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Table of Contents

Note : Remove "Table of Content" before including in CP Book

Each Course Plan shall be printed and made into a book with cover page

Blooms Level in all sections match with A.2, only if you plan to teach / learn at higher levels

17EC54 : INFORMATION THEORY AND CODING

A. COURSE INFORMATION

1. Course Overview

Degree:	B.E	Program:	EC
Year / Semester :	3/5	Academic Year:	2019-20
Course Title:	INFORMATION THEORY AND CODING	Course Code:	17EC54
Credit / L-T-P:	4/L	SEE Duration:	180 Minutes
Total Contact Hours:	50	SEE Marks:	100 Marks
CIA Marks:	40	Assignment	1 / Module
Course Plan Author:	NAYANA HEGDE	Sign	Dt:
Checked By:		Sign	Dt:

2. Course Content

Module	Module Content	Teaching Hours	Module Concepts	Blooms Level
1	Introduction, Measure of information, Information content of message, Average Information content of symbols in Long Independent sequences, Average Information content of symbols in Long dependent sequences, Markov Statistical Model of Information Sources, Entropy and Information rate of Markoff Sources	10	Entropy Markov Model	L2,L3
2	Source coding theorem, Prefix Codes, Kraft McMillan Inequality property – KMI Encoding of the Source Output, Shannon's Encoding Algorithm Shannon Fano Encoding Algorithm, Huffman codes, Extended Huffman coding, Arithmetic Coding, Lempel – Ziv Algorithm	10	Uniqueness of code Encoding Algorithms	L2
3	Communication Channels Channel Models, Channel Matrix,	10	Communicatio	L2,L3

	Joint probability Matrix, Binary Symmetric Channel, System Entropies, Mutual Information, Channel Capacity, Channel Capacity of : Binary Symmetric Channel, Binary Erasure Channel, Muroga,s Theorem, Continuous Channels		n channels Channel capacity	
4	Error Control Coding Introduction, Examples of Error control coding, methods of Controlling Errors, Types of Errors, types of Codes, Linear Block Codes: matrix description of Linear Block Codes, Error Detection and Error Correction Capabilities of Linear Block Codes, Single Error Correcting hamming Codes, Table lookup Decoding using Standard Array. Binary Cyclic Codes: Algebraic Structure of Cyclic Codes, Encoding using an (n-k) Bit Shift register, Syndrome Calculation, Error Detection and Correction	10	Syndrome calculation Error detection and correction	L3,L4
5	Golay Codes, BCH Codes Convolution Codes Convolution Encoder, Time domain approach, Transform domain approach, Code Tree, Trellis and State Diagram, The Viterbi Algorithm	10	Coding Encoder and decoder design	L3,l4

3. Course Material

Module	Details	Available
1	Text books	
	Digital and analog communication systems, K. Sam Shanmugam, John Wiley India Pvt. Ltd, 1996.	In Lib
2	Digital communication, Simon Haykin, John Wiley India Pvt. Ltd, 2008	In Lib
3	Information Theory and Coding, Muralidhar Kulkarni, K.S. Shivaprakasha, Wiley India Pvt. Ltd, 2015, ISBN:978-81-265-5305-1.	
2	Reference books	
1	ITC and Cryptography, Ranjan Bose, TMH, II edition, 2007	In dept
2	Principles of digital communication, J. Das, S. K. Mullick, P. K. Chatterjee, Wiley, 1986 - Technology & Engineering	In dept
3	Digital Communications Fundamentals and Applications, Bernard Sklar, Second Edition, Pearson Education, 2016, ISBN: 9780134724058.	In dept
4	Information Theory and Coding, K.N.Haribhat, D.Ganesh Rao, Cengage Learning, 2017	In dept
3	Others (Web, Video, Simulation, Notes etc.)	
		Not Available

4. Course Prerequisites

SNo	Course Code	Course Name	Module / Topic / Description	Sem	Remarks	Blooms Level
1	17MAT 31	Engineering mathematics	Knowledge on set theory	3		L3
	17MAT 31	Engineering mathematics	Knowledge on probability	3		L3
	17EC44	principles communication system	knowledge of principles communication system	4		L4

Note: If prerequisites are not taught earlier, GAP in curriculum needs to be addressed. Include in Remarks and implement in B.5.

B. OBE PARAMETERS

1. Course Outcomes

#	COs	Teach. Hours	Concept	Instr Method	Assessment Method	Blooms' Level
17EC54.1	Understand entropy by measure of information content of the message	4	Entropy	Lecture	Cia/assignament/quiz	L2 Understand
17EC54.2	Apply entropy and oder of information sources to analyze Markov model	6	Markov Model	Lecture	Cia/assignament/quiz	L3
17EC54.3	Understand uniqueness of code using Kraft Inequality and prefix code	3	Uniqueness property	Lecture	Cia/assignament/quiz	L2
17EC54.4	Understand the conversion of information into binary sequence using Shanon, Shanon Fano and Huffman encoding algorithms	7	Encoding algorithms	Lecture / PPT	Cia/assignament/quiz	L3 Apply
17EC54.5	Model continuous and discrete communication channels using input, out and joint probability matrix	4	Communication channel	Lecture	Cia/assignament/quiz	L2
17EC54.6	Determine channel capacity of	6	Channel	Lecture	Cia/assigna	L3

	binary symmetric and binary erasure channels using mutual information and Muroga's theorem		capacity	and Tutorial	ment/quiz	
17EC54.7	Determine a codeword comprising of the check bits computed using Linear Block codes, cyclic code.	3	Syndrome (error) calculation	Lecture	Cia/assignment/quiz	L3
17EC54.8	Apply syndrome calculation and detect and correct error in binary code using LBC,cyclic code and hamming code,Golay code and BCH code	7	Error detection and correction	Lecture	Cia/assignment/quiz	L2
17EC54.9	Design encoder circuit for for Linear Block codes, cyclic codes, convolution codes, BCH and Golay codes	2	Encoder circuit design	Lecture	Cia/assignment/quiz	L3
17EC54.10	Design decoder circuit for for Linear Block codes, cyclic codes, convolution codes, BCH and Golay codes	8	Decoder circuit design	Lecture	Cia/assignment/quiz	L4
-	**Total**	**50**	-	-	-	-

Note: Identify a max of 2 Concepts per Module. Write 1 CO per concept.

2. Course Applications

SNo	Application Area	CO	Level
1	Provide a generalized method of considering microscopic behavior to make macroscopic predictions, under given conditions.	CO1	L2
2	Markov model used in non-observable biological sequence analysis	CO2	L3
3	Uniqueness property and prefix codes are widely used in applications that compress data, including JPEG for images and MP3 for music.	CO3	L2
4	Encoding algorithms are used in lossless data compression	CO4	L3
5	Transfer information between sender and receiver.	CO5	L2
6	To design MIMO system.	CO6	L2
7	Used in digital communication.	CO7	L3
8	Used in computer memory system	CO8	L2
9	Used for speed, secrecy, security, or saving space by shrinking size of information.	CO9	L2
10	Retrieve original information from received message.	CO10	L4

Note: Write 1 or 2 applications per CO.

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3. Articulation Matrix

(CO – PO MAPPING)

–	Course Outcomes	Program Outcomes												
#	COs	PO 1	PO2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO9	PO 10	PO 11	PO 12	Level
17EC54.1	Understand entropy by measure of information content of the message	3	3	3	2	1	1	1	1	3	1	1	1	L2
17EC54.2	Apply entropy and oder of information sources to statistical Markov model	3	3	3	1	1	1	1	1	3	1	1	1	L2
17EC54.3	Understand uniqueness of code using Kraft Inequality and prefix code	3	3	3	1	1	1	1	1	2	1	1	1	L2
17EC54.4	Understand the conversion of information into binary sequence using Shanon, Shanon Fano and Huffman encoding algorithms	3	3	3	1	1	1	1	1	3	1	1	1	L3
17EC54.5	Model continuous and discrete communication channels using input, out and joint probability matrix	3	3	3	2	1	1	1	1	2	1	1	1	L2
17EC54.6	Determine channel capacity of binary symmetric and binary erasure channels using mutual information and Muroga's theorem	3	3	3	2	1	1	1	1	2	1	1	1	L2
17EC54.7	Determine a codeword comprising of the check bits computed using Linear Block codes, cyclic code.	3	3	3	2	1	1	1	1	3	1	1	1	L3
17EC54.8	Apply syndrome calculation and detect and correct error in binary code using LBC, cyclic code and hamming code,Golay code and BCH code	3	3	3	1	1	1	1	1	3	1	1	1	L2
17EC54.9	Design encoder circuit for Linear Block codes, cyclic codes, convolution codes, BCH and Golay codes	3	3	3	2	1	1	1	1	3	1	1	1	L2
17EC54.10	Design decoder circuit for	3	3	3	**1**	1	1	1	1	**3**	1	1	1	L4

	Linear Block codes, cyclic codes, convolution codes, BCH and Golay codes													

Note: Mention the mapping strength as 1, 2, or 3

4. Mapping Justification

Mapping		Justification	Mapping Level
CO	**PO**	**-**	**-**
CO1	PO1	Applies basic mathematics and science knowledge for solution to engineering problems	L2
CO1	PO2	Identify, formulate and review complex engineering problems	L2
CO1	PO3	Design digital system components	L2
CO1	PO9	Applies to individual and team work for project, internship and mini project	L3
CO2	PO1	Applies basic mathematics and science knowledge for solution to engineering problems	L2
CO2	PO2	Identify, formulate and review complex engineering problems	L2
CO2	PO3	Design digital system components	L3
CO2	PO9	Applies to individual and team work for project, internship and mini project	L2
CO3	PO1	Applies basic mathematics and science knowledge for solution to engineering problems	L2
CO3	PO2	Identify, formulate and review complex engineering problems	L4
CO3	PO3	Design digital system components	L2
CO3	PO9	Applies to individual and team work for project, internship and mini project	L2
CO4	PO1	Applies basic mathematics and science knowledge for solution to engineering problems	L2
CO4	PO2	Identify, formulate and review complex engineering problems	L3
CO4	PO3	Design digital system components	L2
CO4	PO9	Applies to individual and team work for project, internship and mini project	L2
CO5	PO1	Applies basic mathematics and science knowledge for solution to engineering problems	L3
CO5	PO2	Identify, formulate and review complex engineering problems	L2
CO5	PO3	Design digital system components	L2
CO5	PO9	Applies to individual and team work for project, internship and mini project	L4
CO6	PO1	Applies basic mathematics and science knowledge for solution to engineering problems	L2

CO6	PO2	Identify, formulate and review complex engineering problems	L2
CO6	PO3	Design digital system components	L2
CO6	PO9	Applies to individual and team work for project, internship and mini project	L3
CO7	PO1	Applies basic mathematics and science knowledge for solution to engineering problems	L2
CO7	PO2	Identify, formulate and review complex engineering problems	L2
CO7	PO3	Design digital system components	L3
CO7	PO9	Applies to individual and team work for project, internship and mini project	L2
CO8	PO1	Applies basic mathematics and science knowledge for solution to engineering problems	L2
CO8	PO2	Identify, formulate and review complex engineering problems	L4
CO8	PO3	Design digital system components	L2
CO8	PO9	Applies to individual and team work for project, internship and mini project	L2
CO9	PO1	Applies basic mathematics and science knowledge for solution to engineering problems	L2
CO9	PO2	Identify, formulate and review complex engineering problems	L3
CO9	PO3	Design digital system components	L2
CO9	PO9	Applies to individual and team work for project, internship and mini project	L2
CO10	PO1	Applies basic mathematics and science knowledge for solution to engineering problems	L3
CO10	PO2	Identify, formulate and review complex engineering problems	L2
CO10	PO3	Design digital system components	L2
CO10	PO9	Applies to individual and team work for project, internship and mini project	L4

Note: Write justification for each CO-PO mapping.

5. Curricular Gap and Content

SNo	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1					
2					
3					
4					
5					

Note: Write Gap topics from A.4 and add others also.

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6. Content Beyond Syllabus

SNo	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Note: Anything not covered above is included here.

C. COURSE ASSESSMENT

1. Course Coverage

Module #	Title	Teaching Hours	No. of question in Exam						CO	Levels
			CIA-1	CIA-2	CIA-3	Asg	Extra Asg	SEE		
1	Information Theory	10	2	-	-	1	1	2	CO1, CO2	L2, L3
2	Source Coding	10	2	-	-	1	1	2	CO3, CO4	L2, L3
3	Information Channels	10	-	2	-	1	1	2	CO5, CO6	L2, L3
4	Error Control Coding and Binary Cyclic Codes	10	-	2	-	1	1	2	CO7, C08	L2, L3
5	Some Important Cyclic Codes and Convolution Codes	10	-	-	4	1	1	2	CO9, CO10	L3,L4
-	**Total**	**50**	**4**	**4**	**4**	**5**	**5**	**10**	**-**	**-**

Note: Distinct assignment for each student. 1 Assignment per chapter per student. 1 seminar per test per student.

2. Continuous Internal Assessment (CIA)

Evaluation	Weight age in Marks	CO	Levels

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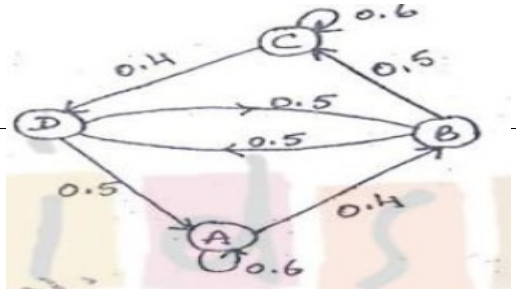
CIA Exam – 1	30	CO1, CO2, CO3, CO4	L2, l3, L2, l3
CIA Exam – 2	30	CO5, CO6, CO7, C08	L2, L3, L2, l3
CIA Exam – 3	30	CO9, CO10	L3, L4
Assignment – 1	05	CO1, CO2, CO3, CO4	L2, l3, L2, l3
Assignment – 2	05	CO5, CO6, CO7, CO8	L2, L3, L2, l3
Assignment – 3	05	CO9, CO10	L3, L4
Seminar – 1			
Seminar – 2			
Seminar – 3			
Other Activities – define – Slip test			
Final CIA Marks	**40**	**-**	**-**

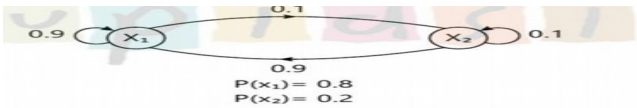
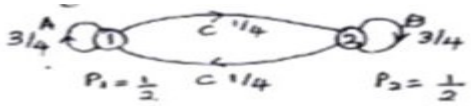
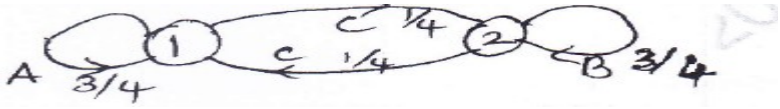
Note : Blooms Level in last column shall match with A.2 above.

D1. TEACHING PLAN – 1

Module – 1

Title:	Information Theory	Appr Time:	16 Hrs
a	***Course Outcomes***	–	**Blooms**
–	The student should be able to:	–	**Level**
1	Understand entropy by measure of information content of the message	CO1	L2
2	Apply entropy and oder of information sources to statistical Markov model	CO2	L3
b	***Course Schedule***	–	–
Class No	**Module Content Covered**	**CO**	**Level**
1	Introduction to Subject, course objectives and outcomes	C01	L2
2	Information, data, measure of information	C01	L2
3	Information content of message	C01	L2
4	Average Information content of symbols in Long Independent sequences	C01	L2
5	Average Information content of symbols in Long dependent sequences	C02	L3
6	Markov Statistical Model of Information Sources	C02	L3
7	Markov Statistical Model of Information Sources	C02	L3
8	Entropy and Information rate of Markov Sources	C02	L3

9	Entropy and Information rate of Markov Sources	C02	L3
10	Entropy and Information rate of Markov Sources	C02	L3
c	**Application Areas**	**CO**	**Level**
1	Provide a generalized method of considering microscopic behavior to make macroscopic predictions, under given conditions.	CO1	L2
2	Markov model used in non-observable biological sequence analysis	CO2	L3
d	**Review Questions**	-	-
1	With a neat block diagram explain information(communication system)	CO1	L2
2	Define symbol rate, self information, zero memory source, average information, information rate	CO1	L2
3	Obtain an expression for entropy of zero memory source information source emitting independent sequence of symbols	CO1	L2
4	Discuss various properties of entropy	CO1	L2
5	A code is composed of dots and dashes. Assuming that adashis 3 times long as a dot has 1/3 probability of occurrence. Calculate i)information in dot and dash ii)the entropy of dot dash code iii)the average rate of information if dot lasts for 10 msec and this time is allowed between symbols.	CO1	L2
6	Find relation between Hartelys, nats and bits	CO1	L2
7	The output of an information source consists of 128 sysmbols,16 of which occur with probability of 1/32 and remaining with a probability of1/224. The source emits 1000 symbols per second. Assuming symbols are chosen randomly, find entropy and average rate of information.	CO1	L2
8	A pair of dice is tossed simultaneously in an experiment. Outcome of the first dice is noted as X1 and outcome of second dice as X2. If the two events are : A={X1,X2 : such as (X1+X2)<=8} ;B={X1,X2 :such as X1>X2} Then find the self-information of A and B and entropy of the experiment.	CO1	L2
9	State diagram of Markov source is shown in fig. Calculate: State probability, state entropy, Entropy of the source.	CO2	L3
10	State diagram of Markov source is shown in fig. Calculate: State probability, state entropy , Entropy of the source. 	CO2	L3

11	For the first order Markov source shown in fig, find state probabilities, entropy of the states, entropy of the source and G1, G2. 	CO2	L3
12	State diagram of Markov source is shown in fig Calculate: State probability, state entropy , Entropy of the source 	CO2	L3
13	For the first order Markoff source shown in fig, find state probabilities, entropy of the states, entropy of the source 	CO2	L3
e	**Experiences**	-	-
1		CO1	L2
2			
3			
4		CO3	L3
5			

Module – 2

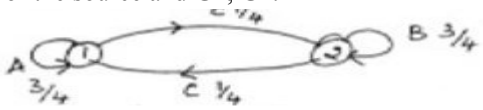
Title:	Source Coding	Appr Time:	10 Hrs
a	***Course Outcomes***	–	**Blooms**
–	The student should be able to:	–	**Level**
1	Understand uniqueness of code using Kraft Inequality and prefix code	CO3	L2
2	Understand the conversion of information into binary sequence using Shanon, Shanon Fano and Huffman encoding algorithms	CO4	L3
b	***Course Schedule***	–	–
Class No	**Module Content Covered**	**CO**	**Level**
11	Source coding theorem	CO3	L2
12	Prefix Codes	CO3	L2
13	Kraft McMillan Inequality property – KMI	CO3	L2
14	Encoding of the Source Output	CO4	L3
15	Shannon's Encoding Algorithm	CO4	L3
16	Shannon Fano Encoding Algorithm	CO4	L3
17	Huffman codes	CO4	L3
18	Extended Huffman coding	CO4	L3
19	Arithmetic Coding	CO4	L3
20	Lempel – Ziv Algorithm	CO4	L3
c	**Application Areas**	**CO**	**Level**
1	Uniqueness property and prefix codes are widely used in applications that compress data, including JPEG for images and MP3 for music.	CO3	L2
2	Encoding algorithms are used in lossless data compression	CO4	L3
d	**Review Questions**	–	–
14	Define coding. Explain necessity of coding.	CO3	L2
15	Explain prefix property with an example.	CO3	L2
16	What is KRAFT inequality? Explain with suitable example.	CO3	L2
17	Explain code efficiency and code redundancy	CO3	L2
18	State and prove source coding theorem.	CO3	L2
19	State and prove Shanon's first theorem	CO3	L2
20	Explain classification of binary codes.	CO3	L2

<table>
<tr><td>21</td><td>Check for KMI property for the following set of codes.
<table><tr><td>A</td><td>1</td></tr><tr><td>B</td><td>10</td></tr><tr><td>C</td><td>110</td></tr><tr><td>D</td><td>1110</td></tr><tr><td>E</td><td>1111</td></tr></table></td><td>CO3</td><td>L2</td></tr>
<tr><td>22</td><td>Apply Shannon encoding algorithm and generate binary codes for the set of symbols given in table below. Also find efficiency.
<table><tr><td>Symbol</td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td><td>G</td></tr><tr><td>P</td><td>1/2</td><td>1/4</td><td>1/8</td><td>1/16</td><td>1/32</td><td>1/64</td><td>1/64</td></tr></table></td><td>CO4</td><td>L2</td></tr>
<tr><td>23</td><td>Using Shanon-Fano encoding algorithms find the code words and efficiency and redundancy for the probabilities given in the table
<table><tr><td>Symbol</td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td><td>G</td><td>H</td><td>I</td></tr><tr><td>P</td><td>0.22</td><td>0.18</td><td>0.15</td><td>0.12</td><td>0.10</td><td>0.08</td><td>0.07</td><td>0.05</td><td>0.03</td></tr></table></td><td>CO4</td><td>L2</td></tr>
<tr><td>24</td><td>A discrete memory less source has an alphabet of seven symbols with probabilities as given below:
<table><tr><td>Symbol</td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td><td>G</td></tr><tr><td>P</td><td>0.25</td><td>0.25</td><td>0.125</td><td>0.125</td><td>0.125</td><td>0.0625</td><td>0.0625</td></tr></table>Compute Huffman Code for the set of symbols shown above by moving combined symbols as high as possible. Find efficiency and variance.</td><td>4</td><td>L2</td></tr>
<tr><td>25</td><td>Consider a DMS with X={X,Y,Z} with respective probabilities P={0.6,0.2,0.2}. Find code word for message “YXZXY” using arithmetic coding.</td><td>CO4</td><td>L2</td></tr>
<tr><td>26</td><td>Encode the following information using LZ algorithm. ”THIS_IS_HIS_HIT”</td><td>CO4</td><td>L2</td></tr>
<tr><td>27</td><td>Encode the following input string using LZ algorithm
W_PNW_NW_WNP_P</td><td>CO4</td><td>L2</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>e</td><td>Experiences</td><td>–</td><td>–</td></tr>
<tr><td>1</td><td></td><td>CO1</td><td>L2</td></tr>
<tr><td>2</td><td></td><td></td><td></td></tr>
<tr><td>3</td><td></td><td></td><td></td></tr>
<tr><td>4</td><td></td><td>CO3</td><td>L3</td></tr>
<tr><td>5</td><td></td><td></td><td></td></tr>
</table>

E1. CIA EXAM – 1

a. Model Question Paper – 1

Crs Code:	15EC54	Sem:5	I	Marks:	30	Time:	75 minutes
Course:	Information Theory and Coding						

-	-	**Note: Answer any 1 full question from each module**	**Marks**	**CO**	**Level**
1	a	Discus various properties of entropy	5	CO1	L2
	b	The output of an information source consists of 128 symbols,16 of which occur with probability of 1/32 and remaining with a probability of1/224. The source emits 1000 symbols per second. Assuming symbols are chosen randomly, find entropy and average rate of information.	5	CO1	L2
	c	A pair of dice is tossed simultaneously in an experiment. Outcome of the first dice is noted as X1 and outcome of second dice as X2. If the two events are : A={X1,X2 : such as (X1+X2)<=8} ;B={X1,X2 :such as X1>X2} Then find the self-information of A and B and entropy of the experiment.	5	CO1	L2
	d				
2	a	Define:- symbol rate, self-information, zero memory source, average self-information, information rate	5	CO1	L2
	b	For the first order Markov source shown in fig, find state probabilities, entropy of the states, entropy of the source and G1, G2.  	10	CO2	L3
3	a	Using Shanon's binary encoding algorithms find the code words and efficiency and redundancy for the probabilities given in the table	5	CO4	L2

Symbol	A	B	C	D	E	F	G	H	I
P	0.25	0.15	0.15	0.12	0.10	0.08	0.06	0.05	0.04

	b	Using Shanon-Fano encoding algorithms find the code words and efficiency and redundancy for the probabilities given in the table	5	CO4	L2

Symbol	A	B	C	D	E
P	0.1	0.5	0.25	0.125	0.125

	c	Explain Kraft Inequality with examples	5	CO3	L2
	d				
4	a	A discrete memory less source has an alphabet of seven symbols with probabilities as given below	8	CO4	L2

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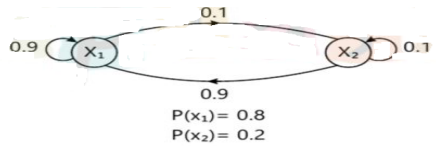
		Symbol	A	B	C	D	E	F	G	H			
		P	7/39	8/39	6/39	10/39	3/39	1/39	2/39	2/39			
		Compute Huffman Code for the set of symbols shown above by moving combined symbols as high as possible. Find efficiency and variance.											
	b	Consider a DMS with X={X,Y,Z} with respective probabilities P={0.6,0.2,0.2}. Find code word for message "YXZXY" using arithmetic coding.									7	CO4	L2
	c												
	d												

b. Assignment -1

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions							
Crs Code:	15EC54	Sem:	I	Marks:	5 / 10	Time:	90 – 120 minutes
Course:	Information Theory and Coding						

Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.

SNo	USN	Assignment Description	Marks	CO	Level
1		Discuss additive and symmetric property of entropy	6	CO1	L2
2		A binary information source produces message 0 and 1 with P and 1-P. Determine the entropy of this source and sketch the variations of entropy with P.	5	CO1	L2
3		Prove that information content of N independent messages are additive.	5	CO1	L2
4		For the Markov source shown, find source entropy and G1, G2, G3 	10	CO2	L3
5		A black and white TV consists of 526 lines of picture information. Assume each line consists of 526 pixels and each can have 255 brightness level. Picture is repeated at30 frames/sec. Calculate the rate of information conveyed by TV for viewer.	4	CO1	L2

6		A pair of dice is tossed simultaneously in an experiment. Outcome of the first dice is noted as X1 and outcome of second dice as X2. If the two events are : A={X1,X2 : such as (X1+X2)<=8} ;B={X1,X2 :such as X1>X2} Then find the self-information of A and B and entropy of the experiment.	5	CO1	L2
7		A certain data source has 8 symbols that are produced in blocks of 4 at a rate of 500 blocks/sec. The first symbol in each block is always the same. The remaining 3 are filled by any of the 8 symbols with equal probability. What is the entropy of this source?	5	CO1	L2
8		The output of an information source consists of 128 symbols,16 of which occur with probability of 1/32 and remaining with a probability of1/224. The source emits 1000 symbols per second. Assuming symbols are chosen randomly, find entropy and average rate of information.	5	CO1	L2
9		Define: - symbol rate, self-information, zero memory sources, average self-information, Information rate	5	CO1	L2
10		A card is drawn from a deck. You are told it is a spade. How much information did you receive. How much information is received if it is told as ace.	5	CO1	L2

D2. TEACHING PLAN - 2

Module - 3

Title:	Information Channels	Appr Time:	10 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Model continuous and discrete communication channels using input, out and joint probability matrix	CO5	L2
2	Determine channel capacity of binary symmetric and binary erasure channels using mutual information and Muroga's theorem	CO6	L3
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
21	Communication Channels	CO5	L2
22	Channel Models, Channel Matrix	CO5	L2

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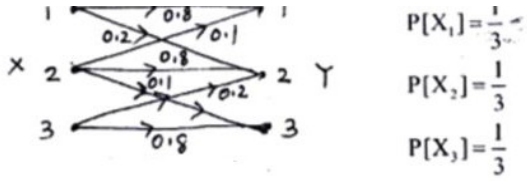
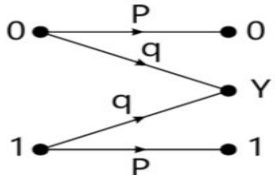
23	Joint probability Matrix, Binary Symmetric Channel	CO5	L2
24	System Entropies	CO5	L3
25	Mutual Information, Channel Capacity	CO6	L3
26	Channel Capacity of Binary Symmetric Channel	CO6	L3
27	Channel Capacity of Binary Symmetric Channel	CO6	L3
28	Channel Capacity Binary Erasure Channel	CO6	L3
29	Muroga,s Theorem	CO6	L3
30	Muroga,s Theorem, Continents Channels	CO6	L3
c	**Application Areas**	**CO**	**Level**
1	Transfer information between sender and receiver.	CO5	L2
2	To design MIMO system.	CO6	L3
d	**Review Questions**	-	-
27	State and prove Shanon Hartley theorem	CO5	L3
28	Write a short note on channel matrix, JPM, properties of JPM and give example for channel diagram.	CO5	L3
29	Prove the identities i)H[X,Y]=H[X]+H[Y] ii)H[X,Y]=H[X]+H[Y/X]	CO5	L3
30	Find H[X],H[Y],H[X Y], H[X/Y] and H[Y/X] for the channel shown below  $P[X_1]=\frac{1}{3}$ $P[X_2]=\frac{1}{3}$ $P[X_3]=\frac{1}{3}$	CO5	L3
31	Define mutual information and its properties	CO6	L3
32	Prove mutual information I(X,Y)=H(X)-H(X/Y)=H(Y)-H(Y/X)	CO6	L3
33	Derive the expression for channel capacity of binary channel shown 	CO6	L3
34	Prove that H(X/Y)=p.H(X) for a binary erasure channel	CO6	L3
35	Two noisy channels are cascaded whose channel matrices are given by $P(y/x)=\begin{bmatrix}1/5 & 1/5 & 3/5\\ 1/2 & 1/3 & 1/6\end{bmatrix}$ $P(z/y)=\begin{bmatrix}0 & 3/5 & 2/5\\ 1/3 & 2/3 & 0\\ 1/2 & 0 & 1/2\end{bmatrix}$ with $P(x_1)=P(x_2)=1/2$,		

	find the overall mutual information I(X,Y) and I(X,Z)		
36	A Gaussian channel has 10 Mhz BW is (S/N) ratio is 100.Calculate channel capacity and maximum information rate.	CO6	L3
e	**Experiences**	–	–
1		CO1	L2
2			
3			
4		CO3	L3
5			

Module – 4

Title:	Error Control Coding	Appr Time:	10 Hrs
a	***Course Outcomes***	–	**Blooms**
–	The student should be able to:	–	**Level**
1	Determine a code word comprising of the check bits computed using Linear Block codes, cyclic code.	CO3	L2
2	Apply syndrome calculation and detect and correct error in binary code using LBC, cyclic code and hamming code	CO4	L3
b	***Course Schedule***	–	–
Class No	**Module Content Covered**	**CO**	**Level**
31	Introduction, Examples of Error control coding	CO7	L2
32	methods of Controlling Errors	CO7	L2
33	Types of Errors, types of Codes	CO7	L2
34	Linear Block Codes: matrix description of Linear Block Codes	CO7	L3
35	Error Detection and Error Correction Capabilities of Linear Block Codes,	CO8	L3
36	Single Error Correcting hamming Codes, Table lookup Decoding using Standard Array.	CO8	L3
37	Algebraic Structure of Cyclic Codes	CO8	L3
38	Encoding using an (n-k) Bit Shift register	CO8	L3
39	Syndrome Calculation	CO8	L3
40	Error Detection and Correction	CO8	L3

c	Application Areas	CO	Level
1	Used in digital communication.	CO7	L2
2	Used in computer memory system	CO8	L3
d	**Review Questions**	-	-37
37	Draw the block diagram of digital communication system and explain functions of each block	CO7	L2
38	What are different methods of controlling errors	CO7	L2
39	What are types of error and types of codes in error control coding	CO7	L2
40	Compare fixed length and variable length code	CO7	L2
41	Define terms burst error, systematic LBC, galois Field, Hamming weight	CO7	L2
42	Define hamming weight, hamming distance and minimum distance of linear block code	CO7	L2
43	If C is valid code vector then prove that $CH^{T=0}$ where H^T is transpose of parity check matrix H	CO7	L2
44	Test Hamming bound of (7,4) hamming code and show that it is a perfect code.	CO7	L3
45	For a systematic LBC (6,3) parity check matrix is $P = \begin{matrix} 1 & 0 & 1 \\ 0 & 1 & 1 \\ 1 & 1 & 1 \end{matrix}$ find all possible code vector, minimum weight of the code, parity check matrix, for received code R=110010, detect and correct the error occurred.	CO8	L3
46	For a Linear Block Code the syndrome is given by: S1= r1+r2 + r3+ r5 , S2= r1+r2 + r4+ r6 , S3= r1+r3+ r4+ r7 (i) Find Generator Matrix (ii) Find Parity Check Matrix (ii) Draw the Encoder Circuit (iii) How many errors can be detected and corrected?	CO8	L3
47	For a (6,3) cyclic code Find out: i)Generator Polynomial ii)Generator Matrix iii)Parity Check matrix iv)Equation for code words	CO8	L3
48	A (7,4) Cyclic Code has the generator polynomial $g(x) = 1+x+x^3$. Calculate the syndrome for received vector R=[1 1 1 1 1 1 1],R=[1 0 1 0 1 0 1]. Draw syndrome calculation circuit.	CO8	L3
e	**Experiences**		-
1			L2
2			
3			

4			L3
5			

E2. CIA EXAM – 2

a. Model Question Paper – 2

Crs Code:	15EC54	Sem:	I	Marks:	30	Time:	75 minutes
Course:	Information Theory and Coding						

-	-	**Note: Answer any 1 full questions, each from one module.**	**Marks**	**CO**	**Level**
1	a	State and prove source coding theorem.	5	CO3	L3
	b	Apply Shannon encoding algorithm and generate binary codes for the set of symbols given in table below. Also find efficiency.	5	CO4	L3
	c	Check for KMI property for the following set of codes	5	CO3	L3
2	a	A discrete memory less source has an alphabet of seven symbols with probabilities as given below: Compute Huffman Code for the set of symbols shown above by moving combined symbols as high as possible. Find efficiency and variance.	8	CO4	L3
	b	Consider a DMS with X={X,Y,Z} with respective probabilities P={0.6,0.2,0.2}. Find code word for message "YXZXY" using arithmetic coding.	7	CO4	L3
	c				
	d				

3	a	Write a short note on channel matrix, JPM, properties of JPM and give example for channel diagram.	10	CO5	L3
	b	An analog source has a bandwidth of 4KHz. The signal is sampled at 2.5 times the Nyquist Rate and each sample is quantized into 256 equally likely levels. Assume that the successive samples are statistically independent. Find the information rate of the source. Can the output of this source be transmitted without error over an analog channel of Bandwidth 50Khz and S/N = 20db. If the output of the source is to be transmitted without error over an analog channel having S/N = 10, compute the bandwidth required.	5	CO5	L3
4	a	Consider a Symmetric Channel whose channel diagram is given by Find channel capacity.	10	CO6	L3
	b	Write a note on continuous channel and differential entropy.	5	CO6	L3

b. Assignment – 2

Note: A distinct assignment to be assigned to each student.

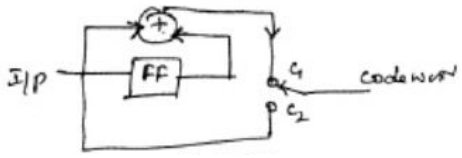
Model Assignment Questions							
Crs Code:	15EC54	Sem:	I	Marks:	5 / 10	Time:	90 – 120 minutes
Course:	Information Theory and Coding						
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.							

SNo	USN	Assignment Description	Marks	CO	Level
1		Construct Huffman code for given data and find theefficiency	5	CO5	L3
2		For the data given apply shanon'sencoding algorithm and find the code words. Find the efficiency.	5	CO5	L3
3		Apply shanon –fano algorithm for the data and find the code words. ½,1/4,1/8,1/8,	5	CO5	L3
4		Using arithmetic coding find out the code words for given input sequence. "ABABHT"	5	CO5	L3
5		Construct the code tree for the given code.	5	CO4	L2
6		Check KMI property for given set of codes.	5	CO4	L2
7		Check whether the given set of codes is prefix code.	5	CO4	L2
8		Using Lempel Ziv coding find out the code words.	5	CO5	L3
9		Encode the following information using LZ algorithm. "THIS_IS_HIS_HIT"	5	CO5	L3
10		Write a short note on Shanon Fano algorithm	5	CO5	L3

D3. TEACHING PLAN - 3

Module - 5

Title:	Some Important Cyclic codes and convolutional code	Appr Time:	10 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Design encoder circuit for Linear Block codes, cyclic codes, convolution codes, BCH and Golay codes	CO3	L2
2	Design decoder circuit for Linear Block codes, cyclic codes, convolution codes	CO4	L3
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
41	Golay Codes, BCH Codes	CO9	L3
42	Convolution Encoder	CO9	L4
43	Time domain approach	CO9	L4
44	Transform domain approach	CO9	L4
45	Code Tree	CO9	L4
46	Code Tree	CO10	L4
47	Trellis and State Diagram	CO10	L4
48	Trellis and State Diagram	CO10	L4
49	The Viterbi Algorithm	CO10	L4
50	The Viterbi Algorithm	CO10	L4
c	**Application Areas**	**CO**	**Level**
1	Used for speed, secrecy, security, or saving space by shrinking size of information.	CO9	L2
2	Retrieve original information from received message.	CO10	L3
d	**Review Questions**	-	-
51	Write short note on Golay code and BCH code	CO9	L3
52	What are convolution codes? How they are different from block codes.	CO9	L3
53	For a (3,1,2) convolution encoder with generator sequences g^1=110, g^2=101,g^3=111 Find the encoder block diagram Find generator matrix and o/p for 11101 Find the code word for 11101 using time domain approach draw the state diagram and tree diagram	CO9	L4
54	A (15,5) binary cyclic code has a generator polynomial	CO9	L4

	$g(x)= 1+x+x^2+x^4+x^5+x^8+x^{10}$ Draw encoder block diagram Find code polynomial for message polynomial $d(x)=1+x^2+x^4$ in systematic form		
55	For a (6,3) cyclic code Find out: i)Generator Polynomial ii)Generator Matrix iii)Parity Check matrix iv)Equation for code words	O9	L4
56	A (7,4) Cyclic Code has the generator polynomial $g(x) = 1+x+x^3$. Calculate the syndrome for received vector R=[1 1 1 1 1 1 1],R=[1 0 1 0 1 0 1]. Draw syndrome calculation circuit	CO9	L4
57	 For the encoder shown in the fig. Draw the state diagram. Draw the code tree. Find code word for 10111.	CO9	L4
e	**Experiences**	–	–
1		CO1	L2
2			
3			
4		CO3	L3
5			

E3. CIA EXAM – 3

a. Model Question Paper – 3

Crs Code:	15EC54	Sem:	I	Marks:	30	Time:	75 minutes
Course:	Information Theory and Coding						

-	-	**Note: Answer any 2 questions, each carry equal marks.**	**Marks**	**CO**	**Level**
1	a	For a Linear Block Code the syndrome is given by:	10	CO9	L4

		S1= r1+r2 + r3+ r5 , S2= r1+r2 + r4+ r6 , S3= r1+r3+ r4+ r7 (i) Find Generator Matrix (ii) Find Parity Check Matrix (ii) Draw the Encoder Circuit (iii) How many errors can be detected and corrected?			
	b	Write short note on Golay code and BCH code	5	CO10	L3
2	a	For a (6,3) cyclic code Find out: i)Generator Polynomial ii)Generator Matrix iii)Parity Check matrix iv)Equation for code words	8	CO9	L4
	b	A (7,4) Cyclic Code has the generator polynomial $g(x) = 1+x+x^3$. Calculate the syndrome for received vector R=[1 1 1 1 1 1 1],R=[1 0 1 0 1 0 1]. Draw syndrome calculation circuit.	7	CO9	L4
	c				
	d				
3	a	Write a note on Trellis diagram with example	15	CO9	L4
	b				
4	a	For a (2,1,3) convolution encoder with g1=1101 and g2=1011 draw the convolution encoder block diagram. Write down state transition table. Draw code tree. Find the encoder output produced by message 11101 traversing through the code tree.	15	CO10	L4

b. Assignment – 3

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions							
Crs Code:	15EC54	Sem: 5	I	Marks:	5 / 10	Time:	90 – 120 minutes
Course:	Information Theory and Coding						
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.							

SNo	USN	Assignment Description	Marks	CO	Level
1		Obtain the output of the (2,1,2) convolution encoder for g1=111,g2= 011 for message 11101. Detail the contents of the shift register after every clock.	10	CO9	L4
2		Consider a convolution encoder with g1=110, g2=101, g3=111 find the constraint length, find the rate. Draw the encoder block diagram.	10	CO9	L4
3		Explain state diagram and state transition table.	5	CO9	L2
4		Explain tree diagram with an example.	5	CO9	L3

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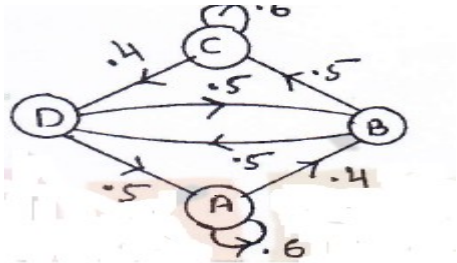
5		Explain Tellis diagram with an example.	5	CO10	L3
6		What do you mean by transfer function of a convolution code.	5	CO10	L3
7		Write distance properties of constitutional codes.	5	CO10	L3
8		Write a short note on decoding of convolution codes.	5	CO10	L3
9		Explain Viterbi algorithm.	10	CO10	L3
10		What do you mean by catastropic code	5	CO10	L3

F. EXAM PREPARATION

1. University Model Question Paper

Course:	Information Theory and Coding					Month / Year	May /2018	
Crs Code:	15EC54	Sem:	5	Marks:	80	Time:	180 minutes	
-	**Note**	Answer all FIVE full questions. All questions carry equal marks.				**Marks**	**CO**	**Level**
1	a	Derive an expression for average entropy of long independent messages.				4	CO1	L2
	b	Explain Markov statistical model used to represent dependent information sources.				4	L2	L2
	c	Find H, G1,G2 for the given model 				8	CO2	L3
		OR						
-	a	Define information. Explain how information is measured. Justify the use of logarithmic function in measure of information.				6	CO1	L2
	b	Establish relation between i)Hartely and nats ii)nats and bits				4	CO2	L2
	c	For the Markov model find State probability, state entropy and source entropy. 				8	CO2	L3
2	a	Apply Shanon's encoding algorithms to generate binary code for set of information				12	C03	L3

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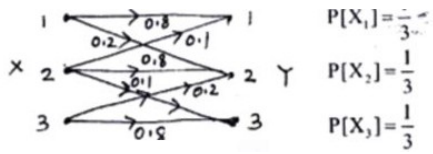
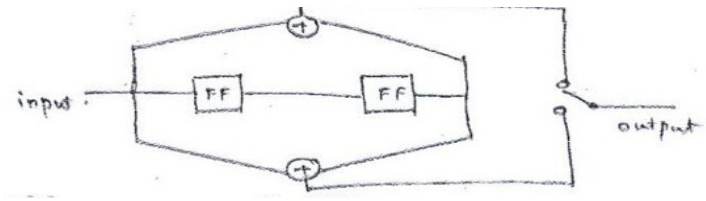
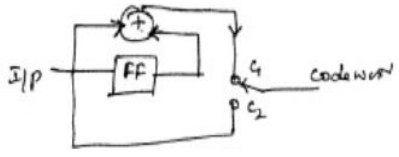
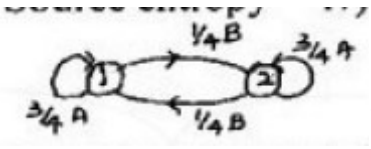
			Sym	AA	BB	CC	DD	EE	FF	GG			
			P	9/32	9/32	3/32	3/32	3/32	3/32	2/32			
	b	Expalin prefix code									04	C03	L3
		OR											
-	a	Consider the following source. Find the code word using Shanon Fano algorithm.	Sym	AA	BB	CC	DD	EE	FF		6	CO3	L3
			P	0.4	0.2	0.2	0.1	0.08	0.02				
	b	Consider the following source. Find the code word using Huffman algorithm.	Sym	AA	BB	CC	DD	EE	FF	GG	10	CO4	L3
			P	1/3	1/27	1/3	1/9	1/27	1/27	1/27			
3	a	Write the channel matrix for the channel diagram given.  									6	CO5	L3
	b	$P(x_2) = .3$ and $P(x_3) = .1$ $P(y/x) = \begin{bmatrix} 1/2 & 1/2 & 0 \\ 1/2 & 0 & 1/2 \\ 0 & 1/2 & 1/2 \end{bmatrix}$. For the channel matrix given calculate H(X),H(Y) and channel capacity if P(x1)=0.6									10		L3
-	a	State and explain Shanon Hartely law. Derive expression for upper limit of channel capacity.									7	CO5	L3
	b	Define mutual information and explain all properties of mutual									9		L3

		information. Explain data rate.			
4	a	Find H for given generator matrix. G=1 1 0 1 0 0 1 1 1 0 1 0 0 11 0 0 0	4	CO7	L4
	b	Consider a systematic (8,4) LBC whose parity check sequence are given by v4=u1+u2+u3 V5=u0+u1+u2 v6=u0+u1+u3 v7=u0+u2+u3 Write generator and parity check matrices. Draw the encoder diagram.	12		L4
-	a	Consider a (7,4) Cyclic code with g(x)=1+x+x2 and obtain the code polynomial in non symmetric form for the input sequence 1010 and 1100	12	CO7	L3
	b	Obtain generator and parity check matrix for an (n,k) cyclic code with g(x)=1+x+x2	4	CO8	L4
5	a	For the convolution code given, find the code rate and constraint length. Draw the tree diagram, trellis diagram 		CO9	L4
	b	For a convolution encoder has generator polynomial vector g1=100,g2=111 and g3=101. Draw encoder diagram. If the input is 10110. find out the output using transform domain approach.	8	CO10	L4
		OR			
	a	Consider the convolution encoder. Draw the state diagram. Draw the code tree. Find the code sequence for 10111 	8	CO9	L4

	b	For a (2,1,2) convolutional encoder with generator sequence g1=111, g2=101 draw the encoder circuit. Find the code word for message sequence 10111 using time domain approach.	8	C010	L4

2. SEE Important Questions

Course:		Information Theory and Coding					Month / Year		May /2018
Crs Code:		15EC54	Sem:	4	Marks:	80	Time:		180 minutes
	Note	Answer all FIVE full questions. All questions carry equal marks.					-	-	
Module	Qno.	Important Question					**Marks**	**CO**	**Year**
1	1	Derive an expression for average information content of long independent sequence					03	CO1	2018
	2	 For the given Markov source find out 1)State probability 2)State entropy 3)Source entropy 4)G1 and G2					10	CO2	2018
	3	Define self information, entropy and information rate					03	CO1	2018
	4	Mention properties of entropy and prove external property.					07	CO1	2018
	5	A source emits s1,s2,s3,s4 with probabilities 7/16,5/16,1/8 and1/8. Prove that $H(s^2)=2H(s)$					04	CO1	2018
	6	A facsimile with $2.25x10^6$ pixels/frame. For a good transmission 12 brightness levels are necessary. All these levels are equally likely to					05	CO1	2018

		occur. Find rate of information is one picture is transmitted in 3 sec.			
2	1	A discrete memory less source has probabilities Symbol: S_0 S_1 S_2 S_3 S_4 Probabilities: 0.55 0.15 0.15 0.1 0.05 find the average code word and variance.	10	CO4	2018
	2	Using Shanon fano encoding theorem $P = \{\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{8}\}$. find the average code word length and efficiency.	06	CO4	2018
	3	Write a short note on Lempel Ziv algorithm	05	CO4	2018
	4	Derive source c M_1 M_2 M_3 M_4 M_5 1/8 1/16 3/16 1/4 3/8	05	CO4	2018
	5	Using Shanon coding algorithm find the code word, efficiency and redundancy.	06	CO4	2018
3	1	Find the capacity of channel whose noise matrix is $P\left(\frac{y}{x}\right) = \begin{bmatrix} 0.8 & 0.2 & 0 \\ 0.1 & 0.8 & 0.1 \\ 0 & 0.2 & 0.8 \end{bmatrix}$	04	CO5	2018
	2	Define r Prove th $P\left(\frac{y}{x}\right) = \begin{bmatrix} \frac{1}{3} & \frac{1}{3} & \frac{1}{6} & \frac{1}{6} \\ \frac{1}{6} & \frac{1}{6} & \frac{1}{3} & \frac{1}{3} \end{bmatrix}$ & $P(x_1) = p(x_2) = \frac{1}{2}$. tion.			
	3	Channel has following characteristics. Find H(X),H(Y),H(X,Y)	06	CO6	2018
	4	Derive expression for channel capacity of binary erasure channel.	05	CO6	2018
	5	Write a note on difference entropy	03	CO6	2018
4	1	For a systematic (6,3) LBC, parity is given by 1)Find all possible code vector 2)Find the minimum weight of the code. 3)Find parity check matrix $P = \begin{matrix} 1 & 0 & 1 \\ 0 & 1 & 1 \\ 1 & 1 & 1 \end{matrix}$	10	CO8	2015

		4)for R=110010 detect and correct the error			
	2	What are different types of methods of controlling errors	06	CO7	2015
5	1	What is binary cyclic code? Describe the features of encoder and decoder used for cyclic codes using (h-k) bit shift register.	10	CO10	2015
	2	Write a short note on Golay code and BCH code.	06	CO9	2015