Ref. No.: Ex/CE/ES/B/ME/T/221/2025

B.E. CIVIL ENGINEERING
SECOND YEAR SECOND SEMESTER - 2025
Subject: THERMODYNAMICS & HEAT POWER

Time: 3 hours **Full Marks: 100**

(All symbols carry their usual meanings/use of the steam table is allowed)

GROUP-A (COMPULSORY)

Q.1 Answer any 5 (five) questions. $2\times5 = 10$

(a) Explain the concept of continuum.
(b) Define dryness fraction.
(c) What is PMM1?
(d) What is PMM2?
(e) Define the critical point.
(f) Define triple point.
(g) State the Carnot theorem.

Q.2 Answer any 5 (five) questions. $3\times5 = 15$

(a) Define system and classify it.
(b) Define property and classify.
(c) Compare heat and work.
(d) Explain: thermodynamic equilibrium.
(e) In case of an ideal gas, show that $C_p - C_v = R$.
(f) Show that throttling is an isenthalpic process.
(g) For an isentropic process, show that $Pv^\gamma = C$
(h) State the entropy principle.

GROUP-B (ANSWER ANY FIVE QUESTIONS)

Q.3 (a) State the 1st law of thermodynamics for a cycle. Hence, show that stored/internal energy is a property of system. 6

(b) The internal energy of a substance varies as u = 3.56 Pv + 84 where u is in kJ/kg, P is in kPa, and v is in m^3/kg. A system comprises of 3kg such substance that expands from an initial state (500 kPa, 0.22 m^3) to a final pressure of 100 kPa in a process that follows $Pv^{1.2}$ = constant. Find the net heat and work transfers, and the change in internal energy by the process. 9

Q.4 (a) In case of an open system, derive an expression for the steady-state energy equation. 8

(b) A nozzle is used to increase the velocity of a steadily flowing stream. At the inlet of a horizontal nozzle, enthalpy and velocity are 2761 kJ/kg and 50 m/s, respectively. Find the velocity at the exit of the nozzle if there is a heat loss of 0.5 kJ/kg from the nozzle during expansion. State assumptions, if required. 7

Q.5 (a) State the Kelvin-Plank and Clausius statements with neat sketches. 6

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	(b)	Starting from Clausius inequility, show that entropy is a property of system.	9
Q.6		A heat pump working on the reversed Carnot cycle takes in heat from a reservoir at 5°C and delivers heat to a reservoir at 60°C. The heat pump is driven by a reversible heat engine which takes in heat from a reservoir at 840°C and rejects heat to the reservoir at 60°C. The reversible engine also drives another machine that absorbs 30 kW. If the heat pump extracts 17kJ/s from the 5°C reservoir, determine (i) rate of heat supply from the 840°C source, and (ii) rate of heat rejection to the 60°C sink.	15
Q.7	(a)	Plot a constant temperature line on P-v plane for pure substances, labelling all states from subcooled liquid to superheated vapour. Define the degree of superheating.	4
	(b)	Plot a constant pressure line and a constant volume line for an ideal gas on the same T-s plane. Which one is steeper and why?	4
	(c)	A fluid undergoes a reversible adiabatic compression from 0.5MPa, 0.2m^3 to 0.05m^3 according to $PV^{1.3}$ = constant. Determine the net change in entropy. C_p = 1.005 kJ/kg.K and R = 0.287 kJ/kg.K	7
Q.8		Consider two bodies of identical mass m and specific heat c. The first body is initially at an absolute temperature T_1, while the second one is at a lower absolute temperature T_2. If the bodies are brought in thermal contact, find the final temperature of the two bodies. Calculate the entropy change in each body and show that the net entropy change is positive.	15
Q:9		For each of the below cases, determine if the heat engine satisfies the first law (energy equation) and if it violates the second law. a. $Q_H = 6$ kW, $\dot{Q}_L = 4$ kW, $\dot{W} = 2$ kW b. $Q_H = 6$ kW, $\dot{Q}_L = 0$ kW, $\dot{W} = 6$ kW c. $Q_H = 6$ kW, $\dot{Q}_L = 2$ kW, $\dot{W} = 5$ kW d. $Q_H = 6$ kW, $\dot{Q}_L = 6$ kW, $\dot{W} = 0$ kW e. $Q_H = 6$ kW, $\dot{Q}_L = 3$ kW, $\dot{W} = 4$ kW	15

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