CBCS SCHEME

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15AE33

Third Semester B.E. Degree Examination, Jan./Feb. 2023

Aerothermodynamics

Time: 3 hrs. Max. Marks: 80

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

Module-1

1 a. Define the following:
(i) System and surrounding
(ii) Quasi-static process
(iii) Intensive property and extensive property **(06 Marks)**

b. Define thermodynamic equilibrium state. **(05 Marks)**

c. 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 the thermometer property of the fluid in the thermometer. If the ice and steam point of the thermometric property are found to be 1.5 and 7.5 respectively, what will be the temperature corresponding to the thermometric property 3.5? **(05 Marks)**

OR

2 a. Derive an expression for workdone for following process:
(i) Constant volume (ii) Constant pressure
(iii) Isothermal process (iv) Polytropic process **(08 Marks)**

b. A simple magnetic substance is one involving only magnetic displacement work; i.e., a change in magnetization of the substance in the presence of a magnetic field. For such a substance undergoing a quasi-static process at constant volume, the displacement work is given by $dW = -C_o H dM$ where H = magnetic field intensity, M = magnetization and C_o = a proportionality constant. For a first approximation, assume that magnetization is proportional to the magnetic field divided by the temperature of the magnetic substance. Determine the work done in an isothermal process when the magnetization changes from M_1 to M_2. What would be the work done if temperature varies from T_1 to T_2 and the magnetic field intensity is constant? **(08 Marks)**

Module-2

3 a. Define enthalpy. Show that internal energy is a property. **(08 Marks)**

b. A perfect gas flow through a nozzle where it expands in a reversible adiabatic manner. The inlet conditions are 30 bar, 600°C, 40 m/s. At exit the pressure is 3 bar. Determine the exit velocity and exit area if the flow rate is 4 kg/s. Take R = 190 J/kgK, $\gamma = 1.35$. **(08 Marks)**

OR

4 a. Define specific heat at constant volume and constant pressure. **(04 Marks)**

b. List the applications of steady flow energy equation and explain any one. **(04 Marks)**

c. A centrifugal compressor delivers 20 kg/min of air. Air enters the compressor at 5 m/s, 100 kPa and leaves at 9 m/s, 600 kPa. Heat lost to the surroundings during this process is 10 kJ/s. If the increase in enthalpy of the fluid is 180 kJ/kg and inlet and outlet specific volume of air are 0.5 m^3/kg and 0.16 m^3/kg respectively, determine the power of the motor to drive the compressor in HP and the ratio of inlet pipe diameter to the outlet pipe diameter. Assume zero elevation difference. **(08 Marks)**

Module-3

5 a. Write the Kelvin-Plancks and Clausius statement of second law of thermodynamics. **(06 Marks)**

b. Explain reversible and irreversible cycle. **(04 Marks)**

c. A reversible heat pump is used for heating a building in the winter season. The heat is absorbed from the earth by a fluid circulating in buried pipes and delivered to the building to maintain the temperature at 26°C. Determine the amount of heat supplied to the building if 2 KW-hr of electrical energy is needed to operate the heat pump. Assume the inside earth temperature is 4°C. **(06 Marks)**

OR

6 a. With usual notations, prove Clausius inequality. **(08 Marks)**

b. 5 kg of water at 303 K is mixed with 2 kg of ice at 273 K. The system is open to atmosphere. Assuming the process of mixing as adiabatic, find the temperature of the mixture and change in entropy. **(08 Marks)**

Module-4

7 a. With the help of P-T and P-V diagram, explain triple point and critical point. **(05 Marks)**

b. With a neat sketch, explain (i) Latent heat (ii) Degree of superheat **(05 Marks)**

c. Steam from a boiler is delivered at 15 bar absolute and dryness fraction of 0.85 into a steam super heater where an additional heat is added at constant pressure. Steam temperature now increases to 573 K. Determine amount of heat added and change in internal energy for unit mass of steam. **(06 Marks)**

OR

8 a. Derive Maxwell relations equation. **(05 Marks)**

b. Internal energy of a perfect gas is a function of temperature only. Using Maxwell relations give a mathematical proof of this statement. **(05 Marks)**

c. A perfect gas has C_p = 1.809 and C_V = 1.507 kJ/kgK. Find its molecular weight and gas constant. A constant volume chamber of 0.5 m^3 capacity contains 4 kg of this gas at 7°C. Heat is transferred to the gas until the temperature is 100°C. Find the workdone, the heat transferred and the changes in internal energy, enthalpy and entropy. **(06 Marks)**

Module-5

9 a. Derive the expression for the air standard efficiency of an Otto cycle. **(08 Marks)**

b. In an air standard diesel cycle, the compression ratio is 16. At the beginning of isentropic compression, the temperature is 15°C and pressure is 0.1 MPa. Heat is added until the temperature at the end of the constant pressure process is 1480°C. Calculate:
(i) Cut-off ratio (ii) Heat supplied per kg of air (iii) Cycle efficiency **(08 Marks)**

OR

10 a. Derive an expression for Rankine cycle with P-V and T-S diagram. **(08 Marks)**

b. Explain Reheat and Regeneration cycle, with neat sketch. **(08 Marks)**

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