



**UTHM**

Universiti Tun Hussein Onn Malaysia

**UNIVERSITI TUN HUSSEIN ONN MALAYSIA**

**FINAL EXAMINATION  
SEMESTER II  
SESSION 2020/2021**

COURSE NAME : FLUID MECHANICS  
COURSE CODE : BDU 11402  
PROGRAMME : BDM  
EXAMINATION DATE : JULY 2021  
DURATION : 2 HOURS  
INSTRUCTION : ANSWER **FOUR (4)** QUESTIONS ONLY.

**TERBUKA**

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  $6^\circ$  and the surface tension to be 1.00 N/m. Determine how high water will rise in the tube. (4 marks)

(c) The weight of the gate separating the two fluids is such that the system shown in **Figure Q1 (c)** is at static equilibrium. If it is known that  $F1/F2 = 1.70$ .

- (i) determine  $h/H$  ; and (8 marks)
- (ii) based on the answer from Q1 (c) (i), if  $h = 1$ , determine the angle of attack,  $\alpha$ ,  $F1$  and  $F2$ . (8 marks)

**Q2** (a) Compare the *Eulerian* and *Lagrangian* description of fluid motion. (4 marks)

(b) A steady, incompressible, two-dimensional velocity field is given by the following components in the  $xy$ -plane:

$$u = 1.85 + 2.33x + 0.656y$$

$$v = 0.754 - 2.18x - 2.33y$$

- (i) Calculate the acceleration field (find expressions for acceleration components  $a_x$  and  $a_y$ )
  - (ii) Calculate the acceleration at the point  $(x, y) = (-1, 2)$  and vector  $\mathbf{a}$
  - (iii) Sketch a vector of the acceleration field at points  $(x,y) = (-1,2)$ ,  $(0,2)$  and  $(1,2)$
- (13 marks)

(c) Air flows through a pipe at a rate of 120 L/s (**Figure Q2 (c)**). The pipe consists of two sections of diameters 22 cm and 10 cm with a smooth reducing section that connects them. The pressure difference between the two pipe sections is measured by a water manometer. Neglecting frictional effects and the air density is  $1.20 \text{ kg/m}^3$ . Determine the differential height of water between the two pipe sections.

**TERBUKA** (8 marks)

- Q3** (a) What is 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  $T = 15^\circ\text{C}$ . 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  $25^\circ\text{C}$  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,  $\rho$ .

(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  $6 \times 10^{-3}$  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.

TERBUKA (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  $30 \text{ m}^2$ , a lift coefficient 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  $150 \text{ m}^2$ . The plane has a cruising speed of 558 km/h and a cruising altitude of 12,000 m, where the air density is  $0.312 \text{ kg/m}^3$ . 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  $1.20 \text{ kg/m}^3$  on the ground and  $0.312 \text{ kg/m}^3$  at cruising altitude. The maximum lift coefficients  $C_{L, \text{max}}$  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 -

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FINAL EXAM

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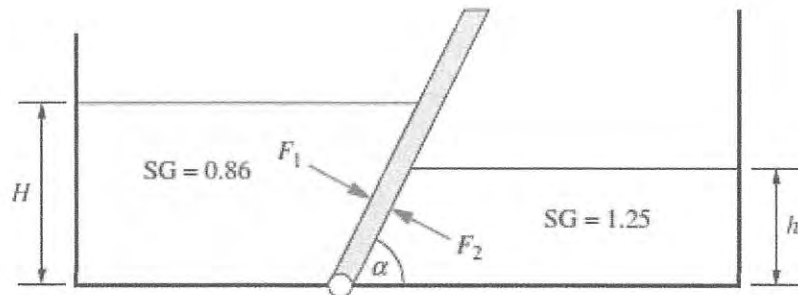


Figure Q1 (c)

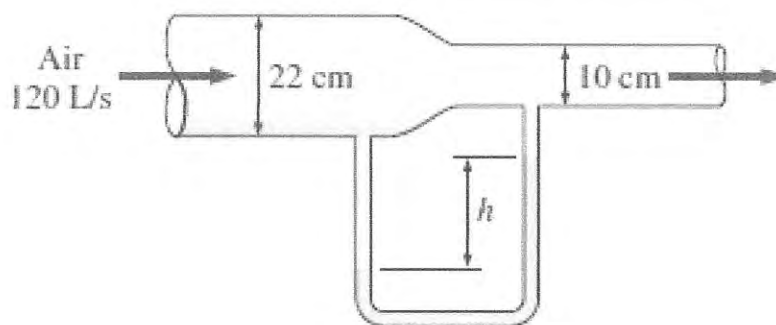


Figure Q2 (c)

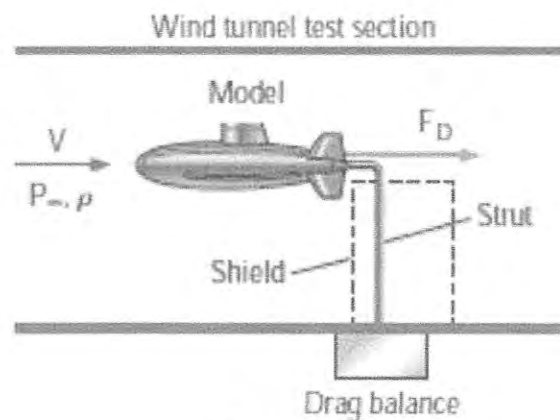


Figure Q3 (c)

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