

Final Exam Topics

In the Computer Science MSc program's Final Exam, the students must complete an oral exam in 3 subjects: Python Programming, Machine Learning and Digital Twins. In each subject, there is a predefined set of 5 possible topics. At the exam, the student randomly draws a topic from each of the 3 subjects, gets a brief preparation time and performs an oral exam in front of the exam committee from the 3 randomly assigned topics. First, the student has to speak about the chosen topic, then he/she must answer the questions asked by members of the committee. The possible topics from the Final Exam subjects are as follows:

I. Python Programming

1. Introduce the 4 standard collections of Python (tuple, list, set, dict)! Compare them against each other!
2. What are the elements of a function definition in Python? Outline the rules for positional and keyword arguments! Compare Python's function concept against mathematical functions!
3. What are the elements of a class definition in Python? Explain the role of the self parameter! Outline the rules of inheritance in Python.
4. Give an overview of NumPy! What are the main characteristics of the N-dimensional array data type? Explain the concept of broadcasting with examples!
5. Give an overview of Pandas! What are the main characteristics of Series and DataFrame? What are the steps of a group-by query?

II. Machine Learning

1. Introduce the linear regression model and derive the formula for the optimal parameter vector! Discuss the differences between linear and logistic regression
2. Introduce the decision tree model! Give an overview of the training algorithm! Discuss the differences between tree based and linear models!
3. Introduce the random forest model! What strategies can it apply to build an accurate and diverse ensemble? Discuss the differences between random forest and gradient boosted trees!
4. Introduce the multilayer perceptron model! Give an overview of the training algorithm! What are the strong and weak points of the neural network approach?
5. Introduce the following evaluation metrics for binary classification: accuracy, balanced accuracy, F1-score. Discuss the effects of changing the decision threshold!

III. Digital Twins

1. Vector spaces, norms, scalar product, Hilbert spaces. Function spaces.
2. Ordinary differential equations, initial and boundary value problems, linearization.
3. Linear ordinary differential equations, exact and numerical solutions in the state space.
4. Laplace transformation, transfer function; approximation with the transfer function.
5. Model order reduction with the proper orthogonal decomposition for linear input-output systems.