UNIVERSITY OF SWAZILAND
MAIN EXAMINATION (SEM - I) DEC, 2009

Title of Paper : THEORY OF COMPUTATION

Course number: CS211

Time allowed : Three (3) hours.

Instructions : (1) Read all the questions in Section-A and Section-B before you start answering any question.

(2) Answer **all** questions in Section-A and **any two** questions of section-B. Maximum mark is 100.

(3) Use correct notation and show all your work on the script.

This paper should not be opened until the invigilator has granted permission.

SECTION-A (Maximum marks 50)

Note: Answer **all** questions in this section.

Q1 (marks 6 + 6 +12). The following languages are given on symbol set {a, b}. Assume that u, v, w ∈ $\{a, b\}^*$.

(i). L1 = {uwv, |u| and |v| = 2}

(ii). L2 = {awa} ∪ {bwb}

(iii). L3 = {w, (|w| mod 3 = 0)}

The following set of words is given -

{λ, a, b, ab, aab, abaa, aaabb, bbbbbab, aaabbbb, aaaaaabb, aabbbbabb, ababab}

(a). From the above set, write all the words belonging to L1, all the words belonging to L2 and all the words belonging to L3.

(b). Write three regular expressions representing L1, L2 and L3 respectively.

(c). Design three deterministic finite acceptors **(dfa's)** accepting L1, L2, and L3 respectively.

Q2 (marks 6 + 8 + 12). The following non deterministic finite acceptor **(nfa)** is given :

M = ({q0, q1, q2, q3, q4}, {0, 1}, q0, δ, {q3}), where the transitions are given as :

δ(q0,0) = {q0, q1} ; δ(q0,1) = {q0} ;
δ(q1,0) = {q2, q3} ; δ(q1,1) = {q3} ;
δ(q2,0) = {q0, q2} ; δ(q2,1) = {q4} ;

(a). Draw the transition digraph of the above **M.**

(b). Compute $\delta^*(q0, w)$, where w = 0000, 0111, 1000 and 1001.

(c). Find an equivalent **dfa** of **M.**

SECTION-B (Maximum marks 50)

Note: Answer **any two** questions in this section.

Q3(a) (marks 4+5). Explain with examples the language of signed and unsigned real data values in PASCAL programming language without considering the exponent form. Write a corresponding right linear grammar.

Q3(b) (marks 5+5+6). Assuming n, m and $k \geq 0$, find Context Free Grammars **(CFG)** G1 and G2 that generate the following languages. -

(i). $L(G1) = \{a^k b^m c^n$, such that either $k < m$, or $n > m\}$

(ii). $L(G2) = \{a^{n+m} b^{m+k} c^k\}$.

Write left most derivations, using G1 for -

1. w1 = bb, (k = 0, m = 2, n = 0),
2. w2 = aabbb, (k = 2, m = 3, n = 0) and
3. w3 = aaaaccc, (k = 4, m = 0, n = 3)

and using G2 for -

4. w4 = aaabbb, (n = 0, m = 3, k = 0),
5. w5 = bbbccc, (n = 0, m = 0, k = 3) and
6. w6 = aaabbbc (n = 1, m = 2, c = 1).

Include production number at each step of your derivation.

Q4(a) (marks 15). Design a deterministic pushdown automaton (**dpda**) to recognize the language –

$L = \{w \in a^n b^m$, such that $n \neq m$ and w always starts with an a $\}$

Clearly describe the conditions when your **dpda** accepts and rejects words of L. Write instantaneous descriptions for w1 = aaab and w2 = aaabb.

Q4(b) (marks 3 + 7). Design a non deterministic pushdown automaton (**npda**) to recognize the language generated by the grammar G, where –

$G = (\{S, Z, B\}, \{a, b\}, S, P)$.

The set of productions P is

$\{$

$S \longrightarrow aZ \mid bB \mid a$

$B \longrightarrow BZ \mid ZZB \mid b$

$Z \longrightarrow aZ \mid b \mid a \}$

Q5 (marks 15 + 5 + 5). Write the design of a Turing Machine (**TM**) to compute –

$F(x) = 2x + 1.$

Assume x to be a nonzero positive integer in unary representation. Clearly write the steps as to how your TM accomplishes the computations. Also write the instantaneous descriptions using the value of x as 11 and 11111 for your Turing Machine.

$q_0\ 111 \vdash^* \ ?$

$q_0\ 11111 \vdash^* \ ?$

What is the final configuration when your TM has stopped.

(End of Examination Paper)