

B.TECH
(SEM-III) THEORY EXAMINATION, 2019-20
THERMODYNAMICS

Time: 3 Hours**Total Marks: 100**

- Note: (1) Notations used have usual meanings.
(2) Use of steam tables and Mollier charts is permitted.
(3) Assume any relevant data, if missing.

SECTION A

- 1. Attempt all question in brief. 2 x10=20**
- a. What is the concept of Continuum?
 - b. Why second law of thermodynamics is called the Law of Degradation of energy?
 - c. Define open system, closed system and isolated system.
 - d. What is meant by degree of superheat and degree of sub-cooling?
 - e. State Zeroth law of thermodynamics. Explain how the Zeroth law of thermodynamics can be used for temperature measurement.
 - f. Draw the P-T diagram of pure substance and explain its various regions of the diagram in detail.
 - g. What are the limitations of first law of thermodynamics?
 - h. Why does free expansion have zero work transfer.
 - i. Define Triple point and Critical point.
 - j. State third law of thermodynamics.

SECTION B

- 2. Attempt any three of the followings: 3x10=30**
- a. Discuss the significance of Clausius inequality. Establish the equivalence of Kelvin-Planck and Clausius statement
 - b. Explain in detail about heat is path function not a property and support your answer with suitable examples.
 - c. Name and explain the various methods to determine the dryness fraction of steam. Draw suitable diagrams.
 - d. In a nozzle air at 627°C and twice atmospheric pressure enters with negligible velocity and leaves at a temperature of 27°C . Determine velocity of air at the exit assuming no heat loss and nozzle is horizontal. Take $c_p = 1.005 \text{ kJ/kg}$ for air.
 - e. Find the change in entropy of steam generated at 400°C from 5 kg of water at 27°C and atmospheric pressure. Take specific heat of water to be 4.2 kJ/kg-K , heat of vaporization at 100°C as 2260 kJ/kg and specific heat for steam given by;

$$C_p = R \left[3.5 + 1.2T^{-1} + 0.14T^{-2} \right] \text{ J/kg-K}$$

SECTION C

- 3. Attempt any one part of the followings: 1x10=10**
- a. Show the efficiency of a reversible heat engine operating between the same temperature limit is same.

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- b. A heat engine operating between two reservoirs at 1000 K and 300 K is used to drive a heat pump which extracts heat from the reservoirs at 300K at a rate twice that at which the engine ejects heat to it. If the efficiency of the engine is 40% of the maximum possible and the COP of the heat pump is 50% of the maximum possible, what is the temperature of the reservoir to which the heat pump ejects heat? What is the rate of the heat ejection from the heat pump if the rate of heat supply to the engine is 50 kW?

4. Attempt any *one* part of the followings: 1x10=10

- a. A mass of 8 kg gas expands within a flexible container so that the $p-v$ relationship is of the form $pv^{1.2} = \text{constant}$. The initial pressure is 1000kPa and the initial volume is 1 m³. The final pressure is 5 kPa. If specific internal energy of the gas decreases by 40 kJ/kg, find the heat transfer in magnitude and direction.
- b. Derive Steady Flow Energy Equation (S.F.E.E.). Also write the steady flow energy equation for nozzle, turbine, compressor and boiler with suitable assumptions.

5. Attempt any *one* part of the followings: 1x10=10

- a. The heat capacity at constant pressure of a certain system is a function of temperature only and may be expressed as $C_p = 2.093 + 41.87/(t+100)$ J/°C where t is the temperature of the system in °C. The system is heated while it is maintained at a pressure of 1 atmosphere until its volume increases from 2000 cm³ to 2400 cm³ and its temperature increases from 0 °C to 100°C. (i) Find the magnitude of the heat interaction. (ii) How much does the internal energy of the system increase.
- b. A heat engine receives half of its heat supply at 1000 K and half at 500 K while rejecting heat to a sink at 300 K. What is the maximum thermal efficiency of the heat engine?

6. Attempt any *one* part of the followings: 1x10=10

- a. In a steam turbine the steam enters at 50 bar, 600°C and 150 m/s and leaves as saturated vapour at 0.1 bar, 50 m/s. During expansion, work of 1000 kJ/kg is delivered. Determine the inlet stream availability, exit stream availability and the irreversibility. Take dead state temperature as 25°C.
- b. A system maintained at constant volume is initially at temperature T_1 , and a heat reservoir at the lower temperature T_0 is available. Show that the maximum work recoverable as the system is cooled to T_0 is $W = C_v[(T_1 - T_0) - T_0 \ln(T_1/T_0)]$

7. Attempt any *one* part of the followings: 1x10=10

- a. Steam initially at 1.5 MPa, 300°C expands reversibly and adiabatically in a steam turbine to 40°C. Determine the ideal work output of the turbine per kg of steam. Draw the T-S diagram.
- b. Write short notes on the following:
 Brake power, Indicated power, Brake specific fuel consumption, Indicated specific fuel consumption, Brake mean effective pressure, Indicated mean effective pressure, Mechanical efficiency, Brake thermal efficiency, Indicated thermal efficiency.