U.S.N.										

B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

January / February 2025 Semester End Main Examinations

Programme: B.E. **Semester : III**
Branch: Mechanical Engineering **Duration: 3 hrs.**
Course Code: 19ME3ESBTD **Max Marks: 100**
Course: Basic Thermodynamics

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

			CO	PO	Marks
		UNIT - I			
1	a)	Define Thermodynamics? Compare the macroscopic and microscopic approach of study system in thermodynamics.	CO1	PO1	**08**
	b)	What is quasistatic process? Why it is a reversible process?	CO1	PO1	**04**
	c)	The temperature 't' on a thermometric scale is defined in terms of a property *K* by the relation $$t = a\,ln(K) + b$$ where *a* and *b* are constants. The values of *K* are found to be 1.83 and 6.78 at the ice point and steam point, the corresponding temperatures of which are assigned the numbers 0 and 100 respectively. Determine the temperature corresponding to a reading of *K* equal to 2.42 on the thermometer.	CO1	PO2	**08**
		OR			
2	a)	What are the characteristics of heat and work?	CO1	PO1	**06**
	b)	Derive the expressions for i) Spring work, ii) Electrical work, and iii) shaft work.	CO1	PO1	**06**
	c)	A gas initially at 100 kPa and 6000 cm^3. The final volume is 2000 cm^3. Determine the moving boundary work for each of the following processes: i) p is proportional to V, ii) p is inversely proportional to V, and iii) and pV^2= Constant.	CO1	PO2	**08**
		UNIT - II			
3	a)	State and explain First law of Thermodynamics for closed system undergoing a cyclic process and prove that internal energy is property of the system.	CO1	PO1	**06**
	b)	A fluid is confined in a cylinder by a spring loaded, friction less piston so that the pressure in the fluid is a linear function of the	CO1	PO2	**08**

			volume ($p = a + bV$).The internal energy of the fluid is given by the following equation $$U = 34 + 3.15pV$$ where U is in kJ, p in kPa, and V in cubic metre. If the fluid changes from an initial state of 170 kPa, 0.03 m^3 to a final state of 400 kPa, 0.06 m^3, with no work other than that done on the piston, find the direction and magnitude of the work and heat transfer.			
		c)	The heat capacity at constant pressure of a certain system is a function of temperature only and may be expressed as $C_p = 2.093 + \frac{41.87\,J}{t+100\,K}$ Where 't' is the temperature of the system in °C. The system is heated while it is maintained at a pressure of 1 atmosphere until its volume increases from 2000 cm^3 to 2400 cm^3 and its temperature increases from 0°C to 100°C. Find: i) The magnitude of heat interaction, and ii) How much does the internal energy of the system increase.	*CO1*	*PO2*	**06**
			OR			
	4	a)	Derive an expression for Steady flow energy equation (SFEE) and reduce it the following process: i) Turbine and ii) Throttling process.	*CO1*	*PO2*	**10**
		b)	Air at a temperature of 15°C passes through a heat exchanger at a velocity of 30 m/s where its temperature is raised to 800°C. It then enters a turbine with the same velocity of 30 m/s and expands until the temperature falls to 650°C. leaving the turbine, the air is taken at a velocity of 60 m/s to a nozzle where it expands until the temperature has fallen to 500°C. If the air flow rate is 2 kg/s. Calculate: i) the rate of heat transfer to the air in the heat exchanger, ii) the power output from the turbine assuming no heat loss, and iii) the velocity at exit from the nozzle, assuming no heat loss. Take the enthalpy of air as $h = C_p t$, where C_p is the specific heat equal to 1.005 kJ kg/K and t is the temperature.	*CO1*	*PO2*	**10**
			UNIT - III			
	5	a)	Give the Clausius and Kelvin-Planck's statements of II law of thermodynamics and show that they are equal.	*CO2*	*PO1*	**10**
		b)	Two Carnot engines A and B are connected in series between two thermal reservoirs maintained at 1000 K and 100 K respectively. Engine A receives 1680 kJ of heat from the high-temperature reservoir and rejects heat to the Carnot engine B. Engine B takes in heat rejected by engine A and rejects heat to the low-temperature reservoir. If engines A and B have equal thermal efficiencies. Determine: i) the heat rejected by engine B, ii) the temperature at which heat is rejected by engine A, and iii) the work done during the process by engines A and B respectively. If engines A and B deliver equal work, determine iv) the amount of heat taken in by engine B, and v) the efficiencies of engines A and B.	*CO2*	*PO2*	**10**
			OR			

	6	a)	State and prove Clausius inequality and show that entropy is a property of the system.	*CO2*	*PO1*	**10**
		b)	A 36 g of water at 30°C are converted in to steam at 250°C at constant atmospheric pressure. The specific heat of water is assumed constant at 4.2 J/gK and the latent heat of vaporization at 100°C is 2260 J/g. For water vapour, assume $pV = mRT$ Where R=0.462 kJ/kgK , and $\frac{C_p}{R} = a + bT + cT^2$, where $a = 3.634$, $b = 1.195 \times 10^{-3} K^{-1}$ and $c = 0.135 \times 10^{-6} K^{-2}$ Calculate the entropy change of the system.	*CO2*	*PO2*	**10**
			UNIT - IV			
	7	a)	Define the following terms: i) Available energy, ii) Availability or Exergy, iii) Dead state, iv) Useful Work, v) Second law efficiency.	*CO3*	*PO1*	**10**
		b)	Air expands through a turbine from 500 kPa, 520°C to 100 kPa, 300°C. During expansion 10 kJ/kg of heat is lost to the surroundings which is at 98 kPa, 20°C. Neglecting the K.E. and P.E. changes, determine per kg of air i) the decrease in availability, ii) the maximum work and iii) the irreversibility. For air, take C_p = 1.005 kJ/kg K, $h = C_p T$ where C_p is constant.	*CO3*	*PO2*	**10**
			OR			
	8	a)	Derive an expression for Exergy Balance for a Steady Flow System.	*CO3*	*PO1*	**10**
		b)	A compressor operating at steady state takes in 1 kg/s of air at 1 bar and 25°C and compresses it to 8 bar and 160°C. Heat transfer from the compressor to its surroundings occurs at a rate of 100 kW. (i) Determine the power input in kW. (ii) Evaluate the second law efficiency for the compressor. Neglect KE and PE, changes. Take T_o = 25 °C and P_o = 1 bar.	*CO3*	*PO2*	**10**
			UNIT - V			
	9	a)	Express the changes in internal energy and enthalpy of an ideal gas in a reversible adiabatic process in terms of the pressure ratio.	*CO4*	*PO1*	**04**
		b)	Derive the expression of heat transfer for an ideal gas in a polytropic process.	*CO4*	*PO1*	**08**
		c)	A certain gas has C_p = 1.96 and C_v = 1.51 kJ/kg-K. Find its molecular weight and the gas constant. A constant volume chamber of 0.3 m^3 capacity contains 2 kg of this gas at 5°C. Heat is transferred to the gas until the temperature is 100°C. Find the work done, the heat transferred, and the changes in internal energy, enthalpy and entropy.	*CO4*	*PO2*	**08**
			OR			

	10	a)	Derive and express the Vander Waals constants in terms of critical properties.	*CO4*	*PO1*	**08**
		b)	Explain the following: i) compressibility factor, ii) compressibility chart, and iii) reduced properties.	*CO4*	*PO1*	**06**
		c)	The gas neon has a molecular weight of 20.18 and its critical temperature, pressure and volume are 44.5 K, 2.73 MPa and 0.0416 m^3 kg mol. Reading from a compressibility chart for a reduced pressure of 2 and a reduced temperature of 1.3, the compressibility factor is 0.7. What are the corresponding specific volume, pressure, temperature, and reduced volume?	*CO4*	*PO2*	**06**

****