Teaching Differential Equations the SIMIODE Way

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Yuba College

The Teaching and Learning of Undergraduate Ordinary Differential Equations

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What is SIMIODE?

SIMIODE = Systemic Initiative for Modeling Investigations & Opportunities with Differential Equation

Founder and Director: Dr. Brian Winkel (emeritus, USMA West Point Department of Mathematical Sciences)

SIMIODE is a free and open community of teachers and learners using modeling first differential equations in an original way

https://www.simiode.org
The Traditional DE Course

• Introduce type of equation
  • First-order linear equations
  • Separable equations
  • Second-order linear equations
    • Homogeneous
    • Nonhomogeneous
  • $n$th-order linear equations
  • and so on
The Traditional DE Course

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  - $n$th-order linear equations
  - and so on
- Show and practice how to solve that type of equation
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  • and so on

• Show and practice how to solve that type of equation
• Introduce models (modeling)
The Flipped Classroom

Flipped classroom is an instructional strategy and a type of blended learning that reverses the traditional educational arrangement by delivering instructional content, often online, outside of the classroom. It moves activities, including those that may have traditionally been considered homework, into the classroom. In a flipped classroom, students watch online lectures, collaborate in online discussions, or carry out research at home and engage in concepts in the classroom with the guidance of the instructor.

—Wikipedia,
https://en.wikipedia.org/wiki/Flipped_classroom
(accessed Oct 19, 2015)
Flipped ≠ Flipped

Flipped  Venues for delivery of instruction and assignments are flipped, but the content is not flipped.

- Outside of class
  - Introduce type of equation
  - Show how to solve
- In class
  - Practice how to solve
  - Introduce models (modeling)
Flipped \neq \text{ Flipped}

\textbf{Flipped}  Venues for delivery of instruction and assignments are flipped, but the \textit{content is not flipped}.

- Outside of class
  - Introduce type of equation
  - Show how to solve

- In class
  - Practice how to solve
  - Introduce models (modeling)

\textbf{SIMIODE}  Content is flipped.
Example


Chapter 3 Second Order Linear Equations 137

3.1 Homogeneous Equations with Constant Coefficients 137

3.2 Solutions of Linear Homogeneous Equations; the Wronskian 145

3.3 Complex Roots of the Characteristic Equation 158

3.4 Repeated Roots; Reduction of Order 167

3.5 Nonhomogeneous Equations; Method of Undetermined Coefficients 175

3.6 Variation of Parameters 186
Example


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3.6 Variation of Parameters 186

3.7 Mechanical and Electrical Vibrations 192

3.8 Forced Vibrations 207
Sample SIMIODE Course Syllabus,
https://www.simiode.org/resources/1265/download/

Week(Day)

4(10) Second order ODE - homogeneous: Modeling a spring mass damper system using collected data
Free Body Diagram used to build ODE and complete analysis of ODE with eigenvalues    [Activity] (data)
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Week(Day)

4(10) Second order ODE - homogeneous: Modeling a spring mass damper system using collected data
Free Body Diagram used to build ODE and complete analysis of ODE with eigenvalues [Activity] (data)

4(11) Second order ODE - homogeneous: Modeling falling objects using experimental data

4(12) Second order ODE - nonhomogeneous: Modeling mystery RLC circuit to analyze results for driver frequencies
Use Kirchhoff’s Law to build circuit and analyze for steady state and transient solutions
Week(Day)

5(13) Second order ODE - nonhomogeneous: Modeling spring mass damper system with driver or forcing function
Resonance and beats along with frequency response analysis are introduced. Frequency Response Analysis

5(14) Second order ODE - nonhomogeneous: Tuned Mass Dampers an introduction to systems of ODEs
Analysis of how to control a nondamped resonant response phenomena using a Tuned Mass Damper

5(15) Second order ODE - nonhomogeneous: Projectile Motion - analysis of several situations
Building model from Newton’s Second Law of Motion and applying it in interesting settings
Modeling Scenarios

Three sample activities:

- Torricelli’s Law;
- Oil Slick;
- M&M Death and Immigration.
Torricelli’s Law

Resource name: 1-15-S-Torricelli

Abstract: We help students develop a model (Torricelli’s Law) for the height of a falling column of water with a small hole in the container at the bottom of the column of water. We offer several sources of simulations on YouTube from which we collect data and ask students to verify their model through parameter estimation.

Student version
Teacher version
Video
Resource name: 1-5-S-OilSlick

Abstract: We describe a modeling activity for students in which modeling with difference and differential equations is appropriate. We have used this model in our coursework for years and have found that it enlightens students as to the model building process and parameter estimation for a linear, first-order, non-homogeneous, ordinary differential equation. The activity also provides a lesson in "knowing what to do when you do not know what to do."

Student version
Teacher version
Abstract: We describe a classroom activity in which students use M&M candies to simulate birth, death, and immigration. Students build a mathematical model, usually a linear first order, difference or differential equation model, estimate parameters, and compare their model prediction with their actual data.

Student version
Teacher version
Learning More about SIMIODE

Systemic Initiative for Modeling Investigations and Opportunities with Differential Equations

SIMIODE Website: www.simiode.org
What Is on the SIMIODE Website?

MODELING SCENARIOS FOR DIFFERENTIAL EQUATIONS

- **MODELING SCENARIOS**
  Browse student versions or login to see teacher versions as well. These are the essence of our repository where faculty can find modeling first approaches to teaching differential equations.

- **TECHNIQUE NARRATIVES**
  Offer traditional solving technique material, often with a modeling context to motivate learning.

- **CONTRIBUTE RESOURCES**
  Contribute materials in our double-blind, peer-reviewed publication system. Please Register/Sign In.

HOW CAN I USE MODELING SCENARIOS IN MY COURSE?

- Here is an **INTRODUCTORY VIDEO** by SIMIODE Director Dr. Brian Winkel explaining more about the modeling first process and the SIMIODE community.

- **SAMPLE SYLLABUS**

- **INDEX**
  Of both modeling scenarios and technique narratives, which conforms to a traditional table of contents.

- **GENERAL RESOURCES**
  A useful set of resource materials to help shape coursework.

- **TESTIMONIALS**
  Success story accounts and good news.

Go to website
Modelling Scenarios for Differential Equations

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How Can I Use Modeling Scenarios in My Course?

Introductory Video

Sample Syllabus

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General Resources A useful set of resource materials to help shape coursework.

Testimonials Success story accounts and good news.
What SIMIODE Needs

You!

SIMIODE seeks to revolutionize the teaching of differential equations with a modeling first approach, but to achieve that the movement requires

• more teachers trying and using the SIMIODE material;
• more contributions to the SIMIODE repository, both modeling scenarios and technique narratives;
• more feedback (comments and suggestions, shared experience) on modeling scenarios or technique narratives.
Finally

In addition to moving to a modeling first approach to teaching differential equations, you might also consider using a low-cost or no-cost textbook. One example is Jiří Lebl’s *Notes on Diffy Qs: Differential Equations for Engineers.*

http://www.jirka.org/diffyqs/

Follow Dina Yagodich’s blog on using Lebl together with SIMIODE. Yagodich is at Frederick Community College in Maryland.

https://www.simiode.org/members/1045/blog
Finally-finally . . . really . . . this is it

Find out more about SIMIODE first hand here at JMM.

- Exhibit Booth #420
  Stop by and learn more, participate in M&M simulation, register for SIMIODE and T-Shirt drawing, pick up sample modeling scenarios, and discuss the prospects of teaching differential equations in a modeling-first approach.

- Open House in the Willow Room of the Sheraton Hotel tonight, Friday, Jan 8, from 7 to 9 p.m.
  There will be food, door prizes, drawings for free SIMIODE T-shirts, free registration for SIMIODE, and informal, topical, and themed discussions about modeling-first teaching of differential equations.
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