



WASTEWATER TECHNOLOGY TRAINERS

Transforming today's operators into tomorrow's water quality professionals

Problem of the Day 2014.Oct.19

Discussion

The current drought in California, from where I am writing, is very serious, staggeringly so. Wastewater treatment plant operators, working around water all the time, may not be as in tune with water conservation as they should be, or maybe they are more so. As stewards protecting the water environment, we need to be cognizant of wasting water and vocal about how important water conservation is. Water is pretty amazing stuff and, obviously, impossible to live without. Just one quote (I am sure there are countless "water quotes") puts water into perspective, at least for me:

"Nothing in the world is as soft and yielding as water. Yet for dissolving the hard and inflexible, nothing can surpass it."

Lao Tzu

Plumbing fixtures in our homes that leak are a colossal waste of water. So let's do a problem that looks at how much a leaking faucet wastes.

Problem

Problem of the Day: My bathroom faucet has been leaking, very little, for the last month or so. Yesterday I noticed it seemed to be leaking worse. Using the stopwatch on my iPhone, I measured the time between two consecutive drips and then repeated the measurement nine additional times. The ten measurements averaged 2.1 seconds. At this rate, how many gallons of water is my faucet wasting per year?

Solution

I recall a drop of water is approximately 0.5 millileters (mL) in volume. I am sure I could Google this but I don't have WiFi in my current location, so we'll go with this. My faucet, therefore, is dripping at the rate of 0.5 mL/2.1 s. This is what we have to convert to gallons per year (gal/yr), so this is how the railroad track is started.

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$$\frac{\text{gal}}{\text{yr}} = \frac{0.5 \text{ mL}}{2.1 \text{ s}}$$

What are these units telling us? First of all, gal and mL, on either side of the equals sign, are both in the numerator. **Both gal and mL are units of volume.** Even though they are not the same units of volume, the fact that they are both units of volume and they are both in the numerator, we know we're starting out right because all we have to do is get from one unit to the other. Same holds true with yr and s: both are in the denominator on either side of the equals sign and both **yr and s are units of time.**

There are a number of different conversion factors that can get us from mL to gal and s to yr. I'm going to use, for the most part, every-day conversion factors that should be well known. This should be emphasized: if you're preparing for a certification exam, you need to be confident in what you do know, because you know a lot. Don't memorize problems and don't memorize a bunch of new conversion factors: you can go a long way with what you already know.

In the metric system of units a mL is the exact same thing as a cubic centimeter, cm³, also sometimes abbreviated "c.c." for cubic centimeter. Don't use the unit, c.c., because it doesn't tell you what you need to know to cancel units. You'd probably would have to be told that a cm³ equals a mL if this problem showed up on a certification exam. Remember, all we do as we work down the railroad track is enter units so they cancel out, as shown.

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$$\frac{\text{gal}}{\text{yr}} = \frac{0.5 \text{ mL} \quad \text{cm}^3}{2.1 \text{ s} \quad \text{mL}}$$

Another conversion factor you would have to be told if this question showed up on a certification exam is that there are 2.54 centimeters per inch, or 2.54 cm/in if we are to use it in the railroad track. But, as you can see, we don't need to cancel cm, we need to cancel cm³. Therefore, the conversion factor has to be cubed as shown on the next page.

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gal	=	0.5 mL	cm ³	in ³	
yr		2.1 s	mL	2.54 ³ ·cm ³	

The next conversion factor, which everybody should know, is that there are 12 inches per foot, or 12 in/ft. But again, we don't need to cancel in, we need to cancel in³, so we have to cube the conversion factor as shown. Again, the units are entered into the railroad track so they cancel numerator and denominator.

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gal	=	0.5 mL	cm ³	in ³	ft ³	
yr		2.1 s	mL	2.54 ³ ·cm ³	12 ³ in ³	

Another well known conversion factor is there are 7.48 gallons per cubic foot, or 7.48 gal/ft³. This is entered into the railroad track to cancel ft³. Notice that this conversion puts the unit, gal, into the numerator. Because this is the unit needed in the numerator of the answer, it is shown in **bold** on both sides of the equals sign.

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gal	=	0.5 mL	cm ³	in ³	ft ³	7.48 gal	
yr		2.1 s	mL	2.54 ³ ·cm ³	12 ³ in ³	ft ³	

Now we have to direct our attention to converting s to yr. I certainly don't know, off hand, how many seconds there are in a year, and even how many seconds there are in a day is not something I have right there at the forefront of my brain. What I **do** know is that there are 60 s per minute, or 60 s/min, and 1,440 min per day, or 1,440 min/d. These are entered into the railroad track so units cancel.

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gal	=	0.5 mL	cm ³	in ³	ft ³	7.48 gal	60 s	1,440 min	
yr		2.1 s	mL	2.54 ³ ·cm ³	12 ³ ·in ³	ft ³	min	d	

Finally, I know there are 365 days between birthdays (except leap years), or 365 d/yr. Entering this conversion factor, so units cancel, completes the railroad track.

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gal	=	0.5 mL	cm³	in ³	ft ³	7.48-gal	60 s	1,440 min	365 d
yr		2.1-s	mL	2.54 ³ -cm ³	12 ³ -in ³	ft³	min	d	yr

Since all the units have canceled except the ones needed in the answer, **gal/yr**, the math is done and the arithmetic gives the answer:

$$0.5 \times 7.48 \times 60 \times 1,440 \times 365 \div 2.1 \div 2.54 \div 2.54 \div 2.54 \div 12 \div 12 \div 12 = \mathbf{1,983 \text{ gal/yr}}$$

If my car got 30 miles per gallon, I could drive 59,490 miles on this amount of gasoline! Since we can live without gasoline but can't live without water, we need to start thinking of water as much more precious.

By the way, none of my faucets leak and I have recently starting taking "military showers," where I turn the water off as I'm sudsing up. I bet I save about 1.5 gallons per shower. Every drop counts.