

UČNI NAČRT PREDMETA / COURSE SYLLABUS (leto / year 2016/17)						
<b>Predmet:</b>		Numerično reševanje parcialnih diferencialnih enačb				
<b>Course title:</b>		Numerical solving of partial differential equations				
<b>Študijski program in stopnja</b> Study programme and level		<b>Študijska smer</b> Study field		<b>Letnik</b> Academic year	<b>Semester</b> Semester	
Magistrski študijski program Matematika		ni smeri		1 ali 2	prvi ali drugi	
Master's study programme Mathematics		none		1 or 2	first or second	
<b>Vrsta predmeta / Course type</b>				izbirni / elective		
<b>Univerzitetna koda predmeta / University course code:</b>				M2411		
<b>Predavanja</b> Lectures	<b>Seminar</b> Seminar	<b>Vaje</b> Tutorial	<b>Klinične vaje</b> work	<b>Druge oblike</b> študija	<b>Samost. delo</b> Individ. work	<b>ECTS</b>
30	15	30			105	6
<b>Nosilec predmeta / Lecturer:</b>		prof. dr. Marjeta Krajnc, prof. dr. Emil Žagar				
<b>Jeziki / Languages:</b>		<b>Predavanja / Lectures:</b> slovenski / Slovene, angleški / English				
		<b>Vaje / Tutorial:</b> slovenski / Slovene, angleški / English				
<b>Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:</b>				<b>Prerequisites:</b>		
Vpis v letnik študija.				Enrolment in the programme.		
<b>Vsebina:</b>				<b>Content (Syllabus outline):</b>		

<p>Parcialne diferencialne enačbe: Uvod v PDE in modelni problemi drugega reda.</p> <p>Enačbe eliptičnega tipa: Poissonova enačba. Diferenčna metoda. Diskretni maksimalni princip in ocena globalne napake. Iterativno reševanje diskretiziranih enačb. Jacobijeva, Gauss-Seidelova in SOR metoda. Simetrična SOR metoda s pospešitvijo Čebiševa. ADI metoda. Metode podprostorov Krilova. Večmrežne metode. Variacijske metode. Metoda končnih elementov.</p> <p>Enačbe parabolnega tipa: Prevajanje toplote. Eksplicitne in implicitne numerične sheme. Crank-Nicolsonova metoda. Konsistenca, stabilnost in konvergenca.</p> <p>Enačbe hiperboličnega tipa: Valovna enačba. Karakteristike, karakteristične spremenljivke. Diferenčna metoda. Courantov pogoj. Konvergenca diferenčnih aproksimacij za modelni primer. Metoda karakteristik.</p>	<p>Partial differential equations: Introduction to PDE and examples of partial differential equations of the second order.</p> <p>Elliptic equations: Poisson's equation. Finite difference method. Discrete maximum principle and global error estimation. Iterative methods for discretized equations. Jacobi, Gauss-Seidel and SOR iterative methods. Symmetric SOR and Chebyshev acceleration. ADI method. Krilov subspace methods. Multigrid methods. Variational methods. Finite element methods.</p> <p>Parabolic equations: Heat transfer equation. Explicit and implicit numerical schemes. Crank-Nicolson's method. Consistency, stability and convergence.</p> <p>Hyperbolic equations: Wave equation. Characteristics. Characteristical variables. Finite difference method. Courant's condition. Convergence of finite difference approximations for a model equation. Method of characteristics.</p>
--	--

### Temeljni literatura in viri / Readings:

<p>J. Kozak: Numerična analiza, DMFA-založništvo, Ljubljana, 2008.</p> <p>W. F. Ames: Numerical Methods for Partial Differential Equations, 3rd edition, Academic Press, Boston, 1992.</p> <p>Z. Bohte: Numerične metode, DMFA-založništvo, Ljubljana, 1991.</p> <p>S. D. Conte, C. de Boor: Elementary Numerical Analysis : An Algorithmic Approach, 3rd edition, McGraw-Hill, Auckland, 1986.</p> <p>J. W. Demmel: Uporabna numerična linearna algebra, DMFA-založništvo, Ljubljana, 2000.</p> <p>E. Isaacson, H. B. Keller: Analysis of Numerical Methods, John Wiley &amp; Sons, New York-London-Sydney, 1966.</p> <p>D. R. Kincaid, E. W. Cheney: Numerical Analysis : Mathematics of Scientific Computing, 3rd edition, Brooks/Cole, Pacific Grove, 2002.</p> <p>K. W. Morton, D. F. Mayers: Numerical Solution of Partial Differential Equations, 2nd edition,</p>
---

Cambridge Univ. Press, Cambridge, 2005.

G. D. Smith: Numerical Solution of Partial Differential Equations : Finite Differences Methods, 3rd edition, Clarendon Press, Oxford (New York), 2004.

### **Cilji in kompetence:**

Slušatelj spozna metode za numerično reševanje parcialnih enačb. Pridobljeno znanje praktično utrdi z reševanjem domačih nalog.

### **Objectives and competences:**

Student supplements knowledge of numerical differentiation, integration and numerical solving of ODE equations. By solving homeworks the obtained theoretical knowledge is consolidated.

### **Predvideni študijski rezultati:**

Znanje in razumevanje: Razumevanje delovanja metod za numerično reševanje parcialnih diferencialnih enačb. Sposobnost numeričnega reševanja parcialnih diferencialnih enačb s pomočjo računalnika. Sposobnost izbire najprimernejšega algoritma glede na lastnosti problema.

Uporaba: Numerično reševanje parcialnih diferencialnih enačb s pomočjo računalnika in ocenjevanje napak na podlagi teorije. V praksi (fizika, mehanika, kemija, ekonomija ...) se pogosto pojavljajo parcialne diferencialne enačbe, ki jih ni mogoče rešiti drugače kot numerično. Refleksija: Razumevanje teorije na podlagi uporabe.

Prenosljive spretnosti – niso vezane le na en predmet: Spretnost uporabe računalnika pri reševanju matematičnih problemov.

Razumevanje razlik med eksaktnim in numeričnim računanjem. Predmet konstruktivno nadgrajuje zahtevnejša znanja analize in drugih področij matematike.

### **Intended learning outcomes:**

Knowledge and understanding: Understanding of numerical methods for solving partial differential equations. Ability of solving partial differential equations with the computer. Capability of choosing the most appropriate algorithm according to some features of the problem.

Application: Numerical solution of partial differential equations using a computer and error estimation based on theory. Problems that can not be solved any other way that numerically occurs very often

in practise (physics, mechanics, chemistry, economy...).

Reflection: Understanding of theory through applications.

Transferable skills: Skill of using computer for solving numerical problems. Understanding differences between exact and numerical computing. Knowledge of analysis and other fields of mathematics is constructively upgraded.

**Metode poučevanja in učenja:**

Predavanja, vaje, domače naloge, konzultacije, projekt.

**Learning and teaching methods:**

Lectures, exercises, homeworks, consultations, project

**Načini ocenjevanja:**

Delež (v %) /

Weight (in %)

**Assessment:**

Način (domače naloge, pisni izpit, ustno izpraševanje, naloge, projekt):	Delež (v %) / Weight (in %)	Type (homeworks, examination, oral, coursework, project):
domače naloge ali projekt		homeworks or project
pisni izpit	20%	written exam
ustni izpit	40%	oral exam
Ocene: 1-5 (negativno), 6-10 (pozitivno) (po Statutu UL)	40%	Grading: 1-5 (fail), 6-10 (pass) (according to the Statute of UL)

**Reference nosilca / Lecturer's references:**

Marjetka Krajnc:

JAKLIČ, Gašper, KOZAK, Jernej, KRAJNC, Marjetka, VITRIH, Vito, ŽAGAR, Emil. High order parametric polynomial approximation of conic sections. Constructive approximation, ISSN 0176-4276, 2013, vol. 38, iss. 1, str. 1-18. [COBISS.SI-ID 16716121]

KRAJNC, Marjetka. Interpolation scheme for planar cubic G<sup>2</sup> spline curves. Acta applicandae mathematicae, ISSN 0167-8019, 2011, vol. 113, no. 2, str. 129-143. [COBISS.SI-ID 16215385]

KRAJNC, Marjetka. Geometric Hermite interpolation by cubic G<sup>1</sup> splines. Nonlinear Analysis, Theory, Methods and Applications, ISSN 0362-546X. [Print ed.], 2009, vol. 70, iss. 7, str. 2614-2626. [COBISS.SI-ID 15508569]

Emil Žagar:

JAKLIČ, Gašper, KOZAK, Jernej, VITRIH, Vito, ŽAGAR, Emil. Lagrange geometric interpolation by rational spatial cubic Bézier curves. Computer Aided Geometric Design, ISSN 0167-8396, 2012, vol. 29, iss. 3-4, str. 175-188. [COBISS.SI-ID 16207449]

KOZAK, Jernej, ŽAGAR, Emil. On geometric interpolation by polynomial curves. SIAM journal on numerical analysis, ISSN 0036-1429, 2004, vol. 42, no. 3, str. 953-967. [COBISS.SI-ID 13398617]

ŽAGAR, Emil. On  $G^2$  continuous spline interpolation of curves in  $\mathbb{R}^d$ . BIT, ISSN 0006-3835, 2002, vol. 42, no. 3, str. 670-688. [COBISS.SI-ID 12027993]