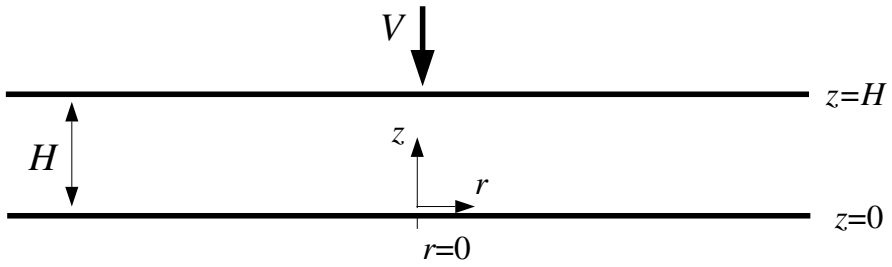
EPS 236: Geological fluid mechanics
Fall 2007

Homework number 7

Due Monday October 8

15. This is a modified version of question 7-1 from Leal.

Two parallel plane, circular disks of radii R lie one above the other. They are separated by a distance H. The space between them is filled with an incompressible Newtonian fluid. One disk approaches the other at constant velocity V, displacing the fluid. The pressure at the edge of the upper disk is atmospheric.



a) Under what conditions are the lubrication equations valid? What is the appropriate choice for the characteristic pressure in the lubrication approximation?

b) What is the velocity as a function of radius r?

c) What is the dynamic pressure distribution?

d) Show that the hydrodynamic force resisting motion is

$$F = \frac{3\pi\mu R^4}{2H^3}\frac{dH}{dt}$$

Hopefully this solution helps you understand why separating microscope slides by pulling them apart (when there is water in between the slides) is not easy.

Many adhesion processes rely on lubrication theory. If gaps are thin (and especially if the fluid is very viscous) then large forces required to separate the surfaces at reasonable rates. Aparently, some insects use lubrication theory to help their feet stick to smooth surfaces and as result they can even walk upside down.