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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	THERMODYNAMICS II
COURSE CODE	:	BDA 30403
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	JULY/AUGUST 2023
DURATION	:	3 HOURS
INSTRUCTION	:	1. **PART A**: ANSWER **THREE (3)** QUESTIONS **ONLY** FROM **FOUR (4)** QUESTIONS. **PART B**: ANSWER **ALL** QUESTIONS. 2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED 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 **SEVEN (7)** PAGES

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PART A: ANSWER THREE (3) QUESTIONS ONLY FROM FOUR (4) QUESTIONS.

Q1 (a) Discuss the four processes of an ideal Rankine cycle.

(3 marks)

(b) Consider a steam power plant operating on ideal Rankine cycle. Steam enters the turbine at 3 MPa and 350 °C and is condensed in the condenser at a pressure of 10 kPa. Determine;

(i) the thermal efficiency of this power plant; and

(ii) the thermal efficiency if steam is superheated to 600 °C instead of 350 °C.

(17 marks)

Q2 (a) Differentiate between open-cycle and closed-cycle gas turbine engine.

(3 marks)

(b) Air enters the compressor at 100 kPa, 300 K with a mass flow rate of 5.807 kg/s. The pressure ratio across the two-stage compressor is 10. The pressure ratio across the two-stage turbine is also 10. The intercooler and reheater operate at 300 kPa. At the inlets to the turbine stages, the temperature is 1400 K. The temperature at the inlet to the second compressor stage is 300 K. The isentropic efficiency of each compressor and turbine stage is 80%. The regenerative effectiveness is 80%. Determine;

(i) the thermal efficiency of the cycle;

(ii) the back work ratio;

(iii) the net power developed in, kW; and

(iv) show the process in a *T-s* diagram.

(17 marks)

Q3 (a) Distinguish between a "single-acting" and "double-acting" air compressor.

(3 marks)

(b) A single stage, double-acting air compressor is required to deliver 8 m^3 of air per minute measured at 1.013 bar and 15 °C. The delivery pressure is 6 bar and the crank speed is 300 rpm. The clearance volume is 5% of swept volume and the index of compressor and expansion is 1.3. Determine;

i) the swept volume of the cylinder, V_S;

ii) the delivery temperature, T_2;

iii) the indicated power; and

iv) propose a method for improving this system by using schematic diagram and a *T-s* diagram.

(17 marks)

Q4 (a) Illustrate a schematic diagram representing a two-stage refrigeration with a flash chamber. Briefly explain the function of flash chamber in this system.

(3 marks)

(b) A two-stage compression refrigeration system operates with refrigerant-134a between the pressure limits of 1.4 MPa and 0.10 MPa. The refrigerant leaves the condenser as a saturated liquid and is throttled to a flash chamber operating at 0.6 MPa. The refrigerant leaving the low-pressure compressor at 0.6 MPa is also routed to the flash chamber. The vapor in the flash chamber is then compressed to the condenser pressure by the high-pressure compressor, and the liquid is throttled to the evaporator pressure. Assuming the refrigerant leaves the evaporator as saturated vapor and both compressors are isentropic, determine;

i) the fraction of the refrigerant that evaporates as it is throttled to the flash chamber;

ii) the rate of heat removed from the refrigerated space for a mass flow rate of 0.25 kg/s through the condenser; and

iii) the coefficient of performance.

(17 marks)

PART B: ANSWER ALL QUESTIONS

Q5 (a) Briefly explain four (4) air standard assumptions used for ideal cycle.

(4 marks)

(b) An ideal Diesel cycle has a compression ratio of 17 and a cut-off ratio of 1.3. Determine the maximum temperature of the air and the rate of heat addition to this cycle when it produces 140 kW of power and the state of the air at the beginning of the compression is 90 kPa and 57 °C. Use constant specific heats at room temperature.

(16 marks)

Q6 (a) Explain the distinction between "dry air" and "atmospheric air".

(2 marks)

(b) At a temperature of 30 °C and total pressure of 100 kPa, a tank holds 21 kg of dry air and 0.3 kg of water vapor. Evaluate the specific humidity, the relative humidity, and the volume of the tank.

(4 marks)

(c) An air-conditioning system operates at a total pressure of 1 atm, 15 °C, and 60 percent relative humidity is first heated to 20 °C in a heating section and then humidified by introducing water vapor. The air leaves the humidifying section at 25 °C and 65 percent relative humidity. Determine the amount of steam added to the air, and the amount of heat transfer to the air in the heating section.

(14 marks)

– END OF QUESTION –

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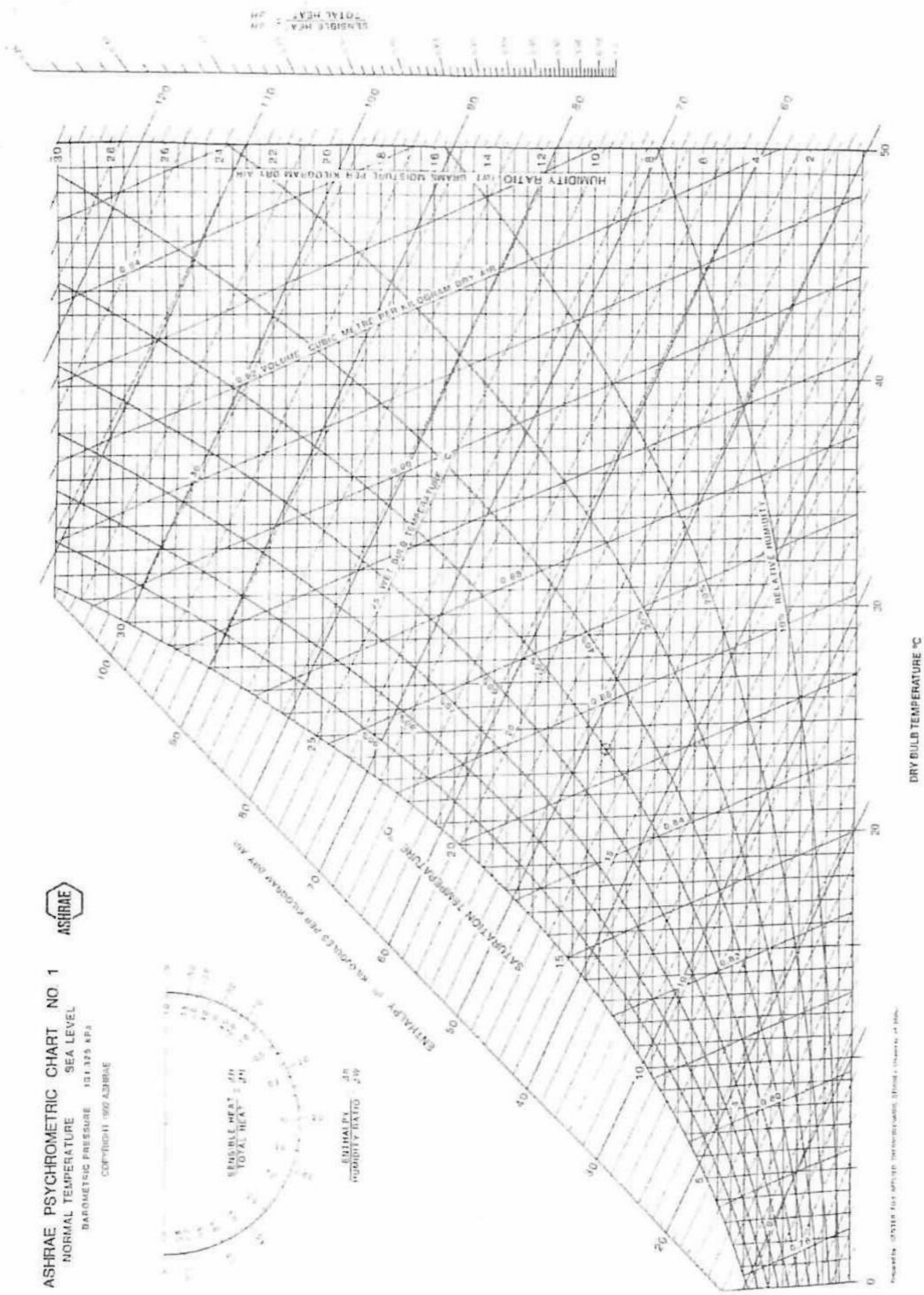

Figure Q6(b)

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List of Formula

$$bwr = \frac{w_{pump}}{w_{turbine}}$$

$$\eta_P = \frac{w_s}{w_a}$$

$$\eta_T = \frac{w_a}{w_s}$$

$$\eta_{th} = \frac{w_{net}}{q_{in}}$$

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{(k-1)}{k}} = \left(\frac{P_3}{P_4}\right)^{\frac{(k-1)}{k}} = \frac{T_3}{T_4}$$

$$\epsilon = \frac{q_{regen_{actual}}}{q_{regen_{maximum}}}$$

$$IP = \frac{n}{n-1} \dot{m} R (T_2 - T_1)$$

$$Isothermal\ Power = \dot{m} RT \ln \frac{P_2}{P_1}$$

$$V_{in} - V_a - V_d$$

$$\eta_v = \frac{V_a - V_d}{V_s}$$

$$V_s = V_a - V_c$$

$$\frac{V_s}{V_c} = \left(\frac{P_2}{P_1}\right)^{\frac{1}{n}}$$

$$COP_R = \frac{q_L}{w_{net,in}}$$

$$P - P_a + P_v$$

$$h_{dry\ air} = C_p T$$

$$\phi = \frac{\omega P}{(0.622 + \omega) P_g}$$

$$h = h_a + \omega h_g$$

$$\dot{Q}_{in} = \dot{m}_a (h_2 - h_1)$$

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$$\dot{Q}_{out} - \dot{m}_a(h_1 - h_2) - \dot{m}_w h_w$$

$$\dot{m}_{make\ up} = \dot{m}_a(\omega_2 - \omega_1) = \dot{m}_3 - \dot{m}_4$$

$$\dot{m}_3 h_3 = \dot{m}_a(h_2 - h_1) + (\dot{m}_3 - \dot{m}_{make\ up})h_4$$

$$\dot{m}_a = \frac{\dot{m}_3(h_3 - h_4)}{(h_2 - h_1) - (\omega_2 - \omega_1)h_4}$$

$$MEP = \frac{w_{net}}{V_s} = \frac{W_{net}}{V_{max} - V_{min}}$$

$$Q_{in} = mC_v(T_3 - T_2)$$

$$Q_{out} = mC_v(T_4 - T_1)$$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\frac{v_1}{v_2} = \left(\frac{P_2}{P_1}\right)^{\frac{1}{k}}$$

$$\frac{T_2}{T_1} - \left(\frac{v_1}{v_2}\right)^{k-1}$$

$$r_c = \frac{P_3}{P_2} = \frac{T_3}{T_2} \quad cutoff\ ratio$$

$$r_v = \frac{v_1}{v_2} = \frac{V_1}{V_2}$$