

**BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI**  
**Second Semester (2022-2023)**

**ME F461 Refrigeration and Air Conditioning**  
**Mid-Semester Examination – Open Book**

**March 18, 2023**

**Max Marks = 60 (30% weightage)**

**Duration: 90 min**

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**Instructions**

- Answer all the questions sequentially. Clearly underline the final answer.
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**Q1.** Explain “Thermostatic Expansion Valve (TEV) with cross charge” and its advantages with proper schematic diagram. Draw and explain the desirable vapor pressure curves of refrigerant and power fluid to handle the load variation. Among the TEV and Automatic Expansion Valve (AEV) which one will you prefer for a refrigeration application with variable load? Justify your answer briefly. **[14 M]**

**Q2.** Explain the system balance point for a complete VCR system (Condensing unit and Evaporator with a TEV valve). Explain transient system performance based on the characteristic curve. **[8 M]**

**Q3.** An aircraft flying at a speed of 950 km/h uses the reduced ambient aircraft refrigeration system. The ambient temperature and pressure are  $-10^{\circ}\text{C}$  and 0.55 bar respectively. Assume the compressor and turbine isentropic efficiencies to be 0.8 and 0.85 respectively, the ramming efficiency as 0.9 and the heat exchanger effectiveness as 0.9. The compression ratio is 3. The pressure drop in the heat exchanger may be neglected. The cabin pressure is 1.06 bar and the air leaves cabin at  $25^{\circ}\text{C}$ . Evaluate the mass flow rate, main and auxiliary compressor work, expander work for 1 TR capacity. Represent the process on the TS diagram. Note that the turbine work is used for running the cooling fan. **[16 M]**

**Q4.** R22 is compressed in a reciprocating compressor from saturation pressure at  $-15^{\circ}\text{C}$  to saturation pressure at  $45^{\circ}\text{C}$ . The specific volume of the refrigerant changes from  $0.0777\text{ m}^3/\text{kg}$  to  $0.01618\text{ m}^3/\text{kg}$  during the compression. The compressor has four cylinders each with a bore of 10 cm and a stroke of 11.5 cm. The clearance volume ratio is 0.04 and runs at 750 rpm. Evaluate the clearance volumetric efficiency, swept flow rate ( $\text{m}^3/\text{s}$ ) and mass flow rate ( $\text{kg}/\text{s}$ ). **[12 M]**

**Q5.** A refrigeration system of 55 kW cooling capacity that uses a water-cooled condenser which has a Heat Rejection Ratio (HRR) of 1.2. The overall heat transfer coefficient (U) of the condenser is  $450\text{ W}/\text{m}^2\cdot\text{K}$  and a heat transfer area (A) of  $18\text{ m}^2$ . If cooling water at a flow rate of 3.2 kg/s enters the condenser at a temperature of  $30^{\circ}\text{C}$ , what is the condensing temperature? Evaluate the COP of the system. Take the specific heat of water as  $4.18\text{ kJ}/\text{kg}\cdot\text{K}$ . **[10 M]**

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