Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	FLUID MECHANICS
COURSE CODE	:	BNJ 20203
PROGRAMME CODE	:	BNG / BNM
EXAMINATION DATE	:	JULY / AUGUST 2023
DURATION	:	3 HOURS
DURATION	:	1. ANSWER **ALL** QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK** 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **NINE (9)** PAGES

Q1 (a) Imagine air movement over the wings of an aircraft and the gas flow through a jet engine. Determine which of the flows is internal and which is external. Explain your answer.

(4 marks)

(b) In fluid mechanics, natural flow and forced flow refer to different types of fluid motion. By means of example, distinguish these flows.

(4 marks)

(c) A very long plate is moved over the lower plate on a layer of fluid as illustrated in **Figure Q1 (c)**. A linear velocity distribution is assumed for a small gap *h*. The viscosity is 0.72 g/ms, and the specific gravity is 0.82. Calculate:

(i) The kinematic viscosity of the liquid.

(2 marks)

(ii) The shear stress on the upper plate.

(4 marks)

(d) Hydrostatic pressure refers to the pressure exerted by a fluid at rest on any surface that is in contact with it. Explain how does the hydrostatic pressure change with depth in a fluid?

(2 marks)

(e) The water in a 30m deep reservoir is kept inside by a 250m wide wall whose cross section is an equilateral triangle, as shown in **Figure Q1 (e)**. Determine the total force acting on the inner surface of the wall, its line of action, and the magnitude of the horizontal component of this force. (Take P_{atm} = 100 kPa)

(9 marks)

Q2 (a) State the Archimedes Principle that can be related to the phenomena of buoyancy.

(2 marks)

(b) The hull of a boat has a volume of 220 m^3, and the total mass of the boat when empty is 9240 kg. Examine how much load this boat can carry without sinking in a lake and seawater with a specific gravity of 1.03.

(7 marks)

(c) Energy equation of an ideal flow along a streamline can be represented as:

$$\frac{P}{\rho} + \frac{V^2}{2} + gz = C$$

Where C is a constant along a streamline. This equation is based on the assumption that no work or heat interaction between a fluid element and the surrounding take place. The sum of these three terms on the left-hand side of the equation represents the total mechanical energy per unit mass. Thus, based on your understanding, explain each term on the left-hand side of the equation.

(3 marks)

(d) A piezometer and a pitot tube are tapped into a horizontal water pipe to measure static and stagnation pressures as depicted in **Figure Q2 (d)**. For the water column heights, calculate the velocity at the center of the pipe.

(5 marks)

(e) Air at 105 kPa and 37°C flows upward through a 7 cm diameter inclined duct at a rate of 0.075 m^3/s as shown in **Figure Q2 (e)**. The duct diameter is then reduced to 4 cm through a reducer. The pressure change across the reducer is measured by a water manometer. The elevation difference between the two points on the pipe where the two arms of the manometer are attached is 0.20 m. Estimate the differential height (h) between the fluid levels of the two arms of the manometer. (Given that the density of air is equal to 1.18 kg/m^3 and the density of water is equal to 1000 kg/m^3).

(8 marks)

Q3 (a) Define the conservation of momentum principle.

(2 marks)

(b) Water flows through a reducing 180° bend as shown in **Figure Q3 (b)**. Determine the magnitude of the force exerted on the bend in the x-direction. Assume energy losses to be negligible.

(9 marks)

(c) A horizontal water jet of constant velocity V impinges normally on a vertical flat plate and splashes off the sides in the vertical plane as shown in **Figure Q3 (c)**. The plate is moving toward the oncoming water jet with a velocity of 1/5 V. If a force F is required to maintain the plate stationary, examine the force required to move the plate toward the water jet.

(4 marks)

(d) Explain the use of Reynolds number.

(2 marks)

(e) Oil flows in a pipe 50 mm bore with a Reynolds number of 450. The dynamic viscosity is 0.018 Ns/m^2 and the density of the oil is 950 kg/m^3. Based on the given information, estimate the velocity of the oil flow inside the pipe.

(2 marks)

(f) By referring to the Table of water properties and Moody diagram and as provided in **Figures Q3 (f) (i) and (ii)**, identify the friction factor if water at 50 °C is flowing at 125 m/s in an uncoated ductile steel pipe having an inside diameter of 23 mm. (Given that the roughness of the ductile steel pipe is equal to 4.6 x 10^{-5} m).

(6 marks)

Q4 (a) Head losses are a common phenomenon in pipe systems. It can be divided into two categories and they are due to the major losses and the minor losses. By using the appropriate equation, describe the factors affecting losses in pipe systems

(i) due to major losses.

(3 marks)

(ii) due to minor losses.

(3 marks)

(b) **Figure Q4 (b)** shows the system using a device to pump a fluid from point A to point B. Given the volume flow rate, $Q = 0.014$ m^3/s, the fluid density, $\rho = 0.86$ kg/m^3 and the total head loss, $h_L = 1.86$ m, determine the energy added by the pump.

(5 marks)

(c) Pump is an energy-absorbing device while the turbine is an energy-producing device. Discuss the purpose of each device and relate it with the fluid pressure and fluid speed.

(4 marks)

(d) A positive displacement pump moves a fluid by repeatedly enclosing a fixed volume and moving it mechanically through the system. The pumping action is cyclic and can be driven by pistons, screws, gears, rollers, diaphragms, or vanes. Sketch, **TWO (2)** examples of positive-displacement pumps.

(4 marks)

(e) Pump Performance Curve gives the information to determine a pump's ability to produce flow under the conditions that affect pump performance. By utilizing the appropriate figure, explain the condition where the pumps can be said to be at their maximum operating efficiency.

(6 marks)

-END OF QUESTIONS-

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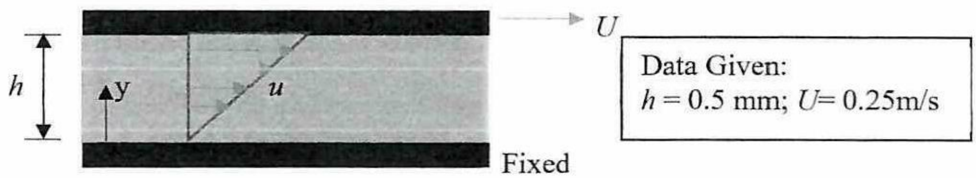

Figure Q1 (c)

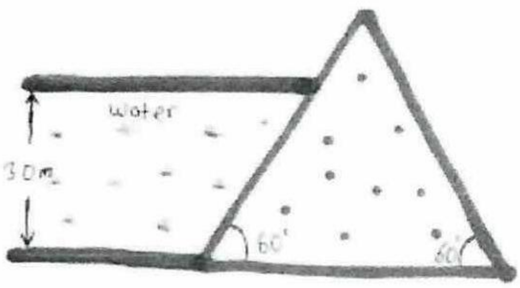

Figure Q1 (e)

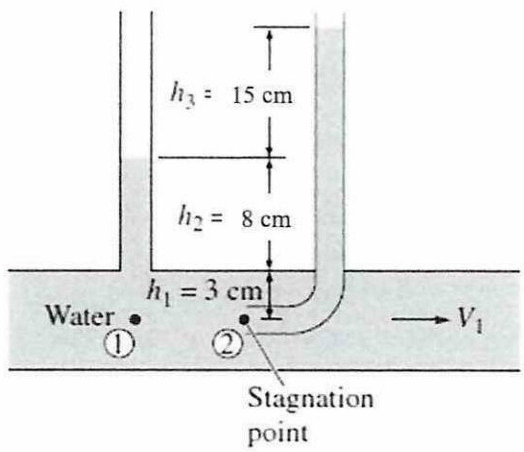

Figure Q2 (d)

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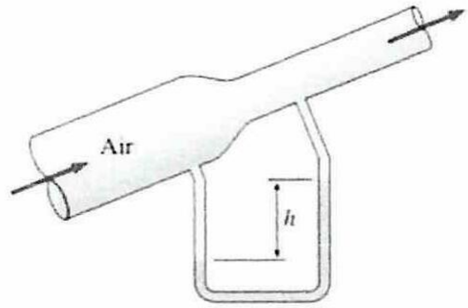

Figure Q2 (e)

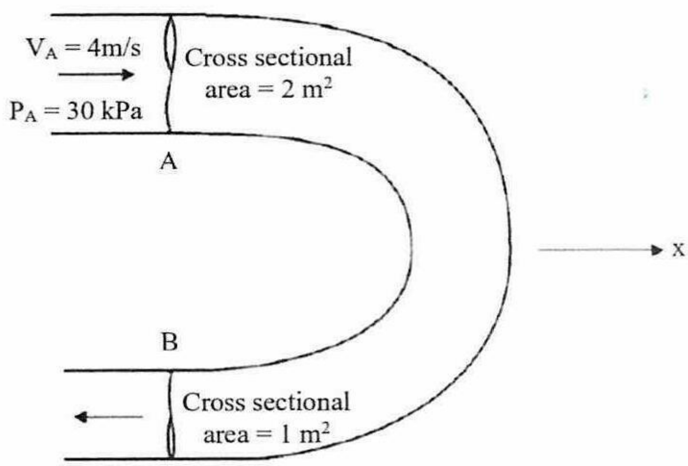

Figure Q3 (b)

1/4V

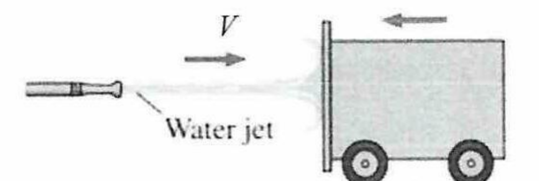

Figure Q3 (c)

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Properties of Water (adapted from Potter and Wiggert (2001))

Temperature (°C)	Density, ρ (kg/m³)	Dynamic Viscosity, μ (Pa-s)	Kinematic Viscosity, ν (m²/s)	Surface Tension, Y (N/m)	Vapor Pressure, p_v (kPa)	Bulk Modulus, K (Pa)
0	999.9	1.792E-03	1.796E-06	0.0762	0.610	2.04E+09
5	1000.0	1.519E-03	1.519E-06	0.0754	0.872	2.06E+09
10	999.7	1.308E-03	1.308E-06	0.0748	1.13	2.11E+09
15	999.1	1.140E-03	1.141E-06	0.0741	1.60	2.14E+09
20	998.2	1.005E-03	1.007E-06	0.0736	2.34	2.20E+09
30	995.7	8.010E-04	8.040E-07	0.0718	4.24	2.23E+09
40	992.2	6.560E-04	6.610E-07	0.0701	7.38	2.27E+09
50	988.1	5.490E-04	5.560E-07	0.0682	12.3	2.30E+09
60	983.2	4.690E-04	4.770E-07	0.0668	19.9	2.28E+09
70	977.8	4.060E-03	4.150E-07	0.0650	31.2	2.25E+09
80	971.8	3.570E-04	3.670E-07	0.0630	47.3	2.21E+09
90	965.3	3.170E-04	3.280E-07	0.0612	70.1	2.16E+09
100	958.4	2.840E-04	2.960E-07	0.0594	101.3	2.07E+09

Reference: Potter, Wiggert, DC., Hondzo, M., and Shih, T.I.P. (2001) Fluid mechanics. Brooks/Cole Thomson Learning: Pacific Grove, California, USA.

(i)

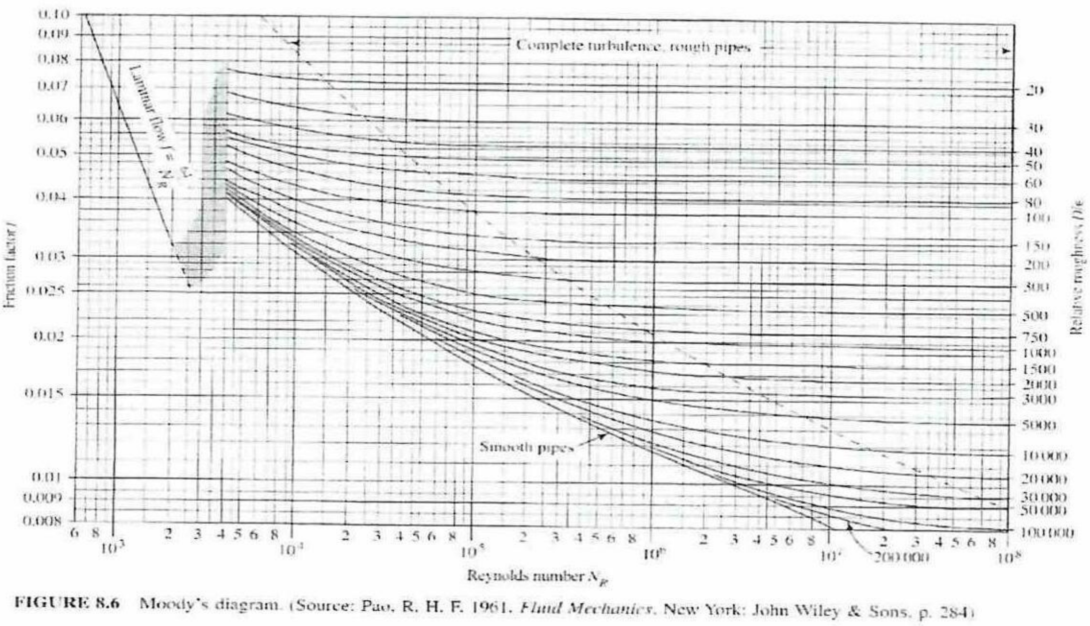

FIGURE 8.6 Moody's diagram. (Source: Pao, R. H. F. 1961. *Fluid Mechanics*. New York: John Wiley & Sons, p. 284)

(ii)

Figure Q3 (f)

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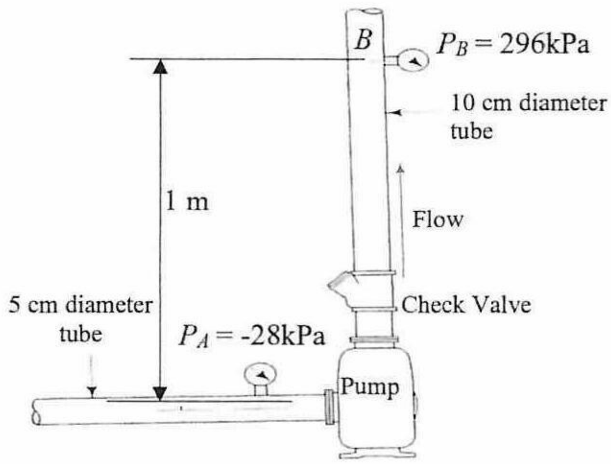

Figure Q4 (b)

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1. $$\gamma = \rho g$$

2. $$SG = \frac{\gamma}{\gamma_{water}}$$

3. $$2\pi R\sigma cos\theta = \rho g\pi R^2 h$$

4. $$F = PA = \rho gh.A$$

5. $$y_R = \frac{I_X}{y_c A} + y_c$$

6. $$h_R = \frac{I_X sin^2\theta}{h_c A} + h_c$$

7. $$W = F_B = \rho gV$$

8. $$\dot{m} = \rho\, A\, v = \rho Q$$

9. $$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P}{\rho g} + \frac{V_2^2}{2g} + z_2$$

10. $$\sum F = \dot{m}\,(v_2 - v_1)$$

11. $$h_L = K_L \left[\frac{V^2}{2g}\right]$$

12. $$h_L = f\frac{L}{D}\left[\frac{V^2}{2g}\right]$$

13. $$\dot{W}_{water\ horsepower} = \dot{m}gH = \rho g\dot{V}H$$