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BAE401

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BANGALORE

Fourth Semester B.E./B.Tech. Degree Examination, June/July 2025
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. Thermodynamic data hand book is permitted.

		Module – 1	M	L	C
Q.1	a.	What are open system, closed system and isolated system? Give examples of each.	6	L1	CO1
	b.	Show that $t_c^\circ = 100\dfrac{(X - X_J)}{(X_S - X_J)}$	6	L2	CO1
	c.	A reading t_A and t_B of two Celsius thermometers A and B agree at ice point and steam point but else where they are related by the equation $t_A = L + Mt_B + nt_B^2$, where L, M and n are constant. When both the thermometers are immersed in oil A indicates 55°C and B indicates 50°C, determine the values of constant L, M and n and also the temperature readings on thermometer A when B reads 25°C?	8	L4	CO1
		OR			
Q.2	a.	With the help of neat diagram, prove that free expansion has zero work transfer.	10	L5	CO1
	b.	A spherical balloon of 0.5 m diameter contains air at a pressure of 500 kPa the diameter increases to 0.55 m in a reversible process during which pressure is proportional to diameter. Determine the work done by the air during this process.	10	L4	CO1
		Module – 2			
Q.3	a.	Derive an expression for temperature ratio in terms of pressure ratio and volume ratio for an adiabatic process.	6	L3	CO2
	b.	Prove that polytropic index $n = \dfrac{\ell n(p_2/p_1)}{\ell n(v_1/v_2)}$	4	L2	CO2
	c.	A cylinder contains 1 kg of a certain fluid at an initial pressure of 20 bar. The fluid is allowed to expand reversibly behind a distance according to a law $pv^2 = c$ until the volume is double. The fluid is then cooled reversibly at constant pressure until the piston regains its original position, heat is then added with the piston firmly locked in position until the pressure rises to original value of 20 bar. Sketch the cycle on the pv-diagram and calculate the network done by the fluid for an initial volume of $0.5 m^3$.	10	L4	CO2

OR

Q.4 a. Write the steady flow energy equation for an open system and explain the terms involved in it. With suitable assumption simplify SFEE for the following systems: i) Nozzle ii) Turbine. — **12 | L4 | CO2**

b. In a steady flow process the working fluid flows at a rate of 240 kg/min the fluid rejects 120 kJ/sec of heat by passing through the control volume the conditions of the fluid at the inlet and the outlet are as follows: — **8 | L4 | CO2**

Inlet	Outlet
$c_1 = 300$ m/s	$c_2 = 150$ m/s
$p_1 = 6.2$ bar	$p_2 = 1.3$ bar
$u_1 = 2100$ kJ/kg	$u_2 = 1500$ kJ/kg
$v_1 = 0.37 m^3/kg$	$v_2 = 1.2\ m^3/kg$

Neglecting any changes in potential energy. Obtain the rate of work transfer in mega watt.

Module – 3

Q.5 a. State Kelvin plank and Clausius statements of second law of thermodynamics and show that they are equivalent. — **8 | L2 | CO2**

b. A reversible engine operates between temperatures T_H and T_I with $T_H > T_I$. The energy rejected from this engine is utilized for driving another reversible engine which operates between the temperature limits T_I and T_L with $T_I > T_L$. For this arrangement show that, — **12 | L5 | CO2**

i) The temperature T_I is the arithmetic mean of the temperature T_H and T_L, if both the engines produce equal amount of work.

ii) The temperature T_I is geometric mean of the temperature T_H and T_L when both the engines have the same thermal efficiency.

OR

Q.6 a. State and prove Clausius inequality. — **8 | L2 | CO2**

b. Two reversible engine operate in series between a high temperature reservoir and a low temperature reservoir, engine (A) rejects heat to engine (B) through an intermediate reservoir maintained at temperature T_I engine (B) rejects heat to the low temperature reservoir which is maintained at temperature $T_L = 300$ K, both the engines have the same thermal efficiency if the work developed by engine (B) is 500 kJ and the heat received by the engine (A) is 2000 kJ from the high temperature reservoir maintained at temperature T_H. Obtain the work developed by engine (A) the heat rejected by engine (B), the intermediate temperature T_I and the source temperature T_H. — **12 | L4 | CO2**

Module – 4

Q.7 a. Define the following: — **4 | L1 | CO2**

i) Critical point
ii) Triple point
iii) Pure substance
iv) Saturation pressure.

b. Find the enthalpy, specific volume and internal energy if the pressure of steam is 50 bar and temperature is 443°C. — **8 | L3 | CO2**

	c.	Sketch and explain P-T diagram of water.	8	L2	CO2
		OR			
Q.8	a.	Derive and explain Maxwells equation.	8	L2	CO2
	b.	1 kg of ideal gas at pressure P_1, volume V_1 and temperature T_1 follows a reversible process to arrive at state (2) where the properties are P_2, V_2 and T_2. Starting from the relation entropy change $ds = \frac{\delta Q}{T}$, derive an expression for change in entropy in terms of pressure and volume. Using the derived expression prove that for an adiabatic process $pv^{\gamma} = c$ where γ = ratio of specific heats.	12	L5	CO2
		Module – 5			
Q.9	a.	With the help of PV and TS diagram, explain the working of diesel cycle. Derive an expression for the efficiency of diesel cycle in terms of its compression and cut off ratio's.	12	L4	CO3
	b.	In an Otto cycle engine, air at a pressure of 1 bar and 60°C is compressed adiabatically to a pressure of 8 bar during constant volume process, 450 kJ of heat is added per kg of air. Determine: i) Compression ratio of the engine ii) Temperature at the end of compression and heat addition. iii) Air standard efficiency for air (Assume C_p = 1 kJ/kg K and C_v = 0.706 kJ/kg K].	8	L4	CO3
		OR			
Q.10	a.	Explain Rankine cycle with the help of a sketch and T-S diagram. Derive an expression for thermal efficiency of Rankine cycle.	10	L4	CO3
	b.	Consider a steam power plant operating on a simple rankine cycle. Steam enters the turbine at 3 MPa and 350°C and is condensed in the condenser at a pressure of 75 kPa. Determine the thermal efficiency of the cycle.	10	L3	CO3

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