Instructions for the Modeling Project for Math 436: Fall 2024

October 18, 2024

The project has a two-fold purpose: to engage you in the modeling experience and to prepare you with a possible model for the group project in Math 438. The goal of the group projects in Math 436 and Math 438 is not necessarily to find a novel model for a well-known phenomenon or model a new phenomenon (although that may be what you do), but to gain experience in the art of modeling and the analysis of models in Math 436, and then the optimal control of some aspect of that (or another) model in Math 438. The optimal situation for you would be to form groups of about 5 in Math 436 and keep in the same groups in Math 438.

In seeking to model for your group's chosen phenomenon it is recommended that you use an ODE. You may use a PDE as part of your group's model, but you will need an ODE for Math 438. The reason for this is that optimal of control of a PDE is beyond the scope of Math 438.

As your group brainstorms on modeling the chosen phenomenon you will have several ideas, most of which will not be viable. This experience of failing many times before finding an appropriate model for the phenomenon is expected. Keep track of the ideas that were not viable. Failed ideas often lead to better ideas! Report the failed ideas in your final report.

The finished project should ideally be something you are proud to show to others, including current and prospective employers. It should make people want to hire you, admit you into their graduate program, and fund your startup idea.

Your final report, due **Friday, December 6, 2024**, will be typeset in LaTeX. Attach a *well-documented* Jupyter notebook to your report showing any code you use.

1 Modeling and Comparison to Data

This is *not* a data project, but a modeling project. Comparison with data may be appropriate depending on the phenomenon that is being modeled. The focus and the main goal of the project is the modeling of the group's chosen phenomenon.

You are encouraged to be daring, even reckless, when selecting your group's phenomenon to model. Be bold and and tackle a (possible very challenging) problem. Maybe it is something your group is passionate about.

You have permission (and are encouraged) to fail and fail miserably.

The point is to put much effort into that failure and thoroughly document it in the final report, so that the instructor can see that your group learned something from the experience.

You also have permission to "reinvent the wheel" for your group project. Be sure to thoroughly research the model and how it was achieved. See if you can add something to it.

No matter which phenomenon your group chooses to model, be sure to include numerical simulations of it. Use the SciPy packages in Python for standard numerical solvers, or code your own numerical algorithms.

2 Format of Final Report

The final report should be no more than 10 pages, not counting any bibliography and any code. The final report should include the following sections. Please use the LaTeX template on Overleaf linked in the Content section of LearningSuite.

- Abstract. The abstract summarizes in one paragraph the main question and conclusions draw from your investigation.

- Background/Motivation and statement of the problem. Give an adequate explanation of the background for the problem that your group is considering. Explain why this problem is important, and what techniques/methods have been previously used (if any) for this problem or similar ones. If you are deriving a and analyzing it for a novel phenomenon you don't need to spend much time on this, but if you are modifying an existing model or reviewing something that is known about a particular model for instance, then you should spend much

more time reviewing what is known. This review should be sufficient to convince the instructor that you know how your results fit in the greater scheme of things and that you are aware of the impacts that your conclusions/results will have on the bigger picture.

- Modeling. The primary aspect of the project is the modeling of the chosen phenomenon. If your group's repeated attempts resulted in abject failure, or your group succeeded, detail them in this section. Be sure to account for the various attempted models and why they were not appropriate. Include numerical simulations for each attempted model.

- Results. Clearly and succinctly state and describe the conclusions that you can draw from the model you have achieved (or the the many failed attempts). Does your model(s) perform well quantitatively or qualitatively?

- Analysis/Conclusions. Discuss the appropriateness of the techniques and methods you employed in modeling. Did your group appropriately model the chosen phenomenon? If not, what different steps could you have taken if you had more time? What did you learn about the techniques/method that were used in the group project? If your model was successful, what additional insight/conclusions could you obtain from it? For instance, if you had a successfully modified SIR model, how might it affect different government policy? If you had a successful model for the spread of inaccurate information on social media, how might it be implemented to help reduce the spread of inaccurate information?

3 Grading Rubric

2 Abstract
3 Background/motivation and statement of the problem
6 Modeling
3 Results
4 Analysis/Conclusions
2 "Wow Me" factor