

## 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.	<b>课程名称 Course Title</b>	应用数学选讲：凸优化的一阶分裂算法 Topics on Applied Mathematics First order splitting methods for convex optimization
2.	<b>授课院系 Originating Department</b>	数学系 Department of Mathematics
3.	<b>课程编号 Course Code</b>	MA406
4.	<b>课程学分 Credit Value</b>	3
5.	<b>课程类别 Course Type</b>	专业选修课 Major Elective Courses
6.	<b>授课学期 Semester</b>	夏季 Summer
7.	<b>授课语言 Teaching Language</b>	英文 English /中文 Chinese
8.	<b>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 &amp; Contact (For team teaching, please list all instructors)</b>	何炳生 数学系 慧园 3 栋 526 <a href="mailto:hebs@sustc.edu.cn">hebs@sustc.edu.cn</a> 0755-88018721 Bingsheng He, Department of Mathematics, Block 3 Room 526, Wisdom Valley <a href="mailto:hebs@sustc.edu.cn">hebs@sustc.edu.cn</a> 0755-88018721
9.	<b>实验员/助教、所属学系、联系方式 Tutor/TA(s), Contact</b>	
10.	<b>选课人数限额(可不填) Maximum Enrolment</b>	

(Optional)					
11. 授课方式 Delivery Method	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
学时数 Credit Hours	48				48
12. 先修课程、其它学习要求 Pre-requisites or Other Academic Requirements	数学分析 III (MA103a) 或数学分析精讲 (MA213) Mathematical Analysis III (MA103a) (or Real Analysis (MA213))				
13. 后续课程、其它学习规划 Courses for which this course is a pre-requisite	无/None				
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

数据科学所产生的许多问题的数学形式是一个大规模的凸优化。本课程以一个统一框架介绍凸优化的一阶分裂收缩算法。框架的特点是简单，需要的知识基础是大学高等数学和线性代数。本课程预期通过学习，使学生能够了解和掌握压缩感知、机器学习、图像和视频处理等应用领域的一些基本算法。课程学习也对构造优化算法提供有益的启示。

The mathematical form of many problems arising from Data Science can be posed in large scale convex optimization. This course will introduce a class of splitting and contraction methods for convex optimization under a uniform framework, which is relative simple because the only background required of the students is a good knowledge of advanced calculus and linear algebra. We expect that through the study, students should be able to understand and grasp some basic algorithms in the applications, such as compressed sensing, machine learning, image and video processing. The study also provides beneficial enlightenment for constructing optimization algorithms.

#### 16. 预达学习成果 Learning Outcomes

通过学习，学生能够了解和掌握压缩感知、机器学习、图像和视频处理等应用领域的一些基本算法。课程学习也对构造优化算法提供有益的启示。

Through the study, students will be able to understand and grasp some basic algorithms in the applications, such as compressed sensing, machine learning, image and video processing. The study also provides beneficial enlightenment for constructing optimization algorithms.

#### 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.)**

预备知识： 引言 微积分和线性代数基础（8 学时）

1. 凸集和凸函数
2. 优化问题的最优性条件

Part I: 单调变分不等式的应用与求解方法（10 学时）

1. 用变分不等式描述管理和优化领域的问题
2. 投影基本不等式和变分不等式的投影收缩算法
3. 单调变分不等式收缩算法的统一框架

Part II: 线性约束凸优化问题的求解方法及应用（10 学时）

1. 邻近点算法概论
2. 为线性约束凸优化问题定制的邻近点算法及其应用
3. 线性约束凸优化问题基于松弛邻近点算法的收缩算法

Part III : 结构型凸优化问题的交替方向法及应用（10 学时）

1. 结构型优化的交替方向收缩算法及其线性化方法
2. 邻近点算法（PPA）意义下的交替方向法及其线性化方法
3. 交替方向法类方法的统一框架和收敛速率
4. 统一框架下对称型乘子交替方向法

Part IV:多个可分离算子凸优化问题带简单校正的分裂方法及应用（10 学时）

1. 三个可分离算子凸优化问题的带 Gauss 回代的 ADMM 类算法
2. 三个可分离算子凸优化问题的部分平行的 ADMM 类算法
3. 线性化的三个可分离算子凸优化的 ADMM 类算法

Preliminaries: Introduction, Required background knowledge of advanced calculus and linear algebra (8 Credit Hours)

1. Convex set and convex function
2. Optimal conditions of minimization problems

Part I: Monotone variational inequalities—Applications and solution methods

(10 Credit Hours)

1. Problems of management and optimization in form of variational inequalities
2. Basic projection inequalities and the projection and contraction methods for variational inequalities
3. A uniform framework of the contraction methods for monotone variational inequalities

Part II: Methods for linearly constrained optimization and their applications (10 Credit Hours)

1. Summary of proximal point algorithm (PPA)
2. Customized PPA for linearly constrained convex optimization and its applications
3. Relaxed PPA-based contraction methods for linearly constrained convex optimization

Part III : Alternating direction methods of multipliers (ADMM) for separable convex programming and their applications (10 Credit Hours)

1. Alternating direction method of multipliers (ADMM) and linearized ADMM for separable convex programming
2. Alternating direction method of multipliers in sense of PPA and its linearized version
3. A uniform framework and the ADMM-like methods and the study of convergence rate
4. Symmetric version of ADMM under the unified framework

Part IV: Splitting methods with simple correction for convex optimization with several separable operators and their applications (10 Credit Hours)

1. ADMM-like method with Gaussian-back substitution for convex optimization with three separable operators
2. Partially parallel ADMM-like methods for convex optimization with three separable operators
3. Linearized version of ADMM-like methods for convex optimization with three separable operators

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

何炳生主页中《凸优化和单调变分不等式的收缩算法——统一框架与应用》。



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 <b>Assignments</b>		10%		
期中考试 <b>Mid-Term Test</b>				
期末考试 <b>Final Exam</b>	2 小时 2 hours	30%		
期末报告 <b>Final Presentation</b>		40%		
其它（可根据需要 改写以上评估方 式） <b>Others (The above may be modified as necessary)</b>		编写程序：20%		

20. 记分方式 **GRADING SYSTEM**

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**

