

UNIVERSITY OF LONDON

GOLDSMITHS COLLEGE

Department of Computing

B. Sc. Examination 2019

IS51009C

Fundamentals of Computer Science

Duration: 3 hours

Date and time:

This paper is in three parts: part A, part B and part C. There is 1 question in part A, 3 in part B and 3 in part C. You should answer the 1 question from part A, the 2 question from part B and 2 questions from part C. Your answers to part C should be written in separate answer book to the answers to part A and B.

Full marks will be awarded for complete answers to a total of 5 questions, 2 from part A, 1 from part B and 2 from part C. The question in part A carries 40 marks each. The questions in parts B and C carry 15 marks each. The marks for each part of a question are indicated at the end of the part in [.] brackets.

Some parts of the question in part A is multiple choice. You should choose one and only one answer and write down the letter of your chosen answer

There are 100 marks available on this paper.

No calculators should be used.

**THIS PAPER MUST NOT BE REMOVED
FROM THE EXAMINATION ROOM**

Part A
Multiple choice

Question 1

- (a) What is a cache? [2]
- a) memory storage as part of the CPU
 - b) a small memory storage that is physically near the CPU and can communicate to it quickly
 - c) the main memory chip of the computer
 - d) a device for long term data storage, for example a hard disc
- (b) Which of these would be easiest to compress using run length encoding? [2]
- a) A cartoon using lots of flat colours.
 - b) A photograph
 - c) A random image like static on an old-style TV
 - d) A smoothly varying colour gradient
- (c) What is a memory address? [2]
- a) The location of a memory chip on a circuit board
 - b) The name of a track on a hard drive
 - c) A number that uniquely identifies a cell in memory
 - d) None of the above
- (d) Lossy compression is better suited to: [2]
- a) text
 - b) images
 - c) both text and images
 - d) neither text nor images
- (e) What is a utility? [2]
- a) The internals of an OS like file system and memory manager
 - b) The part of the OS that controls windows in the GUI
 - c) A data file that forms part of an application
 - d) Small software for a particular task like disc formatting
- (f) The internet is a... [2]
- a) Personal Area Network
 - b) Local Area Network
 - c) Metropolitan Area Network
 - d) Wide Area Network

- (g) If a website uses public key cryptography it means that... [2]
- a) only the server can encrypt or decrypt messages
 - b) any client can encrypt messages, but only the server can decrypt them
 - c) only the server can encrypt messages but any client can decrypt them
 - d) any client can both encrypt and decrypt messages
- (h) Machine Learning is based on [2]
- a) Operands and Operators
 - b) inferring statistical models from data
 - c) Creating sets of rules based on expert knowledge
 - d) computer simulations of how the human brain works
- (i) I am implementing a mixed reality game in which players walk around the city using their phones to interact with things at different places in the city. I need to track where each player and so send their positions from their phone to a server. I have decided to use UDP rather than TCP for sending this position data. What do you think was my main reason for doing so? [2]
- a) Players need to be able to use their phones and move around, rather than being at a fixed desktop
 - b) I need to keep player location data secure
 - c) The server needs to store all the locations in a database
 - d) I only care about the players' most recent position
- (j) A video streaming app has to both download video and play that video at the same time. It is very important that downloading the video doesn't slow down playback. How would that be achieved? [2]
- a) download and play in different processes
 - b) download and play in different applications
 - c) download and play in different memory areas
 - d) download and play in different libraries
- (k) What is $p \rightarrow (p \wedge \neg p)$. [2]
- a) a tautology
 - b) a contradiction
 - c) inconsistent
 - d) consistent

- (l) Which of the following is a proposition? [2]
- a) $x > 7$
 - b) is 2 an even number?
 - c) 5 is an even number
 - d) none of the above
- (m) Which of the following is equivalent to $p \rightarrow q$? [2]
- a) $p \wedge q$
 - b) $\neg q \rightarrow \neg p$
 - c) $p \vee q$
 - d) $\neg q \rightarrow p$
- (n) How many hands of 4 can be dealt from a deck of 10 cards? [2]
- a) 5040
 - b) 40
 - c) 10000
 - d) 210
- (o) What is Σ^+ ? [2]
- a) all non-empty strings over Σ
 - b) any language over Σ
 - c) all strings of length at least 2
 - d) all strings over Σ
- (p) Which of the following is correct? [2]
- a) $A \circ B = B \circ A$
 - b) $A \cup B = B \cup A$
 - c) $A \circ \emptyset = A$
 - d) $A \circ \epsilon = \epsilon$
- (q) What is the worst-case time for Quick sort? [2]
- a) $O(n)$
 - b) $O(n^2)$
 - c) $O(n^3)$
 - d) none of the above

(r) What is the language of the following grammar?

$$S \rightarrow 0S|0V$$

$$V \rightarrow 0V1|\epsilon$$

[2]

- a) all binary words of the form 0^n1^m with $n \geq m$
- b) all binary words starting with 0
- c) all binary words of the form 0^n1^m with $n > m$
- d) none of the above

(s) What is the maximum number of comparisons needed to sort an array of 4 numbers, using Bubble sort ?

[2]

- a) 6
- b) 16
- c) 12
- d) 8

(t) What is the asymptotic upper bound (Big O) of $f(n)$, if $f(n) = n \log n + 7n^2 + 10 \log n$?

[2]

- a) $n \log n$
- b) n^2
- c) $7n^2$
- d) $\log n$

Part B

All questions in this section should be answered in terms of the computer science concepts covered in part 1 of this course. You can gain additional marks by including concepts that go beyond what was taught in class, but must also include concepts from the course. The questions will be marked according to the same rubric. This has the following categories:

Does the answer describe an appropriate range of computer science concepts from this course?

Does the answer illustrate the concepts with a suitable example?

Does the answer explain how the computer system or data format works?

Does the answer predict how different technical choices or situations affect the system

Question 2

Describe, in terms of the computer science concepts you learned in this course, what happens when you use an app like SnapChat to take a video on your mobile phone, apply a filter to it and send it to a friend.

[15]

Question 3

Internet of thing smart home applications allow you to connect home appliances such as central heating or lighting to the internet so that you can control them using a mobile app or an intelligent assistant such as Alexa or Siri. Describe, using the concepts in this course, how you think it might work.

[15]

Question 4

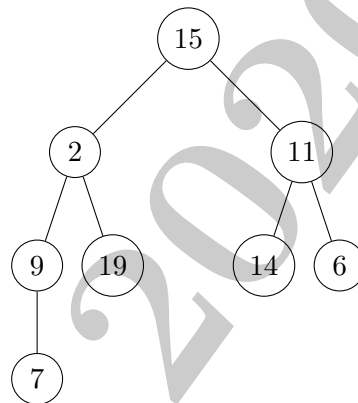
Mobile payments services like ApplePay or AndriodPay allow you to pay in shops using your mobile phone. Explain, using the concepts you learned in this course, how you think the payment process works.

[15]

Part C

Question 5

- (a) Give an instance of the worst and best inputs for insertion sort. [2]
- (b) This is a pseudo code for a recursive algorithm, execute it for input $n = 4$, show your work step by step. Write the output at every step. [3]
- ```
SUM(n)
1 if $n = 1$ then
2 return 1
3 else $x \leftarrow$ SUM($n - 1$)
4 return $x + n$
```
- (c) Use the Master Theorem and compute the time complexity of  $T(n)$ .  $T(n) = T(\frac{n}{3}) + O(n)$ ? [5]
- (d) Heapify the following tree, make every step clear. (Min heap) [5]



**Question 6**

- (a) Construct the truth table for  $p \wedge (p \rightarrow q) \rightarrow q$ . Is this statement a tautology?

[4]

- (b) Prove the following statement by induction. For all  $n \geq 1$

$$n^3 - n \text{ is divisible by } 3$$

[4]

- (c) How many numbers must be selected from the set  $\{1, 2, 3, 4, 5, 6, 7, 8\}$  to guarantee that at least one pair will have the numbers that add up to 9?

[3]

- (d) Each student has a password, which is 6 characters long and each character is either a digit or a lower case letter. Each password must contain at least ONE digit and ONE letter. How many possible passwords are there?

[4]

(you may state this answer in terms of mathematical functions such as powers or logs, you do not have to calculate a the final numerical value)

**Question 7**

- (a) If  $\Sigma = \{0, 1\}$ . What is  $\Sigma^2$ ? [2]
- (b) Build a finite automaton that accepts every binary string that does not contain 01. [5]
- (c) Design a regular expression whose language is all binary strings that start with  $b$  and contain exactly one occurrence of  $aa$ . [3]
- (d) What is the language of the following grammar for  $\Sigma = \{a, b\}$ ?

$$S \rightarrow TST|a$$

$$T \rightarrow bT|b$$

[2]

- (e) Give a context-free grammar  $G$  such that it generates all binary strings with at most TWO a's. State the components of this grammar clearly. [3]