MASENO UNIVERSITY

UNIVERSITY EXAMINATIONS 2012/2013

SECOND YEAR SECOND SEMESTER EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN INFORMATION TECHNOLOGY (MAIN CAMPUS)

CCS 213: AUTOMATA THEORY

Date: 16th July, 2013 *Time: 2.30 – 4.30 p.m.*

INSTRUCTIONS:

- Answer Question ONE and any other TWO questions.
- Use of mobile phones is STRICTLY FORBIDDEN.

Question one (Compulsory 30 marks)

1. What do the terms determinism and non-determinism mean (2 marks)
2. Provide regular expressions that define the following languages: (4 marks)
   a. The set of strings defined over the alphabet $\Sigma = \{x,y,z\}$ such that the number of y's is divisible by 3.
   b. The set of strings defined over the alphabet $\Sigma = \{0,1\}$ such that the accepted strings either begin or end (or both) with 01.
3. Explain the pumping Lemma (2 marks)
4. Show that the following languages are not regular (4 marks)
   a. $0^n 1^m 0^{n+m} \mid m,n>=0$
   b. $W \in \{0,1\}^* \mid$ w is a palindrome
5. Give a NFA accepting the language over the alphabet {a,b} the set of strings that end with ba,bb or baa. Then show that the string baab is not accepted by the NFA (3 marks)
6. Draw the FA and TG for the RE described in b above (6 marks)
7. Give a regular expression that defines the languages generated by the following grammars (4 marks)
   a. $S \rightarrow xA|\lambda$
      $A \rightarrow yS$
   b. $S \rightarrow Wa$
      $W \rightarrow Z$
      $Z \rightarrow Wa$
8. Build a machine that recognizes valid email addresses in the .ke domain, of the form: string0@string1.string2.string3.ke Assume that each string is composed of only lowercase letters from the Roman alphabet, and cannot be null. In addition, string0 must be of length greater than 2, string2 is optional, while string3 can only be one of the following: ac, co or go. (5 marks)

Question two (20 marks)

1. Prove that for any set M, the closure $M^*=(M^*)^*$, using constructive algorithm (2 marks)
2. Give a DFA accepting the language over the alphabet {a,b,c,d}, the set of strings consisting of zero or more a's followed by zero or more b's followed by zero or more c's (2 marks)
3. Write regular expressions for the following languages: (4 marks)
   i. The set of strings over {x,y,z} such that the number of y's is divisible by 3
   ii. The set of strings over {0,1} such that the accepted strings either begin or end with 01.
4. Obtain Right-linear and Left-linear grammars for the language L defined over the alphabet $\Sigma=\{a,b\}$ whose words do not contain the substring bab (6 marks)
5. A soda dispensing machine has the following characteristics:
   i. Drinks cost 20 shillings.

ii. The only coins accepted by the machine are the Five, Ten and Twenty shilling coins abbreviated E, N and Y respectively. The machine accepts any combination of these coins, in any order, that add up to 20 shillings.

iii. If the buyer puts in too much money, the dispenser returns appropriate change.

iv. If the user enters a partial sum, e.g. One five shilling coin (E) and one ten shilling coin (N), and then enters too much money e.g. one twenty shilling coin (Y), the machine will accept the input, move into the final state and return appropriate change.

Ignoring the selection or delivery of drinks, draw a finite-state model of the soda dispensing machine that returns appropriate change when the buyer enters too much money. (6 marks)

Question three (20 marks)

1. Determine the DFA that recognizes the language L defined over the alphabet $\Sigma = \{0,1\}$, where the strings in L contain at least one 1, and an even number of 0s follow the last 1. (3 Marks)
2. Define a context free grammar that generates strings of balanced parentheses. Example of strings or balanced parentheses are (()),()(),(()()) and E, where)(and (() are not accepted (3 marks)
3. Determine the deterministic FA that accepts the language L(r), where r = ab(a + ab* (a + aa)). (5 marks)
4. Define Context free grammars for the following languages
   $\{0^i 1^j \mid i \geq 0, i \leq j \leq 2i\}$ (4 marks)
5. To support the devolved system of government in Kenya, the Registrar of Persons has introduced a new personal ID system. In the new system, each ID is of the form ABCD, where
   a. A is a 2-digit code identifying the county and ranges from 1 to 47
   b. B us a 4-digit code identifying the month and date of birth of the citizen e.g. 02227 indicates that this person was born on February 27
   c. C is a single character indicating gender i.e. F or M
   d. D is a 5-gigit code ranging from 00001 to 99999

   You are required to define a finite state machine that determines the validity of a given ID. For example, given the ID 420230M01234, your system should indicate that it is invalid, while ID 420220M01234 is valid (5 marks)

Question four (20 marks)

1. Give the RE of all strings of a's and b's that contain an odd number of b's or an odd number of a's. (2 marks)
2. Determine a DFA accepting all strings over the alphabet $\Sigma = \{0,1\}$ which end in 1 but do not contain the substring 00. (4 marks)
3. Give a regular expression for the following language of Kiswahili verbs: (4 marks)

KiswahiliVerbs = {imba, ninaimba, anaimba, unaimba, tunaimba, wanaimba, mnaimba, wanaimbia, tunaimbisha, cheza, ninacheza, anacheza, unacheza, tunacheza, wanacheza, mnacheza, mnachezea, unachezesha}

4. In coding transmission messages, a given algorithm works as follows: when two consecutive 1's are followed by two consecutive 0's, the message recipient knowa that there has been a transmission error. Construct a mealy machine that accepts strings defined over th e alphabet $\Sigma=\{0,1\}$, that gives a 0 as its output if a transmission error has occurred and a 1 otherwise (4 marks)
5. Given the language L over the alphabet $\Sigma=\{a,b\}$ and which is defined by the regular expression ab(aa+bb)*ba), define a Turing machines that accepts language L (4 marks)
6. Using the Turing machine M defined above, determine if the following stings are valid strings in L. Show your computation (2 marks)
    a. abbba
    b. abaaba

Question five (20 marks)

1. Show using an example DFA that regular languages are closed under complement (3 marks)
2. Give DFA accepting the language over the alphabet {a,b}, the set of all strings such that the second last symbol is b (2 marks)
3. Give a DFA accepting the language over the alphabet {x,y}, the set of strings that either begin or end (or both) with yx (2 marks)
4. For the forthcoming general elections, IEBC wishes to automate the announcement of the election results. To do this, they require a system that automatically generates announcements of the voting results for all elective posts. The announcements can be in any of the following formats:
    - Z has been duly elected as governor for the county K with P percent of total votes cast
    - The winner of the governor's post for county K is Z, garnering P percent of total votes cast
    - Z has been duly elected as senator for county K with P percent of total votes cast
    - The winner of the senator's post for county K is Z, garnering P percent of total votes cast
    - Z has been duly elected as a member of parliament for a constituency of county K is Z, garnering P percent of the total votes cast

    Note that Counties are names as follows, C01 to C47; Candidates range from CND1 to CND100; Percent of votes cast ranges from 1 to 100.

    i. Ignoring white spaces in the announcements, construct a CFG that generates all possible announcements given the specified format. (6 marks)

ii. Using the CFG defines in i) above, show that the announcements is valid: CND29 has been duly elected as a member of parliament for constituency of county C42 with 67 percent of total votes cast (2 marks)

5. Draw a pushdown Automaton M, that accepts the language $\{a^j b^j b^j : j > 0\}$ (3 marks)
6. Using the pushdown Automaton M defined above, determine if the following input strings are accepted by M. Show a clear trace of the computation (2 marks)
   -
   - aabbbb
   - aabb