USING PROJECTS, CLASS PROBLEMS, AND OTHER RESOURCES IN TEACHING MATHEMATICAL MODELING

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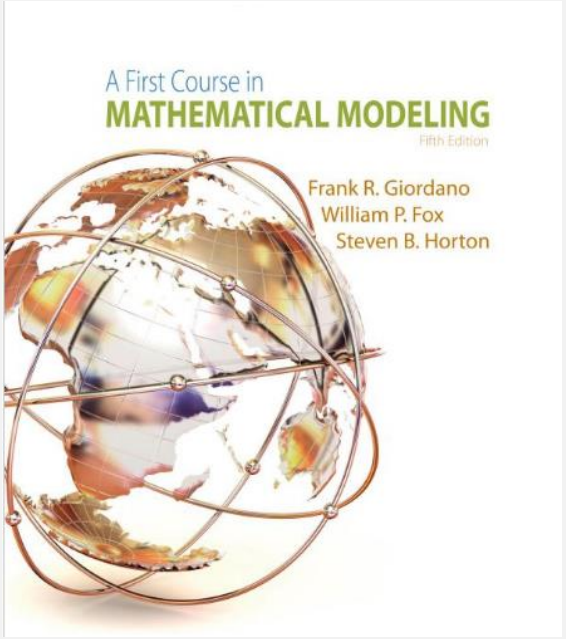
OUTLINE OF THIS PRESENTATION

- Contents Covered in My Mathematical Modeling Course
- What Projects Assigned
- Class Problems and Discussions
- Online Resources
- SCUDEM Participation

PART 1: CONTENTS COVERED IN MY MATHEMATICAL MODELING COURSE



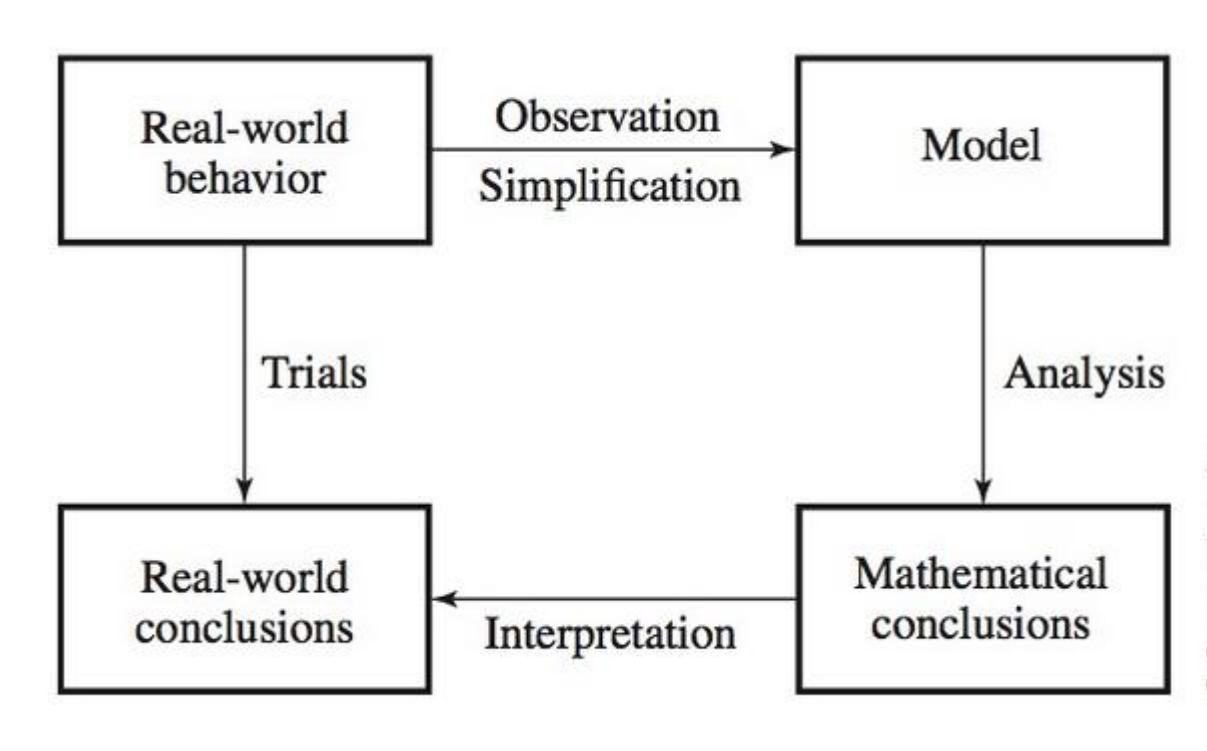
Mathematical modeling is one of the required courses of Math, Math Education, Electrical Engineering, and Computer Science majors in Texas A&M University - Texarkana. This course introduces some discrete and continuous models, and theoretical and empirical (experimental) models. Students learn the process of building these models and explore their applications. The models discussed are from different disciplinaries (finance, logistic, biology, physics, engineering).

To keep this class academically rigorous (and fun to learn hopefully), some projects, class problems and discussion, and homework problems are assigned to help students understand principles and methods.

To encourage creative ideas, students have flexibilities when they work on projects and other assessments.

Students taking this course are usually juniors or seniors. The class size is around 5 to 10 students.

PROCESS OF MATHEMATICAL MODELING



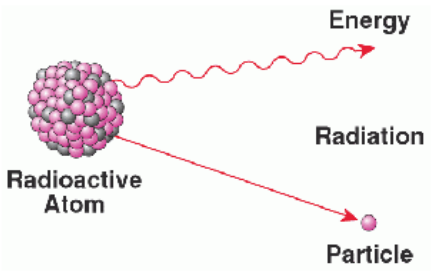
TOPICS COVERED

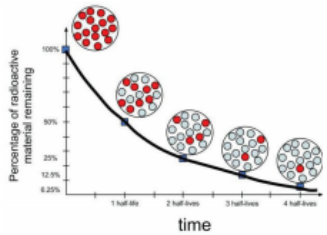
- Procedure of construction of a model (Real-world behavior, model, mathematical conclusions, real-world conclusions)
- Difference Equations, Systems of Difference Equations, and Dynamical System Model; Real-world applications; Numerical and Analytic Solutions
- Linear and Nonlinear (Logistic) models; Long-term behavior of these models and sensitivity analysis if some parameters are changed; Equilibrium solutions

- Data analysis by Excel spreadsheet computation and desmos.com; we will incorporate teaching computer languages (python or matlab) in this part.
- Determine parameters using graphs.
- What assumptions should be included? Are they reasonable?

- Model fitting for linear and nonlinear (logistic) models using least-square criteria, Chebyshev approximation criterion; transformation, and errors.
- Differential Equations models (population growth, prescribing drug dosage, braking distance of vehicles)

Radioactive Decay and Sewage Treatment





After one half-life, half of the radioactive atoms have decayed. After another half-life, half of the remaining atoms have changed. This pattern continues, with half of the atoms changing over each half-life time.
CC Tracy Poulsen

Some Models Introduced in the Courses

Time in hours n	Yeast biomass p_n	Change/ hour $p_{n+1}-p_n$
0	9.6	8.7
1	18.3	10.7
2	29.0	18.2
3	47.2	23.9
4	71.1	48.0
5	119.1	55.5
6	174.6	82.7
7	257.3	93.4
8	350.7	90.3
9	441.0	72.3
10	513.3	46.4
11	559.7	35.1
12	594.8	34.6
13	629.4	11.4
14	640.8	10.3
15	651.1	4.8
16	655.9	3.7
17	659.6	2.2
18	661.8	

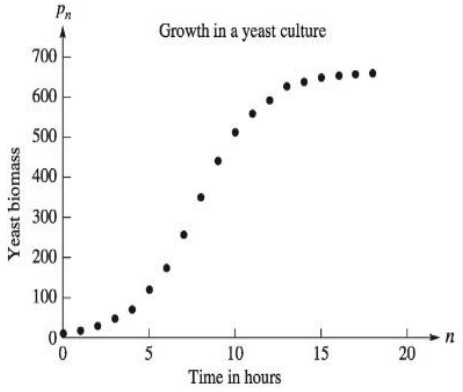


Figure 1.8
Yeast biomass approaches a limiting population level

Population

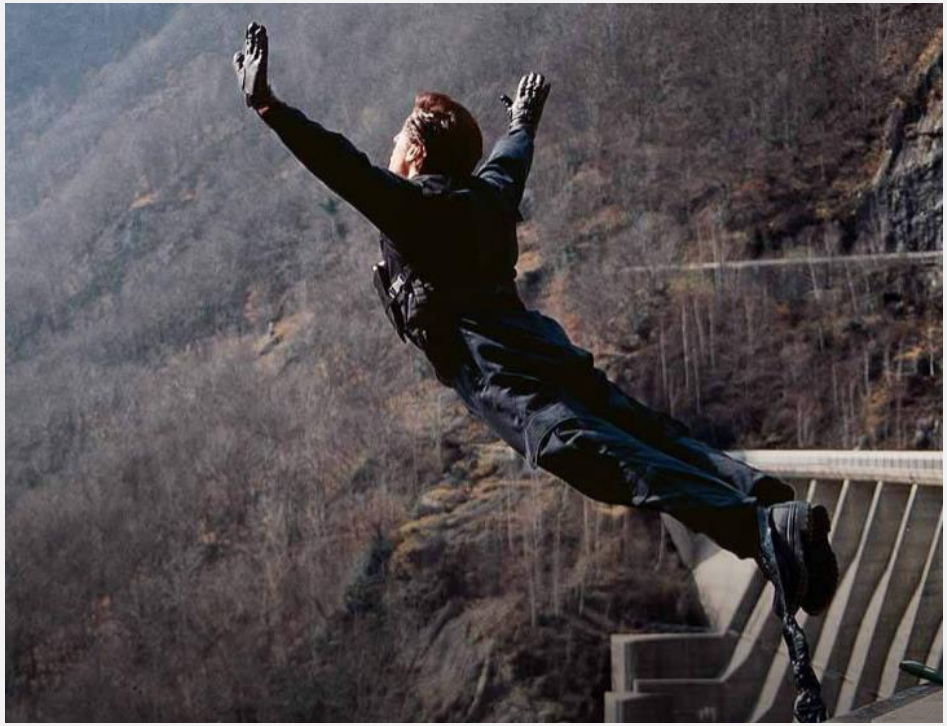
Mortgage

Traveler's tendencies

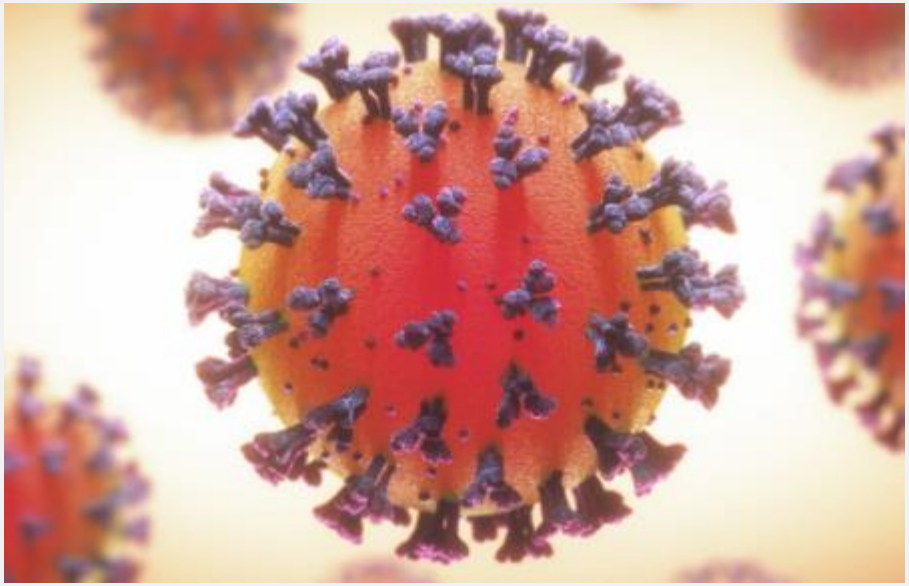
PART 2: PROJECTS

LIST OF PROJECTS

Taste of coffee



Safety of stuntmen



A killing virus – covid-19

ASSIGNED PROJECTS (INDIVIDUAL PROJECT)

In the projects below, students are required to (i) turn in a written report and (ii) present their results.

Spring 2018 Semester	Fall 2020 Semester
What factors are determining the taste of brewed coffee?	What factors are determining the taste of brewed coffee?
When should a person replace his or her vehicle?	Spreading of a killing virus.
	Safety of Stuntmen - An exciting action scene in a movie is going to be filmed, and you are the stunt coordinator!

ASSIGNED PROJECTS (TEAM PROJECT)

In the projects below, teams are required to (i) turn in a written report and (ii) present their results.

Spring 2018 Semester	Fall 2020 Semester
Heart Rate of Birds	SCUDEM V contest
Heart Rate of Mammals	Two teams chose Problem A (Decay of Oil Agglomerates) One team chose Problem B (Spinning a wheel) One team missed the deadline
The Stunt Person - An exciting action scene in a movie is going to be filmed, and you are the stunt coordinator!	

- In spring 2018, my mathematical modeling course was an Interactive Television Class (ITV) course, team projects were presented in class. Students were able to judge the presentation of their classmates.
- In fall 2020, my modeling course was an online class because of pandemic, individual and team projects were presented in class. Students were able to judge the presentation of their classmates using the SCUDEM rubric.
- To team projects of fall 2020, the problems came from SCUDEM V contest. There were 10 students in my class. With 2 additional students from differential equations class students, we formed 4 allied team to compete.

Scoring Rubric

Overview: Report and Presentation will be scored holistically on a 5 point scale from 1 (poor work) to 5 (excellent work) rubric. The score will consider three aspects: execution, communication, and correctness. To earn a 5, work must be *well-executed*, *well-communicated*, and *essentially correct*.

Definitions:

Well-Executed

- Applies a **strategy** that makes sense for the given question
- Applies appropriate mathematical concepts and processes
- Does not offer superfluous material
- Technology is used appropriately
- Work is logical and includes a reality check of the final answer

Well Communicated

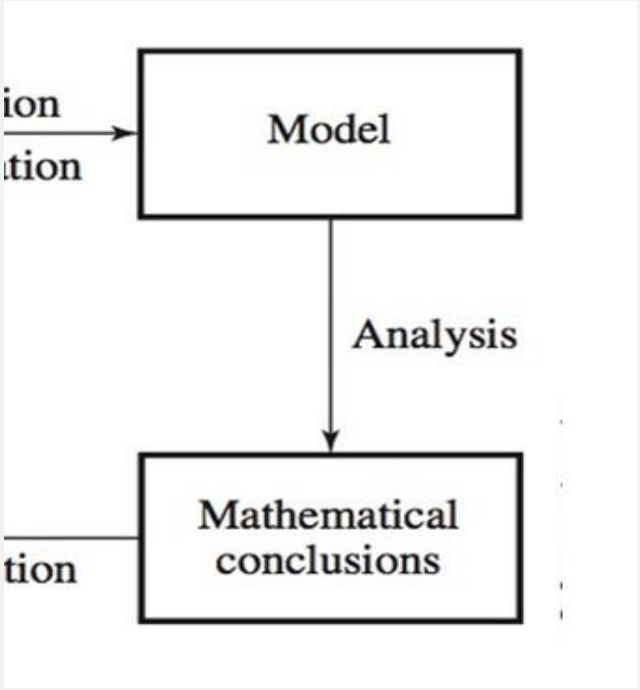
- **Readable:** Work *stands alone* (retains context) and is neat and professional
- **Organized:** Provides a *clear logical* flow
- Provides detail, rationale, explanation
- Work is free from grammatical errors
- Mathematical composition,

Essentially Correct

- **Precision:** Performs mathematical operations correctly
- Makes and uses assumptions clearly
- Uses an appropriate degree of accuracy
- Draws correct inferences from graphical or numerical data
- Any computational or algebraic errors are trivial and isolated

SOLUTIONS AND ANALYSIS

- Most of the time, students spend time to solve models, analyze them, and understand the behavior of solutions. Then, they make conclusion based on the solutions.



COMMON PROBLEMS IN HANDLING PROJECT

- Students have little or no background about mathematical modeling.
- Students do not have experience to set up reasonable assumptions.
- The mathematical formula and relationships do not fit physical laws or without concrete evidence to support.
- When they met problems, they do not know how to handle.
- They have little experience to write a report or a proper powerpoint slides.
- They need practices of their presentations.

PART 3: CLASS PROBLEMS & DISCUSSION

SOME CHANGES

- In fall 2020, some changes of the class arrangement. Students had 4 discussions this semester in the class.
- Discussions are through Zoom.
- Students are divided into 2 to 3 small groups in each breakroom.
- Each group has 2 to 4 students.
- Each group will share their discussion.
- Each discussion period is 20 minutes.
- After this class discussion, students posted their thought of the questions in the Discussion Board at Blackboard.
- Then, they are going to respond some posts there.

SOME CHANGES

- The responses are mostly praise and support their classmates. Students need encouragement.
- Some responses point out different ideas.

SOME CHANGES

- Discussion topics include: COVID-19 spreading, Population Dynamic, National Debt (suggested by students), SCUDEM V preparation (Numerical Method: Runge-Kutta Method and more)…

HIGHLIGHTS OF SOME DISCUSSIONS

- **Pandemics: How are Viruses Spread?**
- The source of this discussion https://www.nctm.org/Classroom-Resources/Illuminations/Interactives/Pandemics-How-Are-Viruses-Spread/ to use the interactive and set the population size to simulate the numbers of infected case.

HIGHLIGHTS OF SOME DISCUSSIONS

- **National Debt**
- In this problem, we are going to discuss the economy of the US. From 2015 to 2019, especially, the unemployment rate of the US is falling from 5.3% to 3.7%. However, the national spending money is exponentially rising.
- Resource of national debt data: https://fiscaldata.treasury.gov/datasets/historical-debt-outstanding/.

PART 4: ONLINE RESOURCES

- SIMIODE Resources; MCM Mathematical Modeling Problems

  https://simiode.org/scudem

  https://www.comap.com/undergraduate/contests/mcm/

- Numerical Methods to Solve Differential Equations (Runge Kuttta methods). My colleague (Dr. Ram Neupane) gave a guest lecture in my modeling class in fall 2020.

  https://reference.wolfram.com/language/tutorial/NumericalSolutionOfDifferentialEquations.html

- Website of Simulation of Covid-19 Virus in a Closed Environment

  https://www.nctm.org/Classroom-Resources/Illuminations/Interactives/Pandemics-How-Are-Viruses-Spread/

PART 5: SCUDEM V PARTICIPATION

WHAT DID WE DO IN PREPARATION?

- Explain the procedure to prepare a report.
- What do they need?
- Students are encouraged to use graphs and diagrams in their report and powerpoint slides.
- Use MS Word (or Latex, we do not give any training about this part. Some students know how to edit documents with this software) to prepare for their writing. Include MS-Excel spreadsheet or others for computations.
- Print their name and what problem they are solving in the cover page.
- **Students are encouraged to produce a short video (about 5 minutes) to incorporate to their presentation**. I have one student create a short video in his individual project.

SCUDEM

- We joined SCUDEM II, III, IV, and V. Students were able to practice the mathematical modeling process.

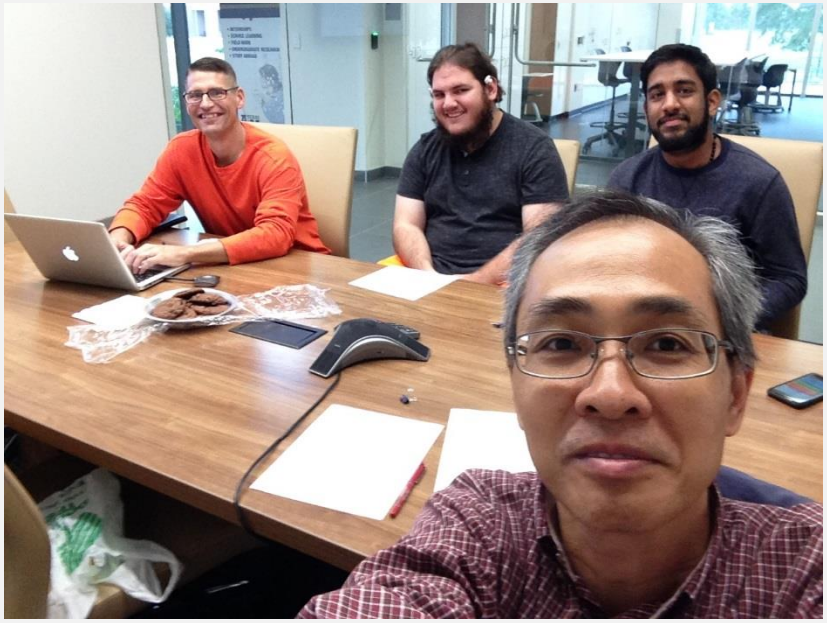
SCUDEM II

SCUDEM III

Group Picture

SCUDEM III

SCUDEM IV



SCUDEM IV

SOME FEEDBACK AFTER SCUDEM

- From what I hear from my former students, they found this contest was fun and meaningful for them.

SOME FEEDBACK AFTER SCUDEM

After the challenge for SCUDEM, I was able to learn how to create a differential equation using real life event … I learned that there is more ways to make a differential equation than the ones that are just given out of the book, like the homework problems we do for my differential equation class.

Nathalie Alvarado, 2018

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Nathalie Alvarado, 2018

SOME FEEDBACK AFTER SCUDEM

SCUDEM IV was a valuable opportunity to work with a team in applying mathematics to find possible solutions to a real world problem. This opportunity strikes me as the type of actual work we may be asked to perform in a future work environment. The time constraints and presentation environment made the opportunity that much more realistic. The problem solving process and presentation development were consistent with what I've been required to do in previous professional employment except that my previous employment did not involve the use of mathematical models. The process was both fun and challenging. Just like in a normal work environment, meetings and communication with other members of the team was challenged by the constraints of our individual schedules. I also found that the problem pushed the limits of our present mathematical capabilities and presentation skills, which increased my curiosity for further study of mathematics. I learned the value of teamwork, i.e., we were able to accomplish much more as a team than I could have ever expected to be able to do alone.

Robert Crayne, 2019

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Robert Crayne, 2019

SOME FEEDBACK AFTER SCUDEM

- In fact, students gained more as well because they learned how to create powerpoint slides, produce video, work together, apply what they known to solve real world problems, organize their ideas and put them together, and enjoy the fun and challenges through this event.

THANK YOU