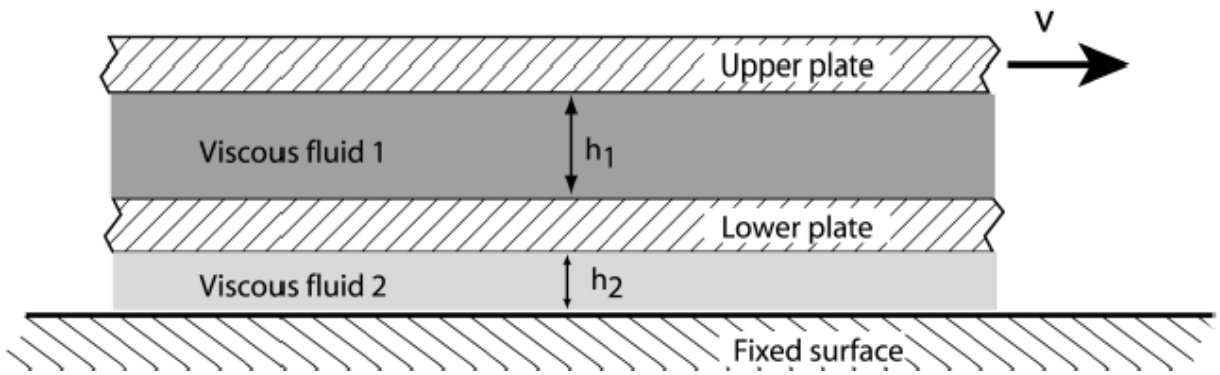
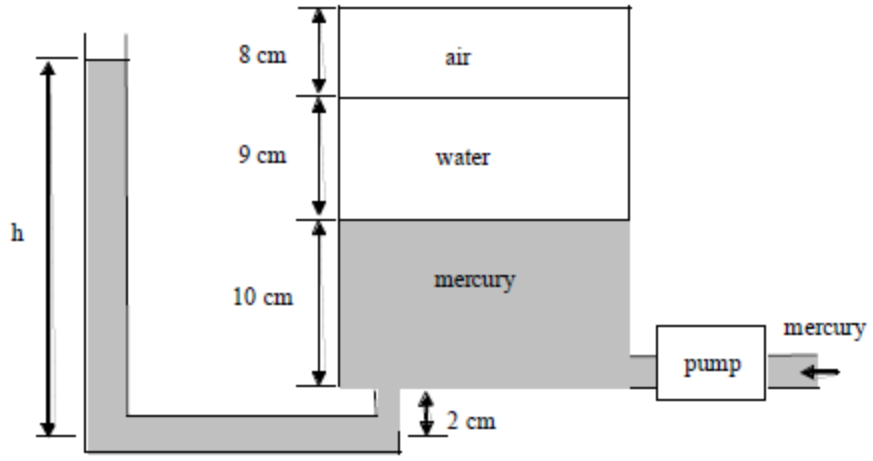
ME 6125 Mechanics of Viscous Fluid (October 2025)
Assignment 1 (Points: 15)

1. (Points: 3) Derive the NS equation (Cartesian coordinates) for incompressible fluid using control volume analysis. Also show the detail analysis of tensors.
2. (Points: 3) Derive the NS equation (Cylindrical coordinates) for incompressible fluid using control volume analysis. Also show the detail analysis of tensors.
3. (Points: 6) Two plates and a fixed surface sandwich two viscous fluid films as shown below. The top plate moves with a velocity v of 1.5 m/s and the lower plate is free to move under the influence of the viscous forces applied to it. The contact areas for the lower surface of the upper plate is the same as the upper surface of the lower plate as well as the lower surface of the lower plate and that of the fixed surface. $h_1 = 2$ mm, $\mu_1 = 0.2$ Pa $-$ s, $h_2 = 1$ mm, $\mu_2 = 0.5$ Pa $-$ s. The density of both fluid is 850 Kg/m^3.
   (a) After steady state conditions have been reached, what is the velocity if the lower plate?
   (b) What is the force per unit area imposed on the upper plate to maintain its velocity?



4. (Points: 3) A pump slowly introduces mercury into the bottom of the closed tank shown in the figure below. At the instant shown, the air pressure P_a= 75 kPa. The pump stops when the air pressure rises to 120 kPa and an engineer closes a valve at the exit of the pump at that time. All fluids remain at 20^o C. At that temperature, the density of water and mercury are 998 and 13,550 kg/m^3, respectively.
   (a) What is the manometer reading *h* when the air pressure reaches 120 kPa, if it is connected to standard sea-level ambient air P_{atm} =101.35 kPa?
   (b) Sketch a profile of the pressure distribution in the tank.
   (c) What is the pressure at the bottom of the tank initially (when pa= 75 kPa)? What is it at the end of the process (when P_a= 120 kPa)?
   (d) With the valve still closed, a hole forms at the top of the tank so that the air becomes in contact with the ambient air.
   If the cross-sectional areas of the tank and manometer are 0.1m^2 and 0.001 m^2 respectively, what is the new manometer reading *h*?


8 cm
air
9 cm
water
h
10 cm
mercury
mercury
pump
2 cm