B.TECH/ME/3RD SEM/MECH 2101(BACKLOG)/2021

APPLIED THERMODYNAMICS
(MECH 2101)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) A control volume refers to
(a) a fixed volume
(b) a specified mass
(c) an isolated system
(d) a closed system whose volume does not change.

(ii) In a reversible process, the entropy of the system
(a) can never decrease (b) can never increase
(c) may increase or decrease (d) will always remain constant

(iii) Volume of wet steam (per unit mass) with dryness fraction x is given by
(a) $x.v_f$
(b) $x.v_g$
(c) $v_f + x.v_{fg}$
(d) $v_g + x.v_{fg}$; Symbols have their usual meaning.

(iv) Internal energy is defined by the
(a) zeroth law of thermodynamics (b) first law of thermodynamics
(c) second law of thermodynamics (d) law of entropy.

(v) The INCORRECT statement about the characteristics of critical point of a pure substance (water) is that
(a) there is no constant temperature vaporization process
(b) it has point of inflection with zero slope
(c) the ice directly converts from solid phase to vapour phase
(d) saturated liquid and saturated vapour states are identical.

(vi) For a reciprocating compressor if the clearance increases then volumetric efficiency
(a) increases (b) remains the same
(c) decreases (d) none of these

(vii) Entropy generation for a reversible isothermal heat addition process is always
(a) positive (b) negative (c) zero (d) unpredictable

(viii) An isentropic process
(a) is always adiabatic (b) is always reversible
(c) is always frictionless (d) need not be adiabatic or reversible

(ix) The refrigerant $CHClF_2$ may be denoted as
(a) R-12 (b) R-10 (c) R-22 (d) R-50.

(x) Regenerative Cycle efficiency is
(a) always greater than simple Rankine thermal efficiency
(b) greater than simple Rankine thermal efficiency only when steam is bled at particular pressure
(c) same as simple Rankine efficiency
(d) always less than simple Rankine efficiency but specific work output is more.

Group–B

2. (a) In a system executing non-flow process, the work and heat transfer per degree change of temperature are given by:
dW/dT = 200 J/°C and dQ/dT = 160 J/°C
Calculate the change of internal energy of the system when its temperature changes from 55°C to 95°C.

(b) Referring to the following data for saturated steam, determine the specific volume and specific enthalpy of steam at 100°C having a quality of 0.6. Also find the saturated pressure at 102°C.

Temp T (°C)	Saturation pressure P (kPa)	Specific Volume (m^3/kg)		Specific Volume (m^3/kg)	
		v_f	v_g	h_f	h_g
100	101.3	0.001044	1.67290	419.02	2676.05
105	120.8	0.001047	1.41936	440.13	2683.83

6 + 6 = 12

3. (a) A Pressure cooker of 10 litre volume contains water vapour mixture at 1 bar with dryness fraction 2%. It is heated in an oven till the pressure reaches 2.5 bar. There is a dead weight that closes a vent connected to the pressure cooker, thus acting as a valve that keeps the pressure 2.5 bar or less. The heating continues and the dead weight lifts up allowing saturated vapour to go out at 2.5 bar. The process continues till the dryness fraction in the cooker reaches 80%. Calculate (i) the mass that leaves the cooker (ii) the amount of heat transfer from the oven to the pressure cooker.

(b) A rigid vessel contains 200 kg of a mixture of saturated water and saturated steam at a pressure of 2 MPa. When the mixture is heated, the state passes through critical point. Determine (a) the volume of the vessel (b) the mass of liquid and vapour initially (c) the quantity of heat addition till critical point.

7 + 5 = 12

Group - C

4. (a) One kg of water at 00C is brought in contact with a constant temperature thermal reservoir at 900 C. When water reaches 900 C, find (i) entropy change of water (ii) entropy change of the reservoir (ii) entropy change of the universe. (ii) If water was heated in two stages first from 00 C to 400 C with a 400 C temperature reservoir and then to 900 C with the 900 C reservoir, what would have been the change of entropy of the universe?

   (b) 300 W of heat is supplied at a constant temperature of 2900 C to three heat engines each.
   The heat rejection takes place at a constant temperature of 850 C. The following results were reported to have been obtained :
   (i) 215 W heat is rejected.
   (ii) 150 W heat is rejected.
   (iii) 75 W heat is rejected
   Classify the above results as reversible/irreversible/impossible cycles in each case.

6 + 6 = 12

5. (a) Source A can supply thermal energy @ 12000 kJ/min at 3200 C while source B can supply thermal energy @ 120000 kJ/min at 700 C. Which source would you choose for running a reversible heat engine to supply large amount of power if the temperature of the surrounding is 350 C?

   (b) An AC motor delivers power in a steady state, at its output shaft @ 16 KW, while it draws a current of 80 amp at 240 V AC with a power factor of 0.9. The outer surface of the motor remains steady at a temperature of 470 C. Assume the motor as the system and find out (a) the rate of heat transfer (b) the rate of entropy generation and (c) the rate of entropy transfer (all with proper signs).

6 + 6 = 12

Group - D

6. (a) A single acting reciprocating air compressor designed to deliver air at a gauge pressure of 7 bar has a stroke of 75 cm length with a clearance of 3% of stroke volume. The compressor was overhauled for the study of the effect of clearance and a distance piece 0.5 cm thick was fixed with cylinder head, thereby decreasing the clearance. The compressor was then commissioned with changed clearance. Make calculations for the percentage change in (i) volume of free air delivered (ii) power necessary to drive the compressor. Intake pressure is 1 bar.

   (b) Obtain an expression for mean effective pressure of an air standard diesel cycle in terms of initial pressure and other standard parameters.

6 + 6 = 12

7. (a) An air-standard dual cycle has a compression ratio 16 and compression begins at 1 bar, 50° C. The maximum pressure attained in the cycle is 70 bar. The heat transferred to air at constant pressure is equal to that at constant volume during

heat addition. Draw the p-V diagrams for this cycle. Find the pressures and temperatures at the cardinal points & the cycle efficiency. Given that, cv= 0.718 kJ/kg, cp = 1.005kJ/kg K.

(b) Show that the volumetric efficiency of a reciprocating compressor is given by $\eta_{vol} = 1 + C - C\left(\frac{P_2}{P_1}\right)^{1/n}$; symbols have their usual meaning

7 + 5 = 12

Group – E

8. (a) In a steam power plant, steam at 20 bar, 3600 C is expanded to 0.08 bar. It then enters a condenser, where it is condensed to saturated liquid water. The pump feeds back water into boiler. Assuming ideal processes, find (a) dryness fraction at turbine exit (b) specific turbine work (b) specific pump work (c) cycle efficiency

(b) Briefly discuss with the help of a p-h diagram the performance of a vapour compression refrigeration system for the following factors: (a) effect of decrease in suction pressure (b) effect of increase in delivery pressure

6 + 6 = 12

9. (a) In a single heater regenerative cycle, the steam enters the turbine at 30 bar, 400°C and the exhausts at a condenser pressure of 0.10 bar. The feedwater heater is adirect contact type which operates at 4 bar. Neglecting pump work , find (a) the turbine work and (b) the efficiency of the cycle.

(b) A standard vapour compression refrigerator using F-12 as the refrigerant operates between the condenser pressure of 10 bar and the evaporator pressure of 1.5 bar. The evaporator absorbs 75 kJ/min of energy as heat and the vapour is dry saturated at exit from the compressor. There is no sub-cooling in the condenser. Calculate (i) mass flow rate of refrigerant (ii) power consumed (iii) COP of the cycle.

The table of properties of Freon-12 is given below:

Pressure (bar)	Saturation temperature (°C)	Enthalpy (kJ/kg)		Entropy (kJ/kg-K)	
		Liquid	Vapour	Liquid	Vapour
10	41.7	76.8	203.65		0.682
1.5	-20.1	17.82	178.84	0.073	0.709

6 + 6 = 12

Department & Section	Submission Link
ME	**Google Classroom joining code:** 23mfcyv **Submission Link:** https://classroom.google.com/c/NDc3NzU4MTAwMTkz?cjc=23mfcyv