CBCS Scheme

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15AE33

Third Semester B.E. Degree Examination, Dec.2017/Jan.2018
Aerothermodynamics

Time: 3 hrs. Max. Marks: 80

Note: ***1. Answer FIVE full questions, choosing one full question from each module.***
2. Use of thermodynamic data handbook/charts/tables is permitted.

Module-1

1 a. With a neat diagram, explain the working of constant volume gas thermometer for the measurement of temperature. **(08 Marks)**

b. In 1709, Sir Issac 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. **(08 Marks)**

OR

2 a. Starting from a convenient common state point on a PV diagram, show the four expansion processes for $n = 0$, $n = 1$, $n = r$ and $n = \infty$. What are these processes called and also discuss the work done during these processes? **(08 Marks)**

b. 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. Calculate the work done. **(08 Marks)**

Module-2

3 a. Show that internal energy is a property of the system. **(08 Marks)**

b. The properties of a certain fluid are related as follows: $U = 196 + 0.718T$ 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. **(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 systems: i) steam turbine, ii) nozzle. **(08 Marks)**

b. A vertical cylinder fitted with a frictionless piston, contains gas at pressure 200 kN/m^2. The upper surface of piston is exposed to atmosphere. The gas executed a cycle by undergoing the following process in sequence.

i) With the cylinder insulated, 1.2 kJ of stirring work is done on the gas by a paddle wheel, projecting through cylinder wall. As a result, the gas temperature rises and piston moves slowly upwards. The increase in volume is 0.0028 m^3.

ii) With the insulation removed and paddle wheel stationary, heat transfer from gas restores gas to original state.

Find work during process (i) and (ii) heat during process (ii). **(08 Marks)**

Module-3

5 a. State the Kelvin-Plank and Clausius statements of the second law of thermodynamics and show that the violation of the former results in the violation of the later. (08 Marks)

b. Two reversible engines A and B are in series. A receives 200 kJ from HTR at 421°C, B rejects heat to sink at 4.4°C. If the work of A is twice of B, find intermediate temperature, efficiency of A and B, heat rejected to sink. (08 Marks)

OR

6 a. State and prove Clausius inequality. What is the significance of Clausius inequality? (08 Marks)

b. 10 gram of water at 20°C is converted into ice at −10°C in a constant pressure process of one atmosphere, calculate change in entropy for the process assuming that C_{pw} = 4.187 kJ/kg.K for ice half of that of water. (08 Marks)

Module-4

7 a. Define: i) Critical point, ii) Tripple point, iii) Dryness fraction, iv) Pure substance. (08 Marks)

b. Derive Vander Waal's constants in terms of critical properties. (08 Marks)

OR

8 a. Write Maxwell relations and explain the terms involved. (08 Marks)

b. A rigid vessel of volume 0.3 m^3 contains 10 kg of air at 300 K. Determine the pressure that would be exerted by air on the vessel, using (i) Perfect gas equation, (ii) Vander Waal's equation. Take for air, R = 287.1 J/kg.K, molecular weight = 28.96, Vander Waal's constants, a = 135.8 kN $m^4/(\text{kg mol})^2$, b = 0.0365 m^3/kg.mol. (08 Marks)

Module-5

9 a. With the help of P-V and T-S diagrams, derive an expression for the air standard efficiency of a petrol engine (Otto cycle). (08 Marks)

b. The minimum pressure and temperature of the air standard Carnot cycle are 1 bar and 15°C respectively. The pressure after isothermal compression is 3.5 bar and the pressure after isentropic compression is 10.5 bar. Determine: (i) efficiency, (ii) mean effective pressure and the power developed, if the Carnot engine makes 2 cycle per second. Take for air, R = 0.287 kJ/kgK and r = 1.4. (08 Marks)

OR

10 a. Draw a neat line diagram and T-S diagram for a practical regenerative Rankine cycle with open feed water heater. Also write the energy balance equation. (08 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 steam turbine is 85%. Determine:

i) The cycle efficiency

ii) The quality of exhaust steam from the turbine

iii) Steam flow rate in kg/hr considering pump work.

Properties of steam,

Pressure (bar)	t_s (°C)	Specific volume (m^3/kg)		Specific enthalpy (kJ/kg)			Specific entropy (kJ/kg.K)		
		V_f	V_g	h_f	h_{fg}	h_g	S_f	S_{fg}	S_g
40	250.3	0.00125	0.049	1087.4	1712.9	2800.3	2.797	3.272	6.069
0.1	45.83	0.0010	14.675	191.8	2392.9	2584.7	0.649	7.502	8.151

(08 Marks)

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