

Capital University of Economics and Business

Overseas Chinese College

Course Syllabus

Year and Semester	2026 Fall					
Course Name	Mathematical Modeling and Analysis					
Course Code	MIS208					
Course Type	☐ General Education (Required) ☐ General Education (Elective) ☐ Basic Disciplinary Course ☐ Professional Course (Required) ☒ Professional Course (Elective) ☐ Professional Course (Expanded) ☐ Professional Course (Advanced)					
Course Credits	2					
Course Hours	Total Class Hours	32	Lecture Hours	16	Experiment (Computer) Hours	16
Applicable object	☐ Freshman ☒ Sophomore ☐ Junior ☐ Senior ☐ Information Management and Information Systems (Finance)					
Prerequisites	None					
Instructor	Meng Li					
Contact Information	Office: C217					
	Tele: (010)83951082					
	Email: occ_limeng@cueb.edu.cn					
Office Hour	TBA					
Learning Centre	TBA					
Grade/Section	2025IT					
Course Time/Place	25IT (data governance) F:13:30-15:05					
Textbook	Giordano, F. R., Fox, W. P., Horton, S. B., & Weir, M. D. A First Course in Mathematical Modeling (5th Edition). Cengage Learning, 2013. A classic, accessible introduction covering the full modeling cycle with diverse case studies.					

ReferenceBook

1.

Meerschaert, M. M.

Mathematical Modeling (4th Edition). Academic Press, 2013.

Rigorous treatment with strong emphasis on stochastic processes, optimization, and dimensional analysis.

Course Description

This course introduces the fundamental principles, methodologies, and analytical techniques of mathematical modeling for real-world problems arising in natural sciences, engineering, economics, and social systems. Students will learn how to translate complex phenomena into mathematical structures—using differential equations, optimization, probability, and dynamical systems—and analyze these models both qualitatively and quantitatively. Emphasis is placed on the entire modeling cycle: problem formulation, model construction, mathematical analysis, numerical simulation, validation, and interpretation. Through case studies and team-based projects, students will develop the ability to critically evaluate model assumptions, assess limitations, and communicate mathematical insights effectively to both technical and non-technical audiences

Student Learning Objectives

On successful completion of this exam, candidates should be able to:

Knowledge	◆ K1. Identify and classify mathematical models based on their structural properties (e.g., linear vs. nonlinear, continuous vs. discrete, deterministic vs. stochastic). ◆ K2. Formulate mathematical representations of real-world phenomena using appropriate mathematical tools, including ordinary and partial differential equations, optimization frameworks, and probabilistic models. ◆ K3. Explain core analytical concepts such as equilibrium, stability, bifurcation, conservation laws, scaling, and dimensional homogeneity. ◆ K4. Describe standard numerical and computational techniques for solving, simulating, and visualizing mathematical models. ◆ K5. Recognize the assumptions, domain of validity, and limitations inherent in any mathematical model.
Capability	C1. Construct a complete mathematical model from a loosely defined real-world problem, clearly documenting assumptions and variable definitions. C2. Perform qualitative and quantitative analysis of models, including stability analysis, phase-portrait sketching, parameter estimation, and sensitivity analysis. C3. Implement models using computational software (MATLAB/Python) to generate numerical solutions, simulations, and data visualizations. C4. Validate models against empirical data or known theoretical benchmarks, and refine model structures when predictions deviate from observations. C5. Communicate complex mathematical ideas and modeling results effectively through written technical reports and oral presentations, adapting the level of detail for both specialist and general audiences.

Mindset	◆ Understand the importance and necessity of teamwork. ◆ Demonstrate Students' pride in their country and nation. ◆ Realize the loyal purpose of serving the people ◆ Apply logic and critical thinking in the process of decision making.
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Website Source

Teaching Methods

This course contains lectures, class discussions, homework, quizzes, presentation and exams. Textbook content will be introduced first. Then real case and practice questions will be delivered to students as a way to test their understanding of the knowledge. This will require individual or group assignment in or after class.

Grade Criterion

Component	Weight	Description
Final Exam	20%	A cumulative final examination will be given based on all the contents of the class. The exam paper may be composed of multiple-choice questions, short answer questions, essay questions. Students should rely primarily on homework assignments and class exercise as reference for exams.
Mid-Term Test	20%	A cumulative midterm test will be given based on all the contents that have been taught in class. The content shows the results of the intermediate nodes of the project. It should be completed within 50 minutes in class.
Homework	10%	Most of the assigned homework is taken from the Exercises in the textbook. Assignments will be collected at the clearly stated date. Late assignments will not be accepted. In general, each assignment should be complete in appropriate software and submit by Xuexitong(学习通) App. The graded will be published on the app.
Quizzes	10%	There will be at least 2 quizzes during the semester. It may also be used to check the attendance. Quizzes will test your theoretical knowledge and application ability.
Presentation	20%	The students will be divided into several groups to prepare a presentation. Each student is required to be involved in the presentation. Each member of the group will receive the group grade with certain weight of his/her contribution. Each group need to finish a code or report of the project, which is given and hand in the related resources to the teacher before the presentation.

Participation	10%	Individuals will be asked to participate individually in question and answer at least 10 times during the semester. The performances should be counted in their participation.
Attendance	10%	Refer to attendance policy listed below.
Total	100%	

Detailed Grade Computation

	Before Midterm	After Midterm
Attendance	5%	5%
Participation	5%	5%
Homework	5%	10%
Quizzes	5%	10%
Presentation		10%
Mid-Term Test	20%	
Final exam		20%
Total	40%	60%

Assessment of Student Performance

☞ Self-Study and Reading ability Practice

Instructor will give out the chapters or the reference books to read and use class hours to have discussion; students should be able to show a proactive attitude and ability for self-study and reading. Knowledge and oral English will be elements of homework or presentation score.

☞ Homework

Students should finish their homework by themselves. Copying from others will be treated as cheating and the homework scores will be lowered. Students should hand in all assignments on time. Late assignments will be accepted at the discretion of the instructor (i.e., when the student was ill or had an excused absence). Late assignments without reasonable proof will be reduced in score by 50%.

☞ Attendance

Because the course covers a great deal of material, attending every class session is very important for performing well.

- ♦ Being late for 15 minutes or more is considered an absence.
- ♦ Five hours or above of unexcused absences will result in the lower level of the final grade by one grade band (e.g. from C – to D +). Any excused absence must be discussed directly with the teacher.
- ♦ Absence which is more than 1/3 of the total teaching hours will cause an F (a failing grade) directly. but students are welcome to continue attending classes.
- ♦ An incomplete grade (I) will be considered in case of medical or family emergencies.

☞ Participation

- ♦ Students should participate in classes actively. Half of participation grade is determined by their presentation in class. They are encouraged to ask questions relevant to the subject and express their own opinions. Every student should respect the ideas, opinions, and questions of their classmates.

- Students should also use office hours to ask questions or talk with the instructor for good communication and effective learning.
- Frequent visiting the instructor and chatting in English during office hours is highly recommended.
- Any misbehavior and non-class related activities in class will result in the lower level of the participation grade, including ringing cell phones.
- All above behaviors will be solely evaluated by the instructor for scoring.

Textbook

Students must bring the textbook to class.

Topical Course Outline (original)

Week	Date Range	Topic & Content	Teaching Format	Key Activities / Deliverables
1	Week 1	Introduction to Mathematical Modeling • What is a model? The modeling cycle (Formulate → Solve → Validate → Refine) • Types of models: discrete vs. continuous, deterministic vs. stochastic • Examples: compound interest, free-fall motion, basic population estimates	Lecture + Discussion	Syllabus review; Ice-breaker: "Model the queue at the cafeteria"
2	Week 2	Dimensional Analysis & Scaling • Units and dimensions; the Buckingham Pi Theorem (intuitive version) • Scaling variables to simplify equations • Example: Estimating the energy of an atomic bomb blast (G.I. Taylor), terminal velocity	Lecture + In-class Exercise	Worksheet: Derive dimensionless groups for a pendulum
3	Week 3	Modeling with First-Order ODEs • Exponential growth & decay; the logistic equation • Mixing problems; Newton's law of cooling • Solving separable and linear first-order ODEs (review)	Lecture + Demo	Hand-in: Solve and sketch solutions for a cooling coffee model
4	Week 4	Modeling with Second-Order ODEs • Harmonic oscillators: mass-spring-damper systems	Lecture + Computer Demo	MATLAB/Python demo: Visualizing predator-prey trajectories

Week	Date Range	Topic & Content	Teaching Format	Key Activities / Deliverables
		- The predator-prey (Lotka-Volterra) model: setup and interpretation - Qualitative behavior: oscillations, equilibria		
5	—	National Day Holiday — No Class	—	—
6	Week 6	Stability and Phase-Line Analysis (Lightweight) - Equilibrium points on the phase line (1D systems) - Stability criteria: sink, source, node (without heavy linear algebra) - Bifurcation intuition: what happens when a parameter changes?	Lecture + Group Work	In-class group challenge: "Predict the fish population collapse"
7	Week 7	Optimization Modeling Basics - Formulating optimization problems: objective function, constraints - Linear programming introduction (graphical method for 2 variables) - Simple real-world cases: diet problem, production scheduling	Lecture + Workshop	Mini-assignment: Set up an LP for a simple business scenario
8	Week 8	Probability & Monte Carlo Simulation - Random variables and distributions in modeling (uniform, normal, exponential) - Introduction to Monte Carlo: estimating π and pricing random events - Law of large numbers in simulation	Lecture + Lab	Computer lab: Run a Monte Carlo simulation to estimate risk
9	Week 9	Midterm Examination	In-class Exam	Covers Weeks 1–8; Focus on formulation, basic analysis, and interpretation
10	Week 10	Discrete-Time Models Difference equations and recurrence relations	Lecture + Exercise	Spreadsheet exercise: Project a loan repayment

Week	Date Range	Topic & Content	Teaching Format	Key Activities / Deliverables
		- The discrete logistic map; chaos in simple systems (conceptual) - Fibonacci in nature; modeling with spreadsheets		schedule
11	Week 11	Graph & Network Models (Introduction) - Graphs, nodes, edges, adjacency matrices - Shortest path problem (Dijkstra's idea, intuitive) - PageRank concept: how does Google rank pages?	Lecture + Discussion	Group puzzle: Find the shortest delivery route on a campus map
12	Week 12	Data Fitting & Parameter Estimation - Least squares method: line of best fit - Fitting models to data: linearization techniques - Goodness of fit: R^2 and residual analysis (intuitive)	Lecture + Computer Lab	Lab: Fit a real dataset (e.g., COVID case data or temperature trends) to a chosen model
13	Week 13	Computational Tools & Simulation Practice - Hands-on session: Python/MATLAB for solving ODEs (ode45, scipy.integrate) - Visualizing solutions; parameter sensitivity via simulation - Debugging and validating simulation output	Computer Lab	Guided lab: Build and simulate your own ODE model from a template
14	Week 14	Model Validation, Sensitivity & Ethics - Sensitivity analysis: "Which parameter matters most?" - Model validation: comparing prediction to reality - Limitations of models; overfitting; ethical considerations in modeling (e.g., algorithmic bias, pandemic predictions)	Lecture + Case Study	Case study discussion: "When models fail: The 2008 financial crisis"
15	Week 15	Interdisciplinary Case Studies Walking through 2–3 complete	Lecture + Q&A	Reading assignment: One-page summary of a

Week	Date Range	Topic & Content	Teaching Format	Key Activities / Deliverables
		modeling stories from different fields (e.g., Biology: epidemic SIR; Engineering: bridge vibration; Economics: market equilibrium) • How to read a modeling paper as a sophomore		provided modeling paper
16	Week 16	Group Presentations & Course Wrap-up • Student teams present their semester modeling projects (15–20 min each) • Peer Q&A and feedback • Course review: What did we learn? Where to go next (advanced courses)?	Student Presentations	Final Deliverable: Group Presentation + Short Written Report

Note: In the first three weeks, Tencent Meeting, Mosoteach and the Wechat group will be used as the main teaching methods. The Wechat group will be mainly used to inform the students' daily study activities and tasks. Tencent Meeting and Mosoteach will be used as the main study platform to teach and organize the study activities. When classes change back to school, Tencent Meeting will be stopped to use. Mosoteach will be mainly used to upload PPTS and release some learning materials.

Some chapters or sections may leave for self-study; this is the students' duty to learn and understand, they may also be included in the quizzes or exams. A review in Chinese may be held during L.C. and O.H. in the semester.

Teacher's Office Hour

- The instructor's office hour is shown in the front of the office door.
- Students are suggested to use the instructor's office hour and learning center to ask questions or talk with the instructor once at least per week for good communication and effective learning, which is recorded in the students' participation.
- The time can be scheduled by instructors or students, or both.

Cheating and Plagiarism

Cheating is not tolerated. Any student caught cheating on a quiz; test or exam will be given a mark of zero (0) for the particular work. At the beginning of the semester the definition of plagiarism will be carefully explained, when any thoughts or writings of another person are used, they must be clearly identified (usually one uses quotation marks) and the source notes. **If any student is caught cheating on any homework assignment, the highest score the student can earn in that course is a "C".**

Important Dates

Midterm Test	Week 7
Final Exam	Week 17 (Refer to the notice of the Academic Affairs Office)



Note: This syllabus is tentative and may be changed or modified throughout the semester. All students will be notified and a new syllabus will be given.

Instructor: Meng Li

Department Head: Jingning Li

