THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

ECX 6235 – Compiler Design

070

Final Examination – 2008 / 2009 (*No Book Type*)

Date : Monday, 29th of March 2009 Time : 09:30 – 12:30

INSTRUCTIONS TO CANDIDATES

You must answer any two questions from Part A and another two questions from Part B. Questions 1 – 3 carry 30 marks each and questions 4 – 7 carry 20 marks each.

Part A

Consider following description of a compiler to answer questions 1 and 2.

A compiler converts expressions of pseudo-Assembler code into their simple arithmetic operation equivalents in the following way:

EQU Acc, #15d	⇒	C = 15;
ADD R_A, R_B	⇒	C = A + B;
SUB R_A, R_B	⇒	C = A – B;
MUL R_A, R_B	⇒	C = A × B;
DIV R_A, R_B	⇒	C = A ÷ B;

where A, B, and C are variables that can carry any decimal number and R_A, R_B denote two registers that are used when performing the arithmetic operations in the pseudo-Assembler code. Assume that all the results of Assembler operations will end up in the Accumulator (Acc). The numbers in the pseudo-Assembler code starts with hyphen (#) mark and have letter "d" at the end to indicate the numbers are in decimal. The output (i.e. the right column of expressions) will be converted to algebraic expressions, like

A = 5; B = 6; C = A + B.

Every line of the input can carry only one expression. Assume all input numerals are whole numbers (no decimal point).

Your task is to build the part of the compiler that performs only the above mentioned operations of the pseudo-Assembler code.

Note: Write down all your assumptions where necessary, when answering questions 1 and 2 below.

1. (a) What is the alphabet of this compiler? [4 marks]

   (b) Give the token table for the lexical analyzer of this alphabet. [6 marks]

   (c) What are the functions of the lexical analyzer in the above compiler? [4 marks]

   (d) Write an algorithm for the above lexical analyzer in pseudo code. [16 marks]

2. (a) What are the functions of the syntax analyzer for the above compiler? [5 marks]

(b) Write the set of rules of the syntax analyzer. [10 marks]

(c) Write an algorithm for the syntax analyzer in pseudo code. [15 marks]

3. (a) Strings are input into the Turing Machine on an unlimited tape. Each string consists only of 1s and 0s. The Turing Machine converts every fourth digit into its opposite, i.e. 1 to 0 and 0 to 1. And if the next digit is the same as the one that was before conversion it changes it back again. 'B' denotes a blank symbol. You may neglect any possible error occurrences. Assume that the length of the string can be only of multiples of four, i.e. 4, 8, 12, ..., and that there are at least two blank symbols between the strings. The tape will consist of five strings at least, but there may be more. If the Turing Machine will encounter a point (.) symbol it will terminate its operation. Note that the point (.) symbol can only be encountered instead of a string.

For example consider following input and output strings:

Input: ... B B B 0 1 0 1 0 1 0 1 1 0 1 0 B B B ...

Output: ... B B B 0 1 0 0 0 1 0 1 1 0 1 1 B B B ...

(Digits to be changed and the changed ones are underlined.)

Draw the transition graph for the above Turing Machine. [20 marks]

(b) Give the transition table for the transition graph drawn above. [10 marks]

Part B

4. (a) Find the Non-Deterministic Finite Automata equivalent to $\mathbf{c(b+a^*)^+b^*aa}$. [5 marks]

(b) Convert the above Non-Deterministic Finite Automata to equivalent Deterministic Finite Automata. [10 marks]

(c) What are three functions in the recognizer's configuration? [5 marks]

5. (a) Find a PDA that accepts the language generated by grammar defined by

$S \rightarrow X\ P\ r\ Q \mid n\ Q\ R$

$P \rightarrow m\ Q\ R \mid x\ m \mid R$

$Y \rightarrow m \mid P\ T\ Q$

$Q \rightarrow P\ r\ r \mid x\ m\ R \mid n$

$R \rightarrow x\ r\ S \mid r \mid X$

$T \rightarrow n\ r\ Q \mid m\ x\ P$

$X \rightarrow r\ Q\ Q \mid m\ P$ (Hint: use GNF) [15 marks]

(b) What are the ways by which languages are accepted by the Pushdown Automata? [5 marks]

6. (a) Prove that language L_1 such that

$L_1 = (a^i\ b^j\ c^j \mid \text{where } i \geq 1 \text{ and } j \geq 1)$

is a context-free language. Explain all your steps clearly. [7 marks]

(b) Consider two context-free languages L_1 and L_2 such that

$L_1 = (a^i b^j c^j \mid \text{where } i \geq 1 \text{ and } j \geq 1)$, and

$L_2 = (a^i b^i c^j \mid \text{where } i \geq 1 \text{ and } j \geq 1)$.

Find the intersection L_3 of L_1 and L_2. Explain your answer. [6 marks]

(c) Prove that the context-free languages are not closed under intersection using the context-free languages L_1 and L_2 given in 6(a) above. [7 marks]

7. (a) State the language hierarchy theorem. [4 marks]

(b) Briefly describe how the multitape Turing Machines work. [8 marks]

(c) State the union theorem for the polynomial space bounds. [8 marks]