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.

THE STUDENTS SHOULD CARRY THEIR OWN STEAM TABLE AND MOLLIER DIAGRAM

Group – A
(Multiple Choice Type Questions)

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

(i) Among which of the following option, there is no work transfer involved in this process?
(a) Adiabatic expansion (b) Isothermal expansion
(c) Polytropic expansion (d) Free expansion.

(ii) In Carnot cycle, the rejection of heat is
(a) at constant pressure
(b) at constant volume
(c) at constant temperature
(d) partially at constant pressure and partially at constant volume.

(iii) If the thermal efficiency of a Carnot heat engine is 40%, then Coefficient of Performance of a refrigerator working within the same temperature limits would be
(a) 1.5 (b) 2.5 (c) 3.5 (d) 4.5.

(iv) Zeroth law: Temperature : : Second law:
(a) Enthalpy (b) Efficiency (c) Internal energy (d) Entropy.

(v) For a Reversible process the area under the curve $\int T\,ds$ is equal to the
(a) work done (b) heat transferred
(c) internal energy change (d) none of the mentioned.

(vi) The point that connects the saturated liquid line to the saturated vapour line is called
(a) Saturated Point (b) Triple Point
(c) Superheated Point (d) Critical Point.

(vii) In comparison with the slopes of constant pressure lines, the slopes of constant volume lines in T-s plot of an ideal gas are
(a) less (b) more (c) same (d) unpredictable.

(viii) What is true of mean temperature of heat addition in a Rankine cycle?
(a) Higher value of this does not necessarily indicate higher efficiency
(b) It is the average of the entry and exit temperatures of steam to and from the boiler
(c) By reheat process, this can definitely be increased
(d) Use of regenerative cycle will lead to its increase.

(ix) Which of the following processes is represented as a line parallel to the abscissa in a Mollier diagram?
(a) Constant pressure (b) Constant temperature
(c) Throttling (d) Adiabatic expansion.

(x) In Rankine cycle, regeneration results in higher thermal efficiency because of
(a) increase in pressure inside the boiler
(b) increase in total work delivered by the turbine
(c) additional heat added before the steam enters the low pressure turbine.
(d) increase in mean temperature of heat addition.

Group - B

2. (a) (i) Define a thermodynamic system. (ii) What are positive and negative work interactions? (iii) What are the similarities between work transfer and heat transfer referred to a thermodynamic system? *[(CO1)(Remember/LOCQ)]*

(b) 2 kgs of a gas is contained in a piston cylinder assembly at an initial condition of $2\ m^3\ and\ 100\ kPa$. The gas is then allowed to expand to $5\ m^3$. Calculate the work done by the gas for the following processes:
(i) pressure remains constant, (ii) isothermal process and (iii) $pV^{\ 2} = constant$.
[(CO2)(Relate/IOCQ)]

6 + 6 = 12

3. (a) Show that energy is a property of a system. Define internal energy.
[(CO2)(Understand/LOCQ)]

(b) A close system contains a fluid system which passes through a complete cycle consisting of four processes. The sum of all heat transfers during the cycle is -17000 kJ. Complete the following table showing the detailed calculations and compute the net work output during the cycle in kJ.

Process	Q (kJ)	W (kJ)	ΔE (kJ)
a - b	0	2170	?
b - c	21000	0	?
c - d	-2100	?	-36600
d - a	?	?	?

[(CO2)(Analyze/HOCQ)]

5 + 7 = 12

Group - C

4. (a) Air at 1 bar pressure, 290 K temperature flows steadily at the rate of 120 m^3/hr into a compressor, where its pressure and temperature are respectively raised

to 15 bar and 390 K. During the compression process, the heat transfer from the compressor is 10 percent of work transfer from the machine. Neglecting changes in kinetic energy and potential energy, evaluate the work and heat interaction. Assume that air behaves as a perfect gas. *[(CO2)(Evaluate/HOCQ)]*

(b) What is a pure substance? What are saturation states? What is critical state? *[(CO3)(Analyze/IOCQ)]*

8 + 4 = 12

5. (a) Explain the terms critical pressure, critical temperature and critical volume with a phase equilibrium diagram with reference to water. What is 'dryness fraction'? What is its value for a superheated steam sample? *[(CO3)(Understand /LOCQ)]*

(b) A rigid vessel contains 5 kgs of steam initially at 0.3 MPa, 250°C. The vessel is cooled down until the steam is transformed to saturated vapour. What is the temperature at this stage? What is the quality when it is further cooled to 80°C? What is the volume of the vessel? *[(CO3)(Analyze/HOCQ)]*

5 + 7 = 12

Group - D

6. (a) A reversible heat engine is supplied 900 kJ of heat from a heat source at 500 K. The engine develops 300 kJ of net work and rejects heat to two heat sinks at 400 K and 300 K. Determine the engine thermal efficiency and magnitude of heat interaction with each of the heat sink. *[(CO4)(Evaluate/HOCQ)]*

(b) Define the C.O.P of a refrigerator. What is heat pump? How does it differ from a refrigerator? *[(CO4)(Understand/LOCQ)]*

6 + 6 = 12

7. (a) What is the maximum work obtainable from a finite body and a Temperature Energy Reservoir? *[(CO4)(Analyse/IOCQ)]*

(b) One kg of water at 273 K is brought into contact with a heat reservoir at 370 K, when the water has reached 370 K. Find the entropy change of the water of the reservoir and of the universe. *[(CO4)(Evaluate/HOCQ)]*

6 + 6 = 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 single cylinder reciprocating air compressor has a piston displacement volume of 0.1 m^3. The suction pressure and temperature are 1 bar and 298 K, respectively. If the delivery pressure after compression is 7 bar, calculate:

(i) the work required to compress the air isentropically with γ = 1.4 and polytropically with an index n = 1.25

(ii) the isothermal efficiency for isentropic and polytropic compression processes. *[(CO5)(Apply/IOCQ)]*

(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) Find out an expression of volumetric efficiency in standard terms and hence show plots indicating its dependence with clearance and pressure ratio.

[(CO5)(Remember/LOCQ)]

7 + 5 = 12

Cognition Level	*LOCQ*	*IOCQ*	*HOCQ*
Percentage distribution	*28.13*	*36.45*	*35.42*

Course Outcome (CO):

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

1. Classify a thermodynamic system and analyze work transfer in various quasi-static processes.
2. Identify the difference and correlation between heat transfer and work transfer.
3. Interpret the values of properties of water/steam from steam table to weigh heat transfer and work transfer.
4. Apply 'Clausius Equality' to heat engine cycles and calculate entropy changes for various processes.
5. Judge thermal efficiency of Otto, Diesel and Dual combustion cycles and examine the working of a reciprocating compressor.
6. Explain the basics of thermal power generation and appraise the efficiencies of Rankine cycles with reheat and regeneration.

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*