B.E. MECHANICAL ENGINEERING FIRST YEAR SECOND SEMESTER – 2022

THERMODYNAMICS

Answer should be precise and 'to-the-point'.

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

Data, if unfurnished, may be assumed consistent with the problem.

Answer any **five** questions.

Time: 3 hours — Full Marks: 100

1) Answer as directed:

a) Define (i) System, (ii) Saturated vapor, (iii) Triple point, (iv) Dryness fraction, (v) Degree of superheat, (vi) sub-cooled liquid. 12

b) Find out the exergy of flowing water at 300 kPa and 200 °C, surrounding pressure and temperature being 100 kPa and 25 °C respectively. 4

c) Find out the properties of water at 500 kPa and 315 °C with relevant plotting on T-v diagram, indicating the interpolation. 4

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 150 kPa and 20 °C. This air is heated isothermally to a final pressure of 500 kPa. 12

- (i) Find out the changes in specific internal energy, specific enthalpy and specific entropy,
- (ii) Calculate the heat transferred and work done during the process.
- (iii) Plot the process on p-v diagram with proper labeling.

3. a) Write down the two statements of the second law of thermodynamics. 4

(b) Show that these two statements of the second law of thermodynamics are equivalent. 10

© A developer claims the efficiency of a heat engine to be 40 %. The engine works between 1000 °C and 25 °C. Evaluate the claim. 6

4. a) Derive the Maxwell's relations. 10

(b) Steam enters a turbine at 3.5 MPa, 400 °C, at the rate of 5 kg/sec. It leaves at a pressure of 15 KPa.
State the assumptions.
Find out: 10

- (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 .

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5. a) State Clausius inequality, and hence show that entropy is a property of a system. 8

(b) Steam enters a nozzle at 0.8 MPa, 200 °C with a velocity of 50 m/s. It leaves at a pressure of 150 KPa and at a velocity of 700 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 efficiency of a turbine, a compressor, and a nozzle. 6

(b) In a steam power plant, steam enters the turbine at 300 °C. Boiler pressure is 4 MPa and condenser pressure is 10 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) The maximum temperature in an air standard Otto cycle is 1400 °C. At the beginning of compression, the temperature, pressure and volume are 25 °C, 125 KPa and 0.3 m3 respectively. Compression ratio is 10. 10

Calculate the heat added, 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 and T-s planes with proper labeling.

(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 -30 °C and the condenser temperature is 50 °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.

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