UNIVERSITY OF SWAZILAND
FINAL EXAMINATION, MAY 2006

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. Answer **any two** questions of section-B. Maximum mark is 100.
(3) Use correct notation and show all your work on the answer script.

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

SECTION-A

QUESTION 1 (marks 6 + 6+ 12). The following languages are given on $\Sigma = \{0, 1\}$. Assume $w \in \{0, 1\}^+$.

(i). L1 = {w, |w| = 2 m, for m = 1, 2, 3, ...}

(ii). L2 = {w, such that 01 is always a substring of w}

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

The following set of words is given -

{λ, 0, 1, 01, 001, 0100, 00101, 1111101,11111, 100000, 0011110, 010101}

(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 regular expressions representing L1, L2 and L3.

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

QUESTION 2 (marks 6 + 8 + 12). The following non deterministic finite acceptor **(nfa)** is given :

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

δ(q0,0) = q1 ; δ(q0,0) = q0 ; δ(q0,1) = q0 ;

δ(q1,1) = q2;

(i). Draw the transition digraph and write the state transition table of the **nfa.**

(ii). Write the corresponding right linear grammar generating L(M).

(iii). Convert the above **nfa** into an equivalent **dfa**.

SECTION-B

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

QUESTION 3(a) (marks 10). The grammar G = ({S}, {a,b}, S, P) is given. The set of productions P is given as

{ S $\rightarrow$ aS | aSbS | λ }.

Using G, write left most and right most derivations for w = aaab. Also show that G is ambiguous by drawing parse trees for w. What the complexity of G?

QUESTION 3(b) (marks 15). Find Context Free **(CFG)** grammars that generate the following languages -

(i). L(G1) = $\{a^n b^m$, where n, m ≥ 0, $n \neq 2m\}$

(ii). L(G2) = $\{a^n b^k c^k d^n$, where n, k $\geq 0\}$

write left most derivations for -

w1 = aaaaaabb (using G1) and w2 = aaabbccddd (using G2).

Include production number of your grammar at each step of derivation.

QUESTION 4(a) (marks 15). Design a deterministic pushdown automaton **(dpda)** to recognize the language –

L = { w $\in$ $\{a, b\}^+$, $n_a(w) = n_b(w)$.}

$n_a(w)$ and $n_b(w)$ are count of a's and b's in w respectively. Describe the functionality of your **dpda**. Write instantaneous descriptions for w = abaabbab.

QUESTION 4(b) (marks 4+6). Transform the following Grammar–

G = ({S, A, B}, {a,b},S, P)

where the set of productions P is

{ S $\rightarrow$ aABB | aAA
A $\rightarrow$ aBB | C
B $\rightarrow$ bBB | A
C $\rightarrow$ a }

into Greibach Normal Form and design the **npda** that accepts L(G).

QUESTION 5 (marks 5+10 + 5 + 5). Write the functional steps of the design of a Turing machine to compute –

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F(x) = x div 2
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Assume x to be a non zero positive integer in unary representation. Also write the design and instantaneous descriptions using the values of x as 1111 and 11111 (in unary representation) for your Turing Machine.

(End of Examination Paper)