

课程大纲 COURSE SYLLABUS

1.	课程代码/名称 Course Code/Title	MAT5002 数值计算方法 Numerical Analysis
2.	课程性质 Compulsory/Elective	硕士生公选课/Compulsory for Master Students
3.	课程学分/学时 Course Credit/Hours	3/48
4.	授课语言 Teaching Language	中文/Chinese
5.	授课教师 Instructor(s)	何炳生/He Bingsheng Dept. Mathematics
6.	是否面向本科生开放 Open to undergraduates or not	否 no
7.	先修要求 Pre-requisites	微积分，线性代数/Calculus, Linear Algebra 对 Matlab 有一定了解。

8. 教学目标 Course Objectives

这门课是针对工程研究生和本科高年级学生开设的。简要介绍基本的数值计算方法：内容包括插值、数值积分、线性方程组求解、线性和非线性最小二乘、常微分方程求解方法，最后讲述与信息科学发展密切相关的线性约束凸优化问题的 **ADMM** 类分裂收缩算法。

This course is designed for the graduate students in engineering and the senior undergraduate students. The basic numerical methods will be briefly introduced. The contents include the interpolation, numerical integration, solution methods of system linear equations, the basic numerical methods for linear and nonlinear least squares, and numerical methods for ordinary differential equations. Finally, some ADMM-like methods of linear constrained convex optimization problems, which are closely related to the development of information science, are introduced.

9. 教学方法 Teaching Methods

课堂教学为主，同时要求学生完成计算实习。

Class teaching, students are required to complete the calculation practice.

10. 教学内容 Course Contents

Chapter 1	绪论/Introduction to Numerical Analysis
4 Hours	1. 计算方法研究对象：数值计算方法概念、特点和本课程的主要内容。 Object of numerical analysis: the concept and the characteristics of numerical methods and an overview of the main contents of this course.

	<p>2. 误差的基本概念：误差的来源，截断误差、舍入误差，绝对误差、相对误差和误差界。 Basic concept of error: source of error, truncation error, round off error, absolute error, relative error, error bound and so on.</p> <p>2. 数值算法设计应遵循的原则：简化计算步骤以节省计算量，减少有效数字的损失，选择数值稳定算法。 Principles for numerical algorithm: simplify the calculation process to save the amount of computation, reduce the loss of significant digits, select the stable numerical algorithm.</p>
<p>Chapter 2</p> <p>6 Hours</p>	<p>插值方法/Interpolation</p> <p>1. Lagrange 插值：线性插值与抛物插值，Lagrange 插值。 Lagrange interpolation: linear interpolation and parabolic interpolation, Lagrange interpolation.</p> <p>2. Newton 插值：Newton 插值公式，等距节点的 Newton 插值公式。 Newton interpolation: Newton interpolation formula, Newton interpolation formula with equidistant nodes.</p> <p>3. Hermite 插值：两点三次 Hermite 插值，非标准 Hermite 插值。 Hermite interpolation: the two-point cubic Hermite interpolation, non-standard Hermite interpolation.</p> <p>4. 分段低次插值：Runge 现象，分段线性插值，样条函数。 Piecewise interpolation: Runge phenomenon, piecewise linear interpolation, Spline functions.</p>
<p>Chapter 3</p> <p>6 Hours</p>	<p>数值微积分/Numerical Integration</p> <p>1. 插值型求积公式：梯型公式，Newton-Cotes 公式，Simpson 公式 Interpolation quadrature: Trapezoid rule, Newton-Cotes formula, Simpson formula.</p> <p>2. Gauss 求积公式, Romberg 算法 Gaussian Quadrature, Romberg Algorithm</p>
<p>Chapter 4</p> <p>6 Hours</p>	<p>求解线性方程组的直接方法/ Direct methods for solving System of Linear Equations</p> <p>1. 矩阵代数，向量和矩阵的范数与谱半径，条件数和病态方程 Matrix Algebra, Norm of Vector and Matrix, Spectral radius of matrix, Condition number and ill-conditioned equations.</p> <p>2. Gauss 消去法，LU 分解和 Cholesky 分解 Gaussian elimination, LU factorization and Cholesky factorization.</p> <p>3. 共轭梯度法 Conjugate Gradient Method.</p>
<p>Chapter 5</p> <p>6 Hours</p>	<p>求解线性方程组的迭代方法/Solving System of Linear Equations by Iterative Methods</p> <p>1. 迭代法的基本概念，Jacobi 方法和 Gauss-Seidel 方法。 Basic concepts of the iterative methods, Jacobian method and Gauss-Seidel method</p>

	<p>2. 迭代法的收敛性分析: 收敛性条件和收敛速度 Convergence analysis of the iterative method, conditions of convergence, convergence rate.</p> <p>3. SOR 方法的迭代公式和收敛条件 Iterative formula of the SOR method, Convergence conditions of the SOR method</p>
<p>Chapter 6</p> <p>6 Hours</p>	<p>线性和非线性最小二乘/Linear and Nonlinear Least Square</p> <p>1. 线性最小二乘, QR 分解, Householder 变换。 Linear least square problem, QR factorization, Householder transformation</p> <p>2. 非线性最小二乘, Gauss-Newton 方法 Nonlinear least square problem, Gauss-Newton method</p>
<p>Chapter 7</p> <p>6 Hours</p>	<p>常微分方程的数值解法/Numerical Solutions of ODEs</p> <p>1. 欧拉方法, 隐式欧拉方法, Runge-Kutta 方法 Euler method, Implicit Euler method, Runge-Kutta method</p> <p>2. 线性多步法的一般形式和构造方法。 The general form and the construction method of linear multi-step method.</p>
<p>Section 8</p> <p>6 Hours</p>	<p>凸优化的分裂收缩算法/Splitting contraction methods for convex optimization</p> <p>1. 线性约束凸优化问题的最优性条件, 邻近点算法。 Optimal conditions of the linearly constrained convex optimization, Proximal Point Algorithms</p> <p>2. 线性约束凸优化问题的增广 Lagrange 乘子法, 原始-对偶方法 Augmented Lagrange Method for linearly constrained convex optimization, Primal-Dual Method.</p> <p>3. 结构型凸优化的交替方向法 ADMM for the structured convex optimization</p>
Review	

11. 课程考核 Course Assessment

百分制 :

出勤率 (10%) + 作业 (书面和编程) (30%) + 期末考试 (60%)

Attendance (10%) + Assignment (written and programming) (30%) + final examination (60%)

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

- 1 D. Kincaid and W. Cheney, Numerical Analysis: Mathematics of Scientific Computing, Third Edition, 2003.
- 2 J. Nocedal and S. J. Wright, Numerical Optimization, 国外数学名著序列, 科学出版社, 2006
- 3 J. Stoer and R. Bulirsch, Introduction to numerical analysis, Texts in Applied Mathematics 12: Springer, New York 2002.
- 4 H.G 巴赫瓦洛夫等, 数值方法, 俄罗斯数学教材选译, 高等教育出版社, 2014.

- 5 李庆扬, 王能超, 易大义, 数值分析, 清华大学出版社, 2008.
- 6 林成森, 数值计算方法, 科学出版社.
- 7 孙志忠等, 计算方法与实习, 东南大学出版社, 2011.
- 8 王能超, 数值分析简明教程, 高等教育出版社, 2003.