Problem of the Day
2014.Sept.26

Discussion

Since most of what we "calculate" in wastewater math problems is converting from one set of units to another, it should be crystal clear why carrying units through all the problems we do is so important. In WWTT's Operator Certification and Math Review classes, designed to help operators pass their **State of California Wastewater Treatment Plant Certification Exams**, it is doggedly emphasized that units, in most cases, tell us how to set up a problem, whether to multiply or divide by a specific conversion factor, and, even, do algebra for us without us knowing! For this reason, operators should understand that very few numbers that we deal with are **without** units. Three numbers that do **not** have units are pi, specific gravity and a percent expressed as a decimal.

There are several conversion factors that are very well known to operators. Two of the most commonly used are:

$$\frac{7.48\text{ gal}}{\text{ft}^3} \quad \text{or} \quad \frac{\text{ft}^3}{7.48\text{ gal}}$$

and

$$\frac{8.34\text{ lb}}{\text{gal}} \quad \text{or} \quad \frac{\text{gal}}{8.34\text{ lb}}$$

The second of these is not really a conversion factor but the **density of water, a physical constant**. For example, the density of gasoline is different than the density of water, but 7.48 gal of gasoline is still equivalent to 1 ft^3 of gasoline. Indeed, 1 ft^3 of anything will contain 7.48 gal.

Just remember to always carrying units through each and every problem.

Problem

Today's problem is very straightforward.

Problem of the Day: A 16-ft high tank has a diameter of 10 ft. It is filled with water to a depth of 14.5 ft. Ignoring the weight of the empty tank, how many pounds does it weigh?

Solution

From the tank's description, it is obviously an upright, cylindrical tank. As discussed in yesterday's Problem of the Day, the volume of any channel, tank, reservoir, pond, even an ocean, is equal to the surface area times the depth. The surface area in this problem is that of circle with a diameter of 10 ft.

Many operators get confused between finding the **circumference** of a circle and the **area** of a circle. The equations for both contain pi (π) and diameter (d). The big difference is that circumference (C) is in units of length, whereas area (A) is in units of length x length. The equations start out the same, but area includes the additional factor, d/4, as shown.

$$C = \pi \times d$$

$$A = \frac{\pi \times d \;\Big|\; d}{\;\Big|\; 4}$$

With the additional factor, the equation for area multiplies out to:

$$A = \frac{\pi \times d^2}{4}$$

Numerically, π is approximately equal to 3.14, and π/4 is approximately equal to 0.785, so the two equations become:

$$C = 3.14 \times d$$

$$A = 0.785 \times d^2$$

Obviously, these are very different equations that operators must keep straight.

The problem asks to calculate the weight of the water in pounds, so the railroad track is started by entering these units between heavy vertical lines followed by an equals sign and the blank track.

Problem of the Day: A 16-ft high tank has a diameter of 10 ft. It is filled with water to a depth of 14.5 ft. Ignoring the weight of the empty tank, how many pounds does it weigh?

$$\Big|\; \text{lb} \;\Big| = \underline{\qquad\qquad\qquad\qquad\qquad\qquad}$$

The units, lb, are required in the answer, but none of the information given in the problem has units of pounds. In order to start the railroad track with lb, therefore, the density of water is entered.

Problem of the Day: A 16-ft high tank has a diameter of 10 ft. It is filled with water to a depth of 14.5 ft. Ignoring the weight of the empty tank, how many pounds does it weigh?

$$\Big|\; \text{lb} \;\Big| = \frac{8.34 \text{ lb}}{\text{gal}} \;\Big|\; \underline{\qquad\qquad\qquad\qquad\qquad\qquad}$$

There is no information in the problem statement in units of gal either, so this is canceled using the conversion factor, 7.48 gal/ft^3, entered so the units, gal, are on opposite sides of the railroad track.

Problem of the Day: A 16-ft high tank has a diameter of 10 ft. It is filled with water to a depth of 14.5 ft. Ignoring the weight of the empty tank, how many pounds does it weigh?

$$\text{lb} = \frac{8.34\ \text{lb}}{\cancel{\text{gal}}} \cdot \frac{7.48\ \cancel{\text{gal}}}{\text{ft}^3} \cdot \frac{\quad}{\quad}$$

The ft^3 in the denominator of the railroad track now sheds light on what "math" needs to be done to solve this problem: the volume of water in the tank, in ft^3, must be calculated, which, as discussed, is equal to the surface area (that is, the area of the 10-ft circle) times the **depth of water** (14.5 ft).

Problem of the Day: A 16-ft high tank has a diameter of 10 ft. It is filled with water to a depth of 14.5 ft. Ignoring the weight of the empty tank, how many pounds does it weigh?

$$\text{lb} = \frac{8.34\ \text{lb}}{\cancel{\text{gal}}} \cdot \frac{7.48\ \cancel{\text{gal}}}{\cancel{\text{ft}^3}} \cdot \frac{0.785}{} \cdot \frac{10\ \cancel{\text{ft}}}{} \cdot \frac{10\ \cancel{\text{ft}}}{} \cdot \frac{14.5\ \cancel{\text{ft}}}{}$$

And the arithmetic gives the answer:

8.34 x 7.48 x 0.785 x 10 x 10 x 14.5 = <u>71,008 lb</u>.

Notice in the railroad track instead of "diameter squared," d^2, the diameter of the circle, 10 ft, is entered twice.