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P.E.S. College of Engineering, Mandy - 571 401

(An Autonomous Institution affiliated to VTU, Belagavi)

Third Semester, B.E. - Mechanical Engineering

Semester End Examination; Dec. - 2019

Basic Thermodynamics

Time: 3 hrs *Max. Marks: 100*

***Note**: Answer **FIVE** full questions, selecting **ONE** full question from each unit.*

UNIT - I

1 a. Distinguish between the following with examples:
i) Intensive and Extensive properties
ii) Open and Closed system
iii) Path function and Point function — 6

b. Fahrenheit and centigrade thermometers are both immersed in a fluid. Fahrenheit reading is numerically twice that of centigrade reading. What are the temperatures of the fluid expressed as °R and °K. — 8

c. What is meant by Thermodynamic equilibrium? Explain Mechanical, Chemical and Thermal equilibrium. — 6

2 a. List out the similarities and dissimilarities between work and heat. — 4

b. Obtain an expression for displacement work done in isothermal and polytrophic process. — 8

c. A gas system has mass *m* occupying volume '*V*' at a pressure of *P* and temperature *T*. These properties are related by the equation $[P+\frac{a}{V^2}](V-b)=mRT$.

Where *a*, *b* and *R* are the constants. Obtain an expression for the displacement work done by the gas system during a constant temperature process where the gas expands from V_1 to V_2. Calculate the work for 10 kg of gas expanding from 1 m^3 to 10 m^3 at a temperature of 293 K. Assume $a=15.7\times10^4, b=1.07\times10^{-2}, R=0.278\ kJ/kg-K$. — 8

UNIT - II

3 a. State first law of the thermodynamics and derive an expression for the same for a system undergoing a thermodynamic cycle and prove that energy is a property of a system. — 10

b. A fluid system, contained in a piston and cylinder machine, passes through a complete cycle of four processes. During the cycle, the sum of all heat transferred during a cycle is −170 kJ. The system completes 100 cycles per minute. Complete the following table showing calculation for each process and compute the net rate of work output in kW. — 10

Process	Q (kJ/min)	W (kJ/min)	ΔE (kJ/min)
1 - 2	0	2170	--
2 - 3	21000	0	--
3 - 4	–2100	-	–36600
4 - 1	-	-	-

Contd…2

4a. What is meant by Steady Flow process? Derive steady flow energy equation for a control volume and state the assumptions made. 10

b. Air at a temperature of 15°C passes through a heat exchanger at a velocity of 30 m/s where its temperature raised to 800°C. It then enters a turbine with the same velocity of 30 m/s and expands until the temperature falls to 650°C. On leaving the turbine, the air is taken at a velocity of 60 m/s to a nozzle where it expands until the temperature has fallen to 500°C. If the air flow rate is 2 kg/s, calculate; 10

i) The rate of heat transfer to the air in the heat exchanger

ii) The power output from the turbine, assuming no heat loss

iii) The velocity at the exit of the nozzle, assuming no heat loss

Take the enthalpy of air as $h = C_p t$, where 'C_p'is the specific heat equal to 1.005 kJ / kg-K and 't' is the temperature

UNIT - III

5 a. With a neat sketch explain the working of combined separating and throttling calorimeter to determine the dryness fraction of wet steam. 8

b. Explain Pressure-Temperature diagram for a pure substance. 5

c. Steam initially at 1.5 MPa , 300°C expands reversibly and adiabatically in a steam turbine to 10 kg. Determine the ideal work output of the turbine per kg of steam. 7

6 a. Explain the phase change of a pure substance with necessary diagram (T - V diagram). 8

b. Define the following terms: 4

i) Pure substance ii) Dryness fraction

c. The following observations were taken with a separating and a throttling calorimeter arranged in series: water separated = 2 kg, steam discharged from the throttling calorimeter = 20.5 kg, temperature of steam after throttling = 110°C, initial pressure = 12 bar, barometer reading = 760 mm of Hg, final pressure = 5 mm of Hg. Estimate the quality of steam supplied. 8

UNIT - IV

7 a. What are the limitations of I-law of thermodynamics, State the Kelvin-Planck and Clausius statement of II law of thermodynamics. Show that Kelvin-Planck statement is equivalent to Clausius statement. 10

b. A heat engine operates between reservoirs at temperature of 177°C and 27°C. Find the efficiency of the engine. Evaluate the heat transfer to the 27°C reservoir if the work output from the engine is 2.7 kJ/s.

If the above engine is operated as a heat pump between the same reservoirs, evaluate COP of heat pump and power required to run the pump when the heat transfer rate from 27°C reservoir is 4.5 kJ/s. 6

Contd…3

c. A reversible engine operates between temperature limits "T_1", "T" where "T_1" is higher temperature. The heat rejected by the engine is received by the second engine at the same temperature "T" which in turn rejects heat to a sink at temperature "T_2" If the engine has equal efficiencies show that , $T = \sqrt{(T_1 * T_2)}$ — 4

8 a. List the factors which make the process irreversible and explain any one of them. — 5

b. A heat engine in a satellite operates between a hot reservoir at "T_1" and a rotating panel at "T_2". The radiation from the panel is proportional to its area and to $(T_2)^4$. For a given work output and the value of "T_1". Show that the area of the panel will be minimum when $T_2/T_1 = 0.75$. Determine the minimum area of the panel for an output of 1 kW if the constant of proportionality is 5.68×10^{-8} W/ m^2K^4 and "T_1" is 1000 K. — 8

c. Define Carnot cycle. Write the P-V and T-S diagram for Carnot cycle and explain each process in the cycle. — 7

UNIT - V

9 a. State and prove Clausius Inequality . — 10

b. A fluid undergoes a reversible adiabatic compression from 4 bar , 0.3 m^3 to 0.08 m^3 according to the law $PV^{1.25}$= constant Detemine:

i) Change in enthalpy
ii) Change in internal energy
iii) Change in entropy
iv) Heat transfer
v) Work transfer — 10

10 a. Derive an expression for entropy change for constant volume and isothermal processes. — 8

b. Explain principle of increase of entropy. — 5

c. A reversible heat engine is supplied with heat from two constant temperature sources at 900 K and 600 K and rejects energy to a constant temperature sink at 300 K. Assuming the engine is developing the 84 kW and rejecting 56 kJ/s of heat , calculate the heat supplied by each source and efficiency of the engine. — 7

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