

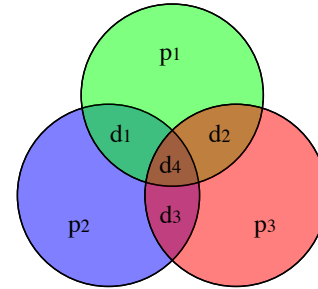
## Error Control Coding

EEL 6550 Sections 0001, 1FE2, 2FED

**Class Periods:** MWF period 5 (11:45 AM – 12:35 PM)

**Location:** 100% online (until further notice)

**Academic Term:** Fall 2020



### Instructor:

Dr. John M. Shea

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Office: 439 NEB

Phone: 352.575.0740 (text messaging is okay)

Office hours: Mondays and Thursdays 1:00 PM – 2:00 PM

Web site (personal): <http://wireless.ece.ufl.edu/jshea>

**Teaching Assistant/Peer Mentor/Supervised Teaching Student:** None

### Course Description:

(3 credits) Introduction to abstract algebra, block coding and decoding, convolutional coding and decoding, trellis coded modulation, and run-length-limited codes.

**Course Pre-requisite:** EEL 5544 or equivalent.



**Note: This course focuses on analysis, design, and algorithms. Both math and programming are critical skills for this!**

### Course Objectives (as time allows):

- Use analysis to determine the performance of coded communication systems
- Build encoders and decoders for common error-control coding schemes
- Use simulation to determine the performance of coded communication systems
- Read communication standards documents and explain the types of codes used, how they are used, and why those codes are used
- Choose an appropriate error-control coding scheme based on communication system constraints

### Material and Supply Fees

None

<sup>1</sup>Hamming Code Diagram (originally created by Bob McEliece) from [https://en.wikipedia.org/wiki/Hamming\(7,4\)#/media/File:Hamming\(7,4\).svg](https://en.wikipedia.org/wiki/Hamming(7,4)#/media/File:Hamming(7,4).svg) CC BY-SA 3.0

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**Required Textbooks and Software:** (*I strongly recommend you purchase this book. I also have requested all books be placed on reserve at Marston Science Library.*)

- Todd K. Moon, *Error Correction Coding: Mathematical Methods and Algorithms*, John Wiley & Sons, Hoboken, New Jersey, 2005.

**Recommended Materials:**

*Optional references:*

- William E. Ryan and Shu Lin, *Channel Codes: Classical and Modern*, Cambridge University Press, Cambridge, 2009.
- Shu Lin and Daniel J. Costello, Jr., *Error Control Coding: Fundamentals and Applications*, 2nd ed., Prentice Hall, 2004 (ISBN 0130426725).
- Stephen B. Wicker, *Error Control Systems for Digital Communication and Storage*, Prentice Hall, 1995 (ISBN 0-13-200809-2).
- Robert J. McEliece, *Finite Fields for Computer Scientists and Engineer*, Kluwer Academic Publishers, 1987 (ISBN 0-89838-191-6).
- Robert G. Gallager, *Low-Density Parity-Check Codes*, MIT Press, 1963.
- John D. Spragins, Joseph L. Hammond, and Krzysztof Pawlikowski, *Telecommunications: Protocols and Design*, Addison-Wesley, 1991 (contains good information on CRC codes in Chapter 6).
- Branka Vucetic and Jinhong Yuan, *Turbo Codes: Principles and Applications*, Kluwer Academic Publishers, 2000 (ISBN 0-7923-7868-7).

**Course Schedule (as time allows):**

- Introduction
  - Intro to modulation and signal spaces
  - Types of error control
  - Types of channels
  - The Hamming code
  - Optimal and suboptimal decoding algorithms
  - Intro to channel capacity and the channel coding theorem
- Block Codes
  - Abstract Algebra I
    - \* Groups

- \* Fields
- \* Binary field arithmetic
- \* Vector spaces over fields
- \* Matrices over fields
- Linear Block Codes
  - \* Encoding
  - \* Decoding
  - \* Syndrome and error detection
  - \* Distance and error-detection and -correction properties
  - \* Array and syndrome decoding
  - \* Probability of error
  - \* Modified linear codes
- Abstract Algebra II
  - \* Rings
  - \* Rings of polynomials
  - \* Quotient rings
- Cyclic codes
  - \* Properties
  - \* Encoding and decoding
  - \* CRC codes
- Reed-Muller codes (MAYBE)
  - \* Majority logic decoding
- Low-Density Parity-Check Codes
  - \* Belief propagation/Gallagher Decoding
- Abstract Algebra III
  - \* Extension fields
  - \* Construction of Galois Field  $GF(2^m)$
  - \* Properties of Galois Field  $GF(2^m)$
  - \*  $GF(2^m)$  arithmetic
- BCH and Reed-Solomon Codes
- Block Code Performance Analysis

**EXAM 1: Online exam on October 14, 2020, 8:20 PM – 10:20 PM.**

- Convolutional and Related Codes
  - Convolutional Codes
    - \* Encoding

- \* Properties
- \* Graphs, state diagrams, and trellises
- \* Distance properties
- \* Maximum likelihood (Viterbi) decoding
- \* Performance analysis
- \* Punctured codes
- Trellis Codes
  - \* M-ary signaling
  - \* Set partitioning
  - \* Distance properties
  - \* Multiple TCM
  - \* Decoding and performance
- Turbo Codes
  - \* Recursive, systematic convolutional codes
  - \* MAP decoding
  - \* Distance properties
  - \* Performance bounds
  - \* Interleaver design
- LDPC Codes
- Polar Codes

**EXAM 2: Online exam on December 9, 2020, 8:20 PM – 10:20 PM.**

**Online Course Recording**

Our class sessions may be audio visually recorded for students in the class to refer back and for enrolled students who are unable to attend live. Students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to consent to have your profile or video image recorded, be sure to keep your camera off and do not use a profile image. Likewise, students who un-mute during class and participate orally are agreeing to have their voices recorded. If you are not willing to consent to have your voice recorded during class, you will need to keep your mute button activated and communicate exclusively using the "chat" feature, which allows students to type questions and comments live. The chat will not be recorded or shared. As in all courses, unauthorized recording and unauthorized sharing of recorded materials is prohibited.

### **Attendance Policy, Class Expectations, and Make-Up Policy:**

This class will be presented online using Zoom and requires access to a working webcam and stable internet connection. I prefer that students keep their camera on during the class so that I can see you as I would during normal face-to-face classes. Studies show that if we can see each other's faces then we will have more engagement, more student success, and more faculty success. However, this is not a requirement. I understand if on certain days you can't have your camera on due to internet bandwidth limitations, other family members, health issues, or any other reasons.

- Unless an assignment is specifically structured as a group project, duplicate assignments written in collaboration with others is not acceptable. Although it is permissible to discuss the homework with others, these discussions should be of a general nature. All work at a detailed level must be done on your own. Students submitting the same or similar solutions to the homework will be considered as having cheated. No statements or actions made by anyone can alter this policy. Please review what constitutes plagiarism: <https://guides.uflib.ufl.edu/copyright/plagiarism>

Excused absences must be consistent with university policies in the Graduate Catalog (<http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#attendance>) and require appropriate documentation.

### **Evaluation of Grades:**

<b>Assignment</b>	<b>Total Points</b>	<b>Percentage of Final Grade</b>
Homeworks and Projects (5)	10 each	20%
Exams (2)	100 each	70%
Participation	10	10%
		100%

### **Grading Policy:**

Grades (and the corresponding grade points) will be assigned according to the [Registrar's official policies](#). Grades will be curved. However, an A grade of > 90% is guaranteed an A, > 80% is guaranteed a B, etc. Undergraduate students, in order to graduate, must have an overall GPA and an upper-division GPA of 2.0 or better (C or better). Note: a C- average is equivalent to a GPA of 1.67, and therefore, it does not satisfy this graduation requirement. Graduate students, in order to graduate, must have an overall GPA of 3.0 or better (B or better). Note: a B- average is equivalent to a GPA of 2.67, and therefore, it does not satisfy this graduation requirement.

Percent	Grade	Grade Points
93.4 - 100	A	4.00
90.0 - 93.3	A-	3.67
86.7 - 89.9	B+	3.33
83.4 - 86.6	B	3.00
80.0 - 83.3	B-	2.67
76.7 - 79.9	C+	2.33
73.4 - 76.6	C	2.00
70.0 - 73.3	C-	1.67
66.7 - 69.9	D+	1.33
63.4 - 66.6	D	1.00
60.0 - 63.3	D-	0.67
0 - 59.9	E	0.00

More information on UF grading policy may be found at: <http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades>

### **Students Requiring Accommodations:**

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting <https://disability.ufl.edu/students/get-started/>. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

### **Course Evaluation:**

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at <https://gatorevals.aa.ufl.edu/students/>. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluera.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.aa.ufl.edu/public-results/>.

### **University Honesty Policy:**

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Honor Code (<https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

### **Commitment to a Safe and Inclusive Learning Environment:**

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination.

It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Robin Bielling, Director of Human Resources, 352-392-0903, rbielling@eng.ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

**Software Use:**

All faculty, staff and student of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

**Student Privacy:**

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <https://registrar.ufl.edu/ferpa.html>

**Campus Resources:***Health and Wellness***U Matter, We Care:**

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact [umatter@ufl.edu](mailto:umatter@ufl.edu) so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

**Counseling and Wellness Center:** <http://www.counseling.ufl.edu/cwc>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

**Sexual Discrimination, Harassment, Assault, or Violence**

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the Office of Title IX Compliance, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, [title-ix@ufl.edu](mailto:title-ix@ufl.edu)

**Sexual Assault Recovery Services (SARS)**

Student Health Care Center, 392-1161.

**University Police Department** at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.



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*Academic Resources*

**E-learning technical support**, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. <https://lss.at.ufl.edu/help.shtml>.

**Career Resource Center**, Reitz Union, 392-1601. Career assistance and counseling. <https://www.crc.ufl.edu/>.

**Library Support**, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

**Teaching Center**, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. <https://teachingcenter.ufl.edu/>.

**Writing Studio**, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers. <https://writing.ufl.edu/writing-studio/>.

**Student Complaints Campus:** [https://www.dso.ufl.edu/documents/UF\\_Complaints\\_policy.pdf](https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf).

**On-Line Students Complaints:** <http://www.distance.ufl.edu/student-complaint-process>.