南方科技大学 SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

课程详述

COURSE SPECIFICATION

以下课程信息可能根据实际授课需要或在课程检讨之后产生变动。如对课程有任何疑问，请联系授课教师。

The course information as follows may be subject to change, either during the session because of unforeseen circumstances, or following review of the course at the end of the session. Queries about the course should be directed to the course instructor.

1.	**课程名称 Course Title**	最优化理论与方法 Optimization Theory and Method
2.	**授课院系 Originating Department**	数学系 Department of Mathematics
3.	**课程编号 Course Code**	MA433
4.	**课程学分 Credit Value**	3
5.	**课程类别 Course Type**	专业选修课 Major Elective Courses
6.	**授课学期 Semester**	秋季 Fall
7.	**授课语言 Teaching Language**	英文 English
8.	**授课教师、所属学系、联系方式（如属团队授课，请列明其他授课教师） Instructor(s), Affiliation& Contact （For team teaching, please list all instructors）**	张进 数学系 慧园 3 栋 509 zhangj9@sustc.edu.cn 0755-88015915 Jin Zhang, Department of Mathematics, Block 3 Room 509, Wisdom Valley. zhangj9@sustc.edu.cn 0755-88015915
9.	**实验员/助教、所属学系、联系方式 Tutor/TA(s), Contact**	待公布 To be announced
10.	**选课人数限额(可不填) Maximum Enrolment （Optional）**	

11.		**讲授 Lectures**	**习题/辅导/讨论 Tutorials**	**实验/实习 Lab/Practical**	**其它(请具体注明) Other（Please specify）**	**总学时 Total**
	授课方式 Delivery Method					
	学时数 Credit Hours	48		N/A		48

12.	先修课程、其它学习要求 Pre-requisites or Other Academic Requirements	线性代数 II(MA104b)或者线性代数精讲（MA109），概率论(MA215)或概率论与数理统计(MA212) Linear Algebra (MA104b) or Advanced Linear Algebra (MA221), Probability theory (MA215) or probability theory and mathematical statistics (MA212)
13.	后续课程、其它学习规划 Courses for which this course is a pre-requisite	
14.	其它要求修读本课程的学系 Cross-listing Dept.	

教学大纲及教学日历 SYLLABUS

15. 教学目标 Course Objectives

本课程是对求解优化问题感兴趣的学生设置的。由于优化方法在科学，工程，经济学和工业中的应用越来越广泛，了解和掌握基本的优化算法成了科学技术从业者必要的知识和技能。课程介绍典型优化算法的优点与局限，让学生掌握不同问题的求解方法，探索研究方向，提高优化算法效率。本课程的目标是全面地介绍求解连续优化问题的先进有效的方法。

This course is for students interested in solving optimization problems. Because of the wide (and growing) use of optimization in science, engineering, economics, and industry, it is essential for students and practitioners alike to develop an understanding of optimization algorithms. Knowledge of the capabilities and limitations of these algorithms leads to a better understanding of their impact on various applications, and points the way to future research on improving and extending optimization algorithms and software. The goal of this course is to give a comprehensive description of the most powerful, state-of-the-art, techniques for solving continuous optimization problems.

16. 预达学习成果 Learning Outcomes

完成本课程后,学生应掌握数值优化中的基本概念和方法，熟悉各种优化方法和技巧，并能解决现实应用中的问题。特别是,在学习本课程后,学生应该能够

1.掌握基本知识,深入理解和掌握各种优化方法。学习后,学生应该能够不仅能够应用各种方法, 同时也能深刻理解各种方法的基本原理和区别。

2.提高解决实际问题的能力。学习本课程后,学生应该能够使用学到的知识对实际问题建立合理的优化模型，从而解决相关的实际应用问题。

After completing this course, students should master the basic concepts and methods in numerical optimization. After learning this course, the students should be familiar with a range of methods and techniques for solving optimization problems arising in practical applications. In particular, after learning this course, the students should be able

1. to master the basic knowledge, deeply to understand and master the nature of the definitions, theorems, probability laws, principles and formulae. After the study, the students should be able not only to remember the above concepts and the basic methods in optimization;
2. to improve the ability of solving practical problems. After learning this course, students should be able to use the learned knowledge to establish a suitable optimization model and to solve the life related practical problems.

17. 课程内容及教学日历 （如授课语言以英文为主，则课程内容介绍可以用英文；如团队教学或模块教学，教学日历须注明主讲人）

Course Contents (in Parts/Chapters/Sections/Weeks. Please notify name of instructor for course section(s), if this is a team teaching or module course.)

第一章：导论（2 学时）

非光滑函数的极小化、图像处理和数据科学送的应用、鞍点公式（2 学时）

Section 1：Introduction (2 Hours)

Minima of non-smooth functions, Applications in image processing, Applications in the data sciences, Saddle-point formulations (2 hours).

第 2 章：凸分析-次微分（6 学时）

2.1、凸性和（凸）函数的性质（2 学时）

2.2、次微分和极小化特征（2 学时）

2.3、强凸性和光滑性、凸共轭和对偶性（2 学时）

Section 2: Convex analysis-subdifferentials (6 Hours)

2.1 Convexity and properties of (convex) functions (2 hours)

2.2 Subdifferentials and characterization of minima (2 hour)

2.3 Strong convexity and smoothness, Convex conjugates and duality (2 hours)

第 3 章：无约束优化方法（10 学时）

3.1、Surrogate 目标和梯度下降、不动点理论（2 学时）

3.2、牛顿型法和拟牛顿法（2 学时）

3.3、变分 inclusions（2 学时）

3.4、临近点算法和向前-向后分裂算法（2 学时）

3.5、Douglas-Rachford 分裂法和 Chambolle–Pock 算法(2 学时)

Section 3：Unconstrained optimization methods (10 Hours)

3.1 Surrogate objectives and gradient descent, fixed point theorems (2 hours)

3.2 Variational inclusions (2 hours)

3.3 The proximal point method and forward backward splitting (2 hours)

3.4 Douglas-Crawford splitting and Chambolle–Pock method (2 hours)

3.5 Basic properties of set-valued maps (1 hours), the Aubin property (1 hours)

第四章：集值映射和灵敏度分析（6 学时）

4.1、Tilt 稳定性和度量正则性（2 学时）

4.2、图导数（2 学时）

4.3、度量次正则性、平稳性条件（2 学时）

Section 4：Set-valued maps and sensitivity analysis (6 hours)

4.1 Tilt stability and metric regularity (2 hours)

4.2 Graphical derivatives (2 hours)

4.3 Metric sub-regularity, calmness (2 hours)

第五章：非凸优化方法（18 学时）

5.1、Kurdyka-Lojasiewicz 条件（2 学时）

5.2、非凸优化问题的向前-向后分裂算法和临近梯度方法（2 学时）

5.3、非凸优化问题的临近交替线性化最小化方法（2 学时）

5.4、约束优化问题的必要性条件（2 学时）

5.5、约束优化问题的充分性条件（2 学时）

5.6、罚函数法(2 学时)

5.7、增广拉格朗日乘子法（6 学时）

Section 5：Nonconvex optimization methods (18 Hours)

5.1 Kurdyka-Lojasiewicz (KL) condition (2 hours)

5.2 Forward-backward splitting and proximal gradient method for non-convex optimization (2 hours)

5.3 Proximal alternating linearized minimization method for non-convex optimization (2hour)

5.4 Necessary optimality conditions of constrained optimization (2 hours)

5.5 Sufficient optimality conditions of constrained optimization (2 hours)

5.6 Penalty function method (2 hours)

5.7 Augmented Lagrange multiplier method (6 hours)

第六章：随机与鲁棒优化 （6 学时）

6.1、随机与鲁棒优化介绍（2 学时）

6.2、随机梯度方法、随机方差下降方法、随机块坐标下降方法（4 学时）

Section 6：Stochastic and robust optimization (6 hours)

6.1 Introduction to stochastic and robust optimization (2 hours)

6.2. Stochastic gradient methods、stochastic variance reduction methods、random block coordinate descent methods(4 hours)

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

Supplementary Readings:

1、R. Fletcher, Practical Methods of Optimization, John Wiley & Sons, New York, 1987.

2、J. Nocedal and Stephen J. Wright, Numerical Optimization, Springer, 1999

3、 Mordukhovich and Nam, An easy path to convex analysis and applications 2015

4、R. T. Rockafellar and R. J-B Wets, Variational Analysis, Springer, 2013

课程评估 ASSESSMENT

19.

评估形式 Type of Assessment	评估时间 Time	占考试总成绩百分比 % of final score	违纪处罚 Penalty	备注 Notes
出勤 Attendance				
课堂表现 Class Performance				
小测验 Quiz				
课程项目 Projects				
平时作业 Assignments		30%		
期中考试 Mid-Term Test		20%		
期末考试 Final Exam		50%		
期末报告 Final Presentation				
其它（可根据需要改写以上评估方式） Others (The above may be modified as necessary)				

20. **记分方式 GRADING SYSTEM**

☑ A. 十三级等级制 **Letter Grading**
☐ B. 二级记分制（通过/不通过） **Pass/Fail Grading**

课程审批 REVIEW AND APPROVAL

21. **本课程设置已经过以下责任人/委员会审议通过**
This Course has been approved by the following person or committee of authority