Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	FLUID MECHANICS I
COURSE CODE	:	BDA 20603
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. PART A: ANSWER **THREE (3)** QUESTIONS OUT OF FOUR (4) QUESTIONS ONLY. PART B: ANSWER ALL QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ Closed book 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

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

PART A

Q1 Basic fluid mechanics is the fundamental study of the behavior of fluids at rest and in motion. Fluids are substances that continuously deform under the application of shear stress, no matter how small. This includes both liquids and gases.

(a) Define the fluid mechanics and state three sub-disciplines under fluid mechanics' field.

(5 marks)

(b) Calculate the dynamic viscosity, weight, specific volume and relative density of the specific liquid substance, if given the value of kinematic viscosity, volume and density of liquid substance are 0.005 m^2/s, 0.25 m^3 and 0.689 kg/m^3, respectively.

(4 marks)

(c) A thick 10 kg plate slides down a flat-inclined surface of 20° to the horizontal plane at a terminal speed of 2 m/s. Prior to this, a thin layer of oil was rubbed onto the inclined surface. Provided that the oil viscosity is 0.003 Ns/m^2. The moving plate has a length of 2 m and a width of 0.5 m.

(i) Determine the thickness of the oil layer;

(ii) Determine the angle of inclination of the surface, if the terminal speed is to be doubled.

(7 marks)

(d) A 1.0 mm diameter tubing is inserted into an unknown liquid with a density of 1100 kg/m^3. The liquid drops by 5 mm in the tube. The surface tension is 0.02 N/m. Determine the contact angle with the tube surface

(4 marks)

Q2 An essential component of fluid mechanics analysis is pressure, which refers to the amount of forces applied perpendicular to a surface divided by the area over which that force is spread. This is an important understanding of the principle of pressure.

(a) Define pressure and how it is being presented in a fluid system

(5 marks)

(b) For the inclined-tube manometer of **Figure Q2.1** the pressure in pipe A is 4000 Pascals. The fluid in both pipes A and B is water, and the gage fluid in the manometer has a specific gravity of 2.6. Calculate the pressure in pipe B if h_1 and h_2 is 7 cm, l_2 is 20 cm and θ is 30°.

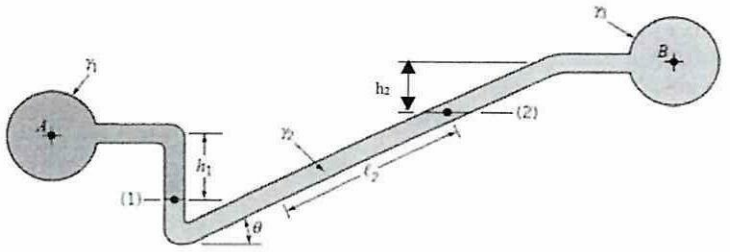

Figure Q2.1: Inclined manometer

(5 marks)

(c) A rectangular gate of uniform material with a width of 1.2 m is submerged in water and restrained by a horizontal, flexible cable as shown in **Figure Q2.2**. The gate is pinned at point A, and frictional effects at the hinge are considered negligible.

(i) Sketch the free-body diagram involved in the calculation.

(ii) Determine the hydrostatics force acting and its location.

(iii) Calculate the tension of the cable.

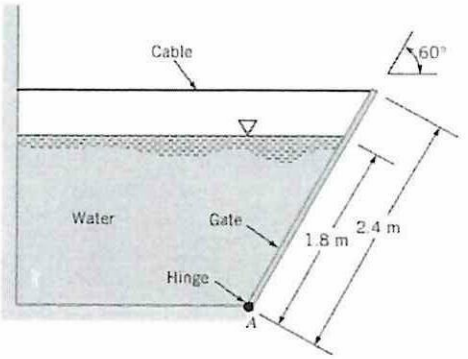

Figure Q2.2: Submerged plane

(10 marks)

Q3 Archimedes' principle is useful knowledge and significant in day-to-day life.

(a) According to Archimedes' principle, the magnitude of buoyancy force (F_B) is equivalent to the weight of the displaced fluid by the submerged object. Determine the relationship between the buoyancy force and the displacement volume.

(5 marks)

(b) Given that a boat's hull has a volume of 182 m^3 and its dry mass is 8563 kg. Determine the heaviest load it can support on the water with a specific gravity of 1.03 and 1 without sinking.

(5 marks)

(c) In a closed tank as in **Figure Q3.1**, here is a rectangular wooden block with a specific gravity of 0.6 and an oil with a specific gravity of 0.8. The wooden block is floating in the oil, with 93% of its volume submerged below the oil surface. Given that the air pressure inside the tank is 3.2 kPa, what is the height of the wooden block?

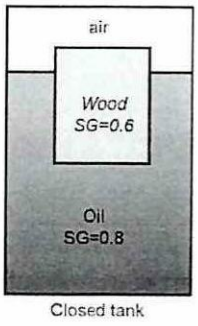

Figure Q3.1: Rectangular wooden block

(5 marks)

(d) In **Figure Q3.2,** there is a cube with each side measuring 150 mm, and it is constructed from aluminium. A string suspends this cube. The cube is partially submerged, half in oil and half in water. Calculate the tension in the string, given that the specific weight of aluminium is 25.9 kN/m³.

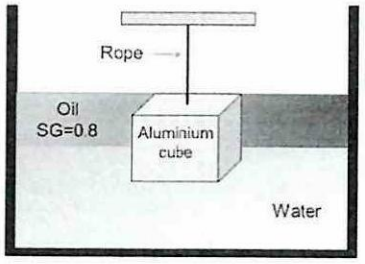

Figure Q3.2: Cube submerged in a liquid substance.

(5 marks)

Q4 Bernoulli equation is among the famous equations used in Fluid Mechanics.

(a) Write the Bernoulli equation in Total Energy, Total Head, and Total Pressure form.

(6 marks)

(b) Water is flowing through a venturi meter whose diameter is 7 cm at the entrance part and 4 cm at the throat. The pressure is measured to be 380 kPa at the entrance and 150 kPa at the throat.

(i) Sketch the venturi meter with a complete label including the information in Q4(b).

(ii) Show that the flow rate can be expressed as

$$Q = A_2 \sqrt{\frac{2(P_1 - P_2)}{\rho(1 - A_2^2/A_1^2)}}$$

(iii) Neglecting frictional effects, determine the flow rate of water, Q.

(14 marks)

PART B

Q5 Momentum equation is commonly used to calculate the forces induced by the flow such as the reaction forces acting on support systems or connectors.

(a) Explain the body forces and surface forces.

(5 marks)

(b) Water and alcohol are mixed in a y-duct as shown in **Figure Q5.1**. The specific gravity of oil is equal to 0.8. Determine the average density of the mixture of alcohol and water.

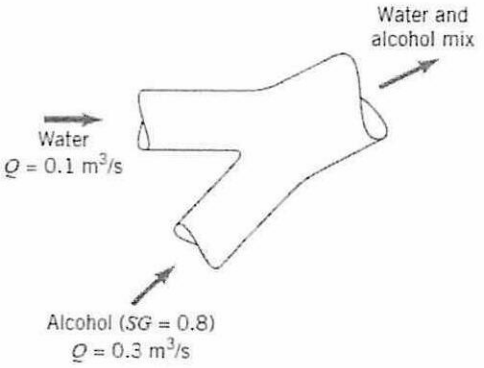

Figure Q5.1: A y-ducting

(5 marks)

(c) A reversing elbow as shown in **Figure Q5.2** makes the fluid 180° U-turn before it is discharged water at a flow rate of 15 kg/s into the atmosphere. The cross-sectional area of the elbow is 113 cm^2 at the inlet and 6 cm^2 at the outlet. The elevation difference between the centers of the outlet and the inlet is 30 cm. The weight of the elbow and the water are to be neglected. Determine

(i) the pressure at point 1.

(ii) the horizontal force of the anchoring force needed to hold the elbow in placed.

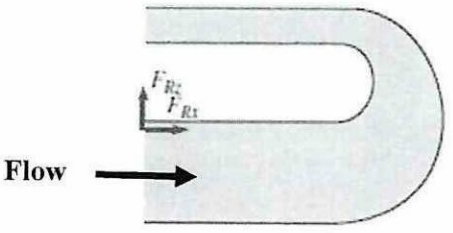

Figure Q5.2: A reversing elbow

(10 marks)

Q6 Dimensional analysis is useful technique to generate nondimensionless parameters that help in the design of experiments and in the reporting of experimental results. Use **Table Q6.1** to answer the following questions.

(a) Verify the reynoulds Number, $Re = \frac{\rho VD}{\mu}$ is dimensionless

Table Q6.1: Nondimensionless parameters

No.	Quantity	Unit
1	Shear stress	N/m^2
2	Drag force	$kg.m/s^2$
3	Pipe Diameter	M
4	Roughness height	M
5	Viscosity	kg/m.s
6	Density	kg/m^3

(5 marks)

(b) **Figure Q6.1** shows water flows over a dam. Assume flowrate (Q), along the dam depends on the head (H), width (b), acceleration of gravity (g), fluid density (ρ) and fluid viscosity (μ). Develop a non-dimensional relationship between Q and the other parameters by choosing b, g, and ρ as the repeating variables.

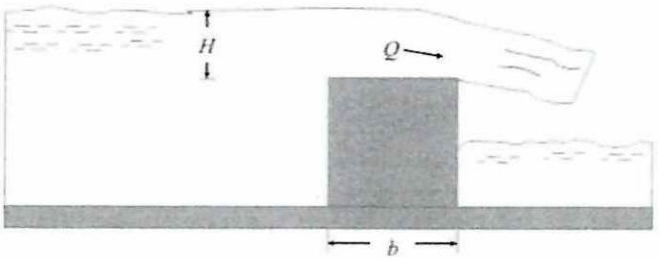

Figure Q6.1: Water flows over a dam

(15 marks)

- END OF QUESTIONS -