- Plane Figures And Solid Shapes
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Plane Figures And Solid Shapes

In geometry, figures are classified based on their dimensions. Two-dimensional (2-D) figures have length and breadth, while three-dimensional (3-D) shapes have length, breadth, and height (or depth). 3-D shapes occupy space and are called solid shapes.

Common 3-D Shapes and Their Properties

- **Cylinder:** Has two parallel circular bases connected by a curved surface.
- **Sphere:** Perfectly round object with all points on the surface equidistant from the center.
- **Cuboid:** Box-like figure with six rectangular faces meeting at right angles.
- **Cube:** Special cuboid with all six faces as equal squares.
- **Cone:** Has a circular base tapering smoothly to a point called the apex.
- **Pyramid:** Solid with a polygonal base and triangular faces meeting at a single apex.

Volume Formulas

- Volume of Cylinder: $\pi r^2 h$
- Volume of Sphere: $\frac{4}{3}\pi r^3$
- Volume of Cuboid: length $\times$ width $\times$ height

- Volume of Cube: a^3
- Volume of Cone: $\frac{1}{3}\pi r^2 h$
- Volume of Pyramid: $\frac{1}{3} \times \text{Base Area} \times \text{Height}$

Common 2-D Figures

- **Rectangle:** Four sides with opposite sides equal and all angles 90°.
- **Circle:** Set of points equidistant from a center point.
- **Triangle:** Three sides with interior angles summing to 180°.
- **Square:** Four equal sides with all angles 90°.
- **Quadrilateral:** Any four-sided polygon.

Note: 2-D figures are flat shapes drawn on paper, while 3-D shapes have depth and occupy space.

Faces, Edges And Vertices

Solid shapes are composed of faces, edges, and vertices:

- **Face:** A flat surface of a solid.
- **Edge:** A line segment where two faces meet.
- **Vertex (Vertices):** A point where edges meet.

Example: A cube has 6 faces, 12 edges, and 8 vertices.

Euler's Formula for Polyhedrons

For polyhedrons (3-D shapes with flat faces), the relationship between vertices (V), edges (E), and faces (F) is given by:

$$V - E + F = 2$$

Verification for cube:

$$8 - 12 + 6 = 2$$

Verification for tetrahedron:

$$4 - 6 + 4 = 2$$

Nets For Building 3-D Shapes

A *net* is a two-dimensional pattern that can be folded to form a three-dimensional shape.

Example: Net of a Rectangular Box (Cuboid)

- Consists of six rectangles arranged so that folding along edges forms the box.
- Dimensions correspond to length, breadth, and height of the cuboid.

Net of a Cone

- Cutting along the slant surface and flattening yields a sector of a circle (often a semicircle).
- The radius of the sector is the slant height l, and the arc length equals the circumference of the base $2\pi r$.

Nets of Common Solids

- **Cube:** Six equal squares arranged in a T-shape.
- **Cylinder:** Two circles and one rectangle (curved surface).
- **Cone:** One circle (base) and one sector of a circle (curved surface).

- **Square Pyramid:** One square base and four triangular faces.

Drawing Solids On A Flat Surface

Drawing 3-D solids on 2-D surfaces involves techniques to create the illusion of depth.

Oblique Sketches

- Draw the front face in true shape.
- Draw the opposite face offset and connect corresponding vertices.
- Use solid lines for visible edges and dashed lines for hidden edges.
- Edges may not be to scale but help visualize the 3-D shape.

Isometric Sketches

- Use isometric dot paper with dots arranged in equilateral triangles.
- Draw edges along three axes at 120° angles.
- Measurements are to scale, preserving proportions.
- Steps include drawing the front face, drawing parallel lines for depth, and connecting corners.

Example: Drawing a Cuboid 4 × 3 × 3

- Draw front rectangle 4 × 3.
- Draw parallel lines of length 3 from each corner.
- Connect endpoints to complete the cuboid.

Visualising Solid Objects

Understanding 3-D objects can be enhanced by counting unit cubes and visualizing arrangements.

Counting Cubes in Composite Shapes

- Count cubes layer-wise and sum to find total volume.
- Different arrangements can have the same volume.

Example: Joining Two Cubes Side by Side

- Two cubes each 2 cm edge placed side by side form a cuboid of dimensions 4 cm × 2 cm × 2 cm.
- Volume: $4 \times 2 \times 2 = 16 \text{ cm}^3$

Viewing Different Sections Of A Solid

Cross-Sections by Slicing

Slicing a solid with a plane produces a cross-section, which is a 2-D shape.

- Example: Vertical slices of a loaf of bread (cuboid) produce square cross-sections.
- Cross-section shape depends on the angle and position of the cut.

Shadow Play

Shadows of 3-D objects on a surface are 2-D projections.

- Example: A cone casts a circular shadow.
- Changing the light source position changes shadow size and shape.

Viewing From Different Angles

Objects look different when viewed from front, side, or top.

- Front view shows height and width.
- Side view shows height and depth.
- Top view shows width and depth.

Orthographic Projections

Representing 3-D objects by their 2-D views (front, side, top) helps in understanding and designing objects.

Practice Set

- **Level 1 – Easy**
- Identify and name the following shapes: cube, cuboid, cone, cylinder, sphere, pyramid.
- Match 2-D figures with their names: square, rectangle, circle, triangle, quadrilateral.
- Count the number of cubes in simple stacked arrangements.
- **Level 2 – Moderate**
- Draw nets for a cube, cuboid, and cone.
- Calculate volume of a cuboid formed by joining two cubes of side 3 cm.
- Draw oblique and isometric sketches of a cuboid with given dimensions.
- Identify cross-sections formed by slicing a cylinder vertically and horizontally.
- **Level 3 – Challenging**
- Verify Euler's formula for a cube and a tetrahedron.
- Given nets, determine which form a tetrahedron.
- Draw orthographic projections (front, side, top) of complex solids made by joining cubes.
- Analyze shadow shapes formed by solids under different light positions.

Answer Key

- **Level 1**
- Shapes identified as per definitions.
- 2-D figures matched correctly.

- Cube counts as per arrangement.
- **Level 2**
- Nets drawn with correct faces.
- Volume of joined cubes: $2 \times 3^3 = 54\ \text{cm}^3$.
- Oblique and isometric sketches show correct dimensions and perspectives.
- Cross-sections identified as circles or rectangles depending on cut.
- **Level 3**
- Euler's formula verified: $V - E + F = 2$.
- Correct nets identified for tetrahedron.
- Orthographic projections match the 3-D solids.
- Shadow shapes correspond to solid and light position.

Quick Reference

Shape	Faces	Edges	Vertices	Volume Formula
Cube	6 squares	12	8	a^3
Cuboid	6 rectangles	12	8	$l \times w \times h$
Cylinder	2 circles + 1 curved	2 circular edges	0	$\pi r^2 h$
Sphere	1 curved surface	0	0	$\frac{4}{3}\pi r^3$
Cone	1 circle + 1 curved	1 circular edge	1 apex	$\frac{1}{3}\pi r^2 h$
Pyramid	Polygon base + triangular faces	Varies	Varies	$\frac{1}{3} \times \text{Base Area} \times h$

Glossary

- **Face:** Flat surface of a solid.
- **Edge:** Line segment where two faces meet.
- **Vertex:** Point where edges meet.
- **Net:** 2-D pattern that folds into a 3-D shape.
- **Oblique Sketch:** 3-D drawing with front face in true shape and depth lines drawn at an angle.
- **Isometric Sketch:** 3-D drawing with measurements to scale using isometric dot paper.
- **Cross-Section:** 2-D shape formed by slicing a solid.

- **Orthographic Projection:** 2-D views (front, side, top) of a 3-D object.