

**MA (BMA) 573 Mathematical Modeling of Physical and Biological
Processes I
Fall 2022
3 Credit Hours**

Instructor: Ralph C Smith
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Office Hours: By appointment

Prerequisite: MA 341 and knowledge of high-level programming language

GEP Category: This course does not fulfill a General Education Program requirement.

Materials/book (Optional): *Mathematical and Experimental Modeling of Physical and Biological Processes*, H.T. Banks and H.T. Tran, CRC press, 2009.

Course Description: Introduction to model development for physical and biological processes. Topics include compartmental analysis and conservation laws including advection, convection and diffusion processes, conservation of mass and the material derivative, and traffic flow models and analysis. Topics also include energy conservation and heat conduction processes and models, the development of population models, and the development of various disease models including SIR models. Supporting topics include analytical and numerical solution techniques for ordinary and partial differential equations and aspects of deterministic and frequentist model calibration. Applications include development of models for a catalytic converter, size-structured population models, traffic flow models, and neutron transport models.

Learning Objectives/Outcomes: By the end of the course, students should be able to:

- Apply conservation principles to derive fundamental models governing mass transport, heat conduction, traffic flow, population dynamics, and disease dynamics.
- Develop closure and constitutive relations to complete the models developed using conservation principles.
- Determine appropriate state variables and parameters based on physical and biological quantities.
- Compute basic analytic and numerical solutions for developed models, which can be employed for subsequent parameter estimation and experimental validation.
- Employ experimental data to infer model parameters using deterministic least squares and frequentist statistical analysis.

Email: All emails will be sent to your specified email address.

Computing: We will use MATLAB and provided software. Students may substitute Python if they are more comfortable with thi packages.

Course Topics Schedule:

Motivating applications and prototypical models and modeling concepts (1 day)
Numerical methods for initial value and boundary value problems (2 days)
Fundamental topics from vector calculus, probability and statistics (1 week)
Deterministic and frequentist model calibration (1 week)
Compartment analysis and conservation laws (3 weeks)
Energy conservation and the heat equation including analytic solutions (3 weeks)
Population models including predator-prey and size-structured models (2 weeks)
Disease and epidemic models (2 weeks)
Neutron transport models (1 week)

Note: This schedule is subject to change.

Course Structure: This class is meeting face-to-face in SAS 2225 on Monday, Wednesday, Friday from 11:45-12:35. Additionally, we will record all classes via Classroom Capture and post the videos on Panopto. By your continued participation in this recorded course, you are providing your permission to be recorded. These videos will also be live-streamed so that they can be watched during class time. This will not provide the capability for immediate feedback from remote attendees during the lecture. All lectures, references and supplemental material will be posted on the class website as well as the class Moodle site. Links to all recorded Panopto lectures will also be posted on Moodle. Students should feel free to contact me via email with any questions or concerns regarding the course, projects, or grading.

Grading:

Homework and projects (5-6): 60%
Midterm exam: 15%
Final exam (December 9): 25%

Final Exam: Friday, December 9, 12:00-2:30 pm

Standard Grading Scale: $99 \leq A+ \leq 100$, $92 \leq A < 98$, $90 \leq A- < 92$, $88 \leq B+ < 90$, $82 \leq B < 87$, $80 \leq B- < 82$, $78 \leq C+ < 80$, $72 \leq C < 77$, $70 \leq C- < 72$, $68 \leq D+ < 70$, $62 \leq D < 67$, $60 \leq D- < 62$, $0 \leq F < 60$

Requirements for Credit-Only (S/U) Grading: To receive a grade of S, students are required to complete all projects and earn a grade of C- or better. Conversion from letter grading to credit only (S/U) grading is subject to university deadlines. Refer to the Registration and Records calendar for deadlines related to grading. For more details refer to <https://policies.ncsu.edu/regulation/reg-02-20-15/>.

It is important that you consult with your advisor to see if the course will count towards your graduation requirements before taking this course as credit-only.

Incomplete Grades: Incomplete grades will be handled on an individual basis. Note, however, that if an extended deadline is not authorized by an instructor or department, an unfinished incomplete grade will automatically change to an F after either (a) the end of the next regular semester in which the student is enrolled (not including summer sessions), or (b) the end of 12 months if the student is not enrolled, whichever is shorter. Incompletes that change to F will count as attempted courses on transcripts. The burden of fulfilling an

incomplete grade is the responsibility of the student. The university policy on incomplete grades is located at <https://policies.ncsu.edu/regulation/reg-02-50-03/>.

Late Homework and Projects: You are expected to complete all homework and projects by the assigned deadlines. You should contact me by email if you anticipate delays regarding a project.

Homework and Projects: The homework and projects are weighted heavily because they include the exercises, which are essential to understanding the course material. You must show complete work to receive full credit. This means that you should provide sufficient details such that others with similar background as yourself can reproduce your results.

Teamwork policy: You may work remotely in groups of up to 3 students to solve the problems in each assignment. Each member of the team should submit their own project report.

Academic Integrity/Honesty: It is my understanding and expectation that your submission of any project means that you have neither given nor received any unauthorized aid. Students are required to comply with the university policy on academic integrity/honesty found in the Code of Student Conduct (<https://policies.ncsu.edu/policy/pol-11-35-01/>).

Electronically-Hosted Course Components: All reading materials are maintained on the course website. Note that I received licenses to include pictures and biographies of the mathematicians and mathematics educators that appear in the notes under the provision that the materials would be located on a secure site. Although you may copy the notes for your own use, you should not share the pages with the pictures and biographies with anyone else.

Digital Course Components: Students may be required to disclose personally identifiable information to other students in the course, via digital tools, such as email or web-postings, where relevant to the course. Examples include online discussions of class topics, and posting of student coursework. All students are expected to respect the privacy of each other by not sharing or using such information outside the course.

Accommodations for Disabilities: Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with the Disability Resource Office at Holmes Hall, Suite 304, Campus Box 7509, 919-515-7653. For more information on NC State's policy on working with students with disabilities, please see the [Academic Accommodations for Students with Disabilities Regulation \(REG02.20.01\)](#).

Non-Discrimination Policy: NC State prohibits discrimination, harassment, and retaliation that are based upon a person's race, color, religion, sex (including pregnancy), national origin, age (40 or older), disability, gender identity, genetic information, sexual orientation, or veteran status (individually and collectively). If you feel that you have been the subject of prohibited discrimination, harassment, or retaliation, you should contact the Office for Institutional Equity and Diversity (OIED) at 919-515-3148.

NC State's policies and regulations covering discrimination, harassment, and retaliation may be accessed at <http://policies.ncsu.edu/policy/pol-04-25-05> or <http://oied.ncsu.edu/divweb>.

Basic Needs Security: Please notify me, if you are comfortable doing so, if you face challenges securing your food or housing or if you have other severe adverse experiences, and you believe your challenges may affect your performance in the course. Alternatively, you can contact the Division of Academic and Student Affairs to learn more about the Pack Essentials program (<https://dasa.ncsu.edu/pack-essentials>).

Supporting Fellow Students in Distress: As members of the NC State Wolfpack community, we each share a personal responsibility to express concern for one another and to ensure that this classroom (as well as the campus as a whole) remains a healthy and safe environment for learning. Occasionally, you may come across a classmate whose personal behavior concerns or worries you, either for your classmate's well-being, for your well-being or for the well-being of others. When this is the case, I would encourage you to report the behavior on the link located on NC State's Students of Concern website (<http://go.ncsu.edu/NCSUcares>).

Diversity, Equity, and Inclusion: Diversity, equity, and inclusion are important to the success of our students at NC State. Every student, every faculty member, and every staff member who comes to NC State enriches us through their varied perspectives, knowledge, and backgrounds. Our classroom is one in which every student is respected and feels heard. In an effort to affirm and respect the identities of transgender students in the classroom and beyond, please contact me if you wish to be referred to using a name and/or pronouns other than those listed in the student directory. I welcome any additional suggestions you have for including the value of diversity, equity, and inclusion in this course.

Health and Well-Being Resources

These are difficult times, and academic and personal stress are natural results. Everyone is encouraged to [take care of themselves](#) and their peers. If you need additional support, there are many resources on campus to help you:

- Counseling Center ([NCSU Counseling Center](#))
- Student Health Services ([Health Services | Student](#))
- If the personal behavior of a classmate concerns or worries you, either for the classmate's well-being or yours, we encourage you to report this behavior to the NC State CARES team: ([Share a Concern](#)).
- If you or someone you know are experiencing food, housing or financial insecurity, please see the Pack Essentials Program ([Pack Essentials](#)).

Need Help?

If you find yourself in a place where you need help, academically or otherwise, please review these [Step-by-Step Help Topics](#).

Other Important Resources

- **Keep Learning:** [Keep Learning](#)
- **Protect the Pack FAQs:** [Frequently Asked Questions | Protect the Pack](#)
- **NC State Protect the Pack Resources for Students:** [Resources for Students | Protect the Pack](#)
- **Academic Success Center** (tutoring, drop in advising, career and wellness advising): [Academic Success Center](#).
- **NC State Keep Learning, tips for students opting to take courses remotely:** [Keep Learning Tips for Remote Learning](#)
- **Introduction to Zoom for students:** <https://youtu.be/5LbPzzPbYEW>
- **Learning with Moodle, a student's guide to using Moodle:** <https://moodle-projects.wolfware.ncsu.edu/course/view.php?id=226>
- **NC State Libraries** [Technology Lending Program](#)

List of Policies: Students are responsible for reviewing the NC State University Policies, Rules, and Regulations (PRRs) which pertain to their course rights and responsibilities, including those referenced both below and above in this syllabus:

- Equal Opportunity and Non-Discrimination Policy Statement <https://policies.ncsu.edu/policy/pol-04-25-05> with additional references at <https://oied.ncsu.edu/divweb/policies/>
- Code of Student Conduct <https://policies.ncsu.edu/policy/pol-11-35-01>.