UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2020/2021

COURSE NAME	:	THERMOFLUIDS
COURSE CODE	:	BDU 10403
PROGRAMME CODE	:	BDC
EXAMINATION DATE	:	JULY 2021
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **TWO (2)** QUESTIONS IN SECTION A AND **TWO (2)** QUESTIONS IN SECTION B

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

SECTION A

Q1 (a) Compare the *Eulerian* and *Lagrangian* description of fluid motion

(4 marks)

(b) A 1.2-mm-diameter tube is inserted into an unknown liquid whose density is 960 kg/m^3, and it is observed that the liquid rises 5 mm in the tube, making a contact angle of 15°. Determine the surface tension of the liquid, σ_s.

(5 marks)

(c) A 3-m-wide, 8-m-high rectangular gate is located at the end of a rectangular passage that is connected to a large open tank filled with water as shown in **Figure Q1 (c)**. The gate is hinged at its bottom and held closed by a horizontal force, F_H, located at the center of the gate. The maximum value for F_H is 3500 kN.

(i) Determine maximum water depth, h, above the center of the gate that can exist without the gate opening.

(8 marks)

(ii) If the gate is hinged at the top, is the answer in **Q1 (c) (i)** the same? Explain your answer.

(8 marks)

Q2 (a) Provide a brief explanation on:

(i) transitional flow,

(1 marks)

(ii) steady and unsteady flow and;

(2 marks)

(iii) uniform and non-uniform flow

(2 marks)

(b) Consider steady, incompressible, two-dimensional flow through a converging duct as shown **Figure Q2(b)**. A simple approximate velocity field for this flow is

$$V = (u,v) = (U_0 + bx)\,\boldsymbol{i} - by\,\boldsymbol{j}$$

where U_0 is the horizontal speed at $x = 0$. This equation ignores viscous effects along the walls but is a reasonable approximation throughout the majority of the flow field.

(i) Determine the material acceleration for fluid particles passing through this duct as acceleration components a_x, a_y and vector $\boldsymbol{a}$.

(6 marks)

(ii) Generate an analytical expression for the flow streamlines.

(4 marks)

(iii) If $U_o = 3.56$ m/s and $b = 7.66\ s^{-1}$, plot several streamlines from $x = 0$ m to 5 m and $y = -2$ m to 2 m based on analytical expression at **Q2(b) (ii)** and show the direction of the streamlines.

(5 marks)

(c) At cruise conditions of Airbus A380, air flows into a Rolls-Royce Trent 900 turbofan engine (**Figure Q2(c)**) at a steady rate of 27.22 kg/s. Fuel enters the engine at a steady rate of 0.27 kg/s. The average velocity of the exhaust gases is 452.2 m/s relative to the engine. If the engine exhaust effective cross section area is 0.325 m^2. Determine the density of the exhaust gases in kg/m^3.

(5 marks)

Q3 (a) Describe the difference between

(i) compressible and incompressible flow.

(2 marks)

(ii) laminar and turbulence flow

(2 marks)

(b) Air flow through the test section of a small wind tunnel at speed V = 7.5 m/s. The temperature of the air is 80°C and length of the wind tunnel test section is 1.5 m. Assume that the boundary layer thickness is negligible prior to the start of the test section.

(i) Determine whether boundary layer along the test section wall laminar or turbulent or transitional

(3 marks)

(ii) Based on the answer in **Q3(b) (i)**, estimate the boundary layer thickness, the displacement thickness and the momentum thickness of the boundary layer at the end of the test section. Compare the three results and discuss.

(8 marks)

(c) The velocity field of a flow is given by

$$V = \frac{20y}{(x^2+y^2)^{1/2}}\,i - \frac{20x}{(x^2+y^2)^{1/2}}\,j \quad \text{(m/s)}$$

where x and y are in meter.

(i) Determine the fluid speed at points along the x-axis and along the y-axis.

(4 marks)

(ii) Determine the angle between the velocity vector and the x-axis at points (x,y) = (5,0) , (5,5) and (0,5).

(3 marks)

(iii) Sketch velocity vectors using the coordinates at **Q3 (b) (ii).**

(3 marks)

SECTION B

Q4 (a) A piston cylinder devise contains water at 115.2° and 1 bar. It is then cooled at constant temperature until the pressure reaches 3 bar. Discuss the phase change from the initial to final state. Sketch the p-v diagram with its important values.

(6 marks)

(b) 0.5 kg of water is at initial condition of 10bar and 90°C. It undergoes series of processes such as the following:

Process 1-2: Isobaric heating until 100% of the water evaporates.
Process 2-3: Isometric cooling the pressure is reduced to 5bar
Process 3-4: Isobaric heating until the temperature is raised to 230°C

Sketch the T-v diagram of the processes mentioned above and determine:

(i) The volume at state 2
(ii) The dryness fraction at state 3
(iii) The work and heat transfer of Process 2-3.

(13 marks)

(c) In an automotive air conditioning system, air is used to cool the refrigerant in the radiator. Air passes through the radiator initially at 1.5bar, 30°C and 0.5m^3/s before the temperature rises to 50°C when it receives the energy from the refrigerant. Determine:

(i) the heat transfer per unit mass between the air and the refrigerant
(ii) the mass flow of the air

(6 marks)

Q5 (a) Describe the difference between:

(i) Reverse and reversible heat engine
(ii) Source and sink
(iii) Work and heat transfer

(6 marks)

(b) A water tank located in a paint processing factory has two inlets and one outlet. Steam at 2 bar, 95°C enters the first inlet at 5kg/s with a velocity of 30m/s. At the same time, saturated vapour at 5 bars enters the second inlet at 2 kg/s with a velocity of 50m/s. The heights of the first, second inlet and outlet are 25m, 10m and 5m respectively. If the velocity and pressure of the mixture at the outlet are 75m/s and 10bar respectively, determine:

(i) Temperature of the mixture at the outlet.

(6 marks)

(ii) Cross sectional area of each inlet and outlet.

(13 marks)

Q6 (a) Explain the Carnot Principle and write the coefficient of performance of an ideal (carnot) heat pump.

(4 marks)

(b) Steam power plant produces 25 MW of power while rejecting 28MW of heat to its surrounding. Determine the heat in MW generated by the burner and calculate plant thermal efficiency. If the temperatures of heat and sink are 2000K and 700K respectively, determine the practicality of the plant.

(8 marks)

(c) Several refrigerators are going to be designed to operate at 200K and 250K. Determine for each design whether the refrigeration cycle is a reversible, irreversible or an impossible cycle:

(i) Design 1: Q_H= 3200kJ and W =500kJ
(ii) Design 2: Q_C= 1200kJ and W= 450 kJ
(iii) Design 3: Q_H= 3000kJ and COP_R = 4.5
(iv) Design 2: Q_C=1500kJ and Q_H= 2300kJ

(13 marks)

- END OF QUESTIONS -

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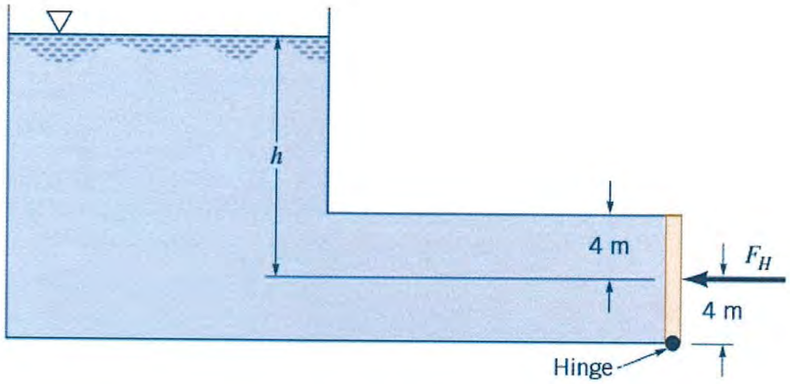

Figure Q1(c)

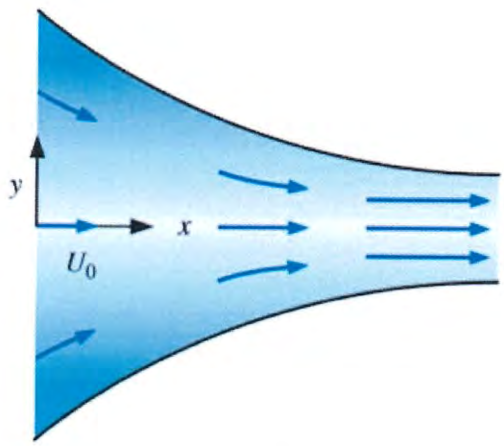

Figure Q2 (b)

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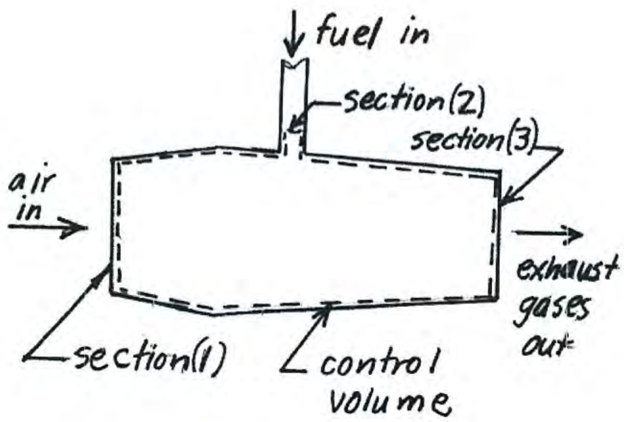

Figure Q2(c)