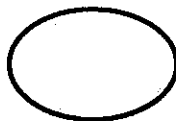
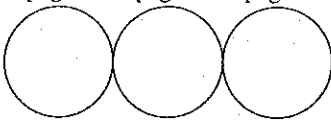


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Please print clearly:

Name:

Login:

@ucsb.edu

No books; No calculator; No computer; No email; No internet; No notes; No phone. Neatness counts! Do your scratch work elsewhere and enter only your final answer into the spaces provided.

I. Given the grammar presented here, and using the style from the LALR(1) handout:

- Construct the characteristic finite state machine (CFSM), sets of items and transition diagram, showing shifts, reductions, and acceptance. [6✓]
- Construct the FOLLOW sets. [3✓]
- Answer yes or no to each of the following questions: [1✓]

Is the grammar LR(0)?

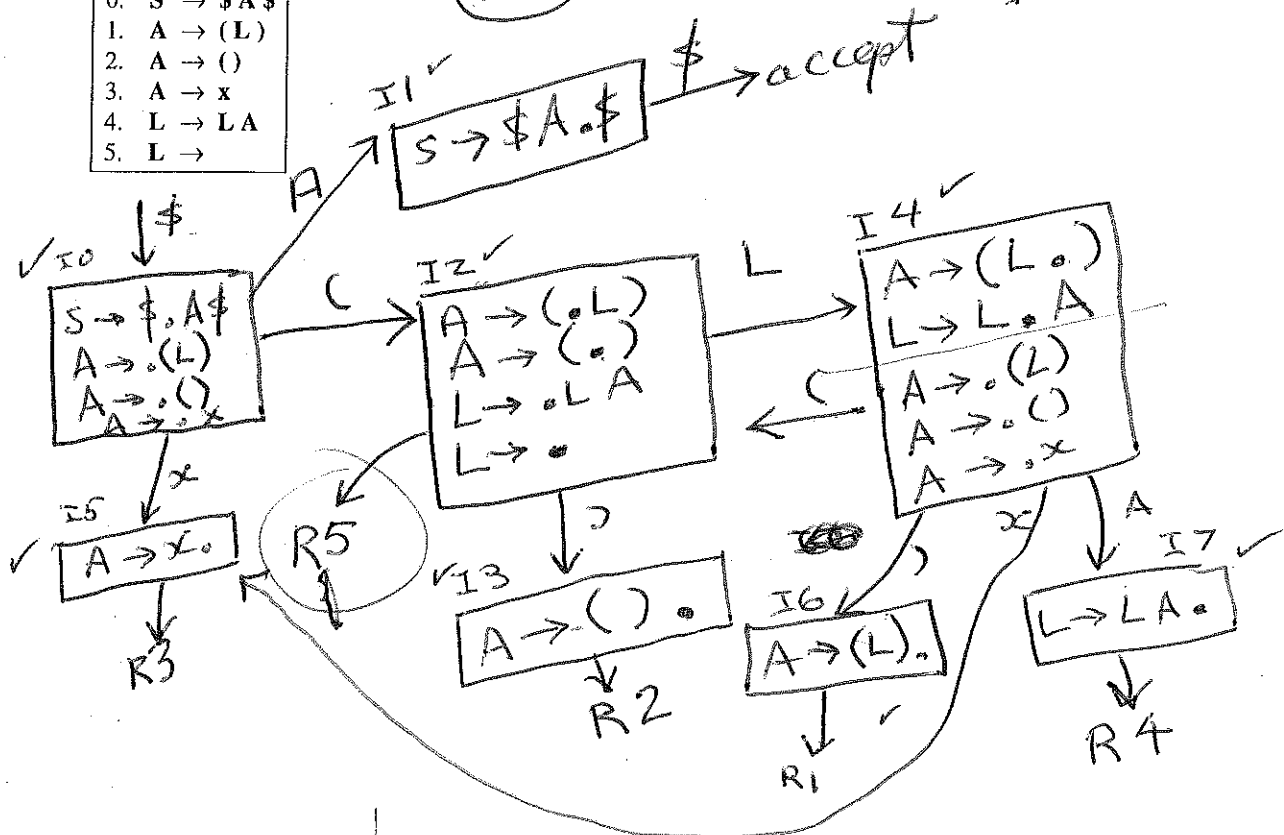
NO  
I2

Is the grammar SLR(1)?

NO

I2SR{}

- $S \rightarrow \$A\$$
- $A \rightarrow (L)$
- $A \rightarrow ()$
- $A \rightarrow x$
- $L \rightarrow LA$
- $L \rightarrow$



Follow

|   |     |    |     |
|---|-----|----|-----|
| A | \$  | R4 | (x) |
| L | (x) |    |     |

 $I_2$   
 $R_5$  { (x) }

ambiguous

$$\begin{array}{c} A \\ \wedge \\ ( ) \end{array} \quad \begin{array}{c} A \\ \wedge \\ ( ( ) ) \end{array}$$

2. Define a grammar for the following language, carefully separating the bison grammar from the flex grammar. Do not show any semantic actions. [5✓]

- (a) A program is a sequence of zero or more expressions. If more than one expression, they are separated by semi-colons.
- (b) An expression is a function call, or an identifier, or a number.
- (c) A function call is an identifier followed by a parenthesized argument list.
- (d) An argument list is a sequence of zero or more expressions, separated by commas if there are more than one expression.
- (e) An identifier is a sequence of one or more upper and lower case letters.
- (f) A number is a sequence of digits, optionally preceded by a + or - sign.
- (g) A comment is a hash (#) followed by any number of characters not including newline.
- (h) White space is ignored and consists of spaces, tabs, and newlines.

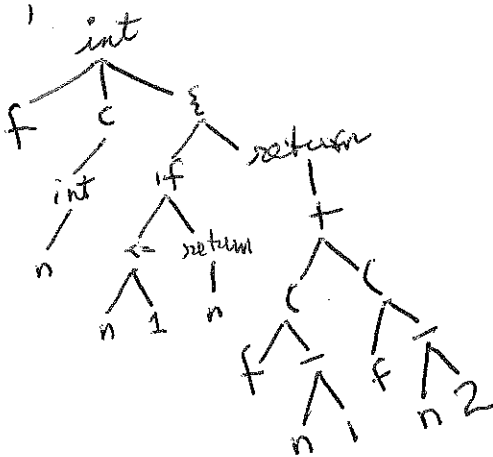
| flex  | bison   |
|---|---|
| <pre> [a-zA-Z]+ [+-]?[0-9]+ #.* [ \t\n]+ "\" "\" "\" "\" "\" </pre> | <pre> %% prog : seq     seq : seq ';' expr           expr     expr : fn           ID           NUM     fn : ID '(' args ')'           ID '(' ')'     args : args ',' expr           expr     ; </pre> |

3. Using the specifications of project 3, draw abstract syntax trees for each of the following. [5✓]

```

int f (int n) { // [2 pts.]
    /* This is O(2^n). */
    if (n <= 1) return n;
    return f (n - 1)
        + f (n - 2);
}

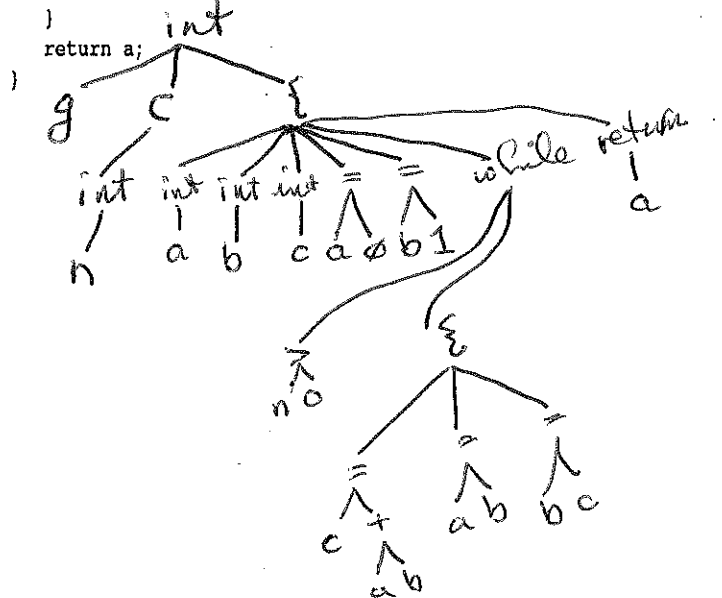
```



```

int g (int n) { // [3 pts.]
    /* This is O(n). */
    int a; int b; int c;
    a = 0; b = 1;
    while (n > 0) {
        c = a + b; a = b; b = c;
    }
    return a;
}

```



Multiple choice. To the *left* of each question, write the letter that indicates your answer. Write Z if you don't want to risk a wrong answer. Wrong answers are worth negative points. [11✓]

|                           |    |                        |       |
|---------------------------|----|------------------------|-------|
| number of correct answers |    | $\times 1 =$           | $= a$ |
| number of wrong answers   |    | $\times \frac{1}{2} =$ | $= b$ |
| number of missing answers |    | $\times 0 =$           | $0$   |
| column total              | 11 |                        | $= c$ |
| $c = \max(a - b, 0)$      |    |                        |       |

1. For a grammar  $G = \langle V_N, V_T, P, S \rangle$ , If LR( $k$ ) analysis generates  $n$  states, then the size of the parsing table will be:

(A)  $n \times |V_N|^k$   
 (B)  $n \times |V_T|^k$   
 (C)  $n^k \times |V_N|$   
 (D)  $n^k \times |V_T|$

A or B  
accept either

2. What variable is used to pass semantic information from yylex to yyparse?

(A) yyerror  
 (B) yyin  
 (C) yylval  
 (D) yytext

3. The part of the compiler that figures out which declaration of the form `int x;` is being referred to by the statement `x = 3;` is:

(A) lexical analyzer  
 (B) parser  
 (C) symbol table manager  
 (D) code generator

4. If  $N$  is the set of languages recognizable by an NFA, and  $D$  is the set of languages recognizable by a DFA, then:

(A)  $N \subset D$   
 (B)  $N = D$   
 (C)  $N \supset D$   
 (D) none of the above

5. What is a reasonable guess as to what might be printed by:

`printf ("%p", malloc(1));`  
 (A) 0x0  
 (B) 0xdb9b030  
 (C) 0x7fff498c72d9  
 (D) 0xabcdefg

B  
`printf("%p", malloc(1));`

6. In order to disambiguate the following grammar consistent with the syntax of C, C++, and Java, we should insert the declaration (x) in the first part of the **bison** grammar, because we need to resolve the shift/reduce conflict in favor of a (y).

```
stmt : IF '(' expr ')' stmt ELSE stmt
      | IF '(' expr ')' stmt %prec ELSE
      | other
      ;
```

(A) (x) = %left ELSE (y) = reduce.  
 (B) (x) = %left ELSE (y) = shift.  
 (C) (x) = %right ELSE (y) = reduce.  
 (D) (x) = %right ELSE (y) = shift.

7. Which statement is true about these languages?

(A)  $LR(0) \subset LALR(1) \subset SLR(1) \subset LR(1)$   
 (B)  $LR(0) \subset LR(1) \subset SLR(1) \subset LALR(1)$   
 (C)  $LR(0) \subset SLR(1) \subset LALR(1) \subset LR(1)$   
 (D)  $LR(1) \subset LALR(1) \subset SLR(1) \subset LR(0)$

8. Which of these items was entered into a state after having propagated a shift transition?

(A)  $E \rightarrow \bullet E + T$   
 (B)  $E \rightarrow E \bullet + T$   
 (C)  $E \rightarrow E + \bullet T$   
 (D)  $E \rightarrow E + T \bullet$

9. Which of the following items in a state will cause a reduction action to be added to the state?

(A)  $E \rightarrow \bullet E + T$   
 (B)  $E \rightarrow E \bullet + T$   
 (C)  $E \rightarrow E + \bullet T$   
 (D)  $E \rightarrow E + T \bullet$

10. How many tokens in the following C code?

```
/* Say hello. */
printf ("Hello, world.\n");
```

(A) 3  
 (B) 5  
 (C) 7  
 (D) 9

11. The name **bison** is a pun on an earlier program whose name is a homonym for:

(A) Buffalo: a kind of African stag or gazelle.  
 (B) Camel: a ruminant used for carrying burdens and for riding.  
 (C) Minotaur: a monster confined to the labyrinth on Crete.  
 (D) Yak: a bovine mammal native to the high plains of central Asia.

lex  
yacc