Math 445 Statistical, Dynamical, and Computational Modeling Fall, 2017

Course Instructors / Information: You may contact either one of the two instructors for help during their office hours:

Name	Office	Office Hours	Phone	Email
Jon Graham	Math 204	To be announced	243-2561	jgraham@mso.umt.edu
Leonid Kalachev	Math 309	MWF 11:00 - noon	243-4373	kalachev@mso.umt.edu

Course Format: 3 lectures + 1 lab/practice session per week: MTWF 2:00 PM - 2:50 PM, Math 306. The lectures and practice sessions will be videotaped and posted on the web.

Prerequisites: Consent of instructors

Course Goals: The main goal of this course is to provide students with a unique opportunity to acquire practical mathematical and computational skills necessary to work on real life biological problems (with an emphasis on dynamics of infectious diseases) and to read specialized literature in the area. The course will briefly review basic fundamental knowledge from three disciplines; statistics, applied dynamical systems, and computational methods (numerical realizations are to be done with the MATLAB software package), and it will allow students to meaningfully choose courses for further deeper study in the respective disciplines. The special feature of the course is that statistical, dynamical and computational content are taught together and their interplay is emphasized. It is shown how a preliminary statistical analysis of experimental data can be performed, how a dynamic model of a process can be constructed, how dynamic model parameters can be evaluated and reliability regions for the parameter values estimated using statistical approaches. It will be also illustrated how the hands-on numerical investigations and computations using the MATLAB software package can be used to make corresponding statistical and dynamical analyses more effective.

Computing Information: **MATLAB** software will be used in class and will be required for some homework problems throughout the course. This software will be available in a number of computer labs (including MA 206 and MA 306). Instruction on specific aspects of the software will be provided in class, and relevant code or functions will be provided on the course Moodle webpage. Both instructors have **MATLAB** on their office computers, so you may ask software questions during instructors' office hours.

Handouts / Write ups: The students will be supplied with handouts summarizing lecture content prior to each lecture, with templates of the computer programs, and with copies of journal articles pertinent to problems and approaches discussed in the course. At the end of some weeks, lecture related material written in a book type format (Write ups) will be distributed to the students for reading and comments. Some supplementary reading material may also be provided if needed.

Incomplete (I) Grades: Incompletes (I's) are given at the discretion of the course instructors. See online UM catalog for the conditions under which an "I" may be given.

Credit/No-Credit Grades; Adding/Dropping the Course: A D- grade is required to receive credit under the Credit/No-Credit option. The last day to add/drop a course or change grading option (between letter grade, Credit / No Credit, Audit) is November 2, 2017. From November 3 and until December 12, 2017 these changes are allowed to be done only by Petition, which requires the signature and approval by the professor. **The final deadline for all changes is December 12, 2017.**

Grading: Several homework assignments will be given during the semester (20% of the final grade). There will be two take home midterm exams (20% each). The final project will involve group work on a modeling problem, a written report and oral presentation by the groups (30% of the final grade). The course is very dense, so to ensure that all students attend the lectures the attendance will be taken into account in calculating the final grade (10% of the final grade); for the students taking the course online to ensure that they view the lectures within one week from their posting date, they will have to send E-mails to instructors answering some specific questions posed in each lectures (10% of the final grade). The homework assignments for *undergraduate students* will consist of a smaller number of problems compared to the assignments for graduate students (i.e., for undergraduates some more complicated problems will be omitted from grading), and the midterms for the undergraduates will contain fewer questions. Your final grade for this course will be given according to the +/- grading system, tentatively based on the percentage intervals given below. You may talk to a course instructor about your grade at any point during the course. For international students the letter grades will be converted to equivalent numerical or percentage grades.

Tentative grading intervals:
A: [85%, 100%]; B: [70%, 85%); C: [55%, 70%); D: [40%, 55%); F: [0%, 40%).

Academic Misconduct: *All students must practice academic honesty. Academic misconduct is subject to an academic penalty by the course instructor and/or a disciplinary sanction by the University. All students need to be familiar with the Student Conduct Code. You can find it in the "A to Z Index" on the UM home page.*

Disability Services: The University of Montana assures equal access to instruction through collaboration between students with disabilities, instructors, and Disability Services for Students (DSS). If you think you may have a disability adversely affecting your academic performance, and you have not already registered with DSS, please contact DSS in Lommasson 154. We will work with you and DSS to provide an appropriate accommodation.

Tentative Topic Outline

Each week 3 lectures will be given with an emphasis on statistics (STAT), dynamics (DYN) or both (STAT-DYN). The computational (COMP) component will be present every week of class (1 lab/practice session related to the topics discussed in a particular week). As much as possible, real data will be used in practical examples. Weekly topics are listed below. The number in parentheses after the week number indicates the number of classes to be held that week.

Week #1 (1): August 28 – September 1 Week #2 (3): September 4 – September 8 (Sept. 4 – Labor Day holiday)	Introduction: course objectives. (STAT) Exploratory data analysis, numerical and graphical forms of data summary, R_0 & properties (COMP) Introduction to MATLAB as a scientific tool; exploratory data analysis with MATLAB.
Week #3 (4): September 11 – September 15	(STAT) Model fitting basics, uncertainty in statistical models, basic statistical inference. (COMP) Statistical inference in MATLAB.
Week #4 (4): September 18 – September 22	(STAT, COMP) The general linear model, model selection, cross-validation, residual analysis
Week #5 (4): September 25 – September 29	(STAT, COMP) Analysis of variance (ANOVA), nonlinear statistical models. **Test #1.**
Week #6 (4): October 2 – October 6	(DYN) Where do models come from? Modeling in terms of scalar nonlinear ordinary differential equations (ODEs): steady states, stability, elementary bifurcations. Applications in population ecology, etc. (COMP) Introduction to MATLAB tools for solving ODEs.
Week #7 (4): October 9 – October 13	(DYN) Second order linear ordinary differential equations and systems of two equations: characteristic types of solution behavior. Homogeneous and non-homogeneous equations. Resonances. (COMP) MATLAB tools for systems of ODEs.
Week #8 (4): October 16 – October 20	(DYN) Systems of two nonlinear ordinary differential equations: steady states, stability, characterization of steady states, elementary bifurcations. Applications in population ecology, etc. (COMP) MATLAB for solving systems of ODEs.
Week #9 (4): October 23 – October 27	(DYN) Applications of dynamical systems in population ecology and disease propagation modeling. Systems of three, four, etc., equations. (COMP) MATLAB for ODEs. **Test #2.**
Week #10 (4): October 30 – November 3	(STAT) Nonlinear statistical models.

Week #11 (3): November 6 – November 10 (Nov. 10 – Veterans' Day holiday)	(STAT-DYN) Applications of methods to real data. Estimation of reliability regions for model parameters. Bootstrapping, MCMC. (COMP) Optimization tools in MATLAB.
Week #12 (4): November 13 – November 17	(STAT-DYN) Applications of methods to real data. Estimation of reliability regions for model parameters. Bootstrapping, MCMC. (COMP) MATLAB templates.
Week #13 (2): November 20, 21 (Nov. 22-24 – Thanksgiving holiday)	(STAT-DYN) Applications of methods to real data. Estimation of reliability regions for model parameters. Bootstrapping, MCMC.
Week #14 (4): November 27 – December 01	Project work days (DYN, COMP, STAT)
Week #15 (4): December 04 – December 08	Project work days (DYN, COMP, STAT)
Week #16 (1): December 12	Project work days (DYN, COMP, STAT)
Week #17 (1): Tuesday, December 19, 1:10-3:10	Final project presentations (room Math 306). For students taking this course on the web special arrangements for the final project presentation will be made.