UNIVERSITY OF LONDON

CM1025

BSc EXAMINATION

COMPUTER SCIENCE

Fundamentals of Computer Science

Release date: Tuesday 14 March 2023 at 12:00 midday Greenwich Mean Time

Submission date: Wednesday 15 March 2023 by 12:00 midday Greenwich Mean Time

Time allowed: 24 hours to submit

INSTRUCTIONS TO CANDIDATES:

Section A of this assessment consists of a set of **TEN** Multiple Choice Questions (MCQs) which you will take separately from this paper. You should attempt to answer **ALL** the questions in Section A. The maximum mark for Section A is **10**.

Section A will be completed online on the VLE. You may choose to access the MCQs at any time following the release of the paper, but once you have accessed the MCQs you must submit your answers before the deadline or within **4 hours** of starting whichever occurs first.

Section B of this assessment is an online assessment to be completed within the same 24-hour window as Section A. We anticipate that approximately **1 hour** is sufficient for you to answer Section B. Candidates must answer **TWO** out of the THREE questions in Section B. The maximum mark for Section B is **60** but counts for 90% of your final mark.

Calculators are permitted in this examination. Credit will only be given if all workings are shown.

You should complete Section B of this paper and submit your answers as **one document**, if possible, in Microsoft Word or a PDF to the appropriate area on the VLE. Each file uploaded must be accompanied by a coversheet containing your **candidate number**. In addition, your answers must have your candidate number written clearly at the top of the page before you upload your work. Do not write your name anywhere in your answers.

UL23/0208

SECTION A

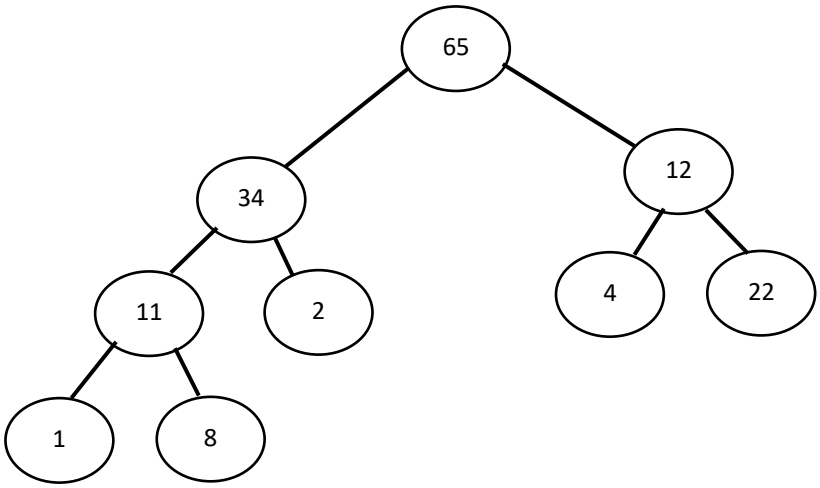
Candidates should answer the Multiple Choice Questions (MCQs) quiz, **Question 1** in Section A on the VLE.

SECTION B

Candidates should answer any **TWO** questions from Section B.

Question 2

(a) Heapify the following tree, make every step clear. (Min heap)



(7 marks)

(b) Design a finite state machine that accepts the language of all binary strings which starts with 0, and has exactly one occurrence of 010. For example, strings such as 01101011, 010, 00010 should be accepted by the finite state machine. Strings such as 1010, 0111, 010010 should be rejected by the finite state machine.

(7 marks)

(c) Answer the following for the context-free grammar G:

G: S→ABBA
A→aAb|ε
B→aB|b

i. Give two strings that can be generated from G. Show the derivations.

(4 marks)

ii. Give two strings that cannot be generated from the context-free grammar G.

(2 marks)

iii. Can this grammar generate a string with length 1? Justify your reasoning.

(2 marks)

iv. What is the language of G?

(3 marks)

(d) Write the time complexity of the following using the Master theorem. Make every step clear.

$T(n)=4T(n/3)+O(n^3)$

(5 marks)

Question 3

(a) Using the Master theorem write the time complexity of the following. Make every step clear.
T(n)=4T(n/2)+O(1)

(5 marks)

(b) Design a context-free grammar for the following language $L=\{a^ib^jc^{i+j} \mid i,j>0\}$

(6 marks)

(c) Design a Turing Machine for the following language: $L=\{a^ib^j \mid i>j>0\}$

(7 marks)

(d) Use the Quick sort to sort the following list in ascending order. Show your work step by step.
5, 7, 12, 23, 8, 1, 2, 4

(7 marks)

(e) Design a finite state machine to accept all binary strings that contain an even number of 0's and an odd number of 1's. For example, 10101, 11111, 001 should be accepted while 1010,10, 0000 should be rejected.

(5 marks)

Question 4

(a) Consider the following array:

A: 5, 3, 7, 12, 2, 8, 4, 1

i. Using insertion sort, show A after one iteration (in ascending order). Show A after the second parsing.

(2 marks)

ii. Using bubble sort show A after one iteration (in ascending order). Show A after the second parsing.

(2 marks)

iii. Give an instance of the best case input for the insertion sort. Explain your reasoning.

(2 marks)

(b) Design a Context-free Grammar for the following language:

L= {W| $N_0(W)>2\ N_1(W)$, W is a binary string},

$N_0(W)$ shows the number of existing 0s in W. For example, if W=10010 then $N_0(W)=3$ and $N_1(W)=2$

(6 marks)

(c) Assume $f(n)=4n^{0.1}$, $g(n)=10 \log n$, $h(n)=2^n$, $p(n)=3^{\log(n)}$

i. Is the following statement correct? Why? f(n)=O(g(n))

(2 marks)

ii. Is the following statement correct? Why? h(n)=O(p(n))

(2 marks)

iii. Is the following statement correct? Why? g(n)=O(h(n))

(2 marks)

(d) Design a Turing Machine that accepts the following language:

$L=\{a^nb^n|\ n>0$ and n is even$\}$

(7 marks)

(e) Use the merge sort to sort the following list in ascending order. Show your work step by step.

7, 12, 34, 23, 16, 1, 14

(5 marks)

END OF PAPER