**Homework #9 • MATH 462 • Last Questions**

- write-ups are due Tuesday 04 April, 5:30pm.
- presentation is a very important aspect of these final problems.

A) **Pipe Poiseuille Flow** (4 pages, 15pts) Use the steady Navier-Stokes equations to calculate *gravity-driven* flow through a pipe which is inclined at an angle α from the horizontal. I recommend using cylindrical coordinates with the $\hat{z}$-axis oriented with the pipe axis – hence, gravity will be seem to be *tilted* in the equations.
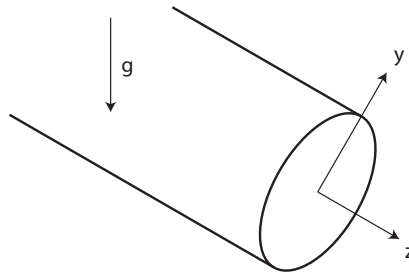
Show that in the above coordinate geometry, the gravitational vector $\vec{g}$ points in the direction

$$- \cos \alpha \ (\sin \theta \, \hat{r} + \cos \theta \, \hat{\theta}) + \sin \alpha \, \hat{z} \ .$$

It is not surprising that the axial velocity is z-independent, but it turns out also to be θ-independent (like usual pipe Poiseuille flow). Thus $W(r)$ only. The pressure is also z-independent, but develops a cross-sectional distribution.

Calculate the mass flux through the pipe. Make a contour plot of the cross-sectional pressure distribution.

B) **Spinning Sphere** (5 pages, 20 pts) Solve the problem as posed by #7.2 in Acheson. Presentation counts for 3/4 of the grade. Show that you understand both the mathematics and fluid dynamics of the problem.