

**ALGORITHMS, DATA AND SECURITY A.Y. 2021/22**  
**Midterm on April 6th, 2022**

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

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

**Question 1 (points 6)**

- a) Consider the fibonacci3 algorithm and explain how you apply it to compute the Fibonacci number when  $n$  is equal to 5.

```
algorithm fibonacci3(integer n) → integer
  Let Fib be an array of n integers
  Fib[2] ← Fib[1] ← 1
  for i=3 to n do
    Fib[i] ← Fib[i - 1] + Fib[i - 2]
  end for
  return Fib[n]
```

- a) Explain the technique used by this algorithm.  
b) What is the running time of this algorithm? Prove it. How much does it improve the running time of the fibonacci2 algorithm?

**Question 2 (points 7)**

- a) Describe the stable marriage problem, its goal and an example of application of this algorithm.  
b) 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}

Women = {A, B, C, D}

Preference lists:

- 1: A C B D (i.e., the man 1 prefers the woman A to C to B to D)
  - 2: D A C B
  - 3: D B C A
  - 4: C D A B
  
  - A: 4 1 2 3
  - B: 1 4 3 2
  - C: 1 2 3 4
  - D: 3 4 1 2
- c) Does the solution you have found change if, when applying the first step of the algorithm, you choose a different ordering on the women (or men)? Motivate your answer.  
d) Without solving the exercise, explain why the solution achieved when you apply the other kind of stable marriage (i.e., men stable marriage rather than women stable marriage or the other way around) may be different from that found when solving b).

**Question 3 (points 7)**

- a) Describe (at least using your words) a sorting algorithm of your choice between SelectionSort and InsertionSort.  
b) Which is the running time of the algorithm (you don't need to prove it)? Which is the difference between that running time and another sorting algorithm having  $O(n \log n)$ ? Which of the two would you choose to use in a computer application and why?  
c) Consider the algorithm described above and apply it to sort the following list in non-decreasing order, describing the various steps of the algorithm application: 21, 3, 6, 9, 6

**Question 4 (points 6)**

- a) Describe the goal and the steps of the collaborative filtering algorithm, also explaining how to measure similarity between users.
- b) Given the ratings shown in the following table, predict Tom's rating for Meet the Parents.

	Sherlock Holmes	Frankestein Junior	Snatch	The Gentlemen	Meet the Parents
Tom	3	4	4	5	?
Mary	5	5		3	4
Lucy	2		5	5	3
Ann		4	2	4	5

The similarity values are as follows:

1.00000000	-0.8528029	0.8164966	0.08111071
-0.85280287	1.0000000	-0.6237783	-0.12105003
0.81649658	-0.6237783	1.0000000	-0.49669963
0.08111071	-0.1210500	-0.4966996	1.00000000

**Question 5 (points 6)**

- a) Describe the collision problem in hash tables and explain how the open addressing technique solves it, also discussing the possible disadvantages of this technique.
- b) Let's use a hash table of size 11 and open addressing with linear probing with the hash function  $h(k) = k \text{ mod } 11$ . Insert the keys 5, 19, 27, 15 and 30 (in that order) and write down the entries of the hash table.