UNIVERSITY OF BRISTOL

January 2018

FACULTY OF ENGINEERING

Examination for the Degrees of
Bachelor of Engineering
Master of Engineering

COMS10001
PROGRAMMING AND ALGORITHMS II

TIME ALLOWED:
2 Hours.

THIS IS A SAMPLE PAPER
This paper contains *four* questions.
Each question is worth *30 marks*.
***Three* answers will be used for assessment.**
The maximum for this paper is 90 marks.

<u>Other instructions</u>

1. **Calculators must have the Engineering Faculty seal of approval.**

TURN OVER ONLY WHEN TOLD TO START WRITING

Q1: This question is about algorithmic complexity and recursion.

(a) Define big-O.

(5 marks)

(b) Define big-Theta.

(5 marks)

(c) Finding the maximum of a list by checking every item has big-Theta of n, why is it we can specify big-Theta rather than big-O?

(5 marks)

(d) What is big-Theta of $(n^2+1)/(n^2+2)$.

(5 marks)

(e) Find big-Theta for the recursion relation

$$T(n) = 8T(n-1) - 7$$

with $T(0) = 0$.

(10 marks)

Solution: Big-O and big-Theta defined as in the notes. The maximum search algorithm has big-Theta since every element has to be checked, so there is no worst case or best case. This is $\Theta(1)$ since the limit as n gets large is a constant. For the recursion use the ansatz $T(n) = A8^n + B$. This gives $B = 8B - 7$ so $B = 1$ and so substituting in to the initial condition $A = 1$.

Q2: This question is about sorting.

(a) Describe the radix sort algorithm and apply it to $(41, 29, 13, 23, 49)$.

(10 marks)

(b) Discuss the algorithmic complex of radix sort.

(20 marks)

Solution: Radix sort as in the notes. The first sweep puts it in the order $(41, 13, 23, 29, 49)$ and the second sorts it, important to note lower significant digit sorting is not spoiled by higher. The algorithmic complexity is done in the notes, important to get the possiblity of $k = \log n$ case and contrast it with what happens when the numbers are less dense.

Q3: This question is about balanced trees.

(a) Define a balanced binary tree. Why might a heap be useful?

(10 marks)

(b) Describe when a LR rotation is needed and explain how the reotation is done.

(10 marks)

(c) Describe when a RR rotation is needed and explain how the reotation is done.

(10 marks)

Solution: This is all in the notes, except the RR rotation is the mirror image of the LL rotation.

Q4: This question is about adverserial search and Euler's theorem.

(a) Draw the tree for the $(3, 1, 1)$ game of nim and use minimax to decide which move the first player should play.

(10 marks)

(b) Consider the four-node undirected graph

$$A = \begin{pmatrix} 0 & 1 & 2 & 3 \\ 1 & 0 & 3 & 1 \\ 2 & 3 & 0 & 1 \\ 3 & 1 & 1 & 0 \end{pmatrix}$$

For which starting and ending nodes does it have an Eulerian path?

(10 marks)

(c) Draw the graph and the path.

(10 marks)

Solution: The first part was on worksheet 3, for the second you need to work out the degrees by adding the rows, to get six, five, six and five, so the path must start at the two or four nodes and will find the other.

END OF EXAM PAPER