1. Answer question 1 and any FOUR from questions 2 to 7.
2. Parts of the same question should be answered together and in the same sequence.

**Time: 3 Hours**

**Total Marks: 100**

1. a) How strings differ from words of a language? Given an alphabet $\Sigma$, what do you mean by a language $L$ over $\Sigma$?
b) What is the difference between deterministic and nondeterministic finite state automata?
c) Distinguish between context free and context sensitive language.
d) When is a language said to be recursively enumerable?
e) What is a cross compiler? Give an example.
f) What are the disadvantages of operator precedence parsing?
g) What is meant by peephole optimization? What are its characteristics?

(7x4)

2. a) Show that $R$ is an equivalence relation in the following question:
$R$ is the relation on the set of integers such that $(a, b) \in R$ if and only if $3a + 4b = 7n$ for some integer $n$.
b) Use mathematical induction to prove that $n^3 + 2n$ is divisible by 3, for $n \geq 1$.
c) Solve the recurrence relation $a_n = 2a_{n-1} + 2^n; a_0 = 2$.

(6+6+6)

3. a) Show that the language $L = \{a^k \mid k = i^2, i \geq 1\}$ is not a finite state language.
b) Construct the transition diagram of the finite automaton $M$ given below and then a minimum state automaton equivalent to $M$.

$M = (Q, \Sigma, \delta, q_0, F)$ where $Q = \{q_0, q_1, q_2, q_3, q_4, q_5, q_6, q_7\}$, $\Sigma = \{0,1\}$, $F = \{q_2\}$ and $\delta$ given as follows.

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<thead>
<tr>
<th>$\delta$</th>
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<tr>
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(9+9)

4. a) Construct a context-free grammar that generates the set of strings of the form $a^m b^n c^p; m, n, p \geq 1$ and hence find the PDA that accepts such strings.
b) Obtain a grammar in Chomsky Normal Form (CNF) equivalent to the grammar $G$ with productions $P$ given by $S \rightarrow AACD, A \rightarrow aAb | \epsilon, C \rightarrow aC | a, D \rightarrow aDa | bDb | \epsilon$.

(9+9)
5. 
   a) Construct a Turing machine that computes the function \( f(n) = n - 3 \), if \( n \geq 3 \) and \( f(n) = 0 \) for \( n = 1, 2 \) for all positive integers \( n \).
   b) Differentiate between P, NP, NP-complete, and NP-hard problems with appropriate examples.
   c) Define passes of a compiler. Which are the factors that decide number of passes for a compiler?

6. 
   a) Consider the grammar:

   \[
   \begin{align*}
   &A \rightarrow a \, A \, a \\
   &B \rightarrow b \, A \, b \\
   &A \rightarrow \varepsilon
   \end{align*}
   \]

   i) Describe the language that the grammar defines.
   ii) Is the grammar ambiguous? Justify your answer.
   iii) Construct a SLR parse table for the grammar.
   iv) Can the conflicts in the table be eliminated?
   b) For the assignment instruction below performs the following:

   \[ x = (a + (b * 2)) + 1 \]

   i) Augment the Syntax Directed Translation (SDT) scheme with a rule corresponding to the production \( E \rightarrow \text{const} \) and using a “value” attribute for the constant with its numeric value.
   ii) Generate three-address instructions using the SDT scheme and without any minimization of temporaries.
   iii) Redo the code generation but reusing temporaries.

7. 
   a) Explain the followings:

   i) Loop-invariant code motion
   ii) Dead-code elimination
   b) What are the different storage allocation strategies? Explain in detail.