Cambridge (CIE) IGCSE Maths: Core

Your notes

Volume & Surface Area

Contents

- Volume
- Problem Solving with Volumes
- Surface Area

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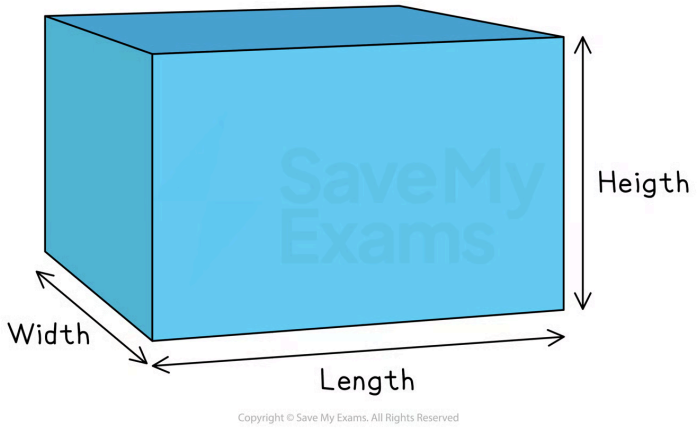
Volume

What is volume?

- The **volume** of a 3D shape is a measure of how much **space** it takes up
- You need to be able to calculate the volumes of a number of **common 3D shapes**, including:
  - Cubes and cuboids
  - Prisms
  - Pyramids
  - Cylinders
  - Spheres

How do I find the volume of a cube or a cuboid?

- A **cube** is a special **cuboid**, where the length, width and height are all of **equal length**
- A **cuboid** is another name for a rectangular-based **prism**
- To find the volume, V, of a **cube** or a **cuboid**, with length, l, width, w, and height, h, use the formula
  - $V = lwh$
  - This formula is **not** given to you in the exam



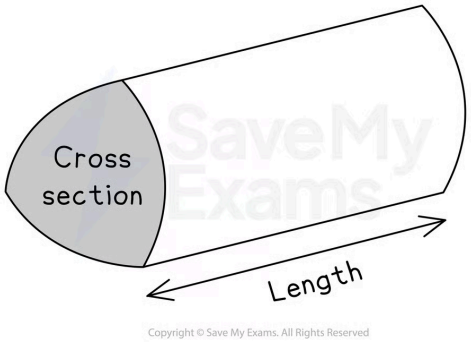
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- You will sometimes see the terms 'depth' or 'breadth' instead of 'height' or 'width'

How do I find the volume of a prism?

- A **prism** is a 3D object with a **constant cross-sectional area**

- To find the volume, V, of a **prism**, with cross-sectional area, A, and length, l, use the formula
  - $V = Al$
  - This formula is given to you in the exam

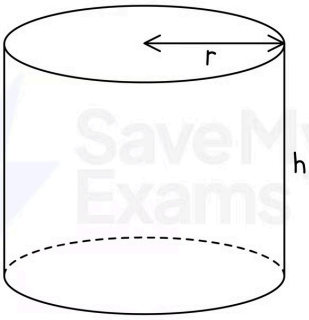


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- Note that the cross-section can be **any shape**, so as long as you know its **area** and the **length** of the prism, you can calculate its **volume**
  - If you know the **volume** and **length** of the prism, you can calculate the **area** of the **cross-section**

How do I find the volume of a cylinder?

- To calculate the volume, V, of a **cylinder** with radius, r, and height, h, use the formula
  - $V = \pi r^2 h$
  - This formula is given to you in the exam



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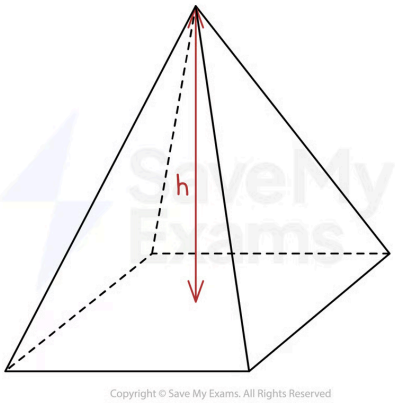
- Note that a cylinder is similar to a **prism,** its cross-section is a circle with area πr^2, and its length is h

How do I find the volume of a pyramid?

- To calculate the volume, V, of a **pyramid** with base area, A, and perpendicular height, h, use the formula

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- $V = \frac{1}{3}Ah$
  - This formula is given to you in the exam

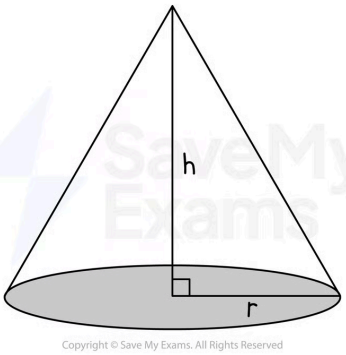


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- The height must be a line from the top of the pyramid that is **perpendicular** to the base
- The **base** of a pyramid could be a square, a rectangle or a triangle

How do I find the volume of a cone?

- To calculate the volume, V, of a **cone** with base radius, r, and perpendicular height, h, use the formula
  - $V = \frac{1}{3}\pi r^2 h$
  - This formula is given to you in the exam



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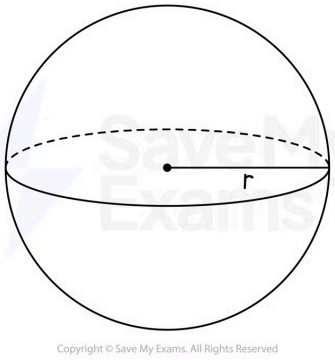
- Note that volume formula for a **cone** is similar to a **pyramid**
- The height must be a line from the top of the cone that is **perpendicular** to the base

How do I find the volume of a sphere?

- To calculate the volume, V, of a **sphere** with radius, r, use the formula

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- $V = \frac{4}{3}\pi r^3$
- This formula is given to you in your exam



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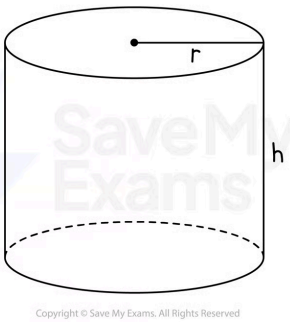
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Examiner Tips and Tricks

You only need to memorise the volume formulae for **cuboids**!

Worked Example

A cylinder is shown.



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The radius, *r*, is 8 cm and the height, *h*, is 20 cm.

Calculate the volume of the cylinder, giving your answer correct to 3 significant figures.

Answer:

A cylinder is similar to a prism but with a circular base
The volume of any prism, *V*, is its base area × height, *h*, where the base area here is for a circle, πr^2

$$V = \pi r^2 h$$

Substitute $r = 8$ and $h = 20$ into the formula

$$V = \pi \times 8^2 \times 20$$

Work out this value on a calculator

4021.238...

Round the answer to 3 significant figures

4020 cm^3



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Problem-solving with volumes

What is problem-solving?

- **Problem-solving**, usually has two key features:
  - A question is given as a **real-life scenario**
    - eg. The volume of water in a swimming pool...
  - There is usually **more than one topic of maths** you will need in order to answer the question
    - eg. Volume and money

What are common problems that involve volume?

- **Volume** is a commonly used topic of **'real-world'** maths
  - For example, a carton of juice in the shape of a cuboid, a cylindrical tin and a triangular prism chocolate box all involve volume
- Typically, the 'real-world' scenarios also have a **cost**
  - A lot of volume problems also involve **calculations with money**

How do I solve problems involving volume?

- Often the 3D object in a question will **not** be a standard cuboid, cone, sphere, etc.
  - It will likely either be:
    - A **prism** (3D shape with the same cross-section running through it)
    - A **portion** or **fraction** of a standard shape (a hemisphere for example)
    - A **compound object** (an object made up of two or more standard 3D objects)
- If the object is a **prism**, recall that the **volume of a prism** is the **cross-sectional area × its length**
  - The cross-sectional area may be a **compound 2D shape**
    - For example, an L-shape, or a combination of a rectangle and a triangle
- If the object is a **fraction** of a standard shape, consider the **"full" version** of the object and find the **appropriate fraction** of it
  - A hemisphere is half a sphere
- If the object is a **compound object**, find the volumes of the **individual** standard 3D objects and **add** them together

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- Problem solving questions could appear on either a **non-calculator paper** or a **calculator paper**

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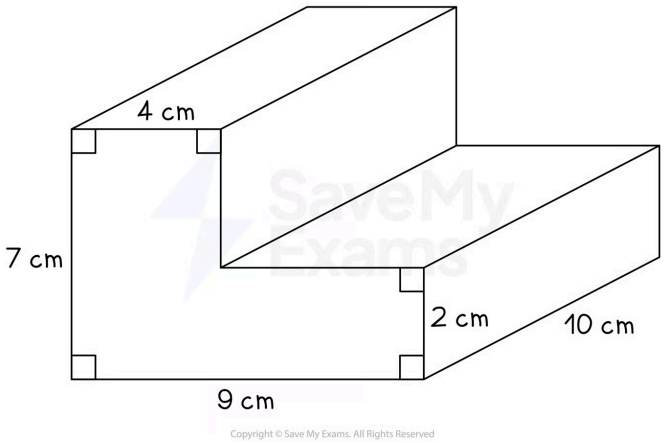
Examiner Tips and Tricks

Before you start calculating, make a quick note of your plan to tackle the question.

For example, "Find the area of the triangle and the rectangle, add together, multiply by the length".

Worked Example

The diagram shows a prism.



Work out the volume of the prism.

Answer:

The volume is the area of the cross section × length (10 cm)
Find the area by splitting into a 7 × 4 and a (9 - 4) × 2 rectangle (or a 9 × 2 and a (7 - 2) × 4 rectangle)

$$7 \times 4 + (9 - 4) \times 2 = 38 \text{ cm}^2$$

Find the volume (by multiplying 38 by 10)

$$38 \times 10$$

380 cm^3

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Surface Area

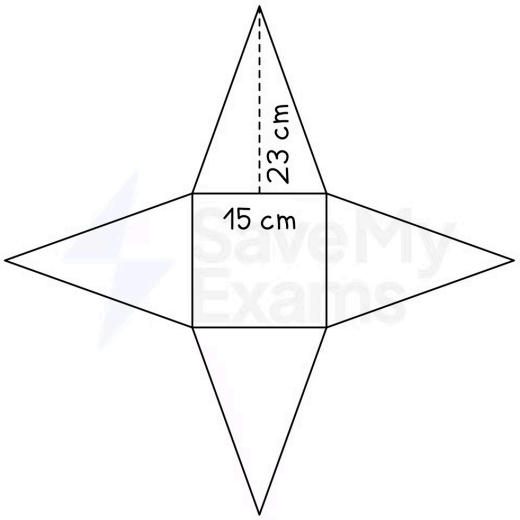
What is surface area?

- The **surface area** of a 3D object is the **sum of the areas of all the faces** that make up the shape
  - Area is a 2D idea being applied into a 3D situation
  - A face is one of the flat or curved **surfaces** that make up a 3D object

How do I find the surface area of cubes, cuboids, pyramids, and prisms?

- In cubes, cuboids, polygonal-based pyramids, and polygonal-based prisms (ie. pyramids and prisms whose bases have straight sides), **all the faces are flat**
- The **surface area** is found by
  - calculating the area of each individual flat face
  - adding these areas together
- You should remember the formula for the **area of a rectangle**, but you are given the **area of a triangle** in your exam
- When calculating surface area, it can be helpful to **draw a 2D net for the 3D shape** in question
  - For example, consider a square-based pyramid where the top of the pyramid is directly above the centre of the base
    - Its net will consist of a square base and four identical isosceles triangular faces
    - Calculate the area of a square and the area of each triangle then add them together

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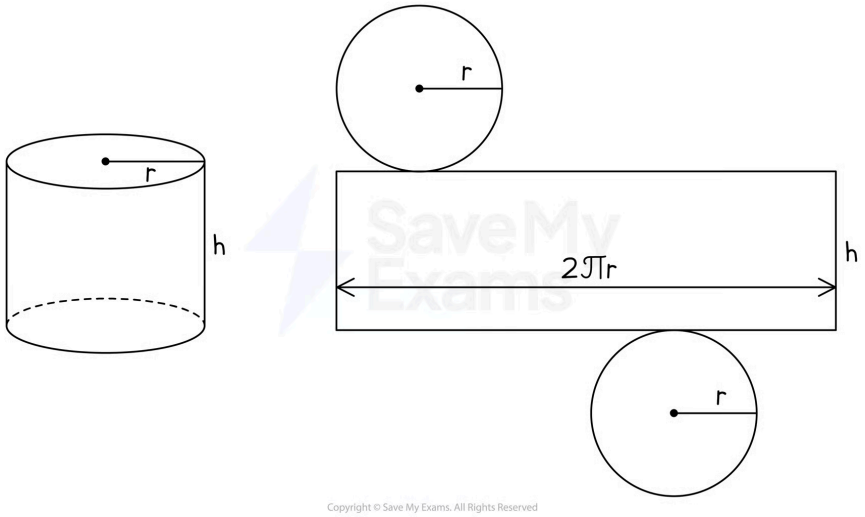


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How do I find the surface area of a cylinder?

- A cylinder has **two flat surfaces** (the top and the base) and **one curved surface**
- The **net** of a cylinder consists of **two circles** and a **rectangle**



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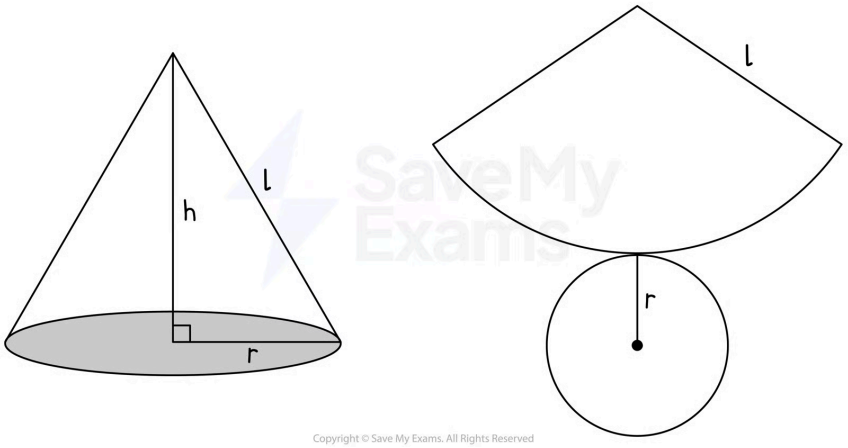
- The **curved surface area** of a cylinder, A, with base radius, r, and height, h, is therefore given by
  - $A = 2\pi r h$
  - This formula is given to you in the exam
- The **total surface area** of a cylinder, A_{Total}, can be found using the formula
  - $A_{Total} = 2\pi r h + 2\pi r^2$
  - This formula is **not** given to you in the exam

How do I find the surface area of a cone?



Your notes

- A cone has **one flat surface** (the base) and **one curved surface**
- The net of a cone, with radius, r, perpendicular height, h, and sloping edge, (slant height), l, consists of
  - A **circular base**
  - A **sector** with radius, l, and an arc length equal to the circumference of the base

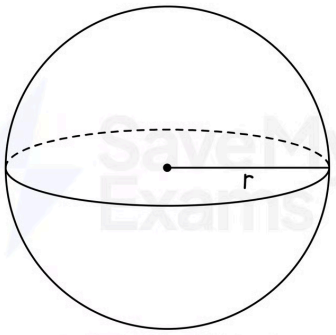


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- The **curved surface area** of a cone, A, with radius, r, perpendicular height, h, and sloping edge, l, can be found using the formula
  - $A = \pi r l$
  - This formula is given to you in the exam
- The **total surface area** of a cone, A_{Total}, can be found using the formula
- $A_{Total} = \pi r l + \pi r^2$
- This formula is **not** given to you in the exam

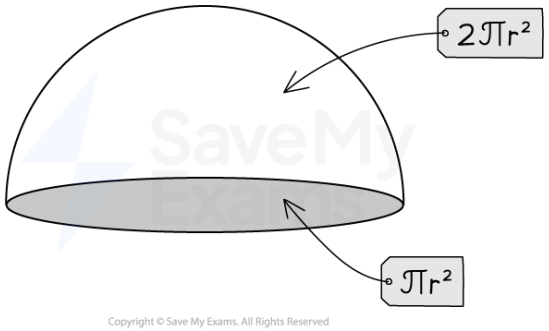
How do I find the surface area of a sphere?

- A sphere has a **single curved surface**



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- The surface area of a sphere, A, with radius, r, can be found using the formula
  - $A = 4\pi r^2$
  - This formula is given to you in the exam
- A **hemisphere** has half the curved surface area of a sphere and the flat circular base



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- The surface area of a hemisphere, A, with radius, r, can be found using the formula
  - $A = 2\pi r^2 + \pi r^2$
  - This formula is **not** given to you in the exam

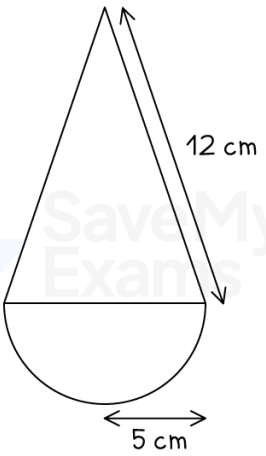
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Examiner Tips and Tricks

- The **curved surface area** for a cylinder, cone and sphere are given to you in the exam
  - Read the question carefully, you may need to add additional areas, e.g. a base
  - Make you are confident in calculating the areas of rectangles, circles and triangles

Worked Example

A toy consists of a cone of radius 5 cm and slant height 12 cm placed on top of a hemisphere with the same radius. Find the total surface area of the toy. Give your answer to 3 significant figures.



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Answer:

Calculate the curved surface area of the cone using the formula, $A = \pi r l$

$$A_{cone} = \pi \times 5 \times 12 = 60\pi$$

Calculate the curved surface area of a hemisphere using the formula for the curved surface area of a sphere, $A = 4\pi r^2$ and dividing it by 2

$$A_{hemisphere} = \frac{4\pi \times 5^2}{2} = 50\pi$$

Add the two areas together to find the total surface area of the toy

$$A_{Totsl} = 60\pi + 50\pi = 110\pi$$

Evaluate on your calc and round to 3 significant figures

$$A_{Total} = 345.57519...$$

346 cm^2 (3 s.f.)