**ME I0800**

**Homework #5: Lubrication Approximation**

Consider viscous incompressible flow through a converging nozzle of length at the bottom of a large tank (see figure; not to scale). Assume the tank is very large so that the pressure at the entrance to the nozzle is hydrostatic. Use a cylindrical coordinate system at the entrance to the nozzle so that it radius can be given by

where and , and the convergence is very slow so that .

1. Write down the governing equations and boundary conditions for the flow through the nozzle using the lubrication approximation.
2. Solve the governing equation for the velocity profile in terms of the pressure gradient.
3. Determine the flow rate, and use the result to determine the pressure distribution
4. Use the result for the pressure to show that the flow rate is given by