

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, there are 3 in part B and 3 in part C. You should answer the 1 question from part A, 2 questions 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, 1 from part A, 2 from part B and 2 from part C. The question in part A carries 40 marks. 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) When transmitting text over the internet, how would each letter be represented? [2]
- a) a bit pattern
 - b) a number
 - c) pulses of light in an optic fibre
 - d) all of the above
- (b) How is an image affected when it is compressed using a lossy compression algorithm [2]
- a) it has fewer pixels
 - b) it loses small details
 - c) it uses a smaller range of colours
 - d) All of the above
- (c) What is a register? [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
- (d) Which machine instruction would be used by an application to load code from a software library? [2]
- a) MEMLOAD
 - b) VALLOAD
 - c) STORE
 - d) JUMP

- (e) Which of these is part of the operating system kernel? [2]
- a) system utilities
 - b) memory manager
 - c) window manager
 - d) none of the above
- (f) If your computer is slowing down due to memory paging, what would be the best way of upgrading it? [2]
- a) buy a faster CPU
 - b) buy more cache
 - c) buy more RAM
 - d) buy a bigger hard disc
- (g) Which of these is typically part of a web server? [2]
- a) a router
 - b) a database
 - c) a browser
 - d) an ISP
- (h) Which of the following is an IP address? [2]
- a) www.gold.ac.uk
 - b) jblog001@gold.ac.uk
 - c) 158.223.43.141
 - d) 0x10AF341C

- (i) A jpeg image file is loading too slowly over the internet. Which of the following would improve load times? [2]
- a) using TCP instead of UDP
 - b) using HTTPS instead of HTTP
 - c) using lossless compression instead of lossy compression
 - d) using a plain white background instead of the background in the photo
- (j) What happens at the end of a time slice? [2]
- a) a new frame of video
 - b) an IP packet is sent
 - c) an interrupt
 - d) a deadlock
- (k) What is an inconsistent formula? [2]
- (l) What is the basis step in the proof by induction? [2]
- (m) State the Pigeonhole Principle. [2]
- (n) What is the language of an automaton? [2]
- (o) State Kleene's Theorem. [2]
- (p) What is the difference between Σ and Σ^1 ? [2]
- (q) What is a binary tree? [2]
- (r) What is a stable match? [2]
- (s) What is the worst-case time for Merge sort? [2]
- (t) Name two components of the Turing Machine. [2]

Part B

Question 2

Describe what happens behind the scenes when you buy an item of clothing from an online store. [15]

Question 3

Imagine scanning a written document, like this exam paper, to send by email. Describe how the data is transferred from the scanner and how it would be represented in a file. [15]

Question 4

You are going to visit your friend in a part of London you have never visited before. On leaving the nearest station, you pull out your phone to find the way to your friend's house. Describe the technologies that enable you to find the right route. [15]

All questions in this section should be answered in terms of the computer science concepts covered in part 1 of this course. They 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
- Is the answer exceptional?

Part C

Question 5

(a) In a maximum of eight sentences describe binary search. [2]

(b) Write the pseudo code for Quicksort. [4]

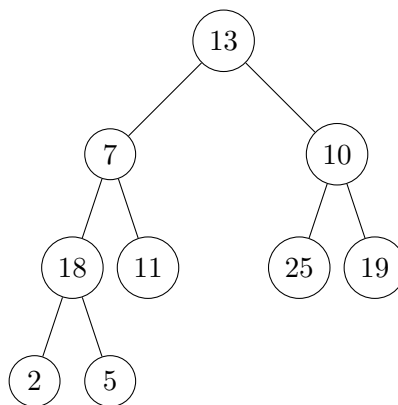
(c) This is a pseudo code for a recursive algorithm, execute it for input $n = 4$, show your work step by step. Write the output at every step. [3]

```

FIB( $n$ )
1  if  $n = 1$  then
2      return 1
3  elseif  $n = 2$  then
4      return 2
5  else  $x \leftarrow$  FIB( $n - 1$ )
6       $y \leftarrow$  FIB( $n - 2$ )
7      return  $x + y$ 
    
```

(d) What is the time complexity of Quicksort (worst, best, and average)? [3]

(e) Heapify the following tree, make every step clear. (Min heap) [3]



Question 6

(a) Fill in the truth table for the XOR and the implication. [4]

p	q	$p \text{ XOR } q$	$p \rightarrow q$
1	1		
1	0		
0	1		
0	0		

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

$$1 + 2 + 3 + \dots + n = \frac{n(n + 1)}{2}$$

[4]

(c) Show in any group of 5 integers there are at least two of them having the same remainder when divided by 4? [3]

(d) Each student has a password, which is 7 characters long and each character is either a digit or a lower case letter. Each password must contain at least TWO digits. Give an expression for the number of possible passwords. [4]

Question 7

(a) If $\Sigma = \{a, b\}$. What is Σ^2 ? [2]

(b) Build a finite automaton that accepts every binary string that ends with 01. [4]

(c) If $\Sigma = \{a, b\}$. What is the language of $a\Sigma^+ \cup b^*$? write four strings belonging to this language. [2]

(d) We know $L = \{x \in a^*b^*\}$ is regular. Using the closure properties, prove $L' = \{a^ib^j \mid i, j \in \mathbb{N}, i \neq j\}$ is not regular. [4]

(e) Give a context-free grammar G such that $L(G) = \{a^n b^n \mid n \in \mathbb{N}\}$ [3]