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) A reversible process requires that
(a) Newton's law of viscosity be satisfied
(b) there be no heat transfer
(c) system and surrounding be at same temperature
(d) there be no viscous or Coulomb friction in the system.

(ii) A series of events, which take place in a certain order and restore the system to initial condition is known as
(a) reversible process (b) reversible cycle
(c) irreversible cycle (d) thermodynamic cycle.

(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) Name the parameter that decreases with an increase in steam pressure
(a) Sensible heat (b) Latent heat of vaporisation
(c) Specific entropy (d) Boiling point.

(v) Mollier diagram is a plot of
(a) Temperature and entropy (b) Enthalpy and entropy
(c) Pressure and enthalpy (d) Pressure and volume.

(vi) The order of values of thermal efficiency of otto, diesel and dual cycle, when they have equal compression ratio and heat rejection, is given
(a) $\eta_{otto} > \eta_{disel} > \eta_{dual}$ (b) $\eta_{disel} > \eta_{dual} > \eta_{otto}$
(c) $\eta_{dual} > \eta_{disel} > \eta_{otto}$ (d) $\eta_{otto} > \eta_{dual} > \eta_{disel}$.

(vii) In a steam power plant, feed water heater is a heat exchanger to preheat feed water by
(a) Live stream from generator
(b) Hot air from the air preheater
(c) Hot flue gases coming out of the boiler furnace
(d) Extracting steam from the turbine.

(viii) For a complete cycle which is irreversible, the entropy of the system
(a) does not change
(b) increases
(c) decreases
(d) depends on the properties of working substance

(ix) A cycle consisting of one constant pressure, one constant volume and two isentropic processes is known as
(a) Carnot cycle (b) Stirling cycle
(c) Otto cycle (d) Diesel cycle.

(x) The efficiency of Diesel cycle approaches to Otto cycle efficiency when
(a) Cut-off is increased (b) Cut-off is decreased
(c) Cut-off is zero (d) Cut-off is constant.

Group – B

2. (a) A fluid at a pressure of 3 bar and with specific volume of 0.18 m^3/kg is contained in a piston cylinder arrangement. The fluid expands reversibly to a pressure of 0.6 bar according to the law of $p = \frac{C}{V^2}$ where C is a constant. Calculate the work done by the fluid on the piston.

(b) The temperature t on a thermometric scale is defined in terms of a property P by the relation, $t = a \log_e P + b$, where a and b are constants. The temperatures of the ice point and steam point are assigned the numbers 32 and 212 respectively. Experiment gives values of P of 1.86 and 6.81 at the ice point and steam point respectively. Evaluate the temperature corresponding to a reading of P = 2.50 on the thermometer. Explain the free expansion process.

5 + (4 + 3) = 12

3. (a) A cylinder contains 1 kg of a certain fluid at an initial pressure of 20 bar and a volume of 0.5 m^3. The fluid is allowed to expand reversibly behind a piston according to a law pV^2 = constant, until the volume becomes 4 times the initial volume. The fluid is then cooled reversibly until the piston regains the initial volume. Heat is then supplied reversibly with the piston firmly locked in position until pressure rises to the original value of 20 bar. Draw the processes on a p-V diagram. Calculate the work transfers in each process. What is the net heat transfer during the entire cycle?

(b) Show that energy is a property of a system.

8 + 4 = 12

Group – C

4. (a) Two boilers are supplying steam to a main pipe steadily. Boiler-1 is supplying superheated steam at 350°C while boiler-2 is supplying unsaturated steam. The pressure in the boilers and the main pipe is 20 bar. Temperature of the steam in main pipe is 250°C. Find the temperature and dryness fraction of the steam supplied by boiler-2.

   (b) Apply the first law of Thermodynamics to show that for an ideal gas $c_p - c_v = R$, symbols have their usual meaning.

6 + 6 = 12

5. (a) Steam at 0.8 MPa, 250°C and flowing at the rate of 1 kg/s passes into a pipe carrying wet steam at 0.8 MPa, 0.95 dry. After adiabatic mixing the flow rate is 2.3 kg/s. Determine the condition of steam after mixing.
   The mixture is now expanding in a frictionless nozzle isentropically to a pressure of 0.4 MPa. Determine the velocity of steam leaving the nozzle. Neglect the velocity of steam in the pipeline.

   (b) Write the steady flow energy equation for a single stream entering and a single stream leaving a control volume and explain the various terms in it.

8 + 4 = 12

Group – D

6. (a) A reversible engine operates between temperatures T_1 and T ($T_1 > T$). The energy rejected from this engine is received by a second reversible engine at the same temperature T. The second engine rejects energy at temperature T_2 ($T_2 < T$).
   Show that:
   (i) Find out the Temperature T if both the engines produce the same amount of work output.
   (ii) Find out the Temperature T if both the engines have the same cycle efficiencies.

   (b) State and prove Carnot Theorem.

6 + 6 = 12

7. (a) An ice plant produces 15 tonnes of ice at 0°C from water at 0°C per day working continuously on a reversed Carnot cycle. The heat is rejected to atmosphere at 25°C. The power to run the plant is supplied by a coupled Carnot engine which absorbs heat from a source which is maintained at 220°C by the combustion of liquid fuel of calorific value 44500 kJ/kg. The engine rejects heat to the atmosphere at 25°C. Determine the power developed by the Carnot engine and fuel consumed per hour.

   (b) Determine the maximum work obtainable from two finite bodies having same heat capacity **C** at temperatures T_1 and T_2.

7 + 5 = 12

Group – E

8. (a) In a diesel engine of compression ratio 14, fuel cut off is delayed and as a result the cut off ratio increases from 1.65 to 2.04. Calculate the percentage loss in ideal efficiency.

(b) The intake condition of an Otto cycle with compression ratio 8 is 100 kPa and 27°C. The amount of heat added to the air per cycle is 1500 kJ/kg. Determine (i) the values of pressure and temperature at the three other salient points of the cycle and (ii) thermal efficiency and specific work. Given for air: c_v = 0.72 kJ/kg-K, γ = 1.4.

4 + 8 = 12

9. (a) A two stage reciprocating air compressor has air entering at 1 bar, 290 K and leaving high pressure state at 5 bar. An intercooler working at 2 bar pressure is provided between the high pressure and low pressure stages which cools the air at constant pressure to 295 K. The air is then taken to the high pressure stage where further compression continues up to delivery pressure. The compression process follows the law $pV^{1.3} = C$ in both the stages and the compressor turns 200 rev/min.

(i) Calculate the power needed in compressing 0.2 m^3 of air at suction conditions to low pressure cylinder.

(ii) What should be the intermediate pressure if the machine is required to operate with minimum work input.

(b) Steam at 20 bar, 400°C is expanded in a steam turbine to 0.08 bar. It then enters a condenser, where it is condensed to saturated liquid water. The pump feeds back the water into the boiler. Assuming ideal processes, find the net work and the cycle efficiency per kg to steam.

6 + 6 = 12

Department & Section	Submission Link
ME-A	https://forms.gle/PLj5BrWirt6ZDGAUA
ME-B	https://classroom.google.com/c/MzEwMDI5OTgzMzg1?cjc=ztknhvi