Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	THERMODYNAMICS
COURSE CODE	:	BDU11303
PROGRAMME CODE	:	BDM
EXAMINATION DATE	:	JULY/AUGUST 2023
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER **FOUR (4)** QUESTIONS ONLY 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 **FIVE (5)** PAGES

Q1 (a) Describe the first law of thermodynamics and give examples of the application.

(3 marks)

(b) Differentiate static and dynamic energy and provide two examples for each energy

(8 marks)

(c) List the mechanical work, boundary work, and spring work equations.

(3 marks)

(d) A Lear Jet 24D aircraft is flying at two altitudes. The data from these two altitudes are recorded from the flight instrument as follows:

Altitude 1

Nozzle inlet temperature	:	40°C
Nozzle outlet temperature	:	10°C
Nozzle inlet velocity	:	250 m/s

Altitude 2

Nozzle inlet temperature	:	13°C
Nozzle outlet temperature	:	-17°C
Nozzle inlet velocity	:	250 m/s

Investigate both flying altitudes to obtain nozzle exit velocities. Compare the answer and discuss why both values are the same or different.

(11 marks)

Q2 (a) Explain the system, surrounding and boundary system briefly. Give an example to support your explanation.

(5 marks)

(b) Water in a piston-cylinder system device is at the phase of compressed liquid with a temperature of 60°C. The water is subjected to a pressure of 5 MPa. The water is then heated at constant pressure until the temperature reaches 300°C and becomes a superheated vapour.

(i) Describe the change of phase in the water from compressed liquid to superheated vapour.
(ii) Sketch the process in a T-v diagram

(5 marks)

(c) 1.5 kg of water at 1 MPa with a dryness fraction of 0.3 in a piston-cylinder device is subjected to the following proses:

Process 1-2 : Heating at a constant volume until the pressure is 1.4 MPa.
Process 2-3 : Heating at constant pressure until the temperature is 350°C

Analyse these processes to obtain the following:

(i) the work and heat transfer for each process; and
(ii) the total work and heat transfer.

Sketch the process in a *T-v* diagram

(15 marks)

Q3 (a) Differentiate the phase of solid and gas in terms of its molecule bonding, arrangement and energy level.

(6 marks)

(b) List the equations to find the work of an isothermal and a polytropic process

(4 marks)

(c) 0.3 kg of air is at the initial condition of 150kPa and 70°C. It undergoes a series of processes, such as the following:

Process 1-2: Isometric heating until the pressure is three times of the initial pressure
Process 2-3: Isobaric heating until the volume is two times of the initial volume.
Process 3-4: Polytropic expansion process with n = 1.35 until the pressure is reduced to 85 kPa

Investigate these processes to obtain the following:
(i) The pressure, temperature, and volume of each process
(ii) The total work and heat transfer

Sketch the *P-V* diagram of the processes mentioned above. Take $R = 0.287\ kJ/kg.K$, $Cp = 1.005\ kJ/kg$, $Cv = 0.718\ kJ/kg$ and $\gamma = 1.4$

(15 marks)

Q4 (a) Describe the Second Law of Thermodynamics with appropriate examples.

(4 marks)

(b) Define a Heat Engine and give two examples of a typical heat engine in today's application.

(6 marks)

(c) You are required to investigate the performance of three refrigerators designed by three different companies. The specifications of the three refrigerators are as follows:

Refrigerators A

The ability to reject heat from the refrigerated space $(\dot{Q}_L)$: 1 kW
Coefficient of Refrigeration (COP_R) : 1.2

Refrigerators B

The ability to reject the heat to the surrounding $(\dot{Q}_H)$: 3 kW
Power required to transfer the heat $(\dot{W}_{net\ in})$: 1.2 kW

Refrigerators C

The ability to reject heat from the refrigerated space $(\dot{Q}_L)$: 2.5 kW
Power required to transfer the heat $(\dot{W}_{net\ in})$: 2 kW

(i) Analyse the specifications of the three refrigerators to obtain $\dot{Q}_L$, $\dot{W}_{net\ in}$ and COP_R. Summarise the results in a table.
(ii) Deduce the information from the analysis and choose which of the three refrigerators performs best.

(10 marks)

(d) The company's engineering team claims to have developed an automobile engine that burns petrol at 350°C with an engine efficiency of 60%. The local air temperature is 21°C. As the company's head of the technology investment unit, evaluate whether the claim is valid using the Carnot principles and whether the company should invest in putting the design into the market.

(5 marks)

Q5 (a) Define the isentropic process and list three equations that relate pressure, temperature, and volume in a typical isentropic process.

(5 marks)

(b) 0.5 kg of air in a piston-cylinder device has an initial condition of 70°C and 150kPa. The air is compressed isentropically until the temperature reaches 300°C. Analyse the compression process to obtain the following:

(i) the pressures, temperatures, and volumes at the initial and end process;
(ii) the entropy change of the compression process.

Sketch the *P-V* diagram. Take $R = 0.287\ kJ/kg.K$, $Cp = 1.005\ kJ/kg$, and $\gamma = 1.4$

(10 marks)

(c) A gas-turbine power plant operating on an ideal Brayton cycle has a pressure ratio of 10. The gas temperature at the inlet of the compressor and turbine is 350K and 1450K, respectively. By the air-standard assumption, investigate the performance of the gas turbine to obtain the following:

(i) the gas temperature at the exits of the compressor and the turbine;
(ii) the back work ratio; and
(iii) the thermal efficiency.

Sketch the Ts diagram of the Brayton Cycle. Take $R = 0.287\ kJ/kg.K$, $Cp = 1.005\ kJ/kg$, and $\gamma = 1.4$

(10 marks)

- END OF QUESTIONS –