Prefix, Number and Name of Course: MAT 318 Mathematical Modeling

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

Catalog Description:
Prerequisites: MAT 162 and MAT 202.
Construction, interpretation and application of mathematical models; various modeling paradigms such as deterministic, probabilistic, discrete and continuous modeling. Models which provide valuable insights into contemporary topics from different fields that may include bio-medical applications, financial mathematics, cellular automata models, mathematical methods for data collection and analysis in geology, mathematical tools for GIS, and weather prediction.

Reasons for Addition:

The proposed course expands the department's course offerings in the broad area of applied mathematics and provides students majoring in applied mathematics, mathematics, and mathematics education with the opportunity to study mathematical modeling as part of their major.

Applied mathematics consists of mathematical techniques and results, including those from "pure" math areas such as algebra or algebraic topology, which are used to assist in the investigation of problems or questions originating outside of mathematics. Modeling is one of the most common tools used to investigate such problems. The proposed course is an introduction to mathematical modeling using graphical, numerical, symbolic, and verbal techniques to describe and explore real-world data and phenomena. Emphasis is on the use of functions, graphs and other mathematical structures to investigate and analyze applied problems and questions, networking, data collection and analysis and other tools as well as the practice of effective oral and written communication of quantitative concepts and results. Computational methods such as cellular automata, which entirely rely on the discrete evolution of computer models and not on analytical mathematical structures, will also be explored.

Student Learning Outcomes: Students will:	**Content Reference**	**Assessment**:
1. apply the central concepts and tools of mathematical modeling to represent real-world phenomena.	III,IV,VI	1. Participation in group work and classroom activities, projects
2. differentiate mathematical models from mathematical theories and discuss the limits and potential of each.	I,II,III,VI	2. Participation in group work and classroom activities, individual assignments
3. analyze applied problems and data using appropriate mathematical tools and methods.	II - VII	3. Participation in group work and classroom activities, projects
4. use mathematical tools and critical thinking to provide insight into real-world phenomena.	II,III,IV,V	4. Individual assignments, quizzes, exams
5. implement mathematical models using appropriate computer tools and interpret the results generated by the computer.	IIIA, IVC	5. Programming assignments
6. communicate mathematical ideas effectively both orally and in writing.	I – VII	6. Class presentations, projects

7. use mathematical models to predict future and past states in real-world phenomena and analyze the limits and benefits of mathematical models.	III,IV,VI, VII	7. Individual assignments, projects

Course Content:

I. The modeling process: Aims and philosophy

II. Contrast between theoretical and practical settings

III. Goals and limitations of modeling
   A. Model construction using proportionality
   B. Model construction using geometric similarity

IV. Modeling dynamical systems
   A. Difference equations
      1. Definitions and application to modeling
      2. Solutions and approximations
      3. Systems of difference equations
   B. Differential equations
      1. Definitions and application to modeling
      2. Solutions and numerical approximation methods
      3. Models with coupled differential equations
   C. Cellular automata
      1. Definitions, examples and applications
      2. One-dimensional automata
      3. Multiple dimensional automata

V. Optimization
   A. Optimization of discrete models
      1. Linear programming
      2. Numerical search methods
      3. Computational methods
   B. Optimization of continuous models
      1. Single and multivariable nonlinear modeling optimization
      2. Equality constrained optimization problems

VI. Modeling and data handling
   A. Model fitting
      1. Graphical methods
      2. Analytical methods
      3. Probabilistic analysis
   B. Experimental modeling
      1. Empirical models
      2. Model validation
   C. Simulation modeling
      1. Simulating deterministic behavior
      2. Simulating random behavior using pseudo-random number generators

VII. Additional modeling tools [selected from the following topics; optional]
   A. Graph theory; definitions, examples and applications
   B. Dimensional analysis and similitude
      1. Definitions, examples and applications
      2. The process of dimensional analysis
   C. Matrices; examples and applications
   D. Functions; examples and applications

Resources

Scholarship:

Adam, J. A. (2003), *Mathematics in Nature: Modeling Patterns in the Natural World*, Princeton University Press.

Bender, E. A. (1977), *An Introduction to Mathematical Modeling*, Wiley.

Bovee, Courtland L. & Thill, J. V. (2000), *Business Communication Today*, Prentice Hall.

Burghes, David N.; Huntley, I. (1982), *Applying Mathematics: A Course in Mathematical Modeling*, Halsted Press.

Dinsmore, P. C. & Cabanis-Brewin, J. (2006), *The AMA Handbook of Project Management*, AMACOM.

Forbes, N. (2004), *Imitation of Life*, The MIT Press.

Giordano, E. E. A. (2009), *A First Course in Mathematical Modeling (fourth ed)*, Brooks/Cole.

Harte, J. (1988), *Consider a Cylindrical Cow, A Course in Environmental Problem Solving*, University Science Books.

Harte, J. (2001), *Consider a Cylindrical Cow, More Adventures in Environmental Problem Solving*, University Science Books.

Howard, J. C. (1979), *Mathematical Modeling of Diverse Phenomena*, National Aeronautics and Space Administration, Scientific and Technical Information Brach: for sale by the Supt. of Docs., U.S. Govt. Print. Off.

Lohiser, A. (2008), *Efficient PR: Understandable, Affordable and Attainable Public Relations and Marketing for Small Businesses: a Master's Project in Public Relations Management*.

Meyer, W. J. (1984), *Concepts of Mathematical Modeling*, McGraw-Hill.

Mezey, P. G. (1991), *Mathematical Modeling in Chemistry*, VCH.

Mooney, D. D. & Swift, R. J. (1999), *A Course in Mathematical Modeling*, Mathematical Association of America.

Orlob, G. T. (1983), *Mathematical Modeling of Water Quality: Streams, Lakes, and Reservoirs*, Wiley.

Otto, S. P. & Day, T. (2007), *A Biologist's Guide to Mathematical Modeling in Ecology and Evolution*, Princeton University Press.

Pritchard, C. L. (2004), *The Project Management Communications Tool Kit*, Artech House.

Shier, D. R. & Wallenius, K. T. (2000), *Applied Mathematical Modeling: A Multidisciplinary Approach*, Chapman and Hall.

Strangeways, I. (2003), *Measuring the Natural Environment*, Cambridge University Press.

Waltham, D. (1994), *Mathematics: A Simple Tool for Geologists*, Chapman and Hall.

Periodicals:

Multiscale Modeling and Simulation
SIAM Journal on Applied Dynamical Systems
SIAM Journal on Applied Mathematics
SIAM Journal on Discrete Mathematics
SIAM Journal on Financial Mathematics
SIAM Journal on Imaging Sciences
SIAM Journal on Optimization
SIAM Journal on Scientific Computing
American Mathematics Monthly
Bulletin of Mathematical Biology
College Mathematics Journal
Nature
Math Horizons

Electronic and/or Audiovisual Resources:

American Mathematical Society: http://www.ams.org

Applied Mathematics E-notes: http://www.math.nthu.edu.tw/~amen/

Applied Mathematics Made Easy: http://www.ammeinc.com/

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

Mathematical Association of America: http://www.maa.org

Sloan Career Cornerstone Center: http://www.careercornerstone.org/math/math.htm

Society for Industrial and Applied Mathematics: http://www.siam.org

U.S. Geological Survey: http://www.usgs.gov/

Wolfram Research: http://www.wolfram.com