Name : ...................................................................

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Invigilator's Signature : .........................................

## CS/B.Tech(IT)/SEM-5/CS-512/2009-10
## 2009
# FORMAL LANGUAGE & AUTOMATA THEORY

Time Allotted : 3 Hours                    Full Marks : 70

*The figures in the margin indicate full marks.*

*Candidates are required to give their answers in their own words
as far as practicable.*

## GROUP – A
### ( Multiple Choice Type Questions )

1. Choose the correct alternatives for any *ten* of the following :

$$10 \times 1 = 10$$

i) Let $R_1$ and $R_2$ be regular sets defined over alphabet $\Sigma$ then

   a) $R_1 \cap R_2$ is not regular

   b) $R_1 \cup R_2$ is regular

   c) $\Sigma \cap R_2$ is not regular

   d) $R_2^*$ is not regular.

ii) Which of the following strings can be obtained by the language $L = \left\{ a^i b^{2i} / i \geq 1 \right\}$ ?

   a) aaabbbbbb          b) aabbb

   c) abbaabbbb          d) aaaabb.

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iii) The regular expression with all strings of 0's and 1's with at least two consecutive 0's is

a)  $1 + (10)^*$

b)  $(0 + 1)^* 00 (0 + 1)^*$

c)  $(0 + 1)^* 011$

d)  $0^* 0^* 1^*$.

iv) Which string can be generated by $S \rightarrow aS / bA$, $A \rightarrow d / ccA$ ?

a)  aabccd

b)  adabcca

c)  abcca

d)  ababab d.

v) The regular sets are closed under

a)  Union

b)  Concatenation

c)  Kleene closure

d)  all of these.

vi) The intersection of CFL and regular language

a)  is always regular

b)  is always context-free

c)  both (a) & (b)

d)  need not be regular.

vii) A grammar that produces more than one parse tree for some sentence is called

a)  ambiguous

b)  unambiguous

c)  regular

d)  none of these.

viii) Consider the regular expression $(0 + 1)(0 + 1) \ldots n$ times. The minimum state finite automation that recognizes the language represented by this regular expression contains

a)  $n$ states

b)  $n + 1$ states

c)  $n + 2$ states

d)  $n - 1$ states.

ix) The vernacular language English, if considered a formal language is a

    a)    regular language

    b)    context-free language

    c)    context-sensitive language

    d)    none of these.

x) Palindromes cannot be recognized by any Finite State Machine because

    a)    an FSM cannot remenber arbitrarily large amount of information

    b)    an FSM cannot fix the mid-point

    c)    FSM cannot find whether the second half of the string matches the first half

    d)    all of these.

xi) NDFA can be constructed equivalent of

    a)    type-0 grammar       b)    type-1 grammar

    c)    type-2 grammar       d)    type-3 grammar.

xii) Pumping lemma for CFG proves that a given language

    a)    belongs to CFG

    b)    does not belong to CFG

    c)    belongs to regular grammar

    d)    none of these.

xiii) Turing machine accepts

    a)    only type-1 grammar    b)    only type-2 grammar

    c)    only type-3 grammar    d)    all grammars.

xiv) If a machine of $n$ states is $\mu$ definite, then

    a)    $\mu \le n - 1$        b)    $\mu \ge n - 1$

    c)    $\mu = n - 1$        d)    none of these.

xv) Merger table is substitute of

    a)    merger graph        b)    compatible graph

    c)    minimized machine    d)    finite state machine.

xvi) If $G = ( \{ S \}, \{ a \}, \{ S \to SS \}, S )$, the language generated by $G$ is

    a)    $L ( G ) = \phi$        b)    $L ( G ) = a^n$

    c)    $L ( G ) = a^\phi$        d)    $L ( G ) = a^n b \, a^n$.

## GROUP – B

### ( Short Answer Type Questions )

Answer any *three* of the following.    $3 \times 5 = 15$

2.  Test the machine below is definiteness or not ? If yes, find the order $\mu$.    5

| PS | NS | |
|---|---|---|
|  | $x = 0$ | $x = 1$ |
| A | A | B |
| B | E | B |
| C | E | F |
| D | E | F |
| E | A | D |
| F | E | B |

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3.  a)  State pumping lemma for Context Free Language.

    b)  Using this lemma prove that $L = \{ a^i b^j \mid j = i^2 \}$ is not Context Free Language.                                  2 + 3

4.  a)  What is ambiguous grammar ?

    b)  Check whether the following grammar is ambiguous :

    $S \rightarrow iCtS \mid iCtSeS \mid a$

    $C \rightarrow b$                                           1 + 4

5.  a)  What are the differences between Moore and Mealy machines ?

    b)  Construct a Moore machine equivalent to the Mealy machine :

| PS | NS | | | |
|---|---|---|---|---|
| | $a = 0$ | | $a = 1$ | |
| | NS | o/p | NS | o/p |
| q1 | q1 | 1 | q2 | 0 |
| q2 | q4 | 1 | q4 | 1 |
| q3 | q2 | 1 | q3 | 1 |
| q4 | q4 | 0 | q1 | 1 |

2 + 3

6.  a)  What are the differences between DFA & NFA ?

    b)  Construct DFA which is equivalent to given NFA.
    $M = ( \{ q0, q1, q2, q3 \}, \{ 0, 1 \}, \delta, q0, \{ q3 \} )$ and $\delta$ is given in table :                                  2 + 3

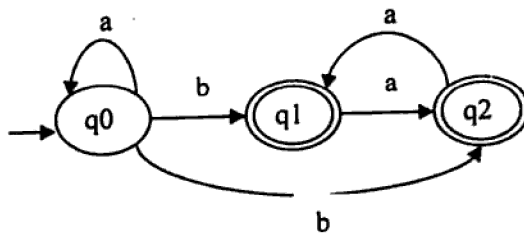| $Q/\Sigma$ | 0 | 1 |
|---|---|---|
| q0 | q0, q1 | q0 |
| q1 | q2 | q1 |
| q2 | q3 | q3 |
| q3 | — | q2 |

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## GROUP – C
### ( Long Answer Type Questions )
Answer any *three* of the following.         $3 \times 15 = 45$

7.   a)   State and prove Arden's Theorem.

     b)   Prove that
$$( 1 + 00^* 1 ) + ( 1 + 00^*1 ) ( 0 + 10^*1 )^*( 0 + 10^*1 )$$
$$= 0^*1 ( 0 + 10^*1 )^*$$

     c)   Find the regular expression for the given transition diagram :



                                                          $5 + 5 + 5$

8.   a)   What is PDA ?

     b)   Design a PDA to accept the following language $L = ( w w^R | w \, \varepsilon ( 0, 1 )^* )$.

     c)   Construct a context free grammar generating following language :
$$L = \{ a^n b^n | n \geq 1 \} \, U \, \{ a^m b^{2m} | m \geq 1 \}$$ and also construct PDA for the above derived CFG.         $1 + 6 + 8$

9.   a)

| PS | NS,z | | |
|---|---|---|---|
| | $I_1$ | $I_2$ | $I_3$ |
| A | C,0 | E,1 | --- |
| B | C,0 | E,-- | --- |
| C | B,-- | C,0 | A,-- |
| D | B,0 | C,-- | E,-- |
| E | --- | E | A,-- |

For the incompletely specified machine shown above, find a minimum state reduced machine containing the original one.

b)

| PS | NS,z | |
|----|------|------|
|    | x=0  | x=1  |
| A  | B,1  | H,1  |
| B  | F,1  | D,1  |
| C  | D,0  | E,1  |
| D  | C,0  | F,1  |
| E  | D,1  | C,1  |
| F  | C,1  | C,1  |
| G  | C,1  | D,1  |
| H  | C,0  | A,1  |

Using this table

i) find the equivalence partition

ii) find the standard form of the corresponding reduced machine.

What is the minimum length sequence that distinguishes state $A$ from state $B$.  $8 + ( 3 + 3 + 1 )$

10. a) For the grammar

$S \to aB | bA$

$A \to a | aS | bAA$

$B \to b | bS | aBB$

Give the left most and right most derivation for the string "aaabbabbba".

b) Design a CFG for the language

$L ( G ) = \{ 0^n 1^m | n \neq m \}$

c) Construct a regular grammar $G$ generating the regular set by $r = 01 ( 0 + 1 )^*$.    $5 + 5 + 5$

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11. a) Remove left recursion from given grammar :

$$A \rightarrow Ba \,|\, b$$

$$B \rightarrow Bc \,|\, Ad \,|\, e$$

 b) Convert the grammar into GNF :

$$S \rightarrow ABb \,|\, a$$

$$A \rightarrow aaA \,|\, B$$

$$B \rightarrow bAb$$

 c) In response to an unknown input sequence, the machine given below produces the output sequence 1110000010. Find the input sequence to the machine if it is known that its initial state is $A$ and final state is $F$.

| PS | NS,z | |
|----|------|------|
|    | x=0  | x=1  |
| A  | B,1  | C,0  |
| B  | D,1  | B,1  |
| C  | E,1  | B,0  |
| D  | A,0  | E,0  |
| E  | F,0  | D,1  |
| F  | D,0  | A,1  |

3 + 5 + 7