Mathematical Foundations of AI (5172010)

Module name english	Mathematical Foundations of AI				
Type of module	Pflichtmodul		**Responsible for module**	Prof. Dr. Martin Storath	
Lecturer	Prof. Dr. Martin Storath				
Language of instruction, L. of examination	Englisch		**Semester**	1	
SWS	4		**Teaching and learning formats**	Seminaristischer Unterricht	
ECTS-Credits	5		**Type of examination**	Schriftliche Prüfung (90 Min.)	
Bonus benefits					
Workload	**Workload (Total)**	150	**Attendance time**	60	**Self-Study time (incl. exam preparation)** 90
Duration of module	1 Semester		**Frequency**	ME/OE	
Type of grading	Differenzierte Note		**Verwendbarkeit**	Artificial Intelligence	
Conditions for participation	None				
Recommended prerequisites					
Module's learning outcomes	- Students refresh and develop further their knowledge and skills on the necessary mathematical foundations for understanding and developing algorithms for AI; in particular, linear algebra, calculus, probability. - Students understand the principles of continuous optimization (constrained and unconstrained), are able to select appropriate approaches and they apply them for problems in AI. - Students are able to apply and evaluate the principles of probabilistic modelling and inference, and they create probabilistic models for frequently occurring kinds of data. - Students use the acquired mathematical skills to design and create frequently occurring building blocks of AI systems, such as linear regression, PCA, Gaussian mixture models and support vector machines.				
Module content	1. Advanced Vector Calculus • Multivariate derivatives and chain rule • Backpropagation and automatic differentiation • Linearization and multivariate Taylor series 2. Advanced Linear Algebra • Eigenvalues and eigenvectors • Singular value decomposition • Matrix approximation 3. Continuous Optimization • Gradient descent • Constrained optimization and Lagrange multipliers • Convex Optimization 4. Models and Data • Change of variables • Empirical risk minimization • Parameter estimation • Probabilistic modelling and inference • Model selection				
Literature	1. M. P. Deisenroth, A. A. Faisal, Cheng Soon Ong: Mathematics for Machine Learning, Cambridge University Press, 2020 2. C. M. Bishop: Pattern Recognition and Machine Learning, Springer, 2006 3. G. James, D. Witten, T. Hastie, R. Tibshirani: An Introduction to Statistical Learning, Second Edition, Springer, 2021				