MANICALAND STATE UNIVERSITY OF APPLIED SCIENCES

FACULTY OF ENGINEERING, SCIENCE AND TECHNOLOGY

DEPARTMENT: CHEMICAL AND PROCESSING ENGINEERING

MODULE: FLUID FLOW I

CODE: CHEP 222

SESSIONAL EXAMINATIONS
April 2023

DURATION: 3 HOURS

EXAMINER: MR C.K. SIMENDE

INSTRUCTIONS

1. *Answer **any four** questions*
2. *Start a new question on a fresh page*
3. *Total marks 100*

Additional material(s): *Calculator*

QUESTION 1

a) Define the following terms and give examples in each case:

i) Rheology [1]

ii) Newtonian fluids [2]

iii) Non-Newtonian fluids [2]

iv) Viscoelastic fluids [1]

b) Illustrate the rheological behavior of fluids using a fully labeled diagram. [4]

c) A general time-independent non-Newtonian liquid of density 961 kg/m^3 flows steadily with an average velocity of 2.0 m/s through a tube 3.048 m long with an inside diameter of 0.0762 m. For these conditions, the pipe flow consistency coefficient $\boldsymbol{K'}$ has a value of 1.48 Pa s$^{0.3}$ and $\boldsymbol{n'}$ a value of 0.3. Calculate the values of the apparent viscosity for pipe flow ($\boldsymbol{\mu_{ap}}$), the generalized Reynolds number $\boldsymbol{Re'}$ and the pressure drop across the tube, neglecting end effects. The Fanning friction factor (f) has a value of 0.0047. [15]

QUESTION 2

a) Calculate the specific weight, specific volume and specific gravity of a liquid having volume of 6 m^3 and weight of 44 kN. [7]

b) Calculate the gauge pressure and absolute pressure at a point 3 m below the free surface of a liquid having a density of 1.53x103 kg/m^3 if the atmospheric pressure is equivalent to 750 mm of mercury? The specific gravity of mercury is 13.6 and density of water is 1000 kg/m^3. [8]

c) Figure 1 shows a conical vessel having its outlet at A to which a U-tube manometer is connected. The reading of the manometer given in the figure shows when the vessel is empty. Find the reading of the manometer when the vessel is completely filled with water. [10]

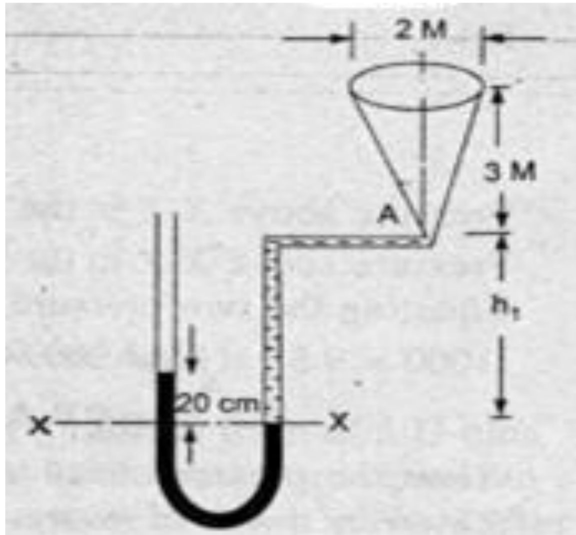

Figure 1: U-tube manometer

QUESTION 3

a) A pipe through which water is flowing is having diameters 20 cm and 10 cm at the cross-sections 1 and 2 respectively. The velocity of water at section 1 is given 4 m/s. Find the velocity head at sections 1 and 2 and also rate of discharge. [9]

b) You are filling your car with petrol, which emerges from pump through a pipe with a 3 cm diameter at a speed of 50 cm/s.

i) Calculate the flow rate. [3]

ii) How long will it take to fill a car with 20 l of fuel? [4]

c) A garden hose has a diameter of 16 mm. The hose can fill a 10 litre bucket in 20 s.

i) What is the speed of the water out the end of the hose? [4]

ii) A nozzle with smaller diameter than the hose is attached to the end of the hose to increase the flow speed out of the hose. What diameter nozzle with circular cross section is needed for the water to exit the hose with a speed 4 times greater than the speed inside the hose? [5]

QUESTION 4

a) Derive the Bernoulli's equation from the Euler equation. [7]

b) The water is flowing through a pipe having diameter 20 cm and 10 cm at sections 1 and 2 respectively (Figure 2). The rate of flow through pipe is 35 litres/s. The section 1 is 6 m above datum and section 2 is 4 m above datum. If the pressure at section 1 is 39.24 N/cm^2, find the intensity of pressure at section 2. [10]

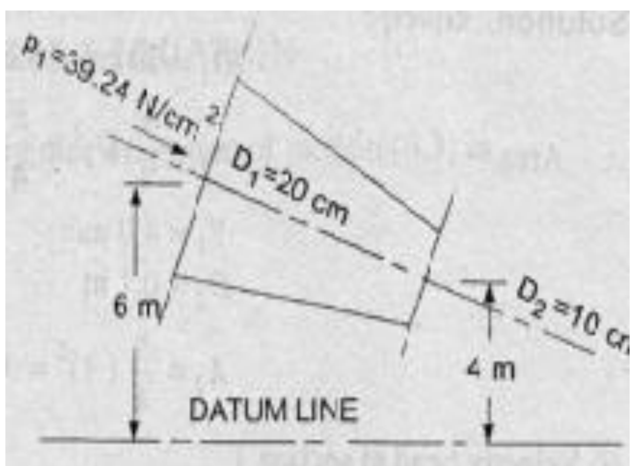

Figure 2: Water flowing through a pipe of varying diameter

c) Water is flowing through a pipe having diameter 300 mm and 200 mm at the bottom and upper end respectively. The intensity of pressure at the bottom end is 24.525 N/cm^2 and the pressure at the upper end is 9.81 N/cm^2.

Determine the difference in datum head if the rate of flow through pipe is 40 lit/s. [8]

QUESTION 5

a) Define dimensional analysis and write down any two methods available for dimensional analysis. [3]

b) Outline the uses of dimension analysis? [3]

c) State Buckingham's π theorem and list the repeating variables used in this theorem. [4]

d) The discharge *Q* through an orifice is a function of the diameter d, the pressure difference P, the density ρ, and the viscosity μ, show that:

$$Q = \frac{d^2 p^{1/2}}{\rho^{1/2}\phi}\left[\frac{d\,\rho^{1/2} p^{1/2}}{\mu}\right]$$

where ϕ is some unknown function. [15]

END OF EXAMINATION

LIST OF FORMULAE

$$\mu_{ap} = K' \left(\frac{8u}{d_i}\right)^{n'-1}$$

$$Re' = \frac{\rho u d_i}{\mu_{ap}}$$

$$F = \frac{8u}{d_i}$$

$$\mu_{ap} = \frac{\tau_w}{8u/d_i} = K' \left(\frac{8u}{d_i}\right)^{n'-1}$$

$$\Delta P_f = 4f\left(\frac{L}{d_i}\right)\frac{\rho u^2}{2} = \frac{2fL\rho u^2}{d_i}$$

$$\rho = \frac{m}{V}, \quad \frac{p_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{v_2^2}{2g} + z_2$$

$$\gamma = \frac{W}{V} = \rho \times g, \quad \Delta H = h_f = f\frac{L}{D}\frac{V^2}{2g}$$

$$v = \frac{V}{m} = \frac{1}{\rho} \quad \frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_L$$

$$\tau = \mu\frac{du}{dy}, \quad P = \frac{\sigma \times \pi d}{\frac{\pi}{4}d^2} = \frac{4\sigma}{d}$$

$$A_1 V_1 = A_2 V_2 = Q$$