UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 2 Examination in Engineering: February 2023

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

[Three Hours]

[Answer **all questions**, each question carries twelve marks]
All standard notations denote their usual meanings.

Q1. a) Hazen-Williams formula relates the flow rate in a pipe (Q) with the physical properties of the pipe and the pressure gradient $\frac{dp}{dx}$ as $Q = C\,D^{2.63}\frac{dp}{dx}^{0.54}$, where D is the pipe diameter and C is a constant. Determine the dimensions of the constant.

[2 Marks]

b) Velocity profile across a pipe for the water flowing in the pipe is given by $u = \frac{C}{4\mu}\left(\frac{d^2}{4} - r^2\right)$, where u= local velocity at any radius r, C is a constant, μ = viscosity of water, d = pipe diameter, and r is the radial distance from the centreline.

(i) Determine the maximum velocity in terms of C and μ.

[2 Marks]

(ii) Prove that the ratio of the mean velocity to the maximum velocity is 0.5.

[3 Marks]

(iii) Calculate the wall shear stress, if the radius of the pipe is 20 mm and the mass flowrate through the tube is 0.5 mg/s.

[5 Marks]

Q2. a) A 1 m diameter log having specific gravity of 0.82 divides two shallow ponds as shown in Figure Q2. Calculate the vertical and horizontal reactions at point A, if the log is 3.5 m long.

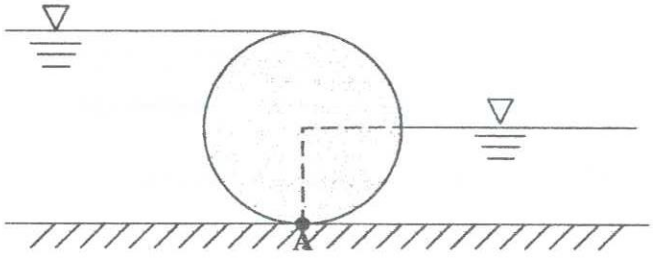

Figure Q2

[6 Marks]

b) A 0.5 m diameter uniform wooden cylinder has a relative density of 0.8. What is the maximum height it can has so that it will just float upright in water? You may consider the second moment of area of a circle as $\pi r^4/4$, where r is the radius.

[6 Marks]

Q3. a) Water is flowing through capilary tubes A and B into tube C as shown in Figure Q3a. If $Q_A = 3\,ml/s$ in tube A, what would be the maximum allowable discharge in tube B for laminar flow in tube C? You may consider the kinemetic viscosity of water as 10^{-6} m^2/s.

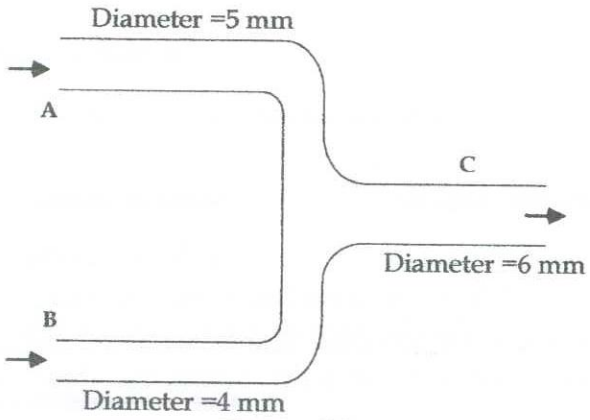

Figure Q3a

[5 Marks]

b) The sprinkler shown in Figure Q3b discharges $0.3\,l/s$ of water through each nozzle. The area of each nozzle opening is $90\,mm^2$. Neglecting friction, calculate its speed of rotation.

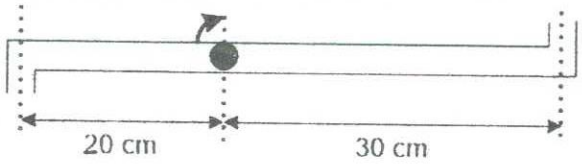

Figure Q3b

[7 Marks]

Q4. A vertical sluice gate is placed across a 0.5 m wide rectangular channel.

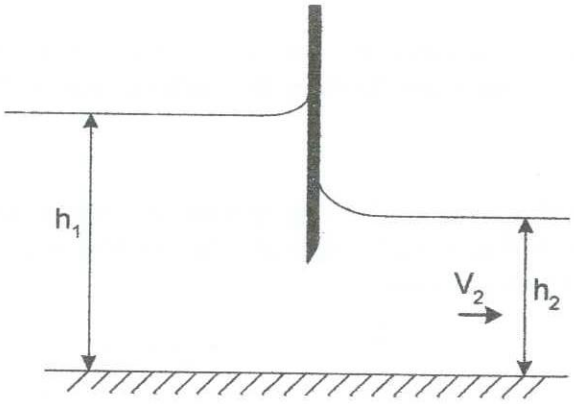

Figure Q4

(i) Derive an expression for V_2 considering $C_v = 0.98$.

[4 Marks]

(ii) If $h_1 = 2.2\,m$; $h_2 = 0.9\,m$; $C_c = 0.62$, calculate the height of the opening.

[8 Marks]

Q5. Oil of specific gravity 0.75 flows from tank A to tank E as shown in Figure Q5. Head losses from A to E may be assumed as; A to B = 0.6 $\frac{V_{BC}^2}{2g}$; B to C = 9 $\frac{V_{BC}^2}{2g}$; C to D = 0.4 $\frac{V_{CE}^2}{2g}$; D to E = 9 $\frac{V_{CE}^2}{2g}$. Calculate the flow rate through the pipes and the pressure at C.

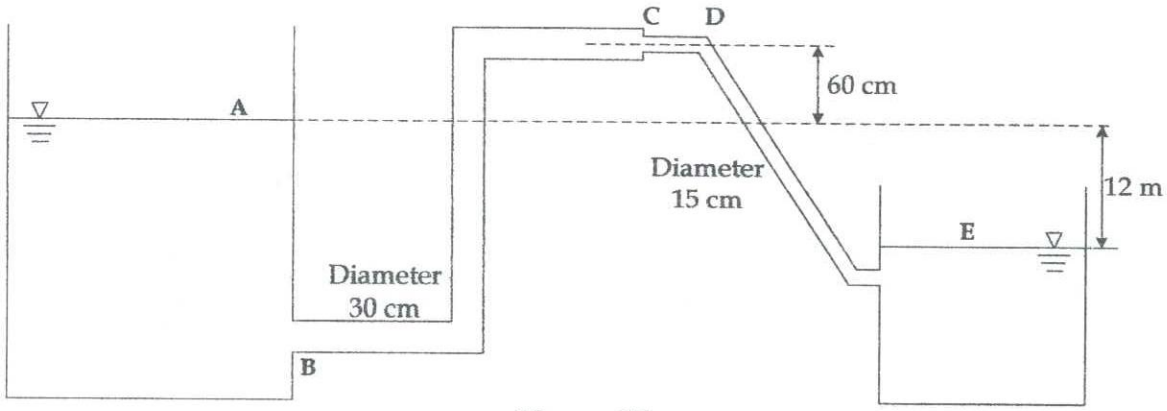

Figure Q5

[12 Marks]