

ALGORITHMS, DATA AND SECURITY A.Y. 2025/26
Midterm on April 14th, 2026

Surname _____ Name _____

ID number _____

Question 1 (points 7)

- a) Consider the fibonacci2 algorithm: explain its goal, describe how it works, and discuss the main issue with this algorithm.
- b) Consider the fibonacci3 algorithm, whose pseudocode is provided below. Write down all the steps of the algorithm when n is equal to 5 and show how the Fib array evolves at each step of the computation. Indicate the output value returned by the algorithm.

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

- c) Which is the running time of fibonacci3 algorithm? Proof it.
- d) Compare it with the running times of fibonacci1 and fibonacci2.

Question 2 (points 6)

- a) Apply the Gale-Shapley algorithm to the following set of men and women to determine a woman-optimal stable matching. Show all the steps of the algorithm, not just the final solution.

Women = {1, 2, 3, 4}

Men = {A, B, C, D}

Preference lists:

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

- A: 1 2 4 3
- B: 3 4 1 2
- C: 2 1 3 4
- D: 2 1 4 3

- b) Now solve the exercise by determining a man-optimal stable matching, and explain whether and why the two solutions may differ.
- c) In the context of the stable marriage problem, explain what a local search heuristic is, and why it might not work correctly when applied to this problem.

Question 3 (points 8)

- a) Explain the InsertionSort sorting algorithm (using either pseudo-code or your own words).
- b) Describe how you apply InsertionSort to sort the list: 29, 31, 12, 15, 8.
- c) InsertionSort employs while loops. Explain in general the goal of the while loop and compare it to the for loop.
- d) Explain the divide-and-conquer technique. Indicate which algorithms you have studied employ this technique and explain how they apply it.

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Question 4 (points 6)

- Consider a hash table of size 7, using separate chaining and the hash function $h(k) = k \bmod 7$. Insert the keys 5, 18, 27, 14, 11, and 1 (in that order) and write down the entries of the hash table, explaining how each slot is chosen.
- Now consider the same hash table but using open addressing with quadratic probing. Insert the same the same keys as above and write down the entries of the hash table, explaining how each slot is chosen.
- Why might we prefer quadratic probing over linear probing? Which problem can quadratic probing suffer from when the hash table is small?

Question 5 (points 5)

- Given the ratings shown in the following table, predict User 1's rating for Movie C by applying the user-based collaborative filtering algorithm and determine whether Movie C should be recommended to User 1.

	Movie A	Movie B	Movie C	Movie D	Movie E
User 1	5	4	?	1	3
User 2	4	5		2	
User 3		3	5		2
User 4	4	3	4	5	5
User 5			4	5	4

The cosine similarity values are provided in the following table:

	User 1	User 2	User 3	User 4	User 5
User 1	1	0.83	0.01	-0.66	-0.59
User 2	0.83	1	-0.1	-0.83	-0.63
User 3	0.01	-0.1	1	-0.28	-0.06
User 4	-0.66	-0.83	-0.28	1	0.24
User 5	-0.59	-0.63	-0.06	0.24	1

- Explain how matrix factorization works, in your own words.