Total Number of Pages: 02 | Integrated Dual Degree (B.Tech and M.Tech)
Sub_Code: RME4C002

4th Semester Regular/Back Examination: 2023-24
SUBJECT: Engineering Thermodynamics
BRANCH(S): MECH,MMEAM, ME
Time: 3 Hour
Max Marks: 100
Q.Code: P399
Answer Question No.1 (Part-1) which is compulsory, any eight from Part-II and any two from Part-III.
The figures in the right hand margin indicate marks.

Part-I

Q1 **Answer the following questions:** **(2 x 10)**
- **a)** In a cyclic process, heat transfers are + 14.7 kJ, − 25.2 kJ, − 3.56 kJ, and +31.5 kJ. Estimate the total work for this cyclic process.
- **b)** 100 % thermal efficiency of a heat engine cycle is not attainable. Justify the statement.
- **c)** Highlight the criteria for reversibility, irreversibility, and impossibility of a thermodynamic process.
- **d)** Describe the principle of increase of entropy for an isolated system.
- **e)** Show that internal energy is a property of the system.
- **f)** Explain the terms exergy and anergy.
- **g)** Draw p-v diagram for a pure substance.
- **h)** Second law of thermodynamics is often called as a directional law of nature. Justify.
- **i)** Explain quasi-static process with a suitable example.
- **j)** Explain Carnot's theorem.

Part-II

Q2 **Only Focused-Short Answer Type Questions- (Answer Any Eight out of Twelve)** **(6 × 8)**
- **a)** Establish the equivalence of Kelvin-Planck and Clausius statement.
- **b)** A piston cylinder device operates 1 kg of fluid at 20 atm. Pressure. The initial volume is 0.04 m^3. The fluid is allowed to expand reversibly following a process $pV^{1.45}$ = Constant so that the volume becomes double. The fluid is then cooled at constant pressure until the piston comes back to the original position. Keeping the piston unaltered, heat is added reversibly to restore it to the initial pressure. Calculate work done in the cycle.
- **c)** Show that the COP of a heat pump is greater than the COP of the refrigerator by unity.
- **d)** A heat engine operates between 290 °C and 8.5 °C. 300 kJ/s of heat is supplied at 290 °C and heat is rejected at 8.5 °C. Classify the cycles if:
  (i) 215 kJ/s are rejected, (ii) 75 kJ/s are rejected, and (iii)150 kJ/s are rejected.
- **e)** 5 kg of water at 0 °C is exposed to reservoir at 98 °C. Calculate the change of entropy of water, reservoir and universe. Assume that specific heat of water is 4.187 kJ/kg K.
- **f)** Describe the working principle of Carnot cycle with a neat sketch. Highlight the assumptions considered. What are the limitations in the cycle?

g) Explain the term "mean temperature of heat addition". Highlight the effect of superheating on it in a Rankine cycle.

h) Discuss the performance of Otto, Diesel, and Dual cycles for the same maximum pressure and temperature with neat sketch of P-V and T-S diagrams.

i) Explain the following terms associated in a gas power cycle:
Air Standard Efficiency, Mean Effective Pressure, Brake Thermal Efficiency, Mechanical Efficiency, Relative Efficiency, and Volumetric Efficiency.

j) A Diesel engine has a compression ratio of 14 and cut off takes place at 6% of the stroke. Find the air standard efficiency.

k) Explain the working principle of vapor compression refrigeration cycle. Differentiate between ideal and actual vapor compression refrigeration cycle in a T-S diagram.

l) Explain air refrigeration cycle highlighting its working principle. Mention the assumptions considered for its analysis. Highlight its advantages.

Part-III
Only Long Answer Type Questions (Answer Any Two out of Four)

Q3 a) A heat engine working on Carnot cycle, absorbs Q heat from heat source and converts one fourth of heat Q into work. If the temperature of the heat sink is decreased by 100 ^{o}C, the efficiency becomes doubled. Calculate the temperature of source and sink. **(8+8)**

b) An investor claims that his engine has the following specifications:
Temperature limits: 727 ^{o}C and 27 ^{o}C
Power developed: 80 kW.
Fuel supplied: 7.92 kg/hr.
Calorific value of fuel: 48,000 kJ/kg
Is the claim of investor true or false? Justify your answer.

Q4 a) A fluid undergoes a reversible adiabatic compression from pressure 1 MPa and volume 0.3 m^3 to volume 0.05 m^3, according to the law of $pV^{1.3}$ = Constant. Determine, (i) Work done, (ii) heat transfer, (iii) change in internal energy, (iv) change of enthalpy, and (v) change of entropy. **(8+8)**

b) 2 kg of water at 94 ^{o}C are mixed with 3 kg of water at 10 ^{o}C in an isolated system. Calculate the change of entropy due to mixing process.

Q5 a) A system at 500 K receives 7200 kJ/min heat from a source at 1000 K. The temperature of atmosphere is 300 K. Assuming that the temperature of system and source remain constant during heat transfer, find out (i) the entropy produced during heat transfer, and (ii) the decrease in available energy after heat transfer. **(8+8)**

b) State Gouy-Stodola theorem. Explain its application with respect to a heat transfer process occurring over a finite temperature difference.

Q6 A cyclic steam power plant is to be designed for a steam temperature at turbine inlet of 360 ^{o}C and an exhaust pressure of 0.08 bar. After isentropic expansion of steam in turbine, the moisture content at the turbine exhaust is not to exceed 15%. Determine the greatest allowable steam pressure at the turbine inlet and calculate the Rankine cycle efficiency for these steam conditions. Also, estimate the mean temperature of heat addition. **(16)**