B.E. MECHANICAL ENGINEERING FIRST YEAR SECOND SEMESTER – 2023
THERMODYNAMICS

Use of Air, Steam and Refrigerant tables and charts is permitted, if necessary.

Answerany **five** questions.

Time: 3 hours Full Marks: 100

1 Answer as directed:

a) Define (i) Closed System, (ii) compressed liquid, (iii) Triple point, (iv) Dryness fraction, (v) Degree of superheat. 10

b) Find out the exergy of flowing water at 400 kPa and 200 °C, surrounding pressure and temperature being 100 kPa and 25 °C respectively. 4

c) Find out the properties of water at 300 kPa and 215 °C with relevant plotting on T-v diagram, indicating the interpolation. 6

2. a)

State the First Law of Thermodynamics for a cycle executed by a system. Hence derive the First Law of Thermodynamics for a non-cyclic process executed by a system. 2+6

(b)

A piston/cylinder arrangement contains air at 700 kPa and 300 °C. This air goes through an isochoric process so that the final pressure becomes 100 kPa. 12
Find out the work done, heat transfer, and change in internal energy, enthalpy & entropy during the process. Also plot the above process on P-v plane with labeling.

3. a) Write down the two statements of the second law of thermodynamics.

b) Show that violation of Kelvin-Planck statement leads to the violation of Clausius statement.

c) A developer claims the COP of a refrigerator to be 7. The refrigerator works between 30 °C and -10 °C. Evaluate the claim with diagram, calculation and argument.

d) Define: Critical point, saturated liquid, mean effective pressure. 4+4+6+6

4.a) Derive Maxwell's relations, and hence derive the Clapeyron equation, using Maxwell's relations. 8

b. Steam enters a turbine at 4 MPa, 300 °C, at the rate of 1 kg/sec. It leaves at a pressure of 20 KPa. State the assumptions. 12

Find out:

(i) the properties at the inlet as well as at the outlet,
(ii) the work output of the turbine, and
(iii) plot the process on T-s diagram with appropriate labeling .

5. a) State Clausius inequality. Hence, find an expression for change of entropy for an irreversible process for a system. 2+6

(b) Steam enters a nozzle at 1 MPa, 300 °C with a velocity of 40 m/s. It leaves at a pressure of 100 KPa and at a velocity of 925 m/s. 12
Determine the properties of steam at nozzle inlet, as well as at nozzle outlet.
Plot the process on T-s diagram with proper labeling.

6. a) Define isentropic efficiencies of: a turbine, a compressor, and a nozzle. 6

b) In a steam power plant, steam enters the turbine at 400 °C. Boiler pressure is 5 MPa and condenser pressure is 350 KPa. Steam comes out of the condenser as saturated liquid. 14
Find out the heat and work transfer in all the components.
Determine the efficiency of the cycle.
Plot the cycle on T-s diagram and label properly.

7 a) In an Otto cycle, at the beginning of compression, the temperature, pressure and volume are 28 °C, 110 KPa and 0.3 m3 respectively. Compression ratio is 11. Amount of heat added in the cycle is 910 KJ/Kg 10

Find the temperature, pressure & specific volume at all the points in the cycle.

Also calculate heat rejected, the net work done, mean effective pressure and the air standard thermal efficiency of the above cycle.

Plot the cycle on P-v plane with proper labeling. Assume Cp=1.004 KJ/Kg-K &Cv=0.717 KJ/Kg-K.

(b) A refrigerator has R-134a as the working fluid. The refrigerant enters the condenser as saturated vapor and leaves as saturated liquid. The evaporator temperature is -20 °C and the condenser temperature is 40 °C. 10

Find out the heat and work transfer in all the components.
Evaluate COP of the refrigerator.
Plot the process on T-s diagram with proper labeling.