Roll No. | | | | | | | | | | |

B.E / B.Tech (Full-Time) DEGREE END SEMESTER EXAMINATIONS, NOV / DEC 2024

MECHANICAL ENGINEERING

ME 7301 ENGINEERING THERMODYNAMICS

(Regulation 2015)
(Use of Steam tables, Mollier & Psychrometric chart permitted)

Time: 3 Hours Answer ALL Questions Max. Marks 100

PART- A (10 x 2 = 20 Marks)

1. Draw a schematic of PMM-I.
2. Mention two differences between work and heat transfer.
3. Represent reversed Carnot cycle on p-v and T-s planes.
4. List atleast two reasons for irreversibility of a thermodynamic process.
5. Define dryness fraction of steam?
6. Define sensible heat and latent heat.
7. Write down the van der Waal's relation. How is it different from equation of state?
8. Define reduced temperature and reduced pressure.
9. Mention one application of Dalton's law.
10. Define dew point temperature.

PART – B (5 x 13 = 65 Marks)

11.a) At the inlet to a certain nozzle the enthalpy of fluid passing is 2800 kJ/kg, and the velocity is 50 m/s. At the discharge end the enthalpy is 2600 kJ/kg. The nozzle is horizontal and there is negligible heat loss from it. (i) Find the velocity at exit of the nozzle. (ii) If the inlet area is 900 cm^2 and the specific volume at inlet is 0.187 m^3/kg, find the mass flow rate.(iii) If the specific volume at the nozzle exit is 0.498 m^3/kg, find the exit area of nozzle.

(OR)

11. b) The internal energy of a certain substance is given by the equation u=3.56 pv+90 where u is in kJ/kg, p is in kPa, and v is in m^3/kg. A system comprising of 3.5 kg of this substance expands from an initial pressure of 500 kPa, and a volume of 0.25 m^3 to a final pressure of 100 kPa in a process in which pressure and volume are related by $pv^{1.25}$=constant. Find the heat transferred, change in internal energy and work done for the process if the expansion is quasi static. If there is 32 kJ heat transfer during the process, find change in internal energy and work done.

12.a) A reversible heat engine operates between two reservoirs at temperatures 700°C and 50°C. The engine drives a reversible refrigerator which operates between reservoirs at temperatures of 50°C and – 25°C. The heat transfer to the engine is 2500 kJ and the net work output of the combined engine refrigerator plant is 400 kJ. (i) Determine the heat transfer to the refrigerant and the net heat transfer to the reservoir at 50°C ; (ii) Reconsider (i) given that the efficiency of the heat engine and the C.O.P. of the refrigerator are each 45 per cent of their maximum possible values.

(OR)

b i) An iron cube at a temperature of 400°C is dropped into an insulated bath containing 10 kg water at 25°C. The water finally reaches a temperature of 50°C at steady state. Given that the specific heat of water is equal to 4186 J/kg K. Find the entropy changes for the iron cube and the water. Is the process reversible ? If so why? (5+4)

ii) Briefly discuss about the inequality of Clausius. (4)

13.a)i) A vessel having a capacity of 0.05 m^3 contains a mixture of saturated water and saturated steam at a temperature of 245°C. The mass of the liquid present is 10 kg. Find the following : (i) The pressure, (ii) The mass, (iii) The specific volume, (iv) The specific enthalpy, (v) The specific entropy, and (vi) The specific internal energy. (10)

ii) Define critical point and latent heat of fusion. (1.5 x 2)

(OR)

b)i) In a steam turbine steam at 20 bar, 360°C is expanded to 0.08 bar. It then enters a condenser, where it is condensed to saturated liquid water. The pump feeds back the water into the boiler. Assume ideal processes, find per kg of steam the net work and the cycle efficiency. (8)

ii) Briefly discuss the reheat and regenerative techniques in Rankine cycle. (5)

14.a i) Starting from the I law of thermodynamics derive the 1st and 2nd Tds equations. Deduce the Maxwell's relation from the Tds equations. (8)

ii) Draw inversion curve and discuss briefly about the Joule-Thomson experiment. (2+3)

(OR)

b i) Describe the Joule-Thomson's inversion curve with a schematic. Mention the significance of it and its applications. (7+3)

ii) Write down the Clausius-Clapeyron equation and mention its significance. (3)

15.a)i) A gas mixture contains 3 kmol of CO_2, 4 kmol of O_2, and 5 kmol of N_2 at 200 kPa and 295 K. Calculate the mole fraction, mass fraction, and partial pressures of each constituent. Also determine the molar mass, gas constant, volume and density of the gas mixture. Take molar mass of CO_2, O_2, and N_2 as 44, 32 and 28 kmol respectively. (8)

ii) One kg of CO_2 has a volume of 1 m^3 at 100°C. Compute the pressure by (i) Van der Waals equation (ii) Perfect gas equation. The values of a and b for CO_2 are a = 362850 $Nm^4/(kg\text{-}mol)^2$ and b = 0.0423 m^3/kg-mol. R = 8314 Nm/kg-mol K (5)

(OR)

b)i) 120 m^3 of air per minute at 35°C DBT and 50% relative humidity is cooled to 20°C DBT by passing through a cooling coil. Determine the following : (i) Relative humidity of out coming air and its wet bulb temperature. (ii) Capacity of cooling coil in tonnes of refrigeration. (iii) Amount of water vapour removed per hour. (10)

ii) Represent the adiabatic saturation process in psychrometric chart. (3)

PART – C (1 x 15 = 15 Marks)

16. i) In an air compressor air flows steadily at the rate of 0.5 kg/s through an air compressor. It enters the compressor at 6 m/s with a pressure of 1 bar and a specific volume of 0.85 m^3/kg and leaves at 5 m/s with a pressure of 7 bar and a specific volume of 0.16 m^3/kg. The internal energy of the air leaving is 90 kJ/kg greater than that of the air entering. Cooling water in a jacket surrounding the cylinder absorbs heat from the air at the rate of 60 kJ/s. Calculate: (i) The power required to drive the compressor ; (ii) The inlet and output pipe cross-sectional areas. Draw a schematic of the same. (9)

ii) A cylinder contains 0.45 m^3 of a gas at 1×10^5 N/m^2 and 80°C. The gas is compressed to a volume of 0.13 m^3, the final pressure being 5×10^5 N/m^2. Determine : (i) The mass of gas ; (ii) The value of index 'n' for compression ; (iii) The increase in internal energy of the gas ; (iv) The heat received or rejected by the gas during compression. Take γ = 1.4, R = 294.2 J/kg°C. (6)