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B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

December 2023 Supplementary Examinations

Programme: B.E. **Semester: III**
Branch: Industrial Engineering and Management **Duration: 3 hrs.**
Course Code: 22IM3PCETD **Max Marks: 100**
Course: Engineering Thermodynamics

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

UNIT - I

1 a) Define thermodynamics? Compare the following: i) closed system and open system, ii) macroscopic approach and microscopic approach of study in thermodynamics, and iii) homogenous and heterogeneous systems. **08**

b) What is quasi-static process? Explain with suitable sketch **04**

c) The readings t_A and t_B of two Celsius thermometers A and B agree at the ice point (0°C), and steam point (100°C), but elsewhere they are related by the equation **08**

$$t_A = l + mt_B + nt_B^2$$

Where l, m and n are constants. When both thermometers are immersed in a well stirred bath, A registers 51°C whereas B registers 50°C. Determine the reading on B when A registers 25°C.

UNIT - II

2 a) Show that heat is a path function and not a property. **04**

b) With the help of P-v diagram derive the work done expression for the following process: i) constant pressure process, ii) isothermal process, and iii) isentropic process **08**

c) A system of volume *V* contains a mass *m* of gas at pressure *P* and temperature *T*. The macroscopic properties of the system obey the following relationship **08**

$$\left(P + \frac{a}{V^2}\right)(V - b) = mRT$$

Where *a*, *b* and *R* are constants.

Obtain an expression for the displacement work done by the system during a constant-temperature expansion from volume V_1 to volume V_2. Calculate the work done by a system which contains 10 kg of this gas expanding from1 m^3 to 10 m^3 at a temperature of 293 K. Use the values a=15.7x10^4 Nm^4, b=1.07x10^{-2} m^3 and R=0.278 kJ/kg-K.

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

UNIT - III

3 a) State the first law of thermodynamics for a closed system undergoing a cyclic process and prove that internal energy is a property of the system. **08**

b) A gas undergoes a thermodynamic cycle consisting of three processes beginning at an initial state where p_1 = 1 bar, V_1 = 1.5 m^3 and U_1 = 512 kJ. **06**

The processes are as follows:

(i) Process 1–2: Compression with pV = constant to p_2 = 2 bar, U_2 = 690 kJ

(ii) Process 2–3: W_{23} = 0, Q_{23} = –150 kJ

(iii) Process 3–1: W_{31} = +50 kJ. Neglecting KE and PE changes.

Determine the heat interactions Q_{12} and Q_{31}.

c) In a steady flow apparatus, 135 kJ of work is done by each kg of fluid. The specific volume of the fluid, pressure, and velocity at the inlet are 0.37 m^3/kg, 600 kPa, and 16 m/s. The inlet is 32 m above the floor, and the discharge pipe is at floor level. The discharge conditions are 0.62 m^3/ kg, 100 kPa, and 270 m/s. The total heat loss between the inlet and discharge is 9 kJ/kg of fluid. In flowing through this apparatus, does the specific internal energy increase or decrease, and by how much? **06**

UNIT - IV

4 a) What is a PMM2? Why is it impossible? **02**

b) With the help of suitable diagrams explain the following: i) Heat Engine, ii) Refrigerator **04**

c) What is a thermal energy reservoir? Explain the terms ‘source’ and ‘sink’ **04**

d) A reversible heat engine operates between two reservoirs at temperatures of 600°C and 40°C. The engine drives a reversible refrigerator which operates between reservoirs at temperatures of 40°C and -20°C. The heat transfer to the heat engine is 2000 kJ and the network output of the combined engine refrigerator plant is 360 kJ. Evaluate the heat transfer to the refrigerant and the net heat transfer to the reservoir at 40°C. **10**

OR

5 a) Give the Clausius and Kelvin-Planck’s statements of second law and establish the equivalence of both the statements. **10**

b) Two Carnot engines A and B are connected in series between two thermal reservoirs maintained **10**

at 1000 K and 100 K respectively. Engine A receives 1680 kJ of heat from the high temperature

reservoir and rejects heat to the Carnot engine B. Engine B takes in heat rejected by engine A and rejects heat to the low-temperature reservoir. If engines A and B have equal thermal efficiencies, determine: i) the heat rejected by engine B, ii) the temperature at which heat is rejected by engine A, and iii) the work done during the process by engines A and B respectively. If engines A and B deliver equal work, determine: iv) the amount of heat taken in by engine B, and v) the efficiencies of engines A and B.

UNIT - V

6 a) What is air standard cycle? What are assumptions considered for analysis of air standard cycles? **06**

b) With the help of P-v and T-s diagrams, derive an expression for efficiency of Otto cycle and show that efficiency of Otto cycle depends only on the compression ratio. **06**

c) An engine working on Otto cycle has an air standard cycle efficiency of 56% and rejects 544 kJ/kg of air. The pressure and temperature of air at the beginning of compression are 0.1 MPa and 60°C respectively. Compute: i) the compression ratio of the engine, ii) the work done per kg of air, iii) the pressure and temperature at the end of compression and iv) the maximum pressure in the cycle. **08**

OR

7 a) With the help of P-v and T-s diagrams, derive an expression for efficiency of constant pressure cycle in terms of compression ratio, pressure ratio and the ratio of specific heats. **10**

b) An air standard diesel cycle, the compression ratio is 16, and at the beginning of isentropic compression, the temperature is 15°C and the pressure is 0.1 MPa. Heat is added until the temperature at the end of constant pressure process is 1480^0C. Calculate: i) the cut-off ratio, ii) the heat supplied per kg of air, iii) the cycle efficiency. **10**

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