UNIVERSITY OF BRISTOL

Mock Exam 2022/2023

FACULTY OF ENGINEERING

First Year Examination for the Degrees of
Bachelor of Engineering
Master of Engineering
Bachelor of Science

COMS-10017
Object-Oriented Programming and Algorithms I

TIME ALLOWED:
2 Hours

This paper contains *three* questions.
All answers will be used for assessment.
The maximum for this paper is *30 marks*.

PLEASE WRITE YOUR 7 DIGIT STUDENT NUMBER (NOT CANDIDATE NUMBER) ON EACH PAGE OF THE ANSWER BOOKLET. YOUR STUDENT NUMBER CAN BE FOUND ON YOUR UCARD.

Other Instructions:

1. Calculators must have the Faculty of Engineering Seal of Approval.
2. Blank paper for your rough workings is available at the end of this question paper.

TURN OVER ONLY WHEN TOLD TO START WRITING

Important Information: Throughout this exam paper log() denotes the binary logarithm, i.e, $\log(n) = \log_2(n)$. We also write $\log\log n$ as an abbreviation for $\log(\log(n))$, and $\log^c n$ as an abbreviation for $(\log n)^c$.

As in the lectures, arrays start at index 0. For example, an array A of length n consists of the elements $A[0], A[1], \ldots, A[n-1]$.

Q1. This question is about Big-O notation and loop invariants.

(a) For each of the following statements, mark in the answer sheets whether the statement is true or false.

1. $1 \in O(n)$
2. $\log n \notin O(n^2)$
3. $2^n \in O(\log n)$

[3 marks]

(b) What is the smallest integer n_0 such that, for every $n \geq n_0$, the inequality

$$\frac{1}{2}n^2 \geq 16n$$

holds? Give your answer in the answer sheets.

[4 marks]

(c) Order the following sets so that each is a subset of the one that comes after it:

(1) $O(\log n)$ (2) $O(\log\log n)$ (3) $O(2^n)$ (4) $O(\sqrt{n})$

Give your answer in the answer sheets in form of a permutation of the numbers $1, 2, 3, 4$ (write exactly one digit in each box). For example, the permutation $2, 3, 1, 4$ corresponds to the ordering

$$O(\log\log n) \subseteq O(2^n) \subseteq O(\log n) \subseteq O(\sqrt{n})\ .$$

[3 marks]

Q2. This question is about sorting.

(a) For each of the following statements, mark in the answer sheets whether the statement is true or false.

1. Insertionsort is a dynamic programming algorithm.
2. The recursion tree of a run of Mergesort on an instance of size n has a depth of $O(\log n)$.

[2 marks]

(b) For the following input to Insertionsort, state the runtime of the algorithm using $\Theta(.)$-notation in the answer sheets (as usual, the objective is to sort in increasing order):

Integer array A of length n with $A[i] = n - i$ for every $0 \leq i \leq n-1$.

[2 marks]

Q3. This question concerns algorithmic design principles and recurrences.

(a) Determine the runtime of Algorithm 1 using Big "Theta" notation. Give your answer in the answer sheets.

Algorithm 1

```
Require: Int n ≥ 1
  x ← 0
  for i = 1 ... n do
    x ← x + i
  end for
  return x
```

[9 marks]

(b) Consider the following recurrence:

$$\begin{aligned} T(n) &= T(n-1) + 1 \text{ , for every } n \geq 2 \\ T(1) &= 1 \text{ .} \end{aligned}$$

For each of the following statements, mark in the answer sheets whether the statement is true or false.

1. $T(n) = \Theta(2^n)$
2. $T(n) = \Theta\left(n^2\right)$
3. $T(n) = \Theta(\log n)$
4. $T(n) = \Theta(n)$

[7 marks]

(cont.)

Rough Workings (page 1)

This page and the following ones are left blank for your rough workings. These pages will NOT be marked - only your answer sheets will be marked.

END OF PAPER