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18AE/AS32

Third Semester B.E. Degree Examination, Dec.2023/Jan.2024
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 / Charts / tables is permitted.*

Module-1

1 a. Explain the following with suitable examples :
i) Open system ii) Closed system iii) Isolated system. **(08 Marks)**

b. A readings t_A and t_B of two Celsius thermometer A and B agree at ice point and stream point but else where they are related by the equation : $t_A = L + mt_B + nt_B^2$, where L, m and b are constant when both the thermometer are immersed in oil. A indicates 55°C and B indicates 50°C, determine the values of constants L, m and n and also the temperature readings on thermometer A when B reads 25°C. **(12 Marks)**

OR

2 a. With the help of neat sketch, prove that free expansion has zero work transfer. **(10 Marks)**

b. A spherical balloon has a diameter of 20cm and it contains air at a pressure of 1.5bar during a certain process the diameter of a balloon increases to 30cm during which the pressure is proportional to diameter. Calculate the work done by the air inside the balloon during the process. **(10 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

$$n = \frac{\ell n\left(P_2/P_1\right)}{\ell n\left(V_1/V_2\right)}.$$

(04 Marks)

c. A cylinder contains 1 kg of a certain fluid at an initial pressure of 20bar. The fluid is allowed to expand reversibility 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 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
$C_1 = 300$ m/sec	$C_2 = 150$ m/sec
$P_1 = 6.2$ bar	$P_2 = 1.3$ bar
$u_1 = 2100$ kJ/kg	$u_2 = 1500$ kJ/kg
$V_i = 0.37 m^3/kg$	$V_2 = 1.2 m^3/kg$

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 Clausuis 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 Clausuis 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 $T_L = 300K$, 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) Pure substance ii) Triple point iii) Critical point. **(06 Marks)**

b. Sketch and explain P – T diagram of water. **(06 Marks)**

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

OR

8 a. Show that the change in entropy when a perfect gas undergoes a polytropic change PV^n = constant is given

$$S_2 - S_1 = \frac{\nu - n}{n-1} C_v \, \ell_n \left(\frac{T_1}{T_2}\right).$$ **(10 Marks)**

b. Determine the change in entropy if 1 kg of perfect gas which is compressed according to the law $PV^{1.3} = C$ from initial pressure of 1 bar and volume of $0.85 m^3$ to a final volume of $0.5 m^3$. Find also the work done and heat supplied during the process. Assume $C_V = 0.7$ kJ/kg K and $\nu = 1.4$. **(10 Marks)**

Module-5

9 a. With the help of P – V and T- S 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 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 $T_2 = T_4 = \sqrt{T_1 \; T_3}$.

i) If the temperature limits 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 350°C and is condensed in the condenser at a pressure of 75KPa. Determine the thermal efficiency of the cycle. **(08 Marks)**

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