The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: ***Final Examination***
Course Code and Title	**: DMX4203 – Applied Fluid Dynamics I**
Academic Year	: 2020/2021
Date	: 29th January 2022
Time	: 09.30-12.30hrs
Duration	: **3 hours**

General Instructions

1. Read all the instructions carefully before answering the questions.
2. This question paper consists of 8 questions. All questions carry equal marks.
3. Answer **any 5** questions only.
4. Take acceleration due to gravity as **9.81 N/kg** and the density of water as **1000 kg/m^3** respectively where necessary.

Q1).

a) By considering a differential fluid element, show that the vector form of the continuity equation for an incompressible fluid flow in usual notation is given by,

5-marks

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0$$

The velocity field ***V(x,y,z,t)*** is given as,

$$V(x,y,z,t)=10\,x^2 i-20\,xyj\;+100\;tk$$

b) Show that the given flow defined by ***V(x,y,z,t)*** can exist. *5-marks*

c) Determine the velocity and acceleration of a flow particle at position x=1m, y=2m, z=5m at t=0.1s *10-marks*

Q2).

a) Show that the distance to the center of pressure of a planar surface of area A from the free surface is given by the expression,

5-marks

$$Y_{cop} = \frac{\int y^2 dA}{\int ydA}$$

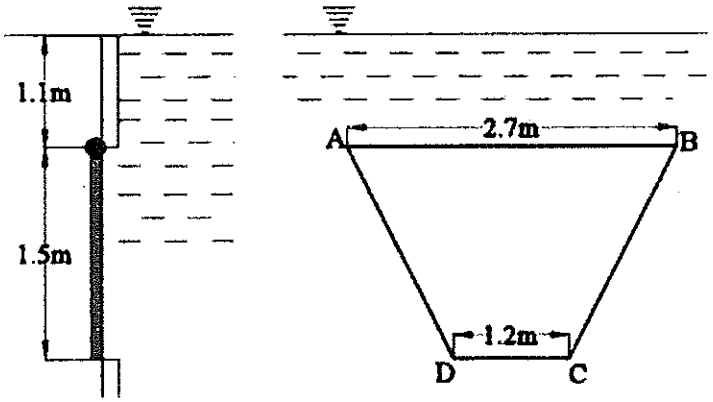

Figure Q2

b) As shown in Figure Q2, A trapezoidal opening *(ABCD)* in the vertical wall of a tank is closed by a flat plate which is hinged at its upper edge *AB*. The plate is symmetrical about its centreline and is 1.5m deep. Its upper edge is 2.7m long and its lower edge is 1.2m long. The free surface of water in the tank stands 1.1m above the upper edge of the plate.

I. Calculate the resultant force on the plate.

7-marks

II. Calculate the moment about the hinge**(AB)** required to keep the plate closed.

8-marks

[NB: The second moment of area of a rectangle and a triangle about the centroidal axis are $bh^3/12$ *and* $bh^3/36$ *respectively (b – breadth, h- height).]*

Q3).

a) Show that the loss of pressure head (h_f) of a viscous flow in a circular pipe of diameter **D** and length **L** is given by,

$$h_f = \frac{32\ \mu UL}{\rho g D^2}$$

8-marks

Where:

μ=viscosity of the fluid, U = mean velocity and ρ=density of the fluid

b) 12-marks

An oil of specific gravity 0.9 and viscosity 1 Nsm^{-2} is flowing through a pipe of diameter 110mm. The velocity at the center is 2 ms^{-1}, determine the:

I. pressure gradient in the direction of flow
II. shear stress at the pipe wall
III. Reynolds number
IV. velocity at a distance of 30 mm from the wall.

Q4).

a) Write down the applications of weirs and notches.

4-marks

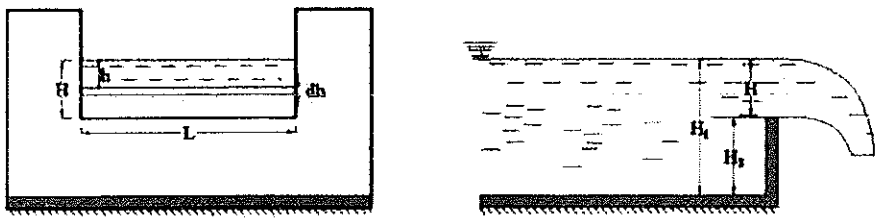

Figure Q4

b) A rectangular notch is shown in Figure Q4. Show that the total discharge can be theoretically expressed as,

6-marks

$$Q = \frac{2}{3} L \sqrt{2g} H^{\frac{3}{2}}$$

c) Determine the height of a rectangular weir (H_2) to be built across a rectangular channel under the following conditions.

10-marks

Length of the weir (L) =6m.
Maximum depth of water on the upstream side of the weir (H_1) =1.8m
Discharge (Q) = 2000 litres/sec
Coefficient of discharge (C_d) = 0.6

Q5).

a) The shear stress τ_0 at the bed of a rough channel depends upon the depth of flow **y**, velocity of the fluid **V**, roughness height of the bed σ, the fluid density ρ and the viscosity μ. Show that τ_0 can be expressed in the dimensionless form as,

$$\frac{\tau_0}{\rho V^2} = \phi\left(\frac{\mu}{\rho V y}, \frac{\sigma}{y}\right)$$

10-marks

b) What is meant by dynamic similarity? **4-marks**

c) Oil of density $917\ kgm^{-3}$ and dynamic viscosity $0.29\ Pa\ s$ flows in a pipe of diameter 15 cm at a velocity of 2.0 ms^{-1}. What should be the velocity of the flow of water in a 1.0 cm diameter pipe, to make the two flows dynamically similar? **6-marks**

[NB: Viscosity of water is $1.31x10^{-3}$ Pa s]

Q6).

a) What is the relationship between the most economical section and the wetted perimeter in an open channel flow. **4-marks**

b) Derive the hydraulic - geometry relationship of the most economical section under fluid flow of a rectangular channel of width **w** and depth **y**. **8-marks**

c) A rectangular channel carries water at the rate of 400 liters/sec when the bed slope is 1 in 2000. Find the most economical dimensions of the channel if C=50. **8-marks**

NB: The discharge Q is given by: $Q = AC\sqrt{RS_0}$

Where A= Area of Flow

R= Hydraulic mean depth

S_0 = Slope of the channel

Q7).

Show that the head loss due to friction (h_f) in pipes can be derived as, **10-marks**

$$h_f = \frac{4 f . L . V^2}{2 g d}$$

Where: L = Length of the pipe, d= Diameter of the pipe and f= friction coefficient.

Calculate the total head loss along the pipe line described in Figure Q7. Take the friction coefficient f=0.0065 and the exit velocity V_{Exit}=1.5 ms^{-1}. **10-marks**

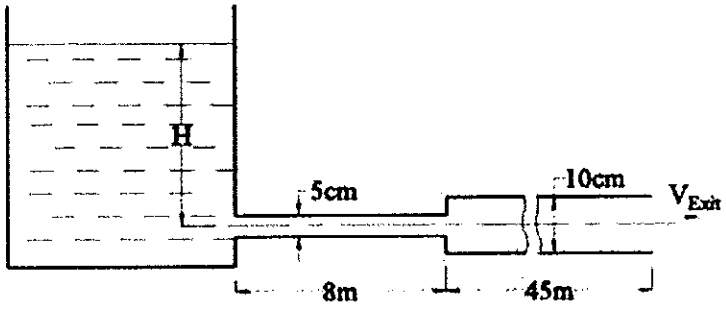

Figure Q7.

Q8).
A water jet is issued out of a pipe with a velocity of 13ms^{-1} as shown in Figure Q8.

a) Calculate the angle(s) of inclination of the water jet to the horizontal. **12-marks**
b) Calculate the amount of water falling on the window per second. **8-marks**

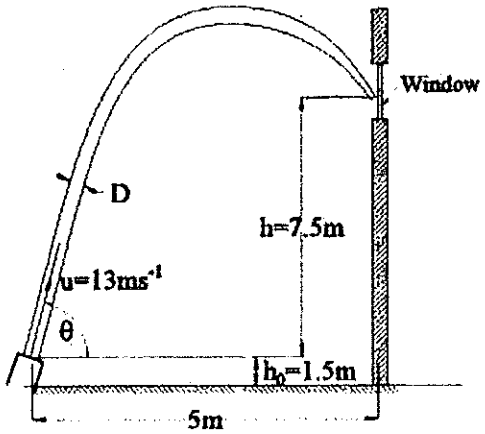

Figure Q8

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