CBCS SCHEME

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21AE/AS43

Fourth Semester B.E. Degree 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. Use of Thermodynamic data hand book permitted.

Module-1

1 a. What are open system, closed system and isolated system? Give examples of each. **(06 Marks)**

b. Show that $t_C^\circ = 100\dfrac{(x - x_I)}{(x_S - x_I)}$. **(06 Marks)**

c. A resistance thermometer follows an equation 'R_t' $R_t = R_O(1+\alpha t)$ where R_t and R_O are the values of resistance at temperature $t^\circ C$ and $0^\circ C$ respectively, α is a constant, the thermometer is caliberated by immersing it in boiling water and boiling sulphur which have the temperature values of $100^\circ C$ and $445^\circ C$ at these temperature the thermometer indicates the resistance values of 14.7 Ω and 29.2 Ω respectively. Find the temperature of a fluid when the thermometer reads 23.5 Ω? **(08 Marks)**

OR

2 a. With the help of neat sketch, prove that free expansion has zero work transfer. **(08 Marks)**

b. Obtain an expression for work done by the isothermal process. **(04 Marks)**

c. A spherical balloon has a diameter of 20 cm and it contains air at a pressure of 1.5 bar during a certain process the diameter of a balloon increases to 30 cm during which the pressure is proportional to diameter. Calculate the work done by the air inside the balloon during this process. **(08 Marks)**

Module-2

3 a. Derive an expression for temperature ratio in terms of pressure ratio and volume ratio for an adiabatic process. **(06 Marks)**

b. Prove that polytropic index, $n = \dfrac{\ln\left(P_2/P_1\right)}{\ln\left(V_1/V_2\right)}$. **(04 Marks)**

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, 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 net work done by the fluid for an initial volume of 0.5 m^3. **(10 Marks)**

OR

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 Marks)**

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 :

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 (MW). **(08 Marks)**

Module-3

5 a. State Kelvin plank and Clausius statements of second law of thermodynamics and show that they are equivalent. **(08 Marks)**

b. A reversible engine operates between temperature 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,

(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 engine have the same thermal efficiency. **(12 Marks)**

OR

6 a. State and prove Clausius inequality. **(08 Marks)**

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 Marks)**

Module-4

7 a. Define the following :

(i) Critical point (ii) Pure substance

(iii) Triple point (iv) Saturation pressure. **(04 Marks)**

b. Find the enthalpy, specific volume and internal energy if the pressure of steam is 50 bar and temperature is 443 °C. **(08 Marks)**

c. Sketch and explain P-T diagram of water. **(08 Marks)**

OR

8 a. Derive and explain Maxwell's equation. **(08 Marks)**

b. 1 kg of ideal gas at pressure P, Volume V and temperature T 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 $d_5 = \frac{\delta Q}{T}$, 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 Marks)**

Module-5

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 ratios. **(12 Marks)**

b. An Otto cycle has upper and lower temperature limits of T_3 and T_1. If maximum work/kg of air is to be done show that the intermediate temperature is given by,

$T_2 = T_4 = \sqrt{T_1 T_3}$.

If the temperature limits are 1500 K and 300 K, find the maximum power developed for air circulation of 0.35 kg/min (Take $C_V = 0.706$ KJ/kgK) **(08 Marks)**

OR

10 a. Explain Rankine cycle with the help of a sketch and T-S diagram. Derive an expression for thermal efficiency of Rankine cycle. **(08 Marks)**

b. What are the methods for increasing the efficiency of Rankine cycle? **(04 Marks)**

c. 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. **(08 Marks)**

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