Q. P. Code: 39993

Time: 3 Hours SE Mech Sem-III CBCS 80 Marks

NOTE:

- Question No 1 is **COMPULSORY**.
- Attempt any **THREE** questions from question number 2 to 6.
- Assume suitable data if required and state it clearly.
- Use of steam table & Mollier chart is permitted.

1. Solve the following **(any Four)** 20
   (a) State first law of thermodynamics for closed system. State its limitations.
   (b) Explain heat engine, heat pump and refrigerator with the help of neat sketch.
   (c) Explain free air delivered and volumetric efficiency. Write their equations also.
   (d) Define: available energy, dead state and irreversibility.
   (e) Explain working of Otto cycle with the help of PV and TS diagram. Write the equation for efficiency of the cycle.
   (f) Define types of steam and represent it on p-v diagram for water.

2. (a) 3 kg of air at a pressure of 150 kPa and temperature 360 K is compressed polytropically to 750 kPa according to law $PV^{1.25}=C$. The gas is then cooled to initial temperature at constant pressure. The air is then expanded at constant temperature till it reaches original pressure of 150 kPa. Draw the cycle on p-V diagram and determine net work and heat transfer. 12
   (b) Prove that energy is property of the system. 8

3. (a) In a steady flow device, the inlet and outlet conditions are given below. Determine the heat loss or gain by the system in kW. Fluid flow rate through the device is 2.1 kg/s and work output of the device is 750 kW. 8

Property	Inlet	Outlet
Pressure (bar)	10	8.93
Specific enthalpy (kJ/kg)	2827	2341
Velocity (m/s)	20	120
Elevation (m)	3.2	0.5

   (b) Explain Kelvin-Planck & Clausius statement with the help of sketch. 6
   (c) A heat engine receives 1000 kW of heat at const temp of 285°C. The heat is rejected at 5 °C. The possible heats rejected are: 840kW, 492kW and 300 kW. Classify the cycle into reversible, irreversible and impossible using Clausius Inequality theorem. 6

4. (a) Define Critical Point and Triple point. Draw p-T diagram for water and show these points on it. 6
   (b) Write four Maxwell relations. 4
   (c) A house is maintained at a temperature of 20°C by means of a heat pump in winter by pumping heat from the atmosphere. Heat losses through the walls of the house are estimated at 0.65 kJ/K temperature different between inside of the house and outside atmosphere. 10
      (i) If atmospheric temperature is –10°C, what is minimum amount of power required to drive the heat pump?
      (ii) It is proposed to use the same heat pump to cool the house in summer. If the same amount of power is supplied to heat pump then what is the maximum permissible atmospheric temperature?

5. (a) Draw Carnot cycle, Stirling cycle and Ericsson cycle on common T-S diagram. Mention all the process on the diagram. 6

(b) Write the classifications of air compressors. 4

(c) A single stage, single acting reciprocating air compressor delivers 0.6 kg/min of air at 6 bar. The temperature and pressure at the suction stroke are 30°C and 1 bar respectively. The bore and stroke are 100 mm and 150 mm respectively. The clearance volume is 3% of the swept volume and index of expansion and compression is 1.3. Determine (i) Volumetric efficiency of compressor (ii) Indicated power (iii) Speed of the compressor in rpm. 10

6. (a) A steam power plant has boiler and condenser pressure of 60 bar and 0.1 bar respectively. Steam coming out of the boiler is dry and saturated. The plant operates on Rankine cycle. Calculate the thermal efficiency of the cycle. 5

(b) Explain the working of vane type rotary air compressor with the help of sketch. 5

(c) In an air standard Dual cycle, pressure and temperature are 0.1 MPa and 27°C. Compression ratio is 18. The pressure ratio for constant volume part of heating process is 1.5 and volume ratio for the constant pressure part of heating is 1.2, Determine (i) Thermal efficiency (ii) Mean effective pressure in MPa. 10
