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: IV**

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

Course Code: 19ME4DCATD **Max Marks: 100**

Course: Applied 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. For Air Take R=287 J/kg-K and γ=1.4.

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)	Explain the concept of air-standard assumptions used in gas power cycle analysis. Why are these assumptions important in simplifying the study of real engines?	*CO1*	*PO1*	**05**
	b)	A Diesel cycle operates with a compression ratio of 18. The heat addition per cycle is 1500 kJ/kg. The cycle starts at a pressure of 1 bar and a temperature of 300 K. Assuming constant specific heats with C_p=1.005 kJ/kg-K and C_v=0.718 kJ/kg-K: i. Determine the maximum temperature in the cycle. ii. Calculate the thermal efficiency of the Diesel cycle.	*CO2*	*PO2*	**07**
	c)	An ideal Brayton cycle has a pressure ratio of 8. Air enters the compressor at 1 bar and 300 K, and the maximum cycle temperature is 1200 K. Assume air behaves as an ideal gas with C_p=1.005 kJ/kg-K and γ=1.4: i. Calculate the compressor work per unit mass of air. ii. Determine the turbine work per unit mass of air. iii. Find the thermal efficiency of the cycle.	*CO1*	*PO2*	**08**
		OR			
2	a)	Explain the main differences between the Otto cycle, Diesel cycle, and Dual cycle in terms of heat addition, compression ratio, and thermal efficiency. Use appropriate diagrams to support your explanation.	*CO1*	*PO1*	**05**
	b)	In air-standard Otto cycle has a compression ratio of 10. The air enters the cycle at P_1=1 bar, T_1=300 K, and the maximum temperature in the cycle is 1500 K. Assume constant specific heats with Cp=1.005 kJ/kg-K and γ=1.4. i. Calculate the thermal efficiency of the cycle. ii. Find the net-work output per unit mass of air.	*CO2*	*PO2*	**07**

		c)	An ideal Brayton cycle operates with air entering the compressor at 1 bar and 300K. The pressure ratio is 6, and the maximum temperature in the cycle is 1100 K. Assume air behaves as an ideal gas i. Calculate the compressor outlet temperature (T_2). ii. Determine the turbine outlet temperature (T_4). iii. Calculate the net-work output and Work ratio iv. Compute the thermal efficiency of the cycle and discuss how it depends on the pressure ratio.	*CO1*	*PO2*	**08**
			UNIT - II			
	3	a)	Explain the phenomenon of knocking in Spark Ignition (SI) and Compression Ignition (CI) engines. Discuss the factors influencing knocking and the methods to control it in both types of engines.	*CO2*	*PO1*	**05**
		b)	A four-stroke petrol engine with 4 cylinders has a bore of 80 mm, stroke length of 100 mm, and a compression ratio of 9. The engine operates at 3000 rpm, with an indicated mean effective pressure of 7 bar. Determine: i. The total swept volume of the engine. ii. The indicated power (IP) of the engine in kW.	*CO2*	*PO2*	**08**
		c)	A diesel engine is tested using the Willian's line method. The fuel consumption is 0.22 kg/min with a calorific value of 44,000 kJ/kg. The brake power (BP) measured is 25 kW, and the frictional power (FP) is 5 kW. Determine: i. The mechanical efficiency of the engine. ii. The brake thermal efficiency of the engine.	*CO2*	*PO2*	**07**
			OR			
	4	a)	Discuss the Morse test for multi-cylinder engines. Explain its procedure and how it is used to determine the indicated power and mechanical efficiency of the engine.	*CO2*	*PO1*	**05**
		b)	A 4-stroke diesel engine has the following specifications: • Number of cylinders: 6 • Bore: 100 mm • Stroke: 120 mm • Brake power (BP): 50 kW • Mechanical efficiency: 80% Determine: i. The total swept volume of the engine. ii. The indicated power (IP) of the engine.	*CO2*	*PO2*	**07**
		c)	A single-cylinder four-stroke engine is tested and the following data is available: • Fuel consumption rate m: 0.25 kg/min. • Calorific value (C_V): 42,000 kJ/kg • Cooling water flow rate: 3 kg/min • Temperature rise in cooling water: 30 °C	*CO2*	*PO2*	**08**

			• Brake power (BP): 5.5 kW Determine: a. The total heat input to the engine. b. The percentage of heat lost to the cooling water. c. Prepare the heat balance sheet on minute basis.			
			UNIT - III			
	5	a)	Explain the working of a single-stage reciprocating compressor with the help of a p-V diagram. Discuss the effect of clearance volume on volumetric efficiency.	*CO1*	*PO1*	**05**
		b)	A single-stage reciprocating compressor takes in air at 1 bar and 27^oC and delivers it at 6 bar. Assume isentropic compression and neglect clearance. The compressor has a bore of 150 mm, stroke of 200 mm, and operates at 300 rpm. Determine: i. The mass flow rate of air handled by the compressor. ii. The power required to run the compressor.	*CO3*	*PO2*	**07**
		c)	A two-stage reciprocating compressor takes in air at 1 bar and 27^0C and delivers it at 16 bar. Perfect intercooling is used. The total mass flow rate of air is 0.05 kg/s. Determine: i. The optimum intermediate pressure for minimum work. ii. The total work input required for compression assuming isentropic compression.	*CO3*	*PO2*	**08**
			OR			
	6	a)	Explain the concept of volumetric efficiency in reciprocating compressors. How does clearance volume affect volumetric efficiency? Discuss measures to improve volumetric efficiency.	*CO1*	*PO1*	**06**
		b)	A single-stage reciprocating air compressor takes in air at 1 bar, 27^0C, and compresses it to 5 bar. The bore of the cylinder is 100 mm, and the stroke length is 120 mm. The clearance volume is 7% of the swept volume. Determine: i. The actual volume of air delivered per cycle (free air delivery). ii. The work done per cycle, assuming isentropic compression.	*CO4*	*PO2*	**07**
		c)	A three-stage reciprocating air compressor compresses air from 1 bar and 27^0C to 27 bar. The mass flow rate is 0.08 kg/s, and perfect intercooling is assumed. Determine: i. The intermediate pressures for minimum work compression. ii. The total work required for compression, assuming isentropic processes.	*CO4*	*PO2*	**07**
			UNIT - IV			
	7	a)	Explain the concept of a pure substance. Using water as an example, describe the various states a pure substance can exist in, such as sub-cooled liquid, saturated liquid, saturated vapor, superheated vapor, and the mixture of saturated liquid and vapor. Represent these states on a P-v diagram.	*CO3*	*PO1*	**06**

		b)	Water is heated at a constant pressure of 10 bar until it becomes superheated vapor at 400 ^{0}C. Using steam tables, Determine: i. The specific enthalpy and specific entropy of water in this state. ii. The amount of heat required to achieve this state if the initial state is saturated liquid.	*CO3*	*PO2*	**07**
		c)	A closed vessel contains 2 kg of wet steam at a pressure of 5 bar, with a dryness fraction of 0.85. With the help of steam tables, determine: i. The specific volume, specific enthalpy, and specific entropy of the wet steam. ii. The total enthalpy of the wet steam in the vessel.	*CO3*	*PO2*	**07**
			OR			
	8	a)	Explain the working of a Rankine cycle with the help of a schematic diagram and T-s diagram. Highlight the assumptions made in the ideal Rankine cycle and discuss its limitations in practical applications.	*CO3*	*PO1*	**06**
		b)	A steam power plant operates on an ideal Rankine cycle with steam entering the turbine at 3 MPa, 400^{o}C and leaving at 10 kPa. Determine: i. The thermal efficiency of the cycle. ii. The specific steam consumption (SSC) in kg/kW-h.	*CO3*	*PO2*	**07**
		c)	A steam power plant uses a regenerative Rankine cycle with one open feedwater heater. Steam is extracted at 0.8 MPa from the turbine and the remaining steam expands to 10 kPa. The boiler pressure is 3 MPa, and the steam enters the turbine at 400 ^{o}C. Assuming ideal processes, determine: i. The fraction of steam extracted for regeneration. ii. The thermal efficiency of the cycle.	*CO3*	*PO2*	**07**
			UNIT - V			
	9	a)	Explain the working principle of the Vapour Compression Refrigeration System with the help of a p-h diagram.	*CO3*	*PO1*	**06**
		b)	An aircraft cooling system operates on a reversed Brayton cycle (air refrigeration cycle). Air enters the compressor at 1 bar, −10 ^{o}C, and leaves at 4 bar. The air then cools to 50 ^{o}C in the heat exchanger before expanding in the turbine to 1 bar. Assume isentropic efficiencies of the compressor and turbine are 85%. Determine: i. The COP of the system. ii. The mass flow rate of air if the cooling capacity is 10 kW.	*CO3*	*PO2*	**07**
		c)	A Vapour Compression Refrigeration system uses R-134a as the refrigerant. The system operates between a condenser pressure of 12 bar and an evaporator pressure of 2 bar. The refrigerant enters the compressor as a saturated vapor and leaves as a superheated	*CO3*	*PO2*	**07**

			vapor at 60 °C. i. Determine the COP of the system. ii. Calculate the refrigeration effect and work input per kg of refrigerant.			
			OR			
	10	a)	Explain the significance of the following terms in psychrometry: i. Dry Bulb Temperature (DBT) ii. Wet Bulb Temperature (WBT) iii. Dew Point Temperature (DPT) iv. Specific Humidity v. Relative Humidity vi. Adiabatic Saturation Temperature	*CO4*	*PO1*	**06**
		b)	A sample of air has a dry bulb temperature (DBT) of 35 °C and a wet bulb temperature (WBT) of 25 °C. Atmospheric pressure is 1.013 bar. Using the following data, determine: i. Partial pressure of water vapor in the air. ii. Relative humidity. iii. Specific humidity. Take Saturation pressure of water at 25 °C as 3.17 kPa.	*CO4*	*PO2*	**07**
		c)	Moist air enters a cooling coil at 30 °C DBT and 50% relative humidity with a flow rate of 2 kg/s. The air leaves the cooling coil at 15 °C DBT and is fully saturated. Determine: i. The rate of heat transfer in the cooling coil. ii. The amount of moisture removed. Following data can be considered: • Enthalpy of air at 30°C, 50% humidity is 70 kJ/kg. • Enthalpy of saturated air at 15 °C is 42 kJ/kg. • Specific humidity of air at 30 °C, 50% is 0.010 kg/kg. • Specific humidity of saturated air at 15 °C is 0.007kg/kg.	*CO4*	*PO2*	**07**

******