Worksheet

Question 1

A fluid is flowing between two large parallel plates (density ρ and viscosity μ). The plates are a distance h apart and the pressure drop is $\Delta P/L$. The plates are inclined at an angle θ. Assuming that the flow is laminar and that there is no slip at the boundaries, calculate the volumetric flowrate through the system per meter of width as a function of the inclination angle. Simplify the Navier-Stokes equation in order to carry out this calculation.

At what angle does the average flow stop in terms of the other variables (you can also check this based on a force balance over the entire system), assuming that the pressure gradient is the direction counteracting gravity?

Question 2

There are two pipes, one inside another. The outer anulus has an inner radius R_i and an outer radius R_i, with the anulus being symmetric around the centre of the pipes. The pipes are horizontal and the pressure drop in the anulus is ΔP and the length of the pipe is L. The fluid in the anulus has a viscosity μ and a density ρ. You can assume that there is no slip at the boundaries and that there is steady laminar flow.

a) Calculate the velocity profile in the anulus. You can either simplify the Navier Stokes equation (you will need to use the version for cylindrical coordinates) or you can do your own momentum/force balance on a volume of fluid.
b) What is the relationship between the volumetric flowrate through this anulus and the pressure drop using the other appropriate variables?
c) As the diameter of the inner pipe tends towards zero do you end up with the same result as flow in an empty pipe?