课程大纲
COURSE SYLLABUS

1.	课程代码/名称 **Course Code/Title**	MAT7088 偏微分方程数值解 Numerical Solutions to Partial Differential Equations
2.	课程性质 **Compulsory/Elective**	选修 Elective
3.	课程学分/学时 **Course Credit/Hours**	3/48
4.	授课语言 **Teaching Language**	英文 English
5.	授课教师 **Instructor(s)**	Alexander Kurganovm, 讲席教授 Alexander Kurganov, Chair Professor;
6.	是否面向本科生开放 **Open to undergraduates or not**	是 Yes
7.	先修要求 **Pre-requisites**	（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.） 1.MA201a 常微分方程 A, 2.MA303 偏微分方程, 3.MA325 偏微分方程数值解 或者 MAT8028 科学计算 1.MA201a Ordinary Differential Equations, 2.MA303 Partial Differential Equations， 3.MA325 Numerical Solutions to Partial Differential Equations OR MAT8028 Scientific Computing

8. 教学目标 Course Objectives

（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）

教给学生时间独立和演化的微分方程的经典的和传统的数值方法。介绍它们的算法，分析，优缺点和相关软件。这会帮助学生在今后的科研工作中，运用他们学到的技能，设计自己的算法，解决非标准的微分方程问题。

To teach the students both classical and modern numerical methods for both time-independent and evolutionary differential equations. To introduce both numerical algorithms and analysis of their properties as well as the reasons behind success and failure of numerical methods and software. This will help the students to apply the studied numerical techniques and to successfully design their own solution approach for any nonstandard problems they may encounter in their research work.

9. 教学方法 Teaching Methods

（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）

理论与编程并重，并辅以前沿课题应用

Teaching in both theory and programming, including applications to cutting edge problems

10. 教学内容 Course Contents

（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）

Section 1	Part I. Numerical Methods for Time-Independent Differential Equations Some Model Problems
Section 2	Finite-Difference Approximations
Section 3	Steady States and Boundary Value Problems - simple finite-difference methods - local truncation error, global error - stability, consistence, convergence - high-order methods - compact finite-difference schemes - fast Poisson solver
Section 4	**Part II. Numerical Methods for Evolutionary Differential Equations** Numerical Methods for ODEs - initial value problems - linear multistep methods - Runge-Kutta methods - stability and stiffness - local truncation error, global error - stability, consistence and convergence - adaptive error control
Section 5	Finite-Difference Methods - local truncation error and order of accuracy - semi-discretization (method of lines): boundary conditions, stability and convergence - fully-discrete schemes: general linear stability and convergence - Lax equivalence theorem - CFL condition - Lax-Friedrichs scheme - Lax-Wendroff scheme - modified equation - explicit and implicit schemes

		- operator splitting methods
	Section 6	Stability for Constant Coefficient Problems - Fourier analysis for scalar equations and for systems - eigenvalue analysis
	Section 7	Variable Coefficient and Nonlinear Problems - freezing coefficients and dissipativity - schemes for one-dimensional hyperbolic systems - nonlinear stability and energy methods
	Section 8	Dispersion and Dissipation - dispersion relation, phase velocity, group velocity - the wave equation - the KdV equation - Lagrangian methods
	Section 9	Numerical Methods for Initial-Boundary Value Problems - parabolic problems - hyperbolic problems - infinite or large domains and artificial boundaries
	Section 10	Several Space Variables and Dimensional Splitting Methods - Alternating Direction Implicit scheme - Locally One-Dimensional (LOD) scheme
	Section 11	Finite-Volume Methods - finite-volume piecewise polynomial approximations - one-dimensional scalar conservation laws - first-order Godunov and Lax-Friedrichs schemes - total variation and nonlinear stability - higher-order schemes

		- systems of conservation laws - multidimensional problems - central and upwind methods
	Section 12	Collocation and spectral methods

11. **课程考核 Course Assessment**

作业（30%）+期中（30%）+期末考试（40%）

Assignment (30%) + Mid-term exam(30%) + final-term exam (40%)

12. **教材及其它参考资料 Textbook and Supplementary Readings**

参考教材 Textbook：

1. Finite Difference Methods for Ordinary and Partial Differential Equations: Steady-State and Time-Dependent Problems, by Randall J. LeVeque, SIAM, 2007.
2. Numerical Methods for Evolutionary Differential Equations, by Uri M. Ascher, SIAM Computational Science and Engineering, 2008
3. Numerical Solution of Partial Differential Equations: An Introduction, 2nd edition, by K. W. Morton, D. F. Mayers, 2005.
4. Finite-Volume Methods for Hyperbolic Problems, by Randall J. LeVeque, Cambridge Texts in Applied Mathematics, 2002.

其他参考资料 Supplementary Readings：

1. Finite Difference and Spectral Methods for Ordinary and Partial Differential Equations, by L. N. Trefethen, Cornell University, 1996.
2. Numerical Methods for Conservation Laws, by Randall J. LeVeque, Birkhauser-Verlag, 1990.