Registration No.: | | | | | | | | | | |

Total Number of Pages: 02 **Course: IDD (B.Tech and M.Tech)**
Sub_Code: RME4C002

4th Semester Back Examination: 2024-25
SUBJECT: Engineering Thermodynamics
BRANCH(S): MECH, MMEAM
Time: 3 Hours
Max Marks: 100
Q.Code: S277

Answer Question No.1 (Part-I) which is compulsory, any eight from Part-II and any two from Part-III.
The figures in the right hand margin indicate marks.

Part-I

Q1 **Answer the following questions:** **(2 x 10)**

a) State the First Law of Thermodynamics for a closed system undergoing a process.
b) What is the physical meaning of entropy generation?
c) Differentiate between reversible work and actual work.
d) What is the physical significance of the Joule-Thomson coefficient?
e) What is the main limitation of the Carnot vapor cycle in practical applications?
f) List two advantages of the regenerative cycle over the basic Rankine cycle.
g) Differentiate between Otto and Diesel cycles based on their heat addition processes.
h) State one advantage and one limitation of the vapor compression refrigeration cycle.
i) List any two common uses of compressed air in industries.
j) What is the effect of clearance volume on the volumetric efficiency of a reciprocating compressor?

Part-II

Q2 **Only Focused-Short Answer Type Questions- (Answer Any Eight out of Twelve)** **(6 x 8)**

a) Derive the First Law of Thermodynamics for a steady flow process. Explain each term with its physical significance.
b) Prove that for any internally reversible process, $dS = (dQ_{rev}/T)$ and explain its limitations.
c) Explain the concept of available energy and quality of energy in thermodynamic systems. Derive the expression for availability for a closed (non-flow) process.
d) Derive the TdS relations from the fundamental thermodynamic equations.
e) A heat engine receives 2000 kJ of heat from a source at 600 K and rejects 1000 kJ to a sink at 300 K. Determine the first law efficiency and the second law efficiency of the engine.
f) Describe the Rankine cycle with a neat schematic and T-S diagram. Derive an expression for its thermal efficiency.

g) Describe the working of a combined cycle power generation system and highlight its advantages.

h) Compare the basic Rankine cycle, reheat cycle, and regenerative cycle in terms of efficiency, complexity, and application.

i) Compare Otto, Diesel, and Dual cycles for the same compression ratio and heat input using P–V and T–S diagrams.

j) Describe the ideal jet propulsion cycle and derive an expression for thrust and propulsion efficiency.

k) Explain the working of a reciprocating air compressor and discuss its industrial applications.

l) Compare single-stage and multistage compression in terms of efficiency and temperature rise.

Part-III

Only Long Answer Type Questions (Answer Any Two out of Four) **(16 x 2)**

Q3 a) Steam enters a turbine steadily at 3 MPa, 400 °C with a velocity of 50 m/s and leaves at 50 kPa, 100 °C with a velocity of 150 m/s. The mass flow rate is 2 kg/s. If the heat loss from the turbine is 30 kW, determine the power output of the turbine. **(8 + 8)**

b) A heat exchanger receives water at 200 °C and discharges it at 100 °C. The heat is transferred to a cold fluid that enters at 20 °C and exits at 80 °C. Assuming steady state and negligible heat losses, determine the entropy generation per kg of water.

Q4 a) A system undergoes a process from 800 K and 1 MPa to the surroundings at 300 K and 100 kPa. The internal energy decreases by 500 kJ, and the system does 100 kJ of work. Calculate the availability destroyed and the availability at the beginning and end of the process. **(8 + 8)**

b) Air at 500 K and 600 kPa enters a turbine and exits at 300 K and 100 kPa. The mass flow rate is 1.2 kg/s. The surrounding temperature is 300 K. Determine the maximum useful work (exergy output) and the irreversibility, assuming ideal gas behavior.

Q5 a) In a simple Rankine cycle, steam enters the turbine at 10 MPa and 500 °C and exits at 10 kPa. The pump operates isentropically. Determine: **(8 + 8)**
I) The thermal efficiency of the cycle
II) The specific work output of the turbine and pump.

b) A regenerative Rankine cycle uses one open feedwater heater. Steam is extracted from the turbine at 1 MPa for feedwater heating. The main steam enters the turbine at 8 MPa, 480 °C and exhausts at 10 kPa. Determine the thermal efficiency of the cycle.

Q6 a) A vapor compression refrigeration system using R-134a operates between –10 °C (evaporator) and 40 °C (condenser). The refrigerant enters the compressor as saturated vapor and leaves the condenser as saturated liquid. Determine: **(8 + 8)**
I) COP of the system.
II) Refrigeration effect and work input per kg of refrigerant.

b) Draw the P–V diagram of a reciprocating compressor cycle with and without clearance and explain the difference in work done.