MATH 303 Final Project
Mathematical Models
Fall 2018

The last assignment of the course is to complete a final research project modeling some real world problem of your choice. The main goal is to identify an interesting problem of study, come up with a set of questions you would like to answer, collect the necessary data needed to explore your problem, formulate a model based on this data, analyze and refine your model, and finally, use your model to provide some answers to your initial questions.

Your project will consist of both a typed report (10 pages) and a presentation (about 15 minutes) during the final exam period. Your report can be written using Maple (which has nice word processing for mathematical symbols), LaTex (if you know it), or a regular word-processing program with a hand-written appendix for mathematical calculations. You are required to work in a small group (2–3 people), although it is expected that each member of the group will contribute equally. Your group does not have to be identical to the one used on the computer projects. The final project is worth 30% of your total course grade.

Timeline and Due Dates:

- November 9: Brief description of final project topic due, including at least three references and a plan for collecting data.
- November 28: Brief progress report (1–2 typed pages) due detailing the status of your project, including results and further lines of inquiry. By this date you should have met with me at least once to discuss the content of your project.
- December 3 and 5: In-class project work days (meet in Swords 219)
- December 7: Detailed outline of your report and presentation due, including title and a list of all group members.
- December 12, 11:30 am – 2:00 pm: Project Presentations (roughly 15 minutes; each member must speak for at least 5 minutes).
- December 12, 2:00 pm: Final Report due (typed, double-spaced, double-sided, color figs, 10 pages).

Project Details:

The aim of this project is for you to model some real world problem that you find interesting. Ideally, you will utilize the mathematics learned in this course, and potentially others, to make an *in-depth* investigation of your topic. You should emphasize depth over breadth when conducting your research. In addition to gathering information and research related to your topic, you should also strive to accomplish each of the following goals. Depending on your topic you might emphasize one more than the other, but try and include both in your project.

1. **Modeling:** Come up with your own mathematical model, or work with a known model, to investigate your topic and make predictions. This might involve a differential equation(s) or a

difference equation(s). Be sure to clearly define all variables and parameters, including units. Once you have a model, you should analyze it and test it against known information. Your analysis could include running different simulations of your model (e.g., comparing results for different parameter values), investigating equilibrium solutions, conducting a bifurcation analysis (e.g., looking for tipping points), tuning your model (i.e., adjusting it to match known data), performing a model reduction (simplification), and/or making model predictions.

2. **Data Analysis:** Find, collect, and analyze data related to your topic. Do some type of best fit (e.g., regression analysis) to model your data. Is it linear, quadratic, periodic, logistic, a power function, etc.? What conclusions can be drawn from the data? What predictions can be made? How can the data be incorporated into your mathematical model?

   There are many good online sources to obtain data and figures (see below). You should also try to find data sets from recently published papers related to your topic.

   - Our World in Data (`https://ourworldindata.org/`)
   - Kaggle.com (`https://www.kaggle.com/` — must sign up for a free account)
   - NOAA Earth System Research Laboratory (`https://www.esrl.noaa.gov/gmd/dv/data/`)
   - NASA Goddard Institute for Space Studies (`https://data.giss.nasa.gov/`)
   - NCAR Climate Data Guide (`https://climatedataguide.ucar.edu/`)

Choosing a Topic:

There are many, many different topics that you can investigate. The important thing is to chose a modeling problem that you are interested in, one that you can find or collect data pertaining to. You should also try to find some mathematical and/or scientific papers relating to your topic. Good articles to use are those that contain data and figures, or involve a mathematical model. I have listed some general topic ideas below. Feel free to investigate something that we have discussed in class or that is presented in the course textbook by K. K. Tung. Try to be specific in your problem formulation. What question(s) are you trying to answer?

- Population models (study the past and future of a population(s) of some species).
- Model something that has personal meaning to you (e.g., pollution in your home state or breast cancer rates in the US).
- What's the best time to get dinner in Kimball in order to avoid long lines? Collect data, create a model, and then make some predictions.
- Water use in the Western US: What is the future of this vital resource and how will it impact agriculture and food prices around the country?
- Continue your analysis of the Blackstone River data from Lab #2. Investigate what other researchers have done in modeling the health of a river.
- How much space junk is orbiting the planet and what are the best strategies for cleaning it up? Do a cost-benefit-risk analysis to help a private company determine the commercial viability of running a space-junk cleaning business.

- Study the effects of human activity on the climate (e.g., deforestation, land use, agricultural practices, population growth, globalization).
- Study the effects of climate change on a particular species or plant (e.g., coral reefs, polar bears, New England lobsters).

Writing Your Paper:

Your paper should be well written, clear, organized, and in your own words. Scientific results and conclusions you gather from articles should be paraphrased rather than quoted in lengthy passages. You should include a brief abstract at the start of your paper (one paragraph) stating the particular problem you are modeling, the questions you are trying to answer, and your major results. Be sure to include both an introduction and conclusion to your paper.

All figures should have captions and be appropriately referenced. For example, if you generate a figure, indicate the program used; if the figure comes from a paper or online source, be sure to cite the paper or website in the caption. Pages should be numbered. It is fine to write mathematical equations by hand in the narrative of your paper, or they may be included in an appendix. Take care to proofread your paper and make sure all equations and calculations are included.

References should be informative and in a consistent style. Be careful using material found on the Internet, as some information is inaccurate or out of date. Always try to find an author and date when using anything from the Internet. It is ok to use *Wikipedia* as a source on occasion, but your primary sources should be published (i.e., peer-reviewed) articles from mathematical and scientific journals.

Grade:

Your final project grade will be divided (approximately) into thirds based on the following rubric:

(i) Quality of presentation (points awarded for creativity, innovation, and artistic flair)

(ii) Quality of the mathematics and research conducted

(iii) Quality of the paper (well-written, organized, readable, in your own words, appropriately referenced, followed the above guidelines, etc.)