MATH 525 ALGEBRAIC CODING THEORY
FALL 2020

SCHEDULE NUMBER: 22394

COURSE INFORMATION

Professor: Dr. J. Carmelo Interlando
Email: interlan@sdsu.edu
Class Days and Times: MWF: 12:00-12:50
Office: GMCS-581
Telephone: (619) 594-7237
Mode of Delivery: On-Line

Zoom Link: https://SDSU.zoom.us/j/97705626537?pwd=RkxaVERwNUtRVFBlNHhZamxhTmYvdz09
Passcode: 998500

Course Website: https://sdsu.instructure.com

Response time for email: I endeavor to reply to emails within 24 hours on weekdays.

Office Hours: You are welcome to join me via Zoom on Thursdays 15:30-17:00 (no appointment needed).
Zoom Link: https://SDSU.zoom.us/j/91894130415?pwd=SzJuVTkzeVV2TjhGZ2RCdmdPWXBsQT09
Passcode: 106959

Additionally, we can arrange a meeting (on weekdays) if you contact me at least 24 hours in advance.

Students are provided with an SDSU Gmail account, and this SDSU email address will be used for all communications. Per University Senate policy, students are responsible for checking their official university email once per day during the academic term. For more information, please see Student Official Email Address Use Policy here.

COURSE OVERVIEW

This course is intended for advanced undergraduate students and graduate students at any level. The fundamentals of coding theory and the most widely used error-correcting codes will be studied. Although the theory of error-correcting codes started in electrical engineering, it soon became a mathematical topic. In a seminal paper published in 1948, Claude Shannon demonstrated that by properly encoding information (i.e., by adding some redundancy to it), errors introduced by a noisy channel or storage medium could be reduced to any desired level without sacrificing the rate of information transmission or storage. Although Shannon's result was a fundamental step, he did not indicate how to effectively construct the codes promised by his theory. This marked the birth of coding theory. Nowadays the use of coding for error control is an integral part in the design of communication systems.

REAL LIFE RELEVANCE

The study of error control codes (ECC) is important both from a theoretical and from a practical point of view. From the theoretical point of view, the design of the so-called good codes involves techniques from algebra (linear and abstract), number theory, combinatorics, and algebraic geometry. Hence, results in the theory of ECC can be regarded as applications of those areas of mathematics. From the practical point of view, error control codes provide the means for achieving the high degree of efficiency and reliability required in modern data transmission and storage systems. The control of errors that occur during the transmission of information is a major concern of the designer of such systems. Therefore, the communications industry can be seen as the main ECC customer.

Student Learning Outcomes

This course will give students insight into a highly interdisciplinary field at the border of mathematics, computer science, and engineering. It has tremendous significance to modern technology. The major learning outcomes are:

1. Recognize the practical need for ECC and explain how they work;
2. Calculate theoretical limits on error-correction;
3. Describe the relevance of linear codes and explain how they are encoded and decoded;
4. Calculate the minimum distance of a linear code from one of its defining matrices;
5. Describe the relevance of cyclic codes and explain how they are encoded;
6. Construct a finite field and perform operations (addition, multiplication, and division) with its elements;
7. Construct a BCH code meeting certain requirements on rate and error-correction capability;
8. Construct Reed-Solomon codes (used for error-correction in CDs, DVDs, Blu-ray discs), and describe their general decoding principle;
9. Design a code that will correct bursts of errors of a given length.

Prerequisites

A solid knowledge of MATH 254 – Introduction to Linear Algebra (excluding eigenvalues and related topics) and polynomial arithmetic is required. MATH 245 – Discrete Mathematics (counting, combinations, and probability) is also a prerequisite.

Enrollment Information

Adding/Dropping Procedure: The deadline for adding or dropping the course is September 4 at 7:59 PM.

Course Materials

Required Text

Hankerson et al., *Coding Theory and Cryptography: The Essentials*. Second Edition, Marcel Dekker, 2000.

References For Further Reading

1. R. Blahut, *Theory and Practice of Error Control Codes.* Addison Wesley, 1983. (engineering perspective, in-depth introduction).
2. R. Hill, *A First Course in Coding Theory*. Oxford Applied Math and Computing Series, 1986. (introduction).
3. W. C. Huffman and V. Pless, *Fundamentals of Error-Correcting Codes,* Cambridge University Press, 2003. (math/engineering perspectives combined).
4. J. Justesen and T. Høholdt, *A Course in Error-Correcting Codes*, EMS Textbooks in Mathematics, 2004. (concise introduction).
5. S. Lin and D. J. Costello, Jr., *Error Control Coding*, Second Edition. Prentice-Hall, 2004. (engineering perspective).
6. F. J. MacWilliams and N. J. A. Sloane, *The Theory of Error-Correcting Codes*. North-Holland, Elsevier Science Publishers, 1977. (advanced, the standard reference).
7. R. J. McEliece, *The Theory of Information and Coding*, Second Edition, Cambridge University Press, Cambridge, 2002. (in-depth introduction).

Course Assessment and Grading

Homework

Weekly homework problems will be posted on the class website. While collaboration is encouraged, attempting and doing the homework problems yourself is essential in order to gain confidence and do well in the course.

Quizzes

Tentatively, there will be 8-10 quizzes throughout the semester (there will be no quizzes during the first week, last week, and exam weeks). Quizzes will cover material from the present week and occasionally from previous weeks. The quizzes will be short (no longer than 15 minutes). There will be no make-up for quizzes except for medical or other extreme situations and provided these are documented.

Exams

- Exam 1: Friday, September 18. Weight: 100 points.
- Exam 2: Friday, October 16. Weight: 150 points.
- Exam 3: Friday, November 13. Weight: 150 points.
- Final Exam: December 16, from 10:30 to 12:30, as scheduled by the University. Weight: 200 points.

Grading Guideline

Quizzes	40%
Exams	60%

The numerical points for letter grades (A, A–, B+,…) will be based only on the quizzes and exams. Roughly, an A is above 85%, A– is above 80%, B is above 70%, C is above 60%, etc.

Estimated Time Commitment

As a 3-unit lecture course, students will spend 3 hours in lecture and between 9-12 hours outside of class per week.

Tips for Success in the Course

Regular and punctual class attendance is expected. This is not a do-it-yourself, work-at-your-own-speed course. The material in this course is technical and will build on each other. If you fall behind, it will be difficult to catch up. It is important that you do the readings and complete the assignments on time. In summary:

- Attend class regularly and ask questions;
- Read the textbook and class notes carefully;
- Do all the suggested homework problems. This is an important part of the learning process in mathematics. As with other math courses, experimentation is fundamental for you to understand the material, see patterns, and obtain results. If you get stuck on a problem, please do not hesitate to contact me;
- Discuss the material and homework problems with classmates as this frequently provides new insight into the techniques.

Please contact me immediately should you face difficulties in the course.

University Policies

Accommodations: If you are a student with a disability and are in need of accommodations for this class, please contact Student Ability Success Center at (619) 594-6473 as soon as possible. Please know accommodations are not retroactive, and I cannot provide accommodations based upon disability until I have received an accommodation letter from Student Ability Success Center.

Student Privacy and Intellectual Property: The Family Educational Rights and Privacy Act (FERPA) mandates the protection of student information, including contact information, grades, and graded assignments. I will use Canvas to communicate with you, and I will not post grades or leave graded assignments in public places. Students will be notified at the time of an assignment if copies of student work will be retained beyond the end of the semester or used as examples for future students or the wider public. Students maintain intellectual property rights to work products they create as part of this course unless they are formally notified otherwise.

Religious Observances: According to the University Policy File, students should notify the instructors of affected courses of planned absences for religious observances by the end of the second week of classes.

Academic Honesty: The University adheres to a strict policy prohibiting cheating and plagiarism. Examples of academic dishonesty include but are not limited to:

- copying, in part or in whole, from another's test or other examination;
- obtaining copies of a test, an examination, or other course material without the permission of the instructor;
- collaborating with another or others in work to be presented without the permission of the instructor;
- falsifying records, laboratory work, or other course data;
- altering or interfering with grading procedures;
- assisting another student in any of the above;
- using sources verbatim or paraphrasing without giving proper attribution (this can include phrases, sentences, paragraphs and/or pages of work);
- copying and pasting work from an online or offline source directly and calling it your own;
- using information you find from an online or offline source without giving the author credit;
- replacing words or phrases from another source and inserting your own words or phrases.

Unauthorized recording or dissemination of virtual course instruction or materials by students, especially with the intent to disrupt normal university operations or facilitate academic dishonesty, is a violation of the Student Conduct Code. This includes posting of exam problems or questions to on-line platforms. Violators may be subject to discipline.

The California State University system requires instructors to report all instances of academic misconduct to the Center for Student Rights and Responsibilities. Academic dishonesty will result in disciplinary review by the University and may lead to probation, suspension, or expulsion. Instructors may also, at their discretion, penalize student grades on any assignment or assessment discovered to have been produced in an academically dishonest manner.

RESOURCES FOR STUDENTS: A complete list of all academic support services--including the Writing Center and Math Learning Center--is available on the Student Affairs' Academic Success website. Counseling and Psychological Services (619-594-5220) offers confidential counseling services by licensed therapists; you can Live Chat with a counselor at http://go.sdsu.edu/student_affairs/cps/therapist-consultation.aspx between 4:00pm and 10:00pm, or call San Diego Access and Crisis 24-hour Hotline at (888) 724-7240.

CLASSROOM CONDUCT STANDARDS: SDSU students are expected to abide by the terms of the Student Conduct Code in classrooms and other instructional settings. Prohibited conduct includes:

- Willful, material and substantial disruption or obstruction of a University-related activity, or any on-campus activity.
- Participating in an activity that substantially and materially disrupts the normal operations of the University or infringes on the rights of members of the University community.
- Unauthorized recording, dissemination, or publication (including on websites or social media) of lectures or other course materials.
- Conduct that threatens or endangers the health or safety of any person within or related to the University community, including:
    1. physical abuse, threats, intimidation, or harassment.
    2. sexual misconduct.

Violation of these standards will result in referral to appropriate campus authorities.

MEDICAL-RELATATED ABSENCES: Students are instructed to contact their professor/instructor/coach in the event they need to miss class, etc. due to an illness, injury or emergency. All decisions about the impact of an absence, as well as any arrangements for making up work, rest with the instructors. Student Health Services (SHS) does not provide medical excuses for short-term absences due to illness or injury. When a medical-related absence persists beyond five days, SHS will work with students to provide appropriate documentation. When a student is hospitalized or has a serious, ongoing illness or injury, SHS will, at the student's request and with the student's consent, communicate with the student's instructors via the Vice President for Student Affairs and may communicate with the student's Assistant Dean and/or the Student Ability Success Center.

SDSU ECONOMIC CRISIS RESPONSE TEAM: If you or a friend are experiencing food or housing insecurity, or any unforeseen financial crisis, visit sdsu.edu/ecrt, email: ecrt@sdsu.edu, or walk-in to Well-being & Health Promotion on the 3rd floor of Calpulli Center.

HELP CONTROL THE COVID-19 PANDEMIC

All SDSU community members are encouraged to make a commitment to health and safety; please consider signing the SDSU Health Commitment. For additional COVID-19 information, visit the university's COVID website.