

King Fahd of Petroleum & Minerals  
College of Computer Science & Engineering  
Information & Computer Science Department

ICS410: Fundamentals of Programming Languages  
First Semester (101)

Major Examination 1

Time Allowed: 90minutes.

Student's Name:.....

Student's ID.....

Notes:

- Attempt ALL questions.
- Write your answers clearly showing all details.
- If you need to make any *reasonable assumptions*, write them down as part of your answers.

Scores:

Question	Points	Score
Q1	8	
Q2	30	
Q3	32	
Q4	10	
Q5	20	
Total	100	

**Q1. (8 points) Answer 8 of the following True and False questions: Each is worth one point.**

1. The more the language is orthogonal the less it has exceptions to the rules? [T]
2. Language implementation systems communicate directly with the processor for accessing resources? [F]
3. EBNF enhances the descriptive power of the BNF? [F]
4. The degree of abstraction allowed by a programming language is very important for its writability? [T]
5. Scientific applications require complex data structures? [ F]
6. Artificial intelligence uses symbolic rather than numeric computations? [T]
7. An attribute grammar is an extension to a context free grammar? [ T]
8. A token is the lowest level syntactic unit of a language? [F]
9. A leftmost derivation is one in which the leftmost terminal in each sentential form is the one that is expanded? [F]

**Q2. (30 points) Answer 5 of the following questions (Each is worth 6 points):**

1. .Discuss two potential problems of Overloaded Operators?
  - Users can define nonsense operations
  - Readability may suffer, even when the operators make sense
  
2. Discuss two reasons for studying concepts of programming languages?
  - Increased ability to express ideas; Improved background for choosing appropriate languages; Increased ability to learn new languages; Better understanding of significance of implementation; Better use of languages that are already known; Overall advancement of computing

3. A language ( for example, JAVA) uses a right brace to mark the end of all compound statements. What are the arguments for and against this design?
  
4. Case sensitivity has readability and writability problems? Explain one problem each?  
 Sol.  
 readability (names that look alike are different)  
 writability (must remember exact spelling)
  
5. What is the difference between an intrinsic attribute and a non intrinsic attribute?  
 Explain?  
 The value of an intrinsic attribute is supplied from outside the attribute evaluation process, usually from the lexical analyzer. A value of a synthesized attribute is computed by an attribute evaluation function.
  
6. Compare the operation of a general language generator with that of a recognizer?
  - a. A recognition device reads input strings over the alphabet of the language and decides whether the input strings belong to the language
  - b. A device that generates sentences of a language  
 One can determine if the syntax of a particular sentence is syntactically correct by comparing it to the structure of the generator

**Q3. (32 points) Answer the following questions:**

- 1- **(8 points)** Compute the weakest precondition for the following sequence of assignment statements and their preconditions?

$a = 3 * (2 * b + a)$

$b = 2 * a - 1$

$\{b > 5\}$

Sol:

$a = 3 * (2 * b + a);$

$b = 2 * a - 1 \{b > 5\}$

$2 * a - 1 > 5$

$2 * a > 6$

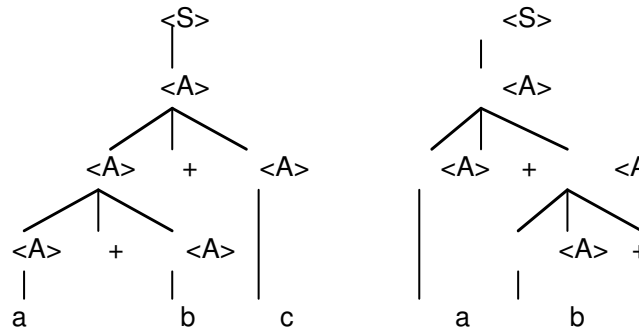
$a > 3$

Now we have:

$$\begin{aligned}
 a &= 3 * (2 * b + a) \{ a > 3 \} \\
 3 * (2 * b + a) &> 3 \\
 6 * b + 3 * a &> 3 \\
 2 * b + a &> 1 \\
 n &> (1 - a) / 2
 \end{aligned}$$

2- (8 points) Is the following grammar ambiguous or unambiguous? Show the proof?

$\langle S \rangle \rightarrow \langle A \rangle$   
 $\langle A \rangle \rightarrow \langle A \rangle + \langle A \rangle \mid \langle id \rangle$   
 $\langle id \rangle \rightarrow a \mid b \mid c$



3- (8 points) Write EBNF rules for the following BNF rules.

$\langle \text{program} \rangle \rightarrow \text{begin } \langle \text{stmt\_list} \rangle \text{ end}$   
 $\langle \text{stmt\_list} \rangle \rightarrow \langle \text{stmt} \rangle$   
 $\quad \mid \langle \text{stmt} \rangle ; \langle \text{stmt\_list} \rangle$   
 $\langle \text{stmt} \rangle \rightarrow \langle \text{var} \rangle = \langle \text{expression} \rangle$   
 $\langle \text{var} \rangle \rightarrow A \mid B \mid C$   
 $\langle \text{expression} \rangle \rightarrow \langle \text{var} \rangle + \langle \text{var} \rangle$   
 $\quad \mid \langle \text{var} \rangle - \langle \text{var} \rangle$   
 $\quad \mid (\langle \text{expr} \rangle)$   
 $\quad \mid \langle \text{var} \rangle$

Sol.

$\langle \text{program} \rangle \rightarrow \text{begin } \langle \text{stmt\_list} \rangle \text{ end}$   
 $\langle \text{stmt\_list} \rangle \rightarrow \langle \text{stmt} \rangle \{ ; \langle \text{stmt\_list} \rangle \}$   
 $\langle \text{stmt} \rangle \rightarrow \langle \text{var} \rangle = \langle \text{expression} \rangle$   
 $\langle \text{var} \rangle \rightarrow A \mid B \mid C$   
 $\langle \text{expression} \rangle \rightarrow \langle \text{var} \rangle \{ (+ \mid -) \langle \text{var} \rangle \}$   
 $\quad \mid (\langle \text{expr} \rangle)$

4- (8 points) Consider the following grammar:

$\langle S \rangle \rightarrow a \langle S \rangle c \langle B \rangle \mid \langle A \rangle \mid b$

$\langle A \rangle \rightarrow c \langle A \rangle \mid c$

$\langle B \rangle \rightarrow d \mid A$

Which of the following sentences are in the language generated by this grammar? Show your derivation?

1. acccbd

2. abcd

**Sol:**

**Q4. (10 points) What is the weakest precondition for the following selection statement**

$\{??\} \text{ while}(x > 0)$   
     $x = x - 1;$   
     $\{x == 0\}$

**Ans:**

$\neg(x > 0) \rightarrow x == 0$

$(x > 0) \rightarrow x - 1 == 0$

$(x - 1 > 0) \rightarrow x - 2 == 0$

$x \leq 0 \rightarrow x == 0 \wedge$

$(x > 0) \wedge x \leq 1 \rightarrow x == 1$

$(x > 1) \wedge x \leq 2 \rightarrow x == 2$

$(x > 2) \wedge x \leq 3 \rightarrow x == 3$

**weakest precondition**  $x \geq 0$

**Q5. ( 20 points) Consider the following grammar:**

- R1:  $\langle \text{program} \rangle \rightarrow \text{begin } \langle \text{stmts} \rangle \text{ end}$   
R2:  $\langle \text{stmts} \rangle \rightarrow \langle \text{stmt} \rangle$   
 $\quad \quad \quad | \langle \text{stmt} \rangle ; \langle \text{stmts} \rangle$   
R4:  $\langle \text{stmt} \rangle \rightarrow \langle \text{var} \rangle = \langle \text{expr} \rangle$   
R5:  $\langle \text{var} \rangle \rightarrow A | B | C | D$   
R9:  $\langle \text{expr} \rangle \rightarrow \langle \text{expr} \rangle + \langle \text{term} \rangle$   
 $\quad \quad \quad | \langle \text{term} \rangle$   
R11:  $\langle \text{term} \rangle \rightarrow \langle \text{term} \rangle * \langle \text{factor} \rangle$   
 $\quad \quad \quad | \langle \text{factor} \rangle$   
R13:  $\langle \text{factor} \rangle \rightarrow ( \langle \text{expr} \rangle )$   
 $\quad \quad \quad | \langle \text{var} \rangle$

1. ( 15 points) Using the above grammar show a parse tree and the left most derivation of the following statement.

$$D = (D+B) * C$$

2. ( 5 points) Modify the above grammar to add a unary minus operator that has higher precedence than either + or \*.