BIEN/CENG 2310
MODELING FOR CHEMICAL AND BIOLOGICAL ENGINEERING

HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY, FALL 2024

COURSE SYLLABUS

INSTRUCTOR

Prof. Henry H. N. LAM (Rm 4561, 2358-7133, kehlam@ust.hk)

TEACHING ASSISTANTS

Mr. James LI (hwliae@connect.ust.hk)
Ms. Francis WU (xwucd@connect.ust.hk)

COURSE WEBSITE

http://canvas.ust.hk/courses/58098/

COURSE DESCRIPTION

BIEN/CENG 2310 is intended to lay the foundation for upper-level engineering courses in chemical and biological engineering by providing students with the mathematical toolkit to model engineering problems. Mathematical modeling is necessary for students to apply their understanding of physical laws and principles to processes or phenomena of interest in engineering applications, namely, to convert such abstract concepts into a mathematical problem that they can solve.

While the course will cover some topics in differential equations, the approach will be different from a typical mathematics-focused course on differential equations, which emphasizes more on mathematical concepts and equation solving techniques. Instead, students will be taught to consider real-life processes (physical, chemical, biological or engineering), make necessary assumptions, and put their conceptual understanding into equation form. Then, they will also be taught to solve the equations, analytically or more often numerically, and then appreciate the significance and limitation of the solution with respect to the real-life process they seek to model. In the second half of the course students will also learn some basic concepts in statistics and probabilities, and their application to modeling. Students will also learn to solve initial and boundary value problems using computer tools such as Excel, Python or MATLAB, as in the workplace.

EXPECTED LEARNING OUTCOMES

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

- Model simple physical, chemical and biological processes as mathematical equations
- Develop and interpret differential equations in initial and boundary value problems
- Solve ordinary differential equations analytical and/or numerically
- Describe elementary concepts in statistics and perform simple hypothesis testing and regression analysis
- Use computing tools for engineering calculations

COURSE REQUIREMENTS

ONLINE VIDEOS AND QUIZZES

This course is taught in the "flipped classroom" mode. Lecture videos are made available online and organized in modules on Canvas. Students are required to watch the videos ***before*** they come to the first lecture of the module, and complete a short online quiz about the videos on Canvas.

LECTURES AND TUTORIALS

Monday 4:30 – 6:50pm, and Fridays, 12:00 – 1:20pm, in Rm 4402 (Note that the scheduled tutorial time on Monday is used for the same purpose.) Students are *expected to attend all classes*, unless otherwise stated. The class time will be used for worked examples, live programming demos, Q&As, and guided homework. Active participation in class is expected.

HOMEWORK

There will be 5 homework assignments, most including MATLAB programming exercises. Students are expected to *work on their homework during class*, under the guidance and supervision of the instructors. Discussion in small groups is allowed and encouraged, but the assignment is submitted individually.

EXAMS

There will be 3 short exams (each about 1 hour long) on Oct. 8, Oct. 30 and Nov. 30 (tentatively) in the evenings at 7:30pm. The exam will contain hand calculations and MATLAB programming questions. For the purpose of computing the final grade, the worst score among the 3 short exams will be half-weighted. There will not be a final exam during the exam period.

PROJECT

Students, in teams of two, will complete a project in mathematical modeling, on a real-life phenomenon of their own choosing, with support from the instructors. The project requirements will be released in early November. The final deliverables of the project will be due during the final exam period.

COMPUTER USE

MATLAB programming is featured heavily in this course. Students are expected to use MATLAB during the interactive class time, to follow the live demos as well as to complete the homework assignment. In the classroom, there will be ~40 desktop computers with MATLAB

installed, *available on a first-come-first-serve basis*. You can also access MATLAB through the Virtual Barn environment of HKUST from your own computer. Since the computation is done remotely, your computer would only need a reliable internet connection.

GRADING POLICY

The final grade will be awarded based on performance in the following categories, with weights in parentheses:

Class participation (5%)

Online quizzes (10%)

Homework (25%)

Short exams (35%)

Project (25%)

Class participation is graded subjectively by the teaching team based on your participation in class.

ACADEMIC INTEGRITY

Please be informed of the University's policy on academic integrity, which can be found here:

https://registry.hkust.edu.hk/resource-library/regulations-student-conduct-and-academic-integrity

In this course, violation of academic integrity includes (i) cheating in examinations, (ii) copying homework from other students or from homework solutions in past offerings of the course, and (iii) claiming credit for work that you have not done, for instance, by downloading MATLAB code from the internet and using it as your own without proper citation.

In this course, learning takes place mainly through the homework. Although peer learning is encouraged, special care will be given to detect plagiarism in homework assignments. Students may be called on to explain their work (e.g. MATLAB code) if plagiarism is suspected. Failing to do so adequately will result in penalty. Depending on severity, penalties may include point deductions, a zero score for the affected homework, and referral to the University for disciplinary actions prescribed under the University's policy on academic integrity.

TENTATIVE COURSE SCHEDULE

Module	Topic	Session	Date	Remarks
1	Course overview / Introduction to modeling	**1**	2/9 (Mon)	
2	Balance equations / First-order ODEs	**2**	6/9 (Fri)	
		3	9/9 (Mon)	
3	Vectors and matrices / Introduction to MATLAB	**1**	13/9 (Fri)	
		2	16/9 (Mon)	
		3	20/9 (Fri)	HW1 due 11:59pm
4	Population dynamics / Systems of ordinary differential equations	**1**	23/9 (Mon)	
		2	27/9 (Fri)	
		3	30/9 (Mon)	
5	Chemical kinetics	**1**	4/10 (Fri)	
		2	7/10 (Mon)	HW2 due 11:59pm
			8/10 (Tue)	**Exam 1 (7:30pm)**
			11/10 (Fri)	*NO CLASS – Chung Yeung Festival*
6	Second-order ODEs	**1**	14/10 (Mon)	
		2	18/10 (Fri)	
		3	21/10 (Mon)	
7	Transport phenomena / Partial differential equations	**1**	25/10 (Fri)	
		2	28/10 (Mon)	HW3 due 11:59pm
			29/10 (Tue)	**Exam 2 (7:30pm)**
9	Introduction to statistics / Stochastic modeling	**1**	1/11 (Fri)	Project requirement released
		2	4/11 (Mon)	
		3	8/11 (Fri)	
10	Regression / Parameter estimation	**1**	11/11 (Mon)	
		2	15/11 (Fri)	HW4 due 11:59pm
		3	18/11 (Mon)	**Project abstract due**
11	Inferential statistics / Model validation	**1**	22/11 (Fri)	
		2	25/11 (Mon)	
		3	29/11 (Fri)	HW5 due 11:59pm
			30/11 (Sat)	**Exam 3 (7:30pm)**
			20/12 (Fri)	**Project due**

Note: The schedule is subject to revision throughout the semester. Updated schedules will be announced and posted on the course website.