LF LearnFrenzy

QUANTITATIVE APTITUDE · FREE STUDY MATERIAL

Volume and Surface Area

Formulas & Shortcut Tricks

Every important formula, shortcut and exam trick for Volume and Surface Area in one place – with solved examples, common mistakes and a one-page revision sheet.

WHAT'S INSIDE

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USEFUL FOR

- SSC CGL / CHSL / MTS
- Railways (RRB NTPC, Group D)
- Bank PO & Clerk (IBPS, SBI, RBI)
- Campus placements (TCS, Infosys, Wipro, Accenture)
- UPSC CSAT & state PSC exams

Practise Volume and Surface Area free on LearnFrenzy – questions with instant explanations →

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1 Topic introduction

What it is, why it matters and how it is asked

Volume is the space a solid fills, measured in cubic units such as cm^3 or m^3. Surface area is the total area of its outer faces, measured in square units. Filling a tank is a volume question; painting or wrapping a box is a surface-area question.

Exams use the standard solids – cube, cuboid, cylinder, cone, sphere, hemisphere and frustum – in practical settings: melting and recasting metal, water rising when a solid is dropped in, earth dug from a well, pipes filling tanks, painted cubes cut into smaller cubes, and percentage change in volume.

Why it matters in exams

- SSC papers ask two to four 3-D mensuration questions.
- Railway and state exams love melting, recasting and water-level problems.
- Placement tests use painted cubes and ratios between solids.

Where it is used

- Capacity of tanks, bottles and containers.
- Material needed to make or paint an object.
- Construction: earth digging, concrete and bricks.

Common question patterns

Cubes and cuboids
Volume, surface areas and diagonals.

Cylinders
Solid and hollow; curved and total surface.

Cones and frustums
Slant height, surface and volume; buckets.

Spheres
Spheres, hemispheres and bowls.

Melting and recasting
Volume stays the same; count the pieces.

Water and earth
Water rising, earth dug and spread, pipe flow.

Painted cubes
Small cubes with 3, 2, 1 or 0 faces painted.

Changes and ratios
Percentage change; ratios between solids.

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2 Important formulas

Cards marked MOST USED are the ones to revise first

Cuboid and cube

Cuboid

MOST USED

$$V = lbh;\ TSA = 2(lb + bh + hl);\ LSA = 2h(l + b);\ \text{diagonal} = \sqrt{(l^2 + b^2 + h^2)}$$

LSA (four walls) leaves out the top and bottom.

l, b, h – length, breadth, height

EXAMPLE 12 × 4 × 3 → V = 144, diagonal = √169 = **13**.

Cube

MOST USED

$$V = a^3;\ TSA = 6a^2;\ LSA = 4a^2;\ \text{diagonal} = a\sqrt{3}$$

From the surface area, find a^2 first, then a.

EXAMPLE TSA 294 → a^2 = 49 → a = 7 → V = **343**.

Cylinders

Right circular cylinder

MOST USED

$$V = \pi r^2 h;\ CSA = 2\pi rh;\ TSA = 2\pi r(r + h)$$

TSA adds the two circular ends to the curved surface.

EXAMPLE r = 7, h = 10 → V = 22/7 × 49 × 10 = **1,540**; CSA 440; TSA 748.

Hollow cylinder (pipe)

$$V = \pi h(R^2 - r^2) = \pi h(R + r)(R - r)$$

Volume of metal = outer cylinder minus inner cylinder.

EXAMPLE R = 4, r = 3, h = 14 → 22/7 × 14 × 7 = **308**.

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Cones and frustums

Right circular cone

MOST USED

$l = \sqrt{(r^2 + h^2)}$; $V = \frac{1}{3}\pi r^2 h$; CSA = πrl; TSA = $\pi r(l + r)$

Curved surface uses the slant height l, not the height h.

EXAMPLE r = 7, h = 24 → l = 25, CSA = 22/7 × 7 × 25 = **550**, V = 1,232.

Frustum (bucket)

$V = \frac{1}{3}\pi h(R^2 + Rr + r^2)$; CSA = $\pi l(R + r)$, $l = \sqrt{[h^2 + (R - r)^2]}$

A cone with its top cut off parallel to the base.

EXAMPLE R = 10, r = 4, h = 8 → V = ⅓π × 8 × 156 = **416π**; l = 10.

Spheres

Sphere

MOST USED

$V = (4/3)\pi r^3$; surface area = $4\pi r^2$

A sphere has only one (curved) surface.

EXAMPLE r = 21 → SA = 4 × 22/7 × 441 = **5,544**; V = 38,808.

Hemisphere

$V = (2/3)\pi r^3$; CSA = $2\pi r^2$; TSA = $3\pi r^2$

Solid hemisphere TSA adds the flat circle πr^2.

EXAMPLE r = 7 → TSA = 3 × 22/7 × 49 = **462**.

Melting, water and changes

Melting and recasting

MOST USED

Volume before = volume after; number of pieces = big volume ÷ one small volume

Surface area changes on recasting; volume never does.

EXAMPLE Sphere r = 6 recast into spheres r = 2 → $(6/2)^3$ = **27**.

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Water level rise

> **Rise in level = volume of solid immersed ÷ base area of the container**

The displaced water takes the shape of the container.

EXAMPLE Sphere r = 3 into a cylinder r = 6 → (4/3 × 27) ÷ 36 = **1 cm**.

Percentage change in volume

MOST USED

> **Every edge +x% → volume × $(1 + x/100)^3$; surface area × $(1 + x/100)^2$**

Volume uses three lengths, surface area two.

EXAMPLE Every edge +10% → volume + **33.1%**.

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3 Shortcut tricks & smart techniques

Each trick says when to use it – that matters as much as the trick

Painted cube cut into n × n × n

MOST USED

USE WHEN A painted cube is cut into equal small cubes.

Faces painted	Number of small cubes
3 (corners)	8
2 (edges)	$12(n-2)$
1 (faces)	$6(n-2)^2$
0 (inside)	$(n-2)^3$

EXAMPLE n = 5 → 8, 36, 54, 27 (total 125) → **8, 36, 54, 27**.

Ratios of standard solids

MOST USED

USE WHEN Cylinder, cone and hemisphere on the same base.

1. Cone = ⅓ of the cylinder with the same base and height.
2. Same r and h = r: cylinder : cone : hemisphere = 3 : 1 : 2.

EXAMPLE $\pi r^3 : \frac{1}{3}\pi r^3 : \frac{2}{3}\pi r^3$ → **3 : 1 : 2**.

Scaling rule

USE WHEN Similar solids, or recasting many equal spheres.

1. Edges in ratio k → surface areas k^2, volumes k^3.
2. Spheres of radius R into radius r → $(R/r)^3$ pieces.

EXAMPLE Edges 2 : 3 → volumes **8 : 27**.

Pipe flow

USE WHEN Water flows through a pipe into a tank.

1. Volume per second = πr^2 × speed of flow.
2. Convert everything to metres; 1 m^3 = 1,000 L.

EXAMPLE Pipe r = 7 cm, speed 5 m/s → 22/7 × 0.0049 × 5 m^3 = **77 L** per second.

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4 Solved examples

The full method on the left, the exam shortcut on the right

1 CUBOID

A tank is 3 m long, 2 m wide and 1.5 m deep. How many litres of water can it hold?

STEP BY STEP

1. Volume = 3 × 2 × 1.5 = 9 m³.
2. 1 m³ = 1,000 L.
3. Capacity = 9,000 L.

SHORTCUT

lbh × 1,000.

Why it works: Capacity is volume in litres.

Answer: 9,000 litres

2 CUBE

The diagonal of a cube is $6\sqrt{3}$ cm. Find its total surface area and volume.

STEP BY STEP

1. $a\sqrt{3} = 6\sqrt{3} \rightarrow a = 6$.
2. TSA = 6 × 36 = 216 cm².
3. V = 6³ = 216 cm³.

SHORTCUT

a = diagonal ÷ $\sqrt{3}$.

Why it works: The diagonal of a cube is $a\sqrt{3}$.

Answer: 216 cm² and 216 cm³

3 CYLINDER

The curved surface of a cylinder of radius 14 cm is 880 cm². Find its volume.

STEP BY STEP

1. 2 × 22/7 × 14 × h = 880 → 88h = 880 → h = 10.
2. V = 22/7 × 196 × 10 = 6,160 cm³.

SHORTCUT

V = CSA × r ÷ 2 = 880 × 7 = 6,160.

Why it works: $\pi r^2 h = (2\pi rh) \times r/2$.

Answer: 6,160 cm³

4 CONE

A cone has base radius 21 cm and height 20 cm. Find its curved and total surface areas.

STEP BY STEP

1. $l = \sqrt{(441 + 400)} = \sqrt{841} = 29$.
2. CSA = 22/7 × 21 × 29 = 1,914 cm².
3. TSA = 22/7 × 21 × (29 + 21) = 3,300 cm².

SHORTCUT

20-21-29 is a Pythagorean triple.

Why it works: Trap: using h = 20 instead of l = 29.

Answer: 1,914 cm² and 3,300 cm²

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5 RECASTING

A metal sphere of radius 9 cm is melted and recast into cones of radius 3 cm and height 9 cm. How many cones are made?

STEP BY STEP

1. Sphere = 4/3 × π × 729 = 972π.
2. One cone = ⅓ × π × 9 × 9 = 27π.
3. Number = 972 ÷ 27 = 36.

SHORTCUT

Cancel π: (4 × 729) ÷ (9 × 9) = 36.

Why it works: The total volume of metal does not change.

Answer: 36

6 HEMISPHERE

A hemispherical bowl has an inner radius of 21 cm. How many litres can it hold?

STEP BY STEP

1. V = 2/3 × 22/7 × 21^3 = 2/3 × 22/7 × 9,261.
2. = 19,404 cm^3.
3. 1 L = 1,000 cm^3 → 19.404 L.

SHORTCUT

44 × 21 × 21 = 19,404.

Why it works: Trap: forgetting to divide cm^3 by 1,000.

Answer: 19.404 litres

7 WATER RISE

A solid sphere of radius 6 cm is dropped into a cylindrical jar of radius 8 cm partly filled with water. By how much does the water level rise?

STEP BY STEP

1. Sphere volume = 4/3 × π × 216 = 288π.
2. Base area of jar = 64π.
3. Rise = 288 ÷ 64 = 4.5 cm.

SHORTCUT

$4r^3 \div (3R^2)$ = 864 ÷ 192.

Why it works: The displaced water spreads over the jar's base.

Answer: 4.5 cm

8 EARTH DUG

A well of diameter 7 m is dug 20 m deep. The earth is spread evenly on a platform 22 m by 14 m. Find the height of the platform.

STEP BY STEP

1. Earth = 22/7 × 3.5^2 × 20 = 770 m^3.
2. Platform area = 22 × 14 = 308 m^2.
3. Height = 770 ÷ 308 = 2.5 m.

SHORTCUT

Volume dug = volume spread.

Why it works: Trap: using the diameter 7 as the radius.

Answer: 2.5 m

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9 PAINTED CUBE

A cube of side 6 cm is painted on all faces and cut into 1 cm cubes. How many small cubes have exactly one face painted?

STEP BY STEP

1. n = 6.
2. Each face has $(6 - 2)^2 = 16$ such cubes.
3. 6 faces → 96.

SHORTCUT

$6(n - 2)^2 = 6 \times 16$.

Why it works: Edge and corner cubes have more than one face painted.

Answer: 96

10 PERCENTAGE CHANGE

The radius of a cylinder is increased by 20% and its height decreased by 20%. Find the change in its volume.

STEP BY STEP

1. $V \propto r^2h$.
2. New $V = 1.2^2 \times 0.8 = 1.152$ of the old.
3. Change = +15.2%.

SHORTCUT

44% (radius twice) then −20%: 44 − 20 − 8.8 = 15.2.

Why it works: The radius counts twice because it is squared.

Answer: 15.2% increase

11 FRUSTUM

A bucket is a frustum with top radius 20 cm, bottom radius 10 cm and depth 30 cm. Find its capacity in litres.

STEP BY STEP

1. $V = \frac{1}{3} \times 22/7 \times 30 \times (400 + 200 + 100)$.
2. $= \frac{1}{3} \times 22/7 \times 30 \times 700 = 22{,}000\ cm^3$.
3. = 22 L.

SHORTCUT

$10 \times 22/7 \times 700 = 22{,}000$.

Why it works: Use $R^2 + Rr + r^2$, not just $R^2 + r^2$.

Answer: 22 litres

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5 Important exam tips

Patterns, traps and habits that save marks

Frequently asked question patterns

- Cube and cuboid volume, surface and diagonal.
- Cylinder and cone surfaces with π = 22/7.
- Spheres, hemispheres and bowls.
- Melting and recasting into smaller solids.
- Water rising and earth dug and spread.
- Painted cube counting.
- Percentage change in volume.

Common mistakes to avoid

- Using the height instead of the slant height in a cone's CSA.
- Leaving out the base or ends in total surface area.
- Taking the diameter as the radius.
- Mixing cm^3, m^3 and litres.
- Double-counting edge and corner cubes in painted-cube questions.
- Squaring instead of cubing when sides change.

Points to remember

- Cone = ⅓ cylinder.
- Sphere: $4/3\ \pi r^3$ and $4\pi r^2$.
- Hemisphere TSA = $3\pi r^2$.
- 1 m^3 = 1,000 L.
- Volume conserved in recasting.

Speed and accuracy

- Cancel π when comparing or recasting.
- Use Pythagorean triples for slant heights.
- Use $(R/r)^3$ for spheres recast into spheres.
- Learn cubes up to 15.

Preparation strategy

- Learn the formula sheet first; most questions are one formula deep.
- Practise on LearnFrenzy in order: Easy → Medium → Hard → Exam Pattern Mix → Data Sufficiency.
- Aim for 45–60 seconds per question.
- Keep an error log of unit and radius/diameter slips.
- Read the Quick Revision Sheet (next page) the night before the exam.

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6 Quick revision sheet

Everything on one page for the night before the exam

Formulas

Cuboid	lbh; $2(lb + bh + hl)$	Cuboid diagonal	$\sqrt{(l^2 + b^2 + h^2)}$
Cube	a^3; $6a^2$; $a\sqrt{3}$	Cylinder	$\pi r^2 h$; $2\pi rh$; $2\pi r(r + h)$
Hollow cylinder	$\pi h(R^2 - r^2)$	Cone slant	$\sqrt{(r^2 + h^2)}$
Cone	$\frac{1}{3}\pi r^2 h$; πrl; $\pi r(l + r)$	Frustum	$\frac{1}{3}\pi h(R^2 + Rr + r^2)$
Sphere	$(4/3)\pi r^3$; $4\pi r^2$	Hemisphere	$(2/3)\pi r^3$; $2\pi r^2$; $3\pi r^2$
Recasting	big V ÷ small V	Water rise	V ÷ base area
Edges +x%	$\times (1 + x/100)^3$		

Shortcut tricks

- Painted cube: 8, 12(n−2), 6(n−2)², (n−2)³.
- Cylinder : cone : hemisphere = 3 : 1 : 2.
- Edges k → volumes k^3.
- Pipe flow = $\pi r^2 \times$ speed.
- Cancel π in recasting.
- 20-21-29 and 7-24-25 for slants.

Must-know numbers

Cubes	6^3 216 · 7^3 343 · 8^3 512 · 9^3 729 · 11^3 1,331 · 12^3 1,728 · 15^3 3,375
Units	1 m^3 = 1,000 L · 1 L = 1,000 cm^3 · 1 m^3 = 10^6 cm^3
Base areas (π = 22/7)	r 7: 154 · r 14: 616 · r 21: 1,386 · r 3.5: 38.5

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7 A message from LearnFrenzy

For everyone preparing for placements, competitive and government exams

Keep going – you are closer than you think

Success in examinations is not just about how many hours you study. It is about how effectively you understand concepts, practise questions, and improve yourself every day.

Every formula you learn, every problem you solve, and every mistake you correct brings you one step closer to your goal.

Whether you are preparing for campus placements, competitive examinations, or government jobs, remember that consistency, confidence, and smart preparation make a real difference.

Don’t just memorize formulas. Understand the concepts, practise smart techniques, and develop the confidence to solve problems independently.

Your hard work today can create the opportunities you dream of tomorrow.

— Team LearnFrenzy

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