Name: _____

Date: _____

Collaborators: _____

(Collaborators submit their individually written assignments together)

Question:	1	2	3	Total
Points:	20	30	30	80
Score:				

Instructor/grader comments:

Quasi-steady flow

1. (20 points) In a water clock (see Figure 1), the height of level of the water in the vessel serves as the time indicator. The height should decrease at a constant speed. Determine the shape of the vessel used in water clocks.

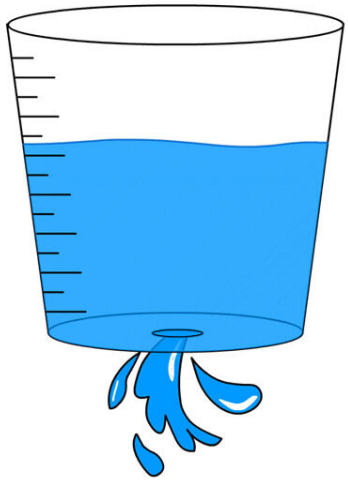

Figure 1: Sketch of the flow

2. (30 points) A container of shaped as a right general cylinder can slide on a long, straight, horizontal, frictionless rail. The container has a little spout at the bottom. The spout is oriented horizontally and is parallel to the rail. The container is filled with fluid up to the height H. When the plug in the spout is suddenly removed, the hydrostatic pressure accelerates the fluid to stream out, thus accelerating the container in the opposite direction. Provided the spout is narrow compared to the size of the container, find the terminal velocity of the container. Assume that at all times the mass of the container is much less than the mass of the remaining fluid.

   Hint: derive the equation of motion for the container; express the velocity of the stream of the fluid leaving the container as a function of the mass of the fluid remaining in the container.

Inviscous flow

3. (30 points) A vertical cylindrical pipe of the internal radius R is filled with inviscous incompressible fluid. A cylinder of negligible mass, of the outer radius $r = R - \delta$ ($\delta \ll R, r$) and of the length L ($L \gg R, r$) is immersed into the fluid and released. Determine the vertical acceleration of the cylinder. Assume that the cylinder and the pipe are co-axial at all times.

Hint: why the following reasoning is wrong? - since the fluid is inviscous, the only forces that act on the cylinder are the buoyant force, $F_b = \pi r^2 L\rho g$, and the gravity, $F_g = mg$. $ma = F_b - F_g$, thus $a = \left(\frac{\pi r^2 L\rho}{m} - 1\right)g$.