

ECE-595: Optimal Estimation and Filtering

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Contact: via course messages

Office hours: By appointment via Zoom

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Course Description (UNM catalog)

This is the second part of a first level graduate level class on stochastic processes with a system theoretic treatment of:

Mean-square estimation, least-squares estimation, optimal non-causal and causal Wiener filtering, optimal linear prediction, Levinson-Durbin recursion, optimal Wiener deconvolution, adaptive Wiener filtering, Wold's decomposition and Kalman filtering.

Course Objectives

By the end of this course, students will be able to:

- (1) Apply concepts pertaining to stochastic processes, convergence of stochastic sequences, stochastic calculus and filtering of stochastic processes towards mean square estimation and optimal Wiener filtering in the context of mean square estimation.
- (2) Apply concepts from mean square estimation to mathematically develop and analyze statistically, the optimal linear predictor of a specific order.
- (3) Apply mean square estimation to mathematically develop and statistically analyze inverse filtering and optimal Wiener deconvolution.
- (4) Apply concepts of mean square estimation and Wiener filtering to develop and analyze adaptive Wiener filtering in the form of the least mean square algorithm and the recursive least squares algorithm.
- (5) Apply concepts of mean square estimation to develop and analyze statistically the discrete Kalman filter.

Prerequisites and Co-requisites

ECE-595: Stochastic Processes

You are expected to be familiar with the following concepts and notions:

- (1) ECE-595: Stochastic Processes: introductory level course on stochastic processes covering classification, filtering, stochastic convergence and calculus, Nyquist sampling and quantization of stochastic processes.
- (2) ECE-340: Probabilistic Methods: axioms of probability, Bayes rule, random variables, random vectors, transformations of random variables and vectors, characteristic functions, Gaussian random vectors, sums of independent random variables.
- (3) Working knowledge of MATLAB: scripts, functions, DSP, communications, and statistics, toolboxes

TECHNICAL SKILLS

In order to participate and succeed in this class, you will need to be able to perform the following basic technical tasks:

- Working knowledge of MATLAB programming and scripts. Students will need to download MATLAB from the UNM-IT website. Homework assignments will contain MATLAB questions.
- Students must be familiar with transform techniques: Fourier, Laplace, Zee for, analysis of LTI systems. Students should download the table of transforms and be able to use them with ease.
- Student must be familiar with basic linear algebra concepts: matrix inversion, subspaces, eigenvalue decomposition, QR decomposition.

TECHNICAL REQUIREMENTS

Computer

- A high-speed Internet connection is highly recommended.
- Supported browsers include: [Detailed Supported Browsers and Operating Systems](#)
- Any computer capable of running a recently updated web browser should be sufficient to access your online course. However, bear in mind that processor speed, amount of RAM and Internet connection speed can **greatly** affect performance. Many locations offer free high-speed Internet access including [UNM's Computer Pods](#) (Need a minimum of 8GB RAM and sufficient hard-drive space).
- Microsoft Office products are available free for all UNM students (more information on the [UNM IT Software Distribution and Downloads page](#)).
- Computer must have enough hard-drive space and a minimum of 8 GB RAM so that the student can download MATLAB from the UNM IT website.

For UNM Canvas Technical Support: (505) 277-0857 (24/7) or visit the [Canvas Info Site](#)

Canvas outages: Unexpected Canvas system outages are rare but, if they occur, I will advise everyone on how to proceed.

Web Conferencing

Web conferencing may be used in this course and will be conducted via Zoom. For the Zoom sessions you will need:

- *A USB headset with microphone. Headsets are widely available at stores that sell electronics, at the UNM Bookstore or online.*
- *A high-speed internet connection is highly recommended for these sessions. A wireless Internet connection may be used if successfully tested for audio quality prior to web conferencing.*
- *For UNM Zoom Conference Technical Help: (505) 277-0857*

Tracking Course Activity

Canvas automatically records all students' activities including: your first and last access to the course, the pages you have accessed, the number of discussion messages you have read and sent, web conferencing, discussion text, and posted discussion topics. This data can be accessed by the instructor to evaluate class participation and to identify students having difficulty

TEXTBOOK

There is no required textbook for this course. All required material can be found in the notes for each module.

Highly recommended book:

H. Starks and J. Woods, "Probability, Statistics, and Random Processes for Engineers," Fourth Edition, Pearson, 2012. (Third edition acceptable).

Other recommended books:

1. Sheldon Ross, "A First Course in Probability," Third edition, Macmillan Publishing Company, New York, 1988.
2. Athanasios Papoulis, "Probability, Random Variables, and Stochastic Processes," Second edition, McGraw-Hill Publications, New York, 1984.
3. Monson H. Hayes, "Statistical Digital Signal Processing and Modeling," John Wiley & Sons Inc, New York 1996.
4. G. Casella and R. L. Berger, "Statistical Inference," Duxbury Press, New York, 1990.
A. V. Oppenheim, R. W. Schaffer, J. R. Buck, "Discrete-Time Signal Processing," Prentice Hall Inc., Upper Saddle River, New Jersey, 1999.
5. K. S. Shanmugam and A. M. Breipohl, "Random Signals: Detection, Estimation and Data Analysis," John Wiley & Sons, New York, 1988.
6. Gilbert Strong, "Linear Algebra and Its Applications," Third Edition, Harcourt Brace Jovanovich Inc., New York, 1988.

COURSEWORK AND PARTICIPATION

Instructor Response Time

I routinely check the course for postings or emails, Monday (9:00 am) – Friday (9:00 pm) and sometimes on the weekend. You can anticipate a 24 - 48 hour response from me, Monday – Thursday. I will try and respond to all weekend (Friday afternoon to Sunday) emails and postings by noon on Monday or earlier. Submitted student assignments will be graded within 2 business days.

Procedures for Completing Coursework

Include:

- *Work turned in after the deadline will receive a 2-point penalty out of 10 points. Exams will need to be submitted on time or will receive no credit.*
- *recommended:*
 - *submitted work will be graded within 2 business days.*
 - *All written work needs to be submitted online. If you have a difficulty using a tool to complete work, please reach out to UNM's [Canvas Support](#) immediately and notify your instructor as well.*

Expectations for Participation

- *time required (12 - 15 hours per week)*
- *students are expected to learn how to navigate in Learn*
- *students are expected to use the Canvas course email as opposed to a personal email address*
- *students are expected to keep instructor informed of class related problems, or problems that may prevent the student from full participation*
- *students are expected to observe course netiquette at all times*

Netiquette

- [Netiquette document](#)

GRADING PROCEDURES

Total number of points: 260

- *6 assignments for the 6 modules worth 60 points*
- *Discussion forum for muddiest issues and comments (12 points)*
- ***Midterm exam worth 80 points (10 points per question)***
- ***Final MATLAB project worth 100 points***

Final grades will be based on the sum of all possible course points as noted above.

Assignments & Quizzes

Each module in the course carries an assignment associated with it to gauge the student's application of the concepts covered in the module. Student are given until the end of the week for the submission of the corresponding assignment. **NOTE:** When you submit an assignment via UNM Canvas, you will receive an email receipt of your submission from notifications@instructure.com. Save this email as confirmation of your submission.

A quiz examines the student's comprehension of the underlying material. The duration of each quiz is 1 hour. Students will scan their work to a PDF file and to submit to UNM Canvas within the allocated time.

Midterm Exam

This is an open-book, open-notes exam of duration 24 hours, MATLAB usage is permitted. This exam will be comprised of 4 problems with multiple parts to solve.

Final Grade Scale

Grade	
110 -125	A
80 -110	B
60-80	C
< 60	F

UNM POLICIES

Title IX: Gender Discrimination

In an effort to meet obligations under Title IX, UNM faculty, Teaching Assistants, and Graduate Assistants are considered “responsible employees” by the [Department of Education](#) (see pg. 15). This designation requires that any report of gender discrimination which includes sexual harassment, sexual misconduct and sexual violence made to a faculty member, TA, or GA must be reported to the Title IX Coordinator at the [Office of Equal Opportunity](#). [Read more about campus policy regarding sexual misconduct.](#)

COPYRIGHT ISSUES

All materials in this course fall under copyright laws and should not be downloaded, distributed, or used by students for any purpose outside this course.

[The UNM Copyright Guide](#) has additional helpful information on this topic.

Accessibility

The American with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodations of their disabilities. If you have a disability requiring accommodation, please contact the [UNM Accessibility Resource Center](#) in 2021 Mesa Vista Hall at 505-277-3506. Information about your disability is confidential.

- [Canvas's Accessibility statement](#)
- [Microsoft's Accessibility statement](#)
- [MATLAB Accessibility statement](#)
- [MATLAB Privacy statement](#)

Academic Misconduct

You should be familiar with UNM's [Policy on Academic Dishonesty](#) and the [Student Code of Conduct](#) which outline academic misconduct defined as plagiarism, cheating, fabrication, or facilitating any such act.

Example Drop Policy:

UNM Policies: This course falls under all UNM policies for last day to drop courses, etc. Please see or the UNM Course Catalog for information on UNM services and policies. Please see the UNM academic calendar for course dates, the last day to drop courses without penalty, and for financial disenrollment dates.

UNM RESOURCES

[CAPS Tutoring Services](#)

CAPS is a free-of-charge educational assistance program available to UNM students enrolled in classes. Online services include the Online Writing Lab, Chatting with or asking a question of a Tutor.

[UNM Libraries](#)

[Student Health & Counseling \(SHAC\) Online Services](#)

FOR MILITARY-CONNECTED STUDENTS

There are resources on campus designed to help you succeed. You can approach any faculty or staff for help with any issues you may encounter. Many faculty and staff have completed the GREEN ZONE training to learn about the unique challenges facing military-connected students. If you feel that you need help beyond what faculty and/or staff can give you, please reach out to the Veterans Resource Center on campus at 505-277-3181, or by email at vrc@unm.edu.