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) All of the following are intensive properties of a thermodynamic system, except
(a) viscosity (b) temperature (c) density (d) potential energy.

(ii) It is the characteristic feature of a quasi-static process
(a) infinite slowness (b) rapidity
(c) stability (d) stationary existence.

(iii) Cyclic integral of this is zero
(a) work transfer (b) heat transfer
(c) internal energy (d) all of these.

(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) Heat transferred reversibly to a simply compressible system at constant pressure is equal to
(a) work transfer (b) change in internal energy
(c) change in enthalpy (d) change in entropy.

(vi) When a system executes a cycle reversibly, any conceivable change in entropy is
(a) maximum (b) zero (c) positive (d) negative.

(vii) Mollier diagram is a plot of
(a) temperature and entropy (b) enthalpy and entropy
(c) pressure and entropy (d) temperature and entropy.

(viii) For the same compression ratio and heat supplied, the following air standard cycle yields more work
(a) Otto cycle (b) Diesel cycle
(c) dual cycle (d) all of these will yield same work.

(ix) This air standard cycle is also known as a constant pressure cycle
(a) Otto cycle (b) Diesel cycle
(c) Dual cycle (d) Carnot cycle.

(x) Which of the following process is not involved in a Rankine Cycle?
(a) isobaric (b) isothermal
(c) isentropic (d) isenthalpic.

Group – B

2. (a) A stationary mass of gas is compressed without friction from initial state of 0.3 m^3 and 0.105 MPa to a final state of 0.15 m^3 and 0.105 MPa, pressure remaining constant during the process. There is a transfer of 37.6 kJ of heat from the gas to the surrounding during the process. How much does the internal energy of the gas change?

(b) A sample of steam at 5 bar is stated to have an enthalpy of 2350 kJ/kg. Make calculation for the specific volume, internal energy and entropy of this sample of steam.

6 + 6 = 12

3. (a) A tank contains100 kg of liquid water and 5 kg of water vapour, both under saturation conditions at 20°C. What are the pressure and dryness fraction of the mixture? What is the volume of the tank?

(b) 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_{1-2} = 10.5 kJ, (ii) Process 2-3: Compression with PV = constant, $U_2 = U_3$, (iii) Process 3-1: Constant volume U_1-U_3 = -26.4 kJ. There is no significant change in KE and PE. (i) Sketch the process on P-V diagram. (ii) Calculate the net work for the cycle. (iii) Calculate the heat transfer for process 1-2. (iv) Show that $Q_{cyclic} = W_{cyclic}$.

5 + 7 = 12

Group – C

4. (a) A heat engine working on Carnot cycle converts one-fifth of the heat input into work. When the temperature of the sink is reduced by 80 K, the efficiency is doubled. What are the temperatures of the source and the sink?

(b) One kg of liquid water at 273 K is heated to 373 K by bringing it in contact with a heat source at 373 K. Determine the entropy change of liquid water, the source and the universe. Given, c_p of water = 4.186 kJ/kg-K.

6 + 6 = 12

5. (a) State and prove Carnot theorem.

(b) A refrigerator operating on a reversed Carnot cycle consumes 150 W power in summer when the ambient atmosphere is at 310 K. The heat leakage into the refrigerator is estimated to be at the continuous rate of 15 W per Kelvin

temperature difference between the ambient air and the refrigerated space. What is the temperature of the refrigerated space for continuous operation of the refrigerator?

6 + (4 + 2) = 12

Group – D

6. (a) A single cylinder reciprocating compressor has a piston displacement 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 the work required per cycle for compressing the gas with a polytropic index n = 1.25. What is the isothermal work required per cycle? Hence find the isothermal efficiency for polytropic compression.

   (b) In an automobile device, work generated is twice as much rejected through the exhaust. What is the compression ratio of an ideal Otto cycle having the same efficiency as the automobile device? Given, $\boldsymbol{y}$ = 1.4.

8 + 4 = 12

7. (a) In an air standard Diesel cycle with compression ratio 15, the conditions of air at the start of compression stroke are 1 bar and 300 K. After addition of heat, the temperature rises to 3000 K. Determine the efficiency of the cycle and net work done per kg of air. Given, $\boldsymbol{c_p}$ = 1.005 kJ/kg-K and $\boldsymbol{y}$ = 1.4.

   (b) An air standard Otto cycle is designed to operate with following data.
   Maximum cycle pressure and temperature: 5 MPa and 2250 K
   Minimum cycle pressure and temperature: 0.1 MPa and 300 K. Determine the thermal efficiency and the net specific work output.

4 + (2 + 2 + 2 + 2) = 12

Group – E

8. (a) A steam turbine working on Rankine cycle is supplied with dry saturated stem at 25 bar and the exhaust takes place at 0.2 bar. Determine the efficiency of the cycle neglecting pump work. What is the Carnot efficiency with same temperature limits?

   (b) In a steam power plant, steam at 80 bar and 500°C enters the HP turbine where it expands isentropically to dry saturated steam. This steam is further reheated at constant pressure to 500°C before it is isentropically expanded in an LP turbine to 0.1 bar. Calculate the dryness fraction at exit and the specific turbine work.

(5 + 1) + (4 + 2) = 12

9. (a) In a regenerative cycle, steam enters the turbine dry and saturated at 30 bar and is condensed to 0.03 bar. Steam is bled from the turbine at 2.75 bar to mix with feed water from condenser so that the mixture comes out as saturated liquid. Calculate the quantity of steam bled per kg of steam flowing in the system.

(b) What is one tonne of refrigeration? What are the most widely used refrigerants? How are they numbered? What is the temperature difference maintained between the condenser and cooling medium?

7 + (1 + 1 + 2 + 1) = 12

N. B.: USE STEAM TABLE / MOLLIER DIAGRAM AS REQUIRED.

Department & Section	Submission Link
ME	https://forms.gle/KaLd8Fz1Z4GTXZz8A Class code: tdfidyl