UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2016/2017

COURSE NAME	:	FLUID MECHANICS I
COURSE CODE	:	BDA 20603
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	JUNE 2017
DURATION	:	3 HOURS
INSTRUCTION	:	PART A ANSWER **THREE (3)** OUT OF FOUR (4) QUESTIONS **ONLY** PART B ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

PART A

Q1 (a) A flowrate measuring device is installed in a horizontal pipe through which water is flowing. A U-tube manometer is connected to the pipe through pressure taps located 8 cm on either side of the device. The gage fluid in the manometer has a specific weight of 30 kN/m^3. Determine the differential reading of the manometer corresponding to a pressure drop between the taps of 3.5 kPa.

(5 marks)

(b) A 5 m-wide, 10 m-high rectangular gate is located at the end of a rectangular passage that is connected to a large open tank filled with water as shown in **Figure Q1 (b)**. The gate is hinged at its bottom and held closed by a horizontal force, F_H, located at the center of the gate. The maximum value for F_H is 4000 kN. Determine

i. the maximum water depth, h, above the center of the gate that can exist without the gate opening; and

(10 marks)

ii. the maximum water depth, h, if the gate is hinged at the top.

(5 marks)

Q2 (a) In an experiment, a tank with cross-sectional area of A is filled with a liquid of density ρ_a.

i. When a cylinder with density ρ_b and volume V is floated in the liquid, the liquid level rises by an amount of Δh. Prove that:

$$\Delta h = \left(\frac{\rho_b}{\rho_a}\right)\left(\frac{V}{A}\right)$$

(4 marks)

ii. Determine the value of Δh if the height of the cylinder is 1.5 m. Assume that the specific weights of the liquid and cylinder are 9810 N/m^3 and 8829 N/m^3, respectively; and

(5 marks)

iii. The cylinder is removed from the tank and replaced with an irregular shape of solid material. The solid material weighs 35 N in air and 23 N when fully immersed in the liquid. Find the density of the material.

(5 marks)

(b) In other experiment, an open U-tube is partially filled with a liquid. The tube is then accelerated with a horizontal acceleration a, and differential height, h developed between the tube legs which are spaced a distance, x apart as shown in **Figure Q2 (b).**

i. Find the relationship between acceleration a, height, h and distance, x; and

(4 marks)

ii. Calculate the height developed between the two legs if the distance, x is 8 cm and the angle the free surface makes is 43°.

(2 marks)

Q3 (a) Water flows through the pipe contraction shown in **Figure Q3 (a)**. For the given 0.4 m difference in manometer level, determine the volume flowrate when the diameter of the small pipe, $D = 0.05$ m

(8 marks)

(b) Air flows steadily through a converging–diverging rectangular channel of constant width as shown in **Figure Q3 (b)**. The height of the channel at the exit and the exit velocity are H_0 and V_0 respectively. The channel is to be shaped so that the distance, d, that water is drawn up into tubes attached to static pressure taps along the channel wall is linear with distance along the channel. The height of the channel,

$$H(x) = H_o - [(H_o - H_i)/L]x,$$

where L is the channel length and H_i is the minimum channel height (at the minimum channel height: $x = L$).

i. Prove that

$$d(x) = \frac{\frac{1}{2}\rho\left[\left[\frac{H_0 V_0}{H_0 - \left(\frac{H_0 - H_i}{L}\right)x}\right]^2 - V_0^{\,2}\right]}{\gamma_{H_2O}}$$

(8 marks)

ii. Given that $H_0 = 0.5$ m, $V_0 = 0.5$ m/s, $H_i = 0.25$ m and $L = 1$ m. Calculate $d(L)$. The density of air is 1.225 kg/m^3.

(4 marks)

Q4 (a) Describe body forces and surface forces by giving the examples, and explain how the net force acting on control volume is determined.

(5 marks)

(b) A 90° elbow as shown in **Figure Q4 (b)** is used to direct water flow at a rate of 25 kg/s in a horizontal pipe upward. The diameter of the entire elbow is 10 cm. The elbow discharges water into the atmosphere, and thus the pressure at the exit is the local atmospheric pressure. The elevation difference between the centers of the exit and the inlet of the elbow is 35 cm. The weight of the elbow and the water in it is considered to be negligible. Determine i the gage pressure at the center of the inlet of the elbow; and

(8 marks)

ii the anchoring force needed to hold the elbow in place; Take the momentum-flux correction factor to be 1.03.

(7 marks)

PART B

Q5 (a) Maintenance A horizontal pipe has an abrupt expansion from 100 mm diameter to 150 mm diameter. The flowrate of the water through the pipe is 1.8 m^3/s. Determine

i the head loss due to sudden enlargement; and

(5 marks)

ii the different pressure between the two pipes.

(5 marks)

(b) Water at 30°C with dynamic viscosity of 1.00 x 10^{-3} kg/m.s is flowing through a wrought iron pipe with the diameter of 4 cm. The length of the pipe is 500 m and the flowrate is 0.03 m^3/s. Determine the head loss of the pipe.

(10 marks)

Q6 (a) State **Four (4)** criteria in selecting repeating variables in Buckingham's π analysis.

(4 marks)

(b) It is desired to determine the wave height when wind blows across a lake. The wave height, *H*, is assumed to be a function of the wind speed, *V*, the water density, ρ, the air density, ρ_a, the water depth, *d*, the distance from the shore, ℓ and the acceleration of gravity, *g*.

i Use *d*, *V*, and ρ as repeating variables and prove that

$H/d = \phi(\rho_a/\rho, \ell/d, gd/V^2)$; and

(14 marks)

ii An experiment indicates that for d = 2 m and V = 5 m/s, H is 2 m. Estimate the value of H when V = 4 m/s.

(2 marks)

-END OF QUESTIONS –

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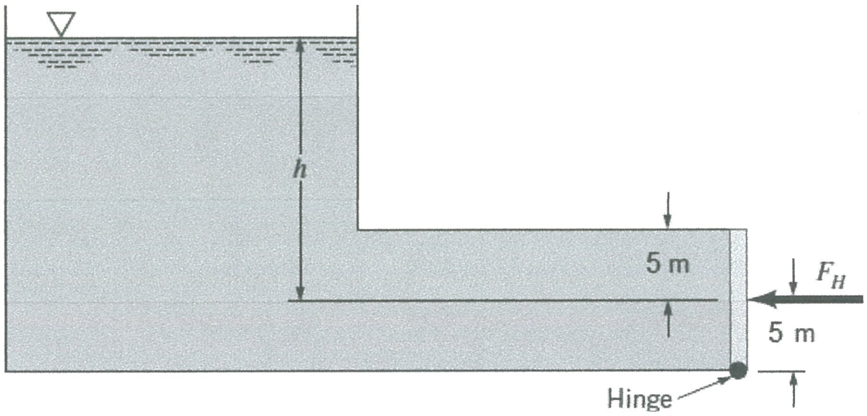

Figure Q1 (b)

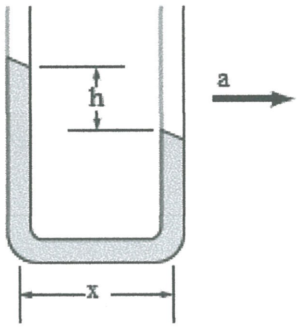

Figure Q2 (b)

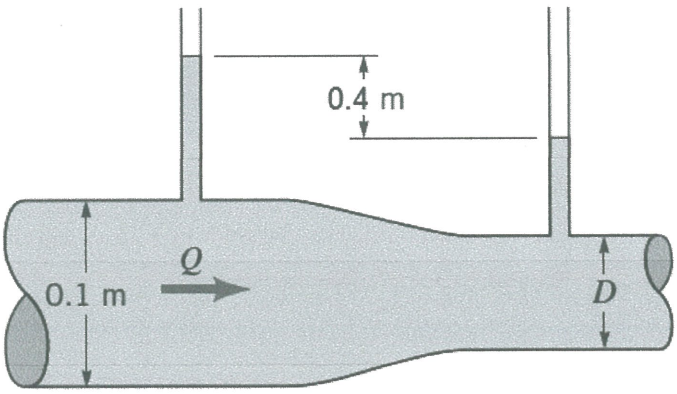

Figure Q3 (a)

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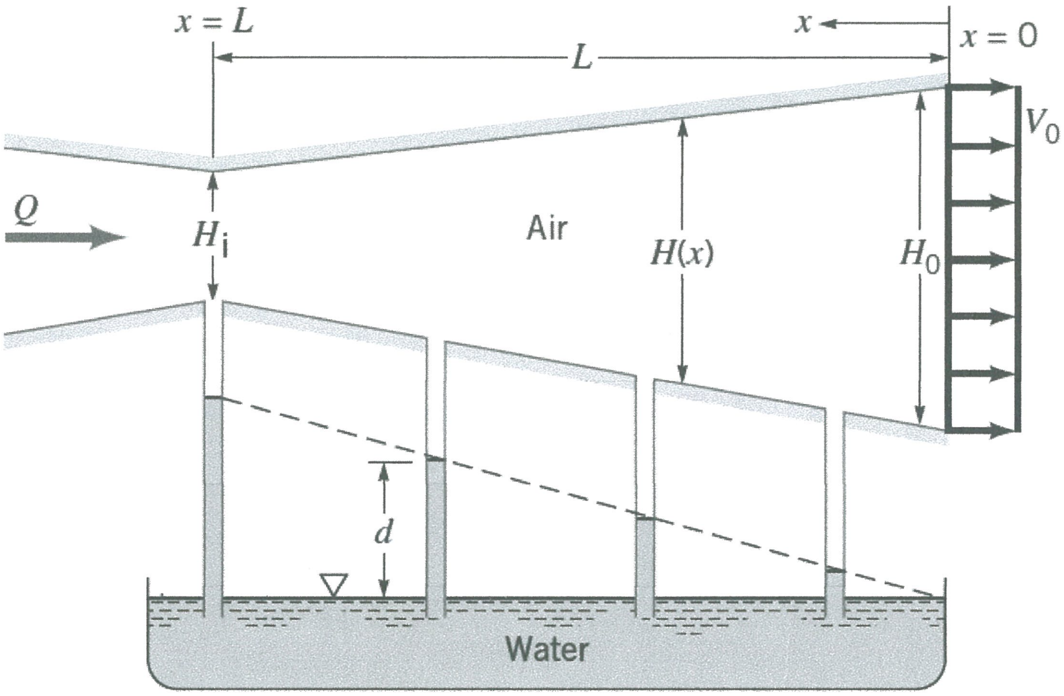

Figure Q3 (b)

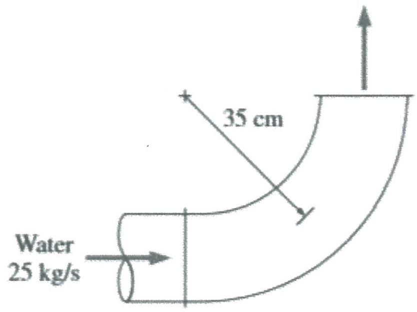

Figure Q4 (b)

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Table Q5: Equivalent Roughness for New Pipes

	Equivalent Roughness, ε	
Pipe	Feet	Millimeters
Riveted steel	0.003–0.03	0.9–9.0
Concrete	0.001–0.01	0.3–3.0
Wood stave	0.0006–0.003	0.18–0.9
Cast iron	0.00085	0.26
Galvanized iron	0.0005	0.15
Commercial steel or wrought iron	0.00015	0.045
Drawn tubing	0.000005	0.0015
Plastic, glass	0.0 (smooth)	0.0 (smooth)

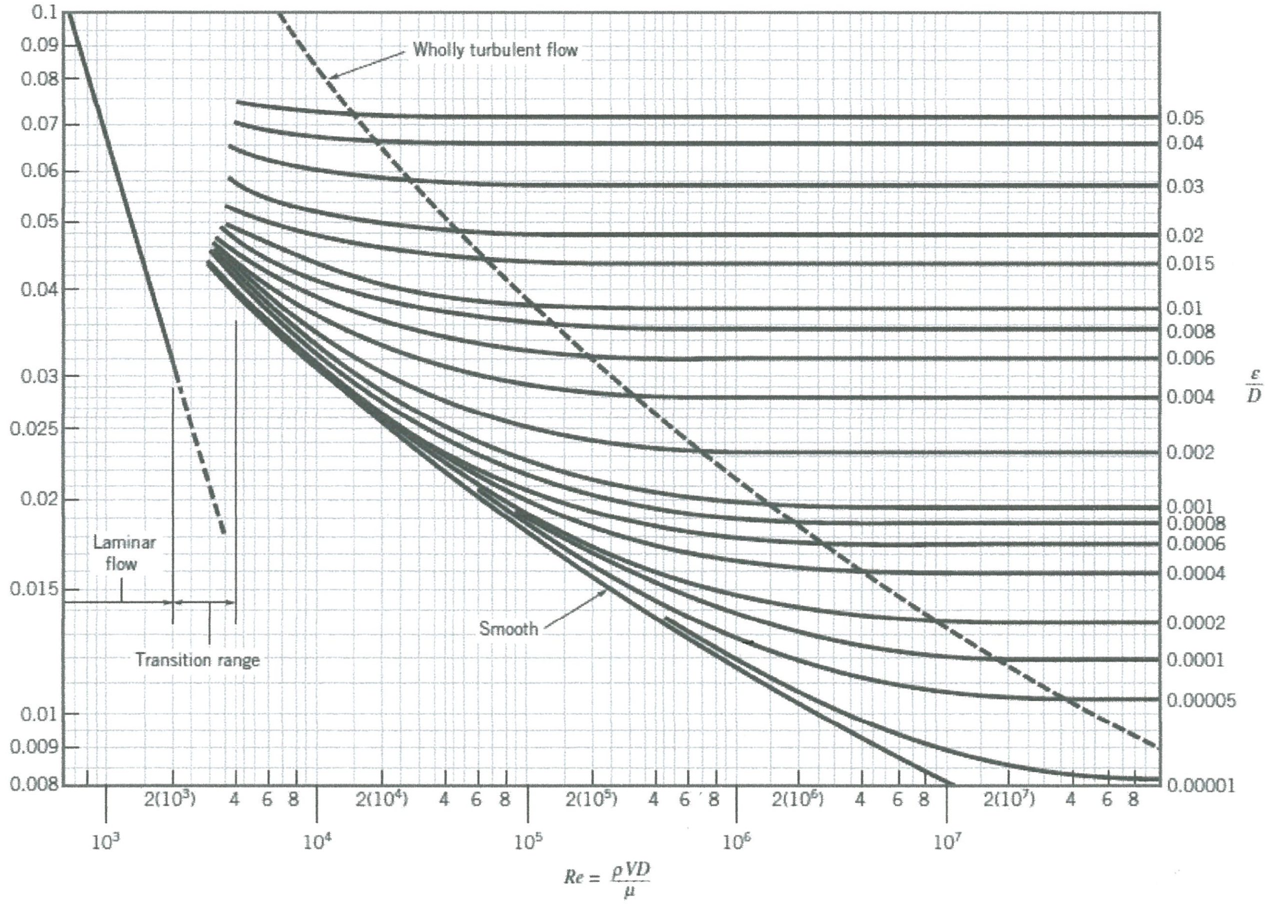

Figure Q5: The Moody Chart