturers to create multiple sizes from a single design, reducing the need for multiple prototypes and minimising production costs. This efficiency enables manufacturers to respond quickly to changing fashion trends and customer demands.

Comfort and Fit

Pattern grading ensures that garments fit comfortably and accurately across different sizes, which is essential for customer satisfaction. A well-graded pattern provides a consistent fit, reducing the likelihood of returns and exchanges.

Economical Manufacturing

By creating multiple sizes from a single design, pattern grading reduces production costs associated with creating multiple prototypes and patterns. This economical approach enables fashion designers to produce high-quality garments at a lower cost, making them competitive in the market.

Accessibility and Inclusivity of Size

Pattern grading promotes size inclusivity by allowing fashion designers to create garments in a range of sizes, catering for diverse customer needs. This approach ensures that customers of various shapes and sizes can access fashionable clothing that fits well and meets their needs.

Personalisation and Adjustments

Grading can also facilitate personalisation and adjustments by providing a foundation for made-to-measure garments. By grading patterns to individual measurements, manufacturers can create custom-made clothing that fits perfectly, enhancing customer satisfaction and loyalty.

Use of Digital Fashion Technology

The use of digital fashion technology, such as computer-aided design (CAD) software and 3D avatars, has revolutionised pattern grading. These tools enable pattern graders to create and grade patterns accurately and efficiently, reducing errors and improving production times, thus minimising paper waste and promoting sustainable practices. Digital technology also facilitates the creation of digital fit models and virtual prototyping, further streamlining the pattern grading process.

Standard Size Chart

In the clothing industry, a standard size chart is a table or chart that outlines the measurements for different garment sizes. It provides a set of standardised measurements for various body parts, such as bust, waist, hip, and inseam, to determine the corresponding garment size. To guarantee uniformity and effectiveness in the manufacturing of apparel, it serves as a reference tool for designers, pattern makers, and manufacturers.

Purpose of a Standard Size Chart

1. **Ensure Consistent Sizing:** Provide a consistent set of measurements across different garment sizes and styles.
2. **Simplify Sizing:** Help customers determine their correct size by comparing their body measurements to the chart.
3. **Supports Mass Production:** Allows manufacturers to cut and sew garments in bulk using pre-defined sizes, thereby reducing production cost. Crucial for creating ready-to-wear (RTW) clothing for retail.
4. **Enhances Fit and Comfort:** Ensures that garments fit well and are proportionate to the body. This minimises returns and exchanges due to sizing issues.
5. **Reduces Waste and Cost:** Minimises errors in cutting and sewing and prevents overproduction of poorly fitting garments.
6. **Support Marketing and Retail:** Size charts are shared with customers online and in stores for better purchase decisions.

Ladies' Standard Size Chart (cm and inches)

The standard size chart for women follows international sizing, a common practice in garment manufacture and pattern making. It provides measurements for bust, waist, and hip, which are essential for determining the correct fit for tops, dresses, and bottoms. Keep in mind that size charts can vary between brands and styles, and areas (e.g., UK, US, EU, and others). You can use this chart as a general reference for pattern changes and instructional purposes.

Here is a **Standard Size Chart for Ladies** presented in centimetres (cm) and inches (in) / (“), which is helpful for pattern grading, tailoring, and garment design. It includes key body measurements: bust, waist, hip, and back waist length.

Table 3.3.1: Ladies' Standard Size Chart (cm and in)

Size	Bust (cm/in)	Waist (cm/in)	Hip (cm/in)	Back Waist Length (cm/in)
6	78 / 30.7	60 / 23.6	84 / 33.1	38 / 15.0
8	82 / 32.3	64 / 25.2	88 / 34.6	39 / 15.4
10	86 / 33.9	68 / 26.8	92 / 36.2	40 / 15.7
12	90 / 35.4	72 / 28.3	96 / 37.8	41 / 16.1
14	94 / 37.0	76 / 29.9	100 / 39.4	42 / 16.5
16	98 / 38.6	80 / 31.5	104 / 40.9	43 / 16.9
18	102 / 40.2	84 / 33.1	108 / 42.5	44 / 17.3
20	106 / 41.7	88 / 34.6	112 / 44.1	45 / 17.7

Table 3.3.2: Other Standard Size Charts

Women's Sizes:

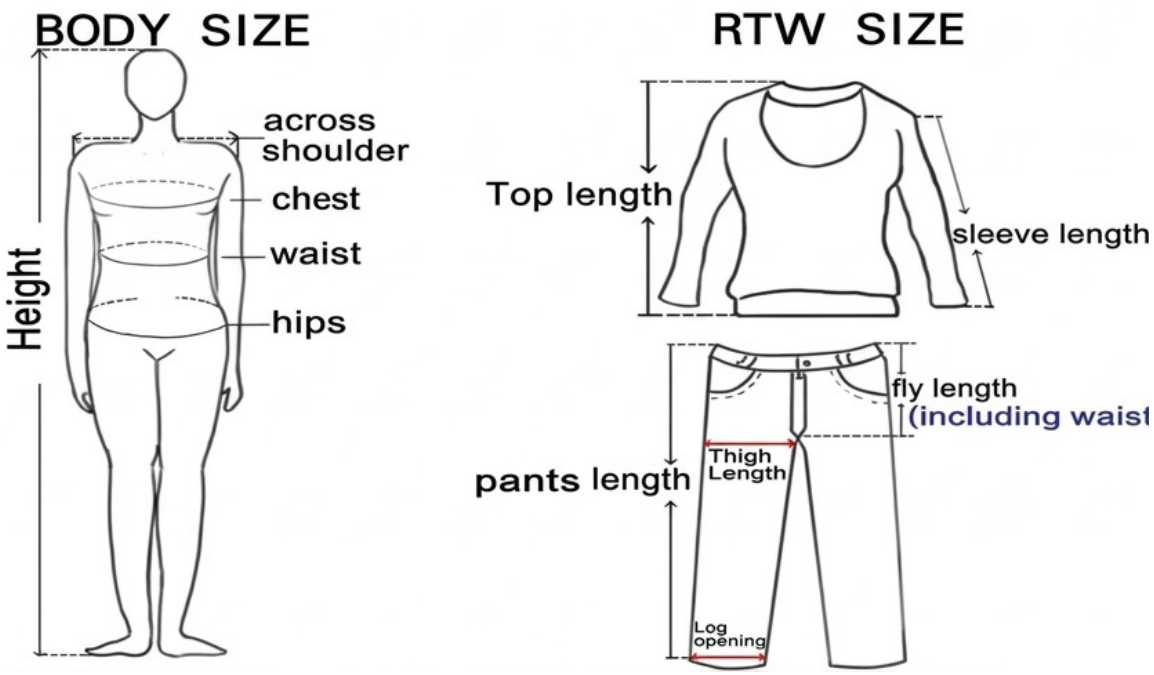
Women's	XS	S	S/M	M	M
Sizes	4	6	8	10	12
Bust	33 1/2"	34 1/2"	35 1/2"	36 1/2"	38"
Waist	25"	26"	27"	28"	29 1/2"
Hips	35 1/2"	36 1/2"	37 1/2"	38 1/2"	40"
Thigh	21 1/4"	22 1/4"	22 1/4"	23 1/2"	23 1/2"
Neck	13 1/2"	14 1/2"	14 1/2"	15"	15"
Sleeve	29"	29 1/2"	30"	30 1/2"	31"
Inseam	29 1/2"	30"	30 1/2"	31"	31 1/2"

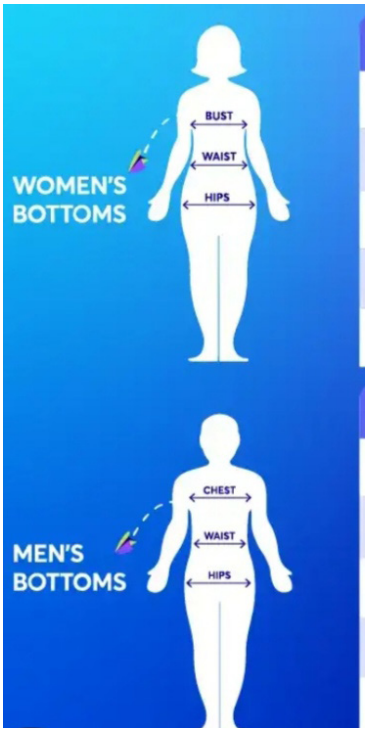
Women`s	L	L	XL	XL
Sizes	14	16	18	20
Bust	39 1/2"	41 1/2"	43 1/2"	45 1/2"
Waist	31"	33"	35"	361/2"
Hips	41 1/2"	43 1/2"	45 1/2"	47 1/2"
Thigh	25"	25"	26 1/2"	26 1/2"
Neck	15 3/4"	15 3/4"	16 1/2"	16 1/2"
Sleeve	31 1/2"	32"	32 1/2"	33 1/2"
Inseam	31 1/2"	32"	32"	33"

Size		Shoulder		Chest		Waist		Hip		Top length		Sleeve length	
ripide	US	CM	INCH	CM	INCH	CM	INCH	CM	INCH	CM	INCH	CM	INCH
XS	S	42	16.5	92	36.2	78	30.7	92	36.2	63	24.8	59	23.2
S	S	43	16.9	96	37.8	82	32.3	96	37.8	64	25.2	60	23.6
M	M	44	17.3	100	39.4	86	33.9	100	39.4	65	25.6	61	24
L	M	45	17.7	104	41	90	35.4	104	41	66	26	62	24.4
XL	L	46	18.1	108	42.5	94	37	108	42.5	67	26.4	63	24.8
2XL	L	47	18.5	112	44.1	98	38.6	112	44.1	68	26.8	64	25.2
3XL	XL	49	19.3	116	45.7	102	40.2	116	45.7	69	27.2	65	25.6
4XL	XL	51	20.1	120	47.2	104	40.9	120	47.2	70	27.6	66	26
5XL	2XL	53	20.9	124	48.8	106	41.7	126	49.6	71	28	67	26.4
6XL	2XL	55	21.7	128	50.4	110	43.3	132	52	72	28.4	68	26.8

SIZE		Pant length		Fly length		Thigh length		Leg Opening	
fripride	US	CM	INCH	CM	INCH	CM	INCH	CM	INCH
XS	S	102	40.2	24.5	9.6	57	22.4	33	13
S	S	103	40.6	25	9.8	58	22.8	34	13.4
M	M	104	41	25.5	10	59	23.2	35	13.8
L	M	105	41.4	26	10.2	60	23.6	36	14.2
XL	L	106	41.7	26.5	10.4	62	24.4	37	14.6
2XL	L	107	42.1	27	10.6	63	24.8	38	15
3XL	XL	108	42.5	27.5	10.8	64	25.2	39	15.4
4XL	XL	109	42.9	28	11	66	26	40	15.7
5XL	2XL	110	43.3	28.5	11.2	69	27.2	41	16.1
6XL	2XL	111	43.7	29	11.4	72	28.3	42	16.5

Measurement schematic





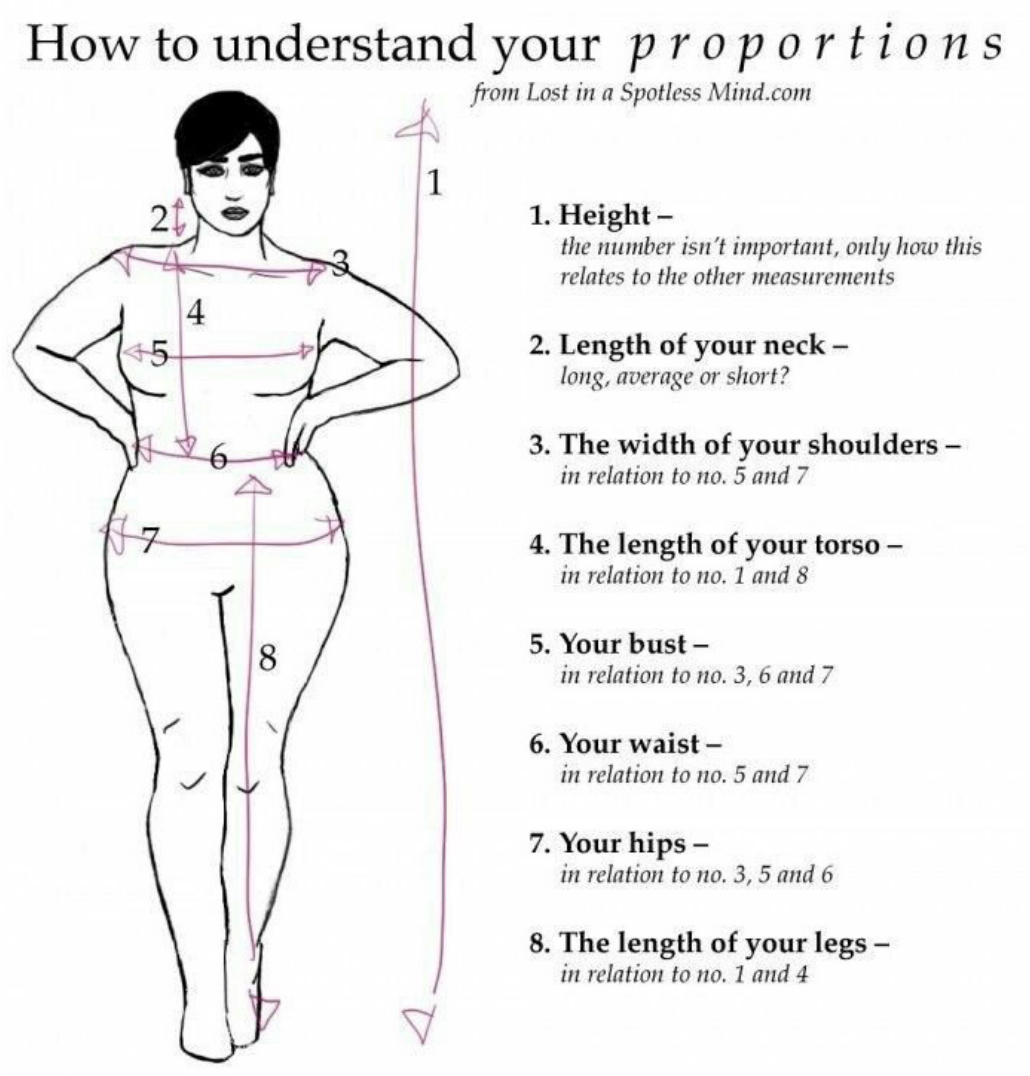
Size	Chest(cm)	Bust(cm)	Hips(cm)
XS	81-84	60-67	84-91
S	86-89	67-74	91-98
M	91-94	74-81	98-105
L	96-99	81-88	105-112
XL	101-106	88-98	112-120

Size	Chest(cm)	Bust(cm)	Hips(cm)
XS	90-95	69-75	82-87
S	95-99	75-80	87-91
M	99-104	80-85	91-95
L	104-110	85-90	95-100
XL	110-115	90-95	100-105

WOMEN'S SIZE CHART				
	US SIZE	BUST	WAIST	HIP
XXS	00	29.5" - 30.5" 75cm - 77.5cm	23.5" - 24.5" 60cm - 62.5cm	33.5" - 34.5" 85cm - 88cm
XS	0 - 2	31.5" - 32.5" 80cm - 83cm	25" - 25.5" 63.5cm - 65cm	35" - 35.5" 89cm - 90cm
S	4 - 6	33.5" - 34.5" 85cm - 88cm	26.5" - 27.5" 67.5cm - 70cm	36.5" - 37.5" 93cm - 95.5cm
M	8 - 10	35.5" - 36.5" 90cm - 93cm	28.5" - 29.5" 72.5cm - 75cm	38.5" - 39.5" 98cm - 100.5cm
L	12	38" 96.5cm	31" 79cm	41" 104cm
XL	14	40" 102cm	33" 84cm	43" 109cm
2X	16	42" 107cm	35" 89cm	45" 114cm

Measurement Descriptions for Pattern Grading

1. **Bust:** Around the fullest part of the chest and shoulder blades.
2. **Waist:** Around the natural waistline, usually the narrowest part of the torso.
3. **Hip:** Around the fullest part of the buttocks/hips.
4. **Back Waist Length:** From the base of the neck (nape) down the spine to the waist.
5. **Shoulder Slope:** From the base of the neck to the shoulder.
6. **Sleeve Length:** From the shoulder tip to the desired sleeve length.
7. **Armhole Length:** From the shoulder tip to the bottom of the armhole.
8. **Neckline:** Around the base of the neck.
9. **Body Length:** From the high point of the shoulder to the desired length.



Methods of Pattern Grading

There are different methods of pattern grading, each with its own technique. These are categorised under manual, drafting, and digital. Examples under them are:

Slash and Spread Method

The slash and spread method is a manual pattern grading technique that adjusts the size of a pattern by cutting (slashing) it and spreading it apart (to enlarge) or overlapping (to reduce). It helps maintain the **shape and proportion** of the original design. This method is ideal for small-scale production, custom tailoring, and educational purposes.

Step-by-Step Procedure for Slash and Spread Pattern Grading

1. **Prepare the Base Pattern**
   - **a.** Choose a clean, accurate base pattern in the sample size (e.g., Size 10).
   - **b.** Make sure all pattern markings (e.g., grainlines, notches, darts) are included.
2. **Identify and Draw Slash Lines**
   - **a.** Mark key areas where the body grows or shrinks (e.g., bust, waist, hip, shoulders).
   - **b.** Draw vertical and/or horizontal lines through these points. (Example: Draw vertical lines through the centre of the bodice, and horizontal lines at the bust or waist level).
3. **Cut Along the Slash Lines**
   - **a.** Use scissors to carefully cut along the marked lines.
   - **b.** Leave a small “hinge” at one edge to keep pieces connected (for minor adjustments).
4. **Spread or Overlap the Pieces**
   - **a.** Place the slashed pieces on a fresh sheet of pattern paper.
   - **b.** **To grade up (increase size):** Spread the pieces apart by the required amount (based on grading increments).
   - **c.** **To grade down (reduce size):** Overlap the pieces by the same amount. (Example: If increasing the bust by 4cm total, spread the front bodice 1cm on each side and the back 1 cm on each side).
5. **Secure the Adjusted Pattern**
   - **a.** Tape or glue the spread/overlapped pieces onto the new paper.
   - **b.** Ensure all sections are properly aligned, especially at the seam lines.

6. **Redraw and Smooth the Seam Lines**
   a. Use a French curve or ruler to redraw curves (e.g., armholes, necklines, side seams).
   b. Make sure all new edges blend smoothly and follow the original shape.
7. **Add Seam Allowances and Markings**
   a. Replace any missing seam allowances.
   b. Re-add notches, darts, points, grainlines, and other construction marks that were affected by the adjustment.
8. **Label the Graded Pattern**
   a. Mark the new size clearly on the pattern piece.
   b. Include other details: pattern name, piece number, size, date, and cutting instructions.
9. **Repeat for Other Sizes (optional)**
   a. Repeat the same process using new increments to create additional sizes.
   b. **Tools:** Pattern-making paper/cardboard, ruler/straight edge, pencil/pen, scissors, tape/adhesive, grading ruler/grading scale, calculator.

HOW TO RESIZE PATTERNS USING THE SLASH AND SPREAD METHOD WITH IMAGES

The first thing to do when grading a pattern is to work out how much width needs to be added or removed. Look at the size chart for the pattern and compare it with your actual measurement. Do not forget that patterns for woven garments have a certain amount of ease (the space between your body and the garment) in them. Make sure you have the same amount of ease in the pattern as when it was designed. The finished garment measurements can help with that.

[Ease = finished garment measurements – body measurements]

Let us assume you need to add 10 cm (4 in) to your hip, waist, and bust patterns, as an example.

Normally, a bodice pattern has front and back pieces that are cut on the fold to create the full garment. Thus, you have four sections - a left front, a left back, a right back, and a right front. This implies that you must divide the change among the pattern's four sections when grading it.

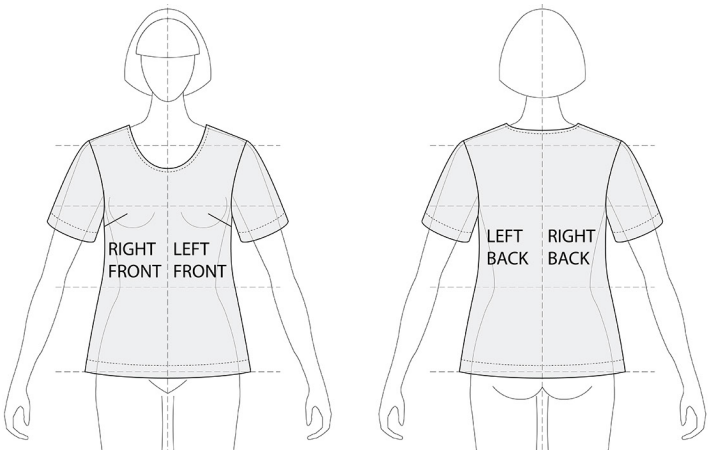


Figure 3.3.1: The four sections on a bodice

The 10cm that we are to add to the pattern is divided by 4 (the four sections of the garment). This means that each component will grow by 2.5 cm. **[10 ÷ 4 = 2.5]**

It is therefore necessary for you to determine what ¼ of this sum (2.5cm) is. To keep these figures in front of me, I find it useful to write them down at the start of the procedure.

[¼ = 0.625cm = 6.25mm (round to 6.2mm). ½ = 1.25cm (round to 1.3cm)], in this instance.

Distribute the Grade Through the Pattern

It's helpful to have a diagram of where the alteration will be made in front of you, as specific parts of a pattern need to be altered, and this will be the same across most patterns.

Mark the lines on the pattern

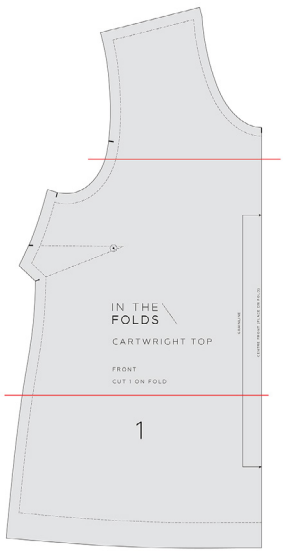


Figure 3.3.2: Marked lines on pattern

Step 1

Mark the horizontal slash lines on the pattern. We are working on a top pattern, so the horizontal lines go through the armhole and the waist. These lines need to be perpendicular to CENTRE FRONT.

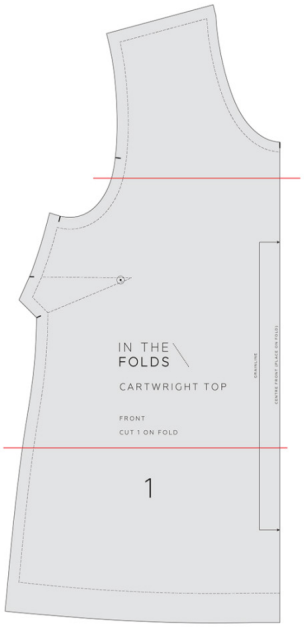


Figure 3.3.3: Horizontal slash lines marked on the pattern

Step 2

Mark in the vertical slash lines. They go through the neckline (close to the centre front), through the shoulder, and through the armhole near the side seam. These lines should be parallel to the CENTRE FRONT.

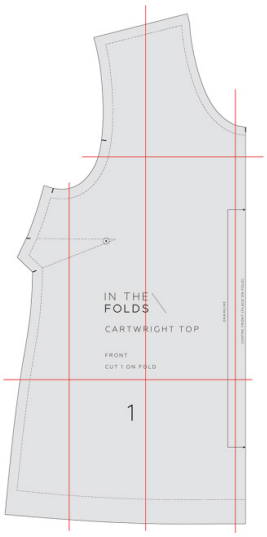


Figure 3.3.4: Vertical slash lines marked on the pattern

Step 3

Take note of how the grade will be distributed throughout the piece.

For the vertical lines, ¼ goes through the line closest to CENTRE FRONT, another ¼ through the shoulder area, and ½ through the armhole area. If you add these fractions together, you get 1, which means the whole grade will be distributed through the piece.

For the horizontal lines, we will distribute ¼ through each line.

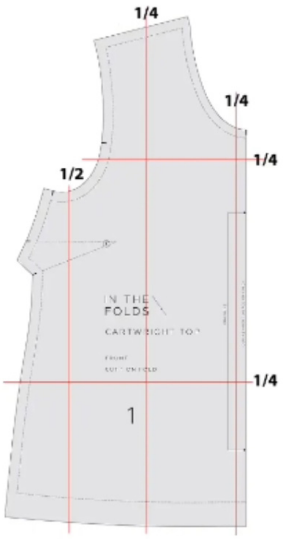


Figure 3.3.5: Grade distribution

Step 4

Cut through the slash lines. Being careful not to mix up the pieces.

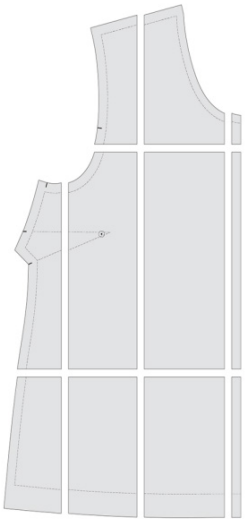


Figure 3.3.6: Slash lines cut through

Step 5

Take a piece of pattern paper that is larger than your pattern piece (if grading the pattern up) and mark in the CENTRE FRONT down one side.

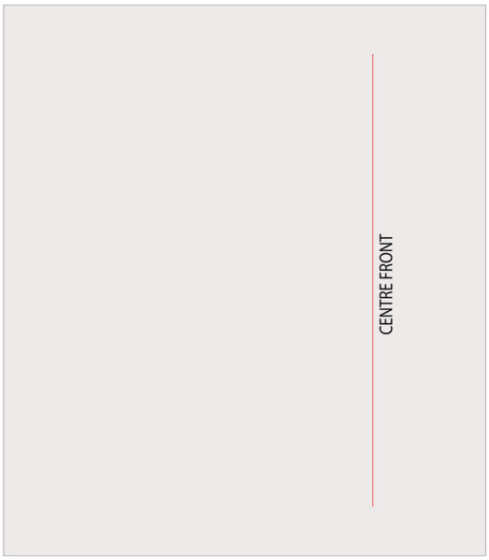


Figure 3.3.7: One side of the centre front marked down

Step 6

Start with the CENTRE FRONT next section of the pattern. Line up the CENTRE FRONT edge with the CENTRE FRONT marked on the page and glue or tape in place.

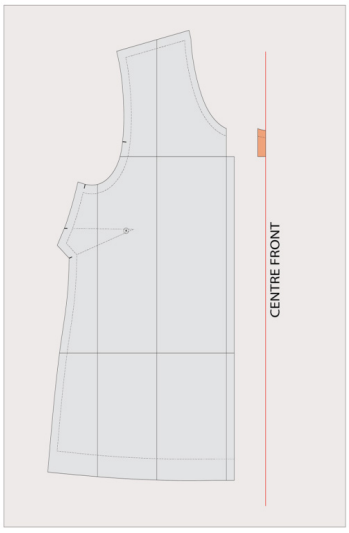


Figure 3.3.8: CENTRE FRONT marked on the page and glued or taped in place

Step 7

Draw a line down the side of the piece that is taped in place, parallel to the CENTRE FRONT. Draw a line across the bottom of the piece, perpendicular to CENTRE FRONT.

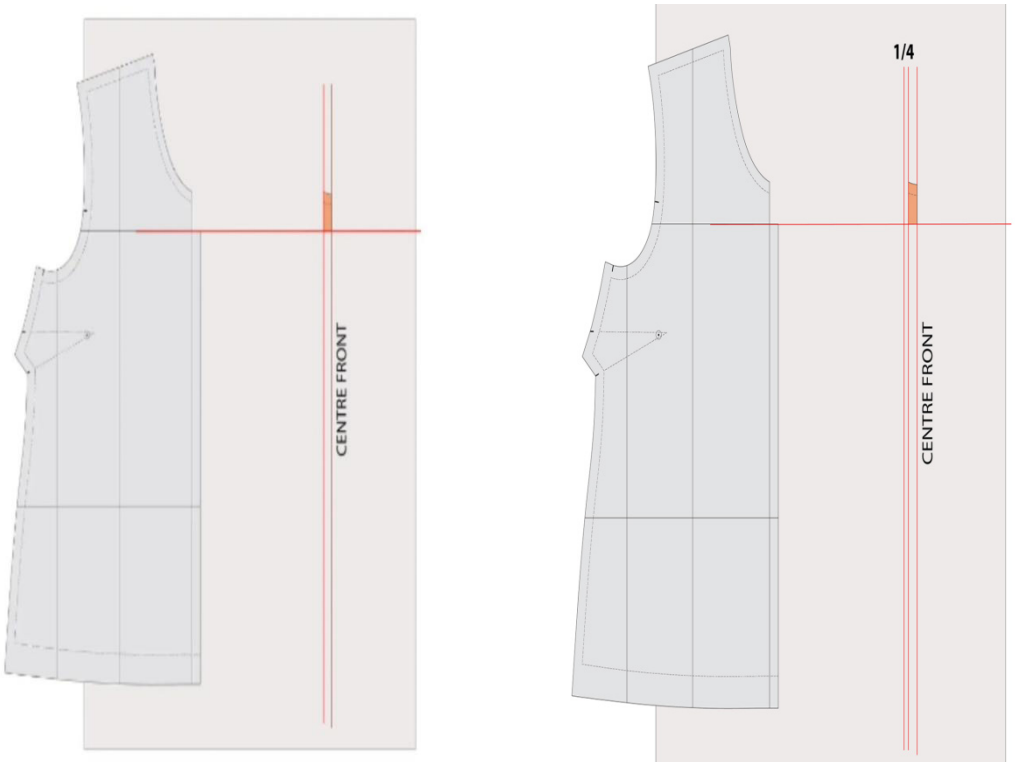


Figure 3.3.9: A line drawn down the side of the piece that is taped in place, parallel to the CENTRE FRONT. A line drawn across the bottom of the piece, perpendicular to CENTRE FRONT.

Step 8

Referring to your diagram in Step 3, you will see that ¼ of the grade (i.e., 6.2 mm) needs to be added to this section.

Draw a line 6.2mm from the vertical line, making sure it's parallel to the first line.

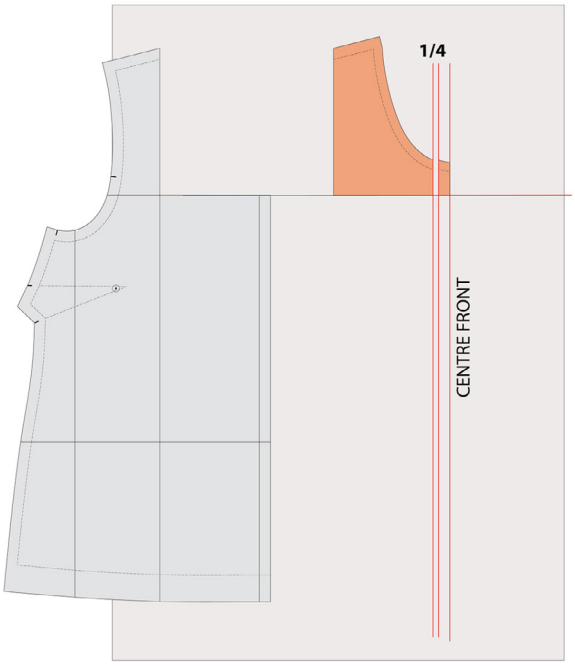


Figure 3.3.10: A line of 6.2mm from the vertical line drawn, parallel to the first line

Step 9

Slide the next piece of the pattern over and line up the corner of the piece with the corner created by the lines. Tape or glue in place.

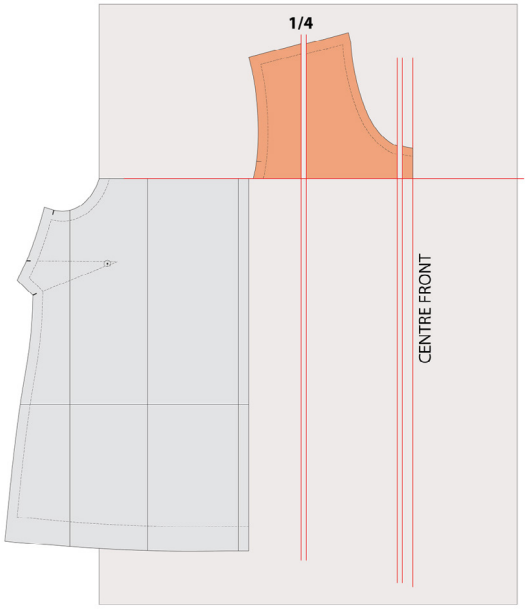


Figure 3.3.11: The next piece of the pattern slides over and lines up to the corner of the piece with the corner created by the lines. Taped or glued in place.

Step 10

Repeat the process on the other side of the piece, again adding ¼ of the grade. Slide the pattern piece over and tape or glue it in place.

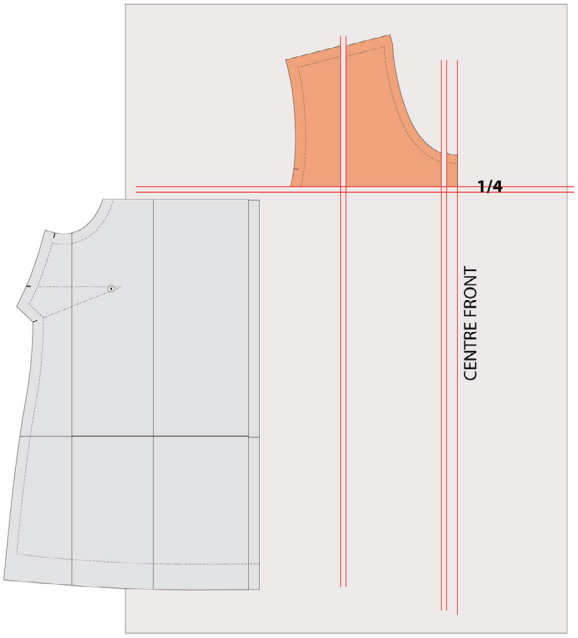


Figure 3.3.12: The process on the other side of the piece repeated, ¼ of the grade in addition added. The pattern piece slides over and is taped or glued in place.

Step 11

At this stage, you have the top section of the pattern in position, so you now need to move to the next row of pieces.

Before we get started, we need to add ¼ of the grade to the piece vertically. Use your ruler to mark this below the pieces that are stuck in place.

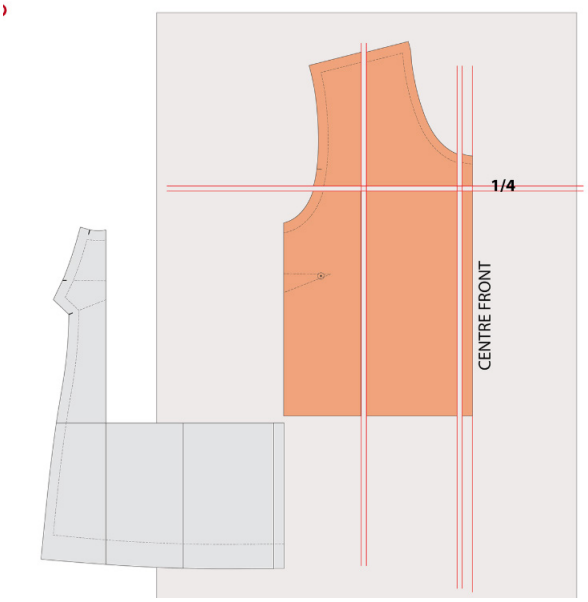


Figure 3.3.13: ¼ of the grade added to the piece vertically

Step 12

Place the next three pieces in position using the guidelines. Stop when you get to the armhole, as we need to add another guideline there.

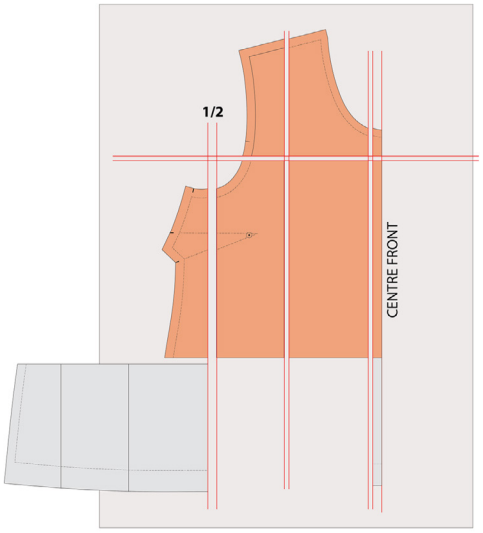


Figure 3.3.14: Another guideline added at the armhole there

Step 13

Draw a line down the side of the last piece that is taped in place, parallel to the CENTRE FRONT.

Mark in another guideline, parallel to the CENTRE FRONT, this time ½ of the grade (i.e. 1.3cm). Slide the next part of the pattern over and tape or glue it in place.

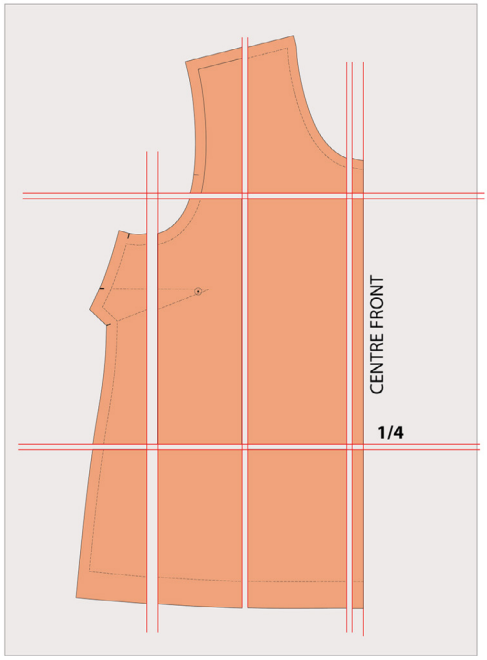


Figure 3.3.15: The next part of the pattern slides over and is taped or glued in place.

Step 14

Rule a line across the bottom of the pieces and another ¼ of the grade down from that. Position the remaining pattern pieces and tape or glue them in place.

Finalise The Pattern

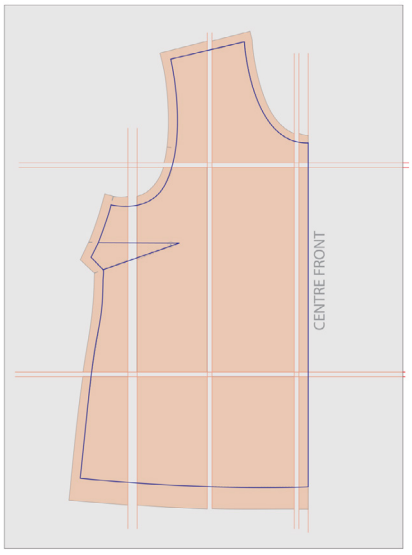


Figure 3.3.16: Final Pattern

Redraw smooth stitch lines over the alteration. Add seam allowance back onto the pattern.

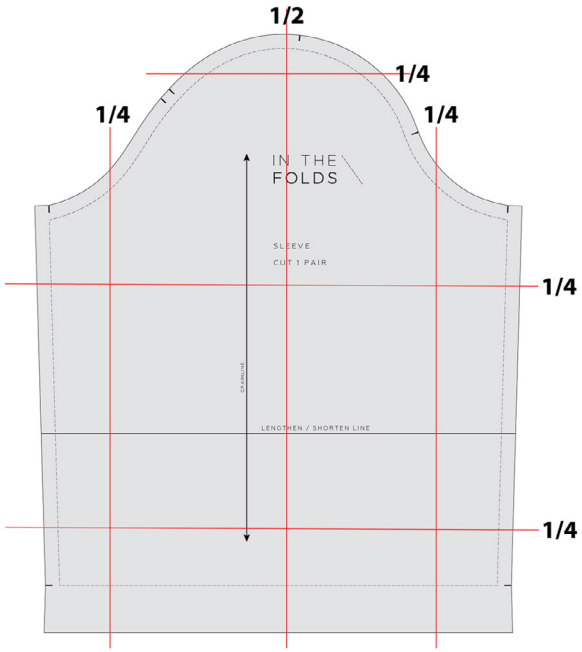


Figure 3.3.17: Repeated process done for the back pattern (with the guidelines in the same positions as on the front) and sleeve (if it has one).

Making the Pattern Smaller

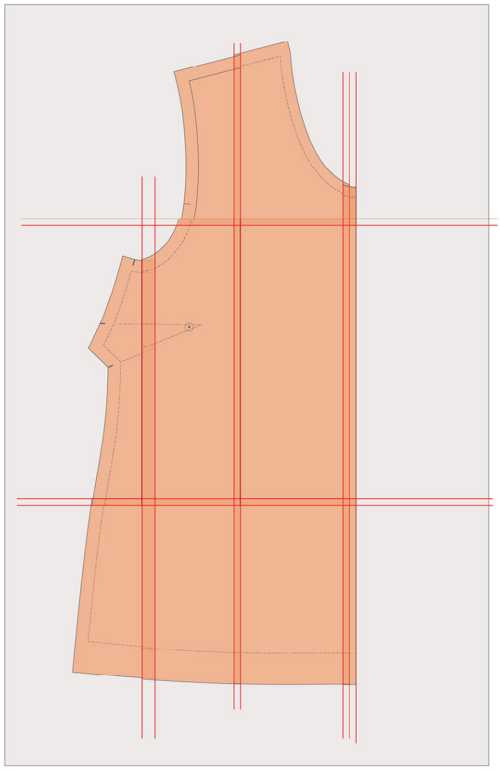


Figure 3.3.18: The same process can be used for making a pattern smaller. Rather than slashing and spreading to add width, you need to overlap the sections of the pattern to make it smaller.

Finally, check the true pattern.

Pattern Grading Using the Shift (Or Cut and Move) Method

Description

This is a manual technique similar to Slash and Spread but involves shifting the entire pattern section horizontally or vertically without slashing it into multiple parts. It is a good option if you do not want to cut up your pattern pieces.

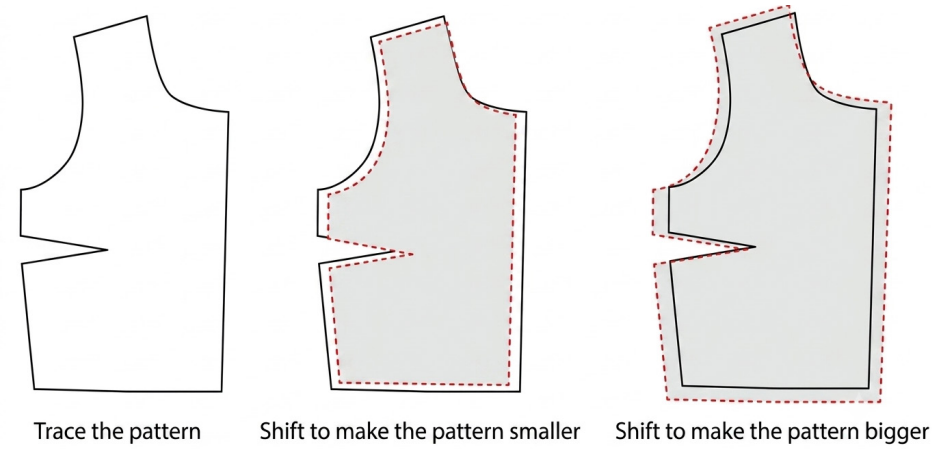


Figure 3.3.19: Shift method showing how to decrease and increase

Steps

1. Develop a base pattern in a specific size, ensuring it fits the desired body measurements.
2. Calculate the grade amounts for each size, based on the body measurements and garment type.
3. Move the pattern pieces proportionally, using the grade amounts, to create new sizes.
4. Ensure the shifted pattern pieces maintain the same proportion and fit as the original base pattern.
5. Check the graded patterns for accuracy and make adjustments as needed.

Best for

1. Professional pattern makers when grading manually.
2. Simple patterns and small grading increments (like children's wear or single-size adjustments).

Computer-Aided Grading (CAD Grading)

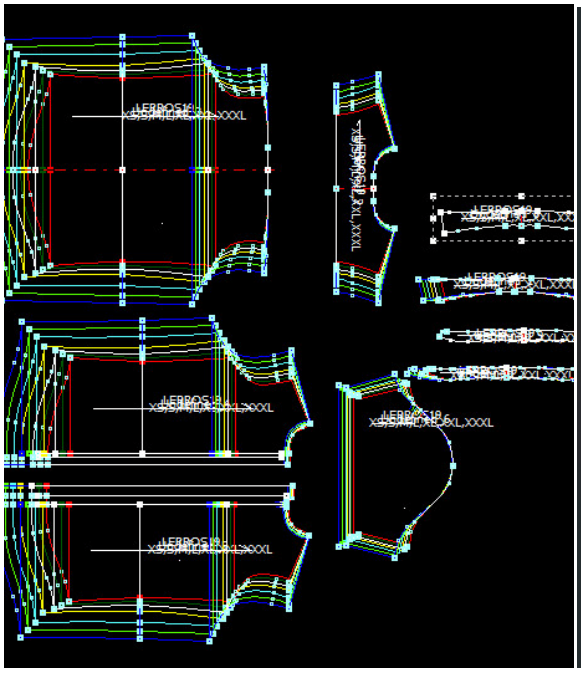
Description

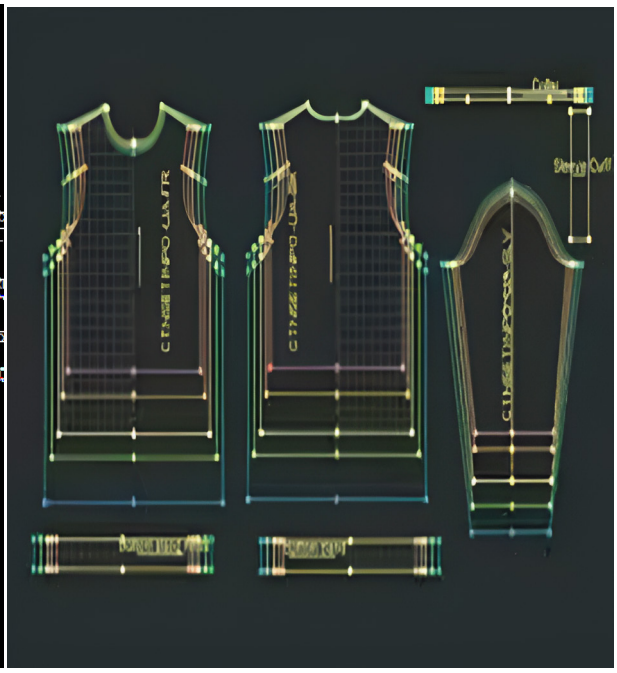
Uses specialised software to grade digital patterns efficiently.

Software like Page maker, Gerber AccuMark, Lectra Modaris, TUKAcad, Optitex, and CLO 3D automate the grading process using predefined rules.

Steps

1. Scan/ import or create a base pattern piece into the computer-aided software.
2. Set up a grading table with the desired size range, grade rules, and measurements'
3. Input the grade rule and measurements into the software, specifying how the pattern pieces should be graded.
4. Use the software to apply the grade rules to the base pattern, creating new sizes.
5. Review the graded patterns for accuracy and make adjustments as needed.
6. Generate the graded pattern pieces in the desired format, such as DXF or PDF.
7. Plot or print the graded patterns for use in the marker making, cutting, or other applications.





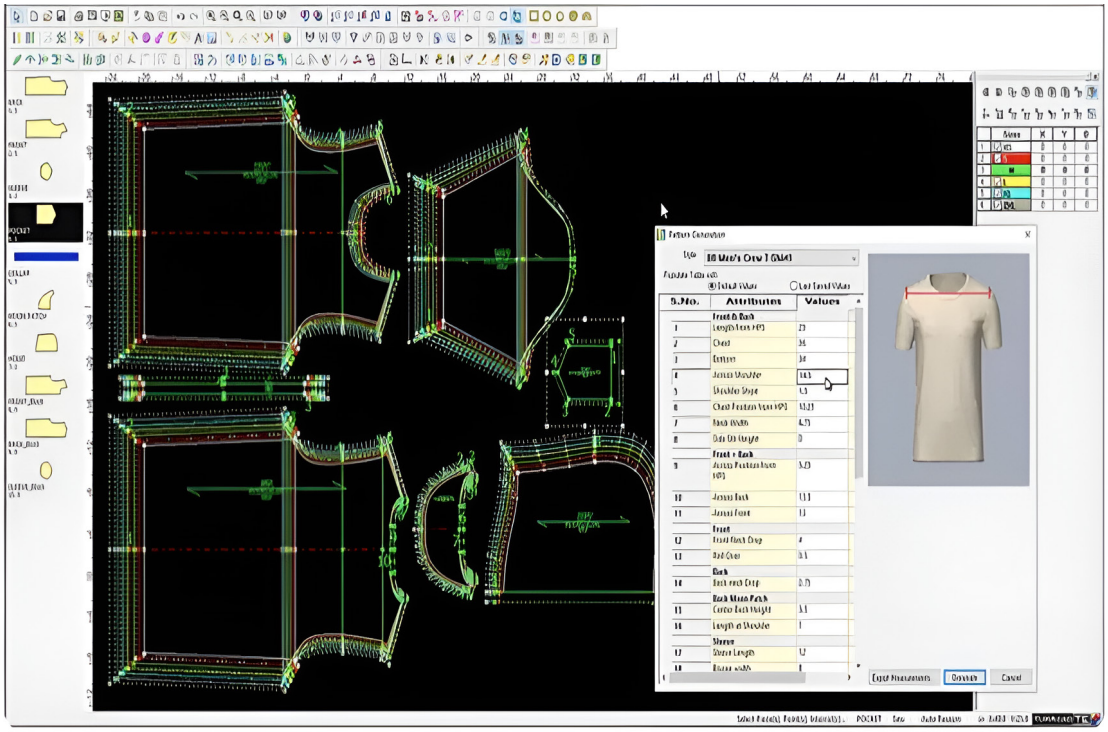


Figure 3.3.20: Auto CAD/ CLO standalone pattern grading

Nested Grading

Description

This refers to the technique of laying out all graded sizes of a pattern piece one on top of the other, creating a “nested” or “tracked” pattern. This allows for easy viewing of the different sizes and ensures that the grading is consistent and proportional across all sizes. Involves stacking or overlaying multiple sizes on a single pattern sheet, often using different coloured lines for each size.

Process

1. Identify the size range for the nested grading, including the smallest and largest sizes.
2. Grade the patterns for each size in the range, using a grading method such as slash and spread or proportional grading.
3. Arrange the graded patterns in a way that minimises fabric waste and optimises fabric usage.
4. Take into account the fabric width and the grain direction when arranging the patterns.
5. Calculate the amount of fabric required for each size and the total amount needed for the production run.
6. Finalise the nesting layout, ensuring that it is efficient and accurate.

7. Review the nesting layout and revise as necessary to ensure optimal fabric usage and minimise fabric waste.

Best for

Size range comparison, home sewing patterns, and visual teaching.

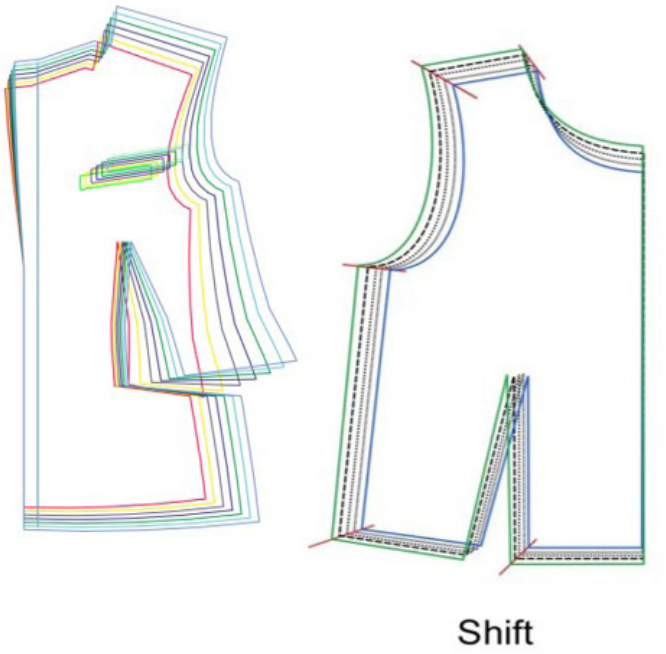


Figure 3.3.21: Nested Grading

Pattern Grading Using The Multiple Sizes Method (Manual Redrafting)

Description

Involves manually drafting each size from scratch using measurement charts rather than modifying a base pattern.

Process

[*Let us assume drafting for a women's blouse, for example*]

1. Create a size chart with measurements for each size, including bust, waist, length, and sleeve length.
2. Draft a base pattern piece for the blouse, using the measurements for the base size.
3. Calculate a new pattern piece for each size, using the measurements and proportions specific to that size. For example.
   a. Size S - Bust 34 in, Waist 26 in, Length 24 in

b. Size M - Bust 36 in, Waist 28 in, Length 25in

c. Size L - Bust 38 in, Waist 30 in, Length 26 in

Each size would have its own unique pattern piece, drafted to fit the specific measurements and proportions.

1. Add seam allowances and notches to each pattern piece, ensuring consistency across all sizes.
2. Review each pattern piece for accuracy and finalise the patterns for production.

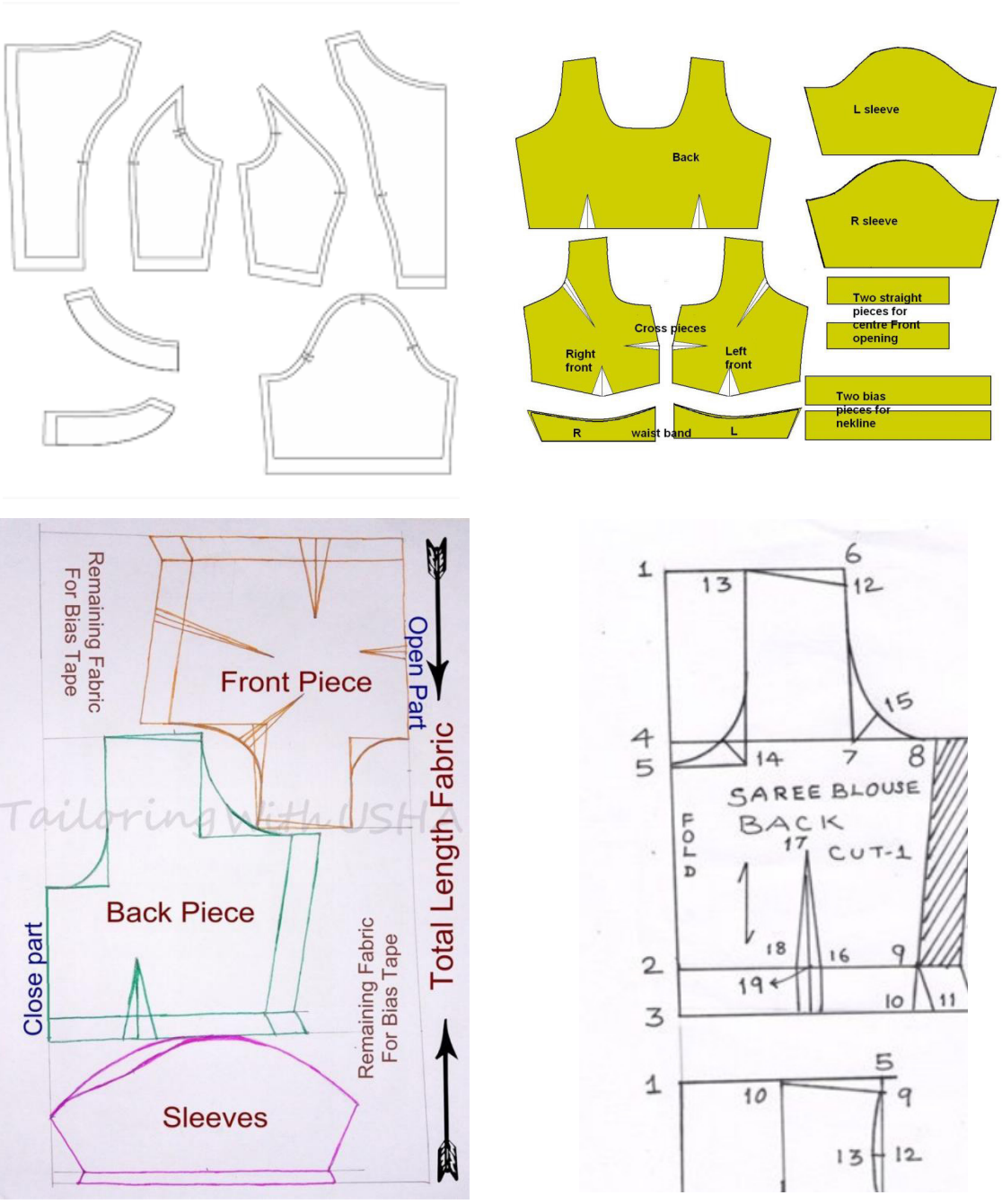


Figure 3.3.22: Different blouse patterns - each pattern set is created separately for different sizes

Best for

Custom tailoring or when grading is not feasible (e.g., when fit must be highly individualised).

Pattern Grading Chart

A pattern grading chart outlines the measurements for each size within a range and is used to scale patterns up or down. It provides a systematic approach to creating multiple sizes from a master pattern, ensuring consistent proportions and fit across the size range.

GRADED MEASUREMENT SHEET							
POINTS OF MEASUREMENTS	**38**	**39**	**40**	**42**	**44**	**46**	**TOL**
GENERAL							
CHEST (1" BELOW ARMHOLE)	20 1/2	21	21 1/2	22 1/2	24	25 1/2	1/4
WAIST (1" BELOW ARMHOLE)	20 1/2	21	21 1/2	24 1/2	25 1/2	26 1/2	1/4
BOTTOM SWEEP (1" BELOW ILE)	20 1/2	21	20 1/2	22 1/2	24	26 1/2	1/4
FRONT NECK DROP (FROM HPS)				1/8			1/8
POCKET (POCKET)							0
POCKET (POCKET)							0
SHOULDER (SHOULDER)	14 1/2	15 1/2	15 1/2	16 1/2	16	17 1/2	1/4
ARMHOLE (ARMOLE)	12	13	13 1/2	14 1/2	15	16	1/4
BICEPS (1" BEOW BICEPS)	20 1/2	22 1/2	21 1/2	21 1/2	22 1/2	23 1/2	1/4
SLEEVE LENGTH (FIRMHOLE)	26 1/2	29 1/2	23 1/2	23 1/2	24 1/2	25 1/2	1/8
SLEEVE PLACKET (FROM HPS)							0
CUFF WIDTH FULL	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	0
CUFF CLOSED (FOLLEX)	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	0
CUFF HEIGHT	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	0

Grade rule between sizes Misses 4 - 18									
Measurement Point	**4**	**5**	**8**	**10**	**12**	**14**	**16**	**16**	**18**
Bust	+/- 1	+/- 1	+/- 1	+/- 1	+/- 1	+/- 1	+/- 2	+/- 2	+/- 2
Waist	+/- 1	+/- 1	+/- 1	+/- 1.5	+/- 1.5	+/- 1.5	+/- 1.5	+/- 1.5	+/- 2
Hip	+/- 1	+/- 1	+/- 1	+/- 2	+/- 2	+/- 2	+/- 2	+/- 2	+/- 2
CB waist length	+/- 1	+/- 2	+/- 1	+/- 2	+/- 2	+/- 2	+/- 1/4	+/- 1/4	+/- 1/4
CB skirt length	3.0	3.0	3.0	30	3.1	3.2	3.2	3.3	3.4
Sleeve length from shoulder	+/- 1	+/- 1.5	+/- 1.5	+/- 1/4	+/- 1/4	+/- 1/4	+/- 1/4	+/- 1/4	+/- 1/4

CLOTHING PATTERNS 101.COM

CUT LINE	FORMULA	LOCATION	OVERALL GRADE 1 IN.	1 ½ IN.	2 IN.
BODICE FRONT/BACK					
line 1/line 6	¼ of A.G.	midpoint of neckline to waist	1/16 in.	3/32 in.	⅛ in.
line 2/line 7	¼ of A.G.	shoulder seam to waist	1/16 in.	3/32 in.	⅛ in.
line 3/line 8	½ of A.G.	lower armhole to waist	⅛ in.	3/16 in.	¼ in.
line 4/line 9	¼ of A.G.	CF/CB to armhole	1/16 in.	3/32 in.	⅛ in.
line 5/line 10	¼ of A.G.	CF/CB to side seam	1/16 in.	3/32 in.	⅛ in.
SKIRT FRONT/BACK					
line 11/line 16	¼ of A.G.	waist to hem before dart	1/16 in.	3/32 in.	⅛ in.
line 12/line 17	¼ of A.G.	waist to hem before dart	1/16 in.	3/32 in.	⅛ in.
line 13/line 18	½ of A.G.	waist to hem after dart	⅛ in.	3/16 in.	¼ in.
line 14/line 19	½ of A.G.	CF/CB to side seam at hipline	⅛ in.	3/16 in.	¼ in.
line 15/line 20	½ of A.G.	CF/CB to side seam at mid-thigh	⅛ in.	3/16 in.	¼ in.
SLEEVE					
line 21	¼ of A.G.	between seam and front notch to hem	1/16 in.	3/32 in.	⅛ in.
line 22	½ of A.G.	center line from top of cap to hem	⅛ in.	3/16 in.	¼ in.
line 23	¼ of A.G.	between seam and back notch to hem	1/16 in.	3/32 in.	⅛ in.
line 24	¼ of A.G.	midway between biceps and top	1/16 in.	3/32 in.	⅛ in.
line 25	¼ of A.G.	midway between biceps and elbow	1/16 in.	3/32 in.	⅛ in.
line 26	¼ of A.G.	midway between elbow and hem	1/16 in.	3/32 in.	⅛ in.
PANTS FRONT/BACK					
line 27/line 33	¼ of A.G.	same as line 11	1/16 in.	3/32 in.	⅛ in.
line 28/line 34	¼ of A.G.	same as line 12	1/16 in.	3/32 in.	⅛ in.
line 29/line 35	½ of A.G.	same as line 13	⅛ in.	3/16 in.	¼ in.
line 30/line 36	½ of A.G.	same as line 14	⅛ in.	3/16 in.	¼ in.
line 31/line 37	½ of A.G.	same as line 15	⅛ in.	3/16 in.	¼ in.
line 32	⅓ of A.G.	midpoint of front crotch extension	⅓ in.	½ in.	⅔ in.
line 38	½ of A.G.	midpoint of back crotch extension	⅛ in.	3/16 in.	¼ in.

Figure 3.3.23: Examples of pattern grading charts

Use this chart to determine grading increments (e.g., between sizes 10 and 12, bust increases by 4 cm / ~1.6").

Distribute increments evenly across key parts of the pattern (e.g., half at the front, half at the back).

Apply consistently to bust, waist, hip, and length areas for professional results.

Activity 3.3.1 Garment Grading Duo

You are a fashion designer tasked with creating a new garment with the same style for two friends for a special occasion. One wears size 12, and the other wears size 14. You have been given a basic bodice pattern in size 12. Using the provided size chart, the necessary materials and your knowledge of pattern grading principles:

1. Analyse the size chart to determine the measurement differences between sizes 12 and 14.
2. Grade the basic bodice pattern up to size 14 using the slash and spread method

3. Mark all the necessary pattern markings on your new pattern, including:
   a. Grainline
   b. Notches
   c. Darts
   d. Seam allowances
   e. Size label
4. On a separate sheet, explain TWO reasons why maintaining the original style proportions is important when grading patterns.

FEMALE GARMENT DESIGNS AND PATTERN BREAKDOWN

As a garment designer, it is important to understand how various garment designs look to simplify the process of pattern construction.

Before designing any garment, you must first understand its components—these are the individual parts that are sewn together to form the complete outfit. Gaining exposure to different styles and how their components interact helps you break down the design into workable patterns.

At this stage, the focus is on **female garments**, with special attention to **dresses**.

Components of Female garments

Female garment components are the individual parts that come together to form a complete outfit. These parts must be carefully understood because they play a key role in garment design, pattern drafting, and sewing.

Most female garments share many basic components, though the exact parts used—and how they are shaped or styled—depend on the specific design of the garment.

Below are the essential components commonly found in female garments and used in pattern making:

Bodice

The bodice is the top part of a garment that covers the body from the shoulders to the waist. It includes important areas like the shoulders, bust, back, and waist. The bodice forms the main structure of most female garments and serves as the base to which other parts are attached.

It is made using key body measurements such as shoulder width, bust, waist, neck, and torso length. The front and back parts are joined together to complete the upper section of the garment.

Depending on the style of the dress, the bodice may have design features like princess lines, yokes, or panels. These style lines make the garment more attractive and stylish, but they do not affect the fit. They can replace darts or add colour contrast to enhance the overall look of the garment.

1. **Front Bodice:** The front piece of the bodice. It often features shaping elements like darts or princess seams to fit the bust.
2. **Back Bodice:** The back piece of the bodice. It can be a single piece or multiple pieces and may include darts or other shaping for the back and shoulders.

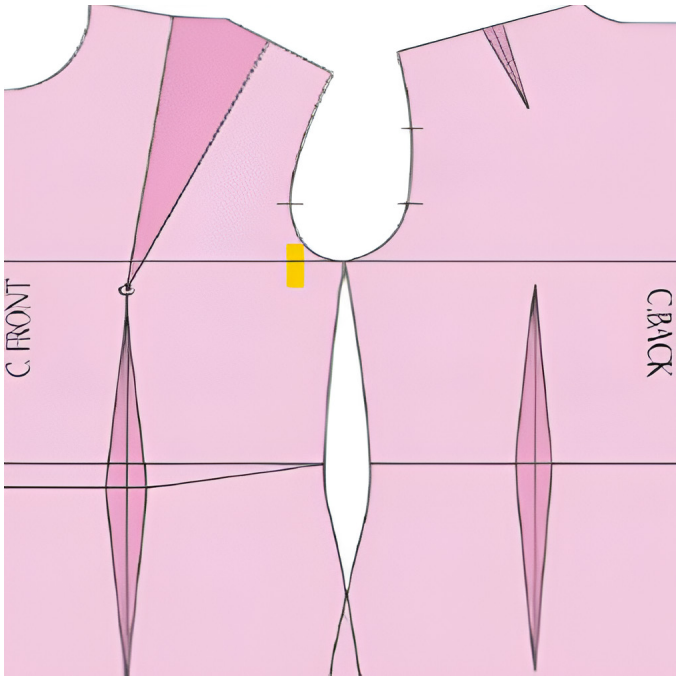


Figure 3.3.25: Front and back bodice

Sleeves

Sleeves are the parts of a garment that cover the arms. They are attached to the armholes of the bodice and can extend to the wrist, elbow, or upper arm, depending on the style.

Sleeves are an important part of the upper garment. They serve both practical and decorative purposes—providing coverage and adding to the garment's overall style.

There are many types of sleeves. Some are close-fitting, while others are designed to be loose or full. The length and style of the sleeve can be adjusted based on the wearer's preference.

Parts of sleeves

A sleeve has five parts, which are discussed below.

1. **Cap Line:** The curved top part of the sleeve above the biceps line.
2. **Cap Height:** The distance from the sleeve cap at the centre to the bicep level. It is the upper portion of the sleeve that is attached at the shoulder.

3. **Side Seam:** The side seam is the area of the stitch where the sleeve is joined to form a tubular structure.
4. **Hemline:** It is the finished bottom edge of the sleeve. It may also consist of the cuff and other treatments.
5. **Upper Sleeve Round:** This is around the fullest part of the sleeve.
6. **Elbow Round:** The fullest part of the elbow is known as the elbow round.
7. **Wrist Round:** This is part of the arm where the palm starts.

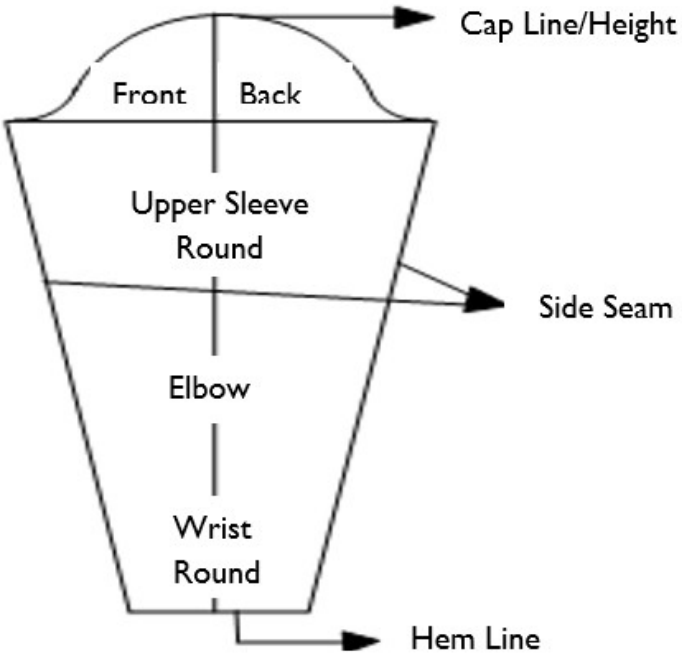


Figure 3.3.26: Parts of a sleeve

Types of sleeves

Sleeves can be classified in two ways according to length and according to stitching.

1. **According to the length:** sleeves can be divided as

a. *Long sleeve:* This is a full-length sleeve from shoulder to wrist.

b. *Bracelet*: This type of sleeve ends just above the wrist.

c. *Third-quarter sleeve:* This sleeve ends just below the elbow.

d. *Elbow sleeve:* The length of the sleeve to the elbow.

e. *Short sleeve:* This is also known as a half sleeve. It ends between the elbow and the shoulder.

f. *Cap sleeve*: This sleeve has a short length and hugs at the shoulder cap.

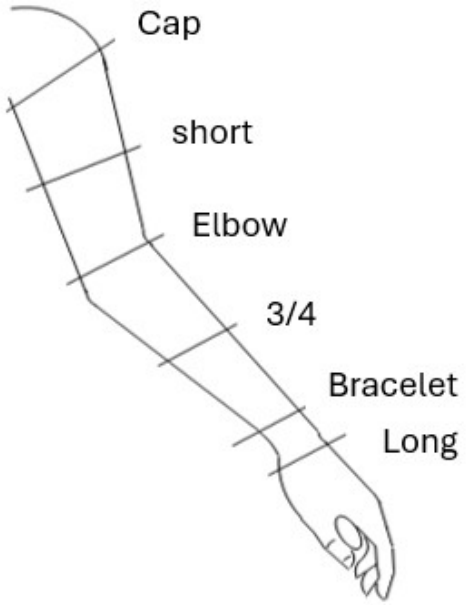


Figure 3.3.27: Type of sleeve length

2. **According to stitching:** Sleeves can be divided according to the method of stitching as:

   a. **Set-in sleeves:** These sleeves are the sleeves in which the side seams are attached to form a circular structure. It is attached to the front and back of the bodice and set into the armhole, creating a smooth and tailored appearance as in ***Figure 3.3.28a***. The primary example of this sleeve is the **sari blouse** sleeve.

   b. **Open construction sleeves:** These sleeves are the sleeves in which the sleeve is first attached to the armscye of the bodice front and back. Then the sleeves and bodices' side seams are stitched as a straight line. Shirt sleeves are the best example of open sleeves ***Figure 3.3.28b***.



Figure 3.3.28a: Set-in Sleeve



Figure 3.3.28b: Open sleeve

3. **Other sleeves**

Various sleeve styles can be loose and flowy, structured or puffy, long or short, and can be made from any fabric. These are discussed below:

   a. **Bell Sleeves:** A sleeve that flares out from the elbow or wrist, creating a bell-like shape, is a bell sleeve. It is also known as peasant sleeves.

b. **Raglan Sleeve:** The sleeve extends to the neckline with a diagonal seam from the underarm to the collarbone.

c. **Kimono Sleeve:** Cut as part of the bodice, wide and often tapered at the wrist.

d. **Bishop Sleeves:** These sleeves give volume at the shoulder with flares and are gathered at the wrist, often with a cuff.

e. **Leg-of-Mutton Sleeves:** These sleeves are structured like the leg of mutton. It is gathered and puffed at the shoulder or upper arm and then fitted on the forearm.

f. **Puffed Sleeves:** These sleeves are puffed at the shoulder and gathered at the hemline, which gives a puffed effect

g. **Cape Sleeves:** Cape sleeves are fully flowing, like capes. The fabric is gathered at the shoulder and flares out like a cape from there.

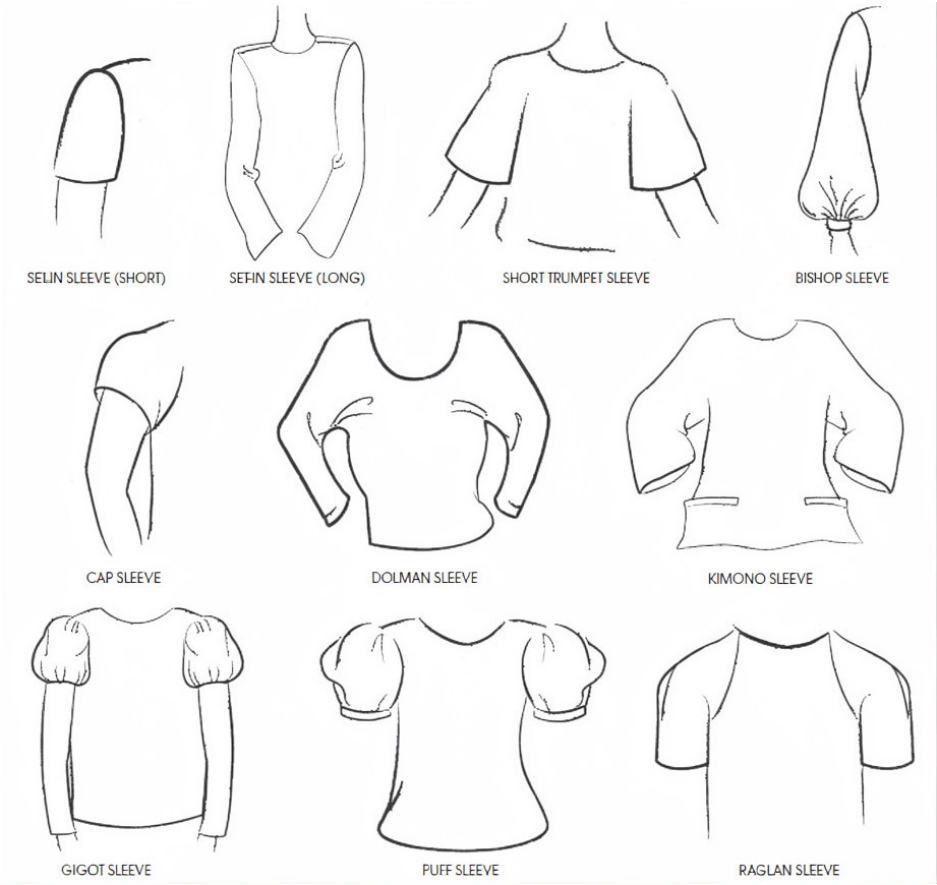


Figure 3.3.29: Other types of sleeves

Cuffs

Cuffs are bands of fabric attached to the ends of sleeves, usually at the wrist. They are made by folding or adding extra fabric and can be rolled up or left down.

Cuffs help close the sleeve around the wrist and are often fastened with buttons or cuff links, especially in formal shirts. Besides their function, cuffs also add style and detail to a garment.

Cuffs are of various types. Let us discuss a few.

1. **Cocktail Cuffs:** It is also known as a turn-back cuff. It is folded until the hems form diagonal lines.
2. **French or Double Cuffs:** This is a trendy type of cuff. It is twice as long as the single cuff. These required cufflinks to close them.
3. **Barrel or Button Cuffs:** It is one of the most popular cuff styles, frequently worn with business and casual attire. They usually involve two horizontally positioned buttons with an approximate 3/4-inch gap between them. That is either fastened with a single button or a pair of buttons.

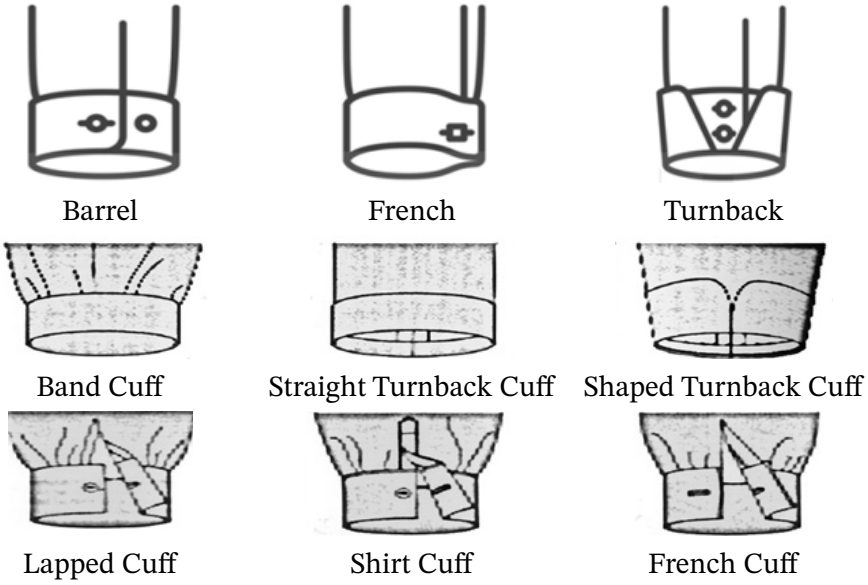


Figure 3.3.30: Types of cuffs

Neckline

The neckline is the shape or style of the opening at the top of a garment that goes around the neck. It is where the head passes through when wearing the garment.

There are two parts to a neckline: the front and the back. Necklines play a big role in the overall appearance and style of the garment.

The depth and width of the neckline can be chosen based on the wearer's preference. To make the neckline neat and strong, it usually needs to be finished with facing, binding, or trimming.

Here are some common types of necklines discussed:

a. **Round Neckline**: This neckline is circular and curved toward the centre front. It is always deeper at the front than at the back. It can be finished by facing and by piping.

b. **Square Neckline:** This neckline is square. It has four sharp corners, two in front and two in back. It can be finished by facing, which makes it contrast.

c. **V-Shape Neckline:** This neck forms the V-Shape in the centre front and is round at the back. It can be finished with piping and facing finishes.

d. **U-Shape Neckline:** This neck forms the U-Shape in centre front and is round at the back with some height. It can be finished with piping and facing finishes.

e. **Heart Shape Neck:** The front line from the heart shape and is deeper at the front.

Other Necklines:

a. **Boat Shape Neckline:** It is a wide, shallow neckline that runs horizontally acrossthe collarbone. There may be a little difference in the front and back neckline.

b. **Keyhole Neckline:** This front neckline is shaped like a keyhole at the front and is high at the back.

c. **Cowl Neck:** This neckline is folded around the front. It can be made with one or two folds. Bias fabric is used for making a cowl.

d. **Halter Neck:** This style has straps instead of the shoulder that wrap around the back of the neck, leaving the shoulder and back bare.

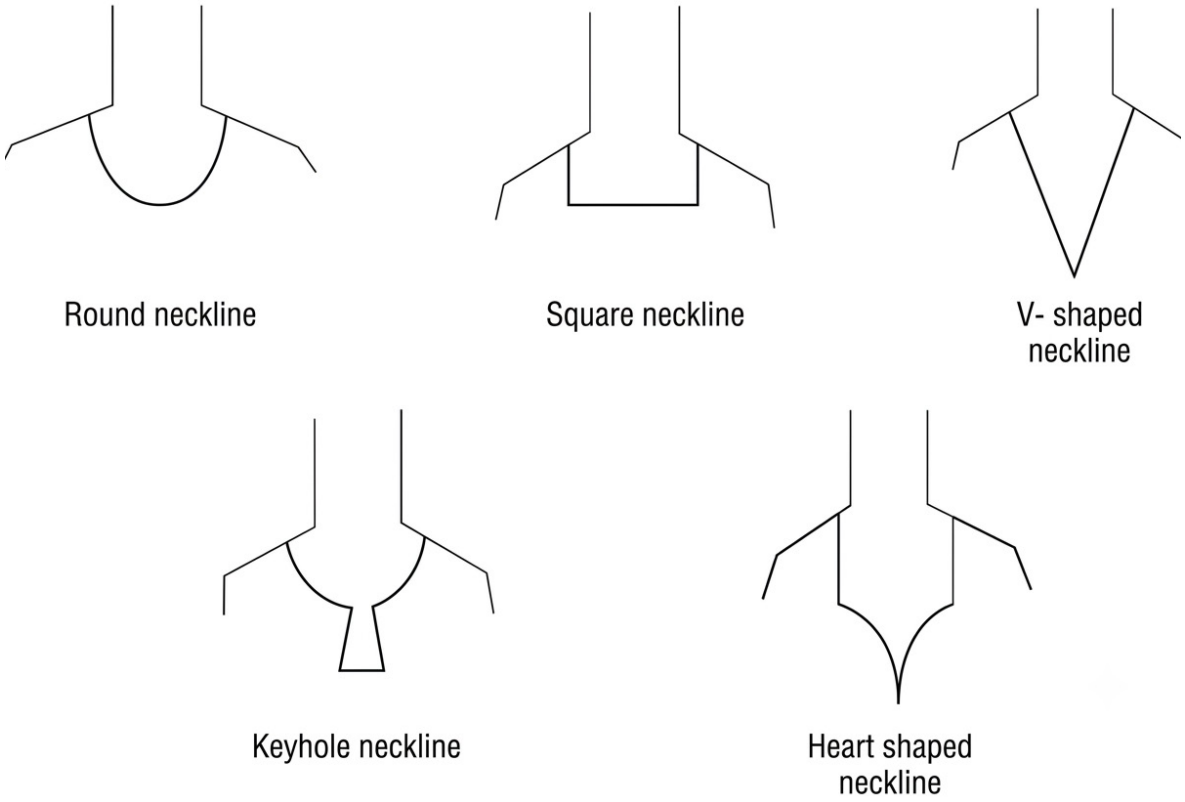


Figure 3.3.31: Types of necklines.

5. Collar

A collar is a band of fabric added around the neckline of garments like shirts, jackets, or coats. Collars help frame the face and enhance the overall style of the garment.

They are important design features and come in many shapes and styles—such as high or low collars, flat bands, pointed or rounded edges—depending on fashion trends and personal preference. A collar usually has three main parts.

a. **Stand**: The part that rises from the neckline up to where the collar starts to turn.

b. **Roll Line**: The line where the collar begins to fold.

c. **Fall**: The part that folds over from the roll line.

Collars can stand upright or fold down, depending on the style (***Figure 2.8***).

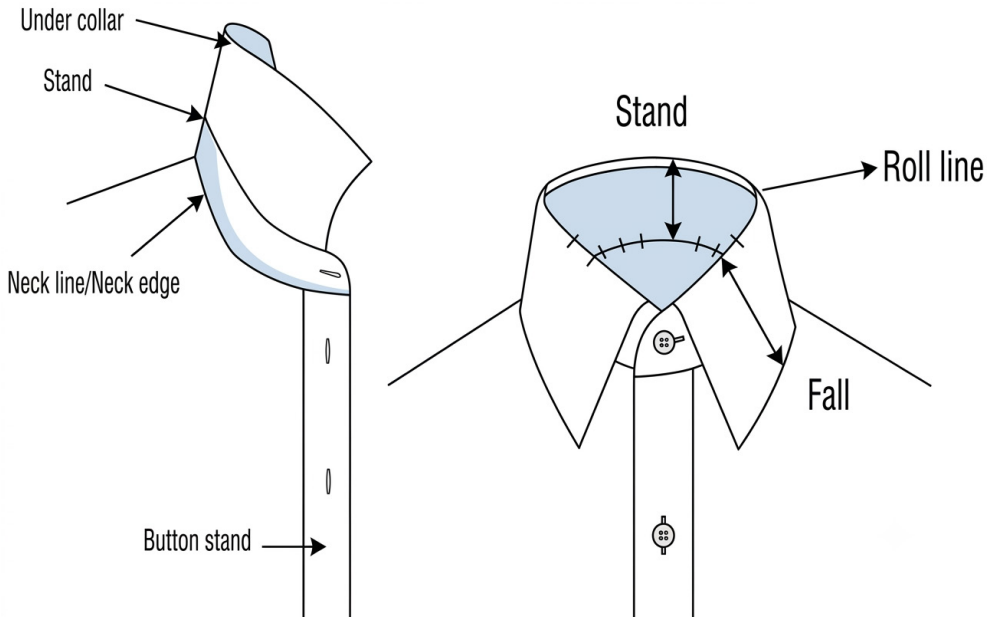


Figure 3.3.32: Parts of the collar

Collar also has other parts like point, spread, neck edge, button stand and under collar (***Fig. 2.6***). Point is the pointed corner of the collar and spread is the space between two points. The stand's lower edge attached to the neckline is known as the neck edge. The back side of the fall is known as the under collar, and the centre front edge of the shirt attached to the collar is the button stand.

Types of Collars

Collars come in a variety of styles. The component lists three fundamental collar types such as:

a. **Stand Collar:** The collar has only a stand without any fall, known as a stand. Mandarin collars are the primary example of the stand collar. It usually rises two to five centimetres vertically from the neckline.

b. Flat Collar: Flat collar slie flat to the neckline against the bodices of the garment. It has no height off of the neckline. One such example of a flat collar is the Peter Pan collar, which has the rounded corners

c. Roll Collar: A collar that has a rolled edge, often found on knitwear. There are two types of collars i.e., full roll and partial roll collars. Full Roll collar has an identical height of stand and fall. Partial roll collars have low stand and more falls.

Other Types of Collars:

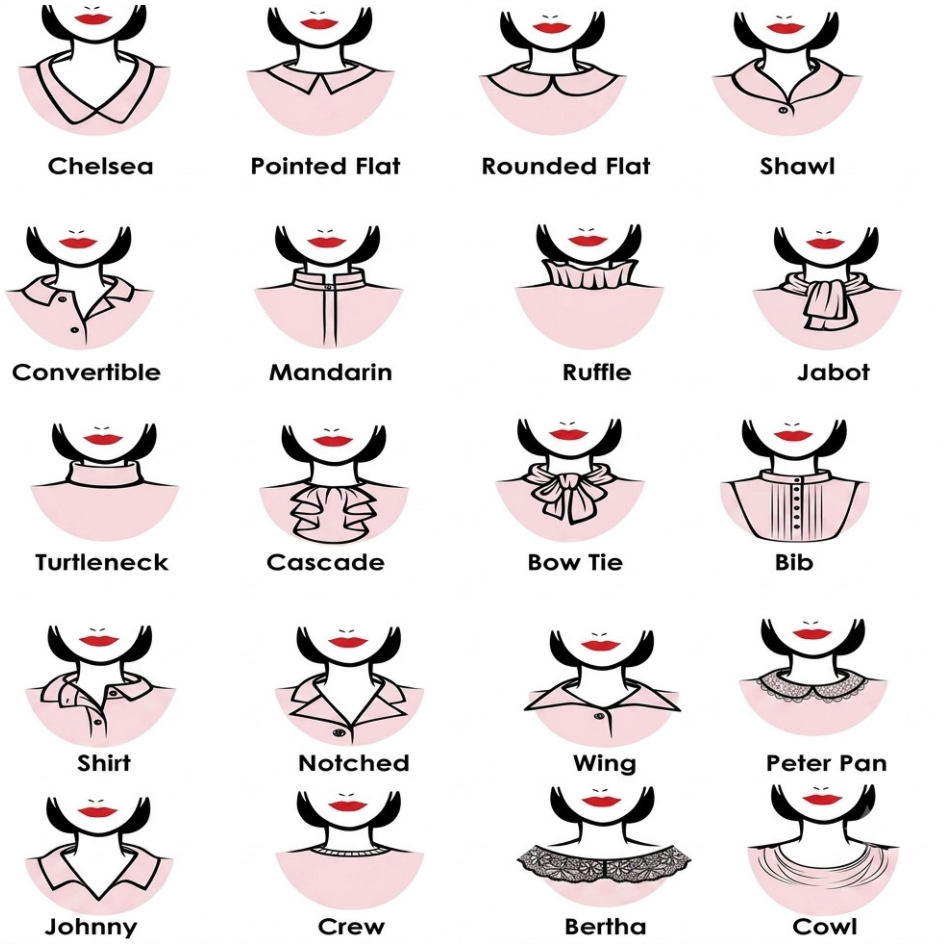
a. Convertible Collar: These collars are the same as full roll collars similar to a whole roll, but hold the neckline closer to the side of the neck or shoulder.

b. Shawl Collar: It is known by its centre back seam. It is wide and rounded and attached to the part of the bodice. Usually found on jackets or coats.

c. Shirt Collar: It has a separate neckband that serves as the stand.

d. Notched collar: a collar that has a v-shaped notch where it meets the lappet of the jacket and coat.

e. Different Styles of Collar: There are numerous collar styles for the dress, like Chelsea, Sailor, Bertha, Puritan, Stove-pipe, Tie (also known as bow and scarf collar) etc.



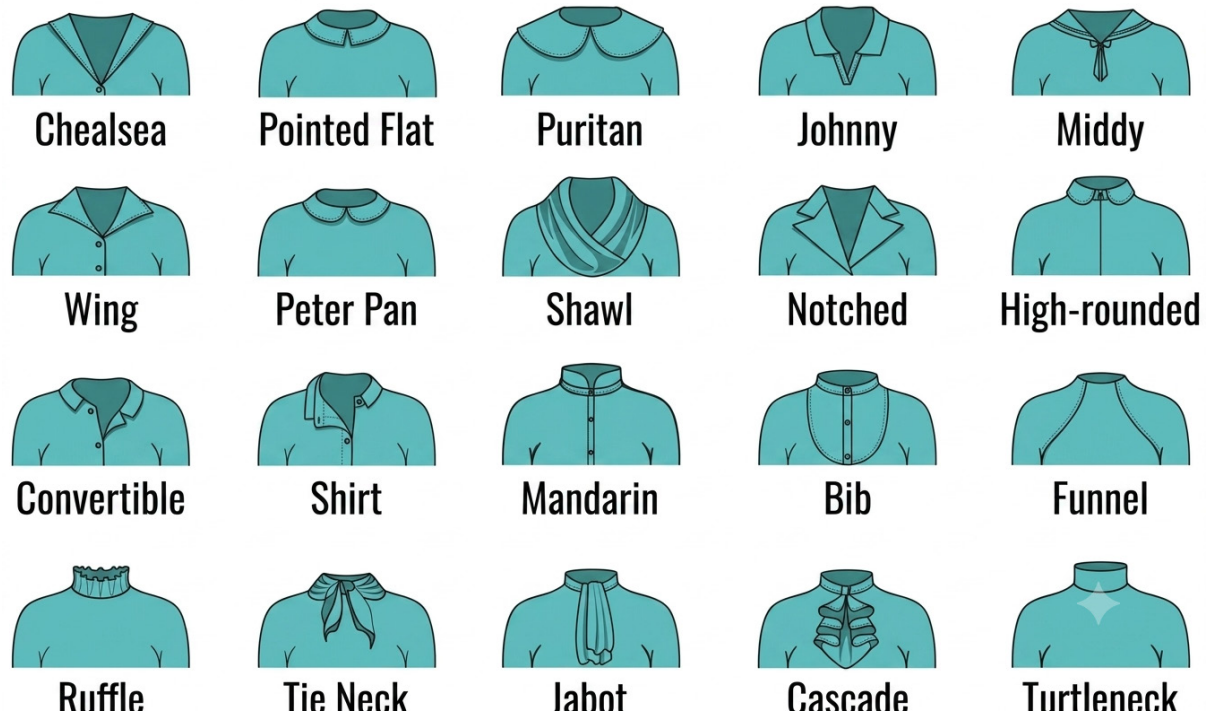


Figure 3.3.33: Types of collars

Pockets

A pocket is a small pouch or compartment sewn into or onto a garment. It is used to carry small personal items like keys, coins, a phone, or a handkerchief.

Pockets are found on many clothing items such as trousers, jackets, shirts, and skirts. They serve both **functional** and **decorative** purposes. Functionally, they help store small items, reducing the need to carry a bag. Decoratively, they can add style and detail to the garment.

Pockets can be made from the same fabric as the garment or from different materials like mesh, leather, or contrasting fabrics. Their **placement**, **size**, and **design** can change

a. **Patch Pocket:** Patch pockets are widespread and mainly seen on shirts (***Figure 3.3.34 A***). These pockets are sewn onto the outside of the garment, typically at the chest or hip. Different styles can also be created in the basic structure, which makes it more appealing and decorative. It is the additional piece of fabric that is patched on the garment from the three sides; the top side is the pocket opening. The raw bottom edges of the pocket can be turned according to shape and the desired width on the wrong side. This is attached to the fabric by the top seam. Variations of the patch pocket are discussed below.

   i. **Patch with Pleat**: A patch pocket with a box pleat creates more space in the pocket. This is used in shirts.

   ii. **Kangaroo:** These are located at the front of the garment, typically on a hoodie or sweatshirt. They are large and have a single opening, allowing

the wearer to put their hands inside. A wide patch pocket is divided into two parts by a stitch line. Patch pockets with top pockets are other patch pocket variations.

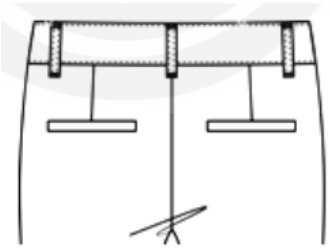
iii. **Flap Pockets:** Flap pockets are produced when the patch pocket is closed with the flap, with or without a button. The flap provides the pocket opening, mainly used on jackets, shirts and pants. They may be available in different styles, such as double-flap pockets.

iv. **Inseam Pockets:** These pockets are also known as secret or invisible pockets. It has a functional purpose in the garment and fulfils aesthetic purposes by using decorative seams to make it more decorative. These pockets have variations, as in ***Figure 3.3.34D***.

b. Side Seam Pocket: Most inseam pockets are side seam pockets. These pockets have openings along the side seam line of the garments. These types of pockets are usually made on pants, skirts, kurties, etc. (***Figure 3.3.34B***)

c. Welt Pocket: A "Welt" refers to the narrow fabric edges (one or two), which are attached separately to the pocket opening. A two-edge welt pocket is the Double welt pocket usually made on jackets. Various welt pockets also have a flap. Welt pockets are mainly used in jackets and formal coats. (***Figure 3.3.34A***).

d. Slashed or Slanted Pockets: These pockets are at a slant position and made for functional purposes. The shape of this pocket allows the wearer to slide their hands in and out quickly.



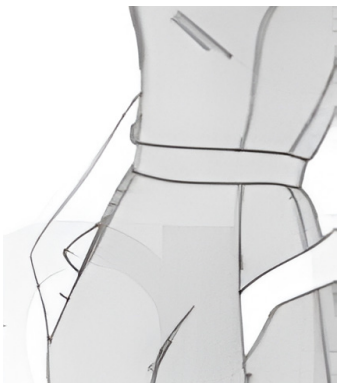
A: Welt Pocket



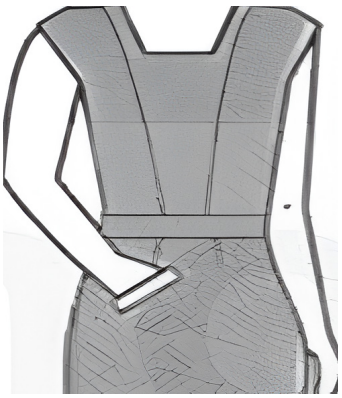
B: Side Seam Pocket



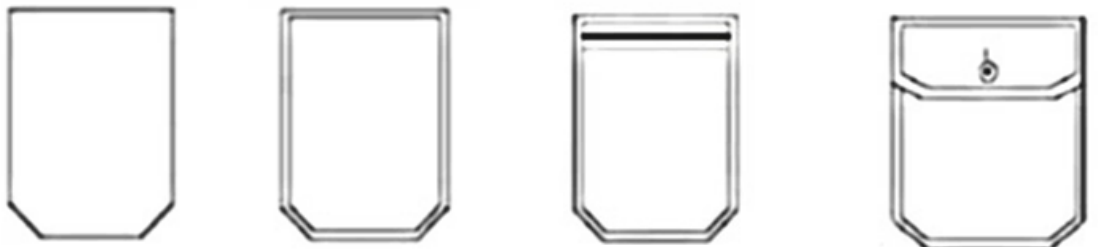
C: Patch Pocket



D: Inseam Pocket



E: Slashed/Slanted Pocket



Patch Pocket | Topstitched Patch | Pipe Patch Pocket | Patch Pocket with Flap

Figure 3.3.34: Types of pockets

Pattern Breakdown in Garment Making

Pattern breakdown is the process of analysing a completed garment or design sketch to identify and understand each component's structure and construction. It involves examining the shape, size, and fit of every individual pattern piece required to produce the garment. This process serves as a crucial bridge between design and production, offering a clear guide for garment reconstruction. Essentially, pattern breakdown translates the designer's vision into workable components for sewing and assembly.

The key steps involved in this process include the following:

Identifying Individual Pieces

Identifying each unique component of the garment, including the collar, sleeves, cuffs, skirt panels, front and back bodices, facings, linings, pockets, and so on.

Analysing Seam Lines

Examining the stitching lines and seam allowances to ascertain where each piece is attached to the others.

Comprehending Construction Specifics

Determining how the garment is put together, including the sequence of steps, the kind of seams used, and any unique methods like pleats, gathers, darts, or fasteners (buttons, zippers, etc.).

Identifying Style Lines

Identifying the design lines, such as princess seams, yokes, or style elements on collars and cuffs, that give the garment its distinct shape and style.

Determining Measurements

This entails getting exact measurements of every pattern component if you're working from an existing garment. Interpreting the desired measurements and proportions is necessary when working from a sketch.

Identification of Notches and Markings

Identifying and comprehending the function of grain-lines, which indicate the direction of the fabric, notches, which serve as alignment guides, and other markings on the pattern pieces.

Importance of Pattern Breakdown

1. *Reverse Engineering*: It's crucial for recreating existing garments or adapting their designs.
2. *Design Analysis*: It helps designers understand how different shapes and construction methods achieve specific looks and fits.
3. *Pattern Making*: It's a foundational step in creating new patterns from existing garments or sketches. By breaking down a design, a pattern maker can then draft the individual pieces accurately.
4. *Manufacturing*: In production, understanding the pattern breakdown ensures that the garment can be efficiently cut and assembled.
5. *Alterations:* Tailors use pattern breakdown to understand how a garment is constructed, which is essential for making effective alterations.
6. *Teaching and Learning:* It's a fundamental skill for fashion design and garment construction students to learn how garments are put together.

Common Female Dress Designs & Pattern Breakdowns

A-Line Dress



Figure 3.3.35: A-Line Dress

Design Features

Fitted bodice, flares out gently from waist. Simple and versatile

Pattern Pieces: (adapt and draft manually or with CAD)

a. Bodice Front (with darts or princess seam)

b. Bodice Back (with darts or zipper allowance)

c. Dress Front (A-line flare)

d. Dress Back (with flare and possibly a back zipper)

e. Sleeve (front and back)

f. Neckline facing or lining

Sheath Dress

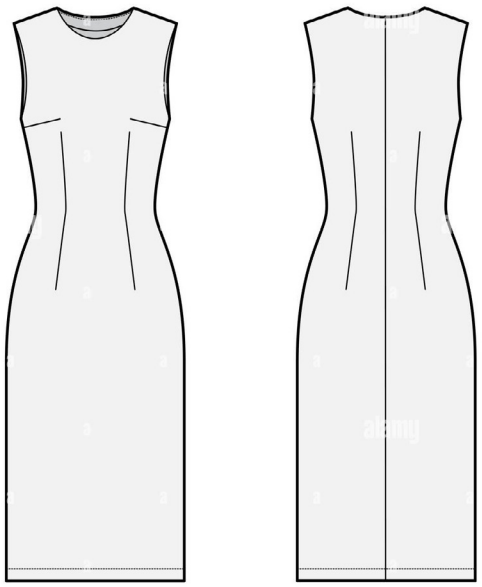


Figure 3.3.36: Sheath dress

Design Features

1. Slim-fit through the body
2. Often knee-length
3. Classic for formal or office wear

Pattern Pieces: (adapt and draft manually or with CAD)

a. Bodice Front (shaped with darts or princess seams)

b. Bodice Back (often with back zip and darts)

c. Dress Front (fitted or slightly tapered)

d. Dress Back (can include walking slit)

e. Lining or facing

f. Sleeveless finish

Wrap Dress

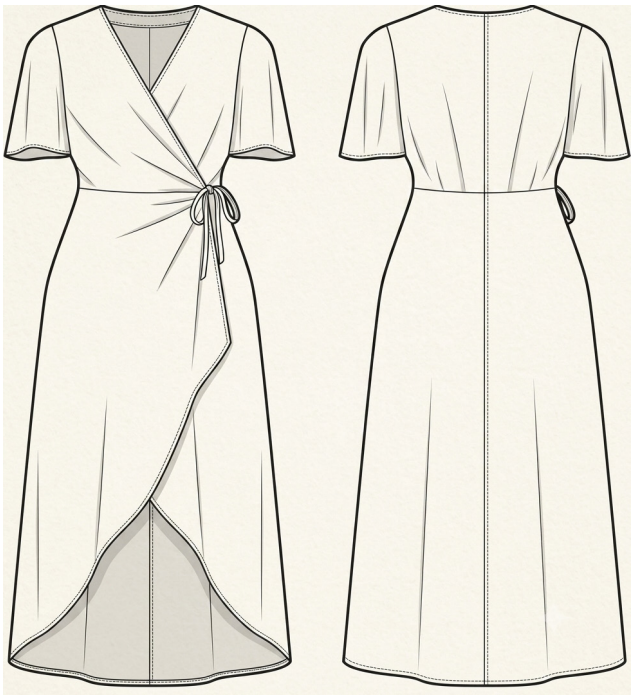


Figure 3.3.37: Wrap dress

Design Features

1. Bodice wraps across the front and ties at the side or back
2. V-neckline
3. Flattering for many body types

Pattern Pieces: (adapt and draft manually or with CAD)

a. Bodice Left Front (with wrap extension)

b. Bodice Right Front (with wrap extension)

c. Bodice Back

d. Dress Front (left/right or one piece)

e. Dress Back

f. Waist tie/belt

g. Sleeve (flutter, cap, or long)

h. Facing for neckline

Empire Waist Dress



Figure 3.3.38: Empire dress

Design Features

1. Waistline just below the bust
2. Flowing dress
3. Great for maternity or romantic looks

Pattern Pieces: (adapt and draft manually or with CAD)

a. Bodice Front (shorter, cut under bust)
b. Bodice Back
c. Skirt Front (starts under bust, flared or gathered)
d. Skirt Back
e. Sleeves (optional)
f. Facings or linings

Peplum Dress



Figure 3.3.39: Peplum dress

Design Features

1. Fitted bodice with a short overskirt (peplum) at the waist
2. Often bodycon

Pattern Pieces: (adapt and draft manually or with CAD)

- **a.** Bodice Front
- **b.** Bodice Back
- **c.** Peplum (circular or flared strip attached at waist)
- **d.** Dress Front (pencil shape)
- **e.** Dress Back
- **f.** Sleeves (cap or short sleeves common)
- **g.** Facings

Maxi Dress



Figure 3.3.40: Maxi dress

Design Features

1. Floor-length
2. Flowy or fitted, depending on style
3. Often features gathered or pleated skirts

Pattern Pieces: (adapt and draft manually or with CAD)

a. Bodice Front

b. Bodice Back

c. Dress Front (gathered)

d. Dress Back

e. Waistband (optional)

f. Sleeves (many variations)

g. Neckline facing or lining

Activity 3.3.2 Female Garment Designs and Pattern Breakdown

Follow the guidelines below to crate female garment design

Materials/Tools

- Sketches/pictures or videos of female garments (blouse, skirt, dress, shirt, etc.)
- A4 drawing sheets
- Pencils, erasers, markers
- Rulers, tape measures
- Scissors
- Pins and adhesive
- Reference textbooks or magazines on fashion and garment design,

1. Choose one female garment from your gathered materials. Take notes on the following:

a. Garment type (e.g., dress, blouse, skirt).

b. Visible design features (neckline, sleeves, hemline, waistline, darts, etc.).

c. Construction details (seams, fastenings, finishing)

2. Recreate the garment.

3. Sketch the garment's front and back views.

4. Identify and label the different pattern pieces needed (e.g., bodice front, bodice back, sleeve, skirt panel).

5. List the measurements required for each piece.

6. Prepare a report on how you carried out the pattern breakdown in the pattern drafting.

After completing the task, compare your findings with other groups and discuss the reasons for any differences.

EXTENDED READING

- https://images.app.goo.gl/jtit3S1XEMzs9svH8
- https://www.pinterest.com/pin/959126051869995747/
- Pattern Lab London. (2023). *What is pattern grading in fashion?* Retrieved from https://patternlab.london/home/what-is-pattern-grading-basic-pattern-making/ patternlab.london
- https://www.theshapesoffabric.com/2022/11/15/how-to-sew-different-types-of-sleeves/

Additional Resources

- **Fashion Pattern-making Techniques series:** A series of books detailing pattern-making techniques for fashion design, including volumes of women's and men's wear
- **Metric Pattern Cutting series:** A range of books covering pattern cutting for women's wear, menswear, and children's wear.
- **Pattern Magic series:** A collection of books featuring creative pattern-making techniques for fashion design.

REVIEW QUESTIONS

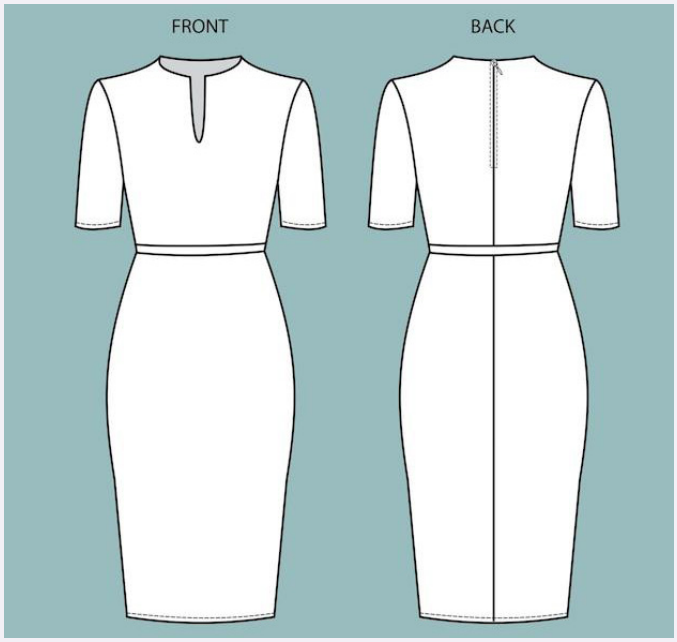


Figure3.3.41: Sample party dress

1. Figure **2.17** above is a party dress photograph; analyse and identify all separate pattern components that would be required to make this garment. Describe three detailed processes you will use to make your own garment.
2. Create a component map that shows:
   - All individual pattern pieces needed
   - How these components relate to each other
   - Order of assembly
   - Critical construction points
3. Prepare the front view and Back view of a complex component (e.g., draped bodice, pleated overlay, structured collar)
   a. Sketch the pattern shape
   b. Explain the drafting approach you would use to create each piece
   c. Justify why your approach would achieve the design effect shown
4. Evaluate which components would require specialised drafting techniques beyond basic pattern manipulation, and explain your reasoning.
5. What is pattern grading, and how do you determine the grade amount for a specific measurement?
6. What are the key components of a garment pattern that need to be considered when breaking it down into smaller parts?

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GLOSSARY

Arch	A curved structure that spreads weight to its supports and is used for strength and decoration.
Artefact	A man-made object or design created for a practical or decorative purpose.
Axis	An imaginary straight line around which a solid object is symmetrical or rotates.
Base	The bottom face or surface of a solid shape on which it stands.
Base Pattern	The original pattern piece used as a starting point for grading.
Base Size	The size used as a reference point for grading other sizes.
Beam	A horizontal member that carries loads and transfers them to supports such as columns or walls.
Bending	A combination of compression and tension forces acting on an object.
Block Pattern	A basic pattern piece used as a starting point for creating garment patterns.
Compression	A pushing force that acts to squeeze or shorten an object.
Curve of Intersection	The line or curve formed where two solid shapes meet or cut through each other.
Cylinder	A three-dimensional shape with two identical circular ends joined by a curved surface.
Direction	The direction in which a force acts or moves, such as up, down, left, or right.
Drape	The way fabric hangs or falls on the body.
Ease	The amount of room added to a garment pattern for comfort and movement.

Elevation (Front/Side/End)	A two-dimensional drawing view showing how an object looks from the front, side, or end.
Fit	The way a garment sits on the body.
Force	A push or pull that can move, support, or change the shape of a structure.
Garment Silhouette	The overall shape and outline of a garment.
Grading	The process of adjusting a pattern piece to create different sizes.
Grading Increment	The amount added to or subtracted from a base pattern piece to create a new size.
Grading Line	A line on a pattern piece where grading occurs.
Grading Point	A specific point on a pattern piece where grading is applied.
Hexagonal Prism	A prism with two identical hexagonal bases connected by rectangular faces.
Magnitude	The size or strength of a force; it shows how strong a push or pull is.
Mannequin	A three-dimensional model of the human body used as a template for garment design and fitting.
Muslin	A lightweight plain-weave fabric used for creating prototypes or test garments.
Orthographic Projection	A method of drawing three-dimensional objects using several two-dimensional views at right angles.
Pattern Making	The process of creating garment patterns using various techniques and methods.
Pattern Piece	A single part of a garment pattern, such as a sleeve or bodice.
Prism	A solid shape with two identical, parallel faces connected by rectangular sides.
Projection Lines	Thin construction lines used to transfer points from one view to another in technical drawing.
Proportional Grading	A grading method that proportionally increases or decreases a pattern piece based on size charts.

Prototype	A trial or test version of a garment used to evaluate design, fit, and construction.
Shear	A sliding force that causes parts of an object to slide past each other.
Size Chart	A chart showing the measurements for each garment size.
Sizing	The process of determining the measurements and fit of a garment.
Slash and Spread	A grading method that involves slashing a pattern piece and spreading or overlapping it to create a new size.
Tension	A force that pulls objects apart.
Torsion	A force that twists an object.
Truss	A strong framework made of triangles that supports heavy loads through tension and compression.

This book is intended to be used for the Year Three Building Construction and Woodwork 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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