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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: Industrial Engineering & Management **Duration: 3 hrs.**
Course Code: 22IM3PCETD **Max Marks: 100**
Course: Engineering Thermodynamics

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.
3. Output of the program to be mentioned wherever applicable

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.

		UNIT - I	*CO*	*PO*	**Marks**
1	a)	Define Open system, closed system, extensive property and intensive property	*CO1*	*PO1*	**04**
	b)	Two Celsius thermometers A and B agree at ice point 0^oC and steam point 100^oC. The thermometers are related by the equation is $T_A = L + MT_B + NT_B^2$, T_A and T_B are thermometer readings and where L, M and N are constants. When both are immersed in an oil bath, thermometer A indicates 11^oC and B indicates 10^oC. Determine the reading of A when thermometer B reads 37.4^oC.	*CO2*	*PO2*	**08**
	c)	The temperature "t" on a Celsius scale is defined in terms of property 'K' by the relation t = A ln P + B where A and B are constants. Experiments gives the value of K of 1.5 and 7.5 at ice and steam point respectively. Determine the temperature corresponding to a value of P = 2.5 on the thermometer.	*CO2*	*PO2*	**08**
		OR			
2	a)	Explain Zeroth law of thermodynamics with example	*CO1*	*PO1*	**04**
	b)	Two Celsius thermometers A and B agree at ice point and steam point. The thermometers are related by the equation is $T_A = L + MT_B + NT_B^2$, T_A and T_B are thermometer readings and where L, M and N are constants. When both are immersed in an oil bath, thermometer A indicates 51^oC and B indicates 50^oC. Determine the reading of A when thermometer B reads 25^oC	*CO2*	*PO2*	**08**
	c)	Newton proposed a linear temperature scale wherein the ice point and normal human body temperature were assumed as the two fixed points and assigned the temperatures of 0^o and 12^o. If the temperature of the	*CO2*	*PO2*	**08**

			human body on the Fahrenheit scale is 98^oF, obtain the relation between the Newton's scale and the Fahrenheit scale			
			UNIT - II			
	3	a)	Derive an expression for work done during adiabatic process	*CO1*	*PO1*	**04**
		b)	A gas having initial pressure, volume and temperature as 275 kN/m^2, 0.09 m^3 and 185^oC, respectively is compressed at constant pressure until its temperature is 15^oC. Calculate the amount of heat transferred and work done during the process. Take R = 0.278 kJ/kgK and C_p = 1.005 kJ/kgK.	*CO2*	*PO2*	**08**
		c)	A system of volume 'V' contains a mass 'm' of gas at pressure 'P' and temperature 'T'. These properties are related by the equation $\{P + (a/V^2)\}\ (V – b) = mRT$, where a, b and R are constants. Obtain an expression for displacement work from volume V_1 to a final volume V_2. Calculate this work for the system which contains 10 kg of this gas expanding from 1 m3 to 10 m3 at a constant temperature of 293 K. Assume a = 15.7 x 10^4 Nm^4, b = 1.07 x 10^{-2} m^3 and R = 0.278 kJ/kgK	*CO2*	*PO2*	**08**
			OR			
	4	a)	Prove that heat is a path function	*CO1*	*PO1*	**04**
		b)	A spherical balloon of 0.8 m diameter contains gas at 120 kPa. The gas in the balloon is heated until the pressure reaches 425 kPa, during which the gas pressure is proportional to the cube of diameter of the balloon. Determine the work done by the gas inside the balloon.	*CO2*	*PO2*	**08**
		c)	A cylinder contains 1 kg of certain fluid at an initial pressure of 20 bar. The fluid is allowed to expand reversibly behind a piston according to a law $PV^2 = C$ until the volume is doubled. The fluid is then cooled reversibly at constant pressure until the piston regains its original position; heat is then supplied reversibly with the piston firmly locked in position until the pressure rises to the original value of 20 bar. Calculate the net work done by the fluid, for an initial volume of 0.5 m^3.	*CO2*	*PO2*	**08**
			UNIT - III			
	5	a)	Prove that energy is a property of the system	*CO1*	*PO1*	**04**
		b)	A fluid system contained in a piston and cylinder machine, passes through a complete cycle of four processes. The total negative heat transferred during a cycle is -170 kJ. The system completes 100 cycles per minute. Complete the following table showing the method for each item and compute the net rate of work output in kW.	*CO2*	*PO2*	**08**

Process	Q (kJ/min)	W (kJ/min)	ΔU (kJ/min)
1-2	0	2170	-
2-3	21000	0	-
3-4	-2100		-36600
4-1	-	-	-

	c)	Show that $R = C_p – C_v$ and relation between C_p and C_v in terms of γ	*CO1*	*PO1*	**08**
		OR			
6	a)	List the terms involved in the steady flow energy equation (SFEE)	*CO1*	*PO1*	**04**
	b)	Centrifugal pump delivers 60 kg of water per second. The inlet and outlet pressure are 10 kPa and 400 kPa respectively. The suction is 2m below and delivery is 8m above the centre line of the pump. The suction and delivery pipe diameter are 0.2m and 0.1m respectively. Determine the capacity of the electric motor to run the pump.	*CO2*	*PO2*	**08**
	c)	Air enters the nozzle at 3 bar, 473K and 30 m/s and leaves at 1bar and 180 m/s. The inlet area of the nozzle is 0.0088 m^2, C_p = 1.02 kJ/kgK and R = 0.287 kJ/kgK. Neglect the heat losses from the nozzle. Determine (i) the mass flow rate through the nozzle (ii) the exit temperature of the air (iii) the exit area of the nozzle (iv) the exit diameter of the nozzle.	*CO2*	*PO2*	**08**
		UNIT - IV			
7	a)	Define Kelvin-Planck and Clausius statements	*CO1*	*PO1*	**04**
	b)	The thermal efficiency of three heat engines which are connected in series is same. A source at 1175 K supplies 2250 kJ of heat to the first engine and the third heat engine 280 kJ of heat to a sink at 145 K. determine the heat rejected and work output from each engine.	*CO2*	*PO2*	**06**
	c)	A reversible heat engine operating between two thermal reservoirs at 7000C and 500C. Engine drives a reversible refrigerator operating between -250C and 500C. The heat transfer to the heat engine is 2500 kJ and the network available from the combined engine and refrigerator cycle is 400 kJ. Determine the heat transferred to the refrigerant and the net heat transferred to 500C reservoir.	*CO2*	*PO2*	**10**
		OR			
8	a)	Prove the equivalence of two statements of second law of thermodynamics	*CO1*	*PO1*	**10**
	b)	Three Carnot engines are connected in series. The first engine absorbs 4000 kJ of heat from a source at 2000 K and delivers 1800 kJ of work, the second and third engines deliver 1200 kJ and 500 kJ of work respectively. Calculate exhaust temperature and heat rejected by the second and third Carnot engines and efficiencies of each engine.	*CO2*	*PO2*	**10**

			UNIT - V			
	9	a)	Derive an air standard efficiency of the Carnot cycle using P-V diagram	*CO*1	*PO1*	**10**
		b)	An engine operates on air standard Diesel cycle. The pressure and temperatures at the beginning of compression are 100 kPa and 27^{o}C. The compression ratio is 18. The heat added per kg of air is 1850 kJ. Determine (i) maximum pressure (ii) maximum temperature (iii) thermal efficiency (iv) network done. Assume γ = 1.4, Cp = 1.005 kJ/kgK, C_v = 0.718 kJ/kgK and R = 0.287	*CO*3	*PO3*	**10**
			OR			
	10	a)	Derive an air standard efficiency of the Dual cycle.	*CO*1	*PO1*	**10**
		b)	In an Otto cycle air at 15^{o}C and 1.05 bar is compressed adiabatically until the pressure is 13 bar. Heat is added at constant volume until the pressure rises to 35 bar. Calculate the air standard efficiency, the compression ratio and the mean effective pressure for the cycle. Assume γ = 1.4, Cp = 1.005 kJ/kgK, C_v = 0.718 kJ/kgK and R = 0.287	*CO*3	*PO3*	**10**

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