《凸优化及其在信息科学中的应用》教学大纲

一、课程基本信息

课程名称:	凸优化及其在信息科学中的应用	英文名称:	Convex Optimization and Its Applications in Information Science
课程类型：	本科	学分/学时:	3/48
主要面向专业：	IE, EE, CS	授课语言：	中文
先修课程：	数学分析，线性代数		
开课单位:	信息学院	课程代码:	SI151A

注：课程类型填写“本科”、“研究生”或“本研一体”

二、课程简介

该本科生课程旨在教授学生识别信息科学应用中各种凸优化问题的能力及工具，强调凸优化问题的建模及求解软件的开发及应用。课程内容主要包括凸优化问题的定义及模型，凸优化的模型语言及软件、求解算法及软件，及其在无线网络，信号处理，机器学习及机器人自动化中的应用。以上凸优化优化模型、算法、软件等知识可为信息学院全院学生在通信、电子、计算机等学科提供重要的优化建模、算法实践经验。

三、课程教学目标

本课程是信息学院本科生重要选修课程，将着重培养学生的知识认知能力和综合素质能力。在知识认知能力培养方面：通过本课程的学习，学生将会掌握如何将信息科学应用中的优化问题建模成或者近似成凸优化问题的能力，并且能通过高级数值及建模软件进行自动化求解。在综合素质能力培养方面：通过凸优化建模及算法基础和软件实践的学习，学生将具有解决通信网络、信号处理、机器学习，电路设计，自动化及机器人等领域的优化建模及软件求解的能力，对保证国家工业生产，提高经济效益具有重要的实际作用；同时本课程通过课程教学和项目设计的形式鼓励学生进行团队项目协作，有利于培养学生的合作精神和人际沟通能力，为学生将来走向社会奠定基础。

四、课程教学方法

本课程采用课堂讲授与讨论，案例教学和实践教学相结合的方法。

在课堂讲授与讨论方面：1）教给学生识别信息科学中凸优化问题模型的能力及工具；2）讲解将凸优化问题转换成锥优化问题形式的基本规则及软件；3）讲解锥优化问题的求解算法及软件实现；4）通过相关应用背景介绍及课堂演示让学生更加深入灵活掌握凸优化在信息科学中的应用。

在案例教学方面：通过通信网络、信号处理、机器学习和机器人等领域中的凸优化问题的建模及算法软件编程实践的实例讲解，使学生在掌握课程基本理论和方法的同时，理解课程知识在信息科学中的应用，激发学生的研究兴趣及提高工程实践能力。

在实践教学方面：采用项目作业的方式加强学生对相关领域凸优化建模及算法软件应用能力。项目作业根据项目难度持续二到四周，激发学生采用课程中介绍的前沿先进技术及软件解决相关信息科学前沿应用问题，同时推荐课后阅读清单，鼓励学生课后延展学习，深度了解凸优化最近前沿进展。

五、课程教学内容与安排

（可按**教学周**或**章节名称**两种方式进行课程教学内容安排，列出主要知识点和教学方法。）

以教学周方式安排教学内容

教学周	**章节名称**	**主要教学内容（主要知识点）**	**学时安排**	**教学方法（仅列名称）**
第 1 周	第 1 章：凸优化定义	凸集定义、性质、及典型例子	4	课堂讲授，讨论
第 2 周	第 1 章：凸优化定义	凸函数定义、性质、及典型例子	4	课堂讲授，讨论
第 3 周	第 2 章：凸优化模型	线性规划，二次锥规划	4	课堂讲授，讨论

第 4 周	第 2 章：凸优化模型	半定规划，几何规划	4	课堂讲授，讨论
第 5 周	第 3 章：凸优化建模语言及软件	模型语言及规则	4	课堂讲授，讨论
第 6 周	第 3 章：凸优化建模语言及软件	模型软件：CVX, CVXPY, Convex.jl	4	课堂讲授，演示
第 7 周	第 4 章：锥优化及求解器软件	同构自对偶最优性条件	4	课堂讲授，讨论
第 8 周	第 4 章：锥优化及求解器软件	锥优化求解器软件：MOSEK, SDPT3, SCS	4	课堂讲授，演示
第 9 周	第 5 章：无线网络应用	功率控制，波束赋形	4	课堂讲授，演示
第 10 周	第 6 章：信号处理应用	稀疏信号恢复，相位恢复，低秩矩阵恢复	4	课堂讲授，演示
第 11 周	第 7 章：机器学习应用	线性回归，支持向量机	4	课堂讲授，演示
第 12 周	第 8 章：自动化及机器人应用	同时定位与地图构建,无人机轨迹优化	4	课堂讲授，演示

六、考核方式和成绩评定方法

（成绩评定方法需符合《上海科技大学课程考核及成绩管理办法（试行）》文件要求。）

考核方式以及成绩评定细节如下：

（1）平时作业占 20%

（2）期末考试占 50%

（3）课程项目占 30%

七、教材和参考书目

（提示：需符合《上海科技大学教材选用管理办法》文件要求）

（一）推荐教材

《凸优化》，Boyd and L. Vandenberghe 著，王书宁 许鋆，黄晓霖 译，清华大学出版社，2013

Convex Optimization, by S. Boyd and L. Vandenberghe, Cambridge University Press, 2004.

（二）参考书目

《最优化：建模、算法与理论》，刘浩洋, 户将, 李勇锋，文再文著, 高教出版社，2020.

八、学术诚信教育

本课程高度重视学术诚信，严禁抄袭、作弊等行为。

“在学习、科研、实习实践等活动中，学生应恪守学术道德，坚守学术诚信，保护知识产权，坚持勇于创新、求真务实的科学精神，努力培养自己严谨求实、诚实自律、真诚协作的科学态度，成为良好学术风气的维护者、严谨治学的力行者、优良学术道德的传承者。”

（具体请参见《上海科技大学学生学术诚信规范与管理办法（试行）》文件要求）

九、其他说明（可选）

Convex Optimization and Its Applications in Information Science

Syllabus

1. Basic Course Information

Course Name:	Convex Optimization and Its Applications in Information Science		
Course Level:	undergraduate	Credit/Contact Hour:	3/48
Major	IE, EE, CS	Teaching Language:	Chinese
Prerequisite:	Mathematical Analysis, Linear Algebra		
School/Institute:	School of Information Science and Technology	Course Code:	SI151A

Notes: Course level includes undergraduate, graduate, or undergraduate/graduate.

2. Course Introduction

This undergraduate course aims to give students the tools and training to recognize different optimization problems that arise in information science applications, followed the convex optimization modeling and solving software, with emphasizing the applications in information science. Topics include the definitions and models of convex optimization, software of convex modeling system and conic program solver, and applications in information science including wireless networking, signal processing, machine learning and robotics.

3. Learning Goal

After learning this course, students will acquire the ability to model or approximate the real-world information science applications into convex optimization problems and to solve them using high-level numerical and modeling software. Besides, students should have the ability to solve optimization problems in the fields of wireless networking, signal processing, machine learning, and robotics. The

students' capability on convex optimization models, algorithms, software, and applications shall ensure the national industry production and improve economic efficiency. At the same time, this course encourages students to collaborate in projects, which is conducive to cultivating students' cooperative spirit and interpersonal communication skills, constructing the foundation for students to enter the society in the future.

4. Textbook & Recommended Reading

(1) Textbook

《凸优化》，Boyd and L. Vandenberghe 著，王书宁 许鋆，黄晓霖 译，清华大学出版社，2013

Convex Optimization, by S. Boyd and L. Vandenberghe, Cambridge University Press, 2004.

(2) Recommended Reading

《最优化：建模、算法与理论》，刘浩洋, 户将, 李勇锋，文再文著, 高教出版社，2020.

5.Grading Policy

Homework	20%
Final Exam	50%
Final Project	30%

6. Instructional Pedagogy

This course adopts a combination of methods for teaching, including classroom teaching and discussions, case teaching and practical teaching.

In terms of classroom teaching and discussions: 1) give students the tools and training to recognize convex optimization problems that arise in information science application; 2) present the basic rules and modelling software to transfer such problems into a standard conic form; 3) give students a thorough understanding of how such problems are solved, and some experience and algorithm software in solving them; 4) give students the background and demo required to use the methods in their own engineering applications.

In terms of case teaching: this course uses examples of convex optimization from wireless networking, signal processing, machine learning, and robotics, so that students can understand the course knowledge while mastering the basic theories, methods and software of the course. The real-world applications can stimulate students' research interest.

In terms of practical teaching: project assignments are used to strengthen students' understanding of the applications of convex optimization algorithms in related fields. A reading list after class is also recommended, encouraging students to extend their learning after class, and to have a deep understanding of the latest frontier developments.

7. Course Structure

(You might choose one of the two course structures listed below. Please list practical training if any.)

Course Structure by Week

Week	Chapter	Teaching Contents	Contact Hours	Teaching Modes
Week 1	Chapter 1: Convex Optimization Definitions	Convex set definitions, properties, examples	4	Lecture, Discussion
Week 2	Chapter 1: Convex Optimization Definitions	Convex function definitions, properties, examples	4	Lecture, Discussion
Week 3	Chapter 2: Convex Optimization Models	Linear programming, second-order cone programming	4	Lecture, Discussion

Week 4	Chapter 2: Convex Optimization Models	Semi-definite programming, geometric programming	4	Lecture, Discussion
Week 5	Chapter 3: Disciplined Convex Program and Modeling Software	Modeling Language, Disciplined Convex Programming	4	Lecture, Discussion
Week 6	Chapter 3: Disciplined Convex Program and Modeling Software	Modeling Software: CVX, CVXPY, Convex.jl	4	Lecture, Demo
Week 7	Chapter 4: Conic Program and Solver Software	Homogeneous self-dual embedding	4	Lecture, Discussion
Week 8	Chapter 4: Conic Program and Solver Software	Conic Solver: MOSEK, SDPT3, SCS	4	Lecture, Demo
Week 9	Chapter 5: Applications in Wireless Networking	Power control, beamforming	4	Lecture, Demo

Week 10	Chapter 6: Applications in Signal Processing	Sparse signal recovery, phase retrieval, low-rank matrix completion	4	Lecture, Demo
Week 11	Chapter 7: Applications in Machine Learning	Linear regression, support vector machine	4	Lecture, Demo
Week 12	Chapter 8: Applications in Automation and Robotics	Simultaneous localization and mapping (SLAM), unmanned aerial vehicle (UAV)	4	Lecture, Demo

8. Academic Integrity

This course highly values academic integrity. Behaviors such as plagiarism and cheating are strictly prohibited. Please list more if you have more specific requirements.

9. Other Information (Optional)