

EE 367000 Introduction to Convex Optimization
(凸最佳化導論)
Spring 2022

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<http://www.ee.nthu.edu.tw/cychi/>

Units: 3

Lecture hours: T3, T4, W2

Classroom: Delta 210

Course web page:

ee.nthu.edu.tw/cychi/teaching/Introduction-to-Mathematics-for-Communications-Convex.php

Office hours: 10:00-12:00 (Thursday)

This course aims to introduce *convex analysis and optimization*. Over the last two decades, the powerful convex optimization theory and tools have been extensively used for solving wide range of cutting edge optimization problems in sciences and engineering, such as (a) multiple-input multiple-output (MIMO) wireless communications and networking for 5G-beyond and 6G, (b) blind source separation (BSS) for biomedical and hyperspectral image analysis, and (c) machine learning (ML). In particular, many ML methods (e.g., Lasso, and Support Vector Machines) are based on the identification of some parameters by minimizing an objective function, defined by the sum of a loss function and some regularization terms (e.g., linear regression, and L1-norm regularization). The resulting optimization problem can be optimally solved through reformulation into a convex problem in many instances, thus *naturally forming a strong link and mutual need between ML and convex optimization in real-world applications*. This course is to equip you with an essential mathematical foundation and off-the-shelf convex solver (CVX and SeDuMi) to efficiently learn advanced “*Convex Optimization*” for the research in your post-graduate study, and for professionals who need to handling various optimization problems.

Background & Prerequisite: A good background in linear algebra and calculus is desirable.

Outline:

1. Review on Basics of Calculus, Linear Algebra, Set Theory and Geometry/Topology
2. Convex Sets
3. Convex Functions
4. Convex Optimization Problems
5. Duality (introductory level)
6. Case studies of Convex Optimization in Engineering and Science

Textbooks:

- Chong-Yung Chi, Wei-Chiang Li, and Chia-Hsiang Lin, Convex Optimization for Signal Processing and Communications: From Fundamentals to Applications, CRC Press, Boca Raton, FL, 2017.
<http://st-ebook.com.tw/bookcomment-2.aspx?BOKNO=TKCP00033> (科大文化圖書公司)

† The material of the textbook systematically introduces how to efficiently and effectively solve an optimization problem, from the fundamental theory, problem definition, reformulation into a convex

problem, analysis, algorithm implementation, to cutting edge research in signal processing and communications (like an exploration journey rather than pure mathematics). It has been used for my 2-week (32 lecture hours) or 3-week (48 lecture hours) invited short course entitled “Convex Optimization for Signal Processing and Communications” at 10 top ranked universities in Mainland China over the last decade, including Shandong University, Tsinghua University, Tianjin University, Tianjin Beijing Jiaotong University (BJTU), University of Electronic Science and Technology of China, Chengdu (UESTC), Xiamen University, Sun-Yet-Sen University (SYSU), and Beijing University of Posts and Telecommunications, Beijing (BUPT), Shandong Normal University, Jinan, and Xidian University.

References:

- S. Boyd and L. Vandenberghe, Convex Optimization. Cambridge: Cambridge University Press, 2004. Free electronic version is available at: <http://www.stanford.edu/~boyd/cvxbook/>.
- R. A. Horn and C. R. Johnson, Matrix Analysis, 2nd ed. Cambridge: Cambridge University Press, 2012.
- C. H. Edwards, Advanced Calculus of Several Variables, Academic Press, 1973.
- Giuseppe Calafiore and Laurent El Ghaoui, Optimization Models, University Press, Cambridge, 2014.
- D. P. Bertsekas, Convex Analysis and Optimization, Athena Scientific, 2003.

Grading:

Homework: 20%

Midterm Exam: 40%

Final Exam: 40%

Teaching assistant: **Chien-Wei Huang** (黃健璋), e-mail: s110064501@gmail.com

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Office hours: Wednesday: 15:00 - 17:00 and Friday: 15:00 - 17:00

Teaching assistant: **Keivan Faghieh Niresi** (克文費利),

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Office hours: Tuesday: 16:30 - 18:30 and Thursday: 17:00 - 19:00.

Remarks:

1. The lecture language is Chinese (English if there are international students).
2. Nonlinear adjustment will be made as needed for the final term grade.
3. Course website:
ee.nthu.edu.tw/cychi/teaching/Introduction-to-Mathematics-for-Communications-Convex.php
4. No make-up for examinations under any circumstances.