

A high school geometry lesson

Eric Blair

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I think of wine glasses and martini glasses as a sort of sobriety test. Wine glasses are so fragile that singing the right note can shatter them, and yet we give them to people filled with alcohol? Martini glasses, with their heavy-end-up conic section, are some sort of perverse engineering school homework: design a glass that maximizes the odds that the user will spill most of the drink while walking across the room.

Which brings us to another, somewhat less perverse question from high school geometry: what is the volume of a Martini glass? We have a good sense of how much liquid a plain cylindrical glass holds, but the martini cone is harder to get a handle on. Glass-makers often produce eye-fooling equipment like those shot glasses with three centimeters of glass surrounding a tiny indentation in the middle for liquid; is a Martini glass just an elaborate shape that holds next to nothing?

[Here's the first use that the nice people at the Oxford English Dictionary could find: "1884 O.H. Byron *Mod. Bartenders' Guide 21*: Martinez cocktail. . . Same as Manhattan, only you substitute gin for whisky." The OED continues: "The earliest examples of the name of the cocktail have the form Martinez, and a number of anecdotes associate the name of the cocktail with the name of the Californian city Martinez. For further details see: P. Tamony in *Western Folklore* (1967) 26 124."]

It's easy to find the area of a *conic section*, as the mathematicians call your Martini glass. I'll leave the double-integral as an exercise for the reader, but the final volume formula is simple: $\pi r^2 h / 3$, where r is the radius of the base of the conic section, and h is its height. [If you're too drunk for these things, notice that $\pi/3$ is about one (1.0472), so as far as inebriated calculations go we can just reduce the formula to $r^2 \cdot h$.] To clarify, here are a few examples, appropriate for any eighth grade geometry class.

Figures 1 and 2, at a hotel bar in DC, are of a rather standard Martini glass. Prominently displayed in Figure One is Ms GP of Washington, Columbia. Ever kind and trusting, she brought the tape measure.

From Figure 1, we see that the height of the glass is about $h = 2.25\text{in}$, or $h =$

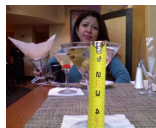


Figure 1: The height is 2.25in, and Ms GP is slightly confused.



Figure 2: The diameter of the rim is 4in.

5.5cm. Now, reading this is not so easy, because the theoretical point of the cone, where the two sides meet, is well into the stem, and I don't recall if this is my first or second Martini, making things only more difficult. So we've got to finesse things a bit; as they say, this is an engineering problem. Below, we'll see that the bottom bit, the corner that would be liquid in a perfect cone but is glass in the real world, is not a concern.

In figure two, we measure the diameter, a line running through the center of the circle, which is $d = 4\text{in}$, or $d = 10\text{cm}$. We cut that in half to get the radius, $r = 5\text{cm}$.

With those two measurements, we have all we need to fill in the above formula ($V = \pi r^2 h / 3$) and find the volume: it's $\pi \cdot 5^2 \cdot 5.5 / 3\text{cm}^3$, or about 144 cubic centimeters. Now, liquids are measured in milliliters, not cubic centimeters, so we need to convert, and here we see why I'm switching from Ms GP's imperial tape measure to metric units: 144 cubic centimeters = 144 milliliters = .144 liters.

The glass bit at the bottom, where the cone is rounded off from the mathematical ideal, is about a cubic centimeter or two. That is, we need to get the height right so we have an idea of the overall cone, but that little corner itself is the least of our worries, and if we took into account that it's not holding liquid, the measurement would be about 142mL instead of 144.

Or, to give you an easier time of it in your bar metrics, let's compare to a shot. Unlike the gill [a quarter pint] or stone [14 pounds], the shot isn't an official part of the Imperial system of measures, so different sources have different ideas of what a shot is. As I understand it, at most places it's 1.5 ounces (45ml), except at corporate bars where they use those ball-in-tube things to measure every frigging drop, where one shot = one ounce = 29.5ml. Going by the more common 45ml shot, the Martini glass in Figures One and Two holds a little more liquid than about three shots. At the corporate chain bar, they probably use smaller martini glasses too.

A taller example You know how, in movies from the fifties, the characters would come up with some odd idea, and say 'oh, waiter, would you bring us a pack of cards, a rifle, and two pigeons' and it'd be no big thing? Yeah, that doesn't happen in the real world, and my request that the waiter ask the maintenance guy for a ruler or tape measure went sour. So, as shown in Figures Three and Four, I went across the street and got a ruler from America's Most Eco-Unfriendly Restaurant, the Rainforest Café.

I repeated the exercise here because the glass looks pretty different: it is much taller and narrower, and gives the impression that the darn thing won't spill as easily. Behind the glass in Figure four, we see Ms ABR of Washington, Columbia, wearing her $QT\pi$ shirt. So, same measurements, blurrier photos: $h = 12\text{cm}$ (to the crux of



Figure 3: This narrower glass has a rim diameter of only 6.5cm.

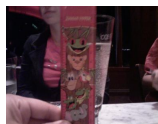


Figure 4: The height is 12cm.

the mathematically perfect cone), $r = 3.25\text{cm}$, and so total volume is about 133 mL. That's within about 10% of the other glass, though given that my lab technique is that of a drunkard, we'll just say that the second is a bit smaller than the first.

The glass is 90% full But here's one more problem: many bartenders don't fill right to the absolute brim, and even if they did, you'd spill all over yourself on the way to your seat across the room. My measurements were from the rim; what if there were half a centimeter less liquid? A half centimeter (.19 inches, .000003 miles, or maybe half the width of your pinky) is a marginal length that you wouldn't notice at the edge of a glass. For the first glass, $h = 5\text{cm}$ now, and $r = 4.5\text{cm}$; total volume is thus 108 mL. Yup: that top sliver is on the order of a quarter of the drink.

If you go down to a centimeter of margin—still less than a pinky's worth of lip—then $h = 4.5\text{cm}$ and $r = 4.1\text{cm}$, for a total volume of 79mL. Down from 144mL, that sub-pinky margin is just shy of half the drink.

For the second, taller glass, same calculations: a half-centimeter off the top gives us $h = 11.5\text{cm}$, $r = 3.1\text{cm}$, and total volume of 117 mL, down from 133mL. So the half centimeter here is about 12% of the volume. Go down a centimeter to $h = 11\text{cm}$ and $r = 2.98\text{cm}$, and you're at 102mL.

The shorter and wider glass is a touch bigger when full, but we quickly see a turn-around when real-world spillage comes into play. The tall and narrow glass holds more liquid when both are just a half-centimeter underfull, and when a centimeter underfull, the narrow glass is holding almost a corporate shot more liquid than the wide-mouthed glass.

Results and implications In terms of other metrics like booze per dollar, how does the Martini compare to other drinks? It's hard to say, because the glass and recipe gives the bartender wide latitude. In theory, a Martini glass, filled, is three shots of gin with a splash of vermouth. But shaking a drink with ice can water it down immensely, and then leaving a pinky of margin at the top means the drink may only be a shot and a half

of liquid. The froofter Martini variants include various mixers, adding still more doubt.

But one thing is certain: the Martini glass's design guarantees that slightest nudge can spill about a quarter of the drink, meaning that I'm too klutzy to be entrusted with such as glass. Also, your bartender can easily give you twice the drink (or half the drink) with only a few millimeters' change in the appearance of the drink. And that's why we tip our bartenders.