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संगणक विज्ञान एंव अभियांत्रिकी विभाग / DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
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No:- **Date:**

CSX4204: Information Theory and Coding

L-T-P-Cr: 3-0-0-3

Pre-requisites: Prior knowledge of fundamentals of Communication Systems

Course Objectives:

1. To define and apply the basic concepts of information theory (entropy, channel capacity etc.)
2. To learn the principles and applications of information theory in communication systems
3. To understand the theoretical framework upon which error-control codes are built
4. To evaluate various data compression methods in today's world.

Course Outcomes:

At the end of the course, a student will be able to:

S.No	Course Outcome (CO)	Mapping to POs
1.	To learn the principles and applications of information theory in communication systems.	PO1,PO4,PO6
2.	To quantify and comprehend the concepts of information, entropy, and channel capacity.	PO1, PO2,PO4
3.	To determine an efficient data compression strategy for a given information source by distinguishing between lossy and lossless compression approaches.	PO1, PO2, PO3
4.	To design communication systems with error control capabilities	PO1,PO3,PO6,PO8
5.	To apply appropriate technique for reasoning under uncertainty as well as widely utilized computational and graphical tools	PO1, PO2, PO5

UNIT I: **Lectures: 10**

Overview: Basic Concepts - Entropy and Mutual information; Lossless Source Coding - Source entropy rate, Kraft inequality; Huffman code; Asymptotic equipartition property, Universal coding; Noisy Channel Coding – Channel capacity; Random channel codes; Noisy channel coding theorem for discrete memoryless channels, Channel Capacity: Examples of Channel Capacity, Symmetric Channels, Properties of Channel Capacity, Preview of the Channel Coding Theorem, Jointly Typical Sequences, Zero-Error Codes, Fano's Inequality and the Converse to the Coding Theorem, Equality in the Converse to the Channel Coding Theorem, Hamming Codes, Feedback Capacity, Source–Channel Separation Theorem.

UNIT II: **Lectures: 10**

Differential Entropy: AEP for Continuous Random Variables, Relation of Differential Entropy to Discrete Entropy, Joint and Conditional Differential Entropy, Relative Entropy and Mutual Information, Properties of Differential Entropy, Relative Entropy, and Mutual Information. Continuous and Gaussian channels, Calculation of the Rate Distortion Function, Converse to the Rate Distortion Theorem, Achievability of the Rate Distortion Function, Strongly Typical Sequences and Rate Distortion, Characterization of the Rate Distortion Function, Computation of Channel Capacity and the Rate Distortion Function.

UNIT III: **Lectures: 10**

Kolmogorov Complexity: Models of Computation, Kolmogorov Complexity: Definitions and Examples, Kolmogorov Complexity and Entropy, Kolmogorov Complexity of Integers, Algorithmically Random and Incompressible Sequences, Universal Probability, Kolmogorov complexity, Universal Gambling, Occam's razor Kolmogorov Complexity and Universal Probability, Kolmogorov Sufficient Statistic,
Minimum Description Length Principle.

UNIT IV: **Lectures: 6**

Error Control Code- Linear Block codes – Syndrome Decoding – Minimum distance consideration – cyclic codes – Generator Polynomial – Parity check polynomial – Encoder for cyclic codes – calculation of syndrome – Convolutional codes.

UNIT IV: **Lectures: 6**

Compression Techniques: Principles – Text compression – Static Huffman Coding – Dynamic Huffman coding – Arithmetic coding – Image Compression – Graphics Interchange format – Tagged Image File Format – Digitized documents – Introduction to JPEG standards.

Reference Books-

1. S. Lin and D. J. Costello, *Error Control Coding – Fundamentals and Applications*, Second Edition, Pearson Education Inc., NJ., USA, 2004
2. J. A. Thomas and T. M. Cover: *Elements of information theory*, Wiley, 2006.
3. R. Bose, *Information Theory, Coding and Cryptography*, Tata McGraw-Hill, 2003.
4. E. R. Berlekamp, *Algebraic Coding Theory*, McGraw-Hill, New York, 1968.
5. R. E. Blahut, *Algebraic Codes for Data Transmission*, Cambridge University Press Cambridge, UK, 2003.