

ECE 633 – Coding Theory
Department of Electrical and Computer Engineering
George Mason University
Fall 2018

Class meetings: Wednesdays 7:20 – 10:00 pm in Planetary Hall, Room 126

Instructor: Brian L. Mark

Nguyen Engineering Building (ENGR), Room 3220
phone: 703-993-4069 email: bmark [at] gmU.edu
web: <http://ece.gmu.edu/~bmark>
office hours: 2:30 - 4:30 pm (tentative)

Course Description:

This course provides an introduction to error correction coding techniques, which enable the detection and correction of errors that arise in the transmission and storage of digital data. Both theoretical and practical implementation aspects of error control coding, as well as selected applications will be addressed. The course covers classical codes such as Hamming, BCH, Reed-Solomon, Reed-Muller, and convolutional codes, as well as modern sparse-graph codes such as turbo codes, LDPC codes, repeat-accumulate codes, and fountain codes. Issues in software and hardware implementation of error correction encoding and decoding schemes will be discussed. The necessary background in discrete mathematics, algebra, and number theory will be covered. Connections of coding theory to related areas of interest such as information theory, machine learning, and cryptography will be explored. The course will address selected applications of error correction codes to modern technologies such as wireless networks, satellite and deep space communications, CD and DVD storage, post-quantum cryptography, and physically unclonable functions (PUFs). The course provides a foundation for further study of topics in coding theory such as performance bounds for codes, network coding, and quantum error correction codes.

Course website: Log in to your account on <http://blackboard.gmu.edu>

- Log into Blackboard using your GMU email account credentials.
- Assignments, solutions, announcements, and other course materials will be posted on Blackboard.
- Piazza:
 - We will be using Piazza for class discussions outside of the classroom. The system is highly catered to getting you help fast and efficiently from classmates and myself. I encourage you to post your questions on Piazza. If you have any problems or feedback for the developers, email team@piazza.com Find our class page at:
<https://piazza.com/gmu/fall2018/ece633/home>

Textbook:

- Todd K. Moon, *Error Correction Coding: Mathematical Methods and Algorithms*, John Wiley & Sons, Inc., 2005. ISBN 0-471-64800-0.
- Supplementary course materials will also be made available to students via Blackboard.

Secondary reference available online:

- David J.C. MacKay, *Information Theory, Inference, and Learning Algorithms*, Cambridge University Press, 2003. This book explores the interconnections among information theory, coding theory, and machine learning, and includes good coverage of relevant topics in modern coding theory, particularly sparse-graph codes. A PDF copy of this book, which is available for on-screen viewing (printing not permitted) can be obtained through the following link: <http://www.inference.org.uk/itprnn/book.pdf>

Other references available online:

- The following books provide comprehensive coverage of topics in modern coding theory and are available for online viewing via Mason's subscription to ProQuest Safari Books through the following link:

<http://proquest.safaribooksonline.com/book/electrical-engineering/communications-engineering/9781107386747>

- Tom Richardson and Ruediger Urbanke, *Modern Coding Theory*, Cambridge University Press, 2008.
- Ronald Roth, *Introduction to Coding Theory*, Cambridge University Press, 2006.
- William E. Ryan and Shu Lin, *Channel Codes: Classical and Modern*, Cambridge University Press, 2009.

Prerequisites: ECE 528, ECE 535, or ECE 542 or permission of instructor.

The course is suitable for graduate students in electrical engineering, computer engineering, computer science, and mathematics. Students should be comfortable with MATLAB (or Octave) or other high-level language with extensive math and scientific libraries such as Python or R, and a general purpose programming language (e.g., C/C++ or Java). In particular, the textbook includes codes and lab exercises written in MATLAB and C++. In this course, Python may also be used. A course project will be done in a group of up to four students and may involve software implementation in a language of the team's choice (e.g., MATLAB, Python, C/C++, CUDA for GPU programming) and/or hardware implementation (e.g., FPGA). The course project may be used to fulfill the ECE 797 Scholarly Paper requirement in the MS EE and MS CpE programs.

Grading (tentative):

- Homeworks = 10%, Labs = 15%, Project = 20% Midterm Exam = 20%, Final Exam = 35%.

Homework Assignments

- Homework problems, mostly from the textbook, will be assigned weekly.
- Sample solutions to homework assignments will be posted on Blackboard.

Programming Lab Exercises

- Lab-type programming exercises will be assigned roughly weekly.

Midterm Exam: Wednesday, Oct. 17, 2018 (in-class, 1.5 - 2 hours).

Project Presentations: Wednesday, Dec. 5, 2018.

Final Exam: Wednesday, Dec. 12, 2018 (7:30 – 10:15 pm)

Honor Code: To promote a stronger sense of mutual responsibility, respect, trust, and fairness among all members of the George Mason University community and with the desire for greater academic and personal achievement, we, the student members of the university community, have set forth this honor code: Student members of the George Mason University community pledge not to cheat, plagiarize, steal, or lie in matters related to academic work.

Course Schedule:

Week 1:	Aug. 29	Context for Error Correction Coding [Moon: Chapter 1] [MacKay: Chapter 11]
Week 2:	Sep. 5	Groups and Vector Spaces [Moon: Chapter 2]
Week 3:	Sep. 12	Linear Block Codes [Moon: Chapter 3] [MacKay: Chapters 13, 14]
Week 4:	Sep. 18	Cyclic Codes [Moon: Chapter 4]
Week 5:	Sep. 25	Rudiments of Number Theory and Algebra [Moon: Chapter 5]
Week 6:	Oct. 3	BCH and Reed-Solomon Codes [Moon: Chapter 6]
Week 7:	Oct. 10	Bursty Channels, Interleavers, and Concatenation [Moon: Chapter 10]
Week 8:	Oct. 17	Convolutional Codes [Moon: Chapter 12]
Week 9:	Oct. 24	Convolutional Codes [Moon: Chapter 12] [MacKay: Chapter 48]
Week 10:	Oct. 31	Turbo Codes [Moon: Chapter 14] [MacKay: Chapter 48]
Week 11:	Nov. 7	Low Density Parity Check Codes [Moon: Chapter 15] [MacKay: Chapter 47]
Week 12:	Nov. 14	Repeat-Accumulate Codes [Moon: Chapter 15] [MacKay: Chapter 49]
Week 13:	Nov. 21	No Class (Thanksgiving Recess)
Week 14:	Nov. 28	Decoding Algorithms on Graphs [Moon: Chapter 16] [MacKay: Chapters 16, 26]
Week 15:	Dec. 5	Fountain Codes [MacKay: Chapter 50]

Student disability: If you are a student with a disability and you need academic accommodations, please see me and contact the Office of Disability Services (ODS) at 703.993.2474. All academic accommodations must be arranged through that office. Students must inform the instructor at the beginning of the semester, and the specific accommodation will be arranged through ODS.

Academic Integrity: GMU is an Honor Code university. Please see the University Catalog for a full description of the code and the honor committee process.

WAVES: Wellness, Alcohol and Violence Education and Services

WAVES promotes wellness within the Mason community through health education, alcohol/drug assessment and education, and violence awareness, prevention and sexual assault response. We help students make healthy, safe choices and encourage lifelong, thoughtful healthy decision-making through individualized support, creative programming, and evidence-based education and outreach.

WAVES office 703-993-9999

SUB I, Suite 3200

24-Hour Sexual and Intimate Partner Violence Crisis Line 703-380-1434

waves.gmu.edu

- 703-360-7273 (Fairfax County Office for Women and Domestic and Sexual Violence Services 25 hotline)
- 703- 228-4848 (Arlington County Domestic Violence Services Hotline)
- 703-368-4141 (Prince William County Sexual Assault Victims Advocacy Services (SAVAS) hotline)
- 1-800-838-8238 (Virginia Family Violence and Sexual Assault Hotline)
- 1-800-656-HOPE (Rape, Abuse and Incest National Network)
<https://ohl.rainn.org/online/>

CAPS: Counseling and Psychological Services

Counseling and Psychological Services (CAPS) provides a wide range of free *confidential* services to students, faculty, and staff. Services are provided by a staff of professional clinical psychologists, social workers, counselors, learning specialists, and psychiatric providers. CAPS individual and group counseling, workshops, and outreach programs are designed to enhance students' personal experience and academic performance.

Visit us at **caps.gmu.edu** for additional resources.

- For consultation or emergency assistance during office hours call 703-993-2380.
- For assistance during non-office hours, call University Police at 703-993-4357.
- 703-527-4077 (CrisisLink)
- 1-800-273-8255 (National Suicide Prevention Lifeline)
- 1-877-838-2838 (Veterans' Crisis Hotline)

Student Health Services (SHS) — Provides *confidential* health care to enrolled students in emergency and non-emergency circumstances on the Fairfax, Arlington and Prince William campuses. If there is a medical emergency and Student Health Services (SHS) is closed, please contact the free after-hours nurse ((703) 993-2831), a hospital emergency room, an urgent care facility, or call 911.

SUB 1, Suite 2300

703-993-2831

University Police:

Emergency: 911 Non-Emergency: (703) 993-2810

Reporting a Crime (Crime Solvers Anonymous Tip Hot-Line): (703) 993-4111

Mason Police Website: <http://police.gmu.edu/>

Eric Heath, Chief of Police Phone: (703) 993-3840

E-mail: eh Heath2@gmu.edu