Cover Sheet for Activity*

Title: Differential Equations – Modeling a Changing World

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Course: Differential Equations

Type/Size of Institutions: The approach was initially implemented at a small liberal arts college. Nevertheless, it is designed to be broadly applicable across a range of institutional types and instructional settings.

Class Sizes: Piloted in courses with enrollments of up to 26 students, though the instructional methods are intended to be adaptable to classes of varying sizes.

Mathematical Content: This module integrates qualitative, graphical, and analytical approaches to differential equations and their applications. Topics include

- Foundational Concepts: slope fields and solution graphs, equilibrium solutions, initial value problems, general and particular solutions
- Techniques for Solving Differential Equations:
    - First-order ODEs: separation of variables, integrating factor method
    - Second-order ODEs: characteristic equation, classification (underdamped, over-damped, critically damped, or undamped)
    - Systems of differential equations
- Applications: savings and financial outlook, spread of misinformation, growth vs. extraction of natural resources, modeling climate change, heart rhythm modeling, infectious disease modeling and pandemic tracking

Learning Objectives:

1. Students will use differential equations to model real-world systems and interpret results in meaningful context.
2. Students will apply differential equations to analyze decisions and evaluate the ethical, social, and environmental impacts of mathematical models.
3. Students will engage in collaborative problem-solving and discussion to deepen their understanding of differential equations concepts and connect quantitative reasoning with ethical reflection.

Time Required and Implementation Plan: These activities can be integrated throughout a semester-long differential equations course using a mix of direct instruction, collaborative discussions, group work, homework assignments, and projects.

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Grading and Assessment Recommendations: In-class worksheets may serve as ungraded practice, supported by instructor observation, peer collaboration, and guided discussion. Homework assignments can be assessed based on conceptual understanding, completeness of responses, and the soundness of reasoning, rather than focusing solely on final answers.

Required resources and technology: A scientific calculator may be used as needed to support computations. In the final activity, students may use GeoGebra to solve a nonlinear system and visualize the solutions. A sample demonstration is provided.

Brief Description/Abstract: This module invites students to reflect on how differential equations function not only as a powerful analytical tool but also as an ethical lens for navigating real-world challenges. Students apply differential equations to model complex systems in areas such as economics, healthcare, and sustainability. Beyond computation, the module emphasizes the importance of interpreting mathematical results within ethical, social, and environmental contexts. By integrating mathematical reasoning with ethical reflection, students develop a deeper understanding of how differential equations can inform responsible decision-making in an increasingly complex world.