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Total Number of Pages: 02

Course: B.Tech/IDD  
Sub\_Code: MEPC2002

3<sup>rd</sup> Semester Regular/Back Examination: 2025-26  
SUBJECT: Engineering Thermodynamics  
BRANCH(S): MECH, MMEAM  
Time: 3 Hours  
Max Marks: 100  
Q.Code: U676

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)
- Write the steady-flow energy equation for a control volume. Mention the assumptions considered for steady flow energy equation.
  - What are the sources of irreversibility in thermodynamic systems?
  - Can entropy of a system decrease? Under what condition?
  - What is meant by the quality of energy?
  - What is the significance of the reference environment in exergy analysis?
  - List the basic components of a Rankine cycle power plant.
  - Why is the Carnot vapour cycle impractical for steam power plants?
  - What are the TdS relations?
  - What is the cut-off ratio in a diesel cycle?
  - Define volumetric efficiency of a compressor.

**Part-II**

- Q2 Only Focused-Short Answer Type Questions- (Answer Any Eight out of Twelve)** (6 x 8)
- Explain the difference between energy balance and entropy balance in a thermodynamic system.
  - Steam enters a turbine at 3 MPa and 400 °C with a velocity of 50 m/s and enthalpy of 3230 kJ/kg and leaves at 50 kPa and 100 °C with a velocity of 100 m/s and enthalpy of 2676 kJ/kg. The mass flow rate is 5 kg/s. Neglect potential energy change. Determine: (i) Power output of the turbine, and (ii) Heat transfer rate if the turbine is not adiabatic.
  - A closed system receives 500 kJ of heat from a reservoir at 800 K while rejecting 200 kJ of heat to the surroundings at 300 K. Determine: (i) Change in entropy of the system, and (ii) Entropy generation.
  - Explain the First law analysis of transient flow for filling and emptying of a tank.
  - A 50 kg block of iron casting at 500 K is thrown into a large lake which is at temperature of 285 K. After the iron block reaches thermal equilibrium with the lake, determine (i) Entropy change of iron block, (ii) Entropy change of lake water, and (iii) Total entropy change during this process. Assume average specific heat of iron block as 0.45 kJ/kg K.

- f) Derive the expression for thermal efficiency of the Rankine cycle. Highlight the various methods of increasing Rankine cycle efficiency.
- g) Explain the reheat Rankine cycle with T–s diagram and discuss its advantages.
- h) Derive the Maxwell relations starting from the fundamental thermodynamic equations.
- i) Explain the Joule–Thomson effect and derive an expression for the Joule–Thomson coefficient.
- j) Explain the simple Brayton cycle with P–V and T–S diagrams. Discuss the effect of pressure ratio on the performance of the Brayton cycle.
- k) Describe the construction and working of a single-stage reciprocating air compressor with a neat sketch.
- l) Derive the condition for optimum intercooler pressure in a two-stage compressor.

### Part-III

#### Only Long Answer Type Questions (Answer Any Two out of Four)

- Q3** a) Explain the limitations of the First Law and how the Second Law overcomes them. **(8 + 8)**
- b) In an air compressor air enters at a 4 m/s, 1 bar, 0.5 m<sup>3</sup>/kg. The exit conditions 7 m/s, 6 bar, 0.12 m<sup>3</sup>/kg. The internal energy of air is gained after compression process is 38 kJ/kg. The system losses 3000 kJ/min of heat to surroundings during process. Mass flow rate of air is 30 kg/min. Calculate (i) shaft work input, (ii) ratio of inlet to outlet areas.
- Q4** a) In steady flow system, the air enters system at 12 bar, 200 °C with velocity of 150 m/s, and after adiabatic process it leaves system at 1.2 bar, 25 °C with velocity 60 m/s. The surrounding pressure and temperature are 1 bar and 25 °C respectively. Determine reversible work. Assume  $C_p = 1.005 \text{ kJ / kg K}$  and  $R = 0.287 \text{ kJ / kg K}$ . **(8 + 8)**
- b) Expansion of gas takes place in a turbine from 8 bar, 550 °C to 1 bar, 350 °C. The 6 kJ of heat per kg is rejected to the surroundings during process. Surrounding temperature and pressure are 20 °C and 0.98 bar respectively. Calculate per kg of gas (i) change of availability (ii) maximum work (iii) irreversibility.
- Q5** a) Consider a steam power plant operating on the simple ideal Rankine cycle. Steam enters the turbine at 3 MPa and 350 °C and is condensed in the condenser at a pressure of 75 kPa. If the isentropic efficiency of the turbine is 87 percent and the isentropic efficiency of the pump is 85 percent, determine (i) the thermal efficiency of the cycle, and (ii) the net power output of the plant for a mass flow rate of 15 kg/s. **(8 + 8)**
- b) Explain the concept of cogeneration and its importance in modern power plants.
- Q6** a) A gas-turbine power plant operating on an ideal Brayton cycle has a pressure ratio of 8. The gas temperature is 300 K at the compressor inlet and 1300 K at the turbine inlet. Assuming a compressor efficiency of 80 percent and a turbine efficiency of 85 percent, determine (i) the back work ratio, (ii) the thermal efficiency, and (iii) the turbine exit temperature of the gas-turbine cycle. **(8 + 8)**
- b) Explain why multistage compression reduces power consumption.