M134	Numerical Methods for Partial Differential Equations	L	P	S	ECTS
		3	2	0	7

Course objectives. To familiarize students with the theory and numerical methods for solving partial differential equations.

Prerequisites. Knowledge of basic results of the real analysis, basics of the object-oriented programming.

Course content.

1. Introduction: examples of partial differential equations, main problems in solving PDEs. Numerical solution.
2. Finite difference method for hyperbolic and parabolic equation in one space dimension, and elliptic equation in two space dimensions. Consistency, stability and convergence, CFL condition, Lax equivalence theorem.
3. Finite element method for elliptic problems. Variational approximation principle, Lax-Milgram lemma and interpolation problem. Lagrange elements. Nonconforming approximation (Strange's lemmas). Numerical integration. Aubin-Nitche lemma. Stationary diffusion equation. Linearized elasticity system. Application development using appropriate software (Deal.II, DUNE, FreeFAM…).
4. Finite element method for parabolic equations. Variational formulation, time derivative discretization. Stability of the discrete problem.
5. Conservation laws. Finite volume method.

LEARNING OUTCOMES

No.	LEARNING OUTCOMES
1.	Known the main differences, advantages and disadvantages of the finite difference and finite element method.
2.	Use Lax equivalence theorem in analysing the finite difference method.
3.	Know how to discretize a partial differential equation in time and in space.
4.	Apply methods on various partial differential equations with initial (boundary) conditions.
5.	Analyse and illustrate the method errors on various examples.
6.	Develop a program code for the numerical solution of PDEs using an adequate software.
7.	Be able to clearly present conclusions based on the knowledge and experience.

RELATING THE LEARNING OUTCOMES, ORGANIZATION OF THE EDUCATIONAL PROCESS AND ASSESSMENT OF THE LEARNING OUTCOMES

TEACHING ACTIVITY	ECTS	LEARNING OUTCOME **	STUDENT ACTIVITY*	EVALUATION METHOD	POINTS	
					min	max
Attending lectures and exercises	1	1-7	Lecture attendance, discussion, team work and independent work on given tasks	Attendance lists, tracking activities	0	4
Written exam (Mid-terms)	3	1-7	Individual solving of the project task	Evaluation	25	48
Final exam	3	1-7	Revision	Oral exam	25	48

TOTAL	7				50	100

Teaching methods and student assessment. Lectures and exercises are obligatory. Exercises are partly auditory and partly laboratory using a computer. The exam consists of a project task and oral exam. Upon completion of the course, students can take the exam.

Can the course be taught in English: Yes

Basic literature:

1. J. C. Strikwerda, *Finite Difference Schemes and Partial differential equations*, The Wadsworth & Brooks/Cole Advanced Book and Software, Pacific Grove, 1989.
2. A. Quateroni, A. Valli, *Numerical Approximation of Partial Differential Equations*, Springer Series in Computational Mathematics Vol. 23, Springer Verlag,1994.
3. P. Knabner, L. Angerman, *Numerical methods for elliptic and Parabolic PDEs*, Springer Verlag, 2003.
4. R. LeVeque, *Numerical Methods for Conservation Laws*, Lecture Notes in Mathematics, Birkhäuser, Basel, 1992.

Recommended literature:

1. J. W. Thomas, *Numerical Partial Differential Equations, Finite Difference Methods*, Springer Verlag, 1995.
2. G. Evans, J. Blackledge, P.Yardley, *Numerical Methods for Partial Differential Equations*, Springer, 1999.
3. M.S.Gockenbach, *Partial differential equations: analytical and numerical methods*, SIAM: Society for Industrial and Applied Mathematics, 2002.
4. C. Johnson, *Numerical solutions of partial differential equations by the finite element method*, Cambridge University Press, 1987.
5. J.A. Trangenstein, *Numerical solution of hyperbolic partial differential equations*, Cambridge University Press, 2007.
6. L. C. Evans, *Partial differential equations*, AMS, 1998.