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

Autonomous Institute Affiliated to VTU

June 2025 Semester End Main Examinations

Programme: B.E. **Semester: III**

Branch: Mechanical Engineering **Duration: 3 hrs.**

Course Code: 23ME3PCETD/22ME3PCETD **Max Marks: 100**

Course: Engineering Thermodynamics

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Use of thermodynamic data handbook is permitted
3. Missing data, if any, may be suitably assumed.

		UNIT - I	*CO*	*PO*	Marks
1	a)	Define a quasi-static process. Why is it considered an idealized process in thermodynamics?	*CO1*	*PO1*	**06**
	b)	A piston-cylinder device contains 0.5 kg of gas at an initial pressure of 100 kPa and a volume of 0.2 m³. The gas undergoes a quasi-static compression to a final volume of 0.1 m³, following the pressure-volume relationship PV=constant. (i) Calculate the work done during the process. (ii) Comment on the sign of the work done based on the thermodynamic sign convention.	*CO1*	*PO2*	**07**
	c)	A system absorbs 2000 kJ of heat while performing 1200 kJ of work. (i) Determine the change in internal energy of the system. (ii) If the system had rejected 500 kJ of heat instead, calculate the new change in internal energy.	*CO2*	*PO2*	**07**
		OR			
2	a)	Explain the following concepts with examples: (i) The distinction between exact and inexact differentials in the context of thermodynamic quantities. (ii) Why work and heat are considered path functions, while properties such as pressure and temperature are state functions.	*CO1*	*PO1*	**10**
	b)	A gas expands in a piston-cylinder assembly from an initial volume of 0.01 m³ to a final volume of 0.05 m³. The pressure-volume relationship during the process is given by $P = 100\,V^{-2}$, where P is in kPa and V is in m³. (i) Determine the work done by the gas during the expansion process.	*CO2*	*PO2*	**05**
	c)	A piston-cylinder device contains 1 kg of air at 100 kPa and	*CO2*	*PO2*	**05**

			25°C. The air undergoes a reversible polytropic process with a polytropic index n = 1.3, compressing it to a final pressure of 400 kPa. (i) Show the process on a *P-V* diagram. (ii) Calculate initial and final volumes. (iii) Calculate the work done by the air during this process.			
			UNIT - II			
	3	a)	Define first law of thermodynamics and obtain the expression for work done in a isothermal process.	*CO2*	*PO1*	**10**
		b)	A rigid tank contains 2 kg of air at 500 kPa and 350 K. Heat is transferred to the air until its temperature rises to 450 K. (i) Assuming the specific heat of air is C_v = 0.718 kJ/kg, calculate the amount of heat transferred. (ii) If there is a heat loss of 20 kJ during the process, how would this affect the calculated heat transfer?	*CO3*	*PO2*	**10**
			OR			
	4	a)	Explain the limitations of the first law of thermodynamics. What is a Perpetual Motion Machine of the First Kind (PMM-1), and why is it impossible?	*CO1*	*PO1*	**10**
		b)	A steam turbine operates steadily with a mass flow rate of 2 kg/s. The inlet conditions are h_1 =3200kJ/kg, velocity V_1 =50 m/s, and elevation Z_1 =10 m. The outlet conditions are h_2 =2500 kJ/kg, velocity V_2 = 150 m/s, and elevation Z_2 = 5 m. Heat loss to the surroundings is 15 kW. Determine the power output of the turbine.	*CO3*	*PO2*	**05**
		c)	A compressor takes in air at 100kPa and 27 °C with a velocity of 10 m/s, and delivers it at 700 kPa and 127 °C with a velocity of 5 m/s. The mass flow rate of air is 1.5 kg/s, and the heat loss to the surroundings is 5 kW. Assuming Cp=1.005 kJ/kg. i) Calculate the work input to the compressor.	*CO3*	*PO2*	**05**
			UNIT - III			
	5	a)	State the Kelvin–Planck and Clausius statements of the second law of thermodynamics and discuss its implications. And also prove the equivalence of Kelvin–Planck and Clausius statements	*CO4*	*PO1*	**10**
		b)	A heat engine operates between a source at 1000 K and a sink at 300 K. i) Calculate the maximum possible efficiency of the engine (Carnot efficiency). ii) If the engine produces 500 kJ of work, calculate the amount of heat absorbed from the source.	*CO4*	*PO2*	**05**
		c)	A refrigerator has a coefficient of performance (COP) of 4.5. The refrigerator removes 200 kJ of heat from the cold space per cycle. Calculate the work input required per cycle. Also, determine the amount of heat rejected to the surroundings per cycle.	*CO4*	*PO2*	**05**

			OR			
	6	a)	Explain the principle of increase of entropy with an example. Discuss how the concept of irreversibility can be used to analyze the efficiency of thermal systems.	*CO4*	*PO1*	**10**
		b)	A reversible heat engine operates between a high-temperature reservoir at 800 K and a low-temperature reservoir at 300 K. If the engine absorbs 1200 kJ of heat from the high-temperature reservoir. Calculate the entropy change of the high-temperature reservoir, the low-temperature reservoir, and the surroundings.	*CO4*	*PO2*	**05**
		c)	A 2-kg block of copper at 200 ^{o}C is placed in a large water bath at 25 ^{o}C. Assuming the specific heat capacity of copper is 0.385kJ/kg.K, determine: (i) The entropy change of the copper block. (ii) The entropy change of the water bath (assume it acts as a thermal reservoir). (iii) The total entropy change of the universe.	*CO4*	*PO2*	**05**
			UNIT - IV			
	7	a)	Explain the differences between ideal gases and real gases. (i) State the assumptions of the ideal gas law and when it is applicable. (ii) Discuss the significance of Van der Waals' equation of state in correcting the ideal gas law for real gases.	*CO4*	*PO1*	**10**
		b)	A cylinder contains 2 kg of a gas, which behaves like a perfect gas. The gas is initially at a pressure of 500 kPa and a temperature of 300 K. The gas undergoes an isothermal expansion to a final pressure of 100 kPa. (i) Calculate the work done by the gas during the expansion process. (ii) Calculate the change in internal energy of the gas during this process. (iii) Find the heat transferred to the gas during the expansion process.	*CO4*	*PO2*	**05**
		c)	Calculate the pressure of 1 mol of a gas at 300 K occupying a volume of 0.02 m^3 using: (i) The ideal gas law. (ii) Van der Waals' equation of state with a=1.39 Pa.m^6/mol^2 and b = 0.039 m^3/mol.	*CO4*	*PO2*	**05**
			OR			
	8	a)	Explain the concepts of reduced coordinates, compressibility factor, and the law of corresponding states with examples.	*CO5*	*PO1*	**10**
		b)	One mole of an ideal gas initially at 300 K and 100 kPa undergoes an isothermal expansion to 200 kPa. Determine: (i) The work done by the gas. (ii) The heat transferred to or from the gas.	*CO4*	*PO2*	**05**

		c)	A semi-perfect gas with a molecular weight of 28 kg/mol has specific heat capacities C_p = 1.005 kJ/kg. and C_v = 0.718 kJ/kg.K. If 0.5 kg of this gas undergoes a polytropic process with n = 1.3, where the initial state is P_1 = 300 kPa, V_1 = 0.2 m^3, and the final state is P_2 = 600 kPa: (i) Calculate the work done during the process. (ii) Find the heat transfer during the process.	*CO4*	*PO2*	**05**
			UNIT - V			
	9	a)	Explain the formation of steam with reference to the sub-cooled liquid, saturated liquid, mixture of saturated liquid and vapour, saturated vapour, and superheated vapour states. Sketch a T-s diagram for water and label the regions corresponding to each state.	*CO5*	*PO1*	**10**
		b)	A closed vessel contains 5 kg of water at a pressure of 200 kPa. Determine: (i) The temperature of the water. (ii) The specific volume if the water is a mixture of saturated liquid and vapour with a dryness fraction of 0.8. Use the steam tables for the necessary properties.	*CO5*	*PO1*	**05**
		c)	A steam turbine operates with steam entering at a pressure of 3 MPa and temperature of 400 ^oC, and leaving at 100 kPa. Assume the process is isentropic. (i) Determine the dryness fraction of steam at the exit. (ii) Calculate the work output per kilogram of steam using the Mollier diagram.	*CO5*	*PO2*	**05**
			OR			
	10	a)	Explain the differences between the ideal Rankine cycle and the actual Rankine cycle, focusing on irreversibilities in components.	*CO5*	*PO1*	**10**
		b)	In a reheat Rankine cycle, steam expands in the high-pressure turbine from 15 MPa and 550^{o}C to 1.2 MPa, where it is reheated to 550 ^oC. It then expands in a low-pressure turbine to 10 kPa. (i) Calculate the total work output per kilogram of steam. (ii) Determine the cycle efficiency if the heat supplied during reheat is 2800 kJ/kg.	*CO5*	*PO2*	**10**

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