VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE
(VJTI)
MATUNGA, MUMBAI 400 019

(Autonomous Institute affiliated to University of Mumbai)

Curriculum
(Scheme of Instruction & Evaluation and Course contents)

For
Two Year Post Graduate Programme
Leading to Master of Technology
(M. Tech.) Degree in
Electronics and Telecommunication Engineering

Implemented from the batch admitted in Academic Year 2022-23

VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE

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For

Post Graduate Programme Leading to
Masters of Technology Degree

In

Electronics and Telecommunication Engineering

From Academic Year 2022-23

M. Tech. Electronics and Telecommunication Engineering

Program Educational Objectives:

1. To provide students with a solid foundation in mathematical, scientific and engineering fundamentals required to formulate, analyze & solve engineering problems related to Electronics Engineering.
2. To enable students to succeed in employment, profession and/or to pursue research education in Electronics Engineering.
3. To help students to exhibit knowledge for innovate, create and design electronic engineering systems.
4. To inculcate in students professional and ethical attitude, effective communication skills and teamwork to become a successful professional in global perspective.

Program Outcomes(POs):

LIST OF PROGRAM OUTCOMES	
PO1	Sufficient knowledge of mathematics, science and Electronics Engineering and be able to apply this knowledge for modelling and solving Electronics Engineering problems using the techniques, skills and modern Electronics Engineering tools necessary for engineering practice.
PO2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	Ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.
PO4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

PO7	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

M.Tech. Electronics and Telecommunication Engineering

Scheme of Instruction and Evaluation

SEMESTER I

Scheme of Instruction					Scheme of Evaluation			
S. No	**Course Code**	**Course Title**	**L-T-P (Hours /week)**	**Credits**	**TA**	**MST**	**ESE**	**ESE hours**
1	EEET5001S	Computational Methods (Program Specific Maths)	3-0-0	3	20	20	60	3
2	EEET5011T	RF Circuits Design and MEMS (Core-1)	3-1-0	4	20	20	60	3
3	EEET5012T	TCP/IP Networks & NetworkManagement (Core-2)	3-0-0	3	20	20	60	3
4	EEET5022S	Program Elective 1	3-1-0	4	20	20	60	3
5	EEET5031T	Program Elective 2	3-0-0	3	20	20	60	3
6	EEET5061S	Open Elective-1	3-1-0	3	20	20	60	3
7	EEET5011P	RF Circuits Design and MEMS (Laboratory -1)	0-0-2	1	60%CIE		40	-
8	EEET5012P	TCP/IP Networks & Network Management (Laboratory-2)	0-0-2	1	60%CIE		40	-
9	EEET5031P	Program Elective 2 (Laboratory-3)	0-0-2	1	60%CIE		40	-
10	MTEC5081L	Liberal Learning	0-0-2	1	100%CIE		-	-
		Total	28	24				

Program Elective -1	**Program Elective - 2**
1. MPLS and Modern Networks (EEET5021S) 2. Network Security Models (EEET5022S) 3. Nano Electronics & Nanomaterials EEET5023S) 4. Electronics in Medicine (EEET5024S)	1. DSP Applications in Modern Communication Systems (EEET5031T) 2. Optical Communication and Networking (EEET5032T) 3. Data Compression and Encryption (EEET5033T) 4. Random Variables and Stochastic Process (EEET5034T)

Open Elective - 1	**Liberal Learning-1 (MTEC5081L)**
1. Artificial Neural Networks and Machine Learning (EEET5061S)	1. Problem Solving and Critical thinking 2. Indian Knowledge System 3. Yoga and Stress Management 4. Corporate Culture and Organizational learning 5. Business Administration 6. German 7. French 8. Defence 9. Information Science

Abbreviations: **L:** Lecture, T**:** Tutorial, **P:** Practical, **TA:** Teacher Assessment/Term work Assessment, **MST:** Mid semester Test ,**ESE:** End semester Written Examination, **CIE:** Continuous In-semester Evaluation

SEMESTER II

Scheme of Instruction					Scheme of Evaluation			
S. No	**Course Code**	**Course Title**	**L-T-P**	**Credits**	**TA**	**MST**	**ESE**	**ESE hours**
1	EEET5002S	Research Methodology & IPR (Mandatory Learning)	3-0-0	3	20	20	60	3
2	EEET5013T	5G Communication (Core-1)	3-1-0	4	20	20	60	3
3	EEET5014T	Embedded System Design (Core-2)	3-0-0	3	20	20	60	3
4	EEET5041S	Program Elective 3	3-1-0	4	20	20	60	3
5	EEET5051T	Program Elective 4	3-0-0	3	20	20	60	3
6	EEET5062S	Open Elective -2	3-1-0	3	20	20	60	3
7	EEET5013P	5G Communication (Laboratory - 4)	0-0-2	1	60%CIE		40	-
8	EEET5014P	Embedded System Design (Laboratory -5)	0-0-2	1	60%CIE		40	-
9	EEET5051P	Program Elective 4 (Laboratory - 6)	0-0-2	1	60%CIE		40	-
10	MTEC5082L	Liberal Learning	0-0-2	1	100%CIE		-	-
		Total	28	24				

Program Elective 3	**Program Elective 4**
1. Error Correcting Codes (EEET5041S) 2. Microwave Communication Systems (EEET5042S) 3. Cognitive Radio (EEET5043S) 4. Virtual Instrumentation (EEET5044S)	1. Antenna Design (EEET5051T) 2. Modern DSP (EEET5052T) 3. Image & Video Processing for Emerging Technology (EEET5053T) 4. FPGA Based System Design (EEET5054T)

Open Elective-2	**Liberal Learning-2 (**MTEC5082L)
1. Mathematical foundation course for data analytics (EEET5062S)	1. Agriculture 2. Holistic health 3. Political science 4. Computerised Modern Film Making 5. Interior design 6. Introduction to Japanese Language and Culture

Abbreviations: **L:** Lecture, T**:** Tutorial, **P:** Practical, **TA:** Teacher Assessment/Term work Assessment, **MST:** Mid semester Test), **ESE:** End semester Written Examination, **CIE:** Continuous In-semester Evaluation

SEMESTER III

Scheme of Instruction					Scheme of Evaluation
S. No	**Course Code**	**Course Title**	**L-T-P**	**Credits**	
1	EEET5091D	Skill Based Course (Project Stage -I)	---	5	100% CIE
2	EEET5092D	Skill Based Course (Project Stage -II)	---	5	100% CIE
3	EEET5101S	Self-Learning Course -1	1-0-0	1	100% ESE of 3 hours or credit transfer
4	EEET5201S	Self-Learning Course -2	1-0-0	1	100% ESE of 3 hours or credit transfer
5	EEET5301S	Mandatory Non-Credit Course	2-0-0	0	100% ESE of 3 hours or credit transfer
		Total		12	

Self-Learning Course-1	**Mandatory Non-Credit Course**
1. Ayurvedic Inheritance of India (EEET5101S) 2. Biology for engineers and other non-biologists (EEET5102S) 3. Human resource planning (EEET5103S) 4. Key to recognising cyber bullying (EEET5104S) 5. Cooperation vs. competition (EEET5105S) **Self-Learning Course-II** 1. Customer Relationship Management (EEET5201S) 2. Patent Search for Engineers and Lawyers (EEET5202S) 3. Design Thinking - A Primer (EEET5203S) 4. Assessment in democratic classroom (EEET5204S) 5. Media and information disorder (EEET5205S)	1. Leadership and Team Effectiveness (EEET5301S) 2. Applied Econometrics (EEET5302S) 3. National Security Policy of India (EEET5303S) 4. Entrepreneurship (EEET5304S) 5. Spatial Statistics and Spatial Econometrics(EEET5305S) 6. Military history of India (EEET5306S) 7. Human rights and Indian Constitutions (EEET5307S) 8. Public Speaking (EEET5308S) 9. Wars in post Independent India (EEET5309S) 10. Consumer Behaviour (EEET5310S)

SEMESTER IV

Scheme of Instruction					Scheme of Evaluation
S. No	**Course Code**	**Course Title**	**L-T-P**	**Credits**	
1	EEET5093D	Skill Based Course (Project Stage -III)	---	5	100% CIE
2	EEET5094D	Skill Based Course (Project Stage -IV)	---	7	100% CIE
				12	

Semester-I

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER I**
Course Code	**EEET5001S**
Course Title	**COMPUTATIONAL METHODS**

COURSE OBJECTIVES

After completion of this course, students should be able to

- develop mathematical models of lower-level engineering problems.
- learn how to curve fit (interpolation and regression) discrete data.
- understand and solve problems using various transform techniques.
- make use of various optimization Techniques.
- learn how to analyse algorithms using various methods

COURSE OUTCOMES

- Understand the concept and steps of problem solving - mathematical modelling, solution and implementation.
- Knowledge and understanding of, and the ability to use, mathematical techniques.
- Ability to understand and apply mathematical reasoning in several different areas of mathematics.
- Describe apply and analyse complexity of greedy and dynamic programming strategy.

Overview

Module 1: Review of Numerical Techniques	
	Newton's divided difference, interpolation polynomials, Lagrange interpolation polynomials, Linear and non-linear regression, multiple linear regression, general linear least squares
Module 2: Transform Techniques	
	Orthogonal/Unitary transform, Fourier transform, Laplace transform, Z Transform, Applications of these transform.
Module 3: Optimization Techniques for Engineers	
	Single Variable Optimization, Multi-Variable Optimization with equality and inequality constraints, Line searches, Steepest descent method, Conjugate gradient method, Quasi Newton method, Penalty function method
Module 4: Analysis of Algorithms	
	a) Greedy Method Approach: General Method, Single source shortest path: Dijkstra Algorithm, Fractional Knapsack problem, Job sequencing with deadlines, minimum cost spanning trees: Kruskal and Prim's algorithms. **b)** Dynamic Programming Approach: General Method, Multistage graphs, Single source shortest path: Bellman Ford Algorithm. All pair shortest path: Floyed Warshall algorithm, Assembly – line scheduling problem0/1 knapsack Problem, Travelling Salesperson problem, Longest common subsequence.

Reference books

1. "Numerical Methods for Engineers', Steven C. Chapra and Raymond P. Canale, McGraw Hill, 8th edition (29 October 2021)
2. "Operations Research – An Introduction", Hamdy A.TAHA, Pearson Education; Tenth edition (31 August 2019)
3. "Numerical Methods for Engineers", Santosh Gupta, New age international publishers 4th edition (01 August 2019)
4. "Introduction to Algorithms", T. H. Cormen, C.E. Leiserson, R.L.Rivest, and C. Stein, 4th Edition, PHI Publication, (April 5, 2022).
5. "Fundamentals of computer Algorithms", Ellis Horowitz, Sartaj Sahni, S. Rajsekaran, University Press, 2nd edition, (4th September 2018)

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER-I**
Course Code	**EEET5011T**
Course Title	**RF CIRCUITS DESIGN AND MEMS**

COURSE OBJECTIVE

- Understand Modern RFIC Architectures, parameters and terminology and study the effects of parasitic on circuit performance at RF.
- Use of graphical design techniques for RFIC design and understanding the key issuesof RFIC design.
- Applications include wireless communications, active and passive remote sensing, location sensing, radar, and radio astronomy.
- This course is focused on the key concepts in having RF capability on a chip.
- To study parasitic effects and current device modeling.
- To design of high-frequency, analog integrated circuits including low noise amplifiers, voltage-controlled oscillators, phase-locked loops, mixers and power amplifiers.

COURSE OUTCOME

- Understanding of the design and analysis of radio frequency integrated circuits and systems (RFICs) for communications is the major outcome of this course.
- Understanding the enabling integrated circuit technology and devices - Understandingthe differences between standard CMOS devices and high-speed, high frequency and high power devices.
- Understanding the basics of RF circuits and systems; such as nonlinearity, sensitivity, dynamic range, matching and impedance transformation networks.
- Understanding RF testing for heterodyne, Homodyne, Image reject, Direct IF and sub sampled receivers.
- Understanding of how to design Receiver and Transmitter architectures. Direct conversion and two-step transmitters.

Overview

Module 1: Introduction	
	RF design and Wireless Technology: Design and Applications, Complexity and Choice of Technology. Basic concepts in RF design, nonlinearity and Time Variance, Intersymbol Interference, random processes and noise. Sensitivity and dynamic range, conversion of gainsand distortion.
Module 2: RF Modulation	
	Analog and digital modulation of RF circuits, Comparison of various techniques for power efficiency, Coherent and non-coherent detection, Mobile RF communication and basics of Multiple Access techniques. Receiver and Transmitter architectures. Direct conversion and two-step transmitters.

Module 3: RF Testing	
	RF testing for heterodyne, Homodyne, Image reject, Direct IF and sub sampled receivers.
Module 4: BJT and MOSFET Behavior at RF Frequencies	
	Overview of RF Filter design and design issues in integrated RF filters, Active RF components & modeling, Matching and Biasing Networks. Basic blocks in RF systems and their VLSI implementation. Low noise Amplifier design in various technologies, Design of Mixers at GHz frequency range, various mixers- working and implementation, Power Amplifier design.
Module 5:RF Circuits Design	
	Basic topologies VCO and definition of phase noise, Noise power and trade off. ResonatorVCO designs, Quadrature and single sideband generators, PLLS, Various RF synthesizer architectures and frequency dividers.
Module 6: RF MEMS	
	Introduction of MEMS in RF, MEMS technology and fabrication techniques, RF MEMS Inductor and Capacitor, RF MEMS Switches, Capacitive shunt and series switches, RF MEMS Filters and Phase Shifters.

Reference books

1. Thomas H. Lee “Design of CMOS RF Integrated Circuits” Cambridge University press 2004.
2. B. Razavi “RF Microelectronics” Pearson Prentice Hall; 2nd edition (22 September 2011)
3. R. Jacob Baker, H.W. Li, D.E. Boyce “CMOS Circiut Design, layout and Simulation” Wiley-IEEE Press; 4th edition (July 11, 2019)
4. Behzad Razavi “Design of CMOS Phase locked loops” Cambridge University press 2020
5. John W.M.Rogers, Calvin Plett “Radio Frequency Integrated circuit design”Artech House 2010.

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER-I**
Course Code	**EEET5011P**
Course Title	**RF CIRCUITS DESIGN AND MEMS LAB**

COURSE OBJECTIVE

- To design and simulate Analog and Digital modulation for RF circuits.
- To get acquainted with BJT & MOSFET behavior at RF frequencies.
- Modeling of transistor & SPICE model.
- To design Low noise amplifier, Mixer, Oscillator, VCO, synthesizer & Poweramplifier.

COURSE OUTCOME

- To differentiate the response of BJT and MOSFET at low frequency and RFfrequency using modeling.
- To get familiarized with various RF devices, PLLs, Various RF synthesizerarchitectures and frequency dividers.

Overview

Experiment based on design and simulation of the following:

1. Analog and Digital modulation for RF circuits.
2. BJT & MOSFET behavior at RF analog and digital modulation for RF frequencies.
3. Modeling of transistor & SPICE model.
4. Low noise amplifier design.
5. Mixer design at Gigahertz frequencies.
6. Oscillator design.
7. VCO design.
8. RF synthesizer and frequency divider.
9. Power amplifier design.

Reference books

1. Thomas H. Lee “Design of CMOS RF Integrated Circuits” Cambridge Universitypress 2004.
2. B. Razavi “RF Microelectronics” Pearson Prentice Hall; 2nd edition (22 September 2011)
3. R. Jacob Baker, H.W. Li, D.E. Boyce “CMOS Circiut Design, layout and Simulation” Wiley-IEEE Press; 4th edition (July 11, 2019)
4. Behzad Razavi “Design of CMOS Phase locked loops” Cambridge Universitypress 2020
5. John W.M.Rogers, Calvin Plett “Radio Frequency Integrated circuit design”Artech House 2010.

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER-I**
Course Code	**EEET5012T**
Course Title	**TCP/IP NETWORKS & NETWORK MANAGEMENT**

COURSE OBJECTIVE

- Develop an understanding of computer communication principles.
- To develop an understanding of the underlying structure of networks and how they operate.
- To describe layered communication, the process of encapsulation, and message routing in network equipped devices using appropriate protocols.
- To study Ethernet (IEEE 802.3), token ring (IEEE802.5), fiber distributed data interface (FDDI), distributed - queue dual-bus (DQDB), Frame Relay and switched multimegabit data service (SMDS).
- To study DLL and MAC layer protocols TCP & UDP protocols, IPV4, IPV6 and FTP.
- To study ATM network, features, addressing, signalling, routing, ATM headerstructure, management and control, BISDN.
- To study network server and cloud computing concept.

COURSE OUTCOME

- To independently understand basic computer network technology. And Data Communications System and its components.
- To identify different types of network topologies and protocols and to enumerate the layers of the OSI model and TCP/IP.
- To understand high-speed, broadband transmission data communication technology based on packet switching.
- To understand concepts and technologies used in network server and Cloud Computing including virtualization, networks, and cloud systems

Overview

Module 1: Review of Networking Concepts	
	Packet switched Networks: OSI and IP models, ARQ retransmission strategies. Selective repeat ARQ. Framing and standard Data Link Control protocol-HDLC, SDLC, LAPD. Queuing models in communication networks. Ethernet (IEEE 802.3), token ring (IEEE802.5), fiber distributed data interface (FDDI), distributed - queue dual-bus (DQDB), Frame Relay and switched multimegabit data service(SMDS). Internetworking issues: Bridges, Routers and Switched networks. Routing and Flow Control algorithms in data networks.
Module 2: Internet and TCP/IP networks	
	Internet protocol,IPV4,Algorithms, Multicast IP,Mobile IP,IPV6, TCP and

	UDP ,FTP,performance of TCP/IP Networks.
Module 3: ATM Network	
	ATM network, features, addressing, signalling, routing, ATM header structure, ATM adaptation layer (AAL), management and control, BISDN,Inter-networking with ATM. Optical networks, WDM systems, cross connects, opticalLAN, Optical paths and Networks.
Module 4: Network Server and Cloud Computing:	
	Types of network severs including file server, web server, mail server, application server, FTP server, proxy server, Cloud computing: architecture of cloud computing, characteristics of cloud computing, cloud management in cloud computing ,uses of cloud management, security in cloud computing.
Module 5: Network Management:	
	What Is Network Management?, The Infrastructure for Network Management, The Internet-Standard Management Framework, Structure of Management Information: SMI, Management Information Base: MIB, SNMP Protocol Operations and Transport Mappings, Security and Administration

Reference books

1. Leon Gracia, Widjaja, "Communication Networks", Tata McGraw Hill, 2004.
2. Behrouz.a. Forouzan, "Data Communication and Networking with TCP/IP Suite", Tata McGraw Hill, 3rd August 2020
3. Larry L. Peterson, Bruce S. Davie, "Computer networks", 5th Edition, Elsevier, 2nd March 2011.
4. Windows Server 2019 Administration Fundamentals: A beginner's guide to managing and administering Windows Server environments, Packt publisher, 2nd Edition by Bekim Daut.
5. Architecting the Cloud: Design Decisions for Cloud Computing Service Models (SaaS, PaaS, and IaaS) (Wiley CIO) 1st Edition, Kindle Edition by Michael J. Kavis, 28th Jan 2014, Wiley Publishing House
6. William Stallings "Wireless Communication Networks & Systems, Global edition, 05 Jan 2016, prentice Hall
7. Jean Walrand, Kallol Bagchi & George W. Zovrist "Network Performance modelling and simulation", 16th August 2019, CRC press.

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER-I**
Course Code	**EEET5012P**
Course Title	**TCP/IP NETWORKS & NETWORK MANAGEMENT LAB**

COURSE OBJECTIVE

- To perform experiments on framing sequence like bit stuffing and character stuffing.
- To implement error detecting code.
- To test different transmission flow control protocols.
- To test various routing information protocol (RIP).

COURSE OUTCOME

- To get familiarized with various routing protocols like Sliding Window Protocol, CSMA/CD, Ethernet, Token Ring Network, IP, TCP, Leaky Bucket Algorithm, ATM.
- Verification of Stop and Wait protocol, Go Back N protocol, Selective Repeat Protocol.
- To get familiarized Execution Load Balancing Policy in Cloud Analyst with the help of cloudsim.

Overview

I. Framing Sequence

Bit Stuffing and character stuffing

II. Error Detecting Code

Cyclic Redundancy Check

III. Transmission Flow Control Protocols

Verification of Stop and Wait protocol

Verification of Go Back N protocol

Verification of Selective Repeat Protocol

IV. Routing Information protocol (RIP)

- Verification of distance vector routing algorithm
- Sliding Window Protocol and Go-back-N ARQ.
- CSMA/CD Media Access Control, Ethernet (IEEE 802.3).
- Token Ring Network.
- Transparent Bridge.

- Internet Protocol (IP).
- Transport Control Protocol (TCP).
- Leaky Bucket Algorithm (Traffic Management).
- ATM PNNI Routing.

V. Cloud Computing:

- To create x datacenters with x hosts, x VMs, x cloudlets in CloudSim
- Perform Equally Spread Current Execution Load Balancing Policy in Cloud Analyst.

Reference books

1. Leon Gracia, Widjaja, "Communication Networks", Tata McGraw Hill, 2004
2. Behrouz.a. Forouzan, "Data Communication and Networking", Tata McGraw Hill
3. Jean Walrand&PravinVaraiya, "High Performance Communication Networks" ,\ Elsevier
4. Wllliam Stallings, "Wireless Communication and Networks", Prentice Hall, 2nd edition, 2005.Prentice
5. Larry L. Peterson, Bruce S. Davie, "Computer networks", 4th Edition, Elsevier

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER-I (Elective-I)**
Course Code	EEET5012S
Course Title	**MPLS AND MODERN NETWORKS**

COURSE OBJECTIVE

- The course is designed to understand the motivation for and goals of next generation networks.
- To understand the technical features, applications and design consideration of new and emerging network technologies.
- To provide a comfortable understanding of applicable technology.

COURSE OUTCOME

- To relate and compare the core differences between traditional and new telecommunication technologies.
- Analyze, implement and apply the components of NGN architecture with NGN standards.
- To understand brief idea of technical features and design considerations of the next generation mobile networks.
- Students will be able to design a network with good capacity and efficiency.

Overview

Module 1: Next Generation Technologies, Networks and Services	
	Introduction: Next Generation (NG) Technologies, Wire line NG Technologies, FTTP, and Long- Haul Managed Ethernet**.** NGN Services: Basic and supplementary services, Multimedia services, NGN access network: DSL,FITL,FTTH
Module 2: IMS and Convergent Management	
	IMS Architecture - IMS services, QoS Control and Authentication, Network and Service management for NGN, IMS advantages, Next Generation OSS Architecture - standardsimportant to OSS architecture, Information framework, OSS interaction with IMS, NGN OSS function/ information view reference model, DMTF CIM
Module 3:MPLS and VPN:	
	Technology overview –MPLS &QoS, MPLS services and components – layer 2 VPN, layer 2. Internetworking, VPN services, signaling, layer 3 VPN –Technology overview, Remote Access and IPsec integration with MPLS VPN.
Module 4: ITU NGN Standards and Protocols and NGN Management	
	Main, drivers to Next Generation Networks NGN , ITU NGN standards , NGN protocols:SIP,H.323, MGCP,SIGTRAN , , NGN Management :Network Management and Provisioning – Configuration, Accounting, performance, security.

Module 5: Wireless NG Technologies:	
	Long Term Evolution (LTE), Enhanced HSPA Evolution Data Optimized (EVDO), Ultra Mobile Broadband (UMB), SDR and cognitive radio IoT, VOIP, IPTV

Reference books

1. Thomas Plavyk, “Next generation Telecommunication Networks, Services and Management”,Wiley& IEEE Press Publications, Sept 2011, 1st edition
2. Neill Wilkinson, “Next Generation Network Services”, John Wiley Publications, 2002.
3. Monique J. Morrow, “Next Generation Networks”, CISCO Press, 2007.
4. Robert Wood, “MPLS and Next Generation Networks: Foundations for NGN and EnterpriseVirtualization", CISCO Press, 2006.
5. Naveen Chilamkurti, Sherali Zeadally, Hakima Chaouchi, “Next Generation Wireless Technologies”, Springer, 5th June 2013.

Programme Name	**M. Tech(Electronics & Telecommunication), SEMESTER-I (Elective-I)**
Course Code	EEET5022S
Course Title	**NETWORK SECURITY MODELS**

COURSE OBJECTIVE

- This course is designed to introduce the concept of E-security, which is of immense importance in the field of networking.
- The basics of network security, concept of firewalls and web security will beintroduced.
- The algorithms and the management techniques will also be studied.

COURSE OUTCOME

- The students will be well acquainted with the concept of E-security.
- They will be able to understand different aspects of management and security of the networking.
- This can encourage the students to further study this field from research point of view.
- To understand concepts in blockchain & IoT security.

Overview

Module 1: INTRODUCTION ON SECURITY	
	Security Goals, Types of Attacks: Passive attack, active attack, attacks on confidentiality, attacks on Integrity and availability, Security services and mechanisms, Techniques: Cryptography, Substitution Ciphers, Transposition Ciphers, Stream and Block Ciphers- Steganography- Revision on Mathematics for Cryptography.
Module 2. SYMMETRIC & ASYMMETRIC KEY ALGORITHMS	
	Data Encryption Standards (DES), Advanced Encryption Standard (AES), RC4, principle of asymmetric key algorithms, RSA Cryptosystem.
Module 3: INTEGRITY, AUTHENTICATION AND KEY MANAGEMENT	
	Message Integrity, Hash functions: SHA 512, Whirlpool, Digital signatures: Digital signature Standards, Authentication: Entity Authentication: Biometrics, Key management Techniques.
Module 4. NETWORK SECURITY, FIREWALLS AND WEB SECURITY, WIRELESS NETWORK SECURITY	
	Introduction on Firewalls, Types of Firewalls, Firewall Configuration and Limitation of Firewall, IP Security Overview, IP security Architecture, Authentication Header, Security payload, Security associations, Key Management, E-mail security: PGP, MIME, S/MIME, Web security requirement, secure sockets layer, transport layer security, secure electronic transaction, dual signature. Security Attack issues specific to Wireless systems: Worm hole, Tunnelling,

	DoS, WEP for Wi Finetwork, Security for Broadband networks: Secure Ad hoc Network, Secure Sensor Networks.
Module 5. Emerging Trends in Cybersecurity	
	Introduction to blockchain technology, IoT Security

Reference books

1. Behrouz A. Forouzan," Cryptography and Network security" Tata McGraw- Hill (January 1, 2010)
2. William Stallings,"Cryptography and Network security: Principles and Practice", 7th Edition, Prentice Hall of India, New Delhi, 2017.
3. Atul Kahate," Cryptography and Network security", 4th Edition, Tata McGraw-Hill, 2019
4. R.K.Nichols and P.C. Lekkas, "Wireless Security", McGraw Hill; 1st edition (November 22, 2001)
5. H. Yang et al., "Security in Mobile Ad Hoc Networks: Challenges and Solution", IEEE Wireless Communications, Feb. 2004.
6. "Securing Ad Hoc Networks", IEEE Network Magazine, vol. 13, no. 6, pp.24-30, December 1999.
7. "Security of Wireless Ad Hoc Networks", http://www.cs.umd.edu/~aram/wireless/survey.pdf
8. David Boel et.al (Jan 2008), "Securing Wireless Sensor Networks – Security Architecture Journal of networks", Vol. 3. No. 1. pp. 65 -76.
9. Perrig, A., Stankovic, J., Wagner, D. (2004), "Security in Wireless Sensor Networks", Communications of the ACM, 47(6), 53-57.

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER-I (Elective-I)**
Course Code	**EEET5023S**
Course Title	**NANO ELECTRONICS AND NANO MATERIALS**

COURSE OUTCOME

- The student should be familiar with Nanoelectronic systems.
- To familiarize with the present research front in Nanoelectronic and to be able to critically assess future trends.
- Obtain the knowledge Nanoelectronic devices.
- To familiarize about characterization of Nanoelectronic materials.

Overview

Module 1: Introduction to Nanoelectronics:	
	Nano-scale electronics, CMOS Scaling, Scaling Issues, Limit to Scaling, System Integration limit, Interconnect Issues, Shrink down approach, Strained Silicon, High k dielectric, Advanced nanoscale MOSFET, UTB – Ultra Thin Body, Metal Gate, FINFET, logic design using FINFET, modes of operation, FINFET SRAM Design
Module 2: Nanoelectronics Devices:	
	Resonant Tunneling Diode (RTD), Electron Tunneling, Coulomb blockedRTD Structure, working, multi valued logic gates, Single Electron Devices, Single Electron Transistor (SET), and Application of Single Electron Devices for logic circuit, Quantum dots, Quantum Cellular Automata (QCA), Spintronics, Introduction to spin, Physical properties of Spintronic Devices, Spin Relaxation Mechanisms, Spin Injection, Spin Detection. Spintronic Devices, Magnetic RAM (MRAM) technology, Molecular Electronics Devices
Module 3: MEMS and NEMS:	
	Nano-and Microsystems, Nanofabrication techniques, Photolithography, Top down and bottom up approach, Biomimetics for NEMS and MEMS, nano sensors, micro and nano actuators
Module 4. Carbon Nanoelectronics	
	Band Structure, Carbon Nano structures and types of Carbon Nano tubes (CNTs), Electronic structure of Graphene, Carbon nano-fibers, Carbon clusters and Fullerenes, Synthesis of CNTs, Physical Properties, Electrical properties of CNTs, CNT Transistor, CNT based Electronics Devices, CNT based Nanocomposites.
Module 5 . Characterization for Nanoelectronic Materials:	

	Introduction of different characterization techniques, Optical Microscopy, Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force Microscopy, XRD diffraction method, X-Ray Photoelectron Spectroscopy, Scanning Tunneling Microscopy, NMR spectroscopy

Reference books

1. Nanoelectronics and information technology: advanced electronic materials and novel devices. Rainer Waser, John Wiley & Sons, 2012. 3rd Edition
2. Introduction to Spintronics, Supriyo Bandyopadhyay, Marc Cahay, 2016, 2nd Edition
3. Microstructural Characterization of Materials, DAVID BRANDON AND WAYNE D. KAPLAN, 2nd Edition, John Wiley & Sons Ltd, 2008
4. Fundamental Principles of Optical Lithography: The Science of Microfabrication, Chris Mack, 2008, Wiley, 1st Edition
5. Nanocomposite science and technology. Ajayan, P.M., Schadler, L.S. and Braun, P.V., 2006. , John Wiley & Sons.
6. MEMS/MOEM Packaging: Concepts, Designs, Materials and Processes, 2005 by Ken Gilleo, 1st Edition, McGraw-Hill
7. Hans Delfs, Helmut Knebl, “Introduction to Cryptography: Principles and Applications”, Springer, 2015.

Programme Name	**M. Tech (Electronics and Telecommunication),Semester-I (Elective-I)**
Course Code	**EEET5024S**
Course Title	**ELECTRONICS IN MEDICINE**

COURSE OUTCOMES

After completion of the course, students should be able to

- To integrate the information about generation of biopotentials
- Apply electronic engineering principles for data acquisition and measurement of biopotentials
- Analyze the working and design aspects of the instruments used in medical field.

Overview

Module 1: Fundamentals of Medical Electronics	
	Anatomy and Physiology, Physiological Systems of the Body, Problems in measuring thePhysiological variables, Components of Medical Instrument.
Module 2: Bioelectric Signals and Electrodes, Transducers	
	Origin of Bioelectric signals, Resting and Action Potentials, Depolarization and Repolarization, Propagation of Action Potentials. Electrode Theory, Recording Electrodes, Silver-Silver Chloride Electrodes, Microelectrodes. Transducer Principle, Classification of Transducers, various Transducers for the measurement of Physiological Events, Amplifiers and Signal Processing.
Module 3: The Cardiovascular System and Measurements	
	The Heart and Cardiovascular System: Heart Sounds and their measurements with Phonocardiograph, Stethoscope etc., Phonocardiogram. Blood Flow: Characteristics of Blood Flow, Measurement of Blood flow and Cardiac output with Magnetic Blood Flow meter, Ultrasonic Blood Flow Meter & Radio Graphic Method. Blood Pressure: Measurement of Blood Pressure with Indirect and Direct methods, Sphygmomanometry, Programmed Electrosphygmomanometry, Digital Blood Pressure meter, Impedance Plethysmography.
Module 4: Generation & Recording of Bio Electrical Activities	
	Electrocardiogram: ECG Electrode Placement- "Bipolar Limb Lead Configuration by Einthoven, Unipolar Limb Leads, Augmented Unipolar Limb Leads, Precordial and Marriott Leads", ECG Recorders. Electromyogram: EMG System, Electrodes used and their placement, Latency, Applications. ElectroEncephalogram: EEG Electrodes and their placement-'Anterior-Posterior' and 'Lateral' measurements, Recording Modes of EEG, Applications of EEG. ElectroRetinogram: Human Eye System, ERG Recording techniques, Standards of ERG, Applications of ERG. ElectroOculogram: EOG Recording methods
Module 5: Medical Imaging Systems	
	Introduction, X-ray Machines and Digital Radiography, Computed Tomography, CT Scanners, Ultrasonic Imaging Systems, MRI & PET Scan, Thermal Imaging Systems
Module 6: Bio Telemetry and Telemedicine	
	Introduction to Biotelemetry, The Components of a Biotelemetry System,

	Implantable Units, Single-Channel/Multi-Channel/Multi-Patient Telemetry Systems, Application of Telemetryin Patient Care, Telemedicine.

Reference books

1. R S Khandpur HANDBOOK OF BIOMEDICAL INSTRUMENTATION [3 edition] McGraw-Hill Education, 2014
2. “Biomedical Instrumentation and Measurements” by Leslie Cromwell, Fred J. Weibell& Erich A. Pfeiffer, Second Edition(2011), Prentice Hall of India publication
3. “Introduction to Biomedical Equipment Technology” by Joseph J. Carr and John M. Brown, Fourth Edition(2011), Pearson Education
4. “Medical Instrumentation Application and Design” by John G. Webster, fourth Edition, Wiley publication, 2009
5. “Biomedical Instruments : Theory and Design” by Walter Welkowitz, Sid Deutsch &MetinAkay, Second Edition, Academic Press

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER-I (Elective-II)**
Course Code	**EEET5031T**
Course Title	**DSP APPLICATIONS IN MODERN COMMUNICATION SYSTEMS**

COURSE OBJECTIVE

- To have a thorough understanding of time and frequency domain concepts and the associated mathematical tools which are fundamental to all DSP techniques
- To provide a thorough understanding about the practical design, implementation, analysis and comparison of digital filters for processing of discrete time signals.

COURSE OUTCOME

- Students should be masters in analyzing discrete-time signals in the time domain and frequency domain, using different transforms.
- Students should be able to design various types of Digital Filters like FIR and IIR and implement it on processors.
- Students should be able take up advanced courses and do projects in signal processing and its applications.

Overview

Module 1: Discrete time systems:	
	Discrete system attributes, Analysis of LTI systems, Z-Transform, Frequency Analysis, Inverse Systems, Discrete Fourier Transform (DFT), Fast Fourier Transform algorithm, Hilbert Transform, Implementation of Discrete Time Systems.
Module2 : FIR Digital filters:	
	Concept of linear phase, types, position of zeros, Design using Window method, Frequency Sampling Techniques, Park-McClellan's method etc.;
Module 3: Design of IIR Digital Filters	
	Design analog filters like Butterworth, Chebyshev and Elliptic Approximations; Various techniques of conversion of analog filter into digital filters like Impulse Invariant, Derivatives, Bilinear transformation, Match Z-transform and its modifications., mapping of s- plane to z-plane, limitations, Effect of finite precision numerical effect.
Module 4: Quantization Effects	
	Quantization methods, Limit cycle oscillations due to Quantization, Errors in frequency response due to coefficient Quantization.
Module 5: DSP Processor Fundamentals	
	DSP processor architecture, Software developments, Selections of DSP processors, Implementation considerations, finite word length effects, real time implementation, Hardware interfacing, DSP processor architectures: TMS 320C54XX, TMS 320C67XX, Blackfin processor: Architecture overview,

	memory management, I/O management, On chip resources, programming considerations, Real time implementations, Applications of DSP systems Design using fixed point and floating point implementations: FIR filters
Module 6: Application of DSP to Speech and Radar signal processing	
	Speech processing: speech analysis, speech coding, sub band coding, channel vocoder, homomorphic vocoder, digital processing of audio signals. Radar signal processing: Radar principles, radar system and parameter considerations, signal design.

Reference books

1. A.V. Oppenheim and Schafer, Discrete Time Signal Processing, Prentice Hall, 2nd edition, 2008
2. John G. Proakis and D.G. Manolakis, Digital Signal Processing: Principles,Algorithms And Applications, Prentice Hall, 3rd edition, 1995
3. L.R. Rabiner and Shafer Ronald W., Theory and Application of Digital Signal Processing, Prentice Hall, 1st edition, 2010
4. B A Shenoi, "Introduction to Digital Signal Processing and Filter Design", Wiley Interscience, 1st edition, 2005.
5. Hall D. J. DeFatta, J. G. Lucas and W. S. Hodgkiss, Digital Signal Processing, J Wiley and Sons, Singapore, 1988
6. Salivahanan, Digital Signal Processing, Mc Graw Hill,3rd edition, 2014.

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER-I**
Course Code	**EEET5031P**
Course Title	**DSP APPLICATIONS IN MODERN COMMUNICATION SYSTEMS LAB**

COURSE OBJECTIVE

- This course will provide a brief knowledge about MATLAB and its applications inthe area of signal processing.
- To emphasize on fundamentals of Digital Signal Processing and verify theoretical aspects with the help of higher level computational languages such as MATLAB.

COURSE OUTCOME

- Students should be able to apply the different transforms for the characterizations of signals and systems.
- Students should be able to design digital filters for various applications.

Overview

1. Characterization of LTI systems
2. Frequency response of the given Transfer function.
3. Fourier transform and Fourier series of time domain digital signal.
4. DTFT of discrete time signals.
5. Fast Fourier Transforms (FFT).
6. Design of different FIR filters.
7. Design of different IIR filters.
8. Effect of finite register length in FIR filter design.
9. Implementation of one algorithm on a DSP Processor.

Reference books

1. A.V. Oppenheim and Schafer, Discrete Time Signal Processing, Prentice Hall.
2. John G. Proakis and D.G. Manolakis, Digital Signal Processing: Principles, Algorithms And Applications, Prentice Hall.
3. L.R. Rabiner and B. Gold, Theory and Application of Digital Signal Processing, Prentice Hall
4. J.R. Johnson, Introduction to Digital Signal Processing, Prentice
5. Hall D. J. DeFatta, J. G. Lucas and W. S. Hodgkiss, Digital Signal Processing, J Wiley and Sons, Singapore
6. Salivahanan S, Vallavaraj A, Gnanapriya, Digital Signal Processing, Mc Graw Hill, 2nd edition

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER-I (Elective-II)**
Course Code	**EEET5032T**
Course Title	**OPTICAL COMMUNICATION AND NETWORKING**

COURSE OBJECTIVE

- The course is basic course of fiber optic communication.
- The optical fiber characteristics are studied with Optical transmitters and Optical receivers.
- To study System design and performance for Voice, video and data transmission.

COURSE OUTCOME

- Students will be aware of working of fiber optic devices, their performance and characteristics.
- Also fiber optic network and the components for the fiber optic network will be studied.

Overview

Module 1: Optical Fiber Structures and Light Guiding Principles	
	The Nature of Light, Basic Laws and Definitions of Optics, Optical Fiber Configurations and Modes, Modes in Circular Waveguides, Single-Mode Fibers, Graded-Index (GI) Fibers. Optical Fiber Materials, Photonic Crystal Fiber Concepts.
Module 2: Optical Signal Attenuation and Dispersion	
	Fiber Attenuation, Optical Signal Dispersion Effects, Design and Characteristics of SMFs, Designs and Use of Specialty Fibers, Character of Multicore Optical Fibers.
Module 3: Light Sources for Fiber Links	
	Basic Concepts of Semiconductor Physics, Principles of Light-Emitting Diodes (LEDs), Principles of Laser Diodes.
Module 4: Digital Optical Fiber Links	
	Basic Optical Fiber Links, Concepts of Link Power Penalties, Detection and Control of Errors, Coherent Detection Schemes, Higher-Order Signal Modulation Formats.
Module 5: Analog Optical Fiber Channels	
	Basic Elements of Analog Links, Concept of Carrier-to-Noise Ratio, Multichannel Amplitude Modulation, Spurious-Free Dynamic Range, Radio-Over-Fiber Links. Microwave Photonics
Module 6: Wavelength Division Multiplexing (WDM)	
	Concepts of WDM, Passive Optical Couplers, Nonreciprocal Isolators and Circulators, WDM Devices Based on Grating Principles, Dielectric Thin-Film Filter (TFF), Arrayed Waveguide Devices, WDM Applications of Diffraction Grating

Reference books

1. A. Selvarajan, SubratKar, T. Srinivas, “Optical Fiber Communications, Principles and Systems”, Tata McGraw-Hill Pub, 2003.

2. G. Keiser, “Optical Fiber Communications”, 2nd Edition, McGraw Hill, 2017.

3. Editor: Alan Willner, “Optical Fiber Telecommunications VII”, Academic Press, 2019.

4. R. Ramaswami, K. N. Sivarajan and Galen Sasaki, “Optical Networks: A practical Perspective”, (3nd Ed), Morgan Kaufmann; 2009.

5. John Senior, Optical Fiber Communications: Principles and Practice, Pearson Education; Third edition, 2014.

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER-I**
Course Code	**EEET5032P**
Course Title	**OPTICAL COMMUNICATION AND NETWORKING LAB**

COURSE OBJECTIVE

- This LAB aims to introduce students to different element of fiber optic communication such as Fiber components and measurements, transmitters and detectors, fiber amplifiers, multimode fiber links, and wavelength division multiplexing.
- To reinforce fundamentals of optical communication systems. Emphasizes theory with elements of design and applications.

COURSE OUTCOME

- Understand and measure the basic properties of the propagation of light in a guided- wave dielectric optical fiber, including attenuation, coupling, and handling.
- Understand the differences between types of light sources utilized in optical systems, including bandwidth, power, modulation, and spectra, and the appropriateness of each in a given system configuration.

Overview

1. Experiments on characteristics of optical fibers, sources and detectors
2. Analog and digital link, WDM system
3. Tutorial on optical fiber system design
4. Simulation of optical fiber modes with OptiSIM
5. Optical fiber cable as a light guide
6. Fiber optic cable transmission
7. Characteristics of connectors and splices
8. Index-matching procedures
9. Fiber optic transmitter
10. Fiber termination techniques

Reference books

1. A. Selvarajan, SubratKar, T. Srinivas, “Optical Fiber Communications, Principles and Systems”, Tata McGraw-Hill Pub, 2003.

2. G. Keiser, “Optical Fiber Communications”, 2nd Edition, McGraw Hill, 2017.

3. Editor: Alan Willner, “Optical Fiber Telecommunications VII”, Academic Press, 2019.

4. R. Ramaswami, K. N. Sivarajan and Galen Sasaki, “Optical Networks: A practical Perspective”, (3nd Ed), Morgan Kaufmann; 2009.

5. John Senior, Optical Fiber Communications: Principles and Practice, Pearson Education; Third edition, 2014.

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER-I (Elective-II)**
Course Code	**EEET5033T**
Course Title	**DATA COMPRESSION AND ENCRYPTION**

COURSE OBJECTIVE

- To study different compression techniques and coding theorems.
- To study different quantization model and compare their compression ratio.
- To study how to achieve lossless compression with significant quality and study of video and audio compression.

COURSE OUTCOME

- Students will be able to perform compression on data with significant quality and with minimum loss.
- Students will be able to perform compression on different type of data like text, audio, video, speech, etc will be analyzed and encoded with variety of techniques.
- Analyse different types of quantizers

Overview

Module 1: Introduction	
	Introduction and Background, Source Modeling, Entropy Rate of a Source, Shannon LosslessSource Coding Theorem
Module 2: Lossless Data Compression	
	Introduction, Entropy based methods, Huffman coding, Adaptive Huffman Coding, Dictionary based methods, Lempel-Ziv Coding., JEPG, Motion estimation
Module 3: Scalar Quantization	
	Scalar Quantization: Quantization problem, Uniform Quantizer, Lloyd-Max Quantizer, Adaptive Quantization, Nonuniform Quantization
Module 4: Vector Quantization	
	Introduction, Preliminaries, Design Problem, Optimality Criteria, LBG Design Algorithm,Cluster based techniques.
Module 5: Audio Compression	
	Introduction, Speech Generation, Speech Analysis, Speech Transmission, LPC Modeling, LPC Analysis, 2.4 kbps LPC Vocoder, 4.8 kbps CELP Coder, 8.0 kbps CS- ACELP Coder, Parametrized Coding, Dolby AC-3 compression.
Module 6: Introduction to Data encryption	
	Introduction – Symmetric key algorithms, Asymmetric key algorithms

Reference books

1. Elements of information theory by Thomas M. Cover, Joy A. Thomas.–2nd ed. p. cm. "A Wiley-Interscience publication, 2006.
2. Data Compression: The Complete Reference,4th edition 2007 by David Salomon, springer Publication.
3. Introduction to Data Compression, Khalid Sayood. 5th Edition, The Morgan Kaufmann Series, 2017.
4. Mark Nelson, Jean-Loup Gailly, "The Data Compression Book", John Wiley & Sons, 2nd Ed., 1995.
5. Allen Gersho and R. M. Gray, Vector Quantization and Signal Compression. The Springer International Series in Engineering and Computer Science, 1992
6. Advances in Visual Data Compression and Communication Meeting the Requirements of New Applications By Feng Wu · 2014

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER-I**
Course Code	**EEET5033P**
Course Title	**DATA COMPRESSION AND ENCRYPTION LAB**

COURSE OBJECTIVE

- This course will provide brief introduction on various aspects of data analysis and compression and build on it.
- The primary focus will be on applying these methodologies on real time data and system to get reasonable and necessary outcomes.

COURSE OUTCOME

- The practical approach toward data handling and analysis will be known to the students.
- Students will acquire some of the basic skills in the field of data compression which canbe applied on various kinds of real-time data.

Overview

1. Basic statistical operations and methods in MATLAB using toolbox
2. Discrete Cosine Transform of time domain signals
3. Huffman coding
4. JPEG lossy using DCT
5. Principal component analysis (PCA) on 1 Dimensional Data
6. Linde-buzo Gray (LBG) algorithm for data clustering
7. Wavelet analysis and synthesis
8. Study of Wavelet Packet toolbox
9. JPEG 2000
10. Set Partitioning in hierarchical trees (SPIHT)

Reference books

1. Elements of information theory by Thomas M. Cover, Joy A. Thomas.–2nd ed. p. cm. "A Wiley-Interscience publication, 2006.
2. Data Compression: The Complete Reference,4th edition 2007 by David Salomon, springer Publication.
3. Introduction to Data Compression, Khalid Sayood. 5th Edition, The Morgan Kaufmann Series, 2017.
4. Mark Nelson, Jean-Loup Gailly, "The Data Compression Book", John Wiley & Sons, 2nd Ed., 1995.
5. Allen Gersho and R. M. Gray, Vector Quantization and Signal Compression. The Springer International Series in Engineering and Computer Science, 1992
6. Advances in Visual Data Compression and Communication Meeting the Requirements of New Applications By Feng Wu · 2014

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER-I (Elective-II)**
Course Code	**EEET5034T**
Course Title	**RANDOM VARIABLES AND STOCHASTIC PROCESS**

COURSE OBJECTIVE

- The course is designed to provide a brief introduction of probability, statistics,random variables and random processes.
- Random variables and random signals will be studied with their statistical behavior.

COURSE OUTCOME

- Students will be able to know the fundamentals of the statistical theory and its different aspects.
- Also the statistical behavior of the random signals and random variables will be studied along with variety of queuing theory problems and their solutions.

Overview

Module 1: The Concept of a Random Variable	
	Introduction, Distribution and Density Functions Specific Random Variables, Conditional Distributions, Asymptotic Approximations for Binomial Random Variable.
Module 2: Functions of One Random Variable	
	The Random Variable g(x), The Distribution of g(x), Mean and Variance, Moments, Characteristic Functions
Module 3: Two Random Variables	
	Bivariate Distributions, One Function of Two Random Variables, Two Functions of Two Random Variables, Joint Moments, Joint Characteristic Functions, Conditional Distributions, Conditional Expected Values.
Module 4: Sequences of Random 'Variables	
	General Concepts, Conditional Densities, Characteristic Functions, and Normality, Mean Square Estimation, Stochastic Convergence and Limit Theorems, Random Numbers: Meaning and Generation
Module 5: STOCHASTIC PROCESSES General Concepts	
	Definitions, Systems with Stochastic Inputs, The Power Spectrum, Discrete-Time Processes
Module 6: Random Walks and Other Applications	
	Random Walks, Poisson Points and Shot Noise, Modulation, Cyclostationary Processes, Bandlimited Processes and Sampling Theory, Deterministic Signals in Noise, Bispectra and System Identification

Reference books

1. Bernard Picinbono,'Random Signals & Systems', by. Pearson Education 1993
2. A. Papoulis 'Probability Random Variables & Stochastic Processes', 4th Edition, 2017
3. Mortensen: Random Signals & Systems, Wiley–Blackwell, 1987.

4. Douglas C. Montgomery and George C. Runger, Applied Statistics and Probability for Engineers, Wiley; Sixth edition,2016.
5. Peyton Peebles, Probability, random variables, and random signal principles, McGraw-Hill, Year: 1987

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER-I**
Course Code	**EEET5034P**
Course Title	**RANDOM VARIABLES AND STOCHASTIC PROCESS**

COURSE OBJECTIVE

- The course is designed to provide a brief introduction of probability, statistics ,randomvariables and random processes.
- Random variables and random signals will be studied with their statistical behavior.

COURSE OUTCOME

- The practical approach towards the fundamentals of the statistical theory and its different aspects will be known to the students.
- The practical approach towards statistical behavior of the random signal and random variables with variety of queuing theory problems and their solutions will be known to the students.

Overview

1. Stochastic Process with Discrete Index Set
2. Demonstrating Stochastic Process with Continuous Index
3. Demonstrating Bernoulli Process.
4. Demonstrating Poisson Process.
5. Demonstrating Renewal Process.
6. Demonstrating Simple Random Walk

Reference books

- Bernard Picinbono,'Random Signals & Systems', by. Pearson Education 1993
- Papoulis 'Probability Random Variables & Stochastic Processes', 4th Edition, 2017 Mortensen: Random Signals & Systems, Wiley–Blackwell, 1987
- Douglas C. Montgomery and George C. Runger, Applied Statistics and Probability for Engineers, Wiley; Sixth edition,2016.
- Peyton Peebles, Probability, random variables, and random signal principles, McGraw-Hill, Year: 1987

Programme Name	**M. Tech. (Electronics & Telecommunication),SEMESTER-I (Open elective)**
Course Code	**EEET5061S**
Course Title	**ARTIFICIAL NEURAL NETWORKS AND MACHINE LEARNING**

COURSE OBJECTIVE

- The course is designed to introduce the field of neural network systems and Artificial Neural Networks.
- The basic concepts of machine learning are also the main goal of this subject.

COURSE OUTCOME

- Students will be able to understand the fundamental concepts of the neural network systems.
- This is a new field of research thus students will get to know about the recent trends in research fields.

Overview

Module 1: Introduction: Biological neurons and memory
Structure and function of a single neuron; Artificial Neural Networks (ANN); Typical applications of ANNs: Classification, Clustering, Vector Quantization, Pattern Recognition, Function Approximation, Forecasting, Control, Optimization.
Module 2: Supervised Learning
Single-layer networks; Perceptron-Linear separability, Training algorithm, Limitations; multi-layer networks-Architecture, Back Propagation Algorithm (BTA) Adaptive Multi-layernetworks-Architecture, training algorithms; Recurrent Networks; Feed-forward networks;Radial-Basis-Function (RBF) networks;
Module 3: Unsupervised Learning
Winner-takes-all networks; Hamming networks; Maxnet; Simple competitive learning; Vector-Quantization; Counter propagation networks; Adaptive Resonance Theory; Kohonen'sSelf-organizing Maps; Principal Component Analysis.
Module 4: Associated Models and Optimization Methods
Hopfield Networks, Brain-in-a-Box network; Boltzmann machine; Hopfield Networks for- TSP, Solution of simultaneous linear equations; Iterated Gradient Descent; Simulated Annealing; Genetic Algorithm.
Module 5: Introductory Material to Machine Learning and AI
Motivations for Studying ML, Supervised and Unsupervised learning, Machine Learning in the Large
Module 6: Classical and Theoretical ML Topics
Concept Learning (also called Learning from Examples), Learning from Analogy, Explanation Based Learning, Structure Learning, Reinforcement Learning, Decision

Tree Learning, Decision List Learning , Oracle Based Learning, Probably Approximately Correct (PAC) Model, Boosting, Bayesian Learning: MaximumLikelihood Estimates, ParameterEstimation, Bayesian Belief Networks
Module 7: Introductory Graphical Models Based Learning
Expectation Maximization as a fundamental technique, Hidden Markov Models (HMM): Motivation for Generative Models, Forward-backward Algorithm, BaumWelch Iteration, Feature Enhanced HMM.
Module 8: Maximum Entropy Markov Models (MEMM)
Motivation for Discriminative Models, Training of MEMMs (v) Introductory Optimization Based Methods: Neural Nets, Support Vector Machines, Genetic Algorithms (v) Applications: Text Learning, Speech Processing, Data Mining, Bioinformatics

Reference books

1. Simon Haykin, "Neural Networks - A Comprehensive Foundation", Macmillan Publishing Co., New York, 1994.
2. A Cichocki and R. Unbehauen, "Neural Networks for Optimization and Signal Processing", John Wiley and Sons, 1993
3. J. M. Zurada, "Introduction to Artificial Neural Networks", (Indian edition) Jaico Publisher, Mumbai, 1997.
4. Hui Jiang, "Machine Learning Fundamentals: A Concise Introduction" Cambridge University Press, 2022
5. Alexander Jung, "Machine Learning: The Basics (Machine Learning: Foundations, Methodologies, and Applications)" Springer, 2022

Semester-II

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER II**
Course Code	**EEET5002S**
Course Title	**RESEARCH METHODOLOGY & IPR**

COURSE OBJECTIVES

After completion of this course, students should be able to

- Develop understanding of the basic framework of research process, various researchdesigns and techniques.
- Identify various sources of information for literature review and data collection
- Develop an understanding of the ethical dimensions of conducting applied research

COURSE OUTCOMES

- Understand research terminology.
- Be aware of the ethical principles of research, ethical challenges and approval processes.
- Describe quantitative, qualitative and mixed methods approaches to research.
- Identify the components of a literature review process
- Critically analyse published research

Overview:

Module 1:	**Review of Statistics**
Concept of mean, mode, median, arithmetic mean, geometric mean, harmonic mean etc., Probability and problem solving, Distributions: Gaussian, chi-square, student-t distribution Design of experiment,Hypothesis, testing and identification, Problems on hypothesis testing	
Module 2:	**Research Skills**
What is research, why research needs to be done, Research problem formulation, Literature survey, Analysis of the problem, Experimental evaluation of the problem, Survey techniques, Statistical analysis. Writing of short and long abstracts, Writing and format of international and national journal papers, Report writing, English writing and communication skills, Power point and other presentation skills	
Module 3:	**Research theory and Practice**
Structuring the research project, research ethics, finding and reviewing the literature.	
Module 4:	**Data Collection and its Analysis**
Data sources, methods and approaches, the nature of data, collecting and analysing secondary data, collecting primary data, quantitative and qualitative data analysis, sampling and selection in qualitative research, making convincing arguments with qualitative data.	

Recommended Readings

- " Fundamentals of Research Methodology" 1st edition Dr Jayanta Kumar Nayak, Dr Priyanka Singh, SSDN Publishers and Distributers, 2015
- "Qualitative Researching": Jennifer Mason, 2nd edition, SAGE Publication, 2002
- "Research methods: the basics" : Walliman and Nicholas, Taylor and Francis India, 2021
- "The Essential Guide to Doing Research", 4th edition, Zina O' Leary, SAGE publications,2021
- "Research Methodology Handbook. Introductory Guide to Research Methods for SocialResearch": Stuart MacDonal & Nichola Headlam, CLES, 2008.

Programme Name	M. Tech. (Electronics & Telecommunication), SEMESTER II
Course Code	EEET5013T
Course Title	5G Communication

COURSE OBJECTIVES

- Learn about underlying technologies and concepts associated with 5G.
- Discover key difference between 5G and previous generation of mobile technology.
- Learn about key technologies of 5G standard along with 5G applications.
- Students will understand the procedures and processes of 5G UE in NG RAN.

COURSE OUTCOMES

- Understand the concept of the channel models and MIMO in 5G and its techniques.
- Understand 5G architecture, its components and functional criteria.
- Understand the concept device to device (D2D) communication and standardization.
- Understand the concept interference management, mobility management and security issues in 5G.

Module 1: The 5G radio-access technologies	
	Access design principles for multi-user communications, Orthogonal multiple-access systems, Spread spectrum multiple access systems, Capacity limits of multiple-access methods, Sparse code multiple access (SCMA), Interleave division multiple access (IDMA), Radio access for dense deployments, OFDM numerology for small-cell deployments, Small-cell sub-frame structure, Radio access for V2X communication, Medium access control for nodes on the move, Radio access for massive machine type communication.
Module 2: Multiple-input multiple-output (MIMO) systems	
	Introduction to Multi-antenna Systems, Motivation, Types of multi-antenna systems, MIMO vs. multi-antenna systems. Diversity, Exploiting multipath diversity, Transmit diversity, Space-time codes, The Alamouti scheme, Delay diversity, Cyclic delay diversity, Space-frequency codes, Receive diversity, The rake receiver, Combining techniques, Spatial Multiplexing
Module 3: The 5G architecture	
	Introduction, NFV and SDN, Basics about RAN architecture, High-level requirements for the 5G architecture, Functional architecture and 5G flexibility, Functional split criteria, Functional split alternatives, Functional optimization for specific applications, Integration of LTE and new air interface to fulfill 5G Requirements, Enhanced Multi-RAT coordination features, Physical architecture and 5G deployment
Module 4: Device-to-device (D2D) communications and 5 G Networking :	
	D2D: from 4G to 5G, D2D standardization: 4G LTE D2D, D2D in 5G: research challenges, Radio resource management for mobile broadband D2D, RRM techniques for mobile broadband D2D, 5G D2D RRM concept. Coordinated multi-point transmission in 5G: Joint Transmission CoMP enablers – Distributed cooperative transmission - JT CoMP with advanced receivers - Relaying and network coding in 5G: Multi-flow wireless backhauling - Buffer-aided relaying.
Module 5: Interference management, mobility management, and security for 5G:	
	Interference management in 5G, Interference management in UDN, Interference management for moving relay nodes, Interference cancelation, mobility management in 5G, User equipment controlled versus network-controlled handover, Mobility management in heterogeneous 5G networks ,Attacks in 5G Wireless Networks , Elements in a 5G security architecture, Security Services in 5G Wireless Networks

Reference books

1. "5G Mobile and Wireless Communications Technology", Afif Osseiran, Jose F.Monserrat, Patrick Marsch ,Cambridge University Press, Second Edition(2011).
2. "5G NR: The Next Generation Wireless Access Technology", Erik Dahlman, Stefan Parkvall, Johan Skold, Elsevier, First Edition(2016)
3. "Fundamentals of 5G Mobile Networks", Jonathan Rodriguez ,Wiley, First Edition (2010)
4. "An Introduction to 5G The New Radio, 5G Network and Beyond", Christopher Cox, Wiley, 14 December 2020
5. "5G NR Architecture, Technology, Implementation, and Operation of 3GPP New Radio Standards", Sassan Ahmadi, Elsevier Science, 15 June 2019.

Programme Name	M. Tech. (Electronics & Telecommunication), SEMESTER II
Course Code	EEET5013P
Course Title	5G Communication Lab

COURSE OBJECTIVES

- Learn about underlying technologies and concepts associated with 5G.
- Discover key difference between 5G and previous generation of mobile technology.
- Learn about key technologies of 5G standard along with 5G applications.
- Students will understand the procedures and processes of 5G UE in NG RAN.

COURSE OUTCOMES

1. Characterize and analyze various modulation and multiplexing techniques e.g. OFDM, NOMA etc.
2. Understand the 5G techniques e.g. massive MIMO. mmWave etc. for the design of communication systems
3. Understand Beamforming and frame structure for 5G.
4. Understand D2D communications, Interference management, mobility management, and security for 5G.

Module 1: The 5G radio-access technologies	
	1. 5G Communications Link Analysis with Ray Tracing using MATLAB. 2. Characterize and analyze various modulation and multiplexing techniques e.g. OFDM, NOMA etc.
Module 2: Multiple-input multiple-output (MIMO) systems	
	1. MIMO Wireless System Design for 5G using MATLAB 2. 5G Waveforms generation using MATLAB 3. MATLAB Project on Massive MIMO System Implementation with Perfect CSI
Module 3: The 5G architecture	
	1. 5G Beamforming Design 2. Frame Structure of 5G technology
Module 4: Device-to-device (D2D) communications and 5 G Networking :	
	1. Wireless Connectivity in the 5G Era for WLAN using MATLAB 2. 5G Beamforming Design 3. Spatial Multiplexing and Hybrid Beamforming for 5G Wireless Communications
Module 5: Interference management, mobility management, and security for 5G:	
	1. Security for 5G Mobile Wireless Networks 2. To study Interference Management in 5G and Beyond Network: Requirement. 3. To study Mobility Management Issues and Solutions in 5G-and-Beyond Network.

Reference books

1. "5G Mobile and Wireless Communications Technology", Afif Osseiran, Jose F.Monserrat, Patrick Marsch ,Cambridge University Press, Second Edition(2011).
2. "5G NR: The Next Generation Wireless Access Technology", Erik Dahlman, Stefan Parkvall, Johan Skold, Elsevier, First Edition(2016)
3. "Fundamentals of 5G Mobile Networks", Jonathan Rodriguez ,Wiley, First Edition (2010)

4. “An Introduction to 5G The New Radio, 5G Network and Beyond”, Christopher Cox, Wiley, 14 December 2020
5. “5G NR Architecture, Technology, Implementation, and Operation of 3GPP New Radio Standards”, Sassan Ahmadi, Elsevier Science, 15 June 2019.

Programme Name	M. Tech. (Electronics & Telecommunication), SEMESTER-II
Course Code	EEET5014T
Course Title	EMBEDDED SYSTEM DESIGN

COURSE OBJECTIVE

- To implement research oriented concepts in embedded system.
- Complete design of an embedded system with functional requirements for hardware and software components including processor, networking components, along with applications, subsystem interfaces, networking, and middleware.
- Understand inter-process communication and the role of middleware.
- Understand network protocol layers and explain the specific role of each.
- Develop standard project plans for a software development team including interface definition.

COURSE OUTCOME

- Students should be able to design embedded systems.
- Students should understand the general process of embedded systemdevelopment
- Ability to use C to develop embedded software.
- Students should be able to interface peripherals, knowledge of typicalinterfacing standards.
- Understanding of what an embedded system R&D project is, and the activitiesit involves.

Module 1. Introduction
Introduction to Embedded System, Classification of Embedded Systems, Applications of Embedded System, Purpose of Embedded System, Skills Required for Embedded Systems Design. Design challenges, optimizing designing metrics, time to market.
Module 2.Embedded Hardware
Von-Neman Architecture, Harvard architecture, super Harvard architecture, study of on- chip peripherals like I/O ports, timers, counters, interrupts, on-chip ADC, DAC, LCD, UART, PWM etc. Stepper Motor Interfacing - DC Motor Interfacing, clock circuitry Watchdog timer, Hardware Architecture of Embedded System, Software Architecture of Embedded Systems. Embedded C program using 8051.
Module 3. Real Time Operating System Concept
Architecture of kernel, task scheduler Algorithm, ISR, Semaphores, mailbox, message queues, pipes, events, timers, memory management, RTOS services In contrast with traditional OS.
Module 4. Embedded communication
Need For Communication Interfaces, OSI Reference Model, Basic Of Networks, Network Topology, RS232/UART,RS422/RS485, USB, Infrared, Ethernet, IEEE 802.11, Bluetooth, SPI, I2C, CAN, Wifi, Digital Thermometer, Navigation Systems, RF Tag.
Module 5. Embedded system design methodology

Different Embedded System Development Models, Requirement Engineering,Design Tradeoff, Co-Design, Hardware Design, Software Design, Implementation, Integration & Testing, Packaging, Configuration Management, Managing Embedded System Development Projects.
Module 6. Embedded processors
ARM Processor Fundamentals, Instruction Set-Data Processing Instruction, Load Store Instruction, DSP Based Embedded Systems- Need for DSP-based Embedded Systems, Advantages of Digital Processing Signals, DSP Architecture.

Reference books

1. "Embedded system" ,Raj Kamal ,Tata McGraw Hill,2003
2. "Embedded Real time systems" Prasad ,Dream tech Wiley Publication,2003
3. "An embedded Software Primer" , David Simon, Pearson Publication,1999
4. "ARM System Developer"s Guide, Designing and Optimizing System Software",Andrew N. Sloss, Dominic Symes, Chris Wright - Morgan Kaufmann Publisher,2004.
5. "Embedded Systems", Frank Vahid ,Wiley India,2006.

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER-II**
Course Code	**EEET5014P**
Course Title	**EMBEDDED SYSTEM DESIGN LAB**

COURSE OBJECTIVE

- Study of different Embedded Software Development Tools like Keil µvision,Proteus, Flowcode.
- To perform experiments on the Embedded Hardware Development Board.
- To perform experiments on RTX51Tiny and study its features.
- To Verify Communication Protocol like RS232,I2C, SPI, CAN, Ethernet Wiredbuses and Bluetooth, IrDA and Zigbee and Wifi buses.

COURSE OUTCOME

- Students should be able to do Embedded C programming.
- Students should be able to perform experiments on different developmentboards.
- Students should get introduced with application of embedded system indifferent fields.

LAB 1) Embedded Software Development Tools:-Keil µ vision 3 and 4 project management, Study How to create Embedded Project, Compile and Test Projectfor 8051 and it's Derivative, Testing of 8051 based project on Target Board.

LAB2) Embedded Hardware Development Board:-To Study 8051 and LPC2148Board Architecture, Study Communication Interface of Board like UART, USB.

LAB3) Interfacing LCD, Interfacing Keyboard and display key pressed on LCD,Interfacing single Digit, Two Digit and 5*7 Led dot matrix with 8051 and ArduinoUNO.

LAB4) Embedded Communication System design: - Verification of Communication Protocol like I2C, SPI, Wired buses and Bluetooth, IrDA and Zigbee and Wifi using Arduino and microcontroller.

LAB5) RTOS: Study of Various Commands of RTOS like RTX51 tiny. Free RTOS,RTLinux and programming.

LAB6) Mini Project: Implement and Design Mini project based on embeddedApplications

Reference books

1. "Embedded system" ,Raj Kamal ,Tata McGraw Hill,2003
2. "Embedded Real time systems" Prasad ,Dream tech Wiley Publication,2003
3. "An embedded Software Primer" , David Simon, Pearson Publication,1999
4. "ARM System Developer"s Guide, Designing and Optimizing System Software",Andrew N. Sloss, Dominic Symes, Chris Wright - Morgan Kaufmann Publisher,2004.
5. "Embedded Systems", Frank Vahid ,Wiley India,2006.

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER-II (Elective – III)**
Course Code	**EEET5041S**
Course Title	**ERROR CORRECTING CODES**

COURSE OBJECTIVE

1. The course is designed to provide a brief idea of linear algebraic functions and differentiate vectors according to their properties.
2. Evaluation of the performance of binary and non-binary error correcting codes.
3. Study of different error correcting codes for wireless environment.

COURSE OUTCOME

After successful completion of this course, students will be able to

1. Understand different codes are used for encoding the data.
2. Design a code with greater compression ratio and with minimum error and high signal to noise ratio.
3. Implement different encoding algorithms for various codes.

COURSE CONTENTS

Module 1	**Linear Abstract Algebra and Finite Fields**
	Groups, Fields, Rings, Vector spaces, subspaces, Galois field, Extension fields, Primitive element, primitive polynomial, GCD of polynomial, LCM ofpolynomial, minimal polynomial, cyclotomic cosets, factorization of (X^n-1) over a Galois field, construction of generator polynomial & parity check polynomial primitive n^{th}root of unity. Linear Block Codes, Cyclic Codes: Properties, Various methods of generation and detection of cyclic codes, error detecting capability, cyclic Hamming code and Golay code.
Module 2	**BCH codes**
	binary primitive BCH codes, decoding, iterative algorithm for finding the error location polynomial, error location numbers and error correction, implementation of error correction. Q-ary linear block codes, primitive BCH codes, RS codes, decoding of BCH and RS codes.
Module 3	**Convolutional Codes**
	Encoder and decoder, structural properties, optimum decoding of Convolutional codes, Viterbi, soft output Viterbi BCGR algorithm.
Module 4	**Turbo coding and Low Density Parity Check Codes**
	Encoding, decoding scheme for Turbo code, Turbo code's application Encoding ,decoding scheme for LDPC , LDPC's application
Module 5	**Compression Techniques and security coding techniques**
	Text compression, image compression and video compression techniques, Public key cryptography, coded based cryptosystem –McEliece and Niederreiter, RSA, cryptosystem based on full decoding, codedbased signature

Reference books:

1. "Error Control Coding", Shu Lin, Daniel J.Costello ,2nd Edition, Pearson, Reprint 2012.
2. " Error Control Coding and security for data network, Analysis of super channel concept",G.Kabatiansky,E.Krouk,S.Semenov, Jhon Wiley & Sons Ltd.,2005
3. "Fundamentals of Error-Correcting Code",W. C. Huffman & Vera Pless, Cambridge University Press; 1st edition (18 February 2010).
4. "Error control systems for Digital communication &storage", Stephen B. Wicker, Prentice Hall,1995
5. "Fundamentals of Multimedia Video Compression",Ze-Nian Li,Mark S Drew and Jiangchuan Liu,2nd Edition,Springer ,(9th April 2014).
6. "Theory and Practice of Error Control Codes", *Richard E. Blahut, Addison Wesley Longman Publishing Co (1 July 1983).*

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER II (Elective – III)**
Course Code	**EEET5042S**
Course Title	**Advanced Communication Systems**

COURSE OBJECTIVES

- To understand the basics of the modern microwave communication systems, its parameters and terminology.
- To study the different communication systems, modulation techniques, reception system, noise considerations and performance of the systems.
- Understanding the key issues of Microwave communication systems.

COURSE OUTCOMES

- Students will be able to know the performance parameters of the different propagation models and their configuration for satellite communication.
- Students will be able to know Up link and down link frequency spectrum.
- Understand the concept of design analysis for Active and Passive Repeater.
- Students will be able to know the concept of design analysis for Satellite Communication and earth design criteria.

Module 1: Noise Consideration and LOS Propagation, System performance	
	Sources of noise, effect of noise on system performance, Noise figure, noise characterization of microwave receiver, Communication link SNR calculation. Introduction to LOS propagation, Introduction of point to point communication, point to point fixed communication technologies, bandwidth and capacity of microwave LOS link. LNA design concept related to satellite communication.
Module 2: Active and Passive Repeater design	
	Active Repeater: Site acquisition, Tower issue, power.Passive repeater: Plane reflector, back to back antenna, and practical issues.
Module 3: Tropo-scatter Propogation	
	Tropo scatter background, Global Application, Tropo scatter path characteristics, Tropo scatter equipment, System architecture, diversity reception.
Module 4: Satellite Communication	
	Satellite orbit, satellite access, FDMA: Single Access Preassigned FDMA, Demand-Assigned FDMA, Spade System Bandwidth-Limited and Power-Limited TWT Amplifier Operation, FDMA Downlink Analysis, TDMA: Preamble and Postamble ,Carrier Recovery ,Network Synchronization ,Unique Word Detection Traffic, Frame Efficiency and Channel Capacity, Demand-Assigned TDMA Speech Interpolation and Prediction, Downlink Analysis for Digital Transmission, On-Board Signal Processing for FDMA/TDM Operation, Spread spectrum modulation, earth segment and satellite application, Slow FHSS and Fast FHSS
Module 5: Earth Station design criteria	
	Earth station configuration, antenna subsystem, Feed subsystem, tracking systems.

Reference books

1. **"**Satellite Communication", Dennis Roddy, McGraw-Hill Education, fourth Edition,(10th February 2006).
2. "Communication Services Via Satellite ,A handbook for Design ,Installation and service Engineer",G.E.Lewis, Elsevier Science, Second Edition (12th May 2014).
3. "Radio Frequency and microwave communication circuit", D. K. Mishra, Wiley Interscience, Second Edition,(2004).
4. "Microwave Radio Transmission design", Trevor Manning ,Artech House ,Second Edition,(2009)
5. "World Satellite Communication and earth station", Brian Ackroyd, BSP Professional,(1990)

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER-II (Elective – III)**
Course Code	**EEET5043S**
Course Title	**COGNITIVE RADIO**

COURSE OBJECTIVES

- To understand the evolving software defined radio and cognitive radio techniques and their essential functionalities.
- To study the basic architecture and standard for cognitive radio.
- To understand the physical, MAC and Network layer design of cognitive radio.

COURSE OUTCOMES

- Students will be able to know the design principles on software defined radio and cognitive radio
- Students will be able to develop the ability to design and implement algorithms for cognitive radio spectrum sensing and dynamic spectrum access.
- Students will be able to gain knowledge about Mac and Network Layer Design for Cognitive Radio.
- Students will be able to understand the concept of Security Management and Spectrum Management of Cognitive Radio Networks.

Module 1: Software Defined Radio Architectures for Cognitive Radio	
	SDR and Cognitive Radio relationship, SDR architecture , Digital Signal Processor and SDR Baseband Architecture, Reconfigurable Wireless Communication Systems: Unified Communication Algorithm ,Reconfigurable OFDM Implementation Reconfigurable OFDM and CDMA, Digital Radio Processing: Conventional RF Digital Radio Processing (DRP) Based System Architecture
Module 2: Cognitive Radio Architecture	
	Network Coding for Cognitive Radio Relay Networks, Cognitive Radio Networks Architecture, Terminal Architecture of CRN, Scaling Laws of Ad-hoc and Cognitive Radio Networks.
Module 3: Spectrum Sensing and Dynamic Spectrum Access for Cognitive Radio	
	Spectrum Sensing to Detect Specific Primary System, Spectrum Sensing for Cognitive OFDMA Systems, Spectrum Sensing for Cognitive Multi-Radio Networks Spectrum Sharing Models of Dynamic Spectrum Access - Unlicensed and Licensed Spectrum Sharing, Fundamental Limits of Cognitive Radio.
Module 4: Mac and Network Layer Design for Cognitive Radio	
	MAC for Cognitive Radios, Multichannel MAC, Slotted-ALOHA with Rate-Distance Adaptability, CSMA with AMC, Routing in Cognitive Radio Networks, Control of CRN, Network Tomography, Self-organisation in Mobile Communication Networks, IEEE 802.11 Protocols
Module 5: Security Management and Spectrum Management of Cognitive Radio Networks	
	Security Properties in Cellular Data Networks, Dilemma of CRN Security, Requirements and Challenges for Preserving User Privacy in CRNs, Implementation of CRN Security. Spectrum Management: Spectrum Sharing, Spectrum Pricing, Mobility Management of Heterogeneous Wireless Networks,Regulatory Issues and International Standards.

Reference books

1. “COGNITIVE RADIO Network”, Kwang-Cheng Chen, Ramjee Prasad,Wiley ,First Edition(2009).
2. “Cognitive Radio Communications and Networks”, Alexander M. Wyglinski, Maziar Nekovee, Thomas Hou Academic Press, Elsevier, 2010.
3. “Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems,” Huseyin Arslan (Ed.), Springer, 2007.
4. “Cognitive Radio Technology”, Bruce Fette, Newnes, 2006.
5. “Principles of Cognitive Radio”, Ezio Biglieri, Professor Andrea J. Goldsmith, Dr Larry J. Greenstein, Narayan B. Mandayam, H. Vincent Poor, Cambridge University Press, 2012.

Programme Name	**M. Tech. (Electronics and Telecommunication), SEMESTER-II (Elective – III)**
Course Code	**EEET5044S**
Course Title	**VIRTUAL INSTRUMENTATION**

COURSE OBJECTIVES

- It provides new concepts towards measurement and automation.
- It imbibes knowledge about how to control an external measuring device by interfacing a computer.
- To become competent in data acquisition and instrument control.
- To learn applications of programming, data acquisition, data analysis, and signal processing used in the design of medical and Laboratory instrumentation.
- To learn LABVIEW as a tool for the design of computer-based virtual instruments, with added software-based intelligence to sensors and basic Laboratory bench devices.

COURSE OUTCOME

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

- Acquire knowledge on how virtual instrumentation can be applied for data acquisition and instrument control.
- Identify salient traits of a virtual instrument and incorporate these traits in their projects.
- Experiment, analyze and document in the Laboratory prototype measurement systems using a computer, plug-in DAQ interfaces and bench level instruments.
- Design instrumentation systems involving signal sensing and conditioning, data acquisition, data analysis, signal processing, and human computer interface.
- Students will get idea of application of VI in embedded systems, image processing, medical field, control system and instrumentation engineering etc.

Module 1: Introduction to Virtual Instrumentation-LABVIEW	
	LABVIEW environment-Pop-Up Menus, Palettes-Tools, Controls and Functions Palette.Editing and debugging tools.
Module 2: Sub VI and Express VI and Structures	
	Sub VI-Definition and utility, creating sub VI-connector and selection method. Express VI- utility, generation of signal using express VI. Formula node, MATLAB script node, Loops- FOR and WHILE loops, use of shift registers, case, event, global VI and flat sequence structure.
Module 3: Arrays and Clusters , Charts and Graphs	
	Arrays, concept of Auto-indexing, creating array controls and indicators, array operations. Clusters, creating clusters controls and indicators, cluster operations. Inter-conversion of arrays and clusters. Charts, scope, strip and sweep charts.

	Graphs, waveform graphs and XY graphs
Module 4: Signal generation, processing and analysis using LABVIEW and File input and outputs	
	Wave and pattern VI, finding FFT using different windows, signal processing and analysis operations, File formats, file I/O functions, path functions, writing to and reading from files andspreadsheet
Module 5: Data acquisition and Applications of Virtual Instruments	
	Measurement and Automation Explorer (MAX),Acquiring and measuring data, DAQ in LABVIEW, DAQ assistant, task timing and task triggering in DAQ assistant, NI-DAQmax task, it's configuration, testing and measurements. Instrument control using LABVIEW, Applications of Virtual Instruments.

Reference books

1. "Virtual Instrumentation using LABVIEW",Sanjay Gupta and Joseph John, TMHPublications, 2013.
2. "LABVIEW for Everyone: Graphical Programming Made Easy and Fun", Jeffrey Travis , Jim Kring, Prentice Hall Publications,2006.
3. "Learning with LABVIEW 2009", Robert H. BishopPrentice Hall Publication,1st edition ,2009
4. "PIC Cookbook for Virtual Instrumentation", Richard Grodzik, Elektor International Media ,2010
5. " A software Engineering approach to LabView",John Conway, Steves Watts, Prentice Hall(2003)

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER-II (Elective – IV)**
Course Code	**EEET5051T**
Course Title	**ANTENNA DESIGN**

COURSE OBJECTIVES

- The course is designed to know and use standard antenna characterization parameters.
- To design simple antenna such as dipole, micro strip antenna, etc. To understand electromagnetic radiation mechanism and design the antenna with required radiation pattern.
- To understand and design antenna system for variety of communication models, RADAR and power transfer system.

COURSE OUTCOME

- Students will be able to know the aspects of the antenna design.
- To design an antenna with required parameters and models.
- Students will be able to know the concept of impedance of antennas.
- Students will be able to know the concept of microstrip antennas and printed antennas for 5-G network.

Module 1: Introduction	
	Integral Equation Methods, Axisymmetric 3D structures, Vector formulations for 3D structures, Entire-domain versus sub-sectional representations, The Finite Element Method, The Finite Element Method applied to the scalar and vector Helmholtz equations, Radiationboundary conditions for open structures.
Module 2: Antenna Fundamentals and Numerical Modeling of Antennas	
	Dipole and Loop Antennas, Antenna Parameters, Noise Temperature, Baluns.,different types of antennas, Numerical Electromagnetic Code (NEC)
Module 3: Impedance of Antennas	
	Reciprocity Theorems and the Induced EMF Method, The Antenna as a Boundary ValueProblem, Impedance of a Waveguide-fed Aperture Antenna, Impedance of a Dipole: Pocklington Equation, Impedance by Numerical Methods: The Method of Moments, Example of General-purpose Numerical Technique: The NEC Code.
Module 4: Phased Array Antennas and Their Synthesis	
	Introduction to Arrays, Uniform and Nonuniform Linear Arrays, Synthesis of Linear ArrayAntennas, Dolph-Chebyshev Arrays, Taylor Distribution Functions.
Module 5: Microstrip Antennas and printed Antennas for 5G	

	Single-mode cavity model for radiation calculations, Multi-mode cavity model for impedance calculations, Feed Structures for Linear and Circular Polarization, Electric-fieldIntegral Equation & Green's Functions, Design of Microstrip Patch Antennas, 5-G Extender antenna systems to enhance indoor millimeter wave reception, Planar printed MIMO antennas for 5-G access point, Multifunctional antennas for 5 –G communication.

Reference books

1. "Printed Antennas for 5-G networks",Ladislau Matekovits,Binod Kumar Kanaujia, Jugul Kishor,Surendra Kumar Gupta,Springer,(2nd April 2022)
2. "Computational Methods for Electromagnetics", Peterson, Ray &Mittra, IEEE Press,1998.
3. "Antenna Theory and Design Stutzman and Theile ,Wiley, 3rd edition, 2012.
4. "Modern Antenna Design", Milligan, T. A., Wiley-IEEE Press, 2nd edition ,2005.
5. "Antenna Theory Analysis and design",Constantine A.Balanis,Wiley, 4th edition,2016

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER-II (Elective – IV)**
Course Code	**EEET5051P**
Course Title	**ANTENNA DESIGN LAB**

COURSE OBJECTIVES

- To be familiar with the most popular antenna design programs
- To investigate the different parameters associated with the specific antenna.
- To deal with various wire antennas, dipole, loop, helix etc.
- To get close to arrays and the different parameters that controls the shape of the pattern.
- To design yagi antenna using designs graphs and software programs.
- To investigate the high directional antennas such as Horn and Reflector antennas.

COURSE OUTCOME

- Students can understand the Antenna Basics, basic Antenna parameters.
- Design Concepts of Different Types of Antennas.VHF, UHF and Microwave Antennas-I&II.
- Different Kinds of Wave Propagation.
- Antenna for Special applications& antenna temperature.
- Practical design considerations of antennas.

Overview

- Perform Polarization test, modulation test, variation of radiation pattern.
- Impedance matching, stub design.
- SWR measurement
- Design basic antennas and study its radiation characteristics.
- Design advance antennas and study its radiation characteristics.
- Design Paraboloid reflector and study its radiation characteristics.
- Design of slot and microstrip antenna and study its radiation characteristics.
- Design rectangular microstrip patch antenna for 5 G application and study its radiation characteristics.

Reference books

1. "Printed Antennas for 5-G networks",Ladislau Matekovits,Binod Kumar Kanaujia, Jugul Kishor,Surendra Kumar Gupta,Springer,(2nd April 2022)
2. "Computational Methods for Electromagnetics", Peterson, Ray &Mittra, IEEE Press, 1998.
3. "Antenna Theory and Design Stutzman and Theile ,Wiley, 3rd edition, 2012.
4. "Modern Antenna Design", Milligan, T. A., Wiley-IEEE Press, 2nd edition ,2005.
5. "Antenna Theory Analysis and design",Constantine A.Balanis,Wiley, 4th edition,2016

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER-II (Elective – IV)**
Course Code	**EEET5052T**
Course Title	**MODERN Digital Signal Processing**

COURSE OBJECTIVE

- To introduce the basic concepts of multi-rate signal processing, random process and wavelets.

COURSE OUTCOME

- Students should be able to analyze signal by splitting into different levels to obtain better frequency resolution.
- Students should be able to model the random processes.
- Students should be able apply wavelet analysis to signal processing applications.

Module 1: Multirate Digital Signal Processing	
	Sampling, Comparison of analog and digital spectrum with different sampling frequency, alising, Decimation, Interpolation, multi stage interpolators and decimators, Filter design and implementation, Application of multirate signal processing
Module 2: Spectral Estimation for Discrete Time random processes	
	Definitions and representation of random process, parametric and non parametric spectral estimations; estimation of auto correlation and power density spectrum. Filtering random process, Non parametric techniques like: periodogram, modified periodogram, Barlett, Welch& Blackman-Tuckey approach
Module 3: Parametric Techniques	
	Yule Walker Method and Power spectrum method for modeling: Autoregressive (AR), Moving Average (MA) and Autoregressive Moving average (ARMA)
Module 4: Wavelets	
	Analysis of wavelets, Continuous time wavelet transform, discrete wavelet transform, Analysis using Harr scaling and wavelet functions, refinement relations, Analysis and synthesis refinement equations, Tiling of the time-frequency plane and wave packet analysis.

Reference books

1. “Optimal and Adapative Signal Processing”,Peter M.Clarkson, CRC Press, 2017.
2. “Digital Time Signal Processing:principles, algorithms, and applications,” J. G. Proakies, D.G. Manolakis, and D. Sharma Pearson Education, 2006.
3. “Digital Signal Processing A Breadth first Approach”,Muhammad Khan, Sayad K Hasnain,Moshin Jamil,River Publisher,2022.
4. “Wavelet Transforms,” R. M. Rao, and A.S. Bopardikar, Pearson Education, 2001.
5. “Digital Signal Processing”, A. Nagoor Kani, Second Edition, Tata McGraw Hill Education Pvt. Ltd., 2012
6. “Digital Signal Processing an Experimental Approach”,Shlomo Engelberg, Springer London,2008

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER-II (Elective – IV)**
Course Code	**EEET5052P**
Course Title	**MODERN Digital Signal Processing Lab**

COURSE OBJECTIVE

- The goal of the course is to develop a complete working set of digital signal processing notions from the ground up.
- The practical models of most real time signals will be generated and verified.

COURSE OUTCOME

- Students will get the gist of Mathematical approach towards understanding the real time signals and their processing.
- The advanced methods introduced will investigate complex properties of widely available real time signals.

Overview

1. Study of random process and its properties.
2. Power spectrum estimation.
3. Yule-walker method.
4. Non-parametric models for WSS random process.
5. Autoregressive models and Moving Average Models.
6. Wavelet analysis of time domain signals.
7. Wavelet Packet analysis and synthesis.
8. Multirate signal processing.

Reference books:

1. "Optimal and Adapative Signal Processing",Peter M.Clarkson, CRC Press, 2017.
2. "Digital Time Signal Processing:principles, algorithms, and applications," J. G. Proakies, D.G. Manolakis, and D. Sharma Pearson Education, 2006.
3. "Digital Signal Processing A Breadth first Approach",Muhammad Khan, Sayad K Hasnain,Moshin Jamil,River Publisher,2022.
4. "Wavelet Transforms," R. M. Rao, and A.S. Bopardikar, Pearson Education, 2001.
5. "Digital Signal Processing", A. Nagoor Kani, Second Edition, Tata McGraw Hill Education Pvt. Ltd., 2012
6. "Digital Signal Processing an Experimental Approach",Shlomo Engelberg, Springer London,2008

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER-II (Elective – IV)**
Course Code	**EEET5053T**
Course Title	**Digital Video Processing**

COURSE OBJECTIVE

- The objectives of this course are for students to learn the fundamental theories and techniques of digital image and video processing.
- To study image representation and different transforms.
- To study pre-processing of images and modeling of images.
- To understand different features of image and extraction of these features from image.
- To understand the basics of video object extractions.

COURSE OUTCOME

- Understanding of digital image processing fundamentals: hardware and software, digitization, enhancement and restoration, encoding, segmentation, feature detection.
- Ability to apply image processing techniques in both the spatial and frequency (Fourier) domains.
- Ability to apply video processing techniques to extract the objects.

Module 1: Image representation and transforms	
	Image Representation- Image Basis Functions- Two dimensional DFT- Discrete cosine Transform-Walsh- Hadamard transform-Wavelet transform Construction of Wavelets-Typesof wavelets principal component analysis
Module 2: Pre-processing and modeling of image	
	Pre-processing of images- Histogram equalization - edge detection- Stochastic presentation ofimages- Stationary and Non-stationary models - Gaussian- HMM - Edge and texture models.
Module 3: Spatial feature extraction	
	Filtering techniques- Localized feature extraction- Boundary Descriptors Moments- TextureDescriptors- Co-occurrence features- Run length features- Feature selection
Module 4 : Classifiers	
	Maximum Likelihood Estimation- Bayesian approach- Pattern Classification by distancefunctions-BPN
Module 5: Video object extraction	
	Static and dynamic background modelling - frame subtraction- optical flow techniques- Handling occlusion- scale and appearance changes - Shadow removal.

Reference books

1. “Introduction to Digital Image Processing” ,William K.Pratt, CRC Press,2013.
2. “Feature Extraction and Image Processing”, Mark Nixon and Alberto Aguado Academic Press,2008.
3. “The Image Processing Handbook”, John C.Russ, CRC Press,2007.
4. “Pattern Classification”,Richard O.Duda,Peter E.Hart,David G.Strok,Second Edition,2012
5. “Computer Vision: Algorithms and Applications”, Richard Szeliski, Springer, 2011.

.**Programme Name**	**M. Tech. (Electronics & Telecommunication), SEMESTER-II (Elective – IV)**
Course Code	**EEET5053P**
Course Title	**Digital Video Processing Lab**

Course Objective

- To study image representation in different domains and their analysis.
- To explore algorithm and techniques involved in image processing.
- Understand the concept of image processing in computers.

Course Outcome

- Students will come to know how the processing on image and video signals takes place before it is transmitted on the communication channel.
- Various transforms will be used for the processing of these signals.

Overview

1. Introduction to Image and Video Processing.
2. 2D and 3D signals and systems, linear and shift invariant systems (convolution).
3. 2D and 3D Fourier transform, 2D and 3D discrete-Fourier transform, uniform sampling.
4. Motion estimation and its applications.
5. Image and video enhancement.
6. Image recovery (restoration, super-resolution).
7. Video recovery (restoration, super-resolution).
8. Lossless compression.
9. Image compression techniques and standards.
10. Image and video analysis (e.g., 2D and 3D segmentation, anomaly detection, clustering).

Reference books

1. "Introduction to Digital Image Processing" ,William K.Pratt, CRC Press,2013.
2. "Feature Extraction and Image Processing", Mark Nixon and Alberto Aguado Academic Press,2008.
3. "The Image Processing Handbook", John C.Russ, CRC Press,2007.
4. "Pattern Classification",Richard O.Duda,Peter E.Hart,David G.Strok,Second Edition,2012
5. "Computer Vision: Algorithms and Applications", Richard Szeliski, Springer, 2011.

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER-II (Elective – IV)**
Course Code	**EEET5054T**
Course Title	**FPGA BASED SYSTEM DESIGN**

COURSE OBJECTIVES:

- To learn the different types of programming elements, programmable logic blocks, programmable input-output blocks and programmable interconnects of various types of FPGAs
- To understand the steps involved in synthesis, simulation, and testing of systems
- To design and implement circuits, subsystem and system using FPGA and I/O boards

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

- Understand the basic concepts of FPGA and its structures
- Understand the steps involved in synthesis, simulation, and testing of systems
- Design combinational and arithmetic circuits using FPGA board
- Design memories and DCTQ processor.
- Design real time applications using FPGA board

Module 1: FPGA ARCHITECTURES	
	FPGA-Based Systems: Basic Concepts - Digital Design and FPGAs - The Role of FPGAs - FPGA Types - FPGAs vs. Custom VLSI - FPGA-Based System Design - Goals and Techniques - Hierarchical Design - Design Abstraction- Methodologies. FPGA Basics: Components of an FPGA - Programming Technology - Antifuse Technology - Logic Circuit Representation of FPGA. FPGA Structure: Logic Block - Logic Cluster – Adaptive LUT - Routing Part - Switch Block - Connection Block - I/O Block - DSP Block - Hard Macros - Embedded Memory - Configuration Chain - PLL and DLL
Module 2: FPGA DESIGN FLOW	
	Design Flow and Design Tools: Design Flow - Design Flow by HDL - HLS Design - IP-Based Design - Design with Processor. Design Methodology: FPGA Design Flow - Technology Mapping - Clustering - Place and Route - Low Power Design Tools. Simulation and Synthesis Concepts - Place and Route – Technology Mapping.
Module 3: FPGA BASED SUBSYSTEM DESIGN	
	Combinational Circuits: Basic Gates - Majority Logic and Concatenation - Shift Operations - Multiplexers - Demultiplexer - Full Adder - Magnitude Comparator. Sequential Circuits: D Flip-flop - Registers - Shift Registers - Counters - Finite State Machines - Pattern Sequence Detector. Arithmetic Circuit Designs: Digital Pipelining - Partitioning of a Design - Signed Adder Design - Multiplier Design.
Module 4 : FPGA BASED SYSTEM DESIGN	
	Design of Memories: On-chip Dual Address ROM Design - Single Address ROM Design - OnChip Dual RAM Design - External Memory Controller Design. System Designs: Discrete Cosine Transform and Quantization Processor - FOSS Motion Estimation Processor - DCTQ Processor
Module 5: FPGA BASED PROJECT DESIGN	
	Project Designs: Traffic Light Controller - Real Time Clock - Digital Signal Processor - PCI Bus Arbiter - DCTQ Processor - Electrostatic Precipitator Controller - JPEG/H.263/MPEG 1/ MPEG 2 Codec.

Reference books

1 .“FPGA-Based System Design”, Wayne Wolf, PTR Prentice Hall, 2004
2. “Principles and Structures of FPGAs”, Hideharu Amano, Springer, 2018
3. “Digital VLSI Systems Design: A Design Manual for Implementation of Projects on FPGAs and ASICs Using Verilog”, S. Ramachandran, Springer, 2007
4. “Design Recipes for FPGAs”, Peter R. Wilson, Springer, 2008
5. “Designing with Xilinx FPGAs Using Vivado”, Sanjay Churiwala, Springer, 2017

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER-II (Elective – IV)**
Course Code	**EEET5054P**
Course Title	**FPGA BASED SYSTEM DESIGN LAB**

COURSE OBJECTIVES

- To understand Verilog and VHDL in modelling of digital circuits and systems.
- To understand the principles of modelling, simulation, synthesis and implementation of digital circuits and systems using FPGA and I/O boards.

COURSE OUTCOMES

- Able to design and implement various combinational circuits using FPGA boards
- Able to design and implement various sequential circuits using FPGA boards
- Able to design and implement various arithmetic circuits using FPGA boards
- Create and import logic modules into FPGA, synthesize and analyze the module with FPGA and I/O boards

List of Experiments:

1. Combinational Circuits: Basic Gates – Majority Logic and Concatenation – Shift Operations – Multiplexers – Demultiplexer – Full Adder – Magnitude Comparator
2. Sequential Circuits: D Flipflop – Registers – Shift Registers – Counters – Finite State machines – Pattern Sequence Detector
3. Arithmetic Circuit Designs: Signed Adder – Multiplier – 8/16 bit MAC – 16 Bit ALU – 8x64 FIFO Buffer
4. System Designs: Traffic Light Controller – Real Time Clock – 4 Bit Slice Processor

Reference books

1 .“FPGA-Based System Design”, Wayne Wolf, PTR Prentice Hall, 2004
2. “Principles and Structures of FPGAs”, Hideharu Amano, Springer, 2018
3. “Digital VLSI Systems Design: A Design Manual for Implementation of Projects on FPGAs and ASICs Using Verilog”, S. Ramachandran, Springer, 2007
4. “Design Recipes for FPGAs”, Peter R. Wilson, Springer, 2008
5. “Designing with Xilinx FPGAs Using Vivado”, Sanjay Churiwala, Springer, 2017

Programme Name	**M. Tech. (Electronics & Telecommunication), SEMESTER – II (Open Elective)**
Course Code	**EEET5062S**
Course Title	**Mathematical Foundation Course for Data Analytics**

Course Objective

- The course will introduce the fundamental concepts of linear algebra, probability and statistics required for a program in data science.
- To enable learners to develop knowledge and skills in current and emerging areas of data analytics.
- To critically assess and evaluate business and technical strategies for data analytics.
- To demonstrate expert knowledge of data analysis, statistics, tools, techniques and technologies of data analytics.

Course Outcomes

- Ability to use the mathematical concepts in the field of data science.
- Employ the techniques and methods related to the area of data science in variety of applications.
- Apply logical thinking to understand and solve the problem in context.

Module 1: Introduction of Data Science	
	Basics of Data Science: Introduction; Typology of problems; Importance of linear algebra, statistics and optimization from a data science perspective; Structured thinking for solving data science problems.
Module 2: Linear Algebra	
	Linear Algebra: Matrices and their properties (determinants, traces, rank, nullity, etc.); Eigenvalues and eigenvectors; Matrix factorizations; Inner products; Distance measures; Projections; Notion of hyperplanes; half-planes.
Module 3: Probability, Statistics and Random Processes:	
	Probability, Statistics and Random Processes: Probability theory and axioms; Random variables; Probability distributions and density functions (univariate and multivariate); Expectations and moments; Covariance and correlation; Statistics and sampling distributions; Hypothesis testing of means, proportions, variances and correlations; Confidence (statistical) intervals; Correlation functions; White-noise process
Module 4 : Optimization Techniques	
	Optimization: Unconstrained optimization; Necessary and sufficiency conditions for optima; Gradient descent methods; Constrained optimization, KKT conditions; Introduction to non-gradient techniques; Introduction to least squares optimization; Optimization view of machine learning. Introduction to Data Science Methods: Linear regression as an exemplar function approximation problem; Linear classification problems.

Reference books

1. "Introduction to Linear Algebra", G. Strang . Wellesley-Cambridge Press, Fifth edition, 2016.
2."Random Data: Analysis and Measurement Procedures", Bendat, J. S. and A. G. Piersol. fourth Edition. John Wiley & Sons, Inc., NY, USA, 2010
3. "Applied Statistics and Probability for Engineers", Montgomery, D. C. and G. C. Runger. Fifth Edition. John Wiley & Sons, Inc., NY, USA, 2011.
4. "Optimization by Vector Space Methods", David G. Luenberger, John Wiley & Sons (NY), 1969.
5 ."Doing Data Science", Cathy O'Neil and Rachel Schutt ,O'Reilly Media, 2013.