课程大纲
COURSE SYLLABUS

<table>
<tr><td>1.</td><td>课程代码/名称
Course Code/Title</td><td colspan="2">MAT7083 凸优化算法 Algorithms for convex optimization</td></tr>
<tr><td>2.</td><td>课程性质
Compulsory/Elective</td><td>专业选修课</td><td>Major Elective Courses</td></tr>
<tr><td>3.</td><td>课程学分/学时
Course Credit/Hours</td><td>3 学分/48 学时</td><td>3 credits/44 hours</td></tr>
<tr><td>4.</td><td>授课语言
Teaching Language</td><td>英文</td><td>English</td></tr>
<tr><td>5.</td><td>授课教师
Instructor(s)</td><td>张进　数学系
0755-88015915</td><td>Jin Zhang, Department of Mathematics
0755-88015915</td></tr>
<tr><td>6.</td><td>是否面向本科生开放
Open to undergraduates or not</td><td colspan="2">是　　　Yes</td></tr>
<tr><td>7.</td><td>先修要求
Pre-requisites</td><td colspan="2">（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.）
高等数学下（MA102b）（或数学分析 II（MA102a）），
线性代数 II（MA104b），概率论（或概率论与数理统计）
运筹学（MA210）

Calculus (MA102b) (or Mathematical Analysis II (MA102a)),
Linear Algebra (MA104b),
Probability theory (or probability theory and mathematical statistics)
Operations Research (MA210)</td></tr>
<tr><td>8.</td><td colspan="3">教学目标
Course Objectives</td></tr>
<tr><td colspan="4">（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.）

本课程是对求解非光滑凸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。课程介绍凸函数，次微分，共轭，Proximal 等基本概念以及典型优化算法的收敛性分析。本课程的目标是全面地介绍求解非光滑优化问题的先进有效的方法。

This course is for students interested in solving nonsmooth convex 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. This course introduces the basic concepts of convex function, subdifferential, conjugate, proximal operator and the analysis of convergence of typical optimization algorithms. The goal of this course is to give a comprehensive description of the most powerful, state-of-the-art, techniques for solving nonsmooth optimization problems.</td></tr>
<tr><td>9.</td><td colspan="3">教学方法
Teaching Methods</td></tr>
<tr><td colspan="4">（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.）

讲授与习题　Lectures，tutorials</td></tr>
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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 导论 Introduction	非光滑函数的极小化、图像处理和数据科学中的应用、鞍点公式 Minima of non-smooth functions, Applications in image processing, Applications in the data sciences, Saddle-point formulations
	Section 2 凸分析-次微分 Convex analysis -subdifferentials	凸性和（凸）函数的性质、次微分的定义以及简单例子、次微分集的性质、方向导数、次微分计算、最优性条件 Convexity and properties of (convex) functions, Subdifferentials and examples, Properties of the subdifferential set, Directional derivatives, Computing Subgradients, Optimality conditions
	Section 3 共轭函数 Conjugate functions	共轭函数与双共轭函数、共轭算子的运算法则和例子、卷积下确界、共轭函数的次微分 Conjugate functions and the biconjugate, Conjugate calculus rules and examples, Infimal convolution and subdifferentials of conjugate functions
	Section 4 光滑性与强凸性 Smoothness and strong convexity	Lipschitz 光滑性、强凸性、光滑性与强凸性的联系 smooth functions, Strongly convexity, Smoothness and strong convexity correspondence
	Section 5 近端算子 The proximal operator	近端算子的存在性与唯一性、近端算子的例子、近端算子的运算法则、指示函数的近端算子、投影、Prox 第二定理、Moreau 包络 Existence, uniqueness and examples of the proximal operator, Prox calculus rules, Prox of indicators—orthogonal projections, The second prox theorem, The Mreau envelope, Prox of indicators—orthogonal projections, The second prox theorem, the Mreau envelope
	Section 6 近端梯度算法和块近端梯度算法 The proximal gradient method and the block proximal gradient method	近端梯度算法简介、不同设定下的近端梯度算法的收敛性分析、循环块近端梯度算法、随机块近端梯度算法 The proximal gradient method, Convergence analysis of the proximal gradient method, The cyclic block proximal gradient method, The randomized block proximal gradient method
	Section 7 交替方向乘子算法 ADMM	交替方向乘子算法 ADMM
11.	课程考核 **Course Assessment**	
	（①考核形式 Form of examination；②.分数构成 grading policy；③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.）	

	小测验、平时作业（30%），期中考试（20%），期末考试（50%） Quiz, Assignments (30%), Mid-Term Test (20%), Final Exam (50%)
12.	**教材及其它参考资料** **Textbook and Supplementary Readings**
	Textbooks 1、 A Beck, First-Order Methods in Optimization, SIAM, 2017 Supplementary Readings: 1、J. Nocedal and Stephen J. Wright, Numerical Optimization, Springer, 1999 2、B Mordukhovich and Nam, An easy path to convex analysis and applications 2015