Prefix, Number and Name of Course: ACM 622 Modeling Change with Dynamical Systems

Credit Hours: 1
In Class Instructional Hours: 1 Labs: 0 Field Work: 0

Catalog Description:
Prerequisites: (MAT 162 and MAT 202) or equivalents
Difference equations; systems of differential equations; Euler and Runge-Kutta methods; error analyses; logistic models; applications to ecology, finance, conflicts, natural and social sciences.

Reasons for Addition or Revision:
To create a one-semester-hour core module for the graduate Professional Applied and Computational Mathematics program where students will formulate and solve systems of equations that relate changing quantities selected from a wide variety of real-world situations.

Student Learning Outcomes: Students will:	**Course Content References:**	**Assessment:**
1. construct theoretical models for quantities that vary over time.	IV, V	1. Group work in class, individual homework assignments, exams.
2. analyze, compare and contrast numerical methods for solving systems of difference/differential equations.	I, II, III	2. Group work in class, individual homework assignments, exams, and computer projects.
3. write and select appropriate computer programs for implementing the Euler and Runge-Kutta methods.	II, III	3. Group work in class, individual homework assignments, and computer projects.

Course Content:

I. Approximating discrete change
   A. Difference equations/dynamical systems
   B. Models for births, deaths and resources

C. Equilibrium values
D. Systems of difference equations
E. Sensitivity analysis and long-term behavior

II. Approximating continuous change
A. The derivative as a rate of change
B. Autonomous differential equations
C. Population growth and exponential decay models
D. Stable and unstable equilibria
E. Euler method for initial value problems
F. Runge-Kutta method
G. Exact methods (optional)

III. Systems of differential equations
A. Reducing to systems of first-order equations
B. Ecological models: predator-prey
C. Euler's method for systems of initial value problems
D. Runge-Kutta method for systems
E. Error analyses

IV. Miscellaneous discrete applications
A. Financial models
B. Modeling ecosystems
C. Conflict analysis

V. Selected continuous applications
A. Approximating irrational numbers
B. Modeling the spread of disease
C. Acceleration-velocity models
D. Logistic models with harvesting
E. Electrical circuits
F. Mechanical Applications

Resources:

Scholarships in the Field:

Abell, M. L. and Braselton, J. P., *Modern Differential Equations*, 2nd ed. New York: Harcourt, 2001.

Blanchard, P., Devaney, R. L. and Hall, G. R., *Differential Equations,* 2nd ed. Pacific Grove, CA: Brooks/Cole, 2002.

Boyce, W. E. and DiPrima, R. C., *Elementary Differential Equations and Boundary Value Problems*, 8th ed. New York: Wiley, 2005.

Clark, C., *Mathematical Bioeconomics: The Optimal Management of Renewable Resources,* New York: Wiley, 1976.

Derrick, W. R. and Grossman, S. I., *Elementary Differential Equations with Applications. Reading,* MA: Addison-Wesley, 1976.

Diacu, F., *An Introduction to Differential Equations, Order and Chaos,* New York: W. H. Freeman, 2000.

Edwards, C. H. and Penney, D. E., *Elementary Differential Equations with Boundary Value Problems*, 6th ed. New Jersey: Pearson Prentice Hall, 2008.

Etgen, G. J. and Morris, W. L., *An Introduction to Ordinary Differential Equations with Difference Equations*, Numerical Methods and Applications. New York: Harper & Row, 1977.

Fox, W. P. and Schnibben, G., "Using Euler's Method in Autonomous Ordinary Differential Equations: The Importance of Step Size." COED Journal (2000), 44-50.

Giordano, F. and Weir, M., *Differential Equations: A Modeling Approach. Reading*, MA: Addison-Wesley, 1991.

Giordano, F. R., Fox, W. P., Horton, S. B. and Weir, M. D., *A First course in Mathematical Modeling*, 4th ed. Belmont, CA: Brooks/Cole, 2009.

Hutchinson, E. G., *An Introduction to Population Ecology*, New Haven, CT: Yale University Press, 1978.

Kells, L. M., *Elementary Differential Equations,* New York: McGraw-Hill, 1960.

Krusemeyer, M., *Differential Equations,* New York: Macmillan, 1994.

Levins, R., "The Strategy of Model Building in Population Biology." American Scientist 54 (1966), 421-431.

May, R. M. (ed.), *Theoretical Ecology: Principles and Applications,* Philadelphia: Saunders, 1976.

May, R. M., Beddington, J. R., Clark, C. W. Holt, S. J., and Lewis, R. M., "Management of Multispecies Fisheries." Science 205 (1979), 267-277.

May, R. M., *Stability and Complexity in Model Ecosystems, Monographs in Population Biology VI,* Princeton, NJ: Princeton University Press, 2001.

McQuie, R., "Military History and Mathematical Analysis." Military Review 50.5 (1970), 8-17.

Nagle, R. K., Saff, E. B. and Snider, A. D., *Fundamentals of Differential Equations*, New York: Addison-Wesley, 2000.

Pearl, R. and Reed, L. J., "On the Rate of Growth of the Population of the United States since 1790." Proceedings of the National Academy of Science 6 (1920), 275-288.

Pennisi, L. L., *Elements of Ordinary Differential Equations*, New York: Holt, Rinehart and Winston, 1972.

Petrovski, I. G., *Ordinary Differential Equations*, New Jersey: Prentice-Hall, 1966.

Polking, J., Boggess, A. and Arnold, D., *Differential Equations with Boundary Value Problems*, New Jersey: Pearson Prentice Hall, 2006.

Rainville, E. D. and Bedient, P. E., *Elementary Differential Equations*, 5th ed. New York: Macmillan, 1974.

Ricardo, H., *A Modern Introduction to Differential Equations*, New York: Houghton Mifflin, 2003.

Schom, A. and Joseph, M. Trafalgar, *Countdown to Battle, 1803-1805*, London: Simon and Shuster, 1990.

Shubik, M. (ed.), *Mathematics of Conflict. Amsterdam*, Elsevier Science, 1983.
Trench, W. F. Elementary Differential Equations. Belmont, CA: Brooks/Cole, 2000.

Zill, D. G., *A First Course in Differential Equations with Modeling Applications*, 8th ed. Belmont, CA: Brooks/Cole, 2005.

Periodicals:
Advances in Difference Equations
Advances in Differential Equations
Differential Equations and Applications
Differential Equations and Dynamical Systems
Electronic Journal of Differential Equations
International Journal of Difference Equations
International Journal of Differential Equations and Applications
Journal of Differential Equations
Journal of Difference Equations and Applications

Electronic and/or Audiovisual Resources:

Interdisciplinary Lively Applications Projects. Consortium for Mathematics and Its Applications, Inc., COMAP (800-772-6627, www.comap.com).

Undergraduate Applications in Mathematics Modules, COMAP.