

2.8.7: Converting Units of Volume

You may use a calculator throughout this module.



Just as we saw with area, converting between units of volume requires us to be careful because cubic units behave differently than linear units.

Quantities of mulch, dirt, or gravel are often measured by the cubic yard. How many cubic feet are in one cubic yard?

1 yard = 3 feet, so we can divide the length into three sections, the width into three sections, and the height into three sections to convert all three dimensions of the cube from yards to feet. This forms a 3 by 3 by 3 cube, which shows us that 1 cubic yard equals 27 cubic feet. The linear conversion ratio of 1 to 3 means that the conversion ratio for the volumes is 1 to 3^3 , or 1 to 27.

Here's another way to think about it without a diagram: $1 \text{ yd} = 3 \text{ ft}$, so $(1 \text{ yd})^3 = (3 \text{ ft})^3$. To remove the parentheses, we must cube the number *and* cube the units: $(3 \text{ ft})^3 = 3^3 \text{ ft}^3 = 27 \text{ ft}^3$.

More generally, we need to **cube** the linear conversion factors when converting units of volume. If the linear units have a ratio of 1 to n , the cubic units will have a ratio of 1 to n^3 .

? Exercises 2.8.7.1

1. Determine the number of cubic inches in 1 cubic foot.
2. Determine the number of cubic inches in 1 cubic yard.
3. Determine the number of cubic millimeters in 1 cubic centimeter.
4. Determine the number of cubic centimeters in 1 cubic meter.

Answer

1. $1,728 \text{ in}^3$
2. $46,656 \text{ in}^3$
3. $1,000 \text{ mm}^3$
4. $1,000,000 \text{ cm}^3$

U.S. System: Converting Measurements of Volume

$$1 \text{ ft}^3 = 1,728 \text{ in}^3$$

$$1 \text{ yd}^3 = 27 \text{ ft}^3$$

$$1 \text{ yd}^3 = 46,656 \text{ in}^3$$

? Exercises 2.8.7.1

5. True story: A friend at the National Guard base gave us three long wooden crates to use as raised planting beds. (The crates probably carried some kind of weapons or ammunition, but our friend wouldn't say.) Henry, who was taking geometry in high school, was asked to measure the crates and figure out how much soil we needed. The inside dimensions of each crate were 112 inches long, 14 inches wide, and 14 inches deep. We wanted to fill them most of the way full with soil, leaving about 4 inches empty at the top. How many cubic yards of soil did we need to order from the supplier?

6. True story, continued: I decided to check our answer and did a rough estimate by rounding each dimension to the nearest foot, then figuring out the volume from there. Did this give the same result?

Answer

5. the result is very close to 1 cubic yard: $(112 \text{ in} \cdot 14 \text{ in} \cdot 10 \text{ in}) \cdot 3 \text{ crates} = 47,040 \text{ in}^3 \approx 1.01 \text{ yd}^3$

6. this estimate is also 1 cubic yard: $(9 \text{ ft} \cdot 1 \text{ ft} \cdot 1 \text{ ft}) \cdot 3 \text{ crates} = 27 \text{ ft}^3 = 1 \text{ yd}^3$

We can convert between units of volume and liquid capacity. As you might expect, the numbers are messy in the U.S. system.

$$1 \text{ fl oz} \approx 1.805 \text{ in}^3 \leftrightarrow 1 \text{ in}^3 \approx 0.554 \text{ fl oz}$$

$$1 \text{ ft}^3 \approx 7.48 \text{ gal} \leftrightarrow 1 \text{ gal} \approx 0.1337 \text{ ft}^3$$

? Exercises 2.8.7.1



7. A wading pool has a diameter of roughly 5 feet and a depth of 6 inches. How many gallons of water are required to fill it about 80% of the way full?

8. A standard U.S. soda pop can has a diameter of $2\frac{1}{2}$ inches and a height of $4\frac{3}{4}$ inches. Verify that the can is able to hold 12 fluid ounces of liquid.

Answer

7. around 60 gallons

8. yes, the can is able to hold 12 fluid ounces; the can's volume is roughly 23.3 cubic inches \approx 12.9 fluid ounces.

Metric System: Converting Measurements of Volume

$$1 \text{ cm}^3 = 1 \text{ cc} = 1 \text{ mL}$$

$$1 \text{ cm}^3 = 1,000 \text{ mm}^3$$

$$1 \text{ m}^3 = 1,000,000 \text{ cm}^3$$

$$1 \text{ L} = 1,000 \text{ cm}^3$$

$$1 \text{ m}^3 = 1,000 \text{ L}$$

It's no surprise that the metric conversion ratios are all powers of 10.

? Exercise 2.8.7.1

9. A can of Perrier mineral water has a diameter of 5.6 cm and a height of 14.7 cm. Verify that the can is able to hold 330 milliliters of liquid.

Answer

yes, the can is able to hold 330 milliliters; the can's volume is roughly 362 cubic centimeters, which is equivalent to 362 milliliters.

Both Systems: Converting Measurements of Volume

Converting between the U.S. and metric systems will of course involve messy decimal values. For example, because $1 \text{ in} = 2.54 \text{ cm}$, we can cube both numbers and find that $1 \text{ in}^3 = (2.54 \text{ cm})^3 \approx 16.387 \text{ cm}^3$. The conversions are rounded to three or four significant figures in the table below.

$$\begin{aligned} 1 \text{ in}^3 &\approx 16.39 \text{ cm}^3 \leftrightarrow 1 \text{ cm}^3 \approx 0.0612 \text{ in}^3 \\ 1 \text{ ft}^3 &\approx 0.0284 \text{ m}^3 \leftrightarrow 1 \text{ m}^3 \approx 35.29 \text{ ft}^3 \\ 1 \text{ yd}^3 &\approx 0.7646 \text{ m}^3 \leftrightarrow 1 \text{ m}^3 \approx 1.308 \text{ yd}^3 \end{aligned}$$

? Exercises 2.8.7.1



10. A “two yard” dumpster has a volume of 2 cubic yards. Convert this to cubic meters.
11. Convert 240 in^3 to cm^3 .
12. Convert 500 cm^3 to in^3 .
13. Convert $1,000 \text{ ft}^3$ to m^3 .
14. Convert 45 m^3 to yd^3 .

Answer

10. 1.53 m^3
11. $3,930 \text{ cm}^3$
12. 30.5 in^3
13. 28.3 m^3
14. 59 yd^3

Density

The density of a material is its weight per volume such as pounds per cubic foot, or mass per volume such as grams per cubic centimeter. Multiplying the volume of an object by its density will give its weight or mass.

? Exercises 2.8.7.1

15. The standard size of a gold bar in the U.S. Federal Reserve is 7 inches by $3\frac{5}{8}$ inches by $1\frac{3}{4}$ inches.^[1] The density of gold is 0.698 pounds per per cubic inch. How much does one gold bar weigh?
16. A cylindrical iron bar has a diameter of 3.0 centimeters and a length of 20.0 centimeters. The density of iron is 7.87 grams per cubic centimeter. What is the bar’s mass, in kilograms?

Answer

15. 31 lb
16. 1.1 kg

Volumes of Similar Solids

Earlier in this module, it was stated that if the linear units have a ratio of 1 to n , the cubic units will have a ratio of 1 to n^3 . This applies to similar solids as well.

If the linear dimensions of two similar solids have a ratio of 1 to n , then the volumes will have a ratio of 1 to n^3 .

We'll verify this in the following exercises.

? Exercises 2.8.7.1



A table tennis (ping pong) ball has a diameter of 4 centimeters. A wiffle® ball has a diameter twice that of a table tennis ball.

17. Determine the volume of the wiffle® ball.
18. Determine the volume of the table tennis ball.
19. What is the ratio of the volumes of the two balls?

Rectangular solid A has dimensions 3 inches by 4 inches by 5 inches. Rectangular solid B has dimensions triple those of A 's.

20. Determine the volume of the larger solid, B .
21. Determine the volume of the smaller solid, A .
22. What is the ratio of the volumes of the two solids?

Answer

17. 268 cm^3
18. 33.5 cm^3
19. 8 to 1
20. $1,620 \text{ in}^3$
21. 60 in^3
22. 27 to 1

1. <https://www.usmint.gov/about/mint-tours-facilities/fort-knox> ↵

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