

California State University Stanislaus  
Department of Computer Science  
Syllabus

**Instructor: Dr. Xuejun Liang**

My Office: DBH 282

Office Hours: MW 1:00 p.m.-2:00 p.m. & Th 11:00 a.m.-12:00 a.m.

ZOOM Meeting ID: 4438930033, Phone: (209) 667-3169, Email: [xliang@csustan.edu](mailto:xliang@csustan.edu)

**Class Information:**

Classroom: Bizzini 111

Class Date & Time: TTh 12:30PM-1:45PM

Class Website: <https://www.cs.csustan.edu/~xliang/Courses2/CS4450-23F>

**Catalog Description:**

CS4450 Coding and Information Theory. (3 Hours) Pre-requisites: CS 3100 and MATH 2300. Topics to be selected from error detecting and correcting codes, encryption and decryption techniques, RSA and knapsack codes, algebraic coding theory, Hamming distance, sphere packing and its relation to optimal codes, Hamming, Huffman and Gray codes, entropy, channel capacity and Shannon's theorem, bandwidth and the sampling theorem.

**Textbook:**

[Information and Coding Theory](#), by Gareth A. Jones and J. Mary Jones, Springer, 2000, ISBN 978-1-85233-622-6

**Reference Books:**

[Information Theory, Coding and Cryptography](#), by Arijit Saha, Nilotpal Manna, Mandal, Pearson India, 2013, Print ISBN-13: 978-81-317-9749-5, Web ISBN-13: 978-93-325-1785-1

**Course Goals/Objectives**

To give students a rigorous mathematical study of the fundamentals of coding methods (including encryption and decryption, error detection and correction, optimal codes) and information theory (including the idea of information, channels, channel capacity, information entropy, and sampling theory), and to prepare students to make sense of current research papers in coding and information theory and cryptography.

**Course Outcomes**

Students who successfully complete the course should be able to

1. Determine whether a given code can be decoded uniquely or is instantaneous, construct instantaneous codes, including Huffman code for a source or an extension of a source, and compute the average word length.
2. Describe the concept of Entropy and the meaning of Shannon's First Theorem, compute Entropy for a source, extension, and products, and compute word lengths for Shannon-Fane codes.

3. Describe the concepts and definitions of information channel, system entropies (input entropy, output entropy, equivocation, and joint entropy), mutual information, and channel capacity, and apply them to BSC and BEC.
4. Describe Shannon's fundamental theorem, apply the ideal observer rule, the maximum likelihood rule, and the nearest neighbor decoding to BSC and BEC, and compute  $P_{rE}$  and  $P_{rC}$
5. Compute the (extended) Hamming code, Hamming's sphere-packing bound, and the Gilbert-Varshamov Bound, and construct a Hadamard matrix and its corresponding codes.
6. Compute the generator matrix and parity-check matrix (in systematic form) of a linear code and the minimum distance of a linear code. Calculate with the Hamming Codes, the Golay Codes and the Standard Array.

### Course Outline\* (Major Topics and Weekly Schedule)

Date	Topics Covered
Week 1: 08/22, 08/24	Course syllabus. Overview of Probability. Overview of coding and information theory. Definitions and examples of codes.
Week 2: 08/29, 08/31	Uniquely Decodable Codes, Instantaneous Codes Constructing Instantaneous Codes, Kraft's Inequality, McMillan's Inequality, Comments on Kraft's and McMillan's Inequalities
Week 3: 09/05, 09/07	Code Optimality. Binary Huffman Codes. Average Word-length of Huffman Codes. Optimality of Binary Huffman Codes. r-ary Huffman Codes. Extensions of Sources
Week 4: 09/12, 09/14	Information and Entropy. Properties of the Entropy Function. Entropy and Average Word-length. Shannon-Fane Coding
Week 5: 09/19, 09/21	Entropy of Extensions and Products. Shannon's First Theorem. An Example of Shannon's First Theorem <b>Test #1 (Overview of Probability and Chapters 1, 2, and 3)</b>
Week 6: 09/26, 09/28	Definitions (Information channel, input and output sources). The Binary Symmetric Channel. System Entropies. System Entropies for the Binary Symmetric Channel
Week 7: 10/03, 10/05	Extension of Shannon's First Theorem to Information Channels. Mutual Information. Mutual Information for the Binary Symmetric Channel. Channel Capacity
Week 8: 10/10, 10/12	Using an Unreliable Channel: Decision Rules. An Example of Improved Reliability. Hamming Distance. Statement and Outline Proof of Shannon's Theorem. The Converse of Shannon's Theorem
Week 9: 10/17, 10/19	Mathematical Fundamentals: Modular Arithmetic, Groups, Field Definition and Examples, Extension Field, Linear (vector) space definition and examples, Subspace and Linearly independent, Basis and Dimension, Orthogonality and Dual Space.
Week 10: 10/24, 10/26	Mathematical Fundamentals: Matrix, Rank of a matrix, Elementary row operations of a matrix, Matrix operation and group of linear equations.
Week 11: 10/31, 11/02	Error-correcting Codes: Introductory Concepts (Galois field, Linear Code, Rate of a code). Examples of Codes. Minimum Distance.
Week 12: 11/07, 11/09	Error-correcting Codes: Hamming's Sphere-packing Bound. The Gilbert-Varshamov Bound. <b>Test #2 (Mathematical Fundamentals and Chapters 4, 5, and 6)</b>
Week 13:	Matrix Description of Linear Code: Dual Code and Orthogonal Code,

11/14, 11/16	Equivalence of Linear Codes: Generator matrix and Parity-check matrix, The Singleton Bound.
	<b>Thanksgiving Holiday</b>
Week 14: 11/28, 11/30	Minimum Distance of Linear Codes. A sufficient and necessary condition for a t-error-correcting linear code. Perfect Hamming code, Standard array of a linear code.
Week 15: 12/05, 12/07	Syndrome Decoding, Syndrome Table. Review for the final examination
Week 16: 12/12, 12/14	<b>Final Examination Schedule</b> <a href="https://www.csustan.edu/class-schedule/finals-schedule">https://www.csustan.edu/class-schedule/finals-schedule</a>

\*It is subject to change.

### Grading Scale

Grading Scale will be assigned on a standard scale as below. Clustering of grades may cause the grading scale to be lowered (to your benefit), but it will not be raised.

A	B	C	D	F
90-100	75-89	60-74	45-59	<45

### Evaluation:

The overall course grade will be the weighted sum of the points earned in the following categories:

Attendance	Homework	Tests	Final Exam
10%	25%	30%	35%

### Other Policies:

1. I will accept the homework assignments late for maximum three days (including holidays) with the point deduction 20% per day.
2. There will be no makeup tests except in a verified emergency with immediate notification.

### Academic Honesty:

The work you do for this course will be your own, unless otherwise specified. You are not to submit other people's or machine's work and represent it as your own. I consider academic honesty to be at the core of the University's activities in education and research. Academic honesty is always expected in this course.

### Accommodations for Students with Disabilities

Students with disabilities seeking academic accommodations must first register with the Disability Resource Services (DRS) program, located in MSR 210, ph. (209) 667-3159. Students are encouraged to talk with the instructor regarding their accommodation needs after registering with DRS.