COURSE UNIT (MODULE) DESCRIPTION

Course unit (module) title	Code
Machine Learning for Science and Engineering Studies	

Lecturer(s)	Department(s) where the course unit (module) is delivered
Coordinator: asist. dr. Aidas Medžiūnas Others: assoc.prof. Rūta Levulienė	Vilnius University Faculty of Mathematics and Informatics Naugarduko str. 24 LT-08663 Vilnius

Study cycle	Type of the course unit (module)
First	Individual studies

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

Requirements for students	
Prerequisites: basics of programming, probability theory and statistics.	**Additional requirements (if any): -**

Course (module) volume in credits	Total student's workload	Contact hours	Self-study hours
5	125	45	80

Purpose of the course unit (module): programme competences to be developed		
The goal of the course is to develop a basic understanding of machine learning and its real-world applications. Students will gain fundamental knowledge of key concepts such as supervised and unsupervised learning, classification models, and deep learning while also learning essential techniques like linear regression, decision trees, and neural networks. Through theoretical lectures and hands-on lab work, students will enhance their analytical skills and practical experience in implementing machine learning models using Python.		
Learning outcomes of the course unit (module)	**Teaching and learning methods**	**Assessment methods**
Ability to independently pursue the investigation and analysis of scientific literature, adoption and application of new scientific material.	Problem-oriented teaching, analysis of examples, laboratories, self-study	Exams, tests
Ability to explain fundamental objects and ideas of mathematics, statistics and computer science in context of machine learning, their use and applications.		
Ability to apply machine learning models in real-world applications.		

Content: breakdown of the topics	Contact hours							Self-study work: time and assignments	
	Lectures	Tutorials	Seminars	Exercises	Laboratory work	Internship/work	Contact hours	Self-study hours	Assignments
1. Introduction to Machine Learning and Python • Introduction to basic notions of machine learning. • Real-world applications of machine learning. • Feature selection and extraction. • Transformation of variables (standardization, normalization, discretization, coding of categorical variables), principal component analysis. • Setting up Python environment, introduction to Jupyter Notebook	2				0		**2**	**8**	Textbook reading, problems, programming exercises, analysis of examples
2. Linear Regression • Model and assumptions, steps of the analysis. • Shrinkage methods: Ridge and Lasso. • Principal component regression. • Goodness-of-fit measures.	3				6		**9**	**12**	
3. Logistic regression • Model and assumptions, steps of the analysis.	2				4		**6**	**12**	

• Measures of classification accuracy. • Understanding and comparing results of classification models.									
4. Classification Trees and Random forests • Basics of classification trees and random forests. • Regression tree interpretation. • Stopping criteria. • Gradient boosting.	2				8		**10**	**16**	
5. Clustering • Introduction to clustering. • Hierarchical clustering: agglomerative and divisive methods. • K-means clustering algorithm steps, choosing the number of clusters, evaluating clustering results.	2				4		**6**	**14**	
6. Neural network models • Basic structure of neural networks, • Activation functions (sigmoid, tanh, and ReLU). • Forward/backpropagation. • Neural networks for regression and classification. • Unsupervised learning with neural networks.	4				8		**12**	**18**	
Total	**15**				**30**		**45**	**80**	

Assessment strategy	**Weight,%**	**Deadline**	**Assessment criteria**
Tests	30	During the semester	3 tests of equal weight on the scheduled date. Tests will assess students' basic understanding and general knowledge of each topic. They will include questions on key concepts, important methods, and their applications. Students may also be asked to explain short pieces of code to demonstrate their ability to interpret and apply machine learning techniques.
Midterm exam	30	Middle of semester	The midterm exam is conducted in written form and covers the first three topics of the subject. During the midterm, theoretical and practical knowledge of the subject is assessed (definitions, concepts, interpretation of analysis results). Students who receive an unsatisfactory grade can answer questions on midterm topics during the final exam.
Final exam	40	End of semester	The exam is conducted in written form and covers the last three topics of the subject. The exam is graded on a 10-point scale. During the final exam, theoretical and practical knowledge of the subject is assessed (definitions, concepts, interpretation of results).
External order			100 % exam; includes tasks of all topics.

Author	**Year of publication**	**Title**	**Issue of a periodical or volume of a publication**	**Publishing place and house or web link**
Compulsory reading				
Aidas Medžiūnas	2025	Course Material		VLE
Müller A. C., Guido S.	2018	Introduction to Machine Learning with Python: A Guide for Data Scientists		O'Reilly Media, Incorporated
Optional reading				
Burkov A.	2019	The Hundred-Page Machine Learning Book		https://themlbook.com/
James G., Witten D., Hastie T., Tibshirani R., Taylor J.	2023	An Introduction to Statistical Learning (with Applications in Python)		Springer