IC ENGINE
(MECH 3211)

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) The intake charge in a Diesel engine consists of
(a) air alone (b) air and lubricating oil
(c) air and fuel (d) air, fuel and lubricating oil.

(ii) In an air standard Diesel cycle, at a fixed value of r and γ, the efficiency $\eta_{thermal}$
(a) increases with increase in heat addition and cut-off ratio
(b) decreases with increase in heat addition and cut-off ratio
(c) remains the same with increase in heat addition and cut-off ratio
(d) none of the above.

(iii) For the same maximum pressure, maximum temperature, and the same quantity of heat rejection, the thermal efficiencies of the air-standard Otto, Diesel and the Dual combustion cycles compare as
(a) $\eta_{Diesel} > \eta_{Dual} > \eta_{Otto}$ (b) $\eta_{Otto} > \eta_{Dual} > \eta_{Diesel}$
(c) $\eta_{Dual} > \eta_{Diesel} > \eta_{Otto}$ (d) $\eta_{Dual} > \eta_{Otto} > \eta_{Diesel}$

(iv) The thermal efficiency varies
(a) inversely as sfc (b) directly as sfc
(c) as square of sfc (d) as root of sfc

(v) If N is the rpm, the number of power strokes per minute in a four-stroke and two-stroke engine is respectively
(a) $2N \; and \; N$ (b) $N \; and \; 2N$
(c) $N/2 \; and \; N$ (d) $N/2 \; and \; N$

(vi) The principal surfaces requiring lubrication in an IC engine are
(a) cylinder head (b) crankcase
(c) inlet and exhaust manifold (d) none of the above

(vii) Crankcase ventilation is provided
(a) to cool cylinder walls (b) to cool crankcase
(c) to cool piston (d) to remove blow-by

(viii) Commonly used injection system in automobiles is
(a) air injection (b) solid injection
(c) combination of (a) and (b) (d) none of the above

(ix) The normal heptane (C_7H_{16}) is given a rating of _____ octane number:
(a) 0 (b) 50
(c) 100 (d) 120

(x) The work ratio of an ideal closed cycle gas turbine cycle depends upon
(a) pressure ratio of the cycle and the specific heat ratio
(b) temperature ratio of the cycle and the specific heat ratio
(c) pressure ratio, temperature ratio and the specific heat ratio
(d) pressure ratio only.

Group- B

2. (a) The indicated thermal efficiency of a four-stroke engine is 32% and its mechanical efficiency is 78% . The fuel consumption rate is 20 kg/hr when the engine runs at a fixed speed. The brake mean pressure developed is 6 bar and the mean piston speed is $12\,m/s$. Take CV = 42000 kJ/kg. Assuming it to be a *single* cylinder, *square* engine, calculate (i) crank radius and (ii) speed of the engine. *[(CO1)(Solve/IOCQ)]*

(b) Define the following: (i) clearance volume (ii) compression ratio. *[(CO1) (Define/LOCQ)]*

(3 + 5) + (2 + 2) = 12

3. (a) State any *five* principal assumptions of the air-standard cycles. *[(CO2) (Explain/LOCQ)]*

(b) With the aid of P-v and T-s plots, assess the thermal performance of the air-standard Otto, Diesel and the Dual combustion cycles for the same peak pressure, same peak temperature, and the same heat input. *[(CO2) (Investigate/HOCQ)]*

5 + 7 = 12

Group - C

4. (a) State the *four* principal realistic considerations and *two* assumptions in fuel-air cycle analysis. *[(CO2) (Discuss/LOCQ)]*

(b) With the help of a $p - V$ diagram, explain the loss due to variation of specific heats in an Otto cycle. *[(CO2) (Examine/IOCQ)]*

6 + 6 = 12

5. (a) Discuss three important qualities *each* of a suitable SI and CI engine fuel. *[(CO3) (List/LOCQ)]*

(b) How are SI and CI engine fuels rated? *[(CO3) (Classify/LOCQ)]*

(3 + 3) + (3 + 3) = 12

Group - D

6. (a) State the principle of carburetion. *[(CO4) (Describe/LOCQ)]*

(b) A simple jet carburettor is required to supply 5 kg of air per minute and 0.5 kg per minute of fuel of density 750 kg/m^3. The air is initially at 1 bar and 300K. Calculate the throat diameter of the choke for an air flow velocity of 100 m/s. Take the velocity coefficient for the venturi to be 0.80 and the coefficient of discharge of the main fuel jet to be 0.6. Assume isentropic flow ($\gamma = 1.4$) and the flow to be compressible. If the pressure drop across the fuel metering orifice is 0.80 of that at the choke, calculate the orifice diameter. *[(CO4) (Solve/IOCQ)]*

5 + 7 = 12

7. (a) A spray penetration of 25 cm is obtained in 20 milliseconds at an injection pressure of 150 bar. If an injection pressure of 250 bar is used, determine the time required by the spray to penetrate the same distance? Assume the same orifice and combustion chamber density. The combustion chamber pressure is 25 bar. Use the relation $S \propto t\sqrt{\Delta p}$ (S: penetration in cm, t: time in millisecond, Δp: pressure difference between injection pressure and combustion chamber pressure). *[(CO4) (Solve/IOCQ)]*

(b) State the functional requirements of an injection system. *[(CO4) (Discuss/LOCQ)]*

5 + 7 = 12

Group - E

8. (a) Briefly describe the principle of a forced circulation system with the aid of a block diagram. State the principal components of the forced circulation system. *[(CO5) (Discuss/LOCQ)]*

(b) A four-cylinder engine running at 1200 rpm delivers power of 20 kW. The average torque when one cylinder is cut off is 110 Nm. The engine uses 0.36 kg of gasoline per kWh. The calorific value of the fuel is 43 MJ/kg. Find the indicated thermal efficiency. *[(CO5) (Solve/IOCQ)]*

(5 + 3) + 4 = 12

9. (a) A four-cylinder, four-stroke engine has a diameter of 100 mm and a stroke of 120 mm. The speed of the engine is 1600 rpm. The fuel consumption is 0.2 kg/min, and the calorific value of fuel is 44000 kJ/kg. The difference in tension on either side of the brake pulley = 40 kg, and the brake circumference is 300 cm. If the mechanical efficiency is 80%, calculate (i) brake thermal efficiency (ii) indicated thermal efficiency (iii) indicated mean effective pressure and the (iv) brake specific fuel consumption. *[(CO5) (Solve/IOCQ)]*

(b) In a gas turbine plant working on Brayton cycle, the air at the inlet is 27℃, 0.1MPa. The pressure ratio is 6.5 and the maximum temperature is 850℃. The turbine and compressor efficiencies are each 84%. Find the (i) compressor work (ii) turbine work (iii) cycle efficiency and (iv) the turbine exhaust temperature. Draw the corresponding $T - s$ diagram. Mass of air may be considered as 1kg. *[(CO6) (Solve/IOCQ)]*

6 + 6 = 12

Cognition Level	*LOCQ*	*IOCQ*	*HOCQ*
Percentage distribution	*40*	*45*	*15*

Course Outcome (CO) :

After the completion of the course students will be able to

- Demonstrate knowledge of the operating characteristics of common IC engines and the ability to perform a thermodynamic analysis of Otto, Diesel, and Dual cycle models (L-3).
- Explain and quantify the differences in work outputs between theoretical cycles and actual cycles in operation (L-2).
- Distinguish between the combustion processes in SI and CI engines and the characteristics of common liquid and gaseous fuels (L-3).
- Implement combustion analysis of fuels for basic engine cycles, apply quantitative analysis to obtain the air-fuel ratio in a simple carburetor in terms of system parameters, and analyze fuel injection aspects in CI engines (L-3).
- Describe the basic technological aspects of the fuel injection, lubrication and cooling systems, explain various performance testing procedures and recognize IHP, BHP, FHP and efficiency parameters (L-2).
- Examine an ideal gas turbine cycle and calculate thermal efficiency and work output (L-4).

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*