NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY
BACHELOR OF ENGINEERING (HONS) DEGREE
Part Two Examination February 2010

TCE2105 Fluid Flow

Duration of Examination 3 Hours

Instructions to Candidates:
Answer ANY FIVE questions.
Each question carries equal marks.
Show all steps clearly in your calculation.
Start the answers for each question on a new page.

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1. **a)** What is the absolute pressure in the sea at a depth of 10m? Assume the density of seawater is constant at 1025 kg/m^3 and that atmospheric pressure is 101325 Pa. **(4 marks)**

b) If a mercury manometer is attached to a tank of oil or relative density 0.8 and the readings were as shown in **Figure** below, what would be the level of water (h) above the point where the manometer was attached? **(7 marks)**

c) Describe the following phenomenon and explain why they occur:

i. The boundary layer; **(3 marks)**
ii. Boundary layer separation; **(3 marks)**
iii. Boundary layer separation at a T-junction; **(3 marks)**

2. **a)** Starting with the Bernoulli and Continuity equations, show that the following expression gives the discharge measured by a venturimeter.

$$Q_{actual} = C_d A_1 A_2 \sqrt{\frac{2g\left[\frac{p_1 - p_2}{\rho g} + z_1 - z_2\right]}{A_1^2 - A_2^2}}$$

(6 marks)

b) A horizontal venturimeter is used to measure the flow of water in a 200mm diameter pipe. The throat diameter of the venturimeter is 80mm and the discharge coefficient is 0.85. If the pressure difference between the two measurement points is 10cm of mercury, calculate the average velocity in the pipe. Assume the relative density of mercury is 13.6.

(8 marks)

c) The velocity of the water flowing in the same pipe is also measured using a pitot-static tube located centrally in the flow. If the height measured on the attached manometer is 60mm and the relative density of the manometer fluid is 1.45, determine the velocity of the water.

(3 marks)

d) Explain why the velocity measured by the pitot-static tube is higher than that measured by the venturimeter.

(3 marks)

3. a) Derive the following expression for the discharge over a rectangular weir. Start with Bernoulli's equation and state all the assumptions that you make.

$$Q_{actual} = C_d \frac{2}{3} B\sqrt{2g} H^{3/2}$$

(6 marks)

(b) Water is flowing over a sharp-crested rectangular weir of width 50cm into a tank with cross-sectional area 0.6 m^2. After a period of 30 s the depth of water in the tank is 1.4m. Assuming a discharge coefficient of 0.9, determine the height of the water above the weir.

(7 marks)

(c) If the rectangular weir is replaced by a 90^o notch weir with the same head and a discharge coefficient of 0.8, calculate the depth increase of the water in the tank after 30s.

(7 marks)

4. a) The discharge of water through a 320º bend, shown in **Figure** below, is 30 L/s. The bend is lying in the horizontal plane and the diameters at the entrance and exit are 200mm and 100mm respectively. The pressure measured at the entrance is 100 kN/m^2, what is the magnitude and direction of the force exerted by the water on the bend? **(17 marks)**

b) Comment on how frictional losses might be included in the above analysis.

(3 marks)

5. a) *600 cm^3/s* of water at *320 K* is pumped in a *40 mm i.d.* pipe through a length of *150 m* in a horizontal direction and up through a vertical height of *10 m*. In the pipe there is a control valve which may be taken as equivalent to *200 pipe diameters* and other pipe fittings equivalent to *60 pipe diameters*. Also in the line there is a heat exchanger across which there is a loss in head of *1.5 m of water*. If the main pipe has a roughness of *0.0002m*, what power must be delivered to the pump if the unit is *60 %* efficient?

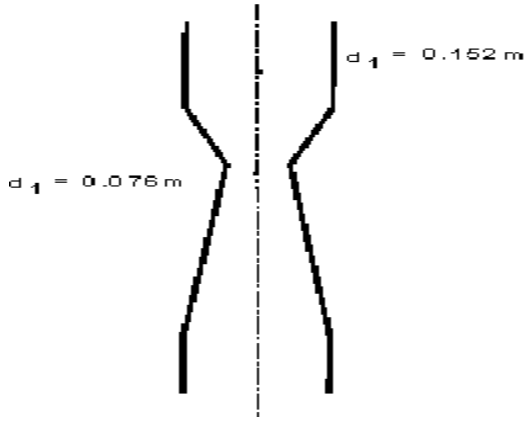
Take: $R/\rho u^2 = 0.0042$ **(15 marks)**

b) The advantages and disadvantages of reciprocating pumps in general over centrifugal pumps. **(5 marks)**

6. (a) A Venturimeter of throat diameter *0.076m* is fitted in a *0.152m* diameter vertical pipe in which liquid of relative density *0.8* flows downwards. Pressure gauges are fitted to the inlet and to the throat sections. The throat being *0.914m* below the inlet. Taking the coefficient of the meter as *0.97* find the discharge

a) when the pressure gauges read the same

b) when the inlet gauge reads *15170 N/m^2* higher than the throat gauge.



(15 marks)

(b) Describe some uses for dimensional analysis. Your explanation should include the meanings and relevance of the terms *geometric similarity, dynamic similarity* and *kinematic similarity.* **(5 marks)**

(requires at least 5 lines per description)