**City University of Hong Kong**
**Course Syllabus**

**offered by School of Data Science**
**with effect from Semester A 2024/25**

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## Part I Course Overview

| | |
|---|---|
| **Course Title:** | Optimization for Data Science |
| **Course Code**: | SDSC6011 |
| **Course Duration:** | One Semester |
| **Credit Units**: | 3 |
| **Level**: | P6 |
| **Medium of Instruction:** | English |
| **Medium of Assessment:** | English |
| **Prerequisites**: *(Course Code and Title)* | Nil |
| **Precursors**: *(Course Code and Title)* | Nil |
| **Equivalent Courses**: *(Course Code and Title)* | Nil |
| **Exclusive Courses**: *(Course Code and Title)* | Nil |

## Part II Course Details

### 1. Abstract

This course offers an introduction to optimization methods with applications in data science. A basic understanding of Calculus and Linear Algebra are assumed. We will introduce the theoretical foundation and the fundamental algorithms for optimization and advanced optimization methods for practical problems arising in data science and machine learning applications. Course content includes convex analysis, Lagrangian duality theory, linear and nonlinear programming, conic programming, etc.

### 2. Course Intended Learning Outcomes (CILOs)

*(CILOs state what the student is expected to be able to do at the end of the course according to a given standard of performance.)*

| No. | CILOs | Weighting (if applicable) | Discovery-enriched curriculum related learning outcomes (please tick where appropriate) | | |
|---|---|---|---|---|---|
| | | | *A1* | *A2* | *A3* |
| 1. | Explain methodologies and the underlying mathematical structures in optimization | 20% | ✓ | ✓ | |
| 2. | Apply basic concepts of mathematics to formulate an optimization problem | 25% | ✓ | ✓ | |
| 3. | Derive optimal solutions for optimization models | 25% | ✓ | ✓ | |
| 4. | Apply commonly used optimization algorithms | 20% | ✓ | ✓ | |
| 5. | Implement optimization programs to solve practical problems | 10% | ✓ | ✓ | ✓ |
| | | 100% | | | |

*A1: Attitude*
*Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.*

*A2: Ability*
*Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to self-life problems.*

A3: *Accomplishments*
*Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.*

## 3. Learning and Teaching Activities (LTAs)

*(LTAs designed to facilitate students' achievement of the CILOs.)*

| LTA | Brief Description | CILO No. | | | | | | Hours/week (if applicable) |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | |
| Lecture | Students will gain knowledge points of optimization methods covered in this course | ✓ | ✓ | ✓ | ✓ | | | 39 hours/semester |

## 4. Assessment Tasks/Activities (ATs)

*(ATs are designed to assess how well the students achieve the CILOs.)*

| Assessment Tasks/Activities | CILO No. | | | | | | Weighting | Remarks |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | | |
| Continuous Assessment: 60 % | | | | | | | | |
| Test | | ✓ | ✓ | ✓ | ✓ | | 40% | |
| Assignments | ✓ | ✓ | ✓ | ✓ | | | 20% | |
| Examination: 40 % (duration: 2 hours , if applicable) | | | | | | | | |
| Examination | ✓ | ✓ | ✓ | ✓ | ✓ | | 40% | |
| | | | | | | | 100% | |

**5. Assessment Rubrics**

*(Grading of student achievements is based on student performance in assessment tasks/activities with the following rubrics.)*

**Applicable to students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter**

| Assessment Task | Criterion | Excellent (A+, A, A-) | Good (B+, B, B-) | Fair (C+, C, C-) | Marginal (D) | Failure (F) |
|---|---|---|---|---|---|---|
| 1. Test | 40% | High | Significant | Moderate | Basic | Not even reaching marginal levels |
| 2. Assignments | 20% | High | Significant | Moderate | Basic | Not even reaching marginal levels |
| 3. Examination | 40% | High | Significant | Moderate | Basic | Not even reaching marginal levels |

**Applicable to students admitted from Semester A 2022/23 to Summer Term 2024**

| Assessment Task | Criterion | Excellent (A+, A, A-) | Good (B+, B) | Marginal (B-, C+, C) | Failure (F) |
|---|---|---|---|---|---|
| 1. Test | 40% | High | Significant | Moderate/basic | Not even reaching marginal levels |
| 2. Assignments | 20% | High | Significant | Moderate/basic | Not even reaching marginal levels |
| 3. Examination | 40% | High | Significant | Moderate/basic | Not even reaching marginal levels |

**Part III Other Information** (more details can be provided separately in the teaching plan)

**1. Keyword Syllabus**

*(An indication of the key topics of the course.)*

- Convex analysis
- Lagrangian duality theory
- Linear and conic programming
- Nonlinear programming
- Gradient descent, subgradient descent, proximal gradient descent
- Barrier methods
- Interior-point methods

**2. Reading List**

**2.1 Compulsory Readings**

*(Compulsory readings can include books, book chapters, or journal/magazine articles. There are also collections of e-books, e-journals available from the CityU Library.)*

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|---|---|
| 1. | *Convex Optimization* (3rd edition), Stephen Boyd and Lieven Vandenberghe © 2004 Cambridge University Press. |
| 2. | Lecture Notes |

**2.2 Additional Readings**

*(Additional references for students to learn to expand their knowledge about the subject.)*

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|---|---|
| 1. | *Lectures on Modern Convex Optimization: Analysis, Algorithms, and Engineering Applications*, Aharon Ben-Tal, Arkadi Nemirovski, © 2001, SIAM Press. |
| 2 | *Linear and Nonlinear Programming* (3rd edition), David G. Luenberger and Yinyu Ye © 2008 Springer |