Problem of the Day

**2015.Dec.21**

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

## Introduction
This is a pretty easy calculation, but there's a lot to say about it, so let's jump right in.

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

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$$\left| \text{gal} \right| = \_\_\_\_\_$$

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 liquid = 15.5 ft

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 a lot of 5s. Be diligent and keep the numbers straight in your head and on your paper.

Do we need to know what the liquid in the tank is to find the volume (i.e., gallons)?

Think about it...

The answer is, NO. A ladle that holds 150 gallons of molten steel will hold 150 gallons of ice water and 150 gallons of air when it's empty. A gallon is a gallon, a $ft^3$ is a $ft^3$ no matter what is in it.

Too often is the case that operators taking certification exams want to use "8.34." But what is "8.34?" Most certification exams 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).

**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.

Since the question doesn't ask for the weight of the liquid in the tank, we don't need the density of the liquid, whatever it is. We don't even know if it is water!

As we have done many times before, we start the solution bridge with the units needed in the numerator of the answer, gal. But there is nothing in the list with units of gal; the list only has units of ft in it. What should we do?

All those ft in our list should give you a hint that we're going to calculate volume in $ft^3$ and then convert it to gal. We all know the conversion factor (truly a conversion factor):

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

Can we start the solution bridge with a conversion factor, use a conversion factor before we know what we're converting? Of course because conversion factors are equivalent to the number 1. We can multiply and divide by 1 as many times as we want to and not change the computation. So, we start with this conversion factor with gal in the numerator as shown in bold.

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

With that simple entry we now have the units in the solution bridge needed in the answer. Proceeding, we cancel unwanted units until only gal remain. We have 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 is what we have to calculate and to calculate the volume of a cylindrical tank we multiply the cross sectional area, which is a circle, by the depth of the liquid, not 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 times the diameter again. In one step we enter the volume of the liquid. Remember to include the units associated with each number so you can see how $ft^3$ cancels with ft × ft × ft.

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

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.

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

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7.48 × 0.785 × 15 × 15 × 15.5 = **20,478 gal**.

## Discussion

True confessions: When I first started working through this problem, instead of "0.785" I wrote "0.748." Bet you've never done that! We all make stupid mistakes, especially under the pressure of an exam, but care and practice (and units!) will vastly minimize them.

***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.***