

**ALGORITHMS, DATA AND SECURITY A.Y. 2022/23**  
**Midterm on April 4th, 2023**

**Surname** \_\_\_\_\_ **Name** \_\_\_\_\_

**ID number** \_\_\_\_\_

**Question 1 (points 9)**

- a) Describe what is a hash table and which are its benefits.
- b) Describe the collision problem in hash tables and explain how the open addressing technique solves it, also discussing the possible implementations of this technique.
- c) Considering the separate chaining technique, which are its main advantages and disadvantages with respect to the open addressing technique with linear probing?
- d) Let's consider a hash table of size 7 and open addressing with linear probing with the hash function  $h(k) = k \bmod 7$ . Insert the keys 3, 18, 17, 21 and 35 (in that order) and write down the entries of the hash table.
- e) How does the hash table change if we rather use open addressing with quadratic probing, considering the same sequence of keys?

**Question 2 (points 8)**

- a) Explain the goal of the stable marriage problem and provides at least one example of its application.
- b) Describe the Gale-Shapley algorithm in our words.
- c) Consider the Gale-Shapley algorithm and perform it on the following set of men and women, choosing either a women stable marriage or a men stable marriage.

Men = {1, 2, 3, 4, 5}

Women = {A, B, C, D, E}

Preference lists:

- 1: E A C B D (i.e., the man 1 prefers the woman E to A to C to B to D)
- 2: A E C D B
- 3: B D E C A
- 4: B D C E A
- 5: C A D B E
  
- A: 4 5 1 2 3
- B: 1 5 4 3 2
- C: 1 4 3 2 5
- D: 4 3 5 1 2
- E: 3 1 4 5 2

- d) Is there a gender bias in this algorithm? Explain your answer.

**Question 3 (points 6)**

- a) Consider the fibonacci2 algorithm: explain its goal, how it works and which is the main issue with this algorithm.
- b) How does the fibonacci3 algorithm improve the solution of finding a Fibonacci number with respect to fibonacci2? Explain the algorithmic technique that it uses.

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**Question 4 (points 9)**

- a) Describe (at least using your words) the sorting algorithm MergeSort.
- b) Describe how to you apply MergeSort to sort the following list in non-decreasing order, describing the various steps of the algorithm application: 45, 12, 5, 16, 12, 8, 3
- c) Which is the running time of this algorithm? Prove it. Which is the difference between its running time and the running time of the SelectionSort algorithm?
- d) Consider the pseudocode of the SelectionSort provided below and describe how you apply this algorithm on the list 43, 5, 12, 8, 3, showing only the first 2 steps ( $i=1$  and  $i=2$ ) of the algorithm.

```
algorithm SelectionSort(list L)  
  for  $i = 1$  to  $n - 1$  do  
    smallest =  $i$   
    for  $j = i + 1$  to  $n$  do  
      if  $L[j] < L[\textit{smallest}]$  then  
        smallest =  $j$   
      end if  
    end for  
    if  $i \neq \textit{smallest}$  then  
      swap  $L[i]$  and  $L[\textit{smallest}]$   
    end if  
  end for
```