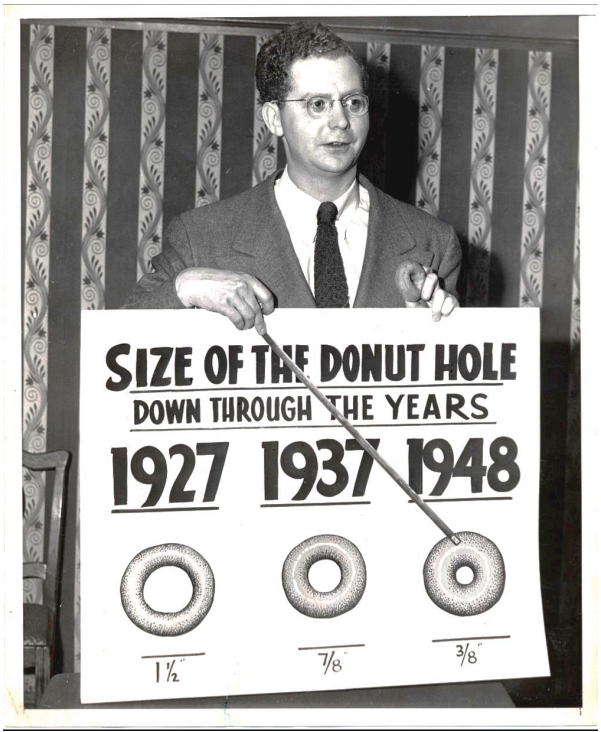
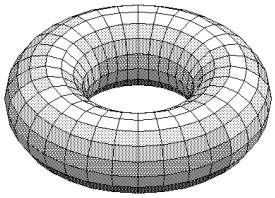
How much more donut is that?



*Part of the Smithsonian's **Sally L. Steinberg Collection of Doughnut Ephemera***

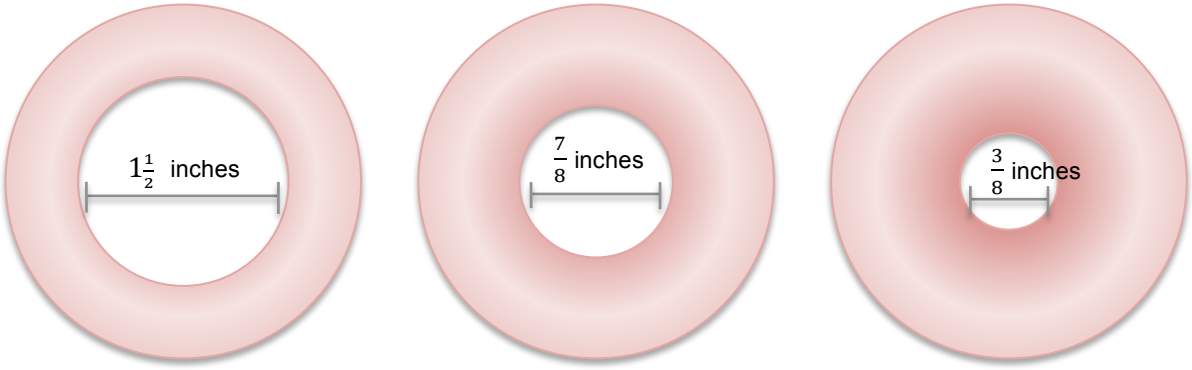
1. According to this picture, how have donuts changed?

The fancy, mathematical name for a donut shaped object is a torus?



The origin of doughnuts (or donuts) is unclear. Some time in the 1800's they were known to be an American confection of sweet dough fried in fat. The hole in the middle of the dough allowed the cake cook thoroughly and avoids a raw center to the cake.

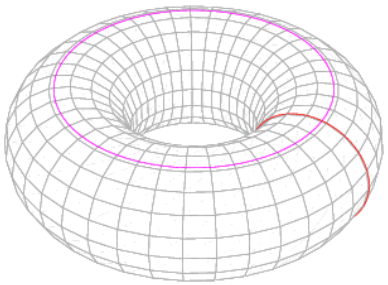
I think the labeling of the picture above doesn't show the dimension of the donut holes clearly enough so I've recreated the poster's markings in these images.



1927 1937 1948

4. What do these images and dimensions make you wonder?

So I guess I'll need figure out how to find the volume of this shape.
Mathematically a torus is defined as a circle or radius r, like a metal washer being spun around a center point on a string of length R.

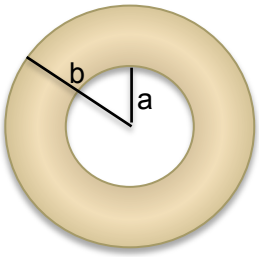


I found this formula for the Volume of a Torus = $\pi * r^2 * 2\pi R$.

This makes some sense to me because the area of the metal washer (if the hole in it is very tiny) is $\pi * r^2$ and if you took that area and repeatedly added it to itself for the whole distance (circumference) around a circle of radius R, you might get a close approximation to the volume of the torus.

Where R = radius to the outside of the torus
and r = radius to the inside of the torus.

But with my donuts, I don't know the value of either r or R. Ach!



Then I found another Torus volume formula. Volume = $(b + a) * (b - a)^2 * \frac{\pi^2}{4}$
This formula might work better with my donut problem but I wonder why I've only found this formula in one place. Where did this formula come from? Is it correct?

5. Can you figure out how this second formula was derived from the first formula that seems to make more sense?

6. Evaluate the volume of each donut. (We didn't give you the exterior dimension of the donuts so you should choose a number that you think is a reasonable choice.) Be careful! In our data we gave you the diameter of the donut and its hole, not their radii (plural for radius).

7. If all of these donuts have the same exterior diameter, we used $3\frac{1}{2} inches,$ by what amounts have the donut volumes changed?

8. Below are pictures of Krispy Kreme and Dunkin Donuts. Should we measure these modern-day donuts to see if their holes have gotten larger or smaller than the donuts pictured in 1948? Do they look about the same? Have donut's holes changed yet again?

Source: https://en.wikipedia.org/wiki/Torus
http://www.murderousmaths.co.uk/books/reslabmn.htm
http://www.murderousmaths.co.uk/books/reslabmn.htm