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| **ECx528** | **Information Theory and Coding** | **L-T-P: 3-0-0; Total 42 Lectures** |

***Prerequisites****:* i) Probability Theory ii) Analog and Digital Communication Engineering

***Objective****:* To expose to students some concepts in information theory, and the performance characteristics of an ideal communications system. To expose to students fundamentals in coding and its applications.

***Topics Covered:***

**Unit 1: Introduction to Information Theory :** Introduction to Information Theory and Coding; Definition of Information Measure and Entropy, Relative Entropy, Extension of An Information Source and Markov Source, Adjoint of An Information Source, Joint and Conditional Information Measure, Properties of Joint and Conditional Information Measures and A Morkov Source, Asymptotic Properties of Entropy and Problem Solving in Entropy, Estimation of Probability Density and Probability Mass Functions, Expectation-Maximization algorithm, Maximum Entropy Principle, Jensen’s Inequality; Fano’s Inequality; Data Processing Inequality. (7L)

**Unit 2: Source Coding :** Introduction to Lossless Coding; Block Code and its Properties, Instantaneous Code and Its Properties, Kraft-Mcmillan Equality and Compact Codes, Shannon’s Source Coding Theorem, Prefix Coding, Huffman Coding and Proof of Its Optamality, Competitive Optamality of The Shannon Code, Adaptive Huffman Coding, Shannon-Fano Coding, Arithmetic Coding, LZW Algorithm. (6L)

**Unit 3: Channel Capacity and Coding :** Introduction to Discrete Information Channels, Equivocation and Mutual Information, Properties of Different Information Channels, Reduction of Information Channels, Noiseless Channel, Properties of Mutual Information and Introduction to Channel Capacity, Calculation of Channel Capacity for Different Information Channels, Shannon’s Channel Coding Theorem, Bandwidth-S/N Trade-Off, Channel Capacity Theorem, Discussion On Error Free Communication Over Noisy Channel, Error Free Communication Over A Binary Symmetric Channel and Introduction to Continuous Sources and Channels, Differential Entropy and Evaluation of Mutual Information for Continuous Sources and Channels, Channel Capacity of A Band-Limited Continuous Channel. (8L)

**Unit 4: Linear Block and Cyclic Error-Correction Coding :** Definition of Terms – Redundancy, Code Efficiency, Systematic Codes, Hamming Distance, Hamming Weight, Hamming Bound; Types of Codes – Parity Check Codes, Hamming Codes, BCH Codes, Reed-Solomon Codes, Concatenated Codes; Linear Block Codes, Generator and Parity Check Matrix, Syndrome Decoding; Cyclic Codes, Generation and Detection; Coding for Reliable Communication, Coding Gain, Bandwidth Expansion Ratio; Comparison of Coded and Un-coded systems. (9L)

**Unit 6: Convolutional Code :** Burst Error Detecting and Correcting Codes; Convolutional Codes; Time Domain and Frequency Domain Approaches; Code Tree, Trellis and State Diagram; Decoding of Convolutional Codes, Viterbi’s Algorithm, Sequential Decoding; Transfer Function and Distance Properties of Convolutional Codes; Bound on the Bit Error Rate; Coding gain. (8L)

**Unit 7: Coded Modulation :** Coding for Bandwidth Constrained Channels -- Combined Coding and Modulation, Trellis Coded Modulation (TCM), Set-partitioning, Encoder and Decoder Design for TCM, Decoding of TCM Codes using the Viterbi Algorithm. (4L)

***Books:***

1. T. M. Cover and J. A. Thomas, ‘Elements of Information Theory’, 2nd Edition, Wiley India Pvt. Ltd, 2013.
2. I. Csiszar and J. Korner, ‘Infromation Theory: Coding Theorems for Discrete Memoryless Systems’, 2nd Edition, Cambridge University Press, 2011.
3. R. G. Gallager, ‘Information Theory and Reliable Communication’, JohnWiley& Sons, 1969.
4. R. E. Blahut, ‘Algebraic Codes for Data Transmission’, 1st Edistion, Cmabridge University Press, 2003.

***Other useful references:***

1. C.E. Shannon, “A Mathematical Theory of Communications”, Bell System Tech. Journal, Vol. 27, July and Oct. 1998.
2. G. Forney and D. Costello, B., “Channel coding: The road to channel capacity”, Proc. IEEE, vol. 95, no. 6, pp. 1150–1177, Jun. 2007.

***Course Outcome****:* Upon successful completion of this course, students should be able to:

1. Have understood the notion of information in the quantitative sense
2. Have understood how the quantity of information could be measure
3. Have understood the concept and properties of entropy and mutual information as it applied to information
4. Have understood, and be able to prove, the noiseless coding theorem (Shannon's First Theorem)
5. Be able to construct compact and non-compact codes for a given data ensemble
6. Have understood the notions of channels, different classes of channel, and channel capacity
7. Have understood the fundamental coding theorem for noisy channels (Shannon's Second Theorem), and its implications
8. Have understood simple methods for construction of error correction codes