Ref. No.: Ex/PE/PE/B/T/323C/2025

B.E. Power Engineering, 3rd Year, 2nd Semester Examination, 2025

IC Engine and Gas Turbine

Time: Three Hours **Full Marks: 100**

Group A: CO1 (30 Marks)

1. Answer the following questions briefly (any four questions)
   a) Differentiate between two-stroke and four-stroke engines using p-v diagram.
   b) Explain the working principle of an open-cycle gas turbine using T-S diagram.
   c) Explain the principle of carburetion and its components in a SI engine.
   d) Describe the factors affecting the efficiency of an internal combustion engine.
   e) Discuss the concepts of turbocharging in an internal combustion engine.

Marks: $4 \times 4 = 16$

2. Answer the following questions (any one question)
   a) For a diesel cycle derive the expression of thermal efficiency $\eta = 1 - \frac{1}{r^{(\gamma-1)}}\left[\frac{r_c^{\gamma}-1}{\gamma(r_c-1)}\right]$, where the symbols correspond to the usual meaning.
   b) Compare the performance of Otto, Diesel, and Dual cycles for the same inlet condition, peak pressure, work output (using P-V and T-S diagrams). Comment on the performance.

Marks: $1 \times 14 = 14$

Group B: CO2 (15 Marks)

3. Answer the following questions briefly (any three questions)
   a) Compare fuel injection systems in SI and CI engines.
   b) Explain the operation of a supercharged Otto cycle with the aid of a pressure-volume (P-V) diagram.
   c) Describe the combustion process in CI engines.
   d) Explain the major emissions from IC engines.

Marks: $3 \times 5 = 15$

Group C: CO3 (30 Marks)

4. Answer the following questions (any two questions)
   a) In an Otto engine, pressure and temperature at the beginning of compression are 1 bar and 37 °C respectively. Calculate the theoretical thermal efficiency of this cycle if the pressure at the end of the adiabatic compression is 15 bar. Peak temperature during the cycle is 2000 K. Calculate (i) the heat supplied per kg of air (ii) the work done per kg of air and (iii) the pressure at the end of adiabatic expansion. Take C_v= 0.717 kJ/kg K and $\gamma = 1.4$.
   b) In an engine working on Diesel cycle inlet pressure and temperature are 1 bar and 17 °C respectively. Pressure at the end of adiabatic compression is 35 bar. The ratio of expansion i.e. after constant pressure heat addition is 5. Calculate the heat addition, heat rejection and the efficiency of the cycle. Assume $\gamma = 1.4$, $C_p = 1.004$ kJ/kg K and $C_v = 0.717$ kJ/kg K.

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c) A four stroke C.I. engine having a cylinder diameter of 39 cm and stroke of 28 cm has a mechanical efficiency of 80%. Assume the frictional power to be 80 kW. Its fuel consumption rate is 86 kg/h with an air-fuel ratio of 18:1. The speed of the engine is 2000 RPM. Calculate (i) IP, (ii) HV, if η_{ith}=40%, (iii) p_{imep} (iv) air flow rate, (v) mean piston speed.

Marks: 2 × 15 = 30

Group D: CO4 (10 Marks)

5. Answer the following questions briefly (any two questions)
   a) Provide a concise explanation of the key components that make up a gas turbine power plant.
   b) Distinguish between open-cycle and closed-cycle gas turbines, and represent each using a temperature-entropy (T-S) diagram.
   c) Explain the Brayton cycle incorporating intercooling, reheating, and regeneration, using a temperature-entropy (T-S) diagram to illustrate the process.

Marks: 2 × 5 = 10

Group E: CO5 (15 Marks)

6. Answer the following questions briefly (any one question)
   a) A gas turbine unit works on an air-standard Brayton cycle. The pressure ratio across the compression is 6. Air enters the compressor at 1 bar and 27 °C. The maximum temperature of the cycle is 850 °C. Calculate the specific output of the cycle. What will be the power developed by the unit for a mass flow rate of 10 kg/s. Would you recommend this cycle for a reciprocating engine? For air γ = 1.4 and C_p = 1.005 kJ/kg K.
   b) The following data refers to a gas turbine power plant
   Power developed = 4.2 MW,
   Inlet pressure and temperature of air to compressor = 1 bar and 303 K. Pressure ratio of the cycle = 4,
   Isentropic efficiency of the compressor = 85%,
   Isentropic efficiency of turbines = 90%,
   Maximum temperature of the cycle = 823 K,
   If a reheater is used between two turbines at a pressure of 2.24 bar, calculate the following:
   (a) Mass flow rate of air,
   (b) Overall efficiency, for air C_p = 1.0 kJ/kg/K, γ = 1.4.
   For gases, C_{pg} = 1.15kJ/kg/K, γ_g = 1.33.

Marks: 1 × 15 = 15