B.E. MECHANICAL ENGINEERING FIRST YEAR SECOND SEMESTER – 2024
THERMODYNAMICS

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

Answer any **five** questions.

Time: 3 hours | Full Marks: 100

1 Answer as directed:

a) Define (i) Control Volume, (ii) sub-cooled liquid, (iii) saturated vapour, (iv) Dryness fraction, (v) Degree of superheat. 10

b) Find out the exergy of flowing water at 4000 kPa and 300 °C, surrounding pressure and temperature being 100 kPa and 25 °C respectively. 4

c) Find out the properties of water at 1000 kPa and 275 °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. Show that energy is a property. 2+6

(b) A piston/cylinder arrangement contains 1 kg of air at 600 kPa and 200 °C. This air goes through an isochoric process so that the final pressure becomes 1000 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. 4

(b) Show that violation of Clausius statement leads to the violation of Kelvin-Planck statement. 4

© A developer claims theCOP of a refrigerator to be 7. The refrigerator works between 35 °C and -15 °C. 6
Evaluate the claim with diagram, calculation and argument.

d) Define: Critical point, saturated liquid, compression ratio. 6

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

4. (b) Steam enters a turbine at 3 MPa, 300 °C, at the rate of 1 kg/sec. It leaves at a pressure of 15 KPa. 12
Assume adiabatic and reversible conditions.
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 h-s diagram with appropriate labeling .

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

(b) Steam enters a nozzle at 2 MPa, 300 °C with a velocity of 40 m/s. It leaves at a pressure of 10 KPa. 12

Determine the velocity of steam at nozzle outlet, and also the other properties of steam at nozzle inlet, as well as at nozzle outlet if isentropic efficiency of the nozzle is 95%.

Plot the process on h-s diagram with proper labeling.

6. a) Show that for a constant pressure process, amount of heat transfer equals to change in enthalpy. 5

(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. 15
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)

Plot the Diesel cycle on p-v and T-s diagram. Derive the expression for efficiency of a Diesel cycle in terms of compression ration, cut-off ration and ratio of specific heats. 10

(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 -10 °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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