National Institute of Technology Rourkela

Department of Computer Science and Engineering
B.Tech/M. Tech. Dual Degree 5th Semester
End Semester Examination (Autumn) 2015

Subject: **Theory of Computation** Subject Code: **CS-331**
Full Marks: **50** Duration: **3 Hours**

Answer ***all*** questions from ***Section A*** and any two from ***Section B***.
Figures at the right margin indicate marks.
All parts of a question must be answered at one place.

Section A

1. (a) Find a CFG that generates the language
L(G) = $\{ a^n b^m \mid 0 \leq n \leq m \leq 2n\}$. [3]
(b) Also, design the NPDA for the above language. [3]

2. (a) Write the pseudocode for DFA minimization. [3]
(b) Minimize the DFA as given in Table 1. Here the state A is the initial state and C is the final state. [3]

Table 1: State transition table for the DFA

State	Input 0	Input 1	State	Input 0	Input 1
→ A	B	F	E	H	F
B	G	C	F	C	G
C	A	C	G	G	E
D	C	G	H	G	C

3. (a) Convert the following grammar into it's equivalent Greibach Normal Form. [3]
$S \rightarrow AB|aB$
$A \rightarrow aab$
$B \rightarrow bbA$
(b) Design a two stack pushdown automaton (TSPDA) to accept the language given below,(**Hint:** Define $\delta : Q \times \sum \cup \{\epsilon\} \times \Gamma_1 \times \Gamma_2 \rightarrow Q \times {\Gamma_1}^* \times {\Gamma_2}^*$) [3]
$L = \{0^n 1^m 0^n 1^m | n, m > 0\}$.

4. (a) Find a context free grammar for the language given below. [3]
$\{1^k 0^i 1^i 0^j 1^j 0^k \mid i, j, k \geq 0\}$
(b) Consider the grammar [3]
$S \rightarrow abScB|\lambda$
$B \rightarrow bB|b$
What language does it generate?

5. (a) Write the regular expression for a language L where all strings in L contains at most two occurrences of the substring 01. [3]
(b) Find DFA that accept the following languages. [3]
(i) $L = L(ab^*a^*) \cup L((ab)^*ba)$
(ii) $L = L(ab^*a^*) \cap L((ab)^*ba)$

6. (a) Prove that every integer greater than 17 is a nonnegative integer combination of 4 and 7. In other words for all n $\in \mathbb{N}$, $n >= 17$, there exists nonnegative integers i_n, j_n such that $n = i_n \times 4 + j_n \times 7$. [3]

   (b) Define an NFA with four states equivalent to the regular expression given below and convert this automaton to its equivalent DFA. [3]
   $(01 + 011 + 0111)*$

7. (a) Show that the following language on $\Sigma = \{a, b, c\}$ is not context-free.(Consider all possible cases) [3]
   $L = \{a^n b^j c^k \mid k = jn$ and $n, j, k >= 0\}$.

   (b) The state transition function of a NPDA is given below which accepts the language by empty stack. Find the CFG. [3]
   $(p, \lambda, Z) \to (q, SZ)$
   $(q, a, S) \to (q, \lambda)$
   $(q, a, S) \to (q, XY)$
   $(q, a, X) \to (q, X)$
   $(q, a, X) \to (q, \lambda)$
   $(q, b, Y) \to (q, Y)$
   $(q, b, Y) \to (q, \lambda)$
   $(q, \lambda, Z) \to (r, \lambda)$

Section B

8. (a) Explain why the grammar below is ambiguous. [2]
   $S \to 0A|1B$
   $A \to 0AA|1S|1$
   $B \to 1BB|0S|0$

   (b) Construct the PDA for the grammar in 8(a). [2]

9. (a) Give the mathematical definition of a Turing machine (TM) and explain the working principle of TM. [2]

   (b) Design a Turing machine to compute the 2's compliment of a given number. [2]

10. (a) What are the differences between NP, NP-Complete and NP-Hard? [2]

    (b) What are decidable and undecidable problems? [2]

———— WISH YOU ALL THE BEST ————