CBCS SCHEME

USN

17AE/AS33

Third Semester B.E. Degree Examination, Jan./Feb. 2021
Aerothermodynamics

Time: 3 hrs. Max. Marks: 100

Note: **1.** ***Answer any FIVE full questions, choosing ONE full question from each module.***
2. ***Use of thermodynamics data hand book is permitted.***

Module-1

1 a. Derive the expression for Celsius and Fahrenheit scale and explicitly bring out their relationship. **(10 Marks)**

b. A readings t_A and t_B of two Celsius thermometer 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 thermometer 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 reading on thermometer A when B reads 25°C. **(10 Marks)**

OR

2 a. Derive an expression for work done for the following:
(i) Shaft work (ii) Spring work **(10 Marks)**

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 proportional to diameter. Determine the work done by the air during this process. **(10 Marks)**

Module-2

3 a. Prove that for a polytropic process $Q_{1-2} = \frac{\gamma - n}{\gamma - 1}.W_{1-2}$ **(10 Marks)**

b. When a certain system executes a process the work transfer per unit temperature rise is given by the relation $\frac{\delta W}{dT} = (4.2 - 0.084T)\,kJ/K$ where T is in °K, the heat transfer during the process for unit temperature rise is given by $\frac{\delta Q}{dT} = 1.05\,kJ/K$. Estimate the change in internal energy when the temperature during the process increases from 200°C to 400°C. **(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 megawatt. **(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 engines have the same thermal efficiency. **(12 Marks)**

OR

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

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

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

c. Define the following: (i) Pure substance (ii) Saturation pressure (iii) Triple point (iv) Critical point **(04 Marks)**

OR

8 a. 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 Marks)**

b. Derive and explain Maxwell's equations. **(08 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 ideal heat engine works on Carnot cycle between the temperature limits of 1100°C and 150°C. If 4000 kJ/min heat is added to the engine at the higher temperature, determine: (i) Power developed by the engine (ii) The quantity of heat rejected (iii) The change in entropy during heat rejection **(08 Marks)**

OR

10 a. With the help of PV and TS diagram, derive an expression for the air standard efficiency of a petrol cycle (Otto cycle). **(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 intermediate temperature is given by $T_2 = T_4 = \sqrt{T_1 T_3}$ **(08 Marks)**