FINAL
Examination Paper

(COVER PAGE)

Session	:	**August 2018**
Programme	:	Diploma In Mechanical Engineering (DMEN)
Course	:	**EGR2178 : Fluid Mechanics 1**
Date of Examination	:	December 12, 2018 (Wednesday)
Time	:	11:00 am – 1:00 pm Reading Time: Nil
Duration	:	2 Hours
Special Instructions	:	

This paper consists of **SIX (6)** questions. Answer any **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks.

Materials permitted :

Calculator

Materials provided :

List of formulas

Examiner (s)	:	**Dr Aaron Edward Teo Sheng Jye** and Iylia Elena Abdul Jamil
Moderator	:	Dr Azli Abdul Razak

*This paper consists of **8** printed pages, including the cover page.*

DIPLOMA IN MECHANICAL ENGINEERING PROGRAMME (DMEN)
EGR2178: FLUID MECHANICS 1
FINAL EXAMINATION: AUGUST 2018 SESSION

Instructions: This paper consists of SIX **(6)** questions. Answer any **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks.

Question 1

(a) Briefly explain the following terms:

(i) Relative density

(ii) Newtonian fluid

(4 marks)

(b) A pressure of 2 MPa is applied to a mass of water that initially filled 1000 cm^3 volume. Find the volume of water after the pressure is applied. Given the bulk modulus of water is 2.2×10^9 Pa.

(6 marks)

(c) In Figure Q1 (c) shows a manometer consisting of water and mercury. If the relative density of mercury is 13.6, the density of water is 1000 kg/m^3 and the atmospheric pressure is 101.3 kPa, determine the absolute pressure at A when $h_1 = 15$cm and $h_2 = 30$cm.

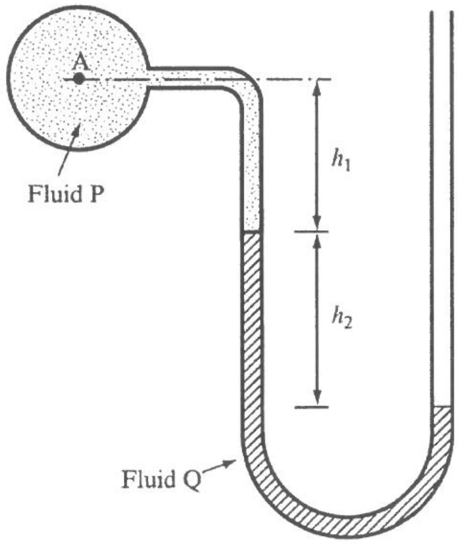

Figure Q1 (c)

(4 marks)

(d) The absolute pressure at a depth of 5 m from free water surface is 145 kPa. Taking density of water to be 1000 kg/m^3. Determine:

(i) the local atmospheric pressure, and

(ii) the absolute pressure at a depth of 5 m in a liquid whose relative density is 0.85 at the same location.

(6 marks)

(iii) An open tank contains oil of relative density 0.75 on top of water. The depth of oil is 2 m and the depth of water 3 m. If atmospheric pressure is 100 kPa, calculate the gauge and absolute pressures at the bottom of the tank.

(5 marks)

Question 2

(a) Figure Q2 (a) shows a 5-m-high, 5-m-wide rectangular plate used as a gate to control the freshwater inside a channel. The gate is hinged at point A and is restrained from opening by a fixed ridge at point B. Determine the force at point B to hold the gate.

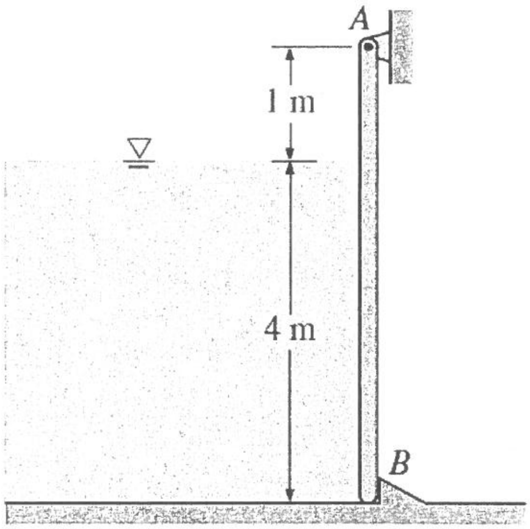

Figure Q2 (a)

(9 marks)

(b) A 170-kg granite rock (density = 2700 kg/m^3) is dropped into a lake. A man dives in and tries to lift the rock. Determine the force the man needs to apply to lift the granite rock from the bottom of the lake.

(6 marks)

(c) Water flows through a 25 mm in diameter pipe at a velocity of 6 ms^{-1}.

(i) Determine whether the flow will be laminar or turbulent. Assuming that the dynamic viscosity of water is 1.30×10^{-3} $kgm^{-1}s^{-1}$ and its density 1000 kgm^{-3}.

(ii) If oil of relative density 0.9 and dynamic viscosity 9.6×10^{-2} $kgm^{-1}s^{-1}$ is pumped through the same pipe, will the flow be laminar or turbulent?

(10 marks)

Question 3

(a) A flat plate is struck normally at the center by a jet of water 50 mm in diameter with a velocity of 18 ms^{-1}. Calculate

(i) The force on the plate when it is stationary.

(ii) The force on the plate when it moves in the same direction as the jet with a velocity of 6 ms^{-1}.

(8 marks)

(b) A 90° elbow directs water flow at a rate of 25 kg/s in a horizontal pipe upward as shown in Figure Q3 (b). 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. Neglect the elbow weight and water weight.

(i) Determine the gage pressure at the elbow inlet.

(6 marks)

(ii) Calculate the magnitude and direction of the anchoring force required to hold the elbow in place.

(11 marks)

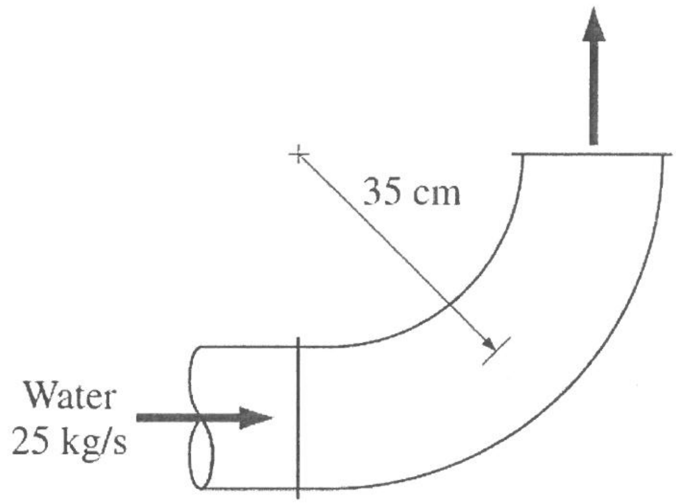

Figure Q3 (b)

Question 4

(a) Air flows through a pipe at a rate of 200 L/s as shown in Figure Q4 (a). The pipe consists of two sections of diameters 20 cm and 10 cm, connected by a smooth reducing section. A water manometer is attached to measure the pressure difference between the two pipes. Neglecting frictional effects, determine the differential height *h* of the manometer. Take the air density to be 1.20 kg/m3.

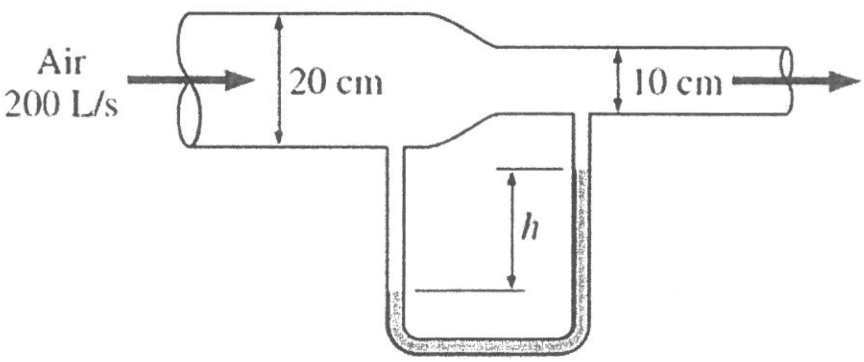

Figure Q4 (a)

(13 marks)

(b) In the ideal flow around a half-body as shown in Figure Q4 (b), the free stream velocity is $0.5ms^{-1}$ and the strength of the source is $2.0m^2\ s^{-1}$. Determine the fluid velocity and its direction at a point, r = 1.0 m and θ = 120°.

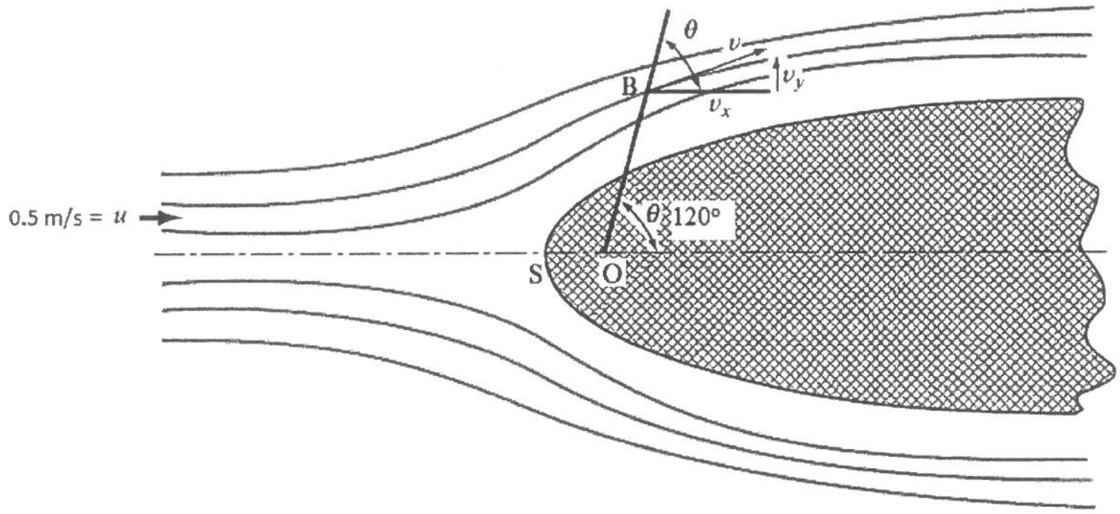

Figure Q4 (b)

(12 marks)

Question 5

(a) In Figure Q5 (a), an incompressible fluid of density ρ and viscosity μ flows at average speed V through a long, horizontal section of round pipe of length L, inner diameter D, and inner wall roughness height ε. To overcome friction, pressure decreases along the pipe where pressure drop $\Delta P = P_1 - P_2$. Develop a non-dimensional relationship between pressure drop and the other parameters in the problem

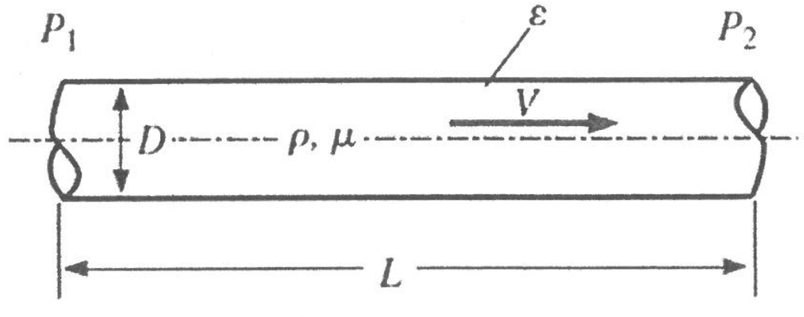

Figure 5 (a)

(15 marks)

(b) The boundary layer velocity profile is approximated as $u = U_s y/\delta$ for $0 \leq y \leq \delta$. Determine the ratio of displacement thickness to momentum thickness for given velocity profile.

(10 marks)

Question 6

(a) Define the boundary layer. Sketch a diagram to aid your explanation

(5 marks)

(b) Briefly explain the meaning of :

(i) Steady uniform flow

(ii) Steady non-uniform flow

(4 marks)

(c) In Figure Q6 (c), oil with density of 850 kg/m^3 and kinematic viscosity of 0.00062 m^2/s is being discharged by a 5mm diameter, 40m long horizontal pipe from an open storage tank. The height from the oil surface inside the tank to the center of the pipe is 3m. Determine:

(i) the dynamic viscosity of the oil.

(2 marks)

(ii) the pressure drop across the pipe line.

(4 marks)

(iii) the volume flow rate of oil through the pipe if losses through the pipe is neglected.

(3 marks)

(iv) the average/mean velocity of the flow through the pipe.

(3 marks)

(v) whether the flow is laminar or turbulent.

(4 marks)

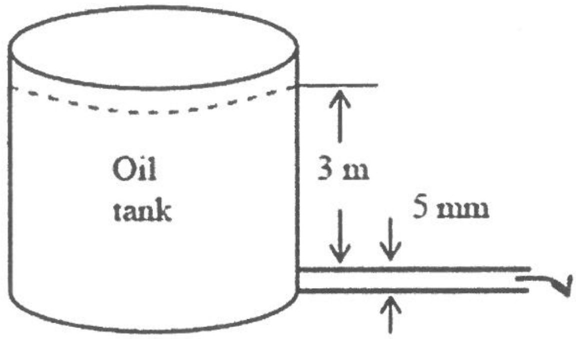

Figure 6 (c)

-THE END-

EGR 2178: Fluid Mechanics I

August 2018 - LIST OF FORMULAS

$$P_{abs} = P_{gage} + P_{atm}$$

$$K = -\frac{\Delta p}{\Delta V / V}$$

$$P = \rho g h = \gamma h$$

$$S.G = \frac{\rho_{substance}}{\rho_{water}}$$

$$F_B = \rho g B l D = \rho g V = W_{obj}$$

$$F_R = P_C A = \rho g h_C sin\theta A = \rho g A \bar{y}$$

$$I_O = \frac{bh^3}{12} \ (rectangle)$$

$$I_O = \frac{\pi r^4}{4} \ (circle)$$

$$I_O = \frac{bh^3}{36} \ (triangle)$$

$$Centroid = \frac{d}{3} \ (triangle)$$

$$y_P = y_c + \frac{I_O}{y_c A}$$

$$h_P = h_c + \frac{I_O}{h_c A}$$

$$D = sin^2\phi \left(\frac{I_o}{A\bar{y}}\right)$$

$$I_o = I_G + Ad^2$$

$$F_T = F_1 + F_2 + F_3$$

$$v_{normal} = (v - u)\cos\theta$$

$$\dot{m} = \rho A v$$

$$\dot{m} = \rho Q$$

$$\bar{u} = \frac{Q}{A}$$

$$\dot{m} = \rho_1 A_1 \bar{u}_1 = \rho_2 A_2 \bar{u}_2$$

$$Change\ in\ momentum = \rho_2 A_2 v_2 v_2 - \rho_1 A_1 v_1 v_1$$

$$F = \dot{m}(v_2 - v_1)$$

$$Q = \frac{A_1}{\sqrt{\left(\frac{A_1}{A_2}\right)^2 - 1}} \cdot \sqrt{\left[2gh\left(\frac{\rho_{man}}{\rho} - 1\right)\right]}$$

$$\frac{P_1}{\rho} + \frac{{V_1}^2}{2} + gz_1 = \frac{P_2}{\rho} + \frac{{V_2}^2}{2} + gz_2$$

$$A = b \times dh$$

$$V = \sqrt{2gh}$$

$$Q_{theoretical} = A \times V$$

$$Q_{theo} = \left(\frac{2}{3}\right) b \sqrt{(2g)} H^{3/2}$$

$$Q_{actual} = Q_{theo} \text{ x } C_d$$

$$Re = \frac{\rho V d}{\mu}$$

$$p^* = (p + \rho g z)$$

$$Pressure\ gradient = \frac{dp^*}{dx}$$

$$\tau = \mu \frac{du}{dy}$$

$$u = \frac{y}{Y} U - \frac{1}{2\mu} \frac{d}{dx} (p + \rho g z)(Yy - y^2)$$

$$u = \frac{U}{a} y + \frac{1}{2\mu} \left[\frac{d}{dx} (p + \rho g z) \right] (y^2 - ay)$$

$$\Psi = \frac{1}{2} q = v_0 r \sin\theta + \frac{q\theta}{2\pi}$$

$$v_r = \frac{1}{r} \frac{d\Psi}{d\theta}$$

$$v_\theta = -\frac{d\Psi}{dr}$$

$$v = \sqrt{(v_r{}^2 + v_\theta{}^2)}$$

$$\tau_0 = 0.332 \frac{U_s}{x} Re_x{}^{\frac{1}{2}}$$

$$Re_x = U_s x / v$$

$$F = 2 \times \frac{1}{2} \rho U_s{}^2 l \times b \times C_f$$

$$C_f = 1.33 Re_l{}^{-1/2}$$

$$Q = \frac{\pi D^4}{128\mu} \left(\frac{\Delta p}{L}\right)$$