Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2021/2022

COURSE NAME	:	THERMODYNAMICS
COURSE CODE	:	BDU11302
PROGRAMME CODE	:	BDM
EXAMINATION DATE	:	JULY 2022
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTION	:	1. **SECTION A:** ANSWER **ALL** QUESTIONS. 2. **SECTION B:** ANSWER **ONE (1)** QUESTION **ONLY**. 3. THIS FINAL EXAMINATION IS CONDUCTED VIA CLOSED BOOK. 4. STUDENTS ARE PROHIBITED TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL SOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK.

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

SECTION A: ANSWER **ALL** QUESTIONS.

Q1 (a) Define the isothermal, isobaric and isochoric processes.

(3 marks)

(b) List three (3) characteristics of a superheated vapor.

(3 marks)

(c) A 1.8 m^3 rigid tank contains steam at 220°C. One-third of the volume is in the liquid phase and the rest is in the vapor form. Find the quality of the saturated mixture.

(9 marks)

(d) A fixed mass of an ideal gas is heated from 50°C to 80°C at constant volume. The same process is also repeated at constant pressure. Discuss which case will require a greater energy and explain your reason.

(3 marks)

(e) A piston–cylinder device contains 0.15 kg of air initially at 2 MPa and 350°C. The air is first expanded isothermally to 500 kPa, then compressed polytropically with a polytrophic exponent of 1.2 to the initial pressure, and finally compressed at the constant pressure to the initial state. Calculate the boundary work for isothermal expansion process.

(7 marks)

Q2 (a) The amount of mass and volume of fluid flowing through a cross-section per unit time is denoted as mass flow rate and volume flow rate, respectively.

(i) For an unsteady-flow process, explain whether the amount of mass entering a control volume have to be equal to the amount of mass leaving.

(ii) Consider a device with one inlet and one outlet. If the volume flow rates at the inlet and at the outlet are the same, discuss whether the flow is necessarily steady.

(iii) A diffuser is an example of steady flow engineering devices. Give another 2 examples of common steady-flow devices.

(5 marks)

(b) Air at 80 kPa, 27°C, and 220 m/s enters a diffuser at a rate of 2.5 kg/s and leaves at 42°C. The exit area of the diffuser is 400 cm^2. The air is estimated to lose heat at a rate of 18 kJ/s during this process.

(i) Deduce three (3) assumptions applicable for the analysis of this device.
(ii) Write the energy balance expression for this system.
(iii) Determine the exit velocity and the exit pressure of the air.

(15 marks)

(c) An inventor claims to have developed an automobile engine that burns biofuel at 317°C with an engine efficiency of 50%. If the local air temperature is 17°C and considering Carnot principles, evaluate whether this claim is valid.

(5 marks)

Q3 (a) Hot combustion gases enter the nozzle of a turbojet engine at 260 kPa and 747°C with a velocity of 80 m/s. The gases exit at a pressure of 85 kPa. The isentropic efficiency is 92% and the combustion gases is treated as air.

(i) Write the energy balance for the isentropic processes.
(ii) Find the exit velocity.
(iii) Calculate the exit temperature.

(12 marks)

(b) 5 kg of air at 427°C and 600 kPa are contained in a piston-cylinder device. The air expands adiabatically until the pressure is 100 kPa and produces 600 kJ of work output. Assume air has constant specific heats evaluated at 300 K.

(i) Write the energy balance expression for this system.
(ii) Determine the entropy change of the air, in KJ/kg.K.
(iii) Since the process is adiabatic, state whether the process is realistic. Support your answer by considering the concepts of the second law.

(13 marks)

SECTION B: ANSWER **ONE (1)** QUESTION **ONLY.**

Q4 (a) Actual gas power cycles are rather complex and commonly require a tedious analysis. Therefore, air-standard assumptions are utilized to reduce the analysis to a manageable level. List three (3) assumptions considered under air-standard assumptions.

(3 marks)

(b) An air-standard cycle with variable specific heats is executed in a closed system and is composed of the following four processes:

1 – 2 Isentropic compression from 120 kPa and 25°C to 500 kPa
2 – 3 v = constant heat addition to 1620 K
3 – 4 Isentropic expansion to 120 kPa
4 – 1 P = constant heat rejection to initial state

(i) Examine the given information and show the cycle given above on P-v and T-s diagrams.
(ii) By considering the air-standard assumptions, determine the properties of air (P and T) at all states.
(iii) Compare the amount of heat addition and heat rejection.

(22 marks)

Q5 (a) State the operating characteristics of an aircraft propelled with:
(i) a propeller-driven engine, and
(ii) a turbojet engine.

(3 marks)

(b) A turbojet aircraft is flying with a velocity of 280 m/s at an altitude of 9150 m, where the ambient conditions are 32 kPa and 232°C. The pressure ratio across the compressor is 12, and the temperature at the turbine inlet is 1100 K. Air enters the compressor at a rate of 50 kg/s, and the jet fuel has a heating value of 42,700 kJ/kg. Assuming ideal operation for all components and constant specific heats for air at room temperature, determine:

(i) the velocity of the exhaust gases,
(ii) the propulsive power developed,
(iii) the rate of fuel consumption, and
(iv) the propulsive efficiency.

(22 marks)

- END OF QUESTIONS -

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LIST OF EQUATIONS

$$H = U + PV$$

$$x = \frac{m_{gas}}{m_{total}}$$

$$a = \frac{A}{mass}$$

$$PV = mRT$$

$$\dot{m} = \rho AV$$

$$R = \frac{R_U}{M} = c_p - c_v$$

$$k = \frac{c_p}{c_v}$$

$$W_b = \int PdV$$

$$W_{b(isothermal)} = RT \ln\left(\frac{V_2}{V_1}\right)$$

$$W_{b(isentropic)} = \frac{P_2V_2 - P_1V_1}{1-k}$$

$$W_{b(polytropic)} = \frac{P_2V_2 - P_1V_1}{1-n}$$

$$\eta_{carnot} = 1 - \frac{T_L}{T_H}$$

$$PV^n = constant$$

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

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{k-1}$$

$$\eta_t = \frac{w_{act}}{w_{isen}}$$

$$s_2 - s_1 = C_v \ln\frac{T_2}{T_1} + R \ln\frac{v_2}{v_1}$$