

The Open University of Sri Lanka

Faculty of Engineering Technology



057

Study Programme : Bachelor of Science Honours in Engineering
Name of the Examination : Final Examination
Course Code and Title : DMX4203 Applied Fluid Dynamics I
Academic Year : 2022/23
Date : 17th February 2024
Time : 0930-1230h
Duration : **3 hours**

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Five (5)** questions in **Four (4)** pages.
3. Answer **all** questions.
4. All questions carry equal marks.
5. Answer for each question should commence from a new page.
6. This is a Closed Book Test (CBT).
7. Answers should be in clear handwriting.
8. Moody Diagram is attached to this paper

Question-1 (20 marks)

- a) Explain the difference between Newtonian and non-Newtonian fluids. 03 marks
- b) The velocity distribution in the flow of a viscous liquid is having $\mu = 2.5 \text{ Pa.s}$ over a fixed boundary of $u = 0.3y - 0.1y^2 + 0.2y^3$, in which u is a point velocity at a distance y from the boundary. Determine the shear stress at the boundary, i.e., at $y = 0.1$ and $y = 0.3 \text{ m}$. 06 marks
- c) What are the crucial factors and engineering applications that highlight the importance of pressure forces of fluid dynamics? 03 marks
- d) A profile of a dam structure is shown in **Figure Q1**. Determine the resultant hydrostatic thrust (F) per meter width of the dam and the distance from A to the point of intersection of F with the base line AX. 08 marks

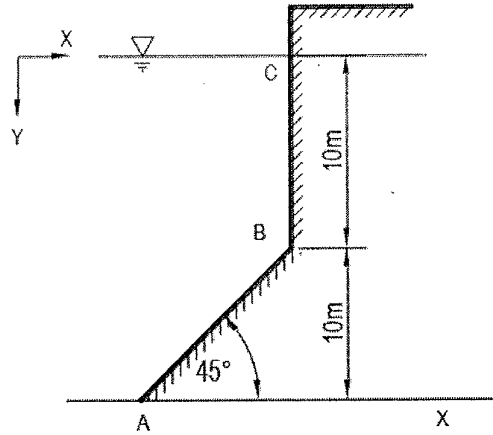


Figure Q1

Question-2 (20 marks)

- a) Discuss the importance of Bernoulli's equation for the subject of fluid dynamics with relevant examples. 04 marks
- b) A venturimeter consists of a converging cone, throat and diverging cone as shown in **Figure Q2**.
 - i. Discuss the behavior of the pressure and velocity of the fluid at converging cone, throat and diverging cone. 10 marks
 - ii. Derive an equation for the discharge (**Q**) of the venturi meter at section 2-2 with the notations of cross-sectional areas (a_1 and a_2), venturi-head (h) and gravitational acceleration (g).

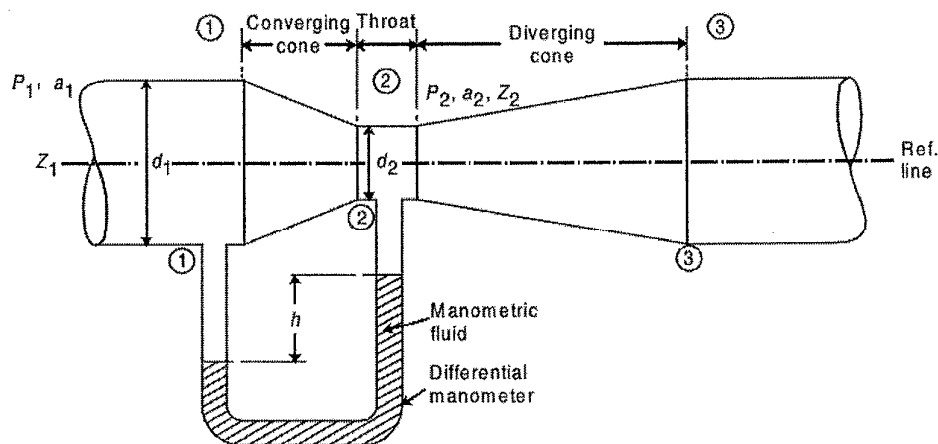


Figure Q2

- c) A venturimeter is provided in the pipeline to determine the discharge of the fluid having specific gravity of 0.8. The diameters at the inlet section and at the outlet section are 20 cm and 10 cm respectively. The oil mercury differential manometer shows a gauge deflection of 15 cm of mercury (Hg). Determine the discharge of the pipe in m^3s^{-1} . (Specific gravity of Hg is 13.6) 06 marks

Question-3 (20 marks)

- a) Discuss the importance of 'dimensional analysis' related to fluid dynamics. 03 marks
- b) Differentiate geometric, kinematic and dynamic similarity using appropriate examples. 03 marks
- c) Write a short note on Buckingham π theorem. 02 marks
- d) Show by the method of dimensions that a rotational formula for the flow over a 'V' notch is given by,

$$Q = g^{1/2} h^{5/2} \phi \left(\frac{v}{g^{1/2} h^{3/2}}, \frac{\gamma}{g h^2 \rho}, \theta \right),$$
 12 marks

Where Q is the flow, h is the head above the vertex, ρ is the density, v is the kinematic viscosity and γ the surface tension coefficient, θ is the angle of notch and g is the acceleration due to gravity.

Question-4 (20 marks)

- a) Discuss the concept of laminar flow in fluid dynamics, emphasizing its characteristics and significance in engineering applications. 03 marks
- b) Laminar flow analysis frequently involves examining the flow resulting from the application of a pressure difference to the fluid that fills the region between two sizable parallel plates. Commencing with Newton's shear law and making relevant assumptions, derive the equation for the flow rate ' Q ' for laminar flow between stationary parallel plates. 07 marks

Additionally, demonstrate mathematically that the mean velocity (V) is two-thirds of the maximum velocity (U_{max}) which is observed at the center. Utilize appropriate notations throughout these derivations.

- c) Two parallel plates kept 100 mm apart have laminar flow of oil between them. The maximum velocity of flow is 1.5 ms^{-1} and viscosity of oil 2.45 Pa.s. Calculate, 10 marks
- Discharge per meter width.
 - Shear stress at the plates.
 - The pressure difference between two points 20 m apart.
 - The velocity gradient at the plates and,
 - Velocity at 20 mm from the plate.

Question-5 (20 marks)

- a) Discuss the importance of using the Moody diagram in pipe systems. 03 marks
- b) Discuss potential losses in a pipe system for gravitational flow between two reservoirs with a relevant diagram. 05 marks
- c) Water at 15°C is flowing steadily in a 5 cm diameter horizontal pipe made of stainless steel at a rate of $0.006 \text{ m}^3\text{s}^{-1}$. The density and viscosity of water are 999 kg/m^3 and $1.138 \times 10^{-3} \text{ kg.s/m}^2$. The surface roughness of the pipe is 0.002 mm. Determine,
- i. Pressure drop of the pipe. 12 marks
 - ii. Head loss of the pipe.
 - iii. Required pumping power input for flow over a 60 m long section of the pipe.

(You may use Moody diagram for the calculations if necessary)

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$$\text{Darcy-Weisbach friction factor } f = \frac{2hDg}{LV^2}$$

