Math 3550 - Course Projects

We will have an individual and a group project which are interconnected. In the individual project you will research existing information and models, summarize them, and develop ideas for important questions that should be addressed in your group project. In the group project, you will develop a full model on your own. A second version of the group project should be written for submission for publication or presentation.

Individual Project Submission

The individual project submission will occur as you are working in your groups. As part of developing your group model, you must read existing research/models critically. In some cases, you might find listed material lacking and might want to expand the scope of your search. Feel free to gather more information by contacting sources, listening to podcasts, etc. You may chose different approaches or similar approaches. You will report on them in the same format as your original group work. Your individual submission must include the following.

- Executive Summary
- Describe several different or interrelated models. State precisely the problems addressed.
- Explain how the models were developed; assumptions and rationale/justification, model fitting or estimation of the values used.
- How were model verification, sensitivity analysis, including error analysis, etc. conducted?
- Discuss the strengths and weaknesses of each model or approach.
- What are the important questions you think should be answered or you like to investigate?

Your entire submission cannot exceed 25 pages. See more information in the Group Project section.

Group Project Submission

Choose one of the following projects. Each group will submit one report. You may choose to make a presentation to the class. Presentation can be part of your or your group's score. I will be inclined to give extra credit to exceptional reports or presentations. A partial or less than optimal solution is acceptable. Follow the general style of the sample report in the course website. However, be sure to include the following.

- One-page Executive Summary
- Table of contents
- Restatement and clarification of the problem: state in your own words what you are going to do.
- Clearly list and describe all variable and hypotheses.
- State the assumptions that bear on the problem and their rationale/justification.
- Present an analysis of the problem motivating your model design. Explain your model.
- Present derivations, computations, or illustrative examples. You may need to summarize some of it and leave lengthy derivations and/or calculations in appropriate appendices.
- Describe model testing and discuss sensitivity analysis, error analysis, and/or stability.
- Discuss the strengths and weaknesses of your model or approach.
- Provide a conclusion and report results explicitly.
- Document resources and references.

Groups

Not every group member will earn the same score on their group project. The individual scores for group projects will vary based on the level of participation and contribution of each member.

Group 1	Group 2	Group 3
Tanner Armstrong	Issac Baker	Max Beard
Wyatt Avondet	Justin Bissonnette	Dunn Cardona
Jerit George	Robert Miliner	Wyatt Krogue
Sofia Jones	Grace Peterson	Cameron Taylor
Rachel Nichols	Korbin Shaw	Asha Willey

Project Dates

Sept 20 – Sept 27: Choose your individual project. Collect many relevant articles, information, data, etc. **Our science librarian Miranda Kispert**, mirandakispert@weber.edu **can be very helpful.**

Sept 27 – Oct 2: Each student must meet me to discuss their individual project, information collected, etc. Plan the write-up for your individual project.

Week of Oct 2: Start writing your individual project.

Week of Oct 9: Groups will be finalized. Exchange information. Devise a plan for sharing information. Choose a project. Assign roles to group members. All individual work should be carefully read and checked by one other person. There must be someone tasked to keep the group on schedule. Discuss how to proceed and what type of model to use. Start search for relevant articles. **Our science librarian Miranda Kispert**, mirandakispert@weber.edu **can be very helpful.**

Week of Oct 16: Start the modeling process. Plan your project.

Mon, Oct 23: Individual project due date.

Week of Oct 23: Develop a rough model and test it.

Week of Oct 30: The groups must meet me and discuss their works. Improve the model, test it, and develop the final model. Start the write up.

Week of Nov 6: Finish the final model and the first draft of the write up.

Week of Nov 13: Improve the write up and finalize your project.

Week of Nov 20: The groups must meet me and discuss their works. Have each portion of the project re-read by at least two people. Verify the calculations. Check the resources. Check the spelling, grammar, etc. Finish your project.

Mon, Nov 27: Project due date.

Week of Nov 27: Develop new versions for classroom presentation and submission for publication or presentation.

Week of Dec 4: Opportunity for presentation in the classroom.

Mon Dec 11: The deadline for submission to Ergo. Consider publishing your paper in other journals or develop a poster for a poster presentation. Be sure to include me in all emails regarding your submission.

Problem A: Thirsty Utah

Utah's population is growing at a rapid rate (http://worldpopulationreview.com/states/utah-population/). In addition to increase in culinary water usage, secondary water, which is suitable for agricultural use, with very little volume restriction, by homeowners for watering lawns and landscaping is increasing. The demand on water resources for industrial and agricultural use is also on the rise. State of Utah is considering Bear River Development Project and is in the process of building a Lake Powell Pipeline (https://water.utah.gov/bear-river-dev/ and http://lpputah.org/). State has developed and refined water plans over the years; Utah's Water Resources 2001, Water for Utah 2018, Flowing Toward 2050, etc. (https://water.utah.gov/, www.nr.state.ut.us/wtrresc/waterplan/, https://drought.unl.edu/archive/plans/Water/state/UT_2001.pdf, https://water.utah.gov/wp-content/uploads/2019/12/Water-for-Utah-2019.pdf, https://extension.usu.edu/employee/files/Recommended-State-Water-Strategy-July-2017.pdf, https://www.mdpi.com/2073-4441/9/3/214, http://www.utahfoundation.org/reports/flowing-toward-2050-utahs-water-outlook). Your group, called Thirsty Utah Advisory Group, is formed to provide further unbiased analysis.

Task 1: Determine all sources of water in the state of Utah. Find all water usage, culinary, secondary, agricultural and industrial, information. Determine what happens to all waste water. Determine the rate at which water resources are being replenished. Determine expected growth in water usage.

Task 2: Develop a model for overall water usage (culinary, secondary, agricultural and industrial) in the state of Utah. This model should take into account the growing population and other expected changes in future.

Task 3: (a) Based on your model, determine the level of availability/scarcity of water in future. (b) Conservation and water price have significant impact on water usage. In addition, development of new resources may increase water resources. Determine how these factors, and others, can influence future water usage.

(c) Present a water plan for the state of Utah. The focus of the plan has to be to provide sufficient culinary water for the growing population while meeting the agricultural and industrial needs. The plan may include, conservation, waste water treatment and reuse, changes in landscaping, agricultural and industrial practices.

Task 4: Analyze state of Utah reports and water plans and comment on their feasibility and consistency. Can any of the plans, including yours, accommodate expected growth in the state of Utah? If not, provide possible solutions to be explored by the next Thirsty Utah Advisory Group.

Problem B: The Next Pandemic

In 2014, the world saw the infectious Ebola virus spreading in western Africa. In 2020, we had start of the much more widespread COVID-19 pandemic. Throughout human history, epidemics have come and gone with some infecting and/or killing thousands and lasting for years and others taking less of a human toll. Some believe these events are just nature's way of controlling the growth of a species while others think they could be a conspiracy or deliberate act to cause harm. This problem will most likely come down to how to expend (or not expend) scarce resources (doctors, containment facilities, money, research, serums, etc…) to deal with a crisis.

Situation: A routine humanitarian mission on an island in Indonesia reported a small village where almost half of its 300 inhabitants are showing similar symptoms. In the past week, 15 of the "infected" have died. This village is known to trade with nearby villages and other islands. Your modeling team works for a major center of disease control in the capital of your country (or if you prefer, for the International World Health Organization).

Task 1: Develop a mathematical model(s) that performs the following functions as well as how/when to best allocate these scarce resources and…

- Determines and classifies the type and severity of the spread of the disease
- Determines if an epidemic is contained or not
- Triggers appropriate measures (when to treat, when to transport victims, when to restrict movement, when to let a disease run its course, etc…) to contain a disease Note: While you may want to start with the well-known "SIR" family of models for parts of this problem, consider others, modifications to the SIR, multiple models, or creating your own.

Task 2: Based on the information given, your model, and the assumptions your team has made, what initial recommendations does your team have for your country's center for disease control? (Give 3-5 recommendations with justifications)

Task 3: *Additional Situational Information*: A multi-national research team just returned to your country's capital after spending 7 days gathering information in the infected village. You can ask them up to 3 questions to improve your model. What would you ask and why?

Task 4: *Additional Situational Information*: The multi-national research team concluded that the disease:

- Appears to spread through contact with bodily fluids of an infected person
- The elderly and children are more likely to die if infected
- A nearby island is starting to show similar signs of infection
- One of the researchers that returned to your capital appears infected

How does the additional information above change/modify your model?

SIR, SEIR, and other infectious disease models. There are many resources for this.

H. Hethcote, "The mathematics of infectious diseases", SIAM Review, vol. 42, no. 4, pp. 599–653, December 2000, https://doi.org/10.1137/S0036144500371907

Patterson Clark, "An Ebola Treatment Center", https://www.alabamapublichealth.gov/alphtn/assets/110315EbolaTreatmentCenter.pdf

"Rapid Operations to Contain the Initial Emergence of Pandemic Influenza: The WHO Interim Protocol", https://www.paho.org/en/documents/who-interim-protocol-rapid-operations-contain-initial-emergence-pandemic-influenza

"Outbreak Surveillance and Response in Humanitarian Emergencies", World Health Organization, https://www.who.int/publications/i/item/outbreak-surveillance-and-response-in-humanitarian-emergencies-who-guidelines-for-ewarn-implementation

Martin I Meltzer and others, "Estimating the Future Number of Cases in the Ebola Epidemic – Liberia and Sierra Leone, 2014-2015", https://www.cdc.gov/mmwr/preview/mmwrhtml/su6303a1.htm

Marisa C. Eisenberg and others, "Modeling surveillance and interventions in the 2014 Ebola epidemic", https://arxiv.org/pdf/1501.05555v1.pdf

Problem C: Fish Migration

Fish consumption has grown steadily, but not uniformly, from about 20 pounds to 35 pounds per capita from 1960s to now. Many communities and countries are fully dependent on this food source for their survival. In fact, local fisheries are an integral part of social fabric and economic engine of many communities. However, with climate change fish are moving from their traditional habitats or certain food fish are being replaced by other species. It is now not unusual to see Chinook salmon in Arctic rivers while Florida fisheries are infested with Lionfish. The problem is worst for communities when fish move to another country's territorial waters, for example, lobsters moving north to Canada from Maine waters. For your individual project research fish migration due to climate change, find general or specific (geographical or species) models, determine important challenges posed by fish migration.

For the group project, consider the following scenario. Suppose your team has been hired by Scottish North Atlantic fishery management consortium. The consortium to gain a better understanding of issues related to the potential migration of Scottish herring and mackerel from their current habitats near Scotland if and when global ocean temperatures increase. These two fish species represent a significant economic contribution to the Scottish fishing industry. Changes in population locations of herring and mackerel could make it economically impractical for smaller Scotland-based fishing companies, who use fishing vessels without on-board refrigeration, to harvest and deliver fresh fish to markets in Scotland fishing ports.

Task 1: Build a mathematical model to identify the most likely locations for these two fish species over the next 50 years, assuming that water temperatures are going to change enough to cause the populations to move.

Task 2: Based upon how rapidly the ocean water temperature change occurs, use your model to predict best case, worst case, and most likely elapsed time(s) until these populations will be too far away for small fishing companies to harvest if the small fishing companies continue to operate out of their current locations.

Task 3: In light of your predictive analysis, should these small fishing companies make changes to their operations?

(a) If yes, use your model to identify and assess practical and economically attractive strategies for small fishing companies. Your strategies should consider, but not be limited to, realistic options that include:

- Relocating some or all of a fishing company's assets from a current location in a Scottish port to closer to where both fish populations are moving;
- Using some proportion of small fishing vessels capable of operating without land-based support for a period of time while still ensuring the freshness and high quality of the catch.
- Other options that your team may identify and model.

(b) If your team rejects the need for any changes, justify reasons for your rejection based on your modeling results as they relate to the assumptions your team has made.

Task 4. Use your model to address how your proposal is affected if some proportion of the fishery moves into the territorial waters (sea) of another country.

https://www.greenfacts.org/en/fisheries/l-2/06-fish-consumption.htm

https://insideclimatenews.org/news/16052018/fish-species-climate-change-migration-pacific-northwest-alaska-atlantic-gulf-maine-cod-pollock

https://www.eenews.net/stories/1060416271

https://www.cleanerseas.com/climate-change-fish-migration/

https://e360.yale.edu/features/feeling-the-heat-warming-oceans-drive-fish-into-cooler-waters

https://worldoceanreview.com/en/

https://www.fisheries.noaa.gov/feature-story/new-study-climate-change-shift-many-fish-species-north

https://www.pnas.org/content/114/32/8435

"Scottish Sea Fisheries Statistics 2018", https://www.gov.scot/publications/scottish-sea-fisheries-statistics-2018/pages/3/

"Common Fisheries Policy", Institute for Government, https://www.instituteforgovernment.org.uk/explainers/common-fisheries-policy

Impacts of Climate Change on Salmon of the Pacific Northwest, https://www.webapps.nwfsc.noaa.gov/assets/4/9042_02102017_105951_Crozier.2016-BIOP-Lit-Rev-Salmon-Climate-Effects-2015.pdf

Modelling and simulations of the migration of pelagic fish
ICES Journal of Marine Science, Volume 66, Issue 5, June 2009, Pages 826–838, https://doi.org/10.1093/icesjms/fsp067

Readying California Fisheries for Climate Change, https://www.oceansciencetrust.org/wp-content/uploads/2016/06/Climate-and-Fisheries_GuidanceDoc.pdf

"Northern distribution of North Sea herring as a response to high water temperatures and/or low food abundance", Fisheries Research, 50(1-2), 189-204, https://doi.org/10.1016/S0165-7836(00)00251-4

Peer, A. C., & Miller, T. J., "Climate change, migration phenology, and fisheries management interact with unanticipated consequences", North American Journal of Fisheries Management, 34(1), 94-110, https://doi.org/10.1080/02755947.2013.847877

"Mackerel migrating to the north: the first climate change related conflict in European politics?" Climate Change Post, Oct 9, 2017, https://www.climatechangepost.com/news/2017/10/9/mackerel-migrating-north-first-climate-change-rela/

Nick Bradford, "Marine Species on the Move", https://www.neefusa.org/weather-and-climate/marine-species-move.

Group Project Publication Submission

Choose one of the following to submit your work for publication. However, you are not limited to this publication list. Your work has to be re-arranged and rewritten to meet the publication or presentation requirement. Please carefully read requirements for each one. Be sure to include me in all emails regarding your submission.

Involve: A Journal of Mathematics, https://msp.org/involve/about/cover/cover.html (Mathematical Science Publishers)

The Mathematics Exchange, https://lib.bsu.edu/beneficencepress/mathexchange/ (Ball State University)

Minnesota Journal of Undergraduate Mathematics, https://mjum.math.umn.edu/index.php/mjum/index (University of Minnesota)

The Rose-Hulman Undergraduate Math Journal, https://scholar.rose-hulman.edu/rhumj/ (Rose-Hulman Institute of Technology)

SIAM Undergraduate Research Online, https://www.siam.org/publications/siuro (Society for Industrial and Applied Mathematics)

Utah academy of Sciences, Arts & Letters, http://www.utahacademy.org/academy-journal/

Intermountain Sustainability Summit, https://weber.edu/ISSummit/contact.html, Student Posters

Attached is also a list of Opportunities in Undergraduate Research in WSU.

OFFICE OF UNDERGRADUATE RESEARCH

UPCOMING *events* 2023-2024

FALL RESEARCH GRANT PROPOSAL DEADLINES

02 OCT

13 NOV

SPRING RESEARCH GRANT PROPOSAL DEADLINES

05 FEB

01 APR

FALL RESEARCH & ENGAGEMENT SYMPOSIUM

20 NOV — Abstracts will be accepted from October 2 to November 20, 2023

05 DEC — Symposium will be held from 10 am -4 pm in the Shepherd Union Building

SPRING RESEARCH & ENGAGEMENT SYMPOSIUM

25 MAR — Abstracts will be accepted from January 8 to March 25, 2024

16 APR — Symposium will be held from 9 am -5 pm in the Shepherd Union Building

NATIONAL CONFERENCE ON UNDERGRADUATE RESEARCH 2024

30 OCT — Deadline for Travel Support from OUR

8 DEC — Abstract Deadline

8-10 APR — Conference

UTAH CONFERENCE ON UNDERGRADUATE RESEARCH 2024

03 NOV — Abstract Deadline

12 JAN — Registration Deadline

16 FEB — Conference

ERGO

11 DEC — Deadline for article submissions

FOR MORE INFO VISIT US AT
https://weber.edu/OUR/calendar