

Long lecture

Explorations of Mathematical Models in Life Sciences with Maple

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Abstract

In this workshop we will share with the participants samples of the instructional materials for an interdisciplinary course on mathematical models of biology with the CAS, Maple. The main goal of the activities is to help students explore and discover mathematical concepts and use these concepts in building and analyzing mathematical models of life science disciplines such as biology, ecology, and environmental sciences.

In this workshop, we introduce the modeling of real life situations with difference equations and matrices using Maple. We will emphasize the use of graphical and numerical techniques, rather than theoretical techniques, to investigate and analyze the behavior of solutions of the mathematical models. We will investigate interesting linear and nonlinear models from diverse life science disciplines.

We utilize a discovery pedagogical approach. To introduce a concept, first we investigate a model numerically and/or graphically and recognize a pattern or certain properties that characterize that concept. Then we give a definition of the concept with examples and applications. For example, to introduce the eigenvalues and corresponding eigenvectors of a square matrix we investigate an age-structure population model with different initial population vectors that lead to a visualization of an eigenvalue and corresponding eigenvectors. Then the definition of the eigenvalues and eigenvectors are introduced and some properties are discussed.

Why modeling with difference equations and matrices? Difference equations represent a very sophisticated and powerful mathematical tool to model a wide range of real life discrete time situations in diverse areas, including the life sciences. And matrices provide an excellent tool in modeling linear problems. Moreover, these powerful tools do not require a sophisticated mathematics background, being accessible to anyone who has successfully completed high school algebra or college algebra.

Why do we use Maple?

All the models presented require the use of computers. For example, in order to investigate and analyze a model it is often required to iterate the difference equation(s) or the matrix difference equation(s) that represent the model and graph it. Sometimes it is required to find the eigenvalues and the corresponding eigenvectors in order to investigate the long-term behavior of a dynamical system. In other instances, in order to investigate the sensitivity of a dynamical system to certain parameters, it is required to change the parameters of the dynamical system and find the corresponding numerical solutions. All these computational activities require a software that is easy to learn and to use. Maple is a user friendly and powerful mathematics software with excellent graphing capabilities. The use of Maple frees students from tedious calculations. This allows them to focus on translating a problem into mathematical notation, finding a solution, interpreting the numerical and the graphical information provided, and then making conjectures and writing about their findings and observations. With the use of Maple the students focus on building and analyzing the models.