CLL 110 Minor 9.30- 10.30 Maximum Marks 30 20-9-2021

After you have finished answering all questions, you are required to submit the scanned copy of your answers as a single pdf file. 20 minutes of extra time is given for this post-examination operation. Once you have created a single pdf file of your answers, please upload this file to the folder 'Minor' on Moodle. No submissions will be accepted after 10.50 am.

Q1. Velocity of a fluid may be determined using the velocity potential 'ϕ' by the following relation

$$\underset{\sim}{v} = \underset{\sim}{\nabla}\phi$$

If $\phi = \frac{5}{3}x^3 - 5xy^2$, determine the velocity profile. **(1)**

a) Does this velocity profile satisfy the equation of continuity for an incompressible fluid? **(1)**

b) Determine the acceleration of the fluid as felt by an observer moving with the velocity of the fluid. **(2)**

Q2. Water is flowing under steady laminar flow conditions through a long pipe of diameter 8 cm with an average velocity of 4 m/sec. At the end, another long pipe of 16 cm diameter joins this pipe. Using the results derived in the Lectures, determine the parabolic velocity profile in both pipes. If the viscosity of water is 1 centi-poise and its density is 1 gm/cm^3, determine the shear stress on the wall as well as the value of the friction factor for both pipes. **You need not show any derivation for the velocity profile.** **(4)**

Q3. Water of density ρ and viscosity μ is picked from a tank by a moving belt of width W, moving upwards in the vertical direction and the water is collected at the top in another tank. If the required flow rate of water is Q and the thickness of the liquid film attached to the belt is 'δ', determine the required velocity, V, of the belt. Use shell momentum balance approach to solve the problem. **(6)**

Q4. Hagen-Poiseeulle for a flow through a tube was derived in the Lecture classes earlier. Derive the form of Poiseulle's law for flow through a long rectangular duct whose planar surfaces are separated by a distance 2B in one direction and W in the other, where W is much-much greater then B. You may assume a steady laminar flow of a Newtonian fluid. The pressure drop across the duct is $\Delta P = \left(p_O - p_L\right)$, where L is the length of the duct. **(6)**