UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2021/2022

COURSE NAME	:	FLUID MECHANICS
COURSE CODE	:	BDU 11402
PROGRAMME	:	BDM
EXAMINATION DATE	:	JULY 2022
DURATION	:	2 HOURS
INSTRUCTION	:	1. ANSWERS **ALL** QUESTIONS. 2. THIS FINAL EXAMINATION IS CONDUCTED VIA CLOSE 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 **SIX (6)** PAGES

Q1 (a) Provide a brief explanation on:

(i) Renolds number, (1 marks)

(ii) surface tension; and (2 marks)

(iii) capillary effect. (2 marks)

(b) A capillary tube of 1.2 mm diameter is immersed vertically in water exposed to the atmosphere. Take the contact angle at the inner wall of the tube to be 6° and the surface tension to be 1.00 N/m. Determine how high water will rise in the tube.

(4 marks)

(c) An oil pipeline and a 1.3-m3 rigid air tank are connected to each other by a manometer, as shown in **Figure** Q1(c). If the tank contains 15 kg of air at 80°C, determine
(i) the absolute pressure in the pipeline and

(8 marks)

(ii) the change in Δh when the temperature in the tank drops to 20°C. Assume the pressure in the oil pipeline to remain constant, and the air volume in the manometer to be negligible relative to the volume of the tank.

(8 marks)

Q2 (a) Compare the *Eulerian* and *Lagrangian* description of fluid motion.

(4 marks)

(b) When an airplane is flying 200 mph at 5000-ft altitude in a standard atmosphere, the air velocity at a certain point on the wing is 273 mph relative to the airplane.
(i) Calculate suction pressure is developed on the wing at that point?

(8 marks)

(ii) Find out the pressure at the leading edge (a stagnation point) of the wing?

(3 marks)

(c) During a trip to the beach (Patm 5 1 atm 5 101.3 kPa), a car runs out of gasoline, and it becomes necessary to siphon gas out of the car of a Good Samaritan (**Figure** 2(c)). The siphon is a small-diameter hose, and to start the siphon it is necessary to insert one siphon end in the full gas tank, fill the hose with gasoline via suction, and then place the other end in a gas can below the level of the gas tank. The difference in pressure between point 1 (at the free surface of the gasoline in the tank) and point 2 (at the outlet of the tube) causes the liquid to flow from the higher to the lower elevation. Point 2 is located 0.75 m below point 1 in this case, and point 3 is located 2 m above point 1. The siphon diameter is 5 mm, and frictional losses in the siphon are to be disregarded.

(i) Compare the minimum time to withdraw 4 L of gasoline from the tank to the can with real time, and

(5 marks)

(ii) Use density of gasoline is 750 kg/m3 to find the pressure at point 3.

(5 marks)

Q3 (a) State the rule of thumb about the Mach number limit in order that the incompressible flow approximation is reasonable? Explain why wind tunnel results would be incorrect if this rule of thumb were violated.

(5 marks)

(b) List and describe the three necessary conditions for complete similarity between a model and a prototype.

(5 marks)

(c) A student team is to design a human-powered submarine for a design competition. The overall length of the prototype submarine is 2.24 m, and they hope that it can travel fully submerged through water at 0.560 m/s. The water is freshwater (a lake) at T = 15°C. The design team builds a one-eighth scale model to test in their university's wind tunnel **Figure 3(c)**. A shield surrounds the drag balance strut so that the aerodynamic drag of the strut itself does not influence the measured drag. The air in the wind tunnel is at 25°C and at one standard atmosphere pressure. Examine at what air speed do they need to run the wind tunnel in order to achieve similarity?

(15 marks)

Q4 (a) State Four (4) criteria in selecting repeating variables in Buckingham's pie analysis.

(5 marks)

(b) The Drag, D on a sphere located in a pipe through which a fluid is flowing to determine experimentally as shown in **Figure 4 (b)**. Assume that the drag is function of the sphere diameter, d, the pipe diameter, D, the fluid velocity, V and the fluid density, ρ.

(10 marks)

(c) An experiments using water indicate that for d = 0.5 cm, D = 1.25 cm and V = 0.6 m/s, Drag is 6×10^{-3} N. Estimate the drag on a sphere located in a 0.6 m diameter pipe through which water is flowing with a velocity of 1.8 m/s if the geometric similarity of sphere diameter is maintained.

(10 marks)

Q5 (a) Explain when an external flow is two-dimensional, three-dimensional, and axisymmetric. What type of flow is the flow of air over a car?

(5 marks)

(b) A small aircraft has a wing area of 30 m^2, a lift coeficient of 0.45 at takeoff settings, and a total mass of 2800 kg. Determine;

(i) the takeoff speed of this aircraft at sea level at standard atmospheric conditions,

(ii) the wing loading, and

(iii) the required power to maintain a constant cruising speed of 300 km/h for a cruising drag coefficient of 0.035.

(7 marks)

(c) A commercial airplane has a total mass of 70,000 kg and a wing planform area of 150 m^2. The plane has a cruising speed of 558 km/h and a cruising altitude of 12,000 m, where the air density is 0.312 kg/m^3. The plane has double-slotted flaps for use during takeoff and landing, but it cruises with all flaps retracted. Assuming the lift and the drag characteristics of the wings can be approximated by NACA 23012, the densities of air are 1.20 kg/m^3 on the ground and 0.312 kg/m^3 at cruising altitude. The maximum lift coefficients *CL*, max of the wings are 3.48 and 1.52 with and without flaps, respectively.

(i) Determine the minimum safe speed for takeoff and landing with and without extending the flaps,

(ii) Determine the angle of attack to cruise steadily at the cruising altitude, and

(iii) Examine the power that needs to be supplied to provide enough thrust to overcome wing drag and propulsion efficiency. Assume the engine is not more than 30% from the propulsion efficiency.

(13 marks)

- END OF QUESTION -

FINAL EXAM

SEMESTER / SESSION	: SEM II / 2021/2022	PROGRAMME	: BDM
COURSE	: FLUID MECHANICS	COURSE CODE	: BDU11402

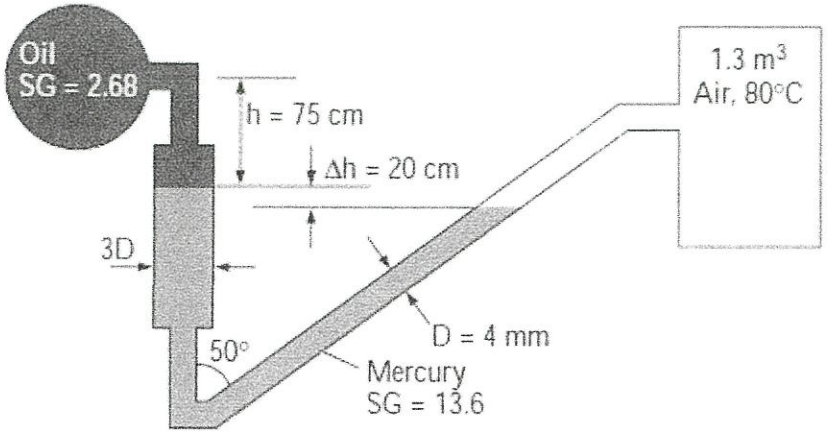

Figure Q1 (c)

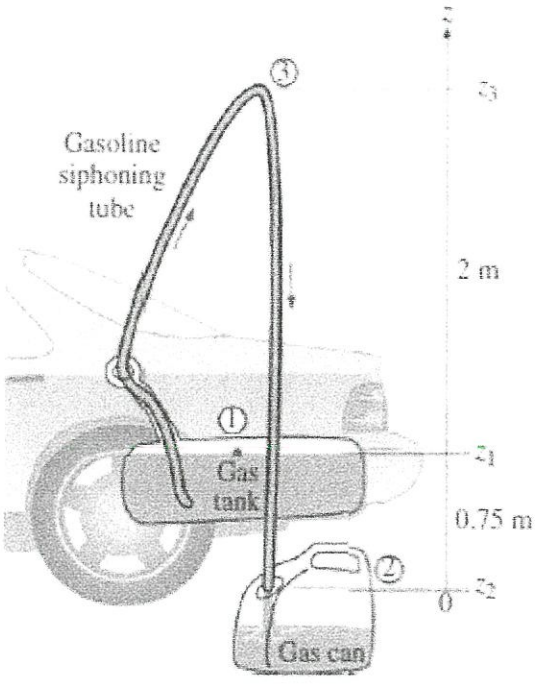

Figure Q2 (c)

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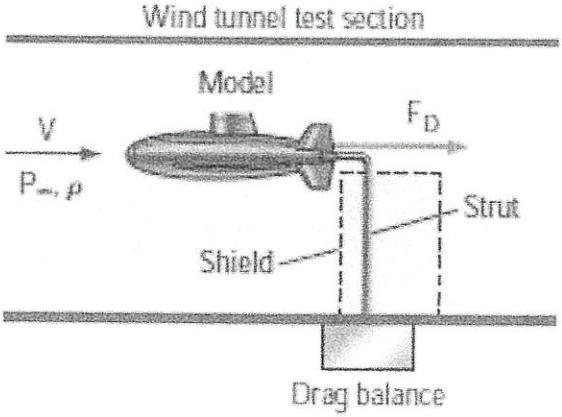

Figure Q3 (c)

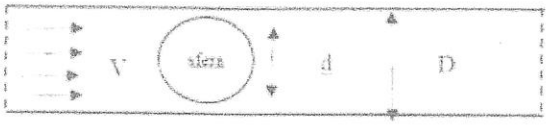

Figure Q4 (b)