Problem of the Day

2015.Dec.22

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A chemical storage tank is 25 ft tall and has a diameter of 15 ft. The depth of water in the tank is 15.5 ft. How many pounds of water are in the tank?

Introduction

This is the same problem as yesterday's Problem of the Day except we are told what liquid is in the tank (water) and asked to calculate the pounds of water in the tank. Do we need to add the weight of the tank into our calculation? No, because the question specifically asks for how many pounds of water are in the tank.

Solution

The question asks to calculate lb. These units, as always, are entered between heavy vertical lines followed by an equals sign and the blank solution bridge.

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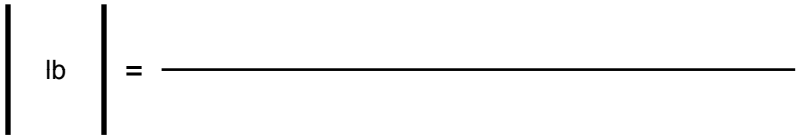

I have recently been working with an operator who struggles terribly with "word problems." A lot of people do. He was telling me it's hard for him to even extract the "givens" out of the problem statement. I suggest that you underline each **number**, with units, given in the problem statement and any "descriptors" that go with each number. So today's problem might look like this with underlines:

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Since these are math problems, the numbers in the problem statement are what are important to us that's why we underline them. We all know problems sometimes give us numbers we don't need, but don't worry about picking up what you need and don't need as you list the information given in the problem statement. Each of the numbers has to be described in our list of givens. Here I say describe them anyway you want to but take as much out of the problem statement descriptors that you've underlined as you can. This is what I see:

1. Tank height (i.e., "tall") = 25 ft
2. Tank diameter = 15 ft
3. Depth of water = 15.5 ft

Again, what I see in this list is a lot of 5s and ft. One of the strategies used by exam question authors is to include numbers that are easily confused, like using numbers with a lot of 5s. Be diligent and keep the numbers straight in your head and on your paper.

Unlike yesterday's problem, today we're asked to calculate weight (pounds) of liquid in the tank. When doing water and wastewater math problems, we are constantly switching back and forth between gallons and pounds. When it comes to liquids, the physical characteristic that allows us to calculate pounds from gallons and vice versa is the density.

The density of the liquid in the tank, however, isn't given. The good news: **We all know the density of water: 8.34 lb/gal**.

The density of liquid water is not constant. It varies a little with temperature. In fact, liquid water is its densest at 4°C. As water cools below 4C it expands. When it freezes at 0C, the density of water, now ice, decreases by about 9%. This is why ice cubes float and why ponds and lakes freeze from the top down. If this were not the case, ponds and lakes would freeze from the bottom up and aquatic life could not survive winter. There are only a few substances that expand on freezing. Water is amazing stuff! Still, we have to add something to our list:

4. Density of water = 8.34 lb/gal

It annoys me that many certification list “8.34 lb/gal” as a conversion factor or “1 gallon = 8.34 pounds” as an equivalent (e.g., http://www.waterboards.ca.gov/water_issues/programs/operator_certification/docs/opcert_formulasheet.pdf, http://www.abccert.org/pdf_docs/abcwwtfctable.pdf). Don’t forget: **8.34 lb/gal is not a conversion factor**. It is a physical characteristic of water called “**density**.” The way to keep it straight in your head is to **always** include the units: 8.34 pounds per gallon or 8.34 lb/gal.

As we have done many times before, we start the solution bridge with the units needed in the numerator of the answer, lb. The only place the units lb shows up is in the numerator of the density (No. 4), so that’s what we use to start the solution bridge giving us the units we need in the answer as shown in bold.

$$\left| \textbf{lb} \right| = \left| \frac{8.34\ \textbf{lb}}{\text{gal}} \right|$$

With this simple entry we now have the units in the solution bridge needed in the answer. Proceeding, we cancel unwanted units until only lb remain. We have to cancel gal but there is nothing in our list that has gal. All those ft in our list should give us a hint that we can calculate volume in ft^3 . We all know the conversion factor that allows us to go between gal and ft^3 and vice versa (truly a conversion factor):

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

We use this to cancel gal on the solution bridge.

$$\left| \textbf{lb} \right| = \left| \frac{8.34\ \textbf{lb} \quad 7.48\ \cancel{\text{gal}}}{\cancel{\text{gal}} \quad ft^3} \right|$$

To cancel ft^3, does it make sense to simply multiply the three ft we have in our list? No. We have to do some thinking here. What ft^3 of volume are we interested in? The volume of the tank? No. The volume of the liquid (water) is what we have to calculate and to calculate the volume of a cylindrical body of water we multiply the cross sectional area, which is a circle, by the depth of the water (No. 3), not the depth of the tank. The area of a circle is calculated by multiplying 0.785 times $diameter^2$ (i.e., “diameter squared”) or 0.785 times the diameter (No. 2) times the diameter (No. 2) again. In one step we enter the volume of the water. Remember to include the units associated with each number so you can see how ft^3 cancels with ft × ft × ft.

$$\left| \textbf{lb} \right| = \left| \frac{8.34\ \textbf{lb} \quad 7.48\ \cancel{\text{gal}} \quad 0.785 \quad 15\ \cancel{\text{ft}} \quad 15\ \cancel{\text{ft}} \quad 15.5\ \cancel{\text{ft}}}{\cancel{\text{gal}} \quad \cancel{ft^3}} \right|$$

We didn’t use the height of the tank (No.1) in the solution bridge. Students ask all the time, “How do I know when I’m not going to use something given in the problem?”

My answer to this is simple: “If you don’t use it in the solution bridge, you didn’t need it.”

I know that sounds a little bit flippant, but I don’t know how else to say it. If you read a problem and start fretting over whether or not you’re going to use all the information given, you’re not thinking about how you’re going to solve the problem! Just . . . don’t . . . worry . . . about it. Test anxiety happens to us all. Get rid of some of your anxiety by not worrying about whether you’re going to use all the information given in the problem.

Because all the units have canceled except those needed in the answer, **lb**,we know the solution bridge is complete and the arithmetic gives the **answer**.

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$$\left| \mathbf{lb} \right| = \left| \frac{8.34\ \mathbf{lb} \mid 7.48\ \cancel{\text{gal}} \mid 0.785 \mid 15\ \cancel{\text{ft}} \mid 15\ \cancel{\text{ft}} \mid 15.5\ \cancel{\text{ft}}}{\cancel{\text{gal}} \mid \cancel{\text{ft}}^3} \right|$$

8.34 × 7.48 × 0.785 × 15 × 15 × 15.5 = **170,786 lb**.

Discussion

I just want to make sure, since I'm always ranting about using units, that readers understand that when I write "the arithmetic gives the answer" and then show the numbers in the solution bridge without units, I'm showing what I am entering into my calculator. Just making sure.

Happy calculating! Let us know, by leaving a comment, if you want us to do a specific problem, if you see a mistake, or if you have a question on any of the Problems of the Day you are looking at.