CPS 5310/6310

Mathematical & Computational Modeling
CRN: 21008-24407
Term: Spring 2026
Credit Hours: 3
Instructor: Dr. Anass Bouchnita
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Instructor office: Bell Hall 202
Time and location: Tuesdays and Thursdays 12:00-1:20 p.m., in Bell Hall 130
Office hours: Thursdays 10:00 a.m.-12:00 p.m., in person and by appointment.
Drop deadline: April 2, 2026.

Prerequisites

Calculus III (MATH 2313), Matrix Algebra (MATH 3323), and Introduction to Computational Science (CPS 5401) with grade of B or better; or permission of the instructors.

Course description

Mathematical and computational modeling provides a robust framework for understanding , analyzing, and predicting the behavior of complex systems across disciplines such as biology, physics, geology, engineering, and social sciences. Modellers use algorithms and numerical methods to solve mathematical models, especially when the analytical solutions of the corresponding mathematical equations are impossible. It allows for the simulation of complex, dynamic systems, which enables the exploration of fictional scenarios, the study of *in silico* experiments, and optimization of processes. As an interdisciplinary tool, mathematical and computational modeling bridges theory and practice, helping researchers and practitioners tackle pressing scientific and societal challenges.

Models are categorized as deterministic or stochastic: deterministic models use fixed parameters and initial conditions for predictable outcomes, while stochastic models incorporate randomness to capture uncertainty and variability. Probability theory is used within stochastic models to measure and estimate uncertainties and randomness. Mechanistic models, which use ordinary and partial differential equations, provide a continuous representation which describe the underlying dynamics governing changes in populations, chemical substances, or physical properties. These approaches together provide frameworks for understanding complex phenomena.

In this course, students will have the chance to familiarize themselves with the key concepts, foundations and approaches in mathematical and computational modeling. They will learn the art of building mathematical models and analyzing them numerically and computationally. They will practice modeling skills during homeworks, interactive lab sessions, and a final project.

Course objectives

By the end of this course, students will be able to:

- Develop mathematical models for complex systems and articulate underlying modeling assumptions.
- Select and apply appropriate modeling frameworks and numerical methods to solve real-world problems.
- Implement mathematical models and numerical methods using computer programming.
- Visualize numerical results effectively to interpret and communicate findings.
- Apply verification and validation techniques to ensure model accuracy and reliability.

Learning modules

The course consists of 14 learning modules. Each module will be covered in one week. The modules cover Chapters 1, 3, and 4 of the textbook, as well as parts from the first three chapters of the book Introduction to Probability Models by Sheldon Ross, 10th Ed. The lecture portion of the class will consist of short lectures interspersed with hands-on interactive activities. Homework assignments will be provided each Thursday. The tentative schedule of the modules is represented in Table 1. The exact schedule may vary depending on the background of the class participants and progress of the class.

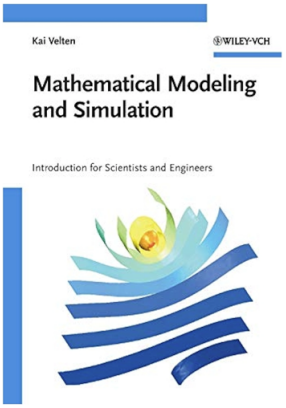
Table 1: Tentative schedule of the course modules and examinations. The schedule might be subject to change depending on the achievement of the learning outcomes. The final exam will be organized during the exam week.

Week / Module	Content
Jan 20 - Jan 22	Welcome to CPS 5310/6310 - Principles of mathematical modeling I (Chapter 1 of the textbook)
Jan 27 - Jan 29	Principles of mathematical modeling II (Chapter 1 of the textbook)
Feb 3 - Feb 5	Phenomenological models: Basic probability theory I (Introduction to Probability Models by Sheldon Ross, 10th Ed)
Feb 10 - Feb 12	Phenomenological models: Basic probability theory II (Introduction to Probability Models by Sheldon Ross, 10th Ed)
Feb 17 - Feb 19	Phenomenological models: Random variables I (Introduction to Probability Models by Sheldon Ross, 10th Ed) - Introduction to course projects
Feb 25 - Feb 27	Phenomenological models: Random variables II (Introduction to Probability Models by Sheldon Ross, 10th Ed)
Feb 3 - Feb 5	Phenomenological models: Markov chains - review (Introduction to Probability Models by Sheldon Ross, 10th Ed)
Mar 10 - Mar 12	Review of Phenomenological models, mock midterm exam and midterm exam I
Mar 17 - Mar 19	Spring break

Mar 24 - Mar 26	Mechanistic models: ODEs I (Chapter 3 of the textbook)
Mar 31 - Apr 2	Mechanistic models: ODEs II (Chapter 3 of the textbook)
Apr 7 - Apr 9	Mechanistic models: ODEs III (Chapter 3 of the textbook)
Apr 14 - Apr 16	Mechanistic models: PDEs I (Chapter 4 of the textbook)
Apr 21 - Apr 23	Mechanistic models: PDEs II (Chapter 4 of the textbook)
Apr 28 - Apr 30	Mechanistic models: PDEs III and particle-based methods, multi-scale and multi-physics problems (Chapter 4 of the textbook)
May 5 - May 7	Term project seminar - course review
May 11 - May 15	Midterm exam I

Required materials

Textbook: Mathematical Modeling and Simulation: Introduction for Scientists and Engineers, Kai Velten, Wiley-VCH, 2009, ISBN: 9783527407588.



Other readings:

- Victor Eijkhout, Introduction to High-performance Scientific Computing
- Sheldon Ross, Introduction to Probability Models, 10th Edition, 2010
- Liu, Moubin, and Gui-Rong Liu. Particle methods for multi-scale and multi-physics. World Scientific, 2017.

Course assignments and grading

The final grade will be calculated based on attendance and participation, weekly homework assignments, two midterm exams and one term project. Exams will be taken during class classes, while homework assignments should be completed and returned during the next week. The lowest two grades obtained in assignments will be dropped when calculating the overall grade.

The overall grade will be calculated as the weighted sum of the grades obtained in the different activities. The grade will be calculated based on the final score as follows:

1000-850 = A; 850-650 = B; 650-400 = C; 400-200 = D; 200 and Below = F

The final score will be calculated as the weighted sum of the grades obtained in the following tests:

- 150 points: Attendance and participation

- o 350 Points: Homework assignments
- o 150 Points: Midterm I
- o 150 Points: Midterm II
- o 200 Points: Term project

Term project

Each year, there will be a grand challenge that require interdisciplinary study and different modelling approaches to solve. The term project involves the following components:

Topic selection: Choose a specific problem for your project and obtain prior approval from the instructor.
Model development and solution: Create and solve a mathematical model for a physical problem not covered in class or assigned as homework.
Comprehensive report: Prepare a detailed report that includes:

- Background information for the model.
- Model definition and formulation.
- Description of the simulation method used.
- Presentation of results and their interpretation.
- Validation of the model.

Project presentation: Deliver a presentation to describe and demonstrate your model, including its definition, simulation method, results, and validation.

You may work individually or in teams of up to two members. For group projects, document the contributions of each member clearly and ensure that the scope and complexity of the work are proportional to the team size.

Technology requirements

Interactive labs will be conducted during the lecture times using available computers in Bell Hall 130 or personal laptops. Some homework assignments that need to be completed on personal computers or CPS labs.

Course contents will be delivered via the Blackboard learning management system. Communication between students and the instructor will be mediated by the Blackboard discussion board or using UTEP email accounts. The student must have the last version of a stable browser like Google Chrome or Mozilla Firefox to explore Blackboard. If you still encounter any difficulties, update your browser, clear your cache, or use a different browser. The Blackboard software will be used for homeworks, surveys, announcements, and additional course material. ADA students are advised to use word-processing software like Microsoft Office programs which is available for free via the UTEP Microsoft Office Portal. In addition, please reach out at the beginning of the course to accommodate the course for you. A tutorial for this software is available upon notice.

IMPORTANT: If you encounter technical difficulties beyond your scope of troubleshooting, please contact the UTEP Help Desk as they are trained specifically in assisting with the technological needs of students. Please do not contact me for this type of assistance. The Help Desk is much better equipped than I am to assist you!

Course communication

This is an in-person course, we will use the following communication channels to stay in contact:

Office Hours: My office hours will be held during the following time:
Wednesdays 12:00-2:00 p.m. Mountain Time in person by appointment.

Email: UTEP e-mail can be used if you have any inquiries regarding the course. I will attempt to answer within 24-48 hours. In the case the question requires a discussion, it is better to come to see me during office hours. Make sure to add the course number and use the UTEP e-mail. Also, make sure that the subject line clearly describes the inquiry. Finally, please provide your full name and university identification number at the end of the e-mail. A typical e-mail should look like this:

To: abouchnita@utep.edu Cc: … Subject: [CPS 5310] Inquiry about homework assignment n° 6, Section 3.2
Hi … … … … Best regards, *First name Last time* *ID ….*

Announcements: Check the Blackboard announcements frequently for any updates, deadlines, or other important messages.

Netiquette

Online communication can be challenging because of the lack of body language and immediate feedback. Therefore, it is essential to follow some netiquette (network etiquette) guidelines to keep a positive and productive environment in the classroom. Failure to comply with these guidelines may result in disciplinary action.

o Communication should reflect polite consideration of others' ideas.
o Respect and courtesy must be provided to classmates and to the instructor at all times. No harassment or inappropriate postings will be tolerated.

o When reacting to someone else's message, address the ideas, not the person. Post only what anyone would comfortably state in a face-to-face situation.
o Blackboard is not a public internet venue; all postings to it should be considered private and confidential. Whatever is posted in these online spaces is intended for classmates and the instructor only. Please do not copy documents and paste them to a publicly accessible website, blog, or other space.

Attendance and participation

Attendance is necessary to complete the homeworks and exams with a satisfactory grade. Further, students are expected to read the textbook and work through the examples covered in class. Further, attendance and participation are explicitly taken into the final grade. Students are expected to attend class and arrive on time. Absent students are responsible to find out the material and homework that need to be made up. Absences due to illness or other emergencies can be justified with appropriate documentation. Participation in the class covers asking questions and participating in class discussions.

Excused absences and drop policy

I will not drop you from the course. However, if you feel that you are unable to complete the course successfully, please let me know and then contact the Registrar's Office to initiate the drop process. If you do not, you are at risk of receiving an "F" for the course. The deadline to drop the course is April 2, 2026.

Deadlines, late work and absence policy

Exams will be held in person during class. Homeworks will be returned in person or over Blackboard. The exact time and modalities will be specified in separate announcements.

Make-up work

Missed exams cannot be made up, either. Again, exceptions can be given only in extraordinary and unavoidable circumstances with reasonable proof, and with advance notice in writing. Make-up work will be given only in case of a documented exceptional emergency.

Accommodations policy

The University is committed to providing reasonable accommodations and auxiliary services to students, staff, faculty, job applicants, applicants for admissions, and other beneficiaries of
University programs, services and activities with documented disabilities in order to provide them with equal opportunities to participate in programs, services, and activities in compliance with sections 503 and 504 of the Rehabilitation Act of 1973, as amended, and the Americans with Disabilities Act (ADA) of 1990 and the Americans with Disabilities Act Amendments Act (ADAAA) of 2008. Reasonable accommodations will be made unless it is determined that doing so would cause undue hardship for the University. Students requesting accommodation based on a disability must register with the UTEP Center for Accommodations and Support Services (CASS). Contact the Center for Accommodations and Support

Services at 915-747-5148, email them at cass@utep.edu, or apply for accommodations online via the CASS portal.

Scholastic integrity

Academic dishonesty is prohibited and is considered a violation of the UTEP Handbook of Operating Procedures. It includes, but is not limited to, cheating, plagiarism, and collusion. Cheating may involve copying from or providing information to another student, possessing unauthorized materials during a test, or falsifying research data on laboratory reports. Plagiarism occurs when someone intentionally or knowingly represents the words or ideas of another as one's own. Collusion involves collaborating with another person to commit any academically dishonest act. Any act of academic dishonesty attempted by a UTEP student is unacceptable and will not be tolerated. All suspected violations of academic integrity at The University of Texas at El Paso must be reported to the Office of Student Conduct and Conflict Resolution (OSCCR) for possible disciplinary action. To learn more, please visit HOOP: Student Conduct and Discipline.

Copyright statement and course materials

All materials used in this course are protected by copyright law. The course materials are only for the use of students currently enrolled in this course and only for the purpose of this course. They may not be further disseminated.

Course resources

UTEP provides a variety of student services and support:

Technology Resources

Help Desk: Students experiencing technological challenges (email, Blackboard, etc.) can submit a ticket to the UTEP Helpdesk for assistance. Contact the Helpdesk via phone, email, chat, website, or in person if on campus.

Academic Resources

UTEP Library: Access a wide range of resources including online, full-text access to thousands of journals and eBooks plus reference service and librarian assistance for enrolled students.

Individual Resources

Military Student Success Center: Assists personnel in any branch of service to reach their educational goals.
Center for Accommodations and Support Services: Assists students with ADA-related accommodations for coursework, housing, and internships. Counseling and Psychological Services: Provides a variety of counseling services including individual, couples, and group sessions as well as career and disability assessments.