EE431 Digital Signal Processing Fall 2023

Catalog Description Digital Signal Processing discusses the representation of discrete-time signals and systems using time-domain methods such as convolution and frequency-domain methods including the DTFT (Discrete Time Fourier Transform), the DFT (Discrete Fourier Transform), and the Z transform. Other topics include digital filter design and analysis, the impact of sampling in the time and frequency domains, and the design of anti-aliasing and reconstruction filters. The laboratory will emphasize practical considerations involved with the implementation of DSP algorithms. MATLAB will be used for digital signal generation, plotting and the implementation and analysis of DSP operations. Required course.

Prerequisites EE230

Textbook *EE431 Course Text* pdf available on Canvas.
Optional: *FE Handbook*, available from www.ncees.org, $20
MATLAB. Free as a cadet; see the Canvas page for Lecture 1 for more details, or visit the barracks helpdesk.

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Stop-ins are welcome, and you can also meet by appointment via email or phone; see numbers above. The best and fastest way to get help is to email; I am very responsive. Even if you plan to stop in, whether during office hours or not, always send me an email in advance with your question – that will make sure I am present and will help me prepare.

Course schedule (2) 50 minute lectures and (1) two-hour laboratory each week

Class:	NEH 428	MW	1000 – 1050
Lab:	NEH 428	W	1400 – 1550

Course Objectives[1]

1. Understand advantages and disadvantages of discrete-time signal processing vs. analog signal processing. [A, B, D]
2. Analyze properties and characteristics of discrete-time signals and systems from a time domain perspective. [A,B,C]
3. Be able to describe, analyze, and design discrete time signals and systems using frequency-domain methods.[A,B,C]
4. Be able to specify, design, and test digital filters.[A,B,C,D,E]

[1] Letters in brackets correspond to Electrical Engineering program objectives

Performance Criteria Students will be able to:

for Objective 1:

a. Explain the advantages and disadvantages digital signal processing has in comparison with continuous-time signal processing techniques.

for Objective 2:

a. Plot DSP signals in the time-domain with the correct sample indexing, and manipulate in the time-domain using amplitude scaling and convolution operators.
b. Design, debug, and test efficient DSP programs using Matlab.
c. Explain what aliasing is, why it occurs during sampling and how to design a filter before sampling to prevent aliasing.

for Objective 3:

a. Explain real-world uses of a discrete signal's DTFT and be able to use a DFT to approximate the signal's DTFT.

b. Compute forward and inverse Z transforms and explain how this method may be used to determine the response of a discrete-time system to an input signal.

for Objective 4:

a. Explain the difference between FIR and IIR filters, and the different types of IIR filters.
b. Be able to choose a digital filter type given a real-world problem, and design to meet given criteria.

Topics DT Signals & Systems in the Time-Domain (chap 1,2)

1. DSP signals and systems: overview
2. Discrete-time signals
3. Discrete-time systems
4. Calculating the output

Test #1

DT Signals in the Frequency-Domain (chap 3)

1. DTFT
2. DFT
3. Properties of the DTFT and DFT
4. Z transform

Test #2

DT Systems in the Frequency Domain (chap 4,5)

1. Transfer functions
2. Filter design
3. Sampling: a freq domain perspective

Advanced topics in DSP

Multirate systems, image processing, spectrograms

Final Exam

Laboratories You must work in lab groups of two cadets; no individuals, and no more than one group of three in a class. The laboratory assignments are two week assignments; download them from the course website. They are due at the start of the next new lab. For instance, if on 1 Sep you begin Lab 1, you continue working on it on the 8 Sep lab period, and it is due at the start of the 15 Sep lab, where you begin working on Lab 2. Only a single lab report is turned in per lab group. Use the templates provided in Canvas. **Work only within your lab group; help outside will be penalized for both groups.**

Grading

Component	Percent
Homework	15
Labs	15
Test 1	20
Test 2	20
Final exam	30
Total	100

All homework, exams, and the laboratory design assignments are work for grade. I *encourage* you to discuss homework problems with classmates, which you then must acknowledge. Do not discuss the labs outside your lab group, or both groups will be penalized. Properly acknowledged all help received, whether or not authorized (e.g. "CDT Jones showed me how to find H(z) given the difference equation. I estimate 70% of this problem represents my own work"). Institute and department work for grade policies are reproduced in the appendix. **You must acknowledge help from all sources (excluding myself and your textbook) including classmates, other professors, other cadets' notes, old homework solutions, and books.**

Late policy Graded requirements are due at the start of class. The only authorized exceptions are by direction of the superintendent, hospitalization, or in the case of extenuating circumstances, by ***prior*** arrangement with me. Attending a scheduled guard duty does not exempt a cadet from turning in the assignment to me, either directly (under my door in advance of class) or to a classmate to turn in on-time. I do not accept late homework; late lab reports start at a 75%.

Professional Component 3 credits of Engineering Topics (specifically, Engineering Science and Design)

Relationship Of Course To Program Outcomes primarily department program outcomes 1, 5, 11, 13, 14 and 15.

Prepared by COL James C. Squire, 08/15/23

Appendix A: Institute Work For Grade Policy

"**Work for grade**" is defined as any work presented to an instructor for a formal grade or undertaken in satisfaction of a requirement for successful completion of a course or degree requirement. All work submitted for grade is considered the cadet's own work. "**Cadet's own work**" means that he or she has composed the work from his or her general accumulation of knowledge and skill except as clearly and fully documented and that it has been composed especially for the current assignment. No work previously submitted in any course at VMI or elsewhere will be resubmitted or reformatted for submission in a current course without the specific approval of the instructor.

In all work for grade, failure to distinguish between the cadet's own work and ideas and the work and ideas of others is known as **plagiarism**. Proper documentation clearly and fully identifies the sources of all borrowed ideas, quotations, or other assistance. The cadet is referred to the VMI-authorized handbook for rules concerning quotations, paraphrases, and documentation.

In all written work for grade, the cadet must include the words "**HELP RECEIVED**" conspicuously on the document, and he or she must then do one of two things: (1) state "none," meaning that no help was received except as documented in the work; or (2) explain in detail the nature of the help received. In oral work for grade, the cadet must make the same declaration before beginning the presentation. Admission of help received may result in a lower grade but will not result in prosecution for an honor violation.

Cadets are prohibited from discussing the contents of a quiz/exam until it is returned to them or final course grades are posted. This enjoinder does not imply that any inadvertent expression or behavior that might indicate one's feeling about the test should be considered a breach of honor. The real issue is whether cadets received information, not available to everyone else in the class, which would give them an unfair advantage. If a cadet inadvertently gives or receives information, the incident must be reported to the professor and the Honor Court.

Each cadet bears the responsibility for familiarizing himself or herself thoroughly with the policies stated in this section, with any supplementary statement regarding work for grade expressed by the academic department in which he or she is taking a course, and with any special conditions provided in writing by the professor for a given assignment. If there is any doubt or uncertainty about the correct interpretation of a policy, the cadet should consult the instructor of the course. There should be no confusion, however, on the basic principle that it is never acceptable to submit someone else's work, written or otherwise, formally graded or not, as one's own.

The violation by a cadet of any of these policies will, if he or she is found guilty by the Honor Court, result in his or her being dismissed from VMI. Neither ignorance nor professed confusion about the correct interpretation of these policies is an excuse.

Appendix B: Department Work For Grade Policy

Revised 14 August 2003

Tutoring [e.g. Writing Center, Academic Center, athletic tutors, private tutors]: The ECE Department supports and encourages cadet use of such learning aids, as offered by the VMI Writing Center, VMI Academic Center, and tutors. All assistance from these, and any other similar aids, must be explicitly described in the cadet statement regarding HELP RECEIVED.

Peer Collaboration: Peer collaboration policies, including policies on CRITICAL COMMENTS, will be established by the individual faculty of the ECE Department, and may vary from assignment to assignment. Each ECE faculty member will clearly indicate the appropriate collaboration policy for each assignment. Policy regarding laboratory groups, team cooperation, interaction between teams, etc. will be established by the individual faculty. All assistance from such peer collaboration must be explicitly described in the cadet statement regarding HELP RECEIVED.

Computer Aids [including calculators, translators, spelling, style, and grammar checkers]: The ECE Department supports and encourages cadet use of computer aids, including calculators, translators, spelling, style, and grammar checkers to improve the quality of the cadets' work. The use of such computer aids does not constitute HELP RECEIVED.

Appendix C: Disability Policy

Disability Statement: VMI abides by Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990 which mandate reasonable accommodations are provided for all students with documented disabilities. If you have a registered disability and may require some type of instructional and/or examination accommodations, please contact me early in the semester so that I can provide or facilitate provision of accommodations you may need. If you have not already done so, you will need to register with the Office of Disabilities Services, the designated office on Post to provide services for cadets with disabilities. The office is located at 207 Carrol Hall in the Miller Academic Center. Please call or stop by the office of LTC Denise Young, Ph.D., Director of Disabilities Services, for more information, 464-7741 or email youngdh125@vmi.edu.