**COURSE UNIT (MODULE) DESCRIPTION**

| Course unit (module) title | Code |
|---|---|
| **Probabilistic machine learning I** | |

| Lecturer(s) | Department(s) where the course unit (module) is delivered |
|---|---|
| **Coordinator: assistant prof. S. Jokubaitis**<br><br>**Other(s):** | Department of Statistical Analysis<br>Faculty of Mathematics and Informatics<br>Vilnius University |

| Study cycle | Level of course | Type of the course unit (module) |
|---|---|---|
| First (BA) | Advanced | Compulsory |

| Mode of delivery | Period when the course unit (module) is delivered | Language(s) of instruction |
|---|---|---|
| Face-to-face | Spring semester | English |

| Requirements for students | |
|---|---|
| **Prerequisites:** basics of R and Python; ability to understand English at the level of independent user (B1 according to CEFR classification), familiarity with simplest parametric statistical models. | **Additional requirements (if any):** |

| Course (module) volume in credits | Total student's workload | Contact hours | Self-study hours |
|---|---|---|---|
| 5 | 125 | 48 | 77 |

| Purpose of the course unit (module): programme competences to be developed (the number in the brackets coincides with that given in the official description of the programme) | | |
|---|---|---|
| • Ability to analyse, systematize, learn and apply the obtained knowledge in practice (1);<br>• Ability to use mathematical language and solve analytical problems by making use of mathematical tools (4);<br>• Ability to choose appropriate methodology and tools (6);<br>• Ability to interpret and represent the results obtained (7); | | |
| **Learning outcomes of the course unit (module); after completing the course students should:** | **Teaching and learning methods** | **Assessment methods** |
| • become familiar with machine learning paradigm;<br>• become familiar with a quite large amount of core supervised learning models on the level appropriate for effective applications;<br>• be able to use several software tools designed for machine learning modelling both on ordinary and large scale data. | Lectures, problem solving and reading, assignments | Tests |

| Content: breakdown of the topics | Contact hours | Self-study work: time and assignments |
|---|---|---|

| | Lectures | Tutorials | Seminars | Exercises | Laboratory work | Internship/work placement | **Contact hours** | **Self-study hours** | **Assignments** |
|---|---|---|---|---|---|---|---|---|---|
| **1. Introduction.** Artificial intelligence and Machine Learning (ML). Terminology, tasks, and their classification, relation to other fields. | 1 | | | | | | **1** | **5** | To read intorductory chapters of [3] and [4]. |
| **2. Theoretical foundations.** Statistical learning framework. Empirical risk minimization. Formal learning model: approximately correct learning, (non-)uniform learnability, VC-dimension. | 3 | | | | 6 | | **9** | **12** | To solve assigned problems. To read assigned subsections of sections 2, 3, 4, and 6 in [3]. |
| **3. Optimization.** Main concepts. Convex functions and sets: main properties. Duality. Numerical algorithms: (non-)stochastic gradient descent, theoretical guaranties, applications for ML problems. | 4 | | | | 6 | | **10** | **12** | To solve assigned problems. To read assigned (sub)sections of [5] and [6]. |
| **4. General methods.** Hyper-parameters, cross validation, regularization, validation and learning curves, bias-variance trade-off | 3 | | | | 3 | | **6** | **10** | To solve assigned problems. To read assigned (sub)sections of [3] and [4]. |
| **5. Software.** sklearn basics: data preparation; modelling; selection of hyper-parameters. | 3 | | | | 3 | | **6** | **10** | To solve assigned problems. To get acquainted with prescribed subsections and examples of [2]. |
| **6. Binary classification: first touch.** Logistic classifier, support vector machines, k nearest neighbours, measuring of classification accuracy. | 2 | | | | 4 | | **6** | **8** | To get acquainted with prescribed subsections and examples of [2]. |
| **7. Tests and exam.** | | | | | | | **10** | **20** | To prepare for assessments. |
| **Iš viso** | | | | | | | **48** | **77** | |

| **Assessment strategy** | **Weight,%** | **Deadline** | **Assessment criteria** |
|---|---|---|---|
| Test 1 | 25 | 4th study week | The test consists of several practical tasks intended to check the level of knowledge obtained. The total weight of these tasks equals to 2.5 points. The weight of each task ranges from 0.1 to 1 point. Tasks are designed to be solved by making use of computer and appropriate software, or by hand.<br>Each task is evaluated as follows: a) the task is divided into parts and each part is assigned an appropriate amount of points; b) if student accomplishes the part without mistakes, the whole amount of that part is attained; otherwise, the amount is reduced considering the mistakes made; c) the parts are evaluated independently. |
| Test 2 | 25 | 8th study week | |
| Test 3 | 25 | 12th study week | |
| Test 4 | 25 | 16th study week | |
| Exam | | The final examination session | Exam is devoted to increase the grade compiled during the semester. For this, the lecturer may choose one of the following strategies: (a) to assign individual tasks; (b) to allow students to rewrite one of the four tests (chosen individually) taken during the regular semester. In case of worse outcome, the grade remains unchanged. |

| **Author** | **Year of public** | **Title** | **Issue of a periodical or volume of a** | **Publishing place and house or web link** |
|---|---|---|---|---|

| | ation | | publication | |
|---|---|---|---|---|
| **Compulsory reading** | | | | |
| 1. S. Jokubaitis | 2024 | ML lecture notes, part I | | Available via Virtual Learning environment |
| 2. scikit-learn developers | 2023 | Documentation of scikit-learn | | https://scikit-learn.org/stable/documentation.html |
| 3. Shai Shalev-Shwartz and Shai Ben-David | 2014 | Understanding Machine Learning: From Theory to Algorithms | | Cambridge University Press (a version very slightly differing from printed is available online) |
| 4. Andreas Lindholm, Niklas Wahlström, Fredrik Lindsten, and Thomas B. Schön | 2022 | Machine Learning - A First Course for Engineers and Scientists | | Cambridge University Press (available online for personal use) |
| 5. Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalkar | 2018 | Foundations of Machine Learning | | MIT Press, Second Edition, 2018 (available online) |
| 6. Hui Jiang | 2021 | Machine Learning Fundamentals: A Concise Introduction | | York University, Toronto, Cambridge University Press, 2021 (available via virtual VU library[1]) |
| **Optional reading** | | | | |
| 1. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani | 2013 | An Introduction to Statistical Learning: with Applications in R | | Springer (available online) |
| 2. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani | 2023, summer | An Introduction to Statistical Learning: with Applications in Python | | Springer (available online) |
| 3. Trevor Hastie, Robert Tibshirani, Jerome Friedman | 2016 | The Elements of Statistical Learning: Data Mining, Inference, and Prediction , Second Edition | | Springer (available online) |

1 to make use of virtual library, one needs to use VPN of Vilnius University