Problem 1. Consider a pan whose shape is a paraboloid: it is a surface of revolution obtained by rotating a parabola around its axis. For a total height $H$ and radius $R$, its volume is given by

$$V = \frac{\pi}{2}R^2H.$$  

The depth $h$ and corresponding radius $r$ satisfy the relation

$$\frac{r^2}{h} = \frac{R^2}{H} \quad (0 \leq h \leq H, r \geq 0).$$

1. Draw a well-labelled picture of the setup.

2. If one pours soup into the pan at a constant rate $\gamma$, determine the velocity at which the surface rises just before the pan overflows.

Problem 2. The curve described by the equation

$$(x^2 + y^2)^2 = x^2 - y^2$$

is called a lemniscate. Determine all the points where the lemniscate has horizontal tangent lines. You can assume that none of them is such that $x = 0$. 