Problem Set (1)

1- The velocity distribution for the flow of Newtonian fluid between two wide parallel plates is given by the equation, $u = \frac{3V}{2}\left[1-\left(\frac{y}{h}\right)^2\right]$ where V is the mean velocity, Figure P.1.

The fluid viscosity is 0.2 Pa.s. When V=0.6 m/s and h=10 mm determine:

a) The shearing stress acting on the bottom wall.
b) The shearing stress acting on a plane parallel to the walls and passing through the centerline (mid plane).

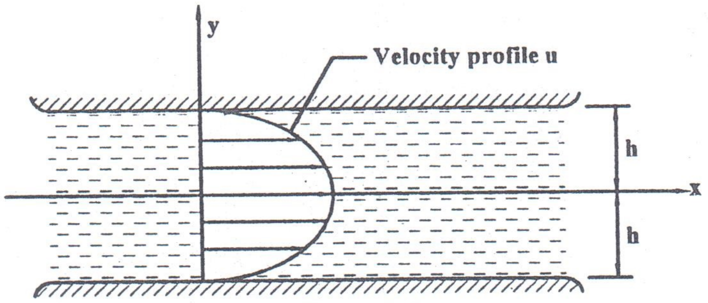

Figure P·1

2- A layer of water flows down an inclined fixed surface with the velocity profile shown in Figure P.2. Determine the magnitude and direction of the shearing stress that water exerts on the fixed surface for U=3 m/s and h=0.1 m. Take the viscosity of water 'μ' as 1 mPa s. The velocity profile is

given by $\frac{u}{U} = \frac{2y}{h} - \frac{y^2}{h^2}$

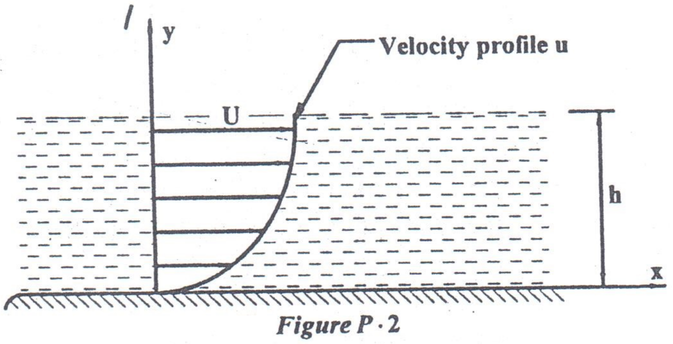

Figure P·2

3- A Newtonian fluid having a specific gravity of 0.92 and a kinematic viscosity of 4×10^{-4} m2/s flows past a fixed surface. The velocity profile near the surface is shown in Figure P.3. Determine the magnitude and direction of the shearing stress developed on the plate. Express your answer in terms of U and □expressed in units of m/s and m, respectively. (The density of water is 1000 kg/m3). The velocity profile is given by $\frac{u}{U} = \frac{3}{2}\frac{y}{\delta} - \frac{1}{2}\left(\frac{y}{\delta}\right)^3$

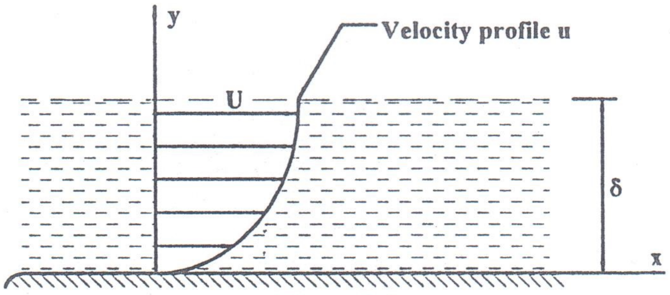

Figure P·3

4- Solve problem number 3 if the velocity profile is given by $\frac{u}{U} = \sin\left(\frac{\pi}{2}\frac{y}{\delta}\right)$.

5- A large movable plate is located between two large fixed plates as shown in Figure P.5. Two Newtonian fluids having the viscosities indicated are contained between the plates. Determine the magnitude and direction of the shearing stresses that act on the fixed walls when the movable plate has a velocity of 4 m/s as shown. Assume that the velocity distribution between plates is linear.

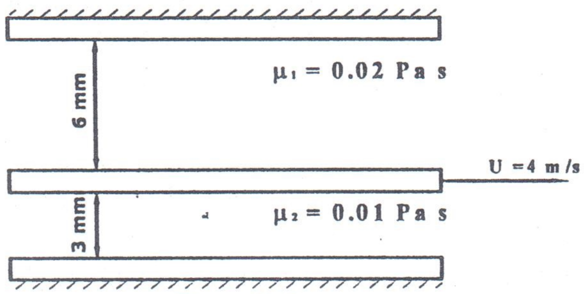

Figure P·5

6- In the device shown in Figure P.6 the outer cylinder is fixed and the inner cylinder is rotating with an angular velocity □. The torque T required to drive the inner cylinder is measured and the viscosity of the fluid □ is calculated from these two measurements. Develop an expression relating □□and T together with the constant l, ro and ri Neglect and effect and assume the velocity distribution in the gab is linear.
(Shearing force on inner cylinder = Shearing stress x radius)
(Torque required to drive the inner cylinder = Shearing force x radius)

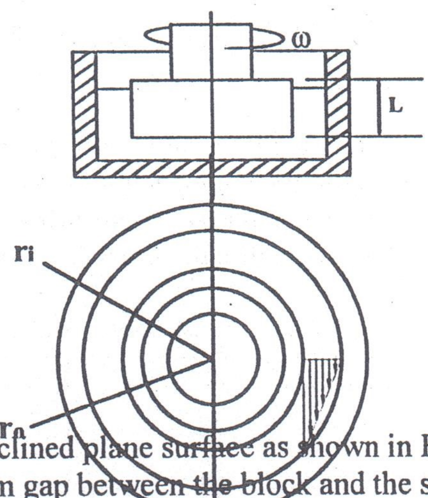

Figure P·6

7- A 10-kg block slides down an inclined plane surface as shown in Figure P.7. Determine the velocity of the block if the 0.1 mm gap between the block and the surface contains oil having a viscosity of 800 mPa s. Assume the velocity distribution in the gap is linear and the area of the block in contact with the oil is 0.2 m2. (Gravitational acceleration, g = 9.8 m/s2).

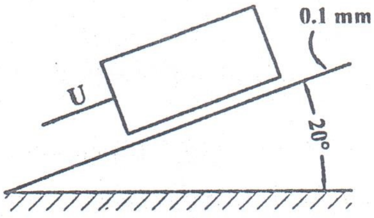

Figure P·7

8- A 25 mm diameter shaft is pulled through a cylinder bearing as shown in Figure P.8. The lubricant that fills the 0.3 mm gap between the shaft and bearing is oil having a kinematic 8×10^{-4} viscosity of m2/s and a specific gravity of 0.91. Determine the force required to pull the shaft at a velocity of 3 m/s. Assume the velocity distribution in the gap is linear. (Density of water is 1000 kg/m3).

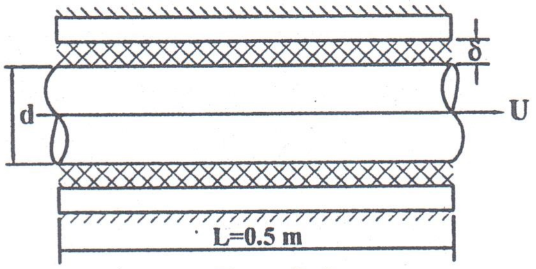

Figure P·8