SDSC8005: OPTIMIZATION

Effective Term
Semester B 2024/25

Part I Course Overview

Course Title
Optimization

Subject Code
SDSC - Data Science
Course Number
8005

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
In this course we will learn how to formulate, analyze and solve various optimization problems. Topics include convex analysis, classifying different types of optimization problems optimality conditions duality, unconstrainted optimization,

and optimization under uncertainty. No prior optimization background is required for this class. However, students should have workable knowledge in multivariable calculus, linear algebra and matrix theory.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Explain the fundamentals and principles of optimization	20	x	x	
2	Explain the theory for different types of optimization problems	50		x	x
3	Use/apply software packages or existing algorithms to formulate and solve various optimization problems	15		x	
4	Model different applications of optimization	15	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	Class Activities	Students will engage in lectures which introduce the understanding and applications of various concepts and methods.	1, 2, 3, 4	32 hours/sem
2	Tutorial Sessions	Students will participate tutorial sessions that have explanation and exercises to familiarize themselves with the methods learnt during the lectures.	1, 2, 3, 4	7 hours/sem

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Assignments Students are required to explain knowledge and apply methodologies learned from the course in solving some problems.	1, 2, 3, 4	20	

2	Midterm/in-lab/take-home exam Students will be assessed via the examination in their ability to explain concepts and apply methodologies in solving optimization problems	1, 2, 3, 4	50	
3	Course project Students will be assessed via course projects in demonstrating their ability in solving real optimization problems	2, 3, 4	30	

Continuous Assessment (%)

100

Examination (%)

0

Assessment Rubrics (AR)

Assessment Task

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

Criterion

Train students' ability to theorize and solve various types of optimization problems.

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal

(D) Basic

Failure

(F) Not even reaching marginal levels

Assessment Task

Midterm/in-lab/take-home exam (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

It assesses students' ability to theorize and solve various types of optimization problems.

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair
(C+, C, C-) Moderate

Marginal
(D) Basic

Failure
(F) Not even reaching marginal levels

Assessment Task
Course project (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion
Nurture students' ability in solving real optimization problems.

Excellent
(A+, A, A-) High

Good
(B+, B, B-) Significant

Fair
(C+, C, C-) Moderate

Marginal
(D) Basic

Failure
(F) Not even reaching marginal levels

Assessment Task
Assignments (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion
Train students' ability to theorize and solve various types of optimization problems.

Excellent
(A+, A, A-) High

Good
(B+, B) Moderate

Marginal
(B-, C+, C) Basic

Failure
(F) Not even reaching marginal levels

Assessment Task
Midterm/in-lab/take-home exam (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion
It assesses students' ability to theorize and solve various types of optimization problems.

Excellent
(A+, A, A-) High

Good
(B+, B) Moderate

Marginal
(B-, C+, C) Basic

Failure
(F) Not even reaching marginal levels

Assessment Task
Course project (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion
Nurture students' ability in solving real optimization problems.

Excellent
(A+, A, A-) High

Good
(B+, B) Moderate

Marginal
(B-, C+, C) Basic

Failure
(F) Not even reaching marginal levels

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

Criterion
Based on submitted written work to evaluate of the ability to explain the knowledge of reinforcement learning learned in class.

Excellent
(A+, A, A-) High

Good
(B+, B, B-) Significant

Fair
(C+, C, C-) Moderate

Marginal
(D) Basic

Failure
(F) Not even reaching marginal levels

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

Criterion
Based on submitted written work and programming code to evaluate their ability to explain core concepts of reinforcement learning, as well as the ability of applying different reinforcement learning algorithms.

Excellent
(A+, A, A-) High

Good
(B+, B, B-) Significant

Fair
(C+, C, C-) Moderate

Marginal
(D) Basic

Failure
(F) Not even reaching marginal levels

Assessment Task
Course project(s) (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion
Based on submitted written work and oral presentation to evaluate students' synthesis ability and clarity their knowledge of reinforcement learning, and their ability to extend their knowledge in reinforcement learning.

Excellent
(A+, A, A-) High

Good
(B+, B, B-) Significant

Fair
(C+, C, C-) Moderate

Marginal
(D) Basic

Failure
(F) Not even reaching marginal levels

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

Criterion
Ability to solve problems of reinforcement learning and Markov decision process with fundamental methods.

Excellent
(A+, A, A-) High

Good
(B+, B, B-) Significant

Fair
(C+, C, C-) Moderate

Marginal
(D) Basic

Failure
(F) Not even reaching marginal levels

Assessment Task
Assignments (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion
Based on submitted written work to evaluate the ability to explain the knowledge of reinforcement learning learned in class.

Excellent
(A+, A, A-) High

Good
(B+, B) Moderate

Marginal
(B-, C+, C) Basic

Failure
(F) Not even reaching marginal levels

Assessment Task
Midterm (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion
Based on submitted written work and programming code to evaluate their ability to explain core concepts of reinforcement learning, as well as the ability of applying different reinforcement learning algorithms.

Excellent
(A+, A, A-) High

Good
(B+, B) Moderate

Marginal
(B-, C+, C) Basic

Failure
(F) Not even reaching marginal levels

Assessment Task
Course project(s) (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion
Based on submitted written work and oral presentation to evaluate students' synthesis ability and clarity their knowledge of reinforcement learning, and their ability to extend their knowledge in reinforcement learning.

Excellent
(A+, A, A-) High

Good
(B+, B) Moderate

Marginal
(B-, C+, C) Basic

Failure
(F) Not even reaching marginal levels

Assessment Task
Examination (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion
Ability to solve problems of reinforcement learning and Markov decision process with fundamental methods.

Excellent
(A+, A, A-) High

Good
(B+, B) Moderate

Marginal
(B-, C+, C) Basic

Failure
(F) Not even reaching marginal levels

Part III Other Information

Keyword Syllabus
Convex analysis, optimality conditions duality, unconstrainted optimization, optimization under uncertainty

Reading List

Compulsory Readings

	Title
1	S. Boyd and L. Vandenberghe. Convex Optimization. Cambridge University Press, Cambridge, 2004. Available online at http://www.stanford.edu/~boyd/cvxbook/.
2	Lecture Notes and Slides

Additional Readings

	Title
1	A. Ben-Tal and A. Nemirovski. Lectures on Modern Convex Optimization: Analysis, Algorithms, and Engineering Applications, volume 2 of MPS{SIAM Series on Optimization. Society for Industrial and Applied Mathematics, Philadelphia, Pennsylvania, 2001.
2	M. S. Bazaraa, H. D. Sherali, and C. M. Shetty. Nonlinear Programming: Theory and Algorithms. Wiley{Interscience Series in Discrete Mathematics and Optimization. John Wiley & Sons, Inc., New York, second edition, 1993.
3	D. P. Bertsekas. Nonlinear Programming. Athena Scienti_c, Belmont, Massachusetts, second edition, 1999.
4	D. G. Luenberger and Y. Ye. Linear and Nonlinear Programming, volume 116 of International Series in Operations Research and Management Science. Springer Science+Business Media, LLC, New York, third edition, 2008.