CBCS SCHEME

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21AE/AS43

Fourth Semester B.E. Degree Examination, Dec.2023/Jan.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 Thermodynamics data handbook and Steam Tables is permitted.

Module-1

1 a. Define the following terms:
(i) Intensive and extensive properties (ii) Control value and control surface
(iii) Thermodynamic state and process (iv) Thermodynamic equilibrium.
Use representative sketches if any. **(10 Marks)**

b. The temperature scale of a certain thermometer is given by the relation $t = a\ln(x) + b$, where a and b are constants, and x is fluid property of the thermometer. If at the ice point and steam point of the thermometric property (x) are found to be 1.5 and 7.5 respectively, find the corresponding temperature at a thermometric property of 3.5. **(10 Marks)**

OR

2 a. Define work and heat. Explain their sign conventions. Differentiate between them. **(10 Marks)**

b. A home cooler fan of 170 W rating and a water circulating pump of 50 W rating. If the cooler operates for 10 hrs, find the energy consumed by the cooler. **(05 Marks)**

c. Discuss in brief about shaft work and write mathematical equations to find shaft work and shaft power, if a shaft undergoes angular displacement when a constant torque T is applied to it. **(05 Marks)**

Module-2

3 a. State the First law of thermodynamics and show that 'energy as a property'. **(10 Marks)**

b. A small turbine runs an aircraft refrigeration system. Air enters turbine at 4 bar and 40°C with a velocity of 40 m/s. At the exit the air is at 1 bar, 2.5°C having a velocity of 200 m/s. If the work output of the turbine is 52 kJ/kg of air, find heat transferred/kg of air. Take $R = 0.287$ kJ/kgK, $C_p = 1.005$ kJ/kgK. **(10 Marks)**

OR

4 a. Derive steady flow energy equation from the fundamentals. State the assumptions made. **(10 Marks)**

b. An empty gas cylinder is filled with 15 kg of gas at an enthalpy of 800 kJ/kg. After filling, the pressure gauge reads 12 bar. If the final enthalpy and specific volume of the gas is 900 kJ/kg and 0.05 m^3/kg, find the heat received by the cylinder from the surroundings. Ignore KE and work interaction. **(10 Marks)**

Module-3

5 a. A heat pump is a device used to convert work into heat. With a schematic block diagram represent a heat pump (reversed heat engine) working between a source and sink and show that COP of heat pump, $COP_{HP} = 1 +$ COP of refrigerator. **(10 Marks)**

b. A reversible heat engine operates between three heat reservoirs 1000 K, 800 K and 600 K and rejects heat to a reservoir at 300 K, the engine develops 10 KW and rejects 412 kJ/min. If heat supplied by the reservoir at 1000 K is 60% of the heat supplied by the reservoir at 600 K, find the quantity of heat supplied by each reservoir. **(10 Marks)**

OR

6 a. State and prove Clausius inequality. **(10 Marks)**

b. An inventor claims to have designed a heat engine that absorbs 260 kJ of energy as heat from a reservoir at 52°C and delivers 72 kJ of work. His claim includes that the engine rejects 100 kJ and 88 kJ of energy to reservoirs at 27°C and 2°C respectively. Verify the claim. How is the temperature of the source to be altered in accordance with the verification, if necessary? **(10 Marks)**

Module-4

7 a. With reference to ideal gas mixtures, define the following terms:
(i) Mass fraction (ii) Mole fraction
Use simple mathematical approach to calculate each of them. **(10 Marks)**

b. Define compressibility factor. Determine the compressibility factor of nitrogen at 10 MPa and –80°C and at 0.5 MPa and 35°C. Take the following properties of N_2. $T_c = 126.20$ K; $P_c = 3.398$ MPa, $\overline{V_c} = 8.99 \times 10^2$ m³/kg.mol. **(10 Marks)**

OR

8 a. With reference to water construct a p-h diagram and label the following regions:
(i) Sub cooled (ii) Saturated vapour (iii) Mixture of liquid and vapour
(iv) Superheated vapour (v) Critical point. Define each term. **(10 Marks)**

b. Using the relation, $C_p - C_v = T\left(\frac{\partial V}{\partial T}\right)_P\left(\frac{\partial P}{\partial T}\right)_V$ for an ideal gas, show that $C_p - C_v = R$. **(10 Marks)**

Module-5

9 a. For an air standard Otto cycle show that the thermal efficiency is given by $\eta = 1 - \frac{1}{r^{(\gamma-1)}}$ where r is the volume compression ratio. **(10 Marks)**

b. An engine working on Carnot cycle rejects heat to the sink and 32°C and has a thermal efficiency of 52.3%. The work output from the engine is 120 kJ. Determine:
(i) Maximum working temperature of the engine
(ii) The heat added in kJ
(iii) The change in entropy during heat rejection. **(10 Marks)**

OR

10 a. Sketch and explain the working of an ideal reheat cycle. Represent all the processes on a T-S or h-s diagram. **(10 Marks)**

b. A steam power plant working on Rankine cycle gets steam at 40 bar and dry saturated. After doing work, the steam is exhausted at 0.3 bar. If the steam flow rate is 60 kg/s, find:
(i) pump work (ii) turbine work (iii) cycle efficiency (iv) heat flow in condenser
Take: At 40 bar, dry saturation steam: $h_1 = 2800.3$ kJ/kg, $s_1 = 6.0685$ kJ/kg
At 0.3 bar: $h_f = 289.3$ kJ/kg, $h_{fg} = 2336.1$ kJ/kg, $v_{f_3} = 0.001$ m³/kg,
$s_{f_2} = 0.9441$ kJ/kg.K, $\beta_{fg_2} = 6.8254$ kJ/kgK **(10 Marks)**

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