Study program	Level of studies		**Third cycle**	
	Title of the study program		**Doctoral studies in physics**	
Course title	**MACHINE LEARNING AND ARTIFICIAL NEURAL NETWORKS IN PHYSICS**			
Course ID	Semester	Course status	ECTS credits	Teaching hours
PCS8011	**I / II**	**Elective**	**10**	**30**
Course aims and expected learning outcomes	The aim of the course is to develop practical skills in machine learning, artificial neural networks, and physics-informed neural networks. Students will learn how to apply these skills and techniques to real-world problems in various branches of physics.			

COURSE CONTENT

- Introduction to machine learning (ML) and artificial neural networks (ANN); Notion of supervised and unsupervised learning; Problem of regression, classification and clustering
- Programming tools; Overview of TensorFlow, PyTorch, and Scikit-Learn
- Data preprocessing
- Regression: linear, polynomial, support vector (SVR), decission tree, random forest
- Classification: logistic, k-nearest neighbors (KNN), support vector machines (SVM), decission tree, random forest
- Clustering: k-means
- Artificial neural networks
- Dimensionality reduction: principal component analysis (PCA), linear discriminant analysis (LDA), active subspace method (ASM)
- Applications of ML and ANN in physics
- Physics informed neural networks (PINN)

LITERATURE	ASSESSMENT OF LEARNING	
1. S. Raschka, Y. Liu, V. Mirjalili, and D. Dzhulgakov, Machine Learning with PyTorch and Scikit-Learn: Develop Machine Learning and Deep Learning Models with Python, Packt Publishing, 2022. 2. N. Thuerey, P. Holl, P. Schnell, F. Trost, K. Um, and M. Mueller, Physics-based Deep Learning, (https://physicsbaseddeeplearning.org), 2021. 3. R. Maziar, P. Perdikaris and G. E. Karniadakis, George E, Physics-informed neural networks: A deep learning framework for solving forward and inverse problems involving nonlinear partial differential equations, Journal of Computational Physics, **378**, 686-707, 2019.	Assessment Method	Points
	Projects	100
	Total	100

Remarks

Student will complete three projects, with two focusing on ML and ANN methods, and the third involving the application of PINN. Each of the first two projects will be worth a maximum of 30 points, while the third project will be worth a maximum of 40 points.