CBCS SCHEME

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BAE401

Fourth Semester B.E./B.Tech. Degree Supplementary Examination, June/July 2024

Aero Engineering Thermodynamics

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. M : Marks , L: Bloom's level , C: Course outcomes.
3. Use of steam tables is permitted.

		Module – 1	M	L	C
Q.1	**a.**	Derive an expression for displacement work in polytropic process, PV^n = constant. Show a P-V diagram and write work done equation for $n = 0$, $n = 1$, $n = \gamma$ and $n = \infty$ in the above expression also name each process.	**10**	**L2**	**CO1**
	b.	As an engineering student suggest the most economical process, when it is desired to compress one mole of air from initial stage of 300 K and 1 bar to a final stage of 300 K and 10 bar from among the following process: (i) Isothermal compression (ii) Cooling at constant pressure and heating at constant volume. (iii) Adiabatic compression followed by cooling at constant volume. (iv) Heating at constant volume followed by cooling at constant pressure.	**10**	**L3**	**CO1**
		OR			
Q.2	**a.**	Explain thermodynamic system and its types.	**6**	**L1**	**CO1**
	b.	State zeroth law of thermodynamics and define Intensive and Extensive property with 2 examples each.	**6**	**L1**	**CO1**
	c.	The length of the mercury column in mercury-in-glass thermometer is 5 cm when the temperature is at the ice point and 25 cm when the thermometer is at steam point. Consider this length as the property x and a scale t' to be defined by the expression $t' = ax^2 + b$ where $t' = 0$ at ice point and $t' = 100$ at steam point. Compare the t' scale with the centigrade scale, where t is linearly defined in terms of x with the same values as t' at ice and steam point.	**8**	**L3**	**CO1**
		Module – 2			
Q.3	**a.**	Explain first law of thermodynamics with respect to open and closed system and show that energy is a property.	**10**	**L2**	**CO2**
	b.	A piston and cylinder machine contains a fluid system which passes through a complete cycle of four processes. During a cycle the sum of all heat transfer is (-170 KJ). The system completes 100 cycles per min. Complete the following table showing the method for each item and compute the net rate of work output in kW.	**10**	**L3**	**CO2**

Process	Q(KJ/min)	W(KJ/min)	ΔE(KJ/min)
a – b	0	2170	-
b – c	21000	0	-
c – d	-2100	-	-36600
d – a	-	-	-

OR					
Q.4	**a.**	Derive mass and energy balance equation for a single stream steady flow process.	**10**	**L1**	**CO2**
	b.	0.2 m^3 of air at 4 bar and 130 °C is contained in a system. A reversible adiabatic expansion takes place till the pressure falls to 1.02 bar. The gas is then heated at a constant pressure till enthalpy increases by 72.5 KJ. Calculate : (i) The work done. (ii) The index of expansion, if the above process are replaced by a single reversible polytropic process giving the same work between the same initial and final states. [Take C_P = 1 KJ/kg K, C_V = 0.714 KJ/kgK]	**10**	**L3**	**CO2**
Module – 3					
Q.5	**a.**	State Kelvin Plank and Clausius statements of second. Law of thermodynamics and show that they are equivalent.	**8**	**L1**	**CO2**
	b.	A reversible heat engine operates between two reservoirs at temperatures 700 °C and 50 °C. The engine drive a reversible refrigerator which operates between reservoirs at temperatures of 50 °C and -25 °C. The heat transfer to the engine is 2500 KJ and the net work output of the combined engine refrigerator plant is 400 KJ. (i) Determine the heat transfer to the refrigerator and the net heat transfer to the reservoir at 50 °C. (ii) Recalculate (i) Given that the efficiency of the heat engine and the COP of the refrigerator are each 45% of their maximum possible values.	**12**	**L3**	**CO2**
OR					
Q.6	**a.**	Apply the Clausius inequality for a system undergoing an irreversible cyclic change and show that change in entropy of a system is given by, $d \geq \frac{\delta Q}{T}$	**10**	**L2**	**CO2**
	b.	Air at 20 °C and 1.05 bar occupies 0.025 m^3. The air is heated at a constant volume until the pressure is 4.5 bar and then cooled at a constant pressure back to original temperature. Calculate : (i) The net heat flow from the air. (ii) The net entropy change. Also check the process on T-S diagram.	**10**	**L2**	**CO4**
Module – 4					
Q.7	**a.**	Define : (i) Critical point (ii) Triple point (iii) Dryness fraction (iv) Pure substance (v) Latent heat	**10**	**L1**	**CO3**
	b.	A fluid at 200 KPa and 300 °C has a volume of 0.8 m^3. In a frictionless process at constant volume the pressure changes to 100 KPa. Find the final temperature and heat transferred, (i) if fluid is air (ii) if the fluid is steam.	**10**	**L3**	**CO4**
OR					
Q.8	**a.**	Derive first and second form of Tds equations.	**10**	**L2**	**CO2**

	b.	The pressure on the block of copper of 1 kg is increased from 20 bar to 800 bar in a reversible isothermal process at 15 $^\circ$C, if volume expansitivity $(\beta) = 5\times10^{-5}/K$, Thermal compressibility (K) = 8.6×10^{-12} m^2/N and Specific volume (v) = 0.114×10^{-3} m^3/kg. Determine (i) Work done on the copper during the process. (ii) Change in entropy (iii) The heat transfer (iv) Change in internal energy (v) $[C_P - C_V]$ for this change of state.	**10**	**L2**	**CO4**
		Module – 5			
Q.9	a.	Assume a simple steam plant working on a Rankine cycle, (i) Show flow diagram (ii) Plot P-V, T-S and h-S diagram (iii) Write S.F.E.E for each component. (iv) Give the efficiency for the plant.	**10**	**L1**	**CO3**
	b.	Steam at 20 bar, 360 $^\circ$C is expanded in a steam turbine to 0.08 bar. It then enters a condenser, where it is condensed to saturated liquid water. The pump feeds back the water into the boiler. (i) Assuming ideal process, find per kg of steam the net work and the cycle efficiency. (ii) If the turbine and the pump have each 80% efficiency. Find the percentage reduction in the net work and the cycle efficiency.	**10**	**L3**	**CO3**
		OR			
Q.10	a.	An engine working on the Otto cycle is supplied with air at 0.1 MPa, 35 $^\circ$C. The compression ratio is 8. Heat supplied is 2100 KJ/kg. Calculate the maximum pressure and temperature of the cycle, the cycle efficiency and the mean effective pressure. (For air C_P = 1.005, C_V = 0.718 and R = 0.287 KJ/kgK)	**10**	**L3**	**CO3**
	b.	With the help of P-V and T-S diagrams, formulate an expression for air standard efficiency of Diesel cycle.	**10**	**L1**	**CO3**

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