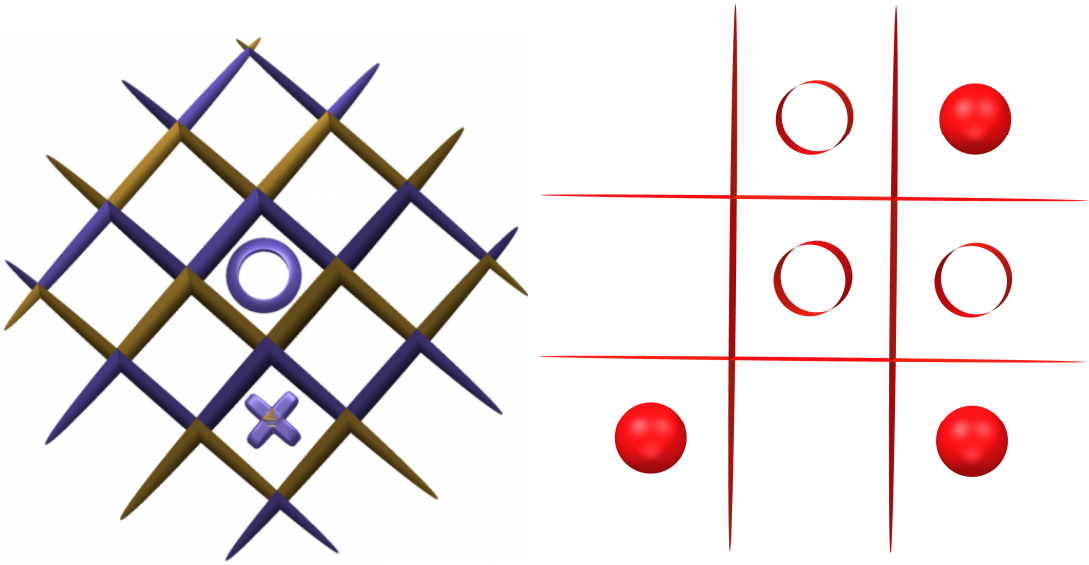
# Tic Tac Toe

**Surfer Experiment**
by Andreas Daniel Matt



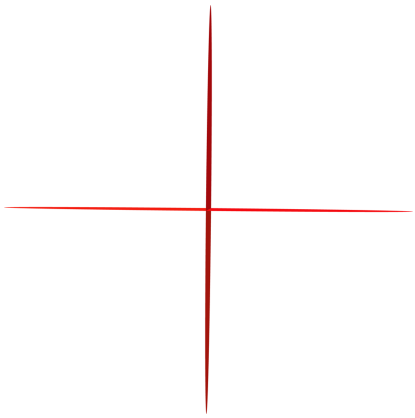
## Motivation

Are you ready for a classical *Tic Tac Toe* game to distract yourself?
The question is: Can we play Tic Tac Toe with SURFER?

## Mathematics behind it

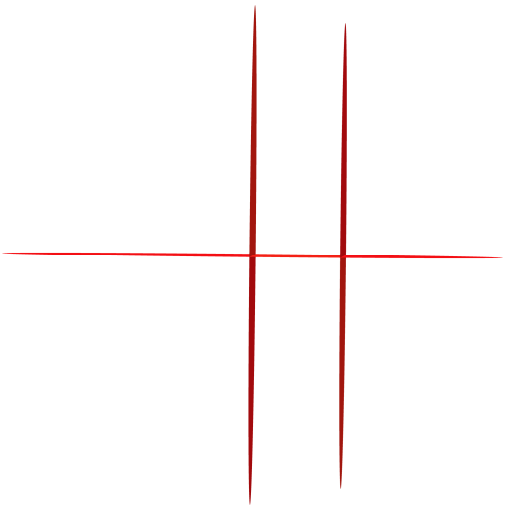
First let's build the Tic Tac Toe board. To make it easy we forget about the third dimension (yes, Tic Tac Toe is usually played in two dimensions on a piece of paper) and start making lines: $x$=0 and $y$=0 for a vertical and a horizontal line. Note that you have to turn the surface shown by SURFER in a way to see the lines only!

SURFER can be downloaded for free: http://imaginary.org/program/surfer



*x*y=0*

Since we need two lines (each horizontally and vertically) and since they should not be centered, we have to set *x* and *y* to numbers different from 0, for example to 1 or -1. This way we “move” the lines to this value. We add for example *x*=1.



*x*y*(x-1)=0*

Instead of the numbers you can also use parameters and place the lines where you want to have them. This way we easily get the following nice board:

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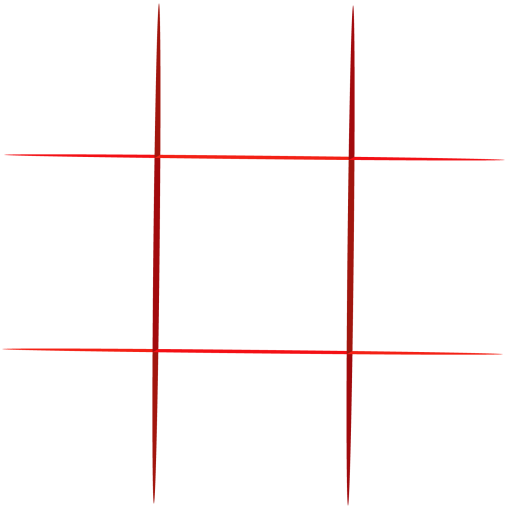
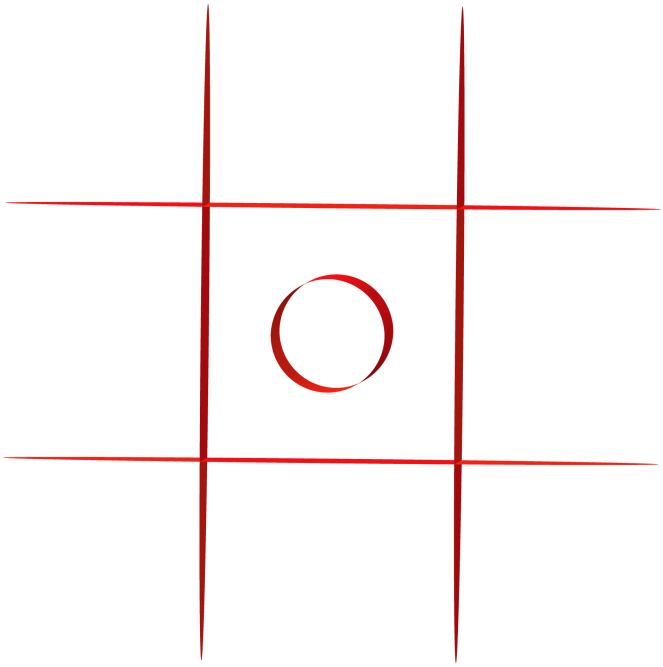


*(x-a)*(x+a)*(y-b)*(y+b)=0* (where usually *a=b*, in our case 1)

To play you have to add marks for each player. We can use small circles. Remember the equation of the circle *x^2+y^2=r^2*. The radius *r* of the circle has to be chosen in a way that it fits into our board!



*(x-1)*(x+1)*(y-1)*(y+1)*(x^2+y^2-0.2)=0*

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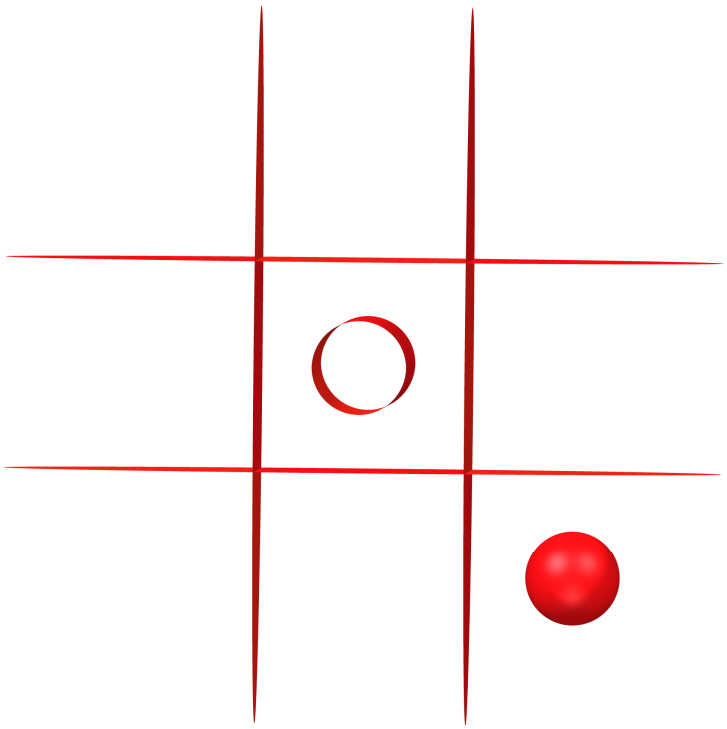
For the second player we can use any other closed form, for example a sphere, which in two dimensions, i.e. on the paper, would look like a filled circle. Now you have to move it into the right position by adding parameters (the right ones!) to *x* and *y* of the equation.

*(x-a)*(x+a)*(y-b)*(y+b)*(x^2+y^2-0.2)*((x-2)^2+(y+2)^2+z^2-0.2)=0*



**Further Questions (without solutions)**

Try to find other interesting forms to be used as marks? Can you make something that looks like the classical X symbol?

Make a real 3D version of the Tic Tac Toe game, where the marks can be set in a 3 x 3 x 3 grid. You could exchange the lines by thin cylinders. Can you devise a winning strategy for Tic-Tac-Toe-3D? How would you play if you start or if you are the second player?