National University of Computer & Emerging Sciences, Karachi

Spring-2018 CS-Department

Final Exam

22nd of May 2018, 9:00 am – 12:00 noon

Course Code: CS301	Course Name: Theory of Automata
Instructors Name:	M.Shahzad, Subhash Sagar and Shaharbano
Student Roll No:	

Instructions :

- Return the question paper.
- Read each question completely before answering it.
- In case of any ambiguity, you may make assumption, but your assumption should not contradict any statement in the question paper.
- Start each question on a new sheet.
- There are total 9 Questions on 2 Pages.

Time: 180 minutes. **Max Marks : 120 points**

Question 1: True or False (With Reasons) **(5) Points**

a) There is a regular language L for which there is exactly one regular expression R with L(R) = L.

b) Union of regular language with context free language is not always a regular language.

c) L4 = L1∩L2∩L3, where L1 and L2 are regular and L3 is CFL. It is possible that L4 will be a regular language.

d) L2 = Complement of L1, where L1 is a CFL. It is possible that L2 will be a regular language.

e) The language L ={ $a^i b^j | i \geq j$} is regular language.

Question 2: Regular exp. (R.E.) & FA's **(5+5+5+5+5) Points**

a) Construct the FA for a language upon ∑ ={a,b,c} which accepts all strings not ending with "abc".

b) Construct the DFA A for strings accepting all 0's and odd 1's. State the R.E.

c) Construct the DFA B for strings accepting all 1's ending with odd 0's. State the R.E.

d) Concatenate the DFA's A and B to find DFA AB.

e) Take the union of A and B to find a DFA for A∪B.

Question 3: CFG **(5+5+5) Points**

Construct a CFG which generates the following languages:

a) L1 ={ $a^n b^n | n \geq 1$}

b) L2 ={ $a^n b^m a^n | n \geq 1$}

c) Find L1L2 and L1∪L2

Question 4: Ambiguity in CFG **(5) Points**

Check whether the following grammar is ambiguous, take expression w=ibtibtaea

S → iCtS|iCtSeS C → b S → a

Question 5: CNF **(5+5) Points**

Consider the following CFG for non empty language:

$S1 \rightarrow S$
$S \rightarrow aSb|BB|BCD\ |ab|BC$
$A \rightarrow DD \mid B \mid BCB \mid D \mid \varepsilon$
$B \rightarrow AB\ |C \mid \varepsilon$
$C \rightarrow Cc|c$

a) Simplify showing each steps clearly.
b) Convert the above CFG into CNF.

Question 6: P.D.A. **(5+5+5) Points**

a) Construct an equivalent P.D.A. from the following CFG:
   $S \rightarrow aTb|\ b$
   $T \rightarrow Ta \mid \varepsilon$
b) Trace the input sring "aaab" using stack.
c) Construct a P.D.A. accepting for the language $L = \{ a^4 b^n c^n | n \geq 0\}$

Question 7: Turing Machines (TM) **(10+5+5) Points**

a) Create Turing Machines for the following languages and function:
   i. $L_2 = \{a^{3n} b^n c^{2n} | n \geq 2\}$.
   ii. $f(x,y) = \begin{cases} x+y & x < y \\ \text{"zero"} & x \geq y \end{cases}$
b) Give an example of infinite loop resulting in Non-Halting TM.
c) Give formal definitions of a two-tape Turing machine for the language
   {w | w^R = w is any string of 0's and 1's}. **[Hint: give some example]**

Question 8: Undecidability & UMT **(5+5+5) Points**

a) Draw the Chomsky hierarchy of languages with the Venn diagram. Also label recursive, recursively enumerable, non recursively enumerable, decidable problems and undecidable problems in the drawn Venn diagram.
b) Define the following terms:
   i. Recursive TM,
   ii. Recursively Enumerable TM,
   iii. Undecidable Problems.
c) Define Universal Turing Machine. Give an example of UTM.

Question 9: 8 **(5+5) Points**

Select and design the best machine for the following language:

$$L = \{ (a^n b^n c^m d^m |\ n=2, m=2) \cup (a^n b^m c^m d^n |\ n=2, m=1\}$$

Justify your selection regarding its working, time cost and storage cost.

BEST OF LUCK!