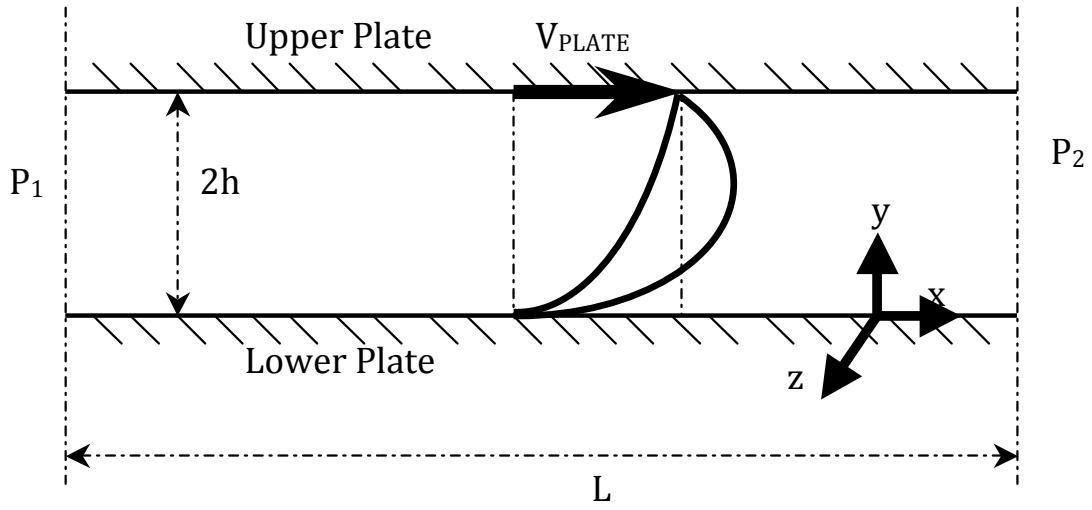
Department of Mechanical Engineering

ME/AA507 Fluid Mechanics Homework #2, due 02-14-19

Problem 1

Fluid flows between two parallel plates under the effect of a pressure gradient and the upper plate sliding with respect to the lower one (see figure below). Depending on the relative importance of the two driving forces, the velocity profile will look like one of the options shown.

- Assuming steady, incompressible, fully developed flow, calculate the velocity profile. Determine what is the criteria for the slope of the velocity profile being positive/negative/zero.
- To complement the calculations and analysis you conducted with the differential form of the conservation equations above, and taking advantage of knowing the velocity and temperature profiles, use an integral formulation of conservation of momentum and energy, to determine what are the forces on the lower and upper plates and the work done by those forces.

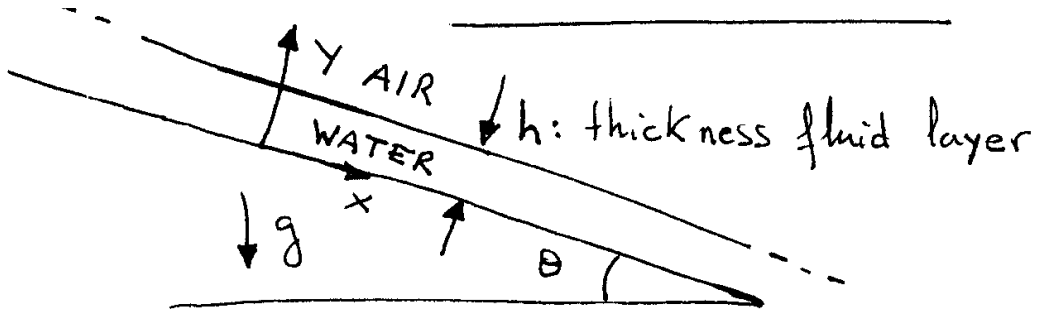


Problem 2

A liquid moves down an inclined plane under the effect of gravity. Assuming the flow is steady, incompressible and fully developed, and that the thickness of the fluid layer, h, and the angle of the plane, θ, are known:

- calculate the velocity distribution in the liquid layer.
- calculate the flow rate of liquid flowing down the slope.

What is friction coefficient in the problem?



Problem 3

A thin liquid film, of constant thickness h, coats a flat plate as it rises out of the liquid pool with a constant velocity V_{plate}. The plate's surface is kept at a constant temperature, T_{plate}, while on the film's free surface, there is a constant heat flux q_s. The gas outside is initially at rest and exerts a negligible stress on the liquid rising up along the plate.

- Assuming steady, incompressible, fully developed flow, calculate the velocity profile. Determine what is the criteria for the slope of the velocity profile being positive/negative/zero. Determine also what is the condition that makes the net flow rate of liquid going up along the plate equal to zero.
- Using the velocity profile and an integral formulation of conservation of momentum and energy, determine what is the force on the plate and the work done by the plate on the fluid.
- Determine the temperature distribution in the fluid film.