# Question Paper

Exam Date & Time: 27-Dec-2019 (09:30 AM - 12:30 PM)

## MANIPAL ACADEMY OF HIGHER EDUCATION

**INTERNATIONAL CENTRE FOR APPLIED SCIENCES END SEMESTER THEORY EXAMINATIONS NOVEMBER2019 III SEMESTER B.sc. (Applied Sciences) in Engg.**

**THERMAL ENGINEERING [IME 231]**

**Marks: 100** **Duration: 180 mins.**

**Answer 5 out of 8 questions.**

**Missing data, if any, may be suitably assumed**
**Use of thermodynamics data hand book and steam tables permitted.**

1) A) Define following terms with suitable examples, (6)
a. Macroscopic and Microscopic point of view
b. Closed system and Open system
c. Isolated system and Adiabatic system
d. Intensive and Extensive property of a system
e. Point function and Path function of a system
f. Heat and work transfer

B) Explain the state of thermodynamic equilibrium of a system with suitable examples.. (4)

C) At the inlet to a convergent-divergent nozzle the enthalpy of the fluid passing is 3000 kJ/kg and the velocity is 60 m/s. At the discharge end, the enthalpy is 2757 kJ/kg. The nozzle is horizontal and the heat loss during the flow is negligible. Find, a) Velocity of the fluid at the exit of the nozzle, b) If inlet area is 0.1 $m^2$ and specific volume at the inlet is 0.187 $m^3$/kg, find the mass flow rate of the fluid, and c) If the specific volume at the outlet is 0.498 $m^3$/kg, find the area at the exit of the nozzle. (10)

2) A) Explain Joule's experiment of Ist law of thermodynamics applied to a closed system. (6)

B) Express assumptions made & derive an expression of a steady flow energy equation applied to an open thermodynamics system. (6)

C) A certain mass of air initially at a pressure of 480 kPa and a temperature $190^0$ C is expanded adiabatically to a pressure of 94 kPa. It is then heated at constant volume until it attains its initial temperature when the pressure is found to be 150 kPa. State the type of compression necessary to bring the system back to its original pressure and volume. Draw P-V and T-S diagram and determine, a) The index of adiabatically expansion, and b) the total work done per kg of air. (8)

3) A) Obtain an expression for PdV work done in the following cases and show the processes on P-V diagram. (i) Polytropic process ii) Isothermal process iii) Adiabatic process, v) Isochonic process (4)

B) Define the two parallel statements of second law of thermodynamics and show that violation of kelvin-plank statement equally violates the Clausius statement. (6)

C) In a closed system, air is at a pressure of 1 bar, temperature of 300 K and volume of 0.025 $m^3$. The system exercise the following processes during the completion of a thermodynamic cycle. (10)
1-2 Constant volume heat addition till pressure reaches 3.8 bar
2-3 Constant pressure cooling of air
3-1 Iso thermal heating to initial state
Determine change in entropy in each process and find the net amount of entropy transfer and show that it obeys the first law of thermodynamics.
Take $C_v$ =718 J/kg.K, R = 0.287 kJK/kg.K

4) A) Define Carnot's theorem and prove that the efficiency of a reversible heat engine is always greater than the efficiency of an irreversible heat engine. (6)

B) Prove that two reversible adiabatic paths cannot intersect each other. (4)

C) Two carnot engines E1 and E2 are connected in series between two thermal reservoirs at 1000 K and 100 K respectively. The engine E1 receives 1680 kJ of heat from the high temperature reservoir and rejects heat to the carnot engine E2. The engine E2 takes in the heat rejected by the engine E1 and rejects heat to the low temperature reservoir at 100 K. If the engines E1 and E2 have equal thermal efficiencies, determine, a) The heat rejected by the engine E2, b) The temperature at which the heat rejected by the engine E1 and c) The work done by the engine E1 and E2. (10)

5) A) Explain different methods to improve the efficiency of a Rankine Vapour Cycle. (5)

B) Explain the working of Ideal Regenerative cycle with the help of sketch and T-S diagram of the cycle. (5)

C) An steam power plant operates on a theoretical reheat cycle. The steam from boiler at 150 bar and $550^0$C expands through the high-pressure turbine. It is reheated at constant pressure at 40 bar to $550^0$C and expands through the low pressure turbine to a condenser pressure of 0.1 bar. Draw T-s and h-s diagrams and find (a) Quality of steam leaving outlet of the low pressure turbine, (b) Thermal efficiency of the cycle, and (c) Steam rate in kg/kWh. (10)

6) A) Derive an expression for air standard efficiency of constant pressure cycle in terms of cut off ratio and compression ratio. (5)

B) Explain and compare efficiencies of Otto and Diesel air standard cycles. (5)

C) In an SI engine working on the ideal otto cycle, the compression ratio is 5.5. The pressure and temperature at the beginning of compression are 1 bar and $27^0$C respectively. The peak pressure is 30 bar. Determine the air standard efficiency and mean effective pressure of the cycle. (10)

7) A) Obtain an expression for Work done of Compression in a 2-Stage compressor with perfect inter cooling and also derive the condition required for minimum work supplied. (6)

B) Explain various factors effecting the co-efficient of performance of Vapor compression refrigeration system (6)

C) A simple vapour compression plant produces 5 tonnes of refrigeration. The enthalpy values at the inlet to compressor, at the exit from the compressor and exit from the condenser are 183.19, 209.41 and 74.59 kJ/kg respectively. Estimate, a) The refrigeration flow rate, b) The COP, c) The power required to drive the compressor, and d) The rate of heat absorbed by the refrigerant in the evaporator. (8)

8) A) What are the different modes of heat transfer? Explain briefly. (5)

B) Explain the morse test to determine the performance of SI Engines. (5)

C) In a test on a three cylinder four stroke internal combustion engine with 220 mm bore and 260 mm stroke. The following were the observation during a trial test conducted for one hour. Fuel consumption = 8 kg, Calorific value = 45,000kJ/kg, Total revolutions of the crank shaft 12,000, Mean effective pressure = 6 bar, Net load on the break drum = 15,000 kN, Break drum diameter = 1.8 m, Rope diameter = 30 mm, Mass of Cooling water = 550 kg, Inlet temperature of water = $27^0$ C, Exit temperature of water $55^0$C, Air consumed = 300 kg, Ambient temperature = $30^0$ C, Exhaust gases temperature = $310^0$ C, Specific heat of exhaust gases = 1.1 kJ/kg.K. Calculate, a) Indicated and break power in kW, b) Mechanical thermal efficiency, c) Indicated and break thermal efficiency, and d) draw heat balance sheet in kJ/min. (10)

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