2/4 B.Tech. FIRST SEMESTER
INFORMATION THEORY

CS3T5 **Required** **Credits: 4**
Lecture: 4 periods/week **Internal assessment: 30 marks**
Tutorial: 1 period /week **Semester end examination: 70 marks**

Course context and Overview: Topics include mathematical definition and properties of information, source coding theorem, lossless compression of data, optimal lossless coding, noisy communication channels, channel coding theorem, the source channel separation theorem, multiple access channels, broadcast channels, Gaussian noise, and time-varying channels.

Prerequisites: understanding of Discrete Probability and elementary enumerating principles, Linear Algebra, and of course Calculus

Objectives:

The objective of the course it to expose students to the principles and practice of information theory, covering both theoretical and applied issues in data/information compression, transmission, storage and processing. The course covers the basic principles of quantitative measure of information theory, including the basic theory and algorithms behind source and channel coding for single-user (point-to-point) and multi-user systems.

Learning Outcomes:

Ability to:

1) Apply the basic concepts of Information Theory (entropy) in discrete and continuous random variables.
2) Differentiate between lossy and lossless data compression methods.
3) Calculate the capacity of communication channels.
4) Understand the basic concepts of noisy and Gaussian channels, relevant theorems on information theory and statistical inference.
5) Determine the capacity region of multiple access channels.

UNIT I
Discrete Sources and Entropy:

Overview, Discrete Information Sources and Entropy, Source Coding, Huffman Coding, Dictionary Codes, Arithmetic Coding, Source models and Adaptive source Coding.

UNIT II
Data Compression:

Examples of Codes, Kraft inequality, Optimal codes, Huffman Codes, Shannon Fano Elias coding, Arithmetic Coding, Optimality of Shannon Code.

UNIT III
Channel Capacity:

Symmetric channels Properties of channel capacity, Channel coding theorem Zero error

codes, Fano's inequality, Hamming Codes, Feedback capacity.

UNIT IV Differential
Entropy:

The AEP for continuous random variables, relation of differential entropy and discrete entropy, Joint and Conditional Entropy, Relative entropy and Mutual information, Properties of entropy and mutual information.

UNIT V
Gaussian Channel:

Definition, theorem for Gaussian channels, band limited channels, parallel Gaussian channels, noisy channel.

UNIT VI
Information Theory and Statistics:

The law of large numbers, Universal source coding, Large deviation theory, the condition limit theorem, Hypothesis testing, Steein's lemma, Chernoff bound, Lempel-Ziv coding, Fisher Information and the Cramer Rao inequality.

UNIT VII
Rate Distortion Theory:

Quantization, calculation, converse and achievability of rate Distortion Function, Strongly typical sequences and rate distortion, computation of channel capacity and the rate distortion function.

UNIT VIII
Network Information Theory:

Gaussian multiple user channels, Jointly typical sequences, the multiple access channel, encoding of correlated sources, the broadcast channel the relay channel, source coding and rate distortion with side information.

Learning Resources

TEXT BOOKS:

1. Elements of Information Theory, Thomas M. Cover & Joy A. Thomas, Willey India 2008.
2. Applied Coding and Information Theory for Engineers, Richard B. Wells, Pearson Education.

REFERENCE BOOKS:

1. Information Theory and Reliable Communication, R. G. Gallager, Wiley, 1968.
2. IEEE Transactions on Information Theory, Special Issue on 50 years of Information Theory, Vol. 44, No. 6, 1998.
3. A Mathematical Theory of Communication : Shannon's original paper
4. Information Theory, Robert Ash, Dover
5. Entropy and Information Theory : Bob Gray