**Spring 2015**
**ECE 549: DETECTION AND ESTIMATION THEORY**

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**Logistics:**

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| Instructor: | Prof. Anand D. Sarwate<br>Office: CoRE 517<br>Email: `asarwate@ece.rutgers.edu`<br>Web: `http://www.ece.rutgers.edu/~asarwate/` |
| Office hours: | TBD |
| Lectures: | Thursday 5:00–8:00 PM in ARC 108 |
| Website: | `http://sakai.rutgers.edu/` |

**Unofficial overview:** This is a course about how to model signals and data using probability and statistics, and then how to analyze those signals and data to estimate parameters of the model or decide which of two (or more) models best matches the data. Although these problems often come up in the context of signal processing and communications, the concepts are fundamental to the basic statistical methodologies used broadly across science, medicine, and engineering.

**Textbooks:** The required textbook is by Kay. Although we will in large part follow the material in this book, there will be additional material covered in the course that is not in the book.

- Steven M. Kay, *Fundamentals of Statistical Signal Processing, Volume I: Estimation Theory*, Prentice Hall, 1993.
- Steven M. Kay, *Fundamentals of Statistical Signal Processing, Volume II: Detection Theory*, Prentice Hall, 1998.

As a warning, this textbook is somewhat expensive new (and there are two volumes). However, since it is old, there are a lot of used copies that one can purchase. I would recommend doing some searching before buying a new copy, especially if you think you may not keep the book later. Some other references that may be useful:

- Harry L. Van Trees, *Detection, Estimation, and Modulation Theory (Part I)*, Wiley-Interscience, 2001.
- Bernard C. Levy, *Principles of Signal Detection and Parameter Estimation*, Springer 2008.
- Peter J. Bickel and Kjell A. Doksum, *Mathematical Statistics, Basic Ideas and Selected Topics, Vol. 1, (2nd Edition)*, Pearson, 2006.
- H. Vincent Poor, *An Introduction to Signal Detection and Estimation*, 2nd Edition, Springer, 1998.

**Prerequisite:** ECE 541 (Stochastic Signals and Systems). This course is fundamentally a course on probability and statistics. Students would also benefit from a background in signal processing or communications, since many of the applications come from those domains.

Students should have a strong background in probability beyond the undergraduate level. If you performed poorly in ECE 541 then you may find this course somewhat challenging. The course will make extensive use of concepts such as density functions, expectation, conditional probabilities, independence, and Markov's inequality. Students will be expected to have the mathematical maturity to read supplementary material as well as the text. If you have any concerns about whether you should take the course, please contact the instructor before classes begin.

**Topics:**

- introduction to the course, probability review, modeling signals and data
- estimation of parameters, Bayesian approaches, MMSE
- Wiener filtering and sequential estimation
- frequentist approaches, bias-variance tradeoffs, Cramer-Rao lower bound
- linear models, best linear unbiased estimators,
- exponential families, sufficient statistics, maximum-likelihood
- asymptotics of maximum-likelihood
- basic hypothesis testing, ROC, Neyman-Pearson testing
- frequentist and Bayesian approaches to hypothesis testing
- transforming the signal space for Gaussian detection
- testing with model uncertainty, sequential testing, false discovery rate

**Grading and assessment:**

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| Short Quizzes (5) | 60% (12% each) |
| Final exam | 40% |

**Homework:** Homeworks will be assigned and solutions posted, but they will not be graded. Students should try to do the homeworks, since the quizzes will be based on the homework problems.

Since this is a more mathematical course, doing the homework is very important! Developing proficiency in applying the concepts will give you a depth of understanding that will help you understand the questions on the quizzes and final. If you have problems, come to office hours, and if you miss a question, make sure you understand the solution when it is posted.

## General policies

**Academic Integrity.** Students should be familiar with the Academic Integrity policy at Rutgers University:

`http://academicintegrity.rutgers.edu`

If you have any questions about whether your actions may compromise academic integrity in some way, please contact the instructor as soon as possible.

**Responsibilities.** As a student, it is your responsibility to manage your schedule such that you can come to lectures prepared and on-time.

Similarly, there will be no make-up exams. If there is a legitimate reason for missing an exam, such as illness supported by a doctor's note, then the score for that exam will be assigned based on scores from the other exams. Without such a legitimate reason, the score assigned will be *zero*.

**Incomplete grades and dropping the course.** Incomplete grades will not be given to students who wish to improve their grade by taking the course in a subsequent semester. An incomplete grade may be given for medical reasons if a doctor's note is provided. The purpose of an incomplete grade is to allow a student *who has essentially completed the course* and who has a legitimate interruption in the course, to complete the remaining material in another semester. Students will not be given an opportunity to improve their grade by doing "extra work".

Students are responsible for being aware of the drop dates for the current semester.