CBCS SCHEME

USN

18AE/AS32

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 data handbook is permitted.

Module-1

1 a. Distinguish between:
(i) Intensive and extensive properties
(ii) Thermal and thermodynamic equilibrium
(iii) Microscopic and Macroscopic approach **(06 Marks)**

b. Explain different thermodynamic system. **(05 Marks)**

c. Sir Isaac Newton proposed a linear temperature scale wherein the ice-point and the normal human body temperature were assumed as the two fixed points and assigned the temperature of 0° and 12° respectively. If the temperature of the human body on the Fahrenheit scale is 98°F, obtain the relation between the Newton's scale and the Fahrenheit scale. **(09 Marks)**

OR

2 a. List out the similarities and dissimilarities between work and heat. **(05 Marks)**

b. Give the sign conversion of heat and work. **(05 Marks)**

c. An engineering student suggest the most economical process when it is desired to compress one mole of air ($\gamma = 1.4$). From an initial state of 300 K to 1 bar to a final state of 300 K and 10 bar from among the following process.
(i) Isothermal
(ii) Cooling at constant pressure followed by heating at constant volume.
(iii) Adiabatic compression followed by cooling at constant volume.
(iv) Heating at constant volume followed by cooling at constant temperature. **(10 Marks)**

Module-2

3 a. Explain the word "specific heat" at constant pressure and constant volume. **(04 Marks)**

b. Write down the Steady Flow Energy equation and explain any two applications of SFEE. **(06 Marks)**

c. A piston and cylinder machine contains a fluid system, which passes through a complete cycle of four processes. During a cycle, the sum of all heat transfer is –170 kJ. The system completes 100 cycles per min. Complete the following table showing the method for each item, and compute the net rate of work output in KW.

Process	Q (kJ/min)	W(kJ/min)	ΔE(kJ/min)
a – b	0	2,170	-
b – c	21,000	0	-
c – d	–2,100	-	–36,600
d – a	-	-	-

(10 Marks)

OR

4 a. State first law of thermodynamics for a non-cyclic process and show that internal energy is a property of a system. **(10 Marks)**

b. In a gas turbine the gas enters at the rate of 5 kg/s with a velocity of 50 m/s and enthalpy 900 kJ/kg and leaves turbine with a velocity of 150 m/s and enthalpy 400 kJ/kg. Loss of heat from the gases to surroundings is 25 kJ/kg. Assume for the gas R = 0.285 kJ/kg.K and C_p = 1.004 kJ/kg.K and inlet conditions at 100 kPa and 27°C. Determine the power output of the turbine and diameter of inlet pipe. **(10 Marks)**

Module-3

5 a. Write the Kelvin-Planck's and Clausius statement of second law of thermodynamics and prove that they are equivalent. **(10 Marks)**

b. What do you mean by PMM-I and PMM-II? **(04 Marks)**

c. An inventor claims that his petrol engine operating between the temperatures 2000°C and 600°C will produce 0.736 KW-hr consuming 0.12 kg of petrol of 46046 kJ/kg calorific value. Check the validity of his claim. **(06 Marks)**

OR

6 a. Apply the Clausius inequality for a system undergoing an irreversible cyclic change and show that the entropy change of the system is given by $ds \geq \frac{\delta Q}{T}$. **(10 Marks)**

b. One kg of air at 1 bar pressure and 15°C is heated in a cylinder under constant pressure conditions to 150°C. Find the final volume, the work done and the changes in internal energy, enthalpy and entropy. **(10 Marks)**

Module-4

7 a. Explain the following with neat sketch:
(i) Sub-cooled liquid state
(ii) Dry saturation curve
(iii) Critical point
(iv) Latent heat
(v) Superheated steam **(10 Marks)**

b. Wet steam initially at a pressure of 3 bar 0.8 dry is heated so that the pressure rises to 4 bar when the steam becomes saturated. The steam is then compressed isentropically to 20 bar. Find the final temperature, and heat and work transfer during isentropic compression. **(10 Marks)**

OR

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

b. Show that entropy of an ideal gas is given by equation $S_2 - S_1 = C_p \ln\left(\frac{V_2}{V_1}\right) + C_V \ln\left(\frac{P_2}{P_1}\right)$ starting from the general property relations Tds = du + PdV and Tds = dh - VdP. **(10 Marks)**

c. A compressor discharges air to a $2m^3$ capacity tank having an initial pressure of 600 kPa and temperature of 200°C. Due to entrance of air, the tank cools and their internal energy decreases by 200 kJ/kg. Determine workdone, final temperature and heat loss. **(05 Marks)**

Module-5

9 a. With the help of P-V and T-S diagram, derive an expression for efficiency of diesel cycle. **(10 Marks)**

b. The pressure and temperature at the beginning of compression in an air standard Otto cycle are 102 kPa and 315 K. Heat is added during the process at the rate of 250 kJ/kg of air and air is used with a compression ratio of 9. Assuming $\gamma = 1.4$ and R = 287 J/kg.K for air, determine:
   (i) The thermal efficiency of the cycle.
   (ii) The maximum cycle temperature
   (iii) The maximum cycle pressure **(10 Marks)**

OR

10 a. With a neat sketch, explain reheat cycle and regenerative 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) The cycle efficiency
   (ii) The quality of exhaust steam from the turbine
   (iii) The steam flow rate in kg per hour, consider pump work. **(10 Marks)**

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