

# Programming Language Qualifying Exam

## Spring 2005

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Answer the following 5 problems.

### 1. Compilation

- (a) A compiler will often compile a language to an intermediate representation, and then compile that into a target machine language. Explain at least two advantages to this approach over simply compiling directly from the source language to machine code.
- (b) Java has the properties of both a compiler and an interpreter. Briefly explain how this is so.

### 2. Abstract Datatypes

- (a) Consider a standard data-structure library. It will contain a stack (LIFO) class, and a list class. The list class will contain all the operations that a stack class provides, and more. Why, then, do most libraries still provide a stack class? Explain why it might be appropriate to use a more restrictive stack class instead of a more general list class.

### 3. Program Verification

- (a) Figures 1–5 show different states and how program  $s$  manipulates them. A “•” indicates a state, and an arrow indicates a state transformation caused by running program  $s$ . A state outside of the box indicates non-termination.

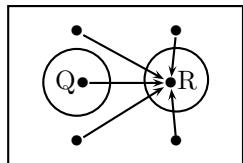


Figure 1:  $wp$  candidate

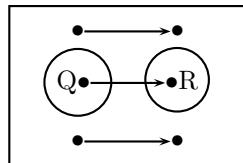


Figure 2:  $wp$  candidate

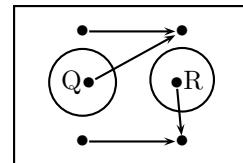


Figure 3:  $wp$  candidate

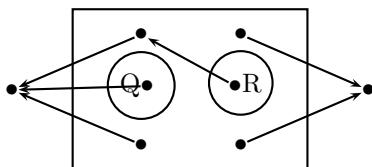


Figure 4:  $wp$  candidate

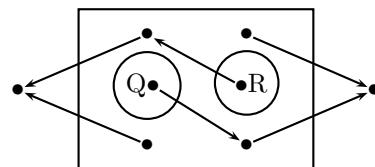


Figure 5:  $wp$  candidate

For each of the following  $wp$  scenarios, indicate in the table below which figure best illustrates it. If none of the figures model the scenario, write “none”.

$wp$ Scenario	Corresponding Figure
$wp(S, R) = Q$	
$wp(S, R) = T$	
$wp(S, R) = F$	
$wp(S, T) = F$	
$wp(S, T) = R$	
$wp(S, T) = R \wedge Q$	
$wp(S, T) = R \vee Q$	

- (b) We want a program that, given a fixed integers  $a$ , and  $b$ , sets  $b$  to 0 and  $a$  to the greatest common divisor of  $a$  and  $b$ . This can be accomplished by a loop that simultaneously sets  $a$  to  $b$  and  $b$  to  $a \bmod b$ .
- Write a specification for your program by giving a precondition  $Q$ , postcondition  $P$  and loop invariant  $R$  for the program.
  - Write the program, and formally show the conditions in which it satisfies the specification.

#### 4. Memory management

- Explain the difference between the stack and the heap (the memory, not the data-structures). Give examples of the kind of data that would be allocated in each.
- What is a garbage collector? What is the difference when programming in a garbage-collected language and a non garbage-collected language?

#### 5. Parsing

- What is the difference between an LL grammar and an LR grammar? Give an example of a grammar that is LL, and a grammar that is not LL.
- What is the difference between a regular expression and a context-free grammar? Give an example of a context-free grammar that is not a regular expression.