SEMESTER S7

INFORMATION THEORY & CODING

Course Code	**PEEVT754**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Linear Algebra and Calculus, Probability, Random Process and Numerical Methods, Signals and Systems.	**Course Type**	Theory

Course Objectives:

1. To lay down the foundation of information theory introducing both source coding and channel coding
2. To expose students to algebraic and probabilistic error-control codes that are used for reliable transmission

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Entropy, Properties of Entropy, Joint and Conditional Entropy, Mutual Information, Properties of Mutual Information. Discrete memoryless sources, Source code, Average length of source code, Bounds on average length, Uniquely decodable and prefix-free source codes. Kraft Inequality (with proof), Huffman code. Shannon's source coding theorem (both achievability and converse) and operational meaning of entropy.	**9**
2	Discrete memoryless channels. Capacity of discrete memoryless channels. Binary symmetric channels (BSC), Binary Erasure channels (BEC). Capacity of BSC and BEC. Channel code. Rate of channel code. Shannon's channel coding theorem (both achievability and converse without proof) and operational meaning of channel capacity. Modeling of Additive White Gaussian channels. Continuous-input channels with average power constraint. Differential entropy. Differential Entropy of Gaussian random variable. Relation between differential entropy and entropy. Shannon-Hartley theorem (with proof – mathematical subtlities	**9**

	regarding power constraint may be overlooked). Inferences from Shannon Hartley theorem – spectral efficiency versus SNR per bit, power-limited and bandwidth-limited regions, Shannon limit, Ultimate Shannon limit.	
3	Overview of Groups, Rings, Finite Fields, Construction of Finite Fields from Polynomial rings, Vector spaces. Block codes and parameters. Error detecting and correcting capability. Linear block codes. Two simple examples -- Repetition code and single parity-check code. Generator and parity-check matrix. Systematic form. Maximum likelihood decoding of linear block codes. Bounded distance decoding. Syndrome. Standard array decoding.	**9**
4	Cyclic codes. Polynomial and matrix description. Interrelation between polynomial and matrix view point. Systematic encoding. Decoding of cyclic codes. (Only description, no decoding algorithms) Hamming Codes, BCH codes, Reed-Solomon Codes Convolutional Codes. State diagram. Trellis diagram. Maximum likelihood decoding. Viterbi algorithm. Low-density parity check (LDPC) codes. Tanner graph representation. Message-passing decoding for transmission over binary erasure channel.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Explain measures of information – entropy, conditional entropy, mutual information	**K2**
CO2	Apply Shannon's source coding theorem and channel capacity for data compression.	**K3**
CO3	Apply linear block codes for error detection and correction	**K3**
CO4	Apply algebraic codes with reduced structural complexity for error correction	**K3**
CO5	Understand encoding and decoding of convolutional and LDPC codes	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3										
CO2	3	3	2	3	3							
CO3	3	3	2	3	3	2						2
CO4	3	3	2	3	3	2						2
CO5	3	3	2	3	3	2						2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Elements of Information Theory.	Joy A Thomas, Thomas M Cover,	Wiley-Interscience	1st
2	Digital Communication Sysmtes	Simon Haykin,	Wiley.	2nd
3	Principles of digital communication	RG Gallager	Cambridge University Press	2010
4	Information Theory, Inference and Learning Algorithms", ,	David JC McKay	Cambridge University Press	1st

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Modern Coding Theory	Rüdiger Urbanke and TJ Richardson	Cambdridge University Press	1st
2	Error Control Coding: Fundamentals and Applications,	Shu Lin & Daniel J. Costello. Jr.,	Wiley	2nd Edition.
3	Introduction to Coding Theory	Ron M Roth	Cambrdige University Press	1st

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/117101053
2	https://nptel.ac.in/courses/117108097
3	https://archive.nptel.ac.in/noc/courses/noc18/SEM2/noc18-ee39/
4	https://archive.nptel.ac.in/courses/117/104/117104120/