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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2016/2017

COURSE NAME	:	THERMODYNAMICS II
COURSE CODE	:	BDA 30403
PROGRAMME	:	BDD
EXAMINATION DATE	:	DECEMBER 2016/ JANUARY 2017
DURATION	:	3 HOURS
INSTRUCTION	:	**PART A** : ANSWER **THREE (3)** QUESTIONS ONLY. **PART B** : ANSWER **ALL** QUESTIONS.

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

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PART A : ANSWER **THREE (3)** QUESTIONS ONLY.

Q1 **Figure Q1** shows a steam power plant operates on an ideal reheat-regenerative Rankine cycle and has a net power output of 100 MW. Steam enters the high-pressure turbine at 150 bar and 600°C and leaves at 12 bar. Some steam is extracted at this pressure to heat the feedwater in a closed feedwater heater. The rest of the steam is reheated to 500°C and is expanded in the low-pressure turbine to the condenser pressure of 0.15 bar. Assume that the feedwater leaves the heater at the condensation temperature of the extracted steam and that the extracted steam leaves the heater as a saturated liquid and is pumped to the line carrying the feedwater. Show the cycle on a *T-s* diagram with respect to saturation lines and determine:

(i) the mass flow rate of steam through the boiler;
(ii) the steam quality at turbine exit; and
(iii) the heat supplied to the system.

(20 marks)

Q2 (a) Explain how does regeneration affect the efficiency of a Brayton cycle, and how it does accomplish it.

(3 marks)

(b) A gas turbine draws in air from atmosphere at 1 bar and 10°C and compresses it to 5 bar with an isentropic efficiency of 80 percent. The air is heated to 1200 K at constant pressure and then expanded through two stages in series back to 1 bar. The high pressure turbine is connected to the compressor and produces just enough power to drive it. The low pressure stage is connected to an external load and produces 80 kW of power. The isentropic efficiency is 85 percent for both stages. Show the process in the *T-s* diagram and calculate;

(i) the inter-stage pressure of the turbines;
(ii) the mass flow of air; and
(iii) the thermal efficiency of the cycle.

For the compressor, take $k = 1.4$ and for the turbines $k = 1.333$. The gas constant R is 0.287 kJ/kg.K for both.

(17 marks)

Q3 (a) **Figure Q3(a)** shows the *p-V* diagram for the compressor with clearance. Explain why and how the curve 3-4 does appears for this compressor with clearance.

(4 marks)

(b) A single stage, double acting air compressor is required to deliver 17 m^3/min of air measured at 1 bar and 15°C. The pressure and temperature at the end of the suction process are 0.98 bar and 32°C, respectively. The delivery pressure is 6.4 bar The clearance ratio is 0.05 and the index for both compression and expansion is 1.32. Show the process on the *p-V* diagram and determine;

(i) the speed of compressor if the swept volume is 0.02 m^3 per stroke; and

(ii) the indicated power of the compressor.

(16 marks)

Q4 Consider a two-stage cascade refrigeration systems operating between the pressure limit of 1.2 MPa and 200 kPa with refrigerant-134a as the working fluid. Heat rejection from the lower cycle to the upper cycle takes place in an adiabatic counterflow heat exchanger where the pressure in the upper and lower cycles are 0.4 and 0.5 MPa, respectively. In both cycles, the refrigerant is a saturated liquid at the condenser exit and a saturated vapor at the compressor inlet, and the isentropic efficiency of the compressor is 80 percent. Show the cycle on a *T-s* diagram with respect to saturation lines. If the mass flow rate of the refrigerant through the lower cycle is 0.15 kg/s, determine;

(i) the mass flow rate of the refrigerant through the upper cycle;

(ii) the rate of heat removed from the refrigerated space; and

(iii) the input power of the compressor.

(20 marks)

PART B : ANSWER ALL QUESTIONS.

Q5 (a) Explain how vapor pressure of the ambient air is determined when the temperature, total pressure, and the relative humidity of air are given.

(3 marks)

(b) A wet cooling tower is to cool 25 kg/s of cooling water from 40 to 30°C at a location where the atmospheric pressure is 96 kPa. Atmospheric air enters the tower at 20°C and 70 percent relative humidity and leaves saturated at 35°C. Neglecting the power input to the fan, determine;

(i) the volume flow rate of air into the cooling tower; and

(ii) the mass flow rate of the required makeup water.

(17 marks)

Q6 (a) Differentiate the operation of SI engines and CI engines with an aided of *p-V* diagram.

(4 marks)

(b) A diesel cycle engine has an inlet temperature and pressure of 20°C and 1 bar respectively. The compression ratio is 11/1 and the maximum cycle temperature is 1200°C. Assuming $k = 1.4$ and $R = 0.287$ kJ/kg.K, calculate;

(i) temperature, pressure and specific volume at each state of the cycle; and

(ii) total work during combustion and power stroke.

Sketch *p-V* diagram for the all above processes.

(16 marks)

- END OF QUESTIONS –

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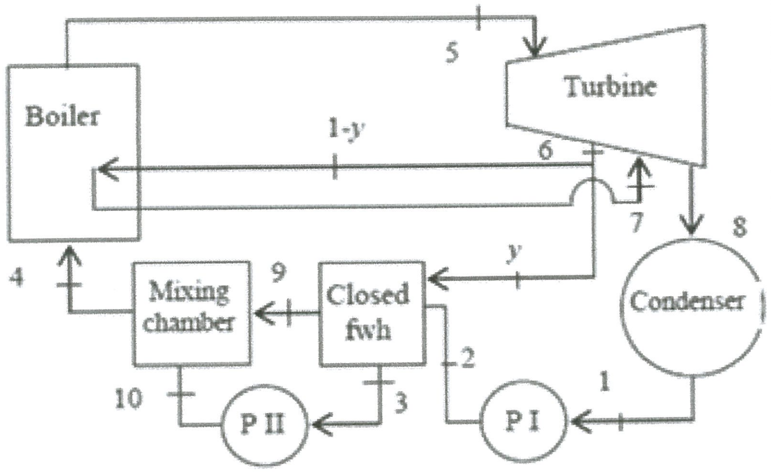

Figure Q1

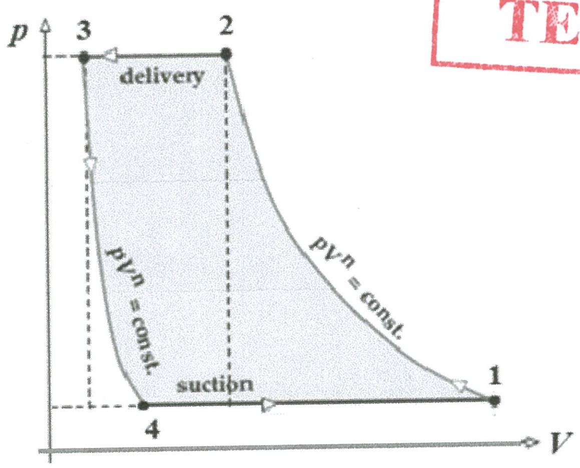

Figure Q3(a)

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Formula

1. *Isentropic relationship and thermal efficiency of Brayton cycle under cold-air-standard assumptions :*

$$\frac{T_2}{T_1}=\left(\frac{P_2}{P_1}\right)^{(k-1)/k} \quad , \quad \eta_{th,Brayton}=1-\frac{1}{r_p^{(k-1)/k}}$$

2. *Compressor work per cycle:*

$$w_{poly}=\frac{n}{n-1}RT_1\left(\frac{T_2}{T_1}-1\right) \quad , \quad w_{isen}=\frac{k}{k-1}RT_1\left(\frac{T_2}{T_1}-1\right) \quad , \quad w_{iso}=RT_1\ln\frac{P_2}{P_1}$$

3. *Free Air Delivery (FAD) :* $\text{FAD}=V_a=V_{in}\dfrac{T_a p_1}{T_1 p_a}$

4. *Volumetric efficiency:* $\eta_v=\dfrac{V_{in}}{V_{swept}}$ *or* $\eta_v=1-\dfrac{V_c}{V_s}\left(\left(\dfrac{P_2}{P_1}\right)^{\frac{1}{n}}-1\right)$

5. *Indicated Power for z-Stages Compressor :* $\dot{W}=z*\dfrac{n-1}{n}\dot{m}RT_1\left(\left(\dfrac{P_2}{P_1}\right)^{(n-1)/zn}-1\right)$

6. *The atmospheric air pressure :* $P=P_a+P_v$

7. *The enthalpy of water vapor in air :* $h_g(T)\cong 2500.9+1.82T$ (T in °C)

8. *The enthalpy of dry air :* $h_a=C_pT$

9. *The enthalpy of atmospheric air :* $h=h_a+\omega h_g$

10. *Specific humidity :* $\omega=\dfrac{m_v}{m_a}=0.622\dfrac{P_v}{P_a}$ (kg H_2O/ kg dry air)

11. *Relative humidity :* $\phi=\dfrac{m_v}{m_g}=\dfrac{P_v}{P_g}$

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