Title Fitting Exponential and Logistic Growth Models to Bacterial Cell Count Data

Description In this activity, students will model a noisy set of bacterial cell count data using both exponential and logistic growth models. For each model the students will plot the data (or a linear transformation of the data) and apply the method of least squares to fit the model's parameters. Activities include both theoretical and conceptual work, exploring the properties of the differential equation models, as well as hands-on computational work, using spreadsheets to quickly process large amounts of data. This activity is meant as a capstone to the differential calculus portion of a typical undergraduate Calculus I course. It explores a biological application of a variety of differential calculus concepts, including: differential equations, numerical differentiation, optimization, and limits. Additional topics explored include semi-log plots and linear regression.

This module was inspired by an existing module by Jaros et al.[1] It covers some of the same material regarding semi-log plots of exponential functions, but was completely rewritten from scratch for use in a college calculus class rather than a college algebra class.

Learning Outcomes After this project, students should be able to:

- Explain the assumptions behind the exponential and logistic growth models, and what they are used for.
- Generate a semi-log plot of data, and understand when doing so might be useful.
- Apply their understanding of minimizing a function to find a mathematical model that minimizes an error.
- Use mathematical analysis in conjunction with computational technology, by developing theoretical results by hand and then implementing those results in a program to quickly process data.
- Use spreadsheet software to organize, process, and display data.

Handouts and Resources This module includes the following documents:

- Instructor notes (`pdf`)
- Student handout (`pdf`)
- Data tables (`xlsx`, `ods`, and `txt`)
- Links to interactive Desmos activities (`txt`)
- Source files (`zip`)

Tags Cellular and Molecular Biology, Microbiology, Concepts in Statistics, Understanding rates, Choosing models, calculus, optimization, linear regression, measurements, exponents, graphing, functions, exponential and logarithmic functions, creating graphs, data analysis, interpreting graphs, interpreting tables, manipulating equations, modeling

[1] Jaros, A. M., Frazier, A., Alford, B., Williams, B. (2021). Graphing bacterial growth rates: semi-log graphs v linear graphs. QB@CC Spring 2020 Incubator 7, QUBES Educational Resources. doi:10.25334/SJ68-XX58

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