ECE 501B
Advanced Linear System Theory
Fall Semester 2023

Instructor: Dr. Hal Tharp
Office: ECE 523
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Office Hours: Mondays & Fridays 10:00am-10:45am via Zoom ID: 822 5243 4035
Response Time for ECE 501B: The goal is to answer questions within 48 hours during the work week.
Lectures: Monday and Wednesday, MLNG 310, 4:00-5:15pm (Zoom ID: 850 2963 6128)
Course Web-Site: d2l.arizona.edu

Course Description: Mathematical fundamentals for analysis of linear systems. The course develops the theory behind maps and operators in finite and infinite dimensional linear vector spaces, metric spaces, and inner-product spaces. The course provides an introduction to representation theory, eigensystems, spectral theorems, singular value decomposition, continuity, convergence, separability, and Sturm-Liouville theory.

Texts:
Required: "Linear Algebra Done Right," Third Edition by Sheldon Axler, Springer, 2015. ISBN: 978-3-319-11079-0. Full Text available Online through the University of Arizona Library (lib.arizona.edu). Here is a direct link if you are on a UA Internet Connection: https://arizona-primo.hosted.exlibrisgroup.com/permalink/f/evot53/01UA_ALMA51529952200003843. Or, the Axler text is also available via "Library Tools" Menu Item (top right corner) on the D2L website. Professor Sheldon Axler has fifty YouTube videos (https://www.youtube.com/watch?v=lkx2BJcnyxk&list=PLGAnmvB9m7zOBVCZBUUmSinFV0wEir2Vw) that are designed to introduce and motivate many of the textbook topics.
Required: "Signal Theory," Revised Edition, by L.E. Franks, Dowden & Culver, Inc., 1981. Available in pdf format from course website.
Optional: "How to Read and Do Proofs: An Introduction to Mathematical Thought Processes," Sixth Edition, by Daniel Solow, John Wiley & Sons, Inc., 2014. ISBN: 978-1-118-16402-0.
Other Optional Texts: "Book of Proof," Third Edition, Richard Hammack, 2018. Available in online or pdf form from Professor Richard Hammack website: https://www.people.vcu.edu/~rhammack/BookOfProof/.
"The Nuts and Bolts of Proofs: An Introduction to Mathematical Proof," Third Edition, Antonella Cupillari, Elsevier Academic Press, 2005. Available as an e-Book via the University of Arizona Library (new.library.arizona.edu). Perform a Title search on 'the nuts and bolts of proofs' to access the e-Book. Or, access the book via the UA Library Permalink: https://arizona-primo.hosted.exlibrisgroup.com/permalink/f/6ljalh/01UA_ALMA51529797440003843.

Examinations: There will be two single-period examinations and one comprehensive final examination. No make-up exams will be given. A grade of zero will be given for a missed exam. Re-grading of an exam must occur within one week after the exam is given. If there are any problems or questions, see the instructor.

Homework: Eight assignments are planned during the semester. Homework will be due by 11:59pm on its due date in the appropriate Assignments folder on D2L.

Determination of Final Grade: Your final grade in this course is based upon your rank in the class, that is, a system of *curving* is used. After each exam, the test distribution will be made available from which you can assess your performance.

(Unless an announcement is made otherwise, the examinations will be held on the following dates.)

Exam #1	(September 27, 2023)	25%
Exam #2	(November 1, 2023)	25%
Homework	(Eight Assignments)	10%
Project		10%
Final Exam	(**Friday**, Dec 8) (3:30pm – 5:30pm)	30%

Class Cancellations:

Monday	September 4	Labor Day

Mask Policy: Face coverings are recommended in the classroom. Please refer to the COVID-19 website for up-to-date information.

Absence and Attendance Policy: The UA's policy concerning Class Attendance, Participation, and Administrative Drops is available at: http://catalog.arizona.edu/policy/class-attendance-participation-and-administrative-drop.

The UA policy regarding absences for any sincerely held religious belief, observance or practice will be accommodated where reasonable, http://policy.arizona.edu/human-resources/religious-accommodation-policy.

Absences pre-approved by the UA Dean of Students (or Dean Designee) will be honored. See: http://deanofstudents.arizona.edu/absences

Participating in course and attending lectures and other course events are vital to the learning process. As such, attendance is required at all lectures and discussion section meetings. Students who miss class due to illness or emergency are required to bring documentation from their healthcare provider or other relevant, professional third parties. Failure to submit third-party documentation will result in unexcused absences.

Accessibility and Accommodations: Our goal in this classroom is that learning experiences be as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, please let me know immediately so that we can discuss options. You are also welcome to contact Disability Resources (520-621-3268) to establish reasonable accommodations. For additional information on Disability Resources and reasonable accommodations, please visit http://drc.arizona.edu/.

If you have reasonable accommodations, please plan to meet with me by appointment or during office hours to discuss accommodations and how my course requirements and activities may impact your ability to fully participate.

Please be aware that the accessible table and chairs in this room should remain available for students who find that standard classroom seating is not usable.

Generative Artificial Intelligence (AI) Policy: Use these Large Language Model based tools (ChatGPT (chat.openai.com), Bard (Bard.google.com), etc.) to help you understand challenging topics/content within the course material, or to build/refresh your foundational knowledge to help you understand more advanced concepts. Don't use AI to cheat. Use AI as a tool to help you learn. Sometimes these AI tools will be wrong or will hallucinate and produce inaccurate information. Please confirm the accuracy of the output generated from these tools. Also, you should acknowledge your use of the tools (which one(s)) and explain how the tools were used and what you learned while using these tools.

Classroom Behavior Policy: To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (i.e. texting, chatting, reading a newspaper, making phone calls, web surfing, etc).

Students are asked to refrain from disruptive conversations with people sitting around them during lecture. Students observed engaging in disruptive activity will be asked to cease this behavior. Those who continue to disrupt the class will be asked to leave lecture or discussion and may be reported to the Dean of Students.

Threatening Behavior Policy: The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to one's self. See: http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students.

Code of Academic Integrity: Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See: http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity.

The University Libraries have some excellent tips for avoiding plagiarism available at: http://new.library.arizona.edu/research/citing/plagiarism.

Selling class notes and/or other course materials to other students or to a third party for resale is not permitted without the instructor's express written consent. Violations to this and other course rules are subject to the Code of Academic Integrity and may result in course sanctions. Additionally, students who use D2L or UA email to sell or buy these copyrighted materials are subject to Code of Conduct Violations for misuse of student email addresses. This conduct may also constitute copyright infringement.

UA Nondiscrimination and Anti-harassment Policy: The University is committed to creating and maintaining an environment free of discrimination, http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy

Our classroom is a place where everyone is encouraged to express well-formed opinions and their reasons for those opinions. We also want to create a tolerant and open environment where such opinions can be expressed without resorting to bullying or discrimination of others.

Additional Resources for Students:

UA Academic policies and procedures are available at: http://catalog.arizona.edu

Student Assistance and Advocacy information is available at:

http://deanofstudents.arizona.edu/student-assistance/students/student-assistance

Subject to Change Statement: Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.

ECE 501B **Course Outline** **Fall 2023**

Vector Spaces (Chapter 1, Axler)
- Definition, Properties, Subspaces, Vector Space Sums, and Vector Space Direct Sums

Finite-Dimensional Vector Spaces (Chapter 2, Axler)
- Span, Linear Independence, and Dimension

Linear Maps (Chapter 3, Axler)
- Definitions, Examples, Null Spaces, Range, Matrix of a Map, Invertibility, and Duality

Polynomials (Chapter 4, Axler)
- Degree and Fundamental Theorem of Algebra

Eigenvalues, Eigenvectors, and Invariant Subspaces (Chapter 5, Axler)
- Invariant Subspaces, Polynomials Applied to Operators, Upper-Triangular and Diagonal Matrices

Inner-Product Spaces (Chapter 6, Axler)
- Inner Products, Norms, Cauchy-Schwarz Inequality, Triangle Inequality, Orthonormal Bases, Gram-Schmidt Procedure, Orthogonal Projections, Minimization Problems, and Linear Functionals

Operators on Inner-Product Spaces (Chapter 7, Axler)
- Adjoints, Self-Adjoint Operators, Normal Operators, The Spectral Theorem, Positive Operators, Isometries, Polar Decomposition, and Singular Value Decomposition

Operators on Complex Vector Spaces and Operators on Real Vector Spaces (Chapters 8 and 9, Axler)

Trace and Determinant (Chapter 10, Axler)

Introduction to Continuous Signals (Chapter 1, Franks)
- Sets of Signals, Mappings, and Functionals

Signal Spaces (Chapter 2, Franks)
- Metric Spaces, Convergence, Linear Spaces, Normed Linear Spaces, Inner Product Spaces, and Linear Functionals