UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 2 Examination in Engineering: July 2022

Module Number: CE2201 **Module Name: Fundamentals of Fluid Mechanics**

[Three Hours]

[Answer **all questions**, each question carries twelve marks]

Q1. a) The velocity profile for a laminar flow is given by $u(r) = U_{max}(1 - r^2/R^2)$, where R is the radius of the pipe, r is the radial distance from the center of the pipe, and U_{max} is the maximum flow velocity, which occurs at the center.

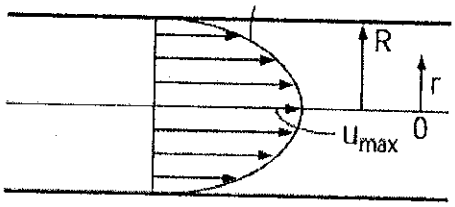

Figure Q1

(i) Obtain a relation for the shear stress.

[3.0 Marks]

(ii) Calculate the wall shear stress for water flow with $R = 0.08\,m$, $L = 15\,m$, $U_{max} = 3\,m/s$, and $\mu = 0.001\,kg/ms$. Draw the shear stress variation across the pipe.

[3.0 Marks]

b) Calculate the Reynolds number for a fluid of density 900 kg/m^3 and dynamic viscosity 0.038 Pas flowing in a 50 mm diameter pipe at the rate of 2.5 L/s. Estimate the mean velocity above which laminar flow would be unlikely.

[2.0 Marks]

c) Explain, using diagrams, the difference between steady flow, unsteady flow, uniform flow, and non-uniform flow in fluid mechanics.

[4.0 Marks]

Q2. a) The inclined face AD of the tank shown in Figure Q2a is a plane surface containing a gate ABC, which is hinged along BC. The shape of the gate is given the plan view. If the tank contains water, determine the magnitude of the force that the water exerts on the gate.

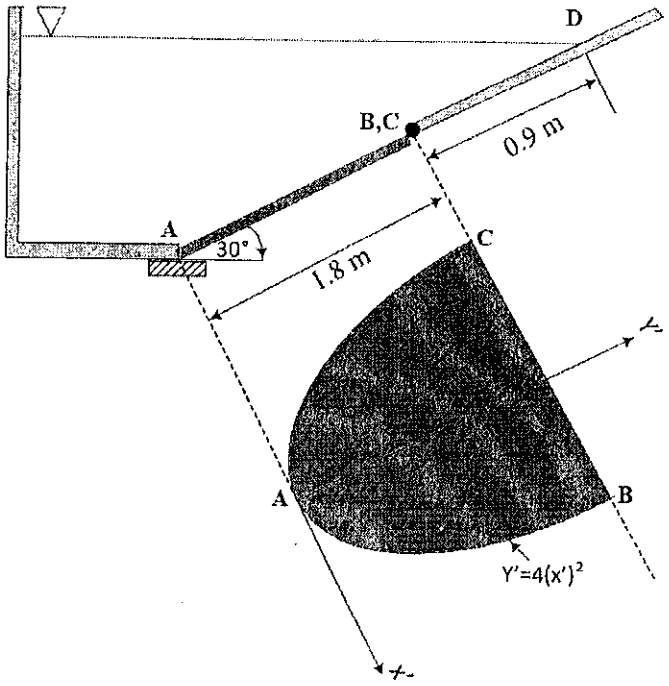

Figure Q2a

[8.0 Marks]

b) A homogeneous wooden block A, 0.7 m x 0.7 m x 1.3 m weighs 2.4 kN. A concrete block B is suspended from A using a slender cable causing A to float as in Figure Q2b. If the specific weight of the concrete is 23.6 kN/m³, calculate the volume of B.

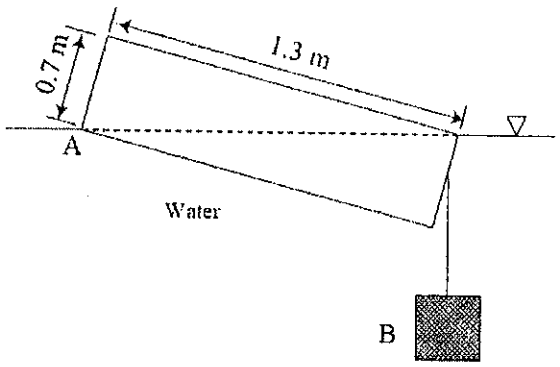

Figure Q2b

[4.0 Marks]

Q3. a) In a fully developed laminar pipe flow, the velocity profile is parabolic which is given by

$$u = U\left[1 - \left(\frac{r}{R}\right)^2\right]$$

Compare the momentum flow rate calculated with the average velocity and with the non-uniform velocity distribution.

[6.0 Marks]

b) Water flows through a horizontal elbow and nozzle combination as shown in Figure Q3. Atmospheric pressure is 100 kPa and the gauge pressure at section (1) is 100 kPa. At section (2), water exists to the atmosphere. Determine the headloss through the elbow nozzle combination and reaction force exerted on the flowing water.

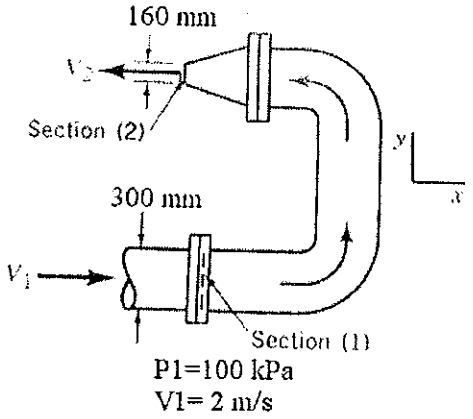

Figure Q3

[6.0 Marks]

Q4. a) Derive an equation for the total discharge through the submerged orifice shown in Figure Q4.

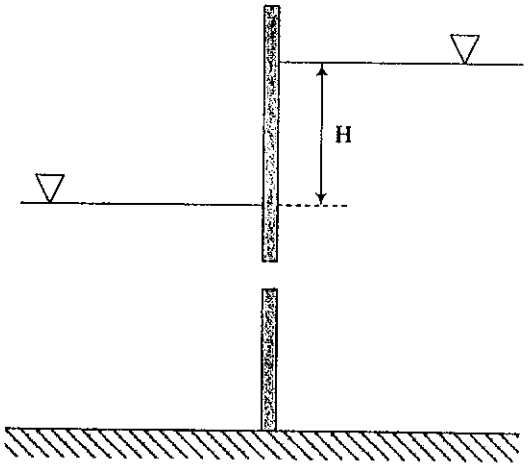

Figure Q4

[4.0 Marks]

b) Derive an expression for the time taken to drop the water level (H) from H_1 to H_2 by applying the mass continuity equation.

[4.0 Marks]

c) In a submerged orifice, water level (H) varies from 600 mm to 300 mm within 50 s.

(i) Calculate the coefficient of discharge using the expression derived in part (b). Consider the area ratio of the upstream water tank to orifice as 400.

(ii) Calculate the discharge through the orifice when the upstream water surface and downstream water surfaces are 1.8 m and 1.2 m above the top of the orifice, respectively

[4.0 Marks]

Q5. Water flows from tank A to tanks B and C as shown in Figure Q5. What is the flow rate into tank B? Neglect all minor losses and assume that the friction factor is 0.02 for all pipes. The diameter of each pipe is 0.01 m. Tank water elevations (Z_A, Z_B, and Z_c are as given in the figure.

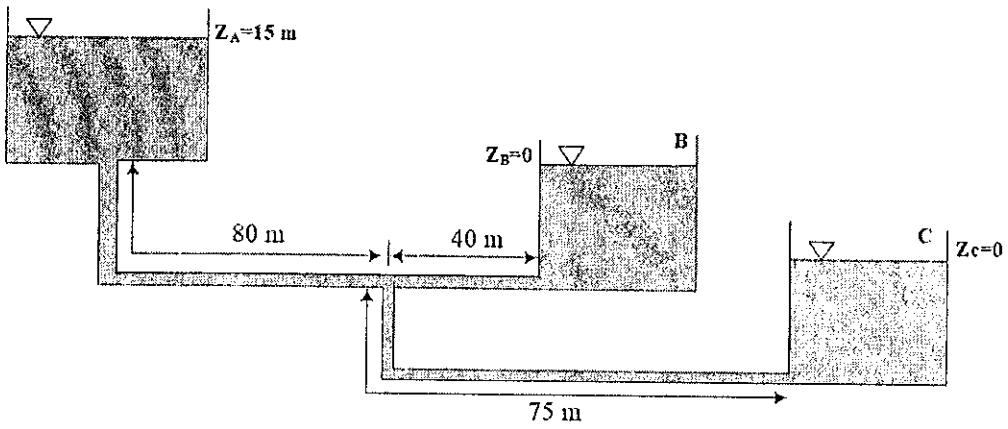

Figure Q5

[12.0 Marks]