

**City University of Hong Kong
Course Syllabus**

**offered by School of Data Science
with effect from Semester B 2019 / 20**

Part I Course Overview

| | |
|--|----------------------------------|
| Course Title: | Online Learning and Optimization |
| Course Code: | SDSC8014 |
| Course Duration: | One semester |
| Credit Units: | 3 |
| Level: | R8 |
| Medium of Instruction: | English |
| Medium of Assessment: | English |
| Prerequisites: <i>(Course Code and Title)</i> | Nil |
| Precursors: <i>(Course Code and Title)</i> | Nil |
| Equivalent Courses: <i>(Course Code and Title)</i> | Nil |
| Exclusive Courses: <i>(Course Code and Title)</i> | Nil |

Part II Course Details

1. Abstract

This course covers the fundamentals and applications of online learning and optimization. Topics include online learning, online convex optimization, competitive analysis, regret analysis, online gradient descent, and online algorithms. Other selective topics include online optimization with prediction, robust optimization, online stochastic optimization, and online optimization with feedbacks. Applications in online learning and optimization in societal systems in the face of input uncertainty will be used to complement the theoretical developments. Students should know about convex optimization, linear algebra, and calculus.

2. Course Intended Learning Outcomes (CILOs)

| No. | CILOs | Weighting | Discovery-enriched curriculum related learning outcomes (please tick where appropriate) | | |
|-----|--|-----------|---|----|----|
| | | | A1 | A2 | A3 |
| 1. | Ability to understand the fundamentals of key online optimization frameworks | 20% | ✓ | | |
| 2. | Ability to understand the basic theory and solution methodologies for online learning and key online optimization approaches | 40% | ✓ | | |
| 3. | Ability to compare and analyze different online optimization approaches | 15% | ✓ | ✓ | |
| 4. | Ability to apply key online optimization frameworks to solve practical problems | 25% | ✓ | ✓ | ✓ |
| | | 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. Teaching and Learning Activities (TLAs)

| TLA | Brief Description | CILO No. | | | | | Hours/week (if applicable) |
|---------------|--|----------|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | |
| Lecture | Learning through teaching is primarily based on lectures and demonstrations. | ✓ | ✓ | ✓ | ✓ | | 30 hours in total |
| Class-project | The students are expected to identify and tackle practical problems by applying online optimization techniques. The students are expected to write a report and give two presentations. This learning activity will be mainly student-led but with the instructor's structural guidance. | ✓ | ✓ | ✓ | ✓ | | 9 hours for in-class check-point presentation and final presentation, as well as after-class project activities |

4. Assessment Tasks/Activities (ATs)

| Assessment Tasks/Activities | CILO No. | | | | | Weighting | Remarks |
|--|----------|---|---|---|---|-----------|---------|
| | 1 | 2 | 3 | 4 | 5 | | |
| Continuous Assessment: <u>100</u> % | | | | | | | |
| <u>Paper Reading</u> Review reports of selected papers will show how well the students can understand the concepts, fundamental theory, analysis, solution methods, and applications of online learning and optimization. This assessment will also train the students' ability for critical thinking and carrying out scientific reviews for academic works. | ✓ | ✓ | ✓ | | | | 25% |
| <u>Test</u> Questions are designed for the first part of the course to see how well the students have learned the basic concepts, fundamental theory, analysis, solution methods, and applications of online learning and optimization. | ✓ | ✓ | ✓ | ✓ | | | 25% |
| <u>Mini-Project</u> The project provides students chances to demonstrate how well they have achieved their intended learning outcomes. | ✓ | ✓ | ✓ | ✓ | | | 25% |
| <u>Mini-Project Presentation</u> The project provides students chances to demonstrate how well they have achieved their intended learning outcomes. | ✓ | ✓ | ✓ | ✓ | | | 25% |
| | | | | | | 100% | |

5. Assessment Rubrics

| Assessment Task | Criterion | Excellent (A+, A, A-) | Good (B+, B, B-) | Fair (C+, C, C-) | Marginal (D) | Failure (F) |
|------------------------------|--|--------------------------|---------------------|---------------------|-----------------|-----------------------------------|
| 1. Paper Reading | Ability to understand and the basic concepts, fundamental theory, analysis, solution methods, and applications of online learning and optimization. | High | Significant | Moderate | Basic | Not even reaching marginal levels |
| 2. Test | Ability to understand and apply the basic concepts, fundamental theory, analysis, solution methods, and applications of online learning and optimization. | High | Significant | Moderate | Basic | Not even reaching marginal levels |
| 3. Mini-Project Report | Ability to demonstrate the understanding of the basic concepts, fundamental theory, analysis, and solution methods of online optimization in practical problems. | High | Significant | Moderate | Basic | Not even reaching marginal levels |
| 4. Mini-Project Presentation | Ability to demonstrate how well the intended learning outcomes are achieved. | 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

Online learning, online optimization, online algorithm, competitive analysis, regret analysis

2. Reading List

2.1 Compulsory Readings

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|----|---|
| 1. | Elad Hazan (2016), "Introduction to Online Convex Optimization", Foundations and Trends® in Optimization: Vol. 2: No. 3-4, pp 157-325. http://dx.doi.org/10.1561/2400000013 (Selected chapters) |
| 2. | Allan Borodin and Ran El-Yaniv (2015), "Online Computation and Competitive Analysis", Cambridge University Press New York, NY, USA (Selected chapters) |

2.2 Additional Readings

| | |
|----|---|
| 1. | Niv Buchbinder and Joseph (Seffi) Naor (2009), "The Design of Competitive Online Algorithms via a Primal–Dual Approach", Foundations and Trends® in Theoretical Computer Science: Vol. 3: No. 2–3, pp 93-263. http://dx.doi.org/10.1561/0400000024 |
| 2. | Shai Shalev-Shwartz (2011), "Online Learning and Online Convex Optimization", Foundations and Trends® in Machine Learning, vol 4, no 2, pp 107–194, 2011. |
| 3. | Sébastien Bubeck and Nicolò Cesa-Bianchi (2012), "Regret Analysis of Stochastic and Nonstochastic Multi-armed Bandit Problems", Foundations and Trends® in Machine Learning: Vol. 5: No. 1, pp 1-122. http://dx.doi.org/10.1561/2200000024 |