ENGINEERING THERMODYNAMICS
(MECH 2203)

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) Choose the correct alternative
(a) density and volume are both intensive properties
(b) specific volume and volume are both extensive properties
(c) specific enthalpy and specific volume are both extensive properties
(d) enthalpy and internal energy are both extensive properties.

(ii) Heat does not spontaneously flow from a colder body to a hotter one. Which of the following thermodynamic law states this?
(a) Zeroth law of thermodynamics
(b) First law of thermodynamics
(c) Second law of thermodynamics
(d) Third law of thermodynamics.

(iii) Which of the following statements are TRUE with respect to heat and work?
(i) They are boundary phenomena
(ii) They are exact differentials
(iii) They are path functions
(a) Both (i) and (ii) correct (b) Both (i) and (iii) correct
(c) Only (iii) correct (d) Both (ii) and (iii) correct.

(iv) Carnot cycle consists of ________
(a) two reversible isochoric and two reversible adibatic processes
(b) two reversible isothermal and two reversible adibatic processes
(c) two reversible constant pressure and two reversible adibatic processes
(d) one constant volume, one constant pressure and two reversible adibatic processes.

(v) An ideal heat heat engine working on Carnot's cycle operates between 127°C and 227°C and absorbs 6×10^4 Joules. The amount of heat converted into work is
(a) 4.8×10^4 Joules (b) 3.5×10^4 Joules
(c) 1.6×10^4 Joules (d) 1.2×10^4 Joules.

(vi) Constant pressure lines in the super-heated region of the Mollier diagram will have

(a) a positive slop (b) a negative slop
(c) zero (d) both positive and negative slop.

(vii) Solids and liquids have

(a) one value of specific heat (b) two values of specific heat
(c) three values of specific heat (d) no specific value of specific heat.

(viii) In CI engines, during compression stroke,

(a) only air is compressed
(b) compression ratios can be much higher
(c) both of the mentioned
(d) none of the mentioned.

(ix) Mixture of ice and liquid water forms

(a) a closed system (b) an open system
(c) a heterogeneous system (d) an isolated system.

(x) Practical Vapour power cycle works on

(a) Carnot cycle (b) Rankine cycle
(c) O tto cycle (d) Stirling cycle.

Group- B

2. (a) A foam cup is filled with hot water and then allowed to cool while being stirred by a paddlewheel. Initially, the water in the cup has an internal energy of 200 kJ after filling, and while cooling it loses 150 kJ of heat. The paddlewheel does 25 kJ of work on the water during cooling. Apply the first law of Thermodynamics with proper sign conventions and find the internal energy of water after cooling. Explain what path functions and point functions are. What is PMM 1?

[(CO1)(Interpret/LOCQ)]

(b) An elastic sphere initially has a diameter of 1.5 m and contains a gas at a pressure of 1 atmosphere. Due to heat transfer, the diameter of the sphere increases to 1.8 m. During the heating process the gas pressure inside the cylinder is proportional to the sphere diameter. Calculate the work done by the gas. [(CO1)(Relate/IOCQ)]

(3 + 4) + 5 = 12

3. (a) A gas undergoes a thermodynamic cycle consisting of the following processes: (i) Process 1-2: Constant pressure p = 1.4 bar, V_1 = 0.028 m^3, W_{12} = 10.5 kJ, (ii) Process 2-3: Compression with pv = constant, $U_3 = U_2$, (iii) Process 3-1: Constant Volume, $U_1 - U_3$ = -26.4 kJ. There are no significant changes in KE and PE. (a) Sketch the cycle on a p-v diagram. (b) Calculate the net work for the cycle in kJ. (c) Calculate the heat transfer for the process 1-2. (d) Show that $\sum_{cycle} \boldsymbol{Q} = \boldsymbol{cycle\ W}$. [(CO2)(Analyze/IOCQ)]

(b) What is the thermodynamic definition of work? Explain thermodynamic equilibrium. [(CO1)(Understand/IOCQ)]

7 + (1 + 4) = 12

Group- C

4. (a) At the inlet to a certain nozzle, the enthalpy of the fluid passing is 2850 kJ/kg and the velocity is 50 m/s. At the discharge end, the enthalpy is 2620 kJ/kg. The nozzle is horizontal and there is negligible heat loss from it. (i) Find the velocity at exit from the nozzle. (ii) If the inlet area is 0.08 m^2 and the specific volume at inlet is 0.184 m^3/kg, find the mass flow rate. (iii) If the specific volume at the nozzle exit is 0.492 m^3/kg, find the exit area of the nozzle.

[(CO3)(Analyze/HOCQ)]

(b) Using steam tables, determine the mean specific heat for superheated stem at 1 bar between 150°C and 250°C. Explain what is meant by 'Triple point'?

[(CO3)(Apply/IOCQ)]

6 + (4 + 2) = 12

5. (a) A vessel of 0.3 m^3capacity contains 1.5 kg mixture of liquid and vapour of water in equilibrium at a pressure of 5 bar. Calculate the volume and mass of (i) liquid and (ii) vapour. [(CO3)(Apply/IOCQ)]

(b) A sample of steam at 10 bar and 200°C is cooled under constant pressure till it becomes dry saturated. It is then throttled to 1 bar pressure. What will be the temperature and entropy after throttling? Also calculate the change in entropy in the throttling process? [(CO3)(Analyze/HOCQ)]

4 + (6 + 2) = 12

Group - D

6. (a) Two Carnot engines A and B are connected in series between two thermal reservoirs maintained at 1000 K and 100 K respectively. Engine A receives 1680 kJ of heat from the high-temperature reservoir and rejects heat to the Carnot engine B. Engine B takes in heat rejected by engine A and rejects heat to the low-temperature reservoir. If engines A and B have equal thermal efficiencies, determine (a) The heat rejected by engine B (b) The temperature at which heat is rejected by engine, A (c) The work done during the process by engines, A and B respectively. If engines A and B deliver equal work, determine (d) The amount of heat taken in by engine B (e) The efficiencies of engines A and B.

[(CO2)(Analyse/IOCQ)]

(b) State the Clausius statement of the second law? What is PPM2?

[(CO2)(Remember/LOCQ)]

8 + 4 = 12

7. (a) What is the maximum work obtainable from two finite bodies at temperature T1 and T2. [(CO4)(Apply/IOCQ)]

(b) Draw the T-s diagram of Carnot cycle? Why is an isentropic process not necessarily an adiabatic process? [(CO4)(Apply/IOCQ)]

6 + (3 + 3) = 12

Group - E

8. (a) A power generating plant operating on Rankine cycle uses saturated steam at 100 bar entering the turbine. The condenser pressure is 0.05 bar. Determine the cycle efficiency and work ratio if all the processes are reversible. How will be the cycle efficiency and work ratio affected if isentropic efficiencies of the turbine and the pump are 80% and 90% respectively? [(CO6)(Apply/IOCQ)]

(b) A two-stage air compressor with perfect intercooling takes in air at 1 bar pressure and 27°C. The law of compression in both the stages is $pv^{1.3}$ = constant. The compressed air is delivered at 9 bar from the H.P. cylinder to an air receiver. Calculate, per kilogram of air, (a) the minimum work done and (b) the heat rejected to the intercooler. [(CO3)(Evaluate/HOCQ)]

(4 + 3) + 5 = 12

9. (a) In an air standard Diesel cycle, the compression ratio is 15 and the fluid properties at the beginning of compression are 100 kPa and 300 k respectively. For a peak temperature of 1600 K, calculate (i) the percentage of stroke at which cut off occurs (ii) the cycle efficiency and (iii) the work output per kg of air. [(CO5)(Apply/IOCQ)]

(b) With the help of p-v and T-s diagram, show that for the same maximum pressure and temperature of the cycle and the same heat rejection, $\eta_{Diesel} > \eta_{Dual} > \eta_{Otto}$ [(CO5)(Understand/LOCQ)]

7 + 5 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	16.66	63.54	19.80

Course Outcome (CO):

After going through the course, the students will be able to

1. Analyze a thermodynamic system and calculate work transfer in various quasi-static processes.
2. Understand the difference and correlation between heat transfer and work transfer
3. Read and interpret the values of properties of water/steam from steam table for evaluation of heat transfer and work transfer in processes involving steam
4. Understand and calculate the change of entropy for some specific cases
5. Calculate thermal efficiency of Otto, Diesel and dual combustion cycle
6. Understand the basics of thermal power generation and calculate the efficiencies of Rankine cycles with reheat and regeneration.