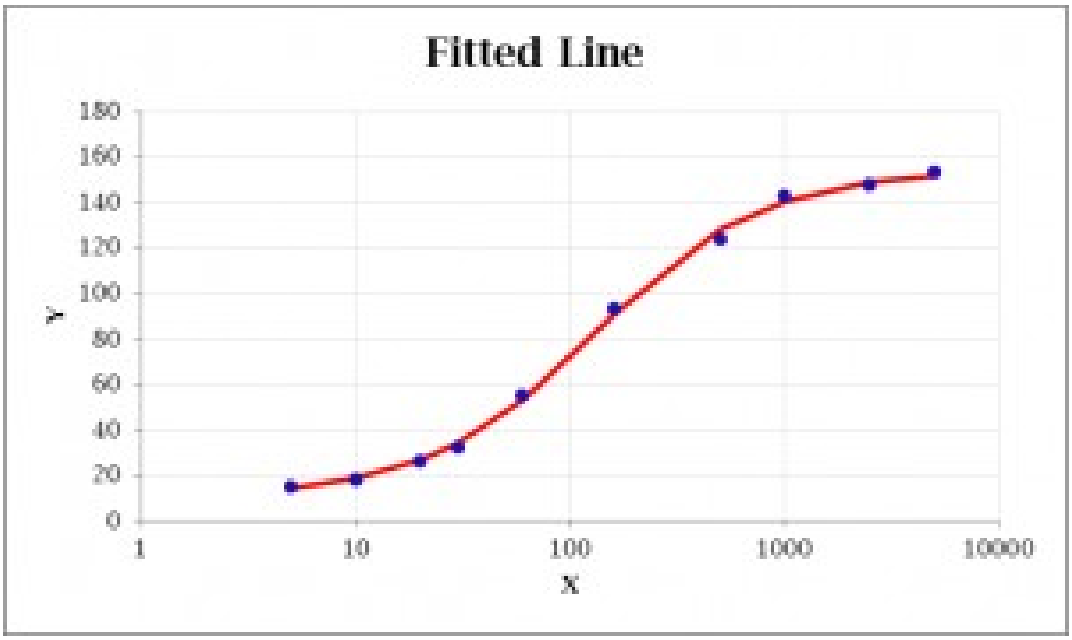
Math 4334: Mathematical Modeling



Fall 2023
Dr. Scott Norris
Umphree Lee 0244
MWF 10:00-10:50

Basic Information

Course Description

An introduction to mathematical modeling, including the formation of physical models from mathematical principles, and estimation of model parameters from data, and the interpretation of model results to inform decision-making.

Course Outcomes

1. Students can construct empirical models by transforming data.
2. Students can construct physical models with mathematical methods.
3. Students can analytically or numerically solve ODEs arising from models.
4. Students can estimate model parameters by fitting solutions to data.
5. Students can use Python to fit, evaluate, and visualize models.

Course Textbook

There is no official textbook. Lecture notes will be the primary source material. However, two helpful references (that I've drawn from) are:

- "A First Course in Mathematical Modeling," by Giordano et. al
- "Principles of Mathematical Modeling," by Dym.

Course Canvas

All course materials will be posted to Canvas.

My Office Hours and Contact Info

Physical Office:	Clements 239
In-person hours:	Mon/Fri 1pm-3pm
Virtual Office:	https://smu.zoom.us/j/5989958308
Virtual hours:	(by appointment)
Email:	snorris@smu.edu
Cell:	316-371-2740

Group Work and Outside Help

Group work is encouraged on homeworks! However, to avoid a false sense of confidence, be sure to try every problem on your own before meeting with your group. Each student must also turn in his or her own copy of the homework.

Grade Components

Distribution and Weights

Grades will be assigned based on a 15-point scale as follows: 95-100 “A+” (honorary), 90-95 A, 85-90 A-, 80-85 B+, … 60-65 C. Final grades below 60/100 will be awarded a C-, D, or F at my discretion. Final scores will be determined using the following weights:

Component	Weight
Weekly Homeworks (x10)	25%
Mini-Projects (x5)	25%
Mini-Exams (x5)	25%
Final Exam	25%

Weekly Homework

Mathematics is difficult, and can almost never be learned well without consistent practice. This is even more true of a data- and project-orientied courses like this one. Hence, an approximately weekly problem set will form a significant part of your grade.

Each homework will be turned in as a writeup in PDF format, using Gradescope. Each problem must begin on a new page, and the pages for each problem must be entered in when the assignment is uploaded. Problem answers should contain text, equations, and figures as needed.

Weekly homeworks will be graded on completion – if you do all the work, you get full credit. However, detailed solutions will be posted online after each homework is turned in. You should carefully compare these solutions to your own work, to see what you did well, and what you could do better. I am very happy to answer any questions that remain after you have done so.

Mini-Exams

In lieu of long, large, in-class exams, we will instead have more frequent, but shorter “mini-exams” that will take about 30 minutes each. Each mini-exam will consist of one to three problems that I might otherwise have put on an midterm. These problems will focus somewhat more heavily on concepts rather than calculation, and may include true/false, multiple choice, simple quantitative, or (very) short-answer responses.

Mini-Projects

Also in lieu of in-class exams, I will assign you a short written project at end of every unit (yes, writing, in a math class!). On these projects, you should plan to incorporate all of the skills in analysis, visualization, presentation, and writing that you have acquired up to that point in the course. They will also be turned in as written documents in PDF format, and expectations regarding writing, organization, and style will be higher than on regular homeworks. The rubric for mini-projects is as follows:

- 6 pts: Completion (did you do the entire project?)
- 6 pts: Accuracy (did you get correct answers?)
- 4 pts: Quality (is it well-written and well-sourced?)
- 2 pts: Neatness (are equations, figures, etc organized?)
- 2 pts: Thoughtfulness (appropriate introduction and conclusion?)

Final Exam

Finally (no pun intended), we will have a cumulative exam at the end of the semester. This will consist of a mix of conceptual and quantitative questions similar to those found on the mini-exams.

What to Expect

What this class will be about

In a specific sense, “Modeling” describes the construction of a mathematical equation that describes a process from the real world – essentially, the first steps of a story problem. More generally, however, “modeling” can describe any attempt to gain quantitative understanding of the world in which we live, and this course will cover many aspects of this more general definition. We will discuss the acquisition of actual data associated with a process, different ways to construct equations that might describe the process, analytical and numerical solution methods, and the interpretation and critical evaluation of the results in the context of the original data.

What you should have learned already

This class will depend **heavily** upon at least the following skills. Make sure you review them before class begins!

- Algebra: identify and avoid all common algebra errors
- Calculus I/II: working with powers, exponentials, logarithms
- Calculus III: gradient, minimization in multiple variables
- ODEs: Solution to basic differential equations, some systems
- Statistics: idea of a probability distribution, linear regression
- Physics: SI unit system, ideas of energy, force, and power balance
- **Matlab/Python**: we will use some simple numerical procedures!!

Amount of Difficulty you should Expect

This class should not encompass too much mathematical difficulty, in the sense of solving lots of hard problems. However, we will draw on a fairly wide variety of background material, and consider applications in a lot of different areas. A willingness to look things up and explore new topics is **essential** – if you are not willing to do this, you should drop the class! Finally, as is becoming true across the quantitative sciences, some basic ability to manipulate and visualize information with code is also essential.

University-wide Policies

Academic Dishonesty

"*[T]he choice which could lead to scoundrelism will come, when it does come, in no very dramatic colors.*" – C.S. Lewis, The Inner Ring

Academic dishonesty is taken very seriously at SMU, and I take it very seriously as well, for different reasons – it represents the first steps along a path that can eventually lead to a life lived entirely without integrity. Even the smallest forms of cheating in this class will be reported to the Honor Council, and carry a minimum penalty of a **full letter reduction** in your final grade. More severe instances will lead to automatically failing the course.

Disability Accommodations

Students needing academic accommodations for a disability must first register with Disability Accommodations & Success Strategies (DASS). Students can call 214-768-1470 or visit http://www.smu.edu/Provost/SASP/DASS to begin the process. Once approved and registered, students will submit a DASS Accommodation Letter to faculty through the electronic portal DASS Link and then communicate directly with each instructor to make appropriate arrangements. Please note that accommodations are not retroactive and require advance notice to implement.

Student Academic Success Programs:

Students needing assistance with writing assignments for SMU courses may schedule an appointment with the Writing Center through Canvas. Students wishing support with subject-specific tutoring or success strategies should contact SASP, Loyd All Sports Center, Suite 202; 214-768-3648; https://www.smu.edu/sasp.

Excused Absences for University Extracurricular Activities

Students participating in an officially sanctioned, scheduled University extracurricular activity should be given the opportunity to make up class assignments or other graded assignments missed as a result of their participation. It is the responsibility of the student to make arrangements with the instructor prior to any missed scheduled examination or other missed assignment for making up the work. (See 2020-2021 SMU Undergraduate Catalog under "Enrollment and Academic Records/Excused Absences.")

Accommodations for pregnant and parenting students:

Under Title IX students who are pregnant or parenting may request academic adjustments by contacting Elsie Johnson (elsiej@smu.edu) in the Office of the Dean of Students, or by calling 214-768-4564. Students seeking assistance must schedule an appointment with their professors as early as possible, present a letter from the Office of the Dean of Students, and make appropriate arrangements. Please note that academic adjustments are not retroactive and, when feasible, require advance notice to implement.

Religious Observance

Religiously observant students wishing to be absent on holidays that require missing class should notify their professors in writing at the beginning of the semester, and should discuss with them, in advance, acceptable ways of making up any work missed because of the absence. (https://www.smu.edu/StudentAffairs/Chaplain/ReligiousHolidays)

Generative AI

The use of generative AI is permitted in this course. For any assignment in which you used generative AI, you must include a brief statement describing how you used it. This will not penalize you in any way, and we will use these statements as the basis for occasional classroom discussion.