THIS PAPER IS NOT TO BE REMOVED FROM THE EXAMINATION HALL

UNIVERSITY OF LONDON

CM1025

BSc EXAMINATION

COMPUTER SCIENCE

Fundamentals of Computer Science

Wednesday 4 March 2020 : 10.00 – 12.00

Time allowed: 2 hours

DO NOT TURN OVER UNTIL TOLD TO BEGIN

INSTRUCTIONS TO CANDIDATES:

This examination paper is in two parts: Part A and Part B. You should answer **ALL** of question 1 in Part A and **TWO** questions from Part B. Part A carries 40 marks, and each question from Part B carries 30 marks. If you answer more than **TWO** questions from **Part B** only your first **TWO** answers will be marked.

All answers must be written in the answer books; answers written on the question paper will not be marked. You may write notes in your answer book. Any notes or additional answers in the answer book(s) should be crossed out.

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.

Calculators are not permitted in this examination.

PART A

Candidates should answer **ALL** of Question 1 in Part A.

Question 1

(a) Conjunction in a truth table is defined as **true** when
Select ALL statements that apply. [4]

i. Both propositions are true
ii. Only one proposition is true
iii. Both propositions are false
iv. The first condition is true.

(b) The exclusive or (XOR) condition is defined as
Choose ONE option. [4]

i. None of the conditions being true
ii. All conditions being true
iii. Either condition being true, but not both
iv. The second condition being true
v. None of the above options is correct.

(c) When we prove by contradiction using an indirect proof, we aim to prove that condition a is true. The first step in this process is
Select ALL correct statements. [4]

i. To assume that a is true
ii. To define a
iii. To assume that a is false
iv. To calculate a
v. To calculate a from b
vi. None of the other options is correct.

(d) We can use the sum rule with a minor defect on a pair of two lists. We can do this if the lists

Select ALL correct statements. [4]

i. Are pairwise disjoint

ii. Contain the same number of elements

iii. Contain the same elements in each list

iv. Each contain over 100 elements

v. Have an intersection that is the empty set

vi. Each contain less than 100 elements

vii. None of the above options is correct.

(e) A finite automaton is a representation of how computations are performed with

Choose ONE option. [4]

i. An infinite memory space

ii. Zero inputs

iii. Zero outputs

iv. Limited memory space.

(f) In the context of regular expressions, empty strings are denoted by
Choose ONE option. [4]

i. $\sum$

ii. $\sum^*$

iii. $\sum^+$

iv. $\mathcal{E}$

v. None of the above options is correct.

(g) A context-free grammar is in Chomsky Normal Form if every rule is of the form
$S \rightarrow XU$
$S \rightarrow a$

Select ALL correct statements. [4]

i. a is any terminal

ii. X, U and S are terminals

iii. X and U are not the start variable

iv. U is not the start variable.

(h) A Turing machine

Choose ONE option. [4]

i. Has an infinite set of states
ii. Has no empty cells
iii. Is a machine where every cell contains more than one character
iv. Is a finite automaton with random access memory.

(i) An algorithm can be defined as having the following characteristic properties

Choose ONE option. [4]

i. Produces an output
ii. Finite
iii. Sequential
iv. Ordered
v. All of the above.

(j) Big O notation describes

Choose ONE option. [4]

i. A lower bound on the growth rate of a function
ii. An upper bound on the growth rate of a function
iii. What an algorithm does
iv. The order in which a series of operations is performed.

PART B

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

Question 2

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

(b) Add the following headings and corresponding truth values to your table $(p \wedge \neg (q \vee r))$ [6]

(c) Describe your process for determining if the formula $(p \to q) \vee (p \to r) \longleftrightarrow (p \wedge \neg (q \vee r))$ is a tautology. [5]

(d) Write the negations of each statement and simplify the expression where possible

i. $p \wedge q \vee \neg r$ [3]

ii. $(p \to r)$ [3]

iii. $\forall x P(x) \wedge \neg Q(x)$ [3]

(e) Each student has a password, which is five characters long and each character is either a digit or a lowercase letter. Each password must contain at least ONE digit and ONE lowercase letter. How many possible passwords are there? [5]

Question 3

A: 18 4 1 6 12 20

(a) Using insertion sort show A after one iteration (in ascending order). Show A after the second parsing. [3]

(b) Show A after the fourth parsing. [3]

(c) How many comparisons are needed to sort A? [2]

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

(e) In a bubble sort, which elements are swapped? [2]

(f) How is it possible to determine when a bubble sort is complete? [2]

(g) Give an instance of the worst case input for the bubble sort. Explain your reasoning. [3]

(h) Why is an insertion sort an inefficient method to use when sorting a large list of items? [5]

(i) Write the asymptotic functions of the following. $f(n) = 5n \log n + 3n, g(n) = n + 7n^3, h(n) = 2\log(n) + 8$ [3]

(j) Explain which function in (i) above grows the fastest and which grows the slowest. [4]

Question 4

If $\Sigma = \{a, b, c\}$, list all the strings in Σ^2 that contain:

(a) a [3]

(b) b [3]

(c) c [3]

(d) What is the cardinality of Σ^5? [3]

(e) What is the limiting factor on a finite state machine's memory? [2]

(f) What components do both a deterministic and non-deterministic finite automaton have? [5]

(g) Give three strings that can be generated from $a\Sigma^* \cap \Sigma^* b$, if $\Sigma = \{a, b\}$. Describe the language of this regular expression. [6]

(h) Give a context-free grammar whose language is all binary words that start and end with the same letter. Assume this language contains the empty word. [5]

END OF PAPER

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