ENG EC517 Introduction to Information Theory

2007-2008 Catalog Data: Prereq: CAS MA 225, ENG EC 381. Discrete memoryless stationary sources and channels; Information measures on discrete and continuous alphabets and their properties: entropy, conditional entropy, relative entropy, mutual information, differential entropy; Elementary constrained convex optimization; Fundamental information inequalities: data-processing, and Fano's; Block source coding with outage: weak law of large numbers, entropically typical sequences and typical sets, asymptotic equipartition property; Block channel coding with and without cost constraints: jointly typical sequences, channel capacity, random coding, Shannon's channel coding theorem, introduction to practical linear block codes; Rate-distortion theory: Shannon's block source coding theorem relative to a fidelity criterion; Source and channel coding for Gaussian sources and channels and parallel Gaussian sources and channels (water-filling and reverse water-filling); Shannon's source-channel separation theorem for point-to-point communication; Lossless data compression: Kraft's inequality, Shannon's lossless source coding theorem, variable-length source codes including Huffman, Shannon-Fano-Elias, and Arithmetic codes; Applications; Mini course-project.

Class/Lab Schedule:
Lecture: 4 hours/week

Textbooks and other required materials:
T. Cover and J. Thomas, Elements of Information Theory, Wiley-Interscience, 1991.

Coordinator:
Prakash Ishwar, Assistant Professor, ECE

Prerequisites by topic:
Multivariate calculus (CAS MA 225), Probability (ENG EC 381).

Goals: 1. Introduce students to the basic concepts of information theory and its applications in electrical and computer engineering. 2) Provide students with analysis tools and models to understand and uncover the fundamental limits of information exchange in modern digital communication systems. 3) Constructive strategies for approaching the fundamental limits

Course Outcomes: As an outcome of completing this course, students will:
1. Understand the core mathematical principles and practical applications of Information Theory for efficient compression and reliable transmission of information in point-to-point communication systems.
2. Understand & work with basic discrete/continuous models for sources/channels
3. Understand & work with block/variable-length source/channel encoding/decoding
4. Understand the notion of rate in source compression and channel transmission
5. Understand & work with basic measures of source information fidelity and channel transmission cost
6. Understand & work with entropy, cross-entropy, and mutual information

7. Understand, analyze, & work with contemporary lossless & lossy source compression algorithms & channel transmission algorithms
8. Design & evaluate constructive source compression & channel transmission strategies
9. Compute, analyze, & interpret the rate-distortion performance for source compression & the capacity-cost performance for channel transmission
10. Understand the basis for the modular architecture of modern point-to-point digital communication systems
11. Understand bits as an optimal currency of information exchange in point-to-point communication
12. Understand source & channel coding as functionally dual operations
13. Initiate research and formally communicate technical ideas in written and oral forms through a course project.

Course Outcomes mapped to Program Outcomes:

Program Outcomes	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
Course Outcomes	**1-9, 13**	**2,3,5,6, 8,9,13**	**8,9 ,13**		**1-9, 13**		**13**		**13**	**1,7, 10-13**	**2,3,5,6,8,9 ,13**
Emphasis (1-5)	**5**	**2**	**4**		**5**		**4**		**5**	**4**	**4**

1 = not at all; 5 = a great deal

Topics in Project Assignments:

1) Classical and contemporary practical channel encoding-decoding algorithms 2) Classical and contemporary text/speech/audio/image/video compression algorithms 3) Topics in network/multiuser information theory 4) Information scaling laws in large-scale wireless ad-hoc and sensor networks 5) Information theory in information security 6) Information theory and data networks 7) Information theory and robust, low-power, high-speed, VLSI circuits 8) Information theory in finance 9) Information theory in statistics, and statistical thermodynamics 10) Information theory in image formation and inverse problems 11) Information theory in pattern matching and classification 12) Information theory and random graphs 13) Generalized information measures and alternating minimization algorithms.

Contribution of Course to Meeting the Professional Component:
Engineering topics: 90%
Math & Basic Science: 10%
General Education: 0%

Status of Continuous Improvement Review of this Course:

Date Last Reviewed:	**Reviewed by**:
December 2006	Graduate Committee, ECE Department

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