MA-4183/6183:
Mathematical Foundations of Machine Learning
(Spring 2026)

Instructor

Prof. Seongjai Kim, Professor of Mathematical AI, Poet, Songwriter
Email: skim@math.msstate.edu
Phone: 325-7163
Office: 459 Alllen Hall

Class

Classroom: 17 Allen; MW 2:00 – 3:15 PM

Office Hours

MTW 10:00–10:50AM, or by appointment

Course Description

(Prerequisite: MA 2743 and MA 3113). Three hours lecture. Basic machine learning principles and classifiers; gradient-based methods for optimization; data preprocessing techniques; feature selection methods; quadratic programming; Lagrange multipliers and duality; kernel methods; mathematics and applications for deep learning.

Course Materials

- **Text**: Seongjai Kim, *Mathematical Foundations of Machine Learning*, Lecture Note. Download: http://skim.math.msstate.edu/LectureNotes/Machine_Learning_Lecture.pdf
- Video Lectures on YouTube Channel:
  MathTalent https://www.youtube.com/channel/UCmRbK4vlGDht-joOQ5g0J2Q
- **Supplemental References**:
  - S. Raschka and V. Mirjalili (2019), *Python Machine Learning, 3rd Ed.*, Packt Publishing.

Class Plan

- The students will complete 8 sets of homework, one for each of Chapters 2-9.
- The students will work on one or two projects, developing and implementing machine learning algorithms. At the end of the semester, students will present outcomes of a project in the class.
- The students will take a mid-term and the final exam, with the final being comprehensive. (**The final scheduled**: Mon 5/11, 3:30 – 6:30 PM)
- There are *Graduate Student Requirements*; see page 4.
- For Campus 5, the students are expected to complete and turn in assignments via Canvas.
- **Class**: begins on **Wed 1/14** and ends on **Mon 5/4**.

Learning Objectives

- To provide advanced undergraduate students and early year graduate students with a solid mathematical background for three of the pillars of modern data science: calculus, linear algebra, and applied probability.
- To recognize mathematical issues that arise in machine learning.
- To discuss recent approaches in machine learning.

Content

The course covers all subjects in Dr. Kim's lecture note.

Ch. 1 Introduction to Machine Learning
Ch. 2 Python Basics
Ch. 3 Simple Machine Learning Algorithms for Classification
Ch. 4 Gradient-based Methods for Optimization
Ch. 5 Popular Machine Learning Classifiers
Ch. 6 Data Preprocessing in Machine Learning
Ch. 7 Feature Extraction: Data Compression
Ch. 8 Cluster Analysis
Ch. 9 Neural Networks and Deep Learning
Ch. 10 Data Mining
Ch. 11 Quadratic Programming (when time available)

Delivery Methods for Campus 5

- A webcam will be installed in the classroom and connected to Canvas for students in Campus 5. Thus for Campus 5, lectures are synchronous through Canvas (WebEx connection).
- All the lectures will be recorded and uploaded on Canvas and YouTube, for students who need flexible time schedules to study. The YouTube URL will be announced in Canvas.

Exams

There will be a mid-term exam and a comprehensive final exam.

- The mid-term will cover Chapters 1–5.
- The final exam will cover all chapters covered.

Homework

Homework will be assigned after finishing each chapter; problems are given in the lecture note, at the end of each chapter as Exercises. Some problems require mathematical derivation/proof and others need to use certain Python Machine Learning packages. Homework will be collected within a week. Students are required not to miss homework. Late homework submissions may be accepted with a penalty of 15$\sim$20% score reduction per week; this is for unexcused absences only and excused absences will not be penalized.

Projects

The students will work on one or two projects, developing and implementing computer algorithms. At the end of the semester, students will present outcomes of a project in the class.

Campus 5: Discussions and Questions

Students in distance learning are encouraged to post questions and other concerns on discussion board in Canvas and communicate with your class mates. Also you may send emails to the instructor to ask questions.

Evaluation

The students' understanding of the concepts covered in this course will be evaluated by a combination of homework assignments, two projects, a mid-term exam, and the final exam. The overall final grade will be calculated in the following manner:

Homework	50%
Mid-term	10%
Projects	20% (10% each)
The final exam	20%

Final Grade

The standard MSU grading scale will be considered:

$\geq 90\,\%$	A
$80\sim 89.99\,\%$	B
$70\sim 79.99\,\%$	C
$60\sim 69.99\,\%$	D
Below 60%	F

When the average performance of students is lower than a certain level, a curve will be given at the end of the class.

Graduate Student Requirements

Homework assignments and projects will include problems which are optional for undergraduate students, but required for graduate students.

- *Implementation*: Most tasks in machine learning require to design effective algorithms, with most of functions being selected from a package in public domain. However, for some functions, students should implement them to understand core concepts; graduate students will implement more functions rather than simply calling built-in functions.
- *Mathematical Derivation*: Assignments will include problems which require deeper mathematical/statistical backgrounds for graduate students. Those problems would be mostly optional for undergraduate students.

Below are the standard MSU policies in education and learning.

Attendance Policy

This section is a face-to-face instructional class. Per Academic Operating Policy 12.09, students are expected to attend all class meetings in person. Should a student expect a university-excused absence from a class, the student should contact the course instructor of record to inform them of the absence and the reason for it. Special instructions regarding illness and contagious infection are included in the syllabus section entitled: Contagious Infection and Other Health Accommodations for face-to-face instruction.

General Class Information

By attending class, you agree to behave in a manner that allows for you and your classmates to learn effectively. If you disrupt class or behave in any other inappropriate fashion, you will be dismissed from class. Repeated instances of disruptive behavior will result in permanent dismissal. Also, all cell phones must be turned off before entering the classroom and left off until class is dismissed.

Student Honor Code

Mississippi State has an approved Honor Code that applies to all students. The code is as follows: “As a Mississippi State University student, I will conduct myself with honor and integrity at all times. I will not lie, cheat, or steal, nor will I accept the actions of those who do." Upon accepting admission to Mississippi State University, a student immediately assumes a commitment to uphold the Honor Code, to accept responsibility for learning, and to follow the philosophy and rules of the Honor Code. For additional information, please visit: https://www.honorcode.msstate.edu.

Title IX

MSU is committed to complying with Title IX, a federal law that prohibits discrimination, including violence and harassment, based on sex. This means that MSU’s educational programs and activities must be free from sexual discrimination, sexual harassment, and other forms of sexual misconduct. If you or someone you know has experienced sex discrimination, sexual violence and/or harassment by and member of the University community, you are encouraged to report the conduct to MSU’s

Director of Title IX/EEO Programs at 325-8124 or by e-mail to titleix@msstate.edu. Additional resources are available at https://www.oci.msstate.edu/focus-areas/title-ix-sexual-misconduct. If you need help, please contact the MSU Safeline at 325-3333.

Student Support Services

Students who need academic accommodations based on a disability should visit the Office of Student Support Services, 01 Montgomery Hall, call 325-3335, or visit the website at http://www.sss.msstate.edu.

University Safety Statement

Mississippi State University values the safety of all campus community members. Students are encouraged to register for Maroon Alert texts and to download the Everbridge App. Visit the Personal Information section in Banner on your mystate portal to register. To report suspicious activity or to request a courtesy escort via Safe Walk, call University Police at 662-325-2121, or in case of emergency, call 911. For more information regarding safety and to view available training resources, including helpful videos, visit ready.msstate.edu.

Attendance policy for Face-to-face Instruction

This section is a face-to-face instructional class. Per Academic Operating Policy 12.09, students are expected to attend all class meetings in person. Should a student expect a university-excused absence from a class, the student should contact the course instructor of record to inform them of the absence and the reason for it. Special instructions regarding illness and contagious infection are included in the syllabus section entitled: *Contagious Infection and Other Health Accommodations for face-to-face instruction.*

Contagious Infection and Other Health Accommodations for Face-to-face Instruction

Students required to isolate due to symptomatic or asymptomatic contagious infection or quarantine due to potential exposure to contagious infection will be accommodated on a case-by-case basis. Such students must provide an excuse from either the Dean of Students, the Longest Student Health Center, or qualified medical practitioner directing quarantine procedures, and the recommended date of return. Information provided will be enforced at the instructor's discretion.

In cases meriting accommodation, quarantining students may be expected to log into the lecture during the scheduled class time or complete equivalent assignments approved by the instructor. If a student is too ill to participate in a class at the scheduled time, the student may be provided a link to a recording of the lecture or offered a similar accommodation as determined by the instructor.

It is the responsibility of the student to initiate and maintain contact with their instructor(s) regarding their quarantine status. All accommodations are subject to the instructions provided by the Dean of Students', Longest Student Health Center, or qualified medical practitioner.

Continuity of Instruction

In the event that face-to-face classes are suspended due to the pandemic or its effects, the instructor will continue instruction in a manner that best supports the course content and student engagement. In this event, all instructors will notify all students of the change via their university email address (the official vehicle for communication with students). At that time, they will provide details about how instruction and communication will continue, how academic integrity will be ensured, and what students may expect during the time that face-to-face classes are suspended. If a student becomes unable to continue class participation, the student should contact their instructor and advisor for guidance.

Facial Coverings

To safeguard the health of all members of the MSU campus during this global pandemic, the university has reconfigured classroom spaces and adjusted room capacities to assure adequate physical distance between all individuals in each room. In addition, the university has published requirements for the use of face coverings for everyone on campus, including specific requirements for their use in all classrooms, labs, and shared office spaces regardless of physical distancing. In order to mutually protect the students' freedom to learn and the instructor's ability to teach in a safe classroom environment, everyone in this classroom is required to wear a face covering in the classroom in accordance with MSU policy. If a student cannot wear a face covering due to a medical condition, they should request an accommodation via the Office of Disability Support Services. If a student simply doesn't want to wear a face covering, they will not be permitted to remain in the classroom or lab.