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: 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.

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.

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		UNIT - I	**Marks**
1	a)	Define Open system, closed system, extensive property and intensive property	**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°C and B indicates 50°C. Determine the reading of A when thermometer B reads 25°C	**08**
	c)	Newton scale N is devised in which the ice point is assigned 100°N and the steam point is assigned 400°N. Establish the relation between the Newton scale and Celsius scale	**08**
		OR	
2	a)	Explain zeroth law of thermodynamics	**04**
	b)	Two Celsius thermometers A and B agree at ice point 0°C and steam point 100°C. 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°C and B indicates 10°C. Determine the reading of A when thermometer B reads 37.4°C.	**08**
	c)	The temperature "t" on a Celsius scale is defined in terms of property 'K' by the relation t = a ln K + b where a and b are constants. Experiments gives the value of K of 1.83 and 6.78 at ice and steam point respectively. Determine the temperature corresponding to a value of K = 2.42 on the thermometer	**08**
		UNIT-II	
3	a)	Explain and derive an expression for displacement work	**04**
	b)	One kg of air having an initial volume of 0.3 m^3 is heated at constant pressure of 3.2 bar until the volume is doubled, calculate (i) Work done (ii) initial and final temperatures of the air (iii) heat added. Take Cp = 1.003 kJ/kgK and R = 0.2927 kJ/kgK	**08**

c) An engine cylinder of diameter 0.225 m, has stroke length of 0.375 m. The swept volume is 4 times clearance volume. The pressure of the gates at the beginning of expansion stroke is 1569 kPa. Find the work done during expansion stroke assuming the process as reversible adiabatic. Take $\gamma = 1.4$ **08**

OR

4 a) Derive the expression for work done during isothermal process **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. **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. **08**

UNIT - III

5 a) Prove energy is a property of the system **06**

b) A fluid system contained in a piston and cylinder machine, passes through a complete cycle of four processes. The sum of all 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. **08**

Process	Q (kJ/min)	W (kJ/min)	ΔU (kJ/min)
a-b	0	2170	-
b-c	21000	0	-
c-d	-2100	-	-36600
d-a	-		--

c) Air flows steadily through a rotary compressor. At entry the air is 20^oC and 101 kPa. At exit the same air is at 200^oC and 600 kPa. Assuming the flow to be adiabatic. (i) evaluate the work done per unit mass of air if the velocity at inlet and exit are negligible (ii) what would be the increase in work input if the velocity at inlet and exit are 50 m/s and 110 m/s. Assume Cp = 1.005 kJ/kgK. **06**

OR

6 a) Deduce the steady flow energy equation (SFEE) **06**

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<table>
<tr><td></td><td></td><td>b)</td><td>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 -340 kJ. The system completes 200 cycles per minute. Complete the following table showing the method for each item and compute the net rate of work output in kW.
<table>
<tr><th>Process</th><th>Q (kJ/min)</th><th>W (kJ/min)</th><th>ΔU (kJ/min)</th></tr>
<tr><td>1-2</td><td>0</td><td>4340</td><td>-</td></tr>
<tr><td>2-3</td><td>42000</td><td>0</td><td>-</td></tr>
<tr><td>3-4</td><td>-4200</td><td></td><td>-73200</td></tr>
<tr><td>4-1</td><td>-</td><td>-</td><td>-</td></tr>
</table></td><td>08</td></tr>
<tr><td></td><td></td><td>c)</td><td>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</td><td>06</td></tr>
<tr><td></td><td></td><td></td><td>UNIT - IV</td><td></td></tr>
<tr><td></td><td>7</td><td>a)</td><td>Define Kelvin-Planck and Clausius statements</td><td>04</td></tr>
<tr><td></td><td></td><td>b)</td><td>Briefly explain Heat Engine, Heat pump and Refrigerator with neat sketch and formula</td><td>06</td></tr>
<tr><td></td><td></td><td>c)</td><td>A reversible heat engine operating between two thermal reservoirs at 973K and 323K. Engine drives a reversible refrigerator operating between 248K and 323K. 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 323K reservoir.</td><td>10</td></tr>
<tr><td></td><td></td><td></td><td>OR</td><td></td></tr>
<tr><td></td><td>8</td><td>a)</td><td>Prove the equivalence of two statements of second law of thermodynamics</td><td>10</td></tr>
<tr><td></td><td></td><td>b)</td><td>A heat engine with an efficiency of 40% drives a heat a refrigerator with a COP of 4. Determine the ratio of total heat rejected to the atmosphere to the heat absorbed by the refrigerator</td><td>10</td></tr>
<tr><td></td><td></td><td></td><td>UNIT - V</td><td></td></tr>
<tr><td></td><td>9</td><td>a)</td><td>Derive an air standard efficiency of the Diesel cycle.</td><td>10</td></tr>
<tr><td></td><td></td><td>b)</td><td>In an Otto cycle air at 15°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. Take γ = 1.4, C_v = 0.718 kJ/kgK and R = 0.287</td><td>10</td></tr>
<tr><td></td><td></td><td></td><td>OR</td><td></td></tr>
<tr><td></td><td>10</td><td>a)</td><td>Derive an air standard efficiency of the Carnot cycle.</td><td>10</td></tr>
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		b)	An amount of a perfect gas has initial conditions of volume 1 m^3, pressure 1 bar and temperature 18^{o}C. It undergoes ideal diesel cycle operations, the pressure after isentropic compression being 50 bar and the volume after constant pressure expansion being 0.1 m^3. Calculate the temperature at the major points of the cycle and evaluate the thermal efficiency of the diesel cycle. Assume γ = 1.4, Cp = 1.005 kJ/kgK, C_v = 0.718 kJ/kgK and R = 0.287	**10**

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