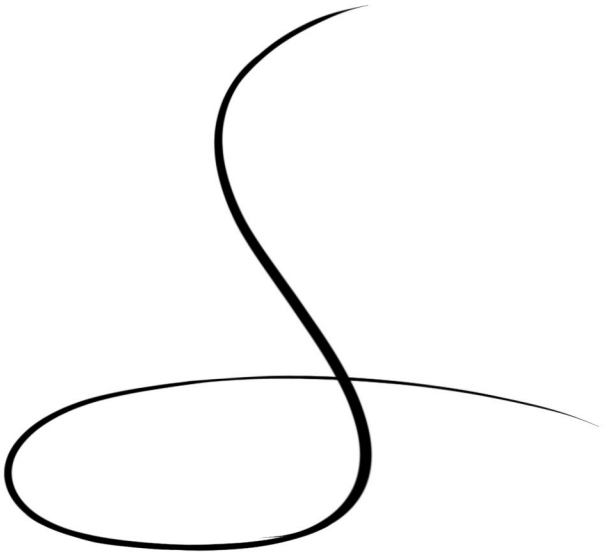
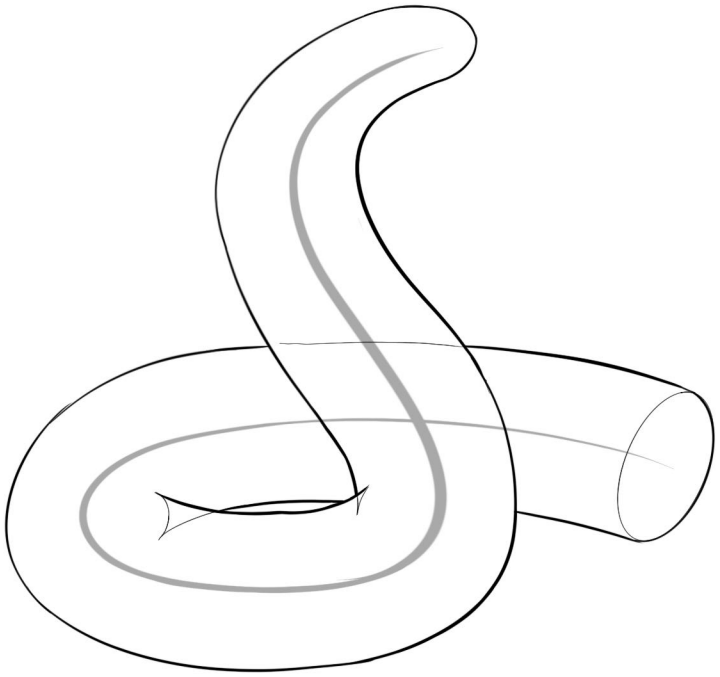
# How to draw a Worm

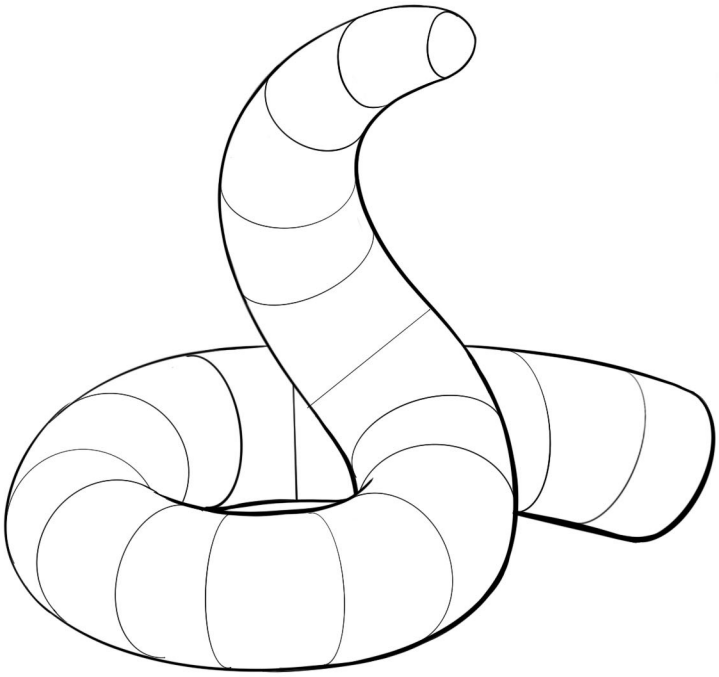
## Step 0: Guiding curve



## Step 1: Outline



## Step 2: Lattitudes



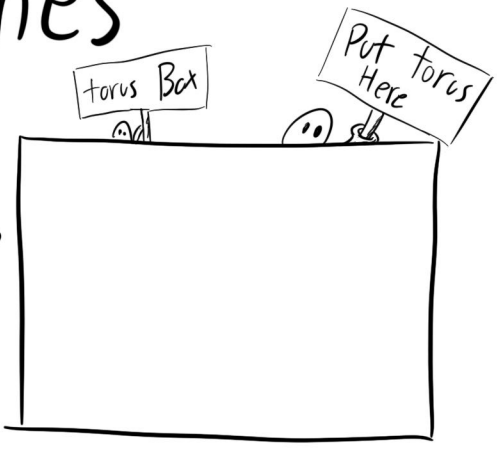
## Step 3: Shading

As mathematicians, we like to draw tori

A Torus is just a circular worm

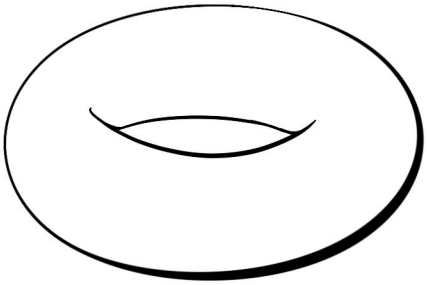
To draw a torus, we must first draw a worm.

# Step 1: Outlines




Draw a picture of a torus here →

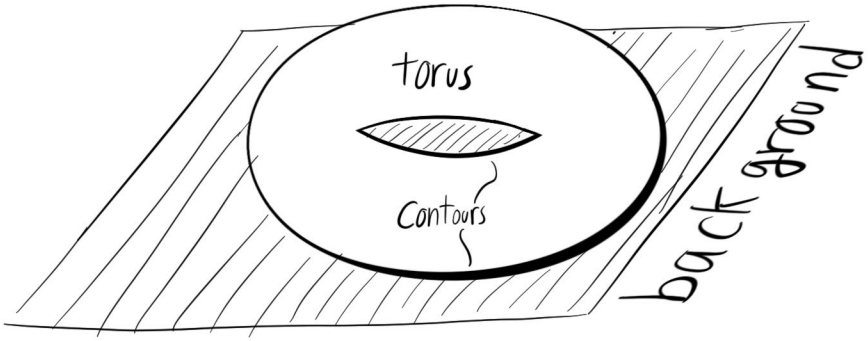
I bet you drew something like this:



What do these penstrokes represent?

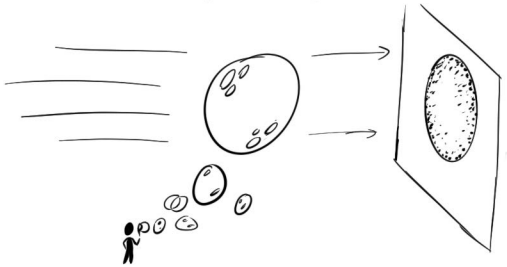
- some of them are the boundary between the torus & the background

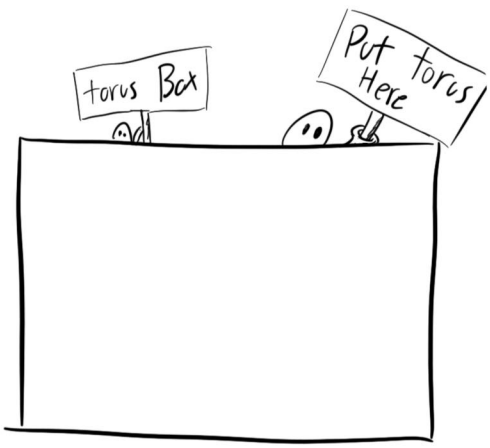
But what are these lines?


Try to draw a "Ghost torus"

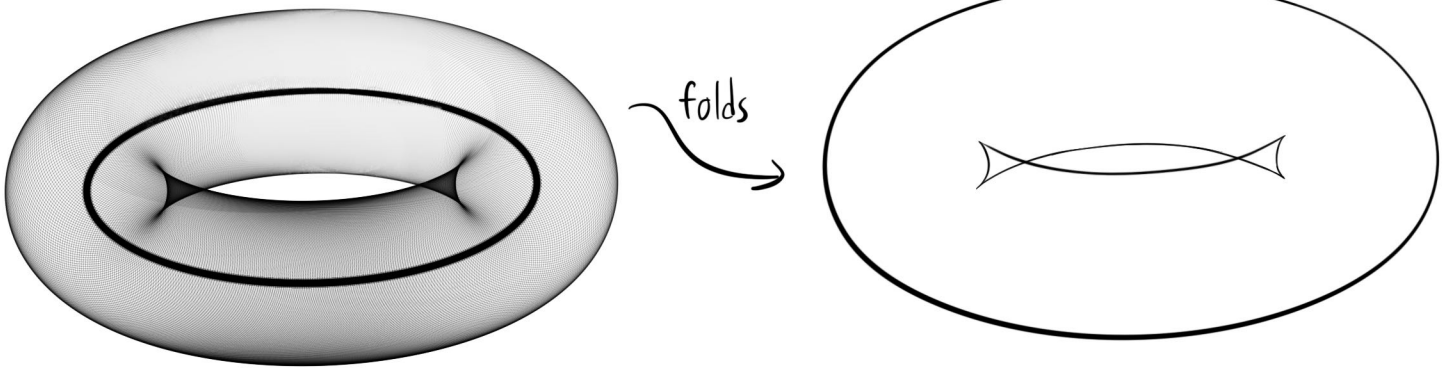
The shadow of a translucent shell of a torus, like a bubble in sunlight

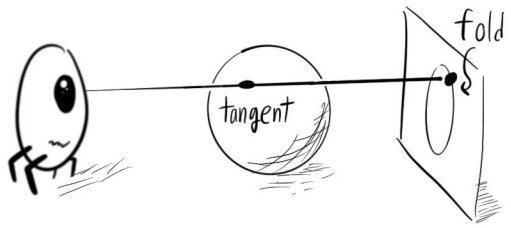




Here's a "perfect" ghost torus.
It is darkest along the edges, where the torus folds over itself.

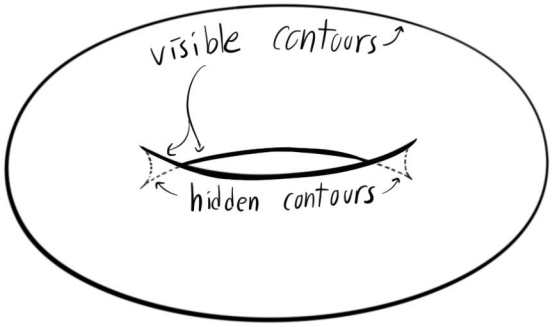
The folds include all the contours from the line diagram, & then some!



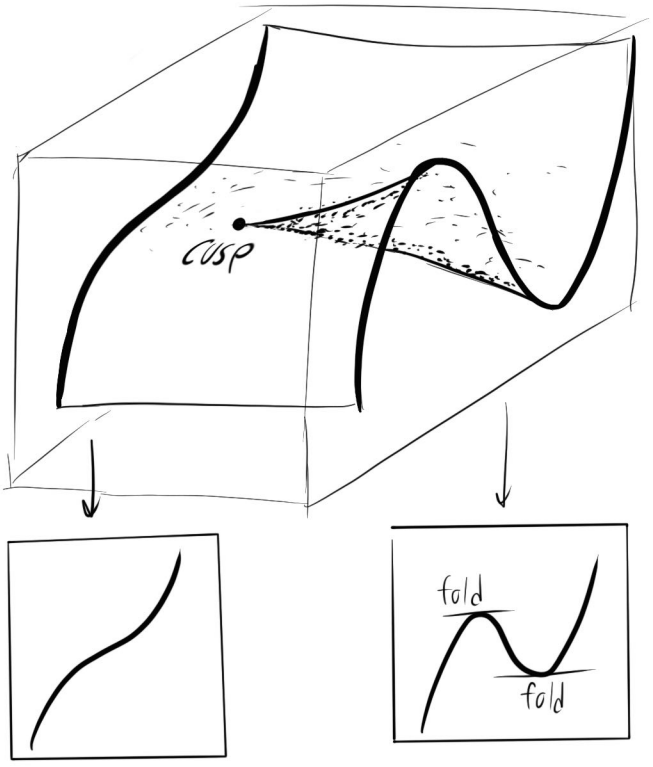




The folds are points where the line from our eye to the picture plane is tangent to the surface

For an opaque surface, folds may be hidden behind the surface. The "smile" shows the visible contours of the torus.

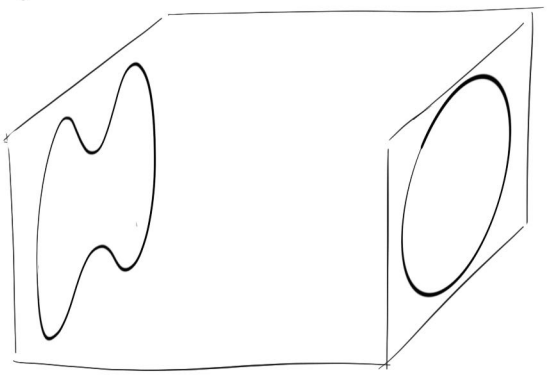



Two folds meet at a "cusp"


Cusps appear generically when projecting surfaces in $\mathbb{R}^3$ onto $\mathbb{R}^2$.

Try it yourself!



interpolate between these two curves. mark the folds & cusps you produce.