



THE UNIVERSITY
of LIVERPOOL

JANUARY 2002 EXAMINATIONS

Master of Science : Year 1

ALGORITHM DESIGN AND IMPLEMENTATION

TIME ALLOWED : Two Hours

INSTRUCTIONS TO CANDIDATES

Answer **four** questions only.

If you attempt to answer more questions than the required number of questions (in any section), the marks awarded for the excess questions will be discarded (starting with your lowest mark).



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1. (a) Give the standard syntax for, and describe the operation of, definite loops, indefinite loops with preconditions and indefinite loops with postconditions. **9 marks**
- (b) Using *one* of these loops give, in Java syntax, the code to print the integers from 5 up to n (marks will not be deducted for small errors in syntax). What will your code do in the case where $n = 0$? **5 marks**
- (c) Give a parse tree for the while statement

while $x > 0$ loop $x := x-1$; endloop;

which is derived from the production for *while_statement* in the grammar below.

8 marks

```

< while_statement > ::= while < boolean_exp >
                        loop < statement_sequence > endloop ;
< statement_sequence > ::= < statement > |
                        < statement > < statement_sequence >
< statement > ::= < assignment_statement > |
                        < while_statement >
< assignment_statement > ::= < identifier > := < exp >;
< boolean_exp > ::= < exp > < comparison_operator > < exp >
< comparison_operator > ::= > | < | ≥ | ≤ | = | ≠
< exp > ::= < term >
                        | < exp > < adding_operator > < term >
< adding_operator > ::= + | -
< term > ::= < identifier > | < constant > | ( < exp > )
< identifier > ::= < letter > | < identifier > < letter >
                        | < identifier > < digit >
< constant > ::= < digit > | < constant > < digit >
< letter > ::= A|B|C|D|E|F|G|H|I|J|K|L|M|N|O
                |P|Q|R|S|T|U|V|W|X|Y|Z|a|b|c|d|e|f
                |g|h|i|j|k|l|m|n|o|p|q|r|s|t|u|v|w|x|y|z
< digit > ::= 0|1|2|3|4|5|6|7|8|9

```

- (d) Why are comments important when writing software? How does one write comments in Java? **3 marks**



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2. (a) What is meant by a recursive procedure or function? What two elements must such a procedure or function have? **3 marks**
- (b) Give pseudocode for a recursive function *listlength* that, when given a list as its only argument, will output the length of the list. **3 marks**
- (c) The function $g(n)$ is as follows

$$\begin{aligned}g(0) &= 1 \\g(1) &= 3 \\g(n) &= g(n-2) + g(n-1) + 2 \text{ for } n \geq 2\end{aligned}$$

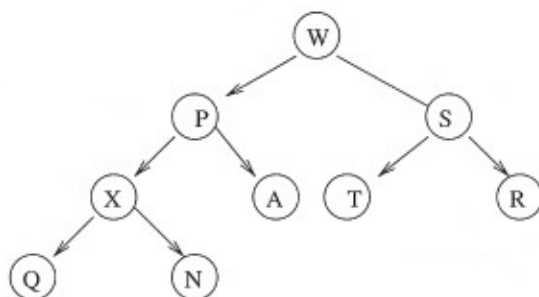
Show how $g(5)$ is calculated recursively. **4 marks**

- (d) Explain why a recursive algorithm for $g(n)$ will terminate (when n is a positive integer or zero). **4 marks**
- (e) Why is this recursive calculation very inefficient? What is the order of $g(n)$? Why? **6 marks**
- (f) How can we calculate $g(n)$ more efficiently? Show how $g(n)$ is calculated this way. **5 marks**
3. (a) What is meant by the *order* of complexity of an algorithm? What is meant by an algorithm that is feasible or tractable? **5 marks**
- (b) Give pseudocode for an algorithm that searches for an item in an *unsorted* list of elements. What is the order of your algorithm? Give a brief explanation why the algorithm has this order. **8 marks**
- (c) Give pseudocode for a more efficient algorithm that searches for an item in a *sorted* list of elements. What is the order of your algorithm? Give a brief explanation why the algorithm has this order. **8 marks**
- (d) What is the *halting problem*? Why is the non-existence of a solution to the halting problem important? **4 marks**



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4. (a) Describe four different ways by which parameters can be passed to functions or procedures in modern high level languages. **8 marks**
- (b) What are the two main ways of parameter passing in Java and on which data types are they used? **4 marks**
- (c) Data types can be categorised into hardware, virtual and abstract data types. Describe the first two of these giving a simple example of each. **4 marks**
- (d) What is the difference between static and dynamic storage allocation? What are the advantages of the latter? What constructs can be used with the latter but, in general, not with the former? **6 marks**
- (e) What is the *heap*? How do we allocate from the heap in Java? **3 marks**
5. (a) What is an *abstract data type*? Why is it useful? How are abstract data types implemented in Java? (You should mention the visibility of instance variables and methods and how the data is accessed.) **6 marks**
- (b) A binary tree data type has a node that carries information and can point to two similar subnodes. Give part of a Java class defining this data type (do not give any methods). **3 marks**
- (c) For the following tree



give

- i. a left-right depth-first in-order walk;
- ii. a left-right depth-first pre-order walk; and
- iii. a left-right breadth-first walk. **6 marks**
- (d) Give pseudocode to perform a left-right depth-first in-order walk. **5 marks**
- (e) What is a binary search tree? Why are binary search trees useful? Show the insertion of 17, 10, 20, 19, 25, 12 into a binary search tree (give a diagram showing the tree after each insertion). **5 marks**