

SDSC8014: ONLINE LEARNING AND OPTIMIZATION

Effective Term

Semester B 2025/26

Part I Course Overview

Course Title

Online Learning and Optimization

Subject Code

SDSC - Data Science

Course Number

8014

Academic Unit

Data Science (DS)

College/School

College of Computing (CC)

Course Duration

One Semester

Credit Units

3

Level

R8 - Research Degree

Medium of Instruction

English

Medium of Assessment

English

Prerequisites

Nil

Precursors

Nil

Equivalent Courses

Nil

Exclusive Courses

Nil

Part II Course Details

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.

Course Intended Learning Outcomes (CILOs)

CILOs		Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Describe the fundamentals of key online optimization frameworks	20	x		
2	Describe the basic theory and solution methodologies for online learning and key online optimization approaches	40	x		
3	Compare and analyze different online optimization approaches	15	x	x	
4	Apply key online optimization frameworks to solve practical problems	25	x	x	x

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 real-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.

Learning and Teaching Activities (LTAs)

LTAs		Brief Description	CILO No.	Hours/week (if applicable)
1	Lectures	Students will engage in formal lectures to gain knowledge about online learning and optimization	1, 2, 3, 4	30 hours in total

2	Class-project	The students will identify and tackle practical problems in various engineering systems, ideally with online learning and optimization techniques learned from the course. The students will write a report and give two presentations. This learning activity will be mainly student-led but with the instructor's structural guidance.	1, 2, 3, 4	30 hours in total 9 hours for in-class check-point presentation and final presentation, as well as after-class project activities
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Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("- " for nil entry)	Allow Use of GenAI?
1	Paper Reading 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.	1, 2, 3	25	-	Yes
2	Test 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.	1, 2, 3, 4	25	-	No

3	Mini-Project The project provides students chances to demonstrate how well they have achieved their intended learning outcomes.	1, 2, 3, 4	25	-	Yes
4	Mini-Project Presentation The project provides students chances to demonstrate how well they have achieved their intended learning outcomes.	1, 2, 3, 4	25	-	Yes

Continuous Assessment (%)

100

Examination (%)

0

Minimum Continuous Assessment Passing Requirement (%)

0

Minimum Examination Passing Requirement (%)

0

Assessment Rubrics (AR)**Assessment Task**

Paper Reading (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

Ability to understand and the basic concepts, fundamental theory analysis, solution methods, and applications of online learning and optimization.

Excellent

A+, A, A-

Good

B+, B, B-

Fair

C+, C, C-

Marginal

D

Failure

F

Assessment Task

Test (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

Ability to understand and apply the basic concepts, fundamental theory analysis, solution methods, and applications of online learning and optimization.

Excellent

A+, A, A-

Good

B+, B, B-

Fair

C+, C, C-

Marginal

D

Failure

F

Assessment Task

Mini-Project Report (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

Ability to demonstrate the understanding of the basic concepts, fundamental theory, analysis and solution methods of online optimization in practical problems.

Excellent

A+, A, A-

Good

B+, B, B-

Fair

C+, C, C-

Marginal

D

Failure

F

Assessment Task

Mini-Project Presentation (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

Ability to demonstrate how well the intended learning outcomes are achieved.

Excellent

A+, A, A-

Good

B+, B, B-

Fair

C+, C, C-

Marginal

D

Failure

F

Assessment Task

Paper Reading (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

Ability to understand and the basic concepts, fundamental theory analysis, solution methods, and applications of online learning and optimization.

Excellent

A+, A, A-

Good

B+, B

Marginal

B-, C+, C

Failure

F

Assessment Task

Test (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

Ability to understand and apply the basic concepts, fundamental theory analysis, solution methods, and applications of online learning and optimization.

Excellent

A+, A, A-

Good

B+, B

Marginal

B-, C+, C

Failure

F

Assessment Task

Mini-Project Report (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

Ability to demonstrate the understanding of the basic concepts, fundamental theory, analysis and solution methods of online optimization in practical problems.

Excellent

A+, A, A-

Good

B+, B

Marginal

B-, C+, C

Failure

F

Assessment Task

Mini-Project Presentation (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

Ability to demonstrate how well the intended learning outcomes are achieved.

Excellent

A+, A, A-

Good

B+, B

Marginal

B-, C+, C

Failure

F

Part III Other Information

Keyword Syllabus

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

Reading List**Compulsory Readings**

Title	
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/10.1561/24000000013 (Selected chapters)

2	Allan Borodin and Ran El-Yaniv (2015), “Online Computation and Competitive Analysis” , Cambridge University Press New York, NY, USA (Selected chapters)
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Additional Readings

Title	
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/10.1561/04000000024
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/10.1561/22000000024