Prefix, Number and Name of Course: MAT 319 Mathematical Biology

Credit Hours: 3
In Class Instructional Hours: 3 **Labs**: 0 **Field Work**: 0

Catalog Description:
Prerequisites: MAT 161 with a minimum grade of C, or equivalent.
A project-oriented, introductory mathematical modeling course with an emphasis on the construction and analysis of mathematical models of biological events and phenomena. Mathematical topics include matrix algebra, difference and differential equations. Biological topics include population dynamics, dynamics of infectious disease and models of molecular evolution.

Reasons for Addition:
The course offers an insight into the basics of mathematical modeling. In particular it provides students the opportunity to transfer biological problems into mathematical expressions, and use these models to draw conclusions. It is designed to be a project-oriented course, so that not only students' creativity, research, and problem-solving skills, but also oral communication skills would be promoted. Students will be required to present their projects at the annual Student Research and Creativity Celebration at Buffalo State College. The course requires a minimal amount of prerequisites, therefore it will be attractive to biology, mathematics education, and allied disciplines' majors as well as applied mathematics majors.

Student Learning Outcomes: Students will:	**Content Reference**	**Assessment**:
1. formulate mathematical models of real world phenomena, apply those models to make predictions about the behavior of the phenomena, apply appropriate problem solving techniques, and critically evaluate the accuracy of the obtained results.	I-III	1. Participation in group work and classroom activities/discussions, individual assignments, quizzes, exams, projects
2. interpret the biological significance of terms in mathematical models of biology.	I-III	2. Participation in group work and classroom activities/discussions, individual assignments, quizzes, exams, projects
3. communicate mathematical ideas effectively.	I-III	3. Individual assignments, projects, exams
4. determine equilibrium points and their stability, and produce phase plane (line) analysis.	II-III	4. Participation in group work and classroom activities/discussions, individual assignments, quizzes, exams, projects
5. describe and apply the Law of Mass Action to modeling population dynamics.	I-III	5. Participation in group work and classroom activities/discussions, individual assignments, quizzes, exams, projects

6. solve difference and differential equations using analytical methods.	II-III	6. Participation in group work and classroom activities/discussions, individual assignments, quizzes, exams, projects
7. solve difference and differential equations numerically using appropriate technology.	II-III	7. Participation in group work and classroom activities/discussions, individual assignments, quizzes, exams, projects

Course Content:

I. Introduction to modeling in biology
   A. The modeling process
   B. Probabilities, rates, and parameters
   C. Law of mass action
   D. Model classes

II. Modeling with difference equations
   A. Modeling with linear and nonlinear difference equations
      i. Malthusian (exponential) model
      ii. Logistic model
   B. Analysis of linear and nonlinear difference equations
      i. Determination of equilibrium points
      ii. Linear stability analysis
      iii. Cobwebbing (graphical iteration)
      iv. Parameter variations, bifurcations and chaos
   C. Biological models using linear difference equations
      i. Cell division
      ii. Models of population growth: An insect population
   D. Modeling with systems of linear difference equations
      i. A matrix algebra review
      ii. An introduction to probability
      iii. Eigenvalues and eigenvectors
      iv. Qualitative behavior of solutions
   E. Modeling with systems of nonlinear difference equations
      i. Determination of equilibrium solutions
      ii. Linearization and stability
   F. Biological models using systems of nonlinear difference equations
      i. Nonlinear models of interacting populations
      ii. Models in epidemiology (e.g., elementary epidemic models such as SIR, SIS)
      iii. Predator-prey models
      iv. Models of infectious diseases
      v. Models of molecular evolution
   G. Numerical simulations with Mathematica (or Matlab)

III. Modeling with differential equations
   A. Modeling with linear first-order differential equations
      i. Determination of equilibrium points
      ii. Phase line analysis

    iii. Bifurcation analysis
    iv. Numerical technique: Euler's Method
B. Systems of linear first-order differential equations
    i. A matrix algebra review
    ii. Eigenvalues and eigenvectors
    iii. Qualitative behavior of solutions
    iv. Determination of equilibrium values
    v. Phase plane analysis
    vi. Nondimensionalization
C. Systems of nonlinear first-order differential equations
    i. Determination of equilibrium points
    ii. Linearization
    iii. Stability analysis
D. Biological models using systems of linear or nonlinear differential equations
    i. Population growth
    ii. Predator-prey models
    iii. Dynamics of epidemics
    iv. Models in physiology
E. Numerical simulations with Mathematica (or Matlab)

Resources

<u>Scholarship:</u>

Allman, E.S. and Rhodes, J.A. *Mathematical Models in Biology*. Cambridge, 2004.

Blanchard, P., Devaney, R., and Hall, R.H. *Differential Equations, 2nd Edition*. Brooks/Cole, 2002.

De Vries G., Hillen, T., Lewis, M., Muller, J., and Schonfisch, B. *A Course in Mathematical Biology, Mathematical Modeling and Computation.* Society for Industrial and Applied Mathematics (SIAM), 2006.

Edelstein-Keshet, L. *Mathematical Models in Biology.* SIAM Classics in Applied Mathematics, Vol. 46, Society for Industrial and Applied Mathematics (SIAM), 2005.

Keener, J. and Sneyd, J. *Mathematical Physiology*. Springer, 1998.

Murray, J.D. *Mathematical Biology: An Introduction, 3rd Edition*. Springer, 2002.

Rubinow, S.I. *Introduction to Mathematical Biology*. John Wiley, 1975.

Steen, L.A. *Math & Bio 2010 Linking Undergraduate Disciplines.* The Mathematical Association of America (MAA), 2005.

<u>Periodicals:</u>

American Mathematics Monthly
Bulletin of Mathematical Biology
College Mathematics Journal
Journal of Mathematical Modeling and Algorithms
Journal of Theoretical Biology

Nature
Math Horizons
SIAM Journal of Applied Mathematics

Electronic and/or Audiovisual Resources:

American Mathematical Society, Mathematical Association of America, and Society for Industrial and Applied Mathematics, Mathematical Sciences Careers, www.ams.org/careers/

COMAP, the Consortium for Mathematics and Its Applications, http://www.comap.com/

Dawkins, Paul, *Paul's Online Math Notes*, http://tutorial.math.lamar.edu/

Mathematical Association of America, *Undergraduate Programs and Courses in the Mathematical Sciences: CUPM Curriculum Guide 2004*, http://www.maa.org/cupm/cupm2004.pdf

McLaughlin, Michael P., *A Tutorial on Mathematical Modeling*, http://www.causascientia.org/math_stat/Tutorial.pdf

National Research Council, *BIO 2010: Transforming Undergraduate Education for Future Research Biologists,* http://books.nap.edu/books/0309085357/html/5.html