



Student Challenge Using Differential Equations Modeling

SCUDEM MODELING GUIDE For Coaches and Students

Prepared by Anthony Stefan, Florida Institute of Technology, Melbourne FL USA
and William Clark, Dixie State University, St. George UT USA
Science Gateway Community Institute and SIMIODE Summer 2020 Interns

We explore applications of differential equations to modeling real world phenomena by student teams who use the tool of mathematics, to develop truth and understanding of our observations or data in the world around us. Eventually, we want to characterize and predict the future of these instances through accurate developed models. Modeling scenarios and challenges, using differential equations, can hold the key to unlocking the nature of such phenomena.

Below is a general modeling guide for what to consider when developing a mathematical model for SCUDEM. You can check your model against these notions and ask your coach about them during pre-Challenge Period mentoring if questions arise:

- Assumptions
- Modeling
- Accuracy
- Solutions
- Limitations
- Future Directions
- Resources

Before creating a model, read through ALL the problems. Although you may love physics, the life-sciences problem may be easier for your team to develop a model, as one team member may have experience with the structure of the life-science problem. Each team's experience is unique. So, these guide suggestions should not restrict what you and your team produce, rather they should open your eyes to realistically make progress.

Assumptions

The key to developing a model that effectively represents your chosen scenario is to understand the assumptions necessary to build a representative model. Assumptions are useful when applied to scenarios, often they reduce the complexity of governing laws that are used in your model. It is always good to begin with the simplest assumptions, removing anything too complicated at first, then applying more as you build. For example, hydrodynamics in a model of how a fish may be moving away from a predator could be neglected for simplicity in modeling the directional movement of the fish. However, there must be a balance, as assumptions may pull the model into a mathematical environment that is not realistic. (See Accuracy section.)

Modeling

When deciding how to model your chosen problem, understanding the variables the problem description gives you is crucial to begin, along with their relationship to each other and how they can be incorporated in terms and equations. Sometimes it helps to find similar known problems and use modeling techniques of these problems to help solve current ones. Therefore, a good way to prepare for modeling is to practice with modeling scenarios. See the modeling scenarios on the [SIMIODE](#) website and [past SCUDEM problems](#) under Challenge Results.

Accuracy

While developing a model might seem tricky, it is important to make sure you are explaining the data or scenario with your model and not using your model to explain what the data *should* be.

Solutions

It is important to remember that this is a modeling challenge. Solutions need not exist or be discussed. Ideally, modeling a scenario that is solvable is beneficial. The problems released are in fact meant for undergraduates who can develop them and use differential equations techniques to find solutions. That being said, take this problem as far as you wish. If time permits, create the model, find solutions, code a simulation, code a program to find solutions, etc. The sky is asymptotical! Therefore, the limit *does not exist*!

Limitations

Speaking of limits, include what the limitations of your model are. Consider how removing or adding more assumptions or variables would impact your model. Think about what your model does *not* address or breaks your model and discuss this shortly in your presentation. This proves your team has a deep understanding of your chosen problem.

Future Directions

Have a short discussion as to where the future directions of your problem or model can go. What are some variables that exist in the model that could and perhaps should change over time? What are some new variables that could be introduced to your problem? Think of how the model you may have developed could be generalized or used in different applications than just your one problem. Also, future directions do not need to change your model, they may just explore the components and enhance the model.

Resources

The resources for your model should be cited at the end of your presentation. The resources are a valuable part of any research. Briefly, explain how your model was influenced by key resources, regardless of whether they were given with the problem statement or not.

Executive Summary

For local site version of SCUDEM (as was the case for SCUDEM I – IV) there is a requirement to produce an Executive Summary. With all this information gathered, take time to write a two page, concise, and scientific executive summary on your model and these aforementioned aspects of your research. Proofread the paper and then do it again, and again, and again. Each time new mistakes or errors occur, and over time you may even change your model at the last minute after thinking it through more while writing your Executive Summary. Thus even this current SCUDEM V challenge in which only a video presentation is offered you can use this Executive Summary to guide your group thinking and as a check list to see your offering and your flow for your presentation.

Consider using LaTeX for writing your paper along with using [Beamer presentation mode](#). The use of LaTeX can help organize and clearly present your results in elegant mathematical notation and symbols. Practice using LaTeX prior to the Challenge Period if you are new to it, as the syntax learning curve takes some time. The use of LaTeX in scientific higher education is very prevalent, therefore, starting to use it as an undergraduate is beneficial. Consider the use of [Overleaf](#) a free LaTeX version which permits collaboration, much as Google Docs does.

Here is a good outline for an Executive Summary and a Presentation.

The Beginning:

- Abstract and Introduction to Your Problem

Then a body of paragraphs that include parts as such:

- Your Model
- Your Solutions
- Limitations
- Future Directions

The Ending:

- A Conclusion
- A Work Cited Page.

With the use of these guidelines, you could create a great presentation and produce an exceptional showcase presentation of your model. Good luck!

References

1. Canfield, Brenten , William Clark, and Jacey Schow. 2020. SCUDEM Lite 2020, Dixie State University DSU-5 Team Presentation. <https://youtu.be/jvICqzn0obU> .
2. Fralish, Zachary, Anthony Stefan, and Bernie Tyson. 2019. Florida Southern University SCUDEM II 2018 Submission. <https://www.youtube.com/watch?v=3-ThqvOFUac> .
3. Fralish, Zachary, Anthony Stefan, and Bernie Tyson. 2019. Using Differential Equations to Model Predator-Prey Relations as Part of SCUDEM Modeling Challenge. *Rose-Hulman Institute of Technology Undergraduate Mathematics Journal*. 20(2): Article 7. pp. 1-11. <https://scholar.rose-hulman.edu/rhumj/vol20/iss2/7/> .