N.B. 1) All questions are compulsory.
2) Figures to the right indicate marks.
3) Draw suitable diagrams and illustrations wherever necessary.
4) Mixing of sub-questions is not allowed.

Q. 1 Attempt All the Questions

A. Choose the correct alternative
   i. The grammar \( G = (\{S\}, \{a, b\}, P, S) \) where \( P \) consists of
      \[ S \rightarrow aSbb, S \rightarrow aab \]
generates the language ______
      a) \( a^n b^m | m > n, m, n \geq 1 \)
      b) \( a^n b^{2n} | n \geq 1 \)
      c) \( a^n b^m | m < n, m, n \geq 1 \)
      d) none of these
   ii. The regular expression \((P+Q)^*\) is equal to
      a) \((P^*+Q^*)^*\)
      b) \((P^*Q^*)^+\)
      c) \((P^*+Q^*)^+\)
      d) \((P^*+Q^*)^\)
   iii. Pumping lemma for context-free languages are used to prove that certain languages
        are not context-free.
        a) True
        b) False
   iv. PDA stands for ______
        a) pull down automata
        b) push direct automata
        c) push down automata
        d) pull direct automata
   v. In ______ machine, the output function \( Z(t) \) depends only on the present state and is
      independent of the current input.
        a) Moore
        b) Mealy
        c) Both a and b
        d) None of these

B. Fill in the blanks (Choose correct one from the pool)
   (type 2, type 1, one, three, not regular, regular, \( a^* \), \( a^+ \), initial, final)
   i. The regular expression \( a^*a^+ \) is same as ______
   ii. A finite automaton can have more than one ______ state.
   iii. The language \( L = \{a^p | p \text{ is a prime} \} \) is ______
   iv. Regular expression \((aaa)^*\) denotes the string \( x \) whose length is divisible by_____
   v. Context sensitive grammar is also known as ______ grammar

C. Explain the following terms in one or two lines
   i. Non deterministic finite automaton
   ii. Regular expression
   iii. Acceptance by PDA
   iv. Derivation tree
   v. Decidable languages
Q.2 Attempt the following: (Any THREE) (15M)
A. What is finite automaton? Briefly explain with suitable example the acceptability of a string by a finite automaton.
B. Compare between Mealy and Moore models.
C. Construct DFA accepting all strings \( w \) over \{a, b\} such that the number of a's in \( w \) is 3 mod 4.
D. Define Grammar. Also explain what is a language generated by a grammar. Give examples.
E. Compare between deterministic and non-deterministic finite automaton. Give suitable examples.
F. Write a note on operations on Languages.

Q.3 Attempt the following: (Any THREE) (15M)
A. Prove that \((a+b)^* = a^*b^*a^*\).
B. Explain with suitable example the leftmost derivation and rightmost derivations. Give example.
C. What is meant by ambiguity in context free grammar? Give example to explain the concept.
D. Write a note on Chomsky Normal Form.
E. State and prove pumping lemma for regular sets.
F. Draw the transition diagram for the expressions
   i. \( a^* + ba^* \)
   ii. \( a^*b + ba^* \)

Q.4 Attempt the following: (Any THREE) (15M)
A. Briefly explain the structure and operation of Push down automata.
B. Write a note on representation of Turing machine.
C. Design a Turing machine to recognize all strings consisting of even number of a's.
D. Write a note on model of Linear Bounded Automaton.
E. Write a note on nondeterministic Turing machine.
F. Write a note on properties of recursive languages.

Q.5 Attempt the following: (Any THREE) (15M)
A. Briefly explain with example the steps of construction of minimum automaton.
B. Consider the grammar \( G \) given by
   \[ S \to 0SA_2, \quad S \to 012, \quad 2A_1 \to A_12, \quad 1A_1 \to 11 \]
   Test whether \( \text{(a)} \ 00112 \in L(G) \quad \text{(b)} \ 001122 \in L(G) \)
C. Construct a DFA with reduced states equivalent to the regular expression \( 10 + (0+11)0^*1 \)
D. Design a Turing Machine that accepts \( \{a^n b^n \mid n \geq 1\} \)
E. Write a note on Universal Turing machines
F. Briefly outline the halting problem of Turing machine.