Electrical and Computer Engineering Course Syllabus

Instructor:	Prof. Henry Pfister	**E-mail:**	henry.pfister@duke.edu
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Class Room:	Teer 203	**Class Time:**	MW 10:05-11:20

Course Name: **ECE 587**

Course Title: **Information Theory**

Prerequisite(s): ECE 581 and ECE 586, or equivalent

Required Text(s): *Elements of Information Theory*, 2nd Ed. by T. Cover and J. Thomas, 2006

Other Text(s): *Information Theory (Lecture Notes)*, 6th Ed. by Stefan Moser, 2024

Information Theory by Yury Polyanskiy and Yihong Wu

Course Objectives:

1. Explore Shannon's mathematical approach to communication. Explore fundamental approaches to quantifying the amount of information contained in a message or transmitted by a signal.
2. Introduce mathematical models for discrete information sources and derive fundamental limits on data compression. Discuss source codes, entropy, Kraft's inequality, Huffman codes, typical sequences, the AEP, and Fano's inequality. State and prove the source coding theorem.
3. Describe the main tools of information theory: joint entropy, conditional entropy, mutual information. State and prove standard identities and bounds.
4. Introduce mathematical models for noisy channels and derive fundamental limits on rates of communication. Discuss DMCs, joint typicality, and the data processing inequality. State and prove the channel coding theorem.
5. Extend previous result to continuous random variables. Discuss differential entropy, the continuous AEP, and the channel coding theorem for Gaussian channels.
6. Explore applications of information theory to statistics and machine learning.
7. Engage the student in an active learning experience. Expose the student to search engines, scholastic resources, research tools, indexes and databases. Prepare the student to become an active contributor to the common body of knowledge.

Course Topics and Hours:

Unit	Topics	Hours
1	Entropy and Mutual Information	3
2	Typical Sequences and Entropy Rates	3
3	Lossless Source Coding	6
4	Channel Coding	4.5
5	Differential Entropy and the Gaussian Channel	3
6	Rate-Distortion	3
7	Universal Compression and Statistical Inference	3
8	Statistical Divergences	4.5
9	Applications	3
	Total Hours	33

Lecture Schedule: 2 meetings / week, 125 minutes total

Student Evaluation:

Homework	25%	Roughly 10 assignments throughout the semester
Midterm 1	25%	First midterm exam (October 9)
Midterm 2	25%	Second midterm exam (December 4)
Final Project	25%	Presentation during final time Dec. 11 9am-Noon

Rules and Guidelines:

The class shall follow all established policies of Duke University.

Tentative Schedule:

Date	Topic	Reading	Assignment	Notes
08/26/24	Introduction	Ch 1 [CT], Ch 1 [M]	HW0 / HW1	1
08/28/24	Measures of Information	Ch 2 [CT], Ch 1 [M]		2
09/02/24	Labor Day			X
09/04/24	M of I	Ch 2 [CT], Ch 1 [M]		2
09/09/24	Typical Sets	Ch 3 [CT], Ch 20 [M]	HW2	3
09/11/24	Entropy Rates	Ch 4 [CT], Ch 5 [M]		4
09/16/24	Lossless Compression	Ch 5 [CT], Ch 3 [M]	HW3	5
09/18/24	LC	Ch 5 [CT], Ch 3 [M]		5
09/23/24	LC	Ch 5 [CT], Ch 3 [M]	HW4	5
09/25/24	canceled			
09/30/24	LC	Ch 5 [CT], Ch 6 [M]		5
09/28/24	Channel Coding	Ch 7 [CT], Ch 9 [M]	HW5	6
10/02/24	CC	Ch 7 [CT], Ch 9 [M]		6
10/04/24	CC	Ch 7 [CT], Ch 9 [M]		6
10/09/24	Midterm 1 Review			
10/11/24	Midterm 1			
10/16/24	Fall Break Begins		Ends 10/15/24	
10/21/24	Differential Entropy	Ch 8 [CT], Ch 16 [M}	HW 6	7
10/23/24	Gaussian Channel	Ch 9 [CT], Ch 17-19 [M]		8
10/28/24	Rate Distortion Theory	Ch 10 [CT], Ch 11 [M+]	HW6 – Due 11/02	9
10/30/24	RDT	Ch 10 [CT], Ch 11 [M+]		9
11/04/24	Universal Compression	Ch 13 [CT], Ch 10 [M+]		TBA
11/06/24	Statistical Inference			TBA
11/11/24	Statistical Divergences			TBA
11/13/24	SD			TBA
11/18/24	SD			TBA
11/20/24	Thanksgiving Break		Ends 11/24/24	
11/25/24	Applications			TBA
11/27/24	Applications			TBA
12/02/24	Midterm 2 Review			
12/04/24	Midterm 2			