Department of Informatics

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Informatics II — Midterm 1
Spring 2021 — 29.03.2021

Name: _____ Matriculation number: _____

Advice

You have 60 minutes to complete and submit the midterm exam of Informatics II. This is an open book exam.

Submit your solution in one of the following ways:

1. You can print the pdf file, use the available whitespace to fill in your solution, scan your solution, and upload the pdf file to EPIS.
2. You can use blank white paper for your solutions, scan the sheets, and upload the pdf file to EPIS. Put your name and matriculation number on every sheet. State all task numbers clearly.
3. You can use a tablet and pen (iPad, Surface, etc) to fill in your solution directly into the pdf file and upload the completed pdf file to EPIS.
4. You can use a text editor to answer the questions and submit the document as pdf.

Notes:

- If you do not have scanner it is possible to take pictures of your solution with your phone. We recommend Microsoft Office Lens or Camscanner. Create a pdf file that includes all pictures and submit a single pdf file.
- There is no extra time for scanning and submission. The allotted time already includes the time for scanning and submission.
- Only submissions through EPIS are accepted.

Signature:

Correction slot — Please do not fill out the part below

Exercise	1	2	3	Total
Points Achieved				
Maximum Points	12	14	14	40

Exercise 1

For a positive integer i, $d(i)$ is the sum all digits of i plus i. For example, $d(75) = 7+5+75 = 87$. Given a positive integer i and a positive integer n, the *D-Numbers* is the sequence of n numbers such that $d(i)$, $d(d(i))$, $d(d(d(i)))$, ... $d(d(d(...)))$. In the *D-Numbers* for the integer i, the first number is $d(i)$; the second number is $d(d(i))$; the $n-th$ number is $d(d(d(...)))$.

a) [1 points] Let $i = 81$ and $n = 4$. Write down the *D-Numbers* for i.

b) [2 points] If i is always less than 1000, what is the asymptotic complexity of `void DNumbers(int i, int n)`? Explain.

c) [9 points] Write the C function `void DNumbers(int i, int n)` that prints the *D-Numbers* for i.

Exercise 2

Consider the C function `WhatDoesItdo` shown below, where $n \geq 2$.

```
int WhatDoesItdo(int n) {
  int i;
  for (i = 1; i< n; i++){
    if (i * (i + 1) == n){
        return True;
    }
  }
  return False;
}
```

a) [1 point] What does `WhatDoesItdo(int n)` return for $n = 25$ and $n = 6$, respectively?

b) [2 points] What does `WhatDoesItdo(int n)` do?

c) [5 points]Write invariants for Initialization, Maintenance and Termination to prove the correctness of the loop.

d) [2 points] What is the asymptotic complexity of the function? Explain.

e) [4 points] Provide better solutions in terms of time complexity. Describe your solutions and show time complexity of your solutions.

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Exercise 3

Divide and Conquer

Consider an array `A[0...N-1]` consisting of N positive integers. Use the divide and conquer approach to find the index of `smallest apex element` in an array. An apex element is an element which is not smaller than its neighbours i.e. `A[i]` is an apex element if $A[i-1] \leq A[i] \geq A[i+1]$. For corner elements, you need to consider only one neighbour.

a) [1 point] What are the apex elements in array `A = [7,19,6,4,8,2,5,10]`.

b) [2 points] Draw a tree that illustrates the divide and conquer approach of determining the smallest apex element in array `A = [7,19,6,4,8,2,5,10]`.

c) [11 points] Write a C code to determine the index of `smallest apex element` for any input array of size N using **divide and conquer approach**. The complexity of your algorithm should be $O(N)$.