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Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	THERMOFLUIDS
COURSE CODE	:	BDU 10403
PROGRAMME	:	BDC
EXAMINATION DATE	:	JULY/AUGUST 2023
DURATION	:	3 HOURS
INSTRUCTION		1. ANSWER **ALL** QUESTIONS IN **SECTION A** AND **TWO (2)** QUESTIONS IN **SECTION B.**
		2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK.**
		3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL SOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK.

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

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SECTION A

Q1 (a) Define incompressible flow and incompressible fluid. Must the flow of a compressible fluid necessarily be treated as compressible? Give few reasons.

(4 marks)

(b) Oil with viscosity 2×10^{-2} Ns/m^2 and density 850 kg/m^3 is pumped along a straight horizontal pipe with a flow rate of 5×10^{-3} m^3/s. The static pressure difference between two tapping points 10 m apart is 80 N/m^2. Assuming laminar flow determine the following.

(i) The pipe diameter; and

(ii) The Reynolds numbers.

Comment on the validity of the assumption that the flow is laminar.

(8 marks)

(c) The diagram in **Figure Q1(c)** shows a vertical elevation of the water surface in the slanted tube is 120 cm. The system is open to 1 atm on the right side.

(i) If L = 120cm, what is the air pressure in container A?

(ii) Conversely, if P_A = 135 kPa, what is the length L?

(8 marks)

Q2 (a) Define and explain uniform and non-uniform flow with

(i) Mathematic equation; and

(ii) Give 2 example for uniform and non-uniform flow.

(4 marks)

(b) A steady, incompressible, two-dimensional velocity field is given by

$$\vec{V} = (u, v) = (1 + 2.5x + y)\,\vec{i} + (-0.5 - 1.5x - 2.5y)\vec{j}$$

where the x- and y-coordinates are in m and the magnitude of velocity is in m/s.

(i) Determine if there are any stagnation points in this flow field, and if so, where they are.

(ii) Sketch velocity vectors at several locations in the upper right quadrant for x = 0 m to 4 m and y = 0 m to 4 m; qualitatively describe the flow field.

(8 marks)

(c) **Figure Q2(c)** shows a nozzle at the end of a pie discharging oil from a tank to atmosphere. Distinguish the oil discharge from the nozzle when head H in the tank is 4.0 m.

(i) When the loss in the pipe as 20 $V^2/2g$ where V = velocity in the pipe. Examine velocity at 2.

(ii) The loss of energy in the nozzle 1 can be assumed to be zero. Appraise the pressure at the base of the nozzle 2.

(8 marks)

Q3 (a) Indicate True or False. Add a very brief explanation if you think the answer could depend on anything not stated in the question.

(i) Knowing the quality (x) and temperature of a substance is enough to 'fix the state', whereas knowing quality and pressure is not sufficient.

(ii) Saturation properties should be read at **T** and **P**, when establishing the quality of a substance know to be in the saturated liquid-vapour mixture phase,

(iii) If a substance is at a pressure lower than saturation pressure corresponding to its temperature, then the substance is in the super-heated vapour phase.

(iv) If the quality of a certain substance is 0.5, then the volume occupied by the liquid portion will be equal to the volume occupied by the vapour portion.

(v) If a substance is in the sub-cooled region, it will always be possible to vaporize the substance completely if enough heat is added at constant pressure.

(vi) In any process involving a fluid passing through a restriction in a pipe, i.e. a throttling process, enthalpy remains constant.

(6 marks)

(b) Complete the following table in **Table Q3(b)**, for Refrigerant 134a. If quality (or any other variable) is not applicable at a certain state, then indicate 'N/A'. Show all working as you proceed, but list a missing value in order at the end of your answer.

(7 marks)

(c) 100-kg of R-134a at 200 kPa are contained in a piston-cylinder device whose volume is $12.322m^3$. The piston is now moved until the volume is one-half its original size. This is done such that the pressure of the R-134a does not change. Determine

(i) the final temperature; and
(ii) the change in the total internal energy of the R-134a.

(7 marks)

SECTION B

Q4 (a) A househusband is cooking 'Lemang' for his family for Hari Raya use. For which case will the cooking time be the shortest? Why? Show illustration for each case.

(i) Bamboo and cook with firewood outside the house,
(ii) Paper cup and steam it; and
(iii) Oven but covered the sticker rice with banana leaves.

(6 marks)

(b) Windmills slow the air and cause it to fill a larger channel as it passes through the blades as shown in **Figure Q4(b)**. Consider a circular windmill with a 7m diameter rotor in 8 m/s wind on a day when the atmospheric pressure is 100 kPa and the temperature is 20°C. The wind speed behind the windmill is measured at 6.5 m/s. Determine the diameter of the wind channel downstream from the rotor and the power produced by this windmill, presuming that the air is incompressible.

(6 marks)

(c) A 3.27m tank contains 100 kg of nitrogen at 175 K. Determine the pressure in the tank, using
(i) the ideal-gas equation,
(ii) the van der Waals equation, and
(iii) the Beattie-Bridgeman equation. Compare your results with the actual value of 1505 kPa

(8 marks)

Q5 (a) The volume of 1 kg of helium in a piston-cylinder device is initially 5 m^3. Now helium is compressed to 2 m^3 while its pressure is maintained constant at 180 kPa. Determine the initial and final temperatures of helium as well as the work required to compress it, in kJ

(5 marks)

(b) Refrigerant-134a in **Figure Q5(b)** enters the condenser of a residential heat pump at 800 kPa and 35°C at a rate of 0.018 kg/s, and leaves at 800 kPa as a saturated liquid. If the compressor consumes 1.2 kW of power, determine:

(i) COP of the heat pump, and
(ii) rate of heat absorption from the outside air.

(5 marks)

(c) An air-standard cycle is executed in a closed system with 0.004kg of air and consists of the following three processes:
1 – 2: Isentropic compression from 100kPa and 27°C to 1MPa,
2 – 3: P = constant heat addition in the amount of 2.76Kj,
3 – 1: $P = c_1v + c_2$ heat rejection to initial state (t and c_2 are constant)
(i) Show the cycle on P – v and T – s diagrams;
(ii) Calculate the heat rejected; and
(iii) Determine the thermal efficiency.

(10 marks)

Q6 (a) Sketch a *P-v* diagram of a Carnot Refrigerator and Carnot Heat Pump, label accordingly and indicate the heat in (Q_{in}), heat out (Q_{out}) and net work done ($W_{net, out}$) during the process of Carnot cycle.

(4 marks)

(b) A Carnot heat pump in **Figure Q6(b)** is to be used to heat a house and maintain it at 25°C in winter. On a day when the average outdoor temperature remains at about 2°C, the house is estimated to lose heat at a rate of 55,000 kJ/h. If the heat pump consumes 4.8 kW of power while operating, determine
(i) how long the heat pump ran on that day;
(ii) the total heating costs, assuming an average price of 11¢/kWh for electricity; and
(iii) the heating cost for the same day if resistance heating is used instead of a heat pump.

(8 marks)

(c) An Engineer proposes a system of two Carnot Cycles, a heat engine and heat pump, to transfer heat from 400K to 500K and 300K, as shown in **Figure Q6(c)**. Examine if there any possible for heat engine has high and low temperatures of 400K and 300K, respectively by finding

(i) the rate of work supplied from combination heat engine and heat pump; and

(ii) appraise that Entropy change more than zero.

(8 marks)

- END OF QUESTION -

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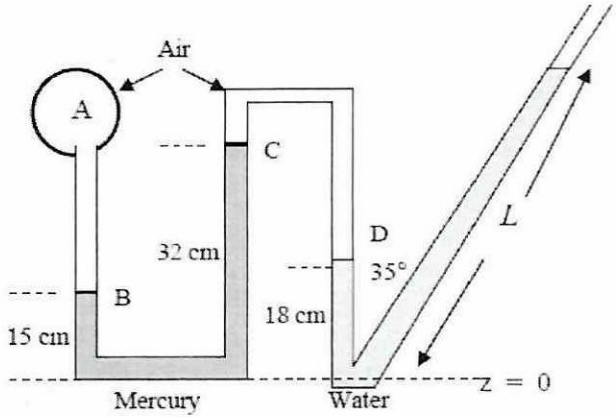

Figure Q1(d)

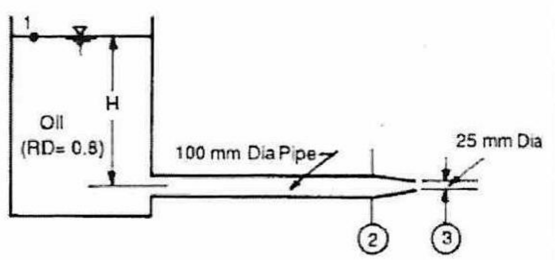

Figure Q2(c)

Table Q3(b)

State	Total Mass $m_T(kg)$	Mass of liquid $m_f\ (kg)$	Mass of vapour $m_g\ (kg)$	Pressure P (MPa)	Temperature (°C)
1	0.7	(i)			80
2		1.3	(v)	1.8	
		215.6	(ii)	(iii)	(iv)
			(vi)	(vii)	Saturated Liquid

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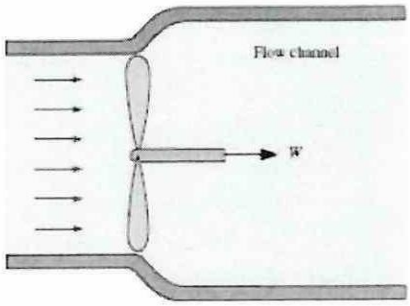

Figure Q4(b)

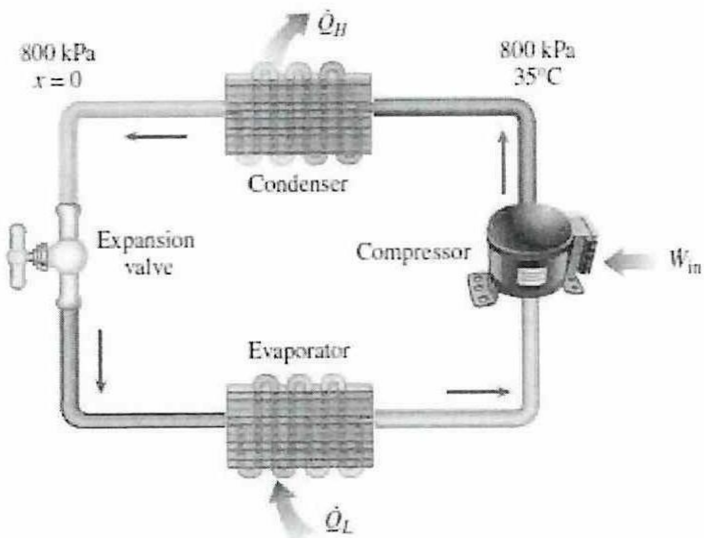

Figure Q5(b)

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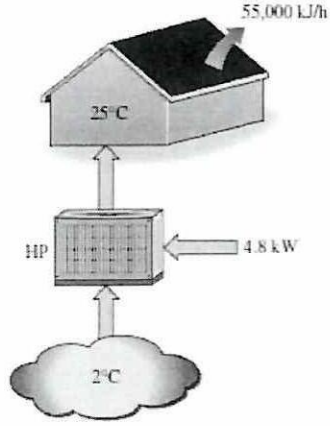

Figure Q6(b)

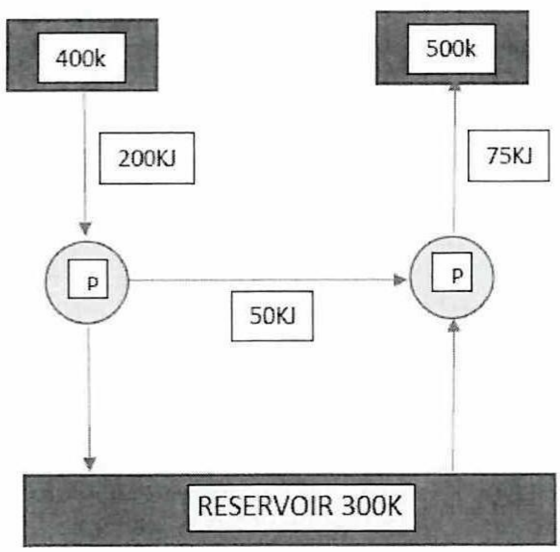

Figure Q6(c)