

Programming Language Qualifying Exam

Fall 2004

Answer any 5 of the following 6 problems. You may attempt all 6 for extra credit. (All the questions are equally weighted.)

1. Compilation

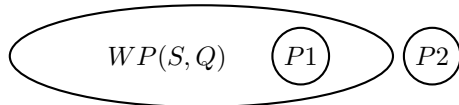
- Explain the difference between a compiler and an interpreter.
- Java has the properties of both a compiler and an interpreter. Briefly explain how this is so.
- What is the purpose of a frame pointer? Describe how it works, and when it is set over the course of a function call and return.

2. Datatypes

- What is an abstract data type? Why are they important?
- Identify the 3 parts that make up the specification of a data type and give a short explanation for each.

3. Program Verification

- Given $\{P\} S \{Q\}$ for a pre-condition P , post-condition Q and program S , define the program's partial correctness and total correctness.
- Consider the following figure where S is a non-deterministic program and $P1$, $P2$ and Q are predicates.



- For a state $S1 \in P1$, is it possible that execution of program S starting from $S1$ will terminate outside Q ? Explain.
 - For a state $S2 \in P2$, is it possible that execution of program S starting from $S2$ will terminate in Q ? Explain.
 - For a state $S1 \in P1$, is it possible that execution of program S starting from $S1$ will not terminate? Explain.
 - For a state $S2 \in P2$, is it possible that execution of program S starting from $S2$ will not terminate?
- Write a program that, given a fixed integer $n > 0$, sets variable i to the highest power of 2 that is at most n . The precondition Q , postcondition R , loop invariant P , and bound function t are
 Q : $0 < n$
 R : $0 < i \leq n < 2 * i \wedge (\exists p : i = 2^p)$
 P : $0 < i \leq n \wedge (\exists p : i = 2^p)$
 t : $n - i$

- (d) Construct a program to compute any possible index, `maxIndex`, of an array $A[0..N]$ such that $A[\text{maxIndex}]$ is a maximum value. Precondition is: $N \geq 0$ Postcondition is: $\{0 \leq \text{maxIndex} \leq N\}$ and $\{\forall \text{index} : 0 \leq \text{index} \leq N : A[\text{maxIndex}] \geq A[\text{index}]\}$
Formally prove that your program is totally correct (partial correctness and termination).

4. Objects

Given the program:

```
public class A extends B {
    public int a;
    public double b;
    public char c;

    public k { ..... }

    public l { ..... }
}
```

Note that there is single inheritance only!

- (a) Diagram the structure of the object as it will be configured in memory.

```
A a = new A( );
```

- (b) In what part of memory would the object be allocated?

5. Parameter Passing

- (a) Describe “Call by Value Result”, “Call by Name”, “Call by Reference” parameter passing.

- (b) Given the program :

```
program main (input, output)
    interger a,b;
    procedure p ( x, y)
    begin
        x := x+a;
        y := y * z+x;
    end

begin
    a := 2;
    b := 3;
    p (a, b);
    print a;
end
```

What’s printed by the program assuming

Call By Value

Explain the result:

Call By Value Result

Explain the result:

Call By Name

Explain the result:

Call By Value Reference

Explain the result:

6. Parsing

(a) Consider the following grammar:

$$\begin{array}{l}
 G ::= S \$ \\
 S ::= (L) \\
 \quad | a \\
 L ::= L , S \\
 \quad | S
 \end{array}$$

- i. Convert the grammar to $LL(1)$. Show all steps in order to get credit.
- ii. Create the parse table and enter the proper production in each cell.
- iii. Draw the FSA for the string $(ab)+bbc$.

(b) Consider the following grammar.

$$\begin{array}{l}
 S \rightarrow E \$ \\
 E \rightarrow E + T \\
 \quad | E - T \\
 \quad | T \\
 T \rightarrow num \\
 \quad | id
 \end{array}$$

- Generate the Characteristic Finite State Machine (CFSM).
- Use your CFSM to parse the input $x + 5 - 3$. Use the table below. Note that you will not necessarily use up the entire table.

