MA 354-01
Computer Assisted Mathematical and Statistical Modeling

Semester: Spring 2002

Instructor: Richard Hitt

Office Hours: TR 8:30 – 9:30, 10:45 – 11:30, S 8:00 – 8:30, 11:10 – 11:30, and by appointment in ILB 306 (enter through ILB 325).

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Class Meeting: TR 12:30 – 1:45 in ILB 245.

Text: There is no specific text for this course. Instead, course material will be provided in class via handouts and will be available on the course web page – go to `http://www.mathstat.usouthal.edu/hitt` and click on the course.

Prerequisites: MA 238 (Applied Differential Equations). Some exposure to statistics as in ST 210 (Statistical Reasoning and Applications) or ST 315 (Applied Probability and Statistics) is recommended. If you have any questions about your preparation for this course you should see the instructor.

Course Description: [*Taken from the Bulletin*] Formulation, development, testing and reporting of mathematical and statistical models of various real world problems. Deterministic and stochastic models, optimization, simulation, parameter estimation, and goodness of fit. Emphasis on the appropriate use of computer software, both as an aid in the solution of mathematical problems and as a tool in the process of model evaluation, simulation, testing and reporting. A term project is an important component of this course. The course is taught in a laboratory setting with computers as lab equipment.

Course Outline: Mathematical and statistical modeling covers an enormously broad range of topics. Material for this course will be selected from the following:

1. Introduction
   (a) What is modeling?
   (b) The modeling process
   (c) Stochastic versus deterministic modeling
   (d) Some mathematical, statistical and computing tools: differential equations, matrices, regression, probability, Maple, Mathematica.
2. Deterministic models of growth and decay
   (a) Fibonacci growth
   (b) Exponential growth and decay
   (c) Logistic models

   (d) Harvesting
   (e) Multiple species systems (predator-prey models)
3. Deterministic Genetic Models
   (a) Mendelian Genetics
   (b) Hardy-Weinberg principle
4. Stochastic Models in Genetics
5. Compartment Models
   (a) Pharmacokinetics
   (b) Lead Toxicity
6. Neurophysiology
   (a) Models of the neuron
   (b) Neural Networks
7. Mechanical systems
8. Pursuit problems
9. Markov process
10. Random walks and applications
11. Queuing theory

Lab Assignments: The main body of the course will consist of lab assignments. These assignments will normally be completed using one of the software packages (Maple, Mathematica, etc.) and e-mailed to the instructor for grading.

Term Project: A central feature of this course will be a term project. Each student will be involved in a major modeling problem for approximately the last five weeks of the semester. The project work is usually done individually. The students, with input from the instructor, will select the topics for their projects. Communication skills are particularly important in modeling, so the projects should result in a well-written final report in addition to a brief in-class presentation.

The selection of a project topic must be done with some realistic idea about what can be accomplished in the remaining time in the semester. Students should select a project that can completed in phases so that suitable progress can be made even if the final goals of the project are not fully attained. It is important to prepare a detailed plan for the completion of the project which gives a precise idea of what must be done each week in order to eventually complete the project. Students will make regular progress reports to the class. This will give everyone an opportunity to share constructive criticism and suggestions for each project.

The following schedule will apply to work on the term projects:

Submission of possible project topics	Week 9
Final selection of project topics	Week 10
Submission of detailed project plan	Week 11
Weekly progress reports	Weeks 12 – 14
Submission of final project reports	Week 15 – Finals Week

Lab Equipment: The computer lab in ILB 410 is equipped with several pentium-class computers. Software packages include Mathematica, Maple, JMP, and SAS. One black-and-white laser printer and one color thermal wax transfer printer in the lab are also available for use. A projector is available for in-class computer demonstrations.

Lab Procedures: Students can download assignments from the course web page. Typically, these assignments will be in the form of a Maple worksheet or a Mathematica notebook. The procedure will be explained in class. You can save your work on one of the lab servers as well.

NOTE: It is very important that you take responsibility for backing up your work. Don't assume it will be on the local disk of one of the lab machines just because you left it there. Other people use these machines and can delete your files. You should save your work in your home directory on the server as well as backing it up to a diskette.

Grading: There will be no tests in this course. The course grade will be based upon the completion of the lab/homework assignments (50%), the submission of a detailed project plan (10%), periodic project progress reports (10%), and a final project report (30%) submitted in lieu of a final exam and presented in class during the final exam period (Thursday, May 2, 1:00 – 3:00).

Audit: If you are auditing the class, you will receive a grade of UA (unsatisfactory audit) if, in my judgement, you do not consistently attend class.

Notes: If you have a specific disability that qualifies you for academic accommodations, please notify the instructor and provide appropriate certification from the Office of Special Student Services (Student Center, Room 270, Phone 460-7212).

Any unforeseen changes required in the above policies and procedures will be disseminated to the class in a timely fashion.

References

[BC98] Robert Borrelli and Courtney S. Coleman. *Differential Equztions, A Modeling Perspective.* John Wiley & Sons, 1998.

[BCB92] Robert L. Borrelli, Courtney Coleman, and Wiliam E. Boyce. *Differential Equations Laboratory Workbook (A collection of experiments, explorations and modeling projects for the computer).* John Wiley & Sons, Inc., 1992.

[BDH98] Paul Blanchard, Robert L. Devaney, and Glen R. Hall. *Differential Equations.* Brooks/Cole, 1998.

[BR93] D. Brown and P. Rothery. *Models in Biology: Mathematics, Statistics and Computing.* John Wiley & Sons, 1993.

[Cus98] J. M. Cushing. *An Introduction to Structured Population Dymanics.* SIAM, 1998.

[EP96] C. H. Edwards and David E. Penney. *Differential Equations, Computing and Modeling.* Prentice-Hall, 1996.

[FM94] Neville D. Fowkes and John J. Mahony. *An Introduction to Mathematical Modeling.* John Wiley & Sons, 1994.

[GW91] Frank Giordano and Maurice D. Weir. *Differential Equations, A Modeling Approach.* Addison-Wesley, 1991.

[GWF97] Frank Giordano, Maurice D. Weir, and William P. Fox. *A first course in Mathematical Modeling.* Brooks/Cole Publishing Company, second edition edition, 1997.

[Hab98] Richard Haberman. *Mathematical Models, Mechanical Vibrations, Populations Dynamics, and Traffic Flow*, volume 21 of *Classics in Applied Mathematics.* SIAM, 1998.

[HP92] F. C. Hoppensteadt and C.S. Peskin. *Mathematics in Medicine and the Life Sciences*, volume 10 of *Texts in Applied Mathematics.* Springer-Verlag, 1992.

[Kla87] Murray S. Klamkin, editor. *Mathematical Modelling: Classroom Notes in Applied Mathematics.* SIAM, 1987.

[Lev94] Simon A. Levin, editor. *Frontiers in Mathematical Biology*, volume 100 of *Lecture Notes in Biomathematics.* Springer-Verlag, 1994.

[MG89] Michael Mesterton-Gibbons. *A Concrete Approach to Mathematical Modelling.* John Wiley & Sons, 1989.

[Mur93] J. D. Murray. *Mathematical Biology*, volume 19 of *Biomathematical Texts.* Springer-Verlag, second edition, 1993.

[NPC98] Douglas Nychka, Walter W. Piegorsch, and Lawrence H. Cox, editors. *Case Studies in Environmental Statistics*, volume 132 of *Lecture Notes in Statistics.* Springer, 1998.

[Svo98] Thomas Svobodny. *Mathematical Modeling for Industry and Engineering.* Prentice-Hall, 1998.

[Tho89] James R. Thompson. *Empirical Model Building.* Wiley Series in Probablity and Mathematical Statistics. John Wiley & Sons, 1989.

[YSH96] Edward K. Yeargers, Ronald W. Shonkwiler, and James V. Herod. *An Introduction to the Mathematics of Biology.* Birkhäuser, 1996.

[Zil98] Dennis G. Zill. *Differential Equations with Computer Lab Experiments.* Brooks/Cole, 1998.

[ZW95] Dennis G. Zill and Warren S. Wright. *Manual for Differential Equations with Compter Lab Experiments.* PWS Publishing Company, 1995.