UNIVERSITY OF LONDON

GOLDSMITHS COLLEGE

B. Sc. Examination 2013

Computer Science

IS52017A Data Communication and Algorithm

Duration: 3 hours

Date and time:

This paper is in two parts: part A and part B. There are a total of three questions in each part. You should answer two questions from part A and two questions from part B. Your answers to part A and part B should be written in separate answer books.

Full marks will be awarded for complete answers to a total of four questions, two from part A and two from part B. Each question carries 25 marks. The marks for each part of a question are indicated at the end of the part in [.] *brackets.*

There are 100 marks available on this paper.

Electronic calculators must not be programmed prior to the examination. Calculators which display graphics, text or algebraic equations are not allowed.

THIS PAPER MUST NOT BE REMOVED
FROM THE EXAMINATION ROOM

Part B

Question 4

(a) What is the meaning of the term *computational complexity* in the context of Algorithms? Discuss briefly the time complexity in the *worst* case for the algorithm below. Indicate the basic operations you have counted. Draw a diagram to plot the time complexity $T(n)$ against input n for $n = 1, 2, 3, 4, 5$. Assume i, j and n are positive integers. [8]

```
1: i ← n
2: while i ≥ 1 do
3:    for j ← 1; j < n; j ← j + 1 do
4:       x ← x + 1
5:    end for
6:    i ← i div 2
7: end while
```

(b) The terms *abstract data structure* and *abstract data type* are often used interchangeably. Explain briefly, with an example of their use, when the abstract data structure is more appropriate and when the abstract data type is more appropriate. [4]

(c) One important standard function for stacks is a boolean `Empty(Stack)`. Explain briefly when the function is normally invoked. Write the Java method `Empty(Stack)` using a reference implementation for stacks. Provide `Node` class if necessary. Write comments on the precondition (`Input:`), the functionality (`Task:`), and the postcondition (`Output:`) of the method. [7]

(d) Write a recursive algorithm `descendOrder(bTreeNode T)` in pseudocode or Java to display integers stored in a Binary Search Tree in descending order. Indicate clearly the *input* and the *output* of your algorithm and the meaning of each variable. Provide the data structure of `bTreeNode` in diagram. [6]

Question 5

(a) A binary heap can be implemented easily by an array. Given a heap stored in the array A[] below, draw a diagram to illustrate the heap structure. [6]

i	1	2	3	4	5	6	7	8
A[i]	2	7	6	10	12	11	8	15

(b) Following part (a) above, if the array A[] has been modified by swapping elements A[4] and A[7], will A[] still be a binary heap? Justify your answer with the aid of a diagram. [5]

(c) Write an algorithm to compute the degree of each vertex in a simple graph. The graph is represented using adjacency lists. Let `adjacentList[`i`]` refer to the first adjacent node to vertex i, where $i = 1, \cdots, n$ and n is the number of nodes of the graph. [6]

(d) What is so-called "greedy approach"? Describe the *coin change* problem and explain how this problem can be solved by a greedy approach? [8]

Question 6

(a) With the aid of an example, explain what a quadtree is. Define a class `quadtreeNode` for quadtrees. Assume there is only one real number label for each node. [10]

(b) Draw the quad-tree for the following 8×8 black-white (B-w) pixel rectangle: [5]

	1	2	3	4	5	6	7	8
1	w	w	w	w	w	w	w	w
2	w	w	w	w	w	w	w	B
3	w	w	w	w	w	w	B	B
4	w	w	w	w	w	B	B	B
5	w	w	w	w	w	B	B	w
6	w	w	w	w	B	B	B	w
7	w	w	w	w	B	B	B	B
8	w	w	B	B	B	B	B	B

(c) Outline the Boyer-Moore pattern matching algorithm, with the aid of an example where the text `T` and the Pattern `P` are as below. Demonstrate step by step the shifts and comparisons performed by the algorithm. [10]

```
T: a b a c a a b a d c a b a c a b a a b b
P: a b a c a b
```