University of Cape Town

Department of Computer Science

CSC3003S Final Exam

2007

Marks : 35

Time : 3 hours

Instructions:

- Answer all questions from Section A and 3 questions from Section B.
- Show all calculations where applicable.

Section A [Answer Question ONE – this is compulsory]

Question 1 [8 marks]

1) What is the purpose of each of the following stages in a hypothetical compiler? [4]
   a) IR code generation
   b) Parsing
   c) Lexical analysis
   d) Maximal Munch
2) Modern compilers are often divided into a front-end and back-end.
   a) Which of the 4 stages above are front-end activities and which are back-end? [2]
   b) Discuss 2 advantages of separating the front-end from the back-end. [2]

Section B [Answer 3 questions ONLY]

For Question 2 and 3 below, consider the grammar and the LR(1) automaton for this grammar in Figures 1 and 2 below:

```
1.   S'   ->   S #
2.     S   ->   E
3.     E   ->   E - T
4.     E   ->   T
5.     T   ->   n
6.     T   ->   ( E )
```

Figure 1: A grammar for differences of numbers

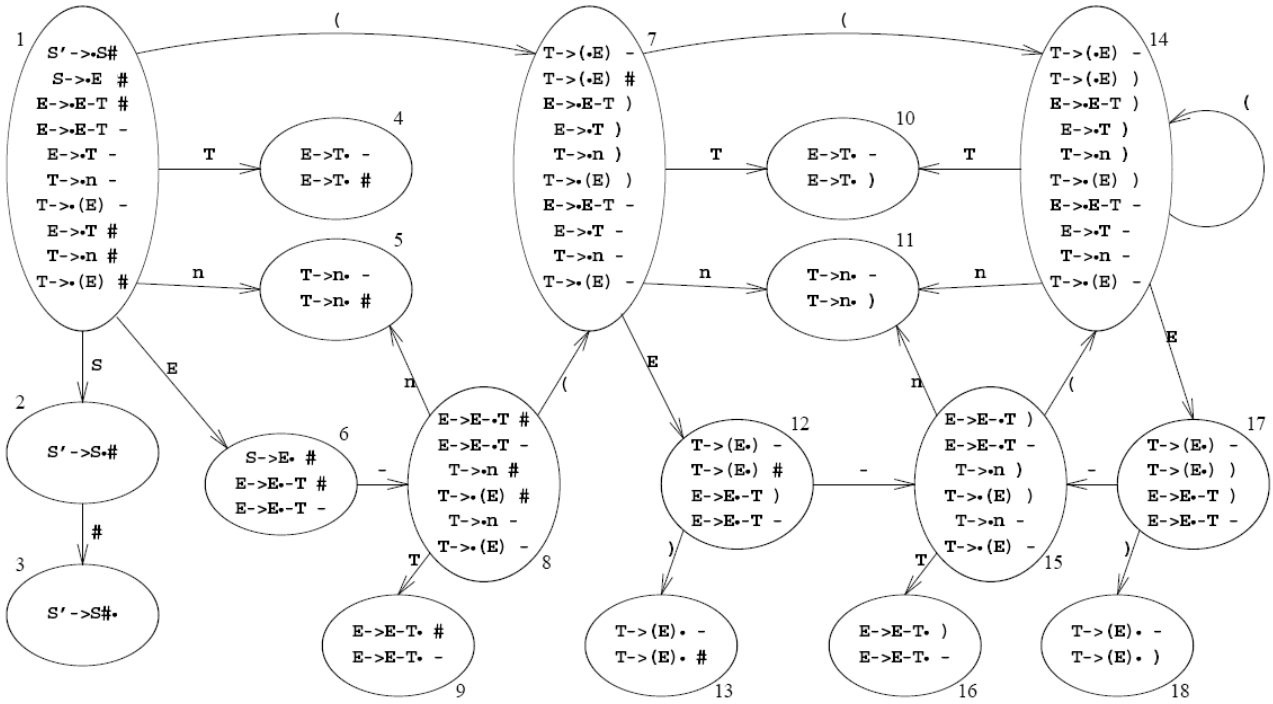

Figure 2: Deterministic LR(1) automaton for the grammar in Figure 1

Question 2: LR(1) Parsing [9 marks]

1) Complete rows 13 and 14 of the LR(1) parsing table in Figure 3 below: [6]

	n	-	(	)	#	S	E	T
1	s5	e	s7	e	e	s2	s6	s4
2	e	e	e	e	s3			
3/acc								
4	e	r4	e	e	r4			
5	e	r5	e	e	r5			
6	e	s8	e	e	r2			
7	s11	e	s14	e	e		s12	s10
8	s5	e	s7	e	e			s9
9	e	r3	e	e	r3			
10	e	r4	e	r4	e			
11	e	r5	e	r5	e			
12	e	s15	e	s13	e			
13								
14								
15	s11	e	s14	e	e			s16
16	e	r3	e	r3	e			
17	e	s15	e	s18	e			
18	e	r6	e	r6	e			

Figure 3: LR(1) table for the grammar in Figure 1

Use the template below for your answer:

	n	-	(	)	#	S	E	T
13								
14								

2) Use the completed LR(1) parsing table from the previous question to parse the string n-n-n. Show only the first 3 steps of the parsing process. [3]

Question 3: LALR(1) and SLR(1) Parsing [9 marks]

1) Consider the LALR(1) automaton in Figure 4 below: [6]

   a) Complete state 2 of the LALR(1) automaton in Figure 4 below.

   b) Complete state 6 of the LALR(1) automaton in Figure 4 below.

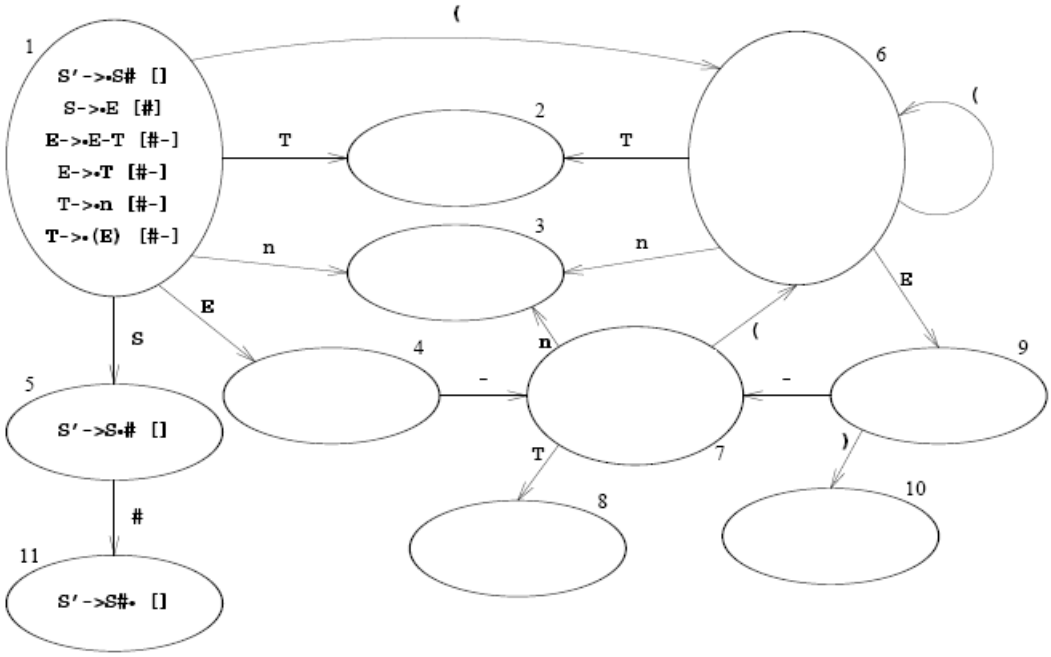

Figure 4: Partial LALR(1) automaton for the grammar in Figure 1

2) Consider the SLR(1) automaton in Figure 5 below, with the look-ahead indicated for the start symbol only: [3]

a) Complete the look-ahead in the rectangle in state 4. Motivate your answer.

b) Complete the look-ahead in the rectangle in state 8. Motivate your answer.

c) Complete the look-ahead in the rectangle in state 3. Motivate your answer.

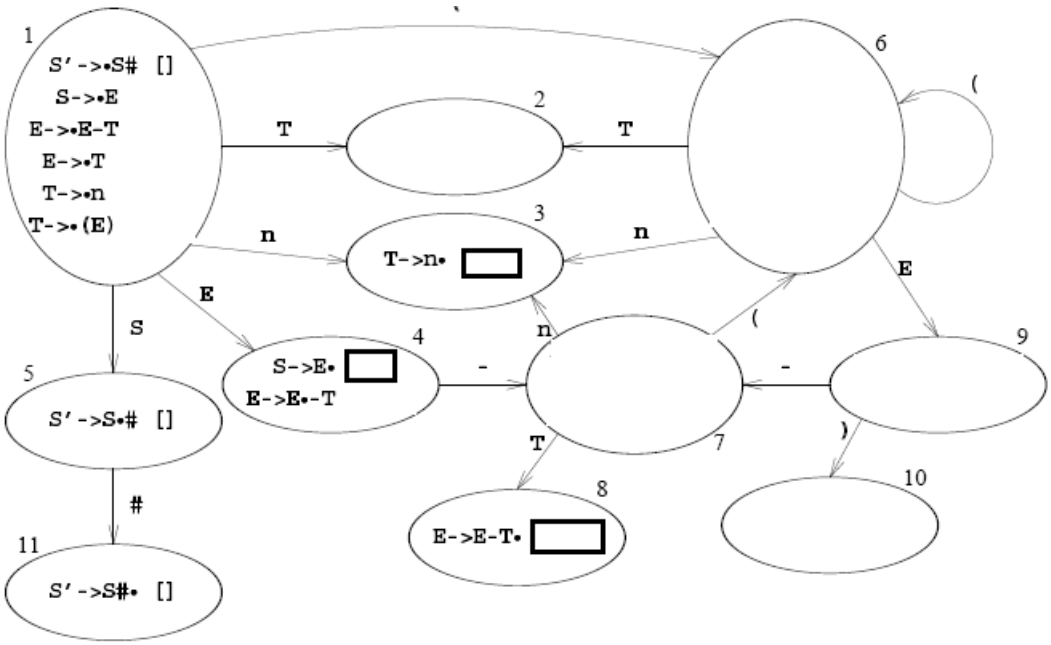

Figure 5: Partial SLR(1) table for the grammar in Figure 1

Question 4: Code Analysis [9 marks]

1) Scope is a key concept in modern programming languages and compilers need to cater for this.
    a) Write a short method (in C, C++ or Java) that attempts to access an out-of-scope variable. Assume there are no global or instance variables available to this method. [1]
    b) What mechanism is used by a compiler to detect such out-of-scope variables? [1]
    c) Briefly discuss 2 other context-sensitive errors that can be detected with the same mechanism. [2]
2) When the program is deemed error-free, activation records are created for each subprogram.
    a) What is the purpose of the static link in an activation record? [1]
    b) What is the purpose of the dynamic link in an activation record? [1]
    c) What are the other 4 fields that can appear in a conceptual activation record? [2]
    d) A display can be used for the same purpose as the static link. What is one advantage of using a display? [1]

Question 5: Code Generation [9 marks]

1) A modern compiler such as GCC allows programmers to specify how much inlining the compiler should apply.
    a) Explain with an example what inlining is. [2]
    b) Inlining can be considered to be a peephole technique. Explain what a peephole optimisation technique is. [1]
    c) Briefly discuss 2 other optimisations that may be applied to IR trees. [2]
2) After optimisations are applied, instructions can be selected using a tiling algorithm.
    a) Describe the steps of an algorithm to select instructions by tiling. [3]
    b) This algorithm may be optimal – what does optimal mean in this context? [1]