Advanced Fluid Mechanics (ME61003)/ Fluid Mechanics (ME60011), Class Test 2, November 2017, IIT Kharagpur, Full Marks = 30, Time: 1 hour

Q1. Two immiscible and incompressible fluid layers of densities ρ_1, ρ_2, respective heights of h_1, h_2, and respective viscosities as μ_1, μ_2 are sandwiched between two parallel plates of large lateral width, with $\rho_2 > \rho_1$, $\mu_2 < \mu_1$. The lower plate is stationery whereas the upper plate moves towards the right with a uniform velocity U_0.

Determine the fully developed velocity profile between the two plates and sketch the same qualitatively.

[30 Marks]

APPENDIX A: Fluid Flow Equations in Rectangular Coordinate Systems (for constant viscosity Newtonian fluids)

Continuity: $$\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial x}(\rho v_x) + \frac{\partial}{\partial y}(\rho v_y) + \frac{\partial}{\partial z}(\rho v_z) = 0$$

x – momentum $$\rho\left(\frac{\partial v_x}{\partial t} + v_x\frac{\partial v_x}{\partial x} + v_y\frac{\partial v_x}{\partial y} + v_z\frac{\partial v_x}{\partial z}\right) = -\frac{\partial p}{\partial x} + \mu\left(\frac{\partial^2 v_x}{\partial x^2} + \frac{\partial^2 v_x}{\partial y^2} + \frac{\partial^2 v_x}{\partial z^2}\right) + \rho b_x$$

y – momentum $$\rho\left(\frac{\partial v_y}{\partial t} + v_x\frac{\partial v_y}{\partial x} + v_y\frac{\partial v_y}{\partial y} + v_z\frac{\partial v_y}{\partial z}\right) = -\frac{\partial p}{\partial y} + \mu\left(\frac{\partial^2 v_y}{\partial x^2} + \frac{\partial^2 v_y}{\partial y^2} + \frac{\partial^2 v_y}{\partial z^2}\right) + \rho b_y$$

z – momentum $$\rho\left(\frac{\partial v_z}{\partial t} + v_x\frac{\partial v_z}{\partial x} + v_y\frac{\partial v_z}{\partial y} + v_z\frac{\partial v_z}{\partial z}\right) = -\frac{\partial p}{\partial z} + \mu\left(\frac{\partial^2 v_z}{\partial x^2} + \frac{\partial^2 v_z}{\partial y^2} + \frac{\partial^2 v_z}{\partial z^2}\right) + \rho b_z$$