UNIVERSITY OF LONDON

CM1025

BSc EXAMINATION

COMPUTER SCIENCE

Fundamentals of Computer Science

Release date: Wednesday 23 September 2020: 12.00 midday British Summer Time

Time allowed: 24 hours to submit

Submission date: Thursday 24 September 2020: 12.00 midday British Summer Time

INSTRUCTIONS TO CANDIDATES:

Part A of this assessment consists of a set of 10 Multiple Choice Questions (MCQs) which you will take separately from this paper. You should attempt to answer **ALL** the questions in Part A. The maximum mark for Part A is **40**.

Part 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. Candidates only have **ONE** attempt at Part A.

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

Calculators are not permitted in this examination. Credit will only be given if all workings are shown.

You should complete **Part 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. You are permitted to upload 30 documents. However, we advise you to upload as few documents as possible. 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 before you upload your work. Do not write your name anywhere in your answers.

PART B

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

Question 1

(a) Construct the truth table for $(p \to q) \wedge (p \to r) \leftrightarrow p \to (q \wedge r)$ [5]

(b) Determine if the formula in part (a) is a tautology or a contradiction and explain your reasoning. [2]

(c) Write the negation of $p \to q$. [3]

(d) Each student has a password, which is SIX characters long. Each character is either a digit or a lowercase letter. Each password must contain at least TWO digits. How many possible passwords are there? Show your working. [6]

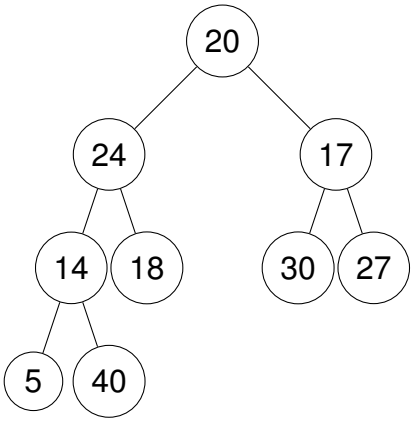
(e) There are 7 red balls, 6 blue balls and 5 green balls in a sack. What is the minimum number of balls one must take out of the sack to guarantee at least 4 balls of the same colour? [3]

(f) Use mathematical induction to prove $n^3 - n$ is divisible by 6, for all $n \geq 0$. [7]

(g) Use contrapositive to prove if $n^2 + 6n + 8$ is odd then n is odd. [4]

Question 2

(a) Heapify the following tree, make every step clear. (Min heap) [6]



(b) Using the Master theorem write the time complexity of $T(n)$,
$T(n) = T(n/3) + O(n)$ [5]

(c) What is the time complexity of the insertion sort? State the best, worst and average cases. [3]

(d) Give one instance of the worst-case and one instance of the best-case input for the insertion sort. Explain your reasoning. [4]

(e) This is the pseudo-code for a recursive algorithm called FACT. Execute it for input $n = 6$. Present the results of this execution as a table showing the values of x and n at each stage and state the final results that are returned. [6]

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FACT(n)
1  if n = 1 then
2        return 1
3  else x ← FACT(n − 1)
4        return x.n
```

(f) Write the asymptotic functions of the following:
$f(n) = 10n + 6n \log n, g(n) = 2n + 3n^2, h(n) = 8 \log(n) + 3$ [6]

Question 3

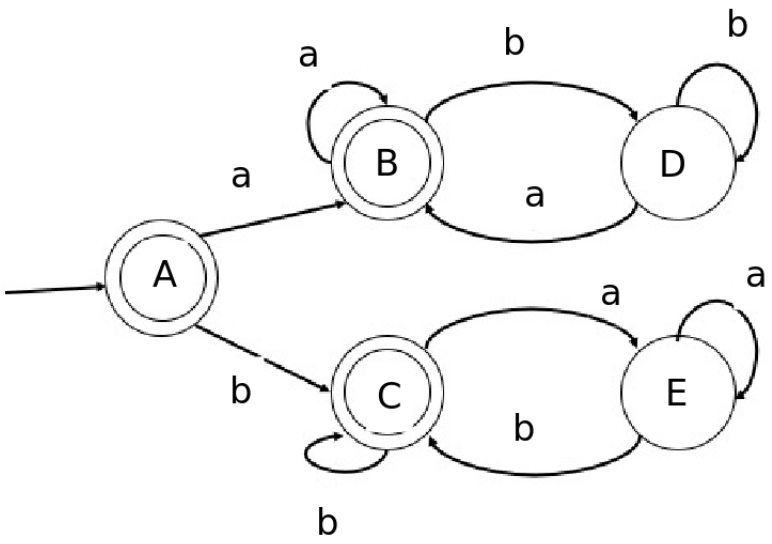
If $\Sigma = \{0, 1, 2\}$,

(a) List all the strings in Σ^2 [3]

(b) What is the cardinality of Σ^4? [2]

(c) Write the paths representing parsing of the following input by the automaton depicted below. State if the input is accepted or rejected. [4]

i. abaa
ii. abbab
iii. babab
iv. baaba



(d) What is the language of the automaton from the previous question? [2]

(e) Give a finite automaton that accepts all binary words that do not contain 101. [7]

(f) Give two strings that can, and two that cannot be generated from:
$b^*ab^* \cup a^*ba^*$
if
$\Sigma = \{a, b\}$

Describe the language of this regular expression. [6]

(g) Give two strings that can, and two that cannot be generated from the context-free grammar G defined below: [4]

$G = \{\{S\}, \{a, b\}, \{S \rightarrow aS|Sb|a|b|\epsilon\}, S\}$.

(h) What is the language of G? [2]

END OF PAPER

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