CBCS SCHEME

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17AE33

Third Semester B.E. Degree Examination, June/July 2023
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 handbook is permitted.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-1

1 a. What is thermodynamic system? Explain the types of thermodynamic system. **(05 Marks)**

b. State zeroth law of thermodynamics and extract the concept of temperature from it. **(05 Marks)**

c. Isaac Newton proposed a new temperature scale. On this scale, the temperature was a linear function of Celsius scale. The reading on this at ice point (0°C) and normal human body temperature (37°C) were 0°N and 12°N respectively. Obtain the relation between the Newton scale and the Celsius scale. **(10 Marks)**

OR

2 a. Distinguish between Heat and Work. **(04 Marks)**

b. Derive an expression for displacement work in a polytropic process PV^n = constant. Show on a P-V diagram, four expansion process for n = 0, n = 1, n = 1.4 and n = ∞. Name each of the process. **(08 Marks)**

c. A spherical balloon has an initial diameter of 25 cm and contains air at 1.2 bar. When heated, the diameter increases to 30 cm. During heating, the pressure is found to be proportional to diameter. Determine the work done. **(08 Marks)**

Module-2

3 a. Write the first law of thermodynamics for any process in (i) Closed system (ii) Open system. **(04 Marks)**

b. Explain Joules experiment with a neat sketch. **(08 Marks)**

c. Prove that internal energy is a property of the system. **(08 Marks)**

OR

4 a. Write the steady flow energy equation for an open system and explain the terms involved in it. Simplify SFEE for the following system: (i) Steam turbine (ii) Nozzle **(10 Marks)**

b. The properties of a certain fluid are related as follows:
U = 196 + 0.718 T and PV = 0.287 (T + 273), U is specific internal energy in kJ/kg, P is pressure in kN/m^2, V is specific volume in m^3/kg. A closed system consisting of 2 kg of this fluid expands in an irreversible adiabatic process related by $PV^{1.2}$ = C. The initial conditions are 1 MPa and 200°C and final pressure is 100 kPa. Determine the work transfer and change in internal energy for the process. **(10 Marks)**

Module-3

5 a. Represent schematically and give performance equation for (i) Heat engine (ii) Refrigerator (iii) Heat pump. Prove that $(COP)_{HP} = (COP)_{Refrigerator} + 1$. **(04 Marks)**

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

c. A reversible refrigerator operates between 35°C and –15°C. If heat rejected to 35°C is 1.5 KW, determine the rate of which heat is leaking into refrigerator. **(08 Marks)**

OR

6 a. Prove that entropy is a property of a system. **(05 Marks)**

b. Define Clausius inequality and entropy of a system. Show that for an irreversible process, $ds \geq \frac{\delta Q}{T}$. **(10 Marks)**

c. One kg of water at 273 K is heated to 373 K by first bringing it in contact with reservoir at 323 K and then reservoir at 373 K. What is the change in entropy of the universe? **(05 Marks)**

Module-4

7 a. Derive Vander Waal's constants in terms of critical properties. **(06 Marks)**

b. A balloon of spherical shape 6m in diameter is filled with hydrogen gas at a pressure of 1 bar absolute and 20°C. At a later time, the pressure of the gas is 94% of its original value of pressure at the same temperature.

(i) What mass of the original gas must have escaped if the dimensions of the balloon is not changed?

(ii) Determine the amount of heat removed to cause the same drop in pressure at constant volume.

Take $C_V = 10400$ J/kgK **(06 Marks)**

c. Write Maxwell relations and explain the terms involved. **(08 Marks)**

OR

8 a. Explain the law of corresponding states with a generalized compressibility chart. **(06 Marks)**

b. The volumetric analysis of a gaseous mixture yields the following results:
$CO_2 = 12\%$, $N_2 = 82\%$, $O_2 = 4\%$, $CO = 2\%$
Determine the analysis on mass basis, the molecular weight and gas constant for the mixture. Assume the ideal gas behaviour. **(06 Marks)**

c. Define and explain : (i) Critical Point (ii) Triple Point (iii) Dryness fraction (iv) Latent heat **(08 Marks)**

Module-5

9 a. With the help of T-S and P-V diagram, evaluate an expression for the air standard efficiency of a Diesel Cycle. **(10 Marks)**

b. A 40 MW steam power plant working on Rankine cycle operates between boiler pressure of 4 MPa and condenser pressure of 10 kPa. The steam leaves the boiler and enters the steam turbine at 400°C. The isentropic efficiency of the steam turbine is 85%. Determine:

(i) Cycle efficiency
(ii) Quality of steam from turbine
(iii) Steam flow rate in kg per hr.

Consider pump work. **(10 Marks)**

OR

10 a. Sketch the flow diagram and T-S diagram of a reheat vapour cycle and evaluate an expression for reheat cycle efficiency. **(10 Marks)**

b. Draw a neat diagram and T-S diagram for a practical regenerative Rankine cycle with open feed water heater. Also write the energy balance equation. **(10 Marks)**

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