RAMAIAH
Institute of Technology

CURRICULUM

(Effective from the Academic Year 2024 – 2025)

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

I – IV SEMESTER M. Tech (DIGITAL ELECTRONICS AND COMMUNICATION ENGINEERING)

RAMAIAH INSTITUTE OF TECHNOLOGY
(Autonomous Institute, Affiliated to VTU)
(Approved by AICTE, New Delhi & Govt. of Karnataka)
Accredited by NBA & NAAC with A^+ Grade

About the Institute

In 1962, Dr. M. S. Ramaiah, a visionary philanthropist, established the Gokula Education Foundation with a noble mission to uplift society through education. The same year marked a pivotal moment in technical education in India with the founding of the M S Ramaiah Institute of Technology (MSRIT).

MSRIT offers an impressive array of 18 undergraduate and 15 postgraduate programs, all approved by the All India Council for Technical Education (AICTE). The National Board of Accreditation (NBA) has accredited all eligible programs at the undergraduate (UG) and postgraduate (PG) levels. In March 2021, MSRIT earned an 'A^{+}' grade from the National Assessment and Accreditation Council (NAAC), underscoring its unwavering commitment to academic excellence. Since 2007, the institute has proudly held Autonomous Status for its UG and PG programs, a prestigious recognition granted by the University Grants Commission (UGC) and Visvesvaraya Technological University (VTU). According to the Ministry of Education, Government of India's NIRF Ranking Framework, MSRIT ranks 75th among 1,584 leading engineering institutions and 31st among 131 architecture schools in India for 2025, highlighting its remarkable impact and leadership in education.

The institute participated in the Technical Education Quality Improvement Program (TEQIP), an initiative of the Government of India. To foster a research culture, the institute has established several specialized centres, including the Centre for Imaging Technologies, the Centre for Advanced Materials Technology, the Centre for Antennas and Radio Frequency Systems (CARFS), the Centre for Cyber Physical Systems, the Schneider Centre of Excellence, the Centre for Bio and Energy Materials Innovation, JSW Centre of Excellence in Power Systems and more. MSRIT boasts a faculty of 380 highly qualified members, 70% of whom hold doctoral degrees, and over 300 scholars currently pursuing Ph.D. degrees.

The Entrepreneurship Development Cell (EDC) and "Ramaiah Evolute" have been established on campus to support startup incubation. MSRIT features a dedicated Placement and Training department, a strong mentoring and proctorial system, a fully equipped sports department, and a spacious, air-conditioned library with a wide range of books and subscriptions to both international and national journals. The Digital Library provides access to online e-journals from renowned publishers, including Elsevier ScienceDirect, IEEE, Taylor & Francis, and SpringerLink. Additionally, the Institute is a member of DELNET, CMTI, and the VTU E- Library Consortium.

The institute features a state-of-the-art auditorium, a well-equipped recording studio, and multiple advanced conference halls with videoconferencing capabilities. Additionally, MSRIT provides excellent hostel accommodations for both boys and girls, ensuring a comfortable living environment. MSRIT alumni have achieved remarkable success, holding prominent positions in India and internationally. They maintain strong connections with the institute through an engaged and active Alumni Association.

Founded on Dr. Ramaiah's unwavering commitment to knowledge and innovation, this remarkable institution continues to inspire generations of students and shape the future of engineering and technology in the country.

About the Department

The Department of Electronics and Communication was started in 1975 and has grown over the years in terms of stature and infrastructure. The department has well equipped simulation and electronic laboratories and is recognized as a research center under VTU. The department currently offers a B. E. program with an intake of 120, and two M. Tech programs, one in Digital Electronics and Communication Engineering, and one in VLSI Design and Embedded Systems, with intakes of 30 and 18 respectively. The department has a Center of Excellence in Food Technologies sponsored by VGST, Government of Karnataka. The department is equipped with numerous UG and PG labs, along with R & D facilities. Past and current research sponsoring agencies include DST, VTU, VGST and AICTE with funding amount worth Rs. 1 crore. The department has modern research ambitions to develop innovative solutions and products and to pursue various research activities focused towards national development in various advanced fields such as Signal Processing, Embedded Systems, Cognitive Sensors and RF Technology, Software Development and Mobile Technology.

VISION OF THE INSTITUTE

To be an Institution of International Eminence, renowned for imparting quality technical education, cutting edge research and innovation to meet global socio-economic needs

MISSION OF THE INSTITUTE

RIT shall meet the global socio-economic needs through

1. Imparting quality technical education by nurturing a conducive learning environment through continuous improvement and customization
2. Establishing research clusters in emerging areas in collaboration with globally reputed organizations
3. Establishing innovative skills development, techno-entrepreneurial activities and consultancy for socio-economic needs

QUALITY POLICY

We at M. S. Ramaiah Institute of Technology strive to deliver comprehensive, continually enhanced, global quality technical and management education through an established Quality Management System complemented by the synergistic interaction of the stake holders concerned

VISION OF THE DEPARTMENT

To evolve into a department of national and international repute for excellence in education and cutting-edge research in the domain of Electronics and Communication Engineering

MISSION OF THE DEPARTMENT

The department will continuously strive to

1. Provide a world-class learning environment that caters to local and global technological and social requirements
2. Initiate research collaborations with academia and industries to perform cutting edge research leading to socio-technological innovations
3. Develop skills for pursuing innovation and entrepreneurial ventures for graduating engineers

Program Educational Objectives (PEOs):

PEO1: Be successful practicing professionals or pursue doctoral studies in digital electronics and communication contributing significantly to research and development activities

PEO2: Engage in professional development in the area of digital electronics and communication by adapting to new technology and career challenges

PEO3: Demonstrate professional, ethical, leadership qualities and social responsibilities of the electronics and communication engineers

Program Outcomes (POs):

PO1: Development of Solutions: An ability to independently carry out research/investigation and development work to solve practical problems

PO2: Technical Presentation Skills: An ability to write and present a substantial technical report/document

PO3: Analyze Complex Systems: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirement in the appropriate bachelor program.

PO4: Develop Novel Designs: An ability to apply their in-depth knowledge in Electronics and Communications domain to evaluate, analyze and synthesize existing and novel designs

PO5: Modern Tools Usage: An ability to apply appropriate techniques and modern tools in design and implementation of system in the domain of Digital Electronics and Communication

CURRICULUM CREDITS DISTRIBUTION

Semester	Professional Core Course (PCC)	Professional Core Course Lab (PCCL)	Professional Elective Course (PEC)	Mandatory Credit Course (MCC)	Project Work / Seminar (PW)	Internship (INT)	Total semester credits
First	6	2	11	3	-	-	22
Second	8	2	12	-	-	-	22
Third	4	-	4	-	4	4	16
Fourth	-	-	-	-	20	-	20
Total	**18**	**4**	**27**	**3**	**24**	**4**	**80**

SCHEME OF TEACHING

M. Tech (Digital Electronics and Communication)

I SEMESTER

S. No	Course Code	Course Title	Category	Credits				Contact Hours
				L	T	P	Total	
1.	MLC11	Advanced Engineering Mathematics	PCC	2	1	0	3	4
2.	MLC12	Advanced Digital Communication	PCC	3	0	0	3	3
3.	MLCExx	Elective 1	PEC	4	0	0	4	4
4.	MLCExx	Elective 2	PEC	3	0	0	3	3
5.	MLCExx	Elective 3	PEC	4	0	0	4	4
6.	RM116	Research Methodology and IPR	MCC	3	0	0	3	3
7.	MLCL13	Advanced Digital Communication Laboratory	PCCL	0	0	1	1	2
8.	MLCL14	Digital System Design Laboratory	PCCL	0	0	1	1	2
Total				**19**	**1**	**2**	**22**	**25**

II SEMESTER

S. No	Course Code	Course Title	Category	Credits				Contact Hours
				L	T	P	Total	
1.	MLC21	Wireless Communication	PCC	3	1	0	4	5
2.	MLC22	Advanced Embedded Systems	PCC	4	0	0	4	4
3.	MLCExx	Elective 4	PEC	4	0	0	4	4
4.	MLCExx	Elective 5	PEC	4	0	0	4	4
5.	MLCExx	Elective 6	PEC	4	0	0	4	4
6.	MLCL23	Advanced Embedded Systems Laboratory	PCCL	0	0	1	1	2
7.	MLCL24	Advanced Signal and Image Processing Laboratory	PCCL	0	0	1	1	2
Total				**19**	**1**	**2**	**22**	**25**

III SEMESTER

S. No	Course Code	Course Title	Category	Credits				Contact Hours
				L	T	P	Total	
1.	MLC31	Multimedia Communication	PCC	3	1	0	4	4
2.	MLCExx	Elective 7	PEC	4	0	0	4	4
3.	MLC32	Internship/Industrial Training	INT	0	0	4	4	4
4.	MLC33	Project Work – I	PW	0	0	4	4	4
Total				**7**	**1**	**8**	**16**	**16**

IV SEMESTER

S. No	Course Code	Course Title	Category	Credits				Contact Hours
				L	T	P	Total	
1.	MLC41	Project Work – II	PW	0	0	20	20	20
Total				**0**	**0**	**20**	**20**	**20**

LIST OF ELECTIVES

S. No	Course Code	Course Name	Credits			
			L	T	P	Total
1.	MLCE01	Antenna Theory and Design	4	0	0	4
2.	MLCE02	Digital System Design using HDL	3	0	0	3
3.	MLCE03	Digital VLSI Design	4	0	0	4
4.	MLCE04	Advanced Signal and Image Processing	4	0	0	4
5.	MLCE05	MEMS and Nano Electronics	4	0	0	4
6.	MLCE06	Machine Learning and Deep Learning	4	0	0	4
7.	MLCE07	Internet of Things (IoT)	4	0	0	4
8.	MLCE08	Advanced Computer Networks	4	0	0	4
9.	MLCE09	Error Control Coding	4	0	0	4
10.	MLCE10	Optical Communication Networks	4	0	0	4
11.	MLCE11	ASIC Design	4	0	0	4
12.	MLCE12	Advanced Computer Architecture	4	0	0	4

ADVANCED ENGINEERING MATHEMATICS	
Course Code: MLC11	**Credits: 2:1:0**
Prerequisite: Engineering Mathematics	**Contact Hours: 28L+14T**
Course Coordinator: Dr. K. Indira	

Course Contents

Unit I

Solving Linear Equations: Systems of Linear Equations**,** Row reduced and Echelon forms, Vector Equations, The Matrix Equation, Solution Sets of Linear Systems, Linear Independence, Introduction to Linear Transformation, Matrix of a Linear Transformation, Inverses, Partitioned matrices, Matrix Factorization and Determinants

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/111106051

Unit II

Vector Spaces: Vector spaces and subspaces, Null spaces, Column spaces and Linear transformation, Linear independent sets: Bases, Coordinate systems, Dimension of a vector space, Rank, Change of basis

Eigen Values and Eigen Vectors: Eigen values, Eigen vectors and diagonalization, Eigen vectors and linear transformations

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/111106051

Unit III

Orthogonality: Inner product, Length and orthogonality, Orthogonal sets, Orthogonal projections, Gram – Schmidt process, Least squares problems, Inner product spaces

Symmetric Matrices and Quadratic Forms: Diagonalization of symmetric matrices, Quadratic forms, Constrained optimization, Singular Value Decomposition (SVD)

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/111106051

Unit IV

Random Variables: Introduction, Distribution functions, Discrete random variables and Probability Mass function (PMF), Continuous random variable and Probability density Function (PDF), Mean and Variance

Special Distributions: Bernoulli, Binomial, Poisson, Uniform, Exponential and Normal distributions

Multiple Random Variables: Introduction, Joint CDF/PMF/PDF, Covariance and coefficient.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/117105085

Unit V

Random Processes: Definitions, Ensemble average**s ,** Gaussian processes, Stationary processes, Autocovariance and Autocorrelation matrices, White noise, Power spectrum, Filtering random processes, Spectral factorization

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://onlinecourses.nptel.ac.in/noc20_ee53/preview

References:

1. Strang. G, "Linear Algebra and its Applications", 4th Edition, Cengage Learning, 2014.
2. David C. Lay, "Linear Algebra and its Applications", 3rd Edition, Pearson Education, 2013.
3. Monson H. Hayes, "Statistical Digital Signal Processing and Modeling" John Wiley & Sons, 2002.
4. Henry Stark, John W. Woods, "Probability and Random Processes with Applications to Signal Processing", 3rd Edition, Prentice Hall, 2002.
5. Peyton Z. Peebles, "Probability Random Variables and Random Signal Principles", 4th Edition, TMH, 2007.
6. Hwei P, Hsu, 'Theory and Problems on Probability, Random Variables and Random Processes, TMH, 2010.

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Apply row reduction and echelon forms to solve systems of linear equations (POs: 1, 3, 4,5)
2. Explain the significance of vector spaces, eigen values and eigen vectors (POs: 1, 3, 4,5)
3. Apply the Gram-Schmidt process to construct an orthonormal set of vectors in an inner product space. (POs: 1, 3, 4,5)
4. Analyze different random variables and their statistical parameters (POs: 1, 3, 4,5)
5. Classify various random processes and analyze the nature of output random process of a LTI system (POs: 1, 3, 4,5)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	**Marks**	**Course outcomes addressed**
Internal test-I	30	CO1, CO2, CO3
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other components		
Quiz	10	CO1, CO2, CO3
Assignment	10	CO3, CO4, CO5
Semester End Examination (SEE)	100	CO1, CO2, CO3, CO4, CO5

ADVANCED DIGITAL COMMUNICATION	
Course Code: MLC12	**Credits: 3:0:0**
Prerequisite: Digital Communication	**Contact Hours: 42 L**
Course Coordinator: Dr. T. D. Senthilkumar	

Course Contents

Unit I

Deterministic and Random signal analysis: Lowpass equivalent of bandbass signals, Energy consideration, Lowpass equivalent of a bandpass system

Digital Communication Systems: Model of digital communication system, geometric interpretation of signals, Gram-Schmidt orthogonalization procedure. Maximum likelihood detection. Implementation of correlation receiver and Matched filter receiver. Properties of Matched filter.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/117104099
- Links: https://nptel.ac.in/courses/117104115

Unit II

Optimum Receivers for AWGN Channel: Waveform and vector AWGN channels – Optimal detection for the vector channel, Optimal detection for binary antipodal signaling and binary orthogonal signaling. Optimal detection and error probability for band-limited (PAM, PSK & QAM) and power-limited signaling (orthogonal signaling).

Digital Communication through Fading Multipath Channel: Frequency-nonselective slowly fading channel, Diversity techniques for fading multipath channel.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/117104099
- Links: https://nptel.ac.in/courses/117104115

Unit III

Digital Communication Through Band-Limited Channels: Optimum receiver for channels with ISI and AWGN. Linear equalization – peak distortion criterion, MSE criterion, Decision feedback equalization.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://www.nptelvideos.com/video.php?id=538&c=5
- Links: https://archive.nptel.ac.in/noc/courses/noc17/SEM2/noc17-ec12/

Unit IV

Adaptive Equalization: Adaptive linear equalizer – zero-forcing algorithm, LMS algorithm. Adaptive decision-feedback equalizer, RLS algorithm for adaptive equalization.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://www.nptelvideos.com/video.php?id=538&c=5
- Links: https://archive.nptel.ac.in/noc/courses/noc17/SEM2/noc17-ec12/

Unit V

Multichannel and Multicarrier Systems: Multichannel digital communications in AWGN channels. Orthogonal frequency division multiplexing – modulation and demodulation in an OFDM system, FFT algorithm implementation of an OFDM system

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/117104099
- Links: https://nptel.ac.in/courses/117104115

References:

1. John G. Proakis and Masoud Salehi, "Digital Communications", 5th Edition, McGraw Hill, 2008.
2. M. K. Simon, S. M. Hinedi and W. C. Lindsey, "Digital Communication Techniques", Prentice Hall India, 2012.
3. Simon Haykin, "Digital Communications", 1st Edition, Wiley India Pvt. Ltd, 2006.

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Appreciate the signal space concepts in the design of optimal receivers (POs:1, 3, 4, 5)
2. Analyze the performance of band- and power-limited signals in the AWGN channel and fading channel (POs:1, 3, 4, 5)
3. Apply equalization techniques to minimize the effect of inter-symbol interference (POs:1, 3, 4, 5)
4. Compare the performance of different adaptive equalization algorithms (POs:1, 3, 4, 5)
5. Employ multicarrier and multichannel modulation in modern wireless communication systems (POs:1, 3, 4, 5)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	**Marks**	**Course outcomes addressed**
Internal test-I	30	CO1, CO2, CO3
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other components		
Quiz	10	CO1, CO2, CO3
Assignment	10	CO3, CO4, CO5
Semester End Examination (SEE):	100	CO1, CO2, CO3, CO4, CO5

RESEARCH METHODOLOGY & IPR	
Course Code: RMI16	**Credits: 3:0:0**
Prerequisite: Nil	**Contact Hours: 42 L**
Course Coordinator: Dr. Shilpa M	

Course Contents

Unit I

Research Methodology: Introduction, Meaning of research, Objectives of research, Motivation in research, Types of research, Research approaches, Significance of research, Research methods versus methodology, Research and scientific method, Importance of knowing how research is done, Research process, Criteria of good research, Problems encountered by researchers in India.

Defining the Research Problem: What is research problem, Selecting the problem, Necessity of defining the problem, Technique involved in defining a problem, An illustration.

- Pedagogy/Course delivery tools: Chalk, power point presentations and talk
- Links: https://archive.nptel.ac.in/courses/110/105/110105139/

Unit II

Literature review: Primary and secondary sources, Reviews, Monograph, Patents, Research databases, Web as a source, Searching the web, Critical literature review, Identifying gap areas from literature and research database, Development of working hypothesis.

Research Design: Meaning of research design, Need for research design, Features of a good design, Important concepts relating to research design, Different research designs, Basic principles of experimental design.

- Pedagogy/Course delivery tools: Chalk, power point presentations and talk
- Links: https://archive.nptel.ac.in/courses/110/105/110105139/

Unit III

Sampling Design: Census and sampling survey, Implications of a sample design, Steps in sampling design, Criteria of selecting a sampling procedure, Characteristics of a good sample design, Different types of sample designs, How to select a random sample, Random sample from an infinite universe, Complex random sampling designs.

Methods of Data Collection: Collection of primary data, Observation method, Interview method, Collection of data through questionnaires, Collection of data through schedules, Different between questionnaires and schedules, some other methods of data collection, Collection of secondary data, Selection of appropriate method for data collection, Case study method.

- Pedagogy/Course delivery tools: Chalk, power point presentations and talk
- Links: https://archive.nptel.ac.in/courses/110/105/110105139/

Unit IV

Multivariate Analysis: The nature of multivariate analysis, Classifying multivariate techniques, Analysis of dependence, Analysis of interdependence.

Probability distributions: Introduction to Probability, Laws of Probability, Baye's theorem, Discrete and Continuous random variables, Binomial, Poisson distributions, Normal and Exponential distributions - Simple problems, applications**.**

- Pedagogy/Course delivery tools: Chalk, power point presentations and talk
- Links: https://archive.nptel.ac.in/courses/110/105/110105139/

Unit V

Research Ethics and Intellectual Property: Ethics- Ethical issues, Ethical committees (human & animal), Research ethics; IPR- Intellectual property rights and Patent law, Commercialization, Copyright, Royalty, Trade related aspects of intellectual property rights (TRIPS); Scholarly publishing- IMRAD concept and design of research paper, Citation and acknowledgement, Plagiarism, Reproducibility and Accountability.

- Pedagogy/Course delivery tools: Chalk, power point presentations and talk
- Links:https://archive.nptel.ac.in/courses/110/105/110105139/

Text Books:

1. Kothari CR and Garg G. 2019. Research Methodology: Methods and Techniques, Fourth Edition, New Age International Publishers, ISBN: 978-81-224-2488-1.
2. Panneerselvam R. 2013. Research Methodology, Second Edition, Prentice Hall India Learning Private Limited, ISBN: 978-81-203-4946-9.

Reference Books:

1. Zikmund WG, Babin BJ, Carr JC and Griffin M. 2013. Business Research Methods, Ninth Edition, Cengage India Private Limited, ISBN: 978-93-535-0326-0.
2. Wadhera BL. 2010. Law Relating to Intellectual Property: Patent, Trademarks, Designs and Geographical Indication, Universal Law Publishing, ISBN: 978-93-503-5030-0.

Course Outcomes (COs):

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

1. Understand the research methodology and define the problem for research (POs: 1, 2, 3, 4, 5)
2. Conduct literature review and apply the principles of research design (POs: 1, 2)
3. Apply the knowledge of various sampling procedures and different methods of data collection in the research (POs: 1, 2)
4. Apply multi-variate techniques and concepts of probability distributions to real-time situations (POs: 1, 2, 3)
5. Apply ethics and concepts of intellectual property in the research process (POs: 1, 2, 3, 4)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	**Marks**	**Course out comes addressed**
Internal test-I	30	CO1, CO2
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30marks.		
Other components		
Quiz/ Presentations	10	CO1, CO2
Assignment	10	CO3, CO4, CO5
Semester End Examination (SEE):	100	CO1, CO2, CO3, CO4, CO5

ADVANCED DIGITAL COMMUNICATION LABORATORY	
Course Code: MLCL13	**Credits: 0:0:1**
Prerequisite: Microwave and Antennas	**Contact Hours: 14P**
Course Coordinator: Dr. Sujatha B & Dr. T D Senthilkumar	

Course Contents

List of Experiments:

1. Experimental studies of radiation pattern of Micro strip Yagi-Uda and Dipole antennas.
2. Impedance measurements of Horn/Yagi/dipole/Parabolic antennas.
3. Determination of the modes transit time, electronic timing range and sensitivity of klystron source.
4. Calculate the directivity and gain of Horn antenna from the radiation pattern.
5. Experimental studies of radiation pattern of Micro strip Patch antenna.
6. Calculate the antenna parameters of different types of antenna using Software/Simulation tool
7. Write a simulation code to analyze the performance of Quadrature Amplitude Modulation (QAM) and M-ary Phase Shift Keying (PSK) scheme in AWGN channel, and compare the results with theoretical results
8. Write a simulation code to compute Bit Error Rate (BER) for different digital modulation scheme in frequency-flat and slowly varying fading channel.
9. Bit error rate analysis of digital communication receivers with Maximal Ratio Combining (MRC) receive diversity in frequency-flat and slowly varying fading channel.
10. Bit error rate analysis of digital communication receivers with Equal Gain Combining (EGC) receive diversity in frequency-flat and slowly varying fading channel.
11. Simulation of Direct Sequence Spread Spectrum (DSSS) techniques.
12. Conduct an experiment for
    (a). Measurement of numerical aperture and attenuation loss in analog fiber optic link.
    (b). Digital link and data multiplexing using optical fiber.

References:

1. John D Kraus, Ronald J Marhefka, Ahmad S Khan, "Antennas", 4th Edition, Tata McGraw Hill TMH, 2006.
2. Constantine. A. Balanis, "Antenna Theory Analysis and Design", 2nd Edition, John Wiley, 1997.
3. J. G. Proakis and M. Salehi, "Contemporary Communication Systems Using MATLAB", PWS Publishing Company, 2007.
4. T.S. Rappaport, "Wireless Communications: Principles and Practice", 2nd Edition, Prentice Hall of India, Third Indian Reprint, 2010.

Web links and Video Lectures (e-Resources):

1. https://www.iitk.ac.in/mimt_lab/vlab/index.php
2. https://www.mathworks.com/help/comm/ug/bit-error-rate-analysis-techniques.html

Course Outcomes (COs):

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

1. Plot the radiation pattern of different types of antennas (POs: 1, 2, 3, 4, 5)
2. Determine the parameters like gain, beam width and directivity of antennas (POs: 1, 2, 3, 4, 5)
3. Design an antenna array and find the various parameters like directivity and gain by plotting the radiation pattern using software/simulation tool. (POs: 1, 2, 3, 4, 5)
4. Analyze the performance of the digital modulation receivers in AWGN channel (POs: 1, 2, 3, 4, 5)
5. Analyze the performance of the digital modulation receivers in fading channel (POs: 1, 2, 3, 4, 5)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	**Marks**	**Course outcomes addressed**
Weekly evaluation of laboratory manuals/records after the conduction of every experiment	30	CO1, CO2, CO3, CO4, CO5
Practical test	20	CO1, CO2, CO3, CO4, CO5
Semester End Examination (SEE):	50	CO1, CO2, CO3, CO4, CO5

DIGITAL SYSTEM DESIGN LABORATORY	
Course Code: MLCL14	**Credits: 0:0:1**
Prerequisite: Digital Electronics	**Contact Hours: 14P**
Course Coordinator: Dr. Rajendra Prasad P	

Course Contents

List of Experiments:

Using Verilog code design, simulate and synthesize the following with a suitable FPGA

1. 8 to 3 programmable priority encoder
2. Full Adder using structural modeling
3. Flip Flops(D,SR,T,JK)
4. 4-bit arbitrary counter,4-bit binary up/down/up-down counter with synchronous reset, 4-bit Johnson counter, BCD counter
5. Sequential block to detect a sequence (say 11101) using appropriate FSM
6. 8-bit ripple carry adder and carry skip adder
7. 8-bit carry select adder
8. Stepper motor and DC motor interface
9. DAC interface

Using System Verilog code, simulate the following

10. Full subtractor using structural modeling
11. Flip Flops(D,SR,T,JK)
12. 4-bit synchronous/asynchronous counters, synchronous arbitrary counter

References:

1. Peter J. Ashenden, "Digital Design: An Embedded Systems Approach using Verilog", Elsevier, 2010.
2. Samir Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis", 2nd Edition, Pearson Education, 2010.
3. Stuart Sutherland, "RTL Modeling with System Verilog for Simulation and Synthesis: using System Verilog for ASIC and FPGA Design", 1st Edition, Create Space Independent Publishing Platform, 2017.

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/108105113
2. https://nptel.ac.in/courses/117103064
3. https://nptel.ac.in/courses/117106086
4. https://nptel.ac.in/courses/117106114
5. https://nptel.ac.in/courses/106105165
6. https://nptel.ac.in/courses/108103179

Course Outcomes (COs):

1. Design and model complex combinational circuits using HDL at behavioral, structural and RTL levels. (POs: 1, 2, 3, 4, 5)
2. Enumerate complex sequential circuits using HDL at behavioral, structural and RTL levels. (POs: 1, 2, 3, 4, 5)
3. Develop test benches to simulate combinational and sequential circuits. (POs: 1, 2, 3, 4, 5)
4. Illustrate how the language infers hardware and helps to simulate and synthesize the digital system. (POs: 1, 2, 3, 4, 5)
5. Implement and analyze the digital systems using FPGAs with respect to speed and area. (POs: 1, 2, 3, 4, 5)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	**Marks**	**Course outcomes addressed**
Weekly evaluation of laboratory manuals/records after the conduction of every experiment	30	CO1, CO2, CO3, CO4, CO5
Practical test	20	CO1, CO2, CO3, CO4, CO5
Semester End Examination (SEE):	50	CO1, CO2, CO3, CO4, CO5

WIRELESS COMMUNICATION	
Course Code: MLC21	**Credits: 3:1:0**
Prerequisite: Advanced Digital Communication	**Contact Hours: 42L+14T**
Course Coordinator: Dr. T. D. Senthilkumar	

Course Contents

Unit I

Wireless Channel: Wireless channel as a linear time-varying system, Physical modeling for wireless channels, Input/output model of wireless channel, Time and frequency response, Statistical models, Reflection from a ground plane, Power decay with distance and shadowing

Point to Point Communication: Baseband equivalent channel model, Detection in Rayleigh fading channel, Repetition coding, Orthogonal Frequency Division Multiplexing.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/117104115

Unit II

Diversity: Introduction, Micro-diversity, Macro-diversity and simulcast, Combination of Signals, Error Probability in fading channels with diversity reception, Transmit diversity

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://www.nptelvideos.com/video.php?id=538&c=5

Unit III

Capacity of Wireless Channels: AWGN channel capacity, Linear time invariant Gaussian channels, Capacity of fading channels

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/117105132

Unit IV

Spatial Multiplexing for 5G Wireless Communications: Receive diversity, Spatial multiplexing and channel modeling, Multiplexing capability of MIMO channels, Physical modeling of MIMO channels, Modeling MIMO fading channels.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/117104115

Unit V

MIMO Capacity and Multiplexing Architectures: V-BLAST architecture, Fast fading MIMO channel, Receiver architectures – Linear de-correlator, Successive cancellation, Linear MMSE receiver, D-BLAST architecture.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/117104115

References:

1. David Tse, P. Viswanath, "Fundamentals of Wireless Communication", Cambridge University Press New York, USA, 2005.
2. Andreas F. Molisch, "Wireless Communications", Wiley Publications, 2009.
3. William C Y Lee, "Mobile Communication Engineering Theory and Applications", 2nd Edition, McGraw Hill Education, 2008.

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Define characteristics of wireless channel strength over time and frequency. (POs: 1, 3, 4, 5)
2. Employ the concept of different diversity techniques to overcome the effect of small scale multi-path propagation. (POs: 1, 3, 4, 5)
3. Demonstrate the impact of channel uncertainty on the performance of diversity combining schemes. (POs: 1, 3, 4, 5)
4. Employ spatial multiplexing for MIMO channels. (POs: 1, 3, 4, 5)
5. Discuss the performance of MIMO receiver architecture. (POs: 1, 3, 4, 5)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	**Marks**	**Course outcomes addressed**
Internal test-I	30	CO1, CO2, CO3
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other components		
Quiz	10	CO1, CO2, CO3
Assignment	10	CO3, CO4, CO5
Semester End Examination (SEE):	100	CO1, CO2, CO3, CO4, CO5

ADVANCED EMBEDDED SYSTEMS	
Course Code: MLC22	**Credits: 4:0:0**
Prerequisite: Microcontroller	**Contact Hours: 56L**
Course Coordinator: Dr. Lakshmi Shrinivasan	

Course Contents

Unit I

Introduction to Embedded System: Core of Embedded systems, memories & communication protocols

Embedded Systems Design and Development Hardware Software Co-Design and Program Modeling: Fundamental issues in the Hardware Software Co-Design, Computational models in the embedded system design: Data Flow-Graph/Diagram (DFG) Model, Control Data Flow Graph / Diagram (CDFG), State machine model with examples. Sequential program model, unified modeling language (UML) building blocks with examples, Life Cycle Models.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/106105159
- Links: https://nptel.ac.in/courses/108105057

Unit II

Introduction to ARM Cortex –M Processors: Advantages of the Cortex M processors, applications of the ARM Cortex –M processors, Resources for using ARM processors and ARM microcontrollers

Technical Overview ARM Cortex –M4: Processor type, architecture, block diagram, memory System, Interrupt and exception support, instructions, features of ARM Cortex –M4

Low Power and System Control Features: Low power features, using WFI and WFE instructions in programming

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/106105193
- Links: https://nptel.ac.in/courses/108102045

Unit III

Architecture of ARM Cortex-M4: Introduction to the architecture, Programmer's model, behavior of the application program status register (APSR), Memory system, Instruction set: Cortex - M4 specific instructions, barrel shifter, exceptions and interrupts, system control block.

Fault Exceptions and Fault Handling: Overview of faults Causes of faults, enabling fault handlers and fault status and address registers

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/106105193
- Links: https://nptel.ac.in/courses/117106111

Unit IV

Real Time Operating System (RTOS) based Embedded System Design: Operating System Basics, Types of OS, Tasks, Process and Threads, Multiprocessing and Multitasking, Task Scheduling, Task Communication, Task Synchronization techniques, how to Choose an RTOS.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/108105057

Unit V

The Embedded System Development Environment: Embedded Firmware design approaches and development, the Integrated Development Environment (IDE), Types of Files Generated on Cross-compilation, Disassembler/Decompiler, Simulators, Emulators and Debugging, Target Hardware Debugging and Boundary Scan

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/108105057
- Links: https://nptel.ac.in/courses/117101004

References:

1. Joseph Yiu, "The definitive guide to ARM Cortex – M3 and Cortex- M4 processors", 3rd edition, NEWNES, An imprint of Elsevier Inc, 2014.
2. Shibu. K. V, "Introduction to Embedded Systems", 1st edition, Tata McGraw Hill Education Private Ltd., 2009.
3. James K Peckol, "Embedded Systems: A Contemporary Design Tool", 2nd edition, John Wiley & Sons, Inc., 2019
4. Rajkamal, "Embedded Systems, Architecture, Programming and Design", 3rd edition, Tata McGraw Hill Education Pvt., Ltd., 2012
5. Frank Vahid, Tony Givargis, "Embedded System Design - A Unified Hardware/ Software
6. Introduction", new edition Edition, John Wiley & Sons, 2002

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Identify the basic building blocks, software & hardware computational models in embedded systems. (POs − 1, 3, 4, 5)
2. Develop the programs using technical knowledge of ARM Cortex M4 for embedded system firmware development. (POs − 1, 3, 4, 5)
3. Describe various architectural features and importance of ARM Cortex M4. (POs − 1, 3,4, 5)
4. Appreciate RTOS for real-time embedded system design. (POs − 1, 3, 4, 5)
5. Interpret the importance of debugger tools for embedded system design and development (POs − 1, 3, 4, 5)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	**Marks**	**Course outcomes addressed**
Internal test-I	30	CO1, CO2, CO3
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other components		
Quiz/ Seminar	10	CO1, CO2, CO3
Assignment	10	CO3, CO4, CO5
Semester End Examination (SEE):	100	CO1, CO2, CO3, CO4, CO5

ADVANCED EMBEDDED SYSTEMS LABORATORY	
Course Code: MLCL23	**Credits: 0:0:1**
Prerequisite: Microcontroller	**Contact Hours: 14P**
Course Coordinator: Dr. Lakshmi Shrinivasan	

Course Contents

List of Experiments:

Programs based on RTOS concepts in Linux environment

1. Introduction to Linux commands and fork () function demo.
2. Create multithreads for a suitable functionality
3. Show Inter Process Communication (IPC) using Pipes, FIFO and Message Queues
4. Demonstrate Task Synchronization using Semaphore and Mutex

Hardware Interfacing Experiments using Microcontroller

5. Design and Interface a DC motor speed control and measurement.
6. Generation of Sine, triangular and square waveform using Dual DAC.
7. Design and Interface a stepper motor for following operations: rotate clockwise, anticlockwise for defined degree of angle.
8. Design and Interface simple elevator system.
9. Design and Interface a simple 3 x 8 calculator type Keypad module.
10. Show how an output interfaced H/W module could be controlled using Relay.

Model the given embedded system using UML tool

11. The static aspects of the system using basic class, use case diagrams
12. Dynamic modeling of embedded system using sequence diagram

References:

1. Joseph Yiu, "The definitive guide to ARM Cortex –M3 and Cortex- M4 processors", Elsevier Ltd., 2014.
2. Shibu K V, "Introduction to Embedded Systems", Tata McGraw Hill Education Private Limited, 2009.
3. James K Peckol, "Embedded Systems: A Contemporary Design Tool", 2nd edition, John Wiley & Sons, Inc., 2019

Web links and Video Lectures (e-Resources):

1. https://a.impartus.com/ilc/#/course/289735/703

Course Outcomes (COs):

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

1. Develop programs to demonstrate IPC concepts (POs – 1, 2, 3, 4, 5)
2. Write RTOS based programs for Task Synchronization (POs – 1, 2, 3, 4, 5)
3. Interface and communicate peripheral modules to ARM Cortex M4 microcontroller (POs – 1, 2, 3, 4, 5)
4. Develop static UML diagrams and models for an embedded system (POs – 1, 2, 3, 4, 5)
5. Develop dynamic UML diagrams and models for an embedded system (POs – 1, 2, 3, 4, 5)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	**Marks**	**Course outcomes addressed**
Weekly evaluation of laboratory manuals/records after the conduction of every experiment	30	CO1, CO2, CO3, CO4, CO5
Practical test	20	CO1, CO2, CO3, CO4, CO5
Semester End Examination (SEE):	50	CO1, CO2, CO3, CO4, CO5

ADVANCED SIGNAL AND IMAGE PROCESSING LABORATORY	
Course Code: MLCL24	**Credits: 0:0:1**
Prerequisite: Nil	**Contact Hours: 14P**
Course Coordinator: Dr. Maya V Karki, Dr. K Indira	

Course Contents

List of Experiments

1. Estimation of power spectrum of AR, MA, and ARMA process
2. Design of lattice predictor of order p
3. Stationary system identification
4. Generation of spectrogram of speech signal
5. FIR filter model using RLS algorithm
6. FIR filter model using LMS algorithm
7. Reading and displaying images, applying transformation function: log transform, power law transform, histogram equalization
8. Smoothing and sharpening spatial filter
9. Point, line and edge detection, Boundary detection, Basic global thresholding, Otsu's method and Region based segmentation
10. Extracting region and boundaries, Chain code representation, Boundary reconstruction using Fourier Descriptor
11. Dilation and Erosion of an image using structuring element, Labelling connected components, Morphological reconstruction
12. Object recognition using minimum distance, Bayes classifier
13. Object recognition using feed forward network classifier

References:

1. J. G. proakis, D. G. Manolakis, "Digital Signal Processing", 4th Edition, Prentice Hall, 2006.
2. Rafael C Gonzalez, Richard E Woods, "Digital Image Processing using MATLAB", 2nd Edition, Tata McGraw Hill, 2012

Web links and Video Lectures (e-Resources):

Course Outcomes (COs):

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

1. Estimation of power spectral density of random processes. (POs – 1, 2, 3, 4, 5)
2. Design and develop FIR filter model using LMS and RLS algorithm. (POs – 1, 2, 3, 4, 5)
3. Analyze various image pre-processing algorithms. (POs – 1, 2, 3, 4, 5)
4. Apply segmentation algorithms to detect objects. (POs – 1, 2, 3, 4, 5)
5. Develop object recognition algorithms using different classifiers. (POs – 1, 2, 3, 4, 5)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	**Marks**	**Course outcomes addressed**
Weekly evaluation of laboratory manuals/records after the conduction of every experiment	30	CO1, CO2, CO3, CO4, CO5
Practical test	20	CO1, CO2, CO3, CO4, CO5
Semester End Examination (SEE):	50	CO1, CO2, CO3, CO4, CO5

MULTIMEDIA COMMUNICATION	
Course Code: MLC31	**Credits: 3:1:0**
Prerequisite: Digital Communication	**Contact Hours: 42L+14T**
Course Coordinator: Dr. S. Sethu Selvi	

Course Contents

Unit I

Introduction: What is multimedia?, A taste of multimedia: Data compression, Graphics and image data representations: Graphics and image data types, Popular file formats, Fundamental concepts in video: Analog video, Digital video, 360^{o} video, 3D video, Video quality assessment (VQA)

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://www.cs.sfu.ca/mmbook/

Unit II

Digital audio: Digitization of sound, Quantization and transmission of audio

Lossless compression algorithms: Variable length coding, Dictionary based coding, Arithmetic coding

Lossy compression algorithms: Quantization, Transform coding, Wavelet based coding, EZW, SPIHT

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://www.cs.sfu.ca/mmbook/

Unit III

Image compression standards: JPEG, JPEG 2000

Video compression standards: H.261, H.263, MPEG – 1, 2, 4, 7, H.264, H.265, H.266

Audio compression standards: MPEG

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://www.cs.sfu.ca/mmbook/

Unit IV

Network services and protocols for multimedia: Protocol layers, LAN and access networks, Internet technologies and protocols, Multicast extension, QoS and QoE, Protocols for multimedia transmission and interaction, Internet telephony

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://www.cs.sfu.ca/mmbook/

Unit V

Multimedia content distribution: Internet multimedia content distribution, Broadcast/Multicast video distribution, Web based media streaming, Multimedia over wireless and mobile networks, Cloud computing

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://www.cs.sfu.ca/mmbook/

References:

1. Z Li, M S Drew, J Liu, "Fundamentals of Multimedia", 3rd Edition, Springer Nature Switzerland, 2021.
2. K Sayood, "Introduction to Data Compression", Third Edition, Morgan Kaufmann Publishers, Elsevier, 2006.
3. G D Gibson, "Multimedia Communications: Directions and Innovations", Academic Press, 2001.

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Appraise basics of multimedia with introduction to graphics, images and video. (POs: 1, 3, 4, 5)
2. Illustrate different lossless and lossy compression algorithms. (POs: 1, 3, 4, 5)
3. Elaborate on image, video and audio compression standards. (POs: 1, 3, 4, 5)
4. Appreciate various network services and protocols for multimedia communication. (POs: 1, 3, 4, 5)
5. Emphasize on multimedia content distribution. (POs: 1, 3, 4, 5)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	**Marks**	**Course outcomes addressed**
Internal test - I	30	CO1, CO2, CO3
Internal test - II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other components		
Quiz	10	CO1, CO2, CO3
Assignment	10	CO3, CO4, CO5
Semester End Examination (SEE)	100	CO1, CO2, CO3, CO4, CO5

INTERNSHIP/INDUSTRIAL TRAINING	
Course Code: MLC32	**Credits: 0:0:4**
Prerequisite: Nil	**Contact Hours:**
Course Coordinator:	

Course Contents

The evaluation of students will be based on an intermediate presentation, along with responses to a questionnaire testing for outcomes attained at the end of the internship. The rubrics for evaluation of the presentation and the questionnaire for the report will be distributed at the beginning of the internship.

EVALUATION RUBRICS

Criteria	Max. Marks	Achievement Levels				CO Mapping
		Inadequate (0% – 33 %)	**Developing (34% – 66%)**	**Proficient (67% – 100%)**	**Marks Awarded**	
Complex Technical Blocks	**10**	No working knowledge of the domain.	Working knowledge of the domain, with some knowledge of internal details.	Detailed understanding of the system, along with underlying mechanisms.		**CO1**
Error Debugging	**10**	No ability to diagnose or correct errors, or improve performance.	An ability to diagnose errors, but not correct them, no intuition on improving performance.	Diagnose and correct erroneous system operation, and propose methods to improve system performance.		**CO2**
Professional and Ethical Behavior	**10**	No knowledge of the requirement of professional and ethical behavior.	Understands the requirement for professional and ethical behavior.	Can predict the effects of non-professional an un-ethical behavior in the workplace.		**CO3**
Engineering and Finance	**10**	Cannot make the connection between engineering decisions and their economic impact.	Predict the cost of engineering decisions.	Creates designs keeping their economic impact in mind.		**CO4**
Lifelong Learning	**10**	No understanding of the requirements for lifelong learning in the engineering profession.	Can present examples of the impact of lifelong learning in the engineering industry.	Can present examples of the impact of lifelong learning, along with predicting future areas of impact of life-long learning.		**CO5**
				TOTAL MARKS AWARDED		

Course Outcomes (COs):

1. Analyze the working of complex technical systems/blocks. (POs: 1, 2, 3, 4, 5)
2. Correct errors during functioning and improve the performance of complex technical systems/blocks. (POs: 1, 2, 3, 4, 5)
3. Understand the importance of professional and ethical behavior in the engineering workplace. (POs: 1, 2, 3, 4, 5)
4. Predict the effect of engineering decisions on financial matters. (POs: 1, 2, 3, 4, 5)
5. Appreciate the requirements for constant technology updation. (POs: 1, 2, 3, 4, 5)

PROJECT WORK – I	
Course Code: MLC33	**Credits: 0:0:4**
Prerequisite: Nil	**Contact Hours:**
Course Coordinator:	

Course Contents

The students will be evaluated based on two oral presentations during the semester. In the presentations they will have to discuss the results of their literature survey and initial implementations of the design.

EVALUATION RUBRICS

Criteria	Max. Marks	Achievement Levels Phase – I, Review – I				CO Mapping
		Inadequate (0% – 33 %)	**Developing (34% – 66%)**	**Proficient (67% – 100%)**	**Marks Awarded**	
Introduction	**5**	Introduction is not clear, or is not technically accurate.	Introduction is accurate, but no in-depth analysis of the domain.	Clear introduction to the domain, along with design decisions and their impacts.		**CO1**
Literature survey	**10**	Few sources of low quality, with no proper discussion of results.	Appropriate discussion of existing results, but quality of sources is low.	Comprehensive list of results presented from recent quality sources.		**CO2**
Methods comparison	**5**	Methods not explained and compared in terms of internal implementation details.	Advantages and disadvantages discussed, but not with reference to actual methods.	Detailed description of existing methods, along with their advantages and disadvantages.		**CO3**
TOTAL MARKS AWARDED						

Criteria	Max. Marks	Achievement Levels Phase – I, Review – II				CO Mapping
		Inadequate (0% – 33 %)	**Developing (34% – 66%)**	**Proficient (67% – 100%)**	**Marks Awarded**	
Methods discussion	**10**	No implementation level discussion of methods used in literature.	Brief discussion of tools used and results obtained therein.	Detailed discussion of tools used and their impact on the quality of results obtained in literature sources.		**CO3**
Technical Block Diagrams & Initial Results	**10**	Block Diagram is not technically justified & initial results are not complete.	Justified block diagram and proper tools used to generate results but are not same as existing literature.	Detailed block diagram with use of suitable tools with appropriate results discussed.		**CO4**
Technical Report	**10**	Poorly written document without paper clarity.	Report includes figures/block diagram but lacks technical aspects/methodologies/approaches.	Report includes figures with clear description, graphical explanation. Document must include a draft of review article.		**CO5**
TOTAL MARKS AWARDED						

Course Outcomes (COs):

1. Introduce the technical area chosen and demonstrate that the focus of the study is on a significant problem worth investigation. (POs: 1, 2, 3, 4, 5)
2. Discuss existing/standard solution strategies for the problem identified and its deficiency in the current scenario. (POs: 1, 2, 3, 4, 5)
3. Compare and contrast various research outcomes as part of a literature survey of quality published academic work. (POs: 1, 2, 3, 4, 5)
4. Implement technical block diagram with usage of modern tools to obtain appropriate initial results. (POs: 1, 2, 3, 4, 5)
5. Prepare quality technical report which includes research review article. (POs: 1, 2, 3, 4, 5)

PROJECT WORK – II	
Course Code: MLC41	**Credits: 0:0:20**
Prerequisite: Nil	**Contact Hours:**
Course Coordinator:	

Course Contents

The students will be evaluated based on two oral presentations, in which they will present their proposed solutions to the problem identified, and discuss the implementation details and results obtained.

EVALUATION RUBRICS

Criteria	Max. Marks	Achievement Levels Phase – II, Review – I				CO Mapping
		Inadequate (0% – 33 %)	**Developing (34% – 66%)**	**Proficient (67% – 100%)**	**Marks Awarded**	
Proposed Block Diagram	**10**	A discussion of methods for optimization is not based on technical arguments.	One or more block diagrams presented for optimization, but not justified with technical arguments.	One or more block diagrams presented for optimization, along with along with accurate technical arguments for justification.		**CO1**
Results	**10**	Results are not matching expectations, or are not complete.	Complete results generated, but not an improvement on existing metrics.	Complete results generated with an improvement over existing approaches due to proposed block diagram.		**CO2**
TOTAL MARKS AWARDED						

Criteria	Max. Marks	Achievement Levels Phase – II, Review – II				CO Mapping
		Inadequate (0% – 33 %)	**Developing (34% – 66%)**	**Proficient (67% – 100%)**	**Marks Awarded**	
Design of Experiments	**10**	Few experiments conducted, with no relation to problem domain.	Significant experiments conducted, but with no structure and relation to problem domain.	Significant experiments conducted, with all relevant parameters being tested in an orderly manner, and with relevance to hypothesis.		**CO3**
Experimental Results & Discussions	**10**	Results and Discussions are not well optimized & qualified.	Methods & its results are moderately discussed but not to the level of the proposed method.	Optimized results and detailed discussion with advantage & disadvantage of the proposed method.		**CO4**
Report Writing & Research Article	**10**	Poorly written document without proper organization.	Properly organized document but lack in depth explanation of individual modules of proposed work.	Well drafted documents with clear explanation & discussion of all aspects of the proposed work. Documents must include a technical article to be submitted to a conference/journal .		**CO5**
TOTAL MARKS AWARDED						

Course Outcomes (COs):

1. Present different methods for improving existing performance metrics with respect to existing literature, along with justified technical arguments. (POs: 1, 2, 3, 4, 5)
2. Implement solutions proposed using appropriate software tools. (POs: 1, 2, 3, 4, 5)
3. Compare implemented solutions and choose the best possible option based on factors such as societal impact, cost, speed, and practicality. (POs: 1, 2, 3, 4, 5)
4. Perform extensive experiments with detailed discussion qualifying the results of the proposed work. (POs: 1, 2, 3, 4, 5)
5. Prepare a comprehensive project report comprising of clear details of implementation & detailed experimental results with required discussion. (POs: 1, 2, 3, 4, 5)

ELECTIVES

ANTENNA THEORY AND DESIGN	
Course Code: MLCE01	**Credits: 4:0:0**
Prerequisite: Electromagnetics, Microwave	**Contact Hours: 56L**
Course Coordinator: Dr. Sujatha B	

Course Contents

Unit I

Antenna fundamentals and definitions: Radiation patterns, Directivity and gain, Effective height and aperture, Antenna impedance, Radiation efficiency, Antenna polarization.

Arrays: Array factor for linear arrays, uniformly excited equally spaced linear arrays, Pattern multiplication, Directivity of linear arrays, Multidimensional arrays.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: nptel.ac.in/courses/117/107/117107035/ nptel.ac.in/courses/108/101/108101092/

Unit II

Resonant Antennas: Dipole antenna (Far field electric and magnetic field components, Radiation resistance), Yagi-Uda antenna.

Broadband antennas: Travelling wave Wire antennas, Helical antennas – Normal mode helix antenna, Axial mode Helix antenna, Bi-conical antennas, sleeve antenna.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: nptel.ac.in/courses/117/107/117107035/ nptel.ac.in/courses/108/101/108101092/

Unit III

Frequency independent antennas: Principle of frequency independent antennas, Log-periodic antenna.

Micro-strip and Printed Antennas: Feeding methods, Rectangular patch, Circular patch, Resonant frequencies and design.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: nptel.ac.in/courses/117/107/117107035/ nptel.ac.in/courses/108/101/108101092/

Unit IV

Aperture antennas: Pyramidal Horn Antenna, Reflector antennas – Parabolic reflector antenna principles, Axi-symmetric parabolic reflector antenna, offset parabolic reflectors, Dual reflector antennas, Feed antennas for reflectors, Feed antennas used in practice.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: nptel.ac.in/courses/117/107/117107035/ nptel.ac.in/courses/108/101/108101092/

Unit V

Antenna Array Synthesis: Formulation of the synthesis problem, Synthesis principles, Line sources shaped beam synthesis, Linear array shaped beam synthesis, Comparison of shaped beam synthesis methods, Dolph Chebyshev linear array method to reduce side lobe narrow main beam synthesis.
Computational Electromagnetics (CEM) for antennas: Introduction to CEM, The methods of moments, Pocklington's integral equation, Integral equation and Kirchhoff's networking equations, Source modeling weighted residual formulations

- Pedagogy/Course delivery tools: Chalk and talk
- Links: http://acl.digimat.in/nptel/courses/video /108105114/L38.html

References:

1. Warren L. Stutzman, Gary A. Thiele, "Antenna Theory and Design", 2nd Edition, John Wiley and Sons, 2012.
2. Constantine. A. Balanis, "Antenna Theory Analysis and Design", 3rd Edition, John Wiley, 2016.
3. John D Kraus, Ronald J Marhefka, Ahmad S Khan, "Antennas", 4th Edition, Tata McGraw Hill, 2006.

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Define the parameters of antenna and analyze the uniform excited array antennas (POs: 1, 3, 4, 5)
2. Design resonant and broad band antennas (POs: 1, 3, 4, 5)
3. Apply different feeding techniques and design micro-strip patch antennas (POs: 1, 3, 4, 5)
4. Design the directivity and gain of parabolic reflector and explain the feed methods of reflector antennas (POs: 1, 3, 4, 5)
5. Synthesize antenna beam pattern using different types of distributions and describe computationally efficient approximations using MOM (POs: 1, 3, 4, 5)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	**Marks**	**Course outcomes addressed**
Internal test-I	30	CO1, CO2, CO3
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other components		
Quiz	10	CO1, CO2, CO3
Assignment	10	CO3, CO4, CO5
Semester End Examination (SEE):	100	CO1, CO2, CO3, CO4, CO5

DIGITAL SYSTEM DESIGN using HDL	
Course Code: MLCE02	**Credits: 3:0:0**
Prerequisite: Digital Design	**Contact Hours: 42L**
Course Coordinator: Dr. Rajendra Prasad P	

Course Contents

Unit I

Introduction and Methodology: Digital systems and embedded systems, Binary representation and circuit elements, Real world circuits, Models, Design methodology

Number Basics: Unsigned and signed integers, Fixed and floating point numbers

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/117108040
- Links: https://nptel.ac.in/courses/117105080

Unit II

Sequential Basics: Storage elements, Counters, Sequential data paths and control, Clocked synchronous timing methodology

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/117106092
- Links: https://nptel.ac.in/courses/117106086

Unit III

Memories and Implementation Fabrics: Concepts, Memory types, Error detection and correction, ICs, PLDs, Packaging and circuit boards, Interconnection and signal integrity

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/117106109
- Links: https://nptel.ac.in/courses/117106114

Unit IV

System Verilog Simulation and Synthesis: System Verilog extension to Verilog, RTL and gate level modeling, RTL synthesis, Subset of System Verilog, System Verilog simulation, Digital synthesis, Modules, Procedural blocks

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/108103179
- Links: https://nptel.ac.in/courses/106105165

Unit V

RTL Modeling Fundamentals: System Verilog language rules – Module, Module instances, Hierarchy, Four state data values, Data types, Variable types, Net types, Operators, Continuous signal assignments, Procedural signal assignments, Modeling combinational logic and sequential logic

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/106105165
- Links: https://nptel.ac.in/courses/108103179

References:

1. Peter J. Ashenden, "Digital Design: An Embedded Systems Approach using Verilog", Elsevier, 2010.
2. Stuart Sutherland, "RTL Modeling with System Verilog for Simulation and Synthesis: Using System Verilog for ASIC and FPGA Design", 1st Edition, Create Space Independent Publishing Platform, 2017.
3. Samir Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis", 2nd Edition, Pearson Education, 2010.
4. Chris Spear, Greogory J Tumbush, "System Verilog for Verification – A Guide to Learning Test Bench Language Features", Springer, 2012.

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Apply the concepts of Verilog modeling to design and verify the operations of complex digital logic circuits. (POs: 1, 3, 4, 5)
2. Design, and test pipelined storage elements, sequential data path controllers based using Verilog. (POs:.1,3,4, 5)
3. Apply the concepts of Verilog modeling to multi-port memories, FIFO data paths and FSMs with respect to integrated circuits. (POs: 1, 3, 4, 5)
4. Employ System Verilog to simulate and synthesize digital systems. (POs: 1, 3, 4, 5)
5. Model combinational and sequential circuits using System Verilog. (POs: 1, 3, 4, 5)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	**Marks**	**Course outcomes addressed**
Internal test-I	30	CO1, CO2, CO3
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other components		
Quiz	10	CO1, CO2, CO3
Assignment	10	CO3, CO4, CO5
Semester End Examination (SEE):	100	CO1, CO2, CO3, CO4, CO5

DIGITAL VLSI DESIGN	
Course Code: MLCE03	**Credits: 4:0:0**
Prerequisite: Digital Design	**Contact Hours: 56L**
Course Coordinator: Manjunath C Lakkannavar	

Course Contents

Unit I

Introduction to CMOS circuits: MOS transistors, CMOS combinational logic gates, multiplexers, latches and flip-flops, CMOS fabrication and layout, VLSI design flow.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/106106089
- Links: https://nptel.ac.in/courses/117101004

Unit II

MOS transistor theory: Ideal I-V and C-V characteristics, non-ideal I-V effects, CMOS Inverter, DC transfer characteristics, Switch level RC delay models.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/106106089
- Links: https://nptel.ac.in/courses/117101004

Unit III

CMOS technologies: Layout design rules, CMOS process enhancement, Technology related CAD issues.

Circuit characterization and performance estimation: Delay estimation, Logical effort and transistor sizing

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/106106089

Unit IV

Power: Introduction, Dynamic power, Static power, Power dissipation, Low power architectures.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/106106089

Unit V

Combinational circuit design: Static CMOS, Ratioed circuits, Cascode voltage switch logic, Dynamic circuits, Pass transistor circuits.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/106106089

References:

1. Neil H E Weste, David Harris, "CMOS VLSI Design: A System Perspective", 4th Edition, Pearson Education, 2014.
2. Jan Rabaey, B. Nikolic, A. Chadrakasan," Digital Integrated Circuits: A Design Perspective", 2nd Edition, Pearson,2016
3. Wayne Wolf, "Modern VLSI Design: System on Silicon", 3rd Edition, PHI, 2008.
4. Douglas A Pucknell, Kamran Eshraghian, "Basic VLSI Design", 3rd Edition, PHI, 2009.

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Analyse the theory behind CMOS digital integrated circuits. (POs:1, 3, 4, 5)
2. Design CMOS inverters with specified noise margin and propagation delay. (POs:1, 3, 4, 5)
3. Employ different performance metrics to predict the performance of VLSI circuits. (POs: 1, 3, 4, 5)
4. Apply low power concepts in VLSI Design. (POs: 1, 3, 4, 5)
5. Implement the logic circuits using MOS and CMOS technology. (POs: 1, 3, 4, 5)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	**Marks**	**Course outcomes addressed**
Internal test-I	30	CO1, CO2, CO3
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other components		
Quiz	10	CO1, CO2, CO3
Assignment	10	CO3, CO4, CO5
Semester End Examination (SEE):	100	CO1, CO2, CO3, CO4, CO5

ADVANCED SIGNAL AND IMAGE PROCESSING	
Course Code: MLCE04	**Credits: 4:0:0**
Prerequisite: Nil	**Contact Hours: 56L**
Course Coordinator: Dr. Maya V Karki	

Course Contents

Unit I

Linear Prediction & Optimum Linear Filters: Random signals, Correlation functions and Power Spectra, Innovations representation of a stationary random process, Forward and backward linear prediction, Solution of normal equations, Properties of linear prediction – Error filters, Lattice and ARMA Lattice-Ladder Filters, Wiener filters for filtering and prediction

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

Unit II

Adaptive filters: Applications of adaptive filters, Linear Predictive Coding (LPC) of speech signal, Adaptive direct form FIR filters, LMS algorithm, Adaptive direct form filters, RLS algorithm

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

Unit III

Image Pre-processing: Basic intensity transformations, Histogram processing, Smoothing and sharpening spatial filters, Segmentation: Point, line and edge detection, Thresholding, Region based segmentation

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

Unit IV

Representation and Morphological Image processing: Representation: Chain codes, signatures, Boundary segments, Image boundary descriptors: Some simple descriptors and Fourier descriptor
Morphological Image Processing: Erosion and dilation, Basic morphological algorithms: Boundary extraction, hole filling extraction of connected components, Thinning, Thickening, skeletons, Morphological reconstruction

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

Unit V

Object Recognition: Patterns and pattern classification. Recognition based on decision theoretic methods: matching, Optimum statistical classifiers, Neural networks. Structural Methods: Matching shape numbers, String matching

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

References:

1. John G Proakis, Dimitris G Manolakis, "Digital Signal Processing", 4th Edition, Prentice Hall, 2006.
2. Rafael C Gonzalez, Richard E Woods, "Digital Image Processing", 3rd Edition, Pearson Education, 2009.
3. Milan Sonka, Vaclav Hlavac, Roger Boyle, "Image Processing, Analysis, and Machine Vision", Cengage Learning, 2013.

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Design linear predictors and optimum linear filters. (POs: 1, 2, 3, 4, 5)
2. Design adaptive filters with LMS and RLS algorithms. (POs: 1, 2, 3, 4, 5)
3. Apply segmentation algorithms to detect and link edges in an image. (POs: 1, 2, 3, 4, 5)
4. Represent and apply morphological algorithms to describe the shape and characteristics of an object. (POs: 1, 2, 3, 4, 5)
5. Apply different object recognition algorithms to detect objects in a scene. (POs: 1, 2, 3, 4, 5)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	**Marks**	**Course outcomes addressed**
Internal test-I	30	CO1, CO2, CO3
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other components		
Quiz	10	CO1, CO2, CO3
Assignment	10	CO3, CO4, CO5
Semester End Examination (SEE):	100	CO1, CO2, CO3, CO4, CO5

MEMS AND NANOELECTRONICS	
Course Code: MLCE05	**Credits: 4:0:0**
Prerequisite: Nil	**Contact Hours: 56L**
Course Coordinator: Dr. Lakshmi S	

Course Contents

Unit I

Introduction to MEMS and MEMS devices and systems: Feynman's vision, multi-disciplinary aspects, application areas. Scaling laws in miniaturization, scaling in geometry, electrostatics, and electromagnetics.

Micro and Smart Devices and Systems – Principles: Transduction principles in MEMS Sensors: Actuators: different actuation mechanisms - silicon capacitive accelerometer, piezo-resistive pressure sensor, blood analyzer, conductometric gas sensor, silicon micro-mirror arrays, piezo-electric based inkjet print head, electrostatic comb-driver.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/108106165
- Links: https://archive.nptel.ac.in/courses/108/108/108108113/

Unit II

Micro manufacturing and Packaging: lithography, thin-film deposition, etching (wet and dry), wafer-bonding, Silicon micromachining: surface, bulk, LIGA process, Wafer bonding process.

Integration and Packaging of MEMS devices: Integration of microelectronics and micro devices at wafer and chip levels, Microelectronic packaging: wire and ball bonding, flipchip,

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/108106165
- Links: https://archive.nptel.ac.in/courses/108/108/108108113/

Unit III

Electrical and Electronics Aspects of MEMS: Electrostatics, Coupled electro mechanics, stability and Pull-in phenomenon, Practical signal conditioning circuits for microsystems, RF MEMS: Switches, varactors.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/108106165

Unit IV

Introduction to Nanoelectronics: Particles and waves- Wave-particle duality- Wave mechanics- Schrödinger wave equation, Electrons in traditional low-dimensional structures- Electrons in quantum wells, Electrons in quantum wires, Electrons in quantum dots- Nanostructure devices- Resonant-tunneling diodes, Single-electron-transfer devices.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/118102003

Unit V

Fabrication and measurement techniques for nanostructures- Bulk crystal and hetero structure growth, Nanolithography.

Measurement and Applications of Nano devices: Techniques for characterization of nanostructures, Injection Lasers: Quantum cascade lasers, Single photon sources. Optical memories, Coulomb blockade devices, Photonic structures

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://www.digimat.in/nptel/courses/video/117108047/L01.html

References:

1. G.K. Ananthasuresh, K.J.Vinoy, S.Gopalakrishnan, K.N.Bhat, V.K.Aatre, "Micro and Smart Systems", Wiley India, First edition, 2010.
2. George W. Hanson, "Fundamentals of Nanoelectronics", Pearson Education India, 2009
3. T R Hsu, "MEMS and Microsystems Design and Manufacturing", Tata McGraw Hill, 2nd Edition, 2008.
4. Vladimir V. Mitin, Viatcheslav A. Kochelap, Michael A. Stroscio, "Introduction to Nanoelectronics: Science, Nanotechnology, Engineering, and Applications", Cambridge University Press 2011

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Analyze scaling laws and operation of various practical MEMS systems. (POs - 1, 2, 3, 5)
2. Describe various fabrication techniques and packaging methods for MEMS devices. (POs – 2, 3, 5)
3. Identify the electronics and RF aspects of MEMS systems. (POs – 1, 2, 3, 4, 5)
4. Recognize the distinguishing aspect of nanoscale devices and systems. (POs – 2, 3, 5)
5. Examine the basic science behind the design and fabrication of nano scale Systems and their applications. (POs- 2, 3, 5)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	**Marks**	**Course outcomes addressed**
Internal test-I	30	CO1, CO2, CO3
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other components		
Quiz	10	CO1, CO2, CO3
Assignment	10	CO3, CO4, CO5
Semester End Examination (SEE):	100	CO1, CO2, CO3, CO4, CO5

MACHINE LEARNING AND DEEP LEARNING	
Course Code: MLCE06	**Credits: 4:0:0**
Prerequisite: Nil	**Contact Hours: 56L**
Course Coordinator: Dr. K. Indira	

Course Contents

Unit I

Introduction: What is machine learning, Example machine learning applications

Supervised Learning: Learning a class from examples, VC dimension, PAC learning, Noise, Learning multiple classes, Regression, Model selection and generalization

Bayesian Decision Theory: Classification, Losses and risks, Discriminant functions, Association rules

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://onlinecourses.nptel.ac.in/noc22_cs29/

Unit II

Parametric Methods: Maximum likelihood estimation, Evaluating an estimator, Bayes estimator, Parametric classification, Regression, Tuning model capacity

Dimensionality Reduction: Subset Selection, Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA)

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://onlinecourses.nptel.ac.in/noc22_cs29/

Unit III

Unsupervised Learning: Clustering: k–Means clustering, EM algorithm, Hierarchical clustering,

Decision Trees: Univariate trees: Classification and regression trees

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://onlinecourses.nptel.ac.in/noc22_cs29/

Unit IV

Multilayer Perceptrons: Perceptron, Training a perceptron, Learning Boolean functions, Multilayer perceptrons, Backpropagation algorithm, learning hidden representation Autoencoders

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/117105084
- Links: https://nptel.ac.in/courses/108108148

Unit V

Deep Learning: Train multiple hidden layers, Impreving training convergence, Regularization, convolutional layers, Tuning the network structure, Learning sequences, GAN.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/117105084

Reference Books:

1. Ethem Alpaydin, "Introduction to Machine Learning", 4th Edition, PHI Learning Pvt. Ltd, 2020.
2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", MIT Press, 2017.
3. Christopher Bishop, "Pattern Recognition and Machine Learning", CBS Publishers & Distributors, 2010.
4. Tom Mitchell, "Machine Learning", McGraw Hill, 1997.

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Examine the concepts of various supervised learning algorithms and employ Bayesian learning for classification (POs – 1, 3, 4,5)
2. Evaluate parametric methods for classification and investigate various dimensionality reduction algorithms (POs –1, 3, 4,5)
3. Analyse unsupervised learning algorithms and decision tree (POs –1, 3, 4,5)
4. Appreciate the concepts of multilayer perceptrons (POs – 1, 3, 4,5)
5. Understand deep neural networks and demonstrate how convolutional networks can be mapped to practical applications (POs – 1, 3, 4,5)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	**Marks**	**Course outcomes addressed**
Internal test-I	30	CO1, CO2, CO3
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other components		
Quiz	10	CO1, CO2, CO3
Assignment	10	CO3, CO4, CO5
Semester End Examination (SEE):	100	CO1, CO2, CO3, CO4, CO5

INTERNET OF THINGS (IoT)	
Course Code: MLCE07	**Credits: 4:0:0**
Prerequisite: Nil	**Contact Hours: 56L**
Course Coordinator: Dr. Lakshmi S	

Course Contents

Unit I

Introduction & Concepts: Definition and Characteristics of IoT, Things in IoT, IoT Protocols, IoT Functional Blocks, IoT Communication Models, IoT Communication APIs, IoT Enabling Technologies, IoT levels and deployment templates, IoT and M2M, SDN and NFV for IoT

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/106105166

Unit II

Developing Internet of Things: IoT Platform design methodology, Specifications: Requirements, Process, Domain, Information, Services, Level, Functional, Operational, Integration, Application Development

Python Language: Data Types and Data Structures, Control Flow, Functions, Modules, Packages, File Handling, Date and Time Operations, Classes, Python packages of interest for IoT

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/106105166

Unit III

IoT Physical Devices and End Points: Basic building blocks of an IoT Device, Raspberry Pi, Linux on Raspberry Pi, Raspberry Pi Interfaces: Serial, SPI, I2C

Programming Raspberry Pi with Python: Controlling LED, Interfacing Switch, Interfacing Light Sensor

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/108108098

Unit IV

Cloud and Data Analytics: Introduction to cloud storage models and communication APIs

Web Application Framework: Django, Web Services for IoT, SkyNet Messaging Platform,

Data Analytics for IoT: Apache: Hadoop, Oozie, Storm, Real-Time Data Analysis, Tools for IoT

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/108108098

Unit V

IoT Case Studies: Home Automation: Smart Lighting, Home Intrusion Detection; Cities: Smart Parking Environment: Weather Monitoring System, Weather Reporting Bot, Air Pollution Monitoring, Forest Fire Detection; Agriculture – Smart Irrigation, IoT Printer.

IOT in Automobiles: Intelligent Transportation and the Connected Vehicle, Vehicular Ad-hoc Networks (VANETs)

- Pedagogy/Course delivery tools: Chalk and talk
- Links: https://nptel.ac.in/courses/108108098

References:

1. Arshdeep Bahga, Vijay Madisetti, "Internet of Things: A Hands-on Approach", University Press, 2015.
2. Pethuru Raj, Anupama C Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases Description", Taylor & Francis, CRC Press, 2017.

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Understand the building blocks of internet of things, characteristics and related communication protocols. (POs-1,3, 5)
2. Learn basics of design, integration and applications of IoT models. (POs-1,3, 4, 5)
3. Acquire the knowledge of basic blocks of an IOT devices using Raspberry Pi. (POs-1, 3, 4, 5)
4. Understand cloud storage models and web services for IoT. (POs-1, 3, 5)
5. Appraise with various case studies. (POs-1,3,4, 5)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	**Marks**	**Course outcomes addressed**
Internal test-I	30	CO1, CO2, CO3
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other components		
Quiz	10	CO1, CO2, CO3
Assignment	10	CO3, CO4, CO5
Semester End Examination (SEE):	100	CO1, CO2, CO3, CO4, CO5

ADVANCED COMPUTER NETWORKS	
Course Code: MLCE08	**Credits: 4:0:0**
Prerequisite: Computer Networks	**Contact Hours: 56L**
Course Coordinator: Flory Francis	

Course Contents

Unit I

Local Area Networks: Ethernet - Physical layer, MAC, LLC, LAN interconnection, Token ring, Physical layer, MAC, LLC, FDDI Switching: Introduction, Circuit switching, Packet switching, Multicasting Scheduling: Introduction, Requirements, Choices, Performance bounds, Best effort techniques, Naming and addressing

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

Unit II

Traffic Management: Introduction, Framework for traffic management, Traffic models, Traffic classes, Traffic scheduling

Control of Networks: Objectives and methods of control, Routing optimization in circuit and datagram networks, Markov chains, Queuing models in circuit and datagram networks

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

Unit III

Congestion and Flow control: Window congestion control, Rate congestion control, Control in ATM networks, Flow control model, Open loop flow control, Closed loop flow control

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

Unit IV

Cryptography: Introduction, Symmetric ciphers, Block cipher structure, DES, AES cipher, Principles of public key cryptosystems, RSA algorithm

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

Unit V

Hash Functions and Message Authentication: One way hash functions using symmetric block algorithms and public key algorithms, Message authentication codes, Hash functions, Digital signature algorithm

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

References:

1. J. Walrand and P. Varaya, "High Performance Communication Networks", Harcourt Asia (Morgan Kaufmann), 2000.
2. S. Keshav, "An Engineering Approach to Computer Networking", Pearson Education, 1997.
3. Leon-Garcia, and I. Widjaja, "Communication Networks: Fundamental Concepts and Key Architectures", TMH, 2000.
4. William Stallings, "Cryptography and Network Security: Principles and Practice", 6th Edition, Pearson Education Inc., 2014.

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Describe the basic networking, data switching and scheduling techniques of networks. (PO:1, 3, 4, 5)
2. Analyze various network traffic management and control techniques. (PO:1, 3, 4, 5)
3. Discuss congestion and flow control. (PO:1, 3, 4, 5)
4. Appraise the working for symmetric and public key ciphers. (POs: PO:1, 3, 4, 5)
5. Illustrate the importance of hash functions and message authentication codes. (PO:1, 3, 4, 5)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	**Marks**	**Course outcomes addressed**
Internal test-I	30	CO1, CO2, CO3
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other components		
Quiz	10	CO1, CO2, CO3
Assignment	10	CO3, CO4, CO5
Semester End Examination (SEE):	100	CO1, CO2, CO3, CO4, CO5

ERROR CONTROL CODING	
Course Code: MLCE09	**Credits: 4:0:0**
Prerequisite: Advanced Digital Communication	**Contact Hours: 56L**
Course Coordinator: Chitra M	

Course Contents

Unit I

Introduction to Algebra: Groups, Fields, Binary field arithmetic, Basic properties of GF(2m),Construction of Galois Field GF(2m) and its properties, Computation using Galois field GF(2m) arithmetic, Vector spaces and matrices on Galois field

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

Unit II

Linear Block Codes: Generator and parity check matrices, Encoding circuits, Syndrome and error detection, Minimum distance considerations, Error detecting and error correcting capabilities, Standard array and syndrome decoding, decoding circuits, Hamming codes, Reed-Muller codes, (24,12) Golay codes, Product codes and interleaved codes, applications

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

Unit III

Cyclic Codes: Introduction, Generator and parity check polynomials, Encoding using multiplication circuits, Systematic cyclic codes – Encoding using feedback shift register circuits, Generator matrix for cyclic code, Syndrome computing and error detection, Meggitt decoder, Error trapping decoding, (23,12) Golay codes, Cyclic Hamming codes, Shortened cyclic codes

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

Unit IV

BCH Codes: Binary primitive BCH codes, Decoding procedures, Implementation of Galois field arithmetic, Implementation of error correction. Non-binary BCH Codes: q-ary linear block codes, Primitive BCH codes over GF(q), Reed – Solomon codes, Decoding of non-binary BCH and RS codes: Berlekamp - Massey algorithm, Gorenstein – Zierler algorithm

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

Unit V

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

Convolutional codes: Encoding of convolutional codes, Structural properties, Distance properties, Viterbi decoding algorithm for decoding, Soft output Viterbi algorithm, Stack and Fano sequential

decoding algorithms, Majority logic decoding, Introduction to LDPC codes, Geometrical structure of LDPC codes, EG-LDPC codes, PG-LDPC codes, Applications

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

References:

1. Shu Lin and Daniel J. Costello. Jr., "Error Control Coding", 2nd Edition, Pearson Education, Prentice Hall, 2014.
2. Todd K. Moon, "Error Correction Coding: Mathematical Methods and Algorithms", 1st Edition, Wiley Publications, 2005.

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Apply properties of Galois field to groups, fields, vector space, row space and sub-spaces. (PO:1, 3, 4, 5)
2. Employ linear block codes, RM codes and Golay codes in error detection and correction. (POs: 1, 3, 4,5)
3. Demonstrate cyclic block codes, cyclic Hamming codes, shortened cyclic codes and (23, 12) Golay codes in error detection and correction. (POs: 1, 3, 4,5)
4. Illustrate BCH, RS and other q-ary coding and decoding algorithms. (POs: 1, 3, 4,5)
5. Describe convolutional encoders and Viterbi and stack algorithm based decoders. (POs: 1, 3, 4,5)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	**Marks**	**Course outcomes addressed**
Internal test-I	30	CO1, CO2, CO3
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other components		
Quiz	10	CO1, CO2, CO3
Assignment	10	CO3, CO4, CO5
Semester End Examination (SEE):	100	CO1, CO2, CO3, CO4, CO5

OPTICAL COMMUNICATION NETWORKS	
Course Code: MLCE10	**Credits: 4:0:0**
Prerequisite: Digital Communication	**Contact Hours: 56L**
Course Coordinator: Dr. M. Naghabhusanam	

Course Contents

Unit I

Introduction: Propagation of signals in optical fiber, Different losses, Nonlinear effects, Solitons, Optical sources, Detectors

Optical Components: Couplers, Isolators, Circulators, Multiplexers and filters, Gratings, Interferometers, Optical amplifiers

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

Unit II

Modulation and Demodulation: Signal formats, Ideal receivers, Practical detection receivers, Optical preamplifier, Noise considerations, Bit error rates, Coherent detection

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

Unit III

Transmission System Engineering: System model, Power penalty, Transmitter, Receiver, Different optical amplifiers, Dispersion

Optical Networks: Client layers of optical layer – SONET/SDH, Multiplexing, Layers, Frame structure, ATM functions, Adaptation layers, Quality of service and flow control, ESCON, HIPPI

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

Unit IV

WDM Network Elements: Optical line terminal optical line amplifiers, Optical cross connectors, WDM network design – cost trade-offs, LTD and RWA problems, Routing and wavelength assignment, Wavelength conversion

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

Unit V

Control and Management: Network management functions, Management framework, Information model, Management protocols, Layers within optical layer performance and fault management, Impact of transparency

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

References:

1. Rajiv Ramswami, K. N. Sivarajan, H.Sasaki, "Optical Networks", 3rd Edition, Morgan Kaufman Publishers, 2010.
2. John M. Senior, "Optical Fiber Communications: Principles & Practice", 3rd Edition, Pearson Education, 2009.
3. Gerd Keiser, "Optical Fiber Communication", 3rd Edition, McGraw-Hill, 2000.
4. Govind. P. Agarwal, "Fiber Optic Communication Systems", 3rd Edition, John Wiley, 2002.

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Demonstrate the function of optical components and light propagation mechanism. (POs: 1, 3, 4,5)
2. Analyze the noise performance in optical communication receivers. (POs: 1, 3, 4,5)
3. Define signal impairment in optical networks. (POs: 1, 3, 4,5)
4. Demonstrate the principle of WDM network elements. (POs: 1, 3, 4,5)
5. Appreciate different network and management protocols in optical networks. (POs: 1, 3, 4,5)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	**Marks**	**Course outcomes addressed**
Internal test-I	30	CO1, CO2, CO3
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other components		
Assignment	10	CO1, CO2, CO3
Assignment	10	CO3, CO4, CO5
Semester End Examination (SEE):	100	CO1, CO2, CO3, CO4, CO5

ASIC DESIGN	
Course Code: MLCE11	**Credits: 4:0:0**
Prerequisite: Nil	**Contact Hours: 56L**
Course Coordinator: Dr. V. Anandi	

Course Contents

Unit I

Introduction to ASICs: Full custom, Semi-custom and programmable ASICs, ASIC design flow, **ASIC cell libraries CMOS Logic:** Datapath logic cells: Data path elements, Adders: Carry skip, Carry bypass, Carry save, Carry select, Conditional sum, Multiplier (Booth encoding), Data path operators, I/O cells

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

Unit II

ASIC Library Design: Logical effort: Predicting delay, Logical area and logical efficiency, Logical paths, Multi stage cells, Optimum delay and number of stages

Programmable ASIC Logic Cells: MUX as Boolean function generators, Actel ACT: ACT 1, ACT 2 and ACT3 logic modules, Xilinx LCA: XC3000 CLB, Altera FLEX and MAX

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

Unit III

Programmable ASIC I/O Cells: Xilinx and Altera I/O Block

Low-level Design Entry: Schematic entry: Hierarchical design, Netlist screener

ASIC Construction: Physical Design, CAD Tools

Partitioning: Goals and objectives, Constructive partitioning, Iterative partitioning improvement, KL and look ahead algorithms

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

Unit IV

Floor Planning: Goals and objectives, Floor planning tools, Channel definition, I/O and Power planning, Clock planning

Placement: Goals and objectives, Min-cut placement algorithm, Iterative placement improvement, Physical design flow

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

Unit V

Routing: Global routing: Goals and objectives, Global routing methods, Back-annotation

Detailed Routing: Goals and objectives, Measurement of channel density, Left-Edge and Area routing algorithms. Special routing, Circuit extraction and DRC

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

References:

1. M J S Smith, "Application Specific Integrated Circuits", Pearson Education, 2003.
2. Jose E France, Yannis Tsividis, "Design of Analog – Digital VLSI Circuits for Telecommunication and Signal Processing", Prentice Hall, 1994.
3. Malcolm R Haskard , Lan C May, "Analog VLSI Design – NMOS and CMOS", Prentice Hall, 1998.
4. Vikram Arkalgud Chandrasetty, "VLSI Design: A Practical Guide for FPGA and ASIC Implementations", Springer, 2011.
5. Rakesh Chadha, J. Bhasker, "An ASIC Low Power Primer: Analysis, Techniques and Specification", Springer Publications, 2015.

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Describe the concepts of ASIC design methodology, data path elements and FPGA architectures. (PO:1, 3, 4, 5)
2. Design data path elements for ASIC cell libraries and compute optimum path delay. (PO:1, 3, 4, 5)
3. Employ industry synthesis tools to achieve desired objectives. (PO:1, 3, 4, 5)
4. Design of FPGAs and ASICs suitable for specific tasks, perform design entry and explain physical design flow. (PO:1, 3, 4, 5)
5. Create floor plan including partition and routing using CAD algorithms. (PO:1, 3, 4, 5)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	**Marks**	**Course outcomes addressed**
Internal test-I	30	CO1, CO2, CO3
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other components		
Quiz	10	CO1, CO2, CO3
Assignment	10	CO3, CO4, CO5
Semester End Examination (SEE):	100	CO1, CO2, CO3, CO4, CO5

ADVANCED COMPUTER ARCHITECTURE	
Course Code: MLCE12	**Credits: 4:0:0**
Prerequisite: Nil	**Contact Hours: 56L**
Course Coordinator: Dr. V. Anandi	

Course Contents

Unit I

Parallel Computer Models: State of computing, Classification of parallel computers, Multiprocessors and multicomputer, Multivectors and SIMD computers grain size and latency

Program and Network Properties: Conditions of parallelism, Data and resource dependencies, Hardware and software parallelism, Program partitioning and scheduling

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

Unit II

Program Flow Mechanisms: Control flow v/s data flow, Comparisons of flow mechanisms, Performance metrics and measures, Data flow architecture, Demand driven mechanisms

Principles of Scalable Performance: Parallel processing applications, Speedup performance laws, Scalability analysis and approaches

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

Unit III

Speedup Performance Laws: Amdhal's law, Gustafson's law, Memory bounded speedup model, Scalability analysis and approaches

Advanced Processors: Advanced processor technology, Instruction set architectures, CISC scalar processors, RISC scalar processors, Superscalar processors, VLIW architectures

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

Unit IV

Pipelining: Linear pipeline processor, Nonlinear pipeline processor, Instruction pipeline, Design mechanisms for instruction pipelining, Dynamic instruction scheduling, Branch handling techniques, Branch prediction, Arithmetic pipeline design

Memory Hierarchy Design: Cache basics and cache performance, Reducing miss rate and miss penalty, Multilevel cache hierarchies, Main memory organization, design of memory hierarchies

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

Unit V

Multiprocessor Architectures: Symmetric shared memory architectures, Distributed shared memory architectures, Models of memory consistency, Scalable cache coherence, Design challenges of directory protocols, Memory based directory protocols, Cache based directory protocols. Cache coherence protocols (MSI, MESI, MOESI), Overview of directory based approaches

- Pedagogy/Course delivery tools: Chalk and talk
- Links:

References:

1. Kai Hwang, "Advanced Computer Architecture: Parallelism, Scalability, Programmability", 1st Edition, Tata McGraw Hill, 2003.
2. Kai Hwang, Zu, "Scalable Parallel Computers Architecture" Tata McGraw Hill, 2003.
3. M.J. Flynn, "Computer Architecture, Pipelined and Parallel Processor Design", Narosa Publishing, 2002.
4. D.A. Patterson, J.L. Hennessy, "Computer Architecture: A Quantitative Approach", Morgan Kauffmann,2012.

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Illustrate contemporary computer architecture issues and techniques. (PO:1, 3, 4, 5)
2. Discuss the role of parallelism in current and future architectures. (PO:1, 3, 4, 5)
3. Analyze the behavior of a processor pipeline for various sequences of instructions. (PO:1, 3, 4, 5)
4. Apply concept of cache and virtual memory for high performance computer architecture. (PO:1, 3, 4, 5)
5. Compare different multi-processor architectures and cache coherence protocols. (PO:1, 3, 4, 5)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment Tool	**Marks**	**Course outcomes addressed**
Internal test-I	30	CO1, CO2, CO3
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other components		
Quiz	10	CO1, CO2, CO3
Assignment	10	CO3, CO4, CO5
Semester End Examination (SEE):	100	CO1, CO2, CO3, CO4, CO5