UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2018/2019

COURSE NAME	:	THERMODYNAMICS II
COURSE CODE	:	BDA 30403
PROGRAMME	:	BDD
EXAMINATION DATE	:	JUNE/JULY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FIVE (5)** QUESTIONS **ONLY**

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

Q1 (a) Discuss how to increase the thermal efficiency of a steam power plant working on Rankine cycle.

(3 marks)

(b) Consider a coal-fired steam power plant that produces 300 MW of electric power. The power plant operates on a simple ideal Rankine cycle with turbine inlet conditions of 5 MPa and 450°C and a condenser pressure of 25 kPa. The coal has a heating value (energy released when the fuel is burned) of 29,300 kJ/kg. Assuming that 75 percent of this energy is transferred to the steam in the boiler and that the electric generator has an efficiency of 96 percent, determine;

(i) the overall plant efficiency (the ratio of net electric power output to the energy input as fuel); and
(ii) the required rate of coal supply.

(17 marks)

Q2 (a) Explain how to achieve 100% effectiveness of a regenerator used in gas-turbine cycles and discuss whether it is possible.

(4 marks)

(b) A two-shaft gas turbine power plant is shown in **Figure Q2 (b)**. All the power developed by the high-pressure turbine (HPT) is used to run the compressors C1 and C2. The low pressure turbine (LPT) provides the net power output. Air is compressed from 100 kPa, 298 K to 1.2 MPa in a two-stage compressor with intercooling (I) between stages. The intercooler pressure is 500 kPa. The air is cooled back to 298 K in the intercooler before entering the second compressor (C2). Each compressor and the HPT operate isentropically. The intercooler and reheater (R) each operates at 500 kPa. The reheater brings the temperature entering the LPT back to the temperature at the HPT inlet. The isentropic efficiency of the low pressure turbine (LPT) is 90%. Determine;

(i) the temperature at the exit of high pressure turbine;
(ii) the thermal efficiency; and
(iii) back work ratio

(16 marks)

Q3 (a) Discuss why the clearance volume is necessary in a compressor.

(3marks)

(b) A single-stage, single-acting air compressor running at 1000 rev/min delivers air at 2.5 MPa bar. For this purpose the induction and free air conditions can be taken as 1 atm and 15 °C, and the FAD as 0.25 m^3/min. The clearance volume is 3% of the swept volume and the stroke/bore ratio is 1.2/1. Determine;

(i) the bore and stroke;
(ii) the swept volume, V_s;
(iii) the delivery temperature, T_2;
(iv) the volumetric efficiency;
(v) the indicated power; and
(vi) the isothermal efficiency.

(17 marks)

Q4 (a) Discuss the advantages of using multi-stage refrigeration cycle for large industrial applications.

(2 marks)

(b) A two-stage compression refrigeration system with an adiabatic liquid-vapor separation unit uses refrigerant-134a as working fluid. The system operates the evaporator at -32 °C, the condenser at 1.4 MPa, and the separator at 8.9 °C. The refrigerant is circulated through the condenser at a rate of 2 kg/s. Given that the refrigerant is saturated liquid at the inlet of each expansion valve and saturated vapor at the inlet of each compressor, and the compressors are isentropic;

(i) show the process on a T-s diagram;
(ii) calculate calculate the rate of cooling produced by evaporator; and
(iii) determine the total power requirement for this system.

(18 marks)

Q5 (a) Describe the purpose of using the wet cooling towers.

(2 marks)

(b) Water enters a cooling tower at 35 °C and at a rate of 1.4 kg/s, and leaves at 25 °C. Humid air enters this tower at 1 atmosphere and 17 °C with a relative humidity of 30 percent and leaves at 22 °C with relative humidity of 80 percent. Determine the mass flow rate of dry air through this tower.

(18 marks)

Q6 (a) State the differences between Otto Cycle and Dual Cycle.

(4 marks)

(b) An ideal Diesel cycle has a compression ratio of 17 and a cutoff 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)

- END OF QUESTION –

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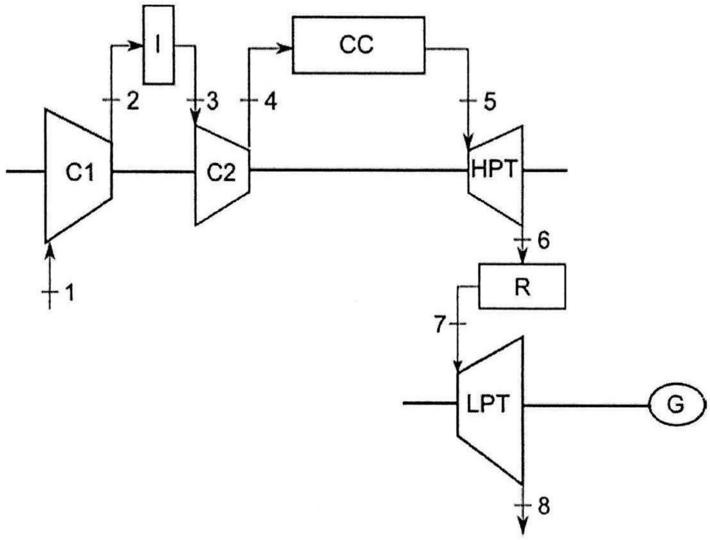

Figure Q2 (b)

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

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

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

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

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

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

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

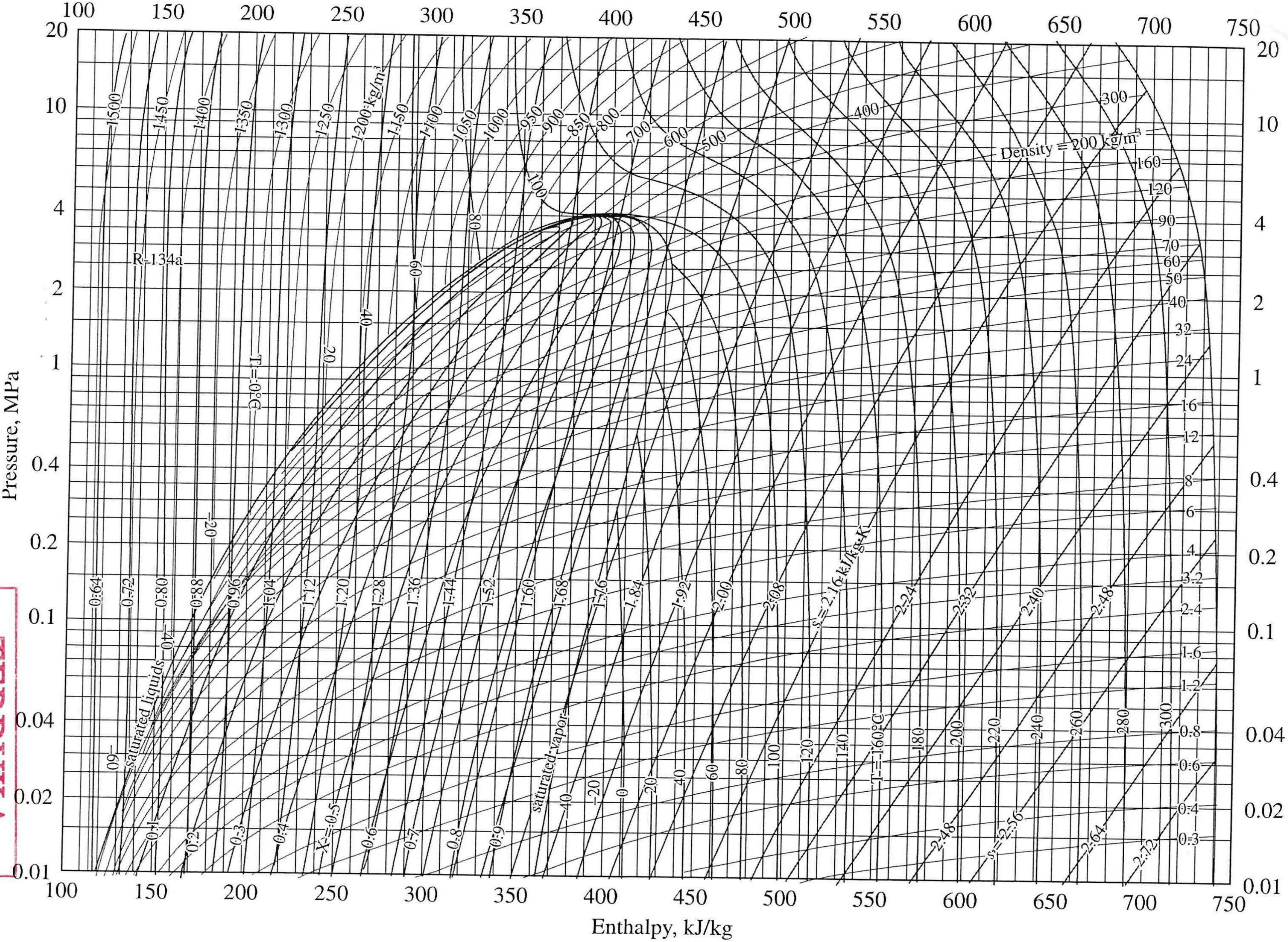
$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

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

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

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

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


R-134a
Pressure, MPa
Enthalpy, kJ/kg
Density = 200 kg/m³
T = 0°C
T = 160°C
s = 2.16 kJ/kg·K
X = 0.5
saturated liquids
saturated vapor
1200 kg/m³
s = 2.56

Normal Temperature
Barometric Pressure: 101.325 kPa

Sea Level