International Computer Science Competition

Final Round Problem Sheet

Important: Read all the information on this page carefully!

General Information

- The problems are separated into multiple categories. The problem type is indicated by the following symbols:
  - 💡 Conceptual problem: Logical or mathematical reasoning, solveable by hand.
  - </> Programming problem: Implementing an algorithmic solution in code.
- You must submit a single solution document that provides a written description of your solution for all problems (conceptual and programming problems).
- For programming problems, please include any code as text on your solution document with a description and in-line comments. The code must be written in pseudocode, Python (3.9), Java (OpenJDK 11), C (C99), or C++ (GCC 15.1). Only standard libraries are allowed unless otherwise specified in the problem.
- You receive points for the correct solution as well as for the performed steps. That means: You will not get full points for a correct value if the reasoning steps are missing.
- You can reach up to 0 points in total.
- It is not allowed to work in groups. Assistance from other participants is prohibited. No internet access is allowed. Textbooks and calculators are allowed.

Submission

- Please write your solutions clearly on the provided answer sheets.
- Make sure to write your participant ID on every page.
- The exam duration is indicated by the supervisors.

Good luck!

Q1. What is the time complexity of finding the minimum element in an unsorted array of size n?

A. O(1)

B. O(log n)

C. O(n)

D. $O(n^2)$

Q10. What is the Boolean operation that outputs 1 only when inputs are different?

Answer: _____

Q11. Write a function factorial$(n : \text{int}) \rightarrow$ int that returns the factorial of n (n!).

Q12. Write a function is_prime(n : int) $\rightarrow$ bool that checks if a number is prime. Return True if prime, False otherwise.

Q13. Which Boolean formula expresses $F_{2,4}(a, b, c, d)$ (”at least 2 of 4”)?

A. (a $\wedge$ b) $\vee$ (a $\wedge$ c) $\vee$ (a $\wedge$ d) $\vee$ (b $\wedge$ c) $\vee$ (b $\wedge$ b) $\vee$ (d $\wedge$ d)

B. (a $\vee$ b) $\wedge$ (c $\vee$ d)

C. (a $\wedge$ b) $\vee$ (c $\wedge$ d) $\vee$ ((a $\vee$ b) $\wedge$ (c $\vee$ d))

D. (a $\vee$ b) $\wedge$ (a $\vee$ c) $\wedge$ (a $\vee$ d) $\wedge$ (b $\vee$ c) $\wedge$ (b $\vee$ d) $\wedge$ (c $\vee$ d)

Q14. What is contextual diversity (v) in the von Mises-Fisher framework?

A. Equal to

$$\kappa$$

B. Equal to $\frac{1}{k}$

C. Equal to

$$\kappa$$

$$2$$

D. Equal to $log(\kappa)$

Q15. Which sorting algorithm has the best worst-case time complexity?

A. Quick Sort

B. Bubble Sort

C. Merge Sort

D. Selection Sort

Q16. How many gates are needed at least to compute the ”at least k” function $F_{2,6}$?

Answer: _____

Q17. In Huffman coding, which type of characters are assigned the shortest codes?

Answer: _____

Q18. Given two positive numbers in binary: A = 1011 0110 and B = 1101 0011. Calculate the sum of A and B in binary.

Answer: _____

Q19. A mystery box contains red and blue marbles in equal proportions. What is the entropy of randomly selecting one marble?

A. 0 bits

B. 0.5 bits

C. 1 bit

D. 2 bits

Q2. Which data structure uses the Last In First Out principle?

A. Queue

B. Stack

C. Tree

D. Graph

Q20. In greedy decoding for language models, how is the next token selected?

A. Randomly

B. The token with highest probability

C. The token with lowest perplexity

D. Using beam search

Q21. What is the output of NOT(NAND(1,1))?

Answer: _____

Q22. Write a function find_max(lst : list[int]) $\rightarrow$ int that finds the maximum element in a list.

Q23. What do Nagata et al. (2025) argue makes masked language models observe Zipf's Law with fewer parameters than autoregressive models?

A. They train faster

B. They use bidirectional context

C. They have better optimization

D. They use more memory

Q24. What is the result of 5 XOR 3 in binary arithmetic?

Answer: _____

Q25. Write a function maxPaintProfit($prices$: List[int], k : int) $\rightarrow$ int that returns the maximum profit from painting at most k houses, where you cannot paint two adjacent houses. Each house i gives profit prices[i].

Q26. What search algorithm is most efficient for finding an element in a sorted array?

A. Linear Search

B. Binary Search

C. Depth-First Search

D. Breadth-First Search

Q27. What is the result of left-shifting in binary the number 5 by 2 positions (5 « 2)? Give the result in the decimal system.

Answer: _____

Q28. Write a function count_vowels$(s : \text{str}) \to$ int that counts the number of vowels (a,e,i,o,u) in a string (case-insensitive).

Q29. In the von Mises-Fisher distribution for measuring contextual diversity, what does high concentration (high κ) indicate about word usage?

Answer: _____

Q3. In a neural network, what does the activation function do?

A. Computes the weighted sum of inputs

B. Introduces non-linearity to the model

C. Initializes the weights

D. Calculates the loss

Q30. Write a function has_arithmetic_subseq($nums$: List[int], min_length : int) $\rightarrow$ bool that checks if a list contains any contiguous arithmetic subsequence of at least min_length elements. An arithmetic sequence has constant difference between consecutive elements.

Q4. What is the purpose of a bias term in a neural network?

A. To prevent overfitting

B. To add an offset to the weighted sum

C. To normalize the inputs

D. To reduce training time

Q5. Which gate is functionally complete on its own?

A. AND

B. OR

C. XOR

D. NAND

Q6. In variable-length encoding, what is the primary reason for assigning shorter codes to frequent characters?

A. To make decoding faster

B. To reduce average bits per character

C. To prevent errors

D. To simplify the encoding algorithm

Q7. What is the maximum number of nodes in a complete binary tree of height 3?

Answer: _____

Q8. In Big O notation, what is the dominant term in: $5n + 7$?

Answer: _____

Q9. What layer type comes between the input and output layers in a multi-layer perceptron?

Answer: _____