

Volume and Measurement Conversion: math lesson, Grade 5 – download the PDF

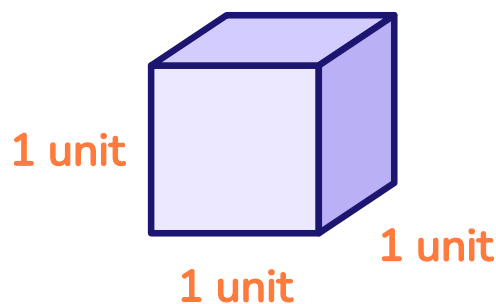
How much juice fits in a carton? How many boxes fit in a crate? How many inches are in a mile? In this chapter you will learn how to measure the space inside a solid with **volume**, and how to switch between measurement units like a pro.

1. Unit cubes and volume

A flat shape has *area*. A solid shape, like a box or a block, takes up space in three directions, and that space is its *volume*. To measure it, we need a small standard piece to count with.

D Volume and unit cube

A **unit cube** is a cube whose edges are each 1 unit long. It has a volume of **1 cubic unit**. The **volume** of a solid is the number of unit cubes needed to fill it with no gaps and no overlaps.



Volume is written in *cubic units*: cubic centimeters (cm^3), cubic inches (in^3), cubic feet (ft^3) or cubic meters (m^3).

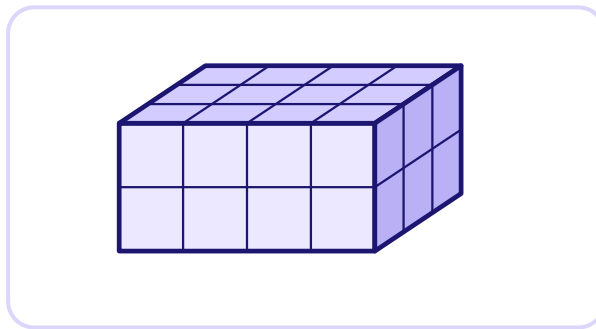


Careful with units

Area is measured in *square* units (flat), volume in *cubic* units (solid). A box that holds 30 cubes has a volume of 30 cubic units, not 30 square units.

2. Counting cubes to find volume

You do not have to count cubes one by one. Build the prism in **layers**. Each layer is a flat rectangle of cubes that has the same shape as the bottom of the prism.



In this prism, one layer has 4 cubes along each row and 3 rows, so a layer holds $4 \times 3 = 12$ cubes. There are 2 layers, so the prism holds $12 \times 2 = 24$ cubes. Its volume is 24 cubic units.



Example 1: counting by layers

A prism is 5 cubes long, 2 cubes wide and 3 layers tall.

One layer: $5 \times 2 = 10$ cubes.

Three layers: $10 \times 3 = 30$ cubes.

The volume is 30 cubic units.

Volume is *additive*: if you cut a solid into pieces that do not overlap, the volume of the whole is the sum of the volumes of the pieces. You will use this idea again in Part 5.

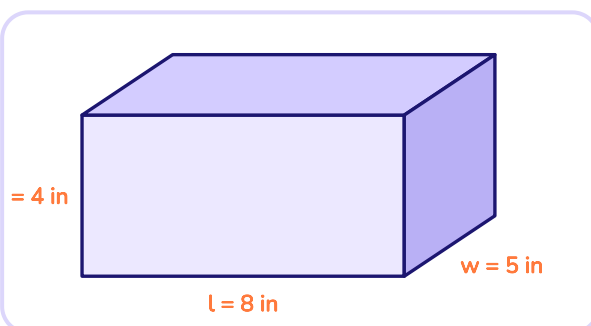
3. The formula $V = l \times w \times h$

Counting layers always follows the same pattern: the number of cubes in one layer is length times width, and the number of layers is the height. That gives a formula that works for any measurements, even when you cannot draw every cube.

P Volume of a rectangular prism

$$V = l \times w \times h$$

where l is the length, w the width and h the height, all in the same unit. A cube with edge s has $V = s \times s \times s$.



E Example 2: a toy chest

A toy chest is 4 ft long, 2 ft wide and 3 ft tall.

$$V = 4 \times 2 \times 3 = 24 \text{ ft}^3$$

The chest holds 24 cubic feet.

M**Finding a missing dimension**

1. Write the formula with the numbers you know, for example $60 = 5 \times 4 \times h$.
2. Multiply the known dimensions: $5 \times 4 = 20$, so $60 = 20 \times h$.
3. Divide: $h = 60 \div 20 = 3$.
4. Check by multiplying again and write the unit in your answer.

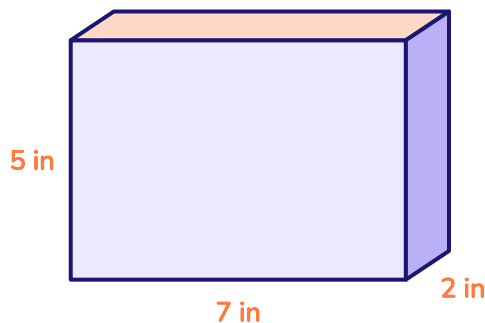
4. Volume as $B \times h$

The product $l \times w$ is the area of the rectangle at the bottom of the prism. We call this area the **base area** and write it B . Every layer has area B , and the height tells you how many layers are stacked.

P**Volume with the base area**

$$V = B \times h$$

B is the area of the base (in square units) and h is the height, measured at a right angle to the base (in linear units). Since $B = l \times w$, this is the same formula as before.



E**Example 3: a cereal box**

The base of a cereal box is 7 in by 2 in, and the box is 5 in tall.

Base area: $B = 7 \times 2 = 14 \text{ in}^2$.

Volume: $V = 14 \times 5 = 70 \text{ in}^3$.

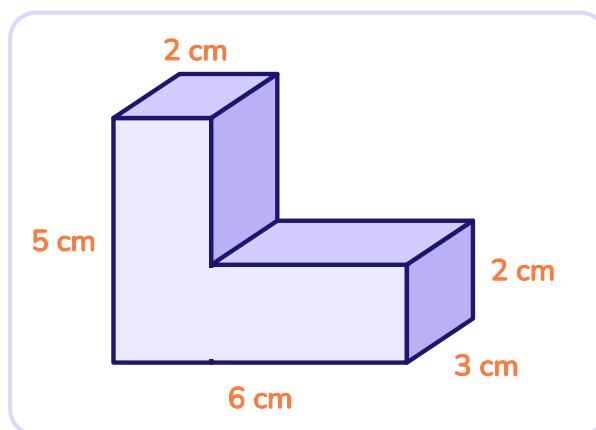
Any face can serve as the base, as long as the height is the edge that is perpendicular to it.

5. Volume of composite solids

A **composite solid** is made of two or more rectangular prisms joined together. Because volume is additive, you can find the volume of each piece and add.

M**Composite solids**

1. Cut the solid into rectangular prisms that do not overlap.
2. Find the length, width and height of each piece. Subtract to find hidden measurements.
3. Compute the volume of each piece.
4. Add the volumes. Write the cubic unit.



E**Example 4: an L-shaped solid**

The solid has a tall part (2 cm long, 3 cm wide, 5 cm high) and a low part (4 cm long, 3 cm wide, 2 cm high).

Tall part: $2 \times 3 \times 5 = 30 \text{ cm}^3$.

Low part: $4 \times 3 \times 2 = 24 \text{ cm}^3$.

Total: $30 + 24 = 54 \text{ cm}^3$.

Check by subtracting: a full block $6 \times 3 \times 5 = 90 \text{ cm}^3$ minus the missing corner $4 \times 3 \times 3 = 36 \text{ cm}^3$ gives 54 cm^3 again.

6. Converting customary units

The same object can be measured with different units. To compare or combine measurements you must convert them to the same unit. Here are the main customary relationships:

Measure	Equivalents
Length	$1 \text{ ft} = 12 \text{ in}$ $1 \text{ yd} = 3 \text{ ft}$ $1 \text{ mi} = 5,280 \text{ ft}$
Capacity	$1 \text{ c} = 8 \text{ fl oz}$ $1 \text{ pt} = 2 \text{ c}$ $1 \text{ qt} = 2 \text{ pt}$ $1 \text{ gal} = 4 \text{ qt}$
Weight	$1 \text{ lb} = 16 \text{ oz}$ $1 \text{ ton} = 2,000 \text{ lb}$

M**Converting**

- Big unit to small unit: **multiply**, because you need more of the smaller pieces.
- Small unit to big unit: **divide**, because you need fewer of the bigger pieces.

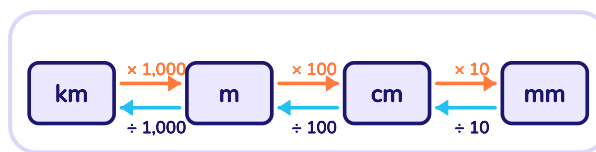
E**Example 5: gallons and inches**

How many cups are in 5 gallons? One gallon is 4 quarts, so 5 gallons is $5 \times 4 = 20$ quarts. Then $20 \times 2 = 40$ pints and $40 \times 2 = 80$ cups.

How many feet are in 90 inches? $90 \div 12 = 7.5$, so 90 in = 7.5 ft, or 7 ft 6 in.

7. Converting metric units

The metric system is built on powers of ten, so converting only moves the decimal point.



Other relationships: 1 kg = 1,000 g, 1 g = 1,000 mg and 1 L = 1,000 mL. Going down the chart you multiply by 10, 100 or 1,000. Going up you divide.

E**Example 6: moving the decimal point**

$$3.6 \text{ m} = 3.6 \times 100 = 360 \text{ cm}$$

$$4,250 \text{ mL} = 4,250 \div 1,000 = 4.25 \text{ L}$$

$$0.8 \text{ km} = 0.8 \times 1,000 = 800 \text{ m}$$

!**Zyro's tip**

On my home planet we measure everything in glorps, and it is a mess! Here on Earth, remember: more pieces means multiply, fewer pieces means divide, and always say the unit out loud.

8. Measurement word problems

Word problems often mix volume with conversions. Read slowly, draw a quick sketch, underline the units, and decide which step comes first.

P Volume and capacity

A cube that is 1 cm on each side holds exactly 1 milliliter of liquid: $1 \text{ cm}^3 = 1 \text{ mL}$. So a container with a volume of $1,000 \text{ cm}^3$ holds 1,000 mL, which is 1 L.

E Example 7: an aquarium

An aquarium is 40 cm long, 25 cm wide and 20 cm tall.

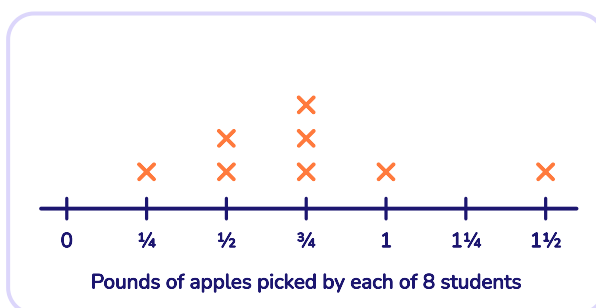
Volume: $40 \times 25 \times 20 = 20,000 \text{ cm}^3$.

Capacity: $20,000 \text{ cm}^3 = 20,000 \text{ mL} = 20 \text{ L}$.

If a bucket holds 4 L, you need $20 \div 4 = 5$ buckets to fill it.

9. Line plots with fractions

A **line plot** shows data above a number line. Each $\times$ stands for one measurement. When the data are fractions, the number line is marked in equal fractional steps, such as fourths or eighths.



The line plot shows the weight of apples picked by 8 students. Three students picked $\frac{3}{4}$ lb, and the biggest basket weighs $1\frac{1}{2}$ lb. The range is $1\frac{1}{2} - \frac{1}{4} = 1\frac{1}{4}$ lb.

E**Example 8: sharing equally**

Add all the data: $\frac{1}{4} + \frac{2}{4} + \frac{2}{4} + \frac{3}{4} + \frac{3}{4} + \frac{3}{4} + \frac{4}{4} + \frac{6}{4} = \frac{24}{4} = 6$ lb.

If the 8 students share the apples equally, each gets $6 \div 8 = \frac{6}{8} = \frac{3}{4}$ lb.

Key takeaways

- Volume counts unit cubes and is measured in cubic units.
- $V = l \times w \times h$ and $V = B \times h$ both work for rectangular prisms.
- For a composite solid, split it into prisms and add their volumes.
- Big unit to small unit: multiply. Small unit to big unit: divide.
- Customary: 12 in = 1 ft, 3 ft = 1 yd, 4 qt = 1 gal, 16 oz = 1 lb. Metric: powers of ten.
- $1 \text{ cm}^3 = 1 \text{ mL}$, and $1,000 \text{ mL} = 1 \text{ L}$.
- On a line plot, each $\times$ is one data value; add the values and divide to share equally.

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