KARNATAK LAW SOCIETY'S

GOGTE INSTITUTE OF TECHNOLOGY

UDYAMBAG, BELAGAVI-590008

(An Autonomous Institution under Visvesvaraya Technological University, Belagavi)

(APPROVED BY AICTE, NEW DELHI)

Department of Electronics and Communication Engineering

Scheme and Syllabus

3rd and 4thSemester M. Tech. (Digital Communication and Networking)

INSTITUTION VISION

Gogte Institute of Technology shall stand out as an institution of excellence in technical education and in training individuals for outstanding caliber, character coupled with creativity and entrepreneurial skills.

MISSION

To train the students to become Quality Engineers with High Standards of Professionalism and Ethics who have Positive Attitude, a Perfect blend of Techno-Managerial Skills and Problem solving ability with an analytical and innovative mindset.

QUALITY POLICY

- Imparting value added technical education with state-of-the-art technology in a congenial, disciplined and a research oriented environment.
- Fostering cultural, ethical, moral and social values in the human resources of the institution.
- Reinforcing our bonds with the Parents, Industry, Alumni, and to seek their suggestions for innovating and excelling in every sphere of quality education.

DEPARTMENT VISION

The Electronics & Communication Engineering department shall impart quality technical education and entrepreneurship skills to develop creative individuals to face changing global scenario.

MISSION

To augment the national talent pool,withElectronics and Communication Engineers having all-encompassing technical knowledge, principled practices and nationalistic outlook.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

1. The graduates will acquire core competence in basic science and Digital Communication and Networking fundamentals necessary to formulate, analyze, and solve engineering problems and to pursue advanced study or research.
2. The graduates will engage in the activities that demonstrate desire for ongoing personal and professional growth and self-confidence to adapt to rapid and major changes.
3. The graduates will maintain high professionalism and ethical standards, effective oral and written communication skills, work as part of teams on multidisciplinary projects under diverse professional environments, and relate engineering issues to the society, global economy and to emerging technologies.

PROGRAM OUTCOMES (POs)

1. **Fundamentals of Engineering:** Graduates shall be able to understand and apply the basic mathematical and scientific concepts in the field of Electronics and Communication Engineering.
2. **Design of Experiments:** Graduates shall possess the ability to design and conduct experiments, analyse and interpret data.
3. **Social Engineering:** Graduates shall possess the ability to identify societal problems and meaningfully contribute with optimal solutions.
4. **Engineering Cognizance:** Graduates shall be able to stay abreast with recent developments in the field of Electronics and Communication Engineering.
5. **Modern tool Usage:** Graduates shall possess critical thinking abilities, problem solving skills and familiarity with the necessary computational tools and procedures.
6. **Impact of Engineering:** Graduates shall be able to understand the impact of engineering solutions in a global, economic, environmental and societal context.
7. **Ethics:** Graduates shall imbibe the professional and ethical responsibilities of their profession.
8. **Collaboration:** Graduates shall have the ability to collaborate productively in multidisciplinary teams with leadership attributes.
9. **Soft skills**: Graduates shall possess proficiency in oral and written communication skills.
10. **Entrepreneurship**: Graduates shall imbibe project management and finance skills to pursue entrepreneurial endeavours.
11. **Research and Innovation:** Graduates shall have the ability to pursue research and provide innovative solutions.
12. **Self motivated Learning:** Graduates shall continue to upgrade the skills and possess the motivation for continuing education and professional growth.

PROGRAM SPECIFIC OUTCOMES (PSOs)

1. Understanding and applying the mathematical and scientific concepts, for analysis and design of basic Electronics and Communication systems.
2. Developing critical thinking abilities coupled with competence in use of computational tools for professional growth;complimented with communication skills and leadership attributes.
3. Identifying societal needs and sensitizing individuals towardsfinding innovative solutions to contemporary issues with multidisciplinary outlook.

Scheme of Teaching
Semester III

S. No.	Course Code	Course		Credits L – T - P	Total credits	Contact Hours/ week	Marks CIE	Marks SEE	Marks Total
1.	16DCN31	Error Control Coding	PC1	4 – 0 - 0	4	4	50	50	100
3.	16DCN32x	**Elective – C**	PE – C	4 – 0 - 0	4	4	50	50	100
4.	16DCN33x	**Elective – D**	PE – D	4 – 0 - 0	4	4	50	50	100
5.	16INT34	#Internship			10		50	50	100
6.		*Project Phase-1	PR		2		25		25
		Total			**24**	**12**	**225**	**200**	**425**

Elective – III	
1.	Signal Compression
2.	Communication Networks Modeling and Simulation
3.	Advanced Computer Networks
4.	Communication System Design using VLSI

Elective – IV	
1.	Business Analytics
2.	Long Term Evolution
3.	Automotive Electronics and Networks
4.	Multi Rate Filters

SEE: SEE (Theory exam) will be conducted for 100marks of 3 hours duration. It is reduced to 50 marks for the calculation of SGPA and CGPA

 # Internship report and presentation.

*** Selection of topic and Literature Review**

Scheme of Teaching
Semester IV

S. No.	Course Code	Course		Credits L – T - P	Total credits	Contact Hours/ week	Marks CIE	Marks SEE	Marks Total
1.		Project Phase -2	PR	4 – 0– 0	4		50 (25+25)		50
2.		Project Phase -3	PR		4		50 (25+25)		50
3.		Project Viva-voce	PR		12			150(50+100)	150
		Total			**20**	**24**	**100**	**150**	**250**

Project Phase -1 and 2: CIE- 100 marks (50 marks –Internal guide + 50 marks- presentation)
Project Viva-voce: SEE- 150 marks (50 marks for report evaluation (Avg. of Internal & external examiner marks) + 100 marks viva- voce)

Error Control Coding

Course Code	16DCN31	**Credits**	4
Course type	PC1	**CIE Marks**	50 marks
Hours/week: L-T-P	4 – 0 – 0	**SEE Marks**	50 marks
Total Hours:	45	**SEE Duration**	3 Hours for 100 marks

Course Learning Objectives (CLOs)

1. To understand the concepts of modern algebra that are necessary to understand the Error Control Coding, also, Linear Block is introduced and develops error detection capability of linear codes.
2. To appreciate Several important classes of linear codes incommunication along with Reed-Muller codes are presented and the basic structure and properties of cyclic codes are explained with syndrome-based decoding methods.
3. Design the error detection and correction system using BCH codes for error detection and implement hardware and software for BCH decoders.
4. To understand the importance of majority-logic decodable codes and learn basic state diagram to study convolutional code structure and distance properties along with Viterbi decoding algorithm.
5. To provide comprehensive introduction to new advanced coding techniques namely, concatenated codes, parallel concatenation or turbo coding, and presents methods for correcting the burst errors and combinations of burst and random errors commonly encountered on fading channels.

Pre-requisites:

1.Digital Communication

2. Information Theory Coding

Unit – I 9Hours

Introduction to algebra: Groups, Fields, binary fields arithmetic, Construction of Galois Fields GF (2^m) and its properties, Computation using Galois filed GF (2^m) arithmetic, Vector spaces and Matrices.

Linear block codes: Generator and parity check matrices, Encoding circuits, Syndrome and error detection, Minimum distance considerations, Error detecting and error correcting capabilities, Standard array and syndrome decoding, decoding circuits

Unit – II 9 Hours

Important Linear block codes: Hamming codes, Reed-Muller codes. Golay codes, Product codes and interleaved codes.

Cyclic codes: Introduction, Generator and parity check polynomials, Encoding using multiplication circuits, Systematic cyclic codes - Encoding using feedback shift register circuits, generator matrix for cyclic code, Syndrome computing and error detection, Meggitt decoder.

Unit – III 9 Hours

BCH codes: Binary primitive BCH codes, Decoding procedures, Implementation of Galois fields arithmetic, Implementation of error correction.

Non-binary BCH codes: q-ary linear block codes, Primitive BCH codes over GF(q), Reed -Solomon codes, decoding of non-binary BCH and RS codes: The Berlekamp - Massey Algorithm.

Unit – IV 9 Hours

Majority Logic decodable codes: One -step majority logic decoding, One-step majority logic decodable codes, Two-step majority logic decoding, Multiple-step majority logic decoding.

Convolution codes: Encoding of convolutional codes, Structural properties, Distance properties, Viterbi decoding algorithm for decoding, Majority logic decoding.

Unit –V **9 Hours**

Concatenated codes and Turbo codes: Single level concatenated codes, Multilevel concatenated codes, Introduction to Turbo coding and their distance properties, design of Turbo codes.

Burst - error - Correcting codes: Introduction, Decoding of Single-Burst-Error-Correcting Codes Cyclic codes, Single-Burst-Error-Correcting Codes, Burst and random error correcting codes, Burst-Error-Correcting Convolutional Codes.

Text Books

1. Shu Lin and Daniel J. Costello, Jr., "Error Control Coding: Fundamentals and Applications," Pearson Education, Prentice Hall.

Reference Books

1. Blahut R. E, “Theory and Practice of Error Control Codes”, Addisson Wesley.
2. Stephen B. Wicker, "Error Control Systems for Digital Communication and Storage," Prentice Hall.
3. Peterson, W. W. and E.J. Weldon, Jr., "Error-Correcting Codes", the M.I.T. Press, Cambridge.

Course Outcome (COs)

At the end of the course, the student will be able to	Bloom’s Level
1. Apply the concept of modern linear algebra for the error control coding technique and demonstrate efficient optimized linear block coder and decoder for communication systems.	L2, L3
2. Develop and analyze the encoding and decoding procedures of cyclic codes.	L4, L3
3. Apply linear block code and BCH code for error detection and correction.	L3
4. Analyze the performance of majority logic decoder and study applicability to convolutional codes.	L4
5. Outline the application of concatenated, turbo, burst-error corrections codes in fading channel.	L2

Program Outcome of this course (POs)	PO No.
1. **Fundamentals of Engineering:**Graduates shall be able to understand and apply the basic mathematical and scientific concepts in the field of Digital Communication and Networking.	1
2. **Design of Experiments:** Graduates shall possess the ability to design and conduct experiments, analyse and interpret data.	2
3. **Engineering Cognizance:** Graduates shall be able to stay abreast with recent developments in the field of Digital Communication and Networking.	3
4. **Research and Innovation:**Graduates shall have the ability to pursue research and provide innovative solutions.	11

Course delivery methods	Assessment methods
1. Classroom Teaching	1. Internal Assessment Tests
2. Presentation	2. Assignments
3. Animations	3. Seminar
4. Videos	4. IEEE paper implementation

Scheme of Continuous Internal Evaluation (CIE):

Components	Average of best two IA tests out of three	**Average of assignments (Two) / activity**	**Seminar/ Mini Project**	Total Marks
Maximum Marks: 50	30	10	10	50
➢ Writing two IA tests is compulsory. ➢ **Minimum marks required to qualify for SEE:** 20				

Self Study topics shall be evaluated during CIE (Assignments and IA tests) and 10% weightage shall be given in SEE question paper.

Scheme of Semester End Examination (SEE):

1. It will be conducted for 100 marks of 3 hours duration. It will be reduced to 50 marks for the calculation of SGPA and CGPA.
2. **Minimum marks required in SEE to pass:**40
3. Question paper contains 08 questions each carrying 20 marks. Students have to answer FIVE full questions. SEE question paper will have two compulsory questions (any 2 units) and choice will be given in the remaining three units.

Elective – III: Signal Compression

Course Code	16DCN321	**Credits**	4
Course type	PE – III	**CIE Marks**	50 marks
Hours/week: L-T-P	4 – 0 – 0	**SEE Marks**	50 marks
Total Hours:	45	**SEE Duration**	3 Hours for 100 marks

Course Learning Objectives (CLOs)

1. To apply quantization for speech, image etc.
2. To appreciate applications of transforms in signal compression.
3. To apply Wavelet to decompose image/voice.
4. To demonstrate VoCoder and Video VoDec.

Unit – I 9Hours

Quantization: Quantization problem, Uniform Quantizer, Adaptive Quantization, Non-uniform Quantization; Entropy coded Quantization, Vector Quantization, LBG algorithm, Tree structured VQ, Structured VQ, Variations of VQ – Gain shape VQ, Mean removed VQ, Classified VQ, Multistage VQ, Adaptive VQ, Trellis coded quantization

Unit – II 9Hours

Transform Coding: Transforms – KLT, DCT; Quantization and coding of transform coefficients
Wavelet Based Compression: Wavelets, Multiresolution analysis & scaling function, Implementation using filters, Image compression – EZW, SPIHT, JPEG 2000.
Self learning topics: Fourier Transform, DCT in image compression

Unit – III 9Hours

Sub-band Coding: Filters, Sub-band coding algorithm, Design of filter banks, Perfect reconstruction using two channel filter banks, M-band QMF filter banks, Polyphase decomposition, Bit allocation, Speech coding – G.722, Audio coding – MPEG audio.
Analysis/Synthesis Schemes: Speech compression – LPC-10, CELP, MELP, Image Compression – Fractal compression.
Differential Encoding: Basic algorithm, Prediction in DPCM, Adaptive DPCM, Delta Modulation, Speech coding – G.726.

Unit – IV 9Hours

Lossless Coding: Huffman coding, Adaptive Huffman coding, Applications of Huffman coding, Arithmetic coding, Algorithm implementation, Applications of Arithmetic coding,
Dictionary techniques – LZ77,LZ78, Applications of LZ78

Unit – V 9Hours

Video Compression: Motion compensation, Video signal representation, Algorithms for video conferencing & videophones – H.261, H. 263, Asymmetric applications –MPEG 1, MPEG 2, MPEG 4, MPEG 7.

Text Books

1. K. Sayood**,** "Introduction to Data Compression," Harcourt India Pvt. Ltd. &Morgan Kaufmann Publishers, 1996.
2. Z. Li and M.S. Drew**,** "Fundamentals of Multimedia," Pearson Education (Asia)Pte. Ltd., 2004.

Course Outcome (COs)

At the end of the course, the student will be able to	Bloom's Level
1. Understand and differentiate with Audio, Speech and video CoDec	L2
2. Apply transforms to compress image/video	L3
3. Optimized and develop Video CoDec	L5

Program Outcome of this course (POs)	PO No.
1. **Fundamentals of Engineering:** Graduates shall be able to understand and apply the basic mathematical and scientific concepts in the field of Digital Communication and Networking.	1
2. **Design of Experiments:** Graduates shall possess the ability to design and conduct experiments, analyse and interpret data.	2
3. **Modern tool Usage:** Graduates shall possess critical thinking abilities, problem solving skills and familiarity with the necessary computational tools and procedures.	5
4. **Self motivated Learning:** Graduates shall continue to upgrade the skills and possess the motivation for continuing education and professional growth.	12

Course delivery methods	Assessment methods
1. Blackboard Teaching	1. Internal Assessment
2. Presentation and Simulation	2. Case Study
3. Videos	3. Assignment

Scheme of Continuous Internal Evaluation (CIE):

Components	Average of best two IA tests out of three	**Average of assignments (Two) / activity**	**Seminar/ Mini Project**	Total Marks
Maximum Marks: 50	30	10	10	50
➢ Writing two IA tests is compulsory. ➢ **Minimum marks required to qualify for SEE:** 20				

Self Study topics shall be evaluated during CIE (Assignments and IA tests) and 10% weightage shall be given in SEE question paper.

Scheme of Semester End Examination (SEE):

1. It will be conducted for 100 marks of 3 hours duration. It will be reduced to 50 marks for the calculation of SGPA and CGPA.
2. **Minimum marks required in SEE to pass:**40
3. Question paper contains 08 questions each carrying 20 marks. Students have to answer FIVE full questions. SEE question paper will have two compulsory questions (any 2 units) and choice will be given in the remaining three units.

Elective – III: Communication Network Modeling and Simulation

Course Code	16DCN322	**Credits**	4
Course type	PE – III	**CIE Marks**	50 marks
Hours/week: L-T-P	4 – 0 – 0	**SEE Marks**	50 marks
Total Hours:	45	**SEE Duration**	3 Hours for 100 marks

Course Learning Objectives (CLOs)

1. To study general computer network model with time related concepts.
2. To study how access the medium connectivity in multiple user models and evaluation of its throughput.
3. Routing of data in the network and finding the stability of network against the link and flow.
4. Optimization of routing schemes.
5. To study data flow and rate control mechanism in the network.

Unit – I **9 Hours**

Delay Models in Data Networks : Queuing models , Little theorem and Application , M/M/1, M/M/m/m and other Markov System , Network Transmission Lines Time Reversibility, Network of Queues.

Unit –II **9 Hours**

Multi-access Communication : Slotted Multi Access and the Aloha System , Splitting Algorithms, Carrier Sensing, Multi –access reservations, Packet Radio Networks.

Unit –III **9 Hours**

Routing in Data Networks : Introduction, Network Algorithms and Shortest Path Routing, Broadcasting Routing Information : Coping with Link Failures, Flow Models, Optimal Routing and Topological Design, Characterization of Optimal Routing, Feasible Direction Methods for Optimal Routing, Projection Methods for Optimum Routing, Routing in the Codex Network.

Unit –IV **9 Hours**

Optimization in Routing : Optimal Routing and Topological Design, Characterization of Optimal Routing, Feasible Direction Methods for Optimal Routing, Projection Methods for Optimum Routing, Routing in the Codex Network.

Unit –V **9 Hours**

Flow and Rate Control : Introduction, Window Flow Control, Rate Control Schemes, Overview of Flow Control in Practice , Rate Adjustment Algorithms.

Text Books

1. Dimitri Bertsekas and Robert Gallanger " Data Networks", 2nd Edition, Prentice Hall of India. 2003.

Reference Books

1. William Stallings " High Speed Networks and Internets", Pearson Education (Asia) PVT. Ltd. 2004.
2. J Warland and P. Varaya, " HighPerform,ance Communication Networks", 2nd edition Harcourt India Pvt. Ltd. & Morgan Kaufman, 2000.

Course Outcome (COs)

At the end of the course, the student will be able to	Bloom's Level
1. Understand computer network model with time related concepts.	L2
2. Apply how access the medium connectivity in multiple user models and evaluation of its throughput.	L4
3. Design optimization of routing schemes.	L5
4. Analyze data flow and rate control mechanism in the network.	L3

Program Outcome of this course (POs)	**PO No.**
1. **Fundamentals of Engineering:** Graduates shall be able to understand and apply the basic mathematical and scientific concepts in the field of Digital Communication and Networking.	1
2. **Engineering Cognizance:** Graduates shall be able to stay abreast with recent developments in the field of Digital Communication and Networking.	4
3. **Self motivated Learning:** Graduates shall continue to upgrade the skills and possess the motivation for continuing education and professional growth.	12

Course delivery methods	**Assessment methods**
1. Blackboard Teaching	1. Internal Assessment
2. Presentations	2. Assignment
	3. Quiz

Scheme of Continuous Internal Evaluation (CIE):

Components	Average of best two IA tests out of three	**Average of assignments (Two) / activity**	**Seminar/ Mini Project**	Total Marks
Maximum Marks: 50	30	10	10	50
➢ Writing two IA tests is compulsory. ➢ **Minimum marks required to qualify for SEE:** 20				

Self Study topics shall be evaluated during CIE (Assignments and IA tests) and 10% weightage shall be given in SEE question paper.

Scheme of Semester End Examination (SEE):

1. It will be conducted for 100 marks of 3 hours duration. It will be reduced to 50 marks for the calculation of SGPA and CGPA.
2. **Minimum marks required in SEE to pass:**40
3. Question paper contains 08 questions each carrying 20 marks. Students have to answer FIVE full questions. SEE question paper will have two compulsory questions (any 2 units) and choice will be given in the remaining three units.

Elective – III: Advanced Computer Networks

Course Code	16DCN323	**Credits**	4
Course type	PE – III	**CIE Marks**	50 marks
Hours/week: L-T-P	4 – 0 – 0	**SEE Marks**	50 marks
Total Hours:	45	**SEE Duration**	3 Hours for 100 marks

Course Learning Objectives (CLOs)

1. To become familiar with the basics of Computer Networks
2. To understand various Network architectures
3. Concepts of fundamental protocols
4. To understand the network traffic, congestion, controlling and resource allocation.

Unit – I 9Hours

Foundation: Building a Network, Requirements, Perspectives, Scalable Connectivity, Cost-Effective Resource sharing , Support for Common Services, Manageability, Protocol layering,Performance, Bandwidth and Latency, Delay X Bandwidth Product, Perspectives on Connecting, Classes of Links, Reliable Transmission, Stop-and-Wait , Sliding Window, Concurrent Logical Channels.
T1: Chapter 1.1, 1.2, 1.5.1, 1.5.2., 2.1, 2.5**T2:** Chapter 4

Unit – II 9Hours

Internetworking- I: Switching and Bridging, Datagram's, Virtual Circuit Switching, Source Routing, Bridges and LAN Switches, Basic Internetworking (IP), What is an Internetwork ?, Service Model, Global Addresses, Datagram Forwarding in IP, sub netting and classless addressing, Address Translation(ARP), Host Configuration(DHCP), Error Reporting(ICMP), Virtual Networks and Tunnels.
T1: Chapter 3.1, 3.2,

Unit – III 9Hours

Internetworking- II: Network as a Graph, Distance Vector(RIP), Link State(OSPF), Metrics, The Global Internet, Routing Areas, Routing among Autonomous systems(BGP), IP Version 6(IPv6), Mobility and Mobile IP T2
T1: Chapter 3.3, 4.1.1,4.1.3**, T2:**Chapter 13.1 to 13.18, Ch 18.

Unit – IV 9Hours

End-to-End Protocols: Simple Demultiplexer (UDP), Reliable Byte Stream(TCP), End-to-End Issues, Segment Format, Connecting Establishment and Termination, Sliding Window Revisited, Triggering Transmission, Adaptive Retransmission, Record Boundaries, TCP Extensions, Queuing Disciplines, FIFO, Fair Queuing, TCP Congestion Control, Additive Increase/ Multiplicative Decrease, Slow Start, Fast Retransmit and Fast Recovery.
T1: Chapter 5.1, 5.2.1 to 5.2.8, 6.2, 6.3

Unit – V 9Hours

Congestion Control and Resource Allocation: Congestion-Avoidance Mechanisms, DEC bit, Random Early Detection (RED), Source-Based Congestion Avoidance. The Domain Name System(DNS),Electronic Mail(SMTP,POP,IMAP,MIME),World Wide Web(HTTP), Network Management(SNMP) .
T1: Chapter 6.4 **T2:** Chapter 23.1 to 23.16, Chapter 24, Chapter 25, Chapter 27.1 to 27.8

Text Books

1. T1: Larry Peterson and Bruce S Davis, "Computer Networks :A System Approach" 5th Edition , Elsevier -2014.
2. T2: Douglas E Comer, "Internetworking with TCP/IP, Principles, Protocols and Architecture" 6th Edition, PHI – 2014.

Reference Books

4. Uyless Black"Computer Networks, Protocols , Standards and Interfaces" 2ndEdition – PHI.
5. Behrouz A Forouzan "TCP/IP Protocol Suite" 4th Edition – Tata McGraw-Hill.

Other Resources

1. http:// www.ece.gmu.edu/.../high performance communication networks_1.pdf
2. http://www.cs.cmu.edu/~prs/wirelessS12.html
3. http://www.amazon.com/dp/1558605746/ref=rdr_ext_tmb

Course Outcome (COs)

At the end of the course, the student will be able to	Bloom's Level
1. List and classify network services, protocols and architectures, explain why they are layered.	L4
2. Choose key Internet applications and their protocols, and apply to develop their own applications (e.g. Client Server applications, Web Services) using the sockets API.	L5
3. Explain develop effective communication mechanisms using techniques like connection establishment, queuing theory, recovery Etc.	L2
4. Explain various congestion control techniques.	L1

Program Outcome of this course (POs)	PO No.
1. **Fundamentals of Engineering:** Graduates shall be able to understand and apply the basic mathematical and scientific concepts in the field of Digital Communication and Networking.	1
2. **Impact of Engineering:** Graduates shall be able to understand the impact of engineering solutions in a global, economic, environmental and societal context.	6
3. **Self motivated Learning:** Graduates shall continue to upgrade the skills and possess the motivation for continuing education and professional growth.	12

Course delivery methods	Assessment methods
1. Blackboard	1. Internal Assessment Tests
2. Presentations	2. Activity
	3. Assignments

Scheme of Continuous Internal Evaluation (CIE):

Components	Average of best two IA tests out of three	**Average of assignments (Two) / activity**	**Seminar/ Mini Project**	Total Marks
Maximum Marks: 50	30	10	10	50
➢ Writing two IA tests is compulsory. ➢ **Minimum marks required to qualify for SEE:** 20				

Self Study topics shall be evaluated during CIE (Assignments and IA tests) and 10% weightage shall be given in SEE question paper.

Scheme of Semester End Examination (SEE):

1. It will be conducted for 100 marks of 3 hours duration. It will be reduced to 50 marks for the calculation of SGPA and CGPA.
2. **Minimum marks required in SEE to pass:**40
3. Question paper contains 08 questions each carrying 20 marks. Students have to answer FIVE full questions. SEE question paper will have two compulsory questions (any 2 units) and choice will be given in the remaining three units.

Elective – III: Communication System Design using VLSI

Course Code	16DCN324	**Credits**	4
Course type	PE – III	**CIE Marks**	50 marks
Hours/week: L-T-P	4 – 0 – 0	**SEE Marks**	50 marks
Total Hours:	45	**SEE Duration**	3 Hours for 100 marks

Course Learning Objectives (CLOs)

1. To view the various communication system concepts namely: modulation, channeling, and coding.
2. To understand the basic concept of Fast Fourier transformation, synchronization and various coding techniques and address their implementation using VLSI technology.
3. To introduce the ASIC design fundamentals to understand the basic concept of pipelining and parallel processing, folding, and time-multiplexing.
4. To address the theory and VLSI implementation of properties and modeling, and channel estimation for a wireless channel
5. To emphasize on low power design of Digital filters at architectural and technological levels and estimation of power consumed.

Pre-requisites:
VLSI design, Signals and Systems, Communication Systems and Data Converters

Unit – I **9 Hours**

Introduction to digital communications: Modulation and detection, vector channel representation, Equalization, Multi-channel systems (modulation methods, waterfiling, bit loading), Practical examples including 802.11a, Coding – sequence detection, gap, convolutional and block codes.

Unit – II **9 Hours**

ASIC design fundamentals: ASIC design flow, tools, system-on-a-chip design issues Micro-architectures and transformations (parallelism, pipelining, folding, time-multiplexing) Hardware description languages: Verilog and System Verilog

Unit – III **9 Hours**

Theory and building blocks: Fast fourier transform (theory, fast algorithms and VLSI implementations) Convolutional and Trellis codes, and Viterbi algorithm (theory, algorithms and VLSI implementations) Synchronization (phase and frequency tracking loops, algorithms and VLSI implementations) Block codes (Hamming, BCH, Reed-Solomon), basic theory and VLSI implementations.

Unit – IV **9 Hours**

Wireless channel fundamentals: Overview of wireless communication systems, Properties and modeling (fading, Doppler effect,...) Channel estimation (theory and VLSI implementations)

Unit – V **9 Hours**

Low power Design: Needs for low power VLSI chips, Theoretical Background :charging and discharging capacitance, short-circuit current of an inverter, CMOS leakage current, Scaling Versus Power Consumption basic principles of low power design, Power Analysis , Power Reduction Techniques and Power Estimation Approaches.

Text Books

1. John G. Proakis, MasoudSalehi, "Communication Systems Engineering", Prentice Hall, 2002
2. KeshabK.Parhi, "VLSI Digital Signal Processing systems, Design and implementation", John Wiley, Reprint 2010
3. Weste and Harris, *CMOS VLSI Design: A Circuits and Systems Perspective*, AW, 3rd edition, 2005.
4. BoscoLeung, *VLSI for Wireless Communications*, Prentice-Hall, 2004
5. Nazeih M. Botros, " HDL Programming Fundamental - Verilog ", Dreamtech Press, 2009
6.. Michael Smith, "Application-Specific Integrated Circuits", 1st Edition , Amazon.

IEEE Papers (few listed)

1. Meng, T. H., B. McFarland, D. Su, and J. Thomson. "Design and Implementation of an All-CMOS 802.11a Wireless LAN Chipset." *Communications Magazine, IEEE* 41, no. 8 (2003):
2. Thomson, J., et al. "An Integrated 802.11a Baseband and MAC Processor." Solid-State Circuits Conference, Digest of Technical Papers. ISSCC, IEEE International (2002):
3. Grass, E., et al. "On the Single-Chip Implementation of a Hiperlan/2 and IEEE 802.11a Capable Modem." *Personal Communications, IEEE* 8, no. 6 (2001): (See also *IEEE Wireless Communications*.)
4. Krstic, M., K. Maharatna, A. Troya, E. Grass, and U. Jagdhold. "Implementation of An IEEE 802.11a Compliant Low-Power Baseband Processor." Telecommunications in Modern Satellite, Cable and Broadcasting Service. TELSIKS 6th International Conference (2003):
5. Mahdavi, N.; Teymourzadeh, R.; Bin Othman, M.VLSI Implementation of High Speed and High Resolution FFT Algorithm Based on Radix 2 for DSP Application" Conference on Research and Development, 2007. SCOReD 2007.
6. Yang Sun; Cavallaro, J.R."A new MIMO detector architecture based on a Forward-Backward trellis algorithm" ,Conference on Signals, Systems and Computers, 2008.
7. Jing-ling Yang, Alfred, K.K. Wong, "Designing of Precomputational-based Low-Power Viterbi Decoder" IEEE 6th CAS Symposium on Emerging Technologies: Mobile and Wireless Communication.

Course Outcome (COs)

At the end of the course, the student will be able to	Bloom's Level
1. Identify the need and describe basic building blocks of an Communication system design.	L4
2. Design and analyze the various of modulation techniques, coding techniques and channelization.	L4, L5
3. Design and implement the fast fourier transform, convolutional code and block code using VLSI technology.	L6
4. Analyze, Implement and estimate the Channel using VLSI circuits for wireless communication.	L5
5. Perform the power analysis of the designed circuits.	L3, L5

Program Outcome of this course (POs)	PO No.
1. **Fundamentals of Engineering**: Graduates shall be able to understand and apply the basic mathematical and scientific concepts in the field of Electronics and Communication Engineering.	1
2. **Design of Experiments**: Graduates shall possess the ability to design and conduct experiments, analyze and interpret data	2
3. **Research and Innovation**: Graduates shall have the ability to pursue research and provide innovative solutions.	11
4. **Self motivated Learning**: Graduates shall continue to upgrade the skills and possess the motivation for continuing education and professional growth.	12

Course delivery methods	Assessment methods
1. Black board	1. IA Tests
2. Presentation	2. Assignment
	3. Activity

Scheme of Continuous Internal Evaluation (CIE):

Components	Average of best two IA tests out of three	**Average of assignments (Two) / activity**	**Seminar/ Mini Project**	Total Marks
Maximum Marks: 50	30	10	10	50
➢ Writing two IA tests is compulsory. ➢ **Minimum marks required to qualify for SEE:** 20				

Self Study topics shall be evaluated during CIE (Assignments and IA tests) and 10% weightage shall be given in SEE question paper.

Scheme of Semester End Examination (SEE):

1. It will be conducted for 100 marks of 3 hours duration. It will be reduced to 50 marks for the calculation of SGPA and CGPA.
2. **Minimum marks required in SEE to pass:**40
3. Question paper contains 08 questions each carrying 20 marks. Students have to answer FIVE full questions. SEE question paper will have two compulsory questions (any 2 units) and choice will be given in the remaining three units.

Elective – IV: Business Analytics

Course Code	16DCN331	**Credits**	4
Course type	PE – IV	**CIE Marks**	50 marks
Hours/week: L-T-P	4 – 0 – 0	**SEE Marks**	50 marks
Total Hours:	45	**SEE Duration**	3 Hours for 100 marks

Course Learning Objectives (CLOs)

1. To use data to develop insights and predictive capabilities using machine learning, data mining and forecasting techniques
2. To understand the use of optimization to support decision-making in the presence of a large number of alternatives and business constraints.
3. To explore the challenges that can arise in implementing analytical approaches within an organization.

Unit – I **9 Hours**

Business Statistics:

Different types of data; Data Visualization; Data summarization methods; Tables, Graphs, Charts, Histograms, Frequency distributions, Relative frequency measures of central tendency and dispersion; Box Plot; Chebychev's Inequality on relationship between the mean and the standard deviation of a probability distribution. Basic probability concepts, Conditional probability, Bayes Theorem, Probability distributions, Continuous and discrete distributions, Sequential decision-making Sampling and estimation: Estimation problems, Point and interval estimates Hypothesis testing: Null and alternate hypotheses; Types of errors, Level of significance, Power of a test, ANOVA Test for goodness of fit, Non-parametric tests.

Unit – II **9 Hours**

Predictive analytics:

Simple linear regression: Coefficient of determination, Significance tests, Residual analysis, Confidence and Prediction intervals Multiple linear regression: Coefficient of multiple coefficient of determination, Interpretation of regression coefficients, Categorical variables, heteroscedasticity, Multi-collinearity, outliers, Autoregression and Transformation of variables Logistic and Multinomial Regression: Logistic function, Estimation of probability using logistic regression, Deviance, Wald Test, HosmerLemshow Test Forecasting: Moving average, Exponential smoothing, Trend, Cyclical and seasonality components, ARIMA (autoregressive integrated moving average). Application of predictive analytics in retail, direct marketing, health care, financial services, insurance, supply chain, etc.

Unit - III **9 Hours**

Optimization Analysis:

Introduction to Operations Research (OR), linear programming (LP), formulating decision problems using linear programming, interpreting the results and sensitivity analysis.Multi-period LP models. Applications of linear programming in product mix, blending, cutting stock, transportation, transshipment, assignment, scheduling, planning and revenue management problems. Network models and project planning. Integer Programming (IP) problems, mixed-integer and zero-one programming.Applications of IP in capital budgeting, location decisions, contracts. Multi-criteria decision making (MCDM) techniques: Goal Programming (GP) and analytic hierarchy process (AHP) and applications of GP and AHP in solving problems with multiple objectives. Non-linear programming, portfolio theory.

Unit - IV **9 Hours**

Stochastic Models:

Introduction to stochastic models, Markov models, Classification of states, Steady-state probability estimation, Brand switching and loyalty modeling, Market share estimation and Customer lifetime value estimation Poisson process, Cumulative Poisson process, Applications of Poisson and cumulative Poisson in operations, marketing and insurance Renewal theory, Applications of renewal theory in operations and supply chain management Markov decision process, Applications of Markov decision process in sequential decision making.

Unit - V **9 Hours**

Advanced analytics

Principal component analysis, Factor analysis, Conjoint analysis, Discriminant analysis, ARCH (autoregressive conditional heteroscedasticity) and GARCH (autoregressive conditional heteroscedasticity), Monte Carlo simulation Survival analysis and its applications: Life tables, KapMeier estimates, Proportional hazards, Predictive hazard modeling using customer history data Six Sigma as a problem solving methodology, DMAIC and DMADV methodology, Six Sigma Tool Box: Seven quality tools, Quality function deployment (QFD), SIPOC, Statistical process control, Value stream mapping, TRIZ Classification and regression trees (CART), Chi-squared automatic interaction detector (CHAID) Lean thinking: Lean manufacturing, Value stream mapping

Text Books

1. Data Science for Business, Provost and Fawcett: O'Reilly
2. Data Mining for Business Intelligence, Concepts, Techniques and Applications, Shmueli, Patel, and Bruce: Wiley
3. Management Science: The Art of Modeling with Spreadsheets, Powell and Baker: Wiley

Reference Books

1. The New Science of Retailing, Fisher and Raman: Harvard Business Press
2. Big data: The next frontier for innovation, competition, and productivity: http://www.mckinsey.com/insights/mgi/research/technology_and_innovation/big_data_the_next_frontier_for_innovation

Course Outcome (COs)

At the end of the course, the student will be able to	Bloom's Level
1. To identify, evaluate, and capture business analytic opportunities that create value.	L4
2. To explain basic analytic methods and analyze case studies on organizations that successfully deployed these techniques	L3

	Program Outcome of this course (POs)	PO No.
1.	**Fundamentals of Engineering**: Graduates shall be able to understand and apply the basic mathematical and scientific concepts in the field of Electronics and Communication Engineering.	1
2.	**Social Engineering:** Graduates shall possess the ability to identify societal problems and meaningfully contribute with optimal solutions.	3
3.	**Impact of Engineering:** Graduates shall be able to understand the impact of engineering solutions in a global, economic, environmental and societal context.	6
4.	**Ethics:** Graduates shall imbibe the professional and ethical responsibilities of their profession.	7
5.	**Self motivated Learning**: Graduates shall continue to upgrade the skills and possess the motivation for continuing education and professional growth.	12

Course delivery methods	Assessment methods
3. Black board	1. IA Tests
4. Presentation	2. Assignment
	3. Activity

Scheme of Continuous Internal Evaluation (CIE):

Components	Average of best two IA tests out of three	**Average of assignments (Two) / activity**	**Seminar/ Mini Project**	Total Marks
Maximum Marks: 50	30	10	10	50
➢ Writing two IA tests is compulsory. ➢ **Minimum marks required to qualify for SEE:** 20				

Self Study topics shall be evaluated during CIE (Assignments and IA tests) and 10% weightage shall be given in SEE question paper.

Scheme of Semester End Examination (SEE):

1. It will be conducted for 100 marks of 3 hours duration. It will be reduced to 50 marks for the calculation of SGPA and CGPA.
2. **Minimum marks required in SEE to pass:**40
3. Question paper contains 08 questions each carrying 20 marks. Students have to answer FIVE full questions. SEE question paper will have two compulsory questions (any 2 units) and choice will be given in the remaining three units.

Elective – IV: Long Term Evolution

Course Code	16DCN332	**Credits**	4
Course type	PE – IV	**CIE Marks**	50 marks
Hours/week: L-T-P	4 – 0 – 0	**SEE Marks**	50 marks
Total Hours:	45	**SEE Duration**	3 Hours for 100 marks

Course Learning Objectives (CLOs)

1. To provide a broad and comprehensive perspective on the evolution to next generation wireless networks.
2. To examine 3G and 4G wireless standards along with resource management and quality of service (QoS) in these networks.
3. To examine the architecture of LTE interface.
4. To identify key enabling technologies for wireless network evolution.

Unit – I **9 Hours**

Introduction: Architectural Review UMTs and GSM, History of Mobile telecommunication systems, The need for LTE, From UMTs to LTE, From LTE-to –LTE-Advanced, The 3GPP specifications for LTE.

System Architecture Evolution: High level architecture of LTE, User Equipment, Evolved UMTs terrestrial radio access network, Evolved packet core, Communication protocols, signaling flows-Examples, Bearer management, state diagrams, spectrum allocation.

Unit – II **9 Hours**

TheWireless Channel:

Digital wireless communications: Radio Transmission and Reception, Radio Transmission in Mobile Cellular network, Impairments to the received signal, Error management.

Orthogonal Frequency Division Multiple Access (OFDMA): Principles, Benefits and additional features, Single carrier Frequency division multiple access.

Unit - III **9 Hours**

Multiple Antenna Techniques: Diversity processing, Spatial Multiplexing, Beam forming, Downlink Multiple User MIMO- revisited.

Architecture of the LTE Air- Interface: Air interface protocol stack, Logical, transport, and physical Channels, the resource grid, Multiple antenna transmission, Resource element mapping.

Cell Acquisition: Acquisition Procedure, Synchronization Levels, Downlink Reference signals, Physical broadcast channel, Physical control format indicator Channel, System information, procedures after acquisition.

Unit - IV **9 Hours**

Data Transmission and Reception: Data Transmission procedures, Transmission of Scheduling messages on the PDCCH, Data Transmission on the PDSCH and PUSCH, Transmission of Hybrid ARQ indicators on the PHICH, uplink control information, Transmission of uplink control information on the PUCCH, Uplink Reference signals, power control, Discontinuous reception.

Random Access: Transmission of random access preambles on the PRACH, Non-contention Based procedure, Contention Based Procedure.

Unit - V **9 Hours**

Air interface layer-2: Medium Access control protocol, Radio link control protocol, Packet data Convergence Protocol.

Power-on and Power-off procedures: Power on sequence, network and cell selection,RRC connection establishment, Attach procedure, detach procedure.

Security Procedures: Network access security, Network domain security.

Mobility management: Transition between mobility management states, cell reselection in RRC_IDLE, Measurements in RRC_CONNECTED, Handover in RRC_CONNECTED.

Text Books

1. An Introduction to LTE, Christopher Cox, Second Ed. John Wiley & sons Ltd. 2014.
2. Fundamentals of LTE, Arunabha Ghosh, JuhJhang, Jeffery G. Andrews, Rias Muhamed , Pearson, 2010

Reference Books

1. LTE: The UMTs Long Term Evolution, Stefania sesia, IssamToufik,Matthew Baker, 2nd Edition, John Wiley & Sons Ltd. 2011.
2. 4G LTE/LTE Advanced for Mobile Broadband, Erik Dahlman, Stefan Parkvall, Johan skold, 2nd Edition, Academic Press, Elsivier Ltd. 2014.
3. Advanced wireless networks, 4G Technologies, Savo G. Glisic, John Wiley & sons Ltd.

Course Outcome (COs)

At the end of the course, the student will be able to	Bloom's Level
1. Understand LTE Network Architecture and Protocols.	L1
2. Understand the importance of QoS and resource management in next generation wireless networks.	L2
3. Describe and compare the network and protocol architectures of GPRS and EDGE and the two principle 3G cellular based wireless standards: UMTS and cdma2000.	L2
4. List and provide a high-level discussion on the key enabling technologies for next generation wireless networks.	L3
5. Identify the relationship between WiFi, WiMAX, and 3G cellular-based wireless networks. In addition, the student will be able to outline and discuss the potential impact of these technologies upon wireless network evolution.	L3

Program Outcome of this course (POs)	**PO No.**
1. **Fundamentals of Engineering**: Graduates shall be able to understand and apply the basic mathematical and scientific concepts in the field of Electronics and Communication Engineering.	1
2. **Research and Innovation**: Graduates shall have the ability to pursue research and provide innovative solutions.	11
3. **Self motivated Learning**: Graduates shall continue to upgrade the skills and possess the motivation for continuing education and professional growth.	12

Course delivery methods	**Assessment methods**
1. Black board	1. IA Tests
2. Presentation	2. Assignment
	3. Activity

Scheme of Continuous Internal Evaluation (CIE):

Components	Average of best two IA tests out of three	**Average of assignments (Two) / activity**	**Seminar/ Mini Project**	Total Marks
Maximum Marks: 50	30	10	10	50
➢ Writing two IA tests is compulsory. ➢ **Minimum marks required to qualify for SEE:** 20				

Self Study topics shall be evaluated during CIE (Assignments and IA tests) and 10% weightage shall be given in SEE question paper.

Scheme of Semester End Examination (SEE):

1. It will be conducted for 100 marks of 3 hours duration. It will be reduced to 50 marks for the calculation of SGPA and CGPA.
2. **Minimum marks required in SEE to pass:**40
3. Question paper contains 08 questions each carrying 20 marks. Students have to answer FIVE full questions. SEE question paper will have two compulsory questions (any 2 units) and choice will be given in the remaining three units.

Elective – IV: Automotive Electronics and Networks

Course Code	16DCN333	**Credits**	4
Course type	PE – IV	**CIE Marks**	50 marks
Hours/week: L-T-P	4 – 0 – 0	**SEE Marks**	50 marks
Total Hours:	45	**SEE Duration**	3 Hours for 100 marks

Course Learning Objectives (CLOs)

1. To understand the concepts of Automotive Electronics and its evolution and trends, Automotive systems & subsystems overview.
2. To understand sensors and sensor monitoring mechanisms aligned to Automotive systems, different signal conditioning techniques, interfacing techniques and actuator mechanisms
3. To understand role of Automotive Grade Microcontrollers in ECU design and choice of appropriate Hardware and Software
4. To understand, design and model various automotive control systems using Model based development technique
5. To understand Safety standards, advances in autonomous vehicles, and vehicle on board and off board diagnostics

Unit - I **7 Hours**

Introduction to Automotive Systems and Design Cycle.

Automotive System: Role of technology in Automotive Electronics and interdisciplinary design tools and processes. Introduction to modern automotive systems and need for electronics in automobiles and application areas of electronic systems in modern automobiles, Introduction to Four Stroke Engines, Spark and Compression Ignition Engines, Automotive transmissions, Vehicle braking fundamentals, Introduction to antilock braking systems, Steering Control, Passenger Safety and Convenience occupant protection systems, Tire pressure monitoring systems, Overview of Hybrid Vehicles.

Design Cycle: V-Model development cycle, Components of ECU, Examples of ECU on Chassis, Infotainment, Body Electronics and clusters.

Unit - II **7 Hours**

Automotive Sensors and Actuators

Systems approach to control and instrumentation: Concept of a system, Analog and Digital systems, Basic measurements systems- Automotive Sensors, Sensor characteristics, Sensor response, Sensor error, Redundancy of sensors in ECUs, Avoiding redundancy, Sensor modeling , Smart Nodes, Examples of sensors in automotive.

Actuators – Examples of actuators in automotive- solenoid and motor based.

Unit - III **7 Hours**

Microcontrollers/Microprocessors in Automotive domain, Communication protocols.

Microcontrollers/Microprocessors in Automotive domain: Critical review of microprocessor, microcontroller and digital signal processor development, Criteria to choose the right microcontroller/processor for various automotive applications, Understanding various architectural attributes relevant to automotive applications, Automotive grade processors.

Communication Protocols: Overview ofAutomotive communication protocols: CAN, LIN, Flex Ray, MOST, Ethernet, D2B and DSI.

Unit – IV **7 Hours**

Automotive Control Systems and Model Based Development.

Automotive Control System: Control system approach in Automotive (State variables approach only): Analog and Digital control methods, modeling of linear systems, System responses. Modeling of Automotive Systems simple examples (PID tuning by Zeigler-Nichols Method).

Model based Development: Model-Based Design for a small system - Motor Model, Generator Model, Controller Model, SimDriveline Intro Simulink Simulations, Explore the system response using different control methods. Tune the system, Explore system limitations , understand and refine motor models, Real time simulations on a Simple target (Arduino/ Rasberry Pi etc), Study of modeling and simulation of any one of the Automotive systems..

Self learning topics: Laplace and Z- Transforms, MATLAB/ Simulink and SIMSCAPE tool boxes.

Unit – V **7 Hours**

Safety Systems in Automobiles and Diagnostic Systems

Active Safety Systems: ABS, TCS, ESP, Brake assist etc

Passive Safety Systems: Airbag systems, Advanced Driver Assistance Systems (ADAS), Examples of assistance applications.

Functional Safety: Need for safety systems, safety concept, safety process for product life cycle, safety by design, validation.

Diagnostics: On board and off board diagnostics in Automobiles, Diagnostic tools, Diagnostic protocols.

Text Books

1. William B. Ribbens, “Understanding Automotive Electronics”, 6th Edition, Newness Publication, An imprint of Elsevier Science, 2003.
2. Ronald K Jurgen: "Automotive Electronics Handbook, 2nd Edition, McGraw-Hill, 1999
3. K. Ogata: “Modern Control Engineering”, Prentice Hall

Reference Books

1. Tom Denton: "Advanced Automotive Diagnosis, 2nd Edition, Elsevier, 2006.
2. Allan Bonnick.: “Automotive Computer Controlled Systems” Diagnostic Tools and Techniques". Elsevier Science, 2001.

Course Outcome (COs)

At the end of the course, the student will be able to	Bloom’s Level
1. Describe different concepts of Automotive Electronics and its evolution and trends, Automotive systems & subsystems overview.	L2
2. Explain sensors, actuators and sensor monitoring mechanisms aligned to Automotive systems, different signal conditioning techniques, interfacing techniques and actuator mechanisms	L1
3. Explain role of Automotive Grade Microcontrollers in ECU design and choice of appropriate Hardware and Software.	L2
4. Design and model various automotive control systems using Model based development technique	L5
5. Describe Safety standards, advances towards autonomous vehicles, and vehicle on board and off board diagnostics	L2

Program Outcome of this course (POs)	PO No.
1. **Fundamentals of Engineering:** Graduates shall be able to understand and apply the basic mathematical and scientific concepts in the field of Electronics and Communication Engineering.	1
2. **Design of Experiments:** Graduates shall possess the ability to design and conduct experiments, analyse and interpret data.	2

3.	**Social Engineering:** Graduates shall possess the ability to identify societal problems and meaningfully contribute with optimal solutions	3
4.	**Engineering Cognizance:** Graduates shall be able to stay abreast with recent developments in the field of Electronics and Communication Engineering	4
5.	**Modern tool Usage:** Graduates shall possess critical thinking abilities, problem solving skills and familiarity with the necessary computational tools and procedures	5
6.	**Self motivated Learning:** Graduates shall continue to upgrade the skills and possess the motivation for continuing education and professional growth	12

Course delivery methods	**Assessment methods**
1. Chalk / Blackboard	1. Assignments
2. Presentations	2. Internal Assessment Tests
3. Workshop	3. Quiz
4. Activity	4. Seminar

Scheme of Continuous Internal Evaluation (CIE):

Components	Average of best two IA tests out of three	**Average of assignments (Two) / activity**	**Seminar/ Mini Project**	Total Marks
Maximum Marks: 50	30	10	10	50
➢ Writing two IA tests is compulsory. ➢ **Minimum marks required to qualify for SEE:** 20				

Self Study topics shall be evaluated during CIE (Assignments and IA tests) and 10% weightage shall be given in SEE question paper.

Scheme of Semester End Examination (SEE):

1. It will be conducted for 100 marks of 3 hours duration. It will be reduced to 50 marks for the calculation of SGPA and CGPA.
2. **Minimum marks required in SEE to pass:**40
3. Question paper contains 08 questions each carrying 20 marks. Students have to answer FIVE full questions. SEE question paper will have two compulsory questions (any 2 units) and choice will be given in the remaining three units.

Elective – IV: Multi Rate Filters

Course Code	16DCN334	**Credits**	4
Course type	PE – IV	**CIE Marks**	50 marks
Hours/week: L-T-P	4 – 0 – 0	**SEE Marks**	50 marks
Total Hours:	45	**SEE Duration**	3 Hours for 100 marks

Course Learning Objectives (CLOs)

1. To introduce the fundamentals of multirate filters
2. To understand the digital filter bank
3. To explore the concepts of QMF Bank
4. To analyze Polyphase structure

Unit – I **9 Hours**

The sampling theorem - sampling at subnyquist rate - Basic Formulations and schemes. Basic Multirate operations- Decimation and Interpolation

Unit – II **9 Hours**

Digital Filter Banks- DFT Filter Bank- Identities- Polyphase representation Maximally decimated filter banks: Polyphase representation - Errors in the QMF bank- Perfect reconstruction (PR) QMF Bank - Design of an alias free QMF Bank.

Self learning topics: Applications of QMF Bank

Unit - III **9 Hours**

Uniform band and non uniform filter bank - tree structured filter bank- Errors created by filter bank system- Polyphase representation- perfect reconstruction systems Paraunitary PR Filter Banks- Filter Bank Properties induced by paraunitarity- Two channel FIR paraunitary.

Unit - IV **9 Hours**

QMF Bank- Linear phase PR Filter banks- Necessary conditions for Linear phase property- Quantization Effects: -Types of quantization effects in filter banks. - coefficient sensitivity effects, dynamic range and scaling.

Unit - V **9 Hours**

Cosine Modulated pseudo QMF Bank- Alas cancellation- phase - Phase distortion- Closed form expression- Polyphase structure- PR Systems.

Text Books

1. P. P. Vaidyanathan, “Multirate Systems and Filter Banks”, Pearson Education, Low Price Edition, ISBN 81 – 7758 – 942 – 3.
2. S.K. Mitra, Digital Signal Processing, A Computer Based approach, Tata McGraw Hill, 1998.

Course Outcome (COs)

At the end of the course, the student will be able to	Bloom’s Level
1. Understand and differentiate interpolation and decimation in filter	L2
2. Apply multirate filters for speech and image application to compress data	L3
3. Analyze QMF filter banks and deploy for different applications	L4

Program Outcome of this course (POs)	PO No.
1. **Fundamentals of Engineering**: Graduates shall be able to understand and apply the basic mathematical and scientific concepts in the field of Electronics and Communication Engineering.	1
2. **Research and Innovation**: Graduates shall have the ability to pursue research and provide innovative solutions.	11
3. **Self motivated Learning**: Graduates shall continue to upgrade the skills and possess the motivation for continuing education and professional growth.	12

Course delivery methods	Assessment methods
3. Black board	1. IA Tests
4. Presentation	2. Assignment
	3. Activity

Scheme of Continuous Internal Evaluation (CIE):

Components	Average of best two IA tests out of three	**Average of assignments (Two) / activity**	**Seminar/ Mini Project**	Total Marks
Maximum Marks: 50	30	10	10	50
➢ Writing two IA tests is compulsory. ➢ **Minimum marks required to qualify for SEE:** 20				

Self Study topics shall be evaluated during CIE (Assignments and IA tests) and 10% weightage shall be given in SEE question paper.

Scheme of Semester End Examination (SEE):

1. It will be conducted for 100 marks of 3 hours duration. It will be reduced to 50 marks for the calculation of SGPA and CGPA.
2. **Minimum marks required in SEE to pass:**40
3. Question paper contains 08 questions each carrying 20 marks. Students have to answer FIVE full questions. SEE question paper will have two compulsory questions (any 2 units) and choice will be given in the remaining three units.