CS 352 – Compilers: Principles and Practice
Mid-term Examination, 10/26/05

Instructions: Read carefully through the whole exam first and plan your time. Note the relative weight of each question and part (as a percentage of the score for the whole exam). The total points is 100 (your grade will be the percentage of your answers that are correct).

This exam is **closed book, closed notes**. You may *not* refer to any book or other materials.

You have **75 minutes** to complete both (2) questions. Write your answers on this paper (use both sides if necessary).

Name:

Student Number:

Signature

1. [Regular expressions, scanning; 40%]

(a) (15%) As described in class, construct an NFA that recognizes the same language as defined by the following regular expression:

$$(ab^*c) \mid (abc^*)$$

Answer:
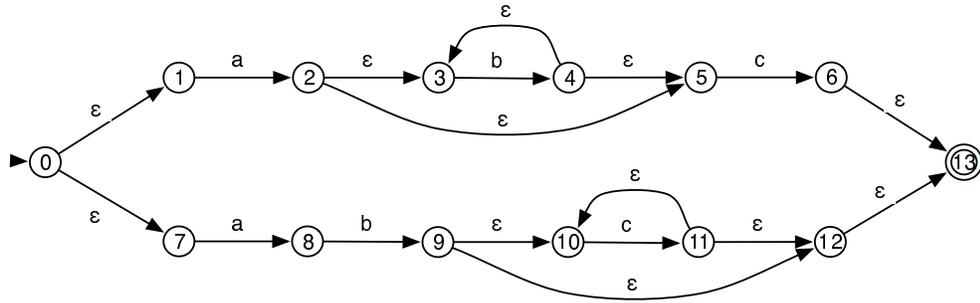
(b) (25%) Using the subset construction, convert the NFA into a DFA. Optimize the resulting DFA by merging equivalent states (if any).

Answer:

	a	b	c
$A = \{0,1,7\}$	B		
$B = \{2,3,5,8\}$		C	D
$C = \{3,4,5,9,10,12,13\}$		E	F
$D = \{6,13\}$			
$E = \{3,4,5\}$		E	D
$F = \{6,10,11,12,13\}$			G
$G = \{10,11,12,13\}$			G

	a	b	c
A	B		
B		C	D
C		E	F
D			
E		E	D
FG			FG

2
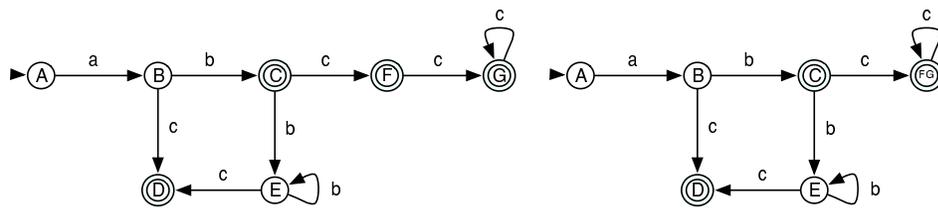
2. [Context Free Grammars, parsing; 60%] Consider the following simple grammar (with numbered productions) and the language it describes:

$$
\begin{array}{c|rcl}
1 & S & \to & AaAb \\
2 & S & \to & BbBa \\
3 & A & \to & \varepsilon \\
4 & B & \to & \varepsilon
\end{array}
$$

(a) (5%) Write a regular expression for this *language*.

Answer:

$ab \mid ba$

(b) (10%) Show the steps of a top-down parser as it parses the input *ab*, showing the input as it is consumed and the parse stack (left is top, right is bottom) at each step of the parse.

Answer:

Stack	Input
S$	ab$
AaAb$	ab$
aAb$	ab$
Ab$	b$
b$	b$
$	$

(c) (5%) Is this language LL(1)? Why or why not?

Answer:

Yes, the language is regular and all regular languages are LL(1).

(d) (10%) Construct the (top-down) LL(1) parse table for this grammar. Is the grammar LL(1)? Why or why not?

Answer:

	FIRST	FOLLOW	a	b	$
S	ab	$	$S \to AaAb$	$S \to BbBa$	
A	ε	ab	$A \to \varepsilon$	$A \to \varepsilon$	
B	ε	ab	$B \to \varepsilon$	$B \to \varepsilon$	

(e) (10%) Show the steps of a bottom-up parser as it parses the input *ab*, showing the input as it is consumed, the parse stack (left is bottom, right is top) at each step of the parse, and the action applied at each step.

Answer:

Stack	Input	Action
$	ab$	reduce
$A	ab$	shift
$Aa	b$	reduce
$AaA	b$	shift
$AaAb	$	reduce
$S	$	accept

3

(f) (10%) Construct the (bottom-up) SLR(1) parse table for this grammar. Is the grammar
SLR(1)? Why or why not?

Answer:

$$
\begin{aligned}
0: \ & S' \rightarrow \ \bullet S\$ \\
& S \rightarrow \ \bullet AaAb \\
& S \rightarrow \ \bullet BbBa \\
& A \rightarrow \ \bullet \\
& B \rightarrow \ \bullet \\
1: \ & S \rightarrow A \bullet aAb \\
2: \ & S \rightarrow B \bullet bBa \\
3: \ & S \rightarrow Aa \bullet Ab \\
& A \rightarrow \ \bullet \\
4: \ & S \rightarrow Bb \bullet Ba \\
& B \rightarrow \ \bullet \\
5: \ & S \rightarrow AaA \bullet b \\
6: \ & S \rightarrow BbB \bullet a \\
7: \ & S \rightarrow AaAb \bullet \\
8: \ & S \rightarrow BbBa \bullet \\
9: \ & S' \rightarrow S \bullet \$
\end{aligned}
$$

	a	b	\$	S	A	B
0	r3/r4	r3/r4		9	1	2
1	s3					
2		s4				
3	r3	r3			5	
4	r4	r4				6
5		s7				
6	s8					
7			r1			
8			r2			
9			a			

(g) (10%) Here is the LR(1) parse table for this grammar:

	a	b	\$	S	A	B
0	r3	r4		9	1	2
1	s3					
2		s4				
3		r3			5	
4	r4					6
5		s7				
6	s8					
7			r1			
8			r2			
9			a			

Show the steps of this LR parser as it uses the table to parse the input *ba*, showing the input as it is consumed, the state stack (left is bottom, right is top) at each step of the parse.

Answer:

Stack	Input	Action
$0_\$$	*ba*$	*r4*
$0_\$\ 2_B$	*ba*$	*s4*
$0_\$\ 2_B 4_b$	*a*$	*r4*
$0_\$\ 2_B 4_b 6_B$	*a*$	*s8*
$0_\$\ 2_B 4_b 6_B 8_a$	$	*r2*
$0_\$ 9_S$	$	*a*