Department of Mechanical Engineering
Indian Institute of Technology Delhi, New Delhi
MCL140 Engineering Thermodynamics
Major Examination

Total duration: 2 hours

Total marks: 35

Answer all questions

1. State Kelvin-Planck and Clausius' statements of the second law of thermodynamics. (2 Marks)

2. Explain briefly an absorption refrigeration system with a neat sketch. How is it different from a vapour compression system? What are the advantages and disadvantages of the absorption refrigeration systems? (6 Marks)

3. A Diesel cycle operates at a pressure of 1 bar at the beginning of compression and the volume is compressed to 1/16 of the initial volume. Heat is supplied until the volume is twice that of the clearance volume. Calculate the mean effective pressure of the cycle. Take $\gamma = 1.4$. (6 Marks)

4. Consider a reheat–regenerative vapor power cycle with two feedwater heaters, a closed feedwater heater and an open feedwater heater. Steam enters the first turbine at 8.0 MPa, 480°C and expands to 0.7 MPa. The steam is reheated to 440°C before entering the second turbine, where it expands to the condenser pressure of 0.008 MPa. Steam is extracted from the first turbine at 2 MPa and fed to the closed feedwater heater. Feedwater leaves the closed heater at 205°C and 8.0 MPa, and condensate exits as saturated liquid at 2 MPa. The condensate is trapped into the open feedwater heater. Steam extracted from the second turbine at 0.3 MPa is also fed into the open feedwater heater, which operates at 0.3 MPa. The stream exiting the open feedwater heater is saturated liquid at 0.3 MPa. The *net* power output of the cycle is 100 MW. There is no stray heat transfer from any component to its surroundings. The working fluid experiences no irreversibilities as it passes through the turbines, pumps, steam generator, reheater, and condenser. Draw the schematic diagram, T-s and h-s plots of this cycle. Determine (a) the thermal efficiency, (b) the mass flow rate of the steam entering the first turbine, in kg/h. (12 marks)

5. Air flows steadily through a horizontal, insulated, variable-area duct. The measurements made at two locations, A and B along the duct are given below. Find the direction of flow of air. $C_p = 1.005$ kJ/kg K, $C_v = 0.717$ kJ/kgK. (4 Marks)

Location	Pressure, kPa	Temperature, °C	Velocity, m/s
A	120	50	150
B	100	30	250

16. Cooling water leaves the condenser of a power plant and enters an induced draft counter flow cooling tower at 35°C at a rate of 100kg/s. The water is cooled to 22°C in the cooling tower by air that enters the tower at 1 atm, 20°C and 60% relative humidity and leaves saturated at 30°C. Neglecting the power input to the fan, obtain (a) the volume flow rate of air into the cooling tower and (b) the mass flow rate of the required make up water.

(5 Marks)

$\dot{m}_4 - \dot{m}_3 = \dot{m}_{make}$

$L = \dot{m}_3 - \dot{m}_4$

$= \dot{m}_a(\omega_2 - \omega_1)$