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CHAPTER NOTES

Surface Area and Volume Class 9 Notes | CBSE Maths

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Your teacher for Surface Area and V...



Hi, I am **Ira**. I teach this syllabus all day, so **Surface Area and Volume** is very much my home ground.

Ask me anything from this chapter. A concept, a numerical, or that one doubt you did not want to raise in class. Pick one to start:

Explain Surface Area and Volume simply

What can the board exam ask?

Most important formulas

Quiz me on this chapter

Ask Ira anything...



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Surface Area and Volume Class 9 Notes | CBSE Maths

Surface Area and Volume is a chapter of CBSE Class 9 Maths (2026-27 syllabus), part of Unit V, Mensuration. It deals with solid, three-dimensional shapes: the cuboid and the cube, the right circular cylinder, the right circular cone, the pyramid, the sphere and the hemisphere. For each solid you learn to describe it by its measurements (length, radius, height, slant height), to find the area of the surface that covers it, and to find the space it takes up.

The chapter covers lateral, curved and total surface areas, volume and capacity, the slant height of a cone and a pyramid, and what happens when dimensions are changed, when one solid is melted and recast into another, and when two solids are joined. School exams test it through numerical problems set in real contexts: painting walls, making tents, filling tanks, recasting metal. The same formulas return in the Class 10 board chapter on surface areas and volumes, where combined solids and recasting are

Quick Answer - Surface Area and

Surface area is the area of all the faces

Volume is the space the solid occupies

and volume lwh ; a cube is the special case

volume $\pi r^2 h$. A cone has slant height l =

pyramid has volume $(1/3) \times \text{base area} \times$

$(4/3)\pi r^3$. Scaling every length by k multi



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All Key Formulas at a Glance

Solid	Surface Area	Volume
Cuboid (l, b, h)	$LSA = 2h(l + b)$; $TSA = 2(lb + bh + hl)$	$V = lbh$
Cube (edge a)	$LSA = 4a^2$; $TSA = 6a^2$	$V = a^3$
Right circular cylinder (r, h)	$CSA = 2\pi rh$; $TSA = 2\pi r(r + h)$	$V = \pi r^2 h$
Hollow cylinder (R outer, r inner)	Outer $CSA = 2\pi Rh$; inner $CSA = 2\pi rh$	$V = \pi(R^2 - r^2)h$
Right circular cone (r, h, l)	$l = \sqrt{r^2 + h^2}$; $CSA = \pi rl$; $TSA = \pi r(l + r)$	$V = (1/3)\pi r^2 h$
Square pyramid (base a, slant height s)	$LSA = 4 \times \frac{1}{2} \times a \times s$	
Any pyramid	Base area + $\frac{1}{2} \times \text{perimeter of base} \times \text{slant height}$	
Sphere (r)	$S = 4\pi r^2$	
Hemisphere (r)	$CSA = 2\pi r^2$	
Units	1 m^2	



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Key Concepts

1. Solids, Surface Area and Volume

A plane figure such as a rectangle lies flat. Its dimensions are length, breadth and height. A solid has three dimensions. Different measurements describe any solid.

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- **Surface area:** the amount of material needed to cover the outside. This is the total area of all its flat faces and curved surfaces. It is measured in **square units:** cm^2 , m^2 .
- **Volume:** the amount of space the solid occupies. This is measured in **cubic units:** cm^3 , m^3 . The volume a hollow container can hold is called its **capacity**, often given in litres.

Painting, wrapping and tin-plating are surface area problems. Filling a tank, digging a pit or melting metal are volume problems. Decide first which of the two a question asks for.

Nets: Seeing a Solid Flat

If you cut a cardboard box along some edges and open it out flat, you get its **net**: six rectangles joined together. The area of the net is the surface area of the box. A cylinder opens into two circles and a rectangle; a cone opens into a circle and a sector; a square pyramid opens into a square with four triangles. Each surface area formula below comes from adding the areas of the pieces of a net.

Units You Must Convert

Quantity	Conversion
Length	$1 \text{ m} = 100 \text{ cm}$
Area	$1 \text{ m}^2 = 100 \times 100 = 10000 \text{ cm}^2$
Volume	$1 \text{ m}^3 = 100 \times 100 \times 100 = 1000000 \text{ cm}^3$
Capacity	$1 \text{ litre} = 1000 \text{ cm}^3$; $1 \text{ m}^3 = 1000 \text{ litres}$
Capacity	$1 \text{ cm}^3 = 1 \text{ millilitre (mL)}$

Unless a question says otherwise, take $\pi = \frac{22}{7}$. This is a signal that $\frac{22}{7}$ will cancel neatly.

2. Cuboid and Cube

A **cuboid** is a solid bounded by six rectangles. Cubes are cuboids. It has 6 faces, 12 edges and 8 vertices. Its length is **l**, its width is **b** and its height is **h**.

Opposite faces of a cuboid are equal, so the surface area is


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- top and bottom, each of area lb
- front and back, each of area lh
- two sides, each of area bh

Total surface area (TSA) = $2lb + 2bh + 2hl = 2(lb + bh + hl)$

The four side faces (front, back and two sides) form the **lateral surface area (LSA)**, the area of the four walls of a room. Opening them out gives one long rectangle whose length is the perimeter of the base, $2(l + b)$, and whose height is h .

LSA = $2h(l + b)$ = perimeter of base $\times$ height

The **volume** counts how many unit cubes fill the cuboid. A layer on the base holds $l \times b$ unit cubes, and there are h layers.

Volume = $l \times b \times h$ = area of base $\times$ height

The longest rod that fits inside a cuboid runs along its **diagonal** is $\sqrt{l^2 + b^2 + h^2}$, from the Baudhayan theorem. If you draw the diagonal of the base, then on the upright right triangle with hypotenuse as the diagonal of the cuboid, you can find the length of the diagonal.

The Cube as a Special Case of the Cuboid

A **cube** is a cuboid whose length, breadth and height are equal. Putting $l = b = h = a$ into each cuboid formula gives no new formulas at all:

Measure	Cuboid
LSA	$2h(l + b)$
TSA	$2(lb + bh + hl)$
Volume	lbh
Diagonal	$\sqrt{l^2 + b^2 + h^2}$

This is what "special case" means: a general case (a cube) when an extra condition is added. For a cube, its edges are equal.



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Illustration: A room is 5 m long, 4 m wide and 3 m high. The area of its four walls is $2 \times 3 \times (5 + 4) = 54 \text{ m}^2$. Walls plus ceiling: $54 + (5 \times 4) = 74 \text{ m}^2$. The volume of air inside is $5 \times 4 \times 3 = 60 \text{ m}^3$.

3. Right Circular Cylinder

A tin can, a water pipe, a pillar and a road roller are cylinders. A **right circular cylinder** has two equal, parallel circular ends (bases), and the line joining their centres (the axis) is perpendicular to the bases. It is fully described by two measurements: the **radius r** of the base and the **height h** , the distance between the two bases. In this chapter "cylinder" always means a right circular cylinder.

Curved Surface Area from the Net

Wrap a sheet of paper exactly once around a can, with no overlap, and cut it to the height of the can. Unroll it: the sheet is a rectangle. Its breadth is the height h of the can, and its length is the distance once round the base, the circumference.

$$\text{CSA of cylinder} = 2\pi r \times h = 2\pi rh$$

Add the two circular ends, each of area πr^2 .

$$\text{TSA of cylinder} = 2\pi rh + 2\pi r^2 = 2\pi r(r + h)$$

A cylinder open at one end (a glass, a tank) or at both ends has only the curved surface $2\pi rh$.

Volume

A cylinder is a stack of thin circular discs, or a stack of rectangles. So volume = area of base $\times$ height.

$$\text{Volume of cylinder} = \pi r^2 h$$

Hollow Cylinder

A pipe has an outer radius R and an inner radius r . The area of the cross-section is of area $\pi R^2 - \pi r^2$, so:

- Volume of material = $\pi(R^2 - r^2)h$
- Outer CSA = $2\pi Rh$; inner CSA = $2\pi rh$



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- $TSA = 2\pi Rh + 2\pi rh + 2\pi(R^2 - r^2)$, the last term being the two ring-shaped ends

Illustration: A cylinder has $r = 7$ cm and $h = 10$ cm. $CSA = 2 \times (22/7) \times 7 \times 10 = 440$ cm². $TSA = 2 \times (22/7) \times 7 \times (7 + 10) = 44 \times 17 = 748$ cm². Volume = $(22/7) \times 49 \times 10 = 1540$ cm³, which is 1.54 litres.

4. Right Circular Cone

An ice-cream cone, a birthday cap, a funnel and a heap of sand are cones. A **right circular cone** has a circular base and a vertex directly above the centre of the base. It is described by the **radius r** of the base and the **height h** , the perpendicular distance from the vertex to the centre of the base. A third length, the **slant height l** , is the distance from the vertex to any point on the edge of the base.

Slant Height

Cut a cone straight down through its vertex to form a right triangle with legs h (the height) and r (the radius). Using the Baudhāyana-Pythagoras theorem:

$$l^2 = r^2 + h^2, \text{ so } l = \sqrt{r^2 + h^2}$$

Since l is the hypotenuse, the slant height

Curved Surface Area from the Net

Cut a paper cone along one slant line and flatten it into a sector of a **circle** whose radius is the slant height l . The arc length is $2\pi r$, so its arc length is $2\pi r$.

A full circle of radius l has circumference $2\pi l$. The fraction r/l of that circle, so its area is $(r/l) \times \pi l^2 = \pi r l$.

$$CSA \text{ of cone} = \pi r l$$

$$TSA \text{ of cone} = \pi r l + \pi r^2 = \pi r(l + r)$$

A cap, a tent or a funnel has no base, so only the curved surface has the TSA.

Volume: One-Third of the Cylinder



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Take a hollow cone and a hollow cylinder with the same base radius and the same height. Fill the cone with sand or water and pour it into the cylinder. It takes exactly three full cones to fill the cylinder. So:

Volume of cone = $(1/3) \times \pi r^2 h$

Illustration: A cone has $r = 7$ cm and $h = 24$ cm. Slant height $l = \sqrt{(49 + 576)} = \sqrt{625} = 25$ cm.
 $CSA = (22/7) \times 7 \times 25 = 550$ cm². $TSA = (22/7) \times 7 \times (25 + 7) = 22 \times 32 = 704$ cm². Volume = $(1/3) \times (22/7) \times 49 \times 24 = 22 \times 7 \times 8 = 1232$ cm³.

Two heights, two jobs: the vertical height h goes into the **volume**; the slant height l goes into the **curved surface area**. Mixing them up is the commonest cone error.

5. Pyramid: Base, Apex, Surface Area and Volume

The Great Pyramid of Giza and a tent with
as its **base** and triangular faces, one on ea
the **apex**. The apex does not lie on the bas
pyramid has a triangle as base, a square p

Pyramid	
Triangular pyramid	4 (all triangles)
Square pyramid	5 (1 square, 4 triangles)
Base with n sides	$n + 1$

Two Different Heights

In a **right pyramid** the apex lies directly above the base. The perpendicular distance from the apex to the base is the height of the pyramid, measured from the apex to the midpoint of the base.

For a right square pyramid with base side a , the distance from the apex to the midpoint of each side of the base is $a/2$. This forms a right triangle:

$$s^2 = h^2 + (a/2)^2, \text{ so } s = \sqrt{h^2 + a^2/4}$$

A screenshot of a chat application. At the top, there is a dark blue header bar. On the left of this bar is a circular profile picture of a woman with long brown hair, smiling. To the right of the profile picture, the name 'Ira' is written in white, bold font. Below the name, the text 'Your teacher for Surface Area and V...' is written in a smaller white font. The main area of the chat is white. On the left side of this area, there is a smaller circular profile picture of the same woman. To the right of this picture, there is a message bubble with a light blue border. The message inside the bubble reads: 'Hi, I am Ira. I teach this syllabus all day, so Surface Area and Volume is very much my home ground. Ask me anything from this chapter. A concept, a numerical, or that one doubt you did not want to raise in class. Pick one to start:'. At the bottom of the screen, there is a white bar with the text 'Free questions, no login needed' and 'AI generated, can make mistakes. Cross-check with NCERT.' in a small, grey font.

Surface Area from the Net

A square pyramid unfolds into a square with a triangle attached to each side. Each triangle has base a and height s , so its area is $(1/2)as$. Four triangles:

$$\text{LSA of square pyramid} = 4 \times (1/2) \times a \times s = 2as$$

$$\text{TSA of square pyramid} = a^2 + 2as$$

For any right pyramid with a regular polygon base, $\text{LSA} = (1/2) \times \text{perimeter of base} \times \text{slant height}$; for a square, $4a$ gives $2as$ again.

Volume: One-Third Again

Joining the centre of a cube of edge a to its 8 corners splits it into 6 identical square pyramids, each with a face of the cube as base, height $a/2$ and volume $a^3/6$. Now $(1/3) \times a^2 \times (a/2) = a^3/6$, which matches. The general rule, true for every pyramid whatever the shape of its base, is:

$$\text{Volume of pyramid} = (1/3) \times \text{base area} \times \text{height}$$

The cone follows the same pattern: each with base area πr^2 and height h .

Illustration: A square pyramid has base side 12 cm and height 10 cm. $\text{LSA} = 2 \times 12 \times 10 = 240$ cm². $\text{Volume} = (1/3) \times 12^2 \times 10 = 384$ cm³. (The two numbers happen to be the same.)

6. Sphere and Hemisphere

A football, a marble, a ball bearing and (near) any point in space at the same distance r from a centre. A sphere has one curved surface and the diameter is $2r$. A sphere has one curved surface and the diameter is $2r$.

$$\text{Surface area of sphere} = 4\pi r^2$$

$$\text{Volume of sphere} = (4/3)\pi r^3$$

Archimedes' Sphere and Cylinder (E)



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This result is for interest and is outside the listed syllabus competencies. Fit a sphere of radius r exactly inside a cylinder, so the cylinder has radius r and height $2r$. Archimedes proved two facts about this pair:

- The surface area of the sphere, $4\pi r^2$, equals the curved surface area of the cylinder, $2\pi r \times 2r = 4\pi r^2$.
- The volume of the sphere, $(4/3)\pi r^3$, is two-thirds of the volume of the cylinder, $\pi r^2 \times 2r = 2\pi r^3$.

Hemisphere

A plane through the centre cuts a sphere into two equal halves called **hemispheres**. A hemisphere has a curved surface (half the sphere) and a flat circular face of radius r .

- **CSA of hemisphere** = $(1/2) \times 4\pi r^2 = 2\pi r^2$
- **TSA of solid hemisphere** = $2\pi r^2 + \pi r^2 = 3\pi r^2$
- **Volume of hemisphere** = $(1/2) \times (4/3)\pi r^3 = (2/3)\pi r^3$

A bowl or a dome uses only the curved surface. A solid hemisphere uses $3\pi r^2$.

Illustration: For $r = 7$ cm, the sphere has surface area $4\pi r^2 = 4 \times \frac{22}{7} \times 49 = 440$ cm², TSA 440 cm² and volume $\frac{4}{3}\pi r^3 = \frac{4}{3} \times \frac{22}{7} \times 343 = 4312/3 \approx 1437.33$ cm³.
Hemisphere has CSA $2\pi r^2 = 220$ cm², TSA 330 cm² and volume $\frac{2}{3}\pi r^3 = 2156/3 \approx 718.67$ cm³.

Hollow sphere (spherical shell): with outer radius R and inner radius r , the surface area is $4\pi(R^2 - r^2)$ and volume is $(4/3)\pi(R^3 - r^3)$.

Cone, Hemisphere and Cylinder Side by Side

Take a cone, a hemisphere and a cylinder, all with radius r and height $h = r$. Their volumes are $(1/3)\pi r^3$, $(2/3)\pi r^3$ and πr^3 , in the ratio **1 : 2 : 3**.

7. Varying Dimensions, Recasting

How Area and Volume Respond to Scaling

Surface area is built from a length times a length, so it scales as k^2 . Volume is built from three lengths, so it scales as k^3 . If you multiply a length by k , the surface area is multiplied by k^2 and the volume by k^3 .



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- surface area is multiplied by k^2
- volume is multiplied by k^3

A cube of edge 1 cm has surface area 6 cm^2 and volume 1 cm^3 . A cube of edge 2 cm has surface area 24 cm^2 (4 times) and volume 8 cm^3 (8 times). Doubling the radius of a ball makes its surface 4 times and its volume 8 times.

When only some dimensions change, substitute into the formula instead of guessing. For a cylinder with the radius halved and height doubled: $V_{\text{new}} = \pi(r/2)^2(2h) = (1/2)\pi r^2 h$, so the volume halves. The halving and doubling do not cancel, because the radius is squared.

Enrichment (beyond the syllabus list): shapes of equal volume can need very different surfaces. Cuboids of volume 64 cm^3 range from TSA 258 cm^2 ($64 \times 1 \times 1$) down to 96 cm^2 for the $4 \times 4 \times 4$ cube: among all cuboids with a fixed volume, the cube has the least surface area (Competency Question 8 checks four whole-number designs).

Recasting

When a solid is melted and **recast** into another shape, **volume stays the same**. The surface area changes.

Volume of the original solid = total volume of the new solid

Example: a metal sphere of radius 6 cm is melted and recast into small spheres of radius 3 cm. Number of small spheres = $\frac{(4/3)\pi \times 216}{(4/3)\pi \times 27} = 8$. Cylinder volume = area of base $\times$ height. To count small solids made from a big one, divide the big volume by the small volume.

Combined Solids

Many objects are two simple solids joined together. For example, a cylinder with a hemisphere at each end, or a cone on top of a cylinder.

- **Volume** of the combination = sum of the volumes of the parts
- **Surface area** of the combination = sum of the surface areas of the parts, but the touching faces are hidden and not counted.

Example: a cone (radius 3 cm, height 4 cm) on top of a cylinder (radius 3 cm, height 6 cm). Volume = $12\pi + 18\pi = 30\pi \text{ cm}^3$. The circular faces where they are joined are not counted.

A step-by-step method works for every combination. For each part, find any missing length (often total height minus a radius), compute each part, then add them up.



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only what the question asks for.

Formula and Theorem Sheet

Solid	Lateral or Curved Surface Area	Total Surface Area	Volume
Cuboid	$2h(l + b)$	$2(lb + bh + hl)$	lbh
Cube	$4a^2$	$6a^2$	a^3
Cylinder	$2\pi rh$	$2\pi r(r + h)$	πr^2h
Hollow cylinder	$2\pi Rh$ (outer), $2\pi rh$ (inner)	$2\pi(R + r)h + 2\pi(R^2 - r^2)$	$\pi(R^2 - r^2)h$
Cone	πrl		
Square pyramid	$2as$		
Any pyramid	Sum of triangular faces		
Sphere	$4\pi r^2$		
Hemisphere	$2\pi r^2$		
Hollow sphere	-		



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Relation	Statement
Diagonal of cuboid	$\sqrt{l^2 + b^2 + h^2}$; for a cube $a\sqrt{3}$
Slant height of cone	$l = \sqrt{r^2 + h^2}$
Slant height of square pyramid	$s = \sqrt{h^2 + (a/2)^2}$
Cone and cylinder, same r and h	$V_{\text{cone}} = (1/3)V_{\text{cylinder}}$
Sphere in cylinder (r, 2r), enrichment	Areas equal; $V_{\text{sphere}} = (2/3)V_{\text{cylinder}}$
Cone : hemisphere : cylinder (radius r, height r)	Volumes 1 : 2 : 3
Scaling by k	Area $\times k^2$; volume $\times k^3$
Recasting	

Important Definitions

- **Solid:** an object with three dimensions (length, breadth, height)
- **Surface area:** the total area of all the faces of a solid
- **Lateral surface area:** the area of the side faces (for a cuboid, the four walls).
- **Curved surface area:** the area of the curved surface (leaving out any flat faces).
- **Total surface area:** the curved or lateral surface area plus the area of the flat faces.
- **Volume:** the amount of space occupied by a solid
- **Capacity:** the volume of the inside of a container
- **Cuboid:** a solid bounded by six rectangular faces
- **Cube:** a cuboid with all edges equal; its faces are squares
- **Right circular cylinder:** a solid with two circular bases connected by a line perpendicular to the bases.
- **Right circular cone:** a solid with a circular base and a single vertex.



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- **Slant height (cone):** the distance from the vertex to any point on the circumference of the base, $l = \sqrt{r^2 + h^2}$.
- **Pyramid:** a solid with a polygon base and triangular faces, one on each side of the base, meeting at a common point.
- **Apex:** the common vertex of all the triangular faces of a pyramid, not lying on the base.
- **Slant height (pyramid):** the height of a triangular face, from the apex to the midpoint of a base edge.
- **Sphere:** the set of all points in space at a fixed distance (the radius) from a fixed point (the centre).
- **Hemisphere:** one of the two equal halves of a sphere made by a plane through its centre.

Solved Examples

Take $\pi = 22/7$ unless stated otherwise.

Example 1: Painting a Tank

Question: An open cuboidal tank is 2.5 m high and its base is 1.6 m by 1.2 m. Find its capacity in litres and the cost of painting its inner surface at Rs 10 per m².

Solution:

$$\text{Capacity} = l \times b \times h = 2.5 \times 1.6 \times 1.2 = 4.8 \text{ m}^3$$

The tank is open, so the inner surface is the area of the four walls and the base.

$$\text{Base} = 2.5 \times 1.6 = 4 \text{ m}^2. \text{ Walls} = 2h(l + b) = 2 \times 2.5(1.6 + 1.2) = 9.84 \text{ m}^2$$

$$\text{Area to paint} = 4 + 9.84 = 13.84 \text{ m}^2. \text{ Cost} = 13.84 \times 10 = \text{Rs } 138.40$$

Example 2: Cylinder from its Curved Surface Area

Question: The curved surface area of a cylinder is 440 cm². If the radius of its base is 7 cm. Find its height and its capacity.

Solution: CSA = circumference $\times$ height, so

$$2\pi r = 110 \text{ gives } r = 110 \times 7/44 = 17.5 \text{ cm.}$$



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$$\text{Volume} = \pi r^2 h = (22/7) \times 17.5 \times 17.5 \times 40 = 22 \times 2.5 \times 17.5 \times 40 = 38500 \text{ cm}^3 = \mathbf{38.5 \text{ litres.}}$$

Example 3: Metal Pipe

Question: A metal pipe is 77 cm long. Its inner diameter is 4 cm and outer diameter 4.4 cm. Find its inner curved surface area, outer curved surface area and the volume of metal.

Solution: $r = 2 \text{ cm}$, $R = 2.2 \text{ cm}$, $h = 77 \text{ cm}$.

$$\text{Inner CSA} = 2\pi rh = 2 \times (22/7) \times 2 \times 77 = \mathbf{968 \text{ cm}^2}.$$

$$\text{Outer CSA} = 2\pi Rh = 2 \times (22/7) \times 2.2 \times 77 = \mathbf{1064.8 \text{ cm}^2}.$$

$$\text{Volume of metal} = \pi(R^2 - r^2)h = (22/7) \times (4.84 - 4) \times 77 = 22 \times 0.84 \times 11 = \mathbf{203.28 \text{ cm}^3}.$$

Example 4: Conical Tent

Question: A conical tent is 24 m high and (b) the length of canvas 5 m wide needed inside.

Solution: (a) $l = \sqrt{7^2 + 24^2} = \sqrt{49 + 576}$

(b) A tent has no floor, so canvas = CSA = $550 \div 5 = \mathbf{110 \text{ m}}$.

(c) Volume = $(1/3)\pi r^2 h = (1/3) \times (22/7) \times 4$

Example 5: Cone from its Volume

Question: The volume of a right circular cone is 196 cm³. Find its height, slant height and curved surface area.

Solution: $r = 14 \text{ cm}$. $(1/3) \times (22/7) \times 196 \times$

$(1/3) \times 22 \times 28 \times h = 9856$, so $(616/3)h = 9856$

$l = \sqrt{14^2 + 48^2} = \sqrt{196 + 2304} = \sqrt{2500}$

CSA = $\pi rl = (22/7) \times 14 \times 50 = \mathbf{2200 \text{ cm}^2}$.



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Example 6: Square Pyramid

Question: A right square pyramid has base side 10 m and slant height 13 m. Find its height, lateral surface area, total surface area and volume.

Solution: Half the base side is 5 m. From $s^2 = h^2 + (a/2)^2$: $h^2 = 169 - 25 = 144$, so $h = 12$ m.

$$\text{LSA} = 2as = 2 \times 10 \times 13 = 260 \text{ m}^2.$$

$$\text{TSA} = a^2 + 2as = 100 + 260 = 360 \text{ m}^2.$$

$$\text{Volume} = (1/3) \times a^2 \times h = (1/3) \times 100 \times 12 = 400 \text{ m}^3.$$

Example 7: Sphere from its Surface Area

Question: The surface area of a sphere is 154 cm^2 . Find its radius and volume.

Solution: $4 \times (22/7) \times r^2 = 154$, so $r^2 = 154 \times 7 / 28 = 38.5$, so $r = 3.5$ cm.

$$\text{Volume} = (4/3) \times (22/7) \times 3.5 \times 3.5 \times 3.5 = 179.5 \text{ cm}^3.$$

Example 8: Hemispherical Bowl

Question: A hemispherical bowl has inner radius 21 cm. Find its capacity and the cost of tin-plating its inner surface at ₹16 per 100 cm^2 .

Solution: Capacity = $(2/3)\pi r^3 = (2/3) \times (22/7) \times 21 \times 21 \times 21 = 2425.5 \text{ cm}^3 \approx 2.43$ litres.

$$\text{Inner surface} = \text{CSA} = 2\pi r^2 = 2 \times (22/7) \times 21 \times 21 = 693 \text{ cm}^2.$$

$$\text{Cost} = 693 \times 16/100 = ₹110.88.$$

Example 9: Balls from a Cylinder

Question: A solid metal cylinder of diameter 14 cm and height 16 cm is melted and recast into spherical balls of diameter 2 cm. How many balls can be made?

Solution: Volume of cylinder = $\pi \times 3^2 \times 16 = 150.72 \text{ cm}^3$.

$$\text{Volume of one ball (r = 1 cm)} = (4/3)\pi \times 1^3 = 4.1888 \text{ cm}^3.$$



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Number of balls = $144\pi \div (4/3)\pi = 144 \times 3/4 = \mathbf{108}$. The value of π cancels, so there is no need to substitute it.

Example 10: Toy Made of a Cone and a Hemisphere

Question: A toy is a cone of radius 3.5 cm mounted on a hemisphere of the same radius. The total height of the toy is 15.5 cm. Find its total surface area and volume.

Solution: Height of cone = $15.5 - 3.5 = 12$ cm. Slant height $l = \sqrt{(12^2 + 3.5^2)} = \sqrt{(144 + 12.25)} = \sqrt{156.25} = 12.5$ cm.

Visible surface = CSA of cone + CSA of hemisphere = $\pi rl + 2\pi r^2$.

$\pi rl = (22/7) \times 3.5 \times 12.5 = 137.5 \text{ cm}^2$. $2\pi r^2 = 2 \times (22/7) \times 12.25 = 77 \text{ cm}^2$.

TSA = $137.5 + 77 = \mathbf{214.5 \text{ cm}^2}$.

Volume of cone = $(1/3) \times (22/7) \times 12.25 \times 12 = 42.875 = 539/6 \approx 89.83 \text{ cm}^3$.

Volume of toy = $154 + 89.83 \approx \mathbf{243.83 \text{ cm}^3}$

Example 11: Changing the Dimensions

Question: (a) The radius of a cylinder is doubled and its height is halved. Find the ratio of its new volume and curved surface area with the original. (b) The radius of a cylinder is increased by 10% and its height is halved. Find the percent change in its surface area and volume.

Solution: (a) New volume = $\pi(2r)^2(h/2) = 2\pi r^2 h$. Original volume = $\pi r^2 h$, so the new volume is 2 times the original. Curved surface area is $2\pi rh$, so the curved surface area is the same.

(b) New radius = $1.1r$. Surface area is multiplied by $1.1^2 = 1.21$, an increase of 21%. Volume is multiplied by $1.1^3 = 1.331$, an increase of 33.1%.

Competency-Based Questions

1. Case-based: The Rooftop Water Tank

A family installs a closed cylindrical water tank of radius 1 m and height 2 m. The family uses about 440 litres of water a day.



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(a) Find the capacity of the tank in litres. $r = 0.7 \text{ m}$. $V = (22/7) \times 0.7 \times 0.7 \times 2 = 3.08 \text{ m}^3 = 3080$ litres.

(b) For how many days will a full tank last? $3080 \div 440 = 7$ days.

(c) The outside of the tank, including the lid and the base, is to be painted. Taking the outer radius as 0.7 m , find the area to be painted. $TSA = 2\pi r(r + h) = 2 \times (22/7) \times 0.7 \times 2.7 = 4.4 \times 2.7 = 11.88 \text{ m}^2$.

2. Case-based: The Ice-Cream Cone

An ice-cream shop fills cones of radius 3.5 cm and height 9 cm completely with ice cream and adds a hemispherical scoop of the same radius on top.

(a) Find the volume of ice cream inside the cone. $(1/3) \times (22/7) \times 12.25 \times 9 = 115.5 \text{ cm}^3$.

(b) Find the total volume of ice cream in one cone. $115.5 + 539/6 \text{ cm}^3$. Total = $693/6 + 539/6 = 1232/6$.

(c) Ice cream arrives in cylindrical containers. How many servings does one container fill? Container volume = $18480/1232 = 15$.

3. Case-based: A Pyramid Tent

A camping tent is a right square pyramid with side length 4 m at the base and height 3 m . The tent is pitched on a flat ground. The four sloping sides are made of canvas.

(a) Find the slant height of each sloping side.

(b) Find the area of canvas for the sloping sides.

(c) Find the volume of air inside the tent.

4. Assertion-Reason

Assertion (A): If the radius of a sphere is r , then the volume of a sphere is proportional to the cube of r .

(a) Both A and R are true, and R is the correct explanation of A. (b) Both A and R are true, but R is not the correct explanation of A. (c) A is true and R is false. (d) A is false and R is true.



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Answer: (a). $V = (4/3)\pi r^3$, so replacing r by $2r$ multiplies V by $2^3 = 8$. R gives the reason.

5. Assertion-Reason

Assertion (A): A cylinder and a cone have the same base radius and the same height, so the volume of the cylinder is three times the volume of the cone. **Reason (R):** The curved surface area of the cylinder is three times the curved surface area of the cone.

(a) Both A and R are true, and R is the correct explanation of A. (b) Both A and R are true, but R is not the correct explanation of A. (c) A is true, but R is false. (d) A is false, but R is true.

Answer: (c). $\pi r^2 h$ is three times $(1/3)\pi r^2 h$, so A is true. The curved areas $2\pi r h$ and $\pi r l$ have ratio $2h : l$, which for $r = 7$, $h = 24$ is $48 : 25$, and since l is always greater than h , $2h$ can never equal $3l$. So R is false.

6. Assertion-Reason

Assertion (A): When a solid metal sphere of radius r is melted and recast into a cylinder of radius r , the surface area of the cylinder equals the surface area of the sphere. The surface area of the sphere does not change.

(a) Both A and R are true, and R is the correct explanation of A. (b) Both A and R are true, but R is not the correct explanation of A. (c) A is true, but R is false. (d) A is false, but R is true.

Answer: (d). Only the volume is conserved. The surface area of the sphere is $4\pi r^2$. The surface area of the cylinder is $2\pi r^2 + 2\pi r h$. If $h = r$, the surface area of the cylinder is $4\pi r^2$. The areas differ.

7. Assertion-Reason

Assertion (A): The curved surface area of a solid hemisphere of radius r is $2\pi r^2$. The total surface area of a solid hemisphere of radius r is $3\pi r^2$.

(a) Both A and R are true, and R is the correct explanation of A. (b) Both A and R are true, but R is not the correct explanation of A. (c) A is true, but R is false. (d) A is false, but R is true.

Answer: (b). $CSA = 2\pi r^2 = 2 \times (22/7) \times 49 = 281.6$. The total surface area is $3\pi r^2 = 3 \times (22/7) \times 49 = 415.8$. The total surface area is not equal to the curved surface area, so it does not explain A.



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8. Data-based: Same Volume, Different Boxes

A company must pack 64 cm^3 of sweets in a closed cuboidal cardboard box with whole-number edges. It compares four designs: $64 \times 1 \times 1$, $16 \times 2 \times 2$, $8 \times 4 \times 2$ and $4 \times 4 \times 4$ (all in cm).

(a) Find the cardboard needed for each design. Using $2(lb + bh + hl)$: 258, 136, 112 and 96 cm^2 respectively.

(b) Which design uses the least cardboard, and what pattern do you see? The cube, $4 \times 4 \times 4$, uses the least (96 cm^2). As the three edges get closer to one another, the surface area falls.

(c) What percent of cardboard does the cube save compared with the $8 \times 4 \times 2$ box? Saving = $112 - 96 = 16 \text{ cm}^2$. Percent = $16/112 \times 100 \approx 14.3\%$.

Important Questions for Exams

1 Mark Questions

Q1. The volume of a cube is 343 cm^3 . Find a .
 $a^3 = 343 = 7^3$, so $a = 7 \text{ cm}$.

Q2. Write the total surface area of a solid cylinder of radius r and height h .
 $2\pi r^2 + \pi r^2 h = 3\pi r^2$.

Q3. Find the slant height of a cone of radius 7 cm and height 24 cm .
 $l = \sqrt{(25 + 144)} = \sqrt{169} = 13 \text{ cm}$.

Q4. How many faces, edges and vertices does a triangular prism have?
5 faces, 8 edges, 5 vertices.

Q5. The radius of a cylinder is halved and its height is doubled. What happens to its volume?
 $V = \pi(r/2)^2 h = (1/4)\pi r^2 h$. It becomes **one-fourth** of the original volume.

2 Marks Questions

Q6. The diameter of a sphere is decreased by 25%. By what percent does its surface area decrease?
New radius = $0.75r$. New area = $4\pi(0.75r)^2 = 9\pi r^2/4$.
that is **43.75%**.



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Q7. How many cubes of edge 2 cm can be cut from a cuboid 12 cm × 8 cm × 6 cm?

Along the edges: $12/2 = 6$, $8/2 = 4$, $6/2 = 3$. Number = $6 \times 4 \times 3 = 72$. (Check: $576 \div 8 = 72$.)

Q8. A cone has volume 1570 cm^3 and base radius 10 cm. Find its height. (Use $\pi = 3.14$.)

$(1/3) \times 3.14 \times 100 \times h = 1570$, so $h = 1570 \times 3/314 = 15 \text{ cm}$.

3 Marks Questions

Q9. The inside of a hemispherical dome of radius 3.5 m is to be painted at ₹40 per m^2 . Find the cost.

Area = CSA = $2\pi r^2 = 2 \times (22/7) \times 3.5 \times 3.5 = 77 \text{ m}^2$. Cost = $77 \times 40 = \text{₹}3080$.

Q10. A conical heap of grain has base diameter 12 m and height 8 m. Find its volume and the area of canvas needed to just cover it.

$r = 6 \text{ m}$, $l = \sqrt{(36 + 64)} = 10 \text{ m}$. Volume = $(1/3) \times (22/7) \times 36 \times 8 = 2112/7 \approx 301.71 \text{ m}^3$. Canvas = $\pi r l = (22/7) \times 6 \times 10 = 1320/7 \approx 188.57 \text{ m}^2$.

Q11. A right square pyramid has base side and volume.

$s = \sqrt{(6^2 + 8^2)} = \sqrt{100} = 10 \text{ cm}$. TSA = $a^2 +$
 $= 512 \text{ cm}^3$.

5 Marks Questions

Q12. A medicine capsule is a cylinder with its diameter is 7 mm. Find its surface

$r = 3.5 \text{ mm}$. Length of cylindrical part = 20
Surface area = $2\pi rh + 2 \times 2\pi r^2 = 2 \times (22/7) \times$
 mm^2 .

Volume = $\pi r^2 h + (4/3)\pi r^3 = (22/7) \times 12.25$
 $500.5 + 179.67 = 680.17 \text{ mm}^3$.

The two hemispheres together form one full

Q13. A tent is a cylinder of radius 6 m and slant height 10 m. Find (a) the canvas needed to cover the tent and (b) the cost of the canvas at ₹70 per m^2 . Find (c) the volume of air inside.

(a) Canvas = CSA of cylinder + CSA of cone = $2\pi rh + \pi r l = 2 \times (22/7) \times 6 \times 8 + (22/7) \times 6 \times 10 = 2112/7 \approx 301.71 \text{ m}^2$. The floor and the joining

(b) Cost = $(2112/7) \times 70 = \text{₹}21120$.

(c) Height of cone = $\sqrt{(100 - 36)} = 8 \text{ m}$. Volume of cone = $(1/3) \times \pi r^2 h = (1/3) \times (22/7) \times 36 \times 8 = 204\pi = 4488/7 \approx 641.14 \text{ m}^3$.



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Q14. A solid hemisphere of radius 6 cm is melted and recast into a cone of the same radius. (a) Find the height of the cone. (b) Find its slant height. (c) Find the ratio of the curved surface area of the hemisphere to that of the cone.

(a) $(\frac{1}{3})\pi r^2 h = (\frac{2}{3})\pi r^3$ gives $h = 2r = \mathbf{12\text{ cm}}$.

(b) $l = \sqrt{(36 + 144)} = \sqrt{180} = \mathbf{6\sqrt{5}\text{ cm}} \approx 13.42\text{ cm}$.

(c) CSA of hemisphere = $2\pi \times 36 = 72\pi$. CSA of cone = $\pi \times 6 \times 6\sqrt{5} = 36\sqrt{5}\pi$. Ratio = $72 : 36\sqrt{5} = \mathbf{2 : \sqrt{5}}$.

Common Mistakes and Examiner Tips

- Using the diameter as the radius.** Fix: the moment you read "diameter", write $r = d/2$ on the first line of your answer.
- Using the height instead of the slant height in πrl or $2\pi rs$.** Fix: vertical height goes into volume; slant height goes into curved or lateral area. Find the slant height first with the Baudhāyana-Pythagoras theorem.
- Forgetting the $1/3$ for cones and pyramids.** Remember: a cylinder and six pyramids fill a cube.
- Taking TSA when the object is open.** Fix: a bowl or an open tank has no top or base.
- Writing TSA of a hemisphere as $2\pi r^2$.** Fix: TSA adds the flat circle, giving $3\pi r^2$.
- Mixing units.** Fix: convert every length to cm. $1\text{ m}^3 = 1000000\text{ cm}^3$, not 100.
- Adding hidden faces in a combined solid.** Fix: only count the outside; the circles where two parts meet are not surfaces.
- Using the total height of a toy as the height of the hemisphere (or the height of the other part).** Fix: find the height of the specific part.
- Expecting surface area to stay the same when volume changes.** Equate volumes, never areas.
- Assuming a doubled length doubles the surface area.** When only some dimensions change, surface area changes differently.



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Quick Revision Points

- Surface area is in square units; volume is in cubic units; capacity is volume inside a container.
- $1\text{ L} = 1000\text{ cm}^3$; $1\text{ m}^3 = 1000\text{ L}$; $1\text{ m}^2 = 10000\text{ cm}^2$.
- Every surface area formula comes from the area of the solid's net.
- Cuboid: LSA $2h(l + b)$, TSA $2(lb + bh + hl)$, $V = lbh$, diagonal $\sqrt{l^2 + b^2 + h^2}$.
- A cube is a cuboid with $l = b = h = a$: LSA $4a^2$, TSA $6a^2$, $V = a^3$, diagonal $a\sqrt{3}$.
- Cylinder: CSA $2\pi rh$ (rectangle $2\pi r$ by h), TSA $2\pi r(r + h)$, $V = \pi r^2 h$.
- Hollow cylinder: $V = \pi(R^2 - r^2)h$.
- Cone: $l = \sqrt{r^2 + h^2}$, CSA πrl (a sector of radius l), TSA $\pi r(l + r)$, $V = (1/3)\pi r^2 h$.
- Slant height is always longer than both the height and the radius.
- Pyramid: polygon base, triangular faces meeting at the apex; named by its base.
- Square pyramid: $s^2 = h^2 + (a/2)^2$; LSA $2as + a^2$.
- Any pyramid: $V = (1/3) \times \text{base area} \times \text{height}$.
- Sphere: surface area $4\pi r^2$, $V = (4/3)\pi r^3$.
- Hemisphere: CSA $2\pi r^2$, TSA $3\pi r^2$, $V = (2/3)\pi r^3$.
- Enrichment, beyond the syllabus list (Area and $2/3$ of the volume).
- Cone, hemisphere, cylinder with radius r and height h .
- Scale every length by k : area $\times k^2$, volume $\times k^3$.
- Enrichment, beyond the syllabus list: for all cuboids.
- Recasting: volume before = volume after.
- Combined solid: volumes add; surface area...



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Weightage and Exam Pattern

Class 9 has no board exam; this chapter is part of the CBSE Class IX Mathematics course structure. **Mensuration, which carries 14 marks** out of 30 in the final exam, is taught over 10 teaching periods. The unit has two chapters.

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and the course structure does not split the 14 marks between them. The other 20 marks are internal assessment.

Unit	Marks (out of 80)
I. Number System	07
II. Algebra	20
III. Coordinate Geometry	04
IV. Geometry	25
V. Mensuration	14
VI. Statistics and Probability	10

The CBSE question paper design weights understanding, 24% applying, and 22% analysis. It means recalling and choosing the right formula and toys, and analysing questions on character. These formulas return in the Class 10 board exam.



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