Ref. No.: Ex/CE/ES/B/ME/T/221 /2023

BACHELOR OF ENGINEERING (CIVIL ENGINEERING) EXAMINATION
SECOND YEAR, SECOND SEMESTER - 2023

Subject: THERMODYNAMICS & HEAT POWER

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

Use of Steam Table is permissible.
All symbols carry their usual meanings. Note assumptions, if required.

Answer any FIVE questions.

Q.1	(a)	Briefly explain the term 'thermodynamic equilibrium'.	(5)
	(b)	Define intensive and extensive properties of a system with examples. Does a specific extensive property refer to an intensive property? Explain.	(2+1)
	(c)	Define a system and its types with neat sketches. In case of an open system, identification of a control volume is necessary. Why?	(4+1)
	(d)	Define specific heats. In case of an ideal gas, show that $C_P - C_v = R$.	(2+2)
	(e)	Differentiate between a process and a path.	(1)
	(f)	Why an adiabatic reversible process is also known as an isentropic process?	(2)
Q.2	(a)	Define critical point for a pure substance. Show the point in a P-v plane.	(1+1)
	(b)	Define triple point for a pure substance. Show triple point in a P-T plane.	(1+1)
	(c)	Define: saturated liquid, dry saturated steam and dryness fraction.	(1+1+2)
	(d)	(i) Plot a constant pressure line in T-v plane for a pure substance labelling all states from subcooled liquid to superheated vapour. (ii) Plot a constant temperature line in T-v plane for a pure substance labelling all states from sub-cooled liquid to superheated vapour.	(2+2)
	(e)	Define degree of sub-cooling and superheating of a pure substance. Show them in T-v plane.	(2+2)
	(f)	A rigid vessel having a volume of 0.6m^3 contains 3.0kg of wet steam in equilibrium at a pressure of 0.5 MPa. Calculate: (i) mass and volume of the liquid, and (ii) mass and volume of the vapour within wet steam using Steam Table.	(4)
Q.3	(a)	Define heat, work, and compare them. Transfer of electric energy in the form of current to a heater is an example of heat or work transfer?	(2+2+1)
	(b)	A fluid is contained in a cylinder by a spring-loaded frictionless piston so that pressure in the fluid is a linear function of its volume as $P = a + bV$ where a and b are constants. The internal energy of the fluid is given as $U = 42 + 3.6PV$ where U is in kJ, P in kPa, and V in m^3. The fluid changes from an initial state of 190kPa and 0.035m^3 to a final state of 420kPa and 0.075m^3 by supplying heat to the fluid. (i) Show the schematic of the system and the process on a P-V plane. Also find the (ii) values of a and b, (iii) change in internal energy, (iv) work done by the fluid, and (v) heat transfer to the fluid.	(4+2+2+4 +3)

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Q.4 (a) State the 'First Law of Thermodynamics' for a cyclic process. Hence, show that the stored energy is a property of a system. (2+8)

(b) Consider expansion of a gas following a polytropic process, i.e., $Pv^n = C$. Find a suitable expression for the work transfer during expansion of the gas. Hence, find expression of (i) related heat transfer and (ii) an equivalent specific heat of the process assuming expansion of ideal gas. (3+2+2)

(c) What is PMM1? Explain limitations of the 'First Law of Thermodynamics'. (2+1)

Q.5 (a) State the assumptions made for a steady state steady flow process. (2)

(b) Derive a standard expression for steady state energy equation in case of open system. (8)

(c) A turbine operating under steady flow conditions, receives steam at 1.5 kg/s. The steam with a specific enthalpy of 2800kJ/kg enters the turbine at a velocity of 50m/s at an elevation of 6m. It leaves the turbine at a velocity of 95m/s at an elevation of 2m having a specific enthalpy of 2300kJ/kg. Heat loss from the turbine to the surroundings is 5W. Find work done by the turbine. Plot the process in a T-s plane assuming the initial state being superheated, final state in two-phase and the expansion in the turbine being isentropic. (8+2)

Q.6 (a) Write statements of the 'Second Law of Thermodynamics'. Explain each with its schematic presentation labelling source, sink, transfer of heat and work, and the cyclic process. (2+2)

(b) Derive 'Clausius Theorem'. Hence, show that entropy is a property of system. (6+2)

(c) A reversible heat engine operates between two reservoirs at temperatures of 700°C and 50°C. The engine drives a reversible refrigerator which operates between reservoirs at temperatures of 50°C and -25°C. Heat added to heat engine is 2500kJ and net work output by the combined engine-refrigerator plant is 400kJ. Determine the heat removed from the reservoir at -25°C and head added to the reservoir at 50°C. (8)

Or

Calculate change of entropy of a 2kg of air expanding polytropically in a piston-cylinder system from 8bar and 700°C to 1.5bar. The index of expansion is 1.25.

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