



# 1.6 Density, Specific Gravity, and Specific Volume

**GOAL** To review the definitions of specific gravity, density, and specific volume and medical math calculations using these principles.

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## OBJECTIVES

This chapter equips students to:

- Define gram, density, specific gravity, and specific volume
  - Given a weight and volume of a substance, calculate its density
  - Given a weight and volume of a substance, calculate its specific gravity using water as the standard
  - Given a weight and volume of a substance, calculate its specific volume using water as the standard
  - Given a specific gravity of a substance, calculate its specific volume
  - Determine if substance is heavier or lighter than water using its specific gravity or specific volume
  - Given the volume and specific gravity of a liquid, calculate its weight
  - Given the weight and specific gravity of a liquid, calculate its volume
  - Calculate the amount of an ingredient required for a drug product using density, specific gravity, or specific volume
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## KEYWORDS

Cubic centimeter (cc)  
Density  
Gram  
Mass  
Specific gravity  
Specific volume  
Volume  
Weight

## Importance for Medical Math and Clinical Practice

The *weight* of a substance has been used in previous chapters to illustrate medical math's importance for understanding how to prepare and dose drugs. The idea that weight expresses the amount of something probably existed well before the dates of any written records known today. It is intuitive that an increasing number of like objects should have an increasing weight. Although there are variations in the definition of weight, *the mass of a substance acted on by gravity* is the definition useful for our purposes. *Weight* is the force acting on the pans of a prescription balance that is measuring grams or milligrams of a drug. *Mass* describes the amount of matter in a substance. Mass depends on the size of atoms making up a substance, the compactness of those atoms within the substance, and various forces of interaction occurring among those atoms. The words *weight* and *mass* are not interchangeable because the same mass of a substance measured by weight on Earth would be different if it were measured by weight on Earth's moon. The difference in gravitational force makes the difference. Mass, then, is a fundamental property of substances.

So, weighing an amount of drug to include in a formulation for a product or to prepare a single dose to administer to a patient is a pretty basic concept. There are times, however, when measuring the amount of a substance becomes very difficult. Although most medical practitioners do not work with large-scale preparation, measuring several gallons of a liquid

substance needed for a drug product may be easier by weighing the liquid rather than by actually measuring its *volume*. Also, in clinical practice, the relative weight of a patient's urine may be an important part of a diagnostic workup. And, when preparing complex intravenous solutions, devices called *gravimetric pumps* (pumps that determine the volume of liquid delivered by noting the weight change in a quantity of liquid) can be very useful in the compounding process. For these reasons, this chapter considers the medical math of *density*, *specific gravity*, and *specific volume* as they relate to the mass of substances. The unit of measure for mass is the *gram* because, for the practical purposes of medical math, weighing of drugs is done under a relatively constant force of gravity.

## Density

- Mass per unit volume of a substance; expressed as grams per cubic centimeter (g/cc).
- Mass is a denominate number, having both a quantity and units.

Calculated by dividing mass by volume:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

- Gram (g): defined as the mass of 1 cubic centimeter (cc) of water at 4°C (remember that 1 mL is equivalent to 1 cc for our calculation purposes, although there is a small difference in actual volumes).

Density of water = 1 g/mL

- **Example:** What is the density of sorbitol solution if 50 mL weighs 80 g?

$$\text{Density} = \frac{80 \text{ g}}{50 \text{ mL}} = 1.6 \text{ g/mL}$$

## Specific Gravity

- The ratio of the weight of a substance to the weight of an equal volume of a substance used as the standard when both temperatures are equal or the temperature of each is known.
- Expressed decimally as an abstract number; it has no units since the calculation cancels them.
- Water is the usual standard for calculating the specific gravities of solids and liquids.

Calculated by dividing the weight of a substance by the weight of an equal volume of water:

$$\text{Specific gravity} = \frac{\text{Weight of a substance}}{\text{Weight of equal volume of water}}$$