BME 260L: Modeling Cellular and Molecular Systems

I. Introduction and Classroom Culture

Welcome to BME260L for the Fall 2025 semester! This undergraduate course introduces essential modeling tools to help you represent, analyze, and interpret biological systems across molecular, cellular, and physiological scales. You'll build a foundation in applying conservation laws, thermodynamics, and kinetics to real-world bioengineering challenges while developing transferable skills in model development, literature analysis, and collaborative problem solving. BME260L prepares you for advanced coursework in biomedical engineering, especially in molecular, cellular, and tissue engineering, by equipping you with a shared modeling language and a mindset for systems thinking. Our classroom values curiosity, inclusivity, and teamwork—we're excited to support your growth throughout the semester. Please reach out to us, the TAs, or your peers anytime during this journey!

Day/time of course meetings:

Dates: 8/25/25-12/5/25
Lecture Time: TTh 8:30-9:45 am
Discussion Time: M 1:25-4:25 pm or 3:05-6:05 pm (We will meet from 3:05-4:25 pm in Weeks 1-4 as a shared discussion section)
Location: Wilkinson 126

Academic credit:

Undergraduate, 1 unit, graded

Course format:

Lecture + Discussion

N.B. We won't go this long each week, these times are staggered to allow for PBL team formation and mentor sessions.

Instructor Information

Instructors:
Prof. Cameron Kim (he/him)
Assistant Professor of the Practice in BME
Email: cameron.kim@duke.edu
Office Hours: Wednesdays 1:00-2:30pm in Hudson Annex 176 and by appointment

About me: I am an assistant professor of the practice in the Duke BME department joining in 2020 after finishing my PhD in Bioengineering at Stanford. I am returning to Duke having completed my undergraduate degrees in BME and Math in 2014. My research experiences have been in mammalian synthetic biology, CRISPR/Cas9 genome engineering, and alternative splicing regulation using synthetic RNA molecules. I am currently researching strategies to incorporate ethics-guided design into bioengineering courses and best practices to train the next generation of BME educators. I have recently started research projects on character formation in engineers, with a focus on how curiosity, intellectual humility, and ethical knowledge corresponds to innovation in design and a promotion of public welfare. I am the faculty advisor of the Duke iGEM team and Out in STEM (oSTEM) and I am also the Associate Director of Undergraduate Studies for the BME department, where I am dedicated to supporting our students' academic journeys. I joined the Duke Science & Society Initiative as an associate faculty member in 2023 and currently serve on the External Review of Environmental, Biosafety, and Biosecurity Considerations for Synthetic Cell Research and Development sponsored by the National Academies of Science, Engineering, and Medicine. In my free time, I have played curling competitively for the past 10 years, I am the father to two cats named Archie and Rocky and have been working on my mixology game!

Prof. John Hickey (he/him)
Assistant Professor in BME
Email: john.hickey@duke.edu
Office Hours: Tuesdays 10-11 am in Wilkinson 305

About me: I am an Assistant Professor in the Biomedical Engineering Department with secondary appointments in the Cell Biology and Biostatistics & Bioinformatics Departments of the School of Medicine. I started in January 2024. My research is at the forefront of using and developing systems biology tools to analyze spatial relationships among cells in tissues. I particularly focus on cancer and cellular therapeutic applications within my own lab, though I collaborate broadly. Four pillars of projects include spatial-omics of human tissues (healthy & diseased), computational algorithm development (bioinformatics, machine learning, mechanistic modeling), single cell technology development, and improving cell therapies for cancer. You can learn more about our research here: https://sites.google.com/view/john-w-hickey/ I thoroughly enjoy teaching and have developed and taught several courses including Immunoengineering, Immunoengineering for the developing world, and Spatial-omics. Besides my love for research, teaching, and mentoring, I love to coach my children's sports teams, cook and travel with my wife, and absorb any knowledge I can.

Syllabus Contents

Teaching Assistants and Guest Lecturers

We are extremely fortunate to have a dedicated team of guest lecturers and teaching assistants supporting our course. Their expertise and commitment to education are invaluable assets that greatly enhance your overall learning experience. Below, you'll find their contact information, and a bit of information about them.

Teaching Assistants

Kinshuk Sahu (he/him) Email: kinshuk.sahu@duke.edu
PhD Candidate in BME Office Hours: TBD OH HOURS
About me: I am a fourth year PhD student in Lingchong You's lab, and am working on building a mechanistic modeling-guided deep learning framework for bacterial colony pattern generation, focusing on *Pseudomonas aeruginosa*, an opportunistic pathogen which forms interesting branching patterns. In my free time, I like to explore good hiking trails in and around Durham/NC in general or playing board and computer games with friends!

Ashwini Shende (she/her) Email: ashwini.shende@duke.edu
PhD Candidate in BME Office Hours: TBD OH HOURS
About me: I am a third year PhD student in Dr. Lingchong You's lab in the BME department. My research focuses on horizontal gene transfer in microbial communities and its effects on antibiotic resistance. In my free time, I enjoy running, playing volleyball, watching movies, and trying new foods!

Guest Speakers (List TBD)

Dr. Richard Eva (he/him) Email: rich.eva@duke.edu
Executive Director of Pratt Character Forward Initiative
About me:

Cloe Liparini, MA (she/her) Email: cloe.liparini@duke.edu
Executive Director of Diversity, Equity, Inclusion & Community
About me:

II. Course Overview

What is this course about? This course focuses on developing models to study and interpret biological systems, enhancing our understanding of complex phenomena and our ability to address bioengineering challenges. By applying principles in mathematical modeling and conservation laws, we accurately represent these systems across various media. Throughout the course, you will learn to analyze assumptions, data, and constraints that affect our interpretation of these systems and facilitate the quantitative description of experimental or simulation findings. We will also provide you with a modeling language for representing mass and energy in various forms, with a special emphasis on cellular, molecular, and biochemical systems, which can be extended to model any biological entity.

This course introduces mathematical modeling concepts applied to study cellular and molecular processes in biological systems, incorporating foundational principles from engineering, physics, and chemistry. Topics covered include conservation of mass/energy, accounting equations for extensive properties, biological thermodynamics, chemical equilibrium and kinetics, enzyme kinetics, formulating open-ended questions in bioengineering, and solving complex problems using analytical and computational methods. We will explore applications in analyzing novel biotechnologies, predicting molecular phenomena, studying human physiology, modeling genetic regulation, and

effectively communicating solutions and findings through mathematical models developed in this course.

Collaboratively solving open-ended modeling problems in both small and large teams is a fundamental aspect of biomedical engineering and this course. We will explore computational frameworks for analyzing biomedical systems and practice presenting model findings through written and oral formats. This course also emphasizes the development of essential skills in teamwork, communication, and organization.

BME260L is a required gateway course for various BME Area Cores, especially the Molecular and Cellular Engineering (MC) core. It will prepare you for advanced courses in drug design, transport phenomena, drug delivery, quantitative physiology, and protein engineering.

Background Knowledge

What should I know before taking this course?

Prerequisite knowledge of general chemistry (Chem 101DL/110DL), molecular and cell biology (Biology 201L/203L) and solving linear systems and differential equations (Math 218D-2) will be important to succeed in this course. Computational modeling and data analysis with Python (EGR 103L/105L) will also be used for problem-based learning and problem sets, which we will cover in discussions, problem-based learning modules, and video lectures. We will also discuss varying aspects of human physiology (BME 244L) that must be taken at the same time or prior to this course.

Course Objectives

What will I learn in this course?

In this course, you will engage actively and upon successful completion, you will:

1. Apply the conservation laws of mass and energy to bioengineering systems.
2. Perform kinetic analysis of reactions (chemical and enzymatic) and establish reaction networks in biological systems.
3. Develop conceptual models and abstract into mathematical models that accurately represent biological systems (tissue, cellular, and molecular scale) using computational analysis.
4. Interpret data and parameters from biochemical and living systems based on primary literature.
5. Work collaboratively on a team to solve engineering problems and present their solutions through oral presentation and written reports.
6. Employ metacognitive strategies to improve learning, including spaced repetition and growth mindset.
7. Reflect on your personal growth as a biomedical engineer, especially in the domains of intellectual curiosity and intellectual humility.

Course Outcomes

What should I be able to do after completing this course?

After completing this course, you should be able to:

1. State the accounting and conservation equation and identify the extensive properties that are conserved in a variety of biological systems.
2. Clearly define and apply system definitions, including open, closed, isolated, steady-state, dynamic, reacting, and non-reacting.
3. Apply total and species mass balance equations to engineering systems, including those characterized as open, dynamic, reacting, multicomponent, and multi-unit.

4. Apply kinetic rate law equations to analyze zero-, first- and second-order systems, including enzyme-mediated and receptor-ligand systems.
5. State the laws of thermodynamics and analyze energy balances in biochemical applications, including those characterized as spontaneous, endo-/exothermic, and at equilibrium.
6. Mathematically model systems with Python (population, tissue, cellular, and molecular scales) using engineering principles in design and analysis.
7. Define project goals, team norms, and management strategies on a project team.
8. Write and orally present mathematical models and their numerical results to a lay audience and to an academic/scientific audience.

Course Structure

What will I do in this course? In-class time is divided among lecture periods and discussion sections. Our lecture time will be used to review content from preview modules, introduce new content that extends from the textbook and current events, and practice problem solving in small groups using various active learning strategies. We will also introduce open-ended problem-based learning during lectures and discussions to prepare for team projects in the semester. Students will work independently and in small groups during lectures and discussions to accomplish learning goals during the semester, including demonstrating mastery of concepts that will replace midterm assessments. Discussion sections will be dedicated to team building, working with TAs on project-based learning problems, presenting results, and completing mastery problem quizzes.

Lectures and Pre-Lecture Videos

- Content: Lectures are designed to introduce new concepts, practice problem solving, and reinforce ideas from pre-lecture videos. They will also provide opportunities to clarify concepts, engage in small-group activities, and deepen understanding through discussion. Textbook readings will supplement learning both before class and during study sessions. Participation, respectful discussion, and collaboration with classmates will be essential to your success in the course.
- Pre-Lecture Videos: Pre-lecture videos will be released each Thursday, building into weekend homework. These interactive 15-minute previews will cover foundational principles, definitions, and examples for lecture. Video concepts will be included in homework, and you are expected to use this knowledge to support problem-solving.
- Problem Solving Studios: On designated days, lectures will be devoted to Problem Solving Studios—sessions focused on active practice, open-ended problem tackling, and collaborative teamwork. These studios are critical for mastering course content, as they allow you to apply concepts, explore multiple solution approaches, and receive feedback from peers and instructors in real time. Active participation is expected and valued.
- Mastery Problems: In lieu of exams, individual mastery problems will be assigned approximately every 3 weeks. These will include 1–2 open-ended problem-solving exercises graded for accuracy and problem set-up, along with terminology and conceptual understanding. In some cases, you will create original problems or write detailed solutions. The Duke Community Standard applies to all mastery problems, and academic dishonesty will not be tolerated.
- Attendance: Regular attendance is vital. Please inform Dr. Kim and Dr. Hickey of any planned absences.

Discussion and Problem-Based Learning (PBL) Projects

- Content: Discussion sections will center on Problem-Based Learning (PBL)—an approach that engages you with ill-structured, open-ended, and complex modeling problems grounded in molecular, cellular, and physiological phenomena. These problems require higher-order thinking, creativity, and integration of technical and conceptual knowledge. You will work in

teams to formulate modeling questions, research primary literature, develop and refine models, and communicate findings both in written reports and oral presentations, while critically evaluating the strengths and weaknesses of your approach.

- PBL#0: Early discussion meetings will guide you through key skills for PBL success: framing effective modeling questions, finding and using primary literature, and working collaboratively to develop a defensible model. We will discuss the process of tackling such problems and reflect on teamwork and deliverables.
- PBL structure: PBL#1 focuses on mass balance modeling, building foundational skills in constructing and analyzing quantitative models. PBL#2 involves more complex modeling with kinetics and higher-order reasoning, challenging you to integrate multiple concepts and modeling strategies. In both problems, your team will prepare a written report and oral presentations that communicate your models and significant findings.
- Expectations Outside of Class: While discussion time will be used for instructor guidance and in-class collaboration, significant out-of-class teamwork will be required, especially for refining models, writing reports, and preparing oral presentations. Successful completion of PBL projects will depend on active engagement both inside and outside scheduled class time.

Homeworks

- Overview: Homeworks will follow a regular schedule after most lecture sessions to build spaced repetition into your learning process. Assignments will reinforce concepts from lectures, pre-lecture videos, and problem-solving sessions, ensuring frequent practice and review.
- Format: Each homework will be similar in length and scope, combining conceptual questions, problem-solving exercises, and at least one Python-based problem for data analysis, model simulation, or solution generation per week. As a class, we will collectively decide on the submission time early in the semester.
- Collaboration & Academic Integrity: You are encouraged to collaborate with classmates and seek help from the instructor or TAs during office hours. However, all submitted work must be your own. If you work in study groups, you must annotate any help received and from whom in your submission.
- Grading Policies: To account for unexpected conflicts, **you may drop two homework assignments** for any reason during the semester. Given the regularity and balanced weighting of assignments, **no late submissions will be accepted**. Religious, athletic, and academic accommodations will be honored with prior planning--please email Dr. Kim and Dr. Hickey at least 24 hours before the deadline to request an extension.

III. Grading

How will my grade be determined?

The following table lists the assignments and their weight in the overall grade:

Grading Category	Learning Objectives	Grade %	Ownership
Homeworks (~20) Graded for accuracy and completion, based on the nature of the assignment	1, 2, 3, 4	30%	
Mastery Problems (5) Graded for accuracy and completeness of final answers	1, 2, 5	15%	
Class Engagement and Attendance Self and Instructor-evaluated	1, 2, 5	10%	
PBL #0 (individual) Individual assignments graded for completion, peer review comments, and mini-presentation	1, 3, 4	5%	Individual Grades
PBL #1 (written and oral) Oral and written rubrics provided with CATME for peer and self-evaluation	1, 3, 4, 5	20%	
PBL #1 (written and oral) Oral and written rubrics provided with CATME for peer and self-evaluation	1, 2, 3, 4, 5	20%	Group Grades
Total		100%	

This course is not "curved" (i.e., a distribution of grades will not be enforced), and a traditional grading scheme will be used (e.g., 90-93.00 = A-, 93.01-97.00 = A, 97.01-100 = A+). All grades will be posted to Canvas throughout the semester to track your performance. Any re-grading requests need to be made within one week of grades for a given assignment being returned, with a description of why you feel a re-grade is appropriate.

IV. Course Expectations

What should I know about this class to prepare for success?

Expected Individual Workload

We have developed this class to provide as much flexibility for students to review content on their own schedules with pre-lecture videos, lead time for mastery problems, content quizzes, and problem sets, plus ample time to work on PBLs in groups during discussions. Please know that the teaching team is here to assist you if you have any challenges accessing materials. We have an anonymous feedback form that students can fill out at any time and will be reviewed within 24 hours upon receipt.

We have developed the course to reduce the high-stakes nature of assignments and exams by distributing quizzes, homeworks, mastery problems, and projects (and their grades) throughout the

semester. Your active engagement with all assignments, lectures, and projects will help you succeed in this course and will provide significant practice to excel on course material. Attendance will be important to practice problem solving and complete mastery problems for your grade. If, however, you find yourself struggling to complete assignments or find their lengths to be excessive, please let us know and we can adjust.

To prepare for this class, we recommend that students actively engage with pre-lecture videos, problem sets, and PBL team members to understand material and practice problem solving. The textbooks are meant to guide you with materials and have ample practice problems with step-by-step solutions and should also be referenced to assist with learning. We also recommend that students work together in groups (virtual or in-person) to solve problems, but all work submitted must be your own work. If you participate in study groups, please annotate what help you received and from whom.

Texts, Materials, and Technologies

There are two textbooks that we will use for this course:

- Bioengineering Fundamentals, 2nd edition, A. Saterbak, L.V. McIntire and K.-Y. San, Pearson Prentice Hall, 2018, ISBN 9780134637433.
    - Chapters 1 and 2 are available on Canvas>Files.
    - I will reference excerpts of Chapters 3 and 4 as needed
- Physical Chemistry: Principles and Applications in Biological Sciences, 5th edition, I. Tinico, et al; Pearson, 2014, ISBN 9780136056065.
    - Chapters 9 and 10 are available on Canvas>Files.
    - I will reference excerpts of Chapters 2-4 as needed

If you are having difficulty with textbooks and supply costs associated with this course, contact the financial aid office (whether or not you are on aid) to receive aid or a loan.

There are additional textbooks and online resources that we recommend that may supplement your learning or extend your knowledge if you're interested in the material from this course:

- Molecular Biology of the Cell, 6th edition, B. Alberts et al. is a fantastic resource for molecular and cell biology review.
- The Molecules of Life, Kuriyan, B. Konforti, and D. Wemmer extends on concepts from physical chemistry with a biology lens.
- Guyton and Hall Textbook of Medical Physiology, J. Hall and M. Hall provides an excellent resource on physiology for biomedical engineers

We will use Canvas for the course to share lecture videos, problem sets, and resources for this course. All pre-lecture quizzes will be submitted via Canvas and problem sets will be submitted via Gradescope. If students find it useful, we will also create an EdDiscussion page for the class to discuss problem sets and course material.

We will be reviewing primary literature throughout the problem-based learning modules, so access to Duke Library and Pubmed will be discussed during this class. You will want to bring your laptop or tablets to classes for these days when we perform literature searches for projects.

For immediate assistance with learning technologies, system errors/outages, or your NetID account and password, contact the OIT Service Desk.

V. Communication Expectations

Most communications in this course will occur over Canvas, including emails, announcements, and reporting grades. Please actively visit Canvas on a regular basis for announcements and any potential changes to meetings, due dates, or syllabus updates.

Office hours are provided to discuss course material, problem sets, and projects in a group setting. If you wish to speak with the instruction team about other matters, please send us an email and we can set up a time to chat one-on-one. We want to assist you in your journey as Duke biomedical engineers!

You are invited to provide feedback on this course, either anonymously or directly to instruction staff. Our emails are provided, or you can email us to request a one-on-one meeting. Please allow us 24 hours to respond to your email. If you wish to provide anonymous feedback, you may use this Qualtrics survey.Links to an external site.

Grades and formal assessments will be posted on Canvas. Please ensure you are familiar with navigating Canvas to access your grades and course materials.

Response Time

Students should anticipate varied response times, as instructors and TAs will prioritize questions asked during normal working hours. We will do our best to respond to items of importance within 24 hours of receipt.

VI. Course Policies

Academic Integrity

As a student, you should abide by the academic honesty standard of the Duke University. Its Community Standard states: Duke University is a community dedicated to scholarship, leadership, and service and to the principles of honesty, fairness, respect, and accountability. Citizens of this community commit to reflect upon and uphold these principles in all academic and nonacademic endeavors, and to protect and promote a culture of integrity.

To uphold the Duke Community Standard:

- I will not lie, cheat, or steal in my academic endeavors;
- I will conduct myself honorably in all my endeavors; and
- I will act if the Standard is compromised.

Academic Policy & Procedures

You are responsible for knowing and adhering to academic policy and procedures as published by the Office of Student Conduct. Please note, an incident of behavioral infraction or academic dishonesty (cheating on a test, plagiarizing, etc.) will result in immediate action from me, in consultation with university administration (e.g., Dean of Undergraduate Studies, Student Conduct, Academic Advising).

Academic Accommodations

If you need to request accommodation for a disability, you need to contact the disabilities management office. I will work with that office to provide you with equal access to course materials and make accommodations for exams and other assessments.

Discussion Guidelines

Civility is an essential ingredient for academic discourse. Differences in beliefs, opinions, and approaches are to be expected. Active interaction with peers and your instructor is essential to success in this course, so please adhere to these guidelines:

- Respect that others' opinions and beliefs may differ from your own. If you disagree, you may critique the idea, but not the person.
- Listen carefully, be courteous and don't interrupt.
- Support your statements with evidence and a rationale.
- Try to moderate how you contribute to the discussion – if you have a lot to say, try to avoid dominating the conversation; if you are reluctant to speak up, try to find an opportunity to share your perspective.

We will establish a set of classroom norms during this semester and expect all students to abide by this agreement. Please bring any communications you believe to be in violation of this class policy to the attention of your instructor.

Respect for diversity

It is our intent that students from all diverse backgrounds and perspectives be well served by this course, that students' learning needs be addressed both in and out of class, and that the diversity that students bring to this class be viewed as a resource, strength and benefit. It is our intent to present materials and activities that are respectful of diversity: gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture. Your suggestions are encouraged and appreciated. Please let me know ways to improve the effectiveness of the course for you personally or for other students or student groups. In addition, if any of our class meetings conflict with your religious events, please let me know so that we can make arrangements for you.

Providing Feedback

You are invited to provide feedback on this course, either anonymously or directly to instruction staff. Our emails are provided or you can email us to request a one-on-one meeting. Please allow us 24 hours to respond to your email. If you wish to provide anonymous feedback, you may use this Qualtrics survey. This feedback form is reviewed as comments come in.

Policies on the use of Artificial Intelligence (AI) in the course

The emergence of generative AI tools (such as ChatGPT and DALL-E) has sparked interest among many students in our discipline. The use of these tools for brainstorming ideas, exploring possible responses to questions or problems, and creative engagement with the materials may be useful for you as you craft responses to class assignments. While there is no substitute for working directly with your instructor, the potential for generative AI tools to provide automatic feedback, assistive technology and language assistance is clearly developing.

We will establish a unified course policy for the use of generative AI this semester, but these are some highlights of DOs and DO NOTs:

Do's

- Use generative AI to brainstorm project ideas, report outlines, and simple coding skeletons
- Use generative AI to debug code, identify sources of error, and refine coding of figures for improved clarity and better visualization
- Use generative AI to proofread project and presentation text for clarity, conciseness, and understanding

Do Not's

- Use generative AI on solutions to homework questions, both quantitative problems and prompts that require curiosity-driven or reflective responses
- Use generative AI to write entire code bases associated with homework or projects
- Use generative AI to *de novo* write project reports

It is a violation of university policy to misrepresent work that you submit or exchange with your instructor by characterizing it as your own, such as submitting responses to assignments that do not acknowledge the use of generative AI tools. Students shall give credit to AI tools whenever used, even if only to generate ideas rather than usable text or illustrations. When using AI tools on assignments, add an appendix showing (a) the entire exchange, highlighting the most relevant sections; (b) a description of precisely which AI tools were used (e.g. ChatGPT private subscription version or DALL-E free version), (c) an explanation of how the AI tools were used (e.g. to generate ideas, turns of phrase, elements of text, long stretches of text, lines of argument, pieces of evidence, maps of the conceptual territory, illustrations of key concepts, etc.); (d) an account of why AI tools were used (e.g. to save time, to surmount writer's block, to stimulate thinking, to handle mounting stress, to clarify prose, to translate text, to experiment for fun, etc.).

Overall, AI tools should be used wisely and reflectively with an aim to deepen understanding of subject matter. Please feel free to reach out to me well in advance of the due date of assignments for which you may be using generative AI tools and I will be happy to discuss what is acceptable.

(Policy adapted from the University of Texas at Austin Center for Teaching and Learning)

Education Research Statement

Your instructor in this course is conducting research on teaching and learning. You are being asked to share your course data for this research project. A representative from the Kenan Institute for Ethics will send you a consent form through Qualtrics that describes what data you are being asked to share and how it will be used. Please read through the information provided there and indicate if you are willing to share your data.

Additional University Resources

What university resources can help me during this course?

Academic Advising and Student Support

Please consult with me about appropriate course preparation and readiness strategies, as needed. The Academic Resource Center (ARC) offers free services to all students (e.g., peer tutoring, learning consultations, ADHD/LD coaching, and help with online learning.

Consult your academic advisors on course performance (i.e., poor grades) and academic decisions (e.g., course changes, incompletes, withdrawals) to ensure you stay on track with degree and graduation requirements. Please speak with the Academic Advising Center for additional support.

Mental Health and Wellness Support

Student mental health and wellness is of primary importance at Duke, and the university offers resources to support students in managing daily stress and self-care. Duke offers several resources for students to seek assistance on coursework and to nurture daily habits that support overall well-being, some of which are listed below:

- The Academic Resource Center: (919) 684-5917, theARC@duke.edu, or arc.duke.edu,

- DuWell: (919) 681-8421, duwell@studentaffairs.duke.edu, or https://studentaffairs.duke.edu/duwell
  If your mental health concerns and/or stressful events negatively affect your daily emotional state, academic performance, or ability to participate in your daily activities, many resources are available to help you through difficult times. Duke encourages all students to access these resources.
- DukeReach: Provides comprehensive outreach services to identify and support students in managing all aspects of well-being. If you have concerns about a student's behavior or health visit the website for resources and assistance. http://studentaffairs.duke.edu/dukereach
- Counseling and Psychological Services (CAPS): CAPS services include individual, group, and couples counseling services, health coaching, psychiatric services, and workshops and discussions. (919) 660-1000. https://studentaffairs.duke.edu/caps
- Blue Devils Care: A convenient and cost-effective way for Duke students to receive 24/7 mental health support through TalkNow and scheduled counseling. bluedevilscare.duke.edu
- Two-Click Support: Duke Student Government and DukeReach partnership that connects students to help in just two clicks. https://bit.ly/TwoClickSupport

Attendance Policy Related to COVID Symptoms, Exposure, or Infection.

Student health, safety, and well-being are the university's top priorities. To help ensure your well-being and the well-being of those around you, please do not come to class if you have symptoms related to COVID-19, have had a known exposure to COVID-19, or have tested positive for COVID-19. If any of these situations apply to you, you must follow university guidance related to the ongoing COVID-19 pandemic and current health and safety protocols. If you are experiencing any COVID-19 symptoms, contact student health. 919-681-9355.

To keep the university community as safe and healthy as possible, you will be expected to follow these guidelines. Please reach out to me and your academic dean as soon as possible if you need to quarantine or isolate so that we can discuss arrangements for your continued participation in class.

Tentative Schedule

Below is a tentative schedule for the semester, which is subject to change. Lecture topics, assignments, and video lectures are included for your reference. A changelog is included in case of any changes, which will be alerted to the class with ample time.

Course Schedule

Week	Monday Discussion	Tuesday Lecture	Thursday Lecture	Video Lecture	Notes	Changelog
Week 1 (Aug 25 - Aug 28)	**Aug 25** The Five W's of Modeling (CK)	**Aug 26** Strategies for Model Building and Problem Solving (JH)	**Aug 28** Introduction to Problem-based Learning (PBL#0) (CK)	Variables Types and Dimensional Analysis	FWOC	
Week 2 (Sep 1 - Sep 4)	**Sep 1** NO CLASS-LABOR DAY	**Sep 2** How to build conceptual models (PBL#0) (JH)	**Sep 4** Fermi Estimation and Numerical Literacy *Problem-Solving Studio #0*	Defining Systems & Surroundings	Drop/add date September 5	
Week 3 (Sep 8 - Sep 11)	**Sep 8** Literature searching, review, and how to read a paper (CK & JH)	**Sep 9** Conservation, Steady State vs. Dynamics (CK)	**Sep 11** Establishing Systems *Problem-Solving Studio #1*	Intro to mass balance analysis		
Week 4 (Sep 15 - Sep 18)	**Sep 15** Solving differential equations in Python and Data Visualizations (JH)	**Sep 16** Principles of mass balance analysis in multi-component systems (CK)	**Sep 18** Continued, Mass Balance Analysis (JH) *Mastery Problem #1*	Reactions in mass balance & solving linear systems in Python		
Week 5 (Sep 22 - Sep 25)	**Sep 22** Writing, teaming, psychological safety Finish mass balance *Release PBL#1 topic*	**Sep 23** Reaction networks, stoichiometry, and modeling variation (JH)	**Sep 25** Dynamic modeling & Ethics in drug delivery systems (CK)	Rate Laws and Chemical Kinetics		
Week 6 (Sep 29 - Oct 2)	**Sep 29** PBL#1: TBA *Problem Definition, Understand Phenomena*	**Sep 30** Full-on Mass Balance Analysis *Problem Solving Studio #2*	**Oct 2** Chemical Kinetics review, series & parallel reactions (JH) *Mastery Problem #2*	Linear and Non-Linear Regression in Python		

Week 7 (Oct 6 - Oct 9)	**Oct 6** PBL#1: TBA *Simplify Phenomena, Conceptual Model to Math Model*	**Oct 7** Applying assumption in quasi-steady state/quasi-equilibrium (CK)	**Oct 9** *Pink Time* OR PBL#1 Work Time	Combining mass balance and dynamic reactions	BMES Annual Meeting in San Diego October 8-12	
Week 8 (Oct 13 - Oct 16)	**Oct 13** NO DISCUSSION-FALL BREAK	**Oct 14** NO LECTURE-FALL BREAK	**Oct 16** Data diving with kinetics Problem Solving Studio #3	Intro to Michaelis-Menten Kinetics		
Week 9 (Oct 20 - Oct 23)	**Oct 20** PBL#1: TBA *Solve mass balances, present data*	**Oct 21** Enzyme networks and inhibition #1 (CK)	Oct 23 PBL#1 Work Time *Mastery Problem #3*	No video lecture: Prepare for PBL #1 presentation		
Week 10 (Oct 27 - Oct 30)	**Oct 27** PBL#1: TBD *Presentations and reports due*	**Oct 28** Enzyme networks and inhibition #2 (JH)	**Oct 30** Clinical trials and side effects of drugs (JH)	Receptor-Ligand Binding	iGEM International Jamboree October 28-November 1	
Week 11 (Nov 3 - Nov 6)	**Nov 3** PBL#2: TBD *PBL#1 post-mortem Problem Definition, Understand Phenomena*	**Nov 4** Hill Kinetics and Cooperativity (CK)	**Nov 6** Gene expression modeling *Problem Solving Studio #4*	1st Law of Thermodynamics	Last day to withdraw from course with W code November 7	
Week 12 (Nov 10 - Nov 13)	**Nov 10** PBL#2: TBD *Simplify Phenomena, Conceptual Model*	**Nov 11** Applying enthalpy to energy balances and heat transfer (JH)	**Nov 13** Enthalpy and multi-step processes in fermentation (CK) *Mastery Problem #4 (take home w/ coding portion)*	2nd Law of Thermodynamics and Derivation of Free Energy		
Week 13 (Nov 17 - Nov 20)	**Nov 17** PBL#2: TBD Solve mass balances, present data	**Nov 18** Free energy and biochemical applications #1 (JH)	**Nov 20** Biochemical applications #2 (CK) *Problem Solving Studio #5*	Equilibrium modeling and acid-base chemistry		
Week 14 (Nov 24 - Nov 27)	**Nov 24** PBL#2: TBD	**Nov 25** Biochemical applications	**Nov 27** NO CLASS-THANKSGIVING			

	Interpret solution, present findings	#3	BREAK			
Week 15 (Dec 1 - Dec 4)	**Dec 1** PBL#2: TBD *Presentations and reports due*	**Dec 2** Dynamical systems modeling (JH)	**Dec 4** Class Debrief *Mastery Problem #5*		May move PBL#2 presentations to Dec 2 and 4 based on feedback	

Course Assignments

Week	Tuesday HW	Thursday HW
Week 1	**Aug 26** None	**Aug 28** HW#0: Find a model + Dimensional Analysis
Week 2	**Sep 2** HW#1: Dimensional Analysis and Models	**Sep 4** HW#2: Concept Mapping + Estimation
Week 3	**Sep 9** HW#3: Systems #1 + Numerical literacy	**Sep 11** HW#4: Systems #2
Week 4	**Sep 16** HW#5: Systems #3 + Simple Mass Balance	**Sep 18** HW#6: Multicomponent Mass Balance
Week 5	**Sep 23** HW#7: Mass Balance + Reactions	**Sep 25** HW#8: Curiosity and Humility
Week 6	**Sep 30** None (start PBL)	**Oct 2** HW#9: Chemical Kinetics #1 (review)
Week 7	**Oct 7** HW#10: Chemical Kinetics #2 (series/parallel)	**Oct 9** None (Fall break)
Week 8	**Oct 14** None (Fall break)	**Oct 16** HW#11: Python + Solving Chemical/Enzyme Reactions
Week 9	**Oct 21** None (PBL work)	**Oct 23** None (PBL work)
Week 10	**Oct 28** HW#12: CATME, Growth Mindset review	**Oct 30** HW#13: Enzyme Kinetics #1
Week 11	**Nov 4** None (start PBL)	**Nov 6** HW#14: Enzyme Kinetics #2 + R-L
Week 12	**Nov 11** None	**Nov 13** HW#15: First law of Thermo

Week 13	**Nov 18** HW#16: First and Second Law of Thermo	**Nov 20** HW#17: Free Energy and Biochem
Week 14	**Nov 25** None (Thanksgiving)	**Nov 27** None (Thanksgiving)
Week 15	**Dec 2** HW#18: Concept map revisited	**Dec 4** HW#19: Curiosity and humility, revisited