Instructions to the candidates:
1) Answer any five questions.
2) Solve Q1 or Q2, Q3 or Q4, Q5 or Q6, Q7 or Q8, Q9 or Q10.
3) Figures to the right indicate full marks.
4) Assume suitable data, wherever necessary.

Q1) a) Explain Basic Machines. What are its limitations? How is Finite Automata more capable than Basic Machines? Justify with examples. [6]

b) Write a CFG that generates language L denoted by,
   \((a+b)^* . bbb . (a+b)^*\). [4]

OR

Q2) a) Convert the following finite automation into its equivalent regular expression using Arden's Theorem. [6]

b) If \(S=\{a, bb\}\), find the set of all strings in \(S^*\) with string length less than or equal to 5. Also for given \(S\), prove whether the following is true or false.
   \((S^*)^* = (S^*)^*\). [4]

Q3) a) Design Moore Machine and Mealy Machine to find one's complement of a binary number. [6]

P.T.O.
b) Write the CFG for language \( L = \{0^i1^j0^k \mid j > i + k\} \).

Show the derivation of the string ‘0111100’. [4]

OR

Q4) a) Define the following and give appropriate examples: [6]
   i) Unrestricted Grammar
   ii) CFG
   iii) Derivation Graph


Q5) a) Design a Turing Machine to recognize an arbitrary string divisible by 4, given \( \Sigma = \{0,1,2\} \). [10]

b) Design a Turing Machine that accepts a language \( L = \{0^n1^n0^n \mid n \geq 1\} \). [8]

OR

Q6) a) Construct a TM that accepts a language \( L = a^* ba^*b \). [6]

b) How can Turing Machines be compared to computers? [6]

c) Prove that the halting problem in Turing Machines is undecidable. [6]

Q7) a) Construct transition table for PDA that accepts the language \( L = \{a^n b^n \mid n \geq 1\} \). Trace your PDA for the input with \( n = 3 \). [10]

b) Define push down automata (PDA). What are the different types of PDA? Give the applications of PDA. [6]

OR

Q8) a) Give a grammar for the language \( L(M) \), where:
   \( M = (\{q_0, q_f\}, \{0,1\}, \{z_o, x\}, \delta, q_0, z_o, \Phi) \). [8]

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And $\delta$ is given by:

$\delta(q_0, l, z_o) = (q_0, xz_o)$  \hspace{1cm} $\delta(q_0, \epsilon, z_o) = (q_0, \epsilon)$

$\delta(q_0, l, x) = (q_0, xx)$  \hspace{1cm} $\delta(q_1, l, x) = (q_1, \epsilon)$

$\delta(q_0, 0, x) = (q_1, x)$  \hspace{1cm} $\delta(q_0, 0, z_o) = (q_0, z_o)$

b) Construct PDA for the following regular grammar:

$S \rightarrow 0A \mid 1B \mid 0$

$A \rightarrow A0 \mid B$

$B \rightarrow c \mid d$

**Q9**  

a) Justify that the SAT Problem is NP-complete.  \hspace{1cm} [8]

b) Explain in detail, the polynomial time reduction approach for proving that a problem is NP-Complete.  \hspace{1cm} [8]

OR

**Q10**  

a) Explain the Node-Cover Problem with a suitable example.  \hspace{1cm} [8]

b) Explain Tractable and In-tractable Problem.  \hspace{1cm} [4]

c) Justify whether the Traveling Salesman Problem is a class P or class NP problem.  \hspace{1cm} [4]