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18AE/AS32

Third Semester B.E. Degree Examination, Dec.2019/Jan.2020

Aerothermodynamics

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 is permitted.***

Module-1

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

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

c. A resistance thermometer follows an equation 'R_t' $R_t = R_o\ (1+\alpha t)$ where R_t R_o are the values of resistance at temperature t^oc and 0ºC respectively α is a constant, the thermometer is calibrated by immersing it in boiling water and boiling sulphur which have the temperature values of 100ºC and 445ºC at these temperature the thermometer indicates the resistance values of 14.7Ω and 29.2Ω respectively. Find the temperature of a fluid when the thermometer reads 23.5Ω. **(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 20cm and it contains air at a pressure of 1.5 bar during a certain process the diameter of a balloon increases to 30cm during which the pressure in 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 polytrophic index $n = \dfrac{\ell n(P_2 / P_1)}{\ell n(V_1 / V_2)}$ **(04 Marks)**

c. A cylinder contains 1kg of a certain fluid at an initial pressure of 20 bar. The fluids is allowed to expand reversibly behind a distance according to a law $PV^2 = C$ untill the volume is double. The fluid is then cooled reversibly at constant pressure untill the piston regains its original position, heat is the added with the piston firmly, locked in position untill 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 $0.5m^3$. **(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 240kg/min the fluid rejects 120kJ/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	=	300m/Sec	C_2	=	150m/Sec
P_1	=	6.2 bar	P_2	=	1.3 bar
u_1	=	2100 kJ/kg	u_2	=	1500 kJ/kg
V_1	=	$0.37m^3/kg$	V_2	=	$1.2m^3/kg$

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 Clausis 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 engine operate in series between a high temperature reservoir and a low temperature reservoir engine (A) reject heat to engine (B) through an intermediate reservoir maintained at temperature T_I Engine (B) reject heat to low temperature reservoir which is maintained at temperature T_L = 300K, both the engines have the same thermal efficiency, if the work developed by engine (B) is 500kJ and the heat received by the engine (A) is 2000kJ 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) Triple point iii) Pure substance iv) Saturation pressure. **(04 Marks)**

b. Find the enthalpy, specific volume and internal energy if the pressure of steam is 50 bars and temperature is 443ºC. **(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. 1kg 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 realtion entropy change $ds = \frac{\sigma Q}{T}$, derive an expression for change in entropy in terms of pressure and volume. Using the derived expression prove that for an adiabatic process $PV^{\nu} = C$ where ν = 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 $T_2 = T_4 = \sqrt{T_I T_3}$.

i) If the temperature limit are 1500k and 300k, find the maximum power developed for air circulation of 0.35kg/min (Take C_v = 0.706 kJ/kg K). **(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 3MPa and 350ºC and is condensed in the condenser at a pressure of 75KPA. Determine the thermal efficiency of the cycle. **(08 Marks)**

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